# The International X-ray Observatory (IXO)

# Mission Concept

1 – Introduction

2 – IXO mission requirements and spacecraft configuration
– Instrument module
– Service module
– Mirror assembly

3 – Summary

# International X-ray Observatory (IXO): terms of reference

A proposal for a joint ESA/JAXA/NASA study of an International X-ray Observatory was accepted at an ESA-NASA bilateral meeting on 2008, July 14, with JAXA concurrence. Input elements to IXO configuration include:

1 - A single large X-ray mirror assembly compatible with both pore optics and slumped glass technology

2 - An extensible optical bench to reach F=20 to 25m + ways to maximise Aeff above 6 keV

3 - Instruments include a wide field imager, a high resolution non-dispersive spectrometer, an X-ray grating spectrometer + instruments with modest resources

4 - The IXO concept must be compatible with both Ariane 5 and Atlas V 551 launchers.

→ The IXO concept will be the input to the US decadal survey and ESA Cosmic Vision selection process

# IXO assessment study overview (preparation for ESA CV selection)

**1) Preparation phase:** (mid-July 2008 → mid-October 2008)

- Building of an international ESA-JAXA-NASA collaboration scheme
- Definition of the preliminary science requirements and draft payload instrumentation
- IXO mission concept studies by NASA and JAXA

**2) IXO Phase 0 study at ESA:** (CDF1: Oct. 9th → Nov. 11th 2008; CDF2 :Feb. 4th → Mar. 18th 2009) )

→ Definition of a mission concept
→ Consolidated payload definition document + science requirements
→ Input to IXO proposal for NASA decadal survey
→ Preparation of ITT to industry

**4) Two parallel Industry Phase A system studies:** (Phase A: Q2 2009 → Q2 2010)

→ ITT release on May 5th , proposals received and evaluated, kick-off in July 2009

**5) ESA synthesis of the assessment study (Cosmic Vision selection process):** (Q3 2010)

- Mission and payload technical feasibility, technology development status
- Risks, programmatic and cost

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# IXO payload model

1 single large aperture X-ray telescope:

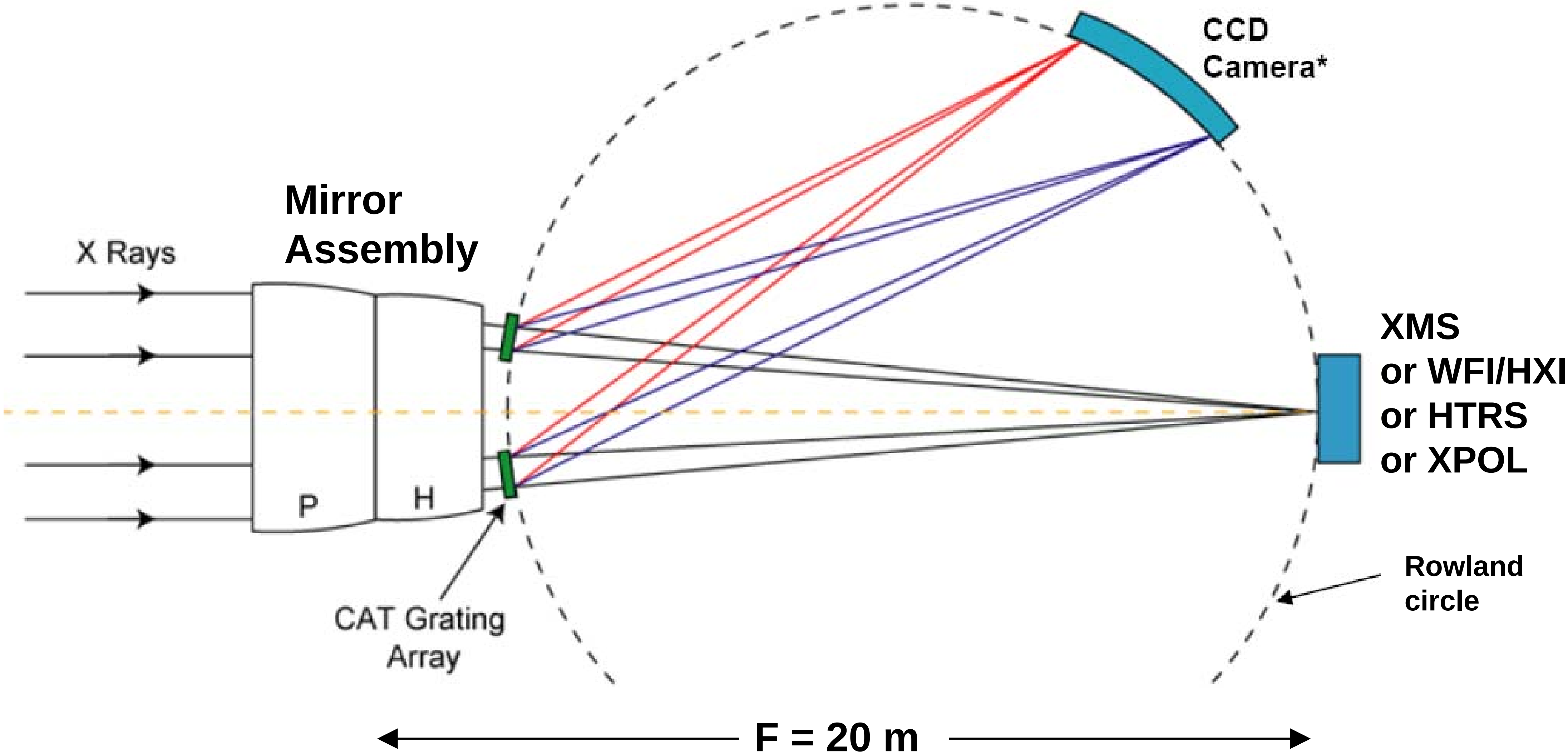
6 instruments:

- Wide Field Imager (WFI)
- Hard X-ray Camera (HXI)
- X-ray Imaging Spectrometer (XMS)
- X-ray Grating Spectrometer (XGS)
- High Time Resolution Spectrometer (HTRS)
- X-ray Polarimeter (XPOL)

# IXO mission requirements: launcher and orbit

- Launcher: Ariane-5 ECA & Atlas V 551
  - Launcher performance Ariane 5 (excl. adapter) ≈ 6170 Kg
  - Launcher performance Atlas V 551 (excl. adapter) ≈ 6108 Kg
- Target Orbit: direct injection into L2 large halo orbit
- 5 years mission (with consumables sized for 10 years operation)
- Launch ≈ 2020

