The CAST Experiment

Status Report to the SPSC at CERN

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CERN, 13.05.03

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Outline:

-Axions

-CAST : Status

-Magnet, power supply, cryogenics, sun tracking

-Detectors:

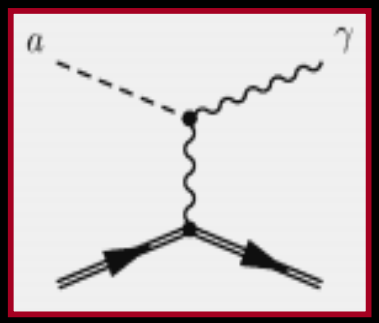
TPC
Micromegas
X-ray Telescope and CCD

-Outlook

Principle of detection

Solar axions

AXION PHOTON CONVERSION



axions

Transverse magnetic field (B)

L

X ray

X ray detector

$$P_{a\gamma} = 1.8 \times 10^{-17} (\frac{B}{8.4T})^2 (\frac{L}{10m})^2 (g_{a\gamma\gamma} \times 10^{10} GeV^{-1})^2 |\mathcal{M}|^2,$$

COHERENCE 1

Axions

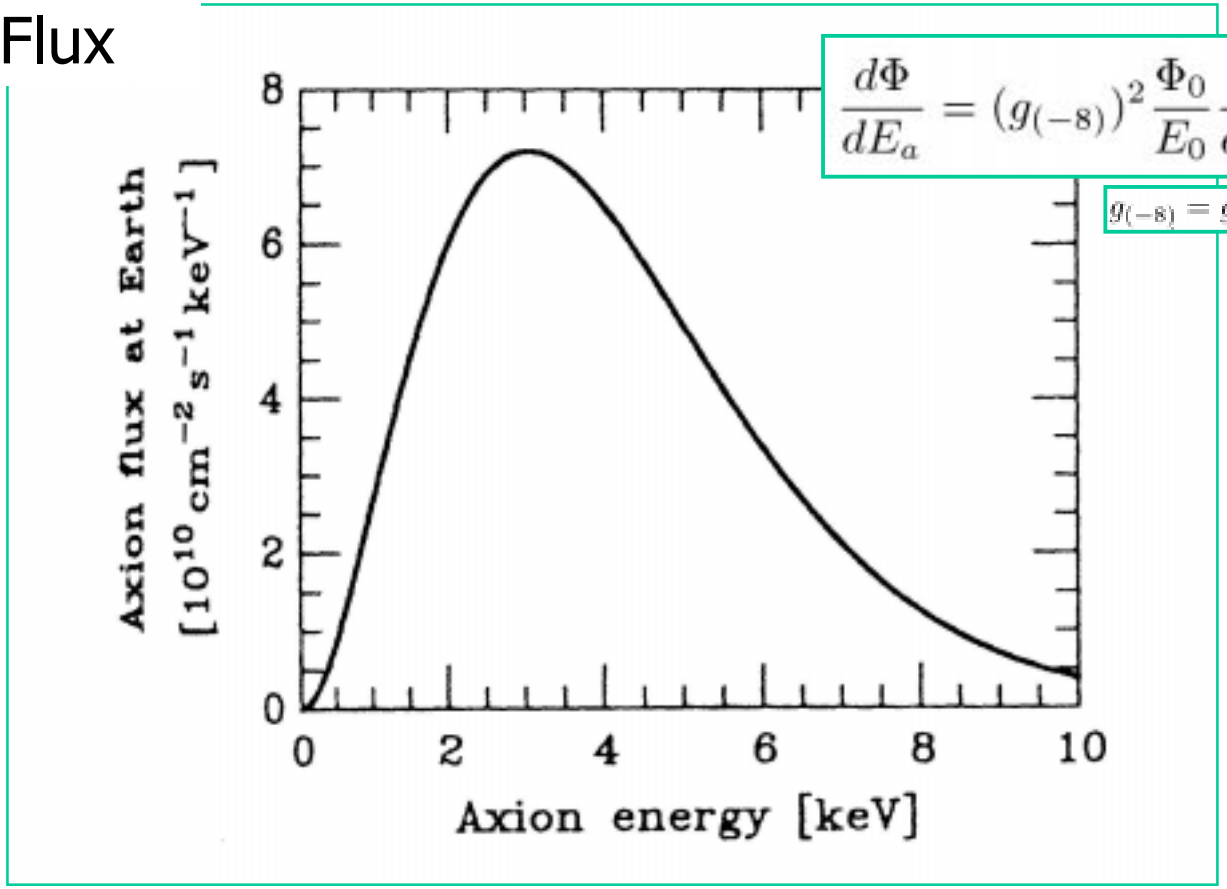
PRIMAKOFF EFFECT

Solar Axions

Flux

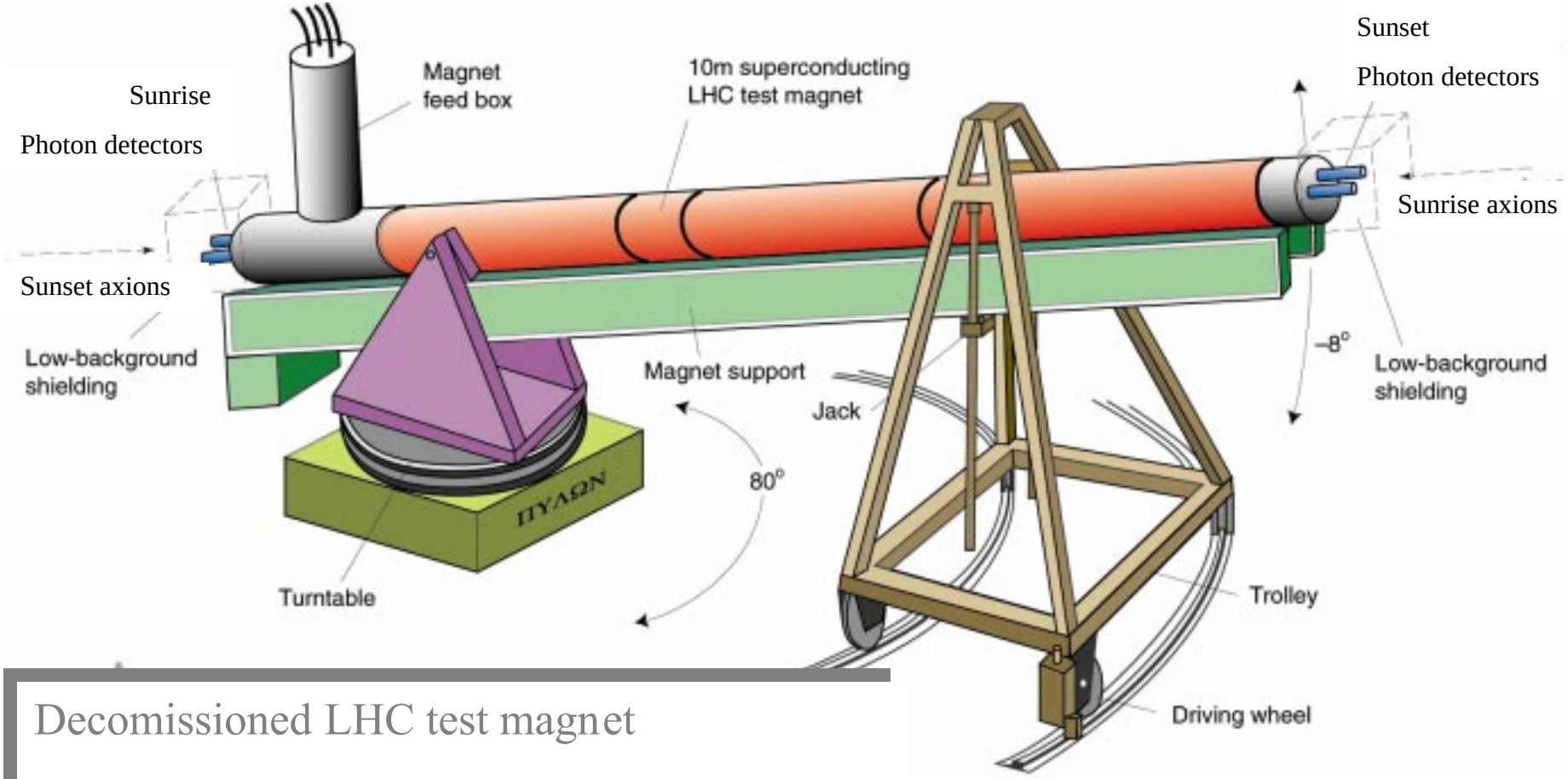
$$\frac{d\Phi}{dE_a} = (g_{(-8)})^2 \frac{\Phi_0}{E_0} \frac{(E_a/E_0)^3}{e^{E/E_0} - 1}$$

$$g_{(-8)} = g_{a\gamma\gamma} \times 10^8/\mathrm{GeV}^{-1}$$



[K.van Bibber et al.,1989]

Cern Axion Solar Telescope



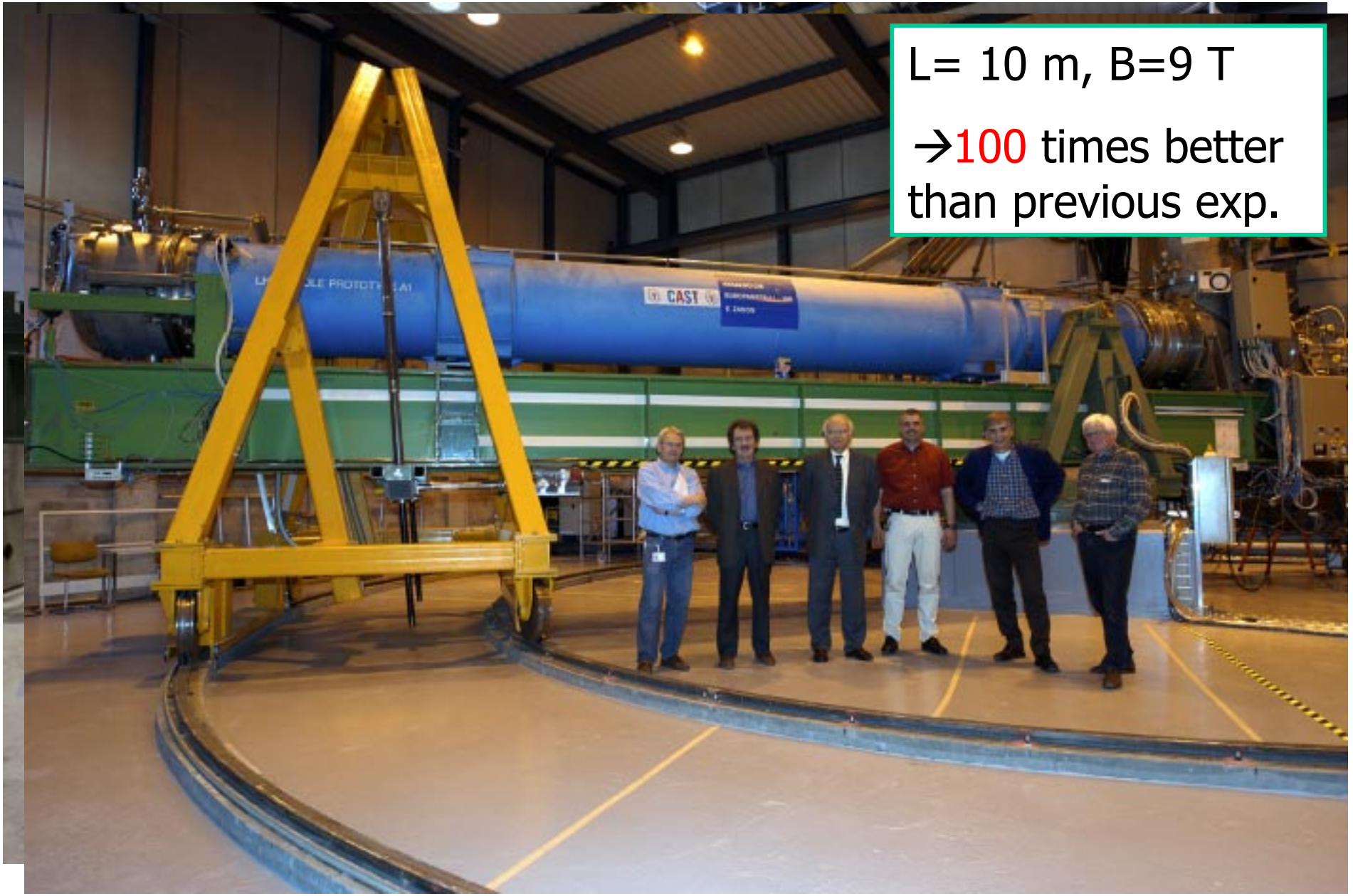
Decomissioned LHC test magnet

Rotating platform

3 X-ray detectors

X-ray Focusing Device

CAST



L= 10 m, B=9 T

→100 times better than previous exp.

