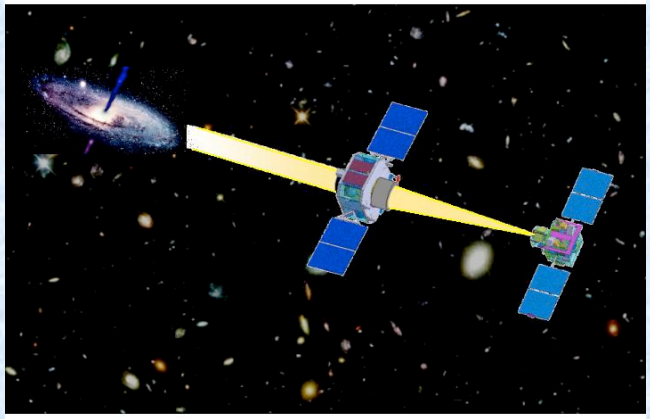


SIMBOL-X

A new generation hard X-ray telescope

P. Ferrando

Service d'Astrophysique CEA & Fédération de Recherche APC

A project proposed by :

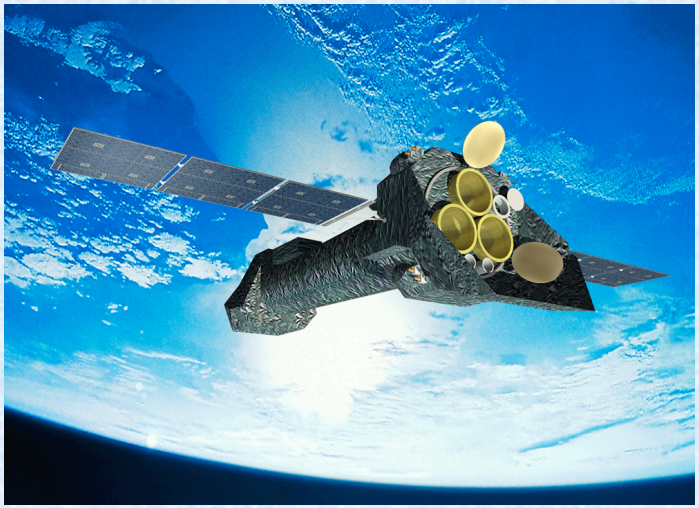
France : Service d'Astrophysique CEA Saclay / CESR Toulouse
LAOG Grenoble / LUTH Meudon
Italy : Observatorio Astronomico di Brera
Germany : MPE Garching / PNSensor GmbH München / IAA Tübingen
England : Dept of Astronomy and Astrophysics, Leicester

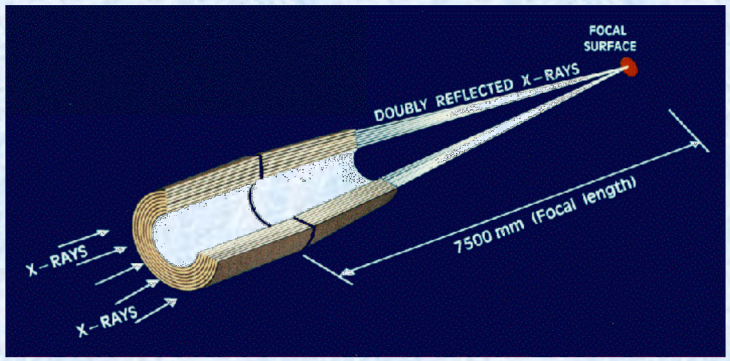
SIMBOL-X science goals

- Physics of accretion / ejection around Black Holes
  - Galactic Centre
  - X-ray binaries in our Galaxy at very low accretion rates
  - X-ray binaries up to a few Mpc
  - Active Galactic Nuclei
- Acceleration processes, in compact and extended objects
  - Quasars and micro-quasars jets
  - Supernova remnants
  - Clusters of galaxies
- Origin of high energy diffuse emissions
  - Galactic Centre
  - X-ray background
- Gamma ray bursts afterglows, star forming regions…

Current high energy telescopes (ESA)

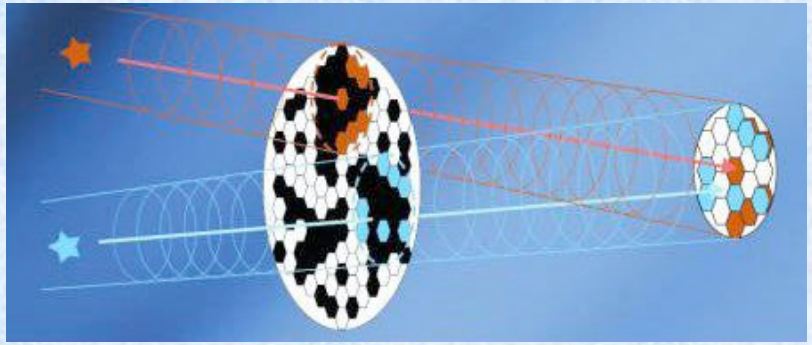
XMM-Newton





0.1-10 keV : focusing optics
Spatial resolution : 15 arcsec
High signal to noise

INTEGRAL



15 keV-10 MeV : coded masks
Spatial resolution : 12 arcmin
Moderate signal to noise

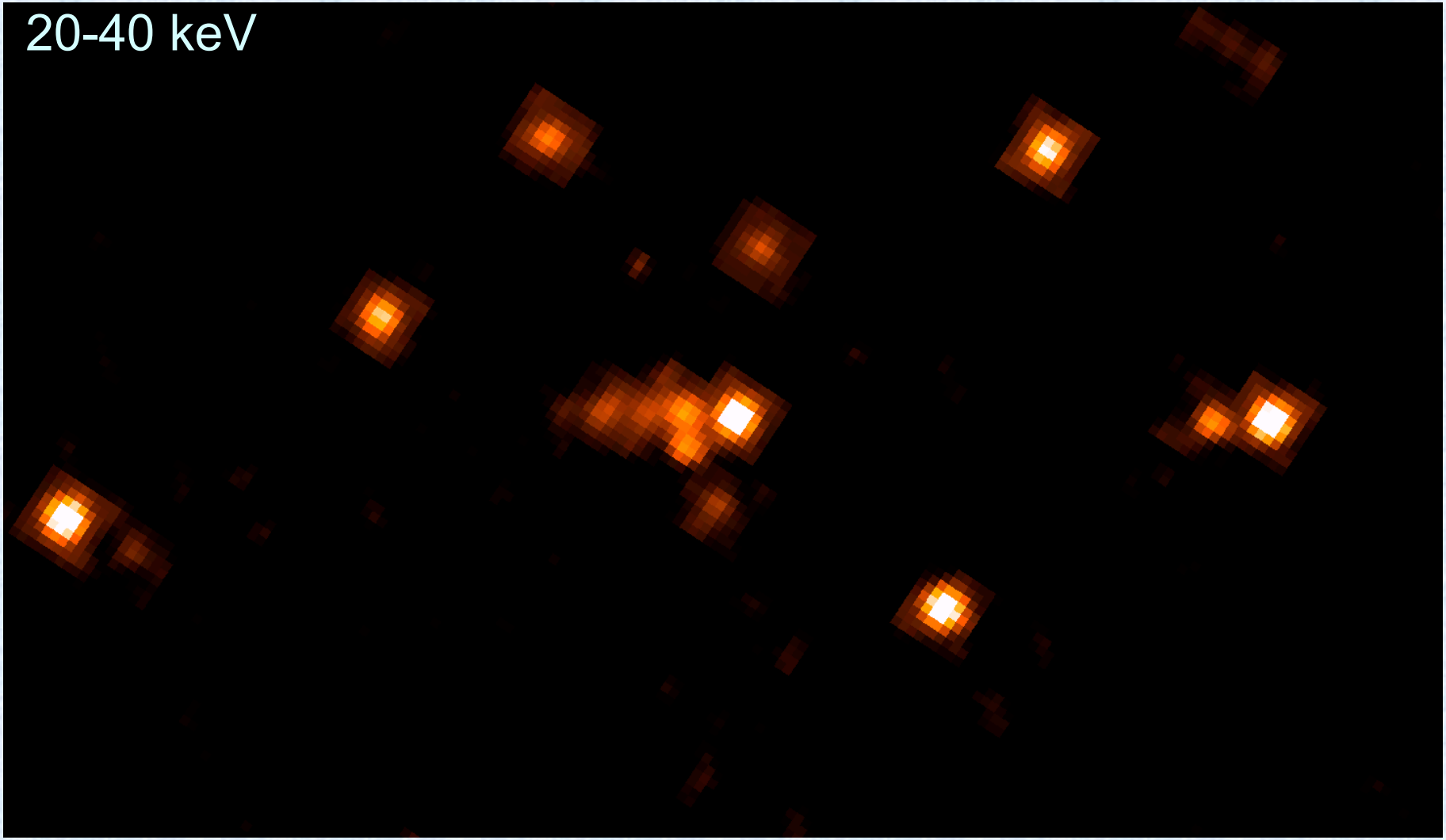
SIMBOL-X proposal

- Emission below 10 keV : thermal + non thermal emission
- Non thermal part crucial for physics of accretion and acceleration
- Current instruments characteristics have a "*2 orders of magnitude*" gap right at separation of thermal and non thermal emissions

