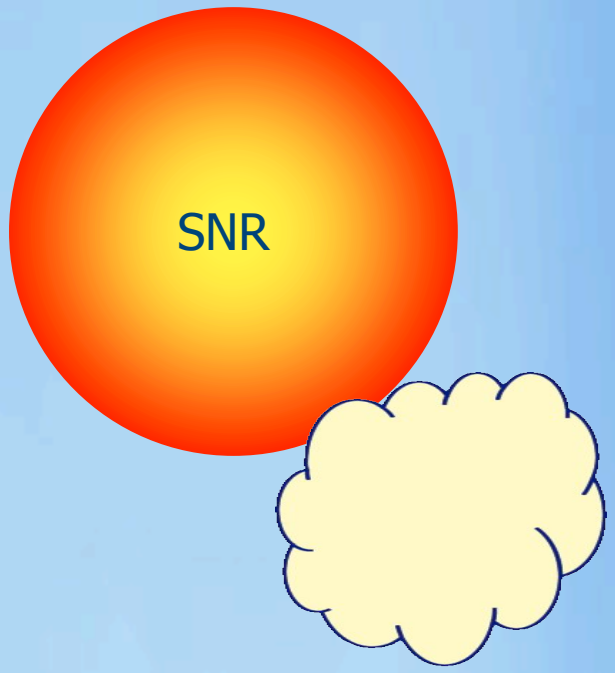
Where to search for Cosmic-Ray and Molecular Clouds interaction ?

