

The IXPE View of GRB 221009A

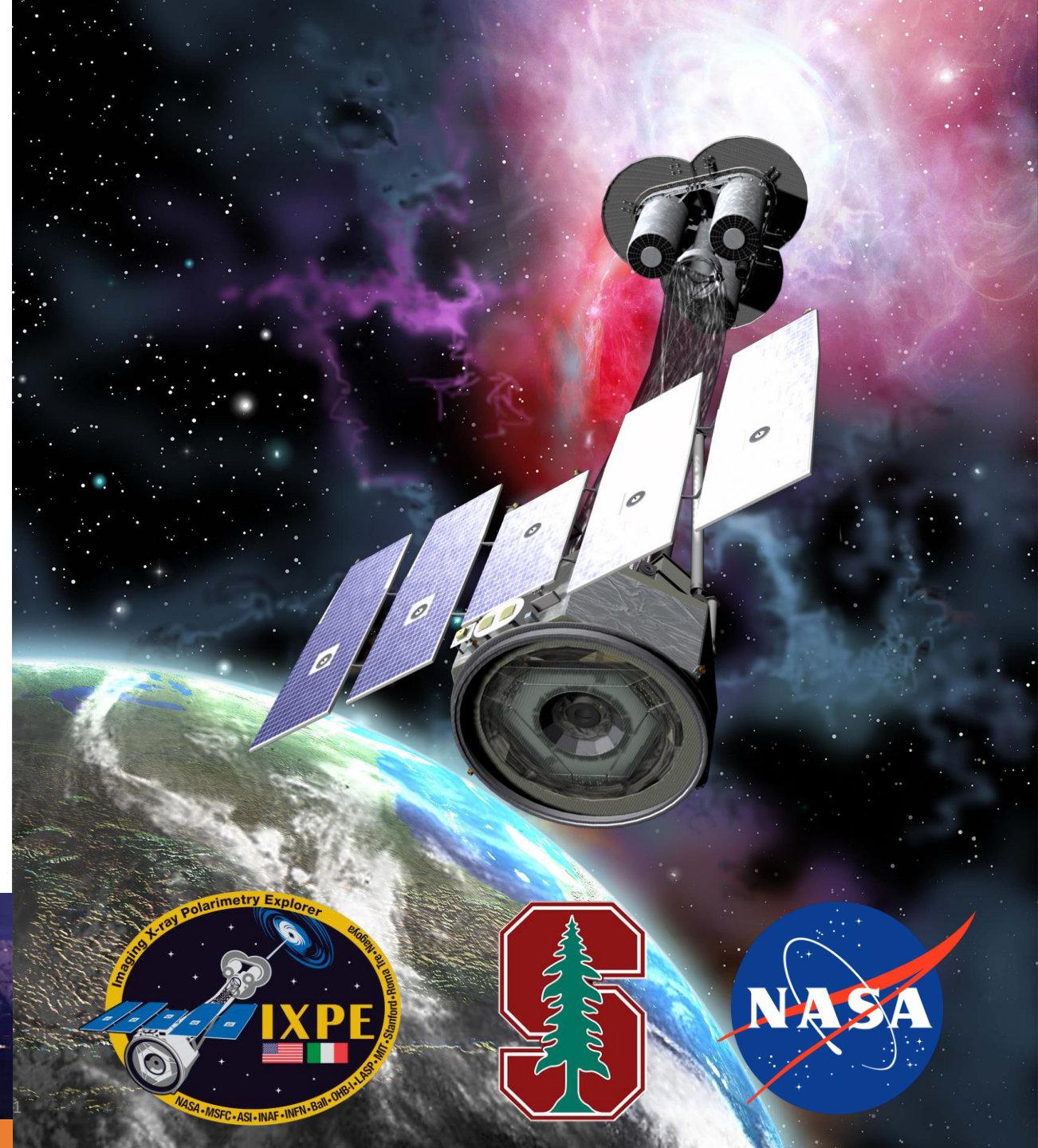
Niccolò Di Lalla
Stanford University

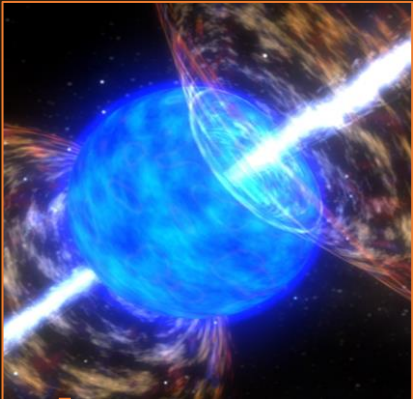
M. Negro, N. Omodei, P. Veres, S. Silvestri,
A. Manfreda, E. Burns

For the IXPE Collaboration

IV Gravi-Gamma-Nu
Workshop

FROM MULTIWAVELENGTH TO MULTIMESSENGER: THE NEW SIGHT OF THE UNIVERSE
OCTOBER 4-6, 2023
GRAN SASSO SCIENCE INSTITUTE- L'AQUILA, ITALY



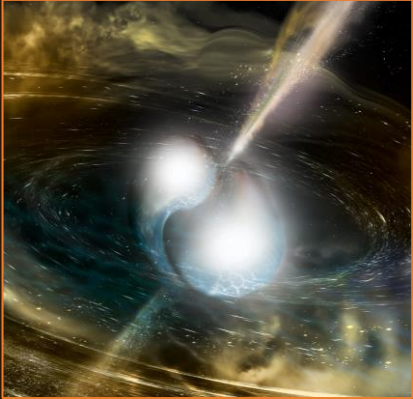
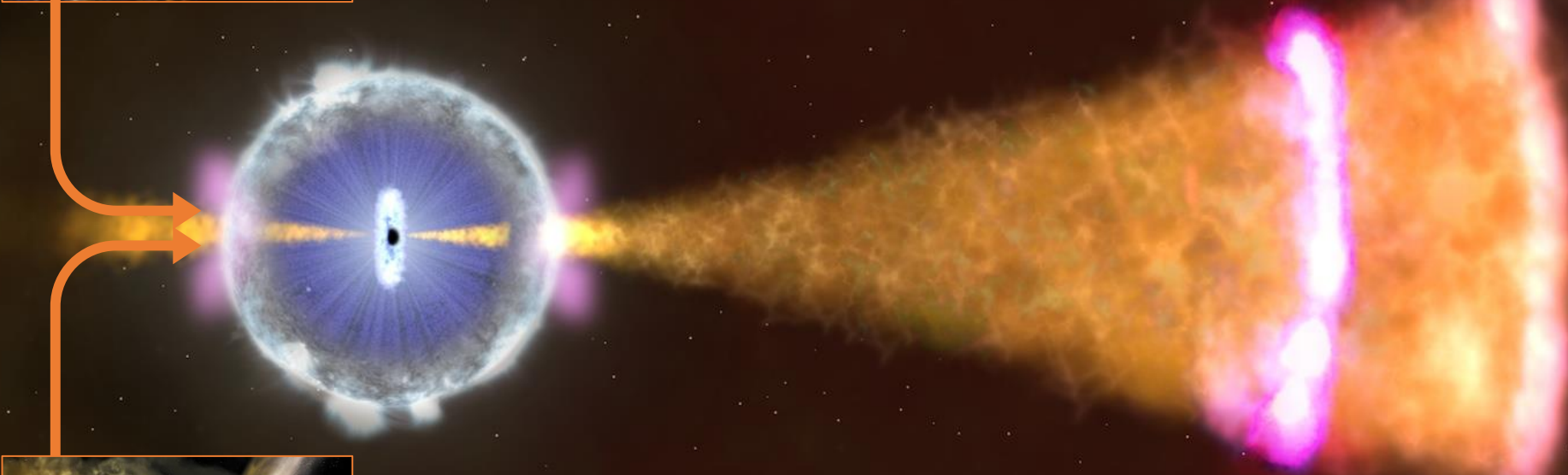


Collapsar → Long GRBs

BeppoSax and follow-up observations (1998)

