# Gamma-ray SNRs highlights

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# *SNRs in gamma-rays*

- **Bright gamma-ray sources:**

  **Inverse Compton : electrons + ISRF photons → $\gamma$ rays**

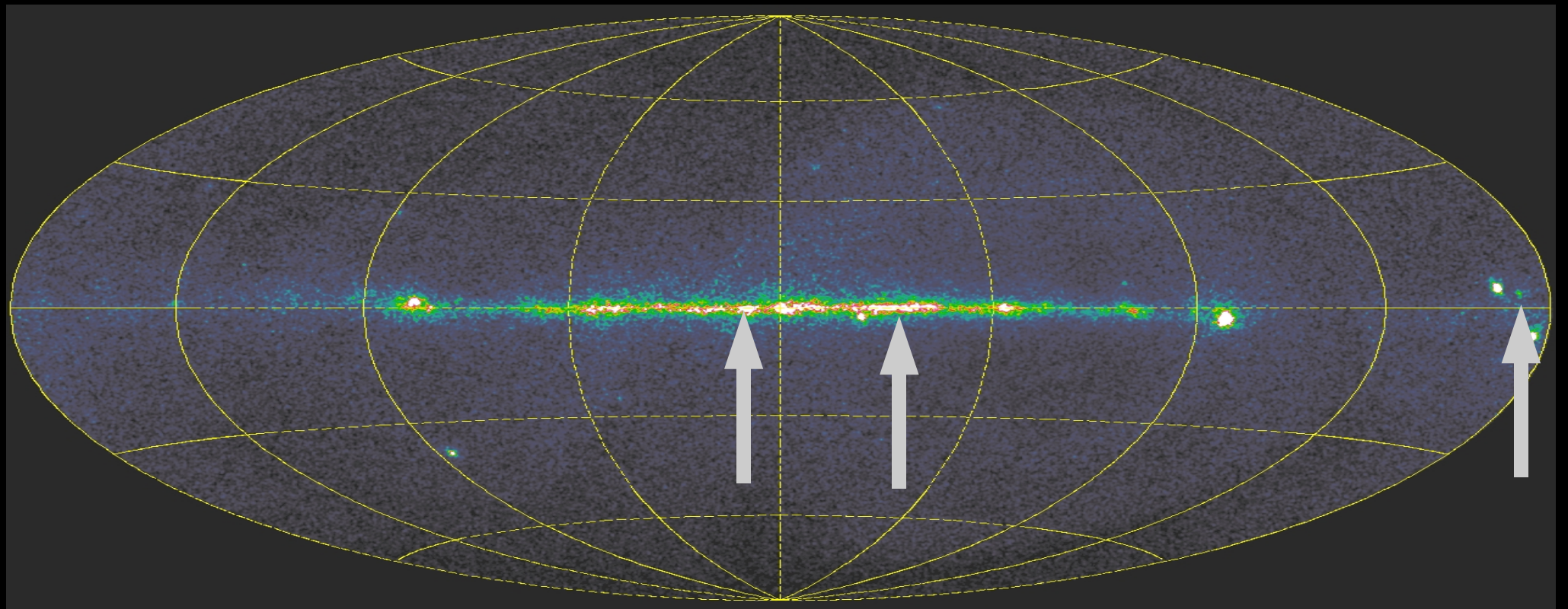
  **Electron Bremsstrahlung: electrons + ISM nuclei → $\gamma$ rays**

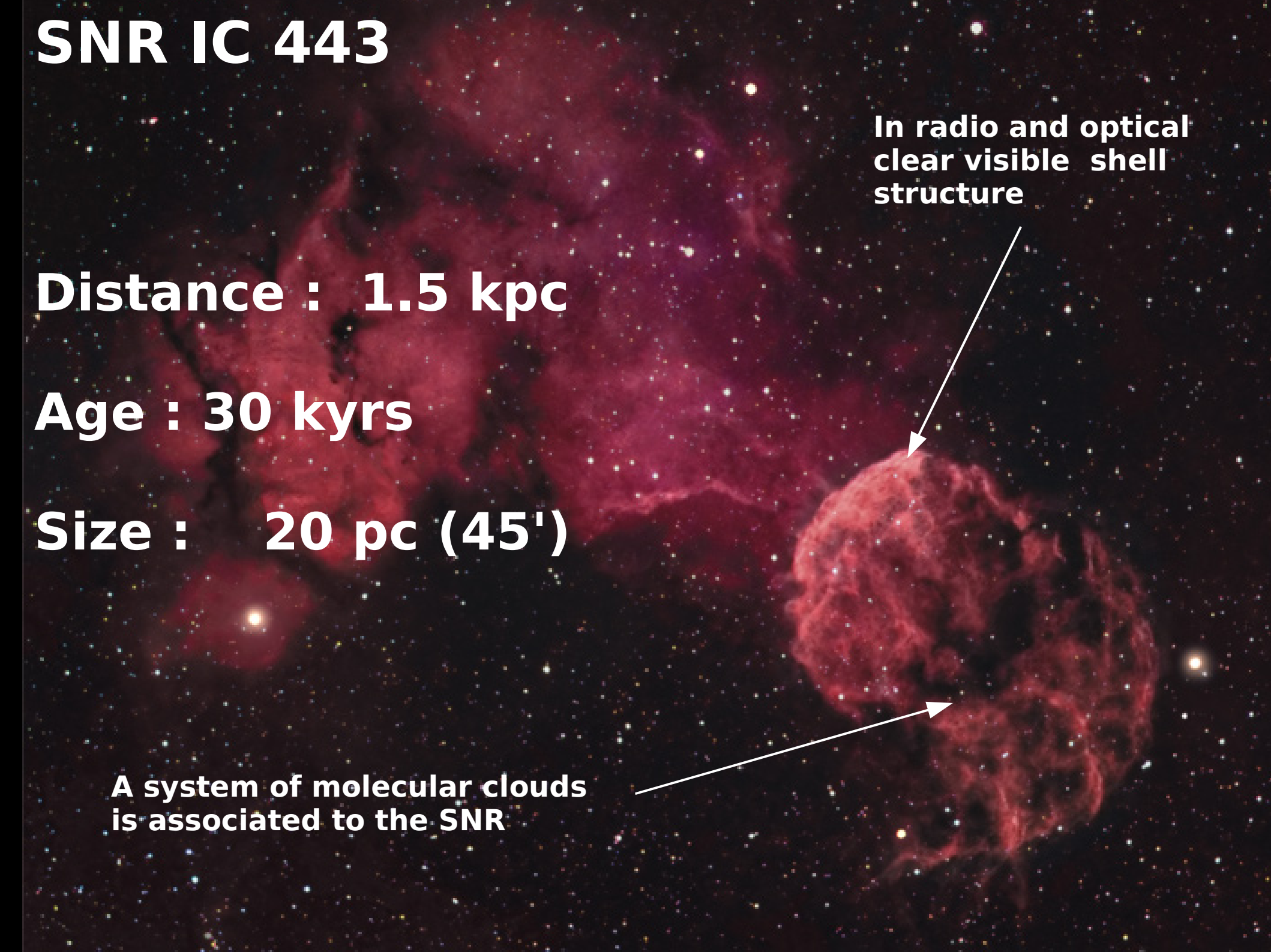
  **Neutral $\pi$ decay : protons + ISM nuclei → $\pi^0$ → $\gamma$ rays**

- **No time signature !**

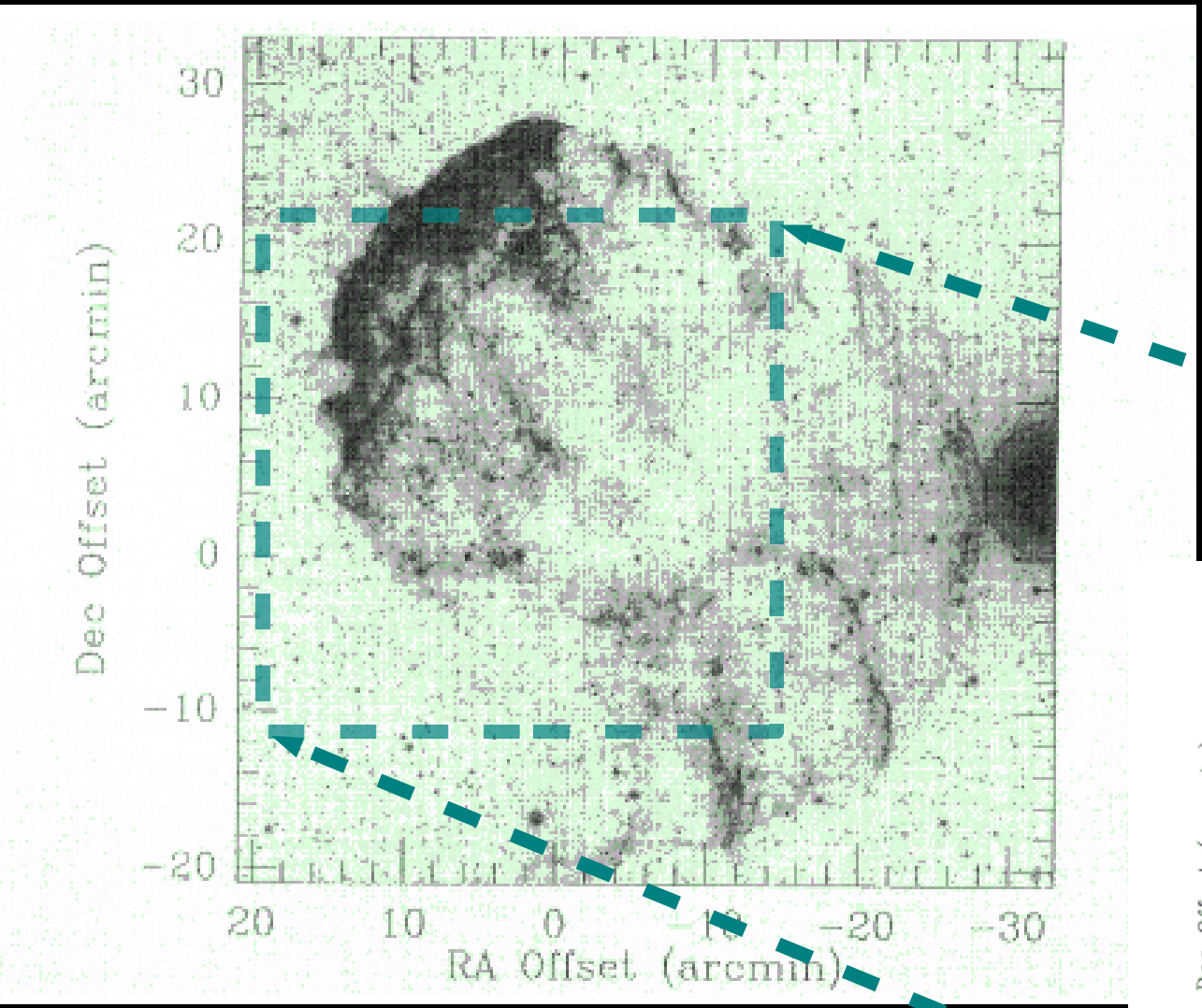
# *AGILE's SNRs*

| | dist (kpc) | age (kyrs) | size(') |
|---|---|---|---|
| IC 443 | 1.5 | 30 | 45 |
| W 28 | 2 - 3 | >35 | 50 |
| RX J1713.7–3946 | 1.2 | 2 | 65 |



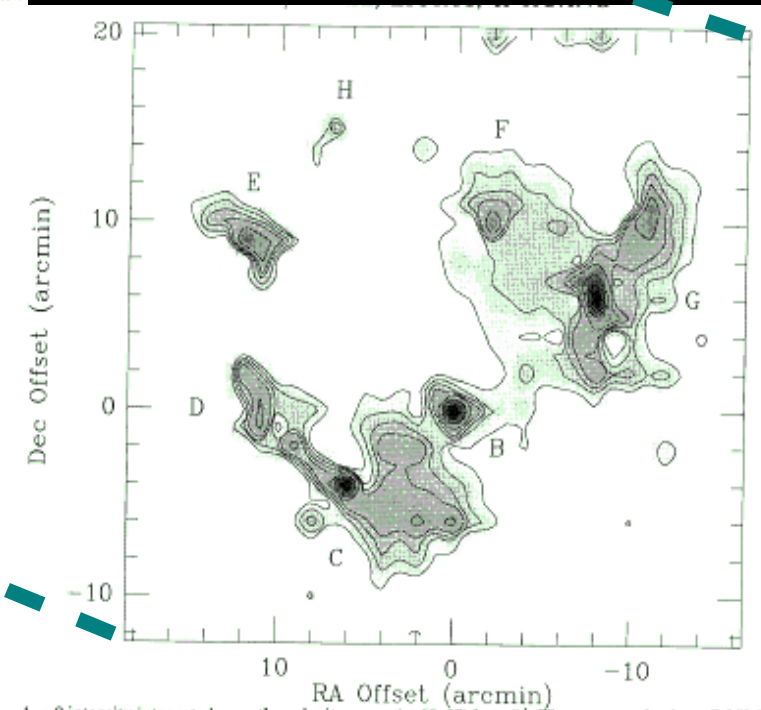

SNR IC 443
Distance : 1.5 kpc
Age : 30 kyrs
Size : 20 pc (45')
In radio and optical clear visible shell structure
A system of molecular clouds is associated to the SNR