With SIMBOL-X, we propose to bridge this gap by bringing X-ray angular resolution and sensitivity into the hard X-ray domain, by focusing technique

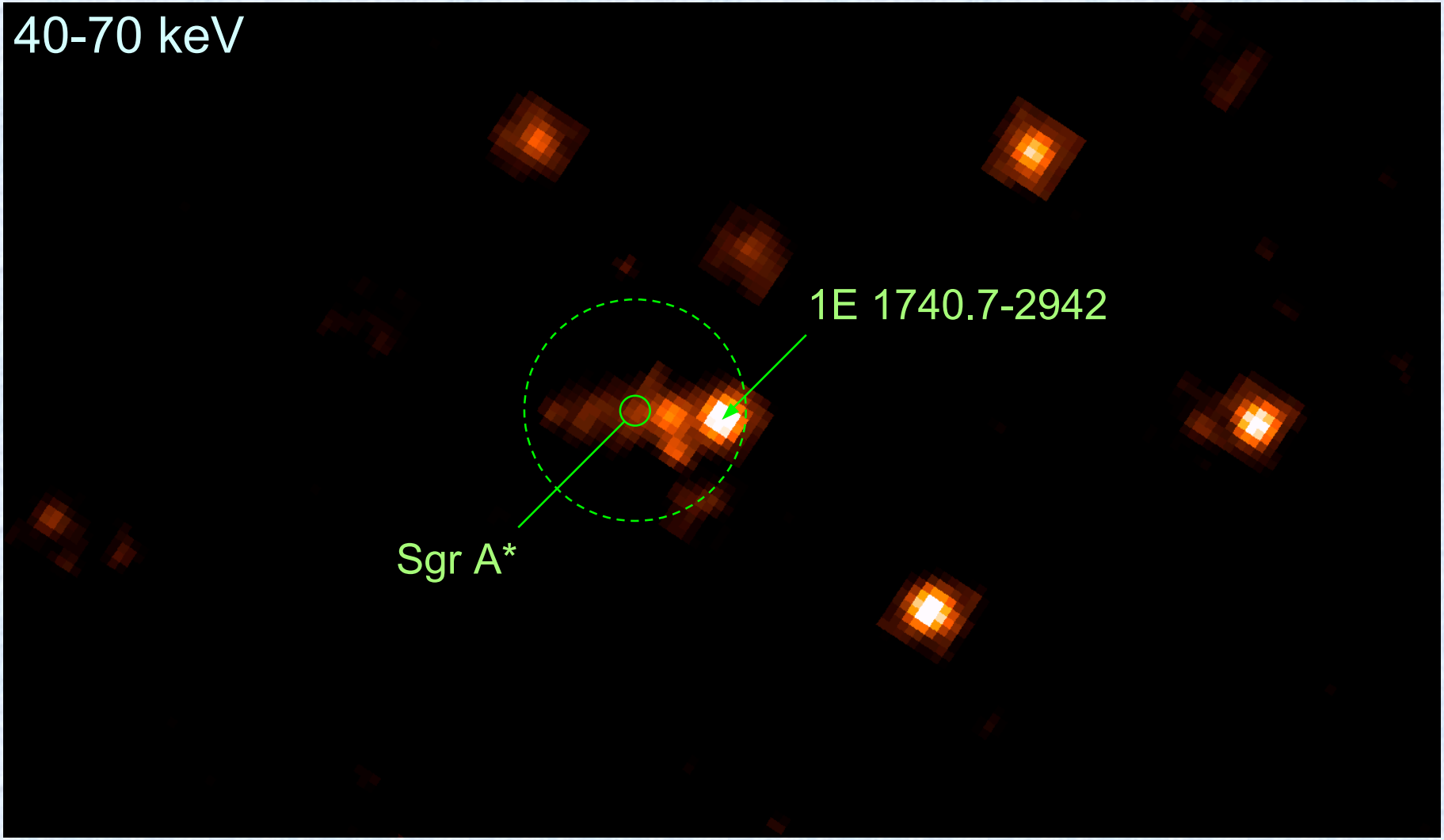
Sensitivity : > 100 times better than IBIS (E < 50 keV)
Angular resolution : < 30 arcsec HEW
Spectral coverage : 0.5-70 keV

INTEGRAL view of Galactic Center



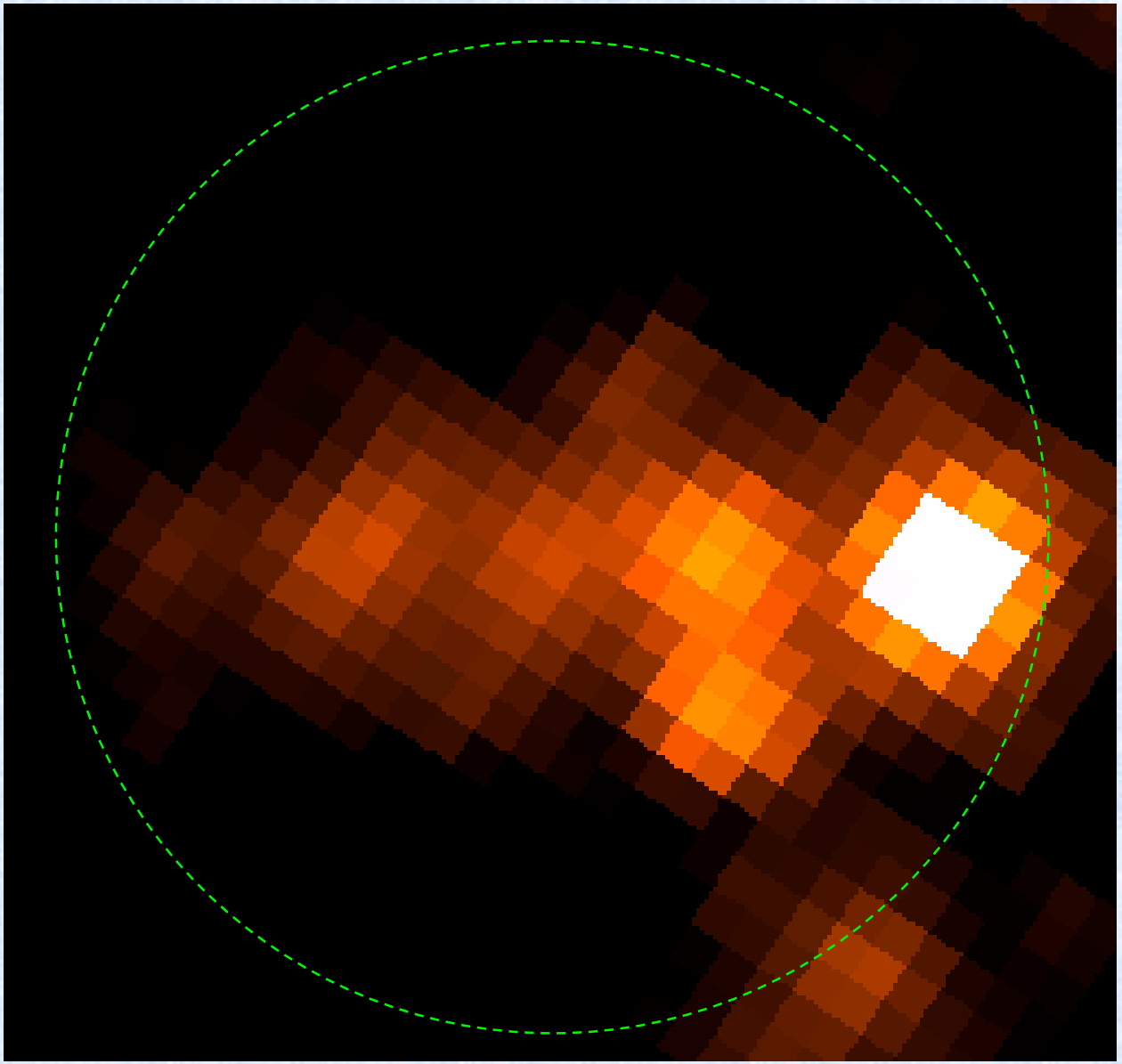
(13 x 7.5°)

