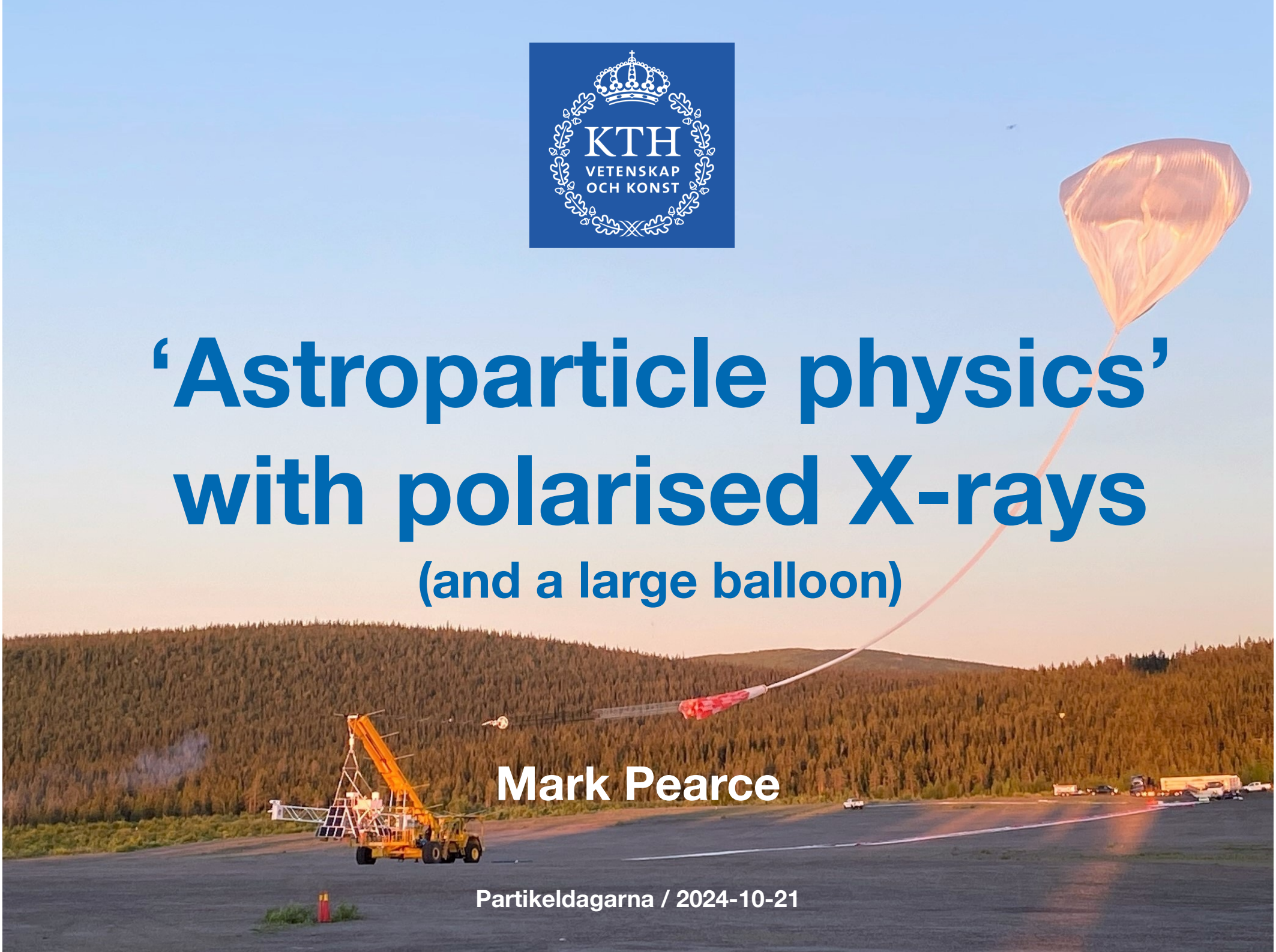


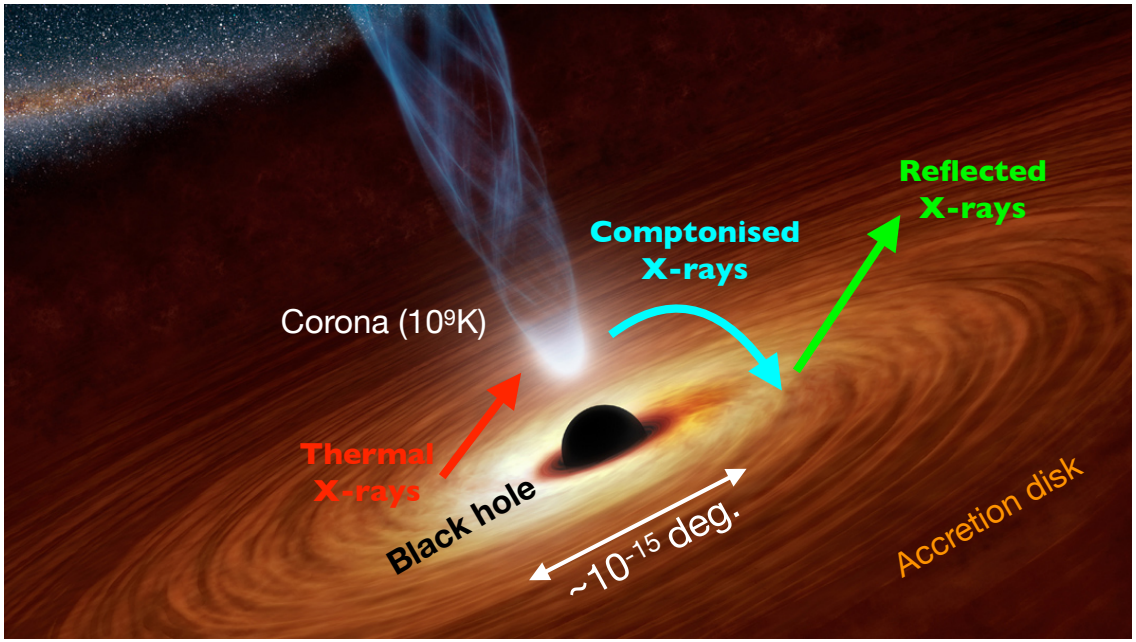
‘Astroparticle physics’ with polarised X-rays

