

H.E.S.S. observations of the Galactic Centre region



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for the H.E.S.S. collaboration***

Radio continuum

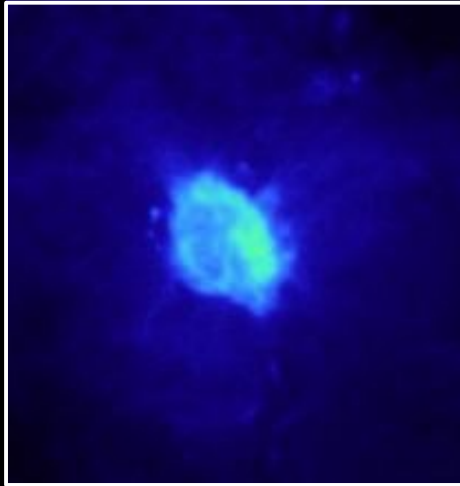


Naval Research Laboratory

Wide-Field Radio Image of the Galactic Center

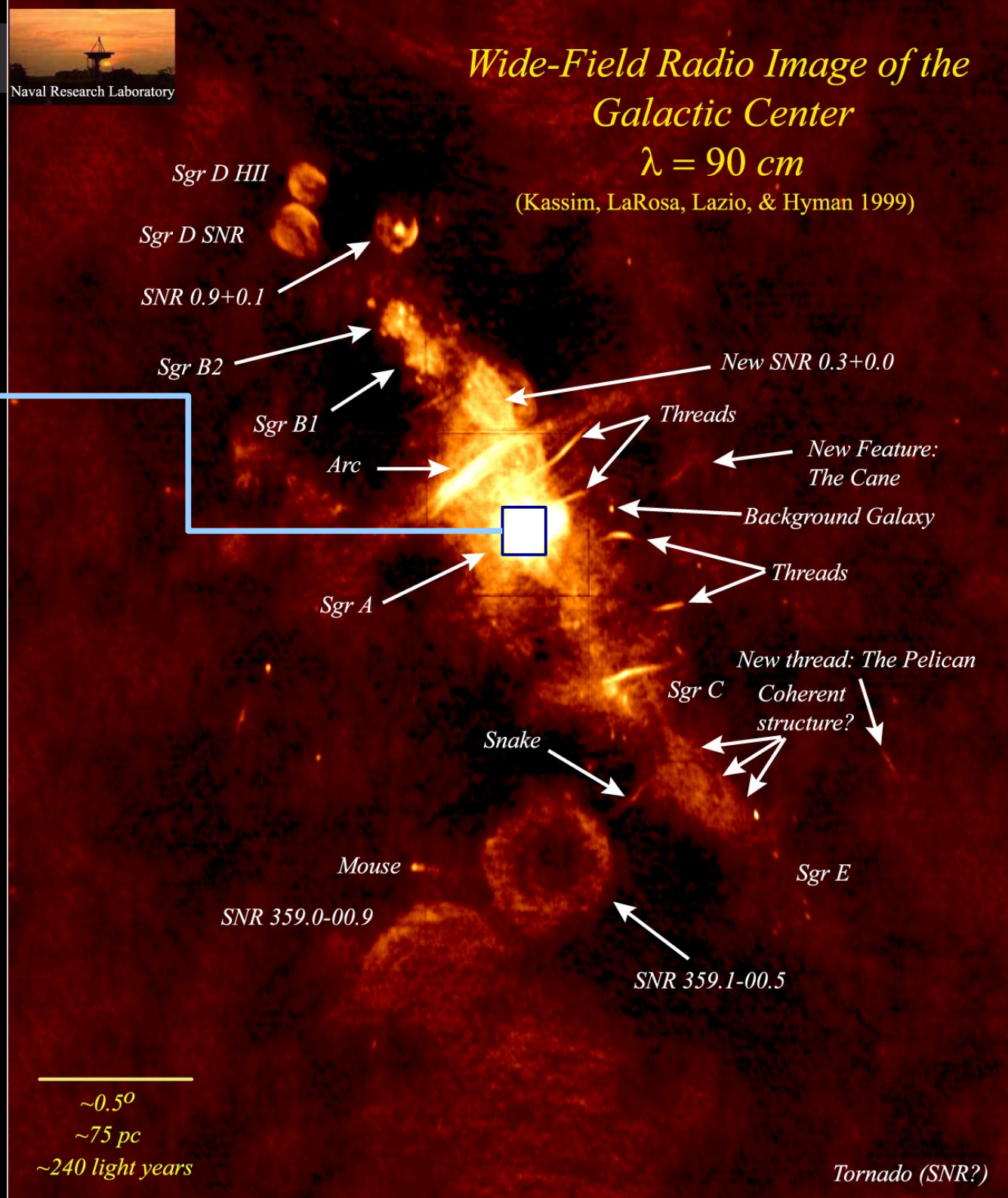
$\lambda = 90 \text{ cm}$

(Kassim, LaRosa, Lazio, & Hyman 1999)

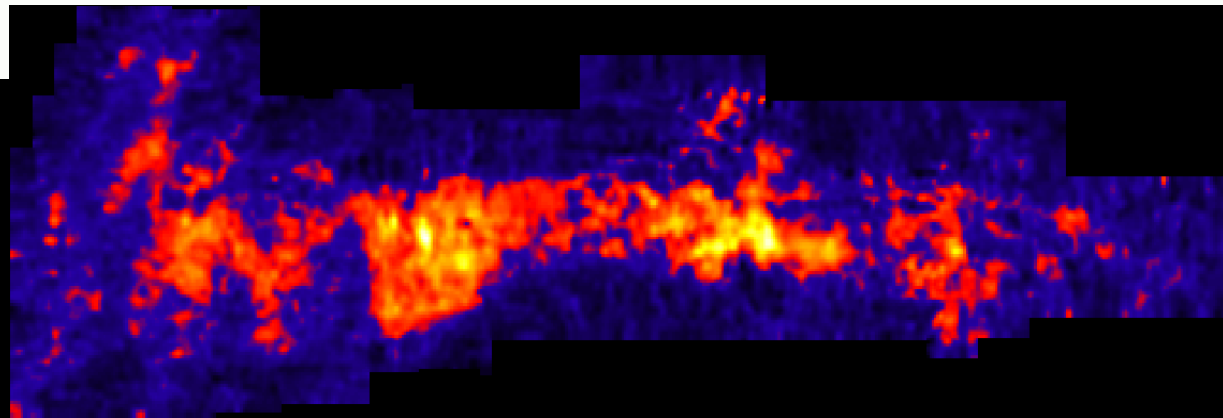
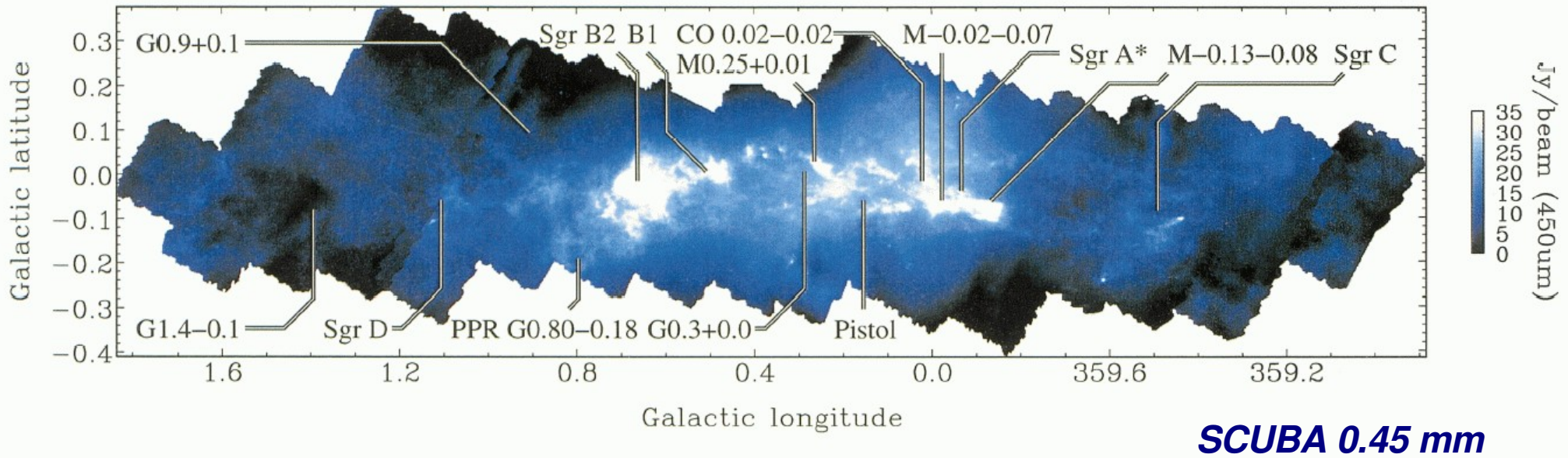


- **non-thermal features all over the FoV**
- **Sgr A region dominated by SNR Sgr A East**

~0.5°
~75 pc
~240 light years



Dust and molecules



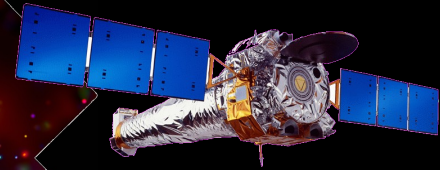
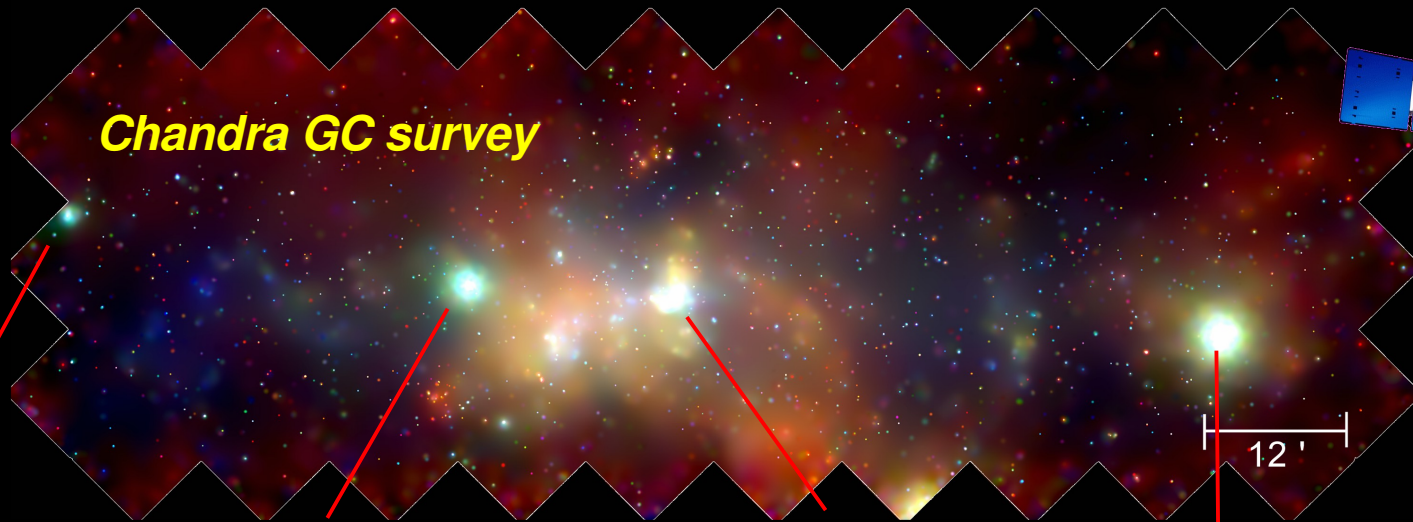
- 50 million solar masses of molecular clouds in central 300 pc ($>10^3 \text{ cm}^{-2}$)
- possible targets for hadronic cosmic rays

