ETH zürich

Gamma-Ray Indirect Rapporteur

Dr Alison Mitchell

23 July 2021, Berlin / online

ICRC 2021
THE ASTROPARTICLE PHYSICS CONFERENCE
Berlin | Germany

icrc2021.desy.de

Introduction

https://www.theverge.com/2017/9/21/16335164/pierre-auger-observatory-cosmic-ray-galaxies-air-shower-particles
A. Chantelauze, S. Staffi, and L. Bret

Gamma-ray Indirect @ ICRC 2021: Statistics

Apologies! Cannot mention everything

- 255 contributions → 18.5% total ICRC (2nd largest after Cosmic Ray Indirect)
- 45min talk → ~10s per contribution
- 14 discussion sessions → 11 joint with other tracks

51 The Census of Gamma-ray Sources	(GAD-GAI) 12/07
52 Analysis, Methods, Catalogues, Community Tools, Machine Learning...	(GAD-GAI) 13/07
48 Modelling AGN’s spectral energy distribution	(GAD-GAI-MM) 13/07
55 Ultra-High-Energy Gamma-Ray Sources and PeVatrons	(GAI) 14/07
47 The central engines of fast transients: Gamma-ray Bursts and Fast Radio Bursts	(GAD-GAI-MM) 14/07
49 Studying the variable emission from AGN in a multi-wavelength context	(GAD-GAI-MM) 15/07
44 The origins of Galactic Cosmic Rays	(GAD-GAI-CRD) 15/07
50 Galactic Compact Objects: Pulsars, Binary Systems, Microquasars	(GAD-GAI) 16/07
45 Probing the Distribution of Cosmic Rays in Galaxies	(GAD-GAI-CRD) 19/07
46 Supernova Remnants	(GAD-GAI-CRD) 20/07
56 New instruments, performance and future projects for ground-based gamma-ray astronomy	(GAI) 20/07
53 PWN and Halos	(GAD-GAI) 20/07
57 New Physics	(CRD-CRI-DM-GAD-GAI-NU-MM-SH) 20/07
54 Gamma-Ray Bursts in the VHE regime	(GAI) 21/07

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55	Ultra-High-Energy Gamma-Ray Sources and PeVatrons	(GAI) 14/07
47	fast transients: Gamma-ray	(-GAI-) 14/07
49	able emission from AGN in a	(-GAI-) 15/07
44	of Galactic Cos	(-GAI-) 15/07
50	, Binary Systems, Microquasars	(-GAI) 16/07
45	bution of Cosmic	(-GAI-) 19/07
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53	and Halos	(-GAI) 20/07
57	Ph	(-GAI-) 20/07
54	Gamma-Ray Bursts in the VHE regime	(GAI) 21/07

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This talk:

- GAI – unique sessions (and presenter forum):
  55 Ultra-High-Energy Gamma-Ray Sources and PeVatrons
  56 New instruments, performance and future projects for ground-based gamma-ray astronomy
  54 Gamma-Ray Bursts in the VHE regime
- Galactic focus sessions (and presenter forum):
  50 Galactic Compact Objects: Pulsars, Binary Systems, Microquasars
  46 Supernova Remnants
  53 PWN and Halos
- GAI – GAD split (general / technical sessions):
  51 The Census of Gamma-ray Sources
  52 Analysis, Methods, Catalogues, Community Tools, Machine Learning...
  44 The origins of Galactic Cosmic Rays
  45 Probing the Distribution of Cosmic Rays in Galaxies
- **Extragalactic aficionados → "GAD"**

Challenges:

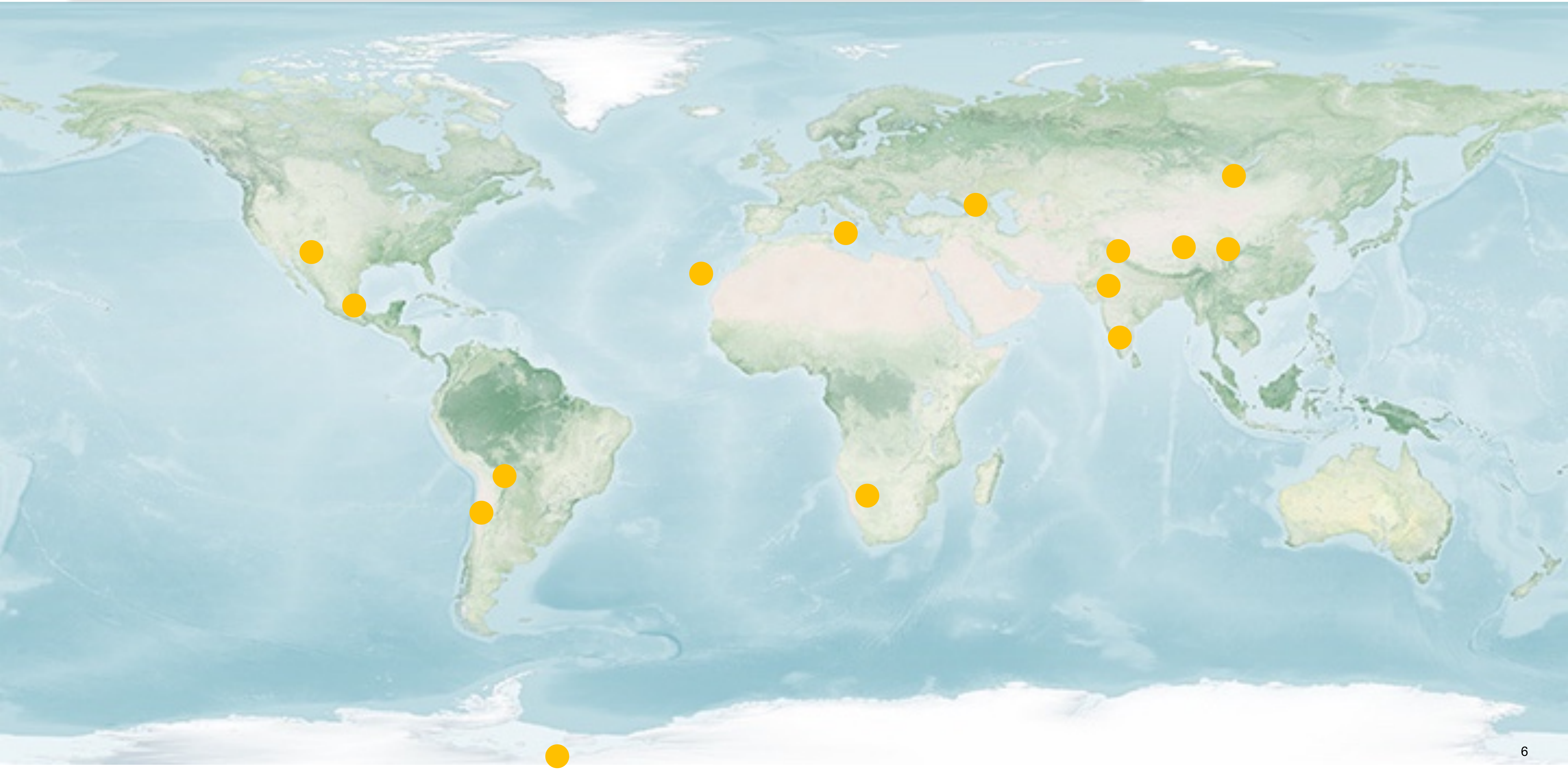
20% increase on ICRC 2019

125 posters, 130 talks...
~ 30 hours of pre-recorded videos

→ 20 hours at x1.5 speed!

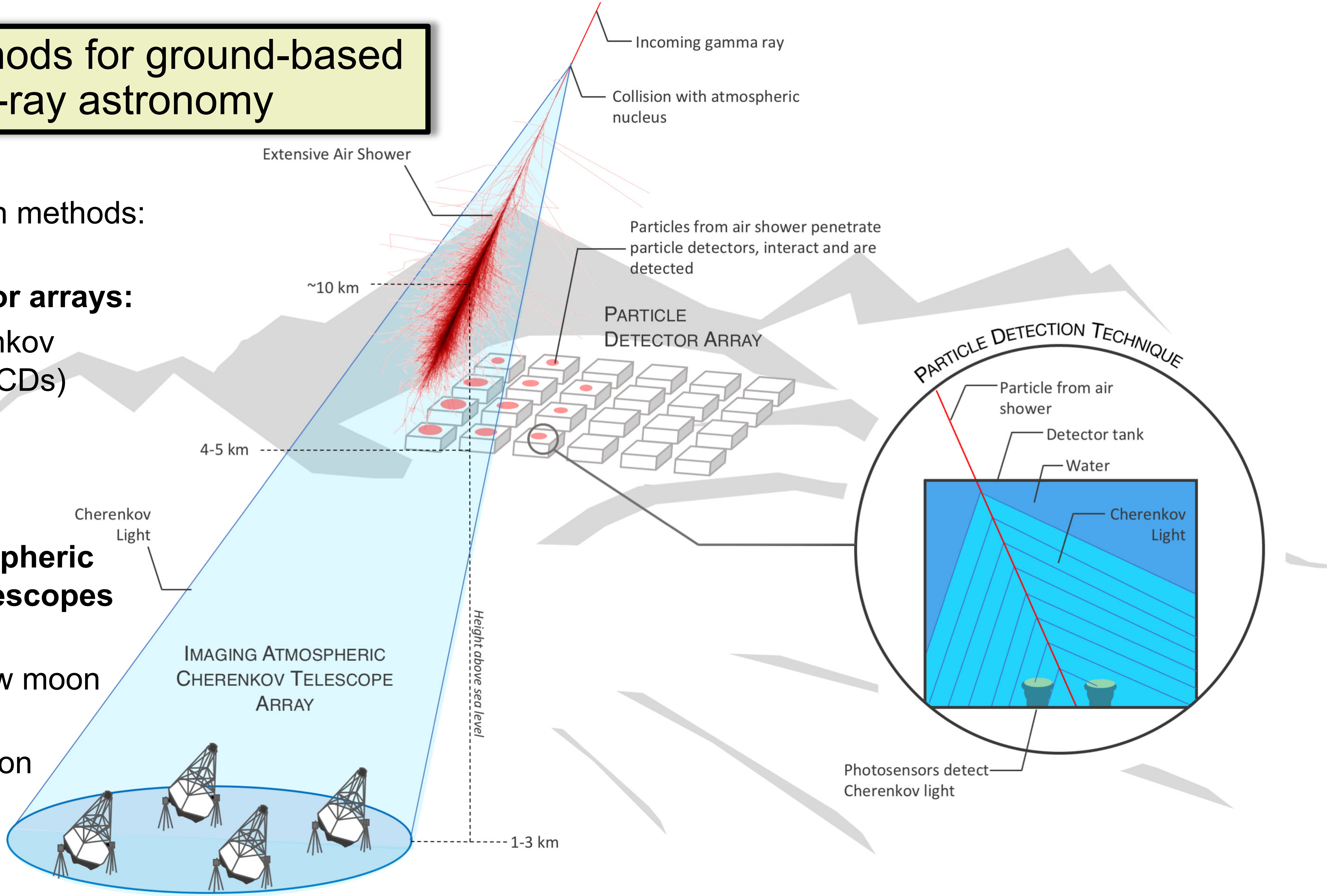
"slides.pdf"
"poster.pdf"
"ICRC_final.pdf"

Ground-based Gamma-ray Astronomy @ ICRC 2021



Detection methods for ground-based gamma-ray astronomy

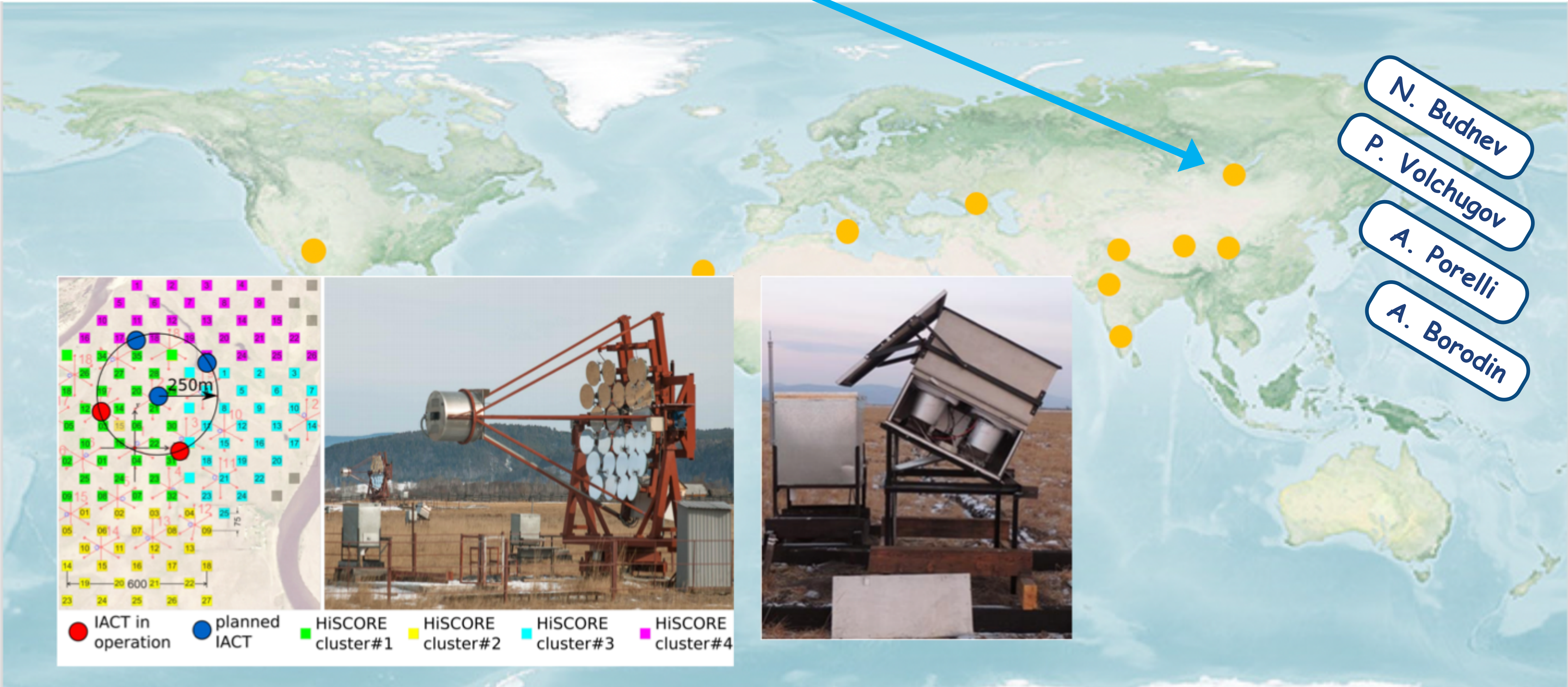
- Two main detection methods:
  - **Particle detector arrays:**
    - Water Cherenkov Detectors (WCDs)
    - Scintillators
    - Up to 24/7
  - **Imaging Atmospheric Cherenkov Telescopes (IACTs)**
    - Night only, low moon
  - ...or a combination



Shower image, 100 GeV γ-ray adapted from: F. Schmidt, J. Knapp, "CORSIKA Shower Images", 2005, https://www-zeuthen.desy.de/~jknapp/fs/showerimages.html

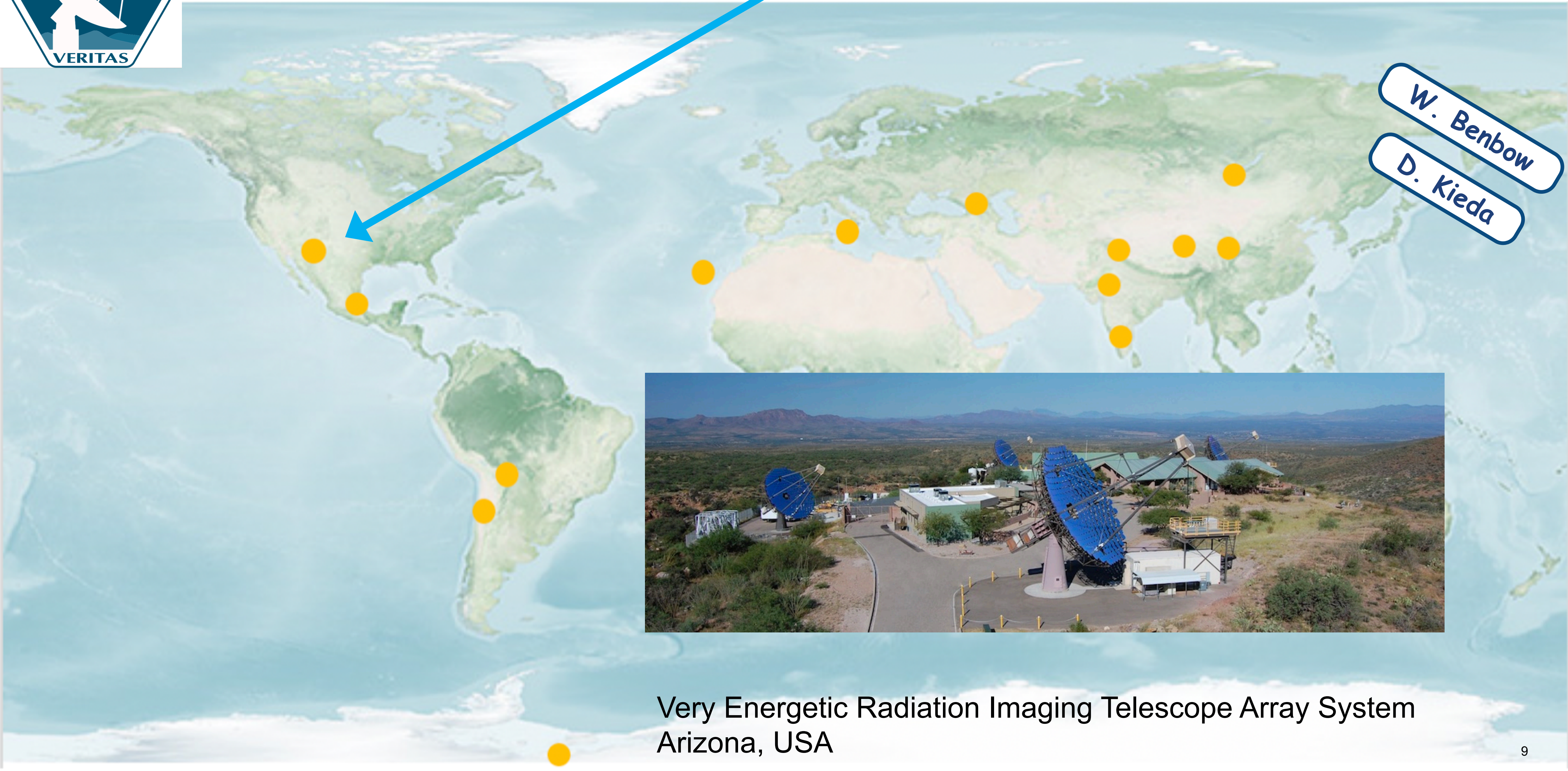
Not to scale

TAIGA 675m



Tunka Advanced Instrument for cosmic ray physics and Gamma Astronomy
Tunka Valley near lake Baikal, Siberia, Russia

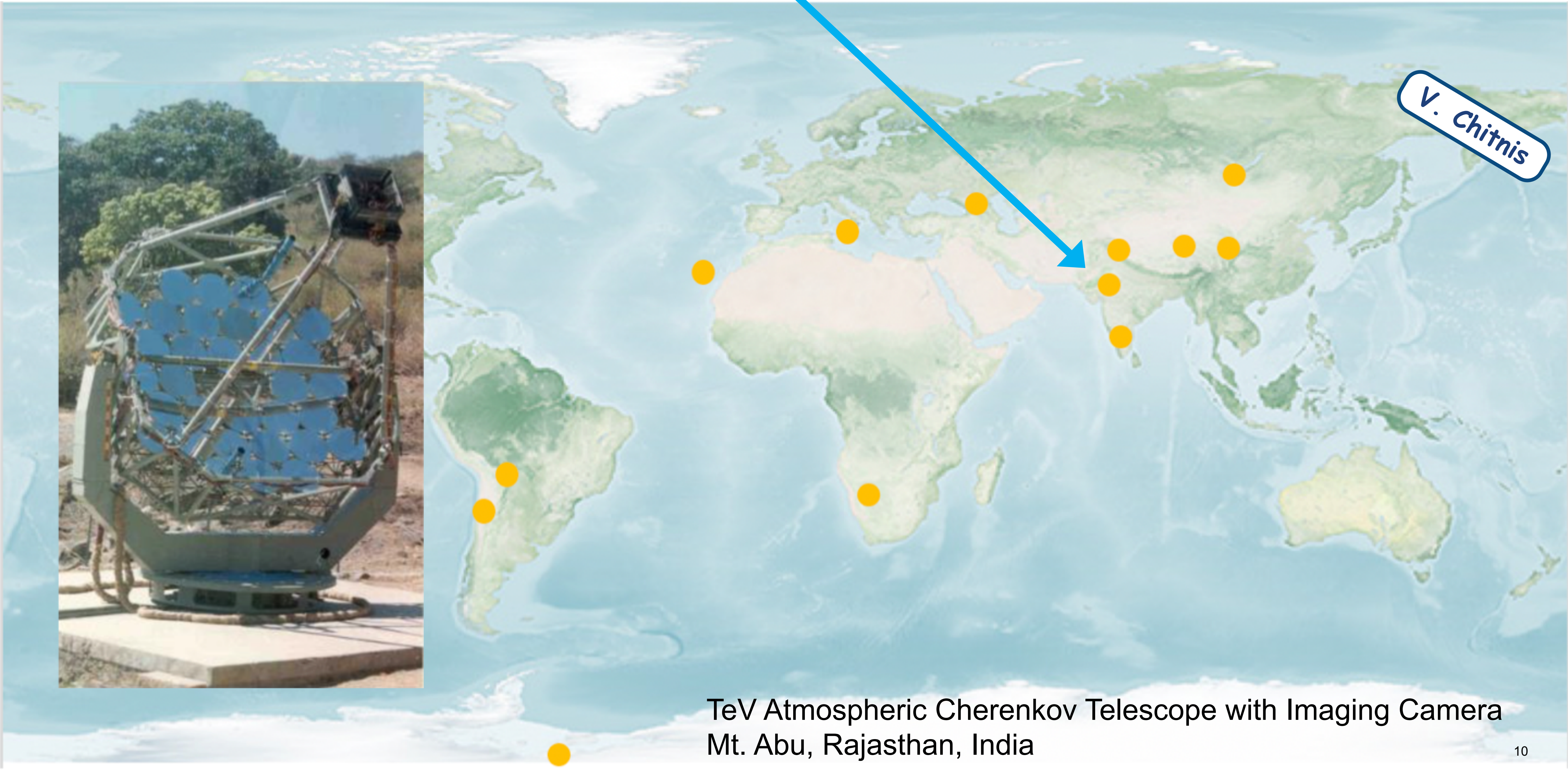
VERITAS 1268m



W. Benbow
D. Kieda

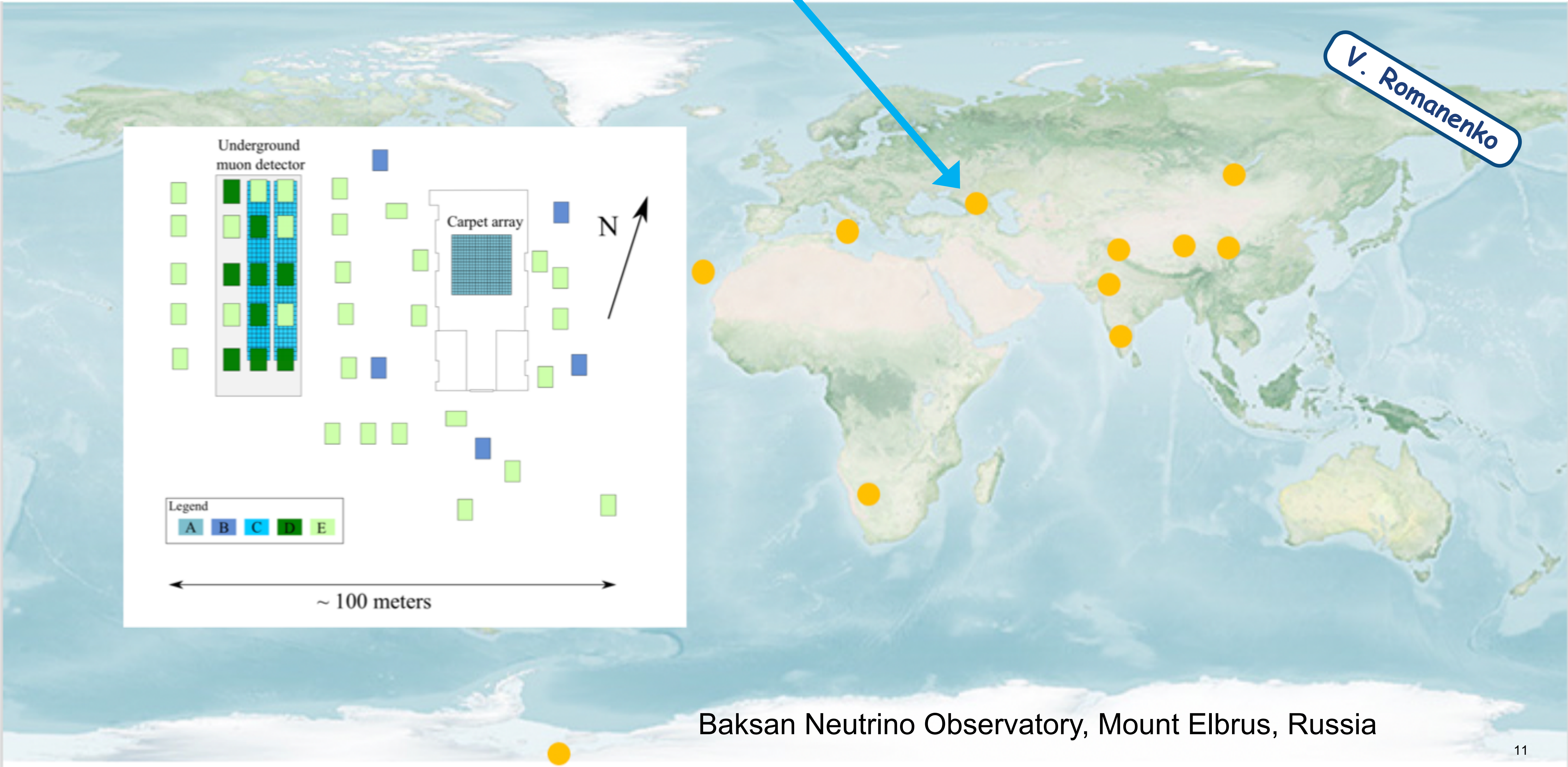
Very Energetic Radiation Imaging Telescope Array System
Arizona, USA

TACTIC 1300m



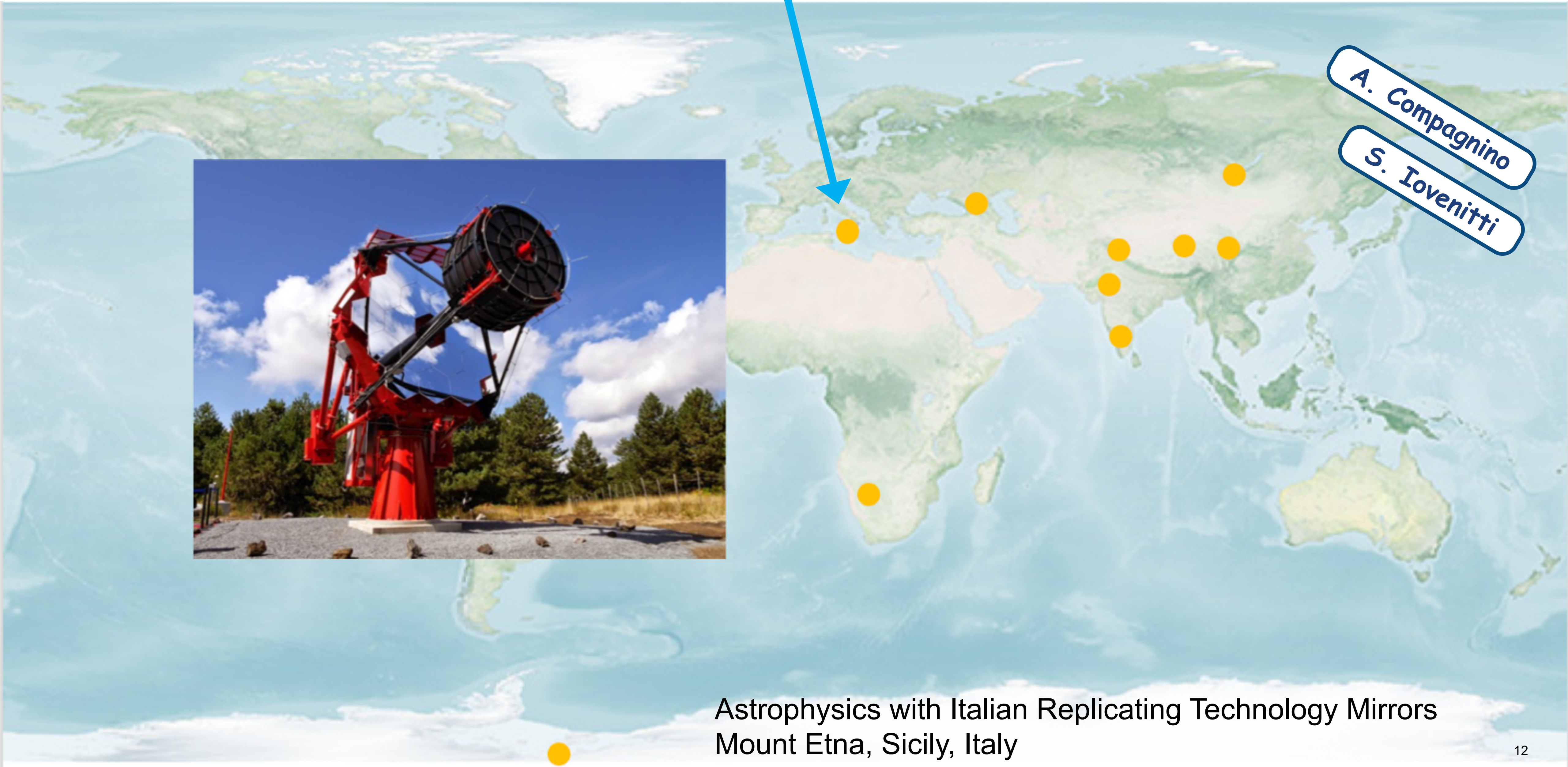
TeV Atmospheric Cherenkov Telescope with Imaging Camera
Mt. Abu, Rajasthan, India

Carpet-3 1700m



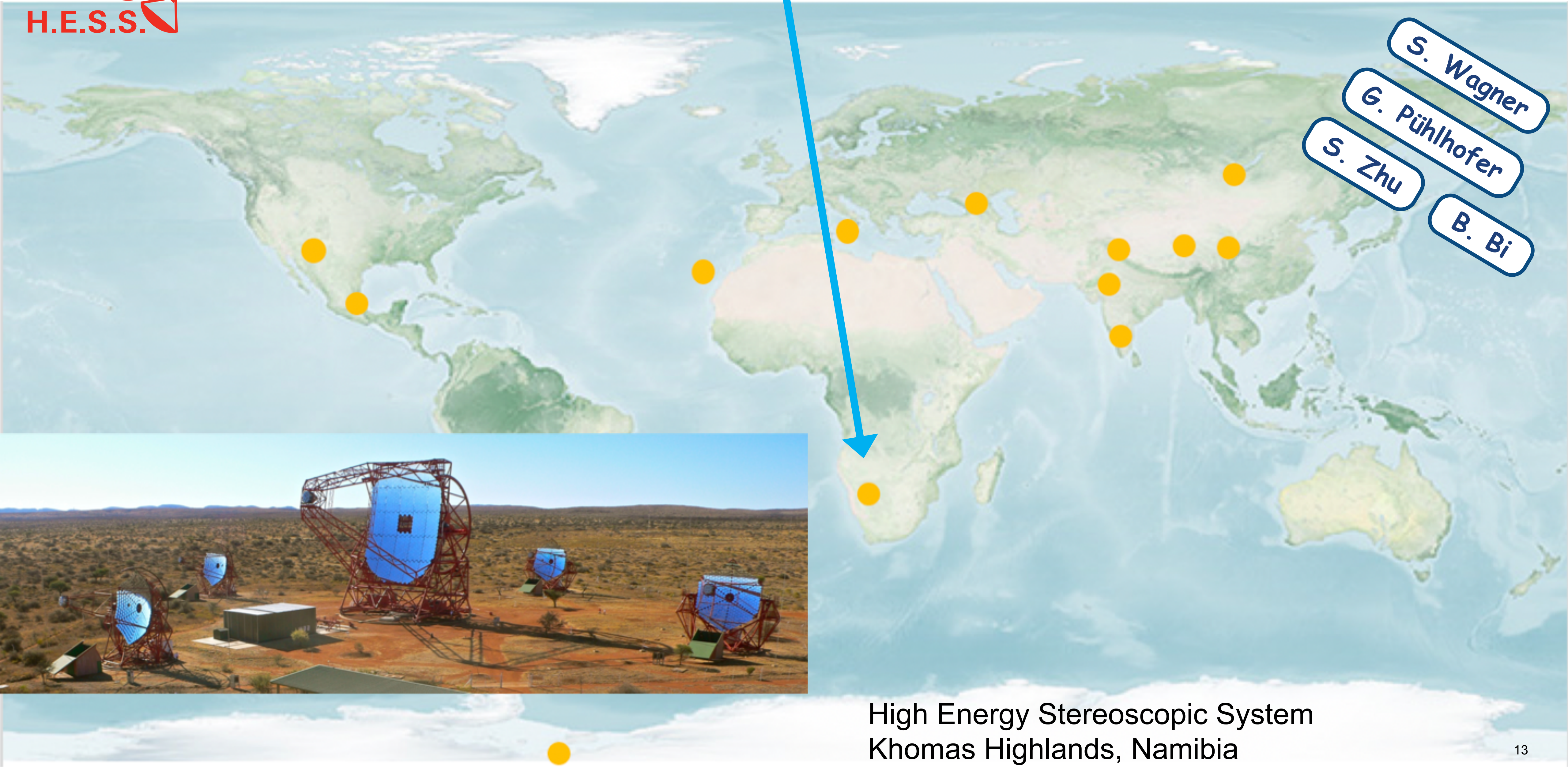
Baksan Neutrino Observatory, Mount Elbrus, Russia

ASTRI-Horn 1740m



Astrophysics with Italian Replicating Technology Mirrors
Mount Etna, Sicily, Italy

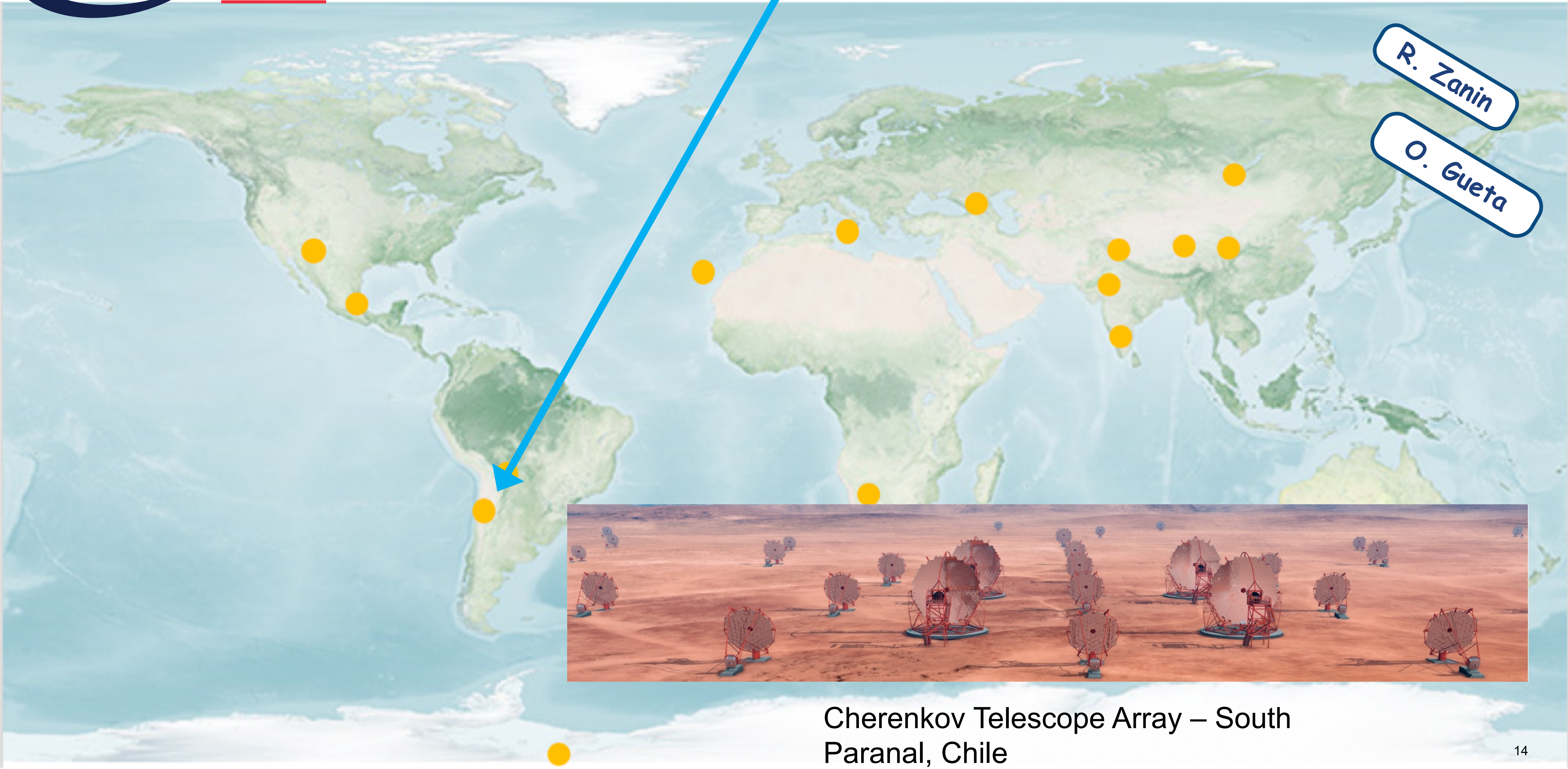
H.E.S.S. 1800m



High Energy Stereoscopic System
Khomas Highlands, Namibia

cherenkov telescope array

CTA-S 1800m



Cherenkov Telescope Array – South
Paranal, Chile

MAGIC 2200m

LST, FACT, CTA-N

R. Mirzoyan
C. Delgado
G. Ceribella

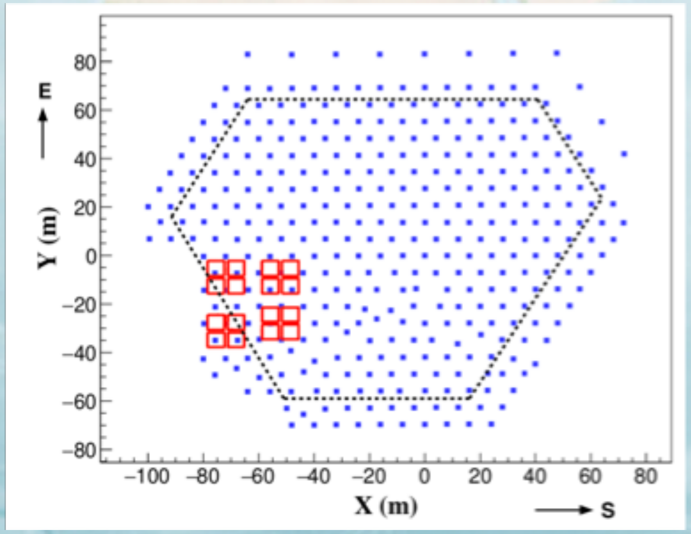
B. Schleicher
D. Dorner
T. Saito
Y. Ohtani
R. Lopéz-Coto
Y. Kobayashi
D. Mazin

