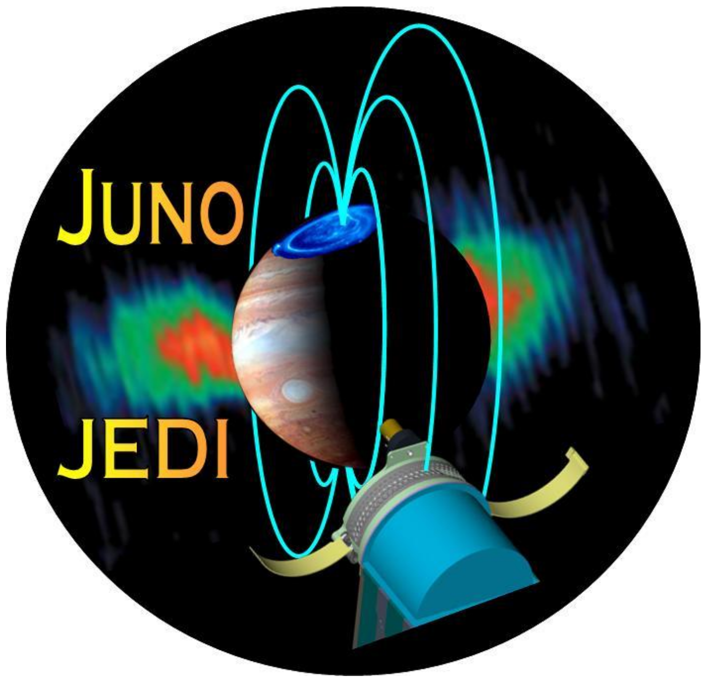
REV.	BY	DESCRIPTION	DATE
		Draft	01/16/10
a	DKH	Submit to PDS for preliminary review	4/30/10
-	DKH	Initial release	7/2/13
A	LB	Updated for level 3 SIS [ECN-05793]	4/7/14
B	DKH	Updated based on review feedback	01/27/17

JUNO

Jupiter Energetic particle Detector Instrument

JEDI Standard Product
Data Record and Archive Volume
Software Interface Specification



June 14, 2017

Document preparation led by D. Haggerty with L. Brown and C. Paranicas

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JUNO/JEDI Software Interface Specification

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A Release stamp electronically affixed at bottom of the pages of this document certifies that the above personnel or designated alternates have approved this release. Please refer to the APL Product Lifecycle Management System (PLM) for record of these approvals.

Contents

Figures

Tables

1 INTRODUCTION

This software interface specification (SIS) describes the format and content of the Jupiter Energetic particles Detector Instrument (JEDI) Planetary Data System (PDS) data archive. It includes descriptions of the Standard Data Products and associated metadata, and the volume archive format, content, and generation pipeline.

1.1 DISTRIBUTION LIST

Table 1: Distribution list

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1.2 DOCUMENT CHANGE LOG

Table 2: Document change log

Change	Date	Affected portion
Initial template	01/15/2010	All
Created official APL document	1/16/2010	Haggerty and others
Populate sections	4/7-30/2010	Haggerty and others
Fold in PDS changes, additions	10/10-4/11	All
Further additions and edits	5/11-2/12	Brown, Paranicas, and others

Edits	2/13-6/13	Brown, Paranicas, Mafi
Added Level 3 SIS	4/7/14	Brown
Respond to SIS reviewers	10/22/15	Brown, Paranicas
Final peer review lien resolution		Brown, Paranicas, Mafi

1.3 TBD ITEMS

Table 3 lists items that are not yet finalized

Table 3: List of TBD items

Item	Section(s)	Page(s)
Minor TBD items	Throughout	

1.4 ABBREVIATIONS

Table 4: Abbreviations and their meaning

Abbreviation	Meaning
ADC	Analog-to-Digital Converter
AMU	Atomic Mass Unit
APL	The Johns Hopkins University Applied Physics Laboratory
ASCII	American Standard Code for Information Interchange
CCSDS	Consultative Committee for Space Data Systems
CD-ROM	Compact Disc – Read-Only Memory
CDR	Calibrated Data Record
CFDP	CCSDS File Delivery Protocol
CK	C-matrix Kernel (NAIF orientation data)
CODMAC	Committee on Data Management, Archiving, and Computing
CRC	Cyclic Redundancy Check
Co-I	Co-Investigator
DAP	Data Analysis Product
DDR	Derived Data Record
DMAS	Data Management and Storage
DN	Digital number, the raw telemetry count
DPU	Data Processing Unit

DSHV	Deflection System High Voltage
DSN	Deep Space Network
E&PO	Educational and Public Outreach
ESA	Electrostatic Analyzer
ET	Ephemeris Time
EDA	End of data acquisition
EDR	Experiment Data Record
EFB	Earth flyby
FEI	File Exchange Interface
FIFO	First In, First Out. An electronic component that stores and retrieves information.
FOV	Field of View
FSW	Flight Software
FTP	File Transfer Protocol
GB	Gigabyte(s)
GCR	Galactic Cosmic Ray
GSFC	Goddard Space Flight Center
HK	Housekeeping
HTML	Hypertext Markup Language
HV	High Voltage
HVPS	High Voltage Power Supply
ICD	Interface Control Document
IOT	Instrument Operations Team
ISO	International Standards Organization
JADE	Jovian Auroral Plasma Distributions Experiment
JEDI	Jupiter Energetic Particle Detector Instrument
JIRAM	Jupiter InfraRed Auroral Mapper
JPL	Jet Propulsion Laboratory
JSC	Johnson Spaceflight Center
JSOC	Juno Science Operations Center – Southwest Research Institute
LET	Lineal Energy Transport
MAG	Magnetometer Instrument
MB	Megabyte(s)
MCP	Micro-channel Plate
MET	Mission Elapsed Time
MOC	Mission Operations Center
MWR	Microwave Radiometer Instrument
NAIF	Navigation and Ancillary Information Facility (JPL)
NASA	National Aeronautics and Space Administration
NSSDC	National Space Science Data Center
ODL	Object Description Language

PCK	Planetary Cartographic and Physical Constants Kernel (NAIF)
PDS	Planetary Data System
PPI	Planetary Plasma Interactions Node (PDS)
PHA	Pulse Height Analysis
RJ	Equatorial radius of Jupiter, typically 71,492 km
RSSG	Radio Science System Group
SCET	Spacecraft Event Time
SCLK	Spacecraft Clock
SIS	Software Interface Specification
SPE	Solar Particle Event
SPICE	Spacecraft, Planet, Instrument, C-matrix, and Events (NAIF data format)
SPDR	Standard Product (Experiment and Pipeline) Data Record
SPWG	Science Planning Working Group
SPK	SPICE (ephemeris) Kernel (NAIF)
SSD	Solid-State Detector
SwRI	Southwest Research Institute
TBC	To Be Confirmed
TBD	To Be Determined
TDB	Barycentric Dynamical Time (see USNO Circular 179)
TEP	Tissue Equivalent Plastic
TOF	Time of Flight
UVS	Ultraviolet Spectrometer Instrument
V-EGA	Venus-Earth Gravity Assist
UTC	Coordinated Universal Time

1.5 GLOSSARY

Archive – An archive consists of one or more data sets along with all the documentation and ancillary information needed to understand and use the data. An archive is a logical construct independent of the medium on which it is stored.

Archive Volume – A volume on which data products are stored. An *archive volume* is a volume containing all or part of an archive; i.e. data products plus documentation and ancillary files.

Archive Volume Set – When an archive spans multiple volumes, they are called an *archive volume set*. Usually the documentation and some ancillary files are repeated on each volume of the set, so that a single volume can be used alone.

BYTES - Specifies the number of bytes allocated for this particular column element.

Calibrated Data Record (CDR) - Data that has been converted to physically meaningful units and corrected (to a greater or lesser degree) for instrumental characteristics.

Catalog Information – High-level descriptive information about a data set (e.g. mission description, spacecraft description, instrument description), expressed in Object Description Language (ODL), which is suitable for loading into a PDS catalog.

COLUMN_NUMBER - Identifies the location of the column within the larger data object (such as a table). For tables consisting of rows (i= 1, N) and columns (j = 1, M) the column number is the jth index of any row.

COLUMNS - Identifies the number of columns (fields) in the table.

Data Product – A labeled grouping of data resulting from a scientific observation, usually stored in one file. A product label identifies, describes, and defines the structure of the data. An example of a data product is a planetary image, a spectral table, or a time series table.

Data Set – A data set is an accumulation of data products together with supporting documentation and ancillary files.

DATA_SET_ID - The data set id element is a unique alphanumeric identifier for a data set or a data product. The data set id value for a given data set or product is constructed according to flight project naming conventions. There is only one data set id for the JEDI EDRs.

DATA_TYPE - Specifies the internal representation and/or mathematical properties of the value being stored in this column.

Experiment Data Record (EDR) – An accumulation of raw output data from a science instrument, in chronological order, with duplicate records removed, together with supporting documentation and ancillary files.

FILE_RECORDS - Indicates the number of physical file records in the data file.

INSTRUMENT_HOST_NAME - The full name of the host on which an instrument is based. In this case it is the JUNO spacecraft.

INSTRUMENT_ID - Provides an abbreviated name or acronym that identifies an instrument.

INSTRUMENT_NAME - Provides the full name of the instrument.

INTERCHANGE_FORMAT - This element specifies whether the data table is in ASCII or binary format.

ITEM_BYTES - The size in bytes of individual items in a column. ITEMS * ITEM_BYTES should equal the value in the BYTES column.

ITEMS - Defines the number of multiple, identical occurrences of a single object. Used mainly in columns containing spectral or histogram data.

MISSION_PHASE_NAME - Provides the commonly used identifier of a mission phase as described in the mission plan.

MD5_CHECKSUM - Used to verify the successful electronic transfer of the EDR from the JSOC to the PDS-PPI Node.

NAME - Indicates a literal value representing the common term used to identify an element or object. NOTE: in the PDS data dictionary, name is restricted to 30 characters and must conform to PDS nomenclature standards.

OBJECT – Indicates the beginning of a PDS TABLE or COLUMN object. This object will contain sub-elements that are also described in this glossary. The end of the object definition is always marked with an END_OBJECT line.

PDS_VERSION_ID - Represents the version number of the PDS standards documents that is valid when a data product label is created. PDS3 is used for the JUNO data products.

Pipeline Data Record – An accumulation of calibrated data from a science instrument, derived from experiment data records, together with supporting documentation, calibration data, and ancillary files.

PRODUCT_CREATION_TIME - Defines the UTC system format time when a product was created.

PRODUCT_ID – PRODUCT_ID is unique within the data set. The combination of DATA_SET_ID and PRODUCT_ID form a unique identifier.

PRODUCT_VERSION_ID - Identifies the version of an individual product within a data set.

Example: 1.0, 2.0, 3.0. Product version id will be incremented if a given EDR has to be regenerated and sent to PDS to replace a previously submitted EDR. Major changes will involve the leading number.

PRODUCT_TYPE - Identifies the type or category of a product within a data set.

ROWS - Identifies the number of rows (records) in the table.

RECORD_BYTES - Indicates the number of bytes in a physical file record, including record terminators and separators. Note: In the PDS, the use of record bytes, along with other file-related data elements is fully described in the Standards Reference.

RECORD_TYPE - Indicates the record format of a file. Note: In the PDS, when record type is used in a detached label file it always describes its corresponding detached data file, not the label file itself. The use of record type along with other file-related data elements is fully described in the PDS Standards Reference.

ROW_BYTES - Specifies the number of bytes for each row in the table.

SOFTWARE_NAME - Identifies the data processing software used to convert from spacecraft telemetry into EDR products.

SOFTWARE_VERSION_ID - Indicates the version of the data processing software used to generate the EDR products from the spacecraft telemetry.

SPACECRAFT_CLOCK_START_COUNT - Provides the value of the spacecraft clock at the beginning of a time period of interest.

SPACECRAFT_CLOCK_STOP_COUNT - Provides the value of the spacecraft clock at the end of a time period of interest.

Spacecraft Event Time (SCET) – As used in this document, this refers to the time something happened on the spacecraft. Within the JEDI files, this is expressed in the "Ephemeris Time" system (aka Barycentric Dynamical Time or TDB).

Standard Data Product – A data product generated in a predefined way using well-understood procedures and processed in "pipeline" fashion. Data products that are generated in a non-standard way are sometimes called *special data products*.

STANDARD_DATA_PRODUCT_ID - Used to link a JEDI EDR file to one of the 4 types of JEDI data products defined within the JEDI EDR SIS.

START_BYTE - Identifies the location of the first byte of the particular column, counting from 1.

START_TIME - Provides the date and time of the beginning of an event or observation (whether it is a spacecraft, ground-based, or system event) in UTC system format.

STOP_TIME - Provides the date and time of the end of an observation or event (whether it be a spacecraft, ground-based, or system event) in UTC system format.

STRUCTURE - This is a pointer to the external file that provides the structure definition for the table object.

TABLE - Pointer to the EDR file that contains the data in BINARY table format. The structure of the data file is defined in a referenced format file.

TARGET_NAME - The target name element identifies a target. The target may be a planet, satellite ring region, feature, asteroid or comet.

1.6 JUNO MISSION OVERVIEW

The launch period for Juno opens on 5 August 2011 and extends for 21 days until 26 August. The spacecraft uses a ΔV-EGA trajectory consisting of a deep space maneuver on 12 September 2012 followed by an Earth gravity assist on 9 October 2013 at an altitude of 500 km. Jupiter arrival is on 5 July 2016 using a 107-day capture orbit prior to commencing operations for a 1-(Earth) year-long prime mission comprising 32 high inclination, high eccentricity orbits of Jupiter. The orbit is polar (90º inclination) with a periapsis altitude of 4500 km and a semi-major axis of 19.91 RJ giving an orbital period of 10.9725 days. The primary science is acquired for approximately 6 hours centered on each periapsis although fields and particles data are acquired at low rates for the remaining portion of each orbit. Currently, 5 of the first 7 periapses are dedicated to microwave radiometry of Jupiter's deep atmosphere with the remaining orbits dedicated to gravity measurements to determine the structure of Jupiter's interior. All orbits will include fields and particles measurements of the planet's auroral regions. Juno is spin stabilized with a rotation rate of 1 – 3 revolutions per minute (RPM). For the radiometry orbits the spin axis is precisely perpendicular to the orbit plane so that the radiometer fields of view pass through the nadir. For gravity passes, the spin axis is aligned to the Earth direction, allowing for Doppler measurements through the periapsis portion of the orbit. The orbit plane is initially very close to perpendicular to the Sun-Jupiter line and evolves over the 1-year mission. Data acquired during the periapsis passes are recorded and played back over the subsequent apoapsis portion of the orbit.

Juno's instrument complement includes Gravity Science using the X and Ka bands to determine the structure of Jupiter's interior; vector fluxgate magnetometer (MAG) to study the magnetic dynamo and interior of Jupiter as well as to explore the polar magnetosphere; and a microwave radiometer (MWR) experiment covering 6 wavelengths between 1.3 and 50 cm to perform deep atmospheric sounding and composition measurements. For studying the polar magnetosphere and Jupiter's aurora the instrument suite also includes a Jupiter Energetic particle Detector Instrument (JEDI), a Jovian auroral (plasma) distributions experiment (JADE), a radio and plasma wave instrument (Waves), an ultraviolet spectrometer (UVS), and a Jupiter infrared auroral mapping instrument (JIRAM). The JunoCam is a camera included for education and public outreach. While this is not a science instrument, we plan to capture the data and archive them in the PDS along with the other mission data. Appendix A lists personnel for JEDI and the associated PDS Discipline Node.

1.7 SIS CONTENT OVERVIEW

Section 2 describes the JEDI instrument. Section 3 describes the data sets, data flow, and validation. Section 4 describes the structure of the archive volumes and contents of each file. Section 5 describes the file formats used in the archive volumes. Section 6 describes the Archive Volume Format. Individuals responsible for generating the archive volumes are listed in Table 26 of APPENDIX A. PDS-compliant label files for all JEDI standard data products are itemized and described in APPENDIX B. CODMAC Level 2 data record formats are found in APPENDIX C, while Level 3 and above are found in APPENDIX D.

Scope of this document

The specifications in this SIS apply to all JEDI Standard Data Record products submitted for archive to the Planetary Data System (PDS), for all phases of the Juno mission. Some sections of this document describe parts of the JEDI archive and archiving process that are managed by the PDS archive team. These sections have been provided for completeness of information and are not maintained by the JEDI team.