*CS line emission
NRO 49 GHz*

X-ray surveys



Chandra GC survey



G0.9+0.1

1E1743.1-2843

Sgr A*

1E1740.7-2942

0.0°

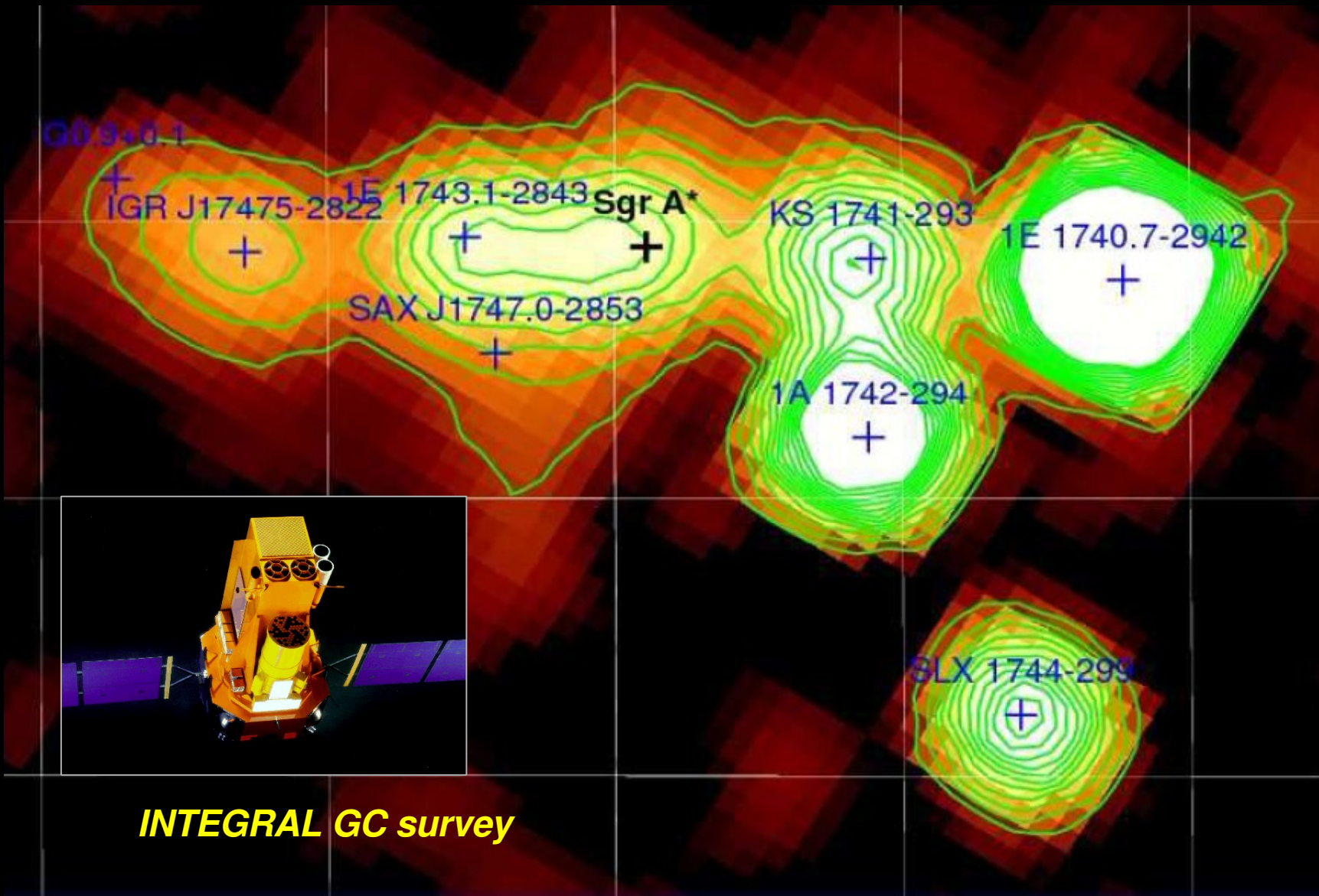
SAX J1747.0-2853

XMM Newton GC survey

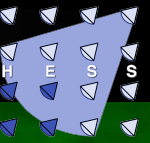
0.10°



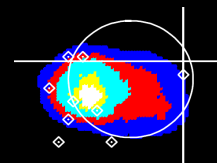
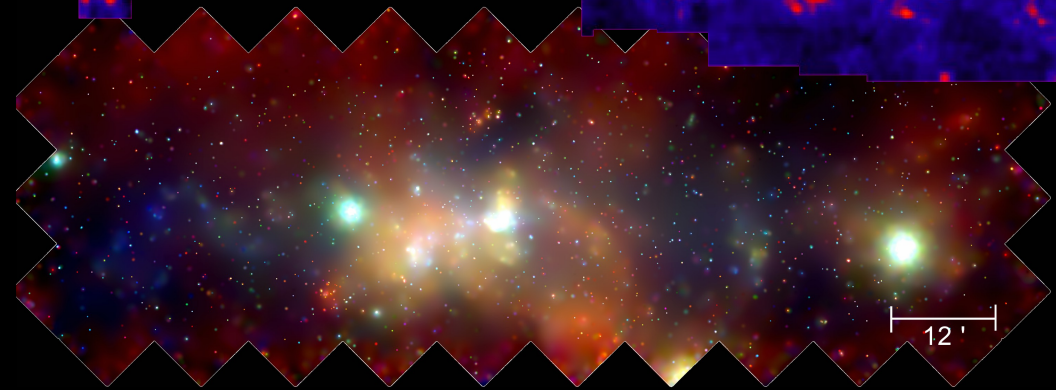
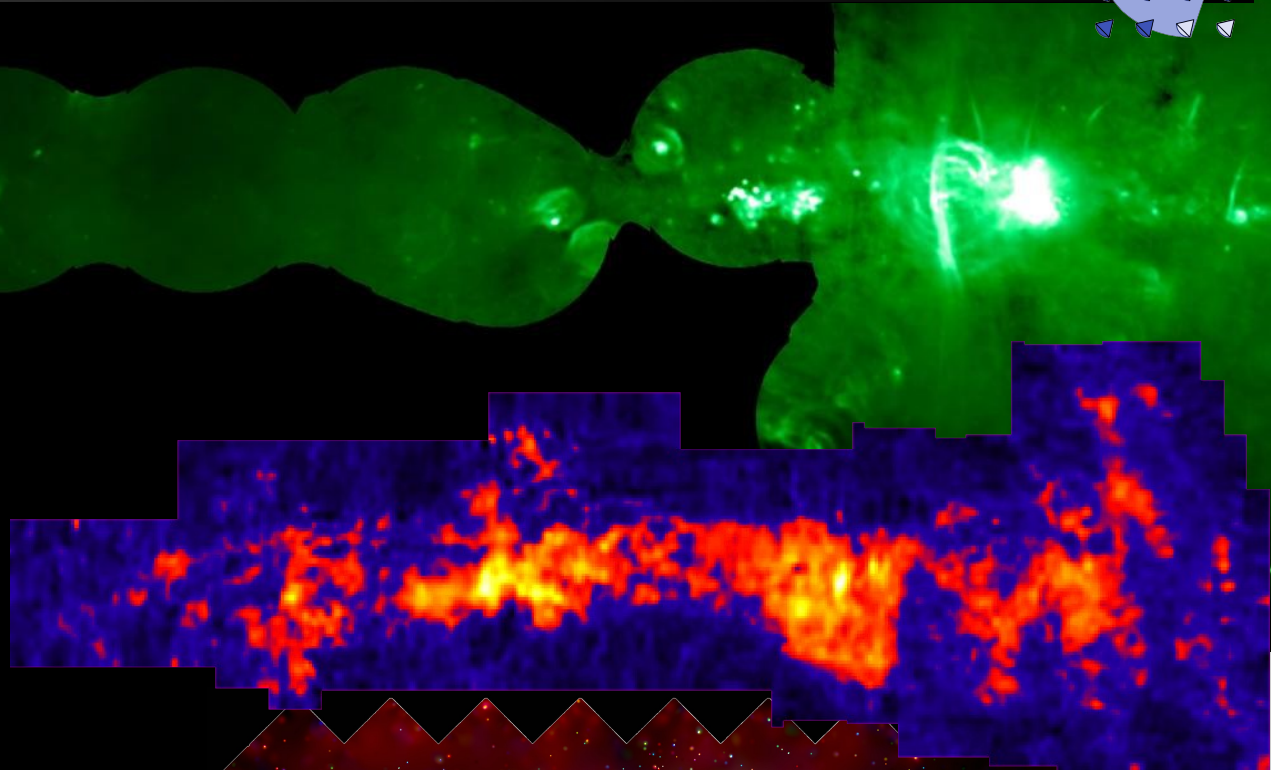
Hard X-rays



Tracers of potential γ -ray sources

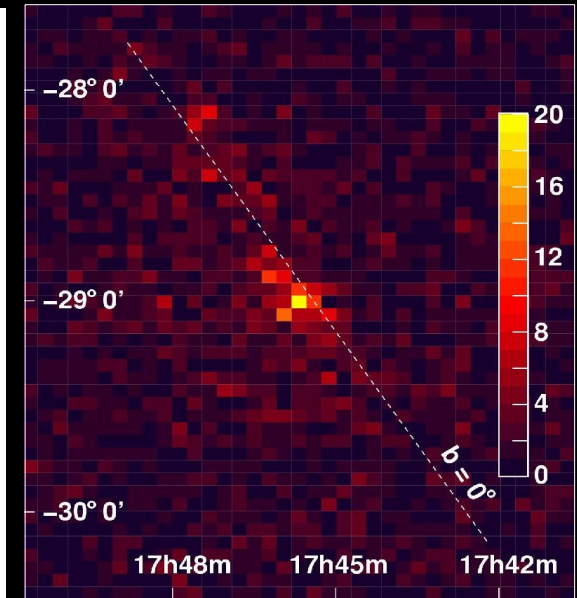
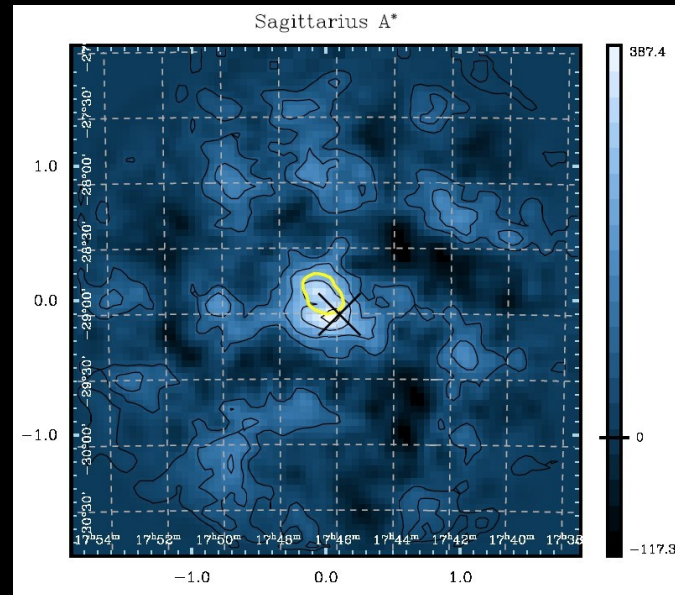
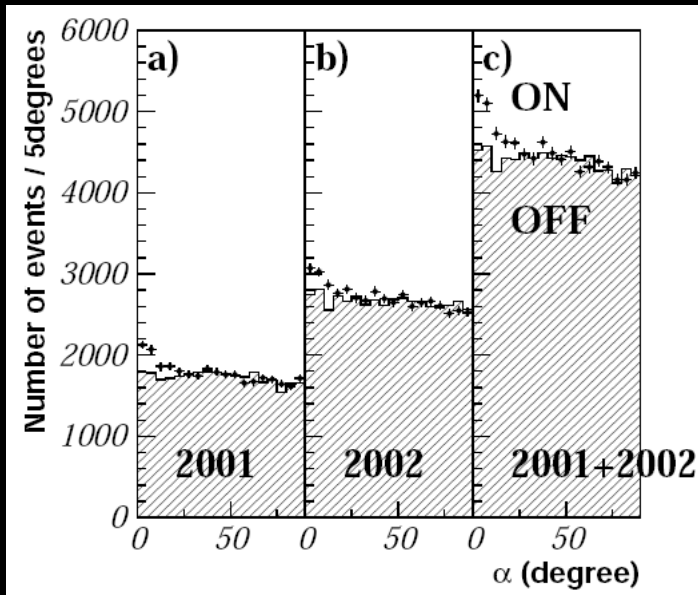


- **radio**
 - many SNRs
 - pulsar wind nebulae
- **sub-mm**
 - giant molecular clouds
- **X-ray**
 - pulsar wind nebulae
 - variable emission from Sgr A*
- **MeV/GeV γ -rays**
 - 2 bright EGRET sources
- **particle physics theory**
 - DM annihilation near Sgr A*?





