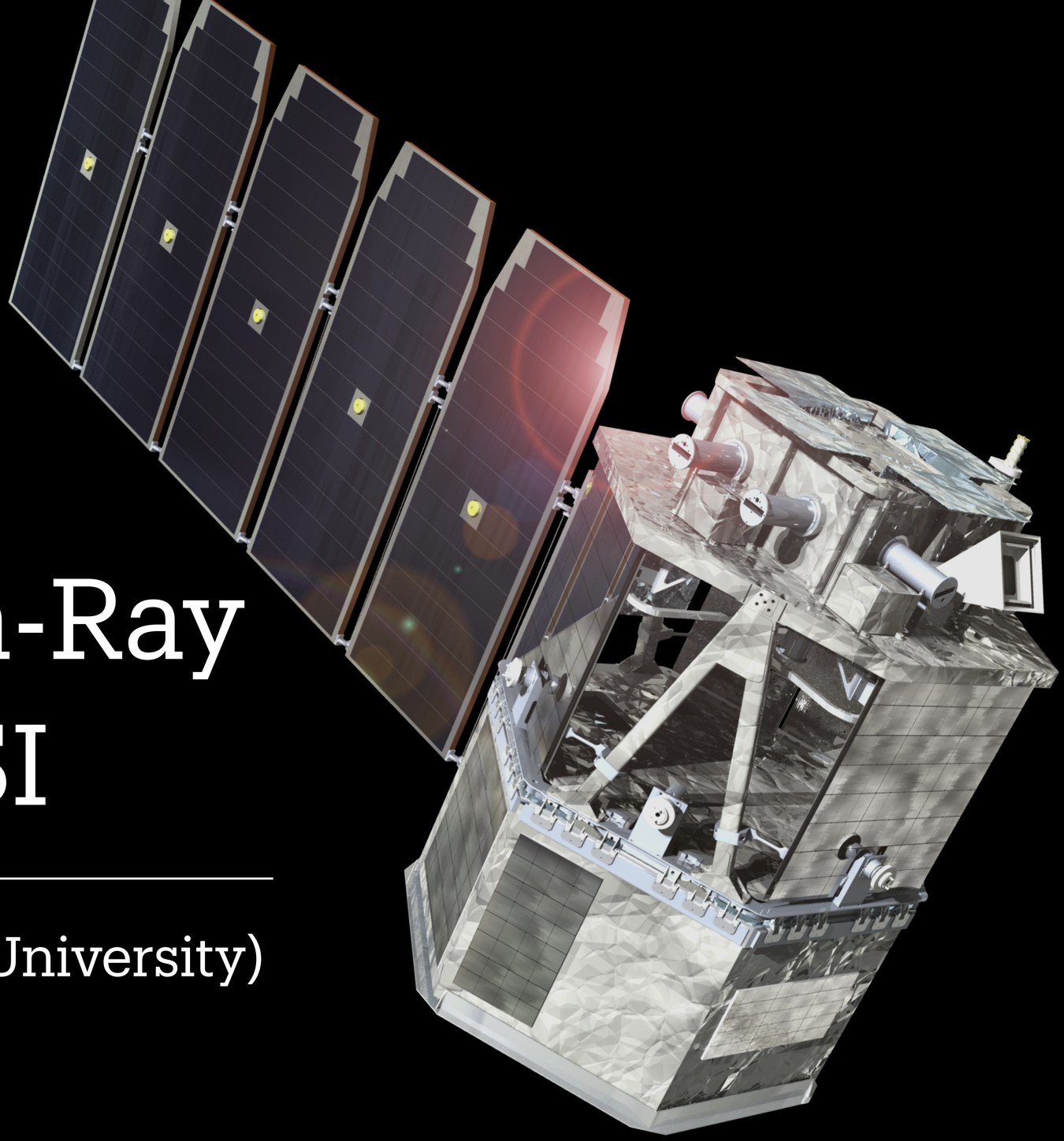
NASA Goddard SPACE FLIGHT CENTER

THE GEORGE WASHINGTON UNIVERSITY
WASHINGTON, DC



Studying Gamma-Ray Bursts Using COSI

Eliza Neights (George Washington University)
on behalf of the COSI science team

COSI Collaboration

University of California

- John Tomsick (Principal Investigator, UCB)
- Steven Boggs (Deputy PI, UCSD)
- Andreas Zoglauer (Project Scientist, UCB)

Naval Research Laboratory

- Eric Wulf (Electronics & BGO shield lead)

Goddard Space Flight Center

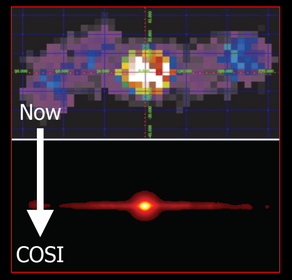
- Albert Shih (CHRS lead)
- Carolyn Kierans (Data pipeline co-lead)

Northrop Grumman

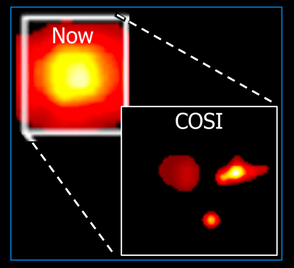
Institutions of Co-Investigators and Collaborators

- Clemson University
- Louisiana State University
- Los Alamos National Laboratory
- Lawrence Berkeley National Laboratory
- IRAP, France
- INAF & ASI, Italy
- Kavli IPMU & Nagoya University, Japan
- JMU (Würzburg) & JGU (Mainz), Germany
- NTHU, Taiwan
- University of Hertfordshire, UK
- Centre for Space Research, North-West University, South Africa
- Deutsches Elektronen Synchrotron (DESY), Germany
- LAPTh-CNRS, France
- Yale University
- Stanford University
- Washington University, St. Louis