INTEGRAL view at higher energy

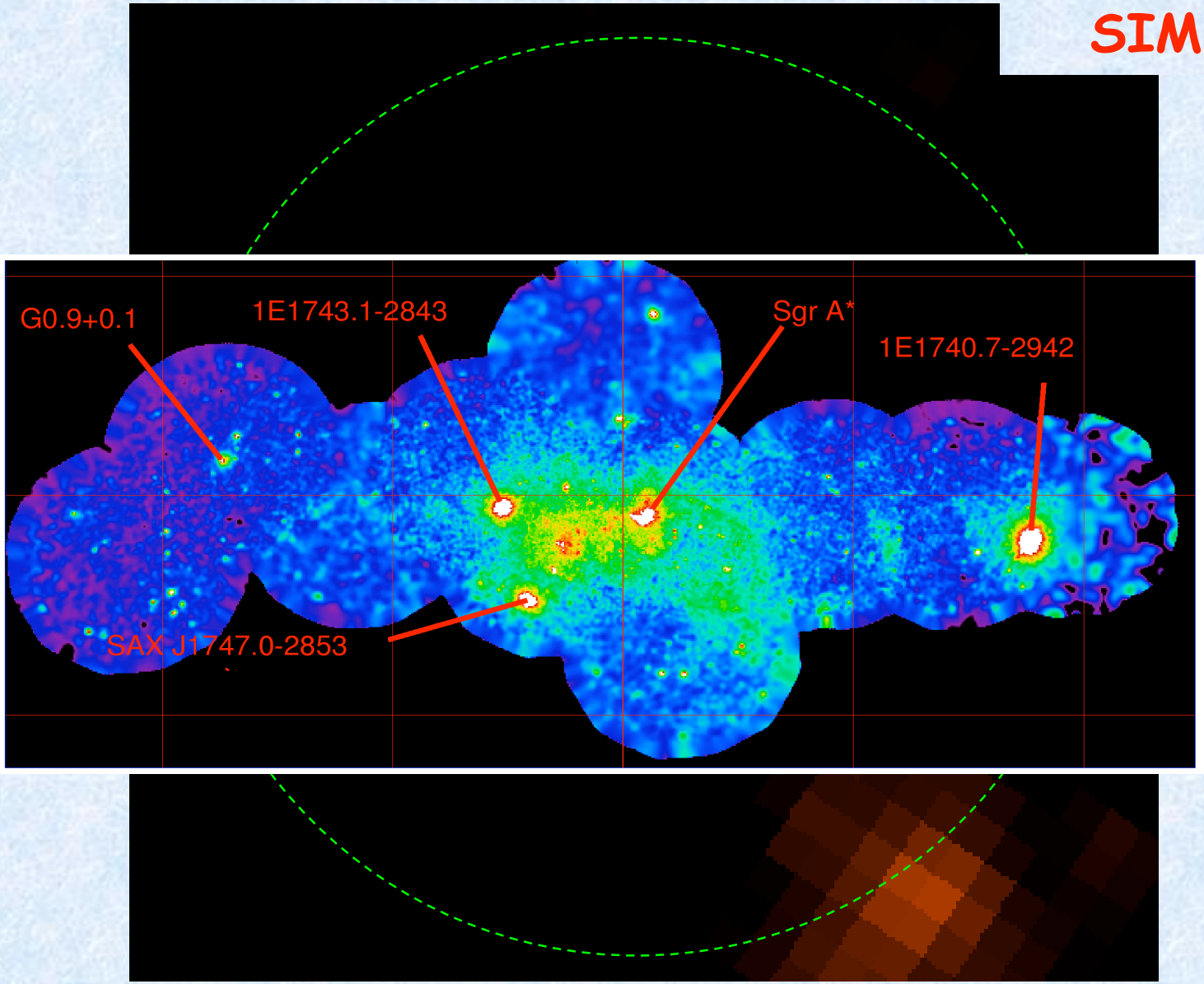


(13 × 7.5°)

The central 2 degrees > 20 keV today



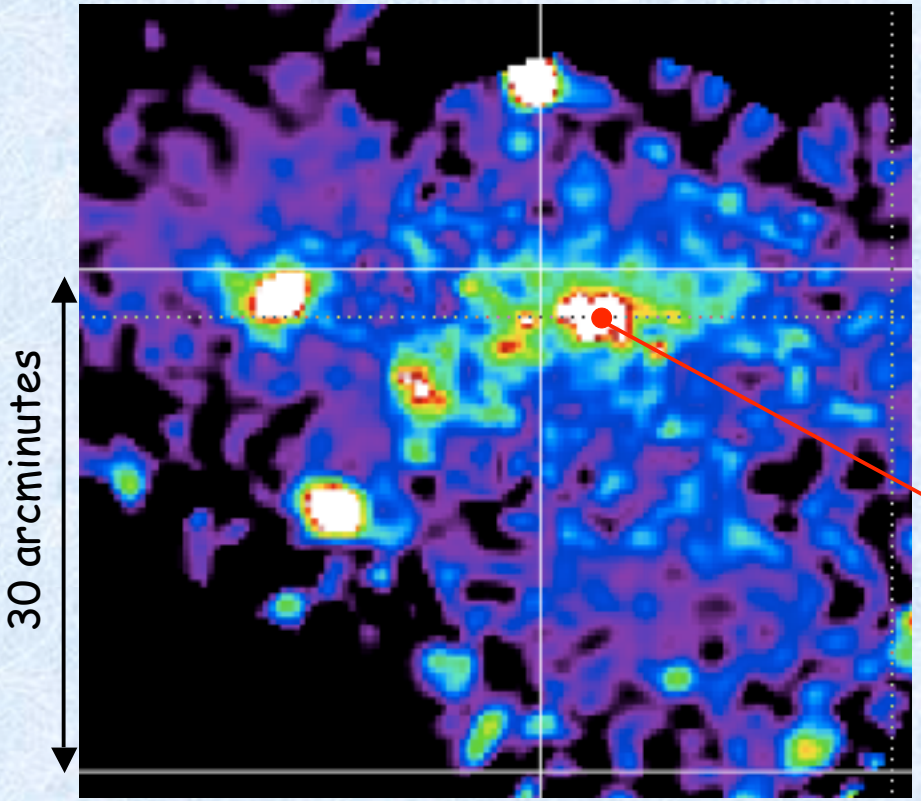
The central 2 degrees > 20 keV in 2011 with SIMBOL-X



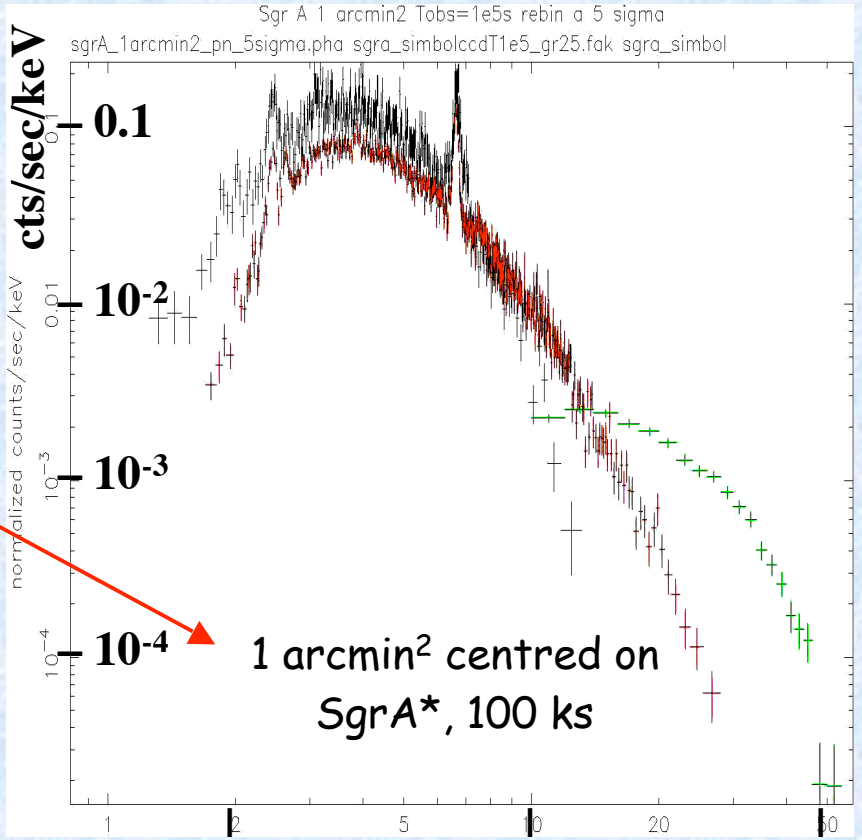
Understanding the Galactic Centre non-thermal emission

