CRC 1491 –
Cosmic Interacting Matter
from source to signal

RUHR-UNIVERSITÄT BOCHUM

GAMMA RAY AND NEUTRINO EMISSION FROM THE GALACTIC CENTER

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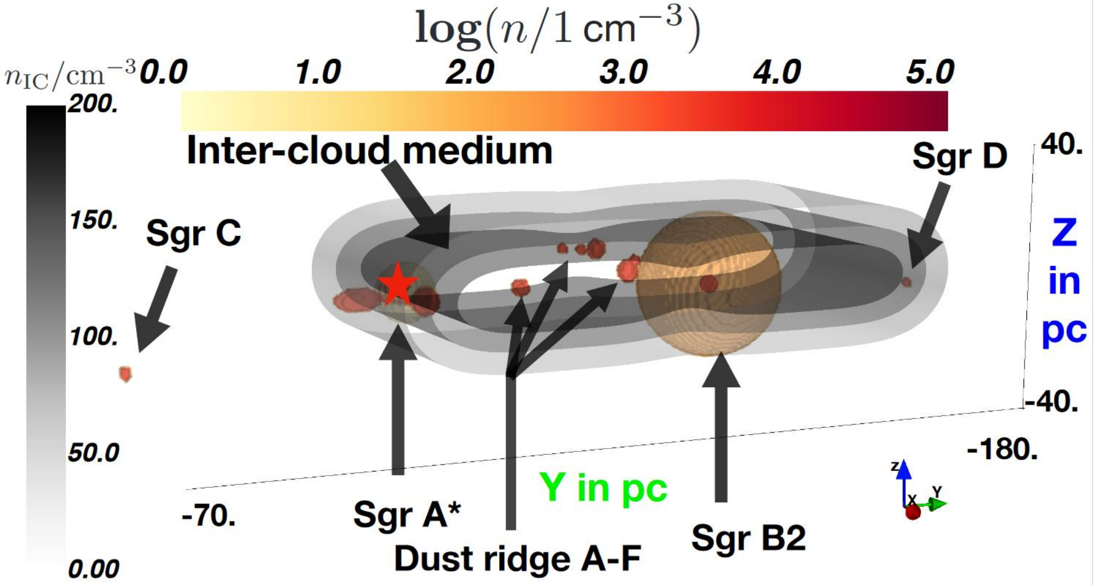
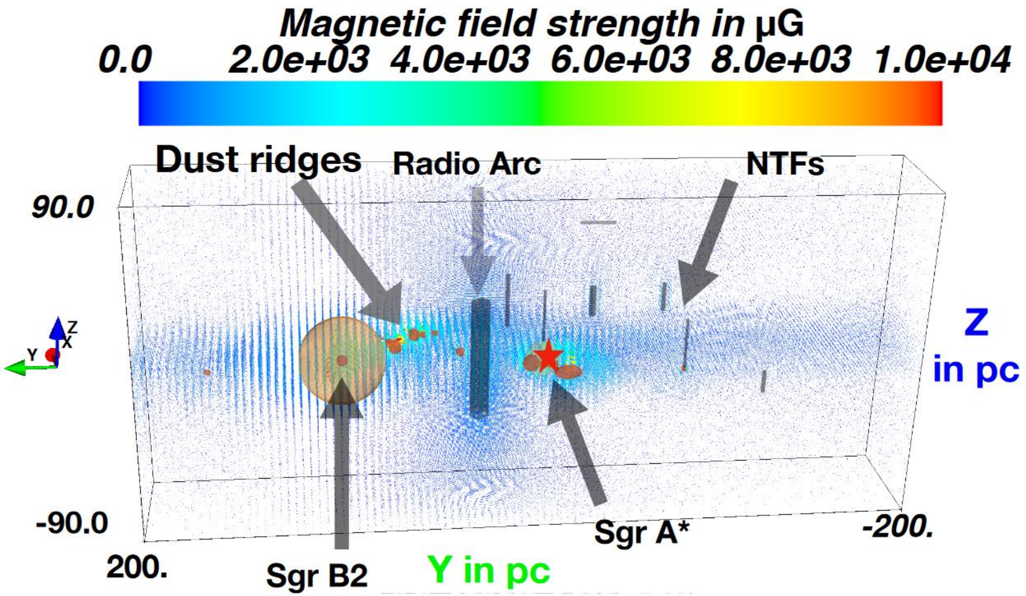
Galactic Center enviroment – gas distribution

