On Fermi-LAT, H.E.S.S. and CTA Sensitivity to Dark Matter Annihilation

Can we distinguish neutrino flavors using gamma-ray telescopes?
Can Fermi-LAT (H.E.S.S.) observe a gamma-ray line at 10 TeV (50 TeV)?

Farinaldo Queiroz

MPIK- Heidelberg

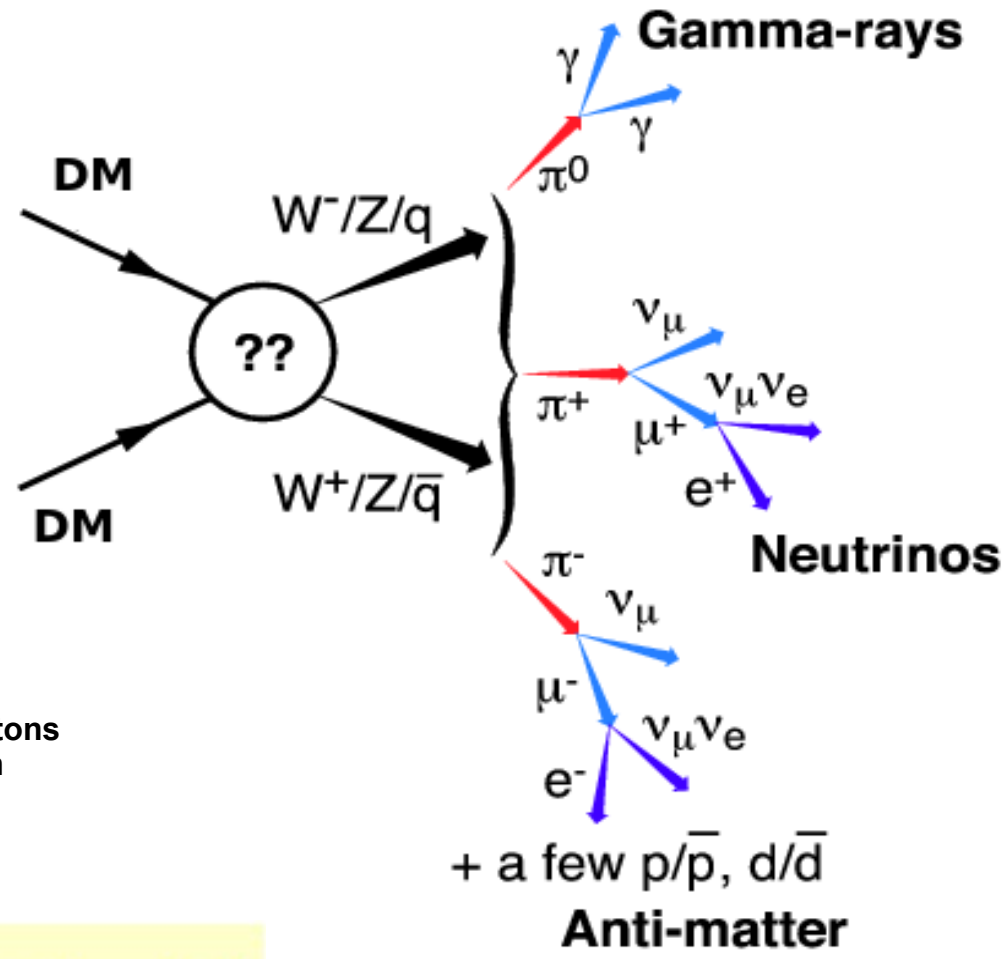
June -2016

Basic Concepts

A. The dark matter particles might still be able to interact with standard model particles and produce an observable signal.

B. We know how to account for hadronization and final state radiation well up to the dark matter mass, which can be very heavy.

Dark Matter Indirect Detection



Differential Flux

Annihilation cross section

Number of photons per annihilation

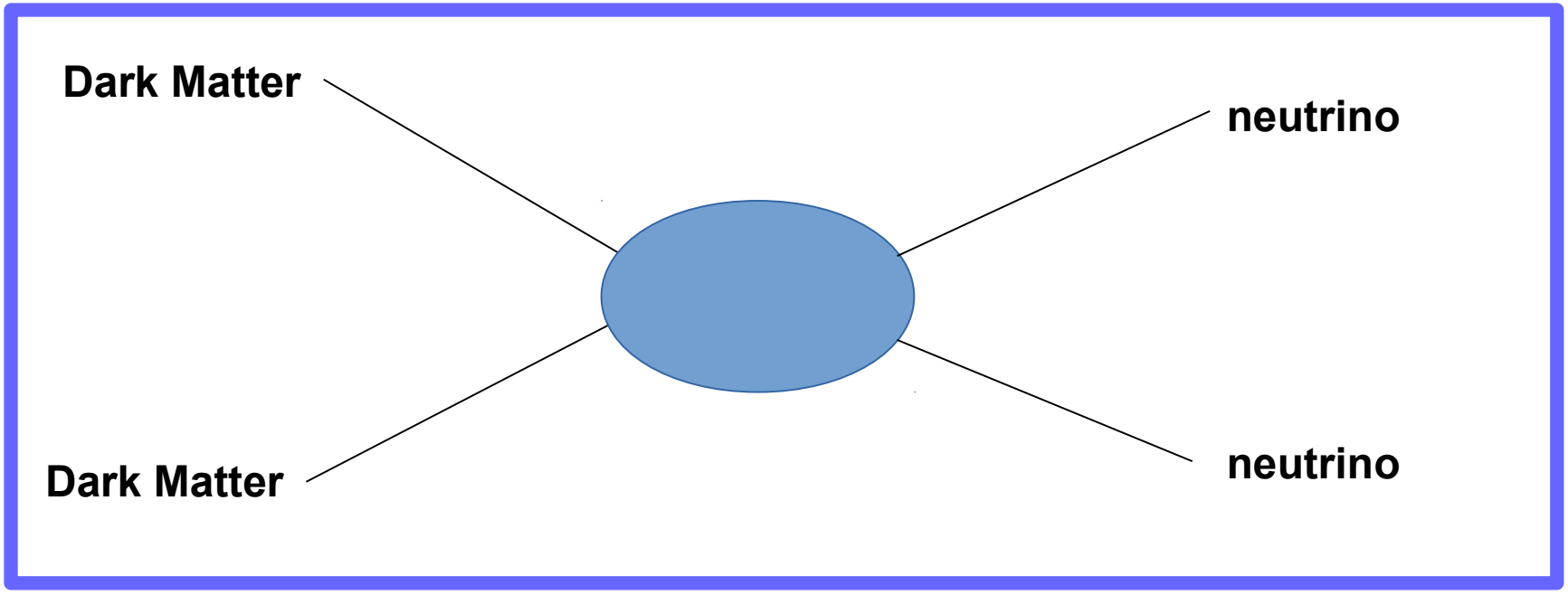
$$\frac{d\phi}{d\Omega dE} = \frac{\langle \sigma v_{\rm rel} \rangle}{8\pi m_\chi^2} \frac{dN_\gamma}{dE} \times \int_{\rm l.o.s.} ds\ \rho(\vec{r}[s,\Omega])^2$$

