Summary of Moriond VHEPU 2022: a selection

since 1966
Rencontres de Moriond

CEA – Saclay

About Moriond VHEPU 2022

- Moriond VHEPU every 4 years.
- About 60 participants
- Topics :
  - Gamma-ray astronomy
  - Neutrinos
  - Cosmic rays
  - Multi-messenger astronomy
  - Dark Matter
- All contributions available :
  https://moriond.in2p3.fr/2022/VHEPU/vhepu-agenda.html

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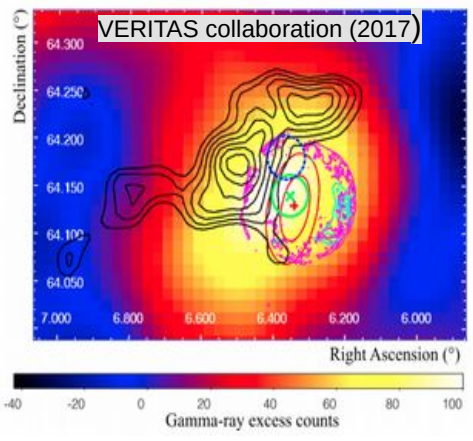
GAMMA-RAY ASTRONOMY

Origin of Galactic Cosmis Rays : Supernova remnants

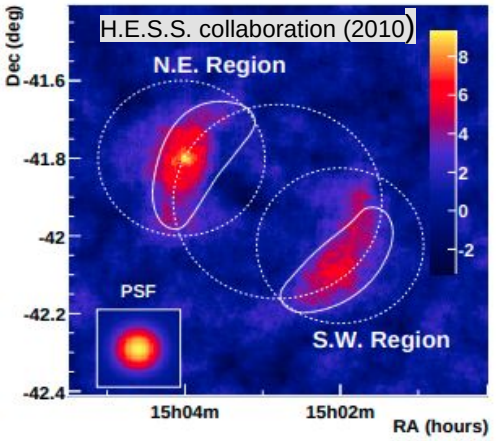
- SNRs as sources of Galactic hadronic CRs
- Historical SNRs detected in VHE gamma rays

Tycho SN (in 1572)



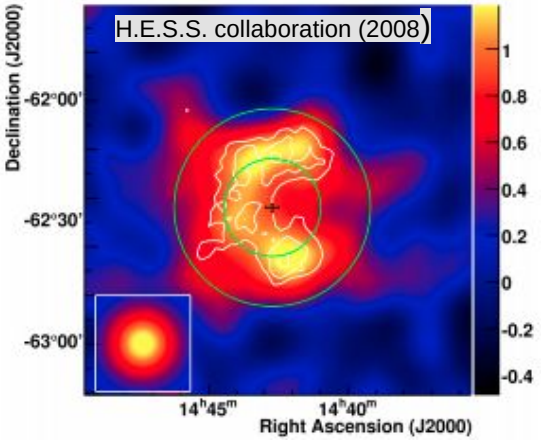
Detected at VHE with VERITAS in 2011 (67 hours)

SN 1006



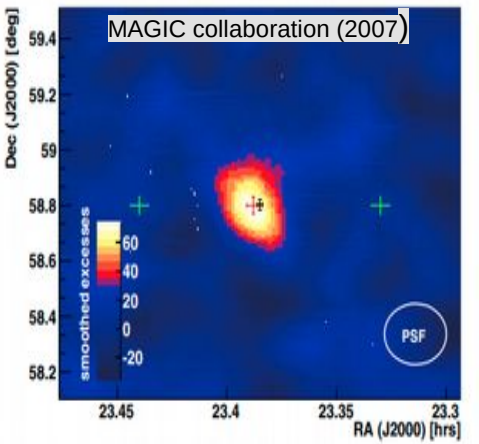
Detected at VHE with H.E.S.S. in 2010 (130 hours)

RCW 86 (SN in 185)



Detected at VHE with H.E.S.S. in 2008 (31 hours)

Cas A (SN around 1680)



Detected at VHE with HEGRA in 2001 (232 hours)

#D. Prokhorov

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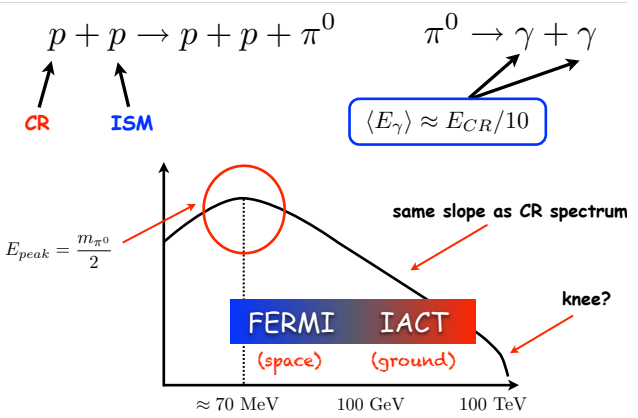
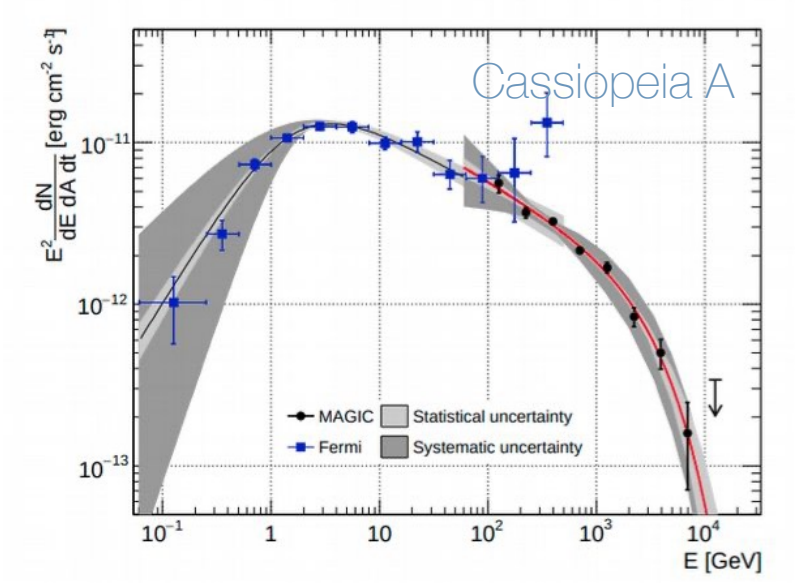
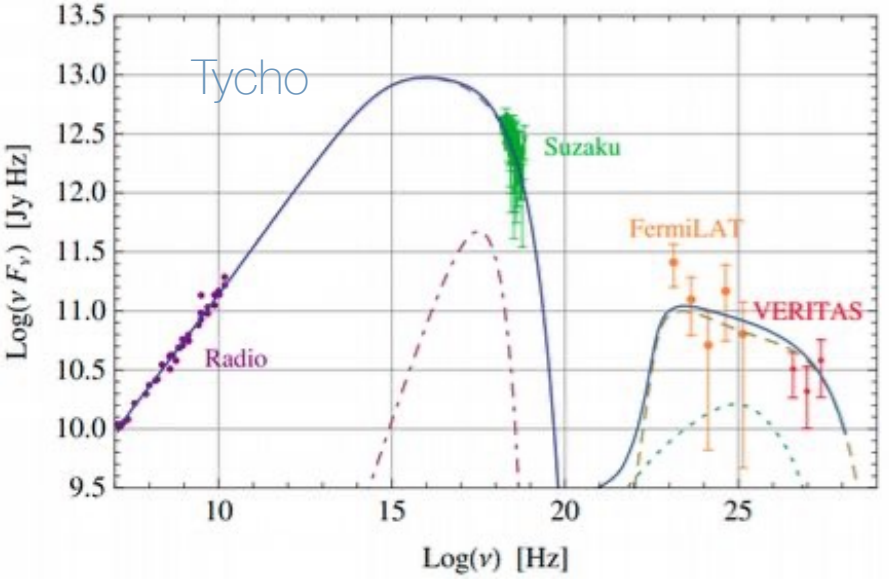
Origin of Galactic Cosmis Rays : Supernova remnants



- SNRs as sources of Galactic hadronic CRs
- Historical SNRs detected in VHE gamma rays
- Hadronic model (pp interaction)

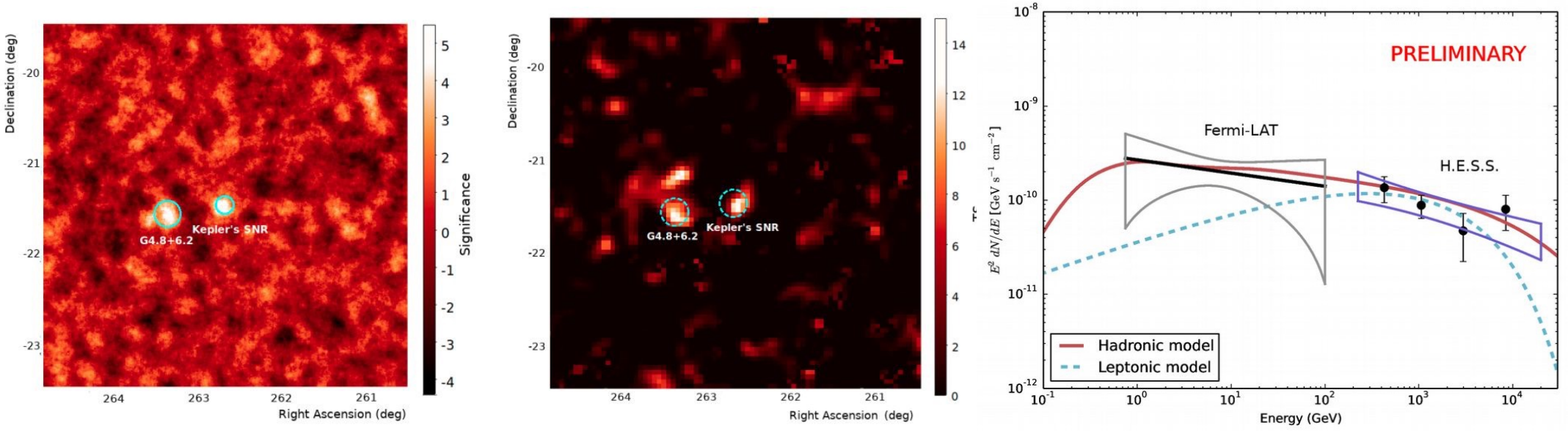




- Significant softening in the energy spectra at the highest energies
  → cannot provide enough CR protons at PeV energies

