

# Cosmic-ray propagation under consideration of spatially resolved source distributions

# Spatially resolved CR source distribution

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- » Galaxy source models limited to axial symmetry and rely on analytical models
- » Approach: combine observed and simulated sources for more realistic source model

# Source model construction

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Hybrid Galaxy model

# Source model construction

observed sources

Hybrid Galaxy model

# Observed source sample

- » H.E.S.S. Galactic plane survey (HGPS, H.E.S.S. Collaboration, A&A 612, A1 (2018))
- » 31 firmly identified sources with distance estimate



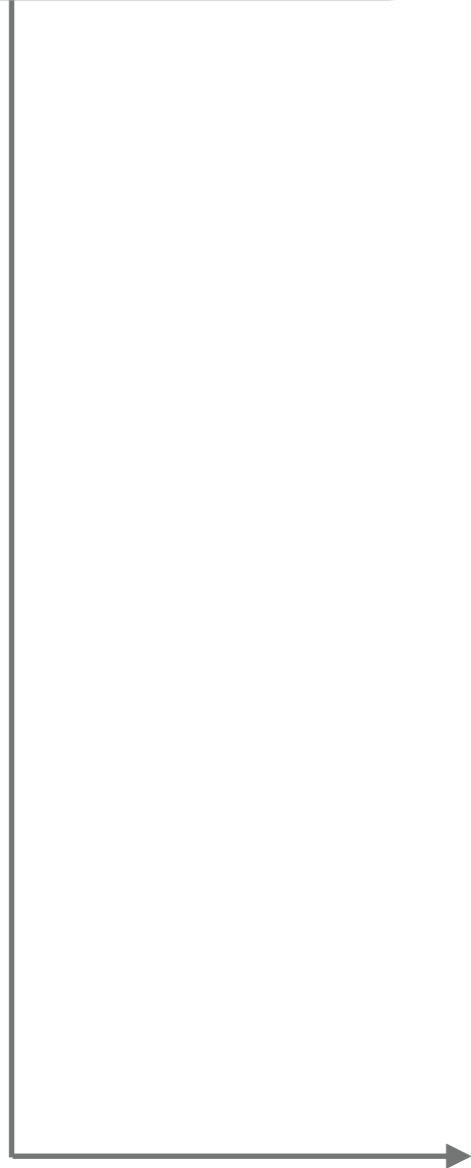
Vikas Chander

# Source model construction

observed sources

HGPS sources with distance estimate

Hybrid Galaxy model



# Observed source sample

- » H.E.S.S. Galactic plane survey (HGPS, H.E.S.S. Collaboration, A&A 612, A1 (2018))
- » 31 firmly identified sources with distance estimate
- » 47 observed sources without counterpart



Vikas Chander

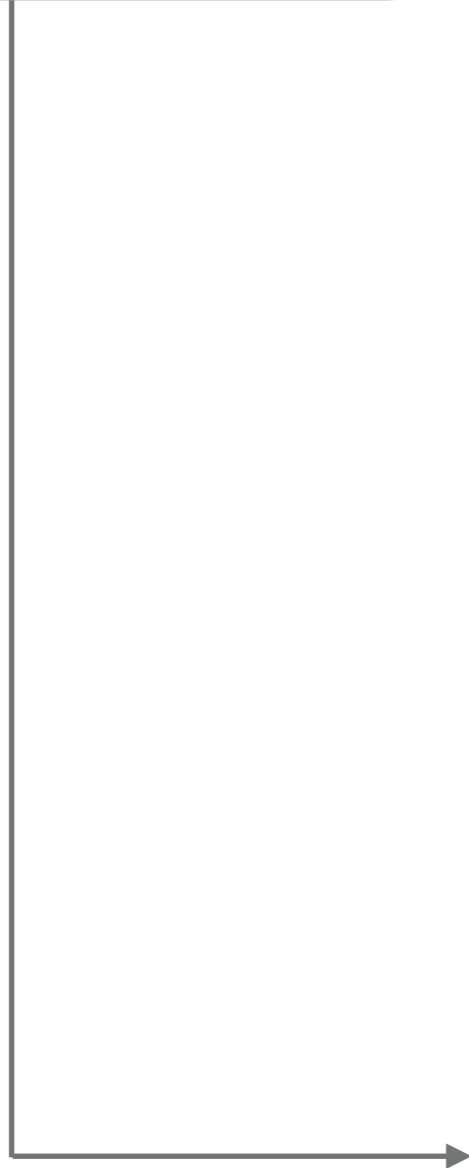
# Source model construction

observed sources

HGPS sources with distance estimate

HGPS sources without distance estimate

Hybrid Galaxy model





# Source model construction

observed sources

HGPS sources with distance estimate

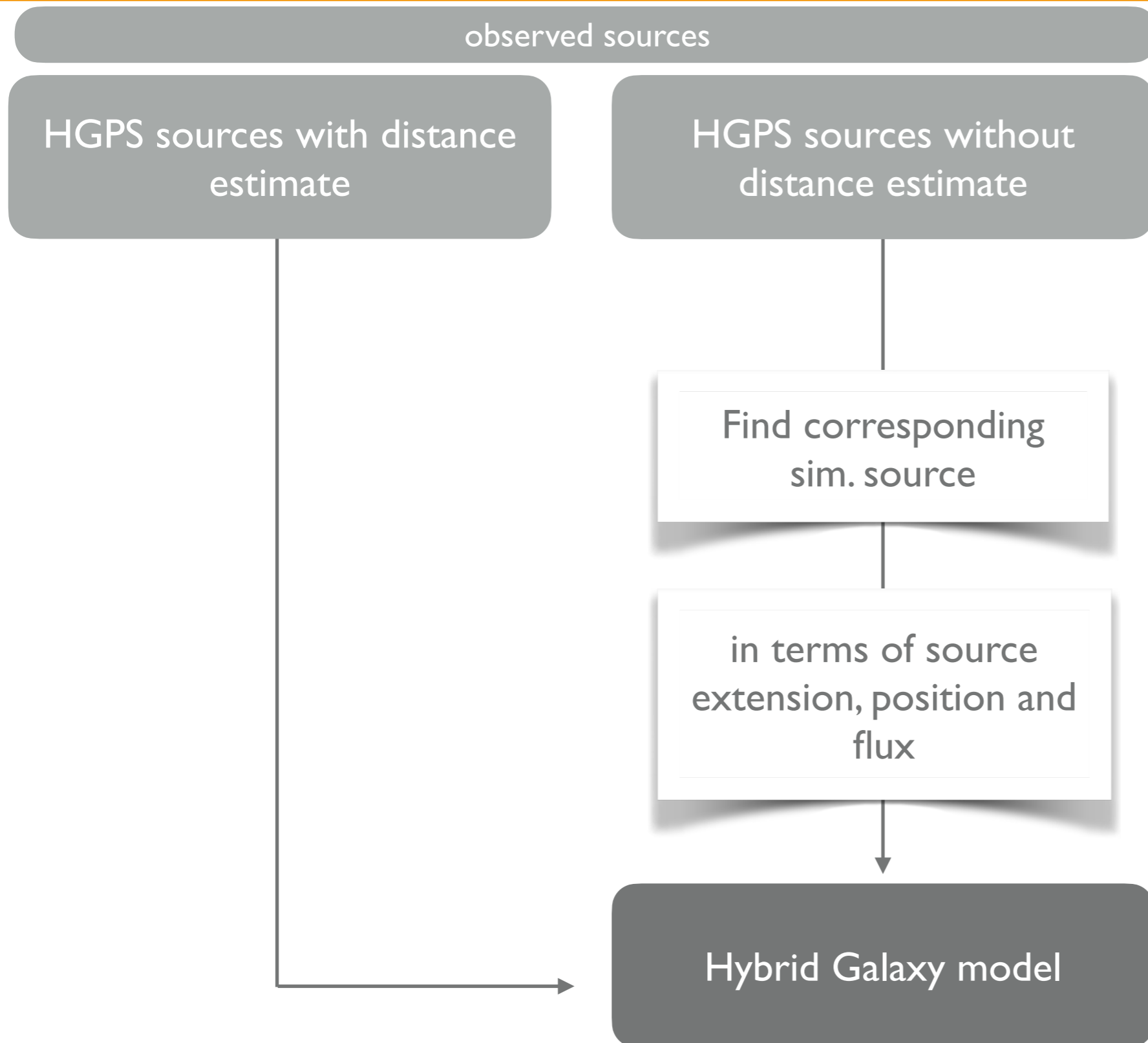
HGPS sources without distance estimate

Find corresponding sim. source

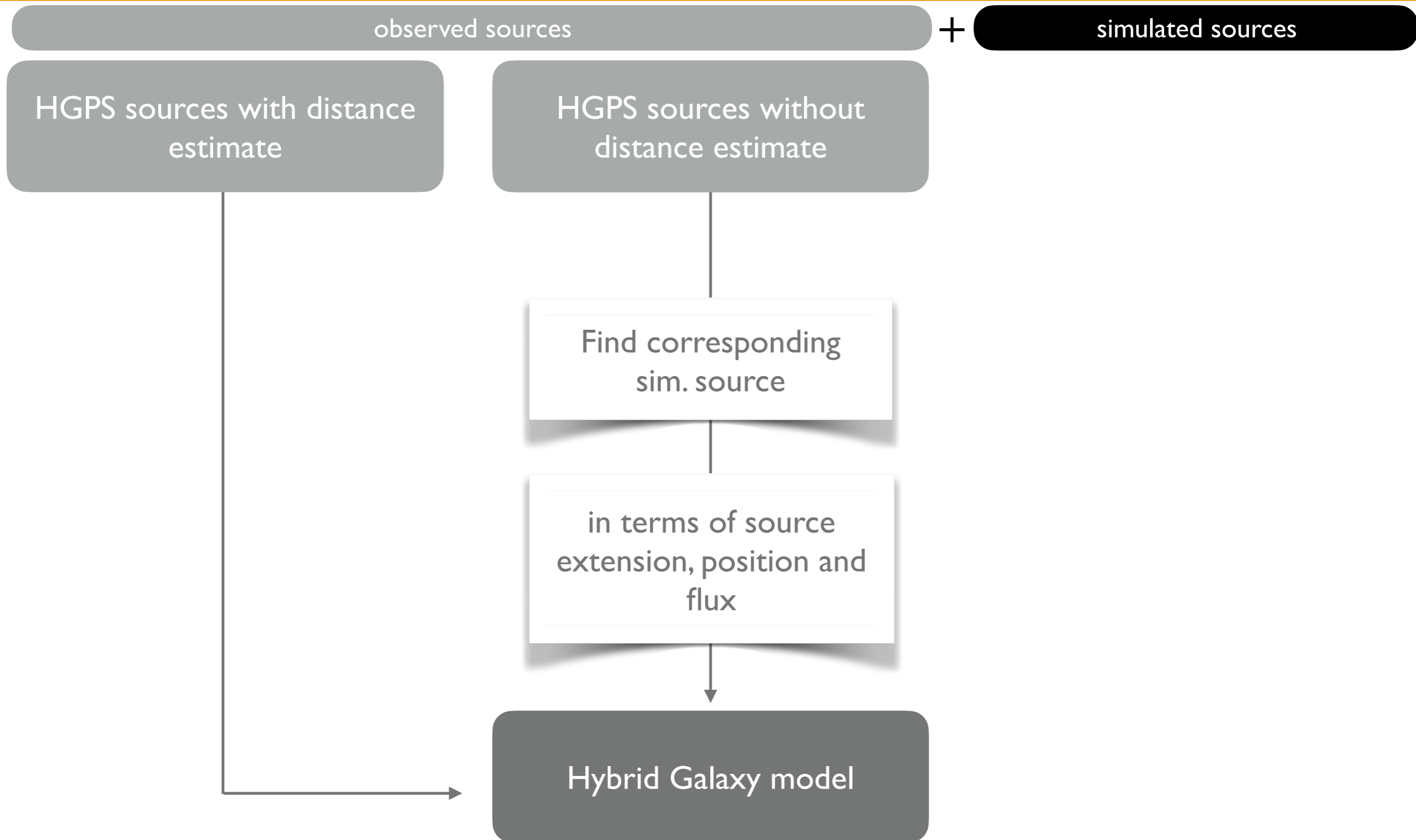
in terms of source extension, position and flux

