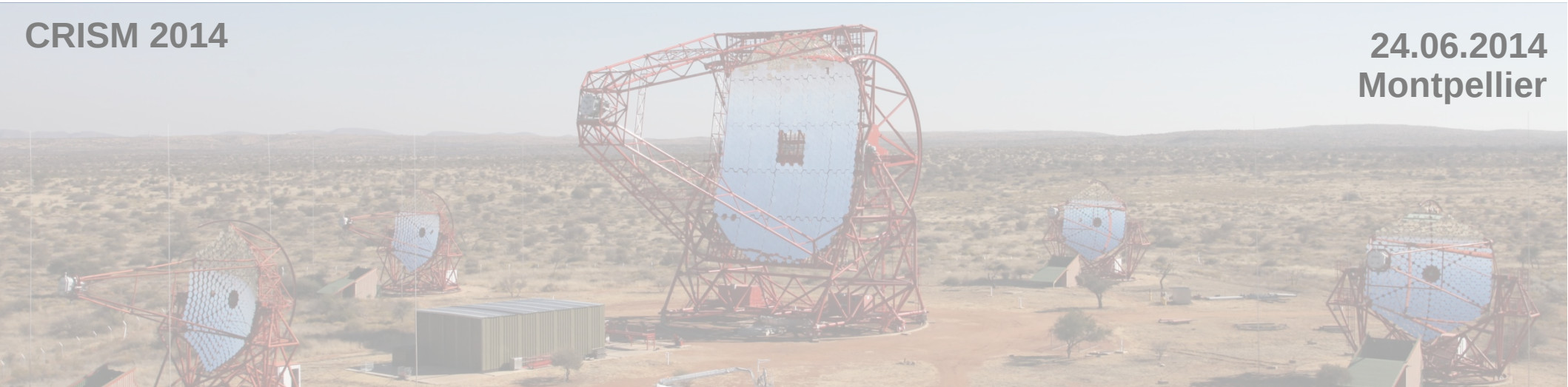
SNR and molecular cloud associations as seen by H.E.S.S.

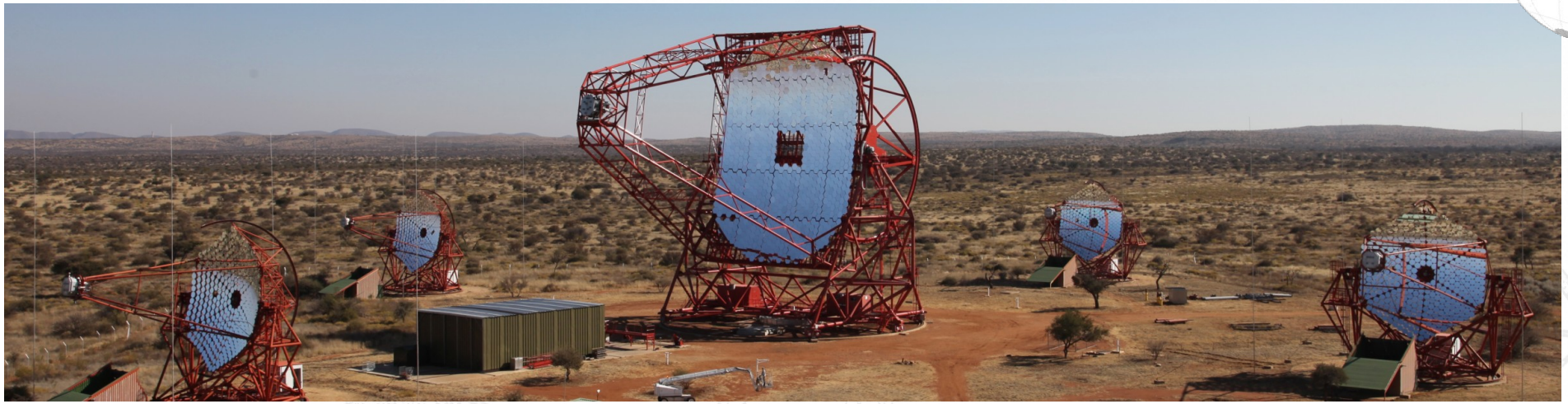
Cyril Trichard,
on behalf of the H.E.S.S. Collaboration



CRISM 2014

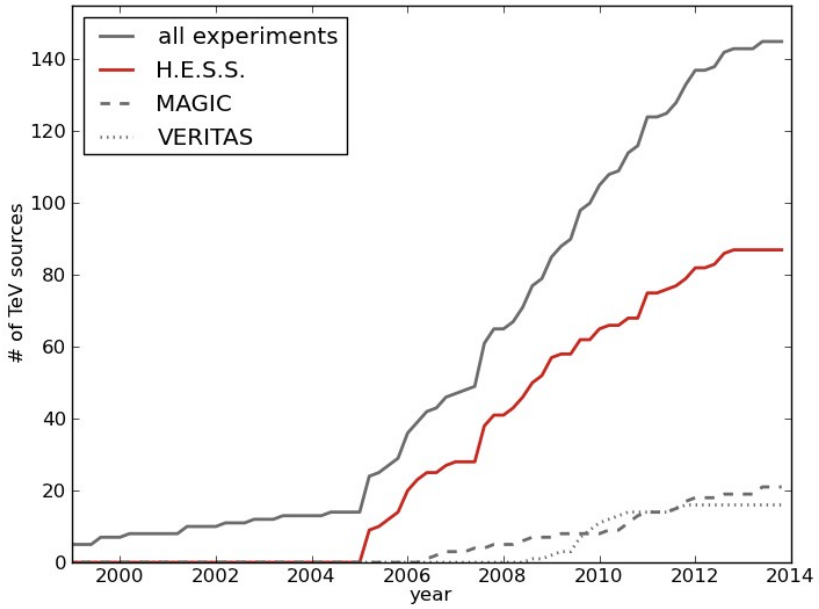
24.06.2014
Montpellier

H.E.S.S. experiment

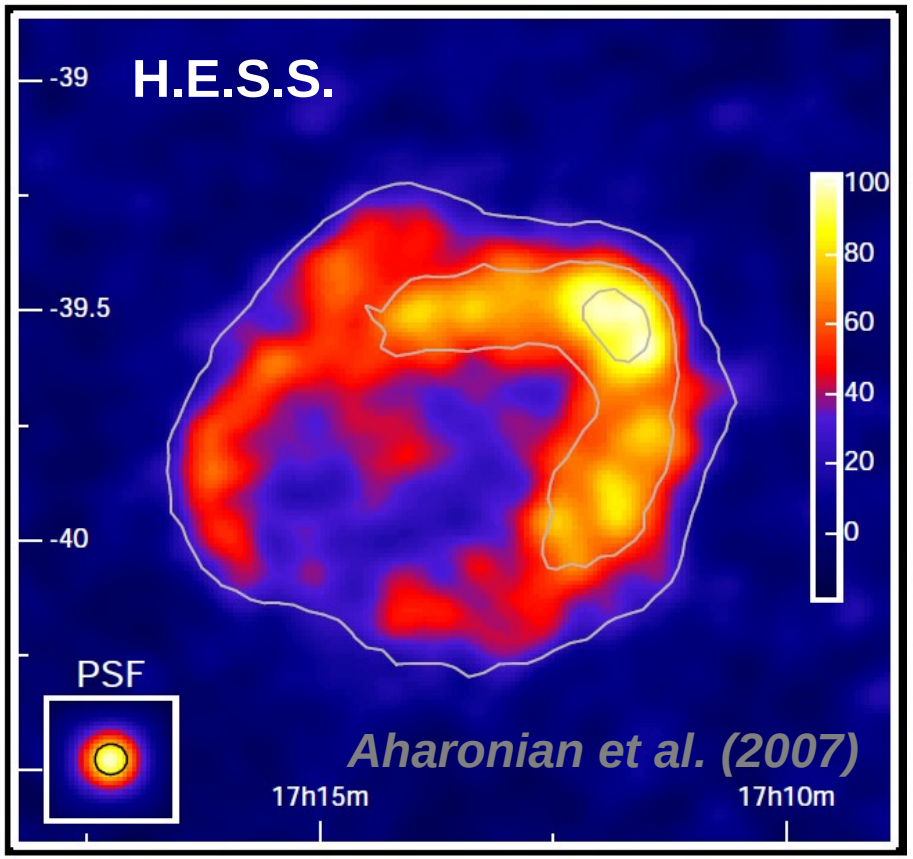


- **Most sensitive Cherenkov Telescopes**
  - **~100 GeV – 100 TeV**
- **Performant strategy for CR acceleration site study :**
  - **Large Galactic observations**
  - **High number of detected sources (>80)**
  - **Angular resolution <0.1 deg**

    => Very sucessful
- **New phase HESS II since 2012**
  - **Lower threshold**



SNR seen by H.E.S.S.



- **SNRs are best candidates for Galactic cosmic rays accelerators**
- **VHE Gamma-rays detected from several SNR shells**

  - Particles confined at shock
  - Evidence of >100 TeV accelerated particles

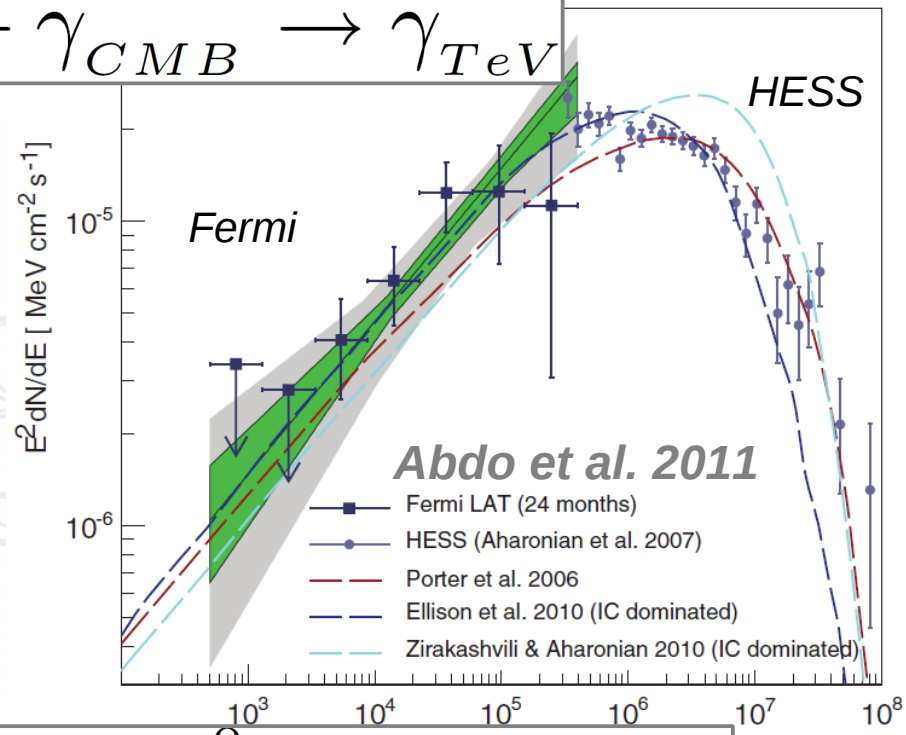
- **What's γ-rays origin ?**

$$e^- + \gamma_{CMB} \rightarrow \gamma_{TeV}$$

$$RC + p \rightarrow \pi^0 + \ldots \rightarrow \gamma_{TeV}$$

SNR seen by H.E.S.S.

$$e^- + \gamma_{CMB} \rightarrow \gamma_{TeV}$$



- **SNRs are best candidates for Galactic cosmic rays accelerators**

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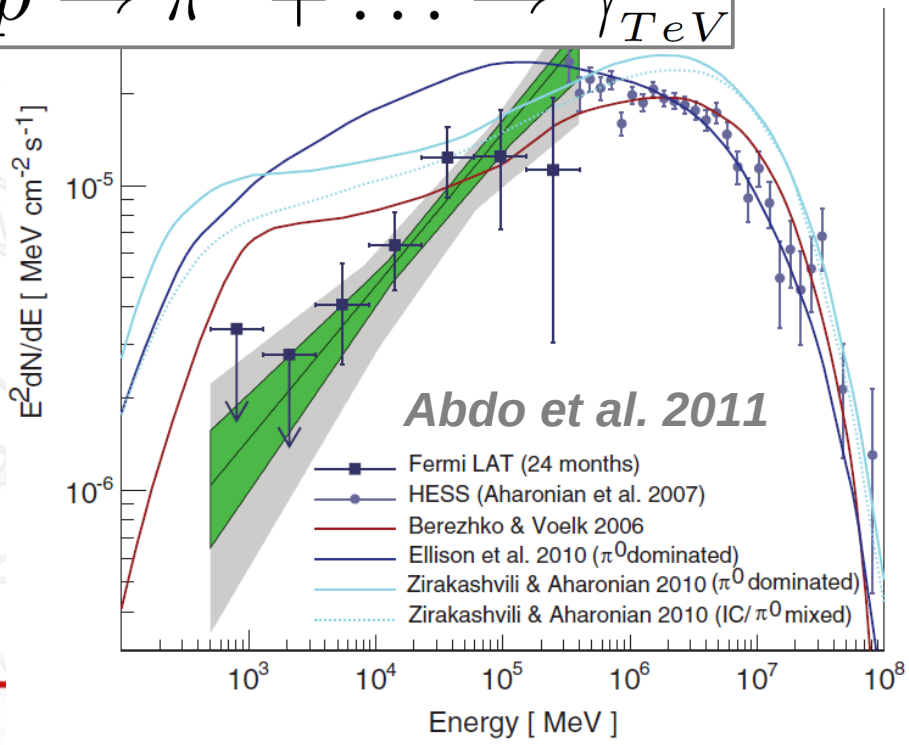


- **MWL measurements from RXJ1713 favor a leptonic origin**

  - **What about hadron acceleration ?**
  - **Not enough dense ISM to detect them ?**