# IC 443 SNR and Molecular Clouds

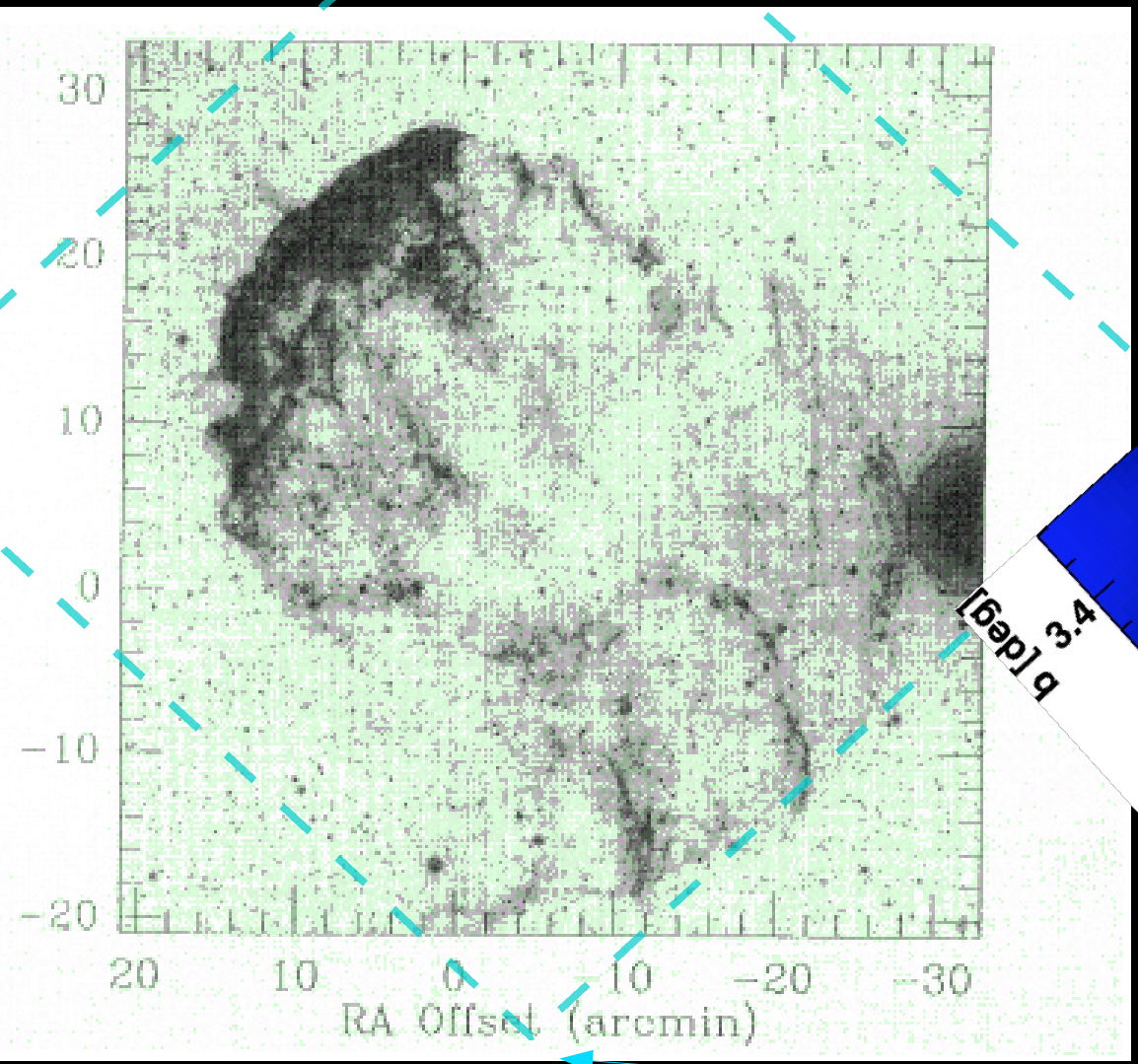


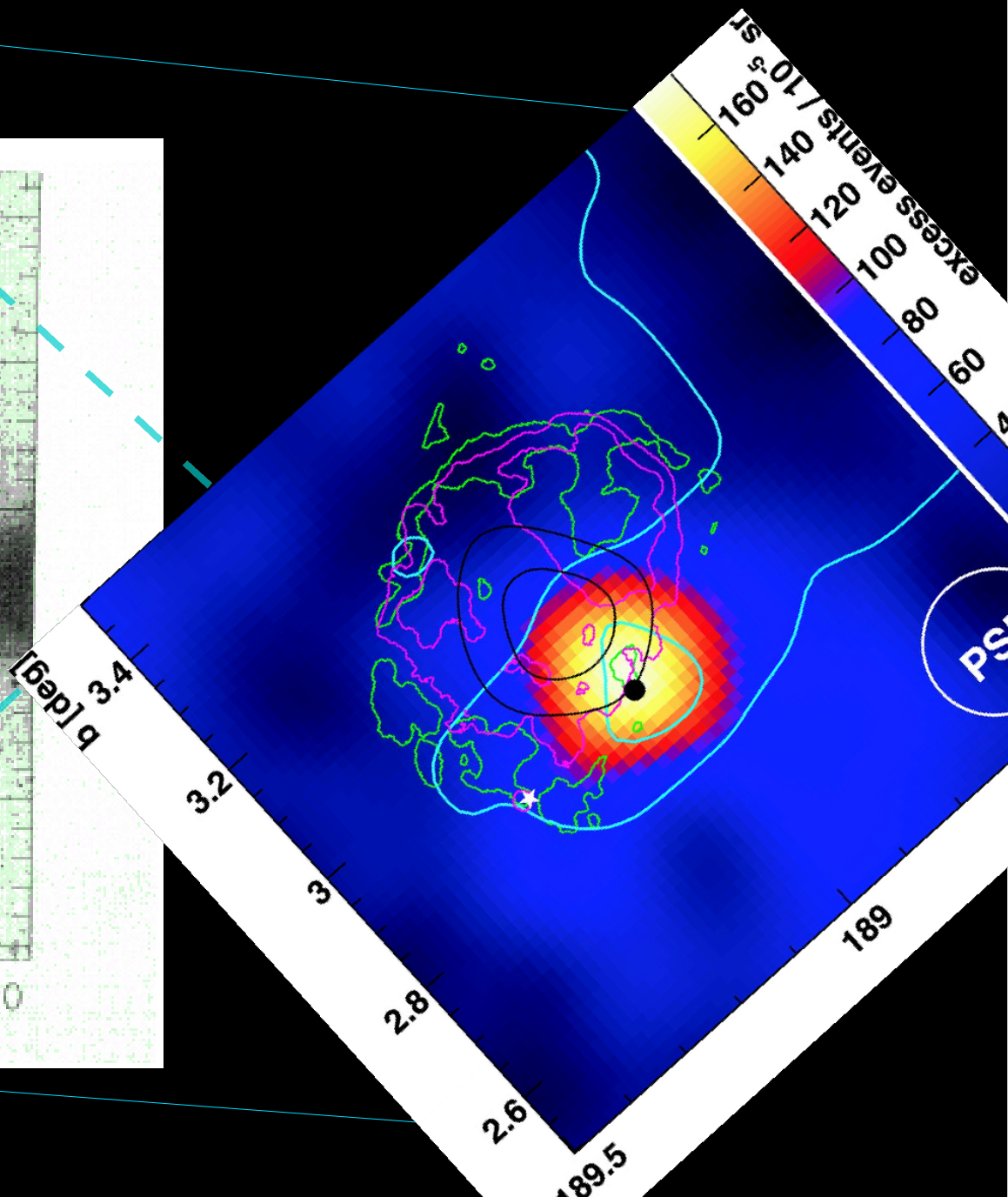

From Dickman et al. 1992

**Evidence of interaction given by the observations of an high value of the ratio CO (J=2-1)/(J =1-0) (Seta, M., et al., 1998. ApJ)**

