Japanese X-ray Polarization Activities

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<10 keV: **IXPE** (Imaging X-ray Polarimetry Explorer)

GEM: RIKEN (Tamagawa-san)

Thermal shield (mirror) : Nagoya U. (Mitsuishi-san)

10s keV: **PoGO+, XL-Calibur balloons** (Next slides)

100s keV:

Hitomi (ASTRO-H)/SGD: Crab detection (2018 PASJ 70, 113)

Analysis software in **Heasoft/ftool**

SMILE balloon

Electron-tracking Compton camera with micro-pixel chamber: Kyoto U. (Takada-san)

MeV: **GRAIN balloon**

Fine image with **emulsion films**: Kobe U., Nagoya U. (Takahashi-san, Rokujo-san)

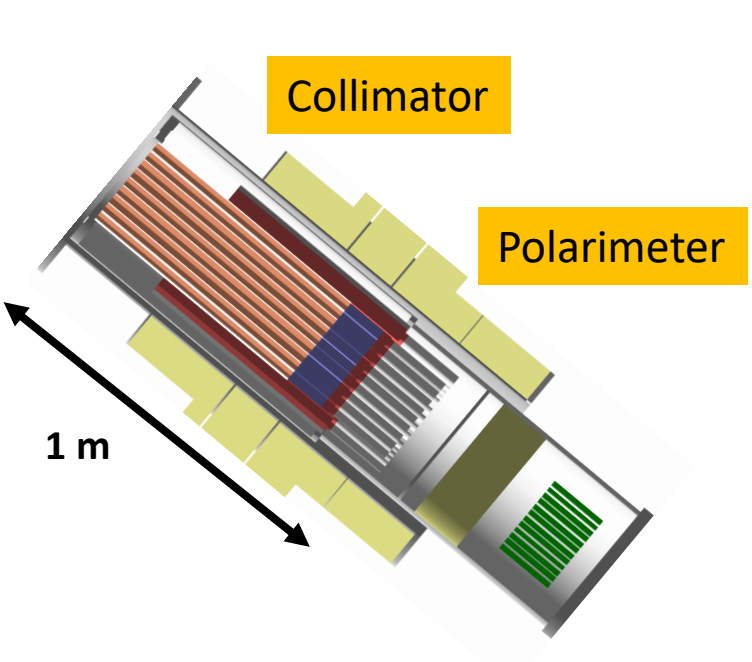
All researchers need more launch opportunities and want better detection/analysis methods. I hope we can start any cooperation at any levels.

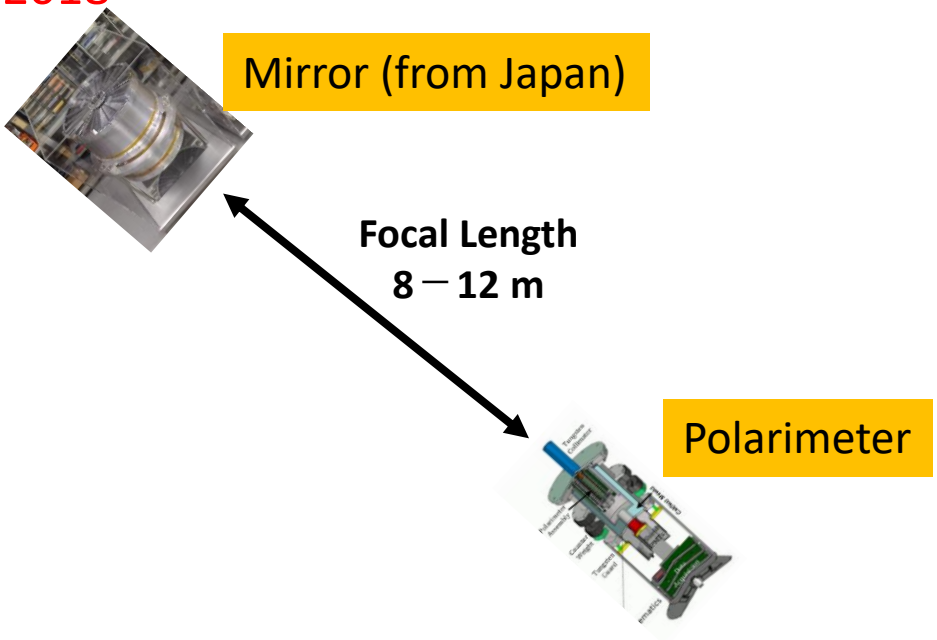
Recent balloon-borne hard X-ray polarimeters

PoGOLite/PoGO+ (2011,2013,2016) PI: Pearce

Sweden + Japan → Joined from 2018 → US + Japan + Sweden

X-Calibur/XL-Calibur (2018,2022,…) PI: Krawczynski





Collimator type (20-180 keV)
Large effective area
but with high background

(Chauvin et al. 2017,2018 etc.)

