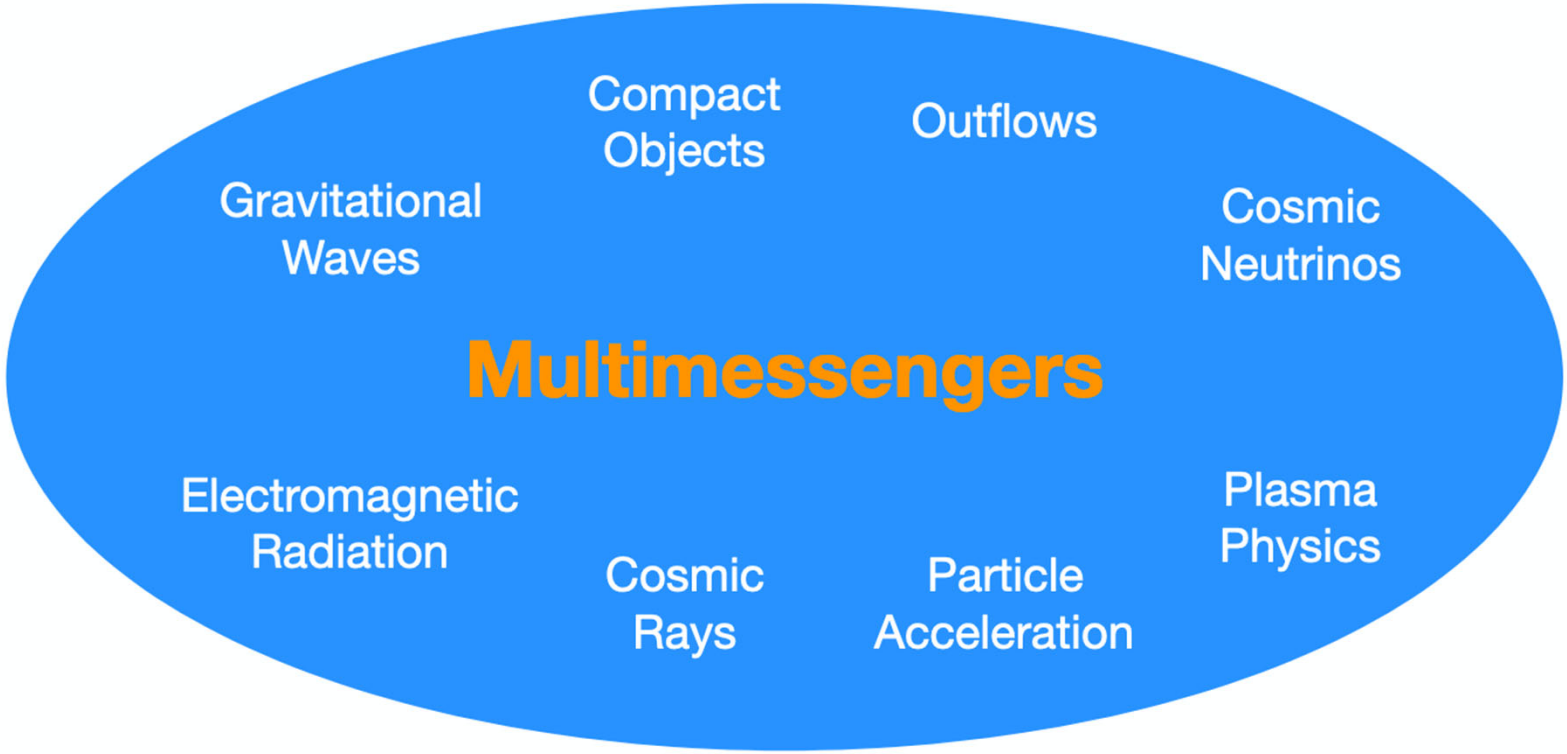
THAT – Theoretical Astroparticle Physics



Martin Pohl, Rafael Porto, Andrew Taylor, Walter Winter, Huirong Yan
Liebenberg retreat, 2022

HELMHOLTZ

DESY.

