Observation of two young supernova remnants (SNRs) with H.E.S.S.

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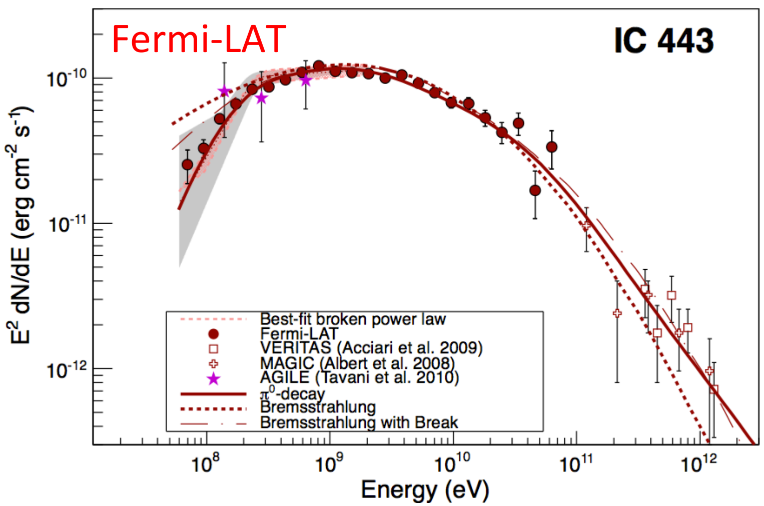
High - Very High Energy (HE-VHE) features of SNRs interacting with Molecular Clouds (MCs):

SNRs interacting with MCs:
W28N, W49B, W51C, IC443, W44

- Luminous GeV & weak TeV sources
- Spectral break at a few GeV, steep at VHE



Ackermann et al., 2013

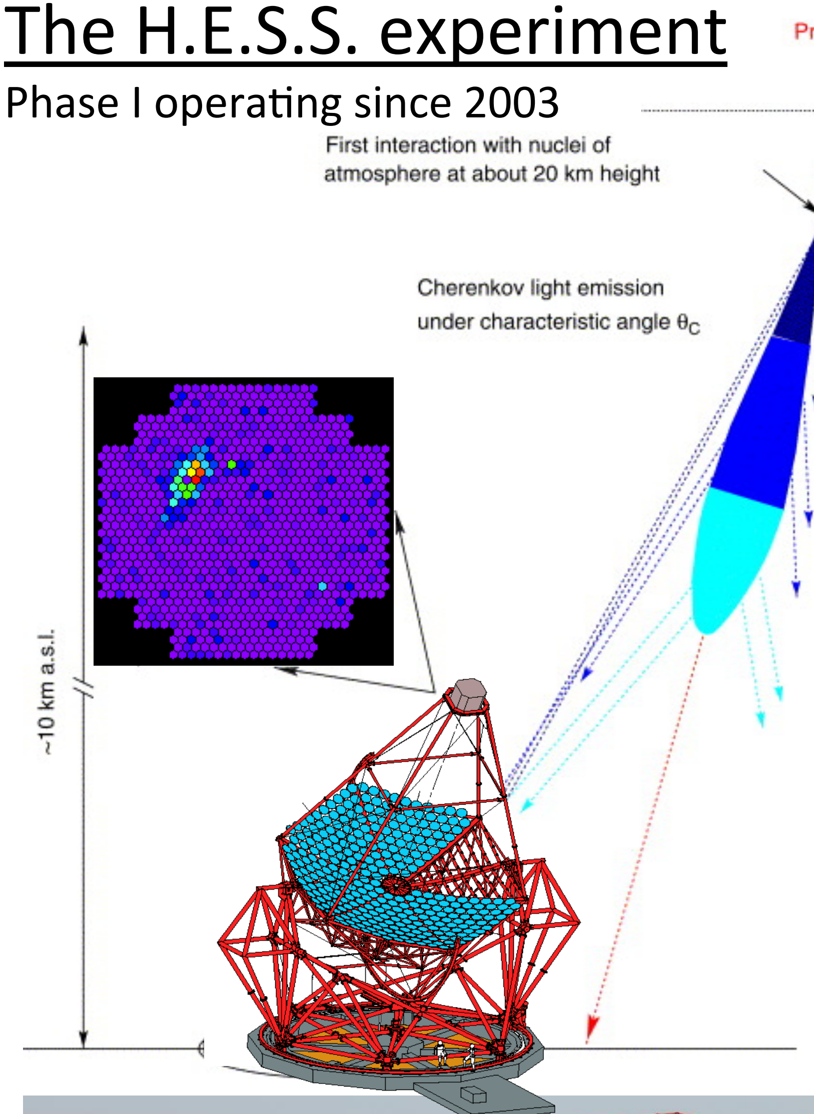
SNR	ΔIndex	E_{break} (GeV)
W28N	0.65±0.30	1.0±0.2
W49B	0.72±0.20	4.8±1.6
IC443	0.63±0.11	3.3±0.6
W44	0.96±0.10	1.9±0.2
W51C	1.3±0.1	1.7±0.5
	0.6-1.3	1-5 GeV

Abdo et al., 2009-2010
Aleskic et al., 2012

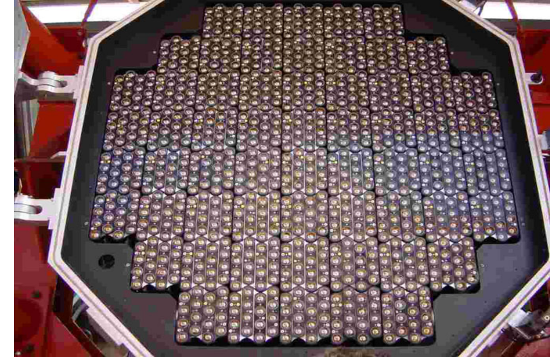
CR spectral break not naturally predicted
by Diffusive Shock Acceleration (DSA) theory