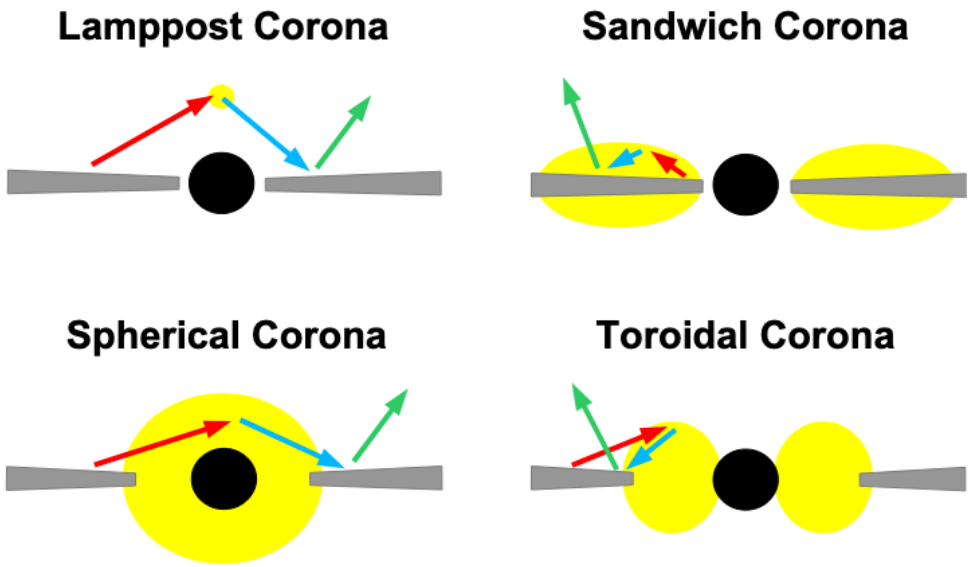
(and a large balloon)

Mark Pearce

Partikeldagarna / 2024-10-21

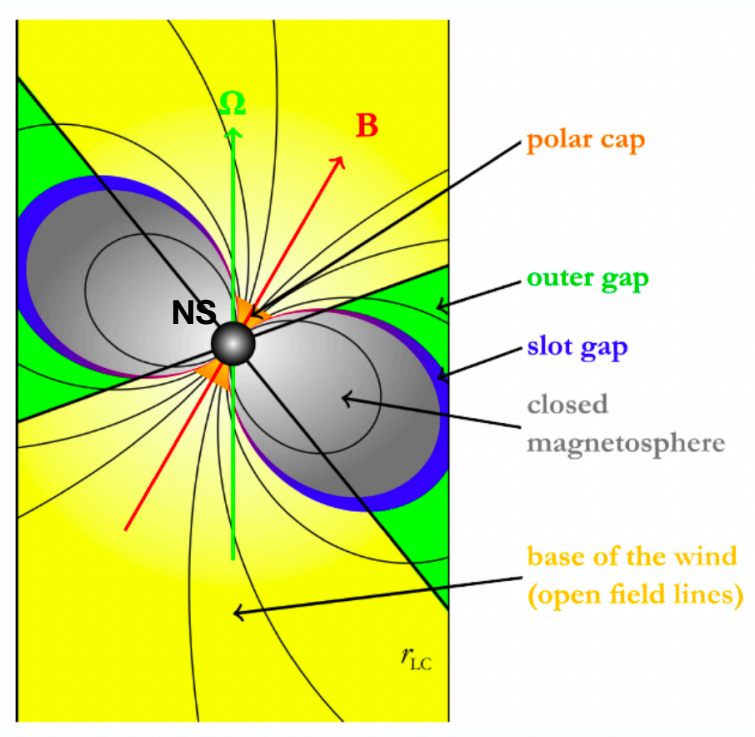
e.g Cyg X-1

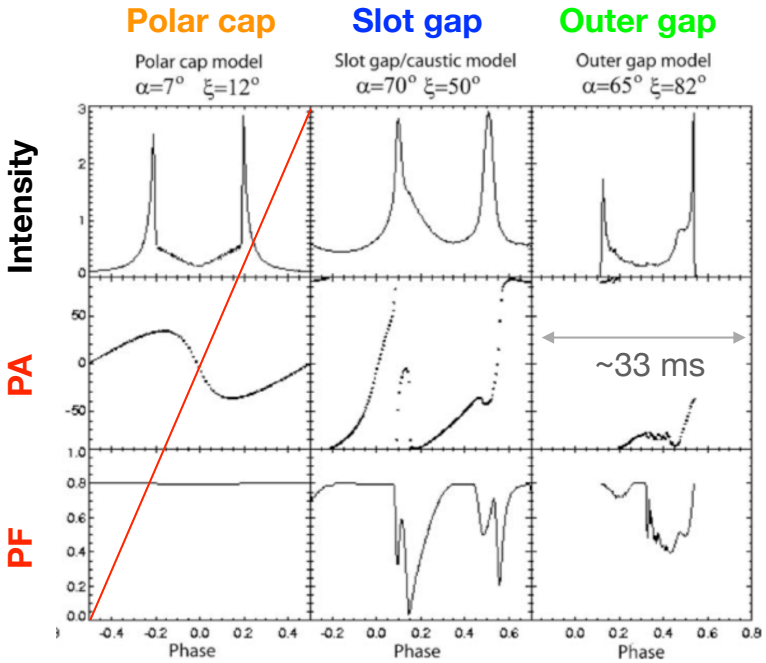




Bambi (2024)

e.g Crab pulsar

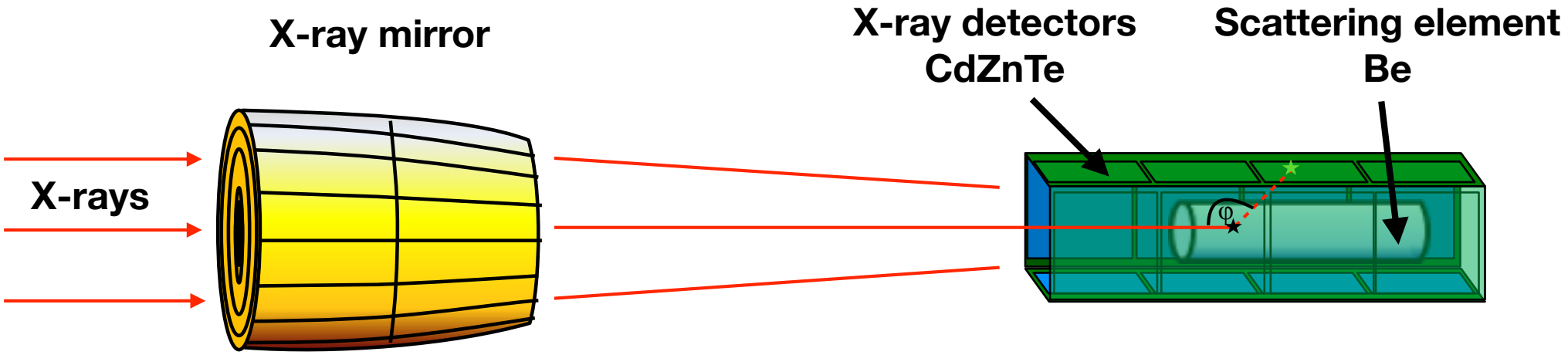




Dyks, Rudak (2003)
Dyks, Harding, Rudak (2004)

