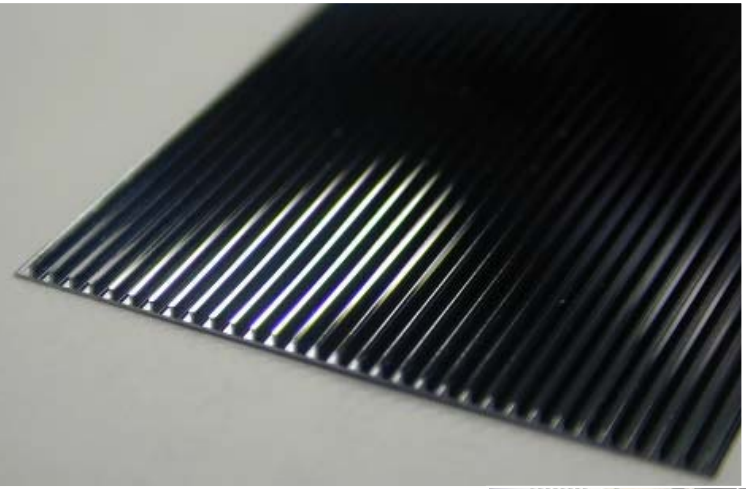
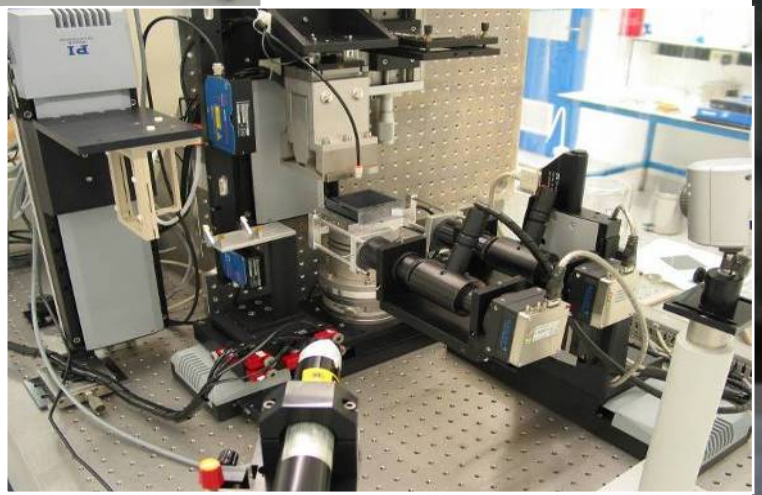
Silicon Pore Optics

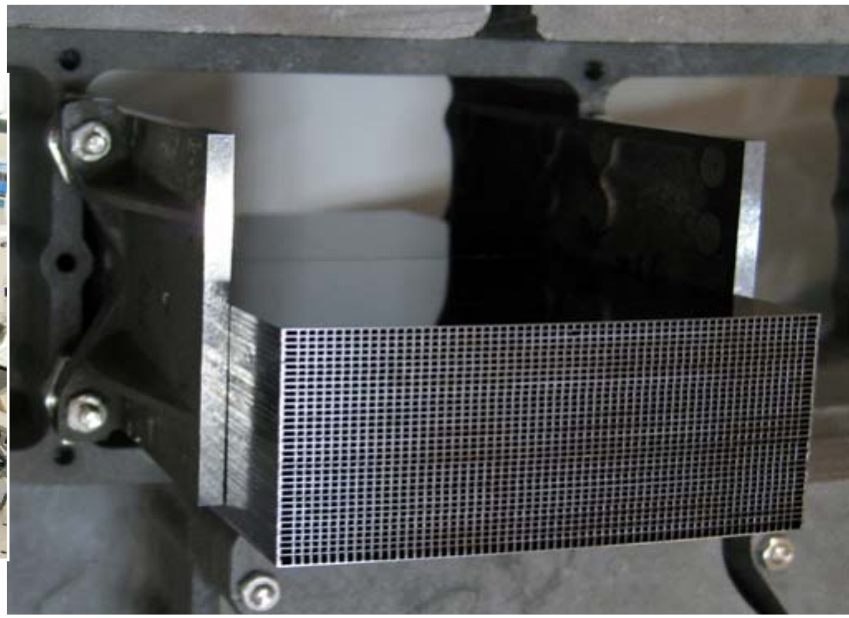
Marcos Bavdaz

ESA/ESTEC

SPO: from mirror plates to Mirror Module and Petal: A multi-industrial/institutional undertaking







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Technology Development Activity: Prototype Petal (industrial activity)

