THE IMAGING X-RAY POLARIMETRY EXPLORER

An Overview

Martin C. Weisskopf & Stephen L. O'Dell
On behalf of the IXPE Team

Directly Participating Institutions

Institutions:

- MSFC- PI Team, Project Management, Systems Engineering, Oversight, Science Operations, Data Analysis and Archiving, Telescope Fabrication, and X-ray Calibration
- Istituto di Astrofisica e Planetologia Spaxiale (Rome) & Istituto Nazionale di Fisica Nucleare (Pisa) – Polarization-sensitive detectors
- Ball Aerospace – Spacecraft, Payload Electronics, Payload Structure, Payload and Observatory I&T
- Laboratory for Astronomy and Space Physics (Boulder) – Mission Operations
- Stanford university & Univ Roma Tre – Theory

Science Team

Martin Weisskopf (MSFC) – PI
Brian Ramsey (MSFC) – Deputy PI and Payload Scientist
Stephen O'Dell (MSFC) – Project Scientist
Allyn Tennant (MSFC) – Science Data Ops Lead
Paolo Soffita (IAPS, IT) – Co-I and PI for Italian effort
Ronaldo Bellazzini (INFN, IT) – Co-I and PI for INFN effort
Victoria Kaspi (McGill, Can) – Co-I SWG Chair
Herman Marshall (MIT) – Co-I and Student Collaboration Scientist
Giorgio Matt (Univ Roma Tre, IT) – Co-I Theory
Roger Romani1 (Stanford) – Co-I Theory

Collaborators

Unfunded

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J. Poutanen, M. Salvati, L. Stella, R. Sunyaev,
R. Turolla, K. Wu, S. Zane

Contributed (INFN)

A. Brez, G. Spandre, L. Baldini, C. Sgrò, N. Omodei,
L. Latronico, M. Minuti, M. Pinchera, L. Deruvo, M. Kuss, M. Pesce-Rollins
M. Razzano

Contributed (IAPS)

E. Del Monte, I. Donnarumma, S. Fabiani, L. Pacciani, A. Rubini

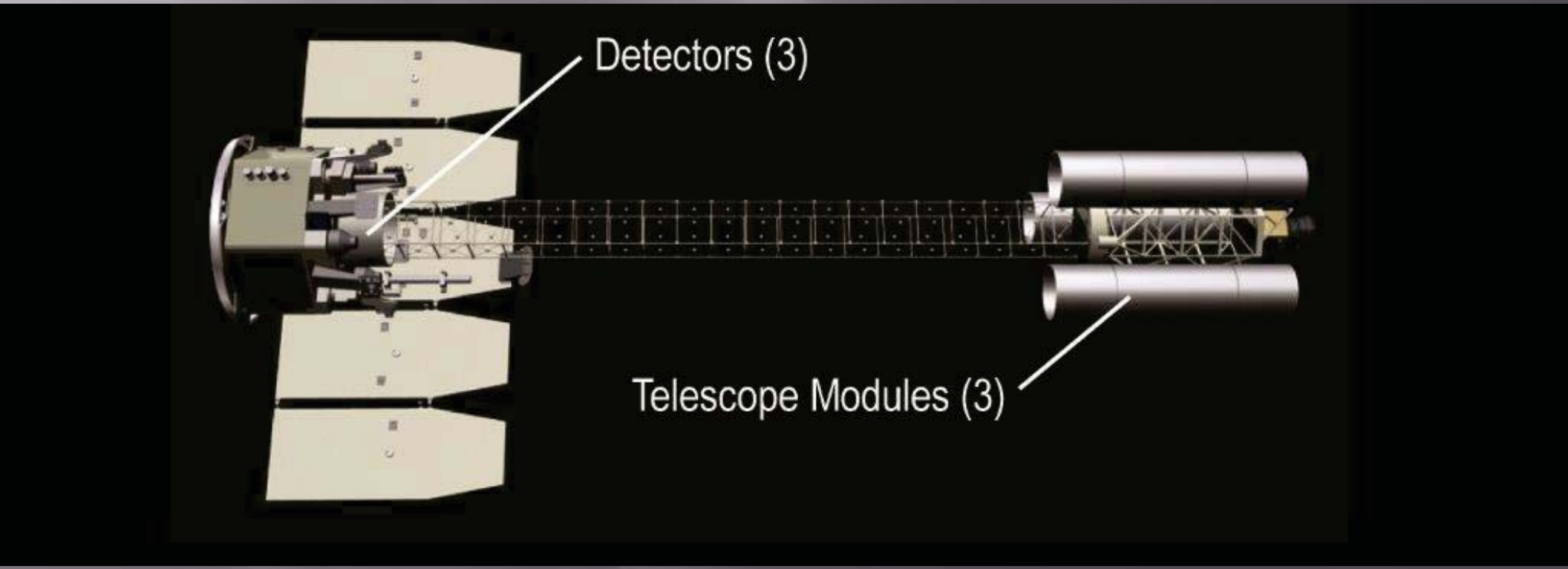
Mature Technology Plus an Experienced Team to Expand the X-ray View of the Universe