For that, SIMBOL-X will allow :

- map the high energy emission
- determine properly the non-thermal part of the spectrum

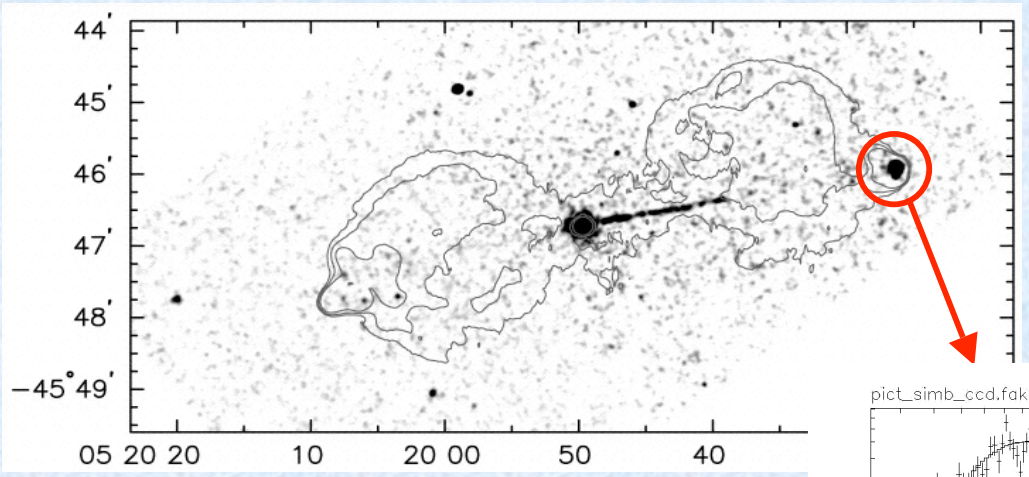


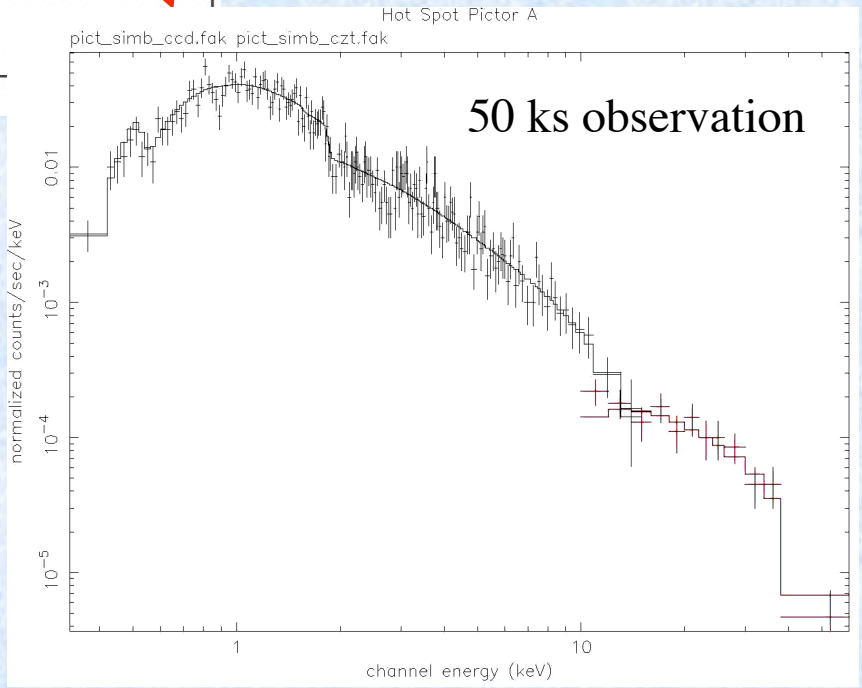
8-10 keV continuum XMM
(Decourchelle et al. 2004)



Galactic and Extra Galactic jets
SIMBOL-X simulation Pictor A

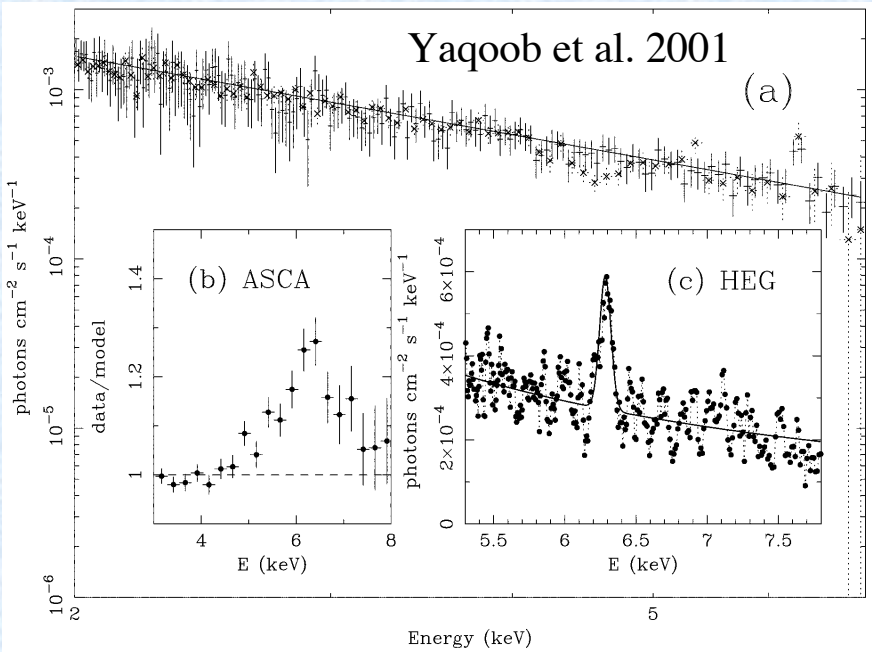
(Chandra et 20 cm, Wilson et al. 2001)

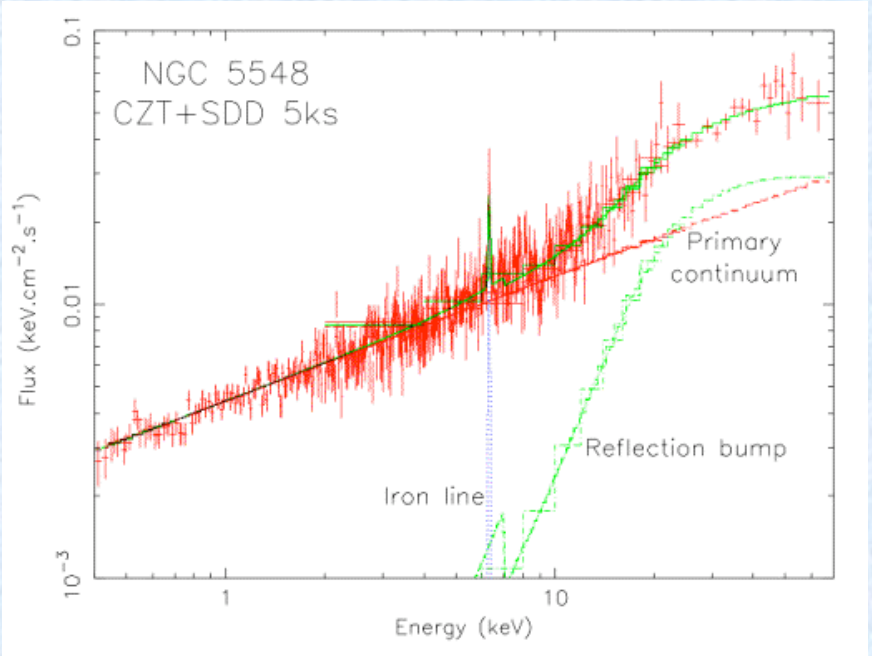




SIMBOL-X and AGN's

NGC 5548 example





Chandra 83 ks, *ASCA* 57 ks

5 ks with *SIMBOL-X*

Variability and broad band spectrum with *SIMBOL-X*

Mission concept

Basically : long focal length telescope, using grazing incidence X-ray optics, with mirror and detectors mounted on two different spacecraft in formation flying.