Phase

X-ray polarimeter

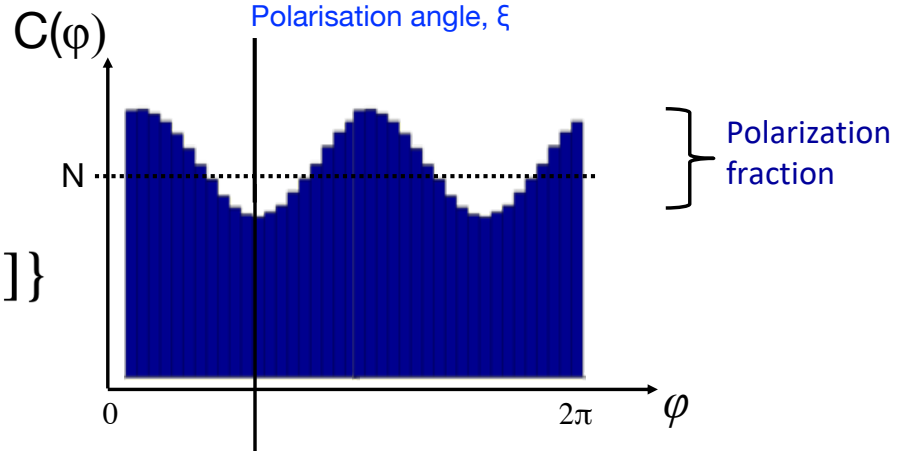


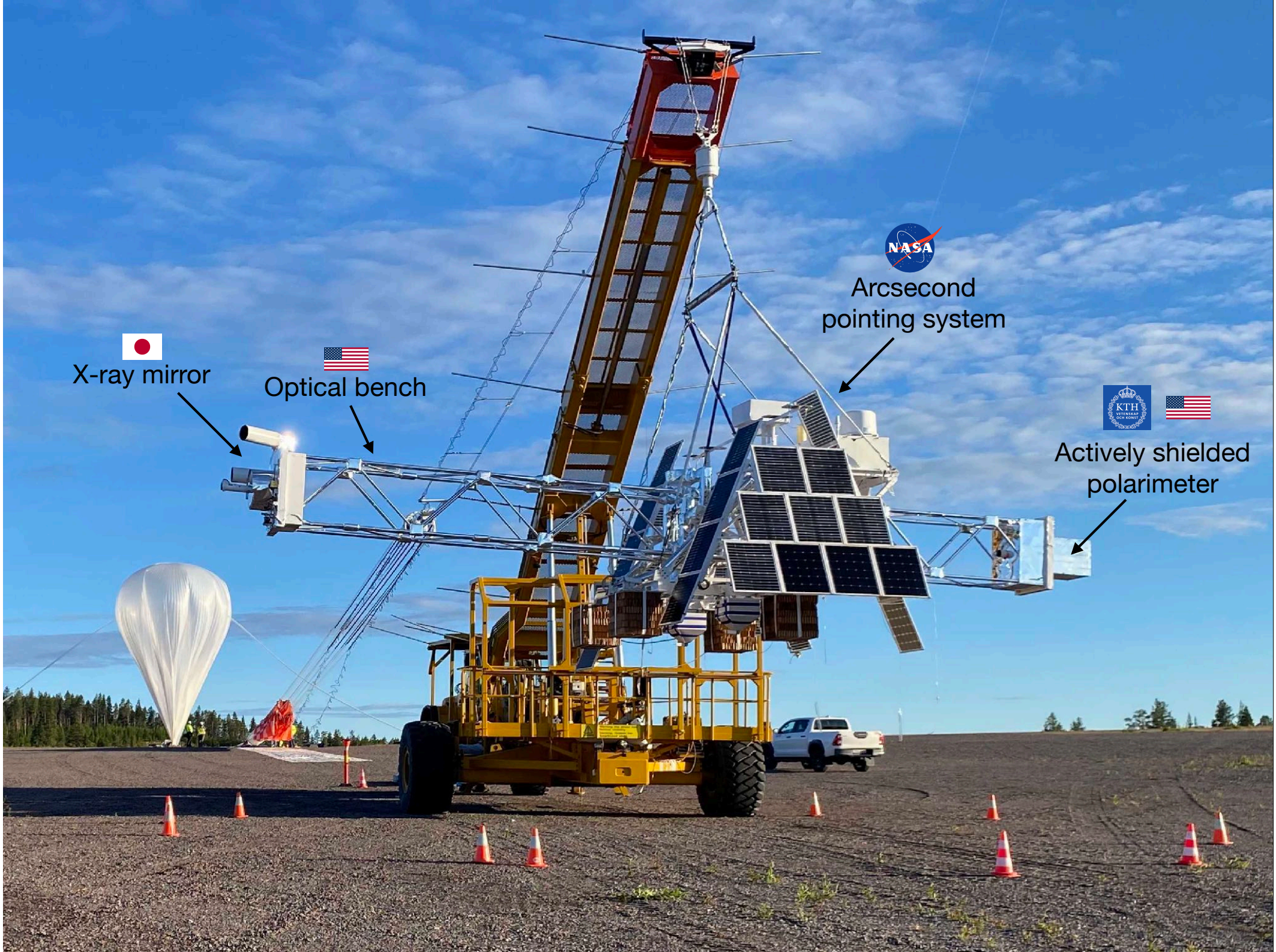
Aim: *measure scattering angle: φ*

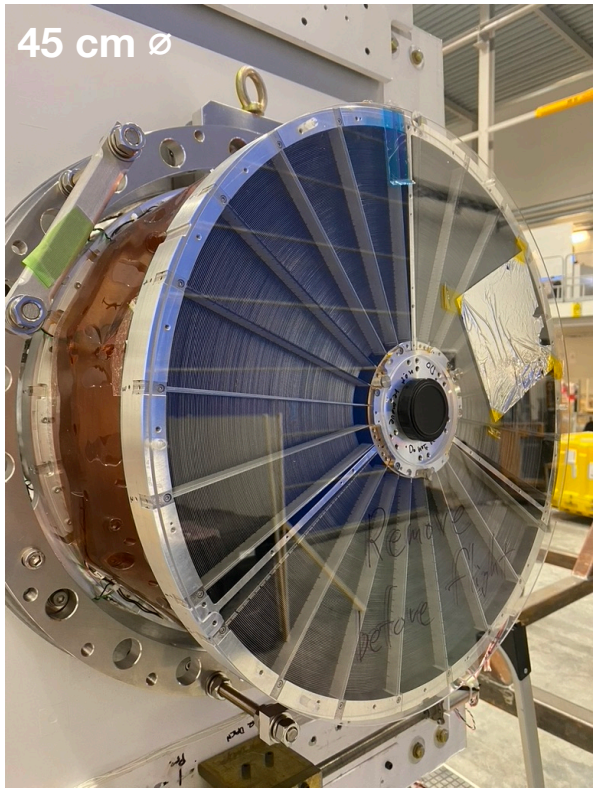
Distribution of **azimuthal scattering angles** (φ) encodes the polarisation properties of the X-ray beam

