

# Energetic particle background observed in X-ray silicon detectors of SphinX experiment

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W. Trzebinski, S. Plocieniak, F. Farnik, S. Kuzin, F. Reale

SRC PAS - Space Research Centre Polish Academy of Sciences Wroclaw, Poland

MECHELEN, June 2010

# OUTLINE

Solar Photometer in X-rays SphinX  
general description

SphinX shielding simulations  
with SPENVIS

# SphinX - team



## **SRC PAS:**

Principal Investigator: **Janusz Sylwester**

Project Manager: **Mirek Kowalinski**

Project Constructor: **Jarek Bakała**

Project Scientist: **Szymon Gburek**

Co-I: **Marek Siarkowski, Barbara Sylwester, Zbigniew Kordylewski, Piotr Podgórski, Witold Trzebiński, Stefan Płoceniak, Anna Kępa**



## **FIAN:**

**Sergey Kuzin**, TESIS PI, SphinX Co-I



## **MEPhI:**

**Yury Kotov**, CORONAS-Photon Project Manager, SphinX Co-I



## **AI CzAS:**

**Franta Farnik**, SphinX Co-I



## **INAFA, Palermo University:**

**Fabio Reale**, SphinX Co-I



## **UCL, London:**

**Ken Phillips**, SphinX Scientist Co-I



## **NASA GSFC:**

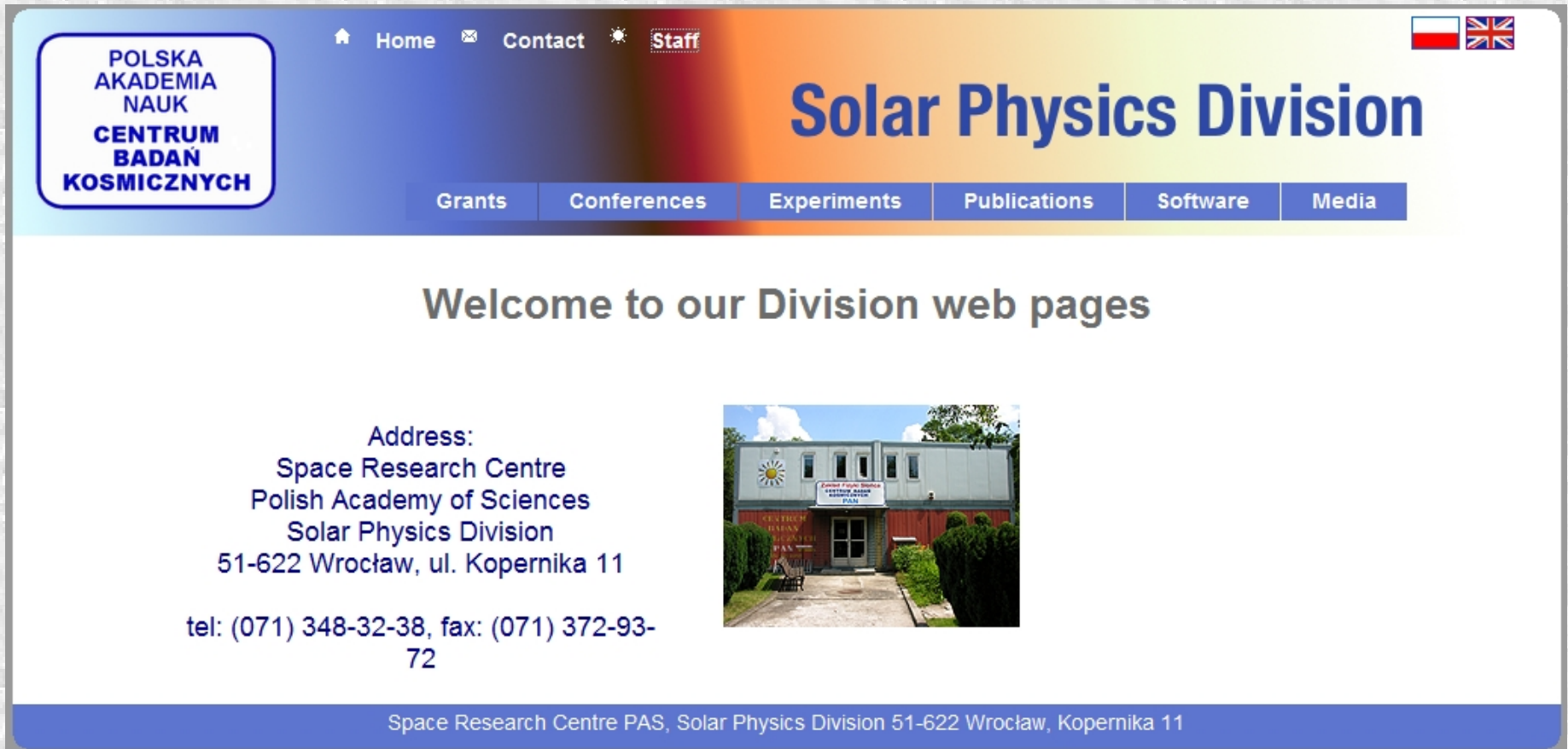
**Brian Dennis**, SphinX Scientist Co-I

SPACE RESEARCH CENTER  
POLISH ACADEMY OF SCIENCES  
WARSAW

SOLAR PHYSICS DIVISION  
WROCLAW



# SOLAR PHYSICS DIVISION, SRC PAS – WROCLAW the website



The image shows a screenshot of the website for the Solar Physics Division at the Space Research Centre PAS in Wrocław. The website has a blue and orange header. On the left, there is a logo for the Polish Academy of Sciences (Polska Akademia Nauk) and the Centre for Space Research (Centrum Badań Kosmicznych). The main navigation menu includes Home, Contact, Staff, Grants, Conferences, Experiments, Publications, Software, and Media. The main content area features a welcome message and contact information. A photograph of the building entrance is also included.

**POLSKA  
AKADEMIA  
NAUK  
CENTRUM  
BADAŃ  
KOSMICZNYCH**

Home Contact Staff


## Solar Physics Division

Grants Conferences Experiments Publications Software Media

### Welcome to our Division web pages

Address:  
Space Research Centre  
Polish Academy of Sciences  
Solar Physics Division  
51-622 Wrocław, ul. Kopernika 11

