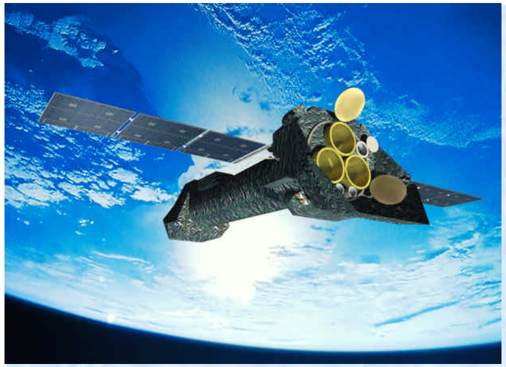
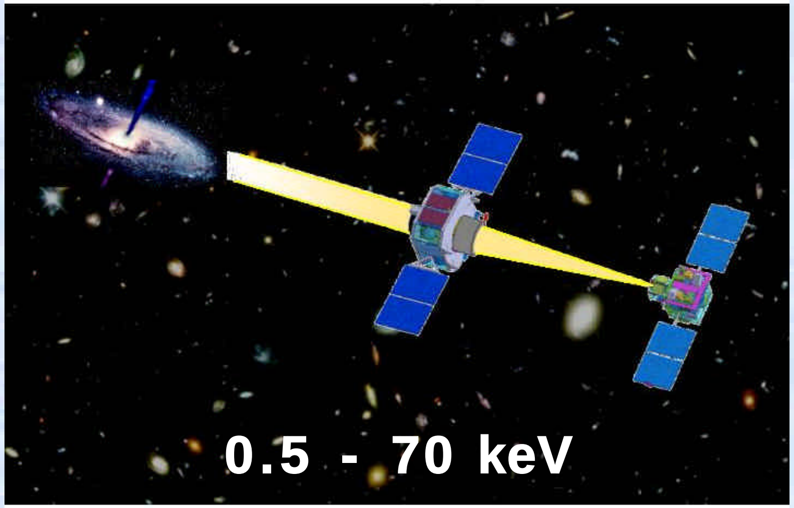


0.1–10 keV



15 keV-10 MeV

Simbol-X

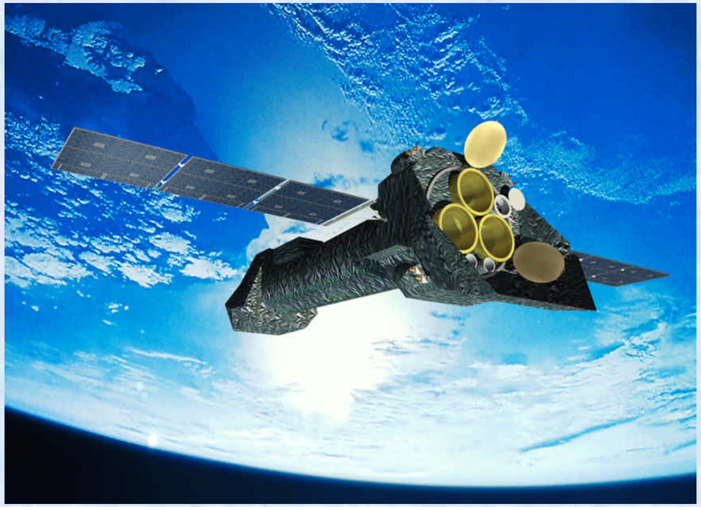
A formation flying mission for hard X-ray astrophysics

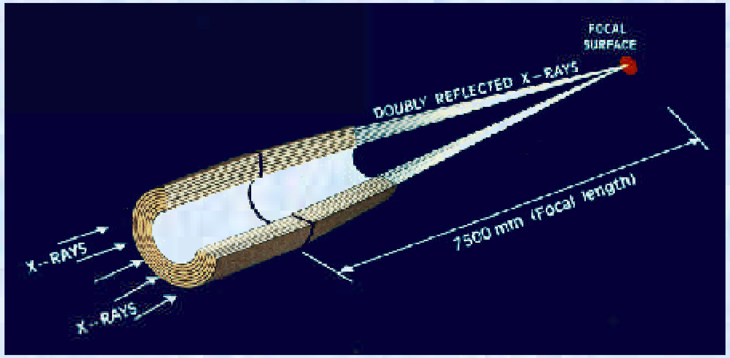
Giovanni Pareschi & Philippe Ferrando

(on behalf of a large collaboration of French, Italian & German researchers)

The 10 keV sensitivity gap reason

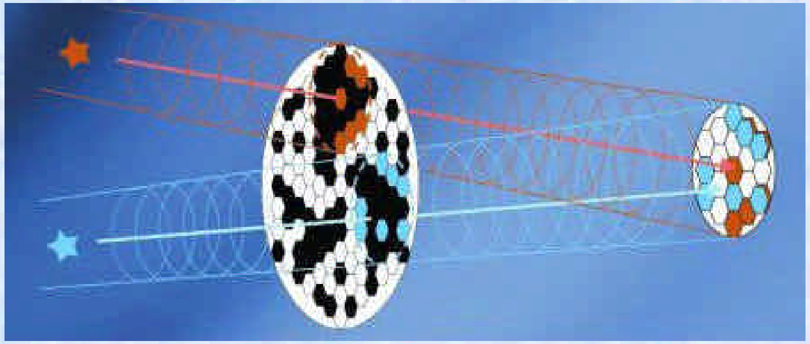
XMM–Newton





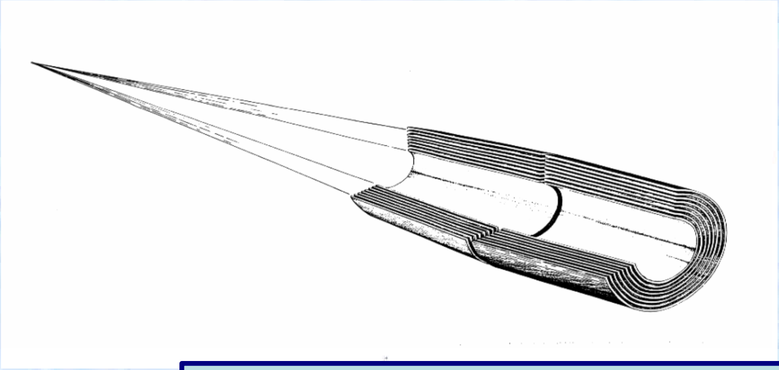
0.1–10 keV : focusing optics
Spatial resolution : 15 arcsec
High signal to noise

INTEGRAL



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

The focusing problem in the hard X-ray region (> 10 keV)