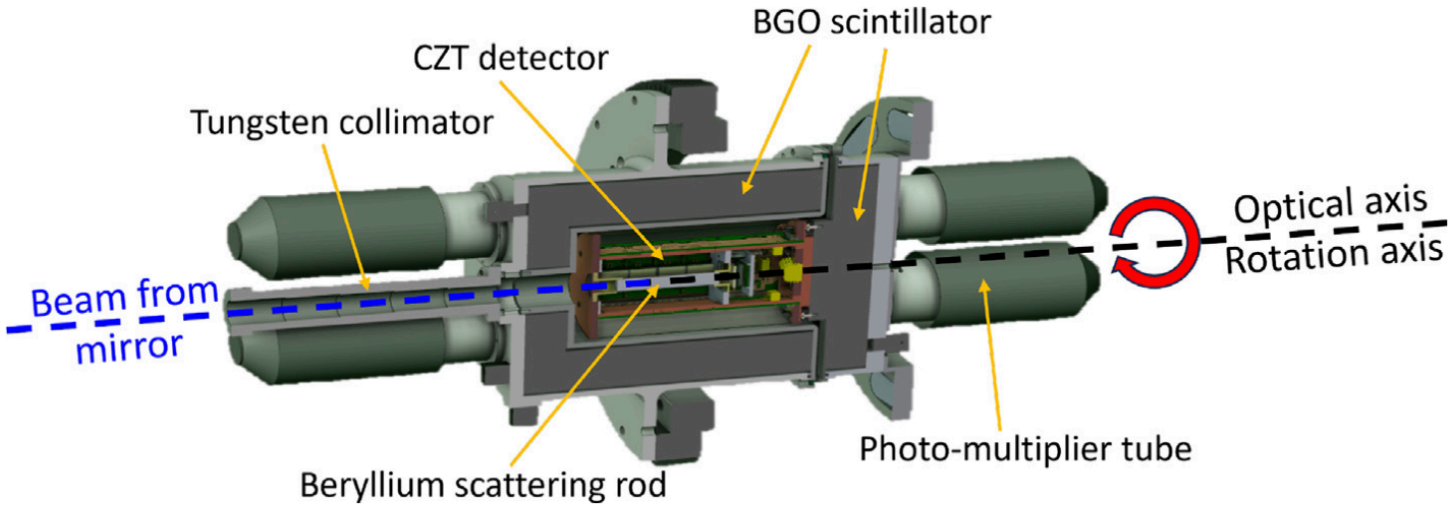
Modulation factor ~0.5

$$C(\phi) = N\{1 + \mu \cos[2(\phi - \xi)]\}$$




X-ray mirror
Optical bench
Arcsecond
pointing system
Actively shielded
polarimeter





X-ray mirror

- 213 nested Al shells Pt/C multilayer coating
- A_{eff} = 300 cm² (20 keV), 130 cm² (40 keV). 80 keV cut-off.
- PSF = 2.1 arcmin HPD
- FoV = 5.9 arcmin

Polarimeter

- Be rod: 8 cm long, 1.2 cm ⌀
- 0.8 mm thick CdZnTe detectors (4×4, 2×2 cm²; 8×8 pixels)
- +1 CZT under Be stick
- ΔE ~5.9 keV FWHM (40 keV)