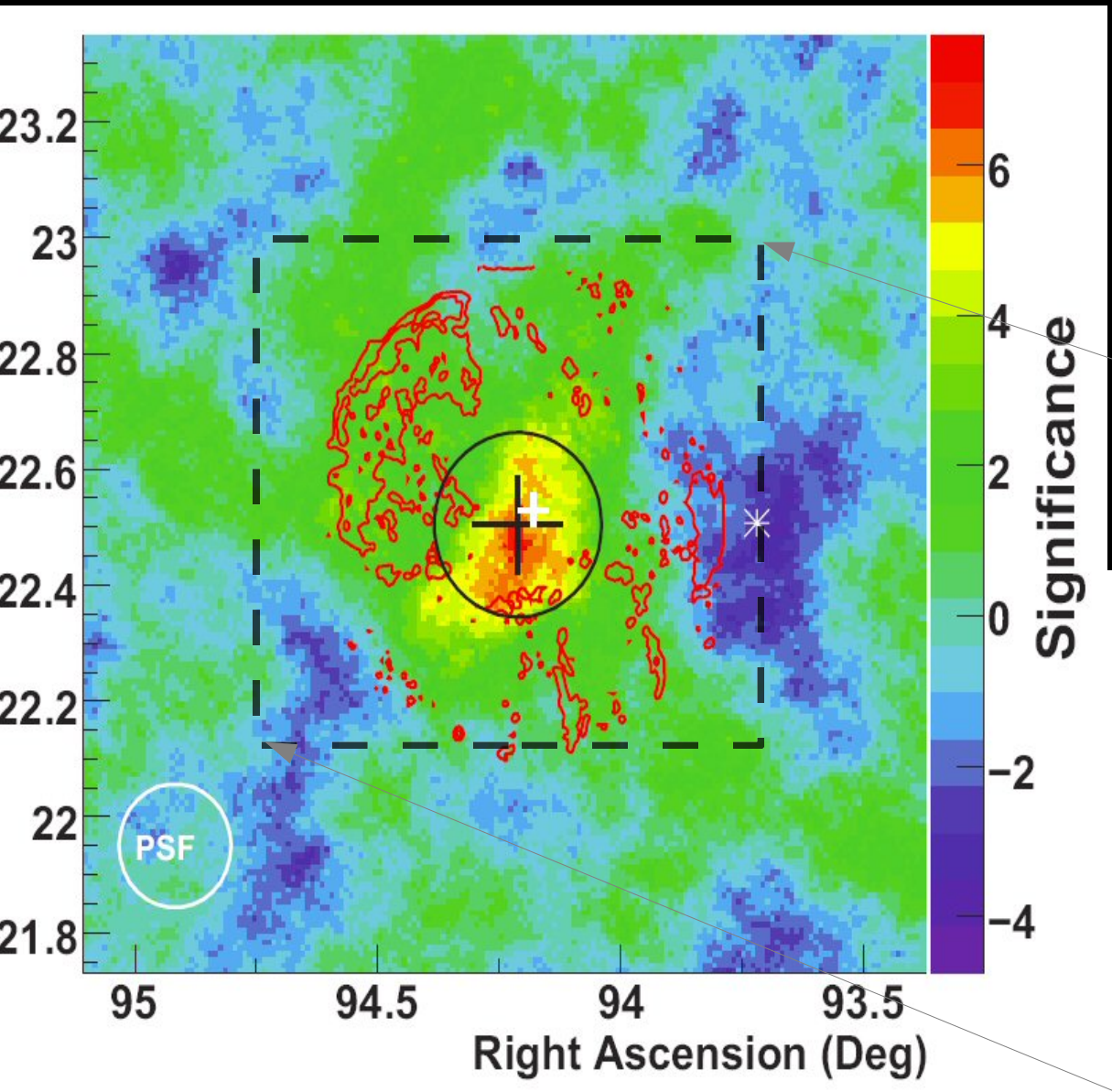


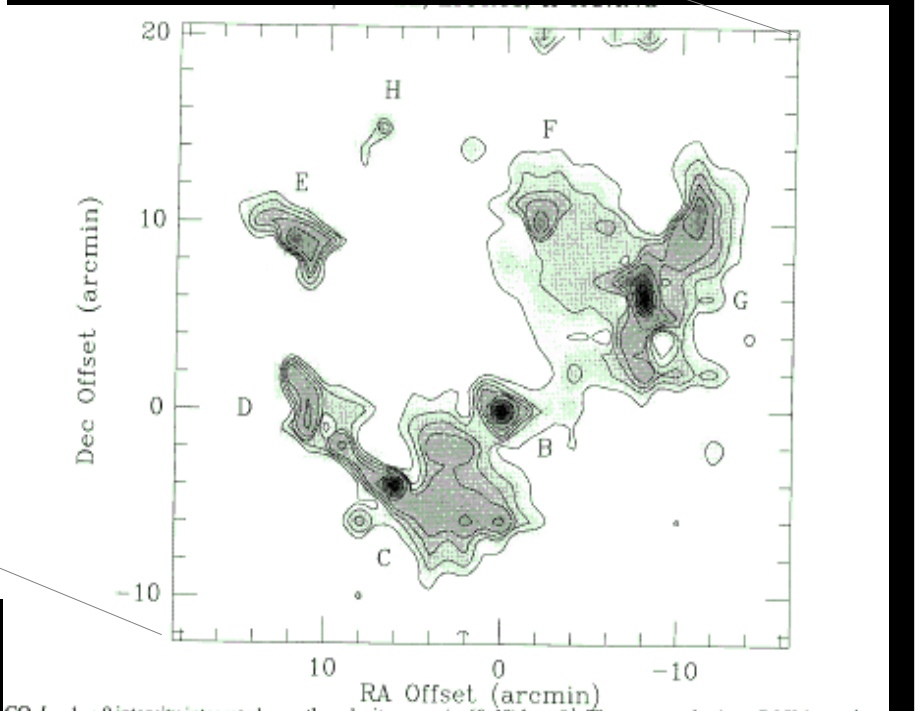
# IC 443 – TeV detection by MAGIC



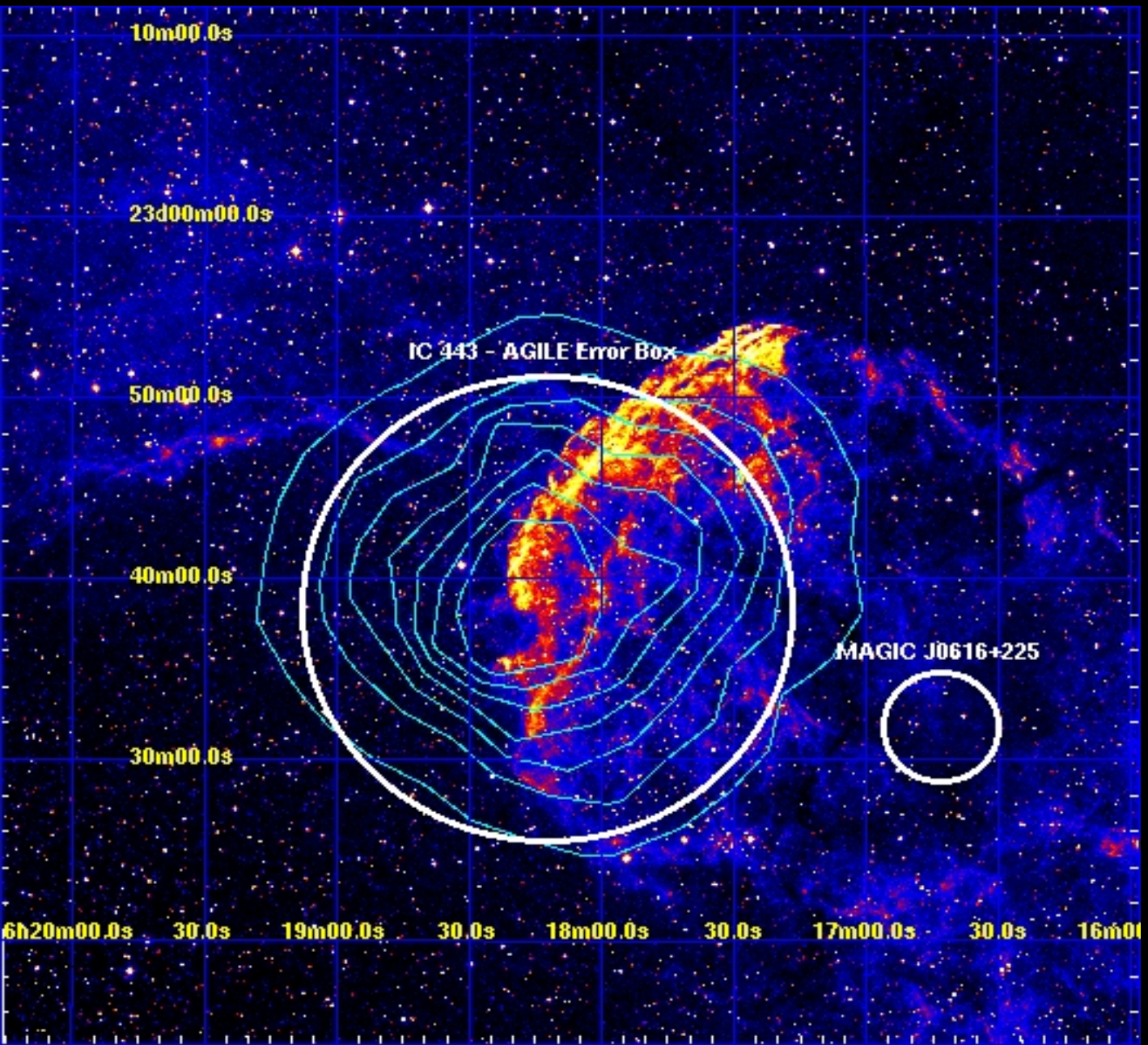
# IC 443 – TeV detection by VERITAS




Acciari et al. 2009

# IC 443 seen by AGILE (2008)




**Gev Source**

**≠**

**TeV Source**

# Diffusion of CR in the Interstellar Medium

$$\frac{df(E,r)}{dt} = D\nabla^2 f(E,r) + \frac{d}{dE}Pf(E,r) + Q(E,r)$$

$$R_{diff} = 2\sqrt{Dt}$$