SNR/MC interest

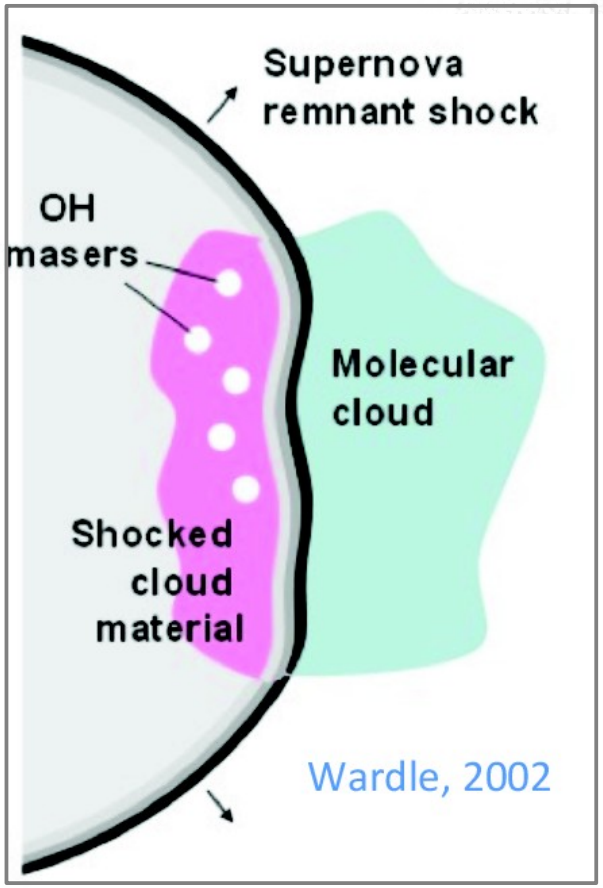
- **SNR shock propagating in dense medium :**

$$RC + p \rightarrow \pi^0 + \ldots \rightarrow \gamma_{TeV}$$

Require dense ISM

  - Gamma-ray emission from hadronic collisions enhanced

  - Illuminated cloud away from the SNR may probe the highest CR energies



- **Massive stars originate inside massive dense coulds**

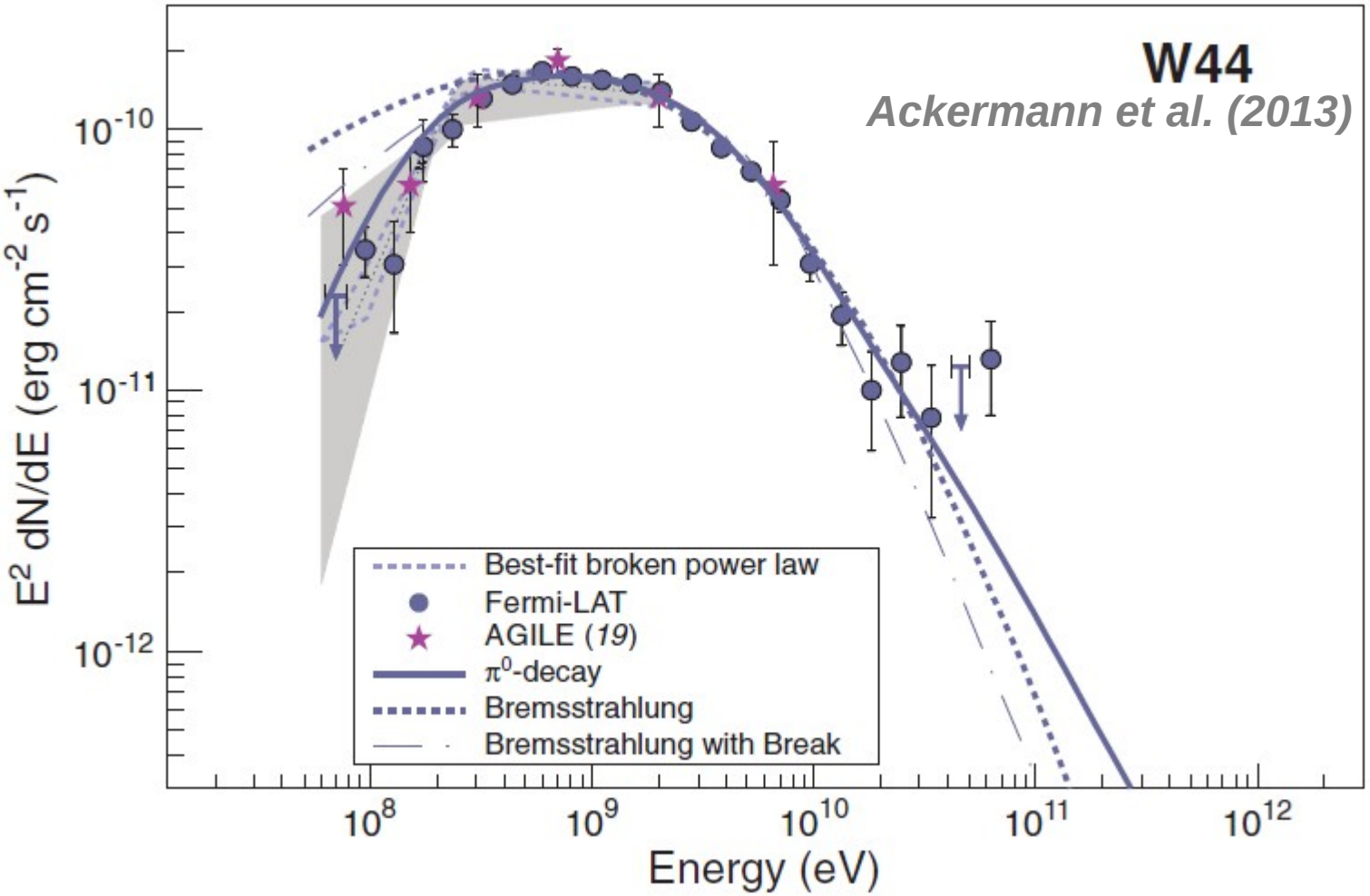
  - Short life time => SNe close to the progenitor clouds

  - Frequent associations expected

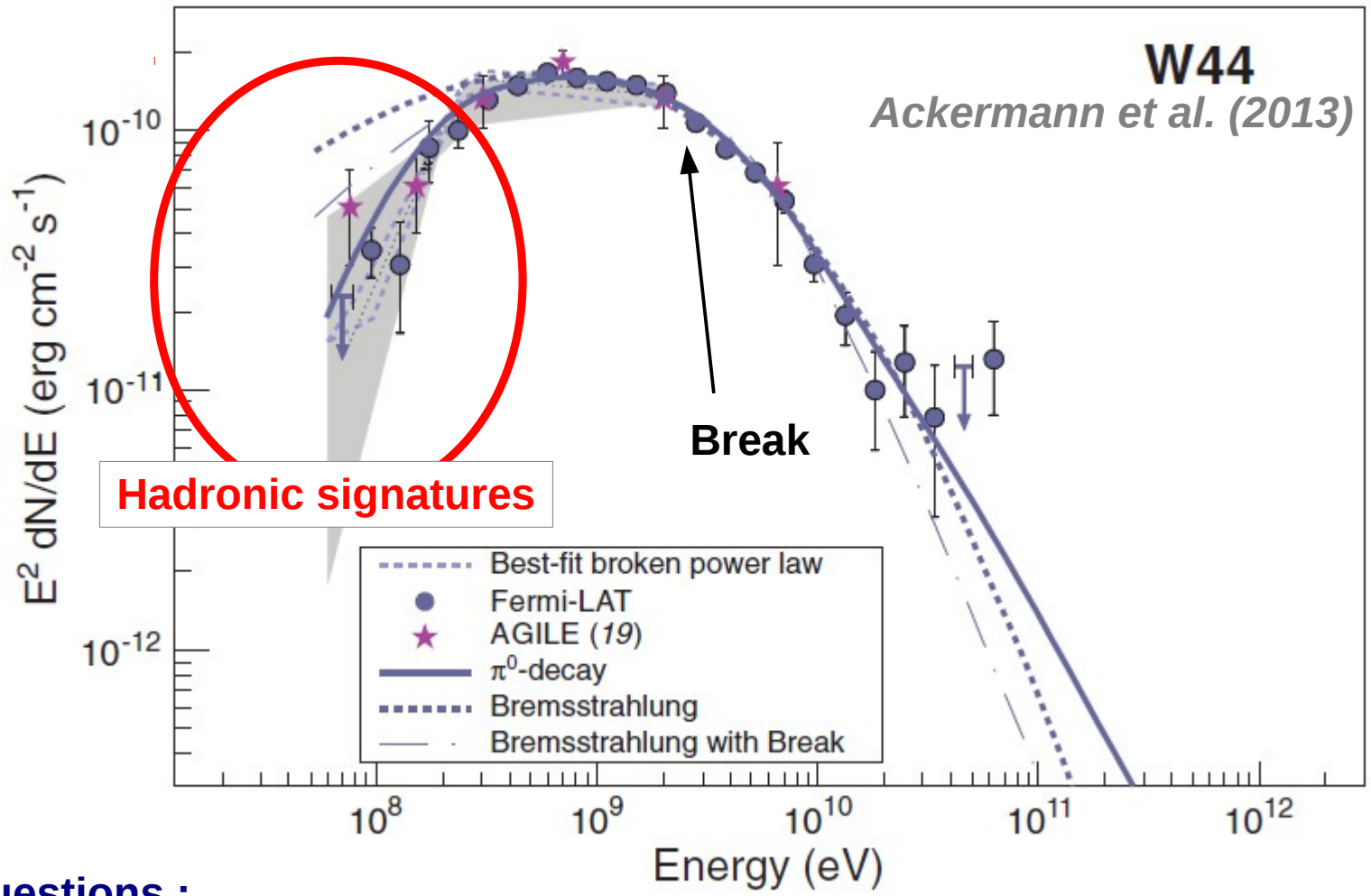
- **Large fraction of SNR show evidence of interaction such as**

  - OH masers (1720 MHz)
  - Shocked molecular lines
  - Dust lines (SiO) heated by shock

SNR/MC interest



SNR/MC interest

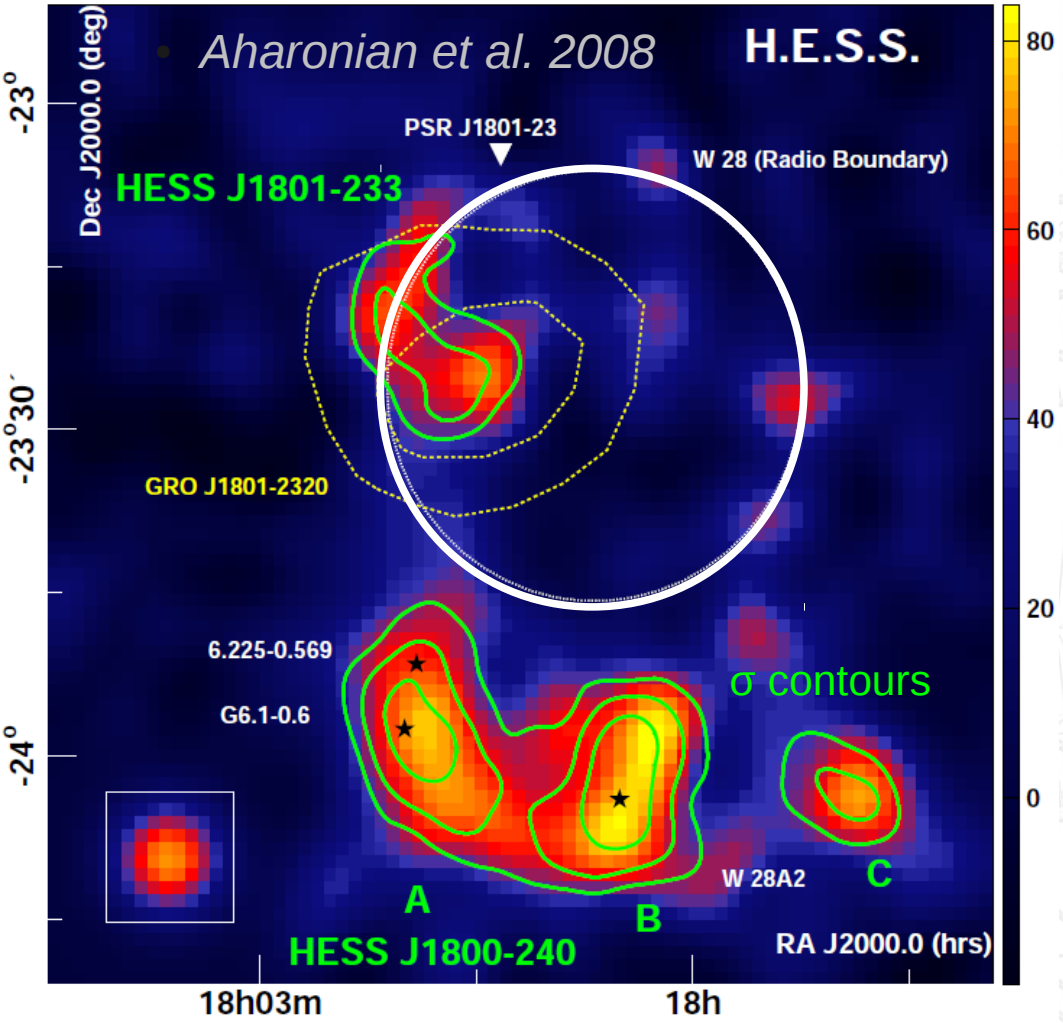


Pending questions :

- **Break between GeV/TeV** *(also for IC443)* **: systematic ?**
- **Are SNRs PEV accelerator?**