$Aeff » F^2 \, x \, q_c^2 \, x \, R^2$

F = foca

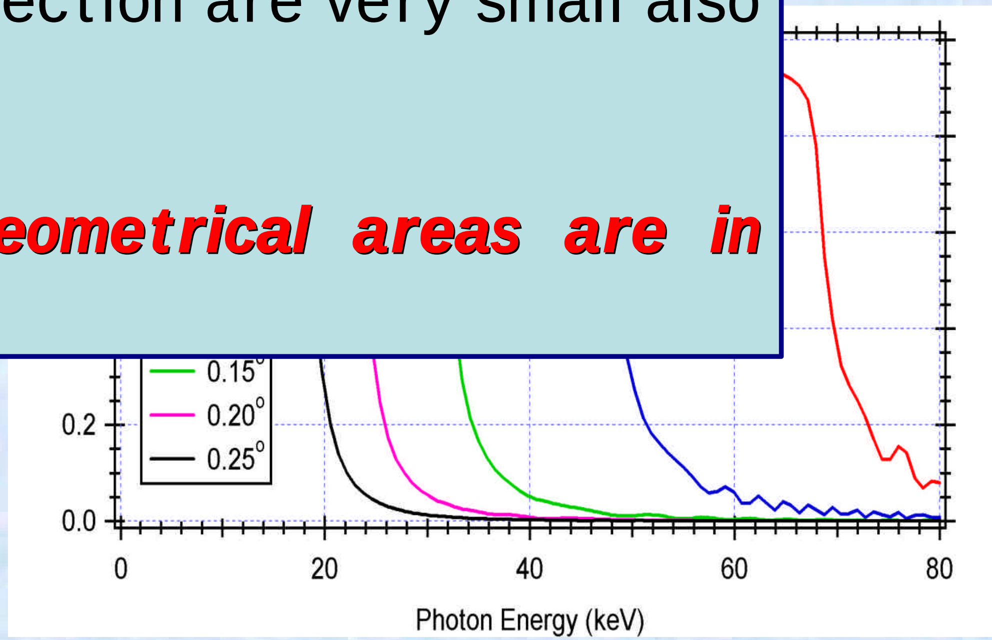
L = mirro

At photon energies > 10 keV the cut-off angles for total reflection are very small also for heavy metals

➔ ***the attained geometrical areas are in general <u>negligible</u>***

b

E



SIMBOL-X telescope: driving design criteria

- use of high density materials coatings or multilayer mirrors (➔ *increase of the reflection angles*)

- possibility to use the Ni replication technology for ***monolithic*** optics (➔ already available and consolidated technology)

- maximum diameter compatible with the standard superpolishing techniques already used for XMM

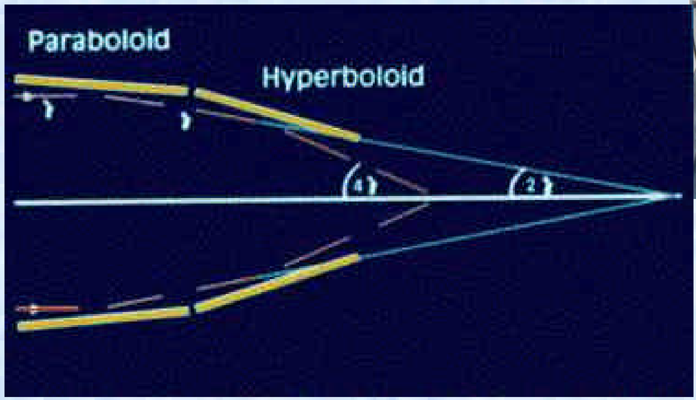
- *low reflecting angles* but, at the same time, large collecting areas ➔ ***long focal length***

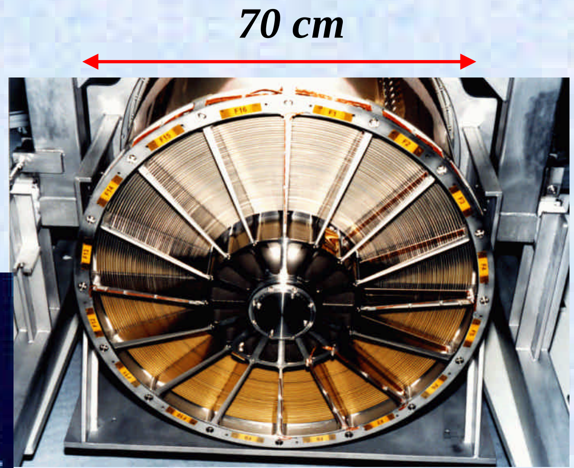
⬇

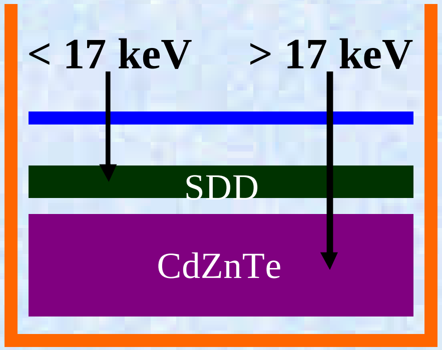
the Formation Flight architecture allow us to implement this concept!

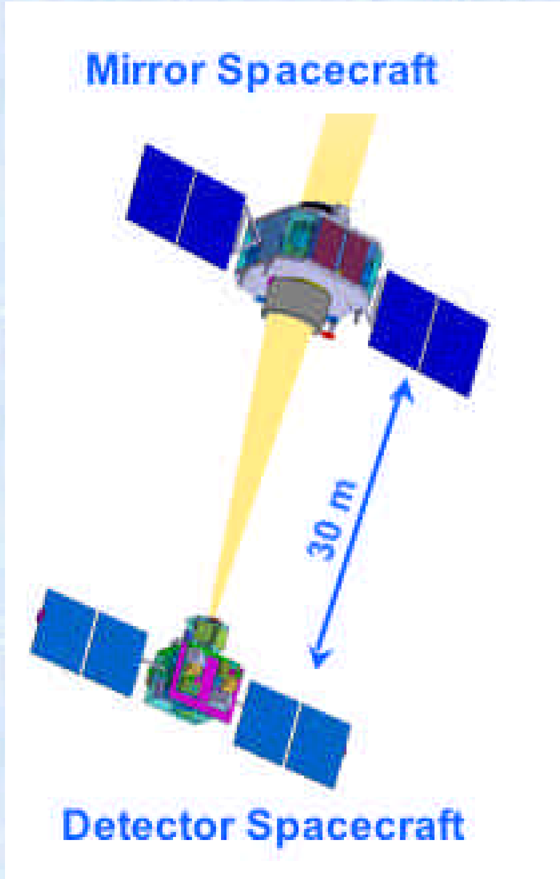
The way to go : extend focusing into hard X-rays domain

