

Strumentazione Astronomica: Ultravioletto-X

- ❖ Per UV si intende quell'intervallo di lunghezze d'onda comprese tra 3400 e 70 Å ($\sim 3.6 \div 180$ eV) (1 eV @ 12400 Å)

I limiti dell'intervallo dipendono fondamentalmente dal cut-off atmosferico e dalla capacità di riflessione delle ottiche impiegate nei telescopi

Questo intervallo si può ulteriormente suddividere in tre:

- 1) Near-UV (3400-2000 Å)
- 2) Far-UV (2000-912 Å)
- 3) Extreme UV (912-70 Å)

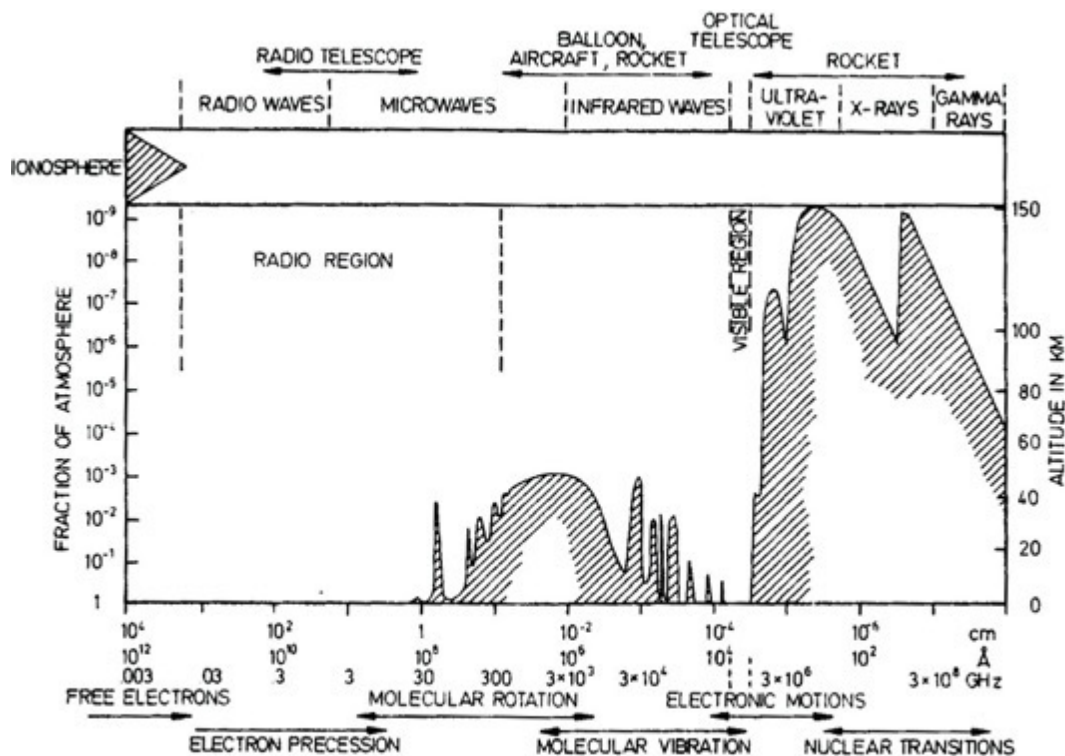


Fig. 1.1. The transmission of the earth's atmosphere for electromagnetic radiation. The diagram gives the height in the atmosphere at which the radiation is attenuated by a factor 1/2

I telescopi UV

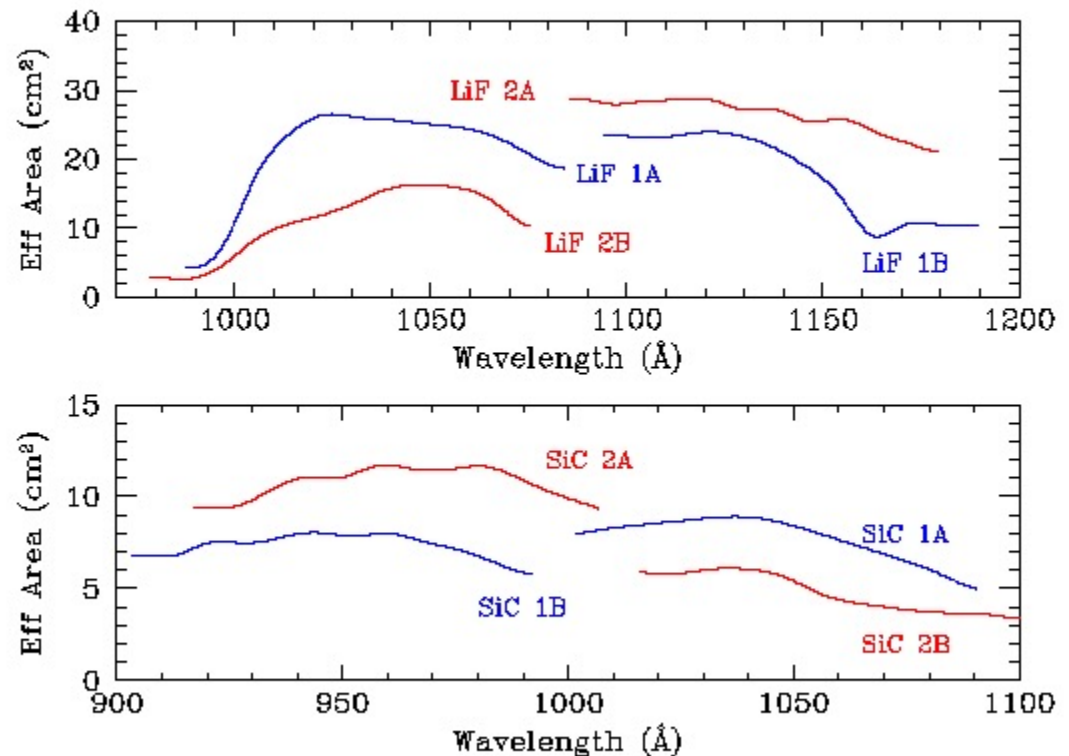
Si utilizzano telescopi ad incidenza NORMALE sino al FAR UV, anche se l'efficienza è molto bassa (pochi %), nell'E-UV si usano telescopi a incidenza radente

Es.: FUSE (*Far Ultraviolet Spectroscopic Explorer*) ha uno specchio di zerodur con un'area di $\sim 1300 \text{ cm}^2$ e rivestito con un coating di Carburo di Silicio (SiC) e Fluoruro di Litio (LiF).

Tenedo conto dell'efficienza di riflessione, in figura sono riportate le aree efficaci

N.B. l'UV danneggia i materiali e queste EA sono relative all'inizio della missione!