Origin of Galactic Cosmis Rays : Supernova remnants

- TeV detection of the Kepler's SNR (SN 1604) by H.E.S.S.
- 152 hours of high-quality data since 2004

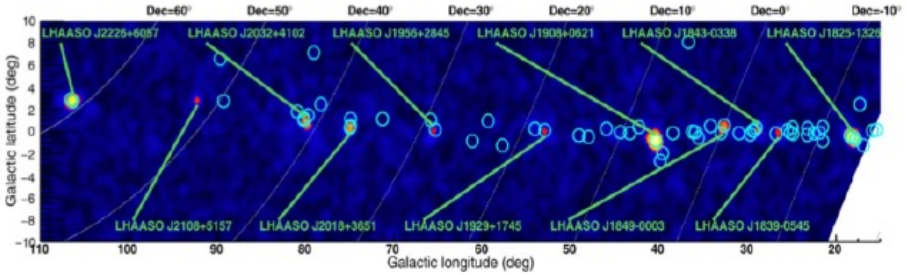


- Hadronic model can well described the data
  - Cosmic-ray proton spectral index, 2.2
  - Exponential cut-off in the cosmic-ray proton spectrum at 100 TeV

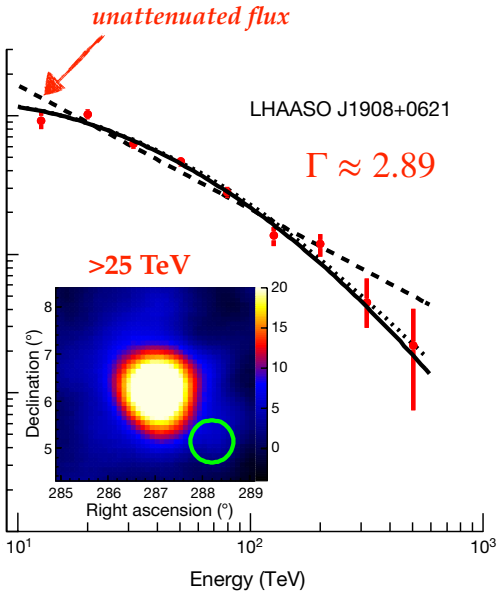
#D. Prokhorov

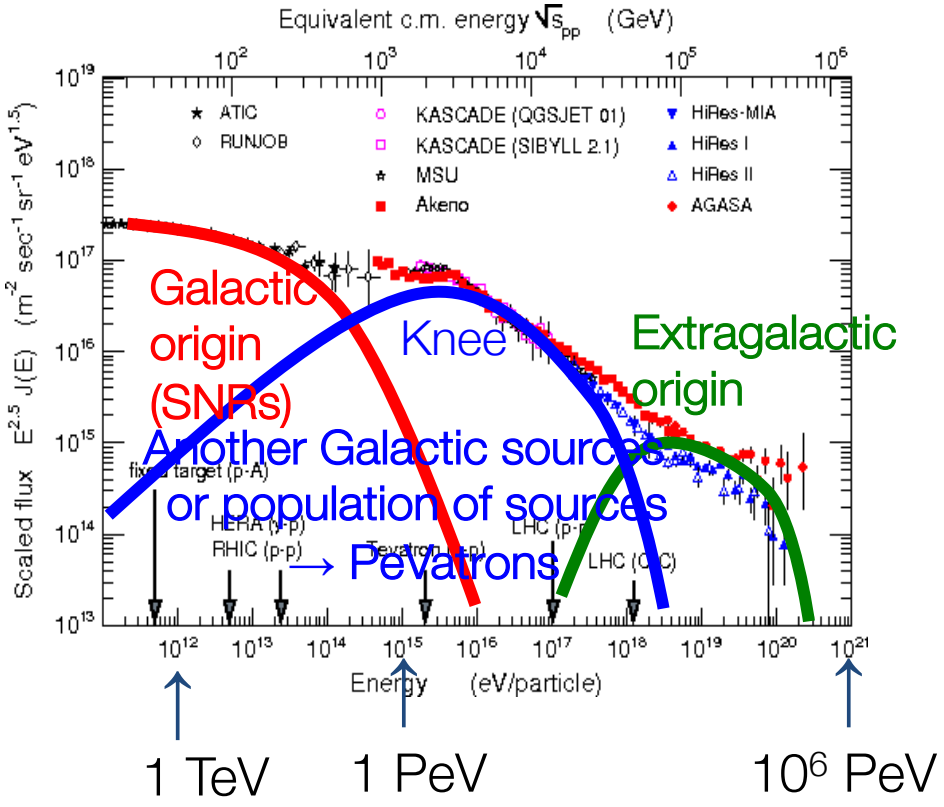
LHAASO: gamma-ray sources above 100 TeV

- 12 sources at > 0.1 PeV
- Most of them are unidentiifed



- The first SNR as PeVatron?





- LHAASO J1908+0621 = SNR G40.5-0.5 ?
- Possible association with MGRO J1908+06 that spatially associate with an Icecube hotspot
- Spectrum suggests >2PeV protons
- Confirmation of association with SNR G40.5-0.5 would be the first evidence of a SNR operating as a pevatron *#G. Siascio*

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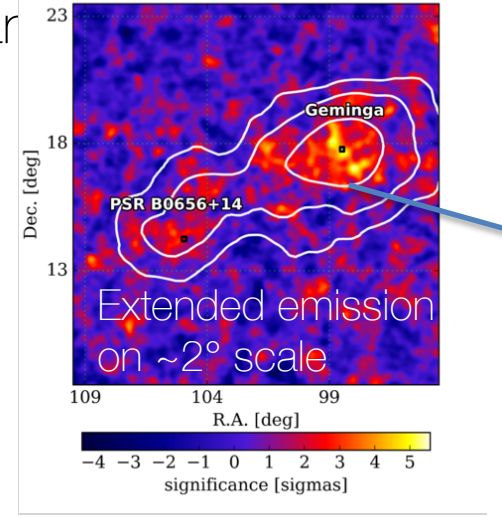
Extended VHE sources: detection of TeV halos

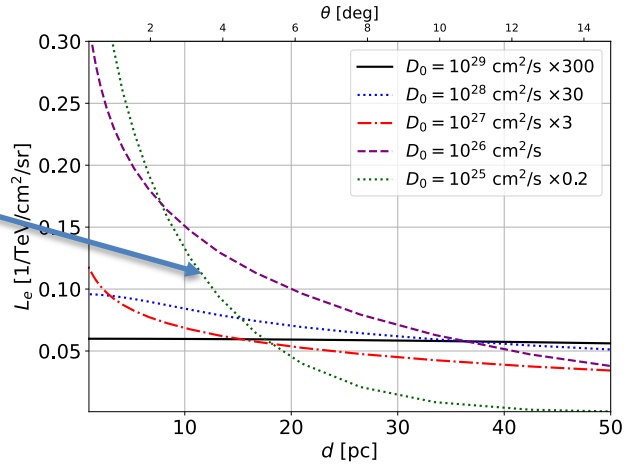
- New source class: Geminga and Monogem pulsars are surrounded by a spatially extended region (~20 pc) emitting multi-TeV gamma-rays

- TeV halos: larger zone in which the pulsar does not dominate the environment: diffusion regime

- Data implied the diffusion coefficient to be two orders of magnitude lower than the one in the Galaxy.

HAWC Collaboration, Science 358, 911 (2017)





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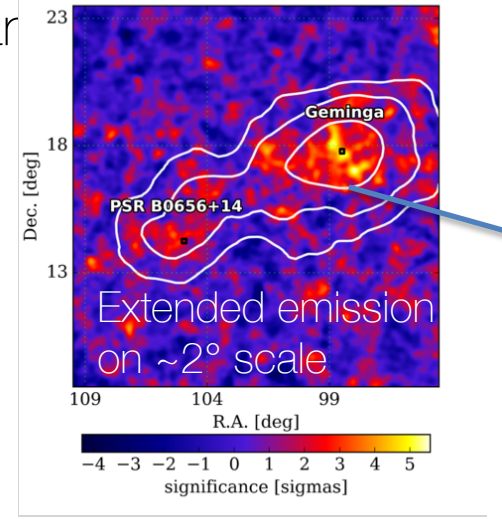
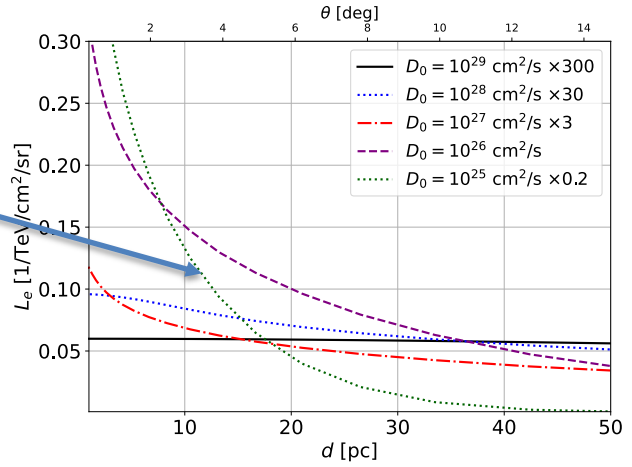


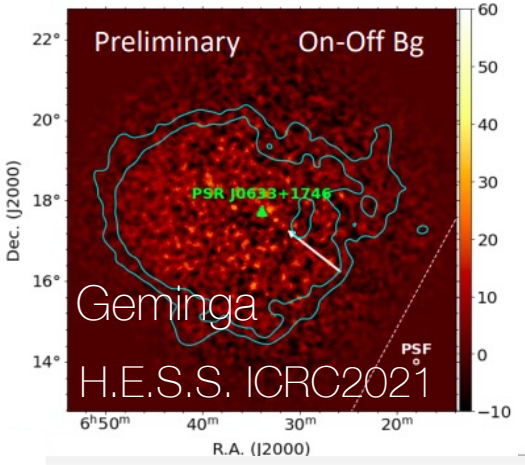


- TeV halos: larger zone in which the pulsar does not dominate the environment: diffusion regime

- Data implied the diffusion coefficient to be two orders of magnitude lower than the one in the Galaxy.