Magnet,platform,cryogenics

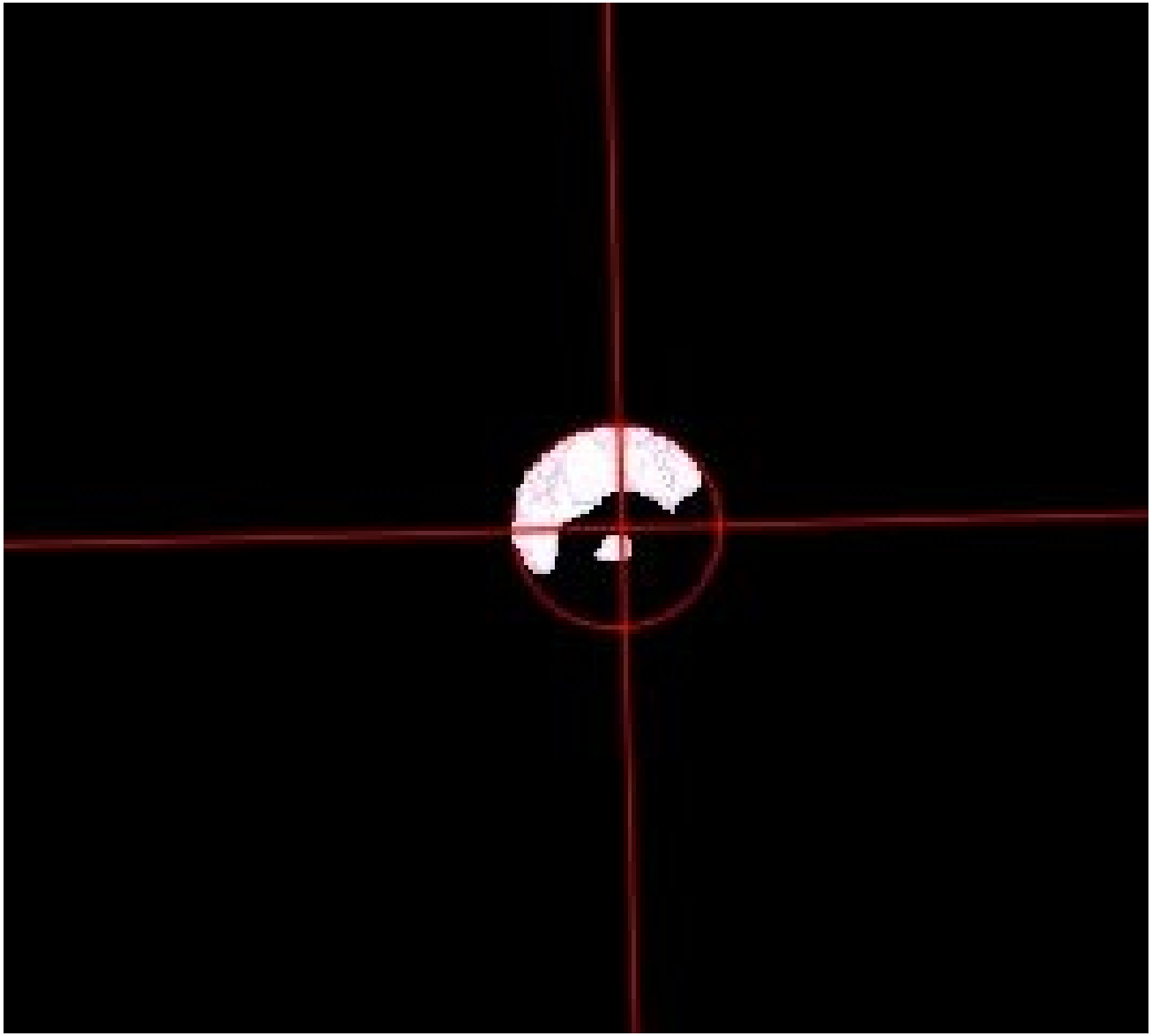
Looking at sunrise

Tracking System:

Calibrated and correlated with celestial coordinates

Twice a year (September&March) we can film the Sun through the window

Tracking the Sun



Magnet Power Supply

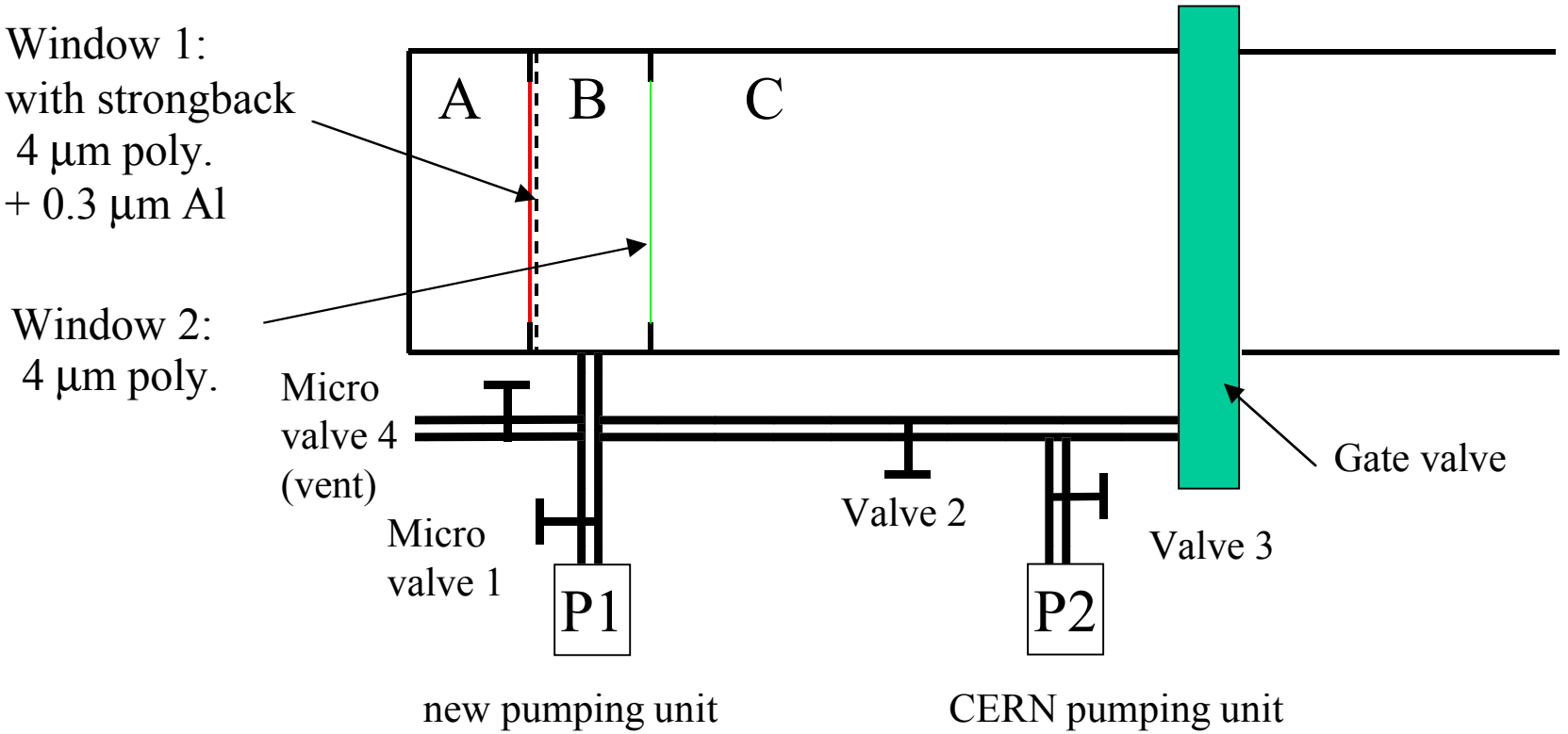
Magnet Quenching

Detectors

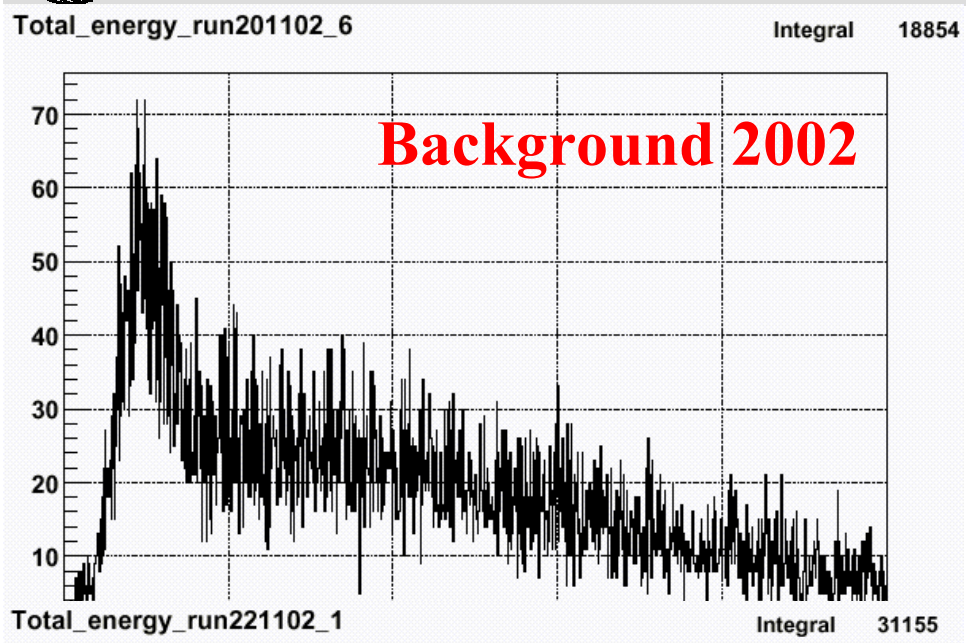
Micromegas

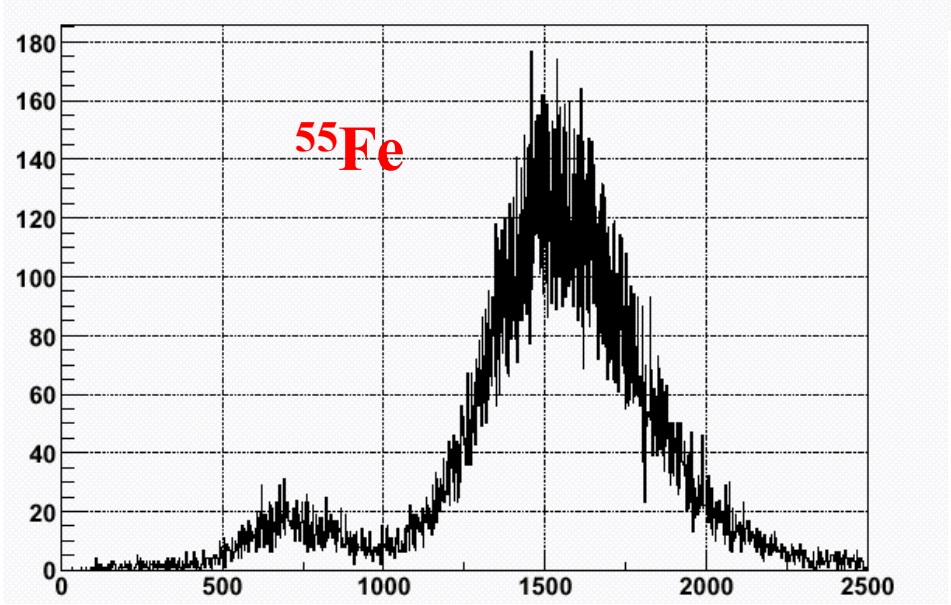
Double polypropylene (C_3H_6) window

Zone A	Zone B	Zone C
Detector	In-between chamber	Tube
P= 1 bar (Ar)	P = 10^{-4} mbar	P = 10^{-6} mbar



Micromegas





Helium leak rate: $3 \cdot 10^{-9}$ mbar l/s

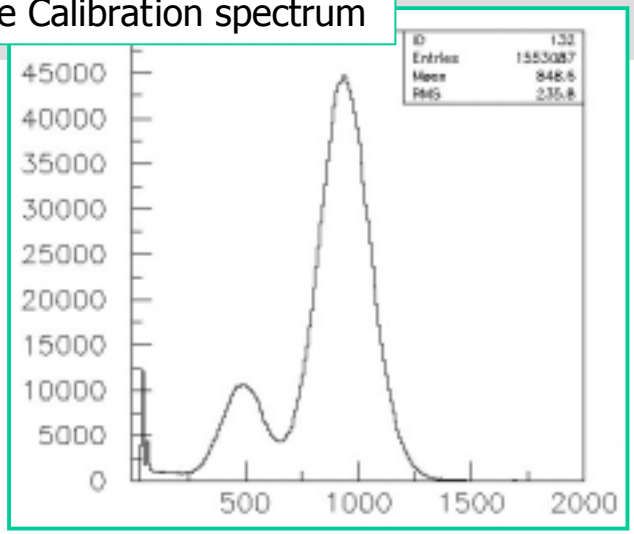
Software efficiency 78.5%

→ $3.7\ 10^{-5}$ /s· cm^2 ·keV

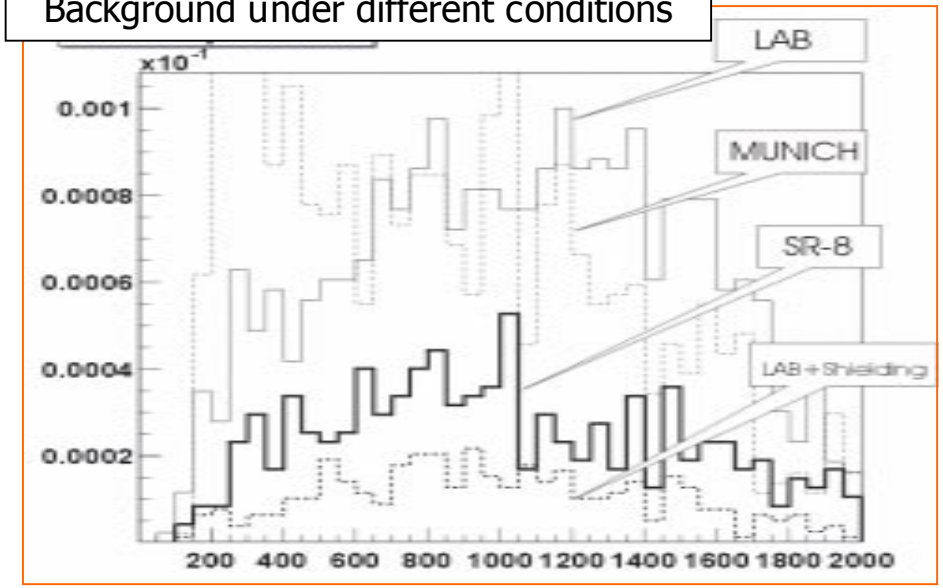
TPC

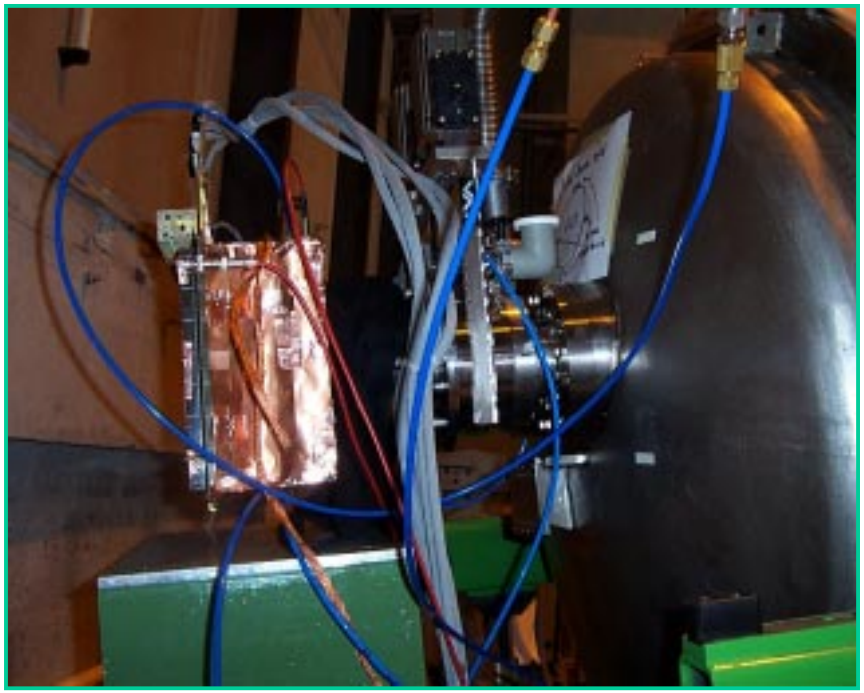
Clean materials +
shielding
(polyethylene+copper+*ancient* lead)