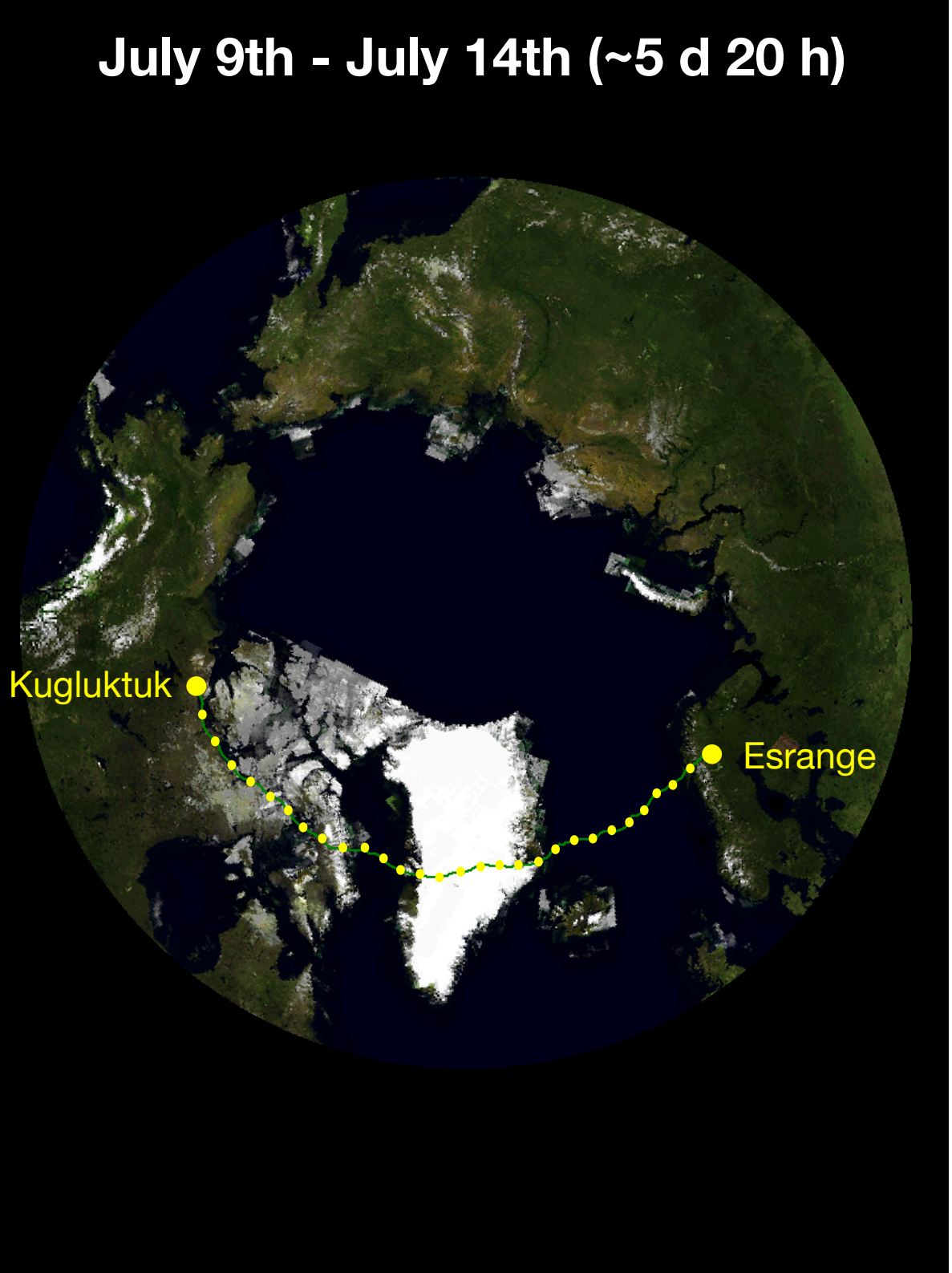
Anticoincidence

- ~3 cm thick $Bi_4Ge_3O_{12}$ (~58 kg)
- Redundant PMT read out
- 50 keV veto threshold

XL-Calibur energy range: 15-80 keV

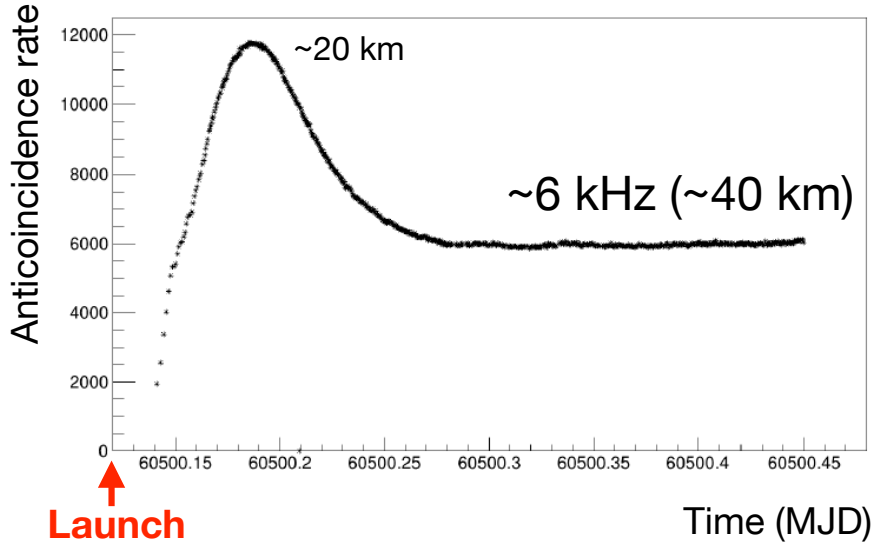
Abarr+/XL-Calibur (2021)


July 9th 2024 ~05:00 LT

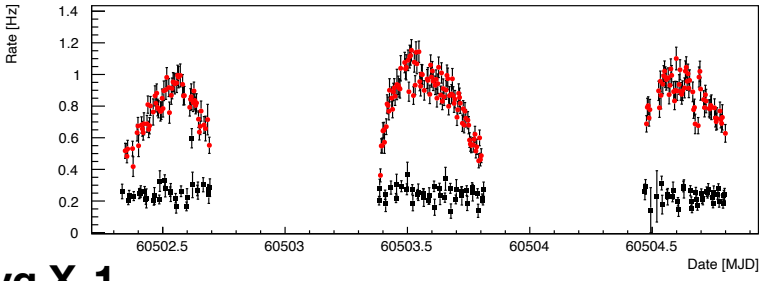

July 9th - July 14th (~5 d 20 h)
Kugluktuk
Esrange

Landing ~45 km SW of Kugluktuk (pop. ~1000), Nunavut, Canada.

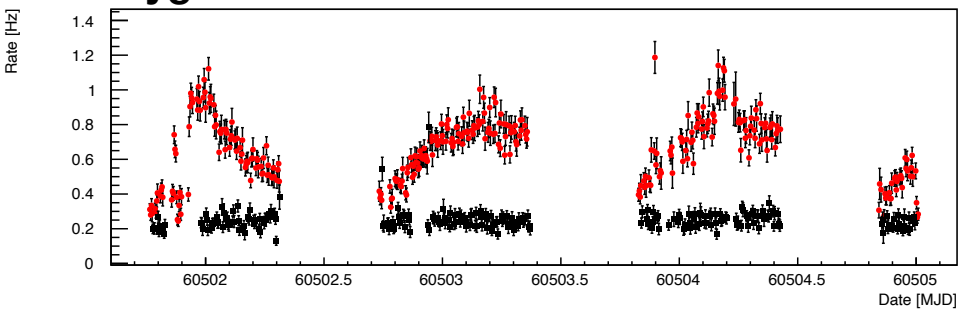
July 9th 03:00 UT - July 14th 22:30 UT (~5 d 20 h)



Crab



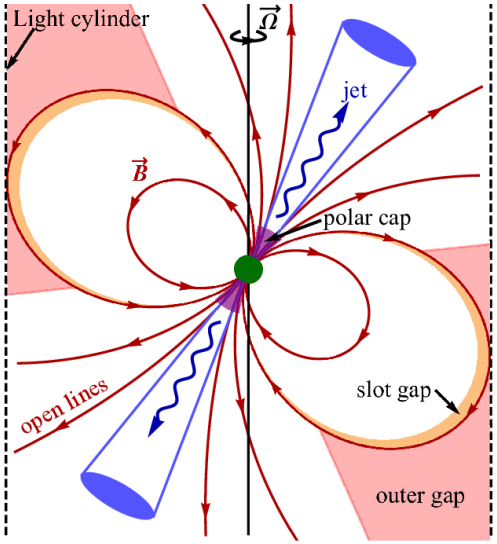
Cyg X-1



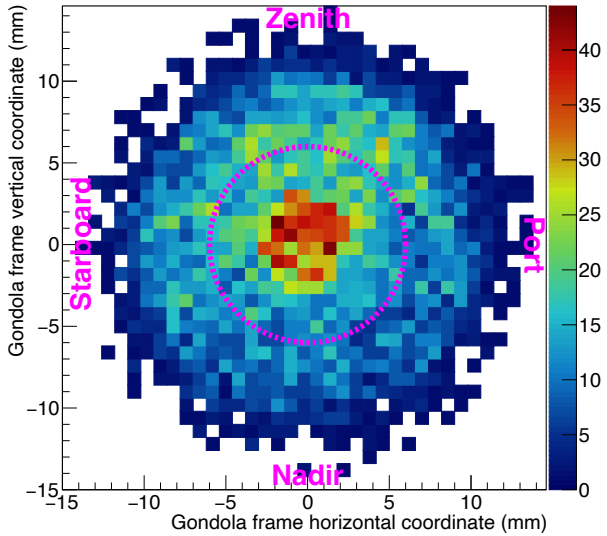
Background rejection

Polarimeter float trigger rate	135 Hz	
1-hit, 20-40 keV	5.9 Hz	1/23
1-hit, 20-40 keV, no shield veto	0.35 Hz	1/17
Pixel noise cleaning	0.2 Hz	