  - Understanding transport of particles in the vicintiy of the sources

  - Input for understanding the origin of the positrons excess' seen by AMS02



- H.E.S.S observations of Geminga

- More halos candidates seen by LHAASO and TibetAS-γ

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Extended VHE sources: detection of TeV halos

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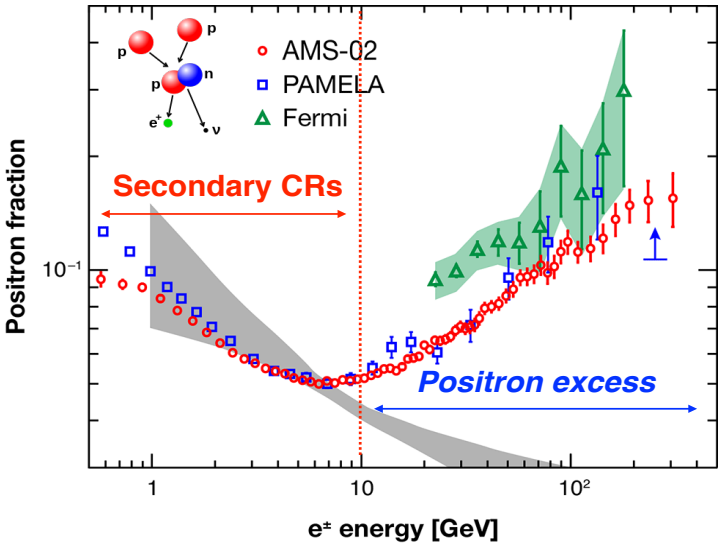
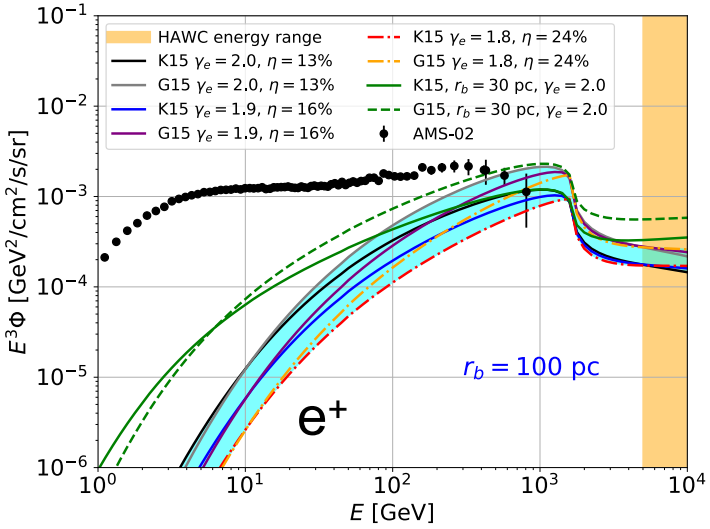


The nearby plusar Geminga alone could contribute to the entire positron excess around 1 TeV.

- The exact contribution depends on the size of the low-diffusion halo

- Other pulsars could contribute as well



#Di Mauro

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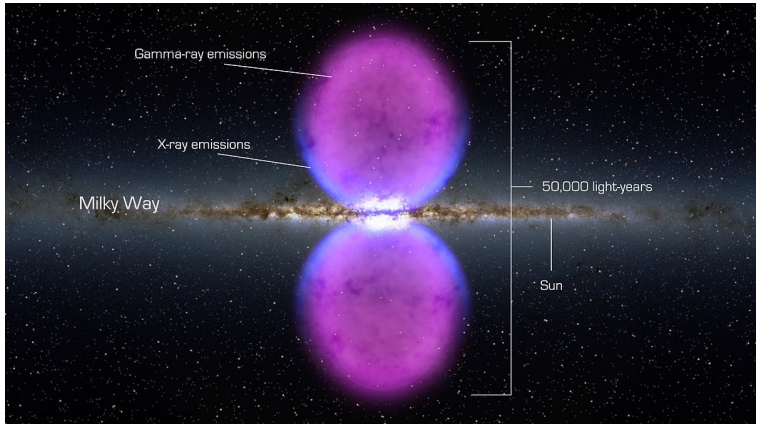
Fermi Bubbles @ VHE ?

- A double-lobe structure observed by Fermi-LAT about a decade ago
  - origin still unknown
    - Counterparts in the X-rays observed by eRosita, and at other wavelengths, e.g., the microwave haze and radio emissions
    - The Fermi Bubbles look like brighter close to GC with an energy spectrum that remains hard ($\sim E^{-2}$) up to ~1 TeV



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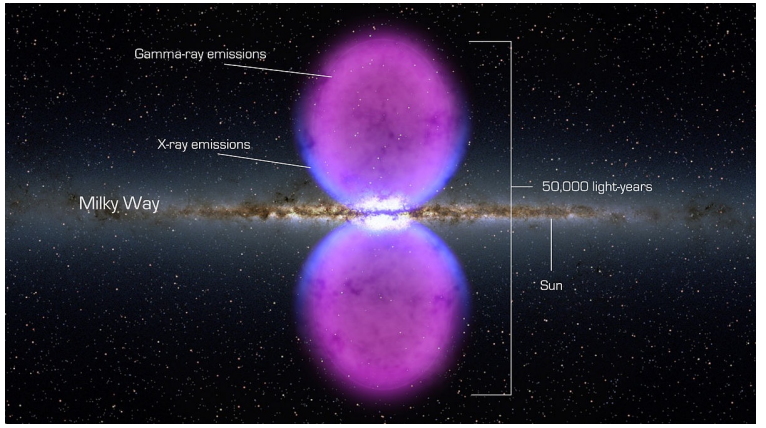
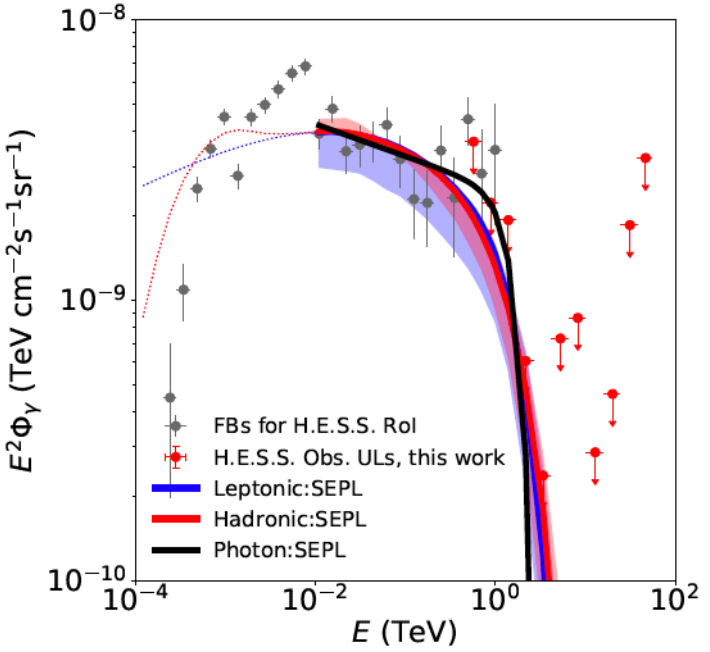


- H.E.S.S. data analysis of 546 hours of high-quality data
  - Differential flux upper limits 95% C.L. UL in the TeV
  - Constraints on model parameters of the injected particle spectrum in leptonic and hadronic scenarios



#A. Montanari

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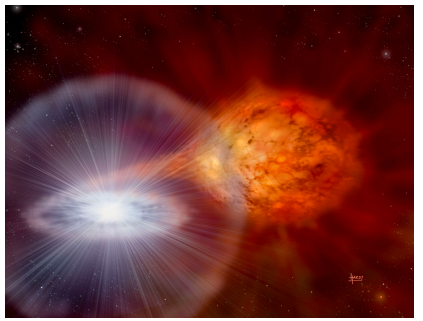
A new class of VHE sources

- Novae – outbursts from accreting binary systems of White Dwarf + massive donor star
- Detected in gamma rays, i.e., Fermi-LAT