Large-Sized Telescope (CTA-N)
First G-APD Cherenkov Telescope

Major Atmospheric Gamma Imaging Cherenkov Telescopes
Roque de los Muchachos, La Palma, Spain

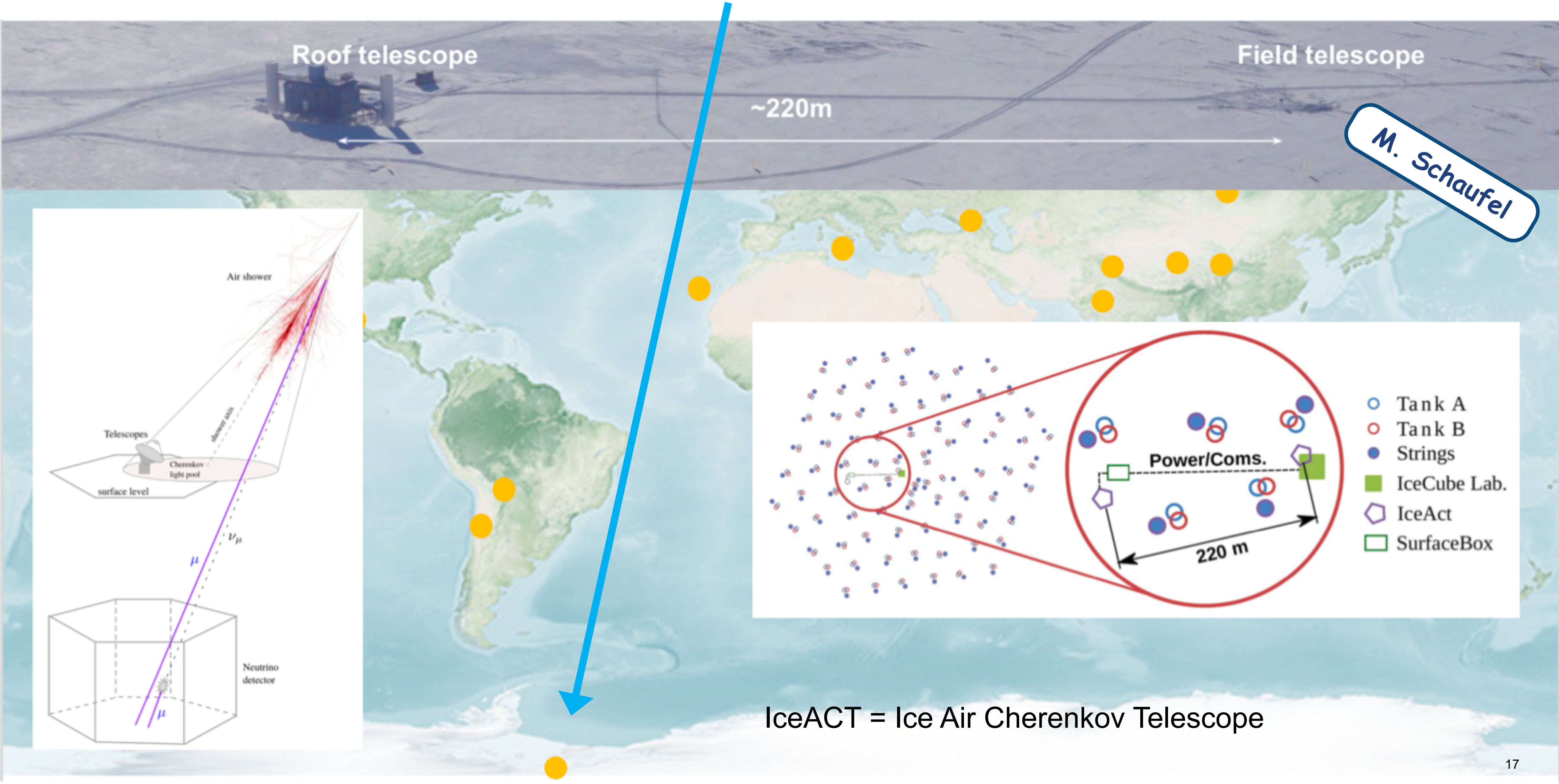
GRAPES-3   2200m

D. Pattanaik
B. Pant



Gamma Ray Astronomy PeV EnergieS phase 3
Ooty, India

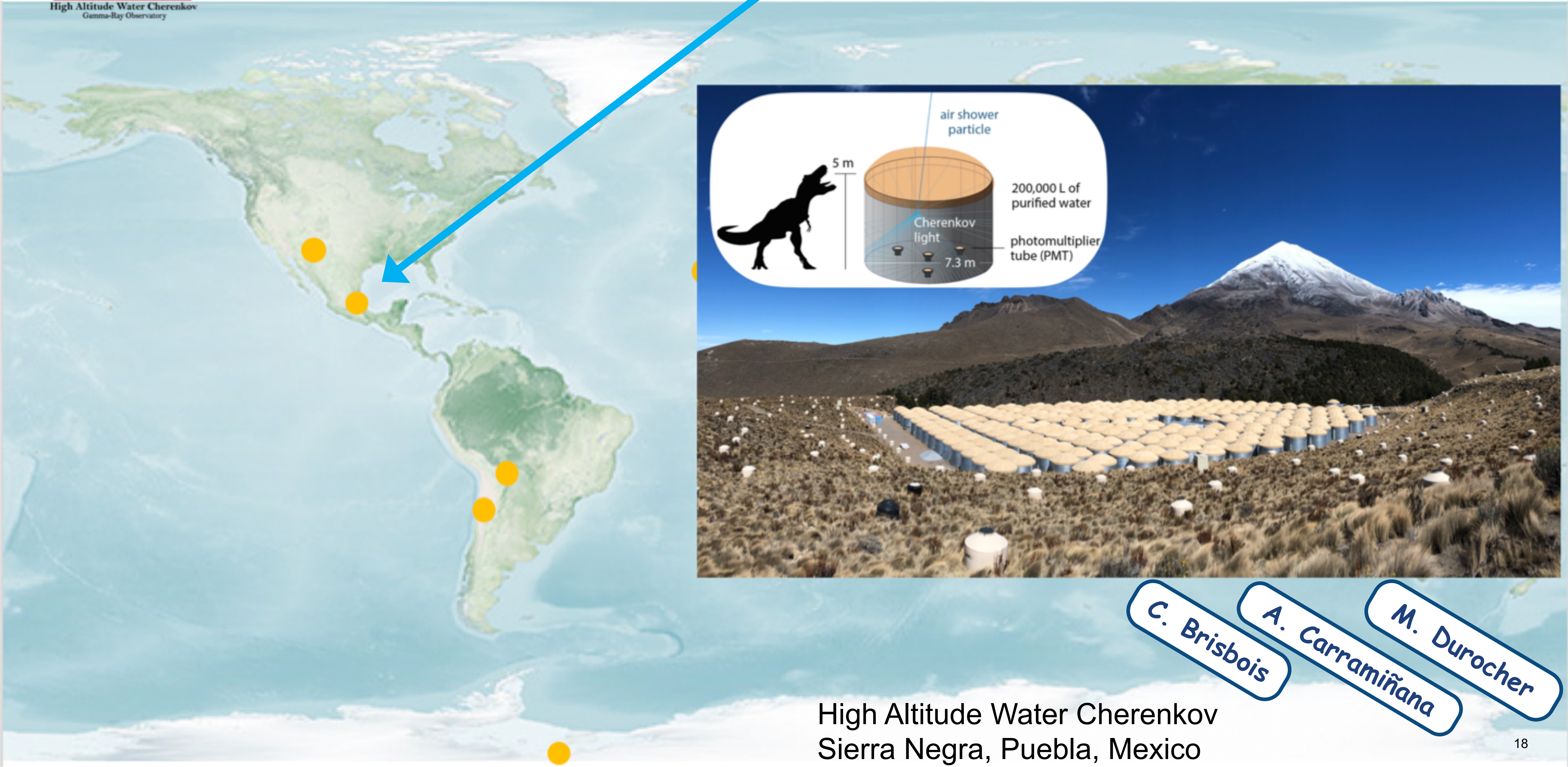
IceACT 2840m



IceACT = Ice Air Cherenkov Telescope

HAWC
High Altitude Water Cherenkov
Gamma-Ray Observatory

HAWC 4100m



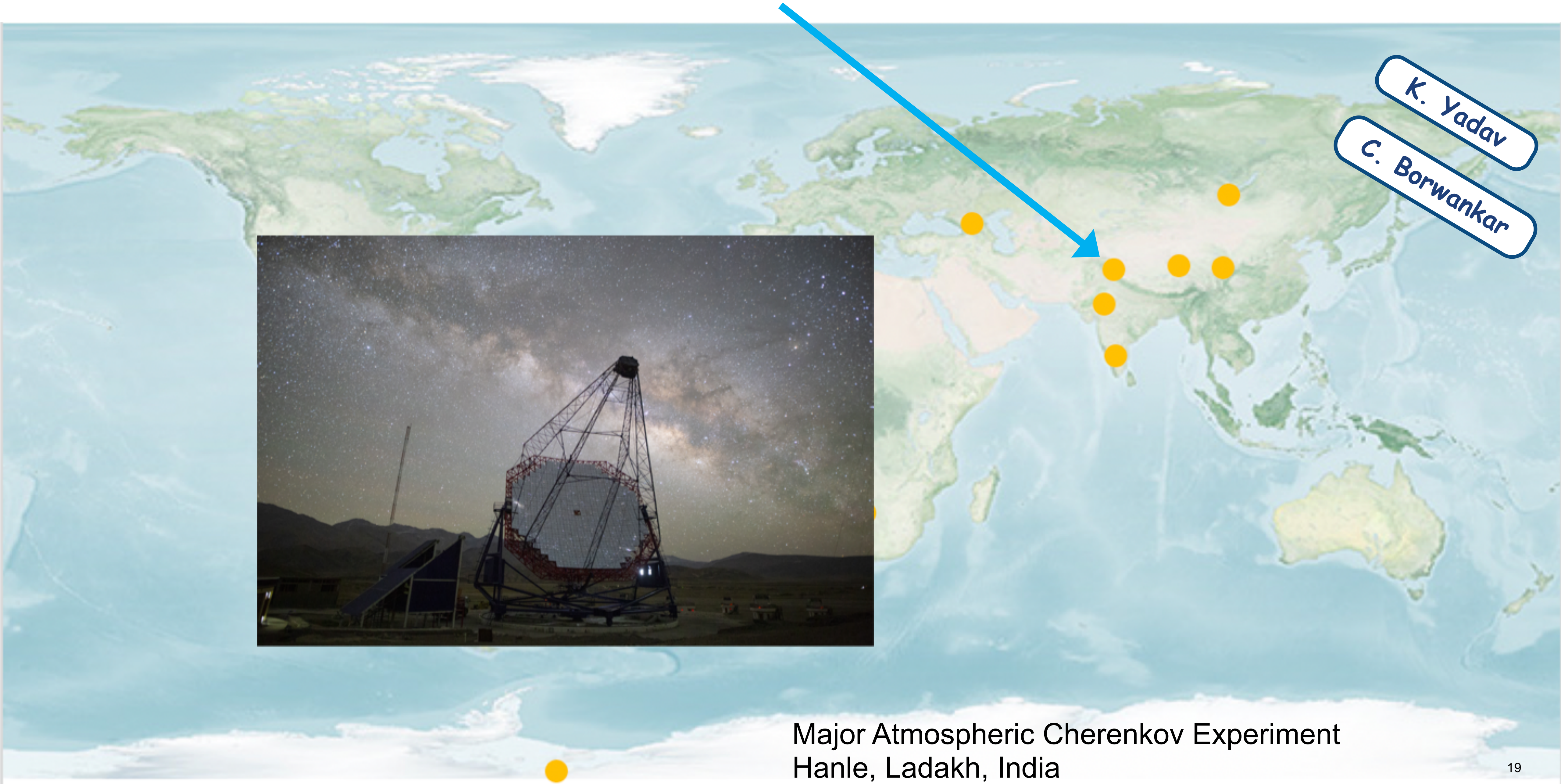
C. Brisbois

A. Carramiñana

M. Durocher

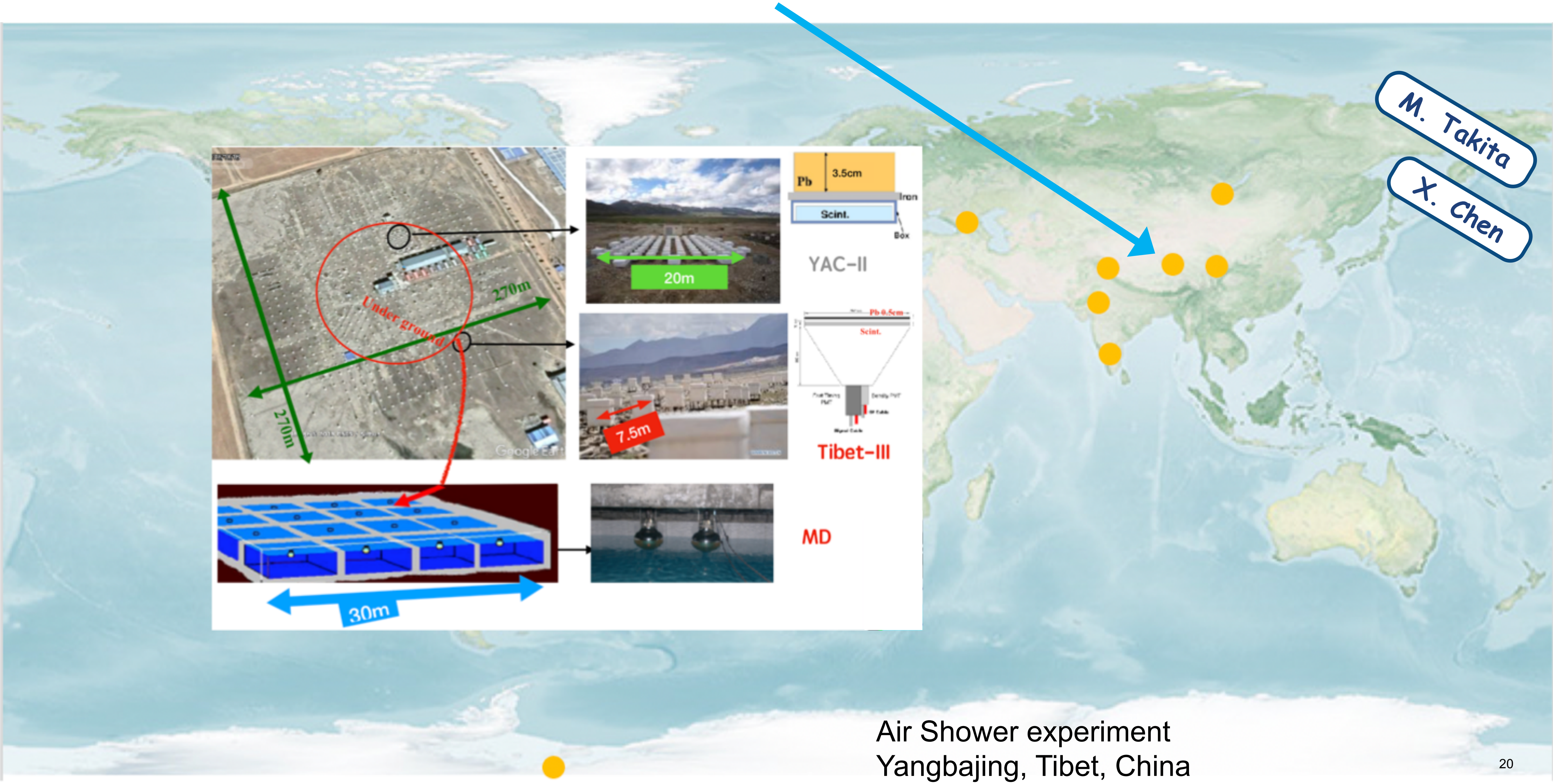
High Altitude Water Cherenkov
Sierra Negra, Puebla, Mexico

MACE 4270m



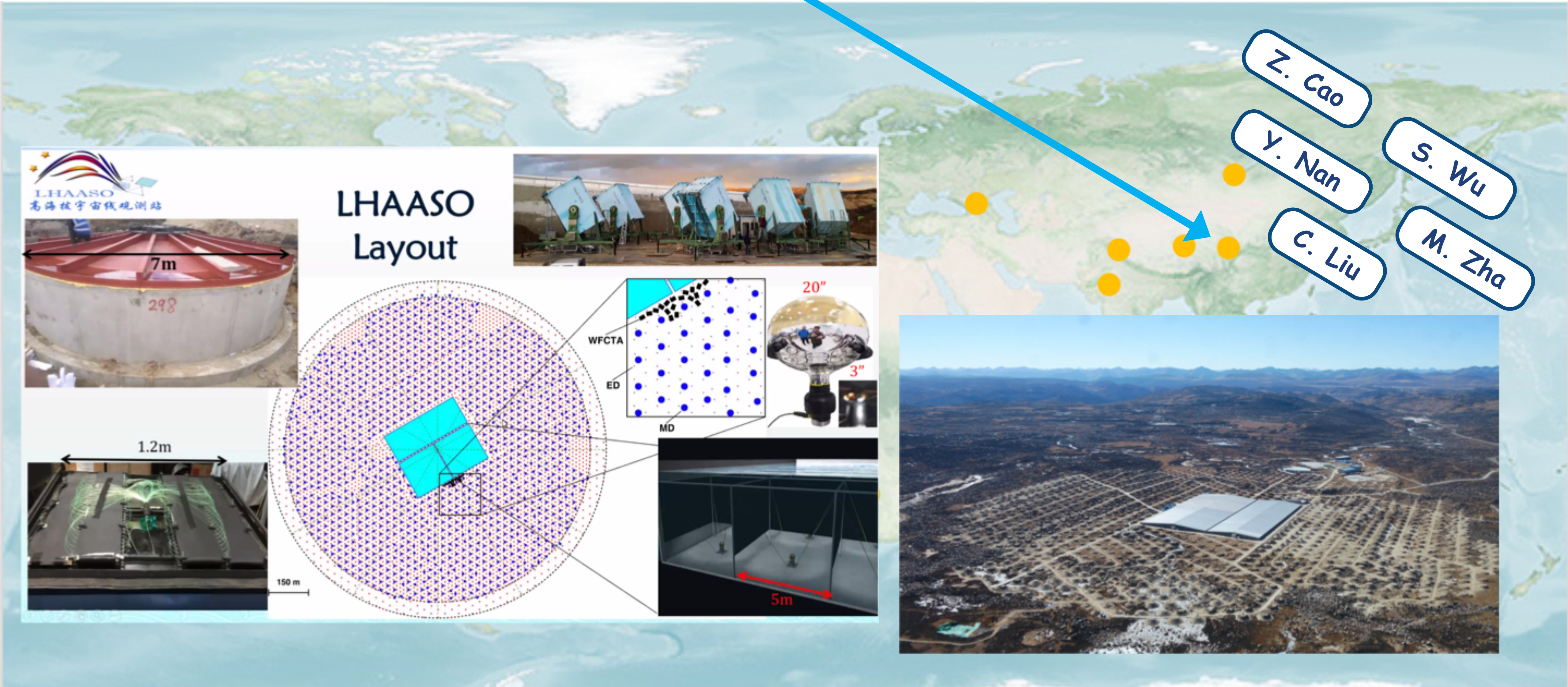
Major Atmospheric Cherenkov Experiment
Hanle, Ladakh, India

Tibet ASγ 4300m



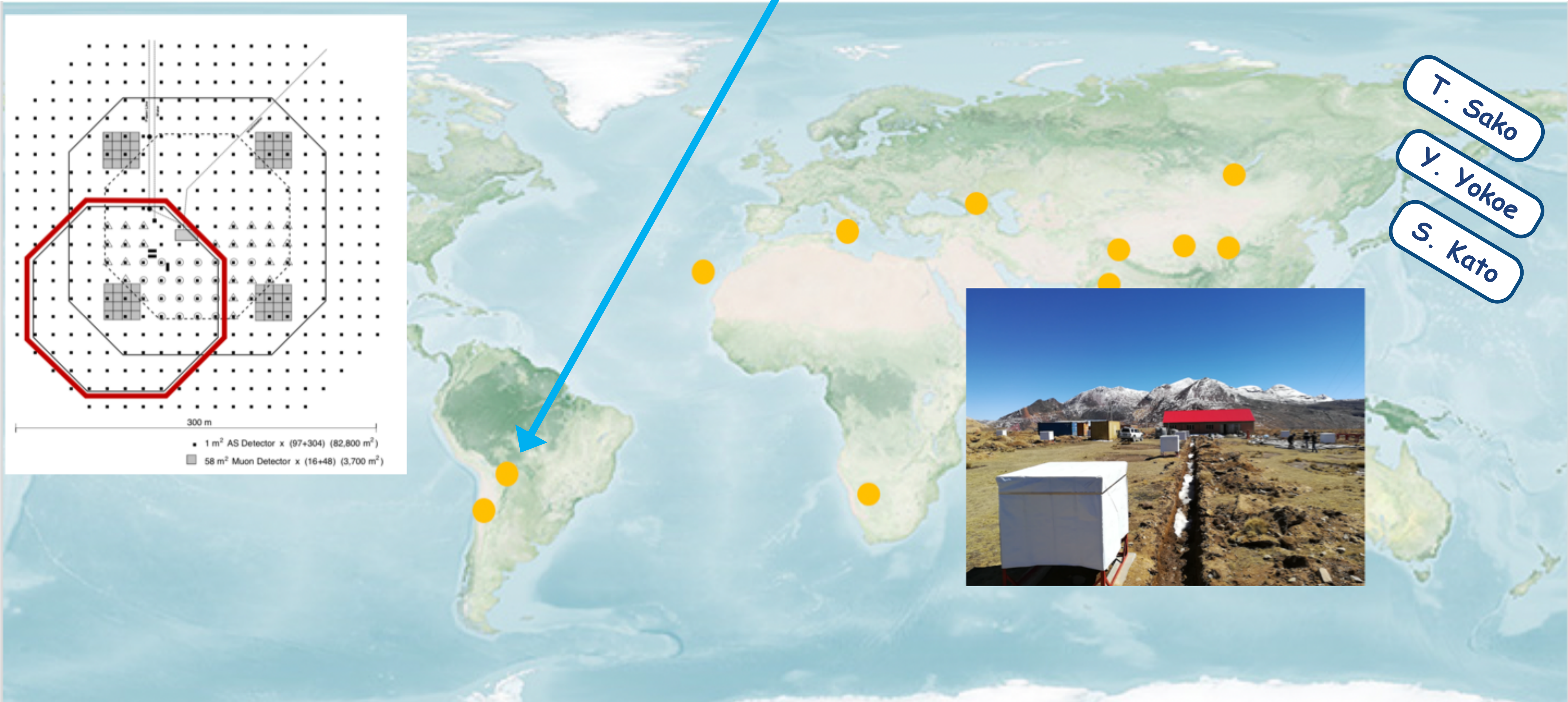
Air Shower experiment
Yangbajing, Tibet, China

高海拔宇宙线观测站　　LHAASO　4410m



Large High Altitude Air Shower Observatory
Daochen site, Sichuan province, China

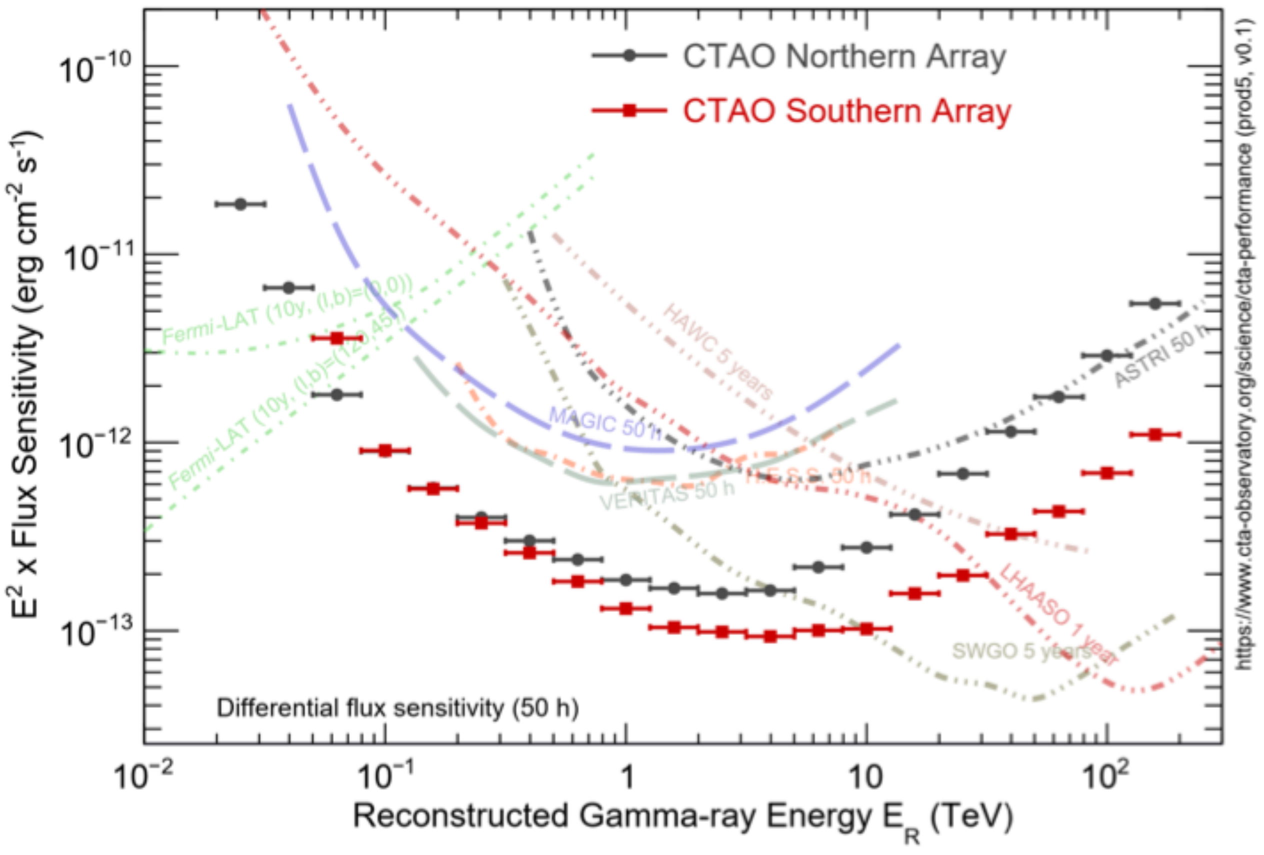
ALPACA 4740m

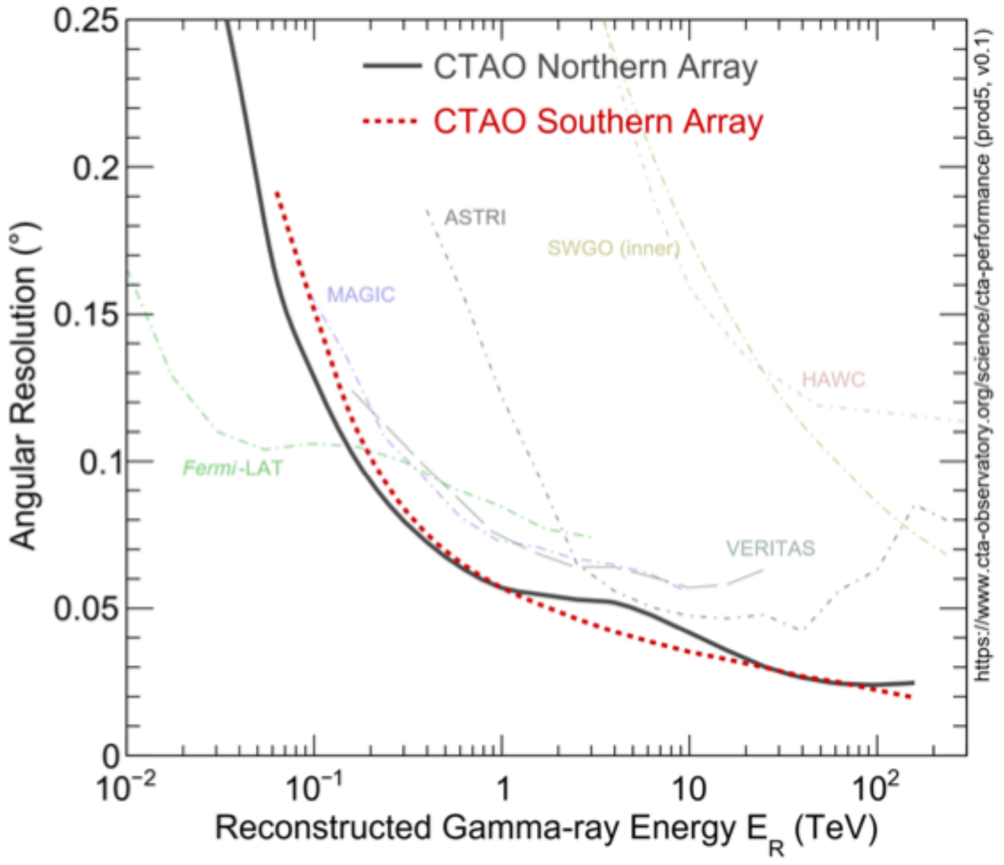


Andes Large-area Particle detector for Cosmic-ray physics and Astronomy
Mt. Chacaltaya, Bolivia

Complementary Facilities

- Different techniques → different performance

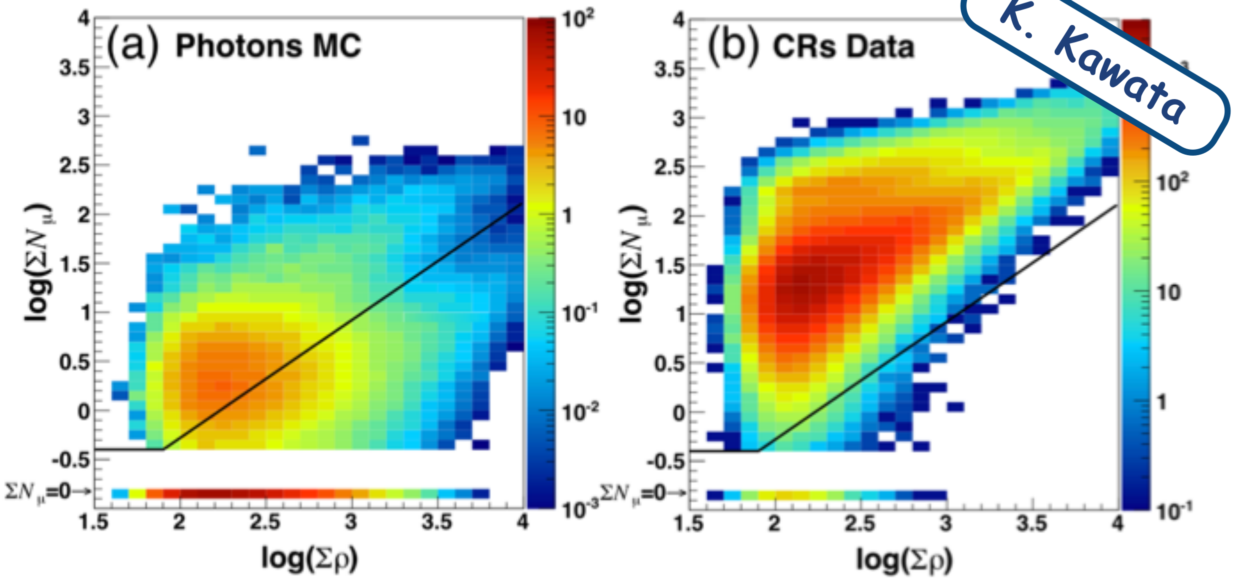




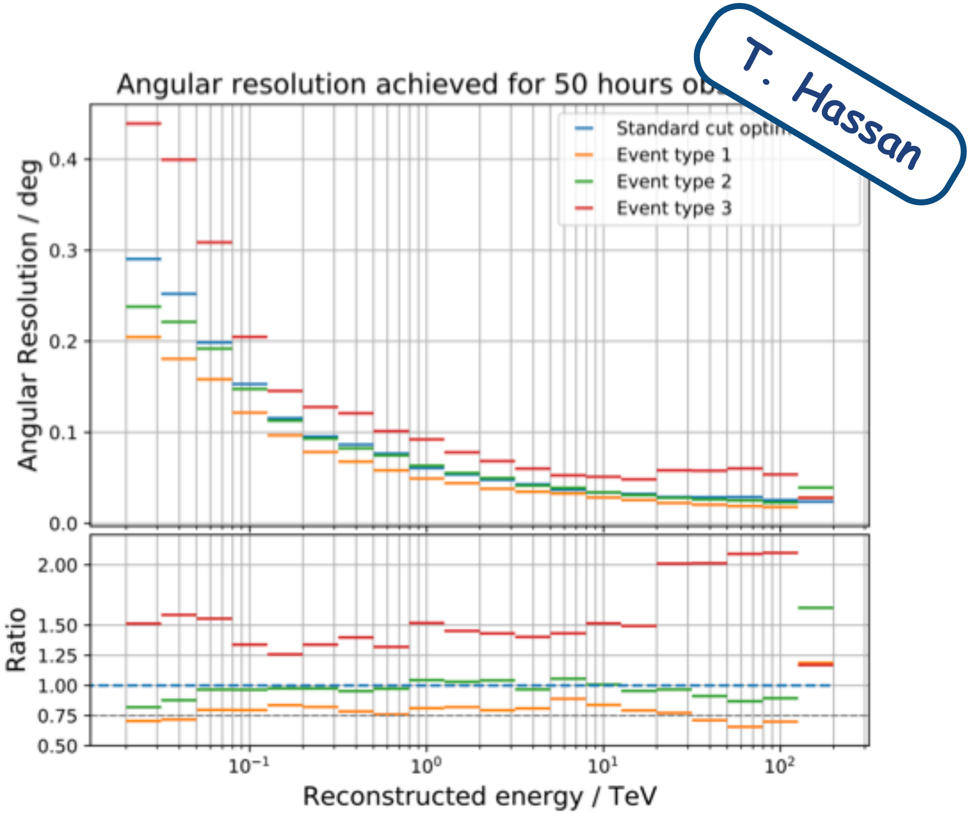
- Background rejection by muon tagging key for LHAASO and Tibet ASγ

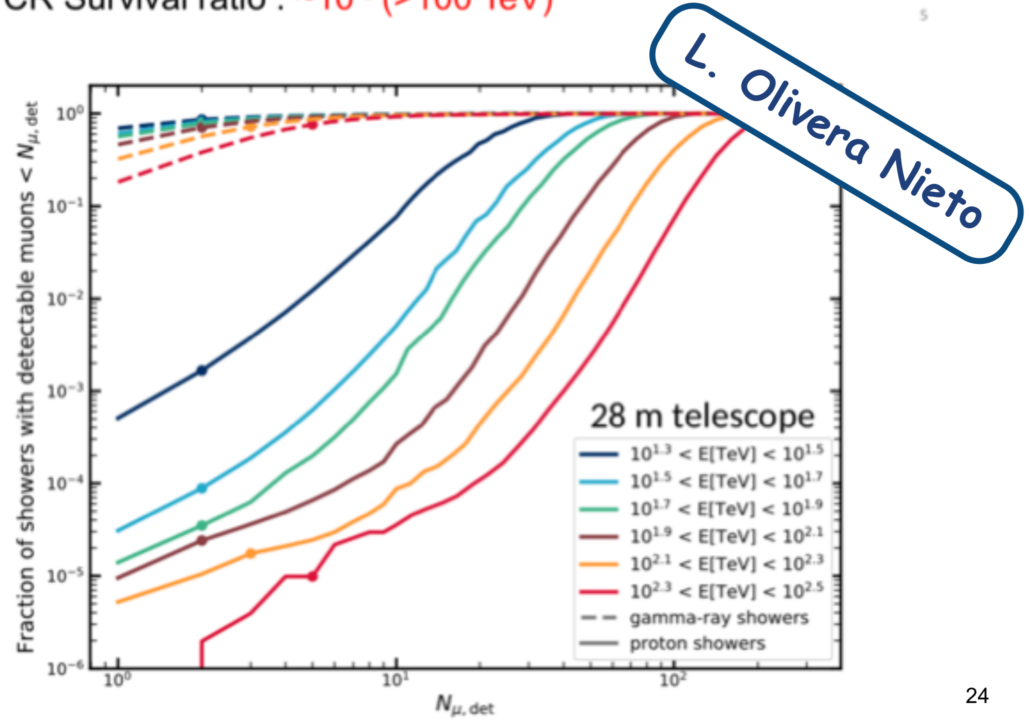
- Potential improvements in background rejection using muon tagging in IACTs

- Improvements in IACT angular resolution using event type sub-division



Gamma Survival ratio : ~90% by MC sim (>100 TeV)
CR Survival ratio : ~10^{-3} (>100 TeV)





