



Prospects for gamma-ray halos around pulsars detection with SWGO

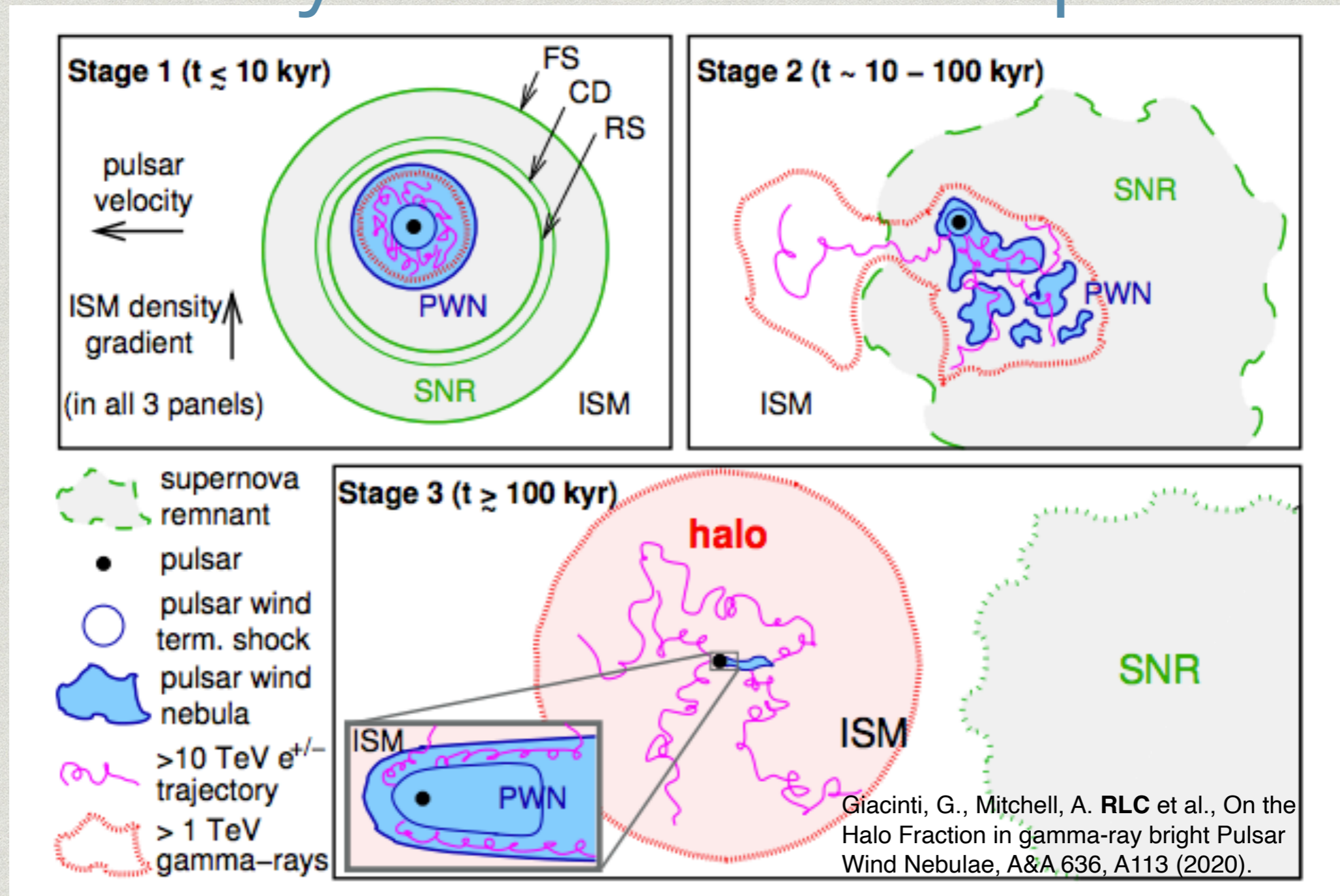
Rubén López-Coto, Alison Mitchell for the SWGO collaboration
1st Workshop on Gamma-ray Halos around pulsars
03/12/20



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Curie FELLINI - Grant 754496**



