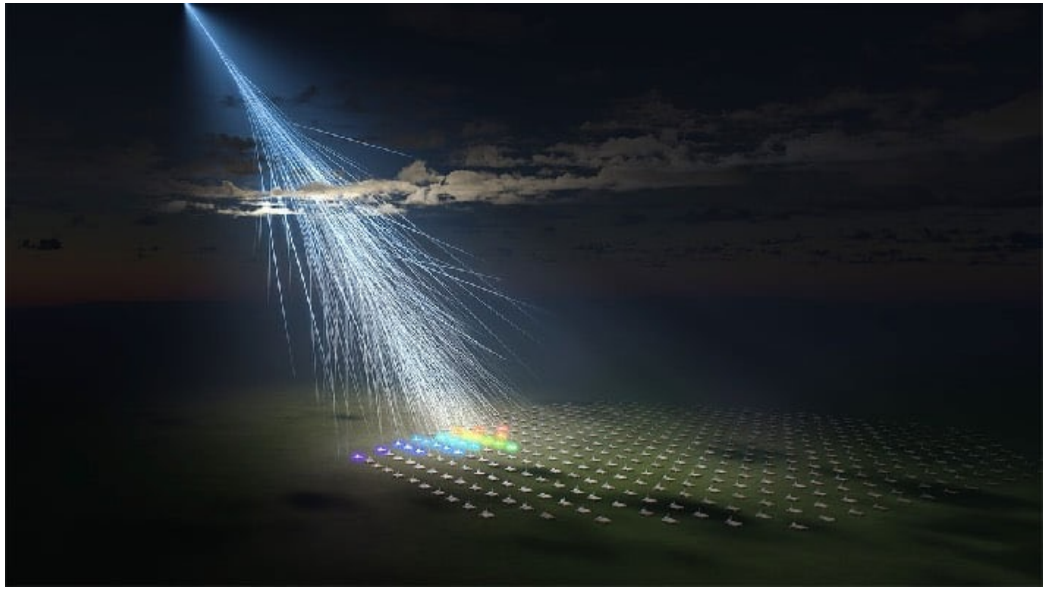
Rencontres de Moriond, VHEPU session Highlights

Mathieu de Bony

Summary

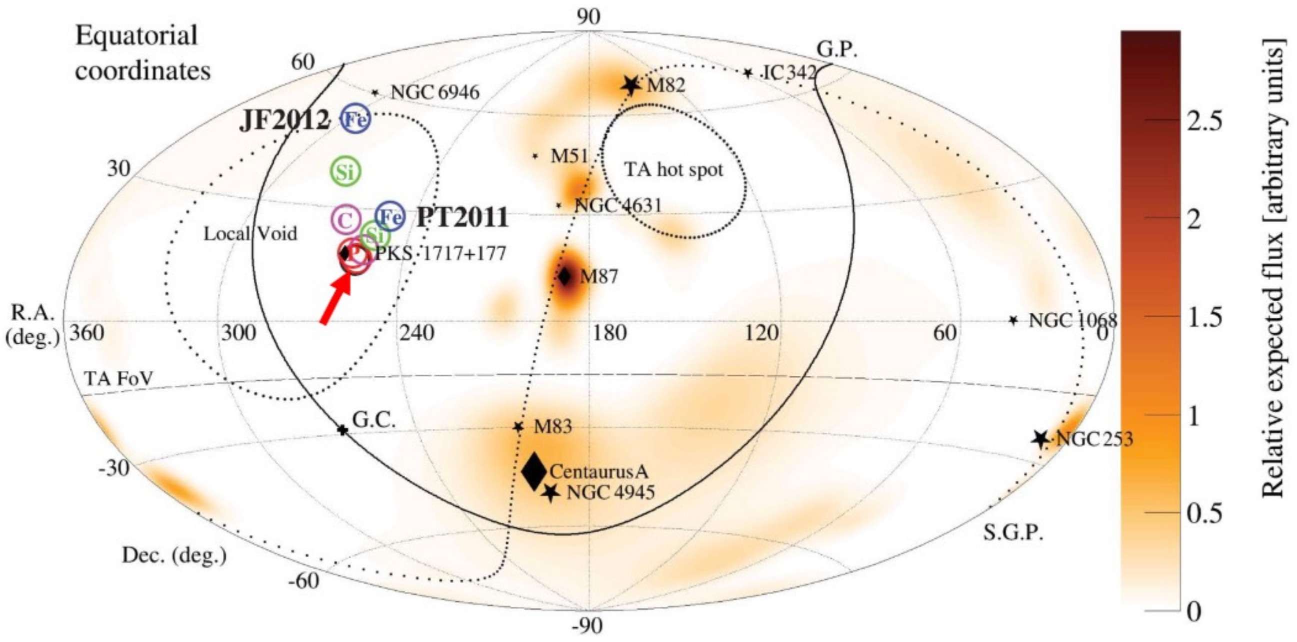
1. UHE cosmic-rays results
2. Future UHE cosmic-rays and neutrino experiments
3. VHE Neutrino astronomy results
4. Dark Matter search results
5. VHE gamma-ray results
6. Cosmology with Gravitational Waves

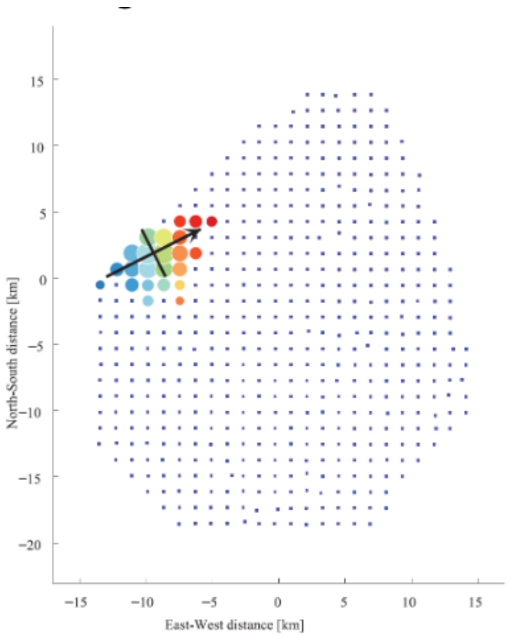
Ultra High Energy cosmic-rays with Pierre Auger Observatory and Telescope Array



An extremely energetic cosmic ray event in Telescope Array

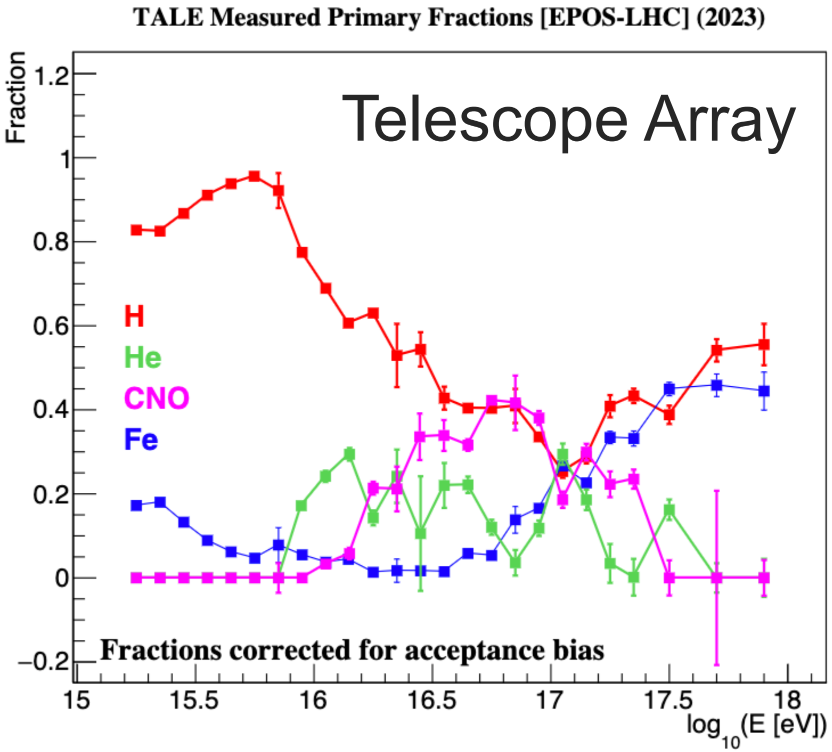
- **Energy : 244±29(stat.)＋51-76(syst.)**

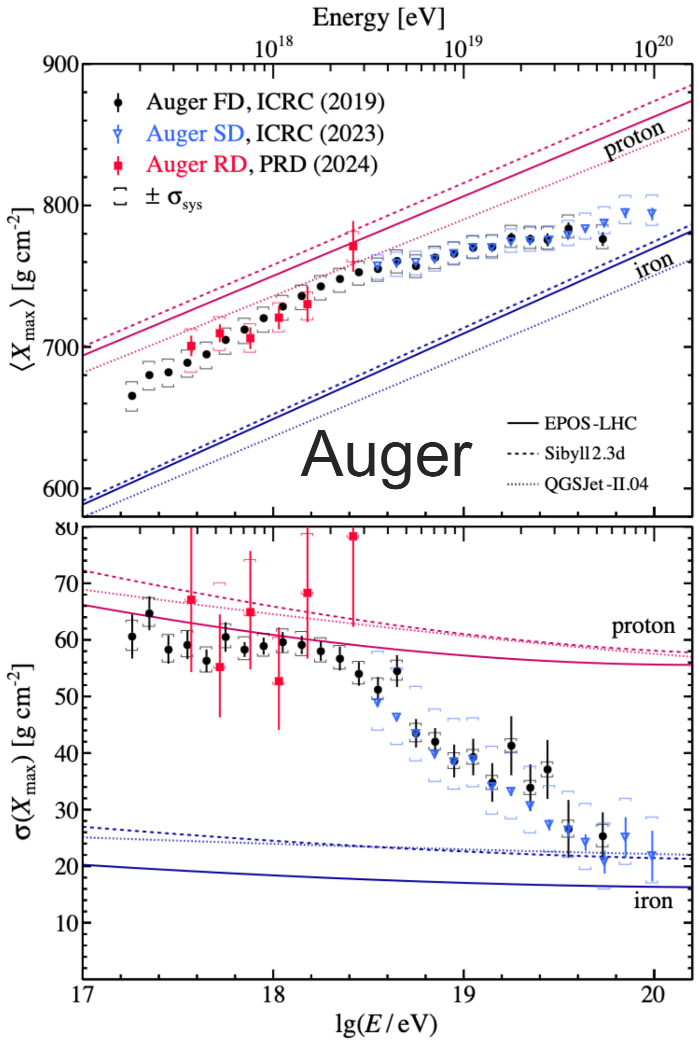




Talk : Review of the Telescope Array results, E. Kido
Publication : TA Collaboration, Science, 382, 903 (2023)

Energy depedendant mass composition

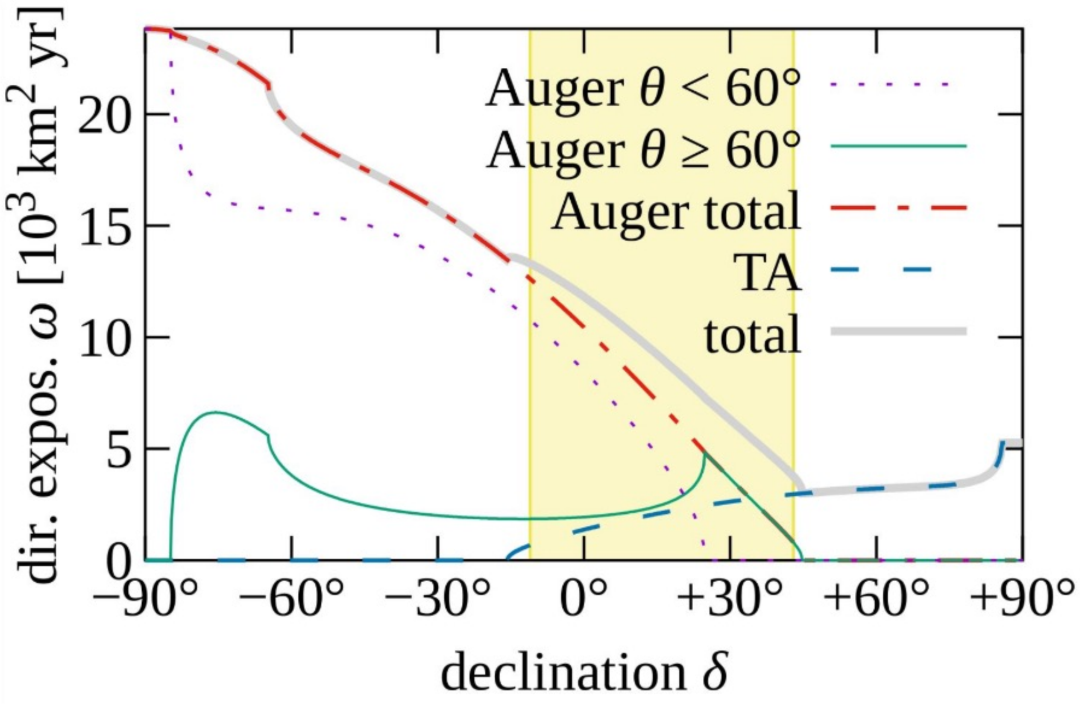




Talk : - Review of the Telescope Array results, E. Kido
- Ultra-high-energy cosmic rays with the Pierre Auger Observatory Current status and future perspectives, M. Roth and I. Maris

