

Imaging X-ray Polarimetry Explorer (IXPE) Mission Overview



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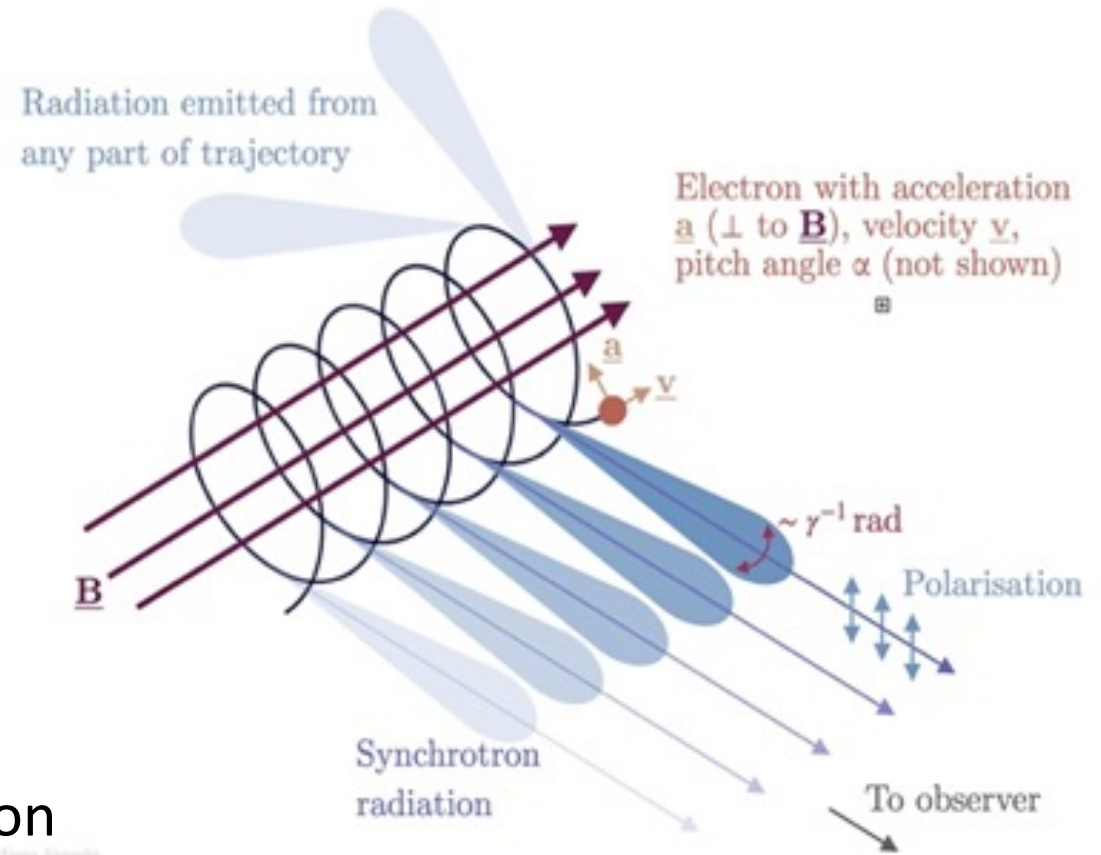


