



Galactic Science with CTA

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- **Presentation based on the Consortium program**
 - Organised in Key Science Projects (KSP)

- **Present Scenario : 40-50% of obs. time in first 10 years**
 - ~40% of total time for galactic KSPs
 - The rest : Extragalactic, dark matter, transients

- **KSP criteria**
 - Excellent scientific case
 - Production of legacy data-sets to a wider community
 - Clear added value of doing this as a KSP
 - Too many hours for a Guest Observer;
 - Coherent approach across multiple targets or pointings;
 - Technical difficulty (consortium expertise).

- **Scenario to be optimised with time**

The telescope arrays

$E < 100 \text{ GeV}$
4 LST
 $\text{Ø } 23\text{m}$
 4.5° FoV

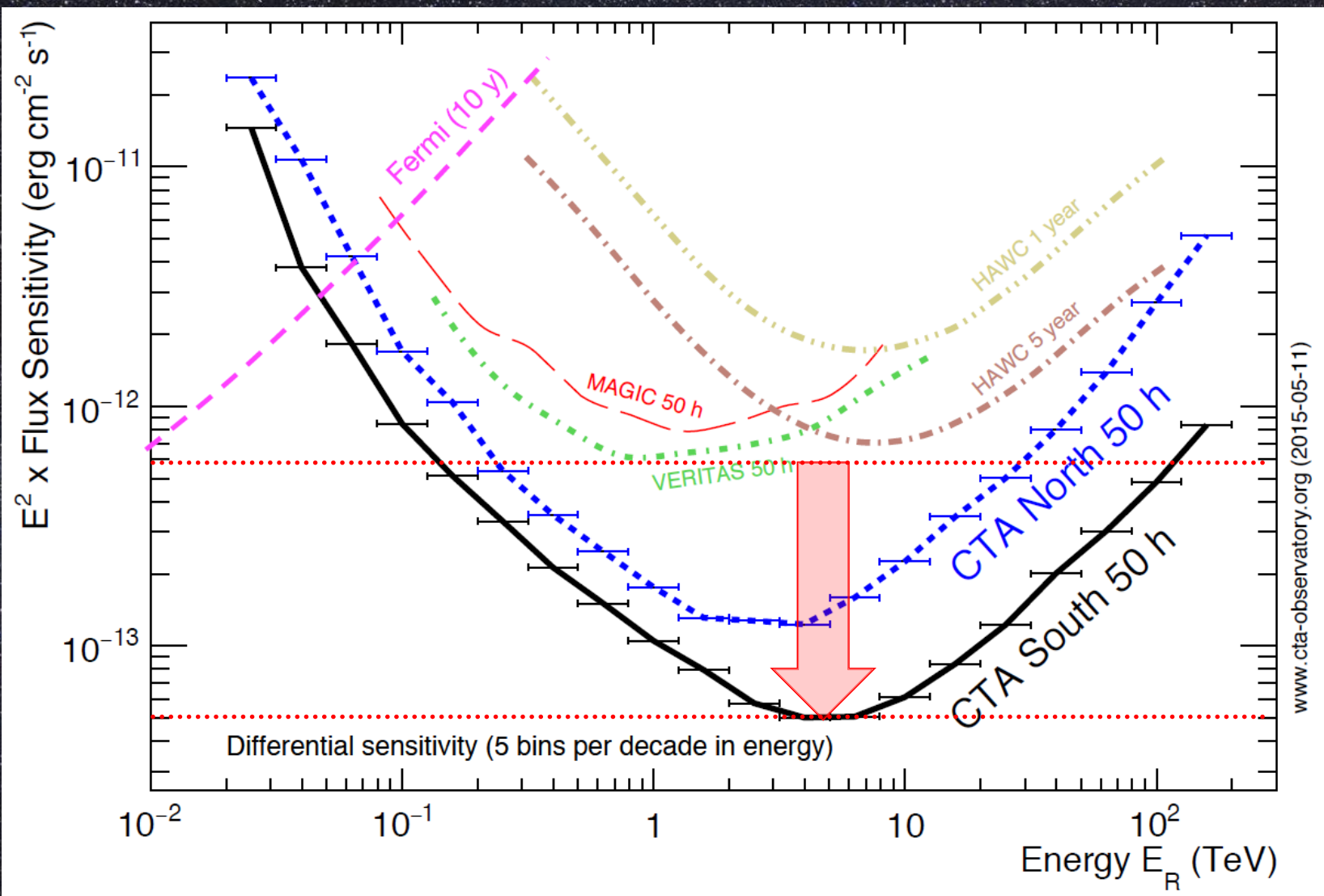
$0.1 - 10 \text{ TeV}$
25 (15) MST
 $\text{Ø } 9-12 \text{ m}$
 $>7^\circ \text{ FoV}$

South only

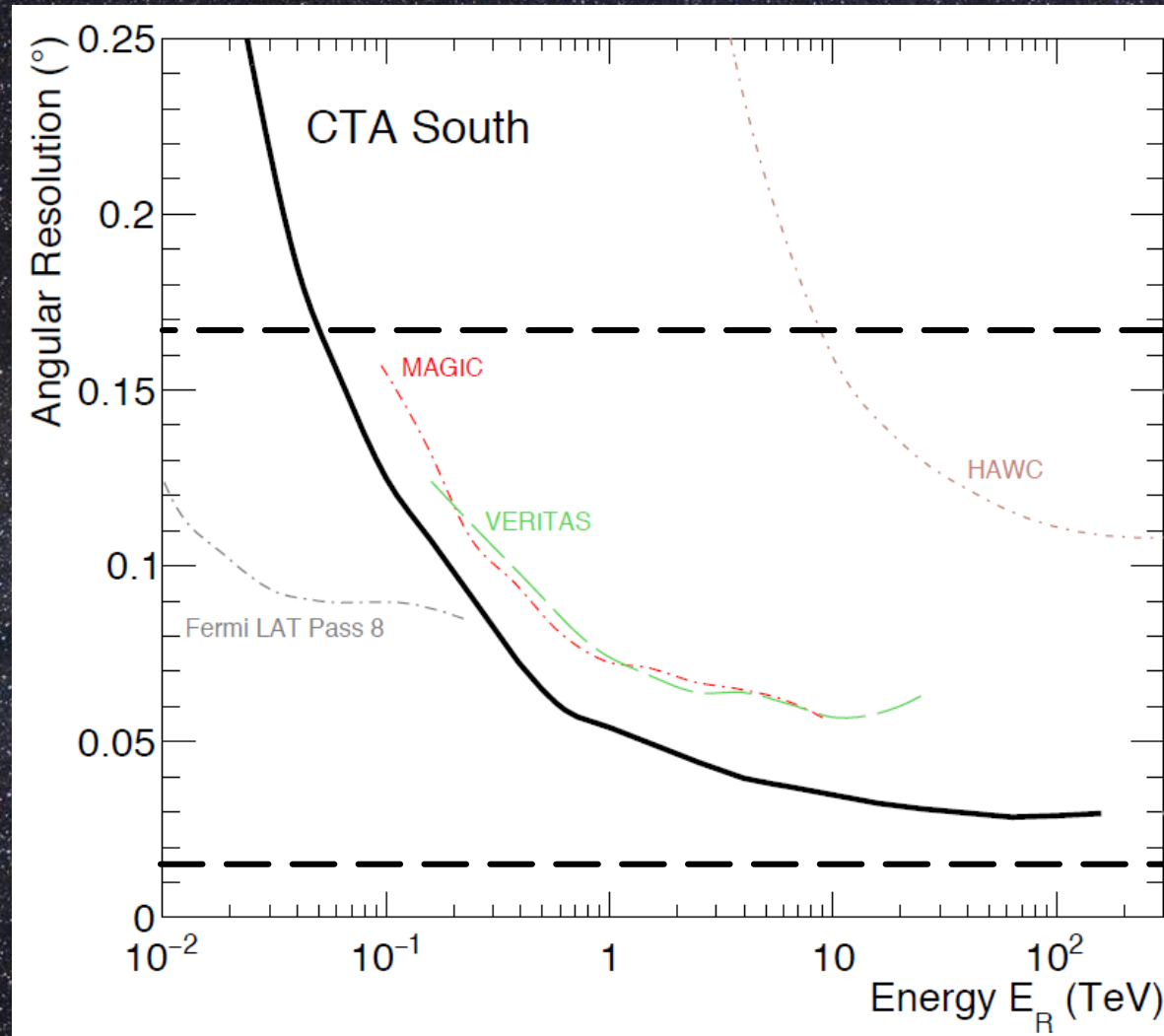
$E > 10 \text{ TeV}$
70 (0) SST
 $\text{Ø } 4 \text{ m}$
 10° FoV

