Diffuse neutrinos from extragalactic supernova remnants: dominating the 100 TeV IceCube flux

Ignacio Izaguirre

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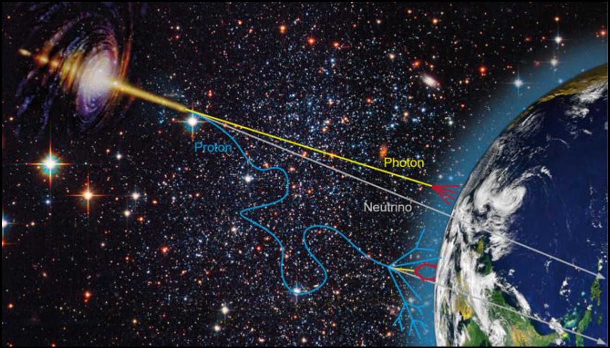
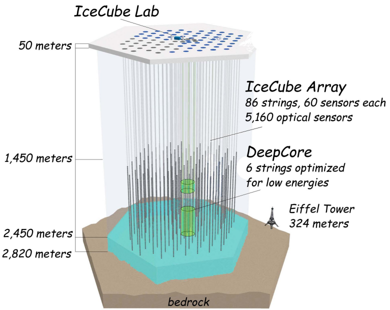
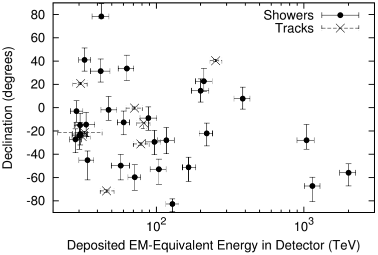
MAX-PLANCK-GESELLSCHAFT
Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

Neutrinos as cosmic messengers



IceCube results (arXiv:1405.5303)





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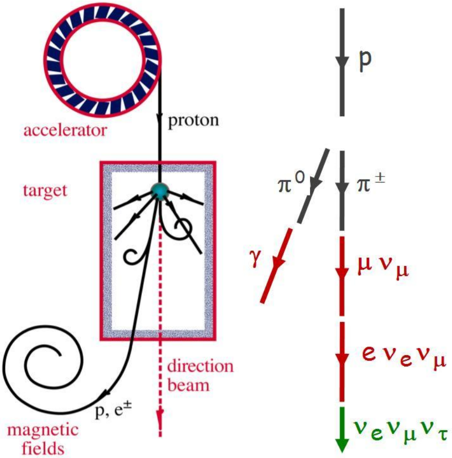
- We will consider two type of host galaxies: Normal star forming galaxies (NSFG) and Starburst galaxies (SBG)

Pionic ν production



Stellar Remnants

Supernova Remmants (SNRs)

- Stars with $M > 8M_\odot$
- $E_{p,max} \propto BR_s\beta_{ej} \backsimeq (10^3 - 10^4)\ TeV$
- Luminosities of $\simeq\ (10^{50} - 10^{51}) erg\ s^{-1}$
- The number of SN in a galaxy follows the SFR

Hypernova Remmants (HNRs)

- Subset of SN ($\simeq 1$ %) with extreme energetic ejecta
- Stars with $M > (50 - 80)M_\odot$, low metallicity (population II)
- $E_{p,max} \backsimeq (10^4 - 10^5)\ TeV$
- Luminosities of $\simeq\ (10^{51} - 10^{52}) erg\ s^{-1}$

Diffuse cosmic neutrino flux

The contribution form each stellar remnant from a particular type of host galaxy is given by ,

$$\frac{dN(E_\nu)}{dE_\nu} = \int_{E_\nu}^{\infty} \eta_\pi(E_p) J_p(E_p) F_\nu(\frac{E_\nu}{E_p}, E_p) \frac{dE_p}{E_p} ,$$

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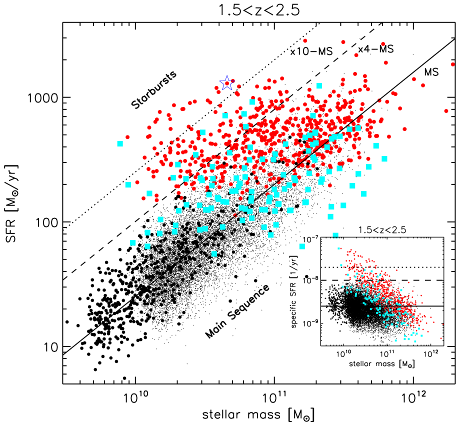
- $J_p(E_p) \rightarrow$ Primary proton spectrum
- $F_\nu(\frac{E_\nu}{E_p}, E_p) \rightarrow$ Secondary neutrino spectrum
- $\eta_\pi(E_p) \rightarrow$ Efficiency of the pion production

R_{SF}: Different types of galaxies (arXiv:1108.0933)



