

# X-ray Astronomy: Future Prospects?

K.P. Singh  
TIFR @ Mumbai  
January

# Science to be done

- Resolving 10-40 keV Cosmic X-ray Background
- Deep surveys (eRosita – soft X-rays, Hard ?)
- WHIM (soft X-rays)
- High Resolution Spectrometry (outflows) – Calorimeters (soft X-rays)
- X-ray Polarization (soft and hard X-rays)

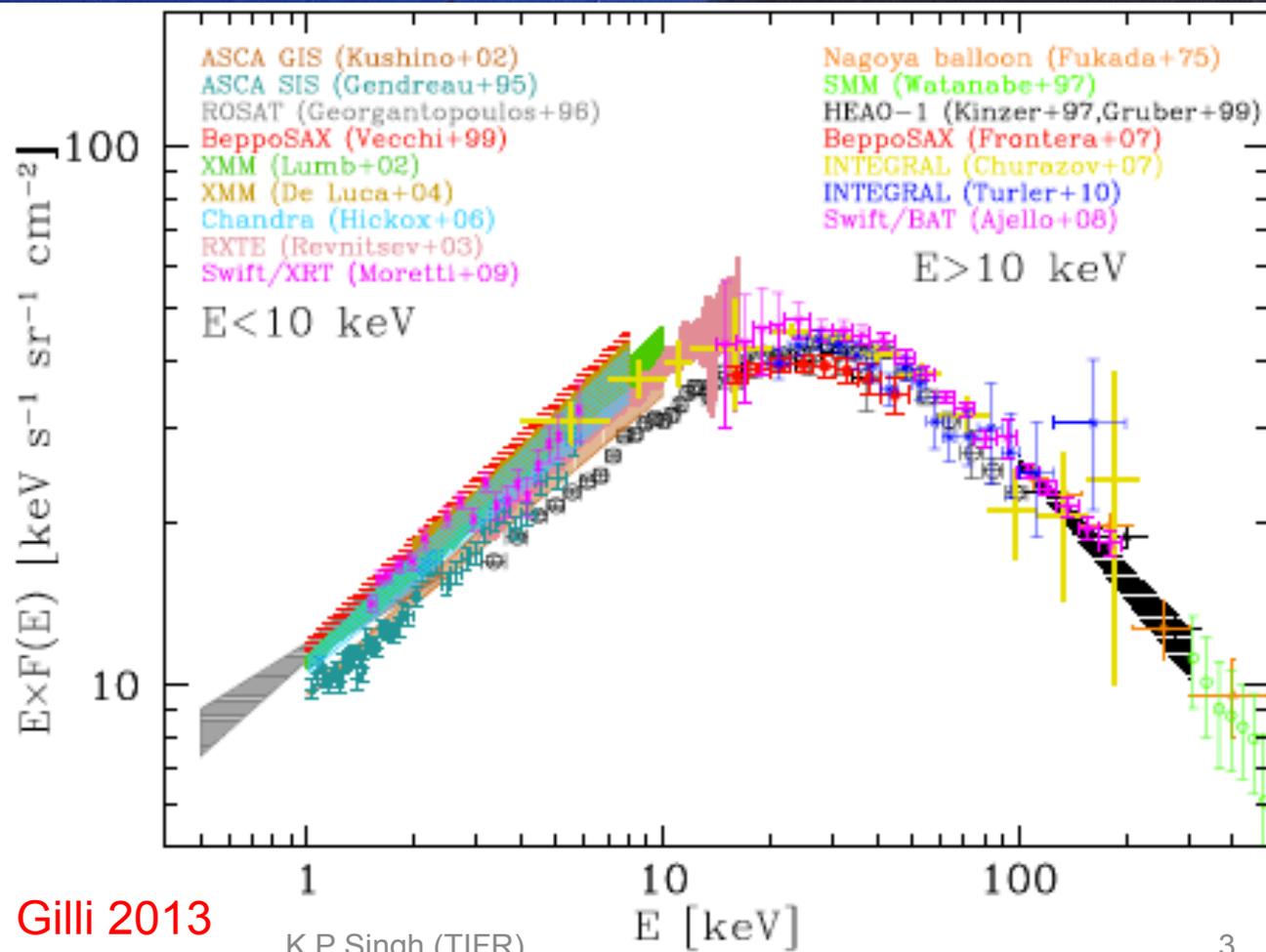
# Cosmic X-ray Background

Measurement problems:

Accurate Flux and spectral Calibration

and

Instrumental background



# Cosmic X-ray Background

Major Contributors:  
AGN or SMBHs

Identifying the AGN types and population in correct proportion for explain the shape of the spectrum from deep surveys.