FUSE Effective Area

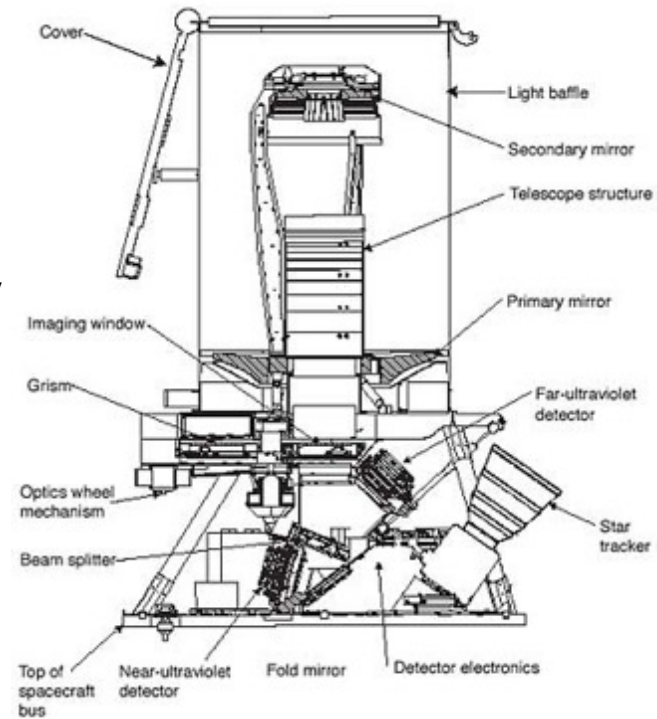


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GALEX 2003-2013

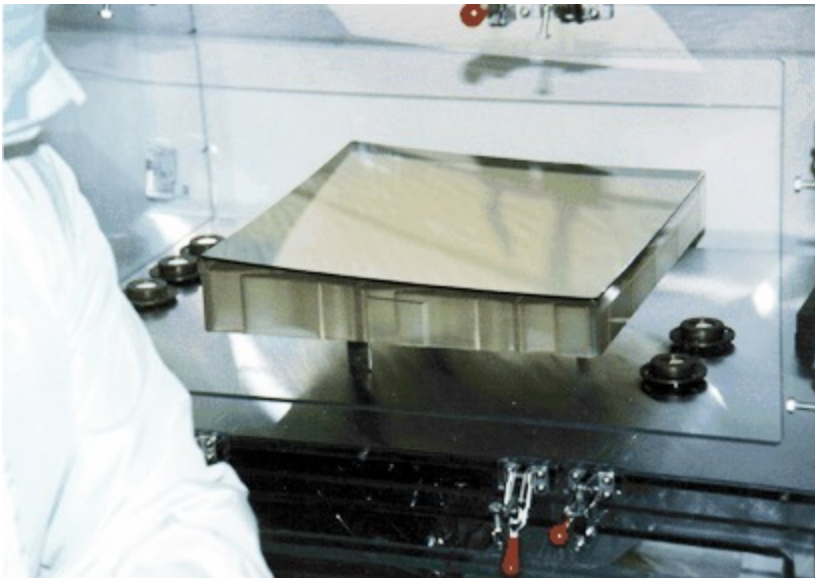


GALEX is a 50cm UV-optimized telescope that obtains images simultaneously in two bands: 1350-1800Å (far-UV, FUV) and 1800-2800Å (near-UV, NUV). The field of view is 1.2 degrees and the angular resolution is ~ 4.5 arcsec. GALEX can also obtain slitless spectroscopy (same field of view and spatial resolution) with spectral resolution of $R=200-350$ (FUV) and 80-150 (NUV). The telescope has one primary 50 cm mirror, which feeds light through either an imaging window or an imaging grism, to a dichroic beamsplitter, and into two sealed-tube microchannel-plate photon-counting detectors. The effective area is ~ 35 cm² for the FUV channel and ~ 65 cm² for the NUV channel.

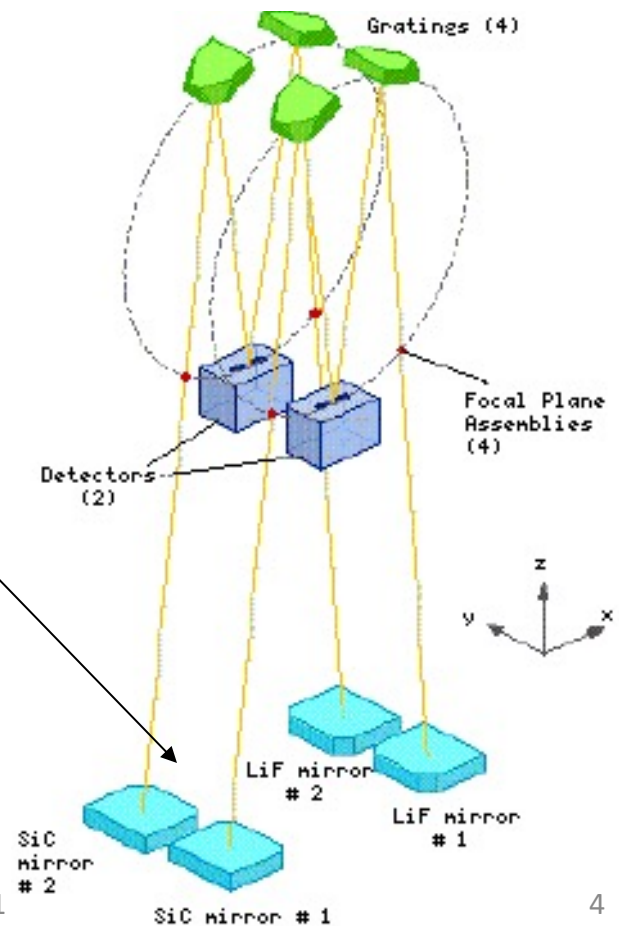


I telescopi UV

Spesso sono schemi off-axis per evitare l'impiego di baffles per schermare la luce diffusa dai sostegni degli specchi



La messa a fuoco è ottenuta tramite movimenti di tip-tilt su ciascuno specchio
Fondamentale è anche la termalizzazione



I telescopi UV per le osservazioni solari

La termostatazione del telescopio è un problema da non sottovalutare:

scarsa riflettività → elevato assorbimento di fotoni energetici

il telescopio si scalda e può dilatarsi compromettendo la configurazione ottica.

