

# Characterizing X-ray Optics for OGRE and its Pathfinder Mission



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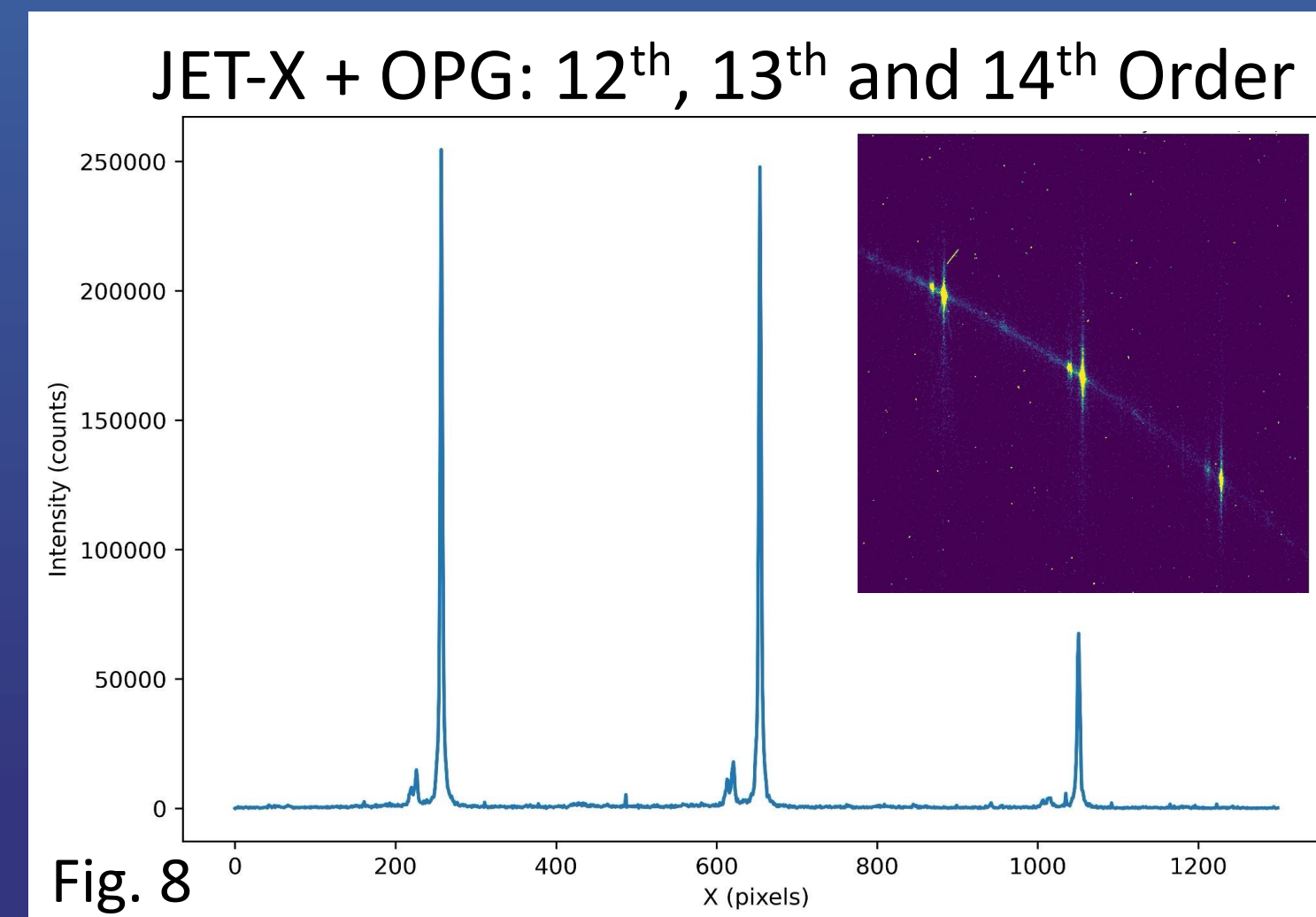
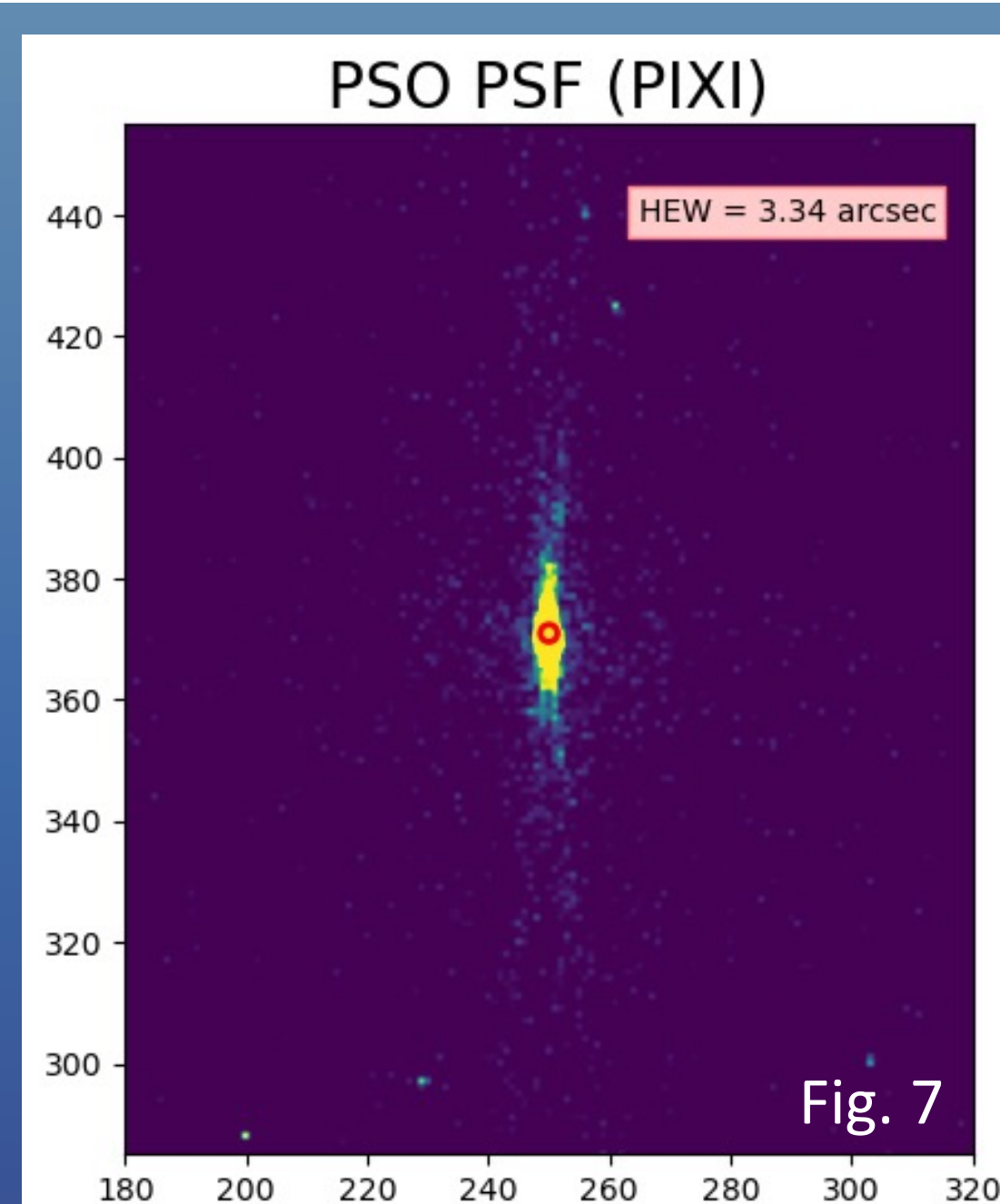
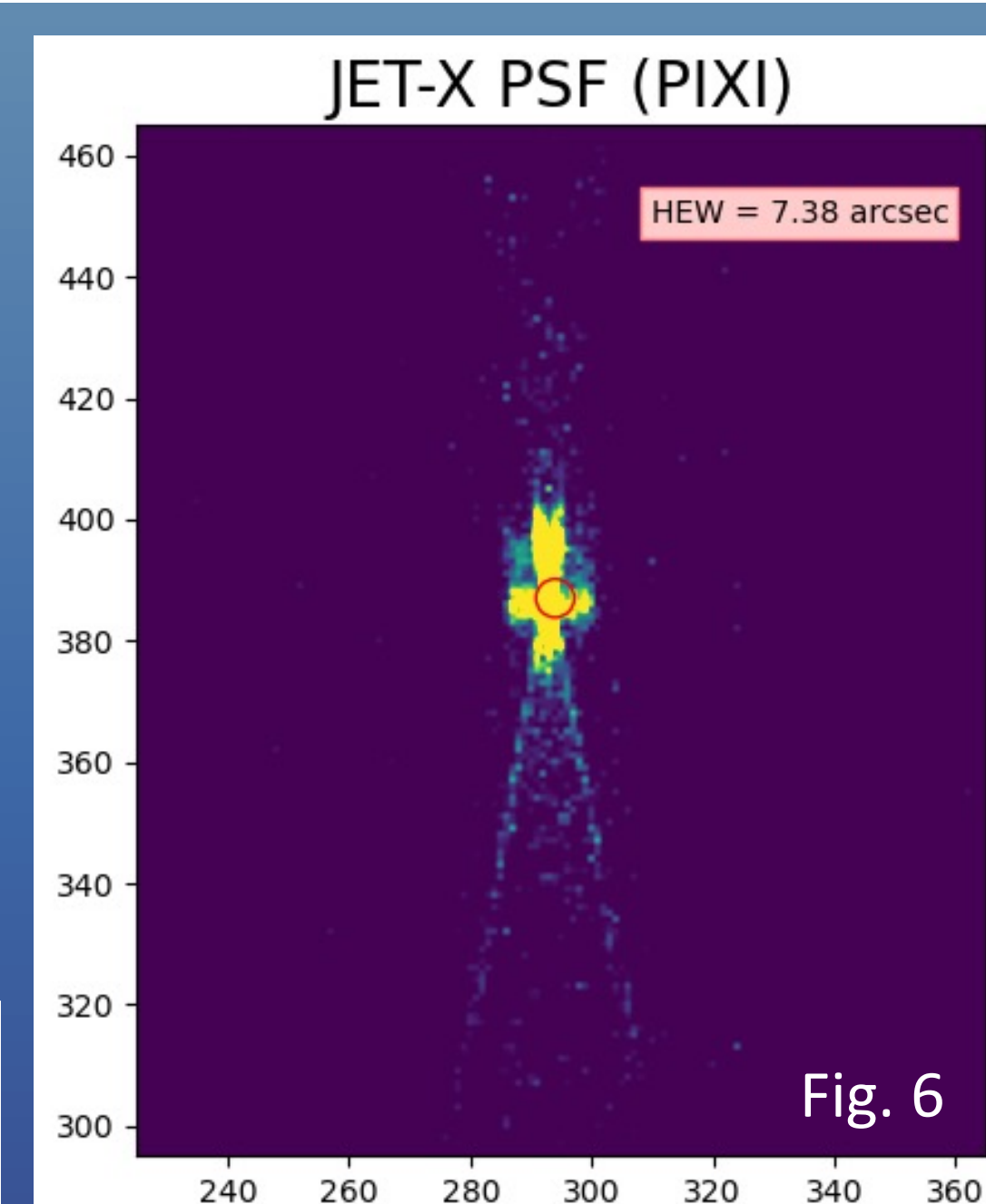
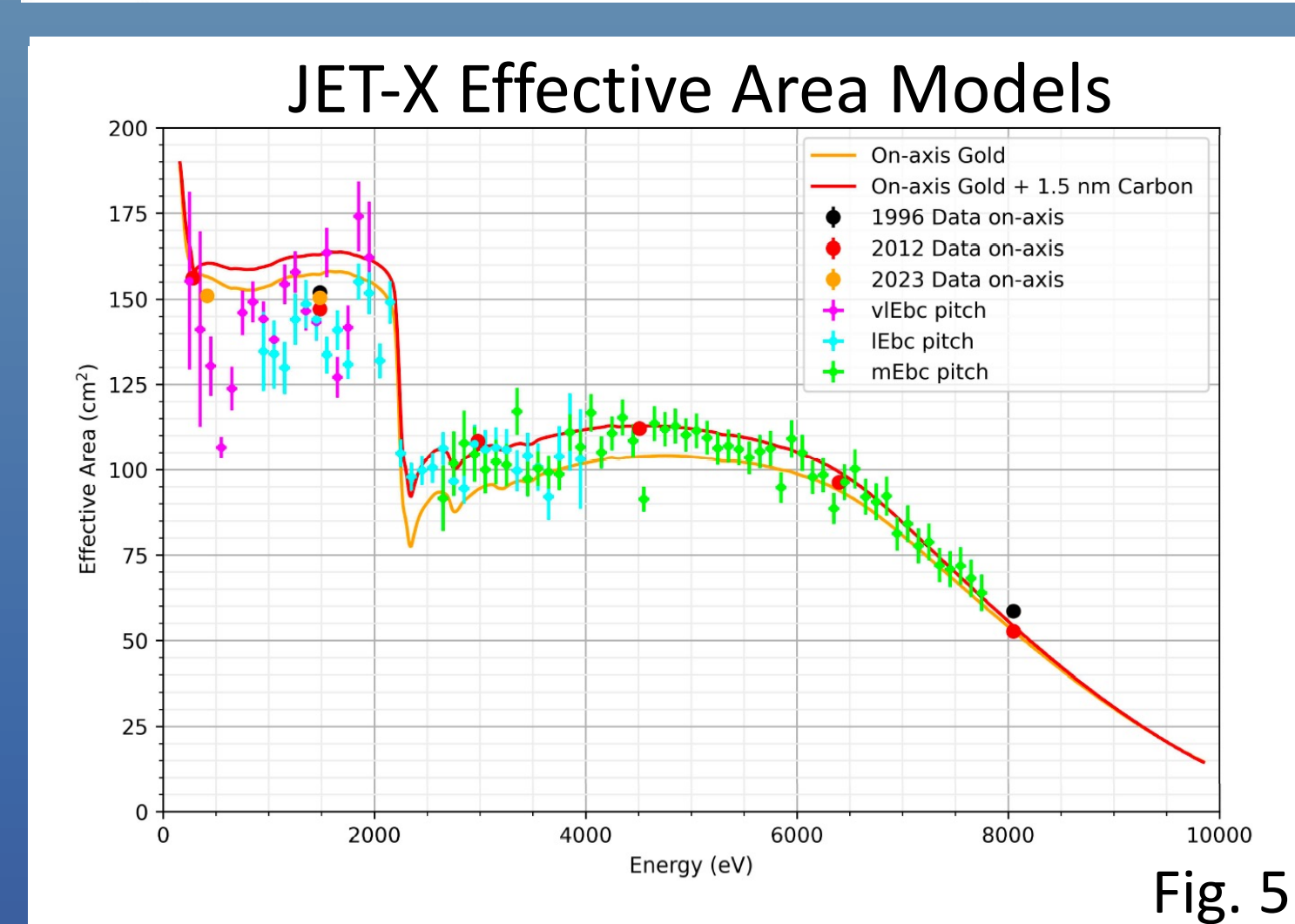
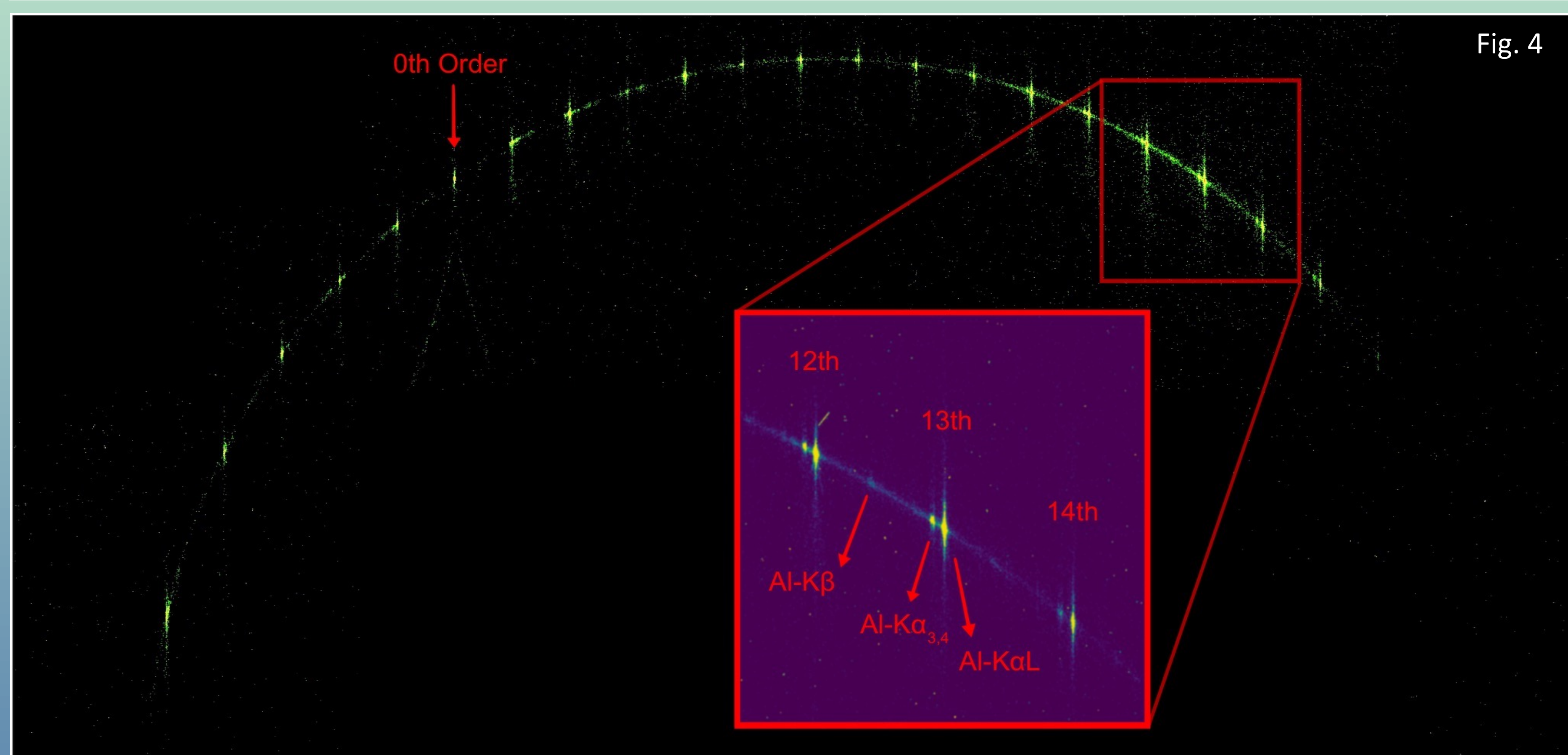