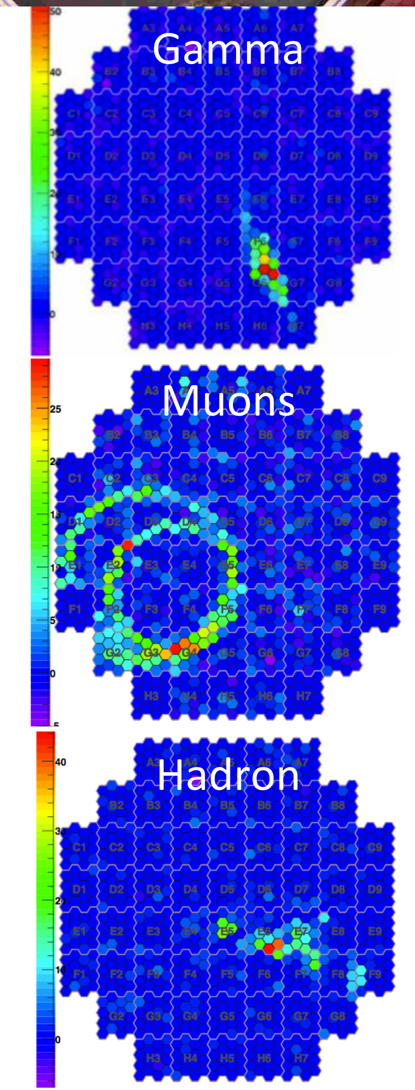
The H.E.S.S. experiment

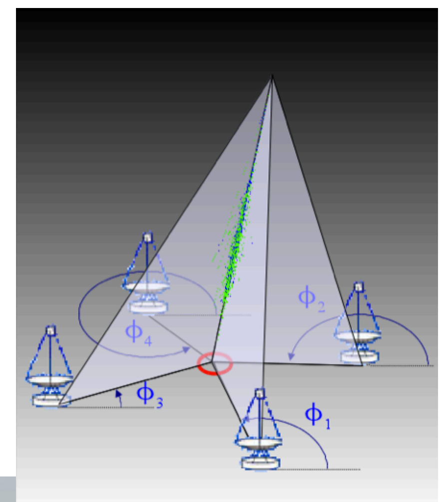
Phase I operating since 2003

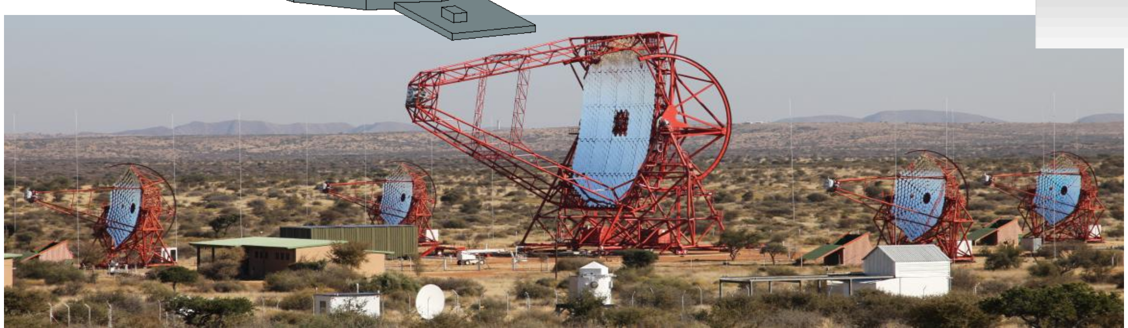


Angular resolution ~ 0.1°
Energy resolution ~ 15%
Effective area ~ 10^5-10^6 m^2



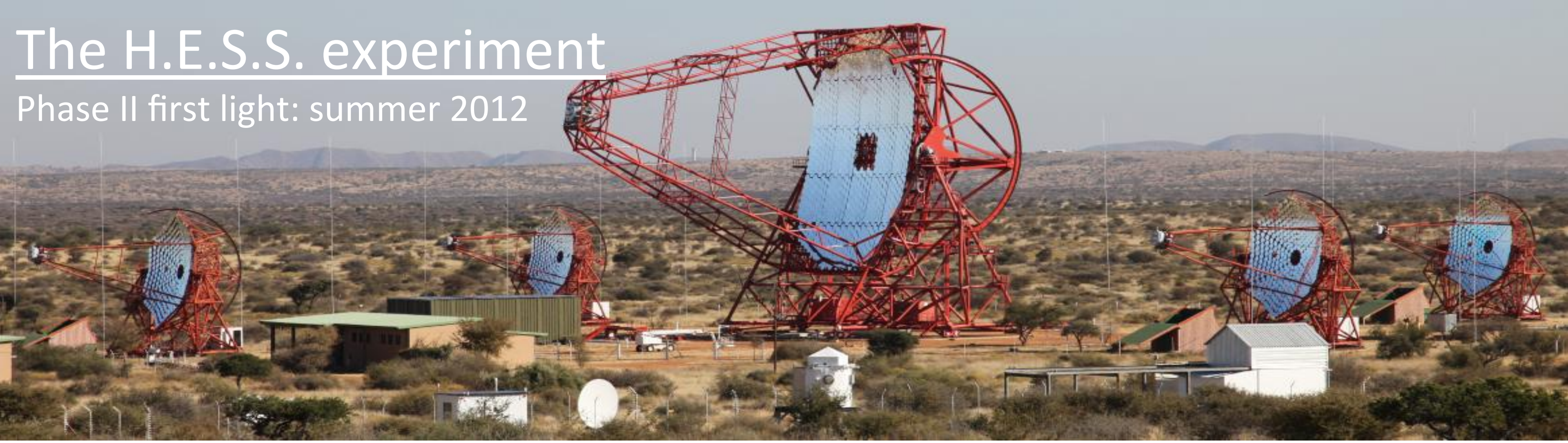




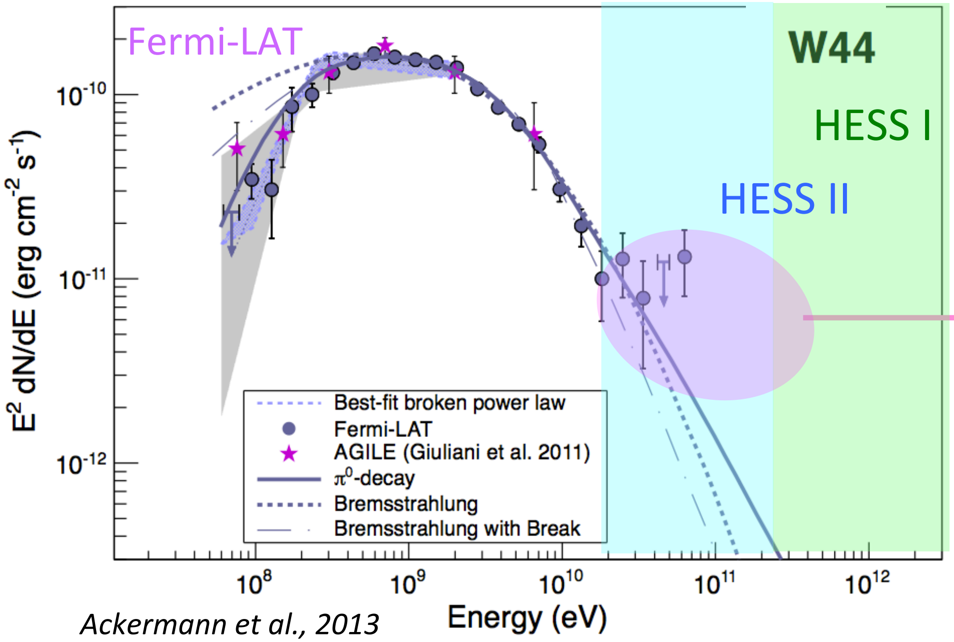


The H.E.S.S. experiment

Phase II first light: summer 2012



H.E.S.S. II: lower energy threshold => 40 GeV



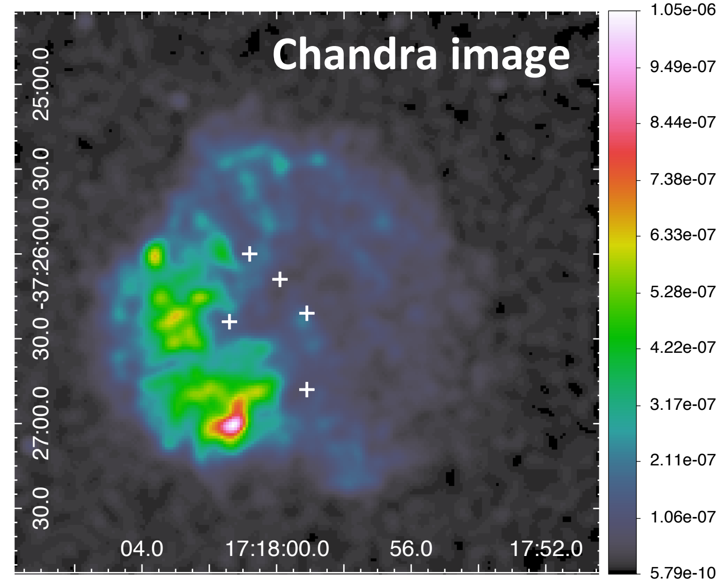
Ackermann et al., 2013

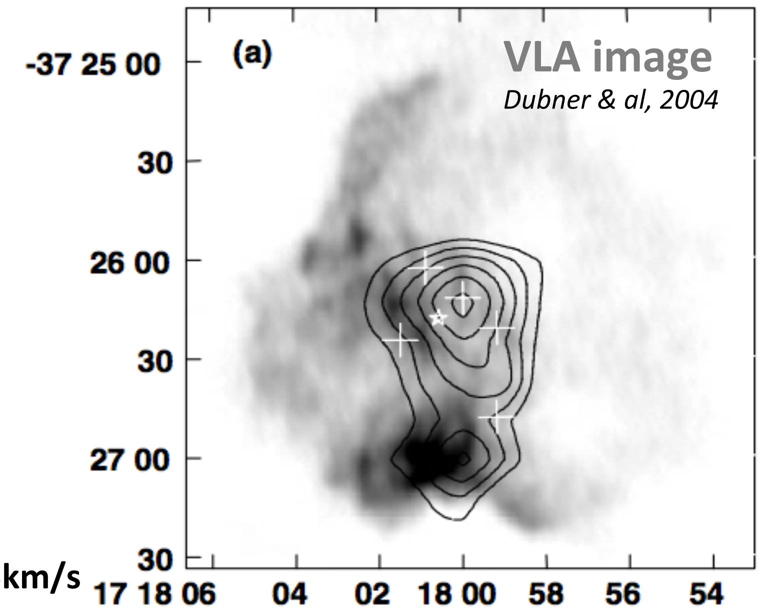
W44: a SNR-MC undetected at VHE

Will be further explored with H.E.S.S. II