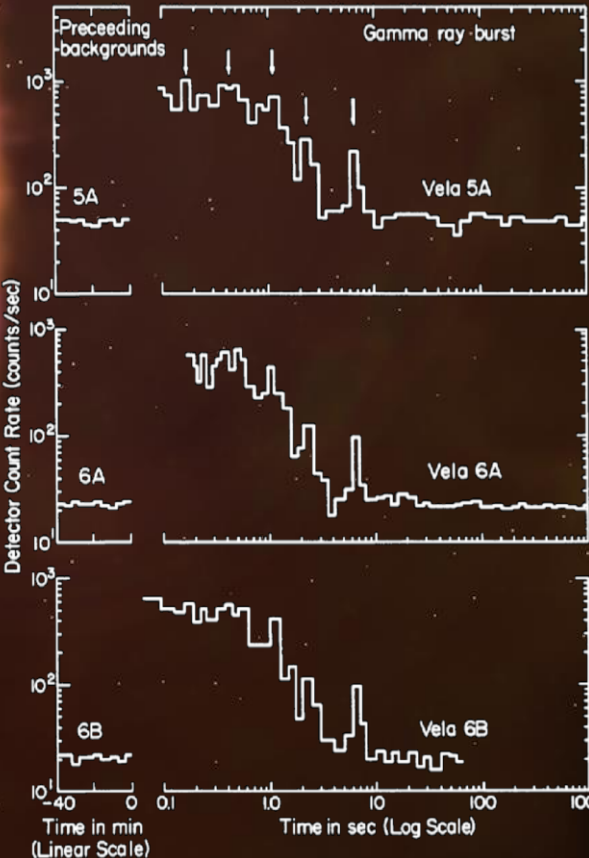


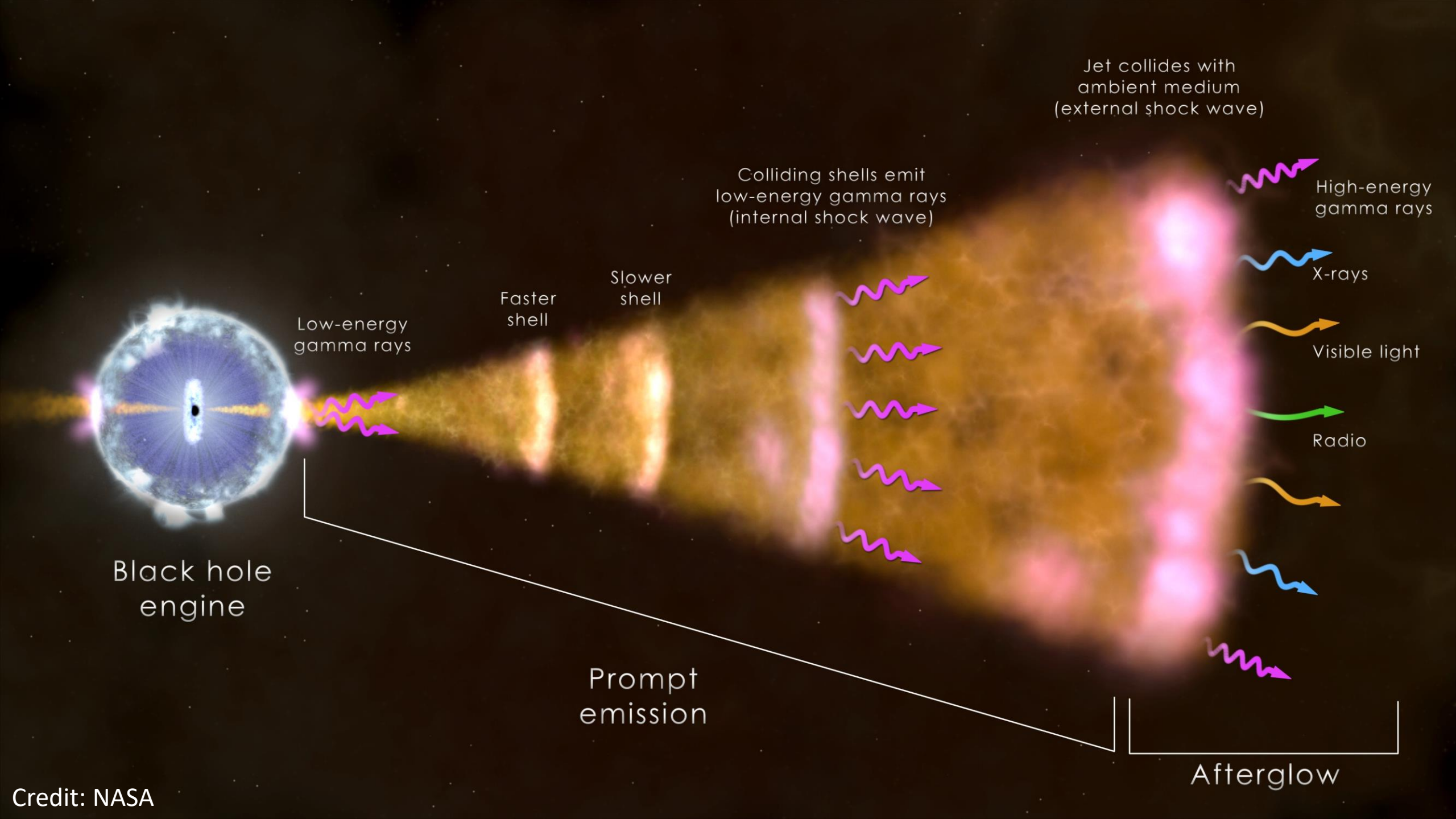
Vela



Binary neutron stars merger → Short GRBs

LIGO, Virgo, Fermi-GBM and INTEGRAL (2017)





Jet collides with ambient medium (external shock wave)

Colliding shells emit low-energy gamma rays (internal shock wave)

High-energy gamma rays

X-rays

Visible light

Radio

Faster shell

Slower shell

Low-energy gamma rays

Black hole engine

Prompt emission

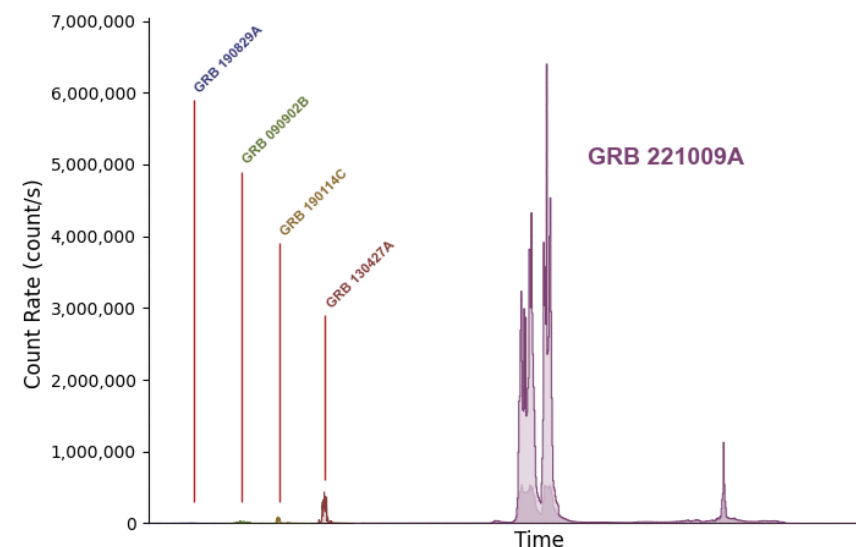
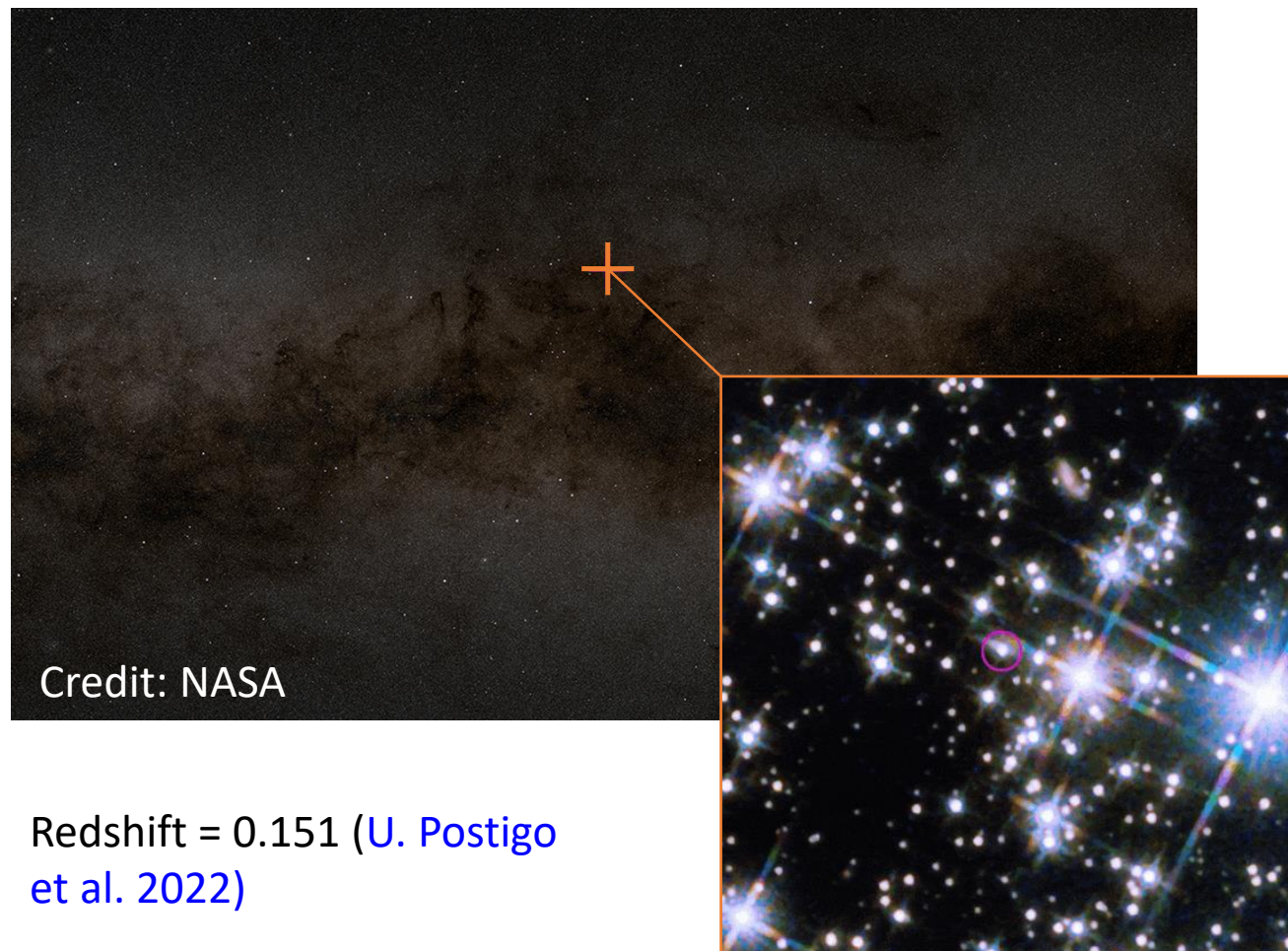
Afterglow

GRB 221009A or “The BOAT”

Credits: [CNN](#)



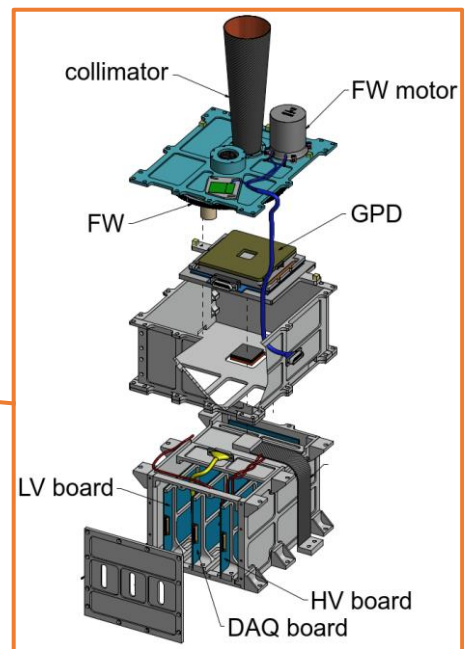
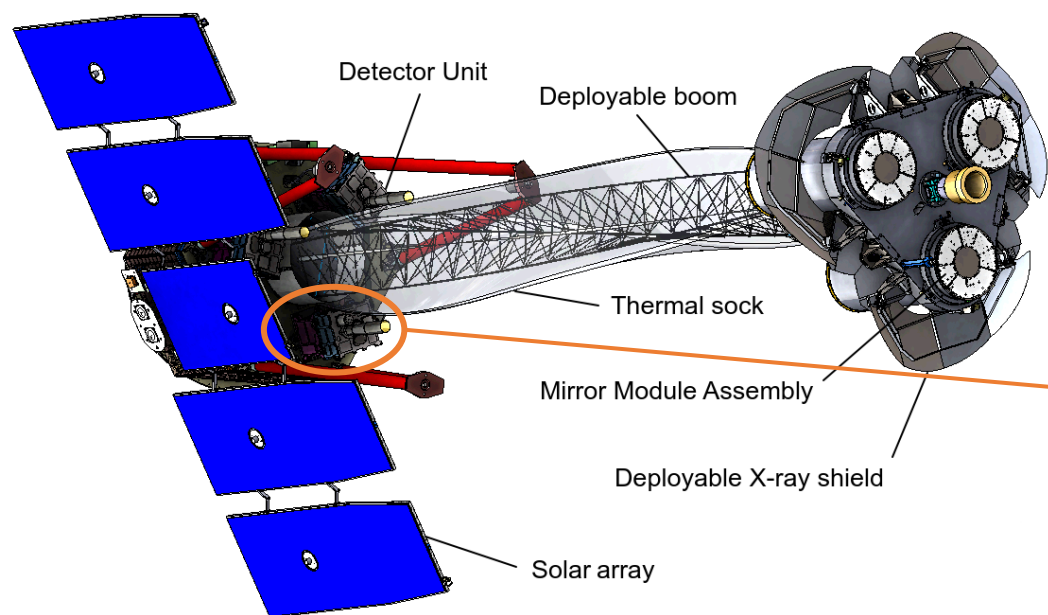
Scientists dub latest telescope sighting
'the BOAT' or 'the Brightest of All Time'