→ Long term evolution of the growth of the SMBHs

Maximally spinning BHs can boost the contribution of AGN to the CXB –  
Vasudevan et al. 2016

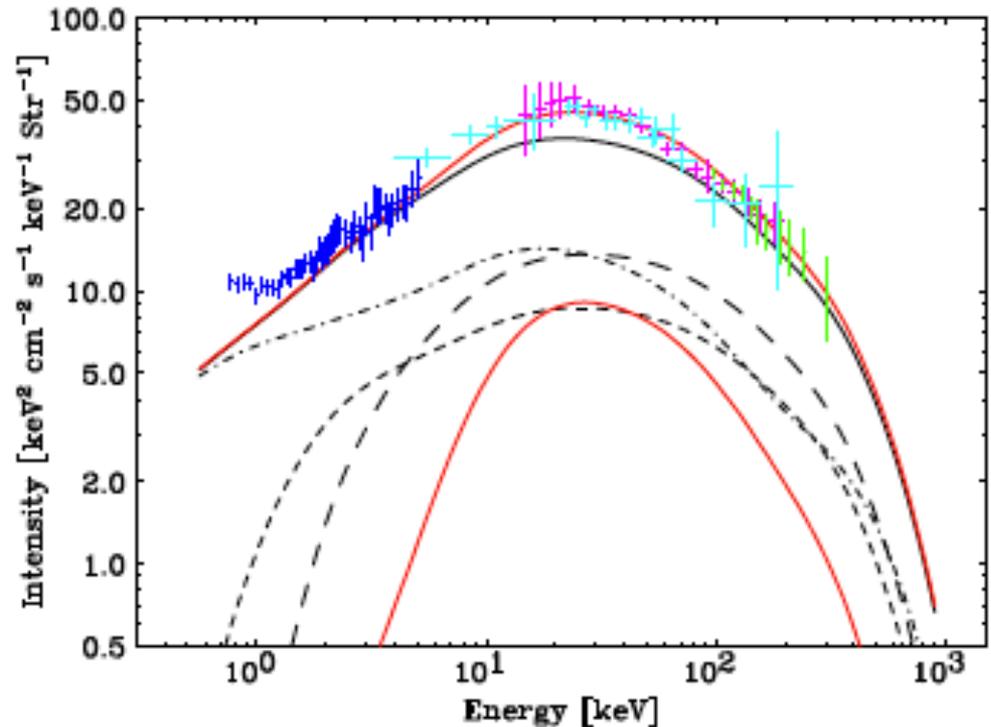


Fig. 2. Spectrum of the CXB of the Universe and its description by the contribution of AGNs with various degrees of absorption. The upper thin solid curve indicates the complete model of emission from the sum of AGNs with absorption on the line of sight from a column density  $\log N_{\text{HL}} < 22 \text{ cm}^{-2}$  to  $\log N_{\text{HL}} \sim 26 \text{ cm}^{-2}$ . The lower thin solid curve indicates the contribution of the so-called Compton-thick AGNs with a column density on the line of sight  $\log N_{\text{HL}} = 24 - 26 \text{ cm}^{-2}$  (from Ueda et al. 2014).

# Cosmic X-ray Background

NuStar, X-ray Surveyor  
MVN- Monitor Vsego  
Neba (All sky monitor)  
of Russia.

NuSTAR has now resolved  
33 - 39% of the X-ray  
background in the 8 - 24  
keV band, directly identifying  
AGN with obscuring  
columns up to  $10^{25} \text{ cm}^{-2}$ .

