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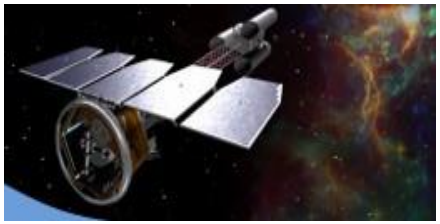

The Imaging X-ray Polarimetry Explorer

Giorgio Matt (Univ. Roma Tre, Italy)
on behalf of the IXPE team

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IXPE

- **Proposed to NASA as a SMall EXplorer (SMEX) mission in December 2014**
- **One of the three proposals selected for an Assessment Study in August 2015**
- **Final down-selection in January 2017**
- **Launch on early 2021**
- **Baseline duration: 2 years**

IXPE will re-open the X-ray polarimetric window after more than 40 years

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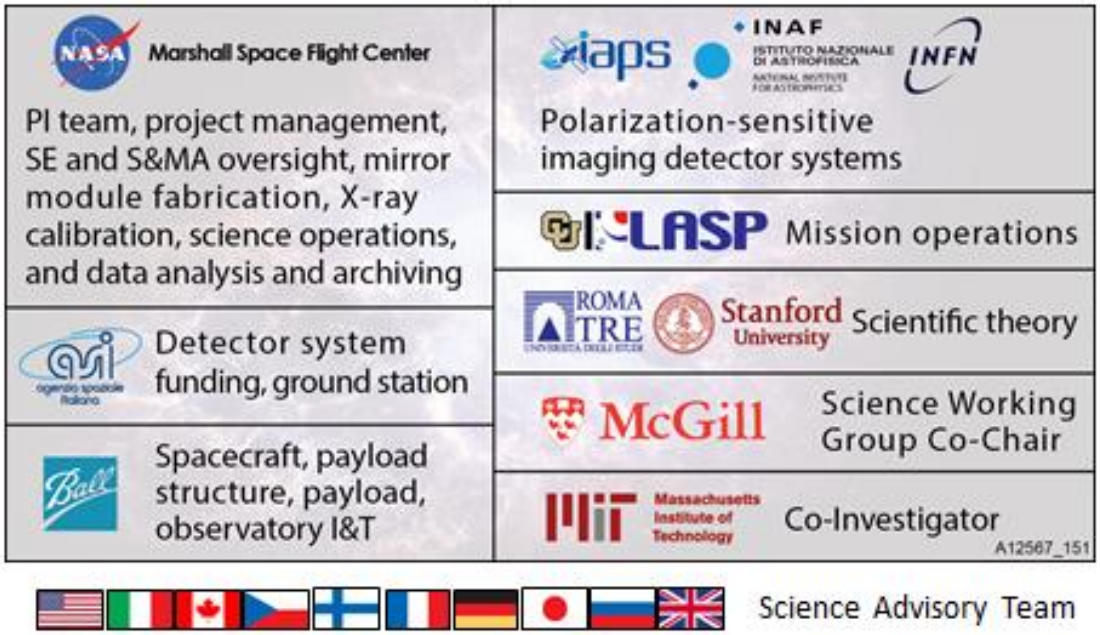
IXPE IN A NUTSHELL

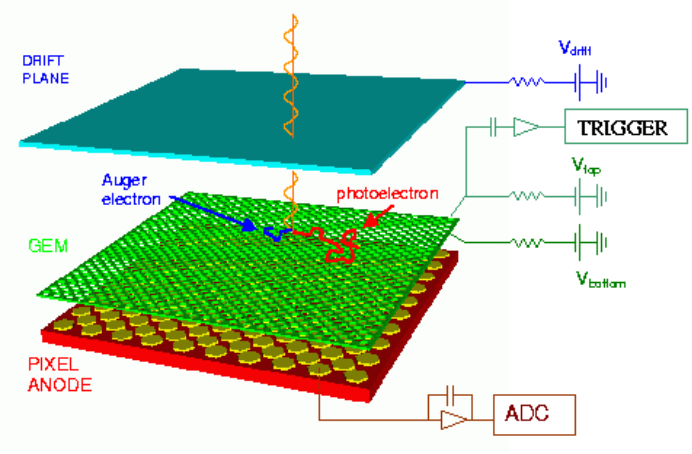
Principal Investigator: **M. C. Weisskopf (MSFC)**

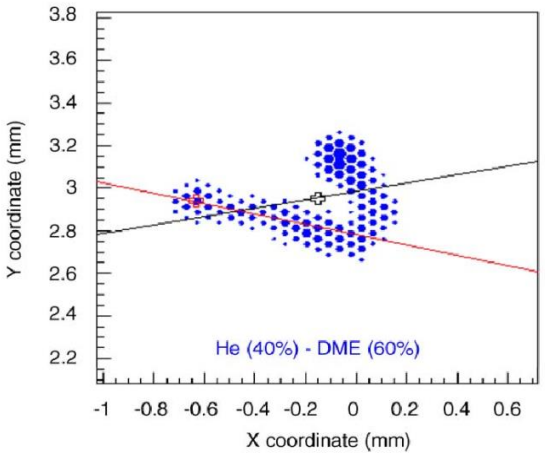
Co-Investigators: *Brian D. Ramsey, Paolo Soffitta, Ronaldo Bellazzini, Enrico Costa, Stephen L. O'Dell, Allyn Tennant, Herman Marshall, Fabio Muleri, Jeffery Kolodziejczak, Roger W. Romani, Giorgio Matt, Victoria Kaspi, Ronald Elsner, L. Baldini, L. Latronico*



- **Pegasus XL launch from Kwajalein**
- **540-km circular orbit at 0° inclination**
- **2 years baseline mission, 1 year SEO**
- **Point-and-stare at known targets**
- **Science Operations Center at MSFC**
- **Mission Operations Center at CU/LASP**
- **Malindi ground station (Singapore Backup)**

- **Mirror based on grazing incidence reflection**
  - Total collecting area: >700 cm^2 at 3 keV
- **Photoelectric polarimeter based on GPD design**
  - Include a Filter & Calibration wheel with
    - Filters for specific observations (very bright sources, background)
    - Calibrations sources (polarized and unpolarized, gain)