- 13 molecular clouds (Guenduez et al. (2020))
- Central 10 pc structure (Ferriere et al. (2012))
- diffuse intercloud component (Ferriere et al. (2007))



Galactic Center enviroment – magnetic field

- 13 molecular clouds
- 7 non-thermal filaments
- Radio arc
- Inter-cloud component



Guenduez+ A&A ***644*** *(2020) A71*

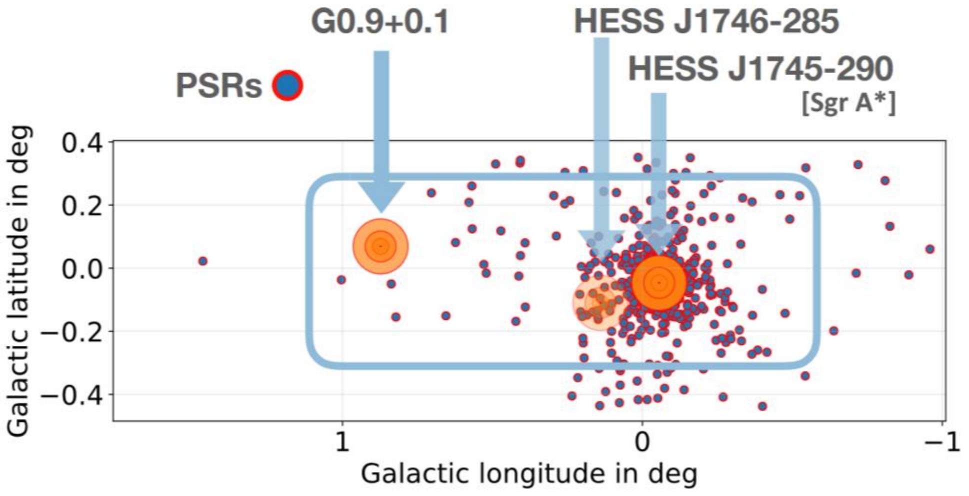
sources of cosmic rays

Testing different source setups:

- **Sgr A*** (also HESS J1745-290)
- **3sr** three SNR
- **uPSR** unresolved pulsar

$$\mathrm{d}n/\mathrm{d}r = k \cdot r^{-\alpha}$$

- **3sr + uPSR**
- **hom** homog. cylinder



Source	Contirbution [3sr]	Contribution [3sr + uPSR]
HESS J1745-290	72 %	58 %
HESS J1746-285	6 %	5 %
G0.9+0.1	22 %	18 %
uPSR	-	19 %

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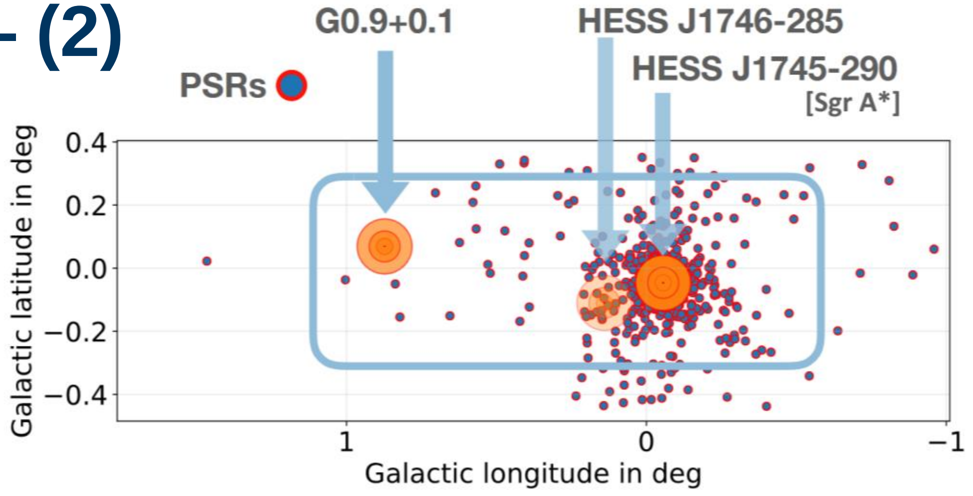
sources of cosmic rays – (2)