1.8 APPLICABLE DOCUMENTS

- *ISO 9660-1988, Information Processing—Volume and File Structure of CD-ROM for Information Exchange*, 04/15/1988.
- *Planetary Data System Archive Preparation Guide*, Version 1.1, `JPL D-31224, 08/29/2006`.
- *Planetary Data System Standards Reference*, JPL D-7669, Part 2, Version 3.8, 02/27/2009.
- *Planetary Science Data Dictionary Document*, Planetary Data System, JPL D-7116, Version 1r65, 02/2007.
- *Juno Mission Operations Concept Document*, JPL D-35531, Version Preliminary, 04/30/2007.
- *Juno Science Data Management and Archive Plan,* Version Final, JPL D-34032, 08/26/2009.
- JUNO Data Management and Science Analysis Plan. The Johns Hopkins University, APL. Document ID number 7384-9019
- JEDI Flight Software Specification, version 1. John Hayes, The Johns Hopkins University Applied Physics Laboratory document JHU/APL 7425-9021, May 19, 2009.
- University Applied Physics Laboratory document JHU/APL 7389-9041, rev B, July 12, 2008

- Juno/JEDI Verification, Validation, and Calibration plan. JHUAPL 7425-9068, Sep 20008

1.9 AUDIENCE

This document is useful to those wishing to understand the format and content of the JEDI PDS data product archive collection. Typically, these individuals would include scientists, data analysts, or software engineers.

2 JEDI INSTRUMENT DESCRIPTION

Provided here is a summary and update to the JEDI overview paper (Mauk et al., 2013, DOI: 10.1007/s11214-013-0025-3)

2.1 SCIENCE OBJECTIVES

Juno will be the first spacecraft to fly over the poles of the planet Jupiter at low altitude. Juno science objectives for the polar magnetosphere include: Investigate the primary auroral processes responsible for particle acceleration, characterize the field-aligned currents that transfer angular momentum from Jupiter to its magnetosphere, identify and characterize auroral radio and plasma wave emissions associated with particle acceleration, and characterize the nature and spatial scale of auroral features. Except for field-aligned current characterization, the analysis and interpretation of JEDI data will address part of each of these objectives.

Juno is ideally suited to determine the auroral distributions of charged particles due to its low altitude passes through the polar region of the planet. For the auroral science, JEDI will directly measure precipitating fluxes including particles that generate the planetary aurora and particles that heat and ionize the planetary atmosphere. Detailed analysis of the particle spectral and angular characteristics will be used to study acceleration mechanisms. JEDI has the capacity, through its electron measurements, to determine the magnetic topology (e.g., open verses closed magnetic field lines) in the polar cap region. JEDI will also use measurements of particle distributions in the auroral region to understand the science of potential drops and field-aligned currents. Juno will also travel into the equatorial magnetosphere allowing for additional science. In the equatorial magnetosphere, JEDI will use measurements of particle distributions to determine structure and dynamics of the plasma sheet region. This includes resolving pressure balance issues, indirectly measuring flow speeds, and detecting injections. Energetic particles detected by JEDI also contain signatures of the structure of Jupiter's space environment, particularly the inner magnetosphere. Next we detail the measurement objectives and capabilities that support these science goals.

JEDI will measure the energetic plasma. The JEDI system covers the energy range of 25 keV to > 500 keV for electrons, and 10 keV/nucleon to ~20 MeV total energy for ions. The Johns Hopkins University/Applied Physics Laboratory constructed the JEDI instrument. It provides electron, high- and low-energy ion, including diagnostic events and some species separation, as a single stream of data that is placed into the JEDI event FIFO for processing by the JEDI flight software. Counts, counts per second, and intensity are all created from the data. These quantities are provided to the PDS so that the reader can reconstruct the parameter used to calculate one quantity from the other. This includes for instance the geometric factor, efficiency, and energy passband needed to convert from counts per second to intensity. We also supply the upper and lower energy to reconstruct the energy passband.

JEDI determines the distributions of the high-energy magnetospheric ions and electrons, including the composition of ions. It does this by measuring the energy and velocity of the particles and then using a look-up table to determine the mass and therefore the species of particle. The measured species for JEDI include electrons and ions of H, He, O, S. Electrons are measured by solid-state detectors behind Aluminum flashing.

Rapid spacecraft motions and slow spacecraft rotation require that JEDI simultaneously and continuously resolve both magnetic loss cones at every position inside of ~ 3 R_J. JEDI uses - multiple views that continuously sample within a 360º plane roughly normal to the spacecraft spin axis. All sky coverage is additionally achieved every spin with an additional sensor that views coplanar to the spin axis (Figure 1). The spacecraft coordinates are as follows: the s/c z-axis points through the high-gain antenna, the x-axis points along the magnetometer boom, and the y-axis completes the right-hand system. Coordinate systems that can be used for magnetospheric analysis can be found in the Space Sci. Rev. article by Bagenal et al. (2014). Sampling at 1/3 s cadence resolves auroral arcs that may be as narrow as ~80 km. The energy resolution capability is ≤ 20% to characterize field-aligned acceleration processes. Electron energy sampling extends to ~1MeV to characterize auroral acceleration/precipitation. Ion energies for O and S extend to ~15 MeV to characterize ion precipitation.

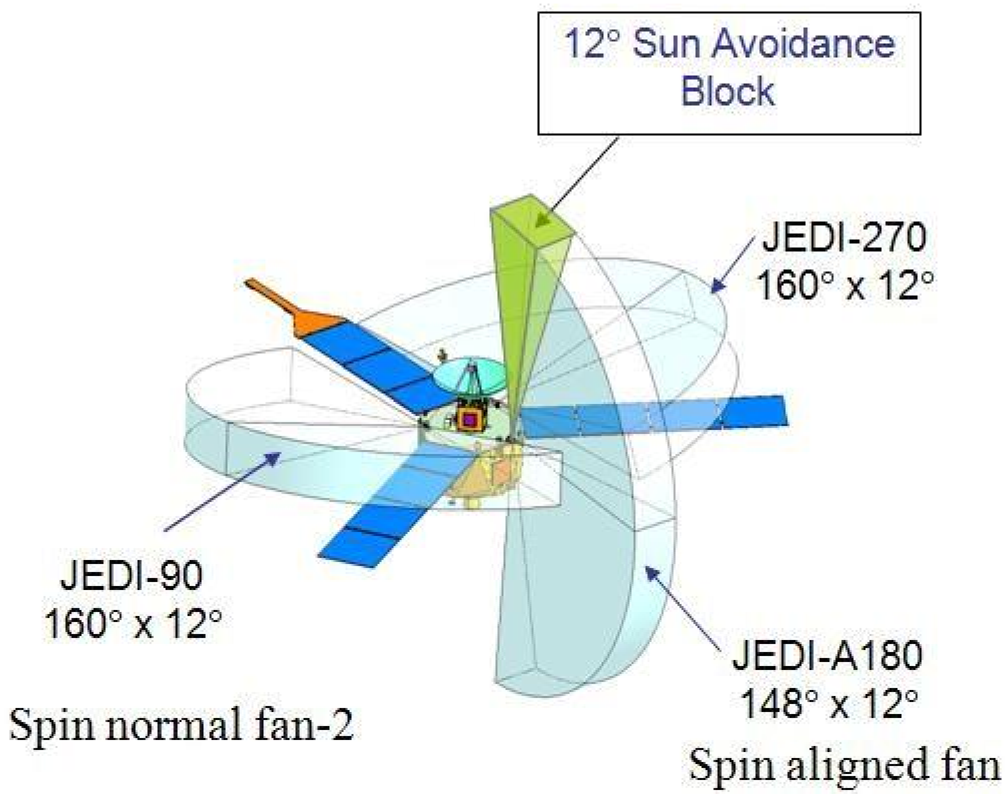

Figure 1: JEDI fields of view

2.2 DETECTORS

Each JEDI sensor consists of a 60 mm diameter, hockey-puck-like cylinder, in which a start foil and stop foil, wrapped around opposite curved sides of the cylinder, constitute the time-of-flight chamber. An incoming energetic ion will pass through the collimator and a passive thin foil designed to keep the cold plasma out of the instrument. Then the ion passes through the start foil generating forward-scattered electrons that are then focused towards the microchannel plate (see Figure 2). The ion will continue through the chamber to the stop foil, generating backscattered electrons, also accumulated on the MCP. The ion will then pass into a solid-state detector, providing the third component of the measurement. Since the time-of-flight (TOF) can be computed from the start and stop signals and the chamber size is known, the particle speed can be obtained. The velocity coupled with the energy yields the ion species. For ions that fall below the discrimination level of the solid-state detectors, a heavy vs. light determination can be made with the TOF and the anode pulse height. The start and stop foils in the JEDI sensor are composed of Carbon-Polyimide-Carbon (50-350-50 Angstroms) that are hung on a thin wire mesh with a measured 88% transmission rate.

The detectors are arranged so that each detector senses the events within a given range of incidence angles (Figure 2). One of the JEDI sensors also contains witness detectors. Each of the six detector modules is composed of four pixels: large and small ion and large and small electron. The electron detectors differ from the ion detectors in that they add a layer of aluminum, which excludes low-energy ions. Each electron and ion detector is split into a small pixel and a large pixel; the large pixel has 20 times the area of the small pixel. This provides 24 detector elements.

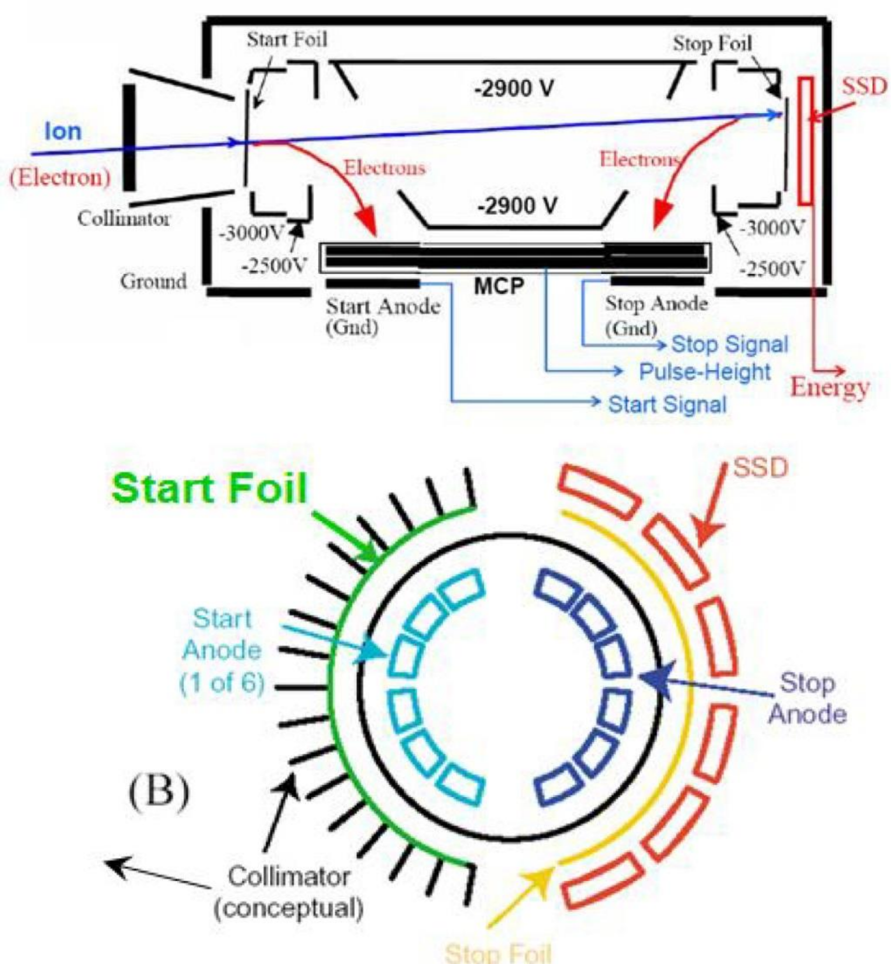

Figure 2: Top shows the conceptual function of the sensor, bottom shows the angular function of the sensor.

2.3 ELECTRONICS

The JEDI electronics box contains all the electronics to run the instrument other than the energy and timing preamps that are located in the sensor head. The box is comprised of three 10 x 15 cm boards mounted into 2.5 mm thick metal frames. The boards stack one on top of the other with a stacking connector providing electrical interconnects between the boards.

EVENT BOARD. The Event board directly processes the sensor SSD and anode preamp output signals and contains all the necessary analog and digital circuitry to process and store event information on an event-by-event basis. The energy signals from the six SSD preamplifiers and the MCP anode pulse height are processed in parallel peak-detect/discriminator circuit/ADC chains. The MCP anode signals are processed via constant-fraction discriminators and time-to-digital conversion circuitry; these measured time differences are converted into event look direction and particle velocity in the FPGA. FPGA-based event logic also determines which signals comprise valid ion and electron events and coordinates all event hardware processing timing. The FPGA also provides all command, control, telemetry, and data processing functions of the instrument. SRAM memory storage is provided on the board to support this processor.

SUPPORT BOARD. The Support board provides a variety of support functions for the instrument. It also contains EEPROM and boot PROM accessible to the FPGA on the Event Board. The command and telemetry interface to the spacecraft is provided on the support board. The board includes the high voltage power supply, which generates the necessary high voltage outputs for the sensor MCP and electron optics; maximum voltage is 3300V.

POWER BOARD. The Power board contains the low voltage power supply. The low voltage board takes spacecraft primary power on a single 9 pin connector and generates 1.5V, 3.3V, and 5V. A 15V output powers the high voltage electronics on the support board. The board also switches power to the sensor cover actuator mechanism and generates and filters 100V bias for the SSD detectors.

2.3.1 HARDWARE MODES

The SSDs contain both ion and electron detectors. There is only one analog electronics processing chain per SSD. Consequently, to collect both electrons and ions, the hardware must be time-multiplexed between the electron and ion detectors. Similarly, the event processing logic is switched between modes that measure ion energy vs. ion species. The hardware is time-multiplexed between three possible modes: electron energy, ion energy, and ion species. These modes are defined in Table 5.

Table 5: Hardware modes

Resource	Electron Energy	Ion Energy	Ion Species
Event Trigger	Set energy trigger		Set TOF trigger
TOF CFD Thresholds	Set TOF CFD thresholds		
TOF Pulse Height Threshold	N/A: set TOF pulse height threshold to max		Set TOF pulse height threshold
Electron vs. Ion Detector	Set electron source	Set ion source	Set ion (or electron) source
Pixel Size	Set pixel size selected for electron	Set pixel size selected for ion energy	Set pixel size selected for ion species
Energy Channel Enable/Disable	Set energy mask for electron and selected pixel size	Set energy mask for ion and selected pixel size	Set energy mask for ion and selected pixel size
Energy Thresholds	Set energy discriminator thresholds for electron and selected pixel size	Set energy discriminator thresholds for ion and selected pixel size	Set energy discriminator thresholds for ion and selected pixel size
Energy Baselines	Set energy baselines for electron and selected pixel size	Set energy baselines for ion and selected pixel size	Set energy baselines for ion and selected pixel size
Coincidence	Set event coincidence window		
Multiple Hit Reject	Enable/disable multiple hit reject for electron	Enable/disable multiple hit reject for ion	
Valid Event	N/A	N/A	Select valid TOF chips for ion species

Event trigger selects what combination of TOF and SSD pulses defines an event. With energy trigger, an SSD energy (E) pulse defines an event. With TOF trigger, a TOF pulse, with or without an E pulse defines an event.

Time-multiplexing the hardware is done by the software, which tries to maintain the illusion of independent electron and ion electronics. So, many commands have options for specifying electron or ion settings. For example, the command that controls energy discriminator thresholds specifies either electron and ion discriminator settings. The software time-multiplexes the actual discriminator threshold between the electron and ion settings. Sensor hardware and associated commands are described in the JEDI Flight Software Specification document # 7425-9021.

2.4 MEASURED PARAMETERS

The following sections describe JEDI in-flight science data processing, from low-level event processing to integration of the science data products.