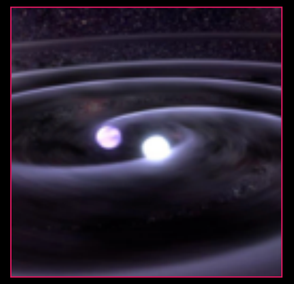
COSI's Science Goals



Uncover the origin of Galactic positrons



Reveal Galactic element formation

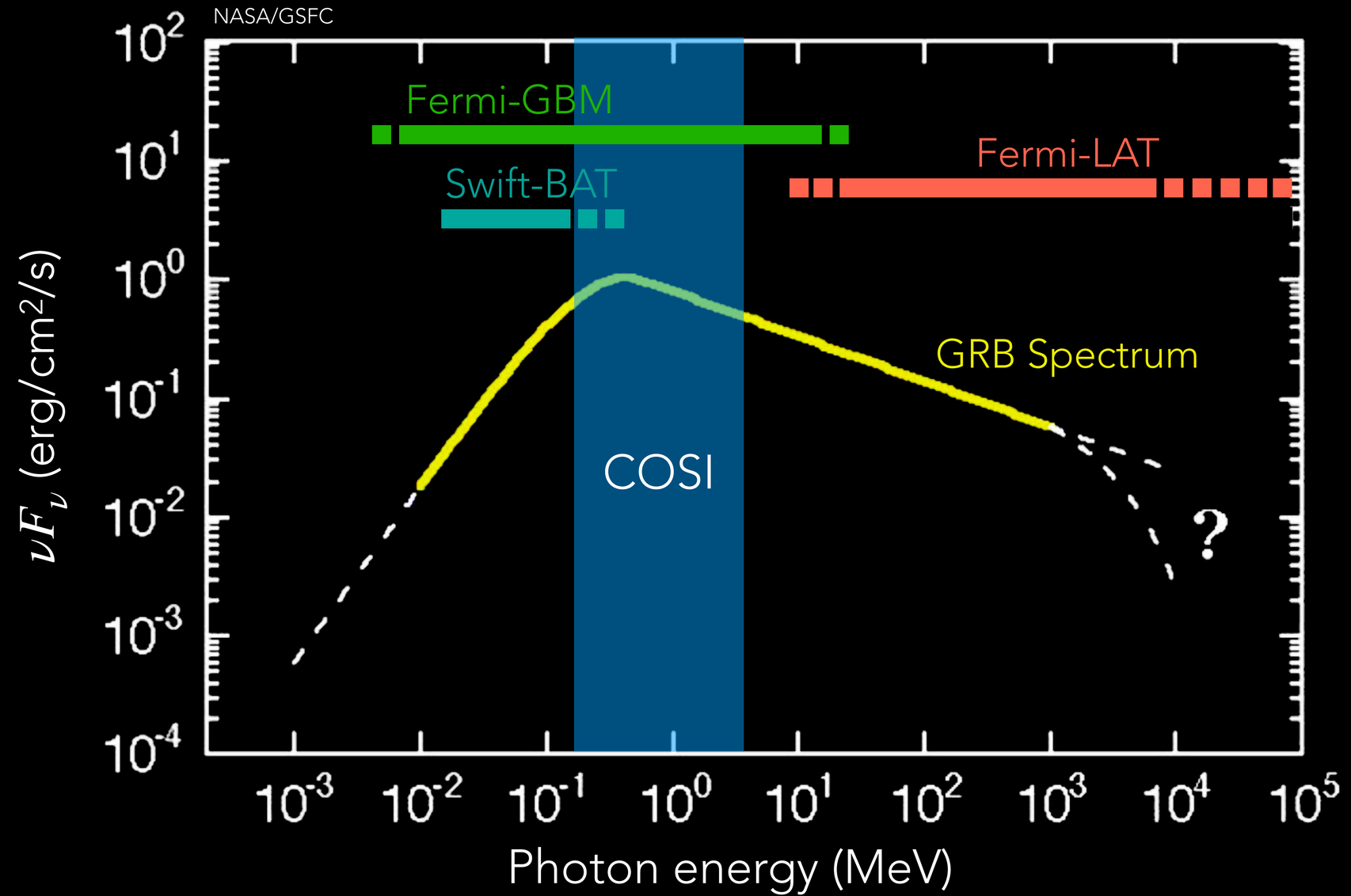


Probe the physics of multimessenger events

Gain insight into extreme environments with polarization

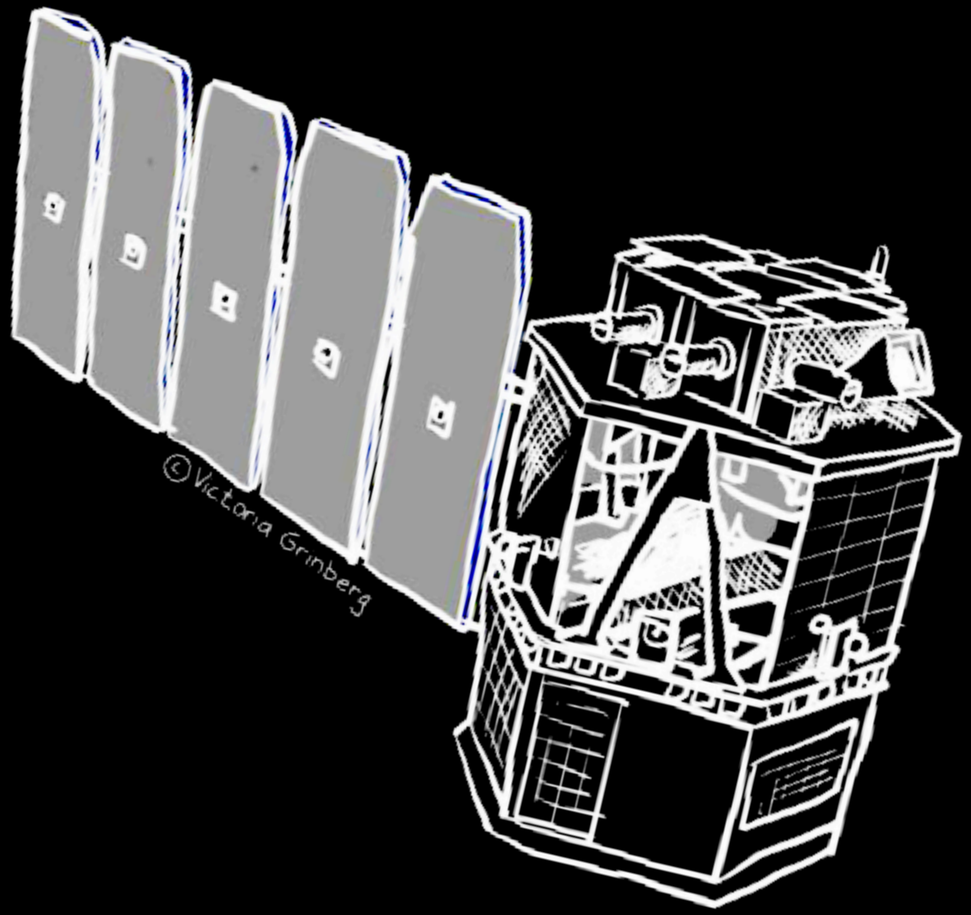
Tomsick et al. 2023

COSI's Energy Range



Compton Spectrometer & Imager (COSI)

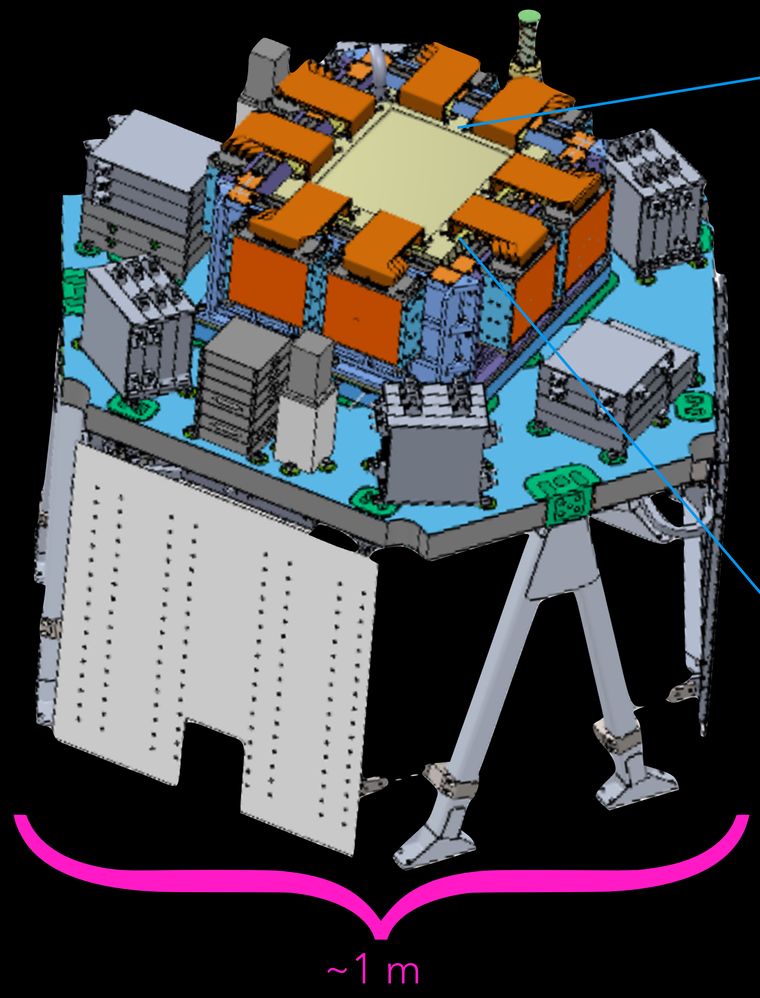
- Soft gamma-ray (0.2-5 MeV) telescope
- 2-year prime mission with a planned launch in 2027
- Imaging, spectroscopy, & polarimetry
- Low-Earth orbit with ~0° inclination
- Daily full sky survey and large field-of-view (25% of sky)