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

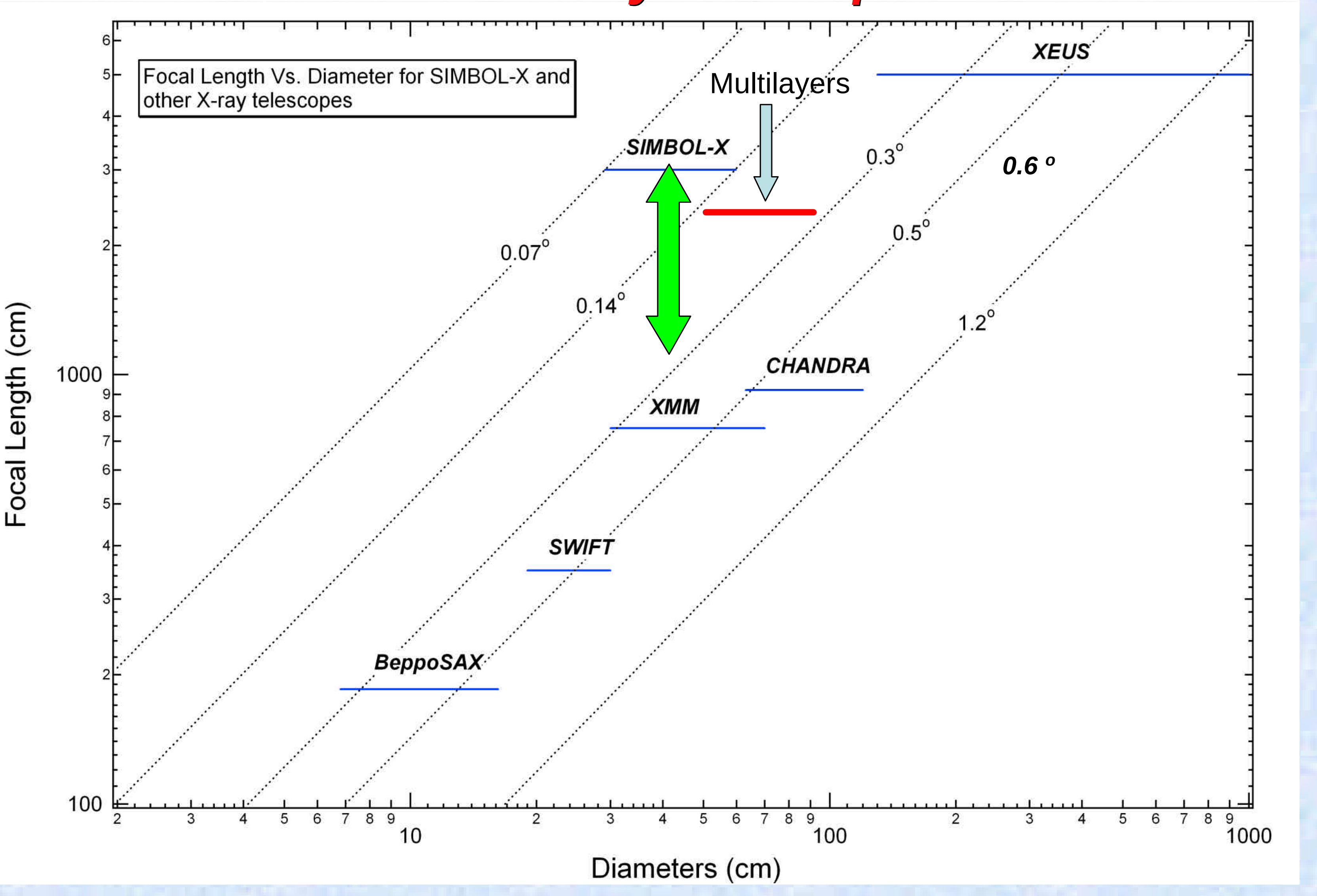






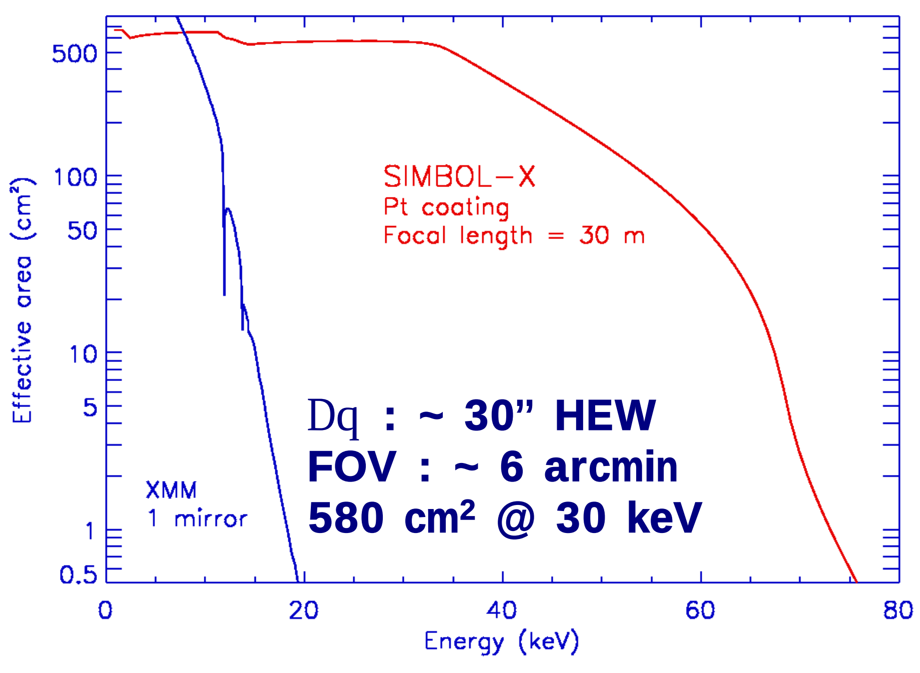


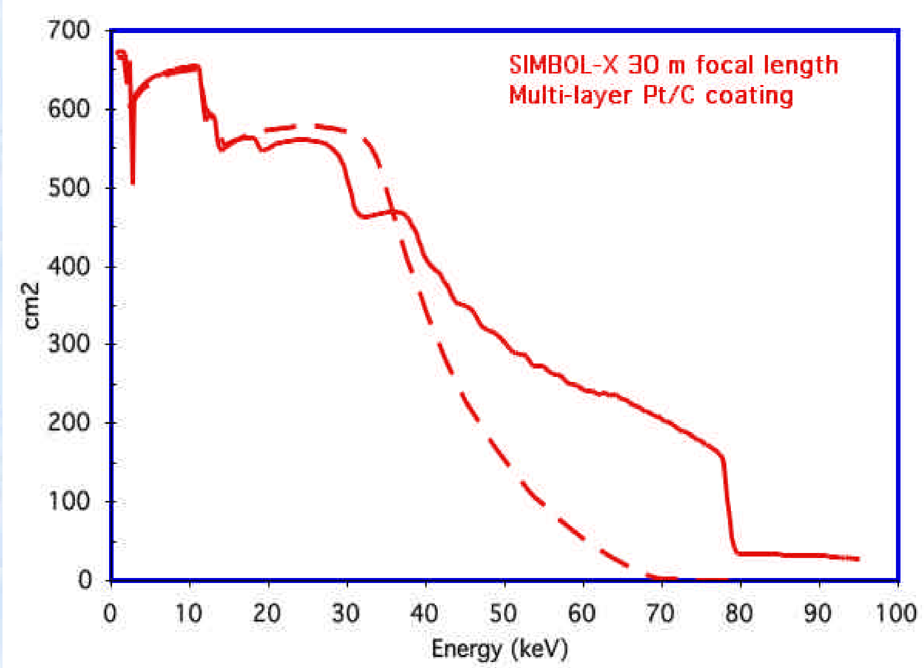
Focal Length Vs. Diameters for SIMBOL-X and other X-ray telescopes



Optics & coating

- **Heritage from XMM–Newton : nickel shells obtained by electroforming replication method; low mass obtained via a reduced thickness of shells**