2.4.1 SPINS, SECTORS, AND SUBSECTORS

The JEDI software divides each spacecraft spin into 60 evenly spaced sectors. As the spin rate varies, the duration of a sector varies accordingly. The spin starts, i.e. sector 0 starts, when the spacecraft's inertial spin phase is zero. Inertial spin phase is defined as the angle between the projection of ecliptic north in spacecraft XY plane and the X-axis in the direction of spacecraft spin. Note that this definition means that sector 0 corresponds to a different inertial direction for each JEDI sensor. The spacecraft provides spin rate and phase data to JEDI. JEDI maintains an internal spin model. At the start of each internal spin, the JEDI software calculates the current phase from the most recently received spacecraft phase data; any difference from zero constitutes a phase error. Based on the phase error and current spacecraft spin rate, the JEDI software calculates a sector duration that reduces the phase error. (Note: if no spacecraft data has been received lately or it is invalid, a nominal 30-second spin period is used.) On startup, it will take several spins for the internal spin model to eliminate its phase error with the actual spacecraft spin. Once the spin model and the actual spin are in phase, they will stay in phase as the spacecraft spin rate varies. Each sector is further divided into three subsectors. The first subsector is longer, 1/2 of a sector. The last two subsectors are shorter, 1/4 of a sector each. As for sectors, subsector timing varies with the spin rate.

The sensor hardware can be placed in a different mode during each subsector with a small fixed dead time (~3.8 ms) for switching between hardware modes. The pattern of modes in each subsector is commandable. Any subsector may collect data in any mode. Each pattern collects different data in different proportions. For example, setting subsector 1 to electron energy and subsectors 2 and 3 to ion species collects electron energy 1/2 of the time and ion species the rest of the time; ion energy is not collected at all. Note: if two adjacent subsectors have the same mode, there will still be a dead-time between the subsectors.

2.4.2 DATA PRODUCT INTEGRATION

The data products generated by the JEDI software depend on the hardware modes commanded for each subsector. For example, if electron energy mode is selected for all three subsectors, only electron energy spectra, basic rates, and raw event data will be collected. The following table lists the products generated in each mode; the precise definition of these products appears in subsequent sections. Only data from the first row of Table 6: Data Products Per Hardware

Mode are present in the PDS archive. The other data types are used by the instrument team for diagnostic and operational purposes. They are documented here since understanding how the Basic Rate and Event Data are collected is important for a clear understanding of the science content of the Spectral Rate data.

Table 6: Data Products Per Hardware Mode

Electron Energy	Ion Energy	Ion Species
Electron Energy Spectra	Ion Energy Spectra	Proton (and Non-Proton) Rates
Basic Rates (Electron Energy)	Basic and Diagnostic Rates (Ion Energy)	Basic and Diagnostic Rates (Ion Species)
Raw Event Data (Electron Energy)	Raw Event Data (Ion Energy)	Raw Event Data (Ion Species)
		Priority Event Data (Ion Species)

The data products generated by the JEDI software are organized into three types depending on their integration time: fast, medium, or slow. The duration of fast, medium, and slow integrations is set by command. The command has three arguments, S, N1, and N2. S specifies the number of sectors to integrate fast data products. N1 specifies the number of fast integrations that make up a medium integration; in other words, medium data products are integrated for S*N1 sectors. Similarly, N2 specifies the number of medium integrations that make up a slow integration, i.e. slow data products are integrated for S*N1*N2 sectors.

Some JEDI data products can be integrated over multiple spins. At the end of its normal integration, if multi-spin integration is enabled, the data product is saved instead of being telemetered. When the spacecraft spin returns to the sector that began the product, integration resumes. The number of spins to integrate is set by command. Figure 3 shows a data product integrated for 12 sectors and two spins. There are five instances of the data product spread over a spin, starting at different sectors. At the start of the first spin, the first instance is integrated for 12 sectors, then saved. Then, the second instance is integrated and saved, etc. At the start of the second spin, the first instance is integrated for another 12 sectors. This data has now been integrated for two spins and can be telemetered. Then, the second instance is further integrated and telemetered, etc.

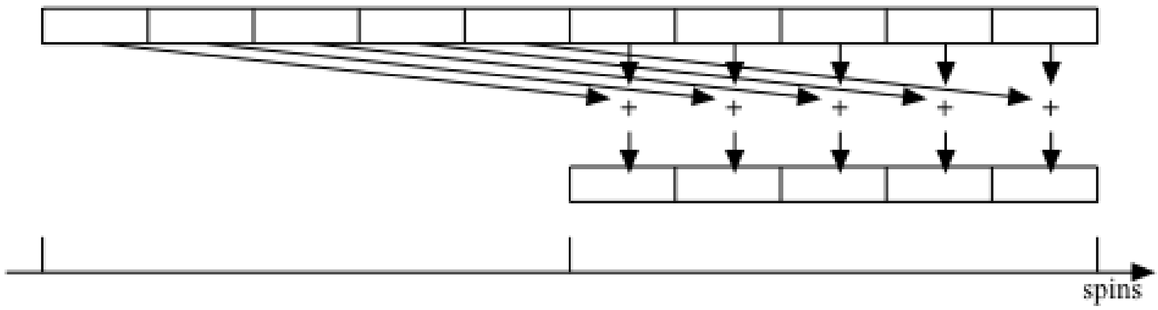

Figure 3: Multi-spin integration example

The following table lists the JEDI data products, their classification of fast, medium, or slow, and whether they can be integrated over multiple spins. The precise definition of these products appears in subsequent sections.

Table 7: Data Product Integration Times

Type	Data Product	Integration Time (Sectors)	Multi-Spin?
Fast	Electron Energy Basic Rates	S	Yes
	Ion Energy Basic Rates		Yes
	Ion Energy Diagnostic Rates		Yes
	Ion Species Basic Rates		Yes
	Ion Species Diagnostic Rates		Yes
	Low Energy-Res./High Time-Res. Ion Spectra		Yes
	Low Energy-Res./High Time-Res. Electron Spectra		Yes
	Low-Res./High Time-Res. TOF x Energy Proton Rates		Yes
	Low-Res./High Time-Res. TOF x Pulse Height Proton Rates		Yes
	Priority Events		
	Raw Electron Energy Event Data		
	Raw Ion Energy Event Data		
	Raw Ion Species Event Data		
Medium	High Energy-Res./Low Time-Res. Ion Spectra	S*N1	Yes
	High Energy-Res./Low Time-Res. Electron Spectra		Yes
	High-Res./Low Time-Res. TOF x Energy Proton Rates		Yes
	High-Res./Low Time-Res. TOF x Pulse Height Proton Rates		Yes
Slow	TOF x Energy Non-Proton Rates	S*N1*N2	Yes
	TOF x Pulse Height Non-Proton Rates		Yes

Each of the data products can be enabled or disabled by command. Most products are explicitly commanded; raw and priority event products are disabled by setting the number of events to zero. Data products will also be disabled automatically if they are not collected. For example, if ion energy mode is not scheduled in any of the subsectors, then Ion Energy Basic Rates will not be produced, regardless of its commanded enable or disable state.

2.4.3 EVENTS

Event analysis varies with the hardware mode, i.e. electron energy, ion energy, and ion species. For electron energy mode events, the JEDI software accumulates histograms of the SSD energy (see 2.4.6). Events are counted as processed by software and included in the basic rate data (see 2.4.4 & 2.4.5). Each event is also a candidate for inclusion in the raw event data (see 2.4.9). Ion energy mode events are processed similarly.

For ion species mode events, the JEDI software accumulates ion species rate counts (see 2.4.7). Ion species events are either high energy with TOF and SSD energy measurements or low energy with TOF only, i.e. no SSD energy. Note: a special value in the SSD number (i.e. the "Telescope" or "Look Direction") encodes the case of no SSD energy measurement. Events are counted as processed by software and included in the basic rate data (see 2.4.4 & 2.4.4). Each event is also a candidate for inclusion in the priority event data (see 2.4.8) and raw event data (see 2.4.9).

2.4.4 COUNTERS

The JEDI hardware counts a variety of pulses from the detectors. In addition to valid particle events, these count foreground, background, and noise events. The valid events seen, as well as the valid events placed in the FIFO, are counted. The software also counts the number of events it is able to process. The hardware counters are 24 bits. For every subsector, they are read out and accumulated in 32-bit counters in software. A different set of counters is collected in electron energy, ion energy, and ion species modes. There is a basic set of counters that are collected in electron or ion energy modes. These are listed in Table 8.

Table 8: Electron (or Ion) Energy Basic Rate Counters

Name	Description
SSD 0	Counts events above SSD energy threshold
...	
SSD 5	
SSD 0 Dead Time	Integrates dead-time in each SSD (100ns units)
...	
SSD 5 Dead Time	
State Machine Idle	Event state machine idle time (100ns units)
Multiple Hit Reject	Counts the number of events rejected due to simultaneous energy channel events
Valid Energy Events	Counts valid energy events
Valid Events Queued	Counts valid events placed in FIFO
Valid Events Processed	Counts valid events processed by software

An additional set of diagnostic counters can be collected in ion energy mode. These are listed in Table 9.

Table 9: Ion Energy Diagnostic Rate Counters

Name	Description
Start0 Anode	Counts events above start0 anode threshold
Start5 Anode	Counts events above start5 anode threshold
Stop0 Anode	Counts events above stop0 anode threshold
Stop5 Anode	Counts events above stop5 anode threshold
TOF Coincidence	Start and stop within 200ns window
SSD 0 with Start	Counts events above SSD energy threshold with a corresponding start
...	
SSD 5 with Start	
SSD 0 with Stop	Counts events above SSD energy threshold with a corresponding stop
...	
SSD 5 with Stop	

A more extensive set of counters are collected in ion species mode. These are shown in Table 10.

Table 10: Ion Species Basic Rate Counters

Name	Description
Start0 Anode	Counts events above start0 anode threshold
Stop0 Anode	Counts events above stop0 anode threshold
TOF Coincidence	Start and stop within 200ns window
Pulse Height	Counts events above TOF pulse height threshold
Start 0	Counts events calculated to be at the given start position
...	
Start 5	
SSD 0	Counts events above SSD energy threshold
...	
SSD 5	
SSD 0 Dead Time	Integrates dead-time in each SSD (100ns units)
...	
SSD 5 Dead Time	
State Machine Idle	Event state machine idle time (100ns units)
Multiple Hit Reject	Counts the number of events rejected due to simultaneous energy channel events
Valid TOF x PH Events	Counts valid TOF and pulse height events
Valid TOF x E Events	Counts valid TOF and energy events
Valid Events Queued	Counts valid events placed in FIFO
Valid Events Processed	Counts valid events processed by software

An additional set of diagnostic counters can be collected in ion species mode. These are listed in Table 11.

Table 11: Ion Species Diagnostic Rate Counters

Name	Description
Start5 Anode	Counts events above start5 anode threshold
Stop5 Anode	Counts events above stop5 anode threshold
TOF Valid 1	Counts valid event events from each TOF chip
...	
TOF Valid 3	
Pulse Height Dead Time	Integrates dead-time (100ns units)
Stop 0	Counts events calculated to be at the given stop position
...	
Stop 5	
RDT	Counts RDT resets of TOF chips

2.4.5 RATE CONTROL

The rate at which events reach the event processing logic is implicitly set by the size of the SSD pixel. The large pixel has 20 times the area of the small pixel and has 20 times the chance of detecting a particle. At high event rates, the small pixel could be used to keep from overwhelming the event processing logic. At low event rates, the large pixel could be used to try to capture every event. Whether to use the small or large pixel can be set manually by command. Or, the JEDI software can be commanded to automatically select the pixel based on the measured event rate. Note: the electron energy, ion energy, and ion species pixel are controlled independently.

The automatic pixel selection algorithm uses the SSD channel counters from hardware, i.e. SSD0 - SSD5, which count events above SSD energy thresholds. These rates are integrated over a sector. The rates are normalized per the data collection pattern (e.g. multiply the rate by 4 if it is only collected for 1/4 of a sector). Assume that the automatic mode is enabled and the large pixel is currently selected. Each sector, the number of channels that have a rate exceeding a threshold are counted; if the count exceeds a maximum channel threshold, a sector counter is incremented. At the end of the spin if the sector count exceeds a threshold, the rate is declared to be too high. (Note: counting sectors filters out rate variability due to the spin.) If the rate is too high for some number (another threshold) of consecutive spins, the small pixel is selected. Similarly, to automatically switch from the small to the large pixel the rate of so many channels would have to be below a threshold for a number of sectors for the rate to be declared too low and the rate would have to be too low for a number of consecutive spins before automatically switching to the large pixel.

2.4.6 ELECTRON AND ION ENERGY PROCESSING

Electrons are processed into energy spectra. Processing an electron starts by reading the SSD channel and SSD energy. Then a composite energy is calculated. If the SSD energy is high, then pulse width is read and used instead; otherwise, the SSD energy is used. The composite energy is mapped to a high-resolution bin number via a lookup table. The SSD number is used to select one of six spectra. An energy bin (representing a specific range in measured particle energy) in the spectral histogram being accumulated, indexed by SSD number and high-resolution bin number, is incremented. Ion processing is similar. Note that electrons and ions have distinct energy binning tables.

The spectral energy histograms are further integrated into a variety of data products for downlink. The spectra are re-binned to produce low energy-resolution but are sent often providing high time-resolution. The spectra are also integrated for longer times thus providing high energy-resolution, but low time-resolution.

2.4.7 ION SPECIES PROCESSING

Ions are categorized into different species and counted. This is done using $E=(1/2)*M*V^2$ for M (species), given E (energy) and V (d/TOF). Rather than a calculation, a lookup table indexed by energy and TOF is used. High energy ions trigger the SSD and thus provide a direct measure of energy. However, low energy ions do not trigger the SSD and the MCP pulse height is used as energy. Processing an ion species event starts by reading the SSD channel. If the SSD number is in the range 0 - 5, indicating that the SSD was triggered, the start position calculated by the event logic, the SSD energy, and the TOF are read. Then a composite energy is calculated. If the SSD energy is high, then pulse width is read and used instead; otherwise, the SSD energy is used. The composite energy and TOF are used to look up a species bin number. The start position and the bin number are used to select a TOF x Energy ion rate counter to increment. If the SSD number is 6, indicating that the SSD was not triggered, the MCP PH and TOF are read. These are used to look up a species bin number; note that this is a different lookup table than used for TOF x Energy events. The start position and the bin number are used to select a TOF x Pulse Height ion rate counter to increment. Details of the TOF X Energy Ion Species Rates and TOF X Pulse Height Ion Species Rates can be found in the JEDI Flight Software Specification Document # 7425-9021

2.4.8 PRIORITY EVENT DATA

JEDI saves details of selected ion species events. A priority number from 0 to 5 is assigned to each event; the priority is computed via a lookup table. JEDI can be commanded to only save events of a given priority; the software can also be commanded to automatically rotate through all priorities. The events are saved in the order in which they are received, i.e. FIFO order. The maximum number of events to collect is commandable. The priority event data is integrated for S sectors. The event's TOF, Start Chan, Stop Chan, and SSD Chan are saved. For TOF x Energy events, the composite energy is saved; for TOF x PH events the MCP PH is saved.

2.4.9 RAW EVENT DATA

JEDI also collects raw event data. Raw data is collected for each of the three hardware modes: electron energy, ion energy, and ion species. The three types of events are placed in three distinct data products. The events are saved in the order in which they are received, i.e. FIFO order. The maximum number of events to collect is commandable. The raw data is integrated for S sectors.

For ion species events, all of the event data is saved. For electron energy and ion energy events, the SSD energy, SSD PW, SSD Coincidence, SSD Flags, and SSD Chan are saved.