Polarization measures geometry

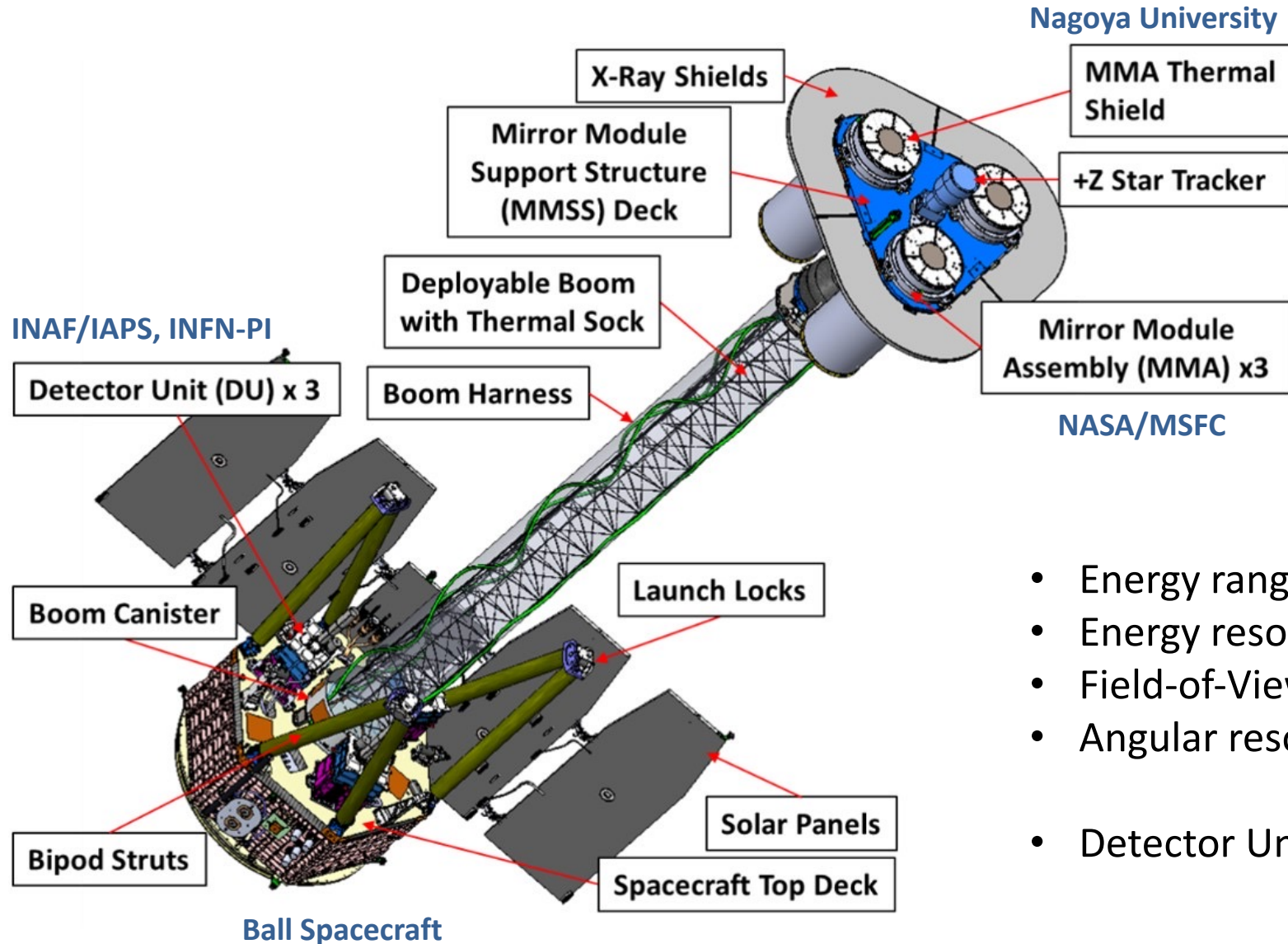
Polarization is a vector → measures geometry

Electric vector position angle = EVPA

- Synchrotron radiation →
EVPA perpendicular to magnetic field lines
- Scattering/reflection →
EVPA perpendicular to scattering plane
- Strong magnetic fields →
EVPA transported along magnetic field orientation
- Strong gravitational fields →
EVPA parallel-transported along space-time geodesics