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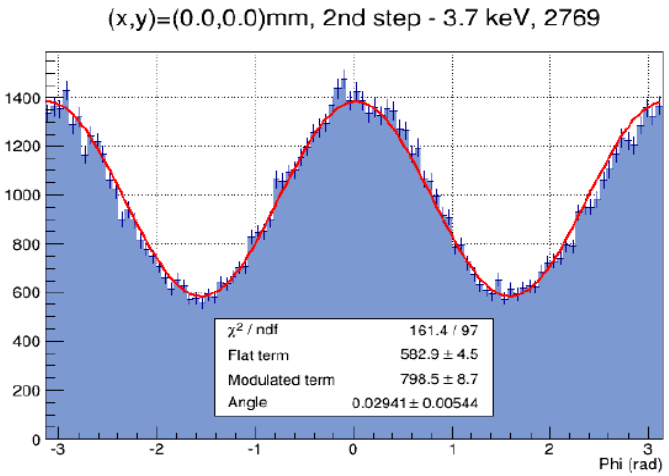
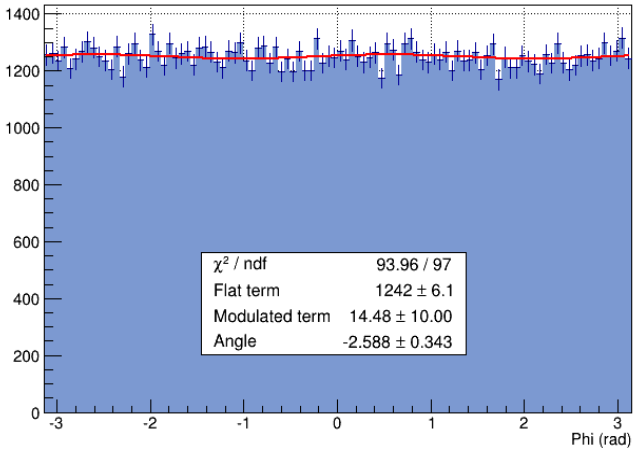


Real modulation curve derived from the measurement of the emission direction of the photoelectron.



Residual modulation for unpolarized photons.

Bellazzini et al. 2012

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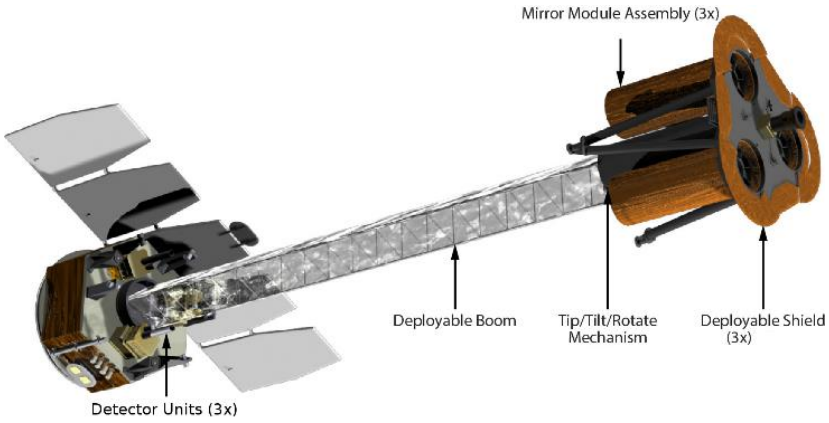
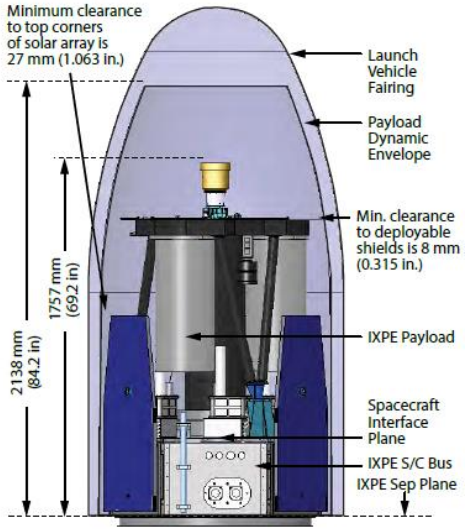
- **3x Telescopes**
  - 3x Mirror Units (MUs) + 3x Detector Units (Dus)
  - A Detectors Service Unit (DSU) with built-in redundancy
  - 4 m focal length, deployable boom and X-ray shield
- **Performance**
  - Polarization sensitivity: $MDP_{99\%}$<5.5% in 1 day for flux of 10^{-10} ergs/cm^2/sec
  - Energy range: 2-8 keV
  - Limit polarization: 0.5% (degree), 1 degree (angle)
  - Angular resolution: better than 30 arcsec, field of view larger than 9 arcmin
  - UTC synchronization: better than 250 μs
  - Energy resolution: better than 25%





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SCIENTIFIC GOALS

- Acceleration processes in PWN and SNR
- Accreting magnetized compact objects
- QED effects in magnetars
- The spin of the black hole in microquasars
- The geometry of the hot corona in microquasars and AGN
- Blazars and radiogalaxies
- Astroarcheology of the Galactic Centre