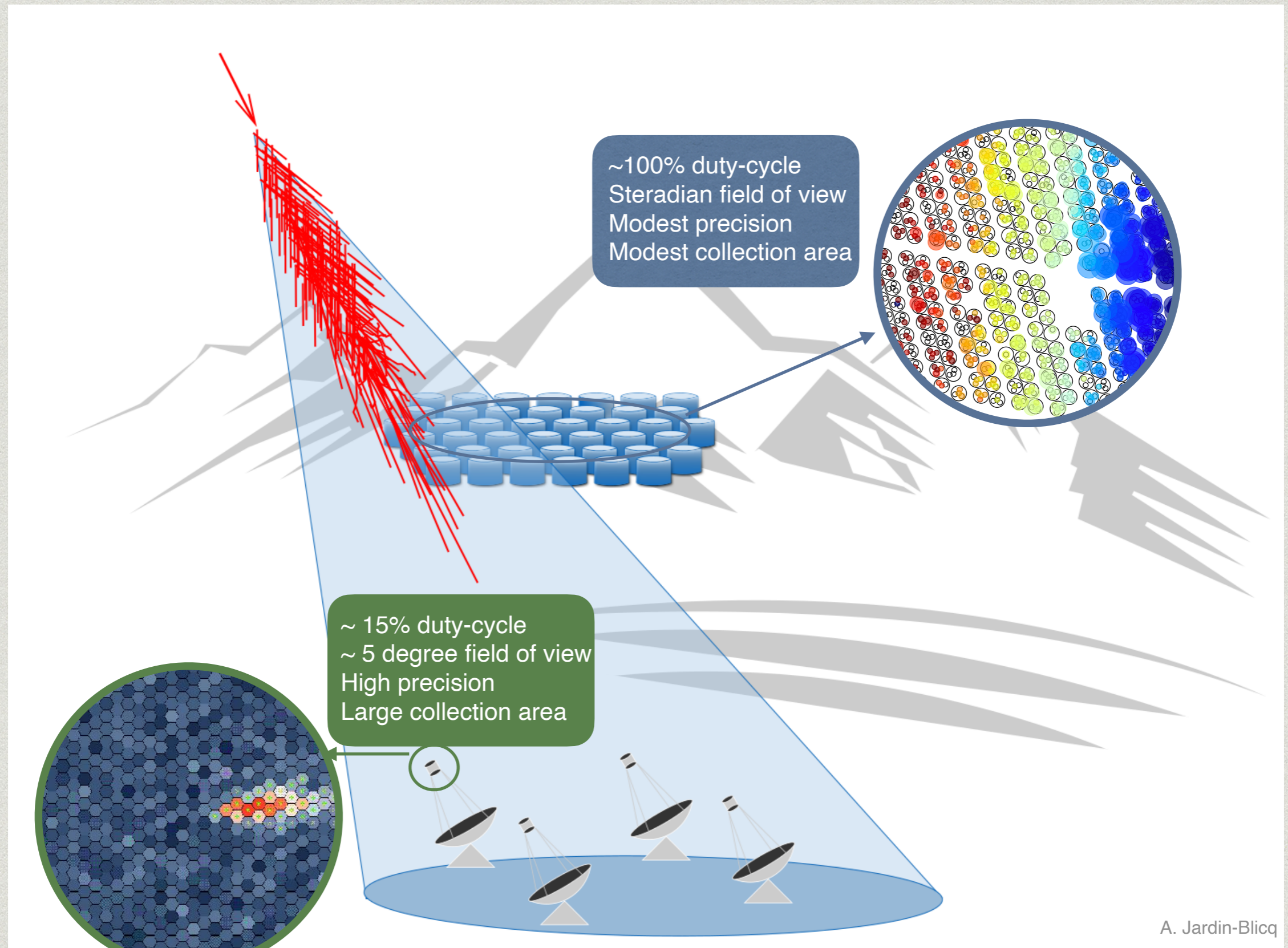
Gamma-ray halos around pulsars



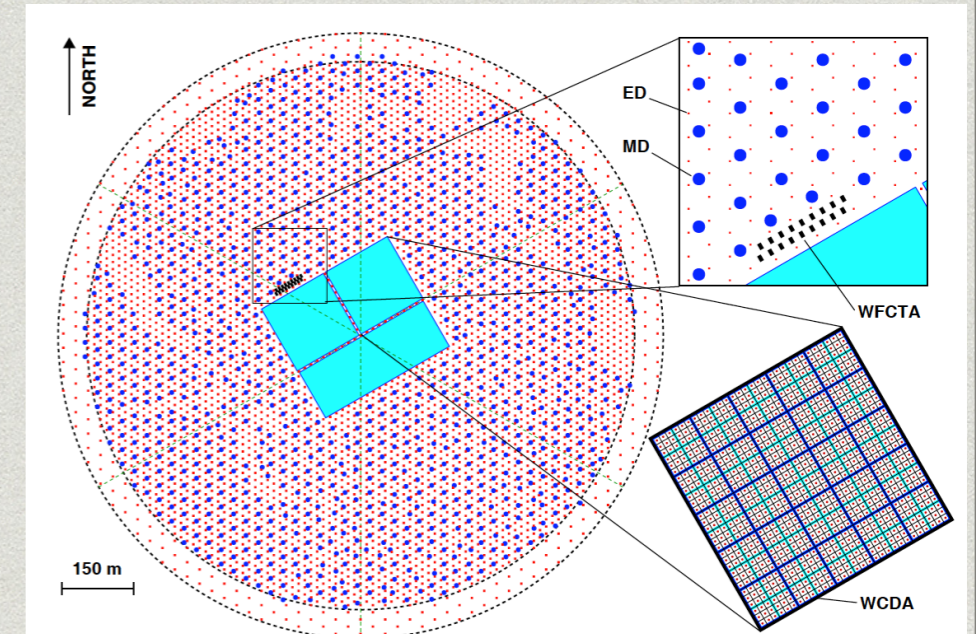
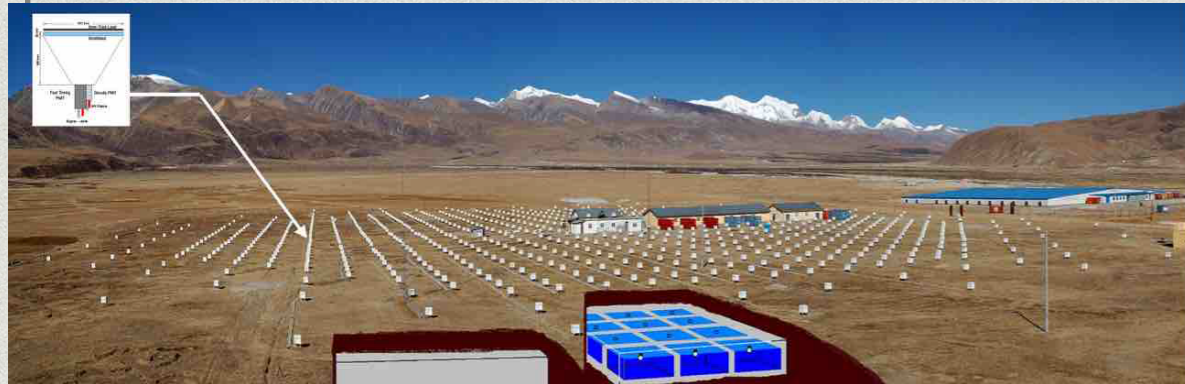
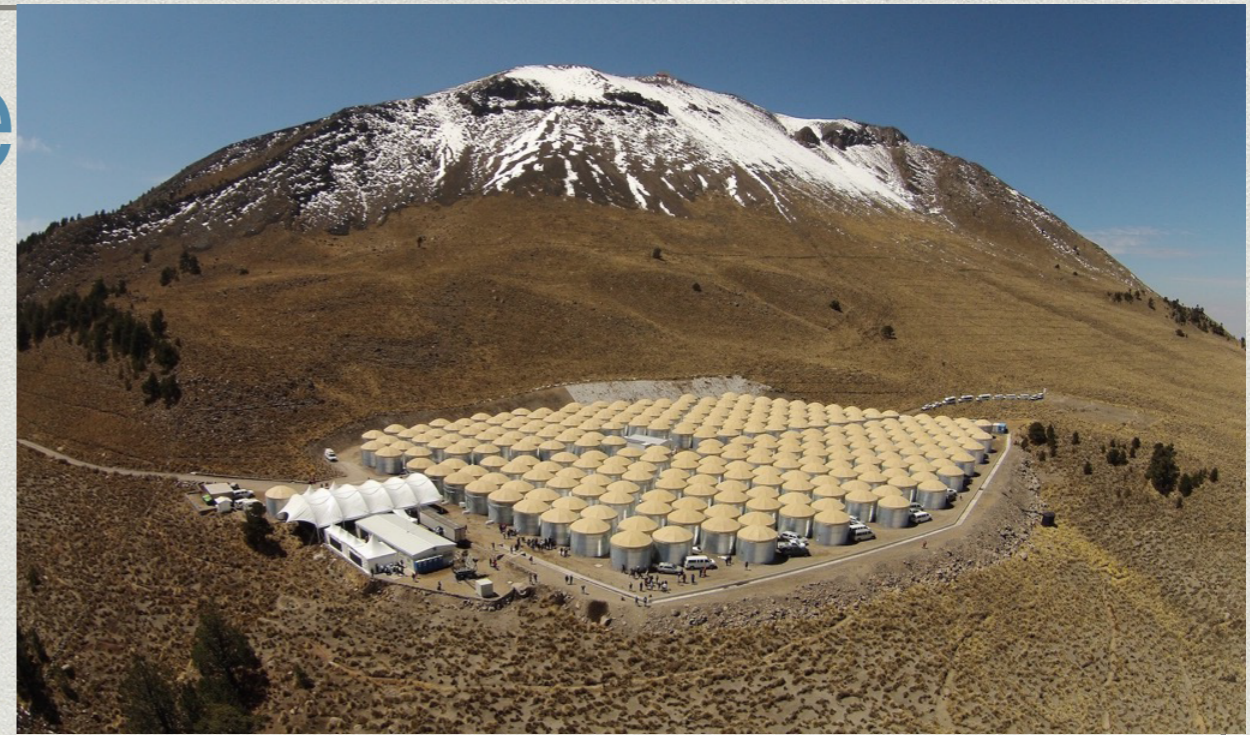
Giacinti, G., Mitchell, A. RLC et al., On the Halo Fraction in gamma-ray bright Pulsar Wind Nebulae, A&A 636, A113 (2020).

- Long-discussions about distinct features this week
- Agreed on formation driven by particles escaping from the shocked wind -> essential to study the morphology

IACTs vs Particle Detectors

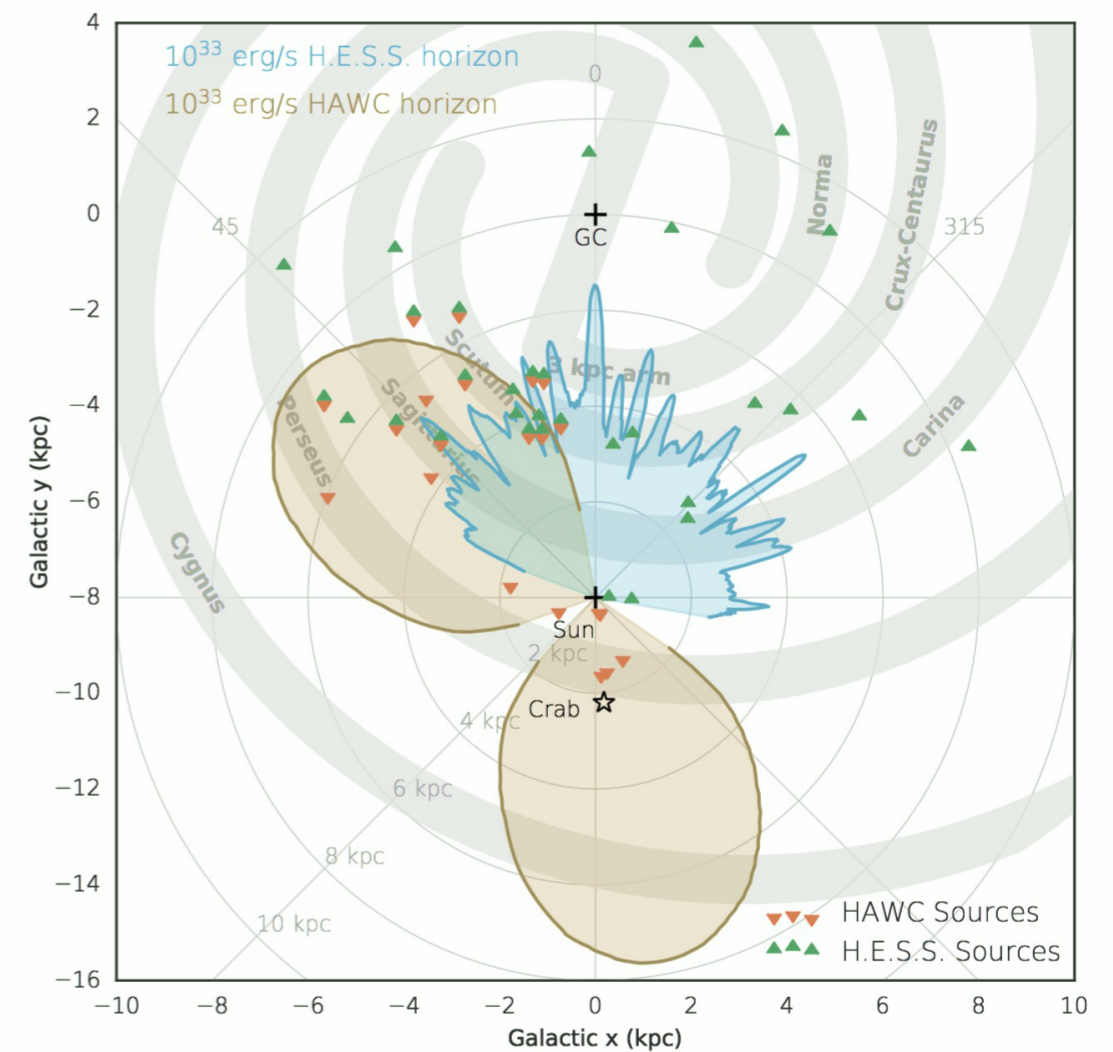
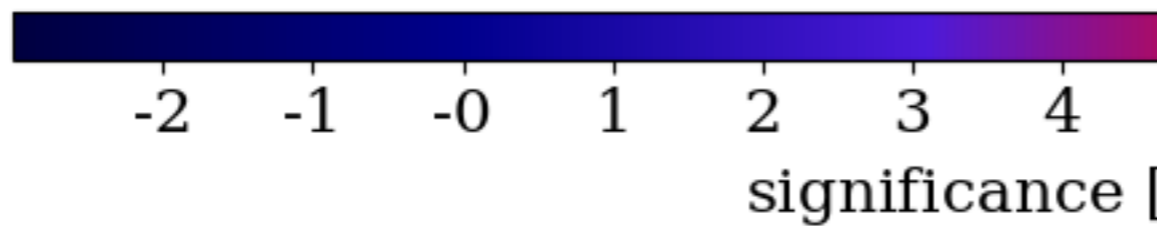
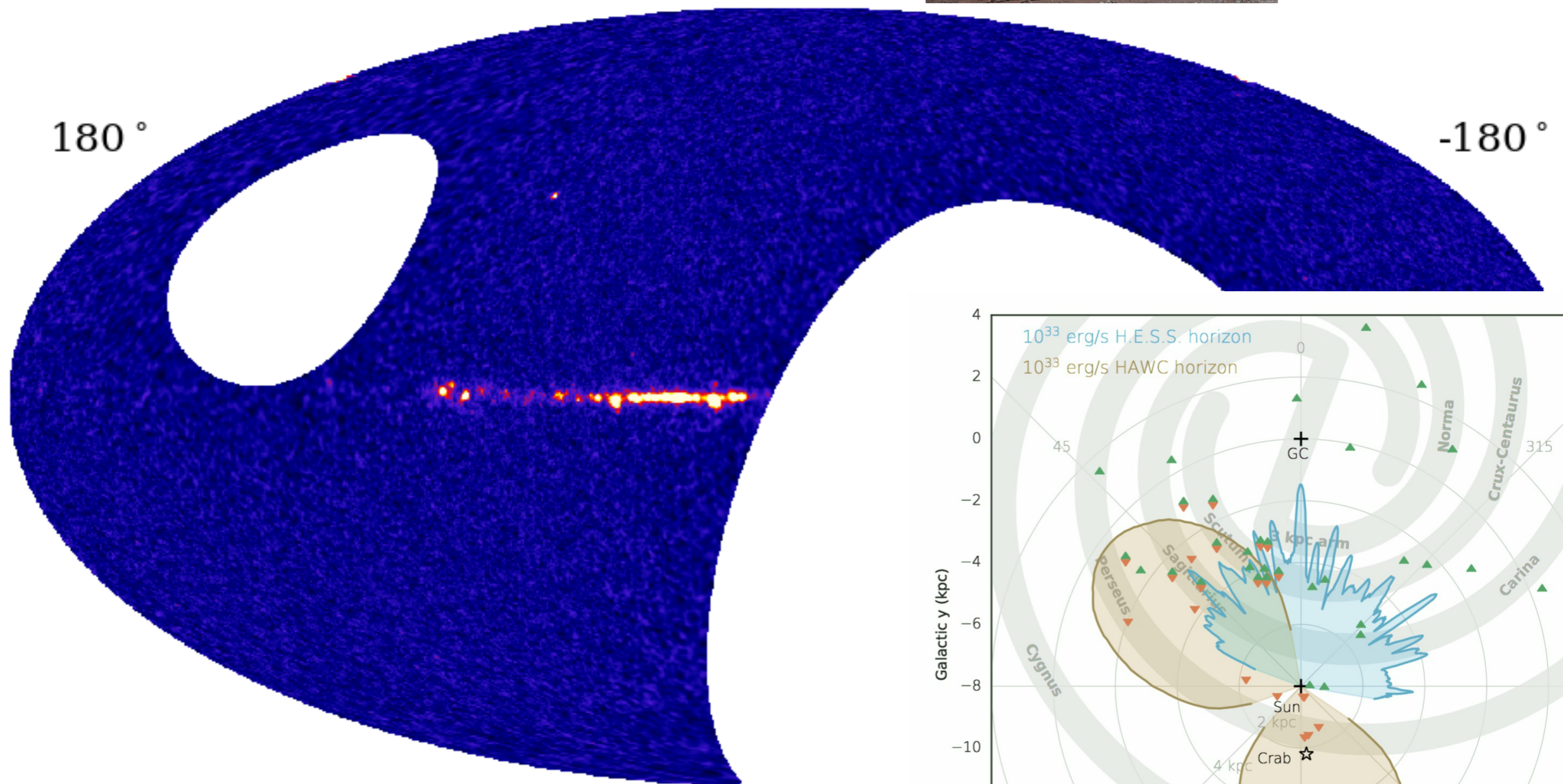


