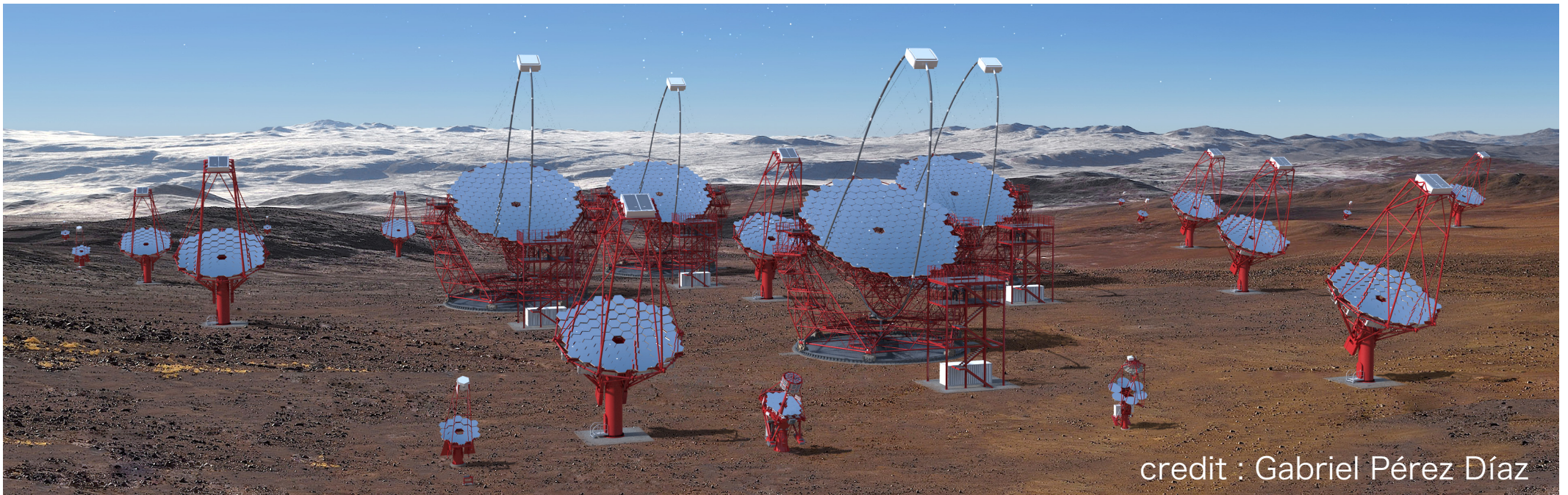


Science with LSTs in Cherenkov Telescope Array South

Takeshi Nakamori (Yamagata U)
for the CTA consortium

and Many thanks to the LST team



credit : Gabriel Pérez Díaz

CTA-South

cta-observatory.org

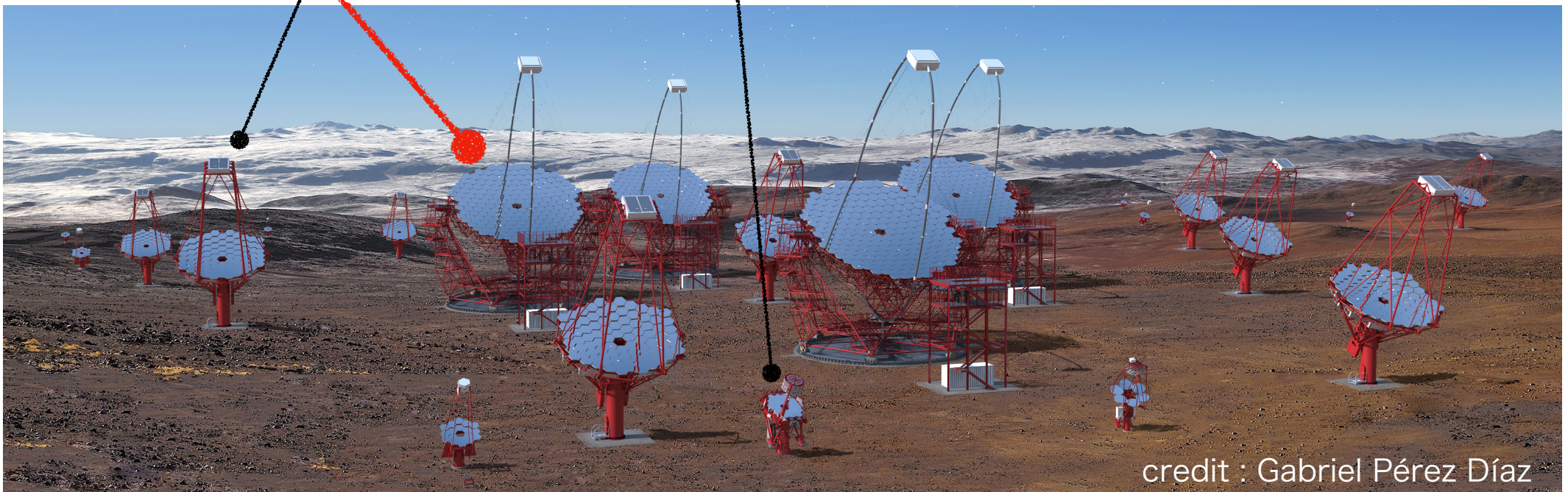
4 Large-Sized Telescopes

25 Medium-Sized Telescopes

70 Small-Sized Telescopes
(see Akira's talk)



Paranal, Chile



credit : Gabriel Pérez Díaz

Large-Sized Telescope

A large-sized telescope structure is shown on a mountain peak. The telescope consists of a large, curved, segmented mirror (the primary mirror) supported by a complex metal structure. The mirror is made of many small, hexagonal segments. The structure is built on a rocky mountain peak. The sky is blue with some clouds. The telescope is pointing towards the sky.

Covers the lowest energy bands down to 20 GeV.