^{55}Fe Calibration spectrum



Background under different conditions

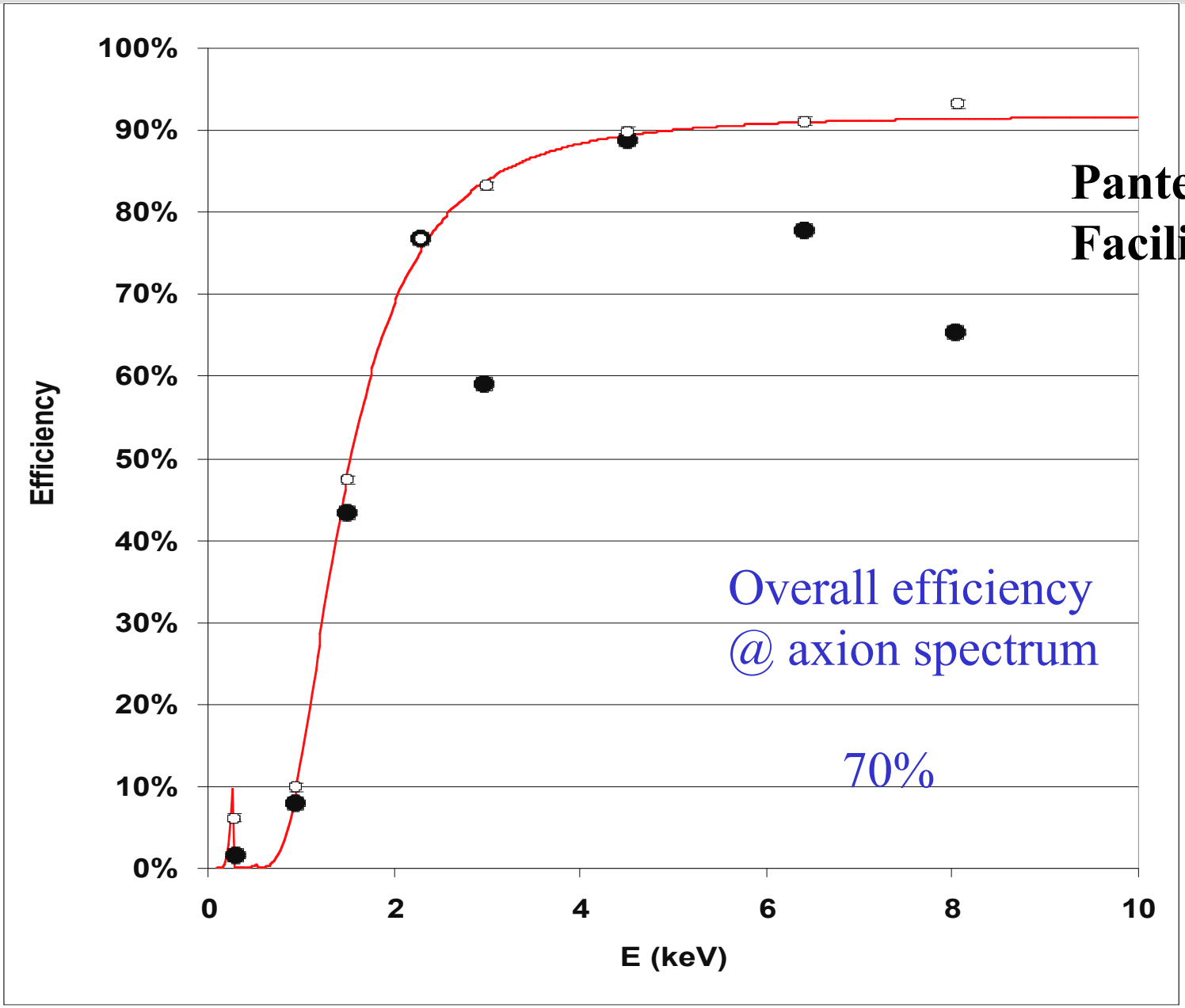




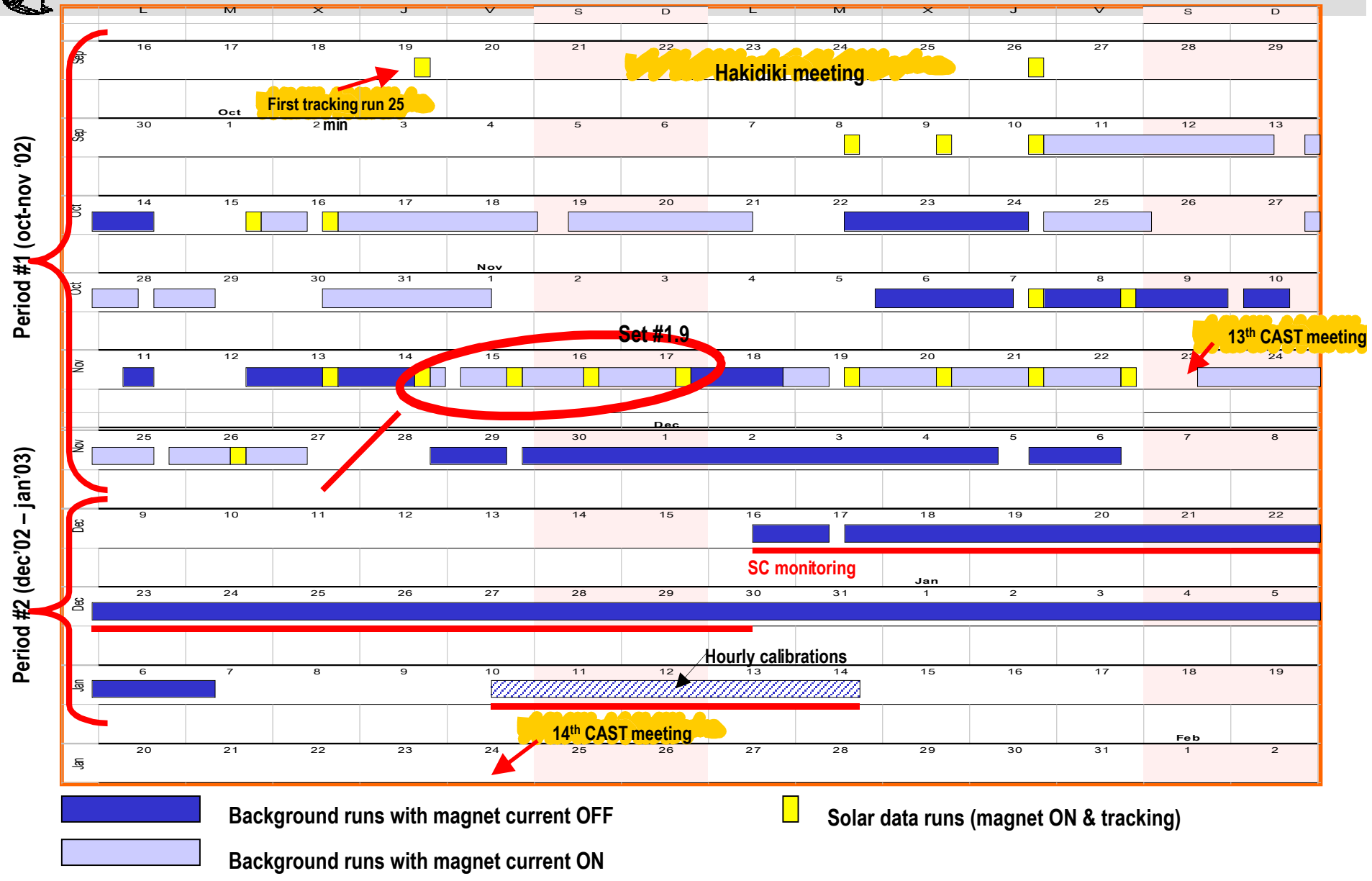
Low Background:

$<10^{-5}$ counts $keV^{-1}cm^{-2}s^{-1}$

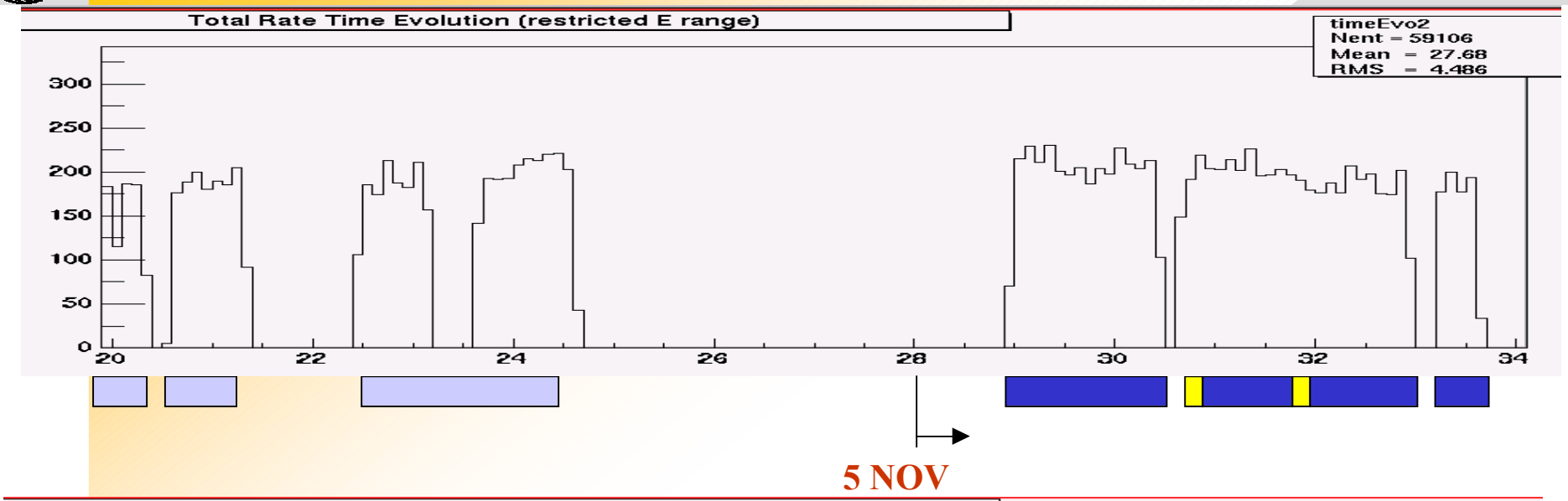
TPC efficiency

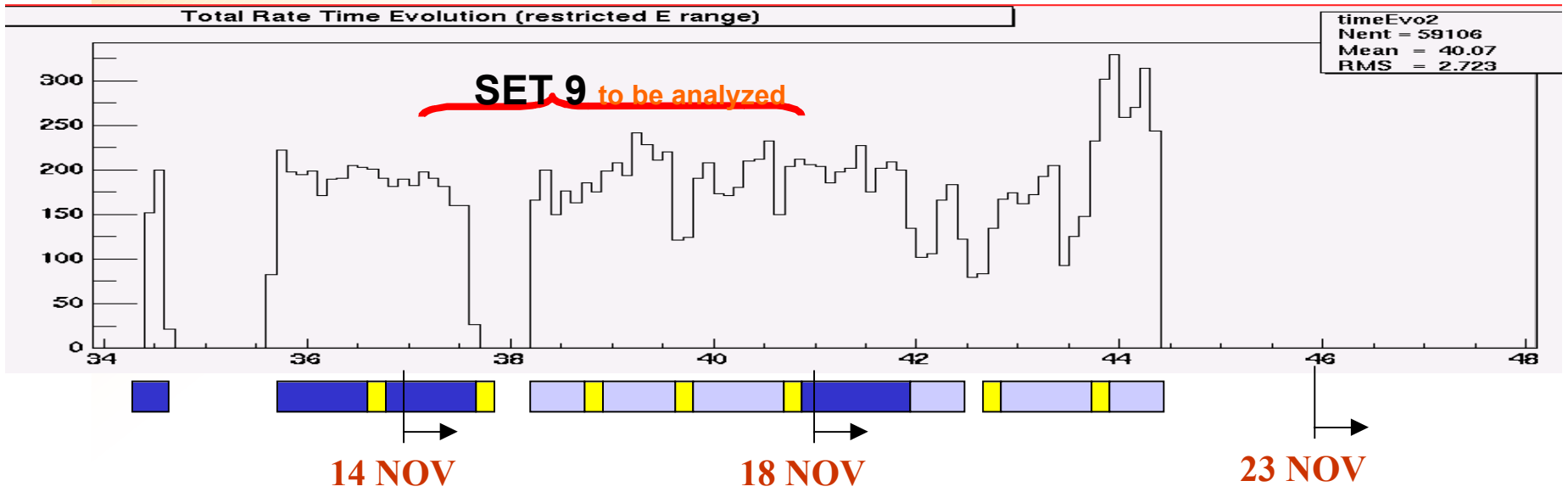


Summary of TPC data (up to Jan'03)



Background data

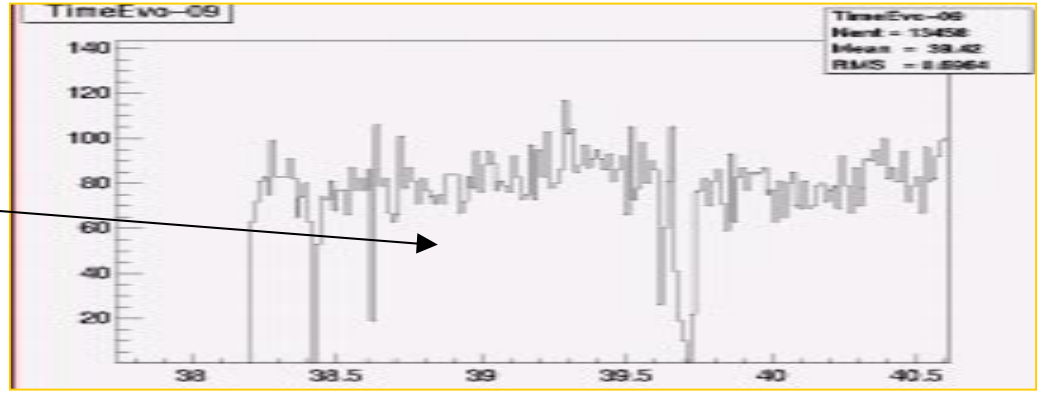




Run 2002

Preliminary Axion Exclusion Plot

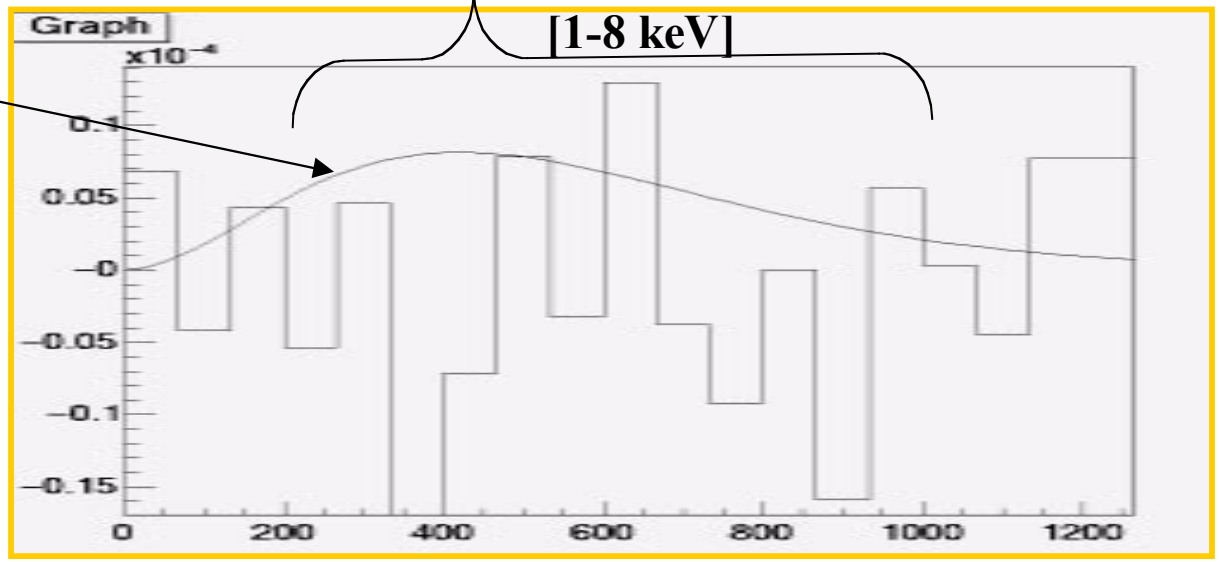
Using only data set #9:
- 4.7 hours of Sun tracking data
- 58 hours of background with reasonable stability



