Ulysses Data System
Kiel Electron Telescope Description

Institut für Experimentelle und Angewandte Physik
der Christian-Albrechts-Universität
zu Kiel

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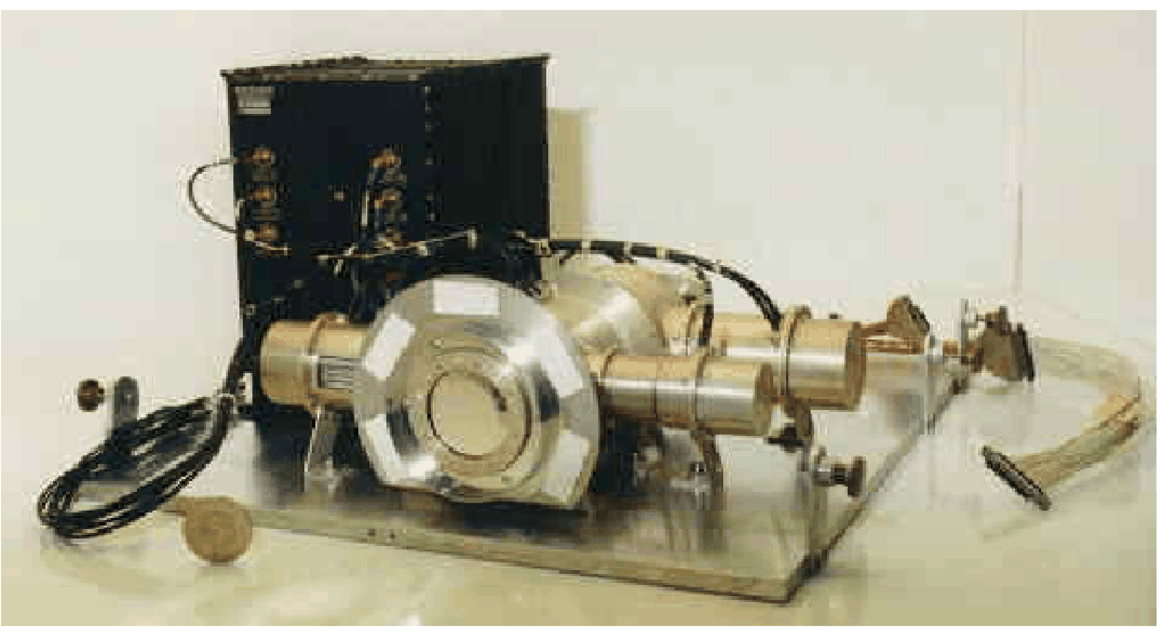
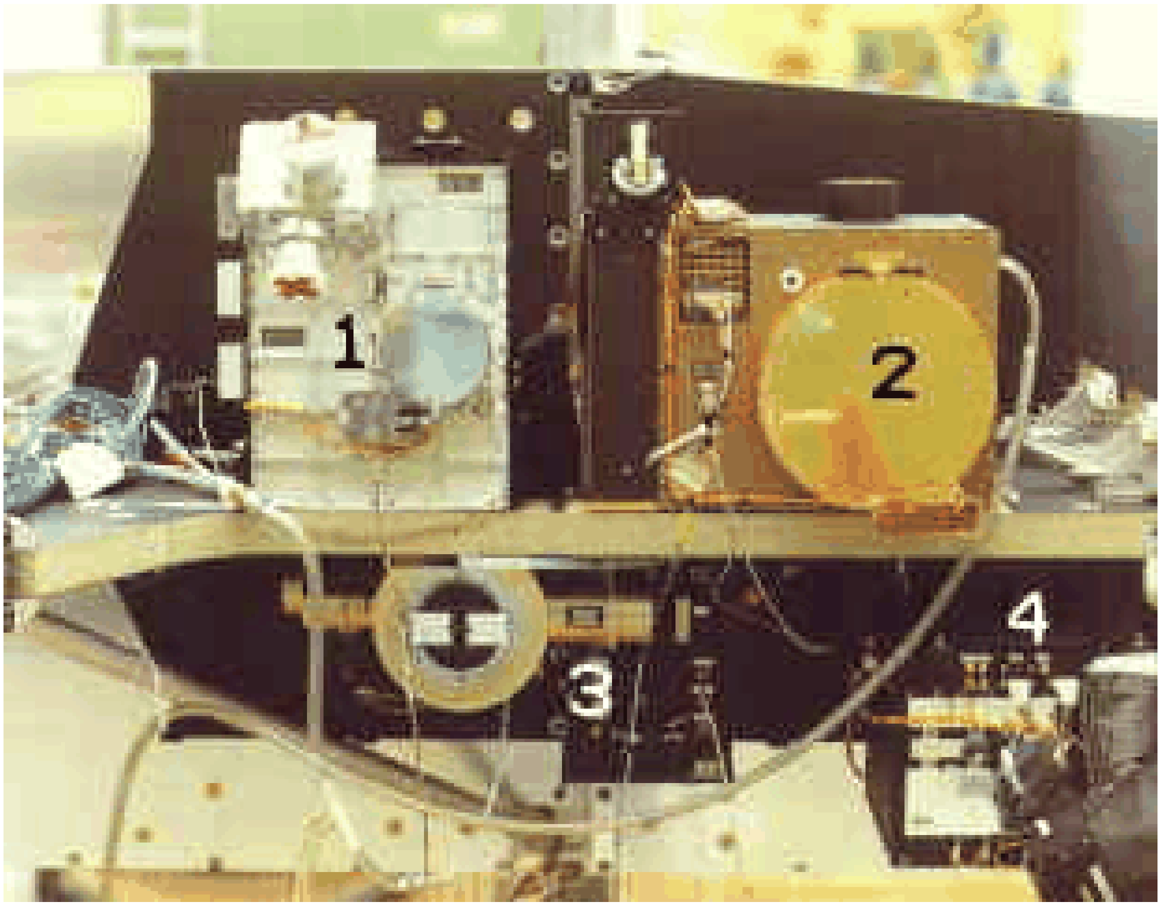
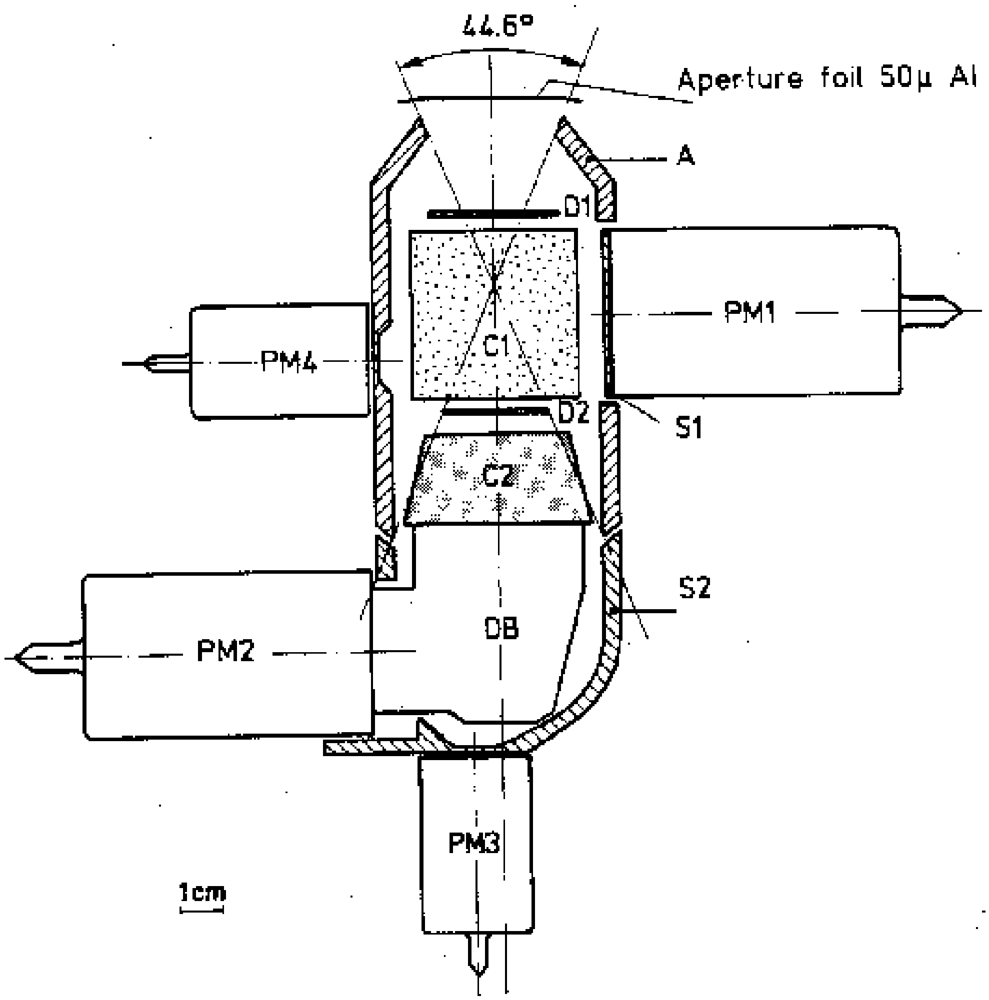
The Kiel Electron Telescope Sensor System