Gamma-ray Particle Detector facilities



- Proposed solutions:
 - **Tibet AS- γ** (Scintillators, Area = 36,900 m²).
 - **ARGO** (Resistive Plate Chambers (RPCs), Area = 6,700 m²).
 - **Milagro** (Water Cherenkov Detector (WCD), Area = 5,000 m²).
 - **HAWC** (WCD, Area = 22,000 m²).
 - **LHAASO** (Hybrid, Inner Area = 80,000 m², Full Area = 1.3 km²).

Northern Sky



SWGGO

Southern Wide-field Gamma-ray Observatory

- In comparison to HAWC -> Higher **altitude**, larger **area**, higher **efficiency detection units**, larger **fill factor**.
 - => lower threshold and better sensitivity.
- Collaboration established in July 2019 to develop the design/plan.
- First collaboration meeting October 2019.
- 3 year program, 12 countries signed up + supporting scientists.

Countries in SWGO

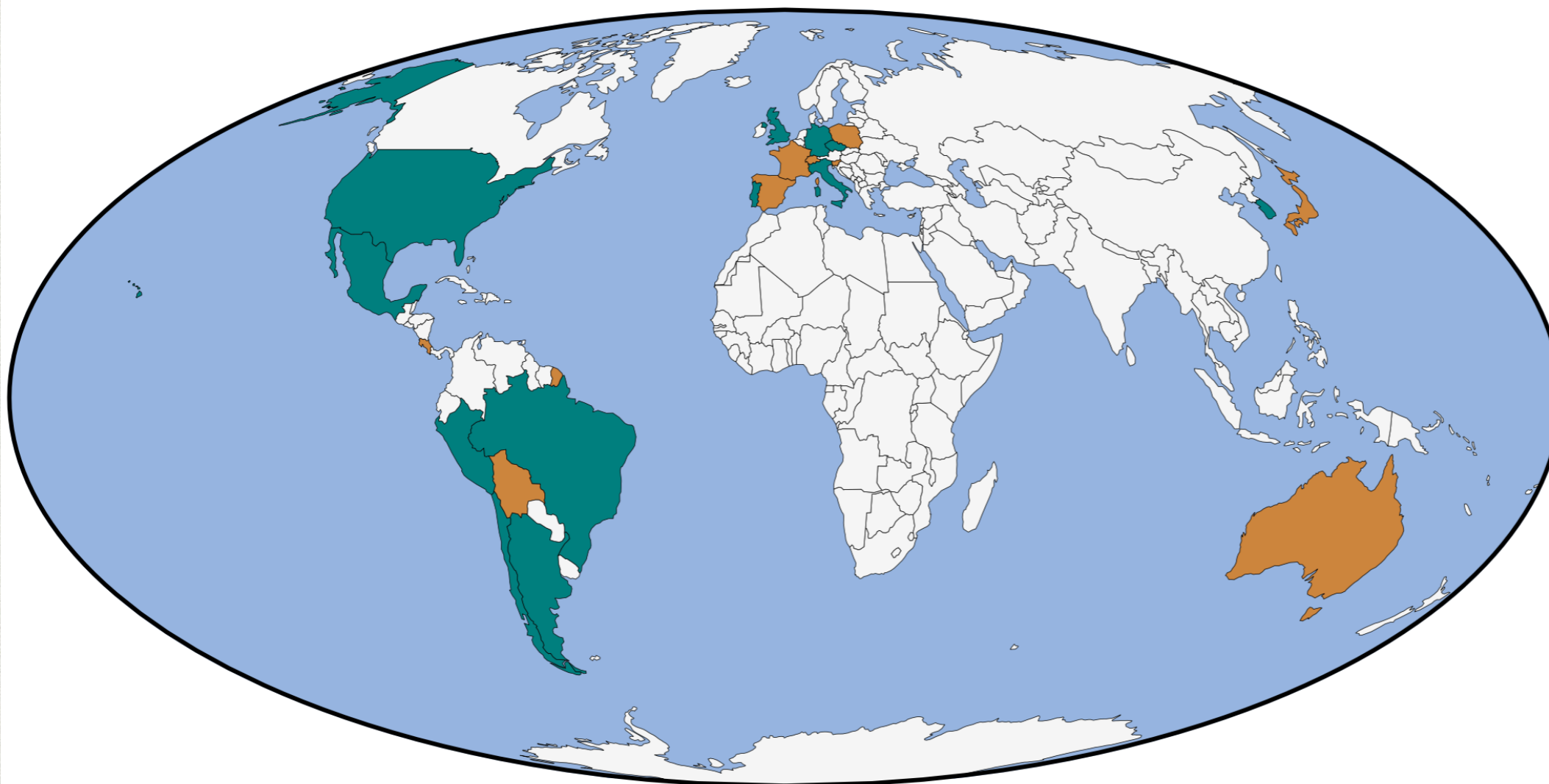
Institutes

Argentina*, Brazil, Chile, Czech Republic, Germany*, Italy, Mexico, Peru, Portugal, South Korea, United Kingdom, United States*

