Time Domain X-ray Astrophysics: ISS-TAO

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on behalf of the ISS-TAO team

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ISS - TAO
Transient Astrophysics Observer

- TAO has been proposed to fly to the International Space Station with
  - **W**ide **F**ield X-ray **I**mager (GSFC, Leicester, MIT)
  - **G**amma-ray **T**ransient **M**onitor (Technion)

- Primary mission science is X, γ - ray transients from the mergers of Black Holes and Neutron Stars and as followup of Gravitational Wave events
  - Also, supernovae, Tidal Disruption Events, Gamma-Ray Bursts

- ISS-TAO and COSI-X are finalists for NASA's MoO program
  - Concept Study Report submitted May 2018
  - Site Visit in September 2018
  - Final selection any day now

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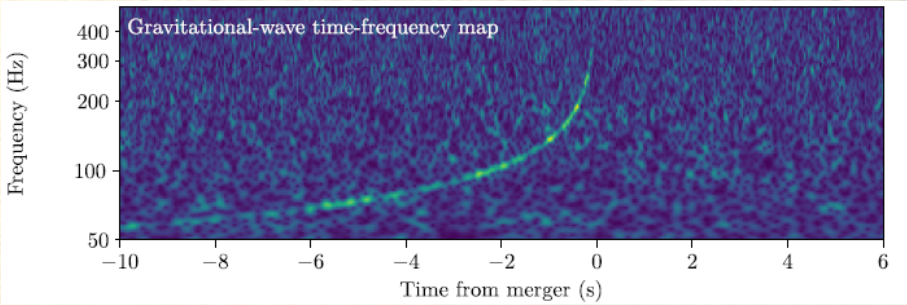
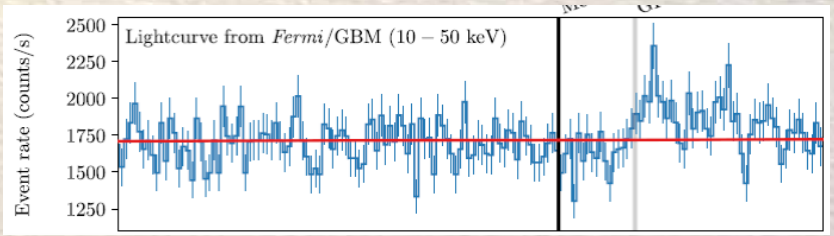
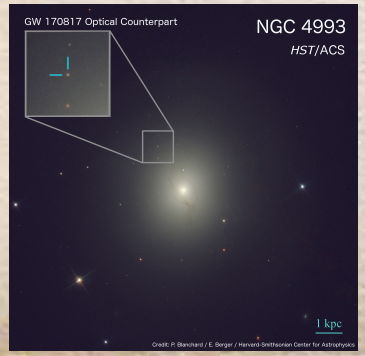
EM Counterparts to GWs

- GWs give masses and possibly spins of merging compact objects
- LIGO localization limited to ~1000 sq. deg. (< 100 with Virgo)



- Coincident EM coincident counterparts increase GW sensitivity
- EM counterparts can be imaged, localizing the host galaxy of the GW source and provide astrophysical context
  - Gamma-, X- ray burst, afterglow
  - Host galaxy, Redshift
  - Gas dynamics, accretion disk, jet?
  - Ejecta after the merger, kilonova





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Most Sensitive All-Sky X-Ray Survey

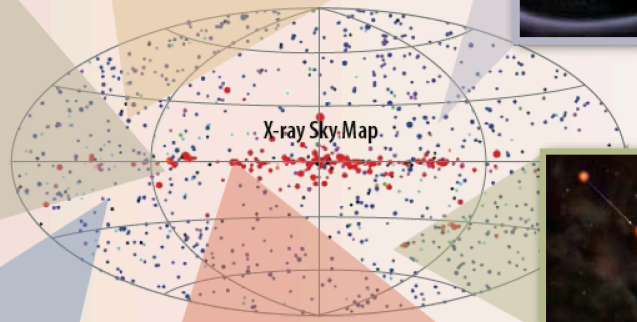
2 Highest Sensitivity Time-Domain Survey of the Transient Soft X-ray Sky: Probing Astrophysics of Extreme Gravity

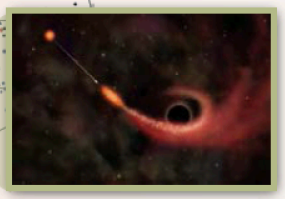
With a 12-fold improvement in sensitivity beyond previous all-sky soft X-ray imagers, ISS-TAO will dramatically extend the discovery space for transient X-ray sources involving black holes and neutron stars. The near continuous ISS-to-ground communications link will allow transient alerts to be rapidly delivered to ground and space observatory networks.

2-4 high redshift GRB locations per year will be passed from ISS-TAO to ground-based telescopes to JWST, for early universe investigations.