> 1000 h available per year per site

Performance - Sensitivity



Performance – PSF



10'

Point-source location accuracy < 3''

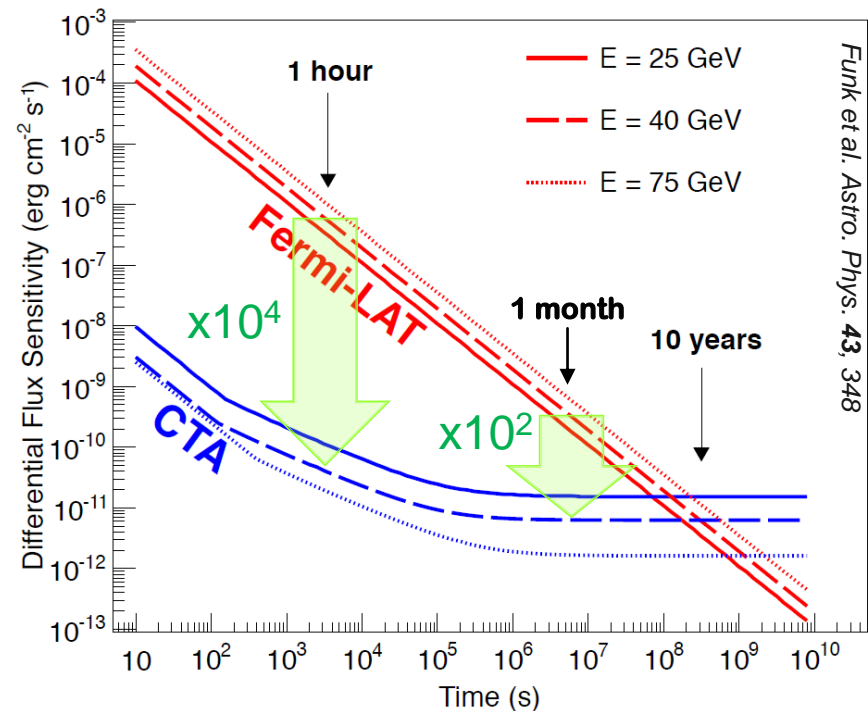
1'

Timing and transients

Larger effective area
→ increased signal rate
→ Timing capabilities

Transients

- Slewing time
 - LST < 50 s
 - SST, MST < 90 s
- Large field of view
 - 4-10°
 - Serendipitous events
- Real Time Analysis
 - Alerts sent < 1 minute



SURVEYS

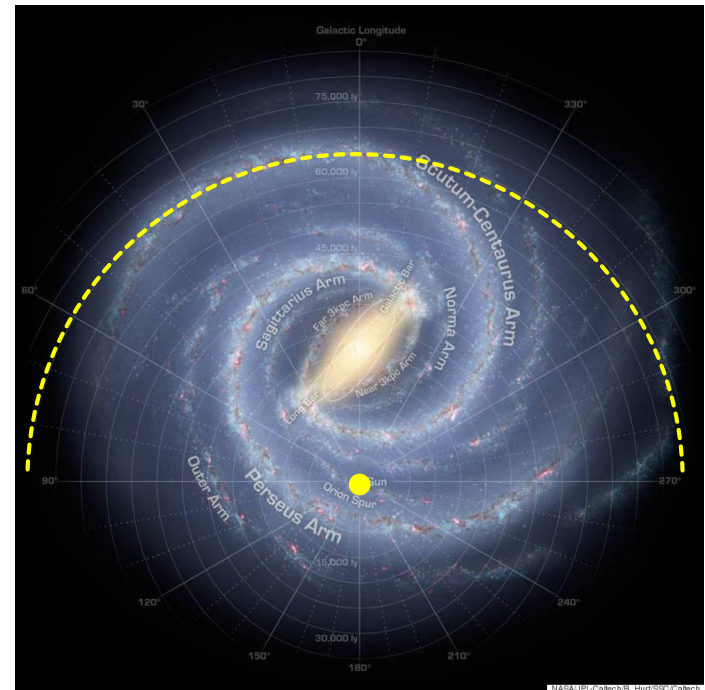
- Planned early
→ Legacy data set
- Galactic plane [$\sim 1500\text{h}$]
- LMC [$\sim 500\text{h}$]
 - 100 times faster than with previous TeV instruments
 - 10-100 times deeper
 - $\text{PSF} < 0.1^\circ$ @ 300 GeV

TARGETS

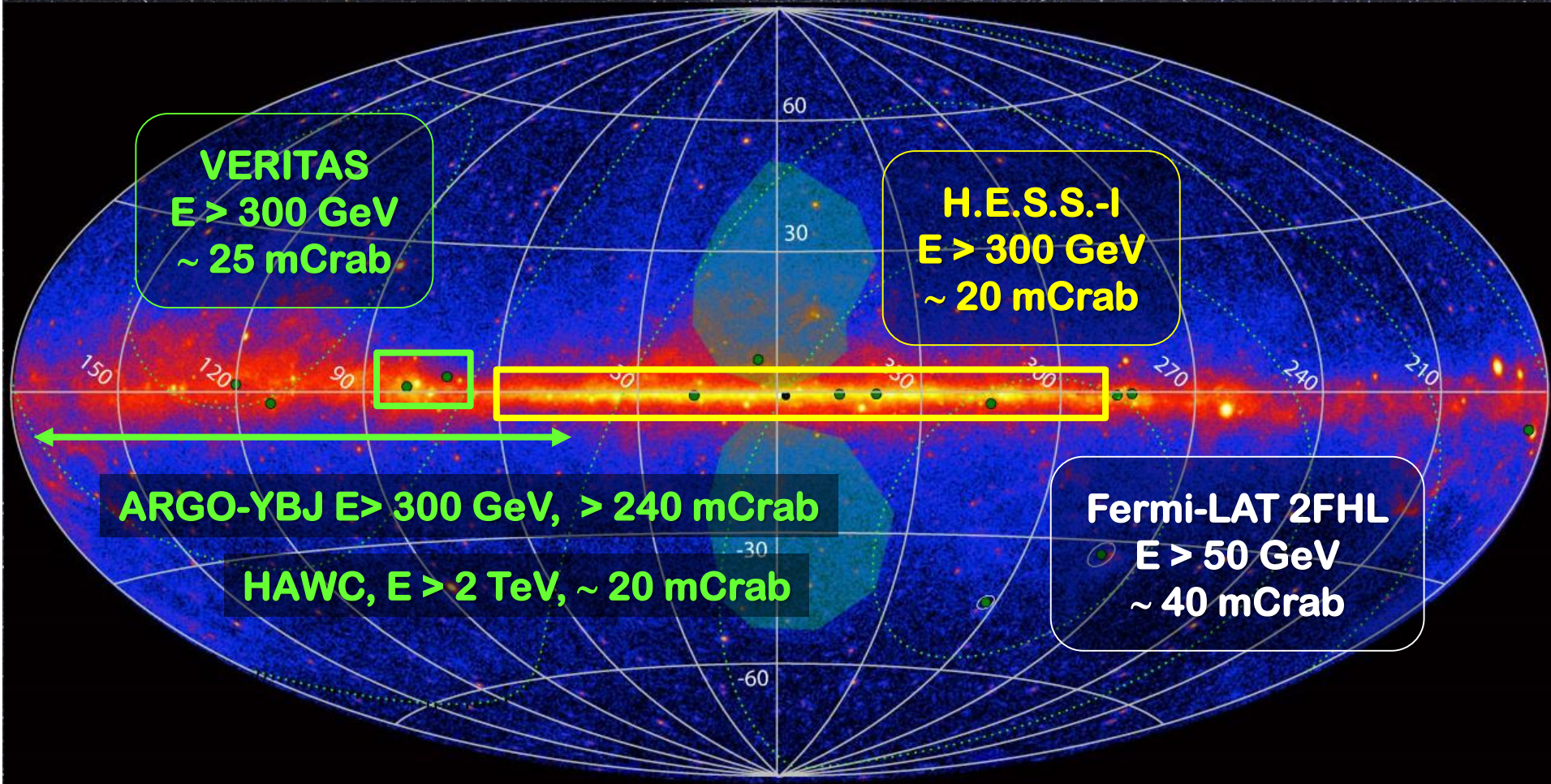
- Galactic centre
- Pevatron search
- Star forming regions
- Transients...