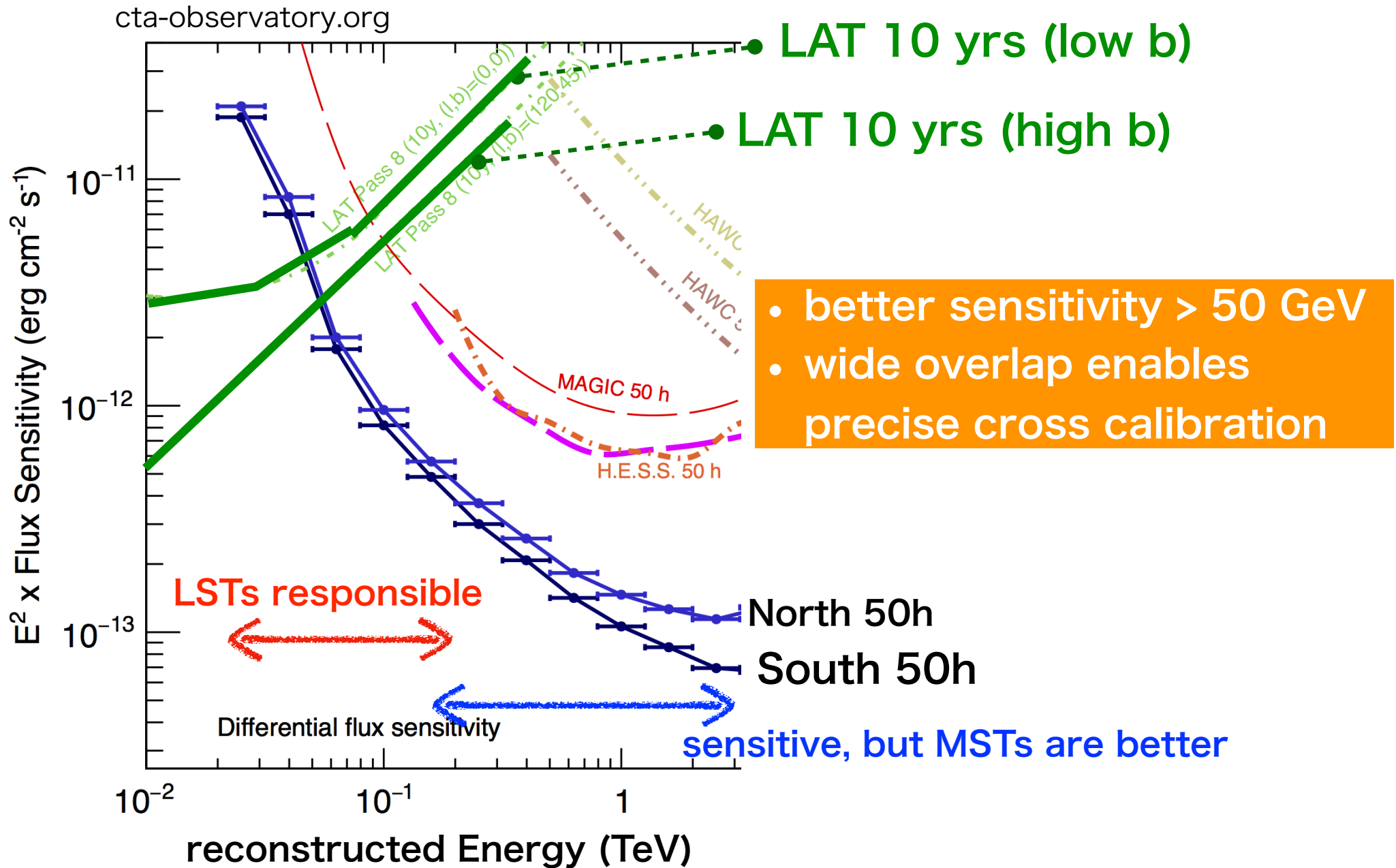
complemental/competing with Fermi/LAT

Fast pointing — 180 deg in 20 sec

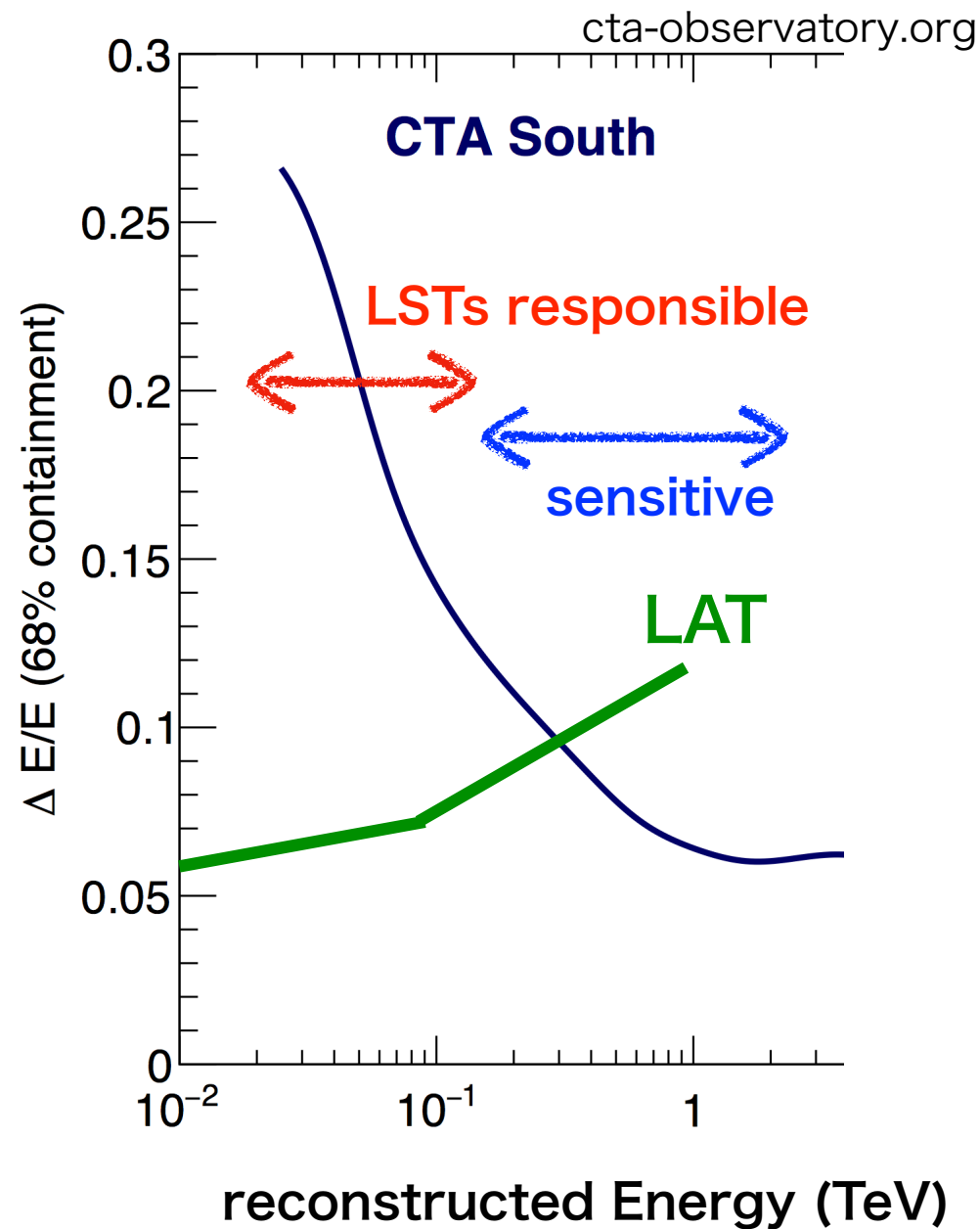
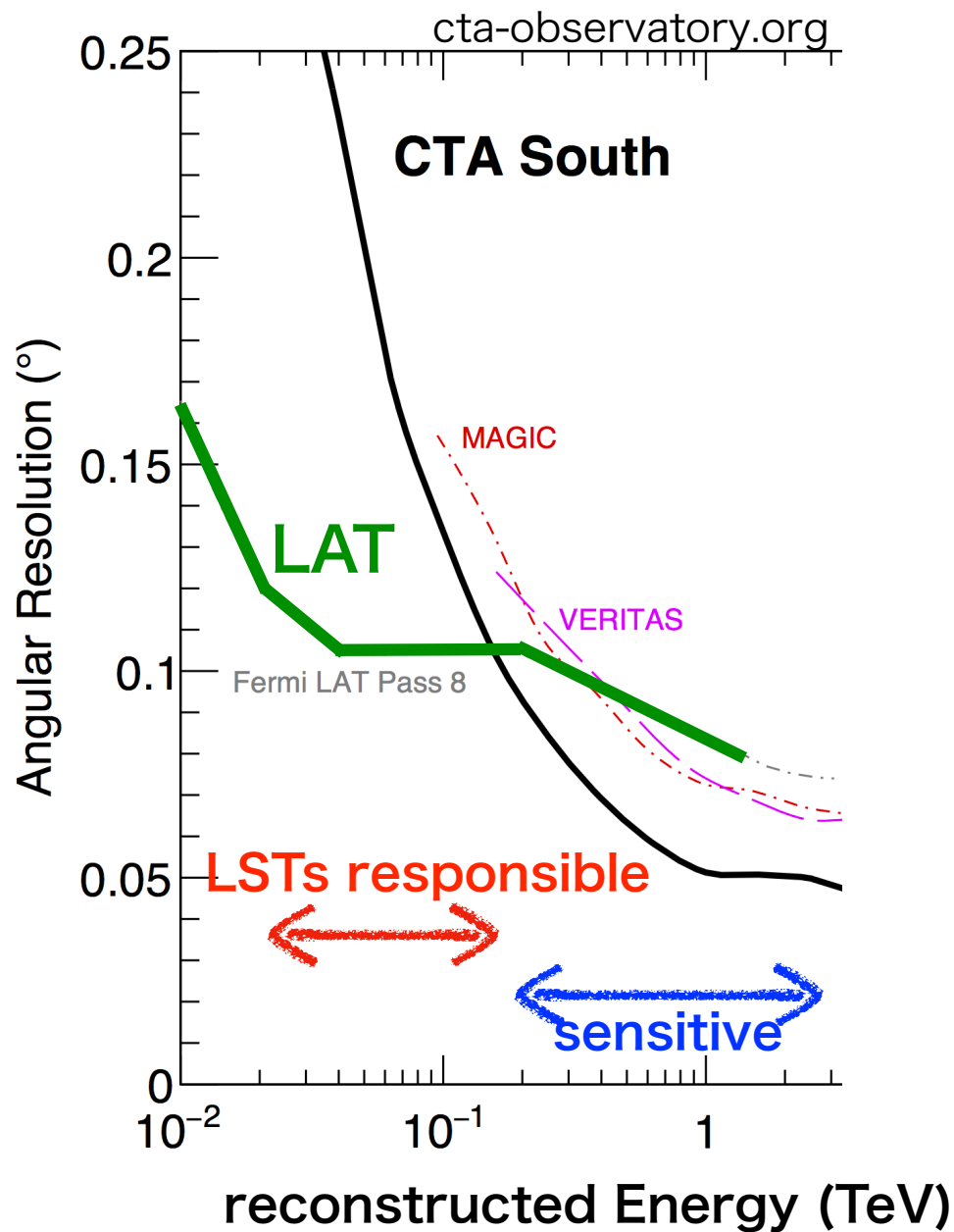
4 LSTs are planned in CTA South

