XMM project’s perspective

Robert Lainé, ex XMM project manager ESA

Main challenges

- X-ray optics
- EPIC-RGS-OM Instruments
- Schedule and budget
- Spacecraft design and launcher
- MOC-SOC

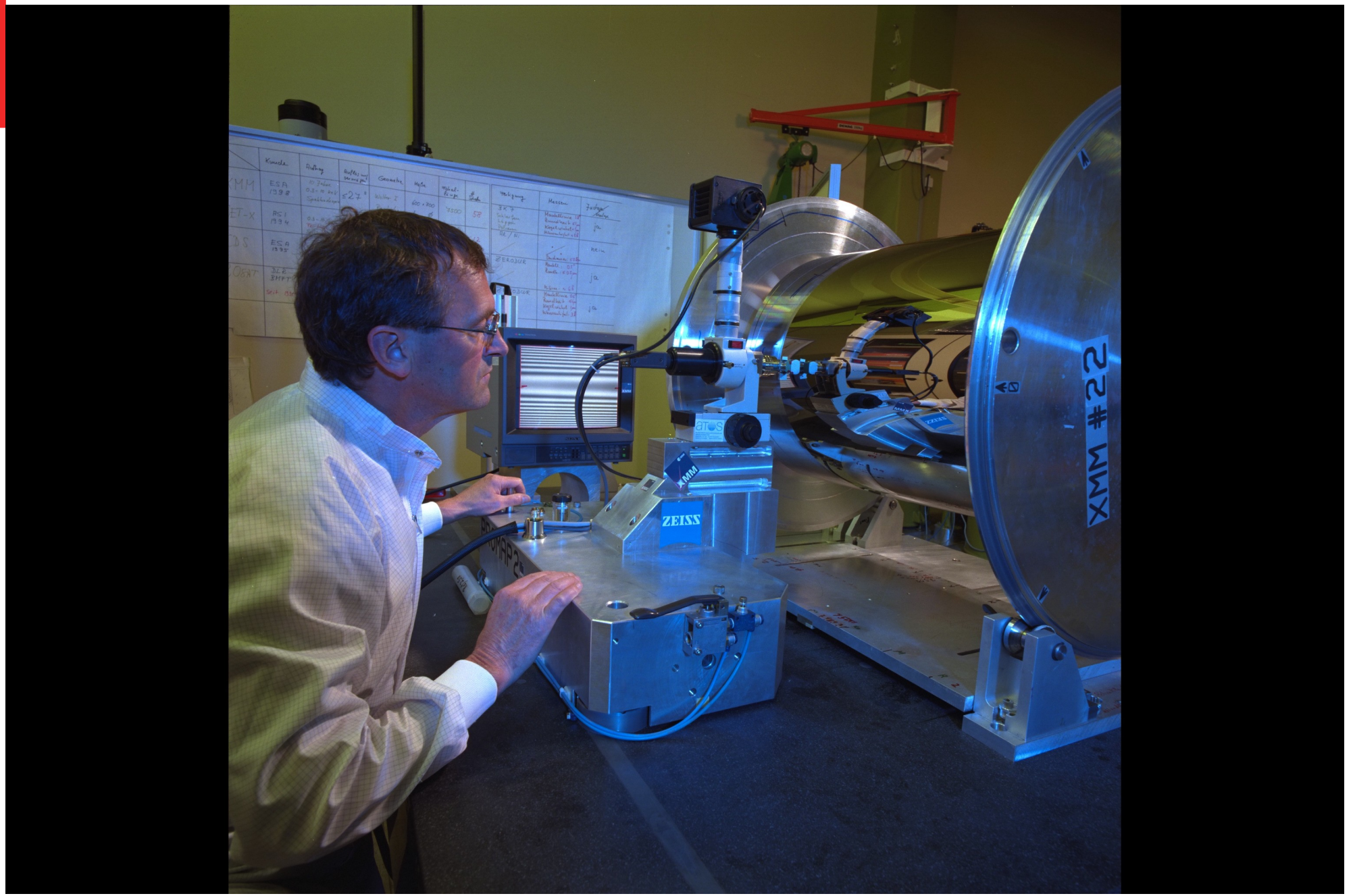
How did we do it ?