- CR protons
- Energy range 1 TeV – 1 PeV
- Simulated source Injection

$$\left.\frac{dN}{dE}\right|_s \propto E^{-2.0}$$

- Reweighted for source index $[-2.0; -2.4]$



transport model

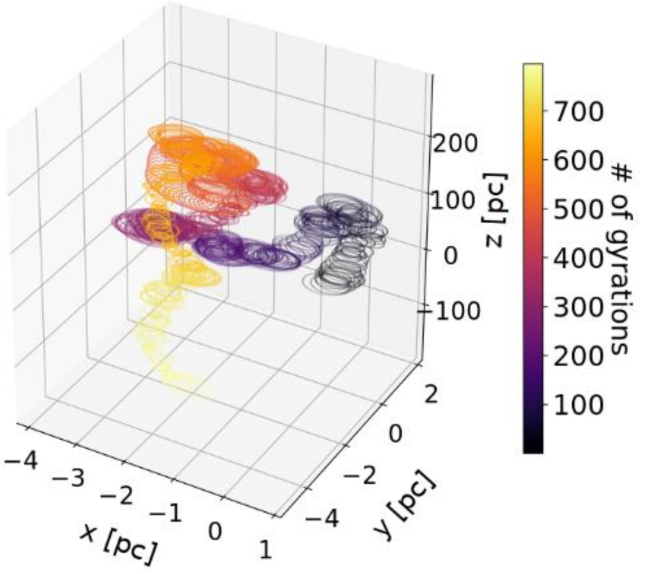
CRPropa

$$\frac{\partial n}{\partial t} = \nabla \cdot (\hat{\kappa}\, \nabla n) + \frac{\partial}{\partial E}\left[\frac{\partial E}{\partial t} n\right] + S(\vec{r}, E)$$

Diffusion:

- anisotropic in local magnetic field system
- $\hat{\kappa} = \mathrm{diag}(\kappa_\perp, \kappa_\perp, \kappa_\parallel) = \kappa_\parallel \cdot \mathrm{diag}(\epsilon, \epsilon, 1)$

  for $\vec{B} = B\, \vec{e}_z$
- spatially constant
- Quasi-linear theory: $\kappa_\parallel = \kappa_0 \cdot \left(\frac{E}{4\ \mathrm{GeV}}\right)^{\frac{1}{3}}$



J. Becker Tjus, L. Merten, Physics Reports **872** (2020)

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transport model – (2)