This figure displays in front the flight spare model sensor unit of the Ulysses Kiel Electron Telescope (KET) and in the back the electronics box. For comparison a five German mark coin is shown to demonstrate the size of the instrument. The KET is part of the Ulysses cosmic ray and solar particle investigation (COSPIN) experiment, which has been described in detail by Simpson et al. [4].



This figure shows the COSPIN sensor units as they are mounted on the spacecraft. The KET (3) is mounted below the Low Energy Telescope (LET), the Anisotropy Telescope (AT), the High Energy Telescope (HET) and the High Flux Telescope (HFT).



This figure shows a schematic sketch of the KET sensor system. D1 and D2 are 0.5 mm thick semiconductor detectors, C1 is an aerogel Cerenkov-detector and A a plastic anticoincidence scintillator. C2 is a lead fluoride Cerenkov-detector and S2 a plastic scintillator. PM1 through PM4 are photomultipliers.

Functionally, the detector system consists of two parts: an entrance telescope and a calorimeter, surrounded by a guard counter A.

The entrance telescope

is composed of a silica-aerogel Cerenkov detector C1 inserted between semi-conductor detectors, D1 and D2. Together with the guard counter A, this combination defines the geometry, selects particles with velocity beta>0.938 and determines the particle charge.

The calorimeter

consists of a 2.5 radiation length lead-fluoride (PbF2) crystal used as Cerenkov detector (C2) and a scintillator S2. In C2 an electromagnetic shower can develop. The number of electrons leaving the PbF2-crystal are counted in S2.

The KET is designed to measure electron, proton and alpha particle fluxes in several energy windows ranging from a few MeV/n up to and above a few GeV/n. The values listed in the following table are based on mean energy losses and geometry of the instrument.

