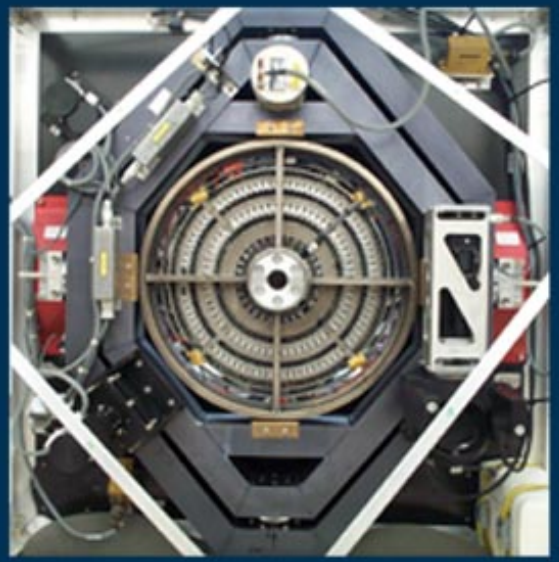
CLAIRE



CLAIRE : first light for a crystal diffraction lens

Peter von Ballmoos, Hubert Halloin, Jean Evrard, Gerry Skinner,
Nicolai Abrosimov, Jose Alvarez, Pierre Bastie, Margarida Hernanz,
Pierre Jean, Jürgen Knödlseder, Bob Smither, Gilbert Vedrenne … and friends

CESR, CNES, I KZ, IEEC, LSP/ILL, ANL

Lens

Calibration

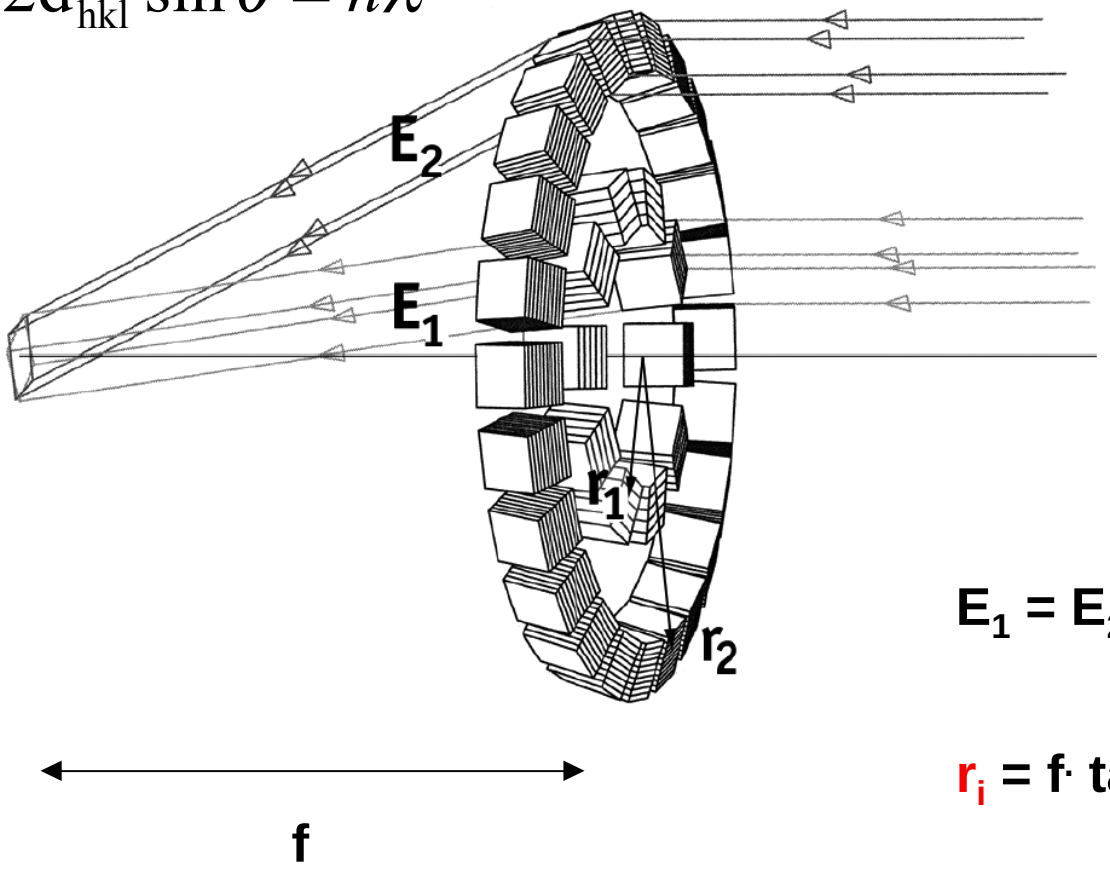
Crystals

Test at finite distances

Crab observation

CLAIRE : a *narrow bandpass* Laue lens

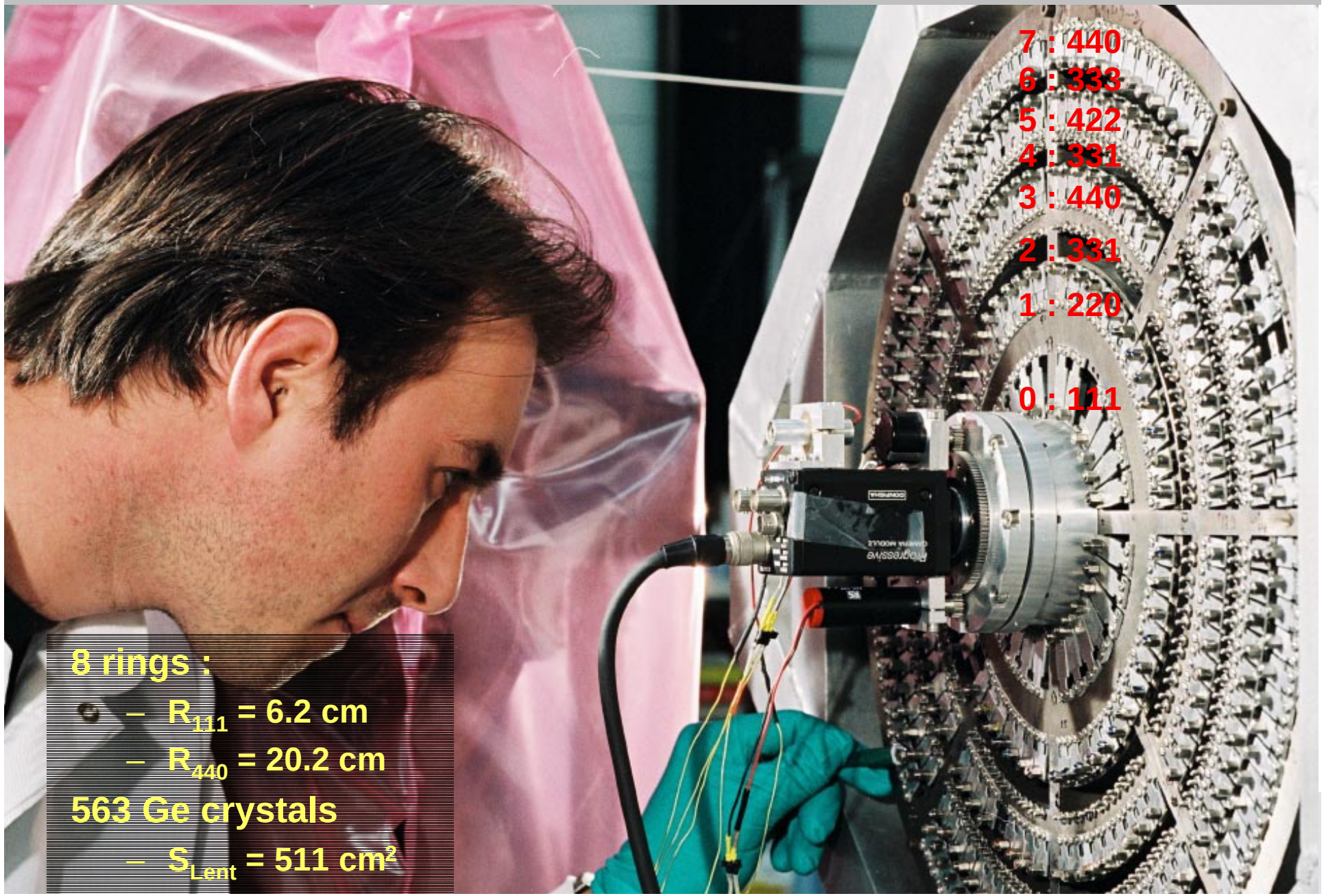
$$2d_{hkl} \sin\theta = n\lambda$$



$E_1 = E_2 = E = 170$ keV (∞)

$r_i = f \cdot \tan [\, 2 \arcsin (n\lambda / 2d_i)$

CLAIRE : the lens



8 rings :

