université PARIS-SACLAY

Irfu - CEA Saclay
Institut de recherche sur les lois fondamentales de l'Univers

Summary of the 36th ICRC @Madison

L. Rinchiuso

université PARIS-SACLAY

Irfu - CEA Saclay
Institut de recherche sur les lois fondamentales de l'Univers

(Biased and partial) Summary of the 36th ICRC @Madison

L. Rinchiuso

Outlook

A selection of topics

- Cosmic rays
- Neutrinos
- Gamma rays
- Dark matter

Outlook

A selection of topics

- Cosmic rays
- Neutrinos
- Gamma rays
- Dark matter

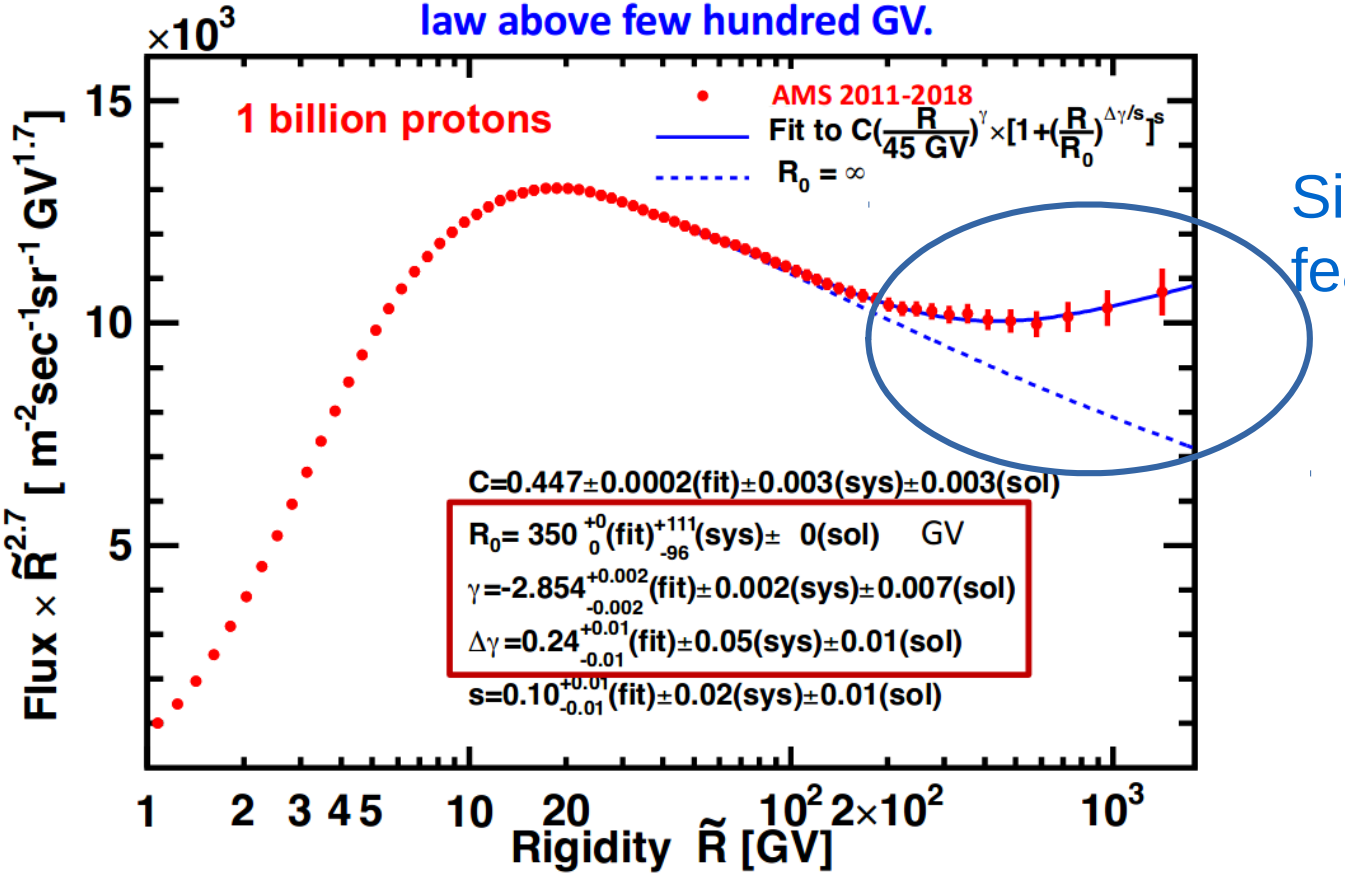
>800 participants, 60 parallel sessions,
>400 talks, >600 posters

Cosmic rays

- p, He, C and O spectra by AMS-02
- Electron spectrum by CALET and DAMPE
- Positron excess by AMS-02
- Dipole anisotropy
- UHE cosmic rays

Proton spectrum by AMS-02

Proton spectrum measured by AMS shows a deviation from a single power law above few hundred GV.



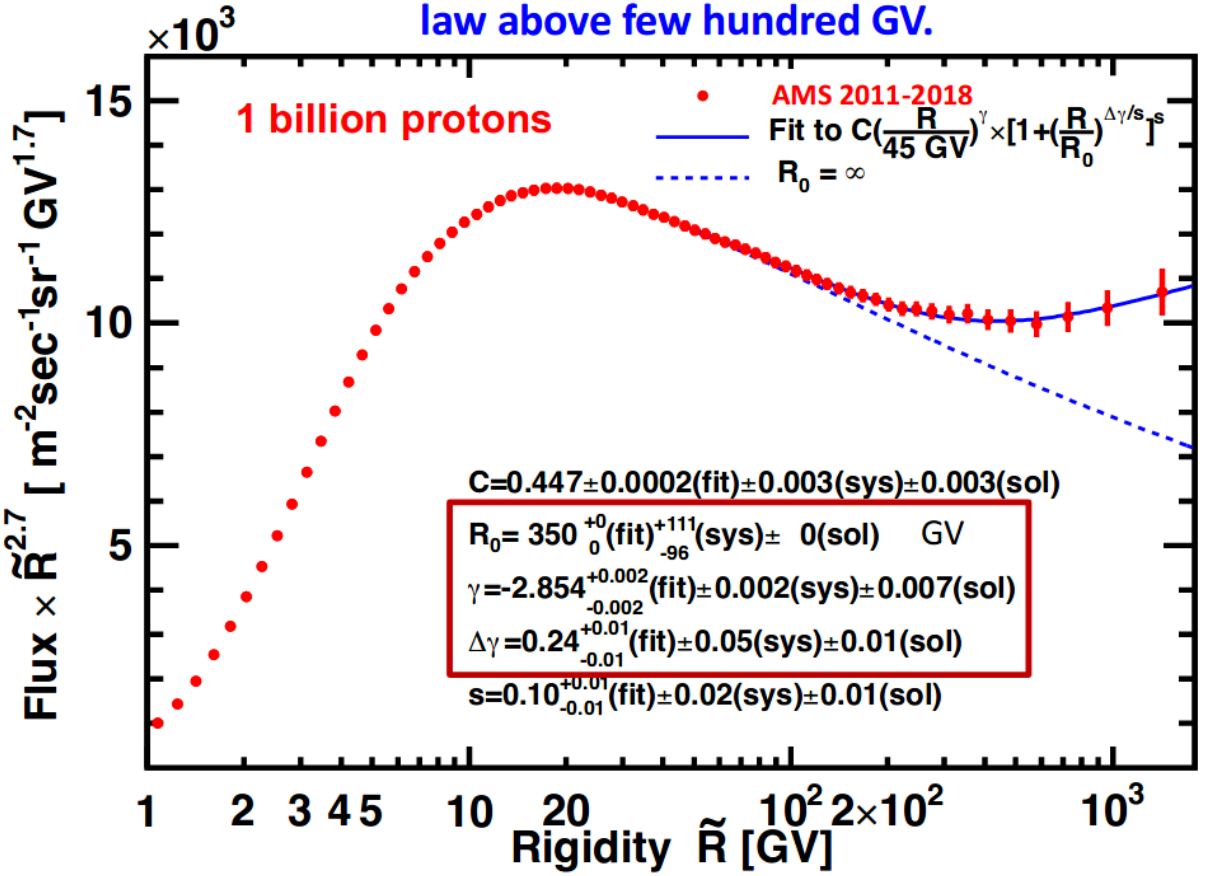
Significant feature

The new AMS result (2011-2018) is consistent with earlier AMS PRL result (2011-2013) "M. Aguilar *et al.*, Phys. Rev. Lett., **114,** 171103 (2015)" but with improved accuracy

6

Proton spectrum by AMS-02

Proton spectrum measured by AMS shows a deviation from a single power law above few hundred GV.



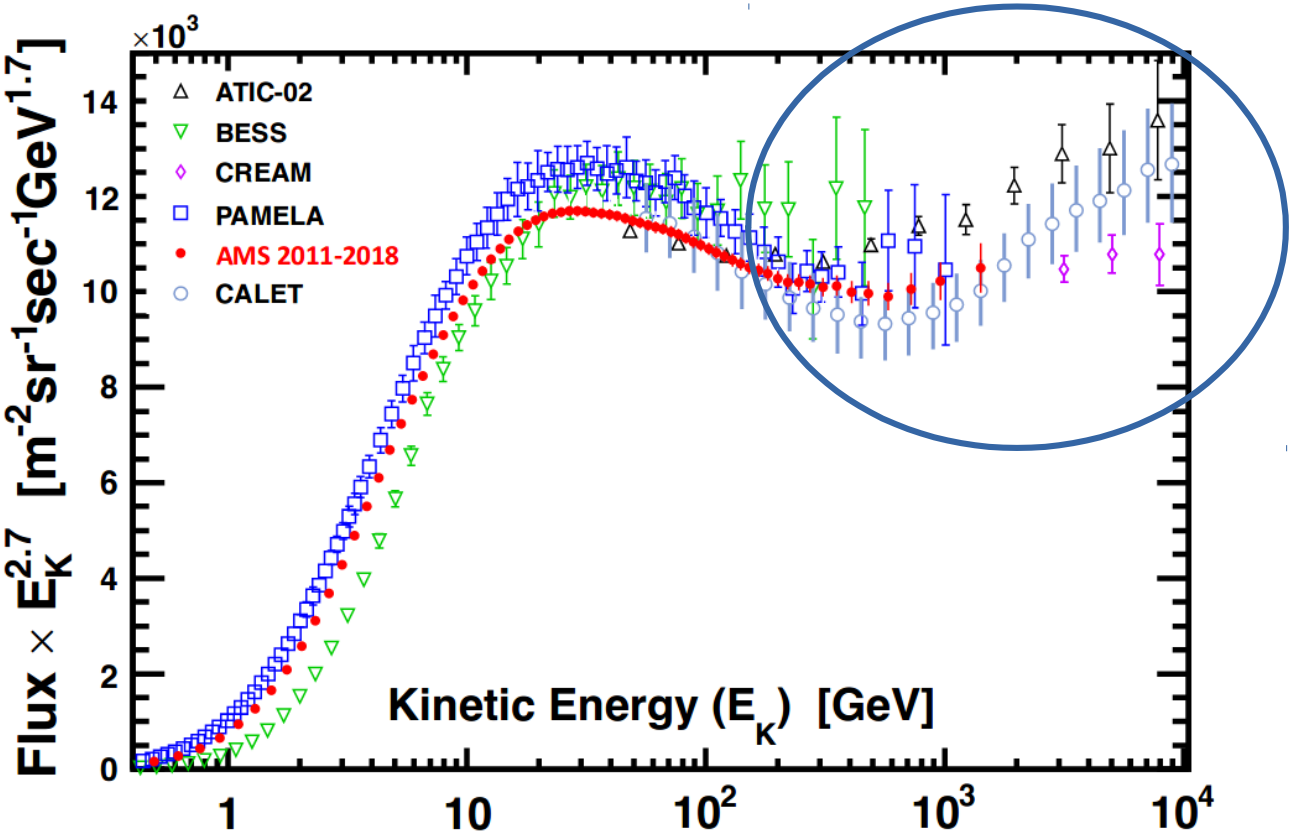
- Primary source?
- Revisit Galactic diffusion models?

The new AMS result (2011-2018) is consistent with earlier AMS PRL result (2011-2013) "M. Aguilar *et al.*, Phys. Rev. Lett., **114,** 171103 (2015)" but with improved accuracy