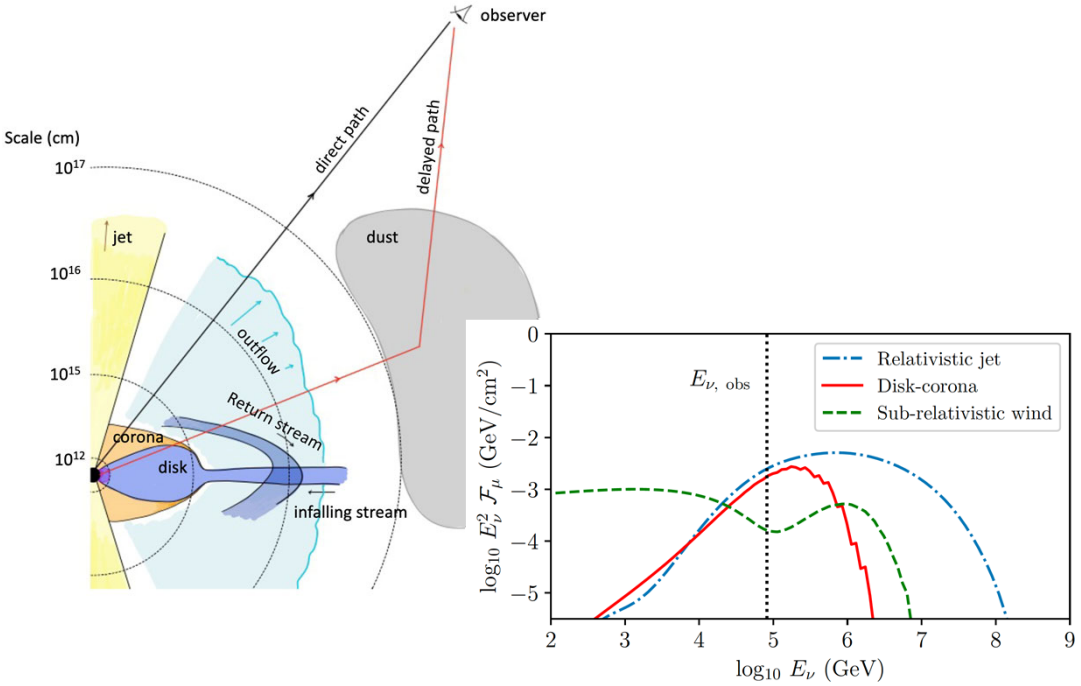
Mission

- Exploit the information from multiple cosmic messengers - electromagnetic radiation, neutrinos, cosmic rays, gravitational waves - to study their origin, the physical processes that shape their sources, as well as fundamental physics.
- This entails particle acceleration, the production of secondaries, transport and detection; it also includes the dynamics of binary compact objects relevant for gravitational wave science.
- We support existing experimental groups at DESY with the interpretation of data, theoretical modeling, and the optimization of instruments and the strategy of their operation.
- More recently, we have begun exploring new paths in gravitational wave astrophysics; an example are high-precision computations necessary, among other things, to maximize the discovery potential of future gravitational wave observatories -- such as the Einstein telescope.

Scientific gold mines (1)

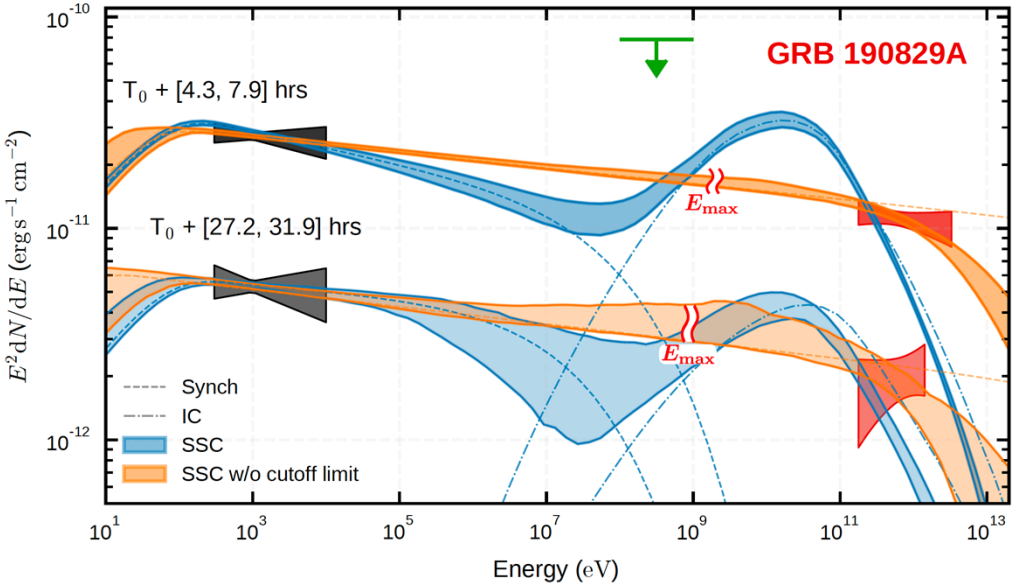
Support of major discoveries with astrophysical background. Provide scientific context.

