Friedrich-Alexander-Universität
Erlangen-Nürnberg

H.E.S.S.

ECAP ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

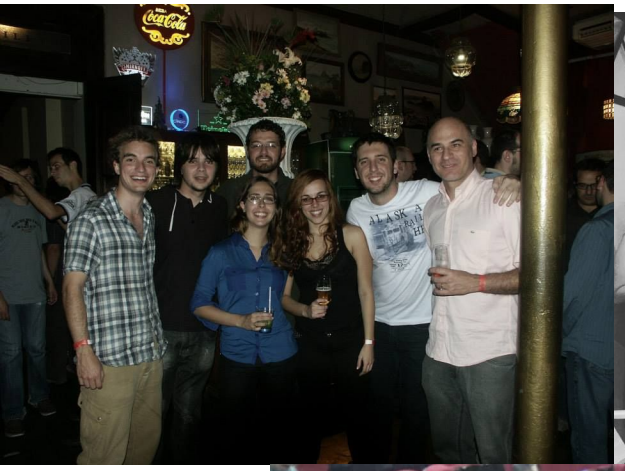
FAU

UHECR, LIV, IACTs, and much more: a X-Tudo presentation

Rodrigo Guedes Lang

High-energy astrophysics in the multi-messenger era workshop, 09/04/2024

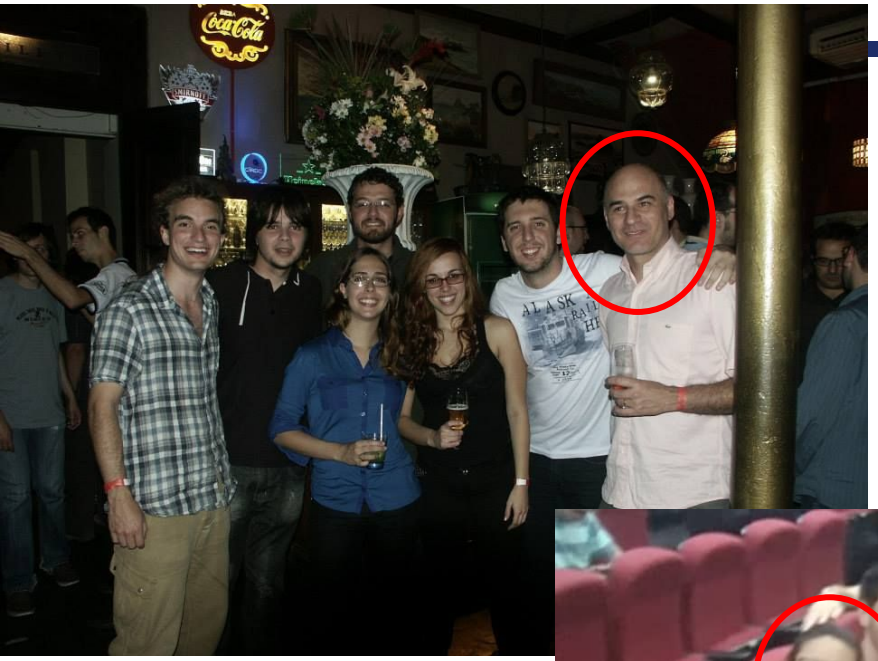
A little on both sides…

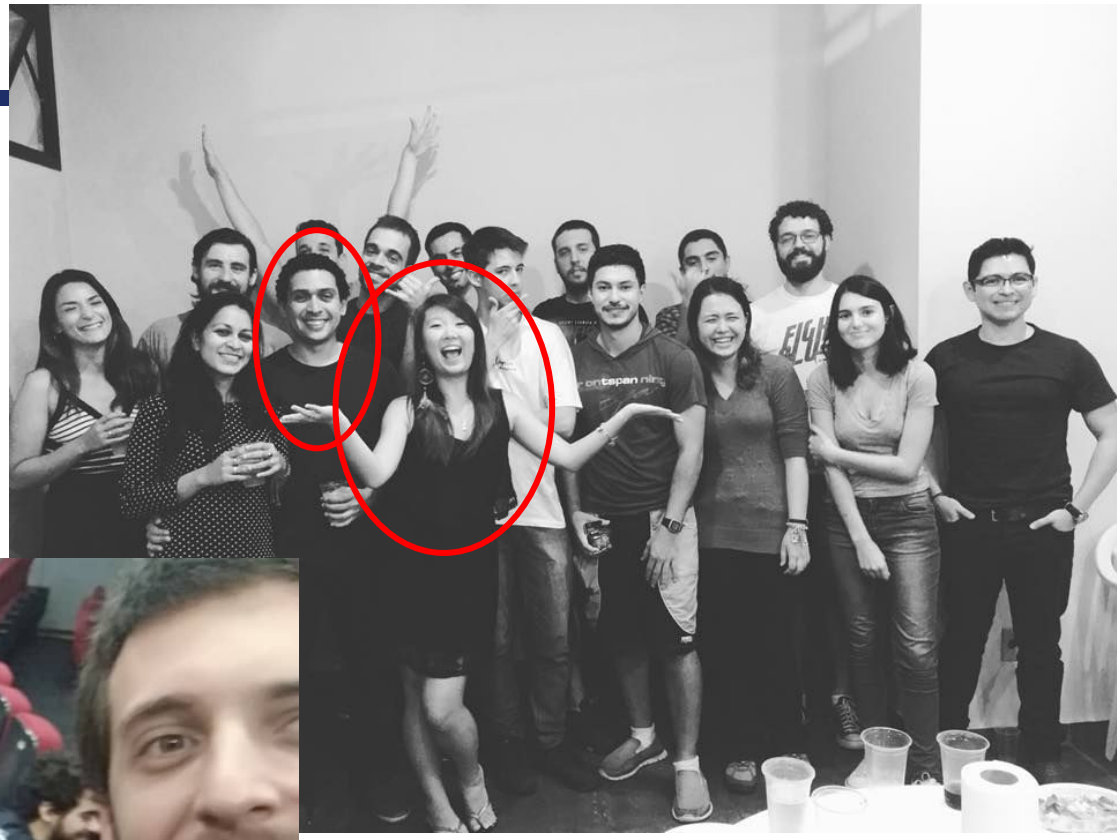


- Bachelor: 2010-2014
- Masters: 2015-2016
- PhD: 2017-2020

- Post-doc: 2021-...

Back in the old days…





That's where we are right now :D

From last year…

HESS

- Reconstruction and gamma/hadron separation;
- Event classes;
- Jelena: time cleaning;
- Tim: improvement of lowest energies for mono;

UHECR

- Origin of UHECR;
- Anisotropy;
- Luciana & Vitor: modelling the dipole;
- Chaimongkol: mass-dependent composition;

SWGO

- Cosmic ray anisotropy and composition;
- Muon reconstruction;

LIV

- Testing LIV with gamma-rays and UHECR;
- EBL interaction;
- Inverse compton emission;

Since last year…

HESS

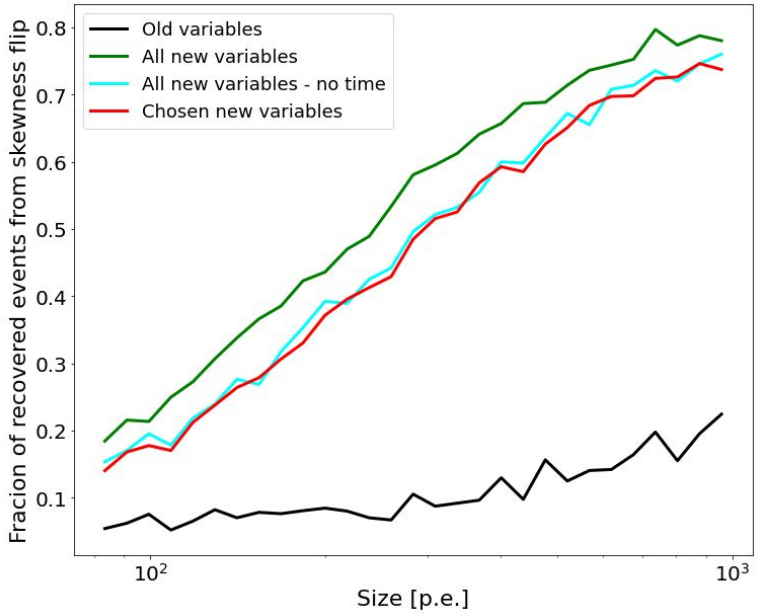
UHECR

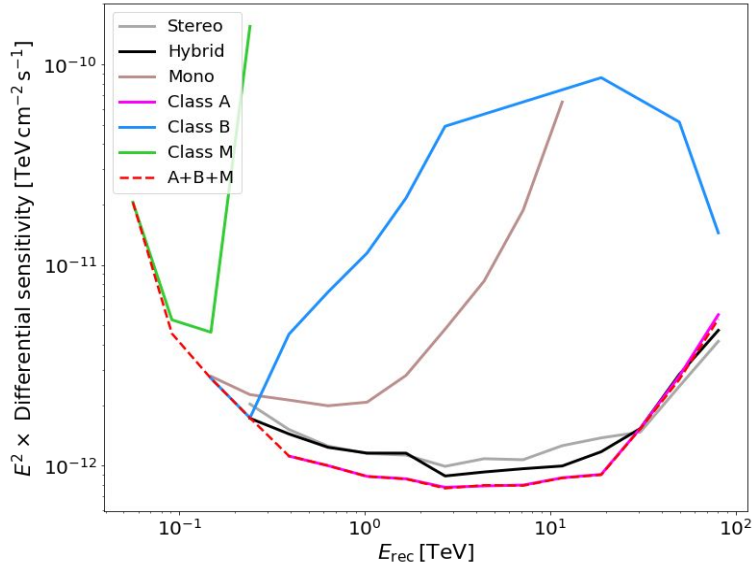
SWGO

LIV

H.E.S.S.