Focusing type (20-80 keV)
Low background with small detector

(Abarr et al. 2020,2021 etc.)

X-Calibur in 2018 (~2 tons)

X(L)-Calibur Polarimeter

20-80 keV

- **Compton scattering is used to measure polarization angle**

  Focus with hard X-ray mirror => Detector is compact and low background

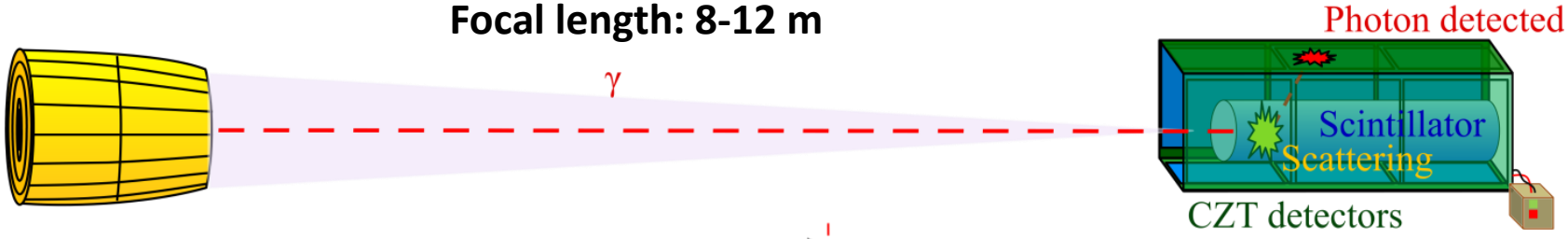
  Scatter: Be (passive), Absorber CZT (256 pix x 4 sides), CsI (next BGO) active shield

  1 CZT (64 pix) at bottom as an imager

- Detector rotates (360 deg/20 s) to cancel systematic errors.

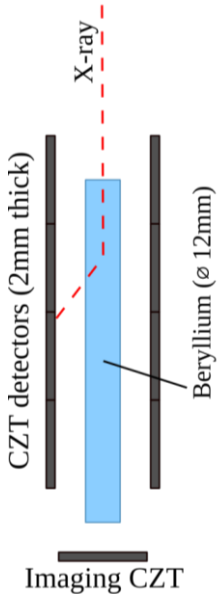
Detector size: ~3x8cm

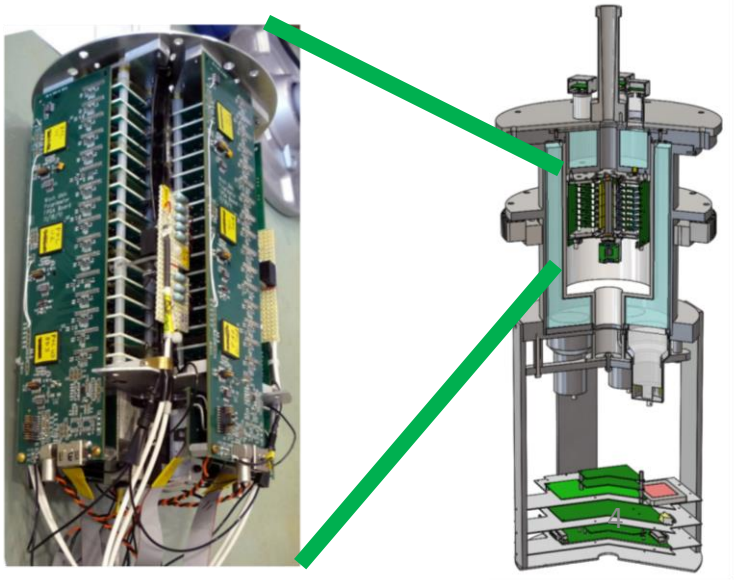
Focal length: 8-12 m



2018: InFOCuS mirror (NASA+Japan)