Harrison et al. 2016

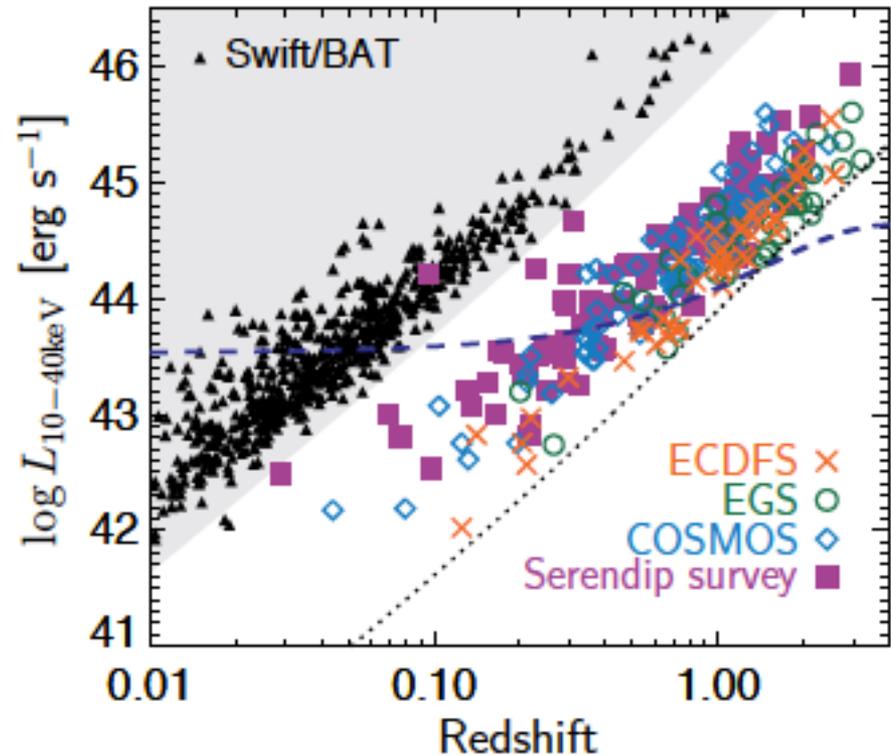
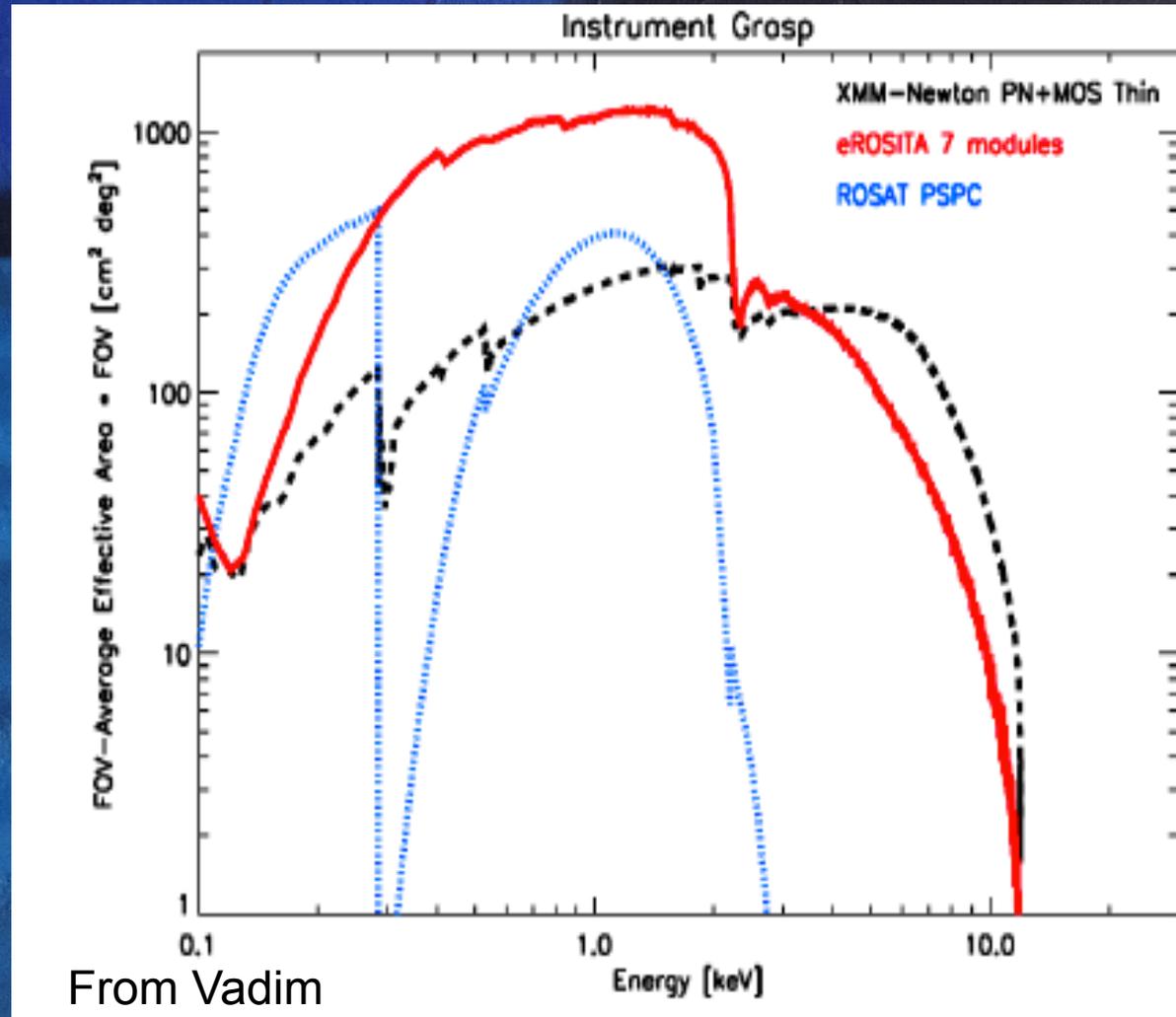


FIG. 2.— Restframe 10 - 40 keV X-ray luminosity versus redshift for the objects included in this work compared to sources in the *Swift*/BAT 70-month all-sky survey catalog (black triangles). The dashed line shows the location of the knee in the luminosity function from Aird et al. (2015b) as a function of redshift. The shaded region indicates the region of sensitivity of *Swift*/BAT, and the dotted line indicates the threshold for the *NuSTAR* surveys.