**Aharonian & Atoyan**, A&A, 309, 1996

**Diffusion Coef :**

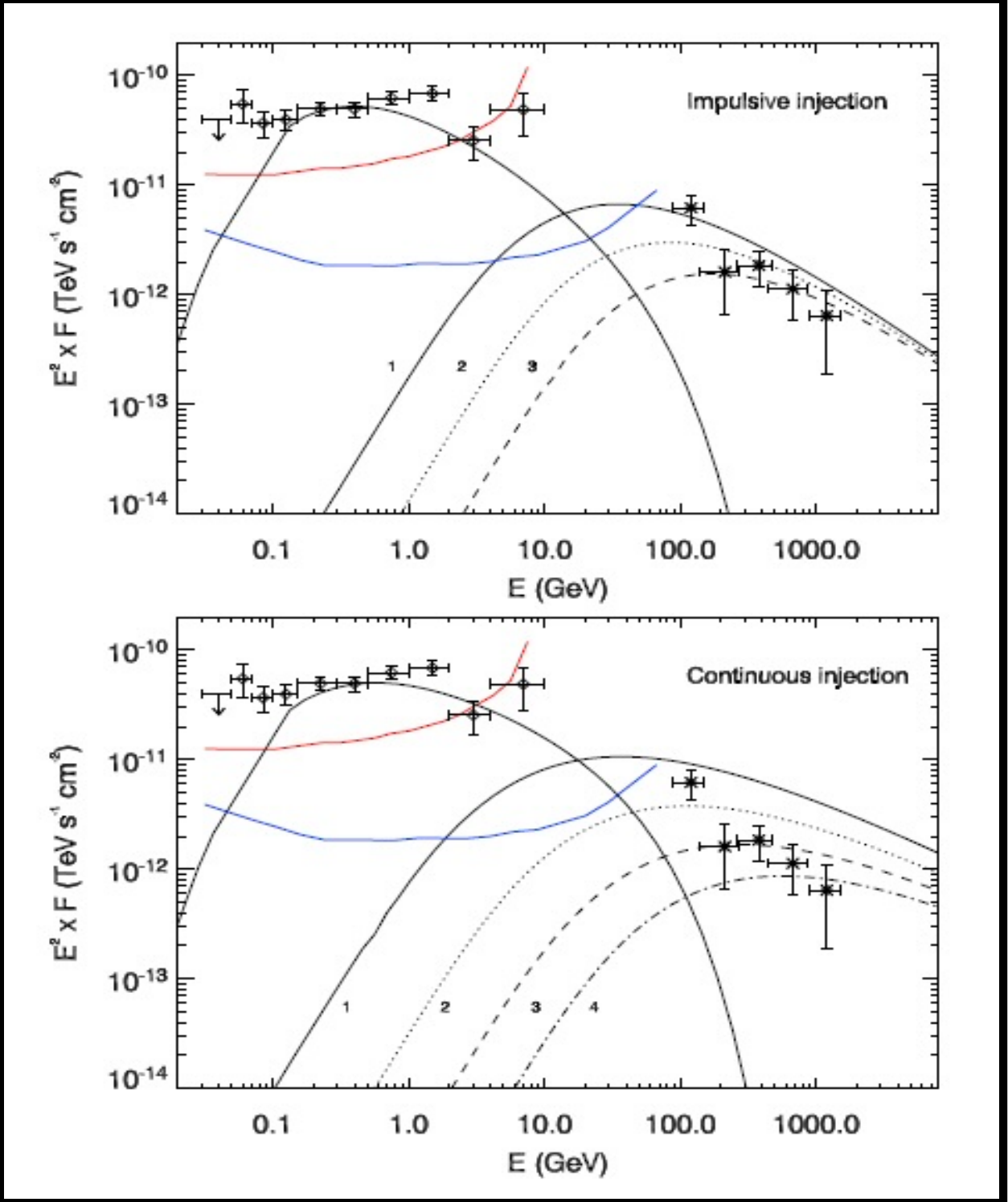
**$D(E) = 10^{26}$ (E/10 GeV)$^{0.5}$**

**t ~ sqrt(E)**

# IC 443: EGRET vs. MAGIC data

## Impulsive vs. continuous injection

Torres et al., MNRAS, 08

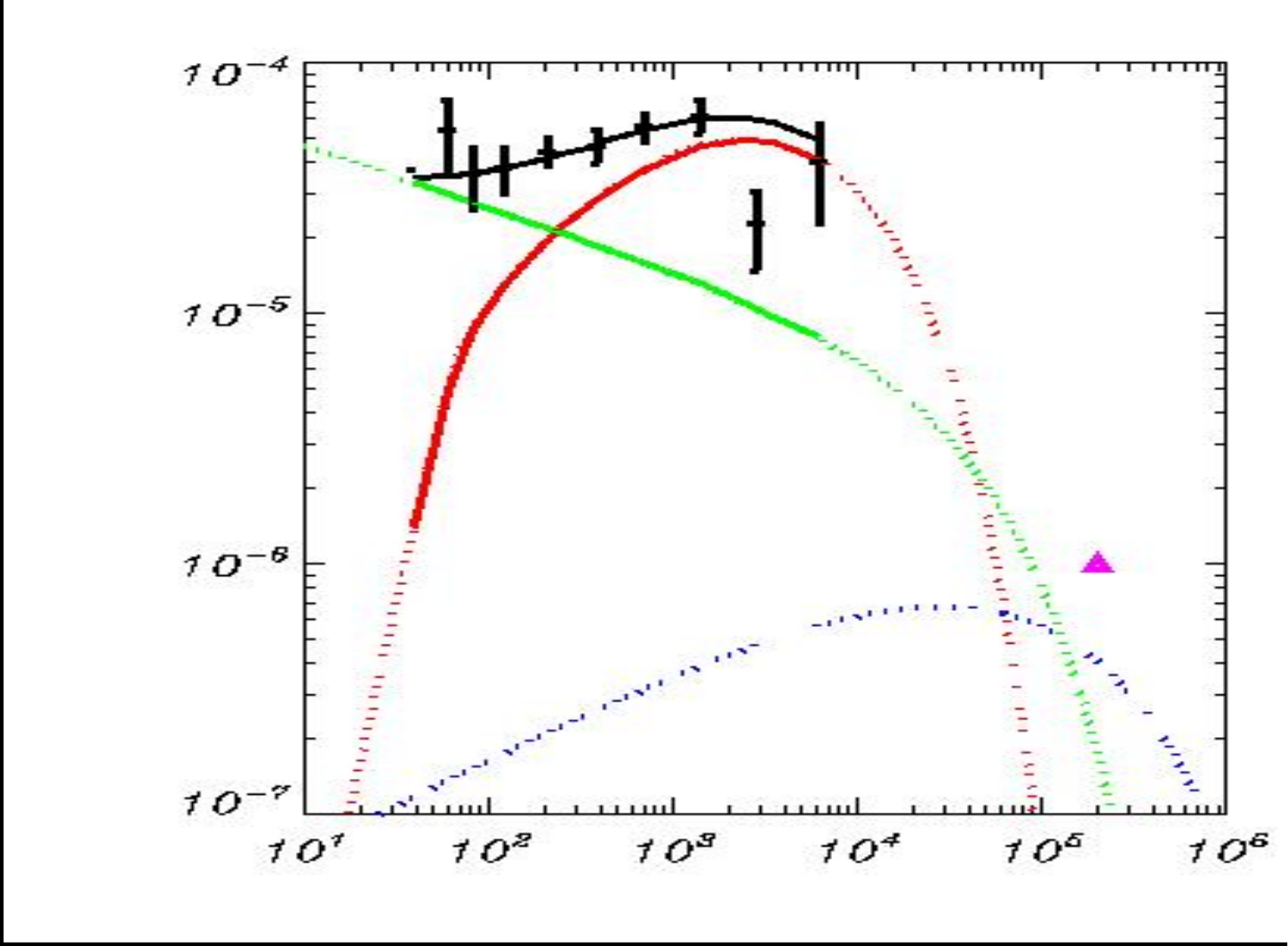


# IC 443 gamma spectrum

**Model:**
**pp collision**
**+**
**$e^-$ bremstrahlung**

**Spectral indices:**
**$\alpha p = \alpha e = 2.25$**

**Mcl = 20 Msol**




see also : Gaisser et al., 1998

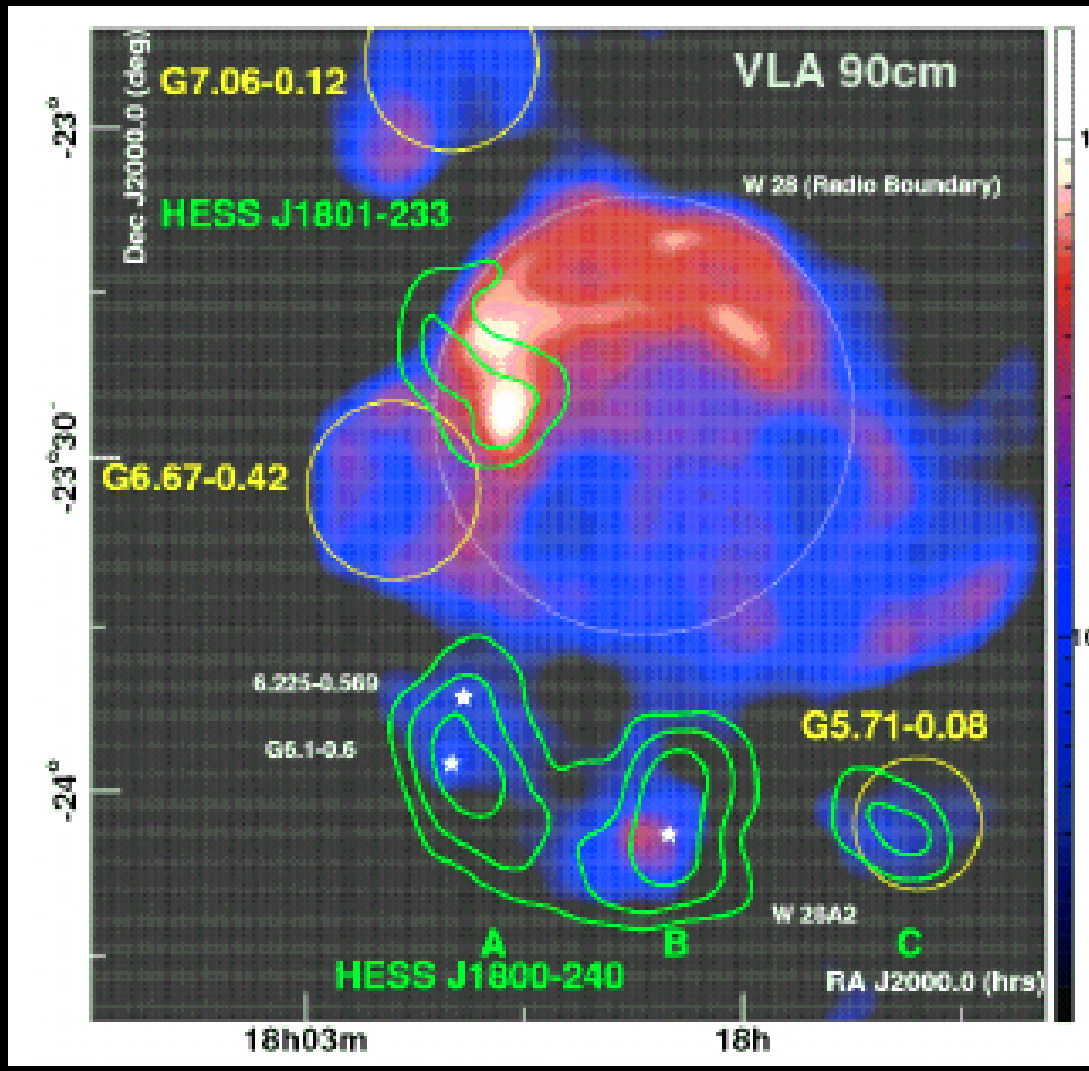