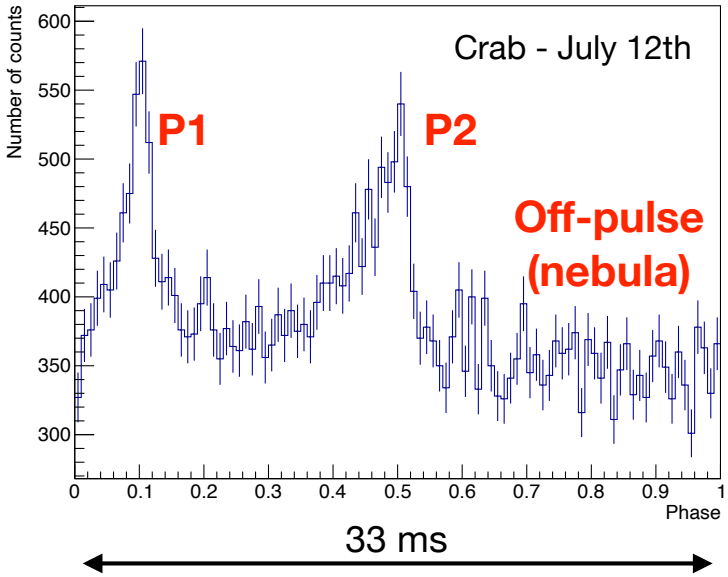
Crab pulsar+ nebula

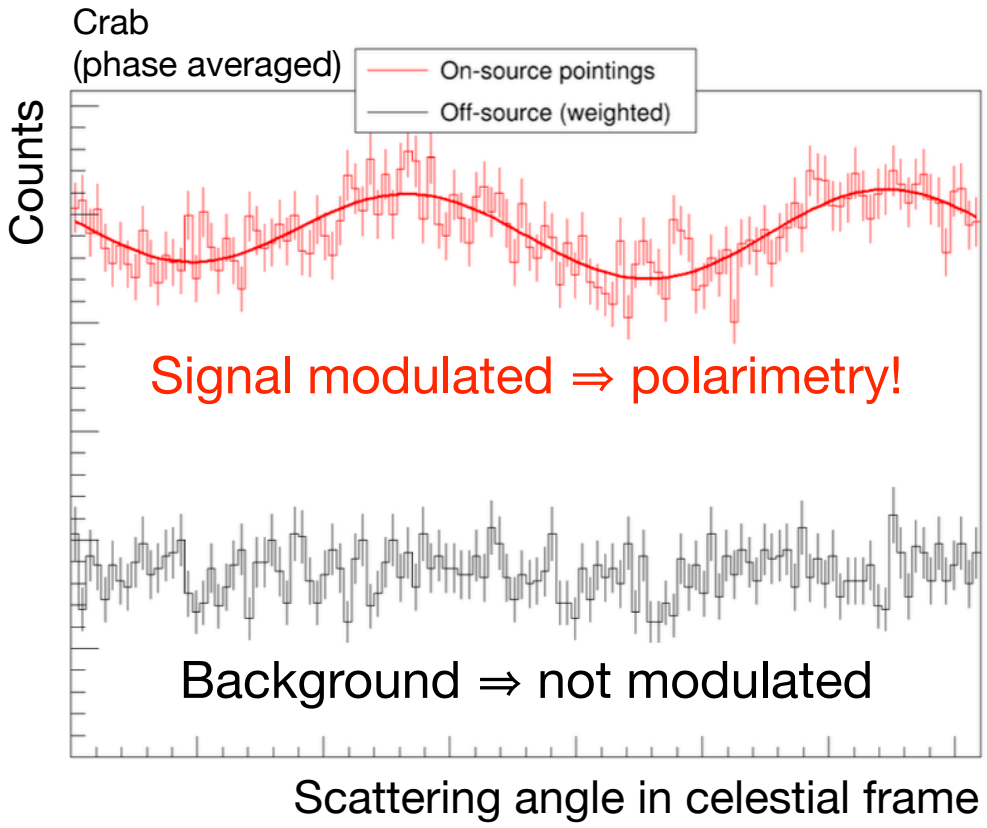


Focussed beam on target



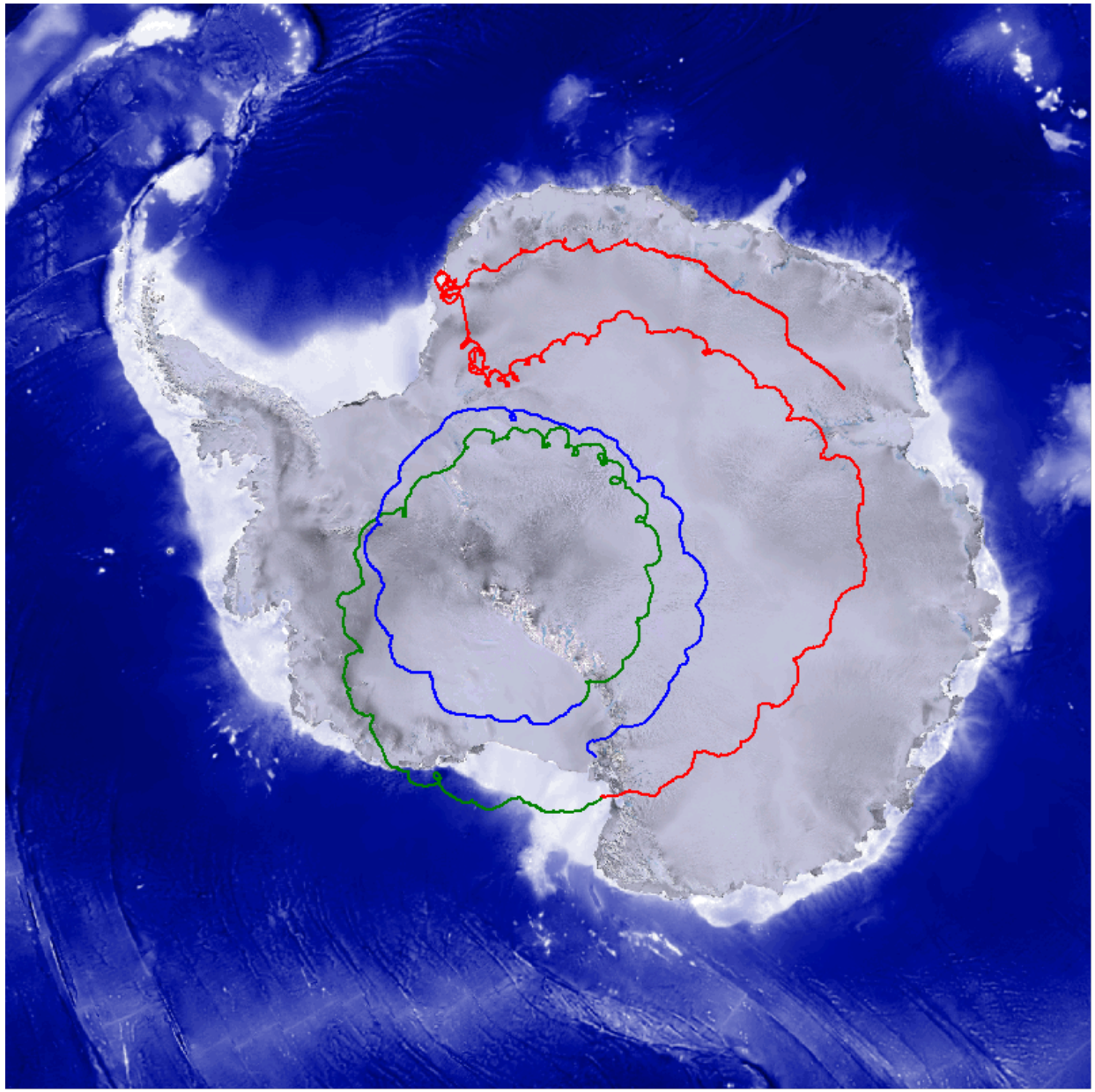
Crab pulsar detected