X-ray optics

- Classic Wolter-I geometry with gold layer.
- Unusual high density nesting of 58 large and very thin mirrors to maximise collecting area.
- 1980’s Carbon fibre craze and mass constraints led to CFRP replicated mirrors...
- CFRP inhomogeneities print-through to the X-ray reflecting layer = EXOSAT lessons lost.
  - **Rule #1**: Optics no good = no mission
  - Something better had to be found !

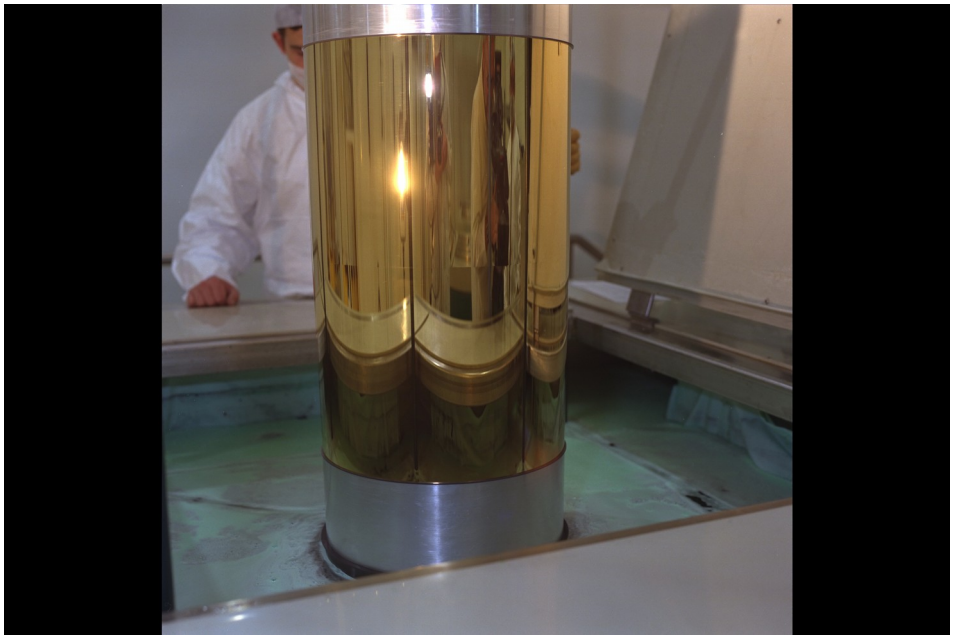
Rule #2: get good mandrels

- Replicated mirrors are only as good as the master mandrel used to produce them!
- Polishing of mandrels to a good geometry is relatively straight forward.
- Polishing it to X-ray quality without degrading geometry is a challenge.
  - ➔ Exosat lessons had to be re-learned and machinery to monitor polishing re-invented.


ZEISS
XMM #2S

X-ray optics in Nickel

- Nickel replication for X-ray optics was known to work... sometime!
- Investment in rigorous control of thin mirrors production processes at Medialario;
- Super clean mirrors integration into modules;
- EUV facility built in CSL for verification of mirror module geometry (Hubble lesson);
- Final calibration in well established X-ray facility of MPE.