***Supernova Shock Breakouts** are the elusive short bright X-ray flashes signaling SNe explosions. **ISS-TAO** will detect them at a rate of ~0.3 per year.*

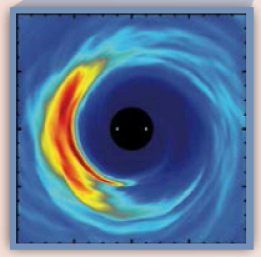
***Binary neutron-star mergers** produce short-lived strong gravitational waves followed by electromagnetic signals. **ISS-TAO** will detect these counterparts and provide insight into both their progenitor systems and the dynamics of strong gravity.*





***Tidal Disruption Events** signal the demise of a star when it wanders too close to a supermassive black hole in the center of a galaxy. **ISS-TAO** will detect >80 per year, elucidating stellar dynamics, and providing super massive black hole demographics.*

***Classical and Recurrent Novae** are the results of thermonuclear burning on the surface of a white dwarf. **ISS-TAO** will detect X-rays from their runaway phases.*



***170 Active Galactic Nuclei** will be monitored weekly by **ISS-TAO**, to search efficiently for modulated X-ray flux associated with the circumbinary disk of inspiraling supermassive black hole binaries.*

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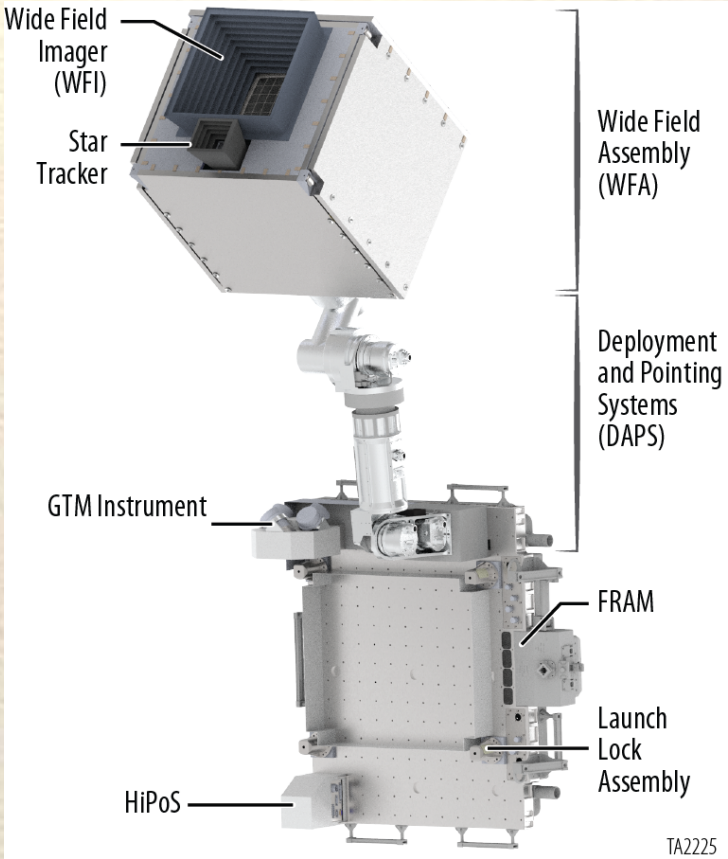
TAO-ISS Payload and Instruments

Gamma-Ray Transient Monitor

10 keV to 1 MeV

Scintillator + PMT

Technion Israel



Wide Field Imager (GSFC)

FoV: 18.6x18.6 sq deg

Fast Slew: 4 deg / s

Localization: 1.5′

Energy: 0.4 - 4 keV

Eff. area 2.3 cm^2

2 ks sensitivity:

2×10^{-11} erg cm^{-2} s^{-1}

Micro-channel optics **(U. Leicester)**

CCDs **(MIT/LL)**

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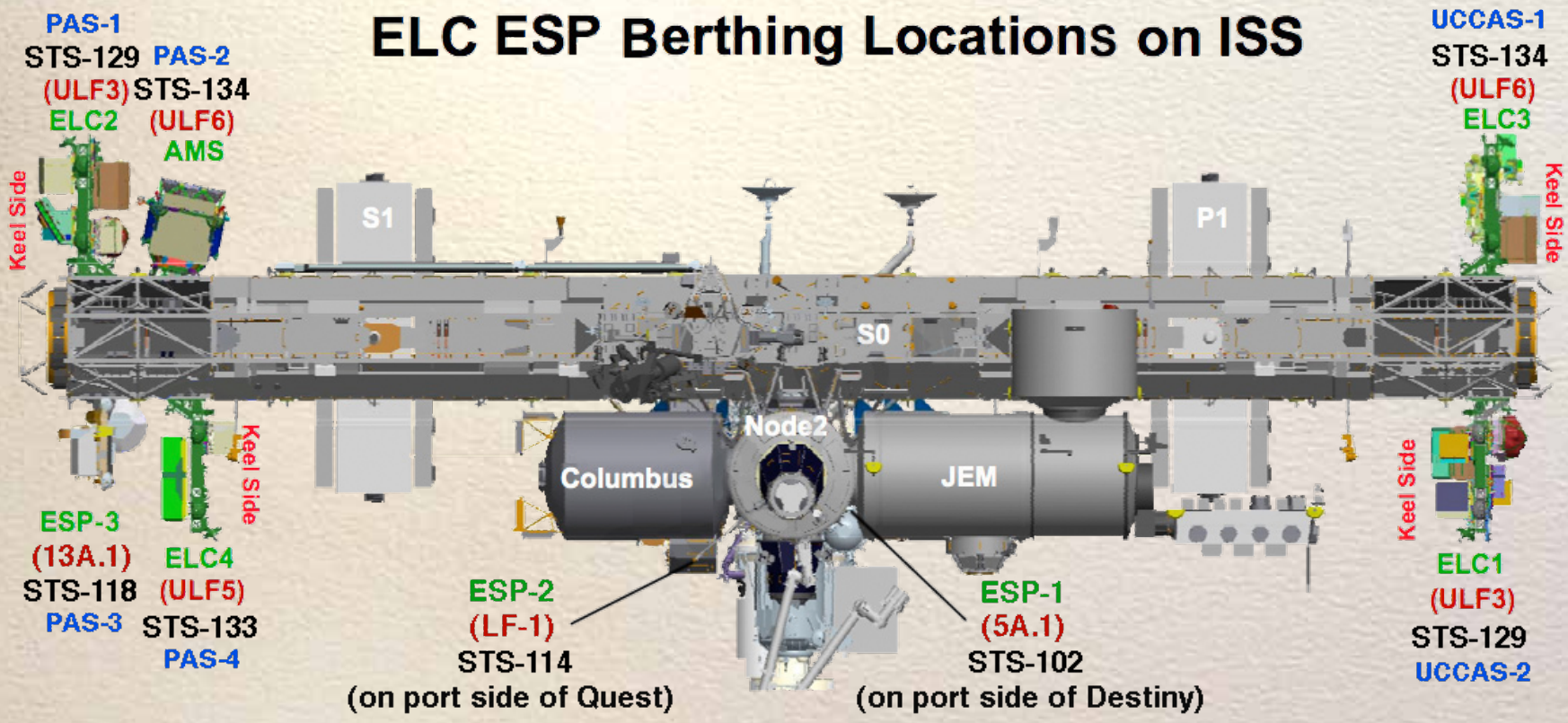
International Space Station



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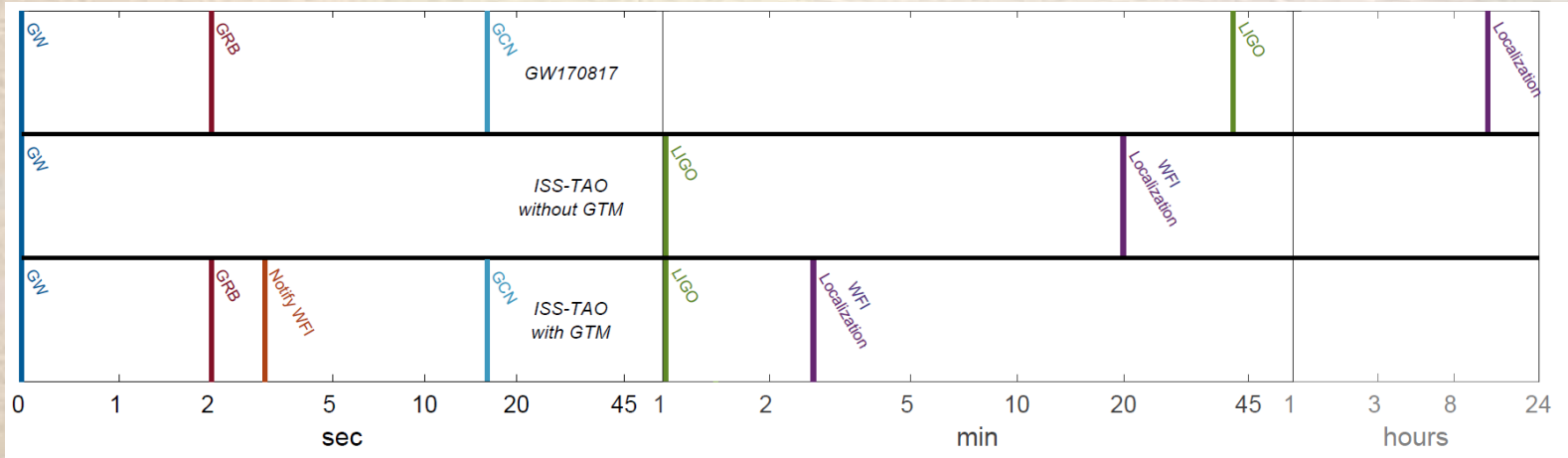
ISS-TAO Fast on Target