coincidence	logic	primary particles	energy range (MeV/N)	geometrical factor (cm^2 sr)	sectors
P1	D11 $\overline{\text{D12 C10 D20 C20 S20 A0}}$	p	2.7-8.4	6.8	—
		p	23.1-34.1		
		He	2.3-2.7		
P4	D12 $\overline{\text{D13 C10 D20 C20 S20 A0}}$	p	8.4-23.1	6.8	8
		He	2.7-6.0		
		He	20.4-34.2		
P32	D11 D20 $\overline{\text{D12 C10 C20 S20 A0}}$	p	34-116	0.72	—
P116	D10 D20 S20 $\overline{\text{D12 C10 C20 A0}}$	p	116-190	1.2	—
		He	126-190		
P190	D10 D20 S20 C20 $\overline{\text{D11 C10 D21 C21 A0}}$	p	190-1880	1.7	—
P4000	D10 C10 D20 S20 C20 $\overline{\text{D11 C11 D21 C21 A0}}$	p	> 1880	1.7	—
A4	D13 $\overline{\text{C10 D20 C20 S20 A0}}$	He	8.4-23.1	6.8	—
A32	D12 D21 $\overline{\text{D13 C10 C20 S20 A0}}$	He	34-116	0.72	—
A116	D12 D21 S20 $\overline{\text{D13 C10 C20 A0}}$	He	116-126	1.2	—
A190	D11 D21 S20 C20 $\overline{\text{D12 C10 A0}}$	He	190-1880	1.7	—
A4000	D11 C10 D21 S20 C20 $\overline{\text{D12 C11 C21 A0}}$	He	> 1880	1.7	—
E4	D10 C10 D20 $\overline{\text{D11 C11 C20 S20 A0}}$	e	4-9	0.26	8
E12	D10 C10 D20 C20 $\overline{\text{D11 C11 D21 S20 A0}}$	e	9-800	1.7	—
E300	D10 C10 D20 C21 S20 $\overline{\text{D11 C11 D21 A0+A1}}$	e	>800	1.7	—

This table summarizes the KET coincidence channels. The coincidence name and trigger condition are displayed in the first two columns. The particles and their corresponding energy range are listed in columns three and four. The geometrical factor and sectorization information of the coincidence channels are in columns five and six.

Monte-Carlo-Simulation of the KET

A treatment of the response functions of particle telescopes, and a number of exact formulae for multi-element telescopes have been given by Sullivan, [5]. However, the determination of the response function of rather complex telescopes like the KET instrument, makes a Monte Carlo simulation mandatory. We assume that the differential coincidence counting rate of a particle telescope can be expressed as:

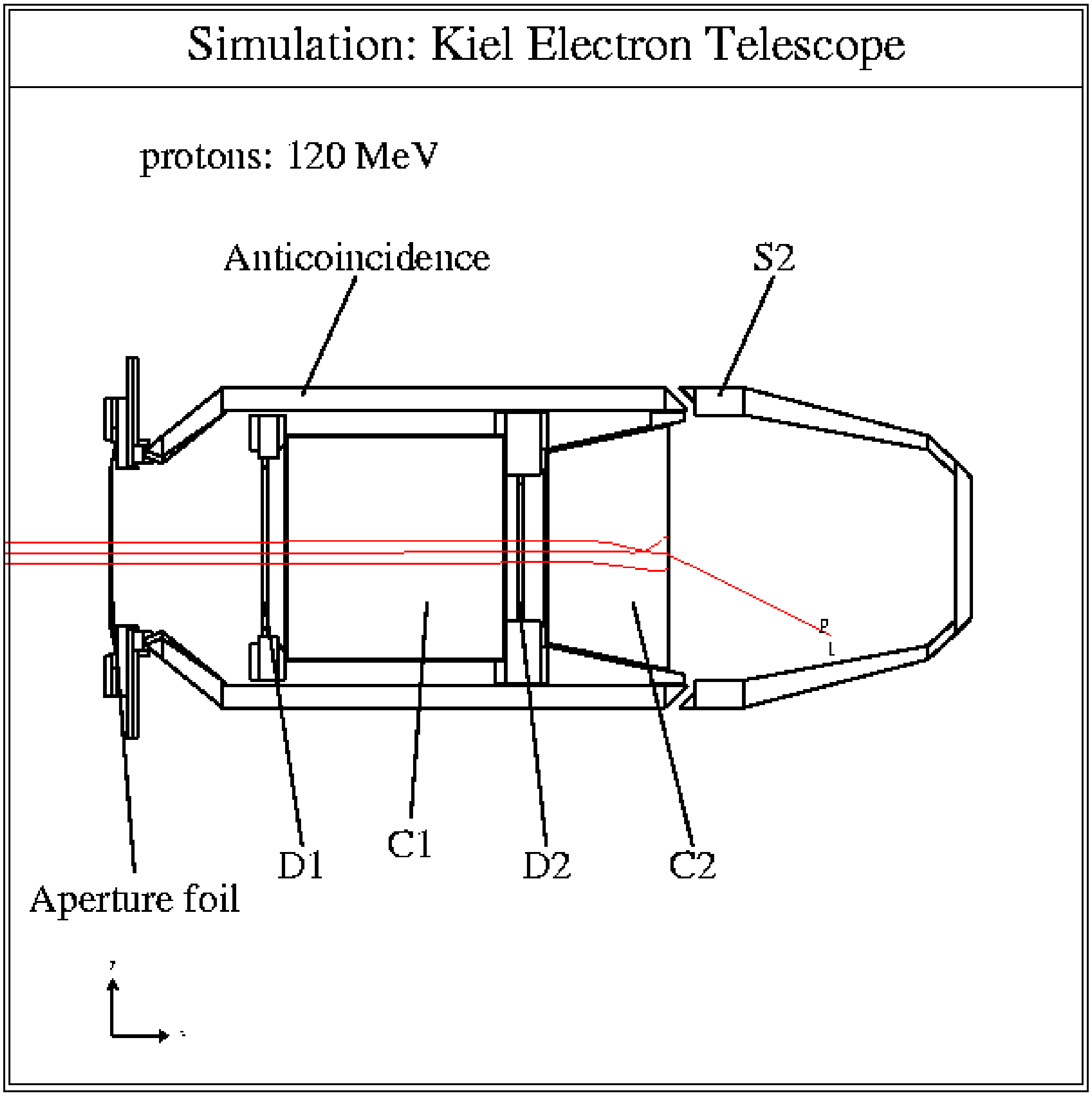
$$dC_{i,k} = dE\ R_i^k(E)\ J_k(E)\ \text{(counts/s)}$$

where $dC_{i,k}$ is the differential coincidence counting rate in channel i, $J_k(E)$ the flux of particle species k with kinetic energy E, and $R_i^k(E)$ the response function for particle species k in channel i, to be determined by the simulation. To get the counting rate C_i for the channel i we have to integrate over E and sum up for all particle species. In general, the response function may depend on many variables like the angular distribution of the incident particle flux, the location where a particle penetrates a detector etc. Here we assume that R(E) is a function only of kinetic energy, valid for particle fluxes which are almost isotropic over the effective opening angle, and that the simulation properly averages over all other dependencies.