# *SNR W 28*

**Distance : 2 – 3 kpc**

**Age : > 35 yrs**

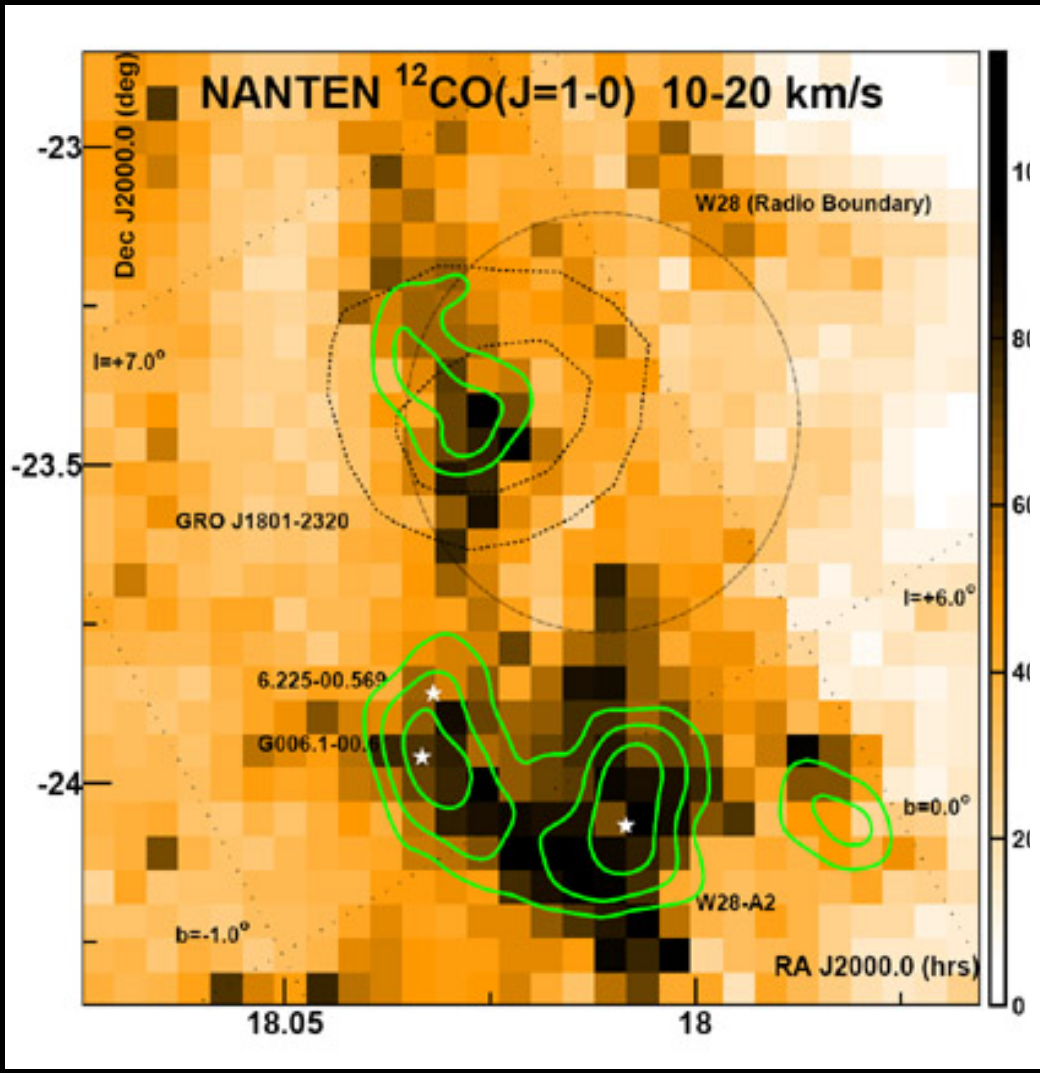
**Size : 20-35 pc (50')**

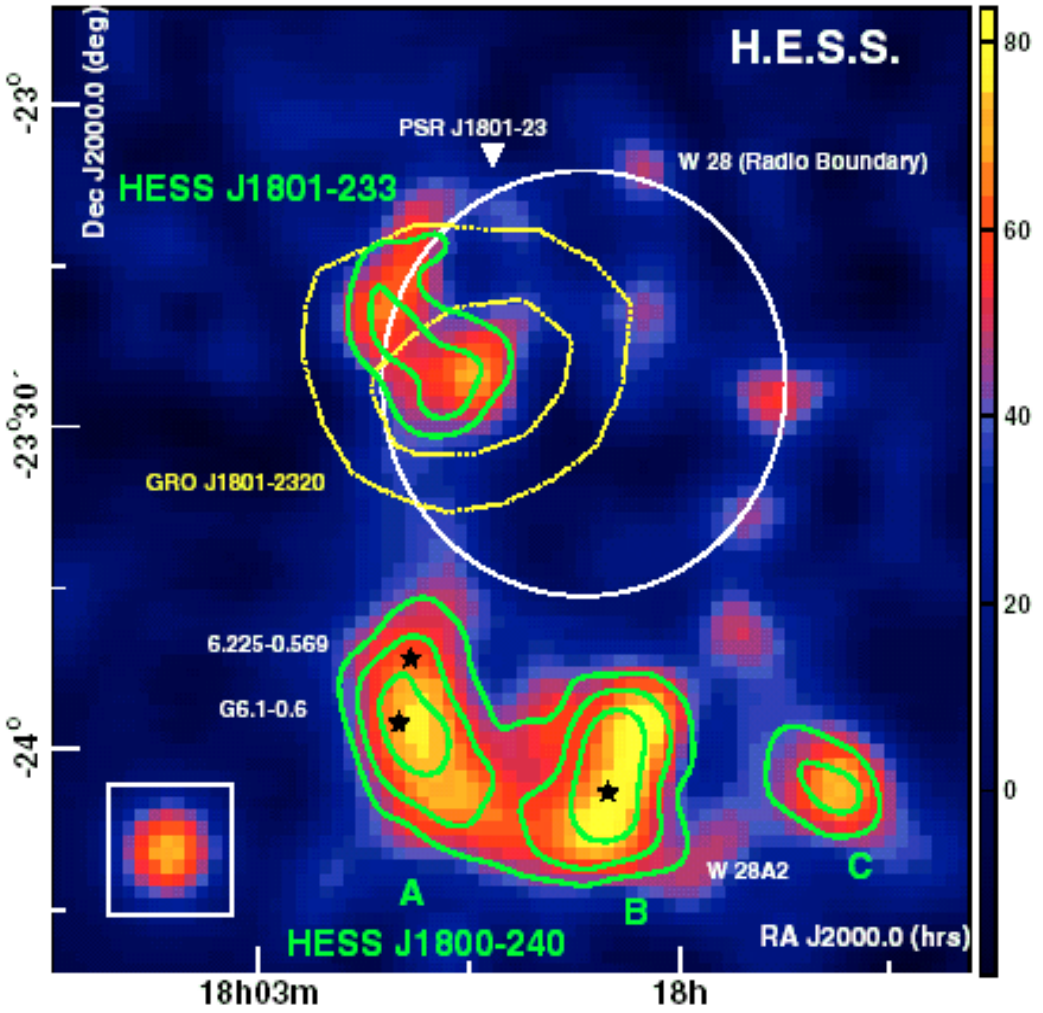
**Mixedmorphology SNR**




from **Aharonian et al. 2008**

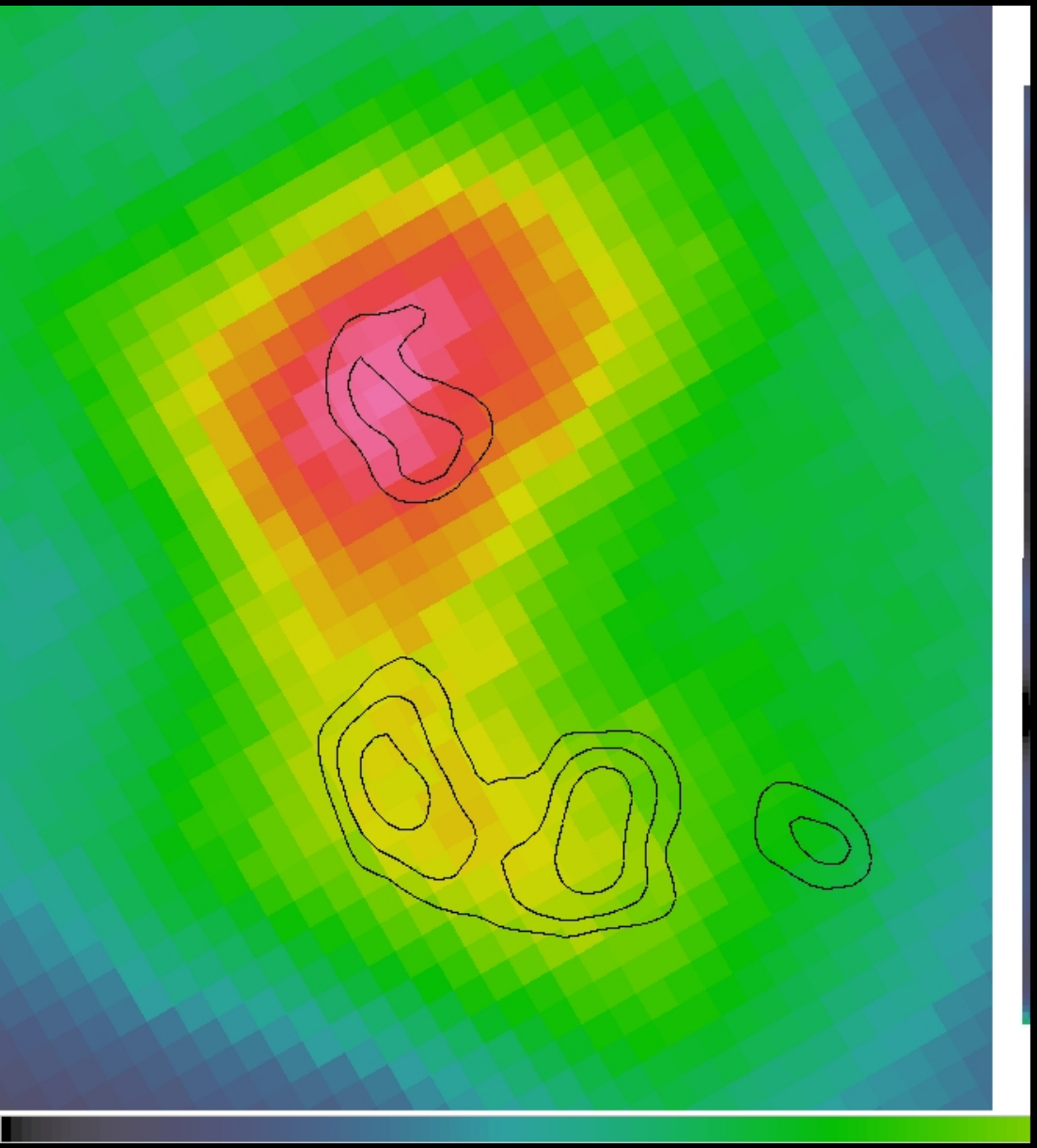
# SNR W 28 : M.Clouds and TeV



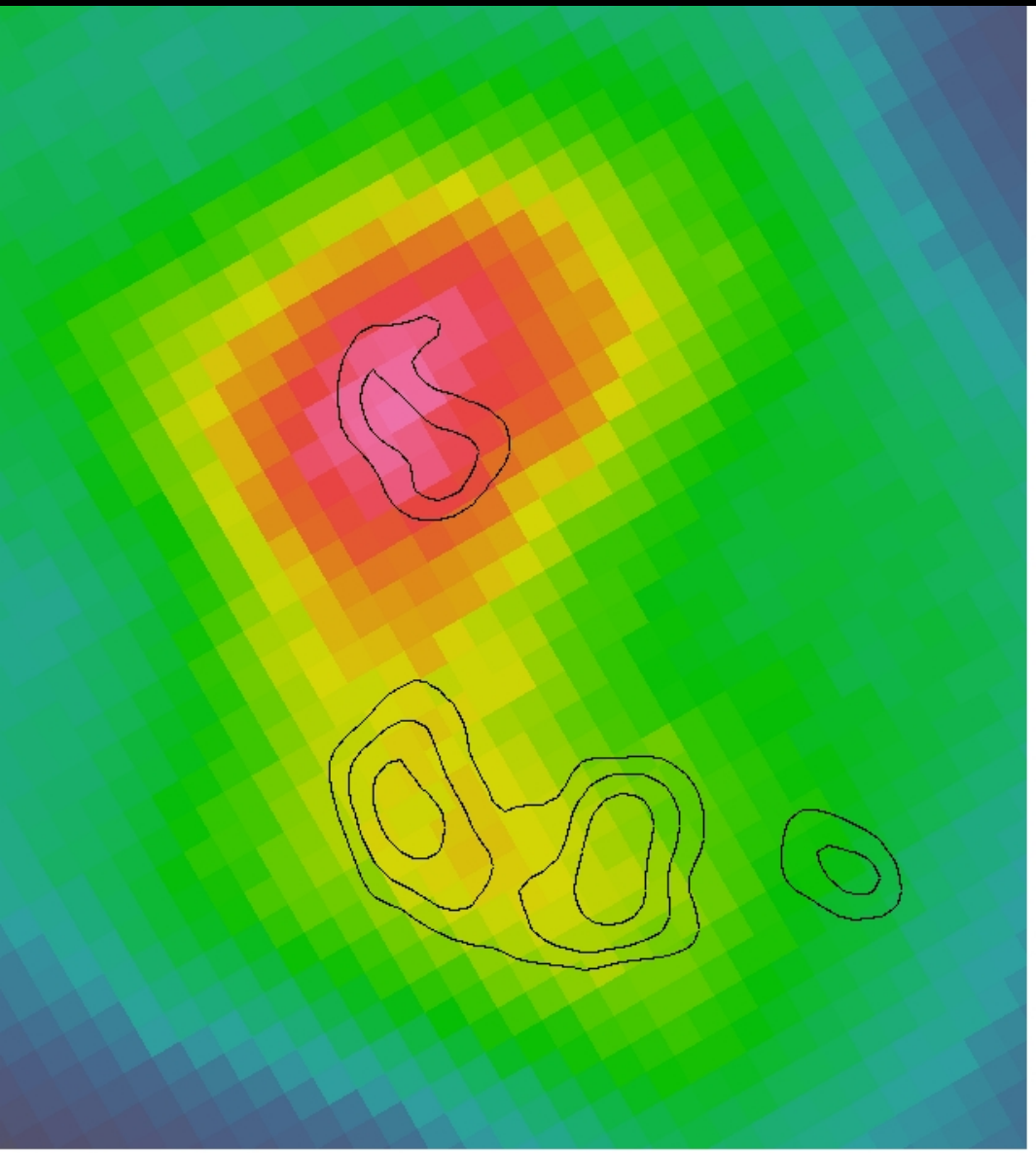

from **Aharonian et al. 2008**

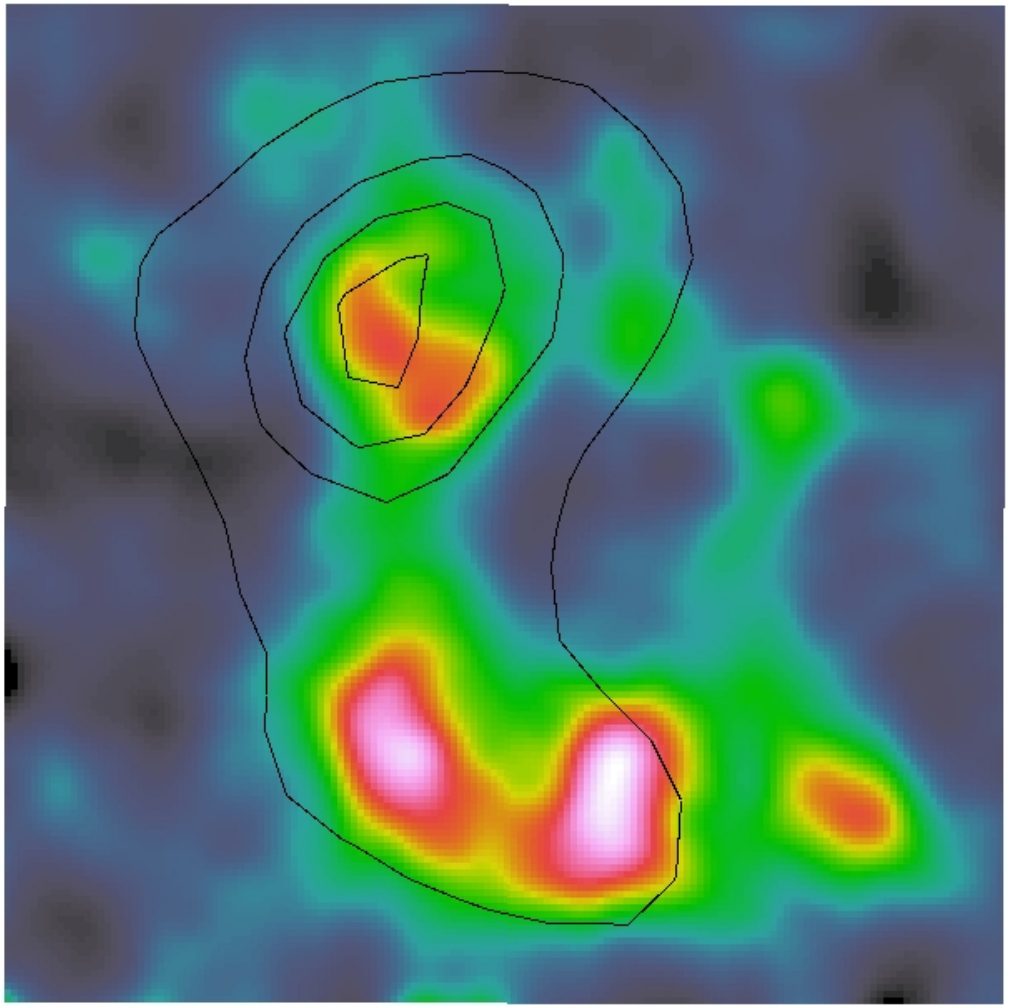
# AGILE/GRID Observations
# E>400 MeV
# (+HESS contours)