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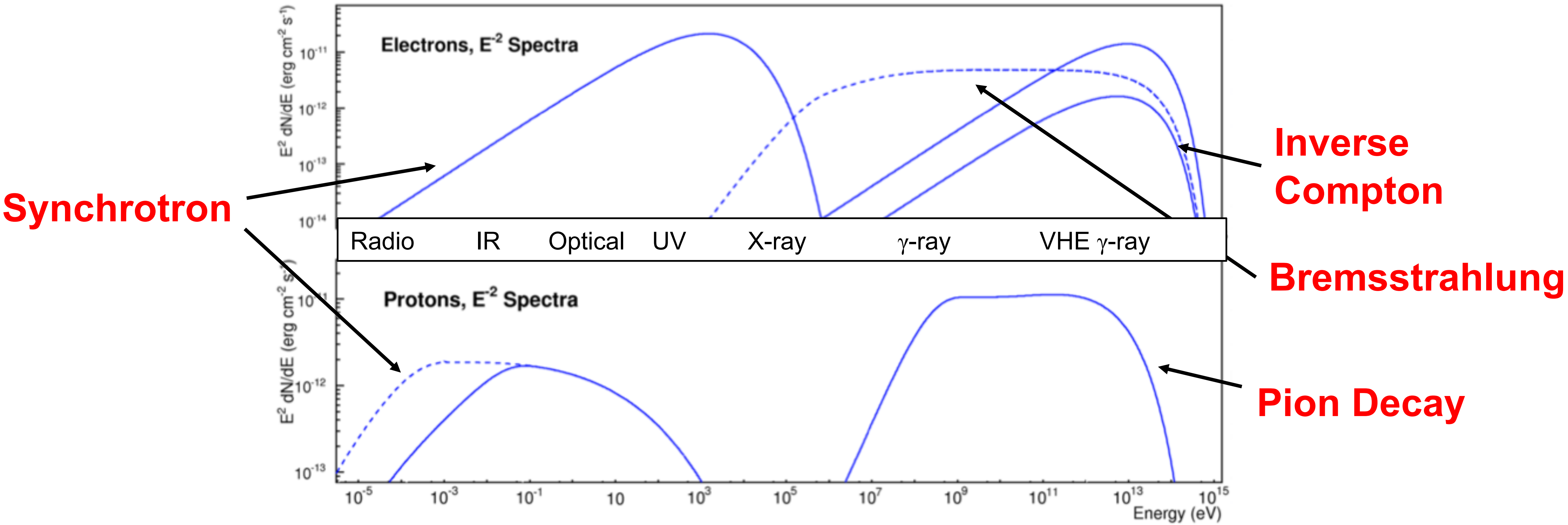
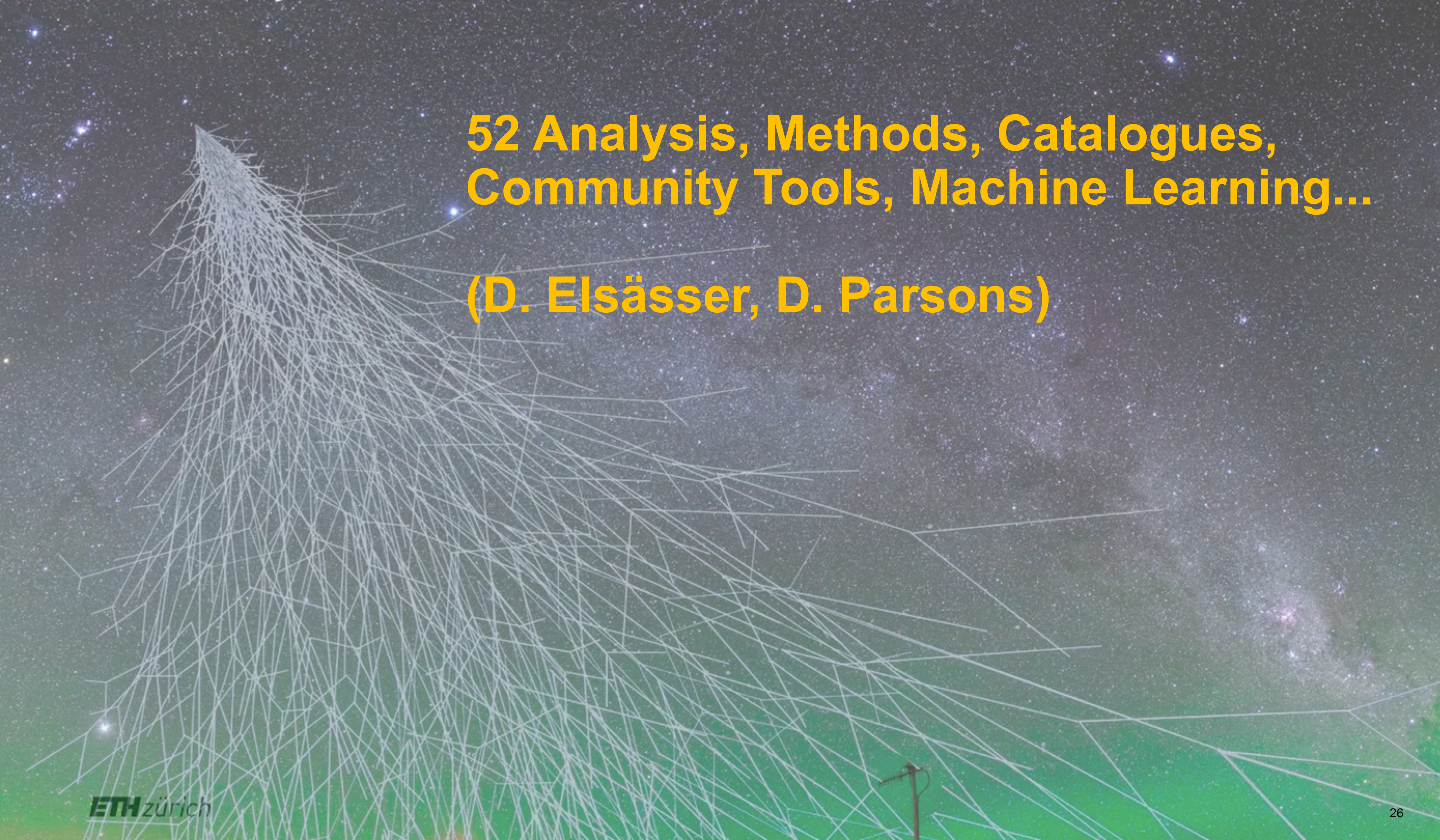
Gamma-ray Emission Mechanisms

Assumed knowledge!

"Hadronic vs Leptonic"



Hinton & Hofmann (2009)



https://www.theverge.com/2017/9/21/16335164/pierre-auger-observatory-cosmic-ray-galaxies-air-shower-particles
A. Chantelauze, S. Staffi, and L. Bret

Open Source Software

- How to support community development? (lead institutes / permanent staff)
- How to recognise contributions? (important for early career researchers)
- Python lead language – scope for others?
- Tied to major experiments (e.g. CTA -- ctapipe)

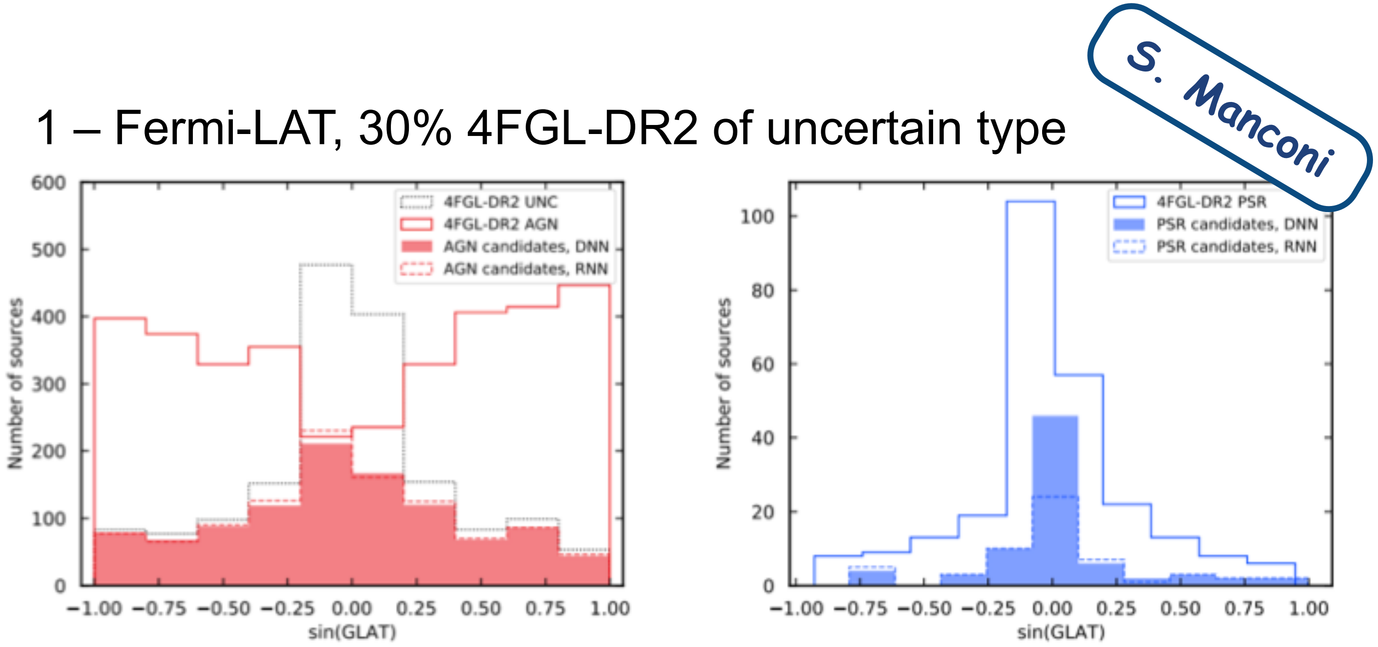
M. Nöthe

A. Donath

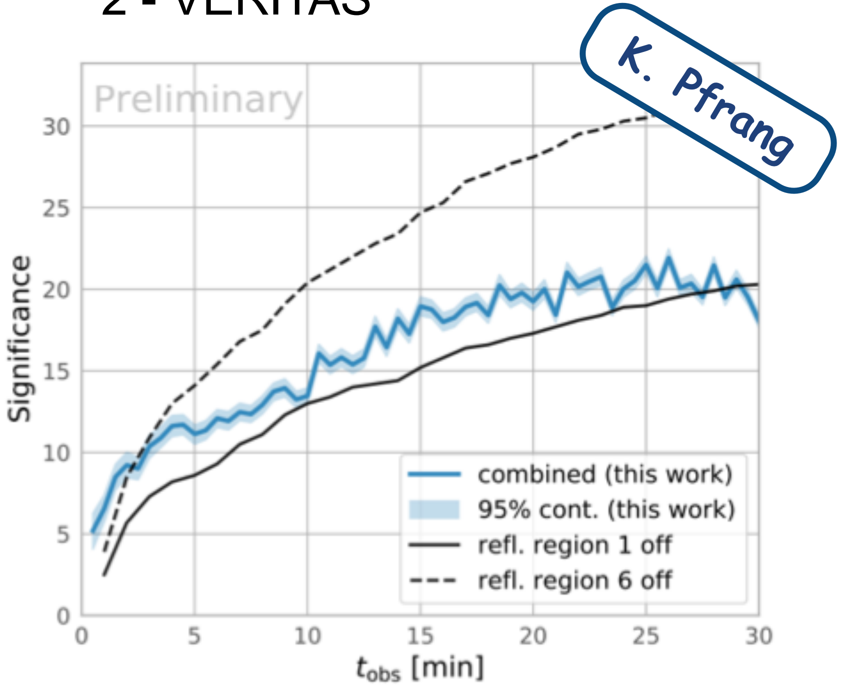
Source detection analysis

1. Source classification using machine learning
2. Transient detection using deep learning
3. Techniques for extended source analysis with IACTs

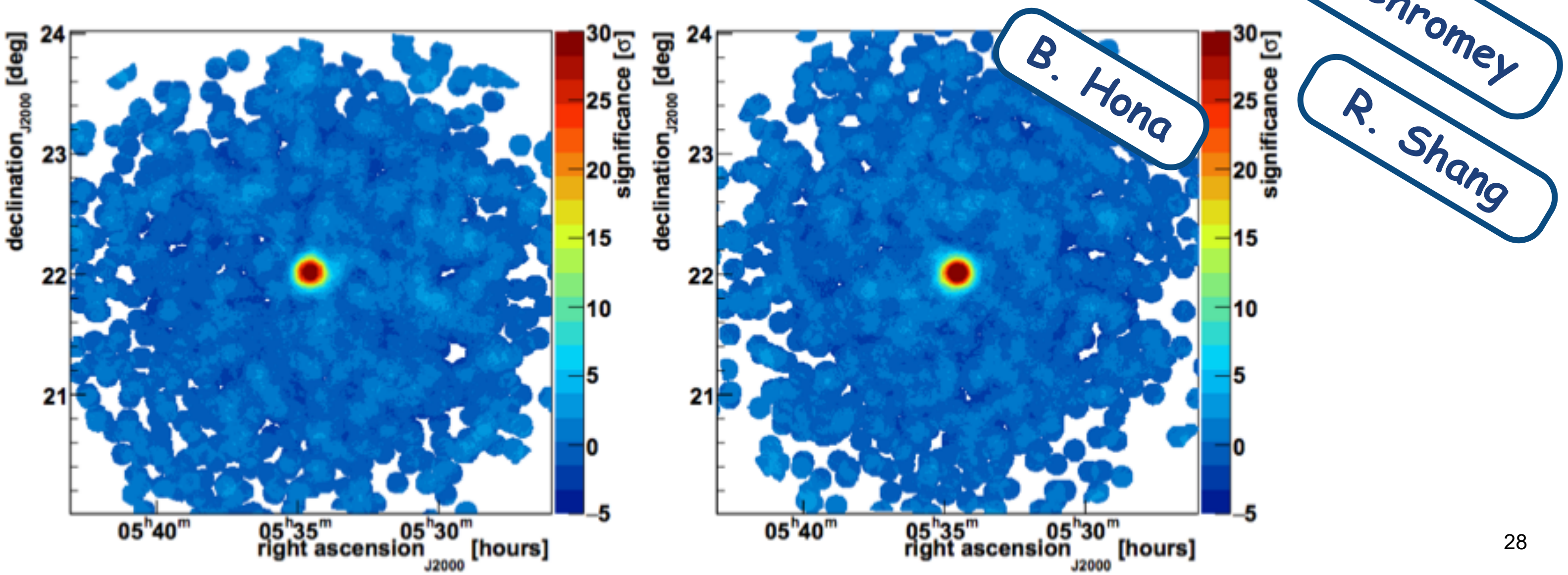
1 – Fermi-LAT, 30% 4FGL-DR2 of uncertain type



2 - VERITAS



3 - VERITAS: validation tests on Crab



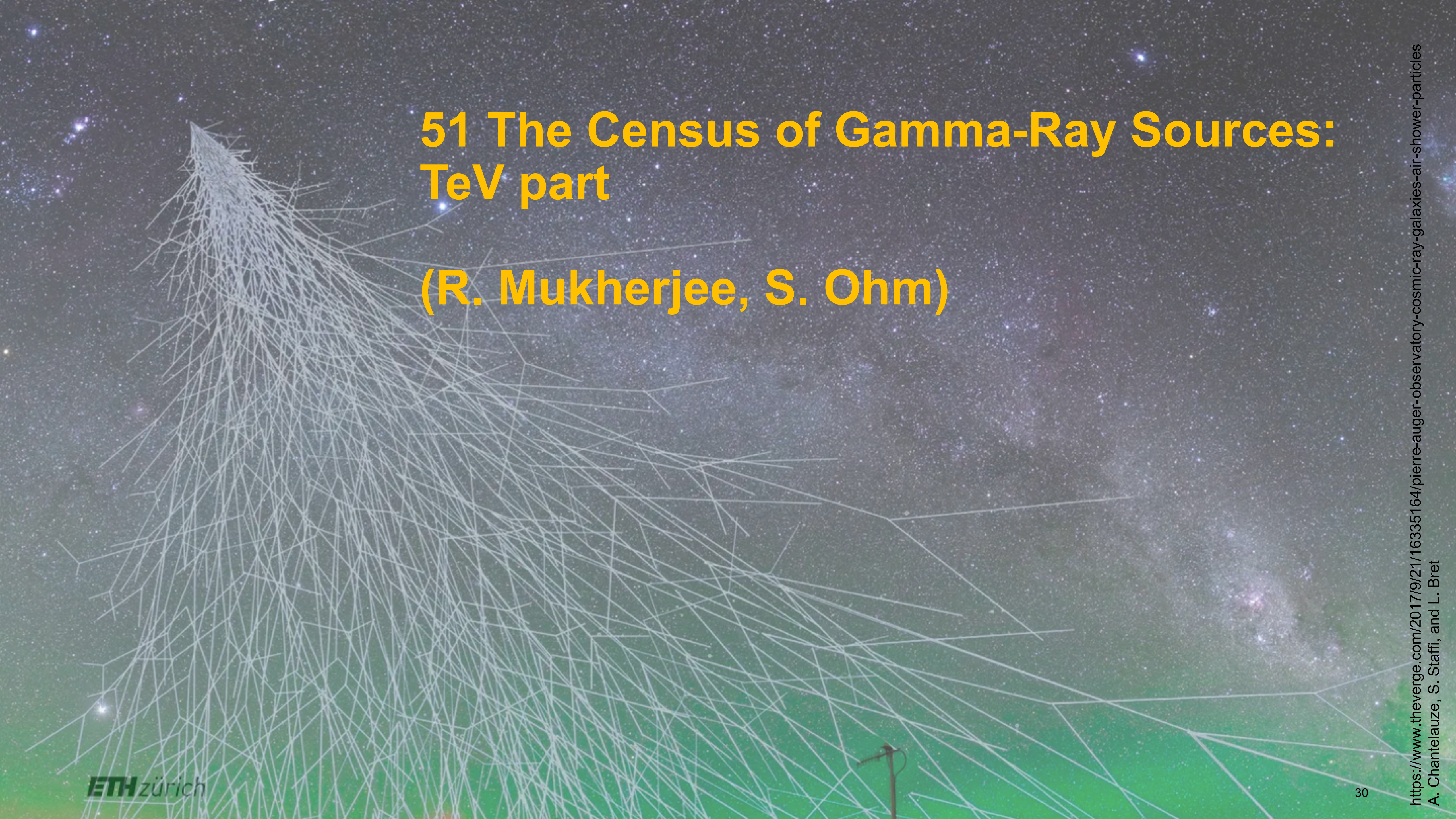
Event reconstruction and classification (Machine Learning vs “traditional”)

- Many contributions! Cannot mention all.
- **Key points**:
  - Deep Learning performance is meeting or exceeding “traditional” approaches.
  - Which approach to use?
    Two opinions:
    1. Use standard approaches where physics is well understood & ML gain negligible
    2. Always use ML where possible / most sophisticated tools available
  - Trade off between computing time and performance gain
    → ML approaches need considerable training data
    → Aim for sustainable solutions

J. Dubenskaya
B. Fraga
I. Lypova
R. Conceiçao
G. Emery
M. Blank
C. Bom
J. Aschersleben
M. de Bony de Lavergne
T. Miener
S. Polyakov
F. Zhang
K. Flanagan
T. Capistrán
T. Bylund
I. Watson

51 The Census of Gamma-Ray Sources: TeV part

(R. Mukherjee, S. Ohm)



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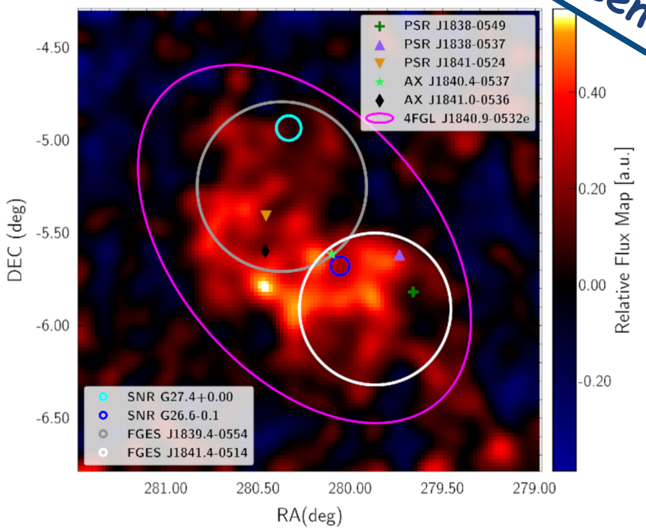
A. Chantelauze, S. Staffi, and L. Bret

- **Key Points**:
  - How to identify new source classes in catalogues?
    1. study individual sources in depth,
    2. add MWL information,
    3. feedback to population studies.
  - Shared methods / tools? Independence of studies for cross-checks?
  - Upcoming missions and prospects for population studies
  - Combining space and ground-based measurements

Shared GAD-GAI

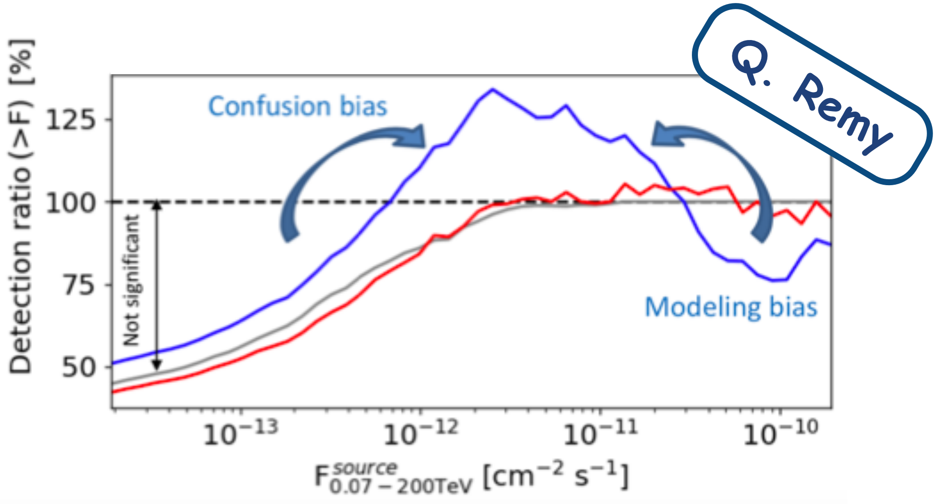
D. Green

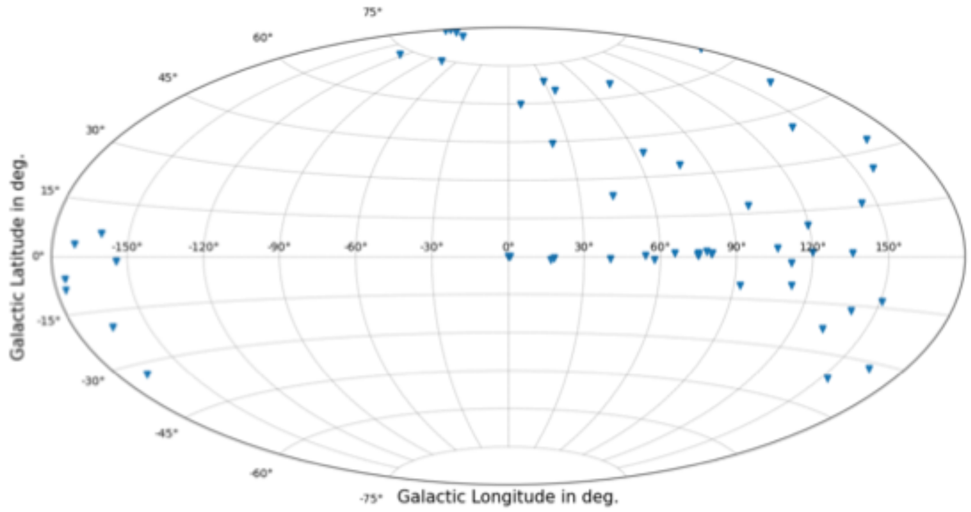


HESS J1841-055 with MAGIC

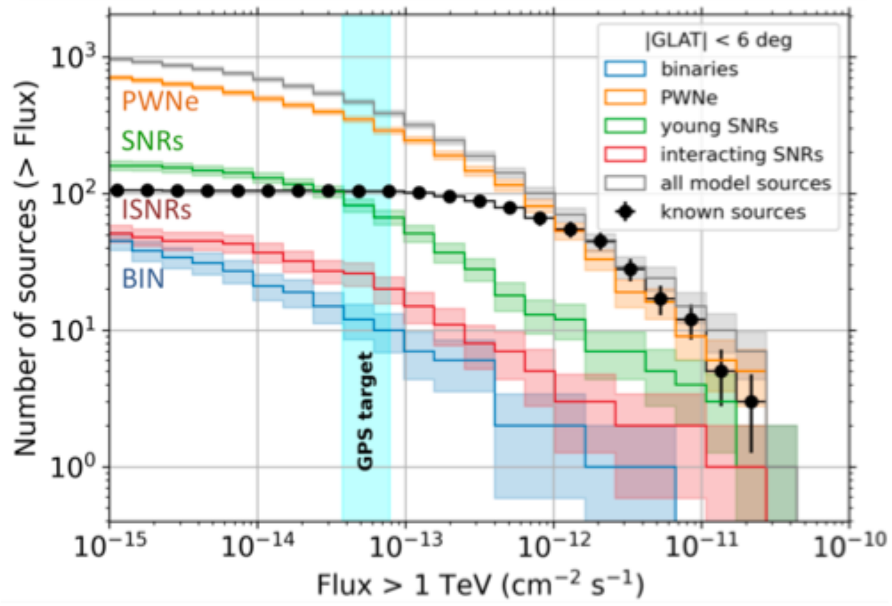
- **Multi-component fitting**:
  - Complex morphology – best described by multiple components.
  - Does multiple components imply multiple sources?
  - MWL information key!

Population Studies

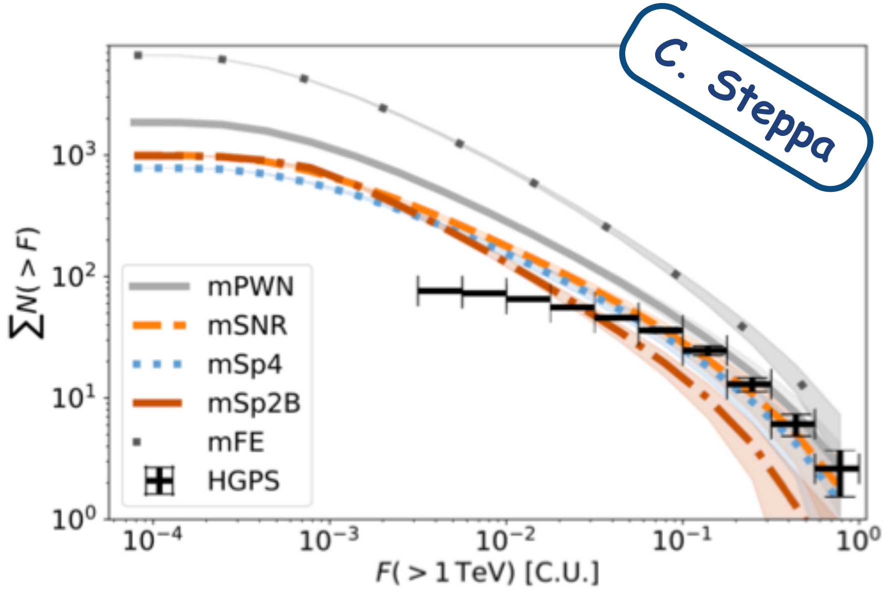




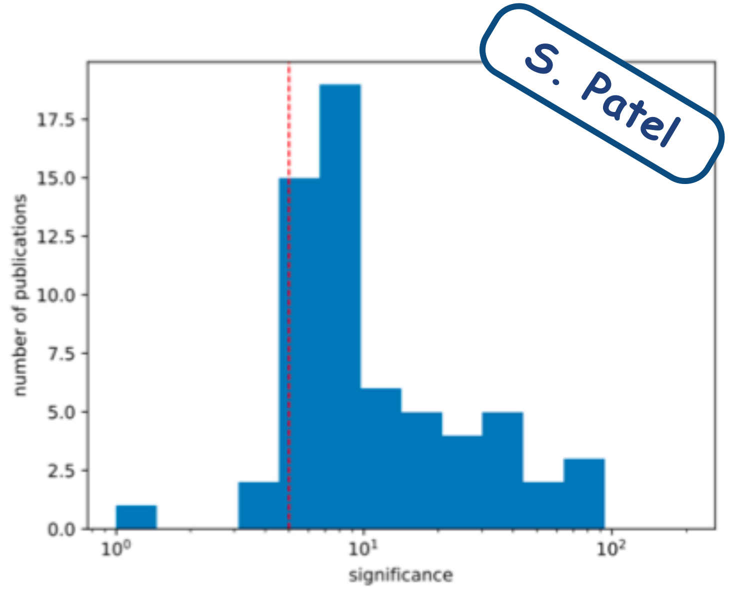
Population Synthesis



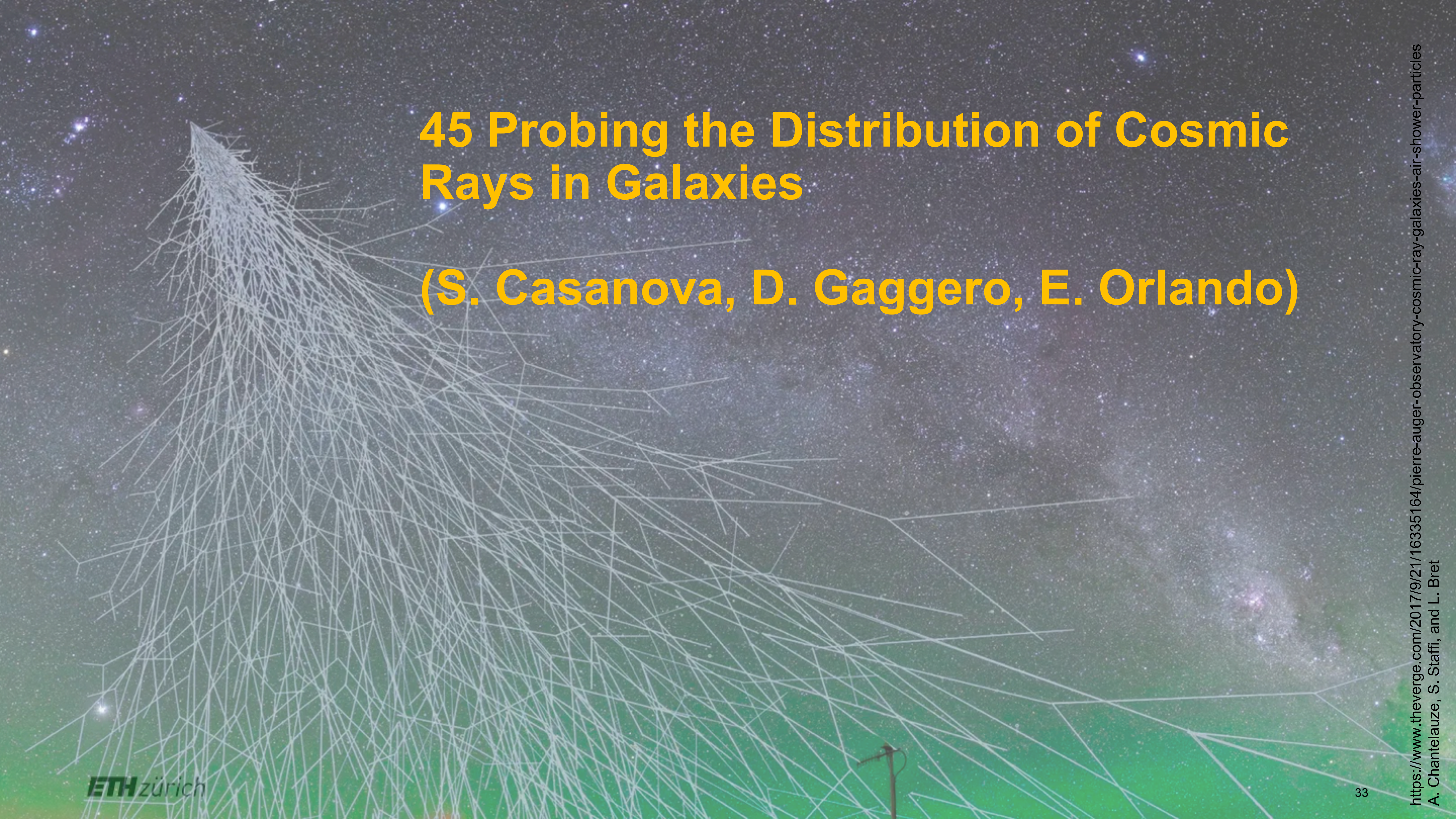
CTA simulation – synthetic model



13-32% of flux in HGPS region attributed to as yet unresolved sources



VTSCat VERITAS



45 Probing the Distribution of Cosmic Rays in Galaxies

(S. Casanova, D. Gaggero, E. Orlando)

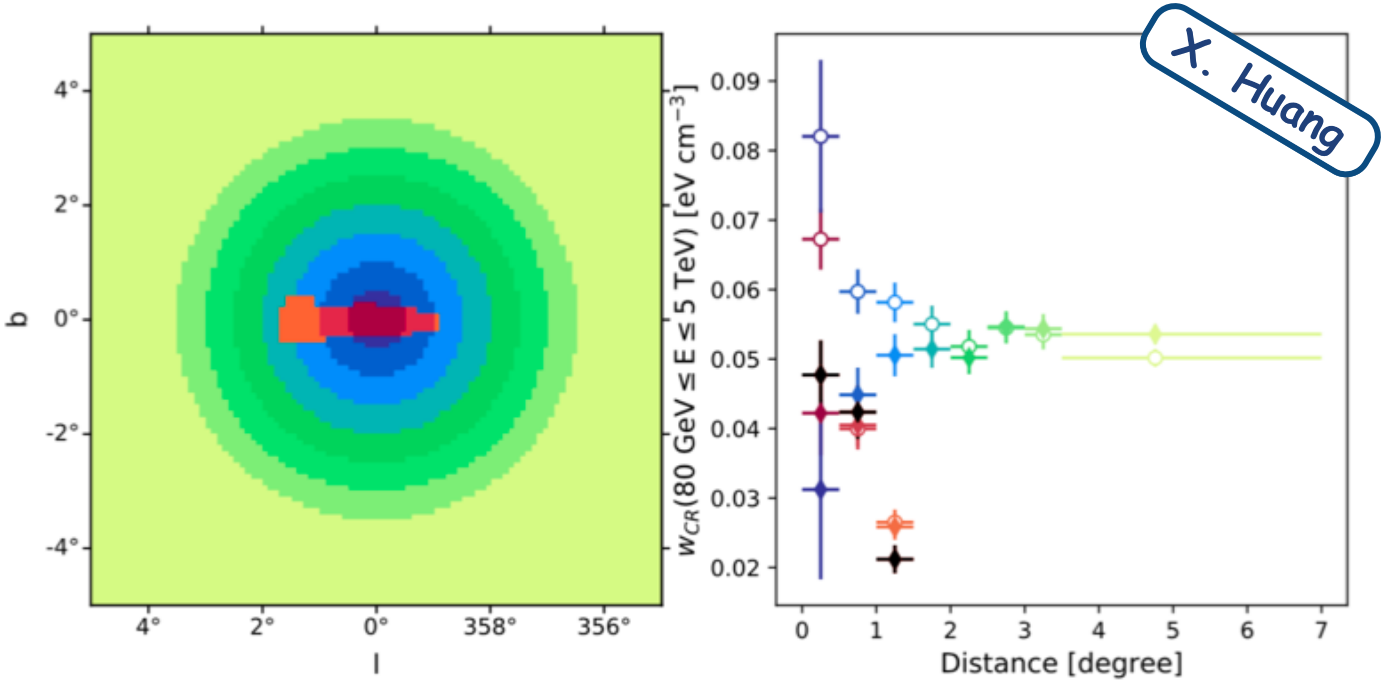
https://www.theverge.com/2017/9/21/16335164/pierre-auger-observatory-cosmic-ray-galaxies-air-shower-particles
A. Chantelauze, S. Staffi, and L. Bret

Key questions

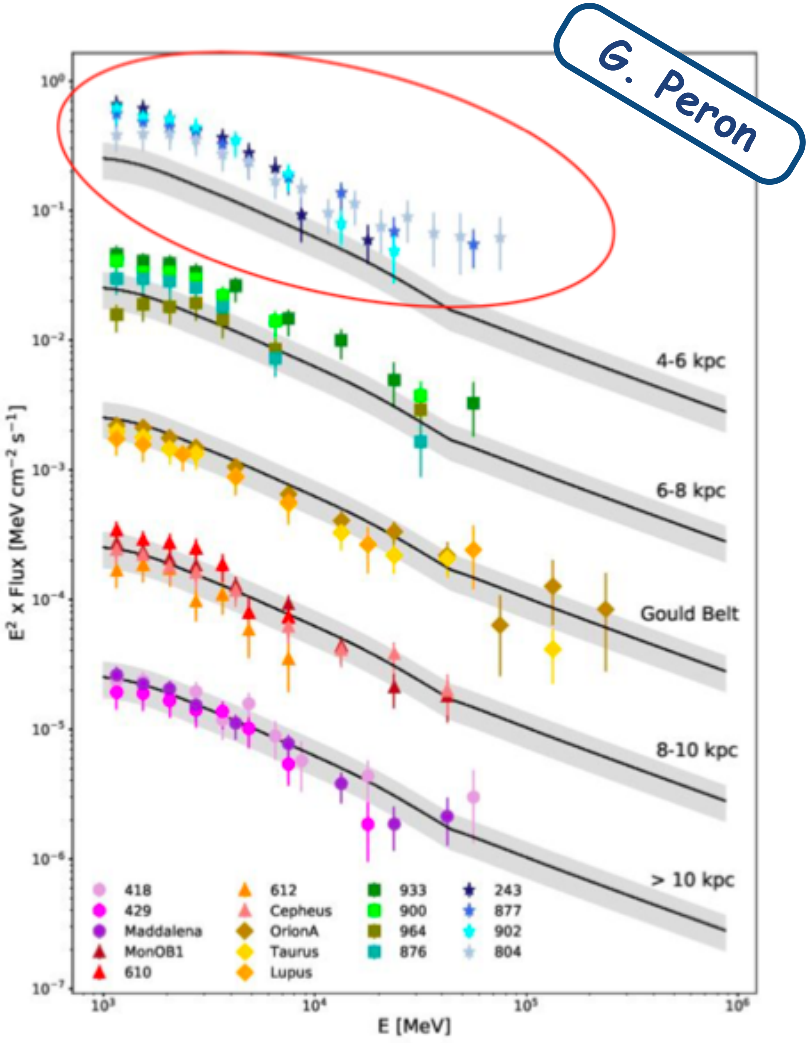
Shared CRD-GAD-GAI

- Does the Cosmic Ray spectrum harden towards the Galactic Centre?
- What is the contribution of unresolved sources to measurements of Galactic diffuse emission?
- Can gamma-ray and neutrino observations help clarify the situation?