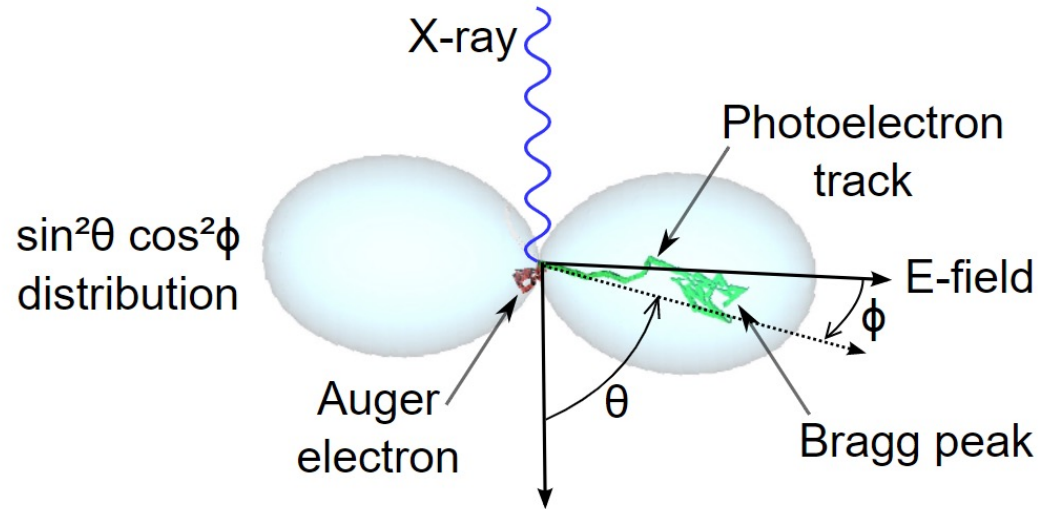


Imaging X-ray Polarimetry Explorer

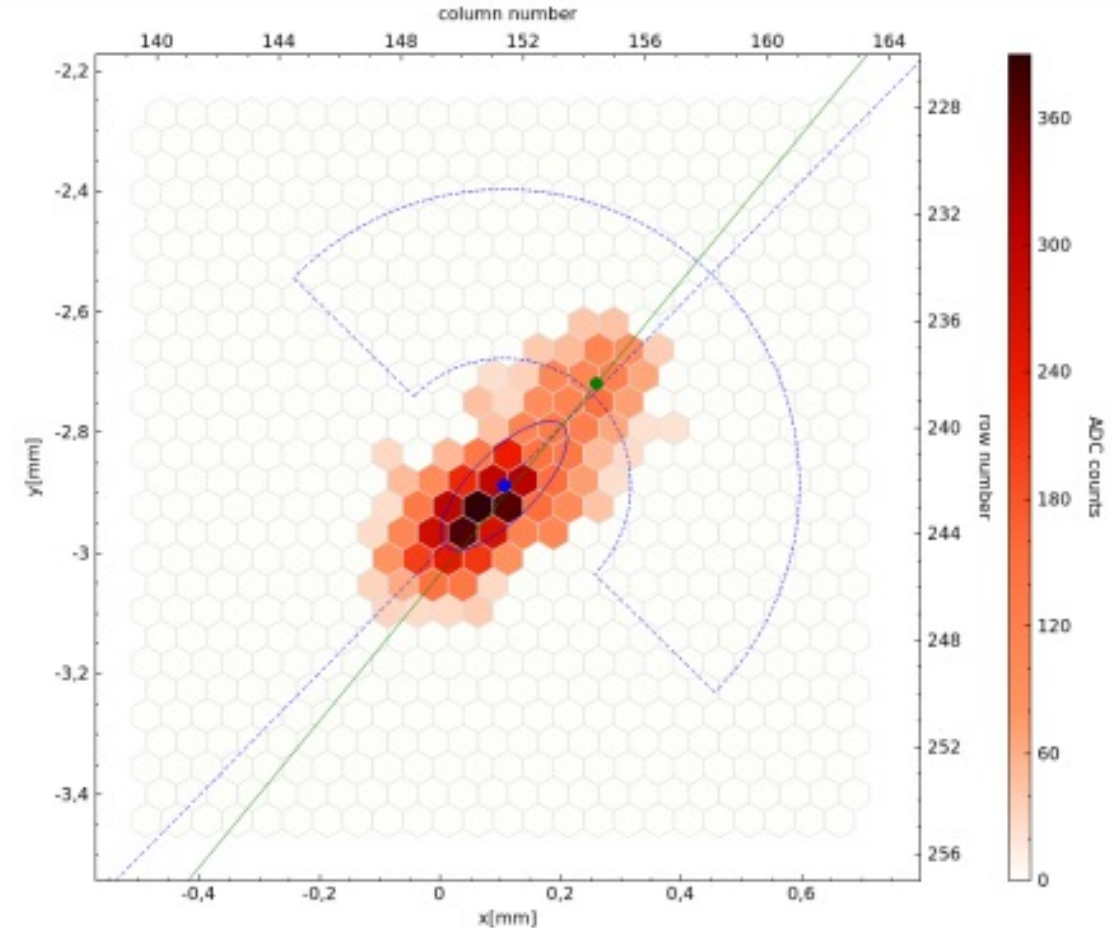


- Energy range: 2–8 keV
- Energy resolution: 0.57 keV FWHM @ 2 keV ($\propto \sqrt{E}$)