6

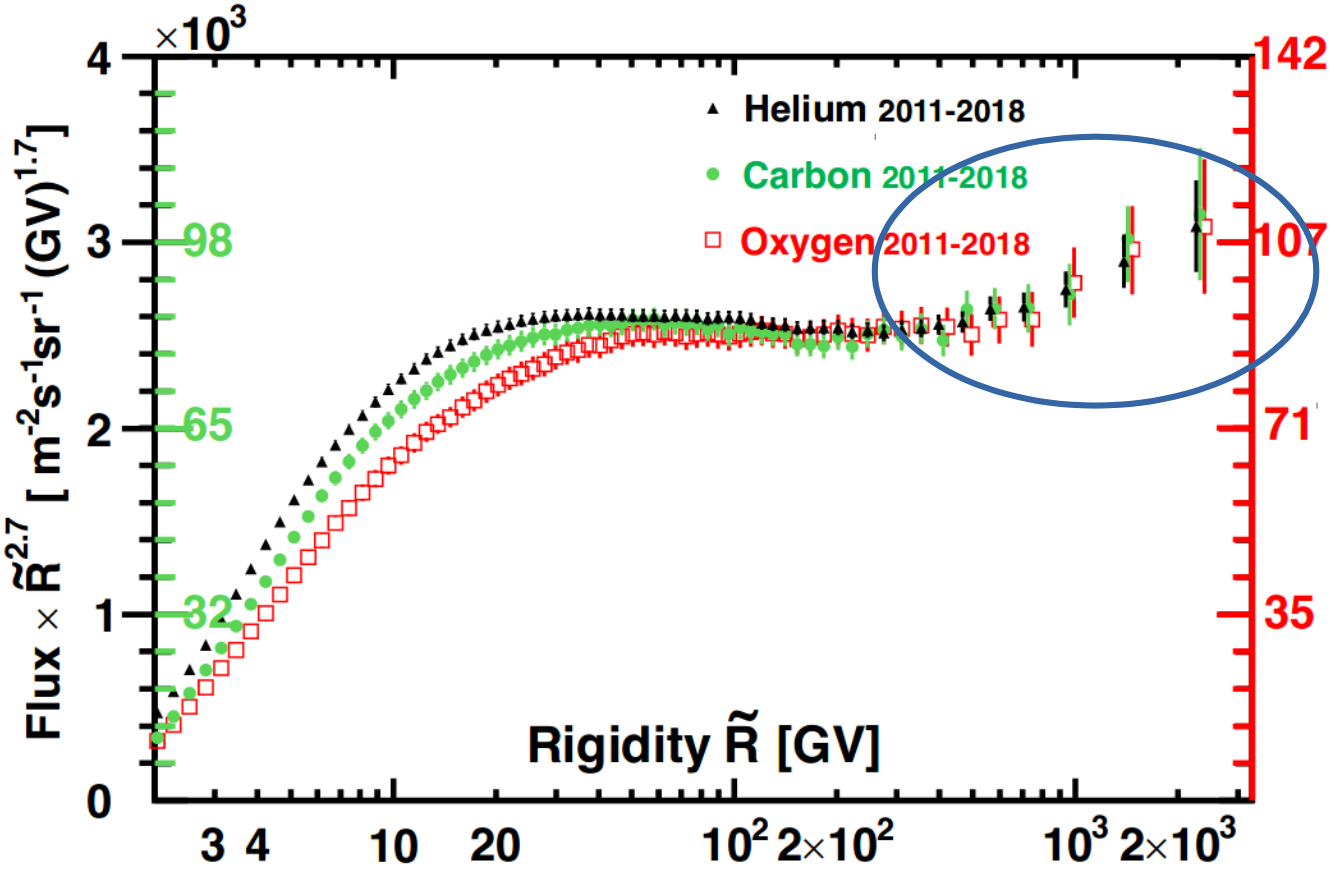
Proton spectrum by AMS-02

Consistent with other measurements



Rise confirmed by other experiments

He, C and O spectra by AMS-02



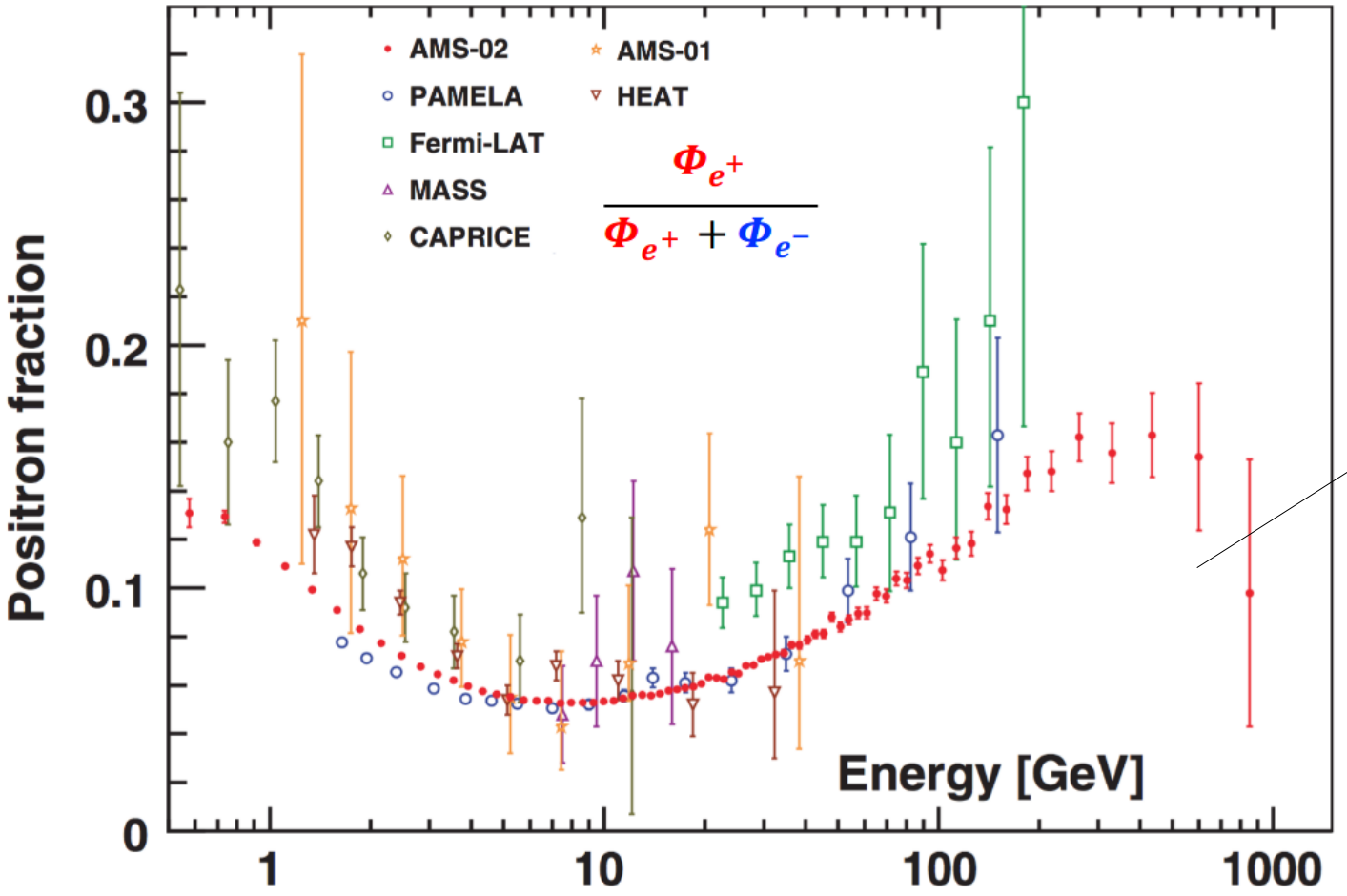
Deviation in all species

The new AMS result (2011-2018) is consistent with earlier AMS PRL result (2011-2016) "M. Aguilar *et al.*, Phys. Rev. Lett., **119**, 251101 (2017)" but with improved accuracy

16

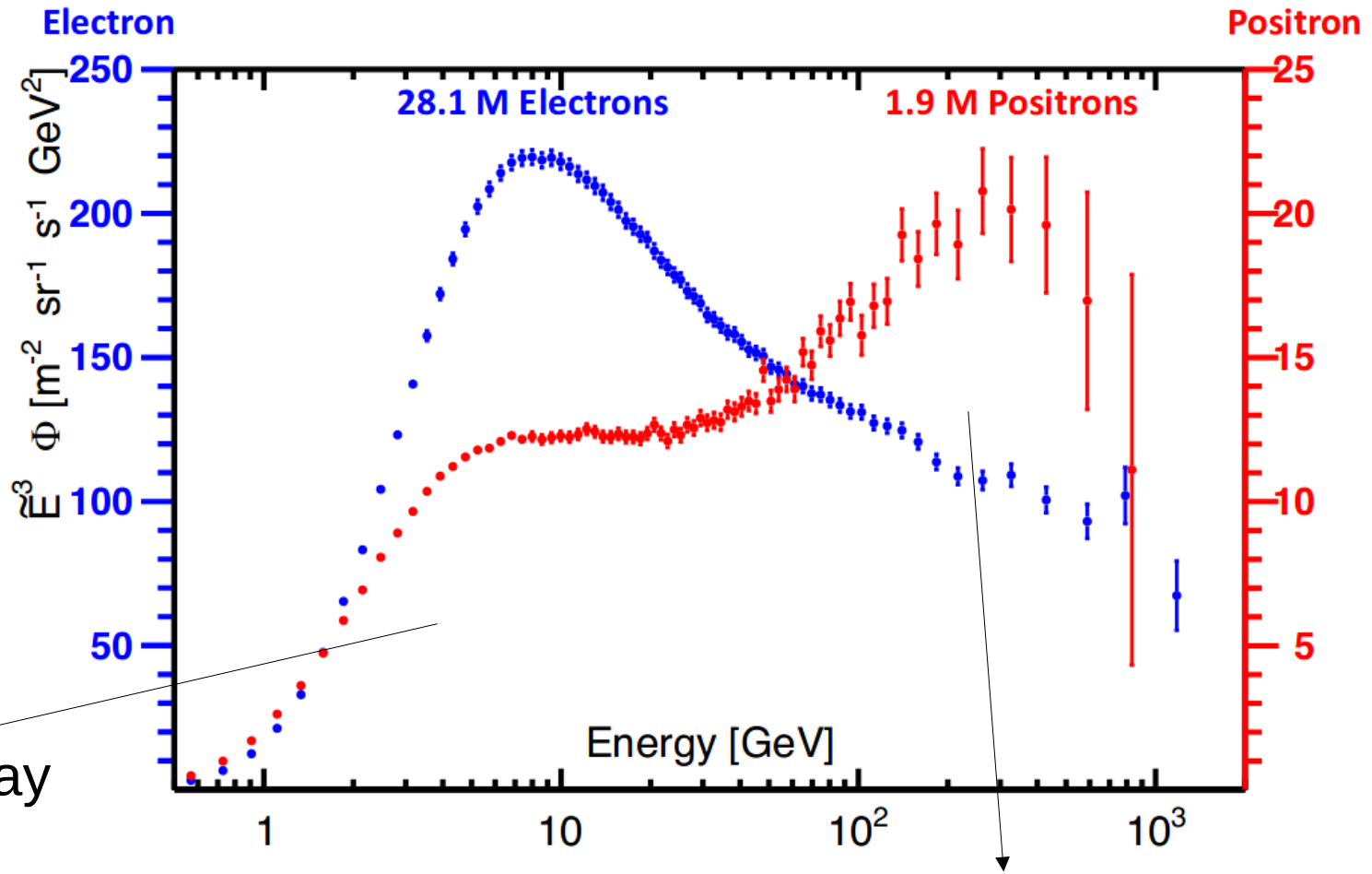
Positron excess with AMS-02

No significant update



Extended energy range + cutoff 800 GeV

Positron excess with AMS-02

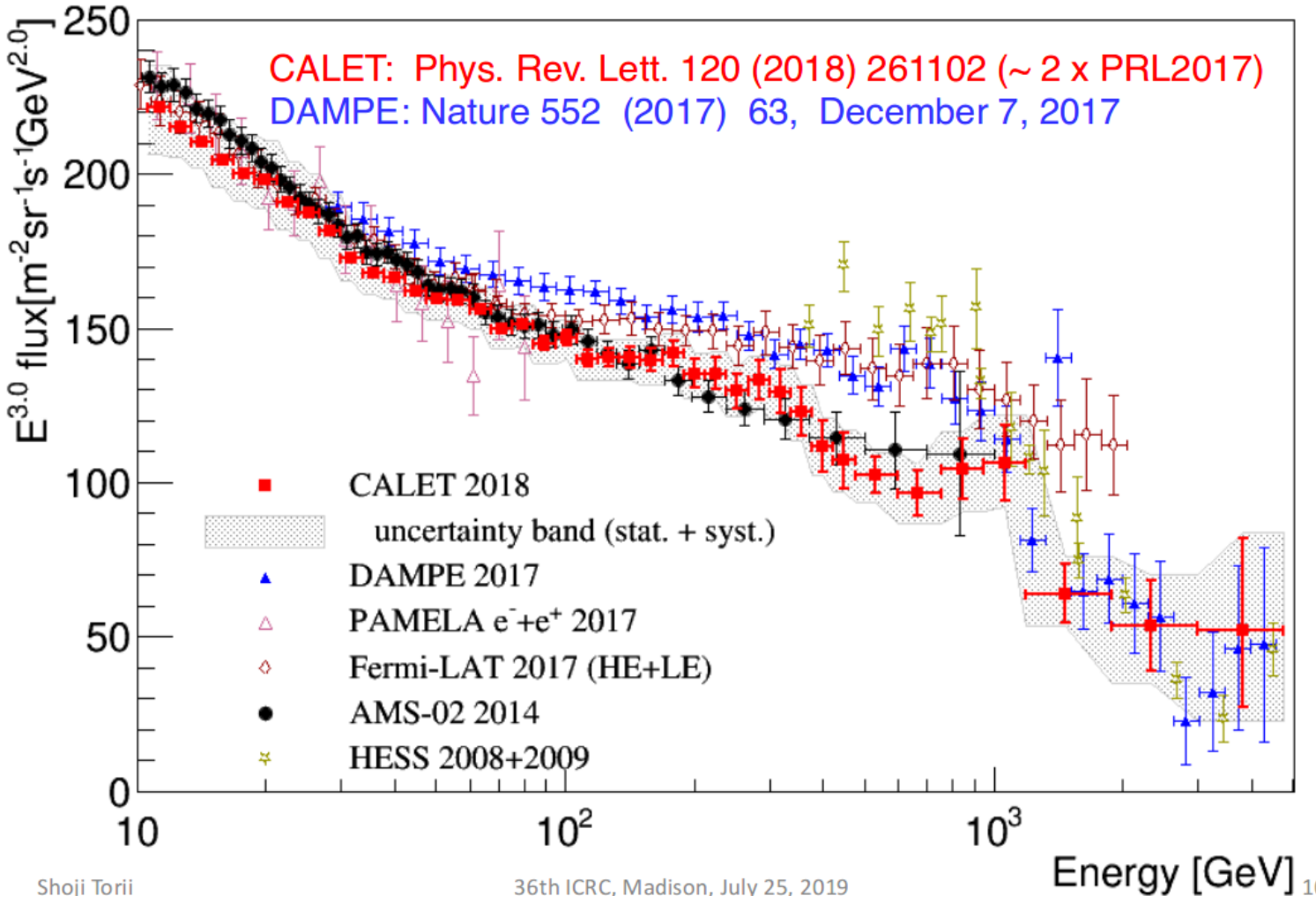


Cosmic-ray collisions

- Astrophysical source? Pulsars?
- ~1 TeV dark matter?