# IXO configuration



# IXO configuration

X-ray telescope with high energy response

→ long telescope focal length

→ **deployable optical bench**

During science operation,

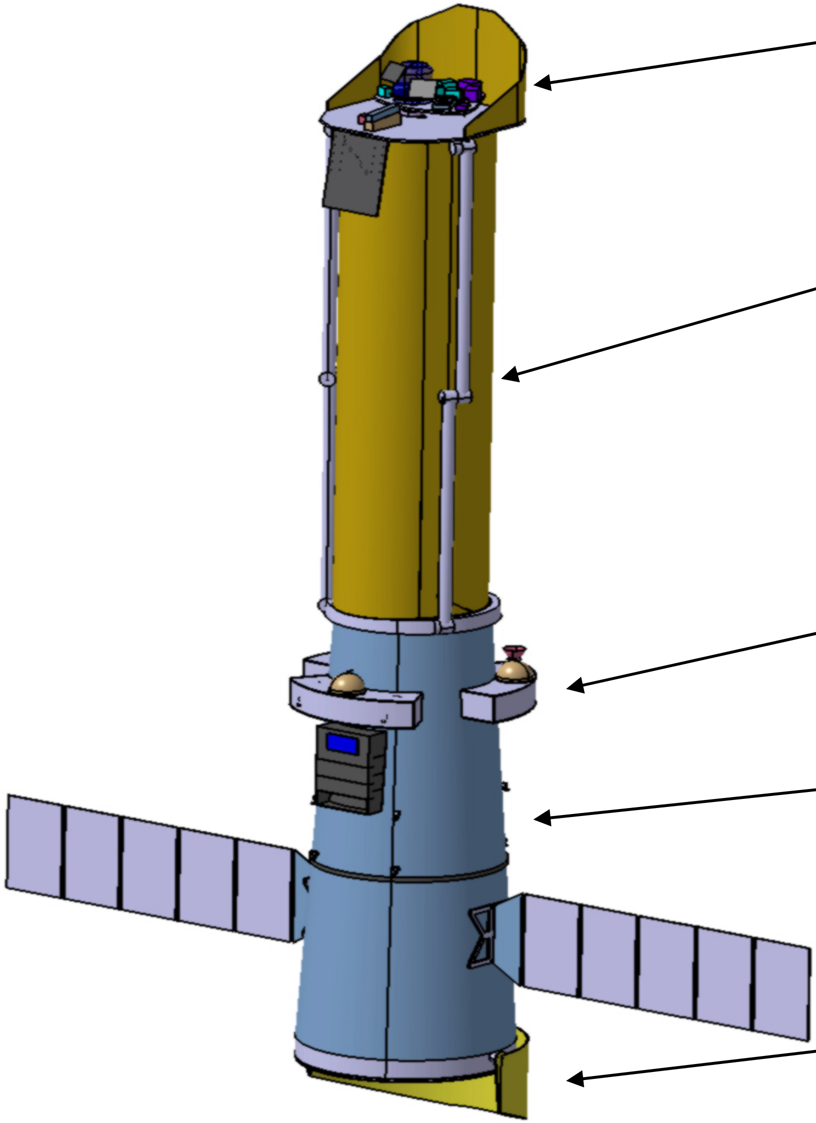
- the grating spectrometer is always operating
- any of the other 5 instruments can be placed at the focus of the X-ray telescope.

→ **instrument exchange mechanism**

The instruments shall be protected from particle background and stray-light

→ **cylindrical baffles and deployable shroud**

# IXO configuration



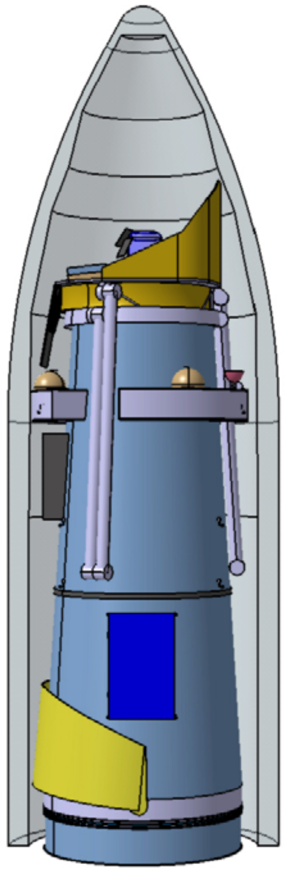
Instrument module

Optical bench deployment mechanism
(+ deployable shroud)

Service module

Fixed conical optical bench

Mirror assembly
(+ deployable sun shield)



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2 – IXO spacecraft configuration

– **Instrument module**

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– Mirror assembly

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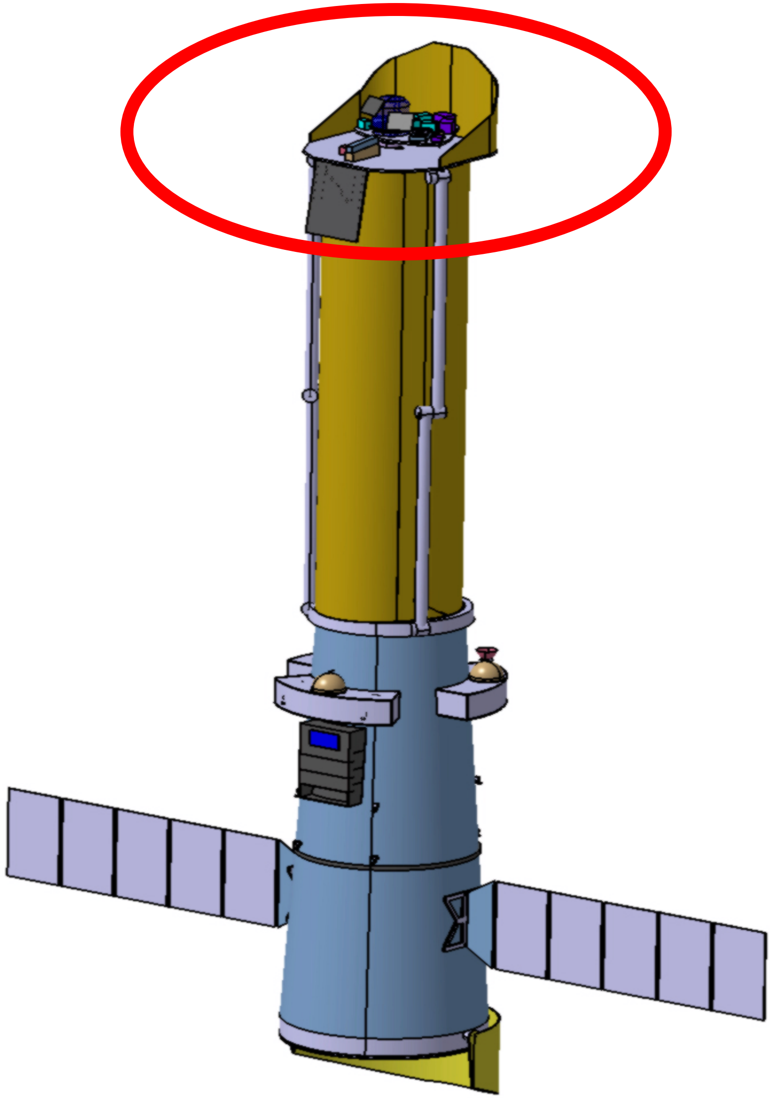
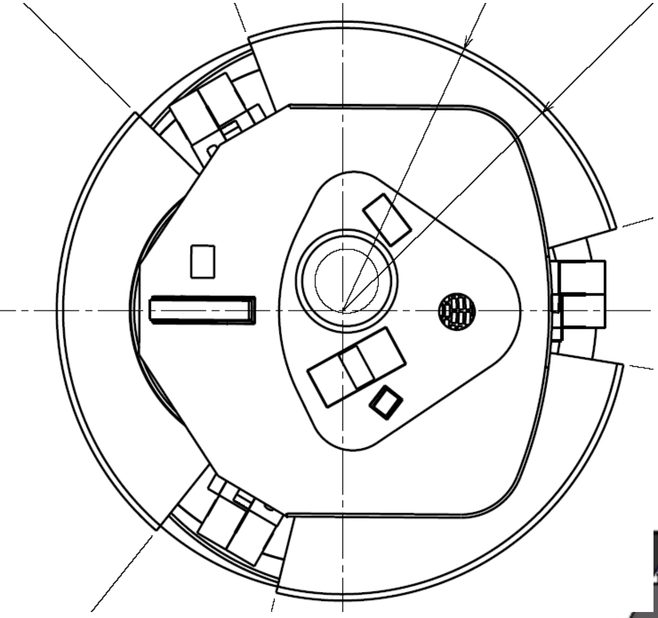
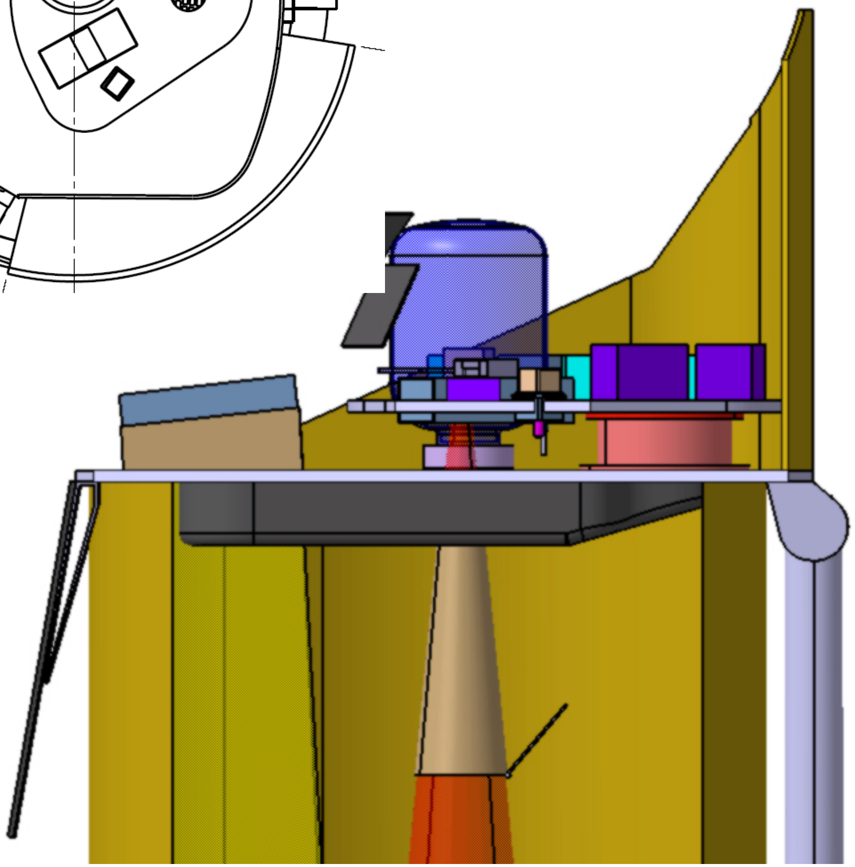