- GW170817 LIGO/VIRGO error circle was about 30 sq. deg.
- GBM error circle was ~ 1000 sq. deg.
- Host galaxy identified only ~11 hours later

- WFI on ISS-TAO can localize GW source within minutes
- Trigger by LIGO (minutes) or by GTM on board (seconds)



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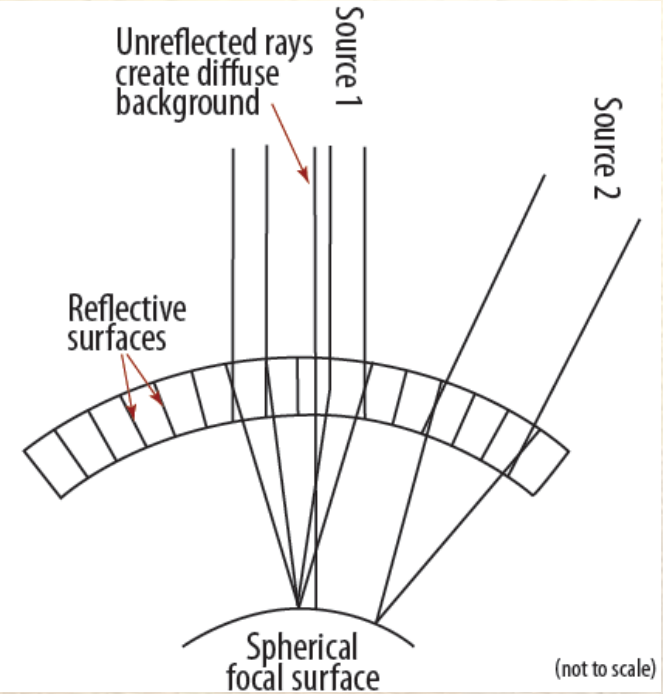
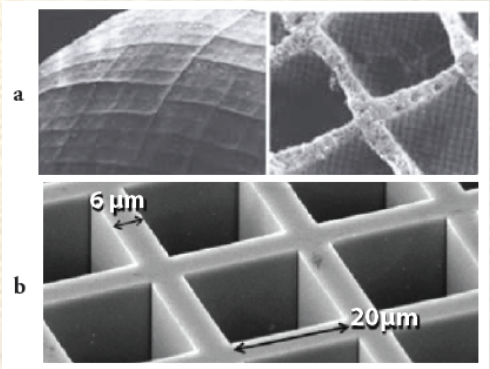
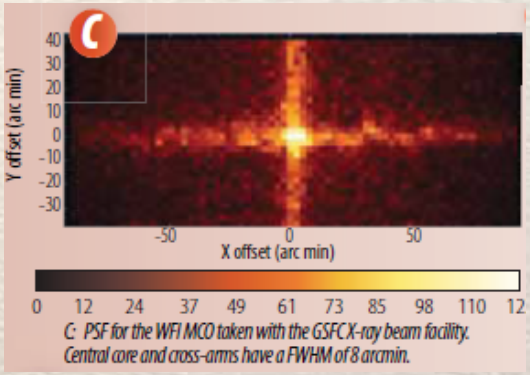
Micro Channel Optics / Leicester
PI R. Willingale





Lobster Eye



Lobster-Eye geometry provides *simultaneous* <u>large FoV</u>, high position resolution and high sensitivity → Time Domain Astronomy