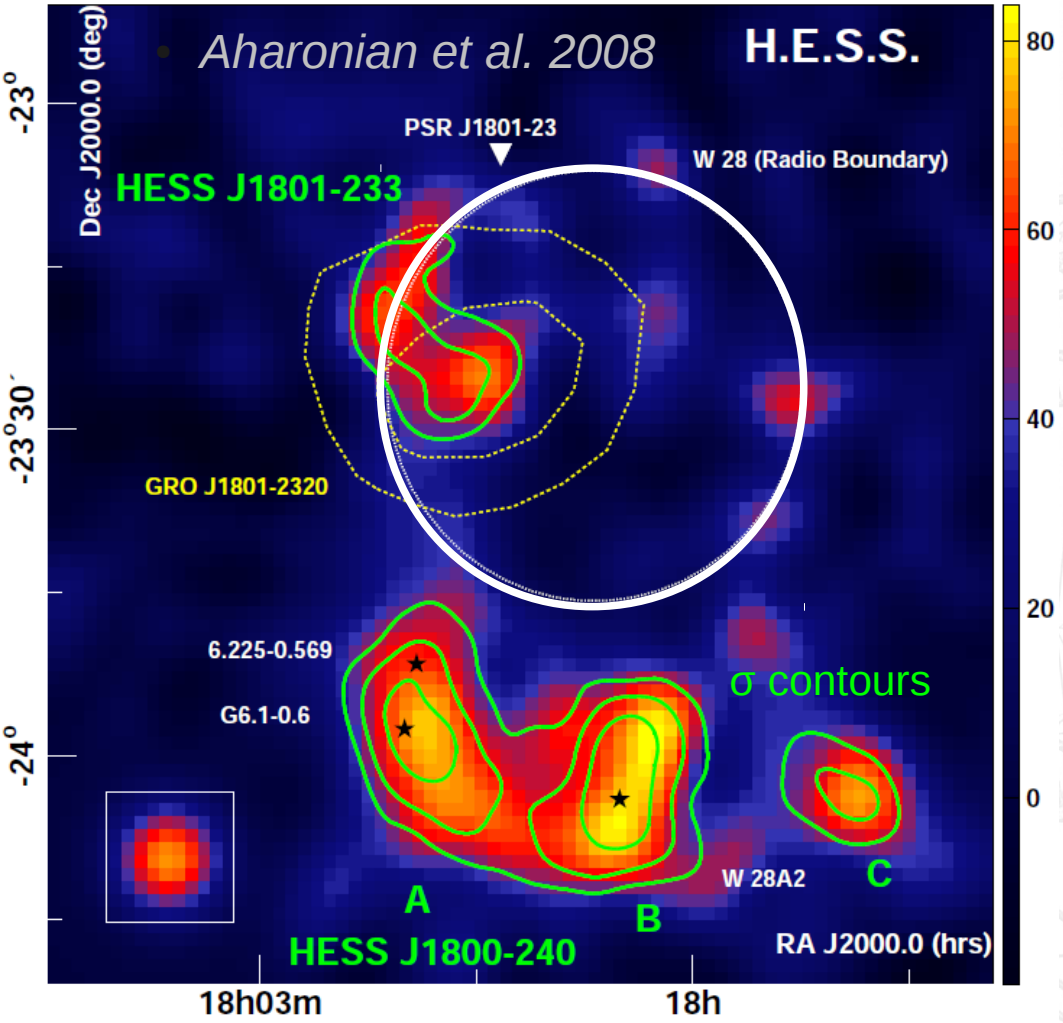
TeV observations required

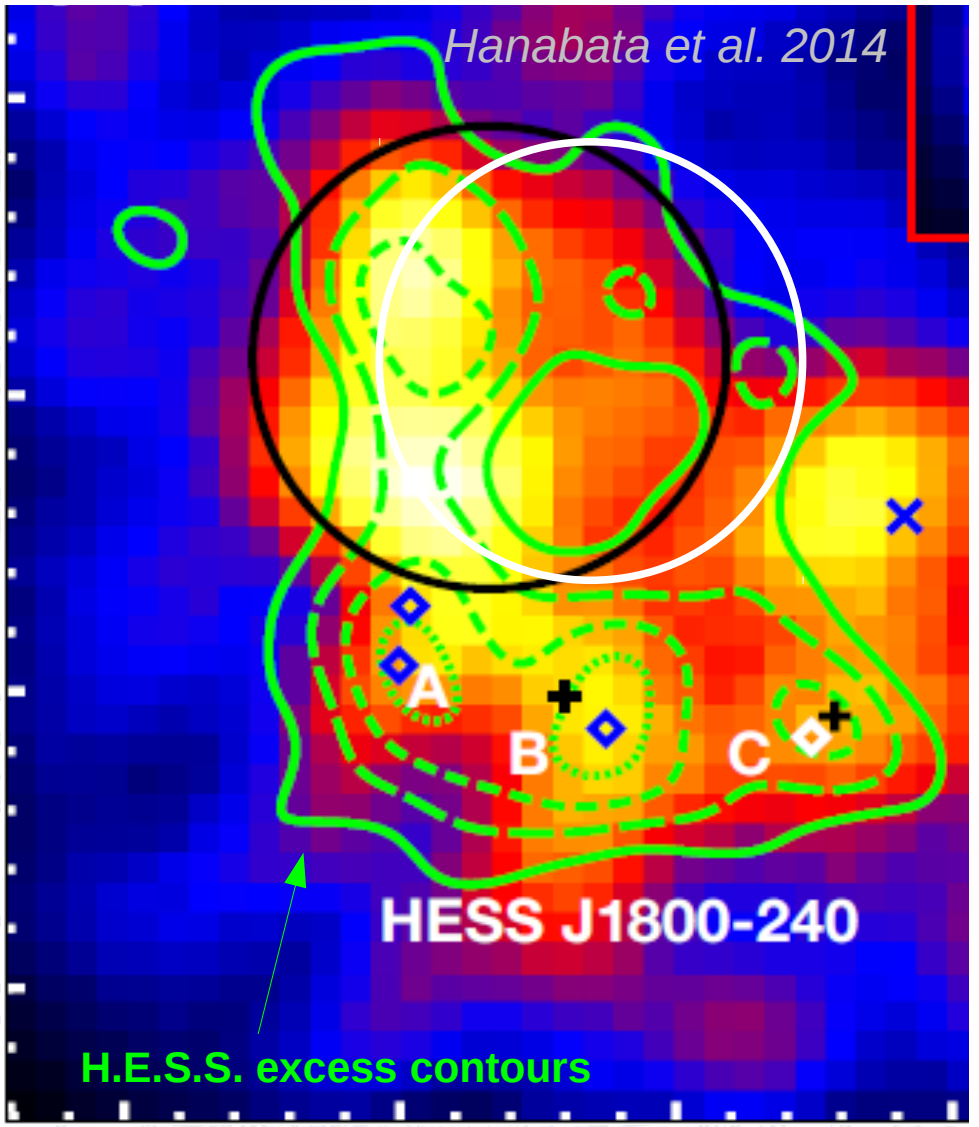
W 28



- D ~ 2-3 kpc
- Age ~ 35 - 150 kyr
- CO coincident with TeV emission
- Two MC complexes North/South
- North cloud is shocked by W28
  OH masers

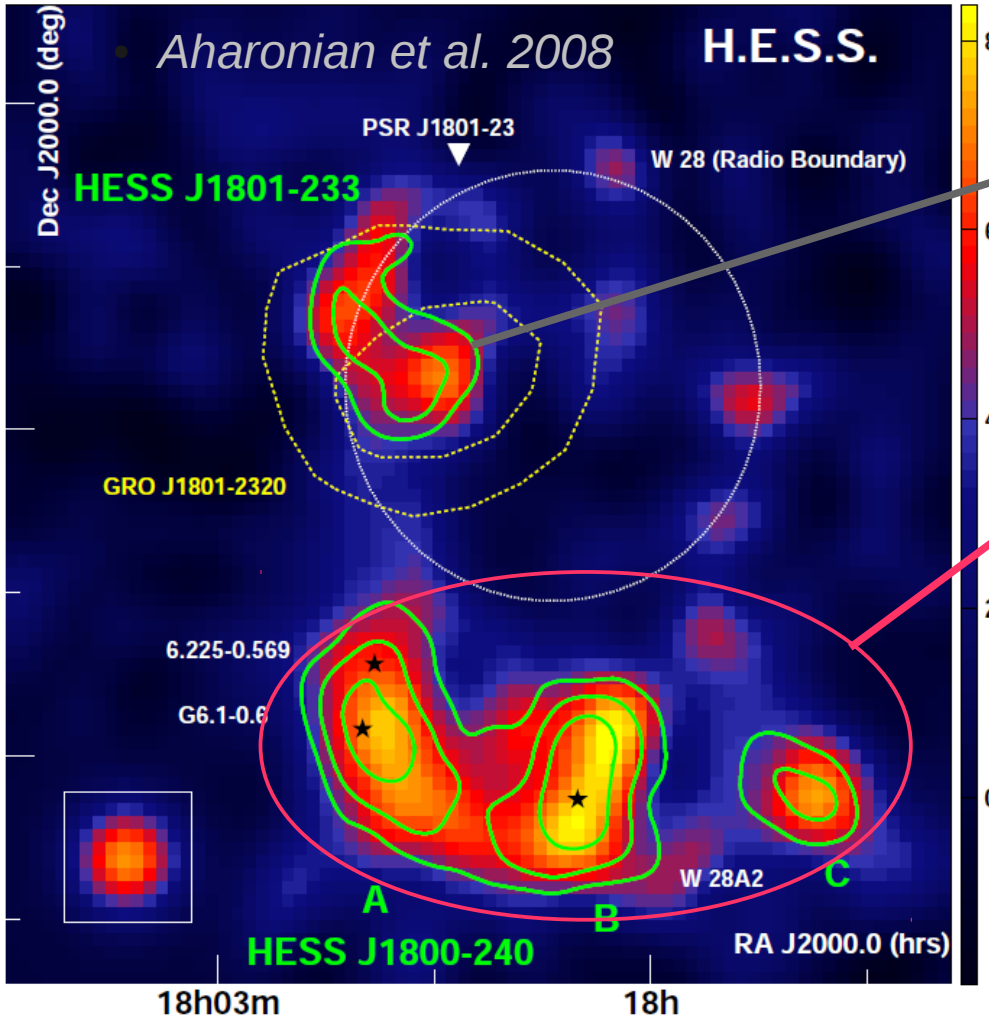
W 28

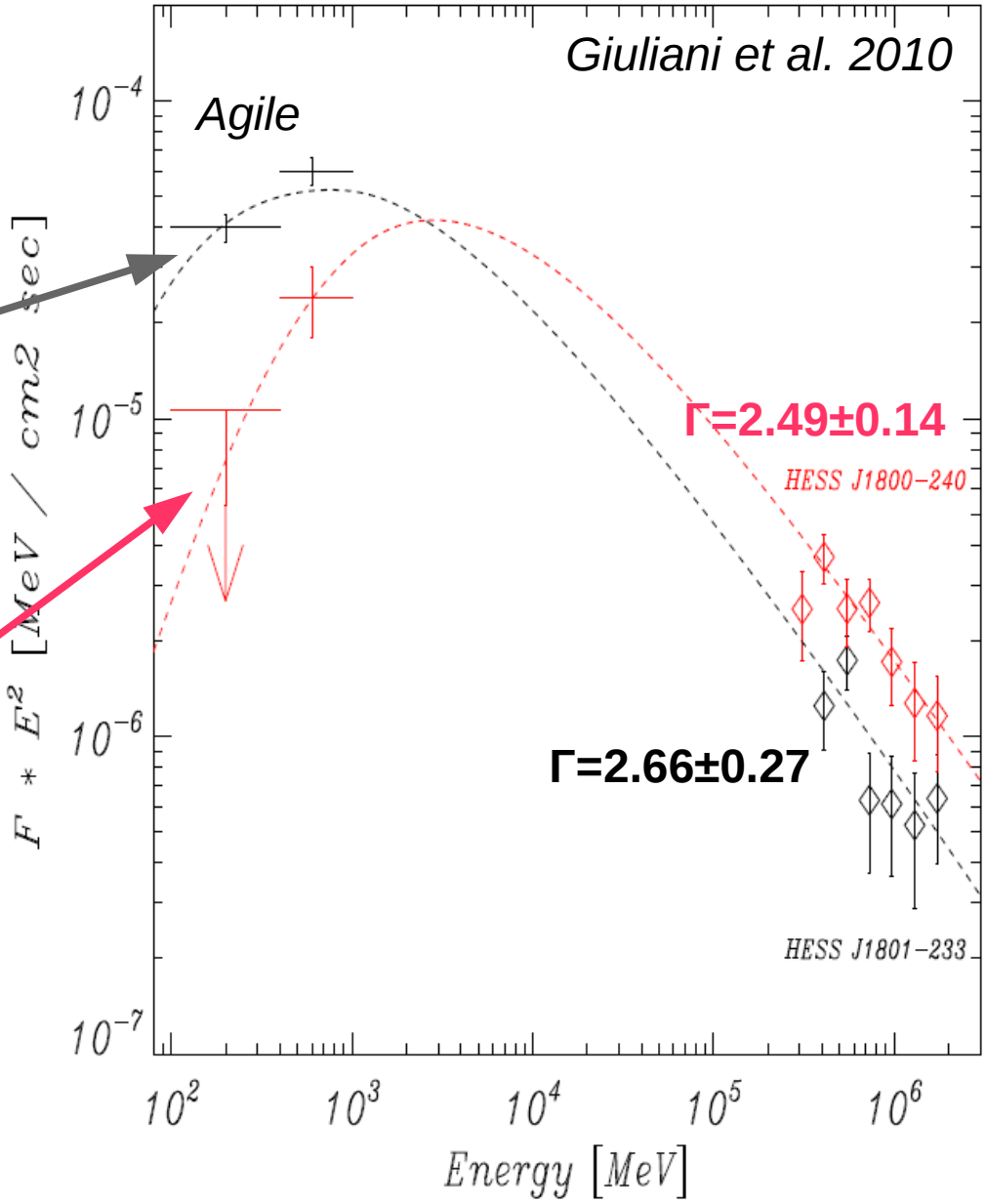




- **Brighest GeV emission from north cloud**

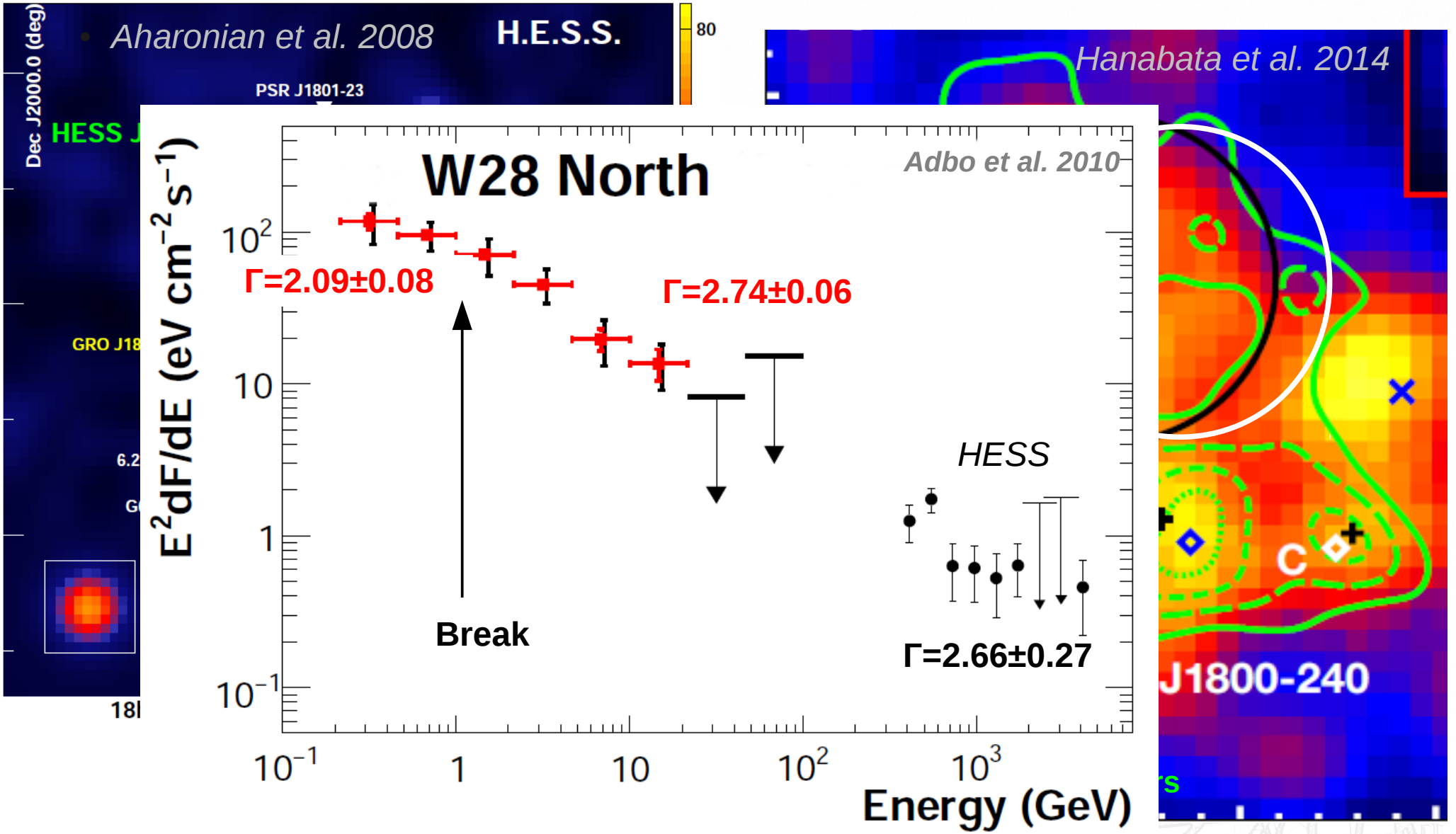
W 28





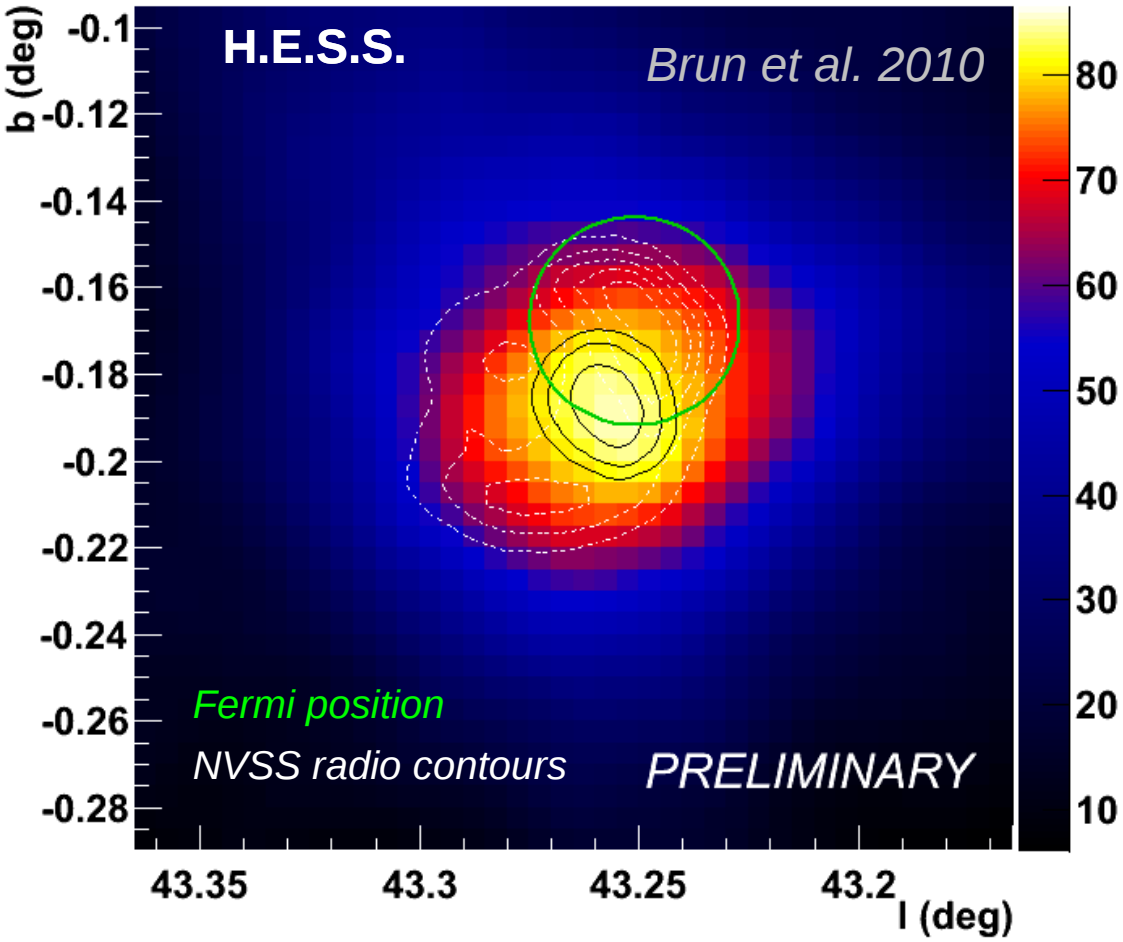
Visible effect of accelerated particle diffusion away from the shock

