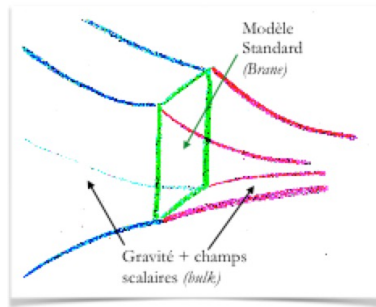
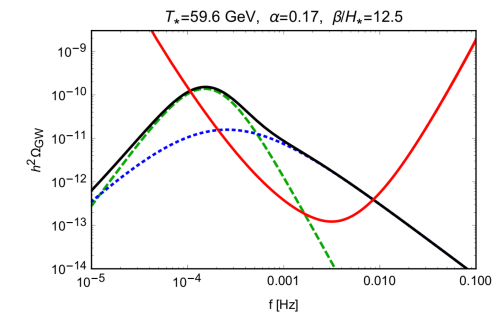
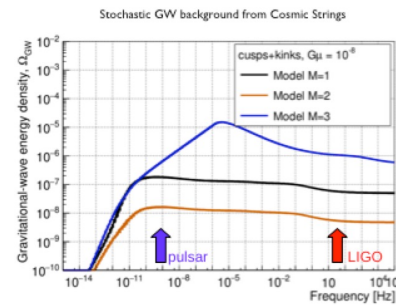
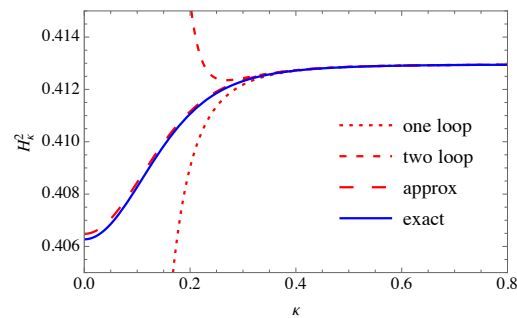
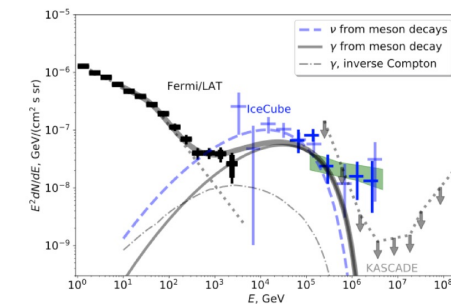
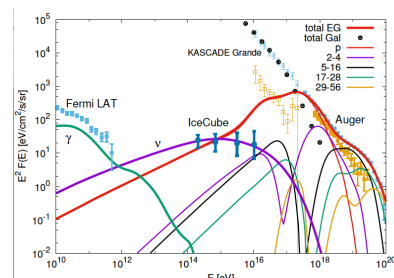
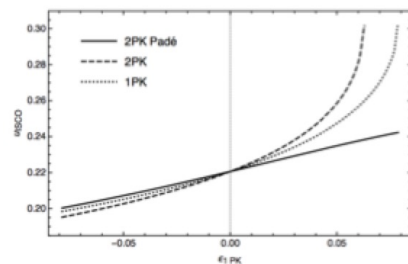