- IXPE uses X-ray polarimetry to dramatically expand observation space and to provide new input to our understanding as to how X-ray emission is produced by compact objects such as neutron stars and black holes.

- The two-year mission is low-risk, making use of mature flight elements combined in a system with conservative resource margins and run by a team with extensive mission experience, specifically in X-ray astronomy and X-ray polarimetry

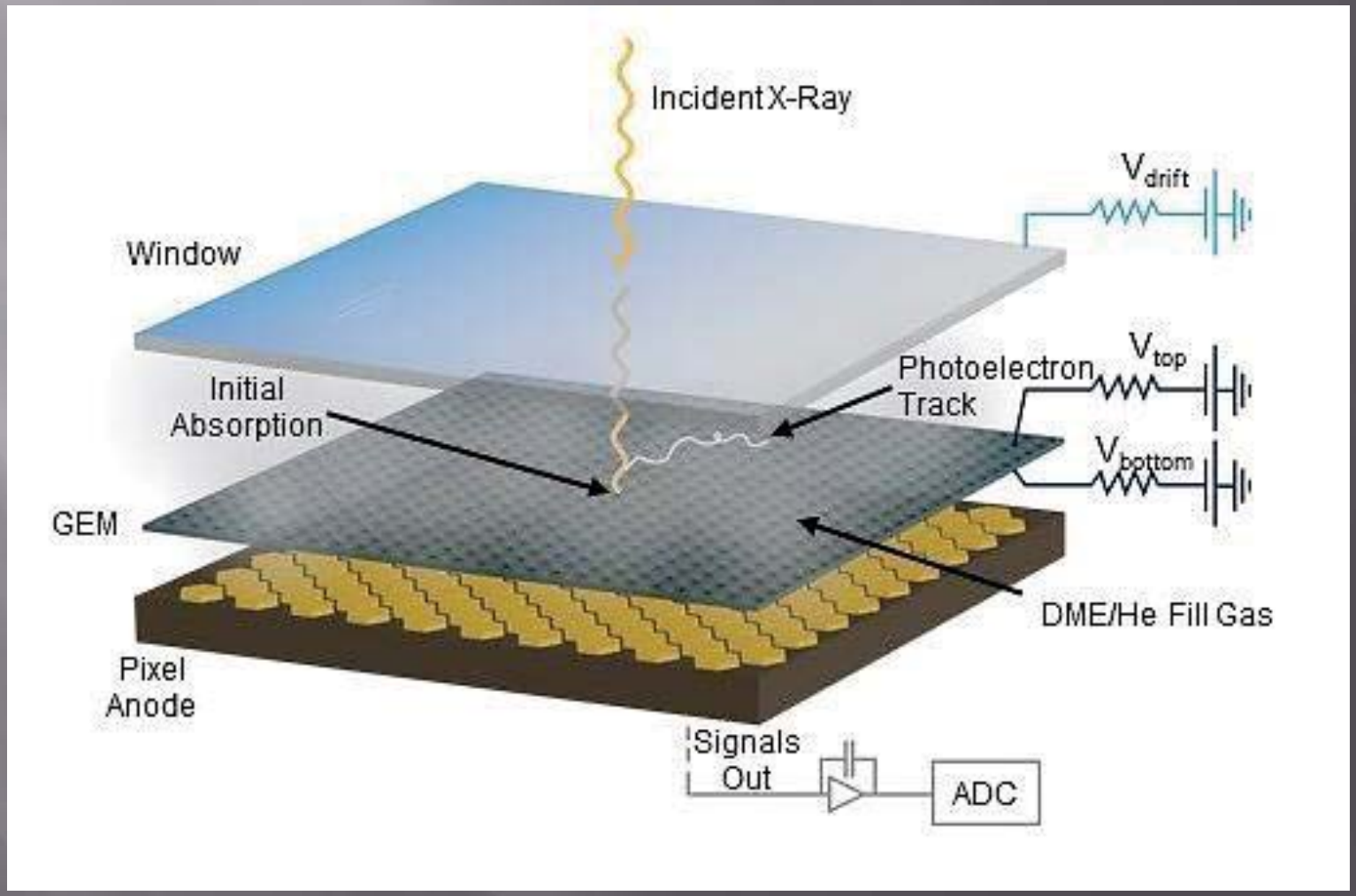
Approach

- Three redundant telescope-detector systems
- Gas pixel electron tracking detectors developed in Italy
- Replicated X-ray telescopes with < 30 arcsecond angular resolution (half-power diameter) developed at MSFC