Galactic plane survey

- **Distance reach of 20 kpc**
 - “All” bright sources visible (10^{33-34} erg/s)
 - Large sample of fainter sources (10^{32} erg/s)
- **Expect population increase x 5,**
 - Mainly SNR and PWNe : $\sim 75 \rightarrow > 300$ galactic sources (500?)
- **Plane diffuse emission**
- **Discoveries**
 - γ -ray binaries ?
 - Pevatrons ?
 - New extended sources...
- **Legacy data set**
 - HL catalogue ~ 18 months
 - First full Catalogue released < 3 yr
→ Seeds for guest observers

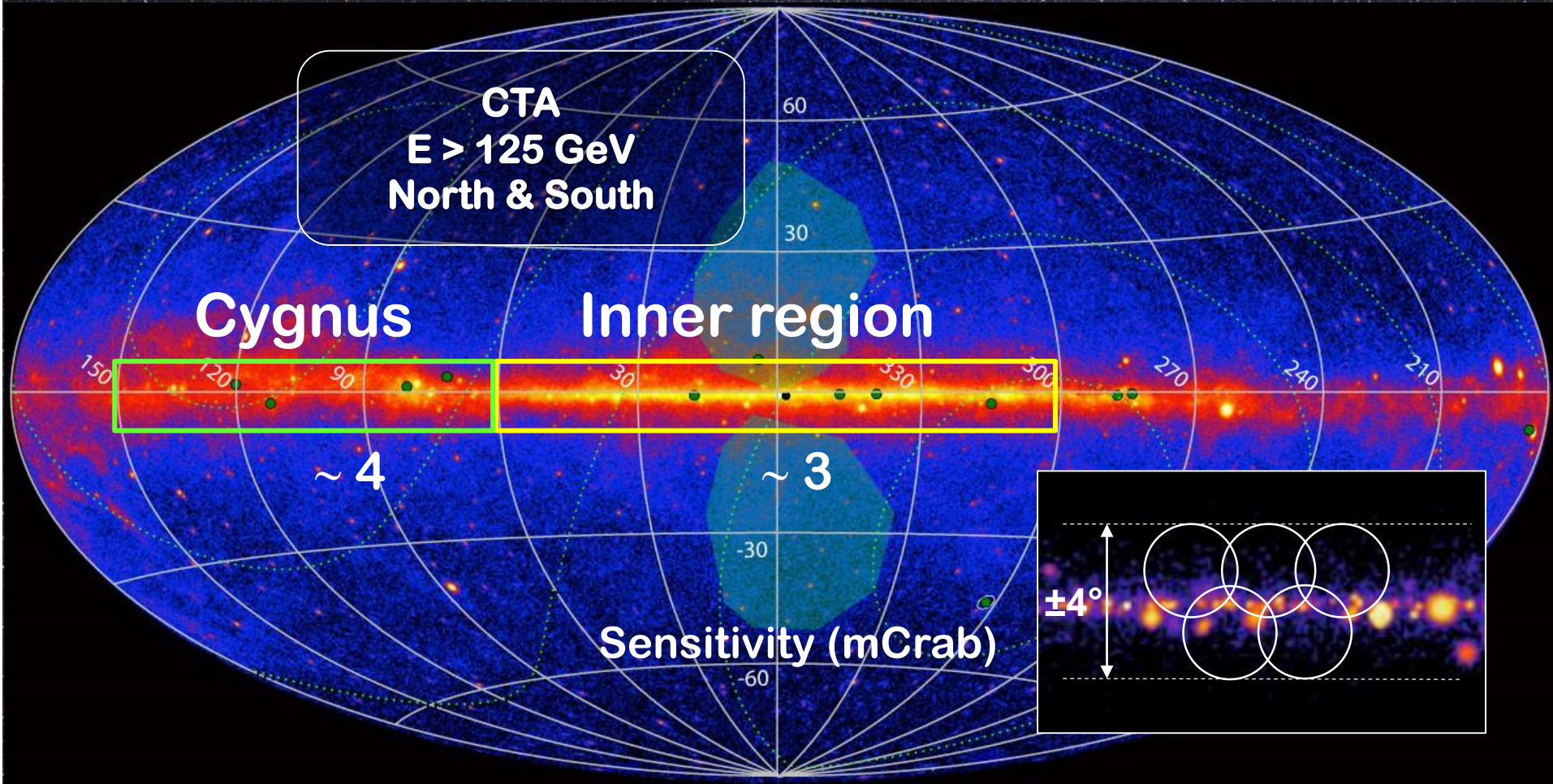


Galactic plane survey



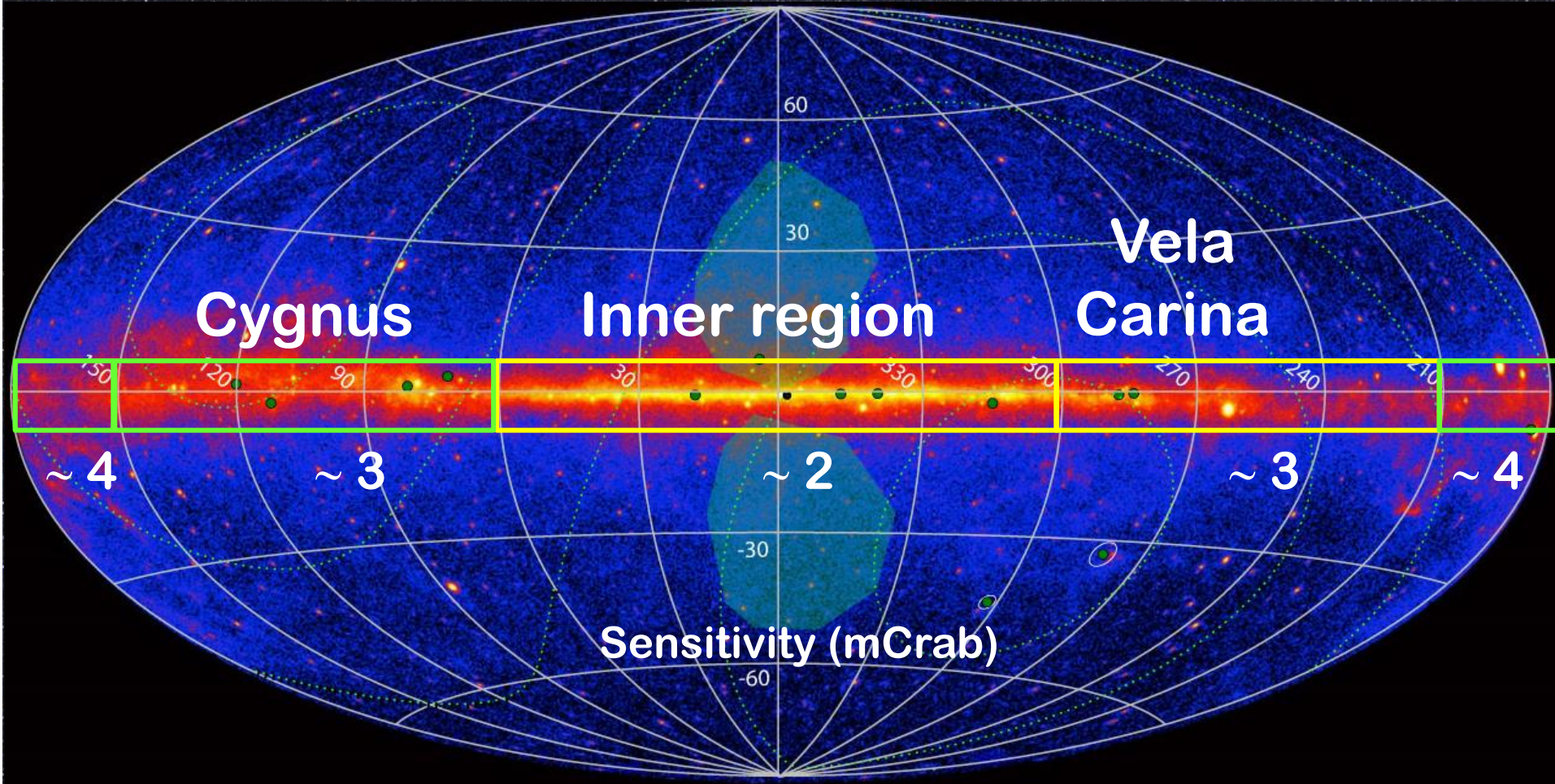
Galactic plane survey

Short term scenario (1-2 yr)



