On the interpretation of high-energy neutrino limits

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Overview

- Neutrino production in astrophysical sources
- Analysis strategies
- Interpreting stacking limits as diffuse limits
- Source class capabilities: north/south

Neutrino production

- $p\gamma \rightarrow \Delta^+ \rightarrow \pi^+ \; n/\pi^0 \; p$
  - $\pi^+ \rightarrow \mu^+ \; \nu_\mu \rightarrow (\nu_\mu) \; e^+ \; \nu_e \; \text{anti-}\nu_\mu$
  - $\pi^0 \rightarrow \gamma \; \gamma \; (E_\gamma \sim \text{TeV})$
  - **Pions**: Correlation TeV **Photons – Neutrinos**
  - Optically thick environment: $E_\gamma \sim$keV-GeV
- Main assumption:
  - $L_\gamma \propto L_p \propto L_\nu$
  - Photon luminosity:

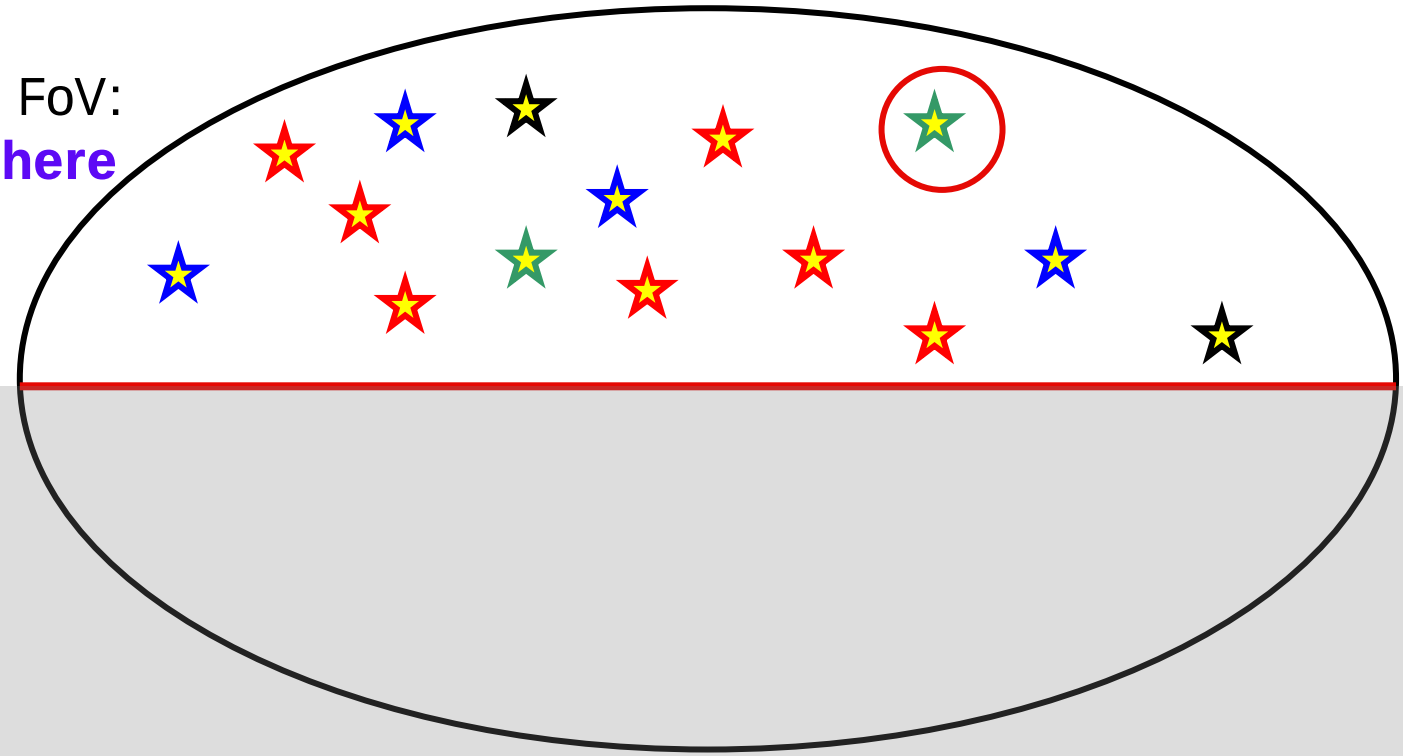
    Sources can be identified
  - Proton luminosity ~ TeV sources
  - Careful! → Other processes (Inverse Compton, proton synchrotron can contribute, too!)