Hybrid Galaxy model

# Source model construction

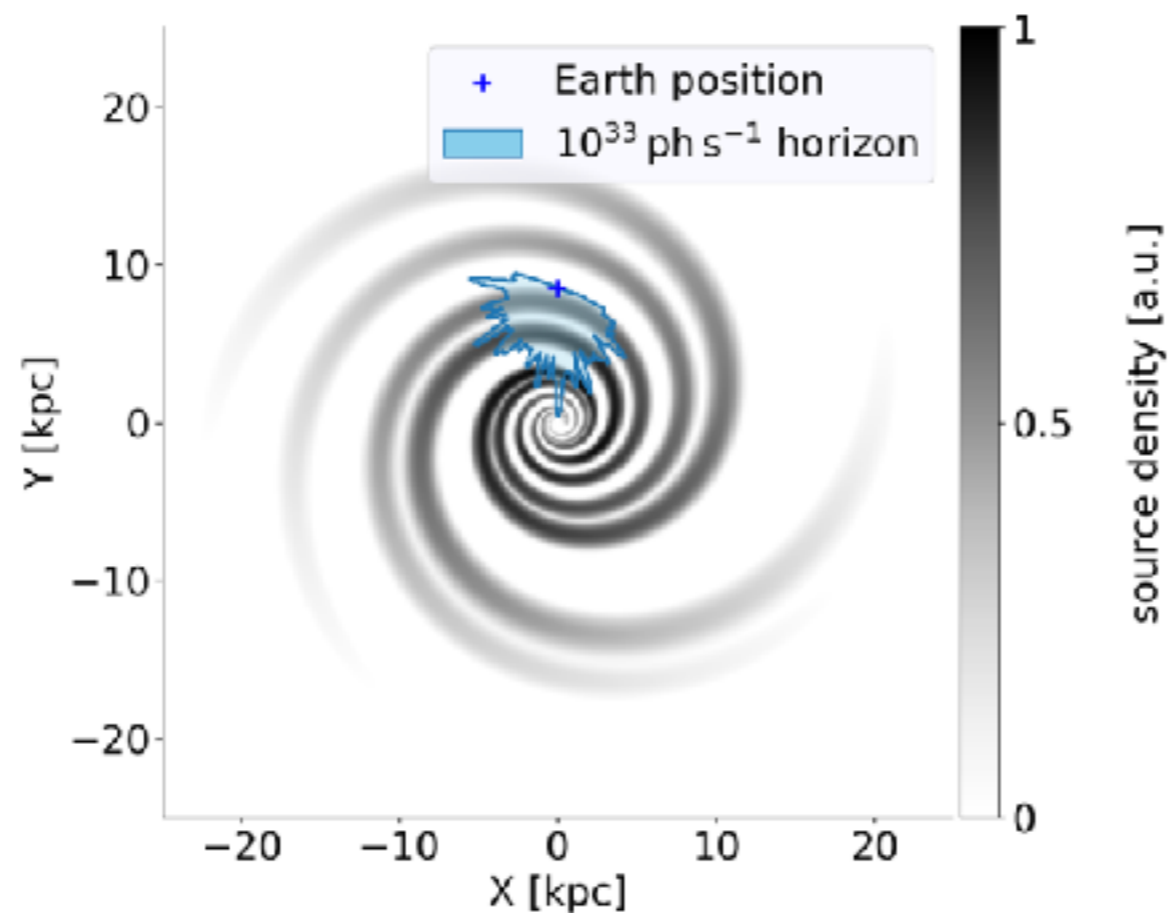


# Source model construction

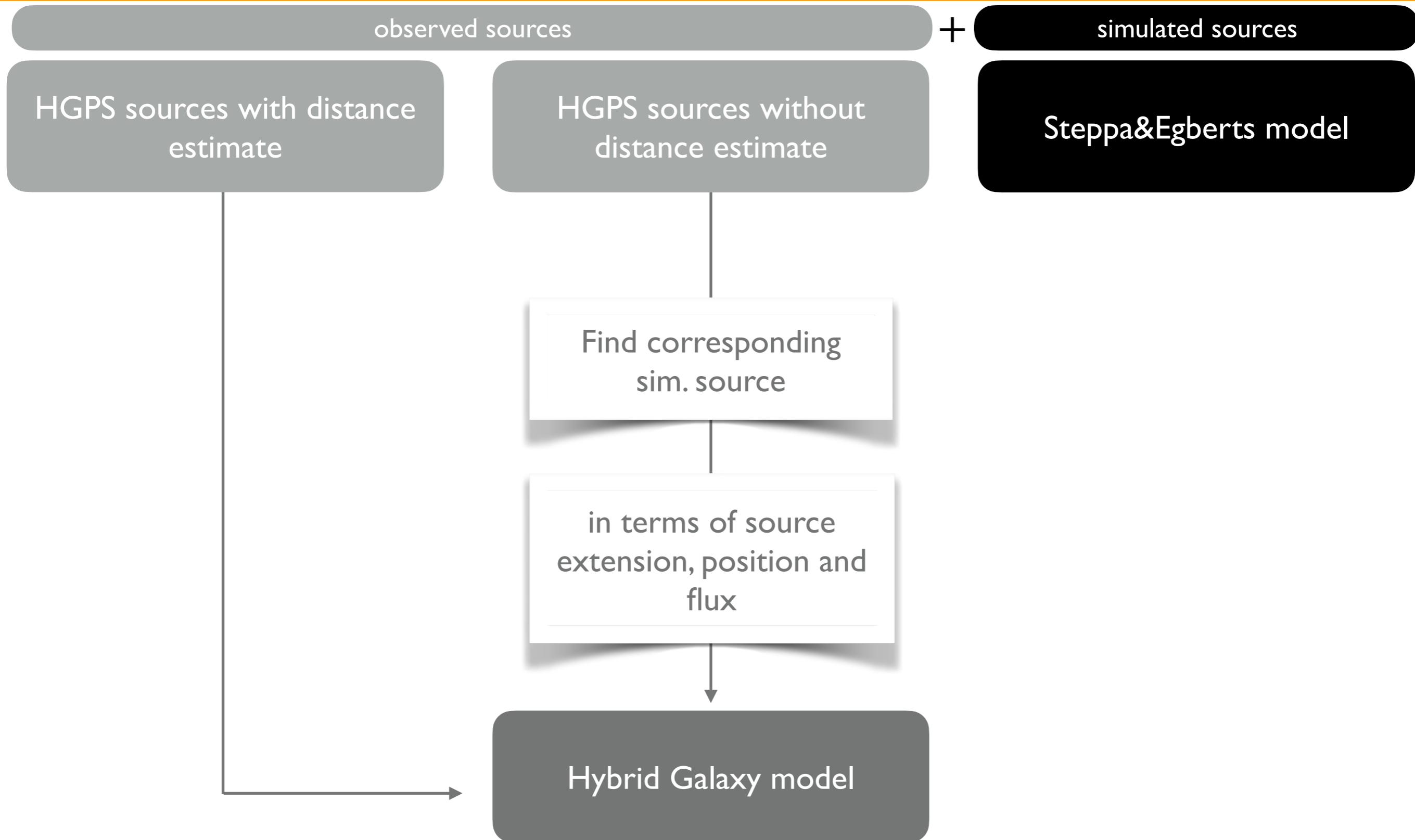


# Simulated source sample

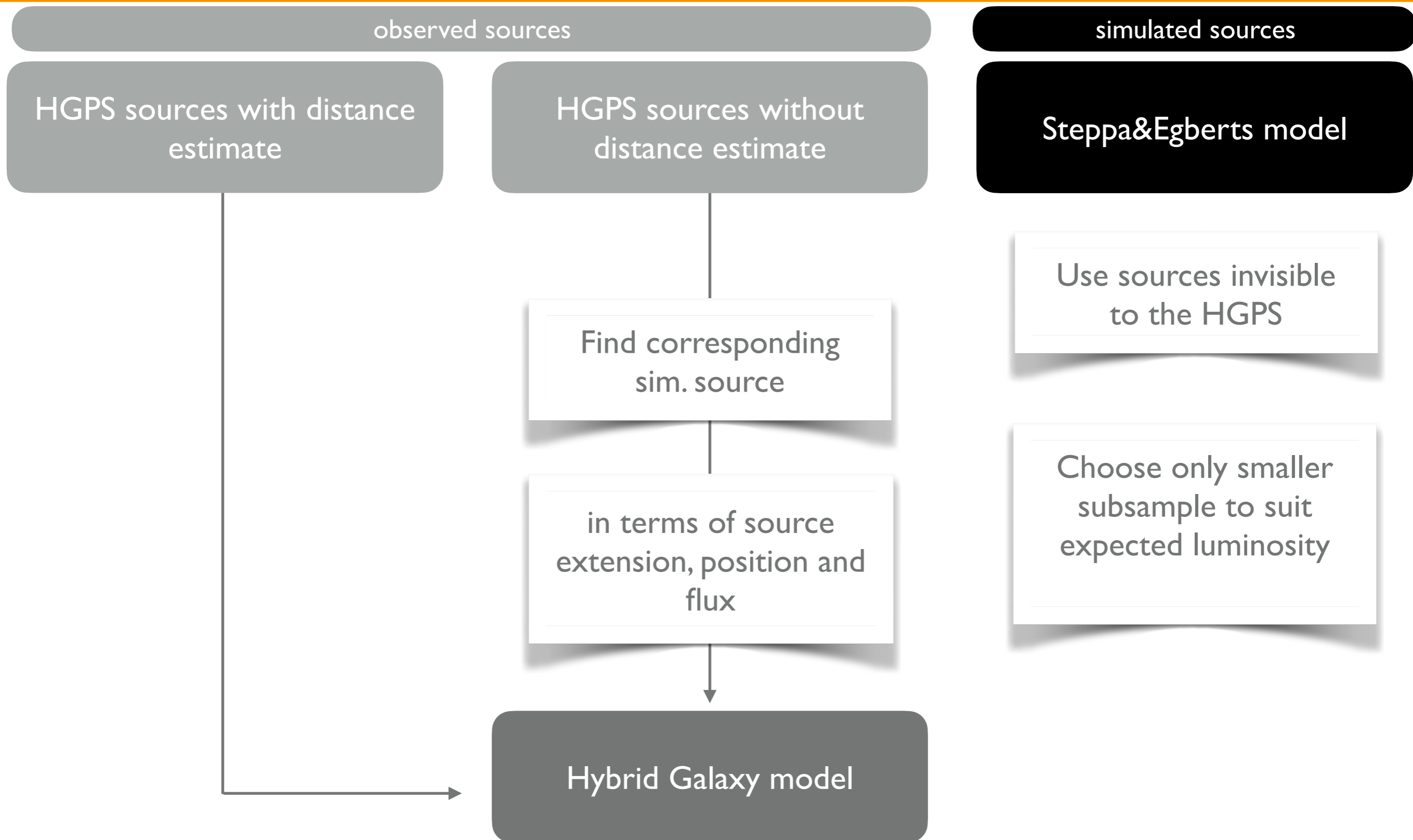
- » Model by Steppa & Egberts, A&A 643, A137 (2020)
- » Four arm spiral Galaxy model without a central bar