## OGRE and Pathfinder OGRE

The Off-Plane Grating Rocket Experiment (OGRE) is a suborbital rocket designed for the capture of high-resolution spectra in the soft X-ray range (0.2 - 2 keV), and will observe Capella while in flight. OGRE utilizes polished silicon optics (PSOs) developed at NASA Goddard to achieve a resolution ( $\lambda/\Delta\lambda$ ) exceeding 2000 across 8-42 Å, and peaking at around 3000. However, these optics are still in development. In the interim, "Pathfinder OGRE" will utilize a module of the Joint European Telescope for X-ray astronomy (JET-X FM2) as the mirror assembly alongside the rest of the OGRE spectrometer with a goal to flight-test Penn State reflection gratings and the OGRE electronics section prior to "Full OGRE," which will use PSOs. One of the JET-X sisters currently serves as the X-ray telescope (XRT) on *The Neil Gehrels Swift Observatory*.

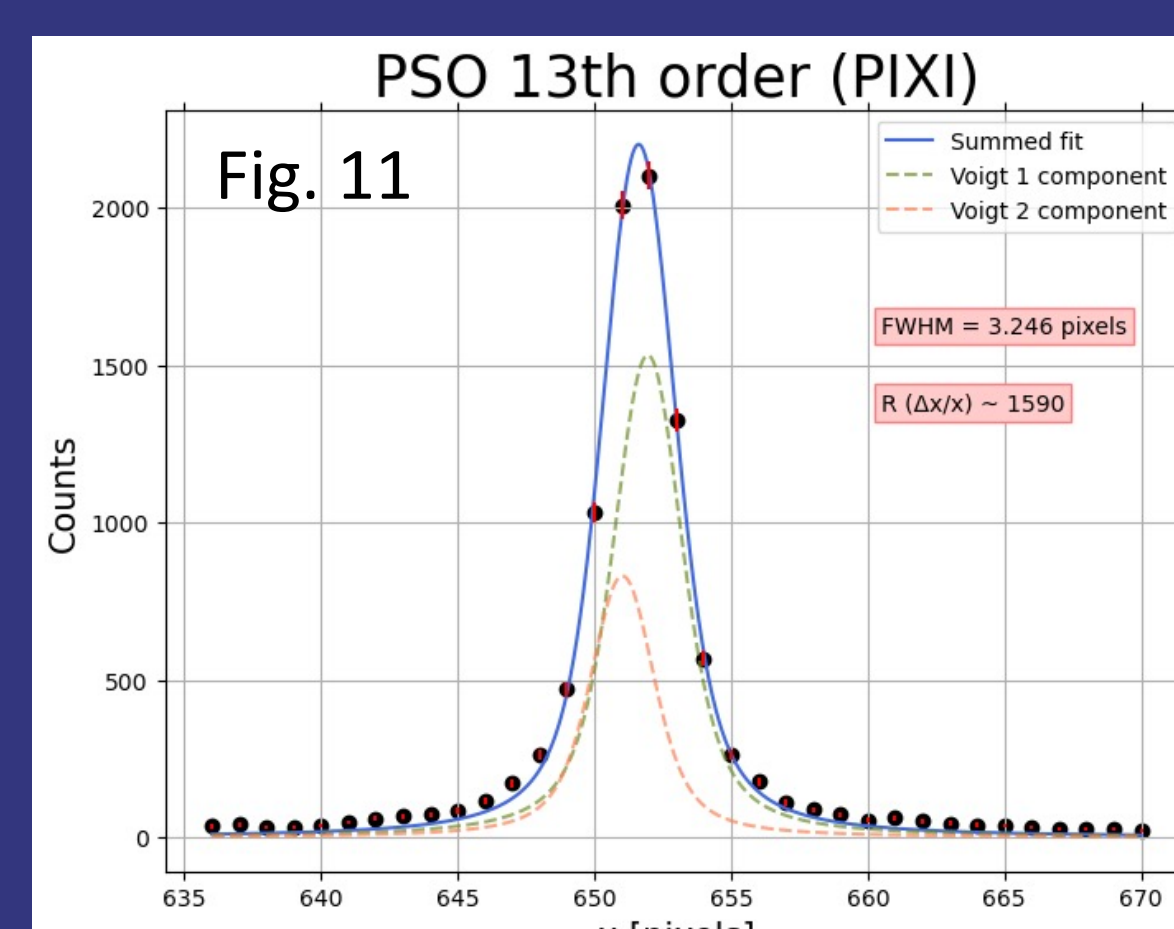
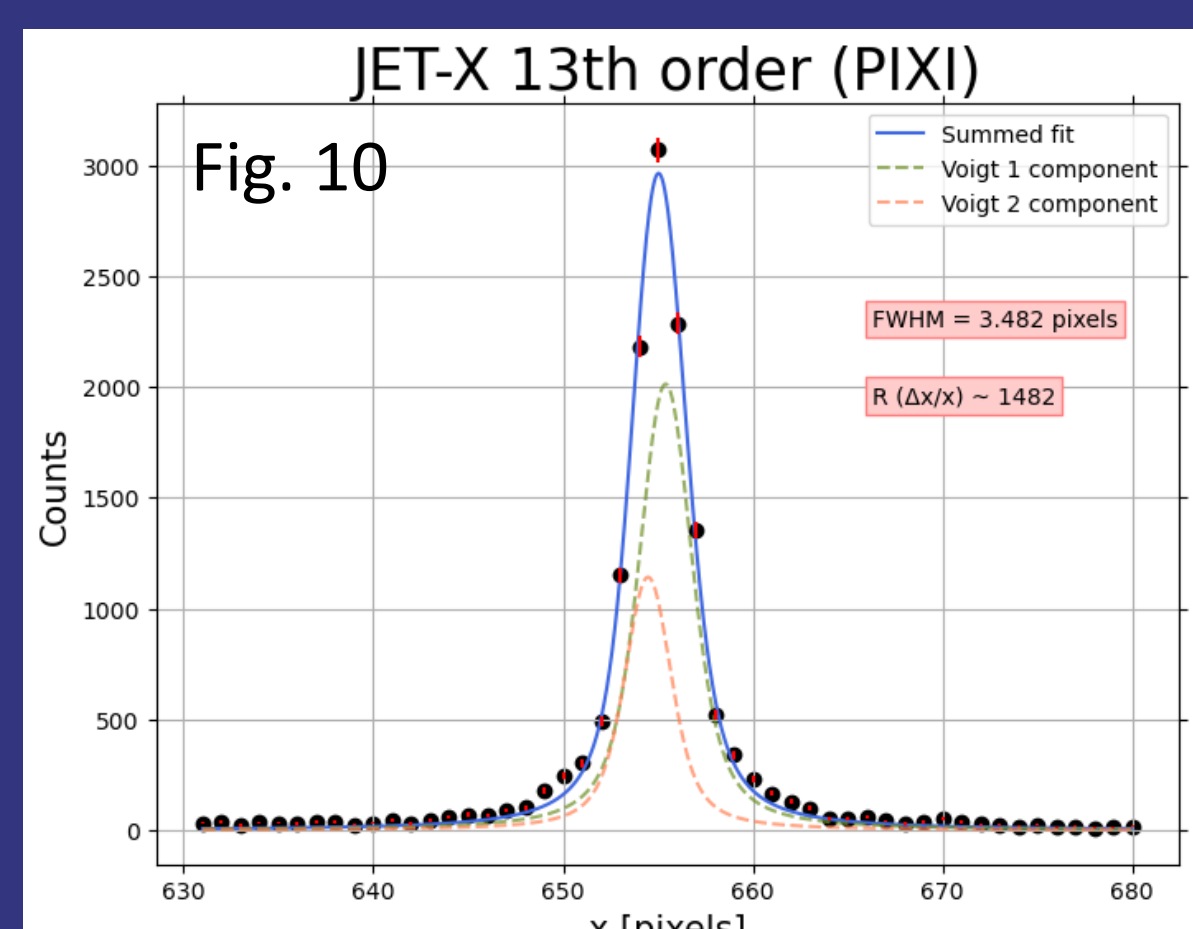
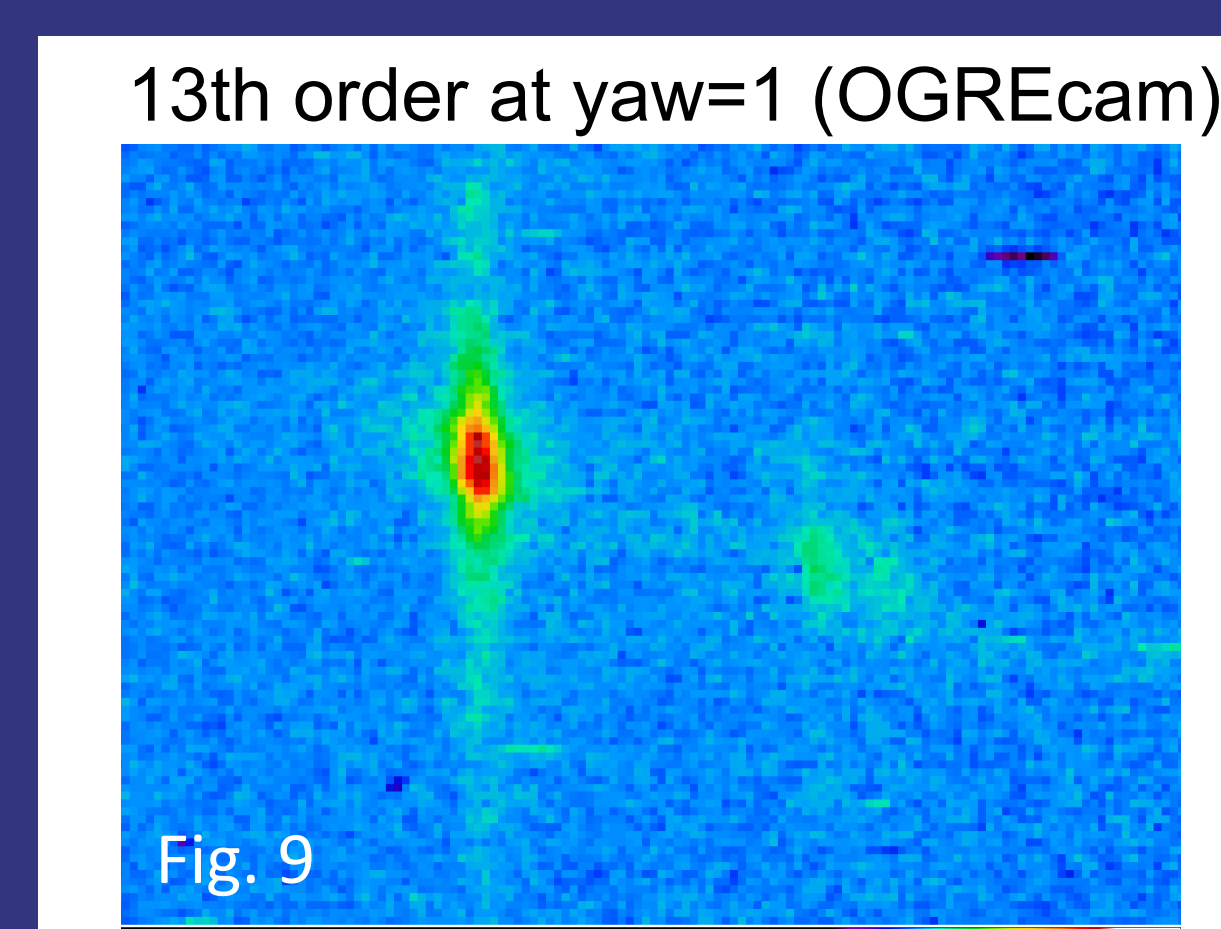
## The Campaign

A recent characterization campaign at the PANTER X-ray test facility in Neuried, Germany aimed to test the performance of both