Table 12: Level-3 measurement requirements

Parameter	Level-3 requirement
Electron Energies	40-500 keV
Ion Energies (measured, not discriminated)	H: 20-1000 keV; He: 30-1000 keV: O: 50-1000 keV; S: 80-1000 keV
Energy Resolution	H E< 40 keV & O, He, S ≤ 30%; H E > 40 keV: ≤25%; Electrons: Max [25%, < 15 keV]
Time sampling	≤ 1 sec
Angle resolution	30º
Angular Coverage	3 heads for ~ 4π sr/spin & Low altitude: instant PA coverage
Time: Full PA coverage for $R \leq 3R_J$	≤ 2 sec
Ion Composition	H & S/O separated for required energies. He for 70-1000 keV
Electron Sensitivity	I = 3E5 – 3E9 $1/cm^2$.s.sr
Ion Sensitivity	I = 1E4 - 1E8 $1/cm^2$.sr

2.5 OPERATIONAL MODES

The JEDI has 5 main modes that it uses in orbit. High, Medium, Low, all refer to the volume of data. These different data modes are necessary to control the volume of data that is available for telemetry while still achieving the LEVEL 1 requirements for the Juno mission. There is also a calibration mode and a ENA mode. The high rate mode is used from 3 hours before perijove to 6 hours after perijove and represents the vast majority of the JEDI telemetry volume each orbit. Two of the sensors (the JEDI-90 and the JEDI-270) are configured exactly the same in each of the modes, with the same time resolution and spectral resolution. The JEDI-A180 sensor will function differently from the other two. This is required to control telemetry while maximizing the science return. The Medium rate mode is used from 9 to 3 hours prior to perijove, and from 6 to 9 hours after perijove. The ENA mode is used from 14.5 to 9 hours prior to perijove and from 9 to 14.5 hours after perijove. The Calibration mode is used for 2 hours near the magnetic equator crossing. The remainder of the orbit is in Low rate mode. During low rate mode the JEDI-90 and JEDI-270 have their high voltages lowered and are not used other than a small amount of housekeeping data. The JEDI-A180 will be the workhorse in the Low rate mode. Note that the time spent in each mode and the total amount of telemetry allocated to JEDI may change numerous times throughout the mission as more or less volume is available.

The operational modes of JEDI are summarized in Table 13 (notional rates only).

Table 13: JEDI Science telemetry modes

Data Mode	High (2 heads)	High (1 head)	Med (2 heads)	Med (1 head)	Cal (3 heads)	Low (2 heads)	Low (1 head)	ENA Imaging
Total each head: bits/sec (compressed)	7990	1447	3579	581	1018	196	227	768
When Mode is used (vs. CA) in hours	-3 to 6	-3 to 6	-9 to -3 and 6 to 9	-9 to -3 and 6 to 9	Near apogee	Outside ±14	Outside ±14.5	-9 to -14.5 and 9 to 14.5
Time spent in mode per orbit (hours)	9	9	9	9	2	243	232	11
Data Accumulated per orbit (Mbits)	565		251		22	534		91
Total Data Accumulated per orbit (Mbits)	1463							

2.6 OPERATIONAL CONSIDERATIONS

The JEDI sensors have high-voltage MCPs and thus are susceptible to problems if the pressure around the sensors is more than ~10^{-6} Torr. Any time the Juno spacecraft uses its main engine the JEDI HV must be reduced. Reducing the HV removes the ability to determine ion species but does not affect energy-only ion and electron spectra.

2.7 GROUND CALIBRATION

The JEDI Verification, Validation and Calibration Plan defines the approach and methods that APL has implemented to verify that JEDI meets the requirements. The JEDI team does not plan to archive the ground calibration data.

2.7.1 CALIBRATIONS AT APL

Most of the calibration of the JEDI sensor was performed at the 170 keV facility at APL. The APL particle accelerator is a versatile system capable of producing a broad range of ion species at energies from 3 to 170 keV. The system includes an electron-impact ionization source, extraction gap, Enzel lens and Wien filter mounted in the insulated terminal structure along with all associated power supplies. The accelerator is capable of producing beams of H, He, O, Ne, Ar with intensities over the range of 10's to 1,000,000 particles/cm^2/s at the target position.

Figure 4 is a summary contour plot showing numerous beam runs at the APL facility. The 6 proton runs shown in Figure 4 (from right to left) were at 170, 150, 125, 100, 75, and 50 keV incident energy. The ordinate is the TOF of each particle and the abscissa is the energy the particle deposited in the SSD, both axis are shown in raw analog to digital units (ADUs) representing the channel number of the pulse height analysis system, which is how they are stored on the instrument. The proton runs show that the lower energy range of the instrument both the energy and the TOF are nearly linear.

As the particle enters the sensor it passes through a number of different foils. The first foil the particle encounters is the Al front foil ~300 angstroms thick. The front foil is used to keep most of the low energy electron (and ion) particles from entering the instrument. The second and third foils, start and stop foils, are described in section 2.2. The final foil is 200 angstroms Al and is used as an additional light shield for the SSD array. The particle loses energy through each of these foils before impacting the SSD so the measured energy is not the incident energy of the particle. The protons lose ~ 20 keV through the system and that loss is fairly uniform at these energies. The amount of energy loss can be simulated on a species by species bases to a high degree of confidence. Below ~ 50 keV the energy loss by the protons becomes much more severe. By 30 keV only a very small percentage of the incident protons leave an energy signal in the SSD, However the TOF of these lower energy protons is measured very accurately so coupled with the anode pulse height, the spectrum can be extended down to very low energy protons.

The Helium runs at (42, 37, 31, 25, and 18) keV/n and the Nitrogen runs at (12, 10, 8, 7, 5) keV/n show the clear species separation at these low energies. A degraded alpha source was also placed inside the chamber to provide Helium observations at higher energies.

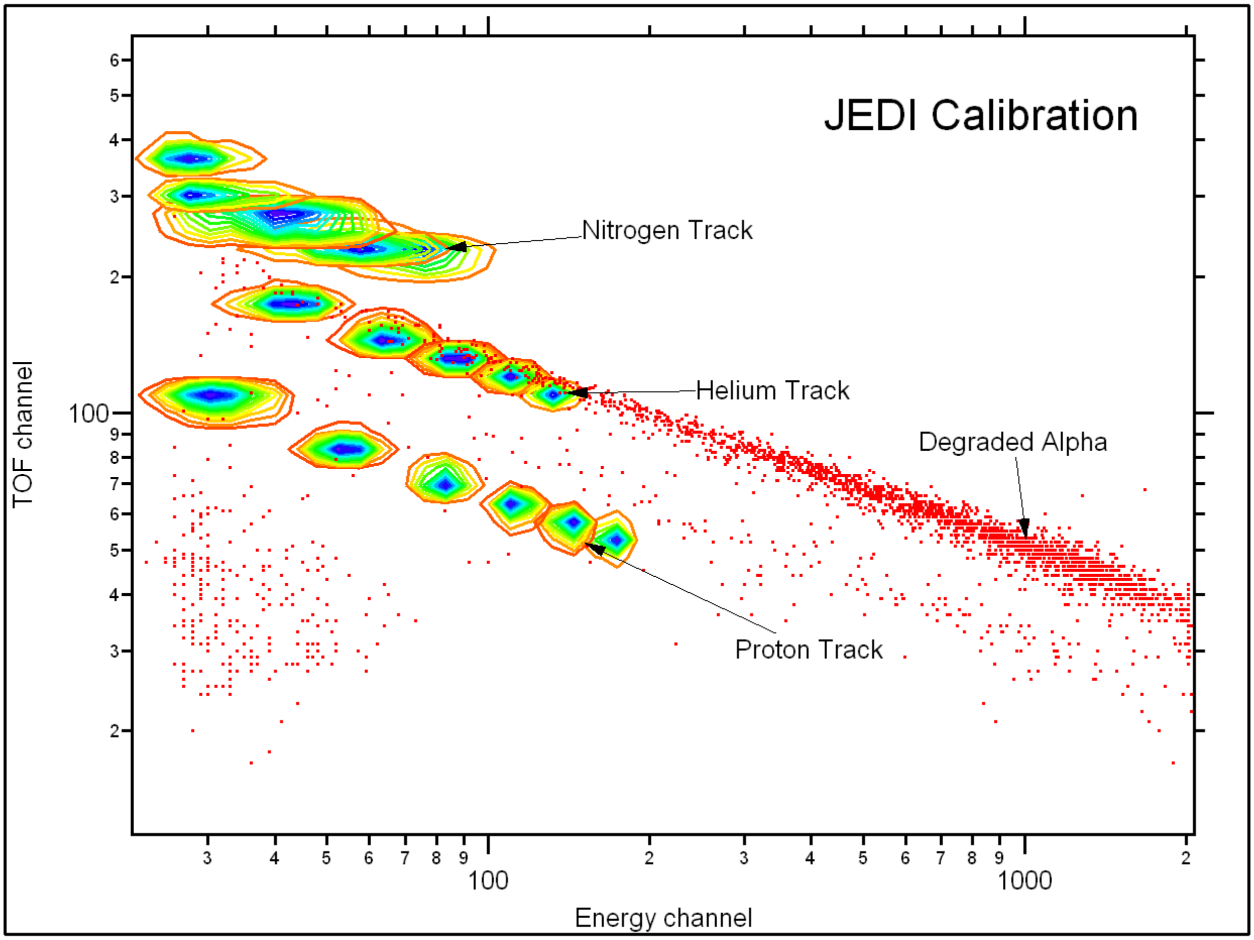

Figure 4: Ion calibration runs at APL

2.7.2 CALIBRATIONS AT GSFC

For higher energy ions and electrons calibrations were performed at Goddard Space Flight Center using their Van de Graff Accelerator. It provides both mono-energetic ion and electron beams at different intensities from 150 keV to 1.5 MeV. Numerous calibration sessions were performed with beams of Ar, N, He, H, and electrons.

Figure 5 is a summary contour plot of a number of runs at the GSFC facility. Included in these runs higher energy protons, He, N, Ar, with an H2O and a Kr run. These higher energy heavy ion runs allow us to calibrate the sensor with particles very similar to what JEDI will measure in orbit around Jupiter.

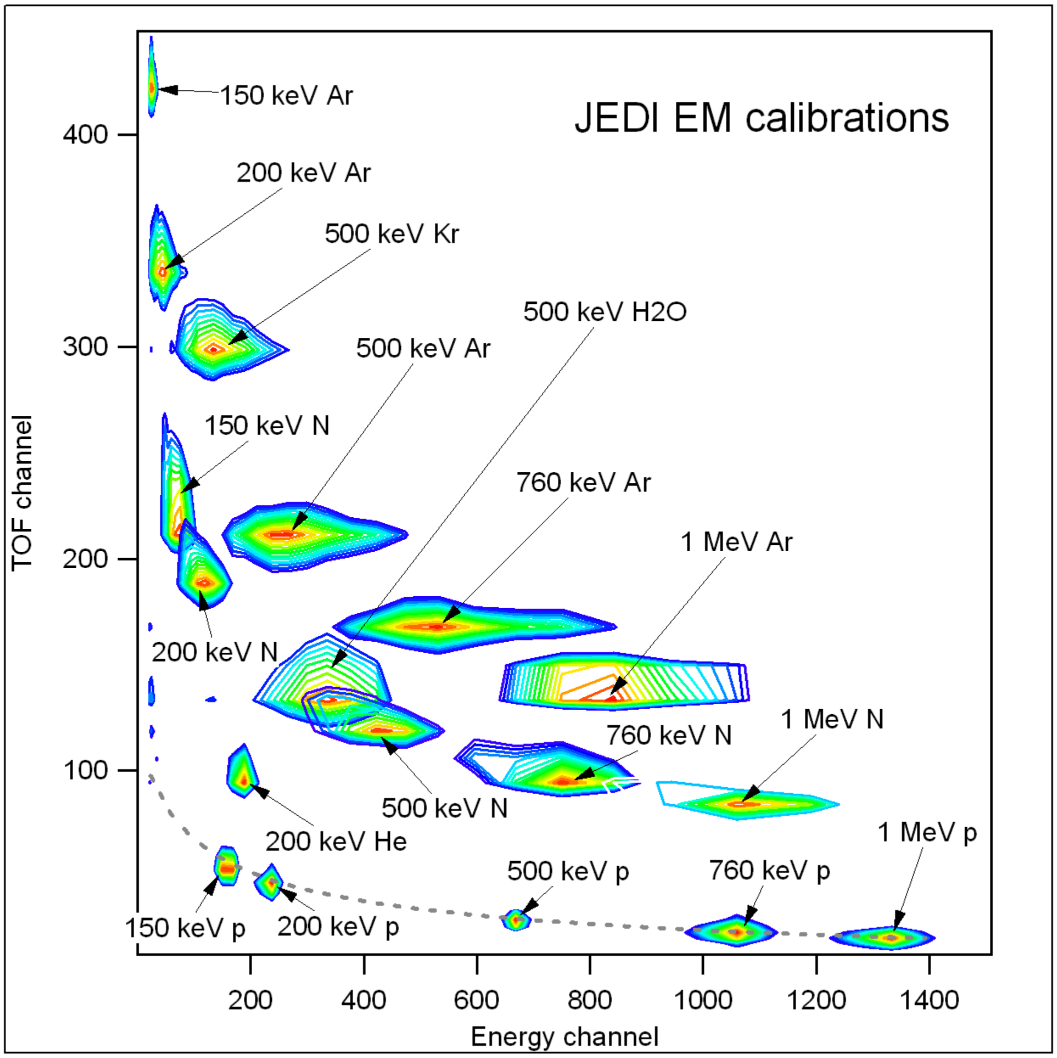

Figure 5: JEDI calibration runs at GSFC

2.8 INFLIGHT CALIBRATION

The following procedures will be used to maintain the calibration state of the JEDI instrument during flight.

A) Rough determination of MCP gain states. Pulse-height analysis (PHA) information is collected for individual particle events all of the time during normal operation of the sensor heads. For particles that generate both a MCP Time-of-flight (TOF) signal and a SSD energy signal, the PHA word includes at least the information to determine: Start direction (1 of 6

directions), Start anodes Pulse Height (PH), Time-of-Flight, SSD sensor identification, Energy, Energy-Mass bin identification. For each of the 6 Start directions, a Pulse-Height distribution can be generated on the ground for any selected Energy-Mass bin
. For example, to get a rough estimate of the gain state of each start section of the MCP, one might choose 170 keV Oxygen ions. Since the peak of the PH distribution is well away from the single electron peak, the peak value is not affected by inaccuracies in the setting of Constant Fraction Discriminator (CFD) discrimination levels. We might choose to perform the resetting of the MCP bias voltage, and the initial resetting of the discrimination levels on the basis of this rough estimate. This relatively simple procedure should be sufficient to decide on the MCP bias voltage. More may need to be done (Item #B) to determine final settings for the CFD discrimination levels.

B) Refined determination of MCP gain states. Once (with Item #A above) we have a rough idea of the MCP gain states and the suitability of CFD discriminator settings, we again obtain PHA words over an extended period of time, but this time we cycle through various Constant Fraction Discriminator (CFC) discrimination levels (both sides of the time-delay chain), using the information gained from #A to limit the search space. For each of the 6 Start directions, Pulse-Height distributions are again generated on the ground for each of the CFD discrimination levels. Using Energy-Mass bins where roughly single electrons are expected to be generated (e.g., > 300 keV protons), we search for the CFD discrimination level which reveals a peak in the PH distribution, and where the peak does not move to lower values as the discrimination levels are reduced. If such peaks cannot be found, the in-flight test might have to be re-performed with a higher MCP bias voltage to raise the gain of the MCP, however Item #A should be sufficient to set the MCP HV, given MCP behaviors learned on the ground. Based on these tests, refined optimum CFD discrimination levels are set. It is anticipated that these levels will be most optimum for some look directions, and less optimum for others. Assuming that the optimization varies according to look direction, we now face the task of quantifying the measurement efficiency as a function of look direction.

C) Determination of MCP efficiencies. Efficiencies are determined by using the standard "mode" of cycling back and forth between the "SSD-initiated ion spectra" mode, and the TOF-initiated Matrix mode on time scales less than 1 second (right now the plan allows this cyclic to occur on a 0.5 sec cyclic basis for Juno JEDI). By finding a period in the orbit when (according to the Matrix measurements) some portion of the spectrum is dominated by protons, one obtains a (singles-event-rate normalized) SSD-only spectrum of protons, and then immediately after obtains a (single-event-rate normalized) Matrix proton spectrum from the same SSD. An energy-by-energy comparison between these two spectra immediately reveals the total MCP efficiency as a function of energy, and the efficiency variation can be tracked by choosing a "standard candle" proton energy. This finding is compared to ground calibrations obtained using the same procedure to determine changes in the MCP efficiencies. Assuming that Items #A and/or #B has been used to optimize the MCP bias voltage and Start discriminators for the Start region of the MCP, the efficiency measurement documented here can be used to optimize the Stop CFD discrimination levels (Item #E).