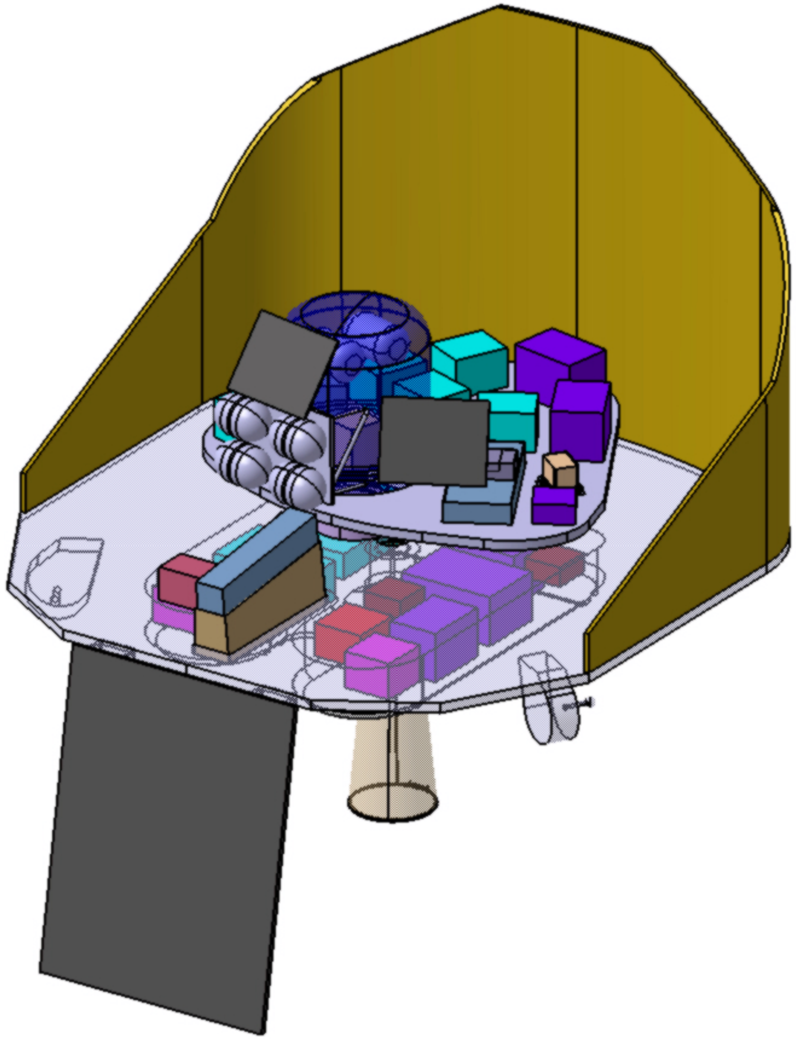
# IXO instrument module: resources summary

| Instrument | Power | Mass | Data rate | Comment |
|---|---|---|---|---|
| WFI | 283 W | 83 kg | < 0.5 Mbps | |
| HXI | 61 W | 33 kg | < 1Mbps | |
| XPOL | 61 W | 11 kg | MM 128 Gbit | |
| HTRS | 165 W | 30 kg | MM TBD | |
| XMS | 1080 W | 352 kg | < 0.84 Mbps | Including ESA cryogenics |
| XGS | 115 W | 51 kg | < 1.5 Mbps | CAT option excluding focussing mechanism |