Fabio Acero
& collaborators

Interaction of CRs with MCs

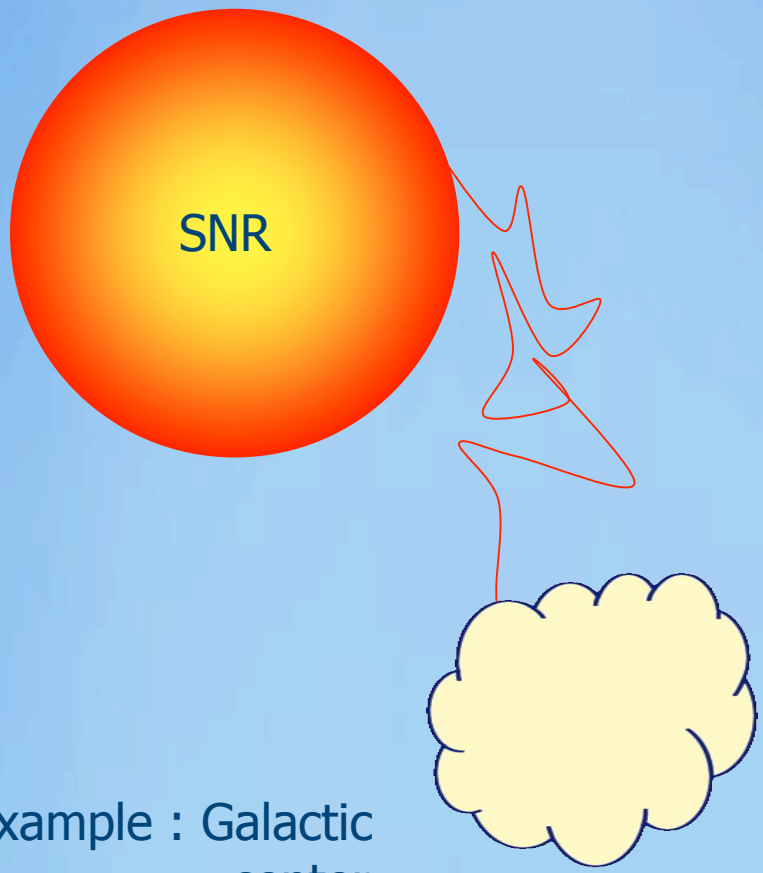
- Direct interaction



Examples : IC443, W28, W44, …

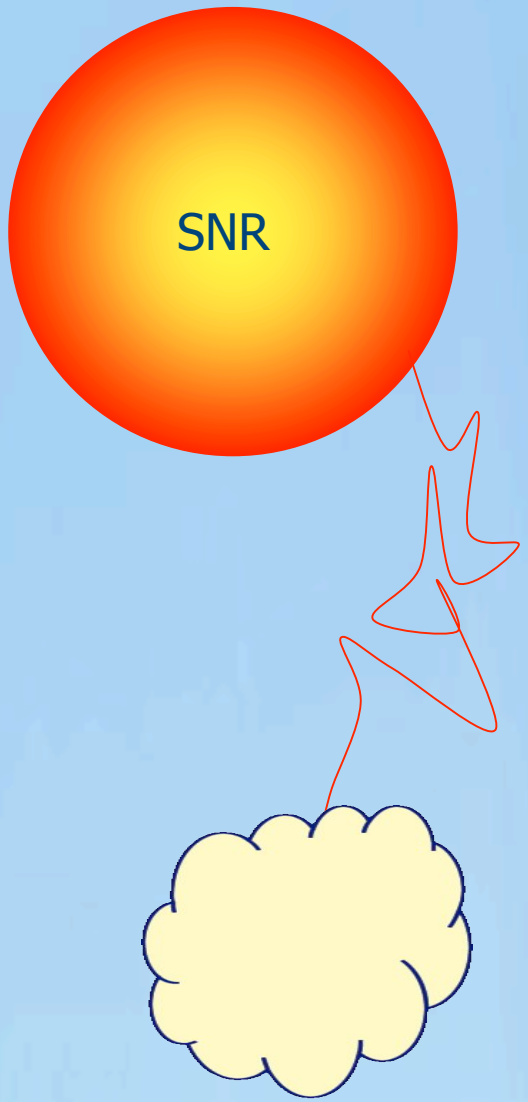
- "Diffusive" interaction

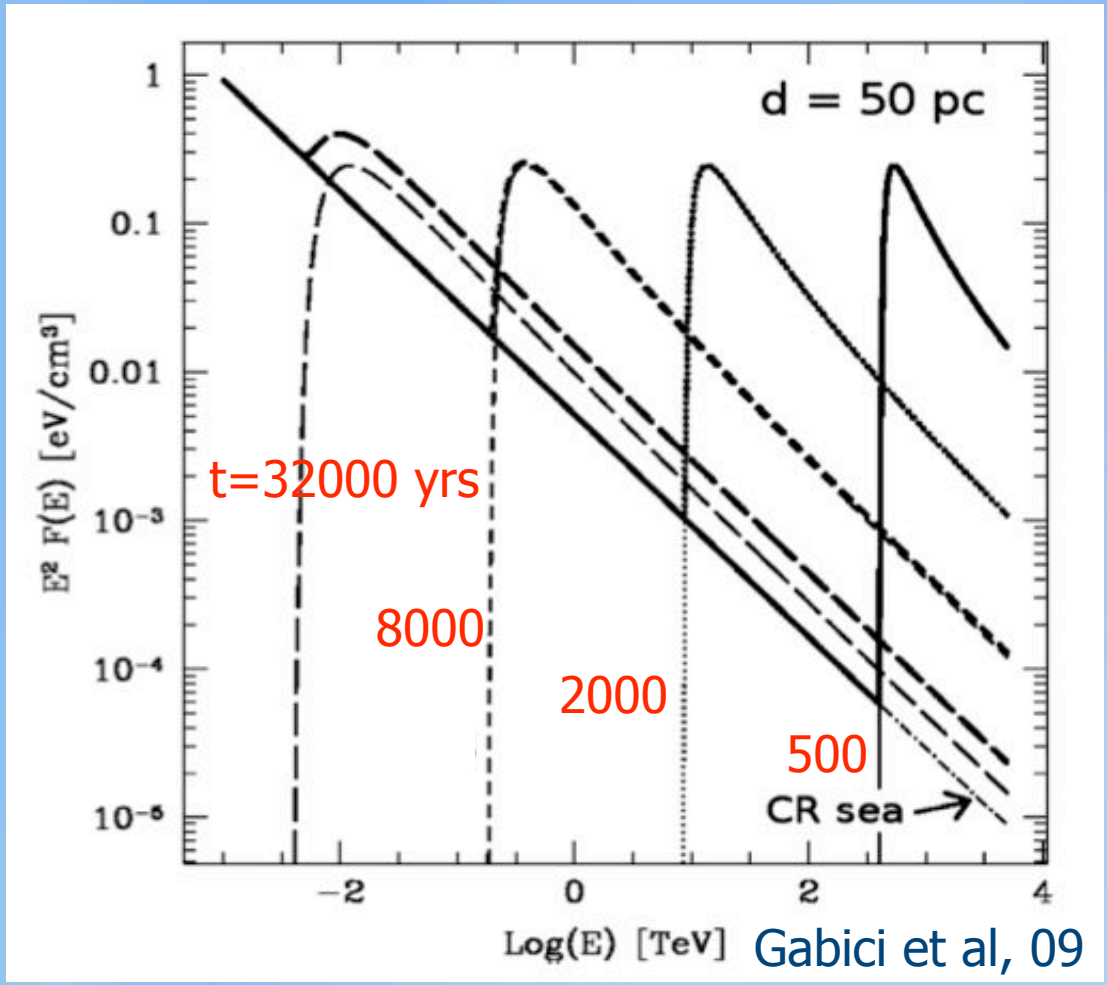
not due to CR sea



Example : Galactic center

Interaction of CRs with MCs

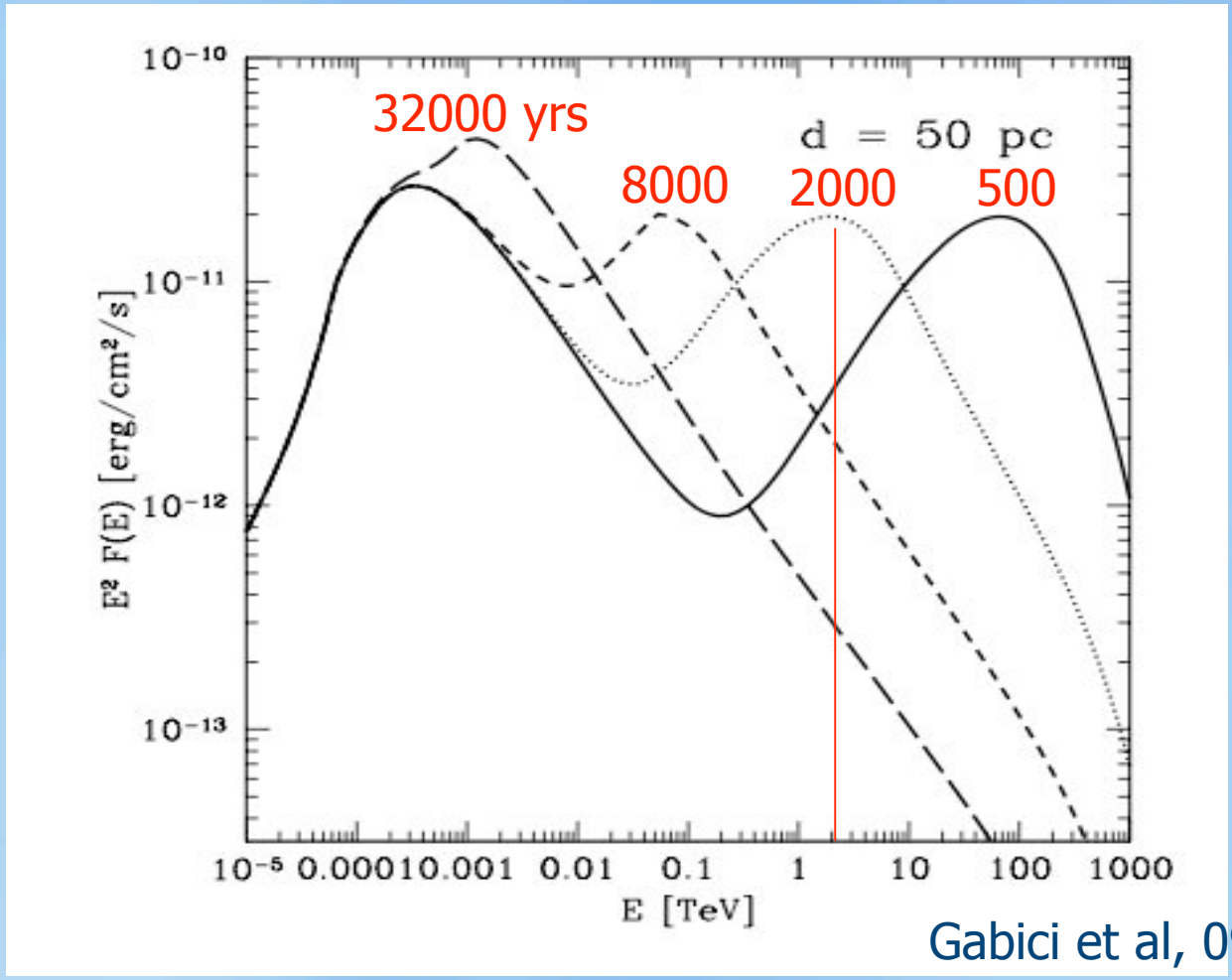




Gabici et al, 09

- Spectrum of Cosmic rays escaped from an SNR of age t