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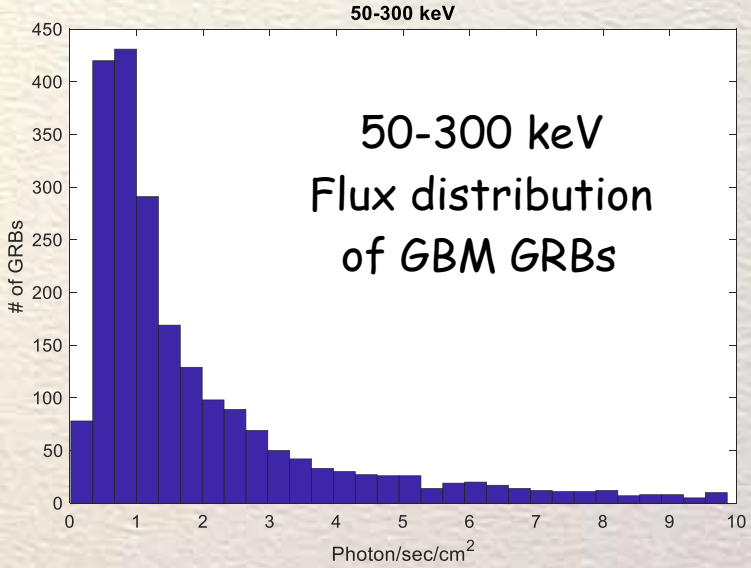
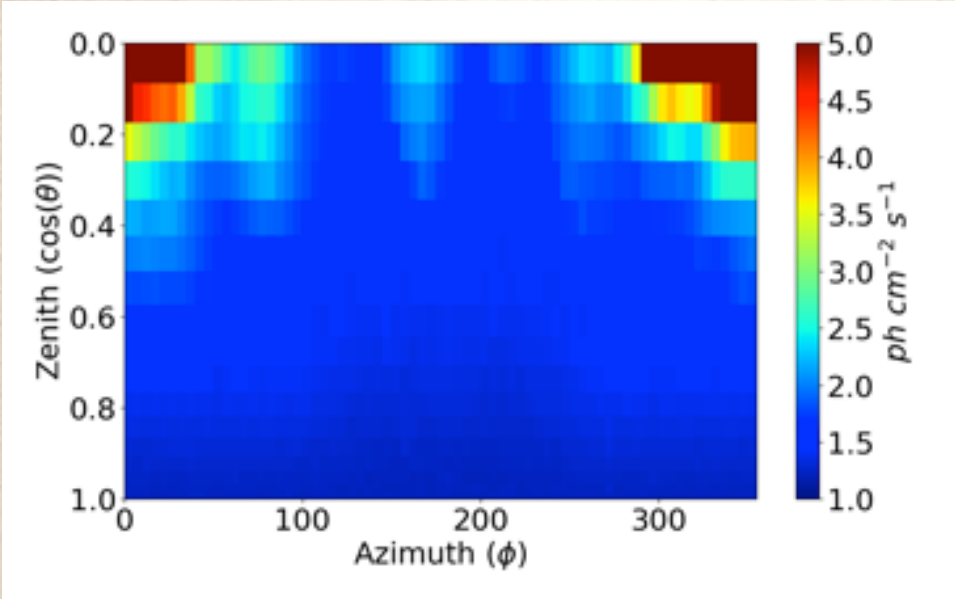
GTM Requirements

- Gamma-ray bursts
  - Detect as many as possible
  - Detect them as weak as possible
  - Identify direction aiming at WFI FoV of 350 sq. deg.
- Coincidence
  - On board – between detectors
  - With gravitational wave events (LIGO)
- Triggering
  - Notify WFI for quick slewing
  - Report to global astronomical community



Concept - Segmented Detector

- Uniform all sky coverage



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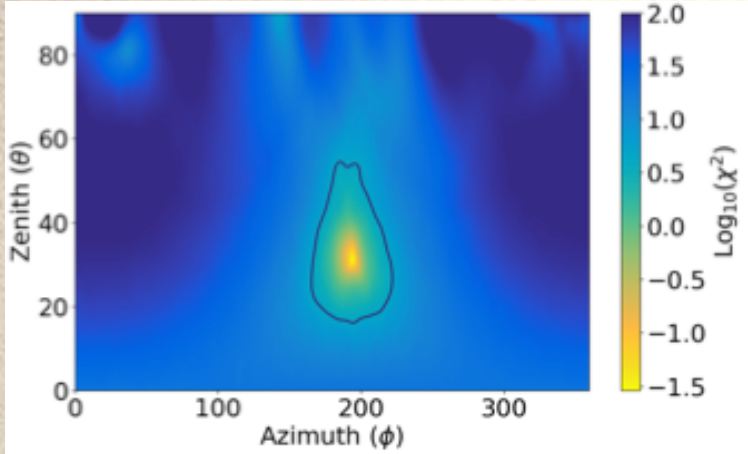
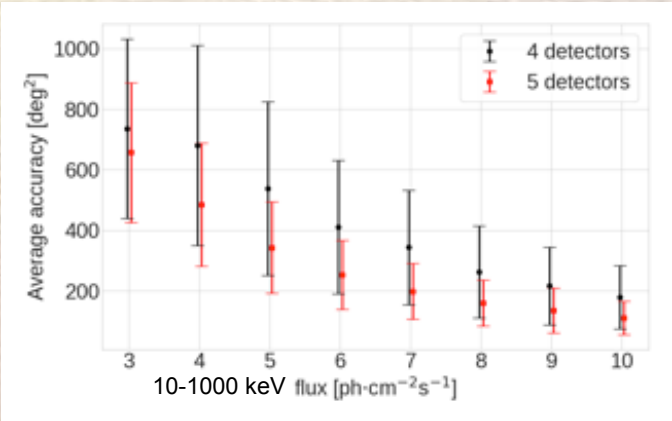
Concept - Segmented Detector (2)