(NB: se richiedo una precisione ottica di $\lambda/10$ con un coefficiente di dilatazione lineare 10^{-7} , uno specchio con $L=300$ mm e $\lambda=100$ nm, devo tenere la temperatura stabile entro 0.3 K)

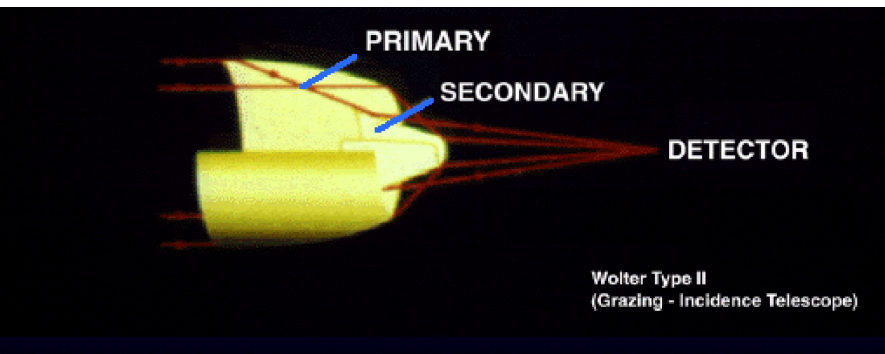
Si impiegano materiali con bassissimo coefficiente di dilatazione termica e si provvede a prelevare efficacemente il calore captato dallo specchio

Per lo stesso motivo risulta difficile compensare la bassa riflettività degli specchi con l'aumento dell'area collettrice

I telescopi E-UV

Nell'Ex-UV si usano telescopi ad incidenza radente come quelli caratteristici dei telescopi X

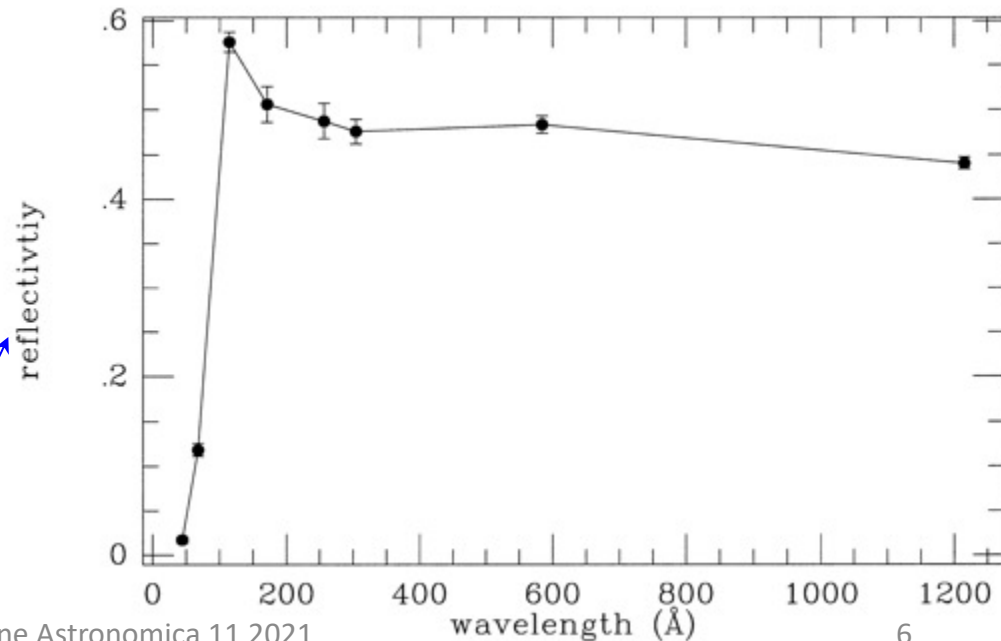
Gli angoli di incidenza per i quali si ha riflessione totale sono di pochi gradi



Materiali tipici sono l'oro e il nickel

La riflettività può essere molto elevata, se paragonata all'incidenza normale

Riflettività del telescopio di EUVE



I telescopi ad incidenza radente

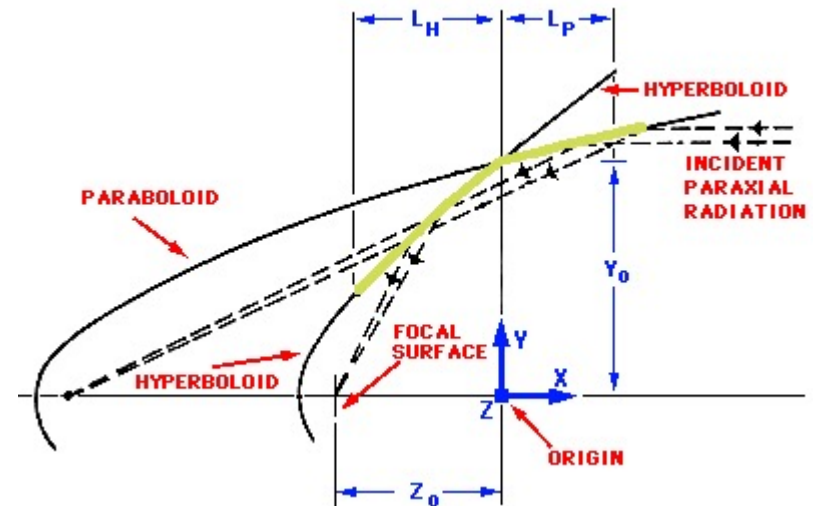
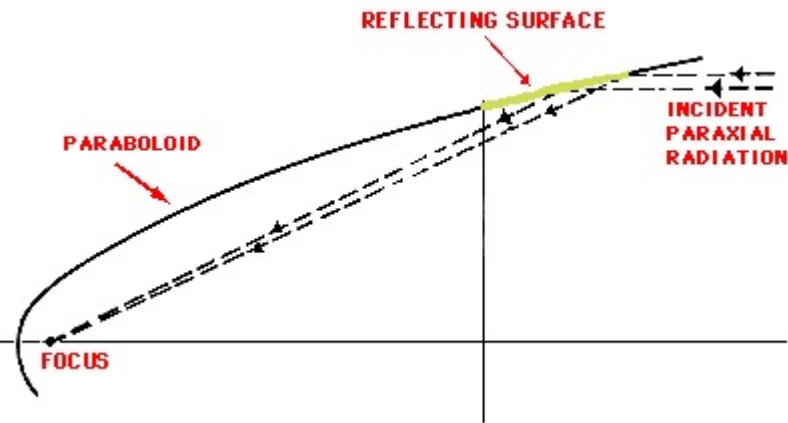
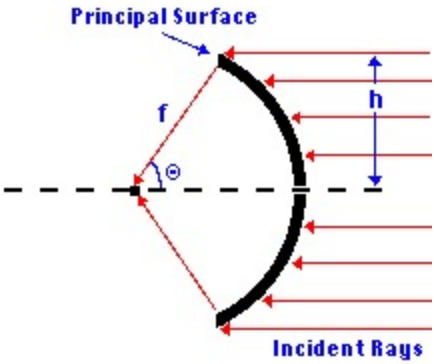