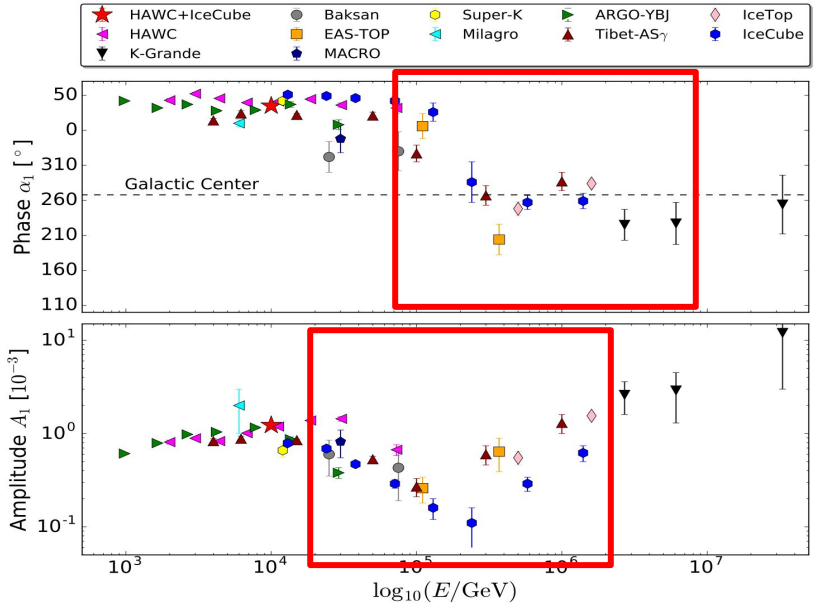
- A (mostly ECAP) team effort to provide the new reconstruction/separation analysis chain for HESS (for the first time the 5 telescopes work well together -> also hopefully much learned for CTA)
- Event classes - Rodrigo++;
- Atmospheric correction - Benedetta, Alison++;
- Improved mono - Tim, Rodrigo++;
- Improved hybrid - Rodrigo++;
- Time cleaning - Jelena, Rodrigo++;

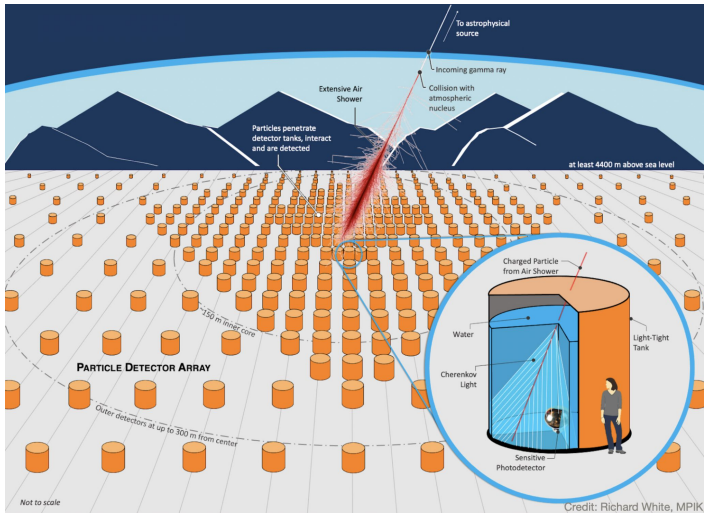


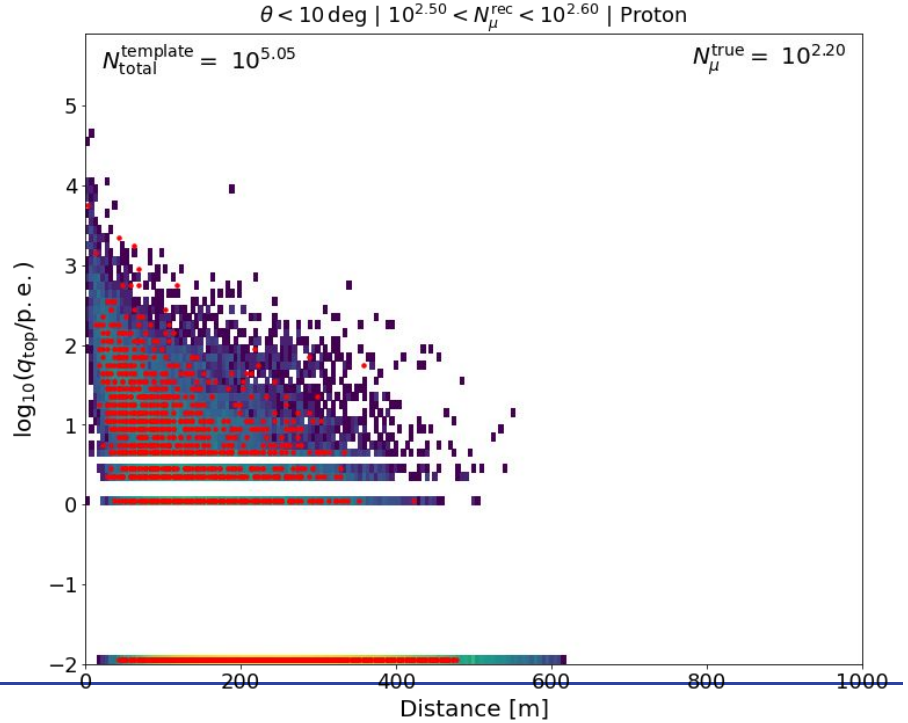


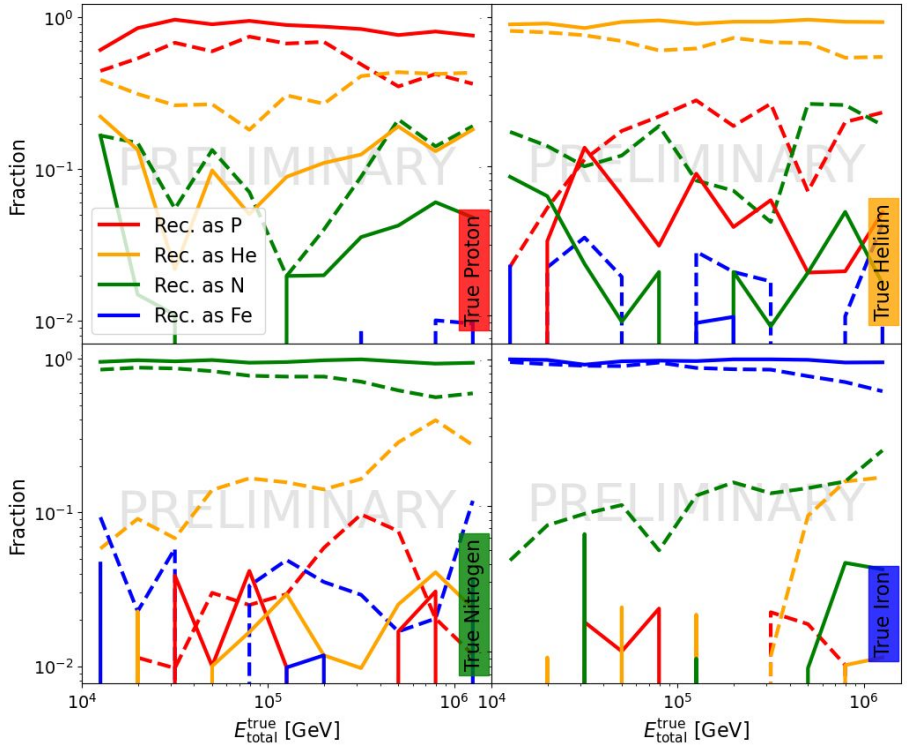
SWGO

- Implementation of a template method for an event-by-event separation of cosmic ray primaries (not gamma/hadron separation!) for ground-based observatories;
- Necessary for a composition-dependent anisotropy;
- We reach a significant separation of > 90% for 4 significative primaries;