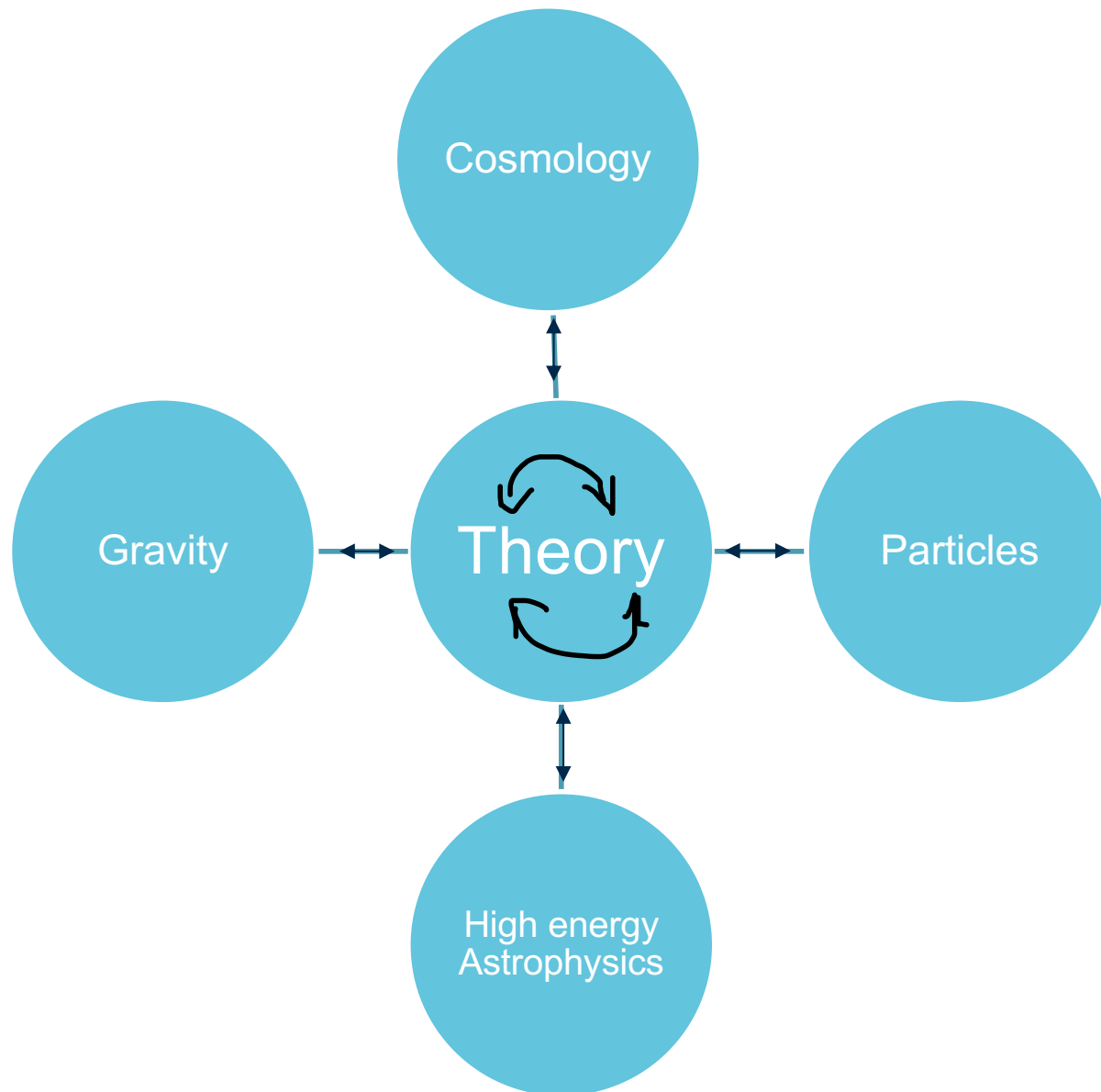
APC Theory Group



Dmitri Semikoz



Theory in APC



Theory group: 28 members

- Responsable scientifique de l'équipe :
- Head of group Dmitri Semikoz, vice-head Eric Huguet

Liste des chercheurs de l'équipe : 12+3 permanents

• CNRS.		University Paris Cite		Emeritus/bénévole
• Gwenaël Giacinti	DR	Huguet Eric	MCF/ HDR	Gazeau Jean-Pierre PR
• Kiritsis Elias	DR	Mourad Jihad	PR	Lachière-Rey Marc. DR
• Langlois David	DR	Neronov Andrii	PR	Renaud Jacques PR
• Lemoine Martin	DR	Nitti Francesco	PR	
• Luca Santoni	CR/HDR	Serreau Julien	MCF/ HDR	
• Semikoz Dmitri	DR			
• Volpe Cristina	DR			

Postdocs: 5

Alessandro Longo (L.Santoni). Wenlian Lee (A.Neronov)
Andrea Olzi (F.Nitti) Alexander Korochkin (D.Semikoz)
Thomas Colas (D.Langlois)