Characteristics

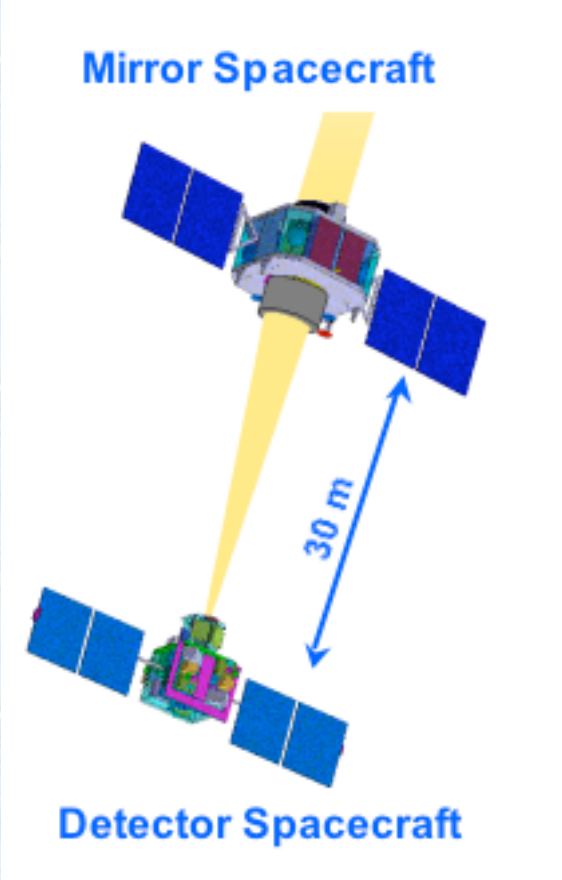
Energy range : 0.5–70 keV

Resolution : < 130 eV @ 6 keV,
1 % @ 60 keV

Angular resol. : < 30 arcsec (local. < 3 arcsec)

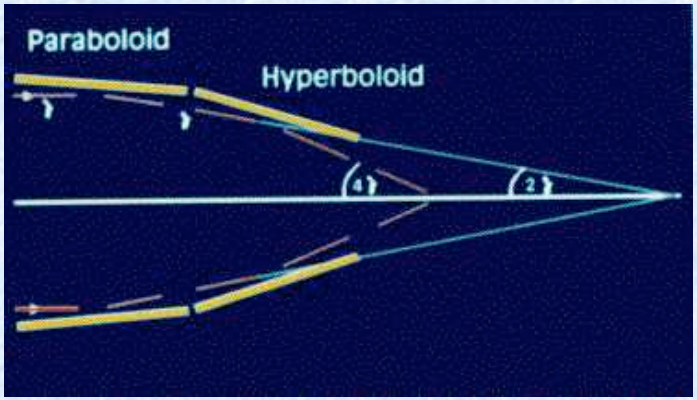
Effective area : > 550 cm^2 E < 35 keV
150 cm^2 @ 50 keV

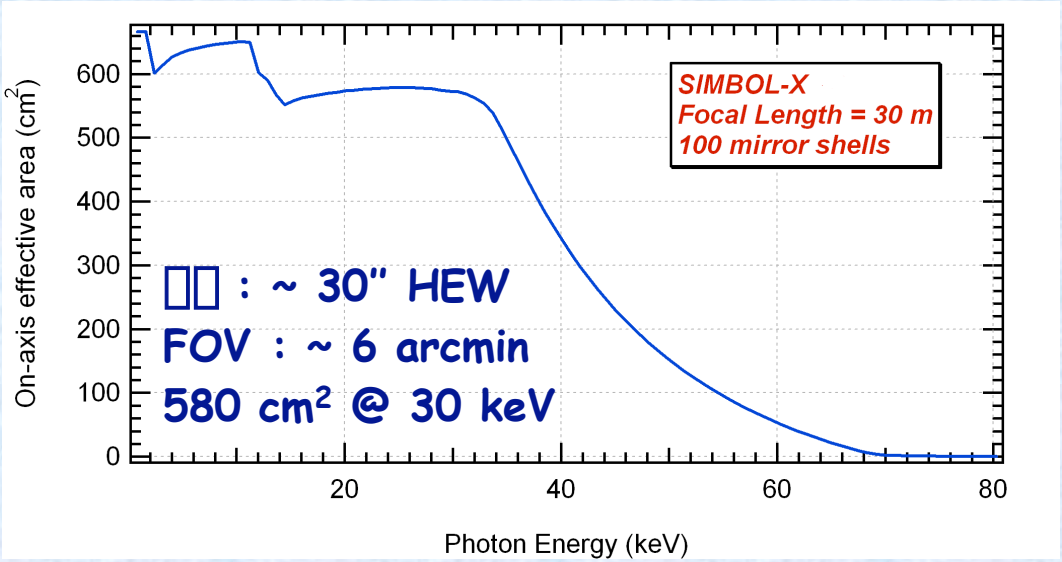
Sensitivity : 5□10^{-8} ph/cm^2/s/keV (E < 40 keV)
(5 □, 100 ks, □E = E/2)



The optics

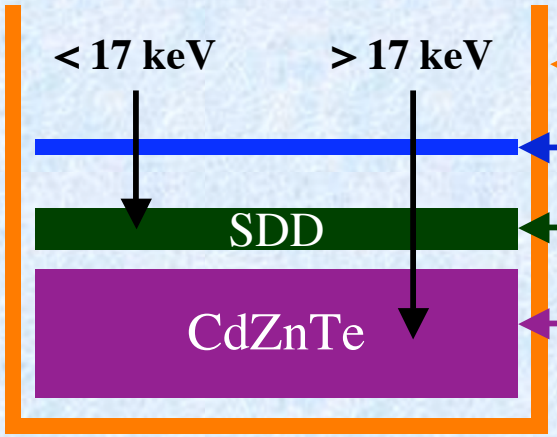
Focusing using a grazing incidence nested shells Wolter I mirror





- Long focal length, 30 m, for high reflectivity at high energy
- Nickel shells with single layer Pt coating, obtained by well proven electroforming replication method
- Low mass : ~ 210 kg mirror, obtained by reduced thickness of shells

Focal plane basic design

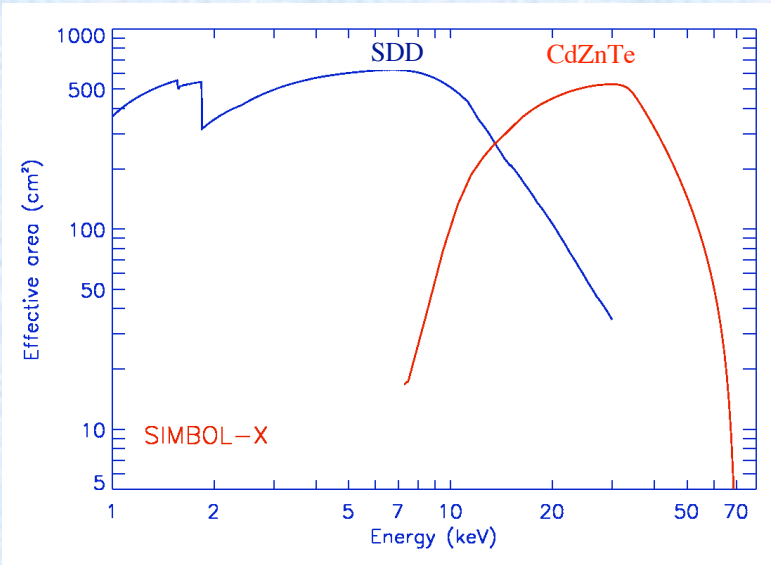


Active anticoincidence

Optical filter (0.1 μm Al)

Low energy detector (0.45 mm Silicium)

High energy detector (2 mm CdZnTe)