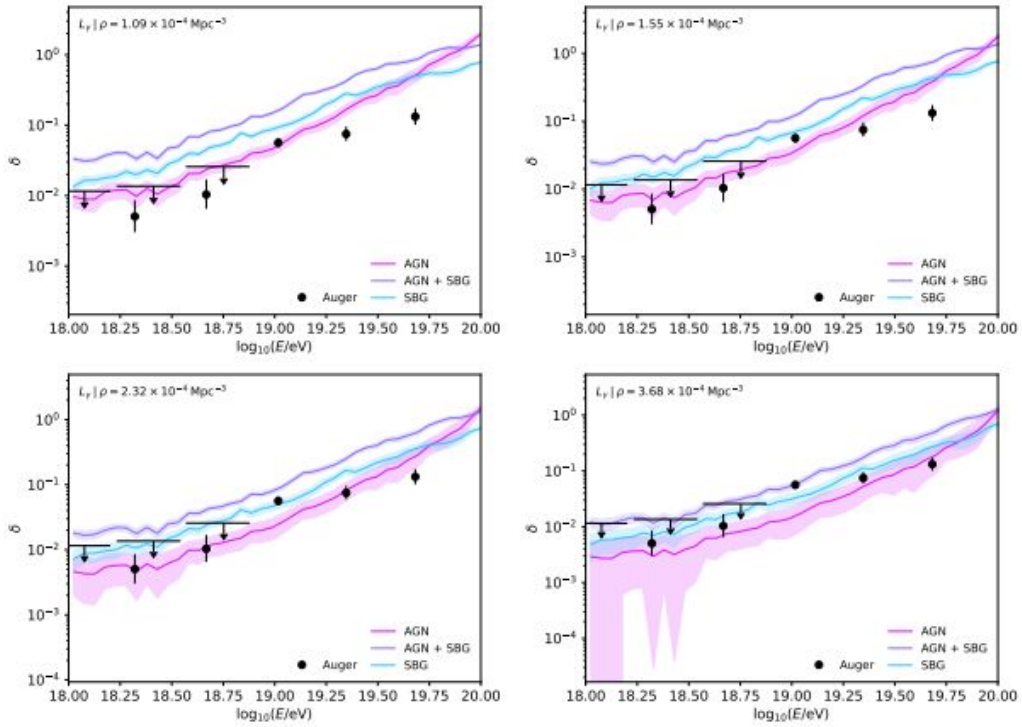




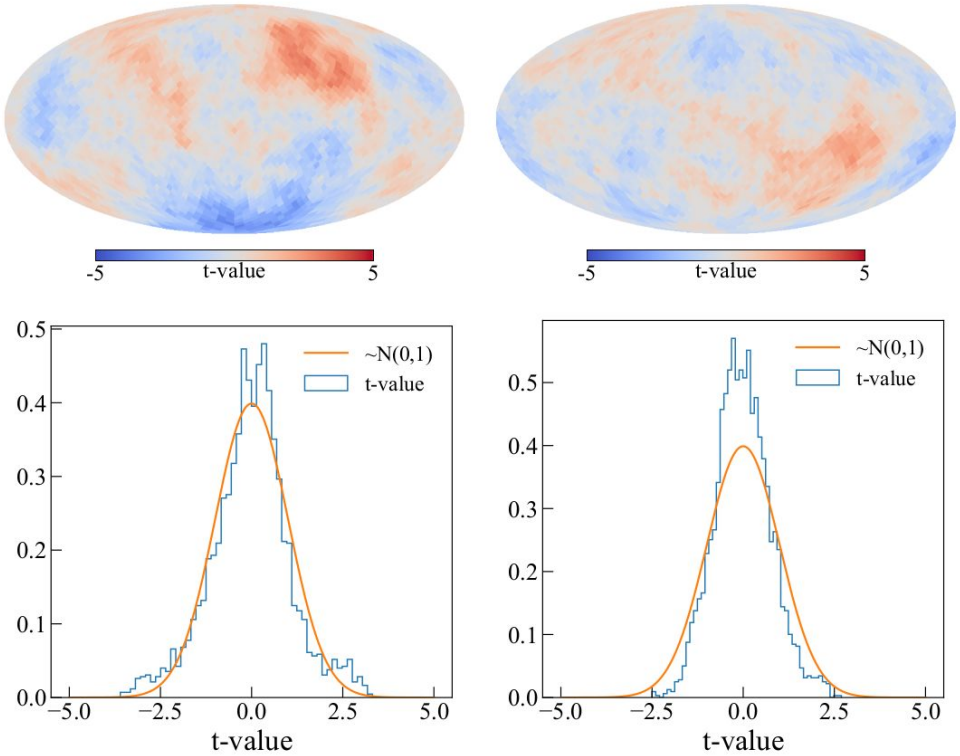
UHECR

- Interested in the origin and anisotropy of UHECR;
- With Luciana & Vitor: further developing a method for phenomenological exploring the role of local sources -> limits on the density of sources (by Luciana);
- With Chaimongkol: exploring the mass-dependent anisotropy hinted by Auger data;

Dourado, L.A., master thesis, 2023. (paper on the way!)



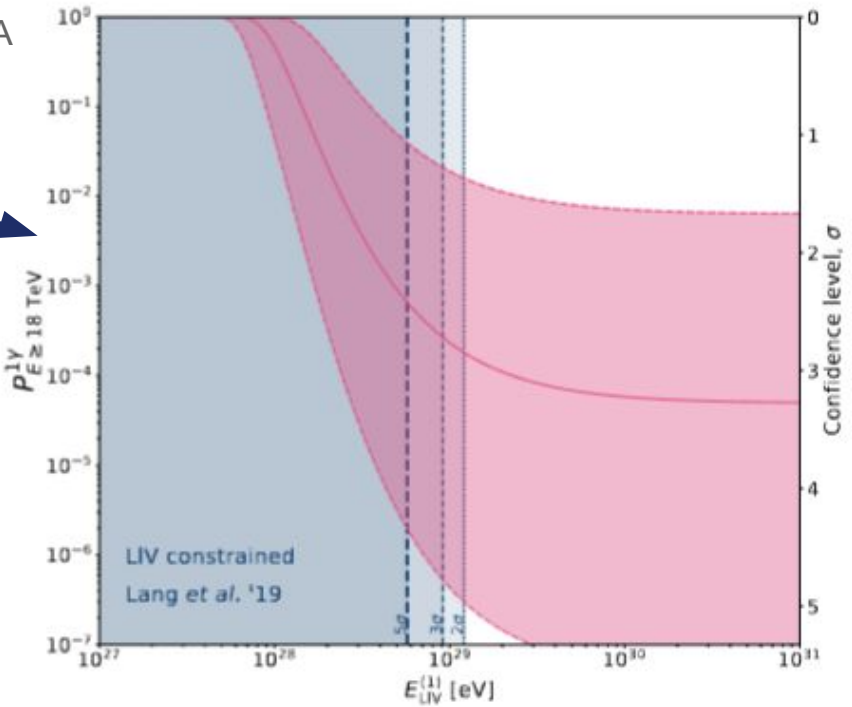
Duangchan, C., master thesis, 2023.

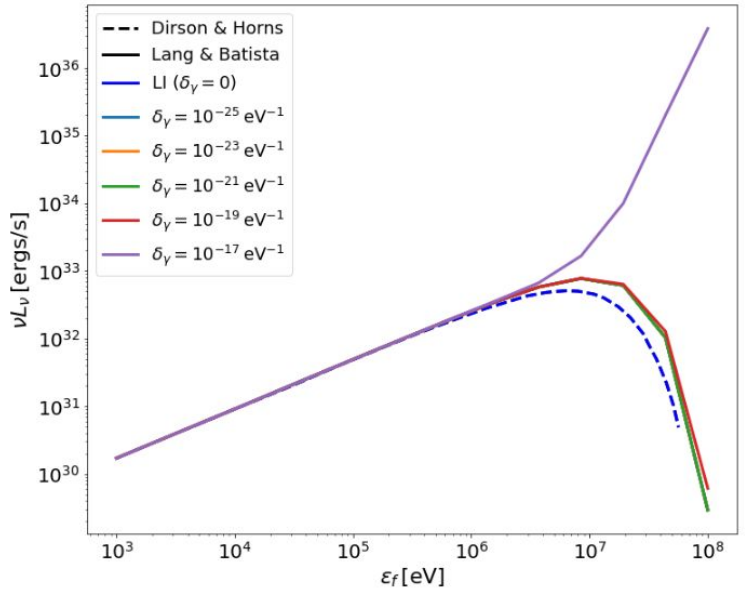


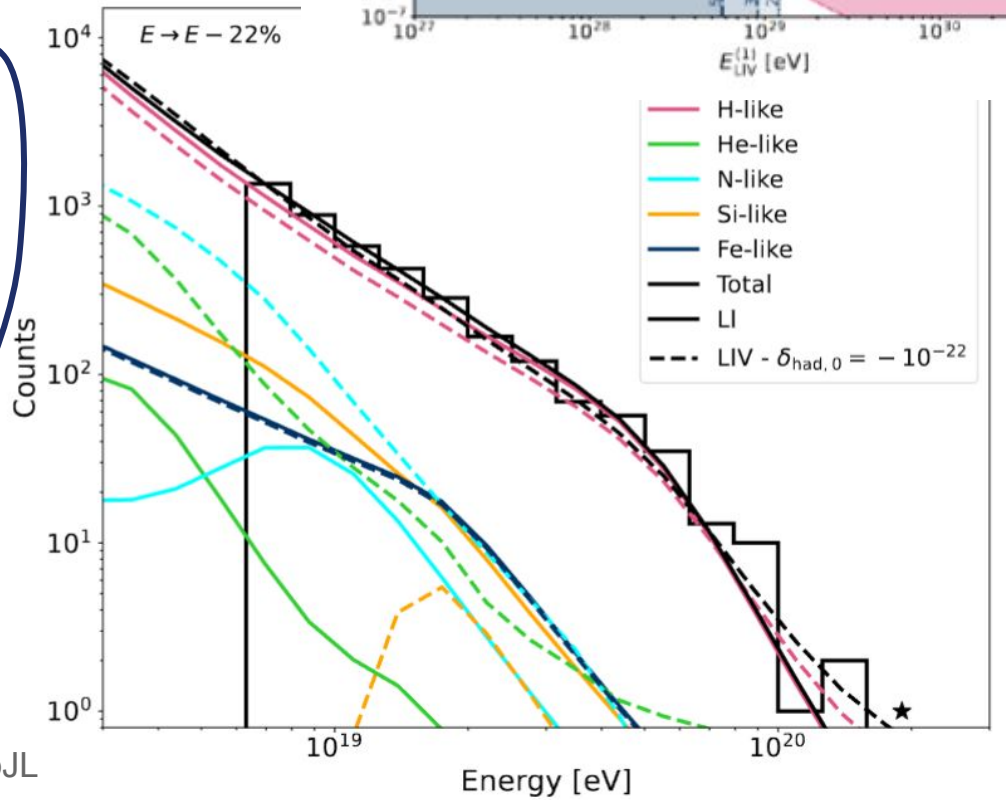
Sánchez-Ramírez, R., RGL, et al., submitted to A&A