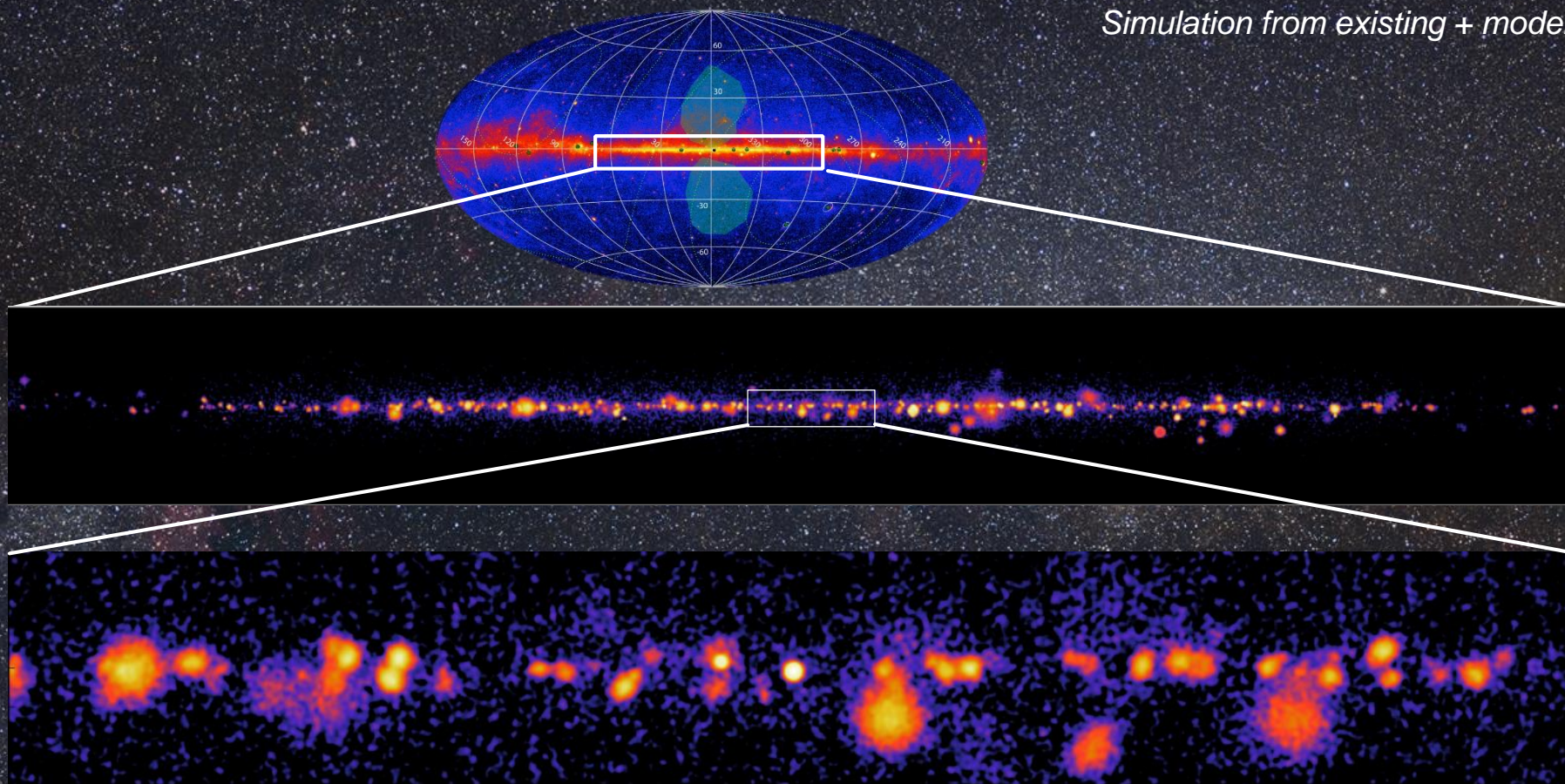
Galactic plane survey

Long term scenario (10 yr)