Line of sight integral

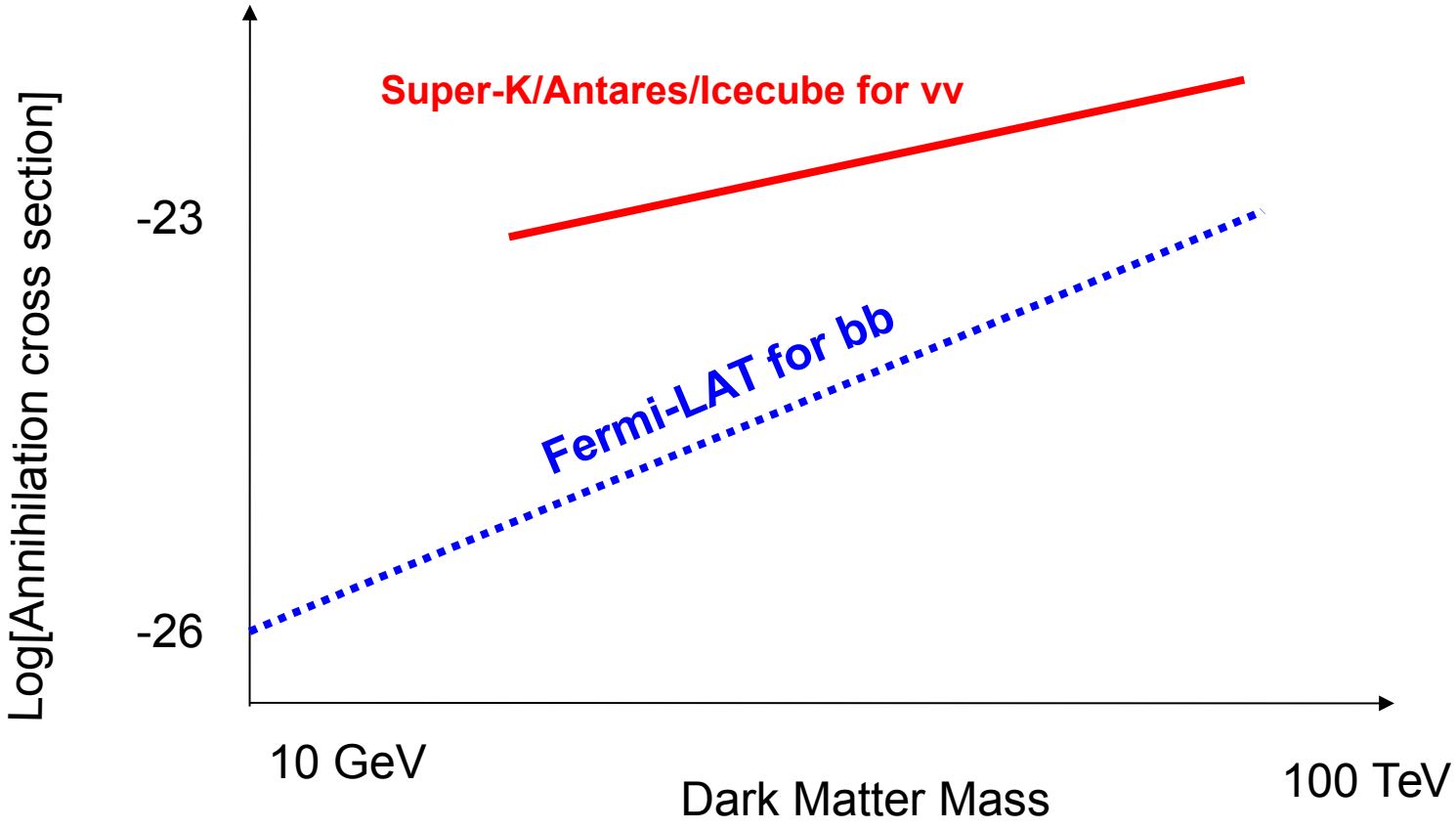
Dark matter density

Which detector would you use to search for this dark matter particle?

Icecube/Antares/Super-K ?