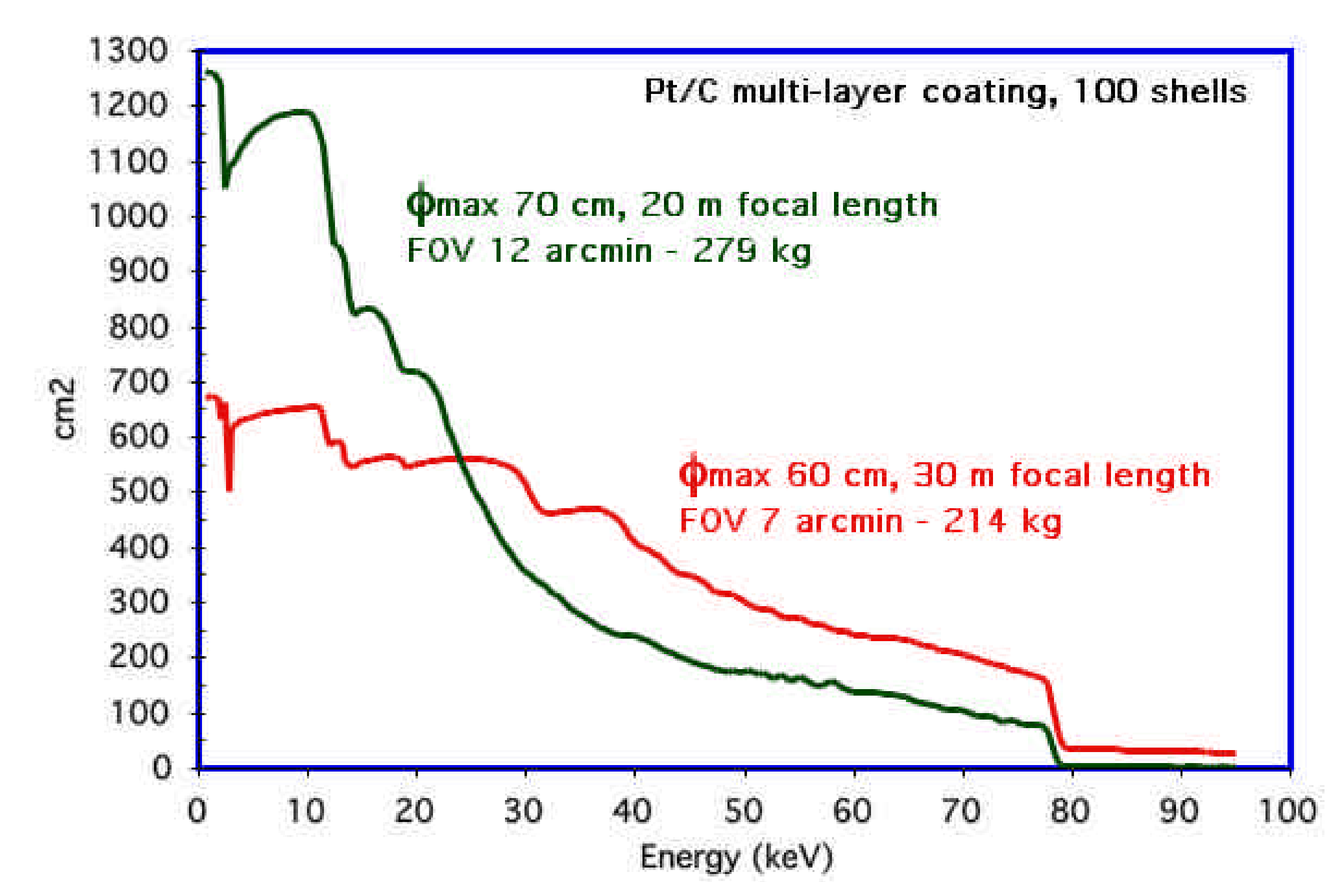




Shell diameters : 290 to 600 mm
Angles : 0.07° to 0.142°
Shell thickness : 0.12 to 0.30 mm
Number of shells : 100
Pt coating
Total mass : 213 kg

Same parameters except for coating, Pt/C multi layer
Strong increase of response above 40 keV
Small increase of field of view : 7 arcmin

Optics, shorter focal length option



- Strong increase of FOV and gain in plate scale, but less effective area above 25 keV, compensated by a smaller focal spot (➔ less background counts)
- Trade-off to be performed between FOV, effective area, and mission constraints during phase A

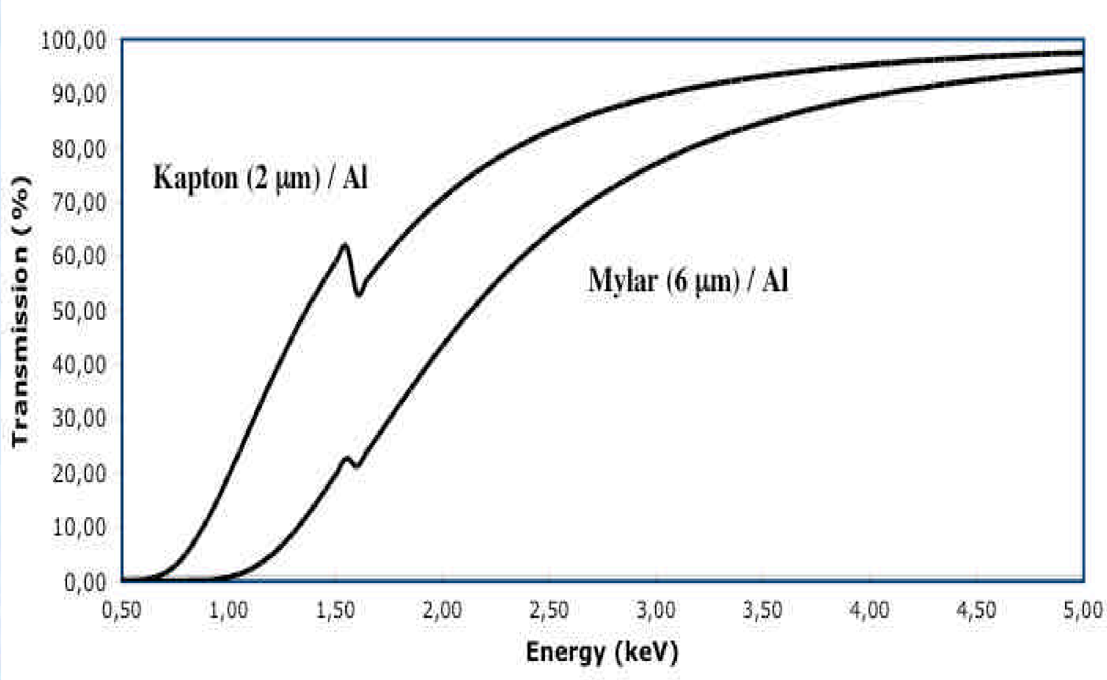
Simbol-X "nominal" characteristics and potential improvements

	Pt coating	Multi-layer
Energy range :	0.5–70 keV	0.5 - 80 keV
Resolution :	~ 130 eV @ 6 keV ~ 2 keV @ 60 keV	1 keV @ 60 keV
Angular resol. :	< 30 arcsec (local. < 3 arcsec) goal 15 arcsec	
Field of View :	6 arcmin	7 - 12 arcmin
Effective area :	> 550 cm^2 E < 35 keV 150 cm^2 @ 50 keV 2 cm^2 @ 70 keV	200 cm^2 @ 70 keV up to ~ 80 keV
Sensitivity :	10^{-8} ph/cm^2/s/keV (E < 40 keV) (3 s, 1 Ms, DE = E/2)	