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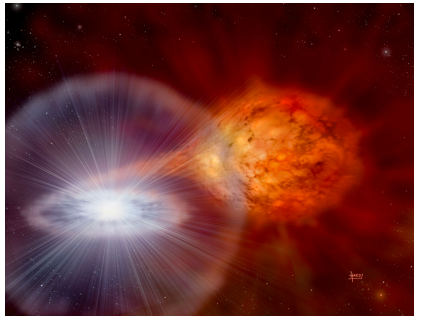
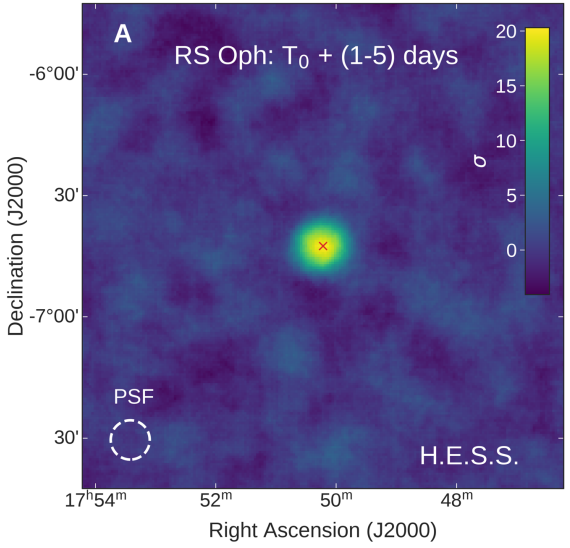
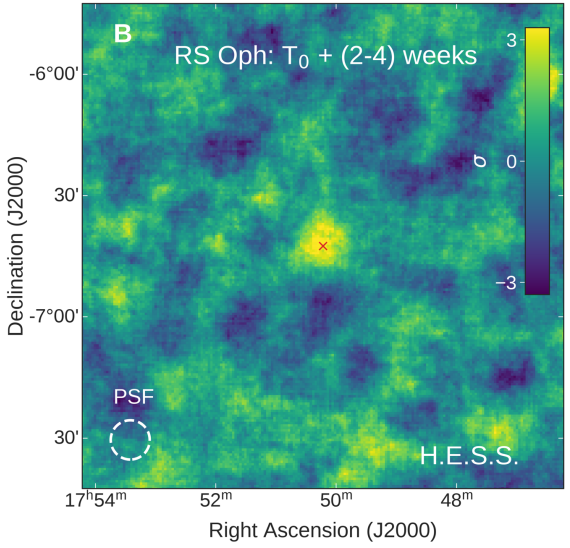
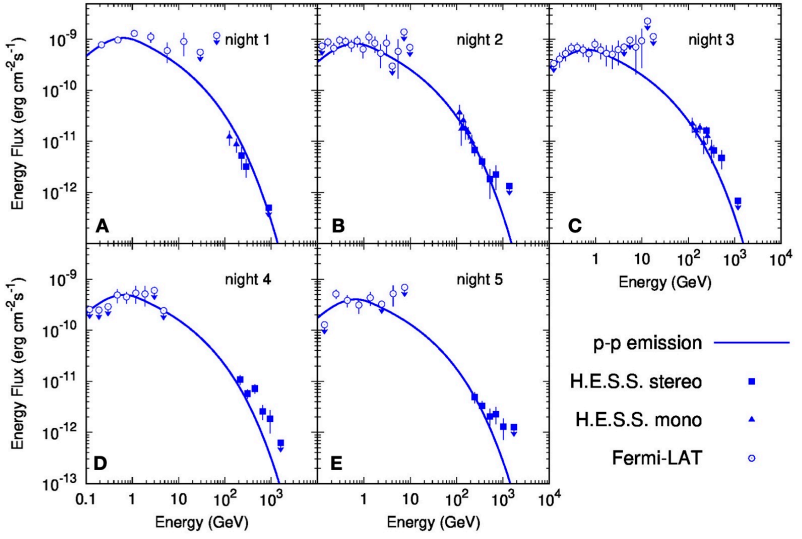


- H.E.S.S. detection of RS Oph







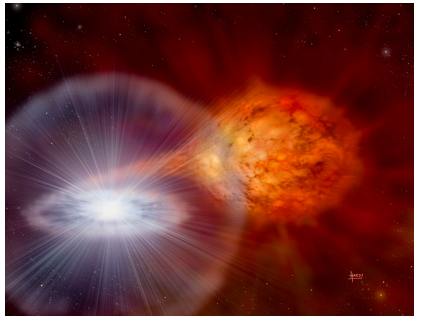
- Detection at > 6 sigma on each night of first five nights
- Hadronic acceleration scenario preferred

#A. Mitchell

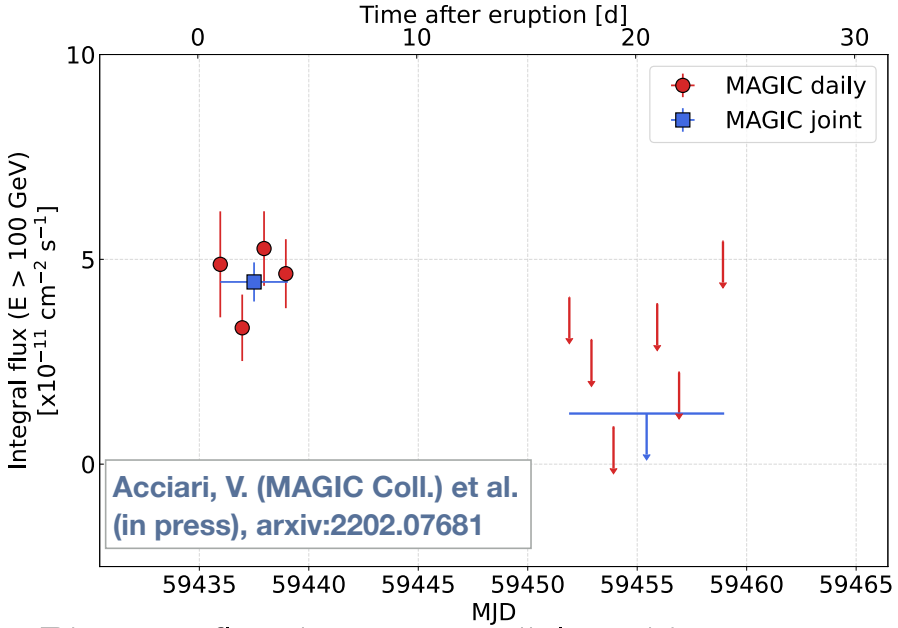
CEA – Saclay

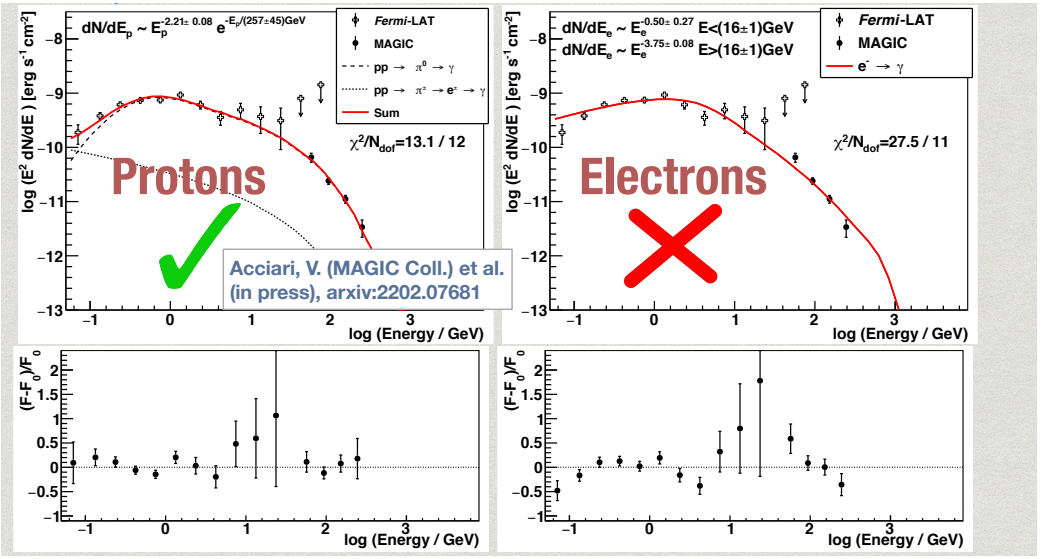
A new class of VHE sources

- Novae – outbursts from accreting binary systems of White Dwarf + massive donor star
- Detected in gamma rays, i.e., Fermi-LAT



- MAGIC detection of RS Oph





- Photon flux is compatible with constant
- Hadronic acceleration scenario preferred

#R. Lopez-Coto

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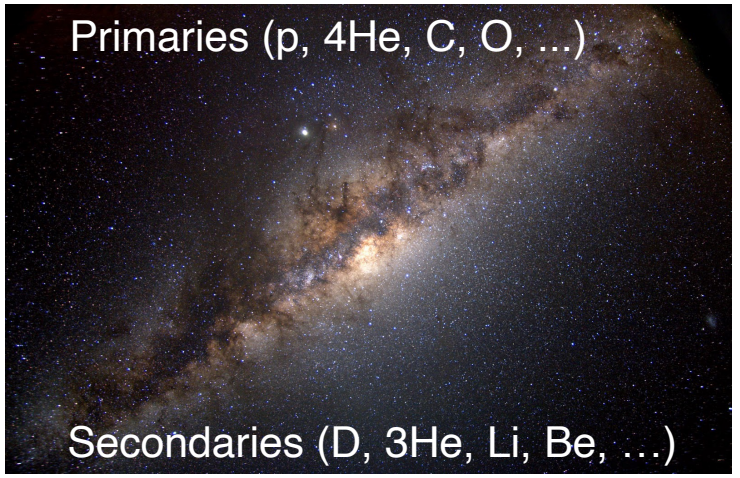
COSMIC RAYS