- R_{111} = 6.2 cm
- R_{440} = 20.2 cm

563 Ge crystals

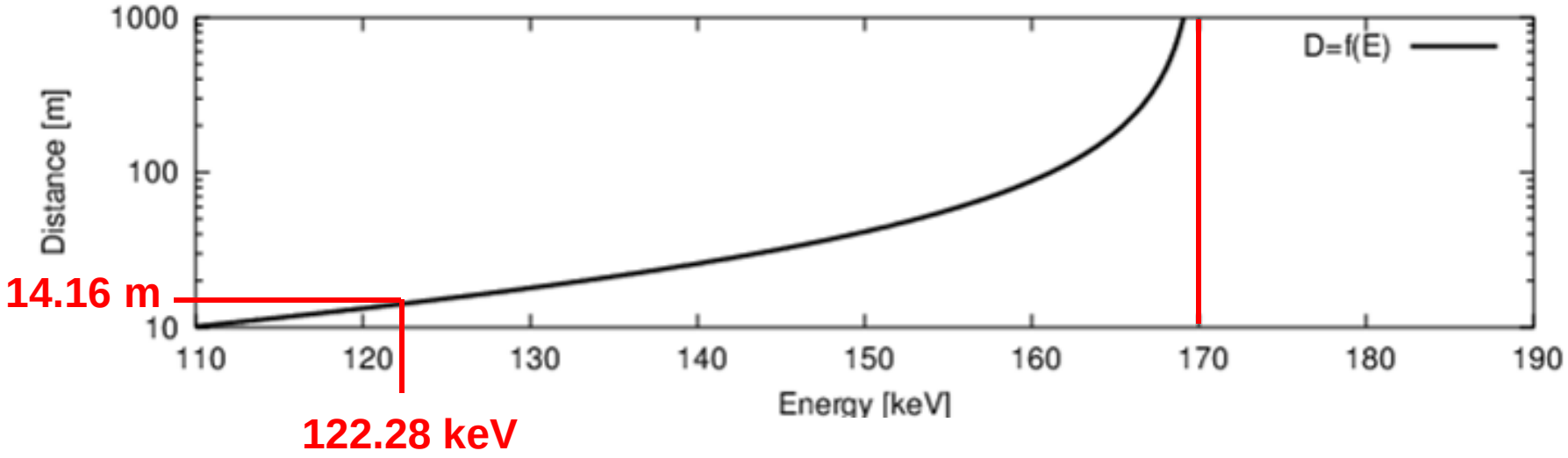
- S_{Lent} = 511 cm²

CLAIRE : tuning of crystals

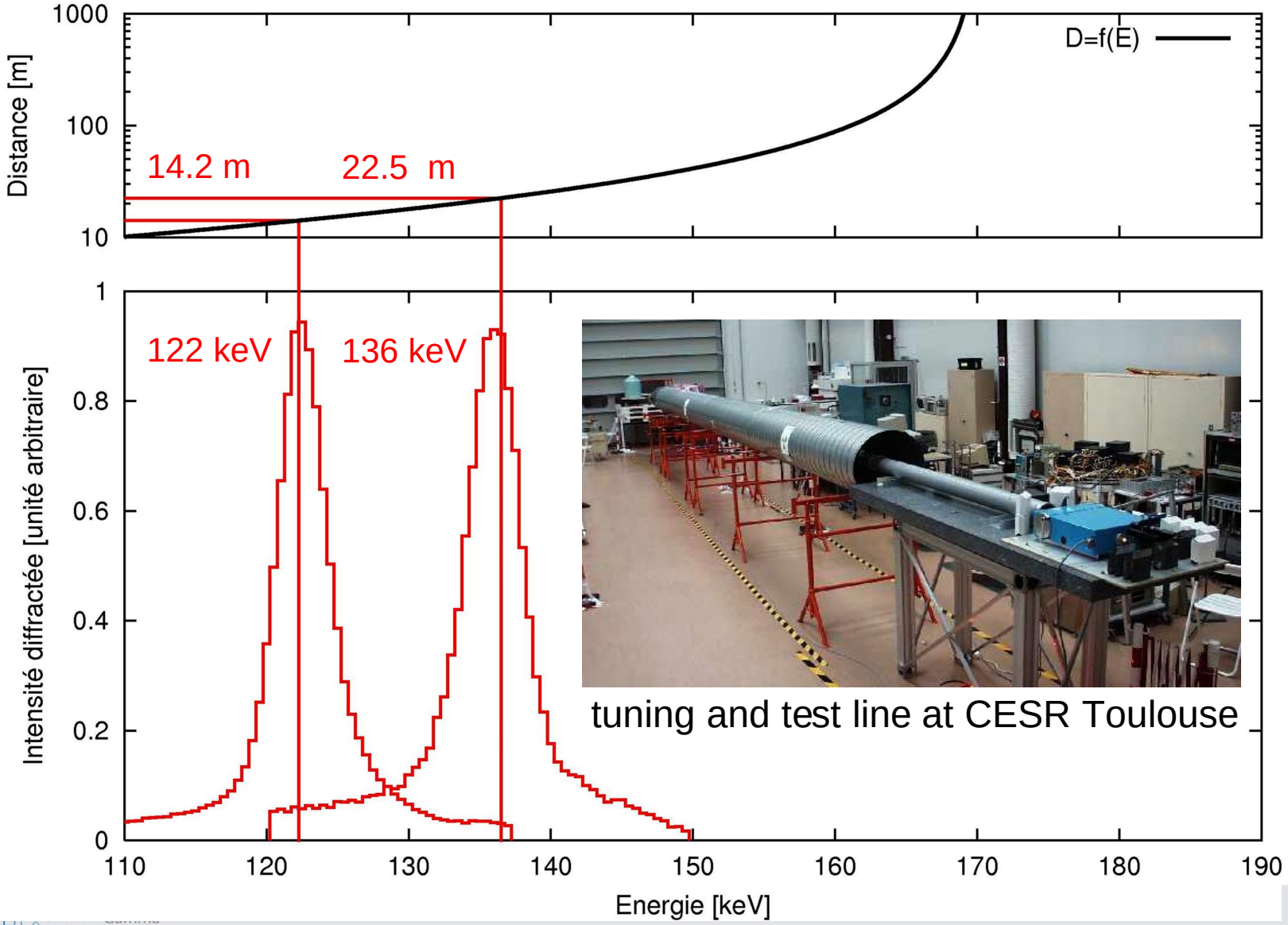
Relation between distance and diffracted energy

$$\frac{100\,\mathrm{keV}}{E} = \frac{100\,\mathrm{keV}}{E_{\infty}} + 0.3251\left(\frac{10\,\mathrm{m}}{D}\right)$$