D) Supportive approach to determining MCP efficiencies. During our meeting we spoke of including the capability of generating the following two singles rates: i) a SSD-initiated coincidence rate where the coincidence is between each (is this right?) SSD and the total MCP start rate, and ii) a coincidence rate where the coincidence is between each SSD and the MCP stop rate. A comparison between these new singles rates and the SSD-alone singles rates provides the “average” efficiency of the MCP, separately for the start anode region and the stop anode region. The “averaging” is over species, energy, and look direction. The averaging over species means that this technique will be most useful when the external environment is dominated by protons (this is more restrictive than just finding a portion of the spectrum dominated by protons). The averaging by energy means that this technique provides a lower fidelity determination of the MCP gain state than does Item #C above. The usefulness of this addition is that it allows us to address the gain state of the Stop Anode region directly and independently without bootstrapping off of the determination of the gain state of the Start Anode region.

E) Determining Stop CFD discrimination levels. Once Items #A, #B, #C, and perhaps #D have been performed, we use several periods of time when we cycle through a range of Stop CFD discrimination levels to search for the response plateau. We use the diagnostic mode where we switch back and forth (on a less than 1 second time basis) between the SSD-initiated ion spectra and the TOF-initiated Matrix mode. We use a portion of the spectra where the protons are expected to be most dominant to determine the Stop CFD levels that optimize the total system efficiency as a function of look direction. “Several time periods” are used because we want to use a time period when protons are most dominant.

3 DATA SET OVERVIEW

The EDR data products generated by the JEDI system, as well as the JEDI instrument status EDR, are described in this section. For all the EDR products there is a detached PDS label file that describes the contents of one data file. Each label file will have the same base name as the data file it is describing, with the extension ".LBL" to denote a label file. The label file defines the start and end time of the observation, product creation time, and the structure of the binary (or ASCII) tables.

3.1 DATA SETS

The JEDI portion of the data archive currently consists of two data products EDR and CDR. The JEDI instrument creates all of its different science data packets during one observation, but the packets are telemetered to the ground at different times. The different formats of these data packets do not lend themselves to standardization into one EDR file format. Therefore, different EDR formats have been developed, each of which captures one specific data grouping such as a specific spectrum. A given EDR data file will contain all the observations obtained on a specific segment of the Juno orbit. Table 14 shows the different JEDI data products.

Table 14: Data Set IDs and Contents

Data Set	Key/Physical Parameters	NASA Level	COD MAC	Processing Inputs	Product Format
EDR	The raw packets JEDI produces, decommutated, decompressed and formatted into ASCII tables		2		ASCII
CDR	Time-ordered electron or ion intensities vs. energy, pitch angles, position and attitude		3/4		ASCII

3.1.1

The Experiment Data Record is the raw data that the JEDI instrument produces, sorted into separate file sets corresponding to different data collection modes, decompressed, "flattened" into a simple tabular format and converted to ASCII. The data set IDs for these raw products are JNO-SS-JED-2-EDR-V1.0 and JNO-J-JED-2-EDR-V1.0. The data set names are "JUNO SS ENERGETIC PARTICLE DETECTOR UNCALIBRATED V1.0" and "JUNO J ENERGETIC PARTICLE DETECTOR UNCALIBRATED V1.0". Here the target designation is as follows: E=Earth, J=Jupiter, SS=Solar System, when the spacecraft is in the solar wind. Table 22 lists the available EDR data product types.

3.1.2

The JEDI instrument measures the count rate of electrons and ions. The data products CDR are the count rates converted by the IOT to physical units of intensity. They are delivered in scientific units (particles/cm^2-sr-s-keV) as a function of incident energy and direction in time ordered ASCII CSV files. The position and attitude of the spacecraft and the measured pitch angle between the look direction and the local magnetic field for each telescope are included in this product. These products make up the data set IDs: JNO-SS-JED-3-CDR-V1.0 and JNO-J-JED-3-CDR-V1.0; data set names: JUNO SS JEDI CDR V1.0 and JUNO J JEDI CDR V1.0.

3.2 DATA FLOW

The Juno Data Management and Storage (DMAS) will receive packets and CCSDS File Delivery Protocol (CFDP) products from the Deep Space Network (DSN) and place these on the Project data repository system. The DMAS will provide the initial processing of the raw telemetry data. At this point compressed data are not decompressed. The JEDI Instrument Operations Team (IOT) will retrieve the data from the DMAS using FEI services and ancillary data from the JPL Mission Support Area (MSA) via the Juno Science Operations Center (JSOC). The IOT will decompress the raw instrument data, where necessary, sort packets into separate files and convert them to simple ASCII tables and return them to the JSOC. The JSOC will also receive and organize higher-level data products developed by the Science Investigation Teams associated with each instrument. JSOC development and operations will be carried out at SwRI, in coordination with the MOC at JPL.

The JEDI Science Investigation Team will verify the content and the format will be validated. The resulting decompressed, restructured Level 2 data will constitute the lowest level of data to be archived with the PDS. JSOC will coordinate the validation of the edited (CODMAC Level 2) data archive volumes created by the IOT. The Science Investigation Team will develop higher level data products based on the Level 2 data and ancillary data and return these to the JSOC. JSOC will support archiving the Level 2 data by building archive volumes and verifying the format of the volumes and included data and metadata. Higher-level data set archives will be coordinated through the JSOC. The Science Investigation Team will be responsible for ensuring that the metadata and documentation included with these data sets are complete and accurate. This means that both JSOC and the Science Investigation Team will need to work closely with the PDS. This coordination will be fostered via the Data Archive Working Group.

A comprehensive description of the Juno Mission System is provided in the Juno Mission Operations Concept. A data flow diagram for the downlink process is shown in Figure 6.

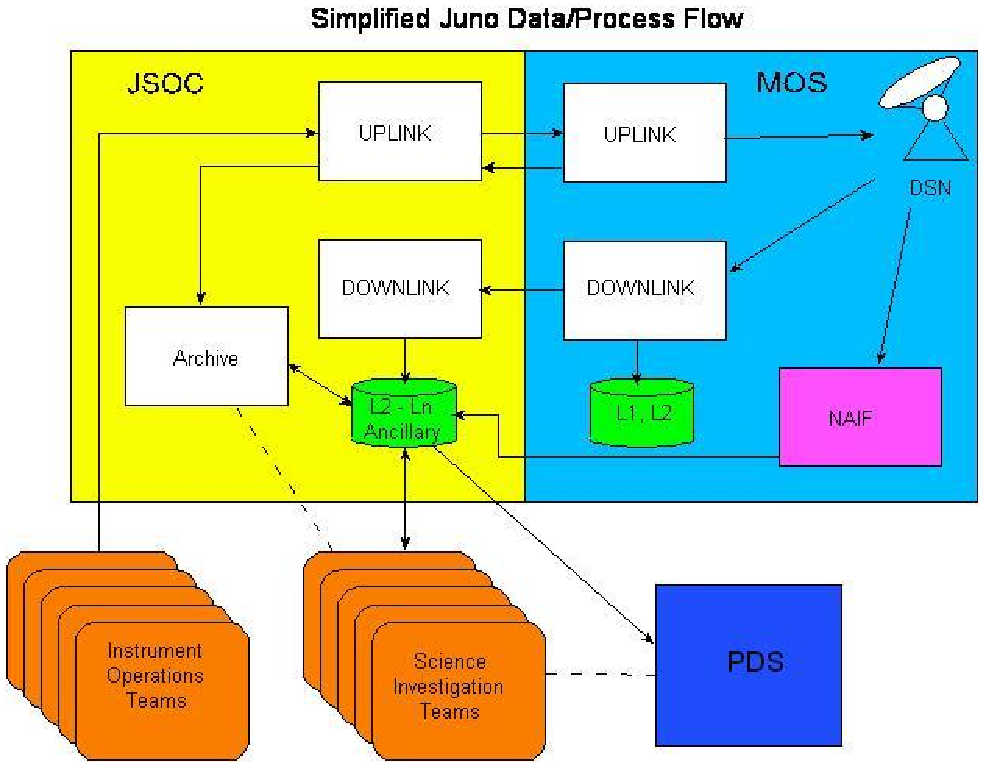

Figure 6: Juno science data flow diagram. White boxes are processes and solid arrows indicate data flow. Dotted lines indicate verification and validation.

3.3 DATA PROCESSING AND PRODUCTION PIPELINE

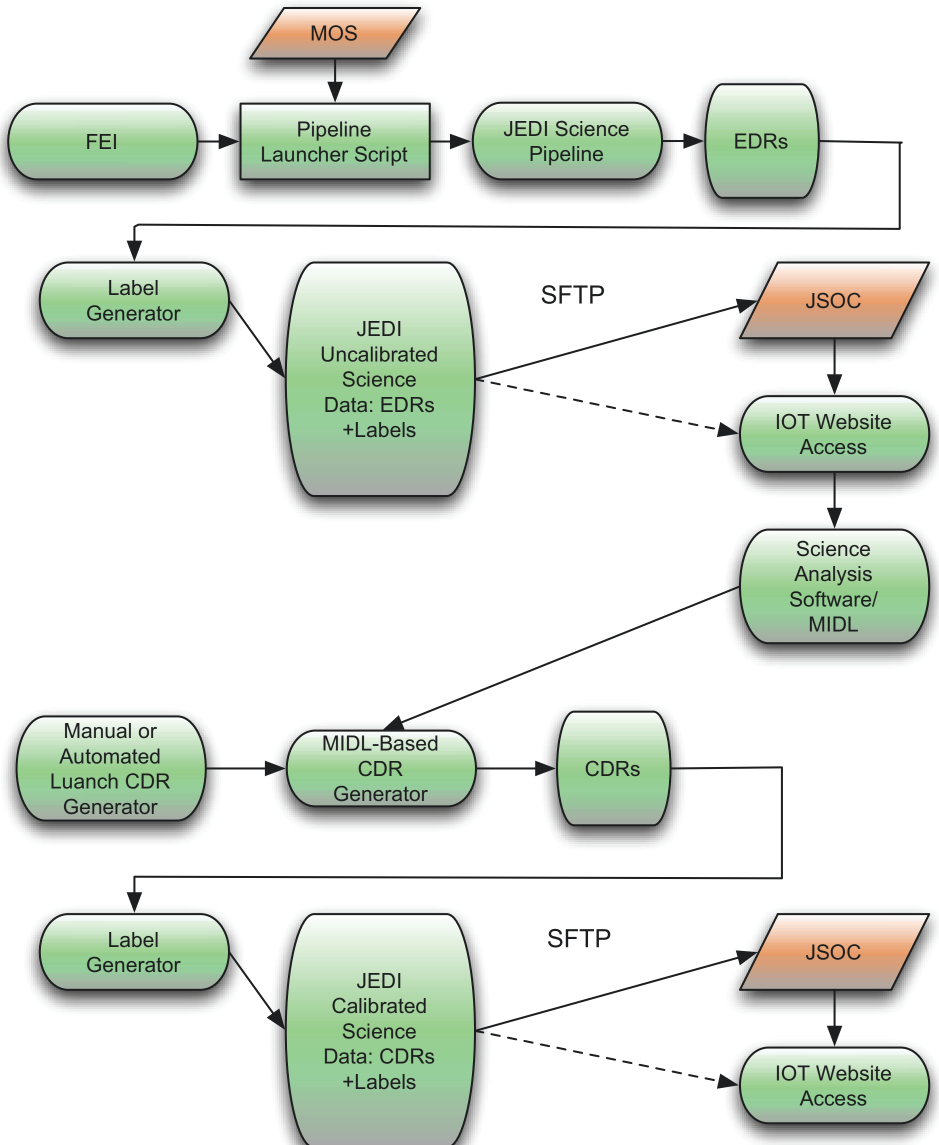

Figure 7: JEDI Science Data Pipelines. The two JEDI pipelines (EDR and CDR) are shown. Processes and data occuring on APL equipment or residing at APL are shown in green

3.3.1 LEVEL 2 DATA PRODUCTION PIPELINE

The CODMAC Level 2 (EDR) data pipeline is triggered by the FEI software provided by JPL that is run on an APL computer. The FEI process triggers a controller script that is responsible for running the rest of the pipeline. When new science or (packetized) engineering files are available, the FEI process transfers the new file to a staging area on the APL computer and launches the controller script. The controller script copies the raw file to the Raw File archive area on the JEDI IOT disk area. Once an hour, the JEDI pipeline system (J-PF, based on APL's "Conduit" Framework) is run on all new files. J-PF ingests a science or engineering file, separates the instrument data subpackets by type and writes a separate output file for each subpacket type to the EDR archive area on the JEDI IOT disk area.

EDR files contain one day's worth of data, in Space Craft Event Time (SCET), for one JEDI subpacket type for one JEDI instrument (APID). If a file of the current data type for the current (SCET) day already exists, it will be replaced with a new one with an incremented version number. Note that scet indicates the time the event occurred on the s/c. If no other qualifiers are present, it is to be assumed that scet is given in ephemeris (i.e., Solar System barycentric time (TDB)).

PDS label generation is done by the same java module that produces the EDR output and will generate PDS label files for each of the new files in the IOT EDR archive area. The controller script will then upload the new data files and labels to the JSOC server via SFTP.

The JEDI IOT website will provide access to JEDI data directly from the EDR archive area or from the JSOC servers or a mixture of the two depending on what is most practical and efficient.

JEDI science analysis software (Mission Independent Data Layer, MIDL) will access the JEDI EDRs through the same mechanism as the JEDI IOT website.

3.3.2 LEVEL 3 AND HIGHER DATA PRODUCTION PIPELINE

The CDR pipeline (Data products E1-E6) can be triggered manually or run automatically at the end of the EDR pipeline. Which method is used will vary over the life of the mission as the IOT gains experience with the data. The CDR pipeline process is initiated by invoking a controller script which will launch an automated version of the JEDI science analysis software which will write calibrated output files for a specified input (SCET) time range to the IOT CDR archive area. The content of the CDR files is described below.

As with the EDR pipeline, PDS labels will be generated by the output module of the pipeline at the same time as the output TABLE products are written. The controller script will then upload the new data files and labels to the JSOC server via SFTP.

The JEDI IOT website will provide access to JEDI data directly from the CDR archive area or from the JSOC servers or a mixture of the two depending on what is most practical and efficient.

3.4 DATA VALIDATION

The JEDI EDR data archive volume set will include all data acquired during the JUNO mission. The archive validation procedure described in this section applies to data products generated during all post launch phases of the mission. The initial release of the volume will occur during the first EDR delivery date as stated in the schedule in **Table 15**. Updates to the data volume will occur according to the same schedule. Updates to the documentation volume will occur at the discretion of the JEDI team.

PDS standards recommend that all data included in the formal archive be validated through a peer-review process. This process is designed to ensure that both the data and documentation are of sufficient quality to be useful to future generations of scientists. The schedule of PDS data deliveries, however, necessitate some modification of the normal PDS review process since it is impractical to convene a review panel to examine the archive volume for every PDS data delivery. The following describes the modified validation process. This peer review is conducted before any volumes are released to the public.

The peer review panel consists of members of the JEDI team, members of JSOC, the PPI node of PDS, the JUNO Archive Scientist, and at least one outside scientist actively working in the field of energetic particles research. The PDS personnel are responsible for validating that the volumes are fully compliant with PDS standards. The instrument team, JSOC, and outside reviewer(s) are responsible for verifying the content of the data set, the completeness of the documentation, and the usability of the data in its archive format.

The peer review will validate the documentation and data archive volumes via a two-step process. First the panel reviews this document and verifies that the volumes and EDRs produced to this specification will be useful. Next the panel reviews the initial release of the data and documentation volumes to verify that the volumes meet this specification and are acceptable. Once automated production begins, software provided by APL produce a summary of each data product and software provided by the PPI node verifies that all the files required by PDS are present and the files themselves conform to PDS standards. If an error is detected by either of the above programs, the error is corrected, if possible, before the update to the volume is delivered. Otherwise the correction will occur in a timely manner. If an error in a data file is uncorrectable, (i.e. an error in the downlink data file) the error is described in the cumulative errata file that is included in the data archive volume.

The peer review will also validate the JEDI EDR data in a two-step process. The first step consists of reviewing a sample data set for compliance with the PDS standards. The sample data set is delivered and reviewed in conjunction with delivery and review of this SIS document. The second step is examination of the data to ensure usability and completeness. The PDS personnel will be responsible for validating that the EDR data set is fully compliant with PDS standards. The instrument team, JSOC, and the outside science reviewer(s) will be responsible for verifying the content of the data set, the completeness of the documentation, and the usability of the data in its archive format.

Any deficiencies in the archive data or documentation volumes will be recorded as liens against the product by the review panel. The sample data set is created using software provided by APL. Once the sample data is validated, and all liens placed against the product or product generation software are resolved, the same software will be used to generate subsequent data products in an automated fashion.