tel: (071) 348-32-38, fax: (071) 372-93-72



Space Research Centre PAS, Solar Physics Division 51-622 Wrocław, Kopernika 11

<http://www.cbk.pan.wroc.pl/>

<http://www.cbk.pan.wroc.pl/?l=EN&act=1> English

# SphinX instrument

## Basic characteristics

Mass 3.7 kg

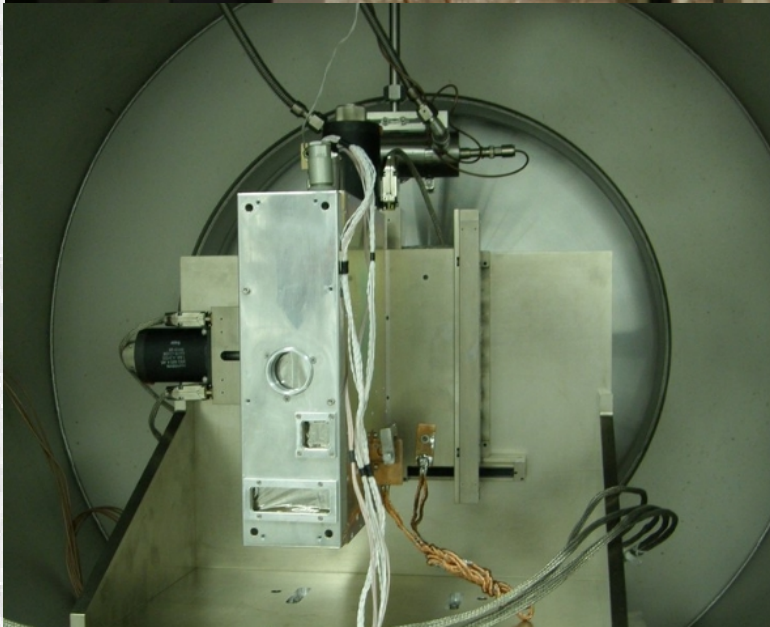
Power 10 W

Telemetry – 60MB a day



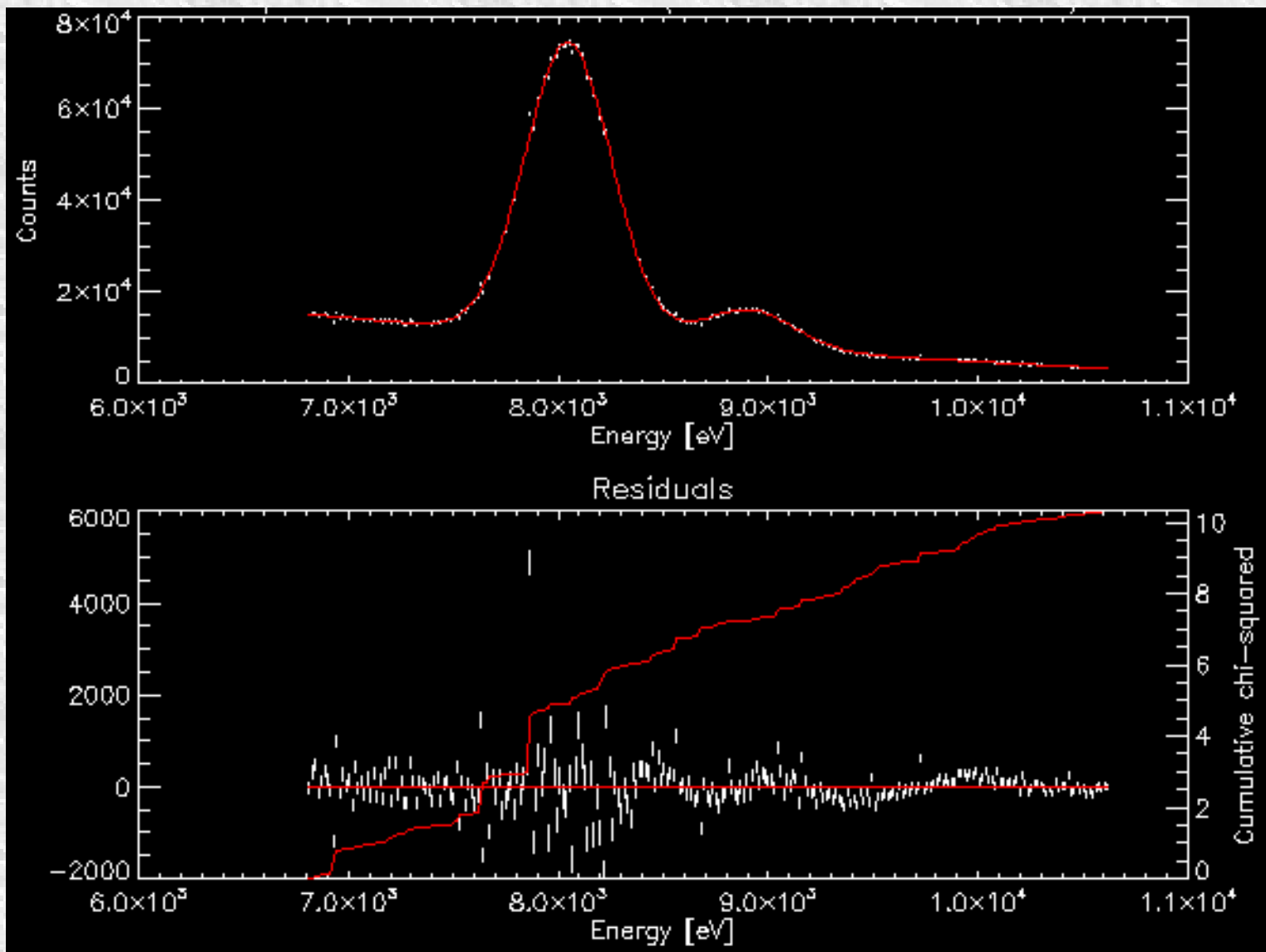
Launched on CORONAS-Photon satellite on  
January 30, 2009 at 13:30 UT  
from the Plesetsk Cosmodrome, northern Russia.  
End of mission 29 November 2009

# Calibration of SphinX at XACT – Palermo

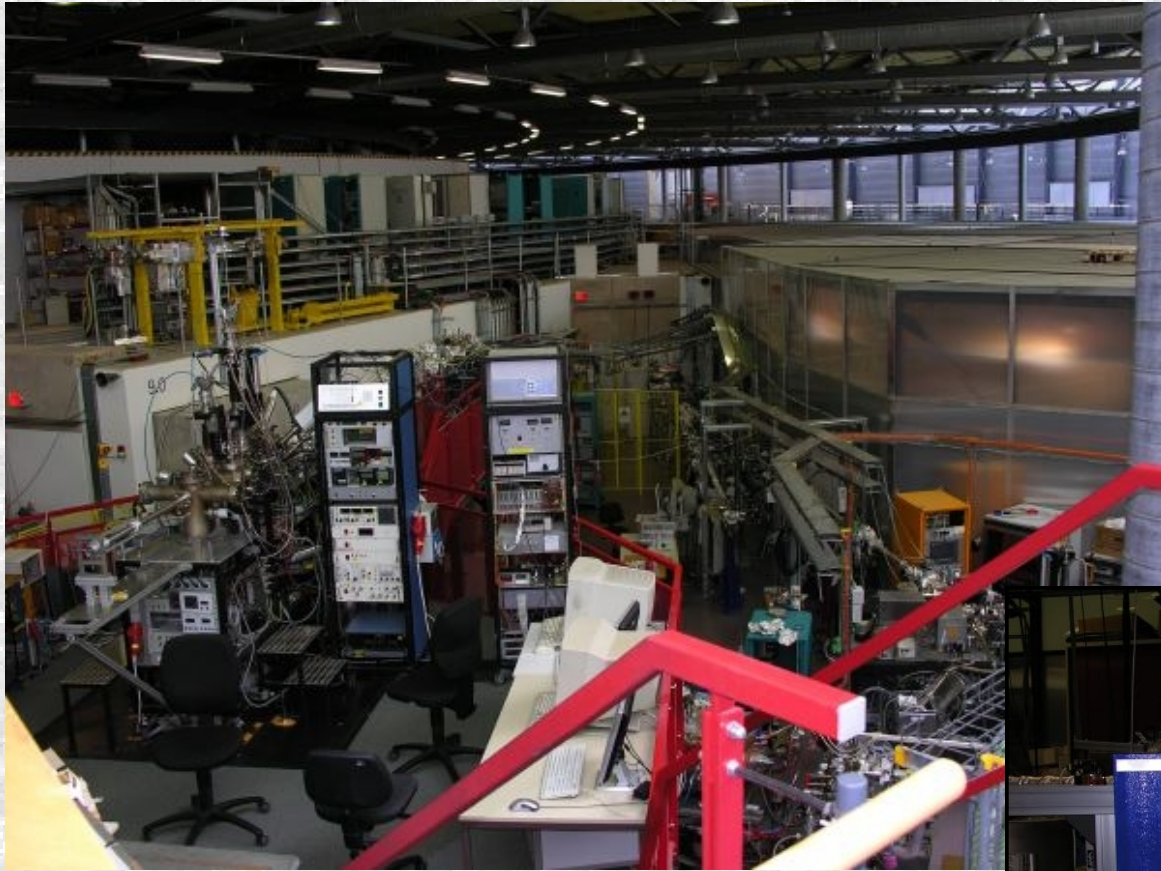


October 2007

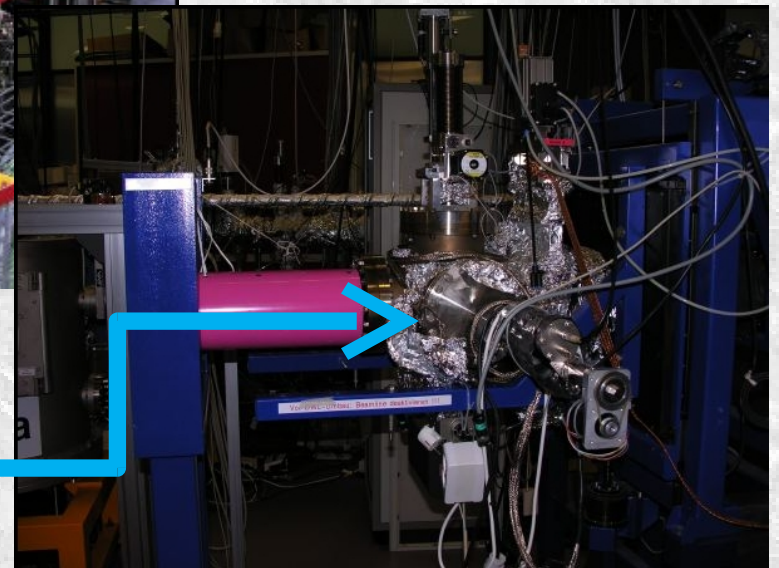
# Example of SphinX spectrum recorded at XACT