η_π:SBGs vs NSFGs

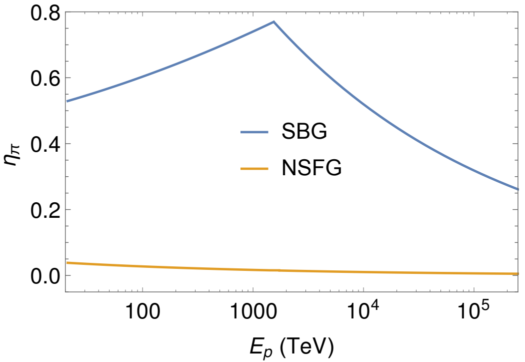
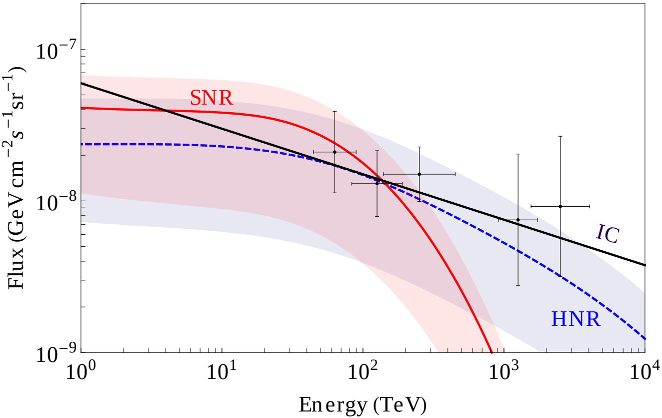


Figure: ν's production efficiency (η_π) as a function of the proton energy

SNR and HNR in NSFG's+SBG's neutrino flux (arXiv:1501.02615)



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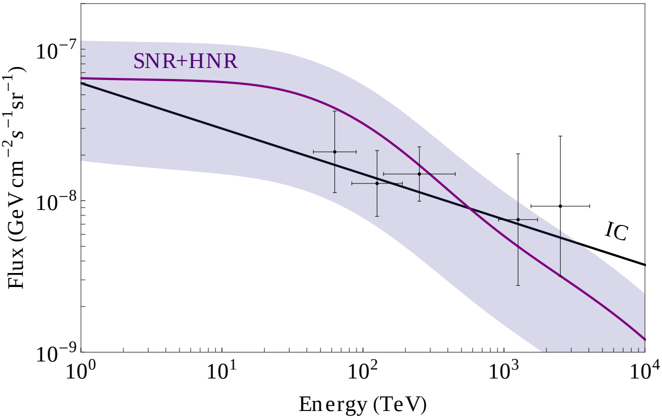

γ ray diffuse flux

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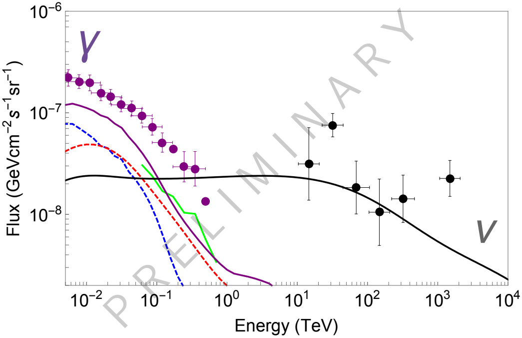
  - e^-/e^+ pairs interact again via the inverse compton mechanism $\rightarrow$ γ-ray
- This γ ray flux ought not exceed the constraints of Fermi-LAT.

γ ray diffuse flux (Work in Progress)



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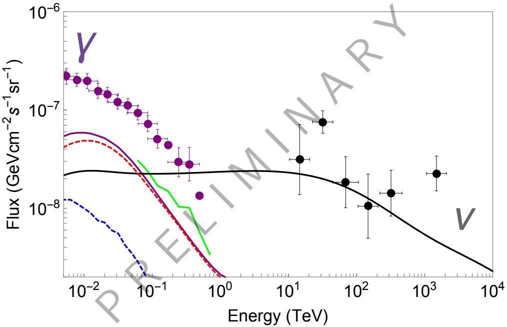


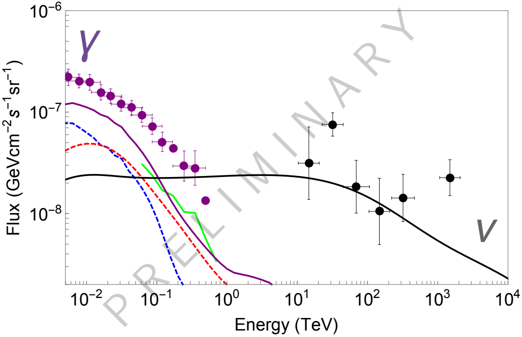
Conclusions

- Cosmic ν's are very useful to study the CR's accelerators in the *multimessenger approach*
- Diffuse neutrino flux might have a (dominant) stellar remnant origin
  - SBG's are very efficient ν producers
  - SNRs-HNRs in NSFGs-SBGs are plausible candidates
    - **The SNR-HNR in NSFGs-SBGs ν dominated flux scenario will result in a break on the spectrum**
- We (desperately) need more events!
- Intragalactic absorption make the associated γ ray diffused flux compatible with current bounds (WIP)