# IXO instrument module: configuration







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**– Service module**

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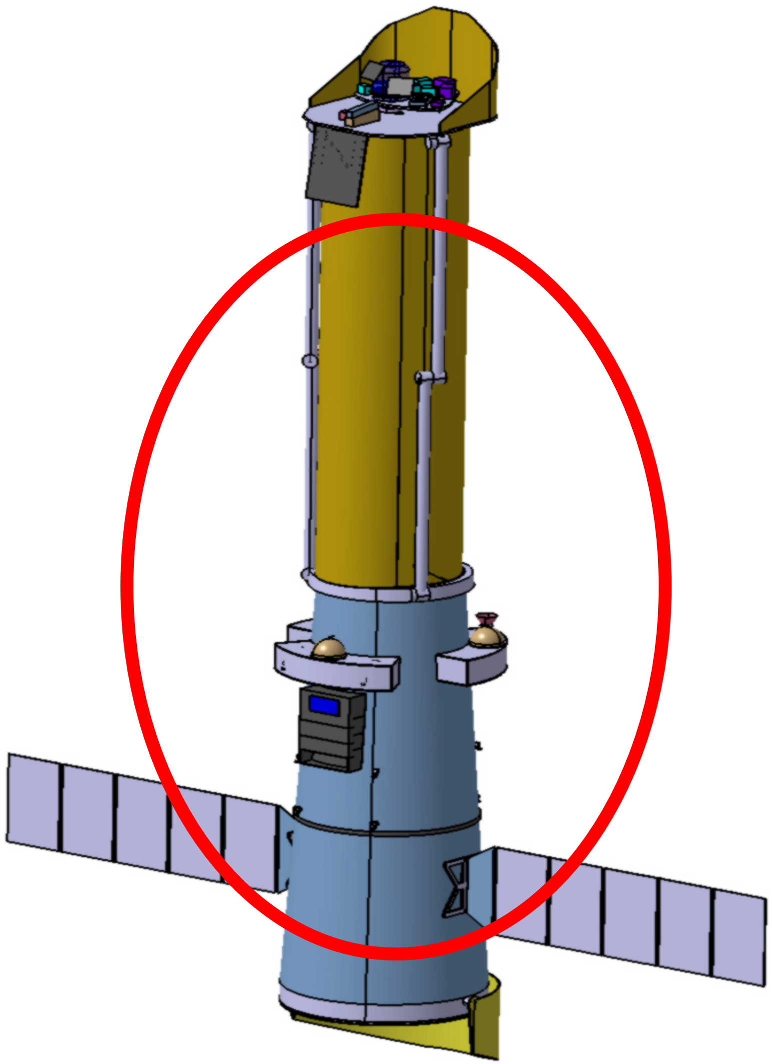


# IXO service module

**Power subsytem:**

- Max- power requirement: 4.5 kW
- 26.4 m2 deployable solar array (Ga As cells)
- Li-ion battery (MA temperature control before Sun acquisition – 650 W during 2 h)

**Telecommunication:**

- 90 Gb/day (8.7 Mbps during 3 hours)
- X bands around 8 GHz (10 MHz band)
- Standard equipment: 10W RF power
  (2 X/X transponder, 2 TWTA, 2 LGA, 1 40cm HGA, 1 RFDU)
- New Norcia 35 m antenna G/S (baseline)

# IXO service module

**Data handling decentralized architecture:**

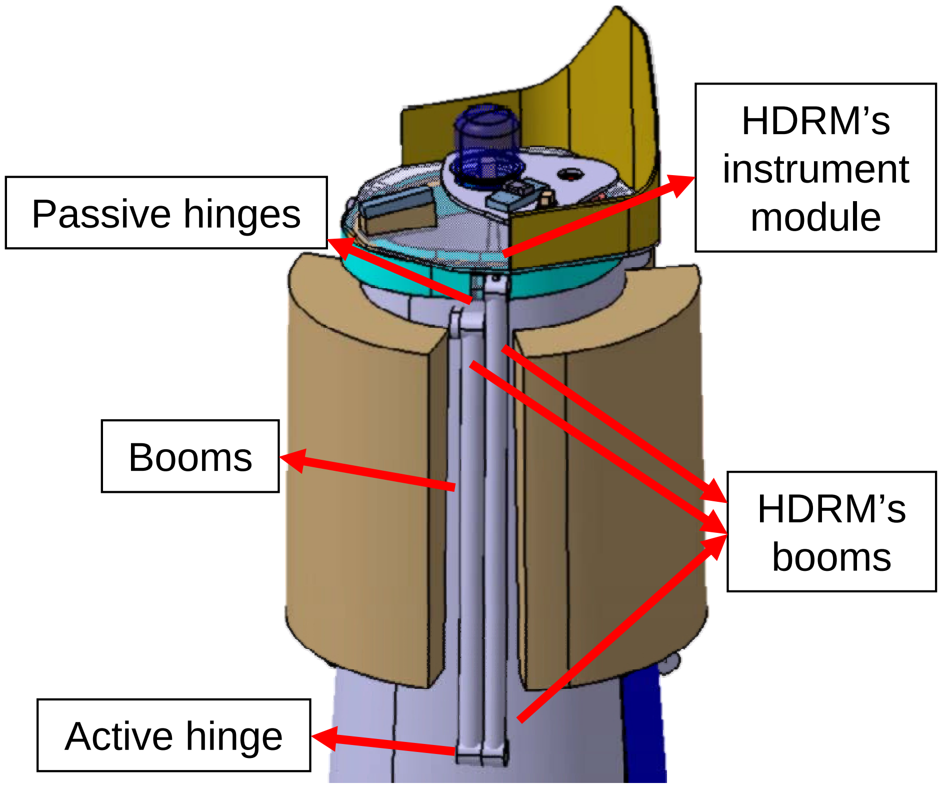
- On Board Computer (OBC) located in the S/C Bus
- Instrument Control Unit (ICU) located on the instrument platform for interfacing the IXO payloads/instruments
- 2 x 250 Gbit memory using SDRAM technology located in the instrument platform

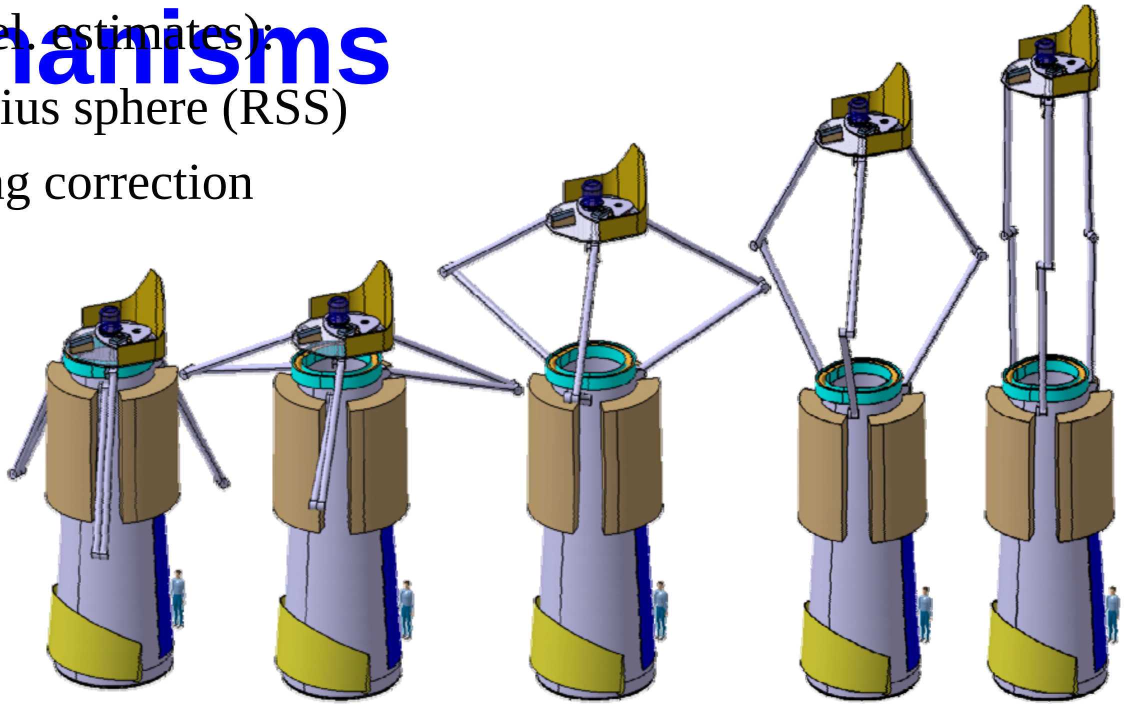
**Propulsion:**

- A bipropellant system (using monomethyl hydrazine and mixed oxydes of nitrogen) is selected:
- 24 20N thrusters
- 6 titanium tanks for propellant (3 fuel and 3 oxidiser) and 1 titanium tank for He pressurant