Uhuru

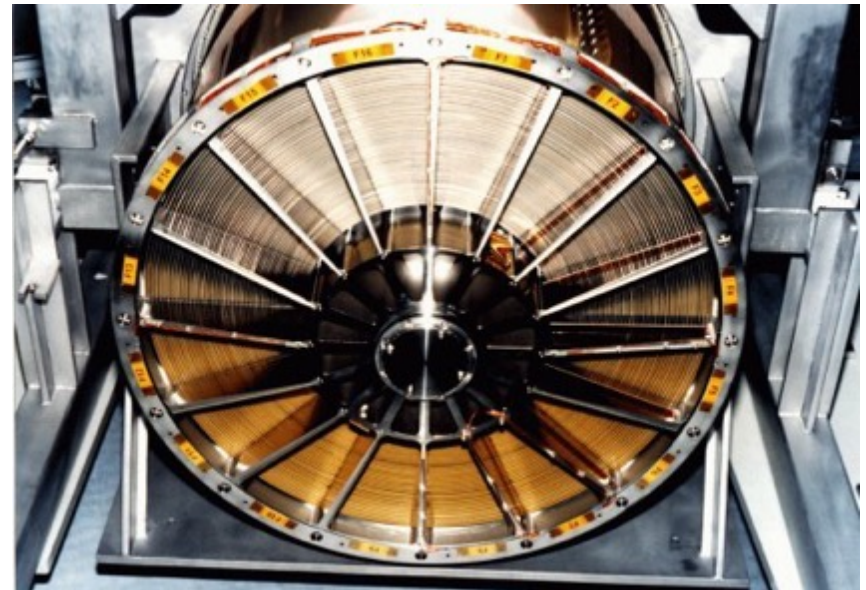
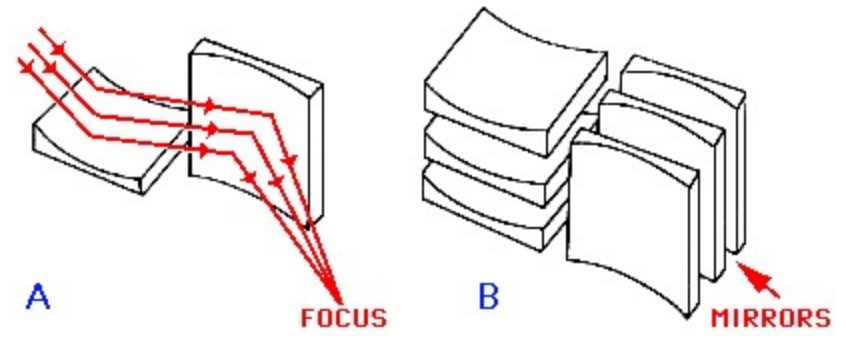
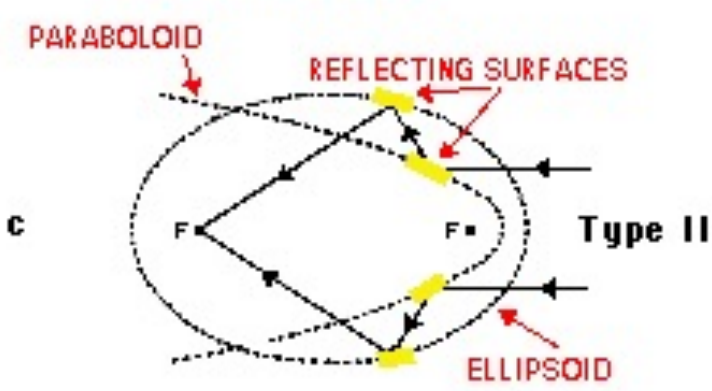
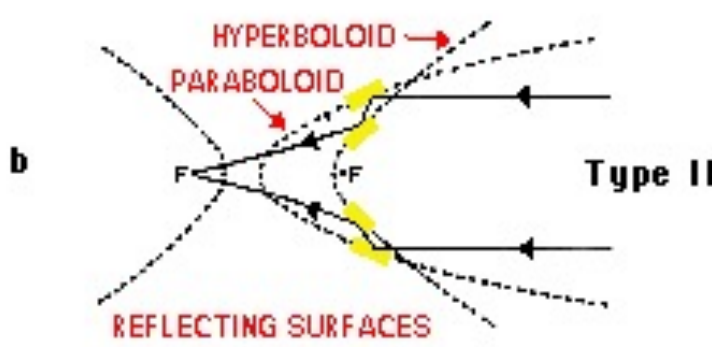
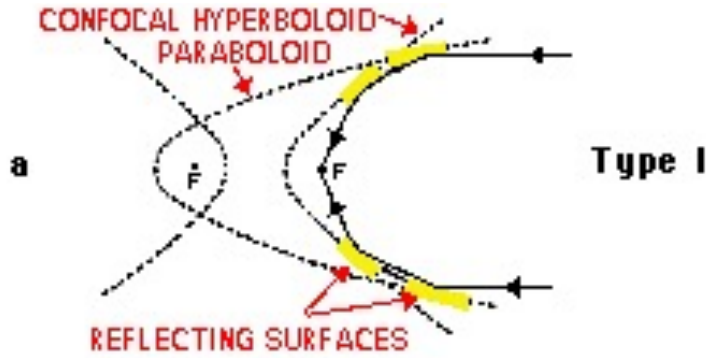
Condizione di Abbe:
 un sistema ottico produce
 un'immagine se agisce come
 una lente sferica ($h/\sin(\theta)=f$)

Negli anni '60 Giacconi e Rossi proposero di utilizzare un semplice sistema parabolico per focalizzare i fotoni X, anche se questo sistema ha delle forti aberrazioni per sorgenti fuori asse.

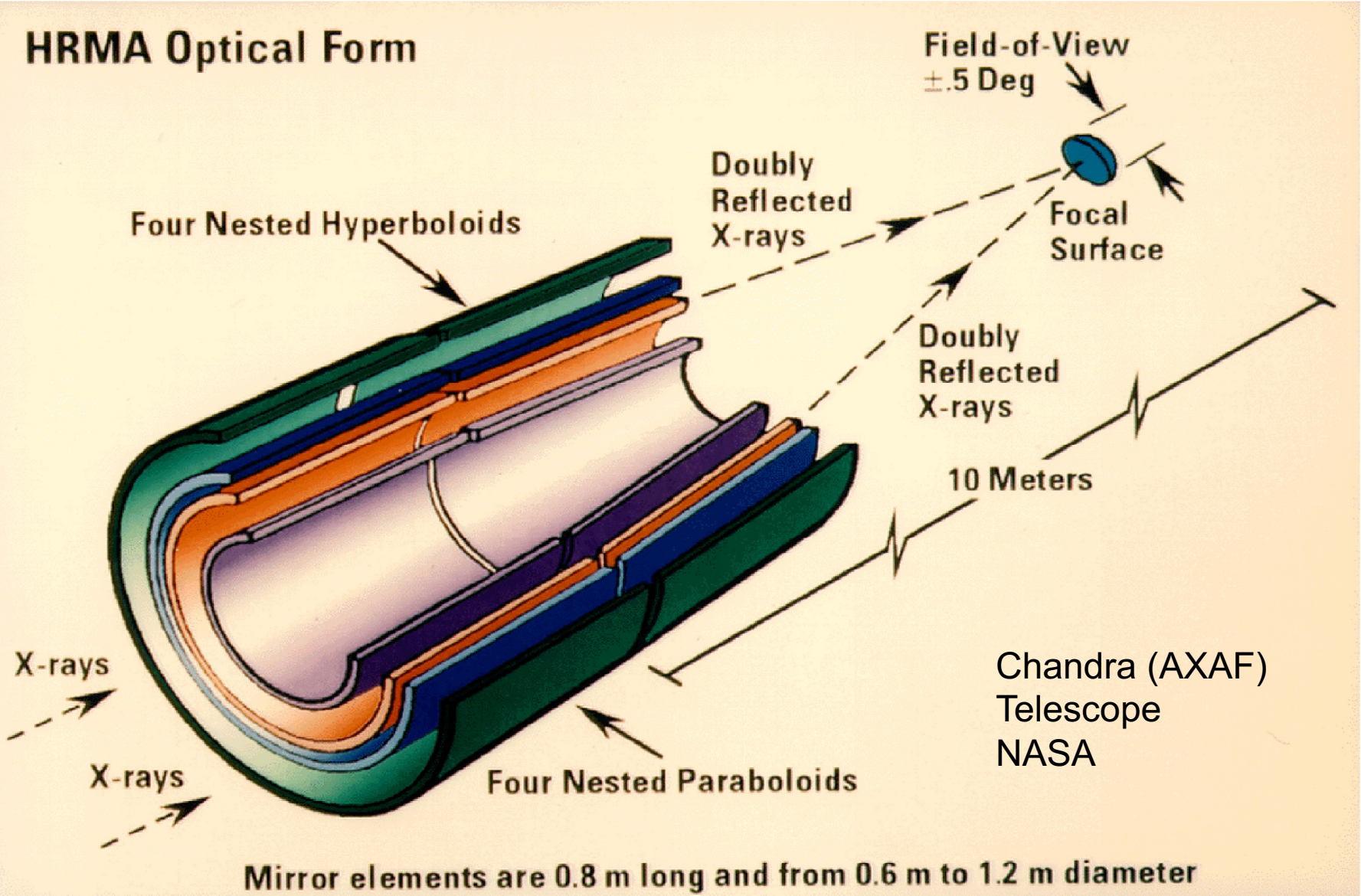
Wolter mostrò che una qualsiasi combinazione PARI di elementi riflettenti può soddisfare la condizione di Abbe quasi perfettamente.