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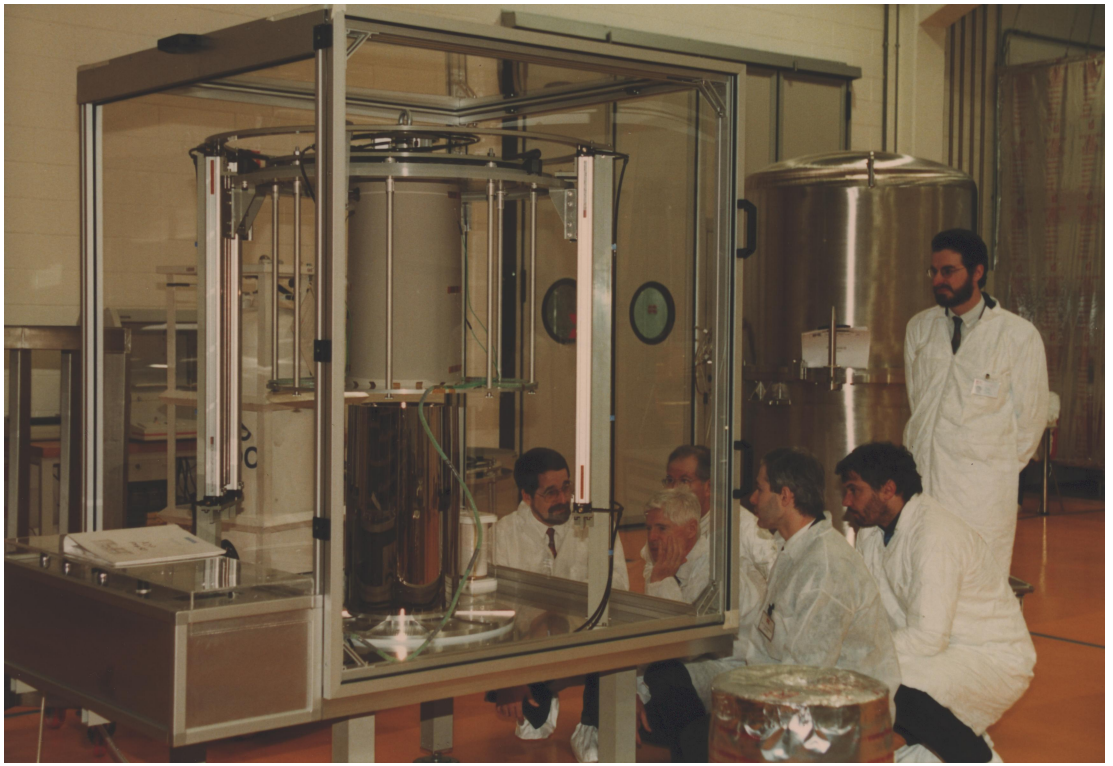
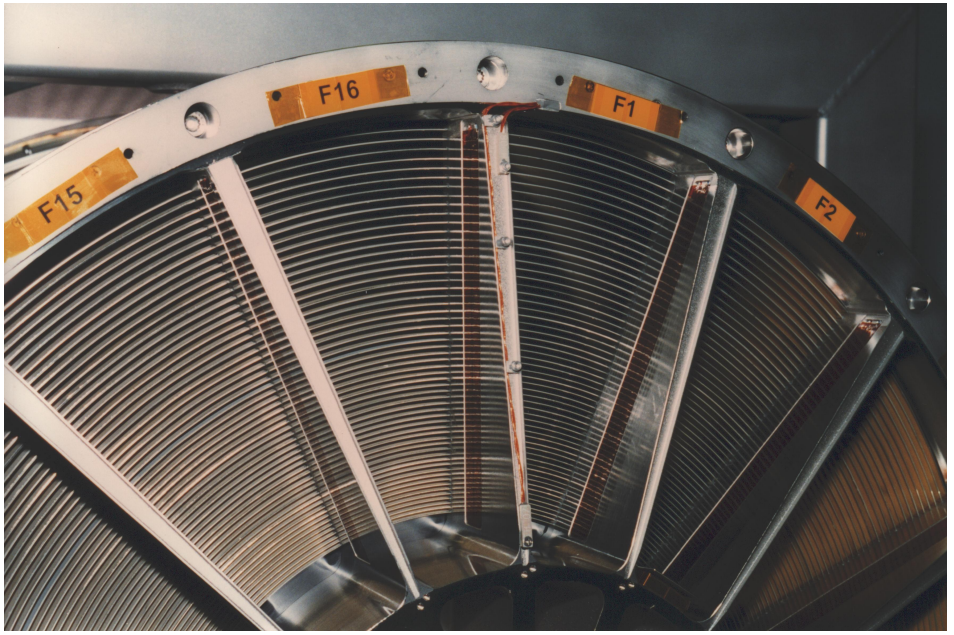