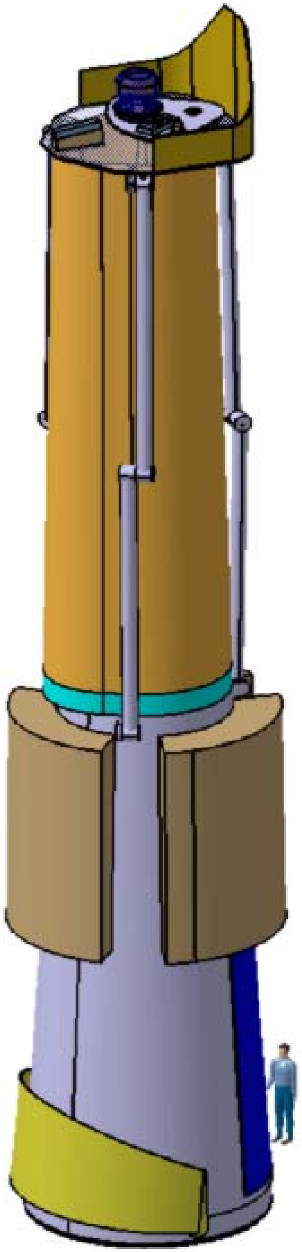
# IXO service module: deployment mechanisms

- Performance in deployed configuration (prel. estimates):
  - Deployment accuracy: 1.2 mm radius sphere (RSS)
  
  → displacement calibration + pointing correction



# Shroud Scale Model



The GSFC Blanket shop created a 1/25th scale prototype that stows to about 7% of nominal extension length. (3.5/49)


49 cm
65 cm max

14.5 cm ID
18 cm OD

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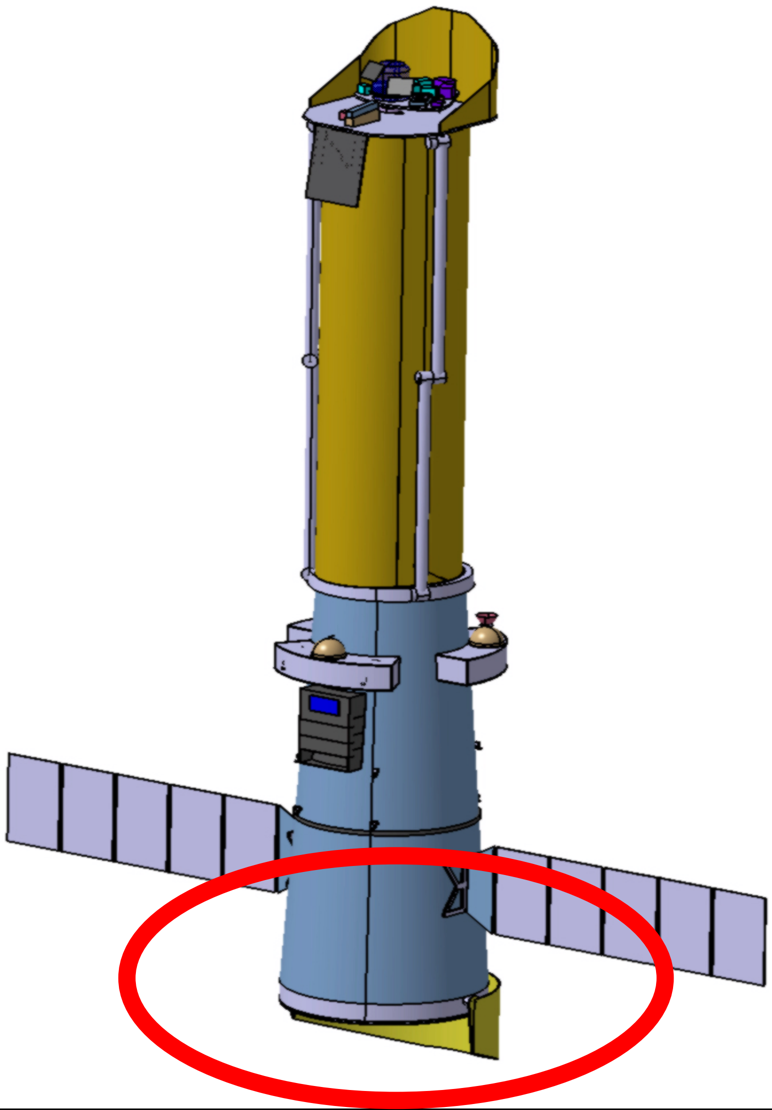
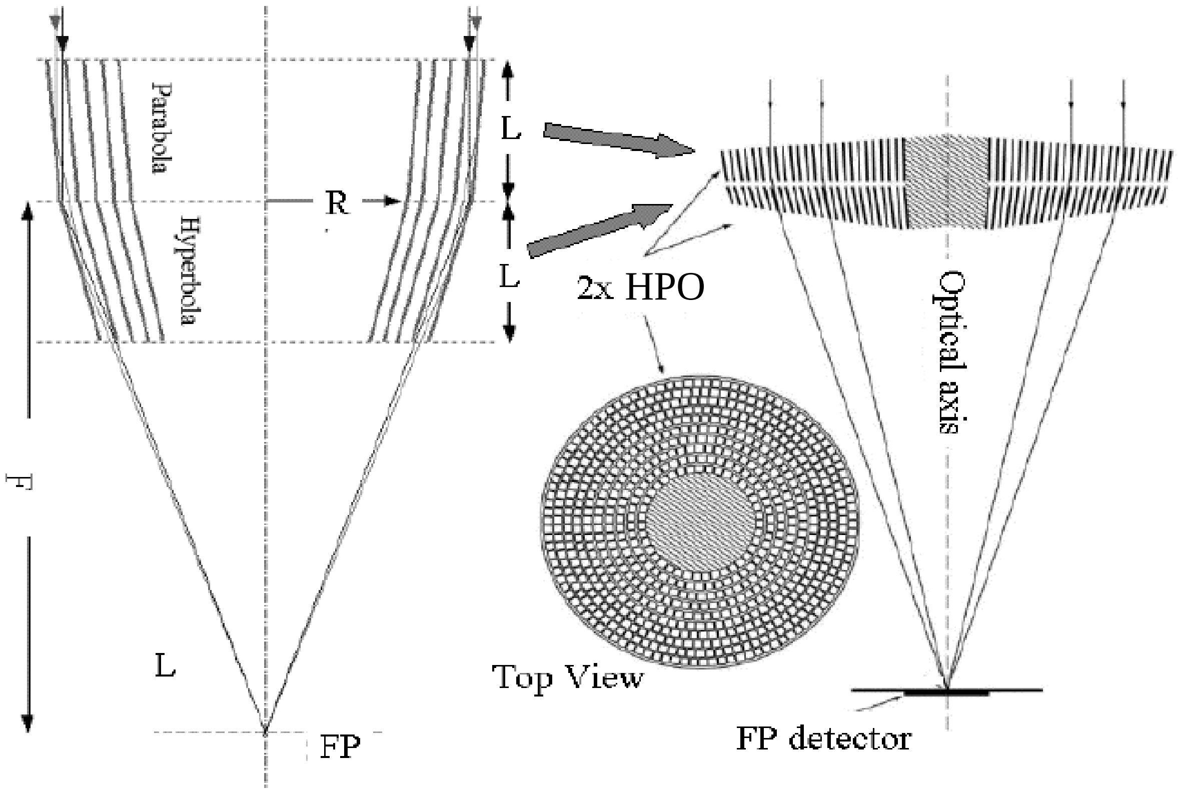
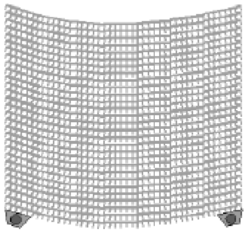