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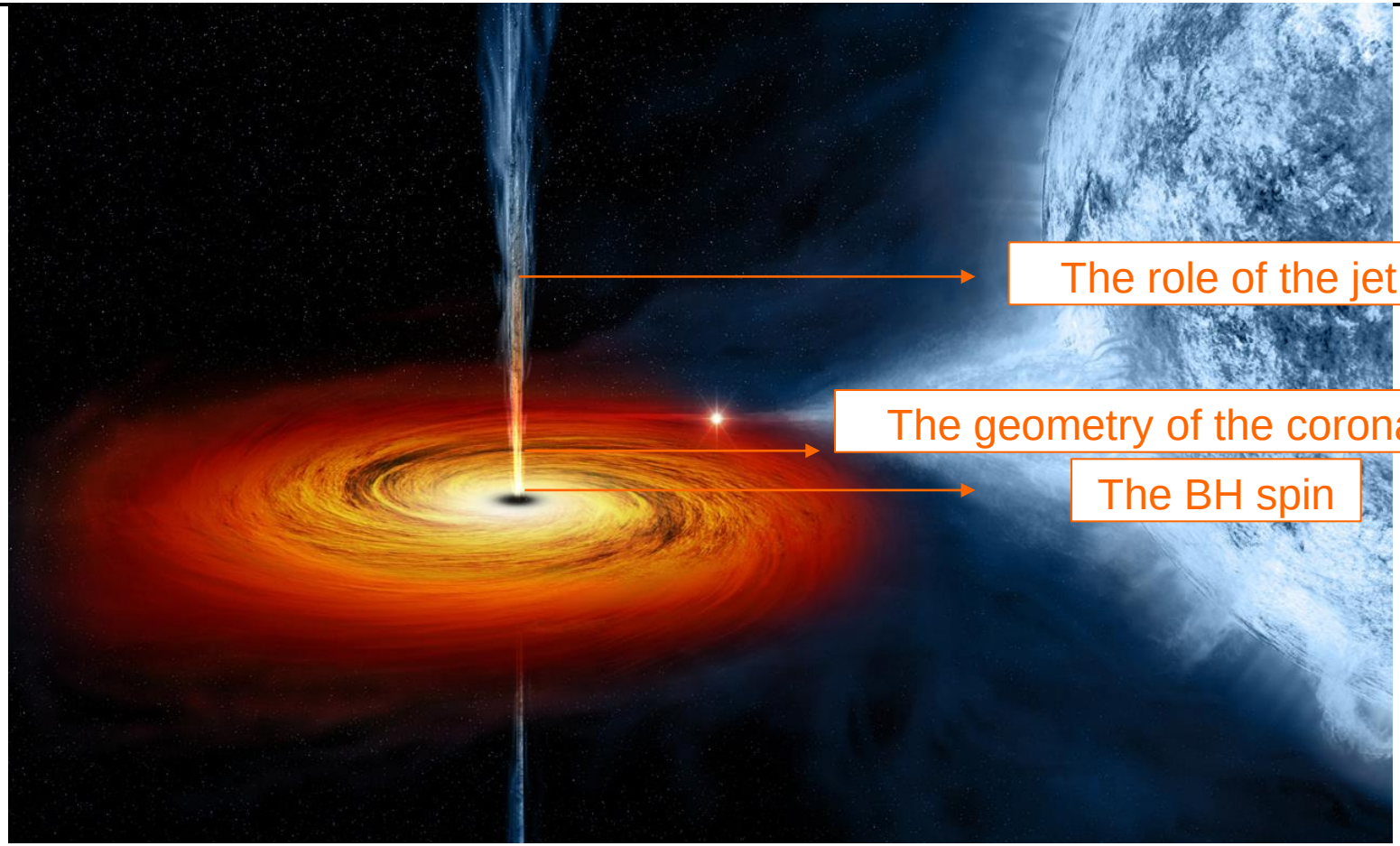
MICROQUASARS



X-ray polarimetry can provide answers to several key problems:

The role of the jet - The geometry of the corona – The spin of the BH

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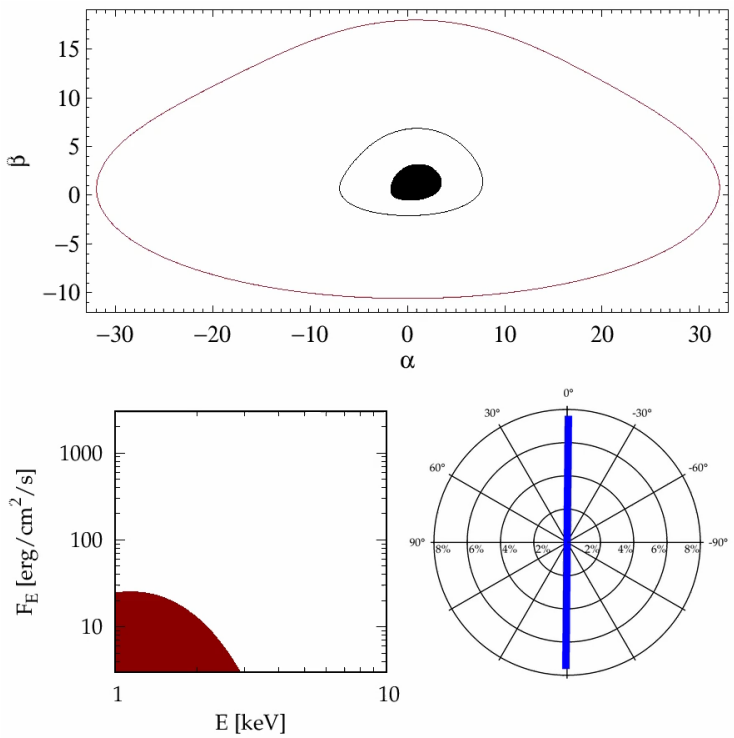
THE SPIN OF THE BLACK HOLE

- **For an accreting Galactic BH in the soft state**
  - Scattering polarizes the thermal disk emission
  - Polarization angle rotates due to GR effects
    - Polarization rotation is greatest for emission from inner disk
    - Inner disk is hotter, producing higher energy X-rays



Rotation of the polarization angle with energy

Courtesy: Michal Dovciak

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Imaging X-Ray Polarimetry Explorer

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Why another method, besides the three ones already in use?

Rotation of the polarization angle with energy

J1655-40:

QPO a = J/Jmax= 0.290±0.003

Continuum: a = J/Jmax 0.7±0.1

Iron line a = J/Jmax 0.95

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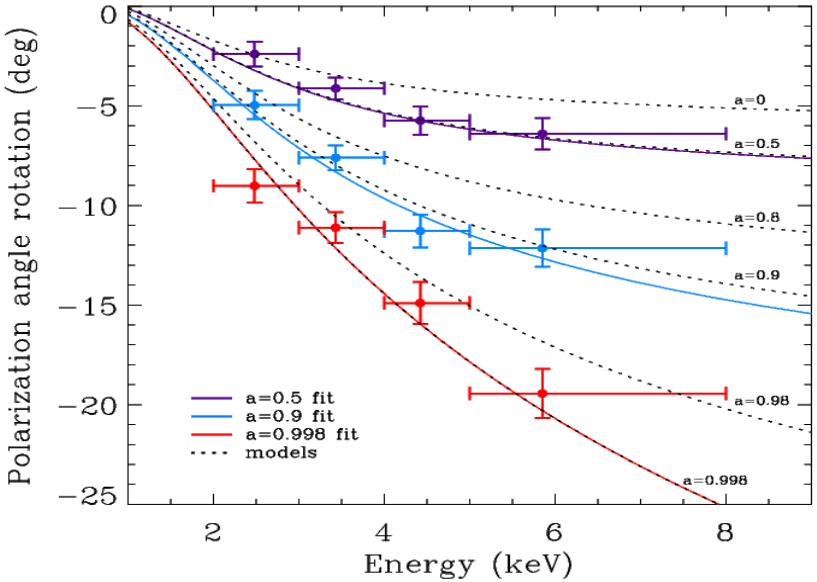

Rotation of the polarization angle with energy

200 ks IXPE observation of GRS1915+105

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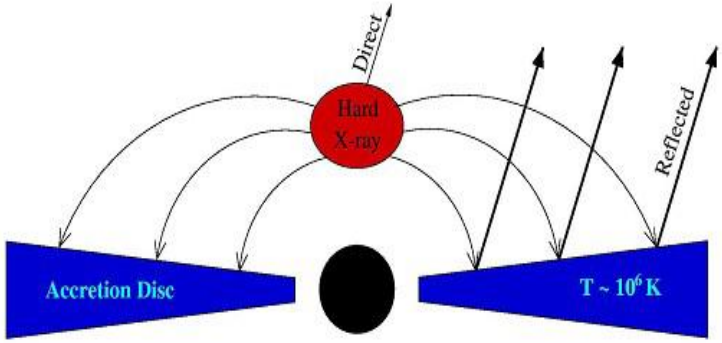
THE GEOMETRY OF THE HOT CORONA

The geometry of the hot corona, considered to be responsible for the X-ray emission in binaries and AGN, is largely un

The geometry is related to the corona origin:

- Slab – high polarisation (up to more than 10%): disc instabilities?
- Sphere – very low polarisation: aborted jet?