FoV=5 degrees radius

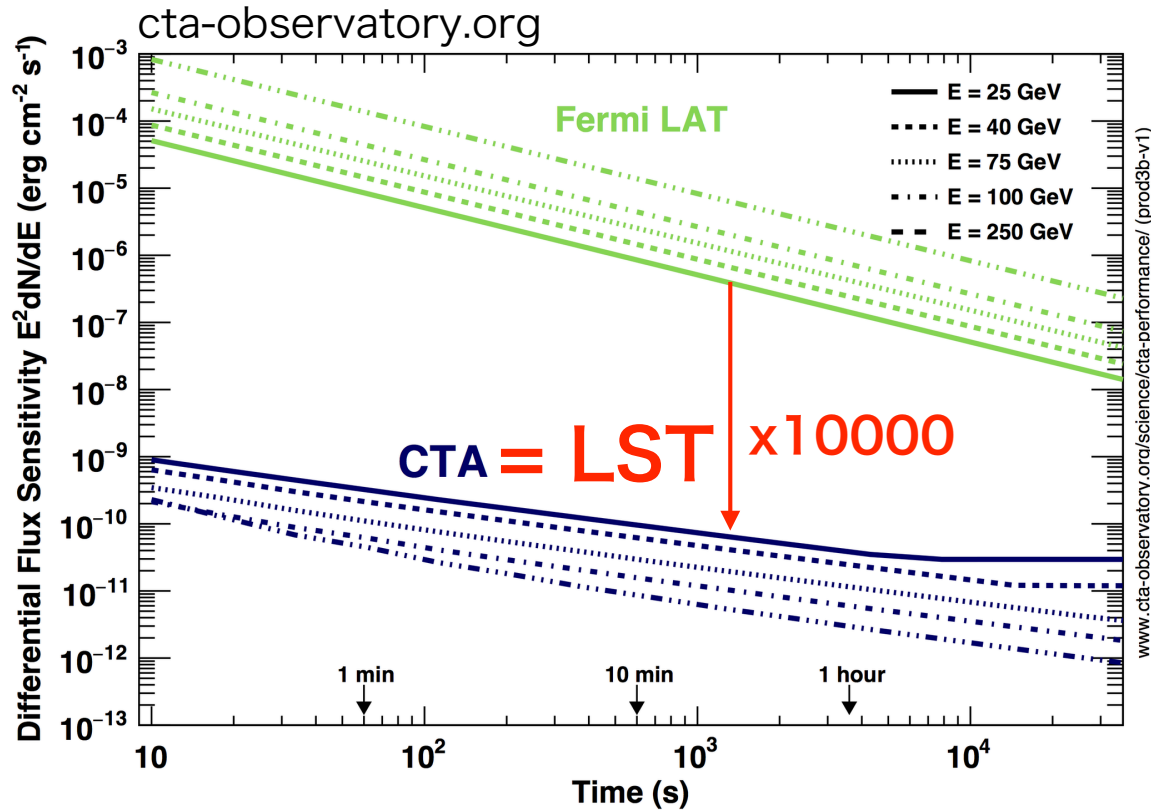
v.s. LAT sensitivity



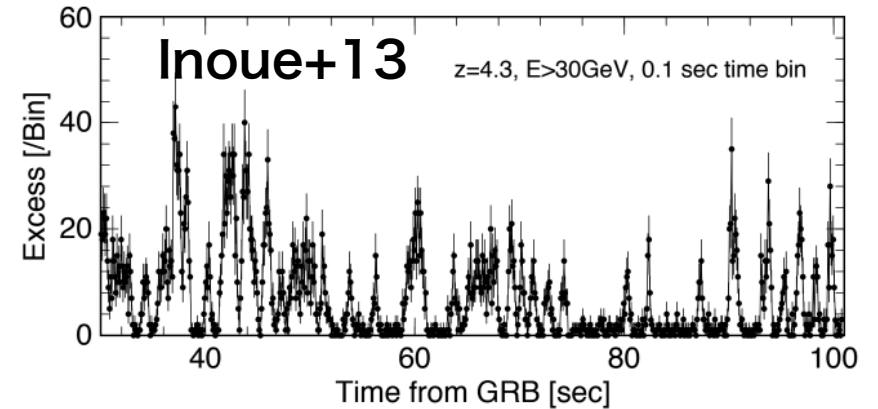
Ang&E resolutions



short time scale

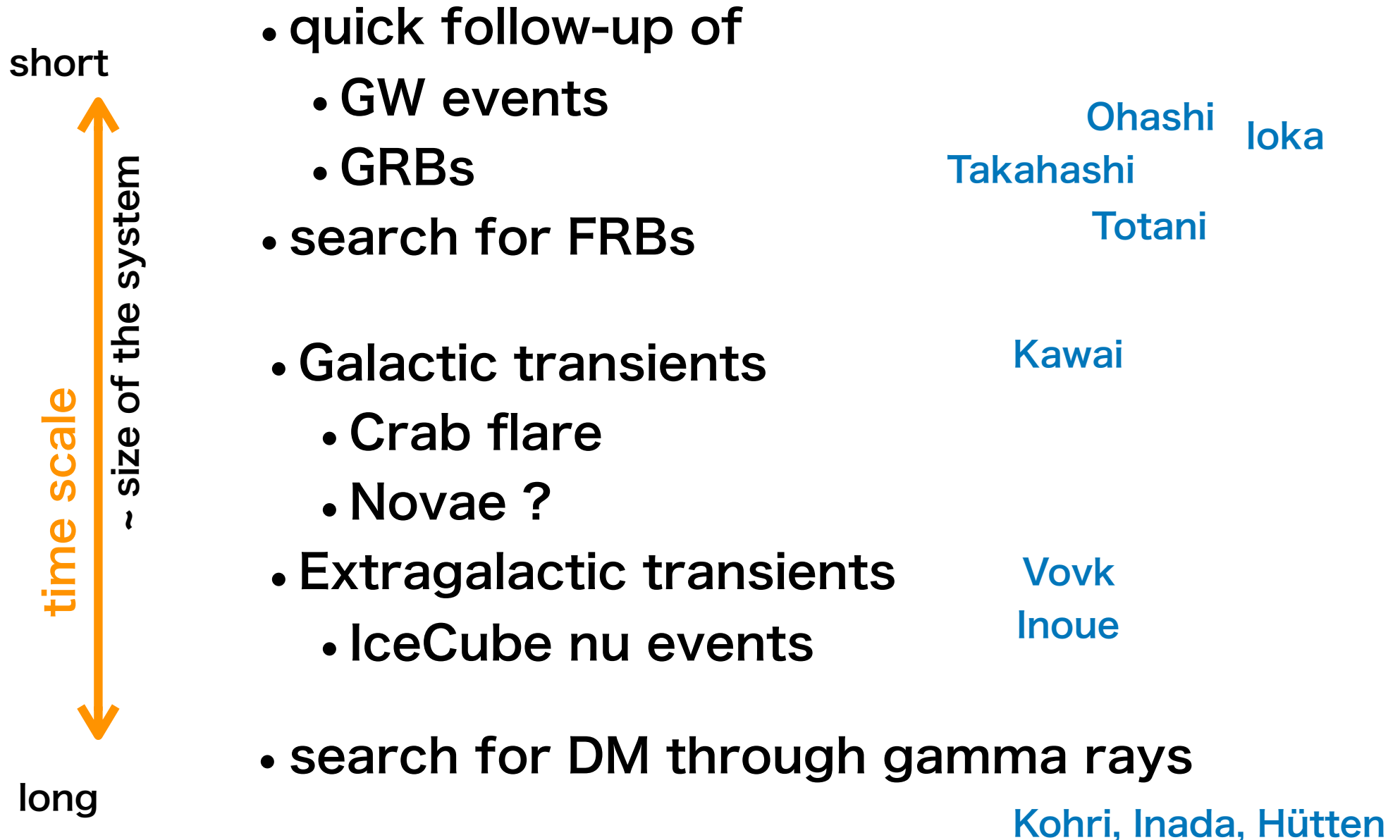


Simulated LST light curve
for GRB 080916C



- Thanks to much larger effective area, plenty of photons will be observed in a short time
- Powerful tool to probe high- z transients

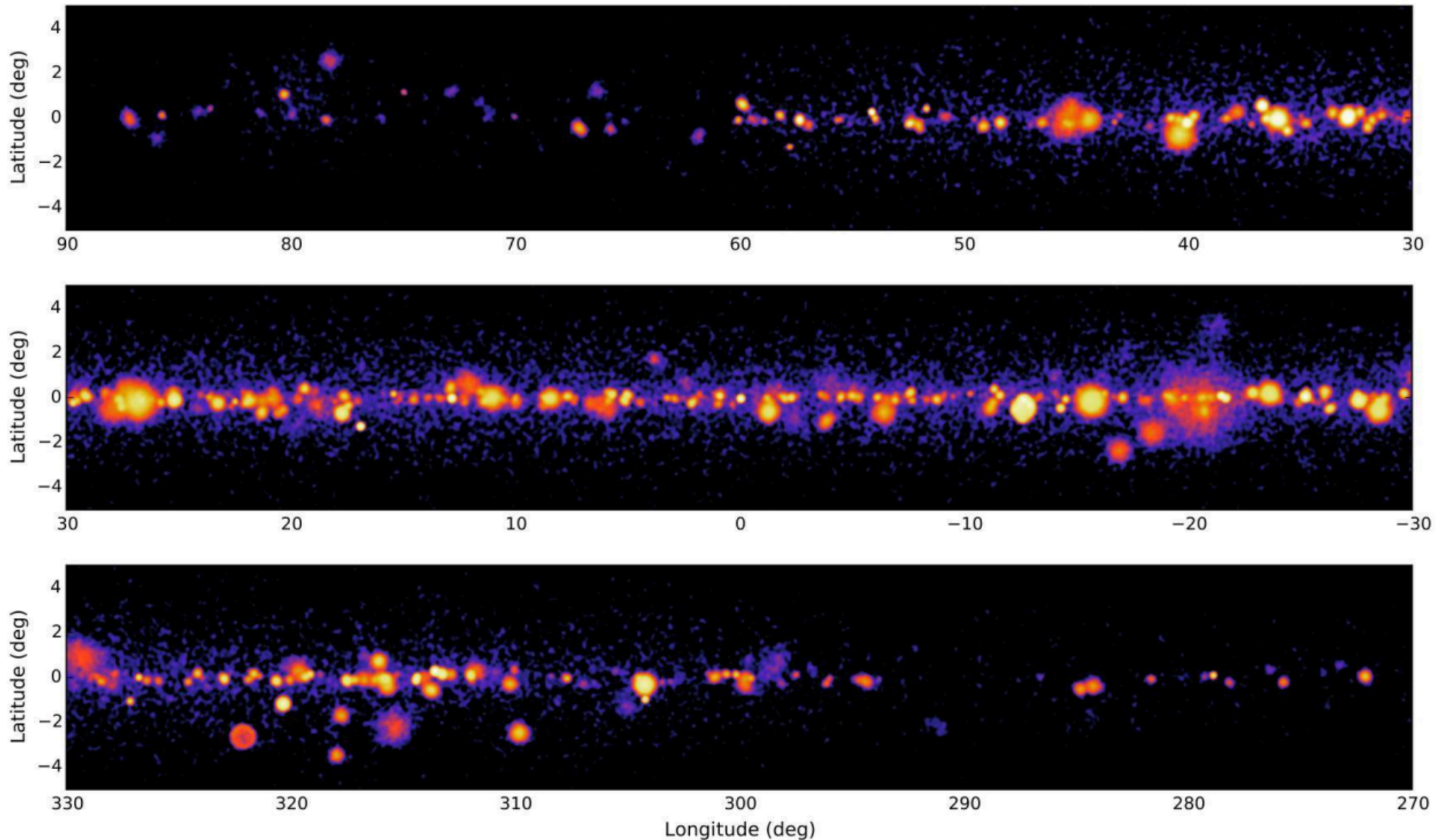
LSTs are mainly expected for



What else should I talk about ?