Interaction of CRs with MCs

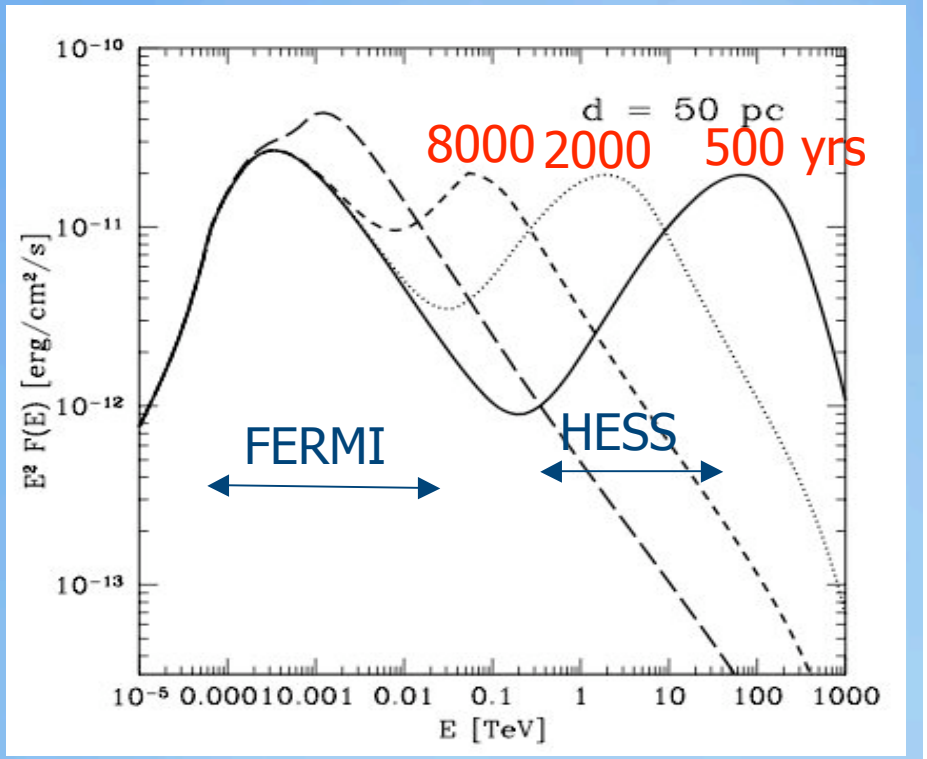


Gabici et al, 09

- Spectrum of the photons emitted by the MC

Molecular-Clouds/SNR
Little How-to

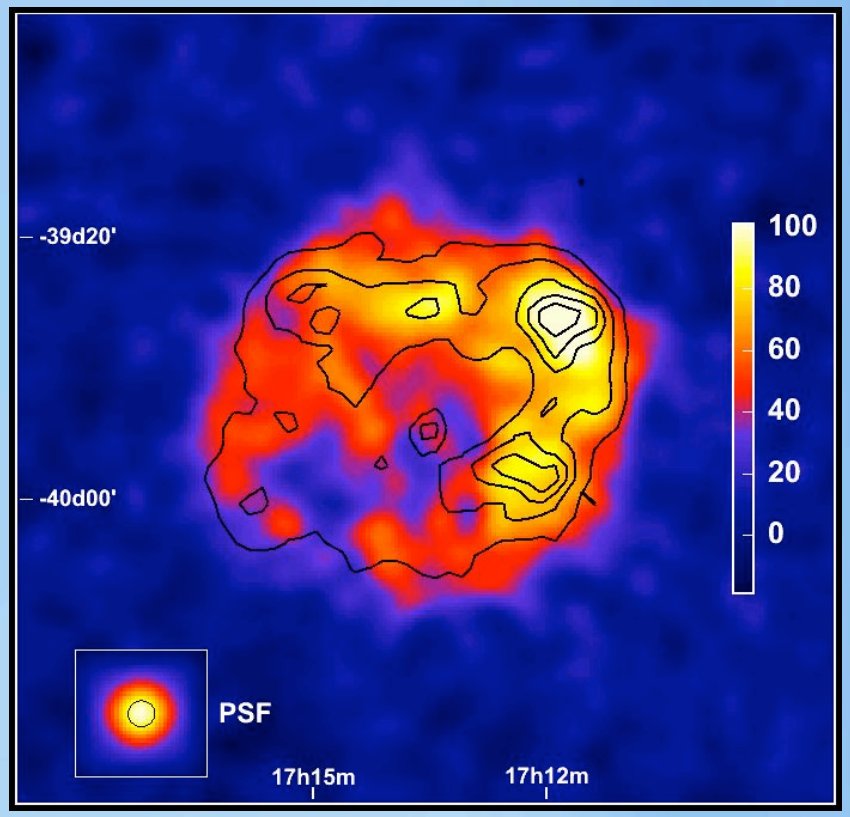
- Good candidates : dark sources
- CO counterpart at d < 100 pc from the SNR
- Young SNR (< 5000 yrs) for a HESS detection
- SNR with detected spectral cutoff is a plus
- Specific spectrum shape of the cloud hard spectrum with cutoff
- FERMI counterpart for MC