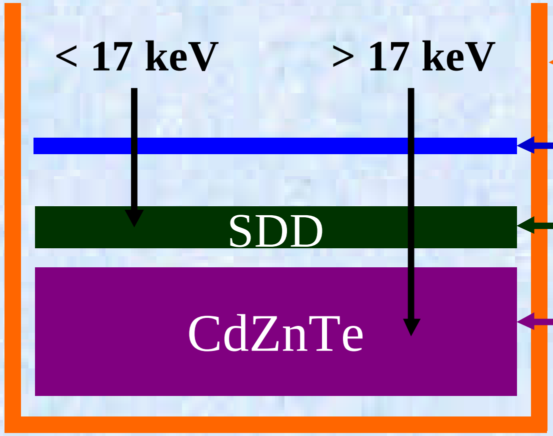
Mirror thermal control and low energy limit

- If mirror fully open to space (2 sides), then a very strong thermal control is needed, with ~ 200 W of heating power, and potential difficulties to ensure necessary homogeneity

- Thermal problem is much relaxed (down to ~ 20 W) by closing mirror apertures with a single foil (on each side) of insulating material
- But cost : loss of very low energies



Focal plane

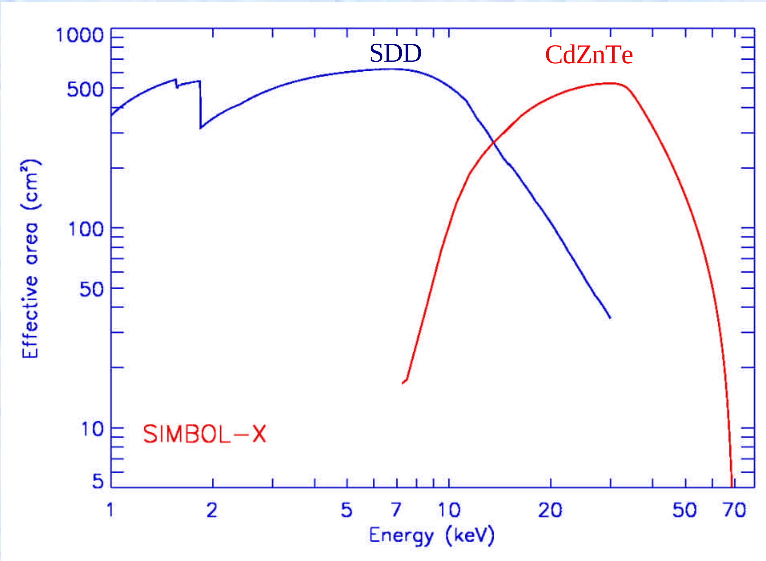


Active anticoincidence

Optical filter (0.1 mm Al)

Low energy detector (450 mm Silicium)

High energy detector (2 mm Cd(Zn)Te)

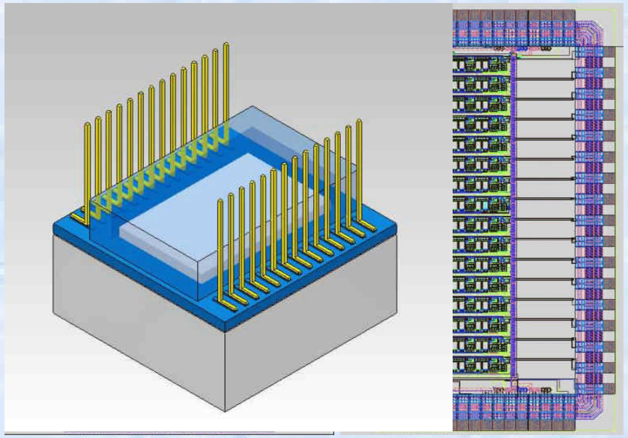


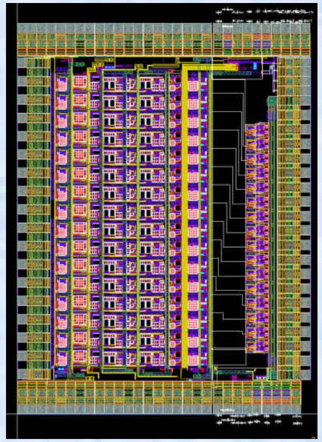
Requirements

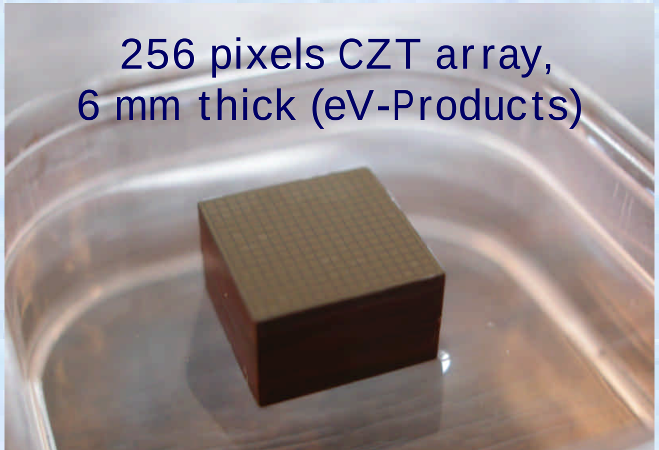
- Pixel size of ~ 500 mm (gives good oversampling of the few mm PSF)
- Full diameter of focal plane : 6 cm
- Fast response detectors for full anticoincidence scheme
- Operation at “room” temperature
- Low energy response down to ~ 1 keV
- Good spectral resolution for Iron line

High Energy Detector : R&D in CEA (CNES funded)

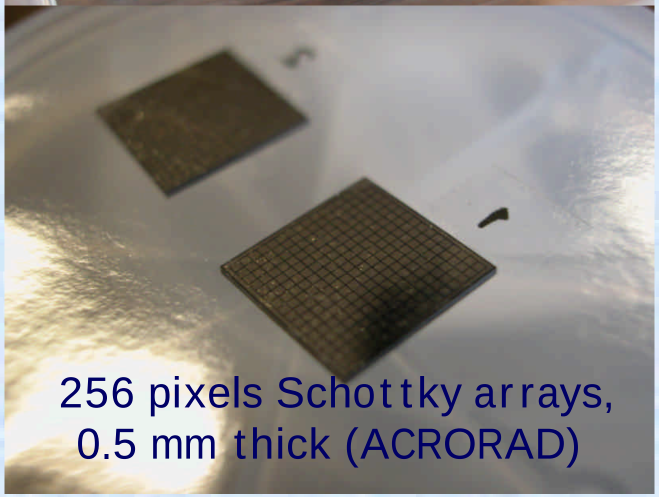
- **Tests pixellated Cd(Zn)Te matrices**
- **ASICs development (IDeF-X Vx.x)**
- **Hybridization**