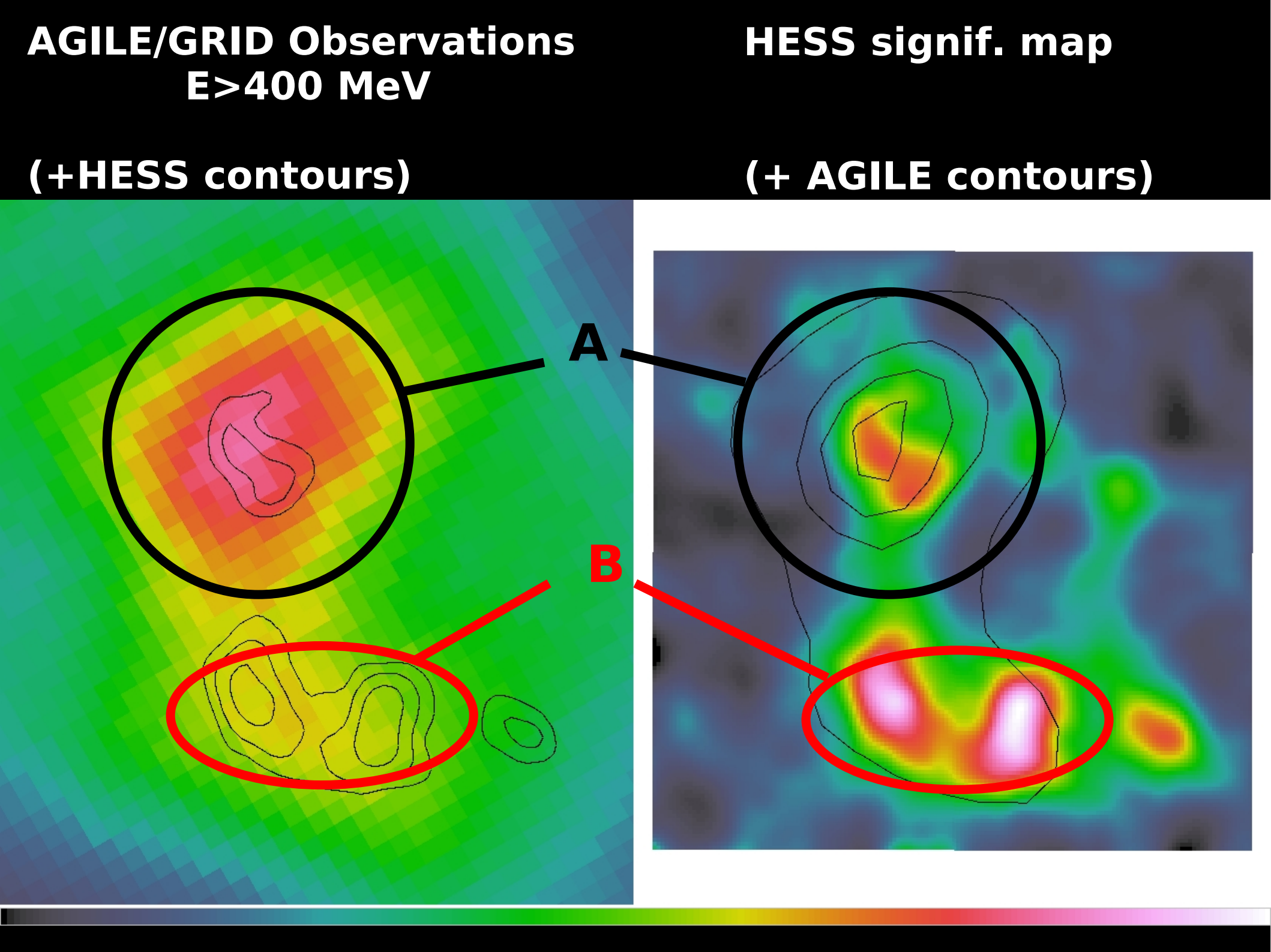


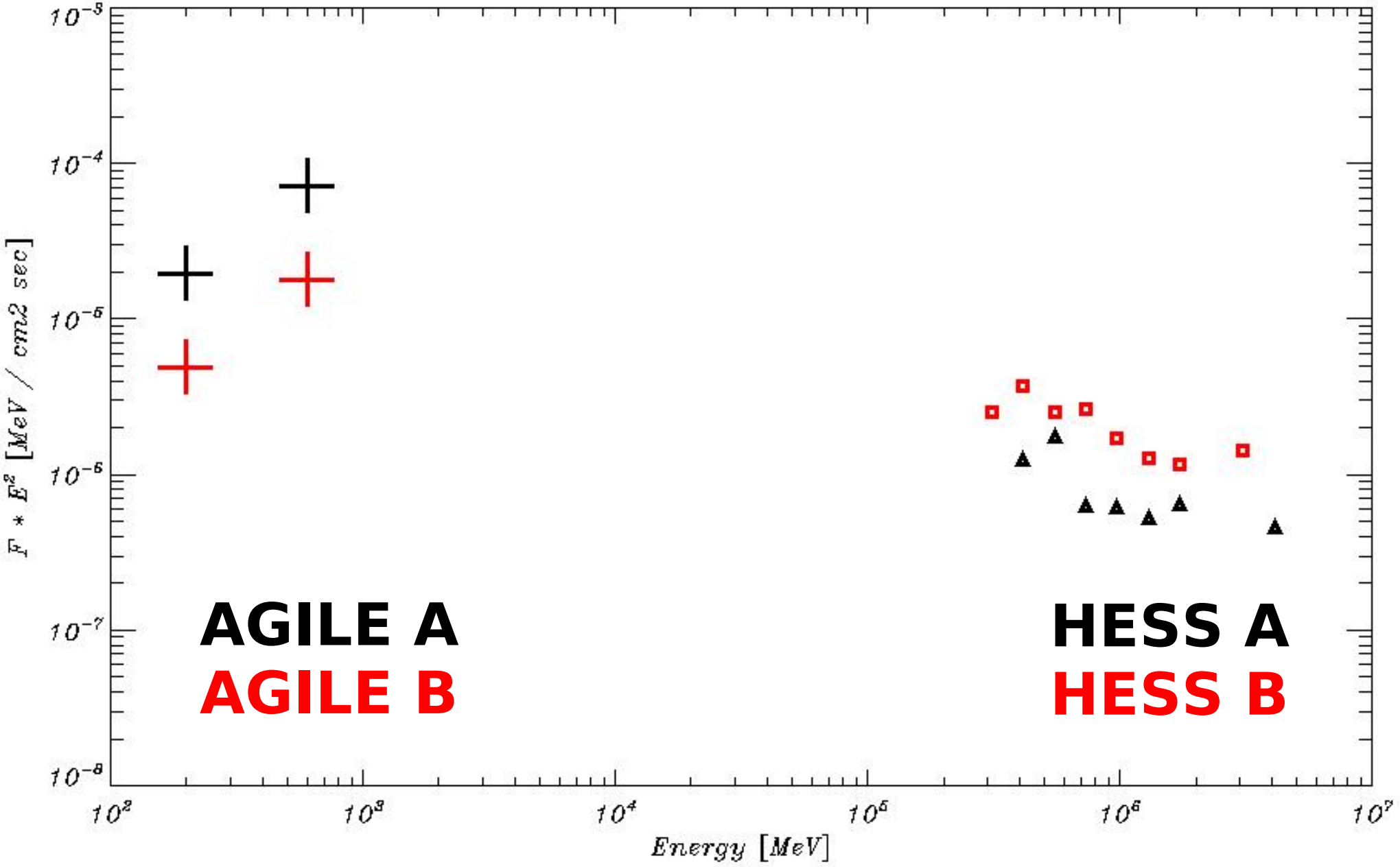
**AGILE/GRID Observations**
**E>400 MeV (+HESS contours)**

**HESS signif. map**
**(+ AGILE contours)**






AGILE/GRID Observations
E>400 MeV
(+HESS contours)
HESS signif. map
(+ AGILE contours)
A
B


AGILE A
AGILE B
HESS A
HESS B
F * E² [MeV / cm2 sec]
Energy [MeV]