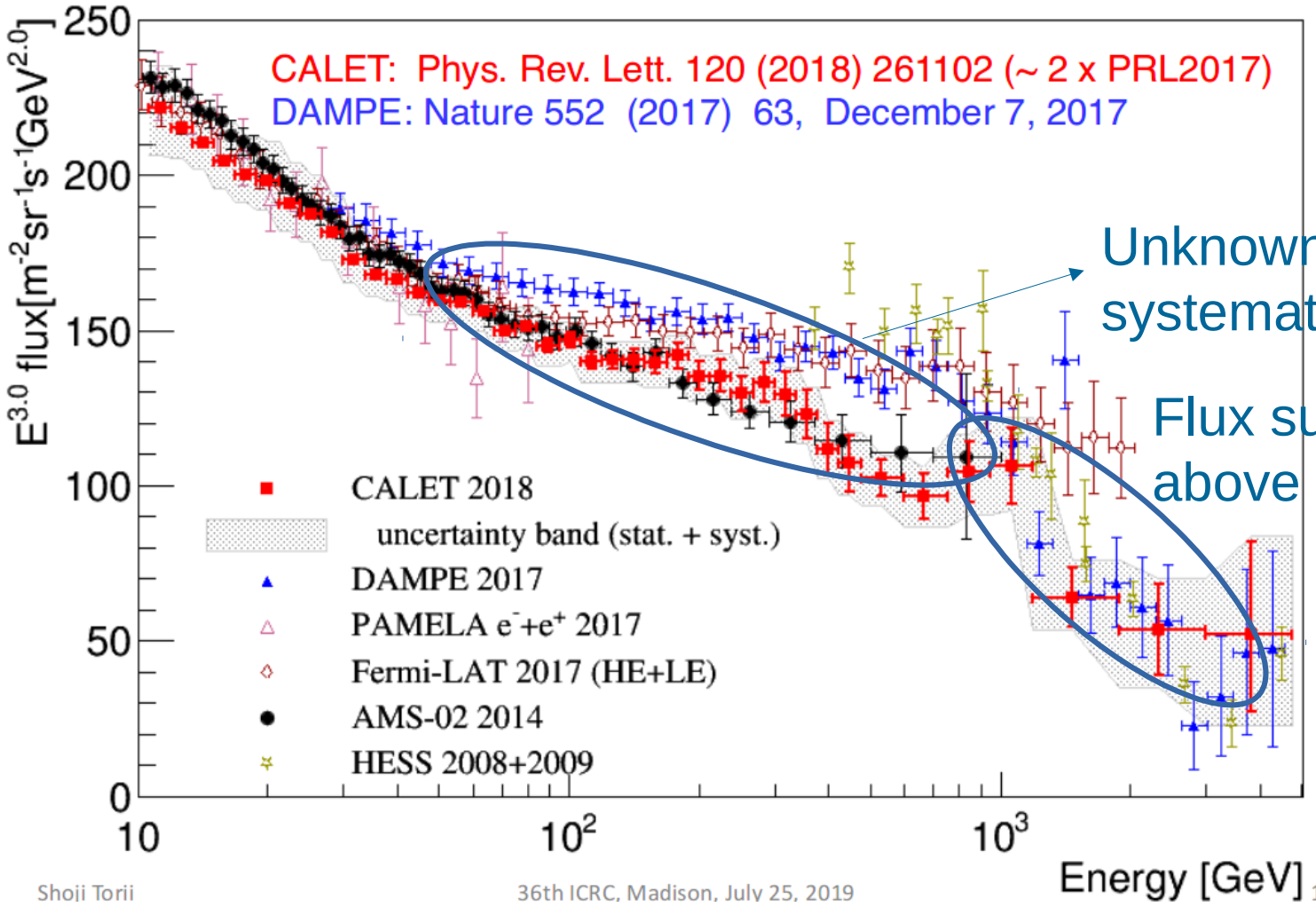
Electron spectrum by CALET and DAMPE

Approximately doubled statistics above 500GeV by using full acceptance of CALET

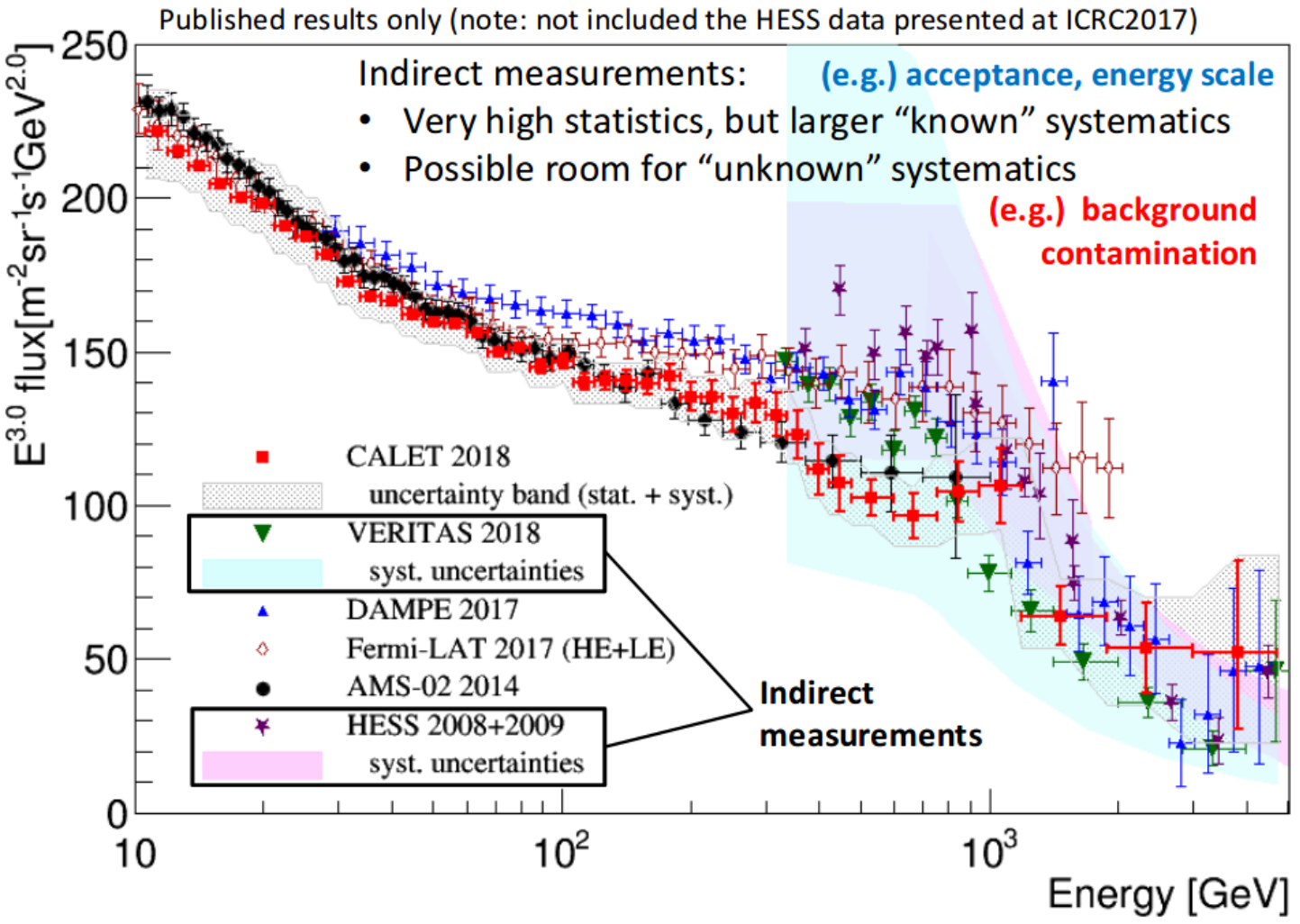


Electron spectrum by CALET and DAMPE

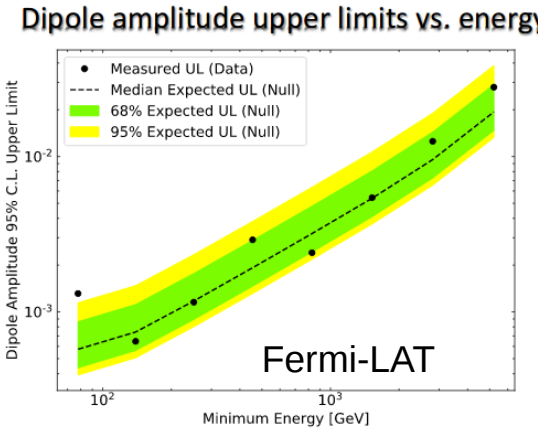
Approximately doubled statistics above 500GeV by using full acceptance of CALET