W 28



- E_{Break} ~1 GeV

W 49B



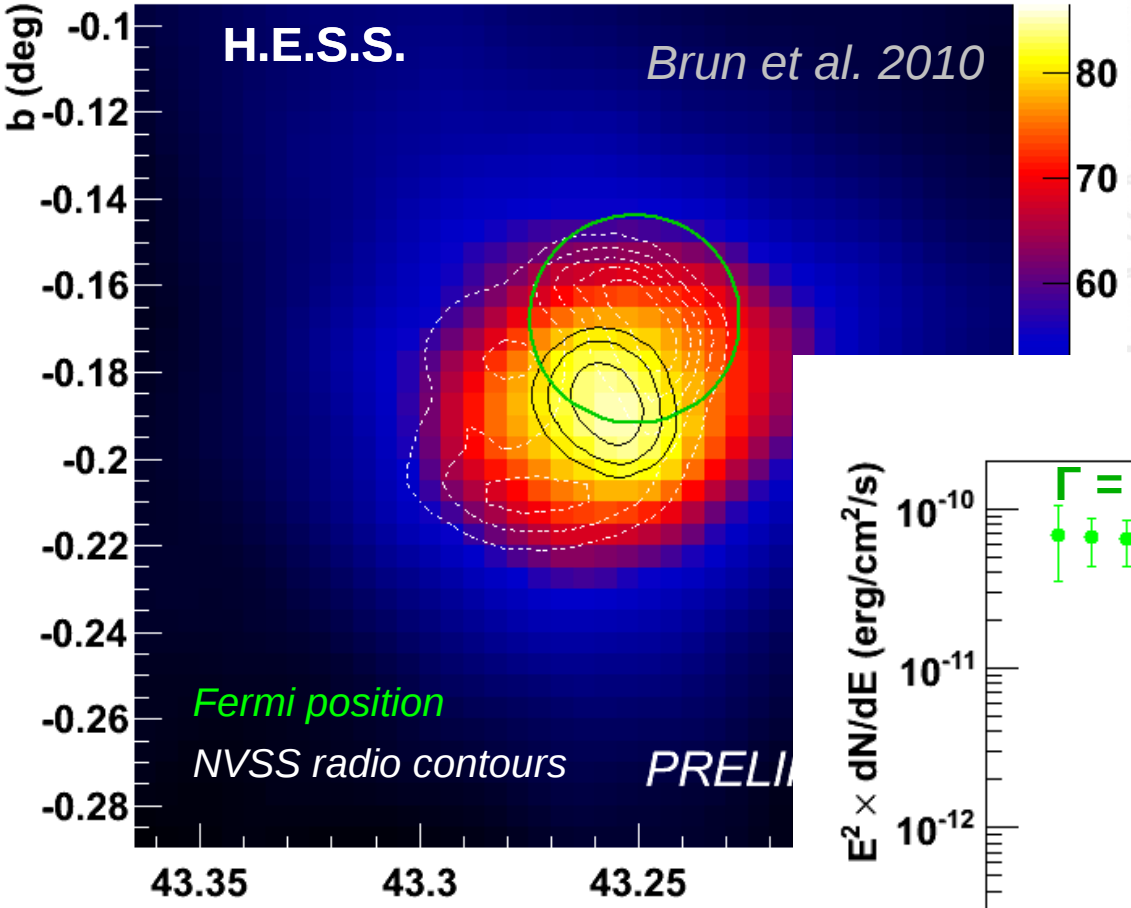
- D ~ 8 - 12 kpc
- Age ~ 1 - 4 kyr

- Evidences of SNR / dense medium interaction
  Shocked molecular lines

- TeV emission at the position of the SNR

- GeV coincident with the H.E.S.S source

W 49B



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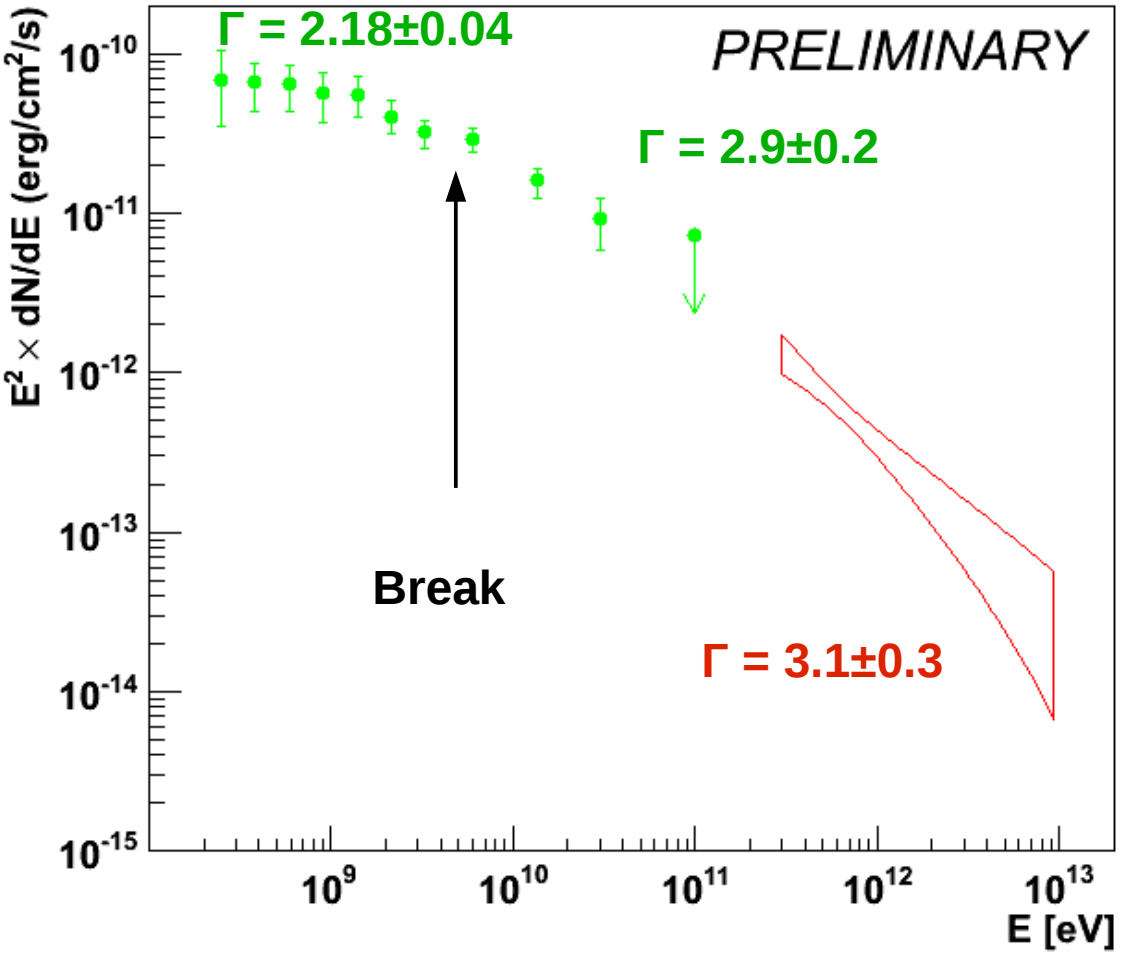
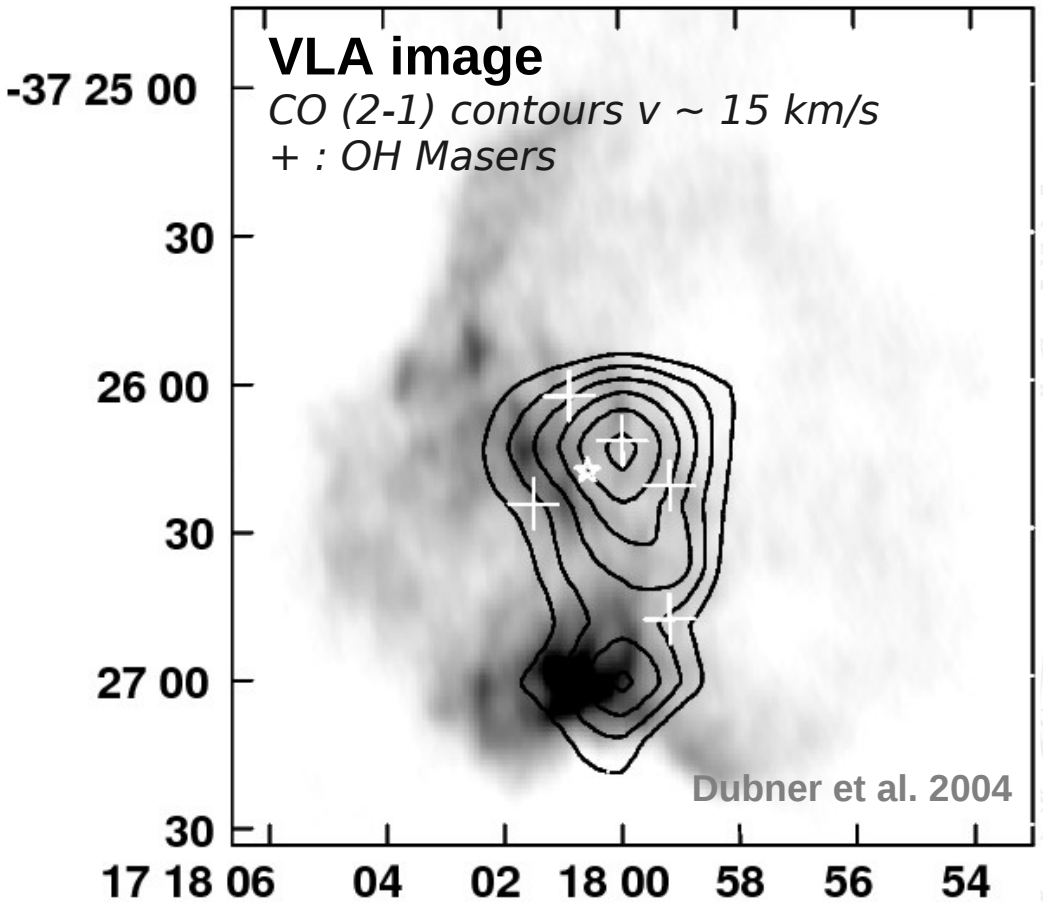


- Nice GeV/TeV spatial and spectral matching

- E_{Break} ~ 5 GeV

G 349.7+0.2



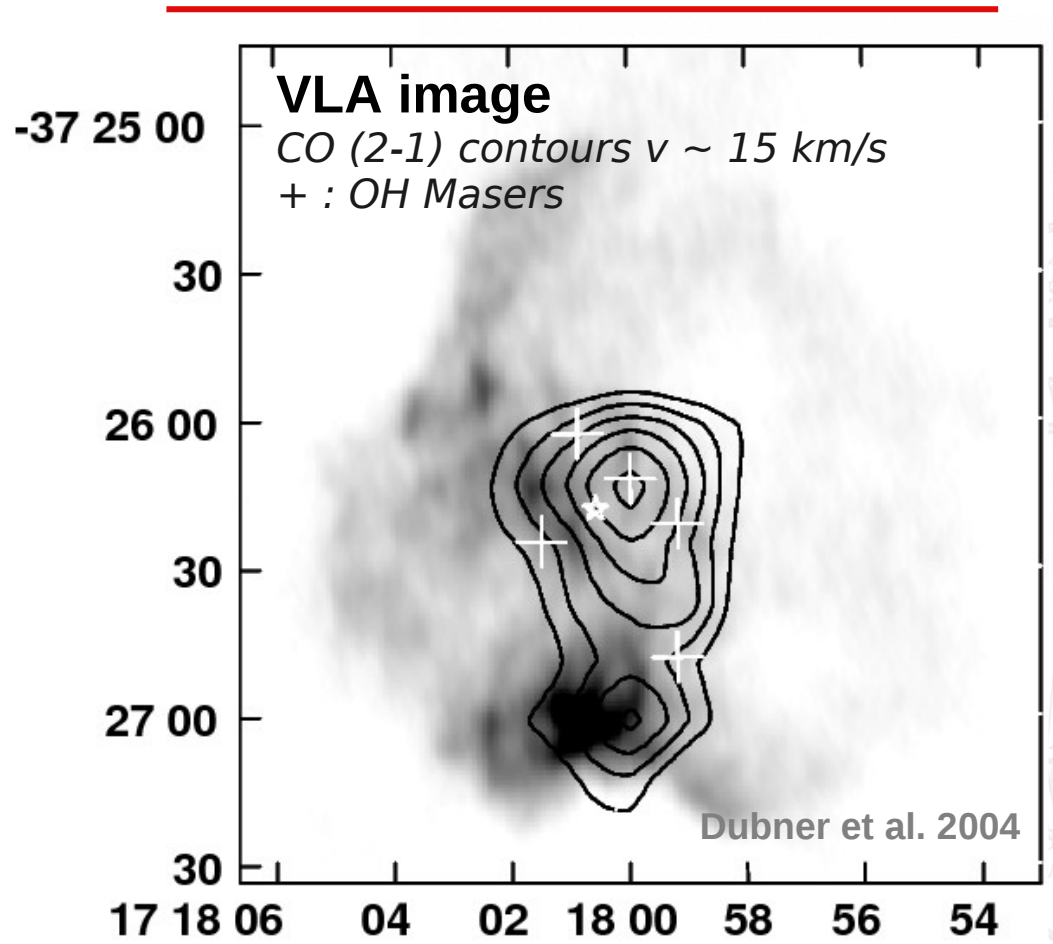
- **D ~ 11 - 12 kpc**
- **Age ~ 1.8 kyr**