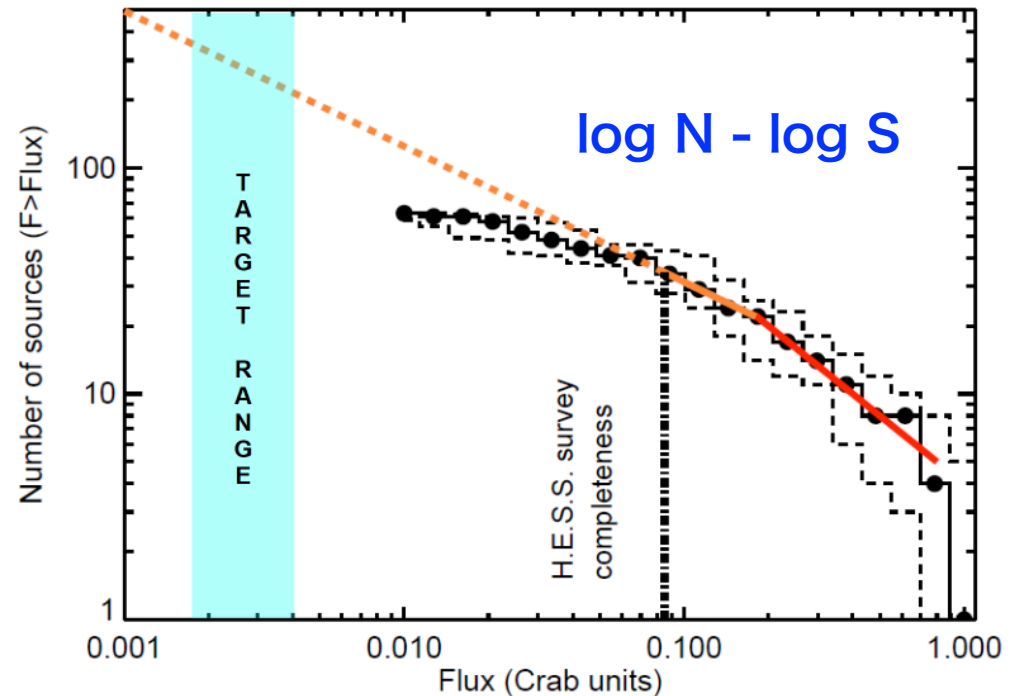
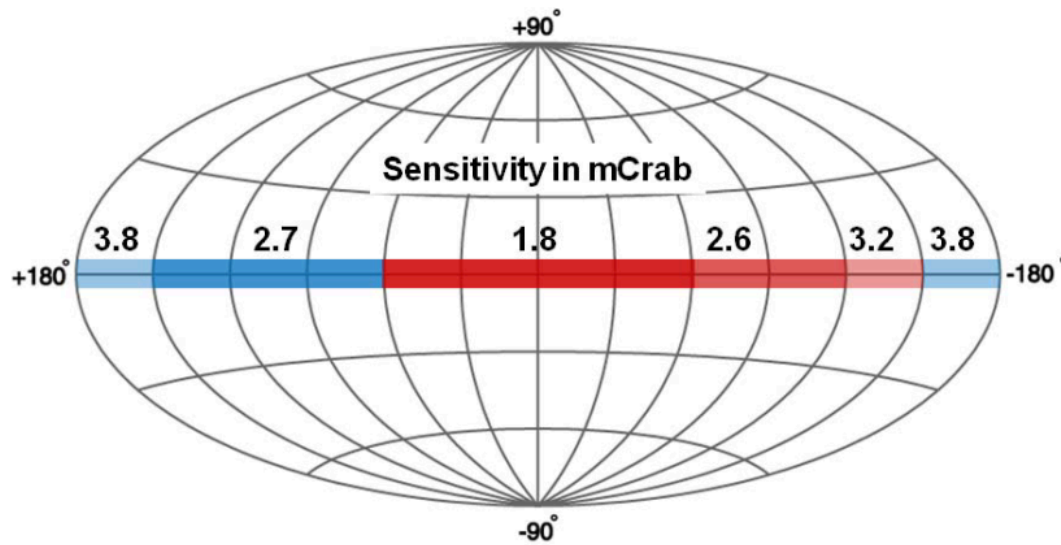
Galactic Plane Survey

Simulated GP image with CTA (full array)



GPS as a Key Science Project

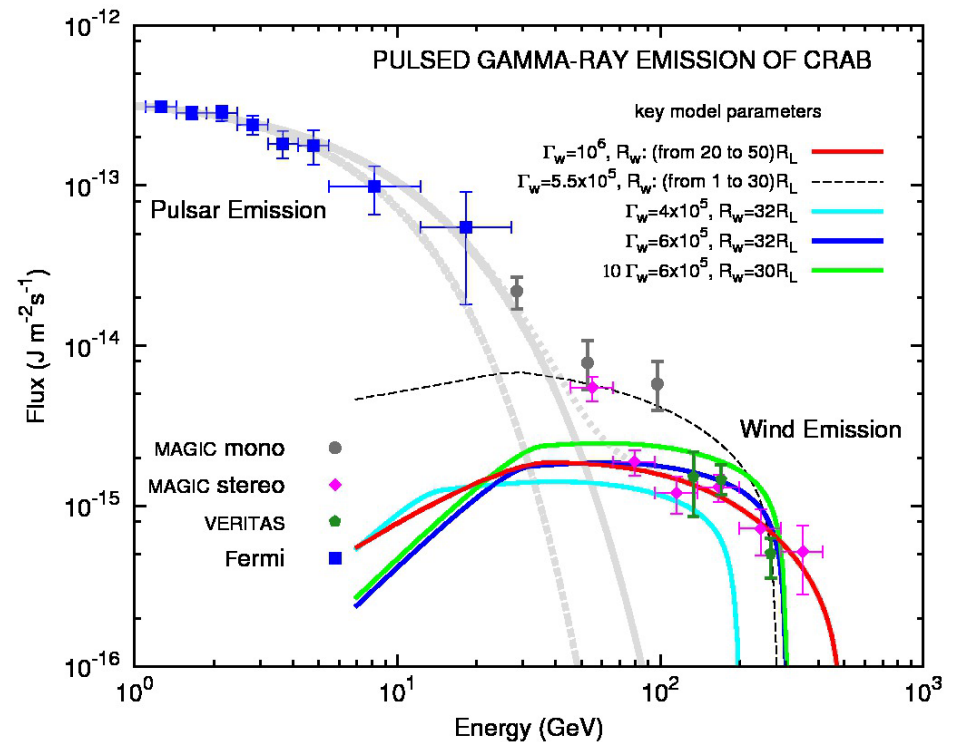
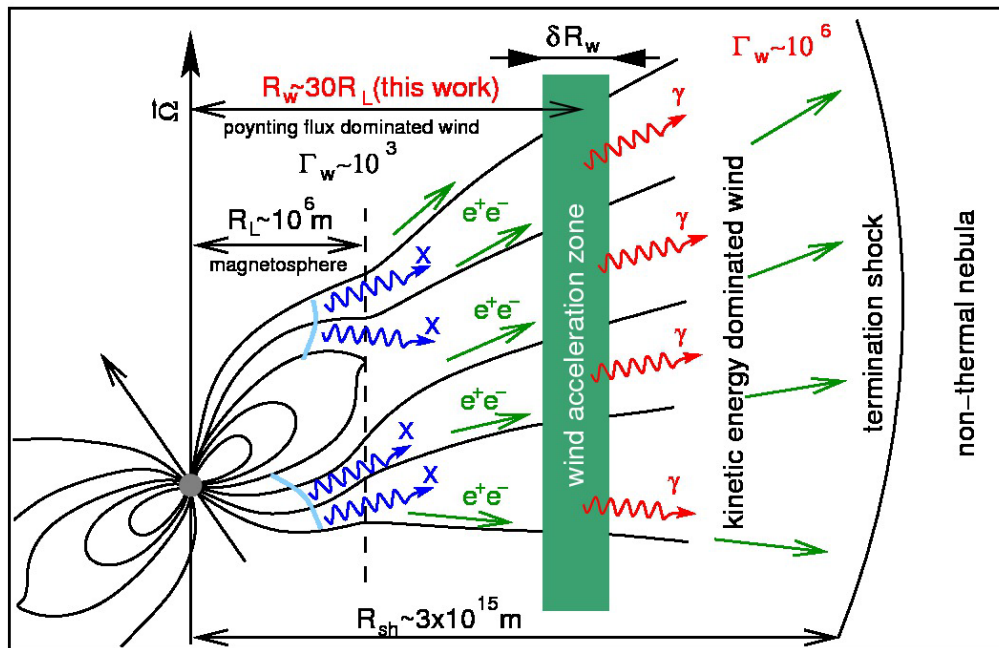
arXiv:1709.07997



- roughly ~50h exposure for Southern sky
- Systematic view of the Galaxy to facilitate our understanding of Galactic sources populations and diffuse emission.
- **Can expect discoveries of new/unexpected phenomena**
- **expecting 3-500 sources, mainly SNRs and PWNe**
- **Making catalogs, useful for further deep investigations**

Pulsars

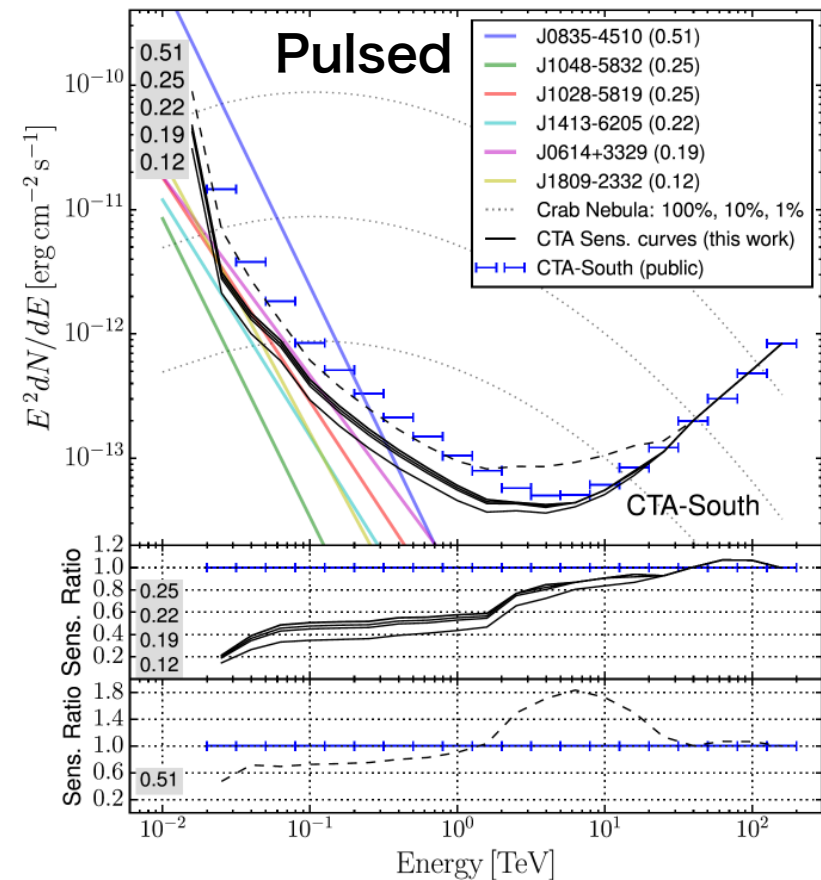
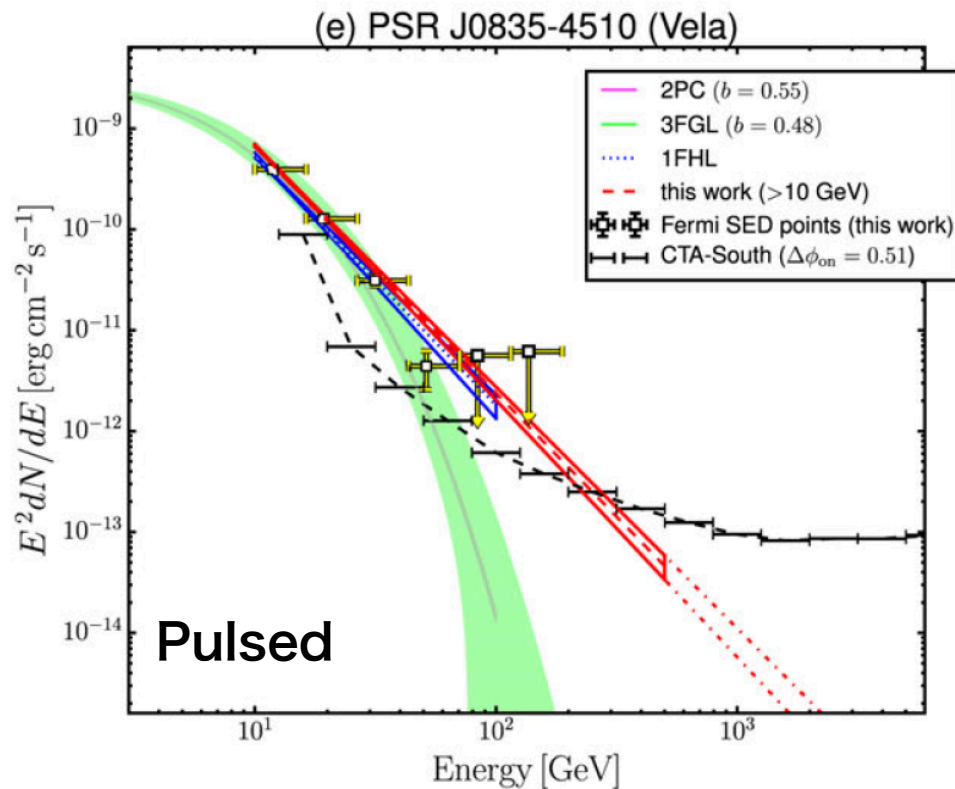
- Pulsed gamma-ray emission with an exponential cut-off in Fermi/LAT energies supporting outer gap related emission models.
- IACTs have reported the Crab has a spectral extension up to TeV
- Challenge to probe the pulsar wind and e- acceleration scenario
- Other pulsars ?