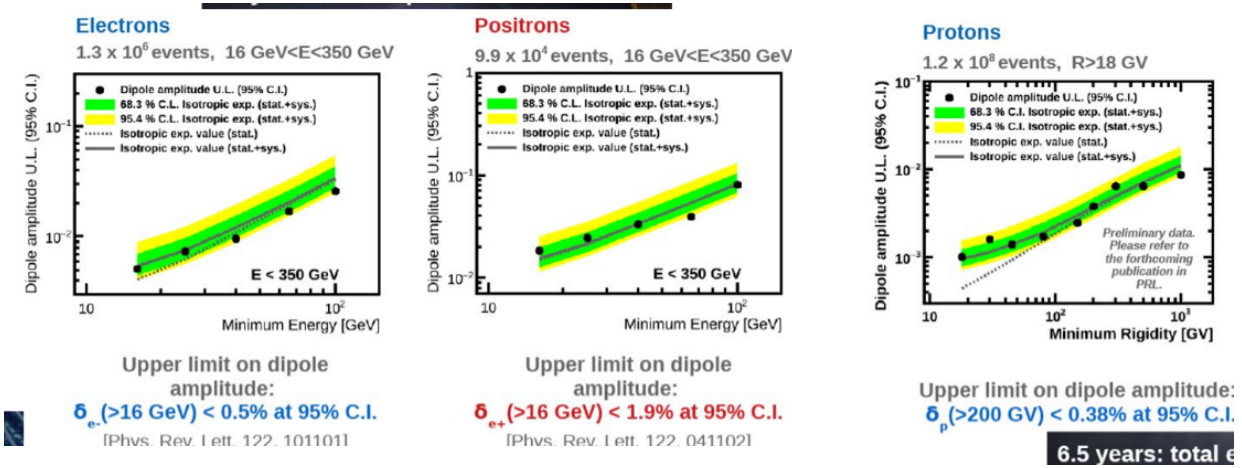


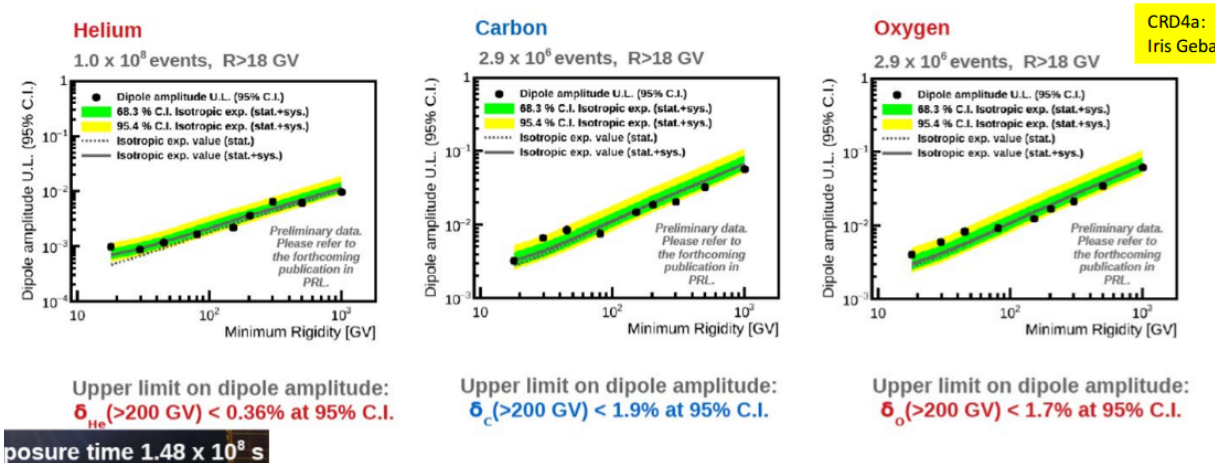
Electron spectrum by CALET and DAMPE



Dipole anisotropy Fermi-LAT and AMS-02



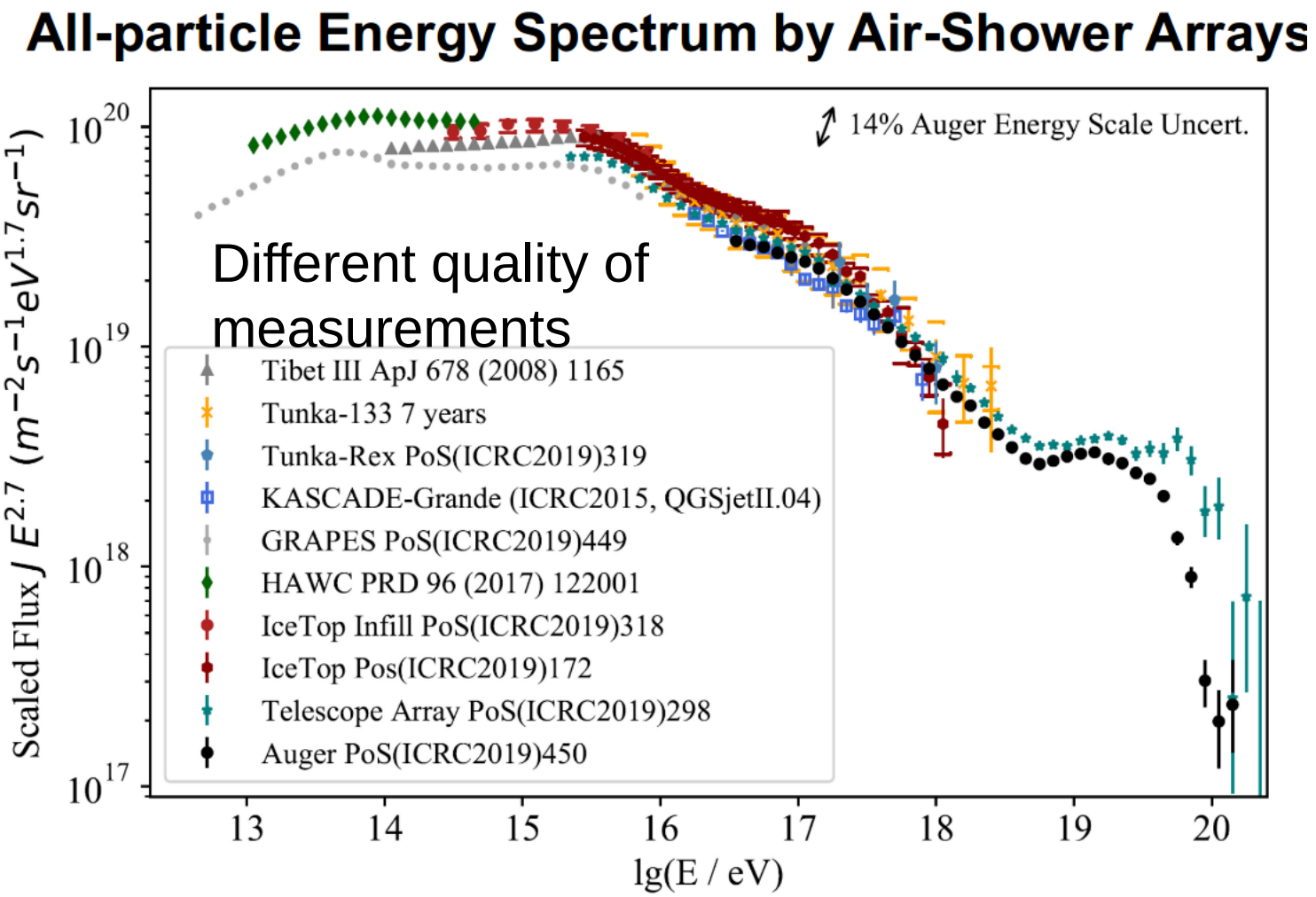




No significant deviation from isotropy

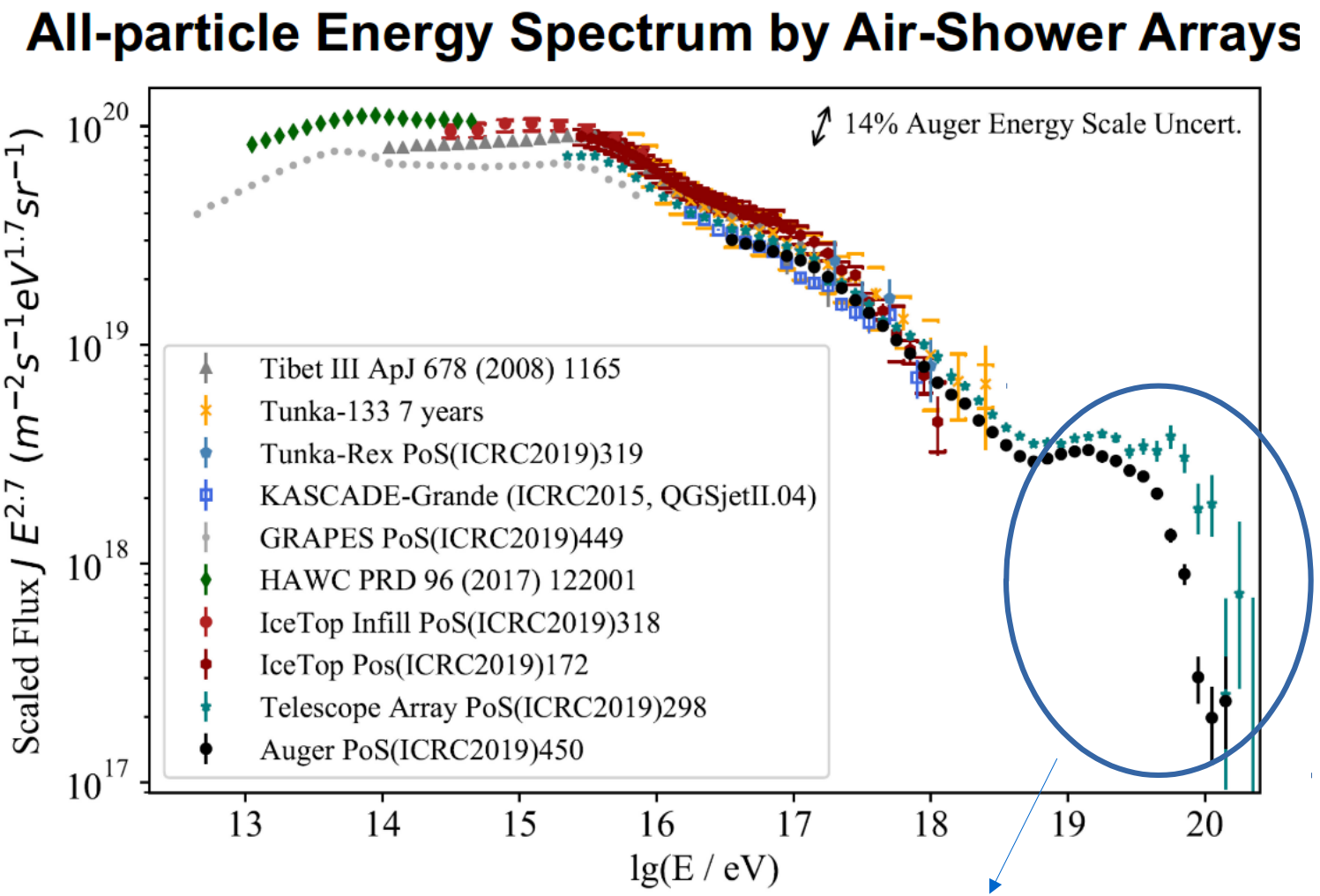
→ set constraints on local sources

UHE cosmic rays



More statistics. No significant update

UHE cosmic rays

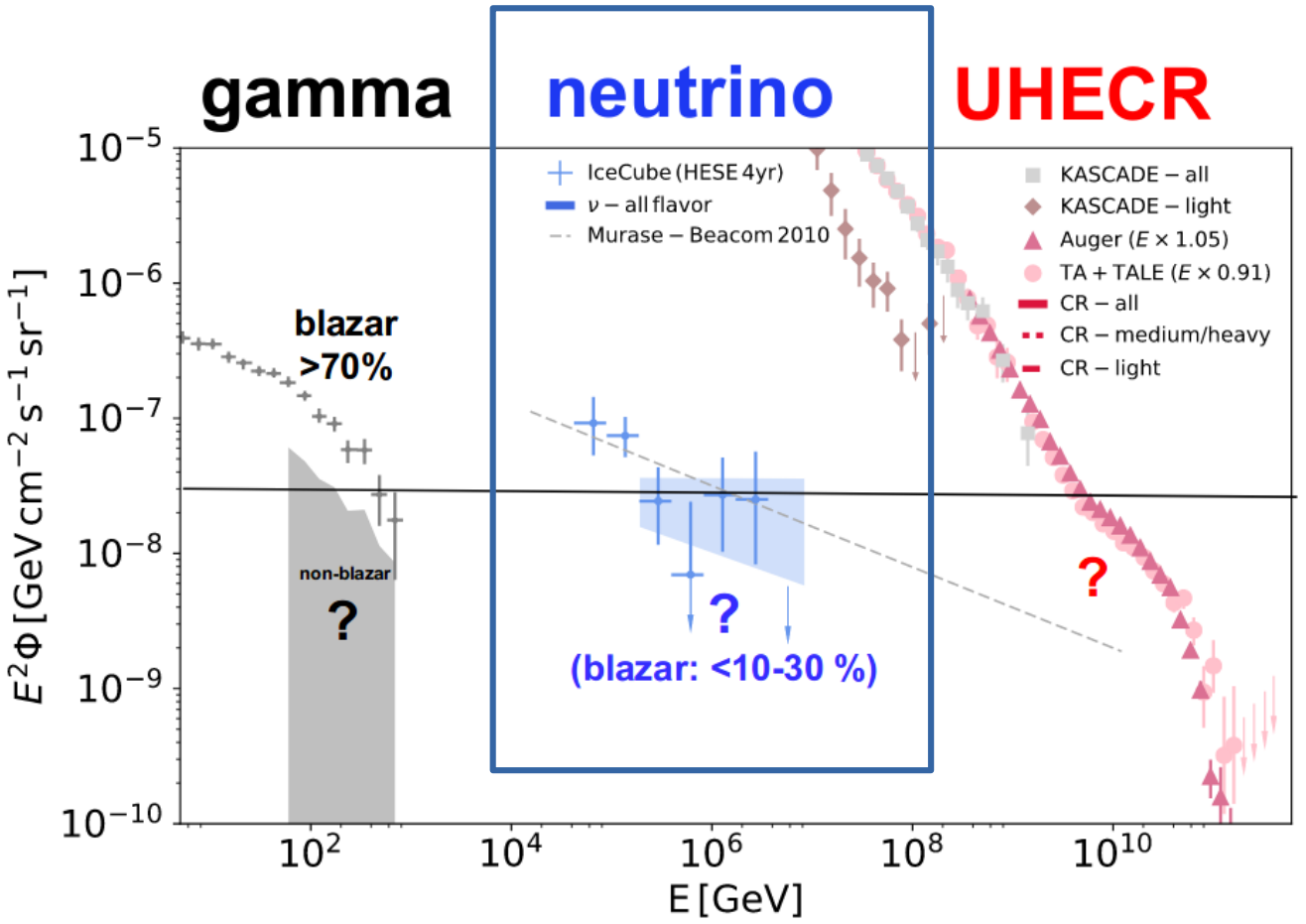


Comparison Auger vs TA still ongoing

Neutrinos

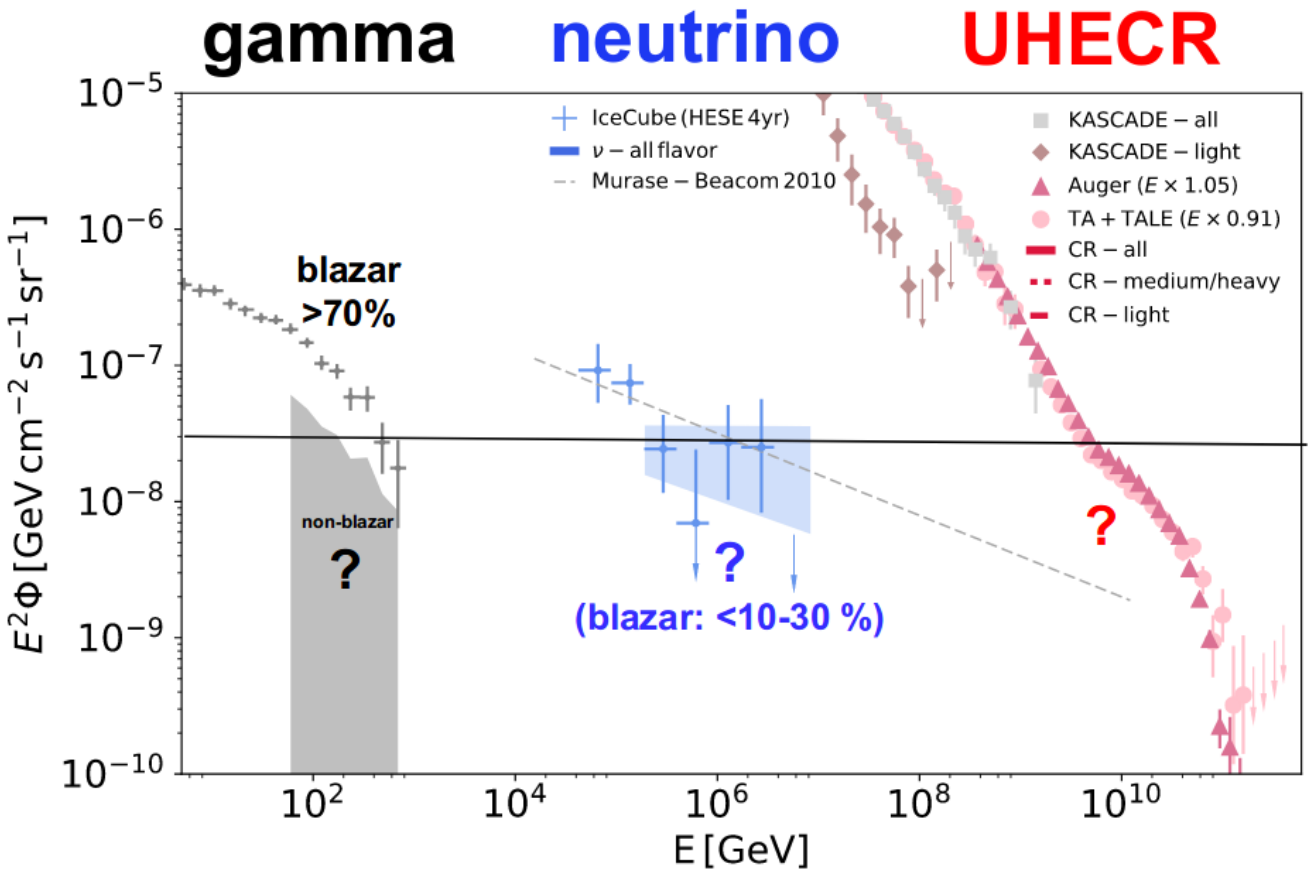
- Extragalactic neutrino diffuse flux
- Search for point-like sources with IceCube
- Tau neutrino candidate
- Neutrino in coincidence with gamma rays: TXS 0506+056
- New instruments: KM3NET and Baikal

Neutrino diffuse flux, >100 TeV



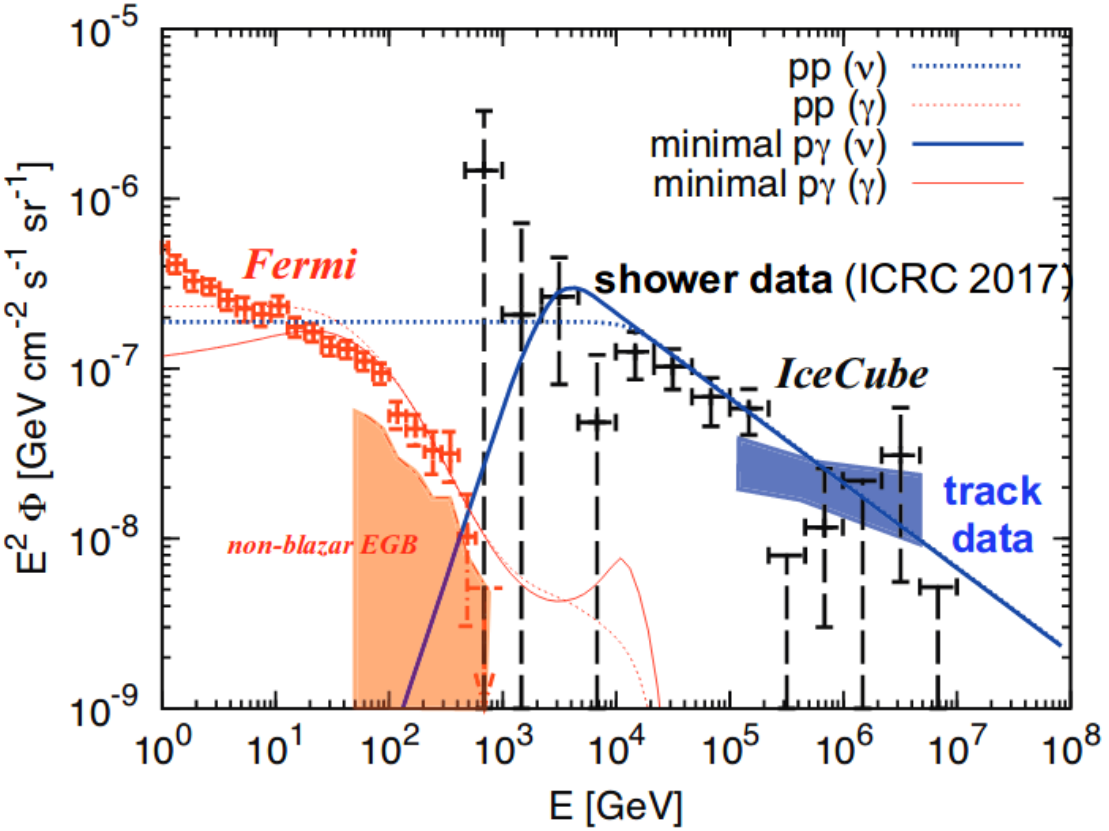
Energy flux of HE (0.1-1 PeV) neutrinos comparable to diffuse sub-TeV gamma-ray and UHECR fluxes

Neutrino diffuse flux, >100 TeV



Candidate: unified models for neutrinos, gamma rays & UHECRs w/ starburst galaxies and galaxy clusters/groups

Neutrino diffuse flux, <100 TeV



1-100 TeV neutrino flux larger

→ Hidden (gamma-ray dark) sources

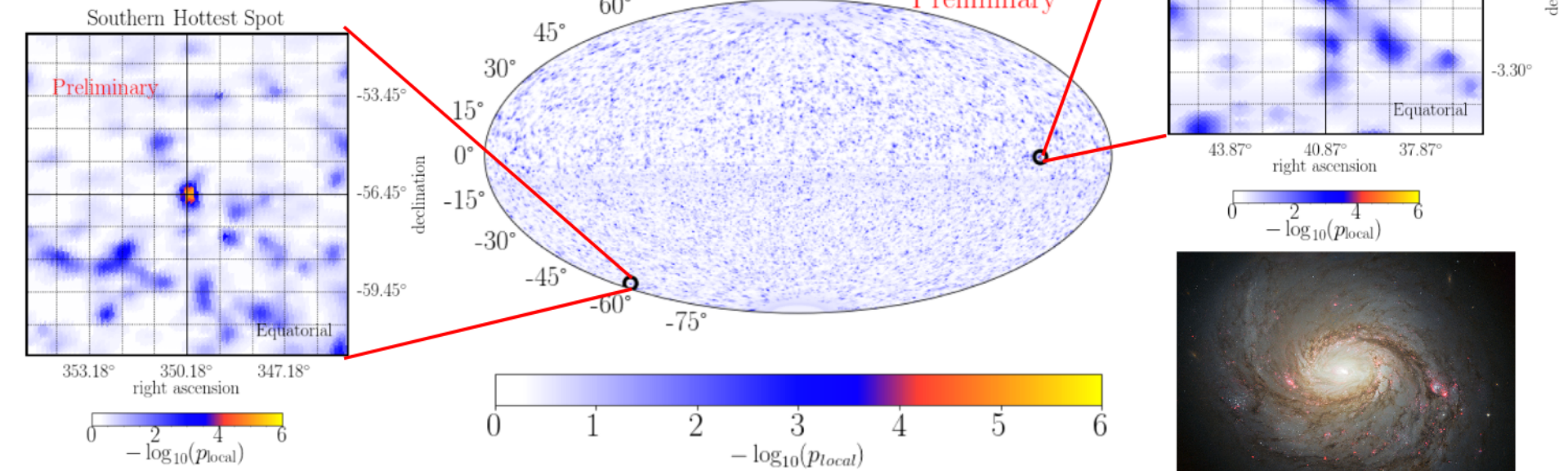
Candidates: chocked GRB jets, AGN cores

Search for point-like sources with IceCube

2 hot-spots

All sky combined 10 year search

Using high energy through-going tracks and tracks optimized for point source searches



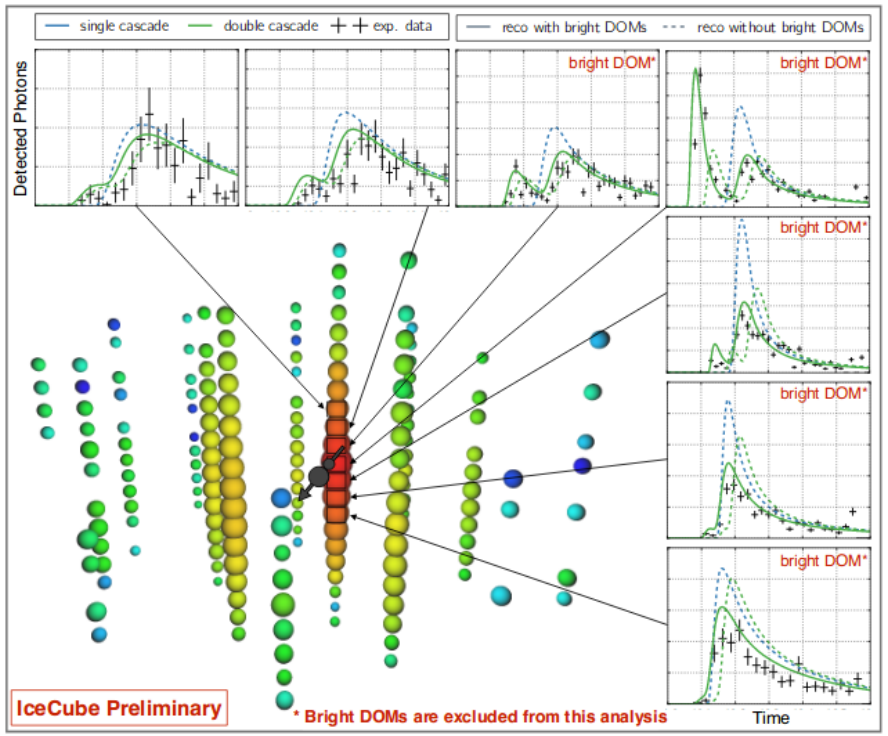
T. Carver NU5c

New source list of 110 Galactic and Extragalactic objects
Hottest spot in Northern Hemisphere coincides with 2.9σ excess at the position of NGC 1068