- **source at GC claimed by 3 groups in 2004**



- **Cangaroo II**

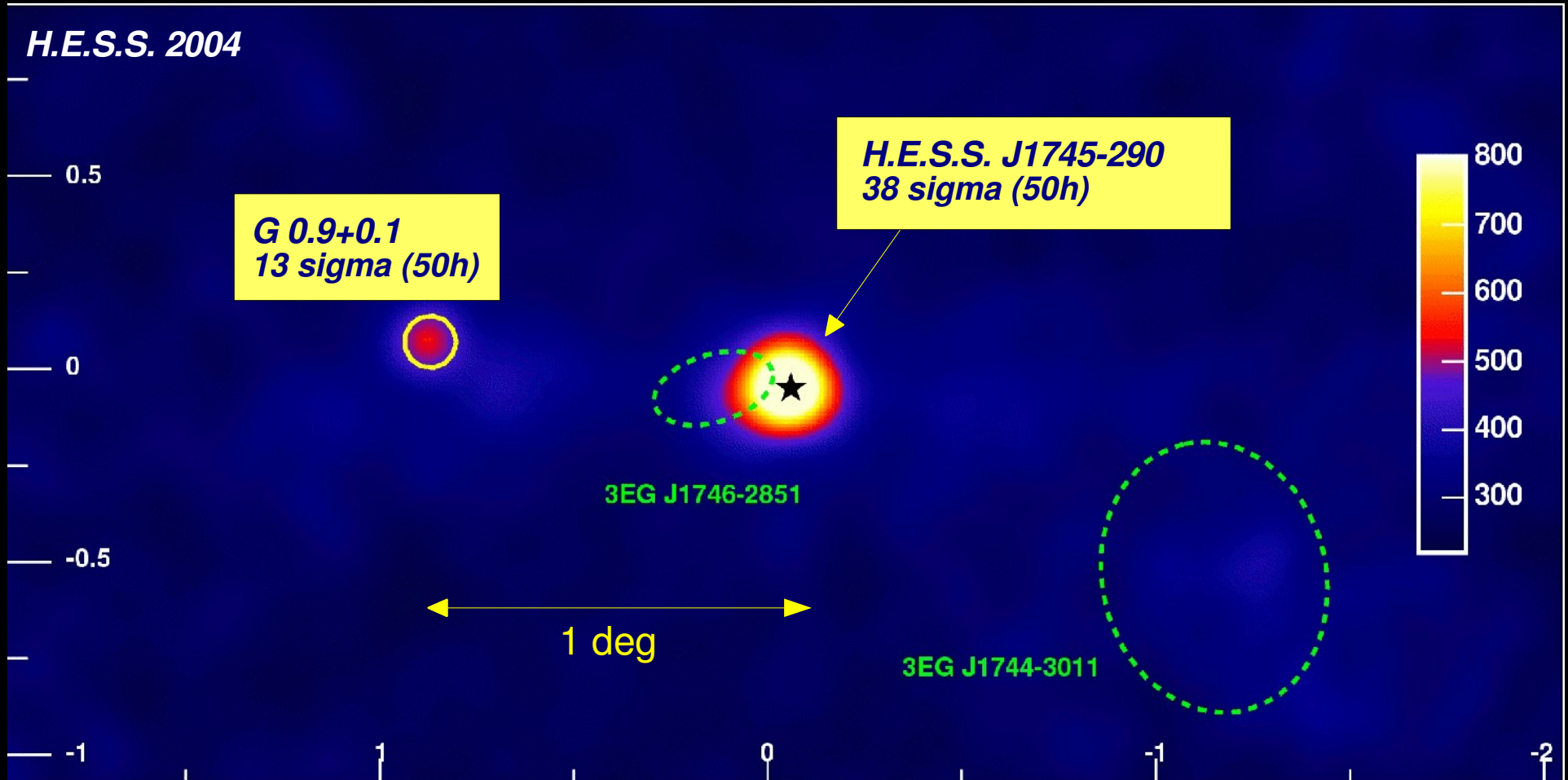
- 67 hours (2 years)
- 250 GeV threshold
- ~10 sigma
- Tsuchiya et al.

- **Whipple**

- 26 hours (8 years)
- 2.8 TeV threshold
- ~3.7 sigma
- Kosack et al.

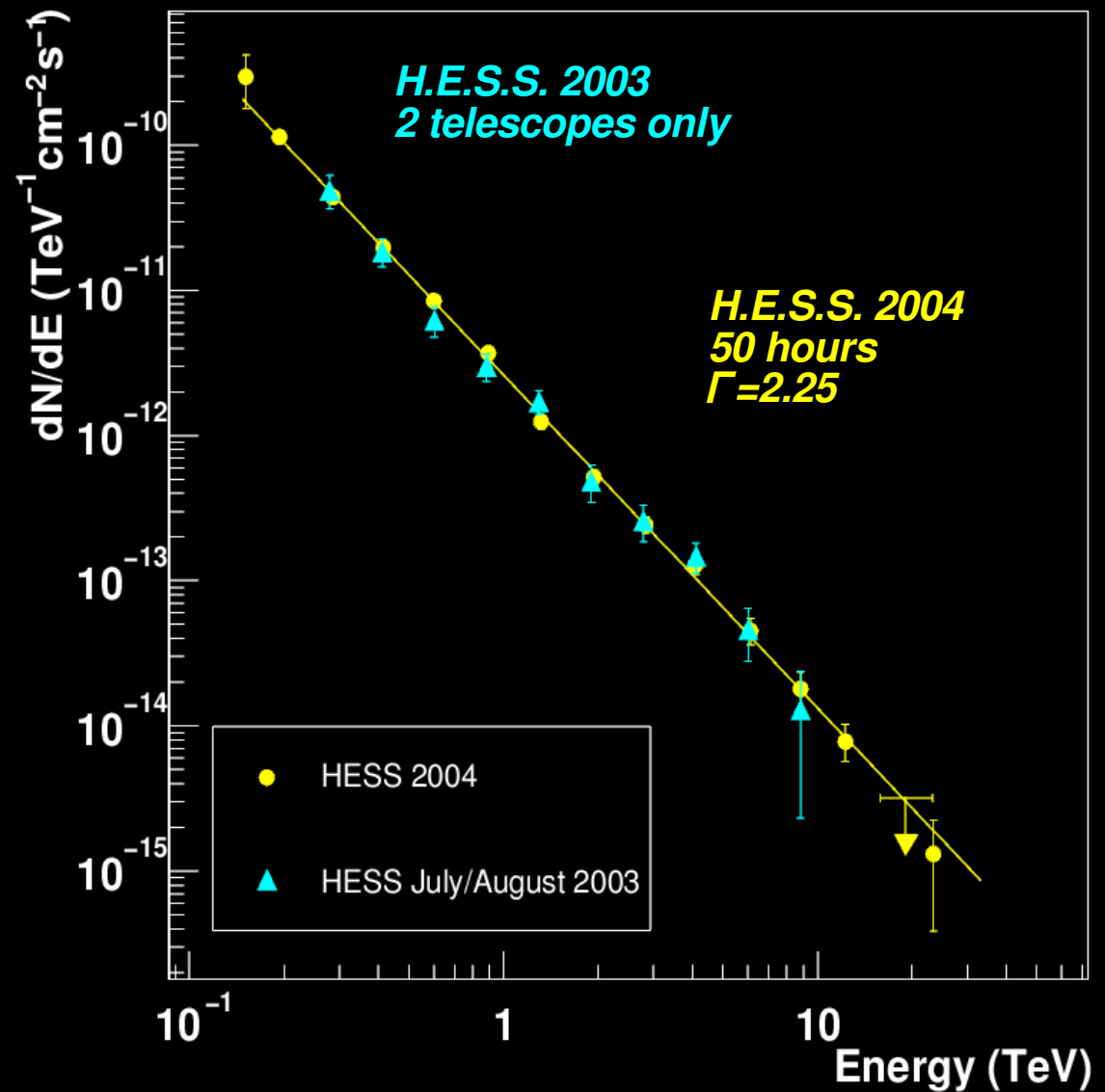
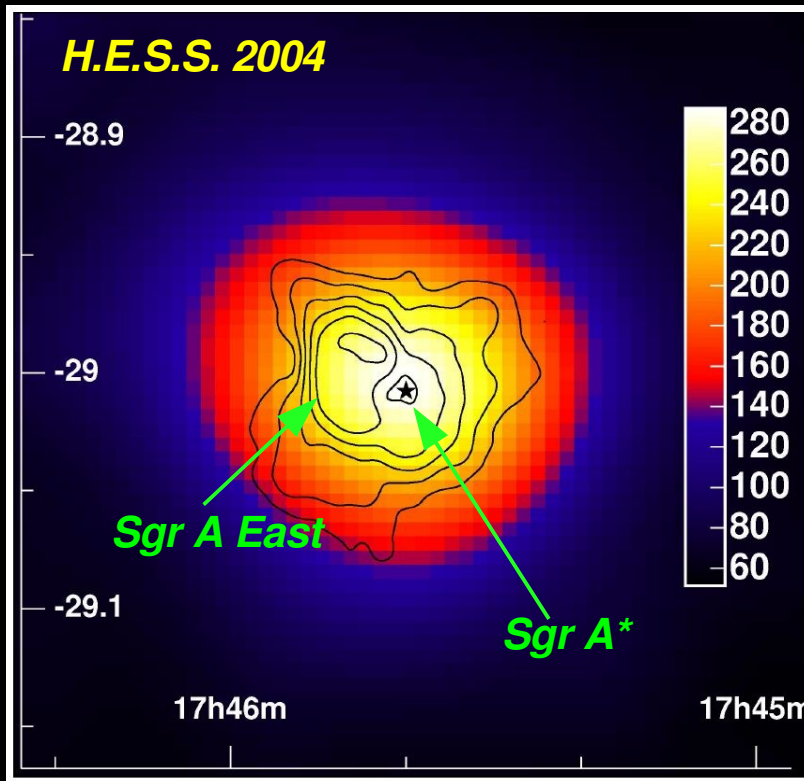
- **H.E.S.S.**

- 17 hours (2 tel only)
- 160 GeV threshold
- 11 sigma
- A&A 425, L13



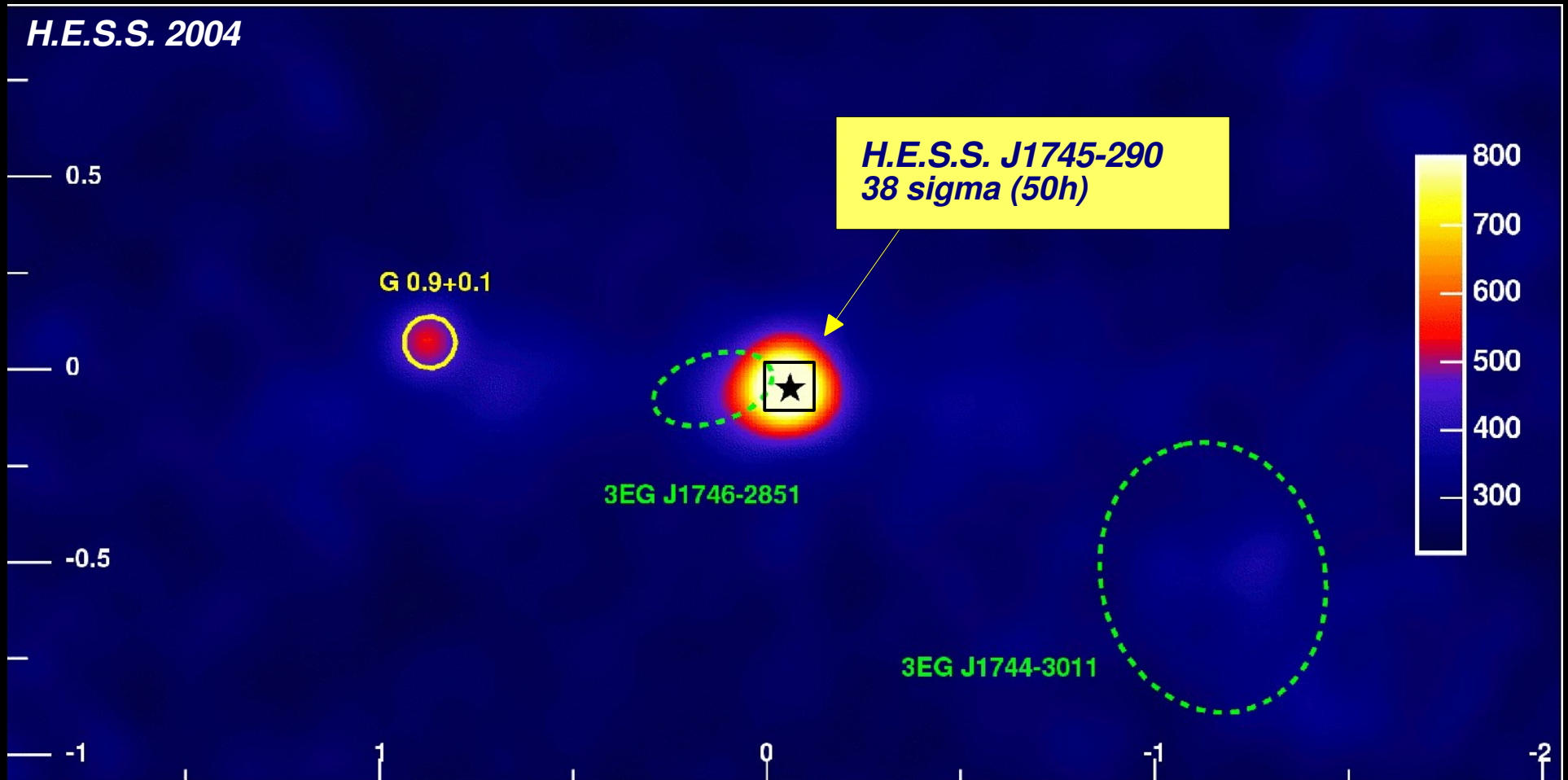
- **unprecedented statistics for GC source H.E.S.S. J1745-290**
- **newly discovered TeV source coincident with SNR G 09+0.1**
 - flux is 2% of Crab
 - one of the faintest sources ever detected in VHE γ -rays