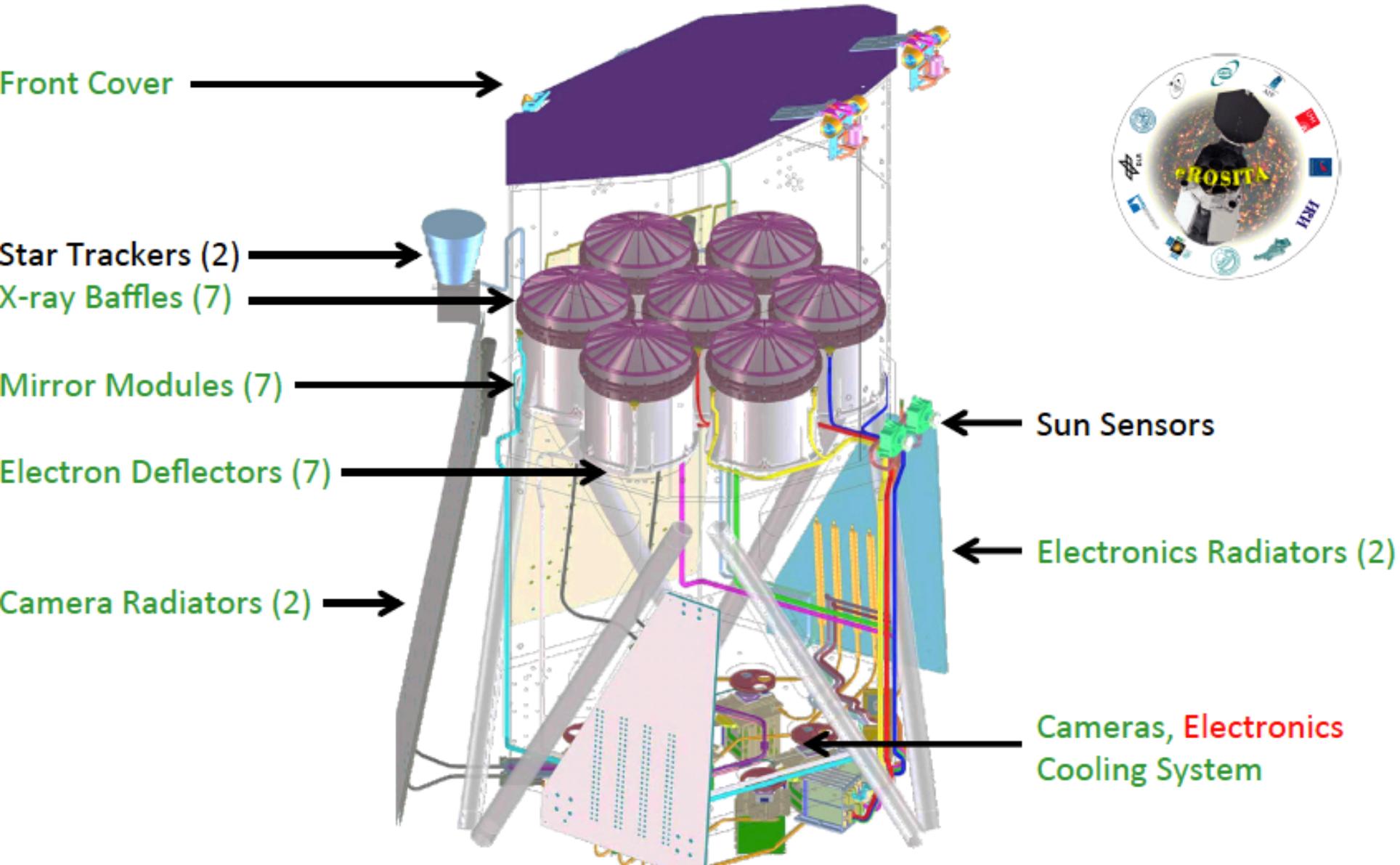
# Deep X-ray surveys

**eRosita(2018):**  
Deeper and with  
better spectral  
resolution than  
ROSAT.

**NuStar:** Hard X-ray  
surveys – on going  
– follow up  
required with a  
deeper sensitivity



# eROSITA - Schematic View



# WHIM

- Broad-band all sky survey in very soft X-rays: eROSITA - CCDs
- The X-ray grating explorer: an ISS-attached high-resolution X-ray grating spectrometer (NASA) with  $R=3000$ , effective area= $1000 \text{ cm}^2$  at 0.5 keV, bandpass covering 0.3-1 keV using the silicon-pore optics proposed for ESA's Athena mission with a 4.3 m focal length, paired with off-plane gratings being developed at the University of Iowa combined with MIT/Lincoln Labs CCDs

# WHIM

**DIOS (Diffuse Intergalactic Oxygen Surveyor)** for JAXA's small mission to be launched ~2022 to search for dark baryons through detecting red-shifted oxygen emission lines from WHIM. Using a TES micro-calorimeter array with a few hundred pixels, energy resolution of a few eV, cooled with cryogen free refrigerators and **a 4-reflection X-ray telescope** (FXT). Energy range of 0.3 - 2 keV, field of view ~50 arcmin diameter, angular resolution ~ 3 arcmin.