- Example: Discovery of a neutrino from the Tidal Disruption Event AT2019fdr



Reusch, …, Winter, et al, Phys. Rev. Lett. 128 (2022) 22;
Fig. left: Winter, Lunardini, arXiv:2205.11538 (ApJ submitted).

- Example: Discovery of VHE gamma-ray emission from a Gamma-Ray Burst afterglow

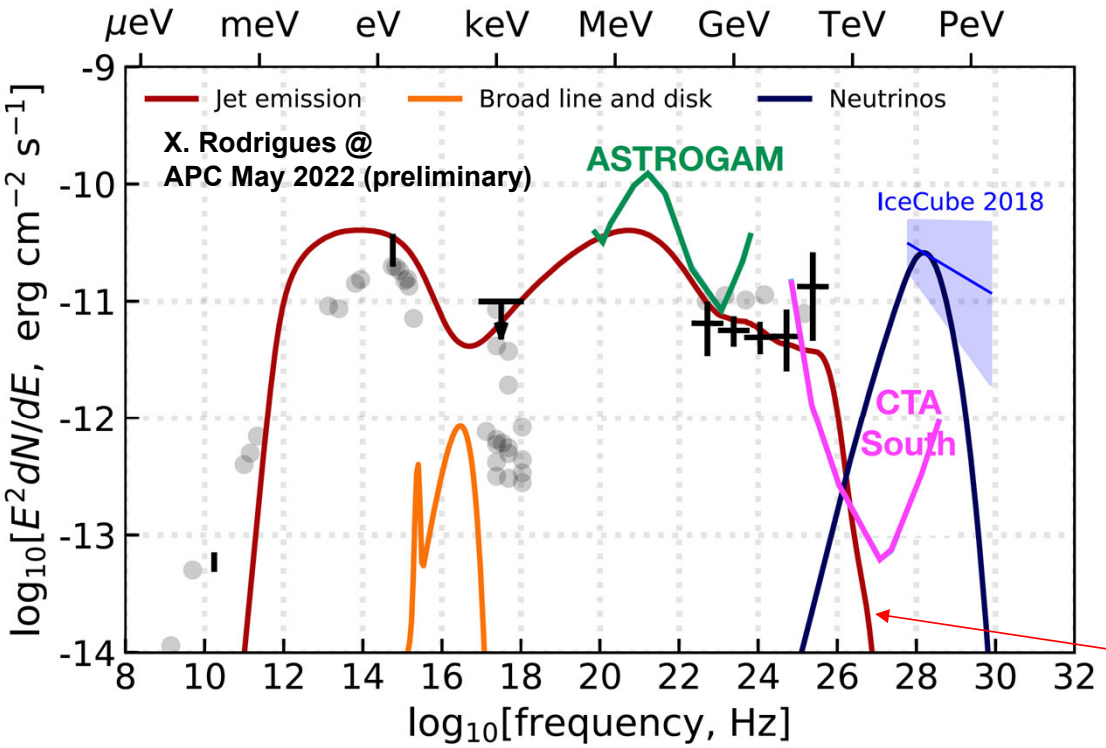


H.E.S.S. collaboration including A. Taylor,
Science 372 (2021) 6546, 1081

Scientific gold mines (2)