The Monte Carlo simulation was performed with the CERN Library Program GEANT 3 (BRUN et al., [1]). Particles were followed down to a low energy cutoff (electrons and gamma-rays 50 keV, protons 300 keV), once reaching this cutoff the particles were considered to be stopped and to have deposited all of their kinetic energy in the traversed material. The geometry of the detectors, mountings, foils, and the relevant structure material as well as the energy resolution of the readout electronics were accounted for in the simulation.

KET geometry

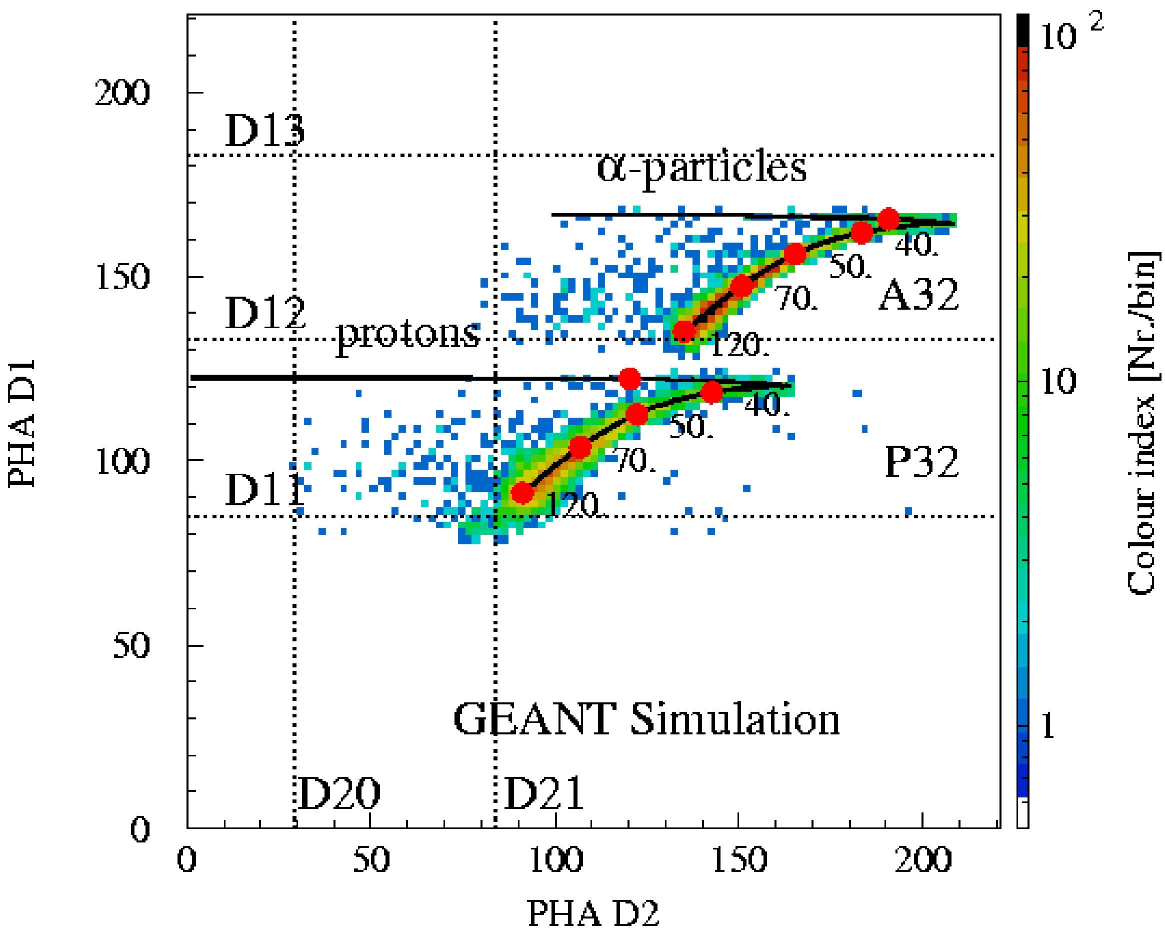
is shown in the following sketch.