*Ohashi et al. 2016*

# High Resolution Spectroscopy with Calorimeters

- DIOS (2022)
- A Successor to Hitomi by JAXA

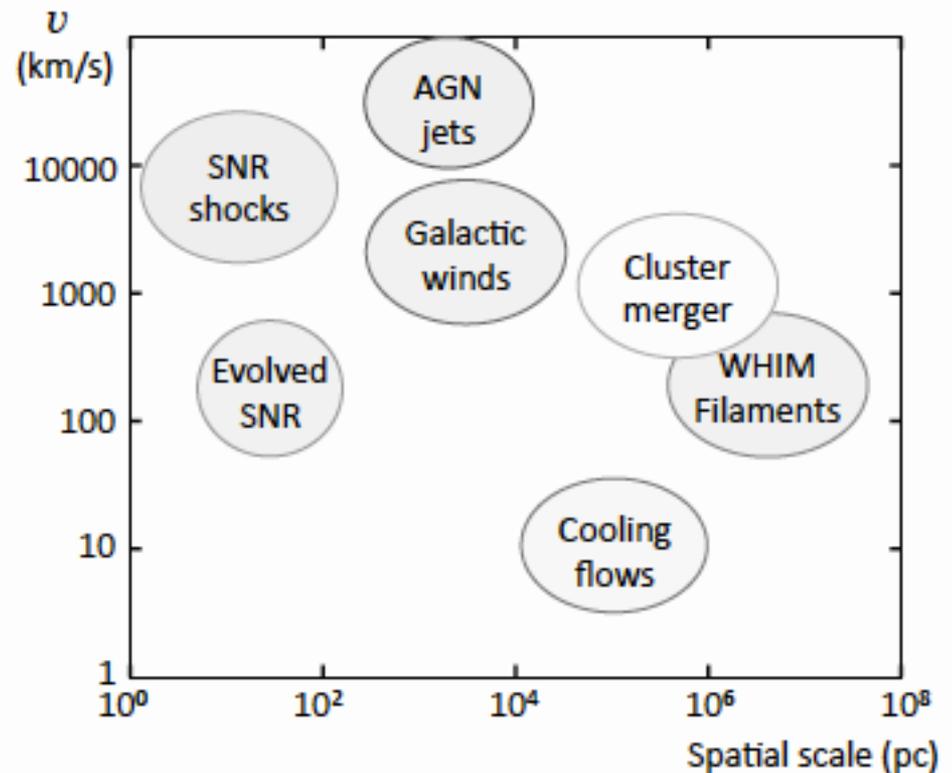
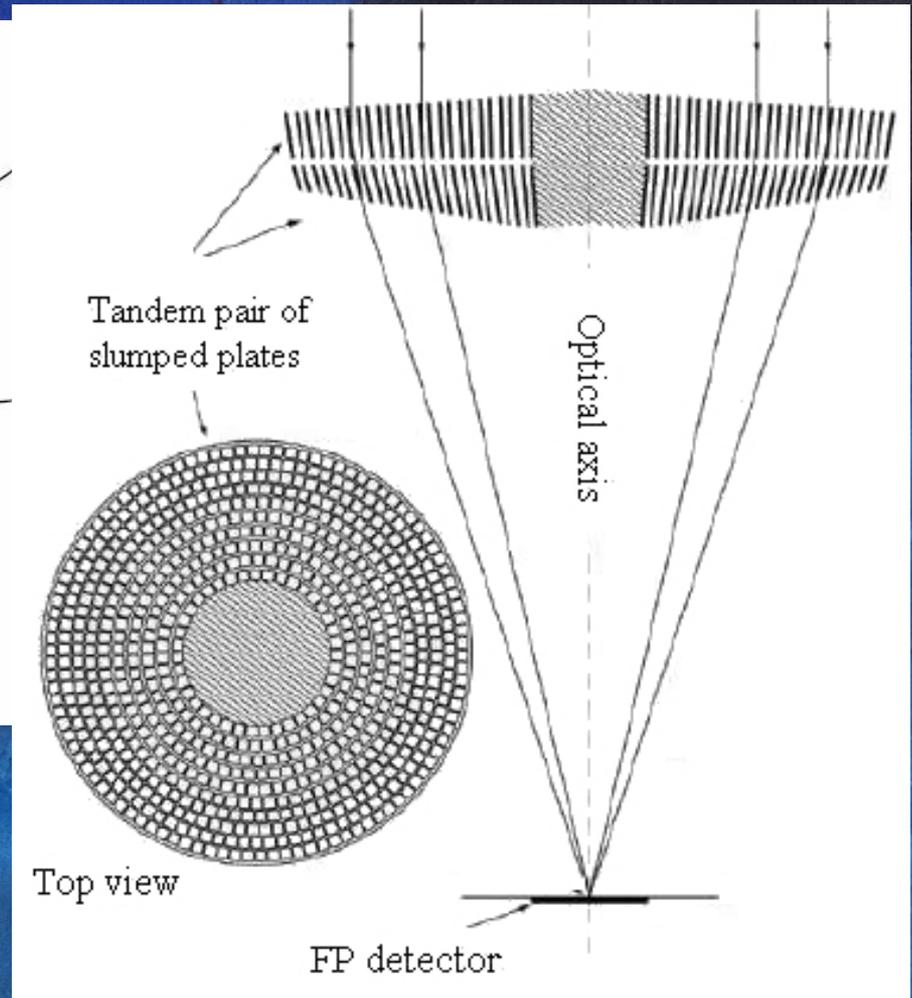
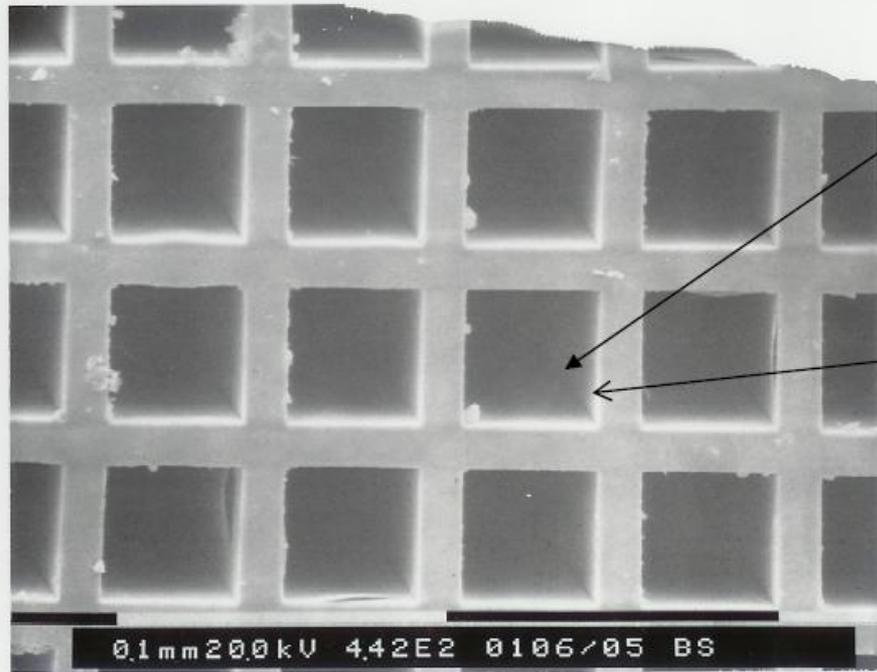