with E_{∞} = 170 keV

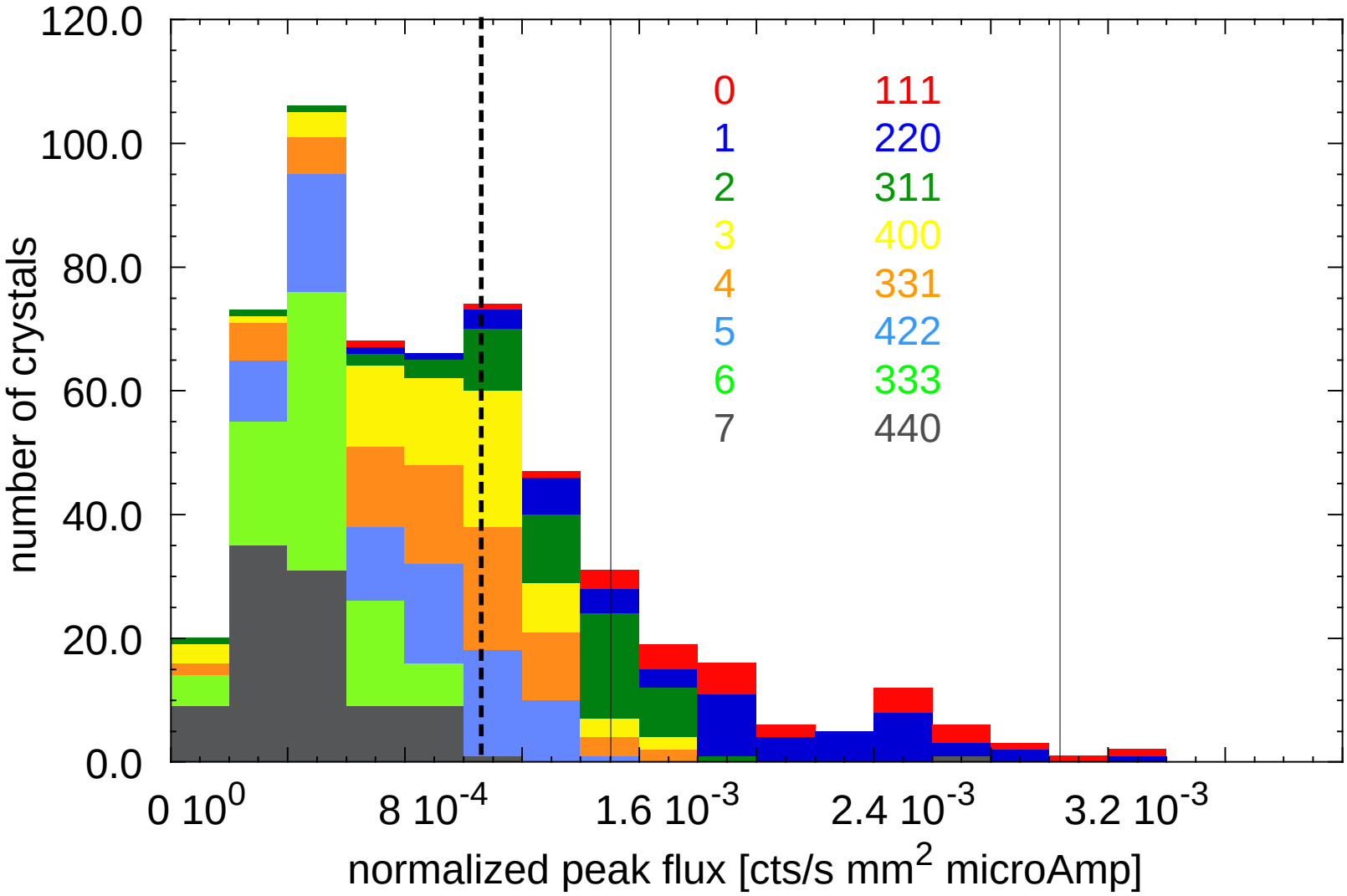


CLAIRE : testing the lens in the lab ... and beyond



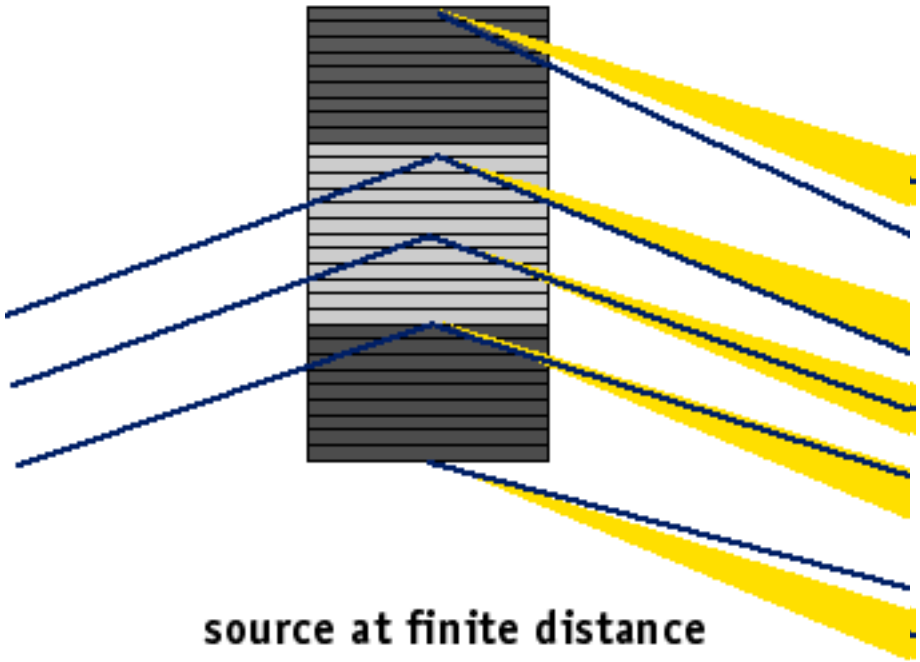
tuning and test line at CESR Toulouse

CLAIRE : diffracted flux of 516 crystals



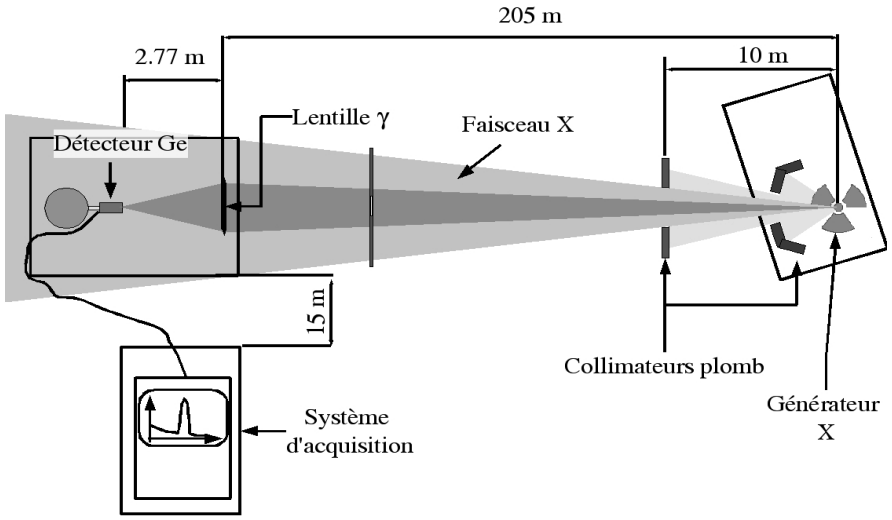
CLAIRE : mesuring the lens efficiency

with radioactive source (^{57}Co) at 14 m
mesured efficiency ε_{14m} ~ 3.2 %

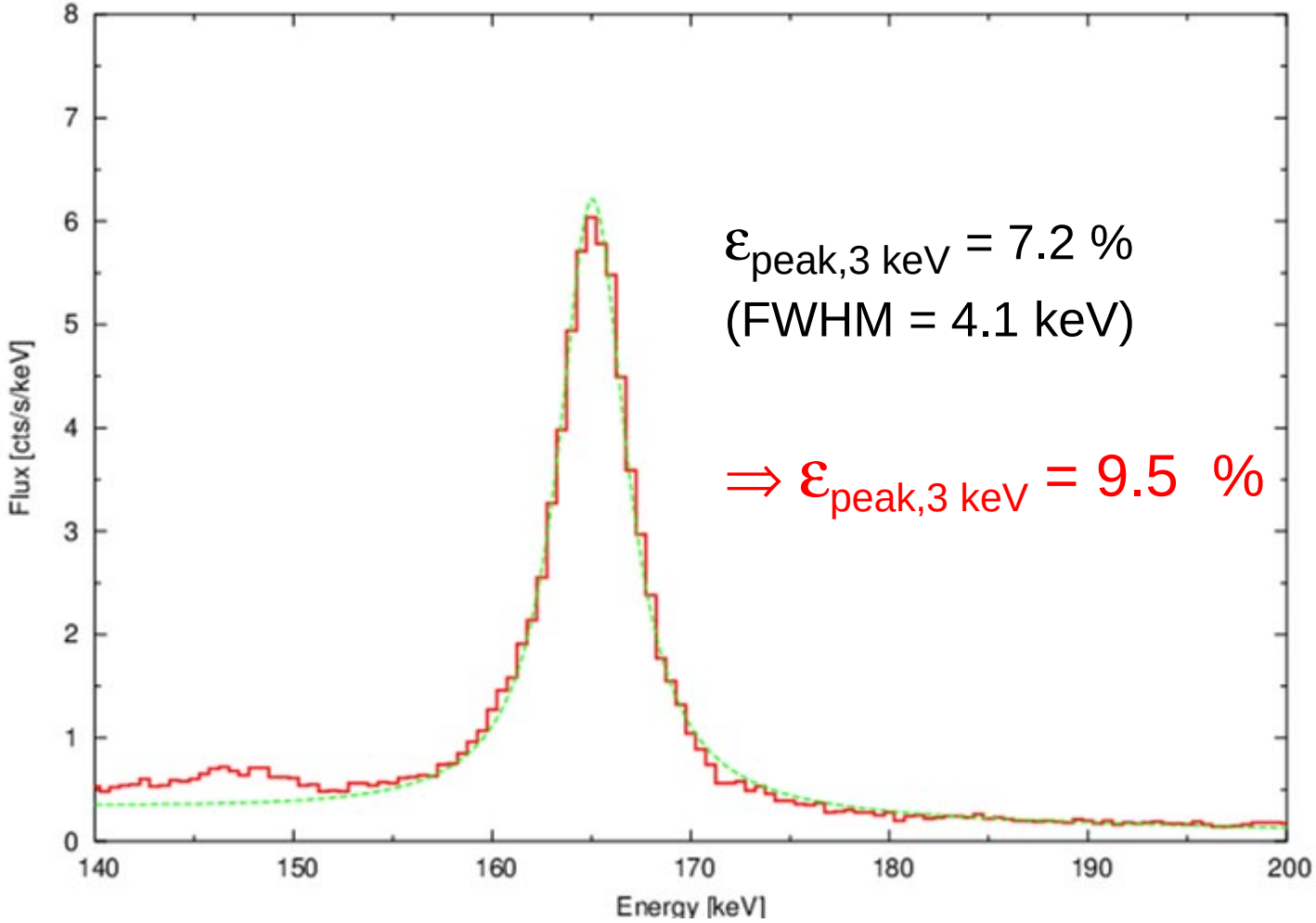


Extrapolation :
170 keV, continuum
$\Rightarrow \varepsilon_{peak} = 12^{\pm 1}$ % (3 keV FWHM)

CLAIRE TGD : a source close to "infinity" ...