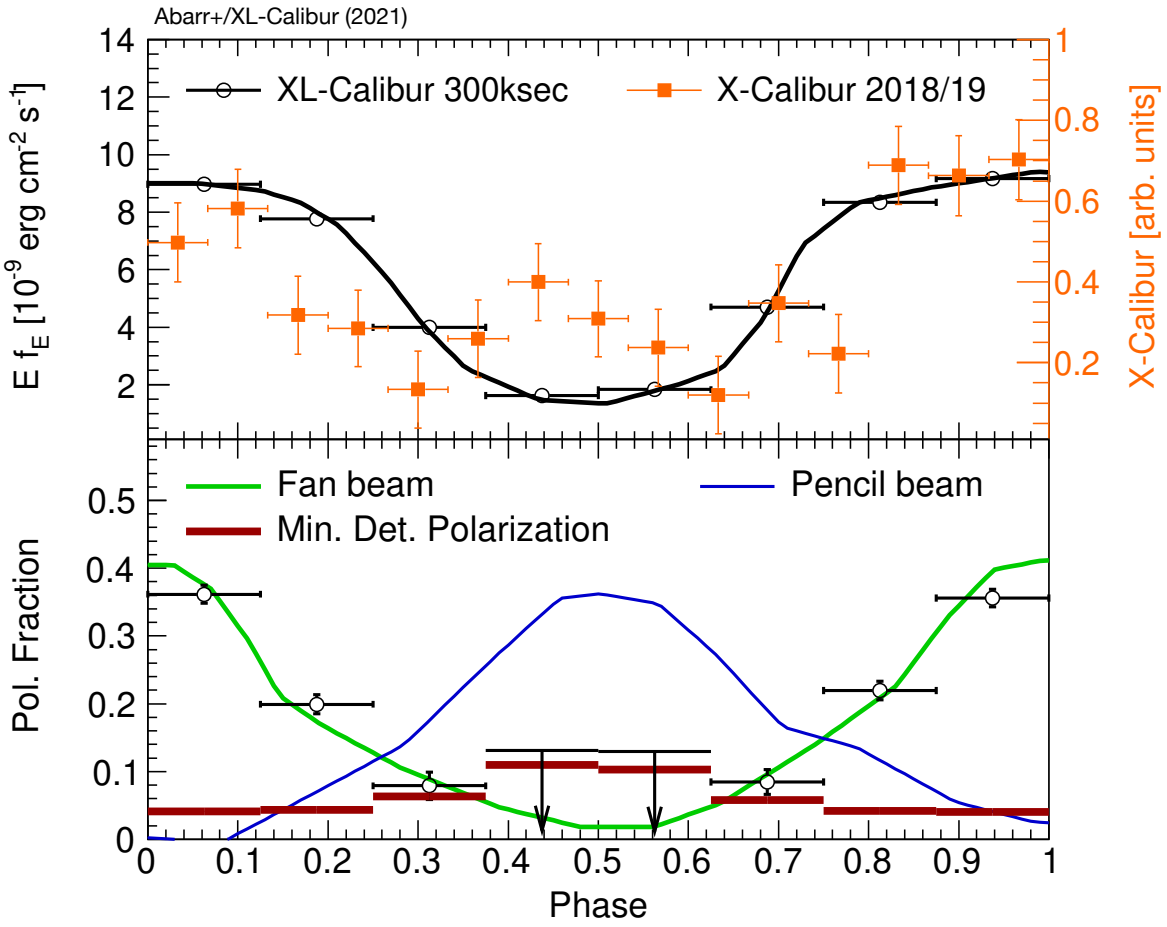
- **XL-Calibur (2024)**
  - **>8σ polarisation detection (Crab)**
- PoGO+ (2016)
  - PF = (20.9 ± 5.0)%
    PA = (131.3 ± 6.8)°
- **+ Off-pulse, P1, P2**