G349.7+0.2: MWL data

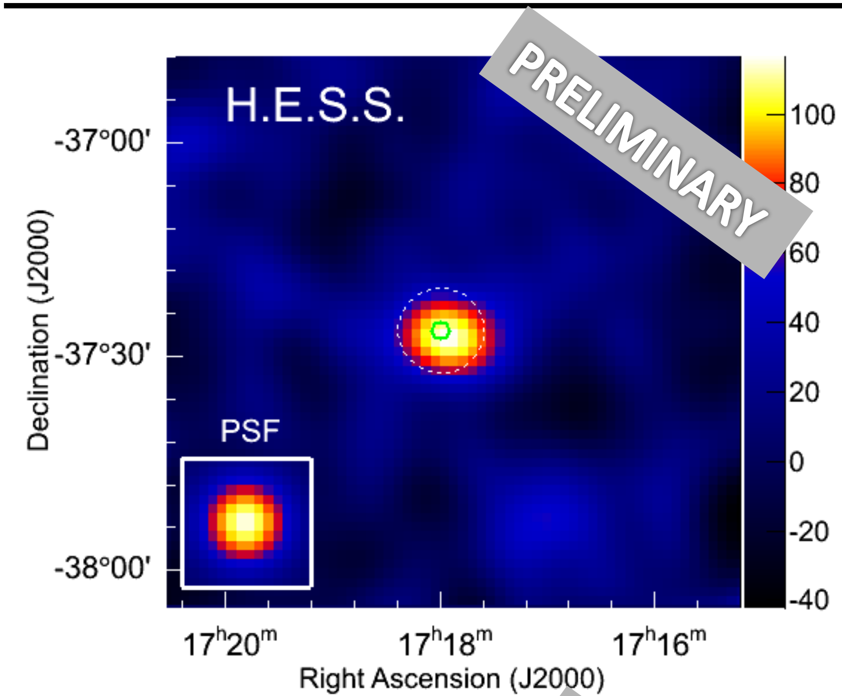
- **Young** SNR ≈ 3000 yrs *(Lazendic et al. 2005)*
- **Very distant** SNR: D ≈ 22 kpc
  OH masers *(Frail et al. 1996)*
  HI absorption *(Lazendic et al. 2005)*
- **One of the 3 brightest galactic SNR in radio & in X-rays**
  Similar Radio & X morphologies
  Ø ≈ 2.5 ‘
  (Shaver et al., 1985; Lazendic et al., 2005; Green 2009)
- Interacting with a MC *(Dubner et al., 2004)*
  H_2 lines *(Hewitt et al. 2009)*
  5 OH masers (1720 MHz) *(Frail et al. 1996)*
- Fermi-LAT counterpart *(Castro & Slane, 2010)*





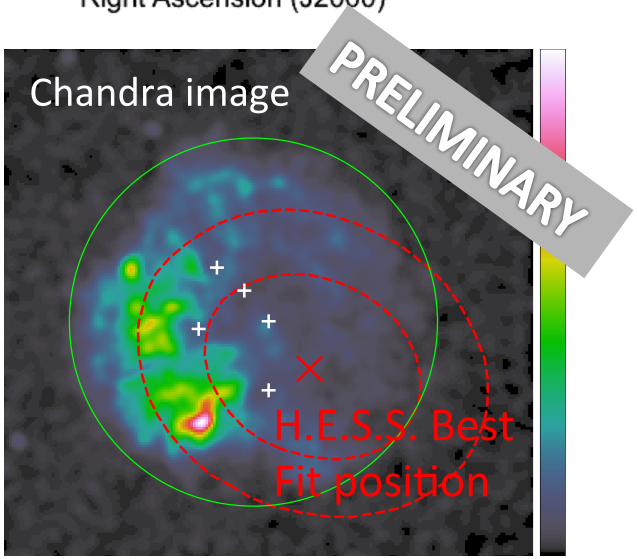
Crosses : OH maser
Contours: ^{12}CO v≈15km/s