LIV

- Explore LIV in different astrophysical scenario and messenger;
- New extreme events:
  - GRB221009a (the BOAT!);
  - Telescope Array's Amaterasu particle
- New methods/effects:
  - Inverse compton emission (with Pedro Batista);
  - Neutrino galactic center correlations (with Jelena);
  - Atmospheric neutrinos anisotropy (with Alba Domi);







Since last year…

HESS

UHECR

SWGO

LIV

also…

- Sharing a bit my experiences in both Brazil and Germany;
- Living abroad;
- etc…

And from the workshop…

HESS

UHECR

SWGO

LIV

also…

- Sharing a bit my experiences in both Brazil and Germany;
- Living abroad;
- etc…

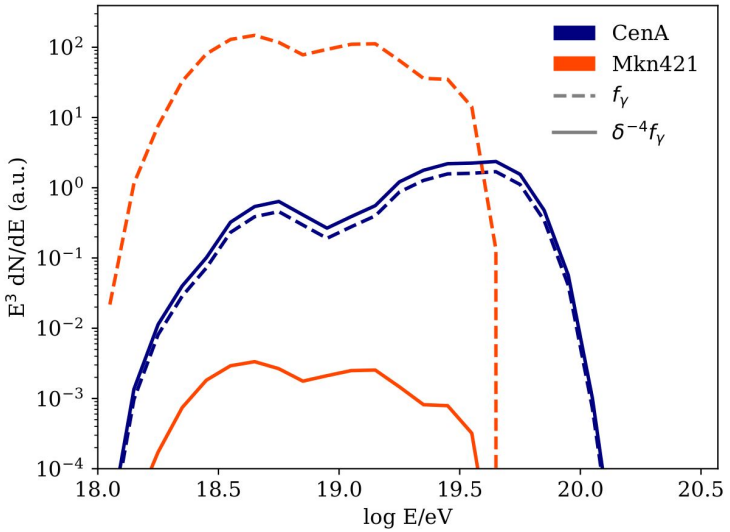
Hadronic models with IACTs
with Benedetta and Luan

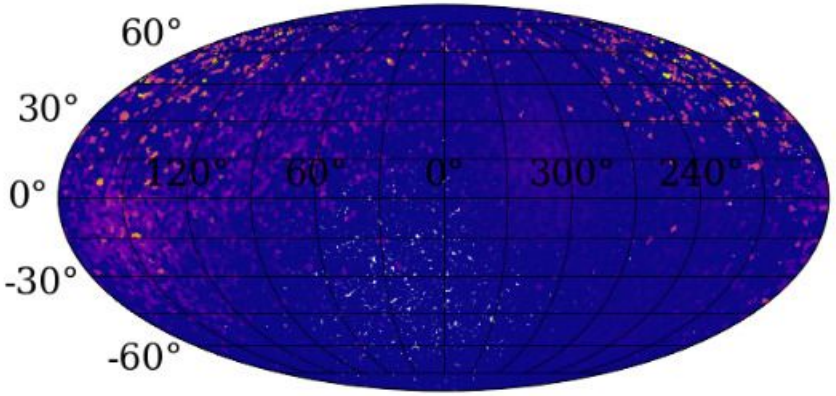
UHECR combined fit with improved models from gamma rays
with Cainã and Pedro

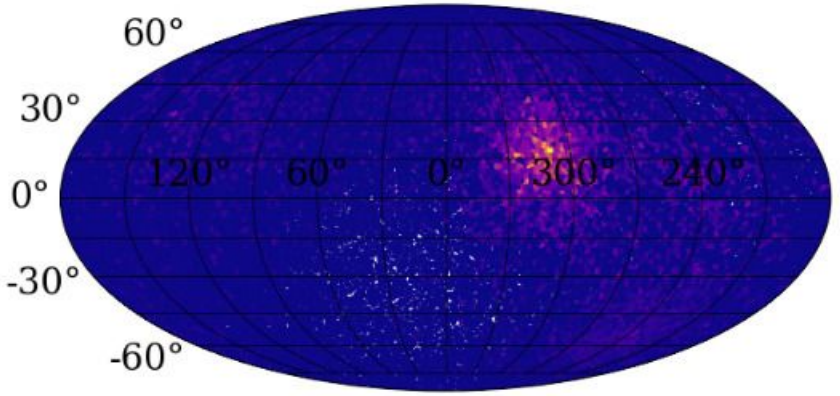
Dark matter with UHECR
with Clarissa and Cainã

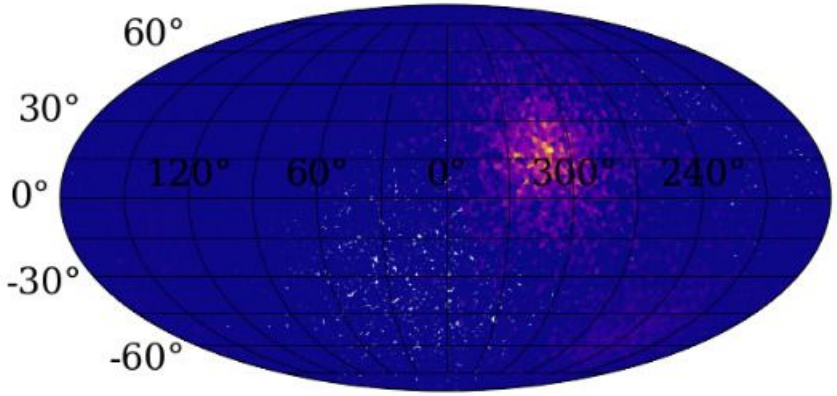
A spin-off from the spin-offs

- When Cainã was in Erlangen for working in the workshop project, he and Pedro came up with another project/idea, which I later joined for the final part of the work;
- Unfortunately, Cainã could not join the workshop this week;
- Current phenomenological studies for fitting UHECR data use gamma rays emissions to weight the contribution of local sources;
- Current combined fit from Auger is inconsistent with nearby AGNs;
- Cainã and Pedro proposed a different weighting from the gamma emission;
- I reran the combined with these assumption;
- News soon (but not today…);







