An update on Mirror Calibrations

Telescope and calibration WG

-------- Messaggio Inoltrato --------

Oggetto: Athena Telescope Calibration Working Group meeting #5 - agenda

Data: Sun, 13 May 2018 11:44:24 +0200

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Dear colleagues,

the presentations given at the 5th Athena Telescope Calibration Working Group as well as summary, actions and recommendations are now available at:
http://www.isdc.unige.ch/athena/wgs-and-tps-meetings/eventdetail/32/-/telescope-calibration-working-group-5.html
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Best Regards,

Matteo & Jan-Willem

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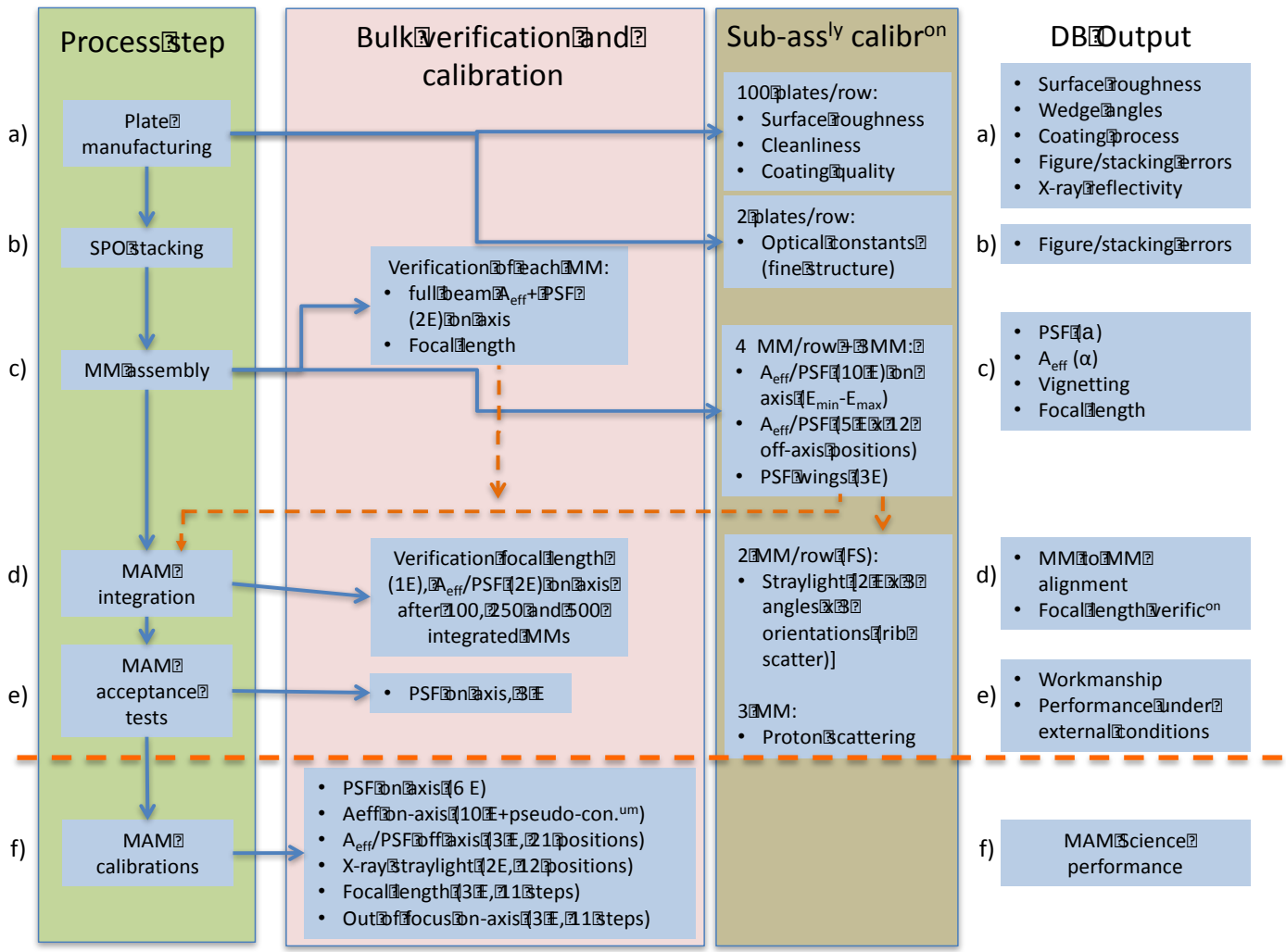
Calibration Matrix

- Properties to be calibrated
  - Point Spread Function
  - Effective area
  - Focal length and plate scale
- As a function of
  - Energy - full band and fine structure over absorption edges
  - Angle - arc second scale for PSF - arc minute scale for area vignetting
- Hardware to be tested and calibrated
  - mirror modules (~700 to ~1100 depending on final design)
  - integrated mirror modules - petals or full aperture mirror

AIV and Mirror calibration flow



Note: MAM stays for “Mirror Assembly Module”