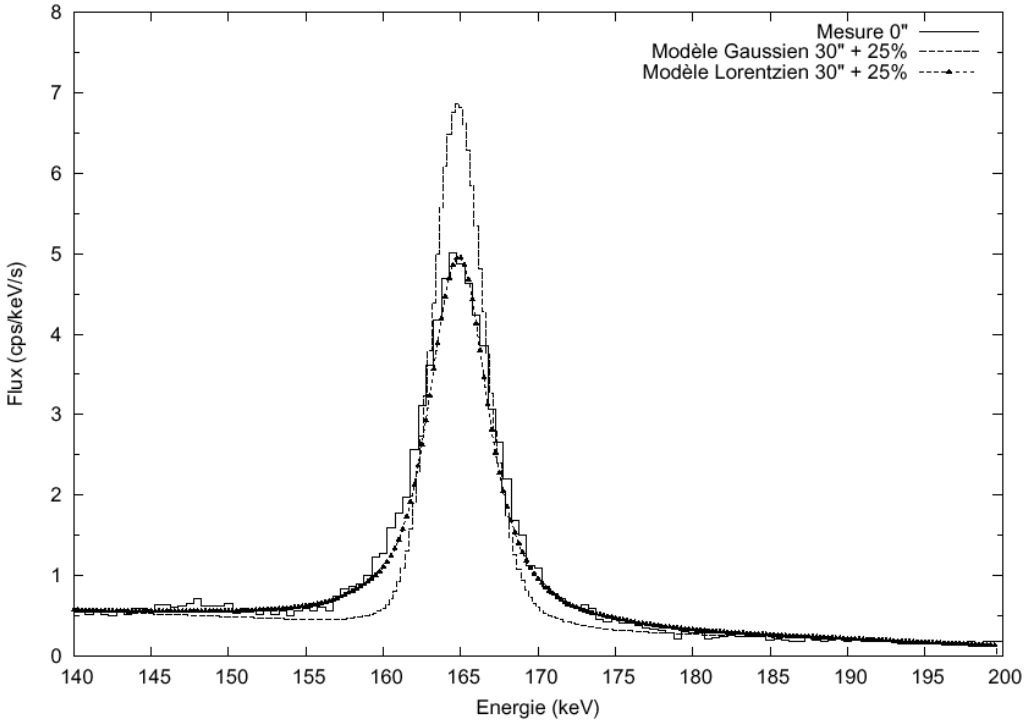
CLAIRE TGD - diffraction efficiency

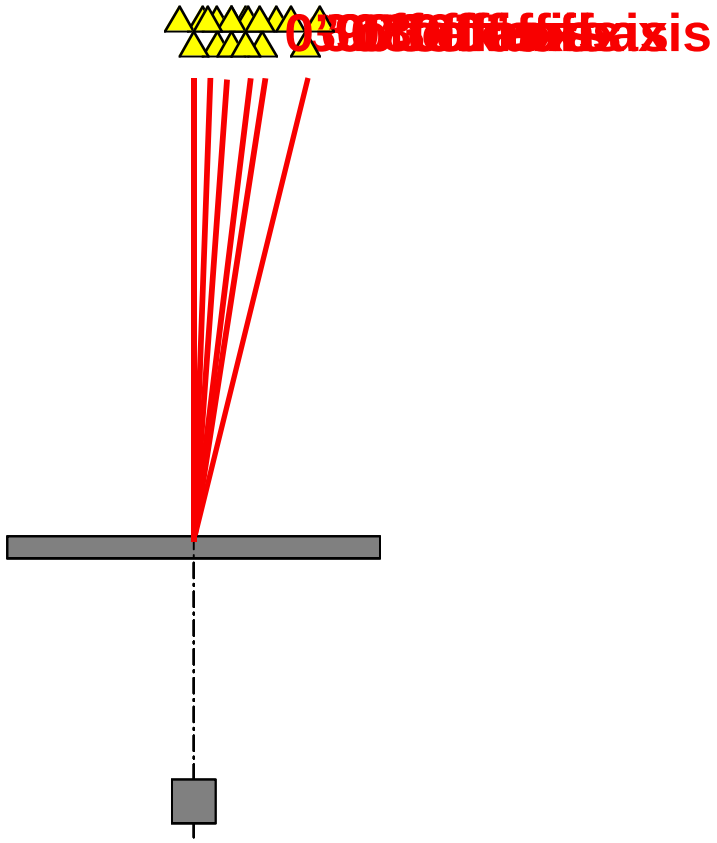


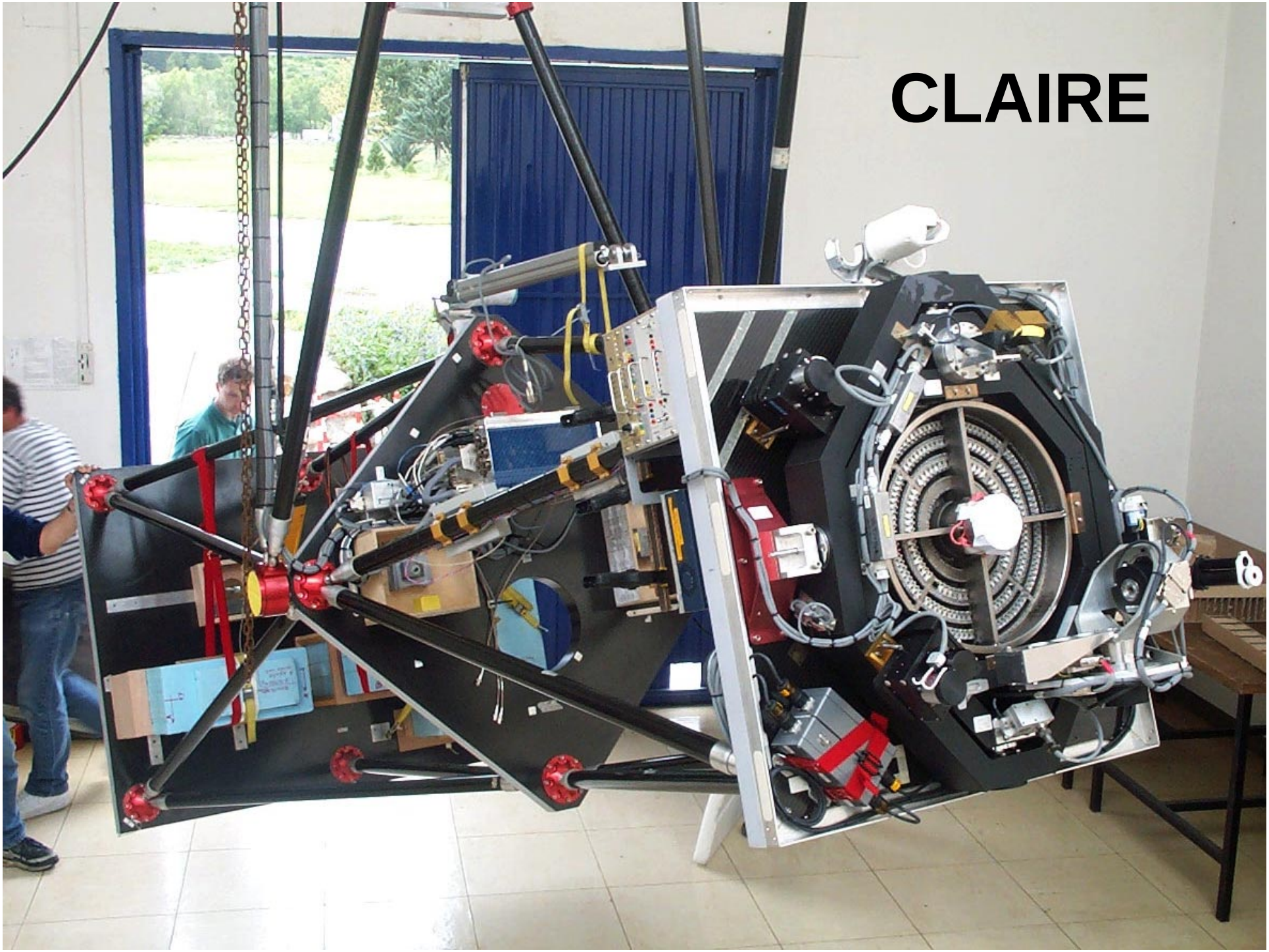
$\varepsilon_{peak,3\ keV}$ = 7.2 %
(FWHM = 4.1 keV)