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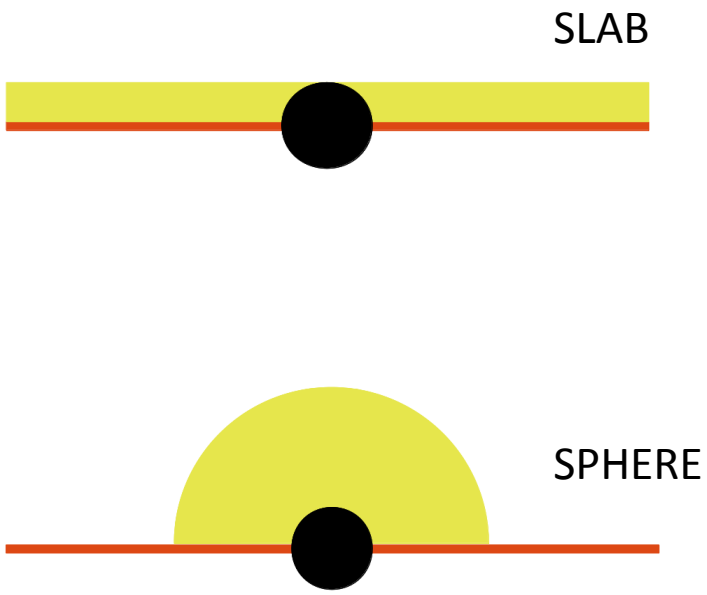

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… IN STELLAR ACCRETING BLACK HOLES

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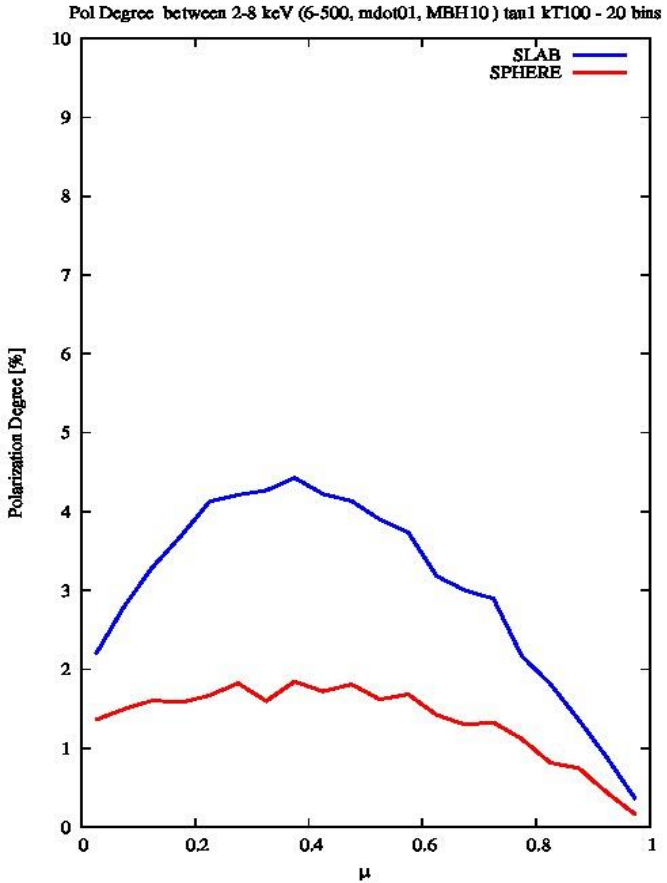

Courtesy: Francesco Tamborra

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… AND IN AGN

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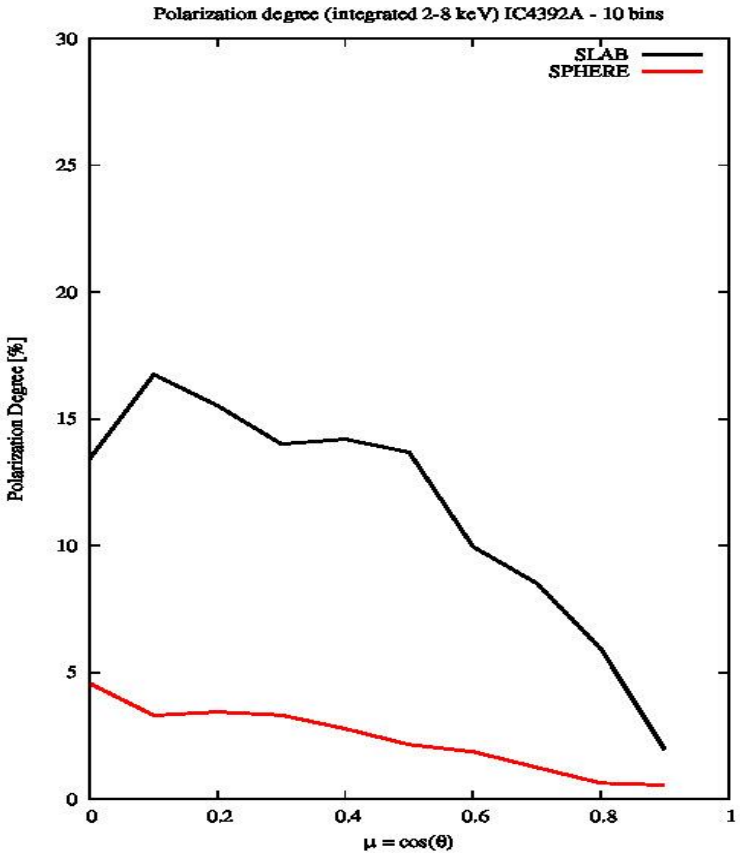