ESA TDP overview: IXO Optics

MM Performance Demo

MM Ruggedizing & Testing

Petal Breadboard

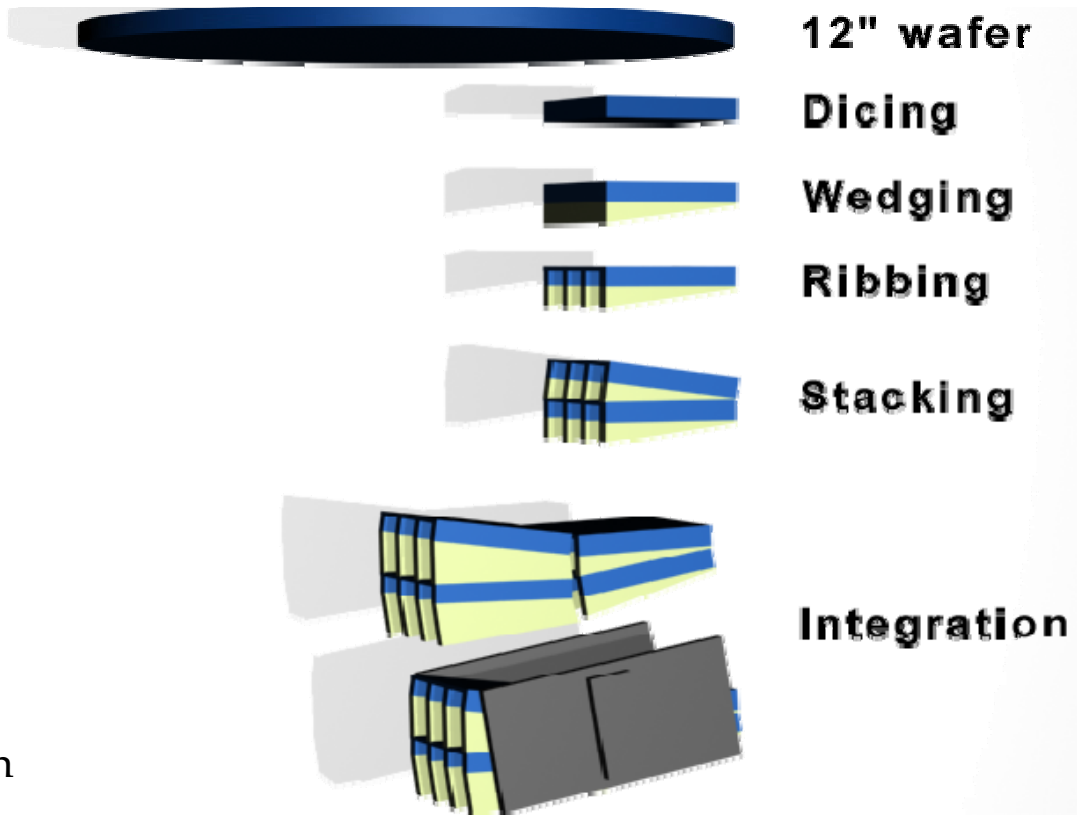
Industrialised Mass Production

Back-up Optics Technology, part 1

Back-up Optics Technology, part 2

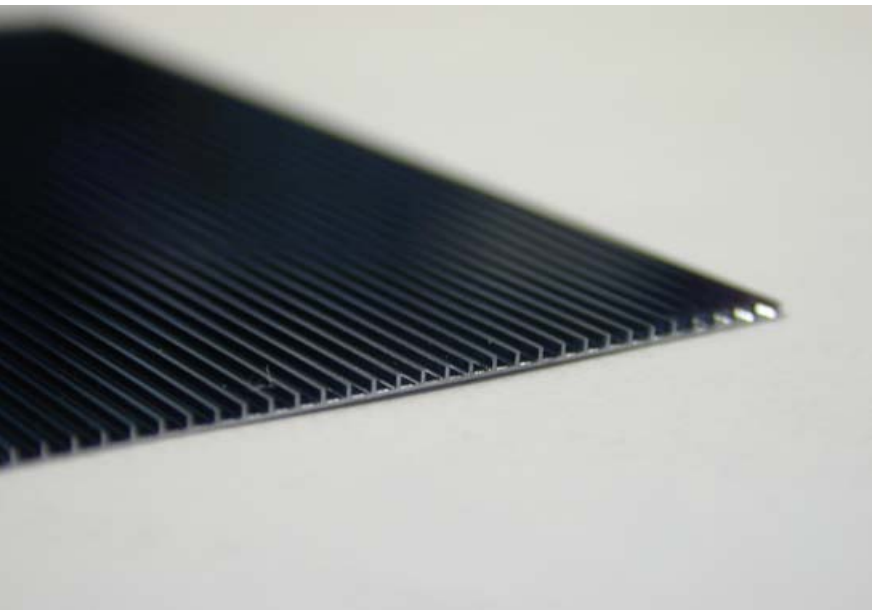
Silicon Pore Optics

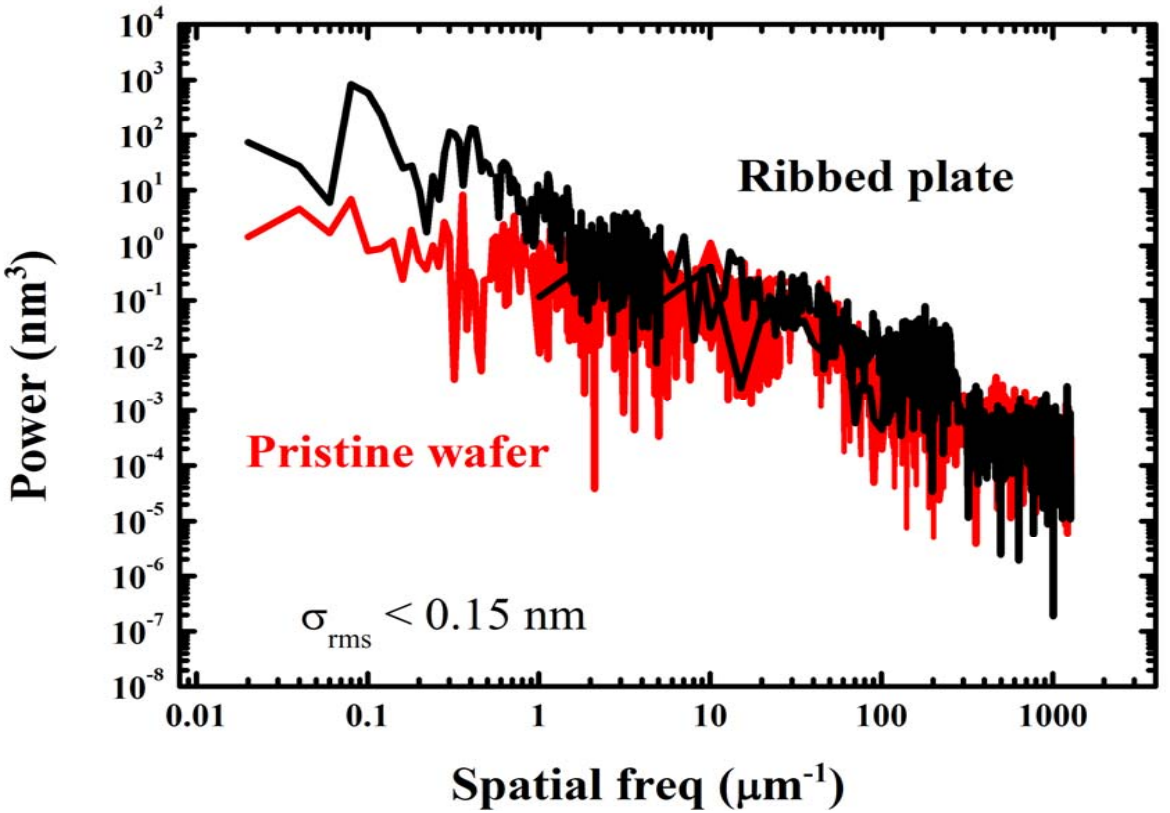
- Uses commercial high-quality 12” silicon wafers
  - plan-parallel < 0.6 μm over 300 mm
  - TTV 0.2 - 0.6 μm over 300 mm
  - large-scale production, cheap
- Ribbed Si plate production and stacking
  - diced and ribbed (66 x 66 mm^2, 64 ribs)
  - elastically bent into a cylindrical shape
  - directly bonded on top of each other
- Stacking process established
  - Automated, Routine production
  - Currently up to 35 plates
- Tandem integration
  - Developed AIT procedures
  - Installed dedicated metrology
  - Assembly directly under X-ray illumination
  - Can set and fix kink-angle between two mirrors to 1” accuracy
- Assembly into petal
  - Demonstrator made