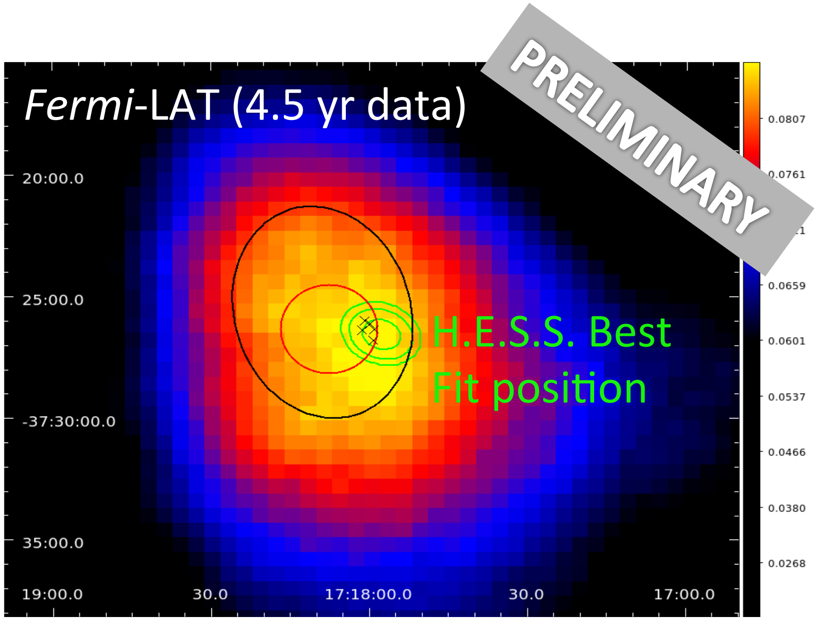
G349.7+0.2: H.E.S.S. & Fermi-LAT results



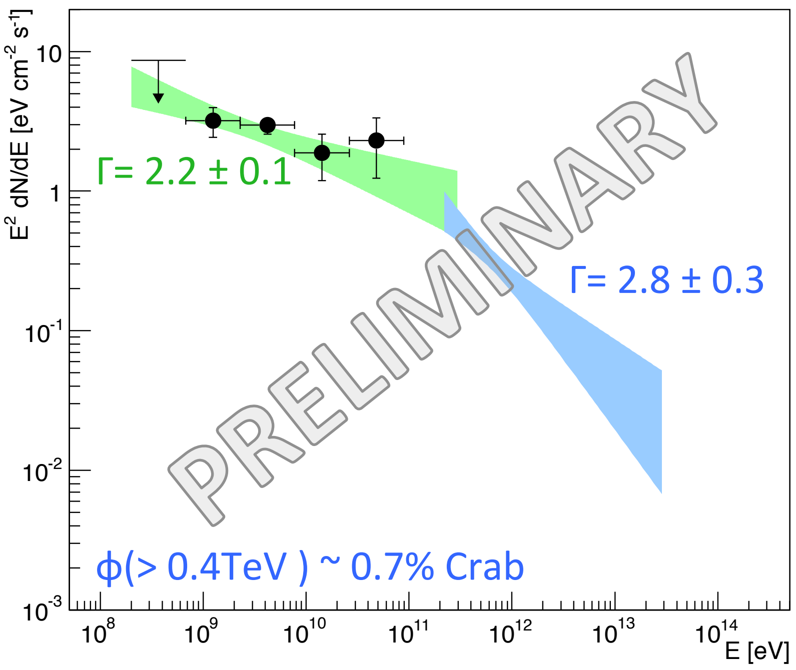
Time exposure: 113 h
Significance: 6.6σ (peak: 7σ)

- **Point-like source**
- 95% CL UL on the H.E.S.S. source extension: $\sigma_{ext}^{95\%} < 0.04°$





G349.7+0.2: H.E.S.S. & Fermi-LAT results

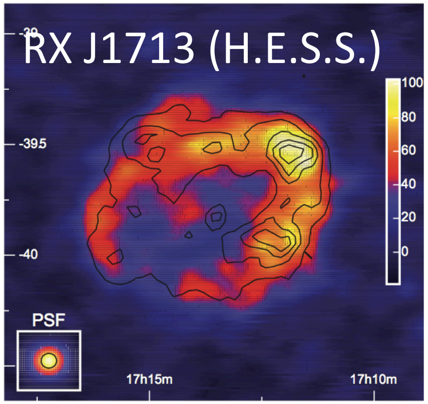


H.E.S.S. data compatible with:

- Broken Power Law spectrum:
  $\Delta\Gamma$ = 0.6 ± 0.3, E_{break} ~ 100 GeV
- Power Law ($\Gamma = \Gamma_{GeV}$= 2.2) spectrum with Exponential cutoff:
  E_{cut} = 300 - 700 GeV @ 95% CL

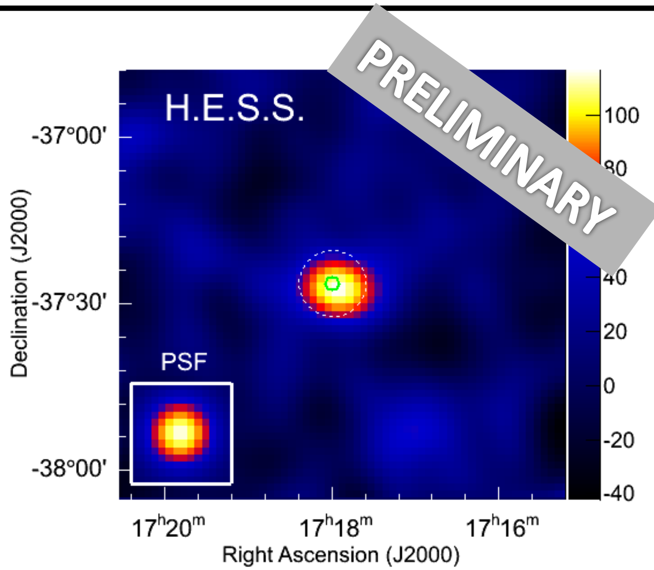
G349 is one of the most luminous Galactic VHE SNR

L_{G349} (E > 400 GeV) ~ $L_{RX\ J1713}$ (E > 400 GeV)

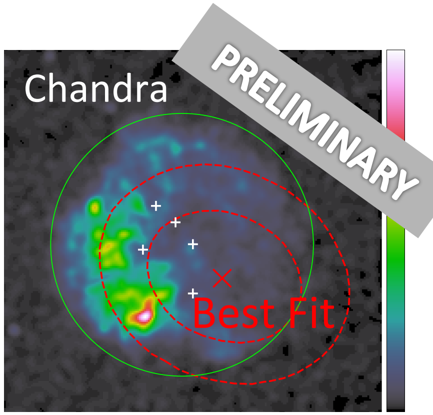


SNR G349.7+0.2

- **Furthest** VHE detection of a Galactic SNR
- One of the **most luminous** Galactic VHE SNR
- One of the very few **young** SNRs known to be **interacting**
- Unresolved VHE emission