I telescopi ad incidenza radente

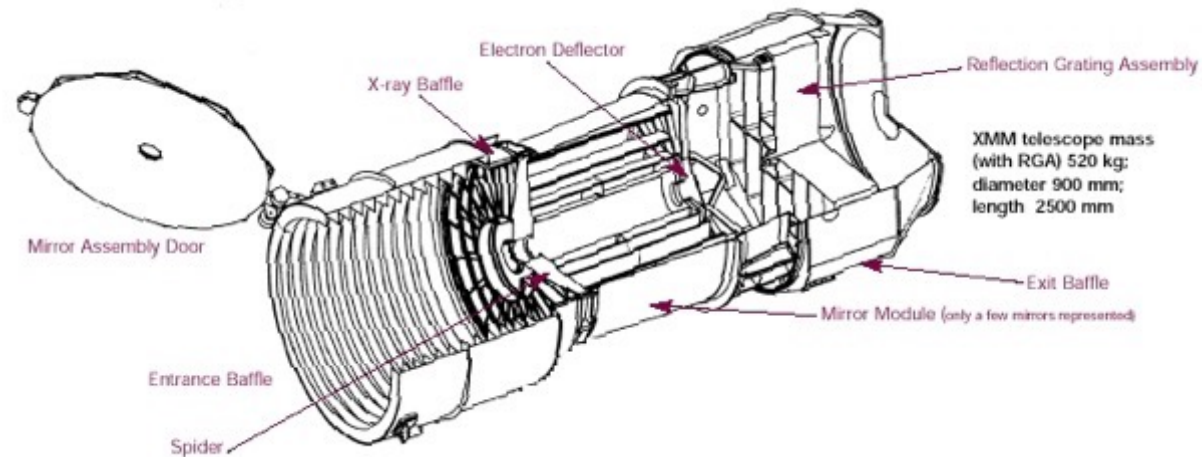
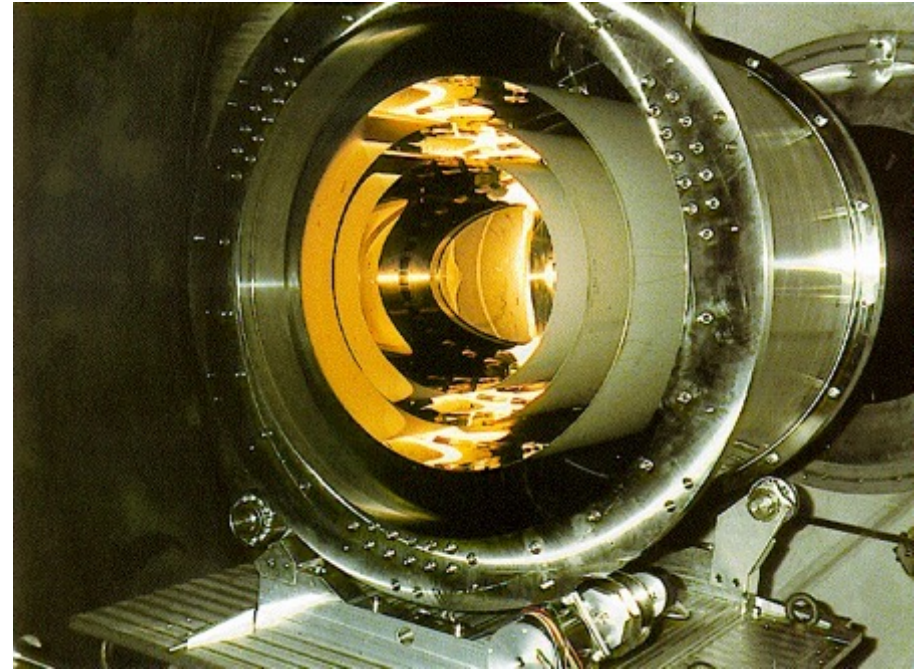


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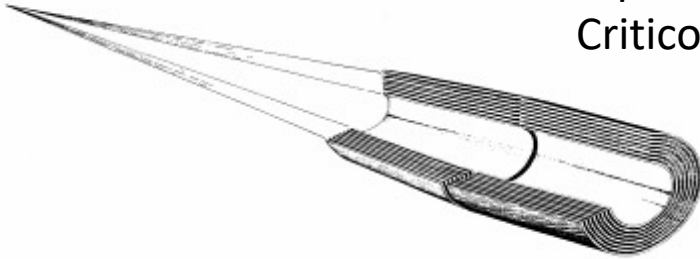
Strumentazione Astronomica: Ultravioletto-X