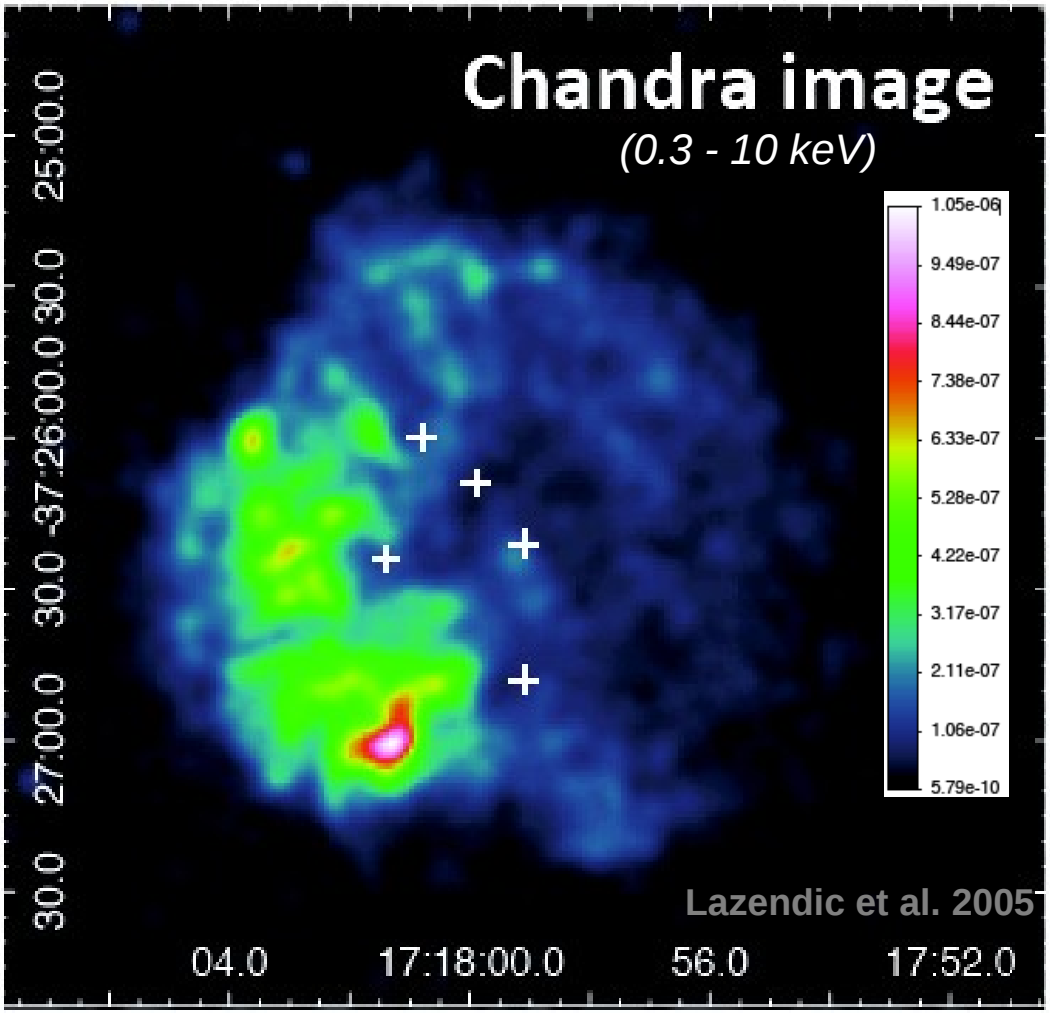
Tian & Leahy 2014

- **Radio emission from the shell**
- **MC (~10^4 $M_\odot$) beyond the SNR**

- **Strong evidences of SNR/MC interaction**
  - **-OH masers toward molecular clouds**
  - **-shocked molecular lines**

G 349.7+0.2



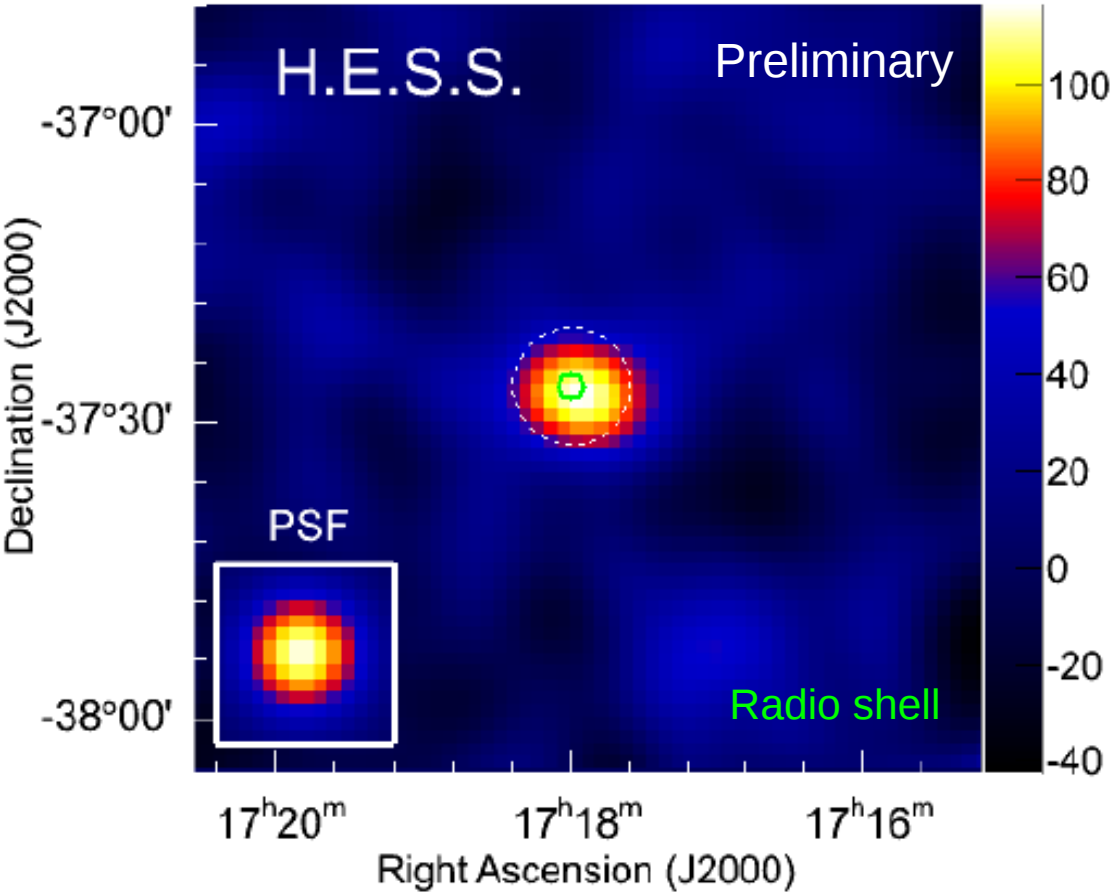


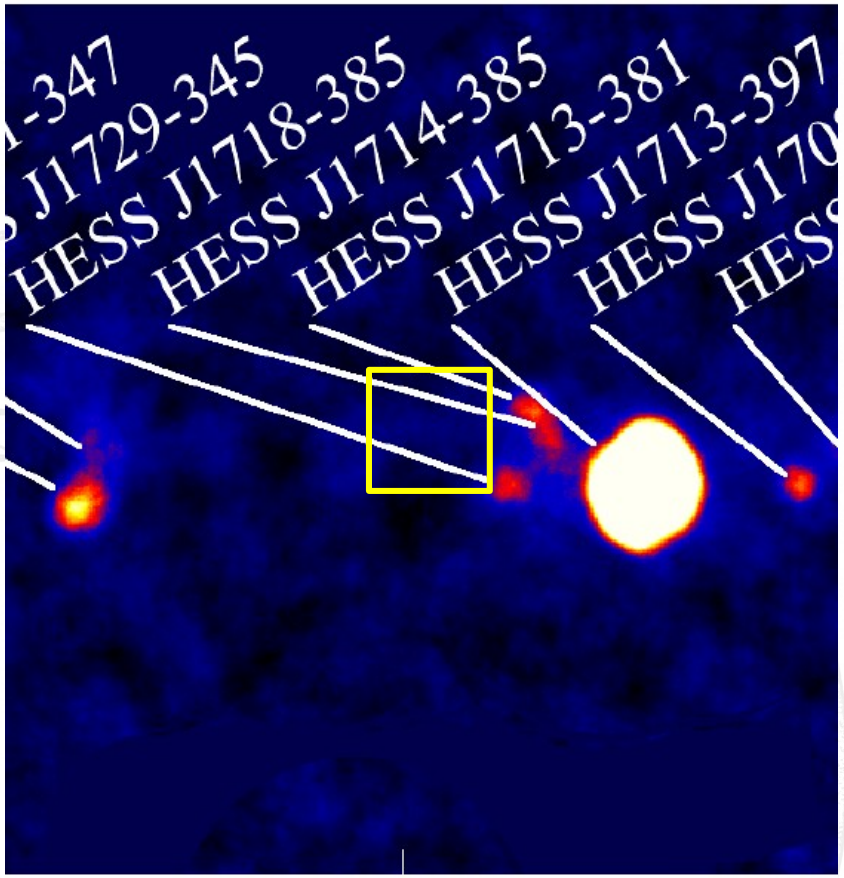
- **Very nice correlation X-rays / Radio**
- **Two thermal X-rays component**
  - **Ejecta**
  - **Shocked gas**

- **No evidence of PWN**
- **No nonthermal X-rays detected**

G 349.7+0.2

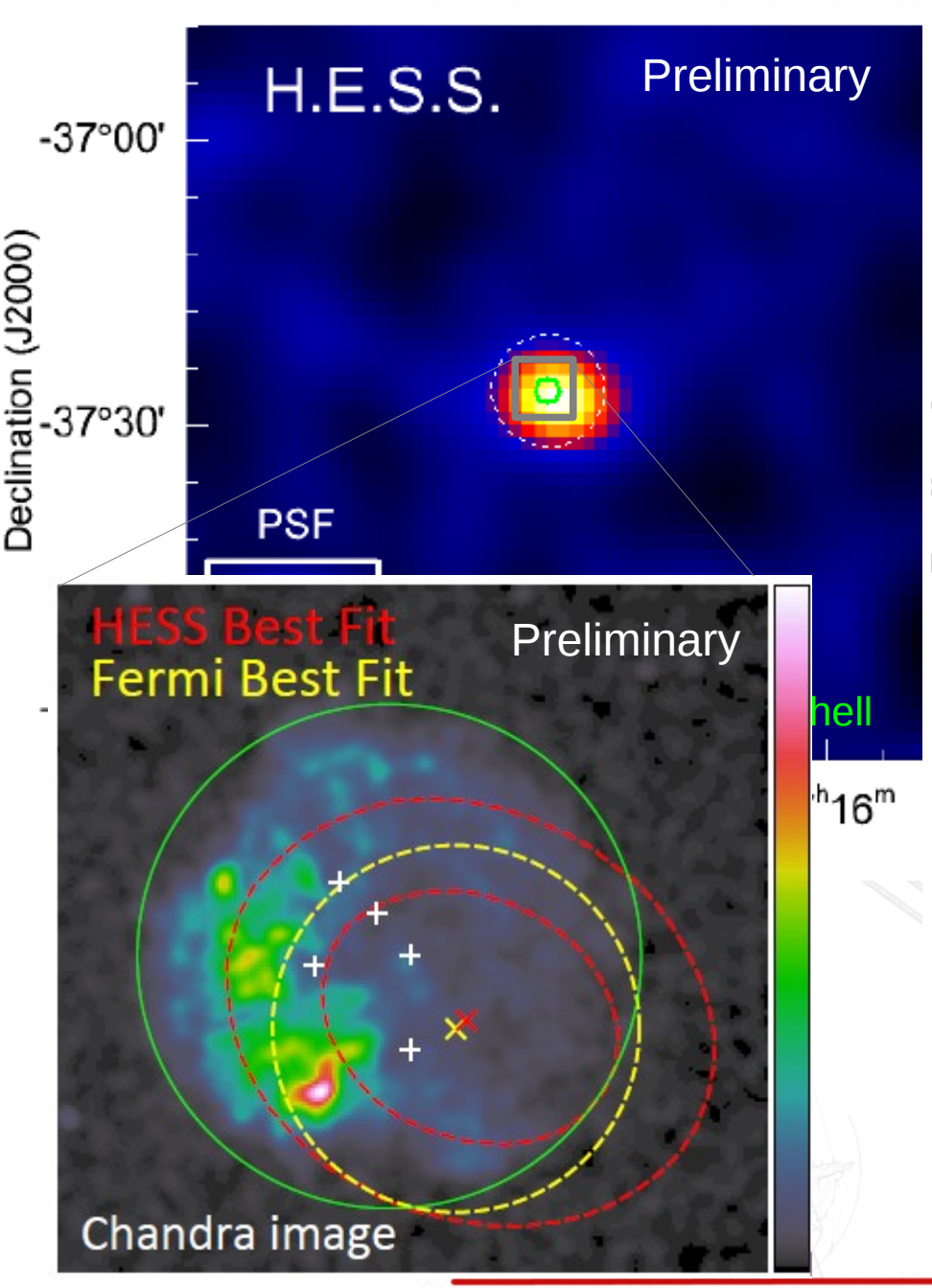
- **Region covered by the Galactic plane survey + dedicated observations**
- **Close to :**
  - **RX J1713.7-3946**
  - **CTB37 A&B**