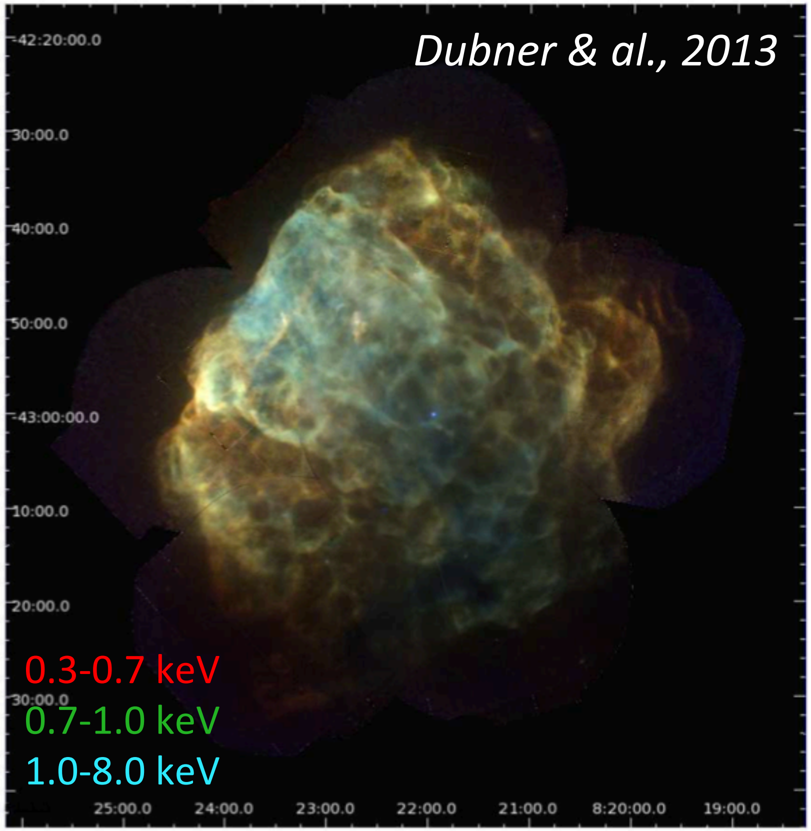


- MWL evidences of interaction with clumps
- **Spectral break at ~ 100 GeV**
  OR
  spectral cutoff at 300-700 GeV (95% CL)



- Energetics & Hydro compatible with emission from a localized region of the shell interacting with dense material $\mathbf{n_H\ W_p \sim 10^{52}\ d_{22\ kpc}^{2}\ \ erg\ cm^{-3}}$

Puppis A: MWL data



Ø = 50' = 0.8° *(Green, 2009)*

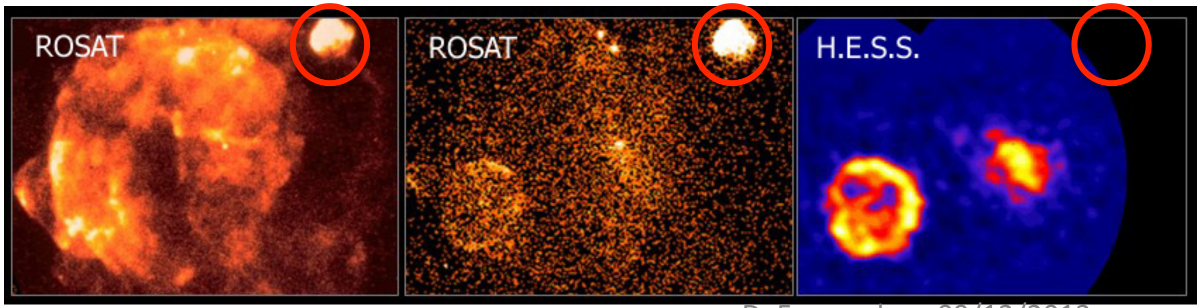
4450 ± 700 yrs (CCO motion & ejecta O knots)
Becker & al., 2012

~ 2.2 kpc (HI & CO)
(Dubner & Arnal 1988; Reynoso & al., 1995, 2003)

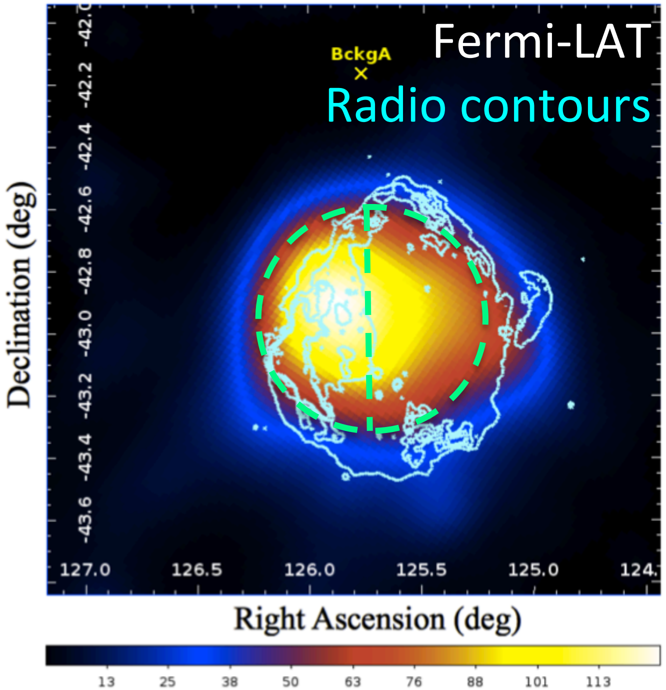
X density gradient NE-SW (x4) *(Dubner & al., 2013)*