X-ray Mirror Test & Calibration Facilities considered so far

FOR TESTING

- Pencil beam - BESSY or equivalent (ESRF, SPring-8, NSLS, Diamond)

- Shorter beam line with beam spreader to produce a monochromatic collimated X-ray beam - BEaTriX (Beam Expander testing X-ray facility) as proposed by Brera

FOR CALIBRATION

- Long beam line - Panter or equivalent - full aperture or glucksrad ("wheel of fortune")

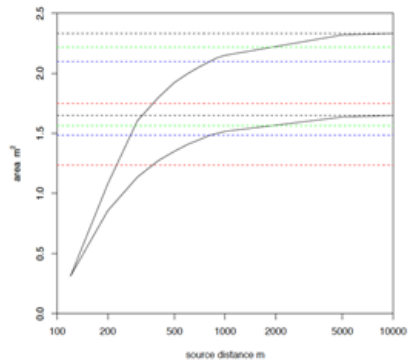
Finite source distance testing

- Full aperture testing is required to:
  - Measure/verify the focal length of the full mirror
  - Verify that the assembly tolerances and alignments are within specification
  - Perform on-ground calibration of the effective area and point spread function of the full telescope aperture

- Testing with a source at finite distance:
  - Compromises the paraxial ray approximation - Ferror
  - Reduces the fraction of the reflecting surfaces tested and hence gives reduced effective area - Aerror
  - Degrades the angular resolution. The point spread function is not fully representative of flight performance. The detector area covered by the PSF is increased - Perror

Willingale Study 2015

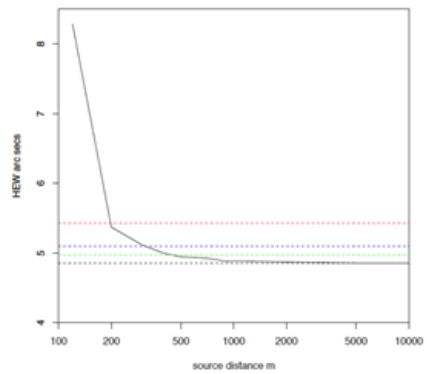
Effective area 1 keV



Upper curve – large aperture
Lower curve – small aperture

Green – no compromise
Blue – calibration
Red - qualification

PSF HEW at 1 keV

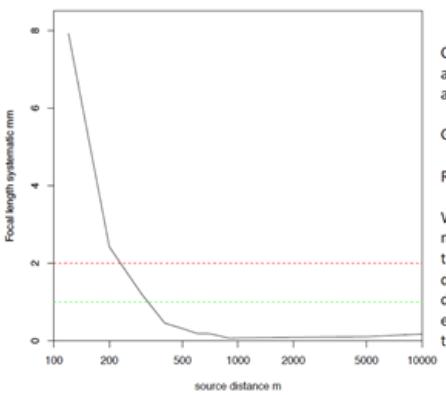


Curves very similar for large and small aperture – the average is plotted

Green – no compromise
Blue – calibration
Red – qualification

HEW for source at infinity 4.80 arc seconds – thermal distortion, gravity release, moisture release and spacecraft jitter not included in simulated PSF

Systematic error in focal length



Curves very similar for large and small aperture – the average is plotted

Green – no compromise

Red – qualification

When the systematic is <0.2 mm the statistical errors in the modelling start to dominate – values at source distance >500 mm are effectively upper limits to the systematic

Finite source distance requirements

- Using the graphs we can extract the minimum finite source distances (m) required to meet the criteria for the large and small aperture

	Area L	Area S	HEW S&L	Ferror S&L
No compromise	2539	2652	440	328
Calibration	811	811	319	
Qualification	374	375	198	235