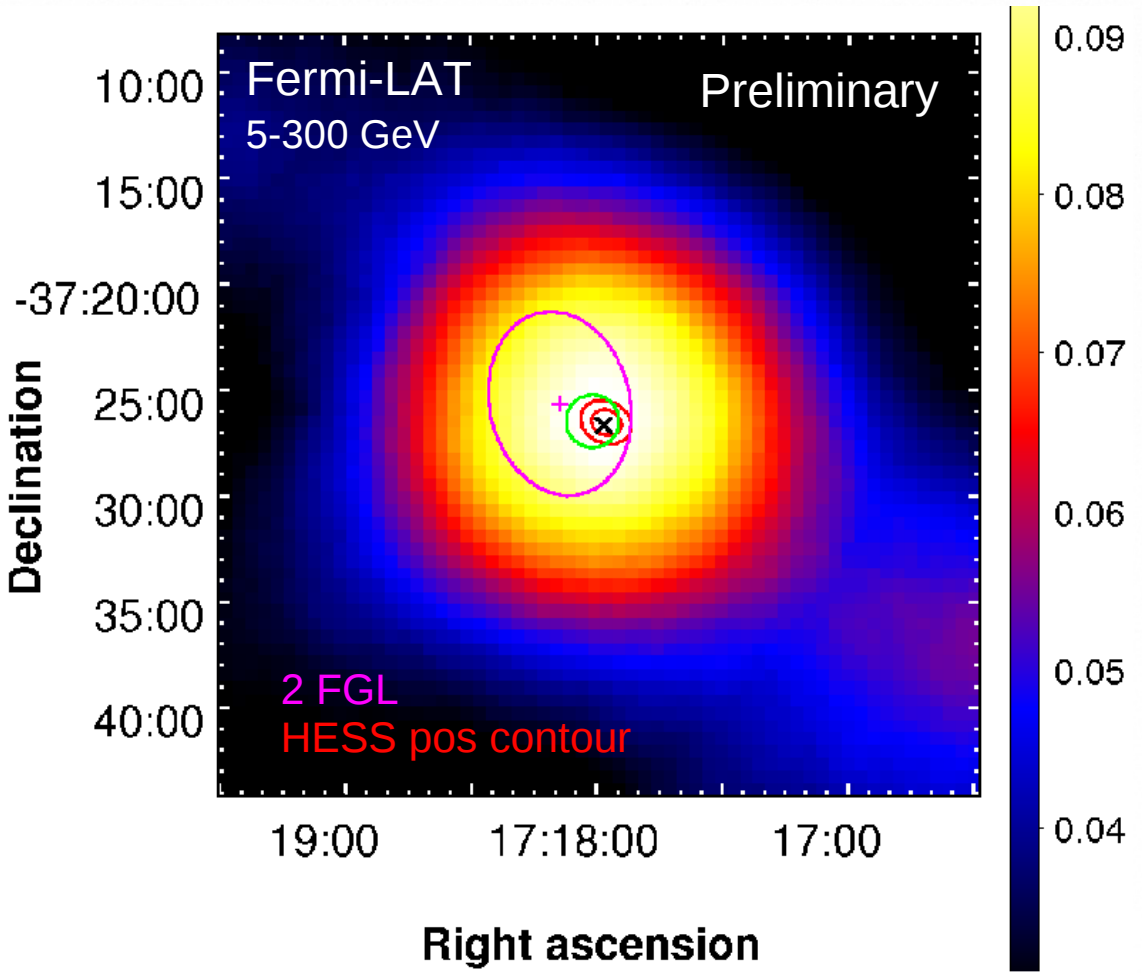




- **Point like TeV excess at the SNR position**

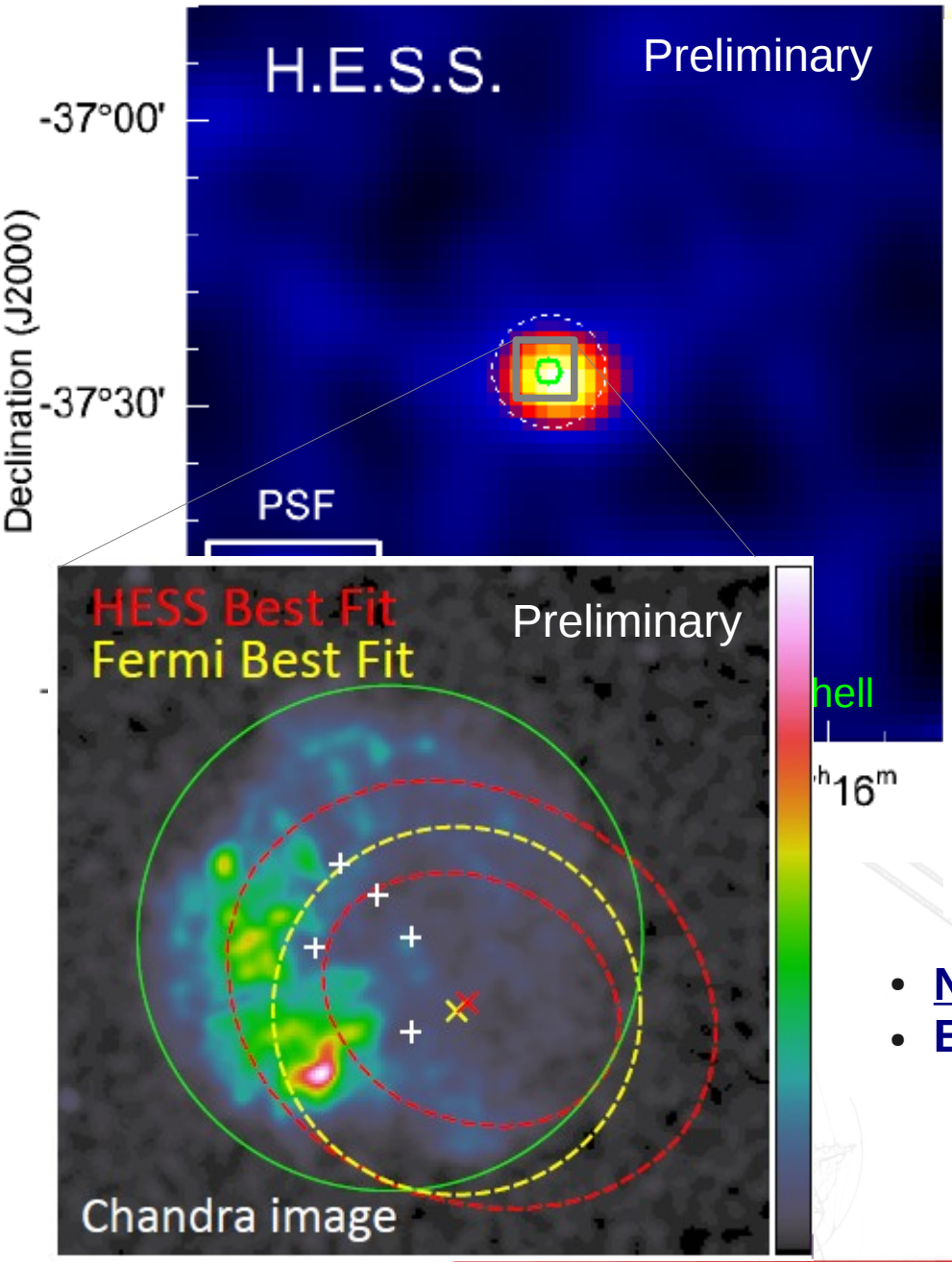
G 349.7+0.2

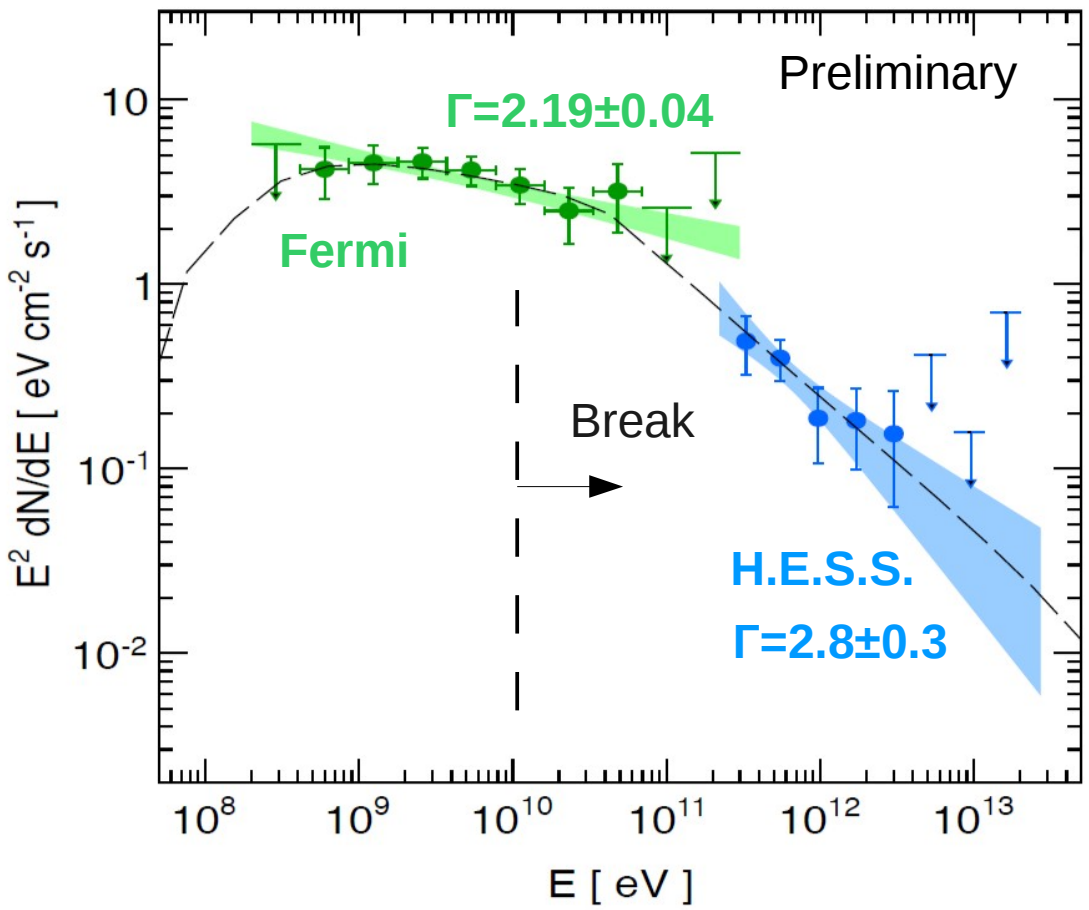




- **Reprocessed GeV data**
- **> 5 yr data analysed (with new IRFs)**
- **Very nice spatial agreement HESS/Fermi**

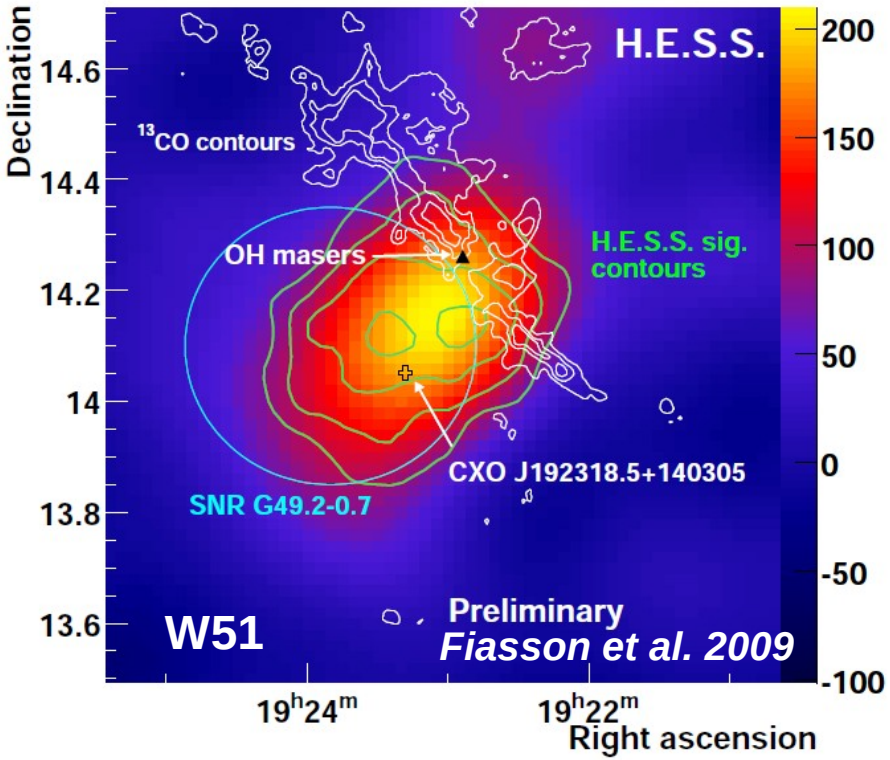
G 349.7+0.2

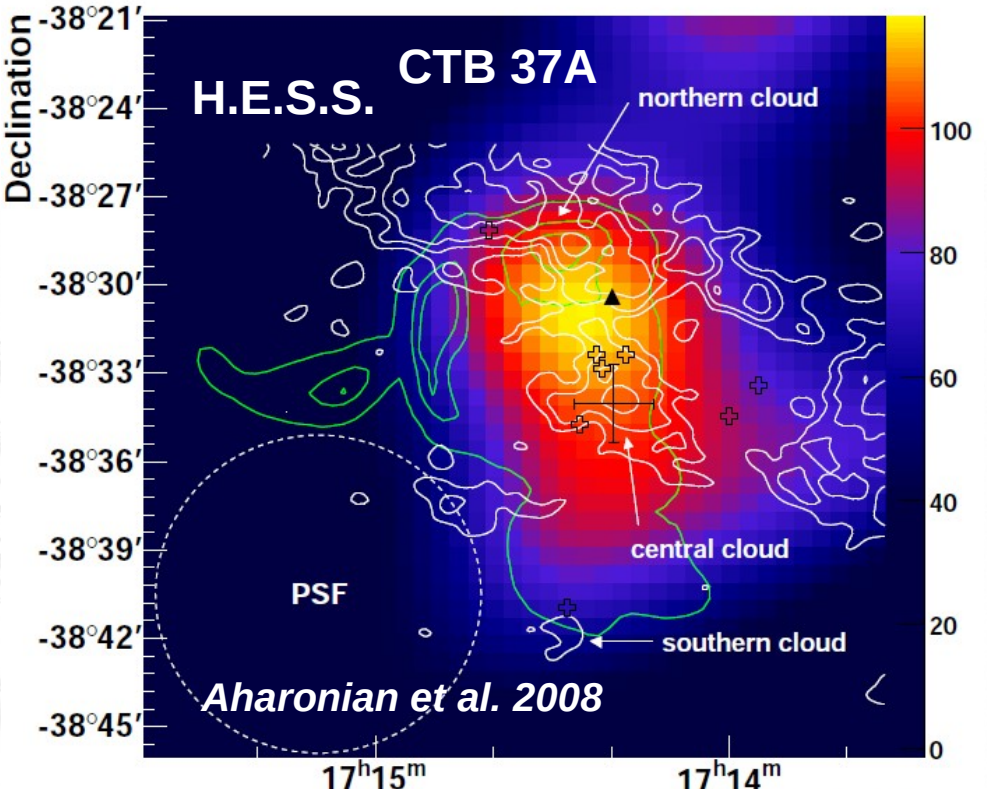




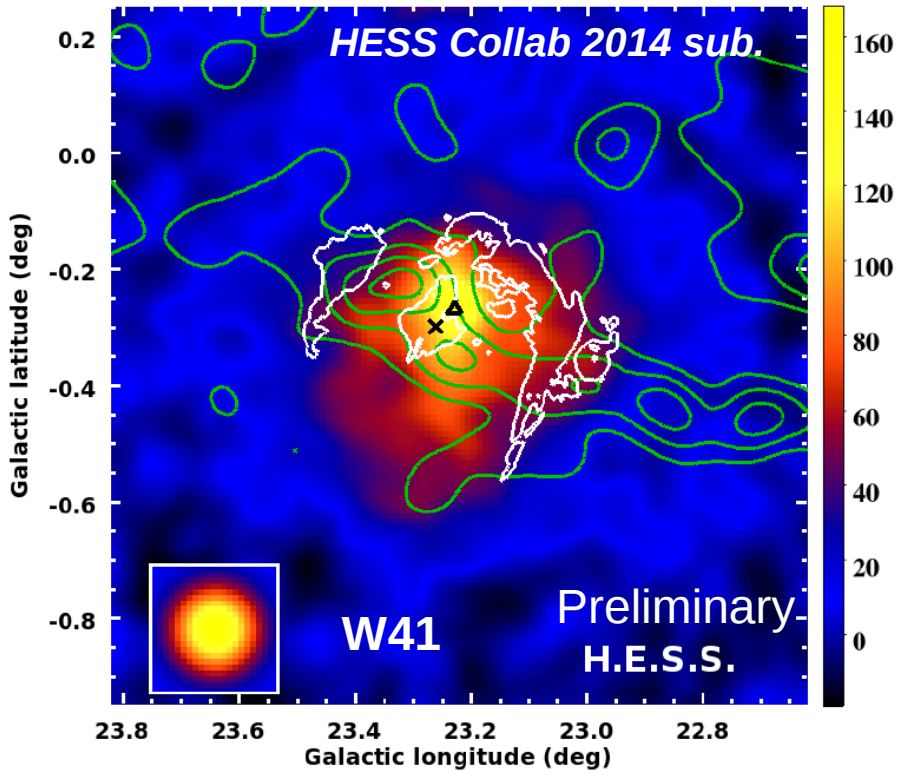
- **No significant spectral break in Fermi data**
- **E_{Break} > 10 GeV** *(under study)*