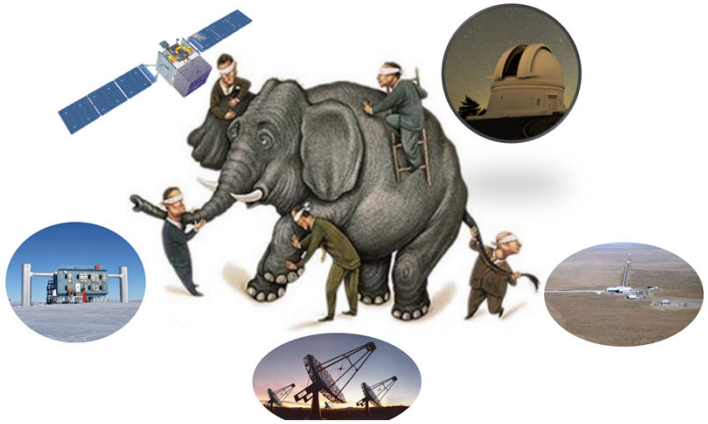
Scientific context beyond experiment boundaries, optimization of future instruments/strategies

- Example: Multi-wavelength observations of the AGN blazar TXS 0506+056



Rodrigues, Gao, Fedynitch, Palladino, Winter, ApJ L874 (2019)

Anna Franckowiak's elephant:



The theory elephant (spherical)

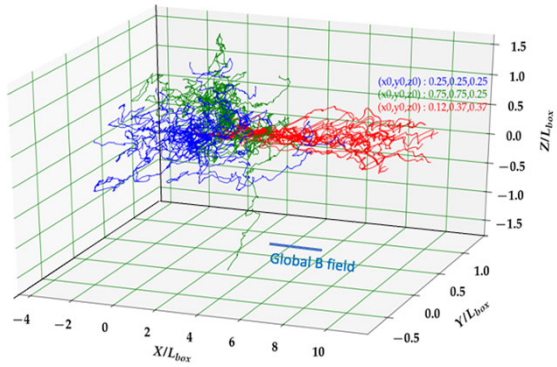
Can be used to address questions beyond individual exps scope, i.e.:
Future strategies?
New instruments?

Scientific gold mines (3)

Towards a fundamental understanding of the Milky Way and our Universe

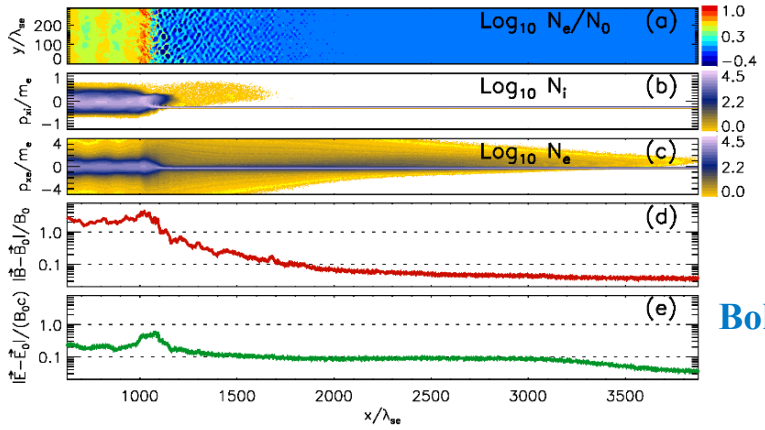
- Role of turbulence for particle acceleration?
- Particle acceleration at shocks
- Structure/role/effects of magnetic fields
- Precision computations for GW events
- Origin of Ultra-High Energy Cosmic Rays
- Radiation models for many different astrophysical object classes
- Macroscopic models for astrophysical systems
- Transport of different messengers

- Example: Diffusion in turbulent magnetic fields



Maiti, Snehanshu+ 2022

- Example: Particle-in-cell simulations of non-rel. shocks



Bohdan et al. (2022)