<500m

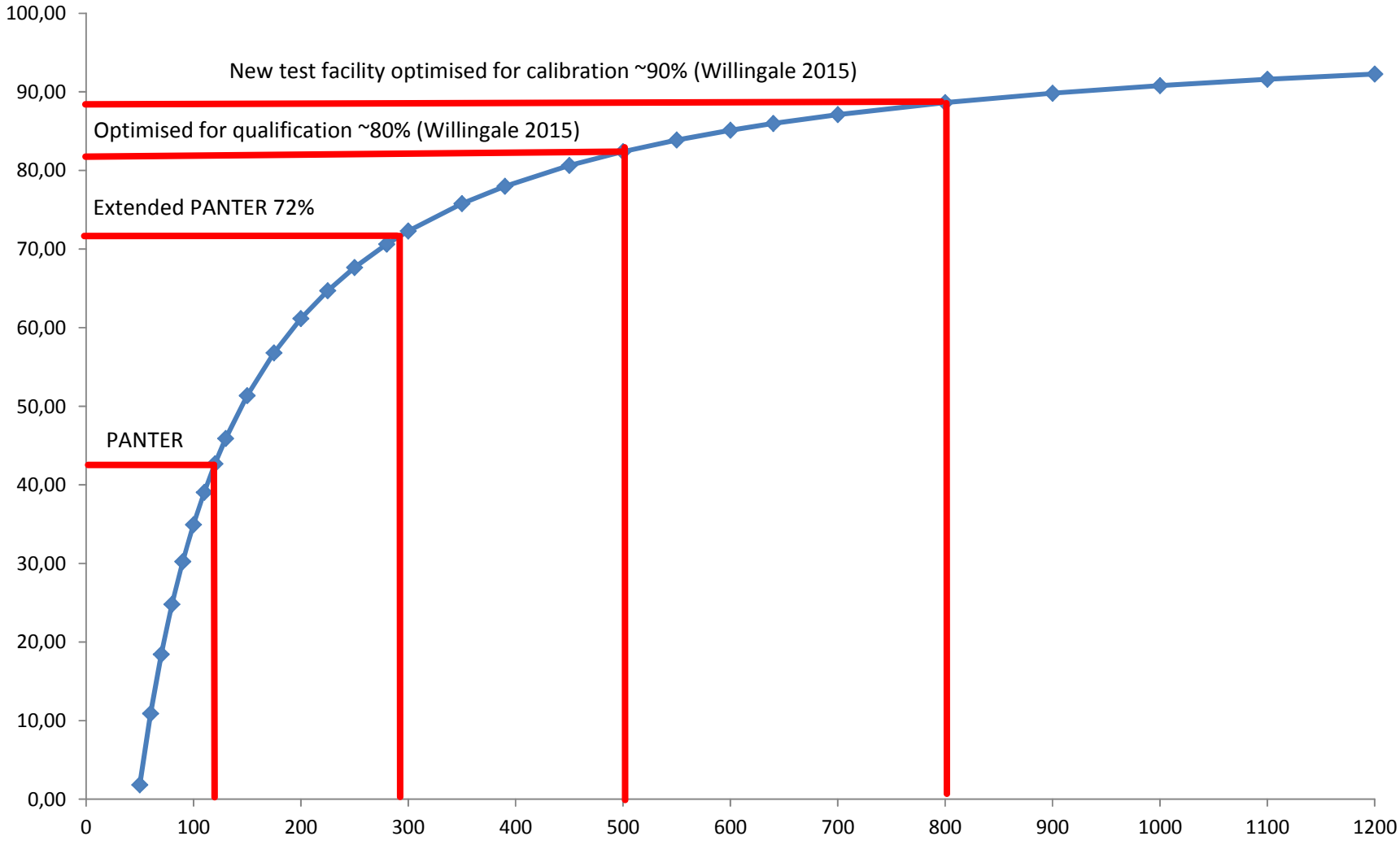
- To summarise:
  - The requirements are the same for the large and small apertures
  - < 200 m is inadequate
  - 400 m is sufficient for qualification
  - 800 m is sufficient for calibration

Figure 6 Viewgraphs from Willingale 2015 [RD9] summarizing the effect of different source distances on the PSF, the effective area and the focal length systematic error for the baseline large aperture Mirror and the CDF small aperture mirror.