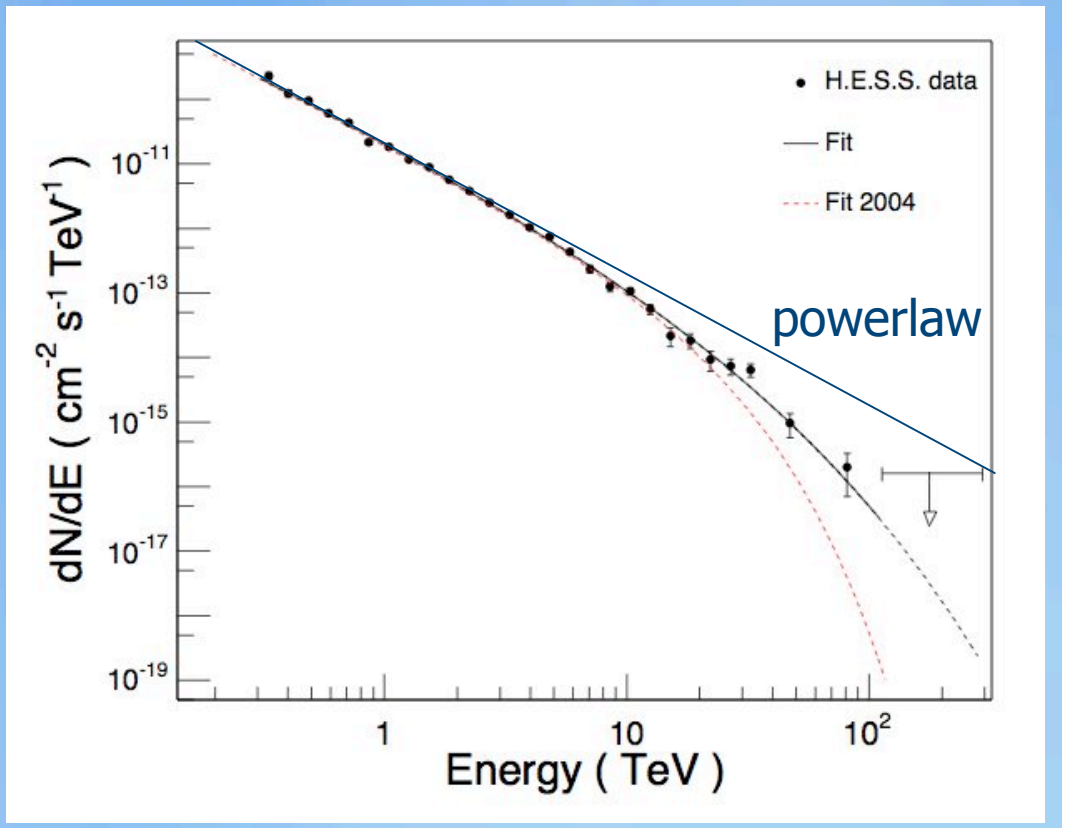


Good candidate : RXJ 1713

Good Example

RX J1713

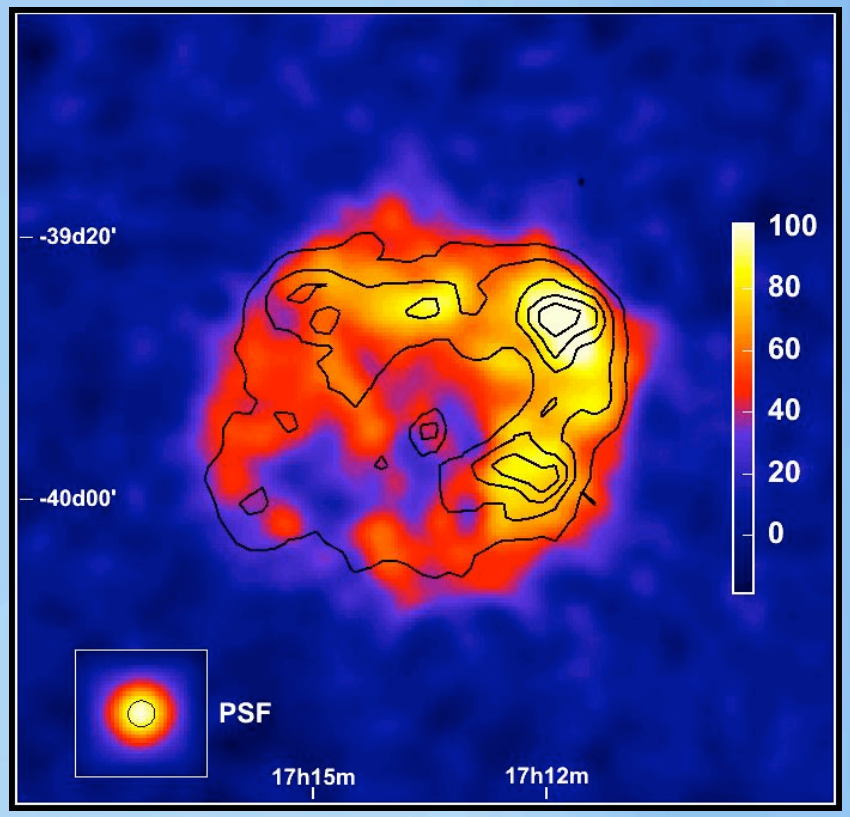