Anysotropy of UHE cosmic ray flux

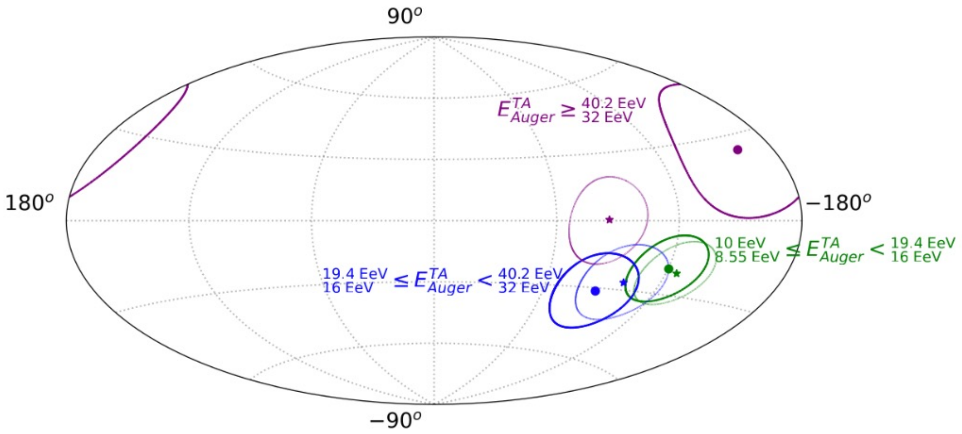
- **Combination of data from Telescope Array and Pierre Auger Observatory**

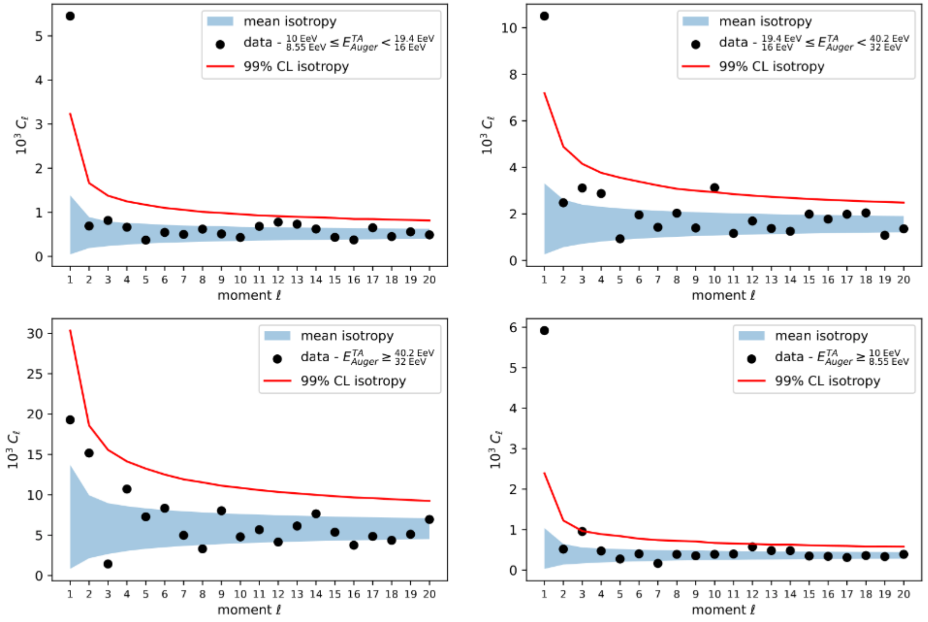


Talk : Results from the Auger-TA working group on UHECR arrival directions, F. Urban

Anysotropy of UHE cosmic ray flux

- Dipoles and angular power spectrum



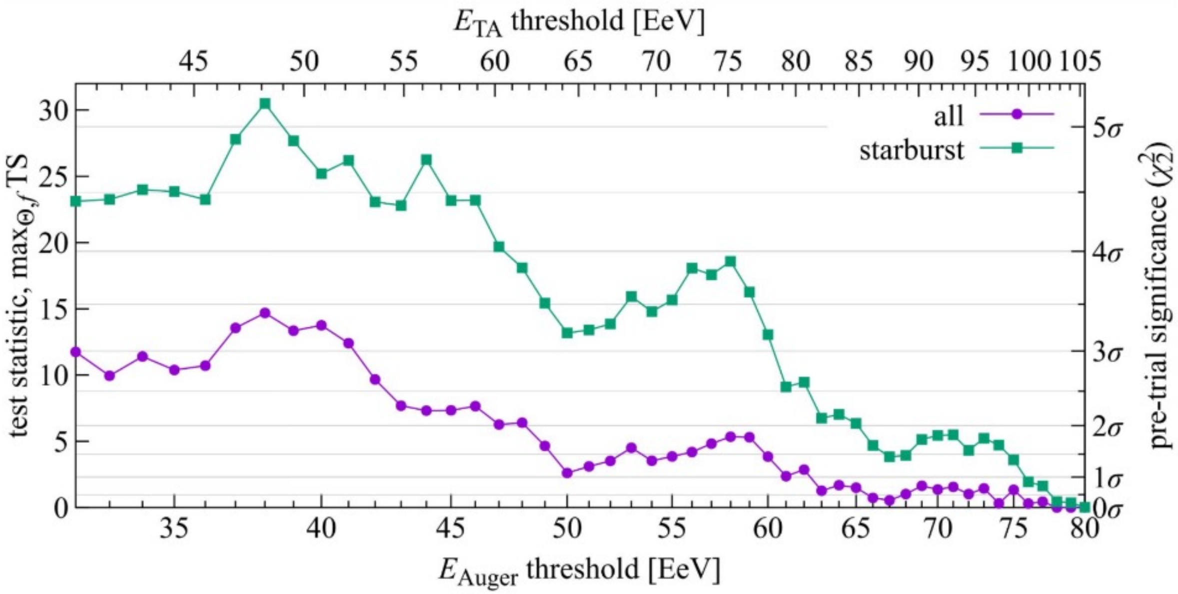


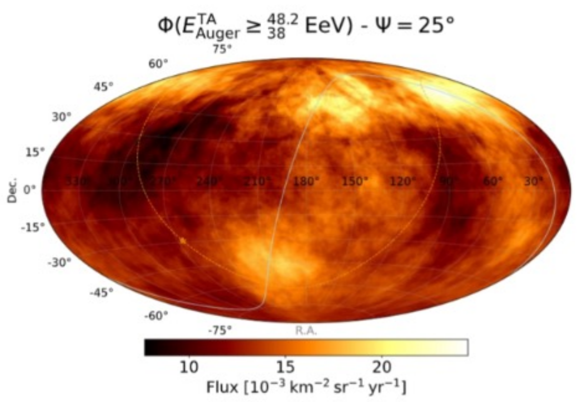
- All energies : l = 1, 4.2σ deviation from isotropy

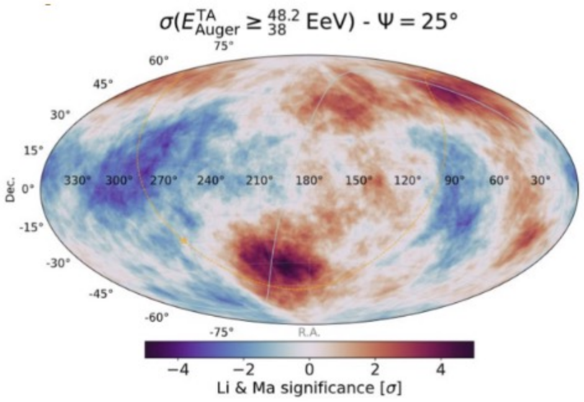
Talk : Results from the Auger-TA working group on UHECR arrival directions, F. Urban

Anysotropy of UHE cosmic ray flux

- 4.6σ correlation with starbust galaxies



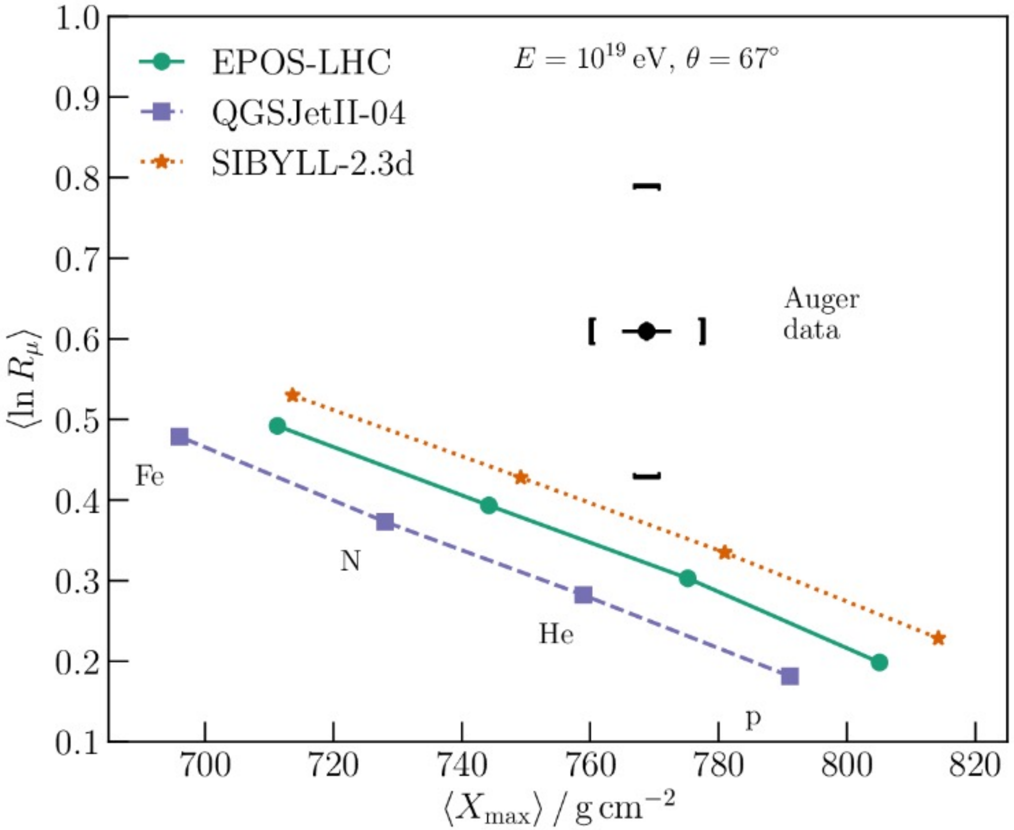


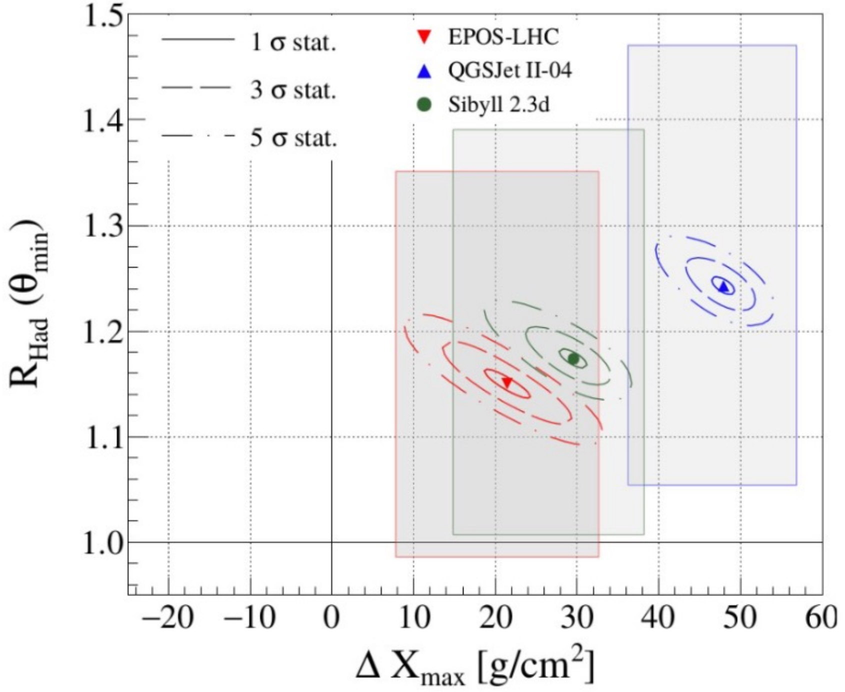


Talk : Results from the Auger-TA working group on UHECR arrival directions, F. Urban