Full-illumination approach for ATHENA

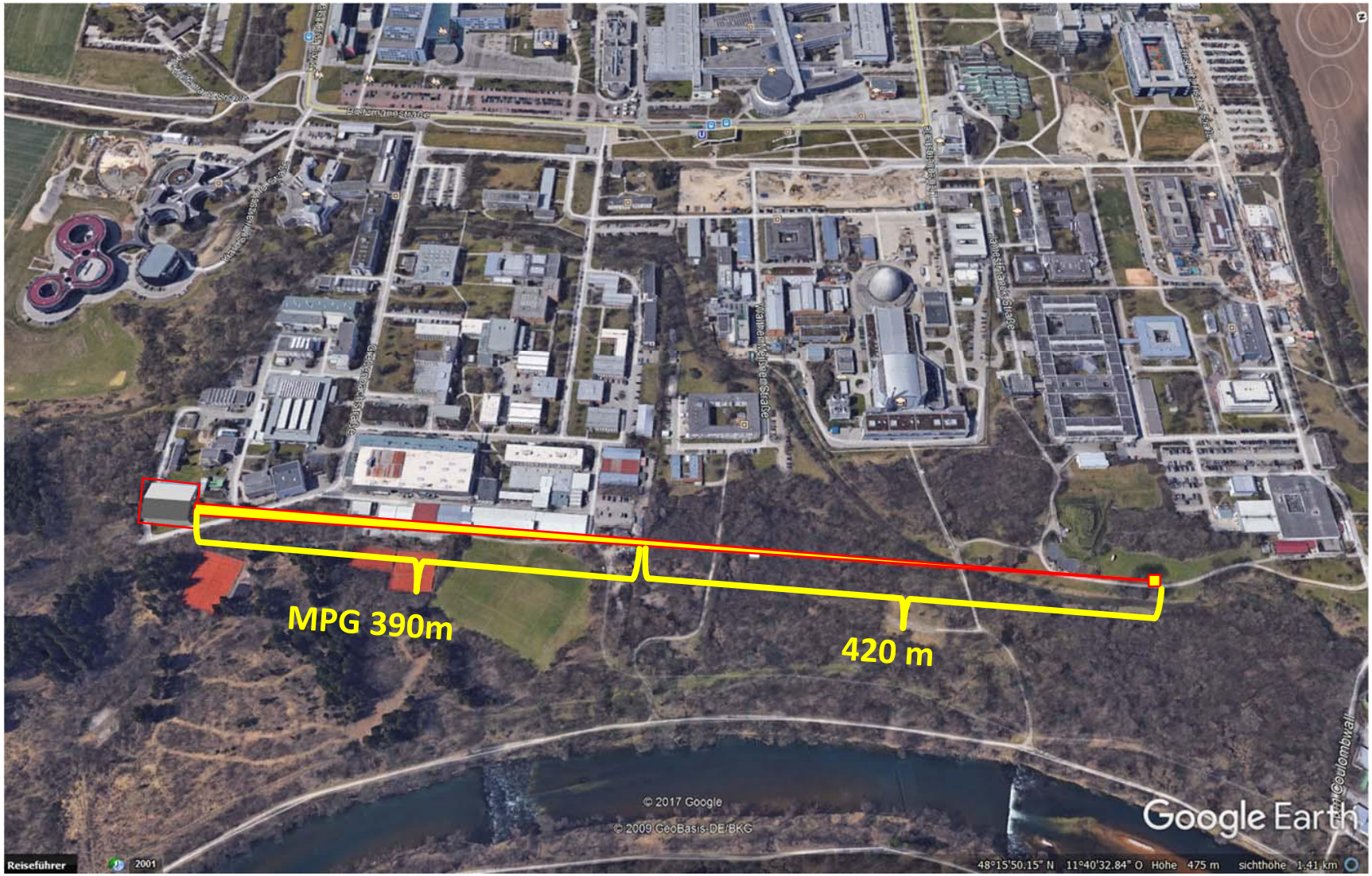
- Full illumination for ATHENA has many advantages but a number of problems:
  - *very long facility to be realized and operated*
  - *a (small) part of the optics will remain non illuminated even implementing superPanter*
  - *a quite expensive jig is required for MSFC/XRF*
  - *the horizontal position of the optics determines depomations not easy to be removed with actuotors or modeling*
  - *no E2E measurement possible for Athena*

Athena Mirror % Illuminated vs. X-ray source distance (m)



Credits: V. Burwitz, MPE

Possible location of 800 m Beamline



Credits: V. Burwitz, MPE

NASA Marshall Space Flight Center

X-Ray and Cryogenic Facility (XRCF)

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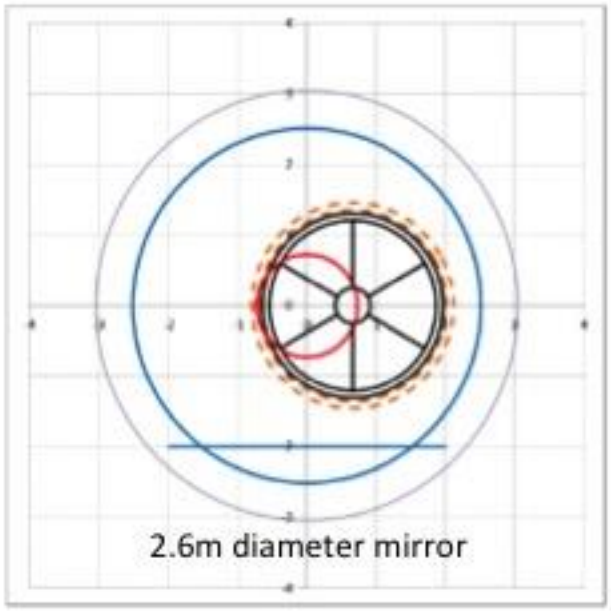
XRCT “wheel of fortune” configuration