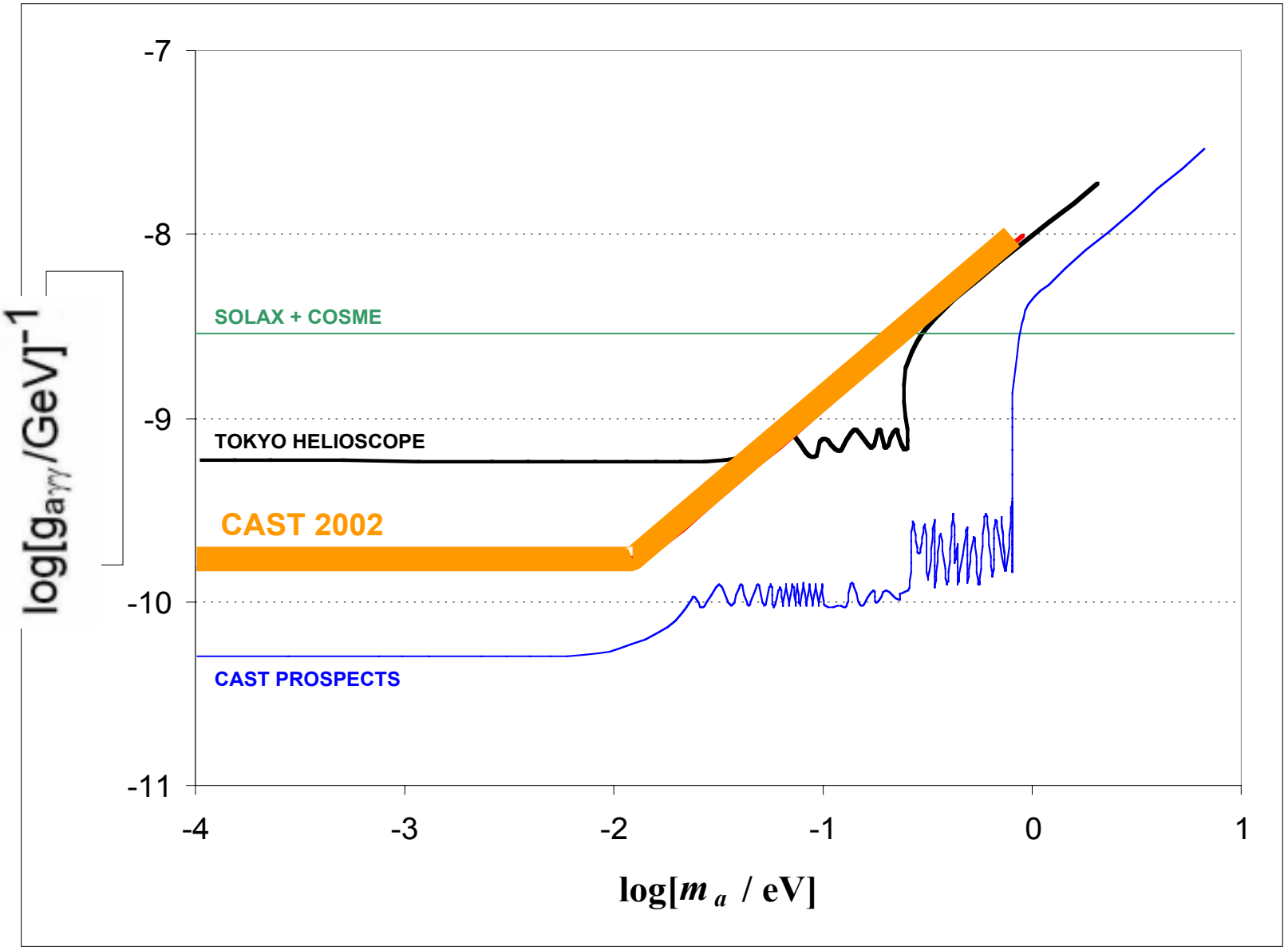
(-3.0 ± 5.0(2σ)) _ 10^{-5} c/cm2/sec

[1-8 keV]

g ~ 1.5 x 10^{-10} GeV^{-1}

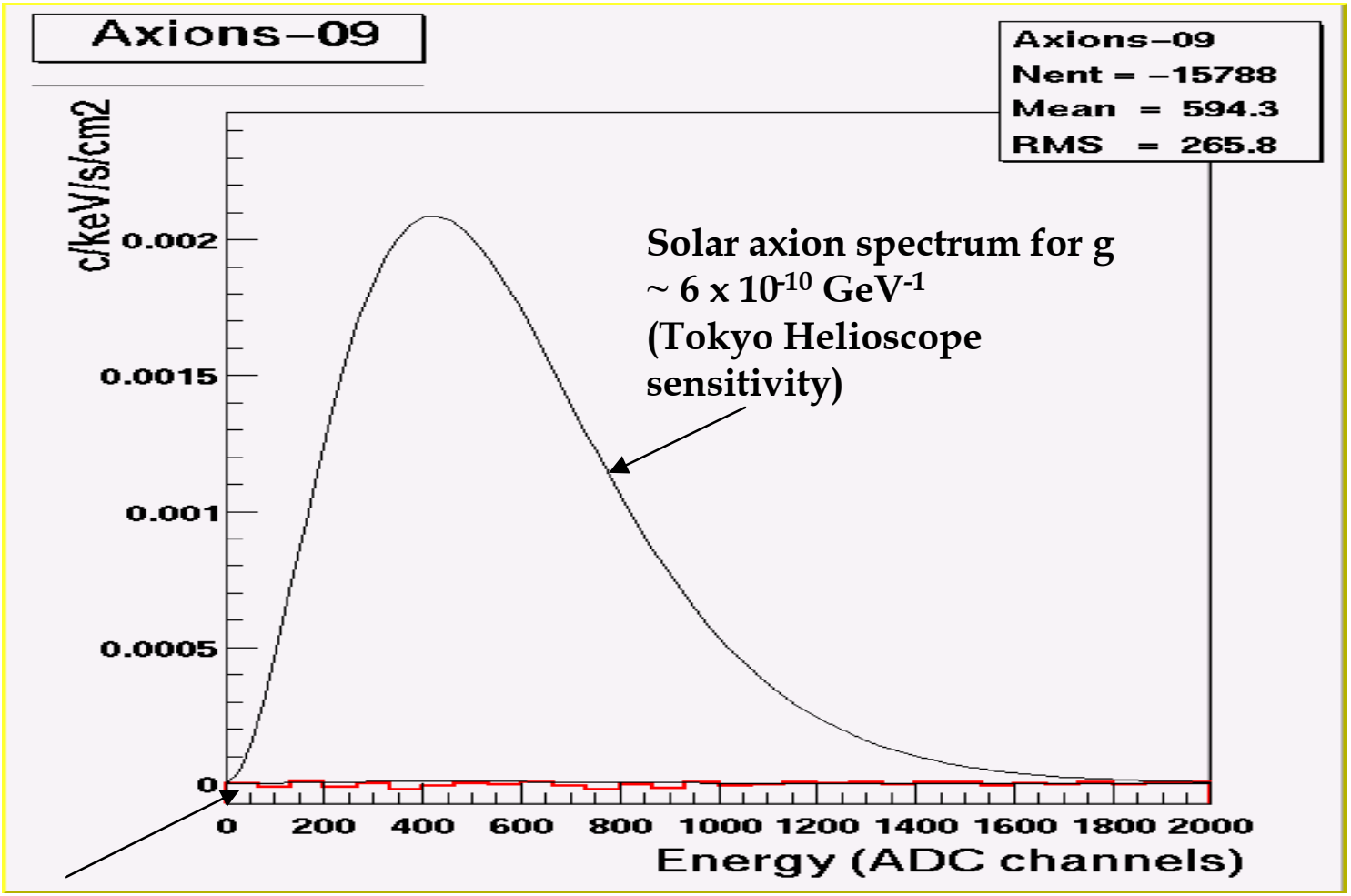


CAST Sensitivity



Preliminary Axion Exclusion Plot

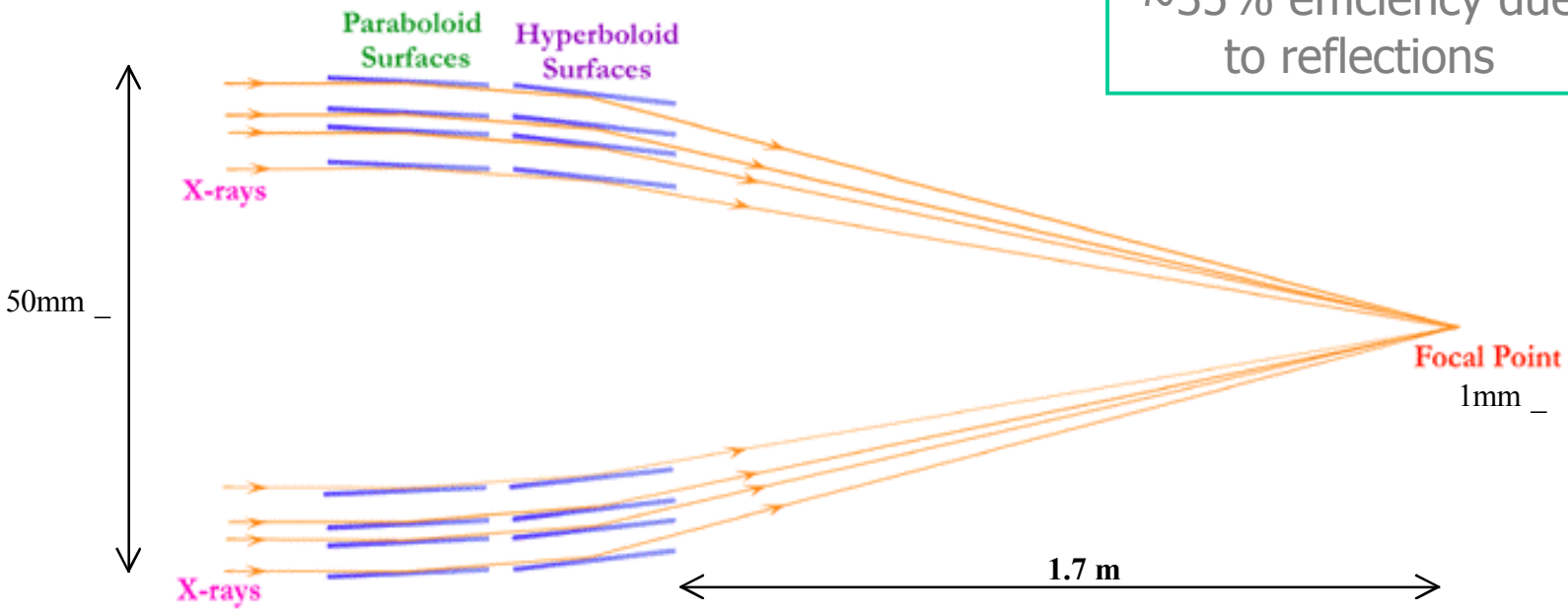
Comparison CAST-Tokyo sensitivities



CAST TPC
4.7 h spectrum
(bck subtracted)