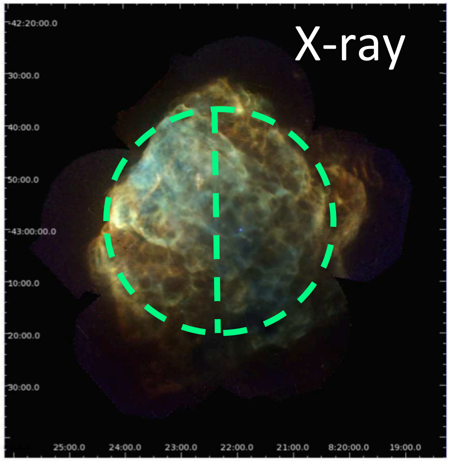
GeV emission *(Hewitt & al., 2012)*

Highly inhomogeneous ISM

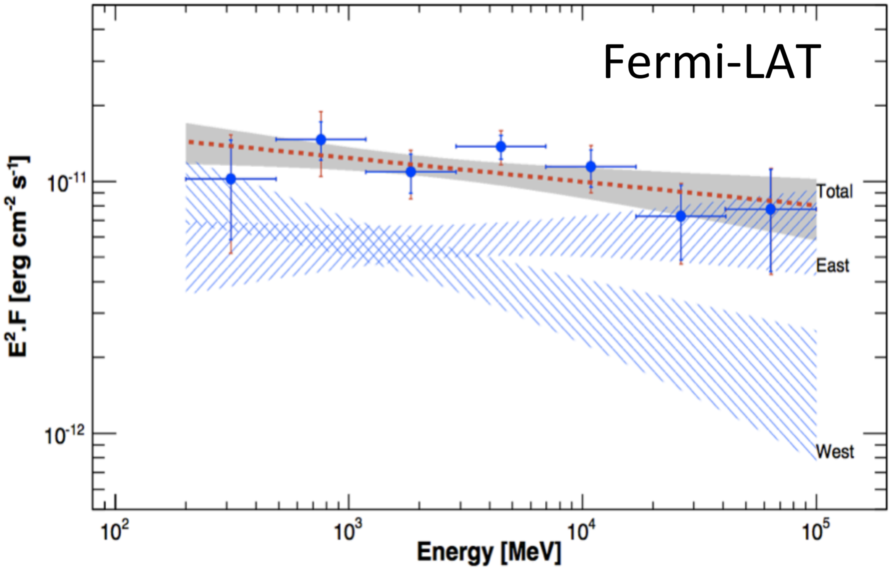


Puppis A: MWL data





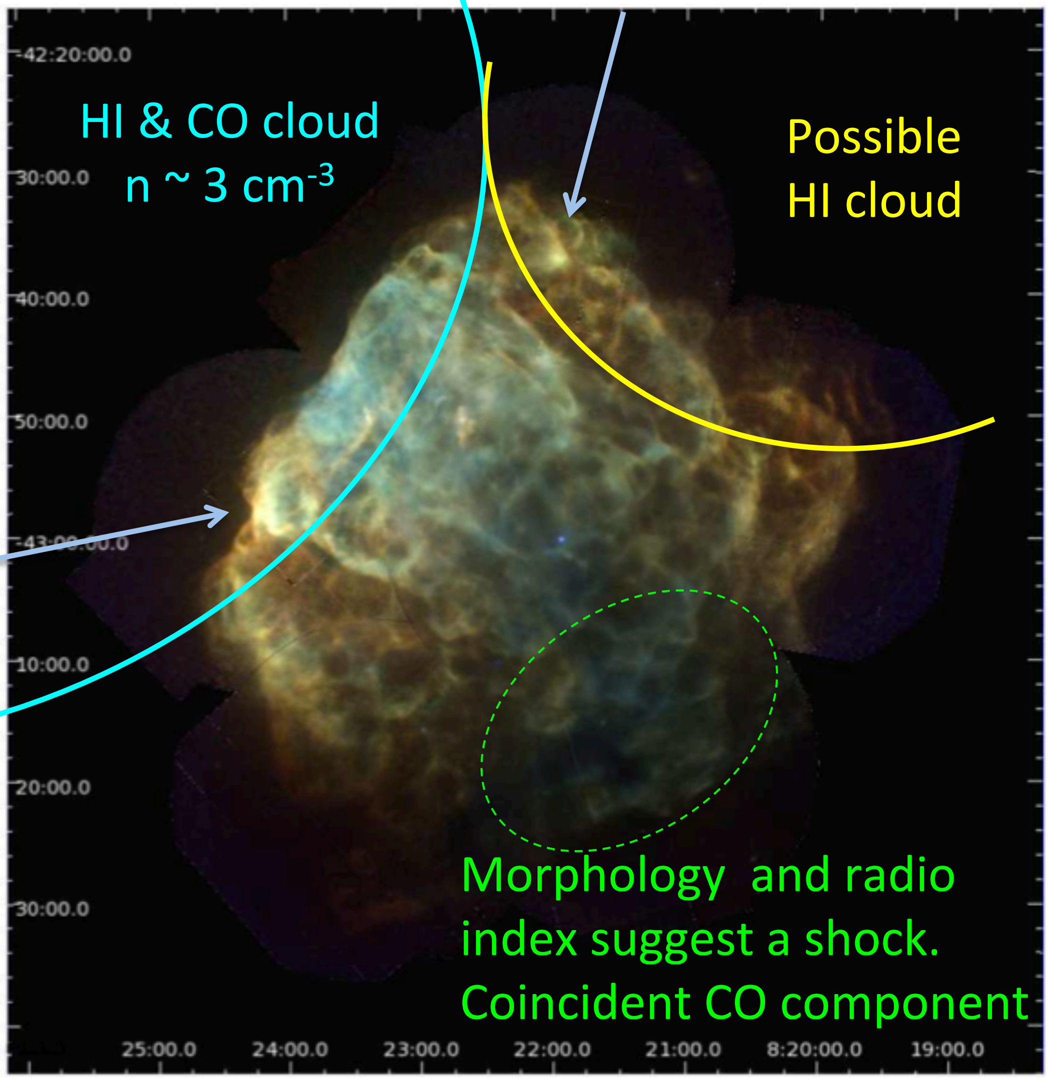
(Hewitt & al., 2012)



Spatial Model	Flux(>200 MeV) $[10^{-8}$ ph cm^{-2} s$^{-1}]$	Photon index	TS
X-ray	$1.64 \pm 0.23 \pm 0.21$	$2.09 \pm 0.07 \pm 0.09$	189
Radio	$1.64 \pm 0.22 \pm 0.22$	$2.06 \pm 0.07 \pm 0.08$	187
Uniform disk ($D1$)	$1.67 \pm 0.23 \pm 0.23$	$2.10 \pm 0.07 \pm 0.10$	190
Two X-ray halves:			
Eastern half-disk	$0.68 \pm 0.24 \pm 0.17$	$1.96 \pm 0.13 \pm 0.08$	82
Western half-disk	$0.94 \pm 0.29 \pm 0.16$	$2.28 \pm 0.14 \pm 0.10$	54