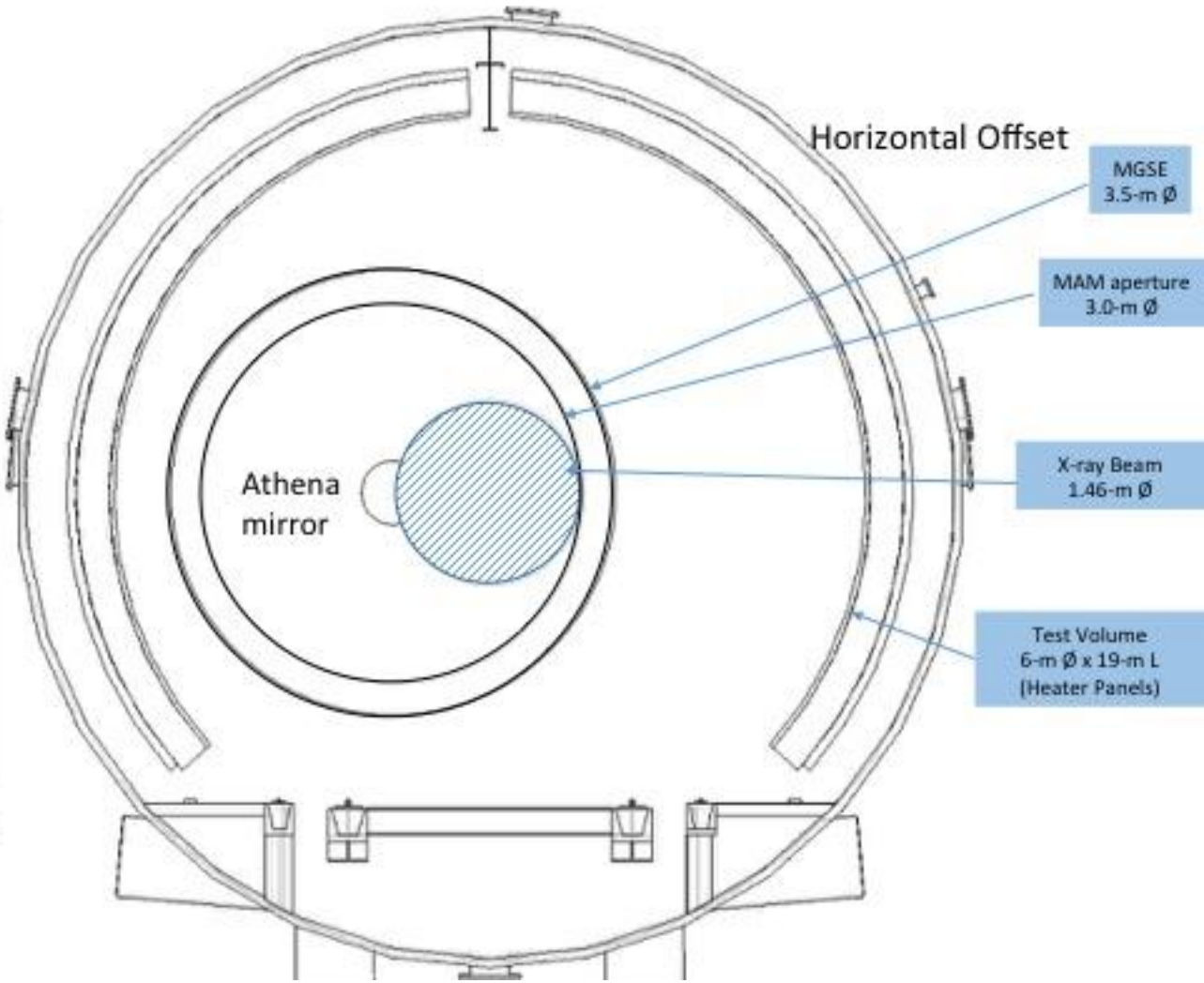
Athena in XRCF main Instrument Chamber

Partial Illumination of MA



Mark Ayre | 27/09/2017 | Slide 21

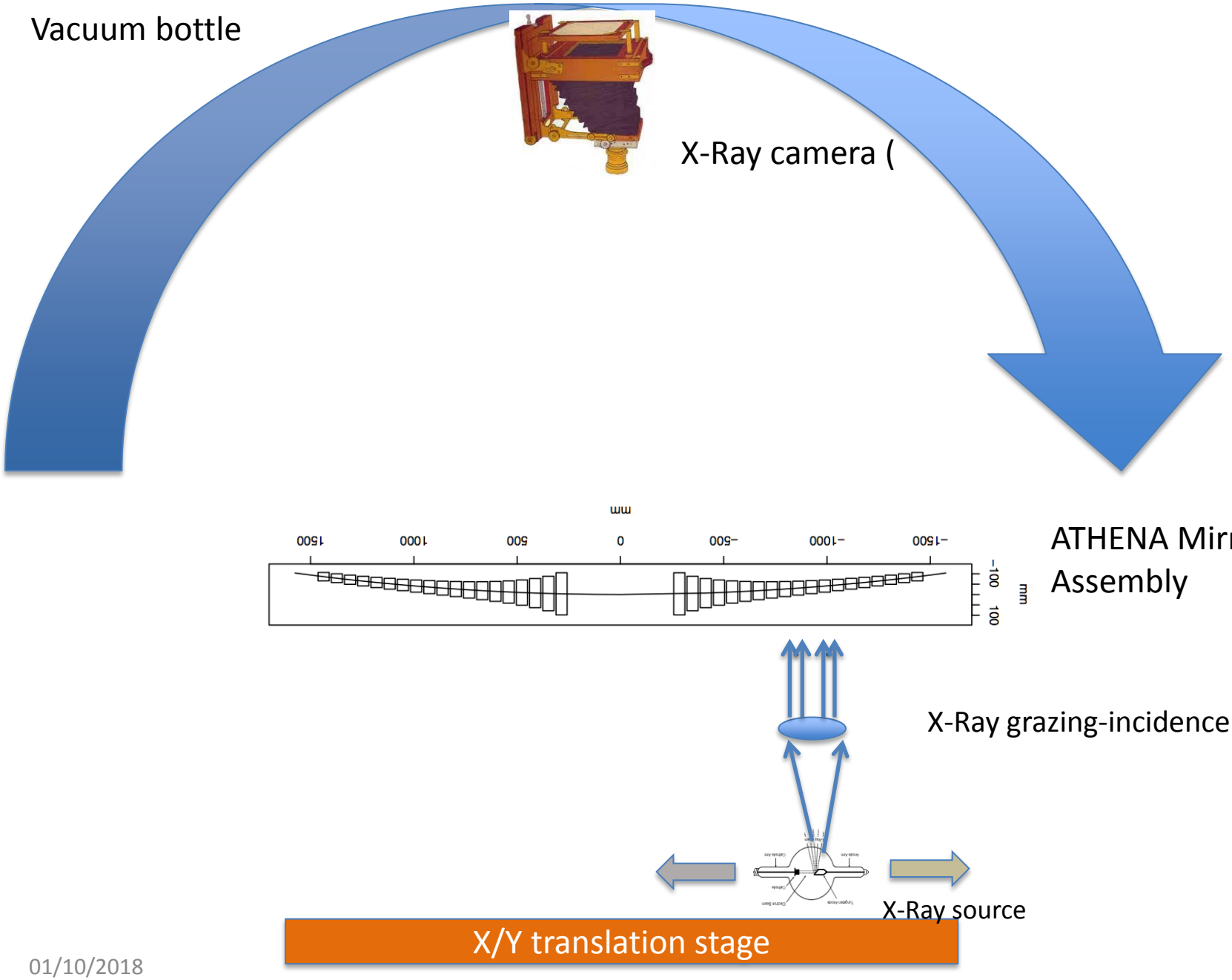
Translate or rotate MAM to scan entire aperture