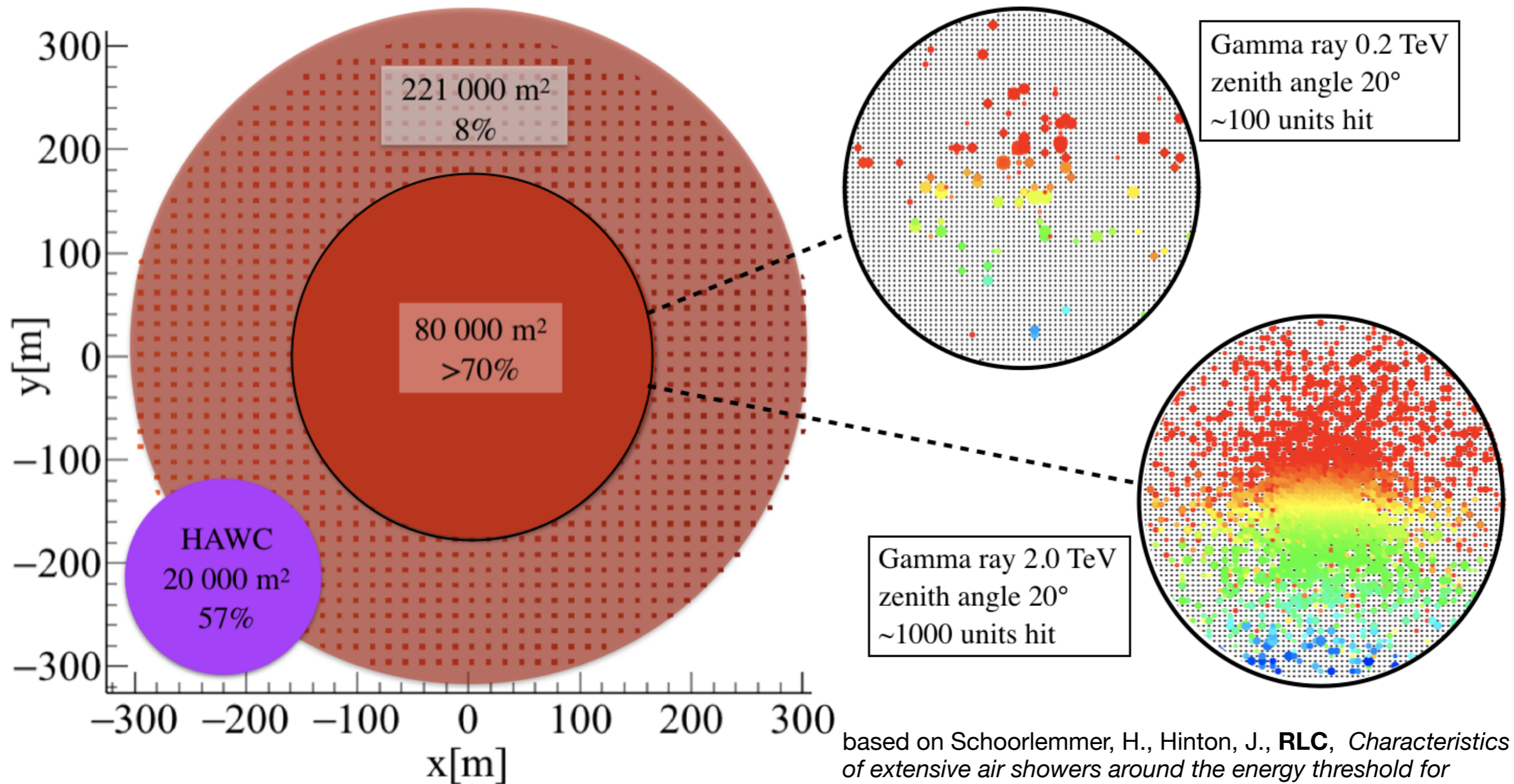
Supporting scientists

Australia, Bolivia, Costa Rica, France, Japan, Poland, Slovenia, Spain, Switzerland

**also supporting scientists*



Strawman detector array



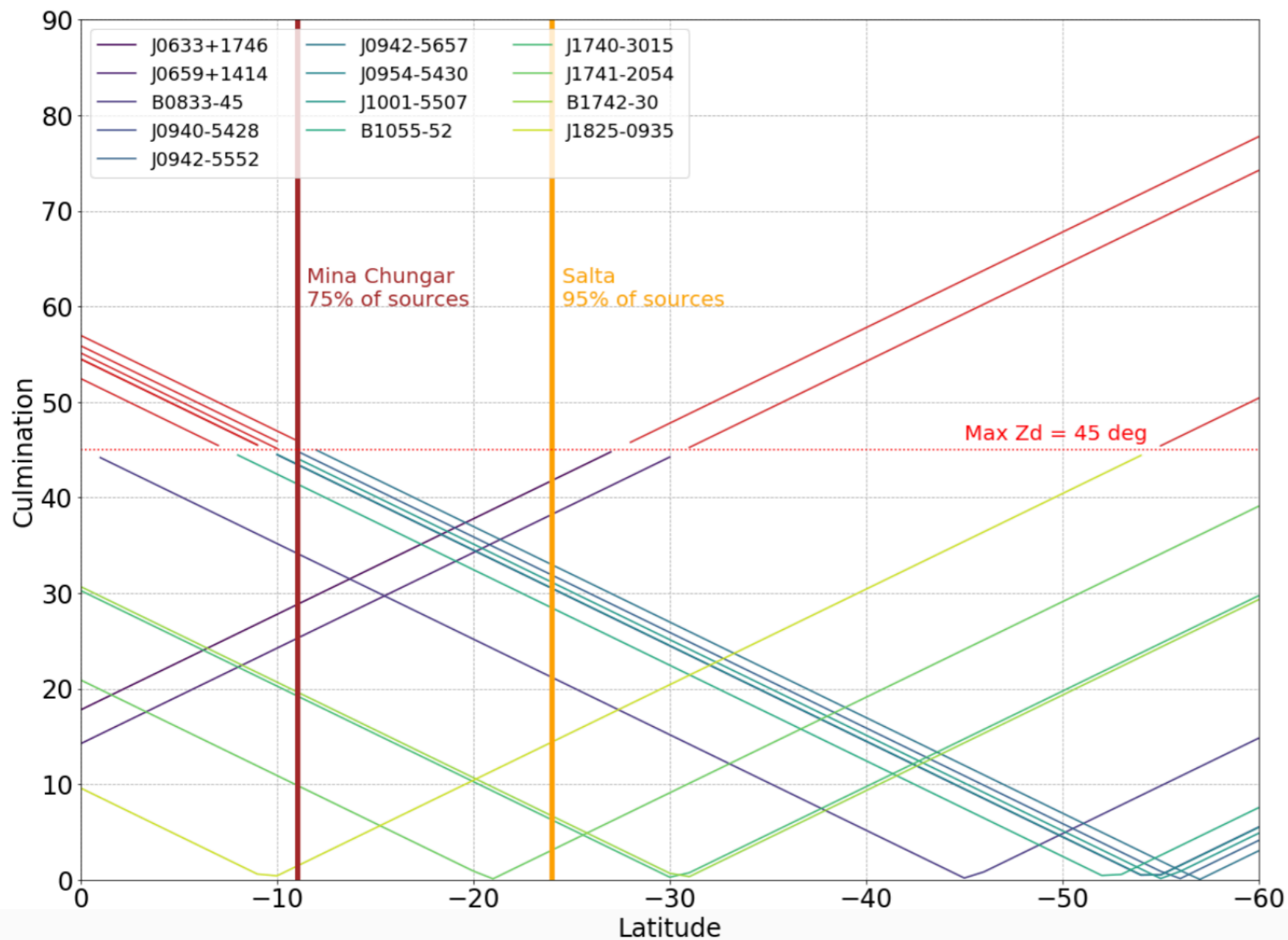
based on Schoorlemmer, H., Hinton, J., **RLC**, *Characteristics of extensive air showers around the energy threshold for ground-particle-based γ -ray observatories*, EPJC, 79 (2019).

The Site

- Proposal: Build it in the **Andes**
- Above 4.4 km to reach sub-TeV sensitivities