Galactic plane survey

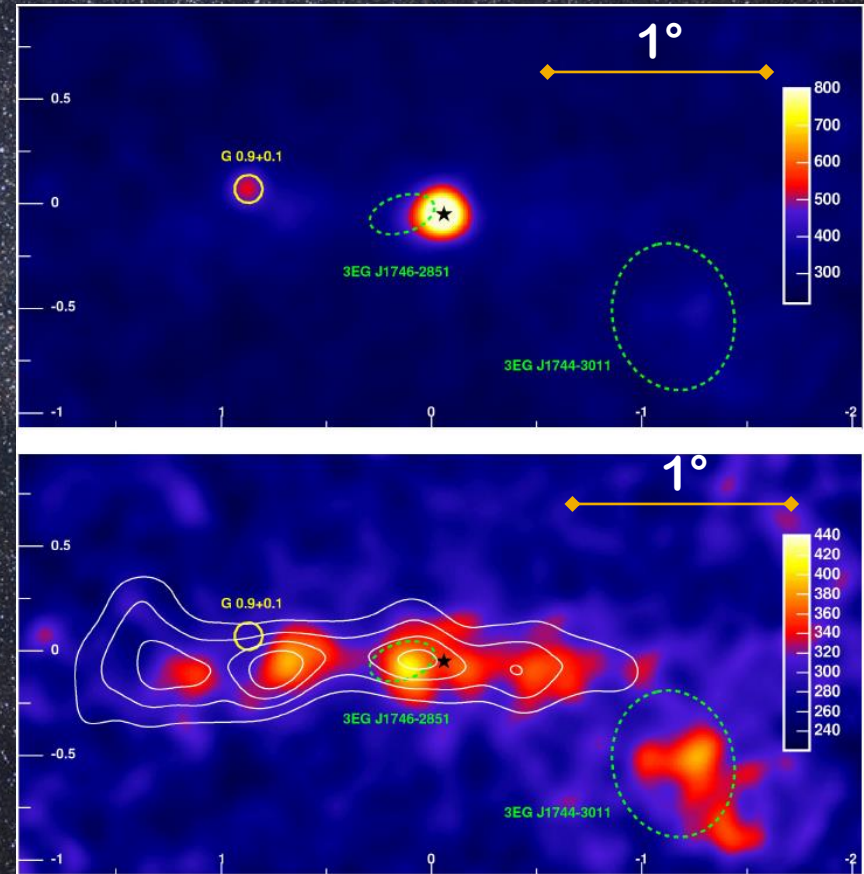
Simulation from existing + models



Up to 3-4 sources per deg^2 \rightarrow (Extended) source confusion

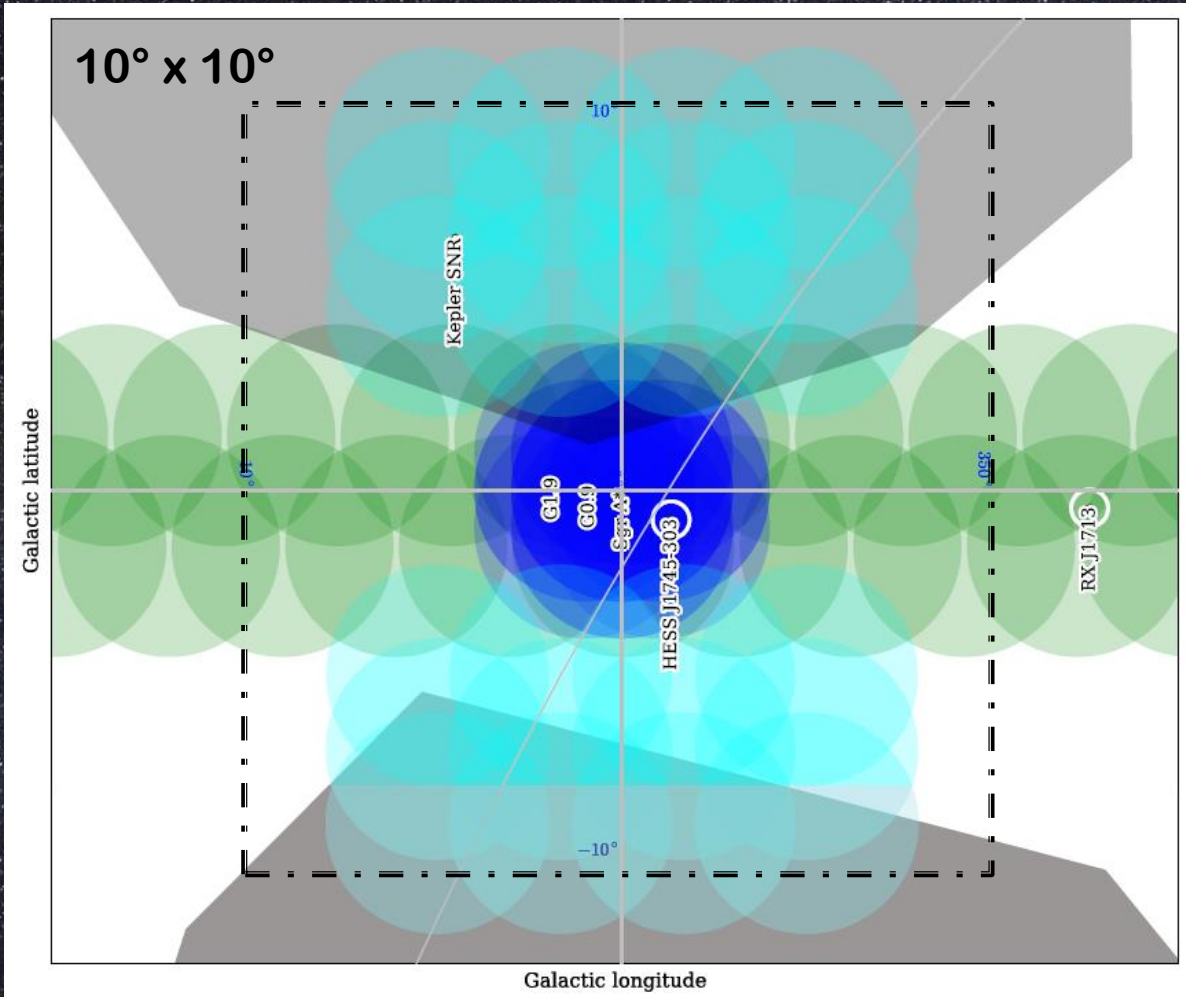
The Galactic centre

- A Long list of questions
→ Well suited for a KSP
 - Very deep exposures with Chandra, XMM, INTEGRAL,...
 - What is the central VHE source ?
 - Winds from Sgr A*?
→ Variability (1' – 1h time scales) ?
 - A pulsar wind nebula ?
 - Others ?
 - Diffuse emission along the ridge
 - From a VHE accelerator ?
(See recent Hess results)
 - Fermi Bubbles
 - CR from SN explosion?
(10% of the SF rate in the Galaxy)
 - Sgr A* past activity ?
- Disentangle diffuse emission and new sources
- Many PWNe, SNR expected



Aharonian F., Akhperjanian A.G., Bazer-Bachj A.R. et al. (2006),
Nature, **439**, 695

The Galactic centre

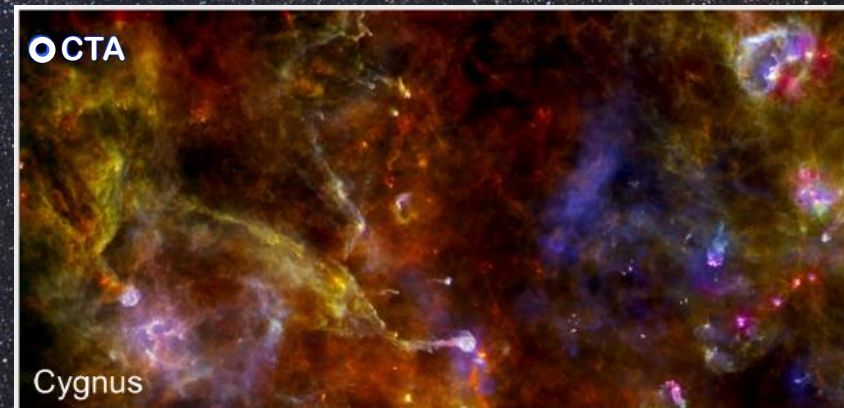


-  Centre
 ~ 500 h
-  Bulge extension
 ~ 300 h
-  GP survey
-  Fermi bubbles

Star forming systems

Questions

- Influence of ISM conditions on CR acceleration and transport ?
 - Role of CR in star formation process ?
- **Galactic targets**
(~mCrab level)
 - Carina ~ 100 h
 - Cygnus (OB1/OB2) ~ 100 h
 - WD1 ~ 40 h
 - **+ extragalactic SFS**