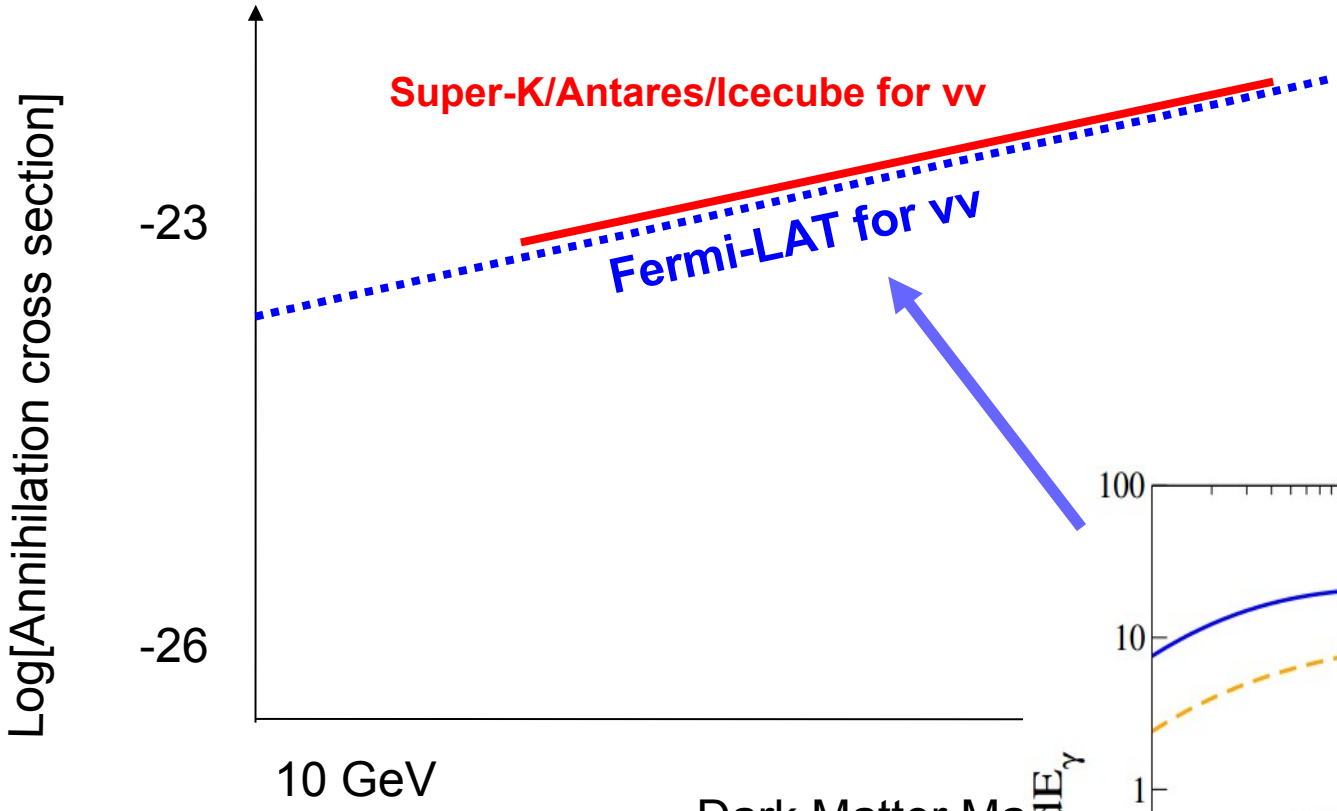
If you have a pair of dark matter particles annihilating purely into neutrinos. Which detector would you use to search for this dark matter particle? Info: Mass in the 10GeV-100TeV range.

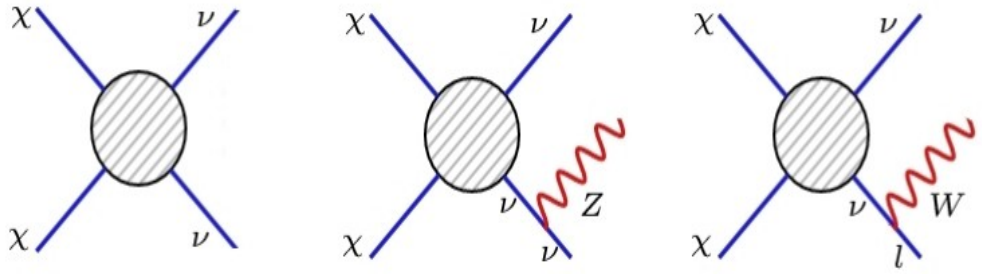


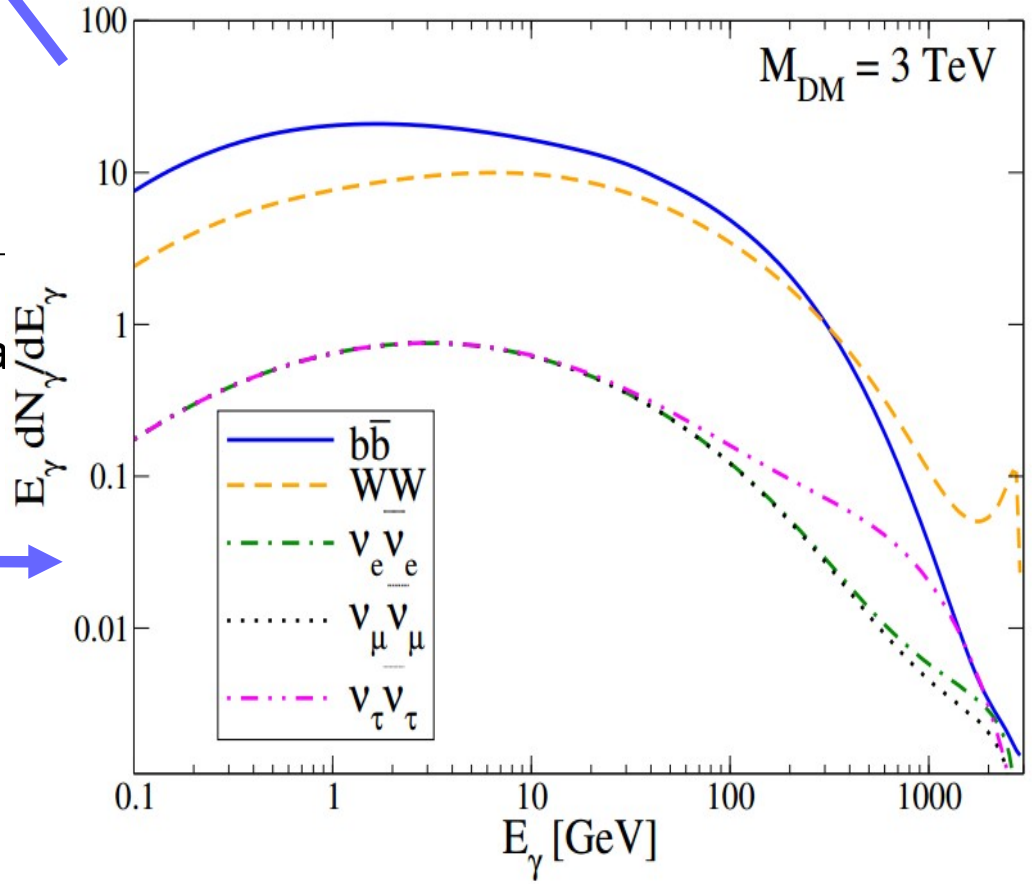
The best limits from Icecube are ~ 3 orders of magnitude weaker than best limits from Fermi-LAT.....

