UV Technology Developments at MPS

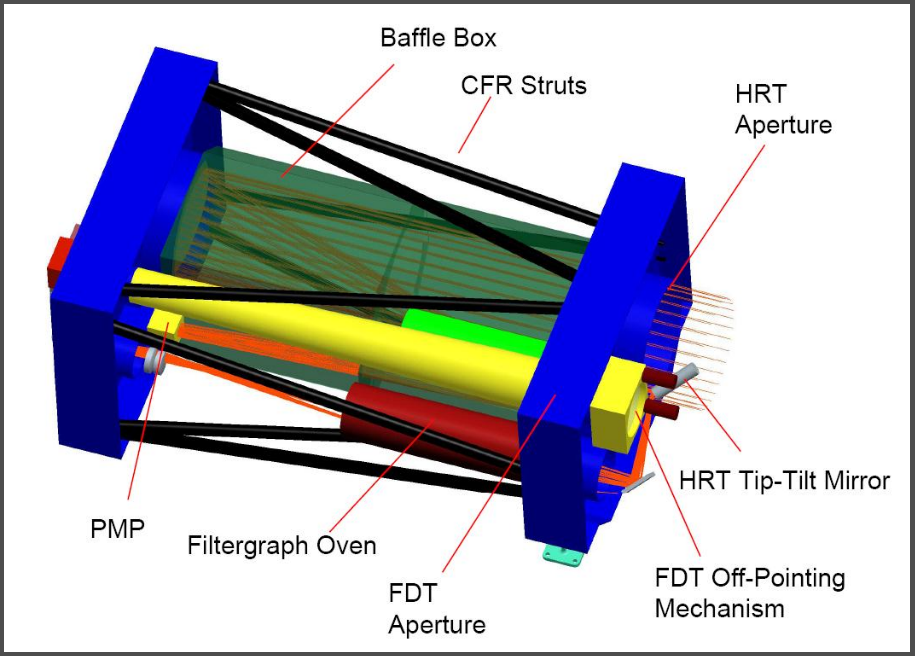
Udo Schühle

SO Instruments with MPS H/W contributions

Investigation	Measurements
Solar Wind Analyzer (SWA)	Solar wind ion and electron bulk properties, ion composition (1eV- 5 keV electrons; 0.2 - 100 keV/q ions)
Energetic Particle Detector (EPD)	Composition, timing, and distribution functions of suprathermal and energetic particles (8 keV/n – 200 MeV/n ions; 20-700 keV electrons)
Magnetometer (MAG)	DC vector magnetic fields (0 – 64 Hz)
Radio & Plasma Waves (RPW)	AC electric and magnetic fields (~DC – 20 MHz)
Polarimetric and Helioseismic Imager (PHI)	Vector magnetic field and line-of-sight velocity in the photosphere
EUV Imager (EUI)	Full-disk EUV and high-resolution EUV and Lyman-α imaging of the solar atmosphere
Spectral Imaging of the Coronal Environment (SPICE)	EUV spectroscopy of the solar disk and corona
X-ray Spectrometer Telescope (STIX)	Solar thermal and non-thermal X-ray emission (4 – 150 keV)
Coronagraph (METIS/COR)	Visible, UV and EUV imaging of the solar corona
Heliospheric Imager (SolOHI)	White-light imaging of the extended corona

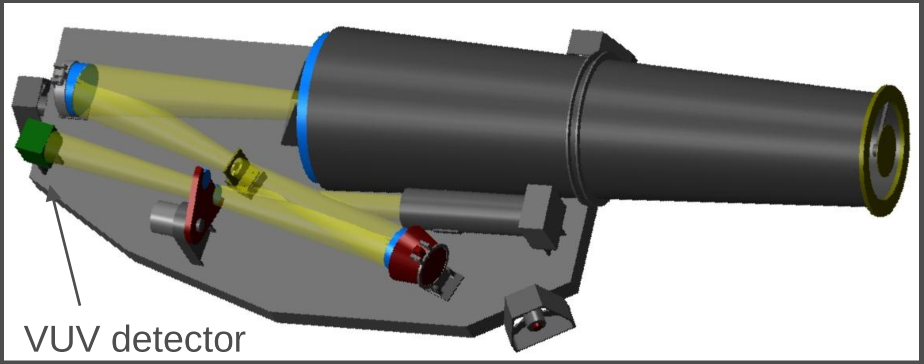
major hardware contributions of MPS

SO Remote-sensing instruments: PHI, METIS

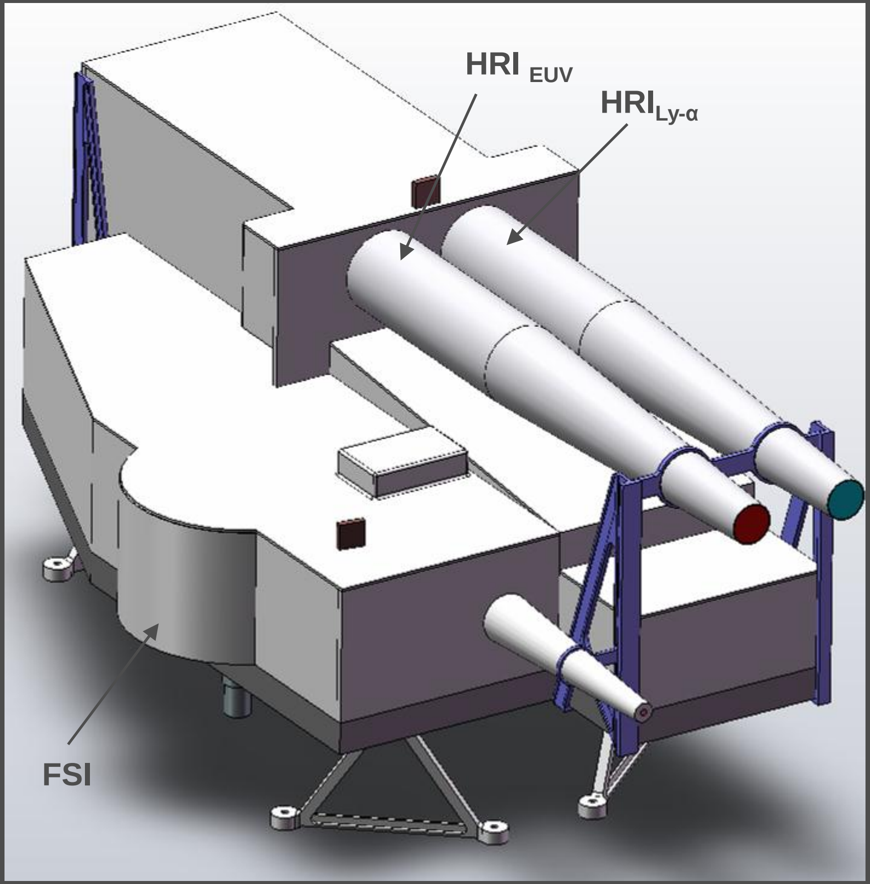


3-D view of **PHI**

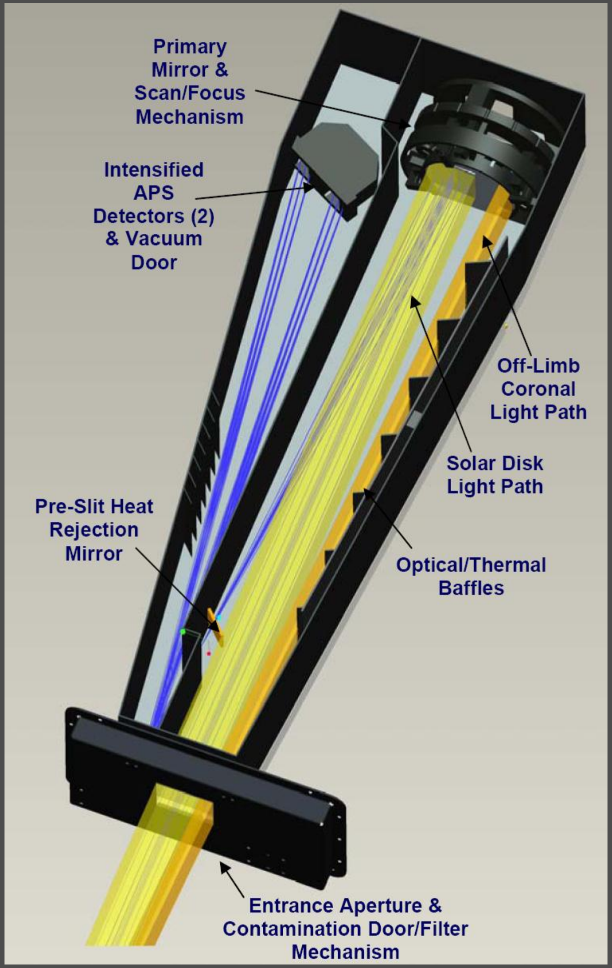
3-D View of **METIS**



SO Remote-sensing instruments: EUI, SPICE



3-D view of the **EUI** instrument configuration



3-D Schematic view of **SPICE**

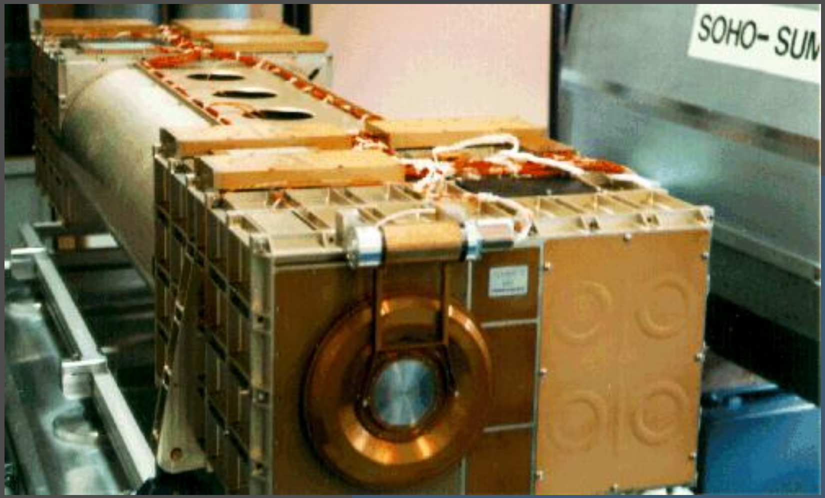
VUV optical technology for Solar Orbiter