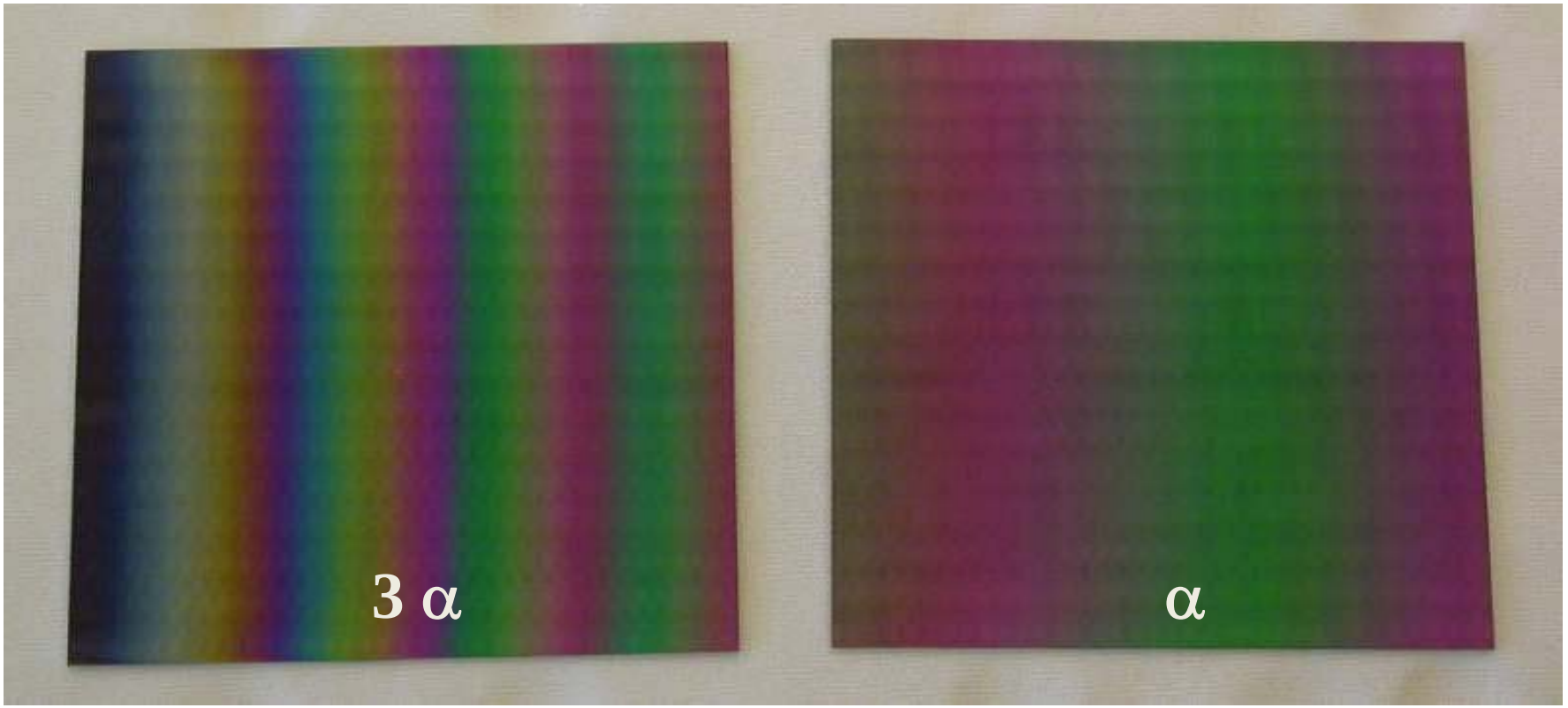
Reflective surface characterization

- Systematic characterization of surfaces as function of different process steps
- Combining different techniques (AFM, XRD, Chapman, Interferometry) to access full spatial frequency range from nm^{-1} up to cm^{-1}