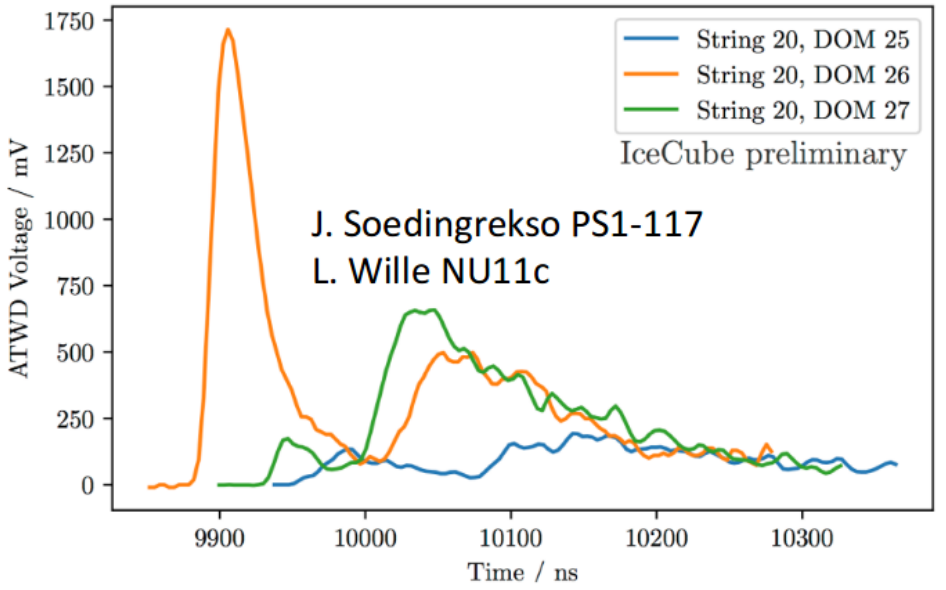
NASA, ESA & A. van der Hoeven

IceCube tau neutrino candidate

First tau neutrino candidate “double double”



“Double Double” is the only event that passes both the double cascade search and double pulse waveform criteria from two independent searches.

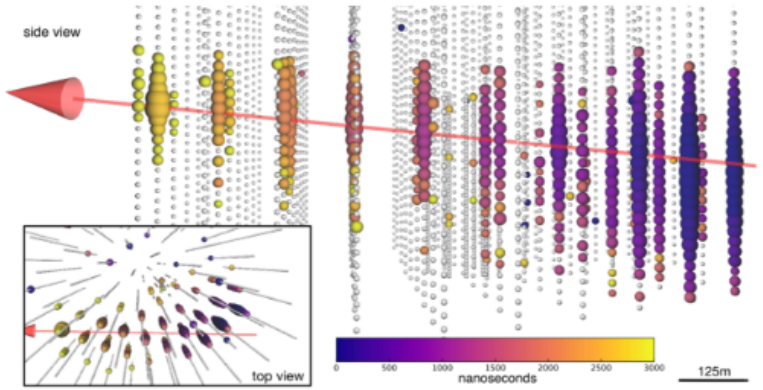


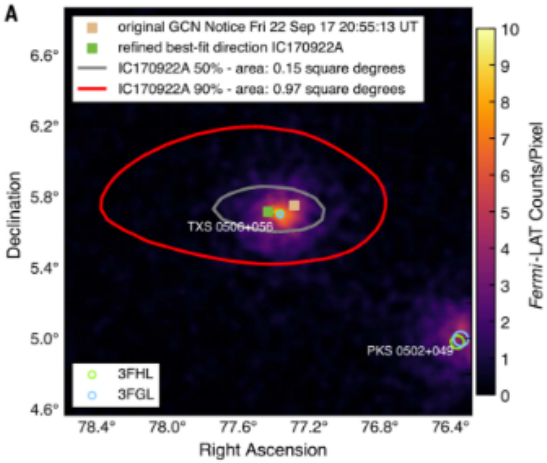
Neutrinos in coincidence with gamma rays

HE neutrino detected on Sept. ‘17 by IceCube at position consistent with TXS 0506+056

- Triggered observations by gamma-ray telescopes
- Blazar flare in gamma rays in coincidence

Sept. 22, 2017:
A neutrino in coincidence with a blazar flare





Observed by Fermi-*LAT* and MAGIC

Significance for correlation: 3σ

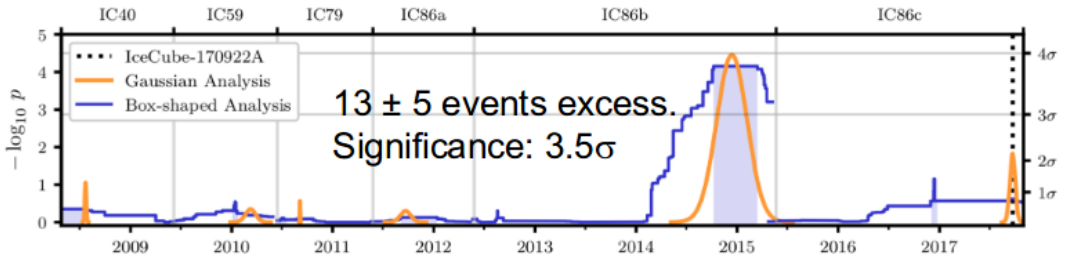
Science 361 (2018) no. 6398, eaat1378

Neutrinos in coincidence with gamma rays

HE neutrino detected on Sept. ‘17 by IceCube at position consistent with TXS 0506+056

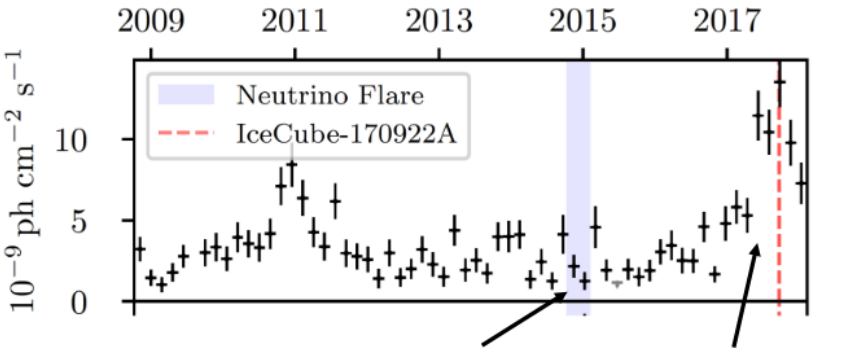
- Triggered observations by gamma-ray telescopes
- Blazar flare in gamma rays in coincidence
- Neutrino flare in historical data

2014-2015: A (orphan) neutrino flare found from the same object in historical data



Science 361 (2018) no. 6398, eaat2890

Fermi-*LAT* data; Padovani et al, MNRAS 480 (2018) 192



Page 2

Neutrinos in coincidence with gamma rays

Interpretation still debated

Understanding neutrinos from TXS 0506+056

PoS(ICRC2019)1032 (Walter Winter)

Summary (long)

Interpretation in terms of one-zone models

- 😀 Simplest possible geometry, few parameters
- 😀 Describe SED and time response reasonably well (modulo some discussion of UV data)
- 🧐 Have to accept that either L_{edd} is significantly exceeded or that neutrino energies does not match
- 🧐 2014-15 neutrino flare: more than two neurino events difficult to accommodate

Interpretation in terms of multi-zone

- 😀 External radiation fields (e
  compact core models
- 😀 Can produce substan larger neutrino event numbers with reasonable energetics
- 😀 Some models (compact core, jet-cloud) can produce a spectral hardening in gamma-rays (2014-15 flare)
- 🧐 Too early for solid conclusions, mostly because of sparseness of data

DESY. | ICRC 2019 | Winter Walter, July 25, 2019, Madison, USA

What did we learn qualitatively from 2017 event?

- Time-response of SED and X-ray data point towards leptonically dominated model
- X-ray/gamma-ray data need to be monitored (indicative for hadronic contribution)
- More such associati ded for solid conclusions ino event rates

e learn qualitatively from 2014-15 flare?

Description of 13 events requires high radiation density with imprints in the SED which seem to be *in contradiction to observations*

- Up to mode
- Expe from
- Need signa

Need better modeling but also more data

Two days ago ...

IceCube-190730A an astrophysical neutrino candidate in spatial coincidence with FSRQ PKS 1502+106

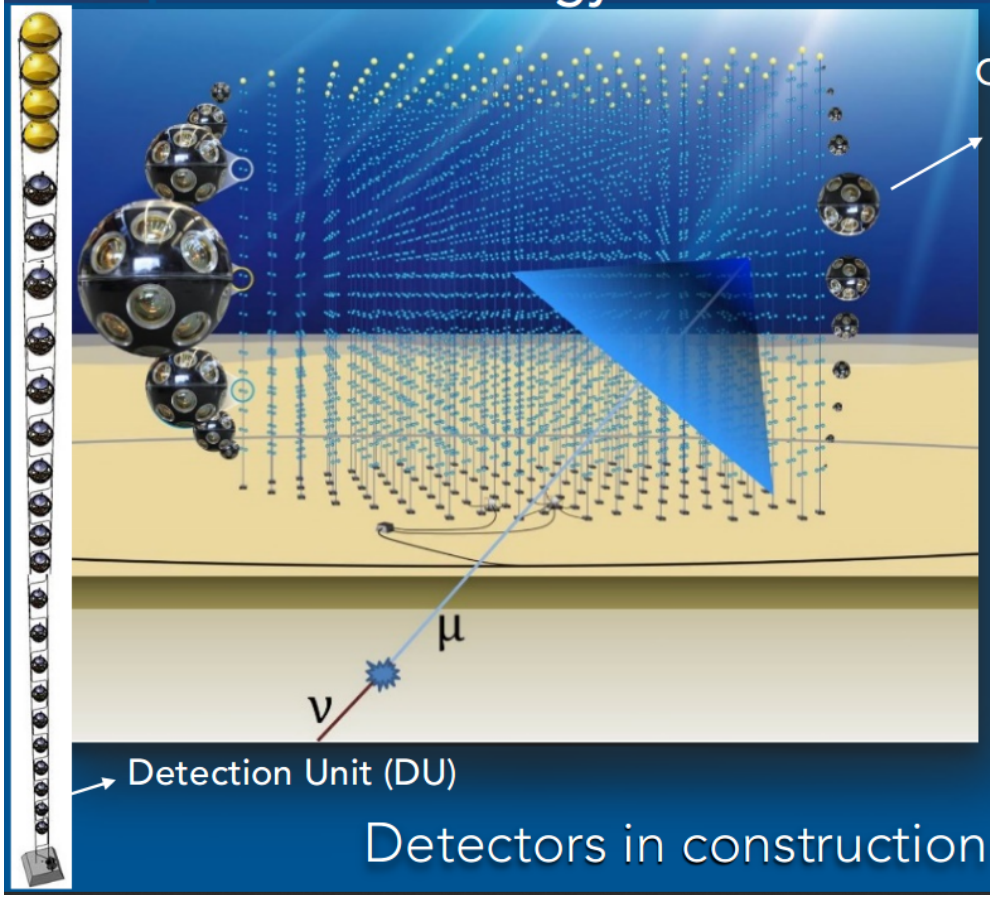
ATel #12967; *Ignacio Taboada (Georgia Institute of Technology), Robert Stein (DESY Zeuthen)*
on 30 Jul 2019; 23:58 UT
Credential Certification: Ignacio Taboada (itaboada@gatech.edu)

Subjects: Neutrinos, AGN

New instruments: KM3NET

THE KM3NET DETECTORS

5 Same technology for the two detectors



Optical sensor (DOM)
31 PMTs of 3 inches

ORCA

- Depth ~2500 m
- One block of 115 Detection Units
- Average distance between Detection Units ~20 m
- Average vertical distance between DOMs ~9 m
- **Volume ≈ 8 Mton**

ARCA

- Depth ~3500 m
- Two blocks of 115 Detection Units each
- Average distance between Detection Units ~90 m
- Vertical distance between DOMs ~36 m
- **Volume (0.5 × 2) km³ ≈1 Gton**

Detectors in construction

New instruments: Baikal Gigaton Volume Detector

New neutrino telescopes coming online — Baikal GVD first results

PoS(ICRC2019)873 (Rastislav Dvornick)

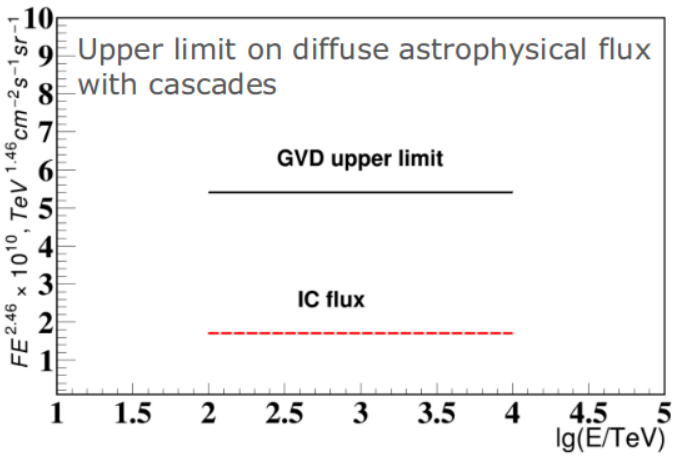
PoS(ICRC2019)1011 (F. Smikovic)

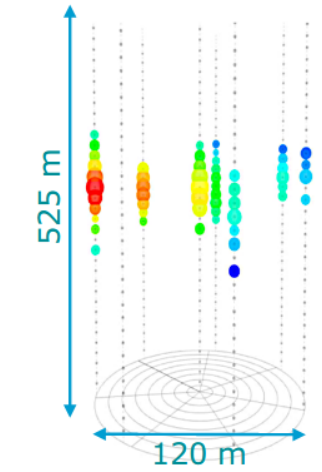
PoS(ICRC2019)876 (L. Fajt)

Stages of the deployment of the GVD-1

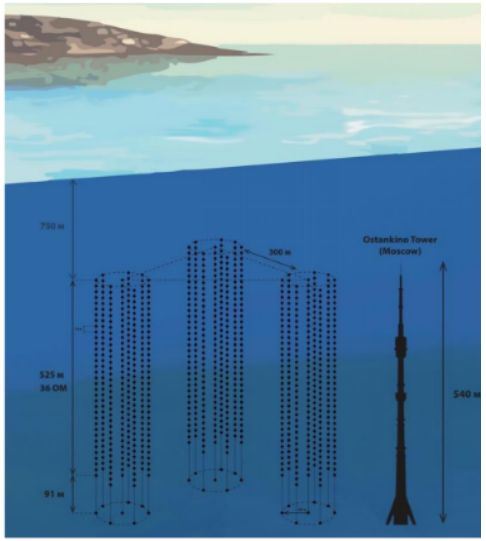
Configuration	2016	2017	2018	2019
The number of OMs	288 (8str×36)	576	864	1 440
Geometric sizes	∅120m×525m	2×∅120m×525m	3×∅120m×525m	5×∅120m×525m
Eff. Vol. (E > 100TeV)	0.05 km^3	0.1 km^3	0.15 km^3	0.25 km^3