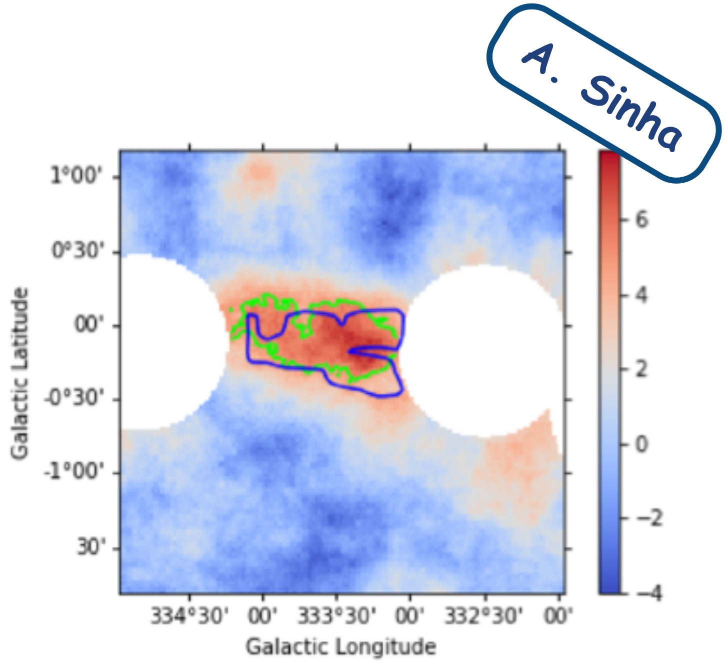
- Is there a barrier that suppresses particles of the cosmic ray sea from penetrating the central molecular zone?



Enhanced gamma-ray emission from molecular clouds?



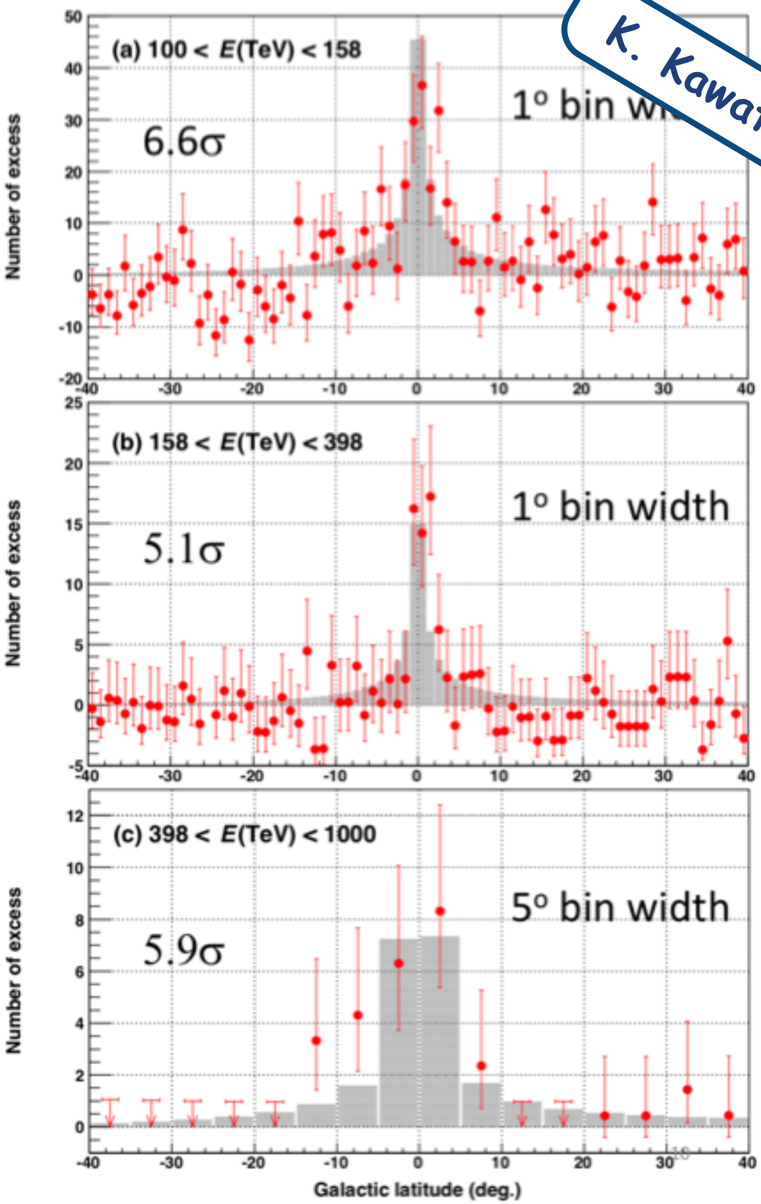
- Analysis of passive Giant Molecular Clouds provide information on local CR spectrum far from Earth
  - Deviations from local emissivity in inner Galaxy at 4-6 kpc
- Candidate cloud 877 shows GeV excess



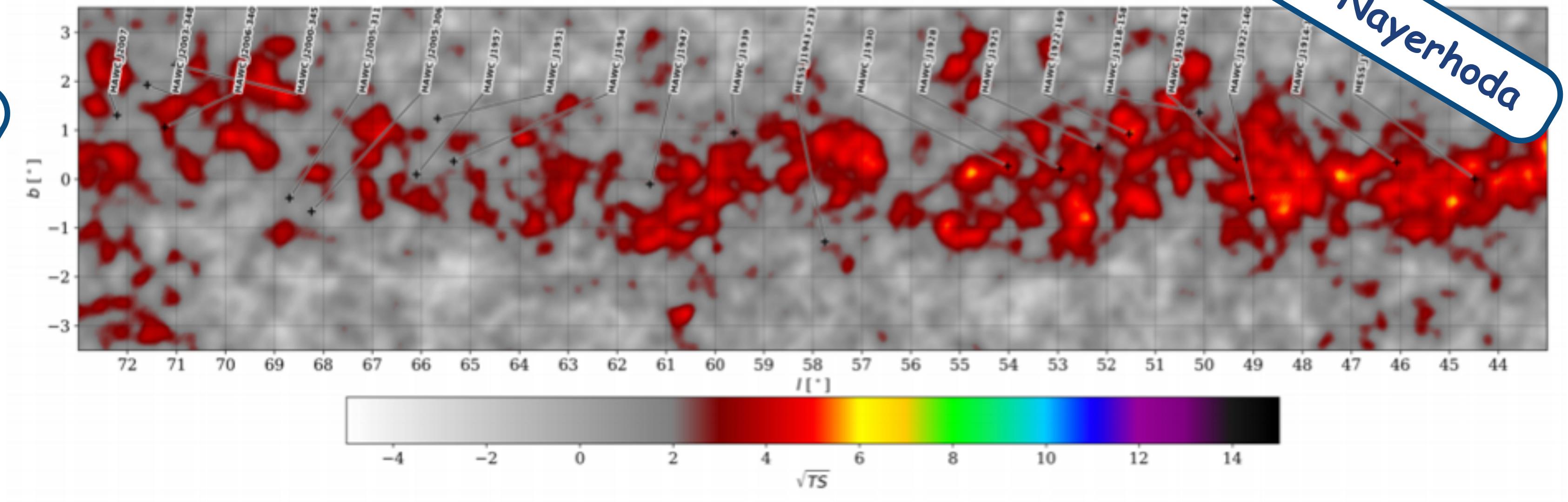
H.E.S.S. cloud “877”

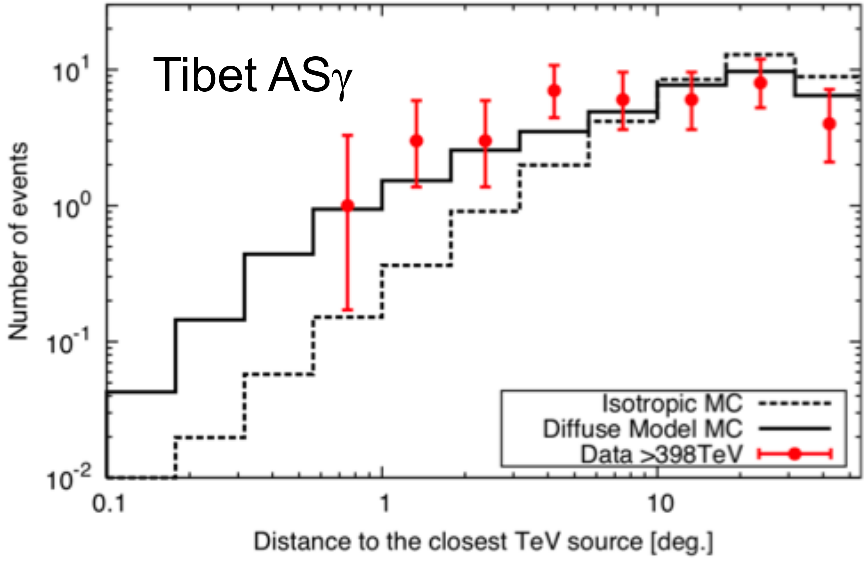
sub-PeV Galactic Diffuse Emission

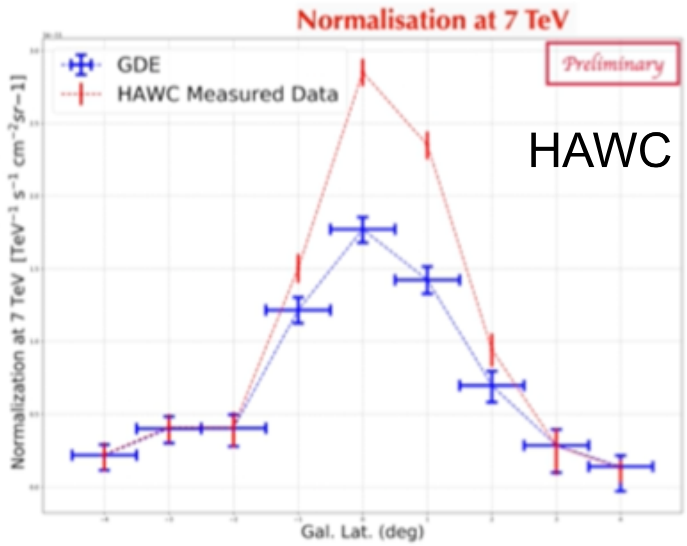
K. Kawata



A. Nayerhoda



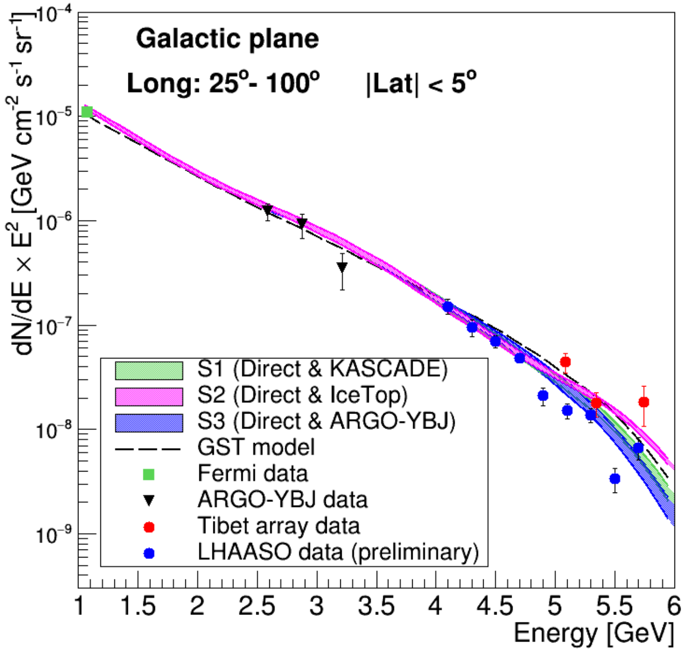




Galactic Diffuse Emission – explained?

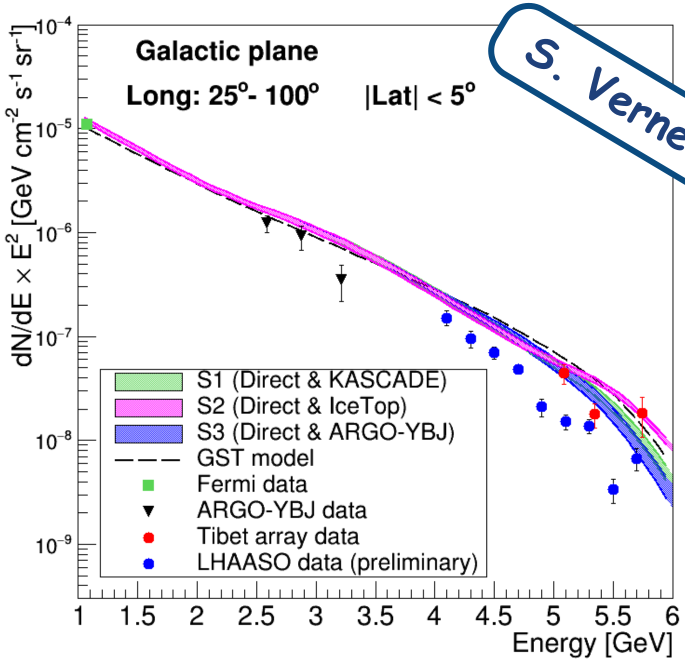
CR model M1

Same spectra in all Galaxy



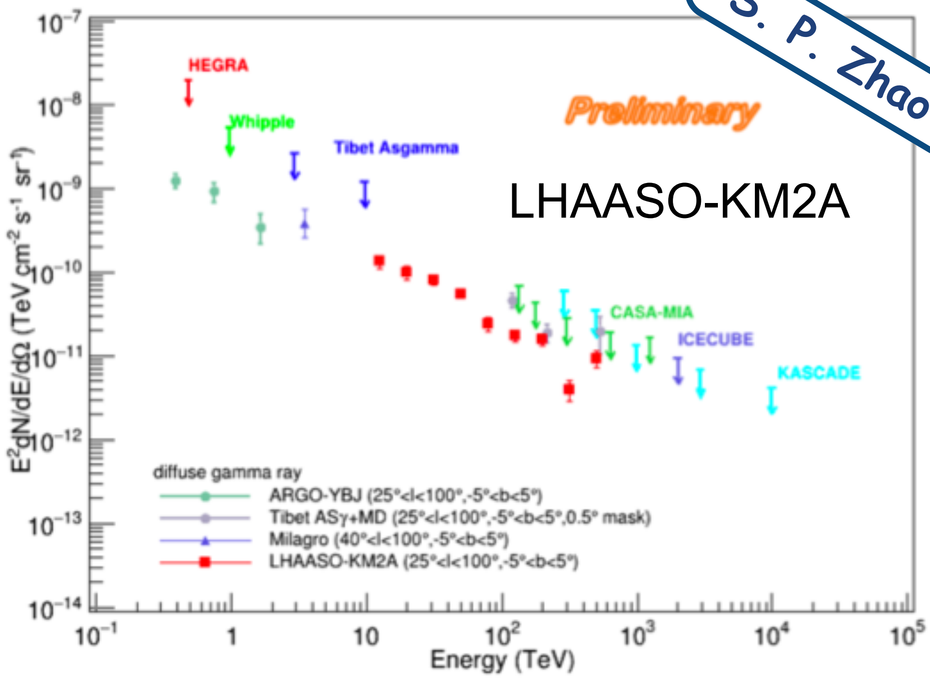
CR model M2

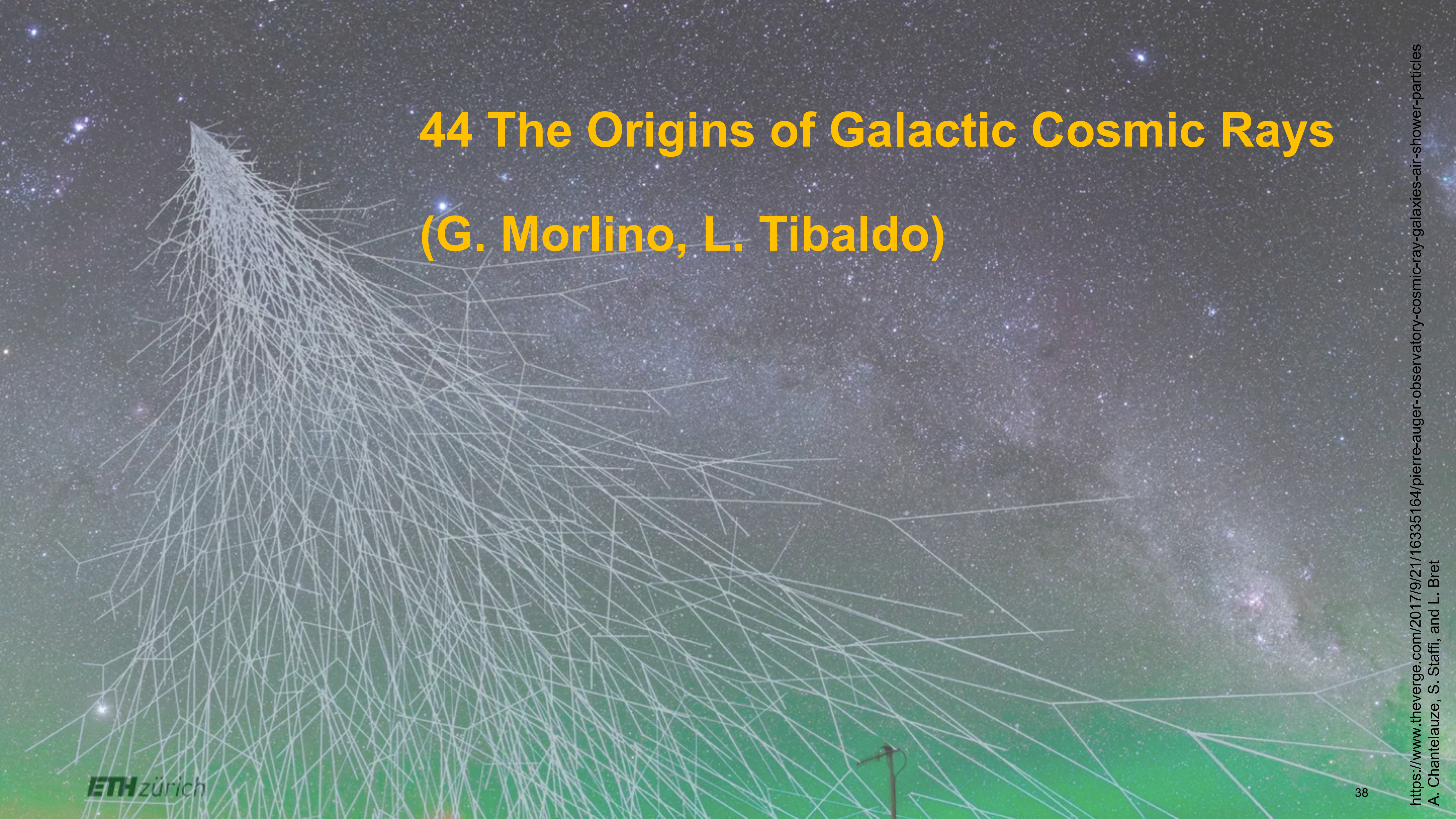
Hardening towards Galactic center



S. Vernetto

S. P. Zhao





44 The Origins of Galactic Cosmic Rays

(G. Morlino, L. Tibaldo)

https://www.theverge.com/2017/9/21/16335164/pierre-auger-observatory-cosmic-ray-galaxies-air-shower-particles
A. Chantelauze, S. Staffi, and L. Bret

Shared CRD-GAD-GAI

The path to become a Cosmic Ray

Acceleration inside sources
- Acceleration
- Injection

Escape from sources
- Energy losses *inside* and *around* the sources

Propagation across the Galaxy
- Escape from the Galaxy
- Energy losses
- Fragmentation

$$f_{acc} \neq f_{inj} \neq f_{Gal}$$

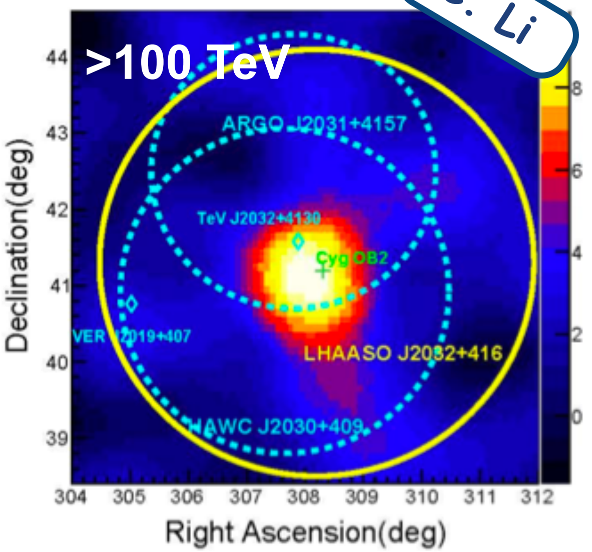
Potential CR Sources

	Power	Chemical composition	Spectrum: Single source	Spectrum: Total	Maximum Energy: Observed	Maximum Energy: Theoretical
SNRs	Yes	OK but few anomalies (^{22}Ne)	If hadronic $E^{-2} \div E^{-2.7}$	probably OK (but depends on escape)	$\lesssim$ 100 TeV	PeV only for rare and powerful events
Stellar winds/ clusters	Yes	Could probably solve the ^{22}Ne anomaly	$\sim E^{-2.2}$	Unclear	$\lesssim$ 100 TeV*	PeV only for very powerful clusters
Super bubbles	?	Unsure	probably $\sim E^{-2.2}$	Unclear	?	PeV if diffusion coefficient is small enough
Proto-stars**	No	Unsure	?	?	?	~0.1 TeV
NS mergers	?	Maybe relevant for ultra heavy elements	?	?	?	?

Cygnus Superbubble

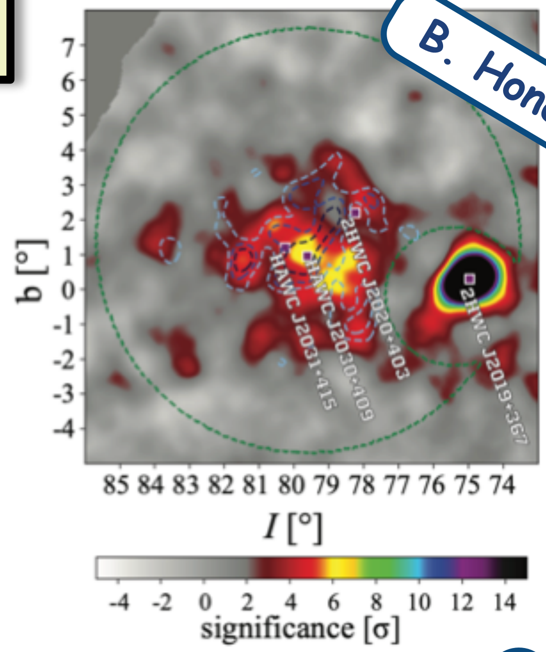
LHAASO

C. Li



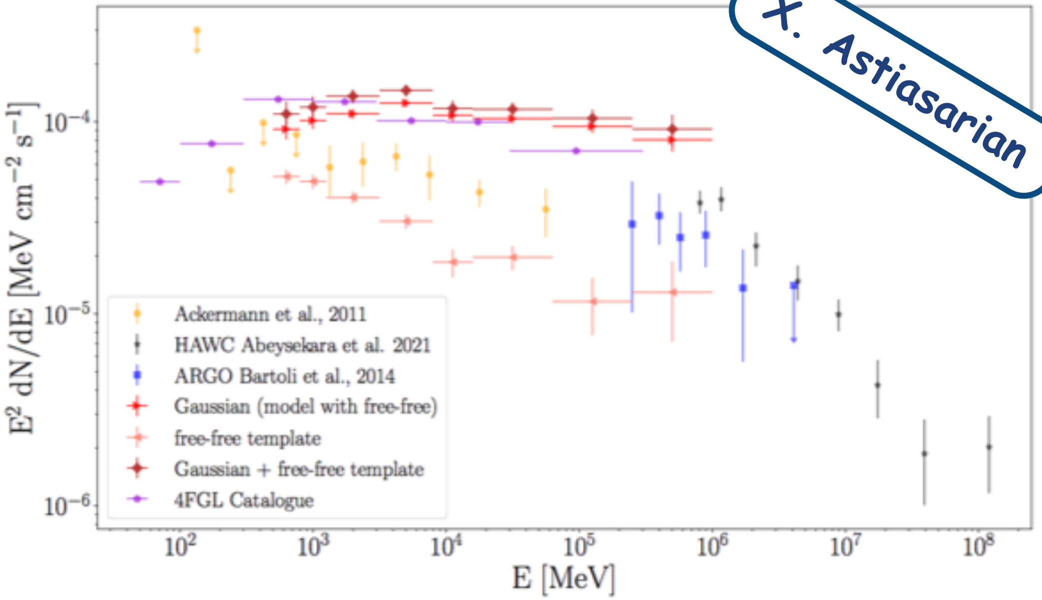
HAWC

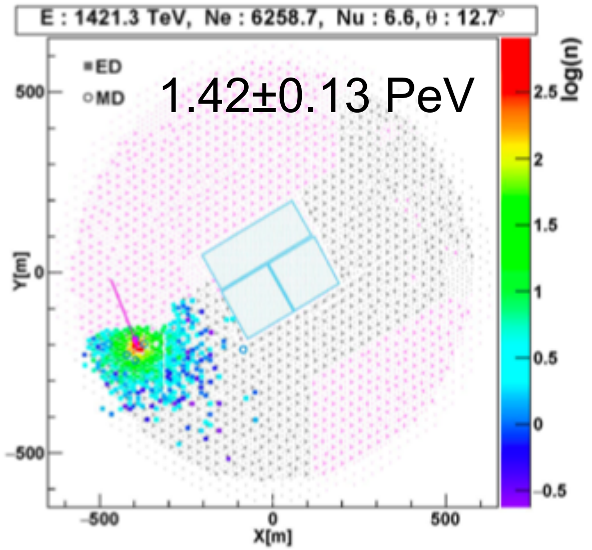
B. Hona



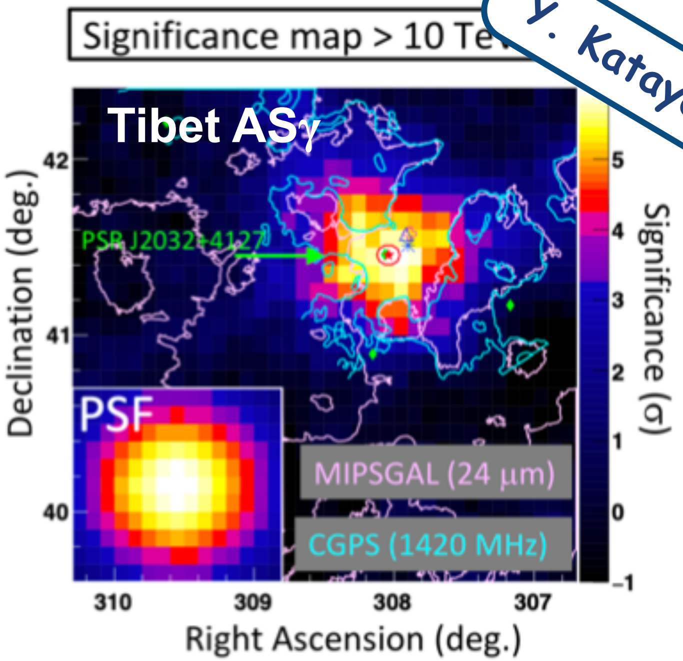
12 years Fermi-LAT

X. Astiasarian

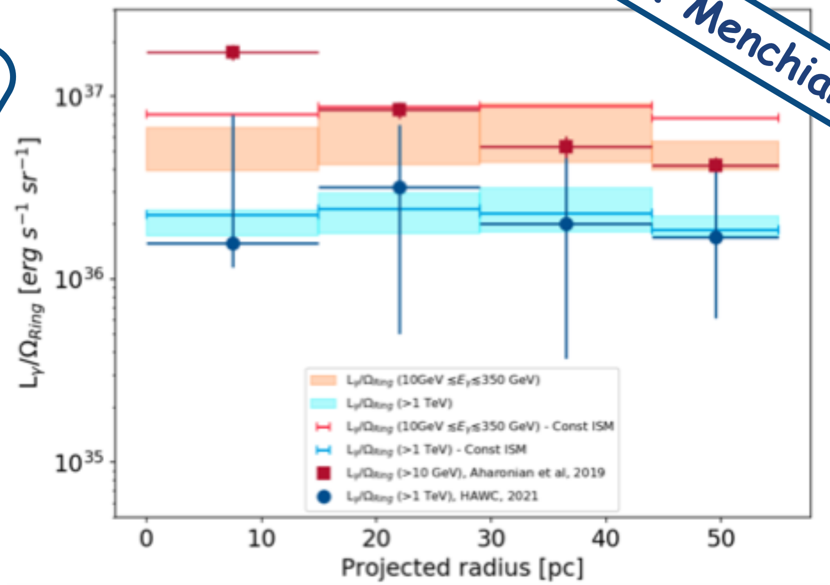




Y. Katayose



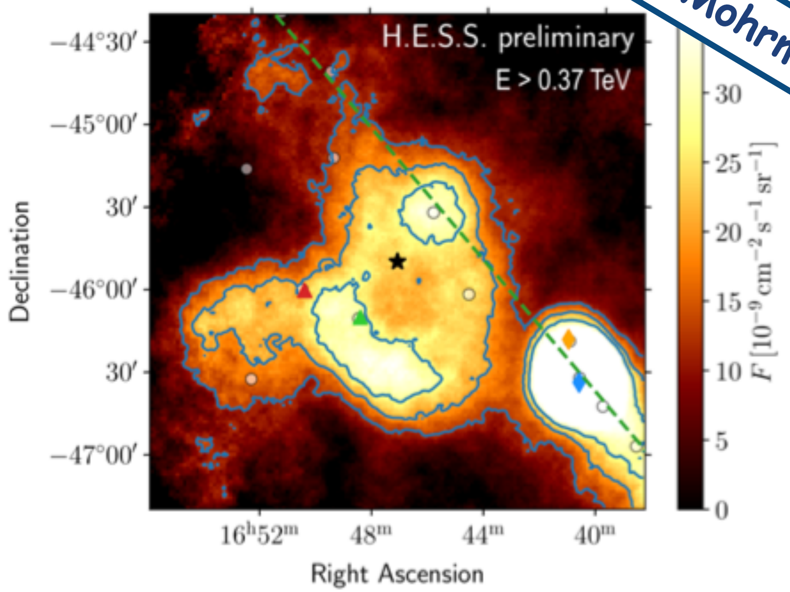
S. Menchiari

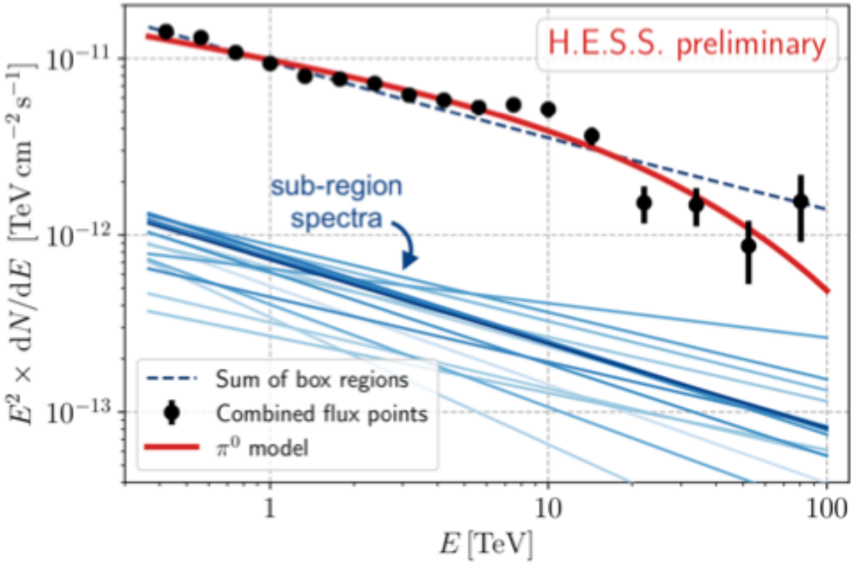


Stellar Clusters

Westerlund 1 with H.E.S.S.

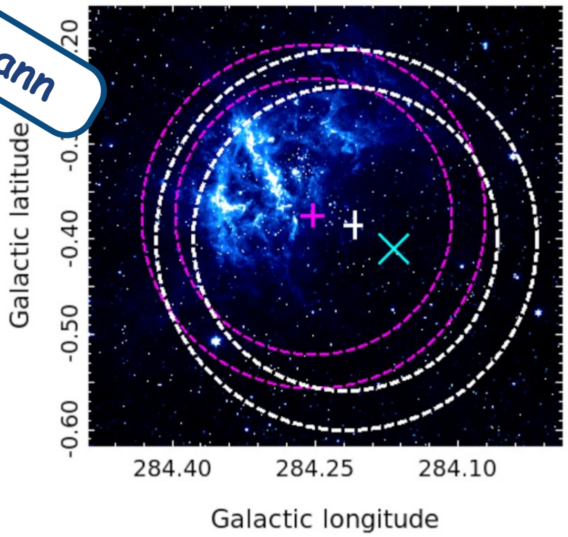
L. Mohrmann

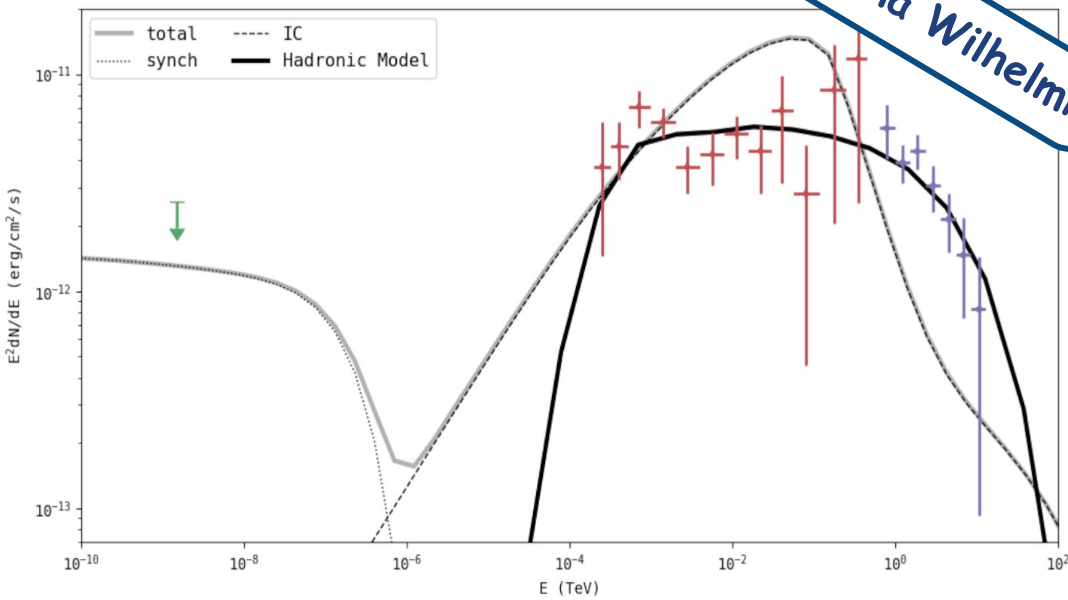


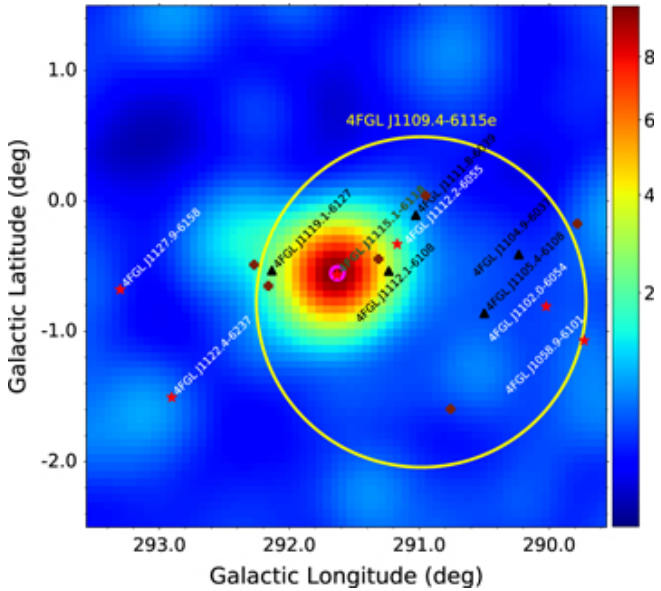


Westerlund 2 with Fermi-LAT

E. de Oña Wilhelmi

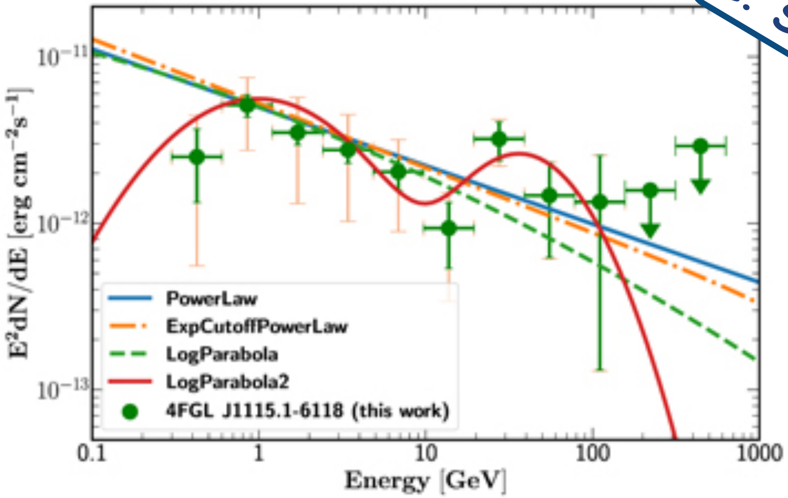






NGC 3603 with Fermi-LAT

L. Saha



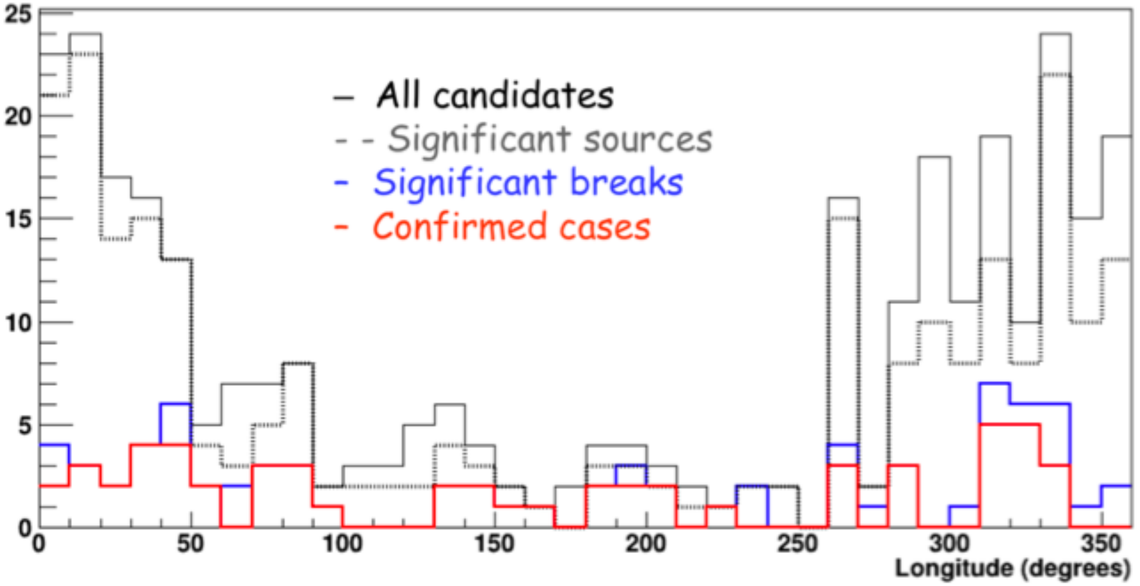
Session 44 summary

- Observations indicate to multiple source classes contribute to Galactic Cosmic Rays
- Star forming regions (SFRs) are promising – in terms of composition and maximum energy (> PeV)