PhD Students: 9

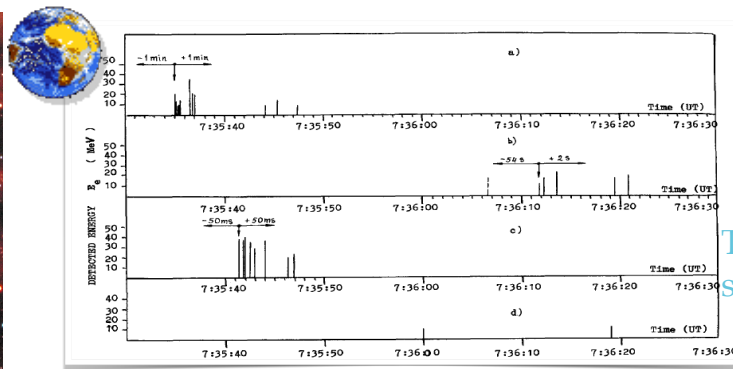
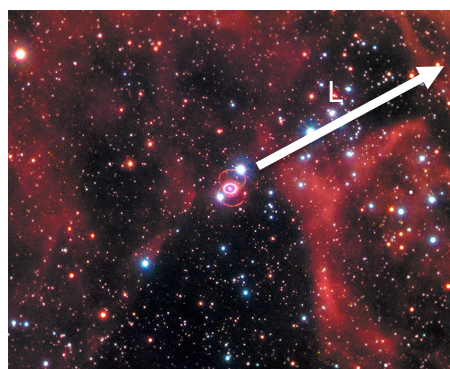
Apostolides Thomas (E.Kiritsis) Maksim Kleimenov (G.Giacinti)
Betrand Theodore (F.Nitti) Le Bihan Sébastien (M.Lemoine)
Blunier Jeffrey (A.Neronov)
Combaluzier-Szteinsznader Oscar (L.Santoni) Raymond Jean-Loup (F.Nitti)
Fourquet Philippe (Eric Huguet) Zhu Zhanfeng (D.Semikoz)

Major theory problems studied in APC theory:

- Unification of particle physics and Gravity:
 - String theory
 - Holography -> dark energy
- New developments in quantum field theory
- Gravity theory – cosmology/ modified gravity
- (pre)-inflation theory
- Neutrinos from SN /decays
- Dark current / cosmic ray physics: acceleration/propagation theory/ source models / GMF models
- Multi-messenger astrophysics /theoretical models
- Cosmological magnetic fields /theory and observational signatures

Highlight #5 neutrino decay to Majoron

Cristina Volpe SN1987A and neutrino non-radiative decay



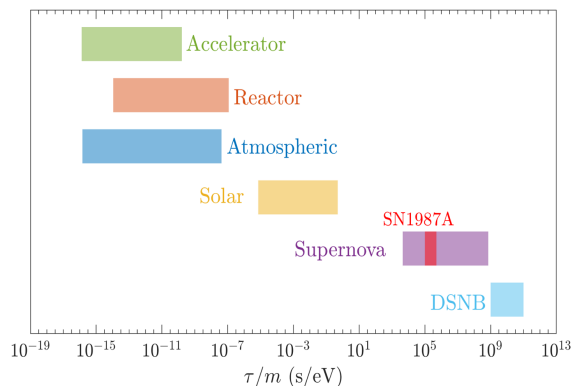
Neutrino being massive, they can decay into a massless (or almost) massless (pseudo)scalar like the Majoron – candidate for light dark matter.

$$\nu_i \rightarrow \nu_j + \phi \quad \text{or} \quad \nu_i \rightarrow \bar{\nu}_j + \phi$$

The neutrino fluxes suppressed by $\exp\left(-\frac{L}{\tau} \times \frac{m_{\text{mass}}}{E_{\text{energy}}}\right)$

lifetime

Neutrino non-radiative decay in vacuum

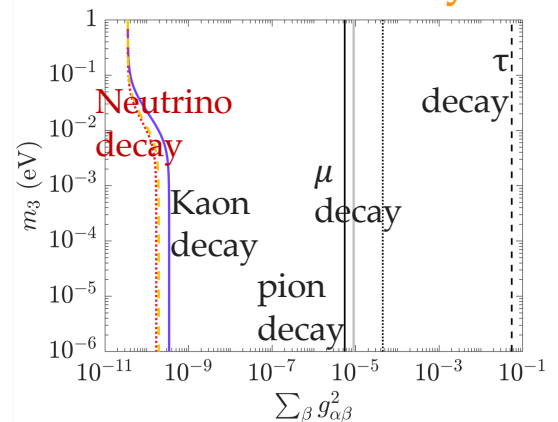


First likelihood analysis of 24 SN1987A in Kamiokande, IMB and Baksan including neutrino decay

$$\frac{\tau}{m} > 1.2 \times 10^5 (90\% \text{ CL}) \text{ for } \nu_1, \nu_2 \text{ (IO)} - \text{PDG 2024}$$