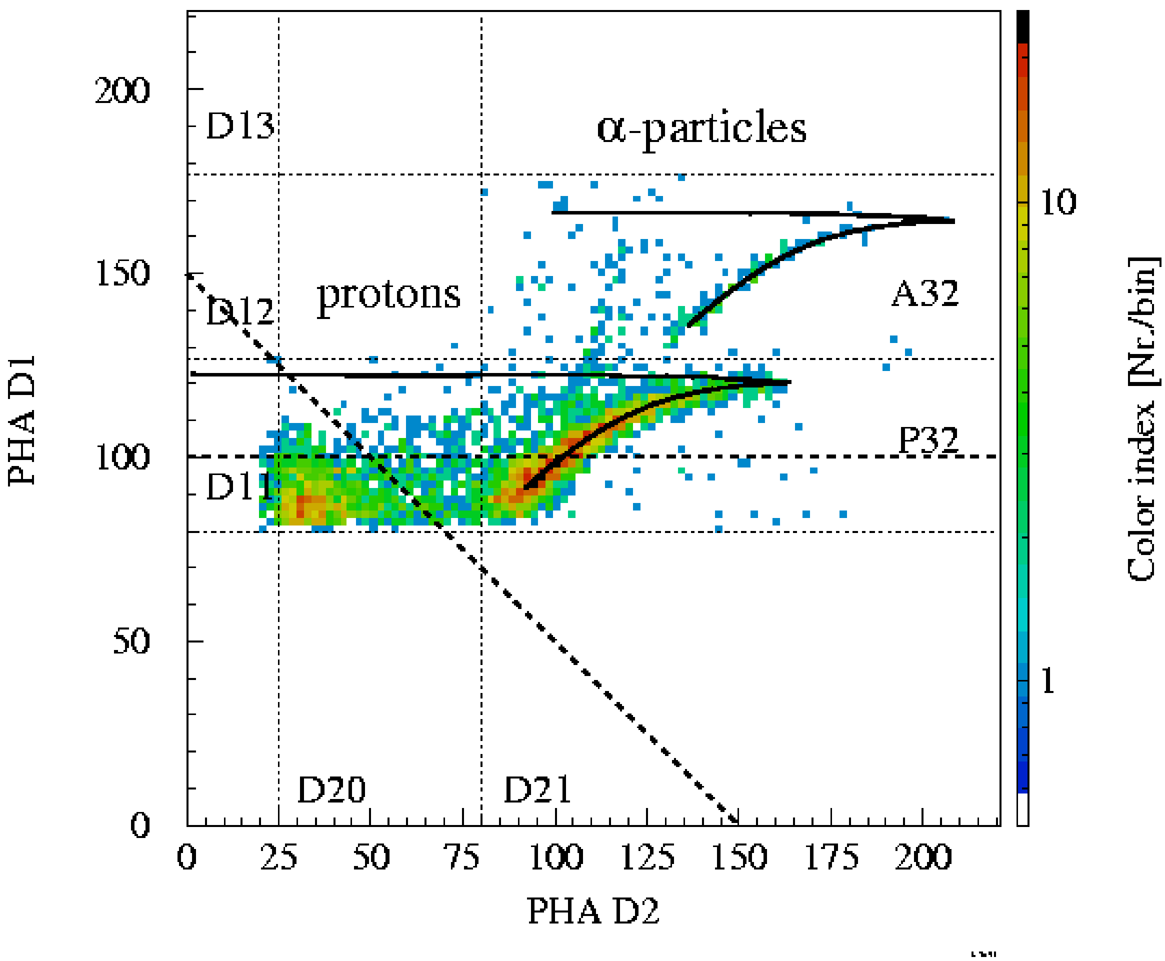
The model of the KET sensor unit in the simulation. Shown are three possible tracks of 120 MeV protons. Two of these tracks are triggering the channel P32 and on of them is counted in P116.

Energy loss distribution:

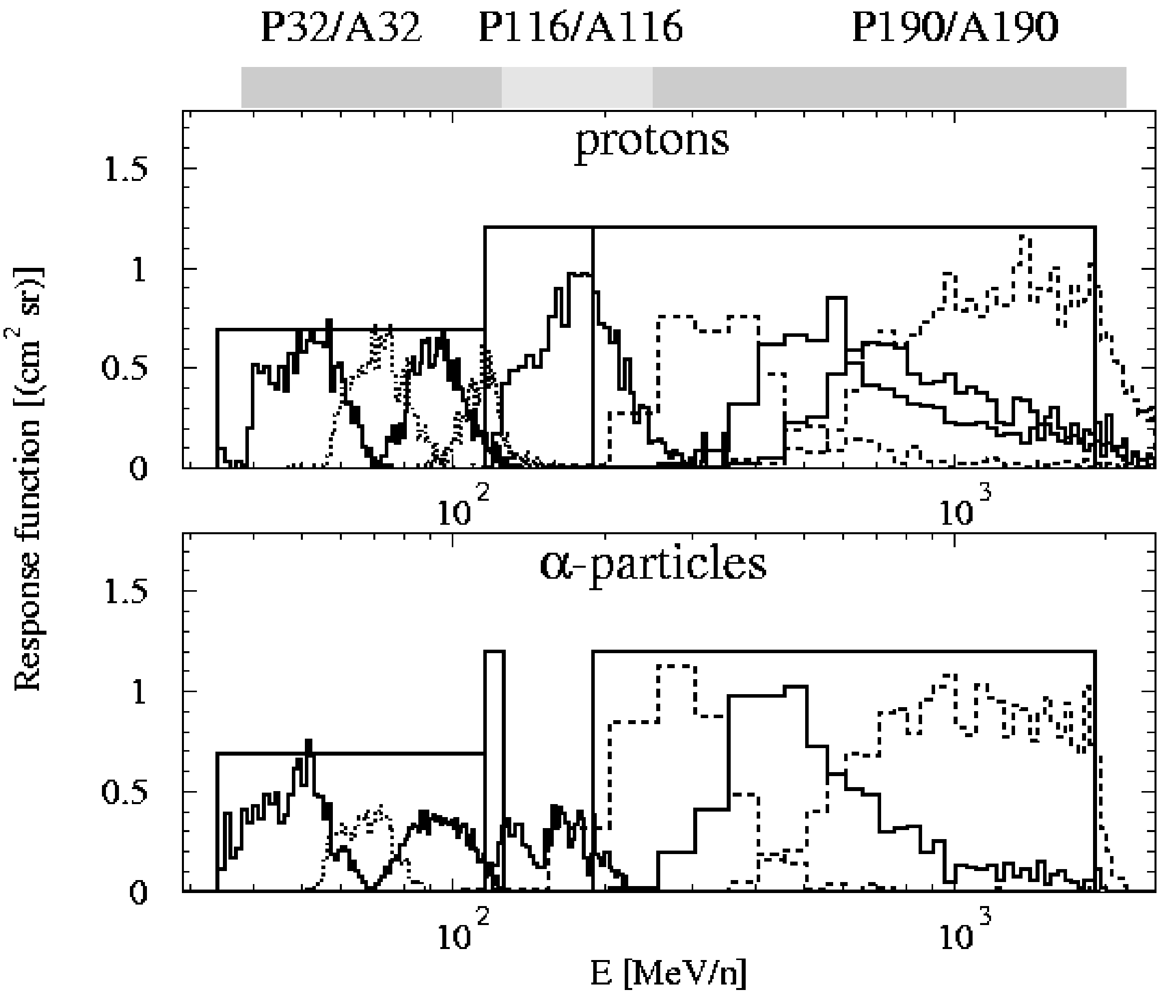
In addition to the count rates in all coincidence channels, the energy losses in D1, D2 and number of photons in C1, C2 and S2 are transmitted. Particle instruments are calibrated by using a particle beam provided by an accelerator (see SIERKS, [3]). In space, particles of different species, incident directions and energies are observed nearly simultanously. Such an environment cannot be simulated at an accelerator but can be simulated using an appropriate computer model. As an example the following figure shows the simulated energy distribution of isotropic protons and alpha-particles in the semiconductor detectors D1 and D2 triggering the P32 and A32 coincidence channels.