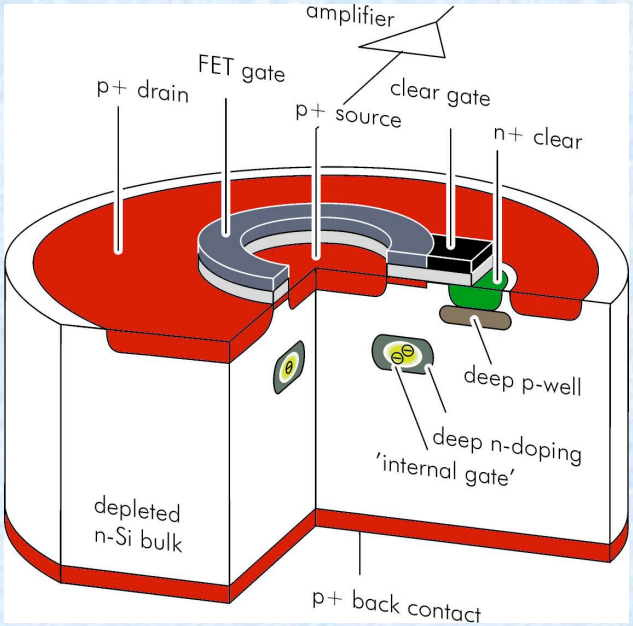


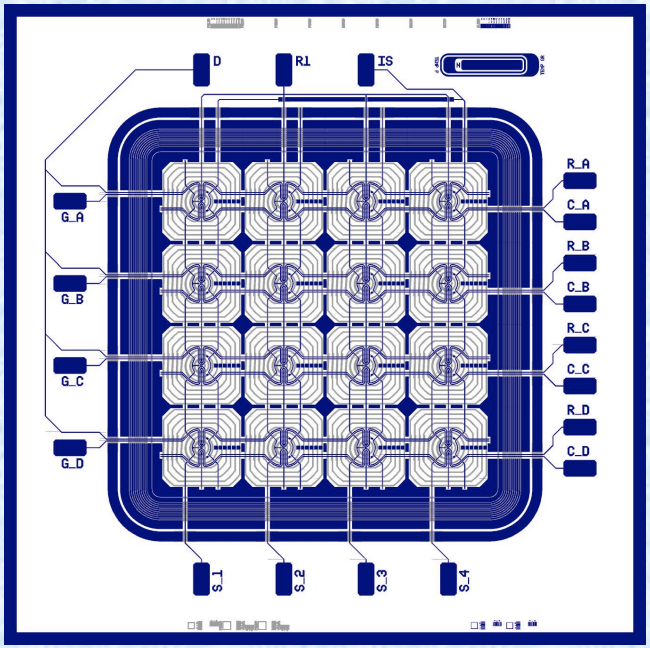
Requirements

- Pixel size of ~ 500 μm (gives good oversampling of the 4.4 mm PSF)
- Full diameter of focal plane : 6 cm
- Fast response detectors for full anticoincidence scheme
- Operation at room temperature
- Low energy response down to 0.5 keV
- Good spectral resolution for Iron line

Low energy detector

Silicon Drift Detector matrix with integrated DEPFET

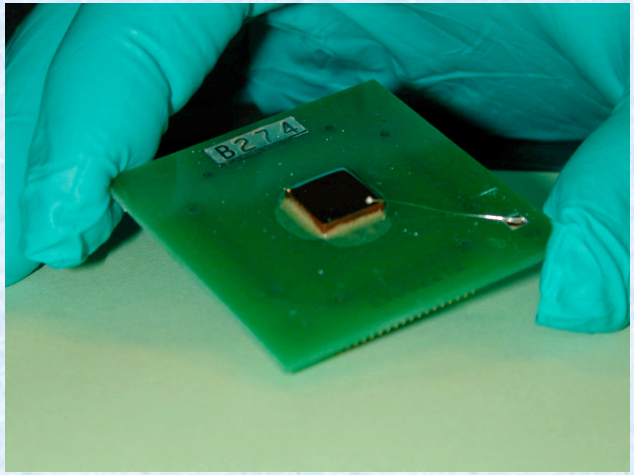




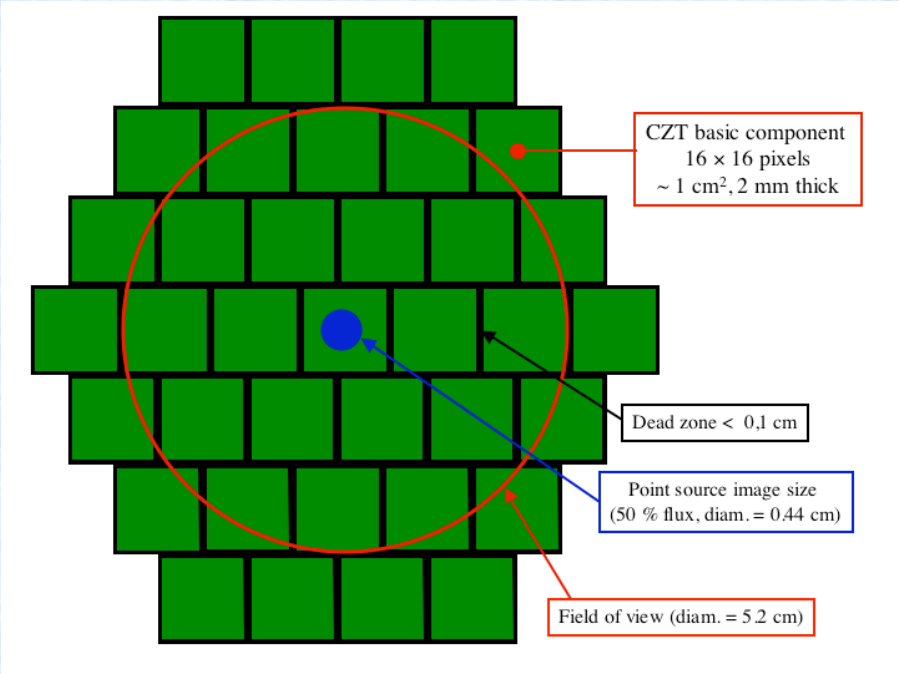
- Low power consumption
- Internal amplification
- Backside illuminated devices
- Room temperature operations
- Active Pixel Sensor type
- 100 % filling factor
- Adjustable pixel size (50 μm to 1 mm)
- Fast, parallel readout possible

High energy detector

Array of pixellated CdZnTe matrices



- 2 mm thick
- room temperature operation
- pixel size 500 × 500 □m²
- ASIC, derived from ISGRI CdTe plane, bumped on anodes
- Development and first tests started, with eV-Products detectors.



Nominal focal plane

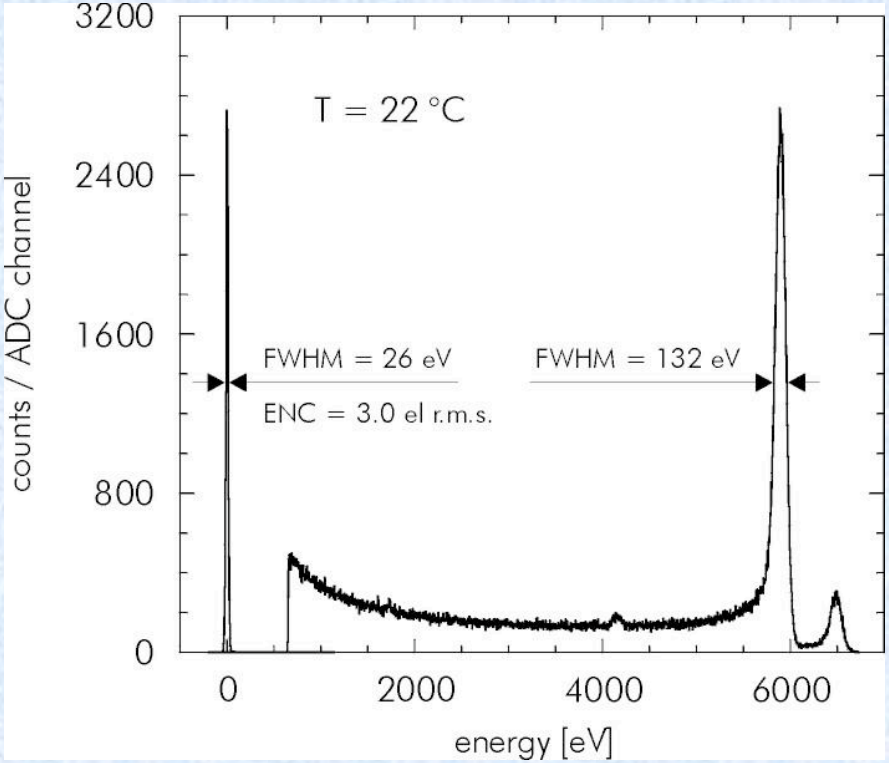
- 37 crystals 1 cm² × 2 mm each
- 16 × 16 pixels each
- ~ 10,000 channels