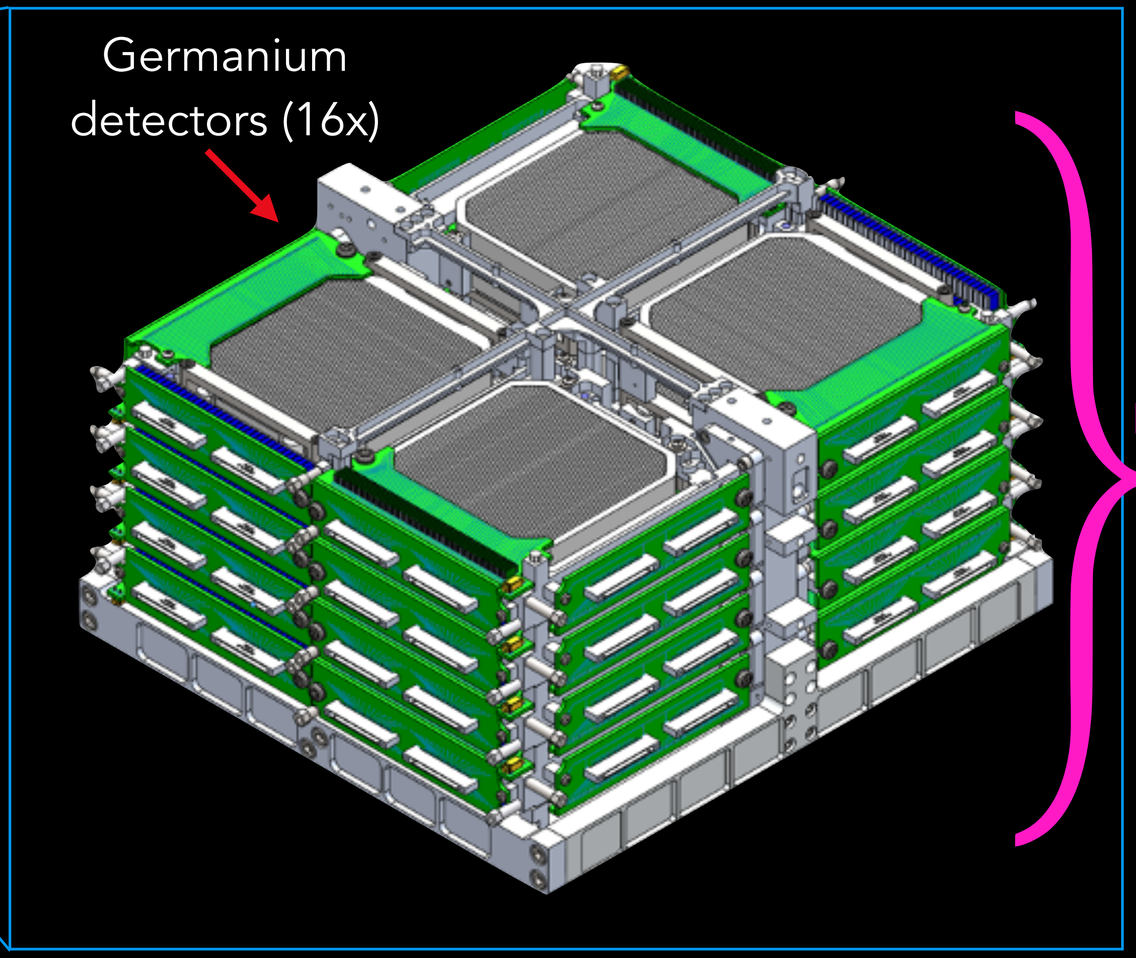
Great for studying GRBs!

