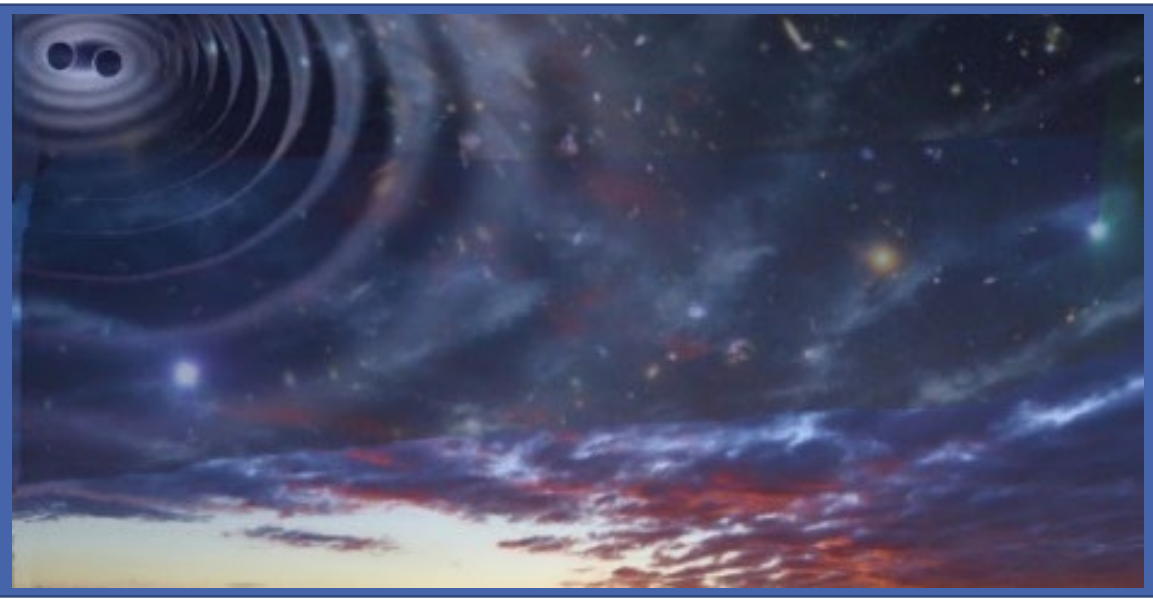
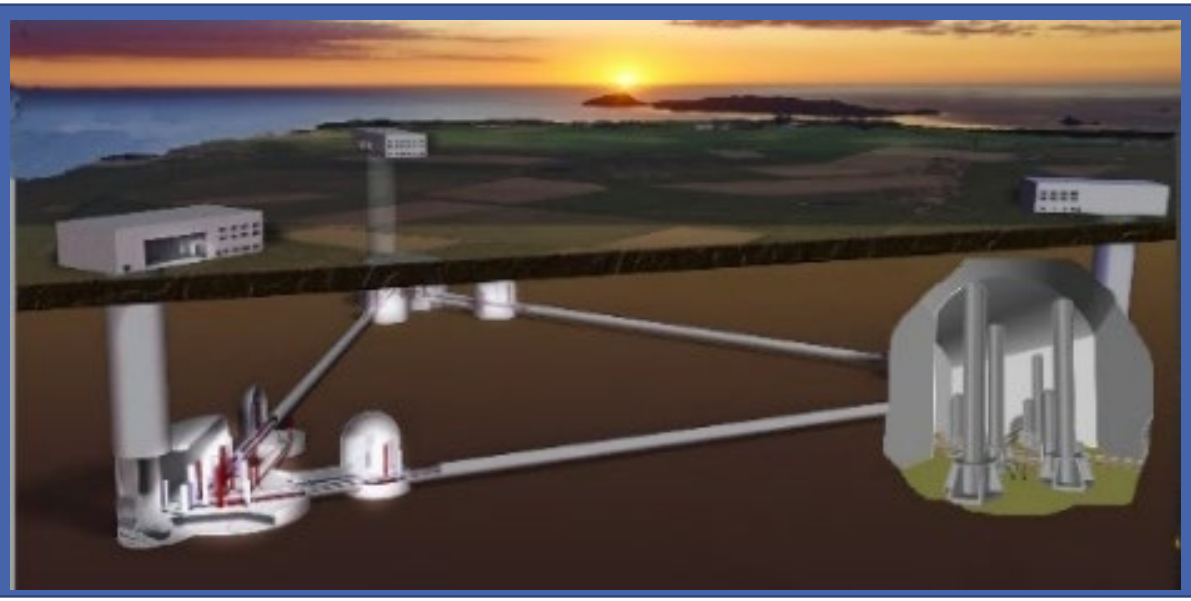
Karlsruher Institut für Technologie