Credits: Adam Goldstein



Imaging X-ray Polarimetry Explorer (IXPE)



IXPE launch
December 9,
2021

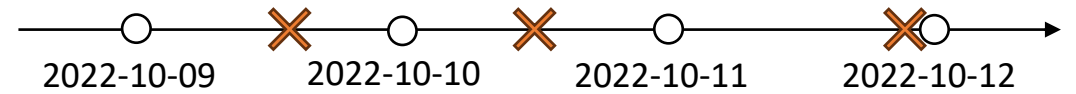
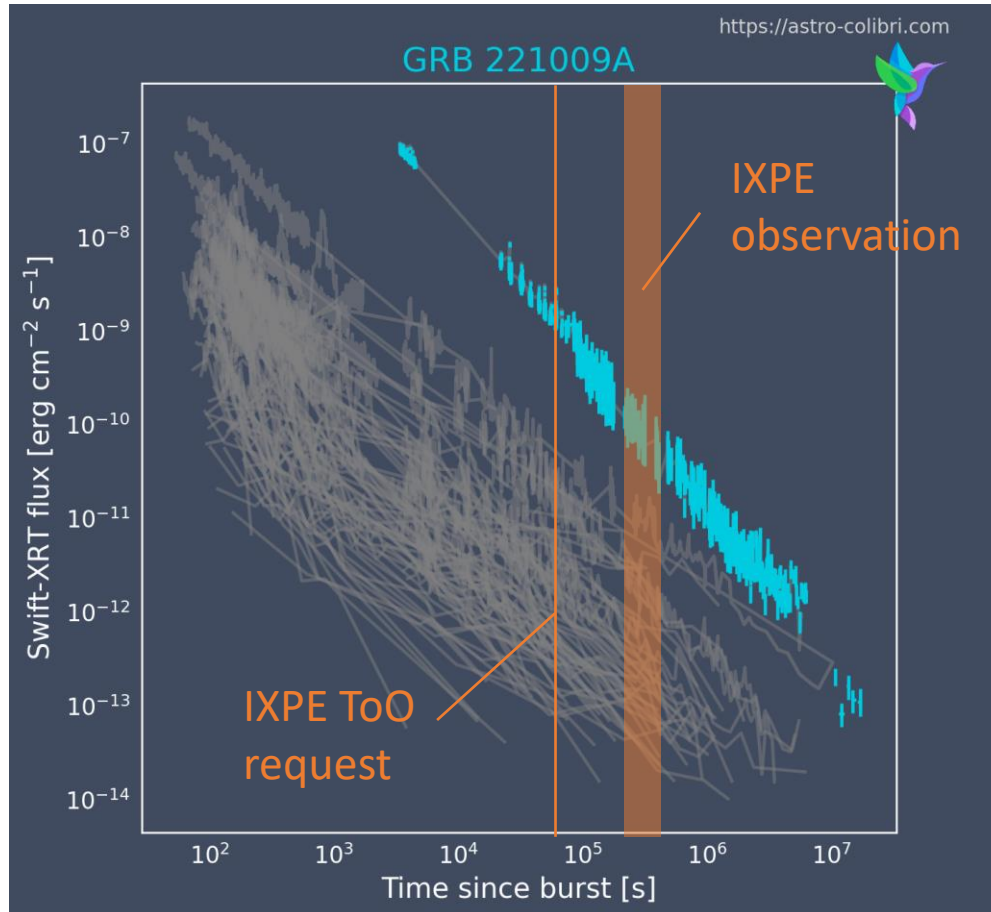
NEWS:

- IXPE mission just extended by 20 months!
- General Observer (GO) program from Feb 2024 through Sep 2025 (proposals due Oct 18, 2023)

<p>PI team, project management, SE and S&MA oversight, mirror module fabrication, X-ray calibration, science operations, and data analysis and archiving</p>	<p>Detector system funding, ground station</p> <p>Spacecraft, payload structure, payload, observatory I&T</p>	<p>INAF ISTITUTO NAZIONALE DI ASTRONOMIA FISICA</p> <p>Polarization-sensitive imaging detector systems</p> <p>Mission operations</p>	<p>Scientific theory</p> <p>Thermal shields</p> <p>Co-Investigator</p>
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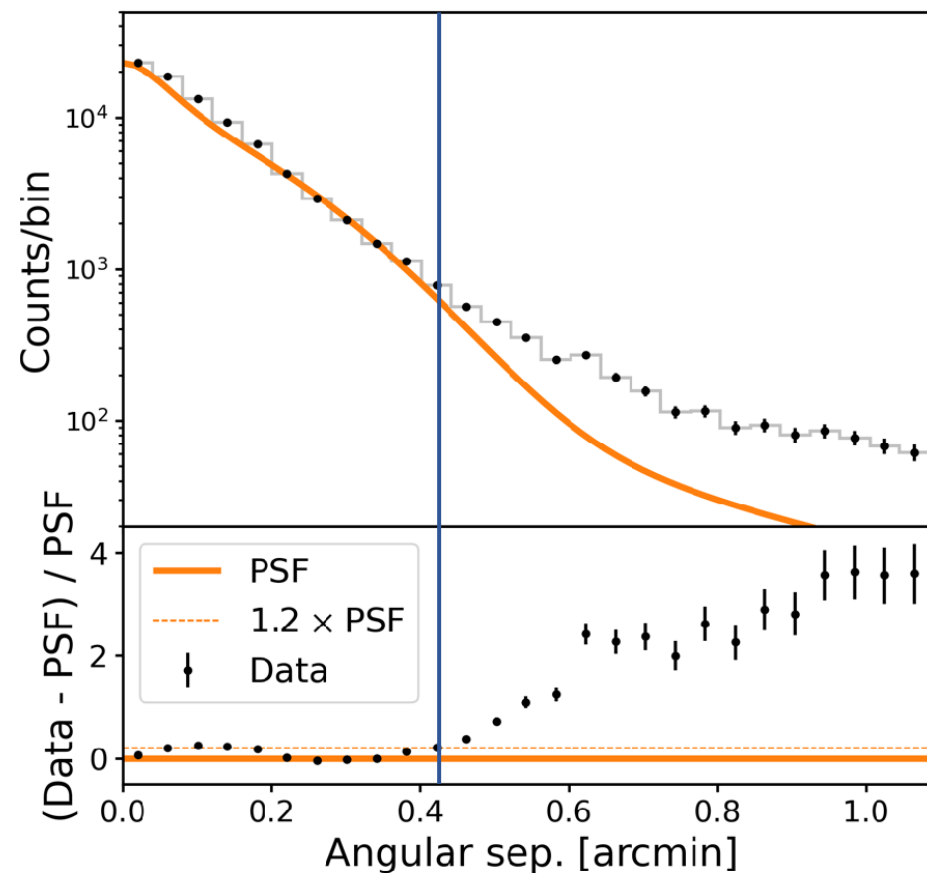
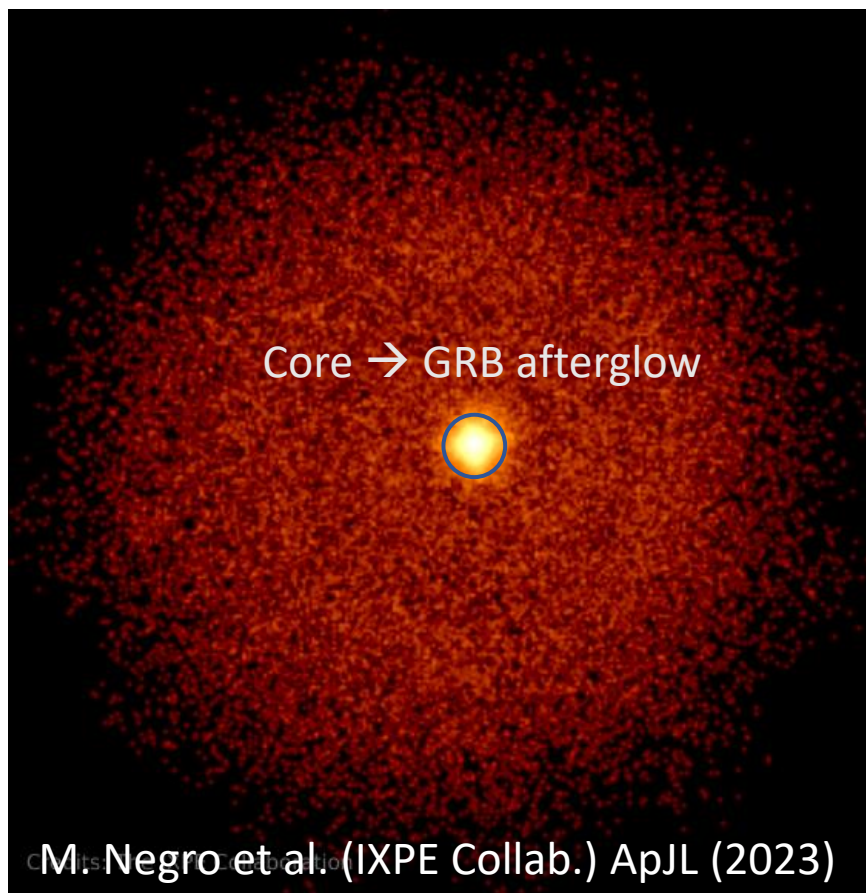
Credits: Jordan Sirokie