$\Rightarrow \varepsilon_{peak,3\ keV}$ = 9.5 %

CLAIRE TGD - off axis response





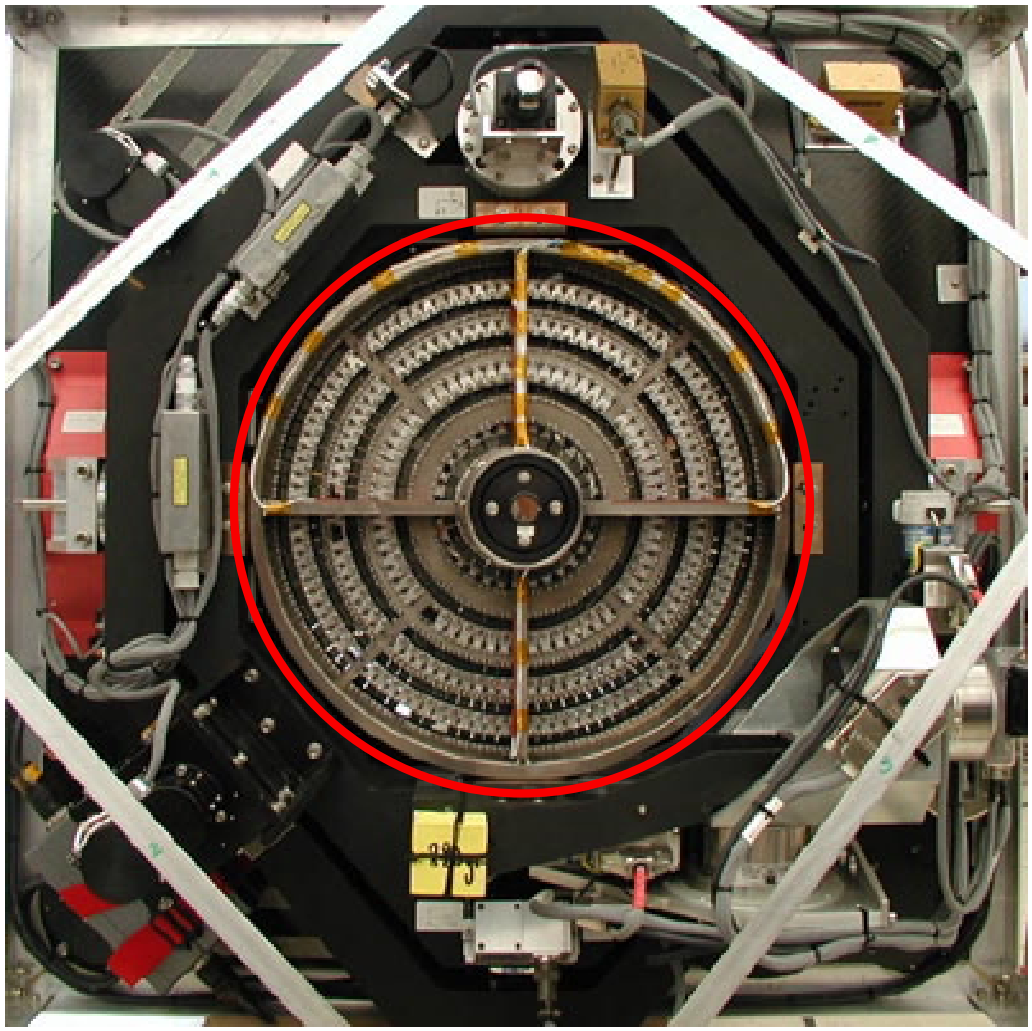

CLAIRE

CLAIRE : proving the the lens on an astrophysical target

but why the Crab nebula ?

- well known source … with a continuum spectrum
- close to the "guide-star" on june 14/15 (~1°)

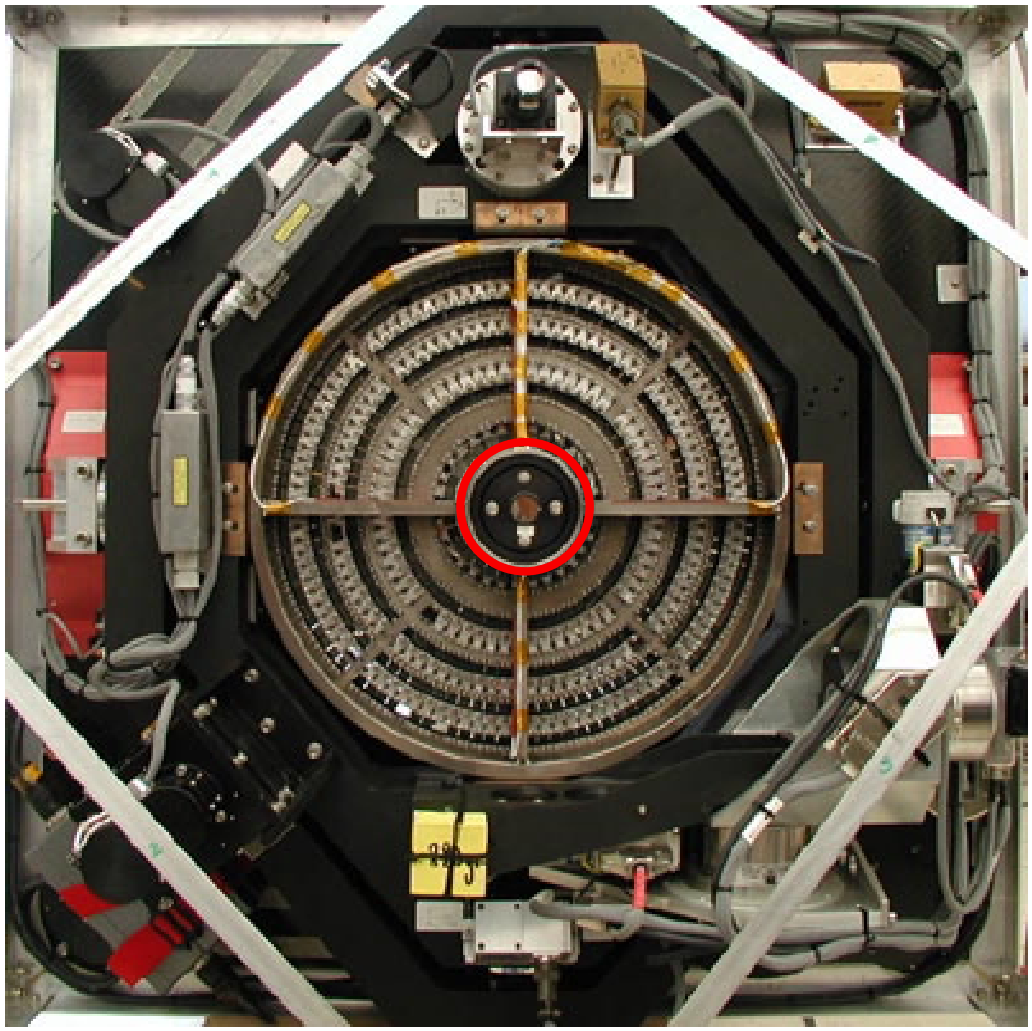
CLAIRE 2001 : Laue lens



lens

- 576 Ge-Si crystals
- A_{geo} = 511 cm^2
- E_{diff} = 170 keV, $\Delta E \approx 3$ keV
- FOV ≈ 45 arcsec

CLAIRE 2001 : Laue lens, optical axis



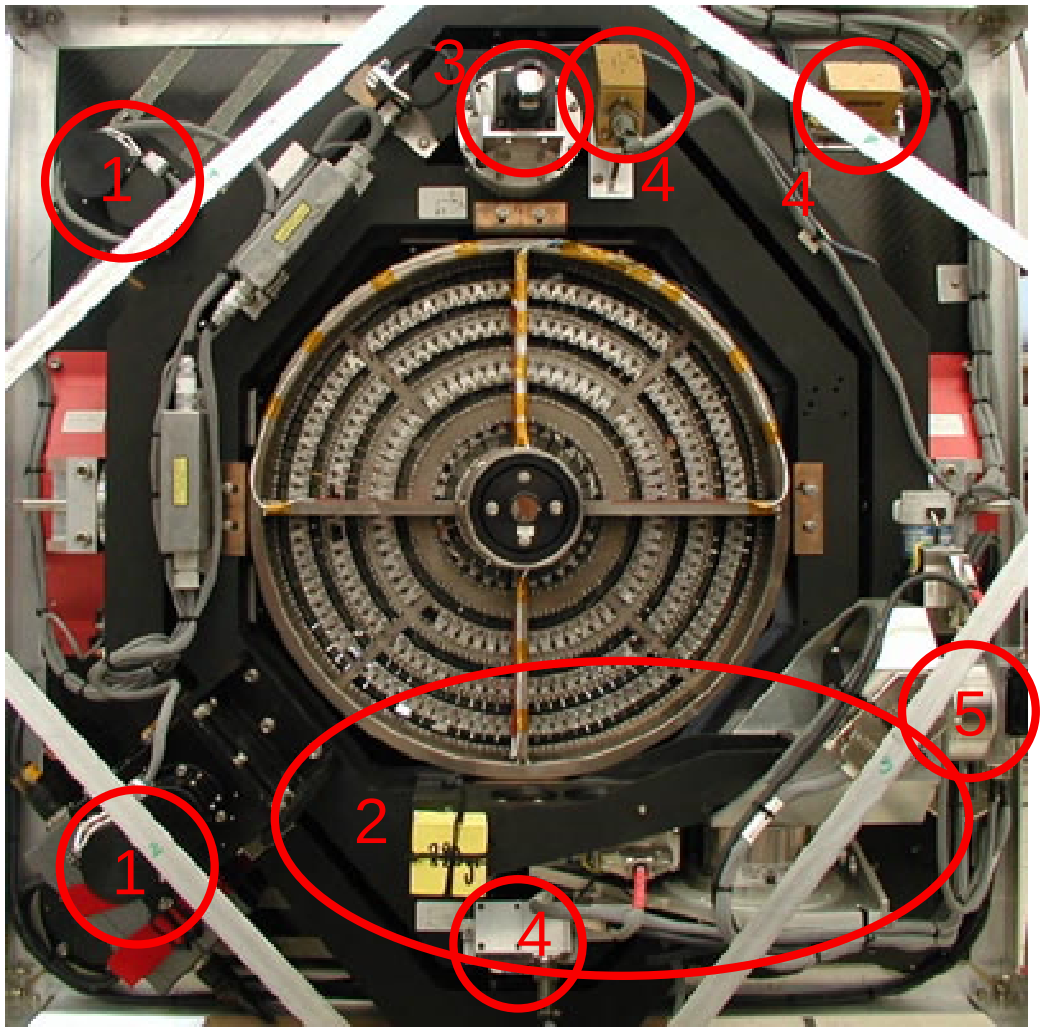
lens

- 576 Ge-Si crystals
- A_{geo} = 511 cm^2
- E_{diff} = 170 keV, $\Delta E \approx 1.5$ keV
- FOV ≈ 45 arcsec