Calculated D1-D2 PHA-distribution (energy loss), using a proton and alpha distribution which is a function of energy and isotropic in direction. The solid lines show the mean energy losses. Marked on these lines are the expected energy losses for 35, 40, 50, 70 and 120 MeV/n. The dotted lines display the electronics thresholds. In comparison the following figure shows a PHA distribution measured in space:



Measured P32-protons and A32-alpha-particle D1-D2 matrix in January 1991. The entries below the dotted line could be identified as background random coincidences (HEBER, [2]). As is discussed in detail in HEBER, [2], the proton and alpha-tracks in that matrix are well described by the Monte-Carlo simulation. One important result of the analysis are the determination of the geometrical factors as a function of energy:



Response functions $R^{Sim}{}_i(E)$ for isotropic protons and alpha-particles. The rectangular boxes indicate the response functions expected by using the Sullivan [5] theory. For the low energy channels this theory is a good approximation.

	G/(cm^2 sr MeV/n)	E /(MeV)/n	Sigma;E/(MeV)/n
protons K3			
S	57.8	81.0	26.1
alpha-particles K33			
S	52.7	78.2	24.0
protons K34			
S	83.3	190	42
alpha-particles K29			
S	23.4	164	25
protons K12			
1	230	315	160
2	500	700	390
3	1370	1250	420
4	1500	950	490

alpha-particles K31			
A	220	315	150
B	480	700	390
C	1320	1250	420
D	1500	950	490

KIEL ELECTRON TELESCOPE readme

This readme was last modified March 10, 1998 and shall explain the file structure of the KET files provided for the Ulysses Data System (UDS). The previous sections "The Kiel Electron Telescope Sensor System" and "Monte-Carlo-Simulation of the KET" explain the instrument. Only count rates are provided for the UDS, because the geometrical factors may change in future. The geometrical factors provided in the previous section should be checked against the values on our homepage:

COSPIN/KET homepage

All Ulysses data system files (UDS files) have the name

UCOSKETAYYDOY.DAT

Herein YY is the year (eg. 90) and DOY the day of the year (eg. 365 of year 90 is 31.12.90).

RECORD FORMAT for the KET

The KET files are written on a VMS machine using Fortran 77 Routines. The format used is:

```
      IMPLICIT REAL(K)
               WRITE(40,'(6I5)') IYEAR,IDOY,IHOUR,IMIN,ISEC,ICOV
               WRITE(40,'(10G11.3)')
     1             K1,K21,K22,K23,K24,K25,K26,K27,K28,P4
               WRITE(40,'(10G11.3)')
     1             K3,K34,K12,K10,K2,K33,K29,K31,K30,K13
               WRITE(40,'(10G11.3)')
     1             K14,K15,K16,K17,K18,K19,K20,E4,K11,K32
               WRITE(40,'(6G11.3)')
     1             D10,D20,C10,C20,A01
```

Parameters are:

IYEAR:	year
IDOY:	day of year

IHOUR:	hour	
IMIN:	minute	
ISEC:	second	
ICOV	coverage in percent	
KET channel	energy range A&A	energy range
		Monte-Carlo simulation
K1:	protons (2.7-5.4 MeV)	
K21-K28:	" (5.4-23.1 MeV) sectors 1 through 8	
P4:	" (5.4-23.1 MeV) omnidirectional	
K3:	" (34.1-125.0 MeV)	
K34:	" (125.0-320.0 MeV)	(125.0-250.0 MeV)
		backward penetrating particles (160.0-260.0 MeV)
K12:	" (320.0-2100.0 MeV	(250.0-2200.0 MeV)
		backward penetrating particles (260.0-2200.0 MeV)
K10:	" (>2100.0 MeV)	(>2200.0 MeV)
		backward penetrating particles (>2200.0 MEV)
K2:	helium (6.0-20.4 MeV)	
K33:	" (34.2-125.0 MeV)	
K29:	" (125.0-320.0 MeV)	(125.0-155.0 MeV)
		backward penetrating particles (155.0-225.0 MeV)
K31:	" (320.0-2100.0 MeV)	(250.0-2100.0 MeV)
		backward penetrating particles (250.0-2100.0 MeV)
K30:	" (>2100.0 MeV)	
K13-K20:	electrons (2.5-7.0 MeV) sectors 1 through 8	
E4:	" (2.5-7.0 MeV) omnidirectional	
K11:	" (7.0-170.0 MeV)	
K32:	" (>170.0 MeV)	
D10 - A01:	single detector count rates	

Note:
Data are Rates not Intensities and given in (/s).
Accumulation time
is 10 minutes.
RTG
corrections not included.
Flag -707:
data gap

Caveats:

1. Only rates C are given, since no simple estimate of the intensities can be done. Intensities (I) must be derived by dividing through the integral geometric factor G_i, and by correcting through Pulse Height Analysis.

$$I = C / G_i$$

Values of geometrical Factor G_i = (counting rate)/(Intensity):

KET channel	G_i
K1	18
K21 - K28	120
P4	120
K3	70.0
K34	152.0
K12	3300.0
K10	na
K2	120
K33	70.0
K29	88.0
K31	3200.0
K13-K20	na
E4	na
K11	na
K32	na

Check against our

COSPIN/KET homepage

2. Background fluxes of K1 are a combination of components, including a high RTG background rate. This channel should be used only during event times.
3. On 10 min averages some of the channels have limitations because of RTG background. Very slow increases are a sign that background levels are reached (a few percent per year).