Once automated production begins, the data file content will be spot checked by members of the JEDI team. “Quick look” products generated by software provided by APL and the JEDI team will be produced routinely and examined by members of the team. In addition, the data will be used actively by team members to perform their analyses. The day-to-day analysis tool (MIDL) will read the same EDR files as delivered to the PDS. Any discrepancies in the data noted during these activities will be investigated. If the discrepancy is a data error, the response will depend on the source of the error. If the error is in the software producing the data product, the error will be corrected and the data affected will be reproduced, replacing the data file. If there is a correctable error in a data file, the file will be replaced. If an error in a data file is uncorrectable, the error will be described in the cumulative errata file included in the archive volume. The structure of data files and labels will be spot checked by the PPI node for compliance with PDS standards and this SIS.

3.4.1 INSTRUMENT TEAM VALIDATION

The individuals involved in the JEDI instrument team validation consist of those listed as the JEDI team in Table 26. The instrument teams primary function in this context is to validate that the sensors are working properly, that the sensors are properly calibrated, that the efficiencies are known, that the lookup tables are kept up to date, that the data has been collected and properly transferred to APL, and that this data has been correctly processed with the JEDI GDS as described in section 3.3.

3.4.2 SCIENCE TEAM VALIDATION

Those involved in validation consist of those listed as the JEDI team in Table 26. Validation of the data by the science team is an ongoing process that began prior to delivery of the JEDI, and will continue through Juno deorbit. The science team will analyze the data in the context of the Jovian system, phases of the mission, and the various operational modes of the instrument as described in section 2.5. The science team will ensure that the data delivered to the PDS is of the highest possible quality available at the time of data delivery.

Improvements to the science teams understanding of the data will also be an ongoing process, and there are many examples of what could improve that knowledge. The foil efficiencies may change as a function of time on the Juno mission and detailed studies of the changing efficiencies would lead to an increased understanding of the data. Given the nature of the high radiation environment that Juno will experience, detailed transport simulation would lead to an increased understanding of the data. As improvements are made to the JEDI data, the data will be released as described in section 1.1.

4 ARCHIVE VOLUME GENERATION

The JEDI Standard Data Record archive collection is produced by the JEDI IOT in cooperation with the JSOC, and with the support of the PDS Planetary Plasma Interactions (PPI) Node at the University of California, Los Angeles (UCLA). The archive volume creation process described in this section sets out the roles and responsibilities of each of these groups. The assignment of tasks has been agreed upon by both parties. Archived data received by the PPI Node from the JEDI team will be made electronically available to PDS users as soon as practicable but no later than as laid out in Table 15.

PDS recommends that data users recheck PDS data holdings periodically to determine whether previously acquired data products have been updated or replaced.

4.1 DATA TRANSFER METHODS AND DELIVERY SCHEDULE

The JSOC acting as agents for the JEDI instrument team will deliver data to the PPI Node in standard product packages containing three months of data, also adhering to the schedule set out in Table 15. Each package will comprise both data and ancillary data files organized into directory structures consistent with the volume design described in Section 5, and combined into a deliverable file(s) using file archive and compression software. When these files are unpacked at the PPI Node in the appropriate location, the constituent files will be organized into the archive volume structure.

Table 15: Archive Schedule and Responsibilities

Instrument	Data Product	Provider	Earth Flyby (EFB)	Other Cruise	Orbital Phase
JEDI	EDR (Level 2)	JEDI	EFB + 18 mo.	Jupiter + 4 mo.	EDA + 3 to 6 mo.
	CDR (Level 3/4)	JEDI	EFB + 18 mo.	Jupiter + 4 mo.	EDA + 3 to 6 mo.

The archives will be sent electronically from the JEDI IOT to a user account on the PPI node using sftp. The IOT operator will copy each volume (see Table 17) in the form of a compressed *tar* archive (a.k.a. *tarball*) to an appropriate location within the PPI file system. Only those files that have changed since the last delivery will be included. The PPI operator will decompress the data, using the *tar* checksums and the `EXTRAS/MANIFEST.TXT` and `EXTRAS/CHECKSUM.TXT` files to verify that the archive is complete. Each step of data submission process will be tracked in a version CATS (Cassini Archive Tracking System) which has been adapted for use by Juno.

Following receipt of a data delivery, PPI will organize the data into PDS archive volume structure within its online data system. PPI will generate all of the required files associated with a PDS archive volume (index file, read-me files, etc.) as part of its routine processing of incoming JEDI data. Newly delivered data will be made available publicly through the PPI online system once accompanying labels and other documentation have been validated. It is anticipated that this validation process will require at least fourteen working days from receipt of the data by PPI. The first two data deliveries are expected to require somewhat more time for the PPI Node to process before making the data publicly available.

The Juno prime mission begins after JOI and two subsequent correction orbits, and lasts for 33 ~11 day orbits. **Table 15** formalizes the data delivery schedule for the entire JEDI mission, including cruise, commissioning and prime mission phases. Data delivery from JSOC to PPI node will occur on the 15th of the month and the data will be publicly available on the 1st of the following month. Archiving of products from any extended mission period will be negotiated with the Project at a later date.

4.2 DATA VALIDATION

The JEDI standard data archive volume set will include all data acquired during the Juno mission. The archive validation procedure described in this section applies to the initial deliver and updates to the volume generated during both the cruise and prime phases of the mission.

PPI node staff will carefully examine the first archive volume that they receive that contains data to determine whether the archive is appropriate to meet the stated science objectives of the instrument. The PPI node will also review the archive product generation process for robustness and ability to detect discrepancies in the end products; documentation will be reviewed for quality and completeness.

As expertise with the instrument and data develops the JEDI team may decide that changes to the structure or content of its standard data products are warranted. Should these changes be implemented, an update to the archive volume will be subjected to a full PDS peer review, and this document will be revised to reflect the modified archive. Table 2 lists the history of all modifications to the archive structure and contents.

Additionally, the JEDI team may generate and archive special data products that cover specific observations or data-taking activities. This document does not specify how, when, or under what schedule, any such special archive products are generated.

4.3 DATA PRODUCT AND ARCHIVE VOLUME SIZE ESTIMATES

JEDI standard data products are organized into files that span a single UTC day, breaking at 0h UTC. Files vary in size depending on the telemetry rate and allocation. Table 16 summarizes the expected sizes of the JEDI standard products.

All JEDI standard data are organized by the PDS team onto a single archive volume. The data on the volume are organized into one-day subdirectories.

Table 16: Data product size and archive volume production rate

Data Product	Production rate (approximate)	Size for primary mission
Level 2 Science & Housekeeping	TBD MB per day	
Level 3 Science	TBD MB per day	
Total	TBD GB per day	

4.4 BACKUPS AND DUPLICATES

The PPI Node keeps three copies of each archive volume. One copy is the primary archive volume, another is an onsite backup copy, and the final copy is a local, off-site backup copy. Once the archive volumes are fully validated and approved for inclusion in the archive, a copy of the data is sent to the National Space Science Data Center (NSSDC) for long-term archive in a NASA-approved deep-storage facility. The PPI Node may maintain additional copies of the archive volumes, either on or off-site as deemed necessary. The process for the dissemination, and preservation JEDI archive volumes is illustrated in Figure 8.

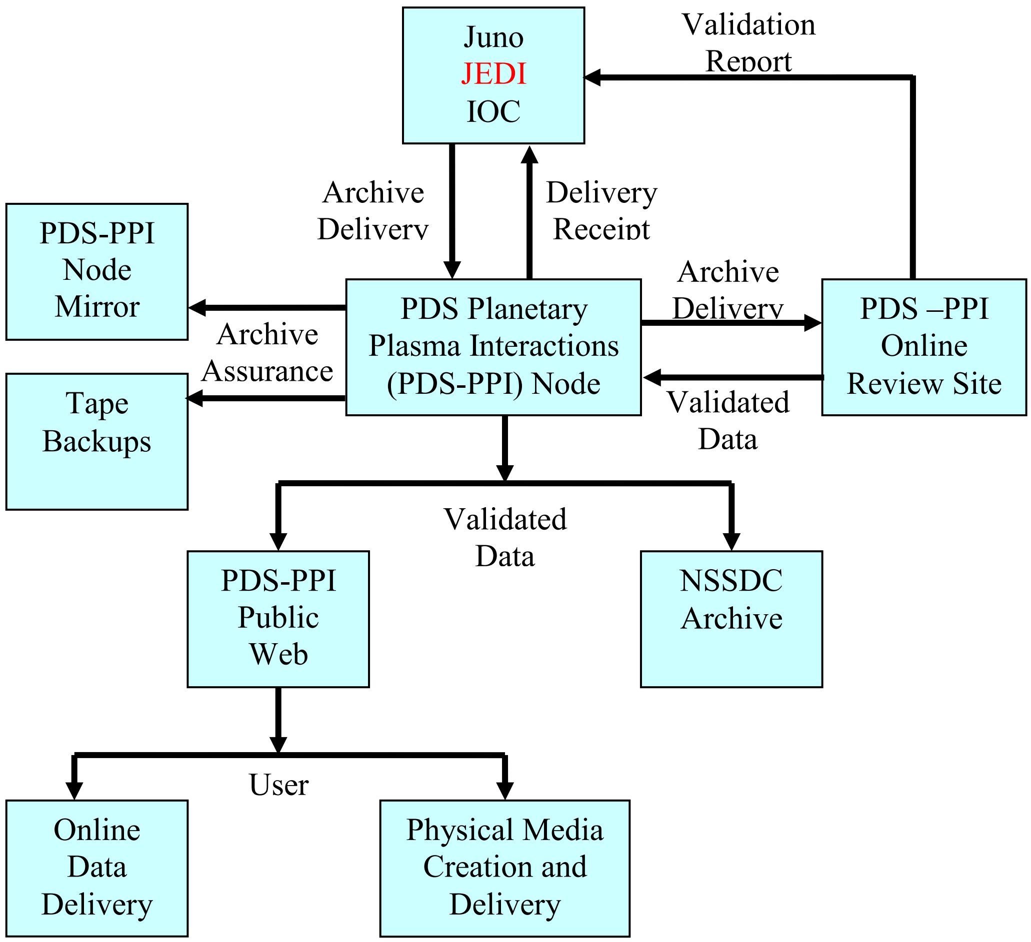

Figure 8: Duplication and dissemination of JEDI standard archive volumes

4.5 LABELING AND IDENTIFICATION

Each JEDI data volume bears a unique volume ID using the last two components of the volume set ID [*PDS Standards Reference*, see §1.9]. For each physical medium, the volume IDs are `USA_NASA_PDS_JNOJED_`*`nnnn`*, where JNOJED is the `VOLUME_SET_ID` defined by the PDS and *`nnnn`* is the sequence number of the individual volume. Hence the first JEDI Level 2 (CDR) volume has the volume ID `JNOJED_2001`, as shown in Table 17.

Table 17: PDS Data Set Name Assignments

Level	DATA_SET_ID	ABREVIATION	VOLUME_ID
2	JNO-SS-JED-2-EDR-V1.0	EDR	JNOJED_2001
2	JNO-J-JED-2-EDR-V1.0	EDR	JNOJED_2002
3/4	JNO-SS-JED-3-CDR-V1.0	CDR	JNOJED_3001
3/4	JNO-J-JED-3-CDR-V1.0	CDR	JNOJED_3002

5 ARCHIVE VOLUME CONTENTS

This section describes the contents of the JEDI standard product archive collection volumes, including the file names, file contents, file types, and the organizations responsible for providing the files. The complete directory structure is shown in Figure 9. All the ancillary files described herein appear on each JEDI standard product volume, except where noted.

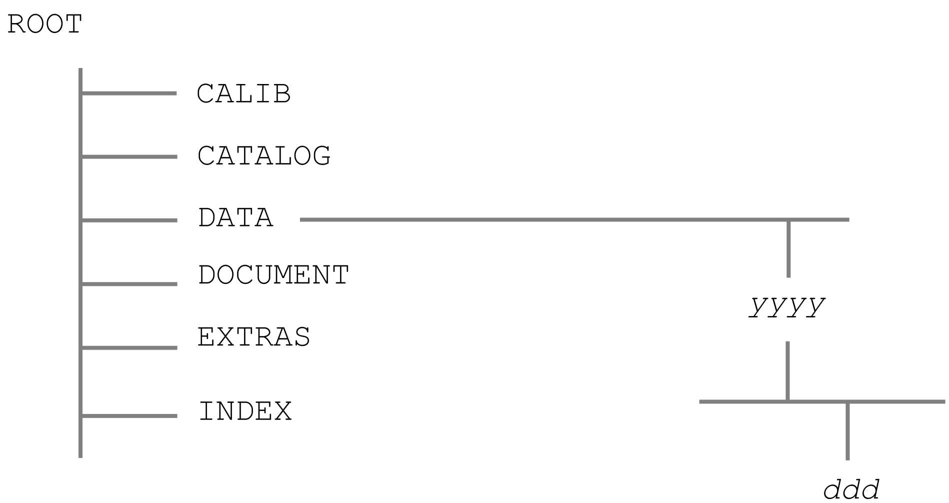

Figure 9: Archive volume directory structure

5.1 ROOT DIRECTORY

The files listed in Table 18 are contained in the (top-level) root directory, and are produced by the JEDI team in consultation with the PPI node of the PDS. All of these files are required by the PDS volume organization standards.

Table 18: Root directory contents

File	Description	Responsibility
AAREADME.TXT	This file completely describes the volume organization and contents (PDS label attached)	PPI
ERRATA.TXT	A text file containing a cumulative listing of comments and updates concerning all JEDI standard products on all JEDI volumes in the volume set published to date	JEDI team
VOLDESC.CAT	A description of the contents of this volume in a PDS format readable by both humans and computers	PPI

5.2 CALIB DIRECTORY

The CALIB directory contains a copy of the calibration plan and the ancillary data used to calibrate the JEDI instrument performance. It also contains files representing the configuration of the instrument. These files are described in section 6.2.8. The contents of this directory are described in Table 19.

Table 19: CALIB directory contents

File	Description	Responsibility
CALINFO.TXT	A description of the contents of this directory	PPI
JED_CAL_YYYYMMDDHHMMSS.CSV	The Passbands, Efficiencies, and Geometric Factors for the count rate bins in JEDI spectral data. Valid from the filename timestamp (Spacecraft Event Time, SCET) onwards	JEDI team
JEDNN_LUT_AAA_YYMMDD.PNG	A representation of the TOF x E and TOF x PH binning lookup tables. Valid from the filename date onwards. AAA is either TOFxE or TOFxPH.	JEDI team

5.3 CATALOG DIRECTORY

The files in the CATALOG directory provide a top-level understanding of the Juno mission, spacecraft, instruments, and data sets in the form of completed PDS templates. The information necessary to create the files is provided by the JEDI team and formatted into standard template formats by the PPI Node. The files in this directory are coordinated with PDS data engineers at both the PPI Node and the PDS Engineering Node.

Table 20: CATALOG directory contents

File	Description	Responsibility
CATINFO.TXT	A description of the contents of this directory	PPI
INST.CAT	Physical description of the JEDI instrument	JEDI team
JEDI_NNNN_DS.CAT	General content of the JEDI data files; includes information about the mission duration and group responsible for data production. NNNN is the dataset abbreviation (EDR, CDR)	JEDI team, PPI Node
INSTHOST.CAT	A description of the Juno spacecraft	Juno Project
MISSION.CAT	Describes the scientific goals and objectives of the Juno mission and identifies key people and institutions	Juno Project
PERSON.CAT	PDS personnel catalog description of JEDI team members and other persons involved with generation of JEDI standard data products	JEDI team
REF.CAT	Provides references to science articles and other relevant publications	Juno Project

5.4 DATA DIRECTORY

5.4.1 CONTENTS

The DATA directory contains the data files produced by the JEDI team. In the Level 2 archive, these files contain the instrument EDR's, which contain the raw instrument data, converted to ASCII, organized into correct time sequence, time tagged, and edited to remove obviously bad data. Some timing information is copied from instrument housekeeping files and included in the JEDI science data files for ease of use and access. In the higher level archives, the contents of the DATA directory are ASCII files that result from passing the corresponding Level 2 files through the processing pipeline. The data files are of the highest quality possible.