Tomsick et al. 2023

COSI Instrument

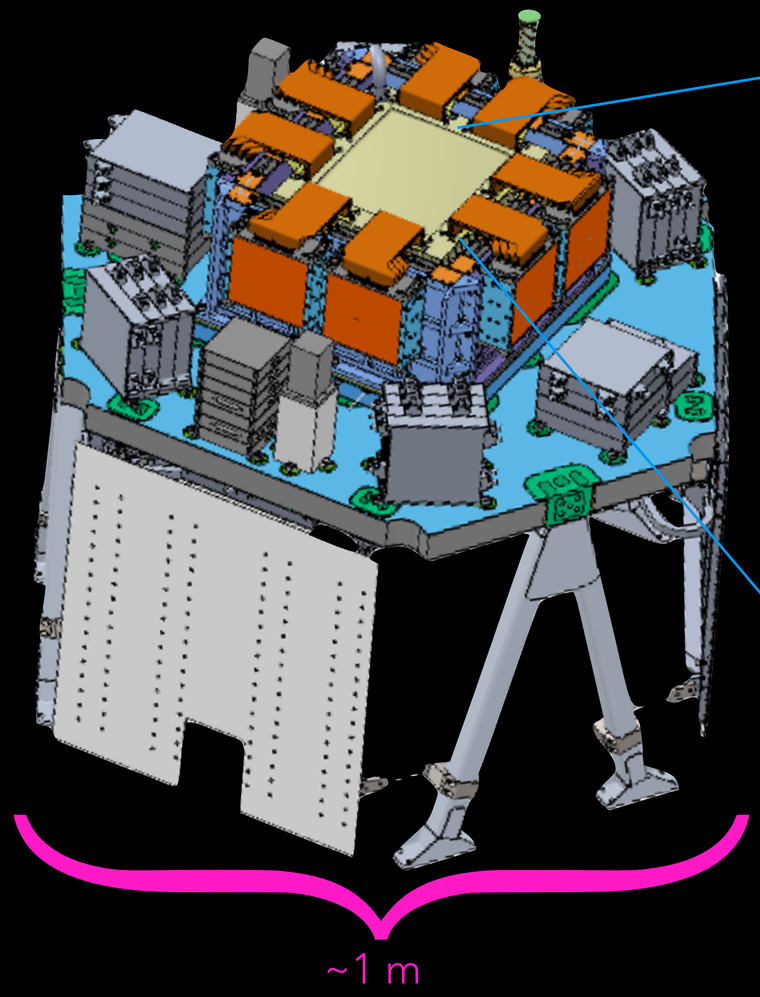


COSI instrument and spacecraft

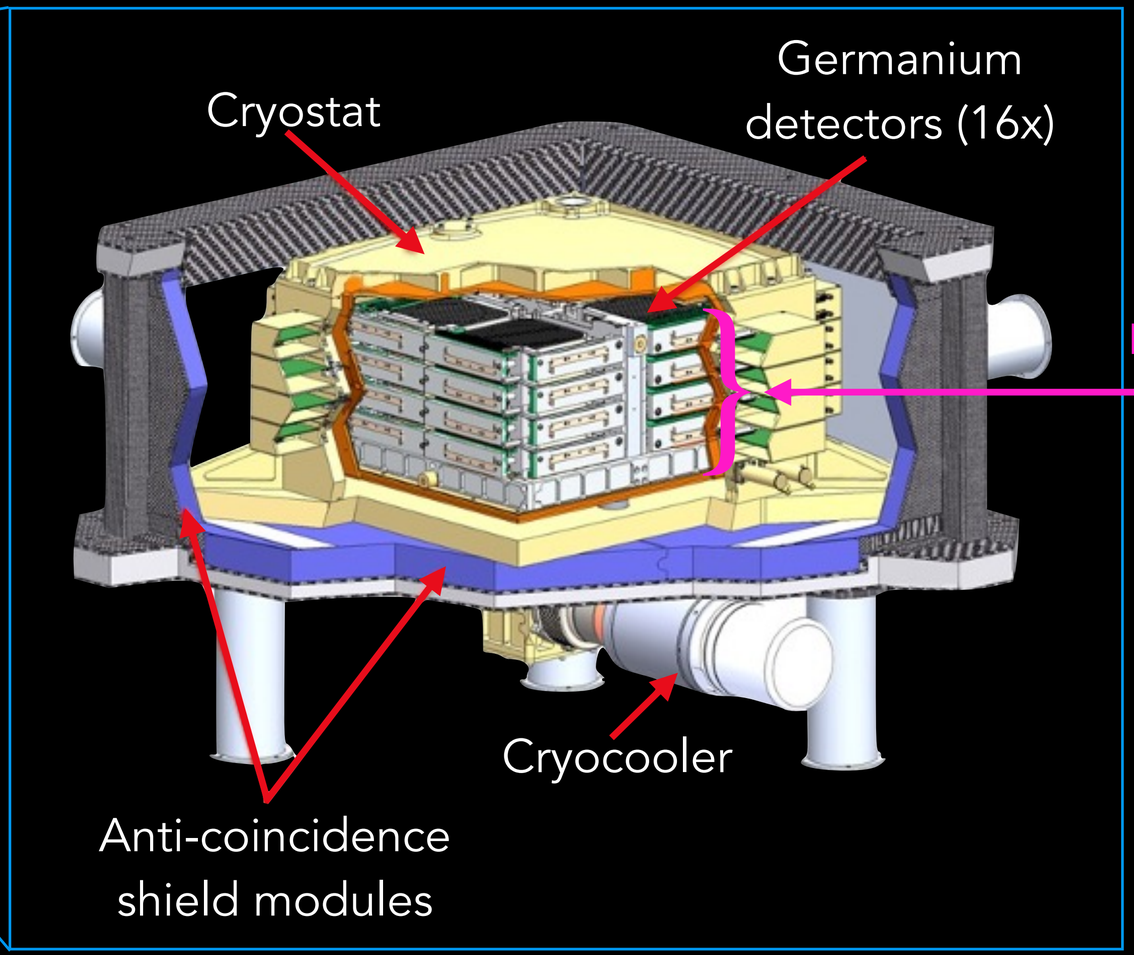


COSI detectors

COSI Instrument

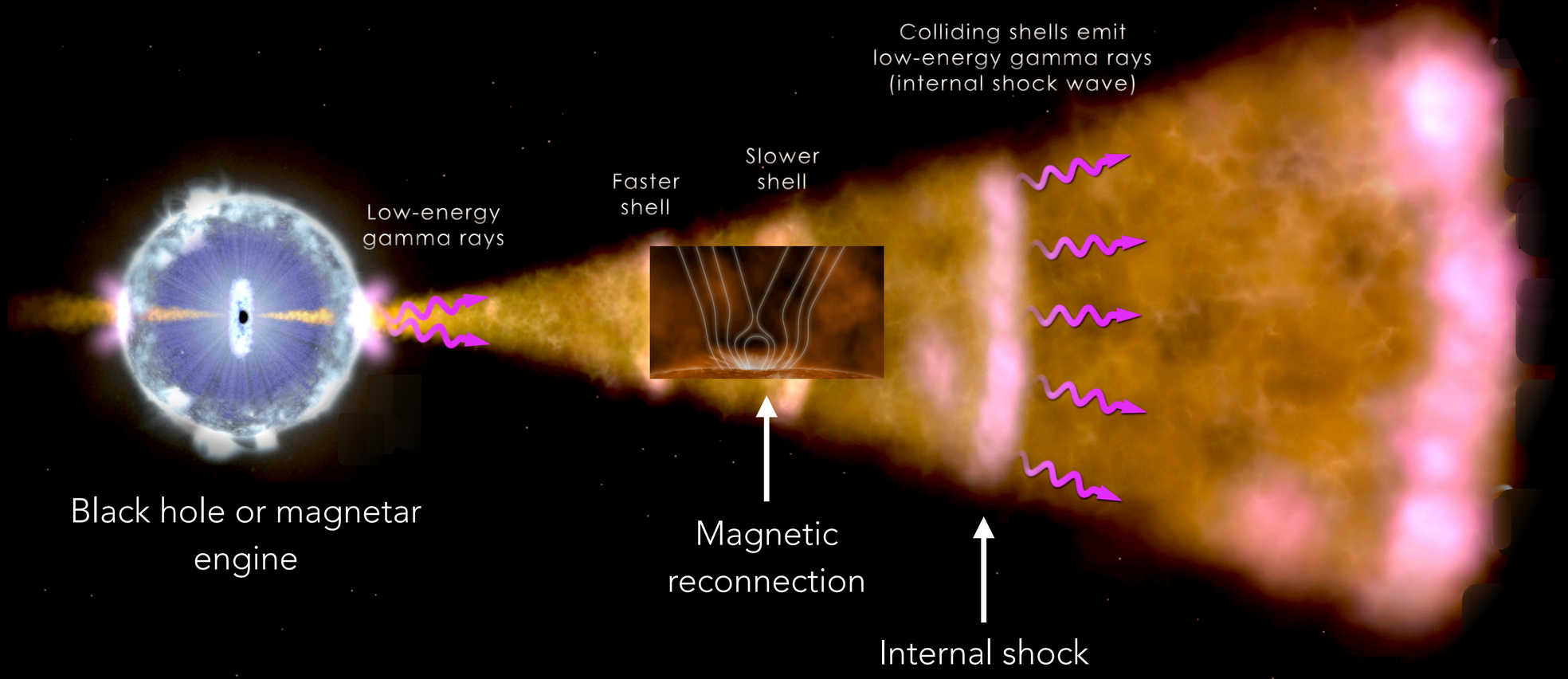


COSI instrument and spacecraft



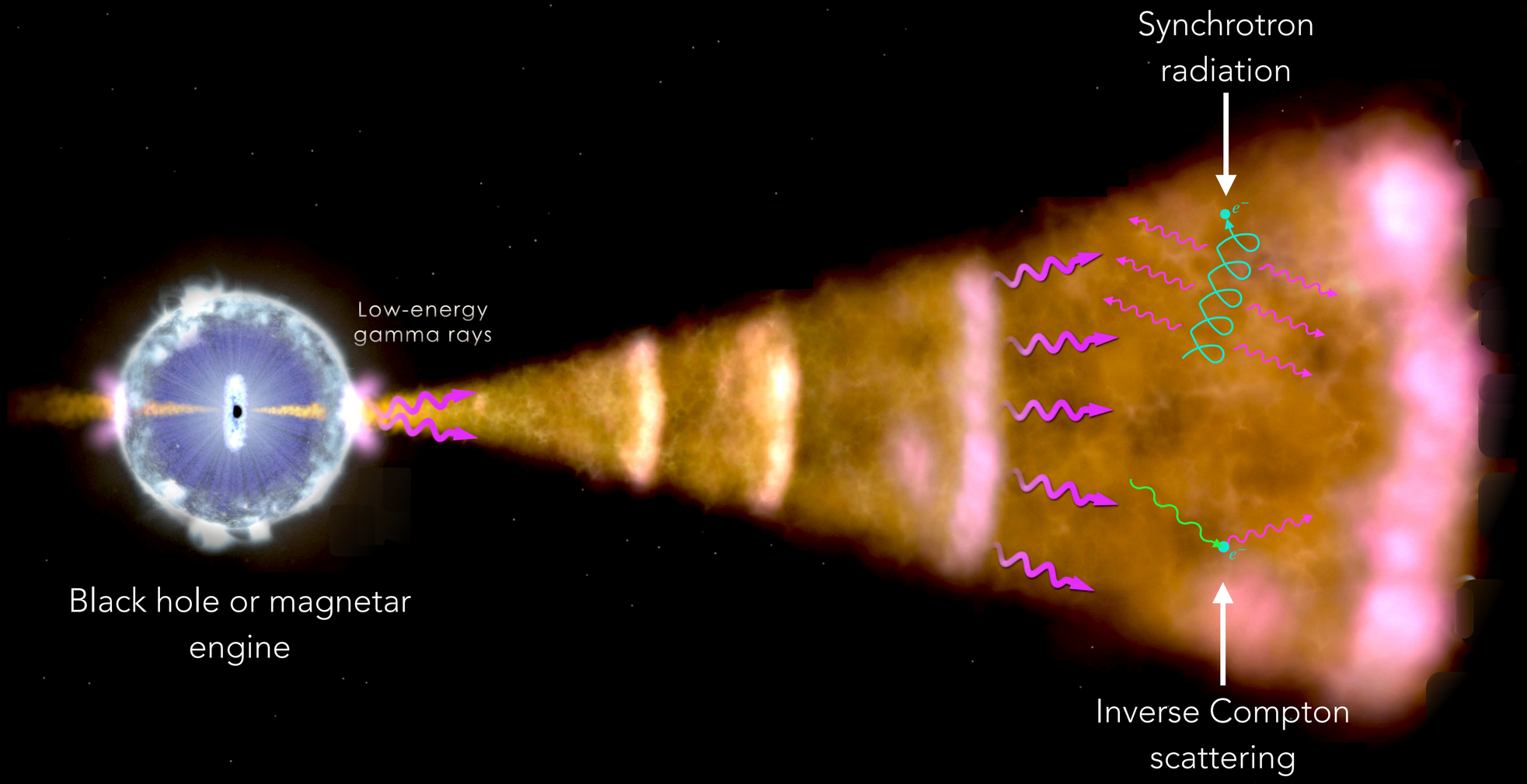
COSI detectors and shields

Gamma-Ray Bursts (GRBs)