First works: Kachelriess, Serpico, 0707.0209
Bell,Dent, Jacques, Weiler, 0805.3423

If you have a pair of dark matter particles annihilating purely into neutrinos. Which detector would you use to search for this dark matter particle? Info: Mass in the 10GeV-100TeV range.







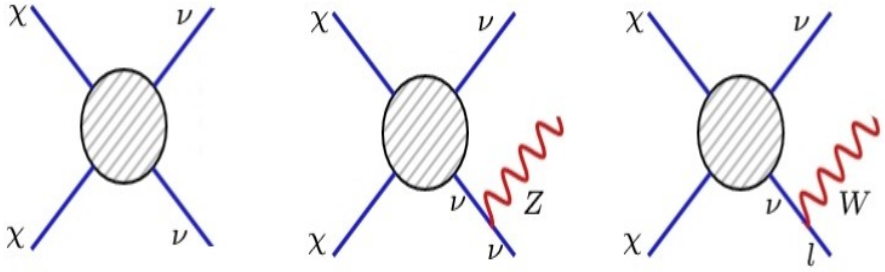
Cirelli+, 1012.4515

Searches for Dark Matter Annihilation into Neutrino Lines

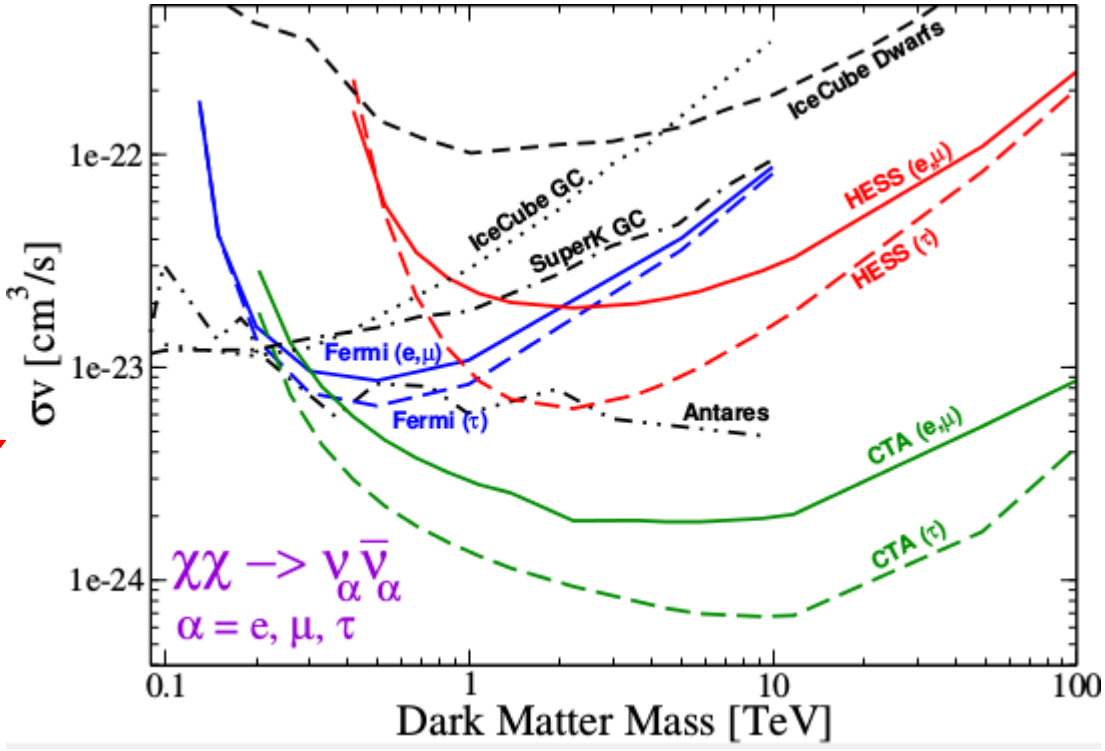
Farinaldo Queiroz, Carlos Yaguna, Christoph Weniger – JCAP 1605 (2016) no.05, 050- arxiv:1602.05966

Several searches for neutrinos flavors from dark matter annihilations have been conducted by Super-K, IceCube and ANTARES collaborations.

Electroweak corrections are important and a neutrino final state also gives rise to a gamma-ray emission which can be probed by Fermi-LAT/H.E.S.S. instruments.



A neutrino signal seen by Icecube/ANTARES/ Super-K from dark matter annihilation should also be seen by Fermi-LAT/H.E.S.S. and definitely by CTA



F. Queiroz, C. Yaguna, C. Weniger - arxiv:1602.05966

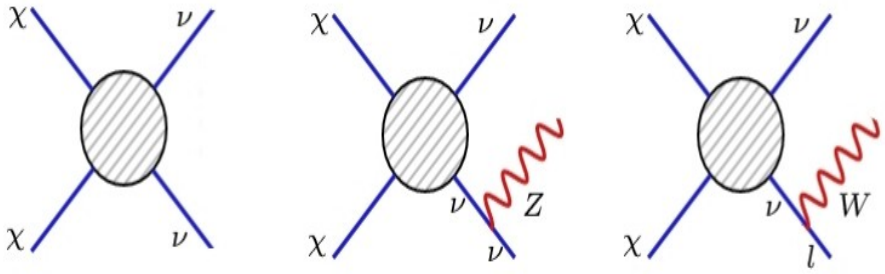
As for dark matter decays, gamma-ray telescopes are not very sensitive