Multimessenger, Realtime, and Computing

ET@KIT

Andreas Haungs et al., IAP, 22/04/2022

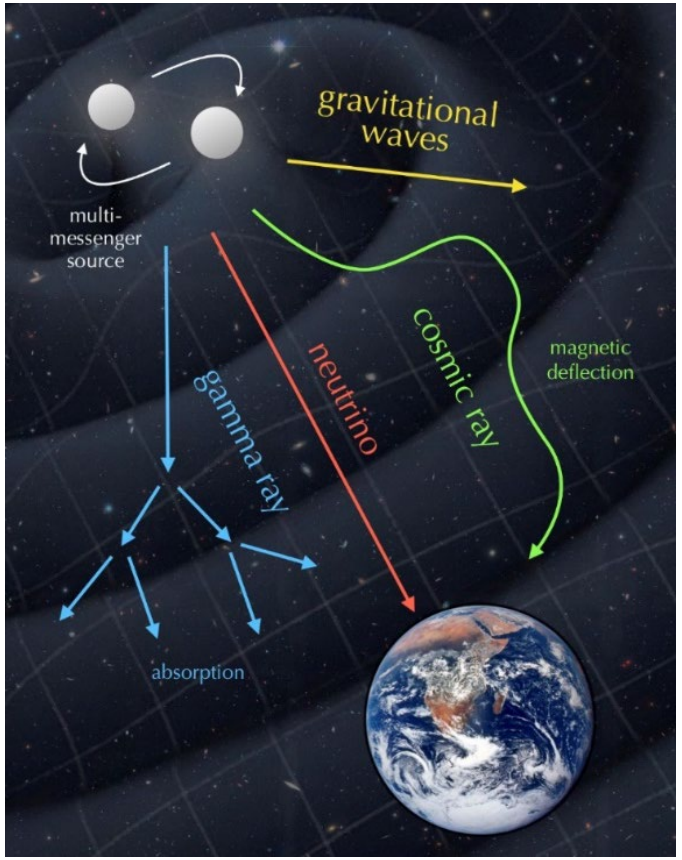


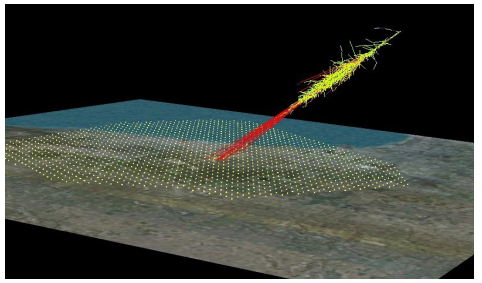


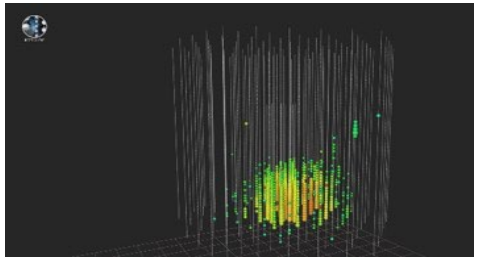
Multi-Messenger Astroparticle Physics

Gravitational wave detection is part of the global multi-messenger efforts:

- **Required to understand the sources of cosmic rays and the physics processes in the high-energy Universe**
- **Needs long-term operational observatories**
- **And a sophisticated Big Data management:**
  - **Big Data Analytics**
  - **Research Data Management**
  - **Data Curation**
  - **Open Data**







IceCube – adv.Virgo Event Coincidence Search

Motivation:

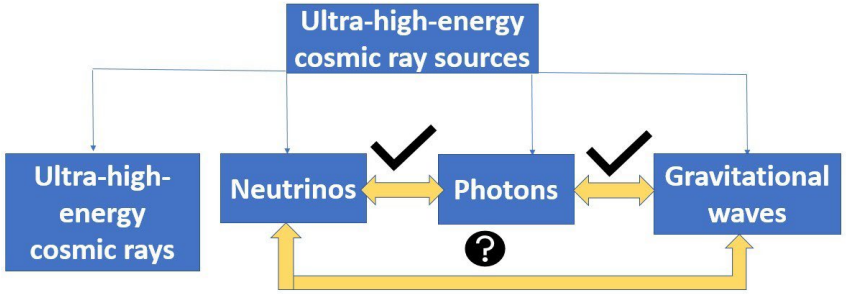
- To access the maximum information that we get from nature to unvail the unknowns of the Universe.