Goal GVD-1:
8 clusters by 2021





reconstructed cascade



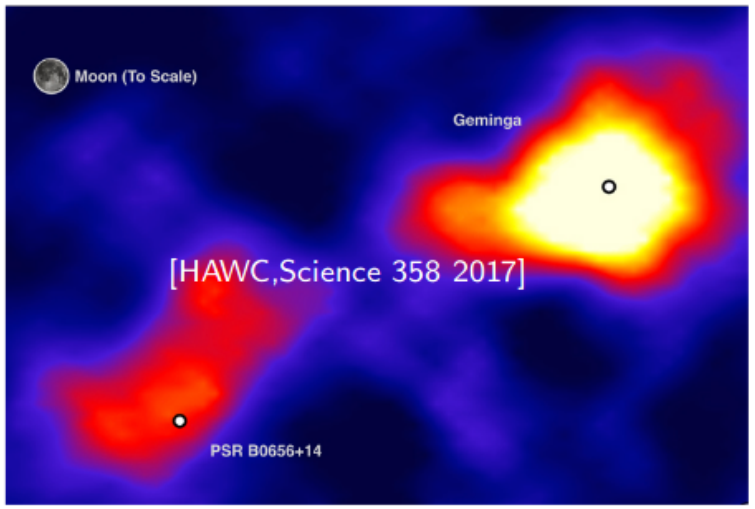
Gamma rays

- Geminga pulsar halo
- New H.E.S.S. pevatron candidate
- GRBs observations by MAGIC and H.E.S.S.
- Galactic plane observed by H.E.S.S. and HAWC
- HAWC sources at E>100 TeV
- First results of LHASSO

Geminga halo

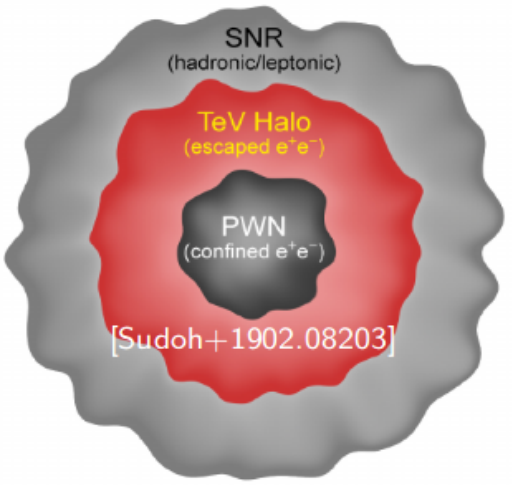
Geminga: nearby + old pulsar

- Halo of ~2-deg observed at ~1-100 TeV (Milagro and HAWC)



Interpreted as $e^{\pm}$ accelerated from the PWNe, and then released in the interstellar medium

First evidence of $e^{\pm}$ diffusing away from the pulsar and up-scatter CMB photons, **inverse Compton emission**



$\sim$ 20 pc extension around Geminga

Geminga halo

Geminga: nearby + old pulsar

- Halo of ~2-deg observed at ~1-100 TeV (Milagro and HAWC)
- Diffusion coefficient in the vicinity of Geminga is ~500 times smaller than average in the ISM
  - ➔ Two-zone diffusion model

$$D(r) = \begin{cases} D_0 (E/1\,\mathrm{GeV})^{\delta} \text{ for } 0 < r < r_b, \\ D_2 (E/1\,\mathrm{GeV})^{\delta} \text{ for } r \geq r_b, \end{cases}$$

Geminga halo

Geminga: nearby + old pulsar

- Halo of ~2-deg observed at ~1-100 TeV (Milagro and HAWC)
- Diffusion coefficient in the vicinity of Geminga is ~500 times smaller than average in the ISM
  - ➔ Two-zone diffusion model

$$D(r) = \begin{cases} D_0 (E/1\,\mathrm{GeV})^{\delta} \text{ for } 0 < r < r_b, \\ D_2 (E/1\,\mathrm{GeV})^{\delta} \text{ for } r \geq r_b, \end{cases}$$

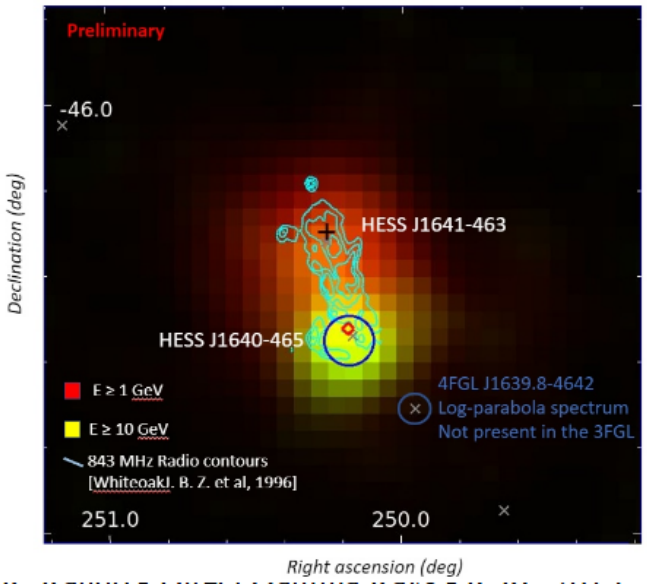
- Lower energy observations useful for comparison to AMS (positron excess)
  - ➔ 7.8-11.8σ detection with Fermi-LAT
  - ➔ Diffusion coefficient compatible with HAWC

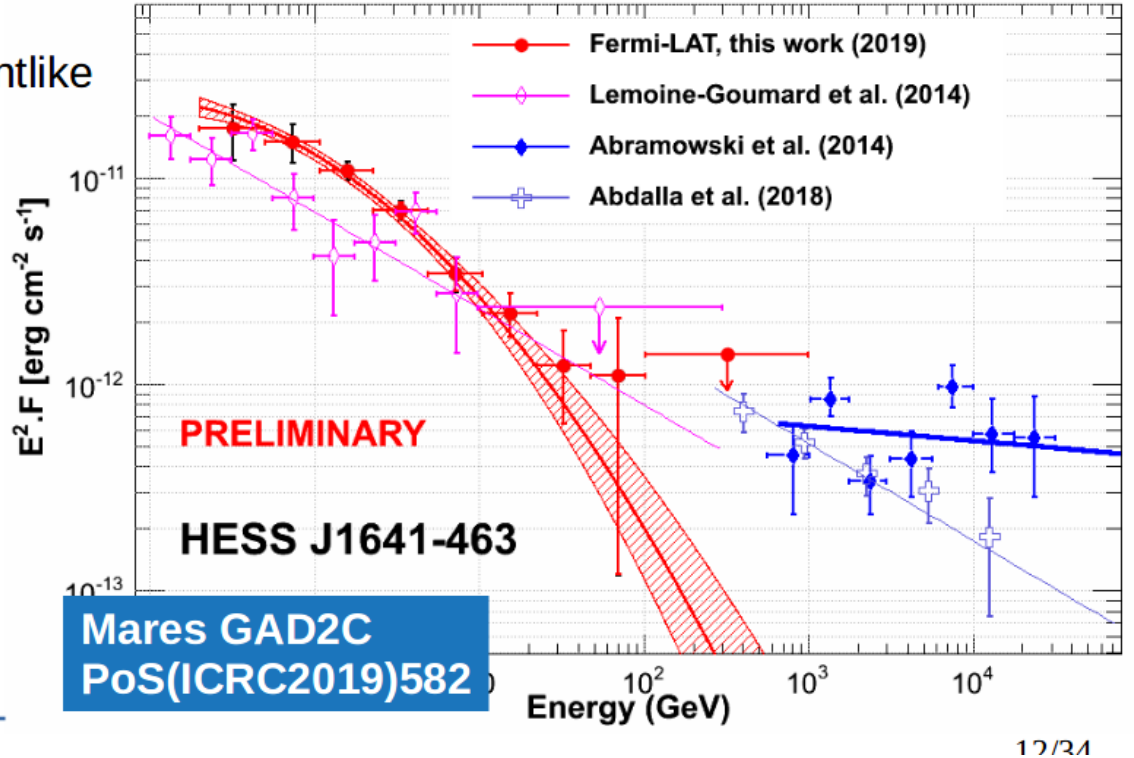
New H.E.S.S. pevatron candidate

Complex structure: 2 SNRs apparently connected by a bridge, very close (~0.25°)

J1640: first detection of extension in LAT data, hard leptonic spectrum

J1641: 4 sigma SED curvature, pointlike
PSR (LAT) + Pevatron (HESS)?





Mares GAD2C
PoS(ICRC2019)582

12/34

GRB observations by MAGIC

GRB 190114C observed by MAGIC

- Observations at T0+50s
- Detection at 25σ significance
- Detection at E>300 GeV

… stay tuned!

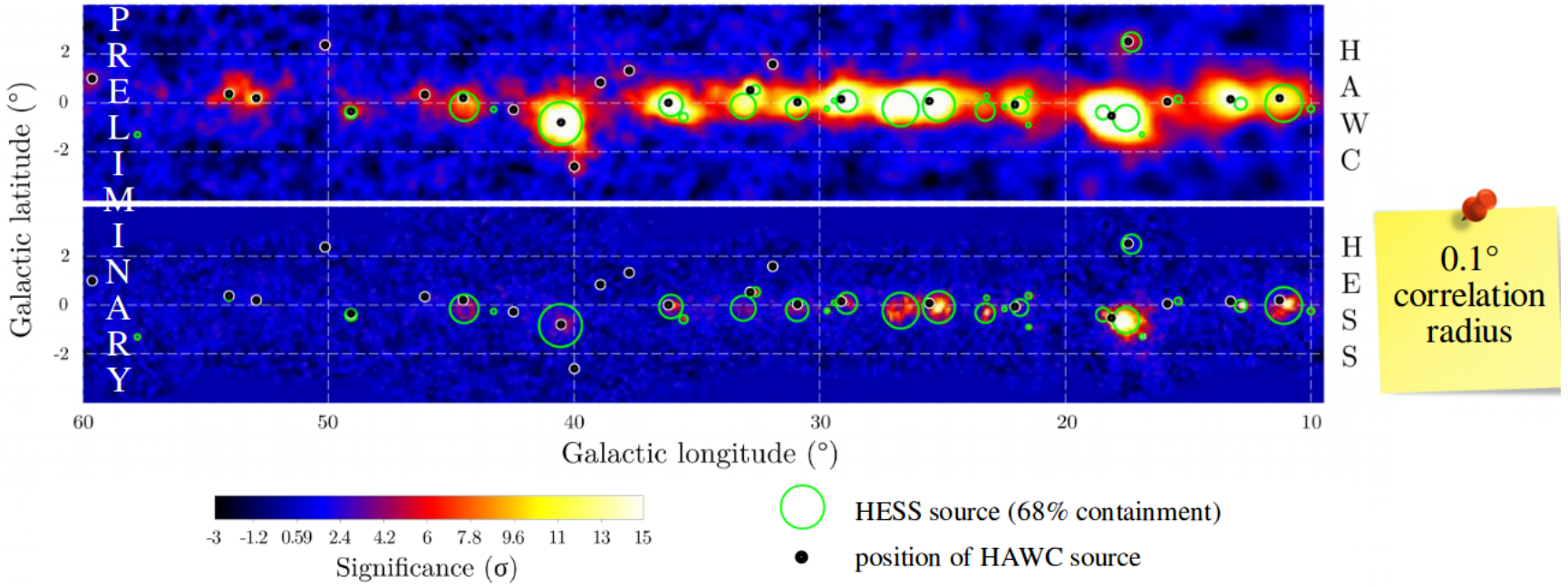
GRB observations by H.E.S.S.

GRB 180720B observed by H.E.S.S.

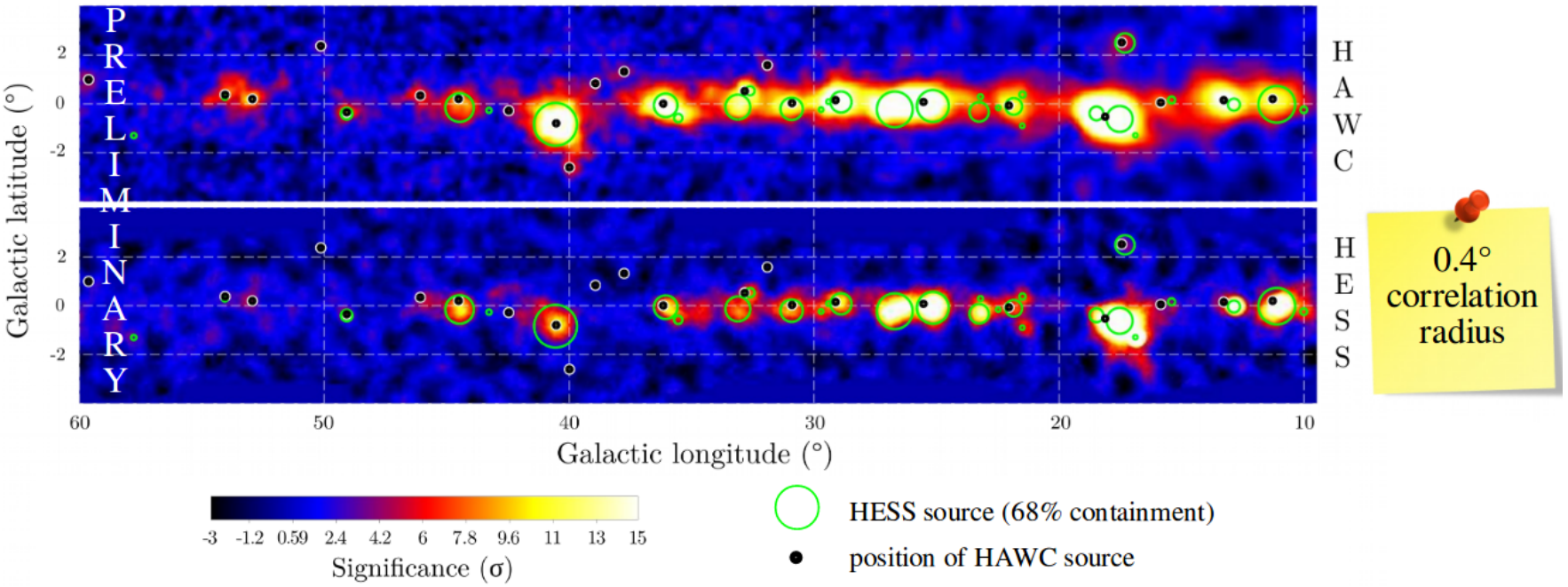
- Observations at T0+10.1h
- Detection at 5σ significance
- Detection at E>100 GeV

… stay tuned!