CR nuclei measurements

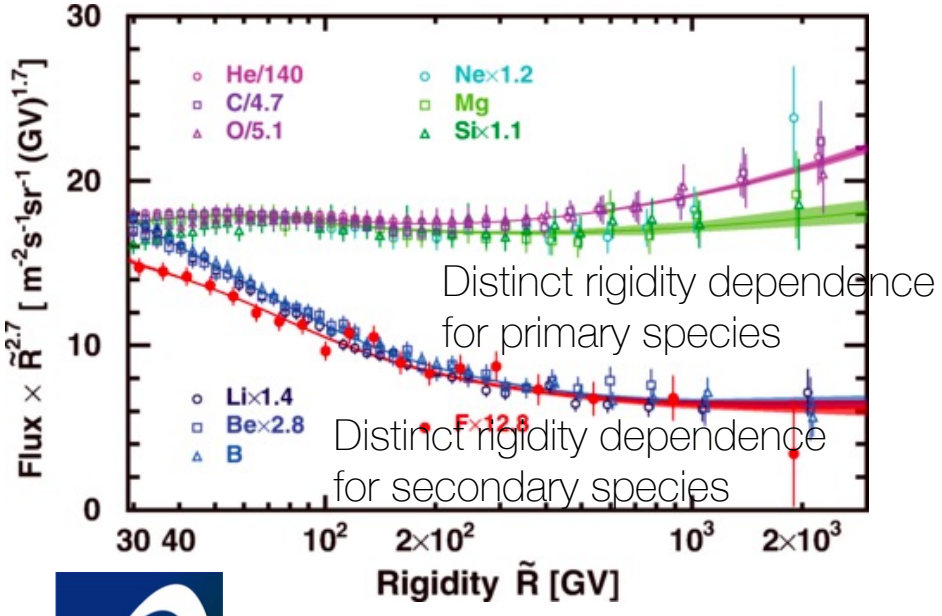


- Primaries are produced and accelerated at the sources. $\Phi_P \propto \frac{q}{K} \propto R^{-\alpha-\delta}$

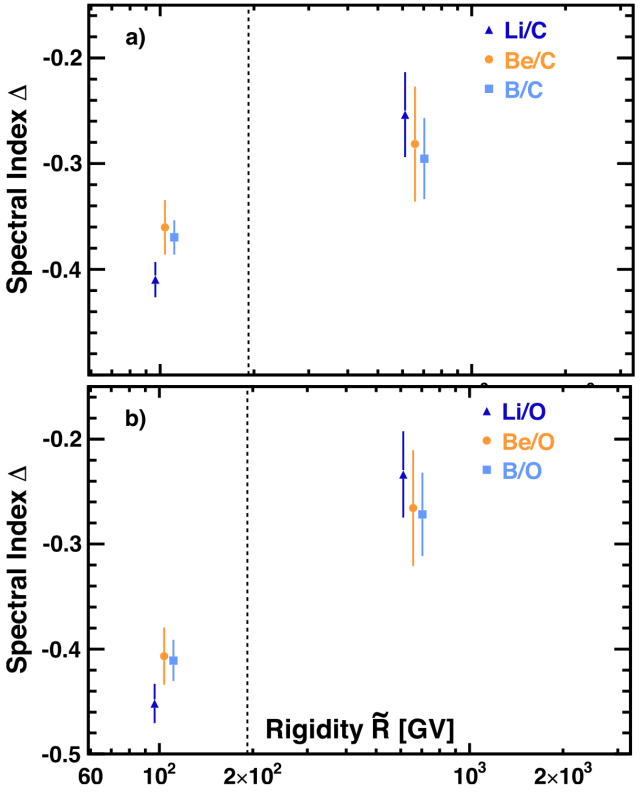
- Secondaries are produced by the collisions of primaries with the interstellar medium (ISM).

$\Phi_S \propto \frac{\Phi_P}{K} \propto R^{-\alpha-2\delta}$

q(R) is the source term (a power-law in rigidity)
K(R) is the diffusion coefficient (a power-law in rigidity)



AMS provides evidence for a break in the B/C



#M. Vecchi

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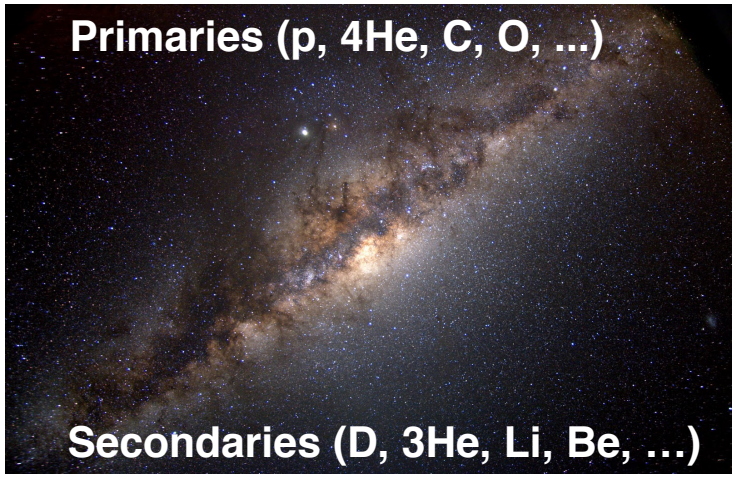
CR nuclei measurements



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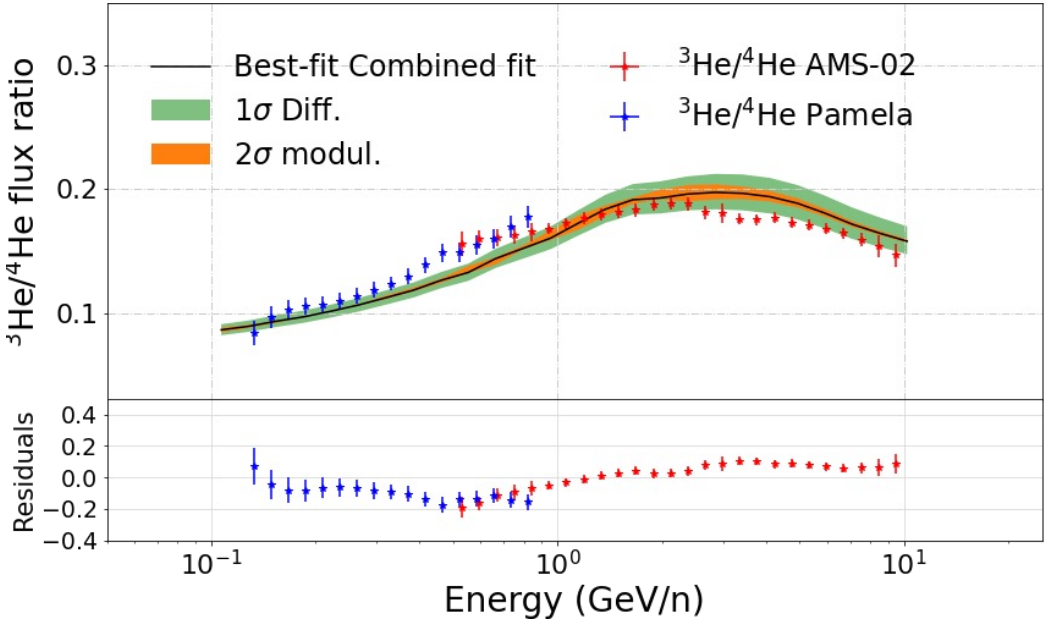
q(R) is the source term (a power-law in rigidity)
K(R) is the diffusion coefficient (a power-law in rigidity)

- Computation of cross sections is a limitation for most of the analyses of propagation of charged particles in the Galaxy

#P. de la Torre Luque



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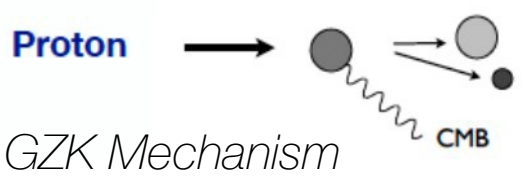
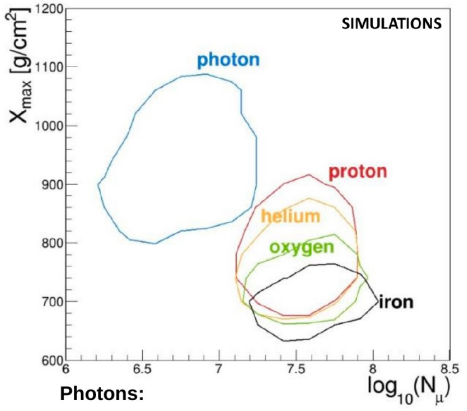
UHECR and neutral CR measurements

- Measurements of neutrals
  - expected from propagation



GZK Mechanism

- Photon shower different from CR nuclei ones
  - Larger Xmax (maximum closer to the ground)
  - Lower number of muons (but not 0 due to photo-nuclear interactions)
  - Best identification using Xmax and Nμ



Deeper depth at the shower maximum
Lower number of muons

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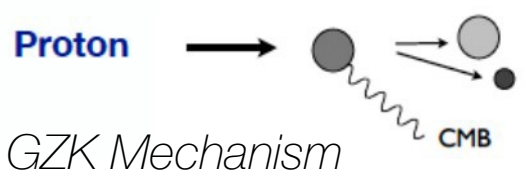

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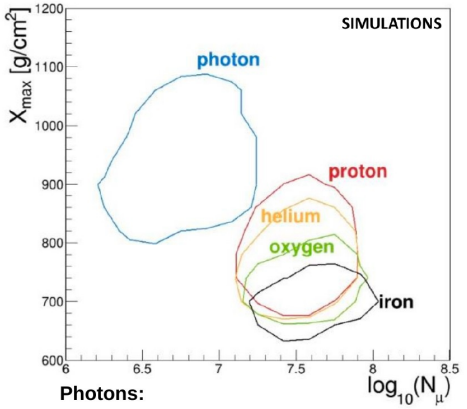

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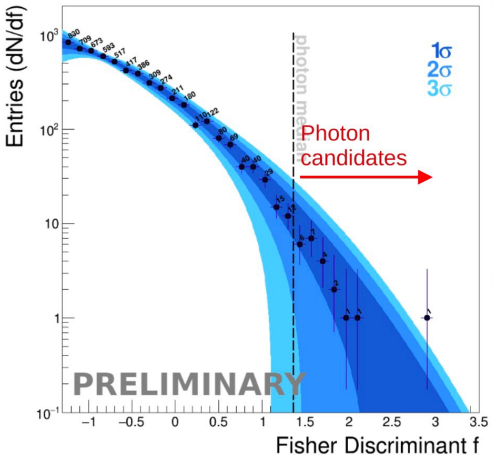