Galactic Centre source HESS J1745-290

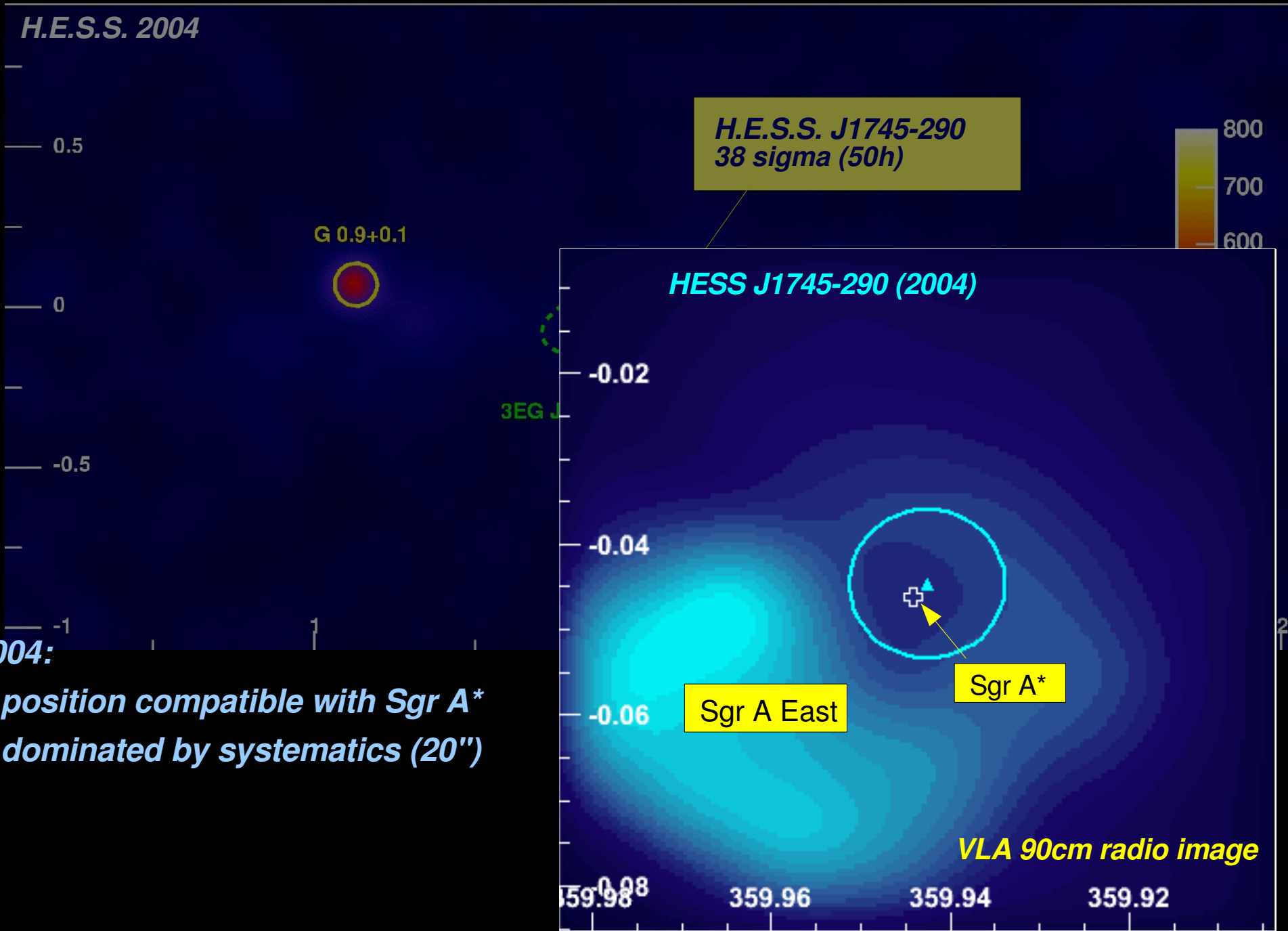


- **hard spectrum ($\Gamma=2.25$)**
- **pure power-law**
- **extension?**
point-like for H.E.S.S.
- **variability?**
not on time scales of years, month, days, hours, minutes
- **position?**

HESS J1745-290 position



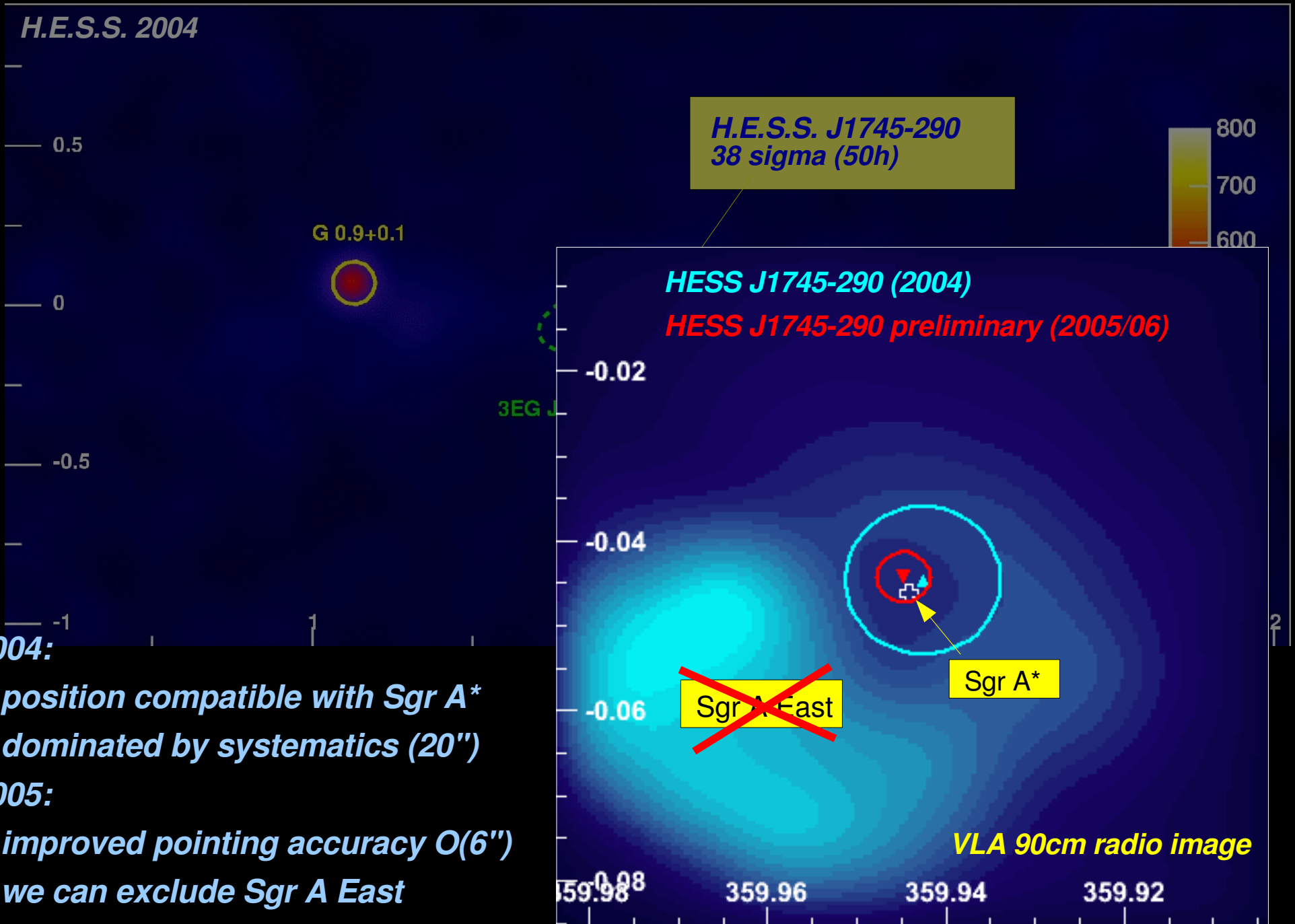
HESS J1745-290 position



2004:

- *position compatible with Sgr A**
- *dominated by systematics (20")*

HESS J1745-290 position



2004:

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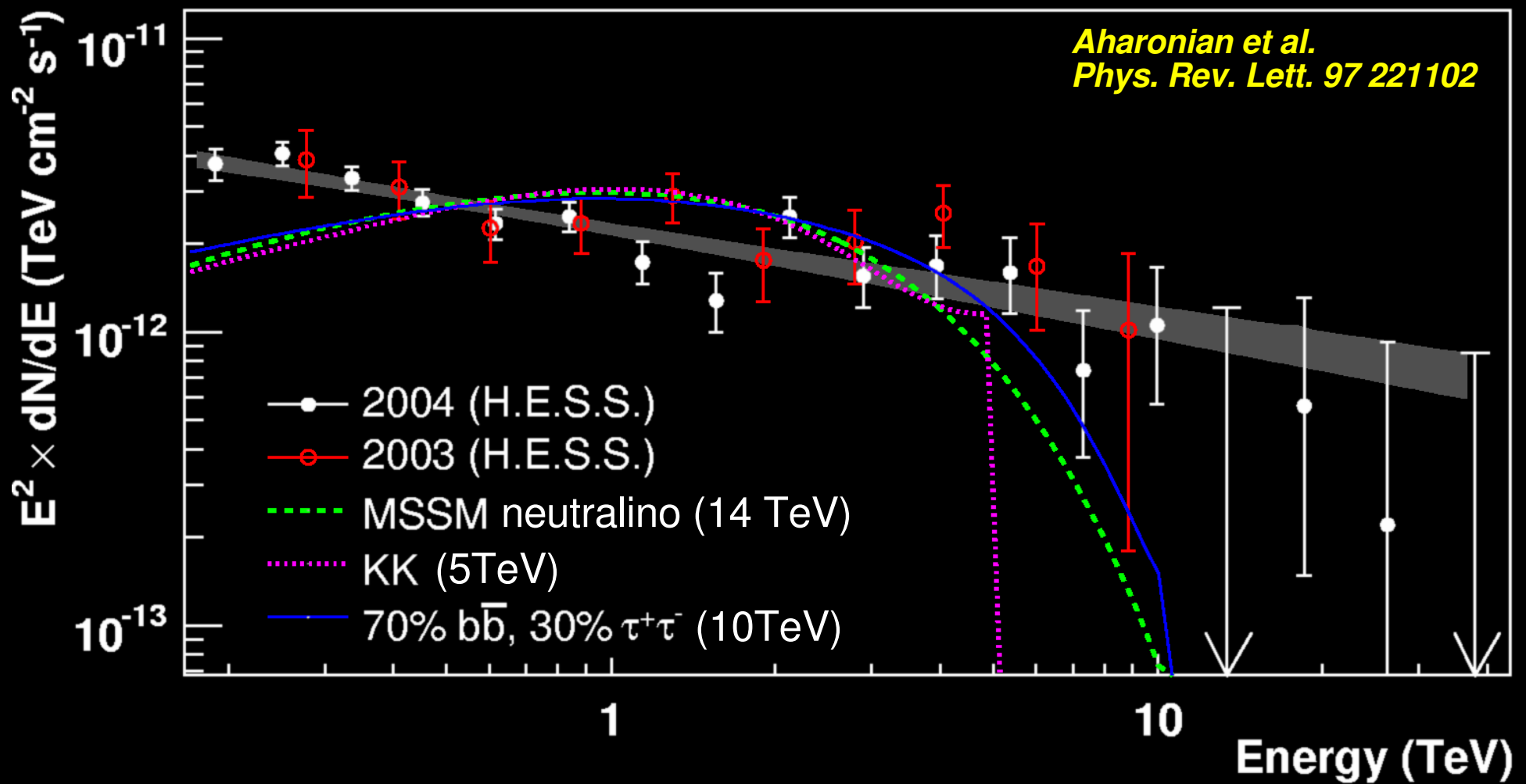
2005:

- *improved pointing accuracy O(6")*
- *we can exclude Sgr A East*

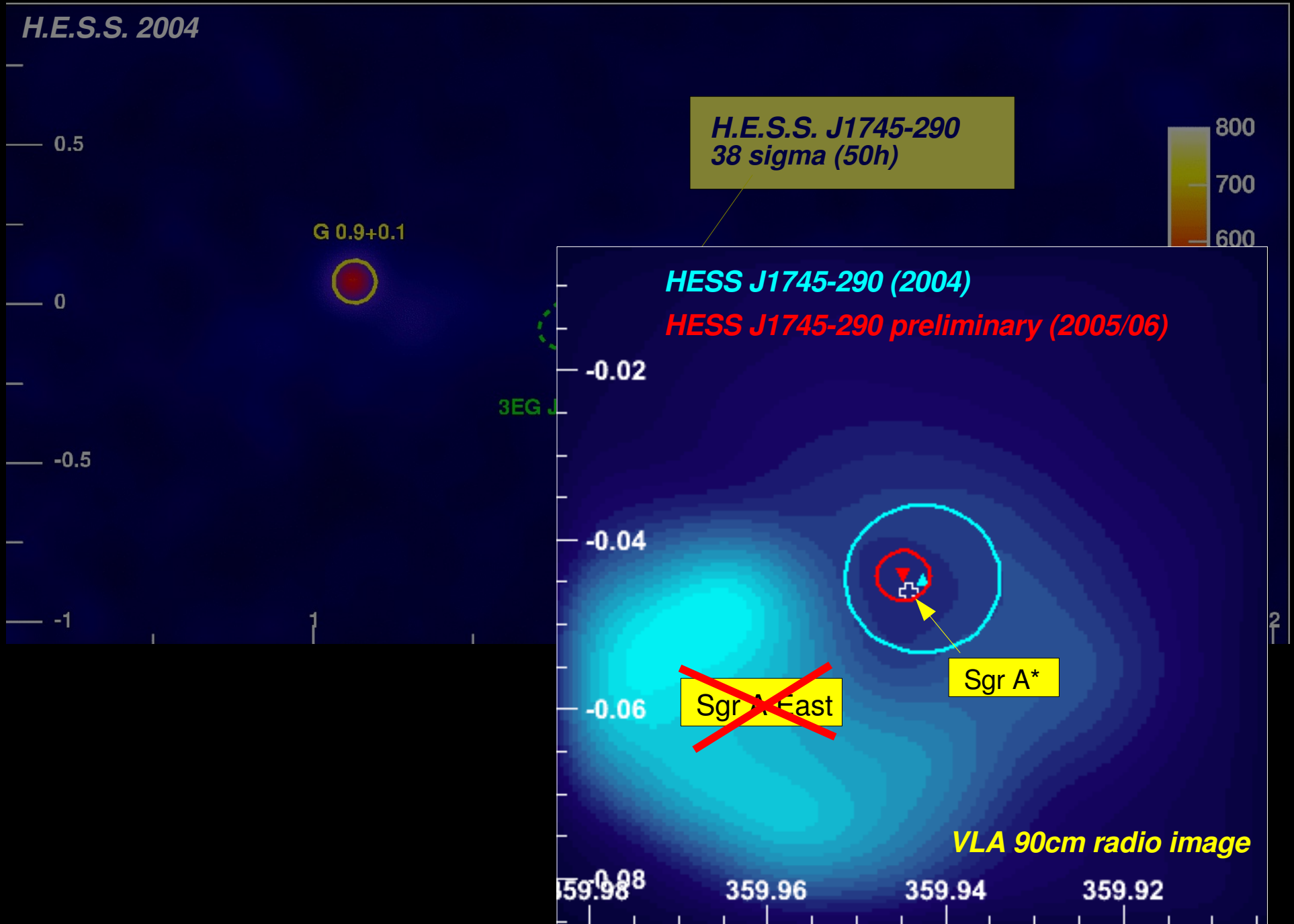
Sgr A*: a source of dark matter particles?