Mirror module

- Integrating very thin mirrors (diameter to thickness ratio = 300) without distorting them is a challenge.
  - ➔ Hyperstatic suspension of individual mirror with active control of its shape while glueing it in the supporting spider.
- Thermal control of modules redesigned after thermal test.
- Integration + alignment of Grating Assembly.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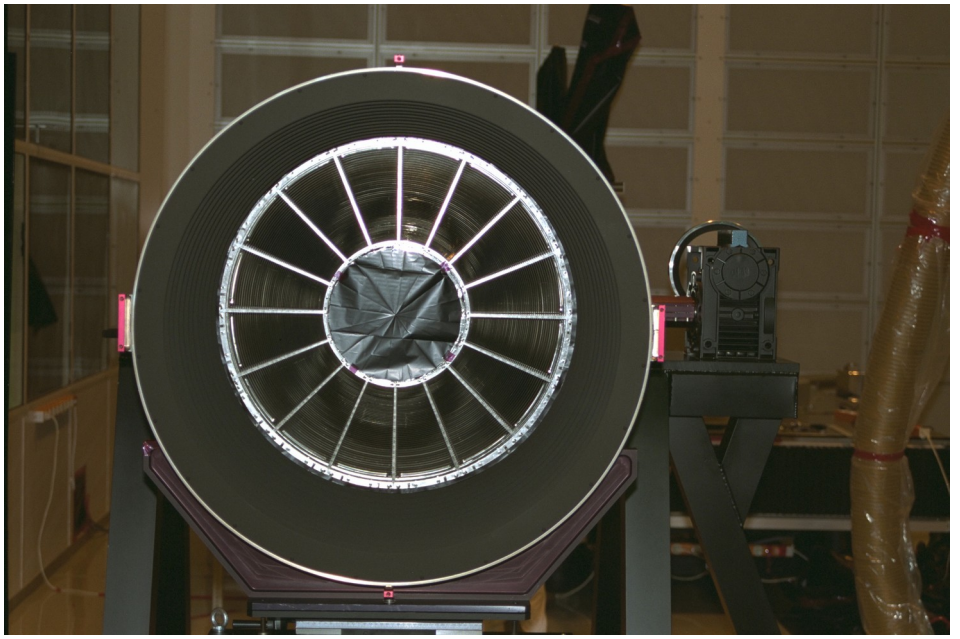
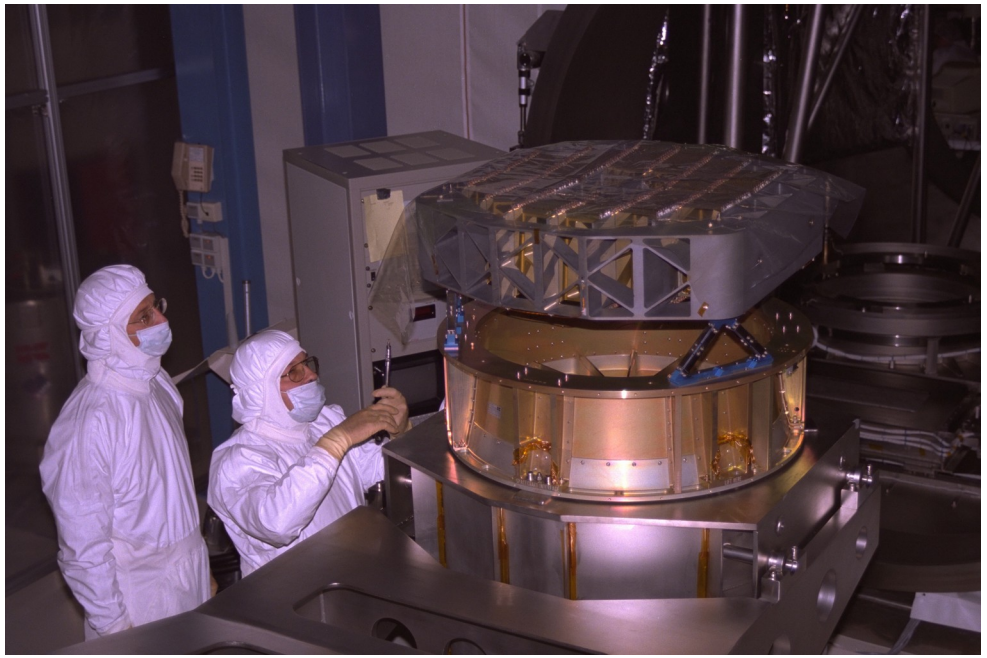
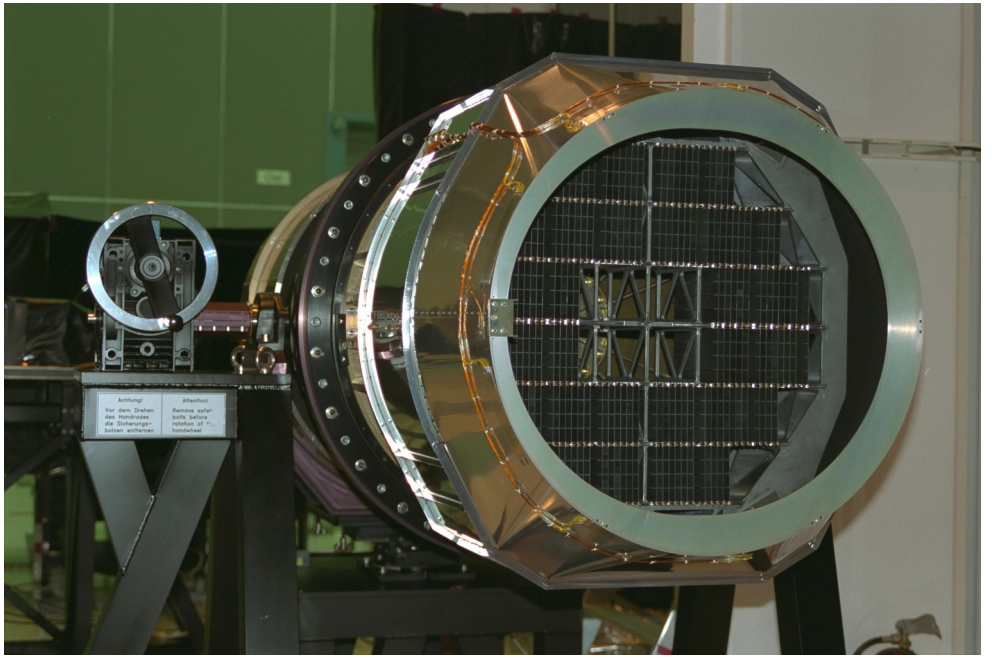
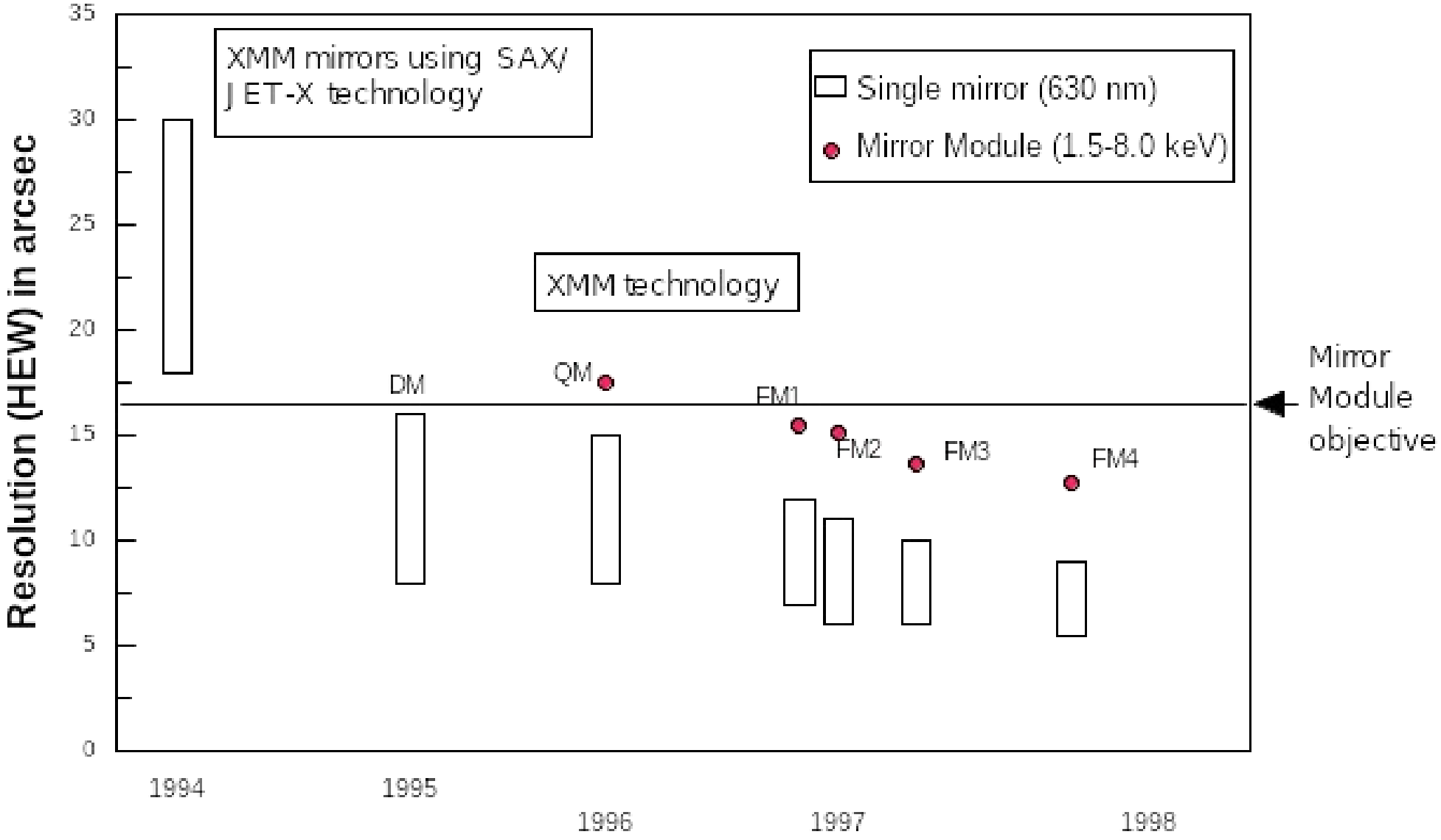