Ivanez-Ballesteros and Volpe, PLB 2023, [2307.03549](#)

Neutrino non-radiative decay in matter



First likelihood analysis including neutrino decay in matter into Majorons: very competitive limits on neutrino-Majoron couplings. - PDG 2026

Ivanez-Ballesteros, Volpe, PRD Letter 2026, [2410.11517](#)

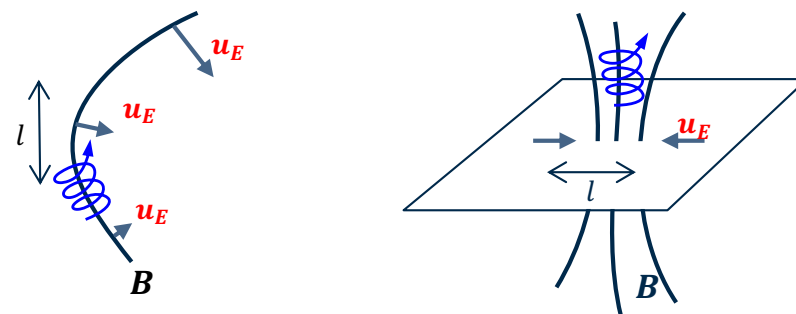
Highlight #6 Acceleration theory and NGC 1068

M. Lemoine

Theory of particle acceleration in extreme environments:

→ an effective theory of stochastic acceleration (“generalized Fermi”) combining GR tools and turbulence physics

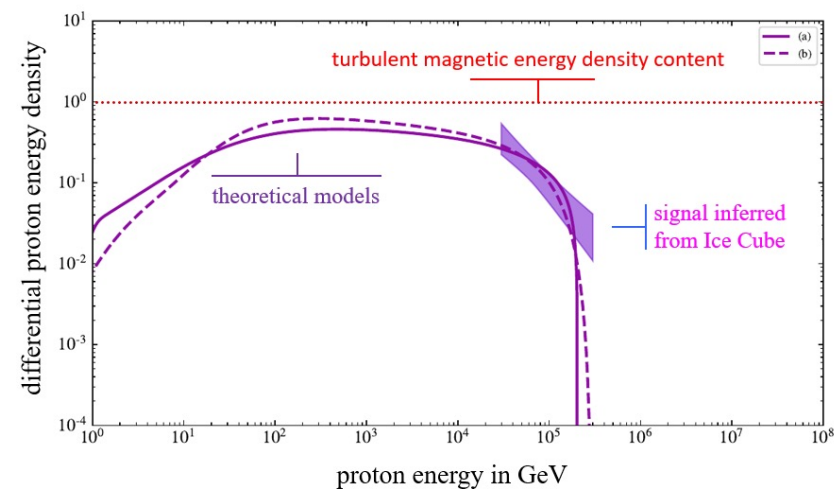
M. Lemoine [Phys. Rev. E, in press (2025), arXiv:2501.19136]



Multimessenger astrophysics:

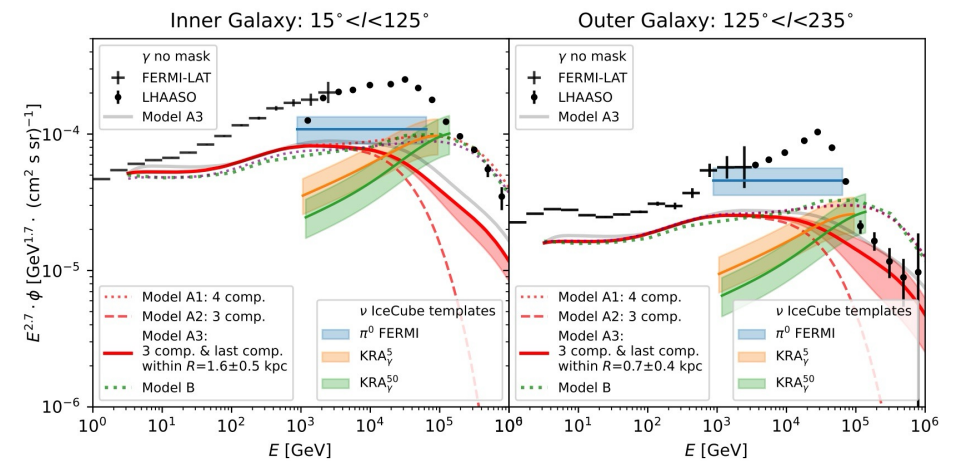
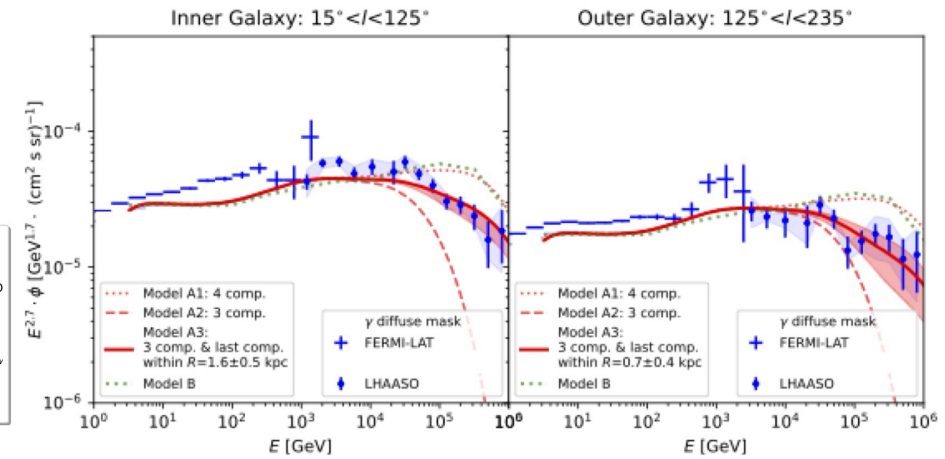
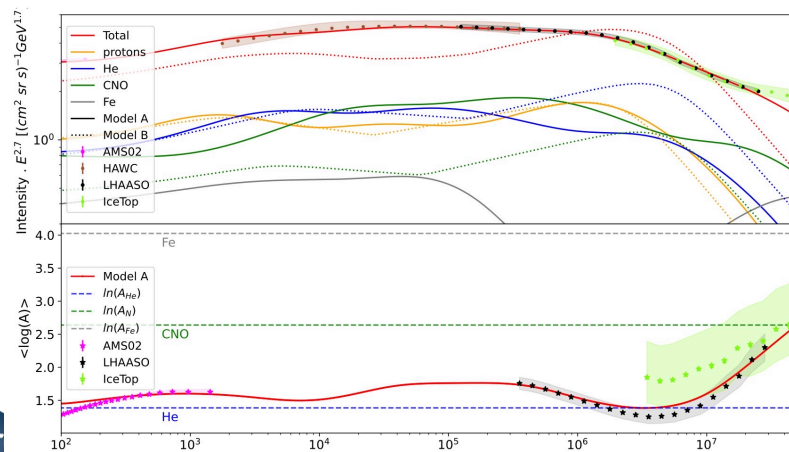
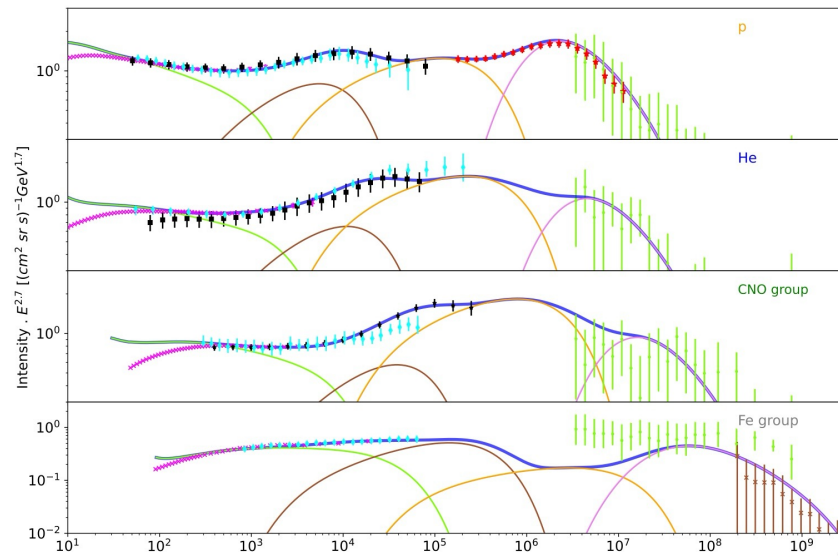
→ a theoretical model of proton acceleration to VHE in the turbulent corona of AGN black holes, connection to neutrinos from NGC1068

M. Lemoine, F. Rieger [A&A **697**, A124 (2025)]



Highlight #7 Multi-messenger study of Milky Way

C. Prevotat, [Zh. Zhu](#), S. Koldobskiy, [A. Neronov](#), [D. Semikoz](#) and M. Ahlers, *Phys.Rev.D* 112 (2025) 12, 123033



Scientist responsible for project : A.Neronov (APC)

ERC synergy 10 Meuro: APC is leading organisation

What is the origin of cosmic magnetism?