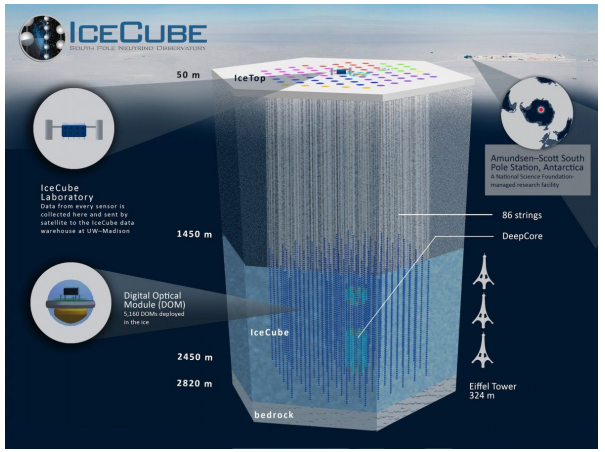
Successes so far:

- GW170817: successful GW and EM correlation [Abbot et al. 2017b, PRL 119, 161101]
- TXS0506+056: successful neutrino and EM correlation [Aartsen et al. 2018, Science 361]

Remaining piece of puzzle:

- Common source of gravitational wave and neutrinos
- Important, because
  - To identify potential ultra-high-energy cosmic ray sources
  - Better source localization



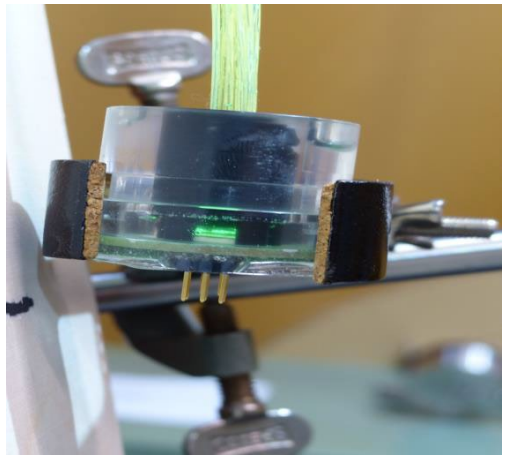


Tista Mukherjee

Environmental Monitoring of Noise

Gravitational Wave Detection of adv.Virgo and Einstein Telescope requires sophisticated monitoring of environmental parameters:

- **Use expertise from Auger and IceCube in muon detector design and construction**
- **Install particle detectors to provide another environmental parameter class**
- **Control the charging of the mirrors by cosmic rays**
- **Study of disturbances by cosmic rays on mirrors and interferometer**
- **Install and test a prototype system at Virgo**
- **Integrate concept in a monitoring system for the Einstein Telescope (synergy with geophysics, computing)**



Thomas Huber et al.