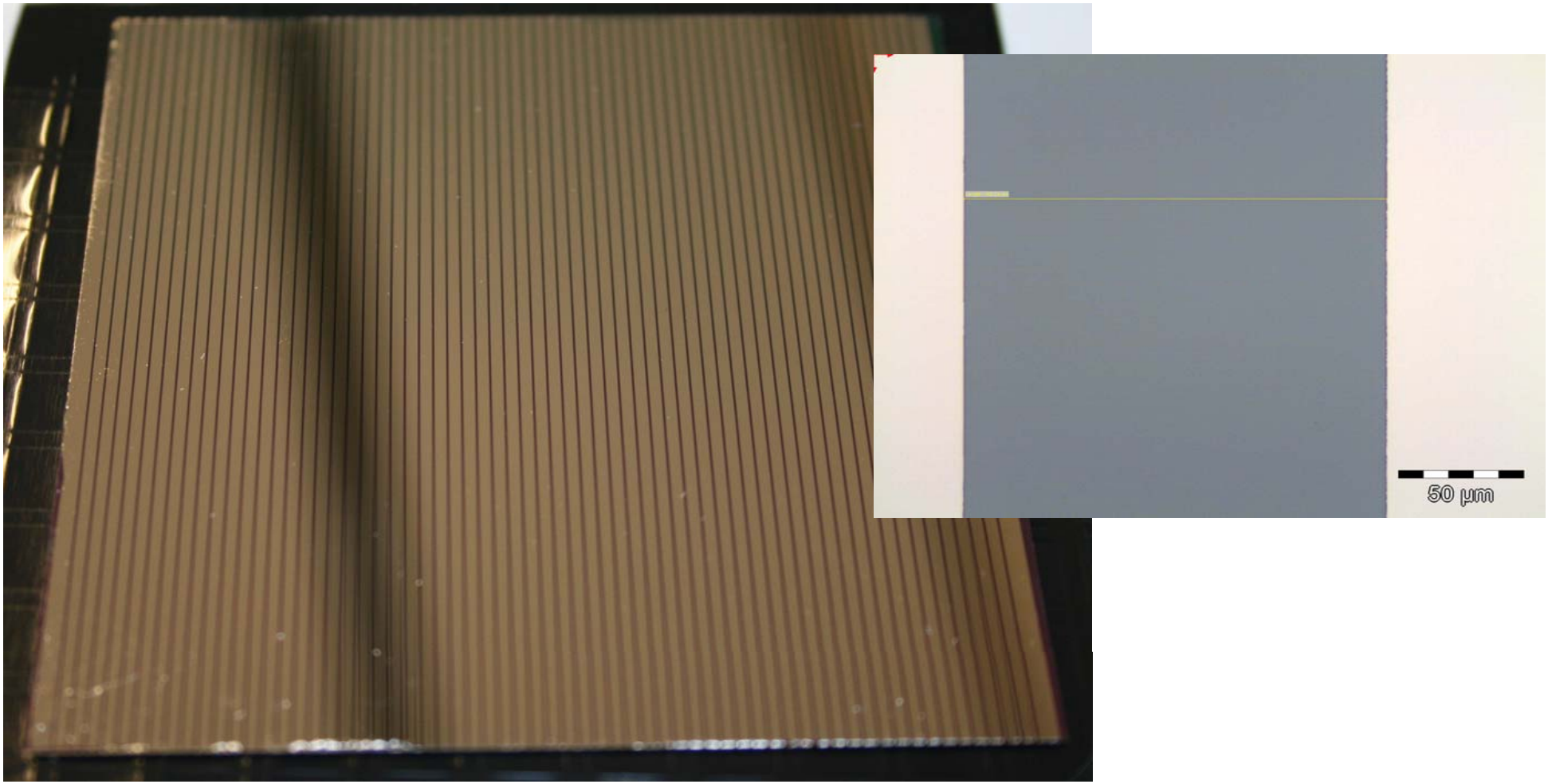


Wedged Mirror Plates manufactured and stacked

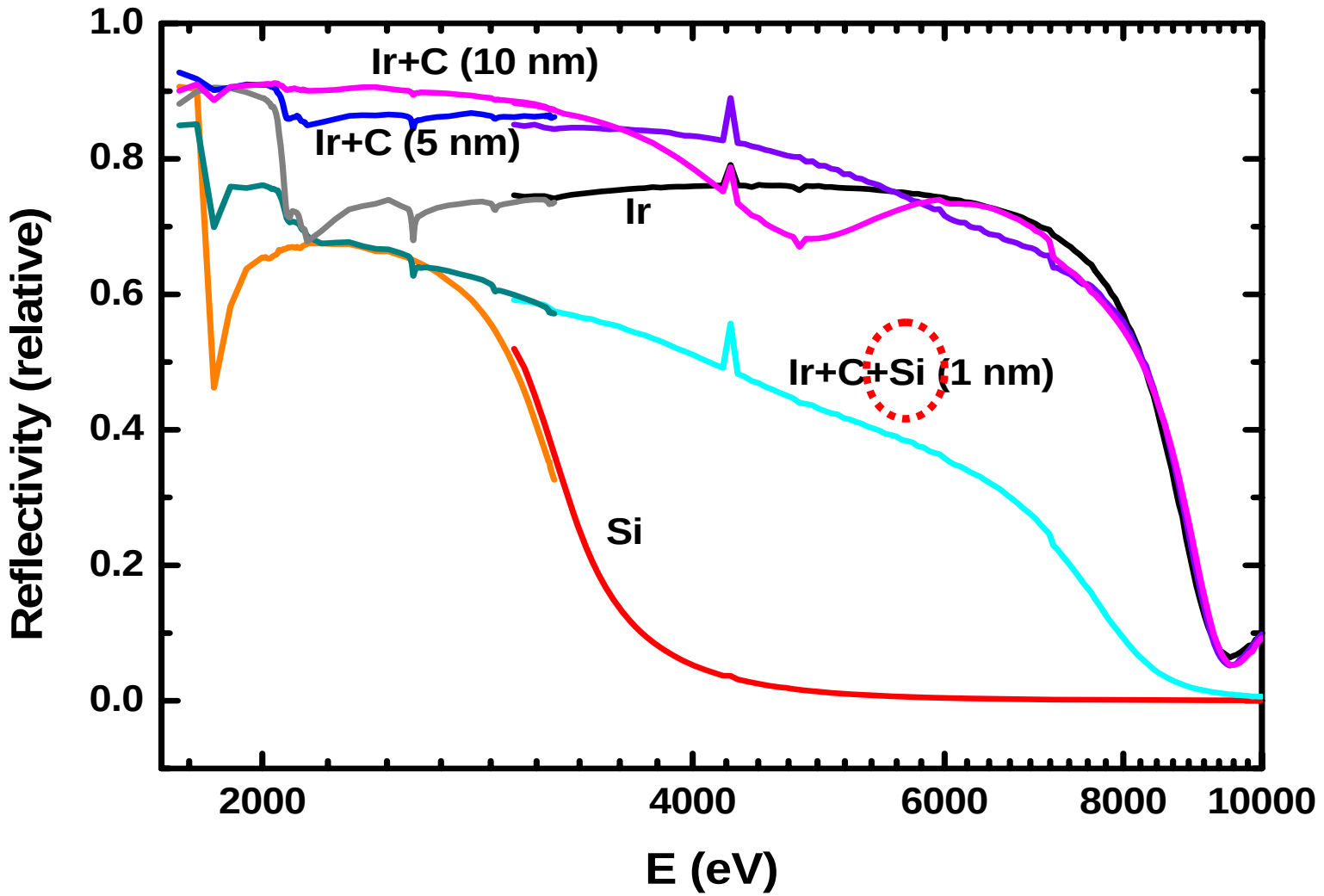


Alternative Structured Coating

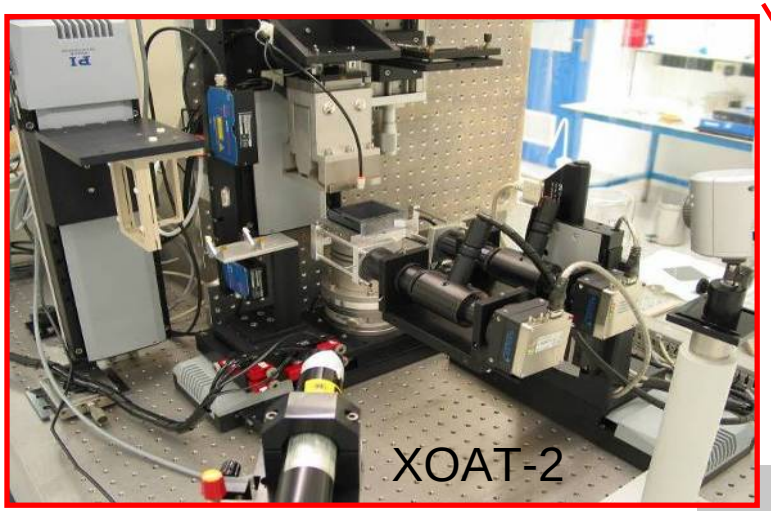
- First trial of lithographic mask successful!