Animation generated with povray

Detection strategies

Point source searches – significance map
identified photon sources

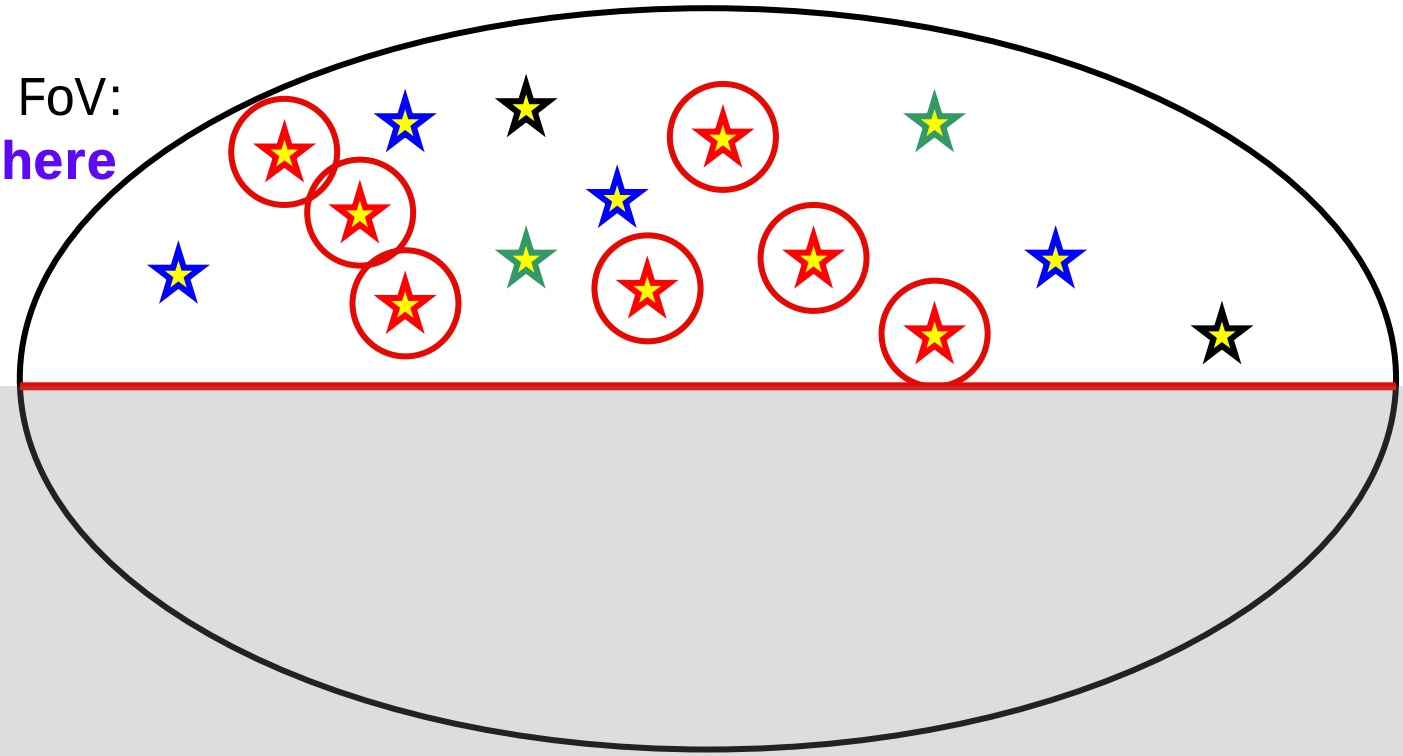
AMANDA/IceCube FoV:
northern hemisphere



Detection strategies

Stacking strategy – sum signal of point sources of same source class

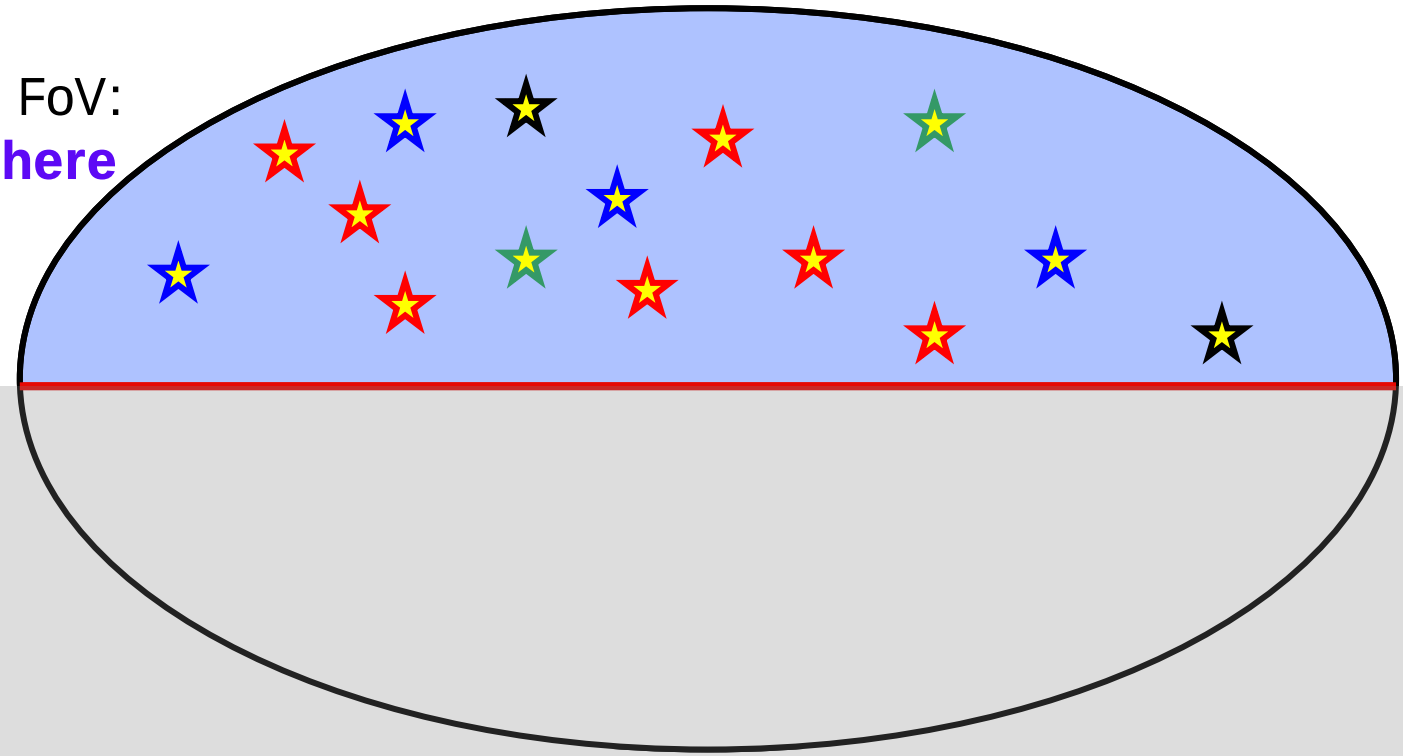
AMANDA/IceCube FoV:
northern hemisphere



Detection strategies

Search for a diffuse signal: use complete northern hemisphere

AMANDA/IceCube FoV:
northern hemisphere



AGN Stacking

- GeV blazars (**EGRET**) – *GeV*
- **Unidentified EGRET** sources – *unidGeV*
- **Infrared** sources – *IR*
- HAEO-A-detected **keV** sources – *keV(H)*
- ROSAT-detected **keV** sources – *keV(R)*
- **TeV** blazars - *TeV*
- **Compact Steep** Spectrum and **Giga-Hertz** peaked sources – *CSS/GpS*
- **FR-I** galaxies including **M87** – *FR-I(M)*
- **FR-I** galaxies without M87 – *FR-I*
- **FR-II** galaxies – *FR-II*
- Radio-weak **quasars** – *QSO*