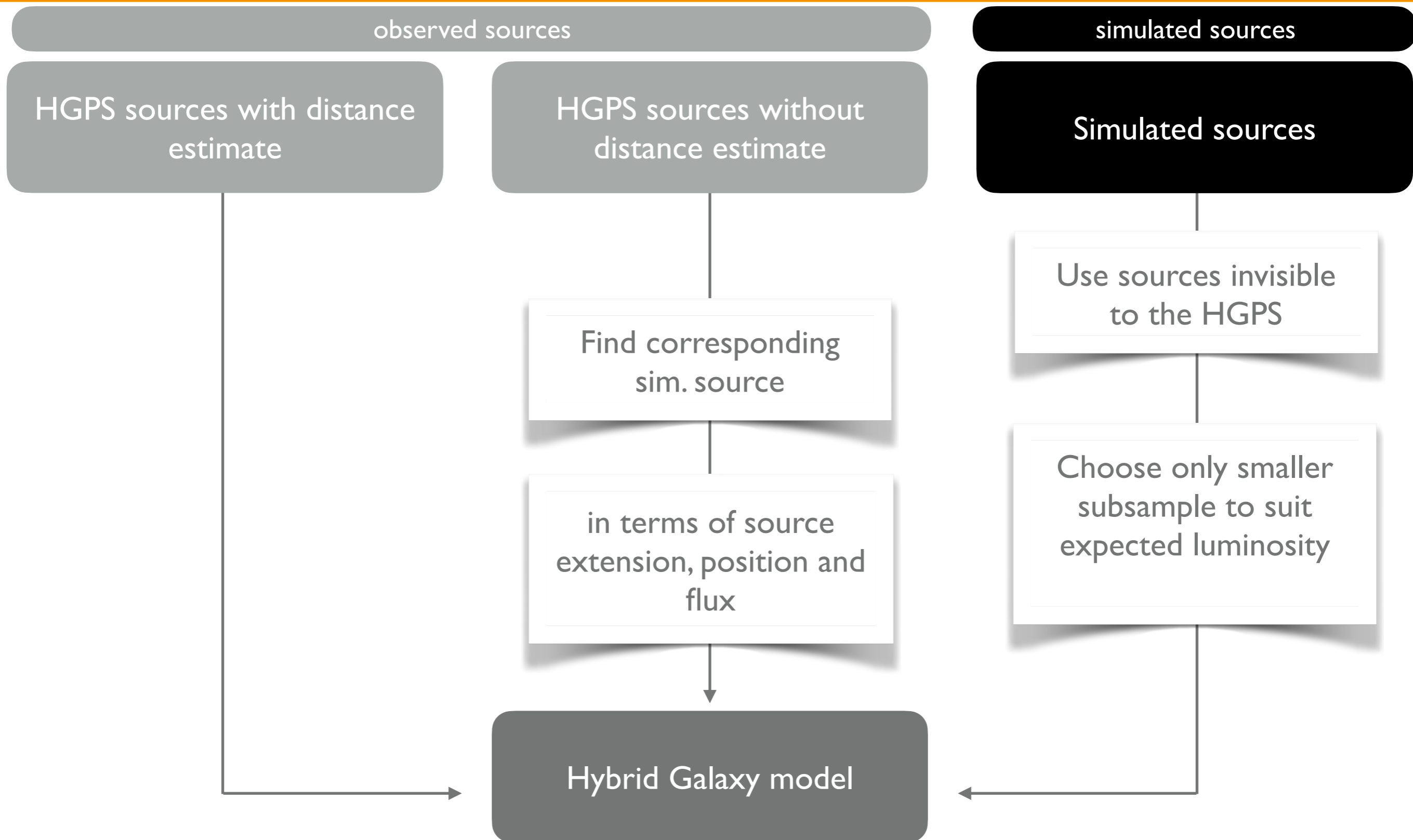
# Source model construction



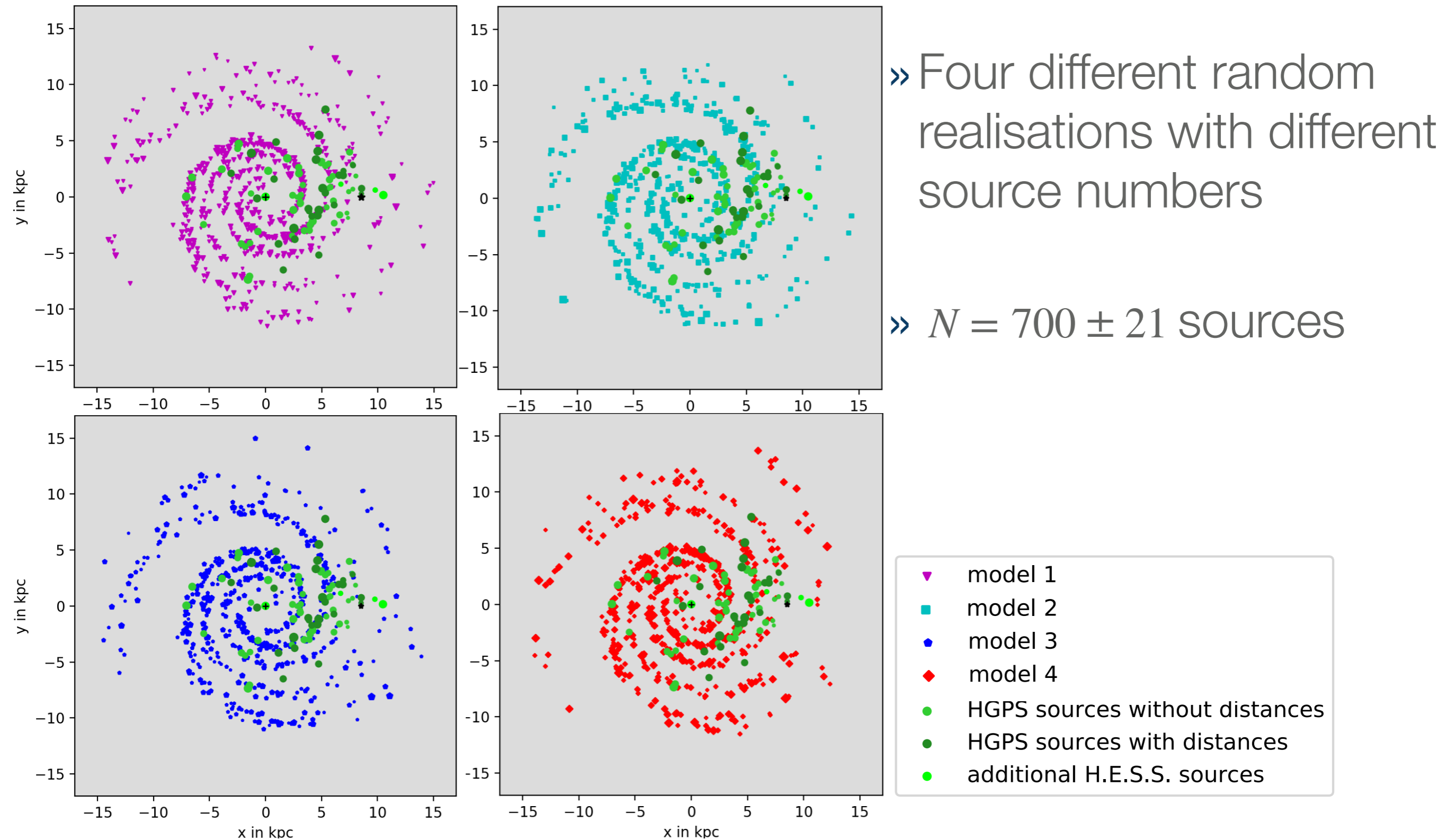
# Source model construction



# Source model construction

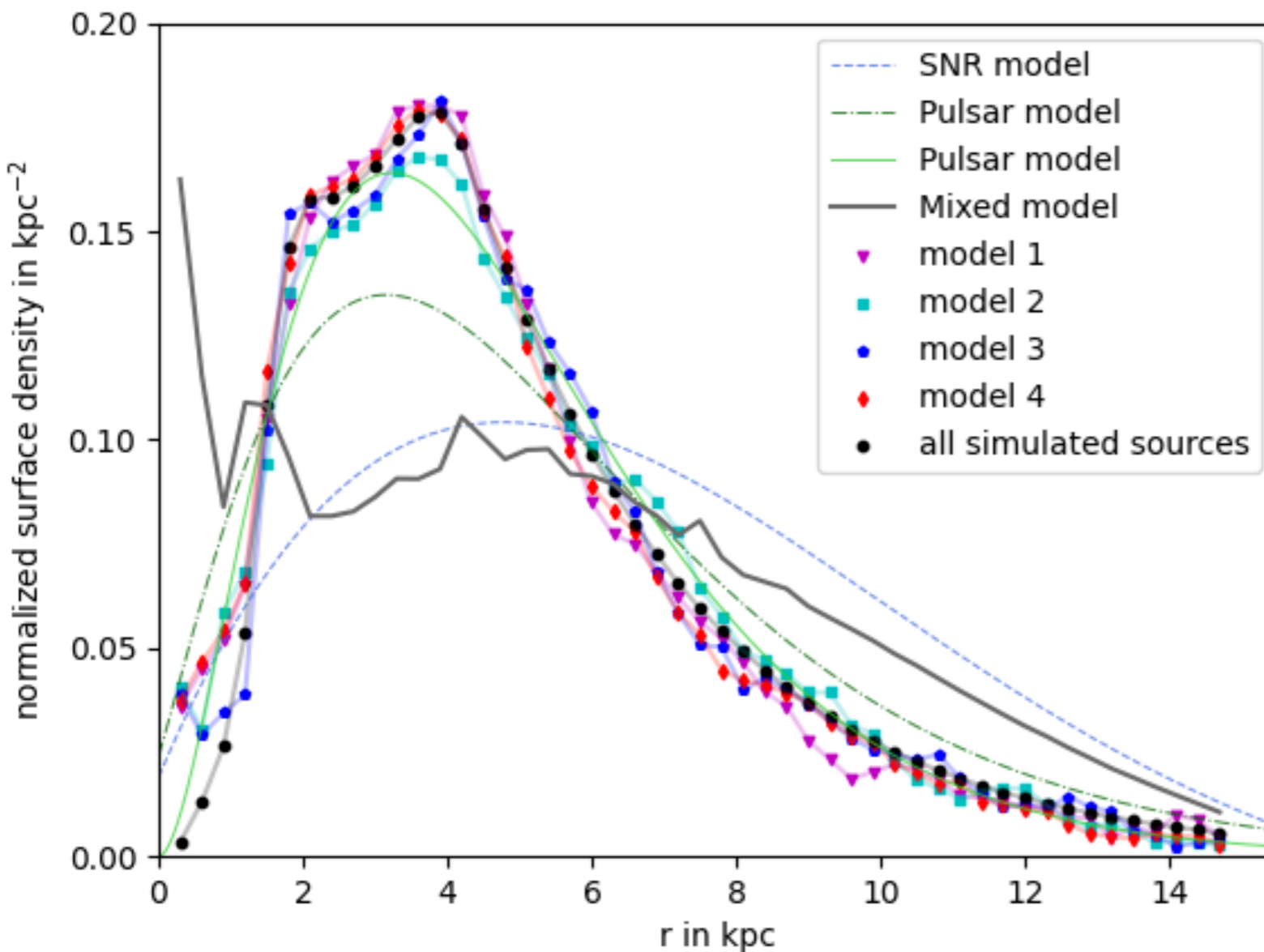


# Source model construction - Results





# Source Model Construction - Radial distributions



Case & Bhattacharya, *Astrophys.J.*504:761,1998  
Yusifov & Küçük, *Astron.Astrophys.* 422 (2004) 545-55  
Lorimer et al, *Mon.Not.Roy.Astron.Soc.*372:777-800,2006  
Carlson et al, *Phys. Rev. D* 94, 063504 (2016)

» Deficiency in the Galactic center → possibly due to lack of Galactic bar in the simulated sample

# Cosmic-ray transport simulation

» PICARD (Kissmann, *Astroparticle Physics* 55, 37-50 (2014))

» Define each source as leptonic or hadronic

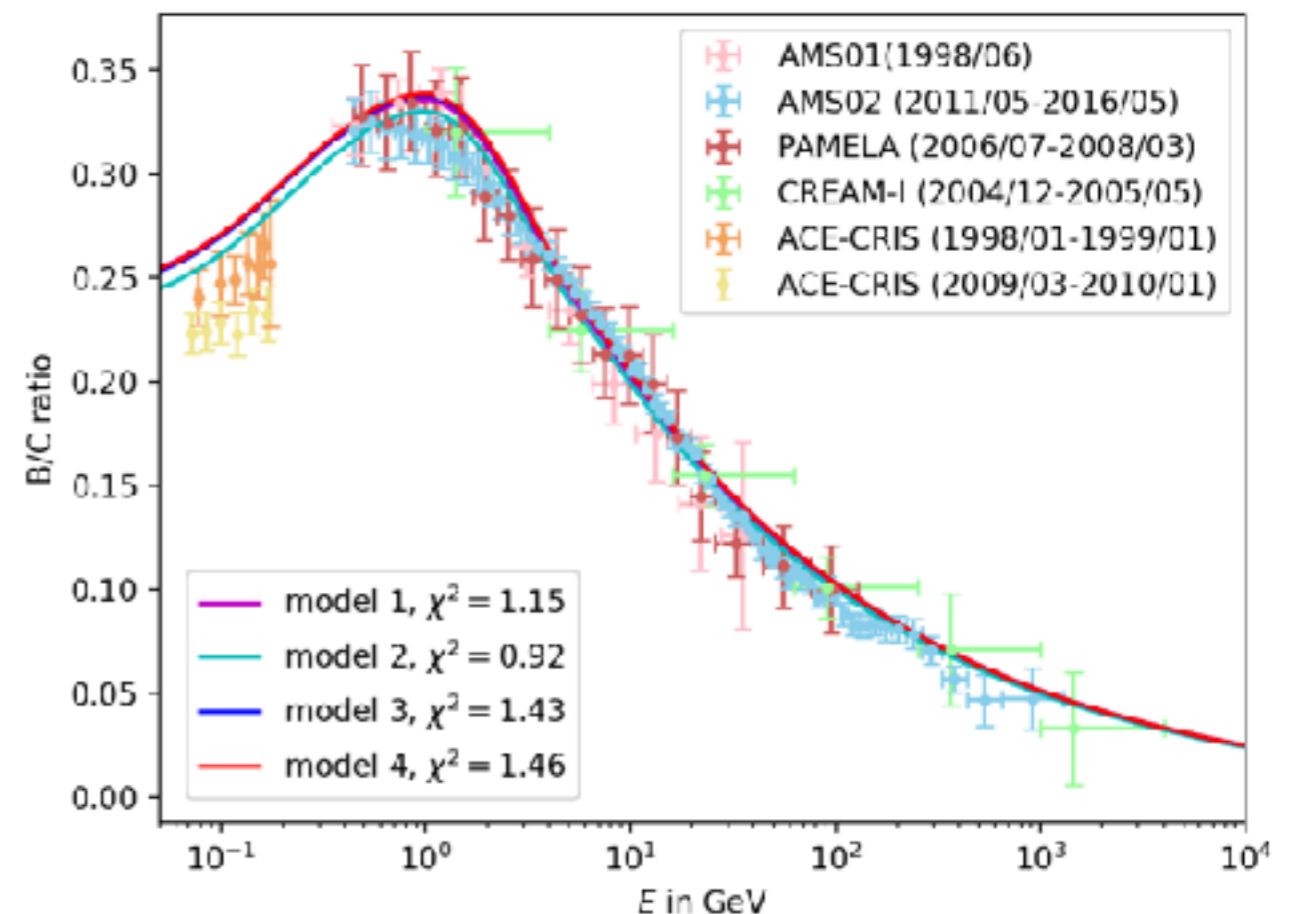
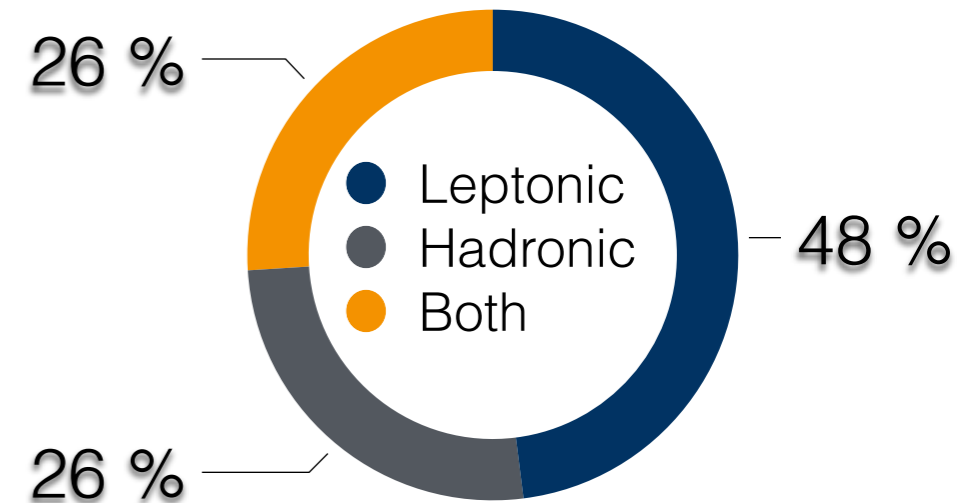
» Tune transport parameter:

- Alfvén speed  $v_A = 36.45 \text{ km/s}$

- diffusion coefficient

$$D_{xx} = 6.1 \cdot 10^{28} \text{ m}^2/\text{s}$$

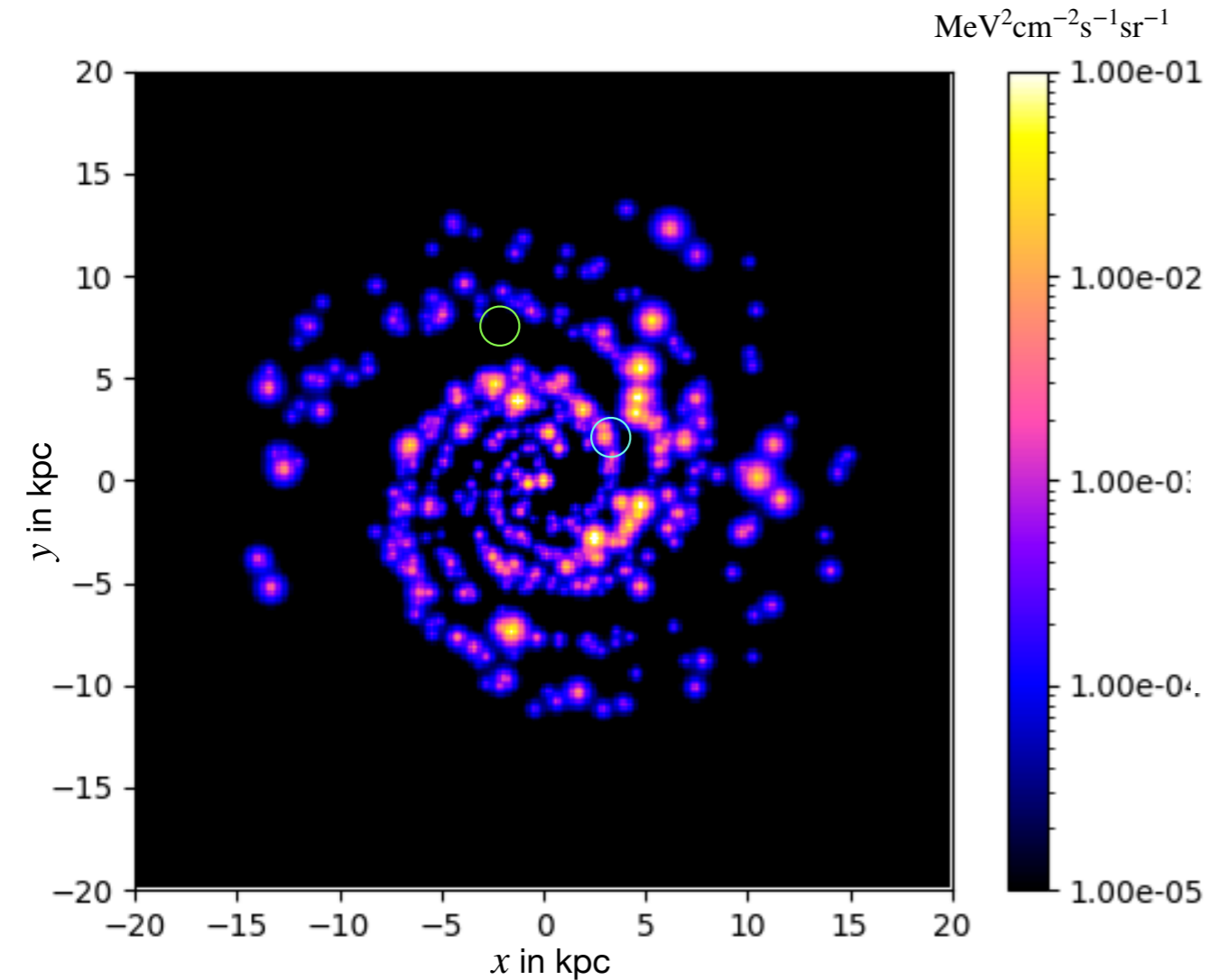
» Boron to carbon flux ratio



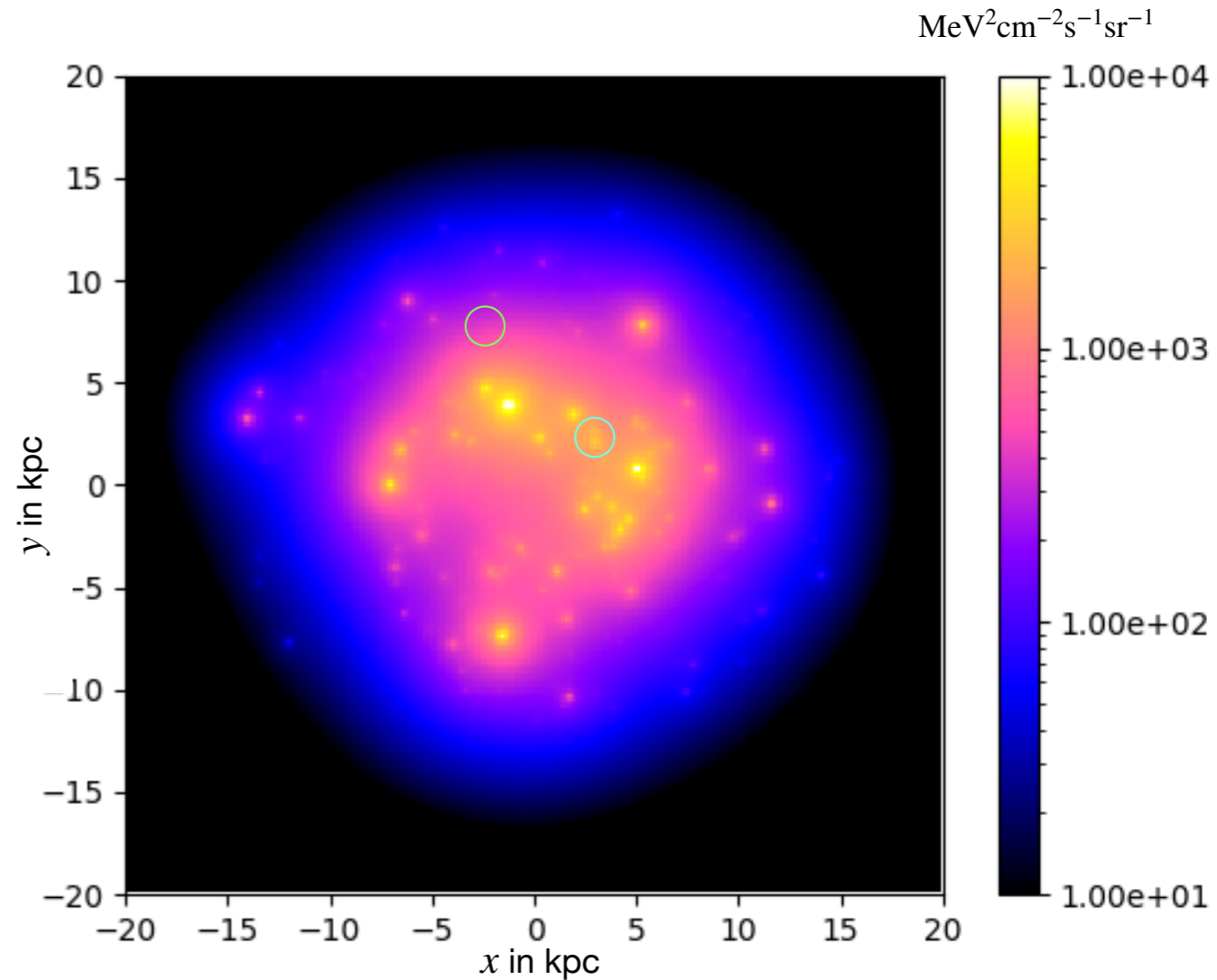
# Results

# Results - Particle distributions

» 10 TeV