IXPE Observation of GRB 221009A



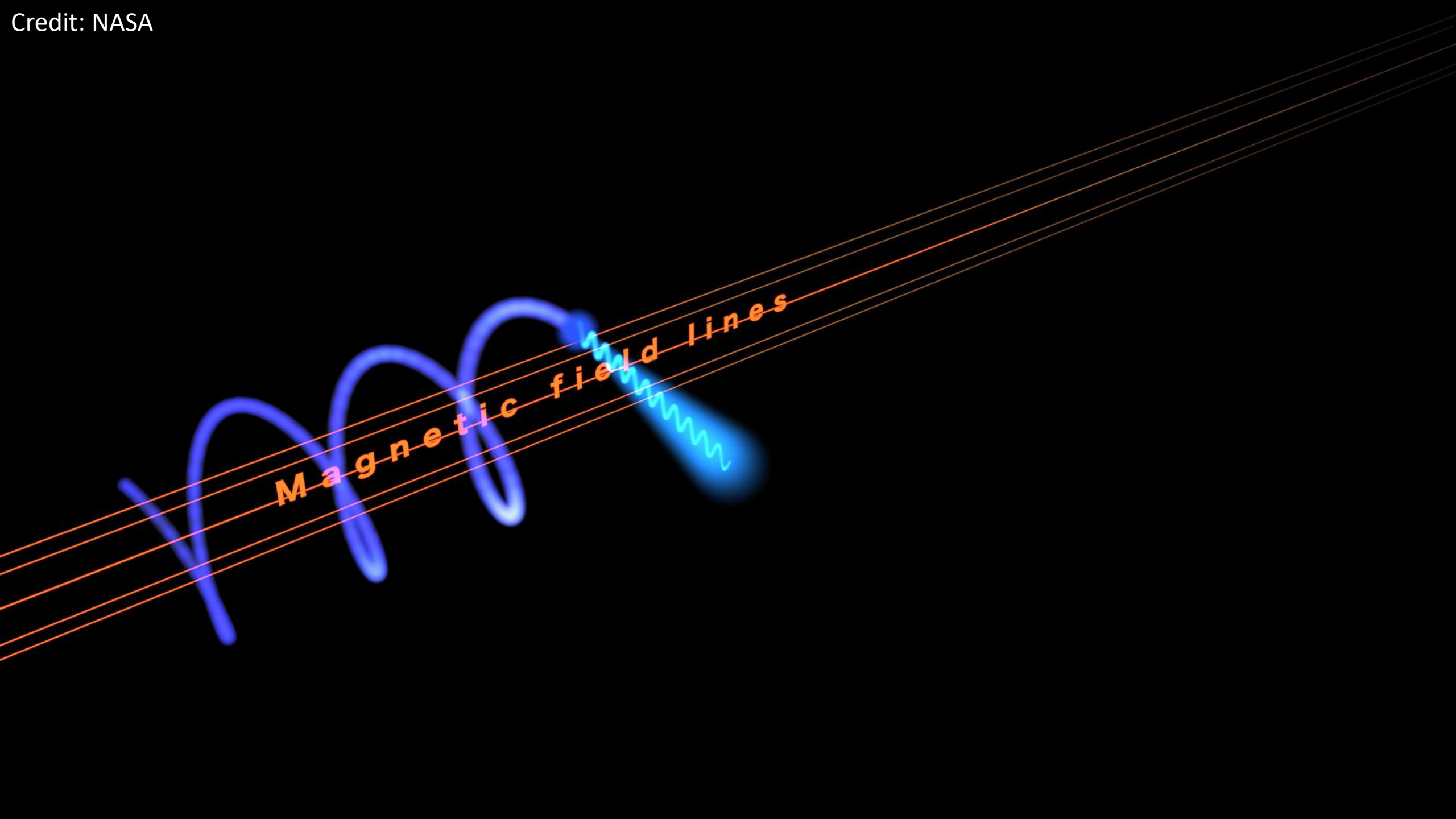
- Trigger from Fermi-GBM on Oct 9 @ 13.17 UTC
- IXPE ToO request sent on Oct 10 @ 11:48 UTC
- IXPE observation:
 - Starts on: Oct 11 @ 23:35 UTC
 - Ends on: Oct 14 @ 00:46 UTC
 - Total livetime: 94,122 s

IXPE Observation of GRB 221009A



Why should GRB afterglows be polarized?

And what can we learn from polarization measurements?

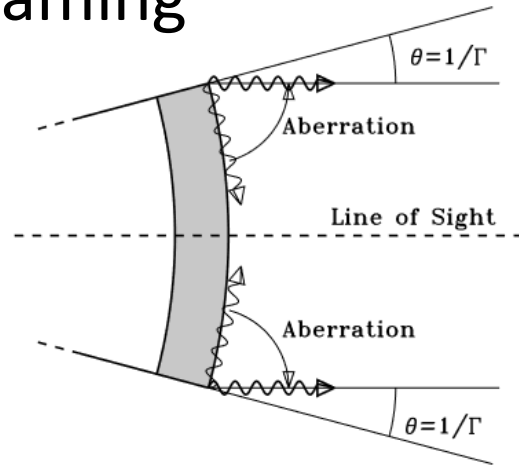


Magnetic field lines

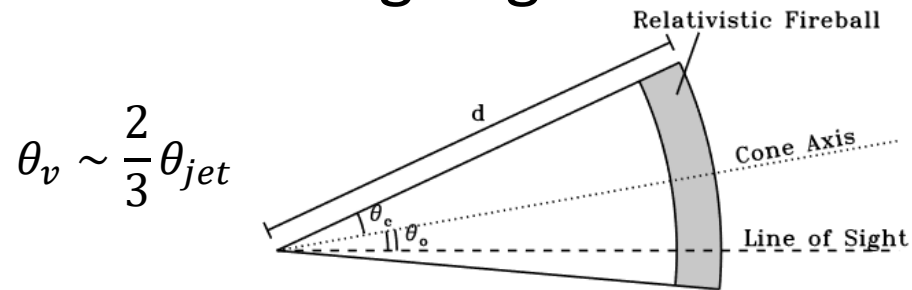
GRB Afterglow Polarization

Shimoda & Toma 2021
Granot et al. 1999

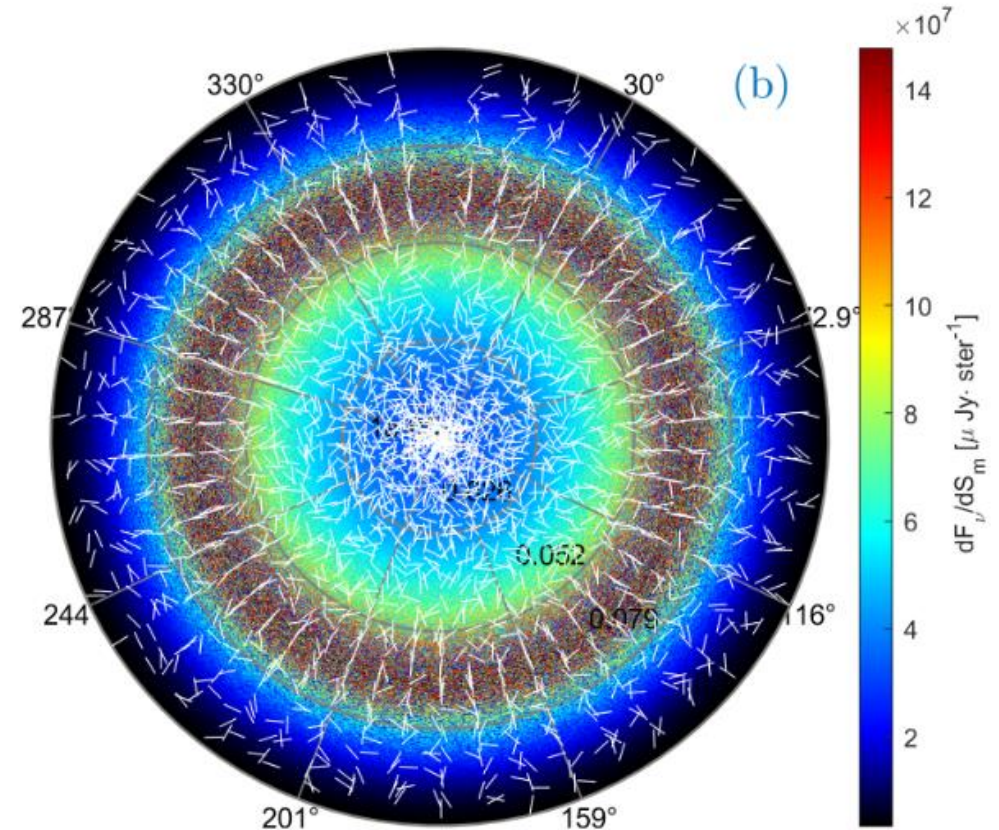
- Doppler beaming



- Off-axis viewing angle

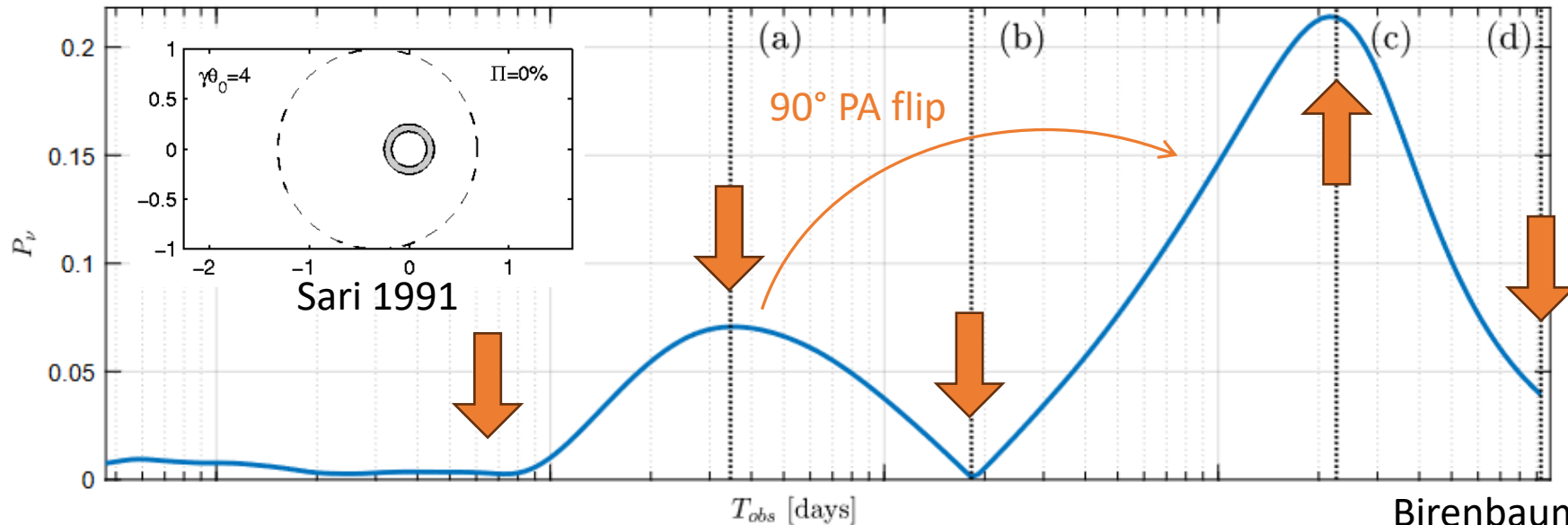
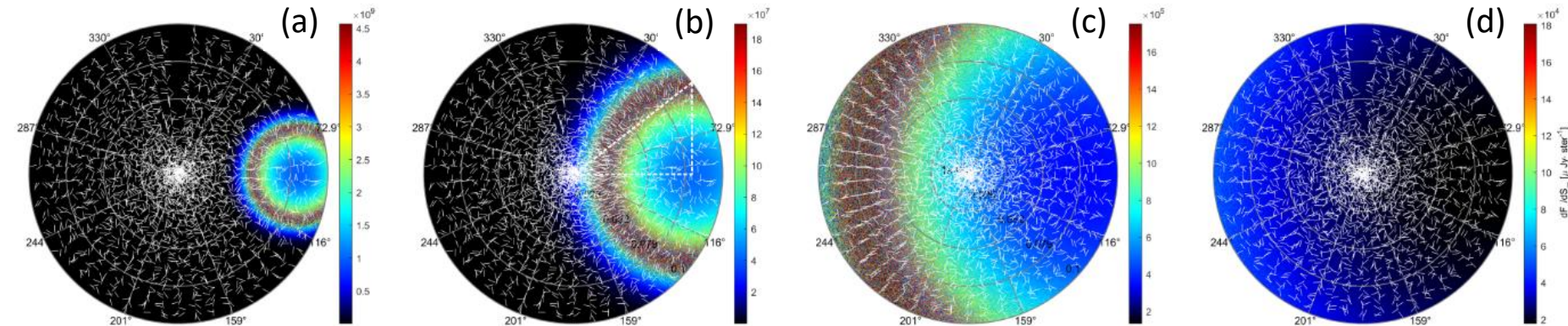