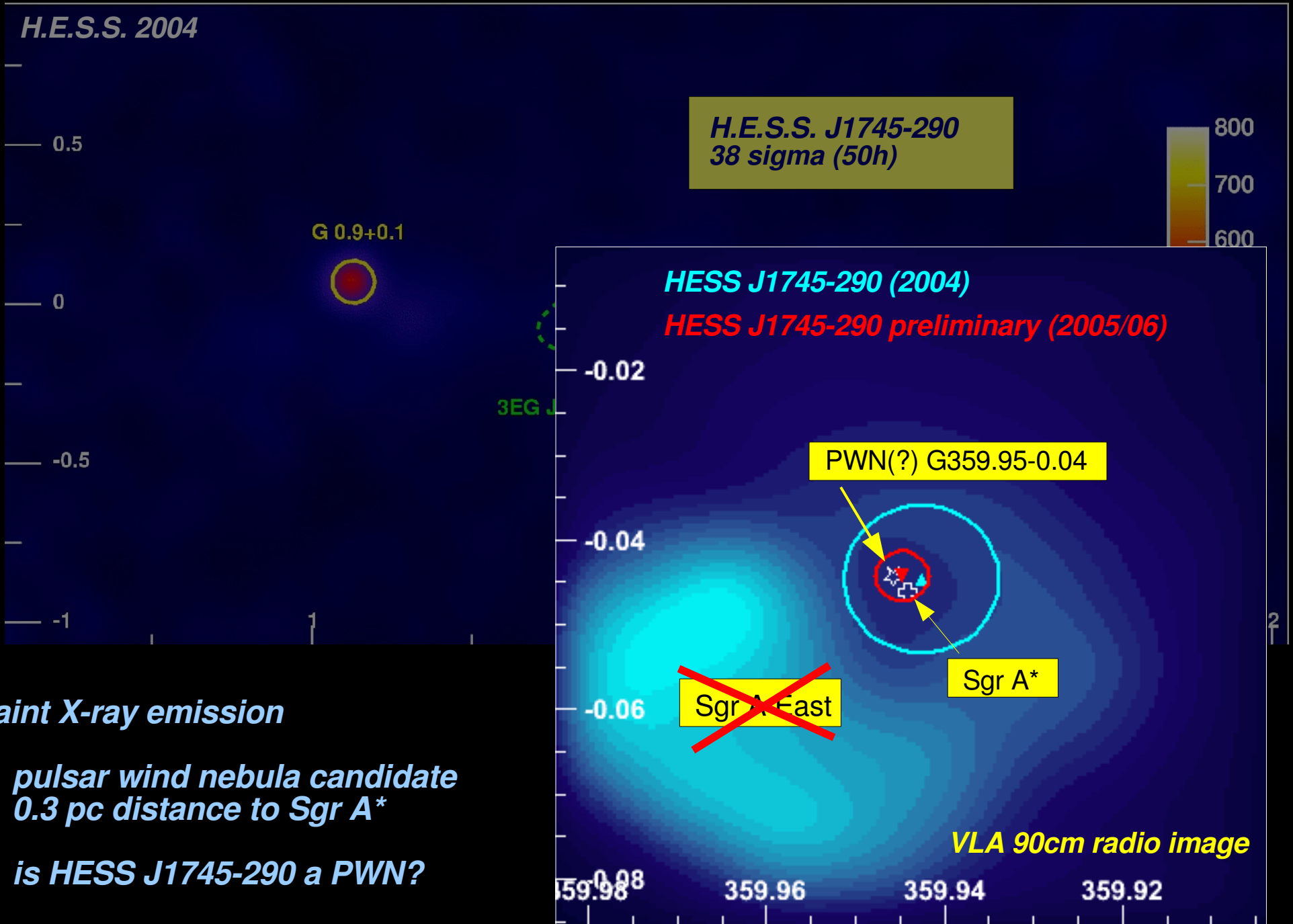
- *source spectrum is incompatible with simple DM scenarios*
- *bulk of γ -rays of astrophysical origin - DM contribution $\sim 10\%$ not ruled out*



HESS J1745-290 position cont'd



HESS J1745-290 position cont'd

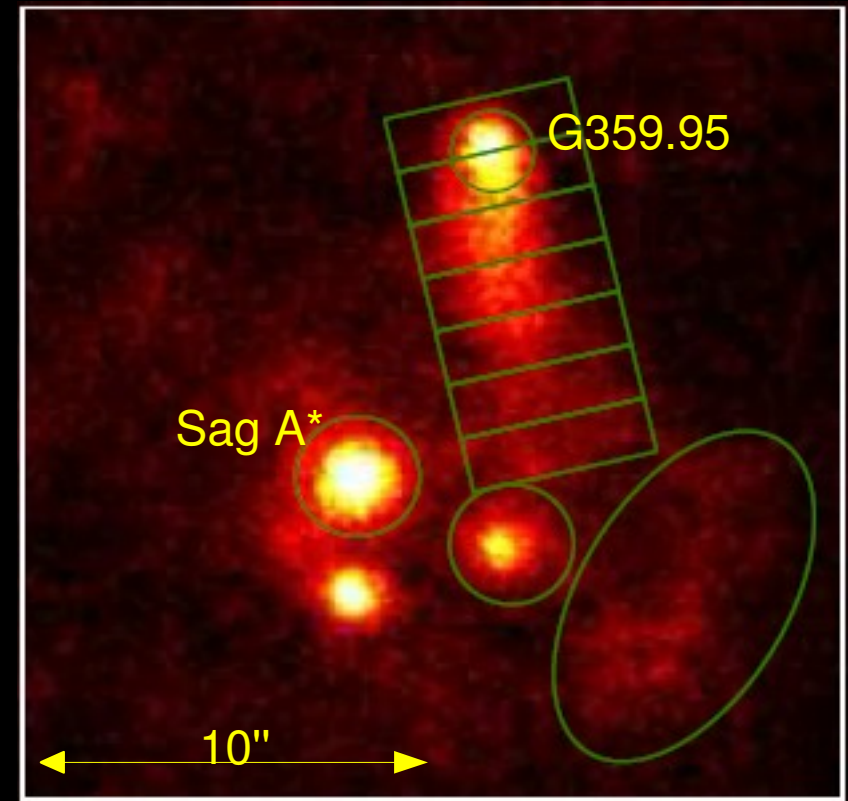


faint X-ray emission

- *pulsar wind nebula candidate*
- *0.3 pc distance to Sgr A**
- *is HESS J1745-290 a PWN?*



- *can the PWN account for the γ -ray emission given its low X-ray flux?*
- *purely non-thermal X-ray spectrum spectral softening away from "head" (synchrotron cooling)*



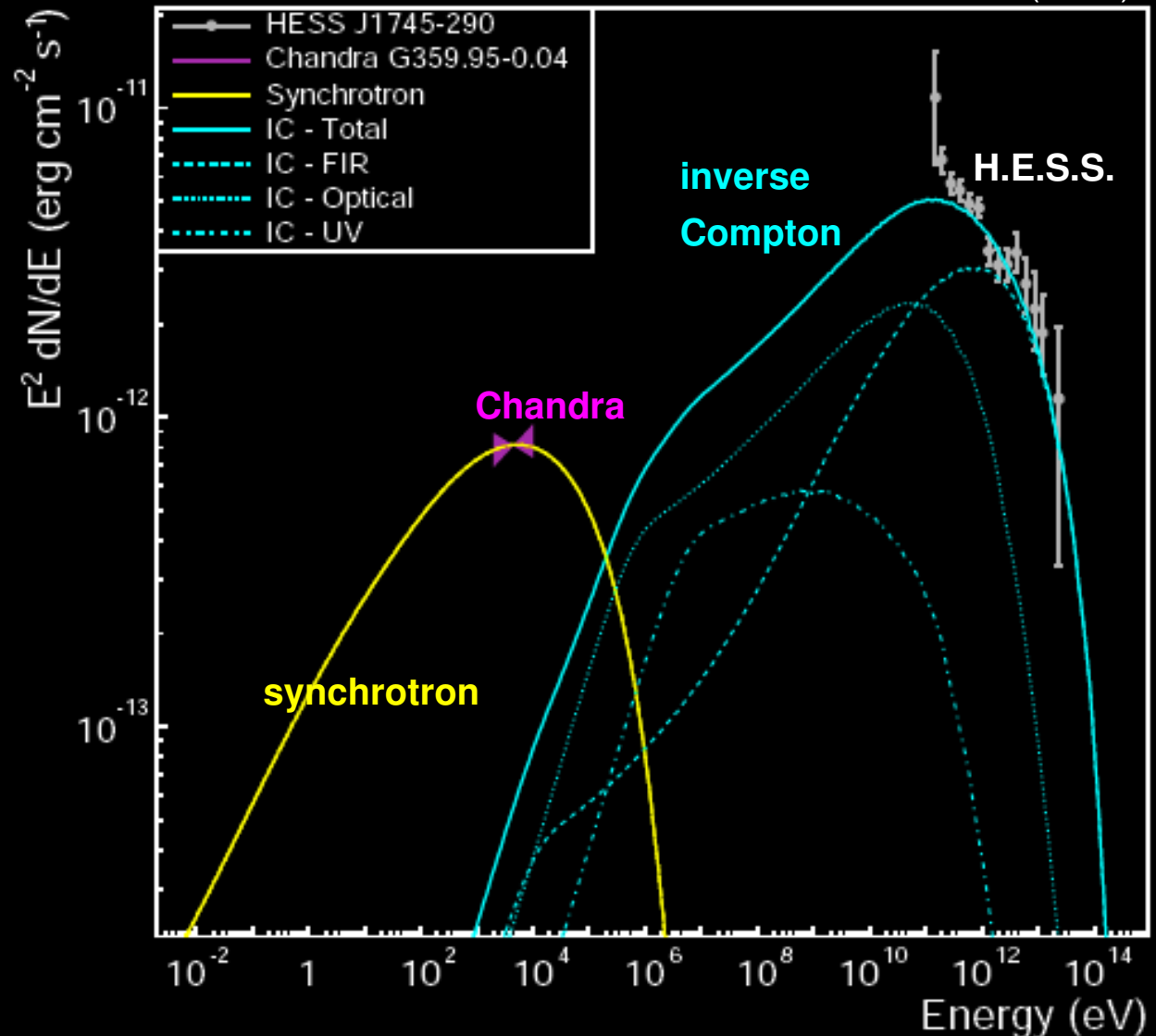
Chandra, Wang et al. (2005)