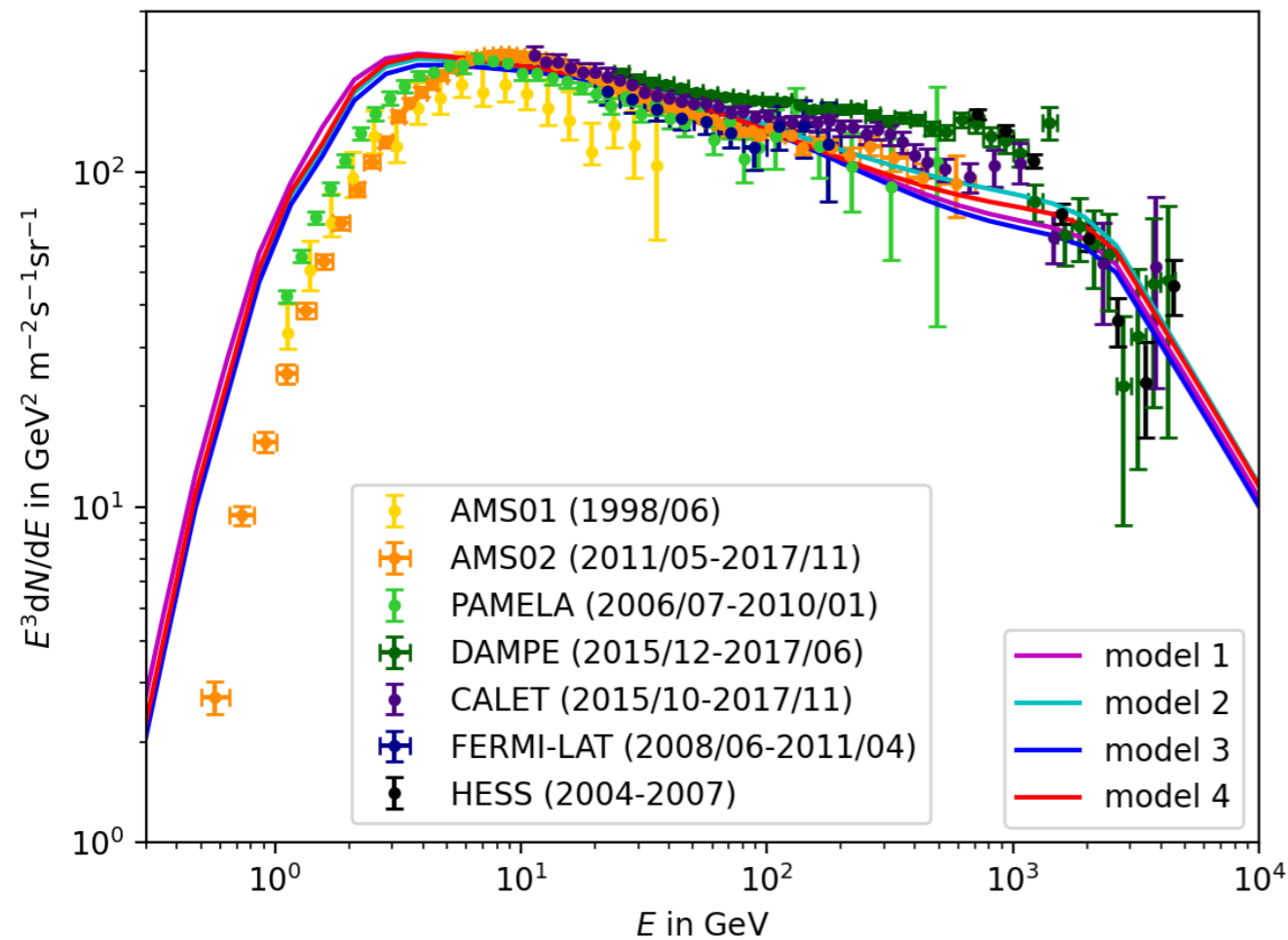
» Electrons



» Protons

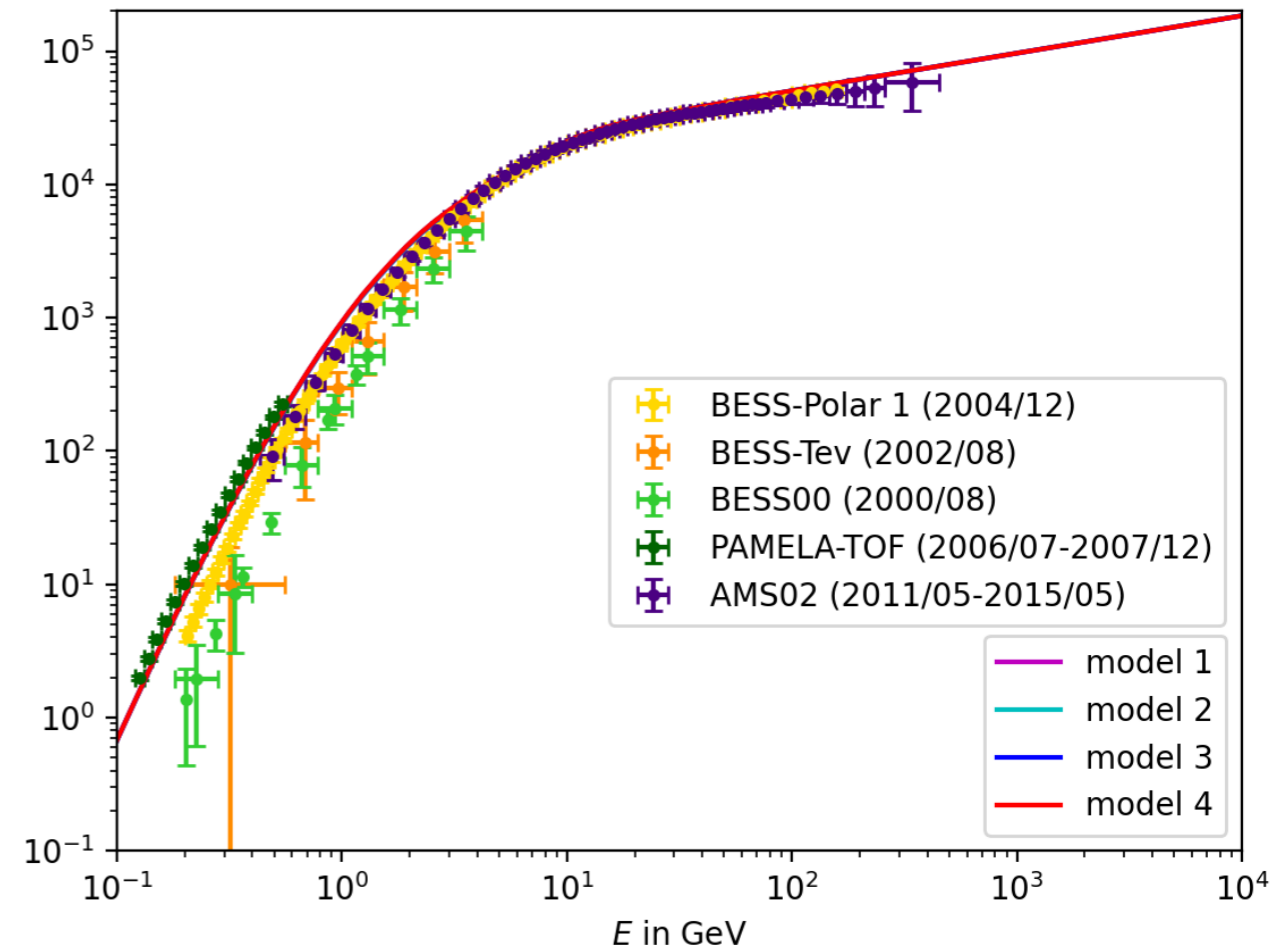
# Results - Particle spectra at Earth

» Electron spectra



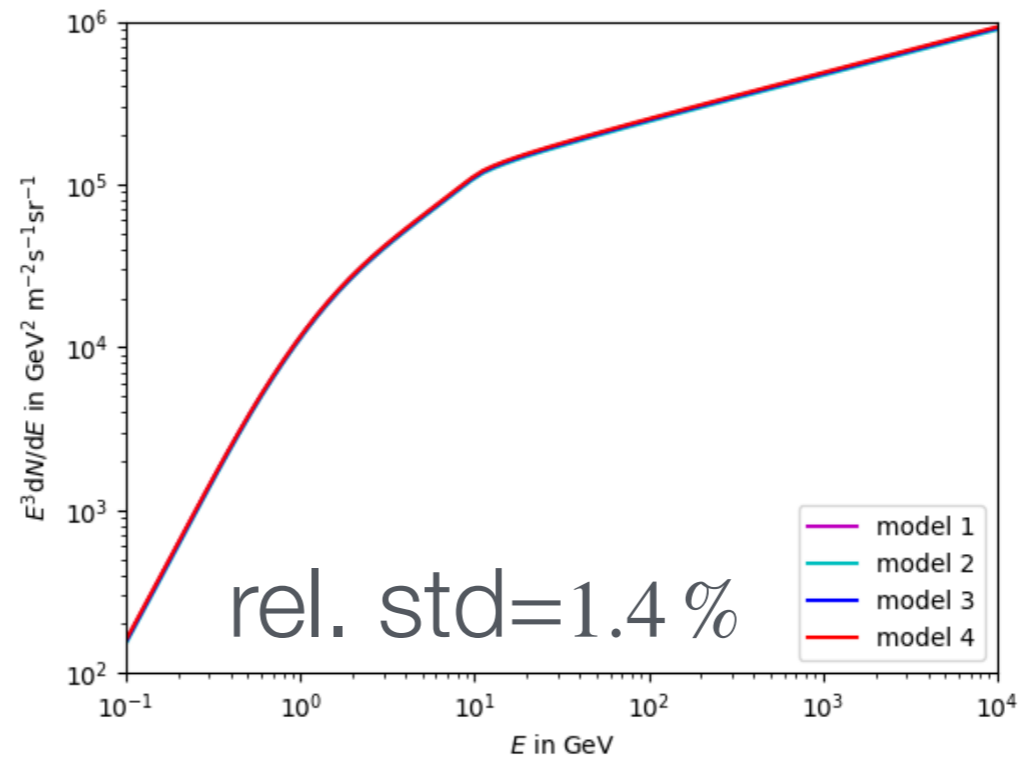
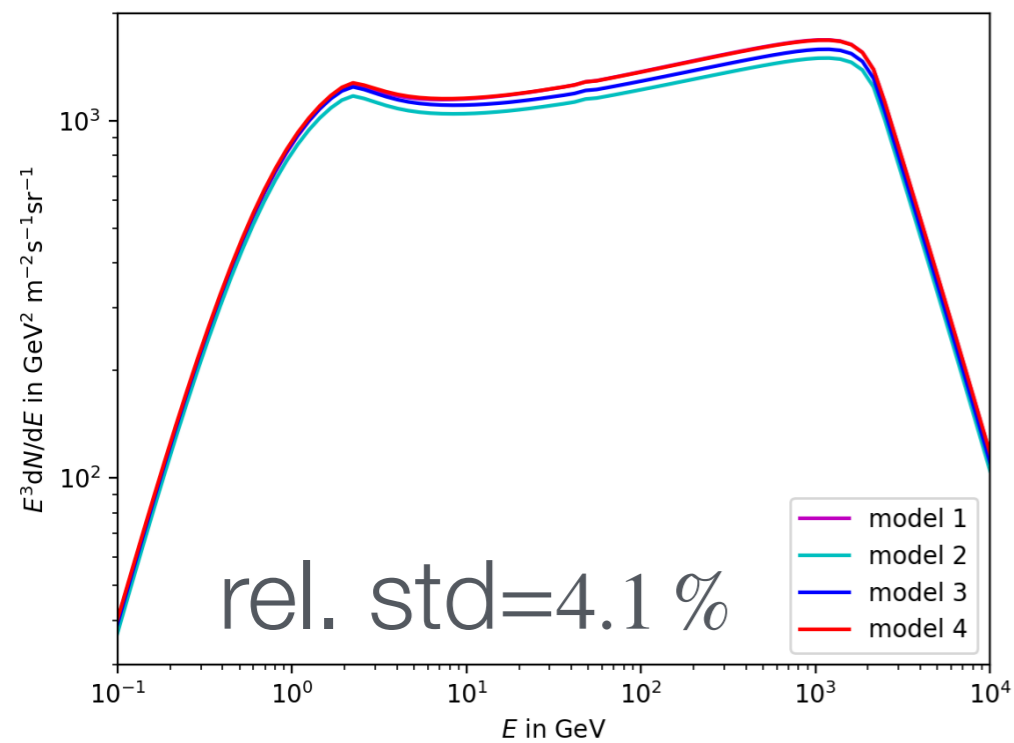
» rel. std = 0.8 %