# Model for W 28

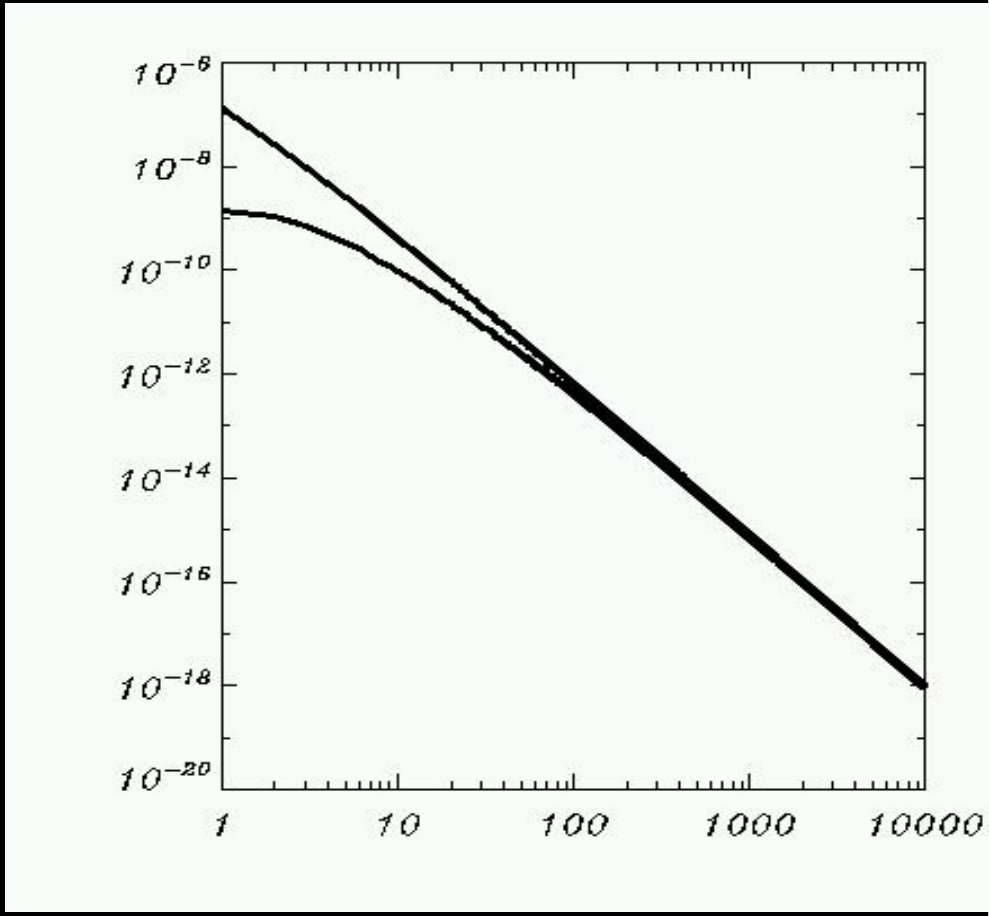
**Gamma ray by $\pi^0$ decay**

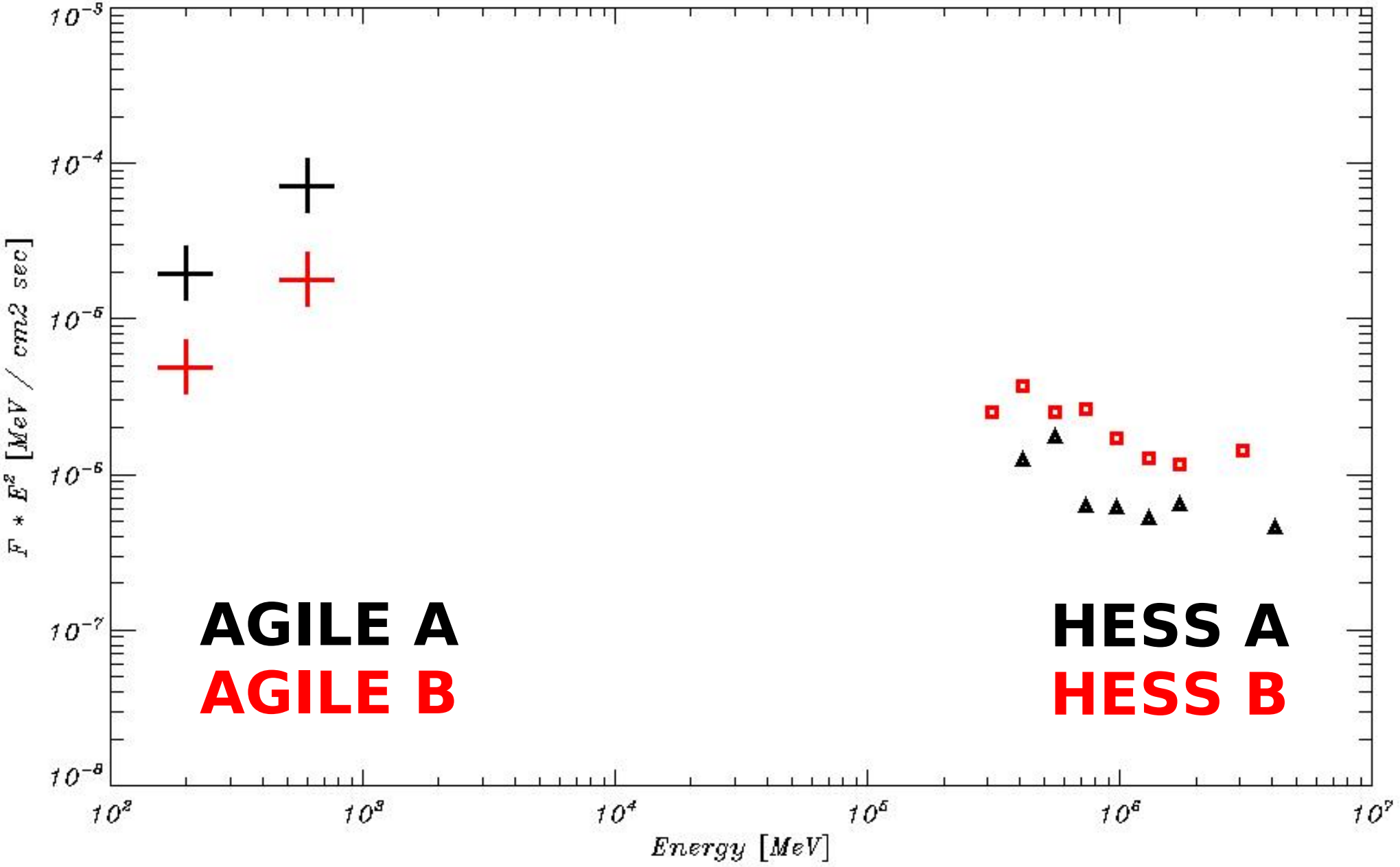
**Proton spectrum @ SNR : $F \sim E^{-2.2}$**

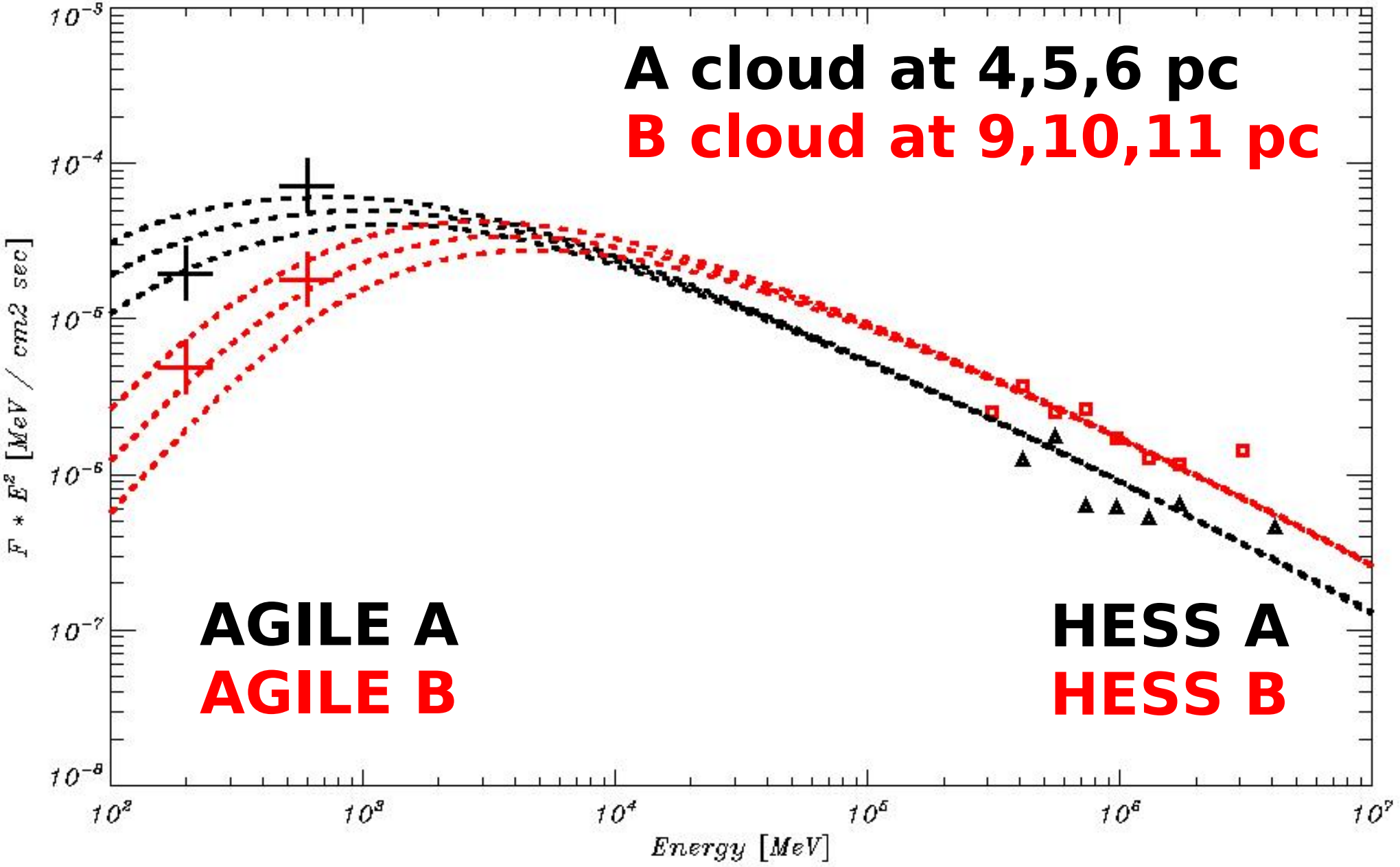
**Diffussion : $D = 10^{26}\ (E/10\ \mathrm{GeV})^{0.5}$**

**Distances of targets:**
**A region : 5 pc**
**B region : 10 pc**

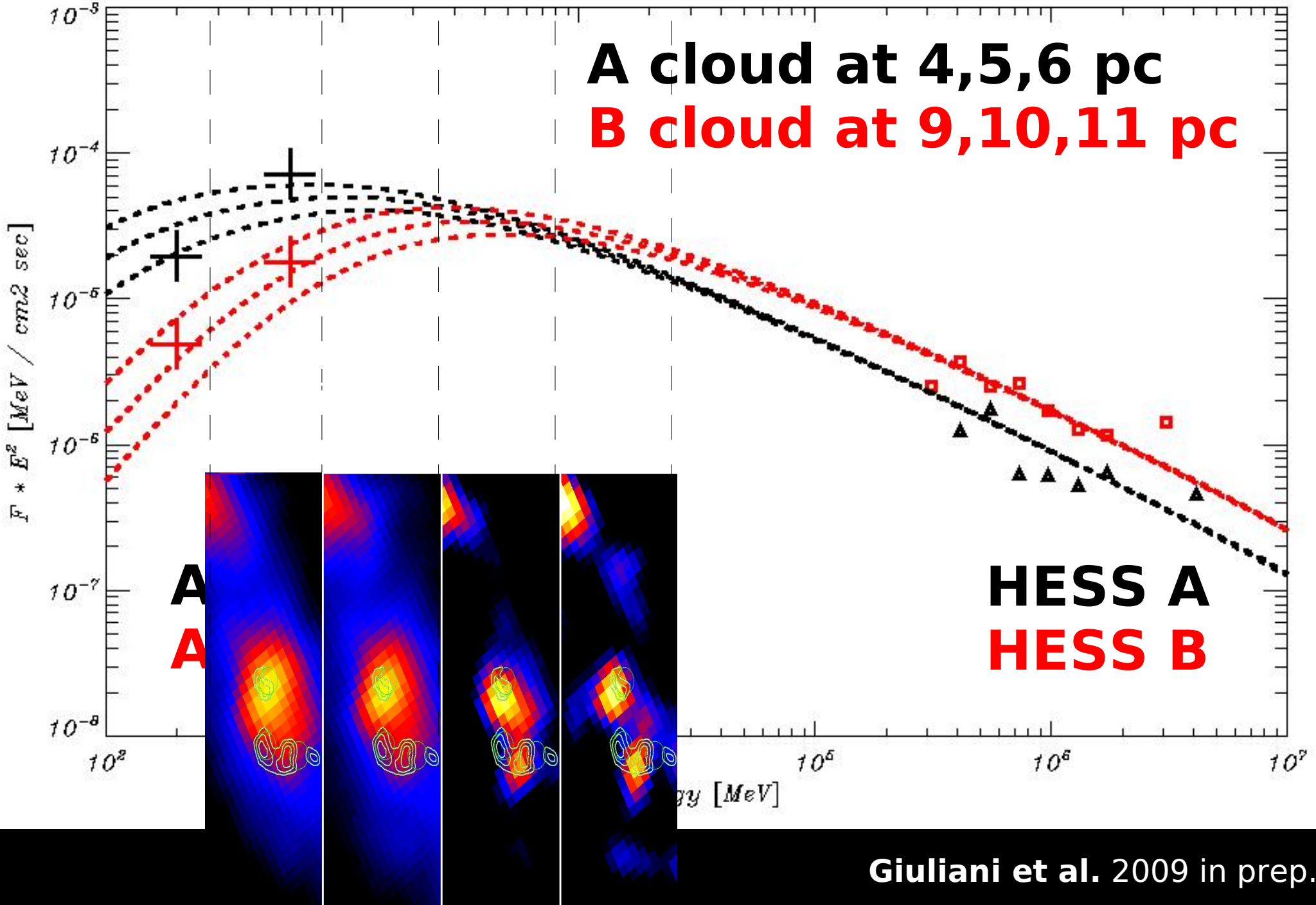
**Age of the SNR : 45 kyrs**




AGILE A
AGILE B
HESS A
HESS B
F * E² [MeV / cm2 sec]
Energy [MeV]