SNR/MC candidates

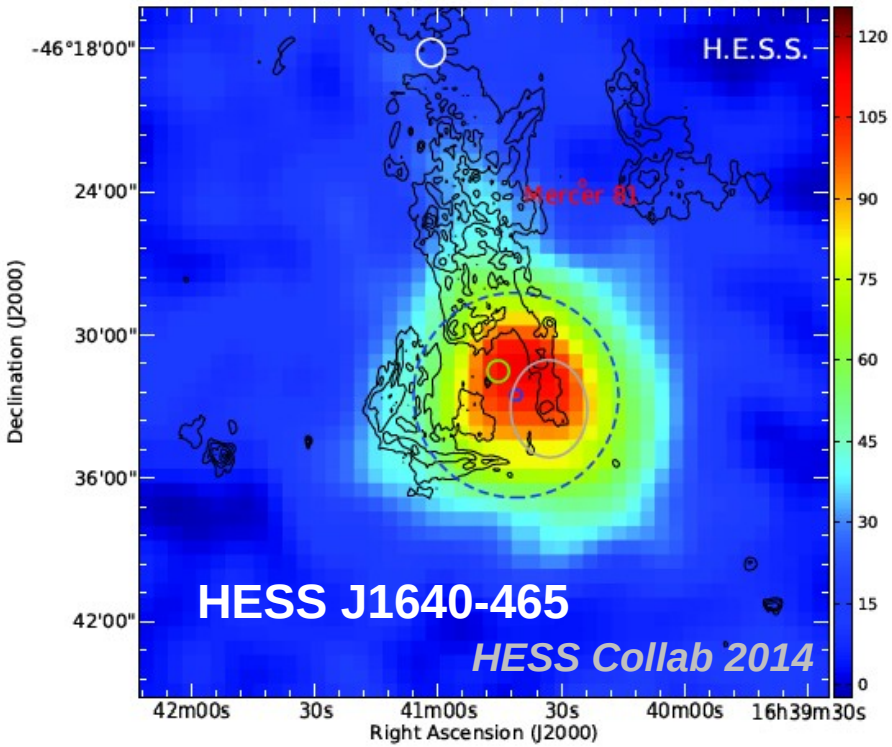


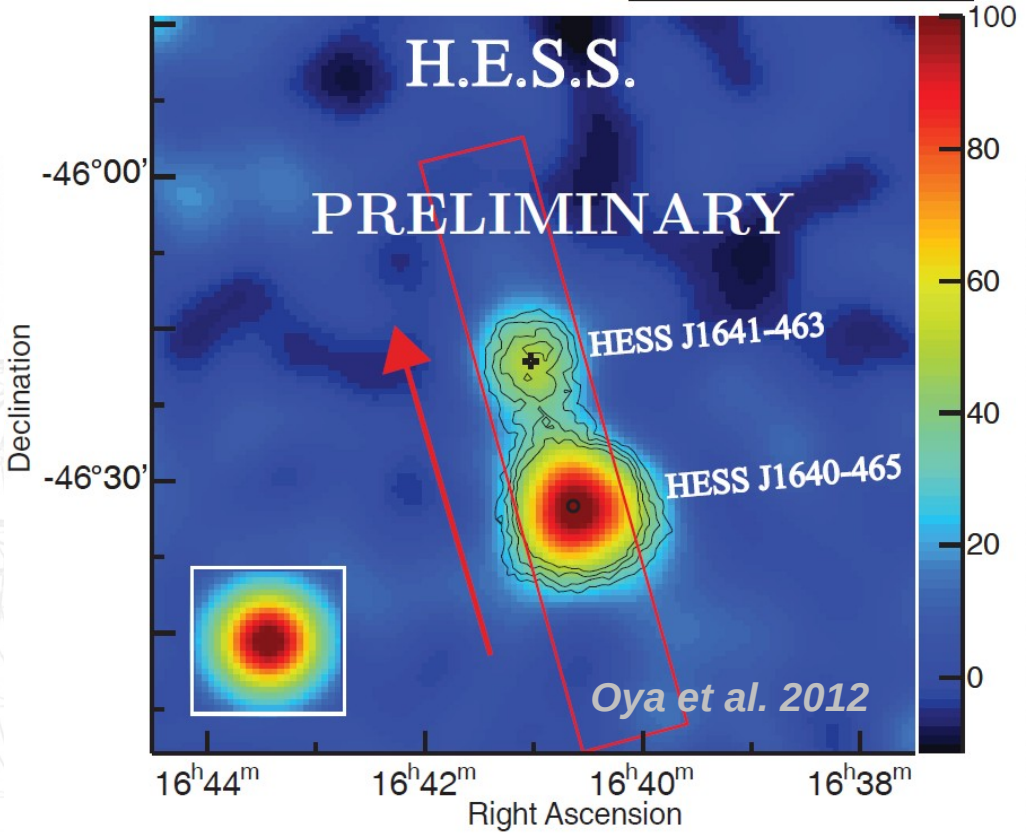


- **W51, W41 & CTB37 A:**
  - **Other scenario possible**
- **Puppis A :**
  - **GeV emission but no TeV detection**

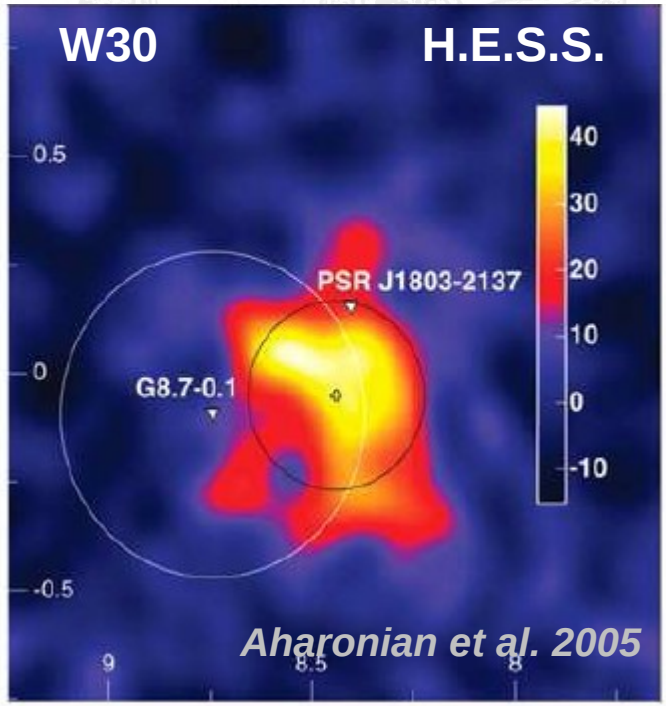


SNRs in dense medium





- **HESS J1640-465**
- **HESS J1641-463**
  - **- No tracer of physical interaction**
  - **- Other scenario possible**
- **Kes 78, W30 :**
  - **Possible PWN emission**
- **...**



Common properties

Many preliminary results

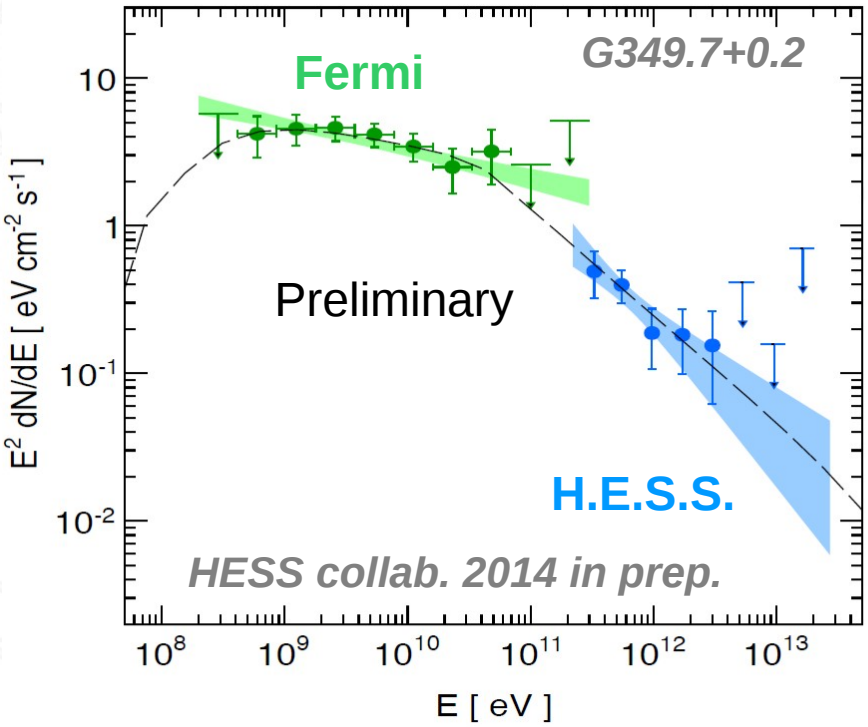
	Age (kyr)	Distance (kpc)	E_{Break} (GeV)	$\Gamma_{E<Break}$ (Fermi-LAT)	$\Gamma_{E>Break}$ (Fermi-LAT)	Γ_{TeV} (H.E.S.S.)
W 28N	~ 35 - 150	~ 2 - 3	1±0.2	2.09±0.08	2.74±0.06	2.66±0.27
W 49B	~ 1 - 4	~ 8 - 12	4.8±1.6	2.18±0.04	2.9±0.2	3.1±0.3
G349.7+0.2	~ 2	~ 11 - 12	>10 (?)	2.19±0.04		2.8±0.3
CTB 37A	-	~ 6 -10	-	LogParabola		2.3±0.13
W 51	~ 30	~ 6	-	LogParabola		detected
Puppis A	~ 4 - 8	~ 2	?	2.6±0.13		U.L.
W 41	~ 60 -200	~ 4	?	2.15±0.12		2.64±0.13
W44	~ 10	~ 3	~ 2	2.36±0.05	3.5±0.3	-
IC 443	~ 10	~ 1 - 2	~ 20	2.36±0.02	3.1±0.1	3.1±0.3

MAGIC

What do we learn ?

- **TeV emission seemed related with SNR/Cloud interaction not from the shell**

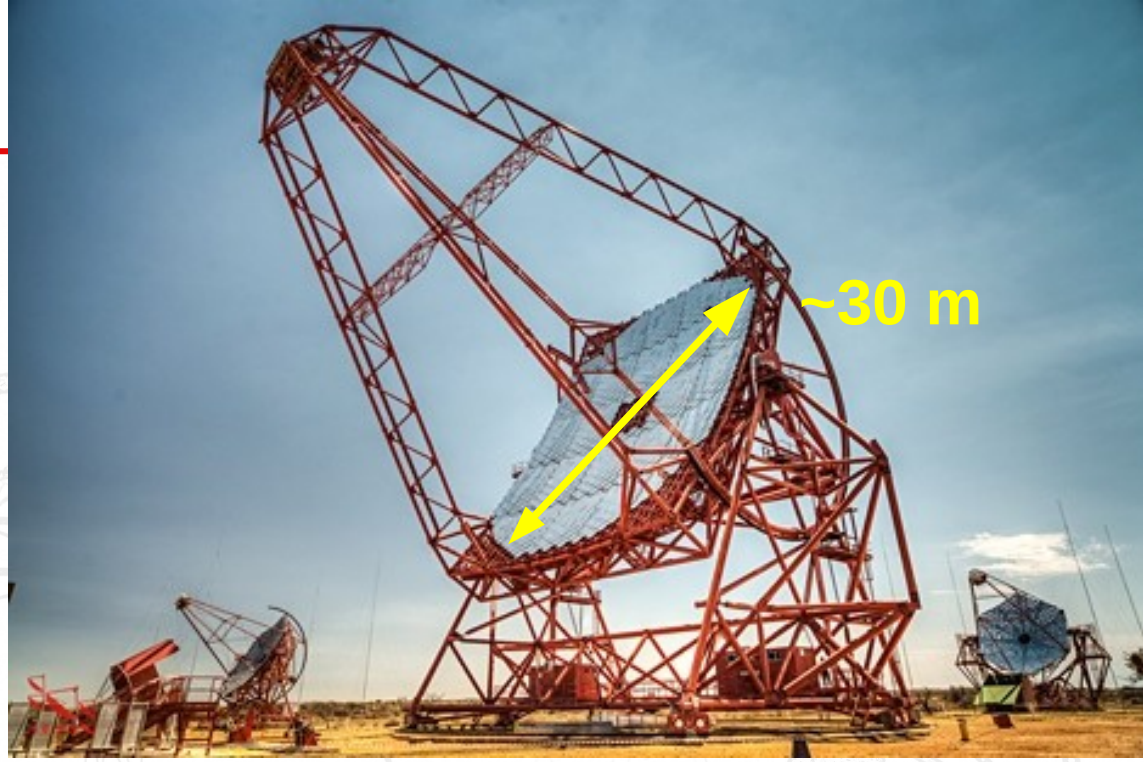
- **Common features:**
  - **Spectral break GeV/TeV PowerLaw**
  - **Bright + "flat" GeV spectra**
    Faint + soft TeV spectra
  - **Hadronic origin of the γ-rays favored**
    - W_p < ~10 % E_{SNR}
    - No detection of VHE cutoff



- **Evolution with age ?**
  - **E_{break}**
  - **Γ_{TeV}**

Strongly depend on environmental conditions
Need bigger set of sources

HESS II

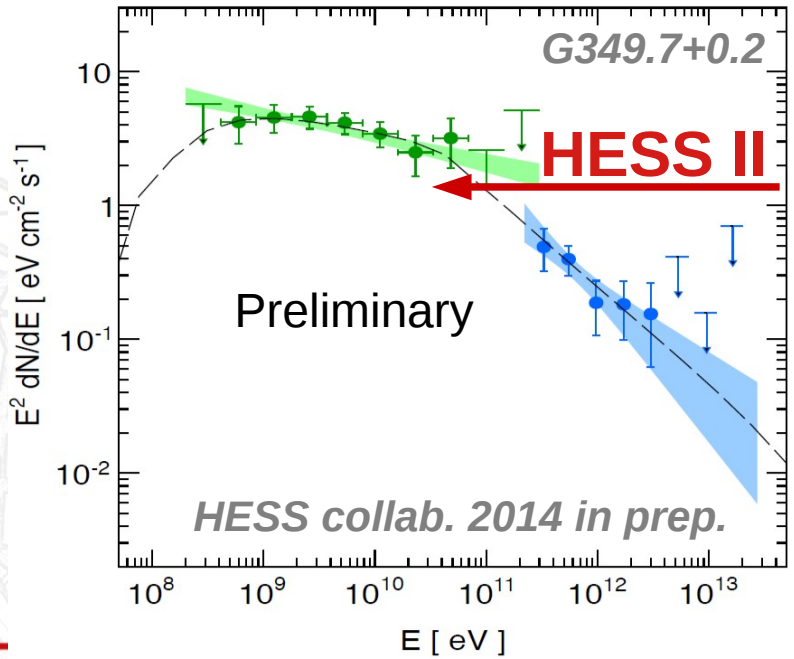


- **Fifth big telescope (2012) :**

  - **Lower threshold : ~ 30 GeV**

- **Which interests for SNR/MC studies ?**

  - **Overlap with Fermi**
  - **SNR/MC exhibit soft faint spectrum**
  - **More constraints on E_{Break}**