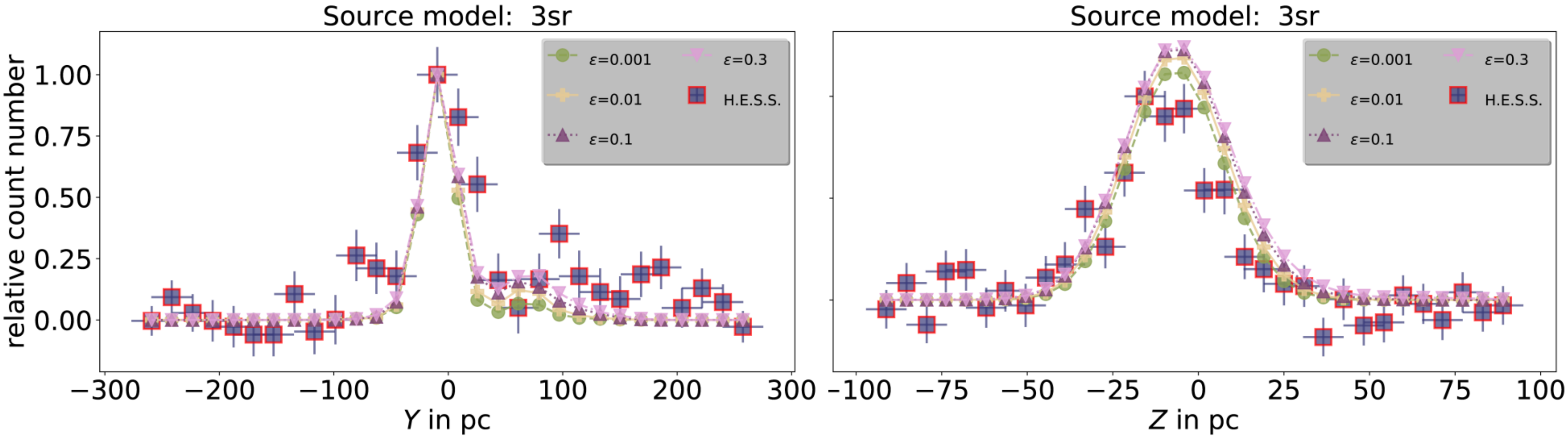
$$\frac{\partial n}{\partial t} = \nabla \cdot (\hat{\kappa}\, \nabla n) + \frac{\partial}{\partial E}\left[\frac{\partial E}{\partial t} n\right] + S(\vec{r}, E)$$

Energy loss:

- Hadronic interaction $p + p \rightarrow \pi^{\pm,0} \rightarrow \begin{cases} e^{+} \;\; \nu_e \;\; \nu_\mu \, \bar{\nu}_\mu \\ e^{-} \;\; \bar{\nu}_e \, \bar{\nu}_\mu \, \nu_\mu \\ \quad 2\gamma \end{cases}$
- Inverse Compton
- EM pair production

Find the best source model

- Compare latitudinal and longitudinal γ-ray emission with H.E.S.S data
- Calulate χ^2 for each scenario
- Best fit: **3sr**