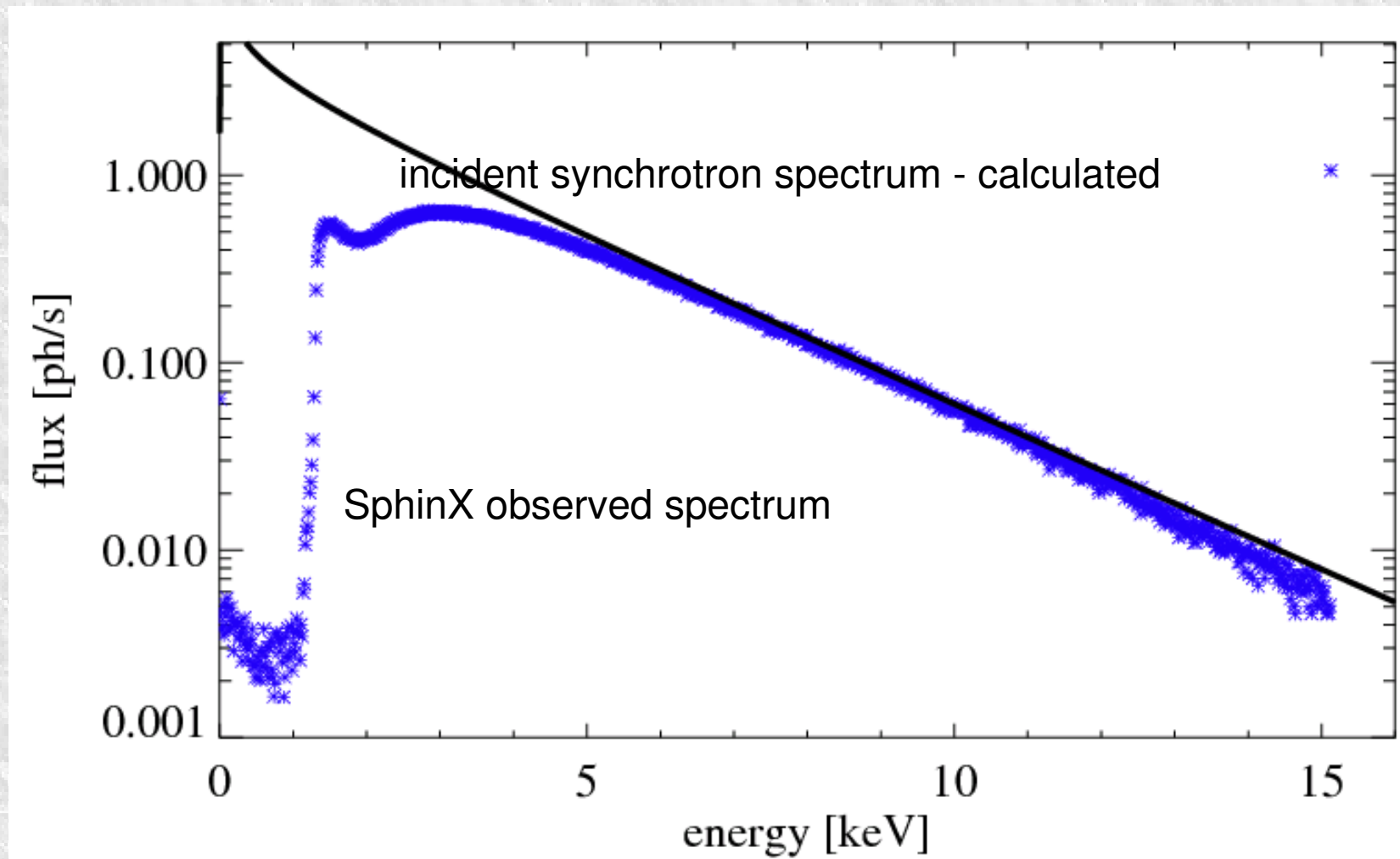
# Calibration of SphinX at BESSY II – Berlin – Feb/Mar 2008