Searches for Dark Matter Annihilation into Neutrino Lines

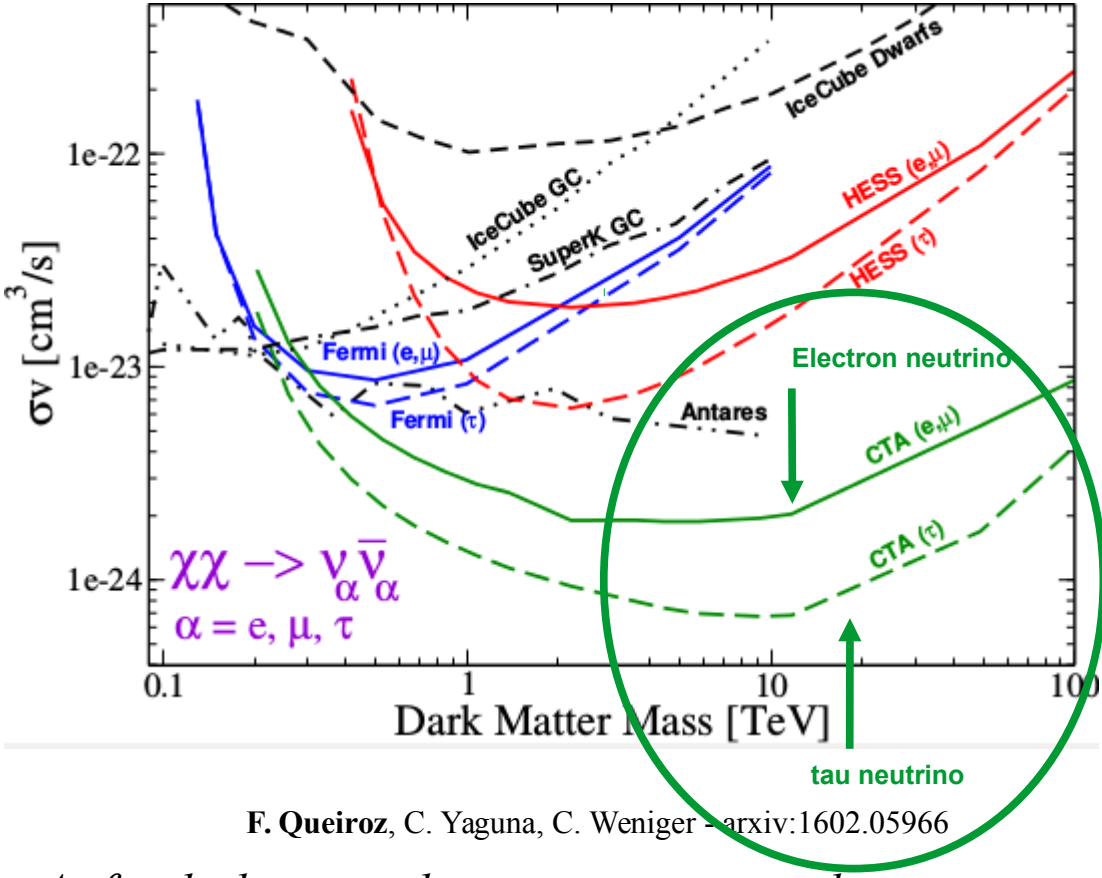
Farinaldo Queiroz, Carlos Yaguna, Christoph Weniger – JCAP 1605 (2016) no.05, 050- arxiv:1602.05966

Several searches for neutrinos flavors from dark matter annihilations have been conducted by Super-K, IceCube and ANTARES collaborations.

Electroweak corrections are important and a neutrino final state also gives rise to a gamma-ray emission which can be probed by Fermi-LAT/H.E.S.S. instruments.



Distinguishing neutrino flavors with gamma-rays



F. Queiroz, C. Yaguna, C. Weniger - arxiv:1602.05966

As for dark matter decays, gamma-ray telescopes are not very sensitive

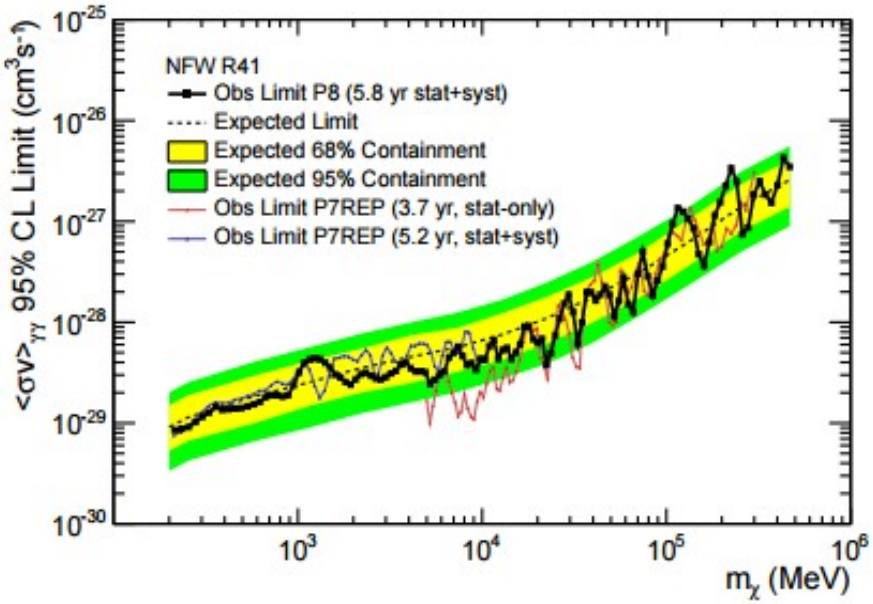
Another promising dark matter signal would be the detection of gamma-ray lines

Fermi-LAT and H.E.S.S. Telecopes have placed stringent limits on the annihilation cross section into photon pairs.

Fermi-LAT - 2015

Break at 500 GeV

~ 6 years of data – PASS 8
Energy: 200 MeV -500 GeV
CLEAN event selection
Target: Milky Way Halo