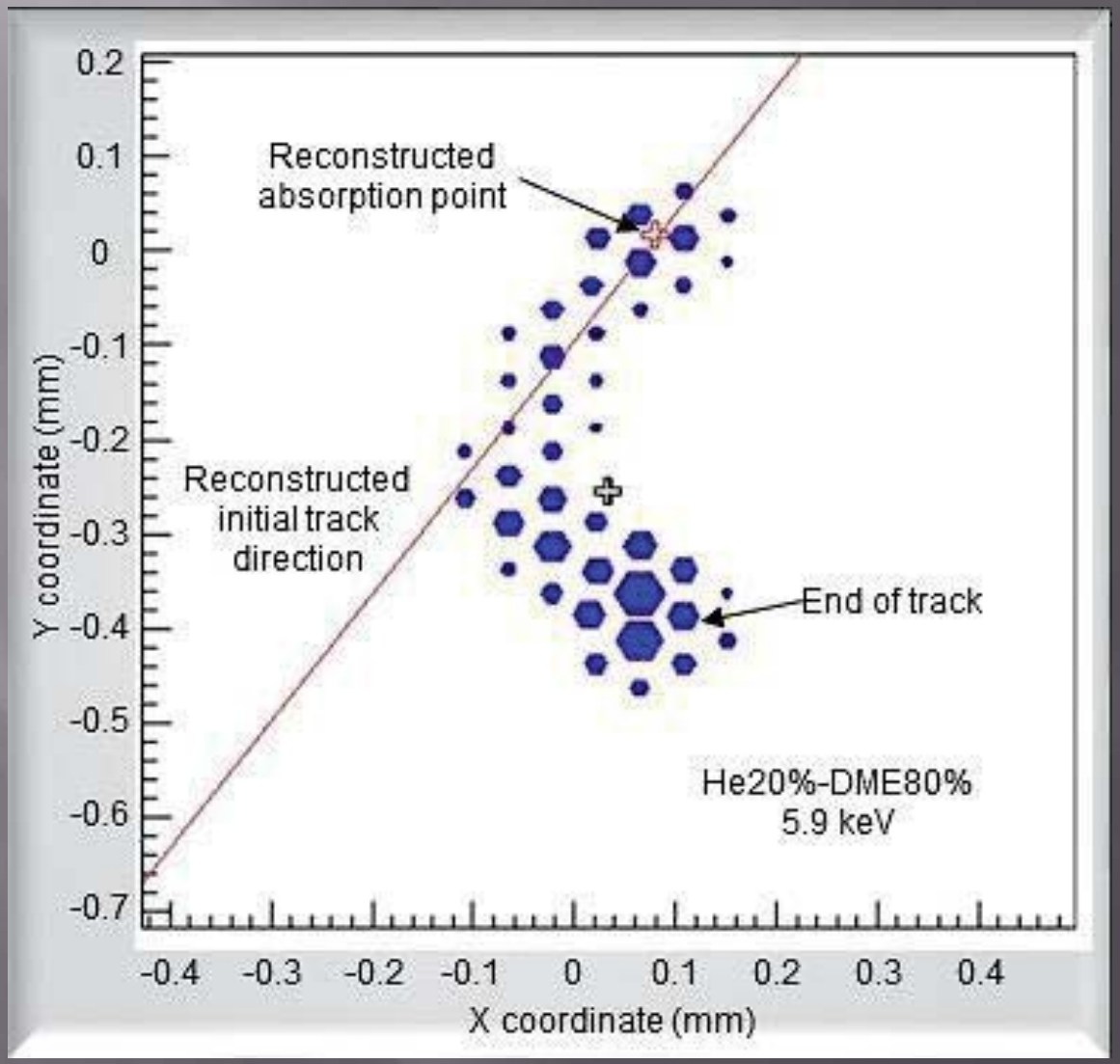
The Polarization Sensitive Detectors

Gas pixel electron tracking detectors developed in Italy



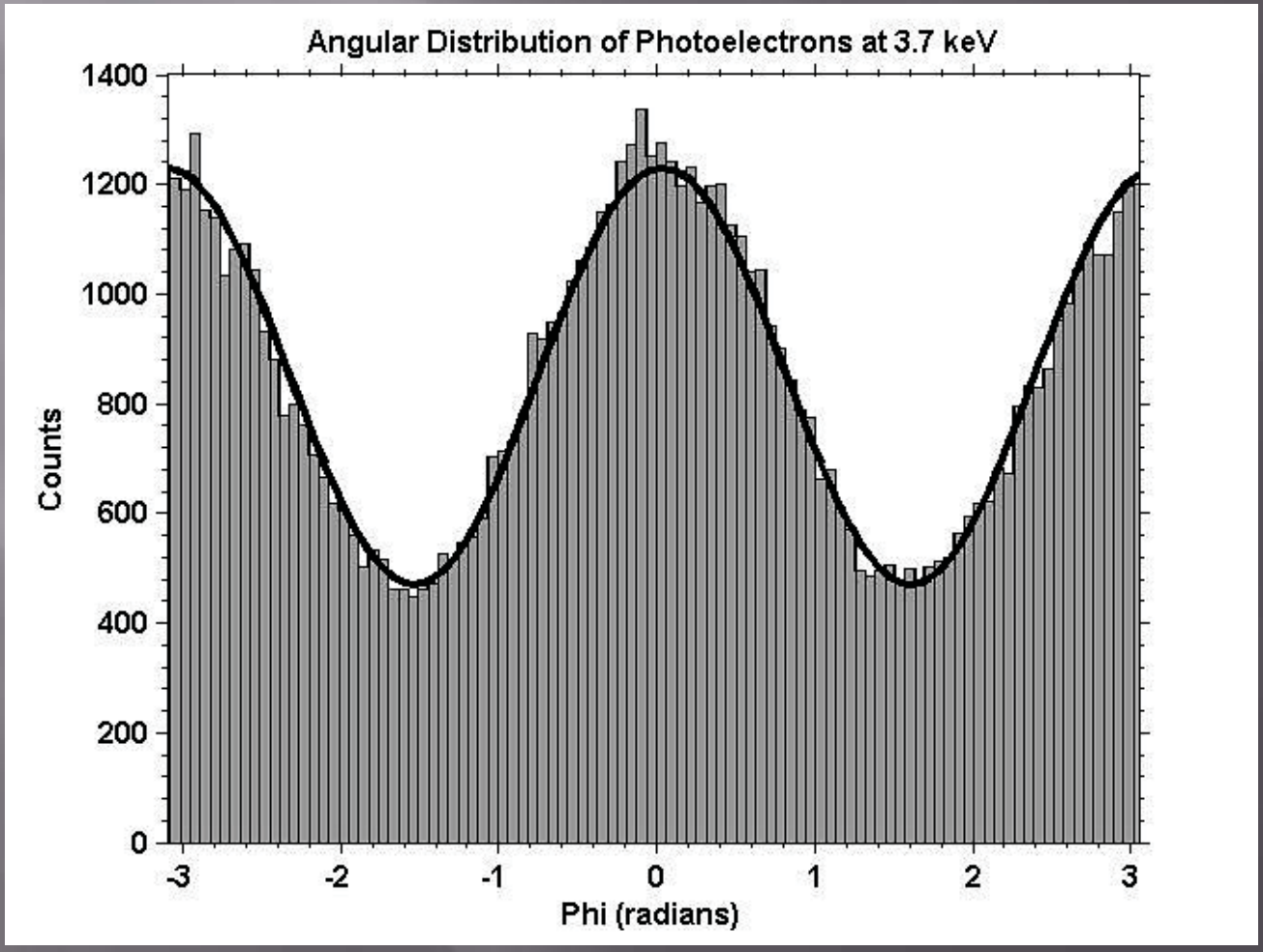
The Polarization Sensitive Detectors

Track reconstruction



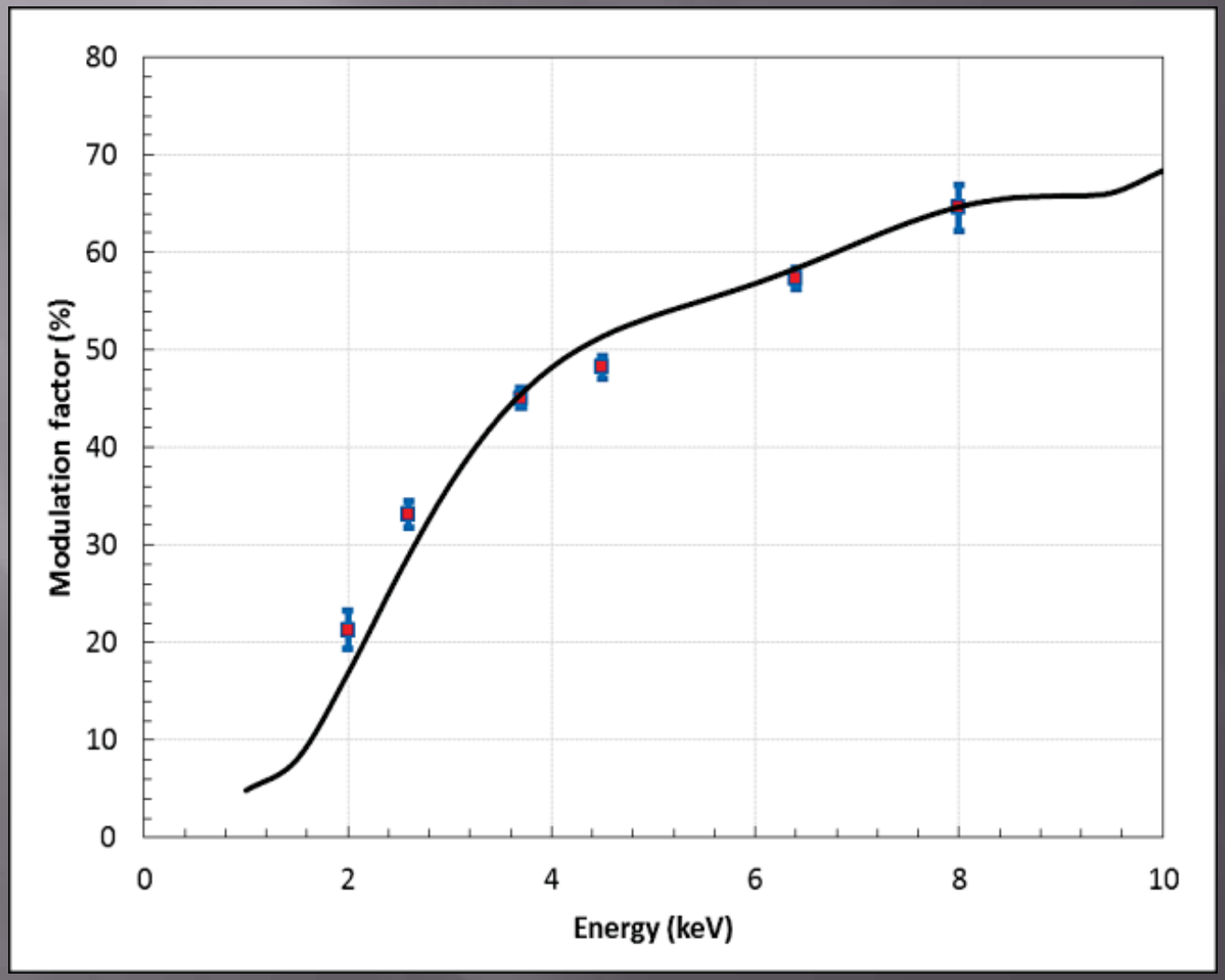
The Modulation Factor

Measurements of the detector modulation with a 100%-polarized beam at 3.7 keV



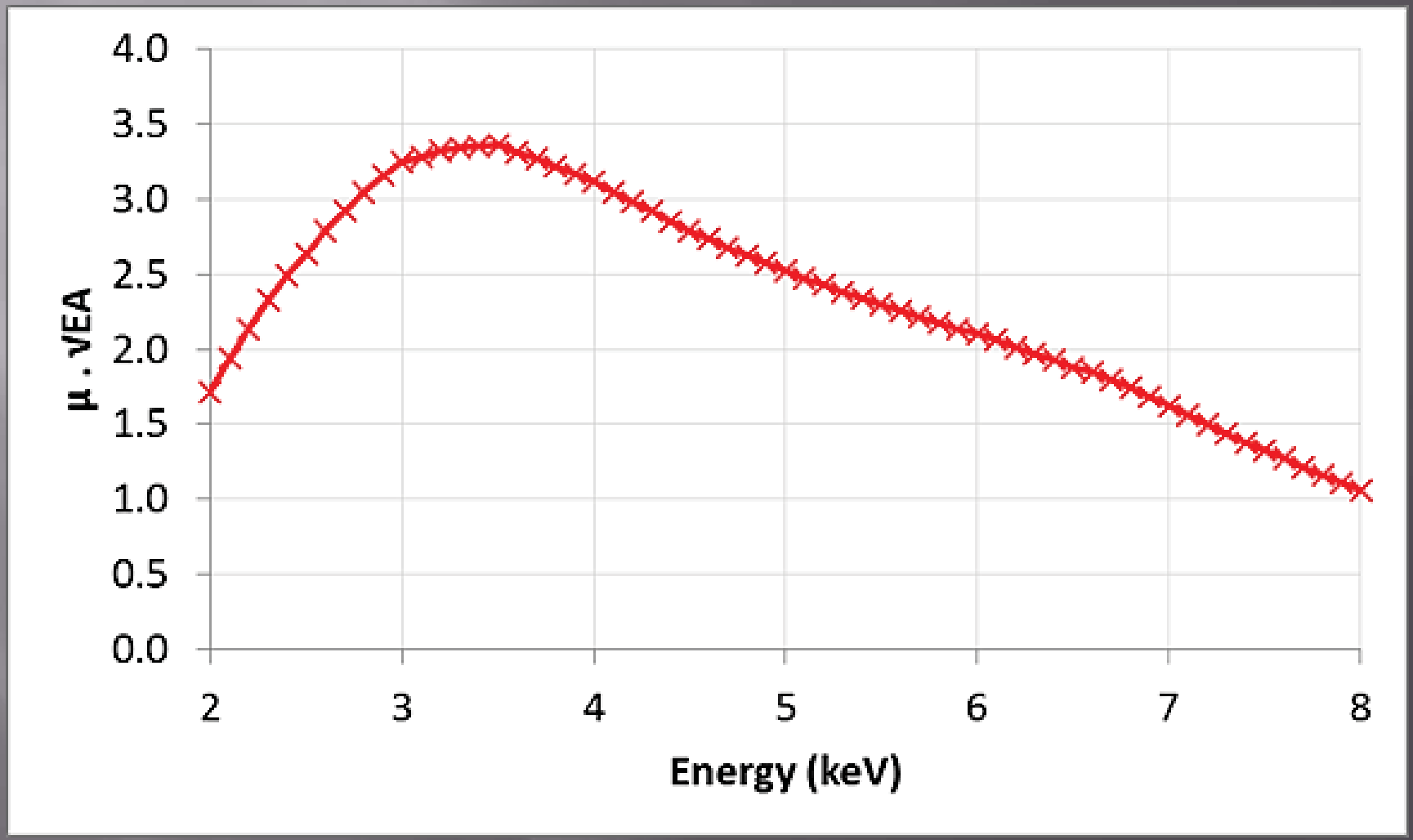