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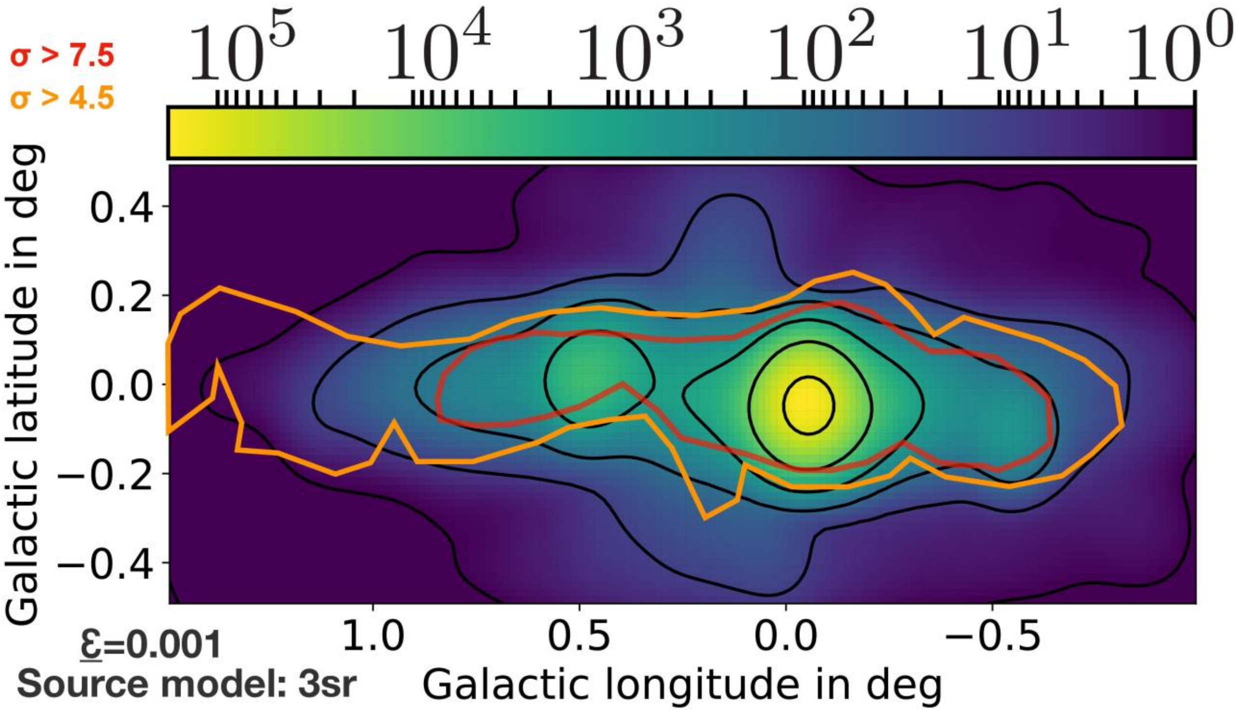
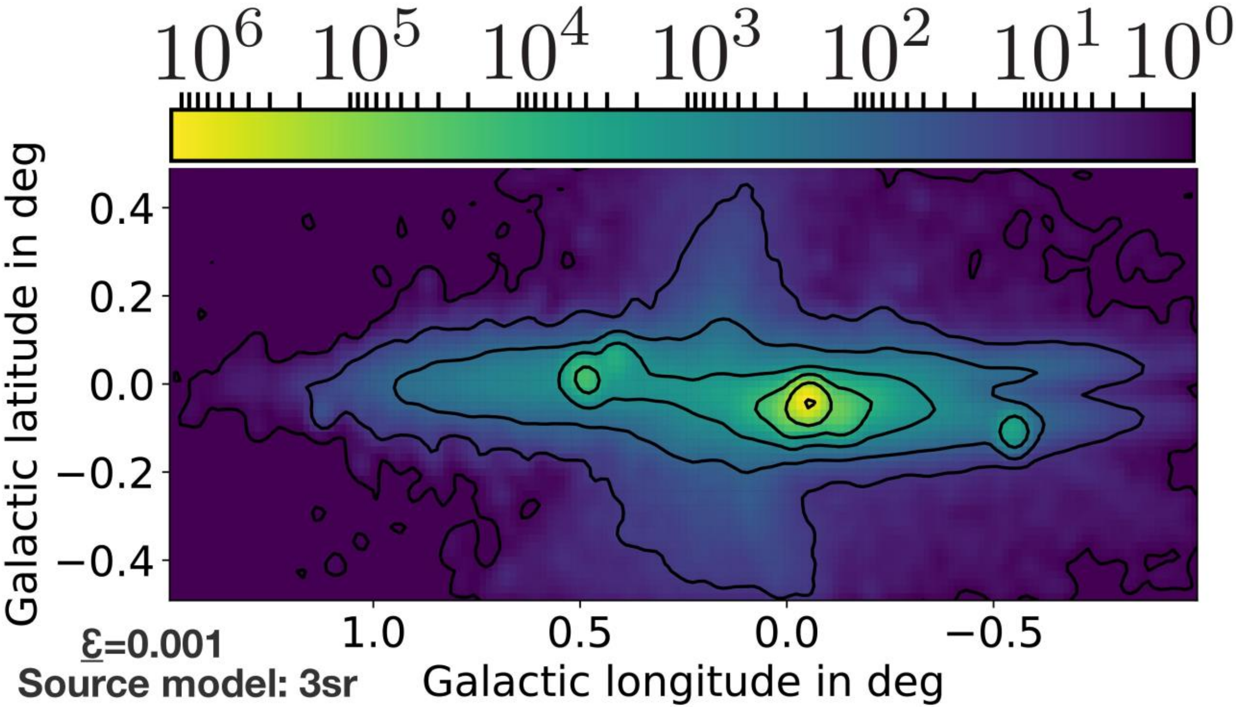
Compare 2d countmaps