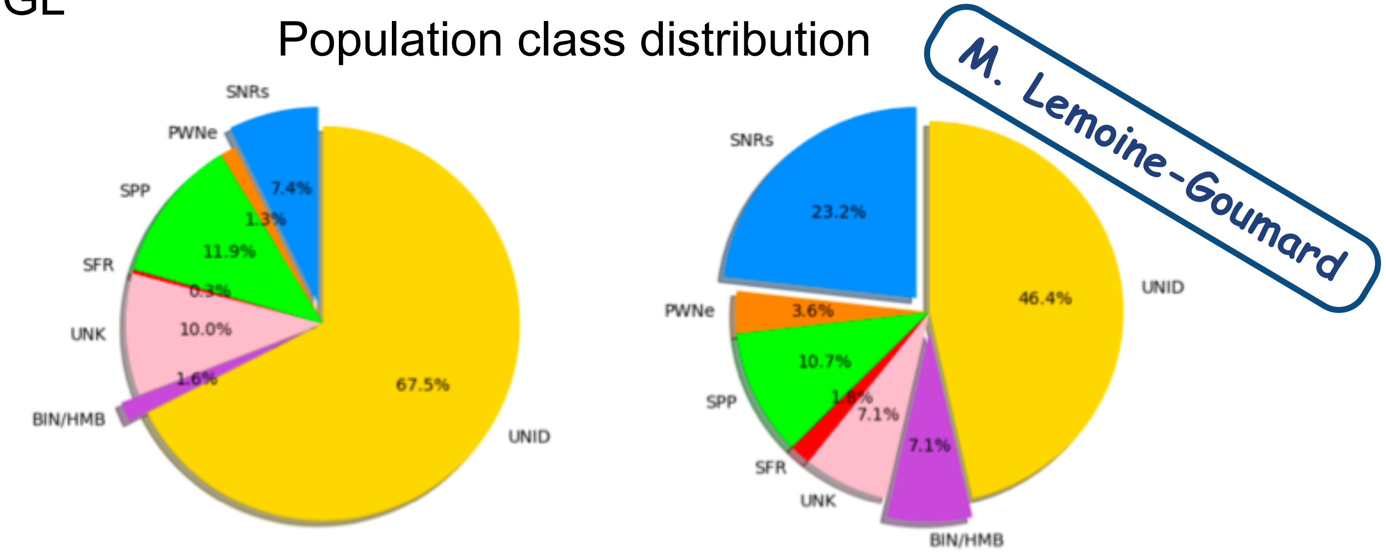
Still need to clarify:

- Observational tests – by how much do different source class contribute to the total?
- Are superbubbles more than the sum of their parts? (collection of individual SNRs & stellar clusters)

Blind search for pion-bump feature with Fermi-LAT 4FGL



Population class distribution



311 sources analysed

56 candidates detected

ETH zürich

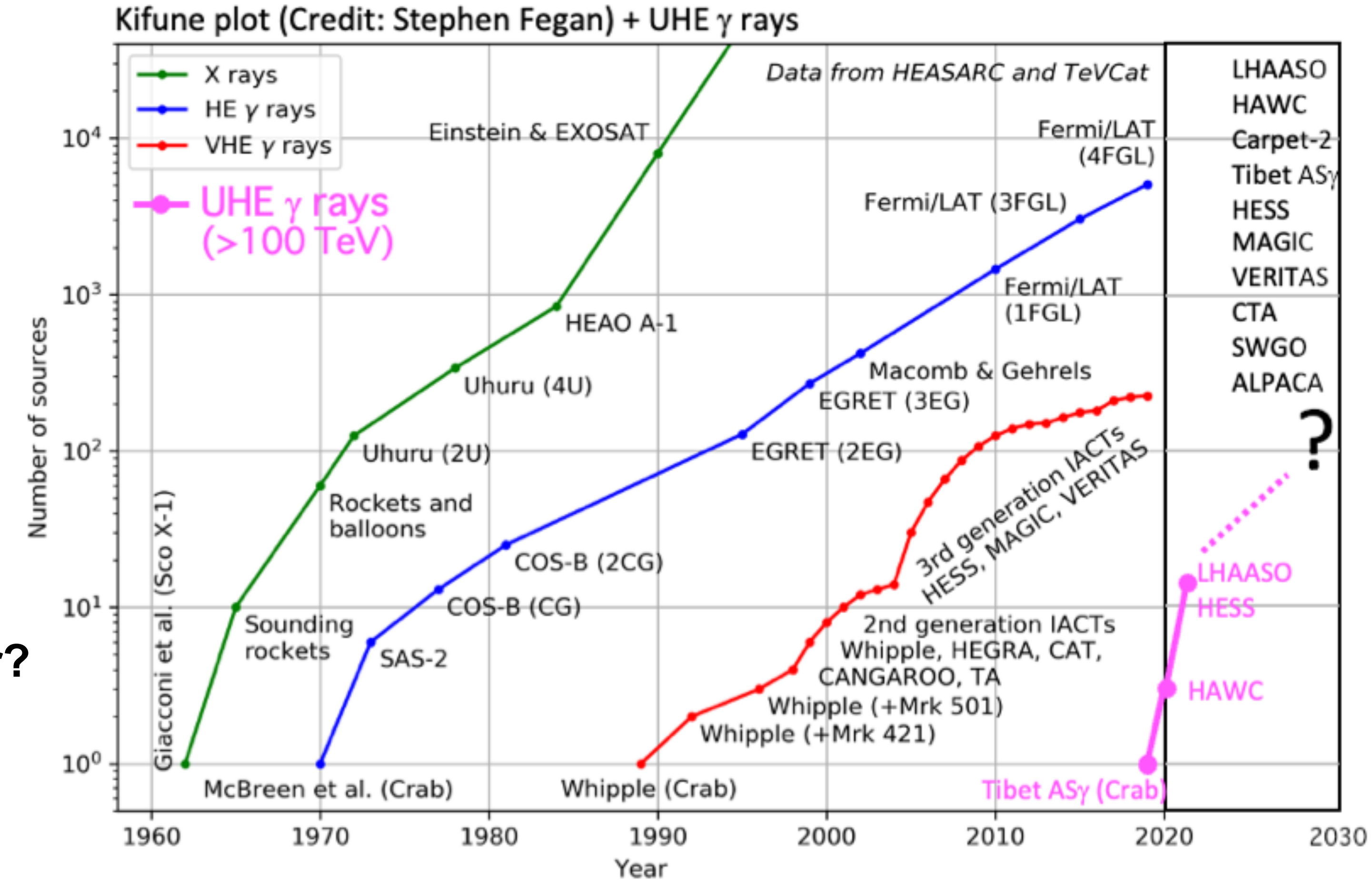
55 Ultra-High-Energy Gamma-Ray Sources and PeVatrons

(E. de la Fuente, K. Kawata)

https://www.theverge.com/2017/9/21/16335164/pierre-auger-observatory-cosmic-ray-galaxies-air-shower-particles
A. Chantelauze, S. Staffi, and L. Bret

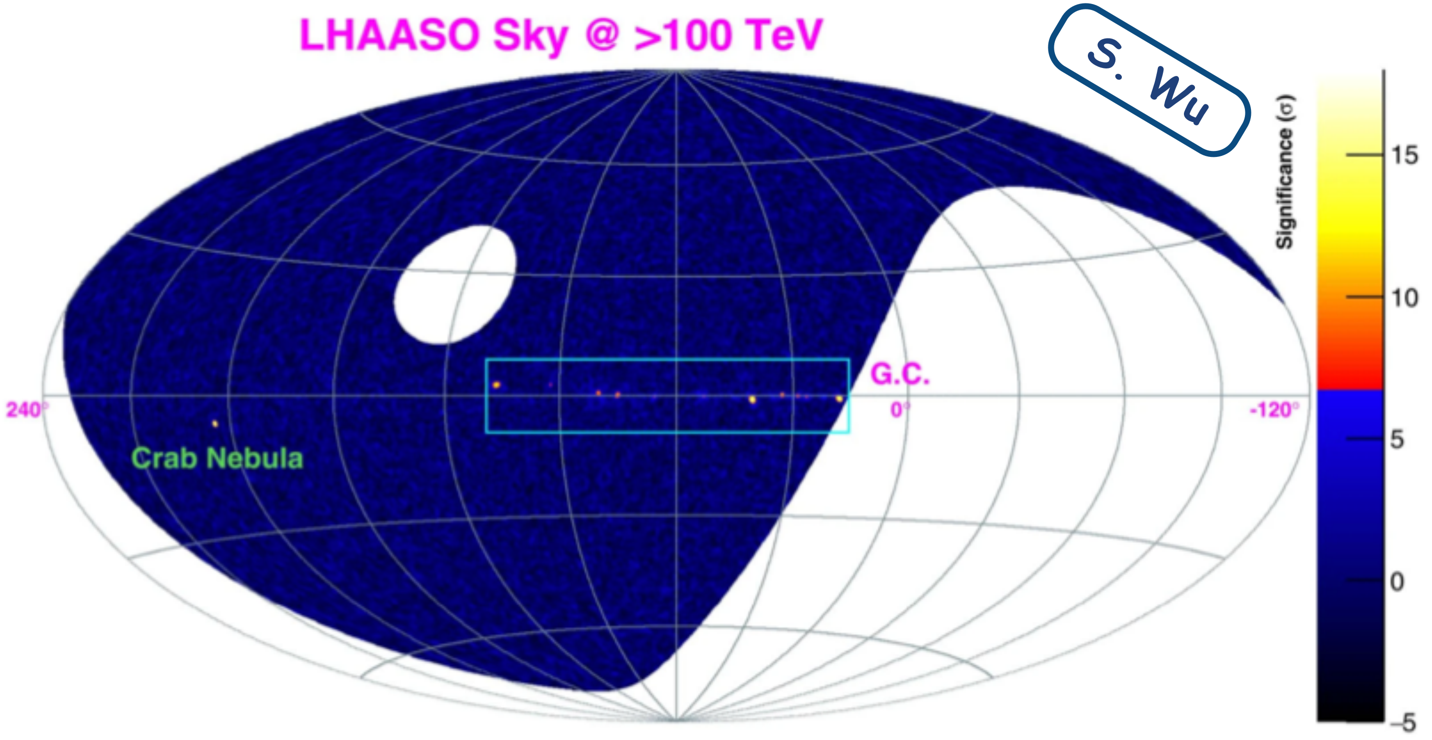
Key Questions

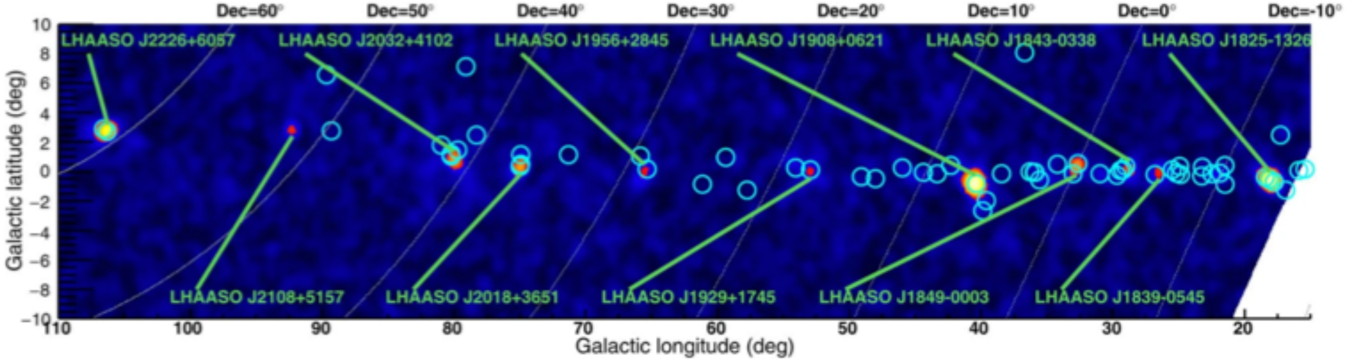
- **What is a PeVatron?**
  - Only hadronic accelerators?
  - "Leptonic PeVatrons"?
- **When is it no longer a candidate?**
  - Clear accelerator (not *just* cloud)
  - Confirmed hadronic
  - Coincident neutrino
- **How many PeVatrons do we know so far?**
  - 14 UHE sources (gamma-rays > ~100 TeV)



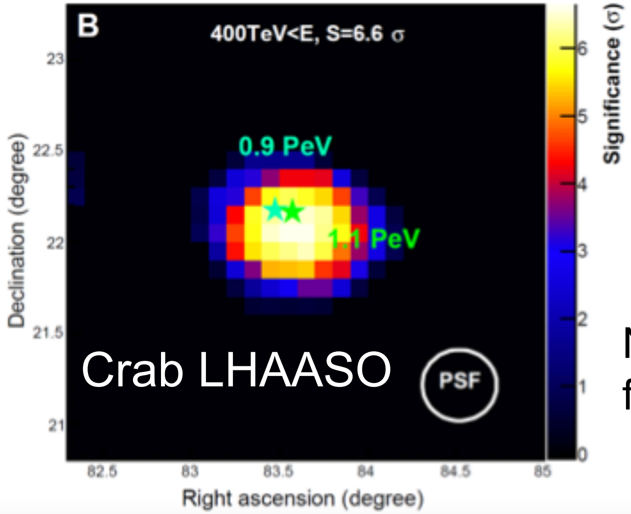
LHAASO Ultra-high-energy photons from 12 Galactic Sources

S. Wu

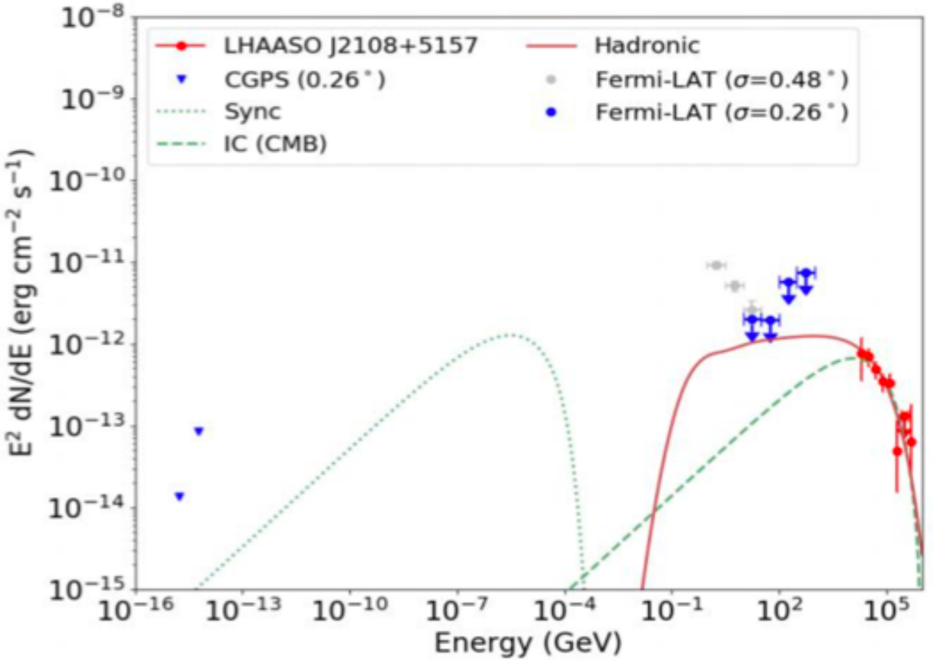




L. Wang



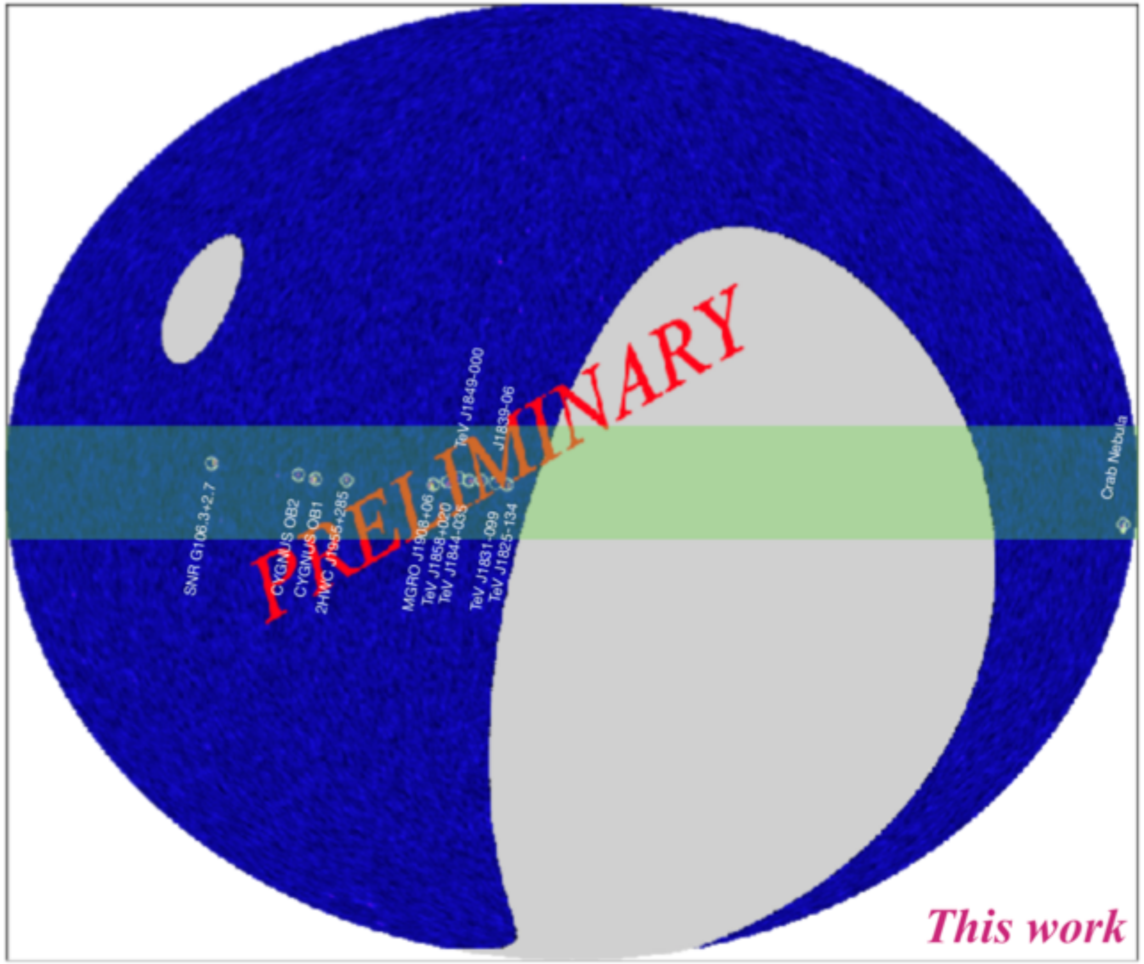
No UHE flares seen



Detection by Tibet ASγ of 12 VHE sources → this ICRC

- ~9 coincident with LHAASO UHE sources

X. Chen

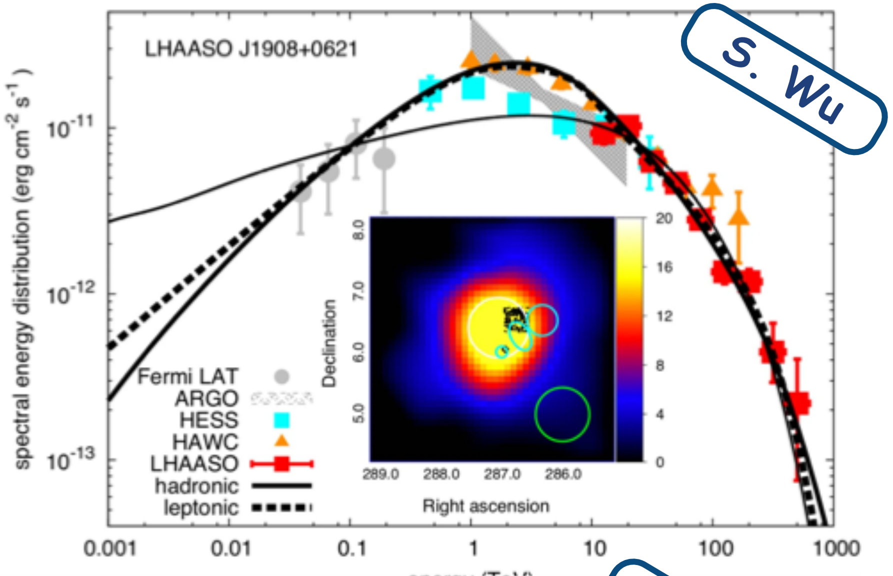


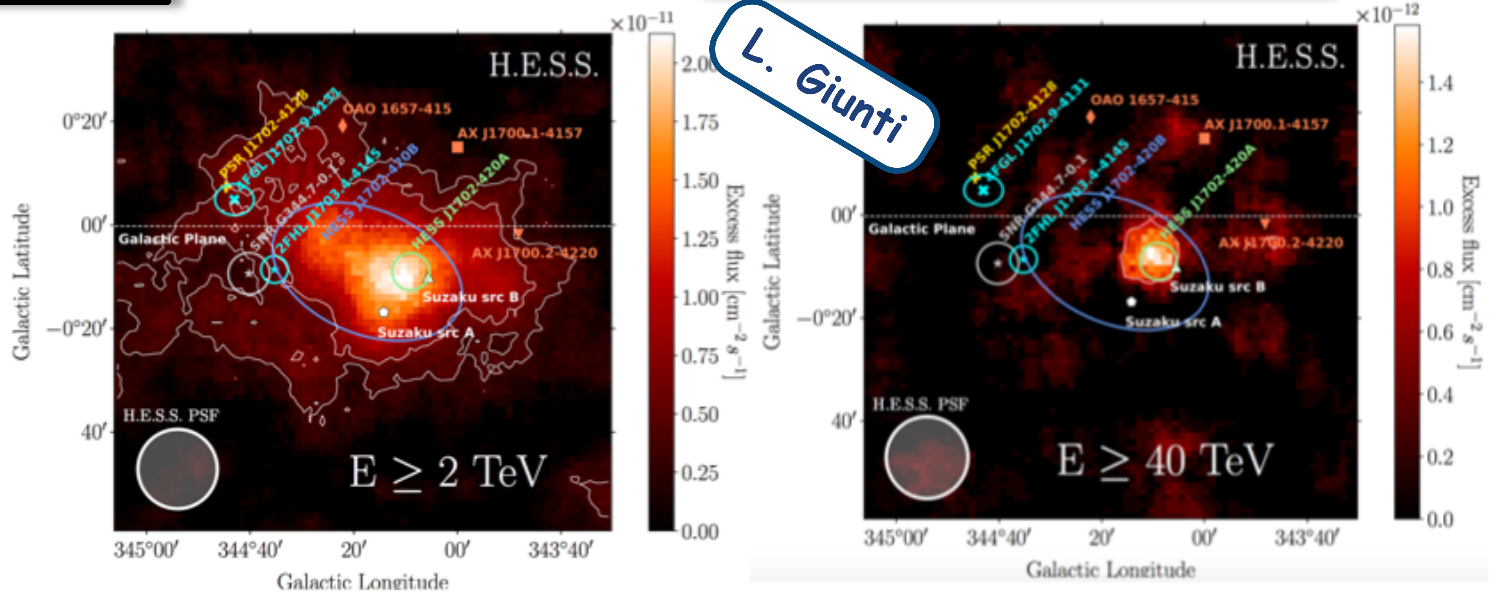
Associated Source	RA[deg]	Dec[Deg]
Crab	83.65	22.02
TeV J1825-134	276.52	-13.4
TeV J1831-099	277.58	-9.84
TeV J1840-055 TeV J1837-065	279.91	-6.03
TeV J1844-035	280.92	-3.58
TeV J1849-000	282.84	0.03
TeV J1857+026	284.70	2.66
MGRO J1908+06	287.01	6.20
2HWC J1955+285	298.87	28.63
Cygnus OB1	305.02	36.77
Cygnus OB2	308.01	41.19
SNR G106.3+2.7	336.77	60.88

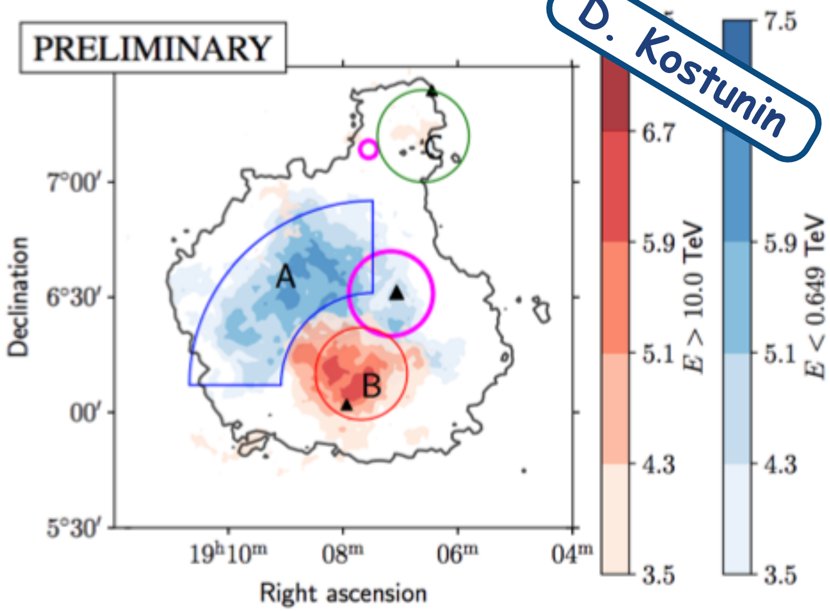
This work

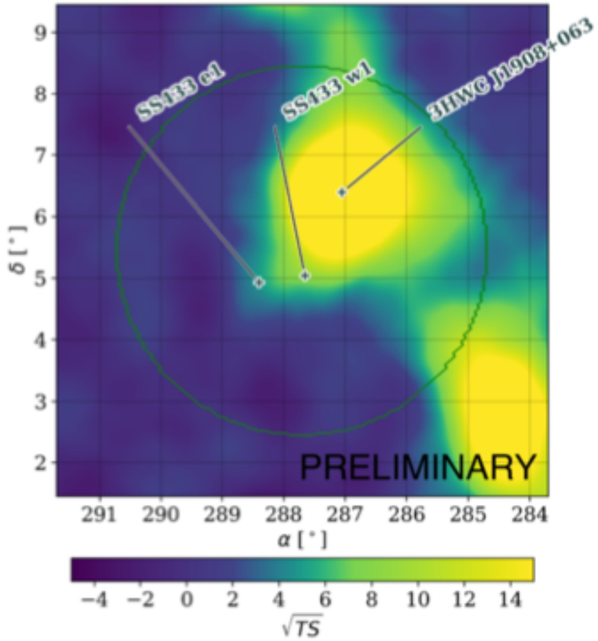
J1908+06: LHAASO, HESS, HAWC

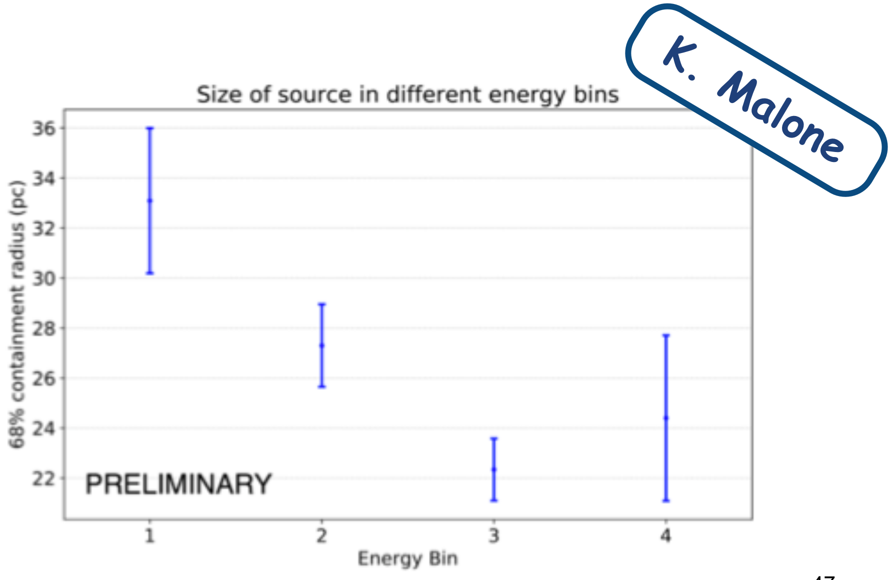
HESS J1702-420



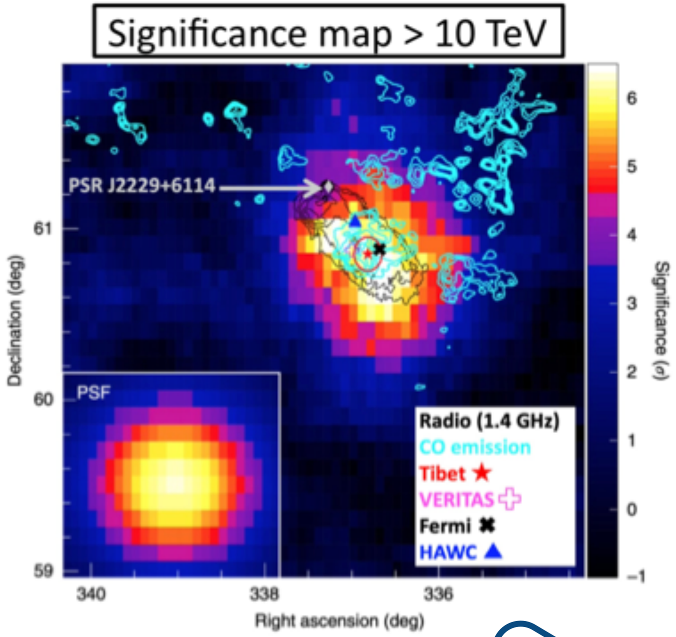




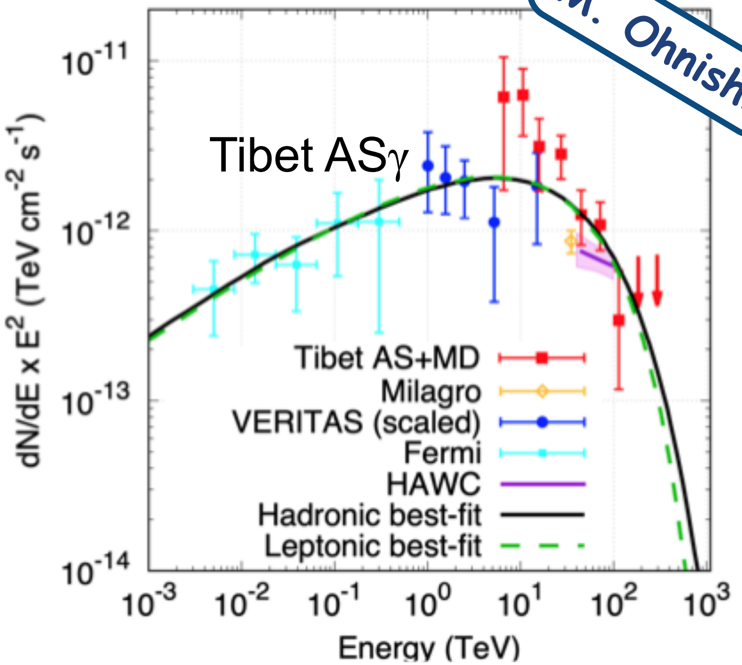




HAWC J2227+610 == SNR G106.3+2.7?