XMM-Newton
ESA



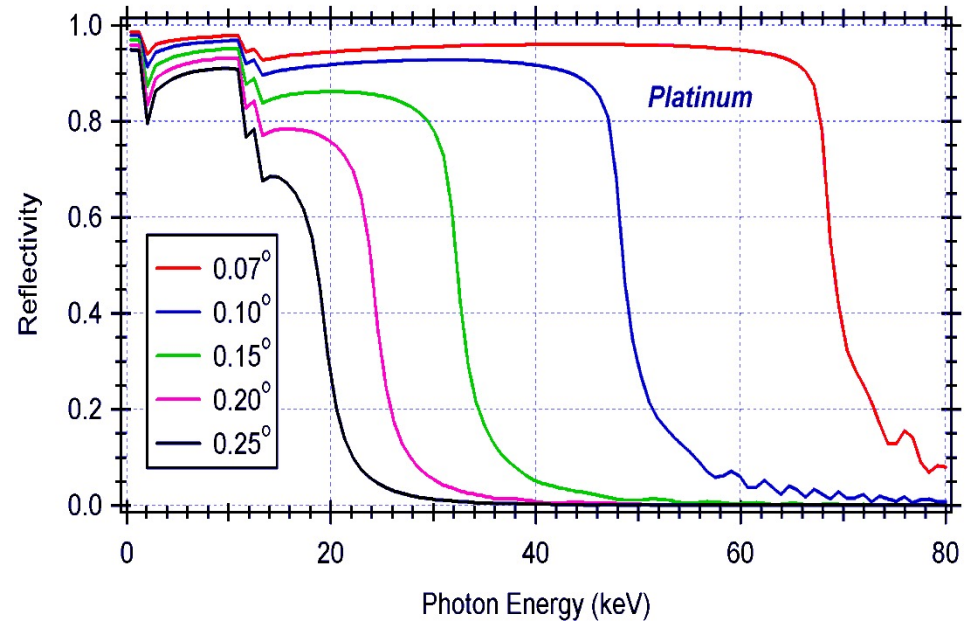
Strumentazione Astronomica: X

Dipendenza dell'Area Efficace dalla Focale, Angolo Critico, Riflettività



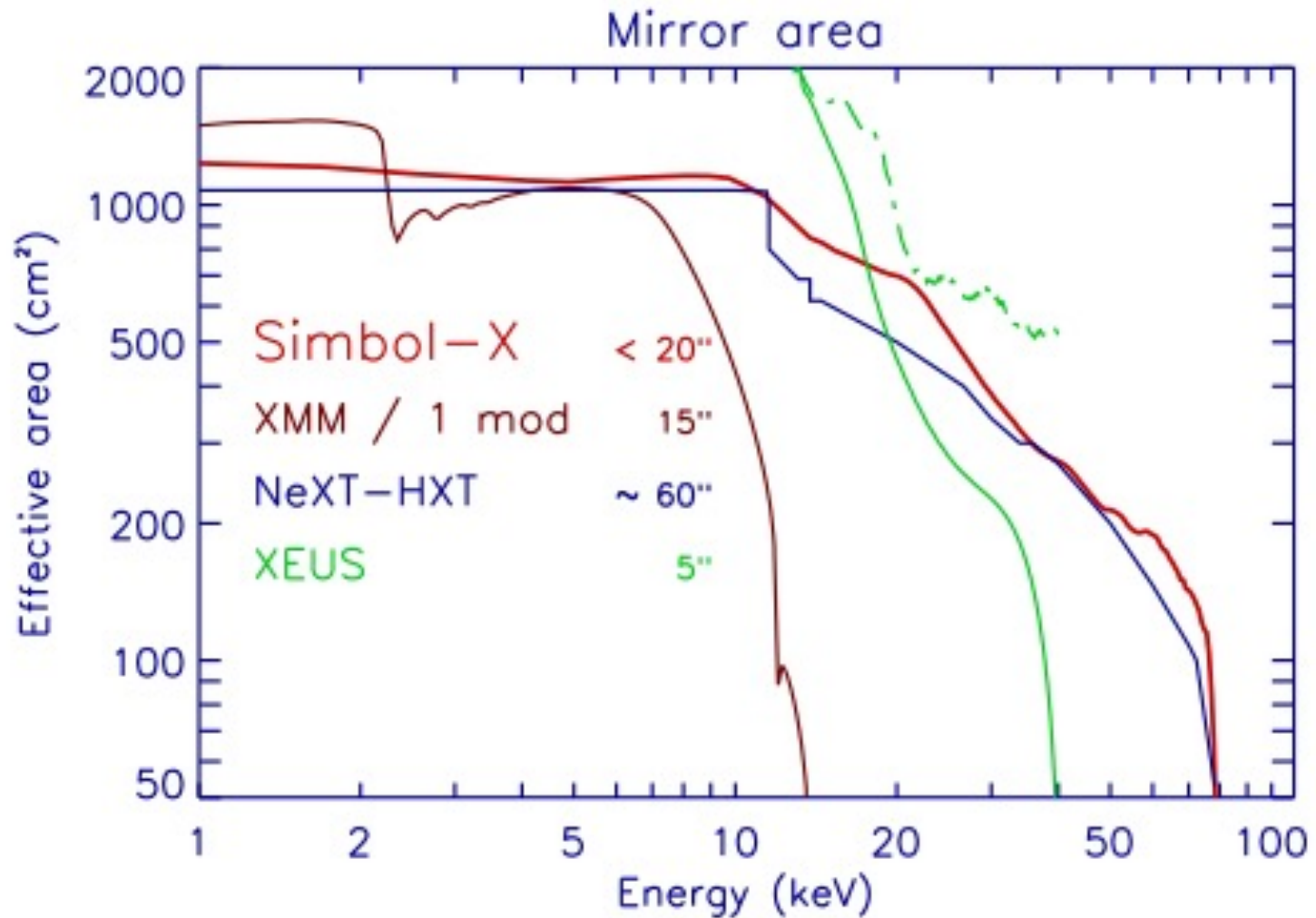
$$A_{eff} \propto F^2 \cdot \vartheta_c^2 \cdot R^2$$

$$\vartheta_c \propto \frac{\sqrt{\rho}}{E}$$



Strumentazione Astronomica: X

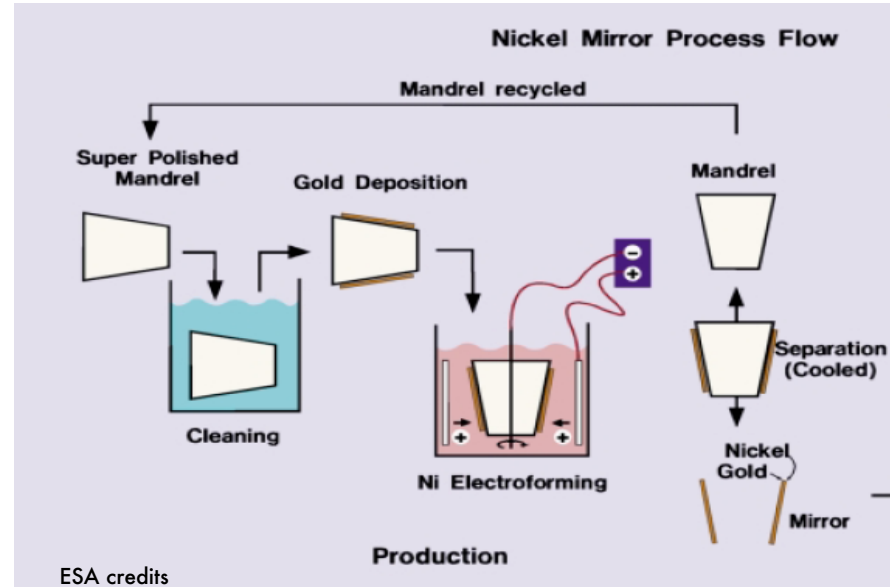
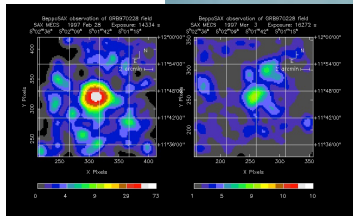
Aree efficaci per diverse missioni
(esistenti o proposte)