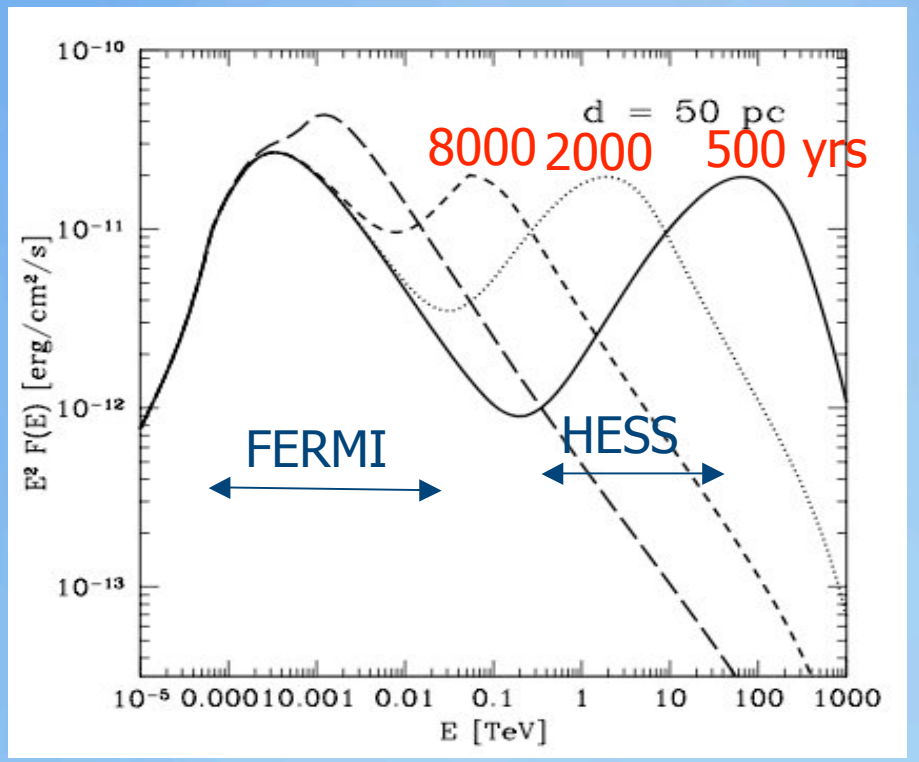


Aharonian et al 07

Good Example

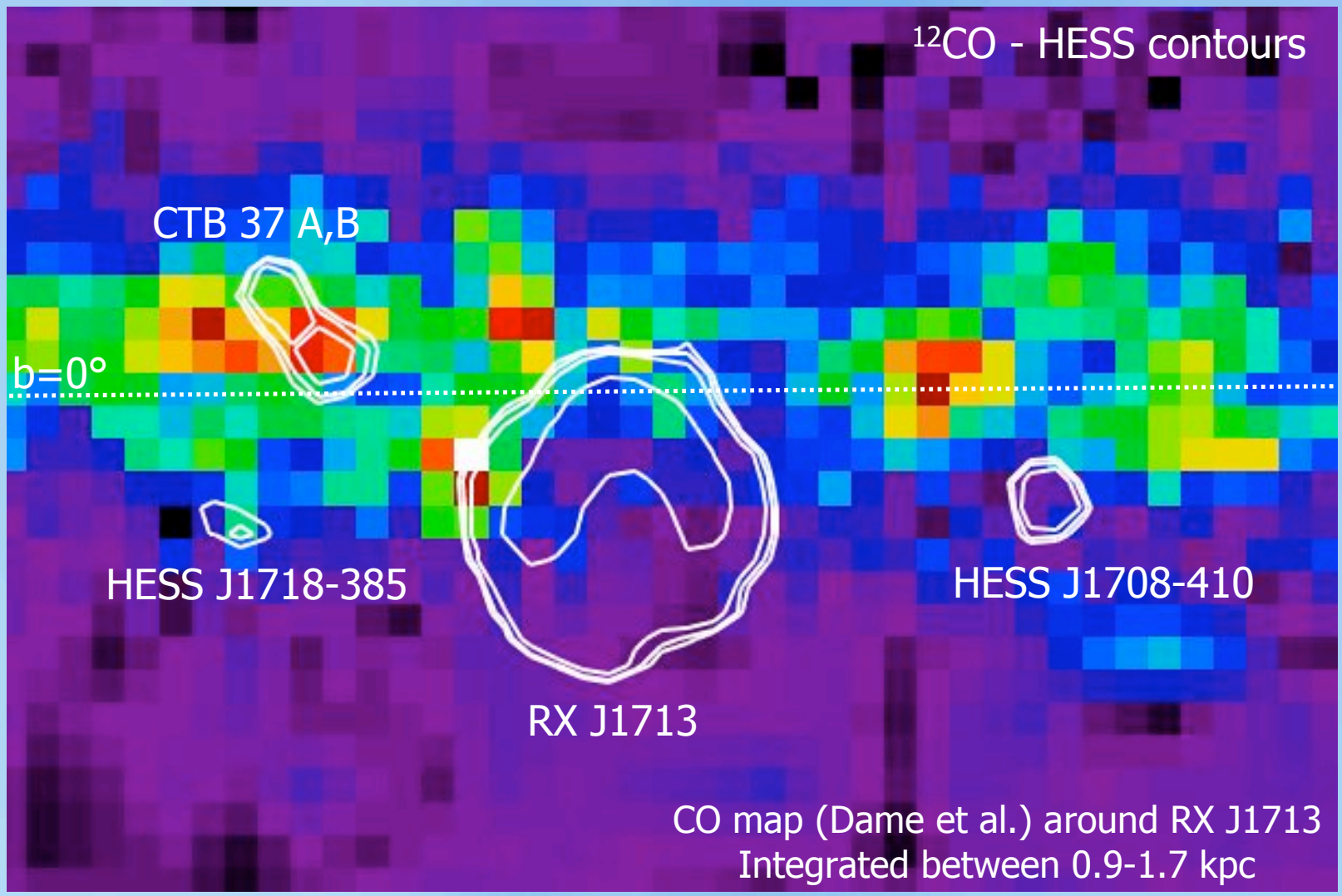
RX J1713





Molecular clouds ?