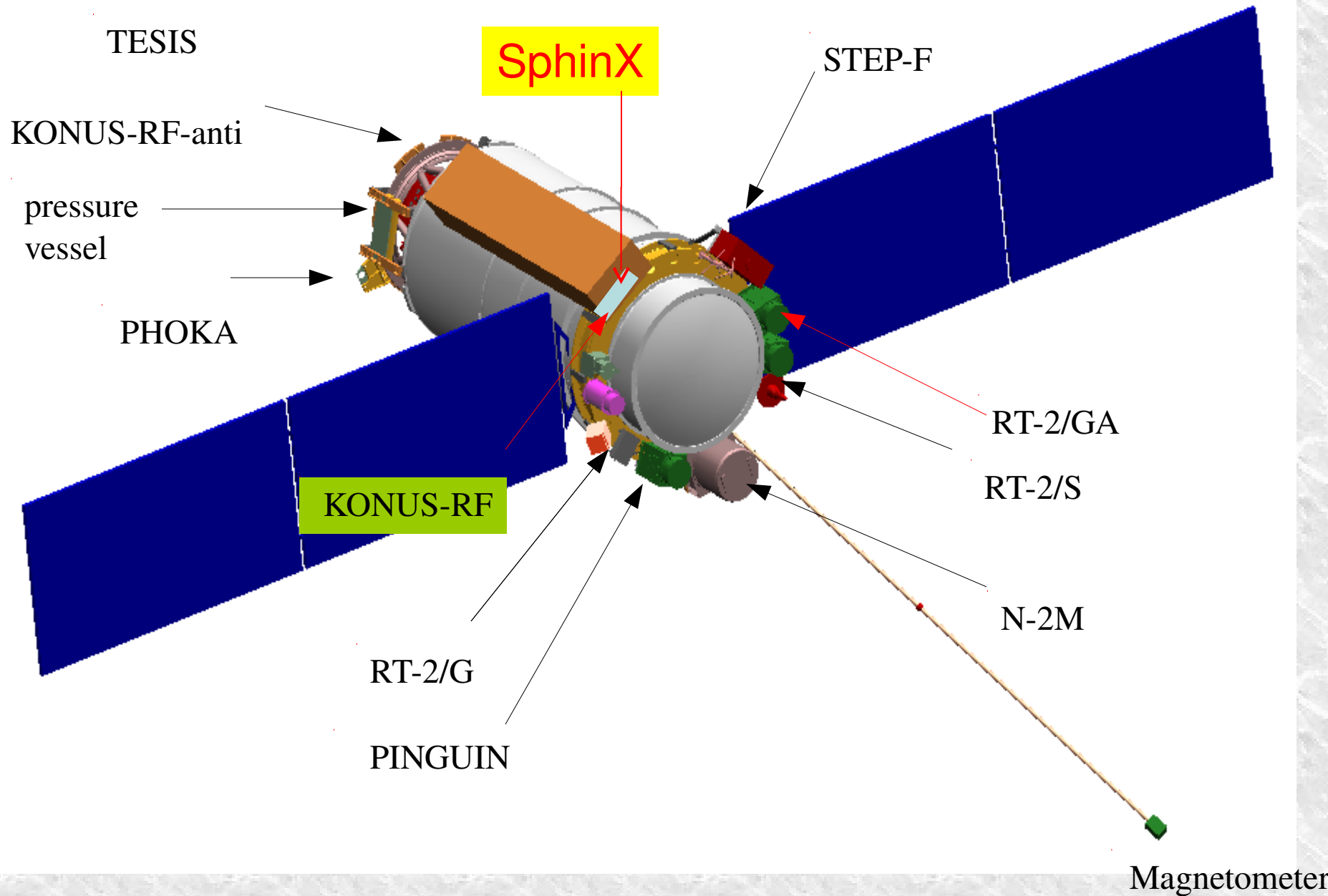
Vacuum chamber with SphinX



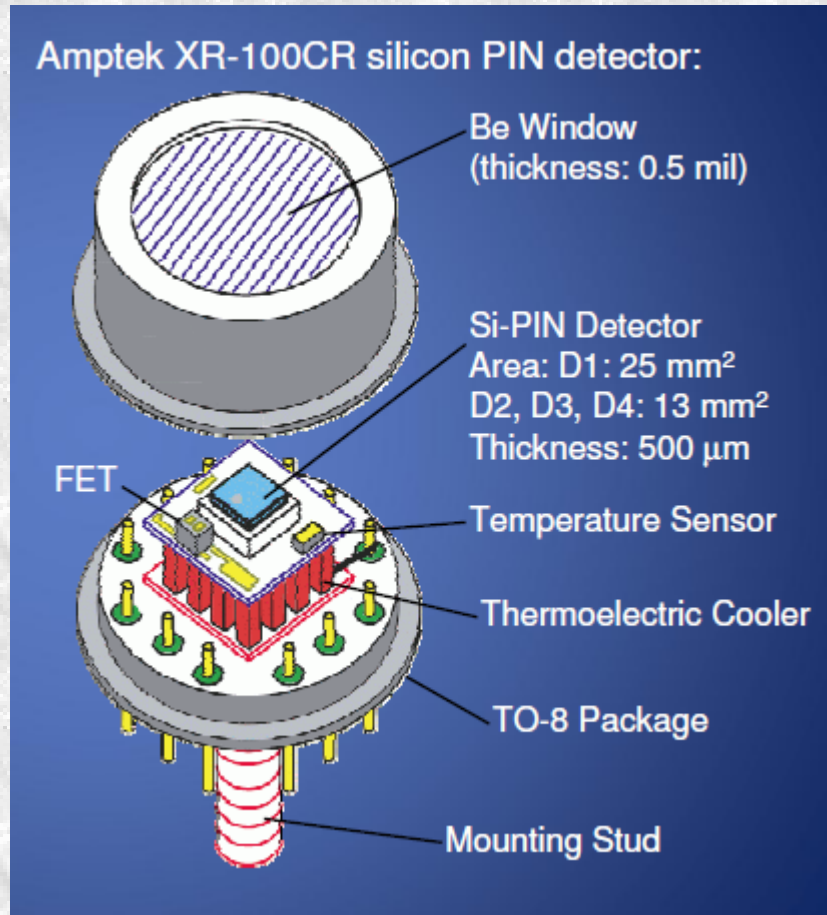
# BESSY II synchrotron calibrations



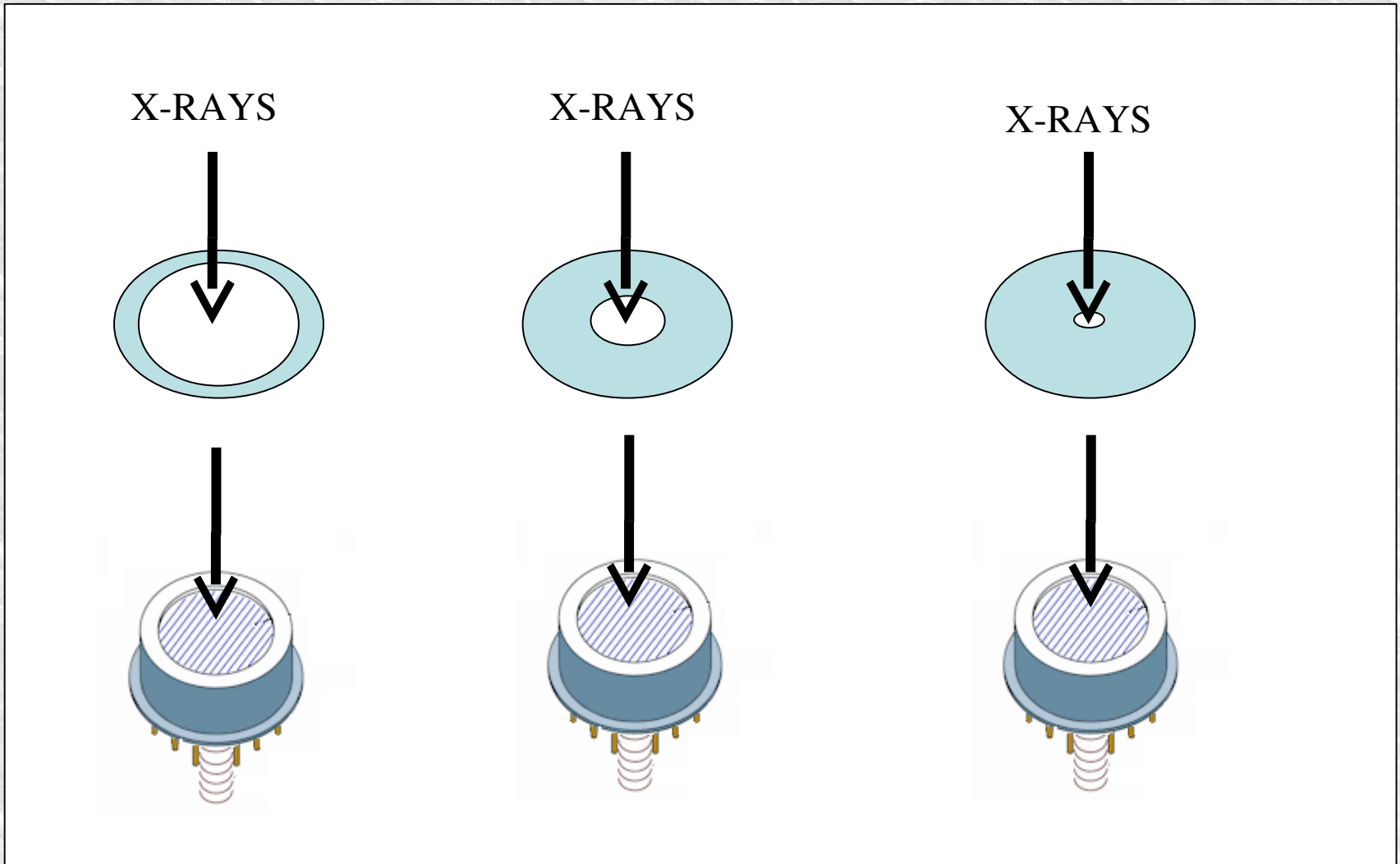
# CORONAS – PHOTON satellite



# SphinX detectors



# SphinX main measurement channel and operation principle



Three PIN-diode detectors with decreasing apertures are used to cover 7 orders of variability of solar X-ray flux magnitude.

# Data coverage

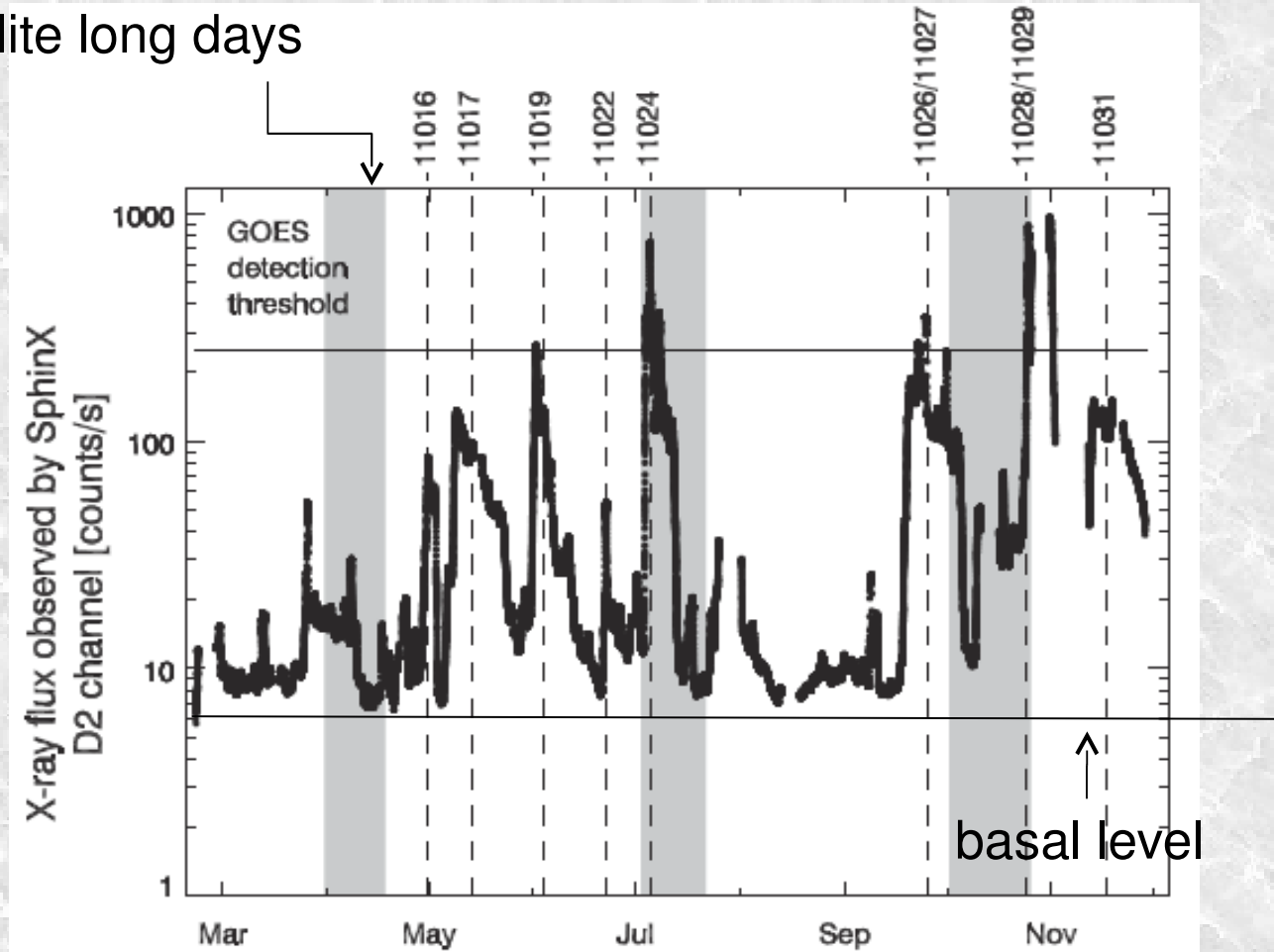
February 20, 2009 – November 29, 2009

Low solar activity

Data from D1 and D2 detectors only

# Mission long plot of solar X-ray flux as seen by SphinX

Satellite long days

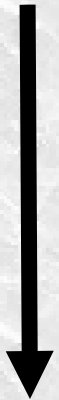


Example of SphinX standard data product

Telemetry raw data



Level 0 data



**SphinX data types**

spectra  
lightcurves  
events sequences  
0.85 keV - 15 keV

Meta data



Level 1 data - FITS format

SphinX dedicated  
data servers  
at PI, Co-is institutions  
All data

DSFA, University of Palermo

Moscow LPI

SRC PAS, Wrocław, Poland

AI ASCR Ondrejov,  
Czech Republic

VSO, EVSO Level 1 data (FITS)

# SphinX data catalogue

All SphinX data available here are not reduced, level 0 - telemetry data.