**Giuliani et al.** 2009 in prep.



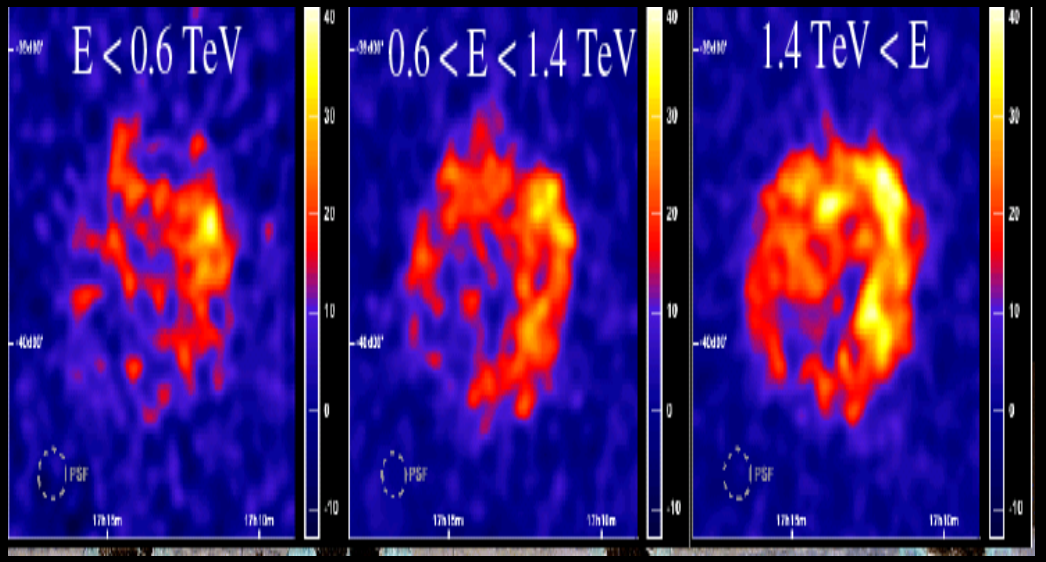

**Giuliani et al.** 2009 in prep.

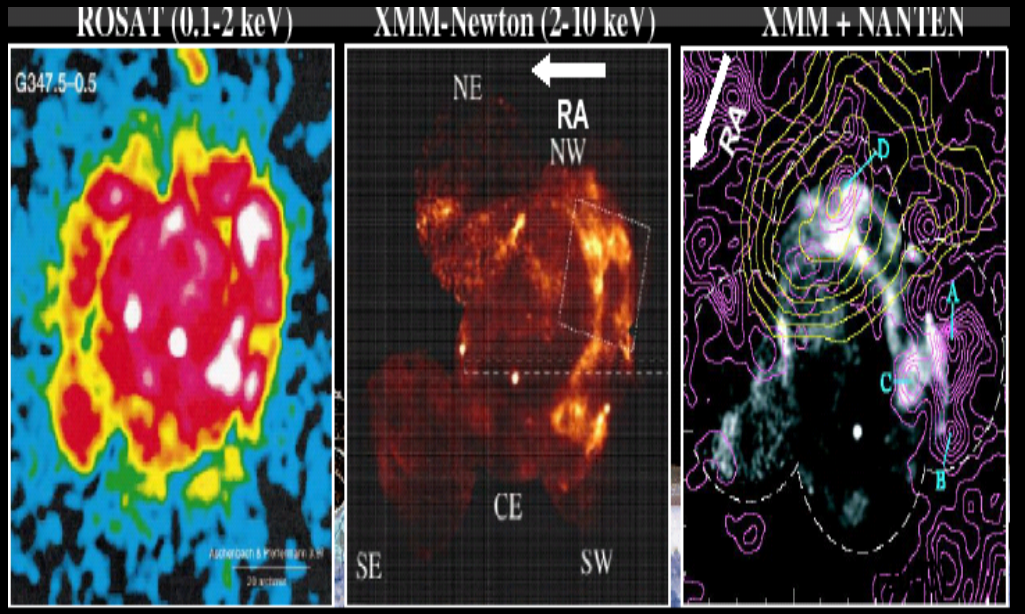
# RX J1713.7–3946

**Distance : 1.2 kpc**

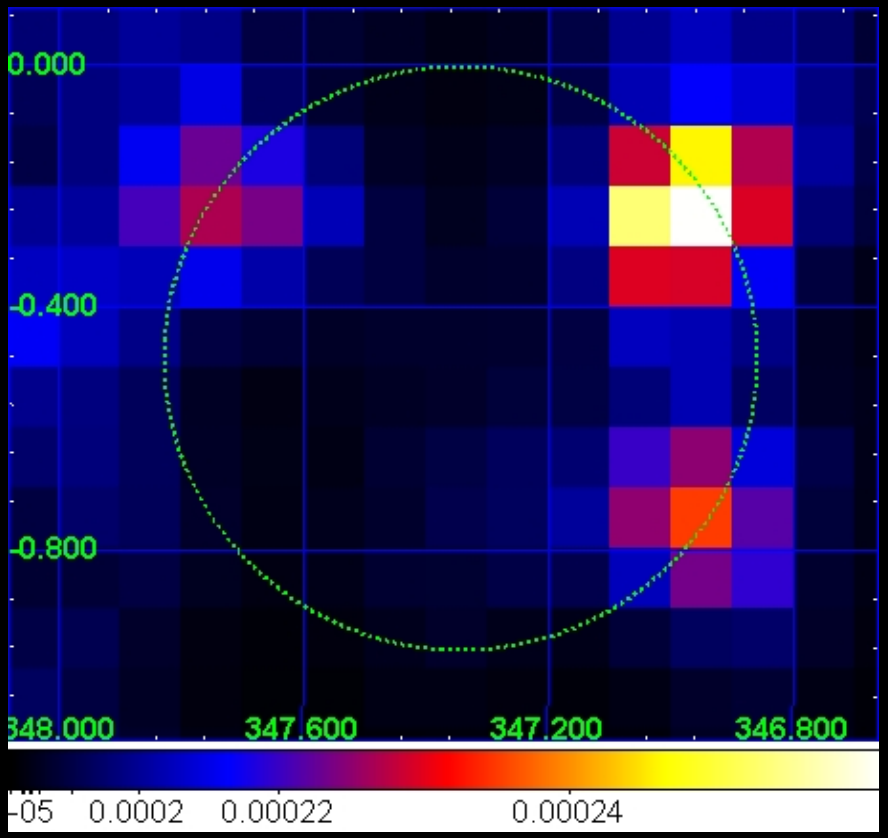
**Age : 2 kyrs**

**Size : 65'**



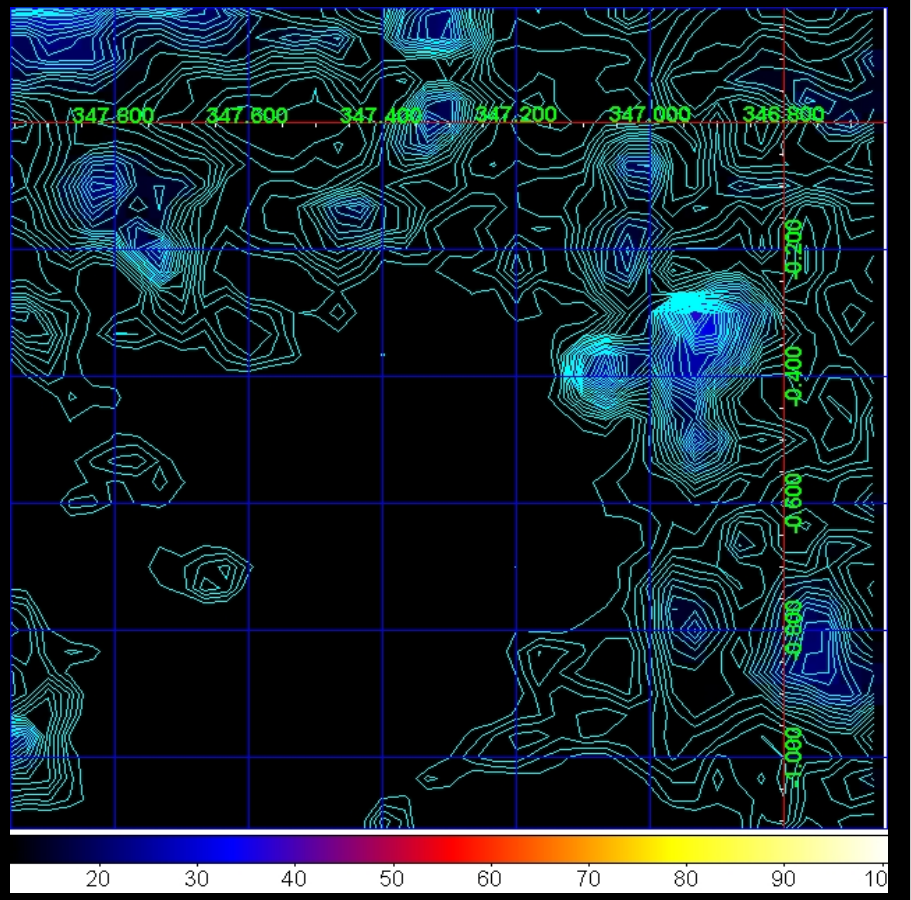



# SNR RX J1713-3946




**AGILE/GRID**

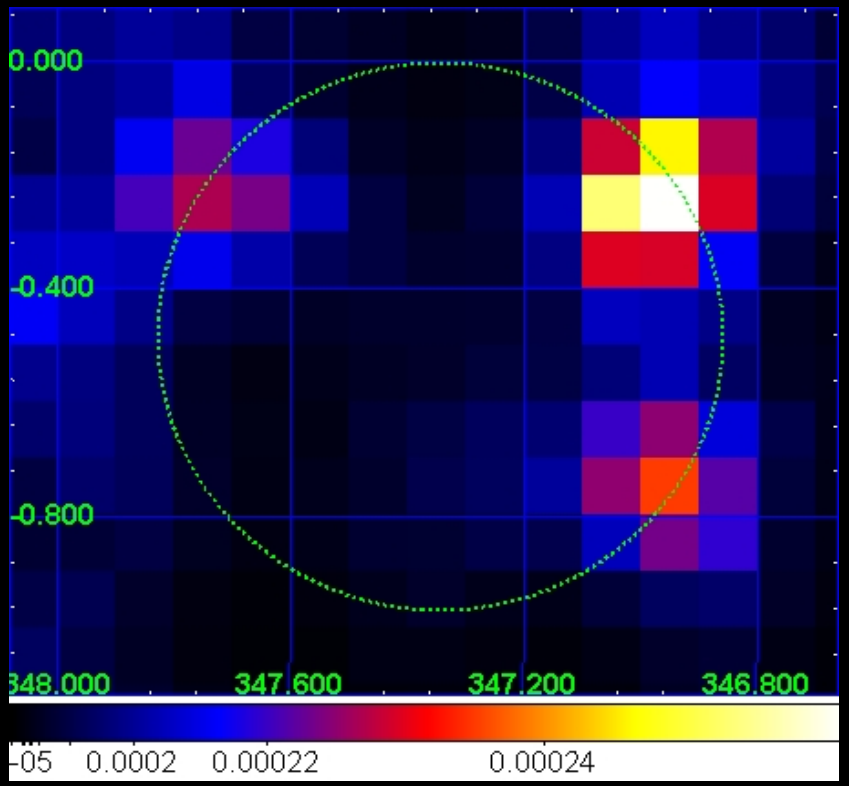
**Intensity Map (E> 400 MeV)**

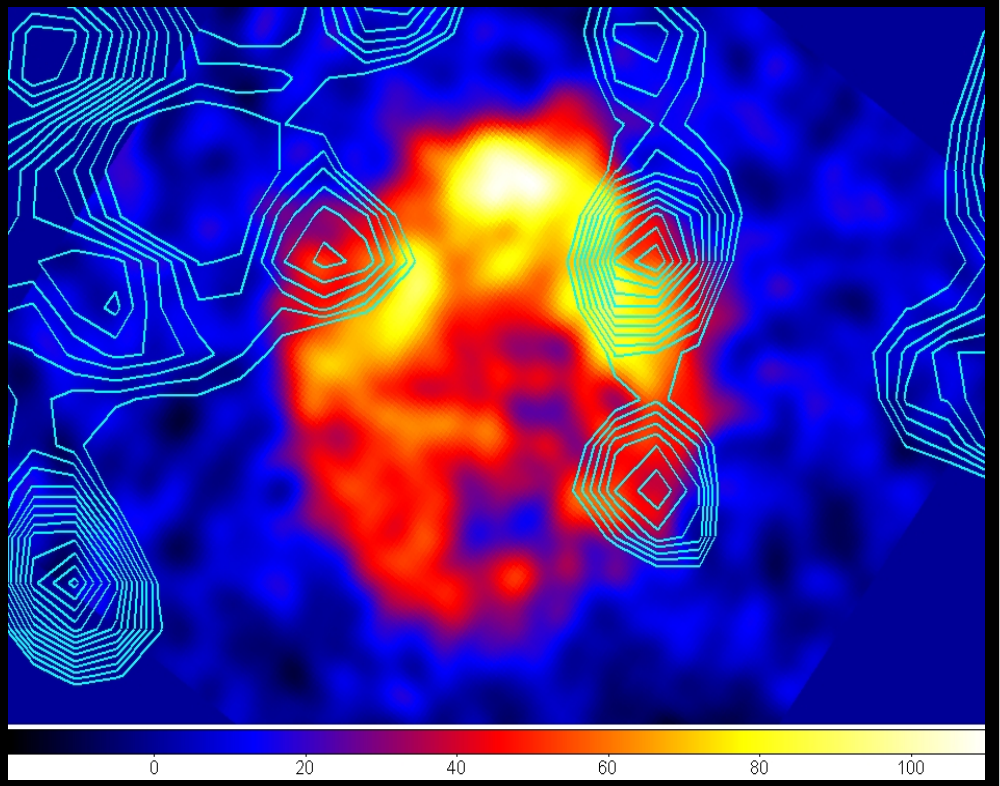



**NANTEN**

**CO map**

# SNR RX J1713-3946




**AGILE/GRID**

**Intensity Map (E> 400 MeV)**

**HESS Intensity Map**

# The puzzling SNR J1713

- Gev and CO correlate strongly
- Gev and TeV correlate weakly

# Conclusions

- SNRs are finally resolved in the MeV-GeV energy range
- Clear correlation between 100 MeV-GeV emission and shocked Molecular Clouds (IC 443, W 28, RX J1713)
- Apparent flux anticorrelation between 100 MeV -Gev and TeV bands
- GeV and TeV connection is crucial to understand the SNRs physics

Thank you !