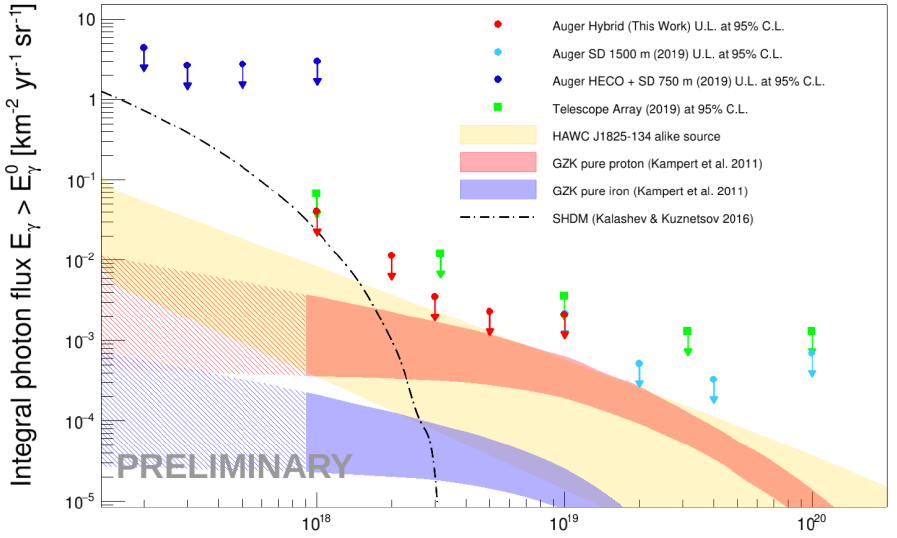
estimated events above median:
$N_{exp}(E > 10^{18.0}$ eV) = 30 ± 16

Candidates found:
$N_{obs}(E > 18.0$ eV) = 22

Median of the photon distribution derived as **photon selection cut** from the study of the background extrapolation.

Photons identified as excess with respect to the expected background

#T. Pierog



PAO starts constraining the most optimistic models of cosmogenic photon production by protons

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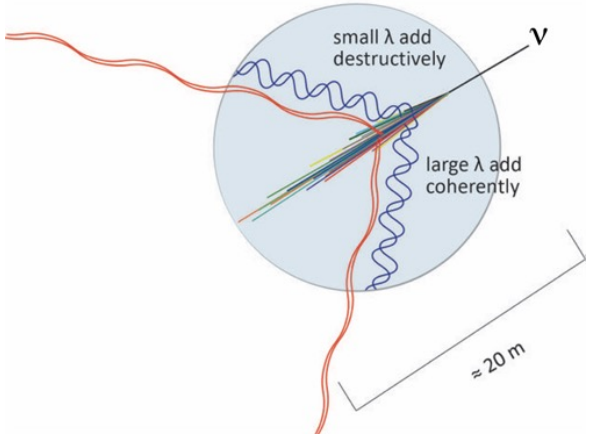
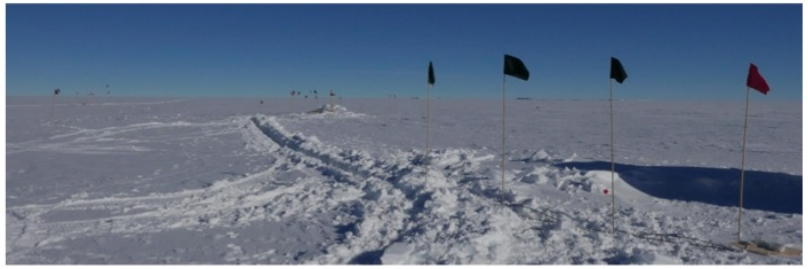
UHE neutrino search with radio



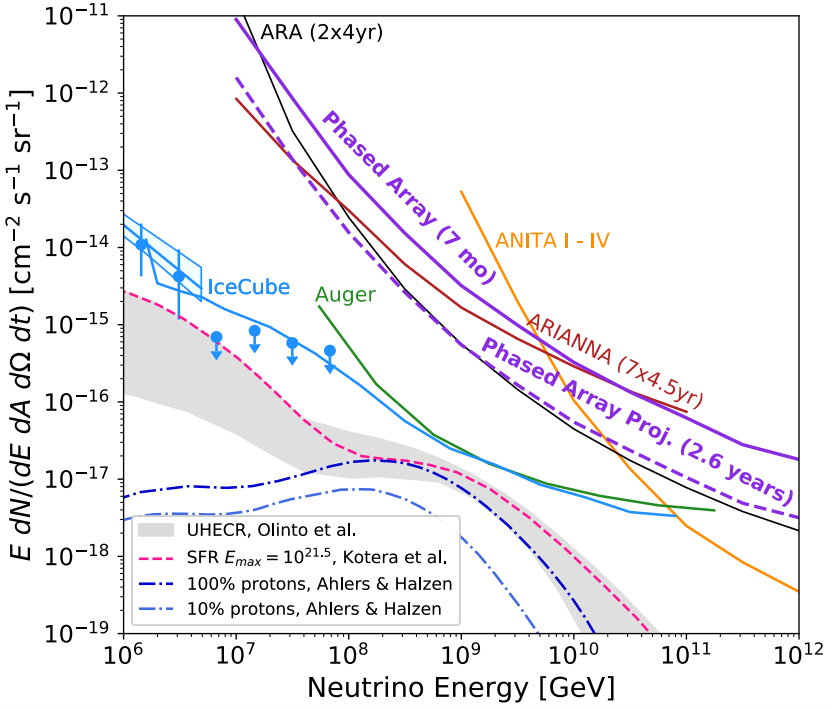
- Askaryan effect: predicted in 1960s and demonstrated in early 2000s
  - particle shower with negative charge excess
  - Cherenkov Radiation: coherent for wavelengths > lateral width of the shower
  - In ice, this coherent radiation is radio waves!
  - Radio attenuation length in ice is ~ 1 km; detectors can be sparely instrumented

- The Askaryan Radio Array (ARA)
  - 5 independent stations spaced 2 km apart
  - Located at the South Pole



  - 208 days of livetime from 2019

#K. Hughes



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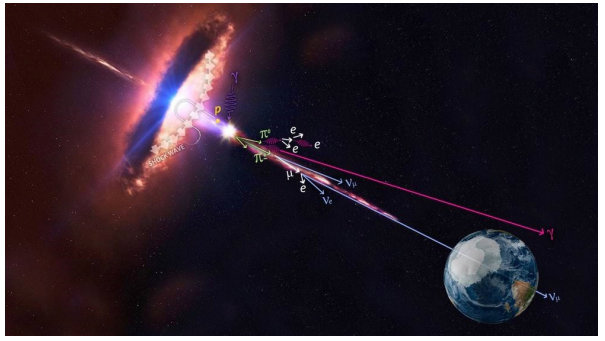
MULTI-MESSENGER ASTRONOMY

Neutrino alerts and VHE gamma-ray follow-up

- Space and time correlations would provide ”smoking gun” signal for joint emission processes
  => CR interaction/acceleration



- Neutrino alert emission
  - Event-by-event estimation of Astro probability
    - Bronze/Gold alert streams (30%/50% astrophysical probability)
  - Follow-ups by IACTs, see TXS 0506+056 for single–neutrino alert

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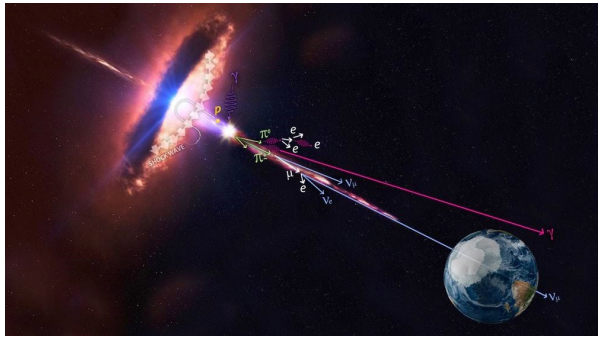
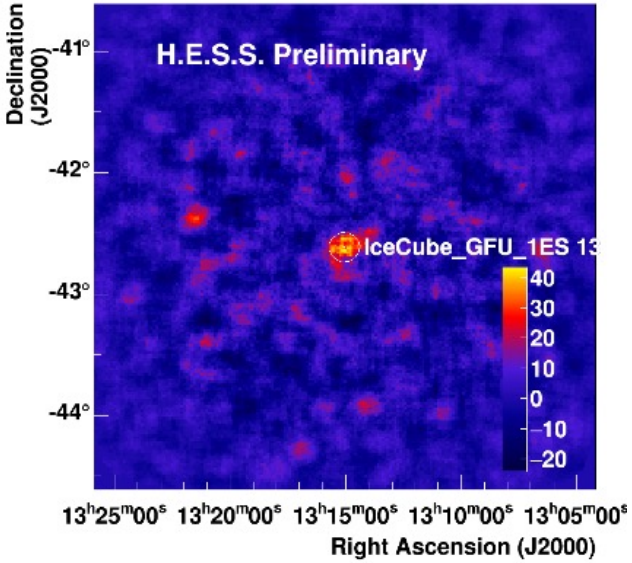
Neutrino alerts and VHE gamma-ray follow-up

- Neutrino alert emission
  - Event-by-event estimation of Astro probability
    - Bronze/Gold alert streams (30%/50% astrophysical probability)
  - Follow-ups by IACTs, see TXS 0506+056 for single–neutrino alert



- Searches for neutrino multiplets (“flares”) in the IC online data stream
  - Neutrino multiplet from 1ES 1312-423
  - H.E.S.S. ToO observations => re-detection of the source (~4sigma)
  - No significant change in the non-thermal emission during the ToO neutrino multiplet from 1ES 1312-423