H.E.S.S. resolution

$\sigma = 0.077°$

Compare 2d countmaps



CTA resolution

$\sigma = 0.03°$

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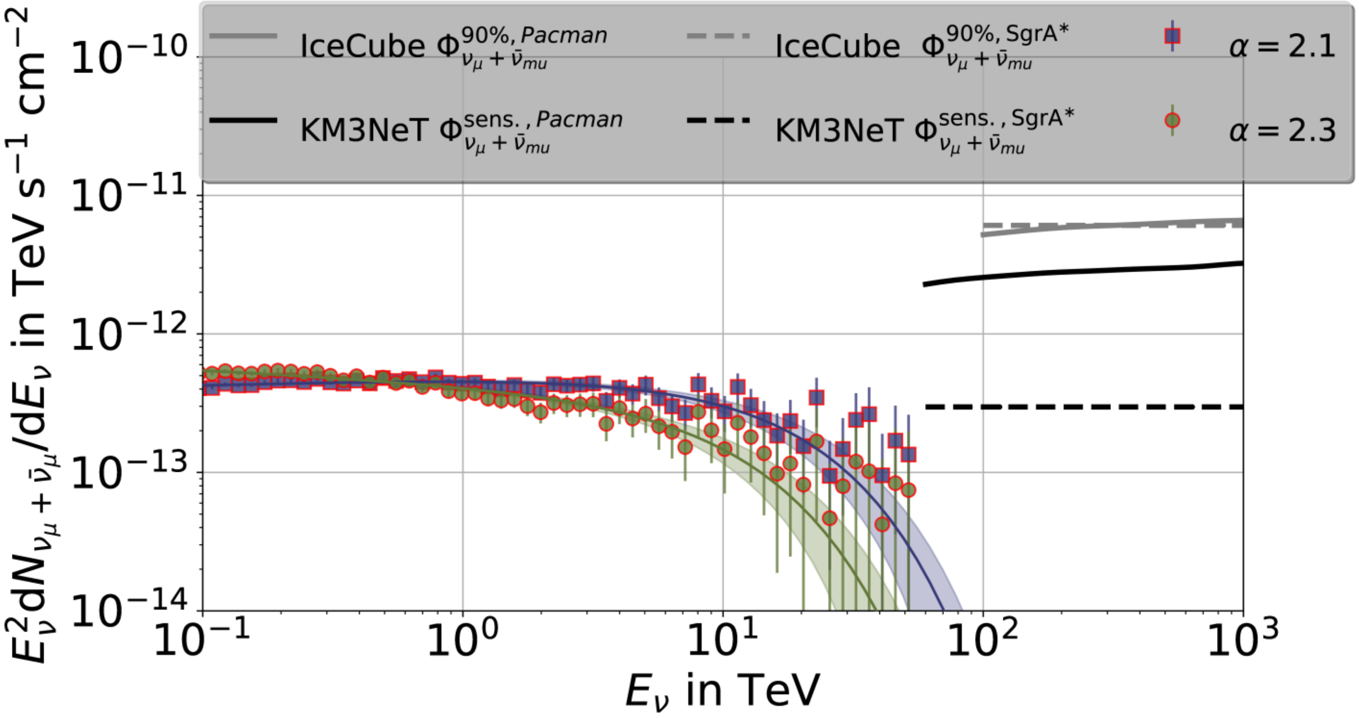
Neutrino flux