- Localization based on count ratios





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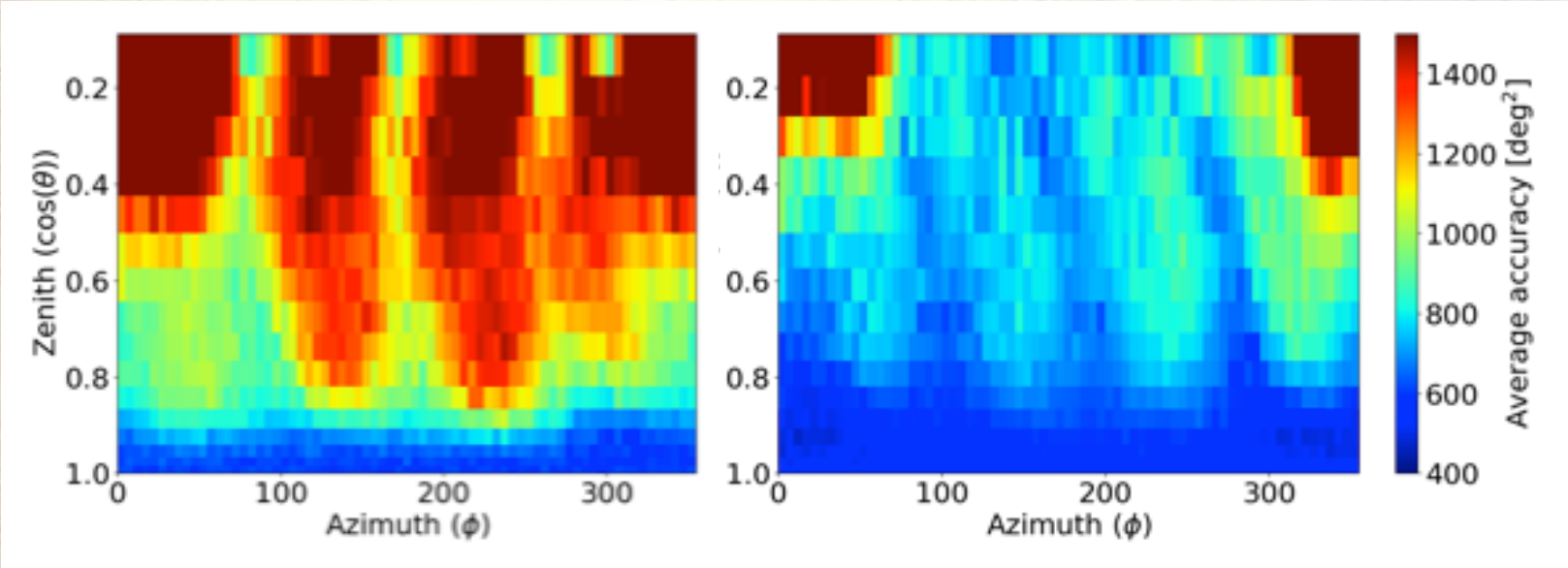
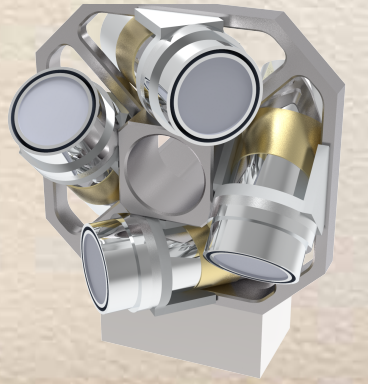
Adding Central (5th) detector





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Summary

- Followup of GW events will significantly improve our understanding of NS and BH mergers
- The transient X-ray sky has never been studied at high sensitivity and with a wide field instrument
- The combination of a wide-field X-ray imager and an all-sky GRB detector are key to being fast on target
- ISS-TAO is ready to meet these challenges of modern high-energy transient astronomy