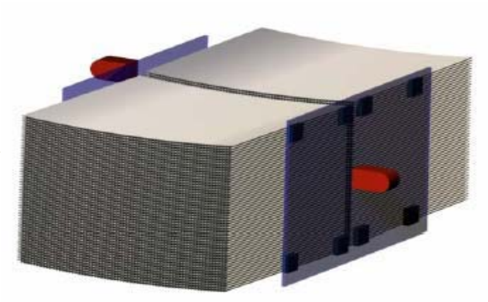
# IXO mirror assembly: requirements

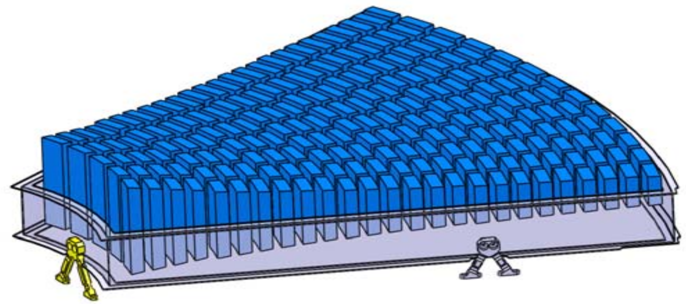


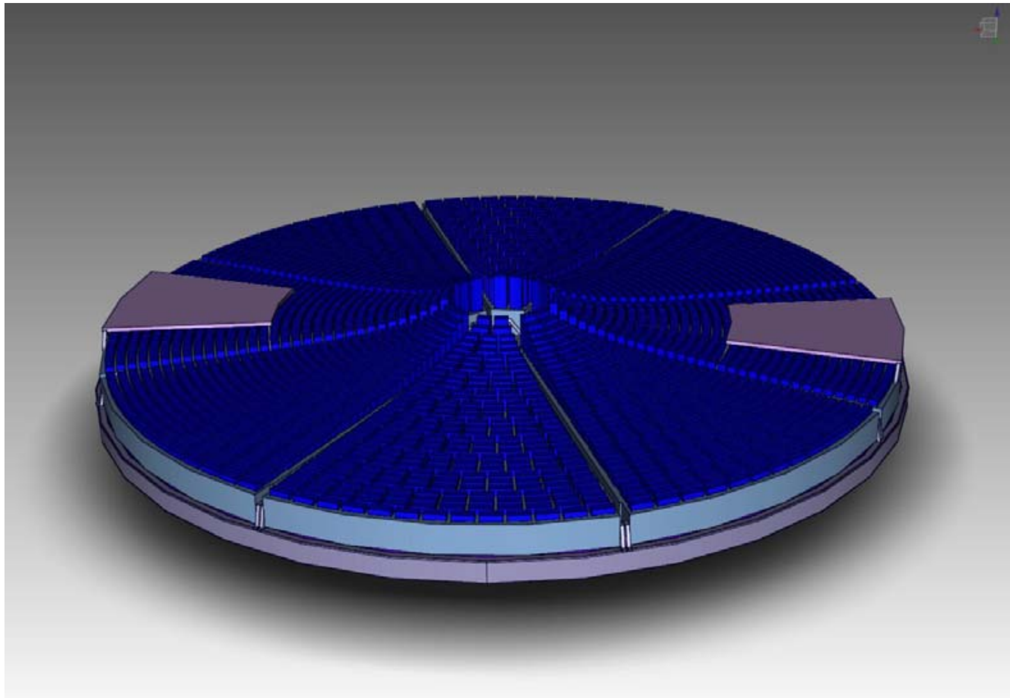

Effective area: 3 m² at 1.25 keV
Image quality: 4.5 arcsec at 1.25 keV
Design: double-conical approx to Wolter I
F = 20 m (accommodation constraints)
FOV = 18 arcmin diameter (WFI)
Technology: pore optics