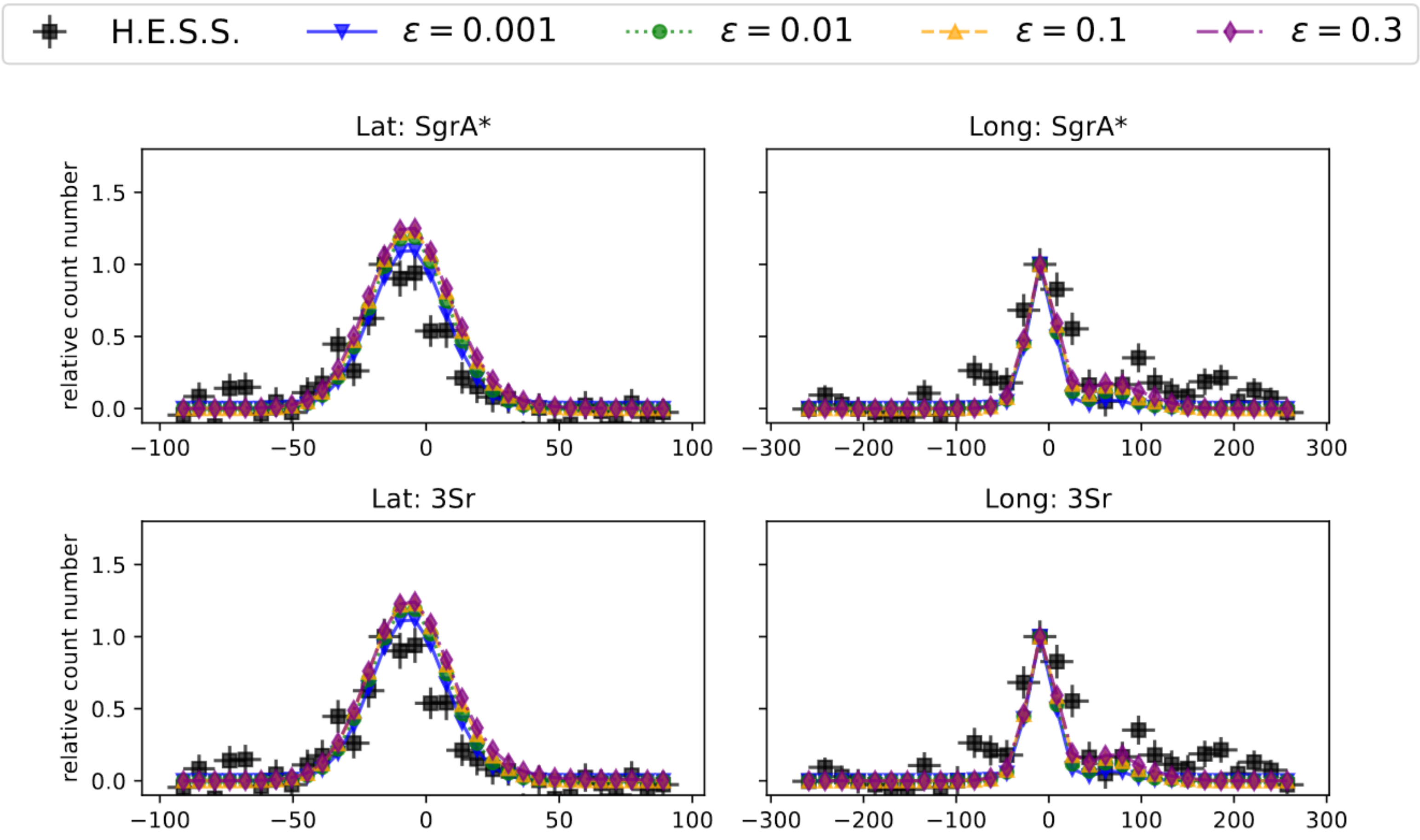
Conclusion

- 3 dominant sources
- Distribution of (unresolved) pulsars does not match the data
- We expect dominating parallel diffusion $\kappa_\perp/\kappa_\parallel = 0.001$
- Some unresolved small-scale features → more detailed gas map
- Neutrino detection unlikely