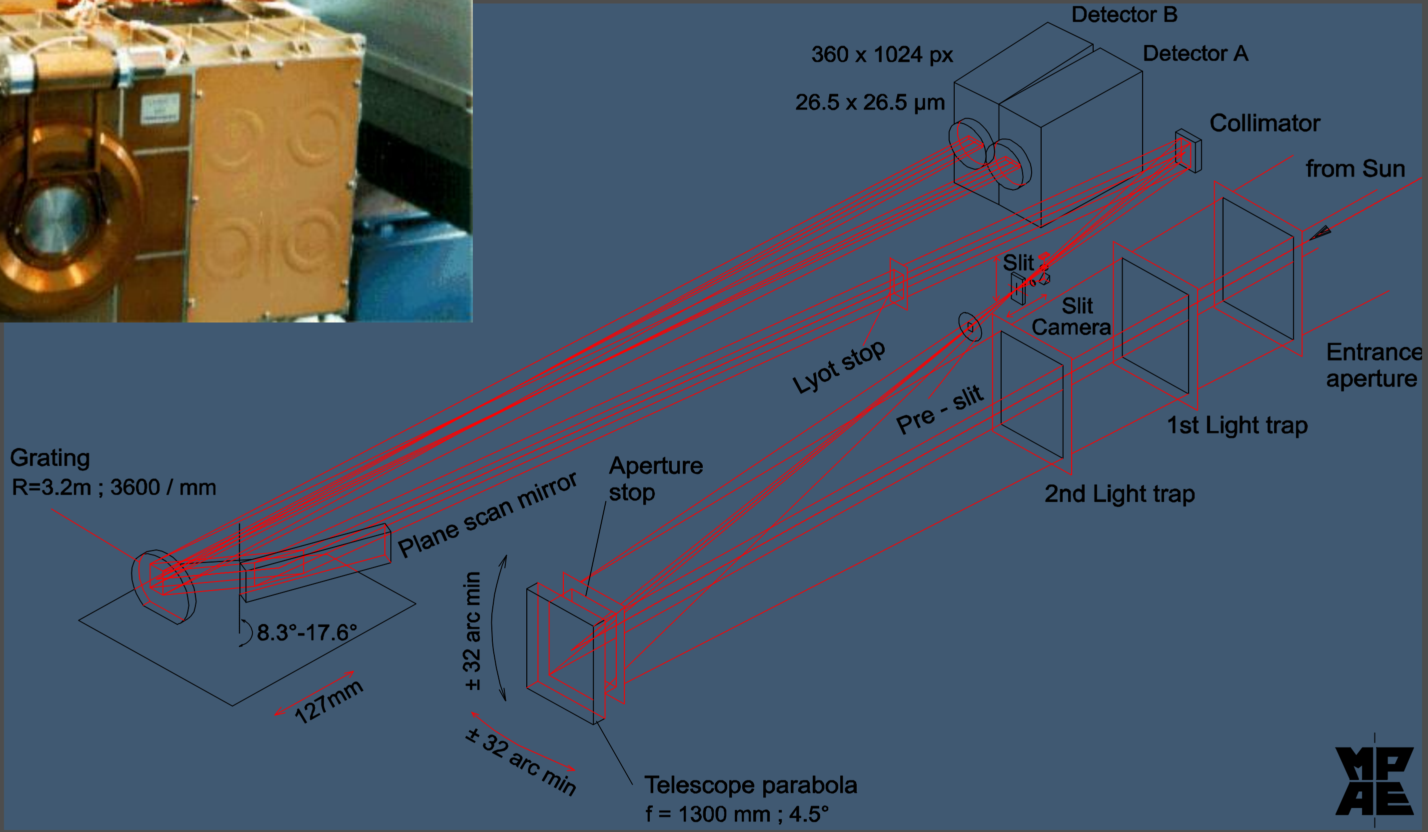
Heritage: VUV spectrograph SUMER on SOHO

Developments for Solar Orbiter:

1. Primary mirror for SPICE
2. Lyman-α telescope for EUI
3. Solar-blind UV detectors for EUI and METIS

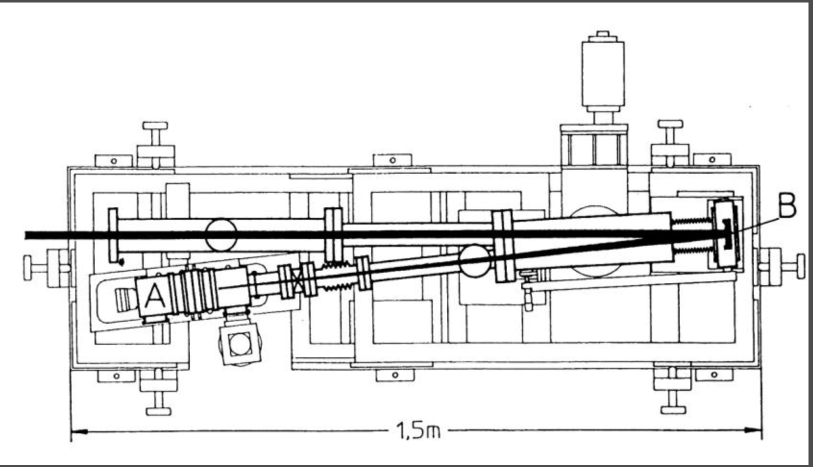
VUV spectrograph SUMER on SOHO





Developements for Solar Orbiter EUS

Radiometric transfer standard source

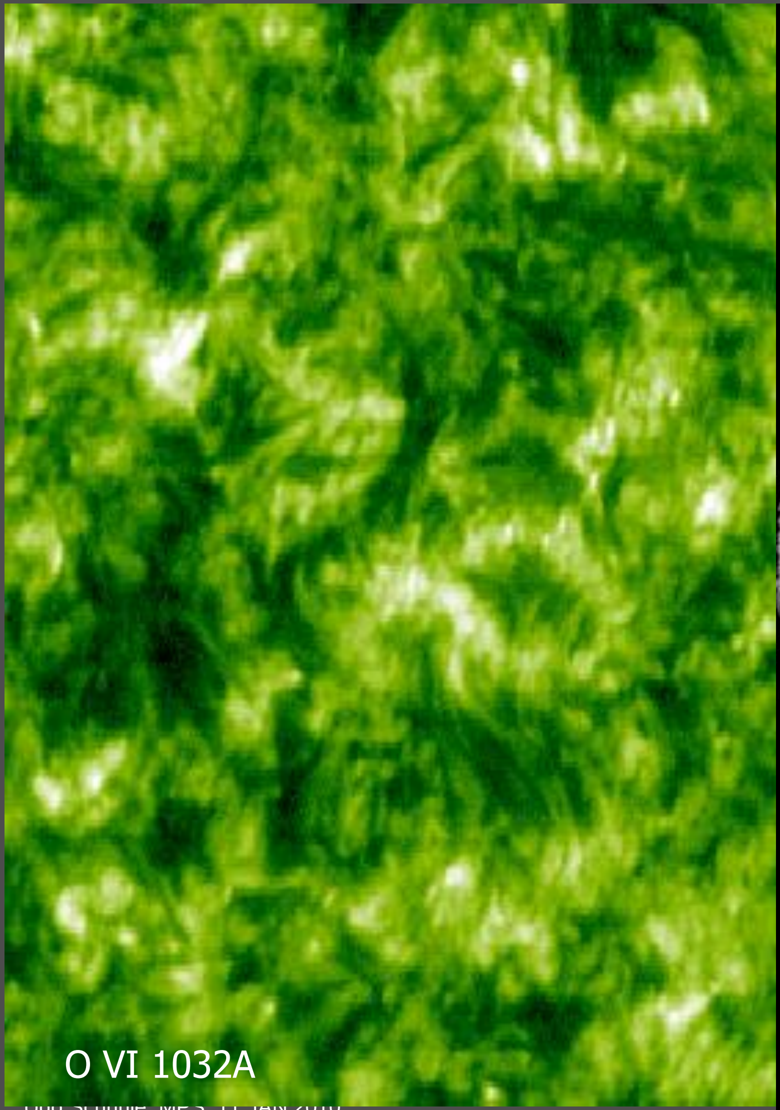


SUMER calibration source recently recalibrated at PTB/BESSY

SUMER test and calibration vacuum tank at MPS: 300 cm x 90 cm diameter

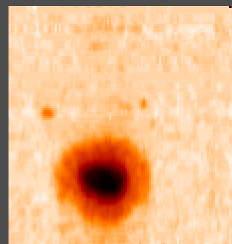
VUV spectrograph SUMER on SOHO

Raster scans of the solar Transition Region

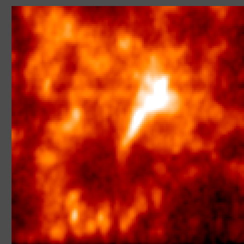


VUV spectrograph SUMER on SOHO

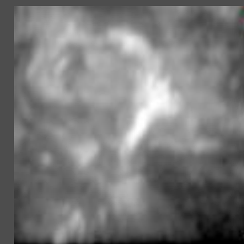
raster scan
of sunspot:



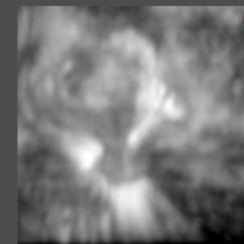
vis 633 nm



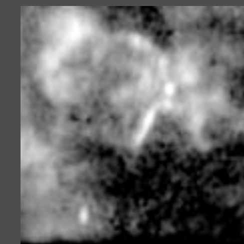
cont. ~125 nm



N V 123.8 nm

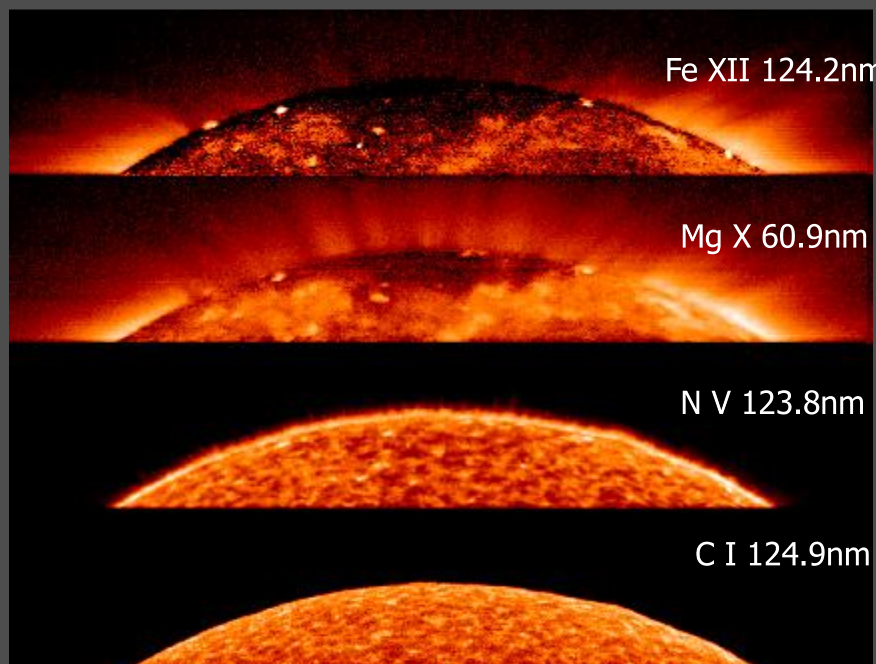


O V 62.9 nm



Fe XII 124.2 nm

raster scan
of polar region:

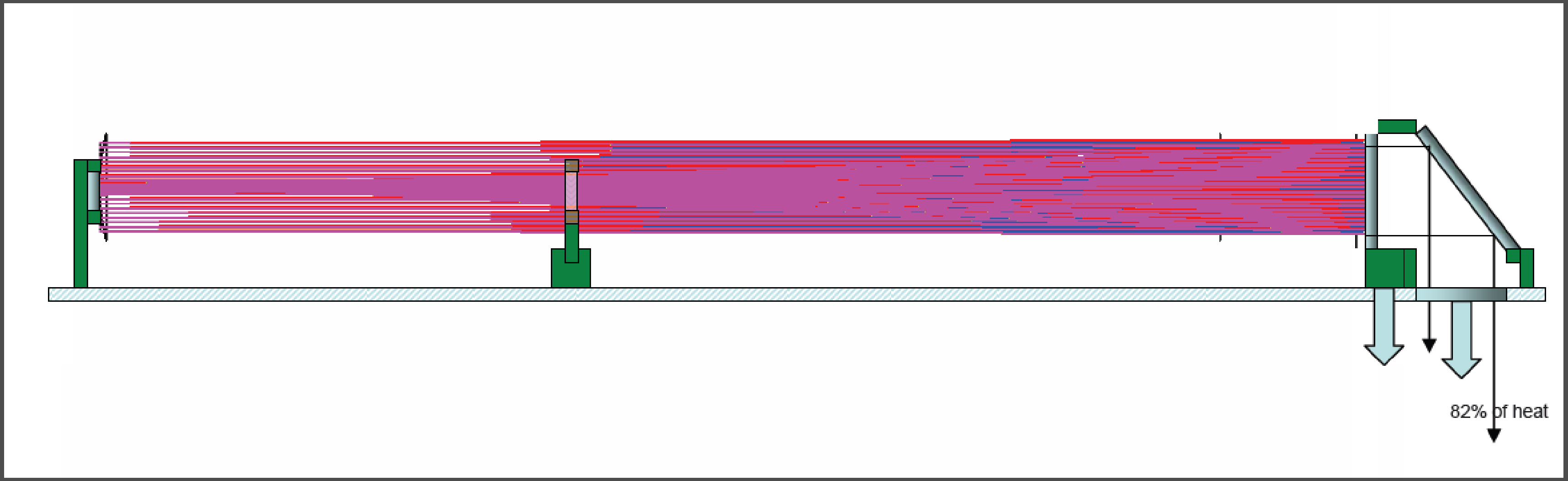


Developments for Solar Orbiter SPICE

design with two optical elements using off-axis parabola telescope and toroidal variable-line space grating