Credits: W. Baumgartner, NASA/MSFC

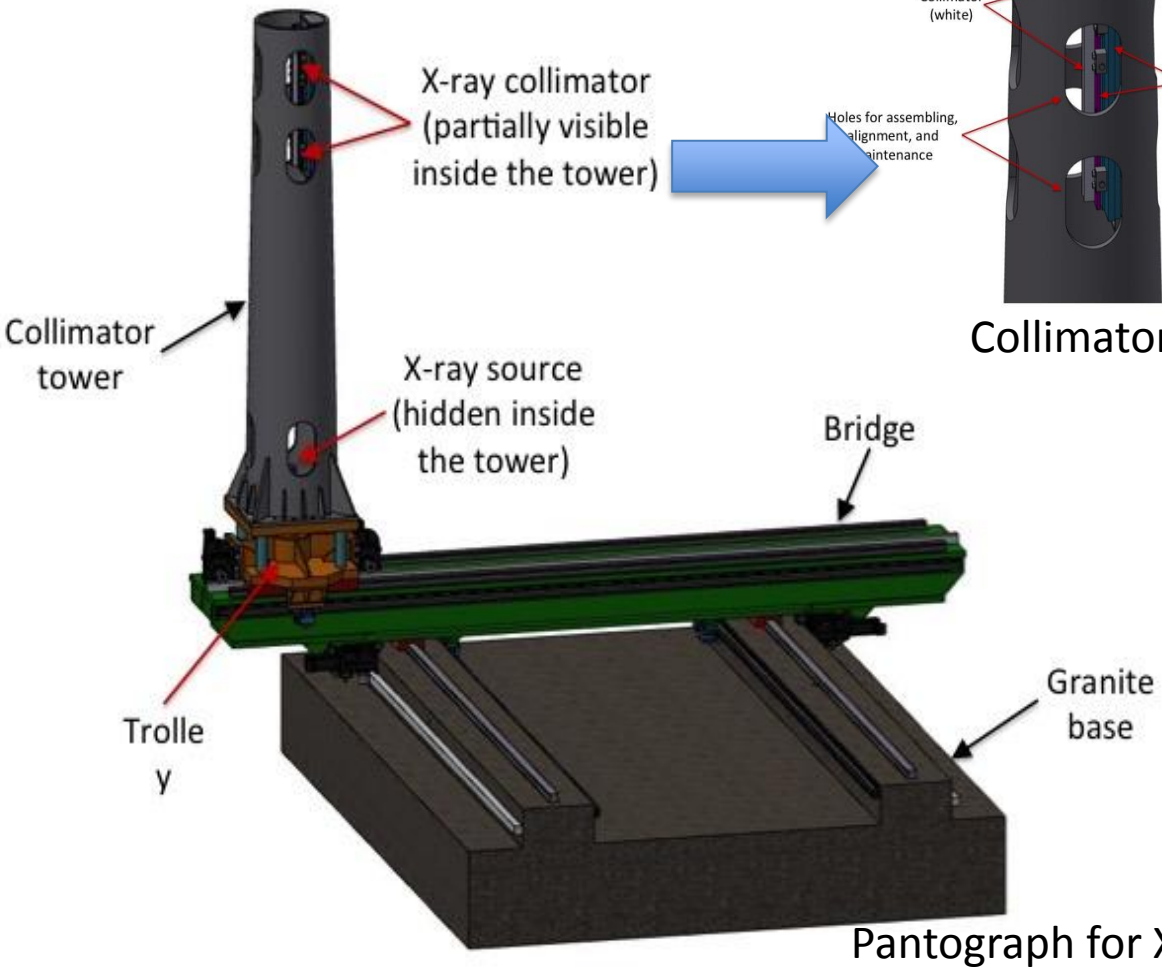
Possible alternative: “wide” raster scan