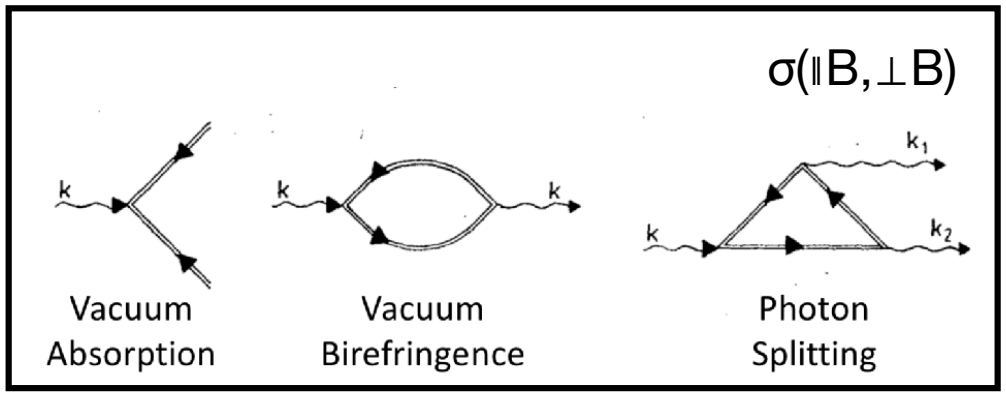
Antarctica (NET 2026): Southern Sky



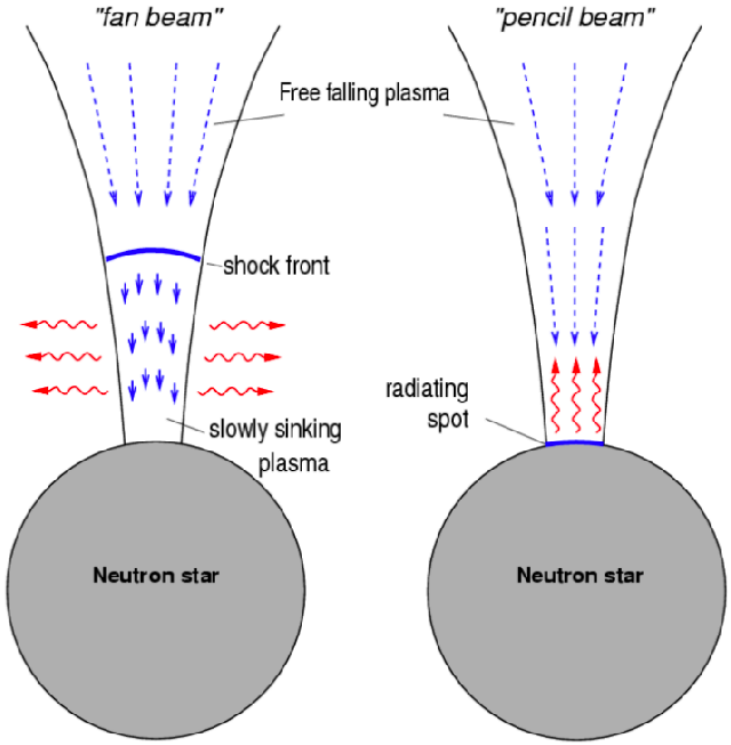
Record duration: 57 days (2024)

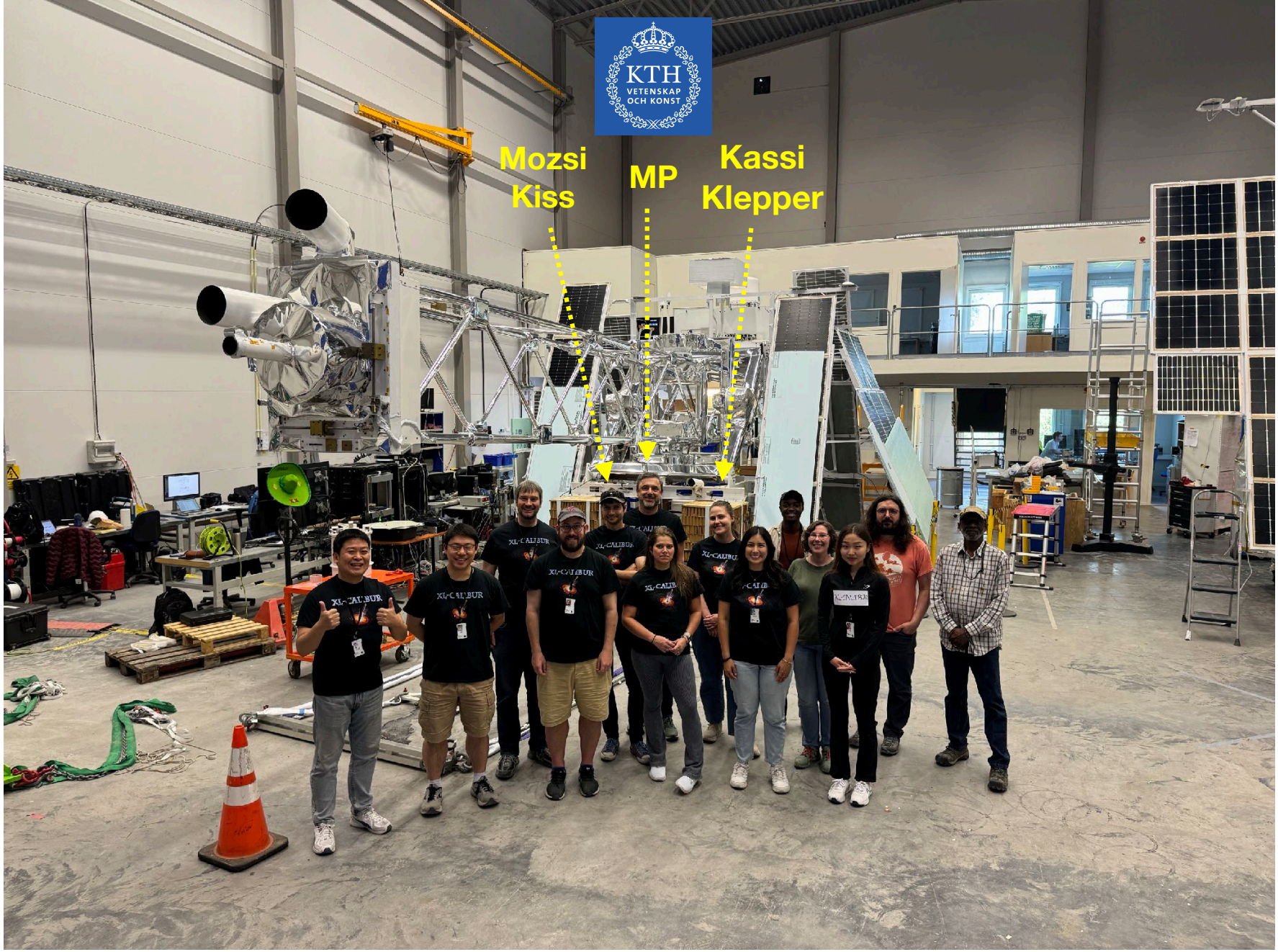
Accreting neutron stars: GX 301-2 and Vela X-1





- Highly magnetised (~10^8 T) neutron stars
  - Constrain emission geometry
  - Sensitive to QED vacuum polarization.





Rymdstyrelsen
Swedish National Space Agency

Vetenskapsrådet