» Proton spectra

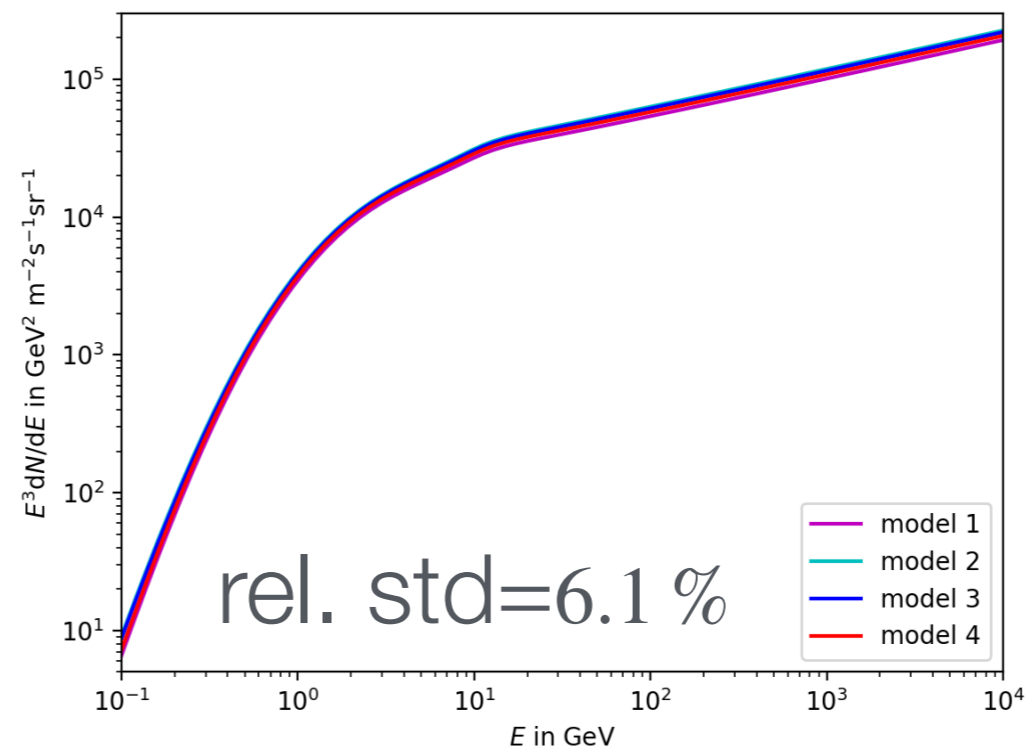
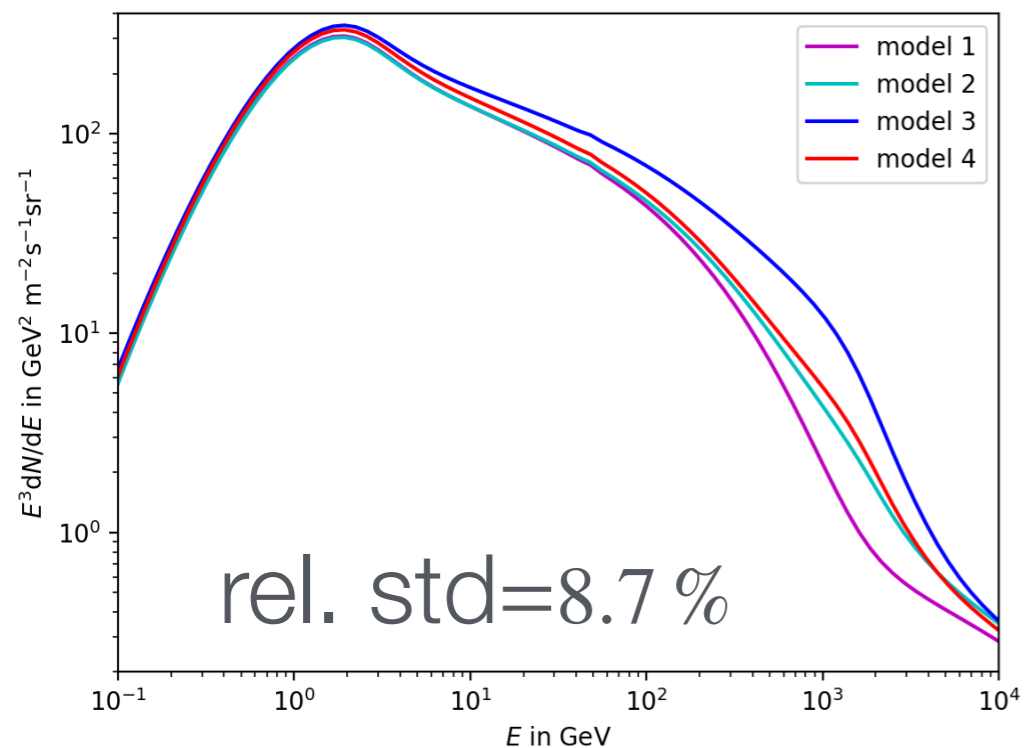