The X-Ray Telescope

~35% efficiency due to reflections

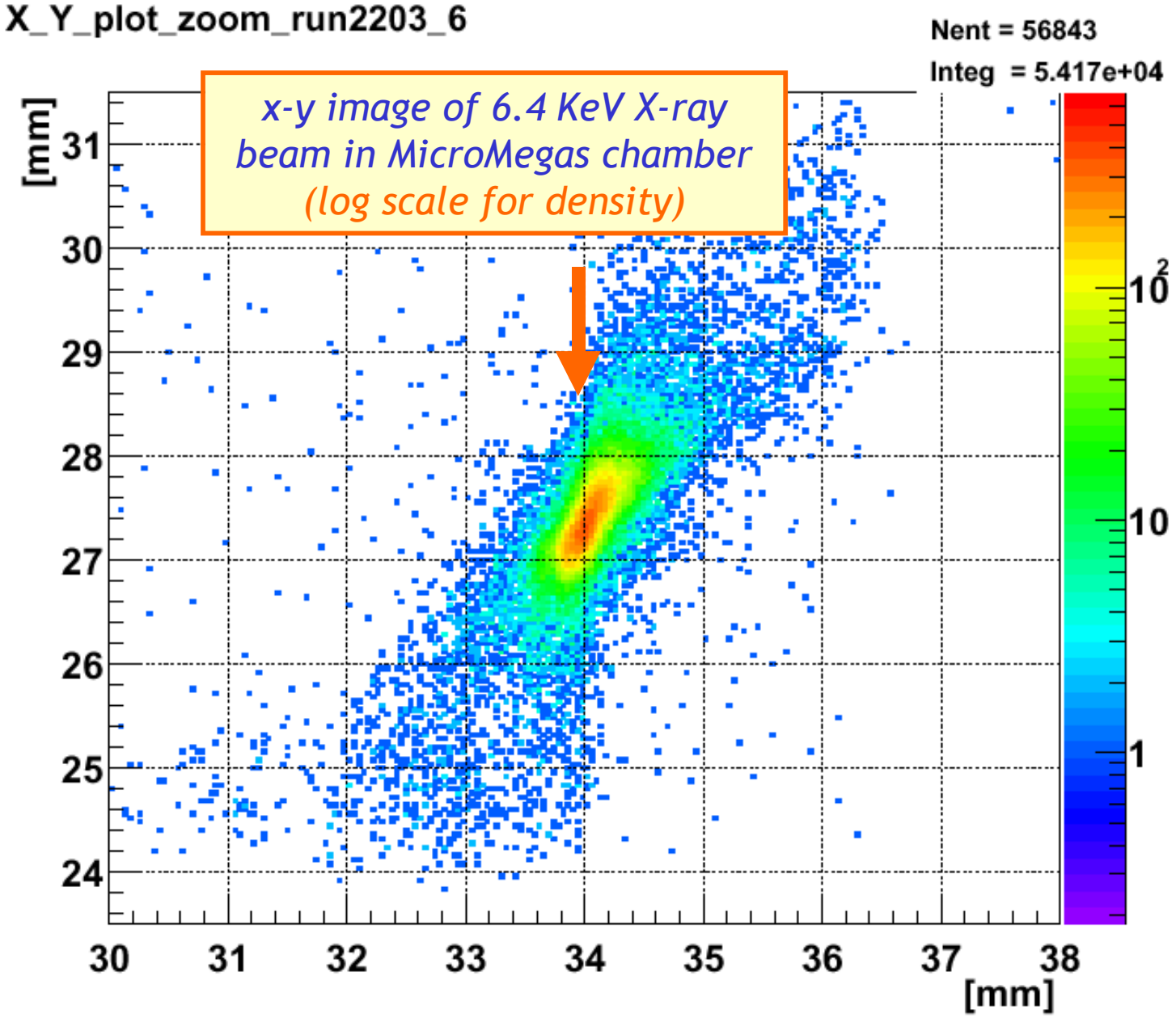


- 27 nested pairs of mirrors
- From 43 mm Δ (LHC magnet aperture) to ~1mm Δ

signal and background simultaneously

signal-to-noise improvement

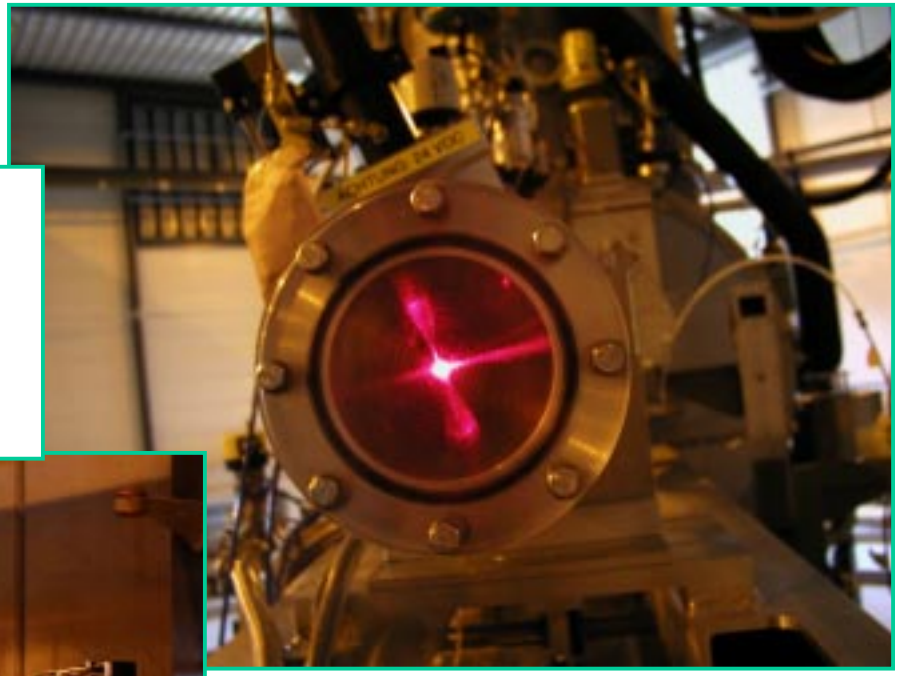
Test @MPE -Panter facility

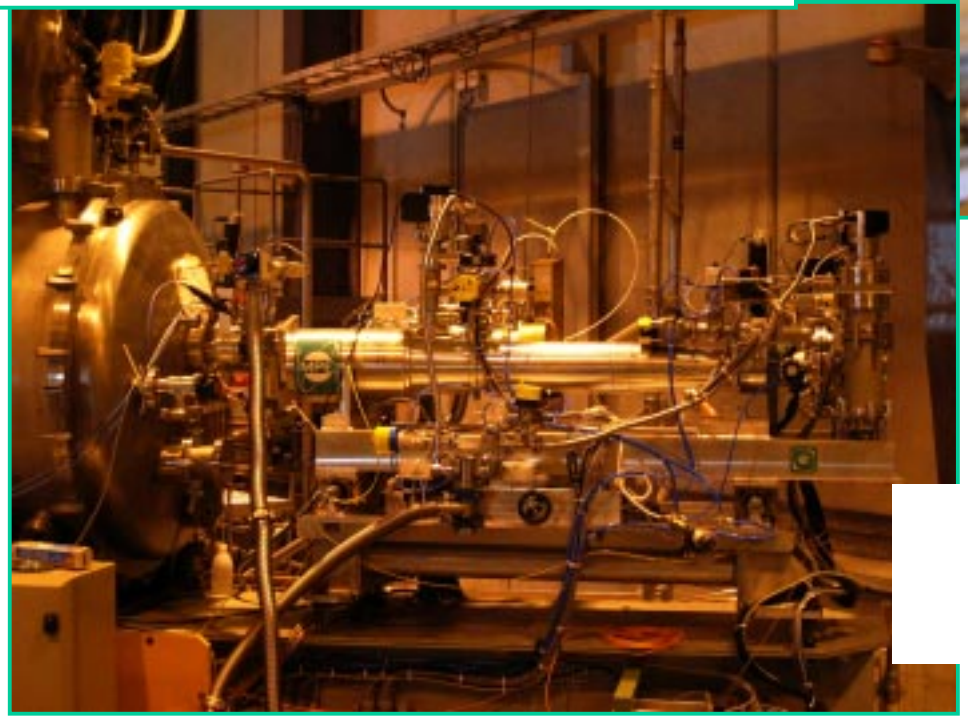


X-Ray telescope alignment

Space technology:

Spare part of the ABRIXAS Space mission

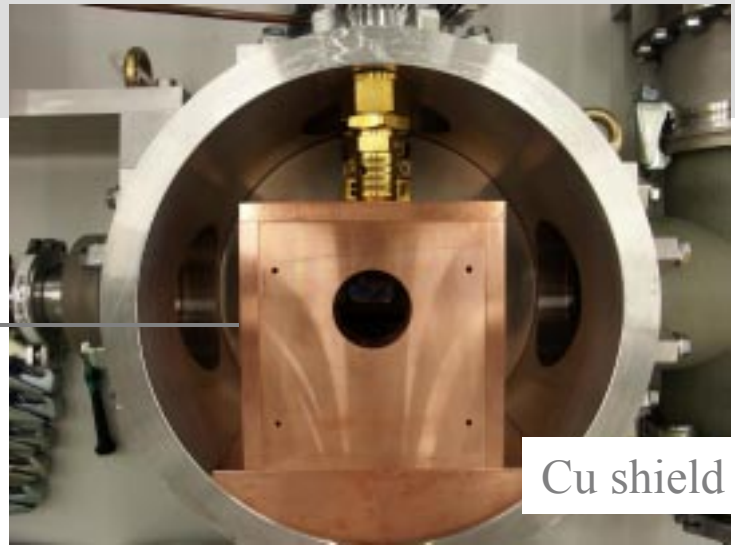




Telescope on the Magnet

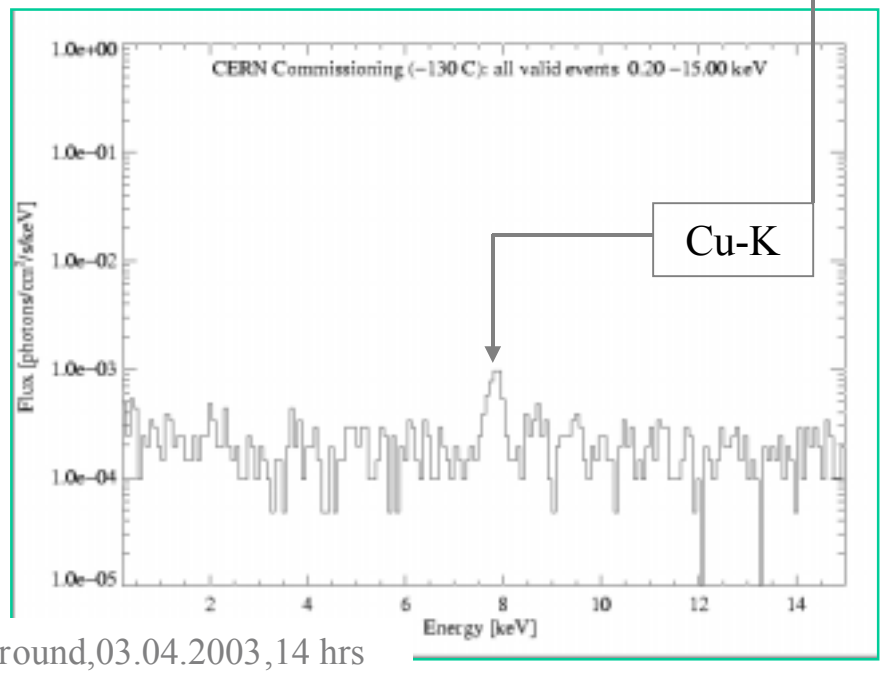
with the CCD in place

CCD



- Background:

$\sim 10^{-4}$ events keV^{-1} s^{-1}cm^{-2}



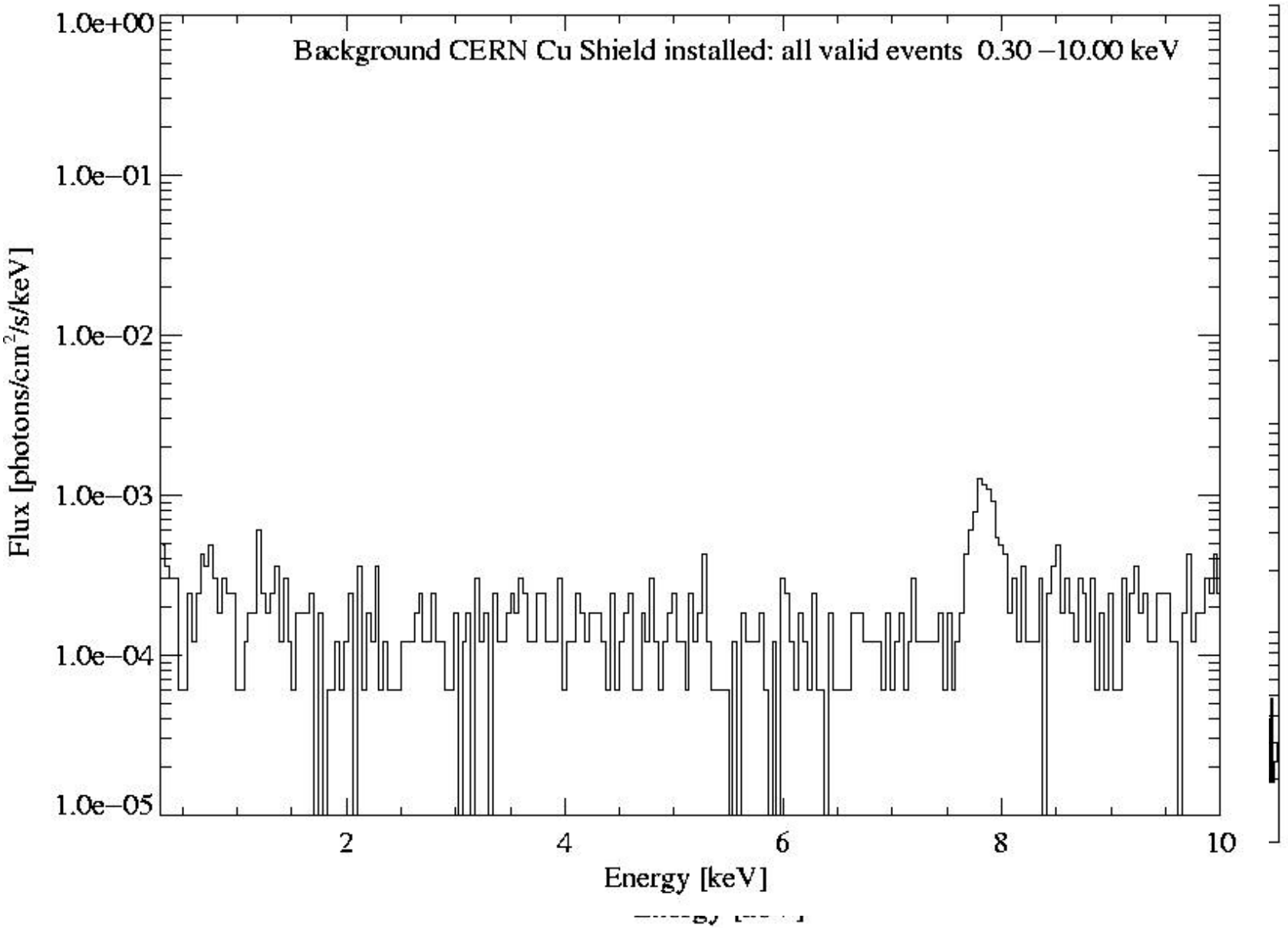
Background,03.04.2003,14 hrs

- Efficiency close to 100% over the full energy range:

Windowless

Threshold = 0.2 keV
Prev. exp. > 3 keV

CCD Background



Vacuum Conditions at CAST

LHC / AT-VAC group

- Requirements for the mirror contamination
- Residual gas analysis by J.P.Bojon

Contamination of the Mirror

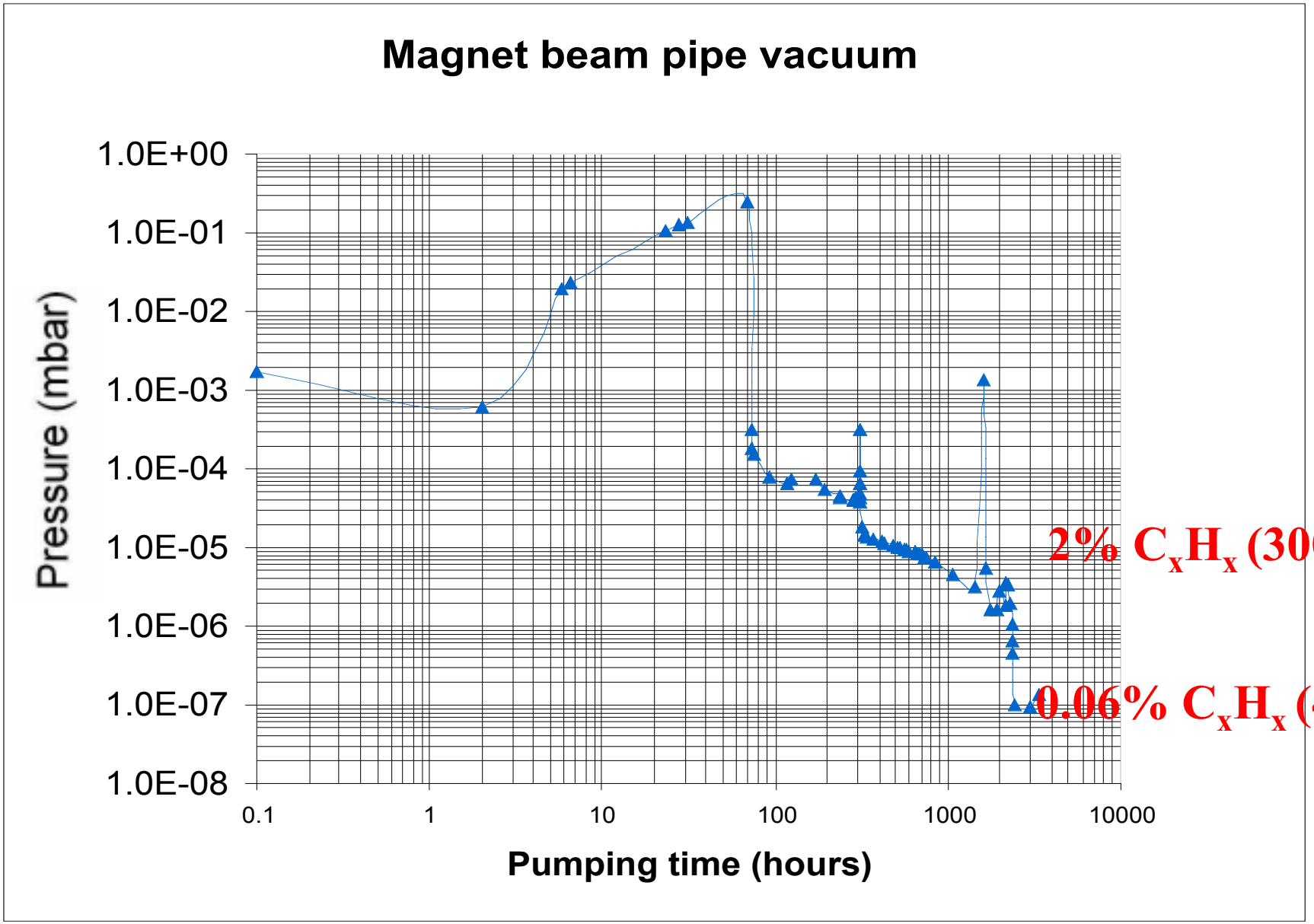
10^{-7} g/cm^2 ~2.5 . 10^{-9} moles/cm2

~ 1.5 10^{15} molecules/cm^2

~1 monolayer (ML)