==
GET LOW FLUX VALUES FROM THE PI ON LONGER ACCUMULATION PERIODS
==

send request to KET PI

The daily averaged and 27 day averaged data are also provided. See readme.daily 3.3 and readme.27days 3.4.

4. Fluxes of K11, K13-K20 and E4 below 2.0e-4, 2.5e-3 are a combination of different components including RTG background. The exact amount of background relative to real electrons are unknown.

==
Levels below 3.0e-3, 2.5e-3 should not be considered.
==

5. Fluxes of K32 are contaminated by high energy protons. Reliable fluxes needs an PHA correction on longer accumulation periods.
6. Determination of the intensities of K29 needs a PHA correction on longer accumulation periods (several

hours).

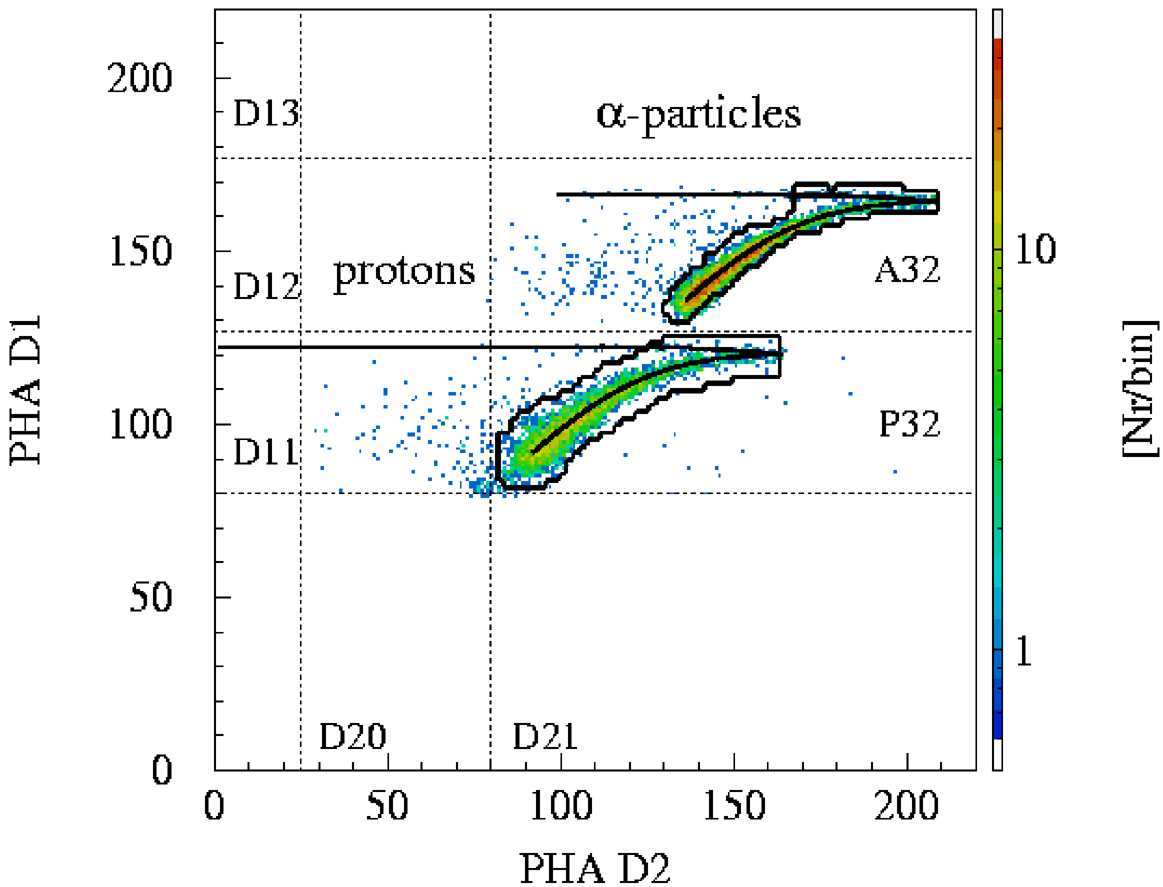
7. Timeperiods when KET is saturated or is working in a "calibration mode" have been omitted:
   eg. March event 1991
   peak fluxes in the June to August period 1991
   Jovian encounter.