Table 21: DATA directory contents

File	Description	Responsibility
yyyy	Subdirectories containing JEDI data acquired in year *yyyy*.	JEDI team

5.4.2 SUBDIRECTORY STRUCTURE

In order to manage files in an archive volume more efficiently the DATA directory is divided into subdirectories. The two levels of division are based on time; data are organized into yearly subdirectories, which are further divided into a number of daily sub-subdirectories. The naming convention for the yearly directories is *yyyy*, and for the daily directories it is *ddd*, where *ddd* is the three-digit day of year. For example, all data for the year 2011 are contained below the directory 2011, with data for Jan 1 2011 UTC found in the subdirectory 2011/001, and so on.

5.4.3 REQUIRED FILES

A PDS label describes each file in the DATA path of an archive volume. Text documentation files have attached (internal) PDS labels and data files have detached labels. Detached PDS label files have the same root name as the file they describe but have the extension LBL. The format of the data files for each standard data product is constant throughout the archive volume and is described in FMT files located in the LABEL directory.

5.4.4 THE YYYY/DDD SUBDIRECTORY

This directory contains JEDI data files and their corresponding PDS labels. As shown in Table 22, the data in these files span a time interval of one day, the particular day being identified from both the file name and the name of the parent directory. The names also contain a 2-digit version. The initial version is V01. Major and minor changes will be reflected separately in the version number, as described above. Thus, a JEDI data file name will be of the form:

JED_AAA_TYPENAME_(E|C)DR_YYYYDDD_VNN.TAB, where AAA is 090, 180, or 270 depending on the specific JEDI sensor. The TYPENAME is followed by EDR or CDR depending on the data level. YYYYDDD is the year and day of year as described above, NN is the version number of the file (starting with 01) and TYPENAME is one of the types described in Table 23.

Table 22: Data File Type Names

File Type Name	Description
HIERSESP	High-Res (E) Electron Spectra
HIERSISP	High-Res (E) Ion Spectra
HIERSTOFXER	High-Res (E) Time Of Flight (TOF) x Energy Ion Rates
HIERSTOFXPHR	High-Res (E) TOF x Pulse Height Ion Rates

File Type Name	Description
LOERSESP	Low-Res (E) Electron Spectra
LOERSISP	Low-Res (E) Ion Spectra
LOERSTOFXER	Low-Res (E) TOF x Energy Ion Rates
LOERSTOFXPHR	Low-Res (E) TOF x Pulse Height Ion Rates
NONPTOFXER	Non-proton TOF x Energy Rates
NONPTOFXPHR	Non-proton TOF x Pulse Height Rates

Rates that are high-energy resolution will be sampled less frequently than low energy resolution rates, so that, for example, HIERSISP, could be described as "High Energy Resolution/Low Time Resolution" rates. The fixed format ASCII data file names have the "TAB" file extension. Each file is accompanied by a PDS label file (LBL) describing its contents, and contains pointers to the relevant format definition files (FMT). The labels permit the contents of most of the products to be browsed by PDS software, e.g., *NASAView*, *tbtool*, etc.

5.5 DOCUMENT DIRECTORY

The DOCUMENT directory contains a range of documentation considered either necessary or useful for users to understand the archive data set. Documents may be included in multiple forms, for example, ASCII, PDF, MS Word, or HTML. PDS standards require that any documentation needed for use of the data be available in an ASCII format. HTML is an acceptable ASCII format in addition to plain text. The following files are contained in the DOCUMENT directory, grouped into the subdirectories shown.

Table 23: DOCUMENT directory contents

Filename	Description	Responsibility
DOCINFO.TXT	A description of the contents of this directory	JEDI team
JUNO_JEDI_SIS.LBL	A PDS detached label for the SIS document	JEDI team
JUNO_JEDI_SIS.PDF	The SIS in PDF format	JEDI team

5.6 INDEX DIRECTORY

The INDEX.TAB file contains a listing of all data products on the archive volume. The index (INDEX.TAB) and index information (INDXINFO.TXT) files are required by the PDS volume standards. The format of these ASCII files is described in section 6.2. An online and web-accessible index file will be available at the PPI Node while data volumes are being produced.

Table 24: INDEX directory contents

File	Description	Responsibility
INDXINFO.TXT	A description of the contents of this directory	JEDI team
INDEX.LBL	A PDS detached label that describes INDEX.TAB	JEDI team
INDEX.TAB	A table listing all JEDI data products on this volume	JEDI team

6 ARCHIVE VOLUME FORMAT

Data that comprise the JEDI standard product archives will be formatted in accordance with PDS specifications [see *Planetary Science Data Dictionary*, *PDS Archiving Guide*, and *PDS Standards Reference* in §1.9].

6.1 VOLUME FORMAT

Although the JEDI team does not control the volume format to be used by the PDS, it is necessary to define the format in which the data sets are to be transmitted via network from the SOC to the PPI node. This will be in the form of compressed *tar* archives, as created by the open source *gtar* program. Pathnames, in upper-case letters only, will be relative to the ROOT directory, e.g., *"./DATA", "./INDEX"*, etc.

6.2 FILE FORMATS

The following section describes file formats for the kinds of files contained on archive volumes. For more information, see the *PDS Archive Preparation Guide* [see section 1.8].

6.2.1 DOCUMENT FILES

Document files with a `TXT` extension exist in nearly all directories. They are ASCII files with embedded PDS labels. All TXT files contain 80-byte fixed-length records; records are terminated with a carriage return (ASCII 13) and line feed character (ASCII 10) in the 79th and 80th byte, respectively. This format allows the files to be read by many operating systems, *e.g.*, UNIX, MacOSX, Windows, etc.

In general, documents are provided in ASCII text format. However, some documents in the `DOCUMENT` directory contain formatting and figures that cannot be rendered as ASCII text. Hence these documents are also given in additional formats such as hypertext, Microsoft Word, and Adobe Acrobat (PDF). Hypertext files contain ASCII text plus hypertext mark-up language (HTML) commands that enable them to be viewed in a web browser such as *Mozilla* or MS Internet Explorer. Hypertext documents may reference ancillary files, such as images, that are incorporated into the document by the web browser.

6.2.2 TABULAR FILES

Tabular files (TAB extension) exist in the DATA and INDEX directories. Tabular files are ASCII files formatted for direct reading into database management systems on various computers. Columns are fixed length, separated by commas or white space, and character fields are enclosed in double quotation marks ("). Character fields are padded with spaces to keep quotation marks in the same columns of successive records. Character fields are left justified, and numeric fields are right justified. The "start byte" and "bytes" values listed in the labels do not include the commas between fields or the quotation marks surrounding character fields. The records are of fixed length, and the last two bytes of each record contain the ASCII carriage return and line feed characters. This line format allows a table to be treated as a fixed length record file on computers that support this file type and as a text file with embedded line delimiters on those that don't support it.

Detached PDS label files will describe all tabular files. A detached label file has the same name as the data file it describes, but with the extension LBL. For example, the file INDEX.TAB is accompanied by the detached label file INDEX.LBL in the same directory.

6.2.3 PDS LABELS

All data files in the JEDI Standard Product Archive Collection have associated detached PDS labels [see the *Planetary Science Data Dictionary* and the *PDS Standards Reference* in section 1.8]. These label files are named using the same prefix as the data file together with an LBL extension.

A PDS label, whether embedded or detached from its associated file, provides descriptive information about the associated file. The PDS label is an object-oriented structure consisting of sets of "keyword = value" declarations. The object that the label refers to (*e.g.* IMAGE, TABLE, etc.) is denoted by a statement of the form:

```
^object = location
```

in which the carat character (^, also called a pointer in this context) indicates where to find the object. In a PDS label, the location denotes the name of the file containing the object, along with the starting record or byte number, if there is more than one object in the file. For example:

```
^HEADER = ("98118.TAB", 1)
^TABLE = ("98118.TAB", 1025 <BYTES>)
```

indicates that the HEADER object begins at record 1 and that the TABLE object begins at byte 1025 of the file 98118.TAB. The file 98118.TAB must be located in the same directory as the detached label file.

Below is a list of the possible formats for the ^object definition in labels in this product.

^object = *n*
^object = *n* <BYTES>
^object = "*filename.ext*"
^object = ("*filename.ext*", *n*)
^object = ("*filename.ext*", *n* <BYTES>)

where

- `n` is the starting record or byte number of the object, counting from the beginning of the file (record 1, byte 1),
- `<BYTES>` indicates that the number given is in units of bytes (the default is records),
- *`filename`* is the up-to-36-character, alphanumeric upper-case file name,
- *`ext`* is the up-to-3-character upper-case file extension,
- and all detached labels contain ASCII records that terminate with a carriage return followed by a line feed (13_{10}, 10_{10}). This allows the files to be read by most computer operating systems, e.g., UNIX, MacOS, MSWindows, etc.

Examples of PDS labels required for the JEDI archive are shown in Appendix B.

6.2.4 CATALOG FILES

Catalog files (extension `CAT`) exist in the `Root` and `CATALOG` directories. They are plain text files formatted in an object-oriented structure consisting of sets of "`keyword = value`" declarations.

6.2.5 INDEX FILES

The PDS team provides PDS index files. The format of these files is described in this SIS document for completeness.

A PDS index table contains a listing of all data products on an archive volume. When a data product is described by a detached PDS label, the index file points to the label file, which in turn points to the data file. When a data product is described by an attached PDS label, the index file points directly to the data product. A PDS index is an ASCII table composed of required columns and optional columns (user defined). When values are constant across an entire volume, it is permissible to promote the value out of the table and into the PDS label for the index table.

To facilitate users' searches of the JEDI data submission, a few optional columns will be included in the index table. In particular, the file start and stop times will be included. Table 25 contains a description of the JEDI archive volume index files. Index files are by definition fixed length ASCII files containing comma-delimited fields. Character strings are quoted using double quotes, and left justified in their field, followed where necessary by trailing blanks. The "Start

Byte" column gives the location of the first byte (counting from 1) of the column within the file, skipping over delimiters and quotation marks.

Table 25: Format of index files

Column Name	Start Byte	Bytes	Description
DATA_SET_ID	2		The PDS ID of the data set of which this file is a member. (see Table 17)
FILE_SPECIFICATION_NAME			The full specification name of the PDS label file (including the file name and the path) that describes the product, relative to the root of the archive volume.
PRODUCT_ID			
STANDARD_DATA_PRODUCT_ID			The "type" of the data file. (see Table)
PRODUCT_CREATION_TIME			Creation time of the PDS labeled data product.
START_TIME			Time (UTC) of the first record in the data file.
STOP_TIME			Time (UTC) of the last record in the data file.

6.2.6 LEVEL 2 DATA FILES (EDR)

The Level 2 (L2) data files are ASCII tables with comma-separated fields so they can be read by COTS products which operate on CSV files (IDL, Excel, etc.). However, they are also standard PDS fixed record length TAB files with associated LBL and FMT files so that standard PDS archive tools can also process them. The first line of the file gives the comma separated field names for the columns in the file.

Ions and Electrons are processed into energy spectra. Processing an electron starts by reading the SSD look direction (numbered 0-5) and SSD energy. The allowed energies are divided into a number of bins. The number of bins depends on the data product. When an electron is detected, its measured energy is used to determine which energy bin it belongs to. That bin in the accumulating spectral histogram for the detecting SSD is then incremented. Ion processing is similar but, when the instrument is operating in species mode, the bin represents not merely an energy range, but a region of the 2-d Time of Flight vs SSD Energy "plane", or in the case of ion events with no SSD Energy registered, the Time of Flight vs Micro Channel Plate Pulse Height plane. Note that electrons and ions have distinct energy binning tables. Every N seconds (N depends on the specific data type), the accumulated binned count totals for each data type are collected as spectra for further processing. These high resolution spectral histograms are binned into high energy resolution(low time resolution) and low energy resolution (high time resolution) packets which are collected in files and placed on the spacecraft recorder for downlinkning.

The following outlines describe the order of the fields in our spectral files. The definition of the fields follows. A descriptive name for each data type is given followed by the file name abbreviation and the 3 letter bin code abbreviation.

The first 14 columns of a JEDI L2 data file constitute a "Timing and Geometry Block" that describes the time period over which the measurement was taken and low level attitude and instrument configuration data needed to calibrate the raw counting rates in these files.

A Timing and Geometry block contains 14 columns:

UTC - A string representing the start time of the measurement window in UTC. This is provided for human ease of use.

ETStart – The Spacecraft Event Time (SCET) of the beginning of the measurement window in "Ephemeris Time" aka Barycentric Dynamical Time (TDB in seconds since J2000).

ETLookDirection - The SCET midpoint of the middle sector measurement window (in TDB in seconds since J2000). For single spin measurements, this is merely the midpoint of the measurement window. For multi-spin integrations, this timestamp is the midpoint of the measurement window for this sector during the "middle" spin of the multi-spin integration (middle is defined as n/2 rounded down). This timestamp is provided because it represents the time corresponding to the best available approximation to the median pointing direction of the total multi-spin integration. Thus, this time should be used to calculate the telescope look direction (i.e. attitude) for sky mapping or for pitch angle calculation. This calculation is performed for the Level 3 files.

ETEnd - The SCET of the end of the measurement window (in TDB in seconds since J2000).

Duration - The total live exposure time during the measurement in seconds. This represents the total time the detector was "on" and taking data in this mode during the measurement. Corrections for sector switching deadtime have been included. Instrument saturation deadtime has not been accounted for in the duration reported here.

SectorDeadTime - "Dead time" corresponding to the sum of the time taken switching between acquisition modes (in seconds) within a sector. The Dead Time occurs at the end of a sub accumulation. This parameter is used in calculating the duration and is retained here for IOT use in validation. Instrumental dead time due to latency or saturation of the data acquisition capability of the instrument is **not** included.

LargePixel – A string value of "true" or "false" depending on whether the large or small detector pixel was used for this measurement.

SCLKStart – The same timestamp as ETStart, expressed as a spacecraft clock (SCLK) string of the form: "partition/field1:field2. The Partition number is incremented whenever an event necessitates a clock reset. On JUNO field1 is seconds and field2 is 1/65536 seconds. Further details of Spacecraft Clock interpretation and SPICE “kernels” for interpreting JUNO SCLK strings can be found at the NAIF website (NASA’s Navigation and Ancillary Information Facility
(NAIF) website: http://naif.jpl.nasa.gov/naif/).

SCLKLookDirection – The same timestamp as ETLookDirection, expressed as a spacecraft clock (SCLK) string.

SCLKEnd - The same timestamp as ETEnd, expressed as a spacecraft clock (SCLK) string.

Quality – A multi-bit flag value indicating data quality issues active during this measurement. A value of 0 means no adverse conditions were present. Specific quality flag values are still in development.

PacketTimeTag - A 32-bit integer representing the onboard packet creation time. This is retained in L2 data for IOT use in validation. This is taken directly from the telemetry packet and should not be used as a timestamp for scientific purposes.

Spin – A 16-bit spin counter (0-65535). This is retained in L2 data for IOT use in validation.

Sector – The first sector (0-59) of the measurement that may include multiple sectors. A full revolution of the spacecraft is divided into 60 evenly spaced sectors. Several sectors are combined for measurements in most data products so that only 6 or 15 measurements, for example, are made in a revolution. Data products may be collected over multiple spins as well. This is retained in L2 data primarily for IOT use in validation, but it may prove useful to other investigators as a simple way of performing rough attitude filtering or grouping.

The measured two dimensional spectral array is “flattened” into a set of simple scalar columns with the energy bin varying “faster” than the Look Direction (i.e. the Telescope Number). Column names are of the form: “LookDir_m_Step_n” where m varies from 0 to 5 over the 6 look directions (or “telescopes”) and n represents the energy bin (ranging from 0 to “number of energy bins”-1). The number of energy bins varies depending on the data product.

The simplest spectra use only a binning in energy.

The different spectral types are defined below. The short three letter designations for each type are used in the Level 3 files to uniquely identify each column.