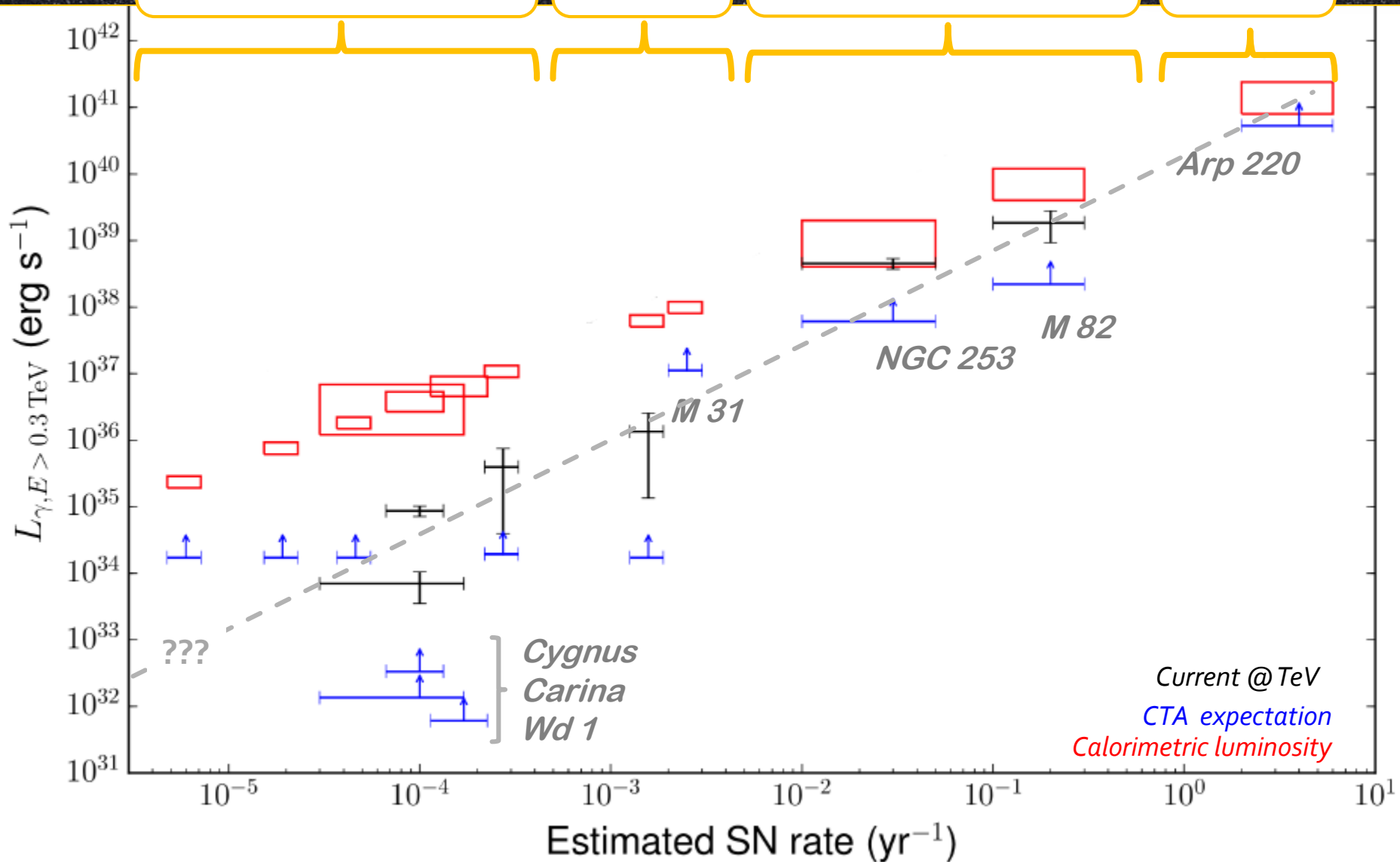


Star forming regions

SF
Galaxies

Starbursts

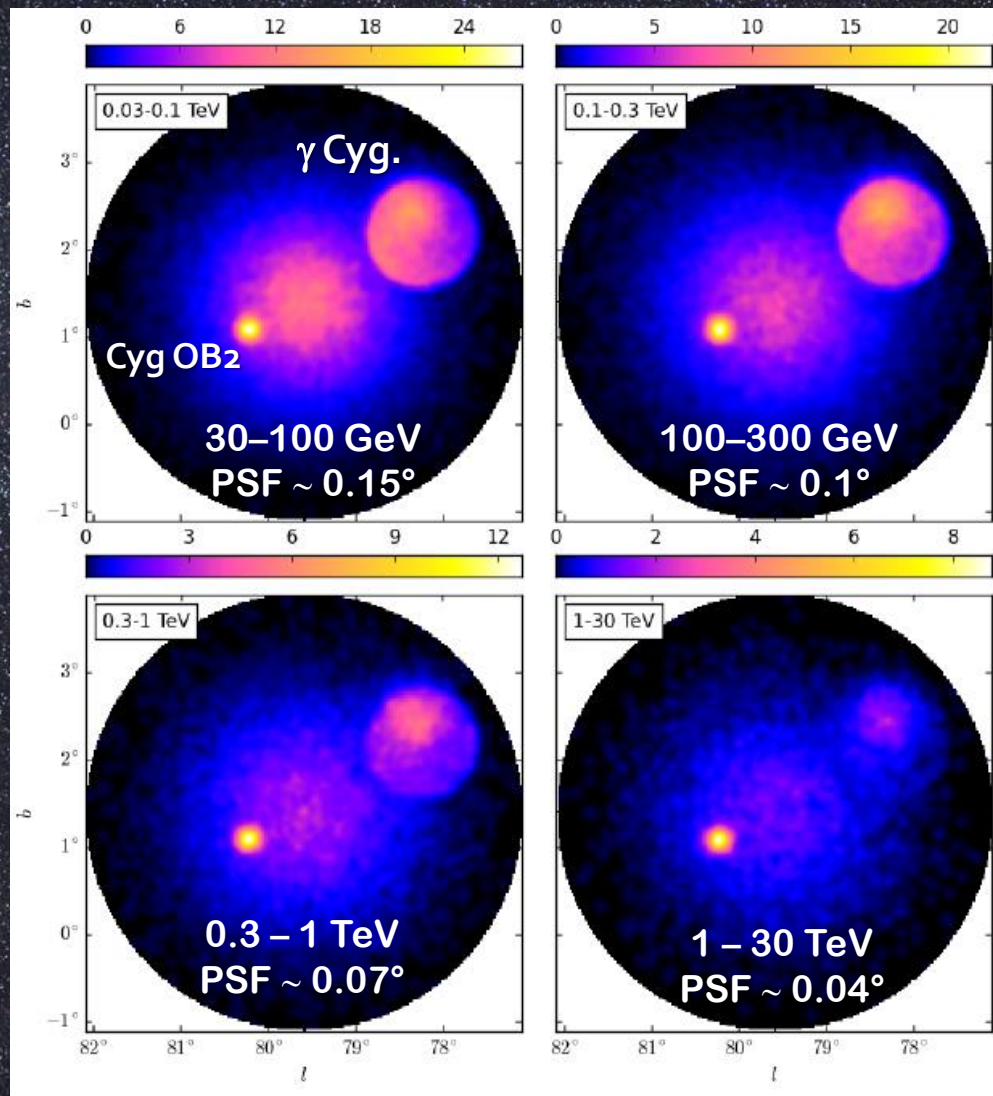
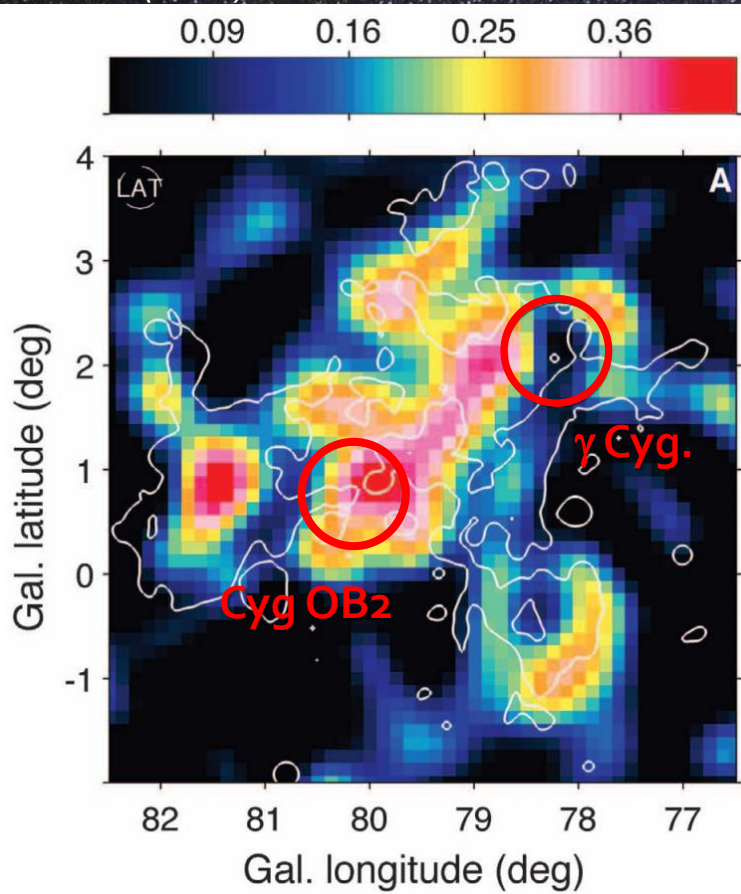
ULIRG



Star forming systems

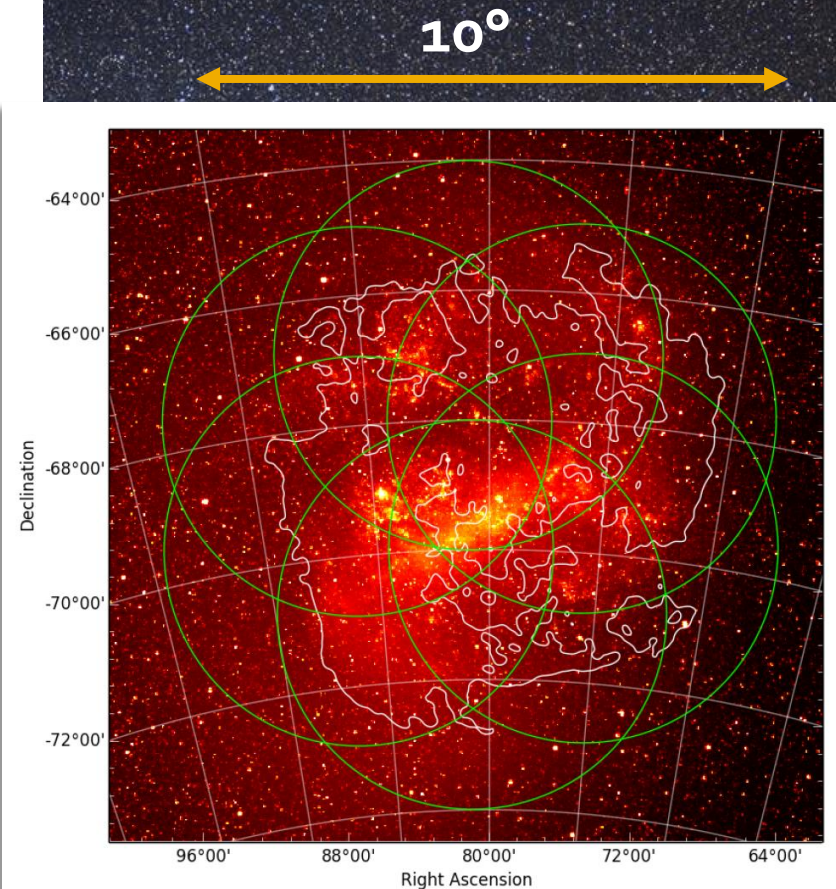
CTA Cygnus KSP
 Cocoon is detected at 18σ