Courtesy: Francesco Tamborra

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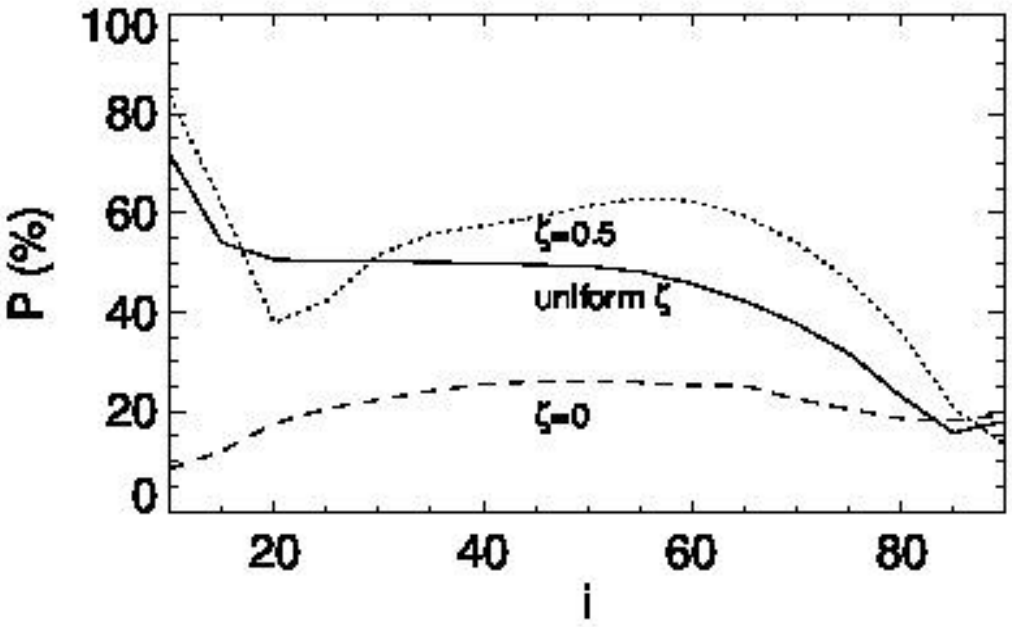
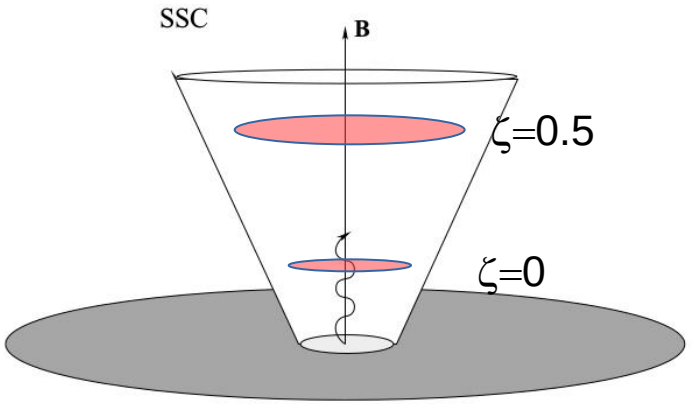
THE ROLE OF THE JET IN MICROQUASARS





McNamara et al. 2009

Corona emission is predicted to be less than 10%.

Much larger polarization degrees are expected for jet emission

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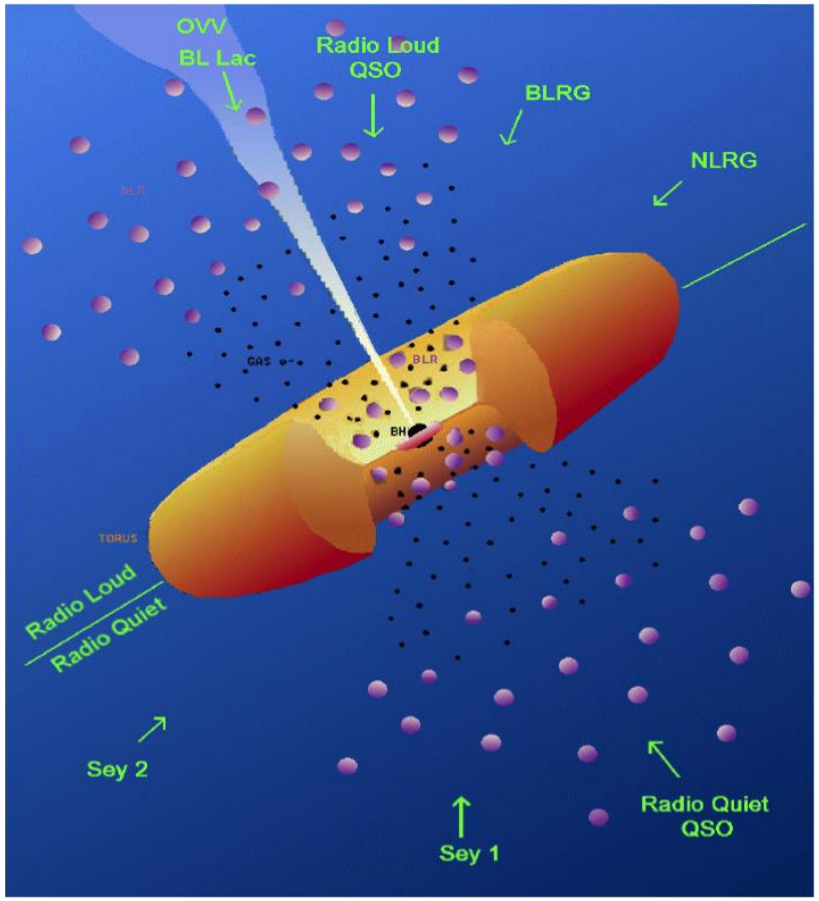
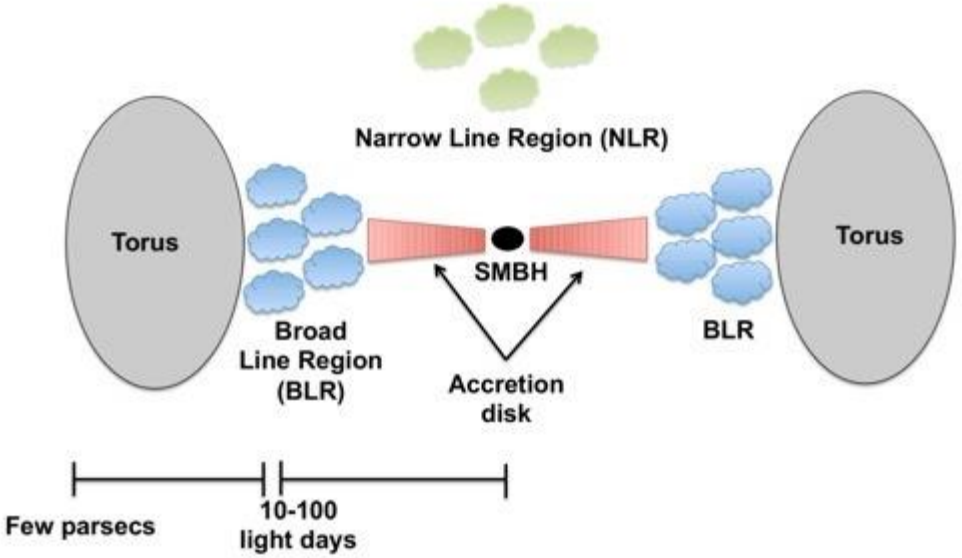
ACTIVE GALACTIC NUCLEI