Ghisellini & Lazzati 1999



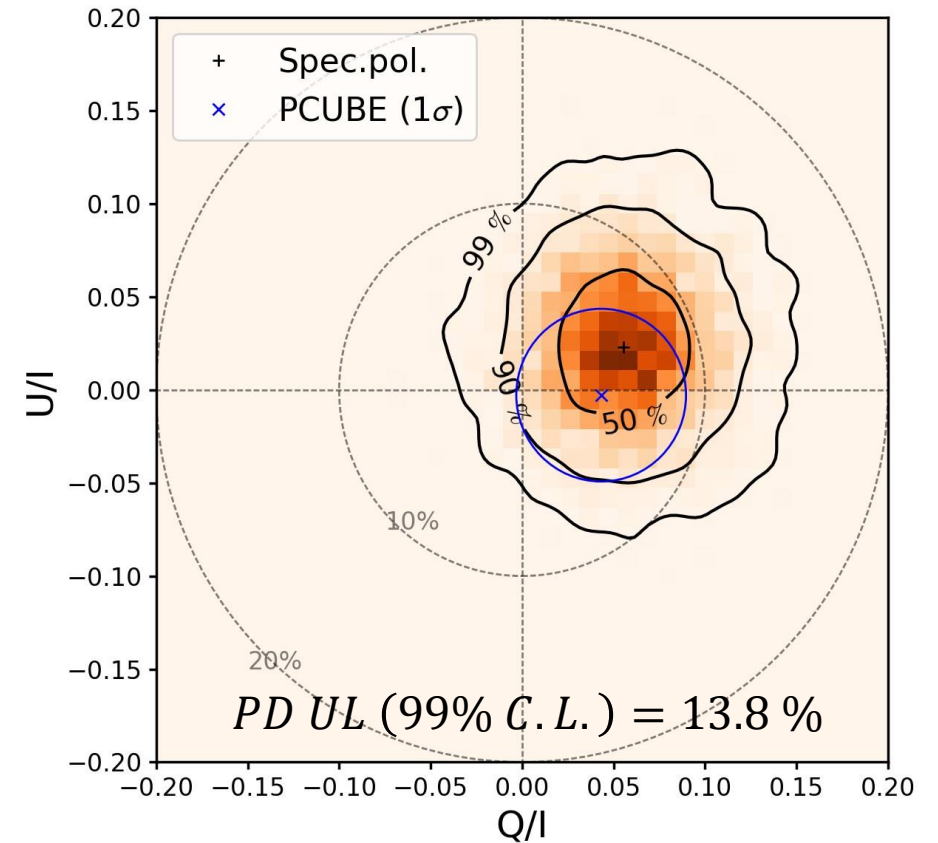
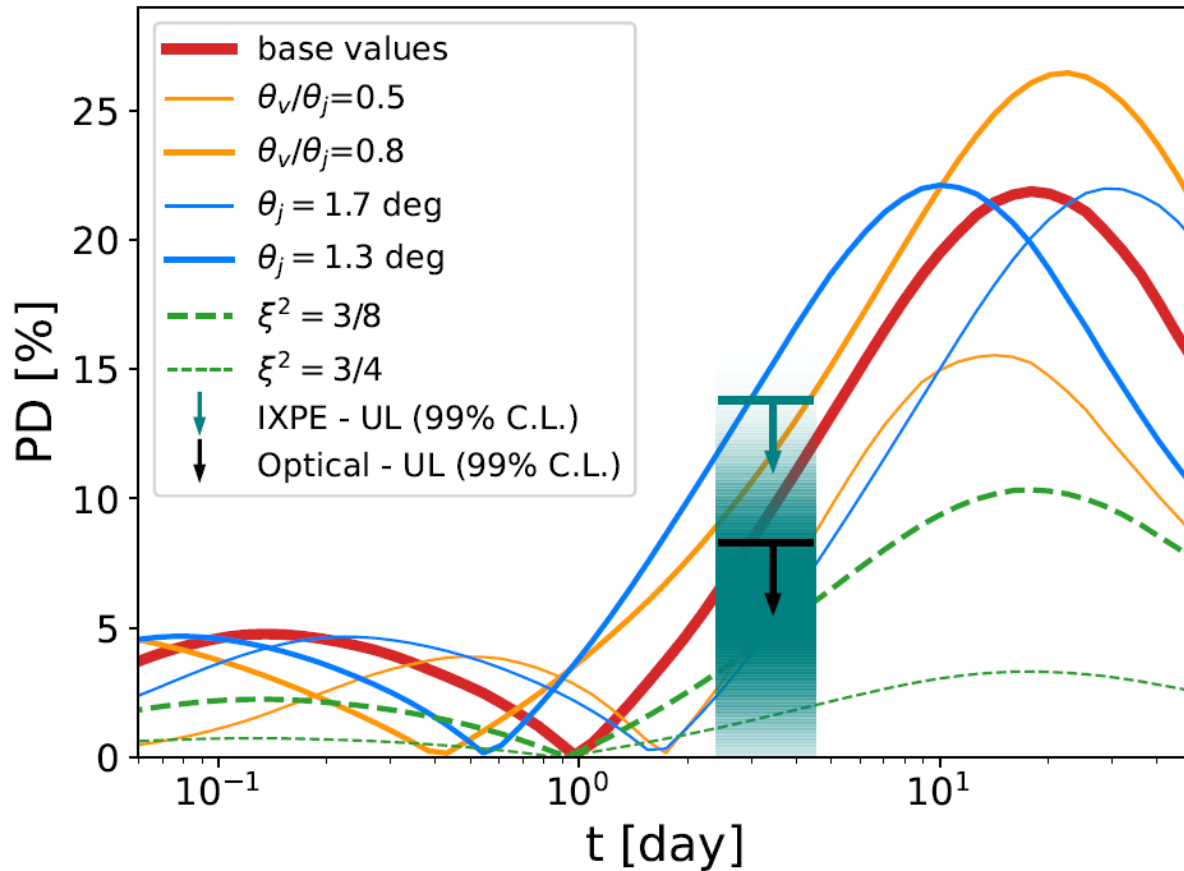
Birenbau & Bromberg 2021