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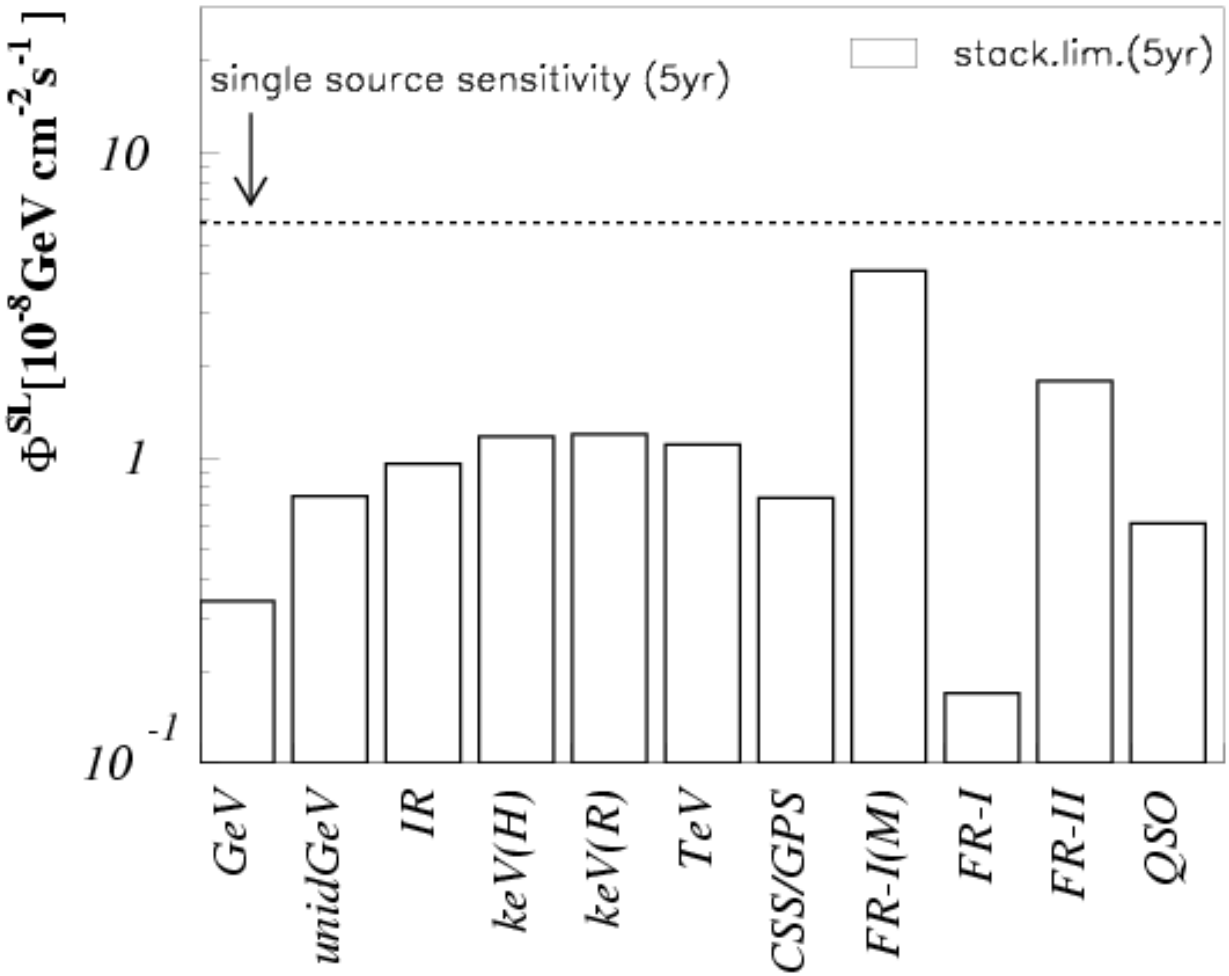
AGN Stacking