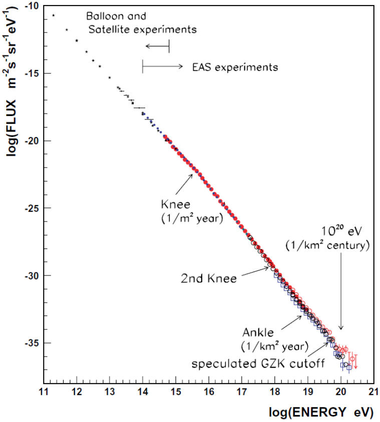
Thank you for your attention

Back up slides

γ ray diffuse flux (Work in Progress)

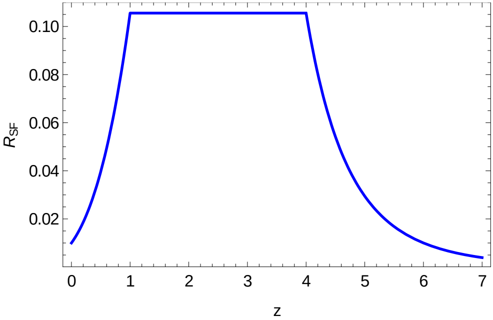


CR Spectrum



Balloon and
Satellite experiments
EAS experiments
Knee
(1/m² year)
2nd Knee
Ankle
(1/km² year)
speculated GZK cutoff
10²⁰ eV
(1/km² century)
log(FLUX m⁻²s⁻¹sr⁻¹eV⁻¹)
log(ENERGY eV)
-10
-15
-20
-25
-30
-35
11
12
13
14
15
16
17
18
19
20
21

R_{SF} as a function of z



Absorption optical depth as a function of z (arXiv:0905.1115)

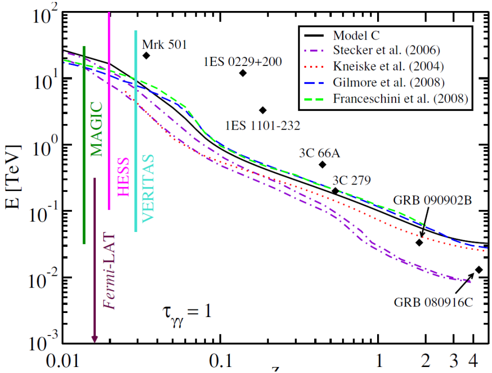


Figure: Plot of $\tau_{\gamma\gamma} = 1$ for several EBL models as a function of redshift.

- Differences between **NSFGs** and **SBGs**

Type	**NSFGs**	**SBGs**
Proton number density n (cm^3)	10	10^2
Diffusion coefficient D_0 ($cm^2 s^{-1}$)	10^{27}	10^{28}
Stellar wind velocity V_w ($km\ s^{-1}$)	500	1500
Scale high h (kpc)	0.5	1

NSFGs (f.e. Milky Way)

- $n_p = 10\text{cm}^3$
- Galaxies with a SFR (4)
- V_w ($\simeq 500$ kms^{-1})
- scale high $h \simeq 0.5$ (kpc)

SBGs

- Dense galaxies ($n = 10^2 \text{cm}^3$)
- High V_w ($\simeq 1500 \text{ kms}^{-1}$)
- scale high $h \simeq 1$ (kpc)
- Relative rate of SBGs $\rightarrow$ (10-20)% of the NSFGs

Diffused ν flux

- The observed diffuse flux of neutrinos from a particular stellar remnant will have contributions from different redshifts:

$$\frac{dN(E_\nu^{ob})}{dE_\nu^{ob}} = \frac{c}{4\pi H_0} \int_0^{z_{max}} \frac{dN(E_\nu)}{dE_\nu} \frac{R_{SR}(z)\ dz}{\sqrt{\Omega_M(1+z)^3 + \Omega_\lambda}}$$

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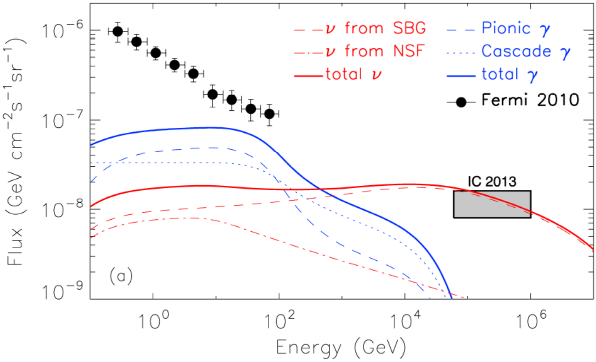
  - The f_{SBG}/f_{NSFR} will range between (0.1-0.2)

HNRs in SBG neutrino flux (arXiv: 1310.1362)



Fermi γ ray flux