Reflectometry of Advanced Coatings

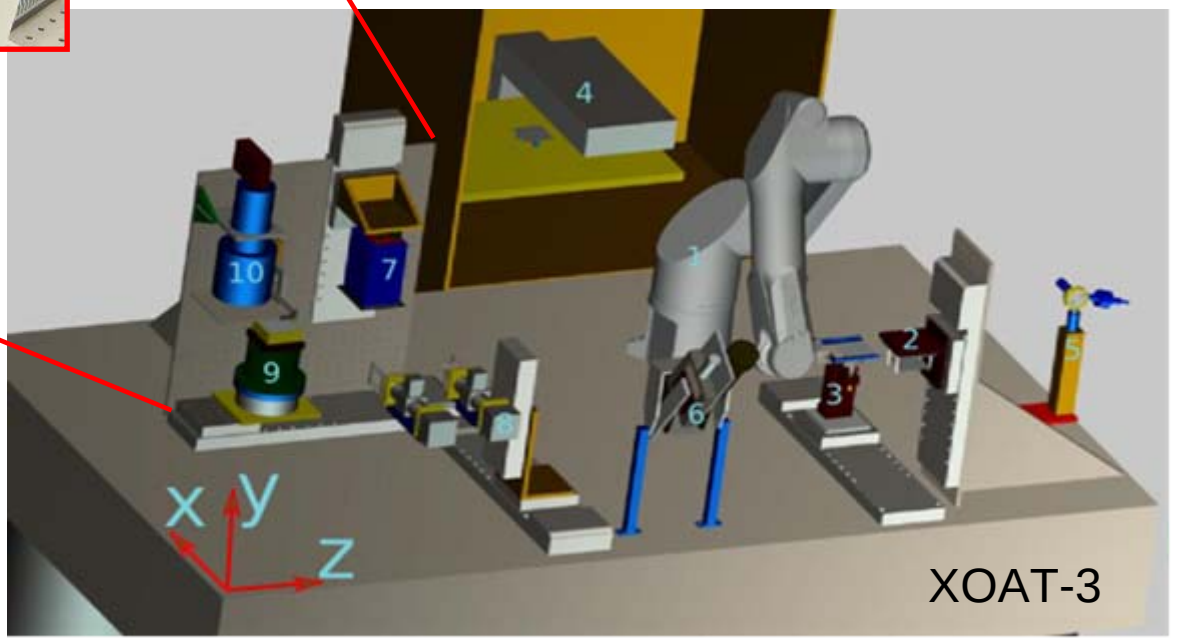


Stacking robot development



Working on three areas:

- Automated particle detection and removal
- Improved stacking figure
- Modularity