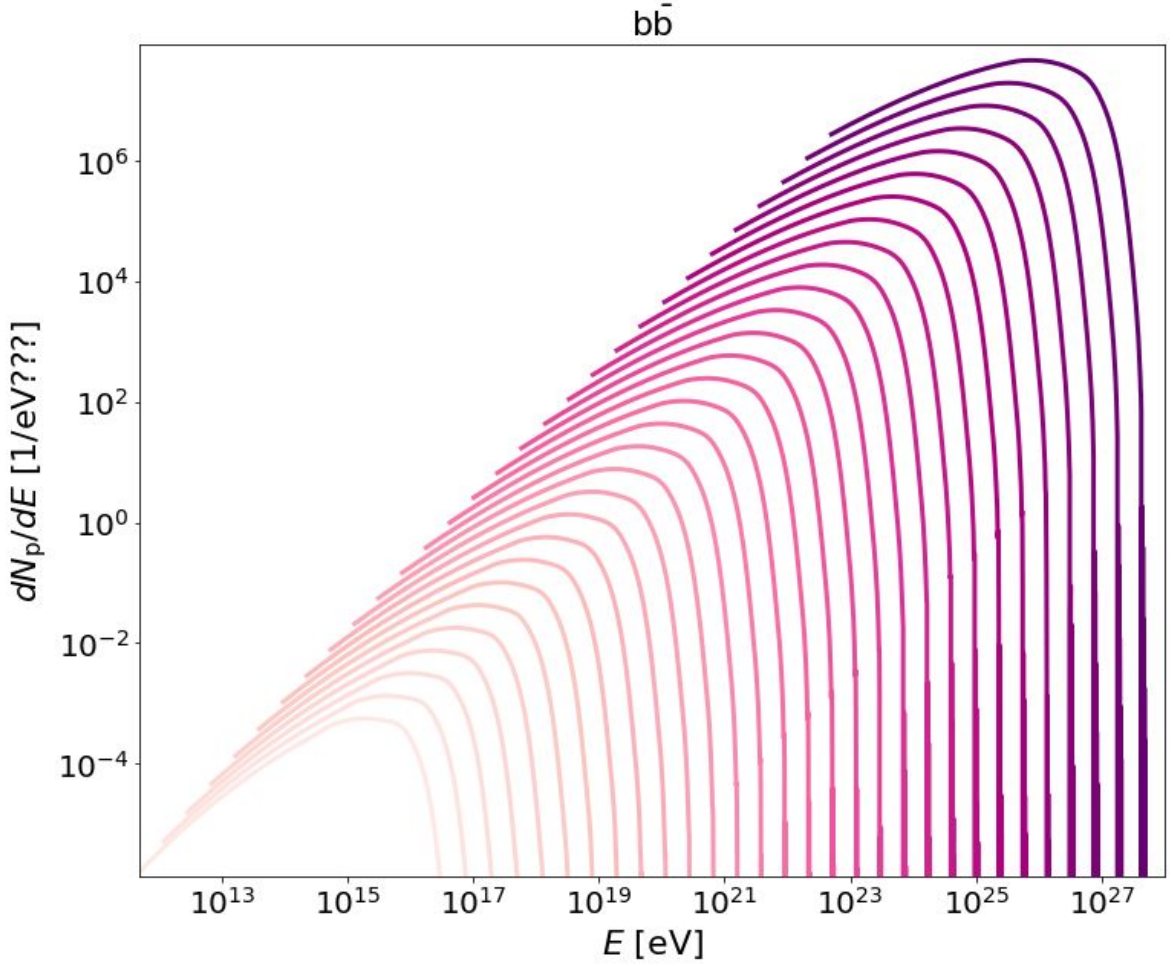


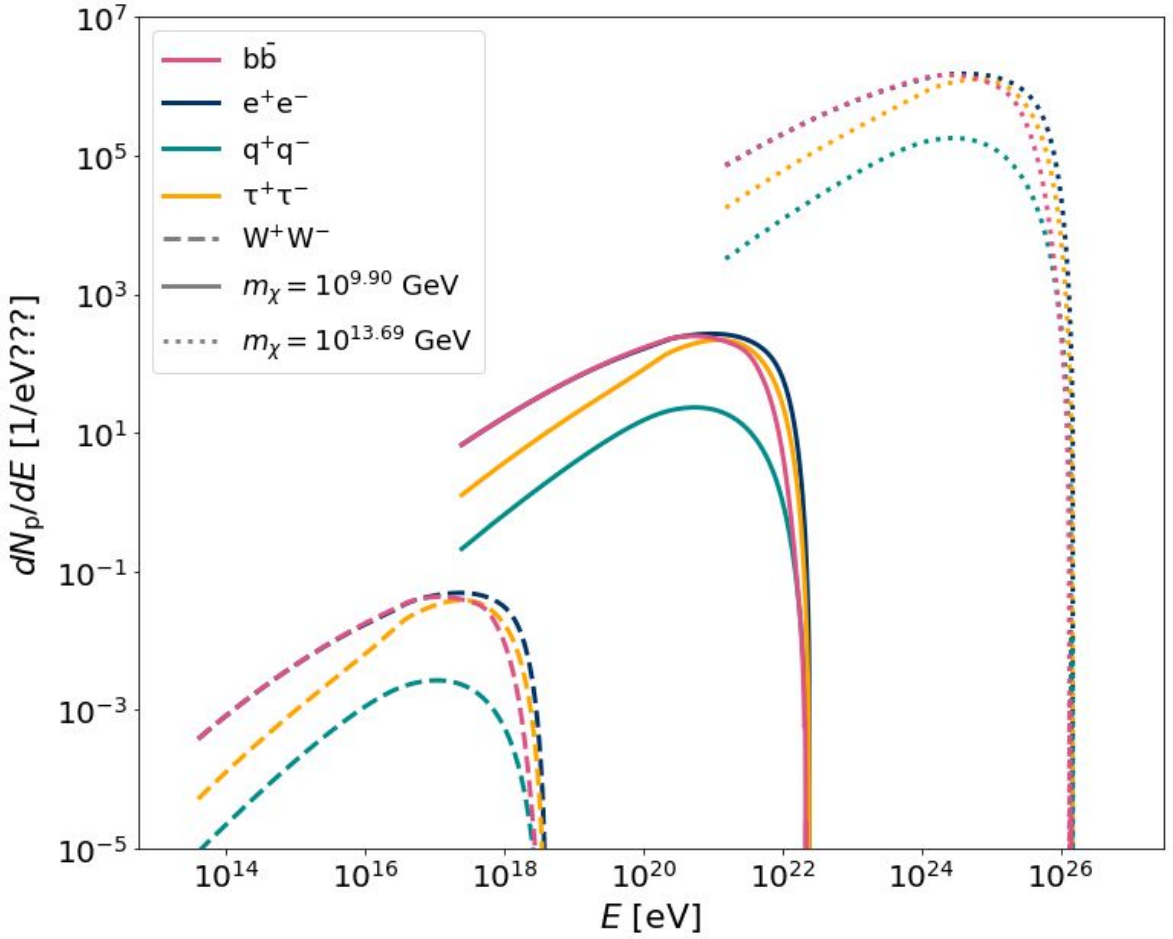
DM with UHECR

- Heavy dark matter models would predict a strong emission of UHECR in the center of the galaxy;
- This could be detected by Auger and would result in a much stronger anisotropy than that measured;
- Previous studies (also from Auger) have explored this;
- We further explored this by testing different assumption/models and more complex propagation of UHECR;

Proton/antiproton emission

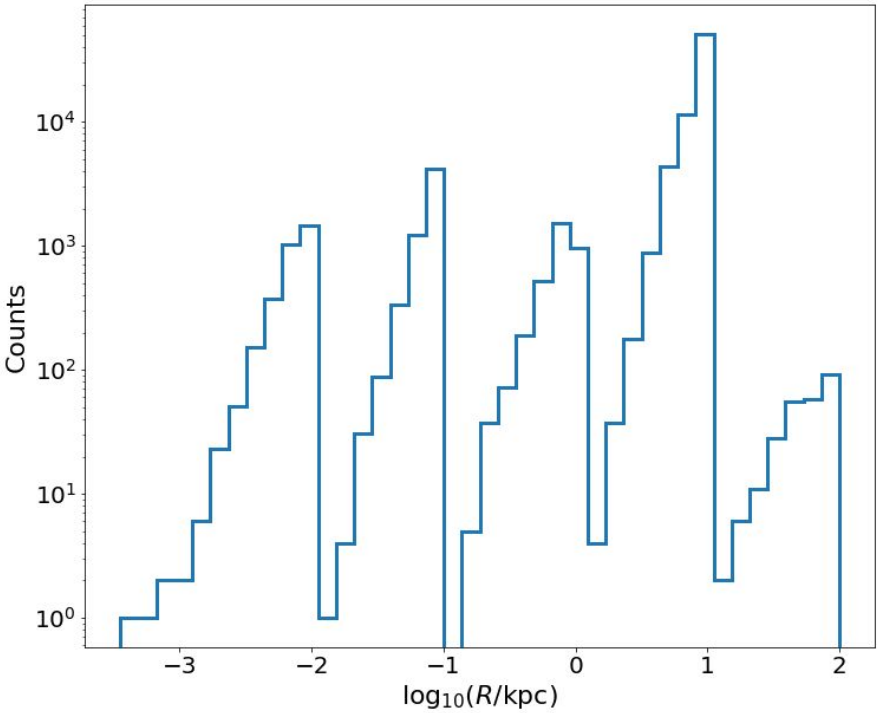
- Clarissa is our DM expert! Unfortunately she needed to leave early and couldn't join the workshop;