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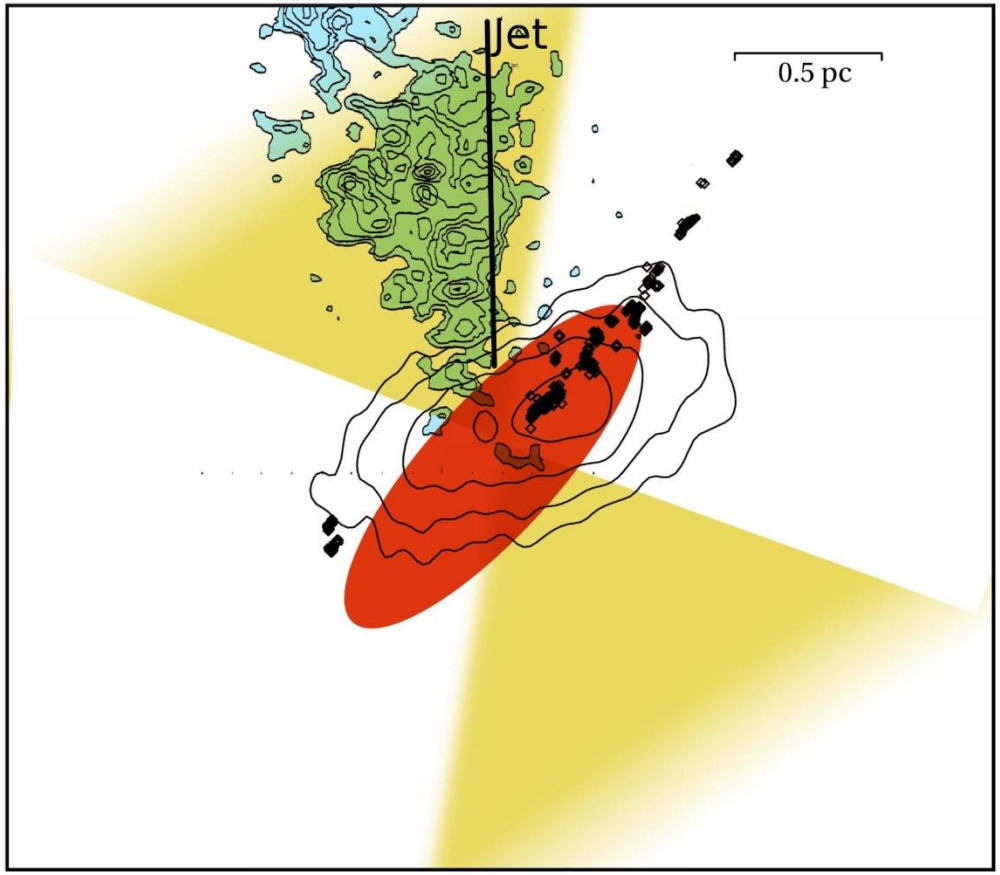
RQ AGN: ORIENTATION OF THE TORUS

Geometry of the torus:

the polarization angle will give us the orientation of the torus, to be compared with IR results, and with the ionization cones (Goosmann & Matt 2011)



Raban et al. (2009)

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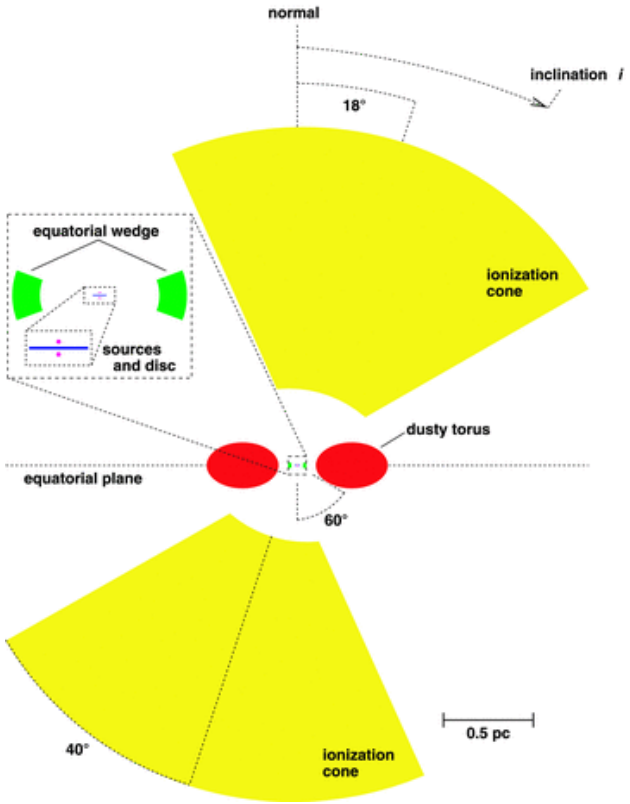