Comparison of the new hadronic interaction models with Pierre Auger data

- **Too much muons in highly inclined showers**





Discrepency between Xmax prediction and measurement

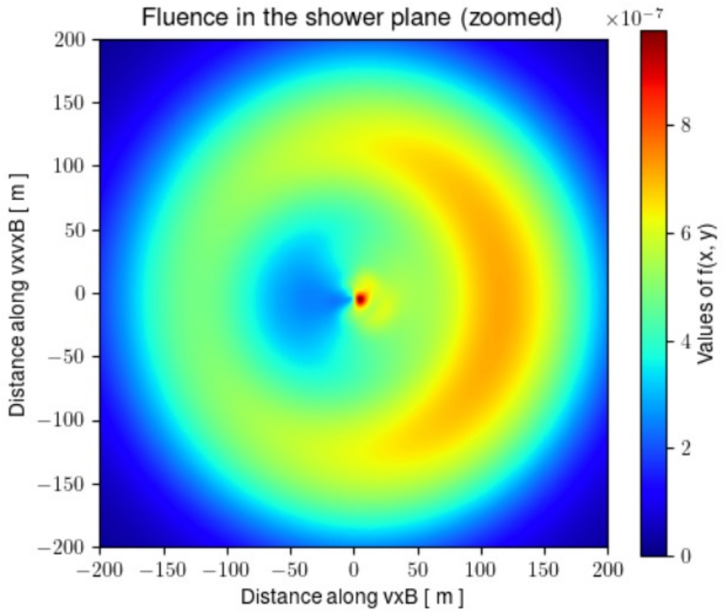
Talk : - Hadron interactions at ultra-high energy with the Pierre Auger Observatory, F. Riehn
- EPOS LHC-R Up-to-date Hadronic Model for EAS Simulations, T. Pierog

New and future instruments UHE detector

- **Radio detection** of atmospheric shower **is the new trend**

Allow large and cheap array

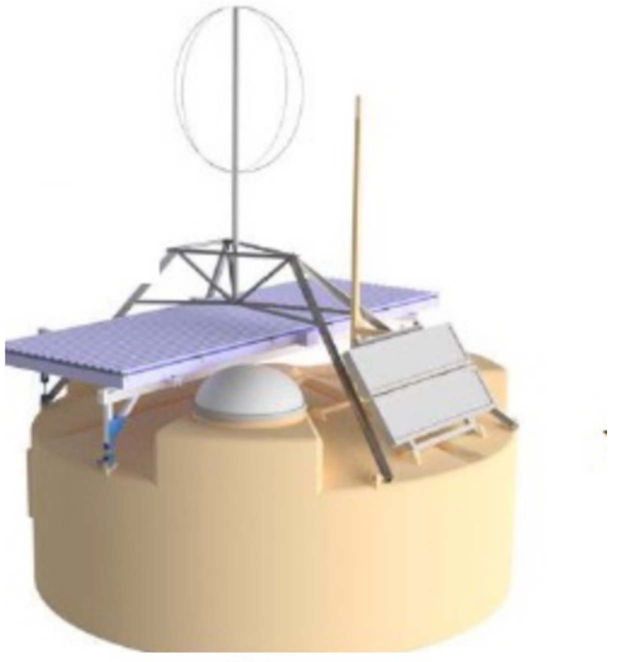
- For UHE cosmic-rays detector
- For UHE neutrino detector



Auger Prime

Objective : better and more details reconstruction of atmospheric showers

- Add **Plastic Scintillator Detector on top of each Water Cherenkov Detector**
- Add smaller PM to WCD for better dynamic
- New electronic for signal processing
- **Radio detector on top of each WCD**
- **Add an Underground Muon Detectors**

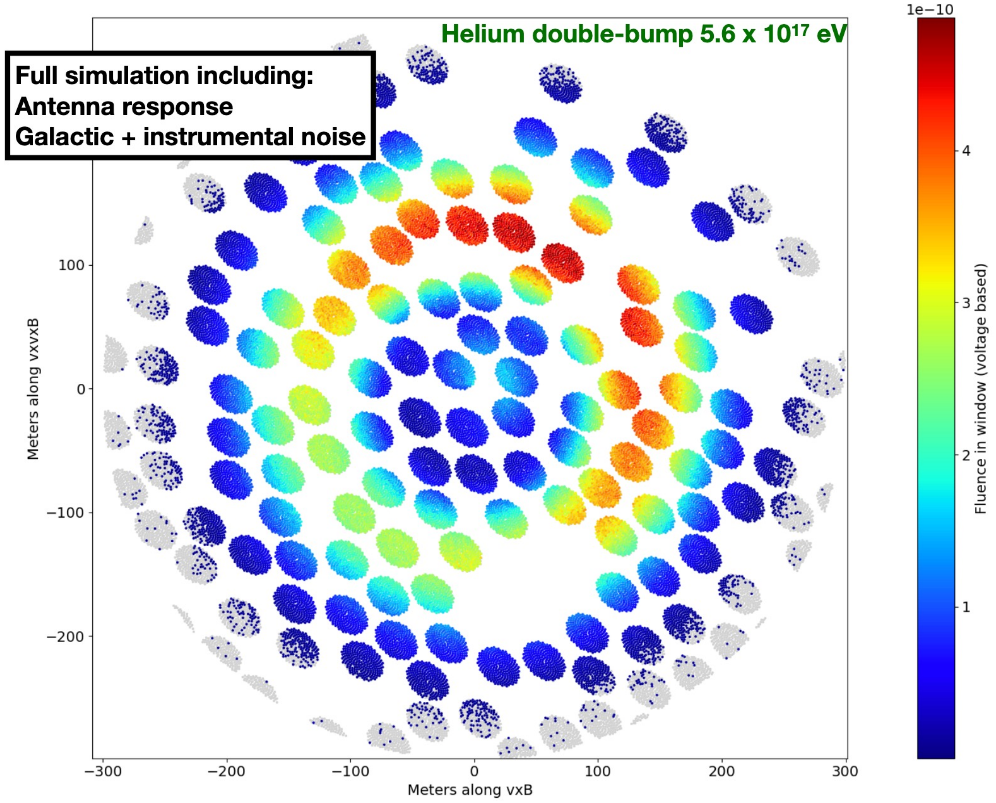


- **Measurement of the muonic content**
- **Better mass reconstruction**

Talk : - The AugerPrime upgrade of the Pierre Auger Observatory, T. Suomijärvi
- Measurements of UHE particles with the Radio Detector at Auge, C. Galea

Cosmic Ray detection with the Square Kilometre Array

- **In continuation of a similar experiment at LOFAR**
- **The radio detectors is a the densest part of SKA-Low**
  - Future most sensitive low frequency radio telescope
  - The whole telescope is composed of 131k antennas
- **Trigger from scintillator detectors**
- **Precise measurement of the energy and Xmax**



Talk : - High resolution air shower observations with the Square Kilometre Array, S. Buitink

GRAND 200k

- **Radio detection of highly inclined showers caused by Tau neutrino**
- In developement phase :
  - GRANDProto300 : 300 antennas over 200 km^2
  - GRAND@Auger : 10 antennas for cross calibration
  - GRAND@Nançay : 4 antennas for trigger testing

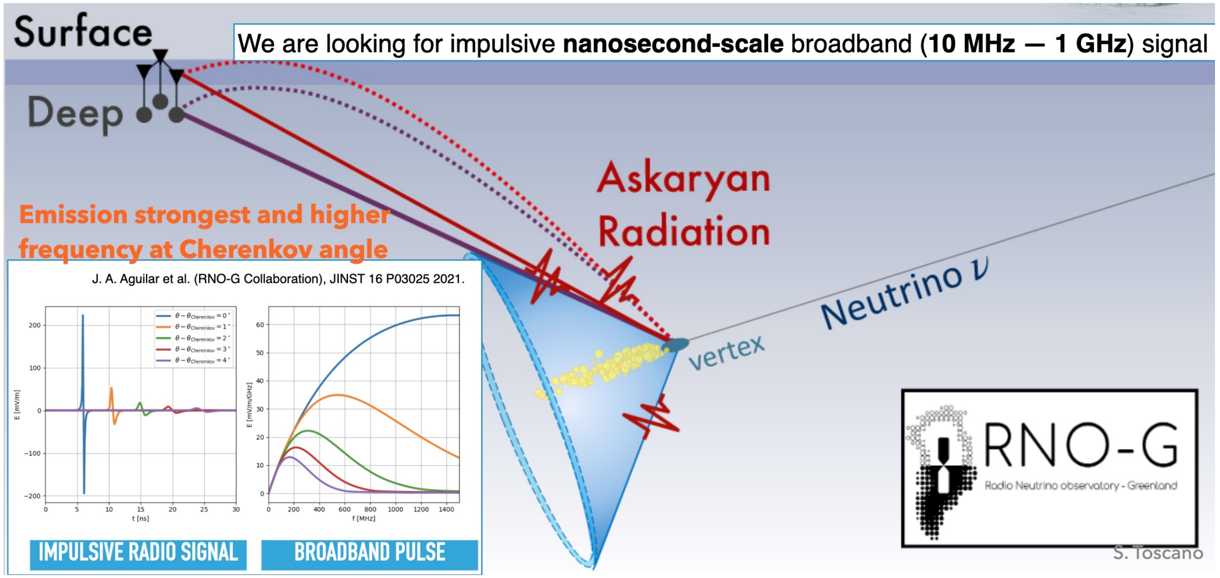
- Target :
  - **200k antennas over 20 sites**
    - Size of site : 10k km^2
    - Number of antenna per site : 10k

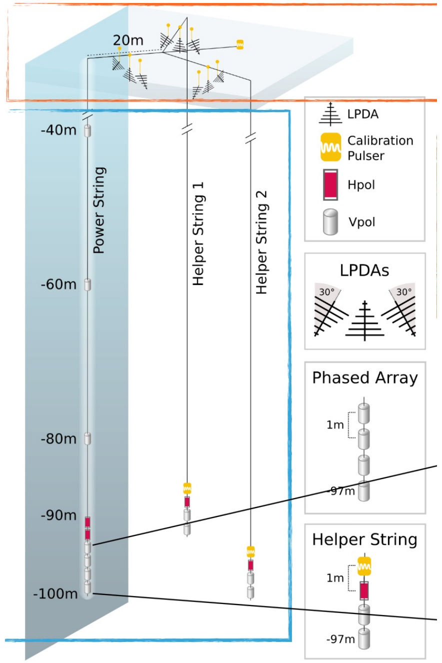
- **Probe cosmogenic neutrino**
- **UHE neutrino astronomy**

Talk : - The Giant Radio Array for Neutrino Detection and its prototype phases, M. Guelfand

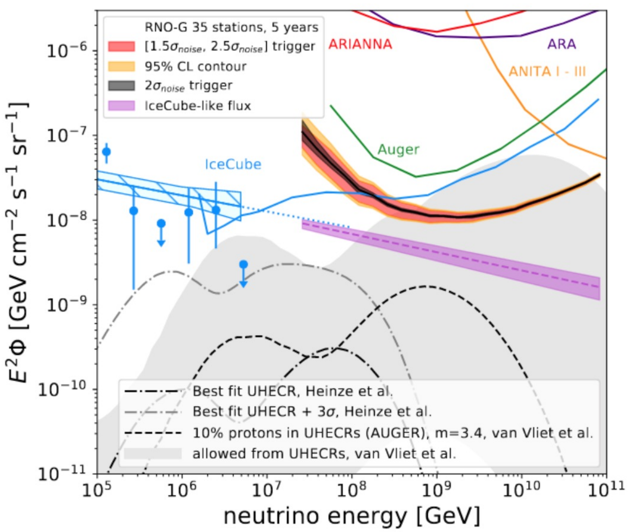
RNO-G

- **Radio detector in the ice to detect UHE neutrino**
- Currently : 7 stations in Groenland
- **Final : 35 stations of 50 km^2**