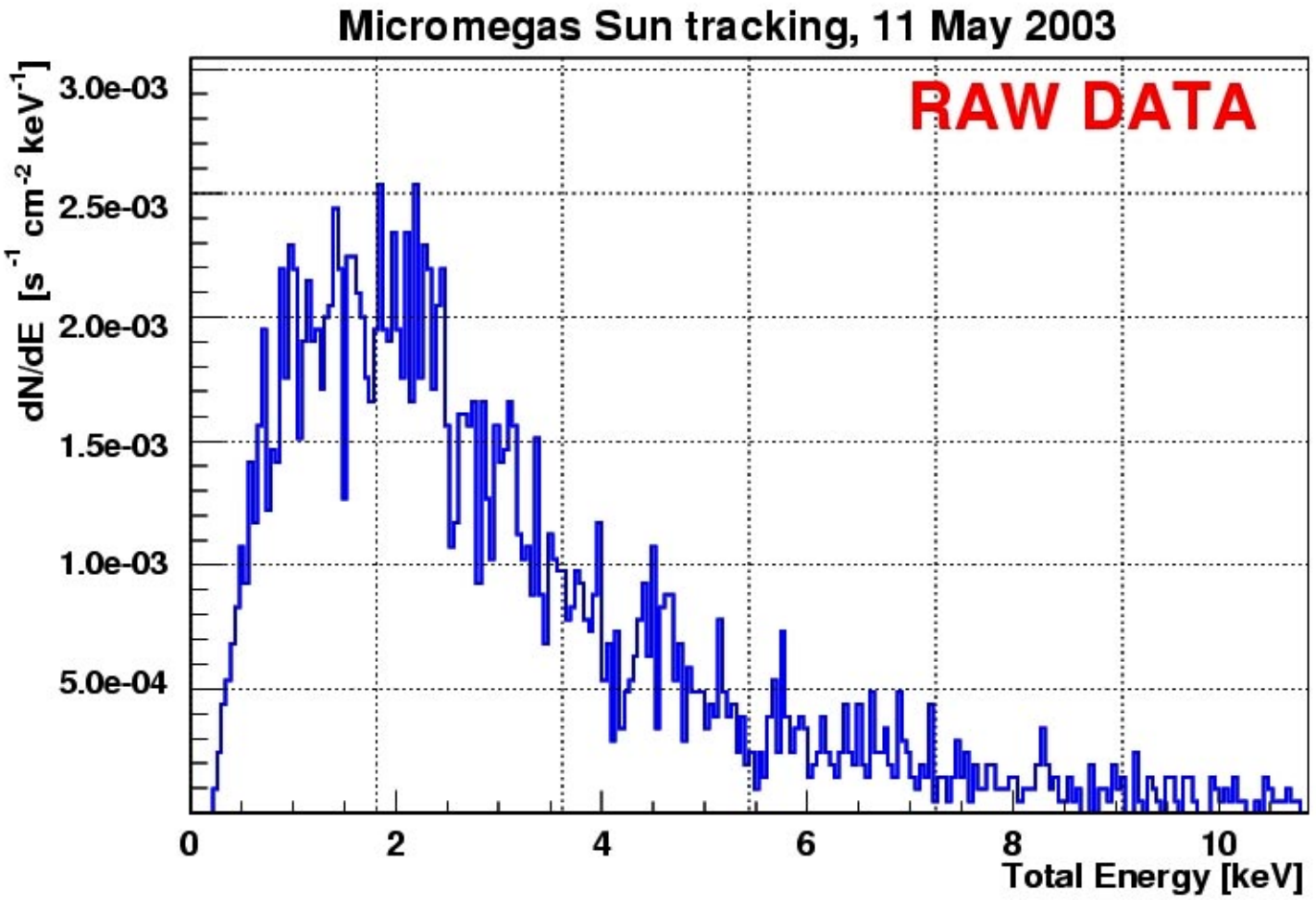
→ We are approximately speaking of 1 ML of heavy molecules

We want a coverage less than 1 monolayer to be attained during 3 years vacuum operation

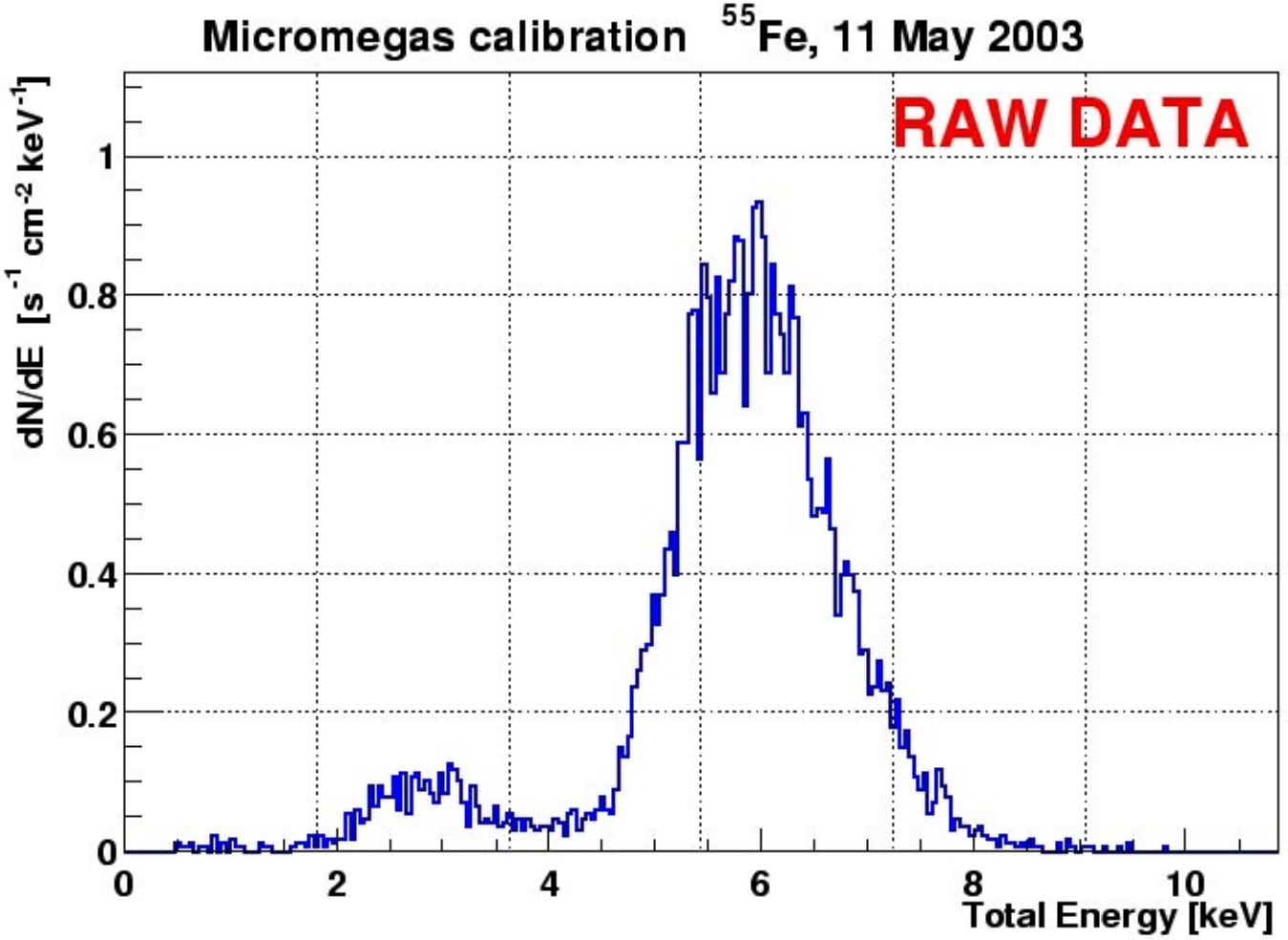

Magnet beam pipe vacuum
Pressure (mbar)
1.0E+00
1.0E-01
1.0E-02
1.0E-03
1.0E-04
1.0E-05
1.0E-06
1.0E-07
1.0E-08
0.1
1
10
100
1000
10000
Pumping time (hours)
2% C_xH_x (300 K)
0.06% C_xH_x (4 K)

...last minute .....

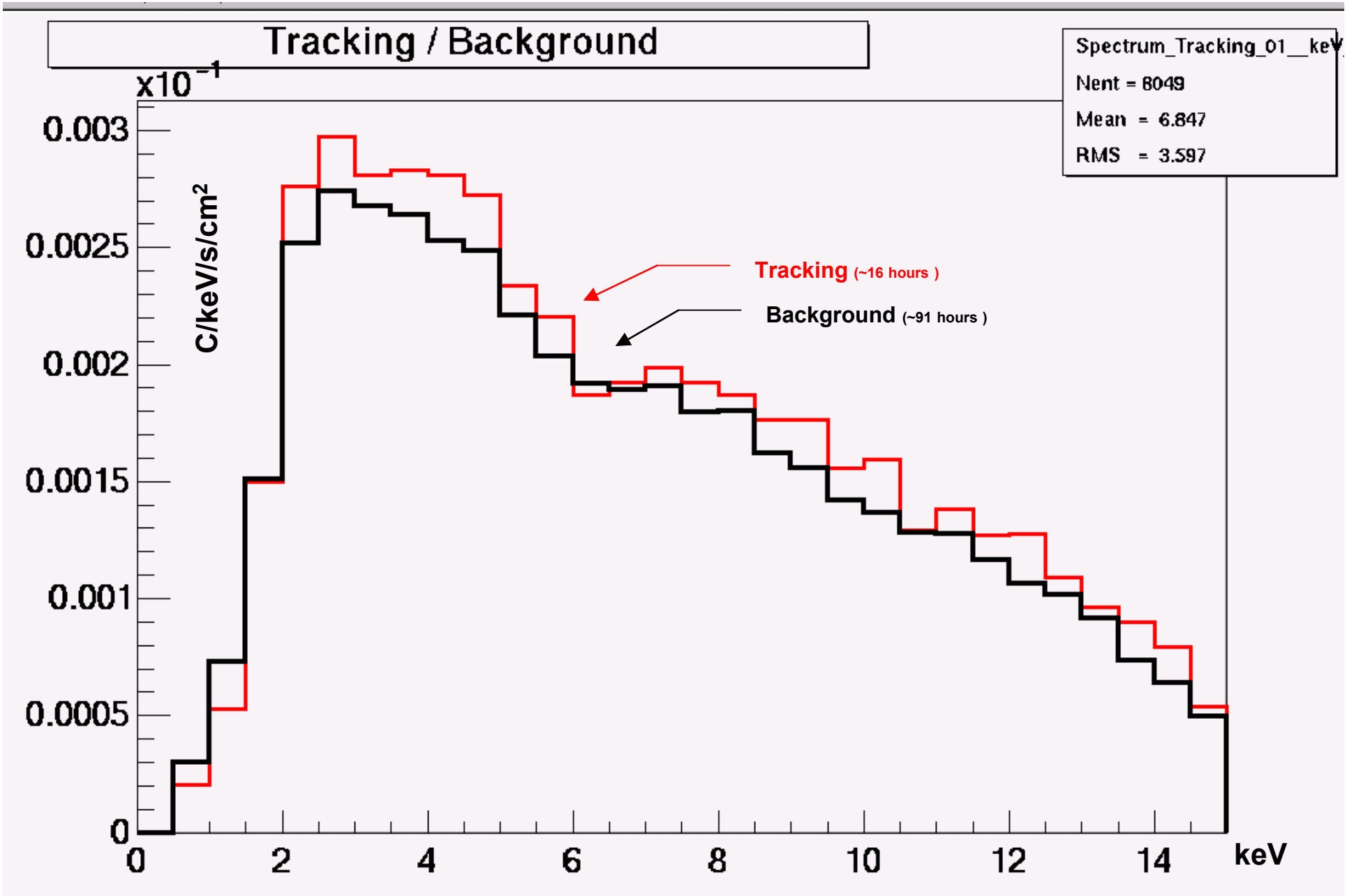
Micromegas


Micromegas Sun tracking, 11 May 2003
RAW DATA
dN/dE [s^{-1} cm^{-2} keV^{-1}]
3.0e-03
2.5e-03
2.0e-03
1.5e-03
1.0e-03
5.0e-04
0
2
4
6
8
10
Total Energy [keV]

Micromegas


Micromegas calibration ^{55}Fe, 11 May 2003
RAW DATA
dN/dE [s^{-1} cm^{-2} keV^{-1}]
0
0.2
0.4
0.6
0.8
1
0
2
4
6
8
10
Total Energy [keV]

TPC


Tracking / Background
Spectrum_Tracking_01__keV
Nent = 8049
Mean = 6.847
RMS = 3.597
x10^-1
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
C/keV/s/cm²
Tracking (~16 hours)
Background (~91 hours)
0
2
4
6
8
10
12
14
keV