Mirror Module Optical Performance

(SPIE-98 paper, D. de Chambure)



EPIC, RGS, OM Instruments

(see publications on the subject)

- Payload instruments funded and developed by labs across Europe and USA.
- EPIC 2 cameras : CCD and PN detectors:
  - Main issues arose from ASI funding issues which made EPIC schedule critical.
- RGS with its large gratings and arrays of CCD progressed evenly.
- OM progressed evenly, apart from some late issues with optics glueing and straylight.
- **Overall: <u>good job from PI's teams</u>!**

Schedule and budget

- Rather than focusing on budget up-front, the team focused on **schedule**,
- Reasons:
  - Space project cost is driven by manpower deployment, not by technical solutions;
  - Meeting a tight schedule does reduce the cost.
- Project did not embark on spacecraft development before having solved the X-ray mirrors issues.

Spacecraft design

- **Rule # 3**: Do Not optimise, **Keep It Simple**!
  - Simplify interfaces between payload and the rest of the spacecraft;
  - Robust design, e.g. imposing nominal gyroless attitude control (SOHO lesson learnt);
  - Radiation and SEU hardening for 48h orbit;
  - Packet telemetry for flexibility in payload data stream;
  - Oversize tanks to accommodate extra fuel if launcher allows.

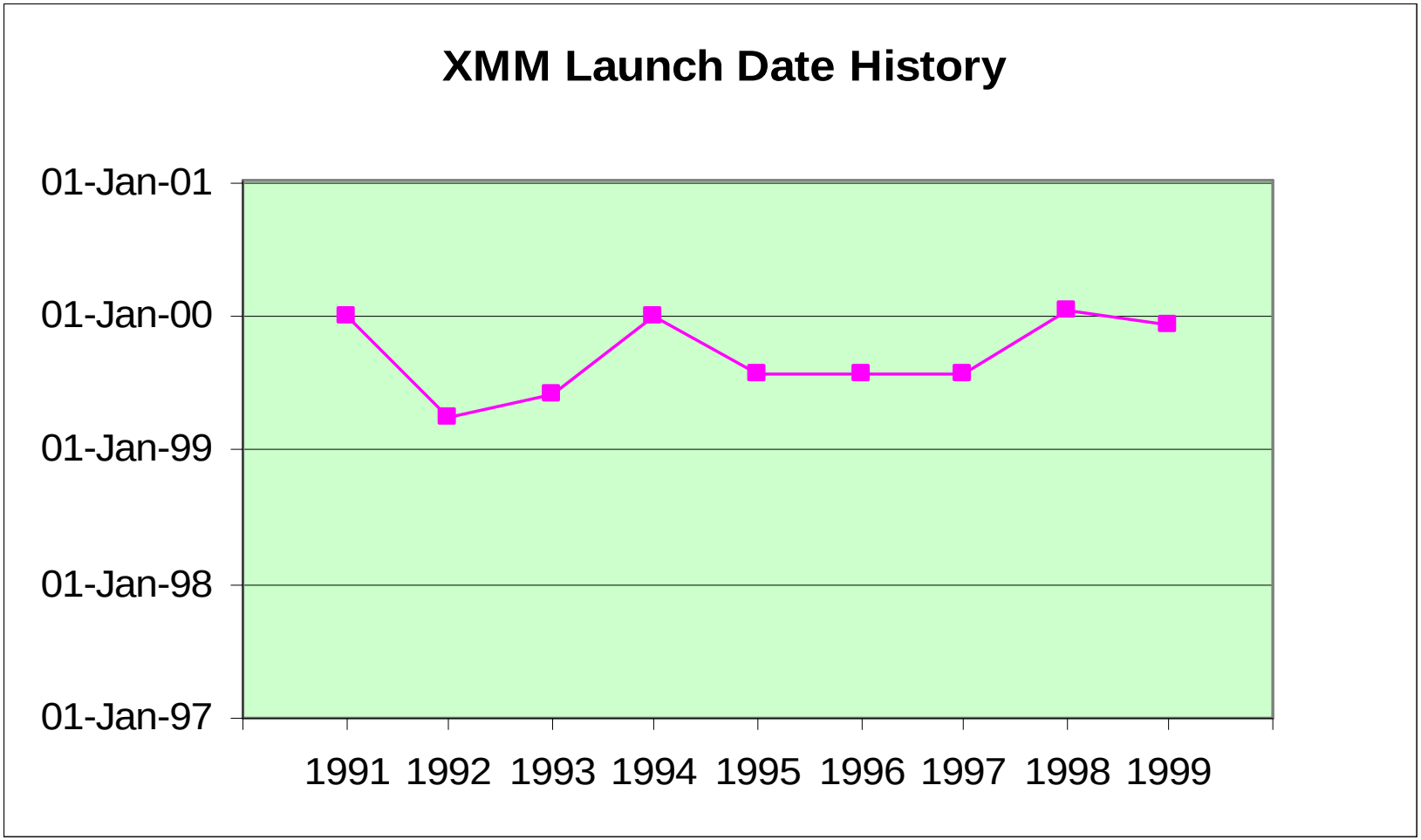
Spacecraft procurement

- Main issue was to contain spacecraft cost:
  - Separate X-ray optics contract and spacecraft contract.
  - Simplify Spacecraft documentation.
  - Impose a competitive flat industrial management structure instead than usual ESA consortium.
- Dornier (now Airbus) as prime contractor did a very good job to maintain spacecraft cost and schedule under control.

Launcher

- Ariane-4 was felt to be a “safe” choice:
  - Unfortunately that safety came with a spacecraft mass limitation which had contributed to the CFRP mirror choice and a 24h orbit...
  - Keeping Ariane-4 baseline would have meant a drastic reduction in number of mirror modules...
- Change to Ariane-5 still under development and perceived as risky was not easy, but it regained a lot of science.
- Dec 10, 1999 Ariane-504 launch at 14:32 UTC was a stressful event after 501 failure.