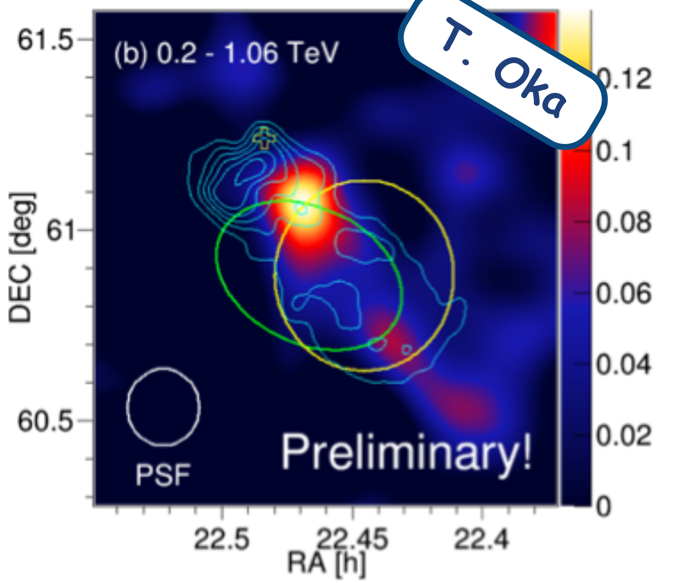


M. Ohnishi

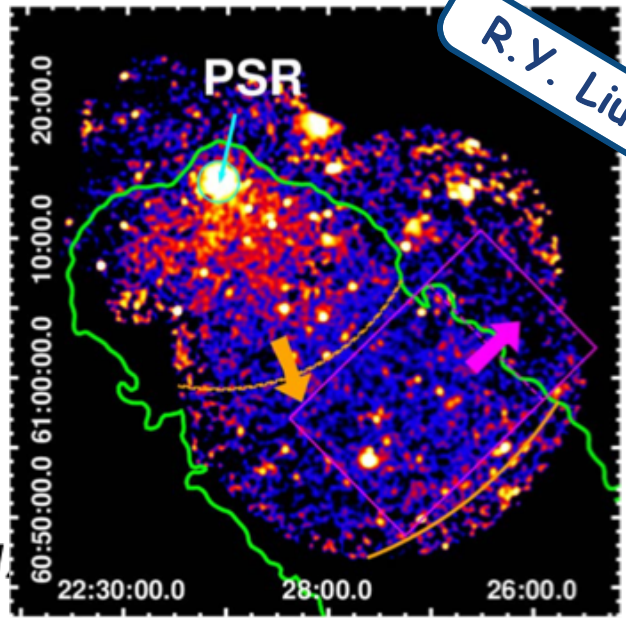


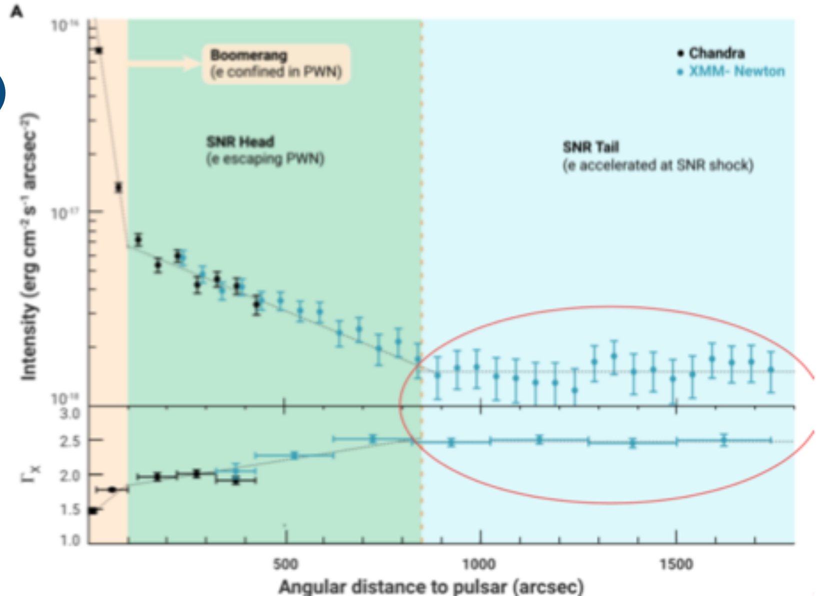
MAGIC

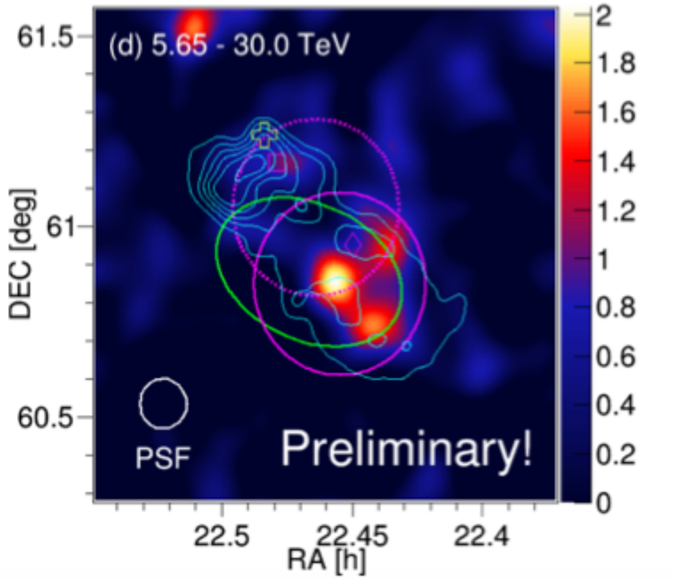
T. Oka



R.Y. Liu

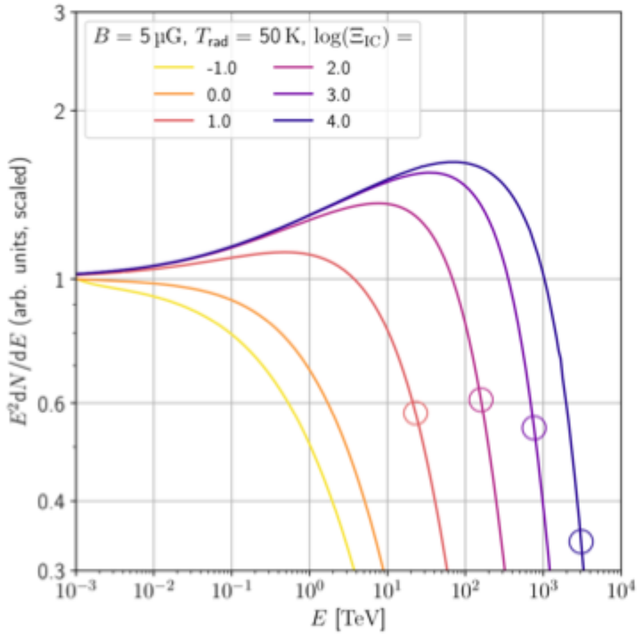


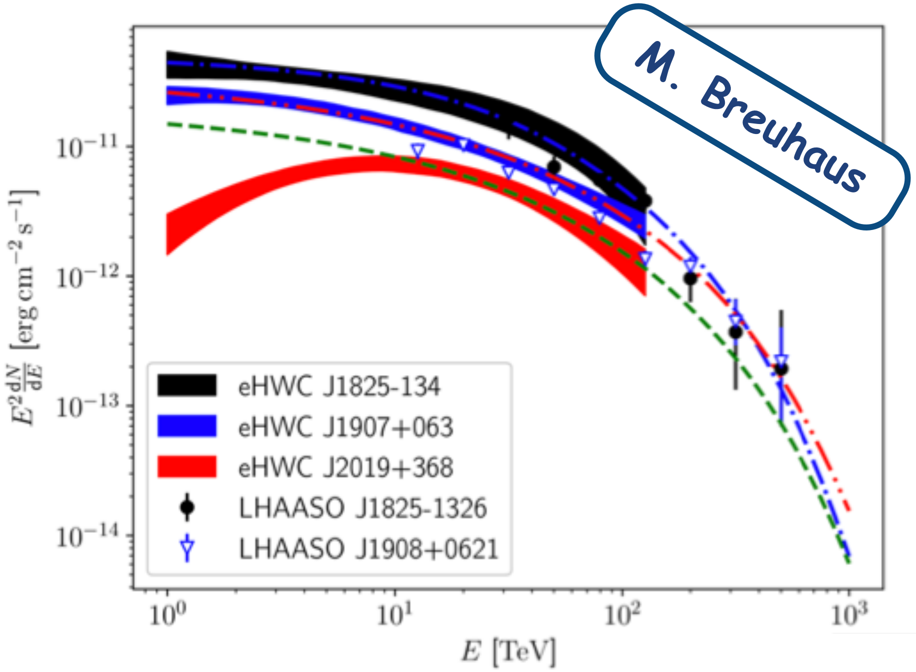


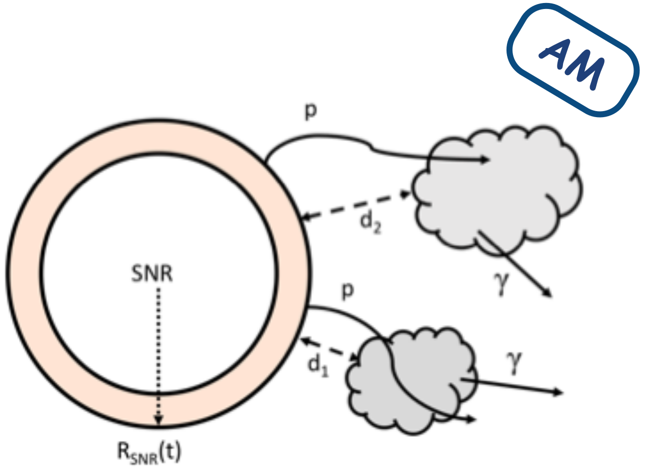


Origins of 100 TeV gamma-ray emission

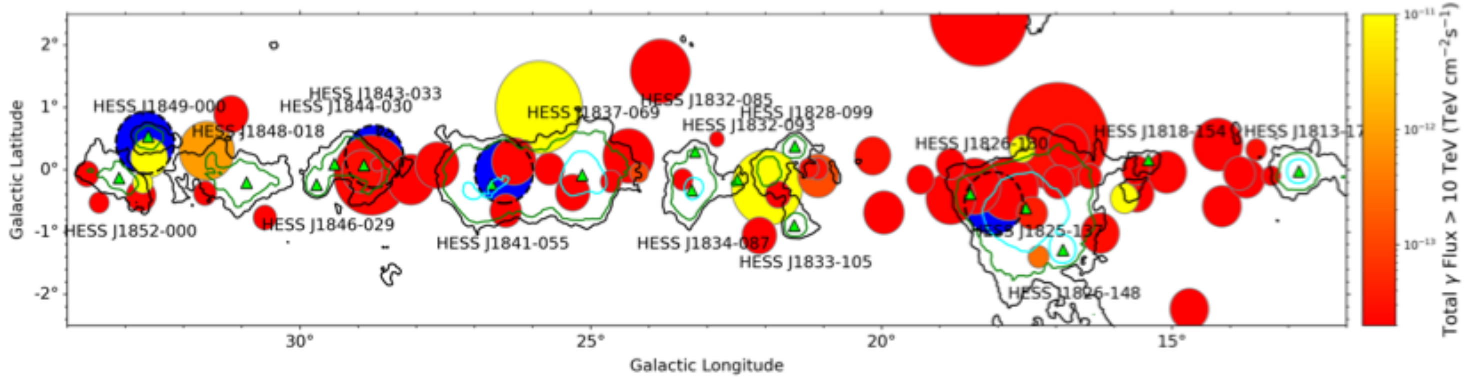
- Equilibrium spectra in radiation dominated environments → hard leptonic IC spectra to 100 TeV

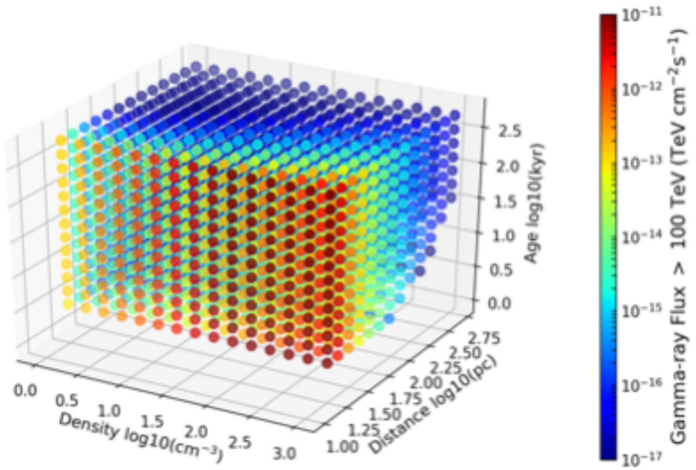






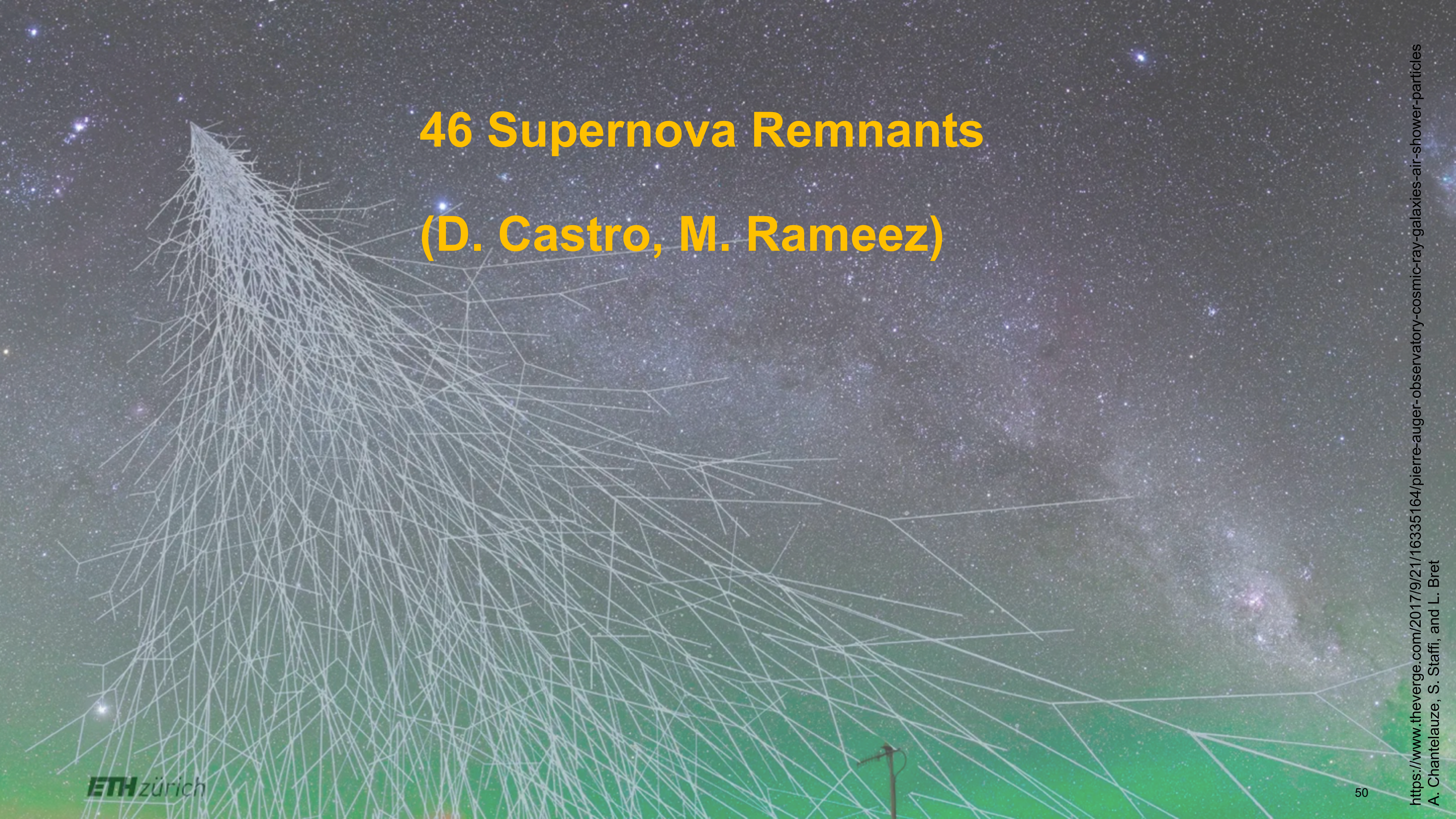
- CR escape from SNRs → illuminate nearby interstellar clouds





46 Supernova Remnants

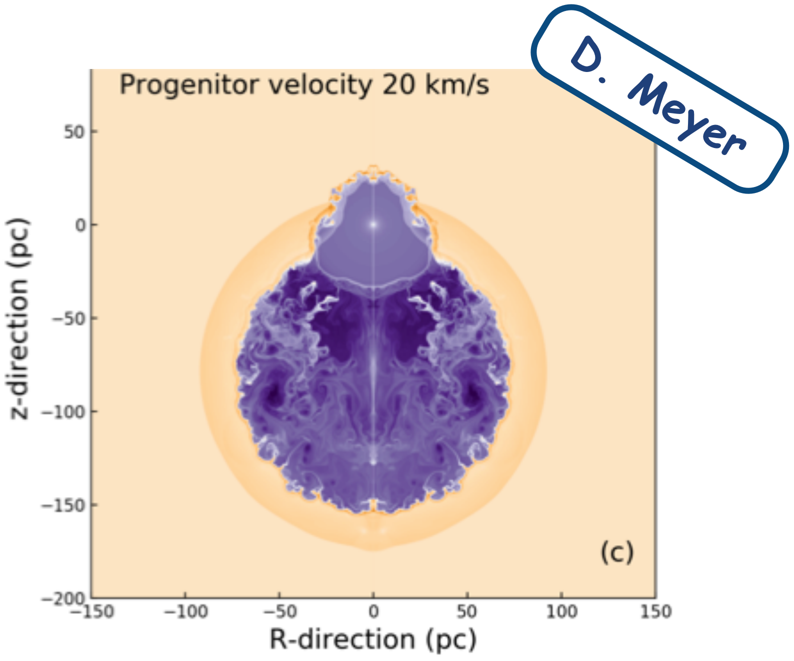
(D. Castro, M. Rameez)

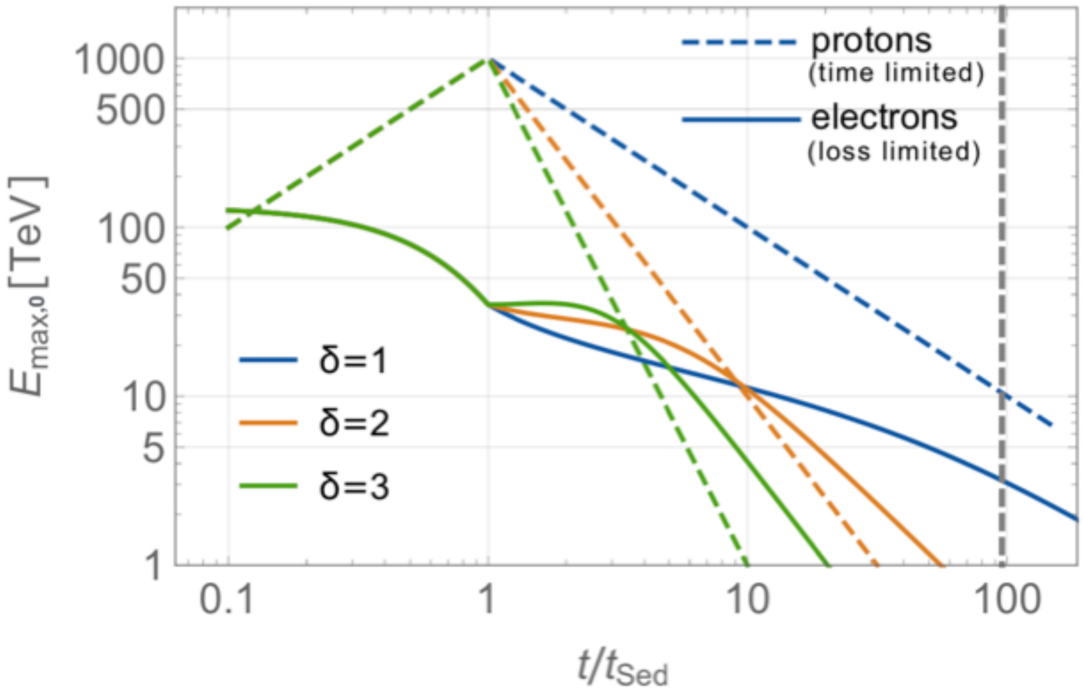


https://www.theverge.com/2017/9/21/16335164/pierre-auger-observatory-cosmic-ray-galaxies-air-shower-particles
A. Chantelauze, S. Staffi, and L. Bret

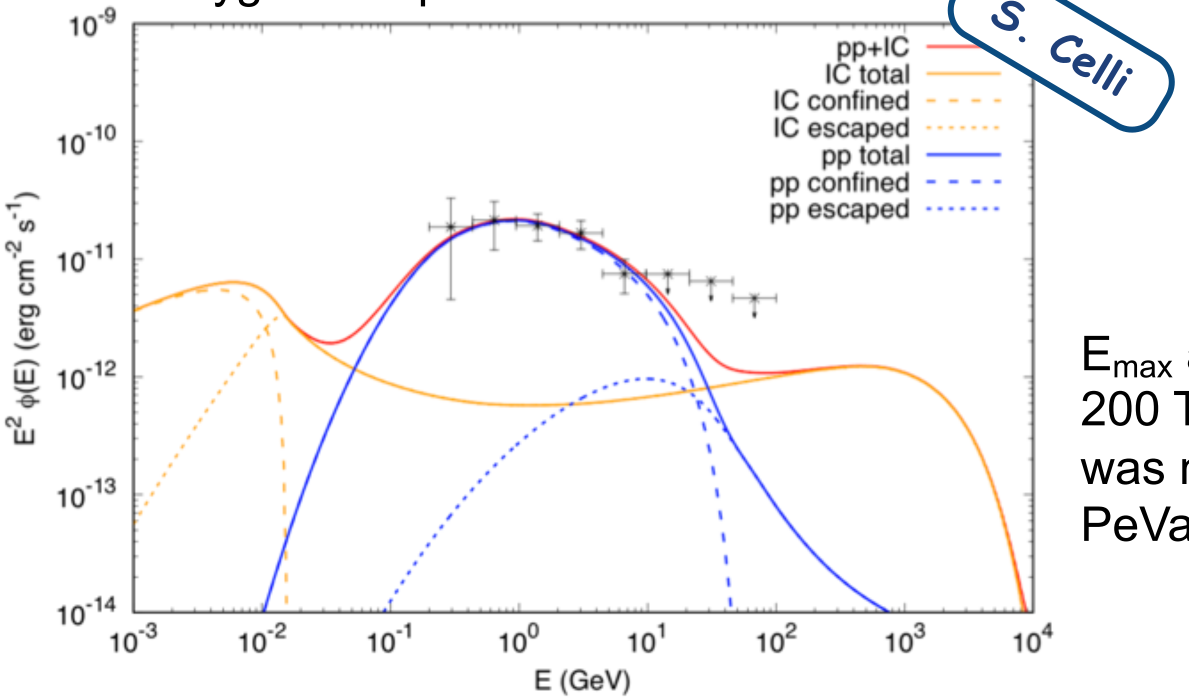
Key themes

- Shell morphologies (asymmetry)
- Circumstellar material / environment
- Particle escape and transport
- Shock interactions with clouds





Cygnus loop SNR



E_{max} at t_{Sed} of 200 TeV → was never a PeVatron!

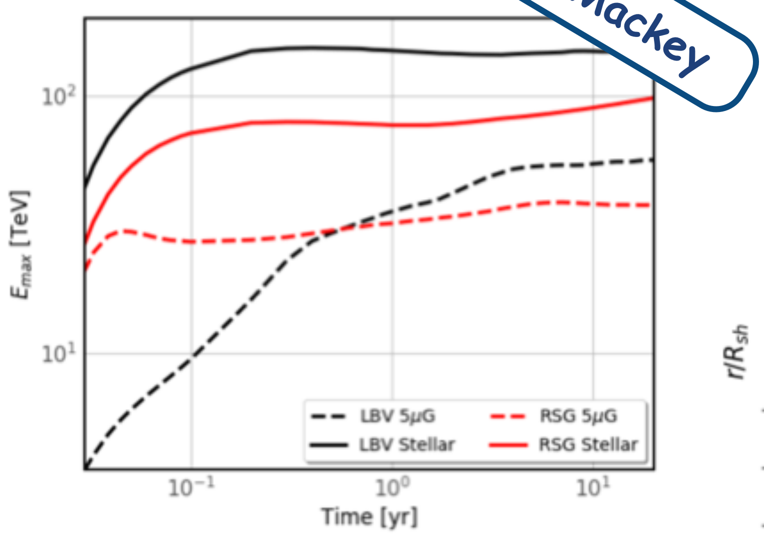
SNRs – theory

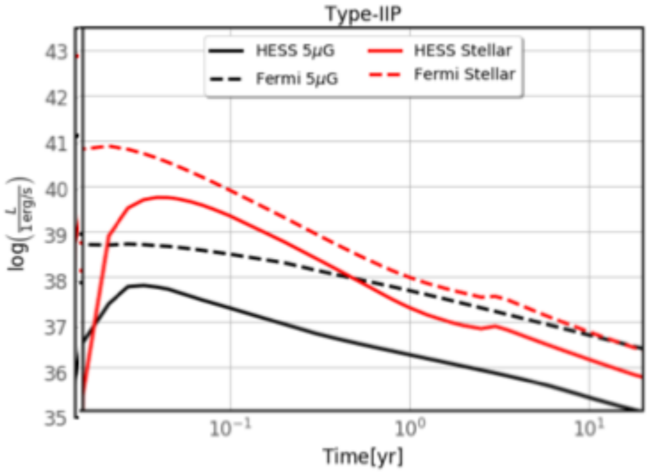
Powered by RATPAC

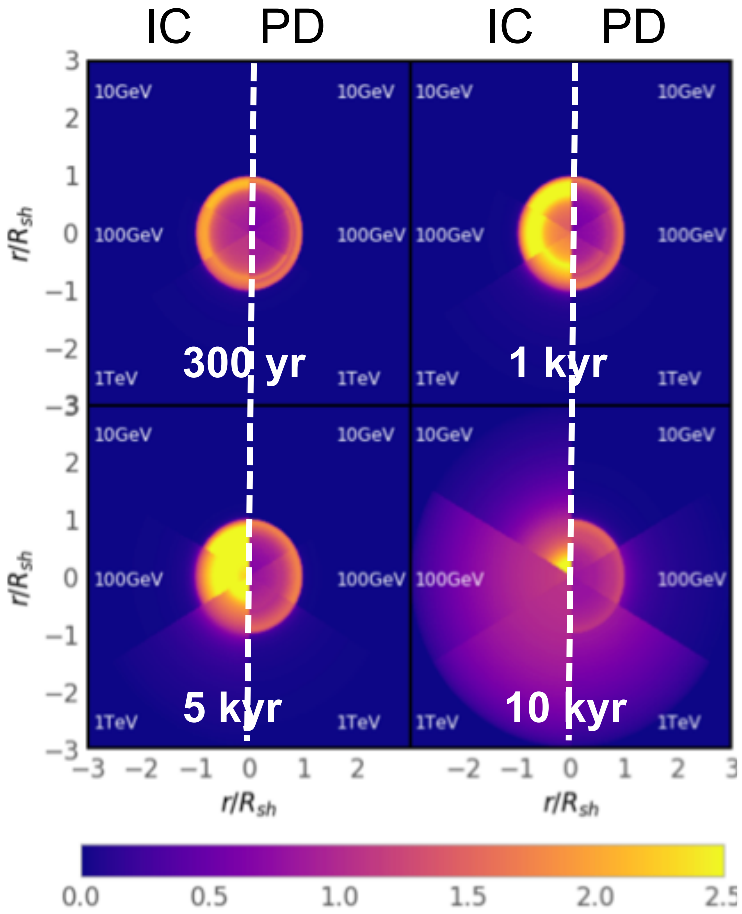
Radiation Acceleration Transport Parallel Code

J. Mackey

Type-II



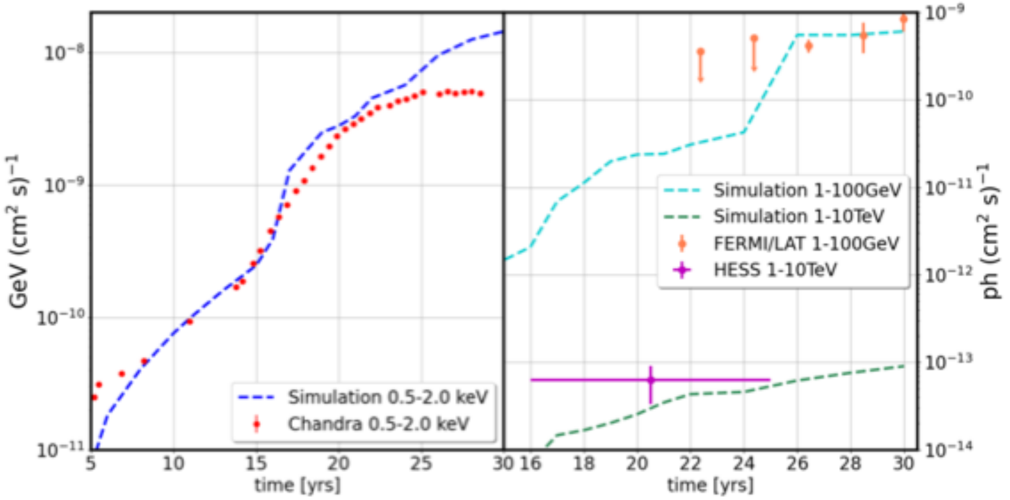




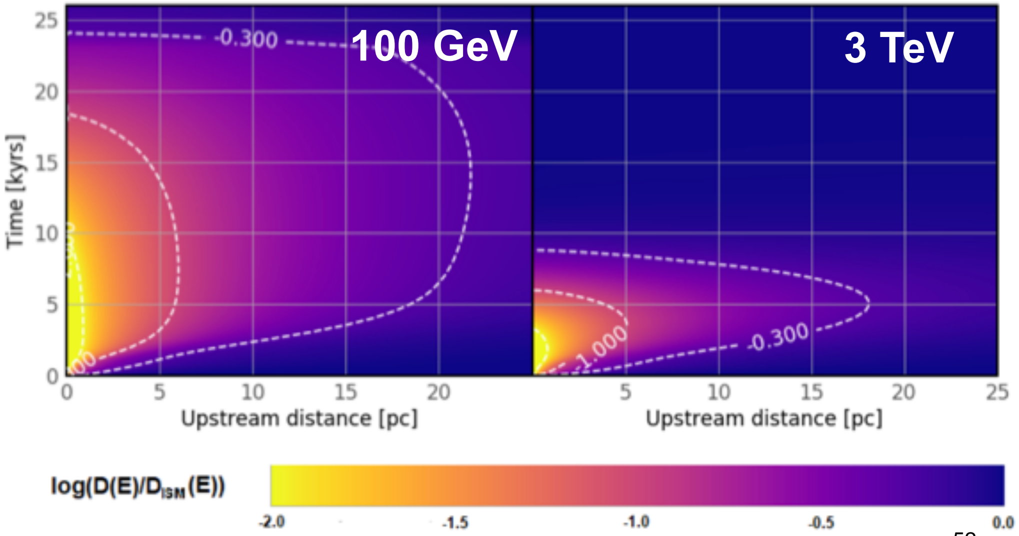
R. Brose

Type-IA

SNR 1987A flux increase



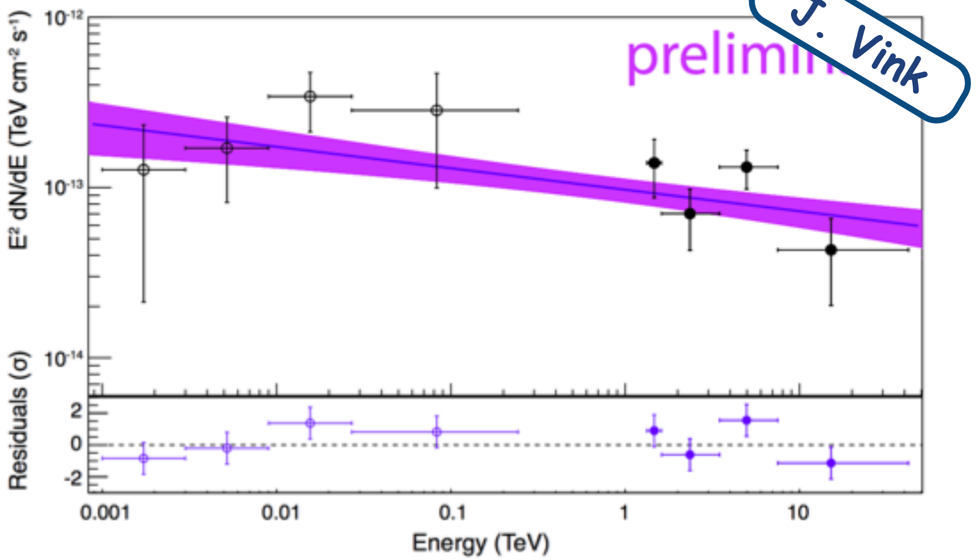
Suppressed diffusion around SNR



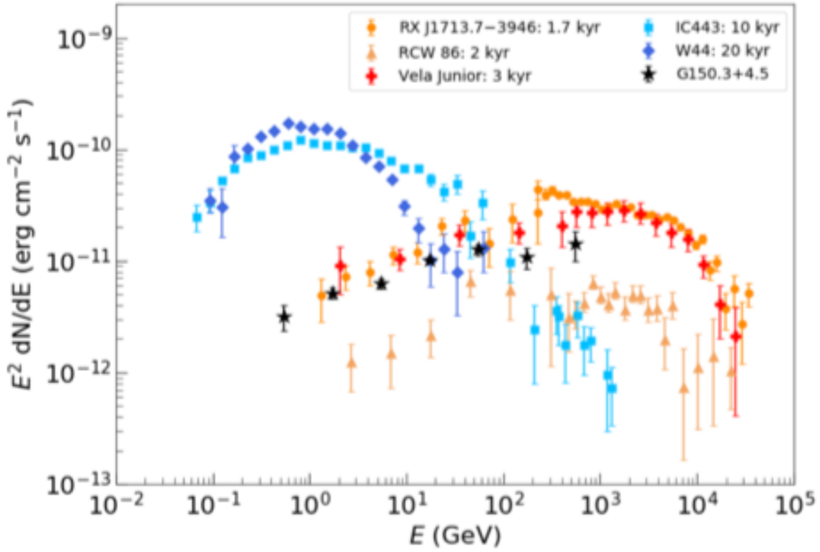
SNRs – Observation

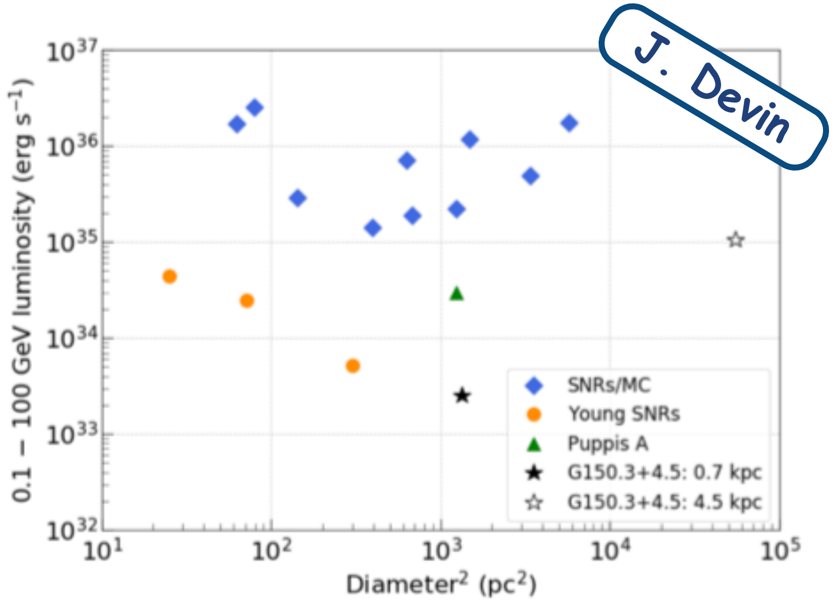
N132D in LMC with H.E.S.S.

~2500 yrs, young spectrum →



G150.3+4.5 with Fermi-LAT → VHE data needed!





G150.3+4.5 is **spectrally similar to the dynamically young and shell-type** SNRs

G150.3+4.5 has likely a **low luminosity** (no hint for an interaction with a molecular cloud)

- W44 – interacting SNR Studies of components
- Kepler SNR
- G39.2-0.3
- HESS J1614-518
- HESS J1858+020

L. Di Venere
G. Peron
D. Prokhorov
I. Sushch
X.-L. Guo
Y. Xin

53 PWN and Halos

(J. Hinton, B. Olmi)

https://www.theverge.com/2017/9/21/16335164/pierre-auger-observatory-cosmic-ray-galaxies-air-shower-particles
A. Chantelauze, S. Staffi, and L. Bret

Pulsar Wind Nebulae and Halos → What and why?

Simplified version!

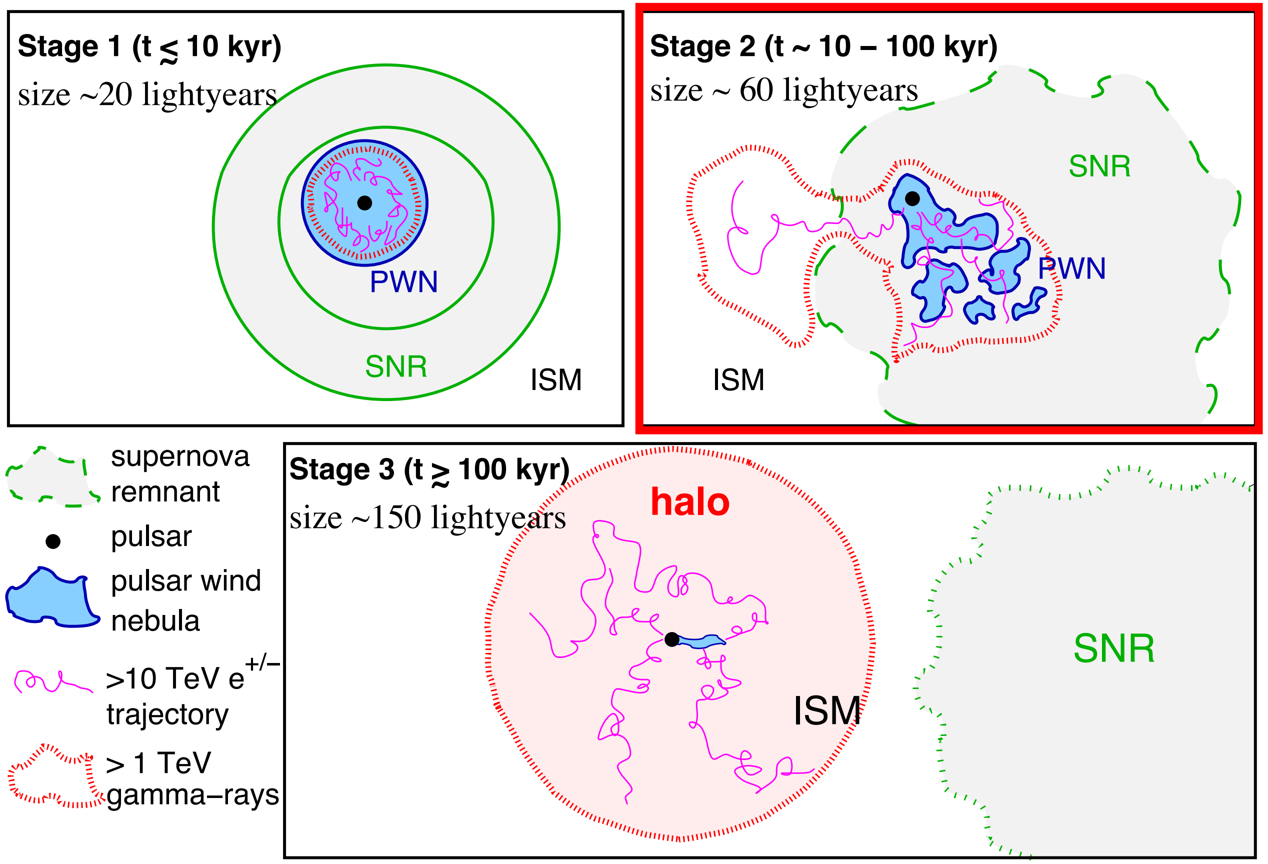
Halo definition under debate!

- **PWN system evolution**:
  - Particle acceleration in PWNe (UHE sources?)
  - Particle escape into ISM → forming a halo
  - Source confusion (highly extended at VHE)

- **Cosmic Ray propagation**:
  - Diffusion seems to be suppressed in halo regions
  - Inhomogeneous diffusion properties of the ISM?
  - Is diffusion always the appropriate transport description?