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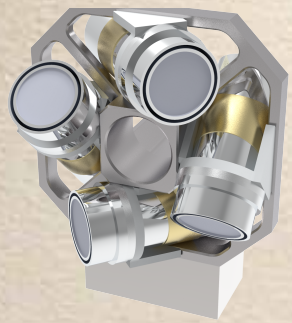
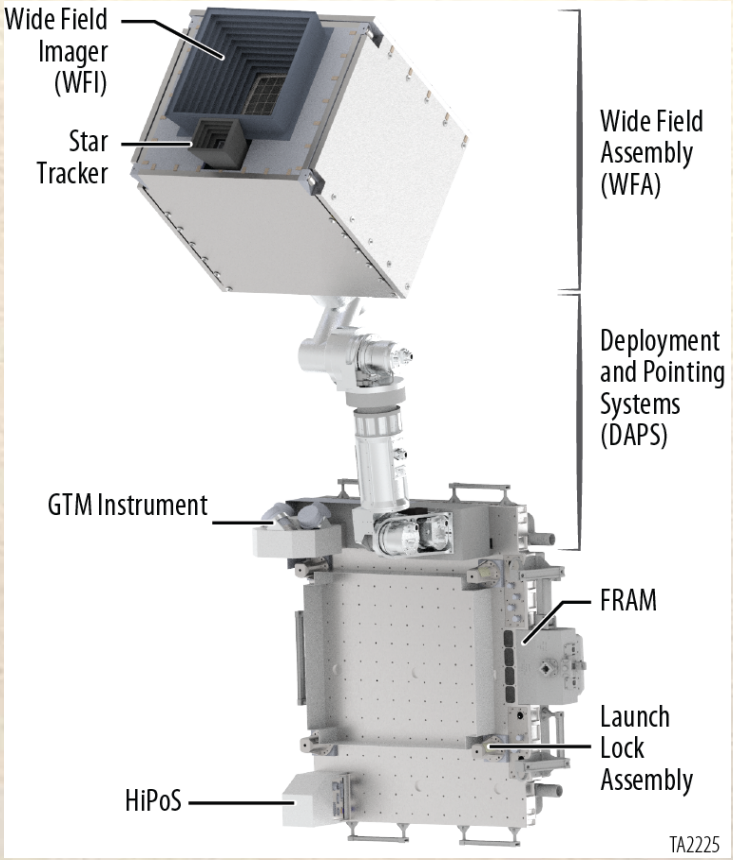
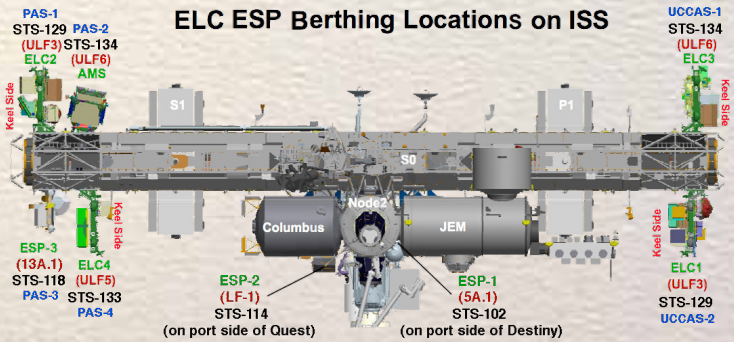
Thank You for Your Attention







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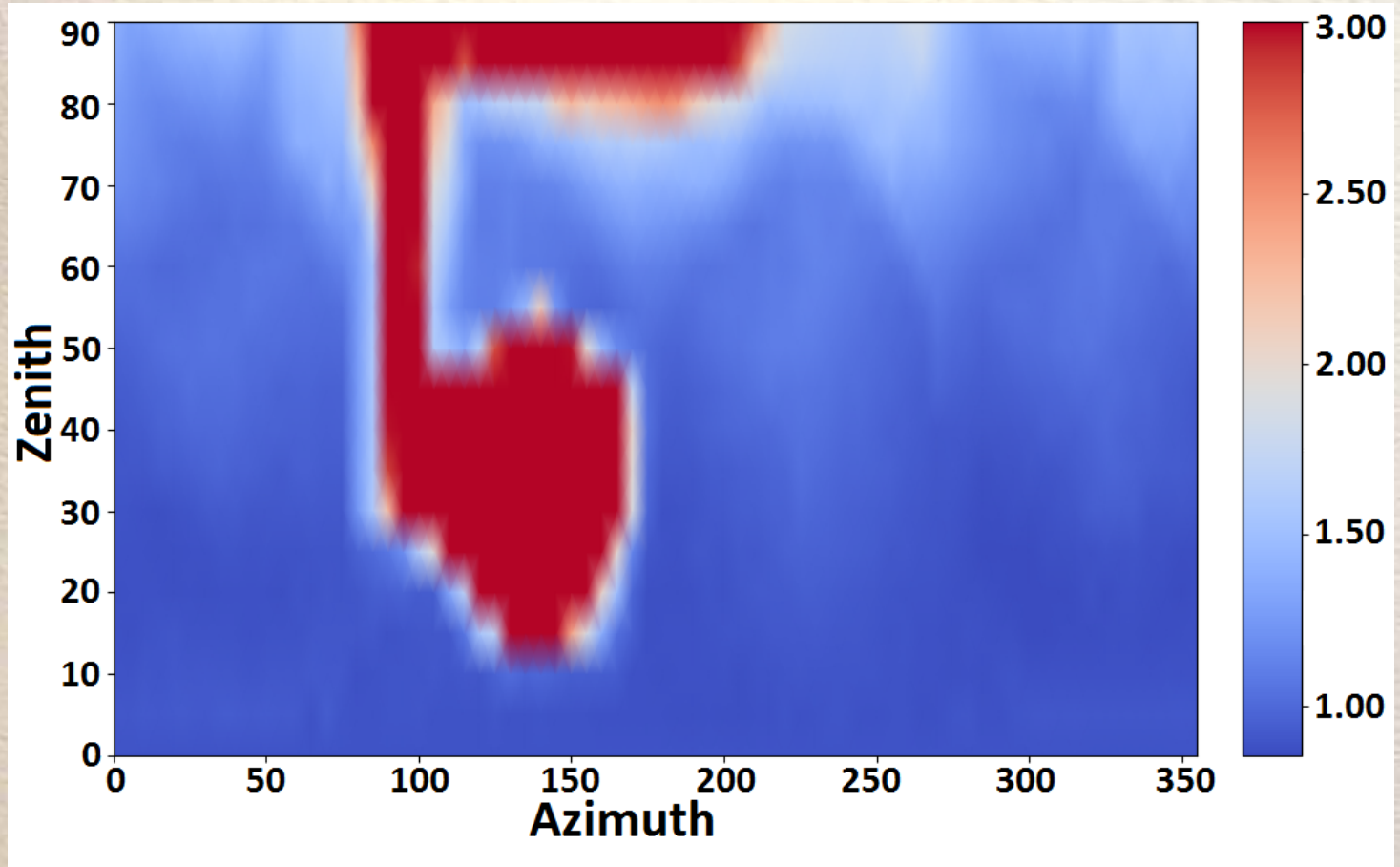