- Field-of-View: 12.9' diameter, useful 10'
- Angular resolution: 30" HPD
- Detector Unit = DU, numbered DU1, DU2, DU3

X-ray polarization via the photoelectric effect

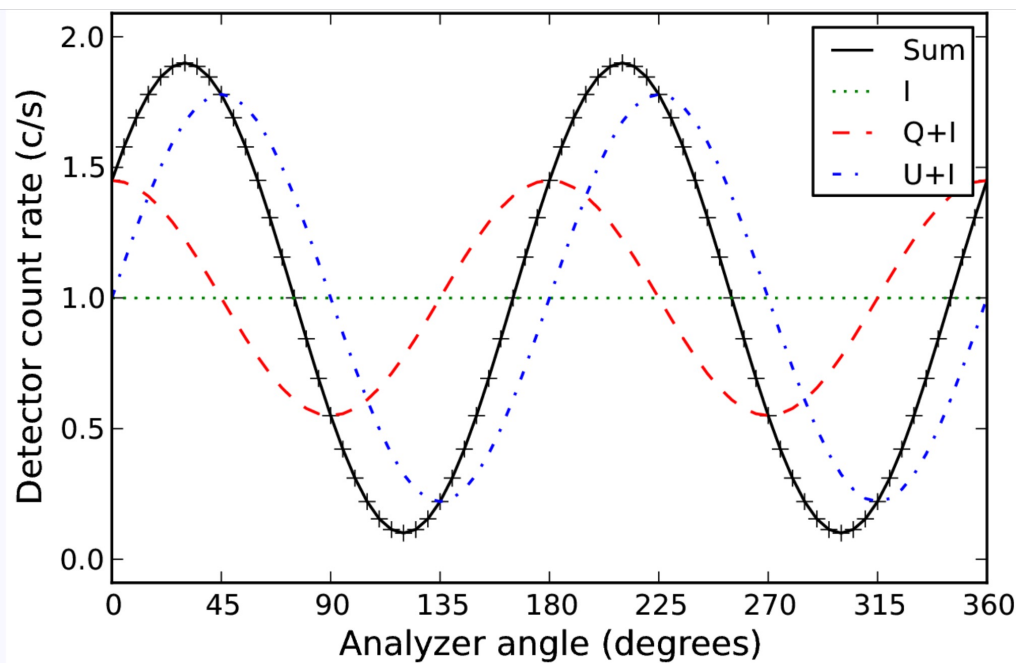
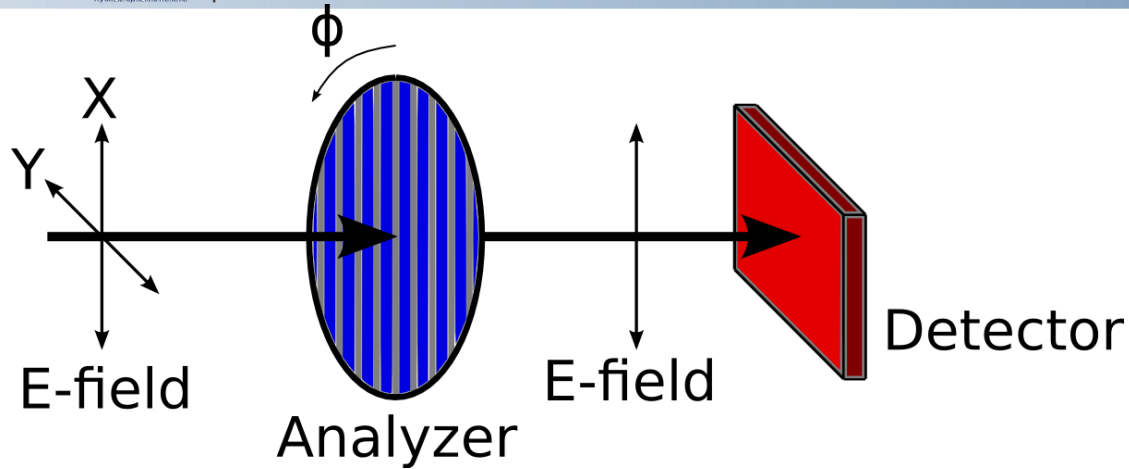