8. Data for the Jovian encounter are available on a 4 min bases.

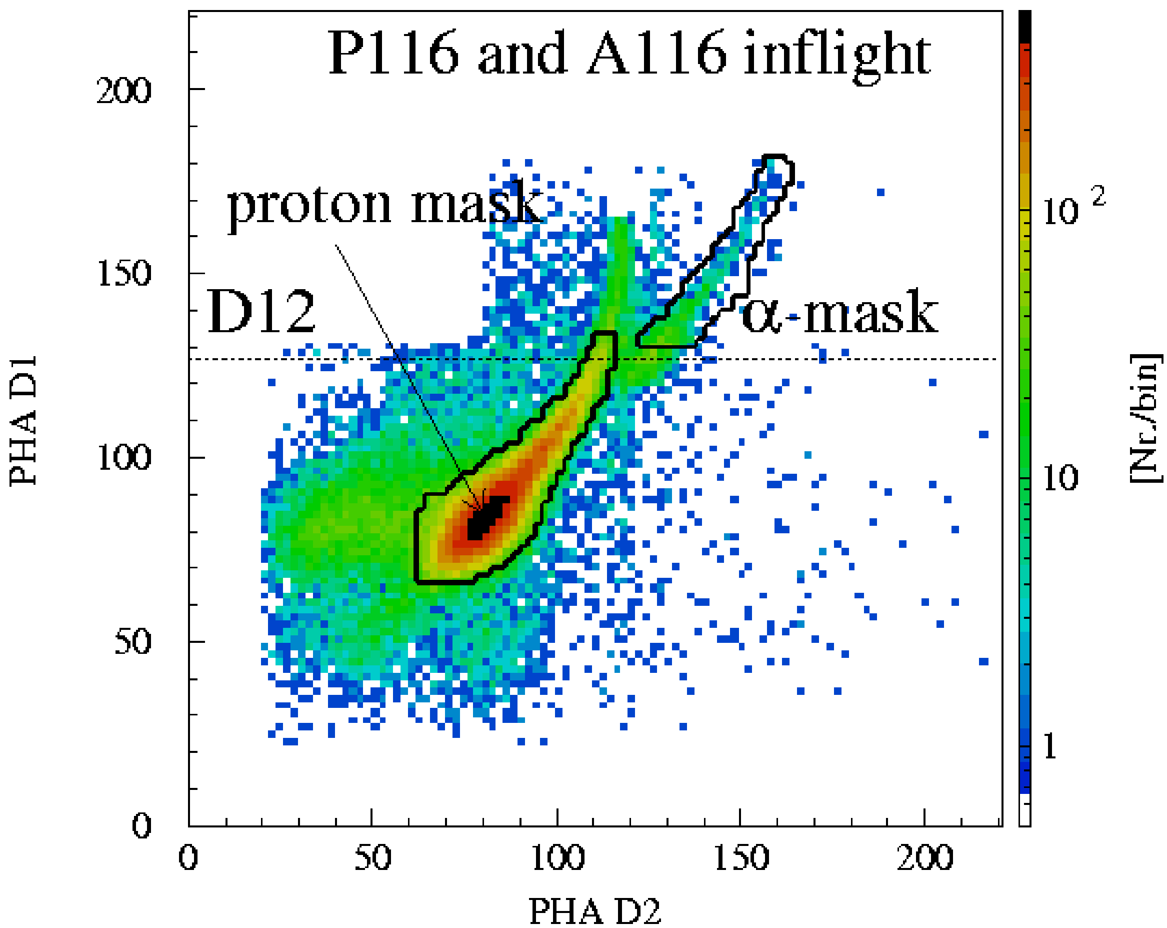
   ==
   Caution: Very high fluxes for KET !!!!
   ==

Readme, KET90-96.DAILY

The daily averaged file KET90-96.DAILY contains a subset of KET coincidence channels which can be corrected by using Pulse Height Analysis (see Heber [2]). As an example the masks choosen for K3 and K34 are shown in the following figure.



Definition of PHA masks in K3, K33 Matrix using the result of a GEANT simulation.



Definition of PHA masks in K34, K29 Matrix using the result of a GEANT simulation. In contrast to the upper panel inflight data are shown. Note that we used a for this figure a time period of 30 days. Because of the low PHA-statistics for K29 no daily averaged corrected rates are given on a one day basis.

The KET file was written on a VMS machine using Fortran 77 Routines. The format used is:

```
       IMPLICIT REAL(K)
                WRITE(40,'(I2,1X,I3,1X,I3,1X,8G10.3/10X,6G10.3)')
      1         IYEAR,IDOY,ICOV
      1         K3,EK3,K34,EK34,K12,EK12,K10,EK10,
      1         K33,EK33,K31,EK34,K30,EK30
```

Parameters are:

IYEAR:	year	
IDOY:	day of year	
ICOV	coverage in percent	
KET channel	energy range A&A	energy range
		Monte-Carlo simulation
K3:	protons (34.1-125.0 MeV)	
EK3:	error of preceeding value	
K34:	" (125.0-320.0 MeV)	(125.0-250.0 MeV)
		backward penetrating particles (160.0-260.0 MeV)

EK34:	error of preceeding value	
K12:	" (320.0-2100.0 MeV	(250.0-2200.0 MeV)
		backward penetrating particles (260.0-2200.0 MeV)
EK12:	error of preceeding value	
K10:	" (>2100.0 MeV)	(>2200.0 MeV)
		backward penetrating particles (>2200.0 MEV)
EK10:	error of preceeding value	
K33:	helium " (34.2-125.0 MeV)	
EK33:	error of preceeding value	
K31:	" (320.0-2100.0 MeV)	(250.0-2100.0 MeV)
		backward penetrating particles (250.0-2100.0 MeV)
EK31:	error of preceeding value	
K30:	" (>2100.0 MeV)	
EK30:	error of preceeding value	

Note:
Data are Rates not Intensities and given in (/s).
Accumulation time
is 1 day.
Flag -707:
data gap or less than 4 entries in PHA selection.

Readme, KET90-96.27DAYS

The KET files are written on a VMS machine using Fortran 77 Routines. The format used is:

```
IMPLICIT REAL(K)
        WRITE(40,'(4I3,2G13.4)') IYEAR,IDOY,IHOUR,IMIN,E4,EE4
```

Parameters are:

IYEAR:	year	
IDOY:	day of year	
IHOUR:	hour	
IMIN:	minute	
KET channel	energy range A&A	energy range
		Monte-Carlo simulation
E4:	" (2.5-7.0 MeV) omnidirectional	
EE4:	error of preceeding value	

Note:
Data are Rates not Intensities and given in (/s).
Accumulation time
is 26 days.
PHA

corrections included.

Flag -707:
data gap

References

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3 H. Sierks. Auswertungen der Eichmessungen des Kieler Elektronen-Teleskops zur Erstellung von Energiespektren an Bord der Raumsonde ULYSSES (International Solar Polar Mission). Master's thesis, Christian-Albrechts-Universität Kiel, 1988.

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About this document ...

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Kiel Electron Telescope Description
Institut für Experimentelle und Angewandte Physik
der Christian-Albrechts-Universität
zu Kiel

The translation was initiated by Bernd Heber on Tue Mar 10 17:17:11 MET 1998