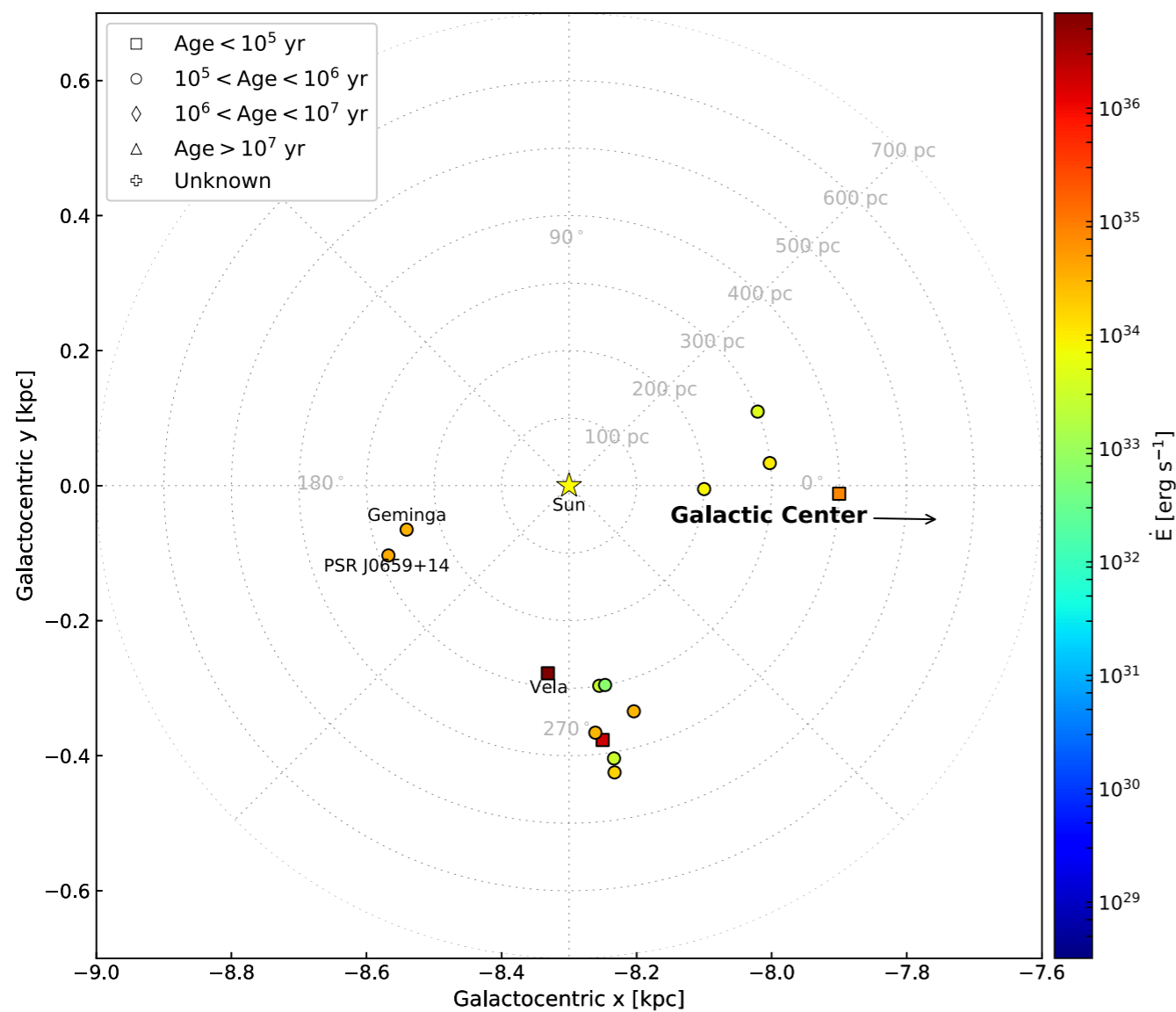


Nearby pulsars observability



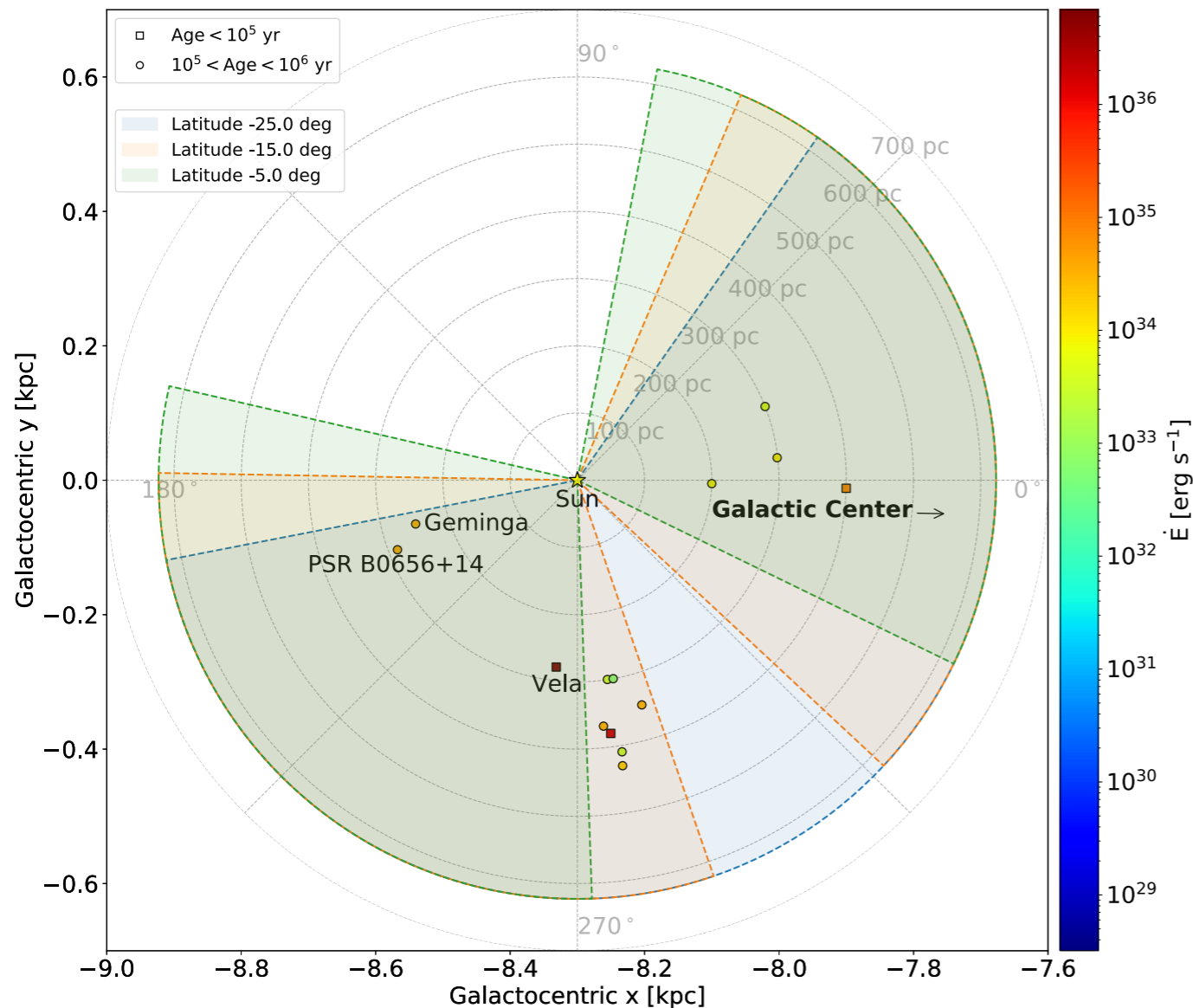
- We took all nearby (<500 pc) pulsars likely to produce a TeV halo
- Some TeV halo candidates out of the reach for low latitudes.
- On the other hand, high latitude sites imply short exposures for two sure TeV halos (Geminga and PSR J0659).

Pulsars in the neighborhood



- Important to focus on nearby sources -> more extended and therefore in which we can excel more.
- Studied the influence of latitude in the number of reachable source
 - Latitudes < 15 deg South may make us lose some sources.