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Stacking → Stacking diffuse

$$\Phi^{SDL} = \frac{\varepsilon \cdot \xi}{2 \cdot \pi \cdot sr} \cdot \Phi^{SL}$$

Stacking diffuse limit

Stacking limit

- ε: „**stacking factor**“ → identified sources not included in stacking analysis
- ξ: „**diffusive factor**“ → diffuse background of corresponding source class

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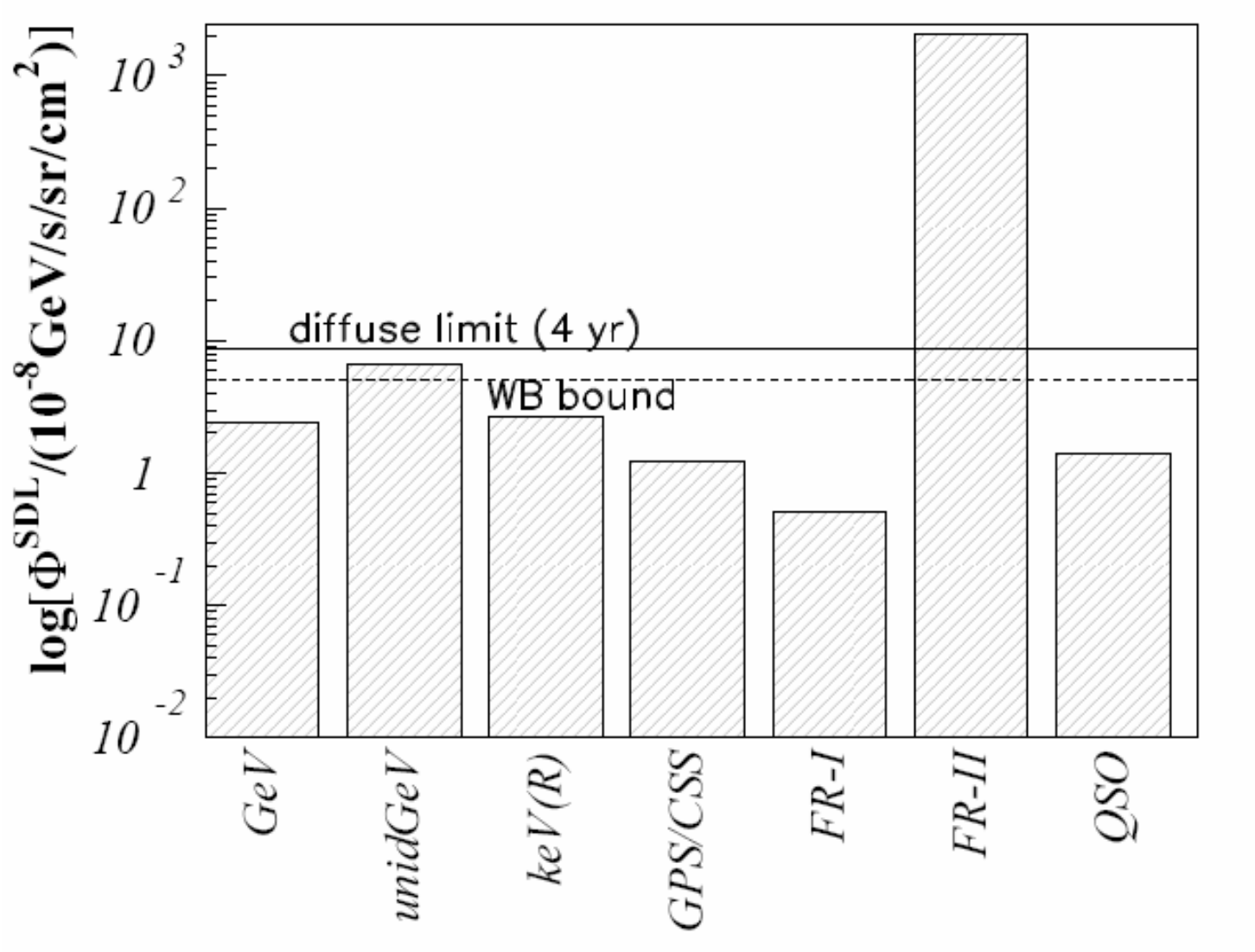
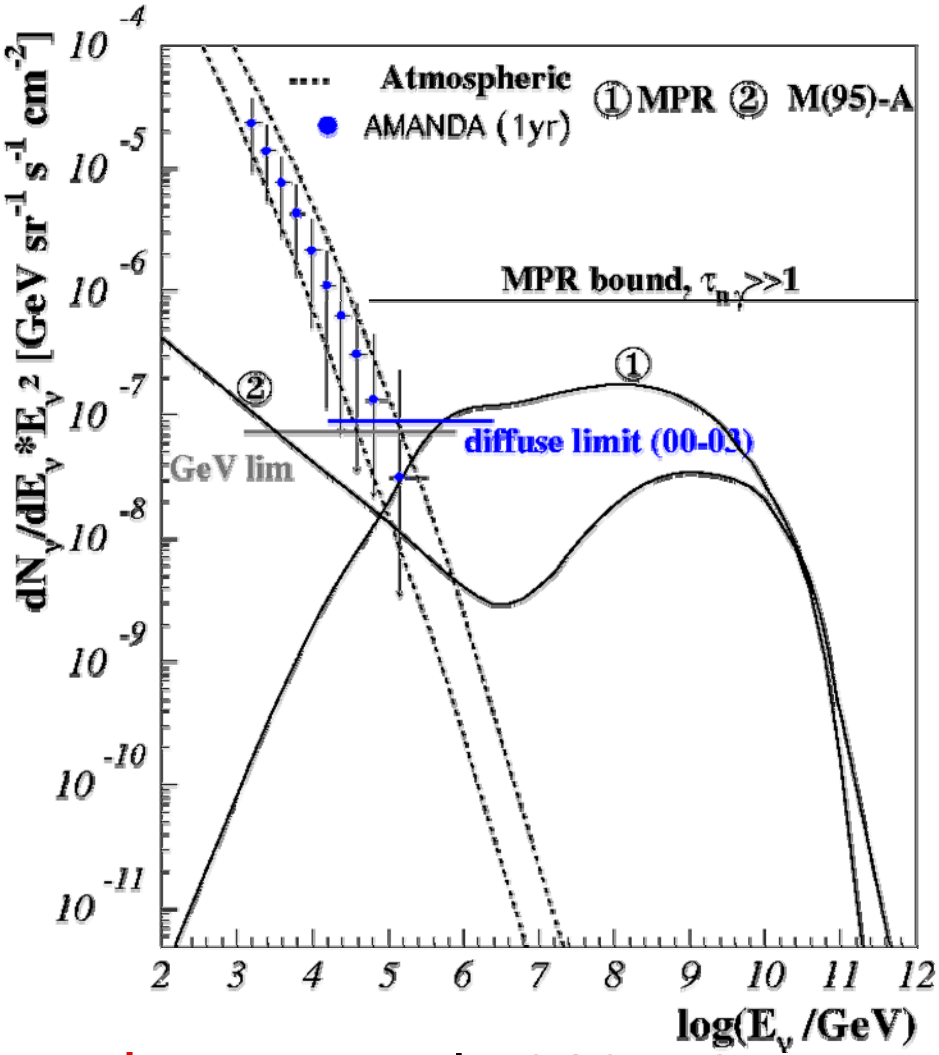
Stacking diffuse limits



Example: EGRET-sources

- AGN with GeV emission
- Flux models normalized to extragalactic background
- GeV limit: stacking
  - Retriction of models
  - Limit far below atmospheric backgorund!
  - Only possible through examination of particular source class