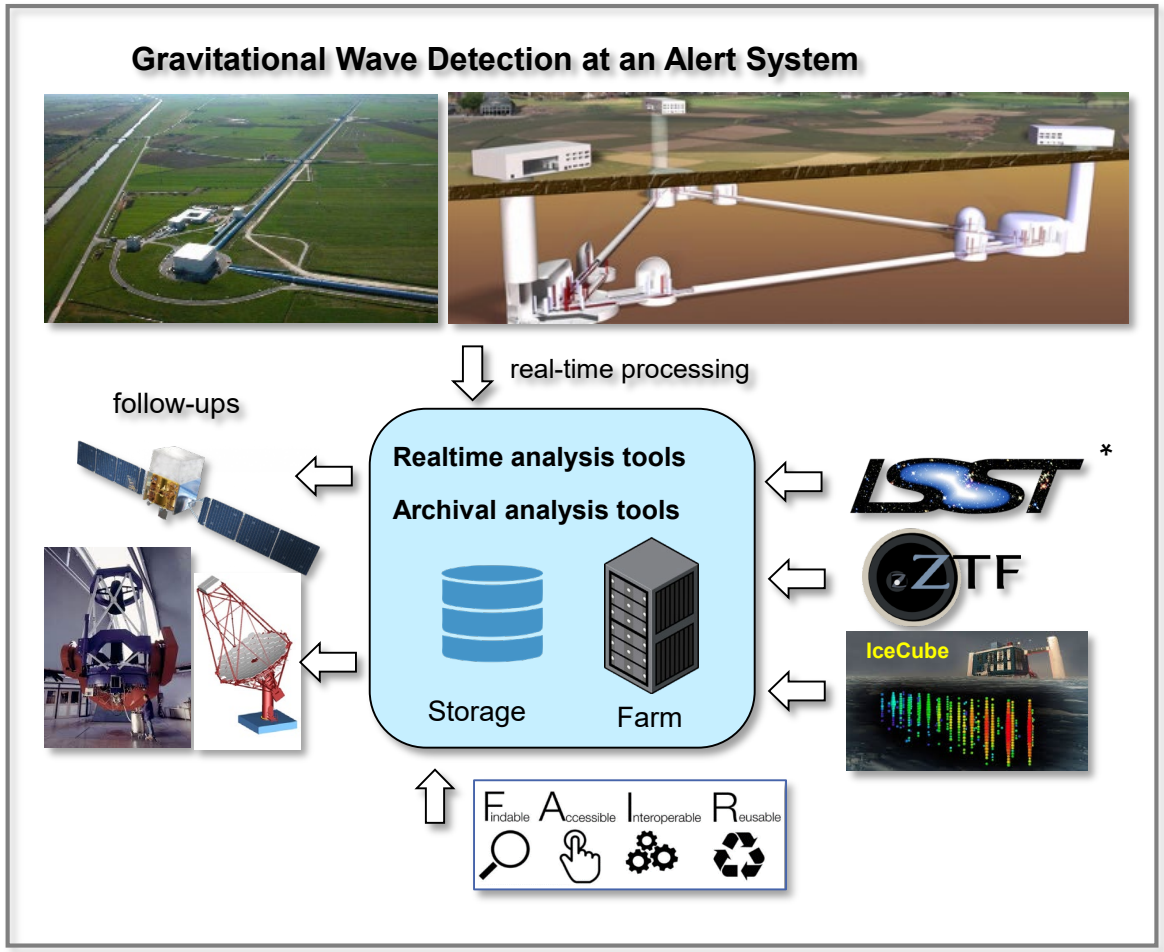
Improvements of Realtime Data Handling

An enhancement of available tools is needed to perform

- Combining data streams of environmental monitoring systems at Virgo and later Einstein Telescope
- Multi-messenger follow-up studies of gravitational wave events (alert systems)
- Gravitational wave observations as part of the multi-messenger astroparticle physics data center

Our activities

- are based on expertise and competences
- has close cooperation with IceCube and Pierre Auger groups
- co-works at KIT with GPI (seismic) and SCC (computing) and with PUNCH4NFDI and ErUM-Data



* new name: Vera C. Rubin Observatory

AMPEL
(https://ampelproject.github.io/)