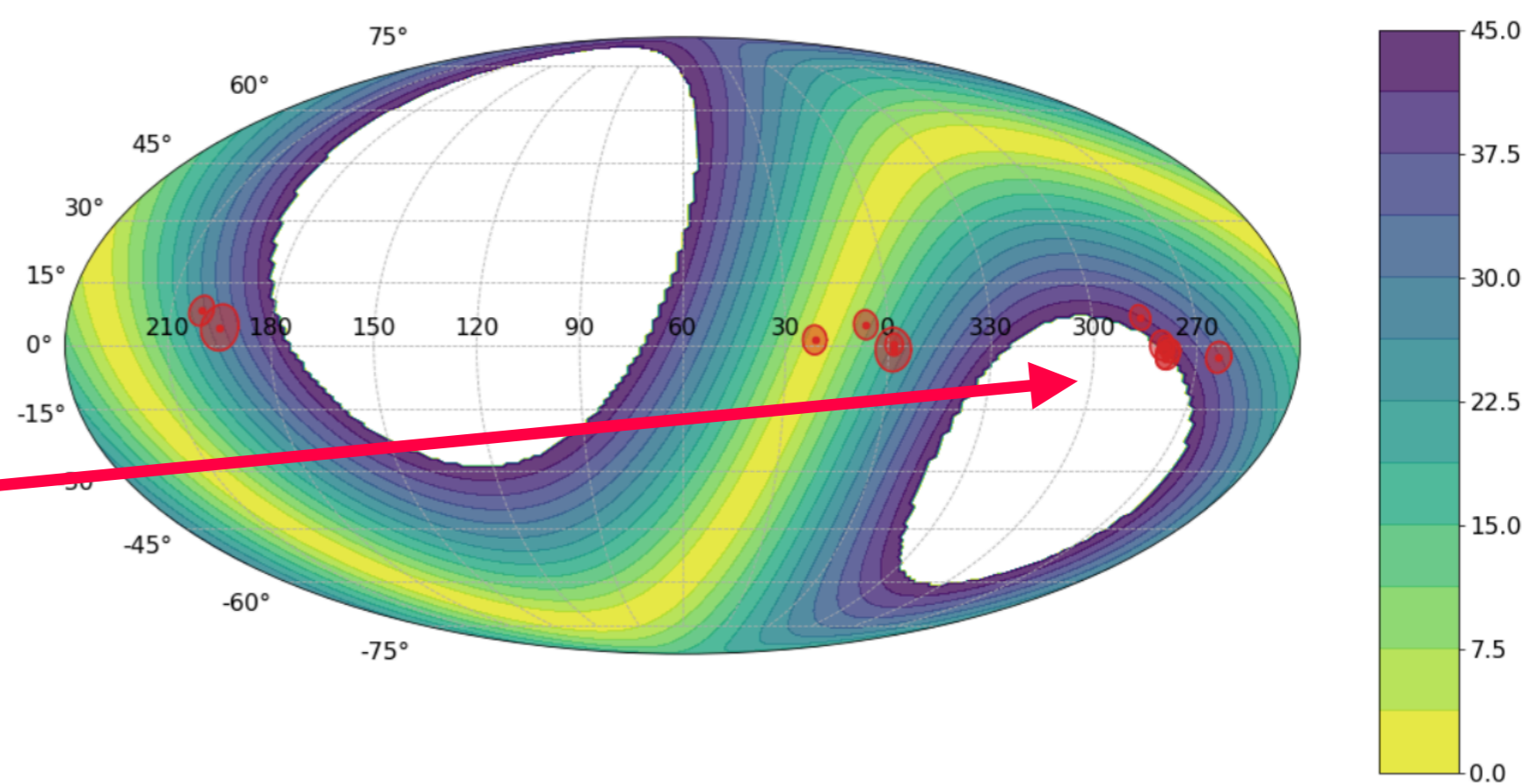
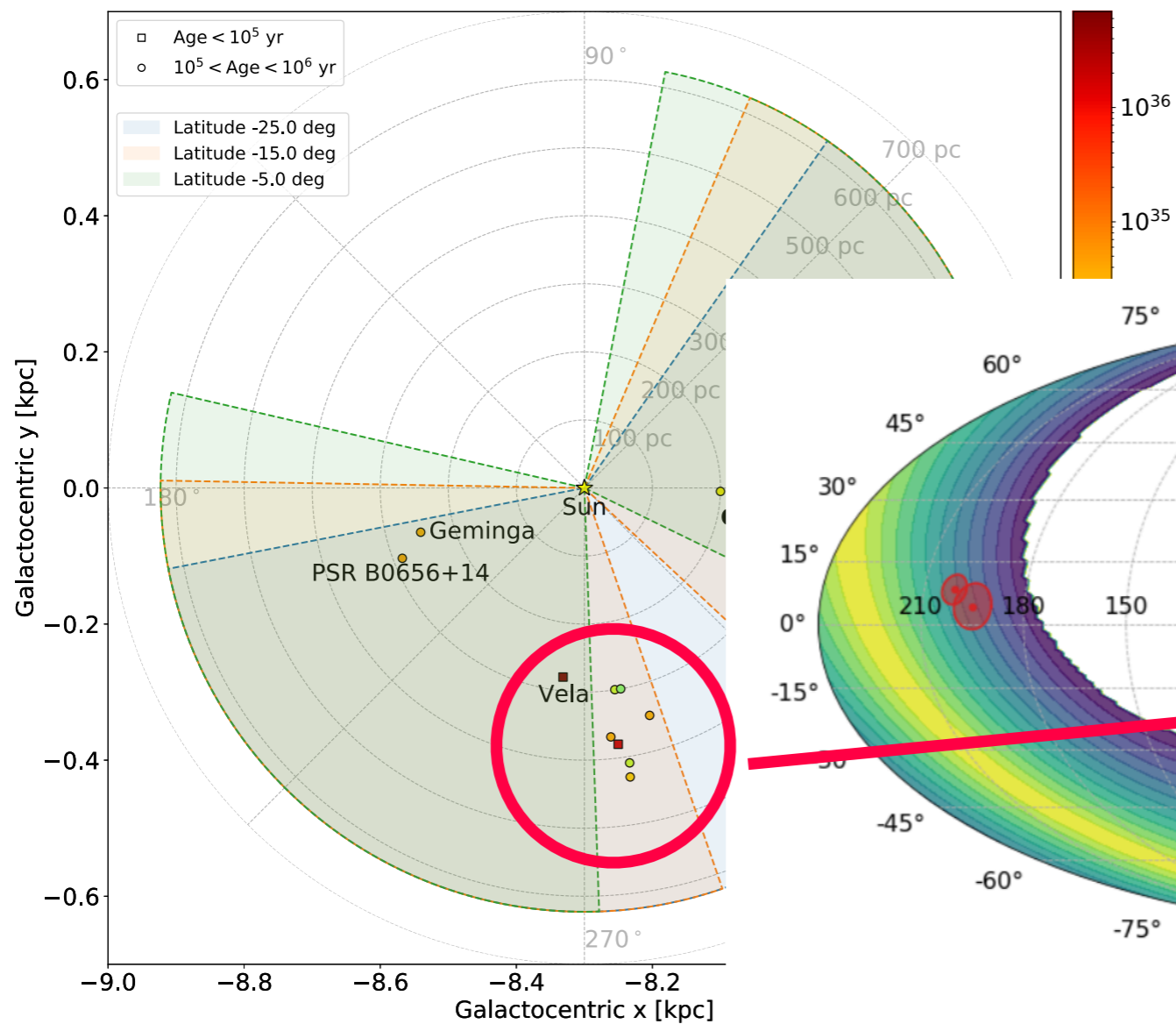
Coverage at different latitude



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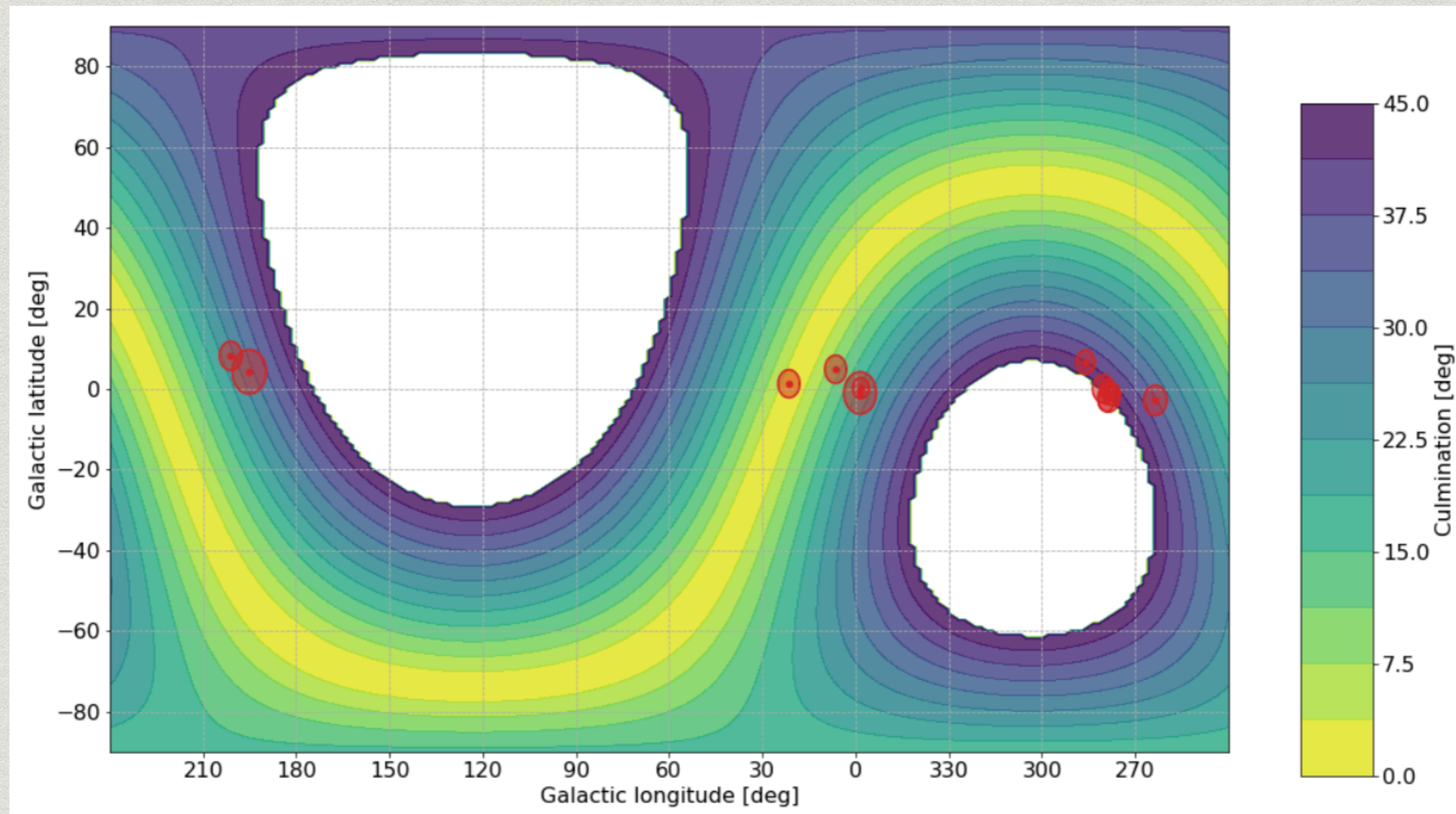
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R. LÓPEZ-COTO

