Silicon Pore Optics for IXO

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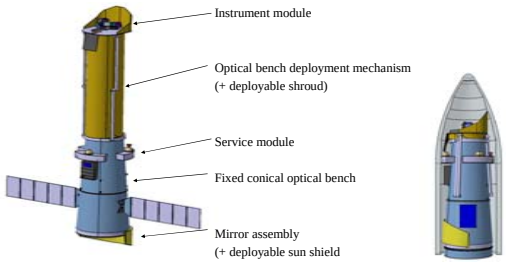
Abstract:
The future X-ray astrophysics missions after XMM and Chandra will require novel optics to be developed, in order to provide the combination of large effective area, low mass and adequate angular resolution. In particular the IXO mission candidate, as selected in the first slice of the Cosmic Vision 1525 programme, has stringent and demanding requirements on the performance of the required X-ray optics forming the core of the mission concept.
In a series of activities led and funded by ESA, an extensive consortium of European industries and institutions is working on the development of the Silicon Pore Optics (SPO) X-ray optics technology. The novel technology is using the latest generation Silicon wafers as starting material to produce highly modular high performance X-ray optics. Excellent quality mirror plates have been produced and successfully stacked into modules and assembled into petals. The mirror elements are fully mounted into double-reflection mirror modules and tested both at synchrotron radiation facilities and at the full illumination Panter facility.

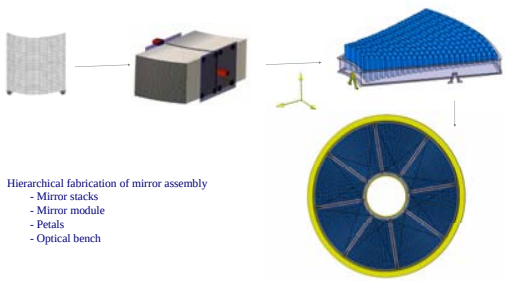
Science Performance Requirements (optics)

Mirror Effective Area	3 m² @1.25 keV 0.65 m² @ 6 keV with a goal of 1 m² 150 cm² @ 30 keV with a goal of 350 cm²	Black hole evolution, large scale structure, cosmic feedback, EOS Strong gravity, EOS Cosmic acceleration, strong gravity
Field of View	FOV = 18' diameter	X-ray surveys, Large scale structure
Mirror Angular Resolution	≤5 arc sec HPD (0.1 – 10 keV) 30 arc sec HPD (10 - 40 keV) with a goal of 5 arc sec	Large scale structure, cosmic feedback, black hole evolution, missing baryons Black hole evolution

IXO Configuration studies by ESA

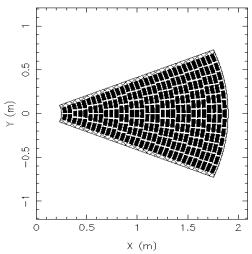


IXO Mirror Assembly and Structure



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

Preliminary Petal Design



Optical design assumption (preliminary):
- 8 petals
- Inner radius 0.25 m
- Outer radius 1.90 m
- 32 rows
- 236 mirror modules/petal
- spoke width (7cm)

Mounted X-ray Optics Technologies

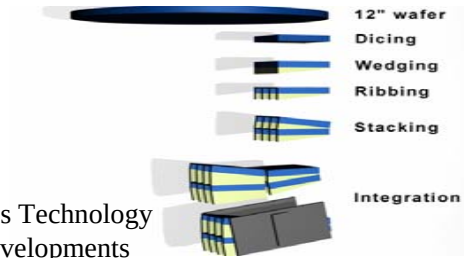
CHANDRA
0.5”
18500 kg/m²
A_{eff} @ 1 keV

XMM-NEWTON
14”
2300 kg/m²
A_{eff} @ 1 keV

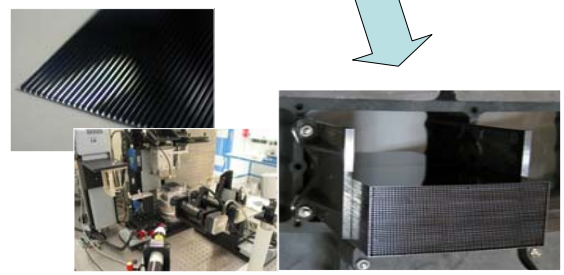
Si-HPO
5”
200 kg/m²
A_{eff} @ 1 keV
IXO ESA Baseline

Glass-MPO
30”
25 kg/m²
A_{eff} @ 1 keV

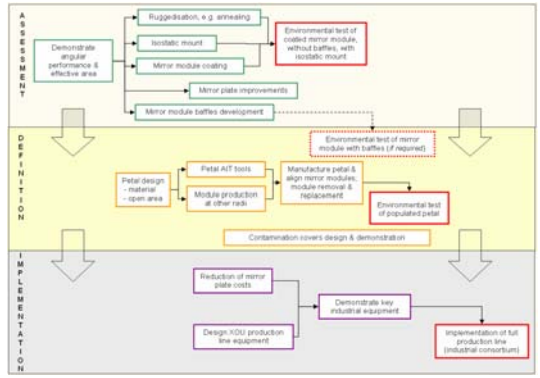
Silicon Pore Optics (SPO) production Steps



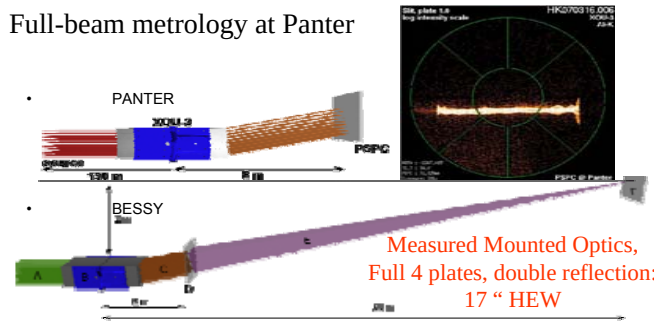
Optics Technology Developments



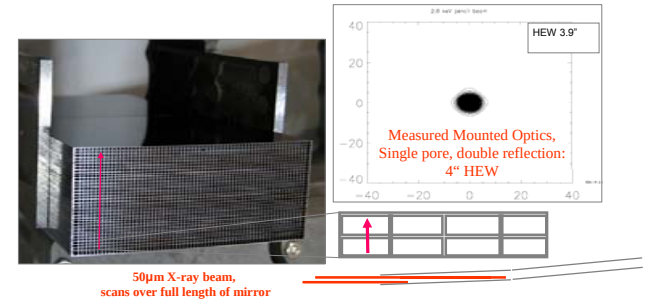
Optics Technology Roadmap



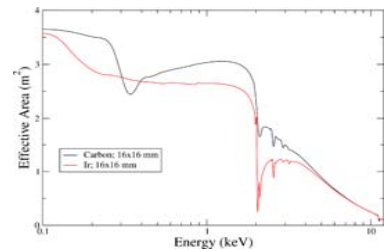
Full-beam metrology at Panter



X-ray metrology at BESSY II

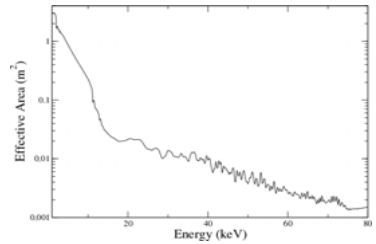


Performance Estimate



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

High Energy Coverage using Multilayer Reflectors



With JAXA/ISAS multilayer design (courtesy H. Kunieda):
Aeff (30 keV) ~ 150 cm²