XMM Launch Date History



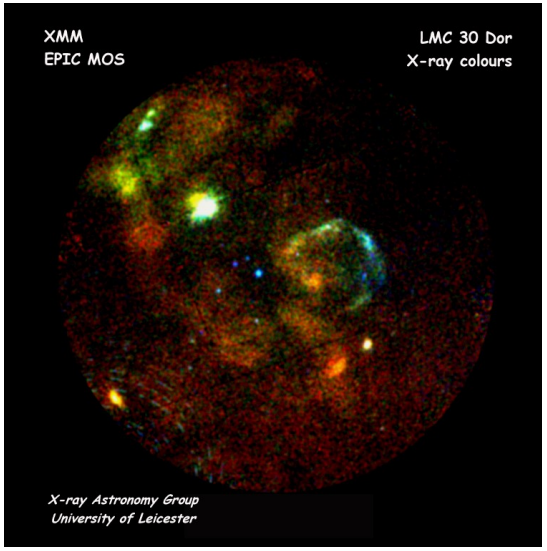
MOC-SOC

- MOC-SOC development handled by ESOC, experience with delivery on time.
  - Decision to hand SOC to ESOC initially not fully supported by all in ESTEC,
  - Blunt actions were necessary to stop SOC requirements flood and ensure all worked to the 1999 launch timeline.
  - Tiger team in ESOC led to successful commissioning of SOC in 2000.
- Since launch, MOC-SOC delivered 99% of up-time and preserved the spacecraft resources for another 10y ops.

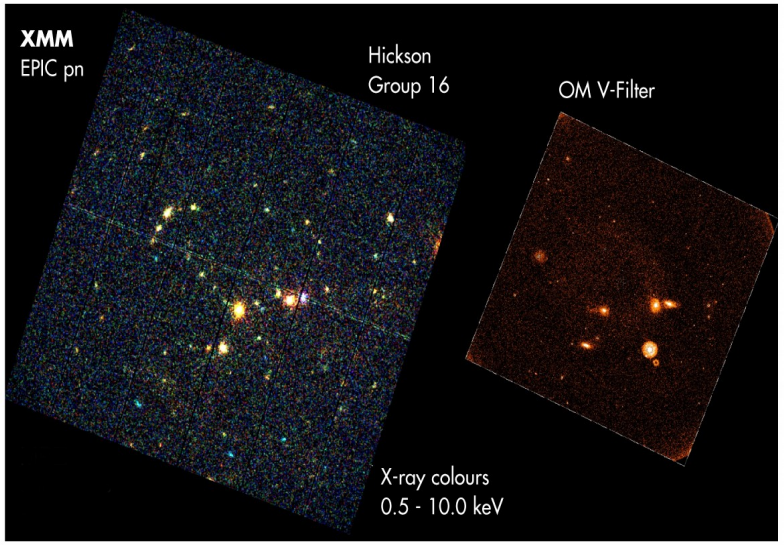
Summary

- Success of XMM-Newton mainly due to attitude of the development team at large:
- **One team with one common objective** =
  - **Science community** with clear mission objectives and competences to built good Instruments;
  - **+ Industry teams** as committed suppliers;
  - **+ ESOC** with experience in operations for the benefit of science;
  - **+ Project team** acting as single minded customer, and not playing games.

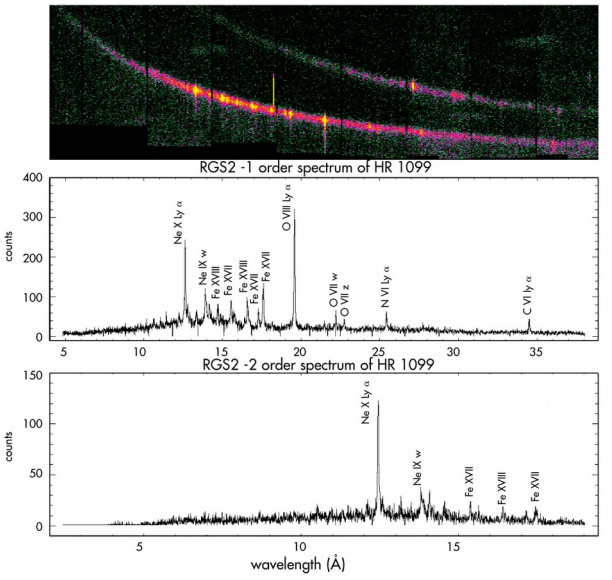
Results: on time, on budget launch, ops and first light



Composite image of EPIC-PN false colour X-ray (left) and OM-V filter (right).



RGS spectrum of HR1099



First data obtained in January 2000

Thank you to the team.
We are looking forward to XMM-Newton 30 years party!