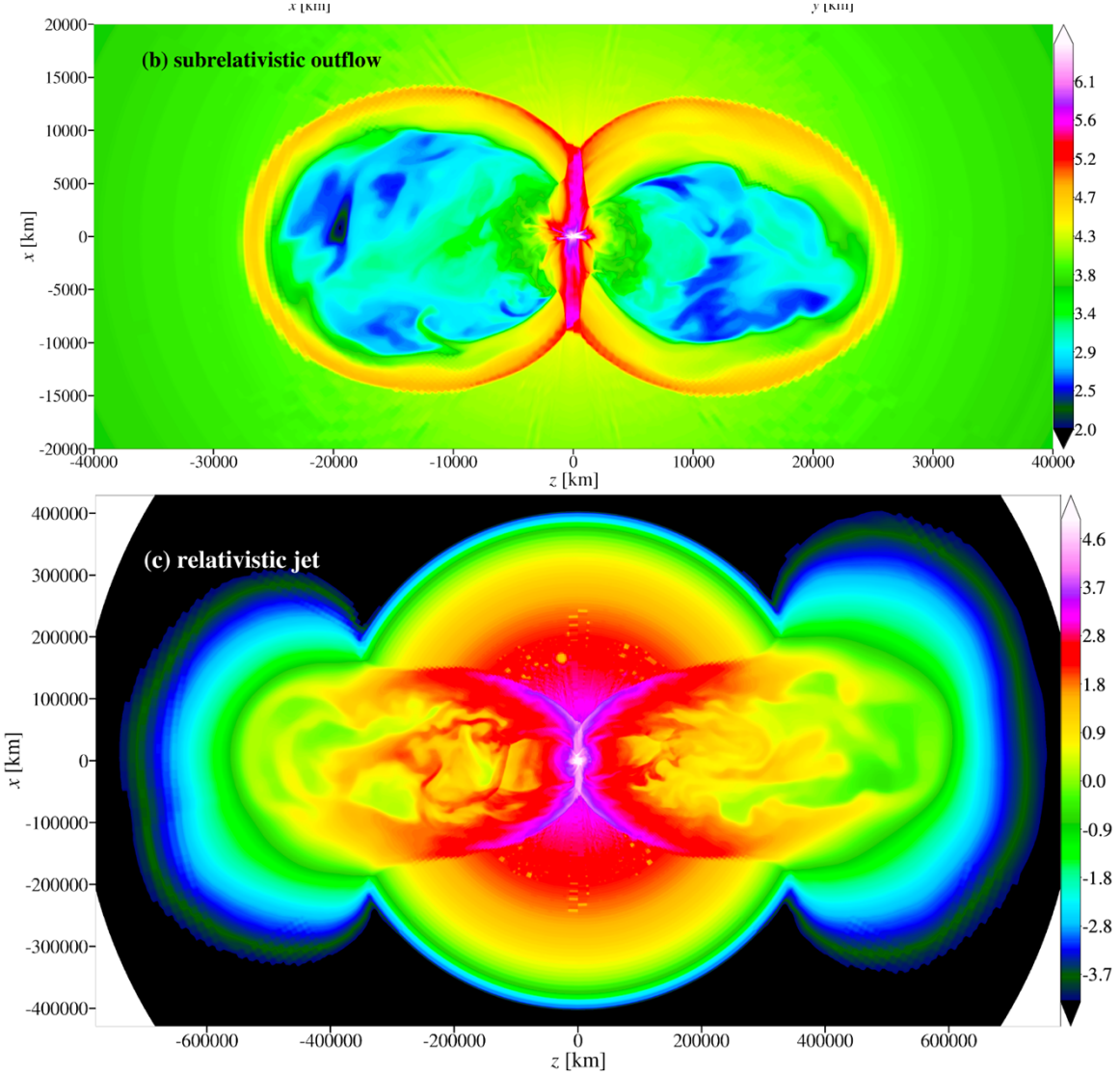
Future application fields

Relativistic Magnetohydrodynamics.

What we do not cover:

Bottom-up calculations of dynamics of outflows, jets, …

HYIG application supported by APC.



From: Gottlieb et al, MNRAS 510 (2022) 4, 4962

Mission-critical “infrastructures”

- **Personell**: Postdocs and PhD students critical for innovation, exchange, internationalization, diversity, creativity, spirit, inspiration, work-load balance, training expertise.
  They are the heart of our business and absolutely mission-critical!
- **Travel**: Dissemination of research, networking and exchange, inspiration (new ideas), new projects.
  Travel to conferences, workshops and theory programmes is mission-critical!
- **Space**: Quiet, comfortable (e.g. warm) and stimulating work environment paired with spaces allowing for interactions, exchange and creativity is critical for results at a *world-leading* level!
- **Computing**: On-site availability of parallel computing (50-500 core jobs) is mission critical, as well as general access to high-performance and large-scale parallel computing. 24/7 availability desirable, but perhaps not mission-critical.