What mechanisms in the primordial Universe could magnetise the cosmic web we observe today?

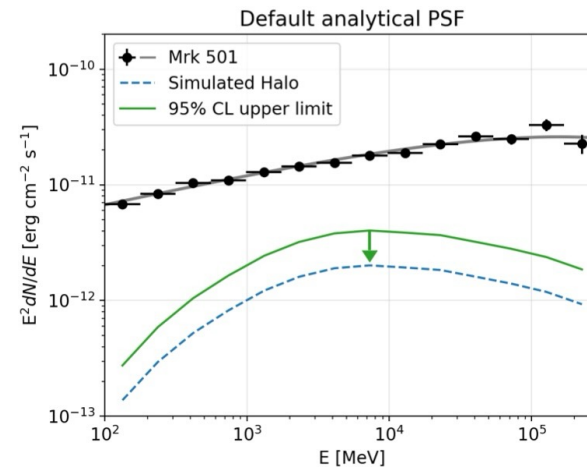
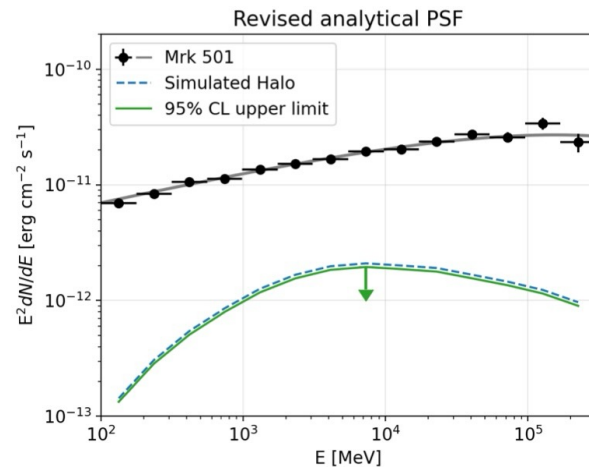
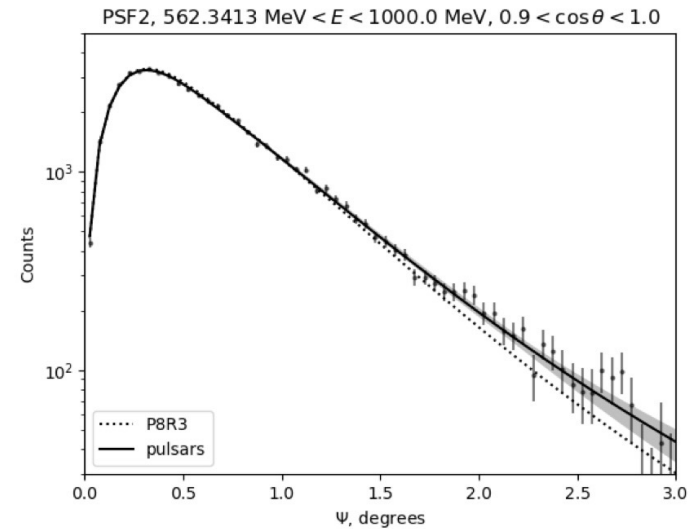
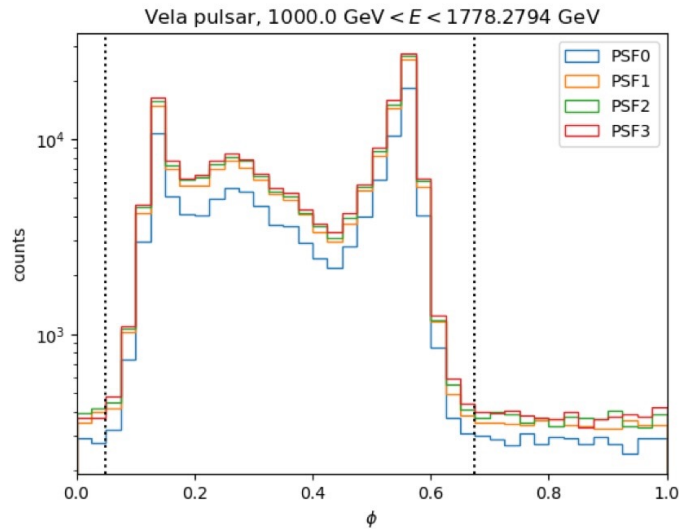
Are magnetic fields the source of the stochastic gravitational wave background?