InnoPool (ADC-MAPP) activitiy

Einstein Telescope Computing Model

Computing Challenges of Einstein Telescope

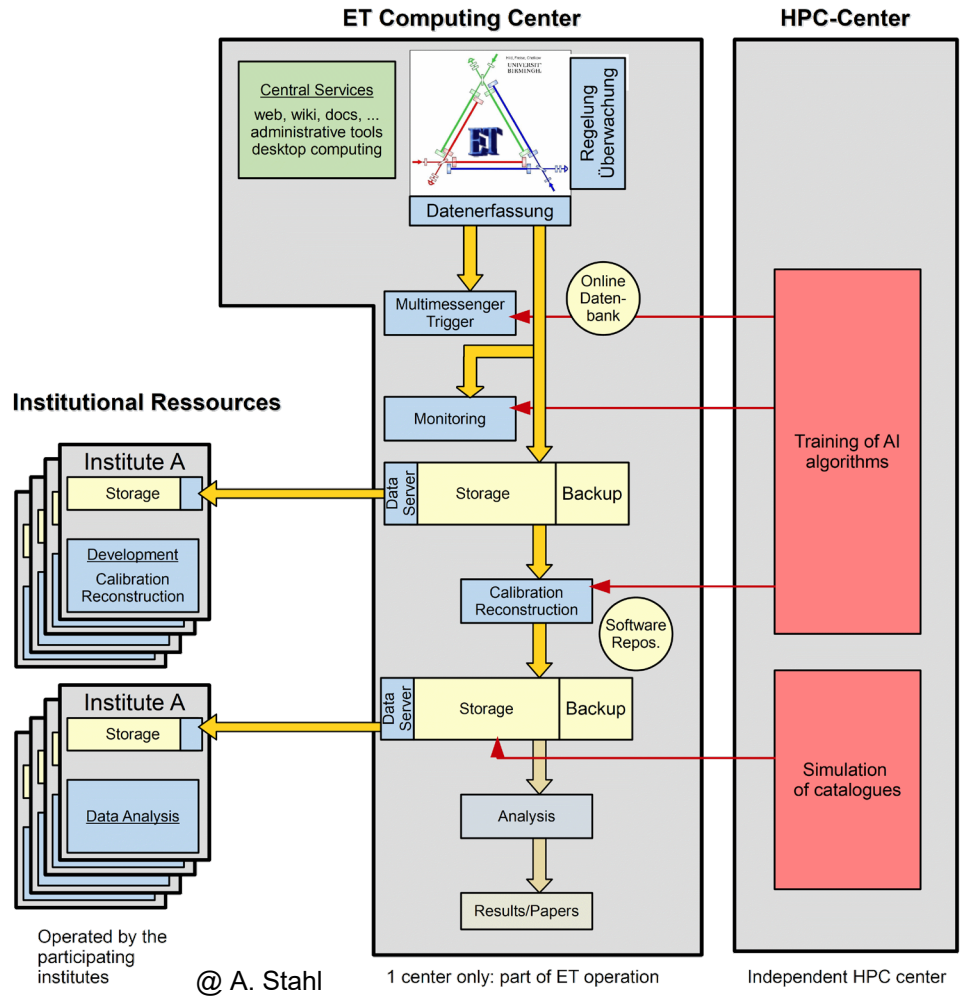
Foreseen Computing Model:

- ET Computing Center, only low latency (= operation costs)
- HPC-Center (= member country costs)
- Institutional Resources (= institutional costs)

Challenge:

- LIGO/Virgo analysis path does not work, since:
  - Many more signals / events
  - Longer signal traces at low frequencies (hours)
  - Parameter set per event much higher (better fit and comparison to template)
  - More parameters available (e.g. polarisation)
  - More types of events, i.e. more template catalogues.
  - Huge amount of (online) monitoring data
- Requests large resources (HPC) for generating and training of catalogues as well as the development of smart algorithms

Andreas Petzold et al.



VIRGO/LIGO GitLab at KIT

GitLab

Karlsruher Institut für Technologie

Request and offer to take over the GitLab for the International Gravitational Wave Detection Network

GitLab:

- Is the version control system of choice for large-scale experiments
- Service for large, global user community
- Tool for creating all collaborative software projects
- Includes storage and access of all analysis and simulation software
- Low-latency analysis tools for monitoring and operation of measurements

Technical requirements:

- Sufficient GitLab license
- Moderate hardware resources
- Level of Service (LoS) agreements / MoUs
- High Availability deployment and efficient access policy

Content:

- Software development environment for Virgo/LIGO/KAGRA
- Repository for all kind of software: Detector Control, Data Analysis, Low Latency, etc.
- Storage and access to internal documents (technical documents, white papers, etc.)
- Further use cases: Optical Simulations files; sensitivity curves; Software Configuration Control Board (SCCB) activities; IGWN Computing HelpDesk (via tickets); IGWN software distribution management (CONDA); Online IGWN Computing Guide; IGWN Computing Planning
- Not yet used as paper repository
- Note: currently GitLab is not involved in any data storage or data management. Data management tools such as Rucio use their own separate databases.