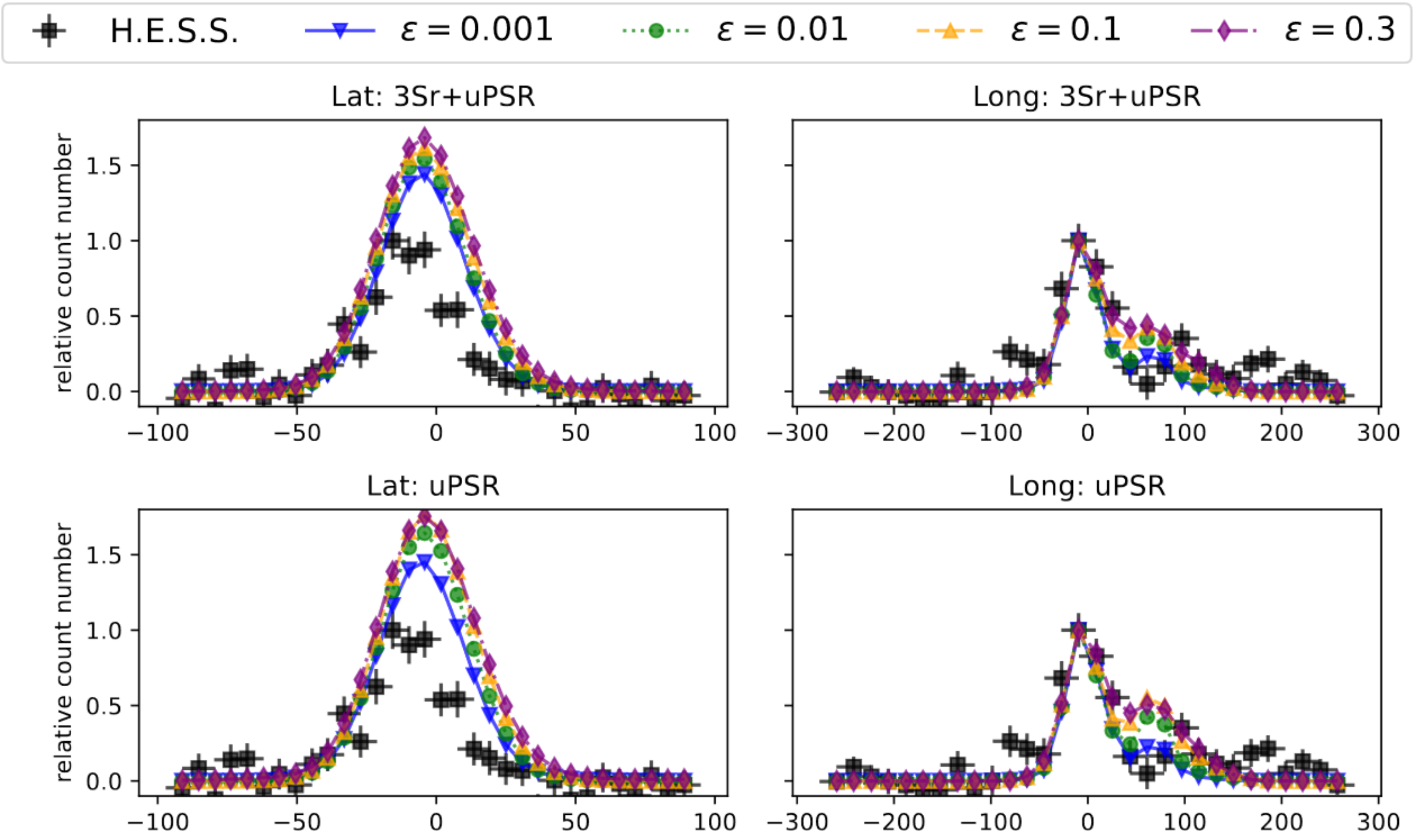
Outlook

- Outflow structure (advection)
- Structure of the Fermi-Bubbles
- Lower energy

Back up



H.E.S.S.
ε = 0.001
ε = 0.01
ε = 0.1
ε = 0.3
Lat: SgrA*
Long: SgrA*
Lat: 3Sr
Long: 3Sr
relative count number
1.5
1.0
0.5
0.0
−100
−50
0
50
100
−300
−200
−100
0
100
200
300



H.E.S.S.
ε = 0.001
ε = 0.01
ε = 0.1
ε = 0.3
Lat: 3Sr+uPSR
Long: 3Sr+uPSR
Lat: uPSR
Long: uPSR
relative count number
0.0
0.5
1.0
1.5
−100
−50
0
50
100
−300
−200
−100
0
100
200
300