Rubén López-Coto - 1st Workshop on Gamma-ray Halos around Pulsars

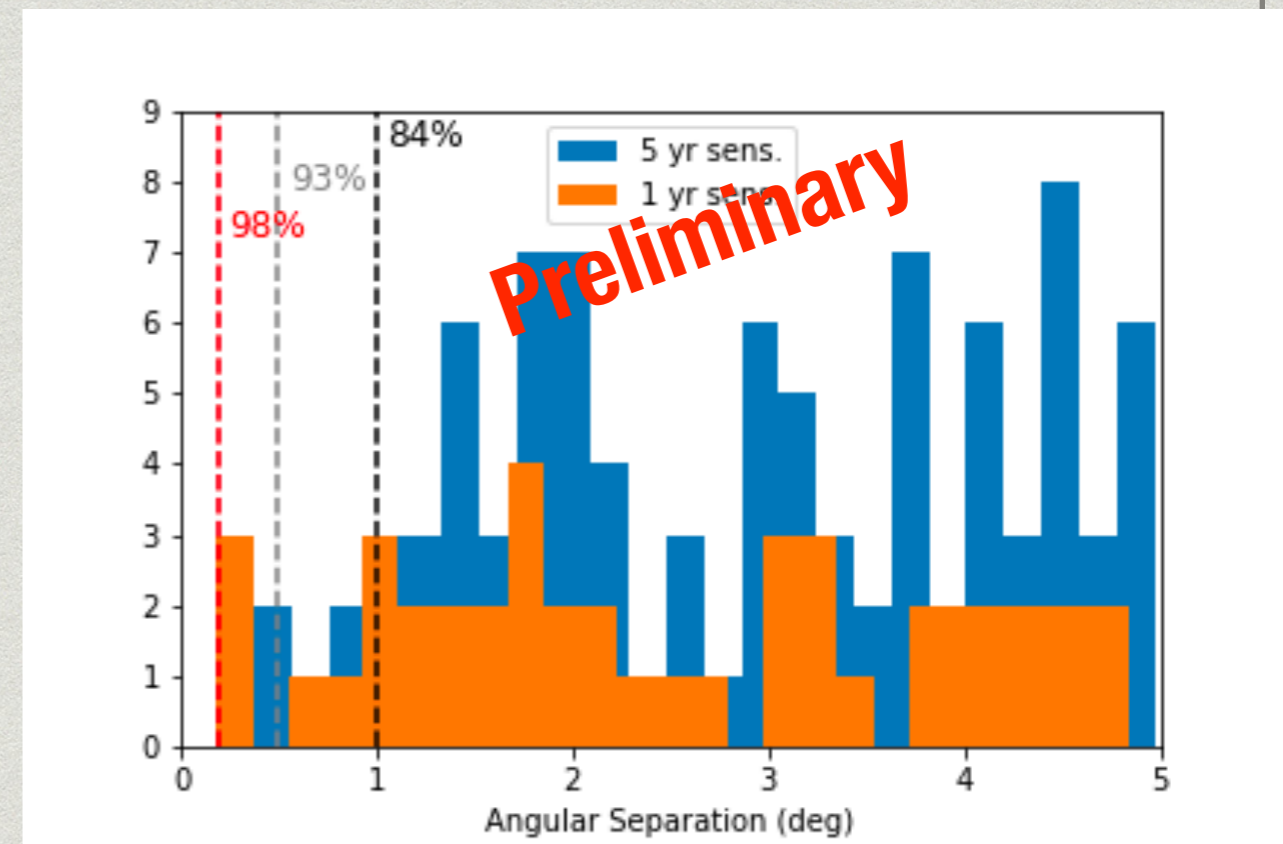
Clustering of sources



- To make proper estimates of the number of observable sources, we need to take into account source separation

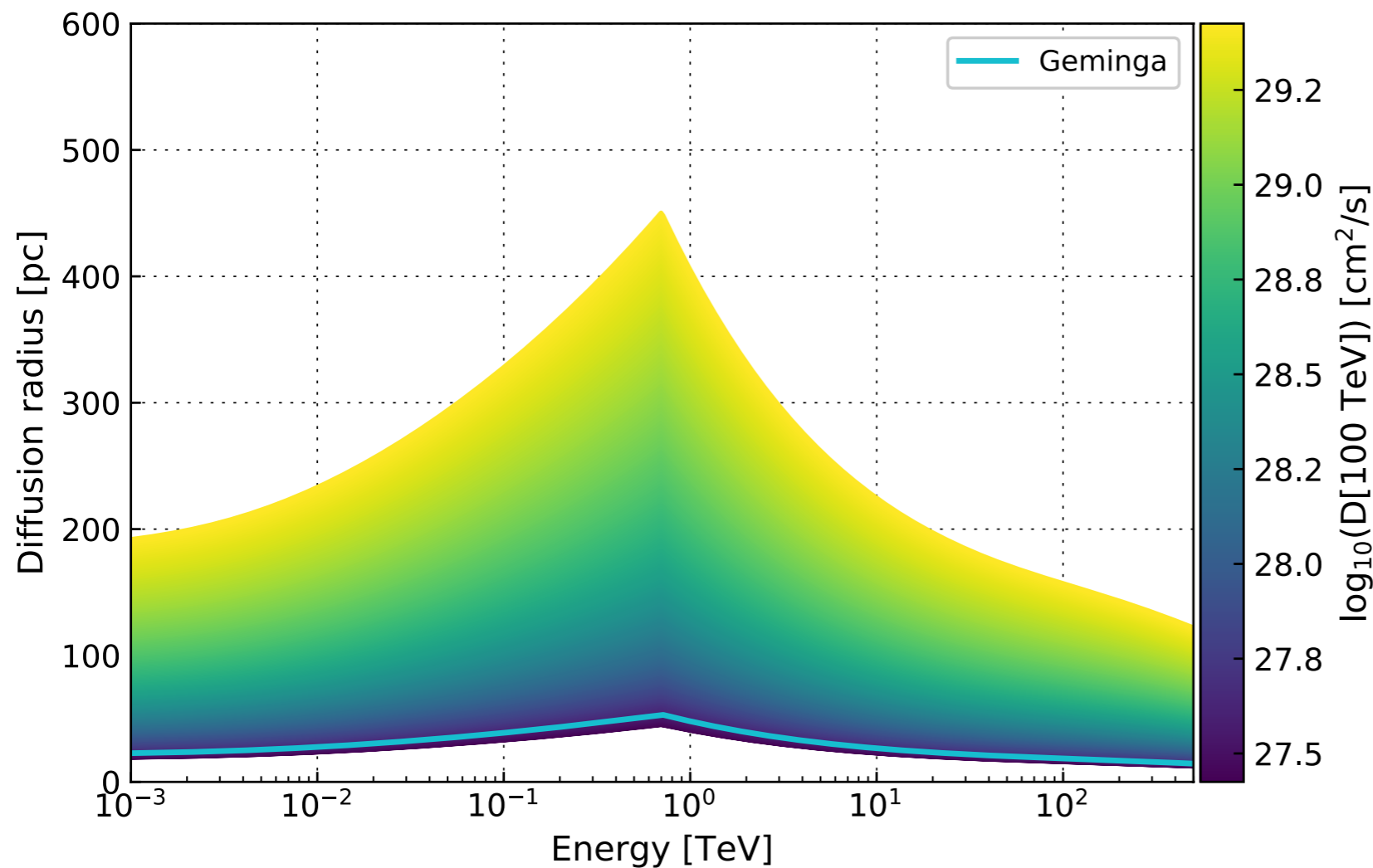
Angular separation between sources

- Angular separation from sources SWGO will be sensitive to within 1 year (orange) and 5 years (blue)
- Simple evolutionary model used for halos (at roughly 1TeV).
 - 0.5° angular resolution \rightarrow resolve 93 (96)% in 1 (5) years
 - 0.2° angular resolution \rightarrow resolve 98 (99)% in 1 (5) years