^{12}CO



CRs would diffuse preferentially along the magnetic fields lines

A new shell type SNR

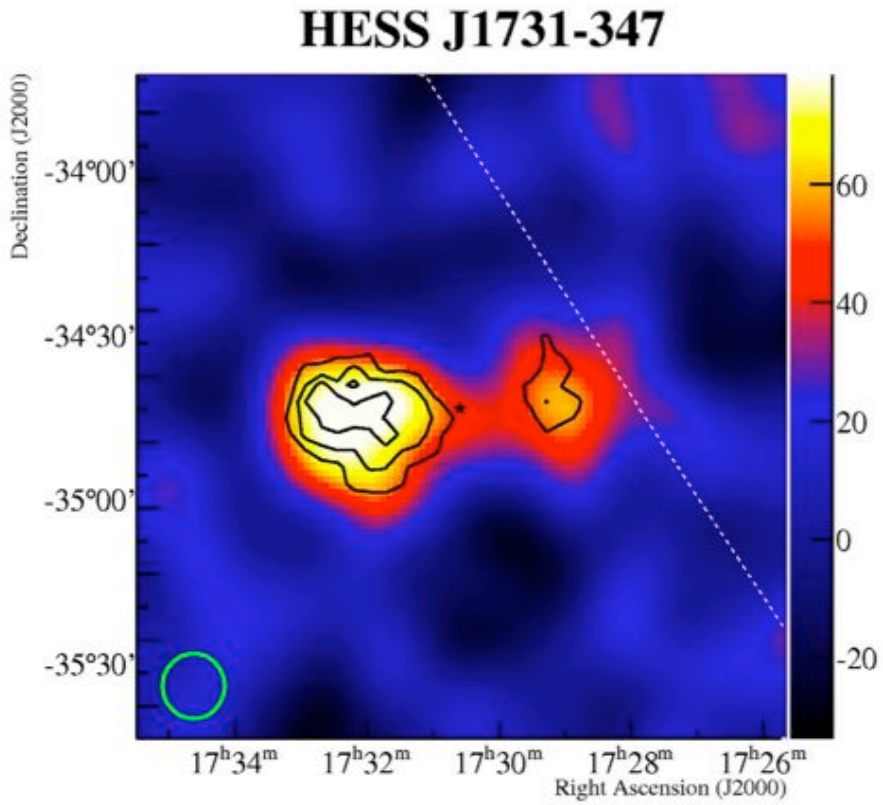
Unidentified sources

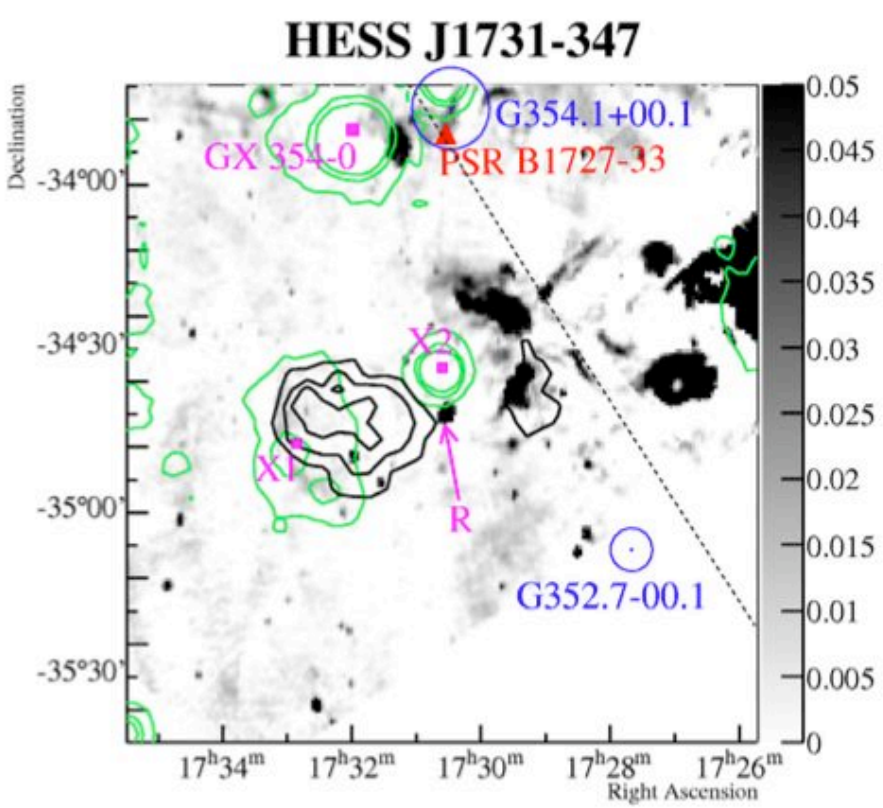
HESS J1731-347

A&A 477, 353–363 (2008)
DOI: 10.1051/0004-6361:20078516

Astronomy & Astrophysics

HESS very-high-energy gamma-ray sources without identified counterparts





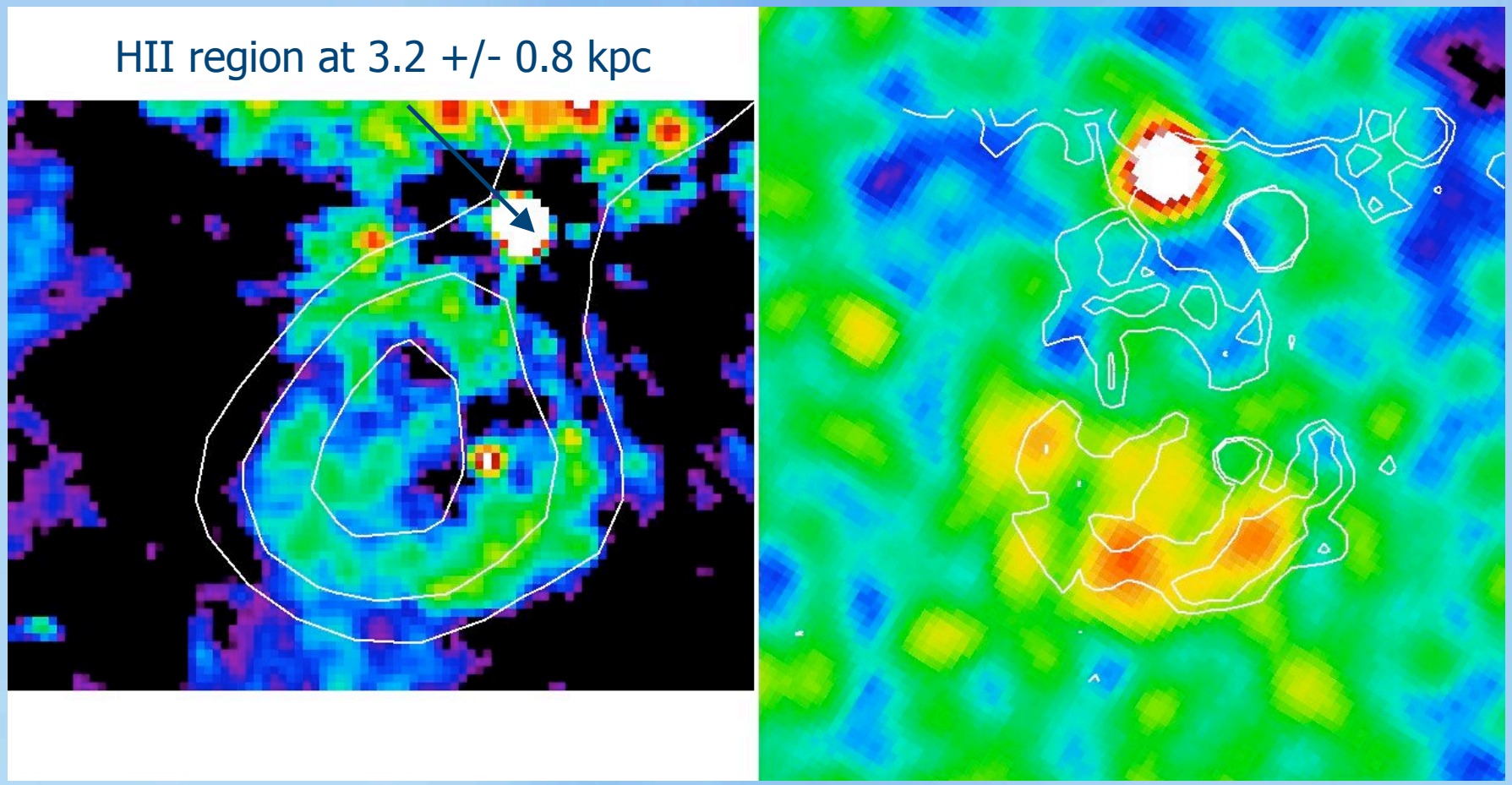
Molonglo radio map

HESS J1731-347

ROSAT

ATCA Radio + HESS contours

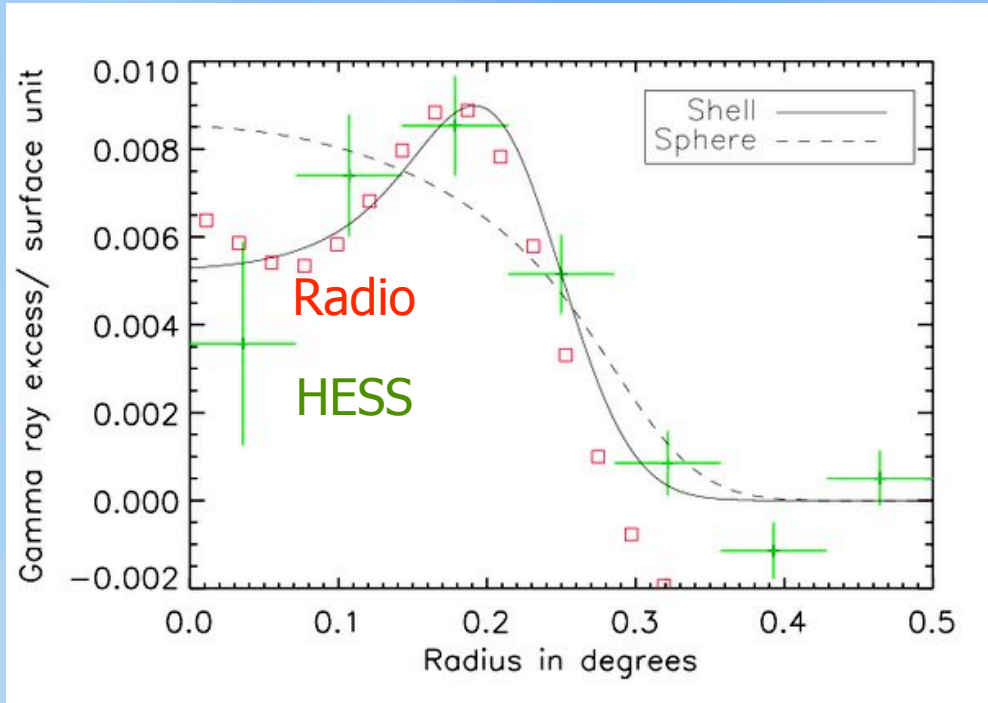