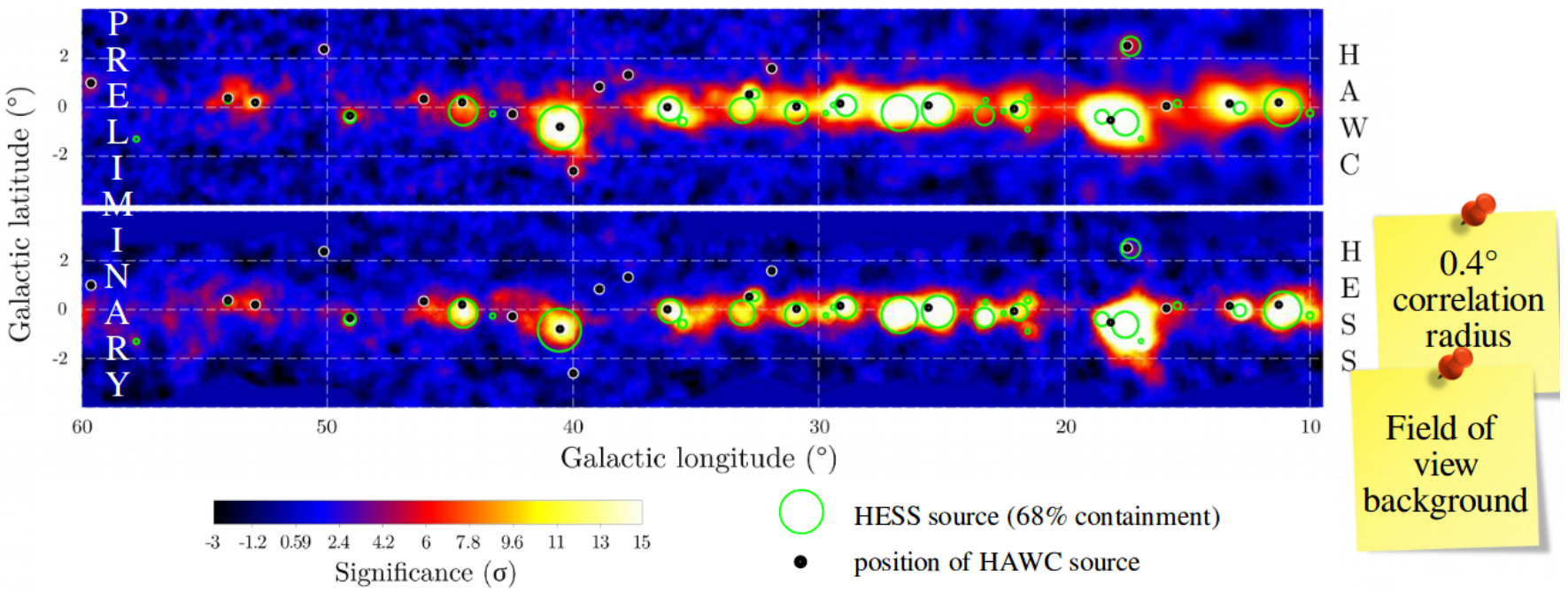
Galactic plane observed by H.E.S.S. and HAWC



Galactic plane observed by H.E.S.S. and HAWC



Galactic plane observed by H.E.S.S. and HAWC

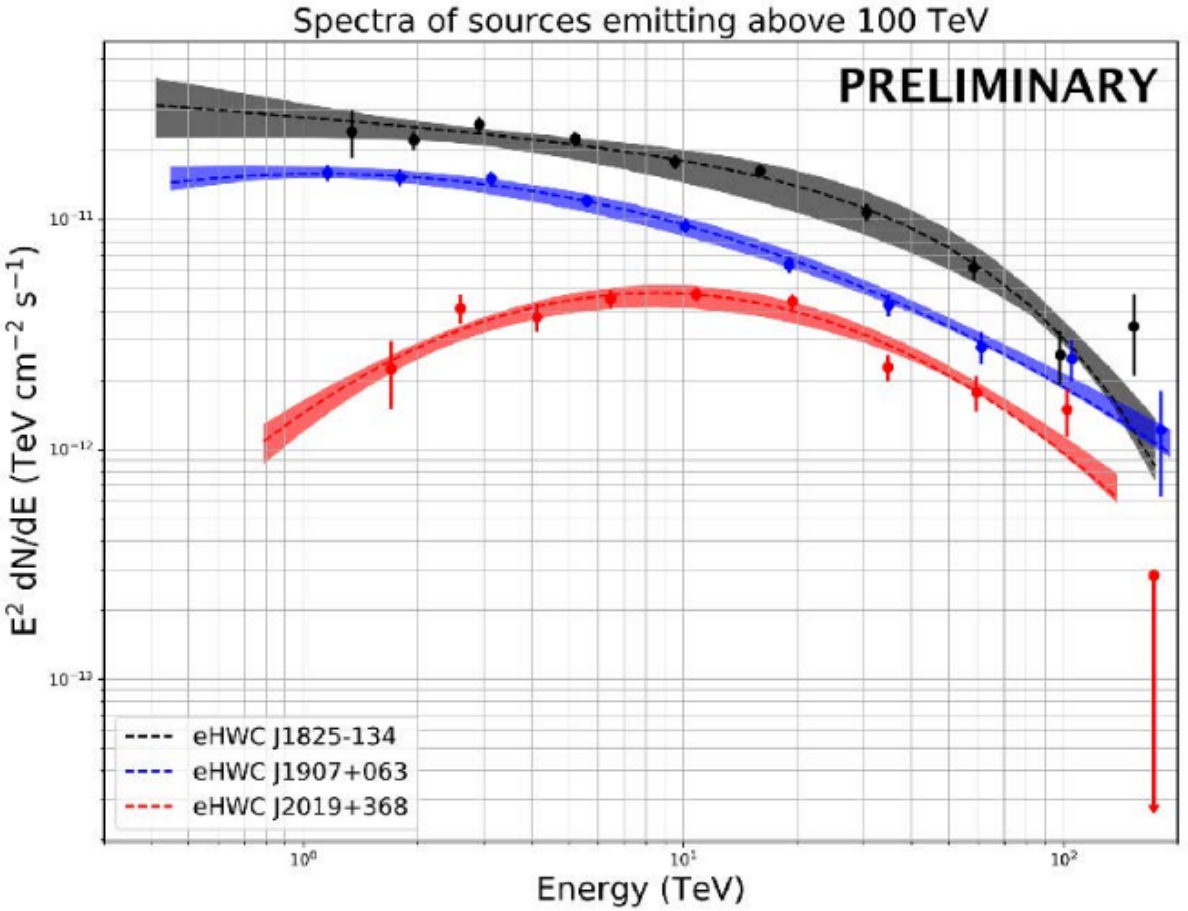


H.E.S.S. and HAWC observe the same TeV sky when put in the same observational conditions

HAWC sources at E>100 TeV

3 sources observed at E>100 TeV

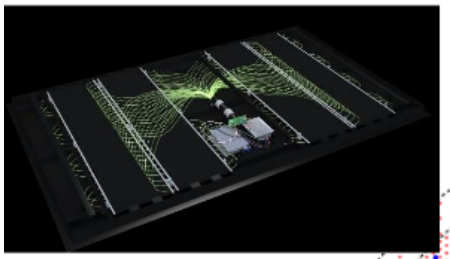
No common spectral behavior



More likely from hadronic processes (higher-E cutoff)

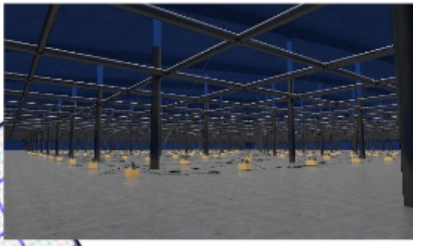
First results of LHAASO

Electro-magnetic Particle detector



covering 1.3 km²

- 5195 EDs
  - 1 m² each
  - 15 m spacing
- 1171 MDs
  - 36 m² each
  - 30 m spacing



3120 WCDs
- 25 m² each

WCDA

WFCTA

MD

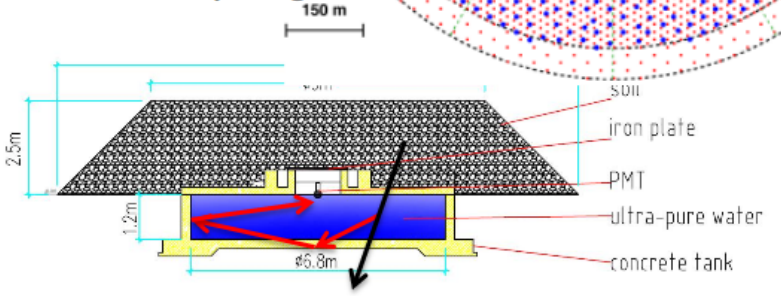
ED

18 WFCTs

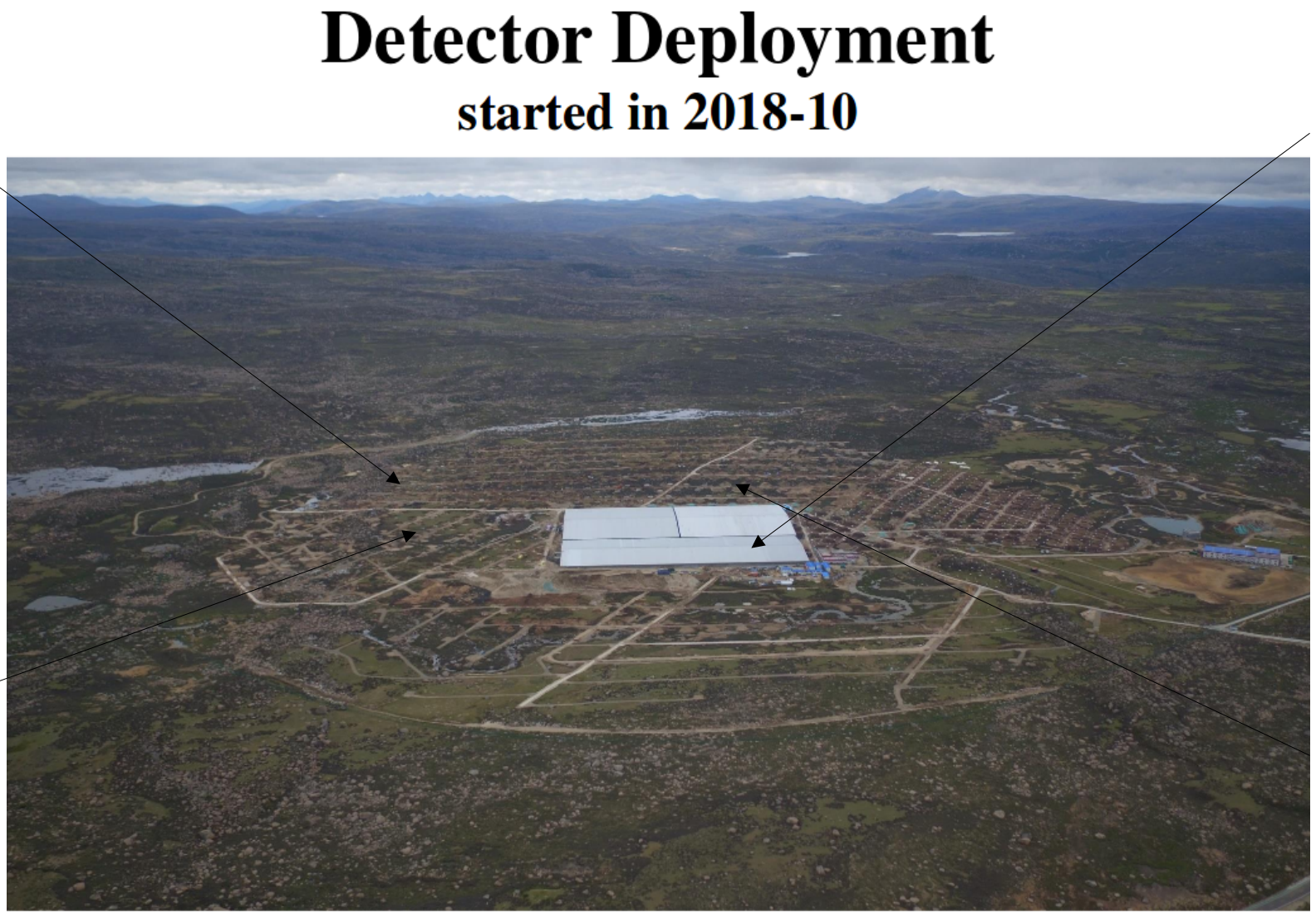
Water Cherenkov detector array

Wide field of view Cherenkov telescope array

Muon detector



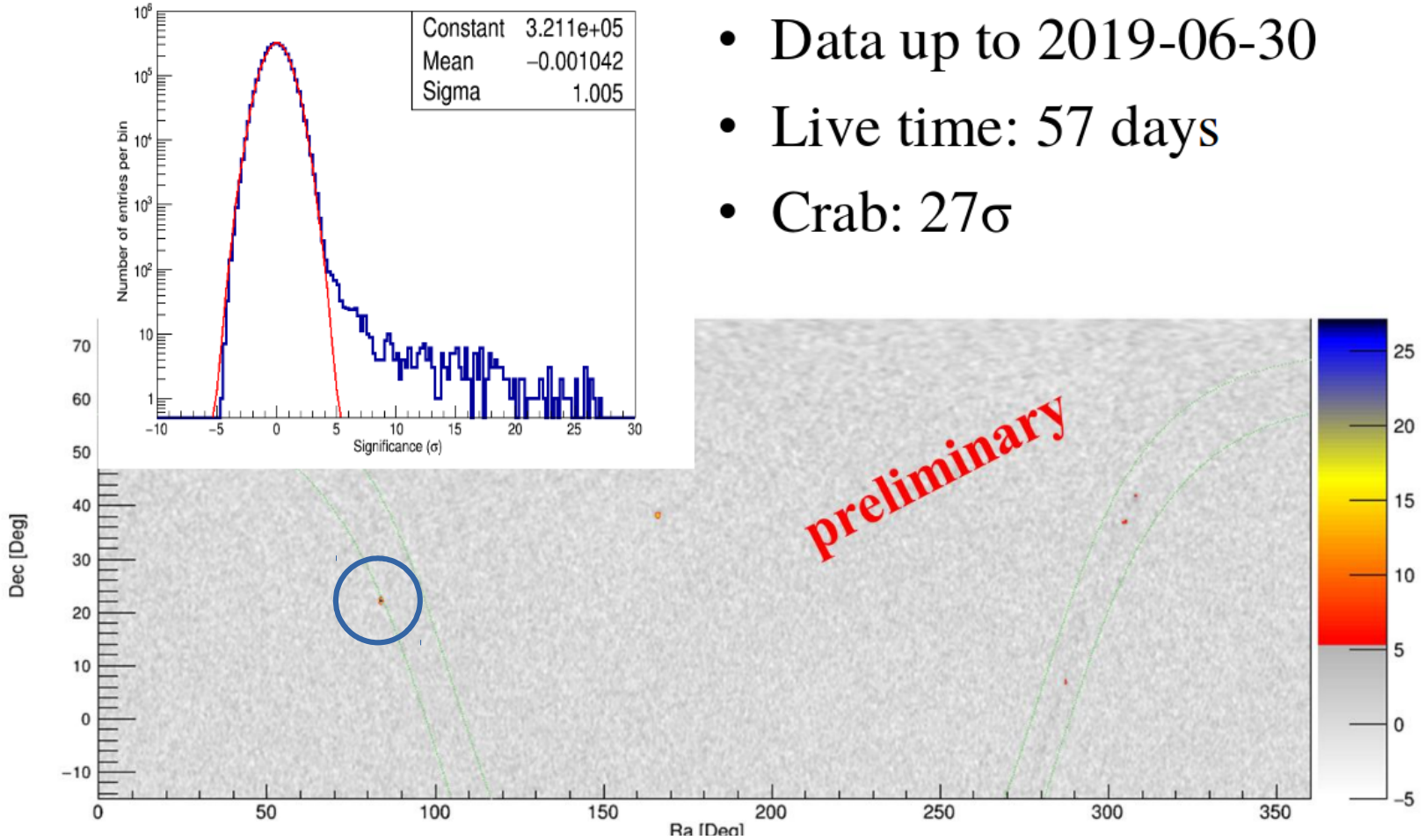
First results of LHAASO



First results of LHAASO

WCDA#1 Sky Map

- Data up to 2019-06-30
- Live time: 57 days
- Crab: 27σ



Dark matter (indirect)