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Comparison of north/south capabilities

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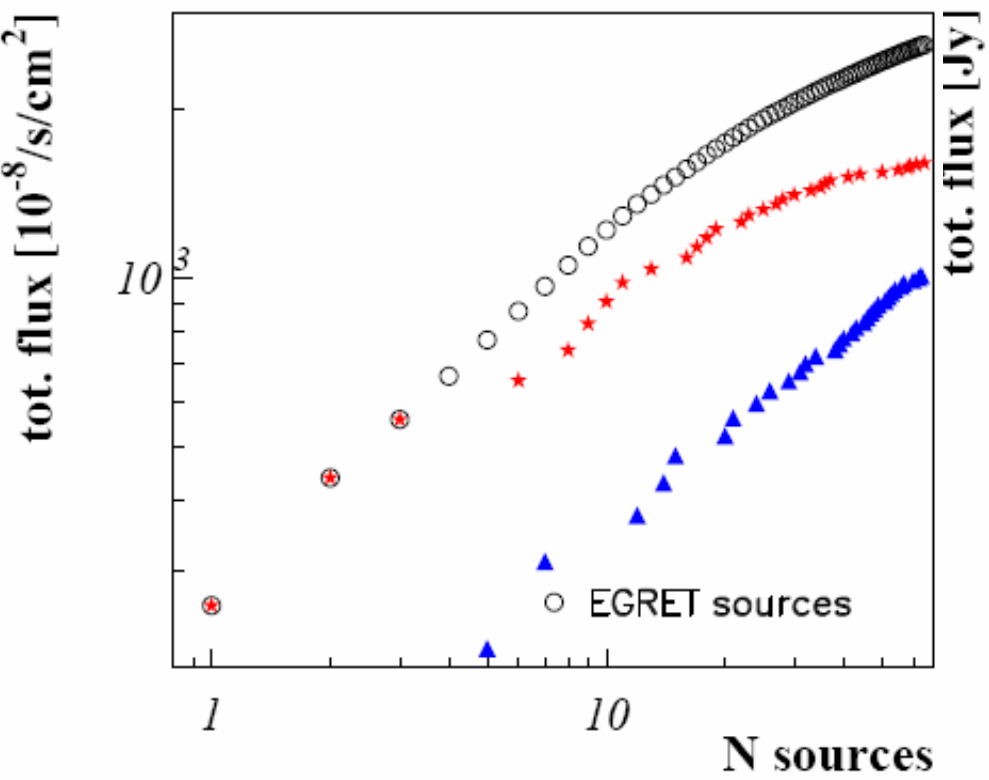
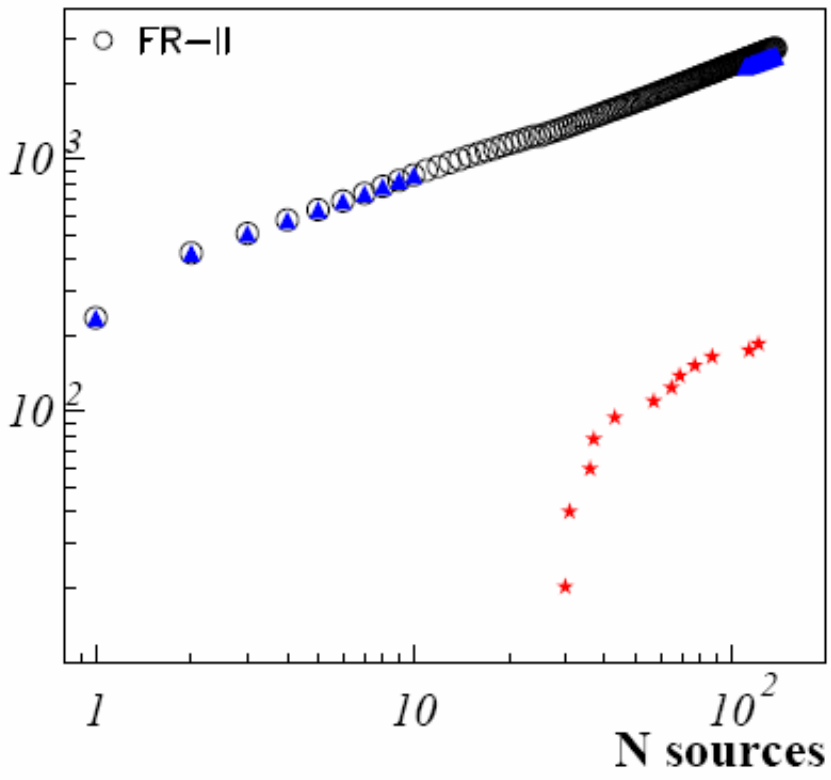
EGRET: south!