Puppis A: MWL data

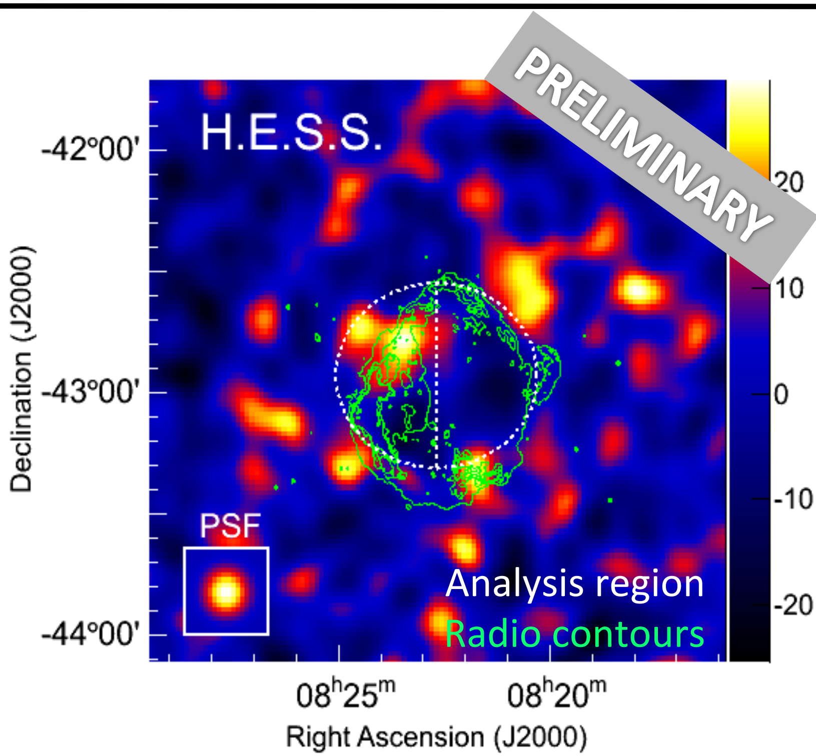
Northern Knot: cloudlet: ~ 18 cm^{-3}

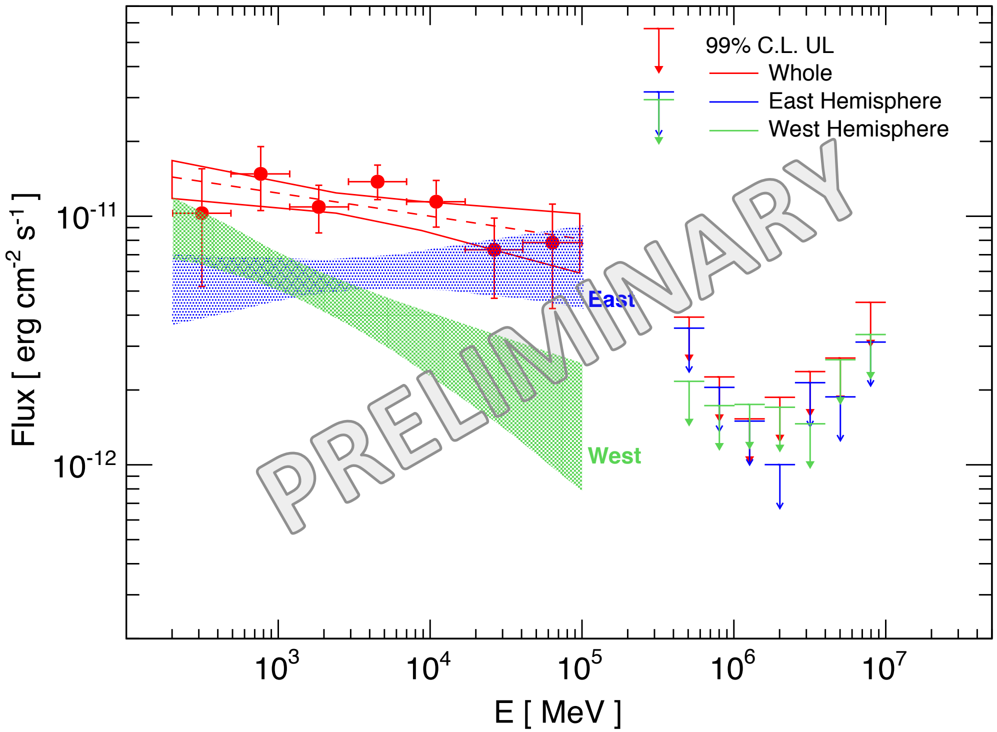


Bright Eastern Knot
cloudlet: ~ 10 cm^{-3}

Dubner & al., 2013
Hwang & al., 2005
Dubner & Arnal, 1988
Petre & al., 1982
Dame & al., 2001

Puppis A: H.E.S.S. Results



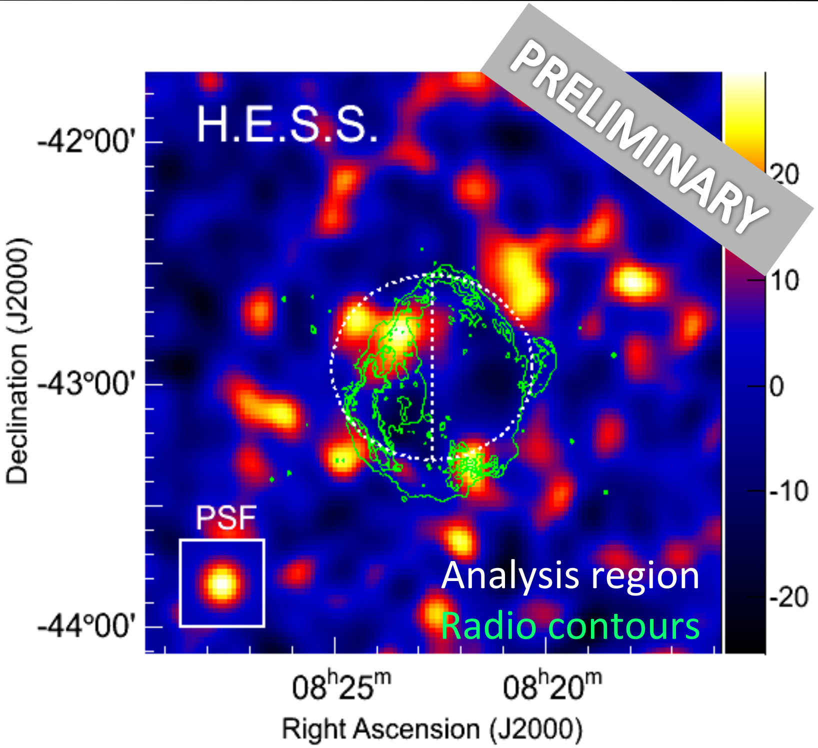


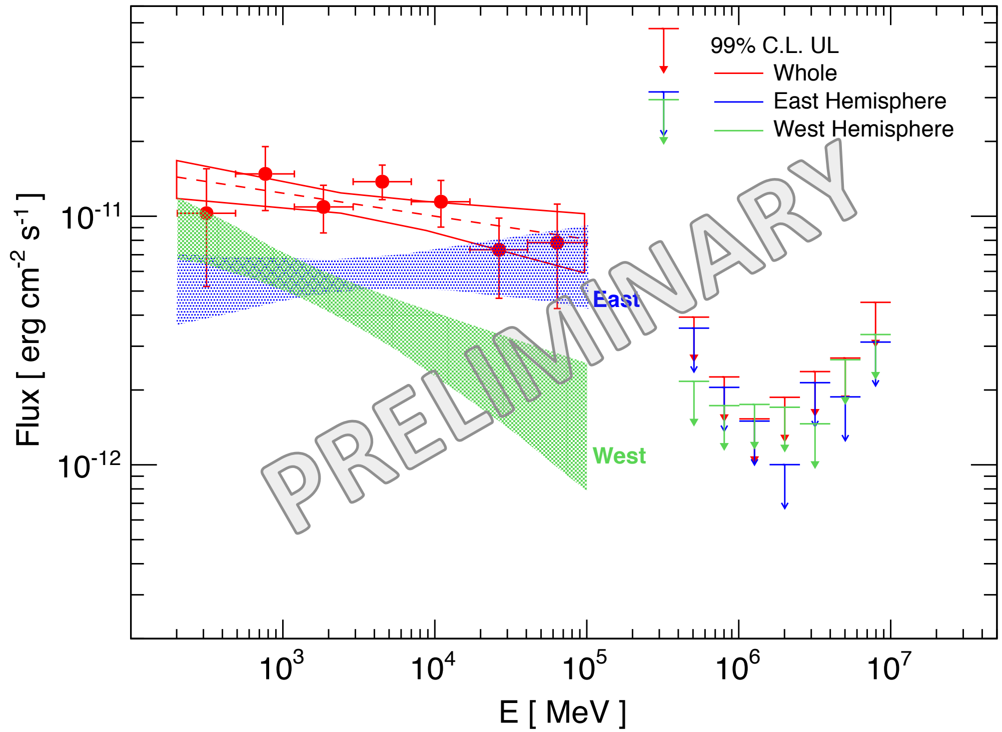
Time exposure : 24 h (2011-2013)