- Joint dark matter search towards dwarf spheroidal galaxies with Fermi-LAT, HAWC, H.E.S.S., MAGIC and VERITAS
- H.E.S.S. search towards dwarf spheroidal galaxies
- HAWC search towards the Virgo cluster
- IceCube and ANTARES searches

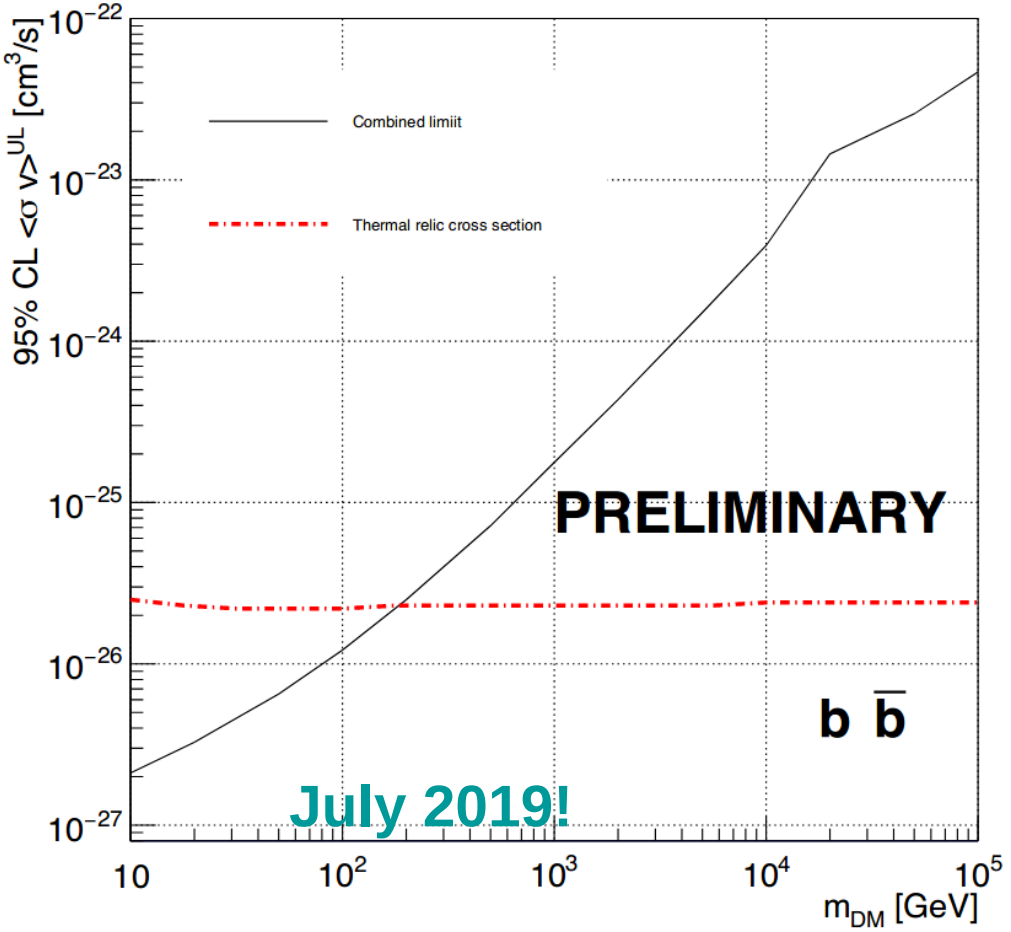
Joint dark matter search FHHMV

- Nature of dark matter is one of the most compelling open questions
- Dwarf spheroidal galaxies are promising for unambiguous dark matter detection
- Joint effort among the different experiment improves the sensitivity

- Highlight talk

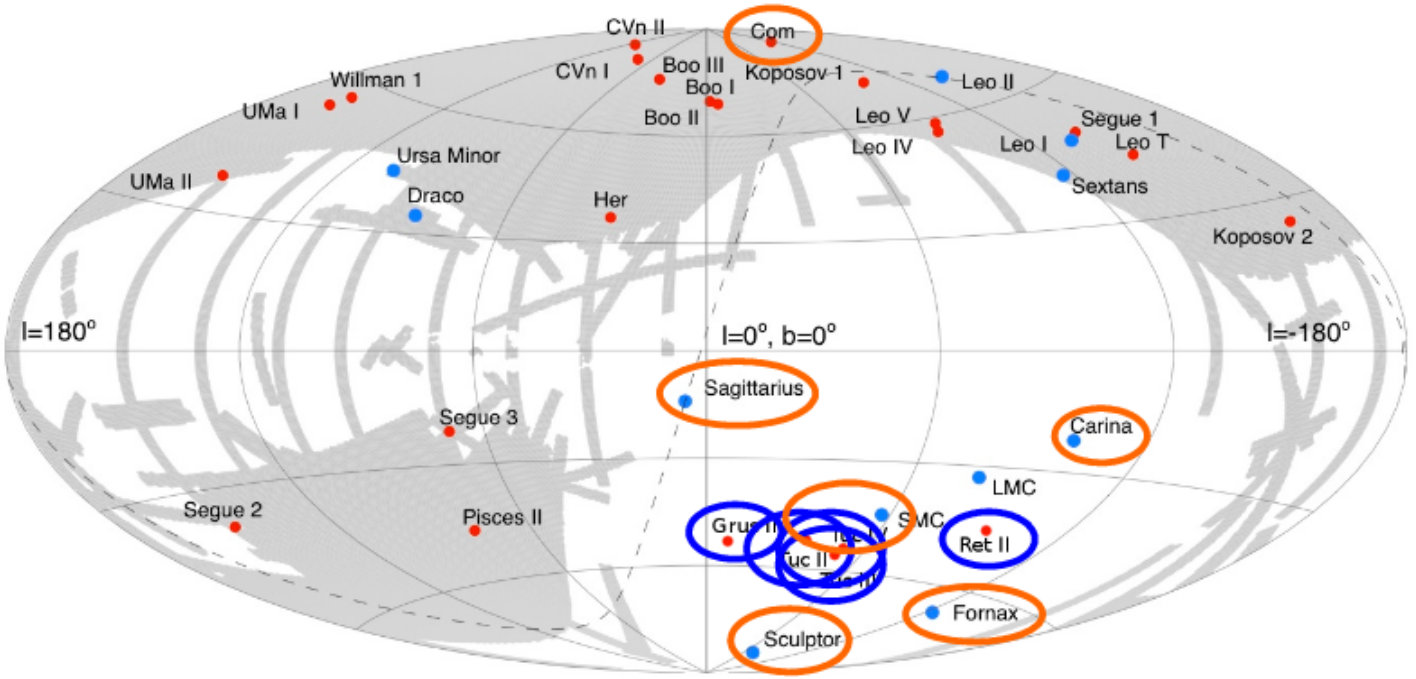
Joint dark matter search FHHMV

- Combination of datasets at the likelihood level (after independent analyses)
- Same dark matter profile
- Preliminary results
- Other annihilation channels will be in-cluded in the paper



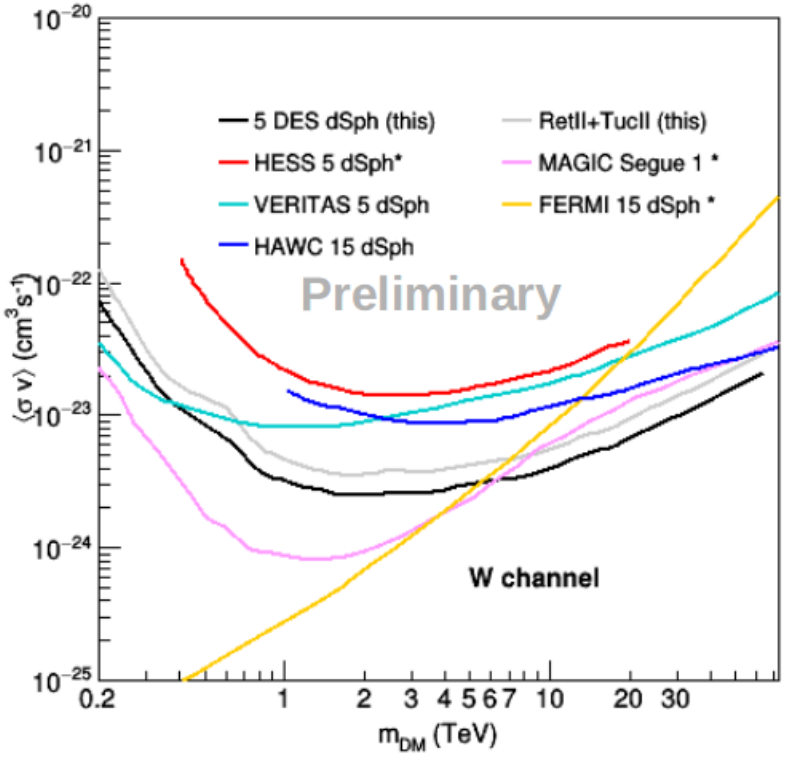
H.E.S.S. search towards dwarf spheroidal galaxies

- Interesting set of dwarf galaxies recently discovered by the Dark Energy Survey
- A selection of them has been observed with H.E.S.S.



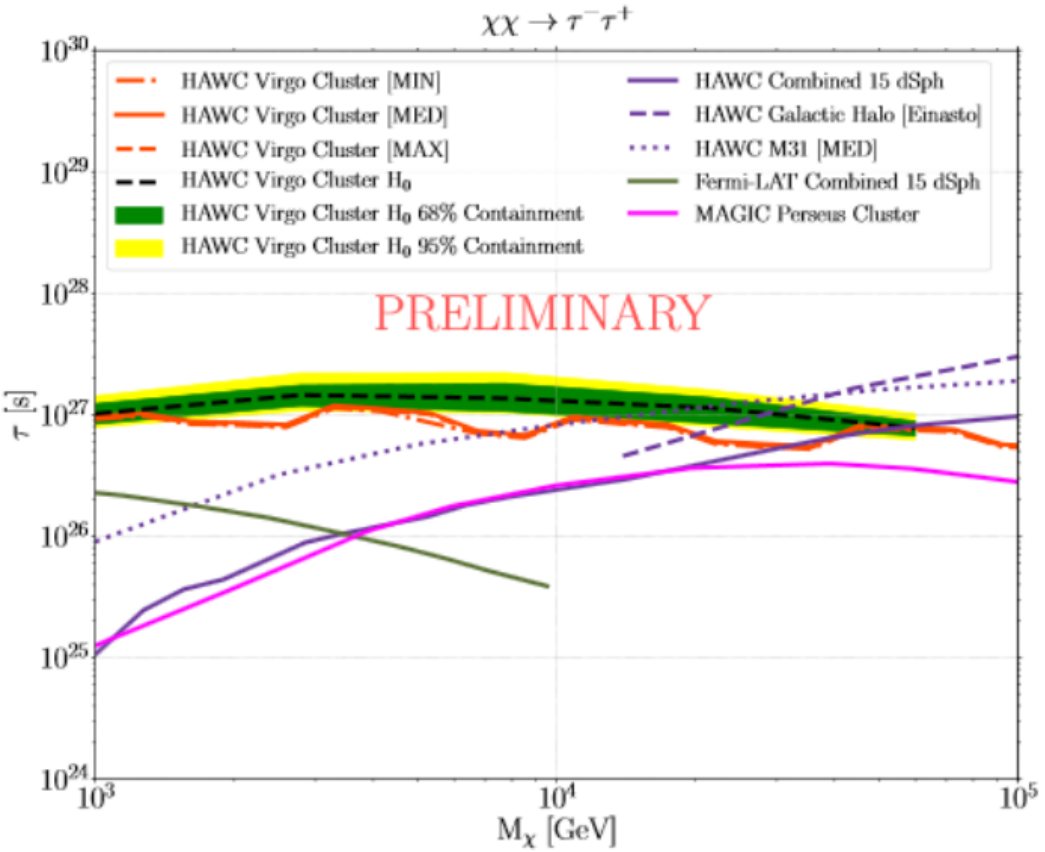
H.E.S.S. search towards dwarf spheroidal galaxies

- Interesting set of dwarf galaxies recently discovered by the Dark Energy Survey
- A selection of them has been observed with H.E.S.S.
- 5 targets combined
- Strong limits
- Limits dominated by Ret II
- Complementary to other experiments



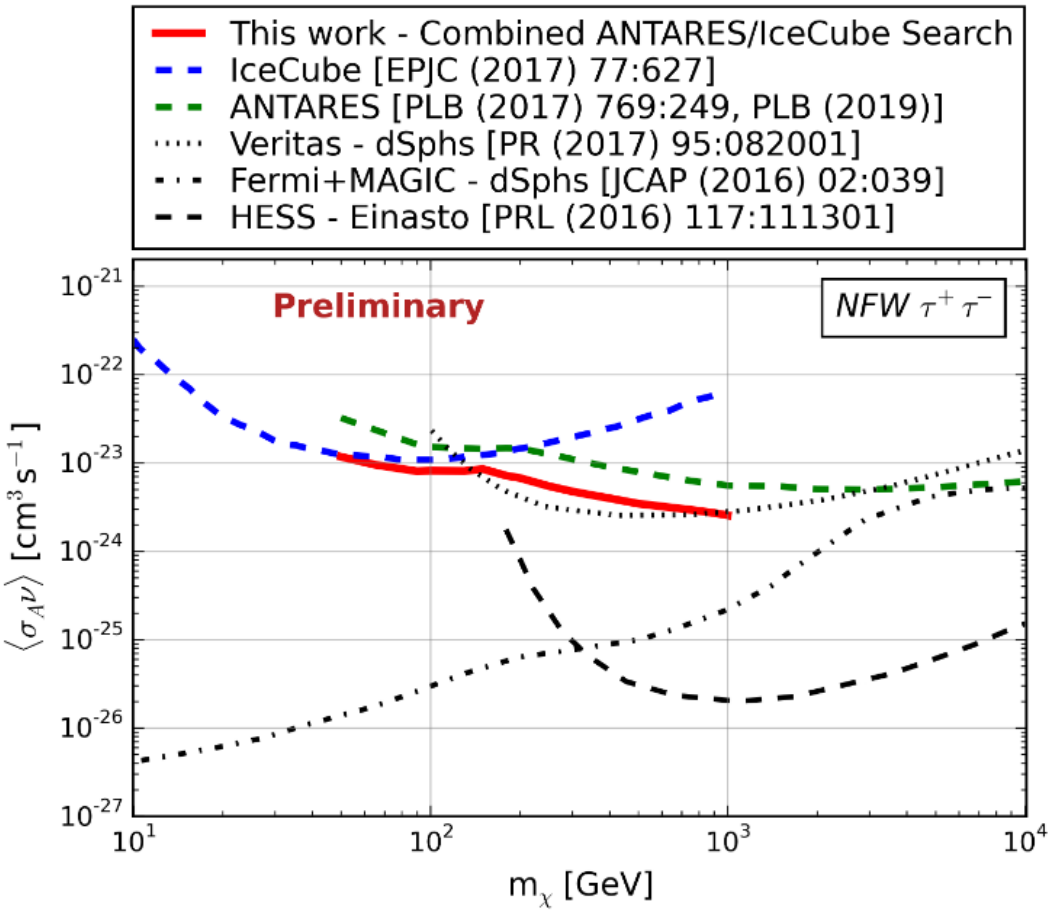
HAWC search towards Virgo cluster

- Decay on timescale longer than age of the Universe
- Clusters promising for searches for DM decay signal
- Extended sources
  → large volume
- Observation of Virgo cluster
- Strongest constraints on DM decay



IceCube and ANTARES searches

- Unification of IceCube and ANTARES analyses (model parameters, analysis method)
- Range 50-1000 GeV
- Improved sensitivity
- Prospects:
  - ➔More years of data
  - ➔New event selection
  - ➔Unbinned likelihood




Thanks for the attention
UW CREDIT UNION
TERRACE STAGE