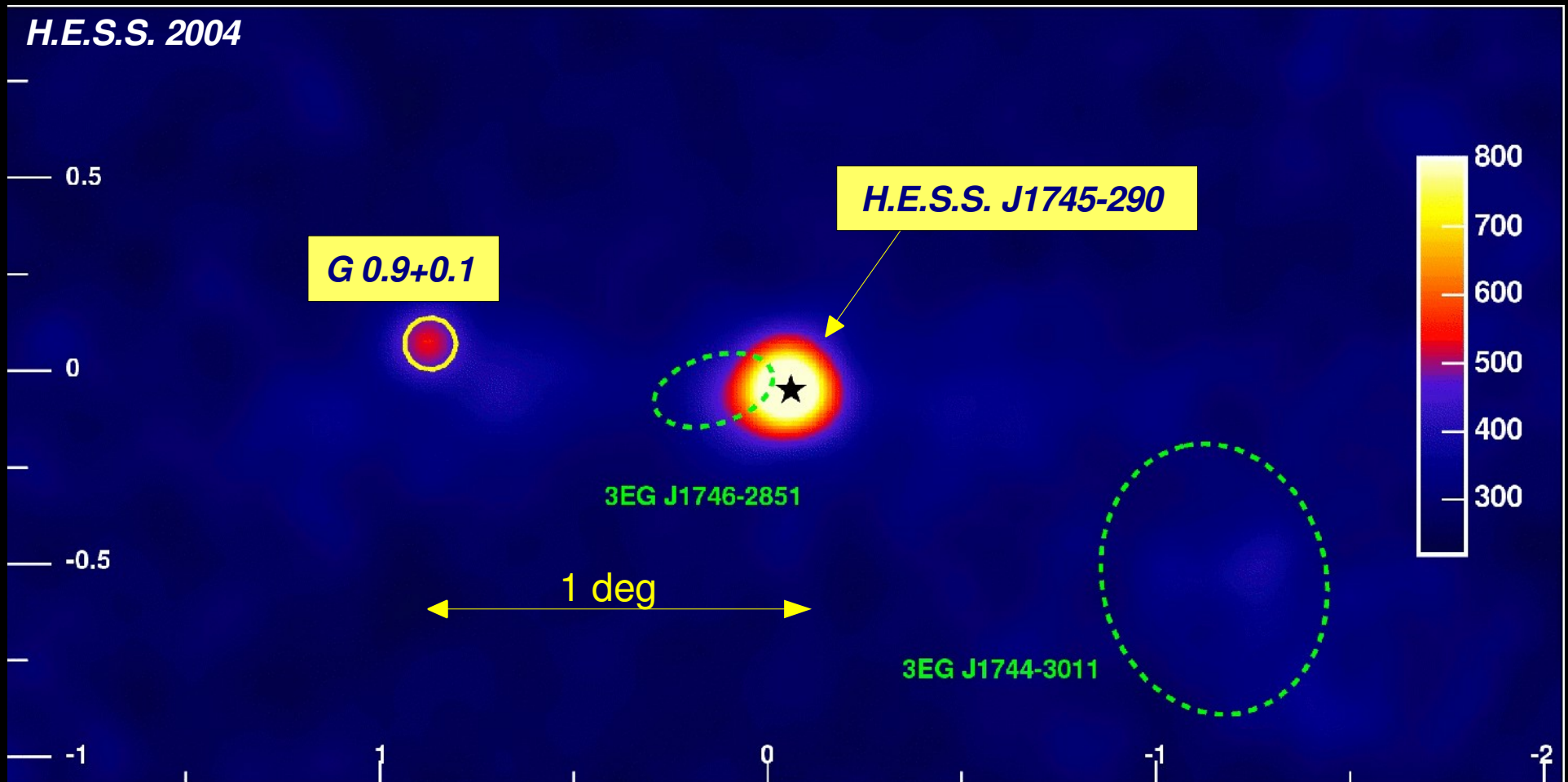
HESS J1745-290: a PWN?



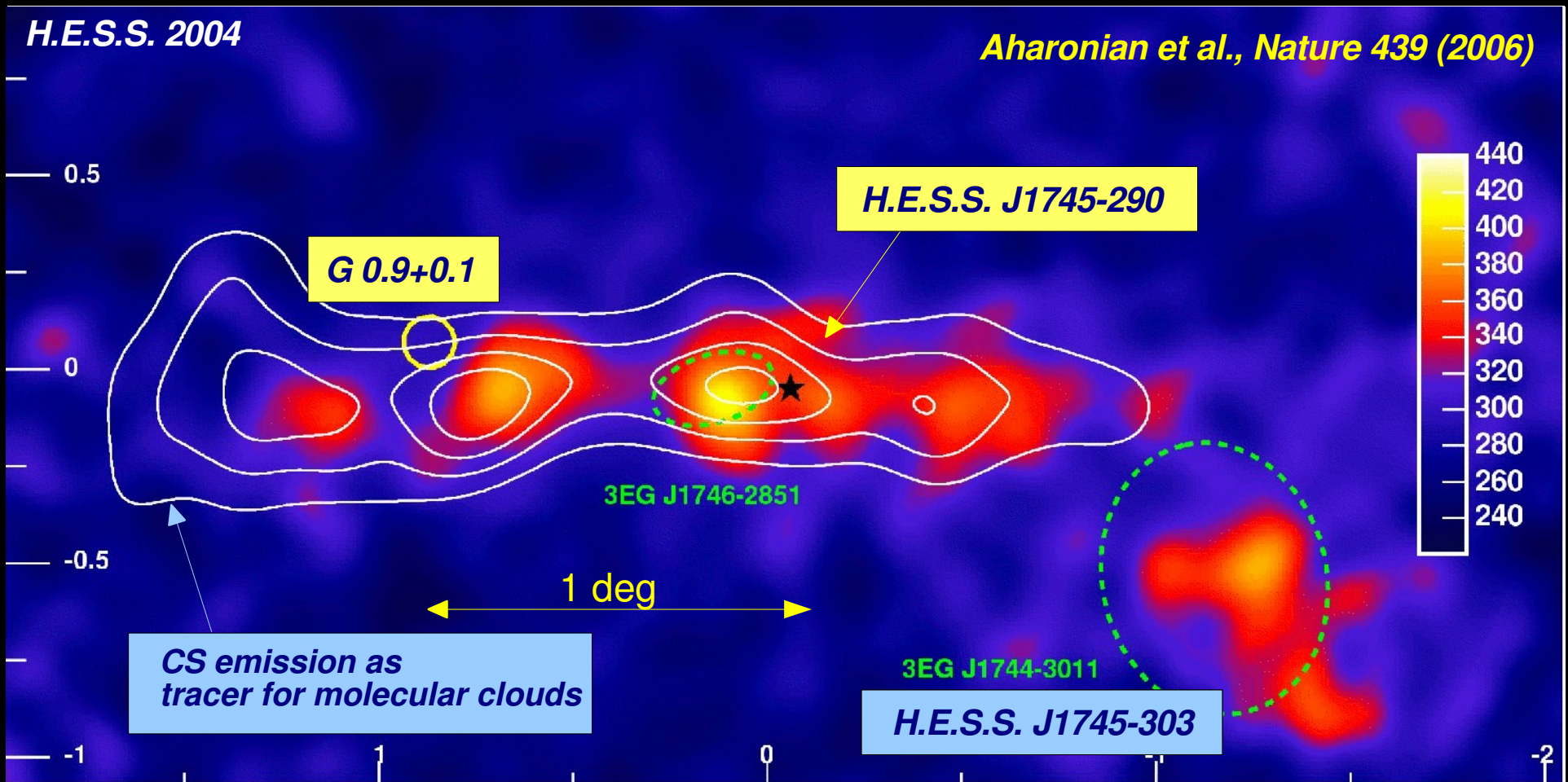
- can the PWN account for the γ -ray emission given its low X-ray flux?
- purely non-thermal spectrum spectral softening away from “head” (synchrotron cooling)
- electron injection spectrum index = 1.8 exponential cutoff (200 TeV)
- **synchrotron cooling** magnetic field 120 μ G
- **inverse Compton** on dense photon field

F.A. Aharonian + J.A. Hinton (2006)

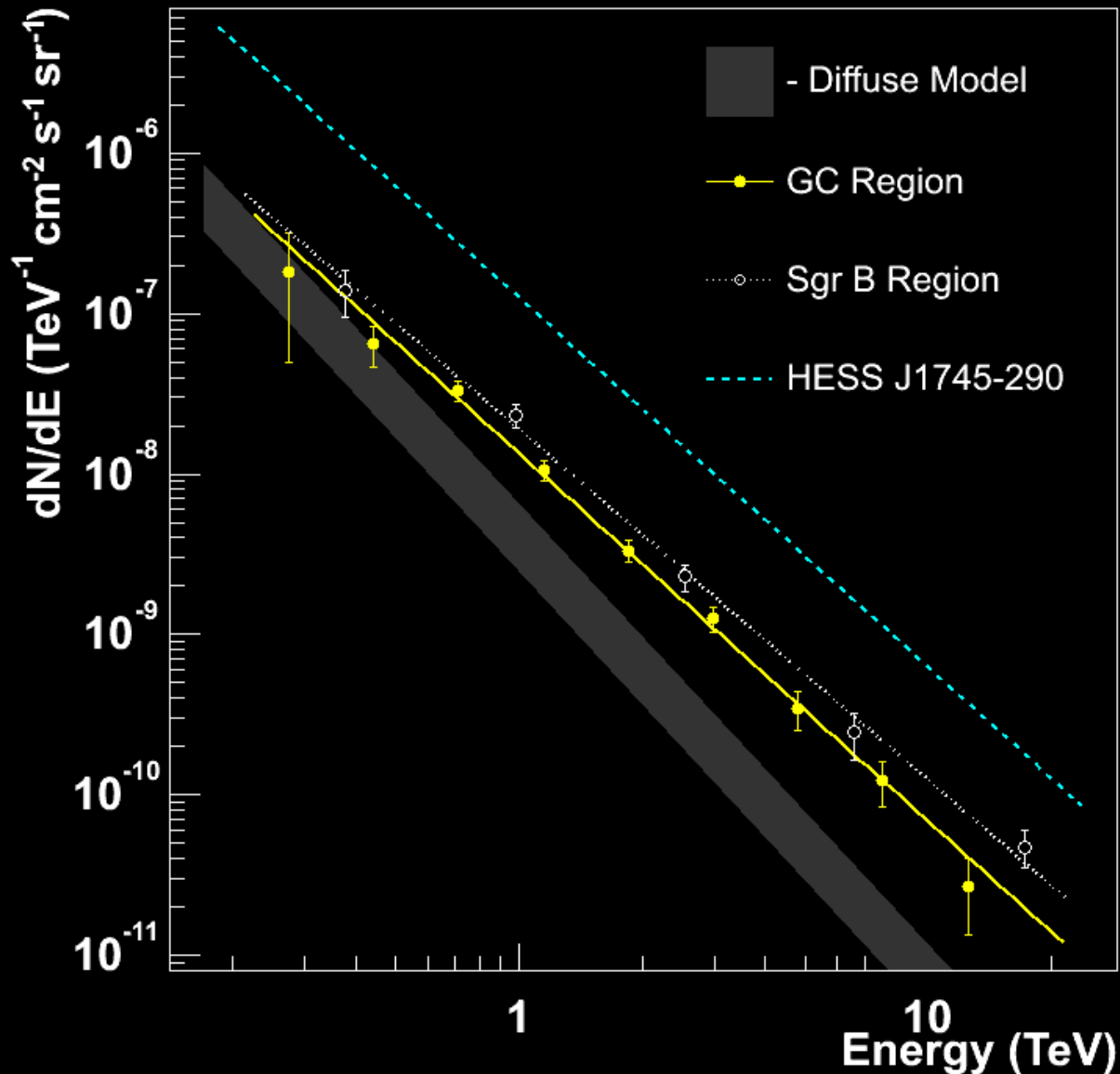




- *analysis of HESS J1745-290 showed evidence for diffuse emission*
→ *subtract the two bright (assumed point-like) sources*



- analysis of HESS J1745-290 showed evidence for diffuse emission
→ subtract the two bright (assumed point-like) sources
- diffuse emission (14.6σ) along the disk coincident with molecular clouds

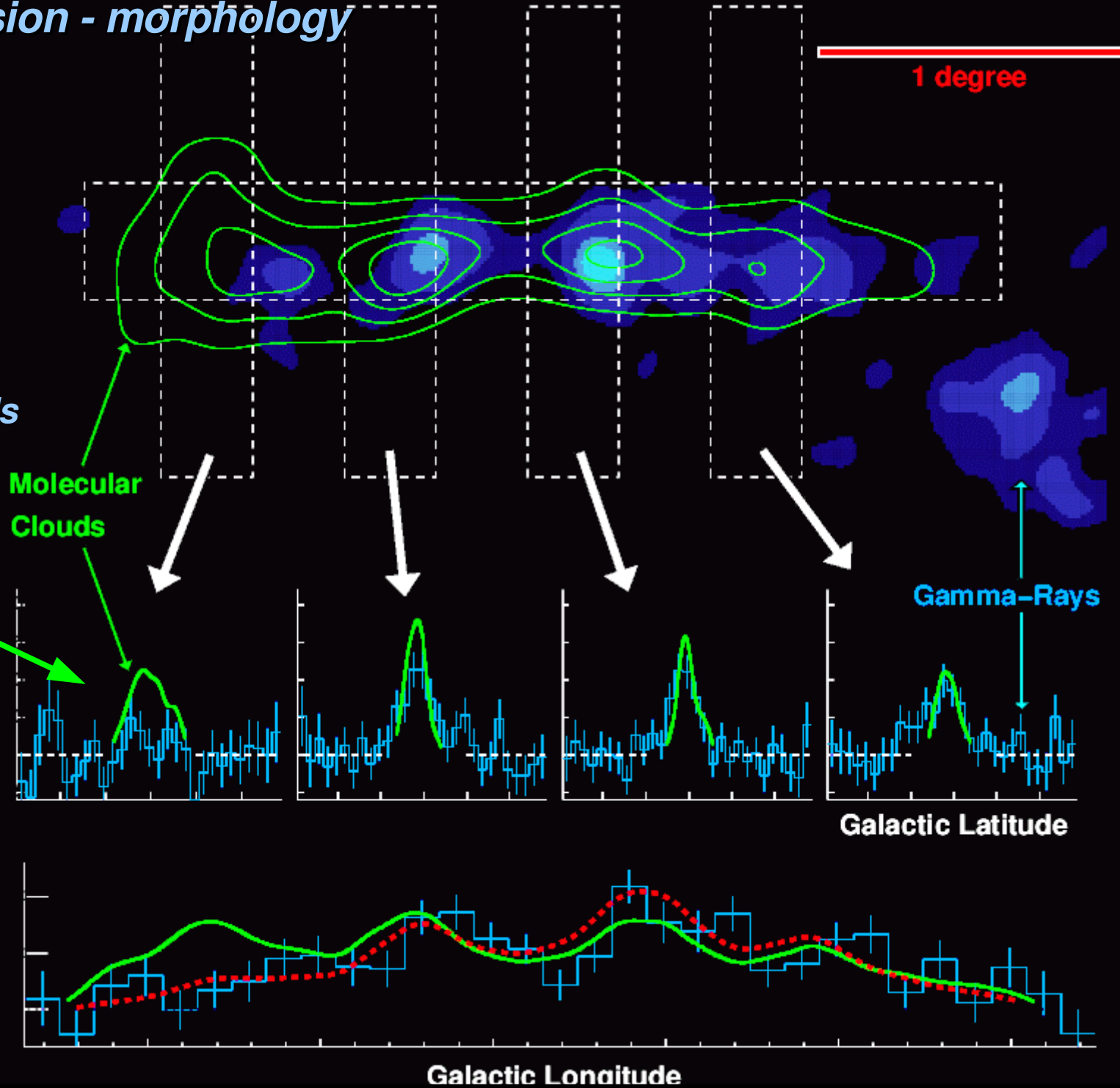


- **CRs from galactic disc?**
- predicted spectrum too soft
- **many different γ -ray sources?**
- close correlation with molecular clouds
- needs many unknown sources
- **electrons?**
- correlation with clouds
- high magnetic fields
-> strong cooling
-> small emission region ($\sim 0.2^\circ$)
- X-ray counterparts
- **HESS J1745-290?**
+ similar photon index
+ flux deficit around $l=1.3^\circ$...