optical axis

- inv. pixel. of rotating CCD

CLAIRE 2001 : Laue lens, optical axis and pointing system



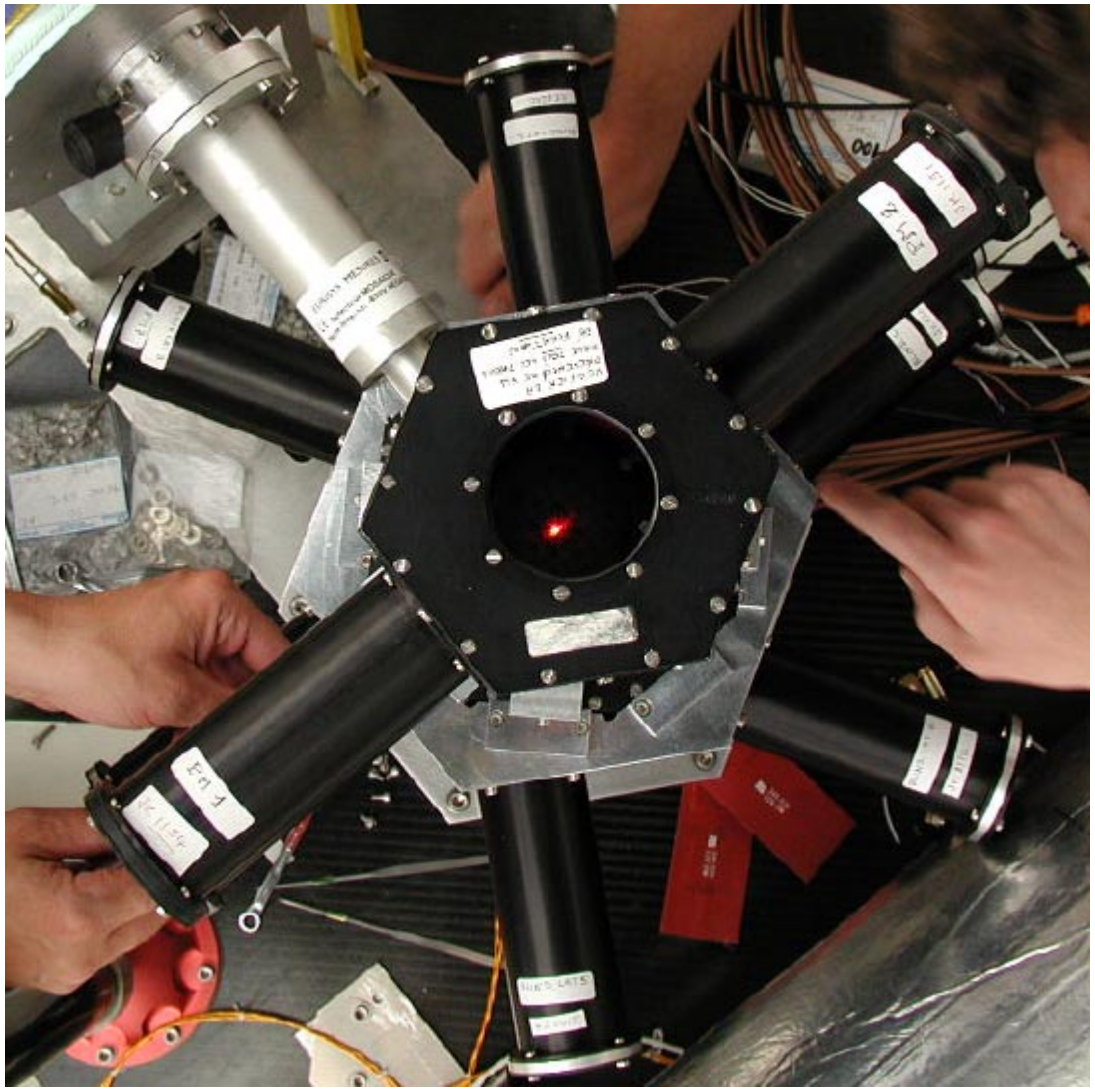
lens
- 576 Ge-Si crystals
- A_{geo} = 511 cm^2
- E_{diff} = 170 keV, $\Delta E \approx 1.5$ keV
- FOV ≈ 45 arcsec

optical axis
- inv. pixel. of rotating CCD

fine pointing system
- actuators 1
- solar sensor 2
- wide field CCD 3
- inclinometres 4
- gyro (Litton) 5