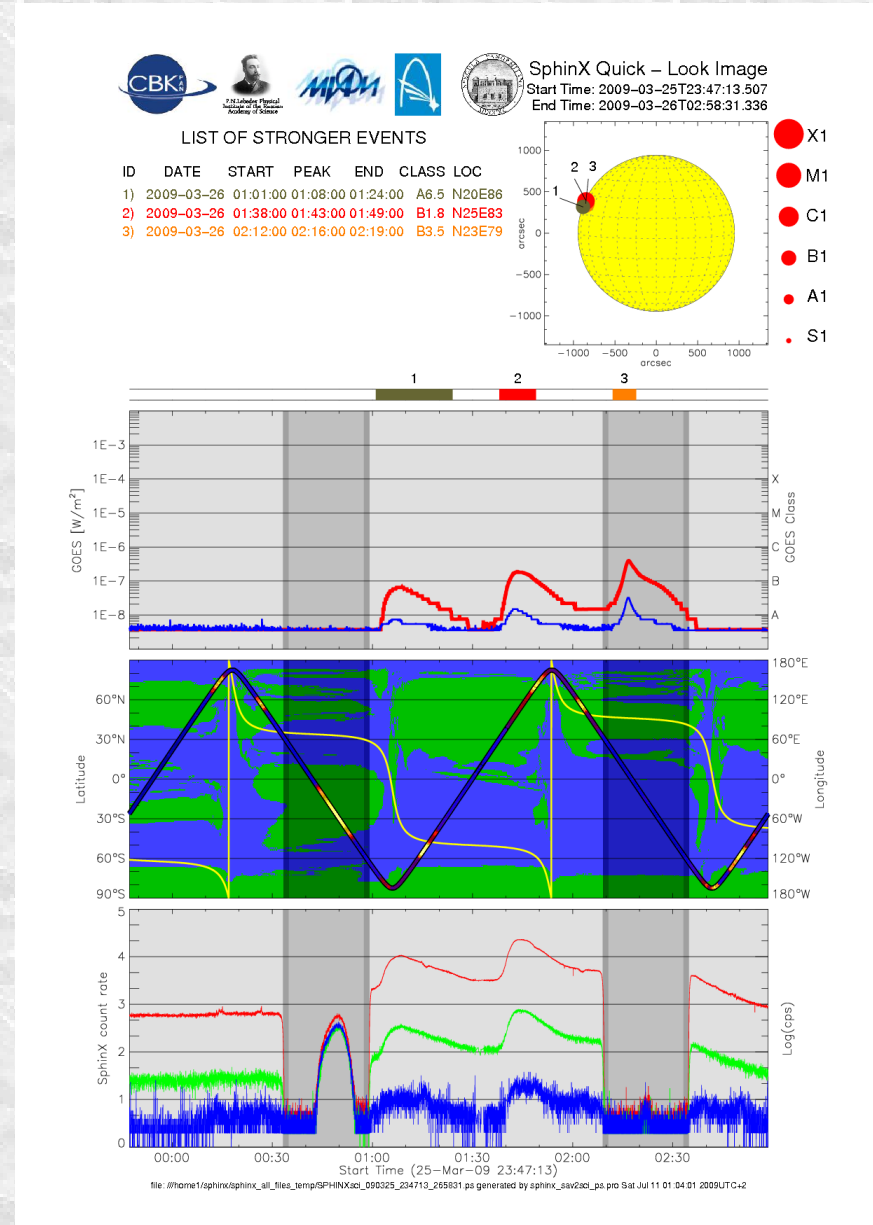


2009																															
January	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
February	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28			
March	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
April	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
May	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
June	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
July	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
August	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
September	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
October	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
November	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
December	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

[http://156.17.94.1/sphinx\\_catalogue/SphinX\\_cat\\_main.html](http://156.17.94.1/sphinx_catalogue/SphinX_cat_main.html)  
(all SphinX data can be downloaded from this site)

# An example of plots available in SphinX catalogue

SphinX summary plot  
Includes information from  
SphinX, GOES, orbit data  
and SphinX events/flare  
catalogue



# Going from level 0 to level 1 data - 40% done

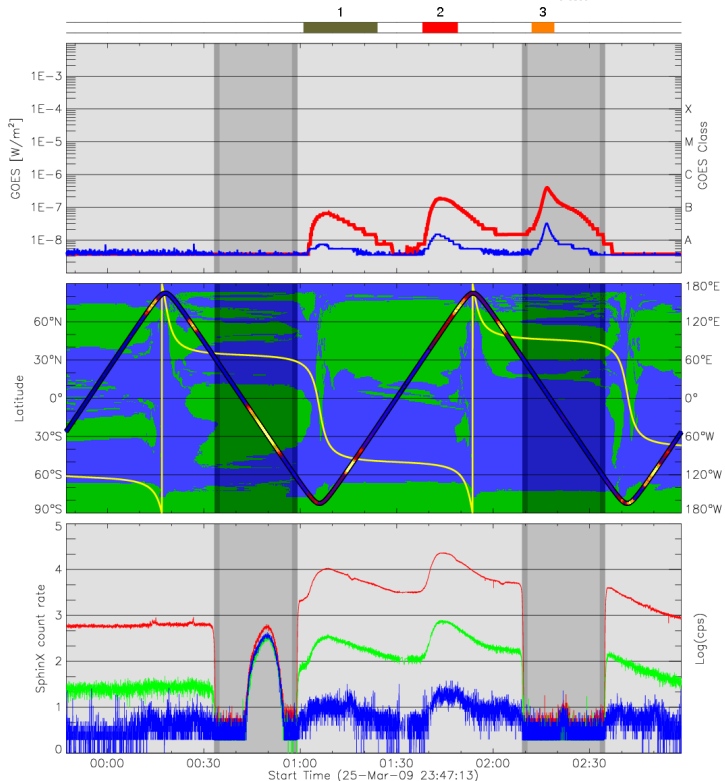
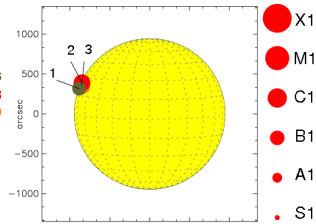


SphinX Quick - Look Image

Start Time: 2009-03-25T23:47:13.507  
End Time: 2009-03-26T02:58:31.336

## LIST OF STRONGER EVENTS

ID	DATE	START	PEAK	END	CLASS	LOC
1)	2009-03-26	01:01:00	01:08:00	01:24:00	A6.5	N20E86
2)	2009-03-26	01:38:00	01:43:00	01:49:00	B1.8	N25E83
3)	2009-03-26	02:12:00	02:16:00	02:19:00	B3.5	N23E79



file: //home1/sphinxsphinx\_all\_files\_temp/SPHINXsci\_090325\_234713\_265831.ps generated by sphinx\_svi2sci.ps pro Sat Jul 11 01:04:01 2009UTC+2

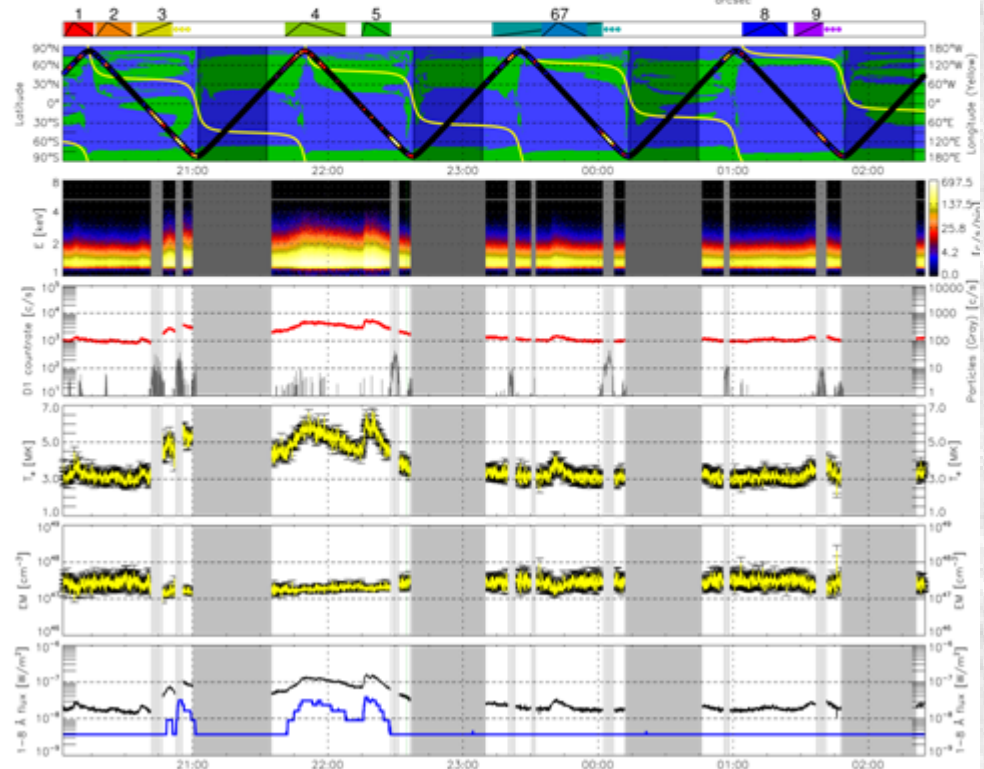
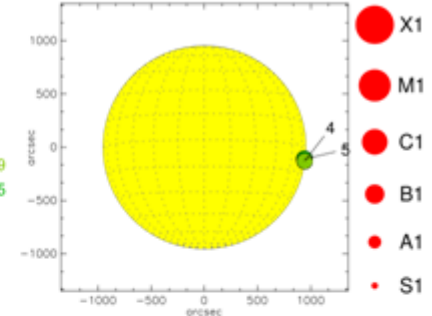