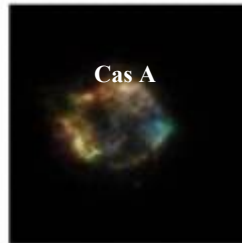
X-ray optics by Ni electroforming replication



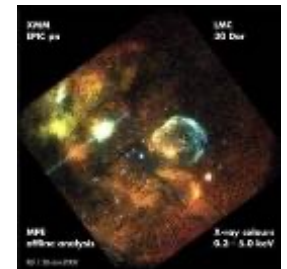
BeppoSAX



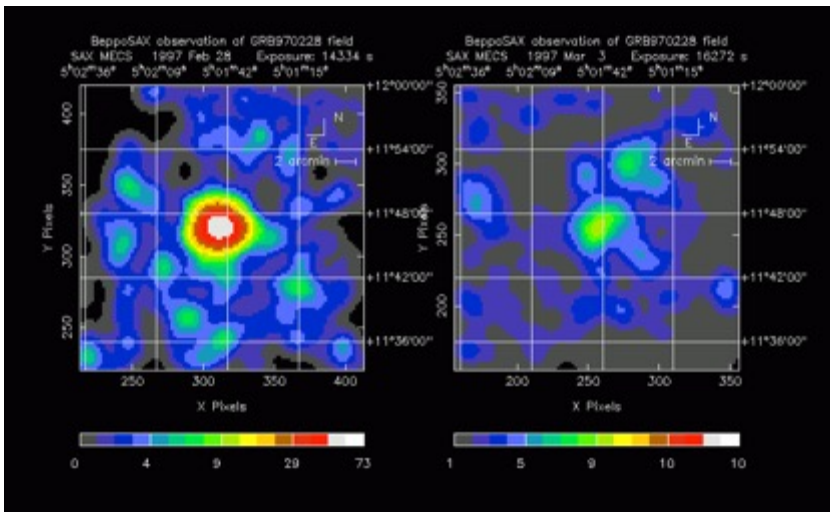
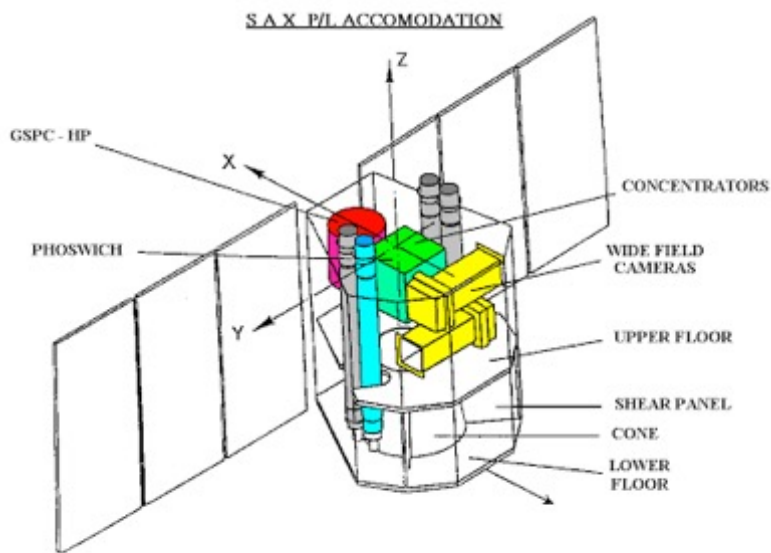
Jet-X/Swift



Cas A



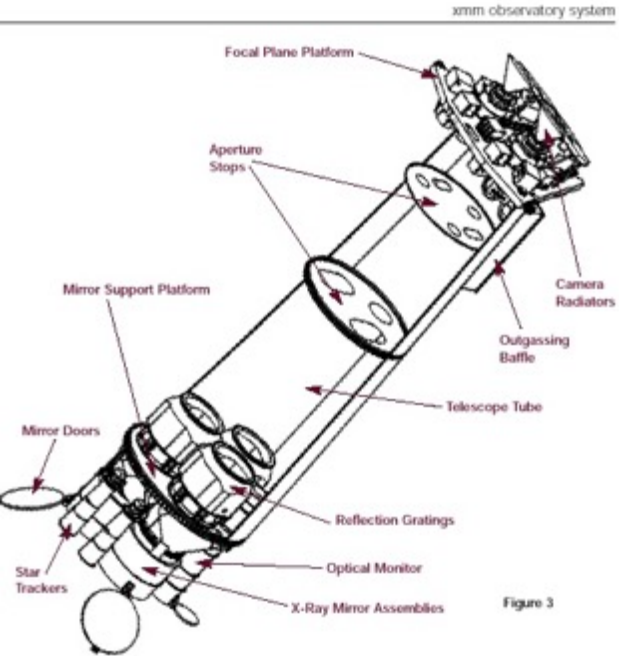
XMM-Newton



BeppoSAX (ASI – Netherland)



XMM – Newton (ESA)



Silicon Pore Optics

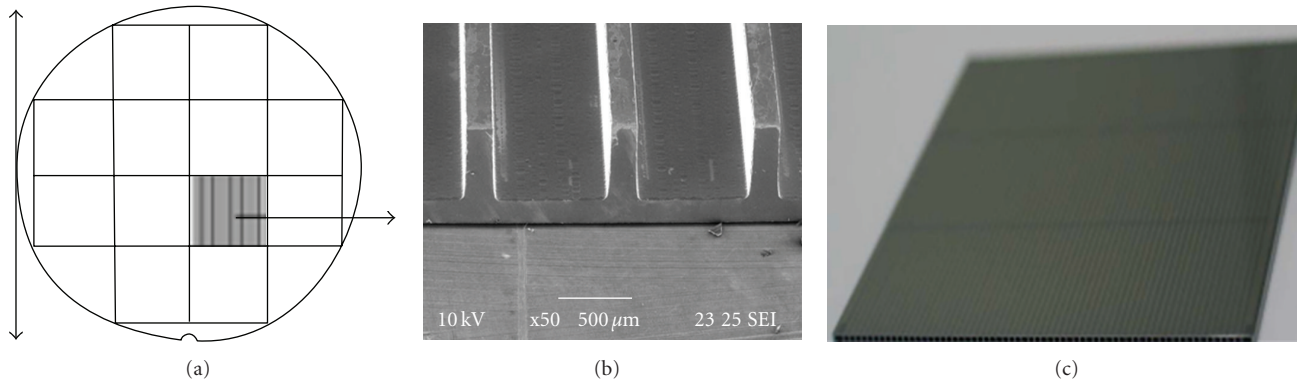


FIGURE 7: (a) Silicon Pore Optics are made from commercial high-quality 12" silicon wafers which are diced into plates. (b) The plates are ribbed (reflecting surface pointing downwards). The 0.17 mm wide ribs have a pitch of 1 mm and the membrane is 0.17 mm thick. The plates are then wedged along the rib direction (not shown) and a patterned iridium coating is applied on the reflective surface (c). The pattern keeps the areas free where the next plate will be bonded. The plate shown has dimensions of $66 \times 66 \text{ mm}^2$ and a thickness of 0.775 mm. Photographs courtesy of Micronit (b) and DNSC (c).