- High Energy Resolution/Low Time Resolution Electron Spectra (HIERSESP, EXF):

<Timing and Geometry Block>

LookDir 0 (24 Energy Bins)
LookDir 1 (24 Energy Bins)
LookDir 2 (24 Energy Bins)
LookDir 3 (24 Energy Bins)
LookDir 4 (24 Energy Bins)
LookDir 5 (24 Energy Bins)

- High Energy Resolution/Low Time Resolution Ion Spectra (HIERSISP, IXF):

<Timing and Geometry Block>
LookDir 0 (24 Energy Bins)
LookDir 1 (24 Energy Bins)
LookDir 2 (24 Energy Bins)
LookDir 3 (24 Energy Bins)
LookDir 4 (24 Energy Bins)
LookDir 5 (24 Energy Bins)

-Low Energy Resolution/High Time Resolution Electron Spectra (LOERSESP, EXC):

<Timing and Geometry Block>
LookDir 0 (8 Energy Bins)
LookDir 1 (8 Energy Bins)
LookDir 2 (8 Energy Bins)
LookDir 3 (8 Energy Bins)
LookDir 4 (8 Energy Bins)
LookDir 5 (8 Energy Bins)

- Low Energy Resolution/High Time Resolution Ion Spectra (LOERSISP, IXC):

<Timing and Geometry Block>
LookDir 0 (8 Energy Bins)
LookDir 1 (8 Energy Bins)
LookDir 2 (8 Energy Bins)
LookDir 3 (8 Energy Bins)
LookDir 4 (8 Energy Bins)
LookDir 5 (8 Energy Bins)

TOF x energy ion species are determined using a lookup table. Given an energy and TOF value, the table yields a bin number.

- High Energy Resolution/Low Time Resolution TOF x E Rates (HIERSTOFXER, TPF):

<Timing and Geometry Block>
LookDir 0 (24 TOF by Energy Bins)
LookDir 1 (24 TOF by Energy Bins)

LookDir 2 (24 TOF by Energy Bins)
LookDir 3 (24 TOF by Energy Bins)
LookDir 4 (24 TOF by Energy Bins)
LookDir 5 (24 TOF by Energy Bins)

- Low Energy Resolution/High Time Resolution TOF x E Rates (LOERSTOFXER, TPC):

<Timing and Geometry Block>
LookDir 0 (6 TOF by Energy Bins)
LookDir 1 (6 TOF by Energy Bins)
LookDir 2 (6 TOF by Energy Bins)
LookDir 3 (6 TOF by Energy Bins)
LookDir 4 (6 TOF by Energy Bins)
LookDir 5 (6 TOF by Energy Bins)

- Non-Proton TOF x E Rates (NONPTOFXER, THX):

<Timing and Geometry Block>
LookDir 0 (18 TOF by Energy Bins)
LookDir 1 (18 TOF by Energy Bins)
LookDir 2 (18 TOF by Energy Bins)
LookDir 3 (18 TOF by Energy Bins)
LookDir 4 (18 TOF by Energy Bins)
LookDir 5 (18 TOF by Energy Bins)

Some ions have insufficient energy to trigger the SSDs. In this case, a pulse height measurement from the TOF subsystem is used in lieu of energy. As for TOF x energy ion rates above, ions are categorized into different species and counted. This is done via a TOF x pulse height lookup table.

- High Energy Resolution/Low Time Resolution TOF x PH Rates (HIERSTOFXPHR, APF):

<Timing and Geometry Block>
LookDir 0 (16 TOF by MCP Pulse Height Bins)
LookDir 1 (16 TOF by MCP Pulse Height Bins)
LookDir 2 (16 TOF by MCP Pulse Height Bins)
LookDir 3 (16 TOF by MCP Pulse Height Bins)
LookDir 4 (16 TOF by MCP Pulse Height Bins)
LookDir 5 (16 TOF by MCP Pulse Height Bins)

- Low Energy Resolution/High Time Resolution TOF x PH Rates (LOERSTOFXPHR, APC):

<Timing and Geometry Block>
LookDir 0 (4 TOF by MCP Pulse Height Bins)

LookDir 1 (4 TOF by MCP Pulse Height Bins)
LookDir 2 (4 TOF by MCP Pulse Height Bins)
LookDir 3 (4 TOF by MCP Pulse Height Bins)
LookDir 4 (4 TOF by MCP Pulse Height Bins)
LookDir 5 (4 TOF by MCP Pulse Height Bins)

- Non-Proton TOF x PH Rates (NONPTOFXPHR, APX):

<Timing and Geometry Block>
LookDir 0 (8 TOF by MCP Pulse Height Bins)
LookDir 1 (8 TOF by MCP Pulse Height Bins)
LookDir 2 (8 TOF by MCP Pulse Height Bins)
LookDir 3 (8 TOF by MCP Pulse Height Bins)
LookDir 4 (8 TOF by MCP Pulse Height Bins)
LookDir 5 (8 TOF by MCP Pulse Height Bins)

6.2.7 LEVEL 3 DATA FILES (CDR)

There are 4 header lines following the one containing the column name: the first gives the lower bound (in keV) of the energy passband, the second gives the upper bound of the energy passband (in keV), the third gives the nominal ion species of the bin, and the fourth gives a list of the coordinate frames used to calculate the quantities in the Ephemeris, Attitude and Pitch Block. The Coordinate Frames are expressed as a comma separated list of "FRAME TYPE: FRAME" pairs, where the FRAME is a NAIF/SPICE standard frame name (example: "POS:JSE").

The CDRs are similar to the EDRs in that the first 14 columns are a <Timing and Geometry Block>. Then, each spectral column becomes three columns:

1. Counts (COUNTS): Raw counts per accumulation. Identical to the L2 data.
2. Rate (CPS): Counts per second. This rate may be corrected for background and dead time (R vs R). Details of the correction will be documented in this SIS as the IOT refines them.
3. Differential Intensity (FLUX): in counts per second per steradian per cm^2 per keV.

Unlike the L2 data, the spectral column names now contain a unique bin identifier composed of the Telescope designator ("Tn" where n ranges from 0-5) a three letter code indicating the spectral type (see spectral type definitions above) and the energy bin number, , followed by the string "COUNTS", "CPS", or "FLUX". Raw, uncorrected counts are included so the user may compute statistical error. Instrument deadtime corrections will be applied to the CPS values in later PDS deliveries.

The factor used to convert counts per second to flux can be recovered by comparing the CPS and FLUX columns. The energy bin edges (and thus the bin width) are given by the second and third header lines in the CDR file. See section 2.1 for a more detailed discussion of calibration.

There is a set of 29 columns following the spectral data containing ephemeris, attitude, and pitch information as follows:

<Ephemeris, Attitude, and Pitch Block>:

Spacecraft Position (3 columns) – X, Y, and Z in the **POS** frame (POS = JSE for observations at Jupiter).

Planetary Position (2 columns) – Latitude and Longitude in the LOC frame (LOC= IAU_JUPITER for observations at Jupiter).

Look Direction Unit Vector (3 columns per telescope = 18 columns) – X, Y, and Z of the "look direction" of the negative of the incident particle velocity vector for each of the six JEDI telescopes expressed in the ATT frame (ATT = JSE for observations at Jupiter).

Pitch Angle (1 column per telescope = 6 columns) – The angle between the incident particle velocity vector (i.e. the negation of the look direction of the telescope) and the local magnetic field as measured by the Juno Magnetometer in degrees. Early versions of the file will calculate this angle using magnetic field data provided to the JEDI instrument on the spacecraft in flight. Later versions of the file will use higher level products from the MAG team to calculate this number.

Finally, there is a set of 8 or 11 basic rate columns provided to give easy insight into the overall activity in the instrument.

<Basic Rate Block>:

For All Data Types:
SSD0-SSD5 (6 columns) – Number of pulses on the Solid State Energy detector for telescope number 0-5
VEP (1 column) – Valid Events Processed – Number of events actually processed by the flight software

For Energy Only Data Types and Electron Data (i.e. Types not containing a "TOF" in their name):

VEE (1 column) – Valid Energy Events – Total number of events in all SSD (Energy) detectors.

For TOFxE and TOFxPH Data Types:

Start0, Stop0 (2 columns) – Number of pulses on the end of the Start or Stop anode nearest to look direction 0.

VTOFXE (1 column) – Number of valid TOFxE events counted.

VTOFXPH (1 column) – Number of valid TOFxPH events counted.

Thus, the CDR file format will be:

Header lines:
binName+(COUNTS|CPS|FLUX)
LowEnergyBound
HighEnergyBound
Species
Coordinate Frames

Data Columns:
<Timing and Geometry Block>
Spectral Information as in EDR, but for 3 different data levels: counts, cps, flux
<Ephemeris, Attitude, and Pitch Block>
<Basic Rate Block>

6.2.8 CALIBRATION

There are two types of calibration files provided to aid in interpretation of JEDI spectral data.

1. The flux calibration file:
   JEDI_CAL_YYYYMMDDHHMMSS.CSV
   The date in the file name is the epoch from which time forward calibration file is valid. This is the calibration file used in the production of the CDR files from the EDR files. This large file contains the energy passbands, geometry factors, efficiencies, and nominal species for each look directions and bin in the spectral data described above. The columns are:

- name – a unique identifier for each value composed of:
    - JED
    - 90 or 18 or 27 for the individual JEDI instrument
    - 0-5 for the look direction
    - Three character data type specifier (see above)
    - L or S for large or small pixel mode

- look dir – the look direction number (0-5) of the JEDI sensor in question
- species – the nominal species of the ion in this measurement
- energy res – “fine” or “coarse” for high or low energy resolution
- pixel used – large or small
- channel – bin number (not to be confused with the “channels” in the MCP system, we have attempted to avoid this usage of “channel” elsewhere in this document to avoid confusion)
- e_in_1 – lower bound of the incident energy passband
- e_in_2 – upper bound of the incident energy passband
- e (keV) – mean incident energy
- geom fact – geometry factor
- cr to j ions – factor to multiply the counts per second by to get differential intensity assuming ions are the measured particles
- cr to j electrons – factor to multiply the counts per second by to get differential intensity assuming electrons are the measured particles

2. Image files representing the binning lookup table for the given data set. One lookup table per data type per instrument. The image represents the TOF x E (or PH) plane where the y-axis is the number of TOF values in raw analog to digital units (ADUs) and the x-axis is the SSD energy or MCP pulse height in raw ADUs. Each pixel is a single integer specifying which bin that value of (TOF, E or PH) belongs to.

   The file name is of the form:

   JEDNN_LUT_AAA_ YYYYMMDDHHMMSS.IMG

   where NN is the JEDI instrument, AAA is the data file type specifier, see Table 22.

7 APPENDIX A SUPPORT STAFF AND CONGNIZANT PERSONS

Table 26: Archive collection support staff

JEDI team			
Name	**Address**	**Phone**	**Email**
Dr. Barry H. Mauk JEDI Co-I	The Johns Hopkins University Applied Physics Laboratory 11100 Johns Hopkins Road Laurel, MD 20723-6099	240-228-6023	Barry.Mauk@jhuapl.edu
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8 APPENDIX B PDS LABEL FILES

All JEDI instrument data files are accompanied by PDS label files, possessing the same names as the files they describe, but with the extension LBL. The basic content for these label files is as follows, where the NOTE field is reserved for product-specific comments. Most data types rely on a pointer to a FMT file to describe the unchanging (from file to file) layout of the file:

SAMPLE LABEL FILE 1

JED_090_HIERSESP_EDR_2012048_V00.LBL

```
PDS_VERSION_ID                 = "PDS3"
RECORD_TYPE                    = "FIXED_LENGTH"
RECORD_BYTES                   = 2553
FILE_RECORDS                   = 1418
PRODUCT_ID                     = "JED_090_HIERSESP_2012048SC_V00_00"
PRODUCT_VERSION_ID             = "00"
PRODUCT_CREATION_TIME          = 2012-053T17:01:15
PRODUCT_TYPE                   = "EDR"
STANDARD_DATA_PRODUCT_ID       = "HIERSESP"
SOFTWARE_NAME                  = "JEDI_EDR_PIPELINE"
SOFTWARE_VERSION_ID            = "1.0"
INSTRUMENT_HOST_NAME           = "JUNO"
INSTRUMENT_NAME                = "JUPITER ENERGETIC-PARTICLE DETECTOR
INSTRUMENT"
INSTRUMENT_ID                  = "JEDI-090"
DATA_SET_ID                    = "JNO-SS-JED-2-EDR-V1.0"
DATA_SET_NAME                  = "JUNO SS JEDI EDR V1.0"
PROCESSING_LEVEL_ID            = "2"
MISSION_PHASE_NAME             = "ATLO"
TARGET_NAME                    = "JUPITER"
START_TIME                     = 2012-02-17T00:00:10
STOP_TIME                      = 2012-02-17T23:59:55
SPACECRAFT_CLOCK_START_COUNT   = "  382708812"
SPACECRAFT_CLOCK_STOP_COUNT    = "  382795197"
^HEADER                        = ("JED_090_HIERSESP_2012048SC_V00.TAB", 1)
^ASCII_TABLE                   = ("JED_090_HIERSESP_2012048SC_V00.TAB", 2)
OBJECT                         = HEADER
  HEADER_TYPE                    = TEXT
  INTERCHANGE_FORMAT             = "ASCII"
  RECORDS                        = 1
  BYTES                          = 2553
  DESCRIPTION                    = "The first record of this file is the
header section. The header contains column names to improve usability."
END_OBJECT                     = HEADER
OBJECT                         = ASCII_TABLE
  COLUMNS                        = 148
```

```
  INTERCHANGE_FORMAT            = ASCII
  ROW_BYTES                     = 2553
  ROWS                          = 1418
  DESCRIPTION                   = "The table contains uncalibrated
HighEnergyResElectronSpectra data from the JEDI-090 instrument"
  ^STRUCTURE                    = "JED_090_HIERSESP_EDR.FMT"
END_OBJECT                    = ASCII_TABLE
MD5_CHECKSUM                  = "51bc29993251a61d54b04f3d49f1d452"
END
```

SAMPLE LABEL FILE 2

JED_090_HIERSESP_EDR_V00.FMT

```
OBJECT                        = COLUMN
  NAME                          = "UTC"
  COLUMN_NUMBER                 = 1
  BYTES                         = 19
  DATA_TYPE                     = CHARACTER
  START_BYTE                    = 1
  DESCRIPTION                   = "Spacecraft Event Time, UTC"
END_OBJECT                    = COLUMN
OBJECT                        = COLUMN
  NAME                          = "MET"
  COLUMN_NUMBER                 = 2
  BYTES                         = 10
  DATA_TYPE                     = ASCII_INTEGER
  START_BYTE                    = 21
  DESCRIPTION                   = "Spacecraft Event Time, MET"
END_OBJECT                    = COLUMN
OBJECT                        = COLUMN
  NAME                          = "Spin"
  COLUMN_NUMBER                 = 3
  BYTES                         = 5
  DATA_TYPE                     = ASCII_INTEGER
  START_BYTE                    = 32
END_OBJECT                    = COLUMN
OBJECT                        = COLUMN
  NAME                          = "Sector"
  COLUMN_NUMBER                 = 4
  BYTES                         = 3
  DATA_TYPE                     = ASCII_INTEGER
  START_BYTE                    = 38
END_OBJECT                    = COLUMN
OBJECT                        = COLUMN
  NAME                          = "LookDir_0_Step_0"
  COLUMN_NUMBER                 = 5
  BYTES                         = 10
  DATA_TYPE                     = ASCII_INTEGER
  START_BYTE                    = 42
END_OBJECT                    = COLUMN
```

```
OBJECT                          = COLUMN
  NAME                            = "LookDir_0_Step_1"
  COLUMN_NUMBER                   = 6
  BYTES                           = 10
  DATA_TYPE                       = ASCII_INTEGER
  START_BYTE                      = 53
END_OBJECT                      = COLUMN
OBJECT                          = COLUMN
  NAME                            = "LookDir_0_Step_2"
  COLUMN_NUMBER                   = 7
  BYTES                           = 10
  DATA_TYPE                       = ASCII_INTEGER
  START_BYTE                      = 64
END_OBJECT                      = COLUMN
OBJECT                          = COLUMN
  NAME                            = "LookDir_0_Step_3"
  COLUMN_NUMBER                   = 8
  BYTES                           = 10
  DATA_TYPE                       = ASCII_INTEGER
  START_BYTE                      = 75
END_OBJECT                      = COLUMN

…………Etc………………….

OBJECT                          = COLUMN
  NAME                            = "LookDir_5_Step_22"
  COLUMN_NUMBER                   = 147
  BYTES                           = 10
  DATA_TYPE                       = ASCII_INTEGER
  START_BYTE                      = 1604
END_OBJECT                      = COLUMN
OBJECT                          = COLUMN
  NAME                            = "LookDir_5_Step_23"
  COLUMN_NUMBER                   = 148
  BYTES                           = 10
  DATA_TYPE                       = ASCII_INTEGER
  START_BYTE                      = 1615
END_OBJECT                      = COLUMN
```