Afterglow Polarization for an Off-axis GRB

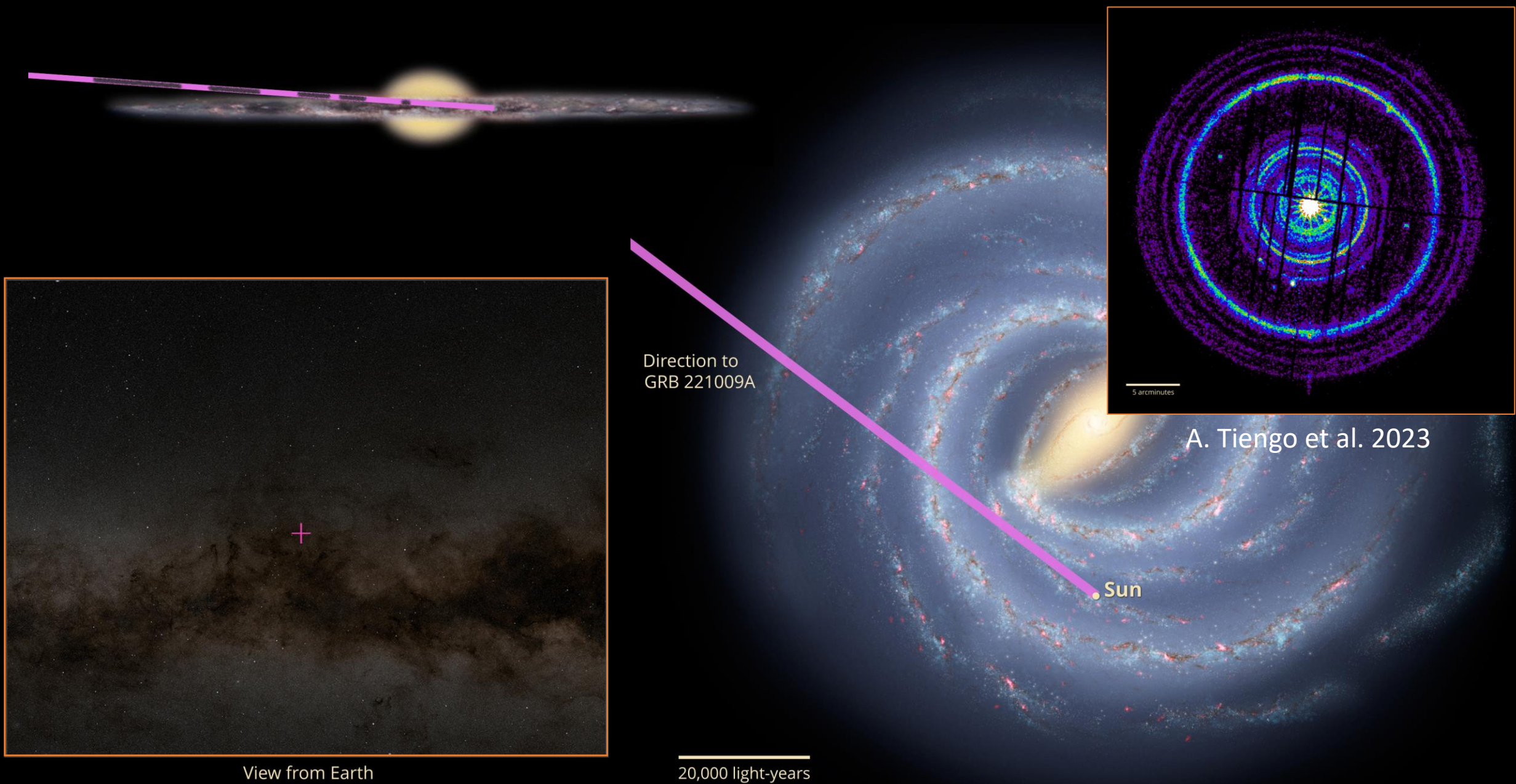


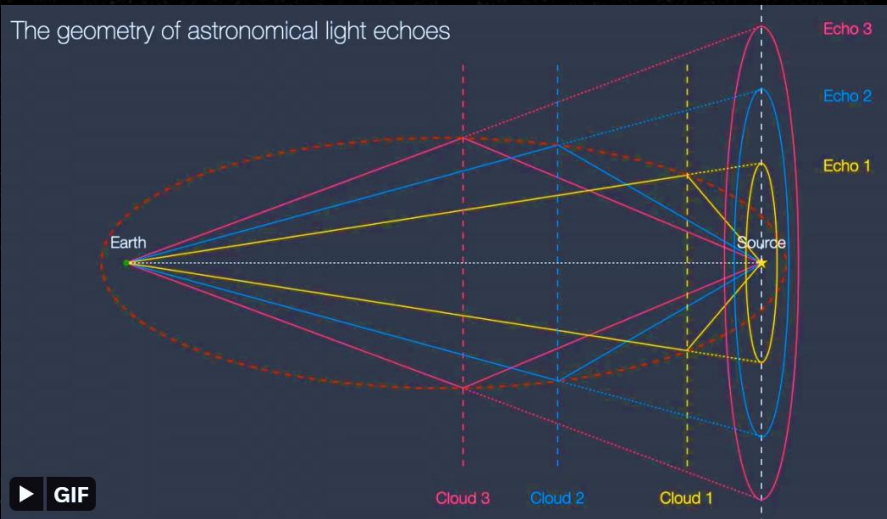
Birebaum & Bromberg 2021

IXPE Afterglow Polarization Measurement



Models with $\theta_j \gtrsim 1.5^\circ$ and $\theta_v/\theta_j \lesssim 2/3$ are favored

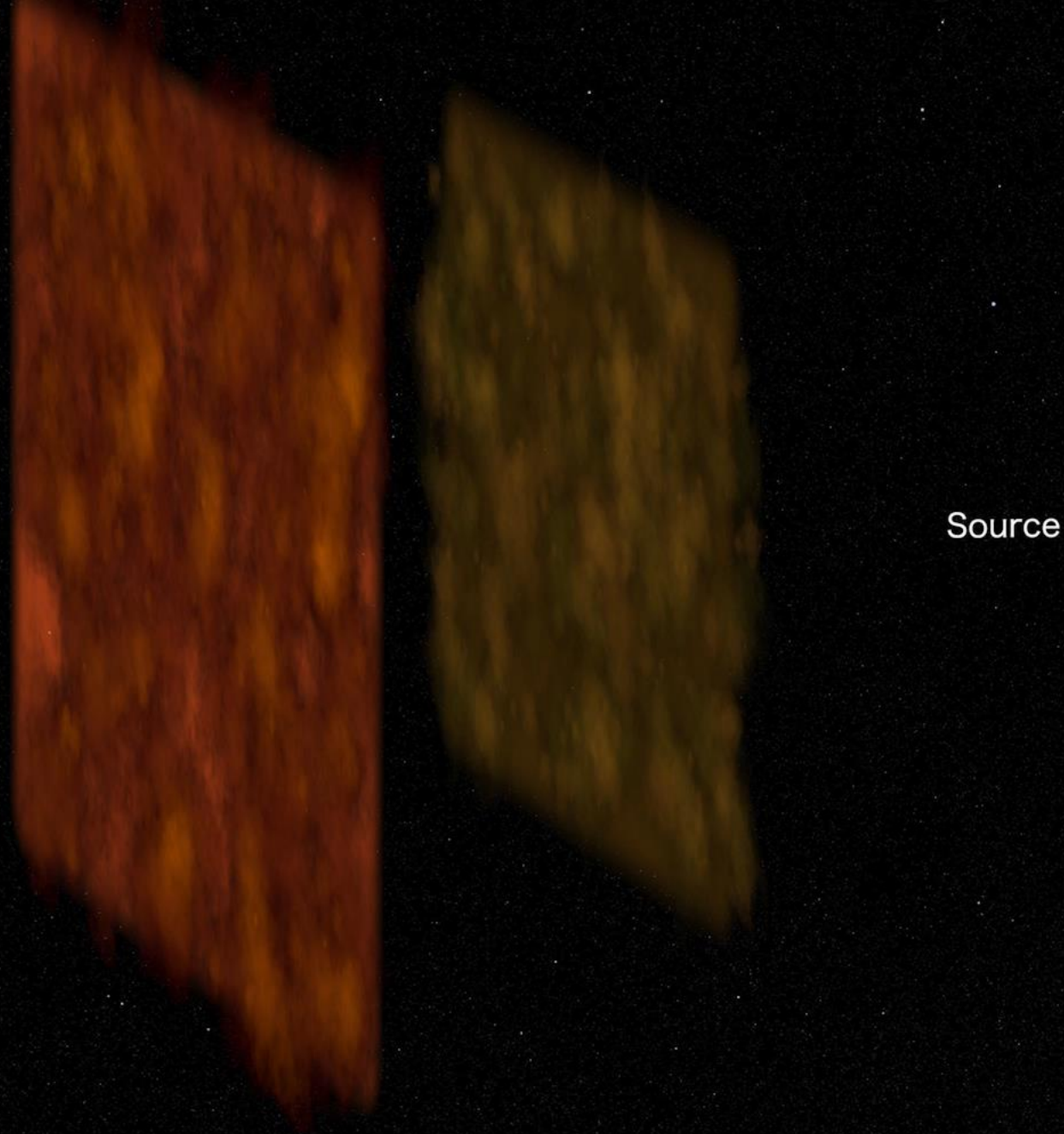




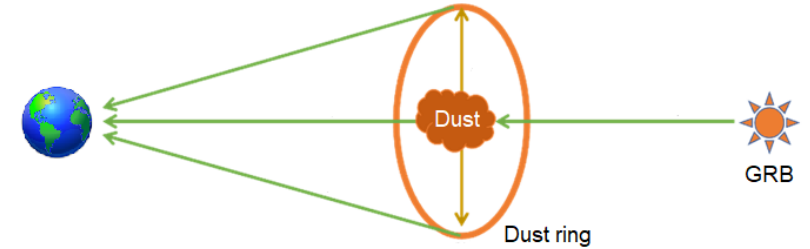
Credits: Mark McCaughrean



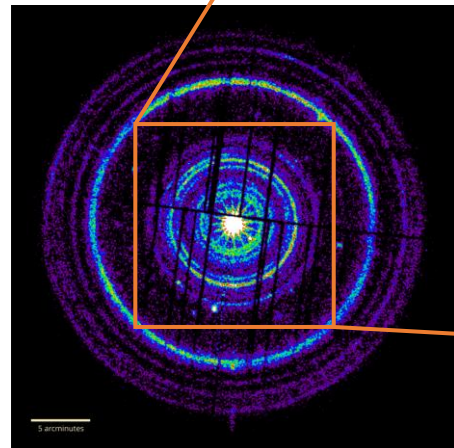
Earth



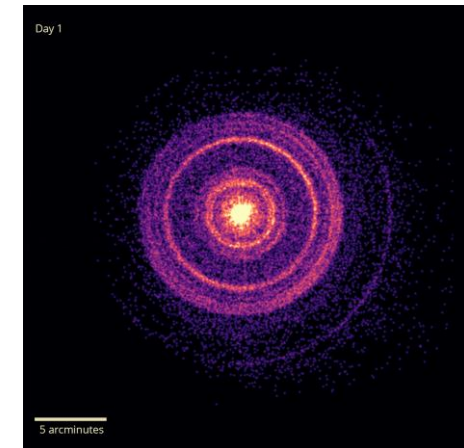
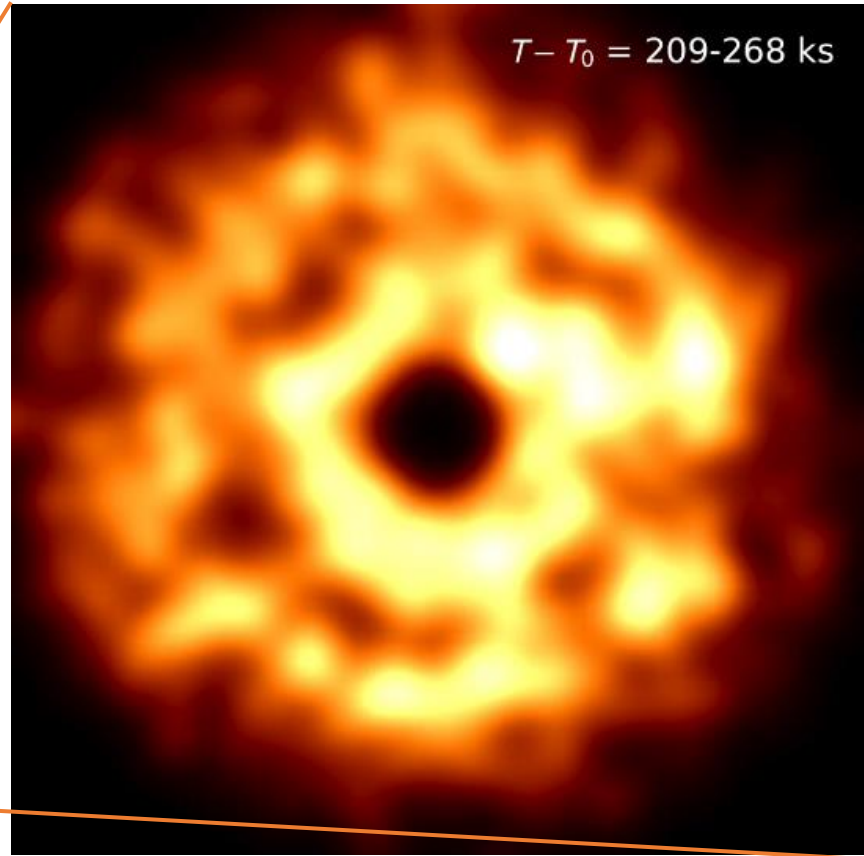
GRB Prompt Emission Echo



Dust rings are the echo of the GRB prompt emission and are expanding in time!