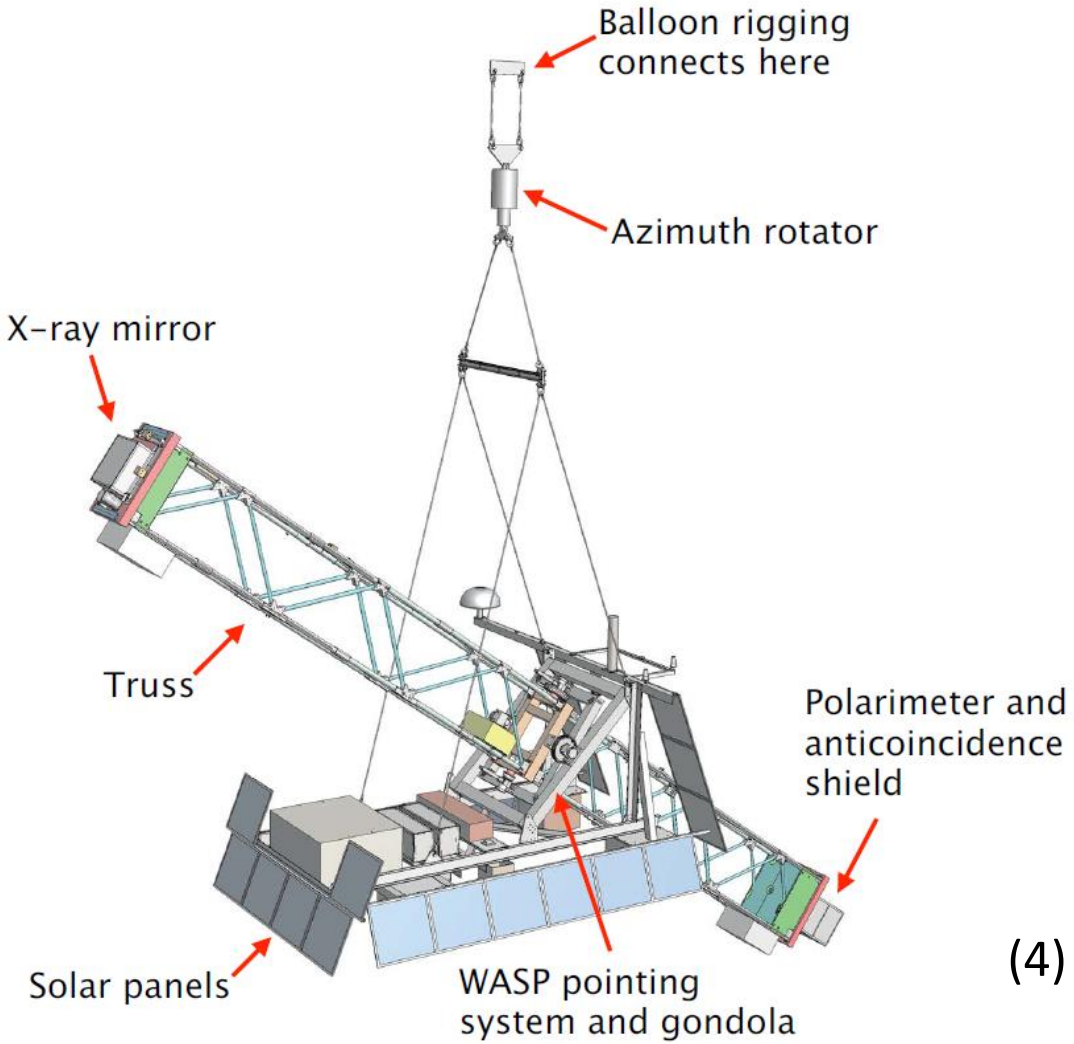
>2022: FFAST mirror (Japan)





Next: XL-Calibur flights in 2022, 2023, …

（**Abarr et al. 2021**）



Updates:

(1) Use larger **mirror**
(developed for FFAST mission)
⇒ Signal increase

(2) Thinner **CZT** (0.8-mm thickness)
(3) Anticoincidence **shield**
Faster circuit (less deadtime)
BGO scintillator
⇒ Background decrease

⇒ **>10 times better S/N ratio**
than the previous X-Calibur.