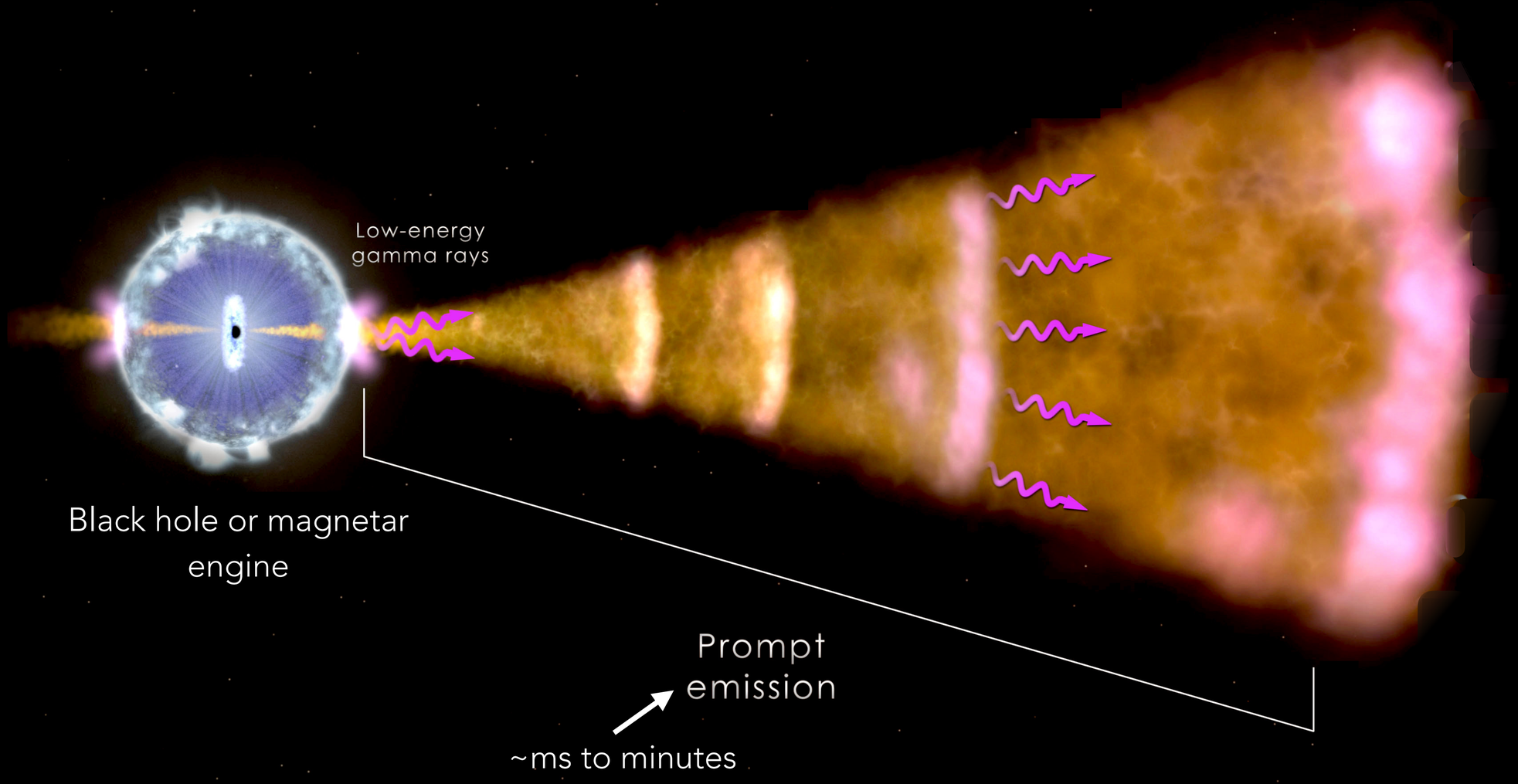
NASA/GSFC

Gamma-Ray Bursts (GRBs)



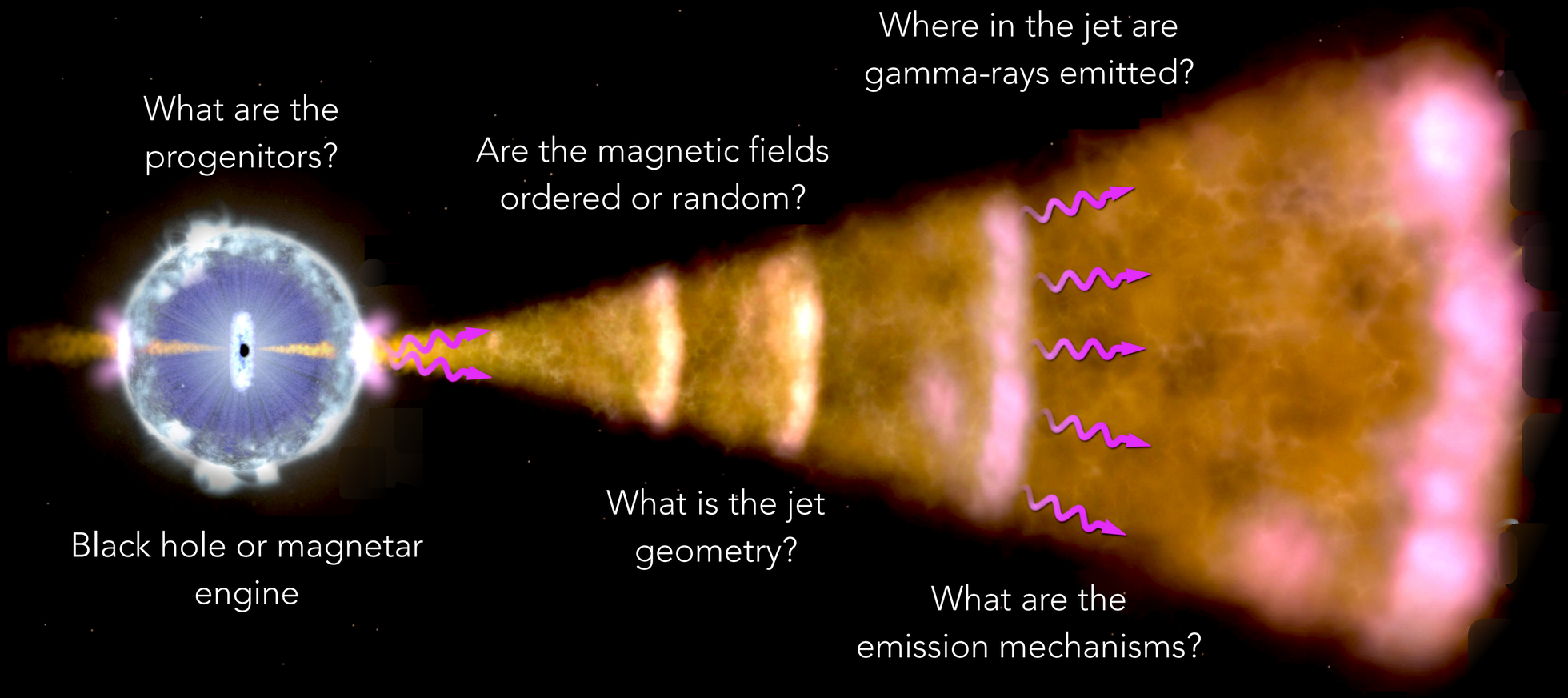
NASA/GSFC

Gamma-Ray Bursts (GRBs)



NASA/GSFC

GRB Open Questions



NASA/GSFC

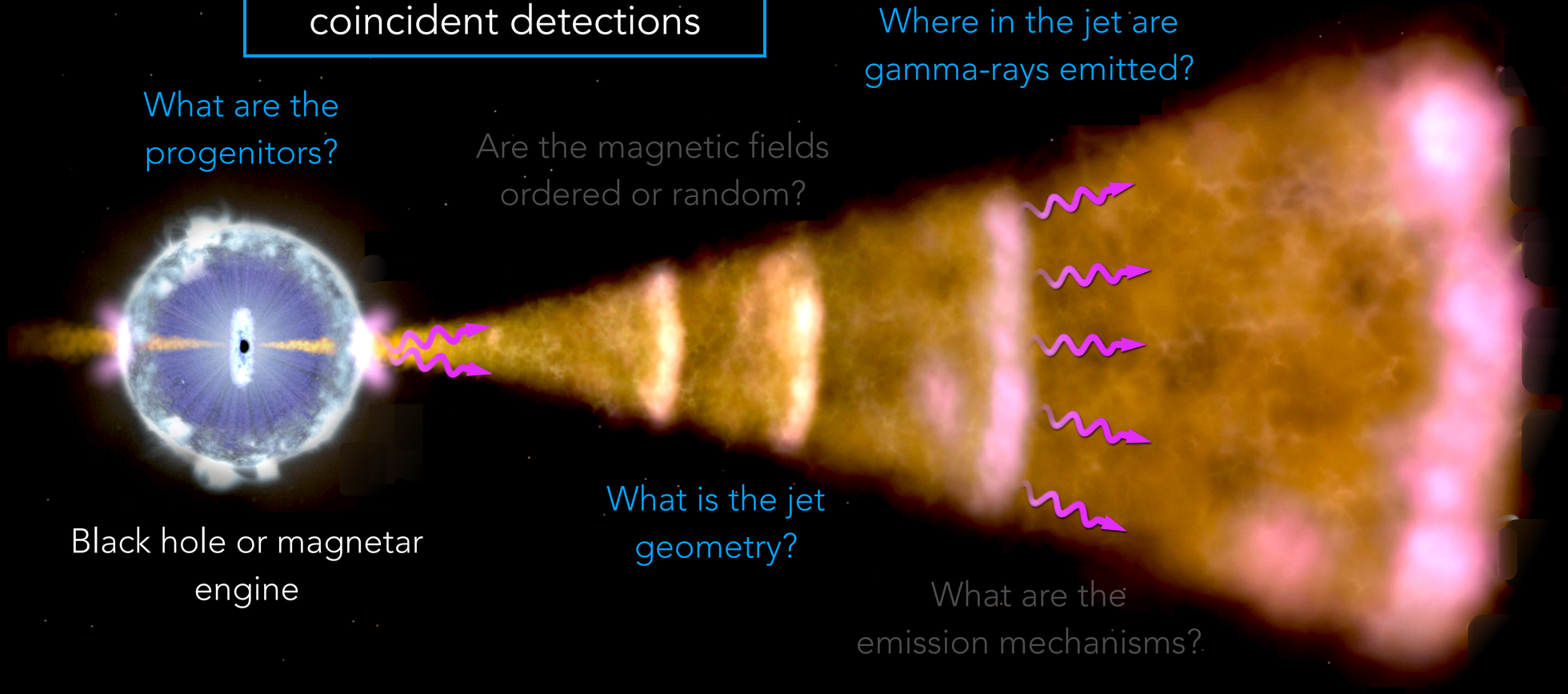
GRB Open Questions

sGRB & gravitational wave coincident detections

What are the progenitors?