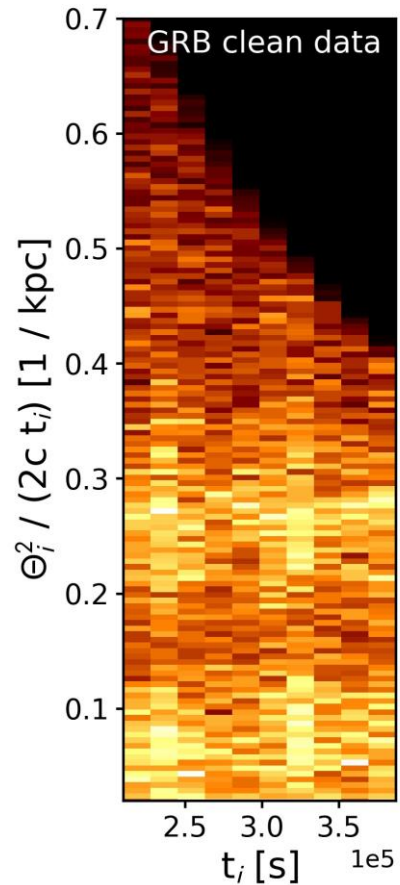


A. Tiengo et al. 2023

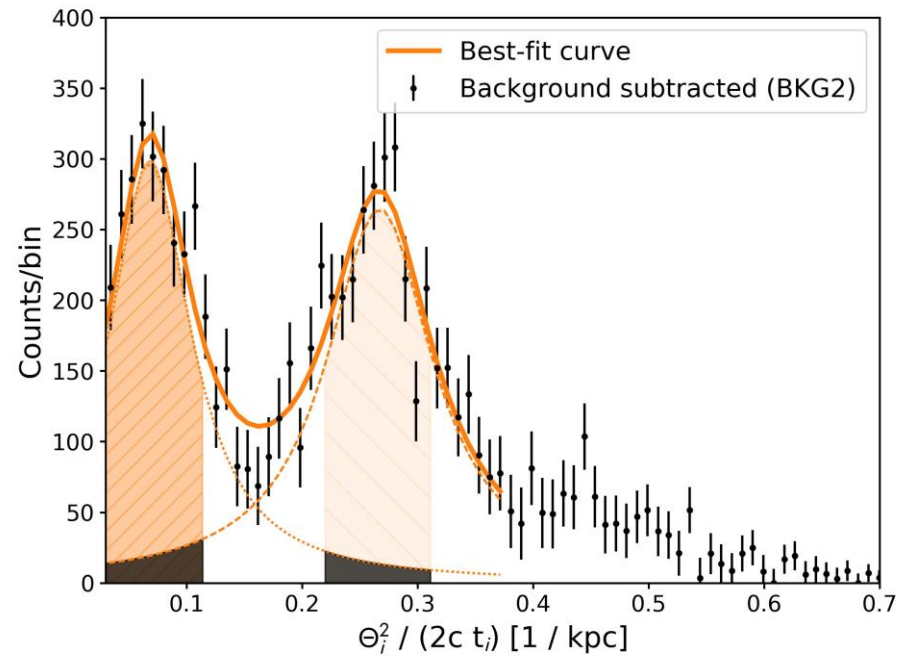


Credit: NASA/Swift/A. Beardmore

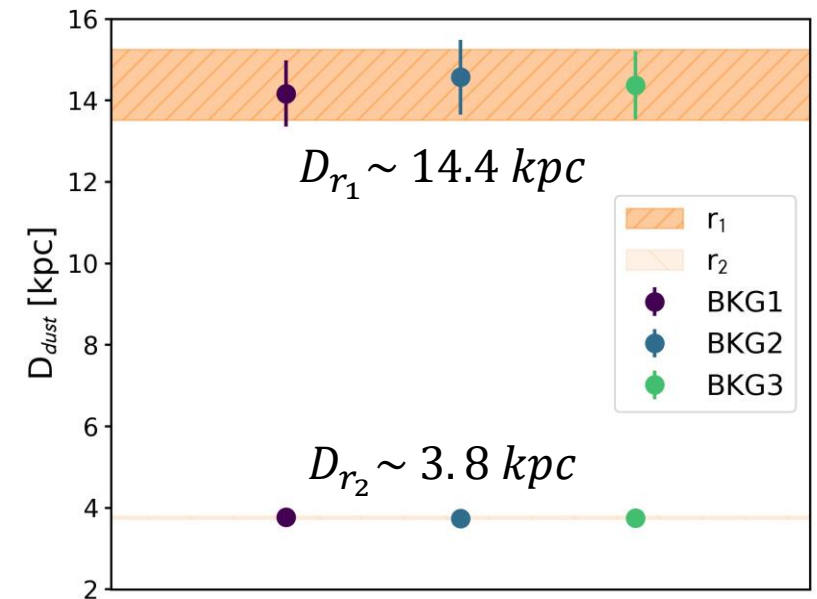
Dust Rings Selection

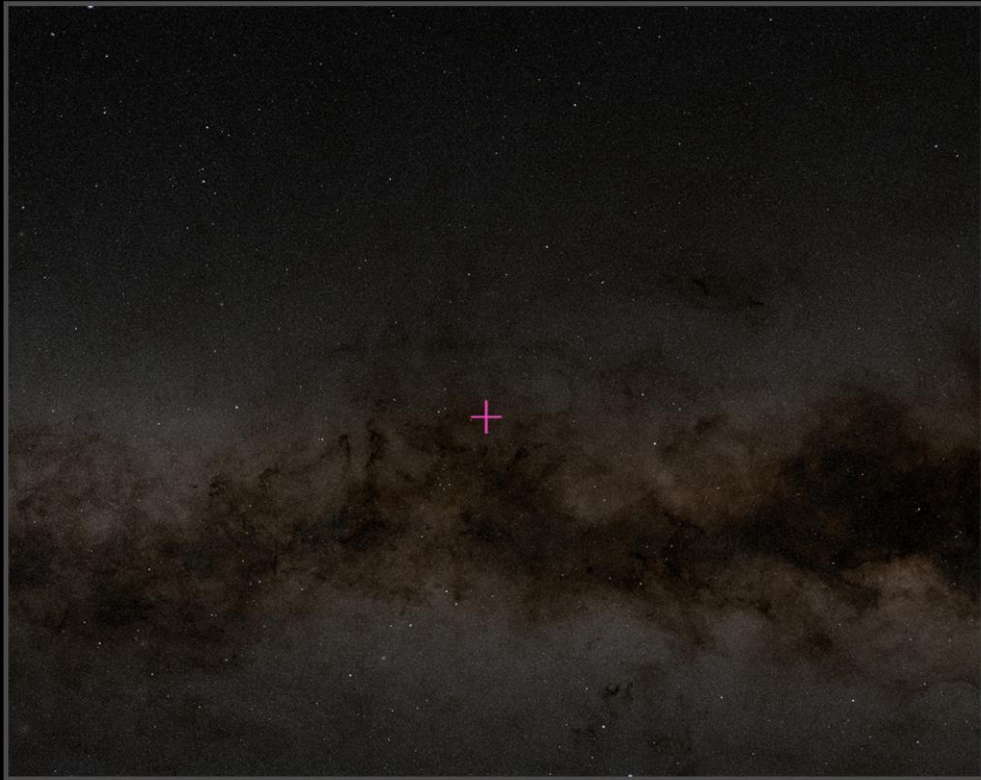


Time-dependent cut to select the expanding rings inspired by [Tiengo, A., & Mereghetti, S. 2006]