J. Aguilar et al, (RNO-G Collaboration),JINST 16 P03025 2021

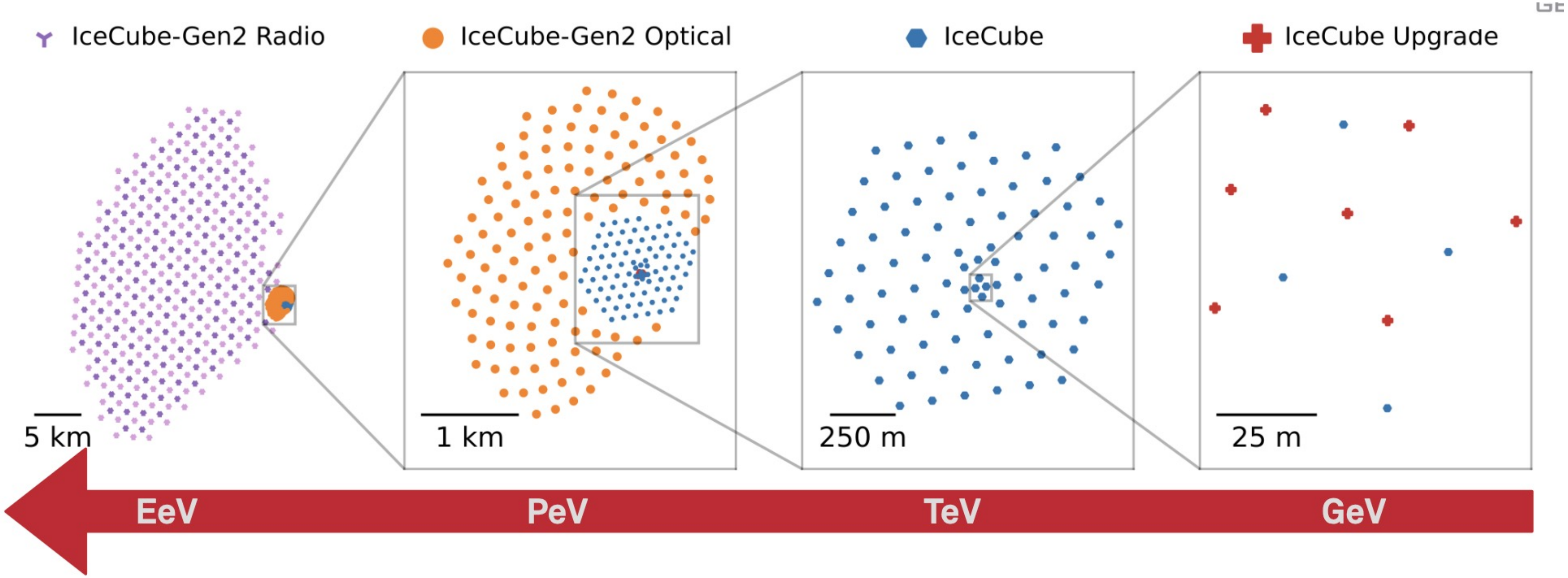


- **Start exploring UHE neutrino astronomy**
- **R&D for IceCube-Gen 2**

Talk : - RNO-G status and first results, S. Toscano

IceCube Gen2

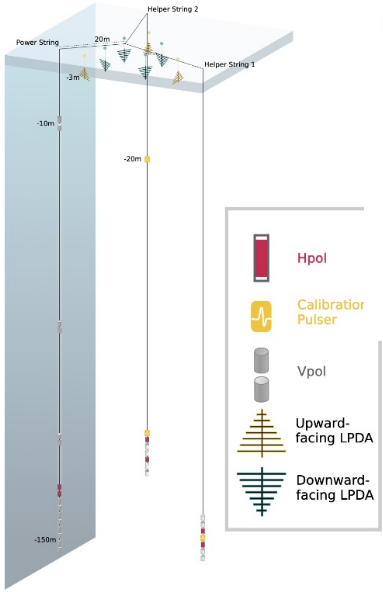
- 8 times larger optical array
- Add a radio array

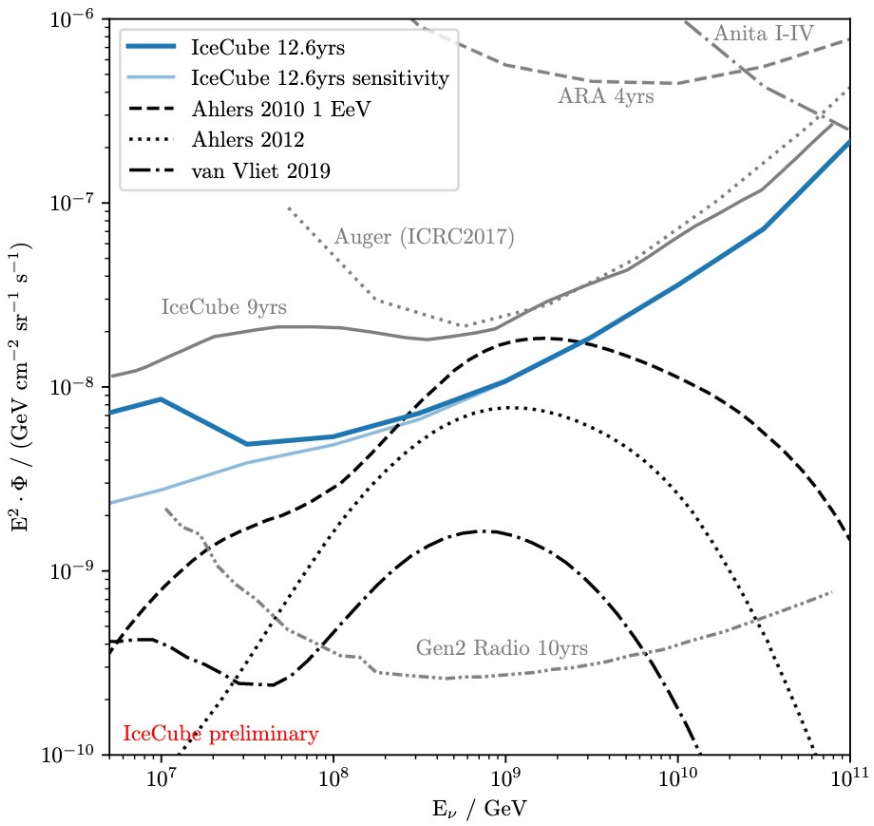


Talk : - Recent cosmogenic neutrino search results with IceCube and prospects with IceCube-Gen2, M. Meier

IceCube Gen2

- **8 times larger optical array**
- **Add a radio array**
  - 360 stations
  - Combination of shallow and deep antennas
  - 500 km^2 array
  - **Will probe the cosmogenic neutrino flux**

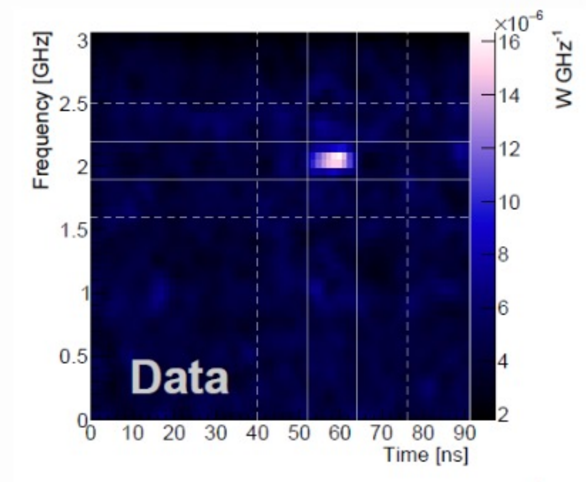


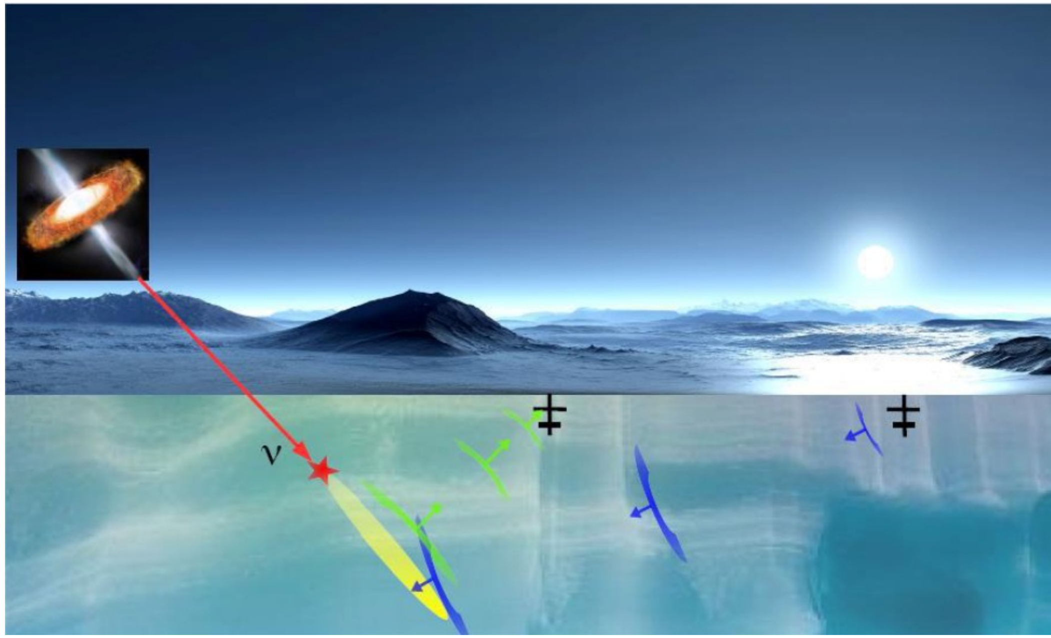


Talk : - Recent cosmogenic neutrino search results with IceCube and prospects with IceCube-Gen2, M. Meier

Radar detector for neutrino

- Detection with a radar system of the plasma created by showers in the ice
- First station deployed in 2023 in Groenland
  - Analysis ongoing





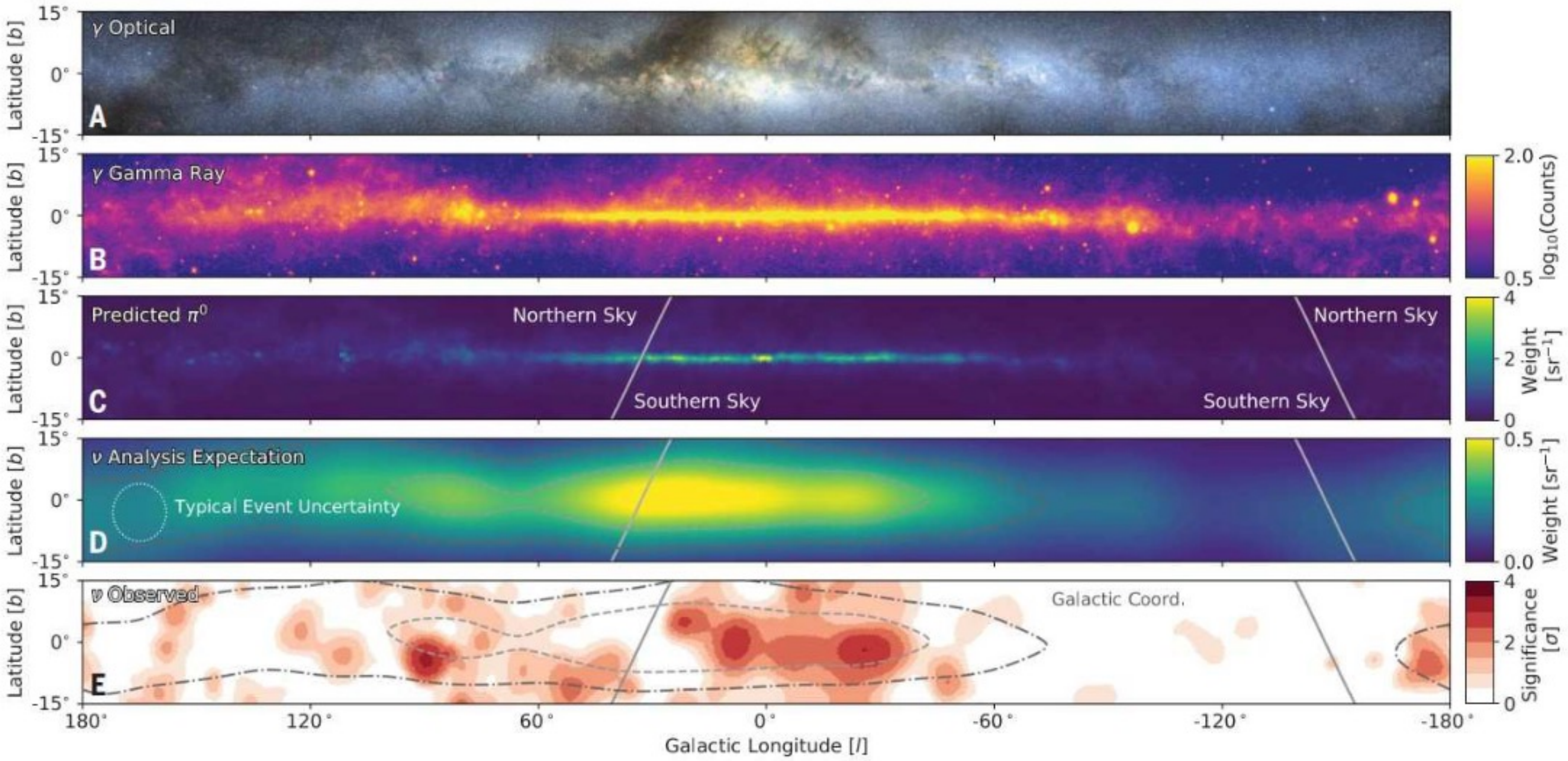
- Probe cosmogenic neutrino
- UHE neutrino astronomy