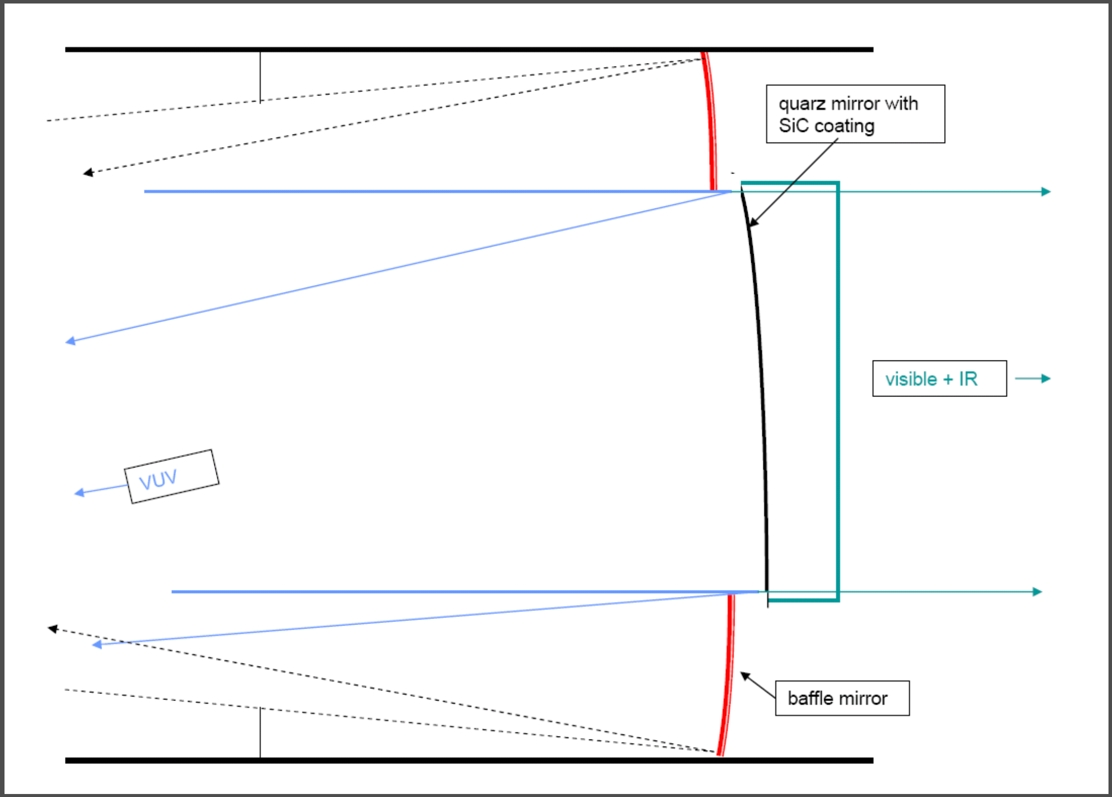
Developments for Solar Orbiter SPICE

heat management through the primary mirror



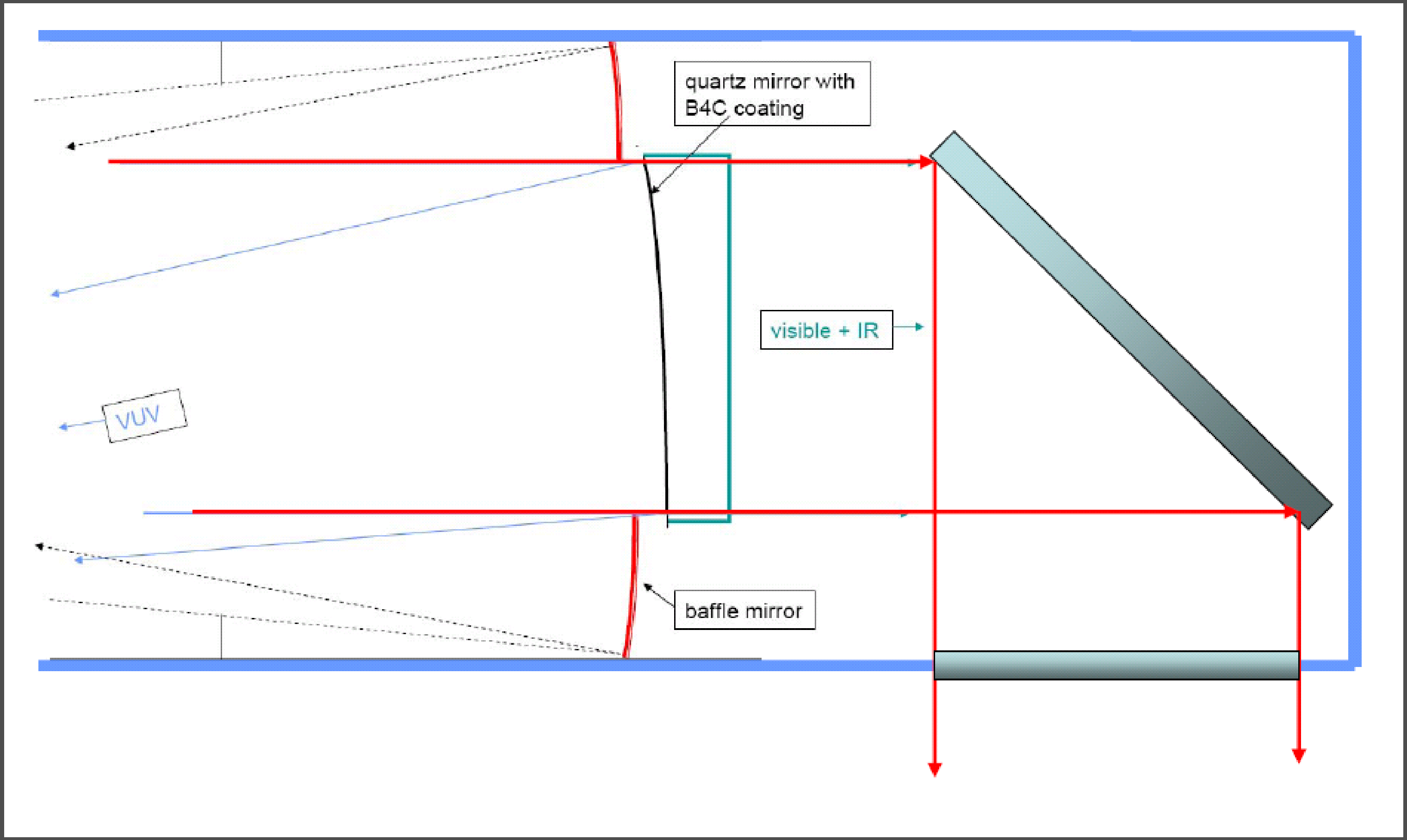
Developments for Solar Orbiter SPICE

Study of a dichroic telescope mirror



==> heat will be transmitted towards a radiator

SPICE primary mirror design with thin B_4C coating



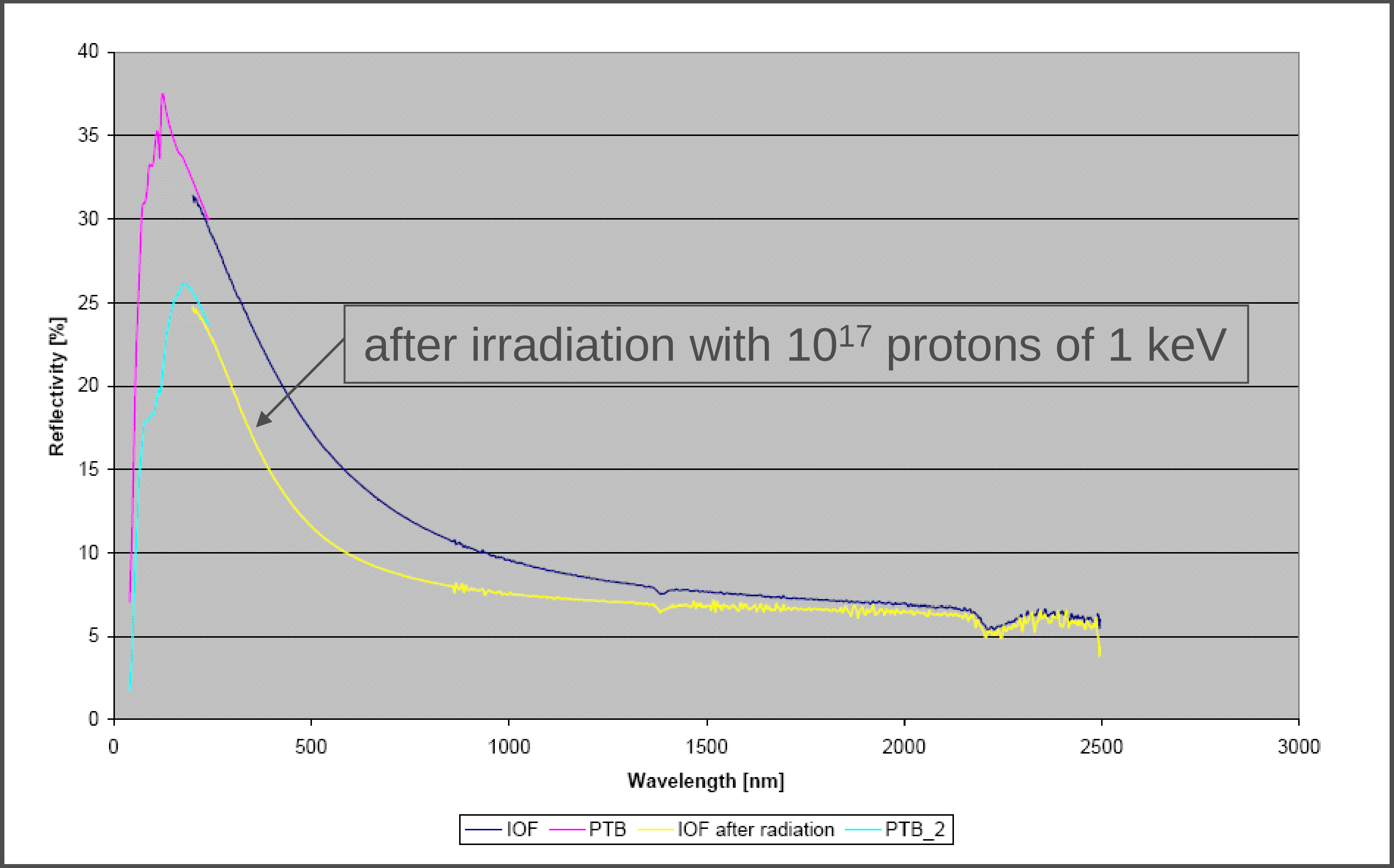
VUV tests with mirror samples

VUV reflectometer

Space qualification of mirror coatings

- Space radiation simulation: irradiation with 10 - 60 MeV protons
- Solar wind simulation: irradiation with 1 keV protons (mission equivalent dose)
- Solar UV simulation: irradiation with UV (20 solar constants)