GC diffuse emission - morphology

close correlation
between γ -rays
and molecular clouds

deficit in
TeV γ -rays



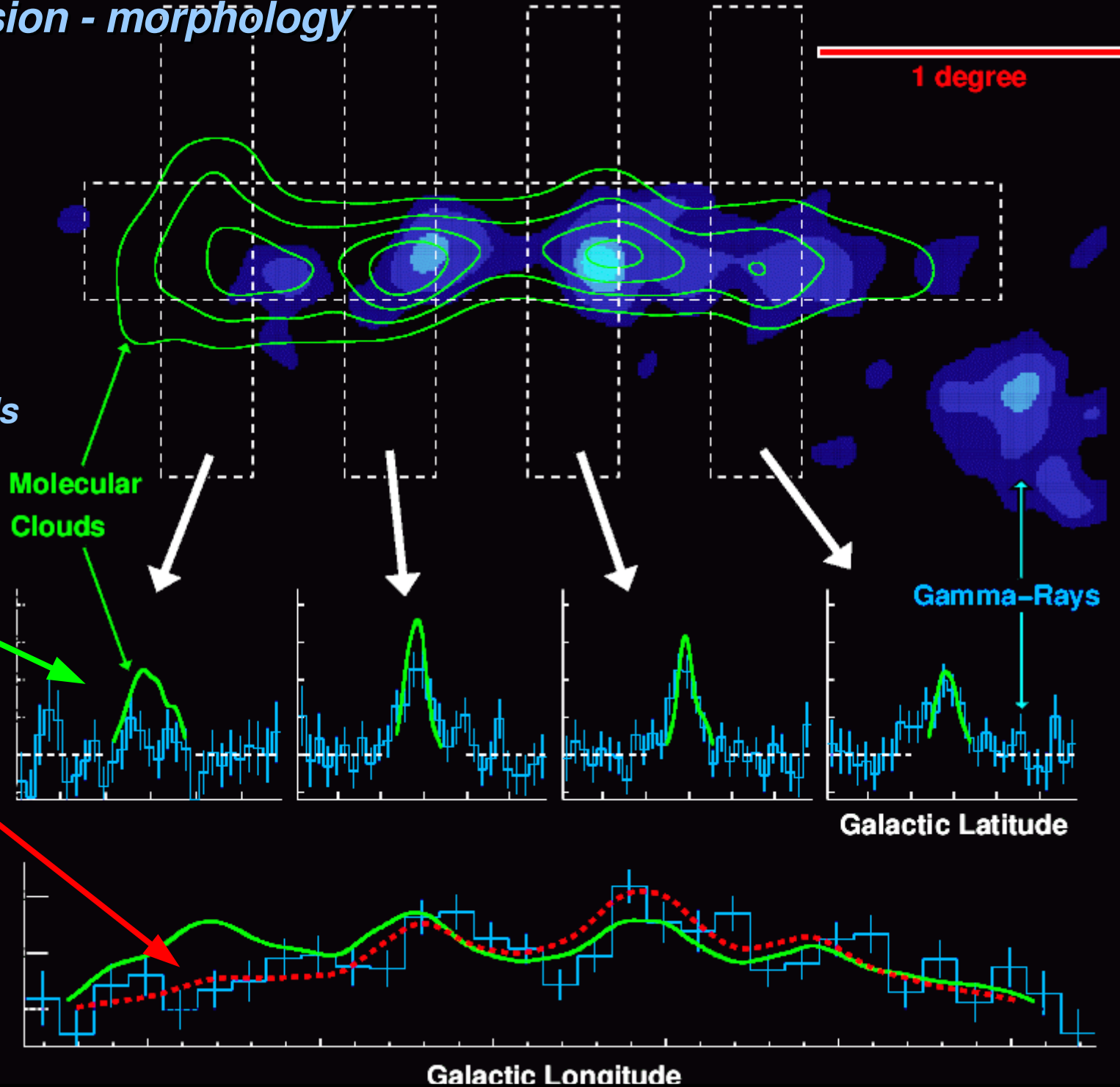
GC diffuse emission - morphology

close correlation
between γ -rays
and molecular clouds

deficit in
TeV γ -rays

simulation
 10^4 years old
source @ GC

strong evidence
for accelerator
of cosmic rays!



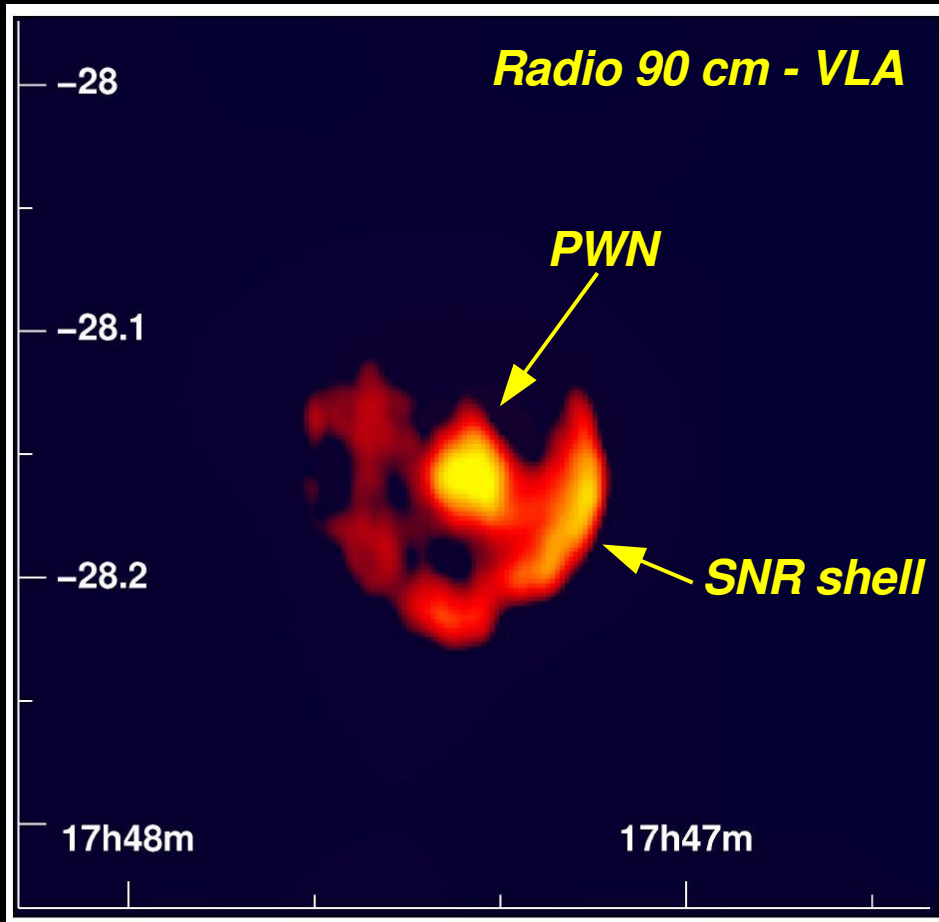
Summary

The H.E.S.S. view of the Galactic Centre:

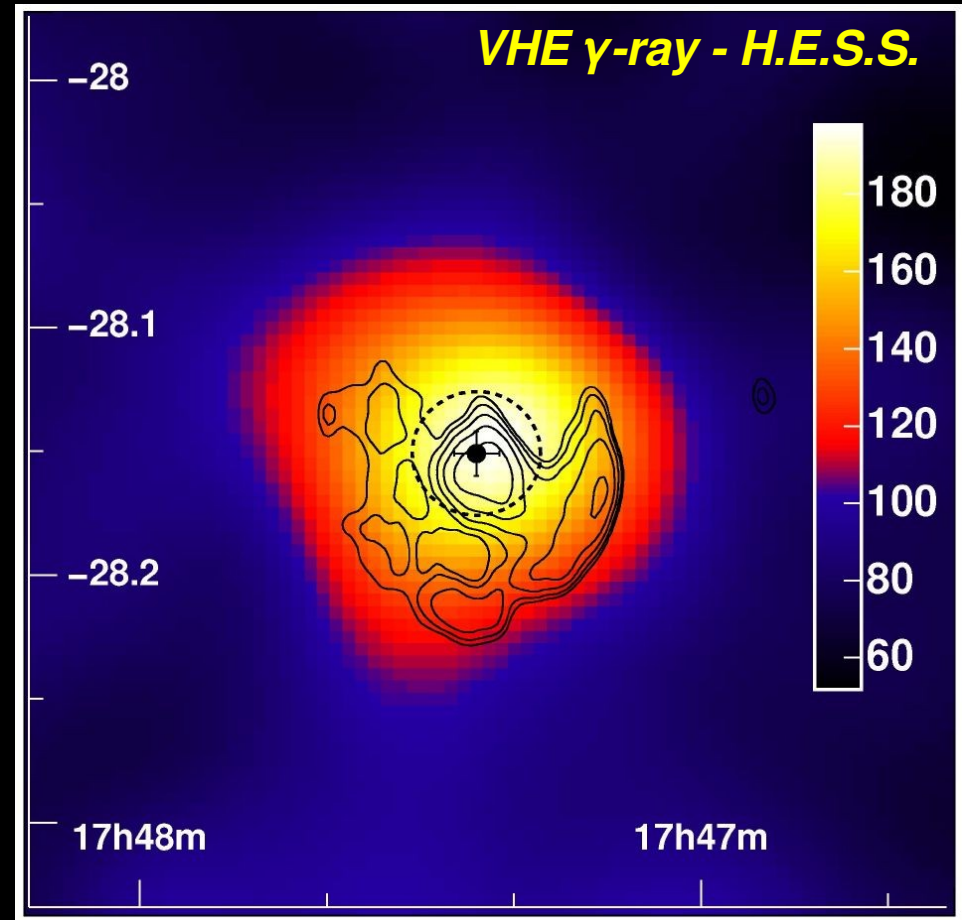
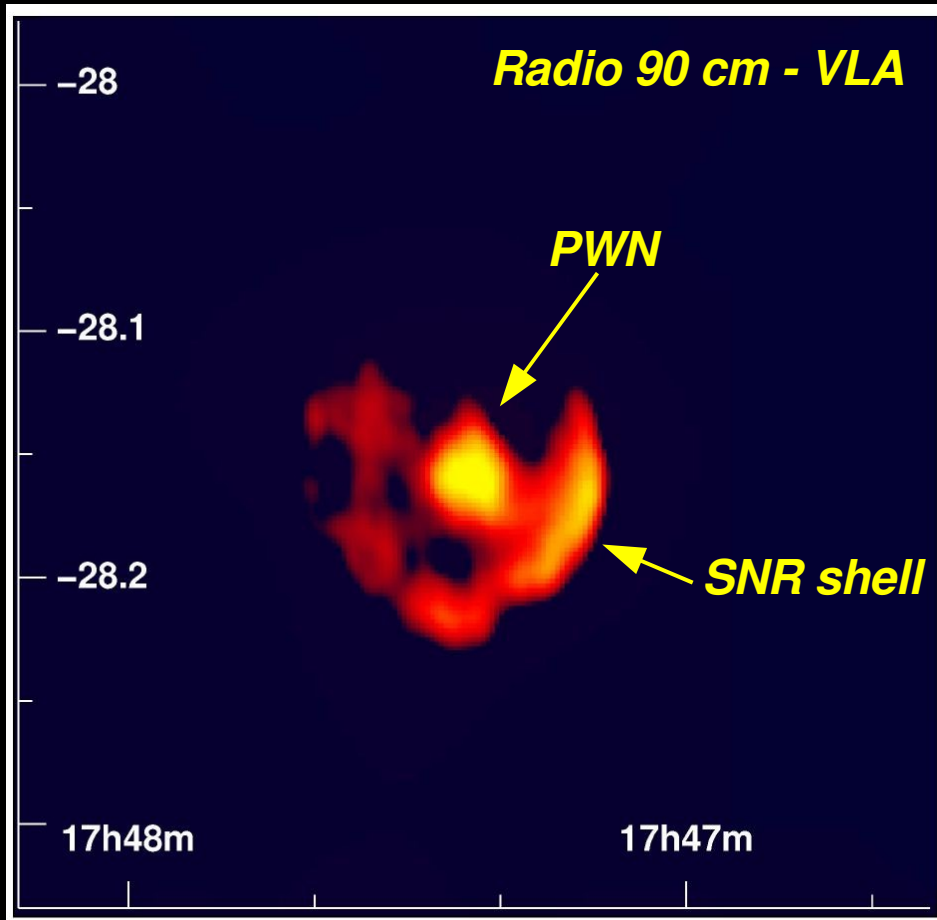
- 3 very high energy particle accelerators
 - HESS J1745-290 – Sgr A* or G359.95-0.04?
 - G0.9+0.1 – a pulsar wind nebula
 - HESS J1745-303 - ??
- diffuse TeV emission correlated with target material
 - a step towards identifying the acceleration sites of hadronic cosmic rays