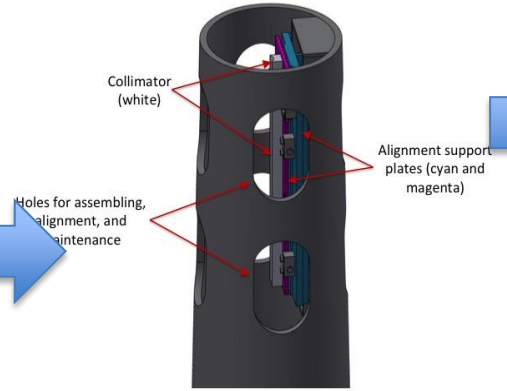
- it will allow us to operate with a much compact system
- it will make possible to use the **vertical configuration** ➔ much smaller gravitational deformations , that can be controlled with proper actuation
- in principle E2E calibration possible
- use of “large” pencil beam (white or monochromatic) can be used to minimize the calibration time
- ***“NO COMPROMISE” CONFIGURATION*** since the divergence is almost absent


Vacuum bottle
X-Ray camera (
ATHENA Mirror Assembly
X-Ray grazing-incidence mirror
X-Ray source
X/Y translation stage

Source translation and widening

Design description – Details





Collimator supprt

X-ray mirror "collimator"

Pantograph for X-Y translation

X-Ray Source

The X-ray source is to be of microfocus type, a focus spot size < 30 µm FWHM (circular – can be posiibly reduced with a pin-hole), in fixed position, connected to the sect. 1 of the vacuum tube via a vacuum flange. The source has to be diverging and with an emittance of 10^{11} - 10^{12} photons/sec/sterad.

The source shall withstand at least 10000 h of operation time, and dissipate a power not higher than 20 W. Anodes: Cu, Ti, Mo, W…)

Pin-hole to further reducing the divergence

2µm Aperture Diameter, Mounted, Precision Pinhole, #56-273

Bremsstrahlung spectrum

- For effective area measurements one can use the continuum
- For PSF measurements one can use the lines (with proper filers or monochromators)

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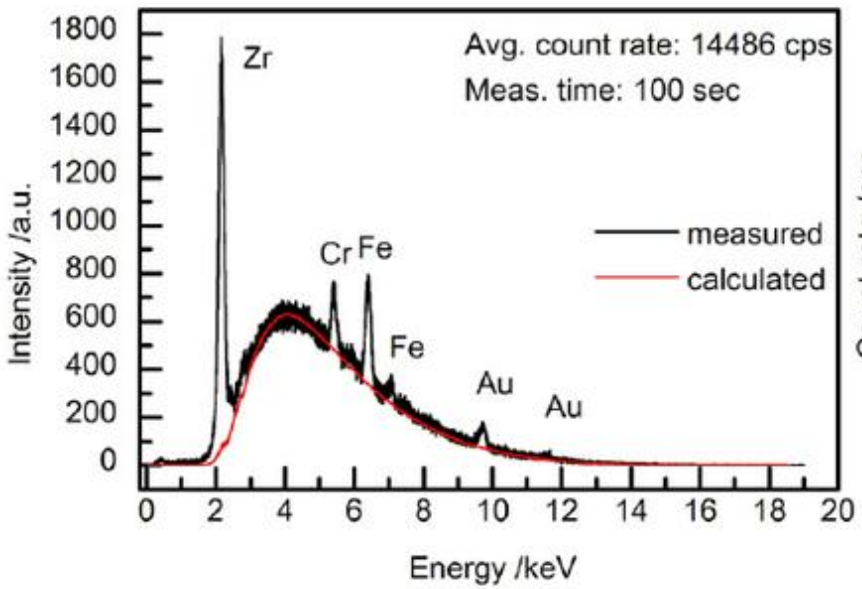
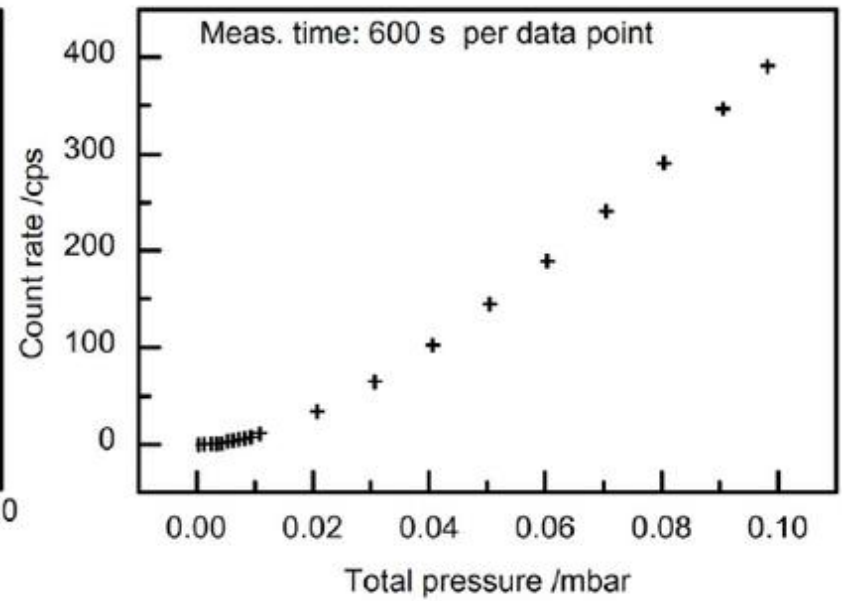
IOP Institute of Physics DEUTSCHE PHYSIKALISCHE GESELLSCHAFT