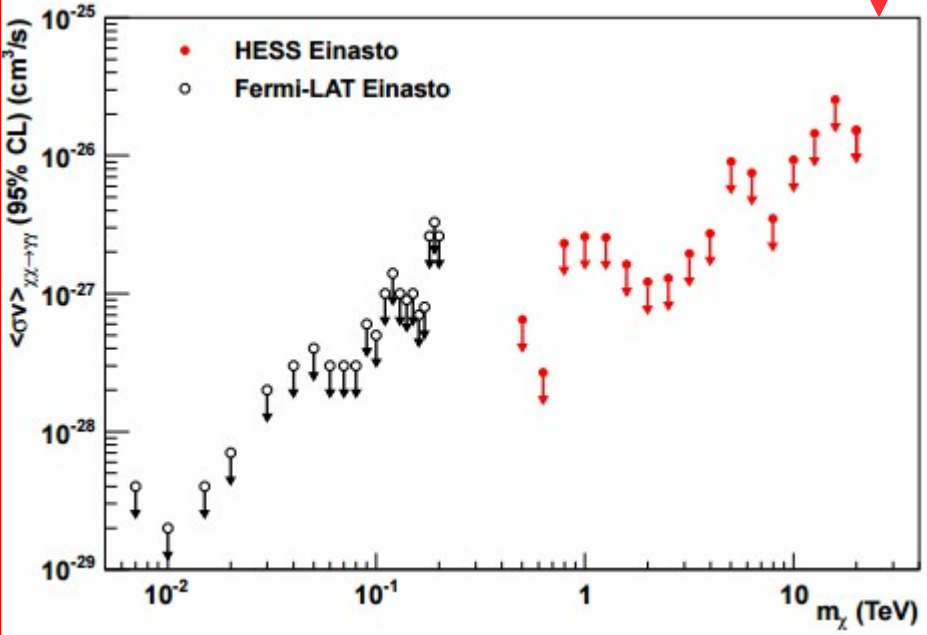


Phys.Rev. D91 (2015) no.12, 122002

H.E.S.S. - 2013

Break at 25 TeV

112 h (live time)
Energy: 500 GeV – 25 TeV
Target: Milky Way Halo



Phys.Rev.Lett. 110 (2013) 041301

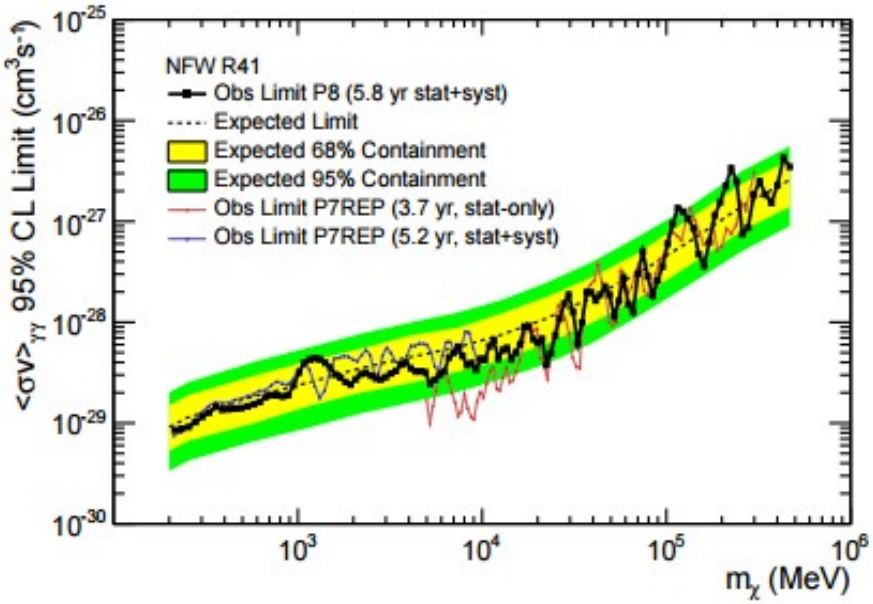
Another promising dark matter signal would be the detection of gamma-ray lines

Can we extend their limits to heavier DM masses? YES.
How? Using the continuum gamma-ray emission data.

Fermi-LAT - 2015

Break at 500 GeV

~ 6 years of data – PASS 8
Energy: 200 MeV -500 GeV
CLEAN event selection
Target: Milky Way Halo

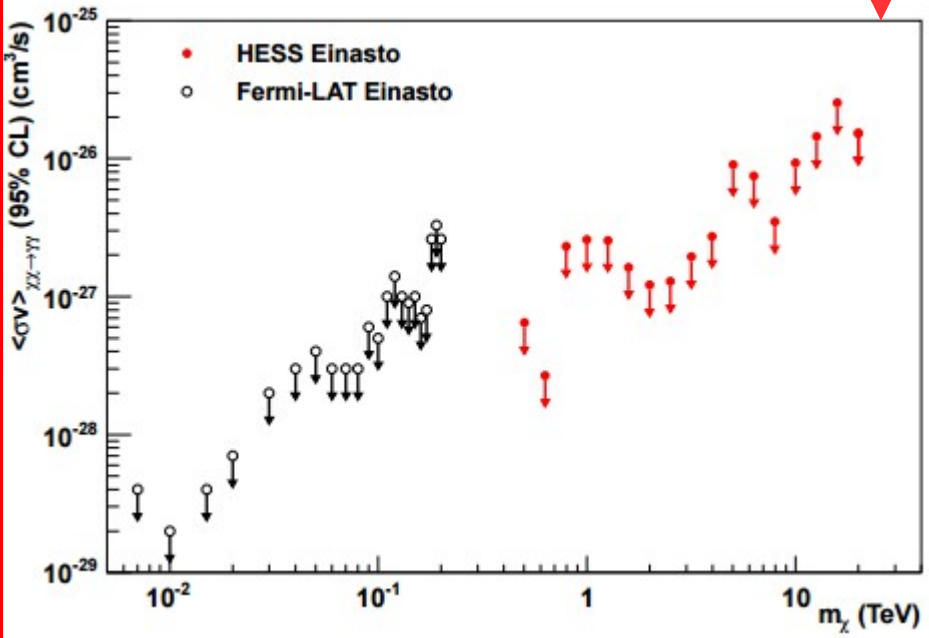


Phys.Rev. D91 (2015) no.12, 122002

H.E.S.S. - 2013

Break at 25 TeV

112 h (live time)
Energy: 500 GeV – 25 TeV
Target: Milky Way Halo



Phys.Rev.Lett. 110 (2013) 041301

Can we extend their limits to heavier DM masses? YES.
How? Using the continuum gamma-ray emission data.