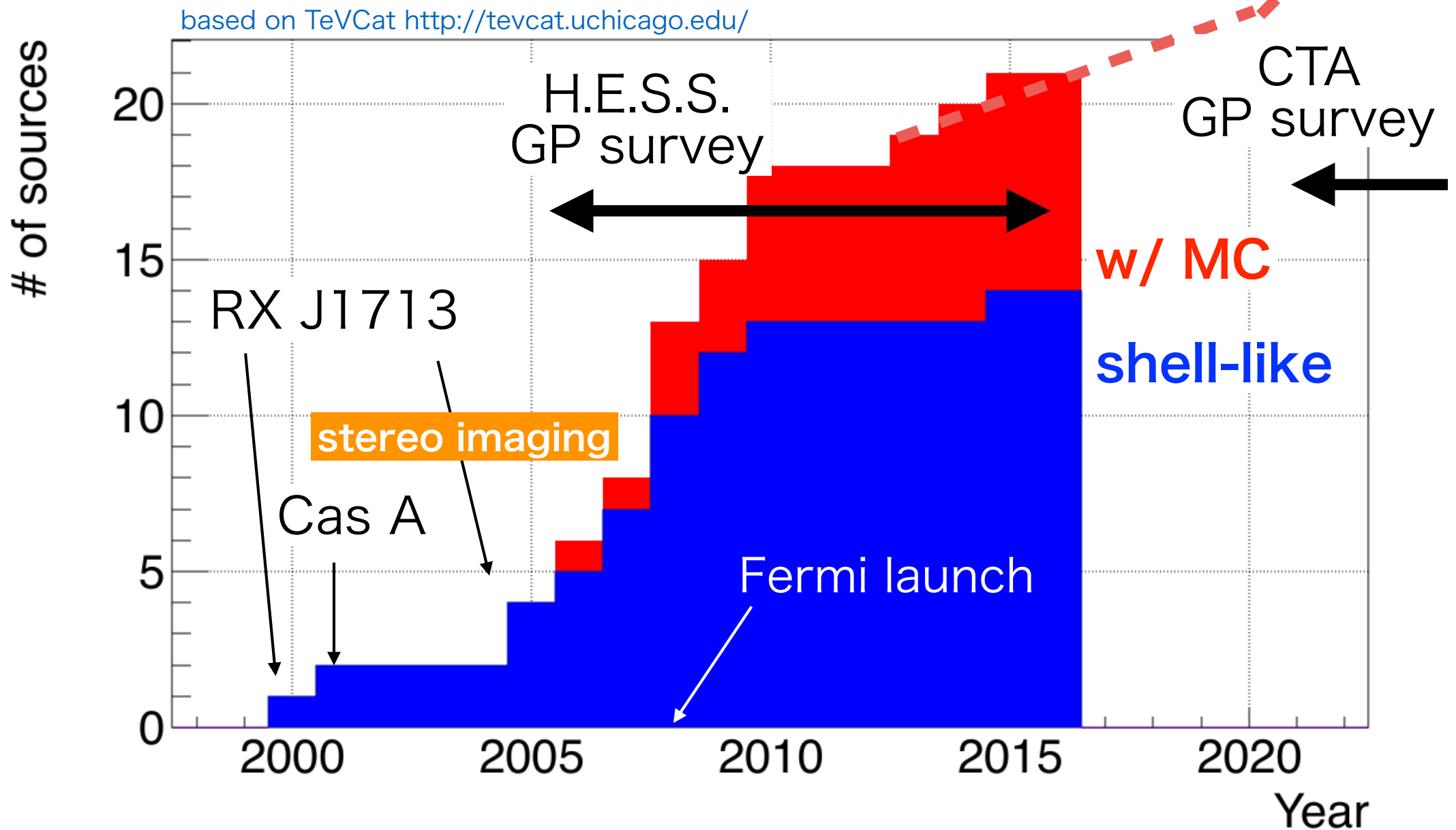
Pulsars in southern sky

- Fermi/LAT pulsars with $E > 25$ GeV emissions are selected.
- 6/12 pulsars are seen from South
- assumed 50 h observations for each PSRs
- Phase-averaged, On-pulse and Off-pulse spectral analysis
- **Vela is promising, others may need more exposure**

J0614-3329
 J0835-4510
 J1082-5819
 J1048-5832
 J1413-6205
 J1809-2332

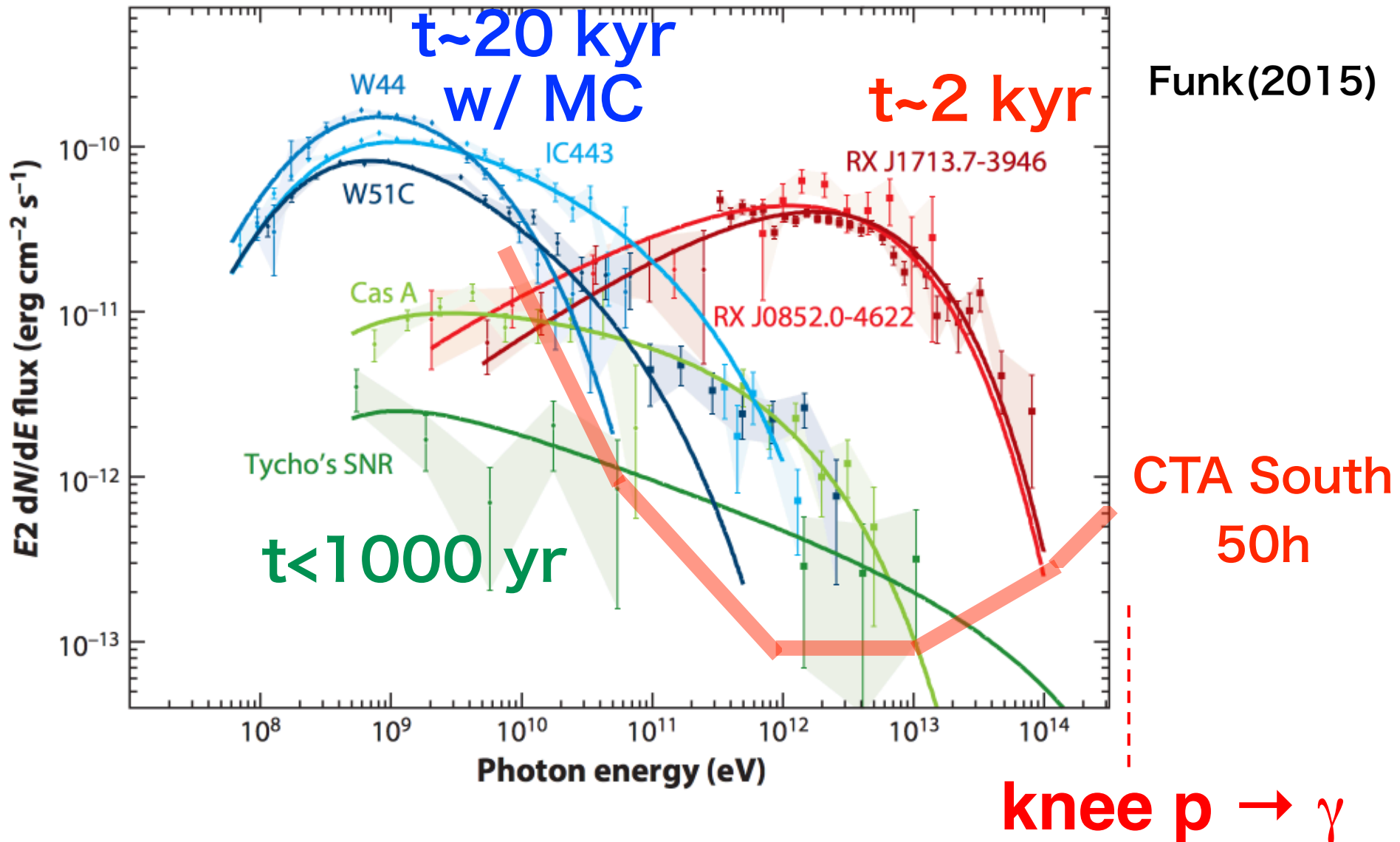


VHE SNRs



Who can touch knees ?