Degradation by solar wind protons



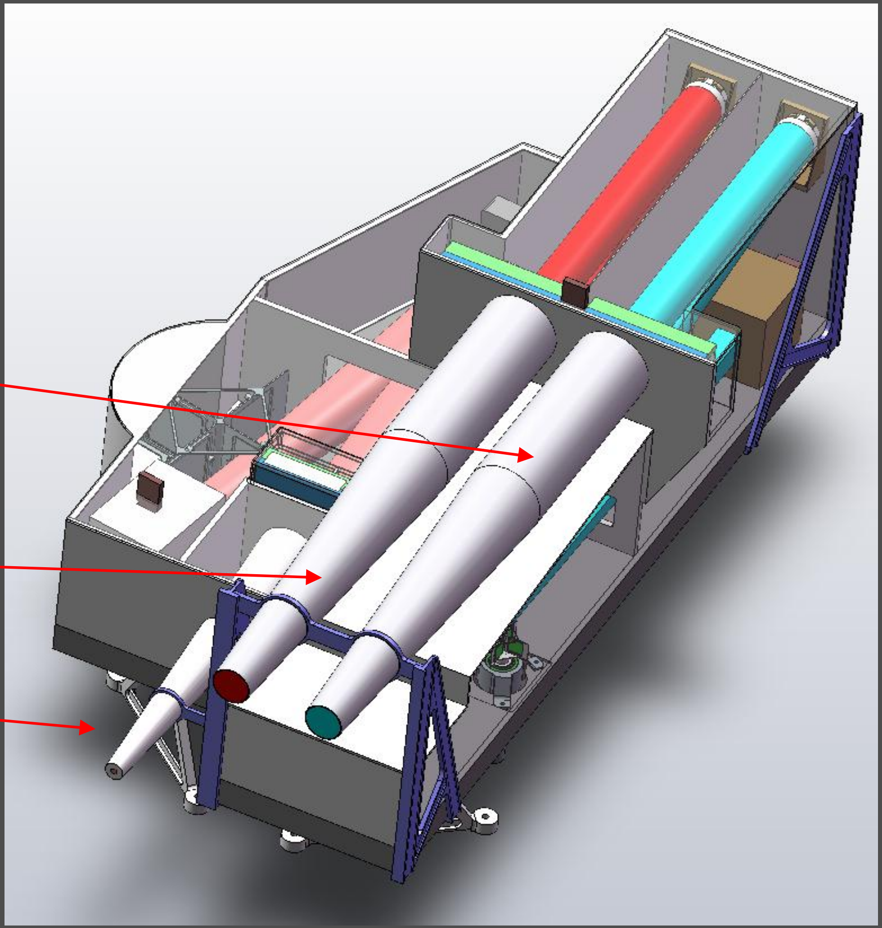
EUI telescope design

EUI: suite of 3 telescopes

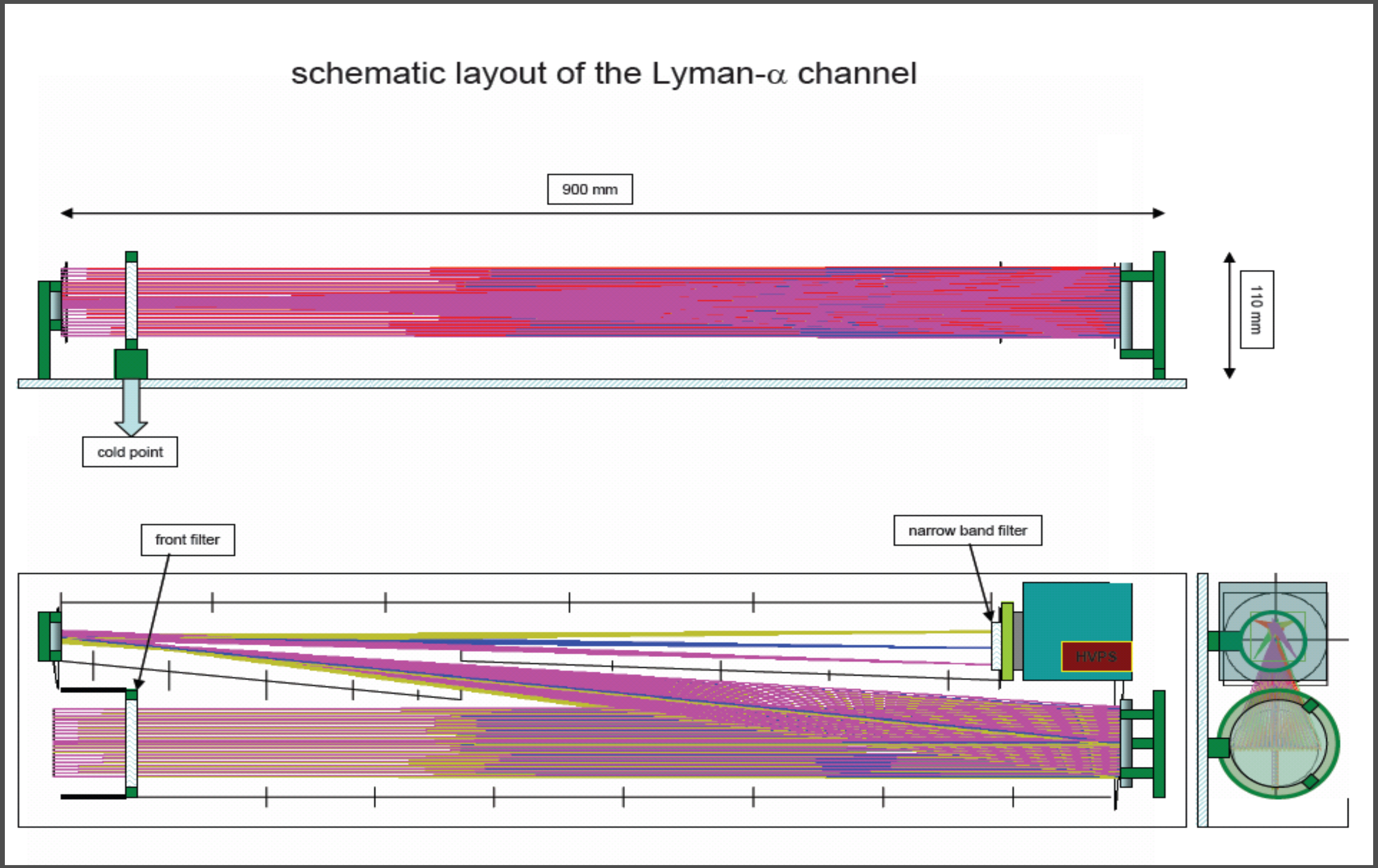
HRI Lyman-α channel 121.6 nm

HRI EUV channel 17.4 nm

FSI dual EUV channel
17.4 and 30.4 nm nm



EUI Lyman-α telescope design



Ly-α channel components

- Telescope entrance baffle door mechanism
- Solar-blind Lyman-α detector
- Optics:
  - Lyman-α narrow band filter (121.6 nm) by Acton Research C. inc.
  - off-axis parabola mirror 30 mm diameter, Al/MgF_2 coating
  - off-axis parabola secondary mirror, Al/MgF_2 coating

EUI Door mechanism design

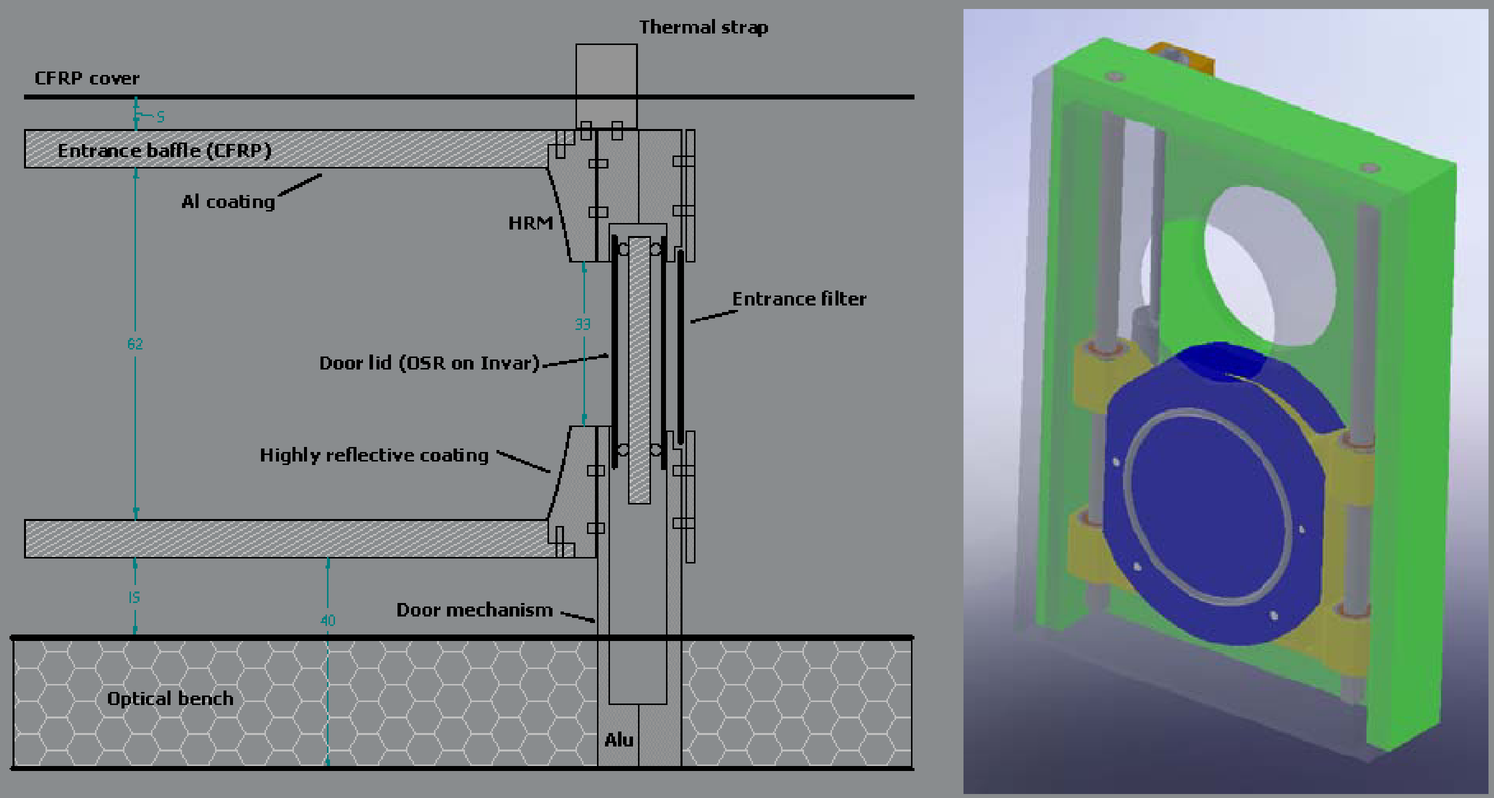
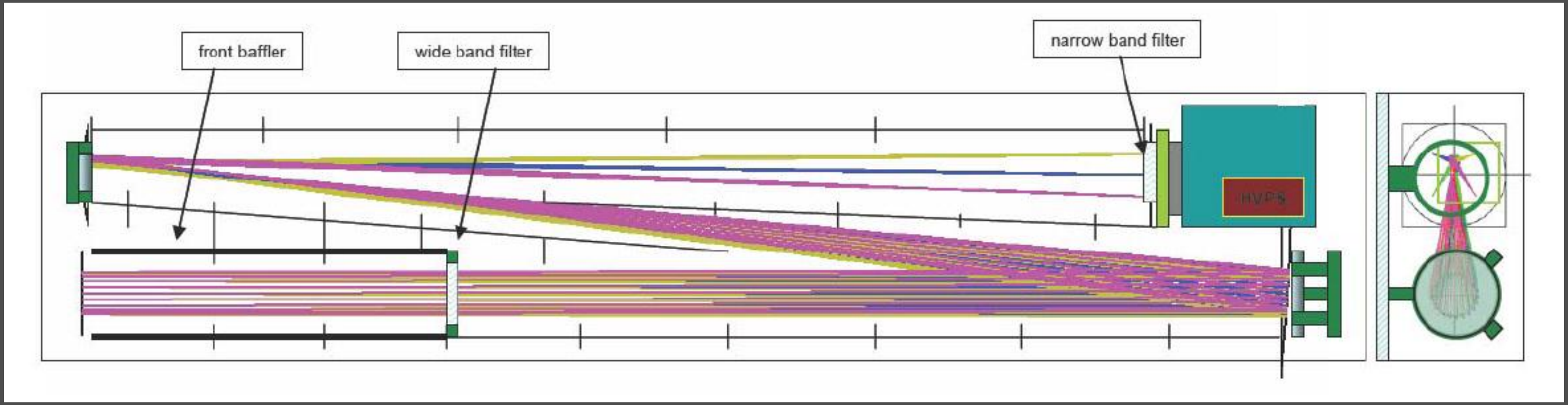


Figure 3-2: EUI preliminary internal door design

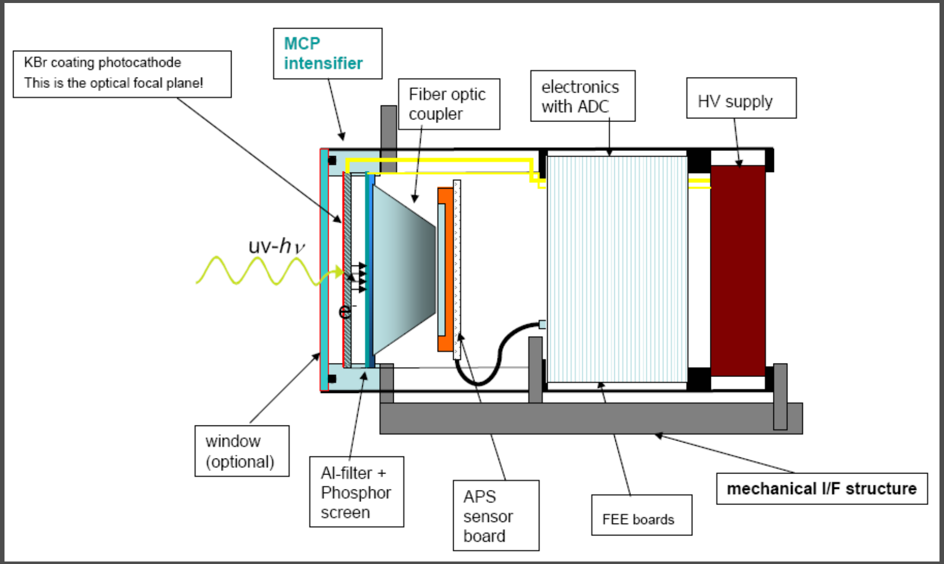
This door mechanism is based on a stepper motor drive moving two lids along two parallel translation bars.