- Discussion session included a report from the 1st workshop on gamma-ray halos around pulsars (1-3 Dec 2020)

R. Lopéz-Coto



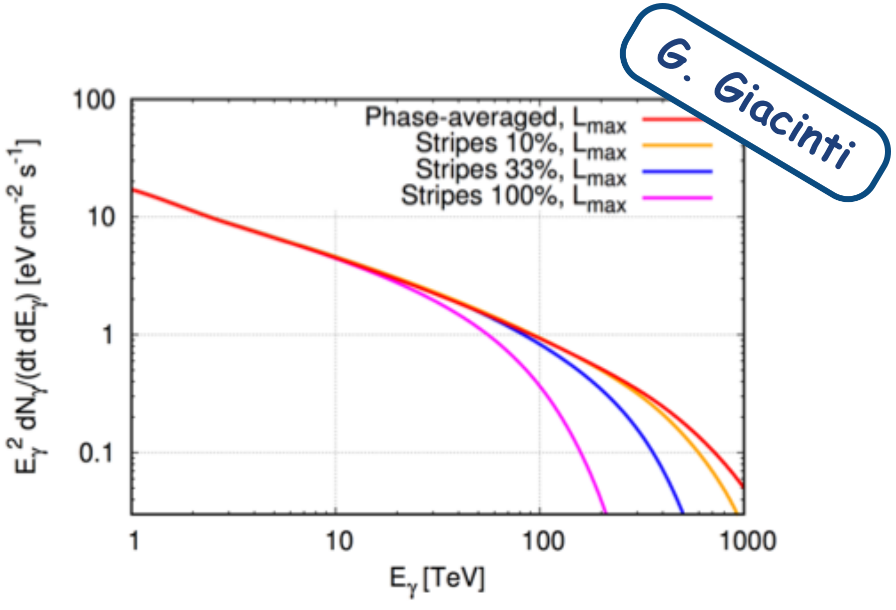
Giacinti, **AM**, Lopez-Coto et al, A&A 636, A113 (2020)

ETH zürich

PWNe – theory

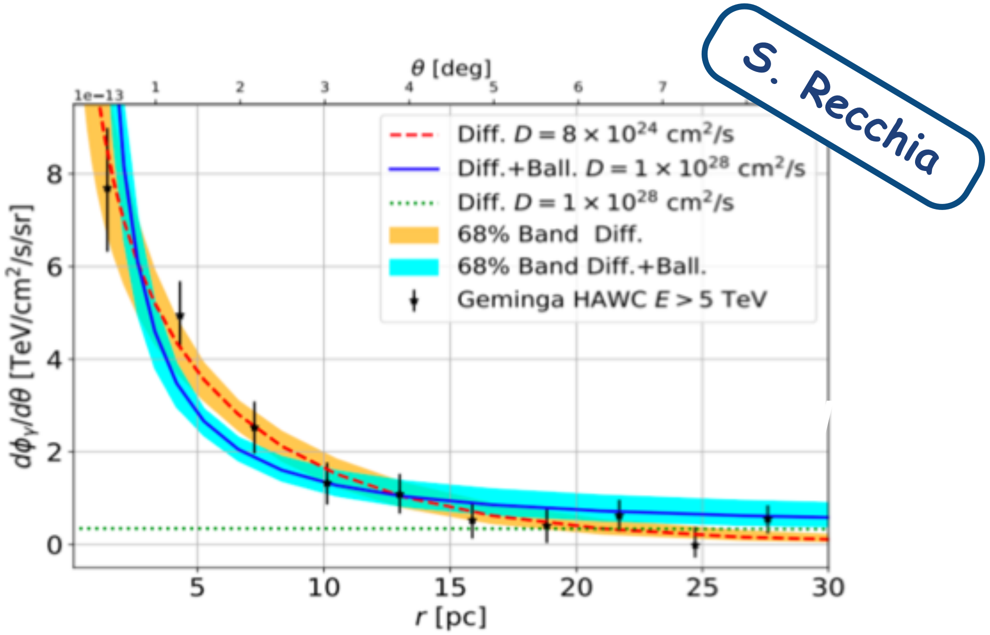
- Electrons accelerated to 1 PeV at wind termination shock!
- Contribution of unresolved pulsar wind nebulae to diffuse emission

G. Pagliaroli



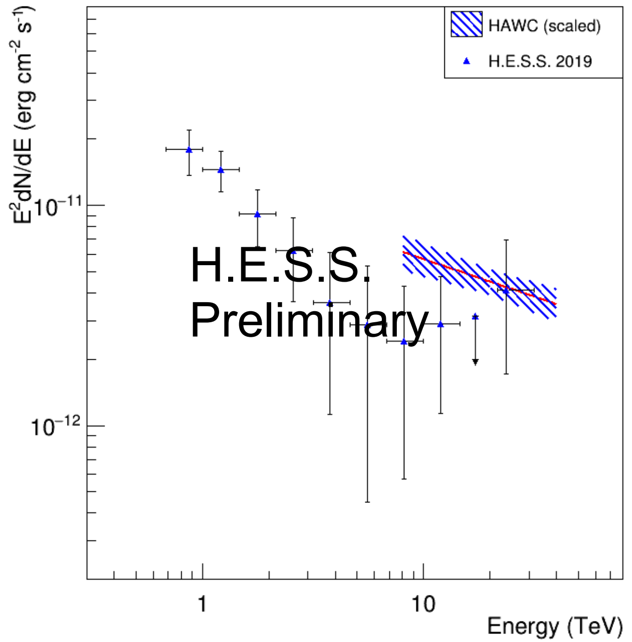
Halos – theory

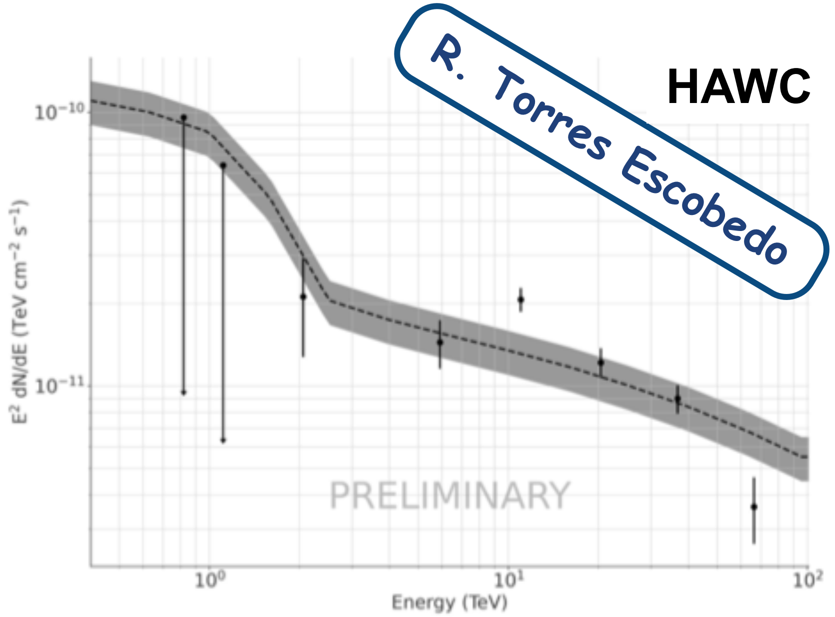
- Escaping particles probe the ISM
- **Local sources**: account for e^- spectrum and e^+ excess?
- HAWC measurements around Geminga → Diffusion coefficient **a factor 100 lower** than B/C ratio
- Can other particle transport models explain **without low D**?
- **Caveats to this model**:
  - "ballistic" → of gyro-centre, not true ballistic
  - Highly efficient conversion of spin-down energy required
  - Assumed isotropy → strong anisotropy in such a regime

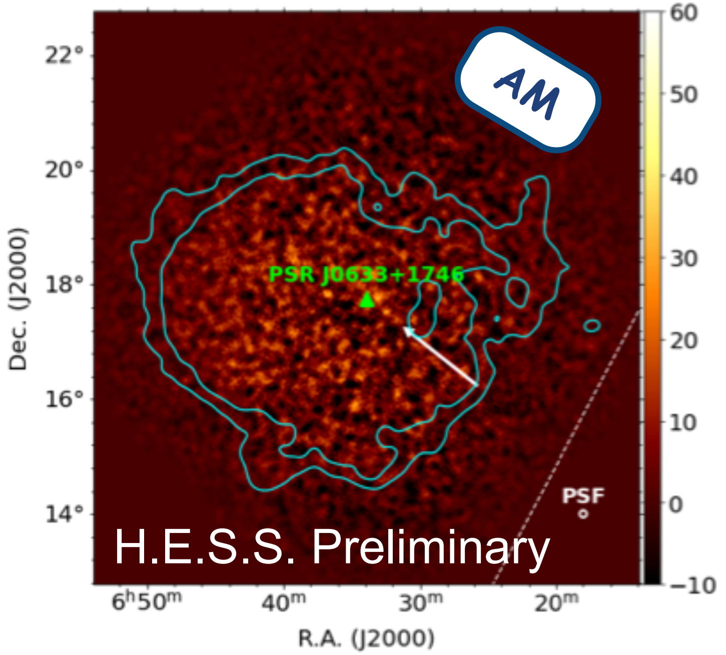


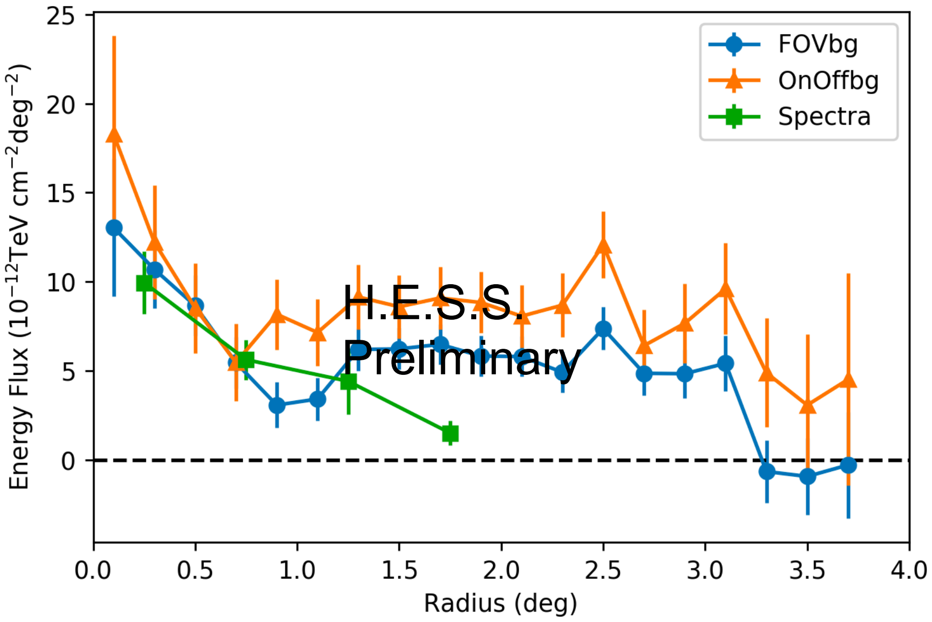
Geminga and Monogem

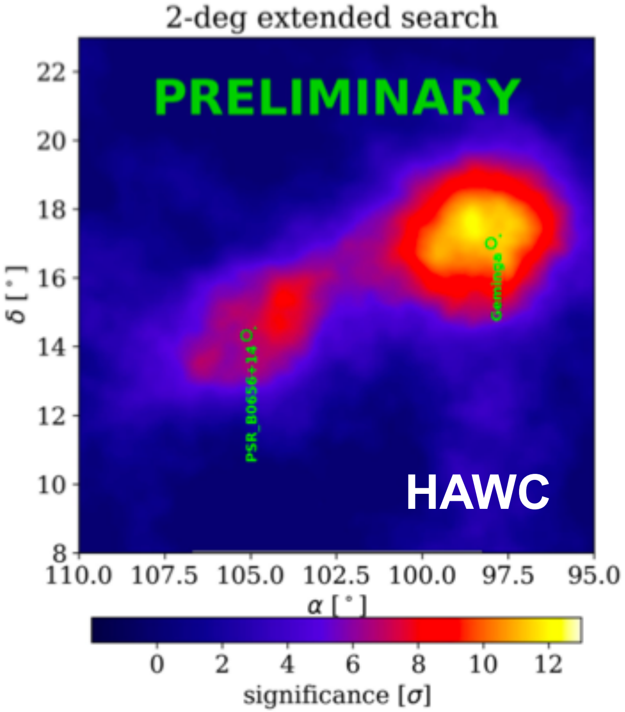
- Prototypical examples of halos
  - PSR J0633+1746 ,
    342 kyr, $\dot{E} = 3.2{\times}10^{34}$ erg/s
  - PSR B0656+14 ,
    111 kyr, $\dot{E} = 3.8{\times}10^{34}$ erg/s











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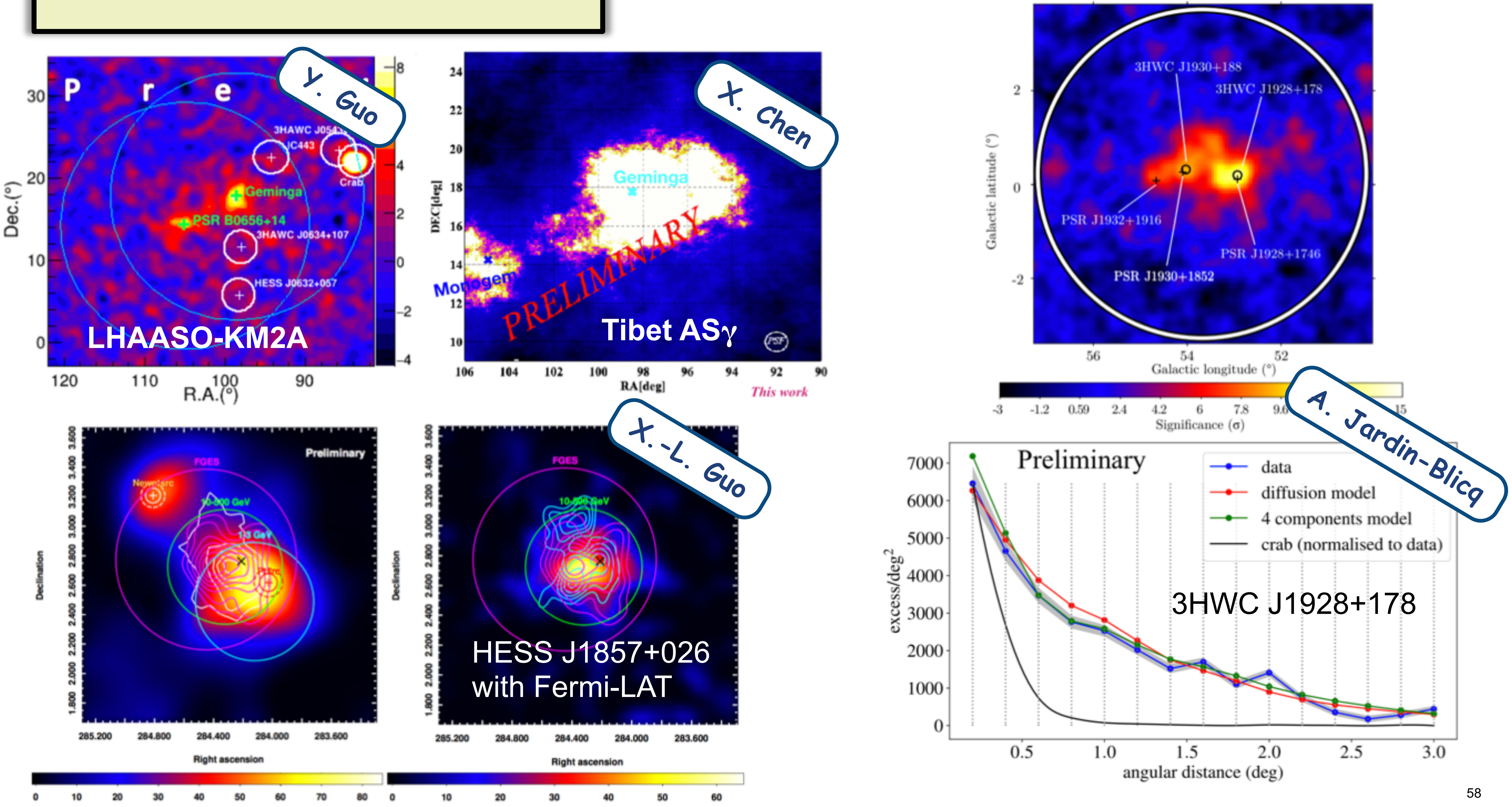
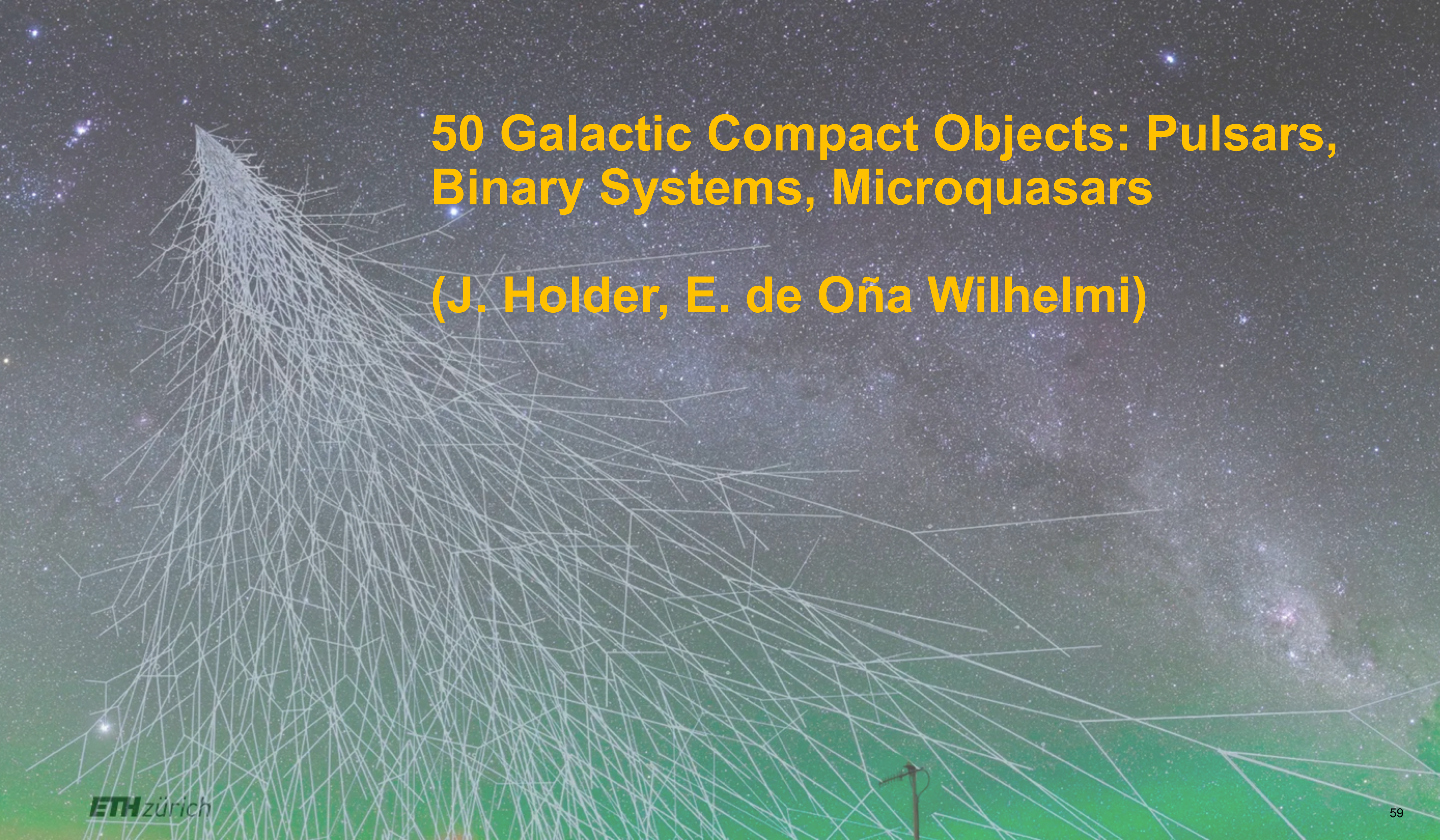
More halos & halo candidates



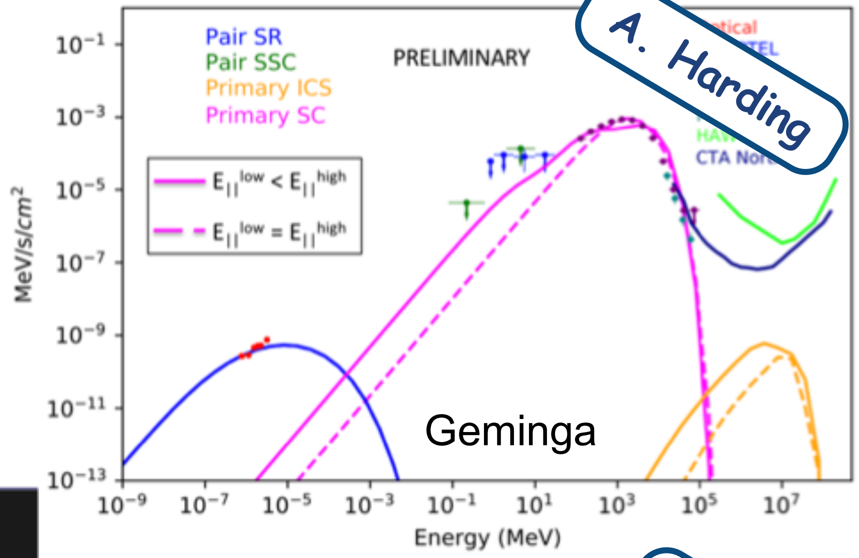


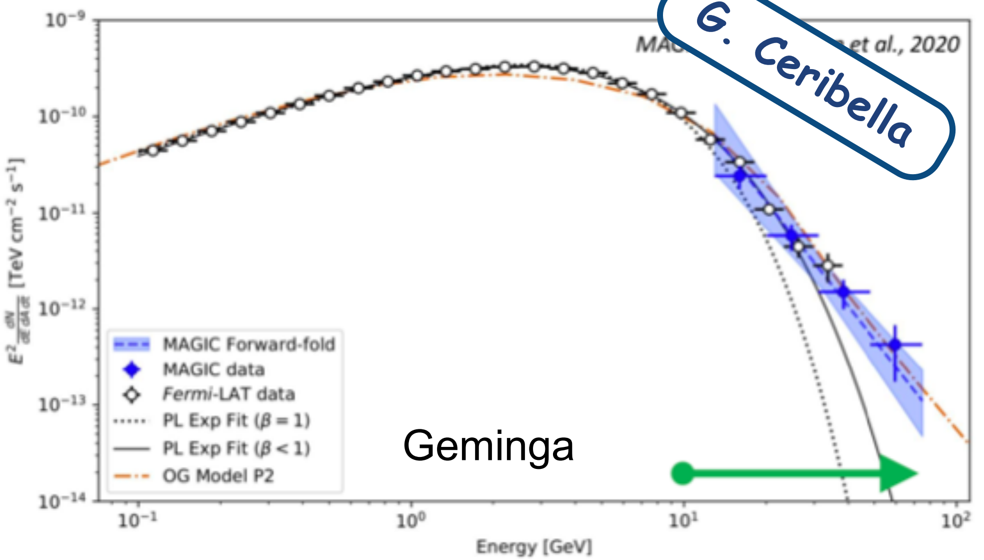
50 Galactic Compact Objects: Pulsars, Binary Systems, Microquasars

(J. Holder, E. de Oña Wilhelmi)

https://www.theverge.com/2017/9/21/16335164/pierre-auger-observatory-cosmic-ray-galaxies-air-shower-particles
A. Chantelauze, S. Staffi, and L. Bret

Pulsars





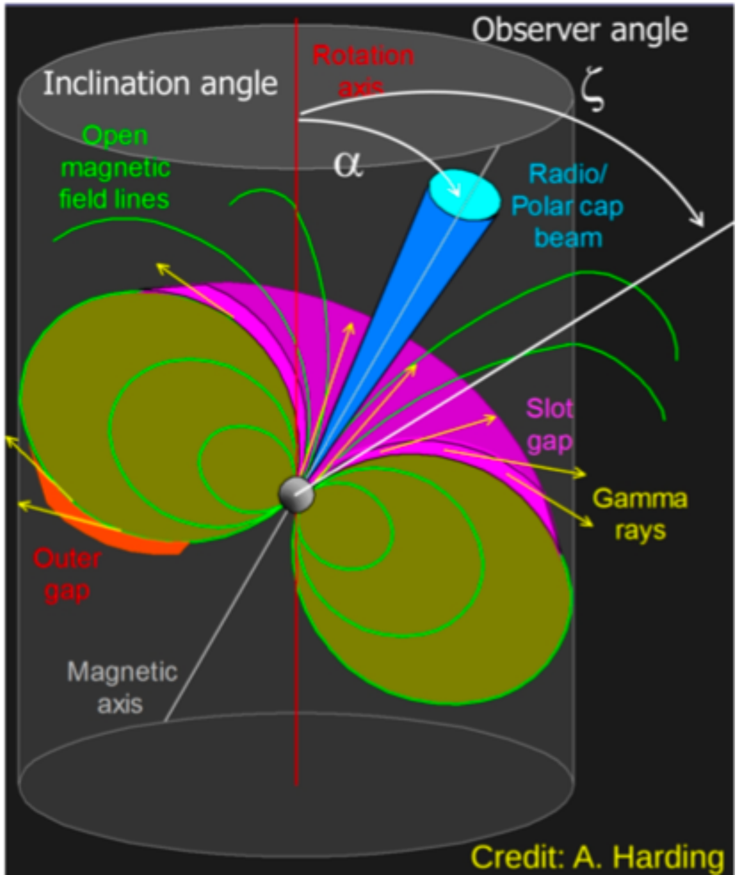
M. Barnard

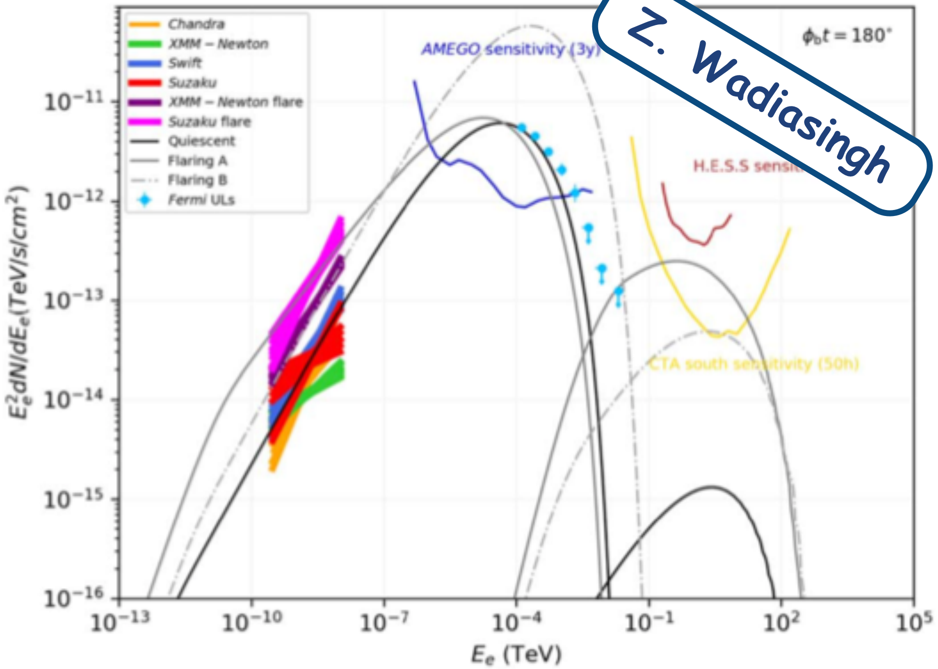
- Vary α and ζ for Vela

A. Fiori

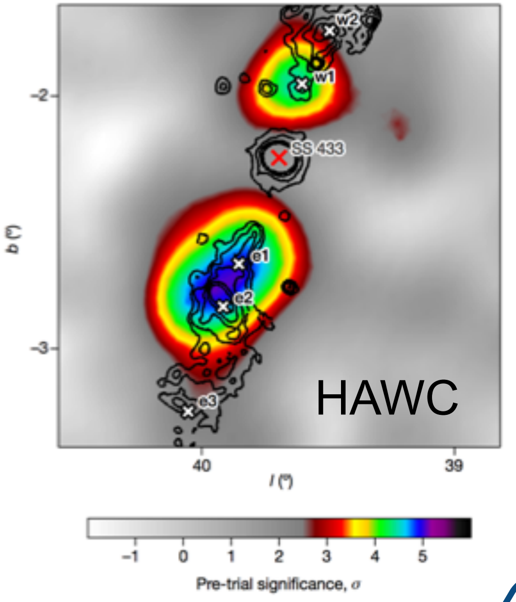
- PSR J2021+4026: Gamma-ray flux variability coincident with changes in spin-down rate.

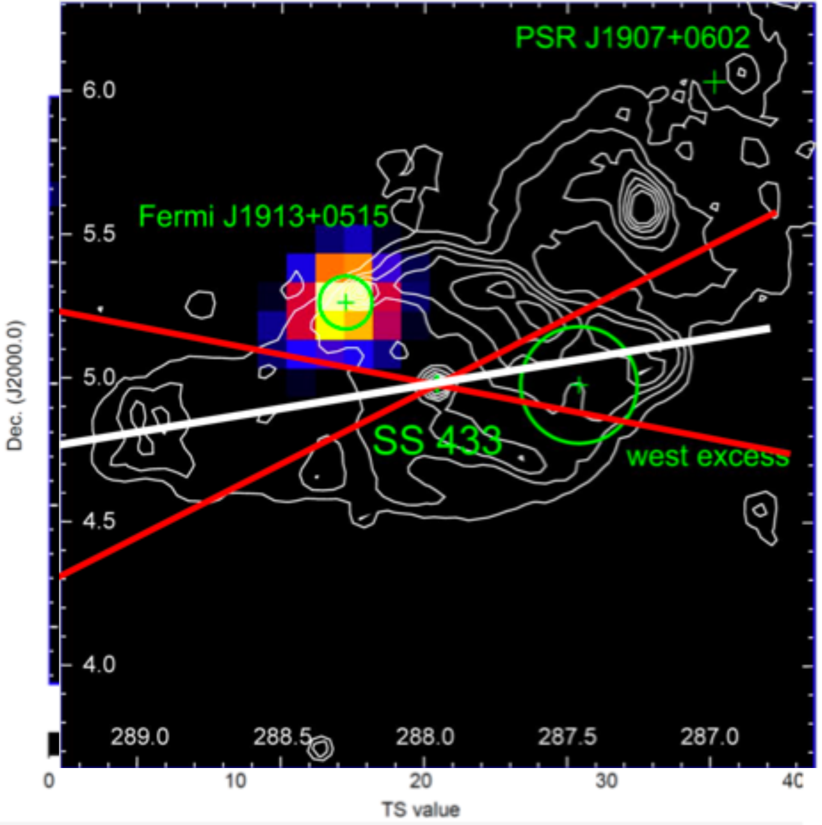
- Black widow MSP J1311-3430, predictions for VHE signal in optical flaring state.

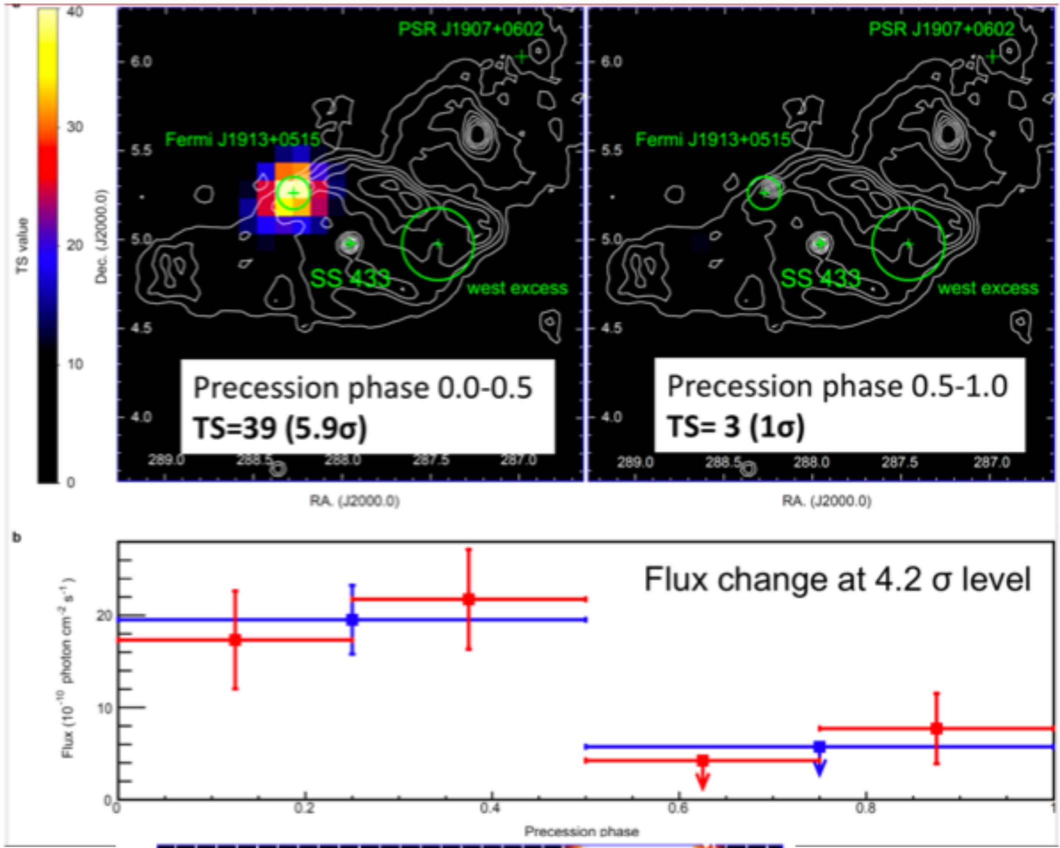




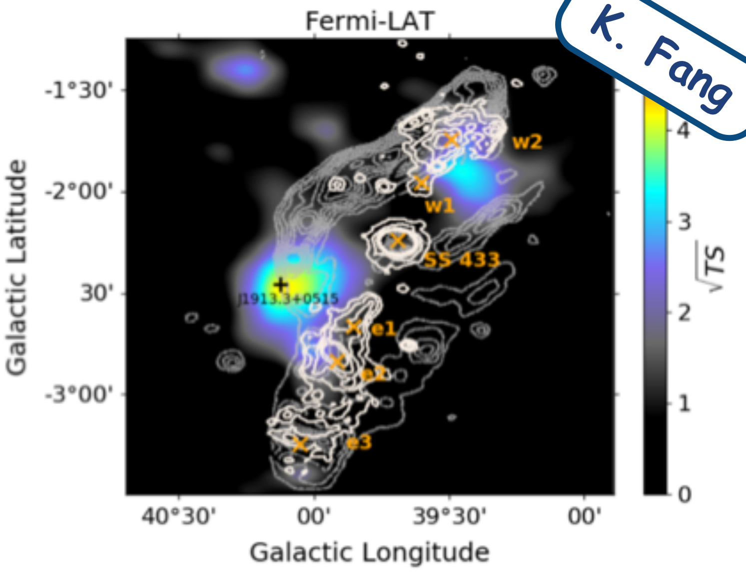
Microquasar: SS433

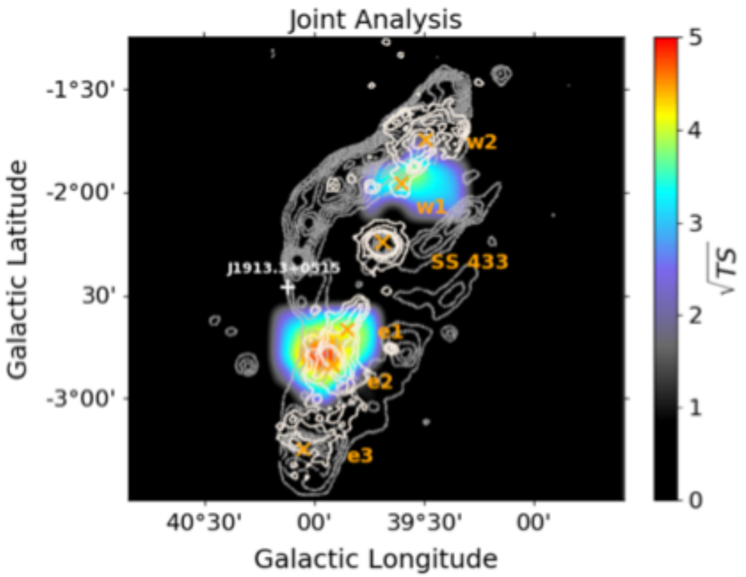


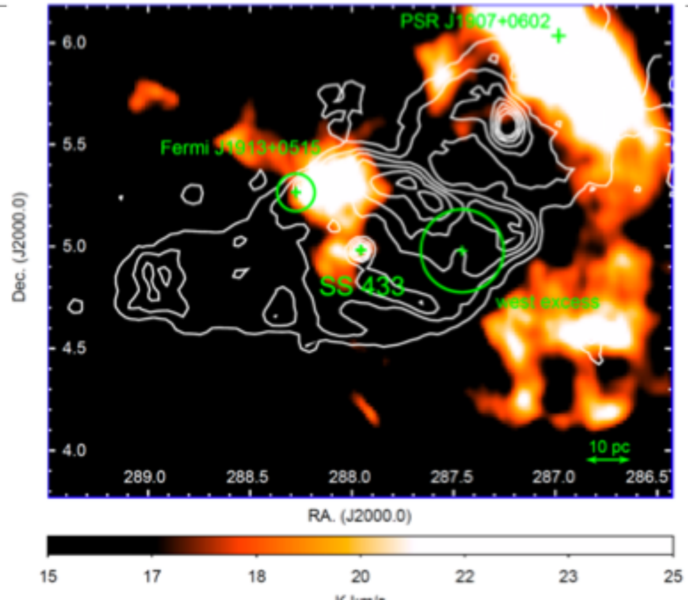




K. Fang



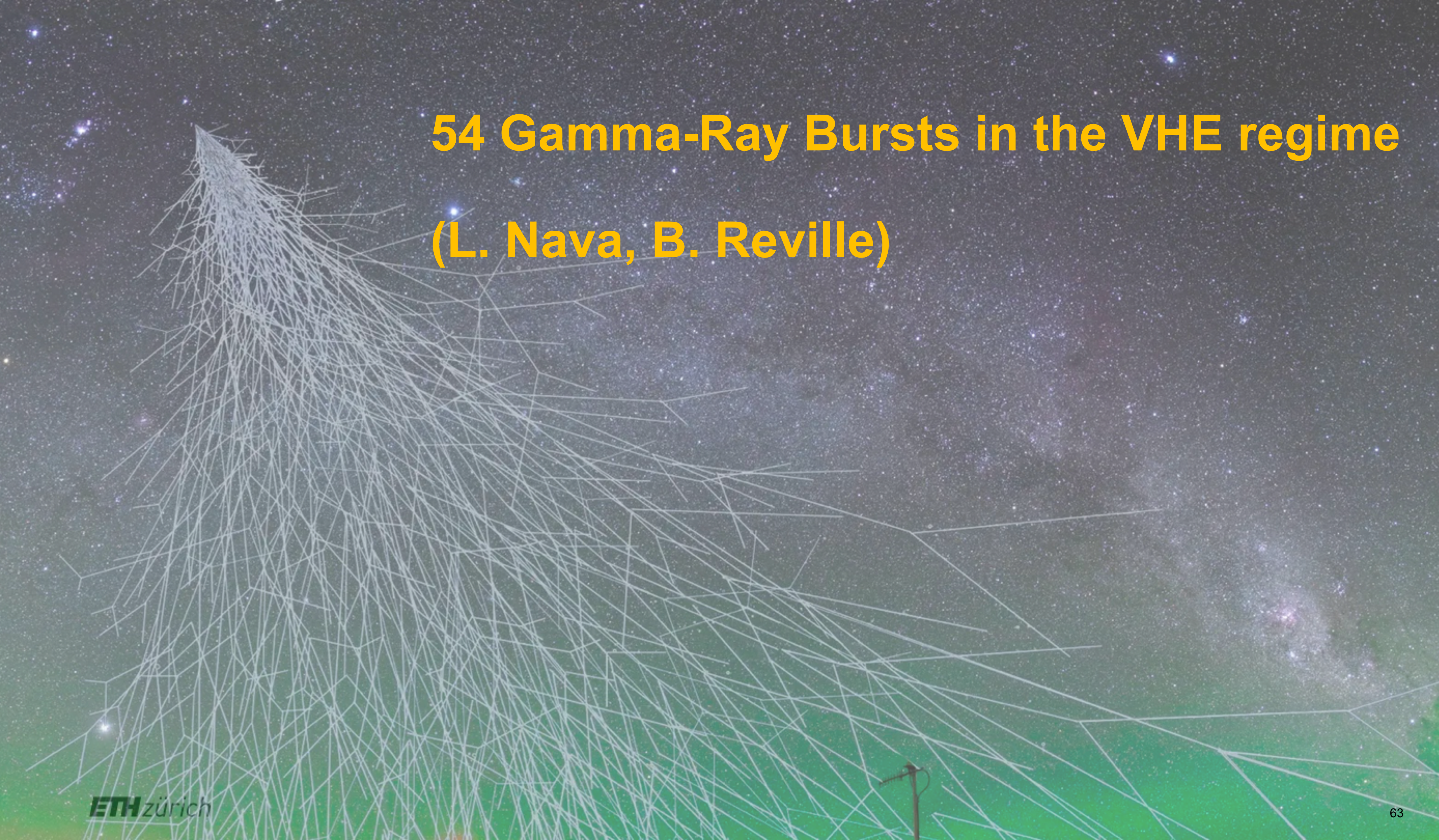




J. Li

54 Gamma-Ray Bursts in the VHE regime

(L. Nava, B. Reville)