Fermi (2011) - 10-100 GeV - PSF $\sim 0.2^\circ$



LMC survey

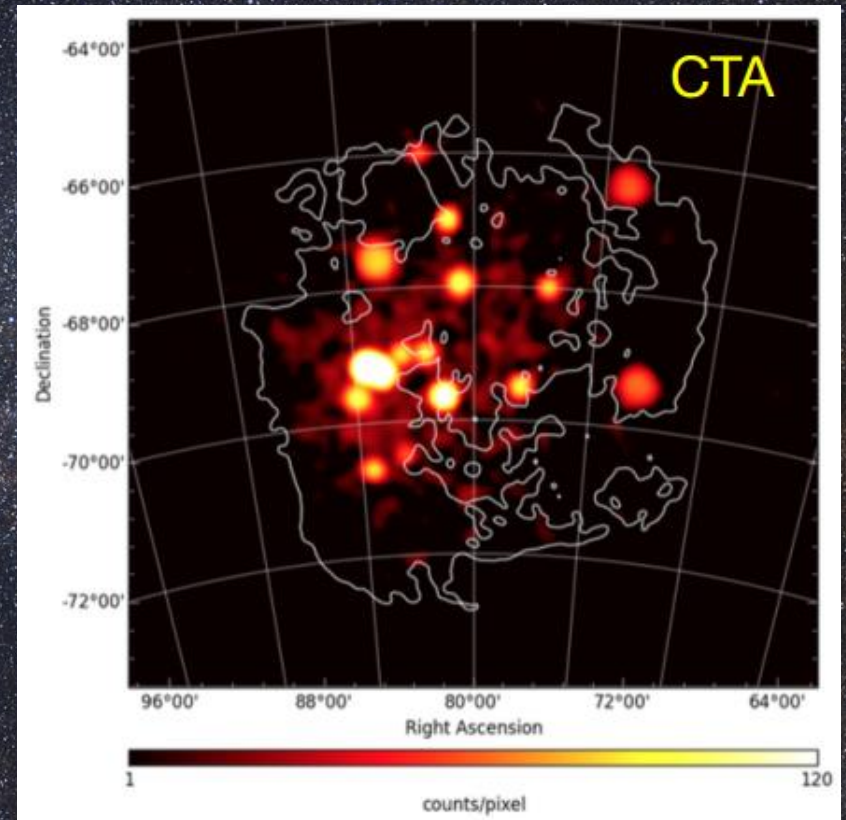
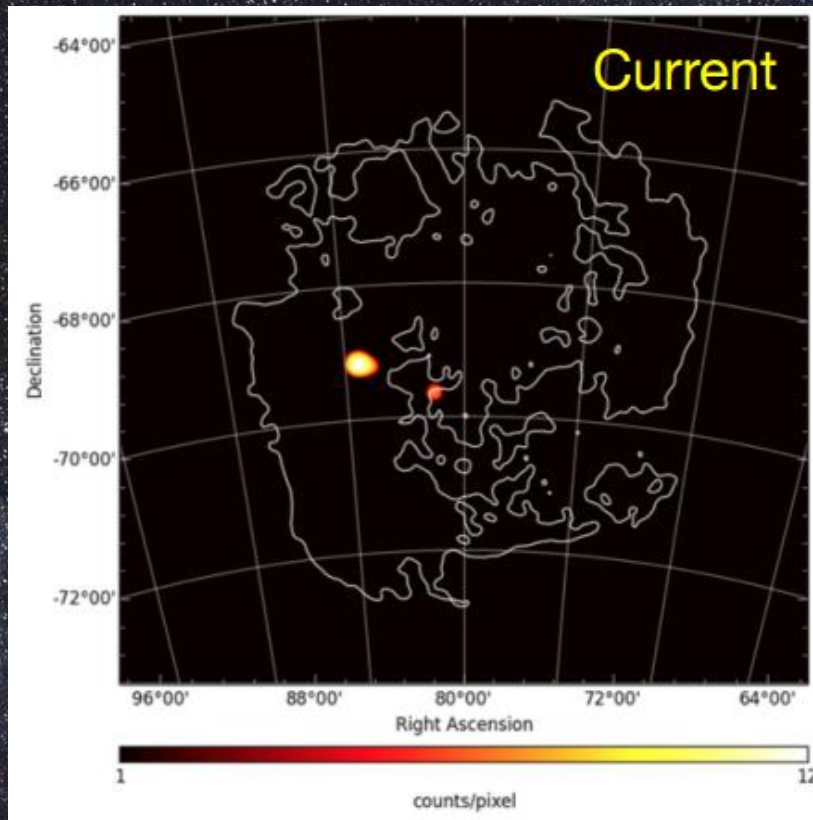
- **A laboratory for CR production and transportation study**
- **Approximately face-on**
 - Distance ~ 49 kpc, known at % level
 - No absorption, nor source confusion
- **10% of MW star formation (2% vol.)**
 - e.g. 30 Doradus, hosting SN1987A
- **Some VHE accelerators**
Recently :
PWNe (N157B), SNR (N132B), 30 Dor C (SB)
(*HESS coll. 2015, Science 347, 406*)
- **Deep survey over 4 years (~ 300 h)**
- **if SN1987A detected, monitoring**
 - 50h every 2 years during 6 years



Illustrative

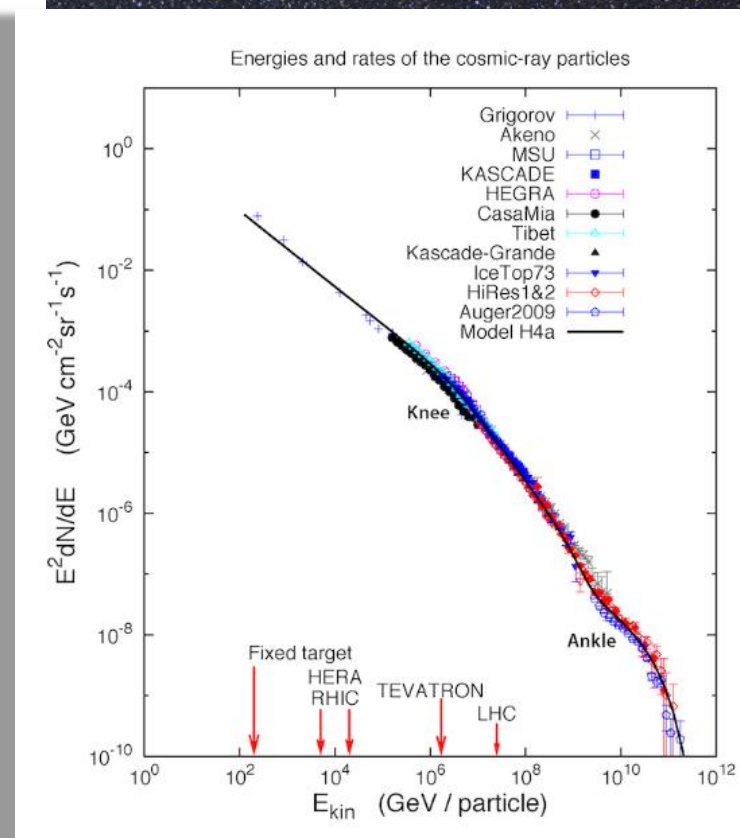
LMC survey

5 kpc



- Resolving regions down to 20 pc in size
- Sensitivity down to 10^{34} erg/s ($E > 200$ GeV)

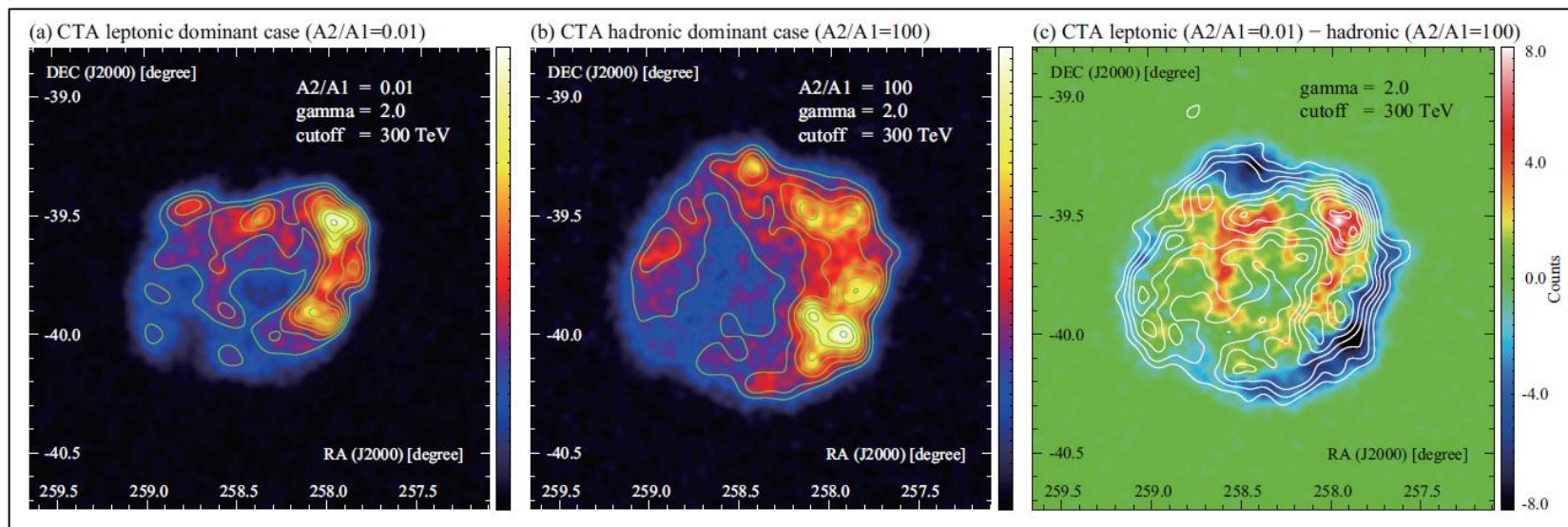
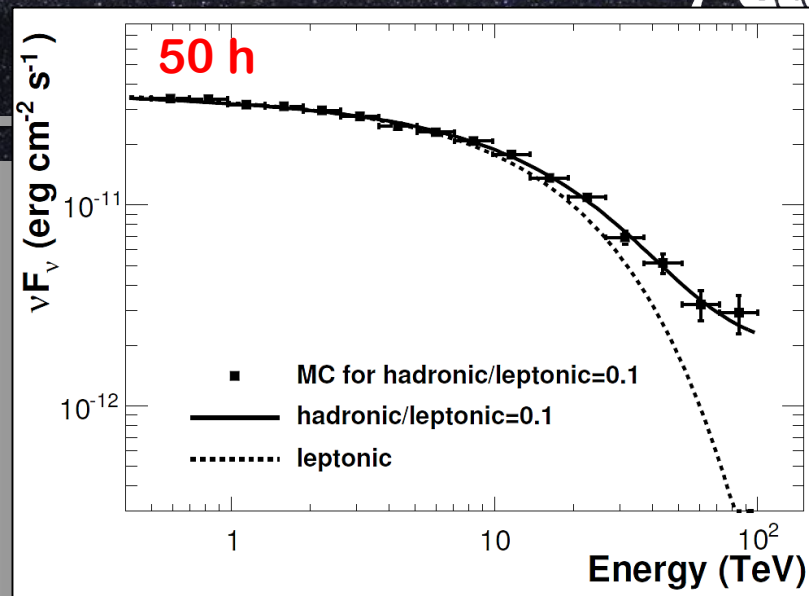
- Origin of cosmic rays $E < 10^{15}$ eV ?
- Search for Galactic pevatrons
 - Current theoretical consensus
 - But, Still no evidence at $E > 20$ TeV
 - SNRs can satisfy CR energy budget
 - Evidence only for IC 443, W44 (evolved SNR, π^0 « observed »)
- Answer
 - Disentangle hadronic/leptonic contributions
 - Target RX J1713.7-3946 [~50 h, first years]
 - Find 5 candidates from GPS [~50 h each]