Are the magnetic fields ordered or random?

Where in the jet are gamma-rays emitted?



Black hole or magnetar engine

What is the jet geometry?

What are the emission mechanisms?

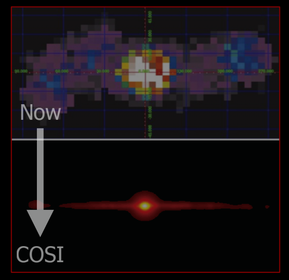
NASA/GSFC

GRB Open Questions

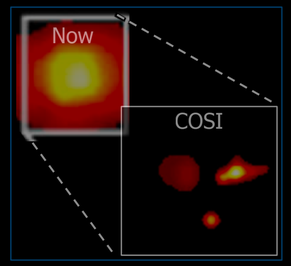
Spectra & polarization measurements

NASA/GSFC

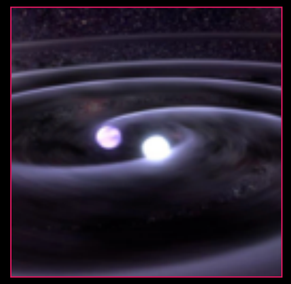
COSI's Science Goals



Uncover the origin of Galactic positrons



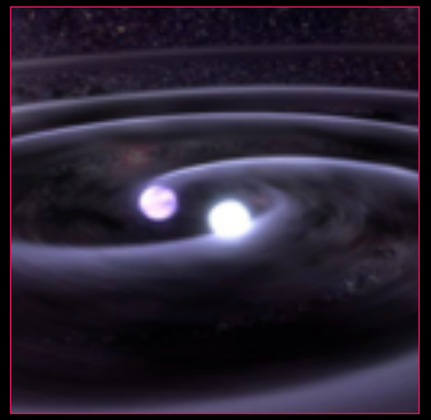
Reveal Galactic element formation



Probe the physics of multimessenger events

Gain insight into extreme environments with polarization

COSI's GRB Science Capabilities



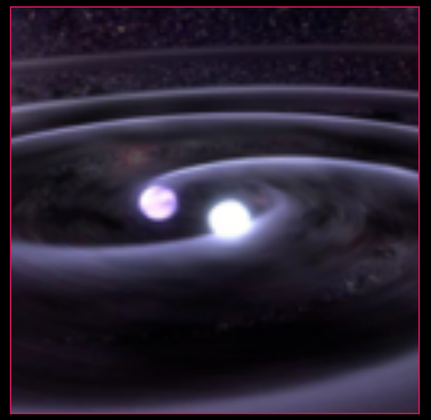
Probe the physics of multimessenger events

- Short GRBs may have coincident gravitational wave detections
- *COSI* will provide <2.5° short GRB localizations within an hour
  Goal in 2 years: ≥10 short GRBs

Gain insight into extreme environments with polarization

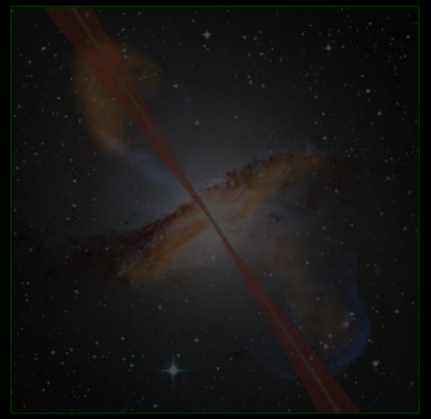
- Polarization measurements can be used to constrain GRB models
- *COSI* will measure prompt emission polarization of GRBs
  Goal in 2 years: >30 GRB polarization measurements

COSI's GRB Science Capabilities



Probe the physics of multimessenger events

- Short GRBs may have coincident gravitational wave detections
- *COSI* will provide <2.5° short GRB localizations within an hour
  Goal in 2 years: ≥10 short GRBs

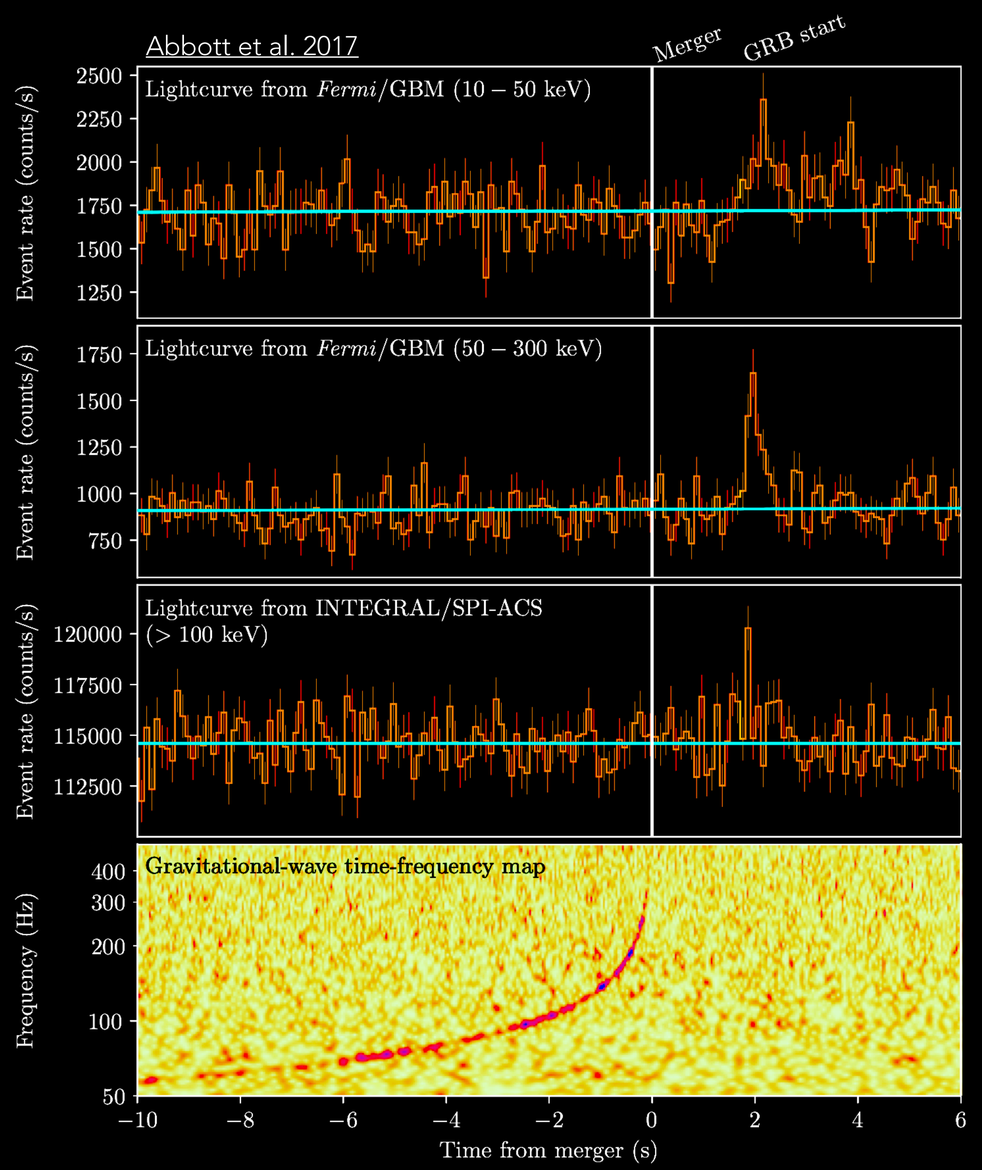


Gain insight into extreme environments with polarization

- Polarization measurements can be used to constrain GRB models
- *COSI* will measure prompt emission polarization of GRBs
  Goal in 2 years: >30 GRB polarization measurements