XOAT: X-ray Optics Assembly Tool

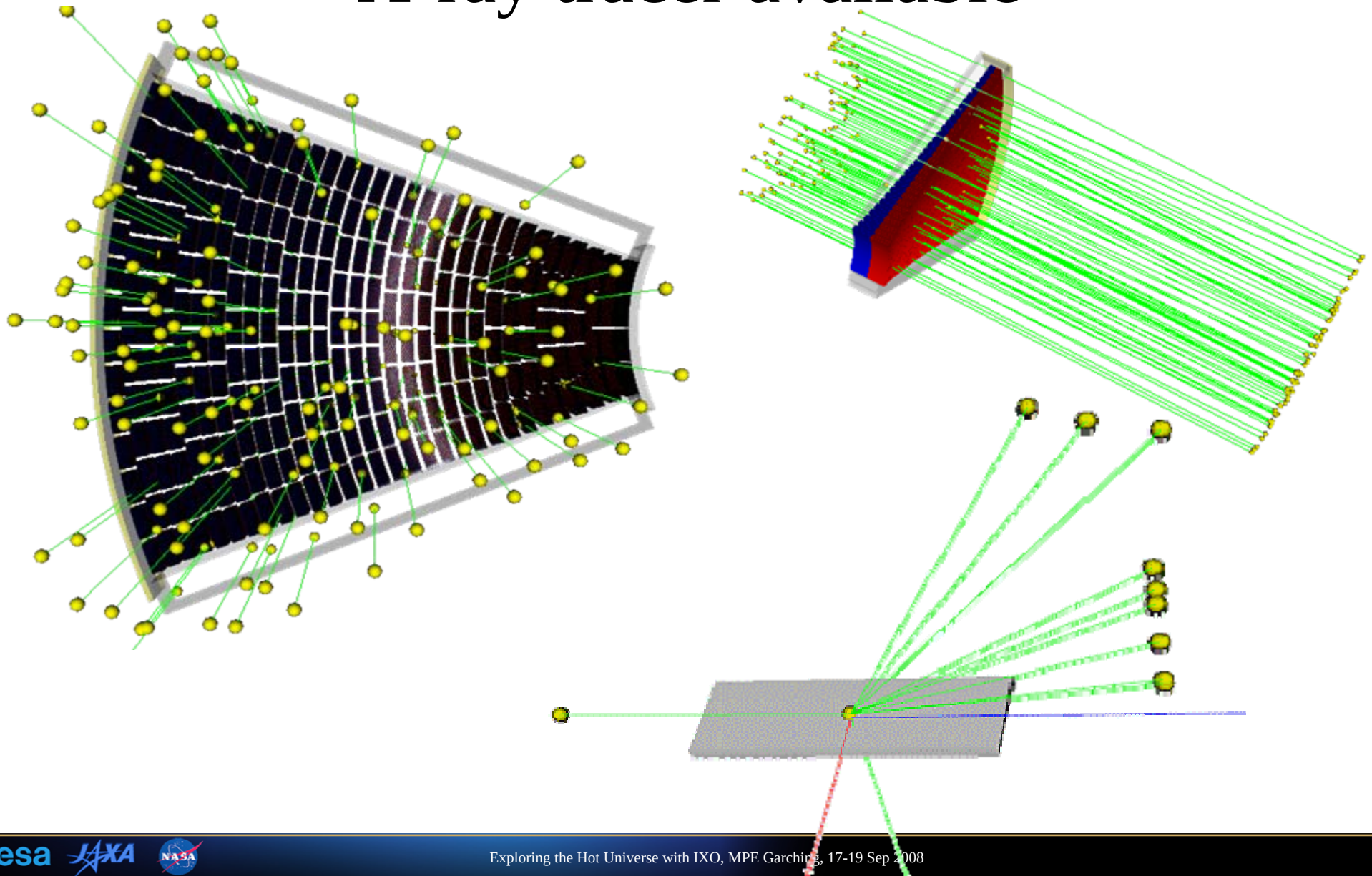
FEM analysis

- Current Cesic bracket design OK after re-analysis
  - Resonance frequencies for inner and outer radii above 490 Hz
  - Safety factor of 3 considered

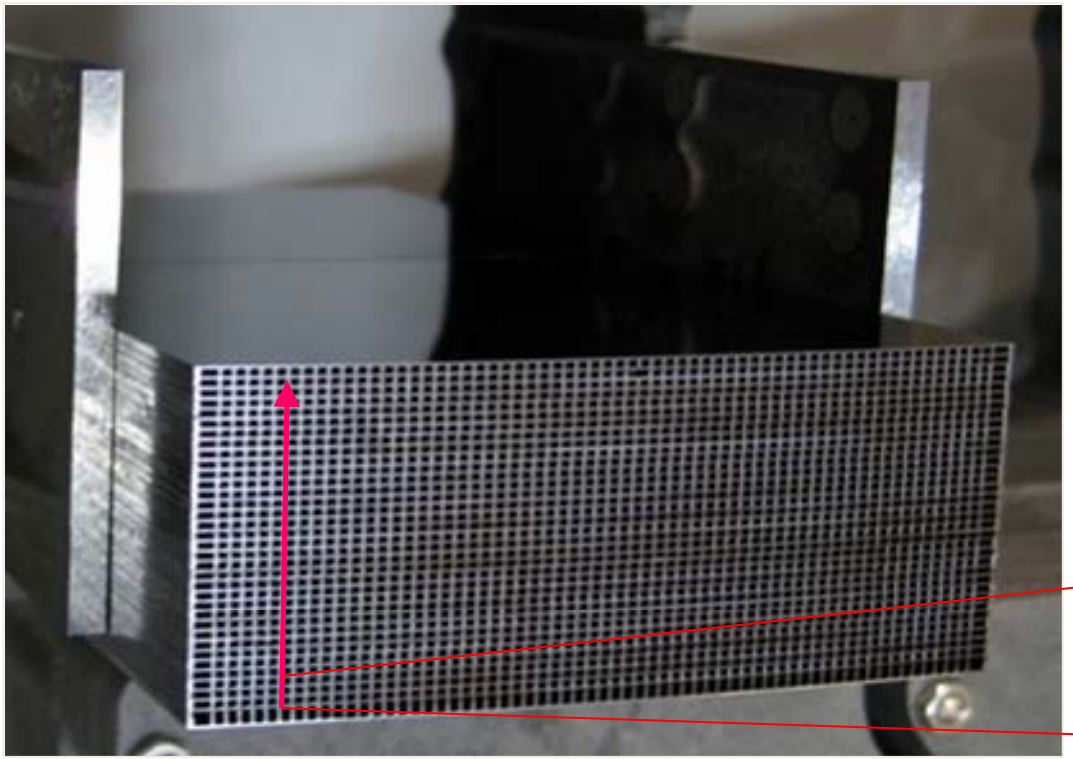
- Interface bracket/petal ("dowel pin") has been improved
  - Have found simple solution that is fully iso-static
  - Improved dowel pins to further increase safety margins
    - for higher quasi-static launch loads (100 → 130 g)
    - different AIV procedure (interface unflatness)

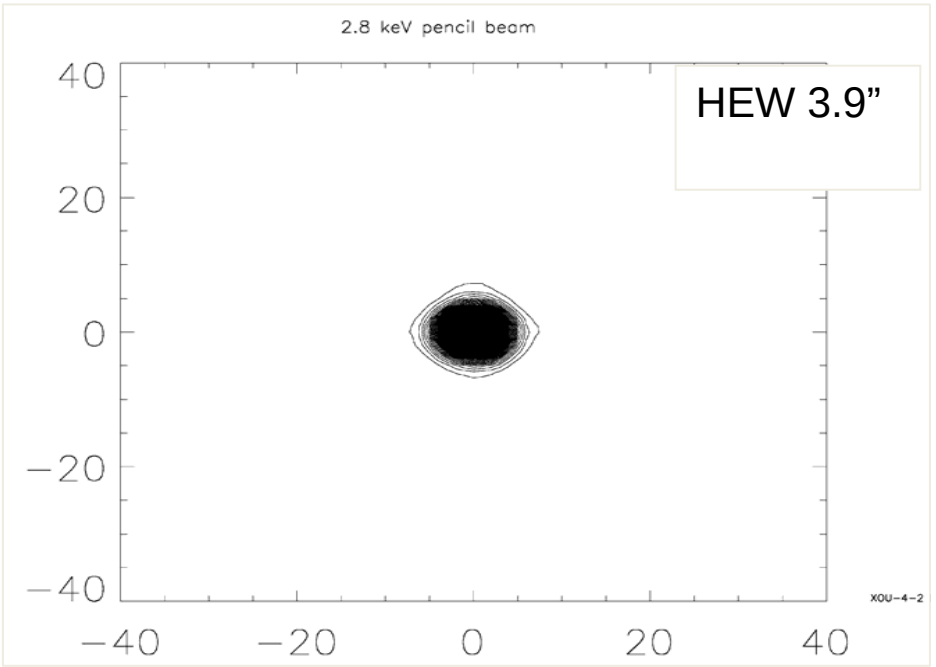
- will be tested in in 2008

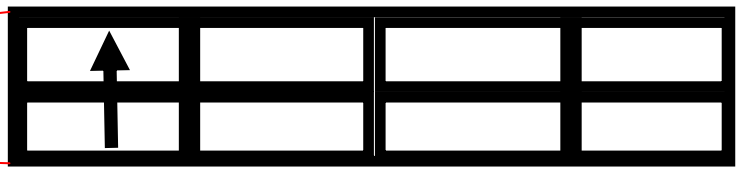
X-ray tracer available



Pencil beam metrology at BESSY:



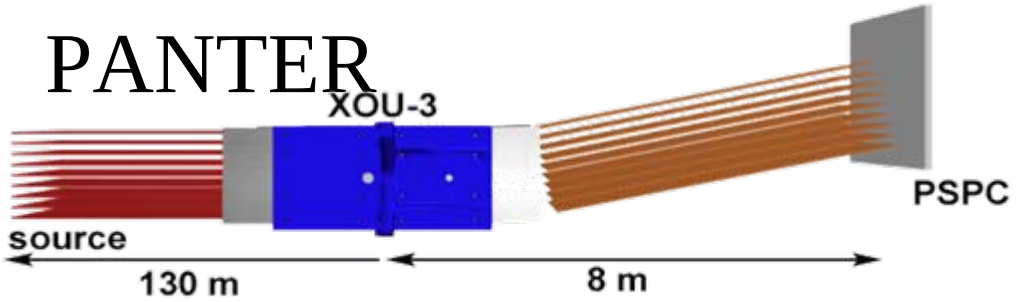


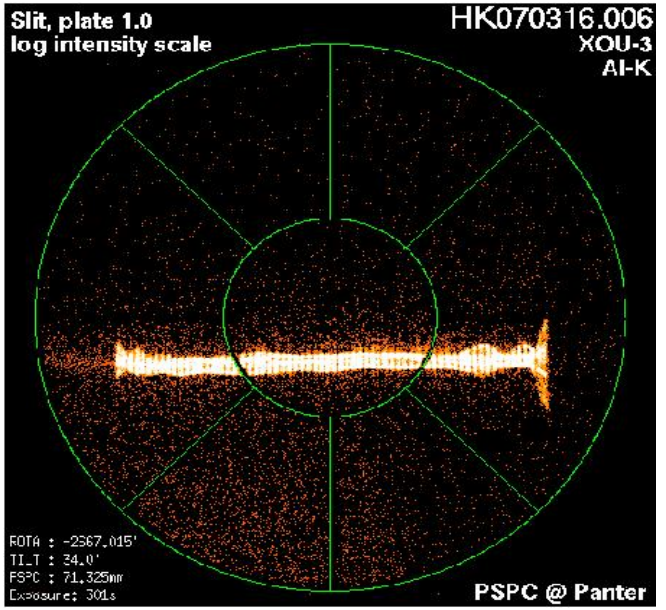


50µm X-ray beam,
scans over full length of mirror

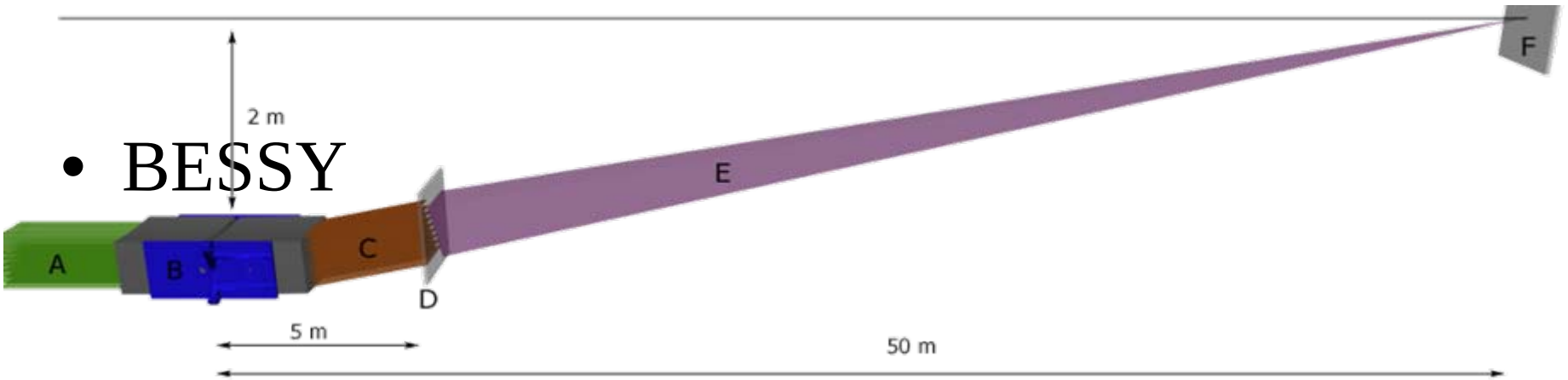
Complementary full-beam metrology at Panter