=> stability ≈ 3 arcsec

CLAIRE 2001 : Ge detector array and ACS



detector

- HPGe
- 3x3 array
- « pixel » 1.5*1.5*4cm

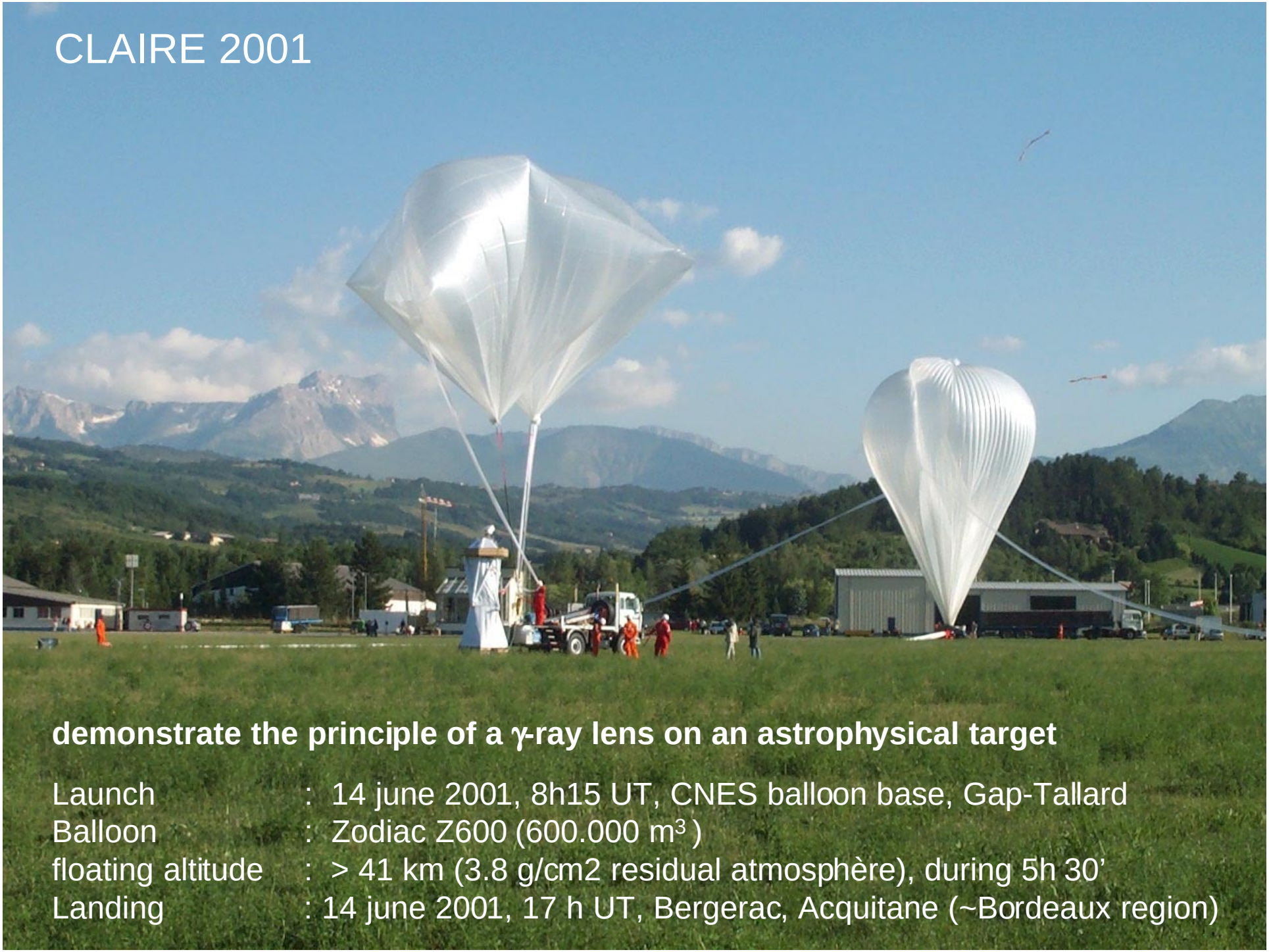
cooling

- pressurized N dewar

ACS

- CsI shield
- BGO collimator

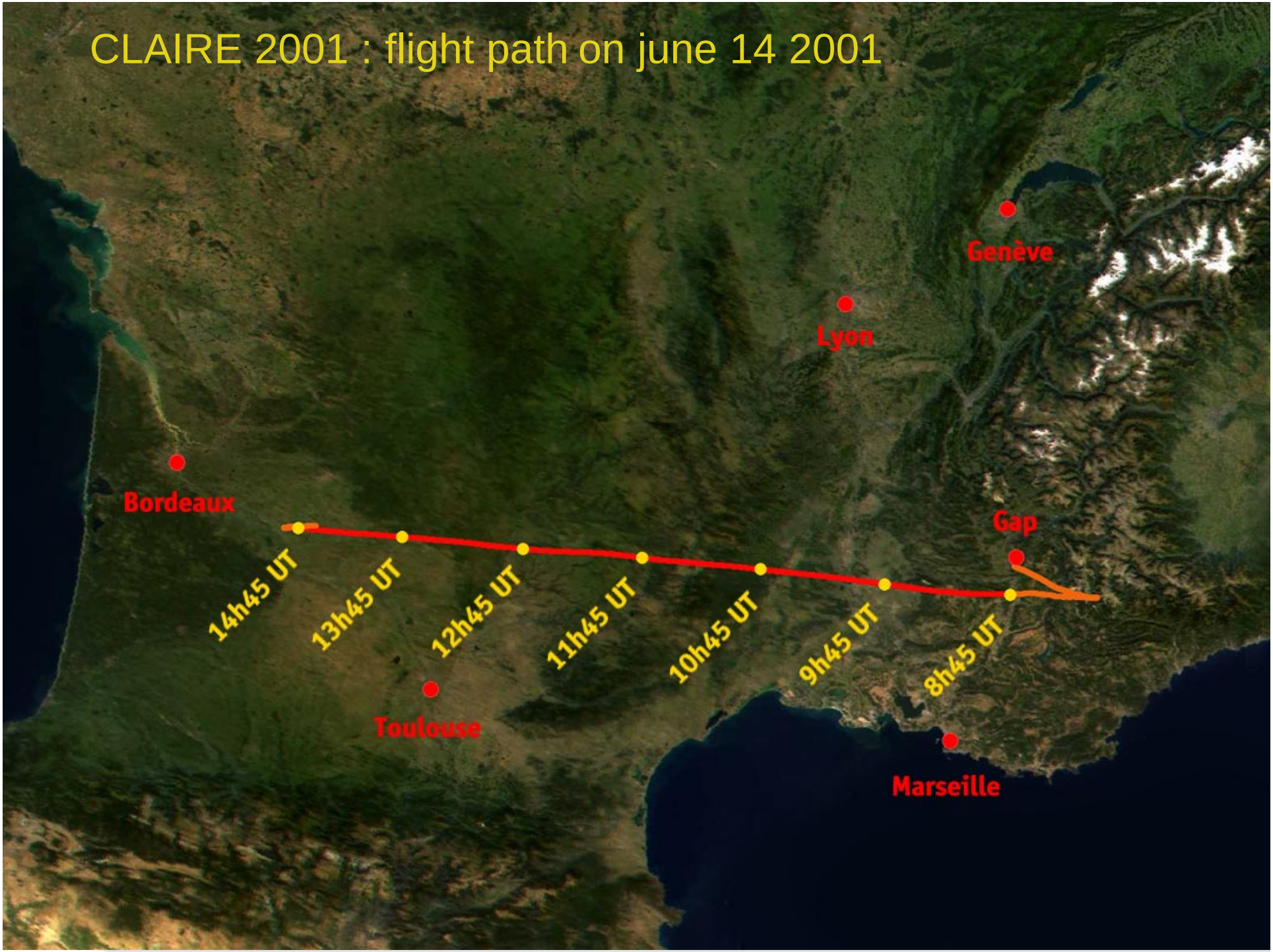
CLAIRE 2001



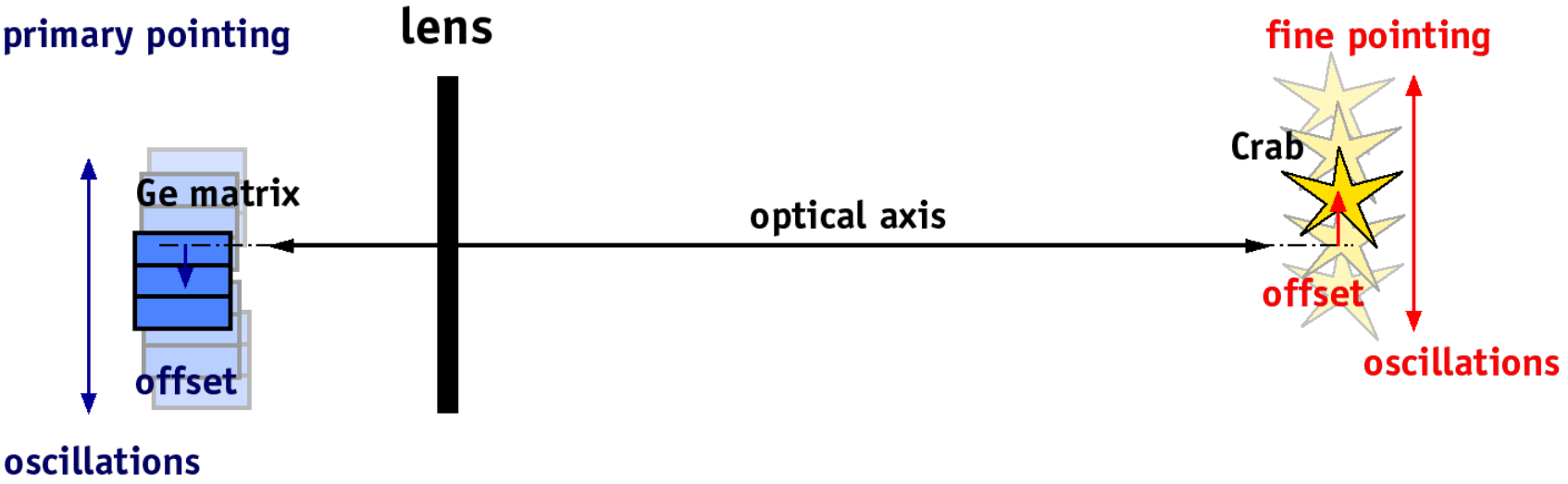
demonstrate the principle of a γ-ray lens on an astrophysical target

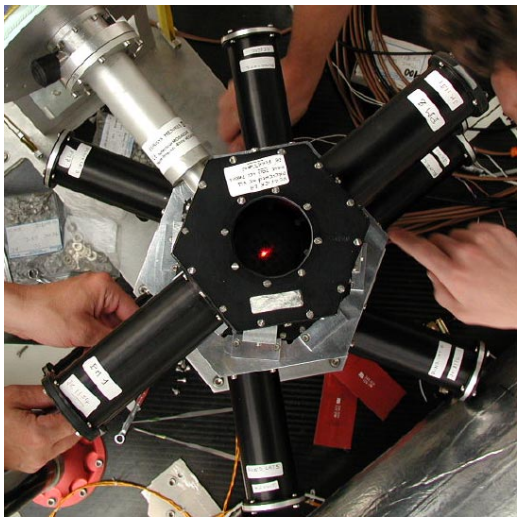
Launch : 14 june 2001, 8h15 UT, CNES balloon base, Gap-Tallard
Balloon : Zodiac Z600 (600.000 m^3)
floating altitude : > 41 km (3.8 g/cm2 residual atmosphère), during 5h 30'
Landing : 14 june 2001, 17 h UT, Bergerac, Acquitane (~Bordeaux region)

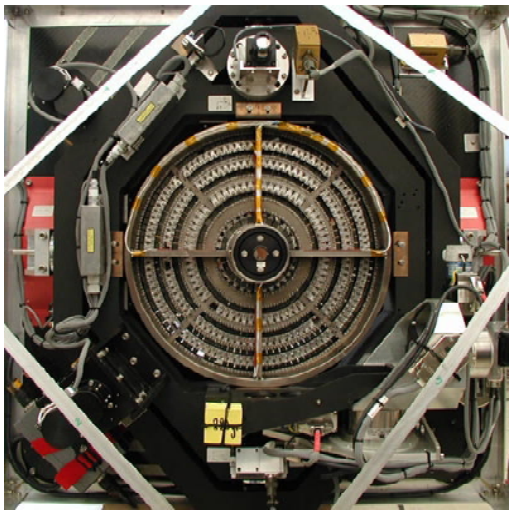
CLAIRE 2001 : flight path on june 14 2001