- Older SNRs with Ecut in GeV, dim in TeV
- Even younger SNRs not confirmed as PeVatrons
- Galactic Center ?

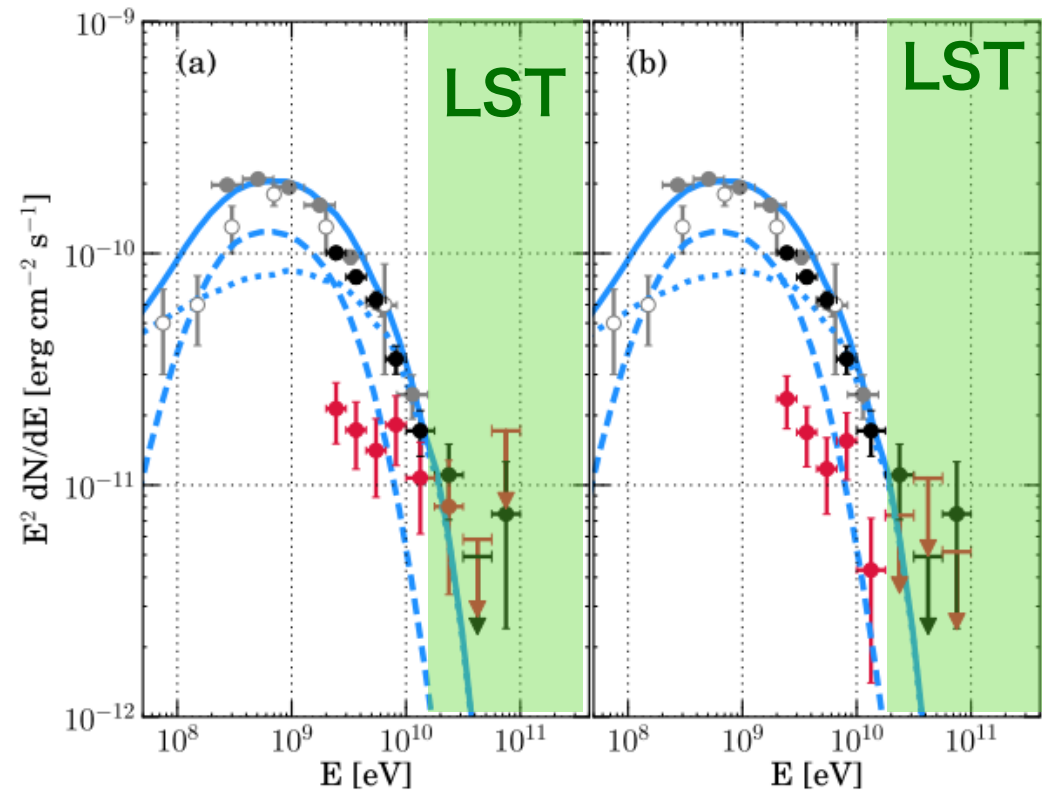
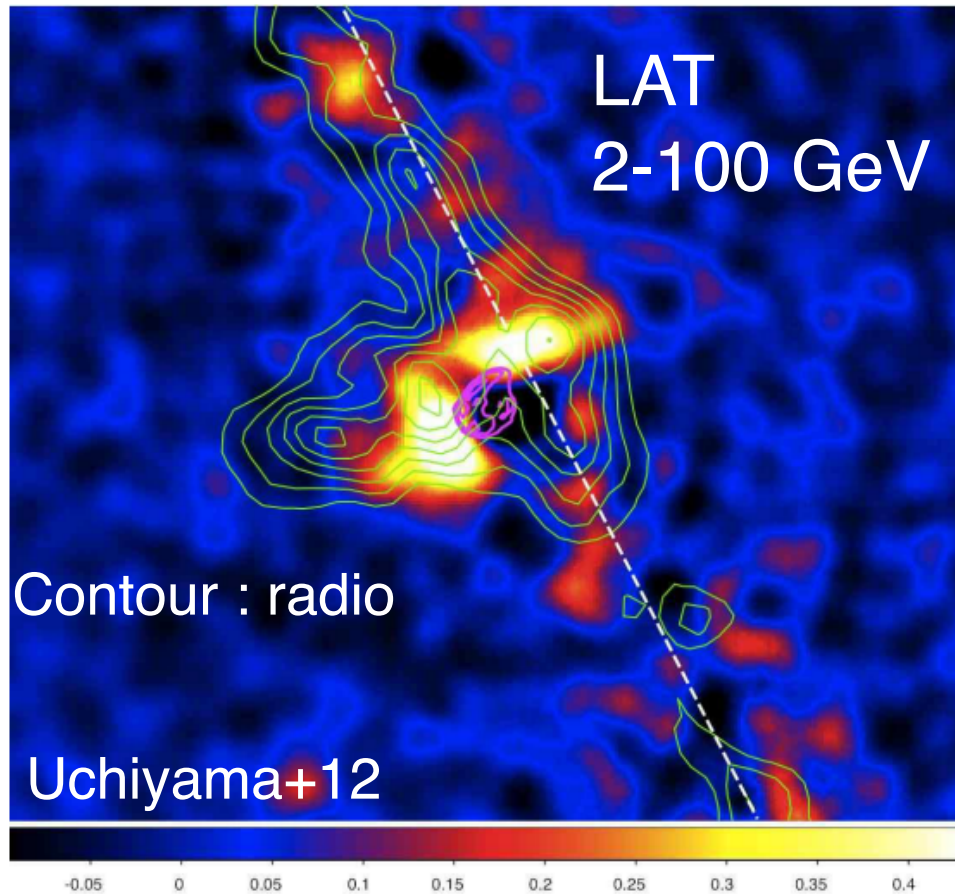


Footprints of Escaping CRs

- Gamma-ray halo surrounding W44 was seen when removing the emission from the SNR itself
- Harder spectra than the SNR

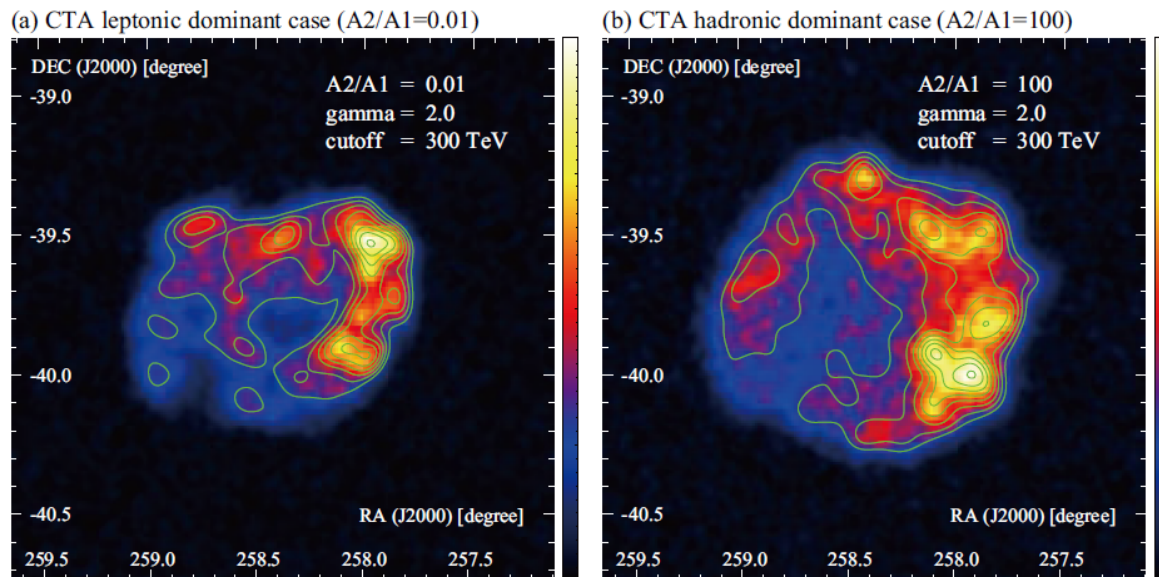
Collision of escaping (energetic) CR and MCs

LST+ will derive more precise spectra/morphology

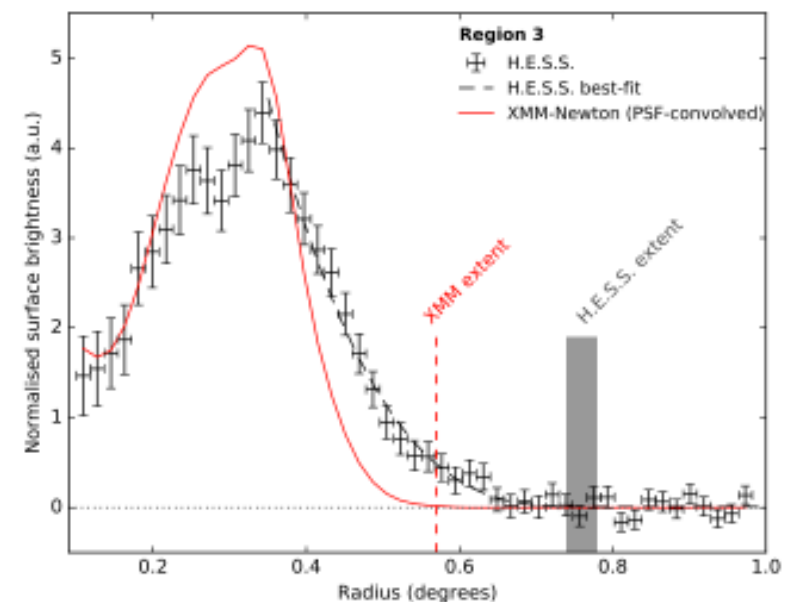


young SNR J1713

- Despite its brightness, the emission scenario has long been in question.
- CTA simulation with leptonic/hadronic scenario expects more extension than X-ray morphology.
- H.E.S.S. observed such extension.
- Escape of the CR e^- ? But no significant energy dependence



Acero+17 (C.A. TN+)



H.E.S.S. collaboration (2017)