- PANTER

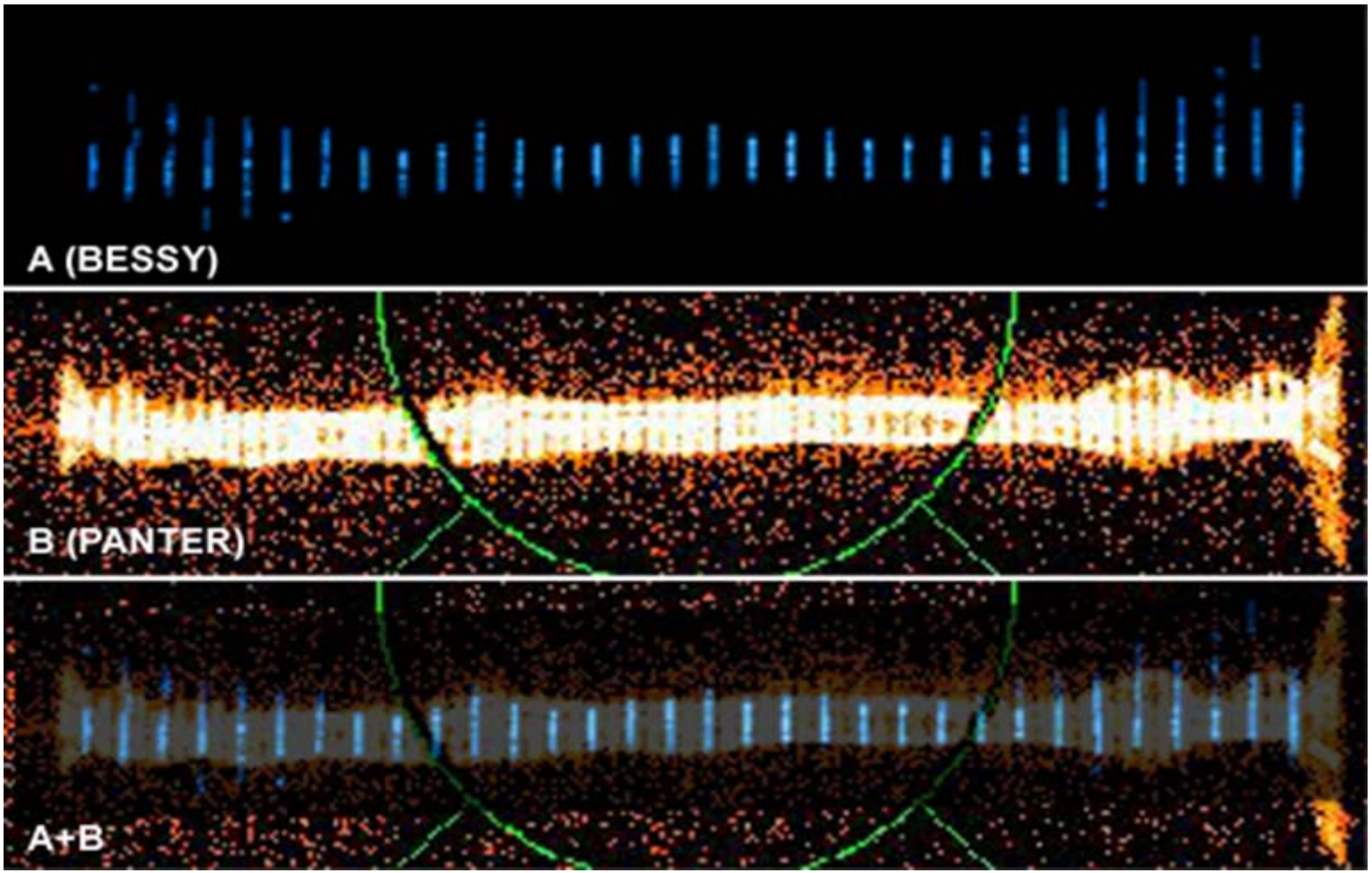




- BESSY

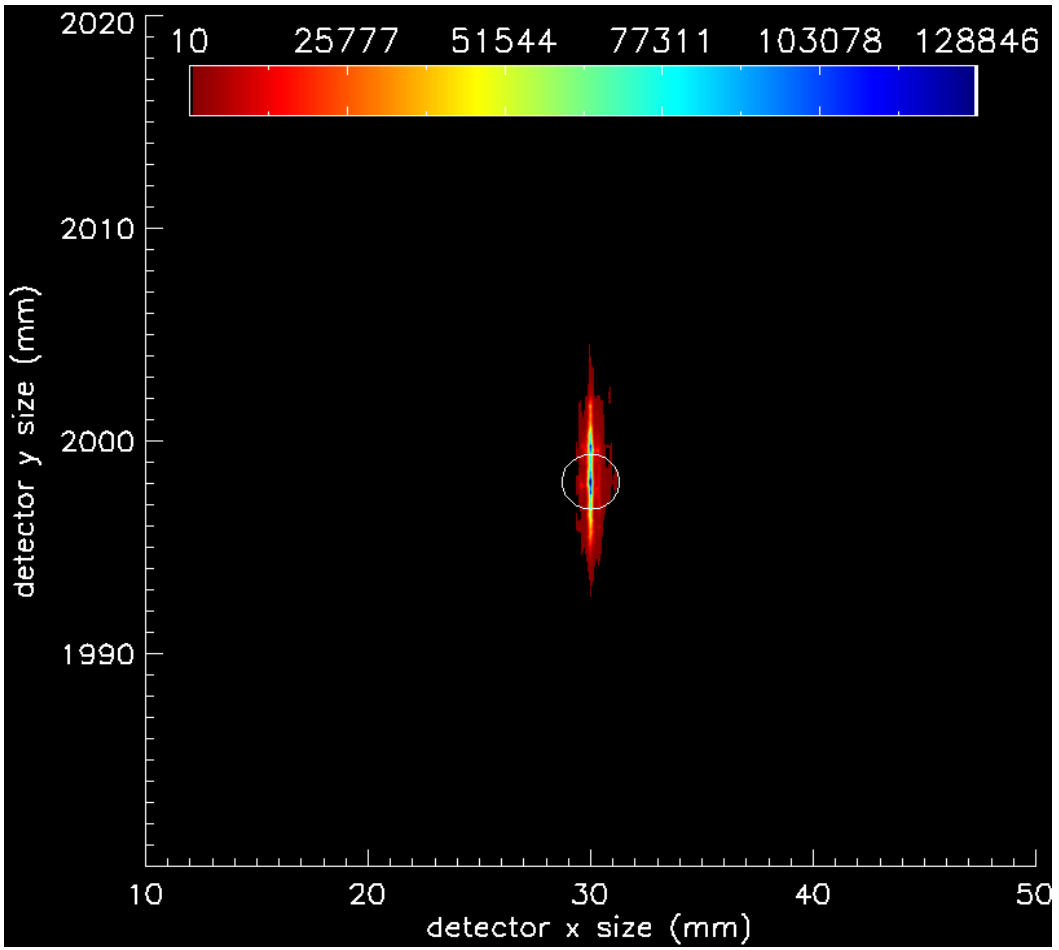


Full area (PANTER) versus pencil beam (BESSY2)



Current performance

- HEW 17” @ 50 m
  - double reflection
  - mounted optics
  - absolute
  - no subtraction
- Plates 1-4
  - full width



Acol = 1.25 cm² (= 13% of innermost XMM mirror shell)

SPO for IXO: 2009 Outlook

- Plate production
  - Simplified and cheaper manufacturing process
  - Coated plates with required pattern
  - Compatible with small inner radia (r~0.3 m)
- Coating
  - Two options available (shadow masking and lift-off technique)
- Stacking: 3rd generation stacking robot
  - Cleaning process being fully automated
  - Particle detection system being calibrated
  - Cleanroom class 2 robotic arm as new centre part, modular concept
  - First new generation XOUs expected early 2009
- X-ray testing and metrology
  - Panter and Bessy2 facility upgrades planned for 2009
  - Combining metrology and X-ray prognosis with analysis