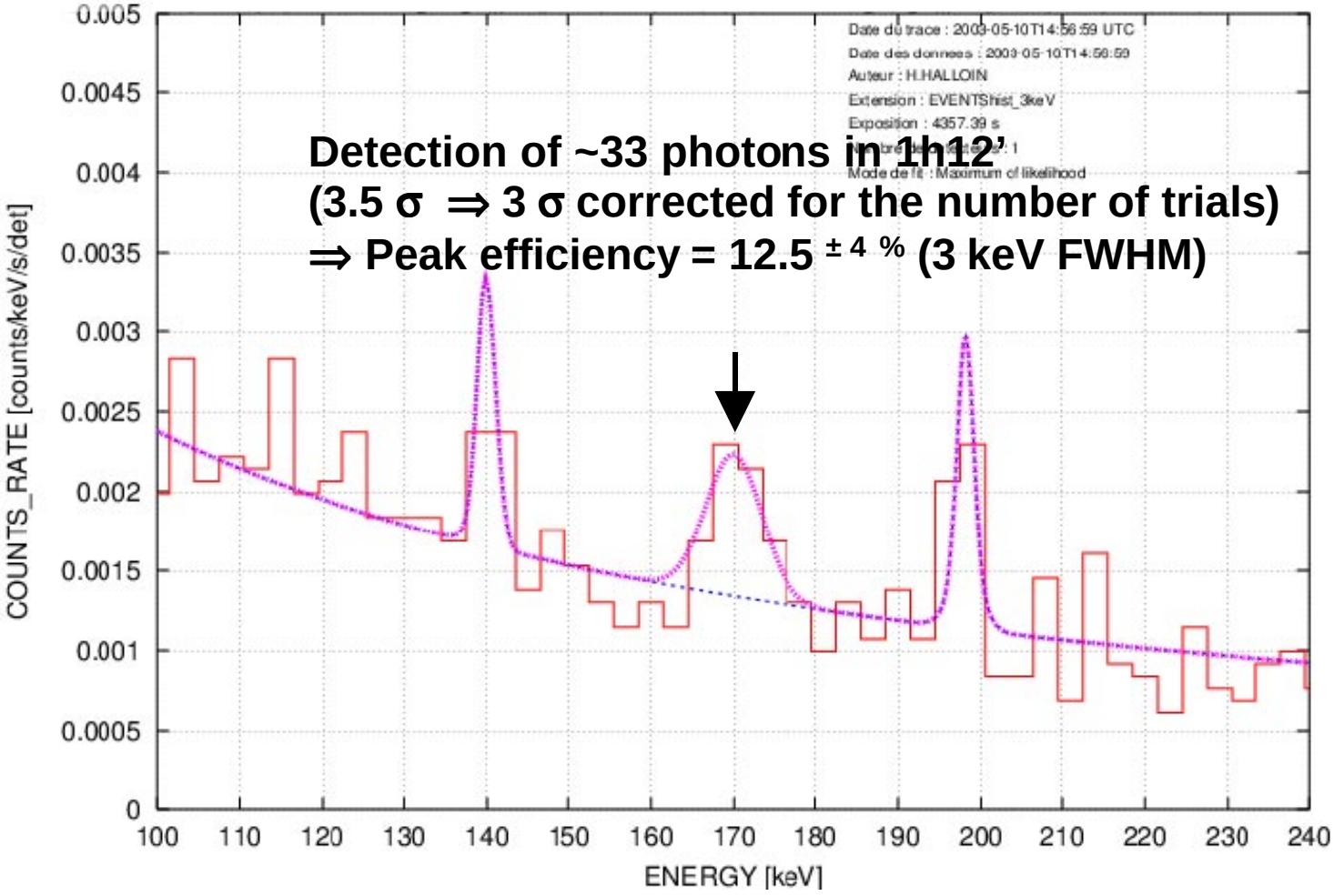
CLAIRE 2001 : pointing



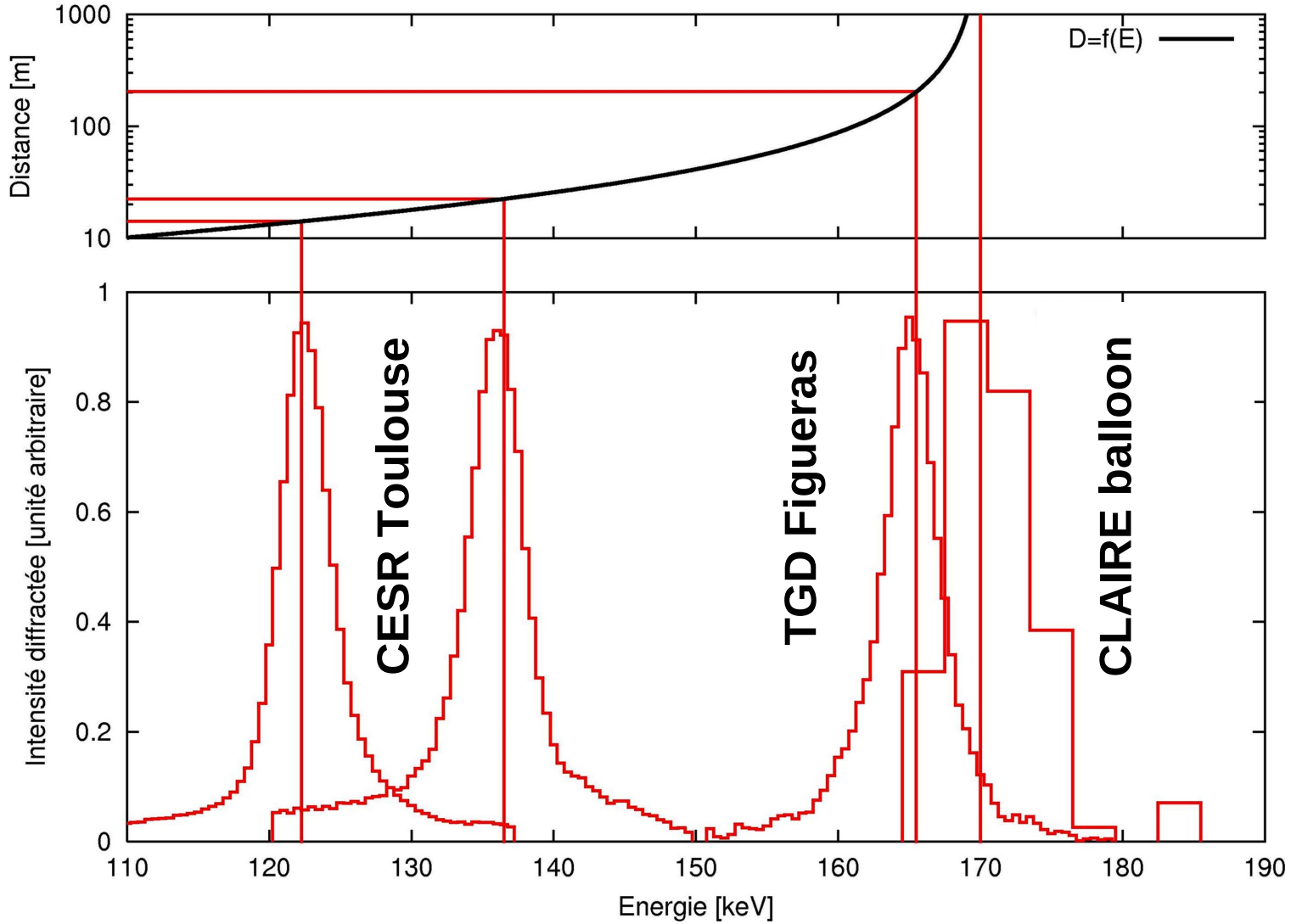


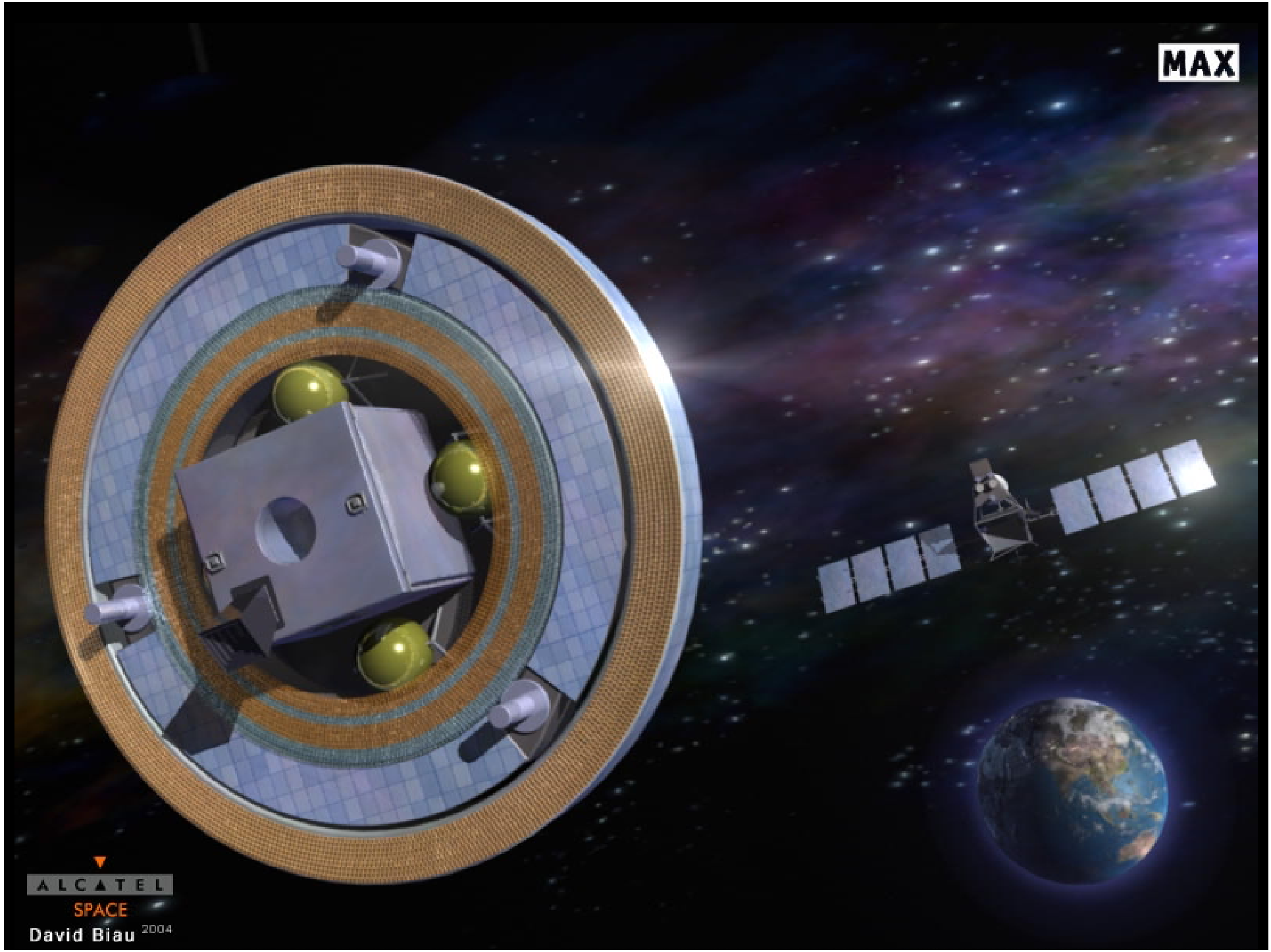


CLAIRE 2001 : first light of an astrophysical source



CLAIRE : 14 m, 22.5 m, 205 m ... infinity !

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ALCATEL
SPACE
David Biau 2004