SPHINX\_090430\_200226\_262512 - Level1

Start Time: 2009-04-30 20:02:23.888  
End Time: 2009-05-01 02:25:09.685

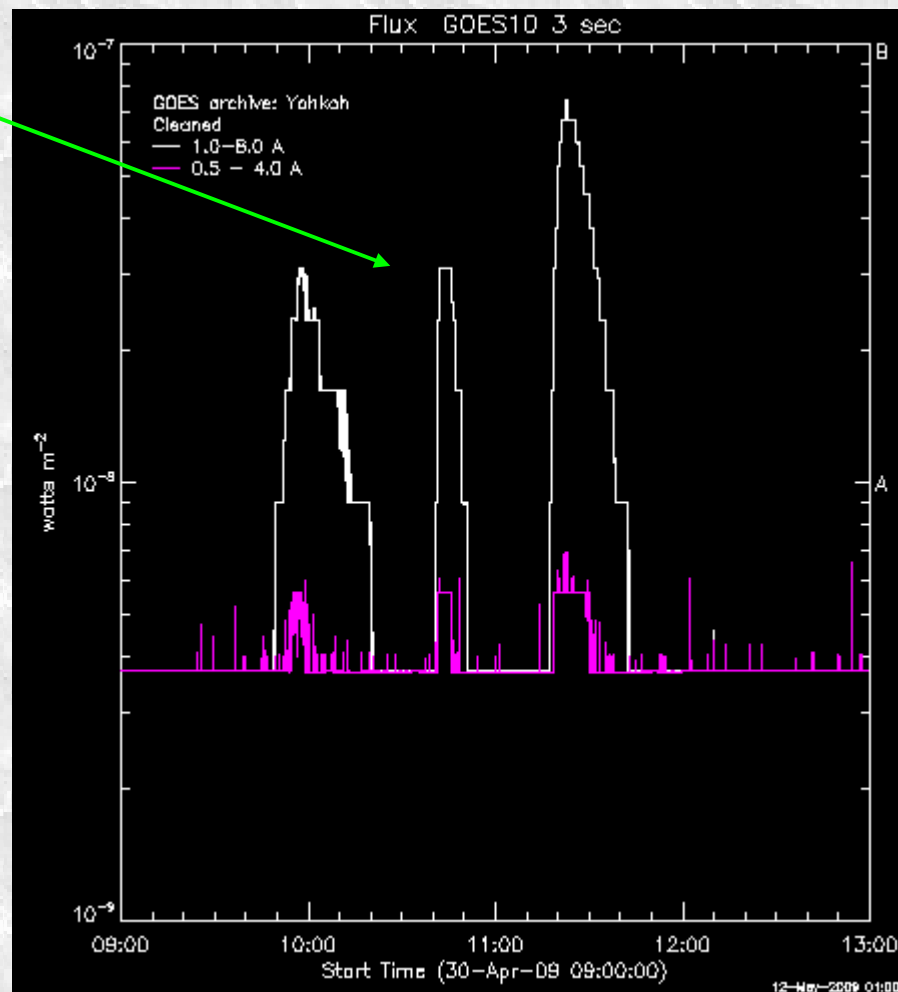
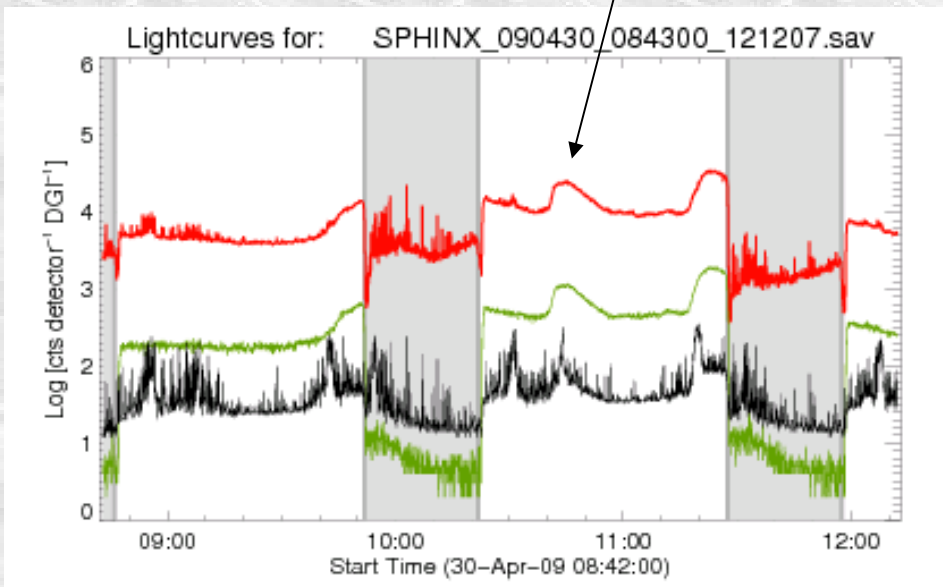
## LIST OF STRONGER EVENTS

ID	DATE	START	PEAK	END	CLASS	LOC
1)	2009-04-30	20:03:00	20:07:00	20:16:00	S3.4	-
2)	2009-04-30	20:17:00	20:22:00	20:33:00	S2.5	-
3)	2009-04-30	20:35:00	20:51:00	-	A1.6	-
4)	2009-04-30	21:41:00	21:49:00	22:08:00	A3.1	S08W89
5)	2009-04-30	22:15:00	22:17:00	22:28:00	A3.7	S07W85
6)	2009-04-30	23:13:00	00:02:00	-	S8.0	-
7)	2009-04-30	23:35:00	23:42:00	23:55:00	S3.6	-
8)	2009-05-01	01:04:00	01:17:00	01:24:00	S2.5	-
9)	2009-05-01	01:27:00	01:40:00	-	S4.0	-



# SphinX vs GOES observations

Goes A3.1



SphinX is about ~30 times more sensitive than GOES

# Energetic particle contribution to SphinX observations

Particle signal – usually in the last energy channel

RB and SAA, GCR, SEPs

Depends on solar cycle phase

# Effects on electronics/detectors

## **Cumulative effects**

Ionising effects surface/volume charging of components, spurious signal increase etc...

Non ionising effects — energy deposit in component volume, changes in element structure, voltage distribution, loss of efficiency, loss of charge transfer efficiency.

## **Single particle hit effects**

spurious signal, memory cell/processor upsets, entire system operation failure.

SEU – single event upset      temporary, reversible

SEL – single event latch-up      permanent

# SphinX shielding simulations with SPENVIS

## **Early development phase**

Estimate minimum shielding necessary for an experiment

## **Construction details and overall geometry of the system known**

Is additional shielding necessary?

## **Cumulative effects**

DOSES — to compare with allowable limits for components used

## **Single particle hit effects**

Rates/Probability of occurrence

# SphinX shielding simulations with SPENVIS

The screenshot displays the SPENVIS Project: SPHINX interface. At the top, a dark blue header bar contains the text "SPENVIS Project: SPHINX", "Model packages", and "Planet: Earth". On the left side of the header is a circular button with an upward arrow and the text "UP". On the right side are two buttons labeled "Output" and "Help". Below the header is a navigation menu with a dark blue background and white text. The menu items are: "Coordinate generators", "Radiation sources and effects", "Radiation sources", "Trapped proton and electron fluxes", "Trapped proton flux anisotropy", "Solar proton fluences", "Solar cell radiation damage", "Damage equivalent fluences for solar cells", "NIEL based damage equivalent fluences for solar cells (MC-SCREAM)", "Radiation doses", "Ionizing and non-ionizing dose models for simple geometries", "Single event effects", "Ion energy and LET spectra", and "Single event upset rates". A large black arrow points from the right side of the screen towards the "Coordinate generators" menu item.