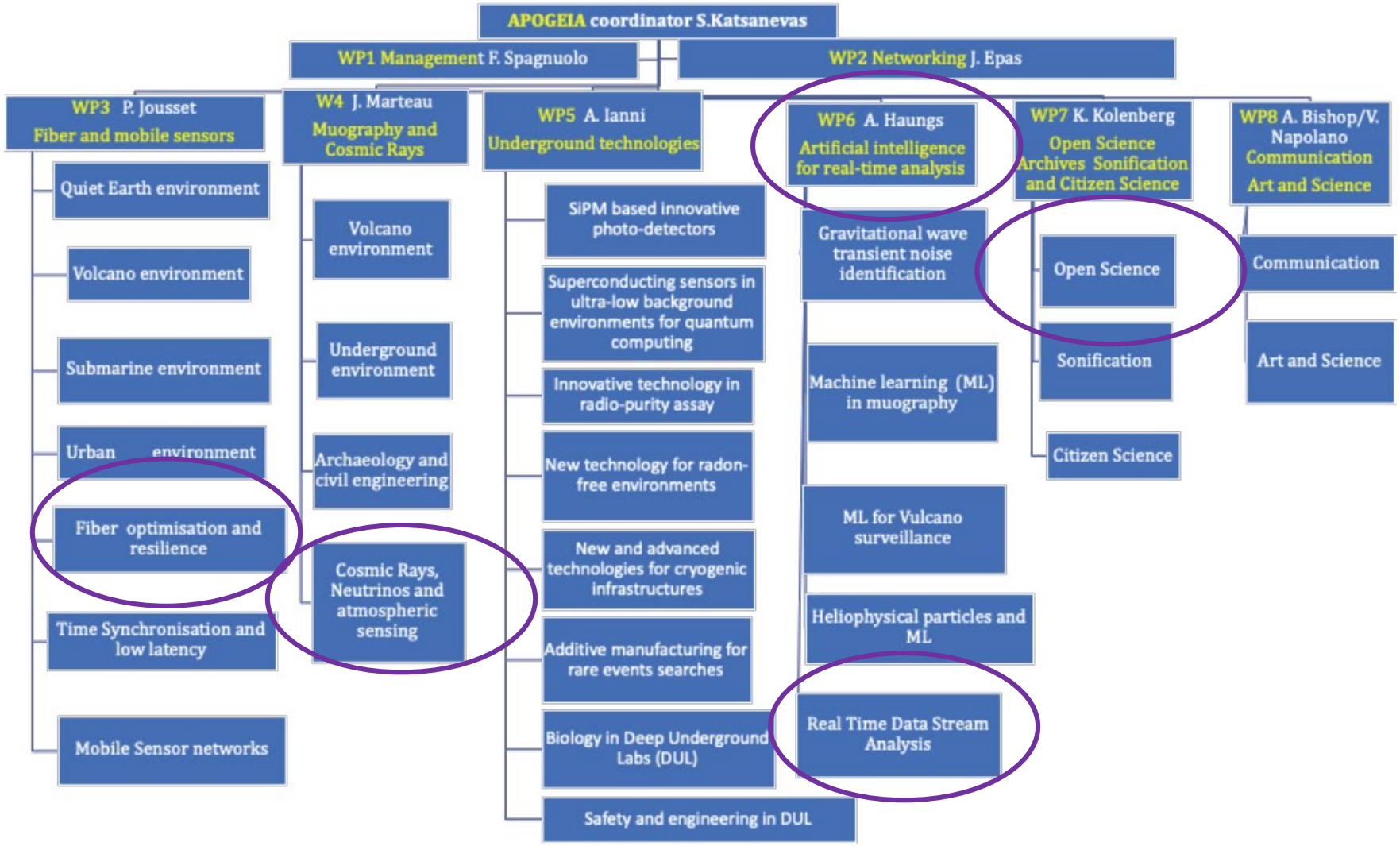
Challenge:

- Integration of the IGWN-GitLab into the KIT GitLab system (licences)
- Providing person power for local support

APOGEIA

20/04/2022 Submission of the APOGEIA proposal (HORIZON-INFRA-2022-TECH) "AstroParticle Observatory and GEoscience Innovation Actions".

- **Coordinator: EGO (Stavros Katsanevas)**
- **45 Partners from 14 countries**
- **Total budget: 10 Mio € for 3 years**
- **KIT activity:** ⬭
- **A. Rietbrock, GPI**
  J. van Wezel, SCC
  A. Haungs, IAP



Astroparticle Physics: Understanding the Multi-Messenger and the Dark Universe

This requires a combination of the measurements of globally distributed experiments…

…including Gravitational Wave Detection

KIT is well placed to make a significant and visible contribution also to multi-messenger, real-time and computing aspects of the Einstein Telescope!