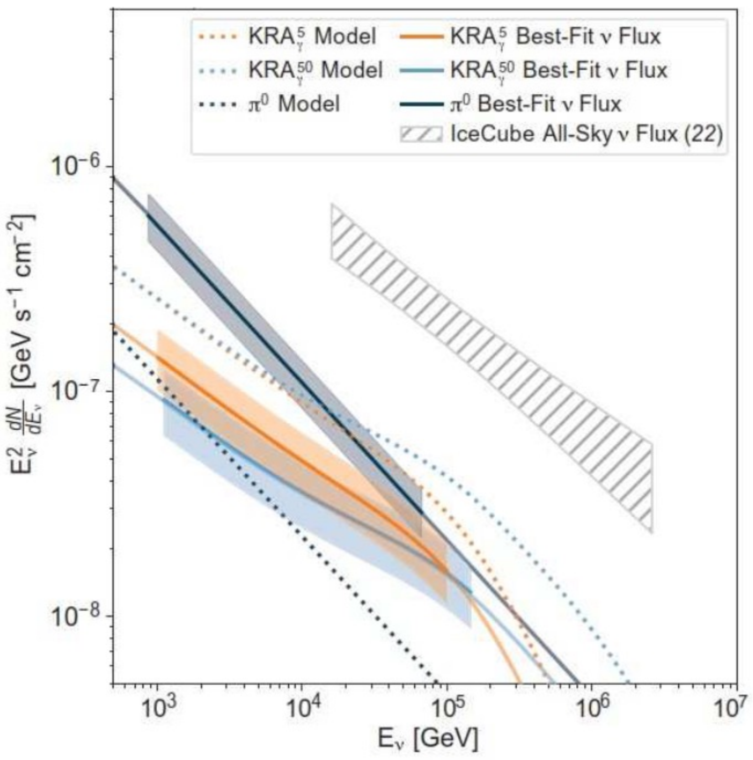
Talk : - The Radar Echo Telescope, K. de Vries

Recent neutrino astronomy results

Neutrino emission from the galactic plane

- **4.48 σ excess for diffuse emission in IceCube**

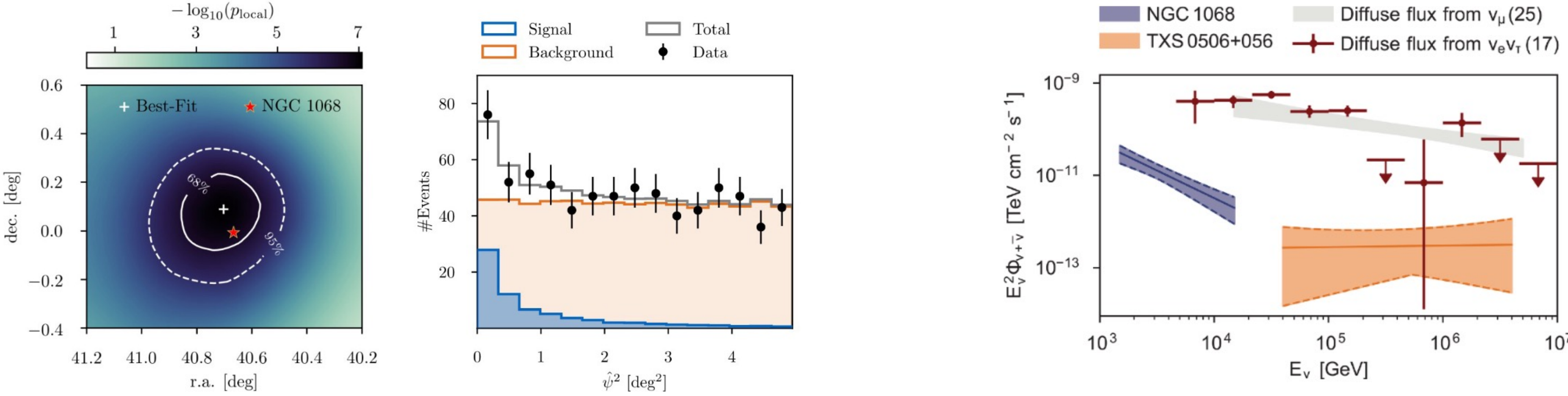




Talk : - Searches for Galactic Neutrinos with the IceCube Neutrino observatory, A. Sandrock

Neutrino emission from NGC 1068

- **4.2 σ excess for emission from NGC 1068 (Seyfert Galaxy)**



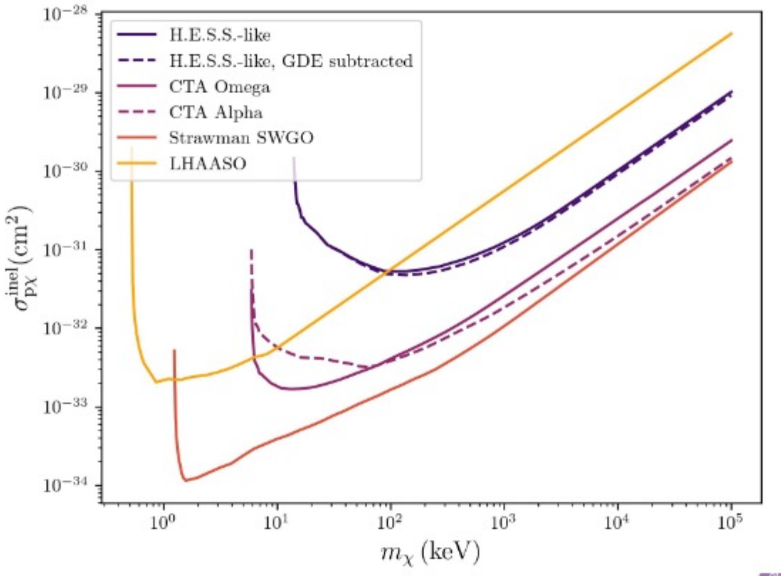
- **3 σ excess for stacked Seyfert galaxies, 2.7 σ excess from 2 other Seyfert galaxies**
- **Not able to explain diffuse emission with these source candidate (too soft spectra)**

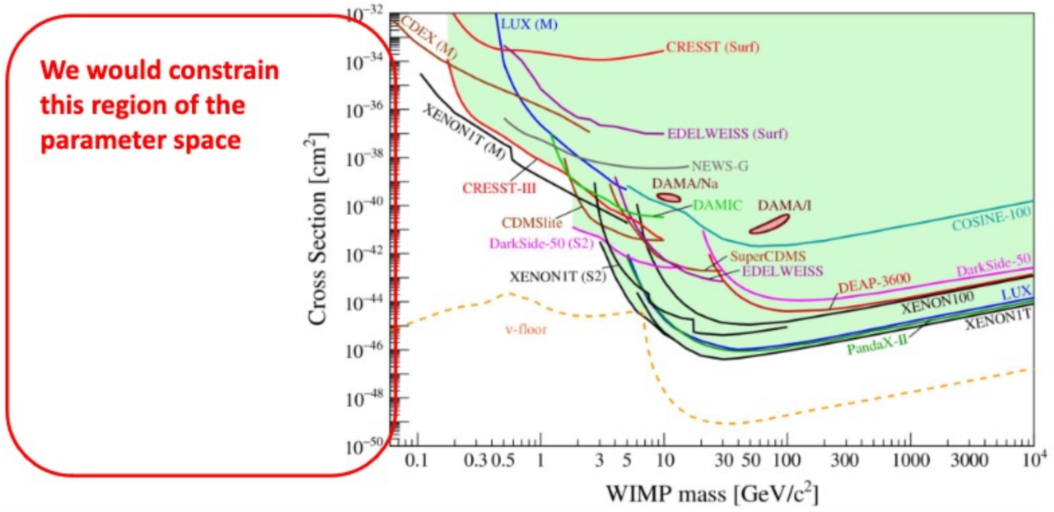
Talk : - Recent IceCube Results: Diffuse Flux, Point Sources, and Dark Matter, M. Jeong
- NGC 1068 constraints on neutrino-dark matter scattering, J. Cline

Recent dark matter results

Inelastic scattering of cosmic rays on dark matter

- **Explore potential for signal cause by inelastic scattering of cosmic-rays on dark matter**
  - Need region with large DM content and large cosmic-ray flux
    - Observation of the Galactic Center with TeV gamma-rays
  - Could lead to limit on the cross section of interaction in an explore parameter space



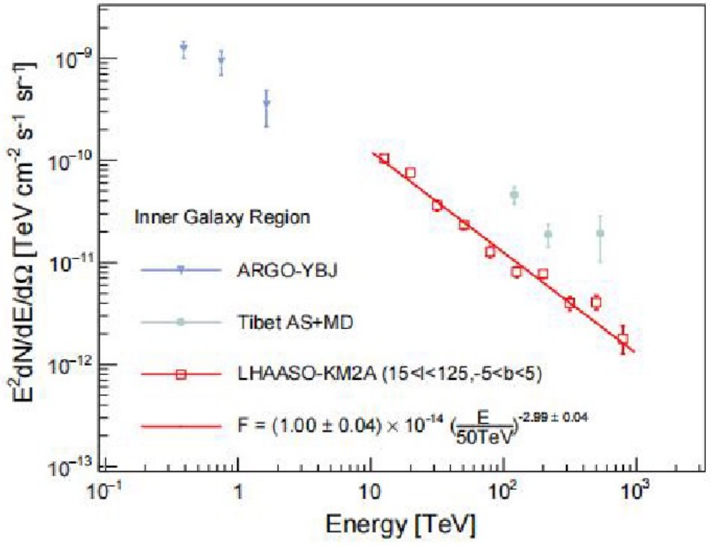


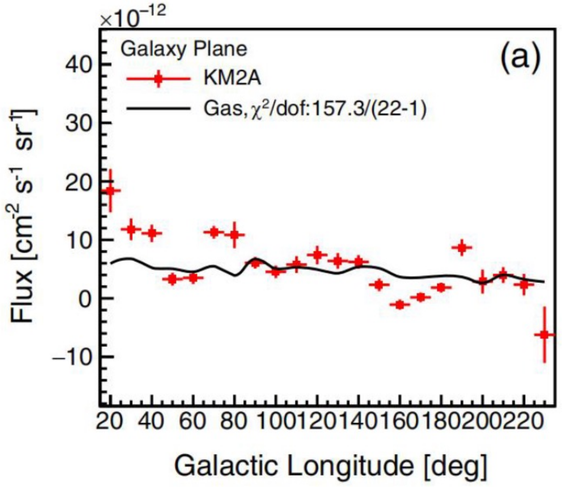
Talk : - Sub-GeV Dark Matter Indirect Detection From Cosmic-Ray Scattering, I. Reis

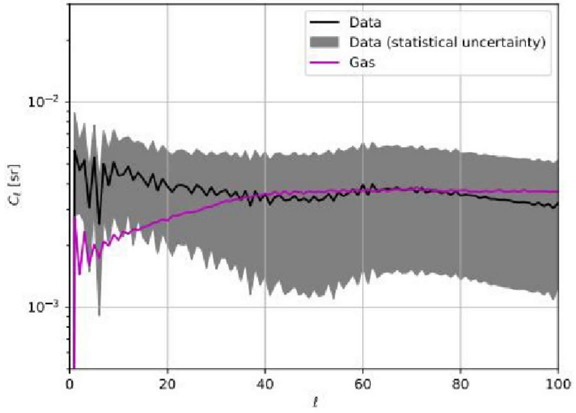
Last results from VHE Gamma-Ray astronomy