FR-II: north!

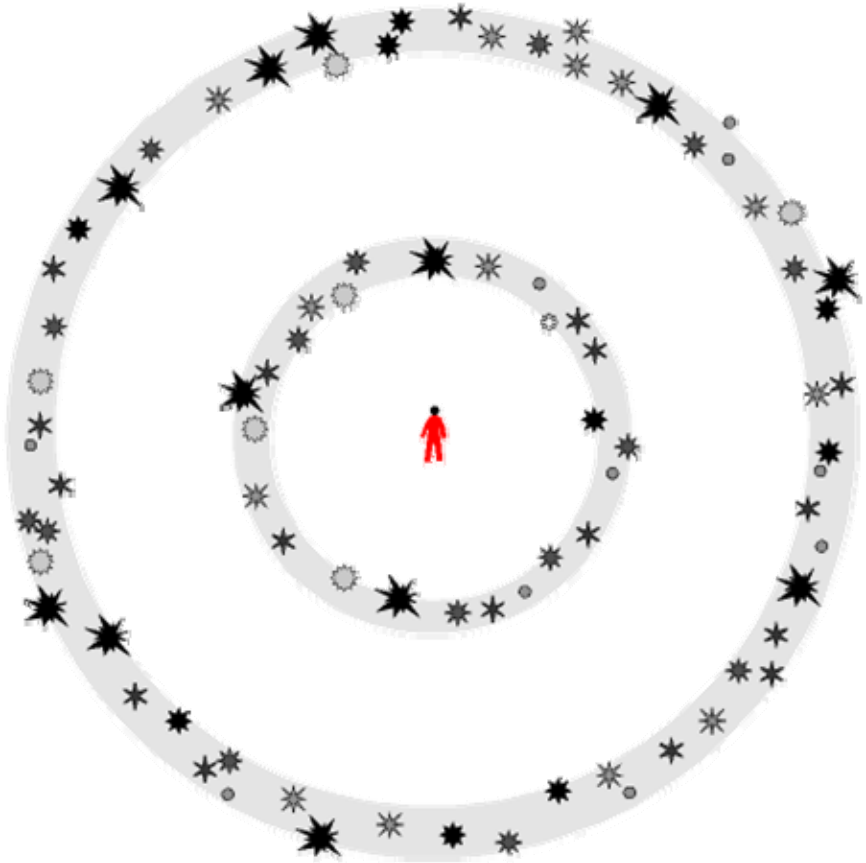




▲ northern sources
★ southern sources

Olbers‘ Paradox (1826)

- Universe infinite in space & timet → **infinite brightness?**
- observation: **No!**
- Physics conclusions:
  - **finite universe**
  - **no thermal equilibrium**
- **Neutrinos**: no detection so far → **physics conclusions**



http://www.aldebaran.cz/astrofyzika/kosmologie/standard/olbers.gif

In conclusion…

- Method to convert stacking limits into diffuse limits
- EGRET sources: stacking diffuse limit starts to constrain low energy region (~1 TeV/ pp interactions in AGN)
- Source class distribution:
  - EGRET sources → most luminous ones in southern hemisphere
  - FR-II galaxies → most identified objects north
  - More source classes presented in astro-ph/0607427