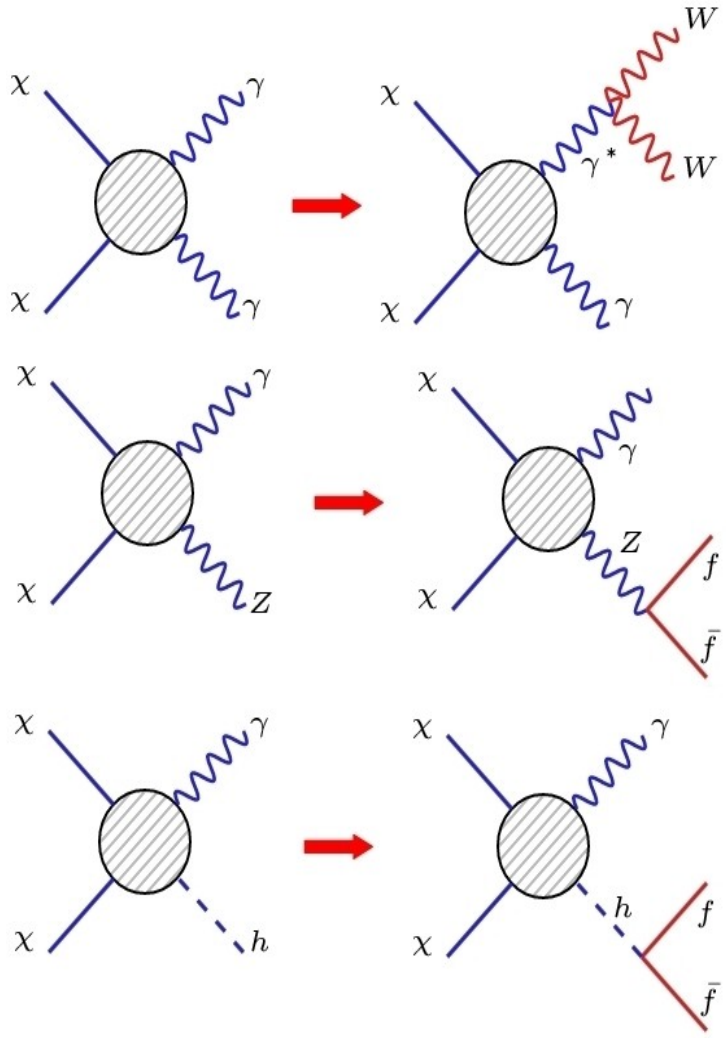
Four steps

I) Assume a 2 TeV DM particle annihilating into gamma gamma or gamma Z or gamma h.

II) The process above is subject to electroweak corrections

III) The gamma-rays resulted from such processes appear at lower energies within Fermi-LAT sensitivity

IV) The same idea can be applied for a 50 TeV particle, in reference to H.E.S.S. telescope.

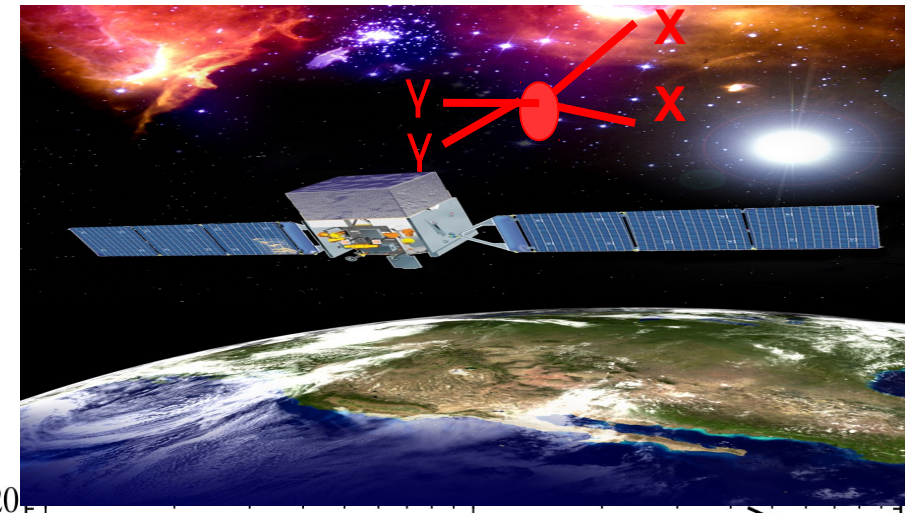


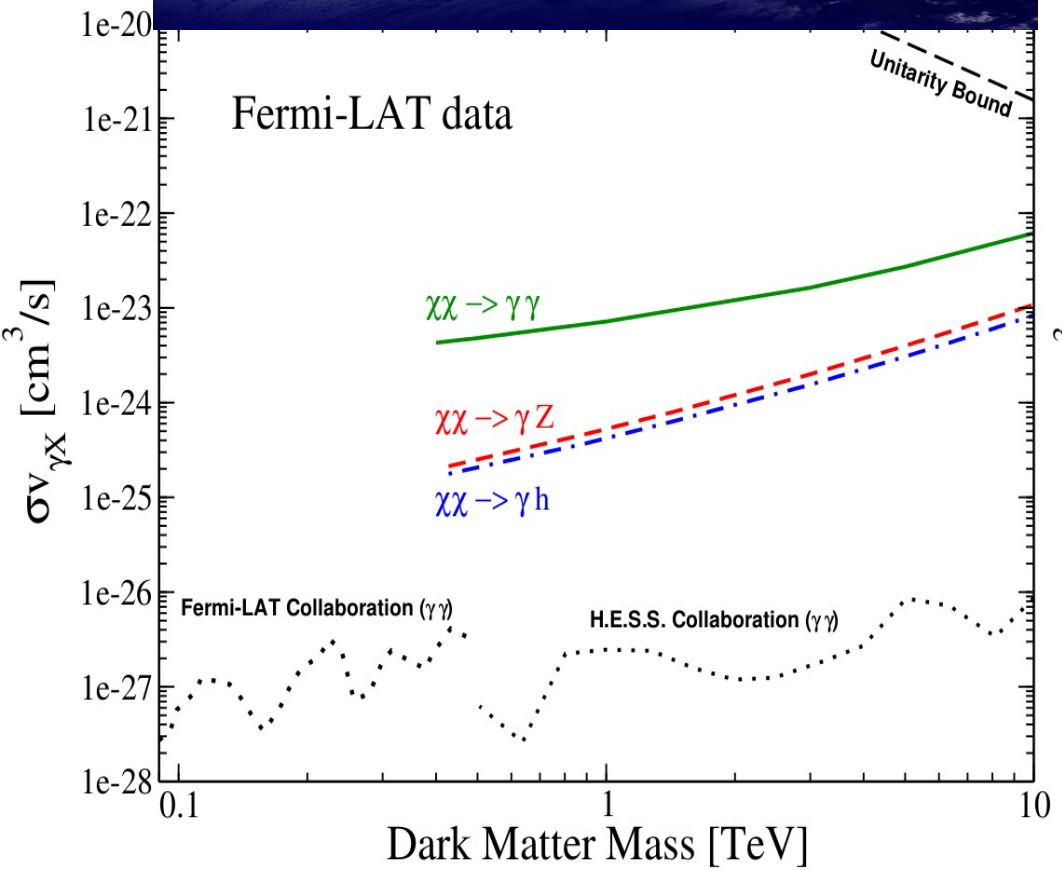
Using the gamma-ray continuum emission one can extend Fermi-LAT and H.E.S.S. limits to heavier dark matter masses.