(4) Sun sensor and another star tracker for pointing Crab (close to Sun).

Estimated sensitivity of XL-Calibur (15-80 keV)

2022: Arctic (Sweden- Canada), ~1 week flight

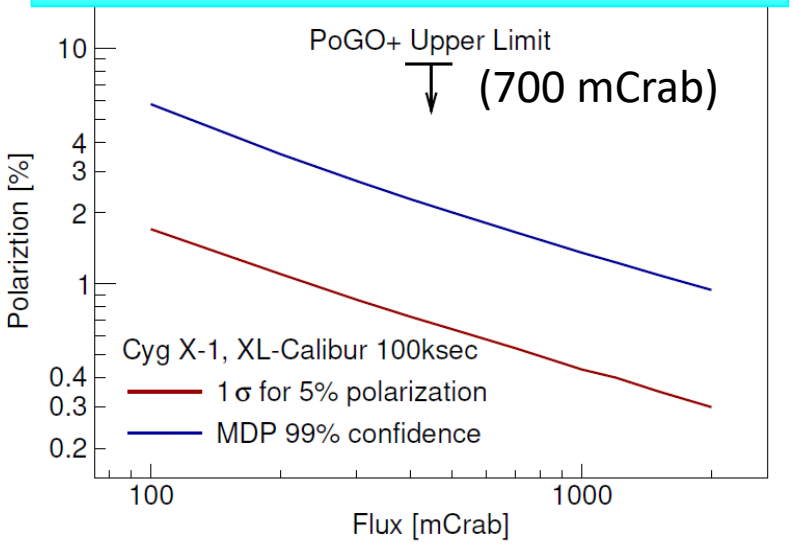
Crab (calibration), Cyg X-1 (BHB) => Accretion corona geometry

2023: Antarctica, ~1 month flight

Vela X-1, GX 301-2 (HMXBs) => Emission mechanism (Fan/Pencil beam?)

Simultaneous observations with IXPE and XPoSat are very interesting.

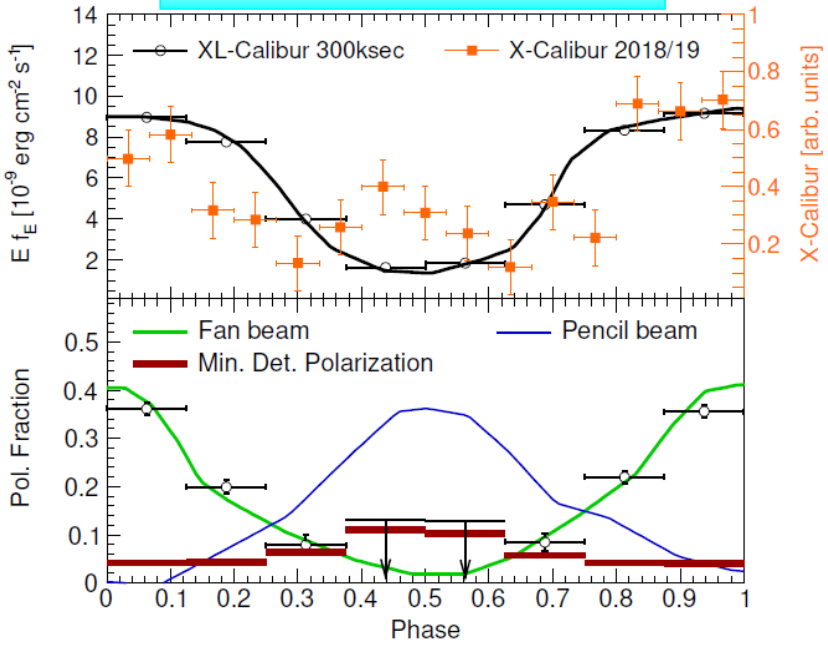
Cyg X-1 (Black-hole binary)



Low/hard state: can detect a few% polarization

High/soft state: upper limit <~5%

GX 301-2 (HMXB)



If flux is in 2018 level,
polarization can be detected significantly.

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