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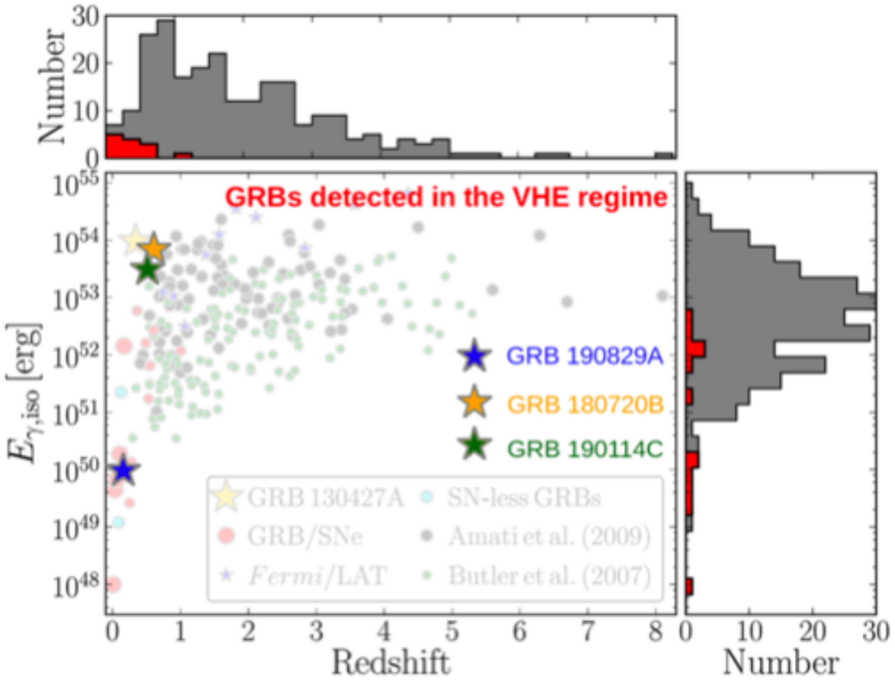
A. Chantelauze, S. Staffi, and L. Bret

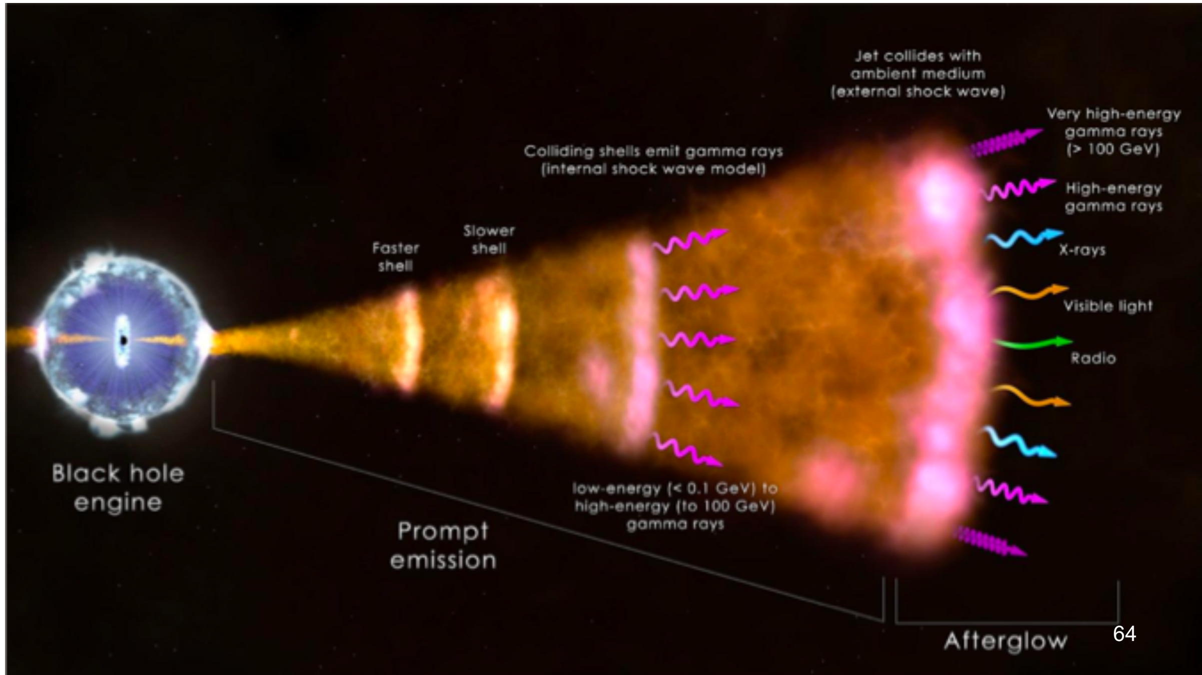
After a > 15 year long search:

- First four VHE GRBs detected by H.E.S.S. & MAGIC between 2018 – 2020
  (long GRBs, detected during afterglow phase)

  - GRB 180720B, z ~ 0.654 (H.E.S.S.)
  - GRB 190114C, z ~ 0.4245 (MAGIC)
  - GRB 190829A, z ~ 0.08 (H.E.S.S.)
  - GRB 201216C, z ~ 1.1 (MAGIC)

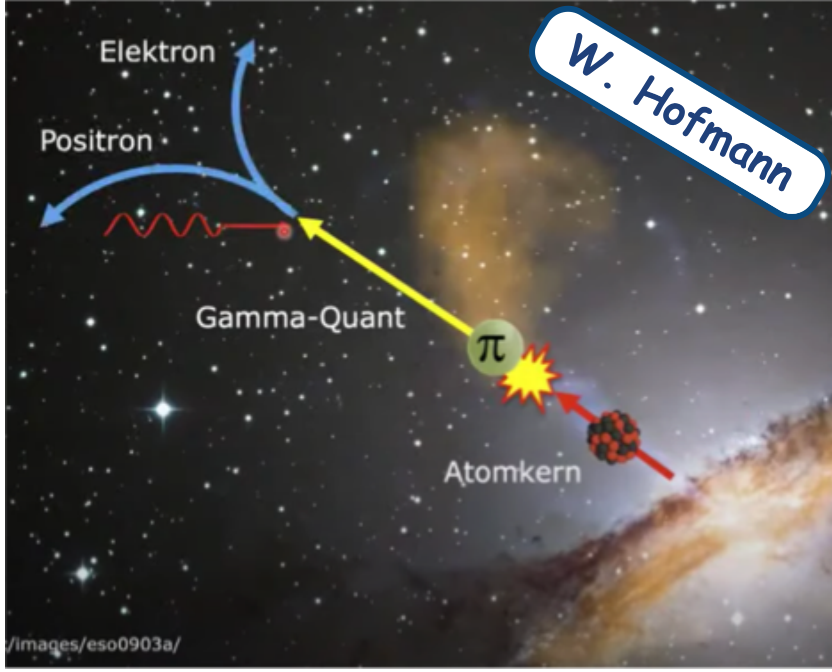
- **Open questions**:
  - What is the origin of the VHE emission?
  - Is VHE emission common?
  - VHE observations constrain E_{max}?
  - SSC component, or pure Synchrotron?
  - Multiple regions of emission?



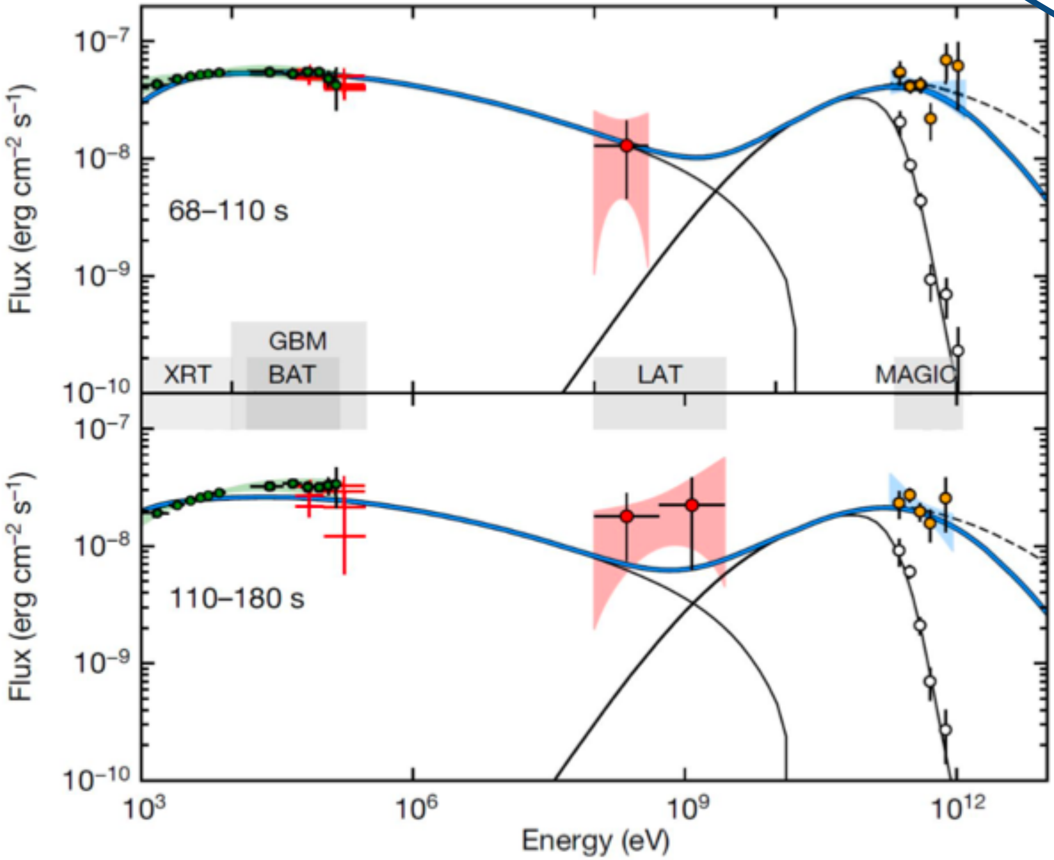


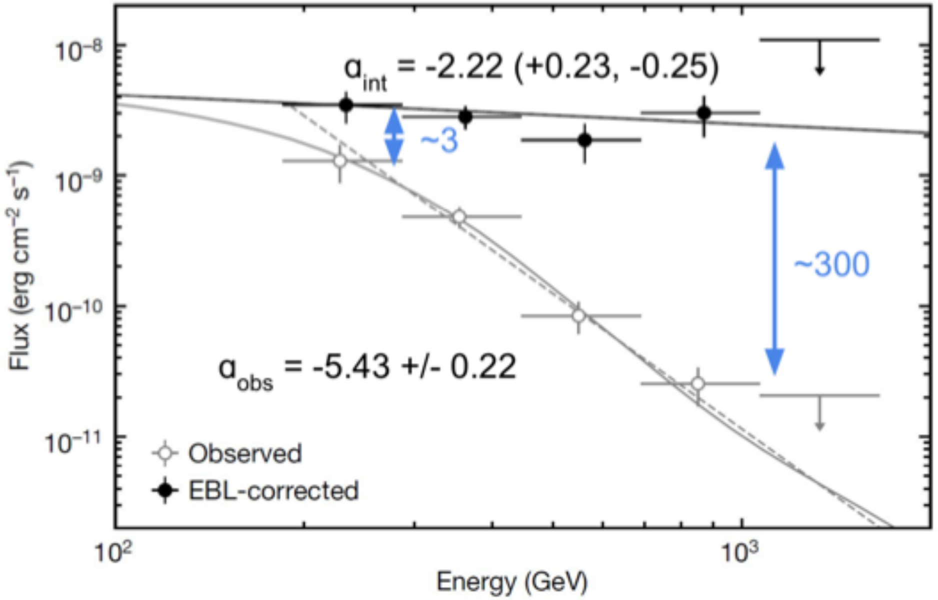
GRB 190114C

- Synchrotron self-Compton (SSC) component: Necessary or not?
- Absorption by Extragalactic Background Light (EBL) → large uncertainties on models
  → Need to correct spectrum



A. Berti





GRB 190829A

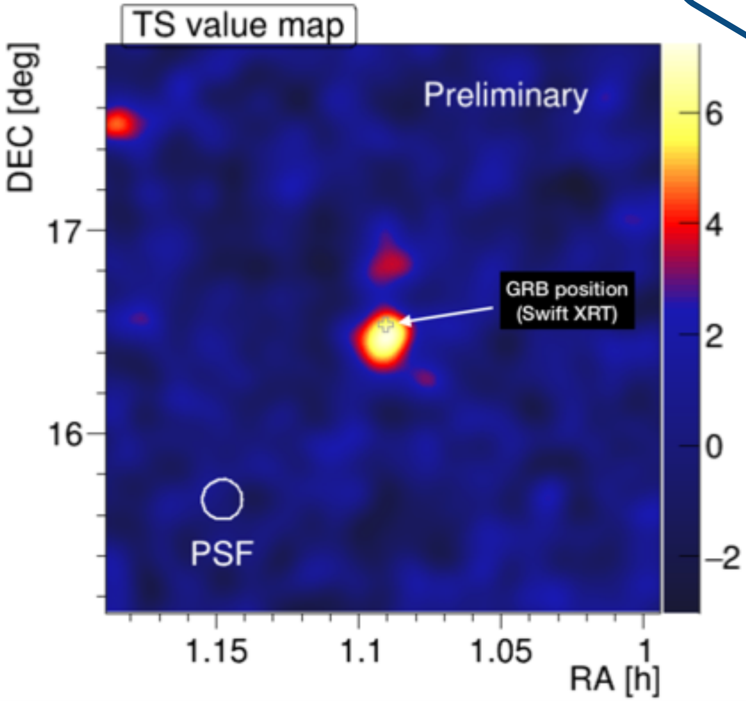
D. Khangulyan

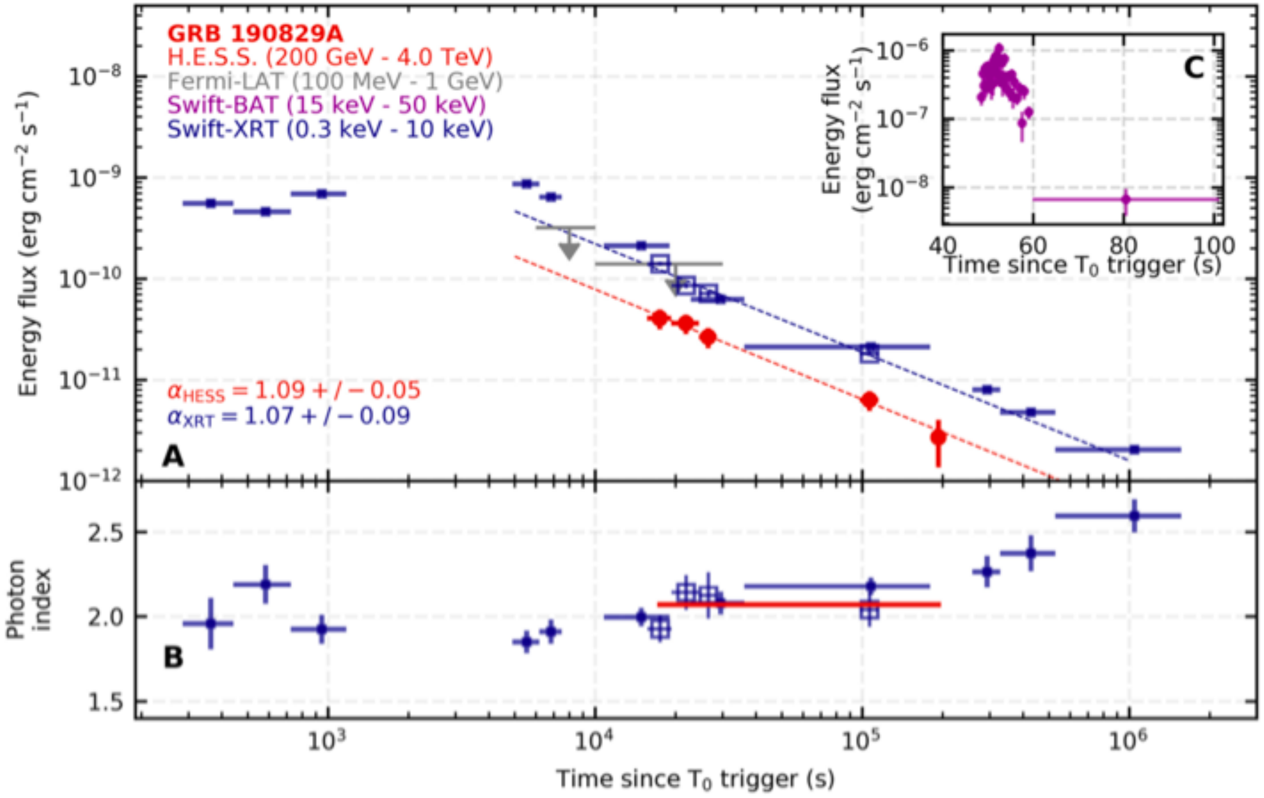
- Observed over three nights by H.E.S.S.

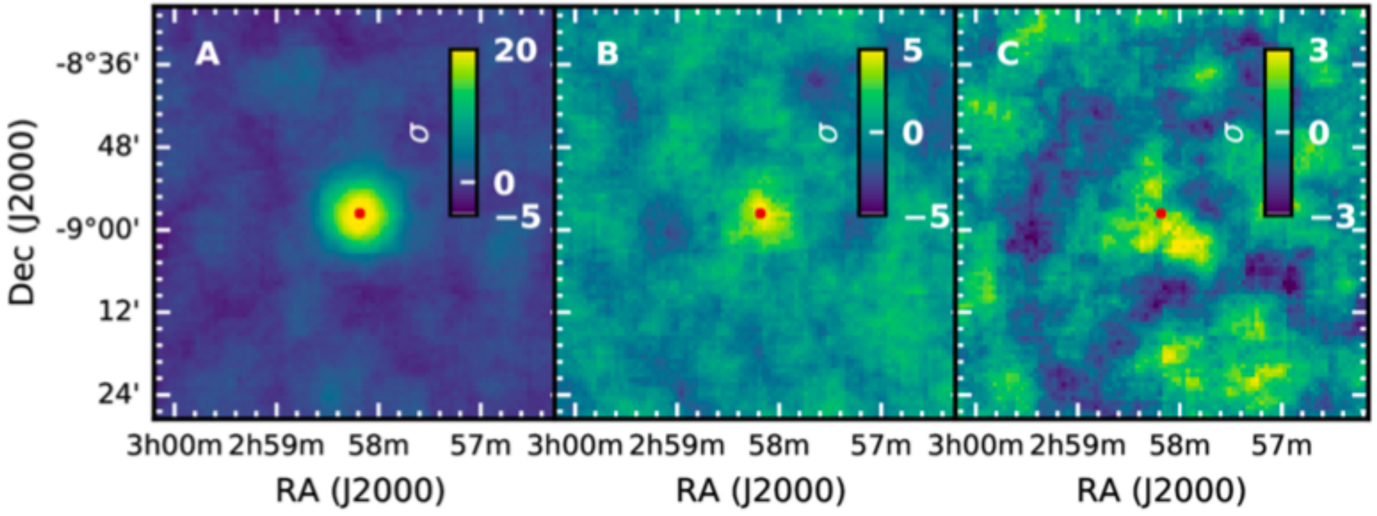
GRB 201216C

- Detected at 6 sigma with MAGIC

S. Fukami

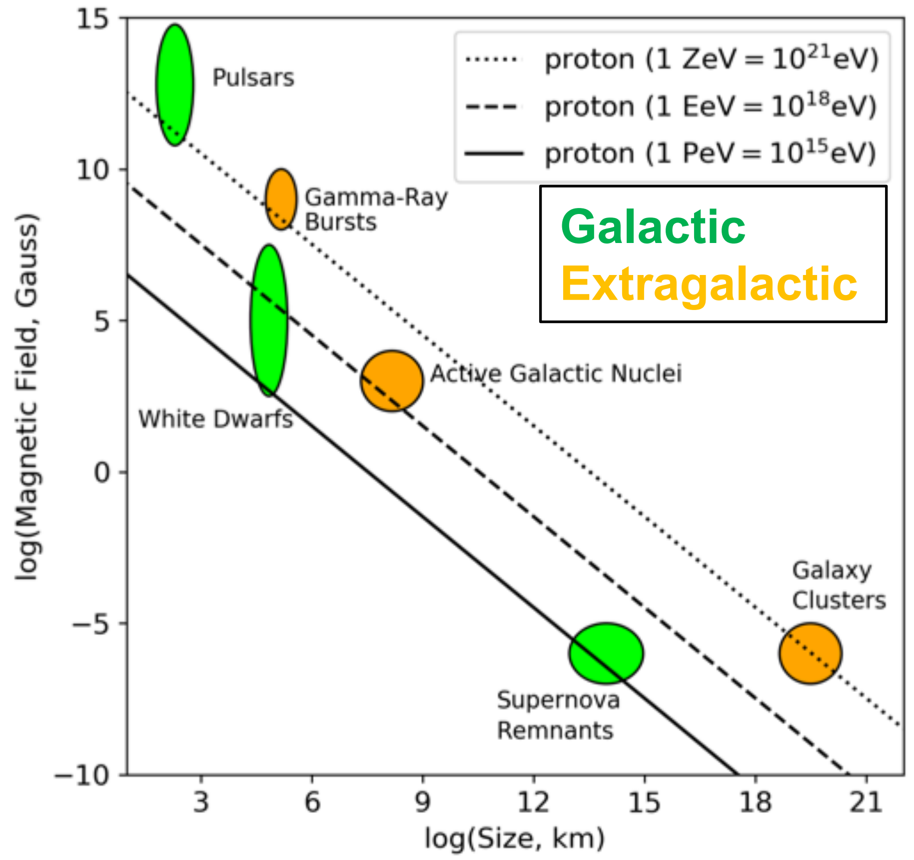


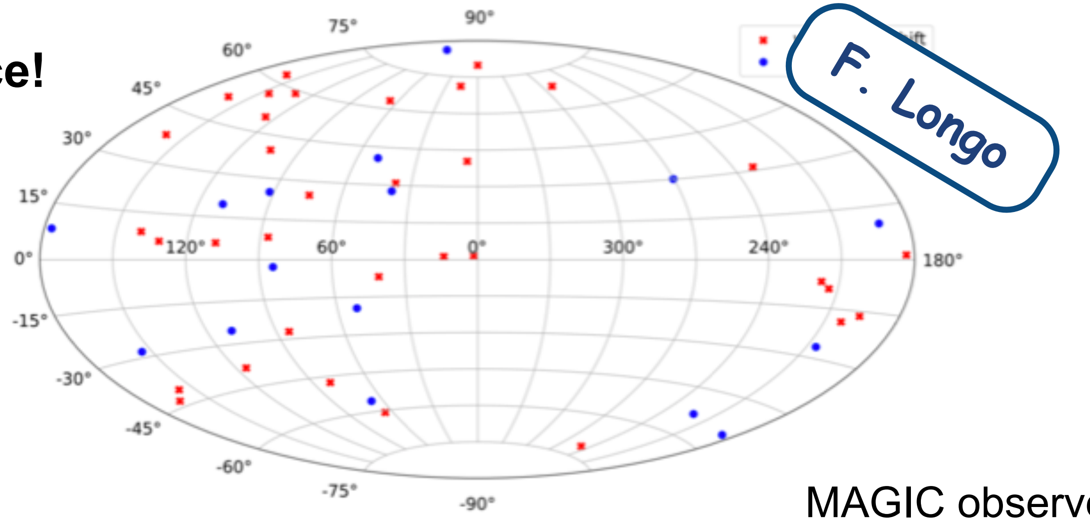




Future GRB detections at VHE?

- **Why now? What changed?**
  - Strategy: observe for longer time after alert
  - Detector and analysis: upgrades and improvements to alert pipelines.
  - Ambition: e.g. GRB 190114C detected under moonlight conditions
- **What next?**
  - Tip of the Iceberg → VHE GRBs are mostly "typical"
  - Searches by HAWC, LHAASO, LAGO...
    Particle detector arrays → particularly important for prompt phase emission
  - Look forward to observations & monitoring by future facilities...
- **Watch this space!**

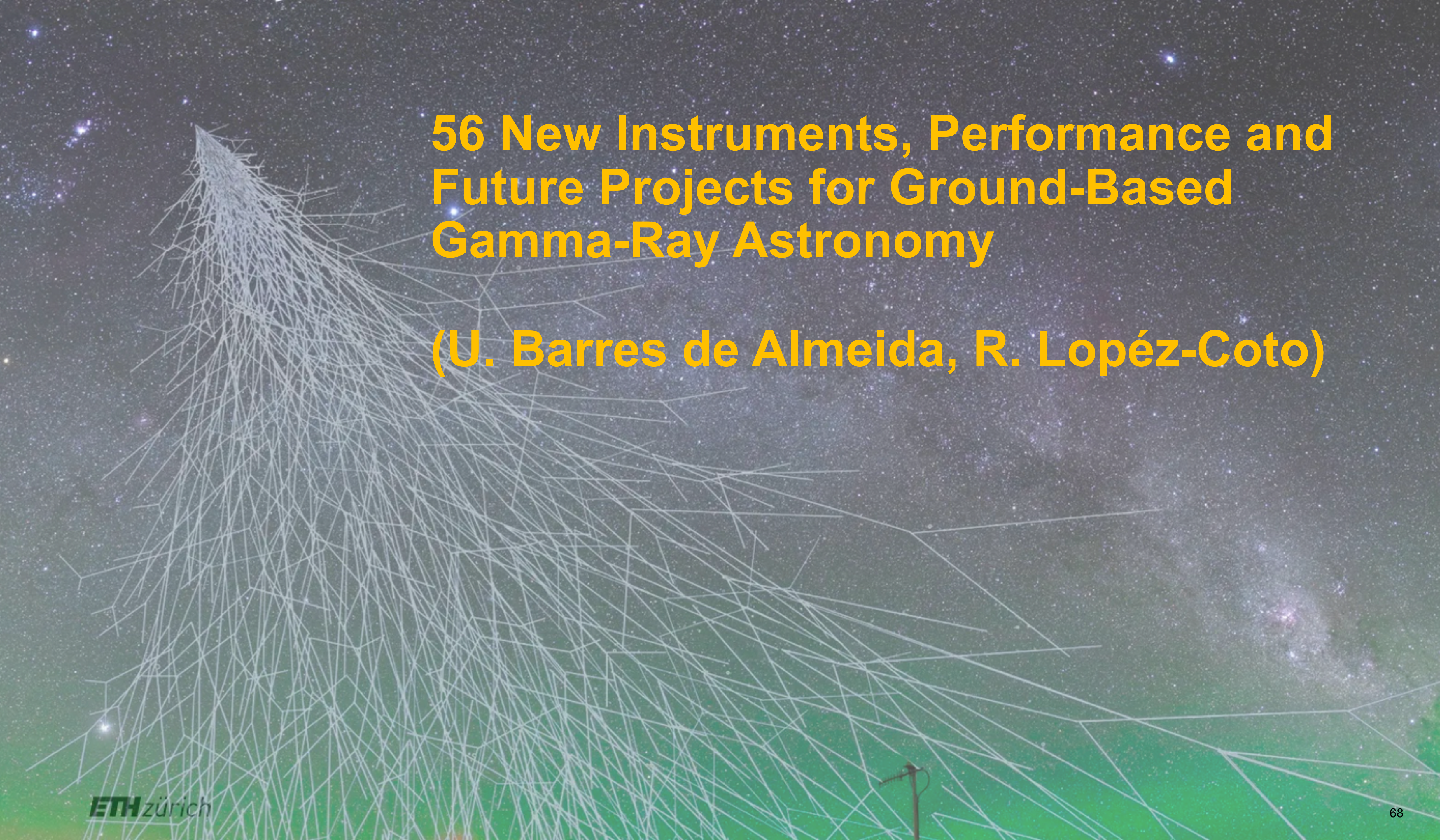




MAGIC observed GRBs

56 New Instruments, Performance and Future Projects for Ground-Based Gamma-Ray Astronomy

(U. Barres de Almeida, R. Lopéz-Coto)



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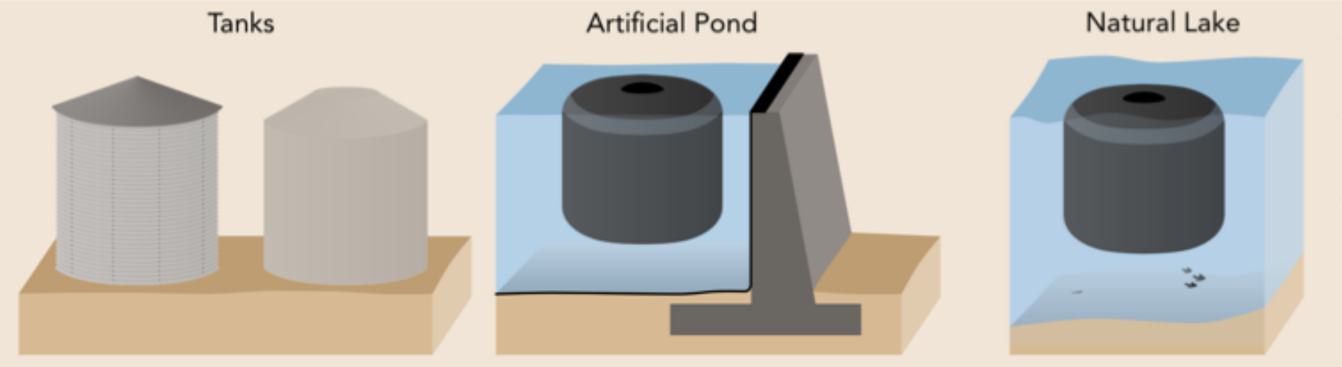
The future: of IACTs and particle detector / hybrid arrays

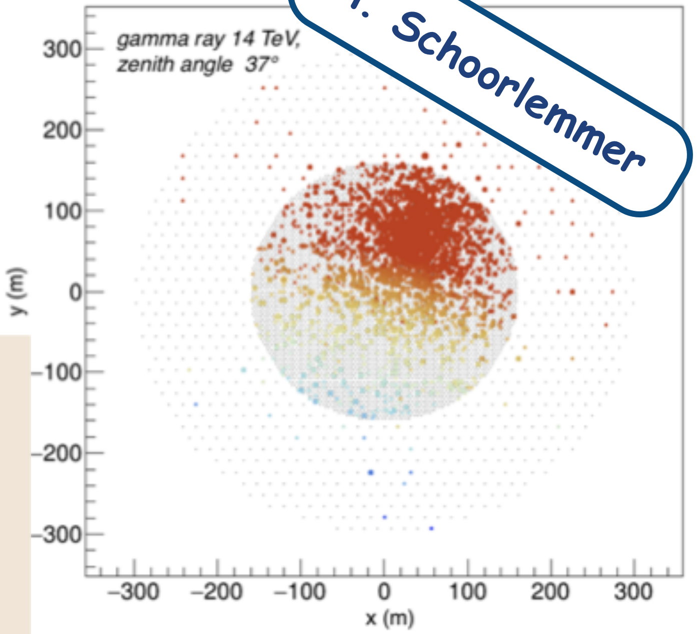
- **Key themes**:
  - Complementarity of techniques (sensitivity and resolution)
  - Operating mode of current IACTs in CTA era?
  - More open community: common tools, open source software, external proposals
  - **Go South!**

F. Werner

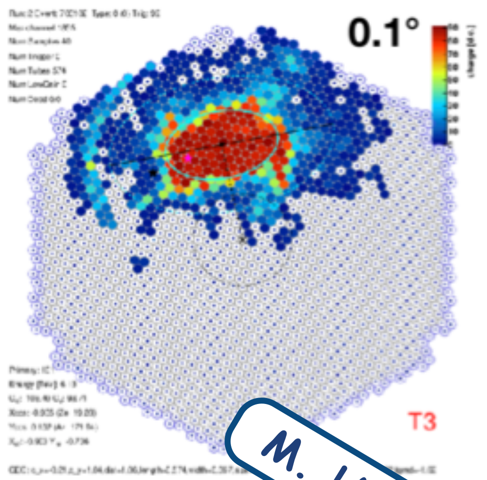
SWGO
The Southern Wide-field Gamma-ray Observatory

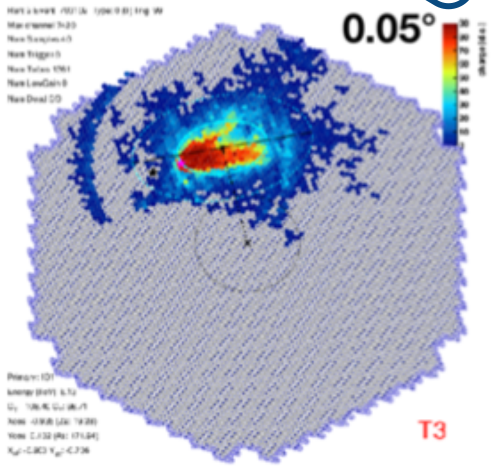


H. Schoorlemmer

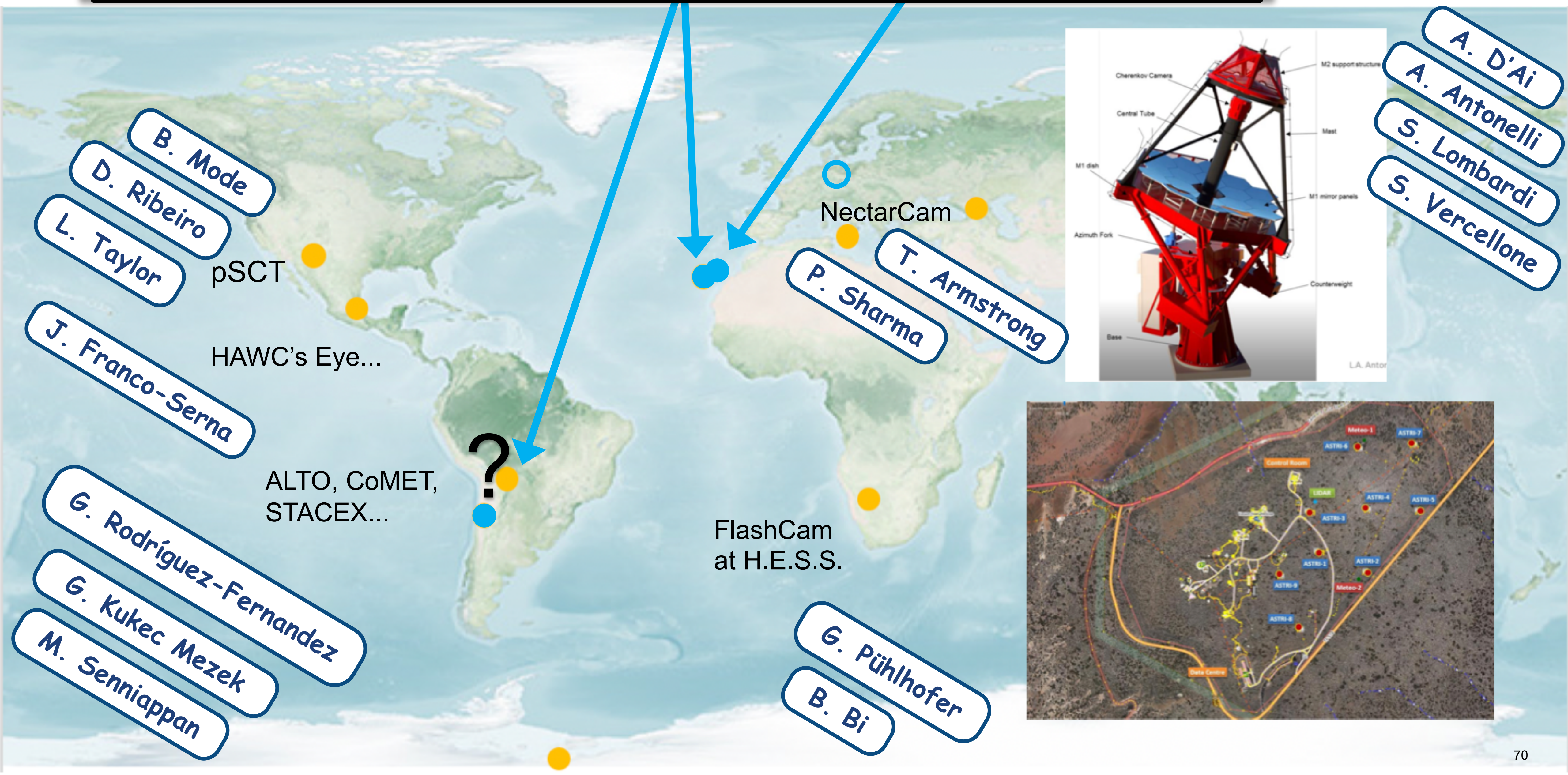


M. Heller





New and future instruments: CTA, SWGO, ASTRI...upgrades++




cta
R. White

Summary and Outlook

Entering the PeV era

Top three topics:
- Particle escape
- PeVatrons
- Transients (GRBs++)

Closing in on the origin of Galactic Cosmic Rays?

An exciting time for VHE gamma-ray astronomy!

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Berlin | Germany

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תודה

ETH zürich

Dr Alison Mitchell

amitchell@phys.ethz.ch

Backup

Virtual Conference – feedback & what next?

Feedback from GAI: The first virtual ICRC

- **No scheduled parallel talks**:
  - **Pro**: watch talks at any time.
    Replay / rewind / change speed etc.
  - **Con**: difficult to watch before discussions!
    Reduced audience? Need summary slide per contribution at start of discussions.
- **Discussion sessions**:
  - **Pro:** not only Q&A, but also discussion on hot topics / key questions
  - **Con**: still not enough time! How much time per speaker?
- **Conference platform**:
  - **Pro**: Q&A at any time
  - **Con**: too many clicks to navigate, no unique ID per contribution

Future ICRCs?

- **Hybrid format:**
  - Enable in person and remote attendance
  - Live chat / Q&A during talks useful
    (and transfer of questions afterwards)
  - Retain scheduled talk times?
  - Keep broader open discussions → very interesting and fruitful
  - Make recordings available
  - Notify presenter when someone is at table / poster
- **Remote advantages**:
  - Many more attendees, cheaper, flexible
- **Remote disadvantages:**
  - Networking, spontaneous discussions, time zones

Feedback from GAI: The first virtual ICRC

- **Discussion Sessions**:
  - Good opportunity for more general discussion
  - Never enough time!
- **Presenter forum:**
  - In general a good tool, but...