⇒ Very few excess counts in the analysis region : R_{ON} = 0.38° = $R_{\text{Fermi-LAT Best Fit}}$ BUT no significant excess is found

⇒ Expected spectral break/cutoff at 99% CL from H.E.S.S. analyses

Puppis A: H.E.S.S. Results





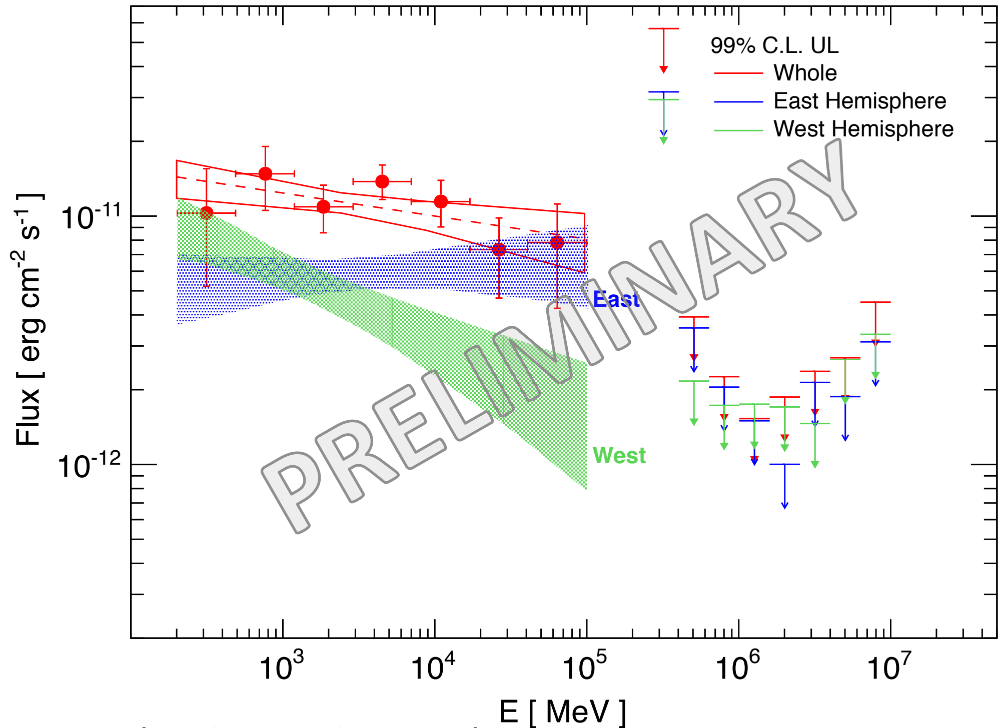
⇒ Power-law spectrum with $\Gamma = \Gamma_{\mathit{Fermi}\text{-LAT}} = 2.1$ in 0.2-10 TeV: Excluded at 5σ CL

⇒ Power-law with exponential cutoff spectrum: $E_{cut} \leq 450$ GeV @ 99% CL

Puppis A: H.E.S.S. Results

Puppis A is a young SNR

⇒ **Unexpected lack of VHE signal from Puppis A**



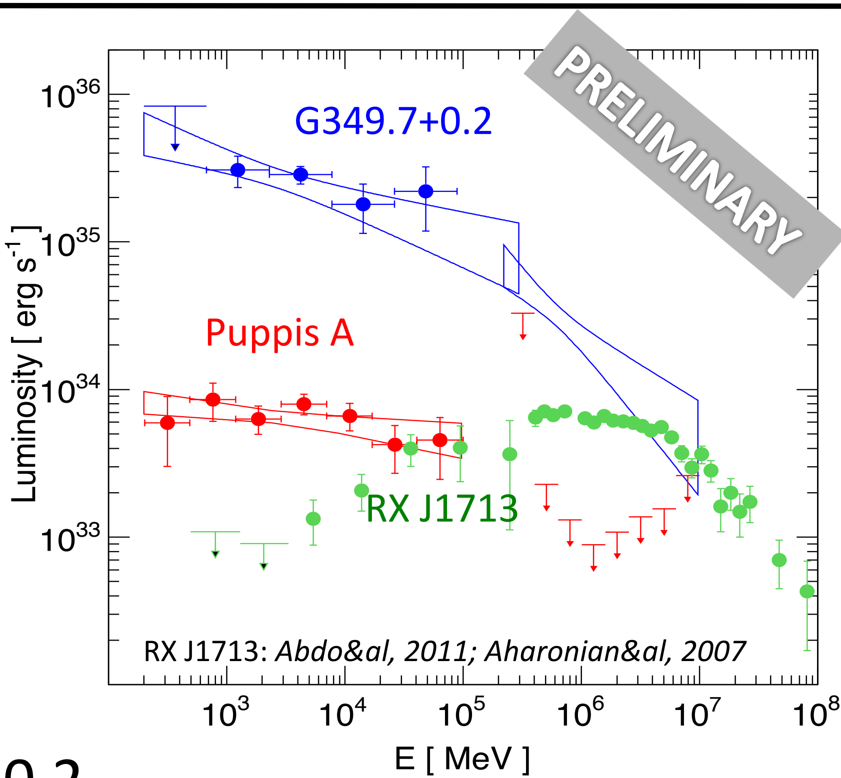
- Is it older than we think ?
  4450 ± 700 yr : CCO motion *(Becker & al., 2012)*
  3700 ± 300 yr : O knots from ejecta *(Winkler & al, 1988, Becker & al., 2012)*
  6000 - 8000 yr : X-ray temperature *(Winkler & Kirshner, 1985)*
  large size R_{SNR}= 15 pc @ 2kpc

- Is it because of interaction with dense material ?
  => Strong wave damping & escape of VHE CRs from the SNR shock ?
  (Malkov & al, 2012; Ohira & al, 2010; Ptuskin & Zirakashvili, 2005)

CONCLUSION

SNRs G349.7+0.2 and Puppis A :

- Young SNRs
- SNR blastwave interacting with dense interstellar material



- TeV emission from SNR G349.7+0.2
  presumably resulting from the localized interaction of the SNR blast-wave with dense material of MC

- Unexpected lack of TeV emission from SNR Puppis A
  Strong wave damping ?

Thank you for your attention.

Puppis A: MWL data

No clear evidence of a SNR-MC shock (no OH maser…)

But many indications of interactions with clouds :

- Asymmetrical expansion => inhomogeneous medium
- 2 bright X-radio knots => the shock has engulfed dense cloudlets
- CO & HI components coincident with the SNR rims
- Good IR/X-ray correlation => thermal emission of swept-up IS dust
- SW: morphology & flat radio index suggest a shock
  + CO component