EUI Lyman-α channel detector

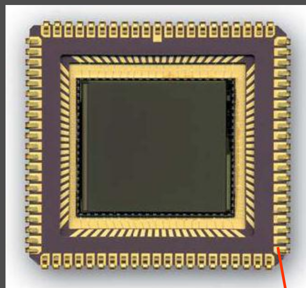


The Lyman-α detector:

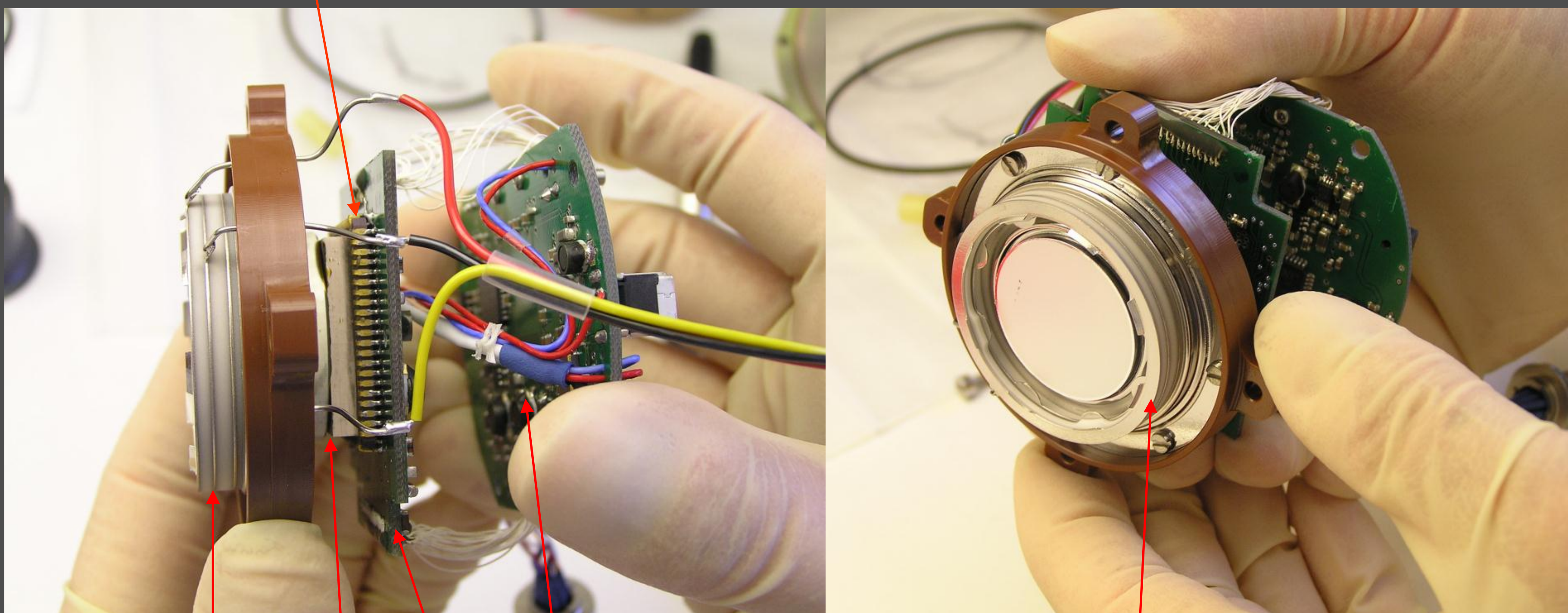
a solar-blind intensified CMOS/APS camera