Short GRB-GW Coincidence

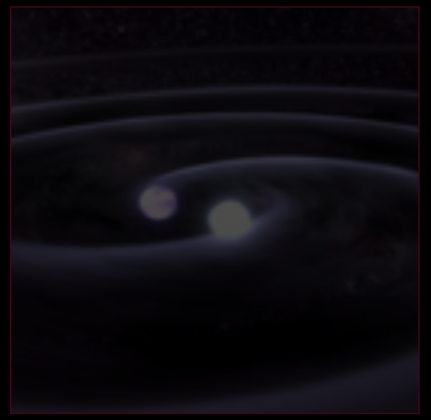
- GRB 170817A & GW170817 confirmed binary neutron star merger as sGRB progenitor
- Used time delay between gravitational waves and gamma-rays to probe physics of GRB jet and fundamental physics



COSI's Short GRB Sensitivity & Alerts

- *COSI*'s goal: detect ≥10* sGRBs
  - ~0.2-1 joint GW detections
  - *Detailed sGRB rate calculation is underway
- Alerting the community
  - Onboard trigger algorithm
  - Data rapidly downlinked by TDRSS
  - Localizations & classifications sent to community

COSI's GRB Science Capabilities



Probe the physics of multimessenger events

- Short GRBs may have coincident gravitational wave detections
- *COSI* will provide <2.5° short GRB localizations within an hour
  Goal in 2 years: ≥10 short GRBs

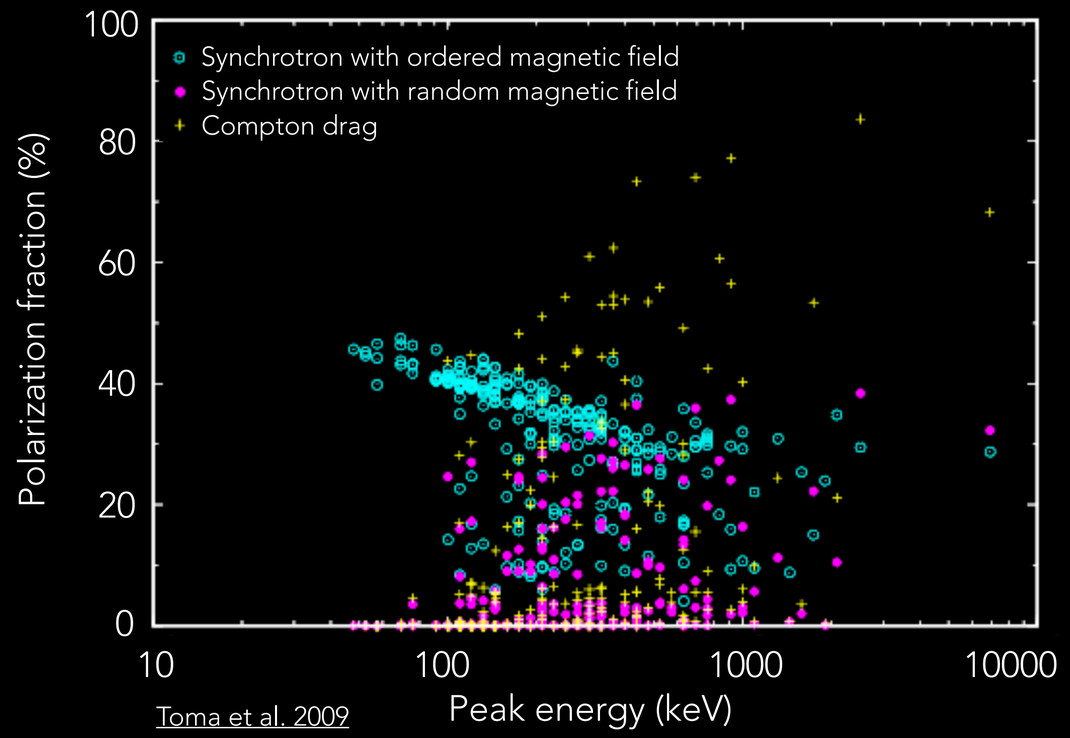
Gain insight into extreme environments with polarization

- Polarization measurements can be used to constrain GRB models
- *COSI* will measure prompt emission polarization of GRBs
  Goal in 2 years: >30 GRB polarization measurements

GRB Polarization

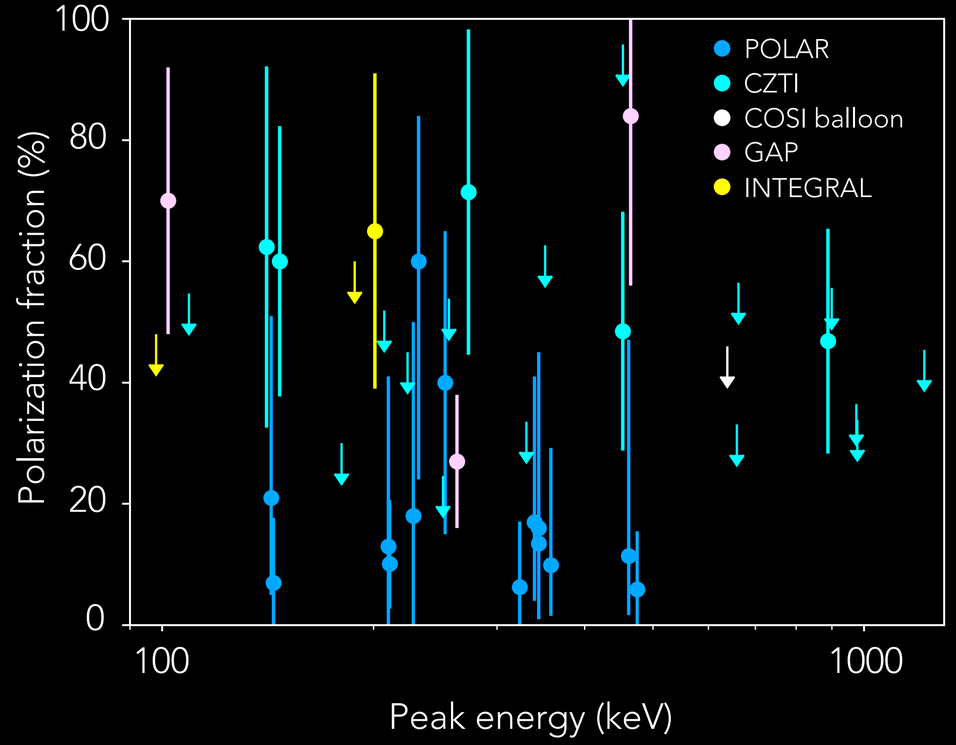
Polarization measurements will help to distinguish between GRB prompt emission models