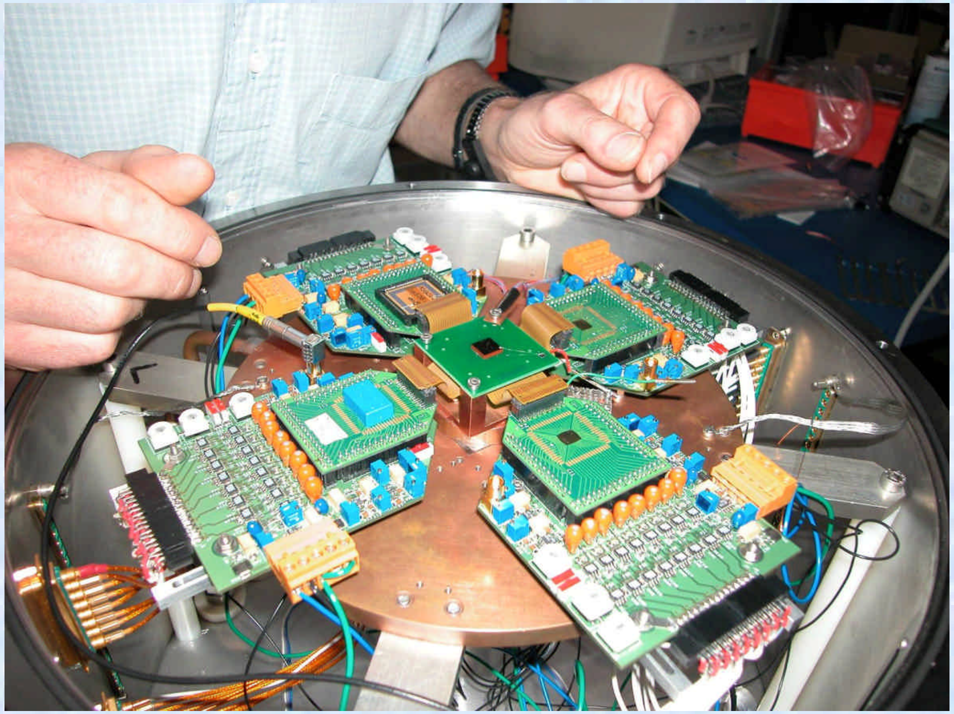




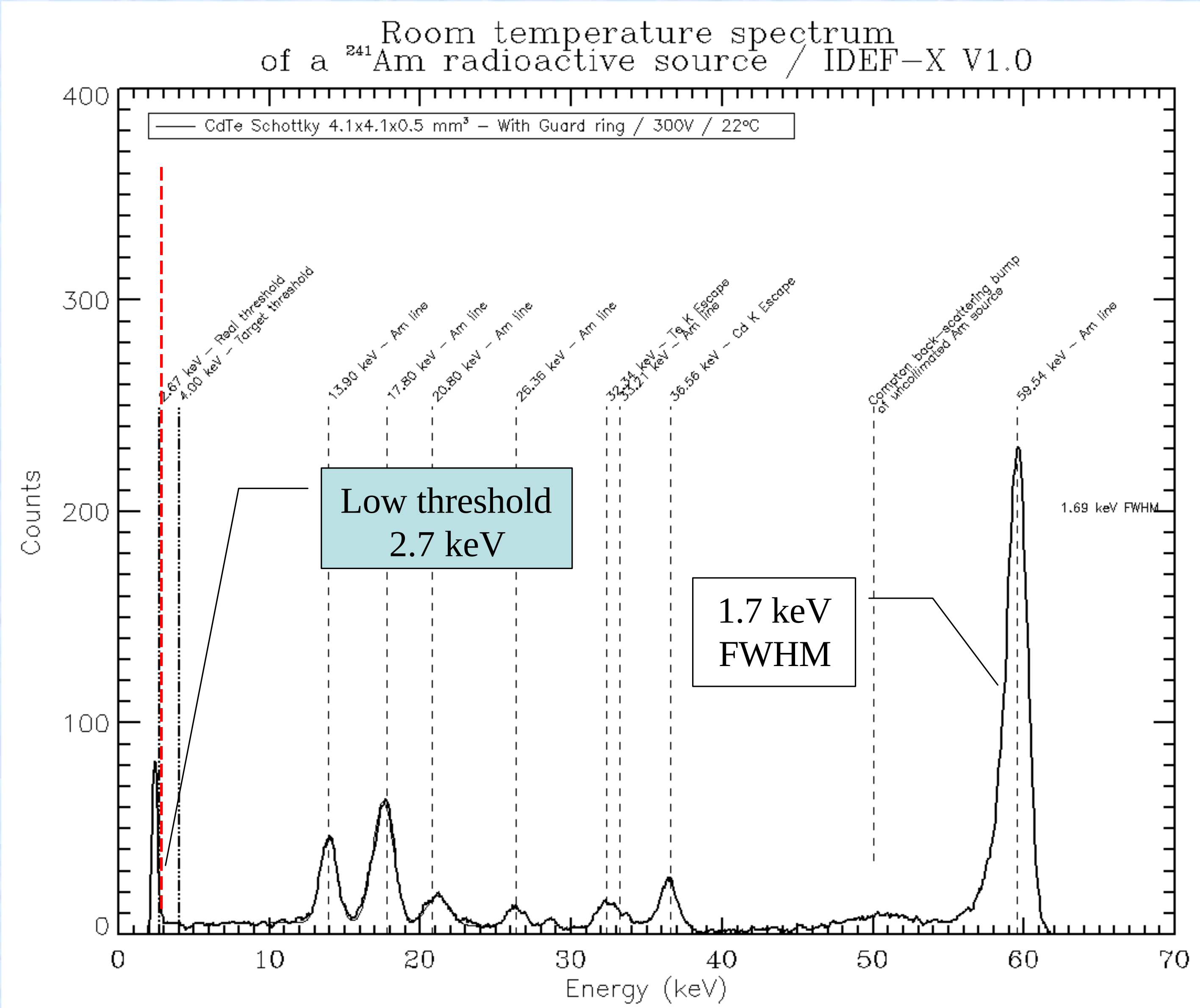
256 pixels CZT array,
6 mm thick (eV-Products)



256 pixels Schottky arrays,
0.5 mm thick (ACRORAD)