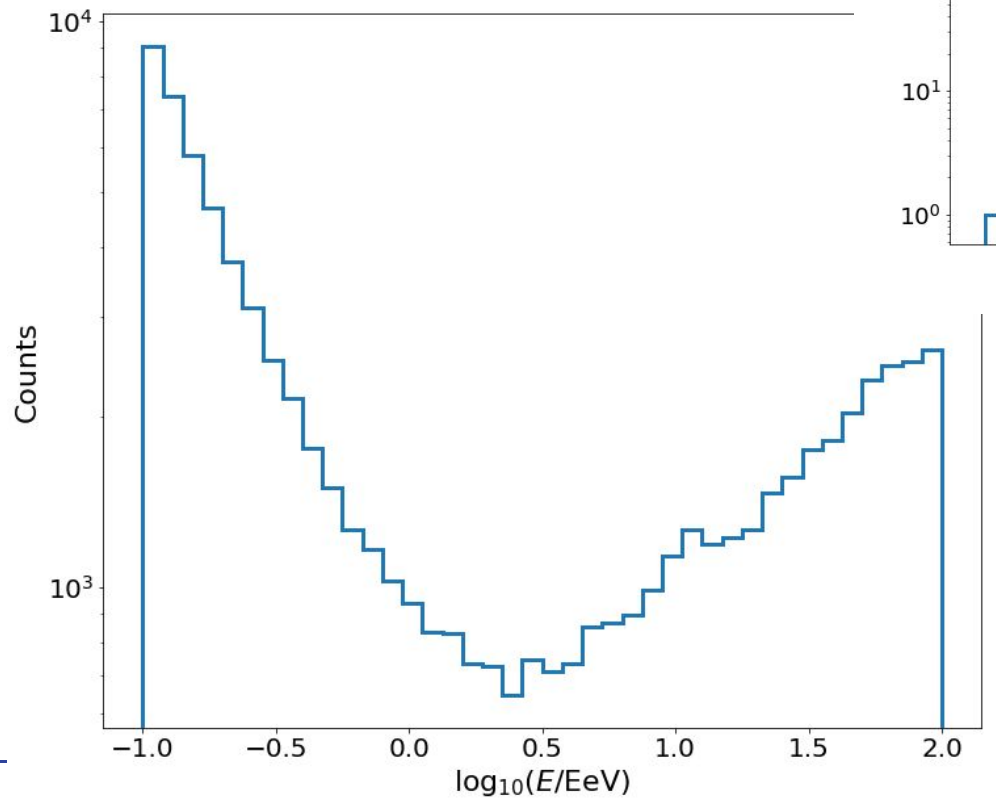




Proton/antiproton propagation

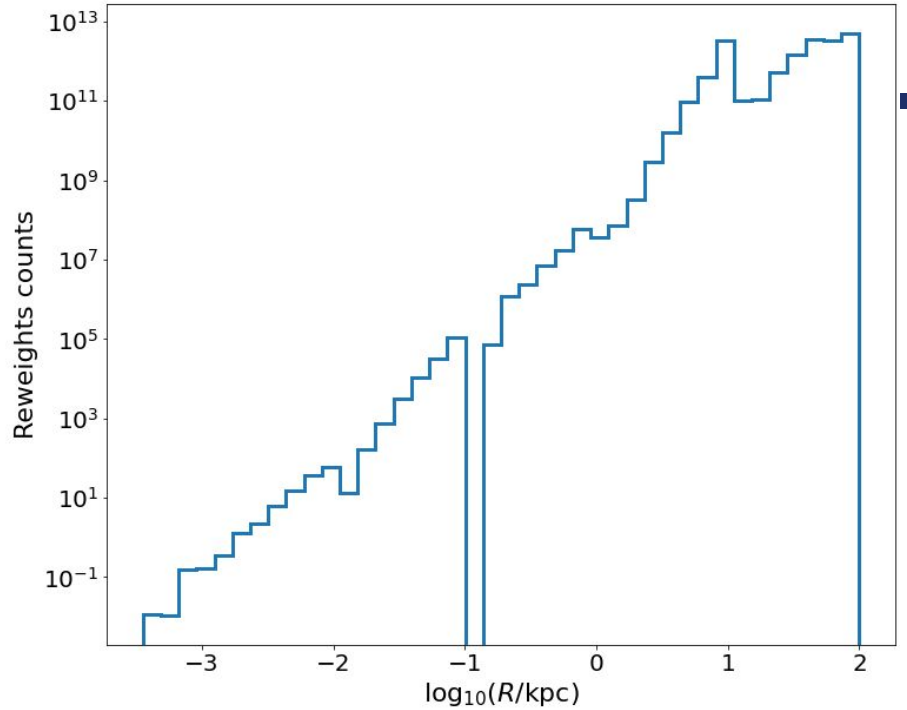
- Simulations by Cainã and I;
- Proton and anti protons;
- Different galactic magnetic fields assumptions;
- No energy losses;

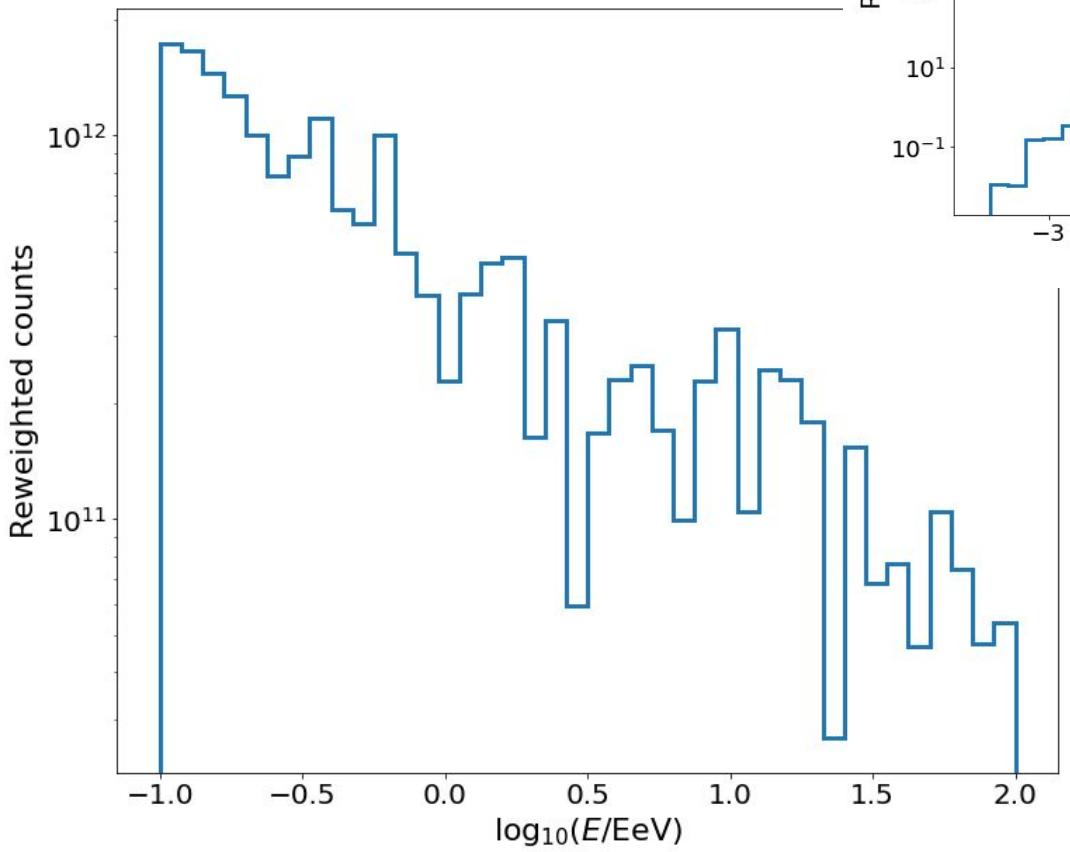




How to compare to data

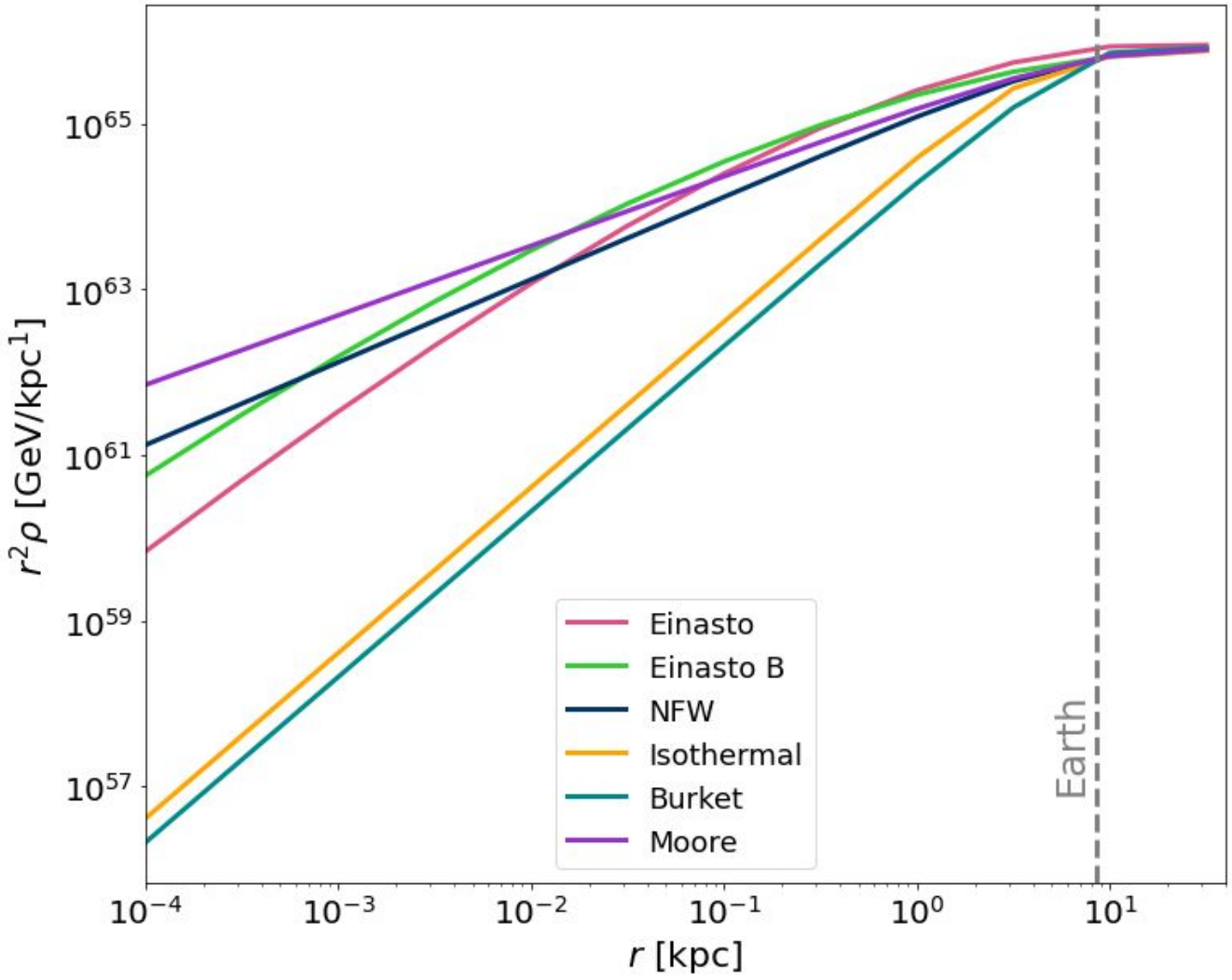
- Simulations by Cainã and I;
- Proton and anti protons;
- Different galactic magnetic fields assumptions;
- No energy losses;
- Weights to correct input data;