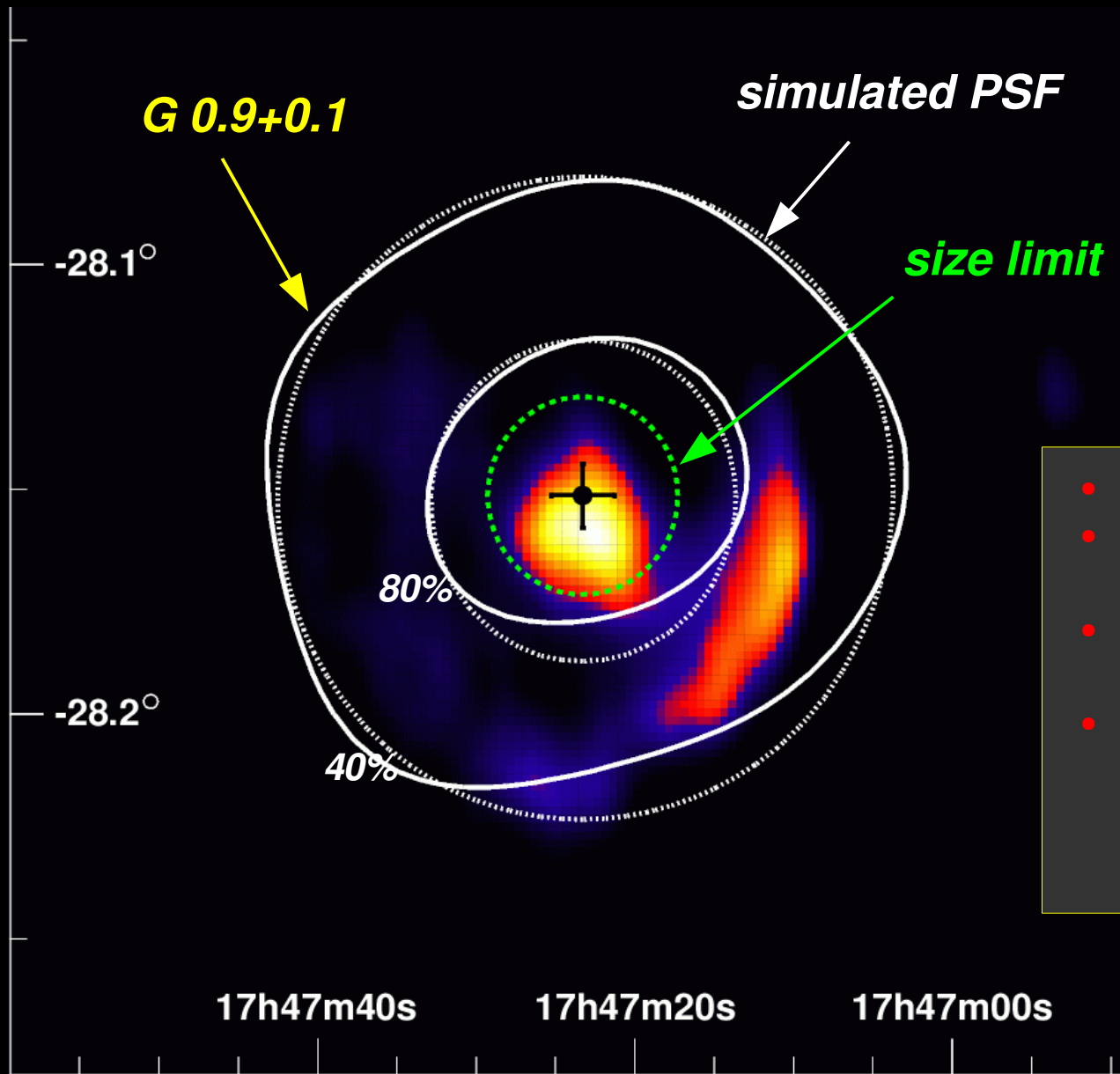
spares



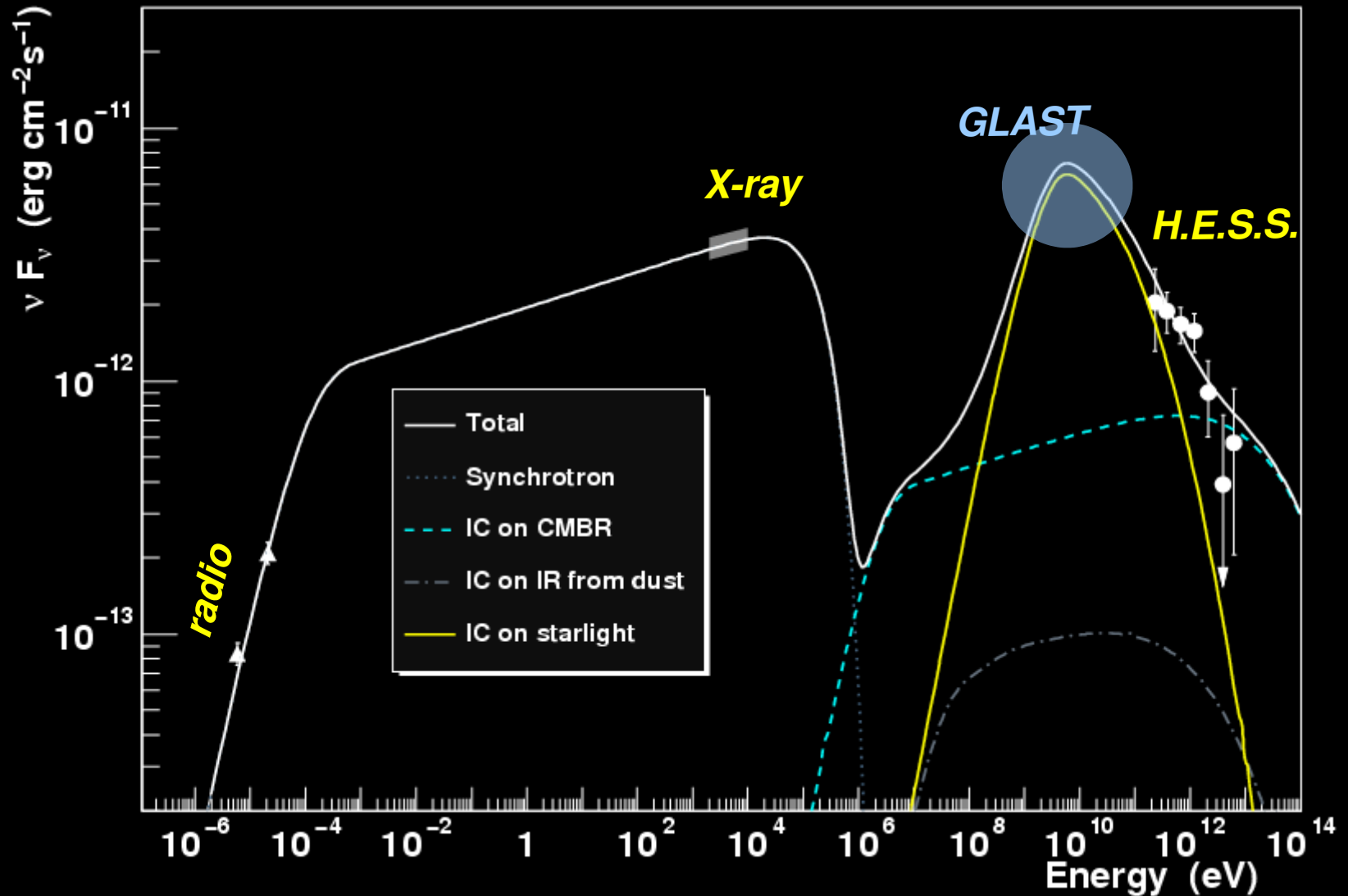
- **Radio:** shell morphology resolved
- **X-rays:** pulsar wind nebula as a core



- **Radio: shell morphology resolved**
- **X-rays: pulsar wind nebula as core**
- **VHE γ -rays: point-like emission on PWN**



- *colours: VLA*
- *contours: H.E.S.S.*
- ***TeV emission coincides with PWN***
- ***no TeV emission from shell***

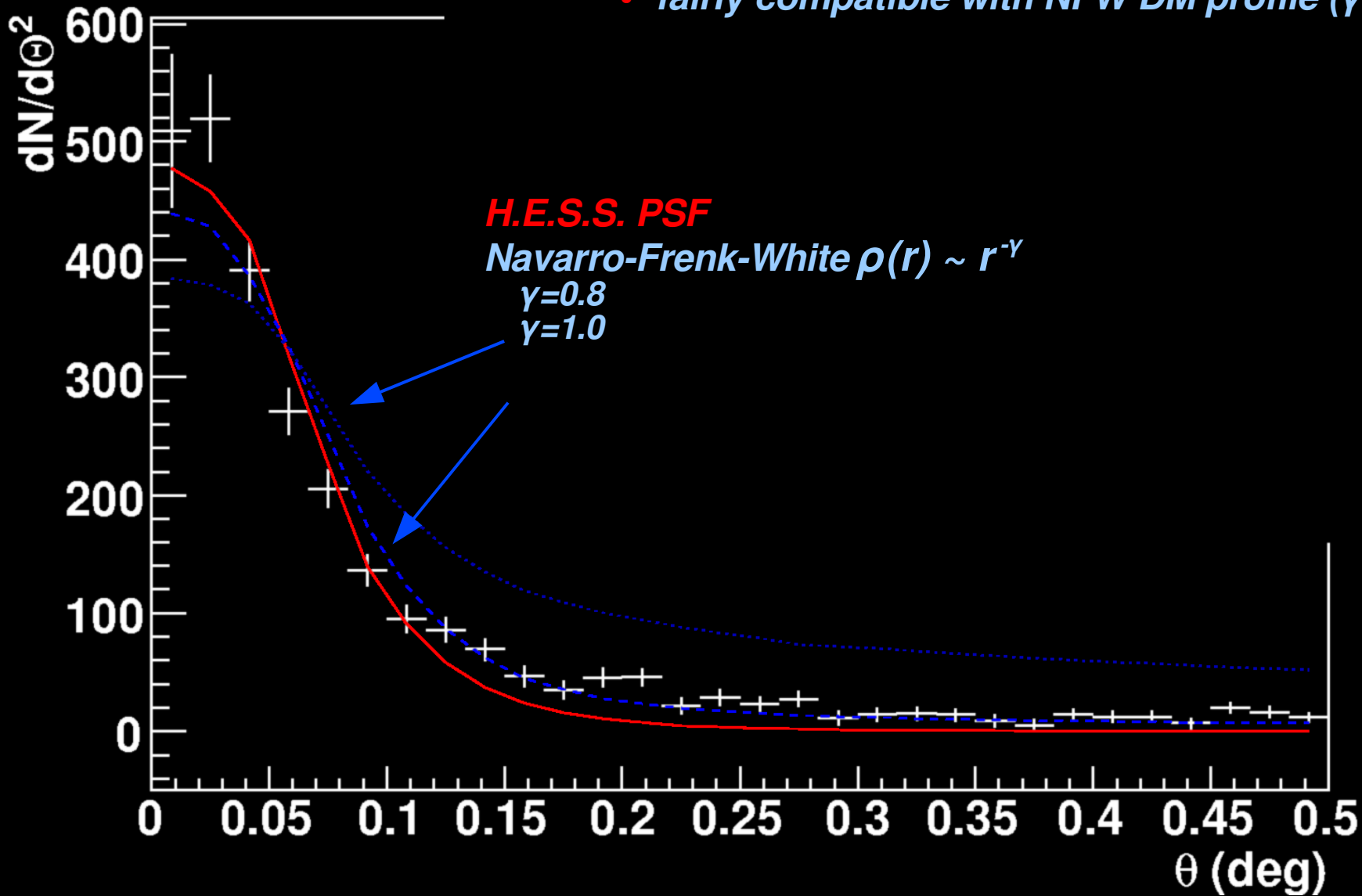


- enhanced IC peak due to dense photon field
- simple one-zone model fits data
- need to resolve IC peak (GLAST)

Sgr A*: a source of dark matter particles?



- radial source profile shows elongated tail
- fairly compatible with NFW DM profile ($\gamma=1.0$)



Sgr A*: a source of dark matter particles?



- radial source profile shows elongated tail
- fairly compatible with NFW DM profile ($\gamma=1.0$)
- **but: profile not radially symmetric!**
strongly disfavours DM interpretation
- diffuse emission in the galactic plane?