» rel. std = 0.1 %

# Results - Particle spectra in the Galaxy

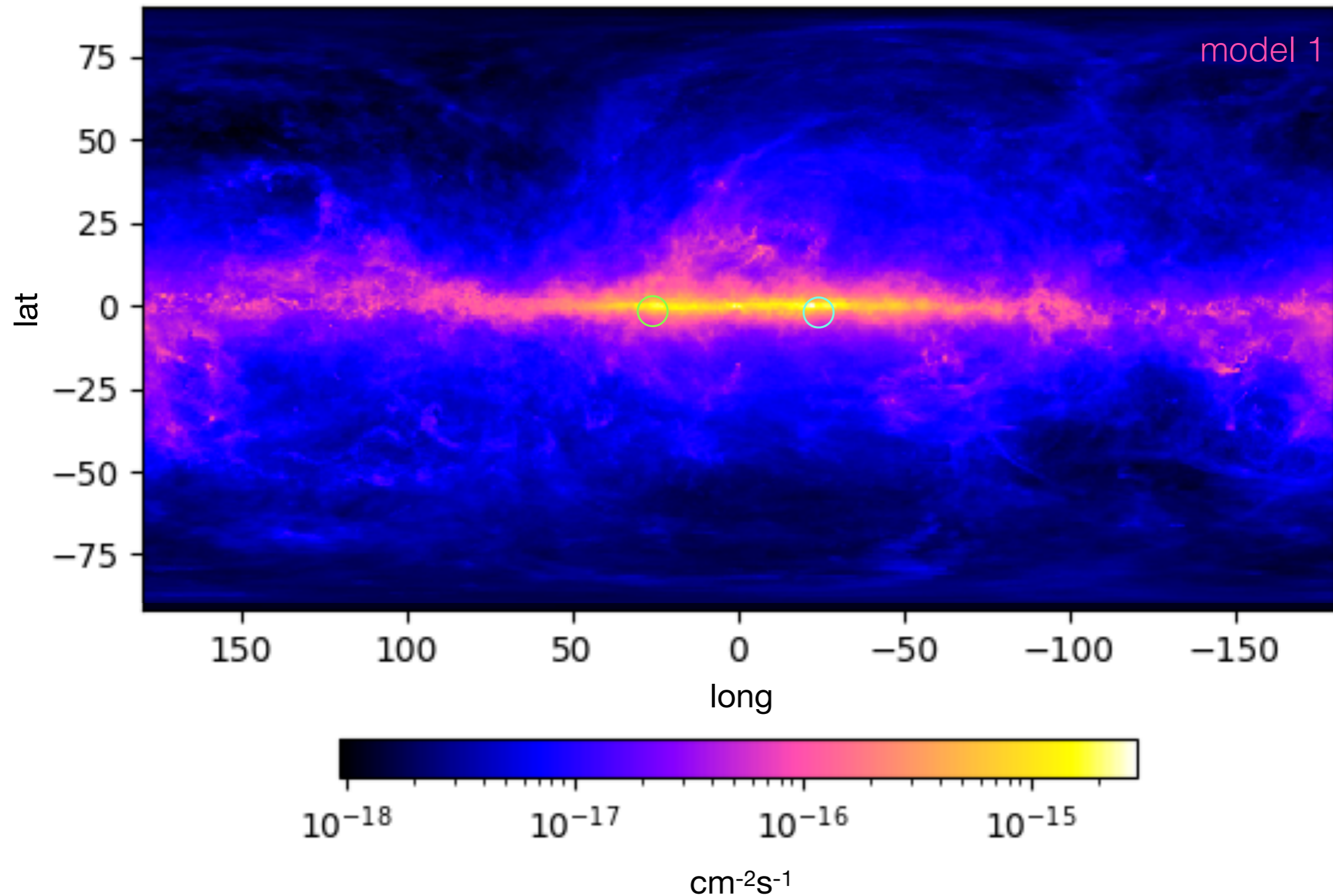


» Norma arm  
(3,2) kpc



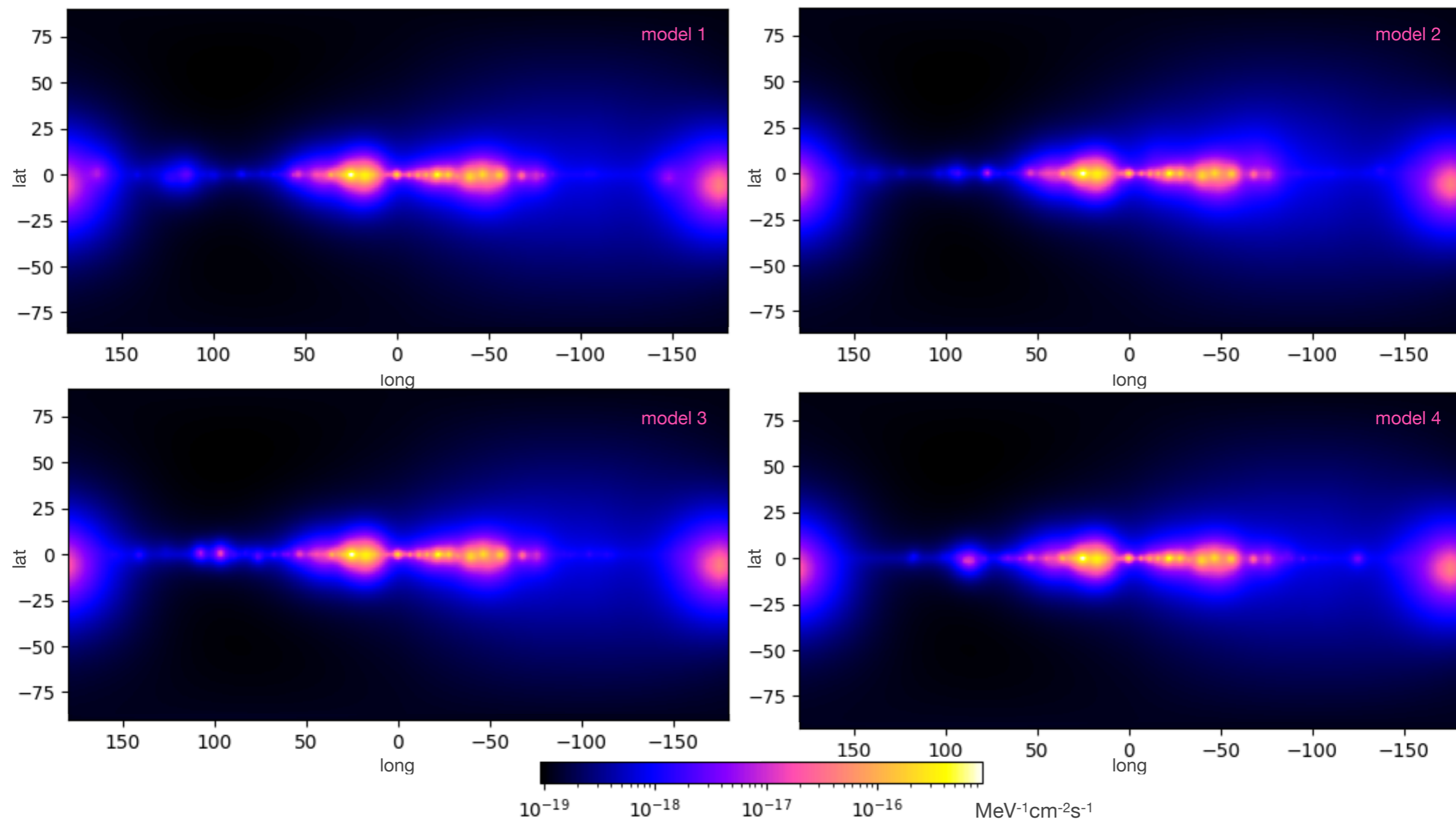
» Interarm  
region  
(-2,7.2) kpc

# Results - Total gamma-ray emission



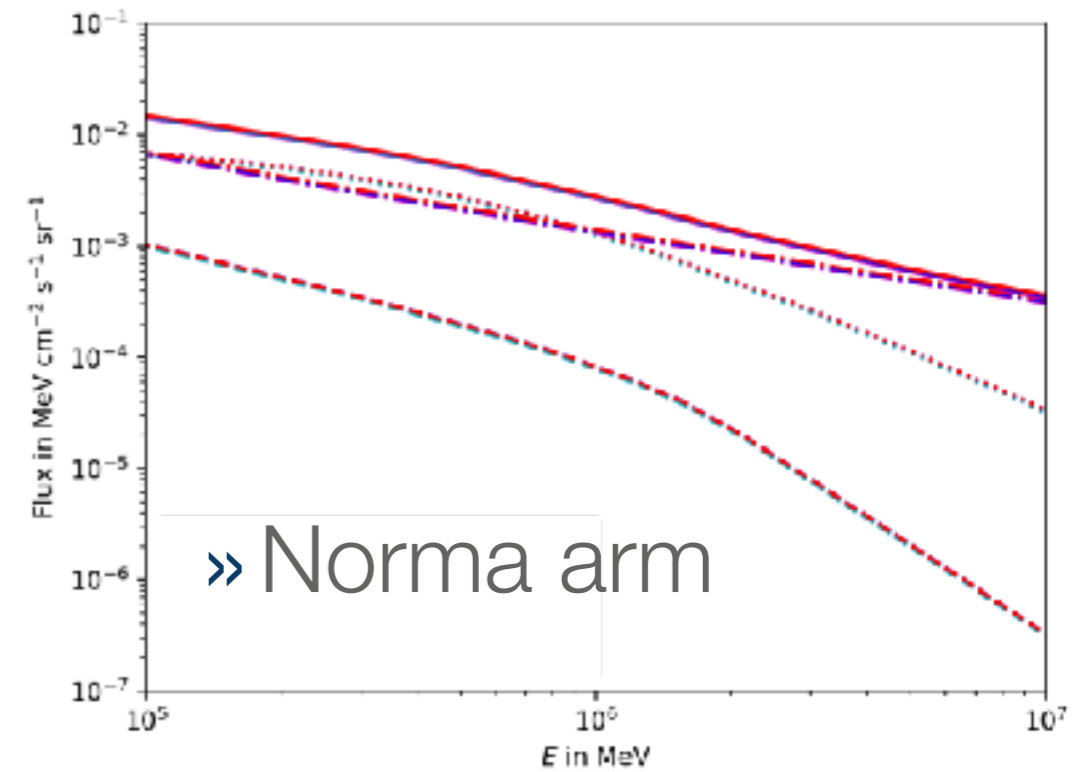
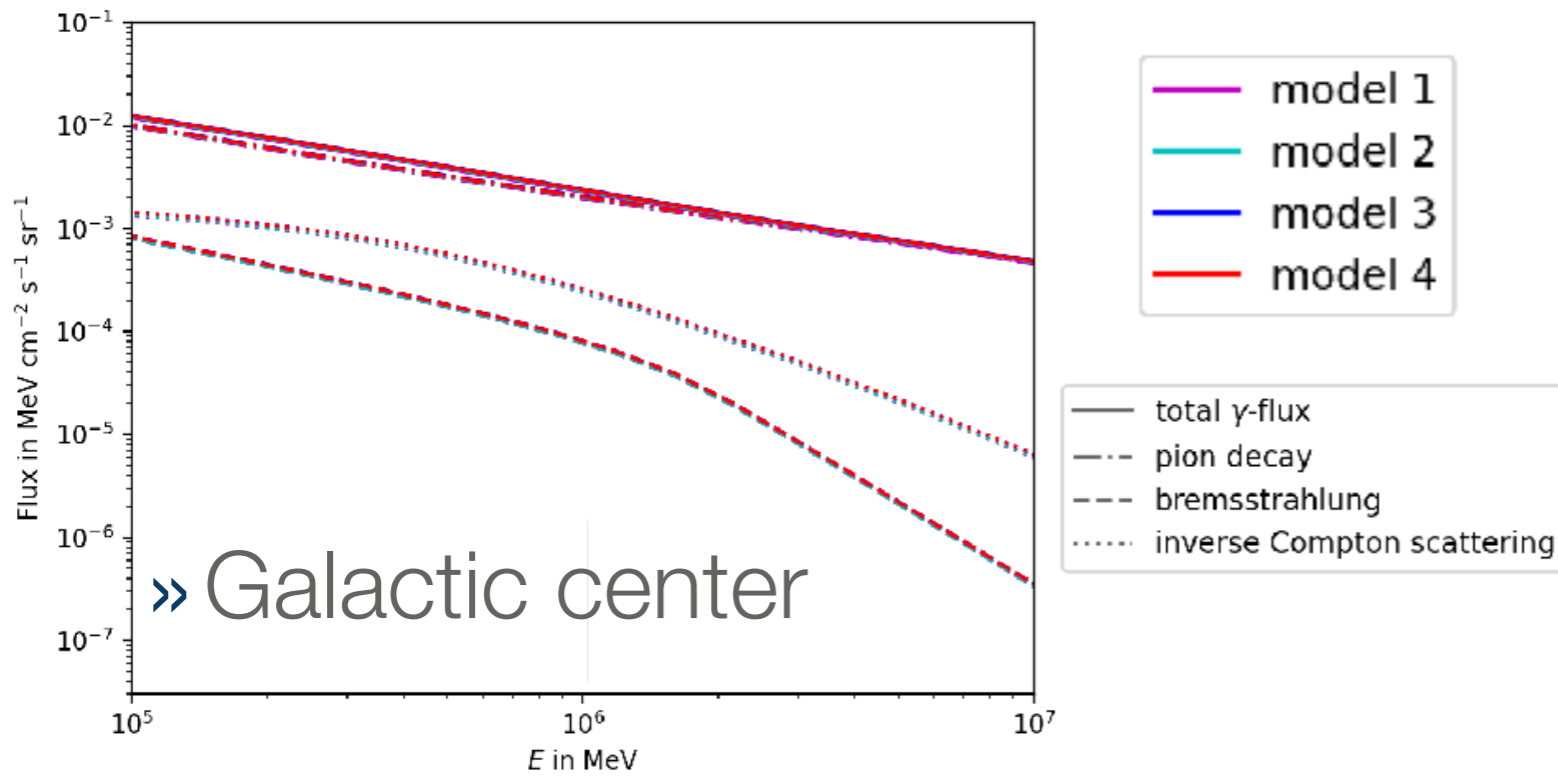
# Results - Inverse Compton emission

» 1 TeV

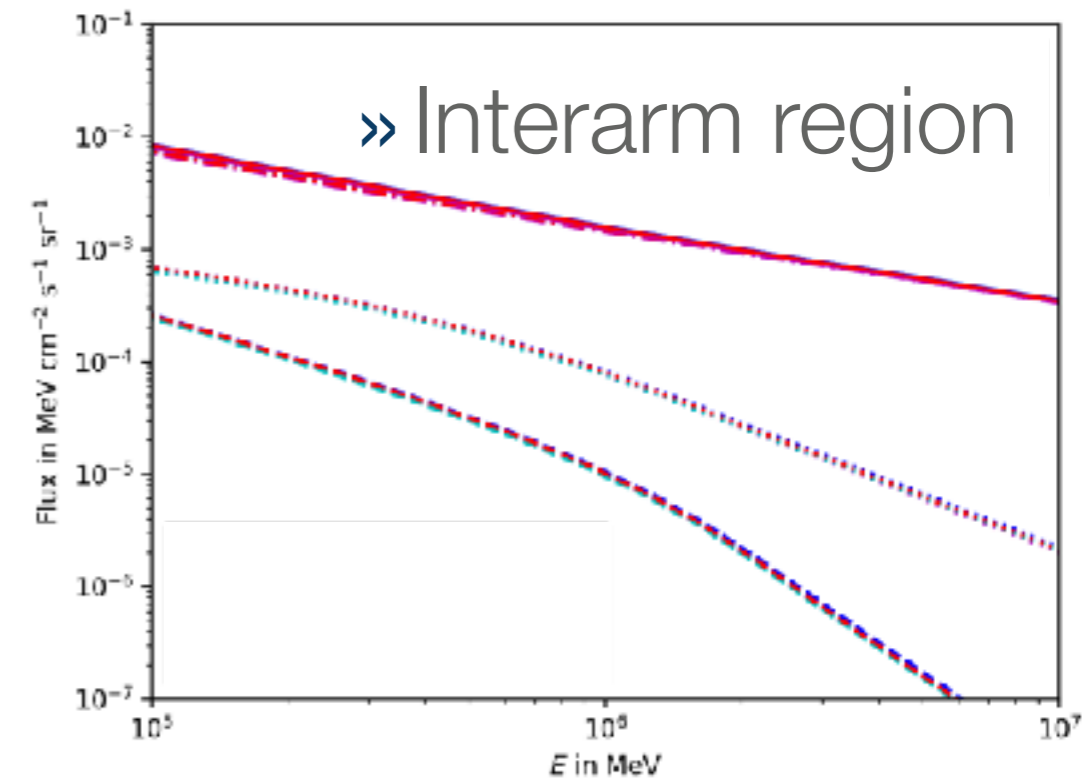




# Results - Gamma-ray spectra



	B	IC	$\pi$	TOT
Gal. Center	3 %	3.4%	2.3%	2.3%
Arm	1.9%	2.1%	3 %	2.5%
Int.Arm	2.1%	2.3%	2.2%	2.2%



# Conclusions and Outlook

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- » New, physically motivated source distribution for CR transport simulations
- » Finite number of sources in the Galaxy → need several models
- » Potential improvement: Adjustment of the underlying simulated source model e.g. by adding a central bar
- » Include more observed sources from different energy regimes