- IXPE uses the photoelectric effect to measure *linear* polarization, no sensitivity to circular polarization.
- Photoelectron ejected along photon E field.
- Key is to find photoelectron direction at interaction point.



Photoelectron track from Cas A for 2.7-keV photon in DU1.

Measuring polarization using Stokes parameters



- Work in Stokes parameters
 - Independent, gaussian errors
 - Simply additive
 - No coordinate singularity at zero polarization
- Compute Stokes parameters (q_i, u_i) from initial direction of photoelectron (φ_i) for each event i
- Make sums of q_i, u_i , intensity (Q, U, I)
- Find polarization degree (PD) and position angle (PA)

$$PD = \sqrt{(Q/I)^2 + (U/I)^2}$$

$$PA = (1/2) \tan^{-1}(U/Q)$$
- Can do this in bins (energy, time, phase, ...)
- Do spectropolarimetry (in Xspec) using spectra in Stokes I, Q, and U and ‘modulation response’.

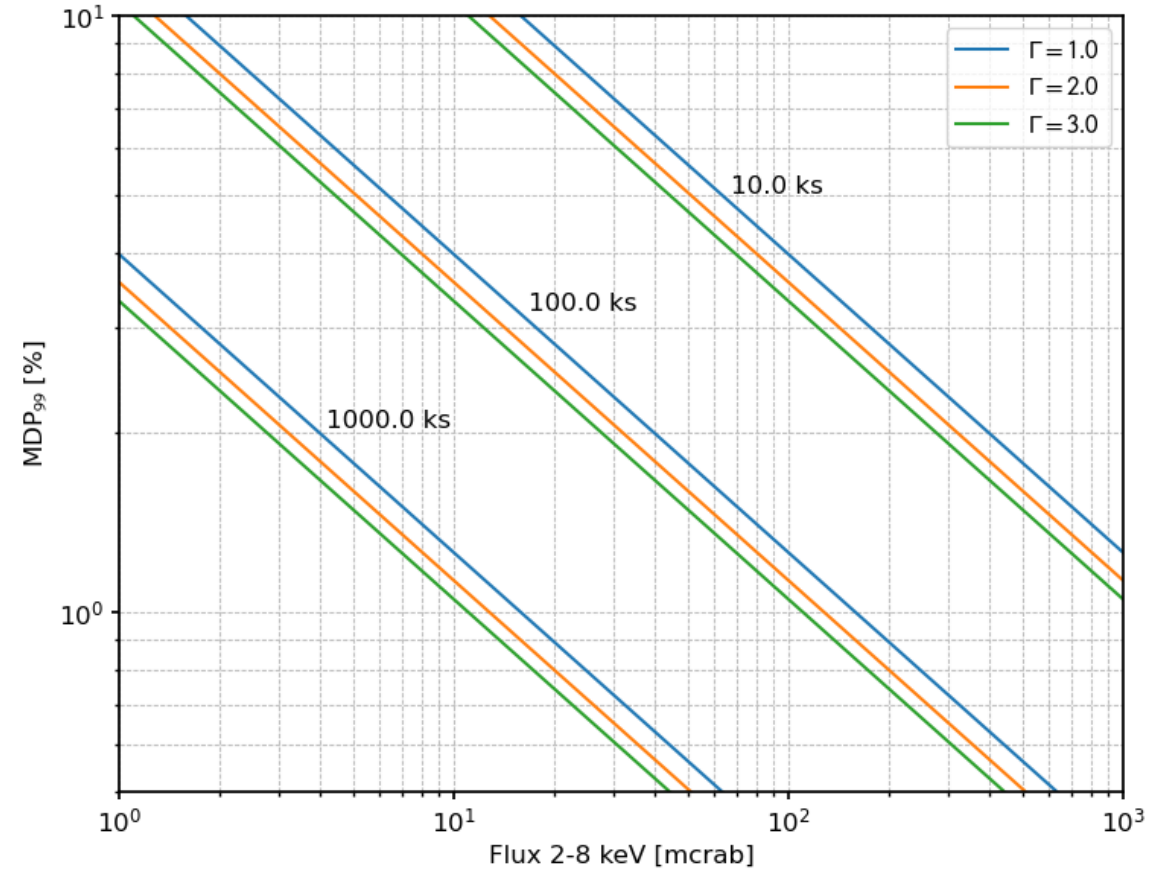
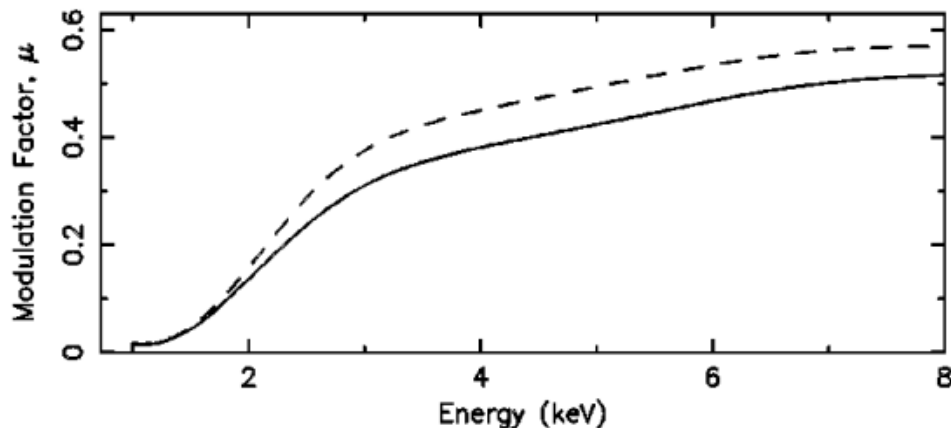
Minimum Detectable Polarization