$$D_{dust} = 2c \frac{\Delta t}{\theta_i^2}$$





View from Earth

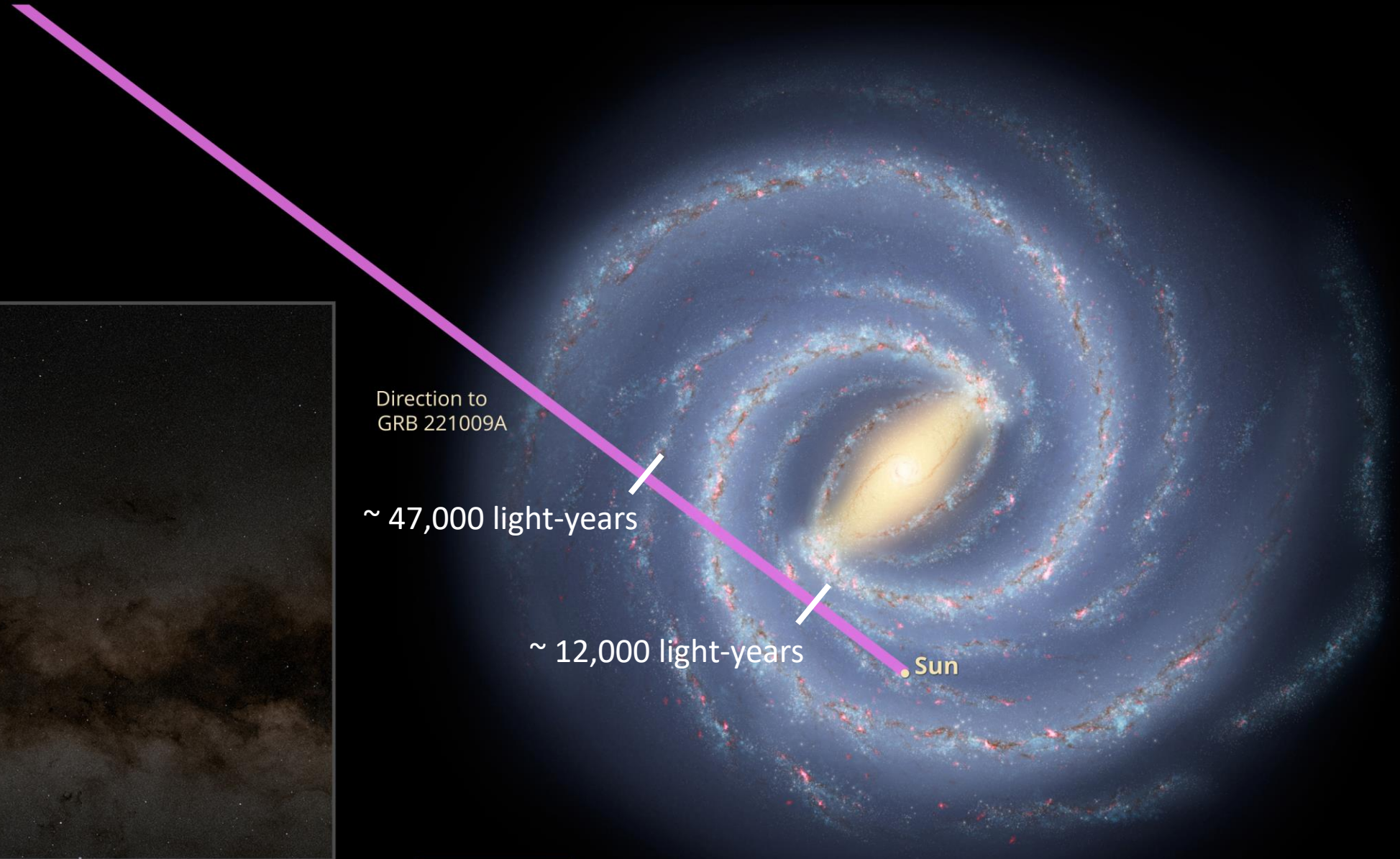
Direction to
GRB 221009A

~ 47,000 light-years

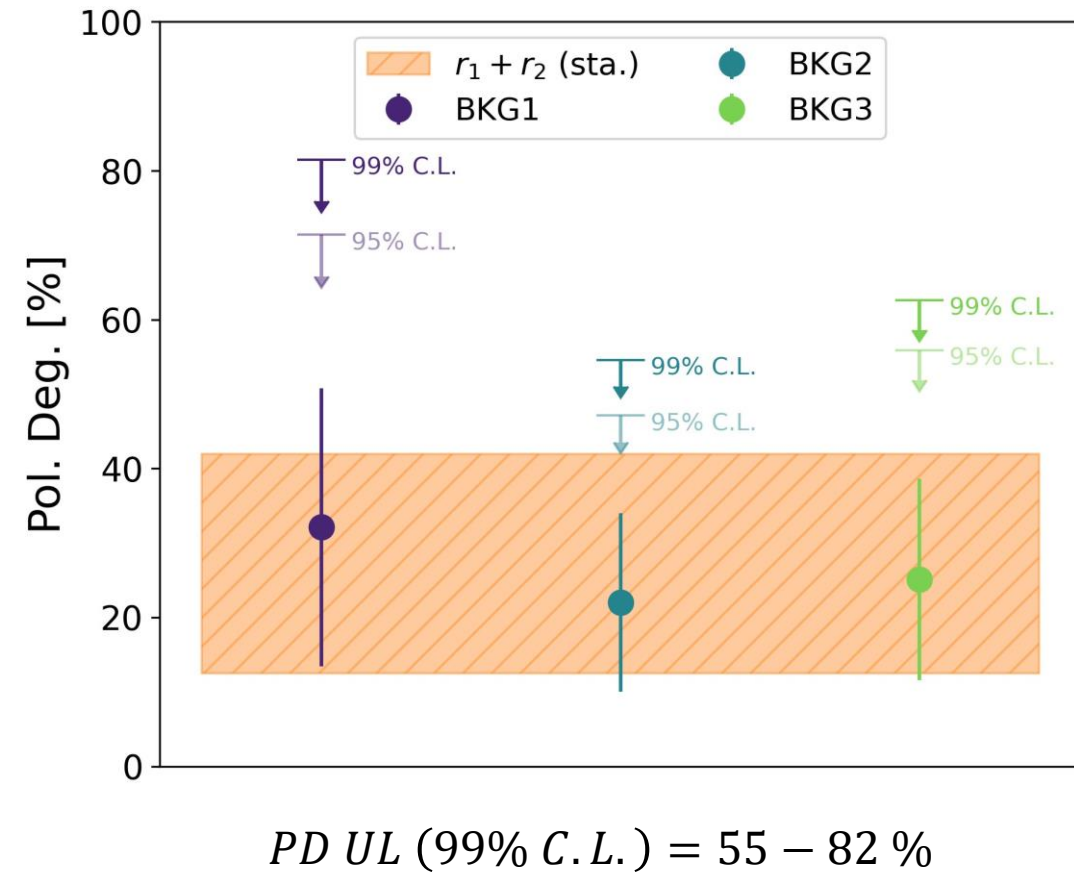
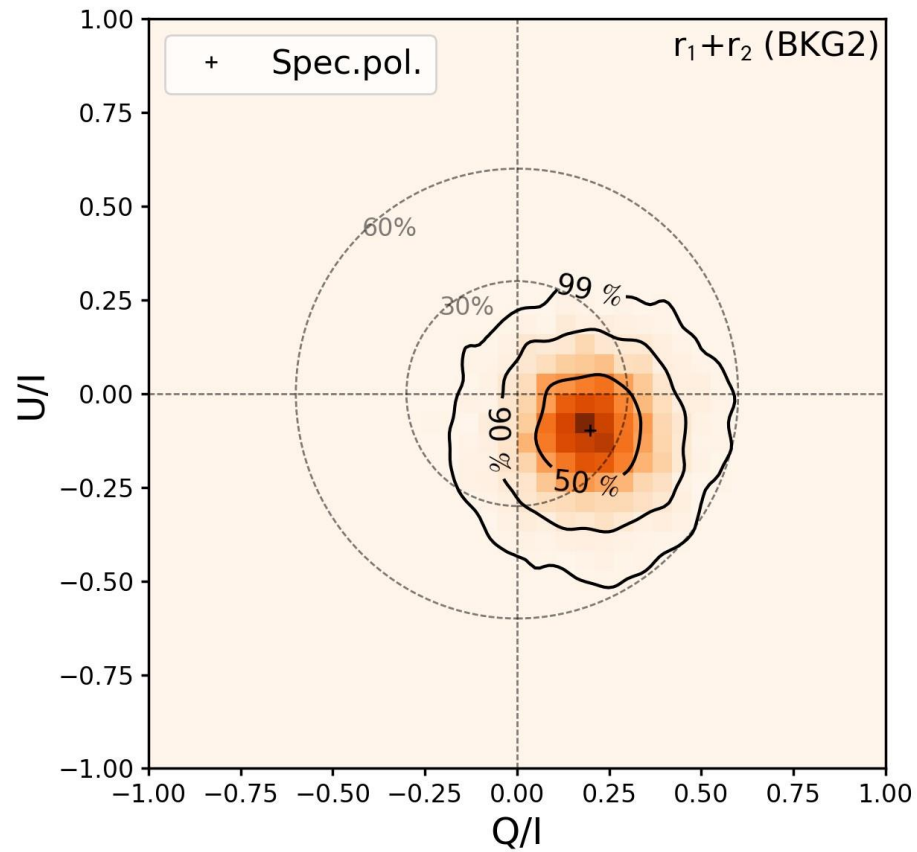
~ 12,000 light-years

Sun

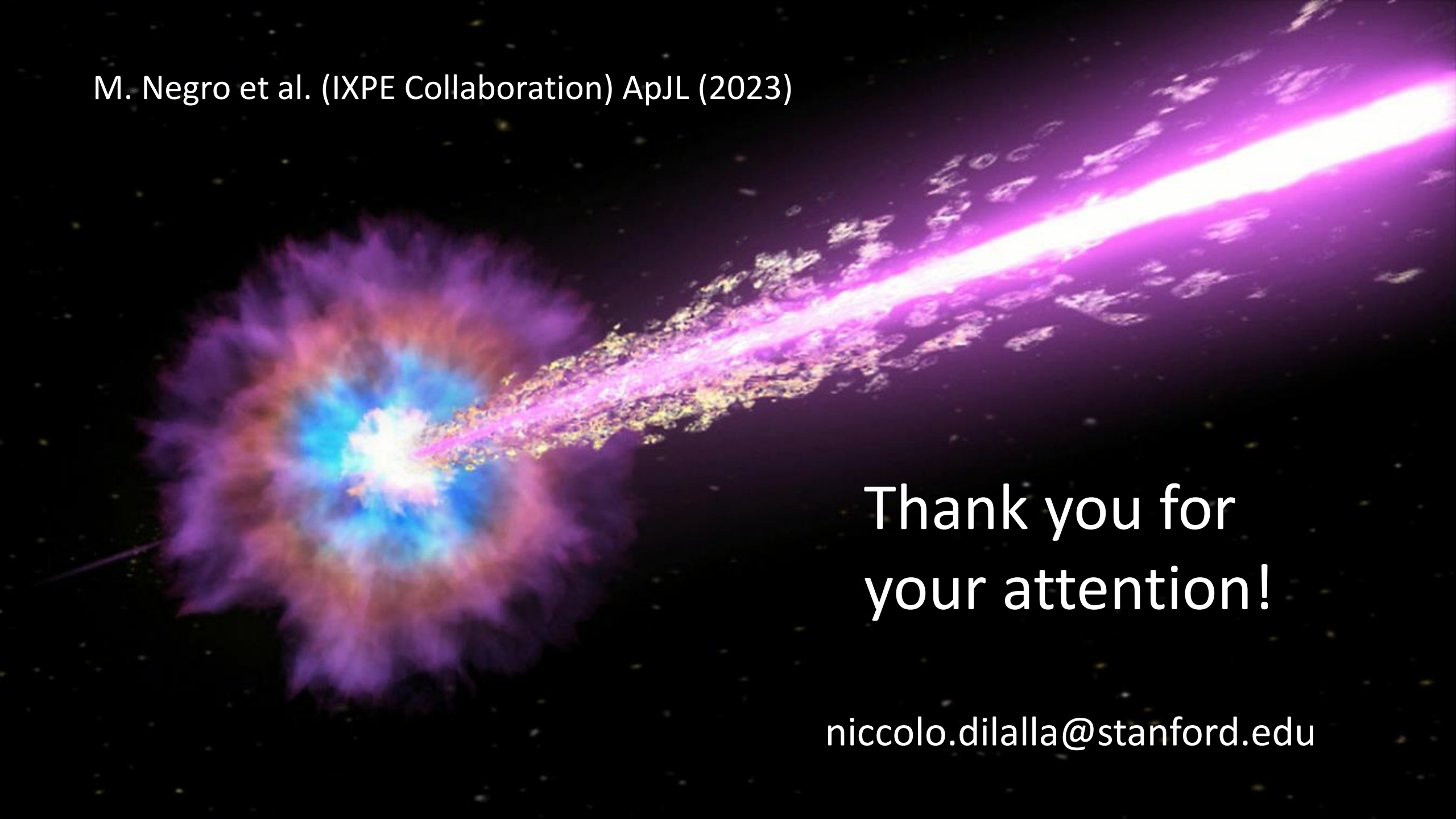
20,000 light-years



IXPE Prompt Polarization Measurement



M. Negro et al. (IXPE Collaboration) ApJL (2023)



Thank you for
your attention!

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