#F. Schussler

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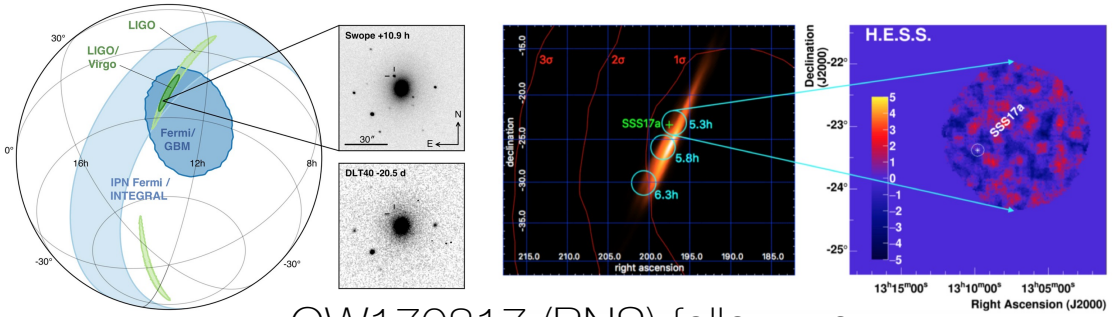
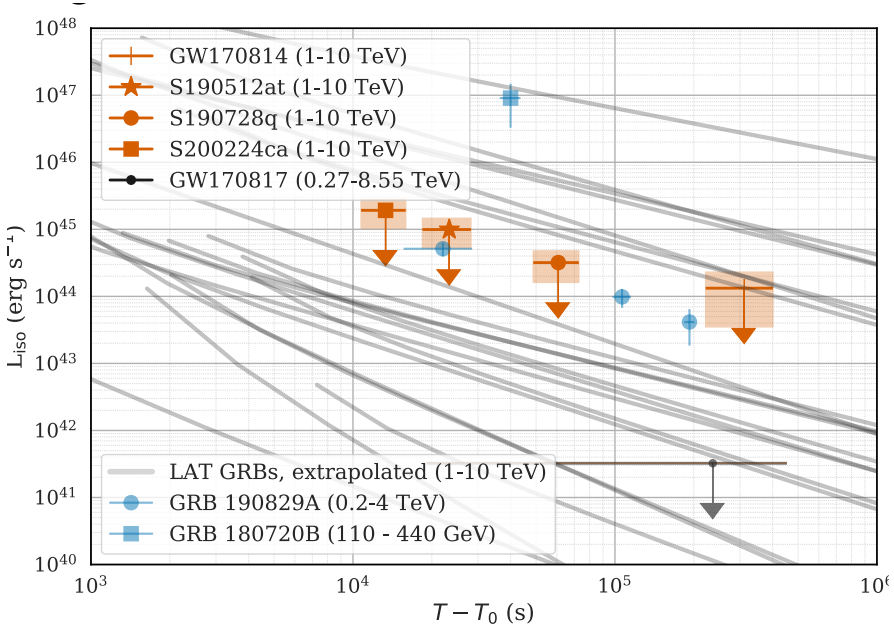
Gravitational wave follow-up with H.E.S.S.

- Since 2017 H.E.S.S successfully followed in total 5 GW events:
  1 BNS and 4 BBH.



GW170817 (BNS) follow-up

- BBH follow-up
  - No significant VHE emission found for GW170814, GW190512, GW190728 and GW200224
  - Comparison with VHE GRBs: GRB 180720B & 190829A
  - GRBs could be detectable by H.E.S.S. if produced by BBH mergers
  - more prompt opportunities during O4 with deeper observations



#H. Askar

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Gravitational wave follow-up with H.E.S.S.

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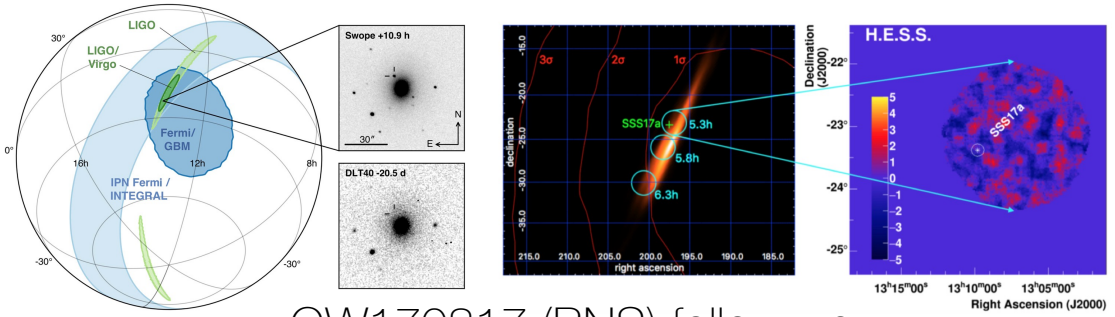

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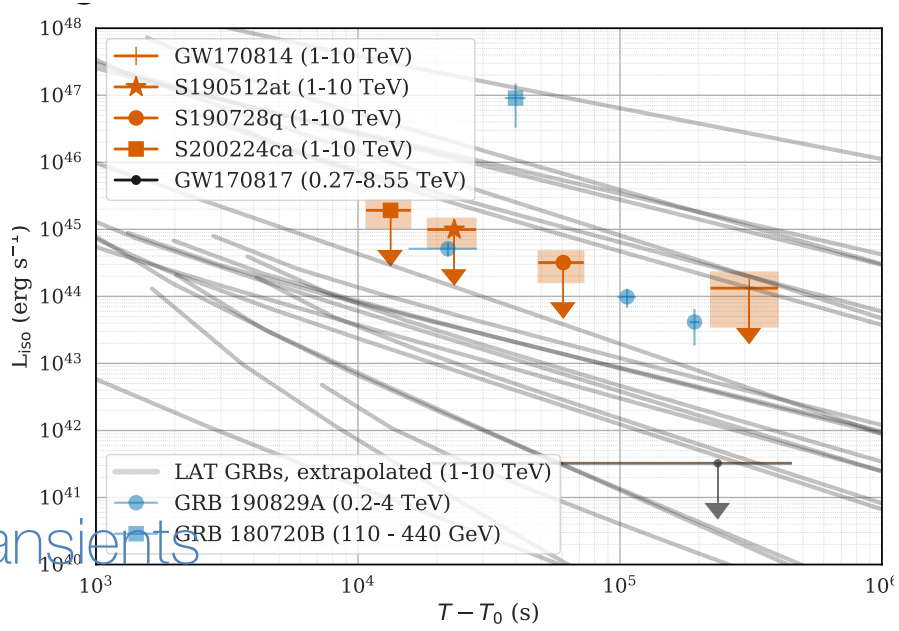
  - more prompt opportunities during O4 with deeper observations
- Astro-COLIBRI for easy access to main transients



#V. Lefranc

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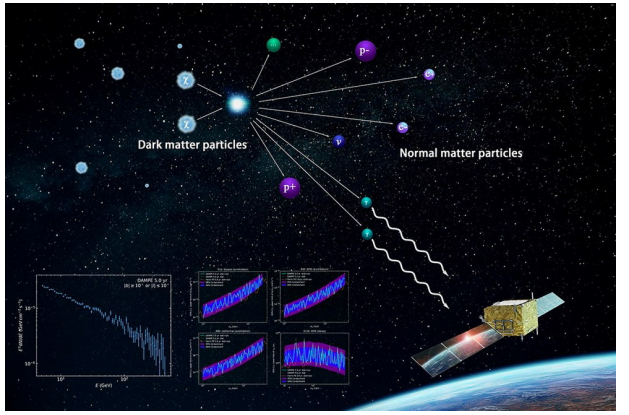
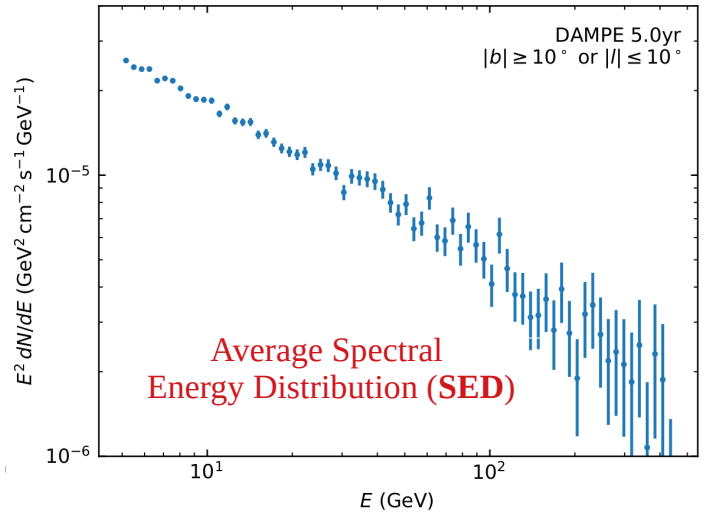
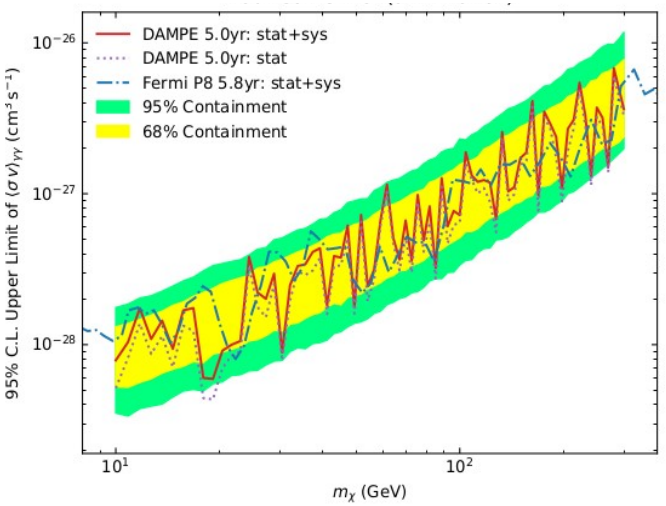
DARK MATTER