Spectral resolution

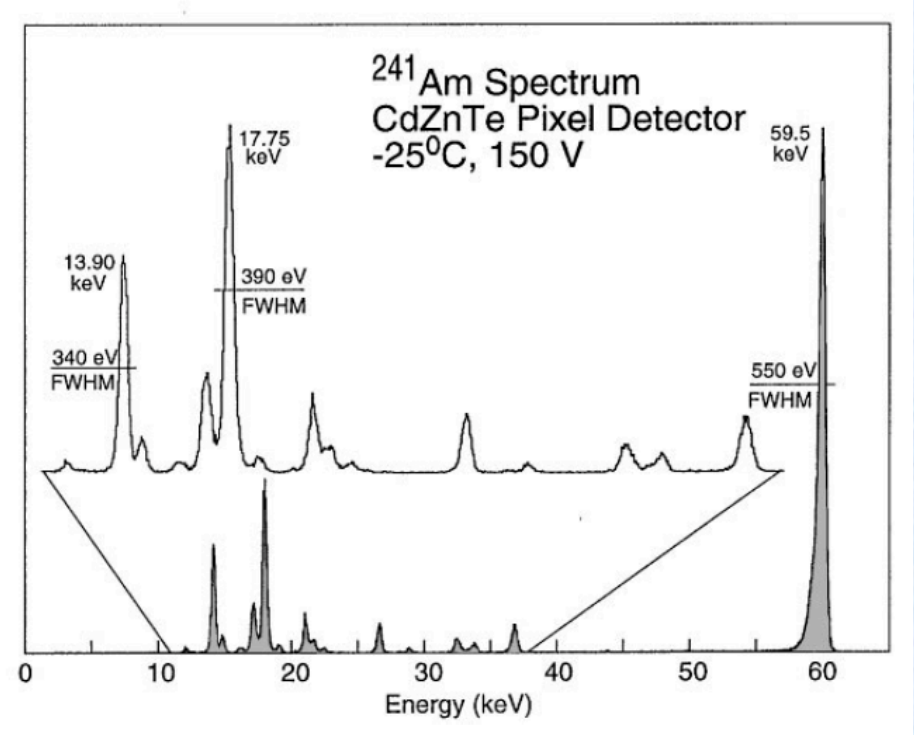
Goal : we will have at least

-the resolution already obtained on a single pixel for SDD,

-the resolution obtained in similar devices by other groups for CZT.



DEPFET single pixel, room temp.