Conclusions

CAST : Status

Magnet ✓
Cryogenics ✓
Power Supply ✓
Sun tracking ✓

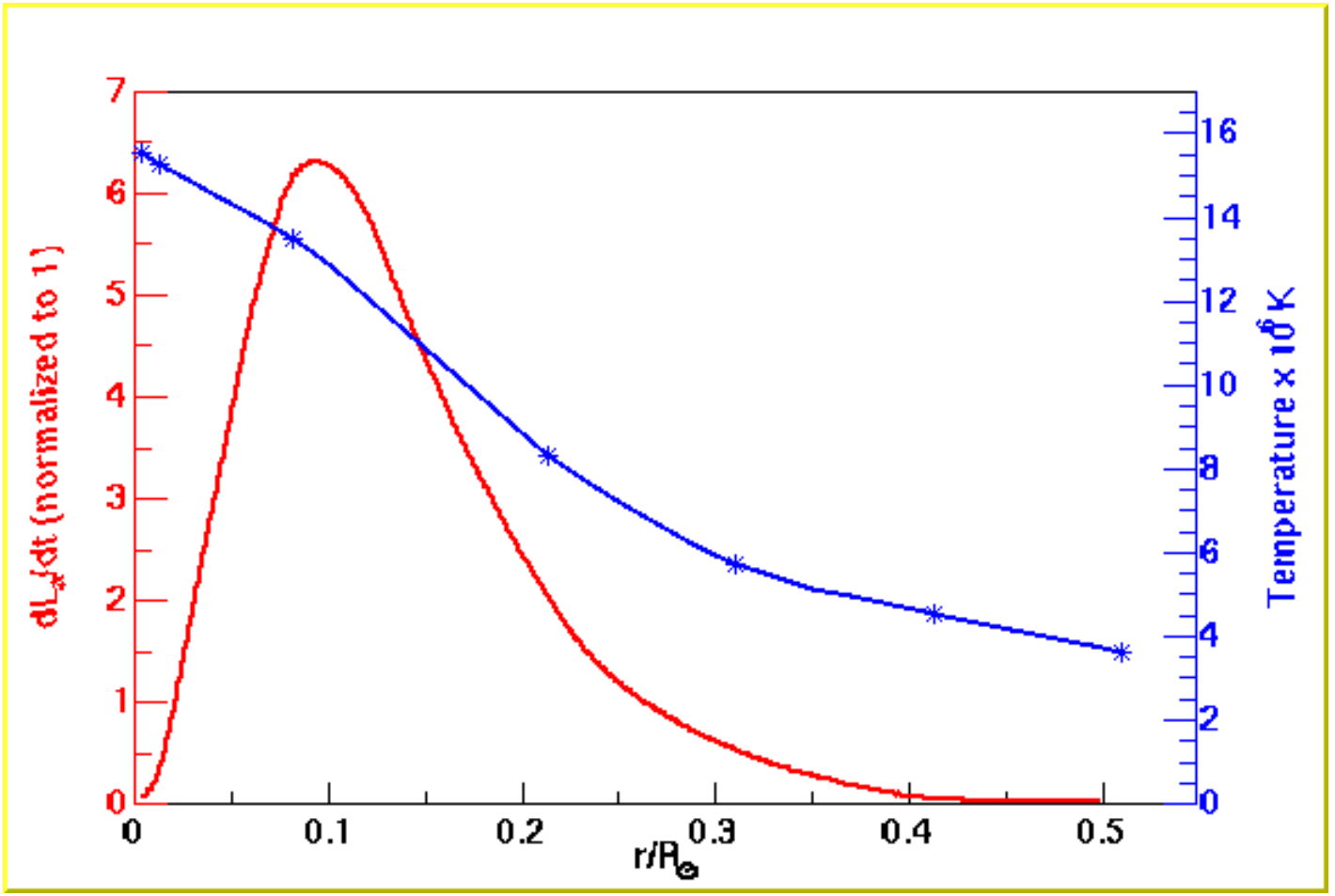
Detectors:

TPC ✓
Micromegas ✓
CCD (✓)

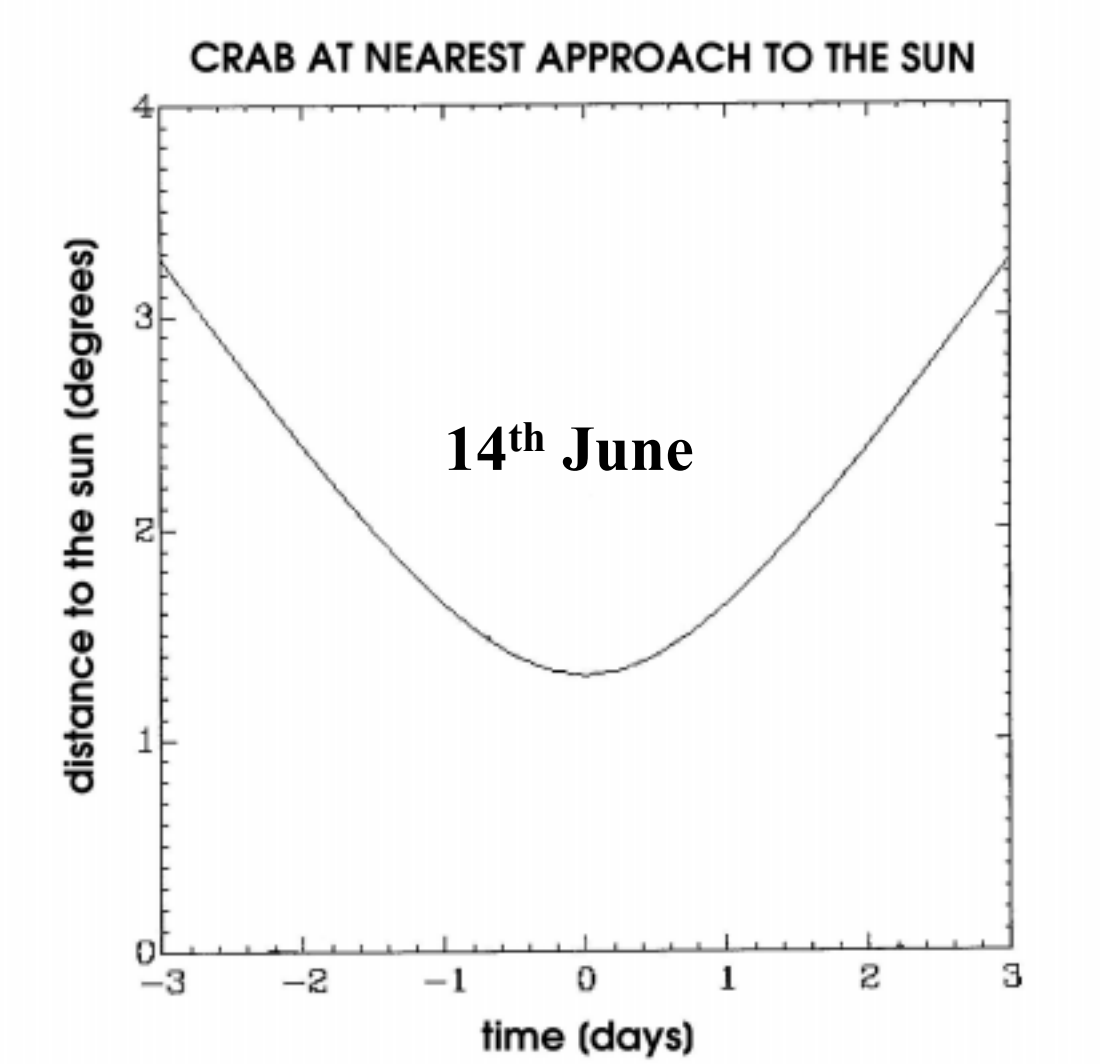
X-ray telescope ✓

May 1st 2003 → data taking

Improvements



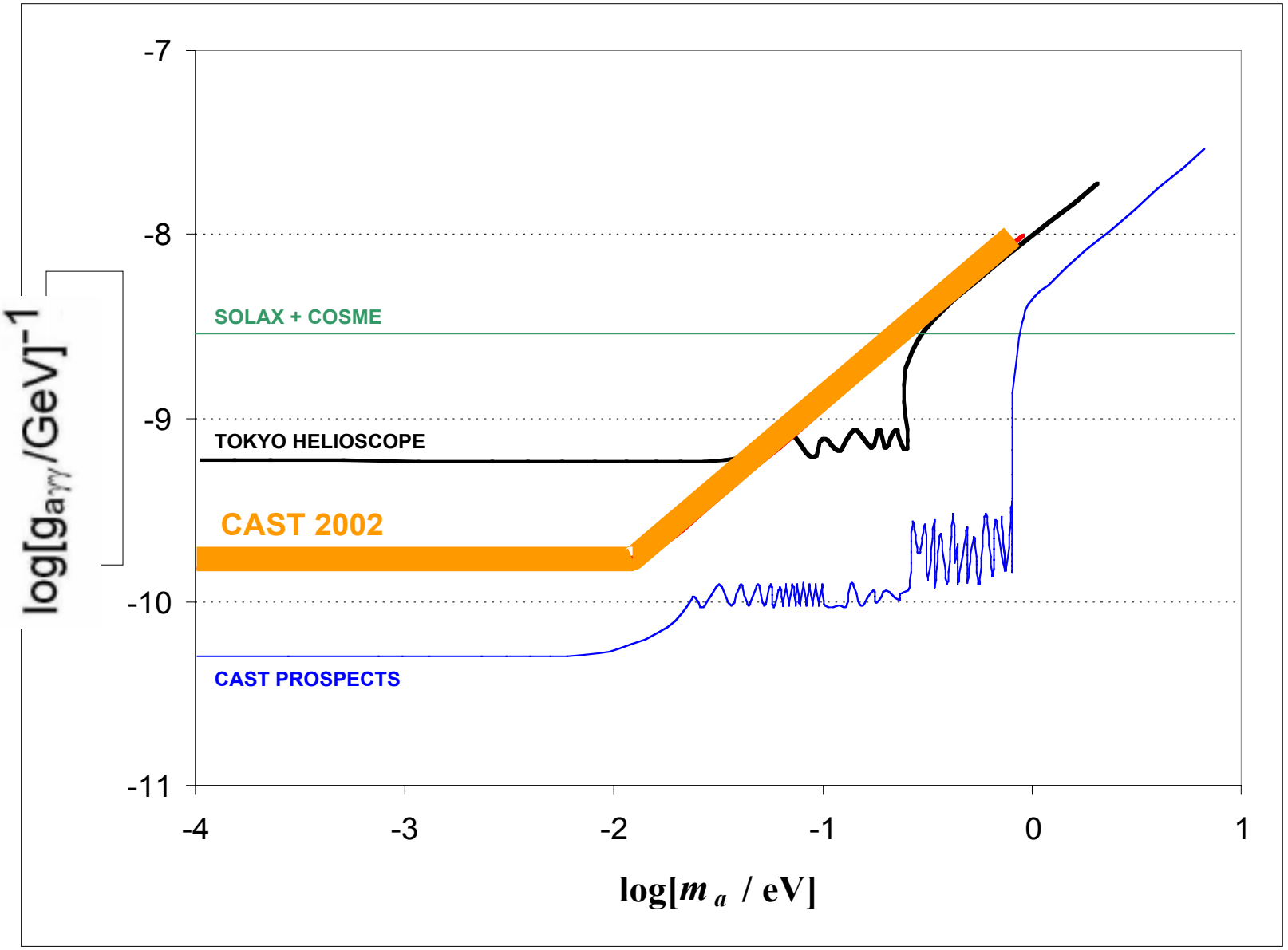
Other (non)solar physics



H.E. Axions

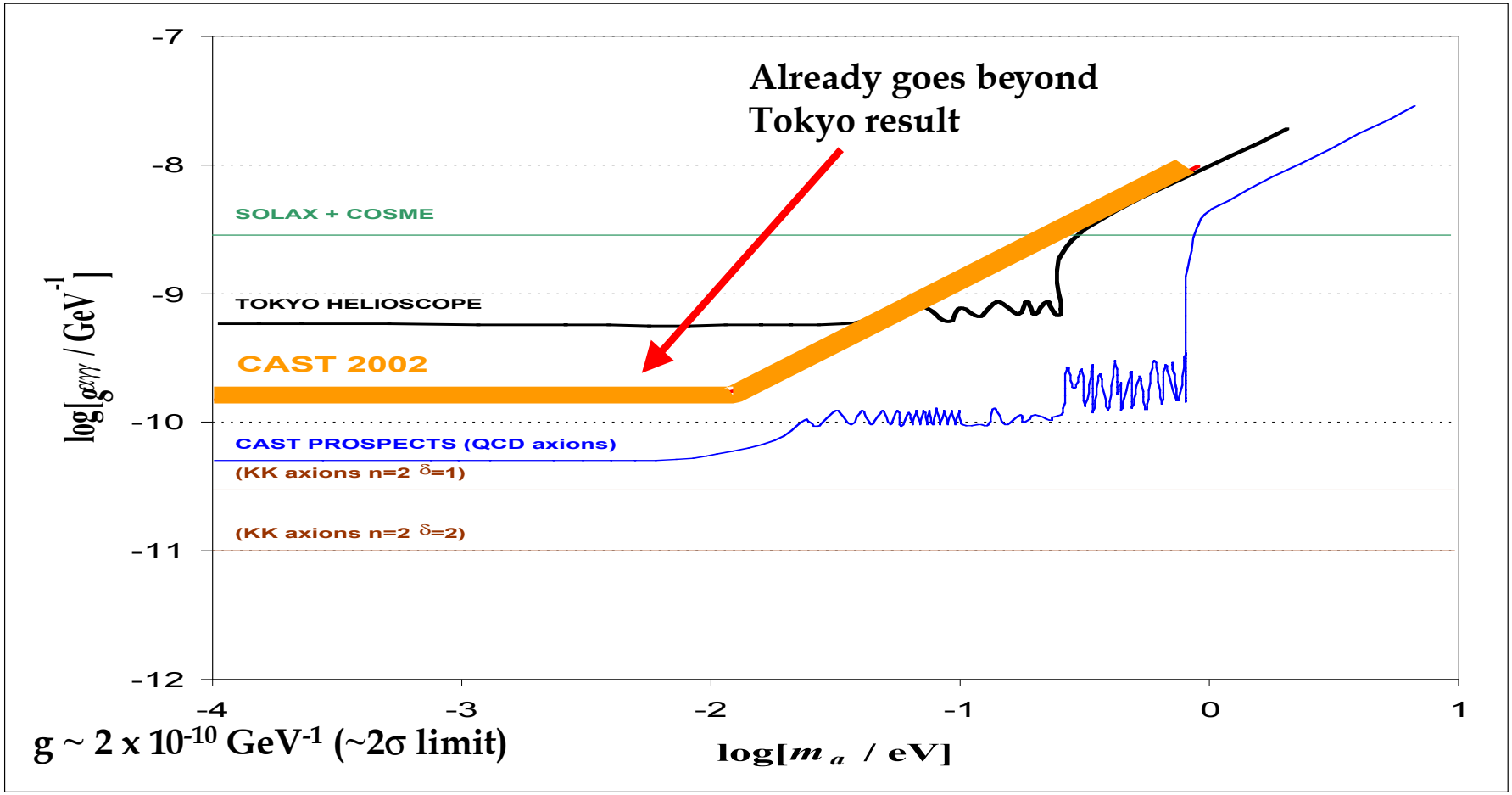
Kaluza-Klein Axions
@2nd phase of CAST

CAST Sensitivity



End

Preliminary Axion Exclusion Plot



Preliminary!