Dark matter line search with DAMPE

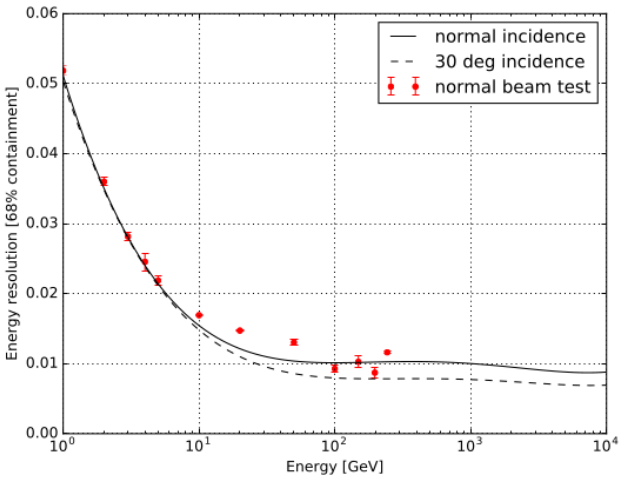
- DAMPE was successfully launched on December 17th 2015 from the Jiuquan Satellite Launch Center
- 5 years of data: 2016 – 2020, Energy range: [5 – 450] GeV, DMDM –> $\gamma\gamma$ search







DAMPE energy resolution for photons and electrons/positron ~ 1% for E>10 GeV



- No obvious line-like structure can be found
- DAMPE 5-year results comparable with 5.8-year results of Fermi-LAT

#F. Alemanno

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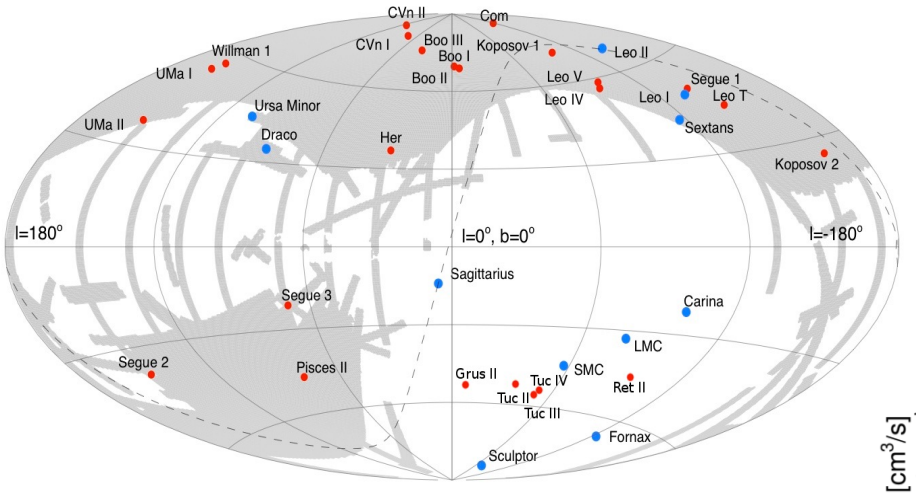
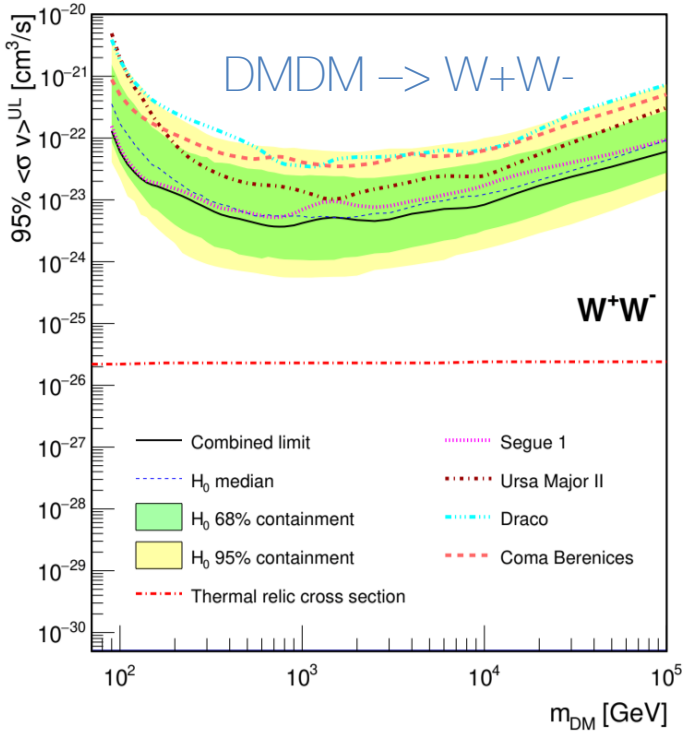
Dwarf galaxy satellites of the Milky Way

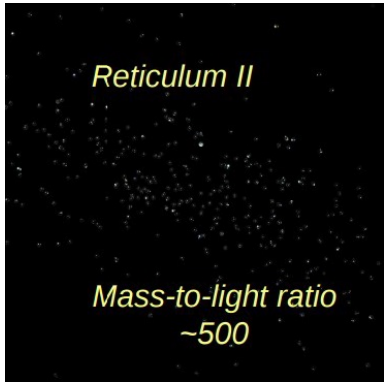


MAGIC combined analysis :
Segue 1 (158 h), Ursa Major II (95 h), Draco (52 h), and Coma Berenices (50h) with a total exposure of 355 h

- DM-dominated objects
- No recent star formation
- Very low gas amount

→ they could give unambiguous detection





- Searches on specific DM models, e.g., Wino, Higgsino, branons, …

- Combined dark matter searches towards dwarf spheroidal galaxies with Fermi-LAT, HAWC, H.E.S.S., MAGIC, and VERITAS

#T. Miener

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Boosted dark matter

- CR-boosted DM scenarios

  e.g., galactic Cosmic Rays (CRs) boosting local DM particle (CRDM scenario)

- Blazar-Boosted Dark Matter (BBDM):

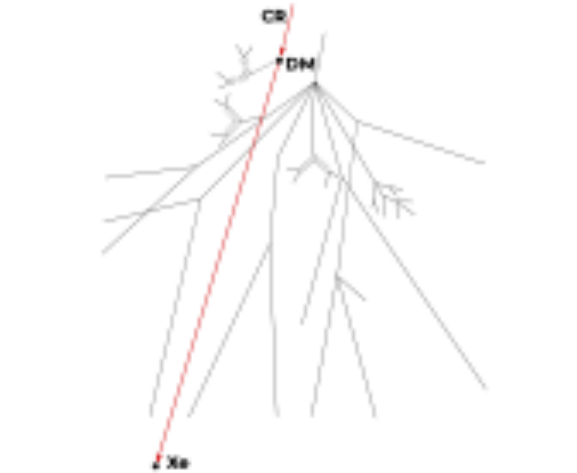
  the possibility of protons and electrons in the jet of a blazar boosting the neighboring DM particles to Earth.

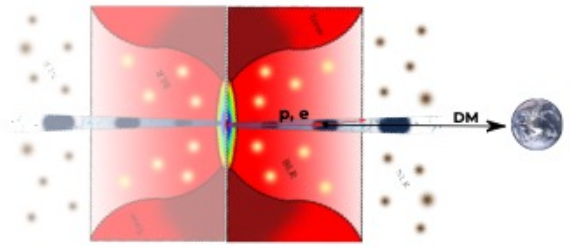
  -> constraints on the DM-proton and DM-electron cross-sections

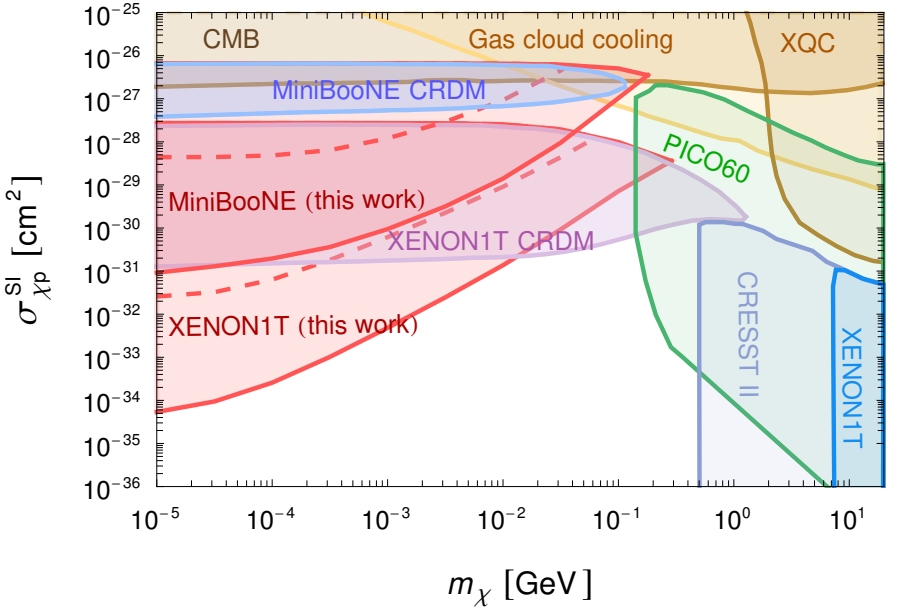
  - Hadronic model for TXS 0506+056
  - The null detection of BBDM signals at XENON1T gives very competitive constraints on $\sigma_{\chi\text{-p}}$

#A. Granelli

Caveat : DM distribution around the SMBH of the balzar…







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THANKS