Diffuse galactic plane gamma-ray emission with LHAASO

- **Measurement of the diffuse gamma-rays galactic plane emission by LHAASO**





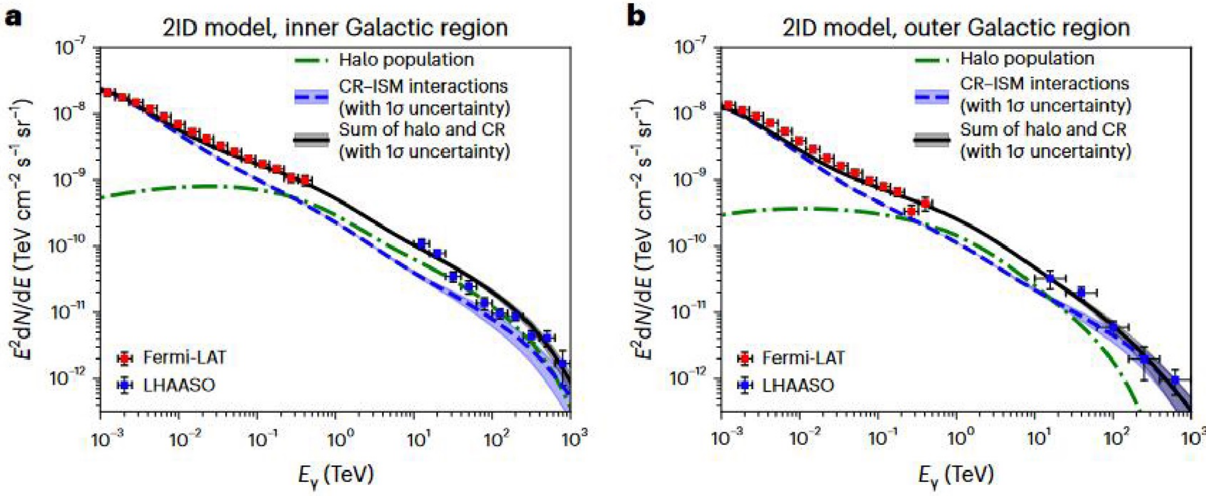


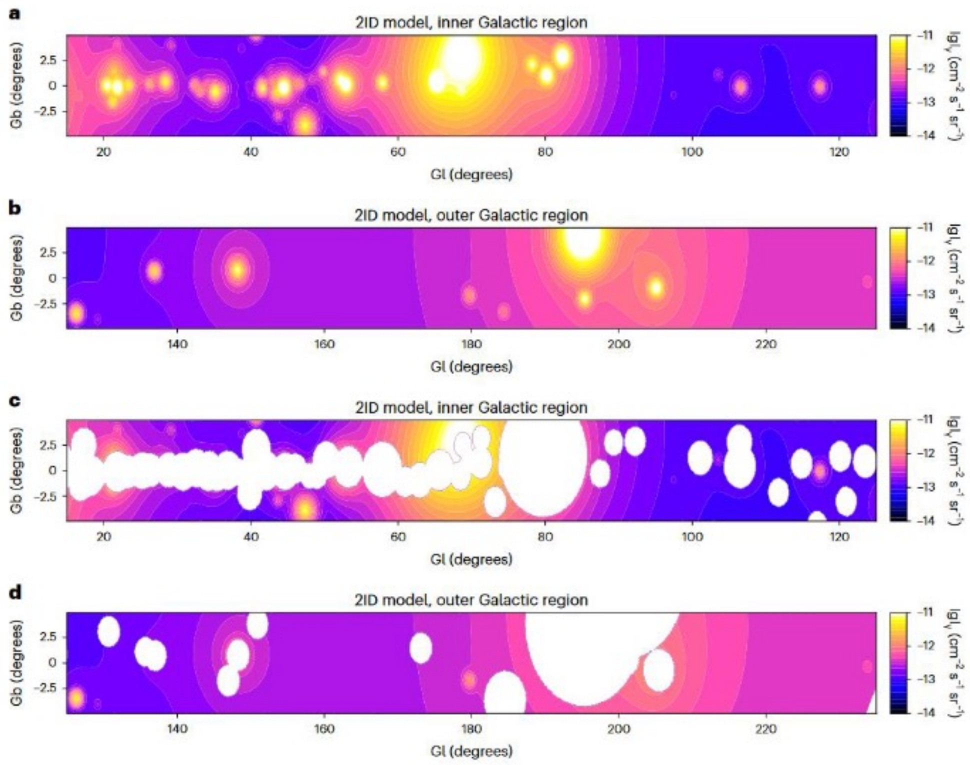
- **Some tension between gas and gamma-ray spatial distribution**

Talk : - Probing cosmic ray origin and propagation with LHAASO, R. Zhang

Diffuse galactic plane gamma-ray emission with LHAASO

- Measured flux 2 to 3 time higher than predicted by models
  - Propagation effect ?
  - Unresolved population sources ?
    - Pulsar Halos ?
      - Not able to explain the inner galaxy region

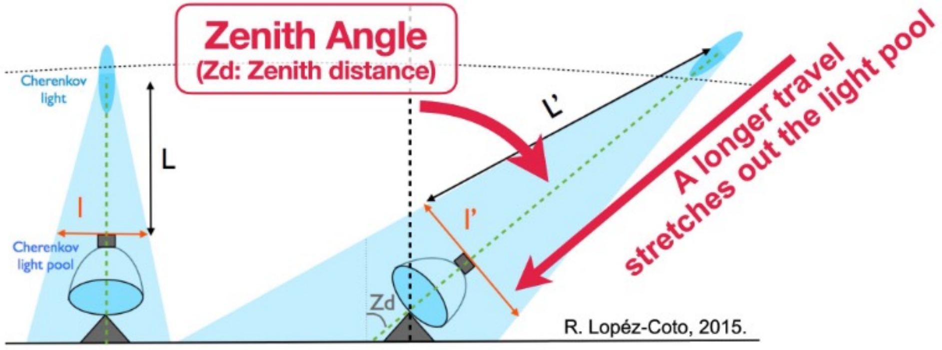


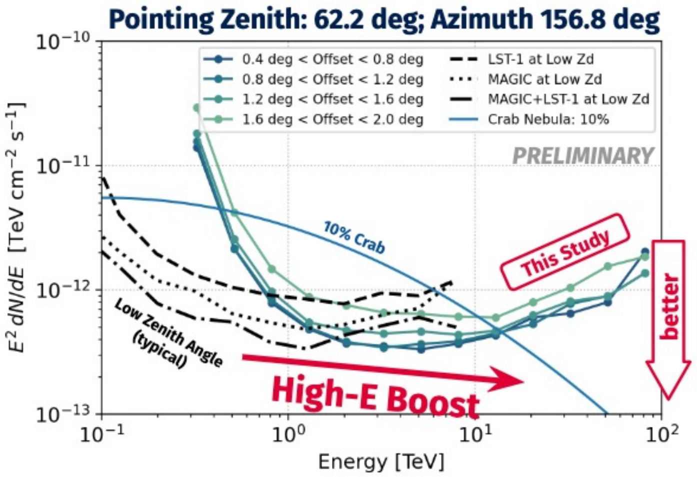


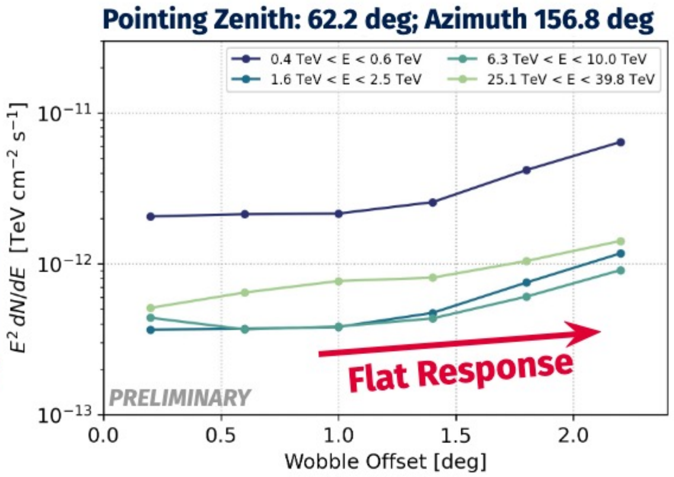
Talk : - Probing cosmic ray origin and propagation with LHAASO, R. Zhang

Galactic center with LST-1

- Observations of the galactic center at large zenith angle with LST-1





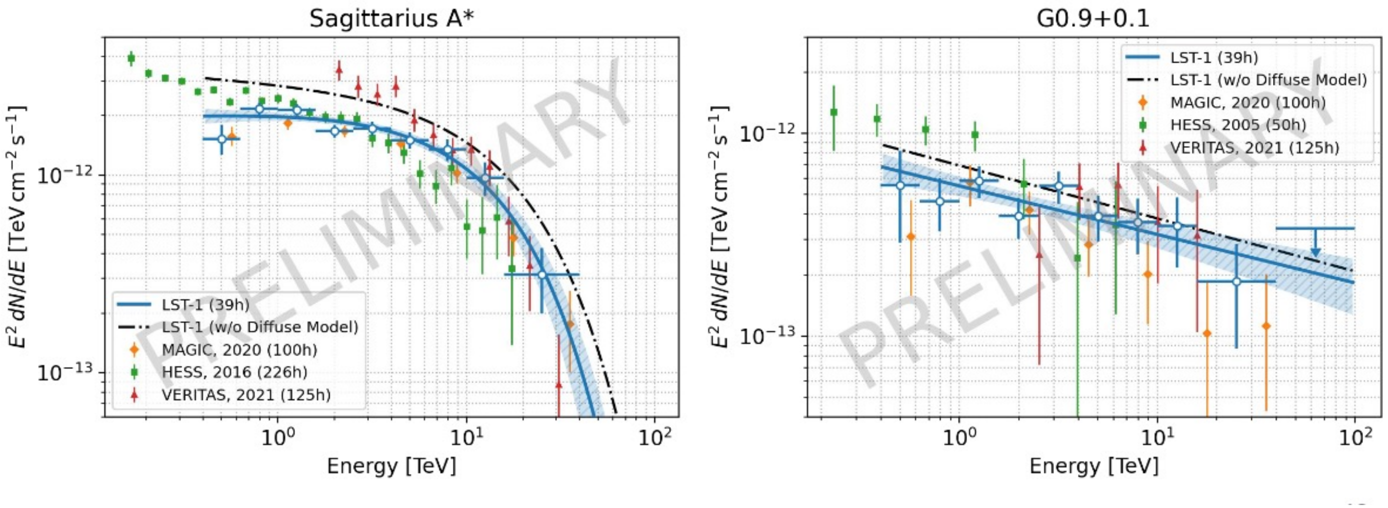


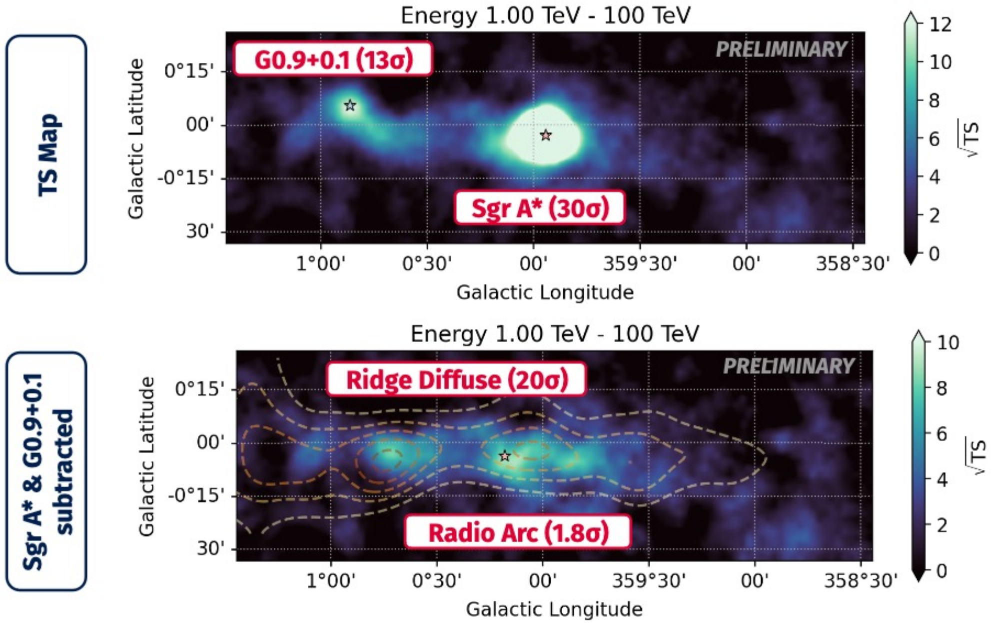
- Larger effective area at high energy
- Performance very sensitive to the zenith angle (even inside the FoV)
- Much higher energy threshold