# IXO mirror assembly: manufacturing conc



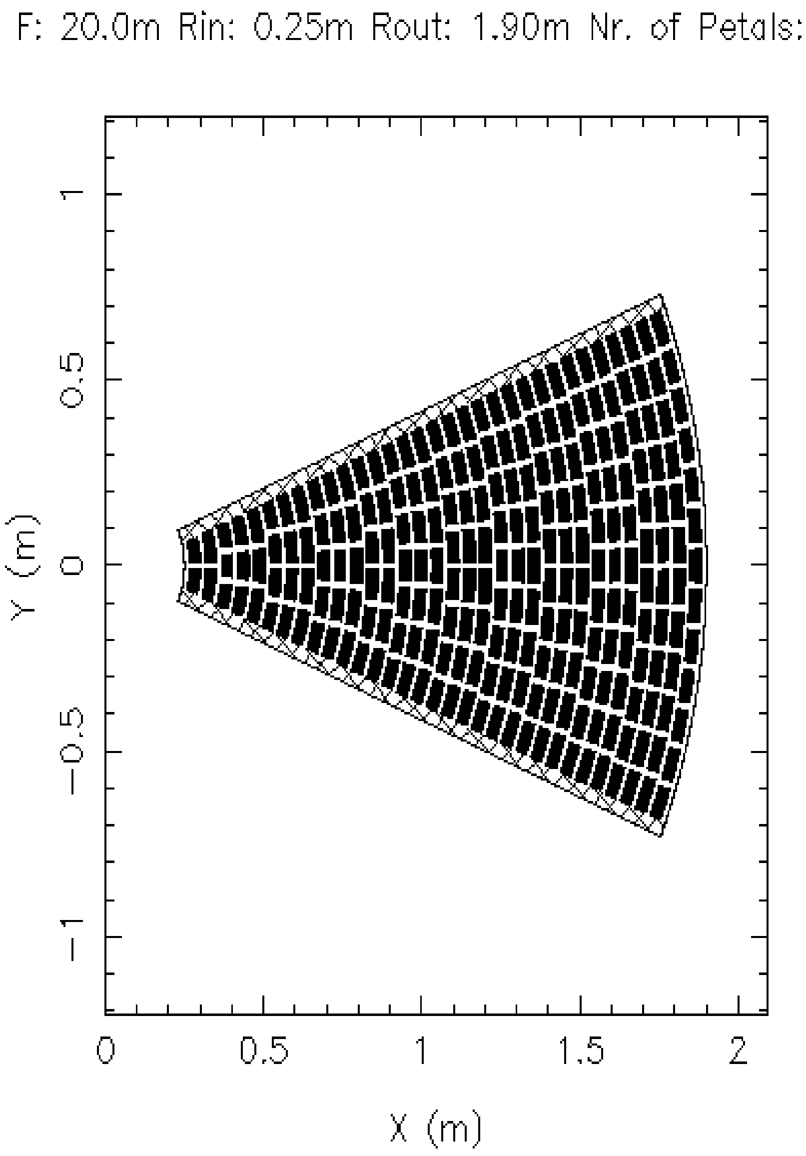






Hierarchical fabrication of mirror assembly
- Mirror stacks
- Mirror module
- Petals
- Optical bench

# IXO mirror assembly: optical design

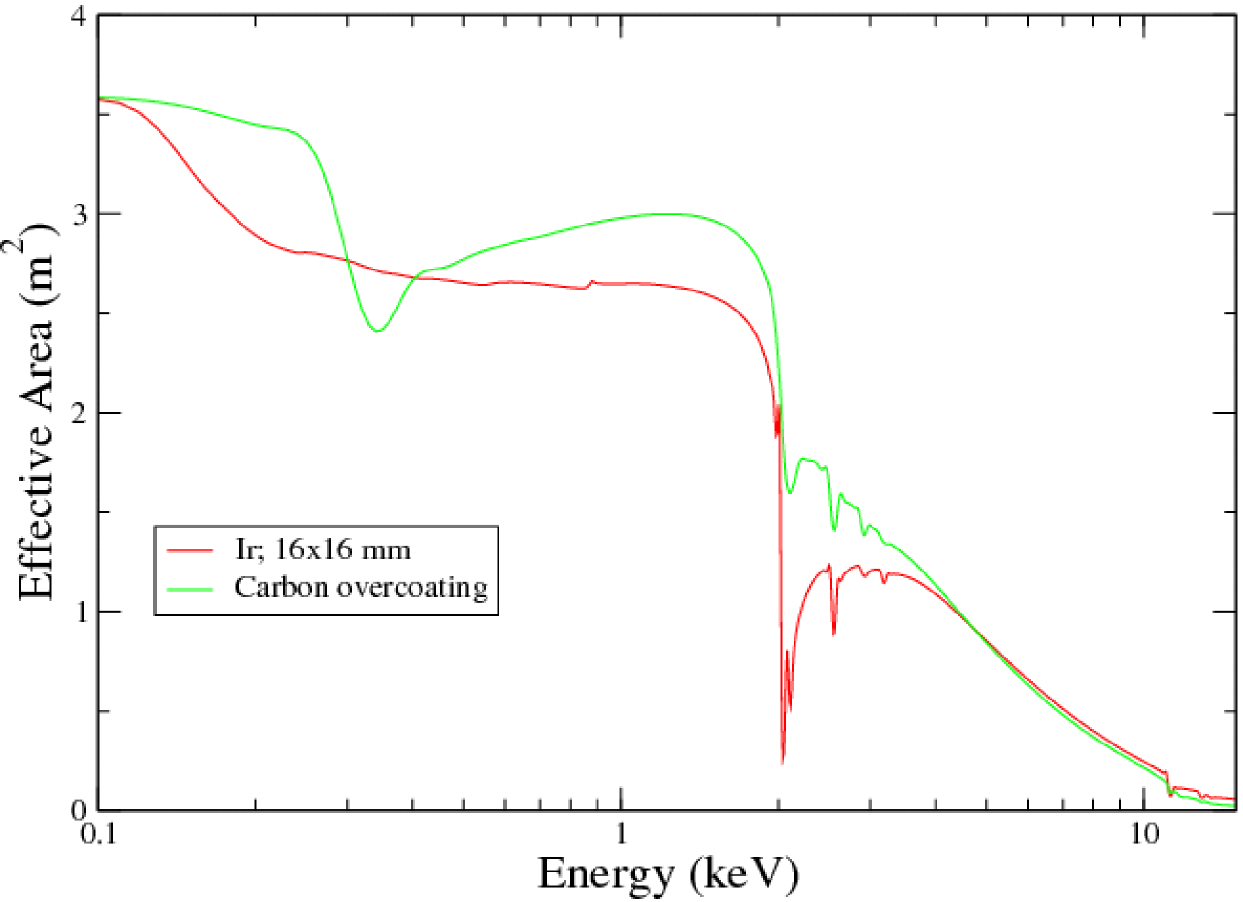



**Optical design assumption:**

- Inner radius 0.25 m, outer radius 1.90 m
- 32 rows
- 236 mirror modules/petal
- spoke width (7cm)

→ **To achieve the 3m2 Aeff requirements, the azimuthal/radial spacing of the mirror modules shall be ≤16 mm**