Orbit - height 500, inclination  $82,5^{\circ}$

# SphinX shielding simulations with SPENVIS

SPENVIS Project: SPHINX  
Model packages  
Planet: Earth

UP

Output  
Help

**Coordinate generators**

**Radiation sources and effects**

**Radiation sources**

[Trapped proton and electron fluxes](#)

[Trapped proton flux anisotropy](#)

[Solar proton fluences](#)

**Solar cell radiation damage**

[Damage equivalent fluences for solar cells](#)

[NIEL based damage equivalent fluences for solar cells \(MC-SCREAM\)](#)

**Radiation doses**

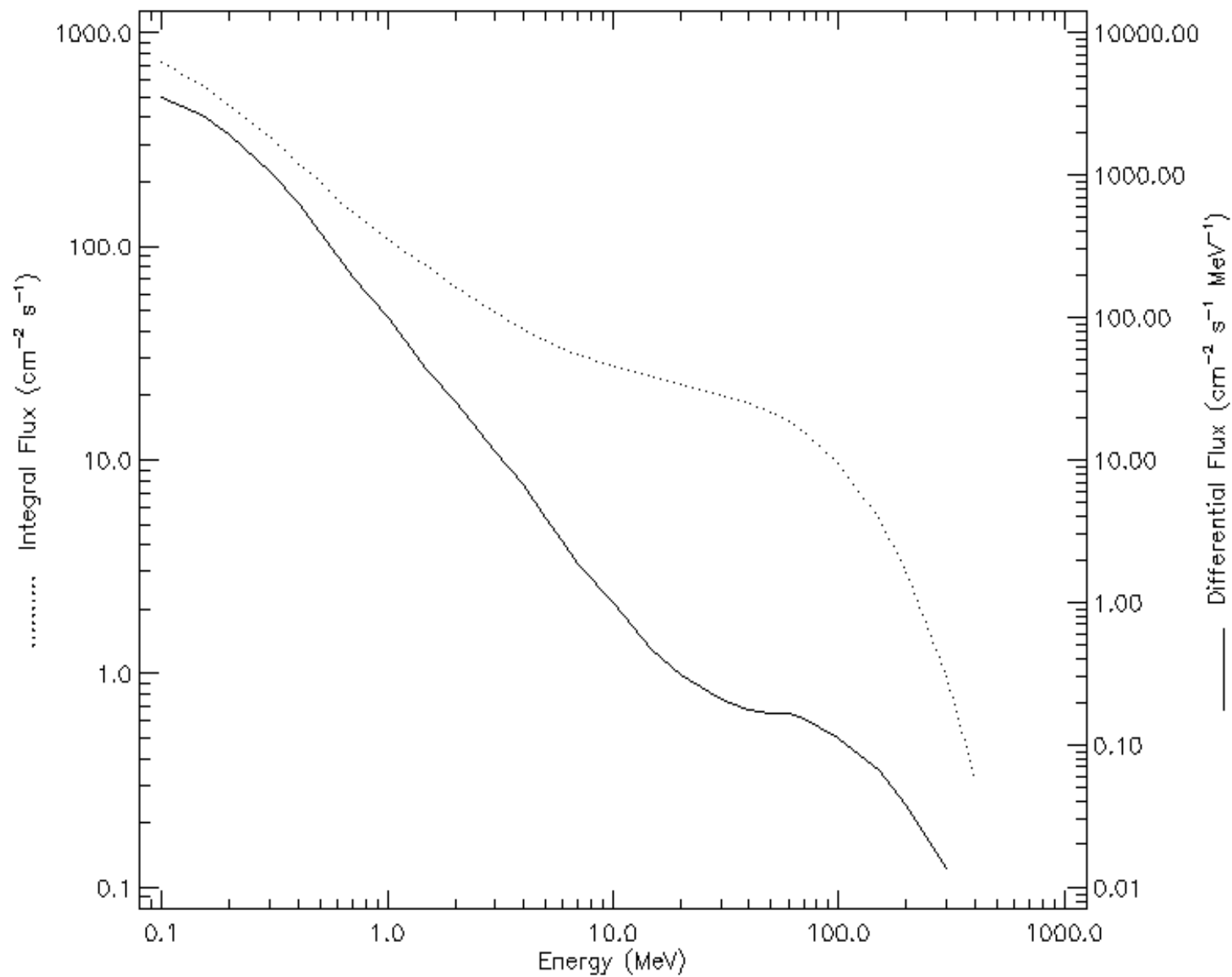
[Ionizing and non-ionizing dose models for simple geometries](#)

**Single event effects**

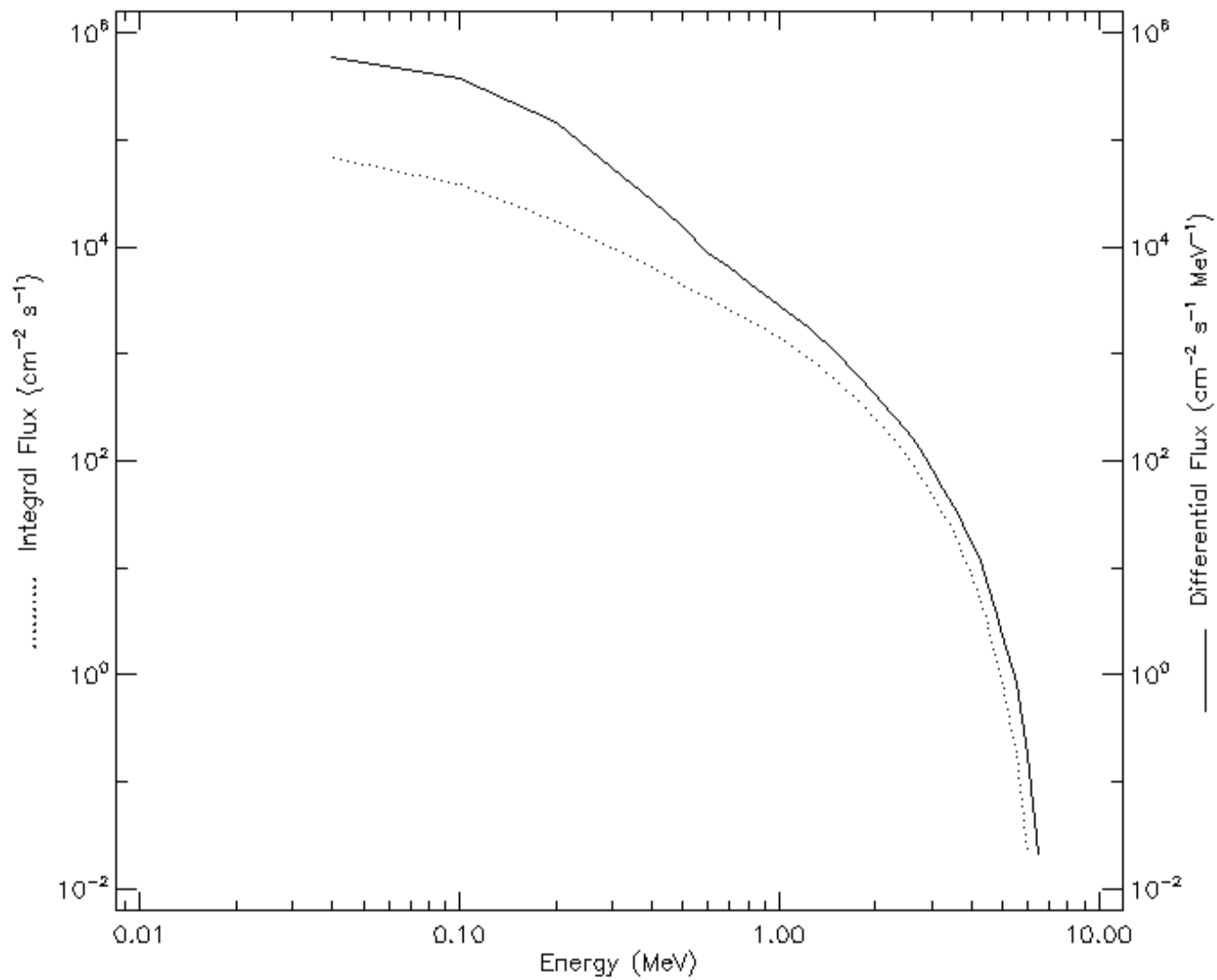
[Ion energy and LET spectra](#)

[Single event upset rates](#)

AP-8 MIN Mission averaged flux



AE-8 MIN Mission averaged flux



# SphinX shielding simulations with SPENVIS

The screenshot shows the SPENVIS Project: SPHINX interface. At the top, there is a dark blue header bar with the text "SPENVIS Project: SPHINX", "Model packages", and "Planet: Earth". On the left side of the header is an "UP" button, and on the right side are "Output" and "Help" buttons. Below the header is a tree view of model packages. The tree view has a dark blue header for "Coordinate generators" and a dark blue header for "Radiation sources and effects". Under "Radiation sources and effects", there are several sub-items: "Radiation sources", "Solar cell radiation damage", "Radiation doses", and "Single event effects". Each of these sub-items has a list of links below it. Two black arrows point to the links "Ionizing and non-ionizing dose models for simple geometries" and "Single event upset rates".