Coupling MCP intensifier with APS image sensor



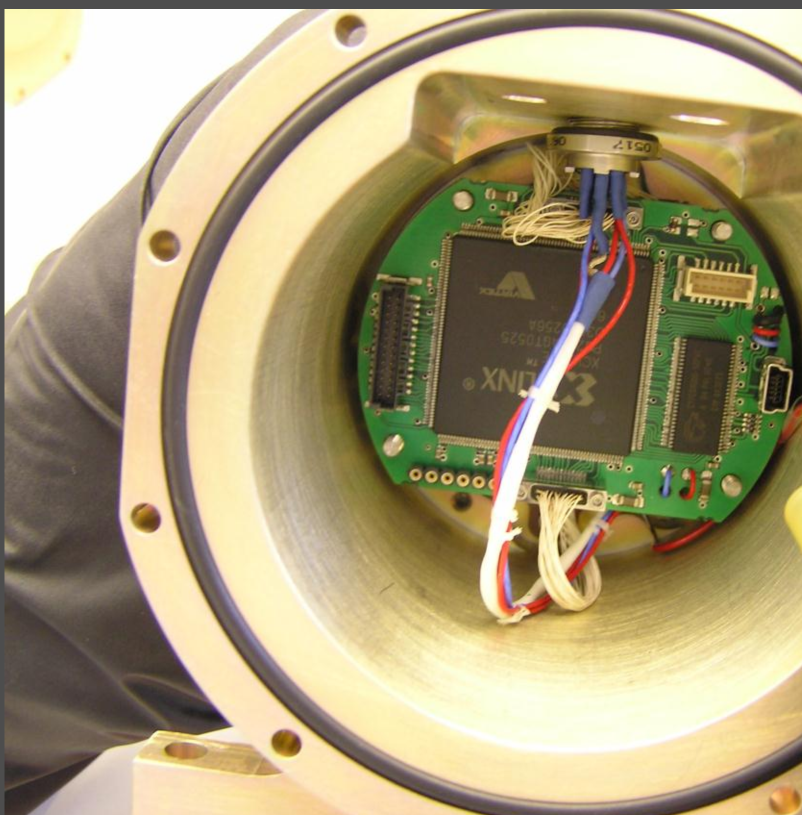
STAR 1000
visible CMOS-APS sensor



MCP stack
fiber optic blocks
APS sensor board
FEE board

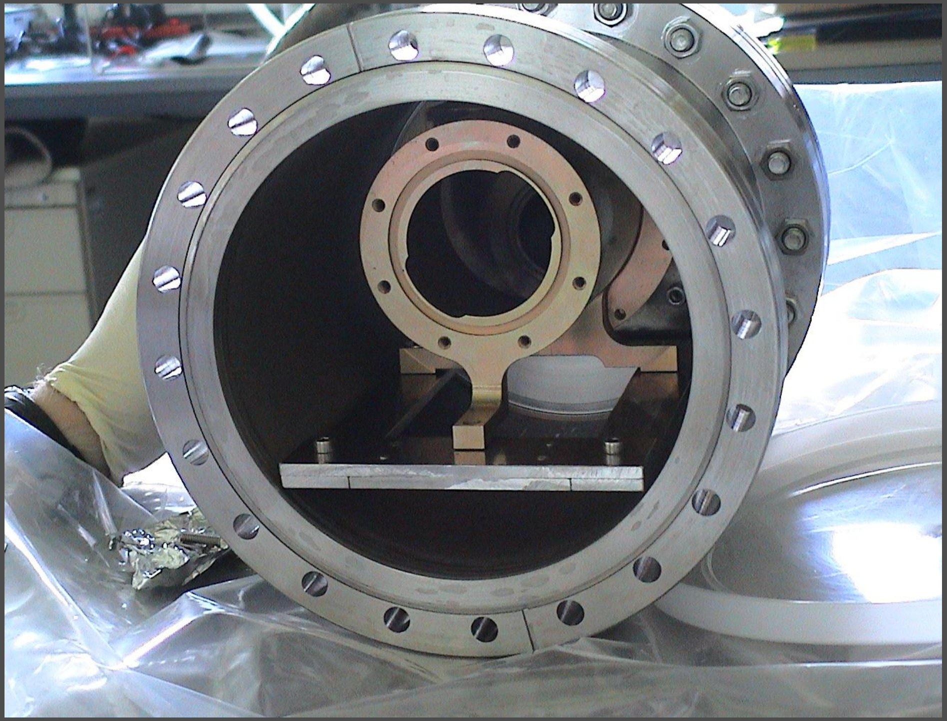
MCP housing

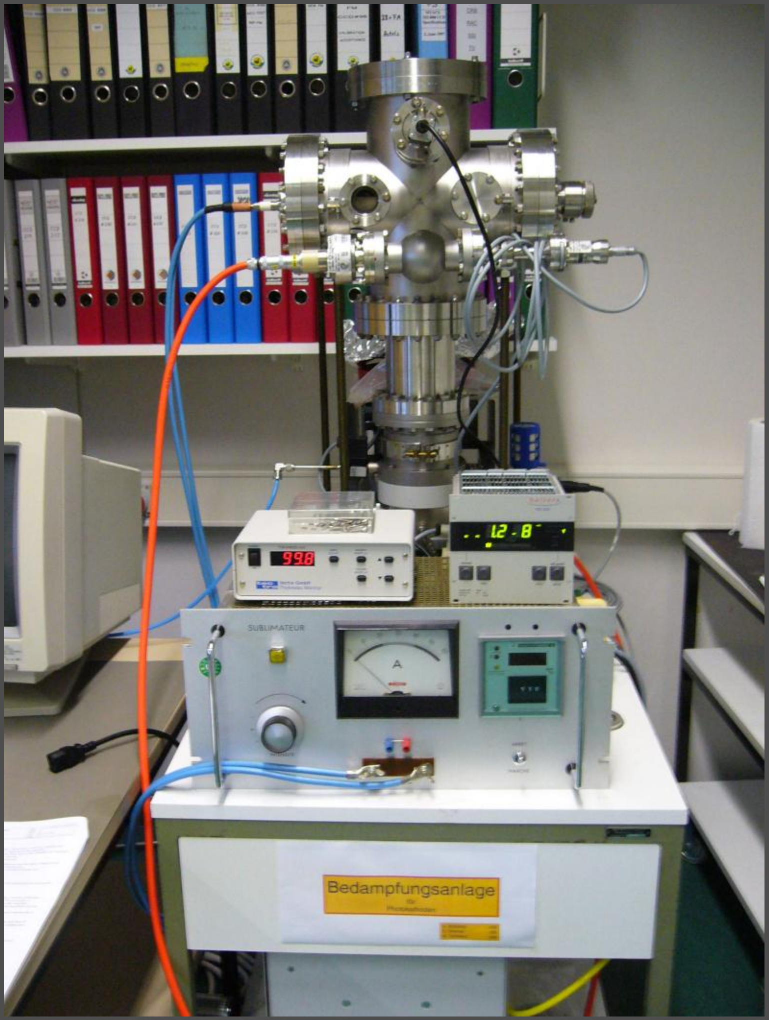
Camera assembly and vibration test



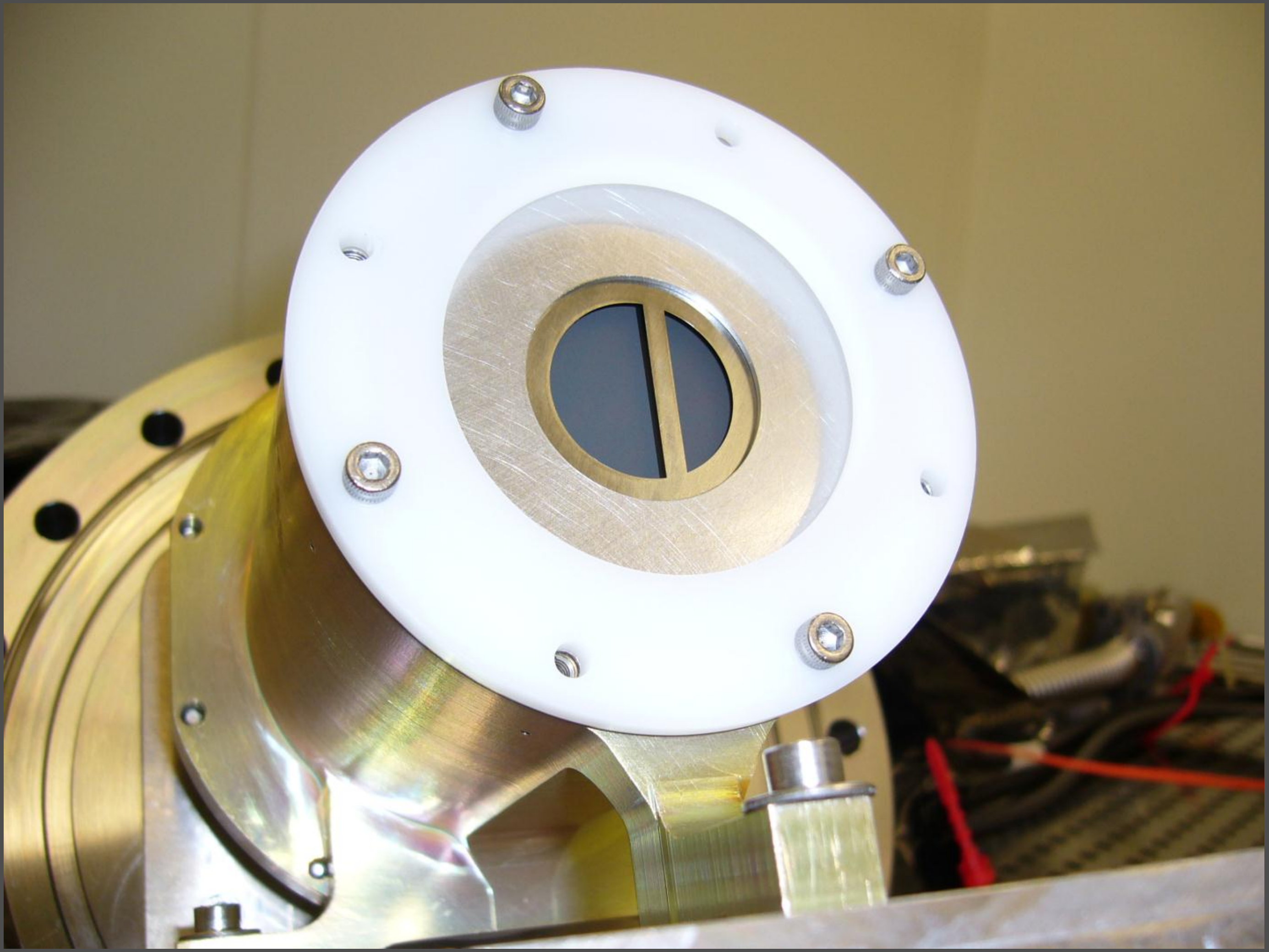
Photocathode deposition chamber at MPS

- made deposition of CsI and KBr up to thickness of 1000 nm with 1 nm resolution



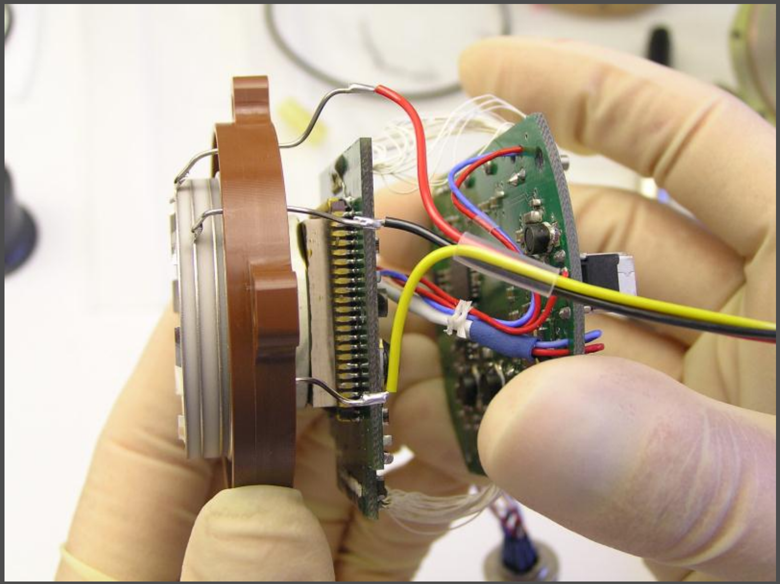


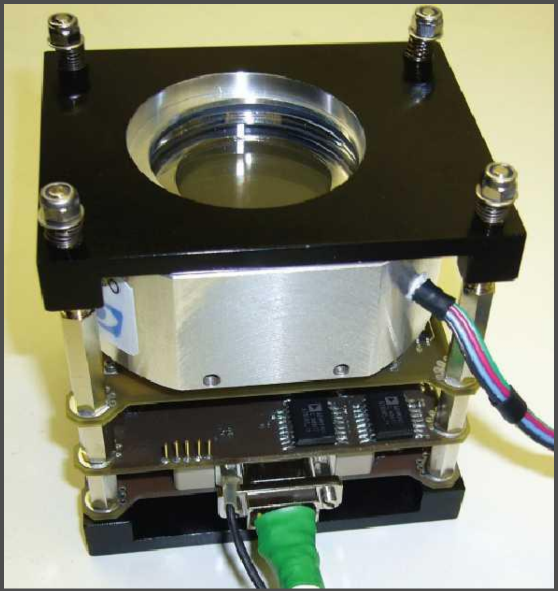
KBr photocathode deposition



Development of I-APS detector

- intensifier based on microchannel plates with KBr photocathode coating
- coupling with active pixel sensor (APS)
- APS electronic readout circuitry
- space qualification: vibration, acoustic, thermal, radiation hard





Advantages of I-APS

PROS:

- most flexible in terms of focal plane size: may be adjusted by fiber optic taper
- most flexible dynamic range: may be adjusted from photon-counting to current-integration mode in several ways:
    - photocathode selection for spectral ranges
    - adjustable gain by HV
    - selectable attenuation of phosphor by ND-filter
- solar blindness (saves a filter!)
- operation at room temperature (less cooling needed, no contamination problem)
- high responsivity in full VUV and EUV range

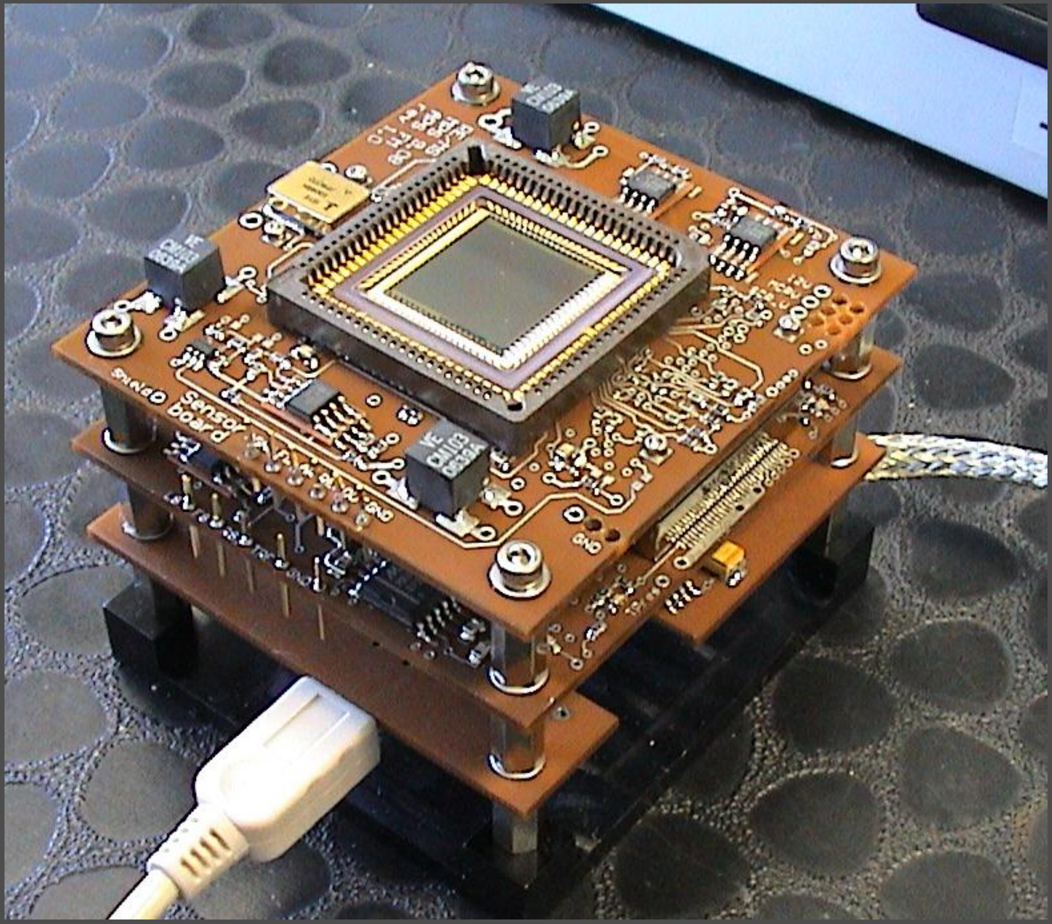
CONS:

- fragile multi-channel plates
- adjustable high voltage needed, up to 10 kV
- limited spatial resolution of MCPs: MTF of ~50 lines/mm

Milestones / Achievements at MPS

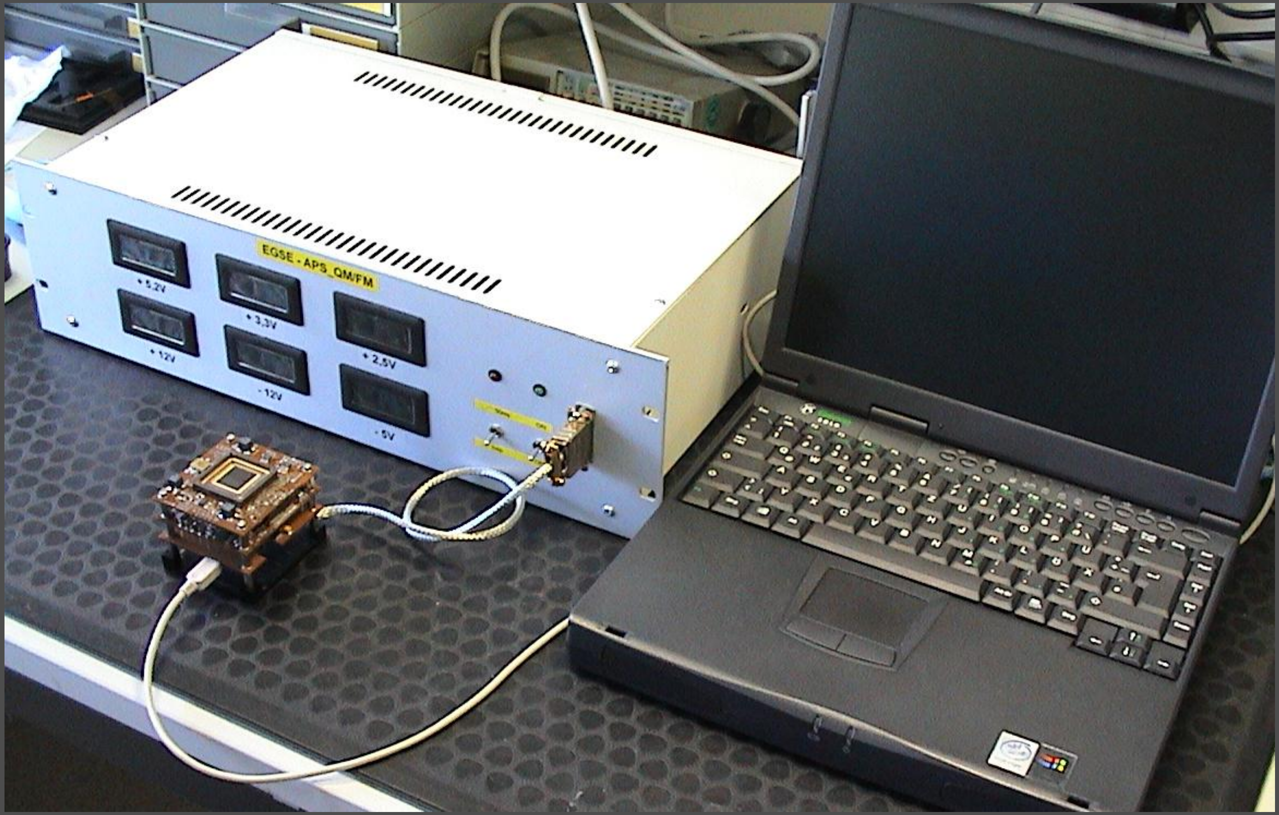
- first coupling of intensifier with fiber optic faceplate and APS sensor achieved in March 2007
- build-up of photocathode deposition system at MPS in 2007
- photocathode deposition with (CsI and KBr) in January 2008
- development of 14-bit electronic readout for 1kx1k APS sensor in 2007
- design of electronic readout with high-rel parts in July 2008
- built first radhard system in 2009

Space-qualifiable camera for the Star-1000 APS sensor



Design description

- The compact camera system is powered by external power system, supplying all voltages needed by the readout system



Performance characterization

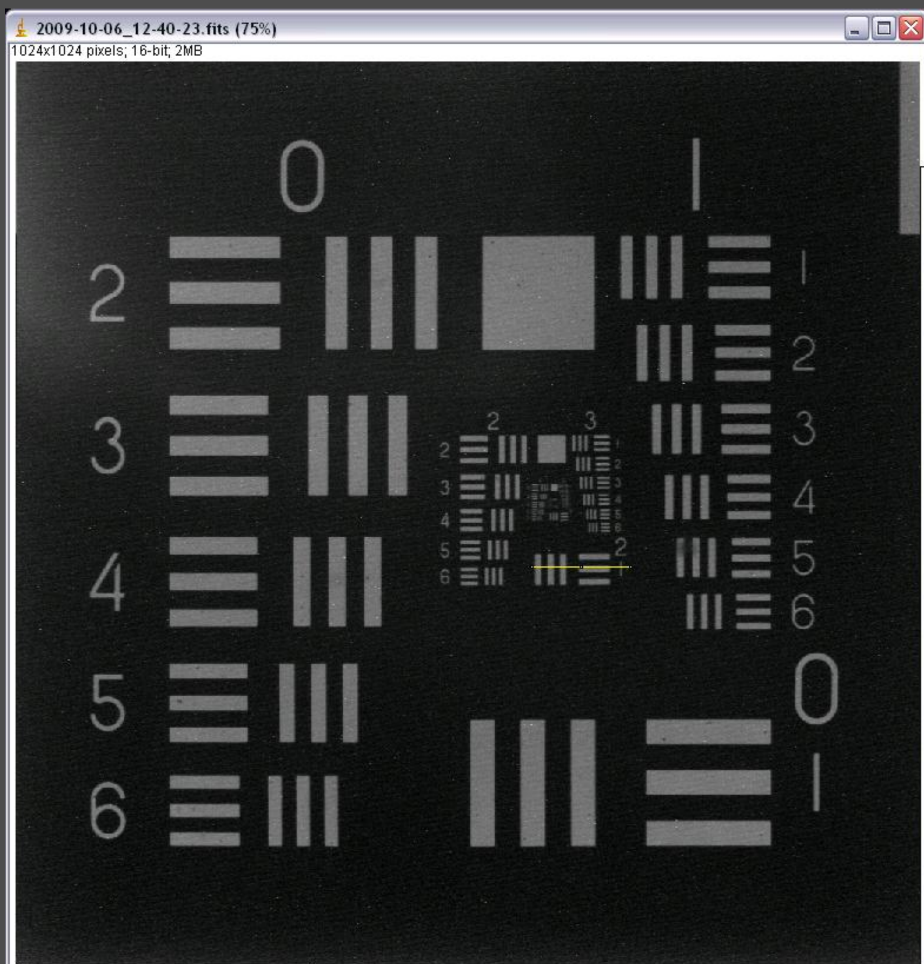
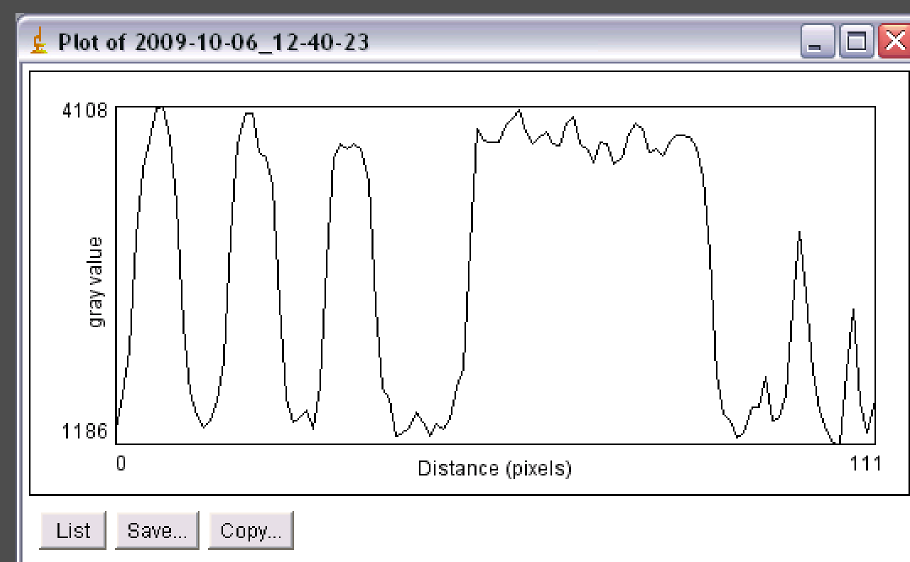


Image of a target. The yellow line is the location of the profile shown below



Perfomance test with Lyman-α lamp and extreme UV lamp