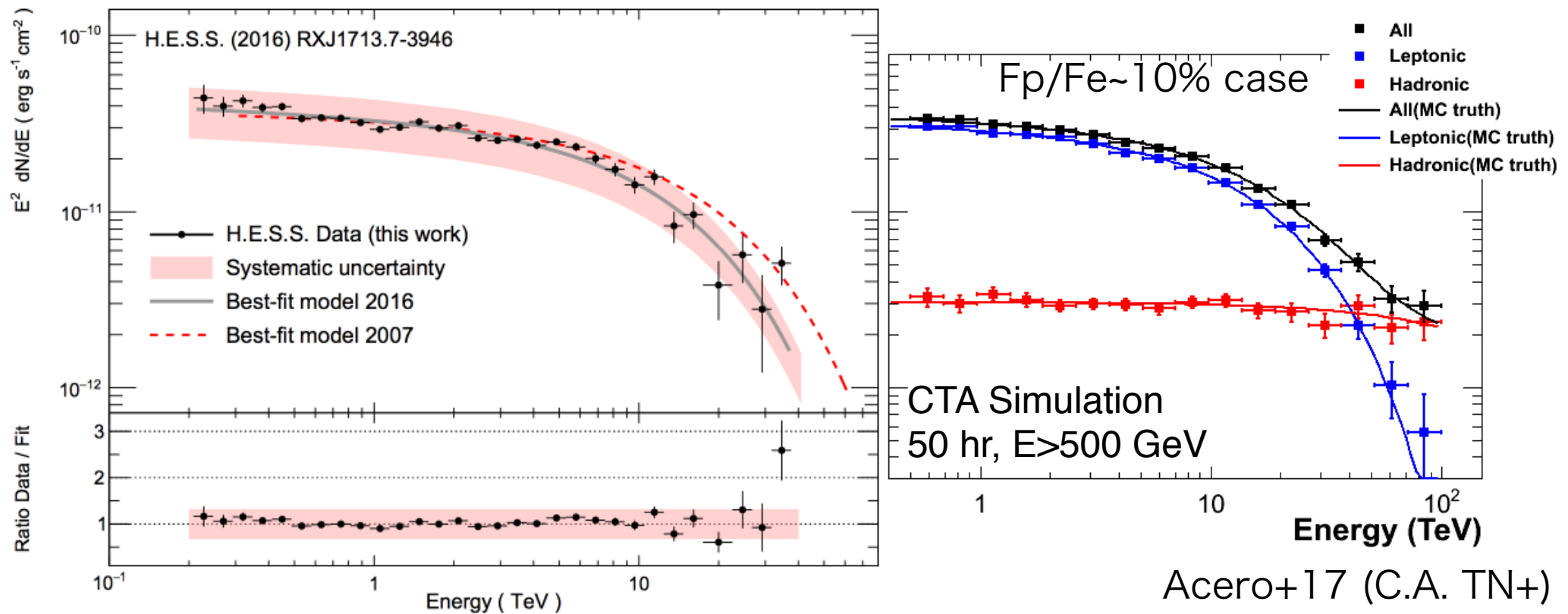
Search for PeVatron clues

Can we detect a “hidden” hadronic component up to knee ?

— even if the leptonic emission is dominated

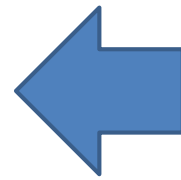
We demonstrated the possibility in 50h observations, if hadronic flux occupies 10% of the total flux.

Mainly SSTs are responsible,
but with LSTs wider band spectroscopy will realized.

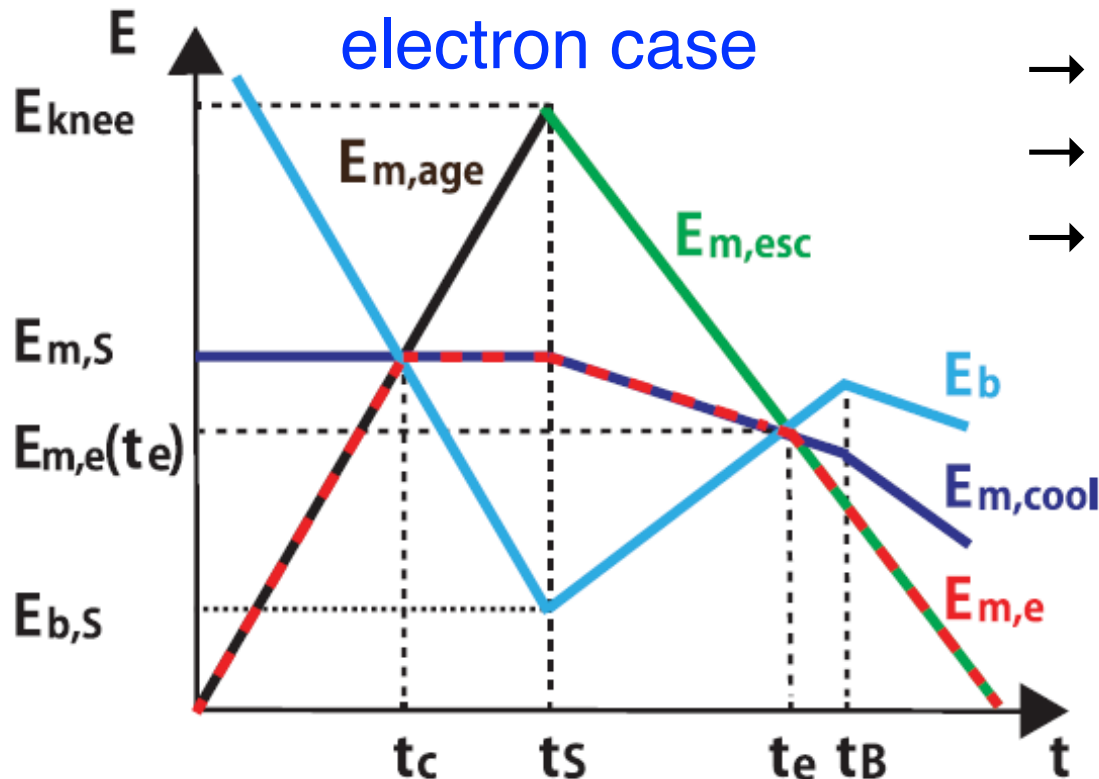


Time evolution of E_c

Maximum energy
 E_c



acceleration
escape
cooling



time variation of E_c

- magnetic field strength
- shock parameters
- acceleration model

$\Delta E_c \sim 5-10\%$ in 20 yr

electron > proton

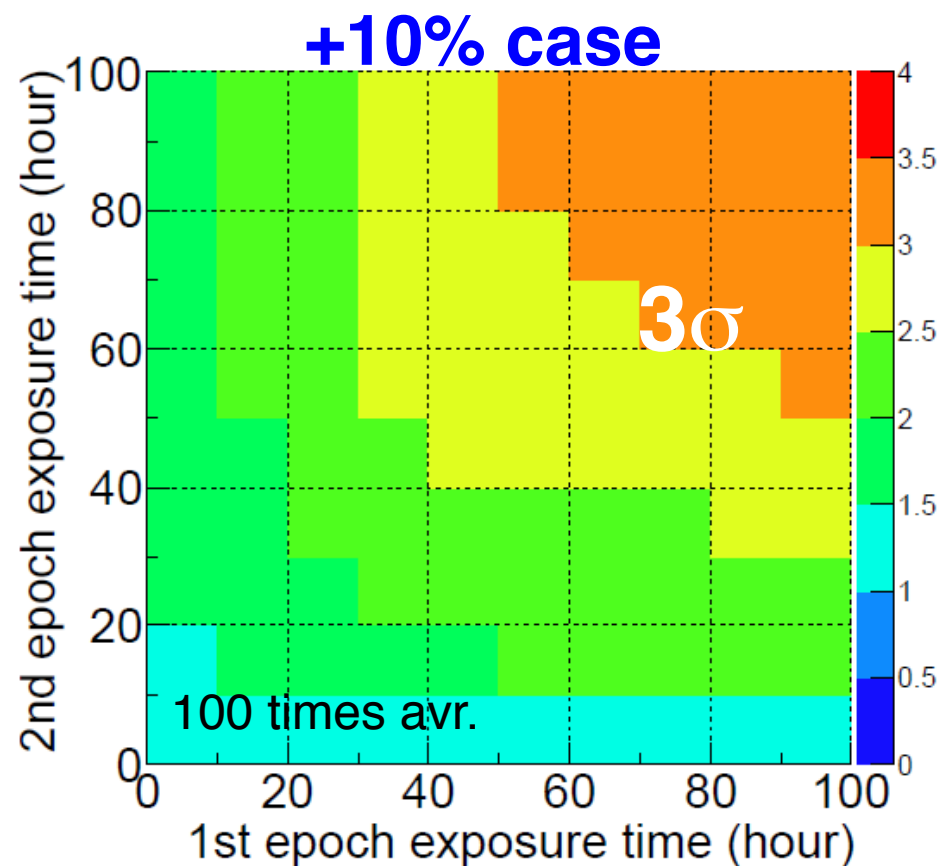
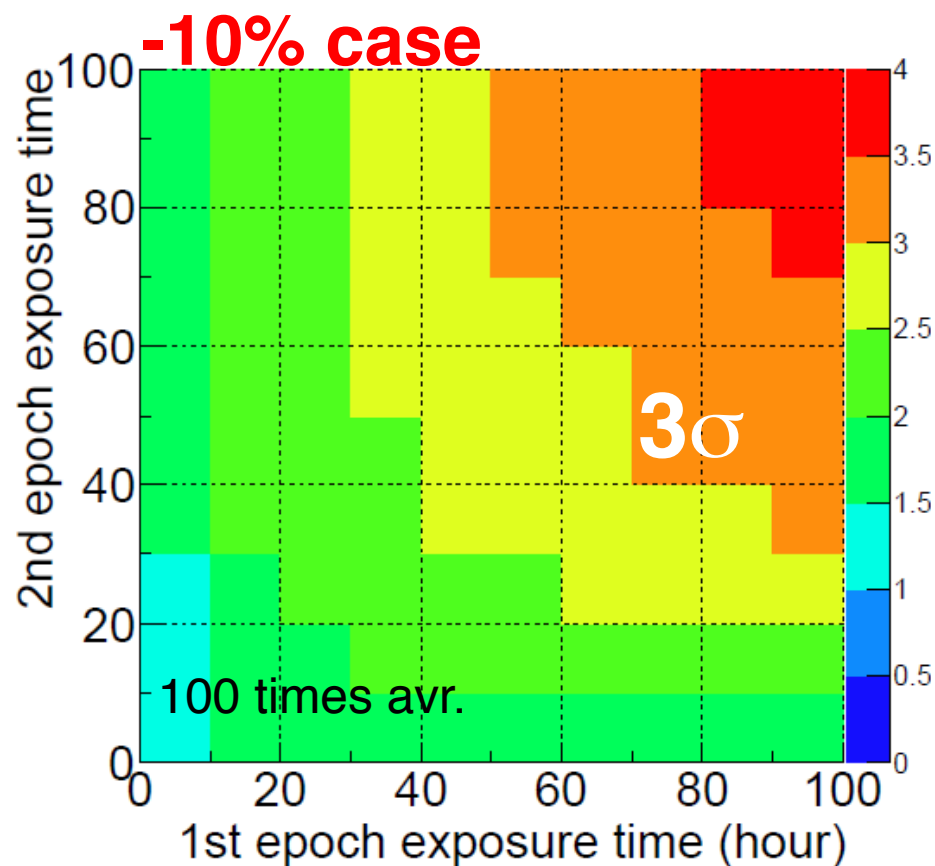
(Ohira+12)