Pevatrons

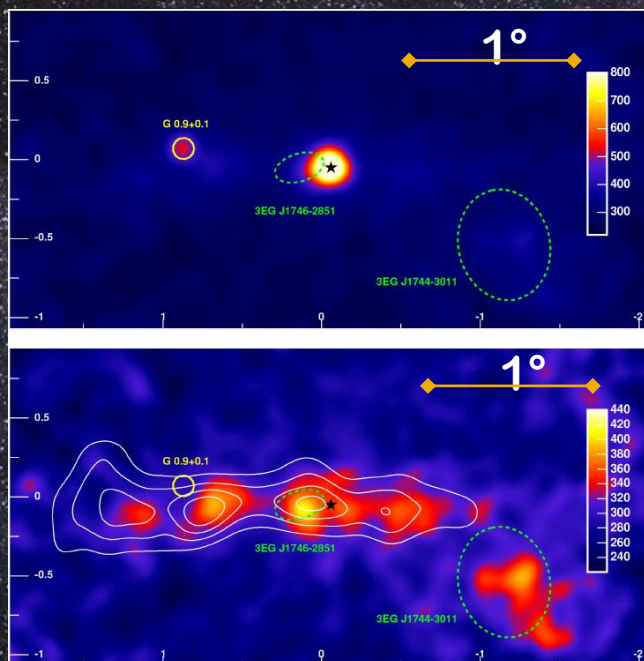
■ RX J1713.7 simulation

- XMM \rightarrow Inv. Compton π°
- HI + CO $\rightarrow \pi^{\circ}\gamma$'s

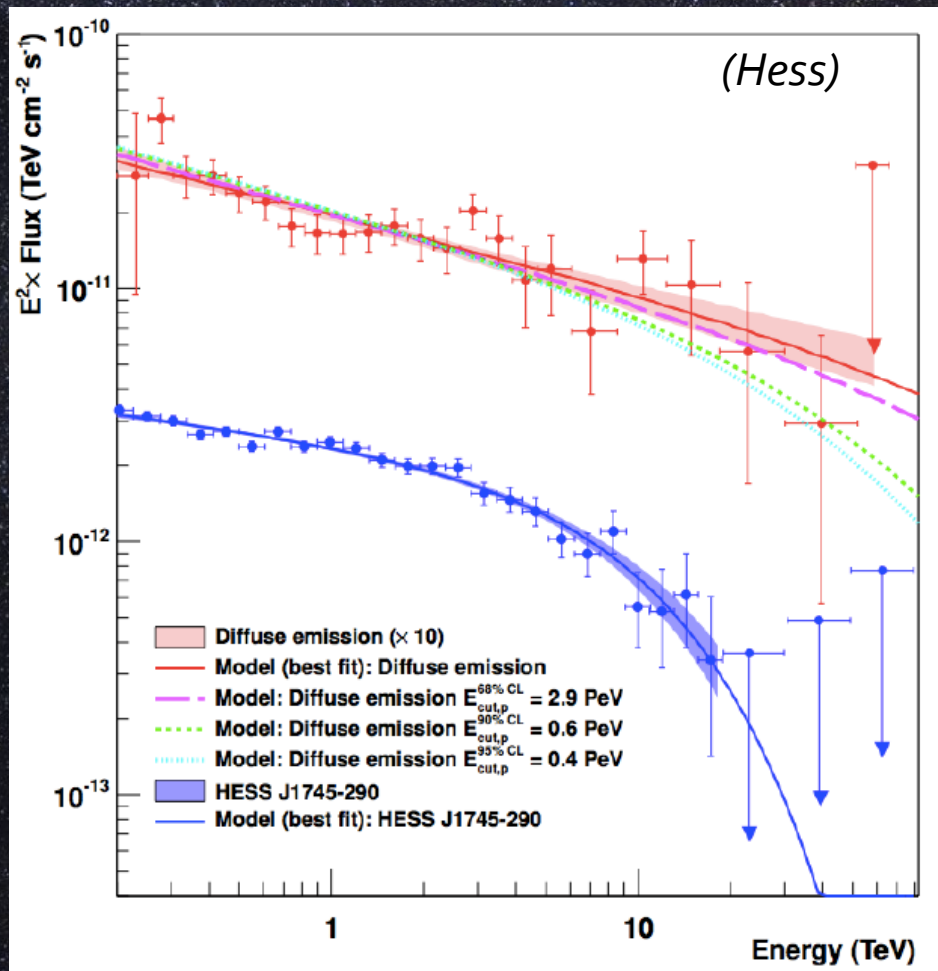


Pevatrons

H.E.S.S. :
 First Pevatron found ?
 A typical target for CTA



Aharonian F., Akhperjanian A.G., Bazer-Bachi A.R. et al. (2006), Nature, 439, 695



Plot from M. De Naurois presentation, ICRC 2015

Galactic Conclusion (I)

- **CTA : a revolution for galactic science at VHE**
 - Unprecedented sensitivity and angular resolution
 - Large field of views (4-8°)
 - Opens new possibilities for MWL analysis
 - Overlap with existing Fermi science ($E > 30$ GeV)

- **Addresses (answers to?) fundamental questions**
 - Origin of PeV Cosmic rays
 - CR influence on ISM and star formation
 - Extreme environment physics
 - (Dark matter)

- **More on CTA**
 - Dark matter – *Emmanuel Moulin* - session 5, Wednesday
 - Extragalactic science – *Lucie Gérard* - session 19, Wednesday
 - Telescope array status - *Michael Daniel* – session 20, Thursday

Galactic Conclusion (II)

- A consortium program based on Key science projects
 - Explore important CTA science in a coherent fashion
 - Starting point : surveys (Galaxy + LMC)
 - Intended to evolve before/after the construction phase
 - Produce legacy data set for the whole community
 - Becomes public after a proprietary period
 - Many iconic HE/VHE sources are not in KSP

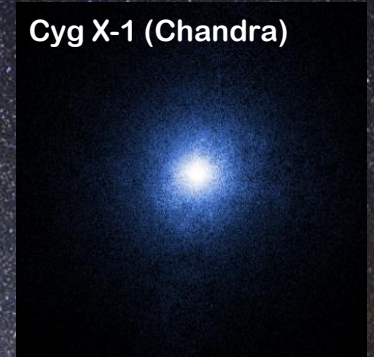
~ 50% of the observing time over 10 years



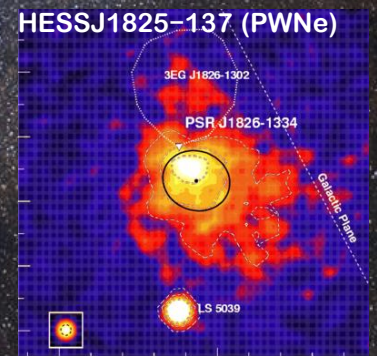
As much as 50% of open time over 10 years

An exciting Scientific program to come !

Cyg X-1 (Chandra)



HESSJ1825-137 (PWNe)



Vela PSR (Chandra)