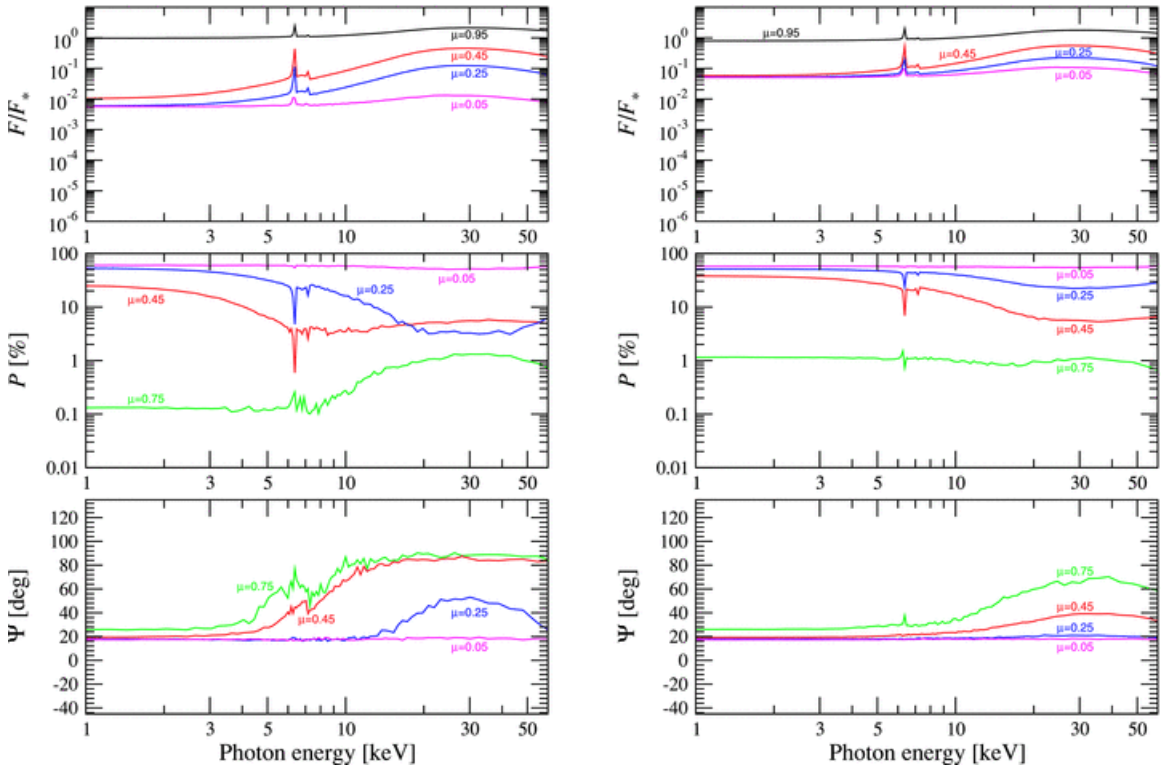

Goosmann & Matt (2011)

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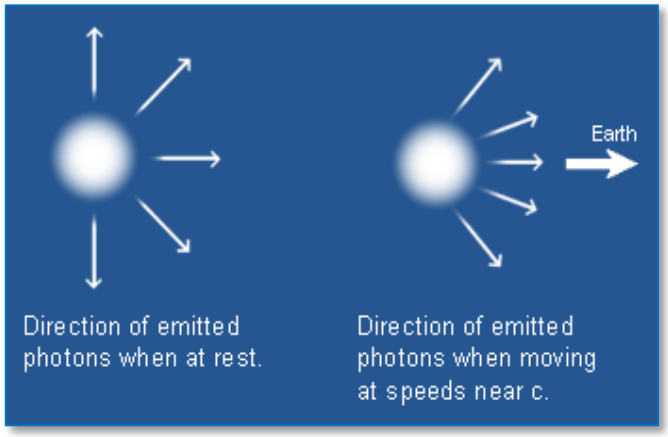
BLAZARS …

Blazars are Active Galactic Nuclei with a jet directed towards us



Due to a Special Relativity effect (aberration), the jet emission dominates over other emission components.

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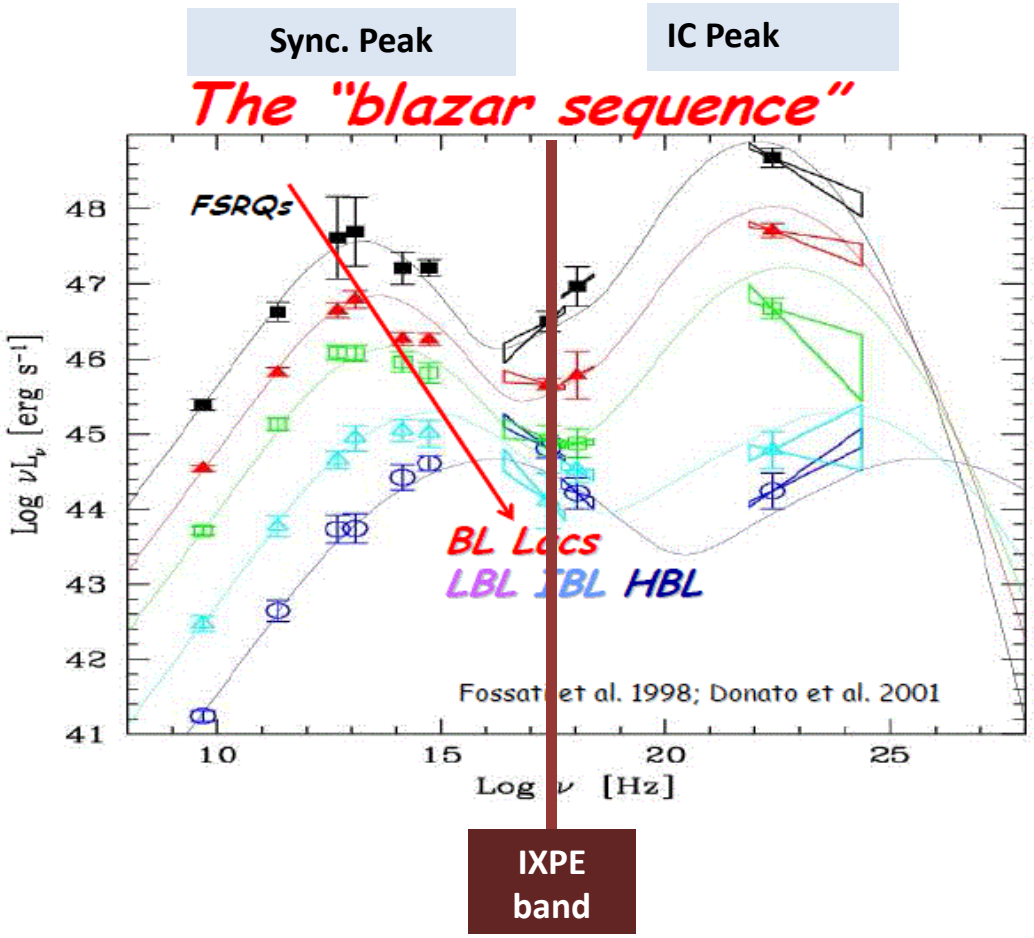
BLAZARS …

In synchrotron-dominated X-ray Blazars, multi-λ polarimetry probes **the structure** of the jet and of its **magnetic field**