might be faster

when interacting with MCs

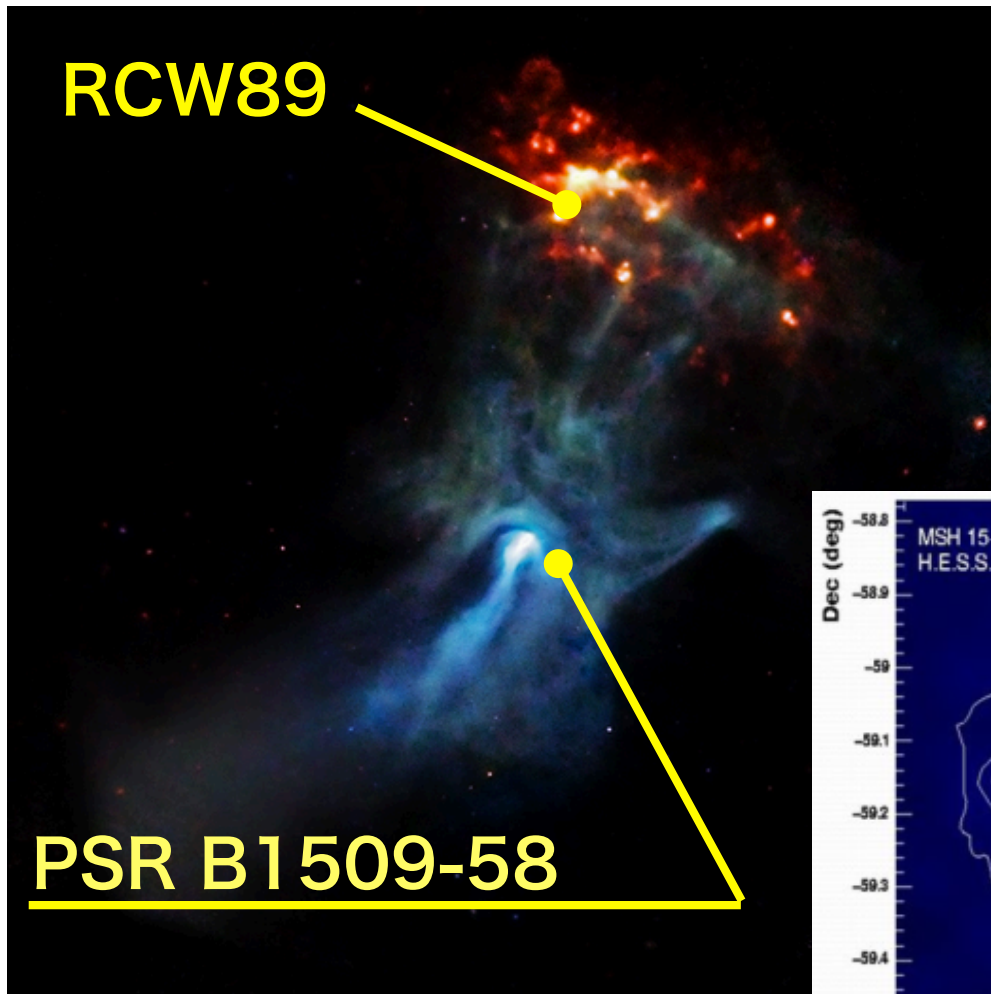
Search for E_c variations

- only E_c is modified, $E > 200$ GeV analysis
- Combination of obs. time in each epoch examined
- -10% case is easier to detect
- >5 -60 hrs in the 1st epoch is necessary for 3σ
- **By using LST, higher significance could be expected**



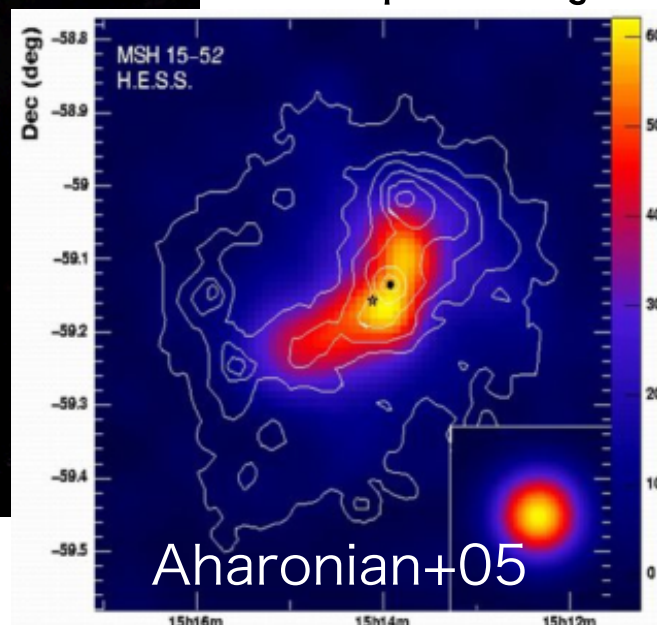
Pulsars as CR source ?

Apart from knee CRs, do we already know sufficient CR source in the Galaxy ? Are SNRs enough?



Hadronic gamma-ray emission from PWNe has ever been discussed e.g., Bednarek+, Horns+ But not confirmed yet.

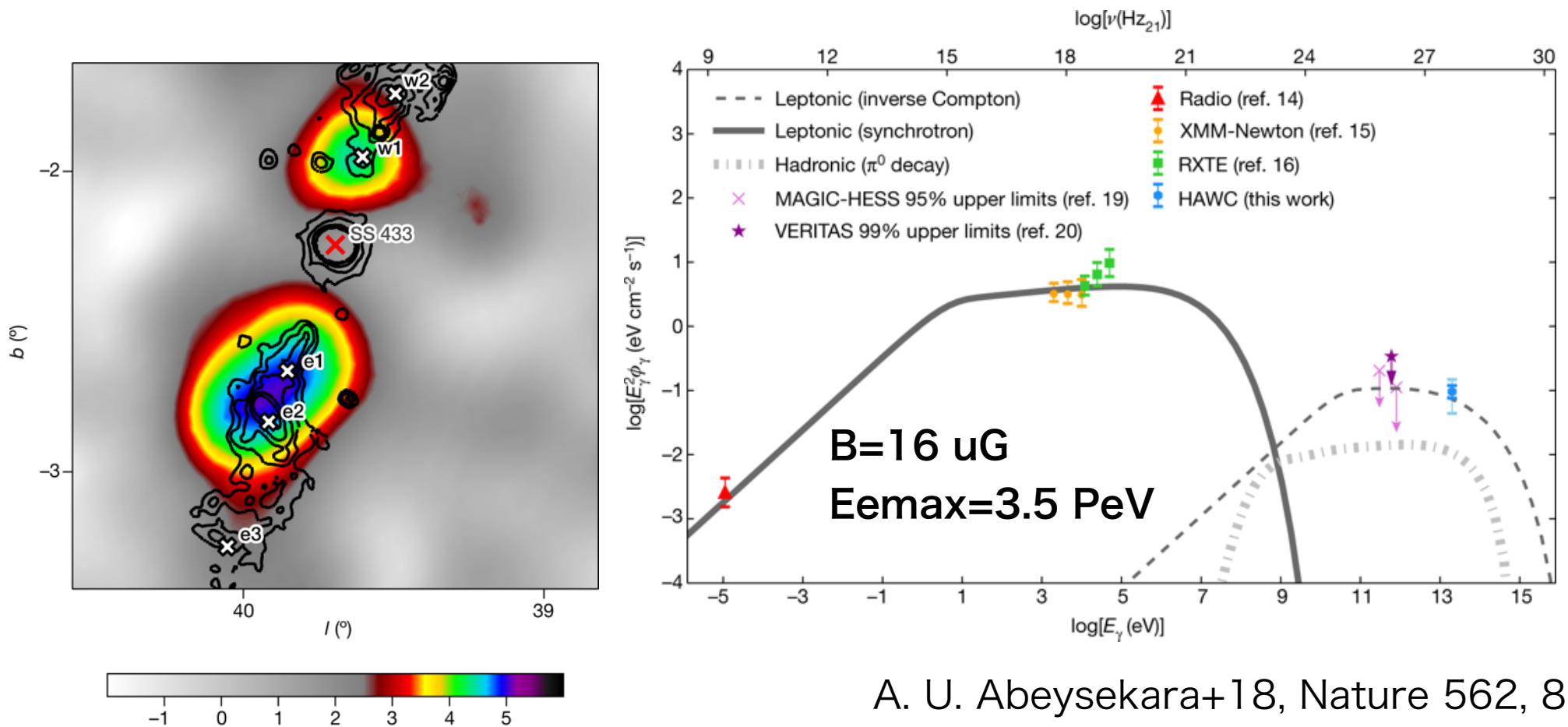
RCW89 is a HII region interacting with pulsar jet (Yatsu+05)



Challenge to Hidden emission at RCW89 by CRs?

similar to SS 433/W50 ?

- accreting BH or NS
- bipolar jets terminated at the SNR shell
- leptonic gamma rays dominate ?



Summary

- 4 LSTs are planned to be built in CTA South
- With their low energy threshold and fast driving system, the LSTs are a very powerful tool probing short time-scale transients.
- Extragalactic transients are one of the major targets; follow-ups for GW, GRB, neutrino sources.
- Even for steady sources, the sensitivity is better than Fermi/LAT with $E > 50$ GeV
- Never forget LSTs are important/crucial instruments to study Galactic HE sources like pulsars.