ROSAT + ATCA radio contours



HESS J1731-347

HESS

Radial profiles



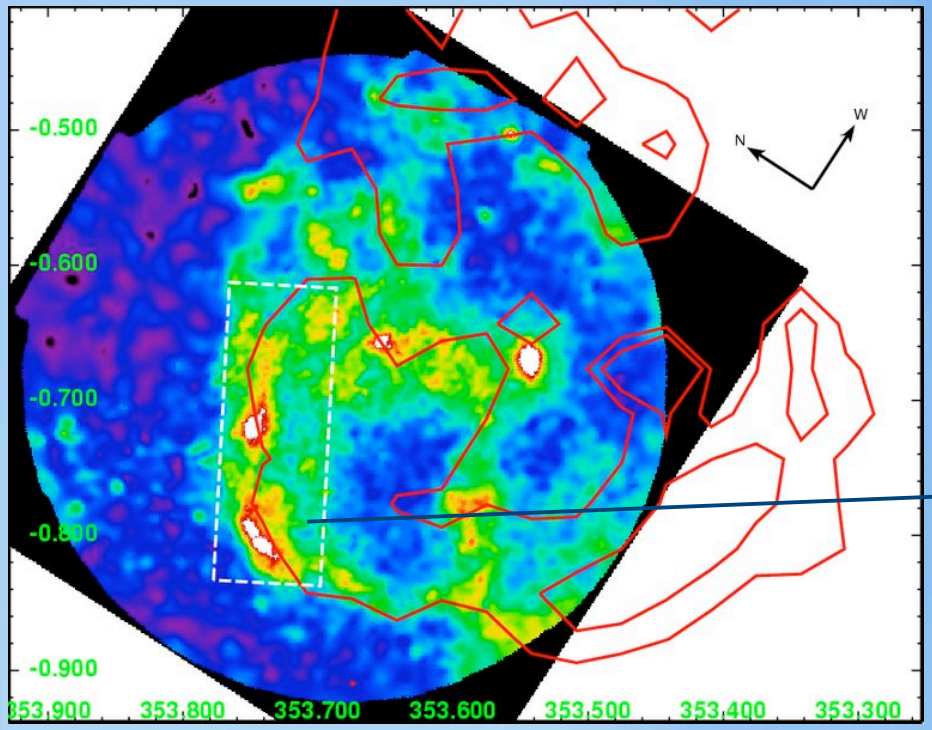
Acero et al '09, arXiv:0907.0642

*Spatially coincident with radio shell
*Indication of shell like morphology
Not statistically significant (yet)

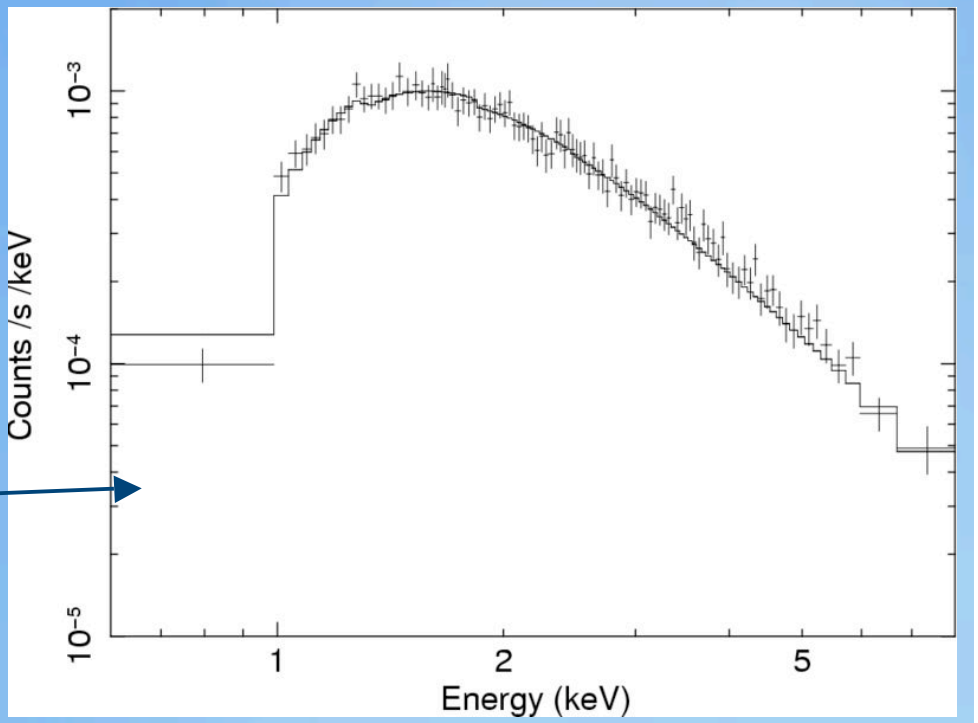
HESS J1731-347

Non thermal shell !

XMM + ATCA radio contours



MOS instrument spectrum



Acero et al '09

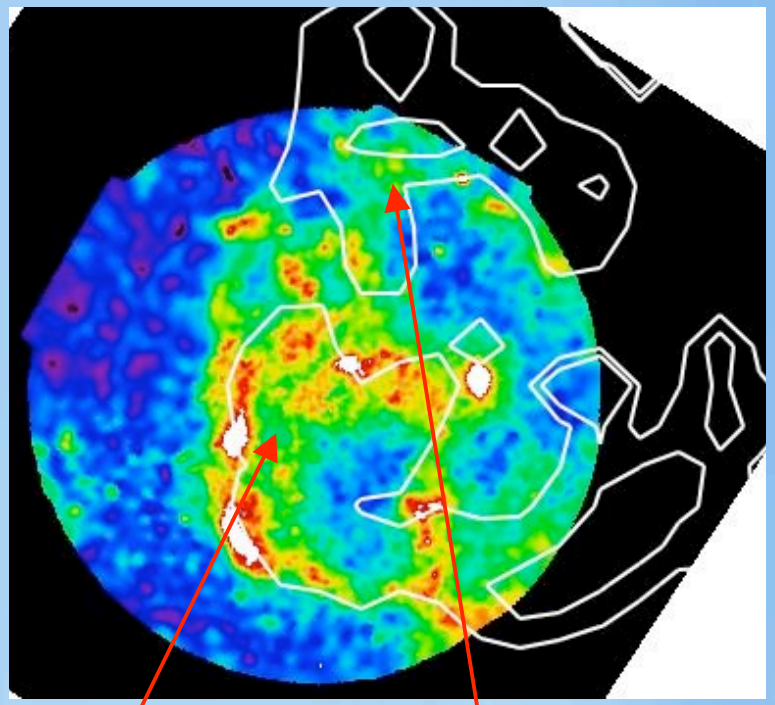
SNR's filament well fitted by an absorbed powerlaw