Figure 14. Large-scale gas motion expected in various systems, which will be the subject of high-resolution spectroscopy from DIOS.

# Athena (2028) Si-pore Optics + TES Calorimeter



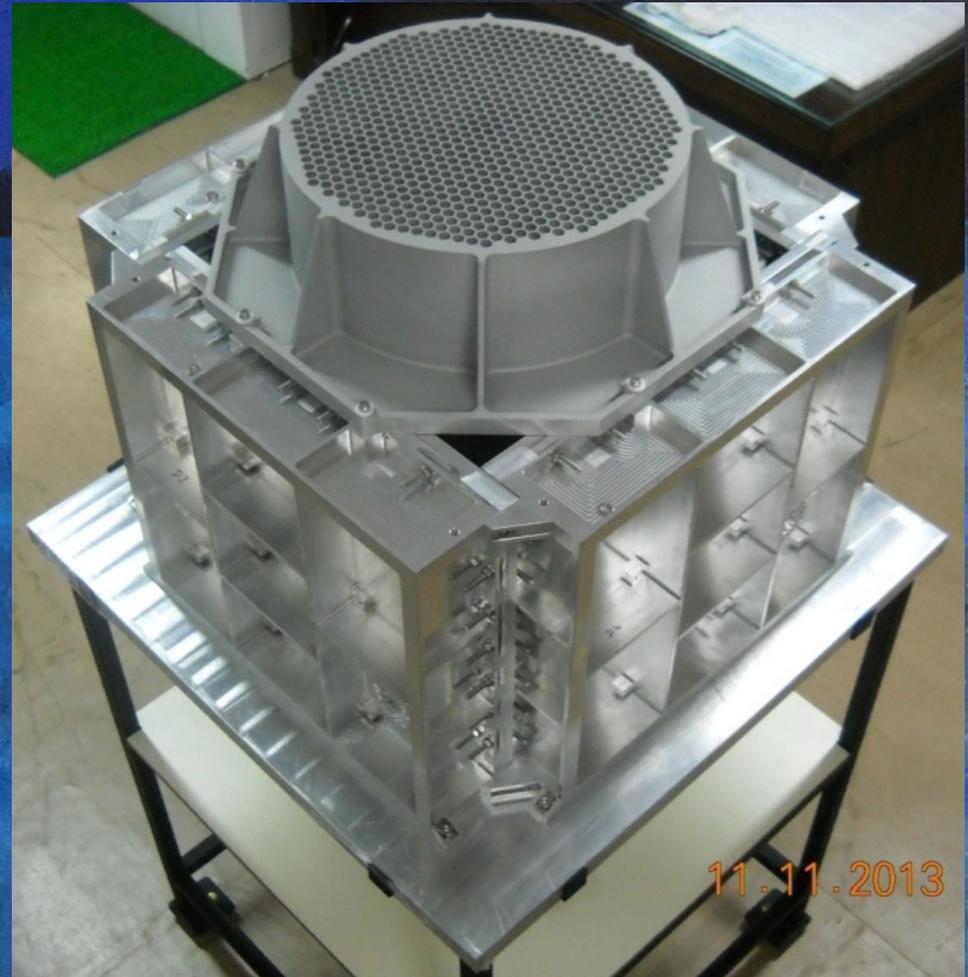
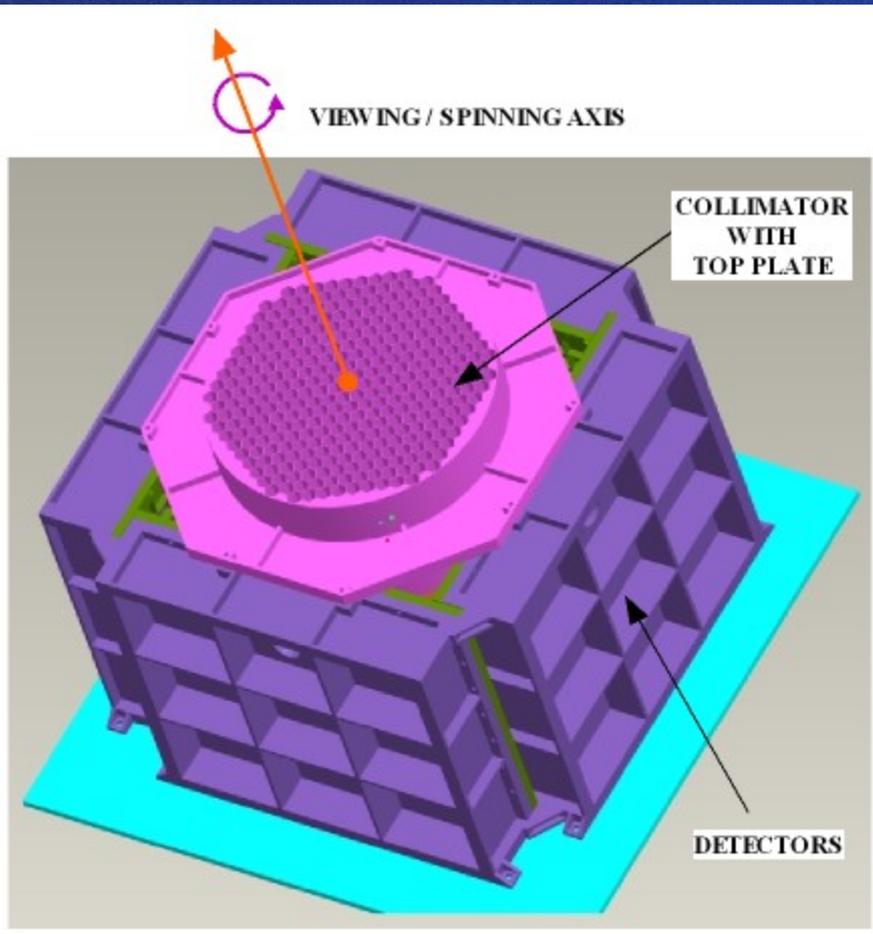
# X-ray Polarization

**IXPE- Imaging X-ray Polarimetry Explorer** - 3 identical nickel-replicated grazing-incidence X-ray telescopes. Each telescope focuses X-rays into a GEM designed to track the path of the photo-ejected electron in the detector gas. The signature of linear polarization lies in the distribution of the electron-track initial direction—aligned to the incident X ray's electric field – *Weisskopf et al.*