The Modulation Factor

Modulation factor as a function of energy
Comparision to simulations



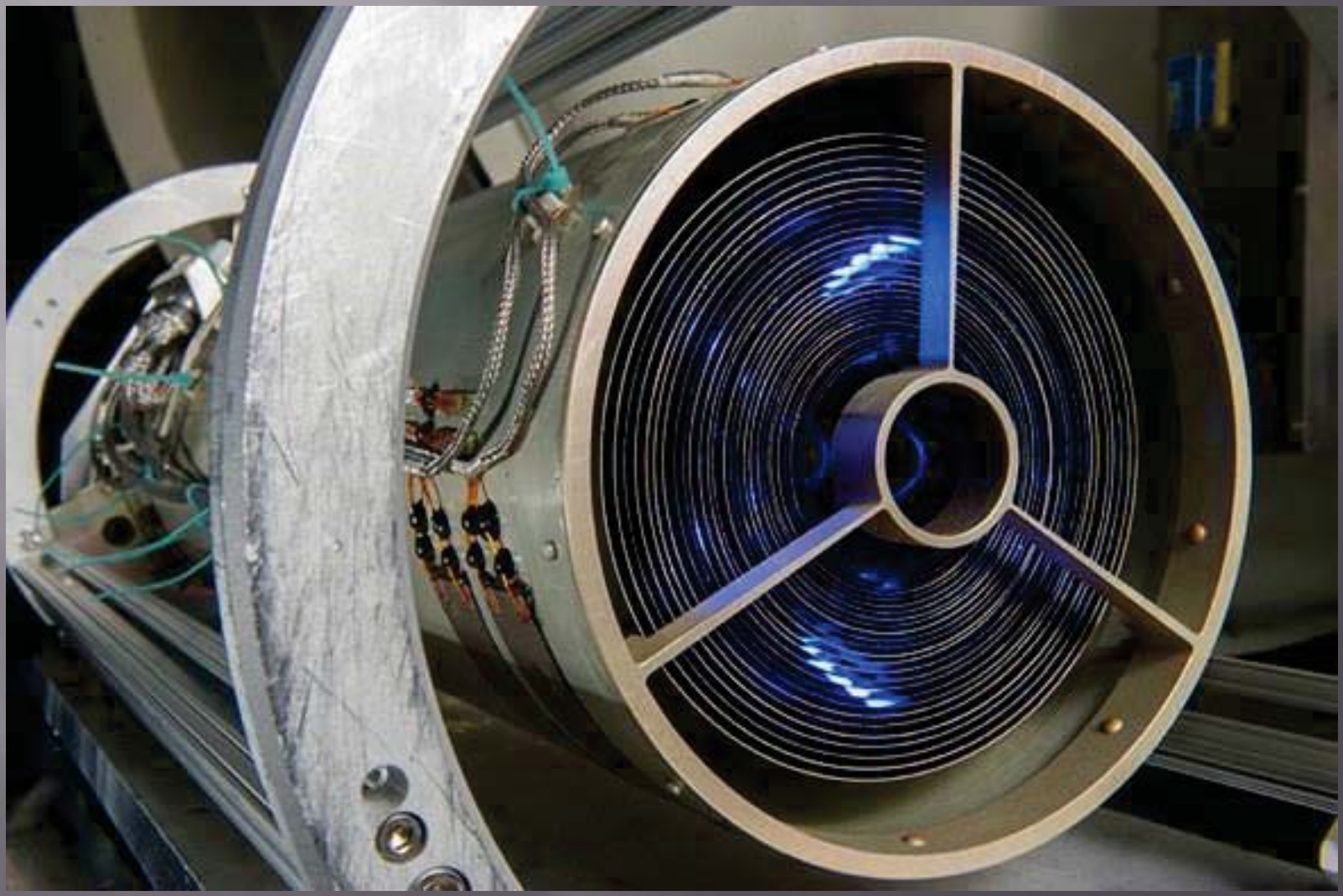
The Energy Response

Modulation factor × square root of the effective area versus energy



The 25 Arcsecond X-ray Telescopes

An ART-XC flight module in its support frame
rear view



The Sensitivity to Polarization

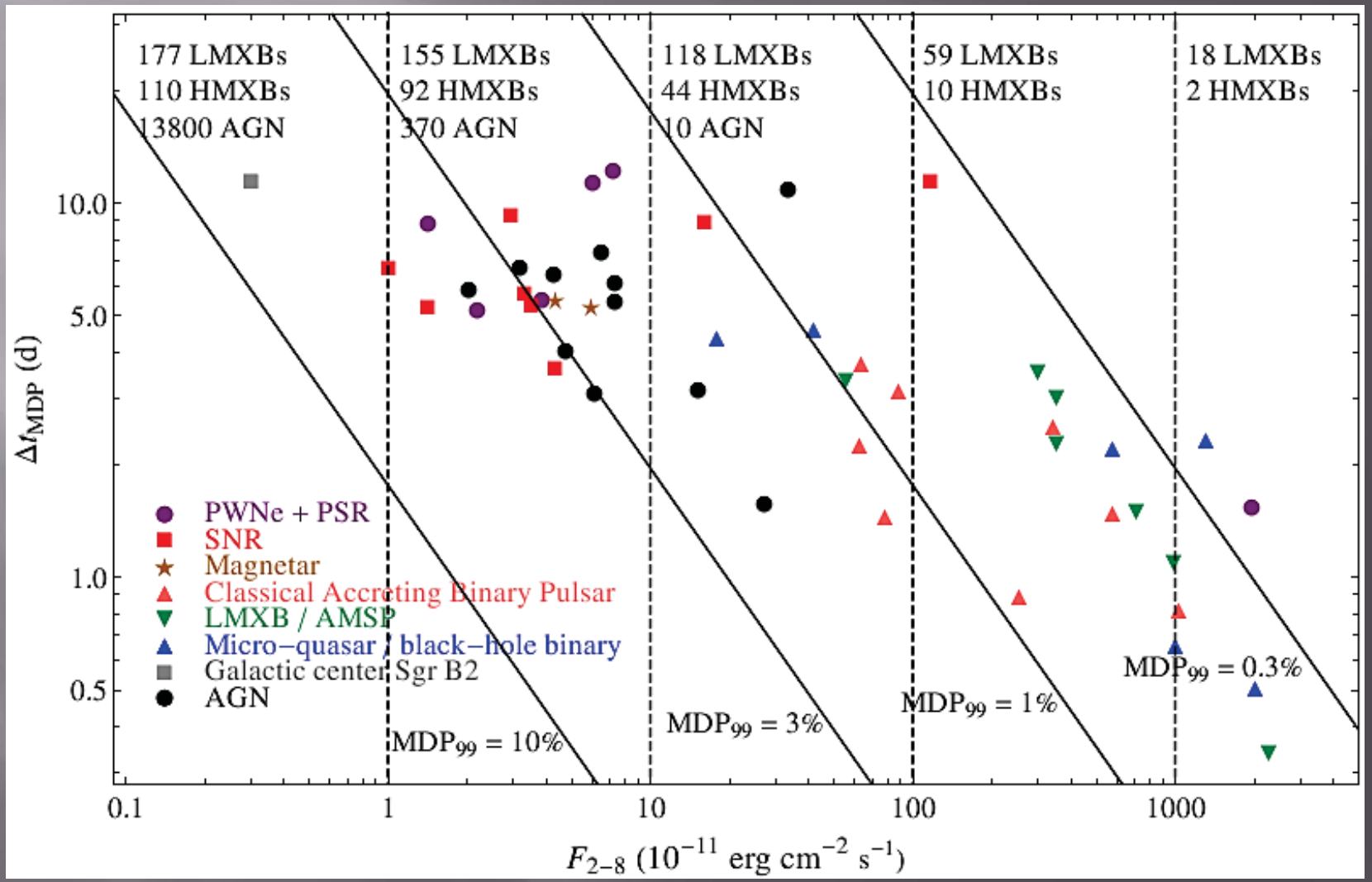