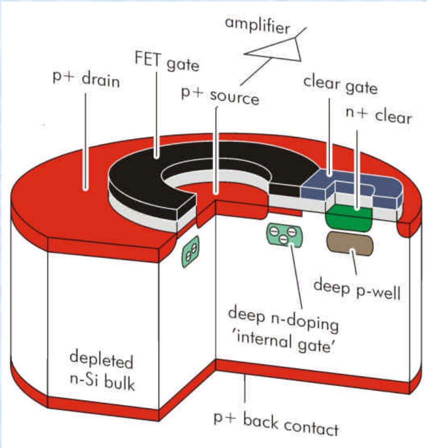


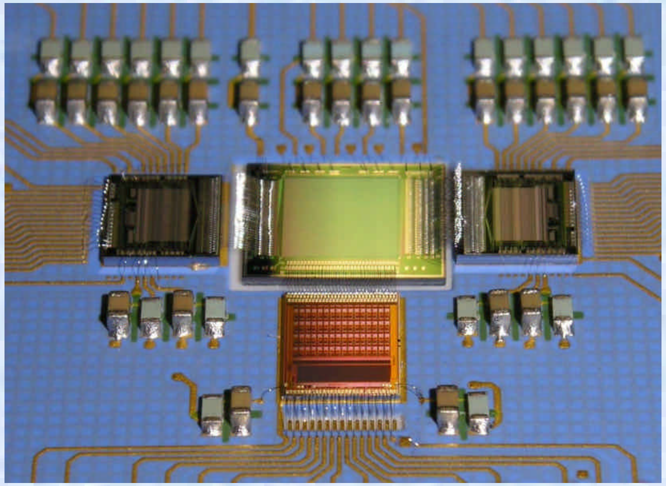
R&D in CEA, first light of IDeF-X V1.0

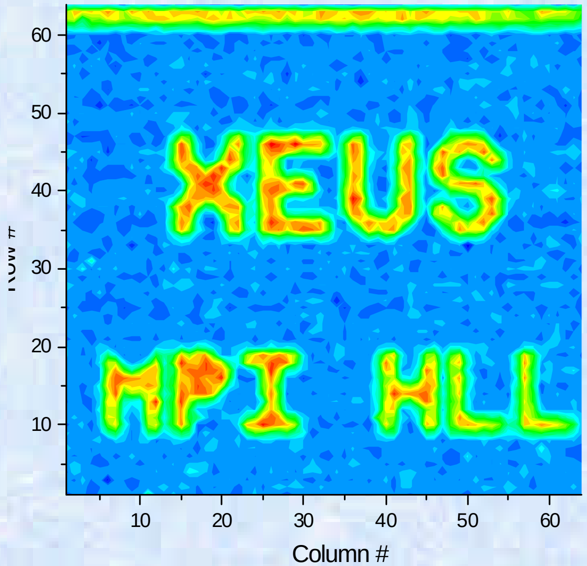


Low energy detector

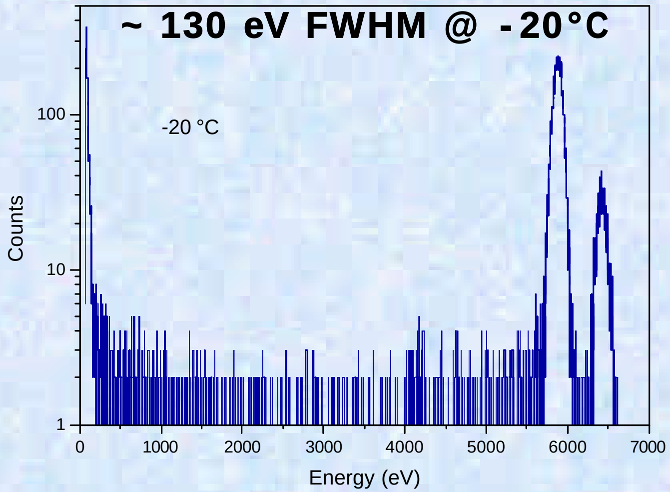
Silicon Drift Detector matrix with integrated DEPFET



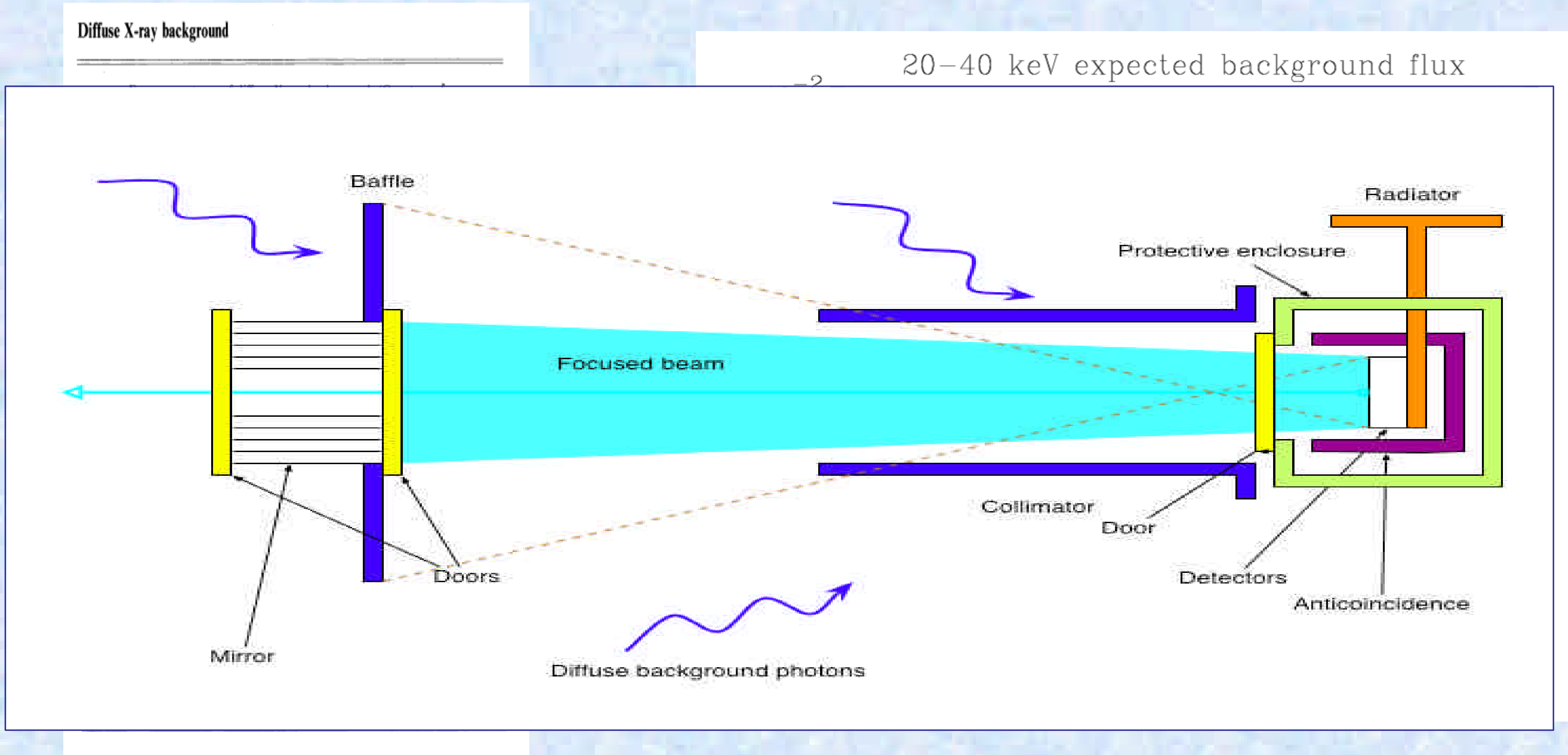




- Low power consumption
- Internal amplification
- Room temperature operations
- Active Pixel Sensor type
- 100 % filling factor
- Adjustable pixel size (50 mm to 1 mm)
- Fast, parallel readout possible