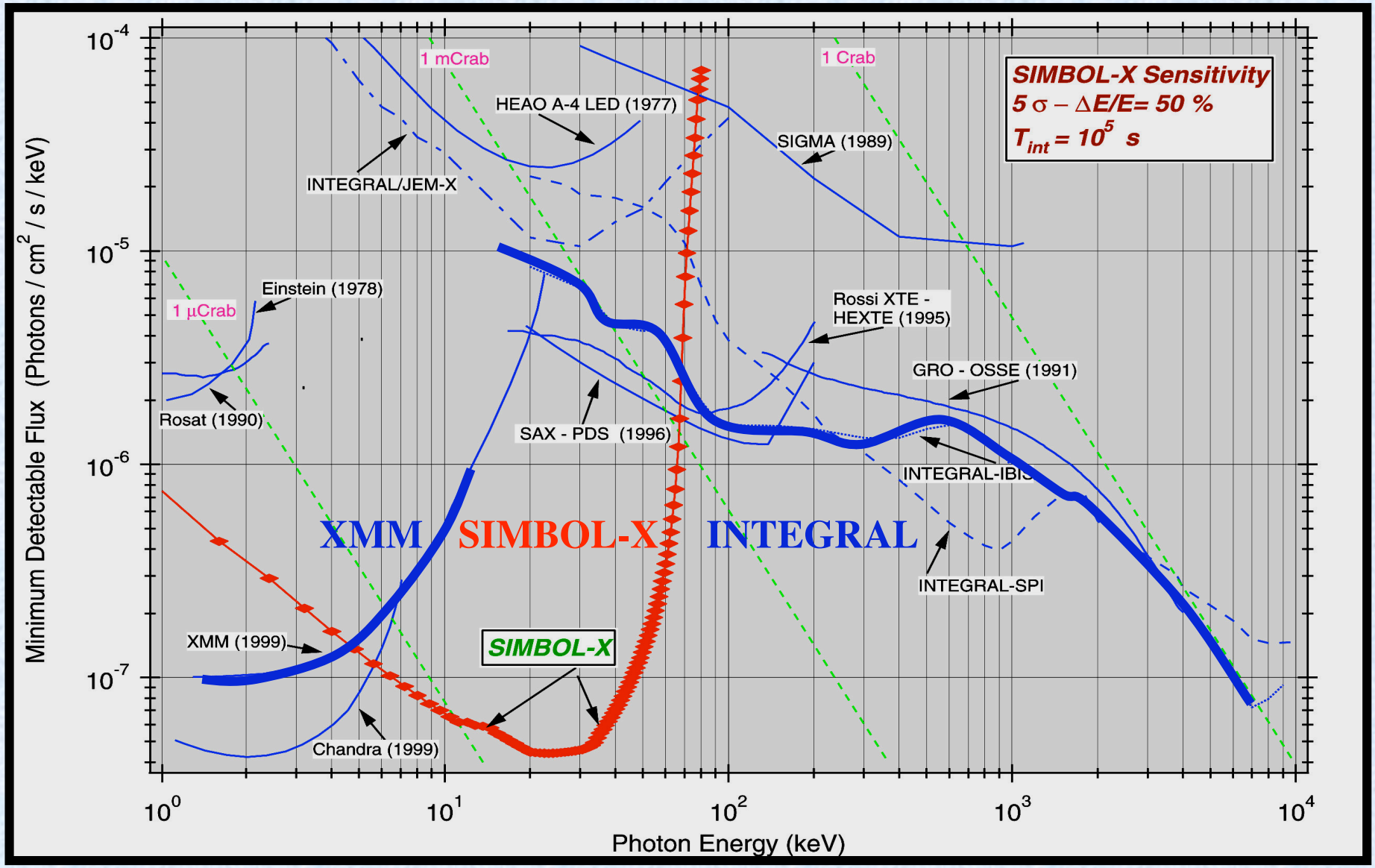


Single pixel in CZT array,

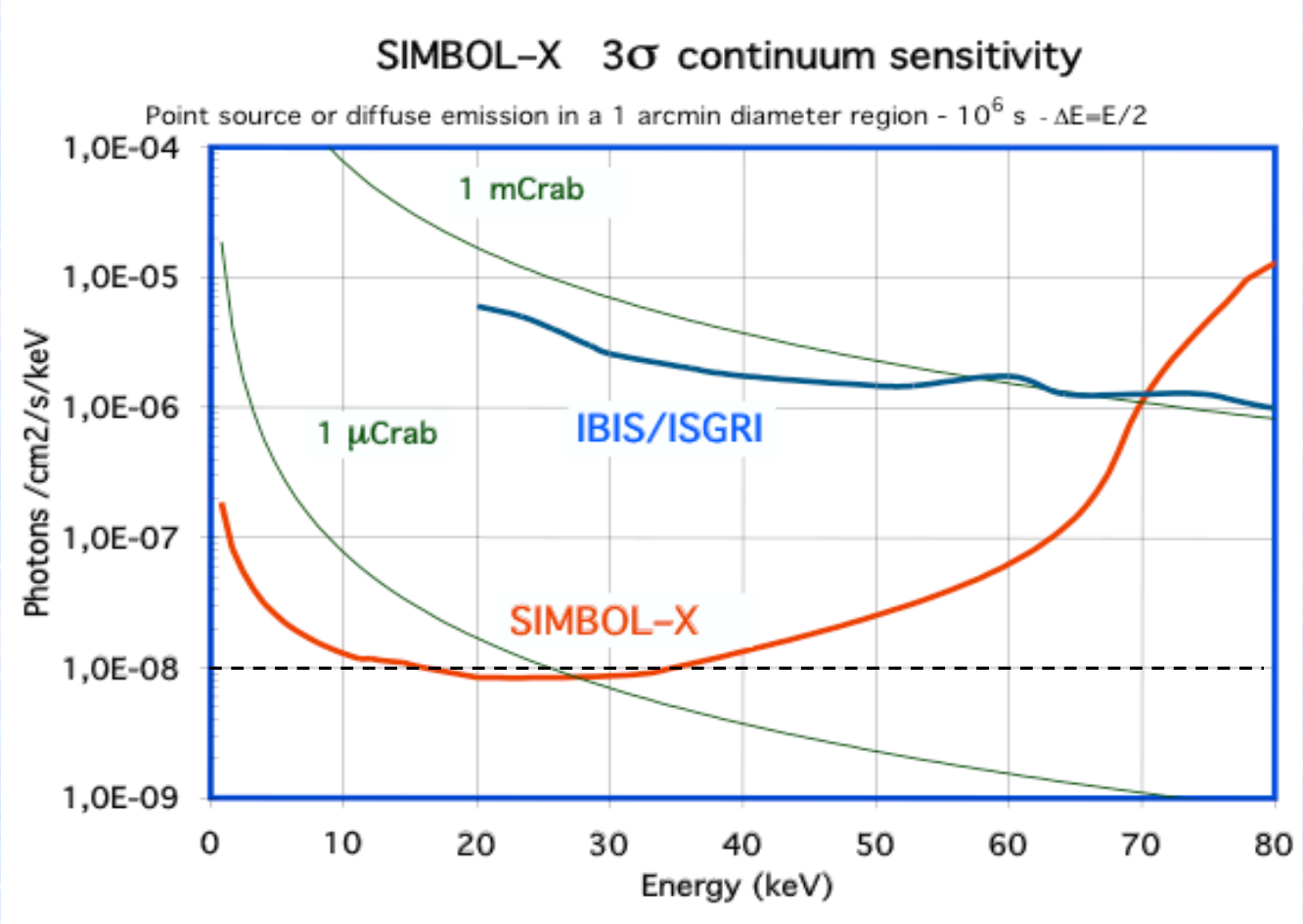
600 × 600 □m × 2 mm pixels,

Bolotnikov et al. (2001), HEFT developt

Sensitivity

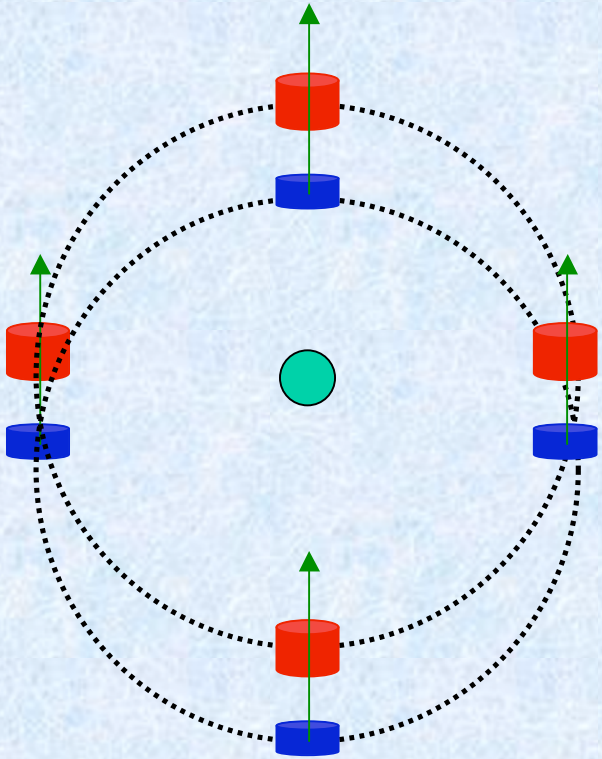


Sensitivity



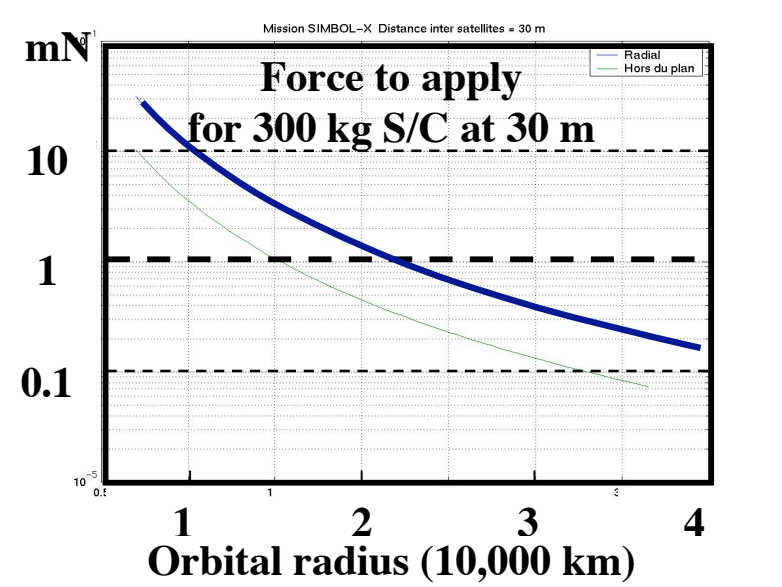
Calculation for a 1 arcmin extraction region, detection at 3 □, 1 Ms observing time, □E = E/2

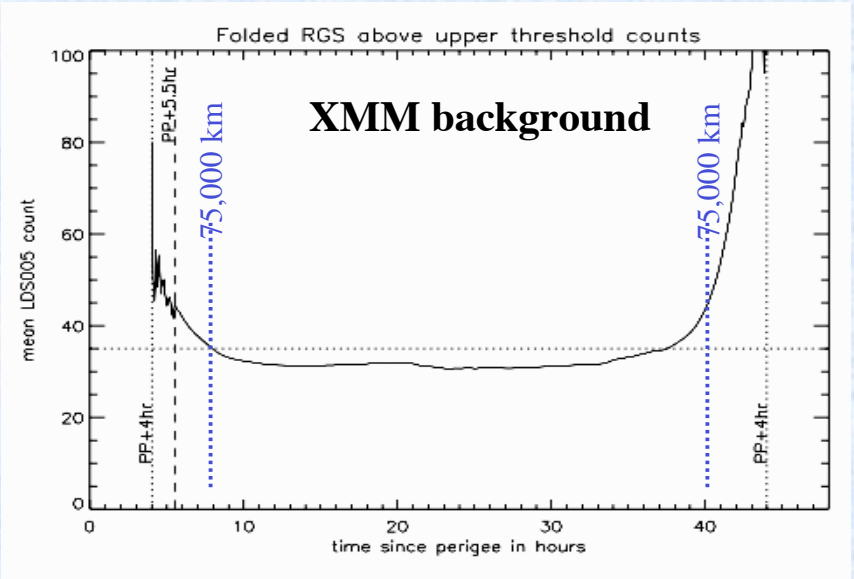
Formation flying requirements



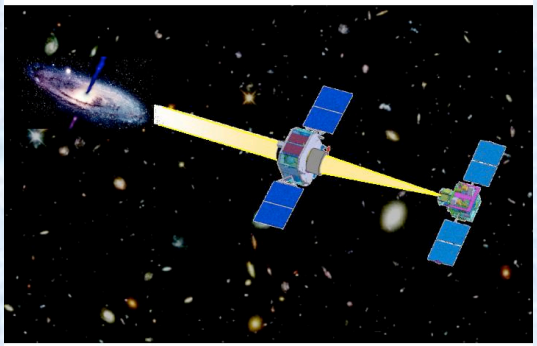
- Pointed telescope
- Up to > 100 ks uninterrupted observations
- Relative positionning :
  ± 1 cm along the telescope axis
  ± 1 cm perpendicular
- Attitude reconstruction : knowledge of telescope axis position within < 3 arcsec
- Low background orbit
- Two real years of observations
- Stay in middle class mission

Formation flying CNES study





- Feasibility demonstrated with a large number of options !
- Nominal (and optimal) choice :
  - orbit : 81,500 km of altitude (3 days period), circular
  - dedicated spacecrafts and launcher
  - maximum use of existing or qualified equipments
  - 3 years mission overall



Final remarks

- By using focusing optics for the first time above 10 keV SIMBOL-X will be a revolution in high energy astrophysics
- Guarantee of a huge scientific return for the full astrophysics community (open observatory)
- Demonstrated to be feasible : no major development for the equipments, neither for the spacecrafts nor for the payloads
- Launch in 2011, 3 years of operation, ideally suited between the end of current observatories, and the future large observatories