- Minimum Detectable Polarization 99% (MDP99) is the Polarization Degree that has only a 1% probability of being produced by random fluctuations from an unpolarized source.

$$MDP_{99} = \frac{4.29}{\mu s} \sqrt{\frac{s + b}{T}}$$

where μ = modulation factor, s = source rate, b = background rate, T = exposure time.

For MDP = 2% with $\mu = 0.4$ and $b = 0$, need 3×10^5 X-rays.



MDP99 versus flux in 2-8 keV band for various exposures and photon indices with no background.

One mCrab in the 2-8 keV range $\approx 2.1 \times 10^{-11}$ erg cm⁻² s⁻¹.

IXPE observations to date by class

Category	Average Time per Source [ks]	Sources [#]	Observations [#]
PWN	940	4	7
SNR	800	5	7
Stellar BH	670	7	15
NS LMXB	150	9	11
Accreting Pulsar	420	9	17
Magnetar	970	4	4
Blazar Radio Gal	390	12	17
Radio Quiet AGN Sgr A	820	5	6
GRB	100	1	1
Total	540	56	85

ToOs: 13 observations of 10 targets with an average exposure of 210 ks per trigger.

Targets of Opportunity (ToOs)

ToOs can be proposed in the GO program.

- Proposals must include a list of up to 6 pre-defined targets, triggers accepted only for targets on the list.
- Priority levels:
 - High: IXPE observations to begin within 72 hours of the trigger
 - Medium: IXPE observations to begin between 3 days to 3 weeks from the trigger
 - Low: IXPE observations to begin after 3 weeks from the trigger
- We anticipate executing ~8 high/medium triggers in this GO cycle.
- Each ToO trigger is limited to a maximum exposure of 1.5 Ms.

Unanticipated ToOs can be requested via the IXPE ToO web site

- https://ixpe.msfc.nasa.gov/for_scientists/too.html
- This is working now.

**We anticipate that the IXPE
General Observer program will
produce outstanding science.**