# IXO mirror assembly: performance estimate




**Without C overcoating:**

Aeff (1.25 keV) ~ 2.6 m2

Aeff (6.00 keV) ~ 0.65 m2

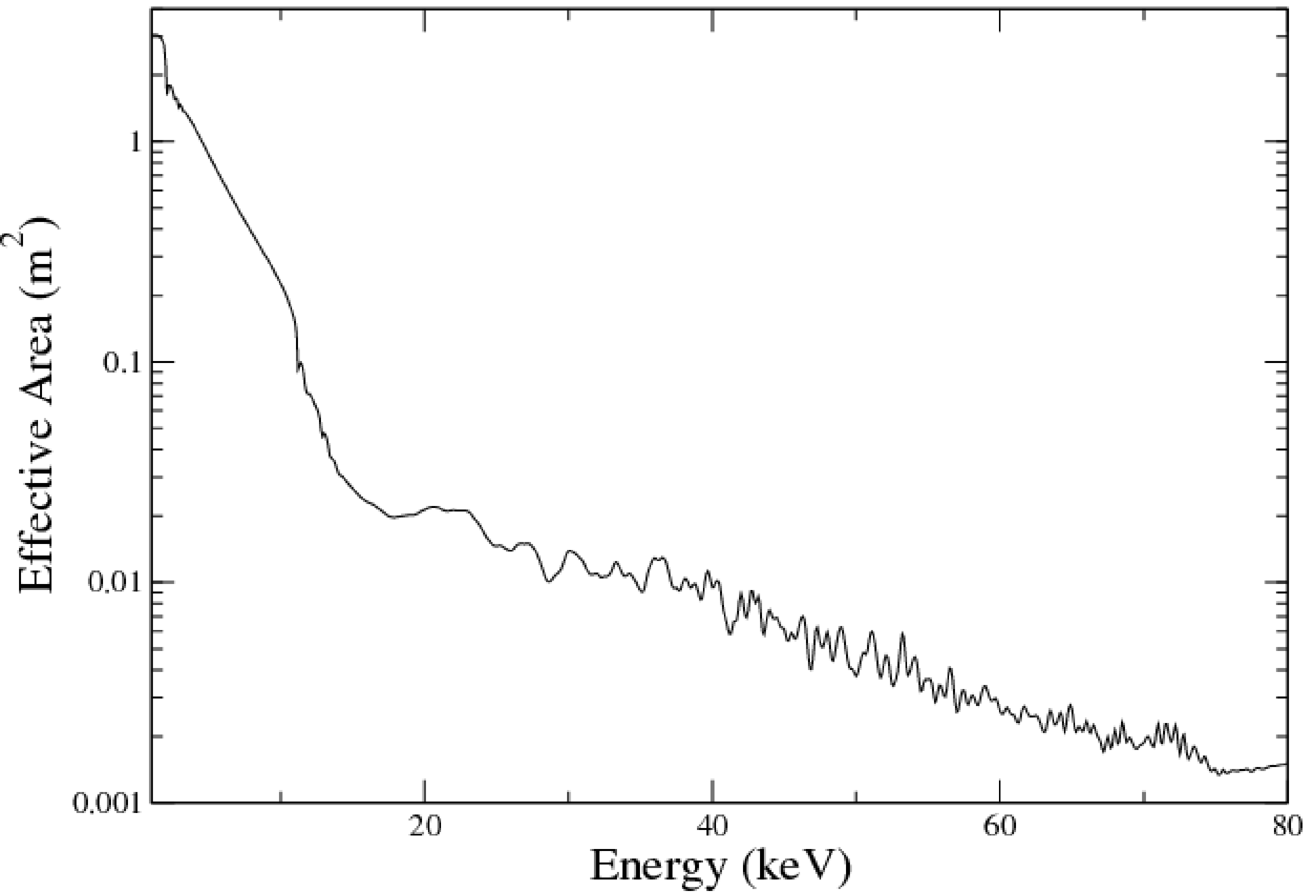
**With 90 Angstrom C overcoating:**

Aeff (1.25 keV) ~ 3.0 m2

Aeff (6.00 keV) ~ 0.65 m2

**To achieve the 3m² Aeff at 1.25 keV requirements, the mirror modules shall be covered with a C overcoating**

# IXO mirror assembly: performance estimate

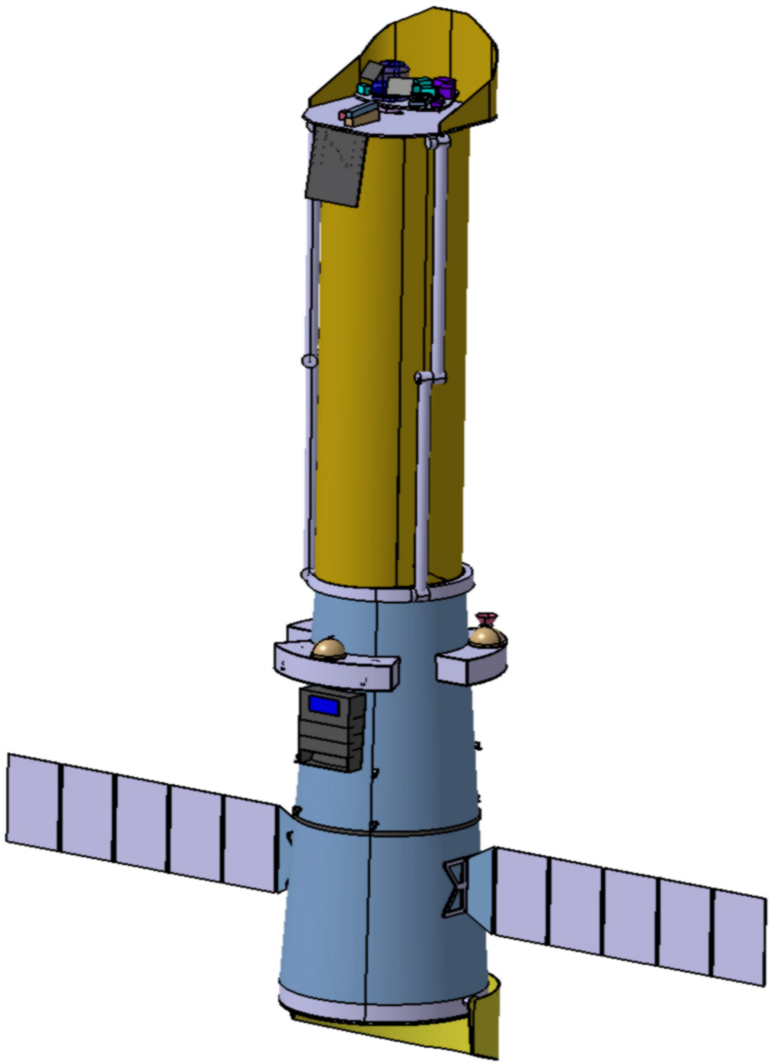



**With JAXA/ISAS multilayer design (courtesy H. Kunieda) on mirrors with grazing incidence lower than 0.342° (R< 0.477 m)**

Aeff (30 keV) ~ 150 cm²

# IXO mission concept summary





| | | |
|---|---|---|
| Mirror Effective Area | 3 $m^2$ @1.25 keV<br>0.65 $m^2$ @ 6 keV with a goal of 1 $m^2$<br>150 $cm^2$ @ 30 keV with a goal of 350 $cm^2$ | Black hole evolution, large scale structure, cosmic feedback, EOS<br>Strong gravity, EOS<br>Cosmic acceleration, strong gravity |
| Spectral Resolution | $\Delta$E = 2.5 eV within 2 x 2 arc min (0.3 – 7 keV) . $\Delta$E = 10 eV within 5 x 5 arc min (0.3 - 7 keV)<br>$\Delta$E < 150 eV @ 6 keV within 18 arc min diameter (0.1 - 15 keV)<br>E/$\Delta$E = 3000 from 0.3–1 keV with an area of 1,000 $cm^2$ for point sources<br>$\Delta$E = 1 keV within 8 x 8 arc min (10 – 40 keV) | Black Hole evolution,<br>Large scale structure<br>Missing baryons using tens of background AGN |
| Mirror Angular Resolution | ≤5 arc sec HPD (0.1 – 10 keV)<br>30 arc sec HPD (10 - 40 keV) with a goal of 5 arc sec | Large scale structure, cosmic feedback, black hole evolution, missing baryons<br>Black hole evolution |
| Count Rate | 1 Crab with >90% throughput. $\Delta$E < 200 eV (0.1 – 15 keV) | Strong gravity, EOS |
| Polarimetry | 1% MDP on 1 mCrab in 100 ksec (2 - 6 keV) | AGN geometry, strong gravity |
| Astrometry | 1 arcsec at 3$\sigma$ confidence | Black hole evolution |
| Absolute Timing | 50 $\mu$sec | Neutron star studies |

# IXO mission concept: conclusion

An IXO mission concept has been identified that is:

- compatible with IXO science performance requirements
- technically promising (no show-stopper identified)
- modular and well-suited to an International collaboration

Highest technical risk areas include:

- mirror technology and overall mirror assembly,
- X-ray microcalorimeter spectrometer including cryogenic chain,

▸ a technology development program is running at ESA that includes the development of pore optics mirrors and cryo-coolers for IXO