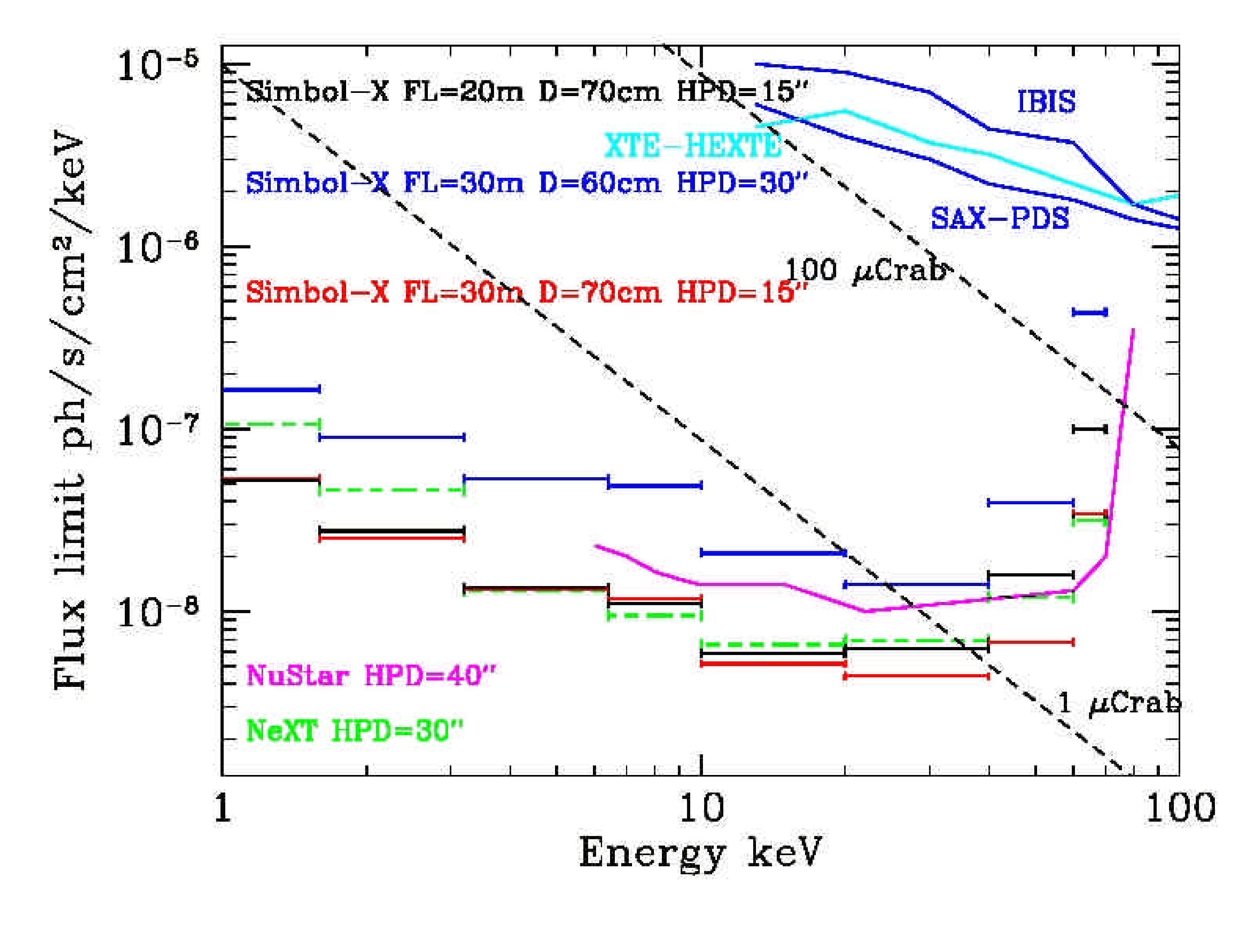


Collimator & sky-shield optimization

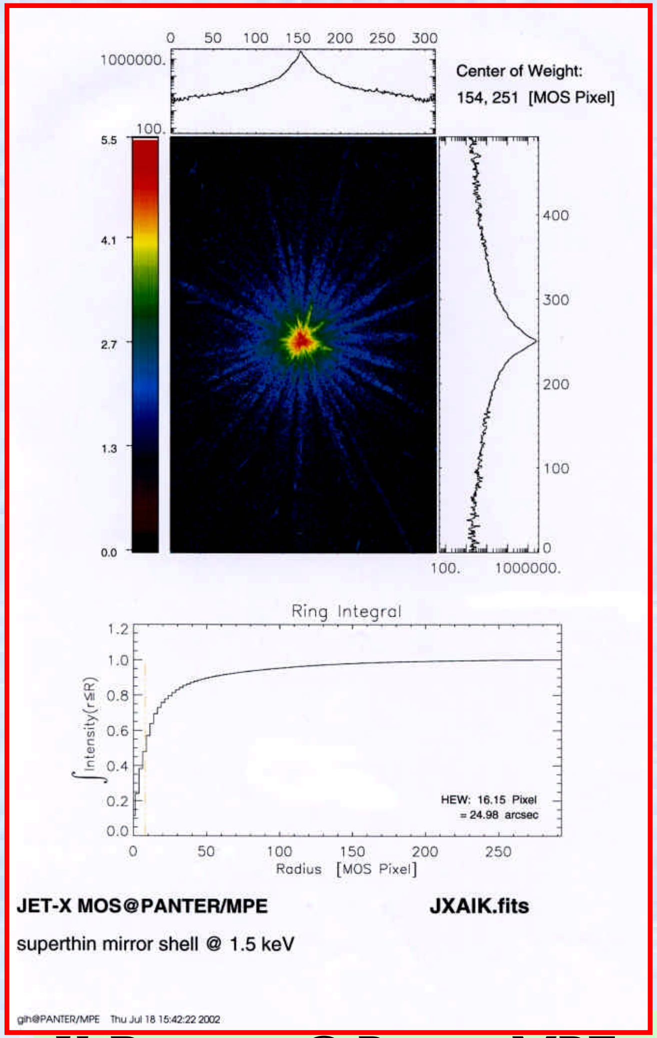


To obtain ~1´10^{-4} cts cm-2 s-1 keV-1
the collimator FOV must be < 3°

Flux sensitivity

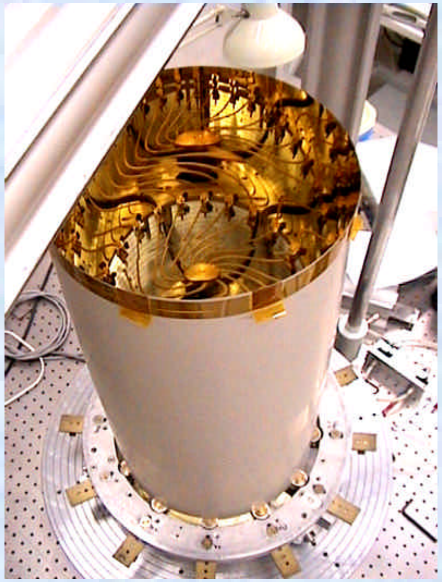


X-ray imaging test of a thin JET-X mirror shell



X-Ray test @ Panter-MPE (July '02) - **E = 1.5 keV**

- diam. = 30 cm
- thickness = 130 μm
- wall thickness ***8.5 times*** less than JET-X and ***3.4 times*** less than XMM



HEW$_{meas}$ = 25 arcsec

Simbol-X : conclusion and next phases

- Results of assessment phase : Simbol-X is mature, and well in the 30 % required margin in this study phase (total mass 2.2 tons with all system and sub-system margins, for a Soyuz capability of 2.3 tons) ➔ talk by R. Cledassou
- No show-stoppers identified neither for the formation flying, nor for the payload

- Selection for phase A (2 missions) in October 2005
- End of phase A, and selection of the flying mission : end 2006
- Launch date for Simbol-X : end of 2012
- Operations : 2.5-3 years, with a requirement of 2 full years of science data taking, and over 1000 targets possible

• **Expression of a strong interest of ASI for a large involvement in the mission. Discussions under finalization between CNES and ASI for doing a common phase A.**

July – September 2005: Scientific topics and requirement document prepared by representative of the French & Italian community with the endorsement of ASI & CNES ➔ very important to fix a common baseline for pursuing the Phase A study

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P. Caraveo
S. Mereghetti
G. Malaguti
G. Cusumano
G. Pareschi

Thanks !