The quantity most useful for assessing the performance of a polarimeter is the minimum detectable polarization (MDP) at 99% confidence, given by:

$$MDP(\%) = (429/\mu)\sqrt{\frac{R_S+R_B}{R_S^2 t}}$$

μ = Modulation factor
R_S = Source counting rate
R_B = Background counting rate
t = Integration time

Sensitivity

Time to reach a minimum detectable polarization as a function of source flux



FUNDAMENTAL NEW MEASUREMENTS

- IXPE sensitivity is two orders of magnitude better than OSO-8 and provides, for the first time, imaging capability to reach new objectives.
- Measurements with IXPE will provide previously unobtainable data to understand the nature of X-ray sources, helping to answer such questions as:
  - What is the geometry and the emission mechanism(s) of AGN & microquasars?
  - What is the geometry and strength of the magnetic field in magnetars?
  - What is the geometry and origin of the X-radiation from radio pulsars?
  - How are particles accelerated in Pulsar Wind Nebulae?

FUNDAMENTAL NEW MEASUREMENTS (Examples)

- Obtain X-ray polarimetric images of an AGN core and jet
- Exploit imaging polarimetry to infer past activity of Sgr A*
- Map magnetic field of X-ray-emitting regions in Pulsar Wind Nebulae and in shell-type Supernova Remnants
- Perform phase-resolved polarimetry of rotation-powered pulsars using imaging to reduce nebular background
- Explore Magnetar physics and vacuum birefringence
- Obtain energy-resolved polarimetry of AGN and microquasars to test models and assess black-hole spin
- Perform phase- and energy-resolved polarimetry of accreting X-ray pulsars to test emission models