Vertical lines correspond to the percentage of sources for the 1 year case

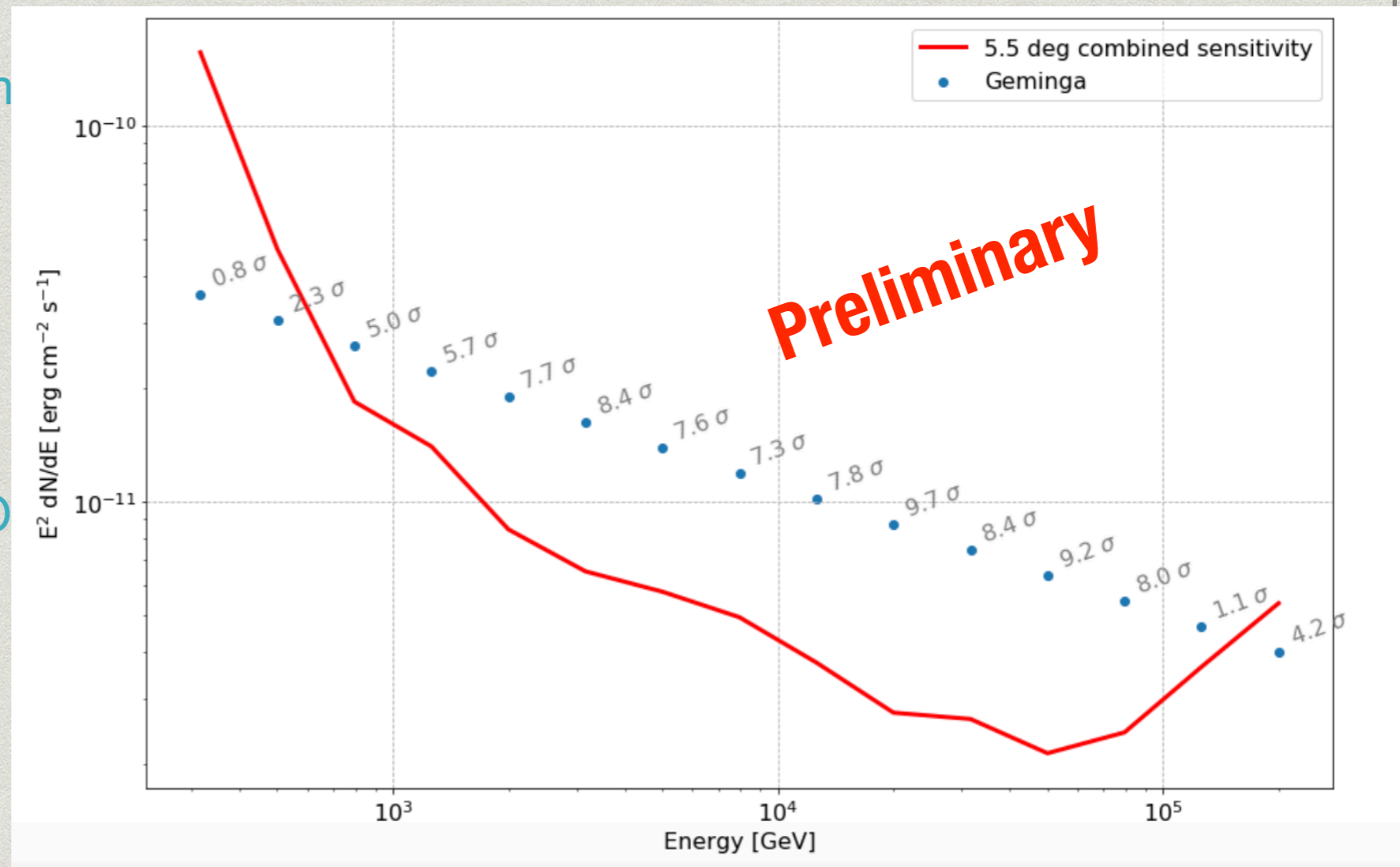
Not only nearby sources. Halos size



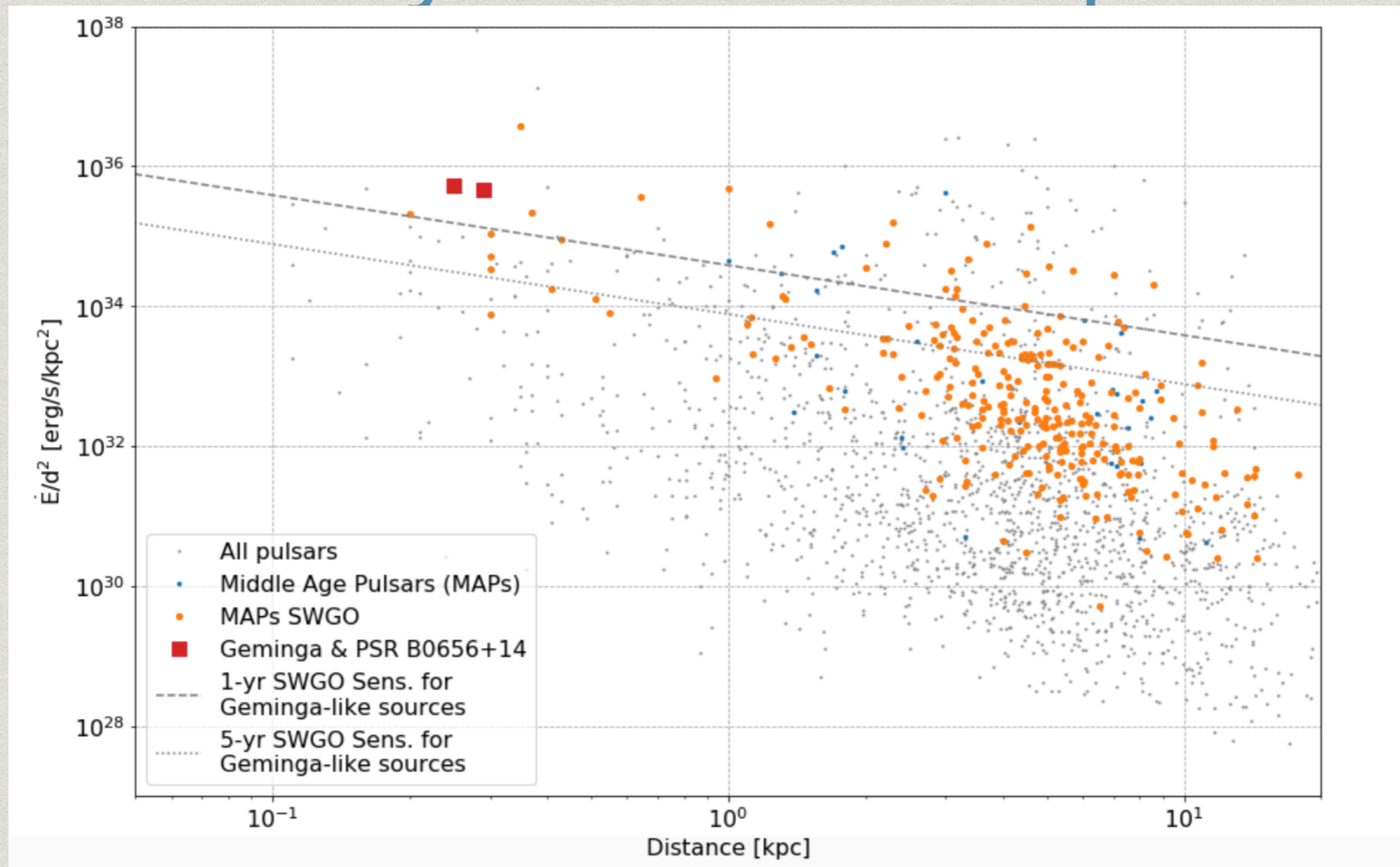
- Given the age and spin-down power of the system, we can make size predictions vs Energy
- For known distances we can also predict their VHE gamma-ray flux
- Compare with the sensitivity for different extensions

Sensitivity

- Using the IRFs derived from SWGO sensitivity for a Geminga-like spectrum
- Caveat: usage of inner detector to compute the significance
 - Sensitivity is 1-yr SWGO straw-man **inner+outer array**

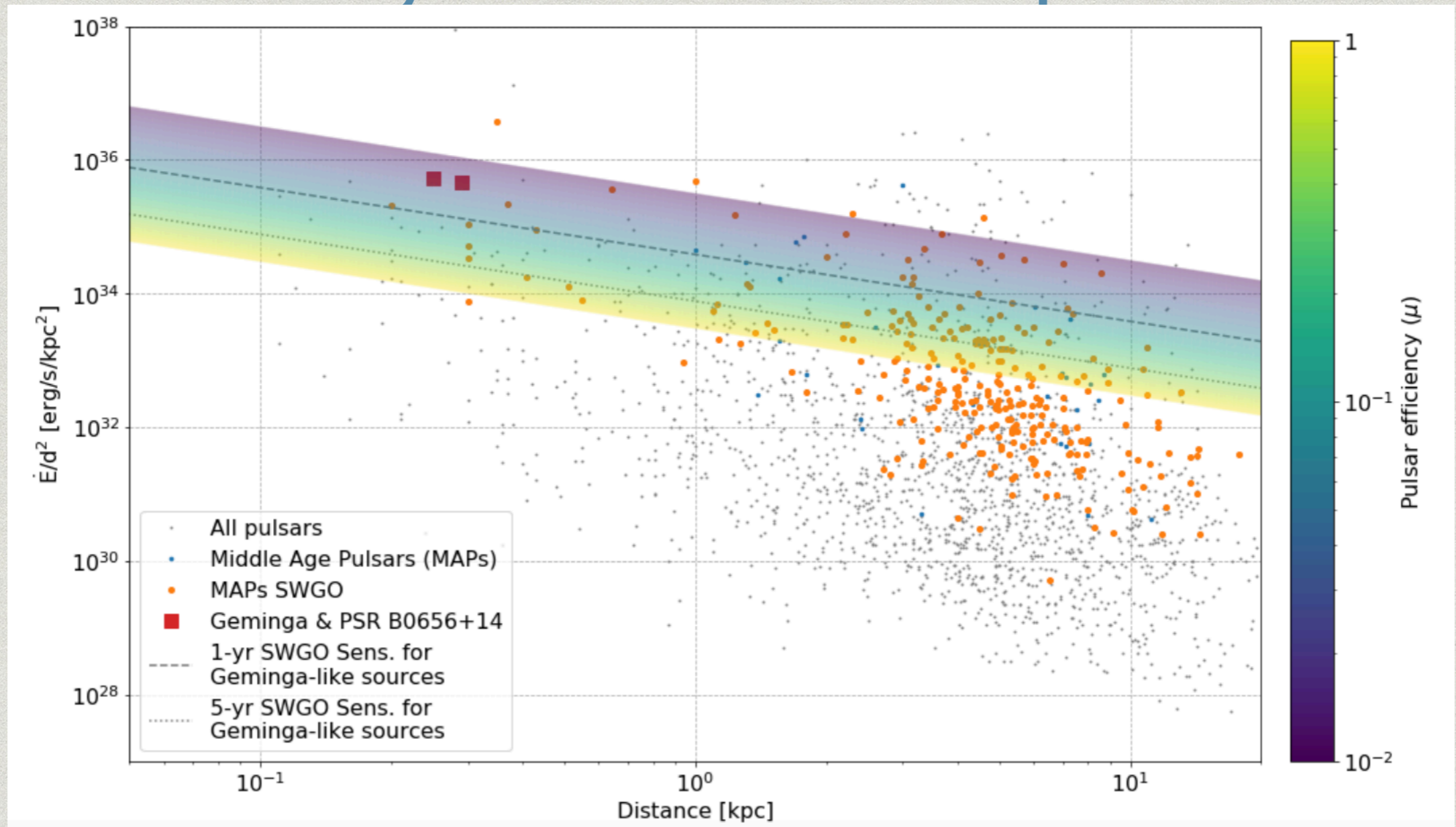


Sensitivity to known pulsars



- Sensitivity using Strawman SWGO IRFs
- Also interested on further sources to complete these studies.
- Sensitivity will be further limited by the angular resolution of the instrument

Sensitivity to known pulsars



- Color scale representing the pulsar efficiency for transforming rotational energy into accelerated electrons and positrons

Conclusions

SWGGO will be essential for the study of VHE gamma-ray halos in the Southern Hemisphere

- Detectability not only of known VHE gamma-ray halos, but also promising new candidates

Sensitivity for nearby sources with very large extensions already proved by the wide FoV technique.

- May be more challenging for observatories like CTA

Angular resolution of the experiment also very important

- Source separation.
- And morphological studies of further sources.

Thanks!



Proposed Site,
Salta Province, Argentina