- Integral rate used only (more statistical refinements using spectral information could give better result)
- Conservative cuts

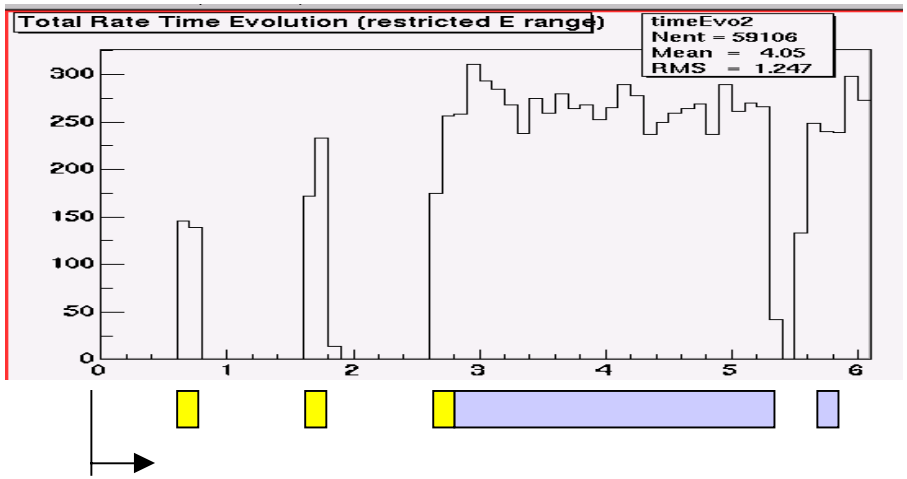
- No efficiency correction (small change)

Background data

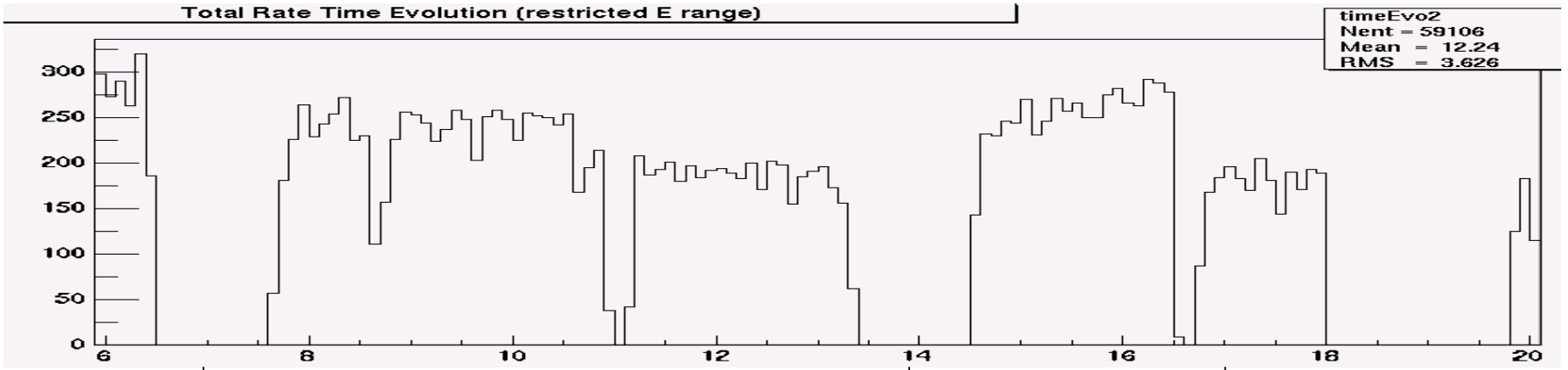
Evolution of background with time during October-November

- Events after cuts
- Rate in fixed ADC range (roughly 3-7 keV) far from threshold and saturation limits

→ Physical background (no noise)



8 OCT

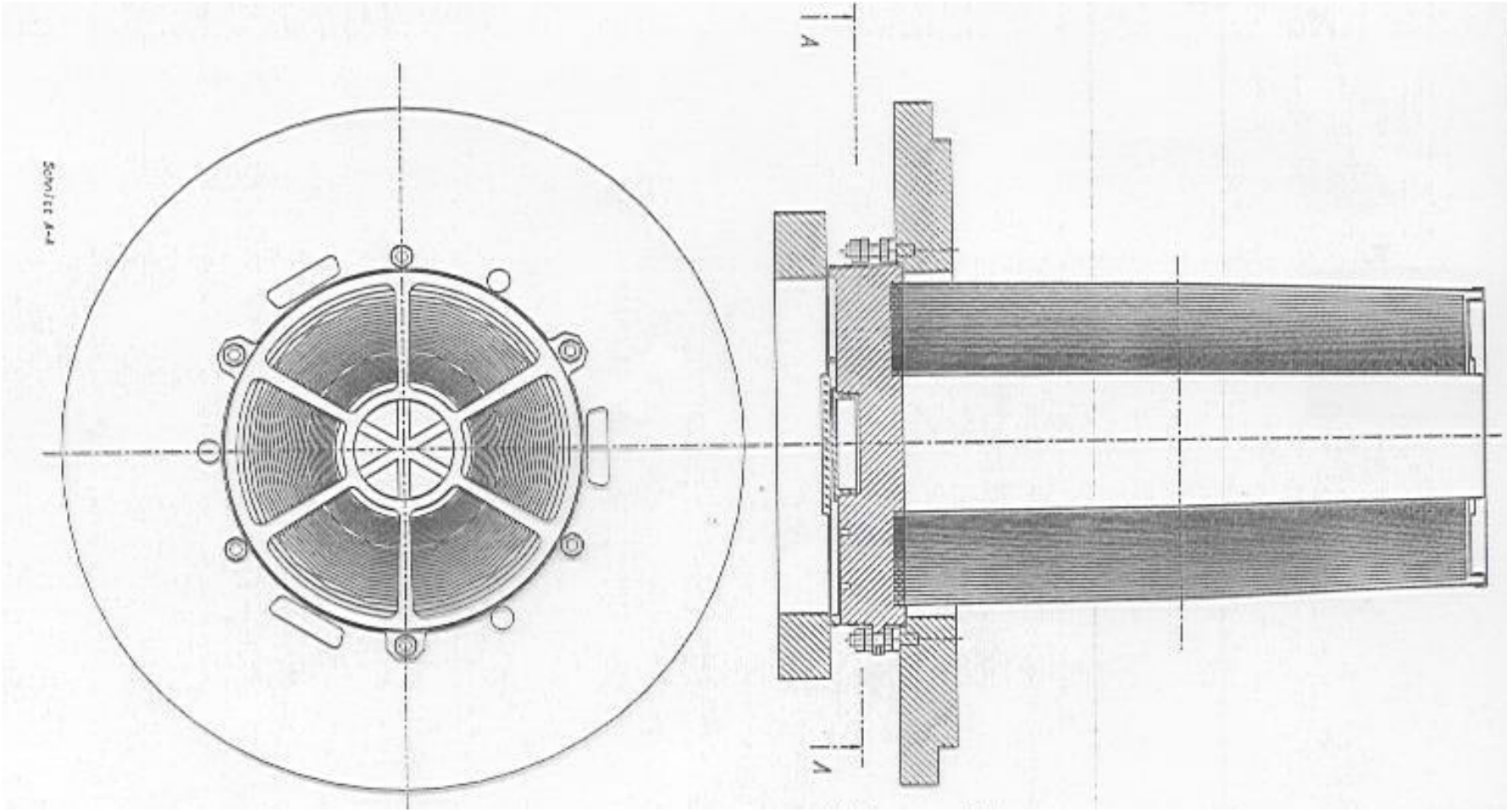


15 OCT

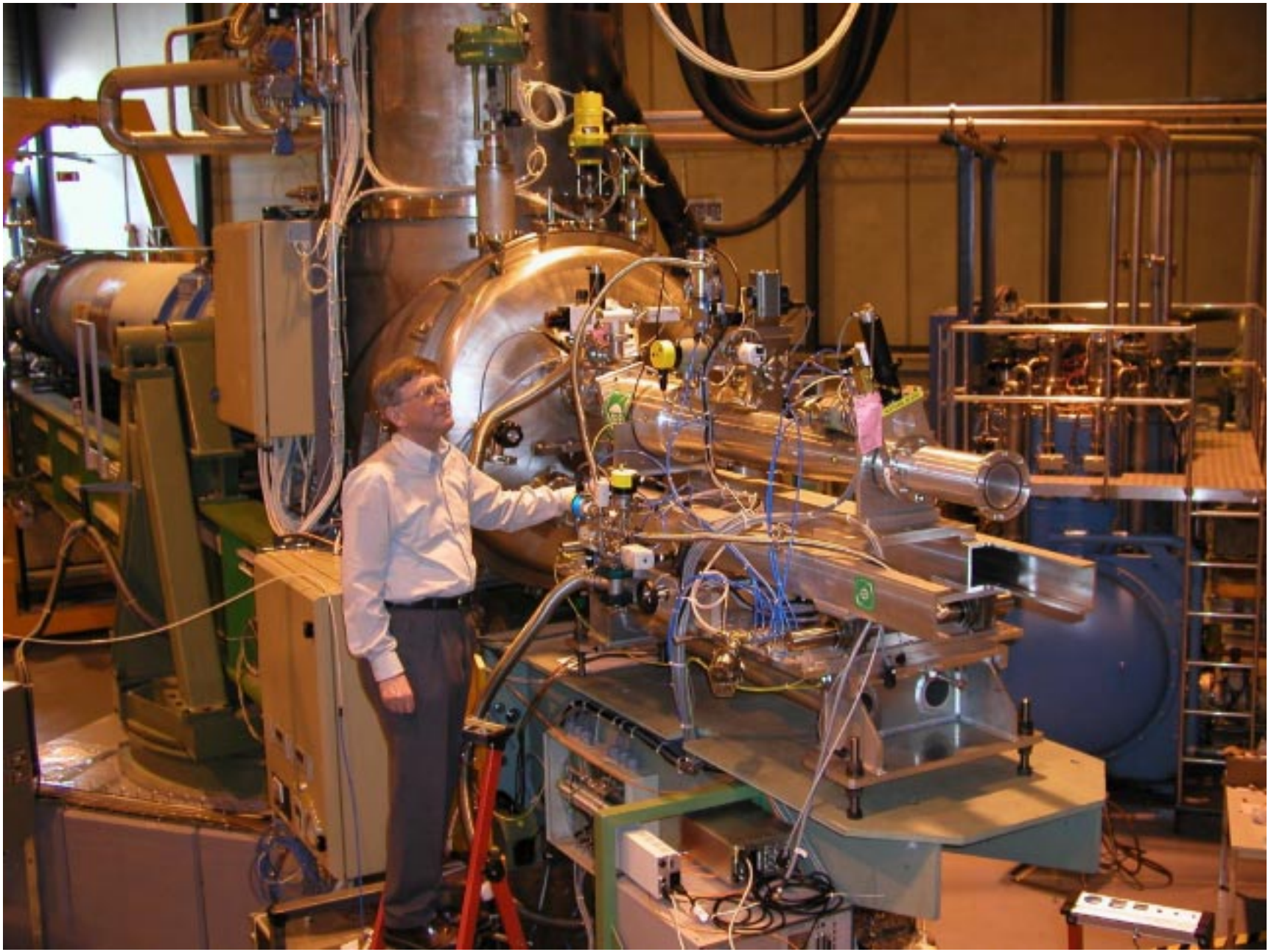
22 OCT

25 OCT

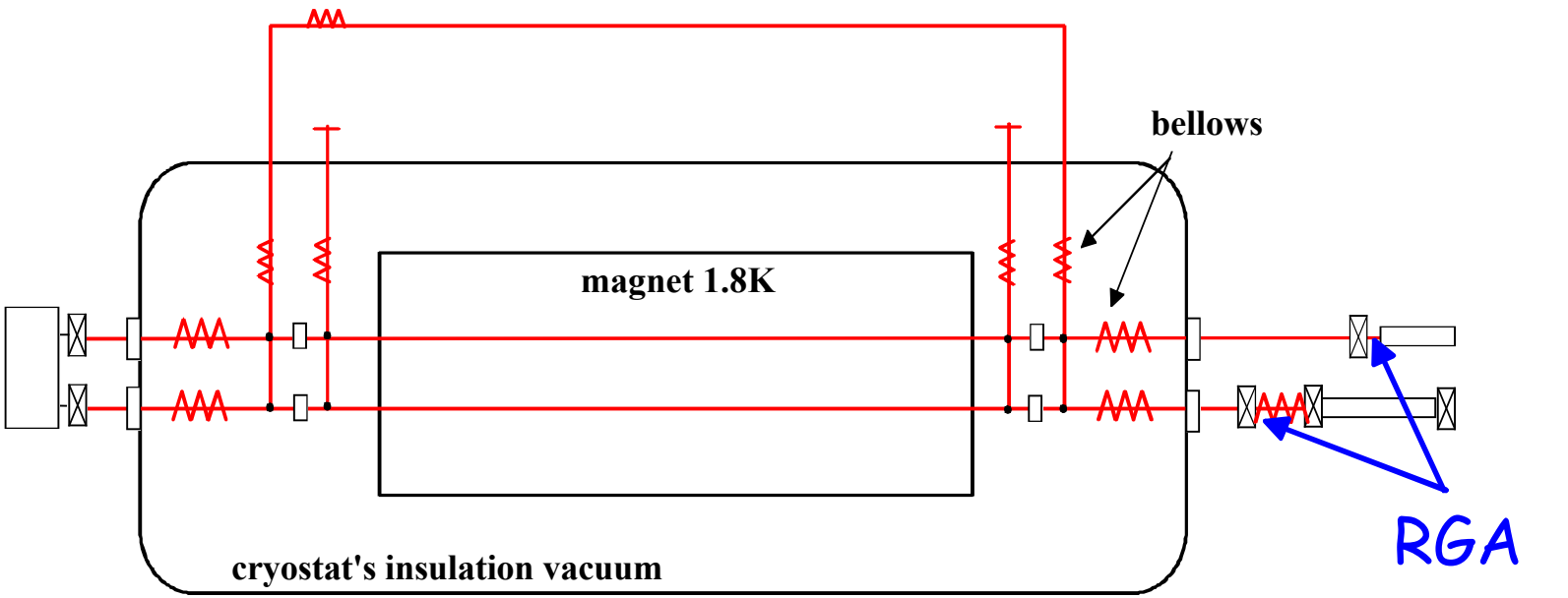
X-ray focusing device (MPI)



- ✓Technology for space X-ray telescopes
- ✓Recycled for CAST



CAST Vacuum scheme



Procedure

A baseline BLANK spectrum is obtained with valve closed before any analysis

Valve is opened and a spectrum taken