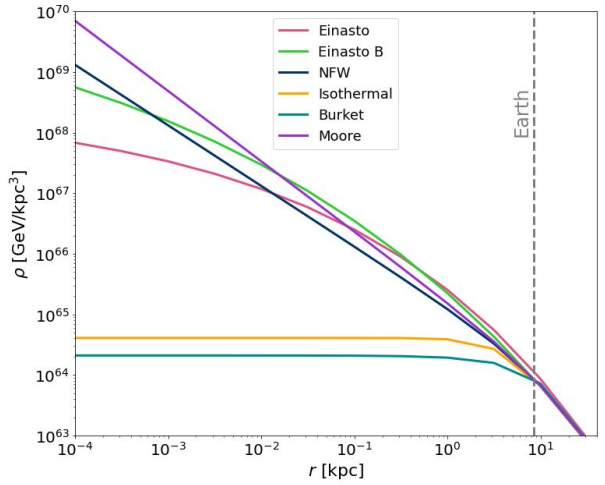
How to compare to data

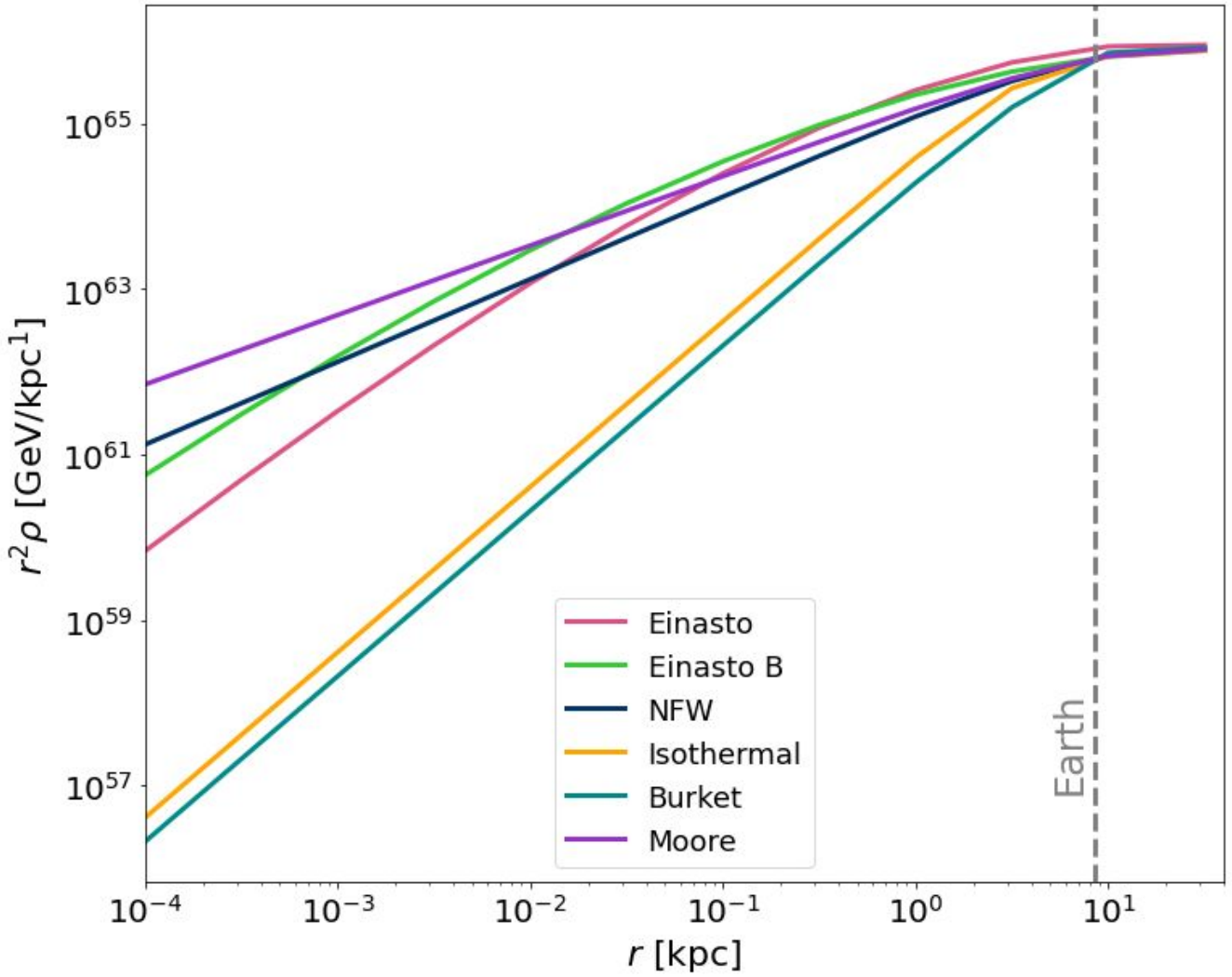
- Simulations by Cainã and I;
- Proton and anti protons;
- Different galactic magnetic fields assumptions;
- No energy losses;
- Weights to correct input data;
- Then convolve with the DM distribution;



How to compare to data

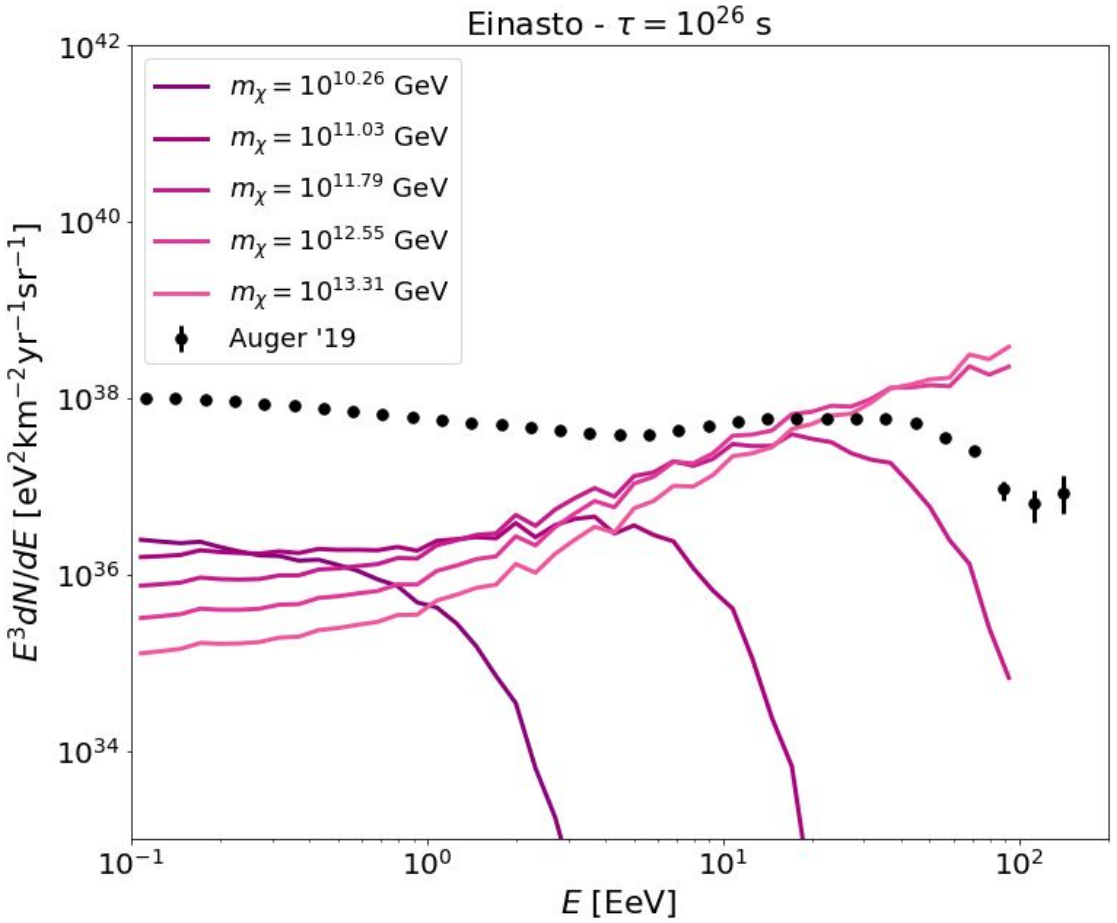
- Simulations by Cainã and I;
- Proton and anti protons;
- Different galactic magnetic fields assumptions;
- No energy losses;
- Weights to correct input data;
- Then convolve with the DM distribution;