SYDOR INSTRUMENTS

A SYDOR TECHNOLOGIES COMPANY

COMPLEX MEASUREMENTS
CRITICAL RESULTS

DATASHEET

Sydor Fast CCD X-ray Detector

The Sydor Fast CCD X-ray Detector is a complete direct detection, x-ray imaging system that combines a custom, LBNL developed, in vacuum sensor module with a commercial-off-the-shelf data acquisition system. The camera head is an in-vacuum, 960 x 960 pixel, frame store, fast CCD sensor with a maximum frame readout rate of 200 frames per second. The readout system is implemented on an ATCA backbone and is used to control and readout the camera head, store raw camera data to hard disk, perform simple signal processing tasks and provide a simple user interface.

Cost: 1 M$

Production Time: about 9 months

Invitation to Tender for X-RAY RASTER SCAN FACILITY FOR THE ATHENA MIRROR ASSEMBLY

ESA AO/1-9549/18/NL/AR

Activity No. 1000023850 in the “esa-star” system

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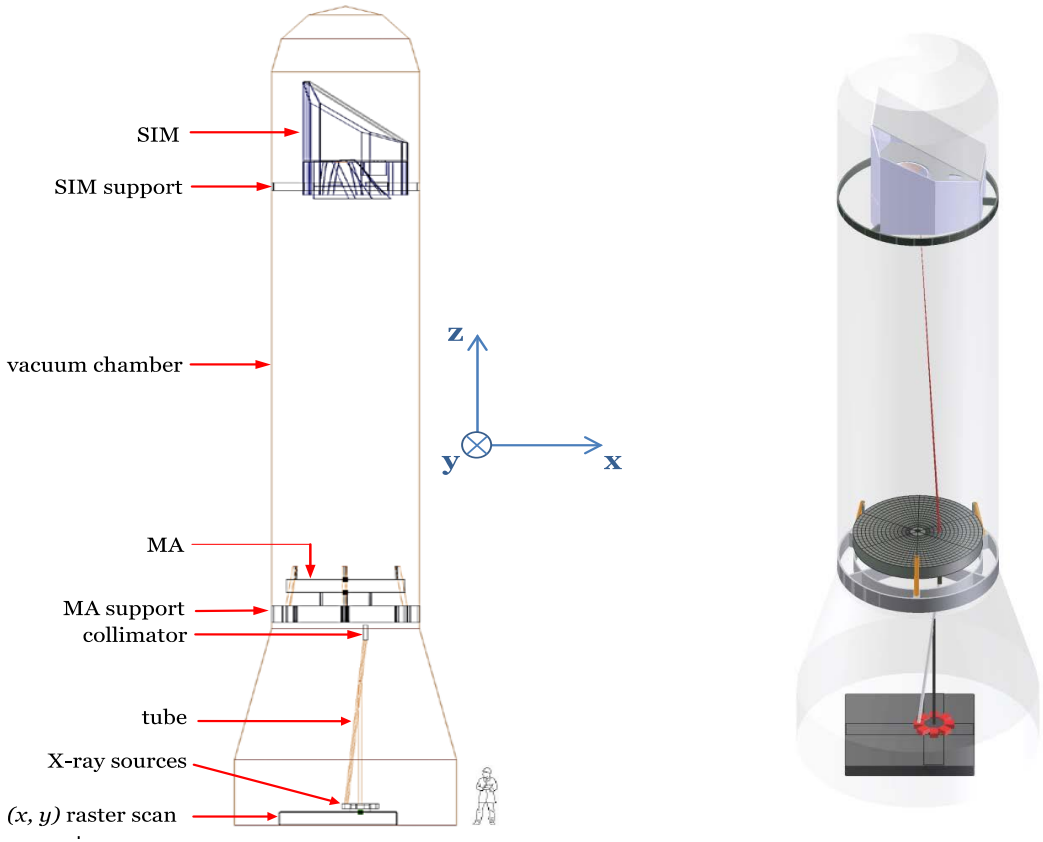

2D frame sketch and 3D conceptual model of the vacuum chamber of the X-ray Vertical Facility (VERTEX), containing the X-ray source, collimator and x-y raster scan stage, the ATHENA Mirror Assembly and the SIM (or the service camera) with respective interface to the vacuum chamber (CREDITS: ESA).