**Coordinate generators**

**Radiation sources and effects**

**Radiation sources**

- [Trapped proton and electron fluxes](#)
- [Trapped proton flux anisotropy](#)
- [Solar proton fluences](#)

**Solar cell radiation damage**

- [Damage equivalent fluences for solar cells](#)
- [NIEL based damage equivalent fluences for solar cells \(MC-SCREAM\)](#)

**Radiation doses**

- [Ionizing and non-ionizing dose models for simple geometries](#)

**Single event effects**

- [Ion energy and LET spectra](#)
- [Single event upset rates](#)

# DOSES

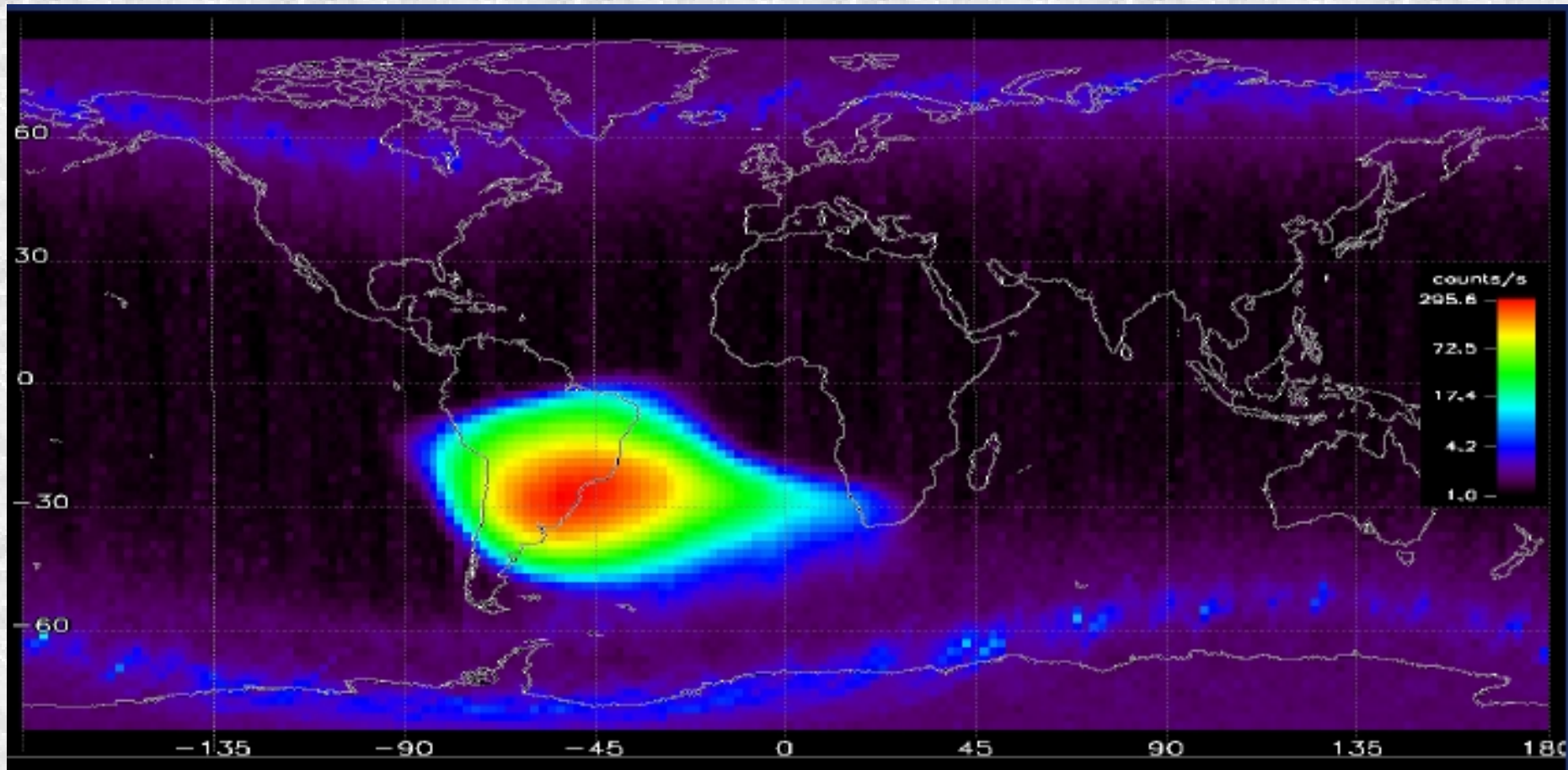
SphinX electronics component tolerance  $5 \cdot 10^3$  -  $1 \cdot 10^4$  rad

SPENVIS calculated doses (3years)  $1 \cdot 10^3$  rad

SEU – single event upset  
Maximum two per day per instrument

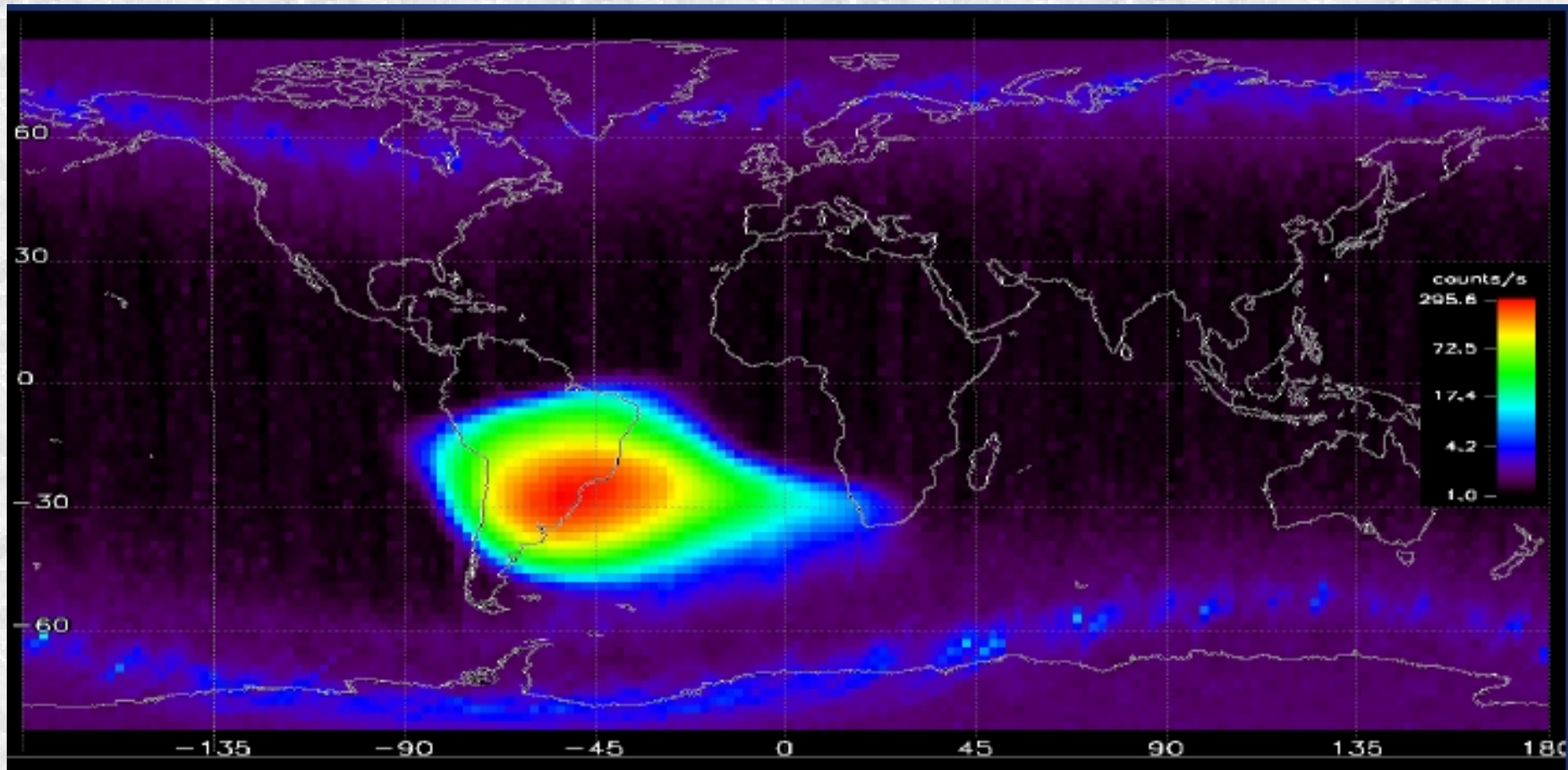
# Observations of energetic particle distribution at SphinX orbit

(particle signal comes from the highest energy channel of SphinX detectors)



# Observations of energetic particle distribution at SphinX orbit

(particle signal comes from the highest energy channel of SphinX detectors)



# Thank you

## Acknowledgement:

The research leading to these results has received funding from the European Commission's Seventh Framework Programme (FP7/2007-2013) under the grant agreement n° 218816 (SOTERIA project, [www.soteria-space.eu](http://www.soteria-space.eu) )