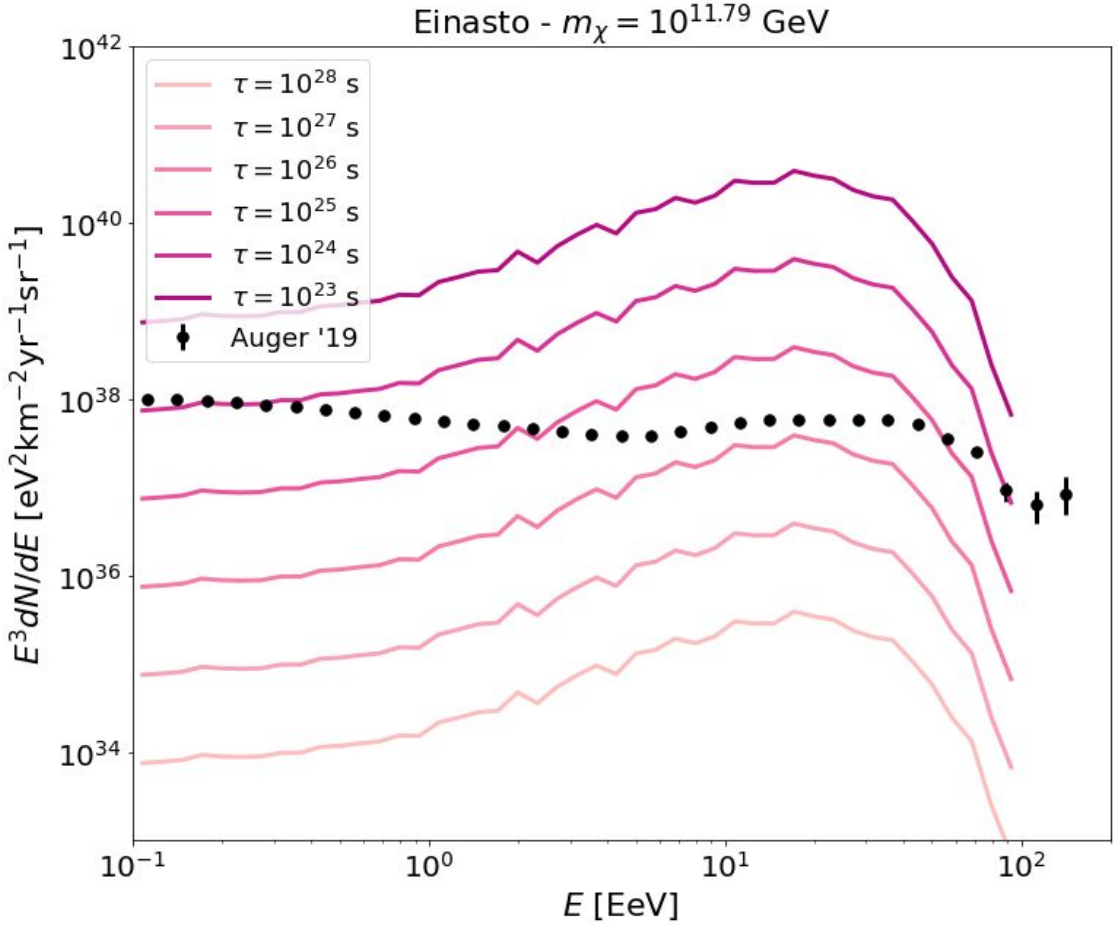




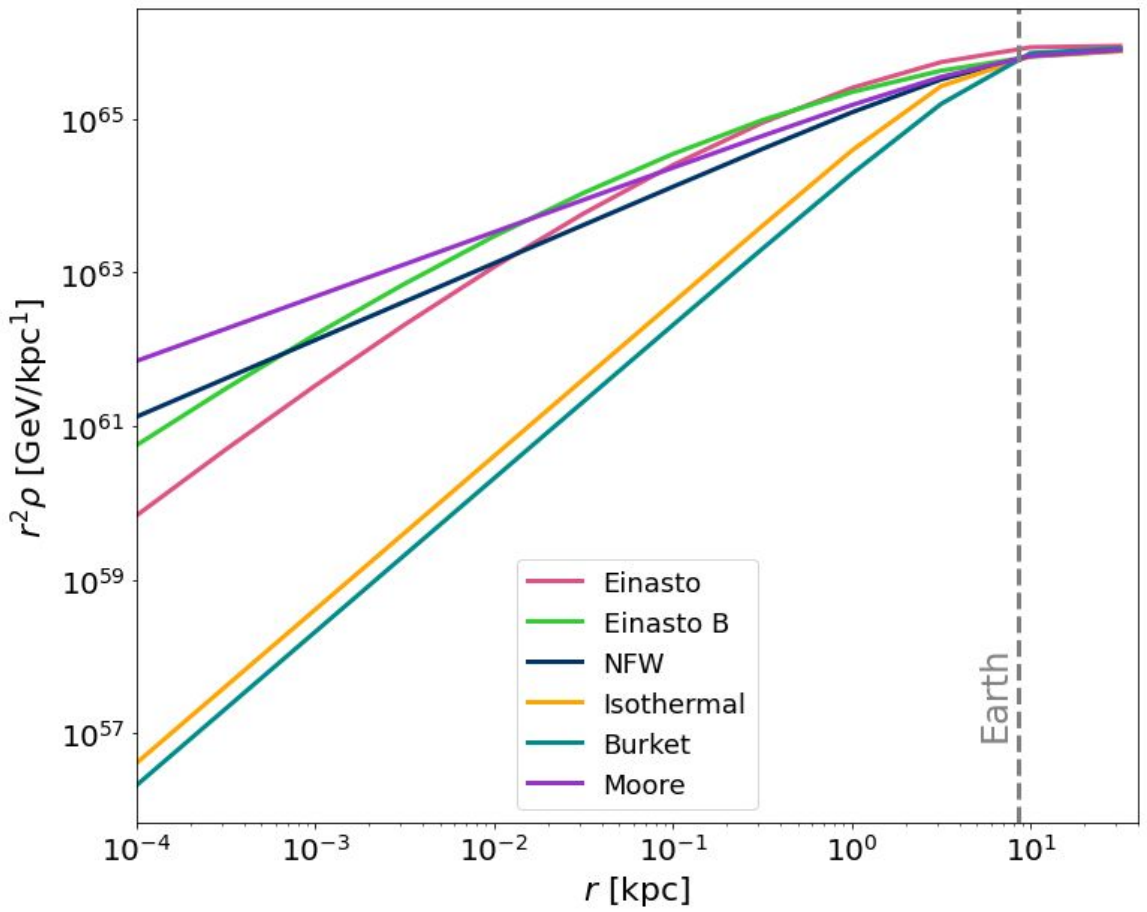
How to compare to data

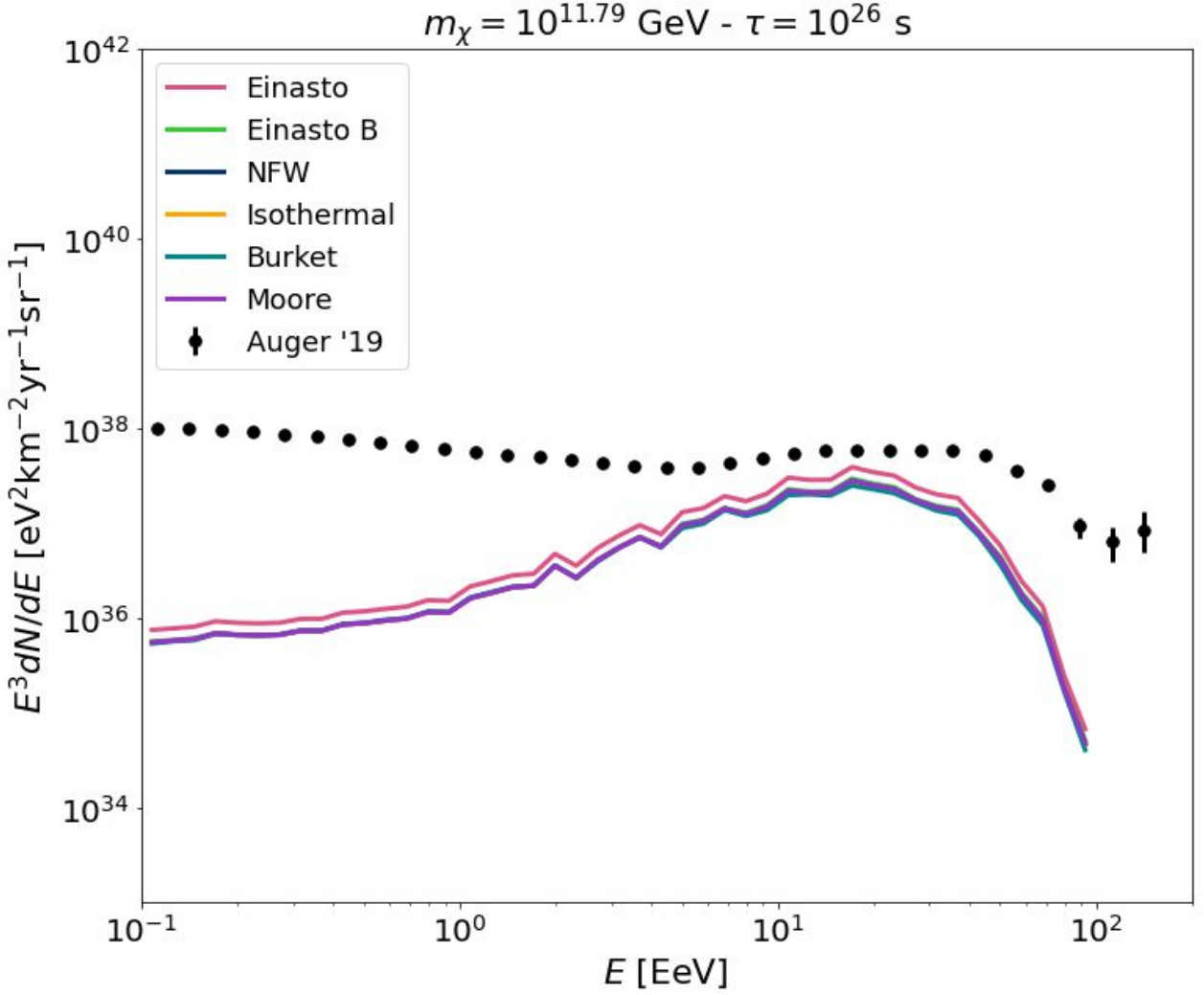
- Finally get the spectrum;





Does the DM profile matter for the spectrum?





What we still didn't have time to finish

- Anisotropy instead of all-sky spectrum;
- The final idea is to explore (mostly done) and show the effect of different assumptions:
  - Different galactic magnetic fields;
  - Different DM profiles;
  - All-sky spectrum versus anisotropy;

Friedrich-Alexander-Universität
Erlangen-Nürnberg

H.E.S.S.

ECAP ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

FAU

Muito obrigado
Vielen Dank
Thank you very much
:D