- *Approved for SMEX by NASA a week ago.*

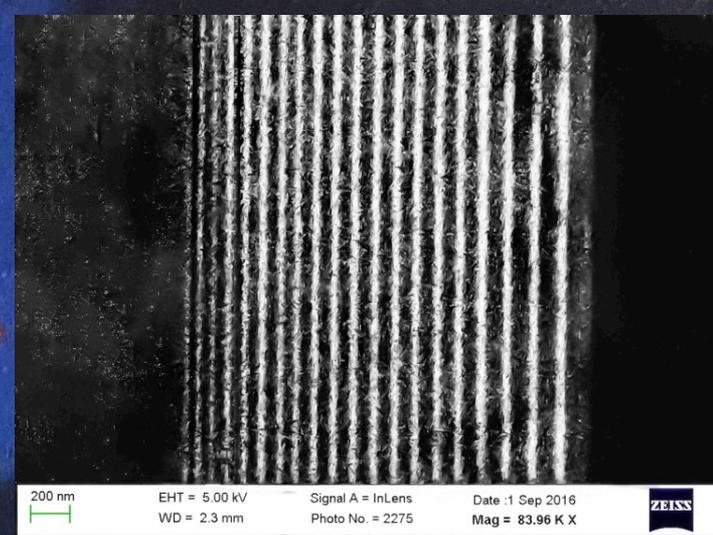
# POLIX: A Thomson X-ray Polarimeter

B. Paul (RRI)



# Developing Technology for the future in India

- Hard X-ray telescope
- + Polarization

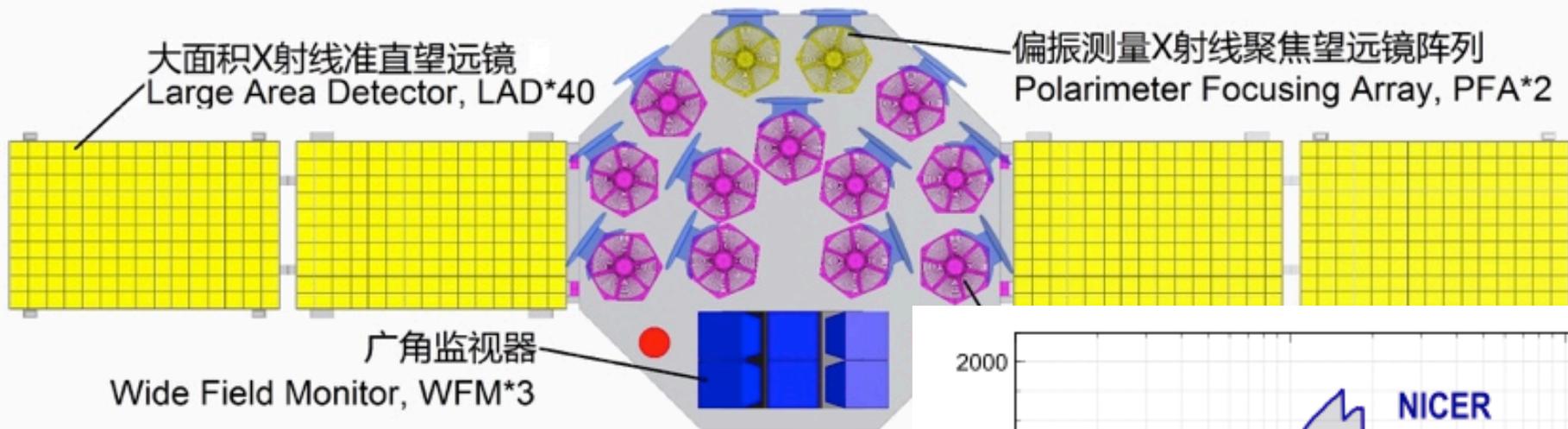


We are producing multilayer optic elements for hard X-ray reflection (upto 80 keV) at TIFR – needs to be carried to completion into a telescope for the future. Designed for a 6.5m focal length telescope (*Vinita Navalkar et al.*)

Such a telescope can be combined with a detector for hard X-ray polarization – an ongoing development at PRL.

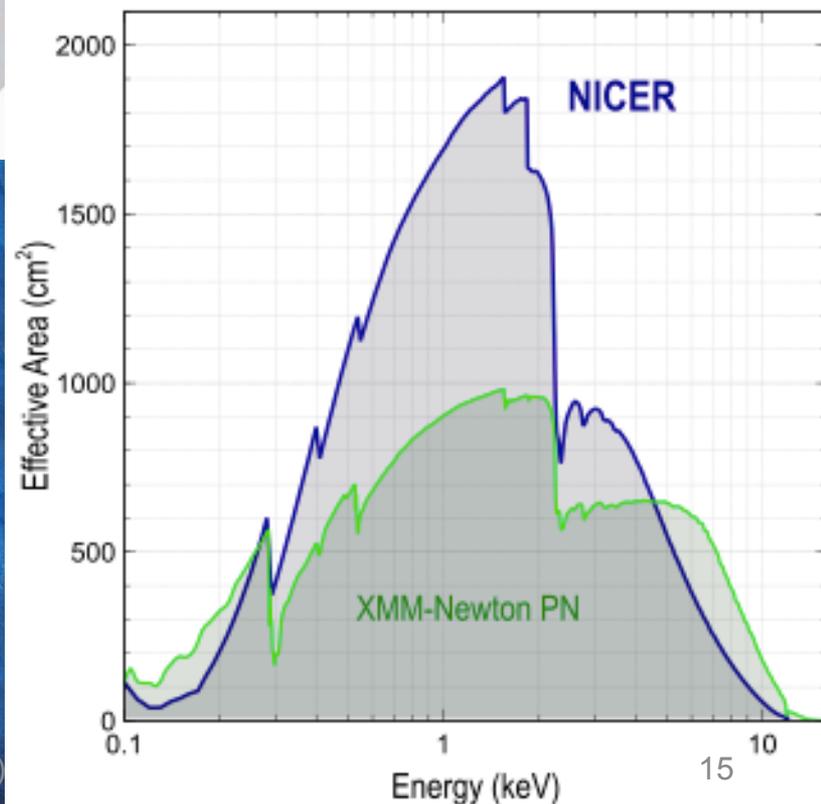
# Other Missions

eXTP: enhanced X-ray Timing and Polarimetry (2025)



- NICER (2017) – Neutron Star Interior Composition Explorer on ISS

100 ns timing with SDD



Thanks !