Can we do early Universe cosmology combining gravitational waves and magnetic fields?



Highlight #8 Pulsar-based modeling of Fermi PSF

- [J. Blunier](#), [A. Neronov](#) and [D. Semikoz](#), 2602.14764



No evidence of signal around Mkn 501

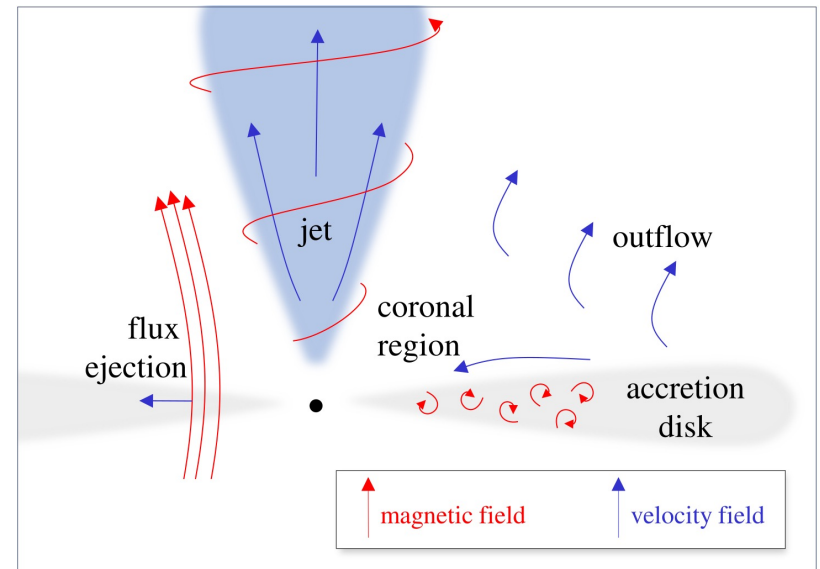
ANR HENBoS (High Energy Neutrinos from massive Black hOle Systems)

PRME: single team at APC (groups: **Théorie, AHE and Particules**) – D. Allard, J. Aublin, B. Baret, F. Casse, M. Cerutti, S. Gabici, M. Lemoine (PI), A. Neronov, E. Parizot, D. Semikoz, R. Terrier, P. Varnière

Funded personnel: 1 post-doc (3yrs) + 1 PhD

Rationale: develop a self-consistent, first-principles view of massive black hole environments as sources of VHE particles (cosmic rays, photons and neutrinos), by combining:

1. theoretical expertise in particle acceleration
2. numerical simulations (GRMHD, GRMHD-PIC, PIC)
3. expertise in phenomenology and detection of VHE multi-messengers.



Scientist responsible for project : D.Semikoz

List of researchers in the project: S.Gabici, G.Giacinti, A.Neronov

- **Postdocs: A.Korochkin, Wenlian Li**
- **PhD A.Inventar, J.Blunier, Zh.Zhu**

- **APC contribution to LHAASO**
- Microquasar V4641 in high zenith angle analysis
- Microquasar Cyg X3 data analysis
- Theoretical models for several LHAASO papers
- APC team is one of 3 working groups on Second LHAASO Catalog of sources
- APC team one of two working groups on diffuse gamma-rays
- New directions in LHAASO including cosmological magnetic fields

Conclusion

- APC Theory team is strong in many theoretical directions and has expertise in all essential directions of APC research including cosmology, gravity, field theory, neutrinos and astroparticle physics
- APC theory team actively interacts with other teams in APC
- In next 3-5 years APC theory team will develop theoretical research within directions financed by ANR and ERC including Holography, Gravity theory, high energy neutrino from BH, multi-messenger signatures of Cosmic Rays and Cosmological Magnetic Fields