Talk : - Galactic Center Observations with CTA-LST-1, S. Abe

Galactic center with LST-1

- Observations of the galactic center at large zenith angle with LST-1



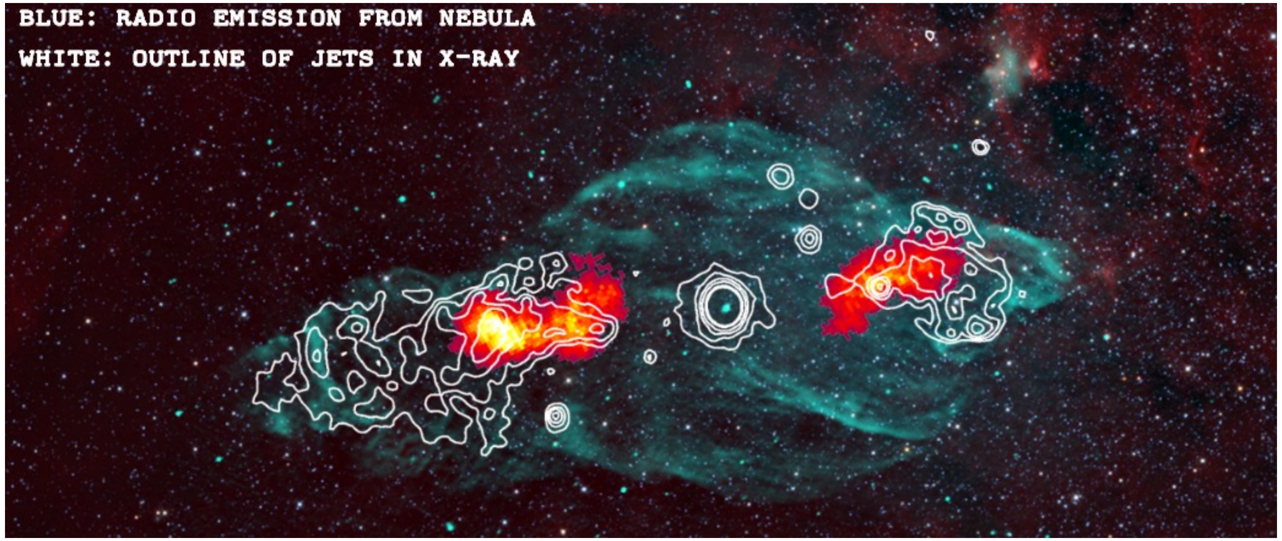


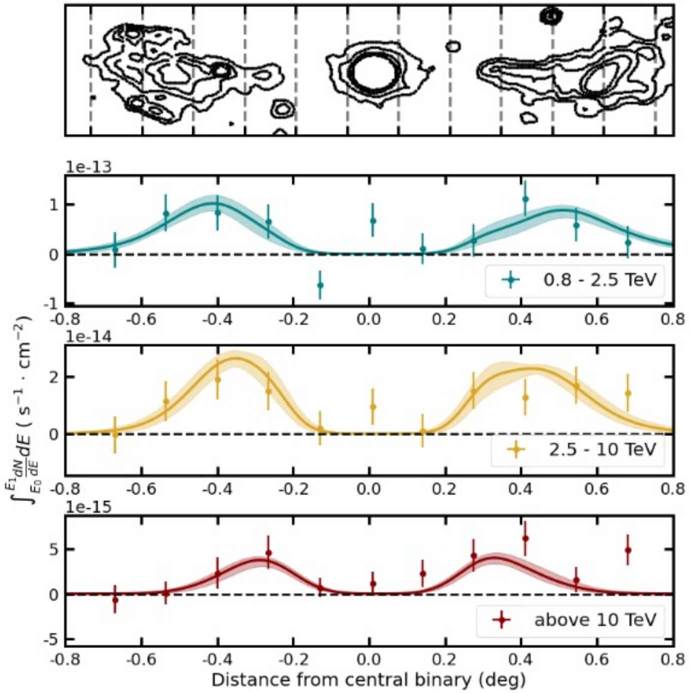
- Clear detection of the central source and the diffuse emission
- Results in agreement with previous experiments
- We could hope for high precision measurement once CTA is completed

Talk : - Galactic Center Observations with CTA-LST-1, S. Abe

Detection of the jets of SS 443

- Detection of the jets of SS 443 at VHE by H.E.S.S.



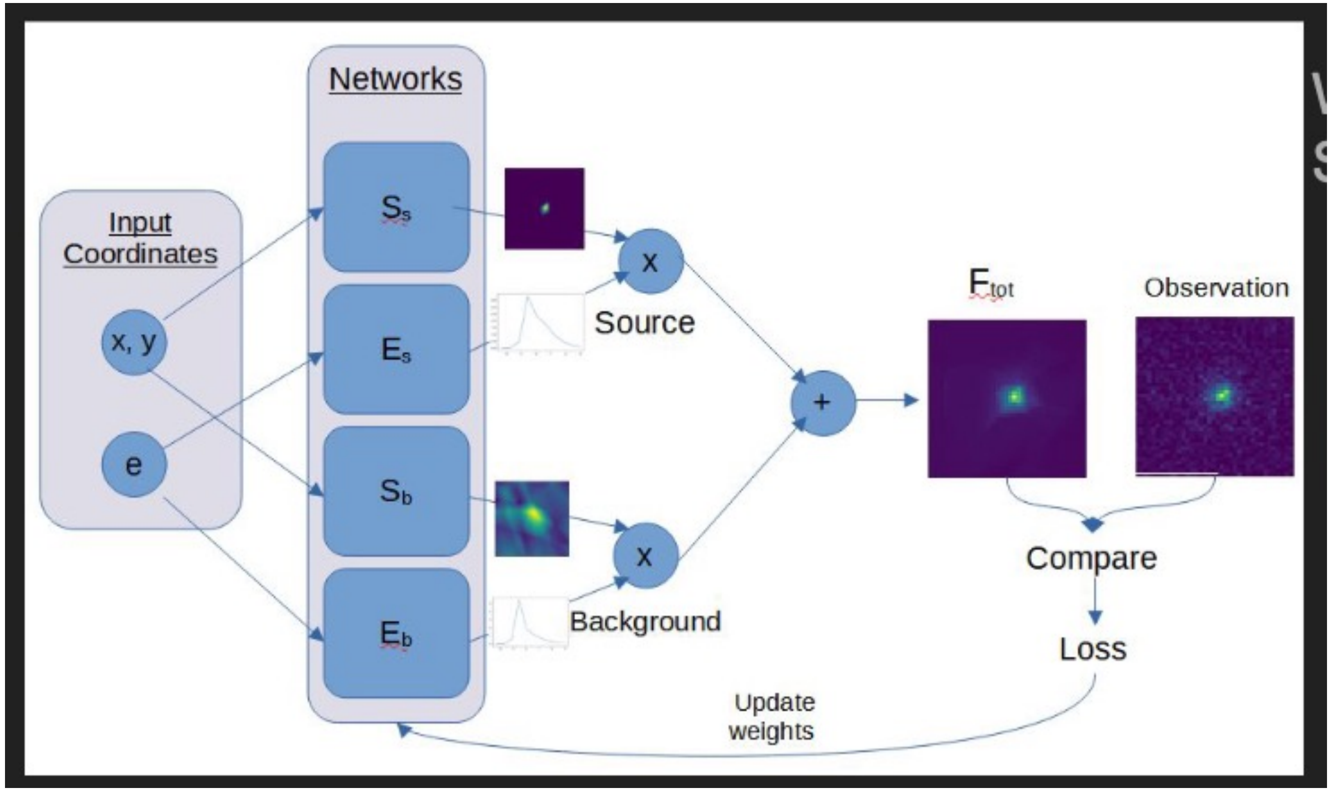


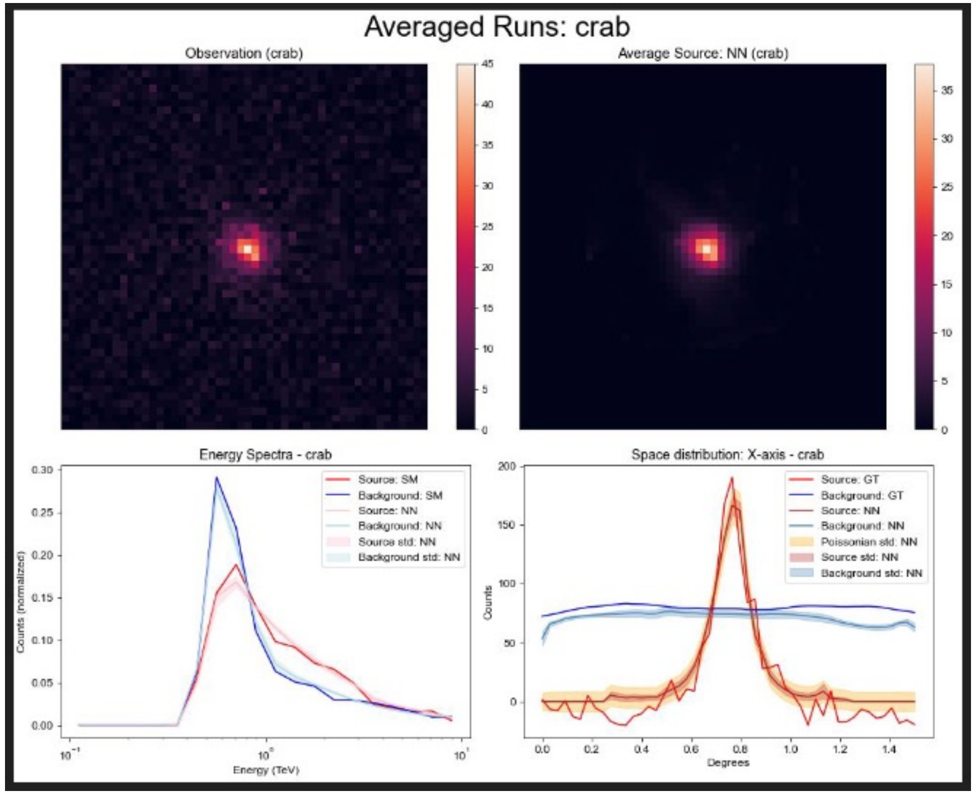
- Electrons accelerated due to shocks at the base of the outer jet
- Inverse compton emission of VHE photons
- Origin of the shock region ?

Talk : - Acceleration and transport of relativistic electrons in the parsec-scale jets of the microquasar SS 433, L. Oliviera-Nieto

Separation of sources from background with ML

- Look at the potential of ML algorithm to separate source from background in IACT data

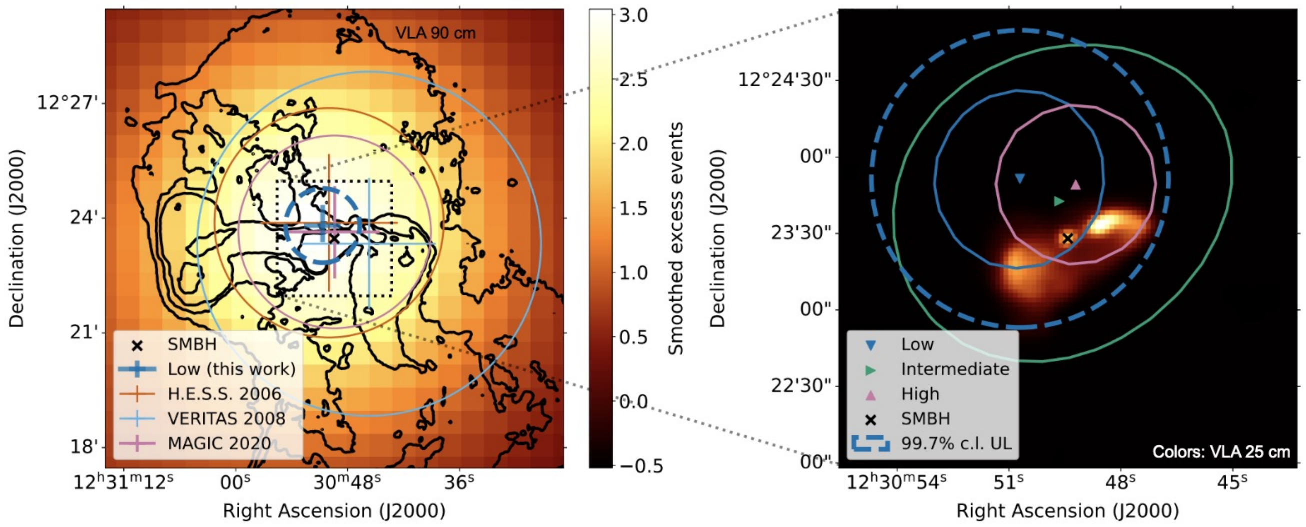




Talk : - Non-parametric Signal Separation with Probabilistic Machine Learning, M. Ullmo

Gamma-ray emission from M87

- **Search for diffuse emission due to hadronic interaction in the low state of M87 by H.E.S.S.**