the OGRE and "Pathfinder OGRE" spectrometers. The campaign investigated both the spectrometers to see if they meet the science requirement of resolution ( $\lambda/\Delta\lambda$ ) 1800. It additionally tested the angular resolution and effective area of both JET-X, and the PSOs. Source used for the duration of the campaign was Al-K $\alpha$  (1.49 keV)

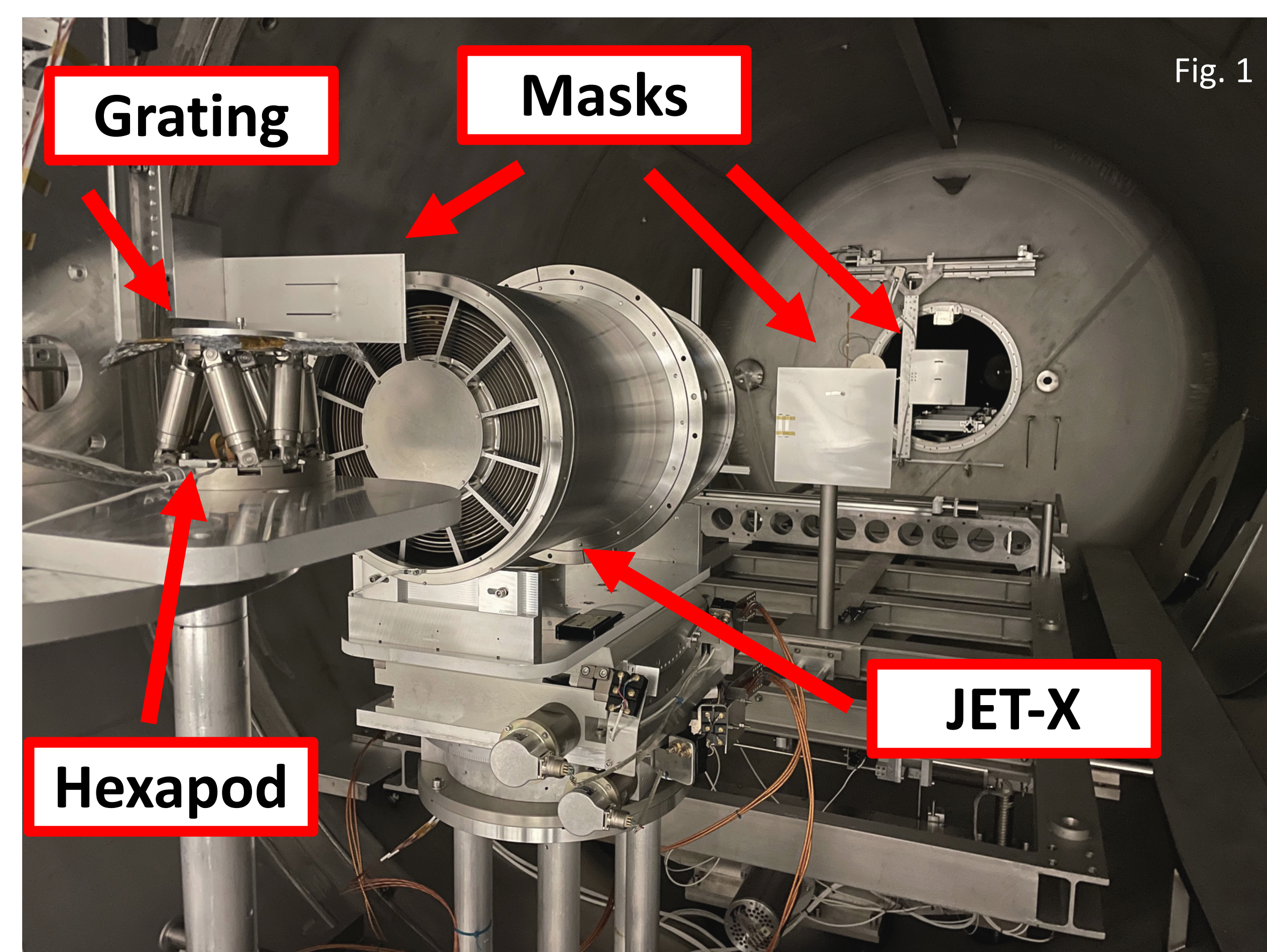
## Results



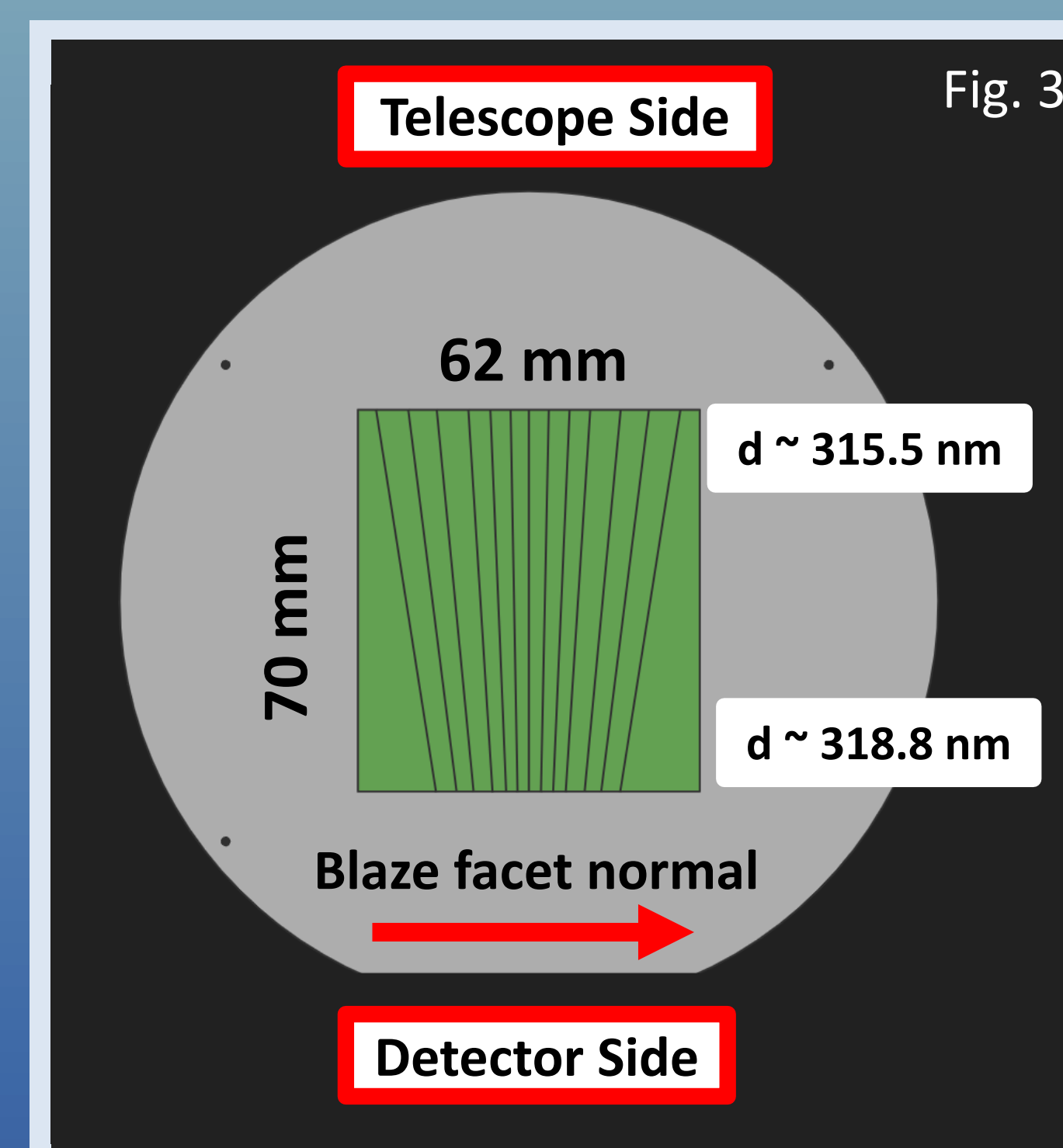
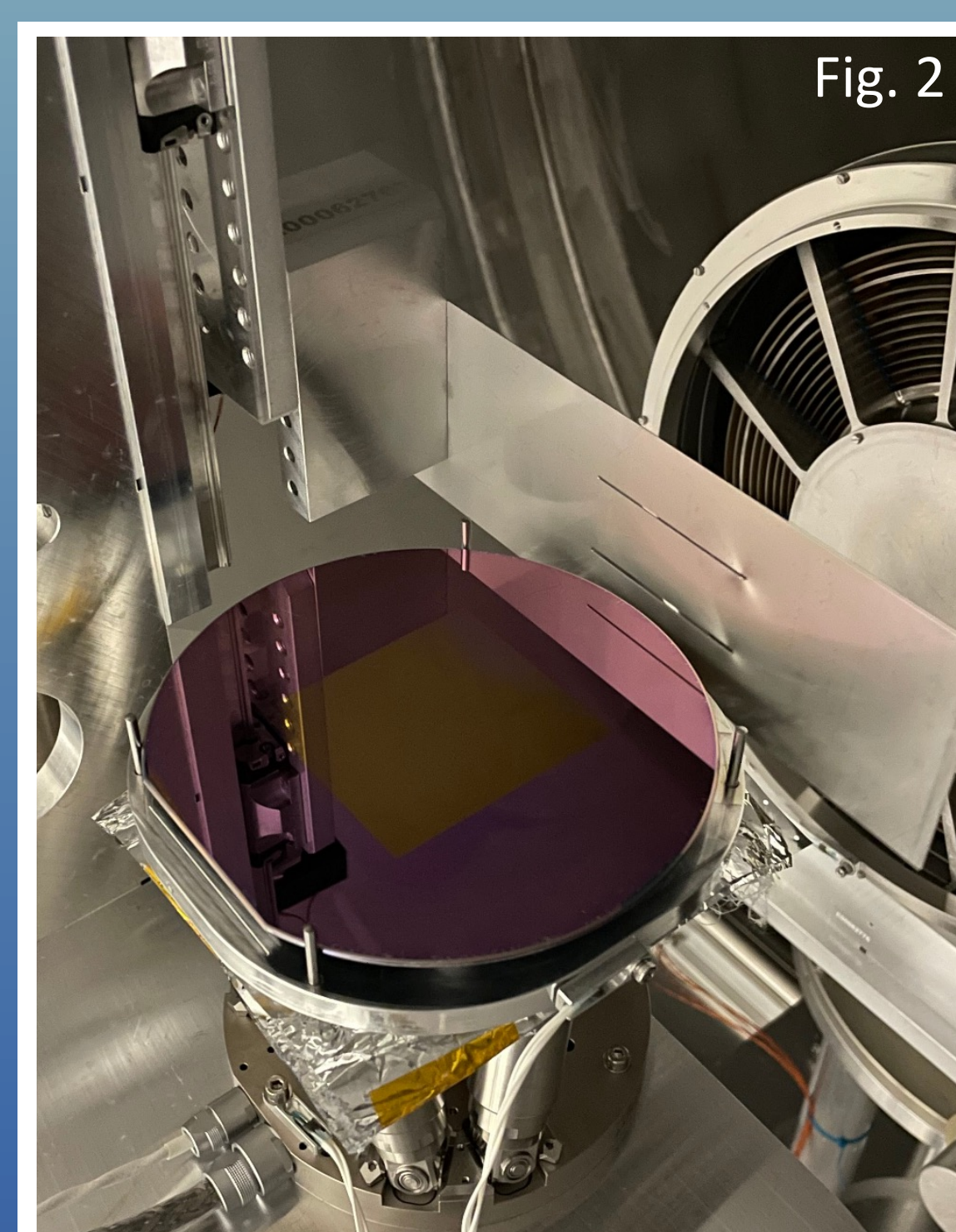
The angular resolution of JET-X remains consistent with measurements made in 1996 and 2012 (The 2023 angular resolution using Al-K is  $14.6 \pm 0.3$  arcseconds, measured with PIXI). The effective area of JET-X is also consistent with previous measurements.



## Inside the Chamber



## The Off-Plane Grating (OPG)



OGRE gratings are blazed reflection gratings with a radial groove profile. This radial groove profile corrects for aberrations, and the blaze increases efficiency by diffracting light preferentially into one direction. Diffracted light accumulates at some non-zero order, referred to as the blaze order. With a blaze of 33°, this grating puts efficiency into the 13th order when in Littrow.

## References & Acknowledgements

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Fig. 3: adapted from O'Meara  
 Fig. 5: Provided by the PANTER team; Using values from Spiga et al (2014)  
 Fig. 8 & 9: Provided by the PANTER team

Thank you to the PANTER team for their support!