Extending Fermi-LAT and H.E.S.S. Limits on Gamma-ray Lines from Dark Matter Annihilation

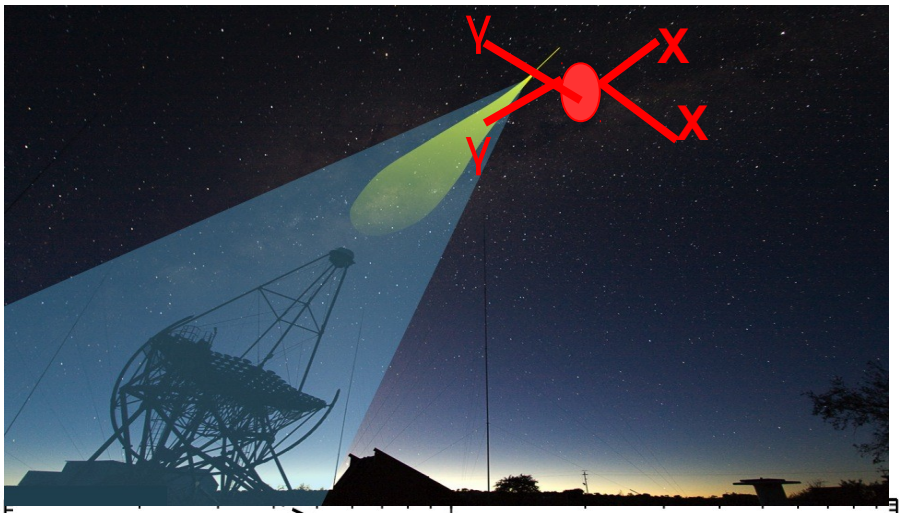
Stefano Profumo, **Farinaldo Queiroz**, Carlos Yaguna, Submitted to MNRAS – arxiv:1602.08501

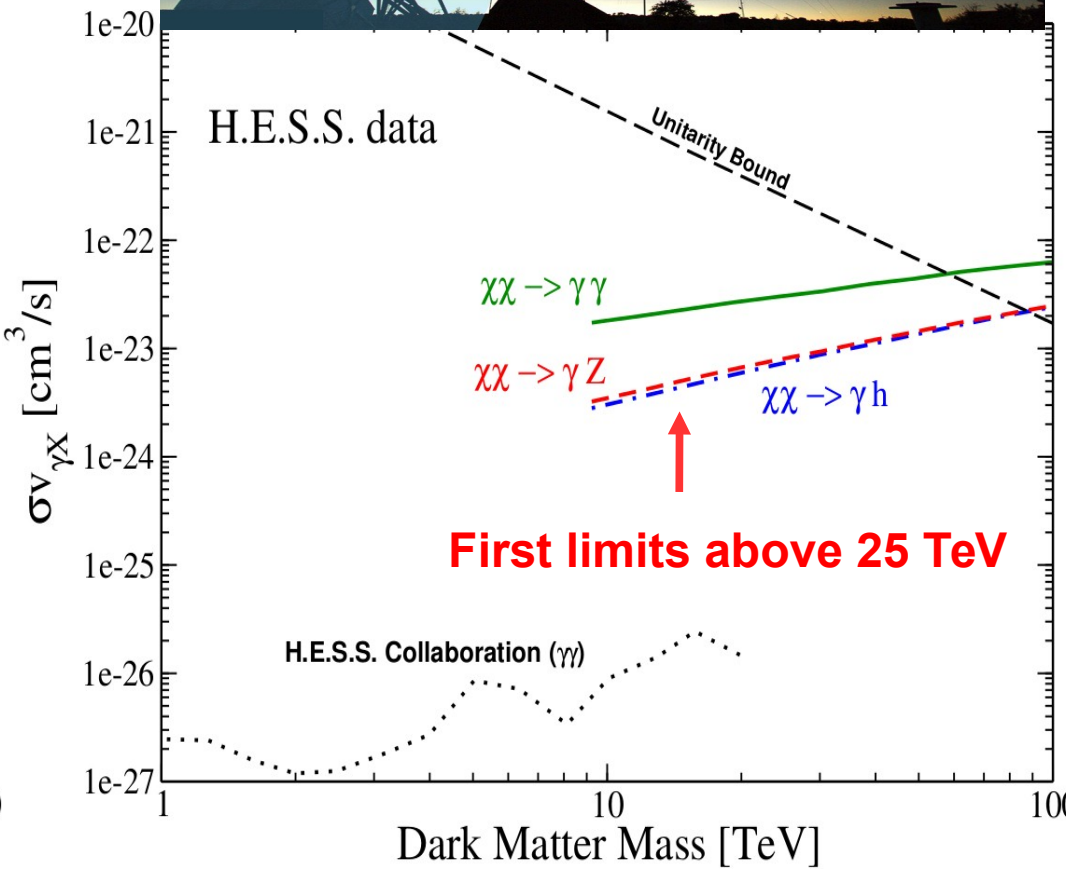
Fermi-LAT





H.E.S.S.





Three take home messages

First: **Gamma-ray Telescopes are as sensitive as Neutrino detectors to neutrino signals (ANTARES/ICECUBE/Super-K)**

Second: **Gamma-ray Telescopes have the potential to distinguish neutrino flavors.**

Third: **Gamma-ray Limits on Spectral Line emissions can be extended to heavier dark matter masses using the continuum gamma-ray emission analysis.**

Based on

- **Farinaldo Queiroz**, Carlos Yaguna, Christoph Weniger – JCAP 1605 (2016) no.05, 050- arxiv:1602.05966
- Stefano Profumo, **Farinaldo Queiroz**, Carlos Yaguna, to appear in MNRAS – arxiv:1602.08501