In inverse Compton dominated Blazars, multi-λ polarimetry observations can determine:

- **the composition of the jet** (hadronic vs. leptonic)
- **the origin of the seed photons** Synchrotron-Self Compton (SSC) or External Compton (EC)



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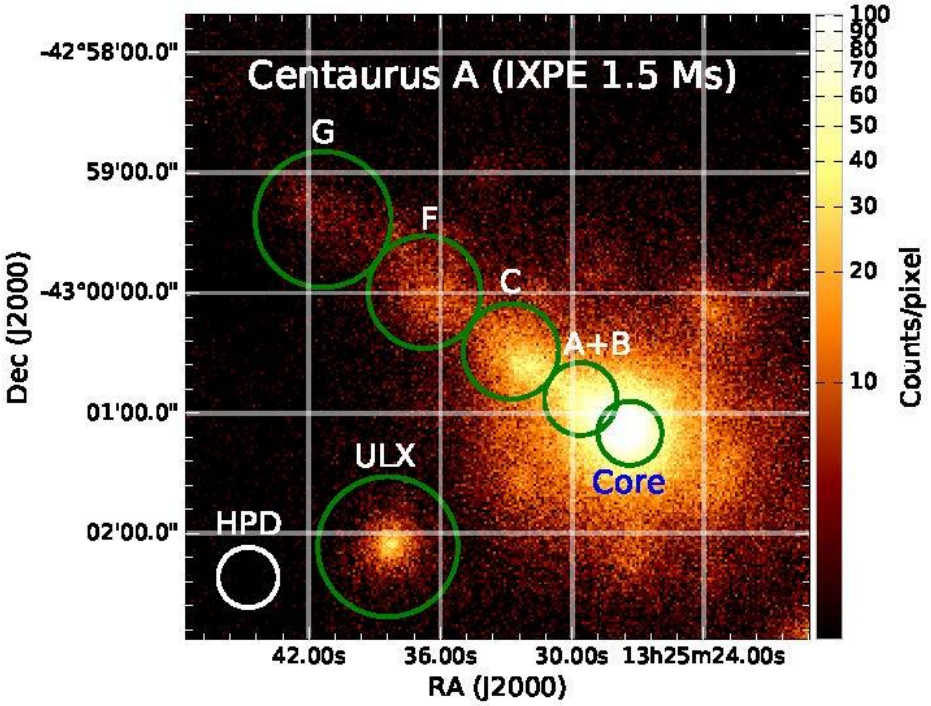
… AND RADIOGALAXIES



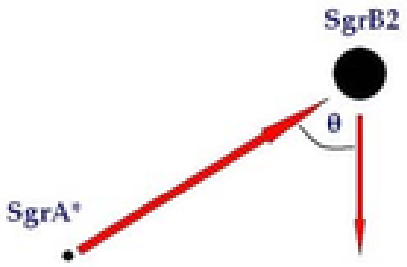
Region	MDP_{99}
Core	**0.4%**
Jet	**10.9%**
Knot A+B	17.6%
Knot C	16.5%
Knot F	23.5%
Knot G	30.9%
ULX	**14.8%**

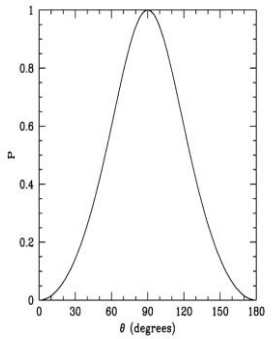
Includes effects of dilution by unpolarized diffuse emission

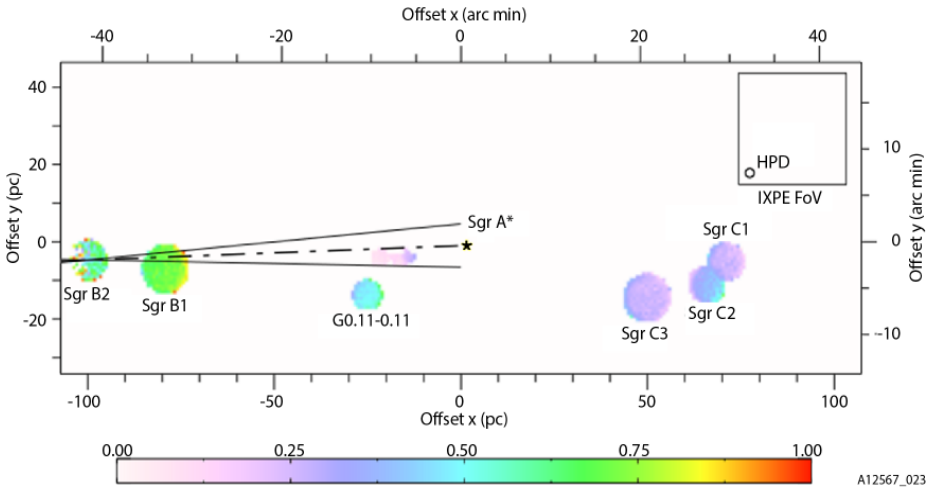
IXPE Imaging X-Ray Polarimetry Explorer

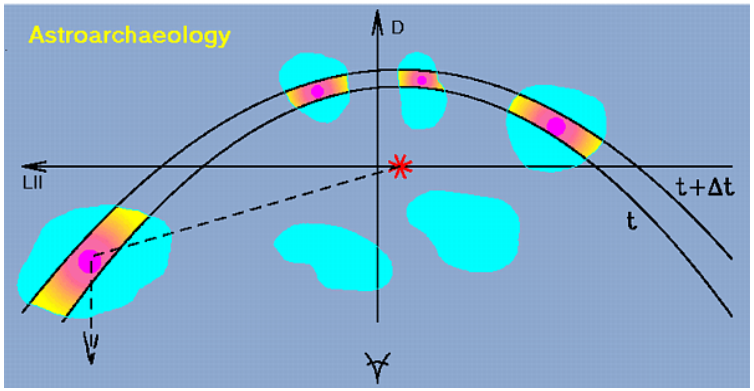
WAS THE GC ACTIVE A FEW CENTURIES AGO?

- **Galactic Center molecular clouds (MC) are known X-ray sources**
  - Are MCs reflecting X-rays from Sgr A* ? (supermassive black hole in the GC)
    - X-radiation would be *highly polarized* perpendicular to plane of reflection and indicates the direction back to Sgr A*
    - Sgr A* X-ray luminosity was 10^6 larger ≈ 300 years ago









Payload, spacecraft and system reviews successfully passed. No major problems found.

Next major steps:

End June: Mission Preliminary Design Review

Mid August: Key Decision Point