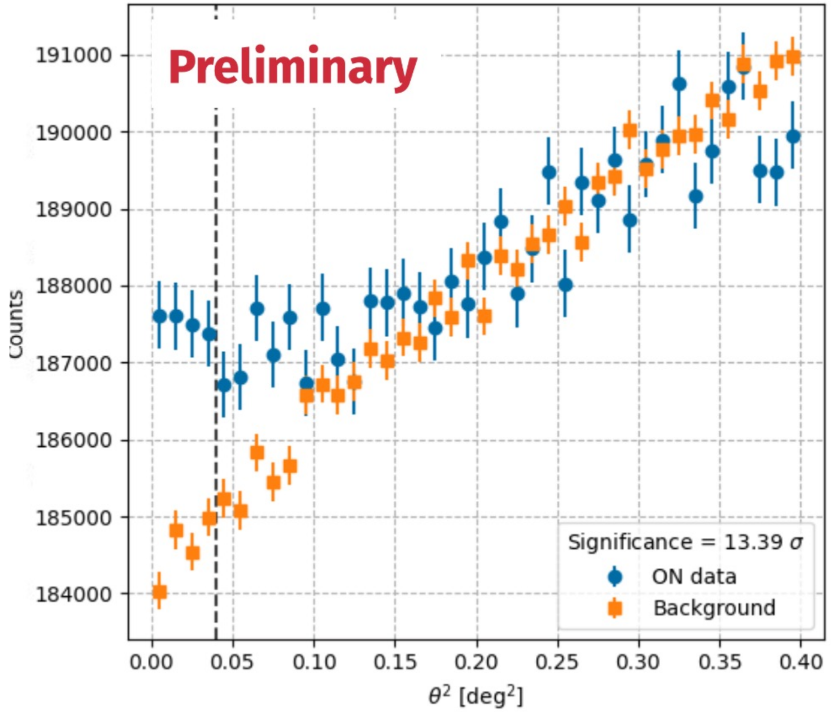


- **Gamma-ray emission linked to hadronic process could not be more than 55% of the flux**
- **The leptonic emission could not come from radio lobes**
- Unexplained curvature of the spectrum during flares

Talk : - Unveiling the gamma-ray mysteries of M87, V. Barbosa Martins

Furthest blazar ever detected at VHE by LST-1

- Detection at VHE of OP 313 (z=0.997) during a flare, 19h of data (LST-1)

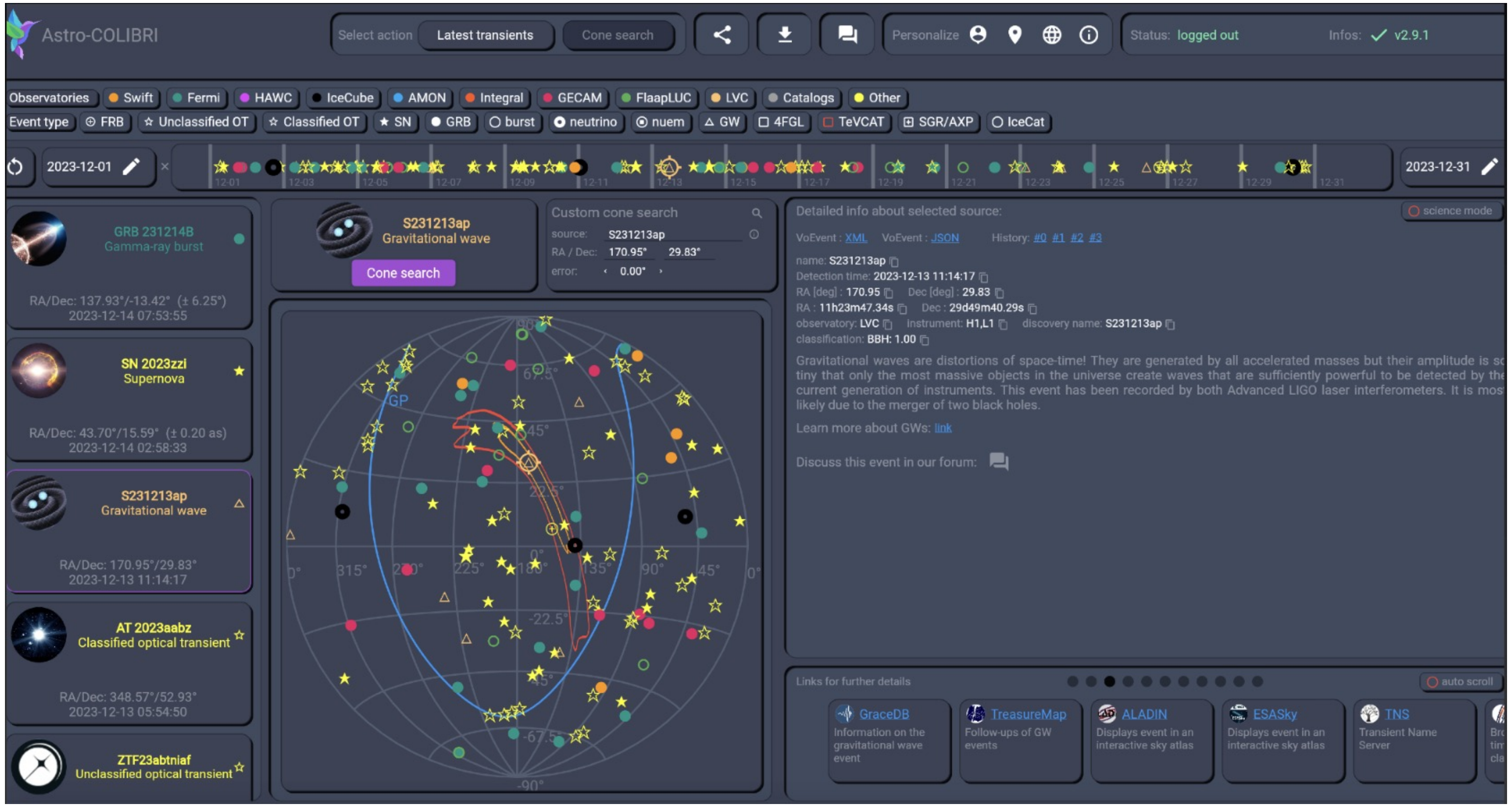


- Average flux : 0.28 Crab
- Show the ability of LSTs and CTA at detecting high redshift sources

Talk : - AGN observations with LST-1: first results and discovery of the flat spectrum radio quasar OP 313, J. Otero-Santos

Astro-COLIBRI

- **A tool to help at observations of transient phenomena**
- astro-colibri.com



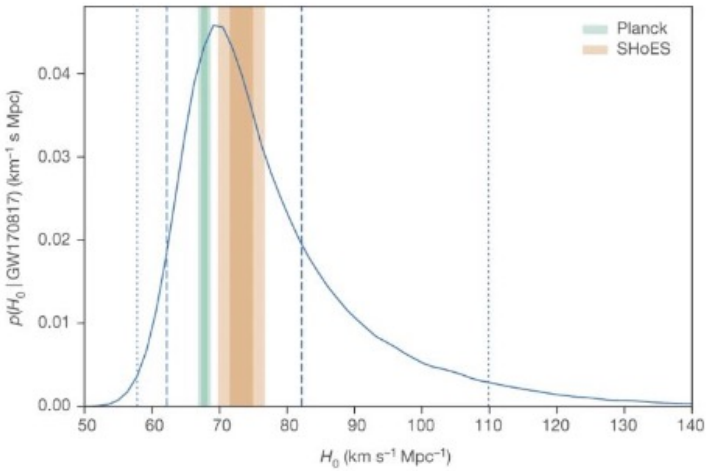
Talk : - Multi-messenger follow-up observations using Astro-COLIBRI, F. Schüssler

Cosmology with gravitational waves

- **Attempt at new independant measurement of the Hubble constant**

Hubble constant : Brigth Sirens

- **Comoving distance measurement from GW interferometer**
- **Redshift measurement by optical telescope**

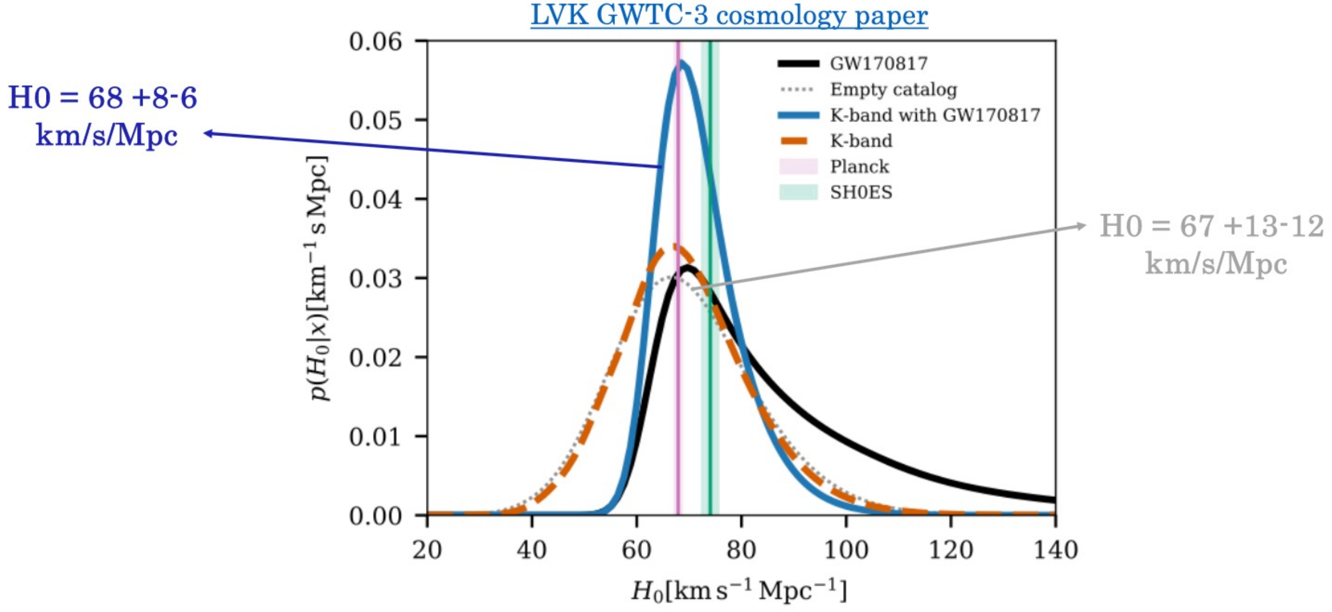


- **H0 = 68+8-6 km/s/Mpc**
- Detection of such events very rare (only one so far, GW 170817)
- **Would need O(100) events for precise measurement**

Talk : - Results from multi-messenger investigations during the LIGO/Virgo/KAGRA O3 and O4a runs, R. Poggiani

Hubble constant : Dark Sirens

- Comoving distance and redshift measured by GW interferometer
- Degeneracy between mass and redshift



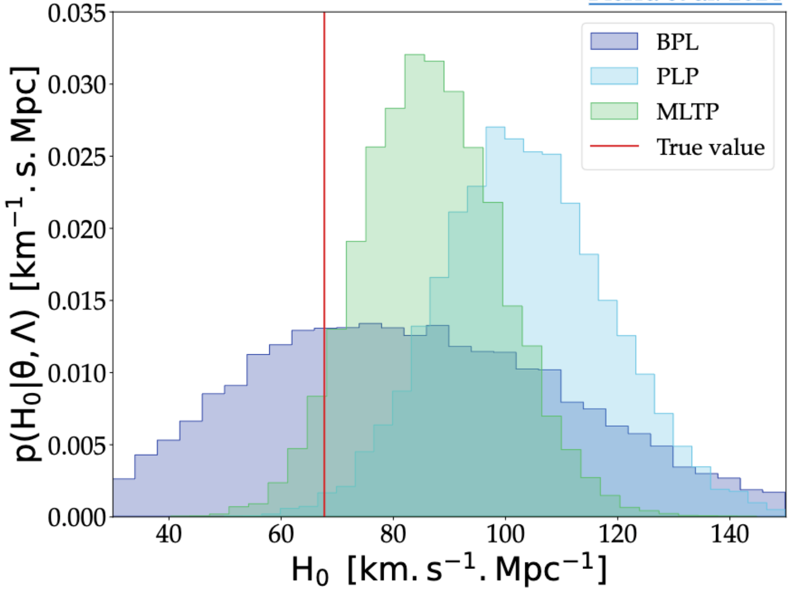
- H0 = 67+13-12 km/s/Mpc

Talk : - Gravitational Wave Cosmology: Be Careful of the Black Hole Mass Spectrum, G. Pierra

Hubble constant : Dark Sirens

- Comoving distance and redshift measured by GW interferometer
- Degeneracy between mass and redshift

Pierra et al. 2024



- Need a very good knowledge of the redshift dependant mass distributions of black holes
- Looking at how to improve robustness to systematic from the mass distribution

Talk : - Gravitational Wave Cosmology: Be Careful of the Black Hole Mass Spectrum, G. Pierra

Thanks for your attention