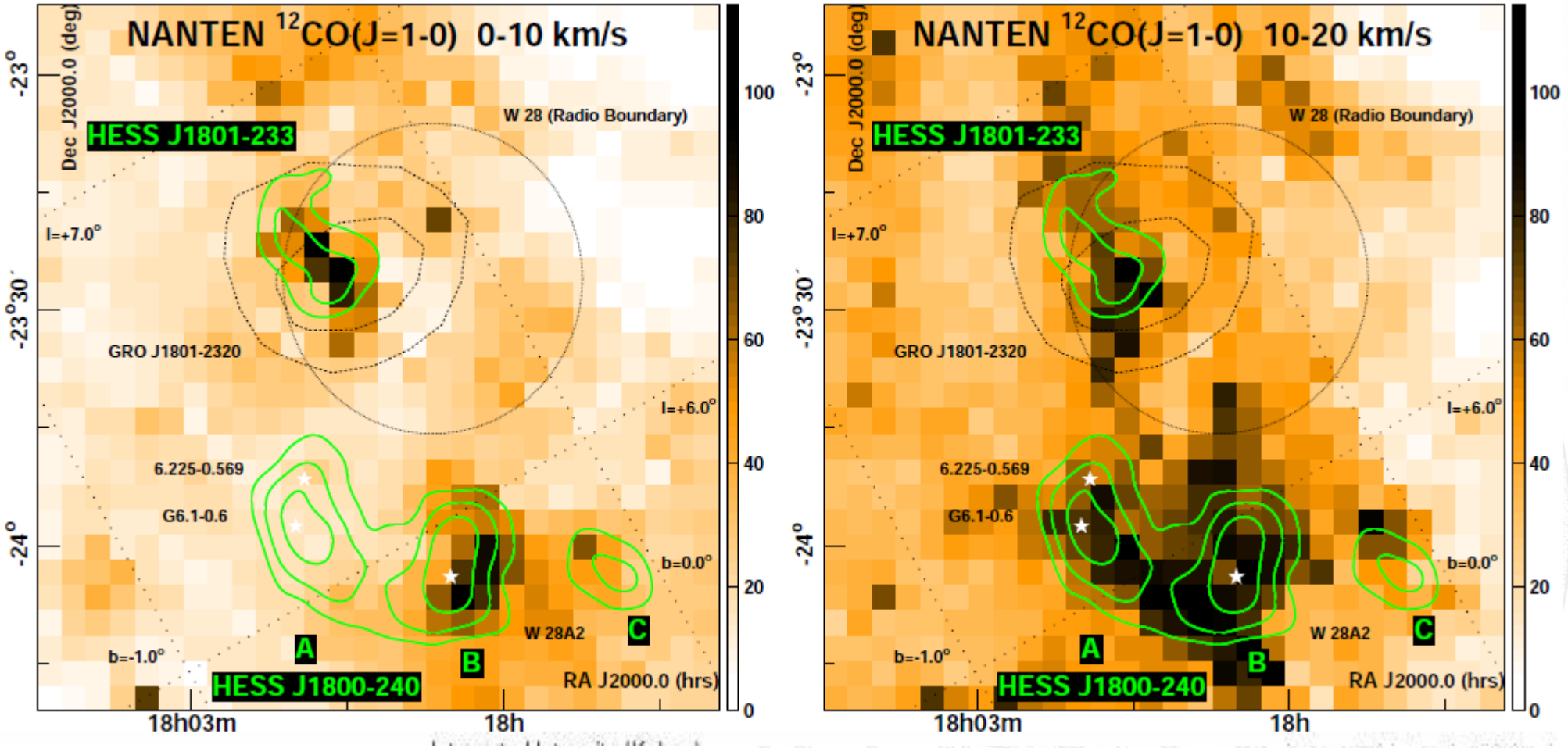


Summary

- **Number of SNR/MC detected at GeV and TeV increase steadily (new G349.7+0.2) + Large number of candidates**
- **Common spectral features appeared :**
  - **Spectral break GeV / TeV**
    TeV observations needed
  - **No signature of VHE cutoff**
- **Interesting objects for the whole CR community**
  Acceletation/Diffusion/Propagation
  Cloud ionisation / ISM Chemistry

Thank you

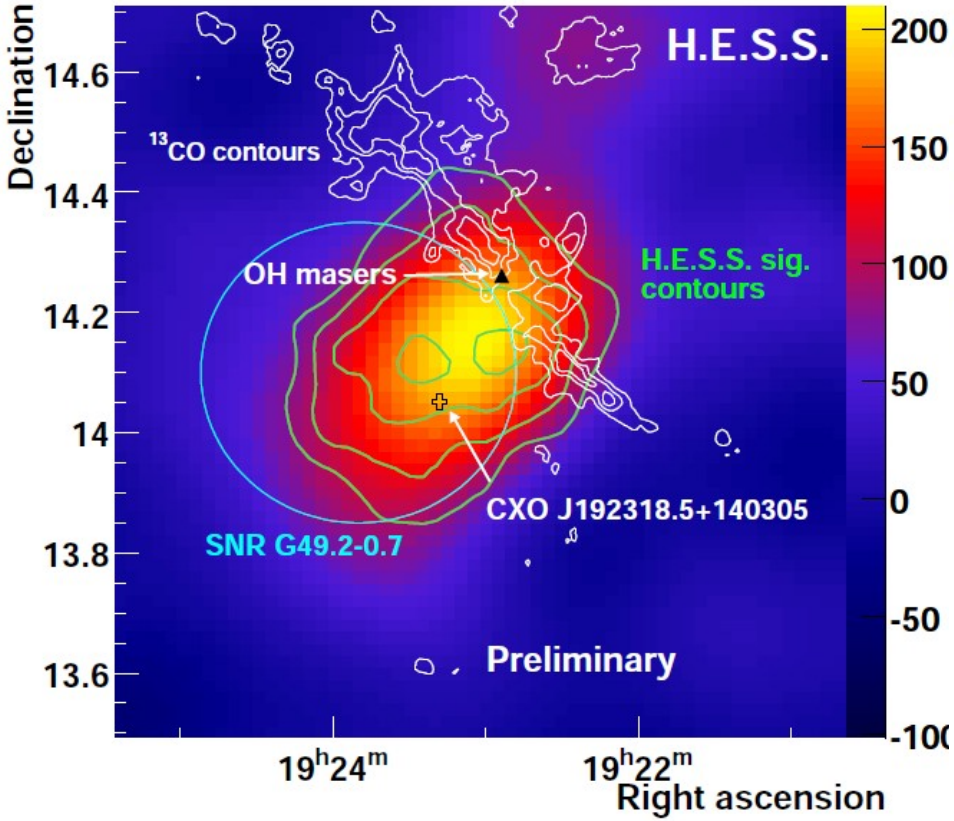
W28 clouds

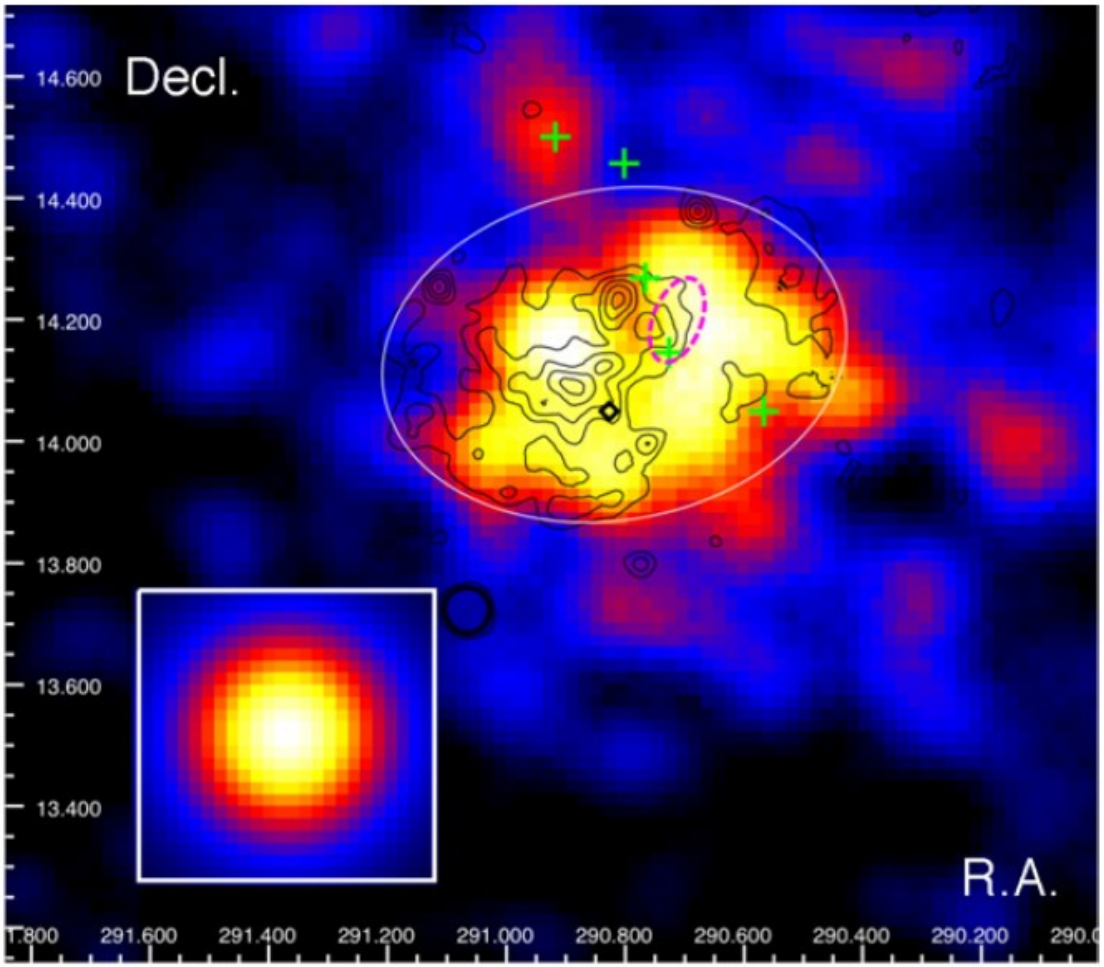


NANTEN ^{12}CO(J= 1-0) image of theW28 region

H.E.S.S.

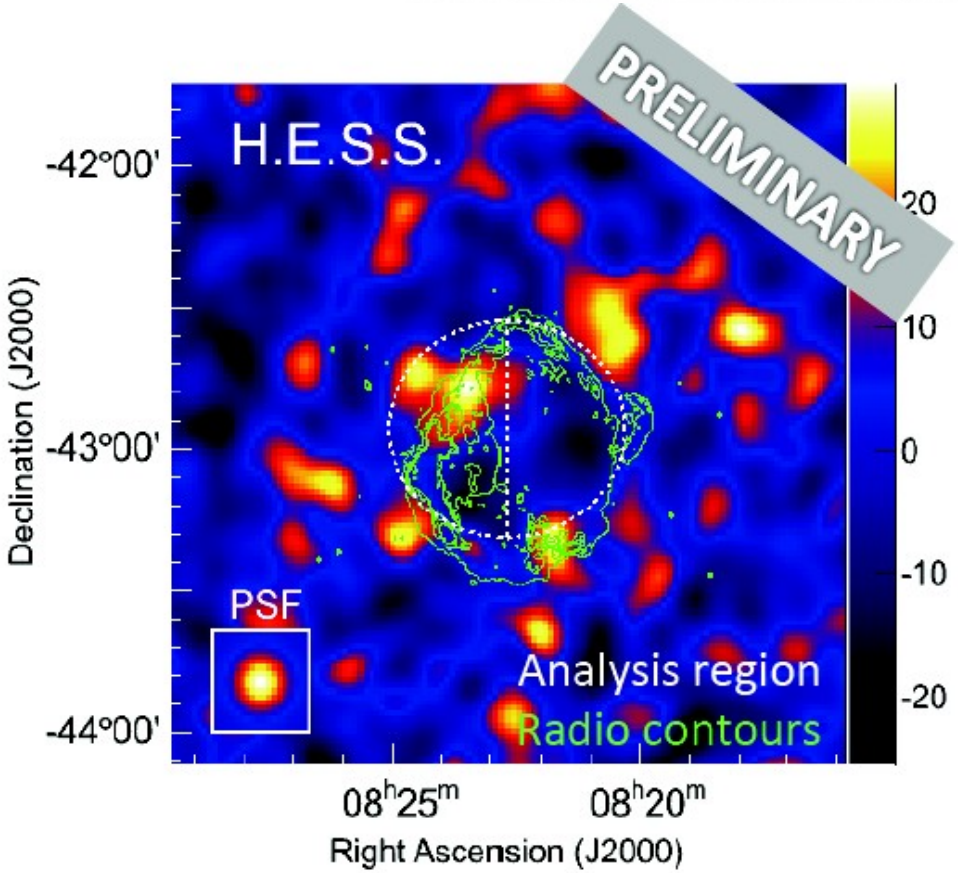
W 51

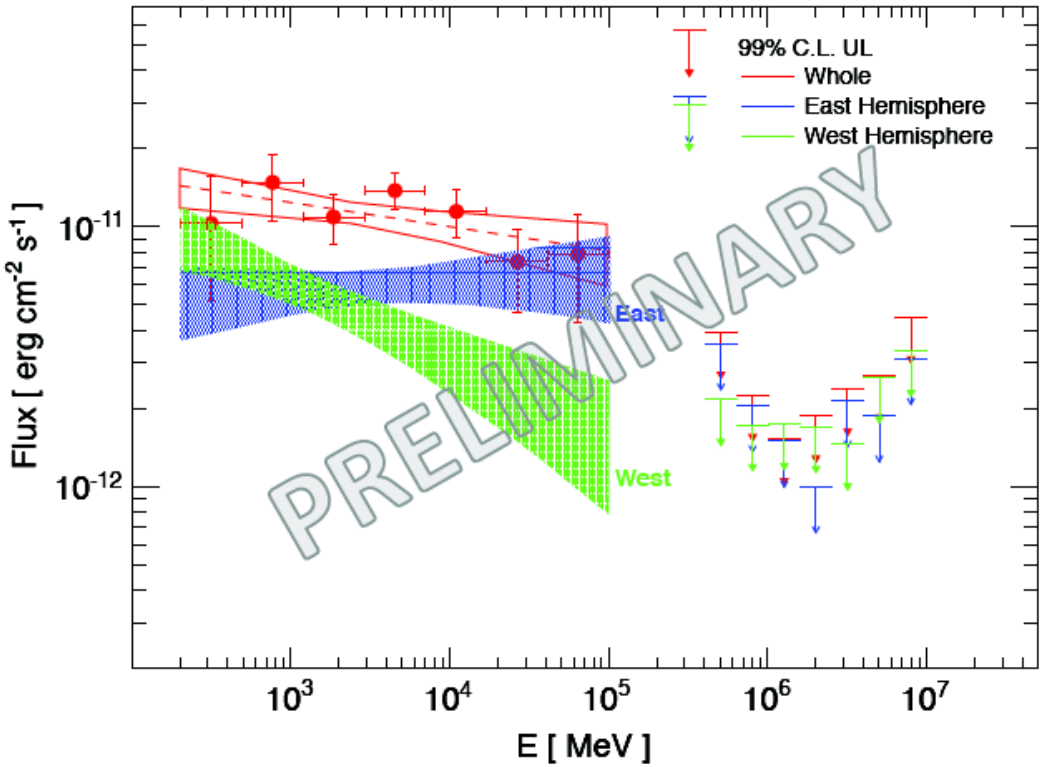

H.E.S.S.
^{13}CO contours
OH masers
H.E.S.S. sig. contours
CXO J192318.5+140305
SNR G49.2-0.7
Preliminary
Declination
14.6
14.4
14.2
14
13.8
13.6
200
150
100
50
0
-50
-100
19^h24^m
19^h22^m
Right ascension


Decl.
R.A.
14.600
14.400
14.200
14.000
13.800
13.600
13.400
291.600
291.400
291.200
291.000
290.800
290.600
290.400
290.200

H.E.S.S.

Puppis A





Unexpected lack of TeV emission from this young SNR