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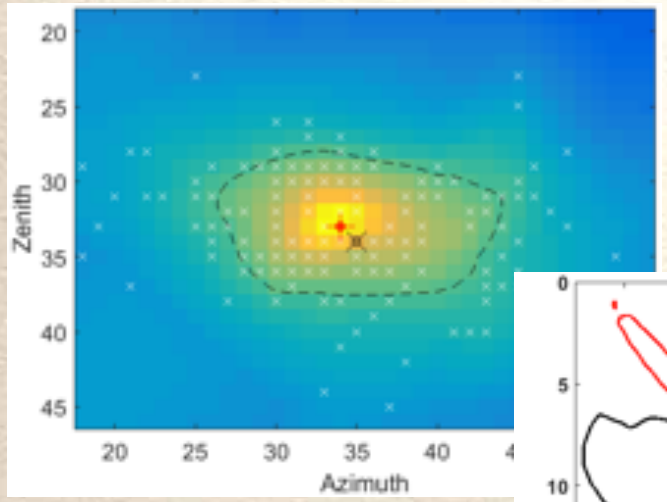
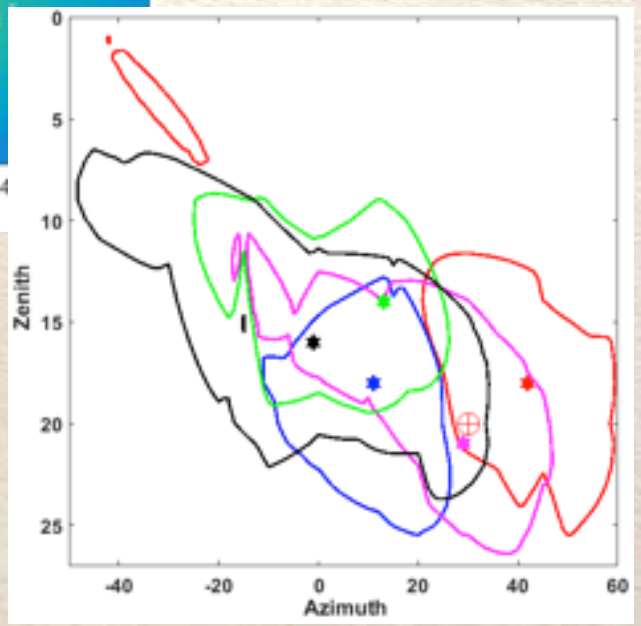
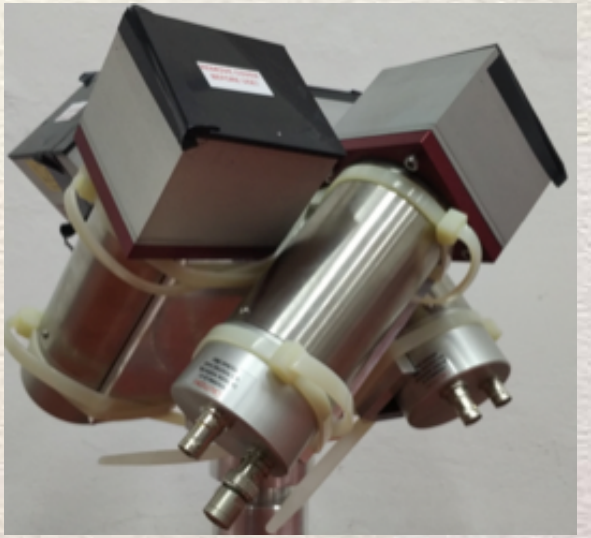
Laboratory Measurements (with Cs 662 keV source)







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