Theoretical models



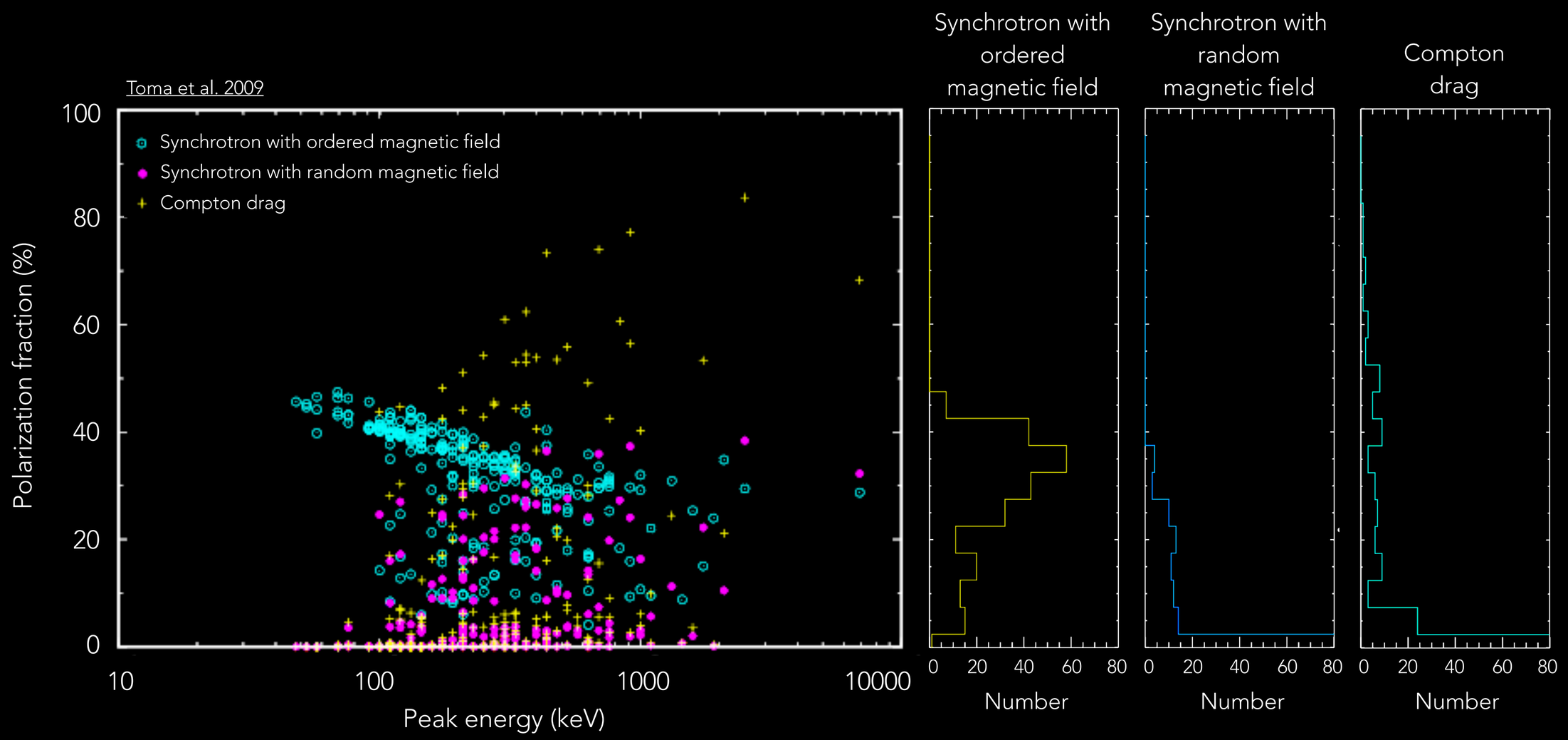
Toma et al. 2009

Current measurements



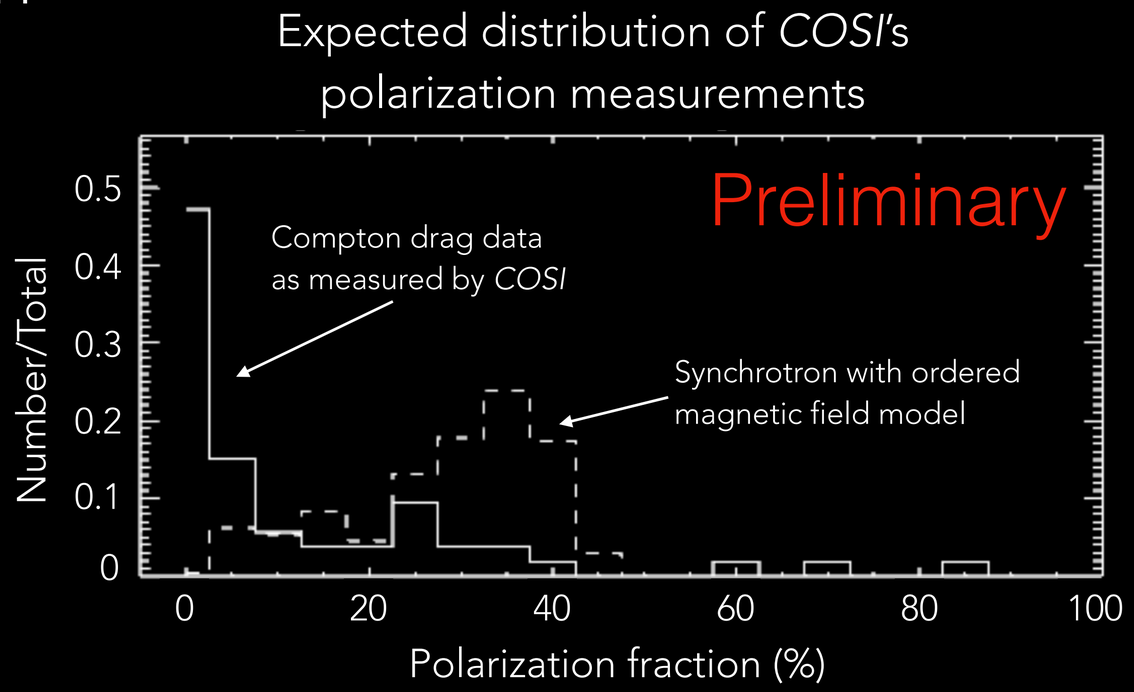
Kole et al. 2020
Chattopadhyay et al. 2022
Lowell et al. 2017
Yonetoku et al. 2012
Götz et al. 2019

GRB Polarization



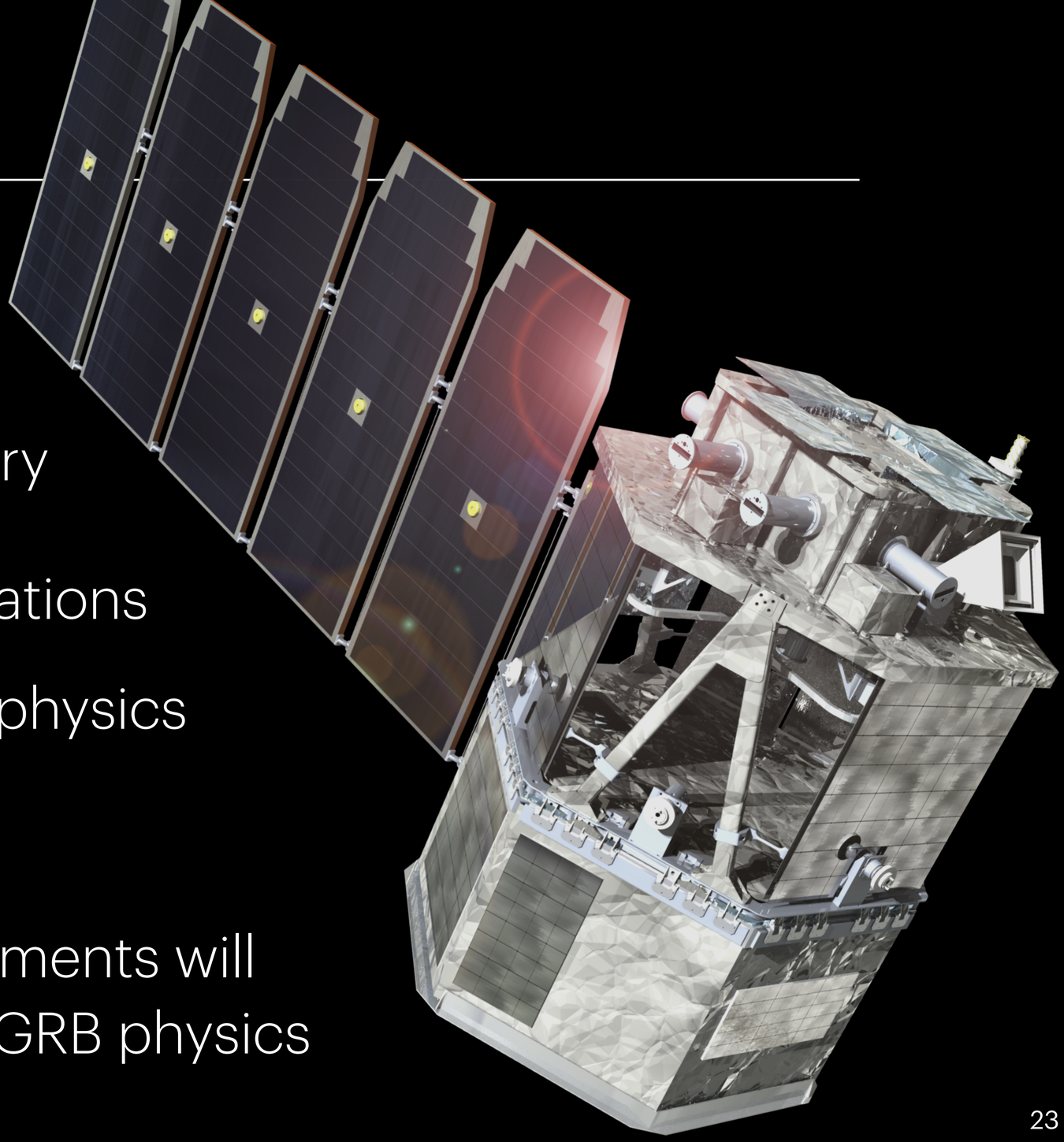
Constraining GRB Physics with COSI

- *COSI*'s goal: measure polarization of >30 GRBs
- Distinguish between synchrotron with an ordered magnetic field & Compton drag models
- Accurate estimation of *COSI*'s ability to distinguish between models is underway



Conclusion

- *COSI* will be launching in 2027 and will provide imaging, spectral analysis, and polarimetry
- sGRB detections & rapid localizations
  - enable multimessenger astrophysics
  - multi-wavelength follow-up
- Spectra & polarization measurements will enhance our understanding of GRB physics



Get Involved!

Data Challenge 2

- First release of high-level analysis tools (*cosipy*)
- Become familiar with *cosipy* and *COSI* data

COSI tools

Data Challenge 2

https://github.com/cositools/cosi-data-challenge-2