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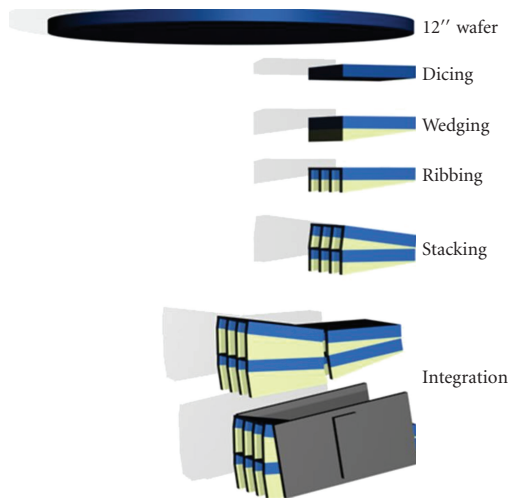


FIGURE 5: The production of SPO modules starts with commercial silicon wafers and utilises, as far as possible, existing methods and processes. The stacking is done automatically using a stacking robot.

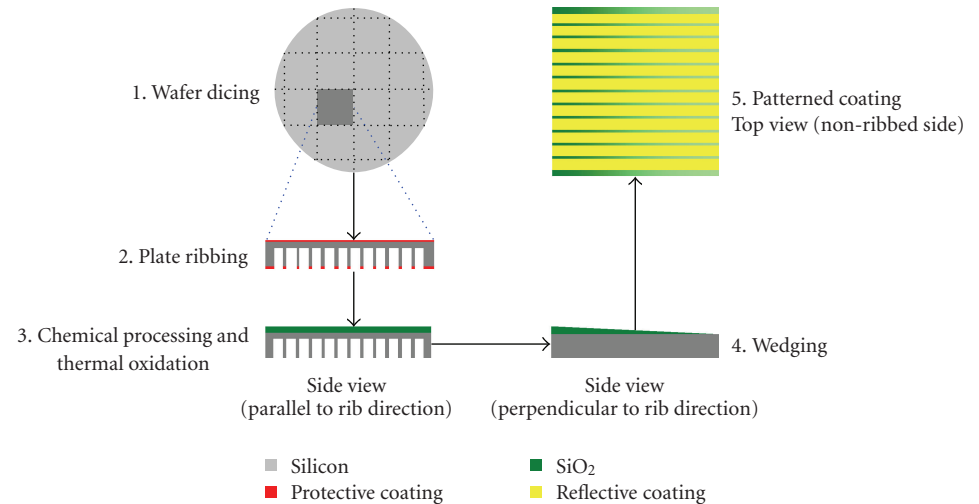


FIGURE 6: Schematic overview of process flow for production of Si mirror plates (Reproduced from [20]).

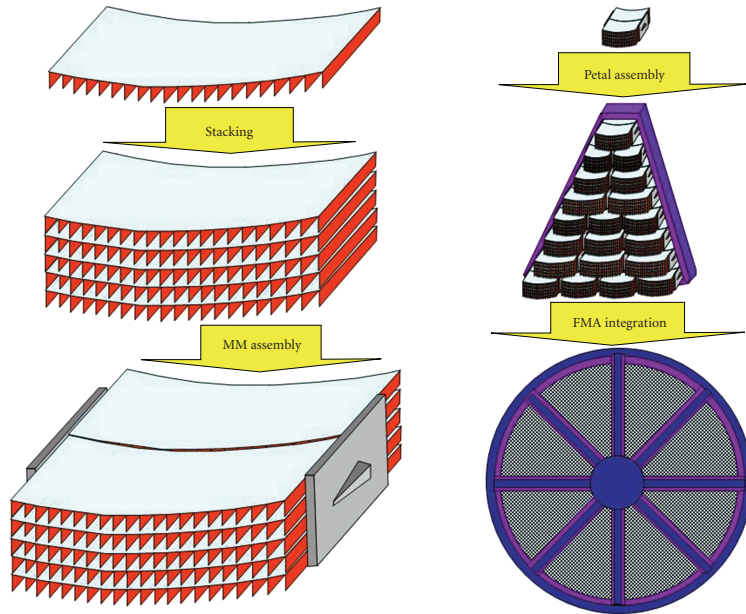


FIGURE 4: The production streams for a telescope using SPO technology.

Silicon Pore Optics (ATHENA)

<http://www.the-athena-x-ray-observatory.eu>

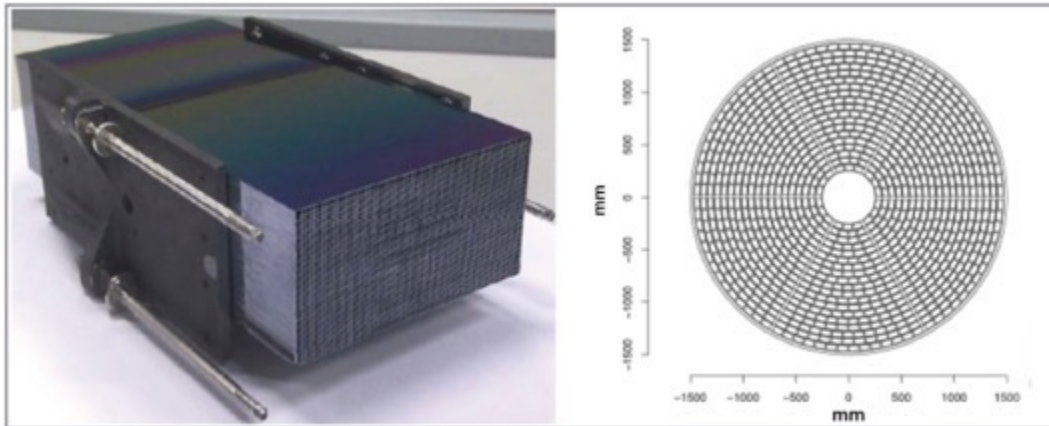


Figure 6.1: Left) A complete SPO module comprising two stacks. Right) Modules are arranged in 6 sectors and 19 rings to populate the aperture.