X-ray synchrotron emission -> e^- accelerated to ~10 TeV

12C0 study

Spectra

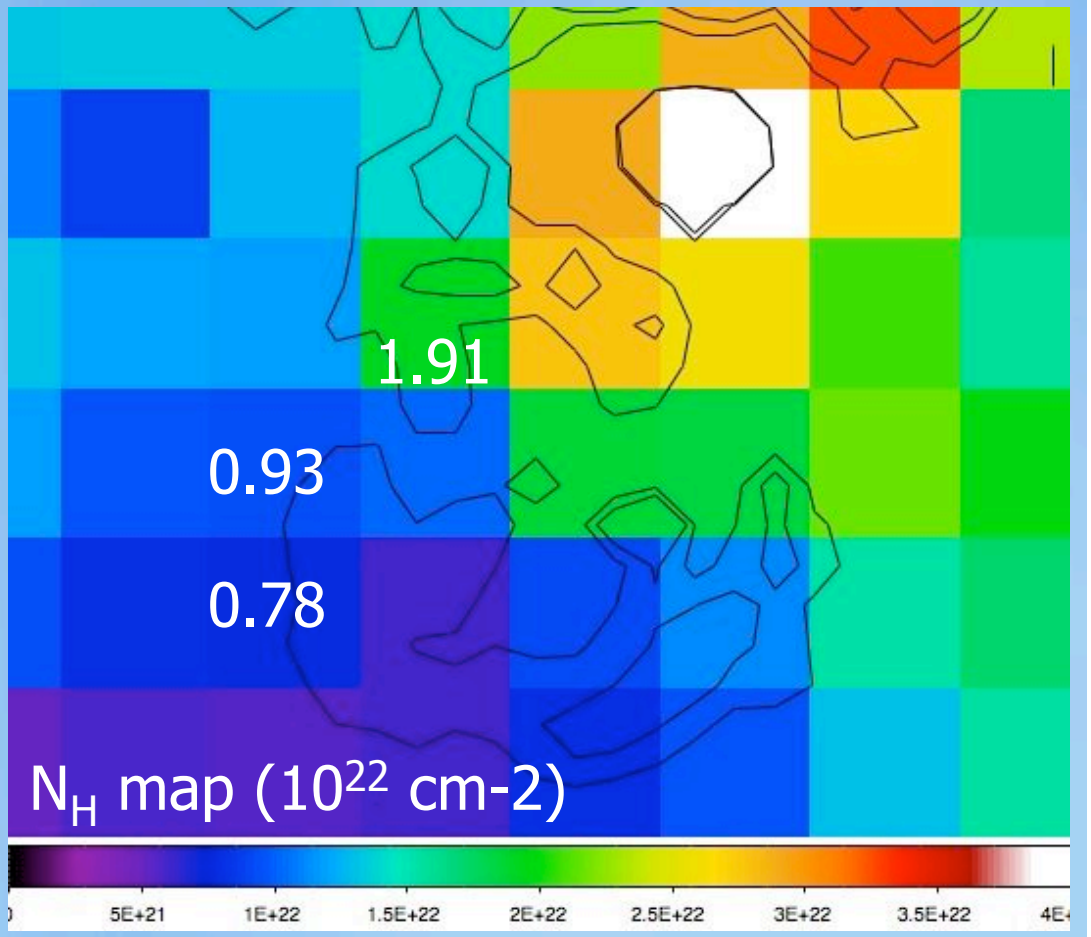
XMM
ATCA contours



1.05 (1.01-1.11) 1.96 (1.75-2.20)

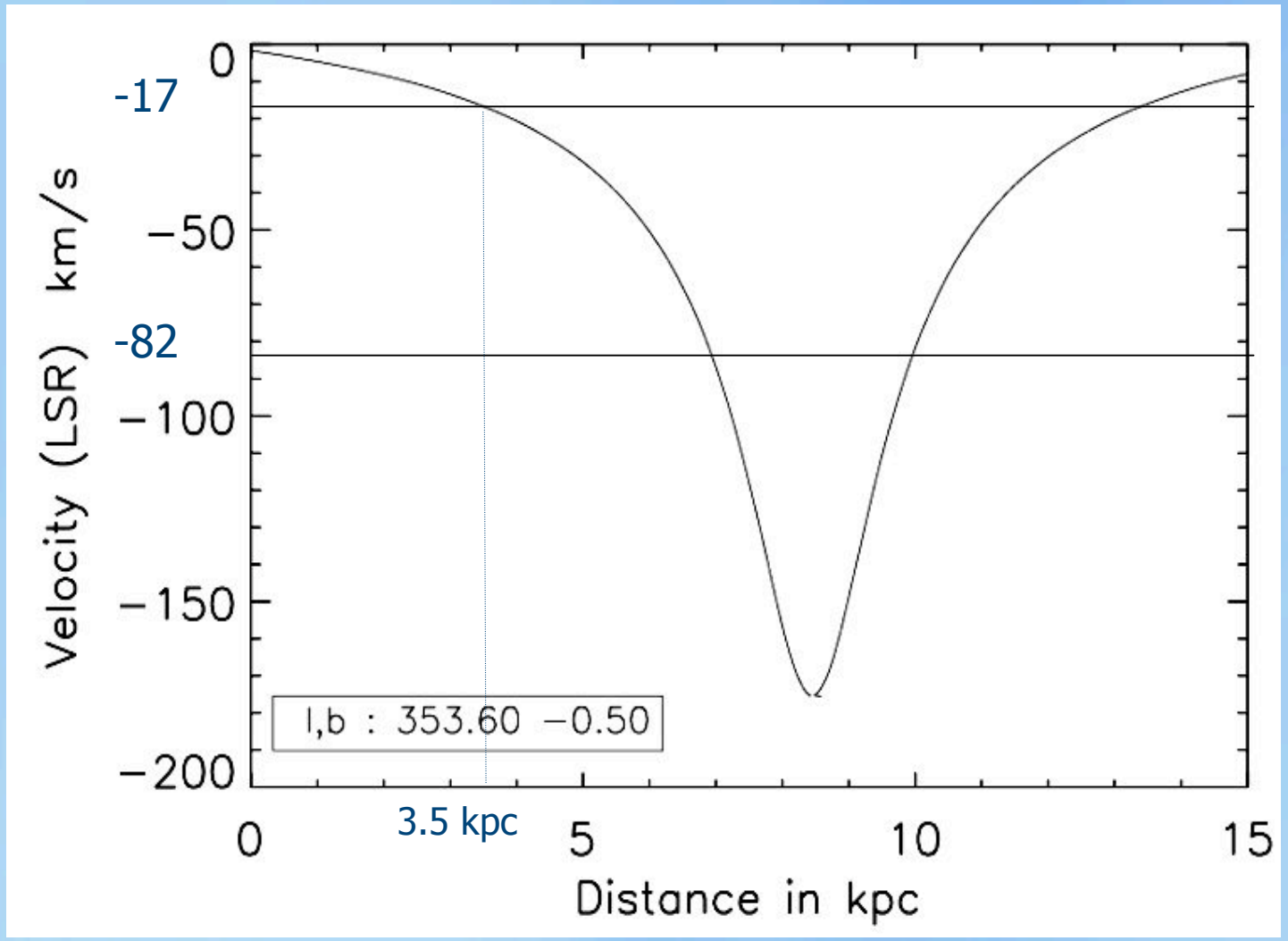
$N_H(10^{22}\ cm^{-2})$

12CO
ATCA contours



12 CO Integrated between 0->-17 km/s

12CO study
Distance

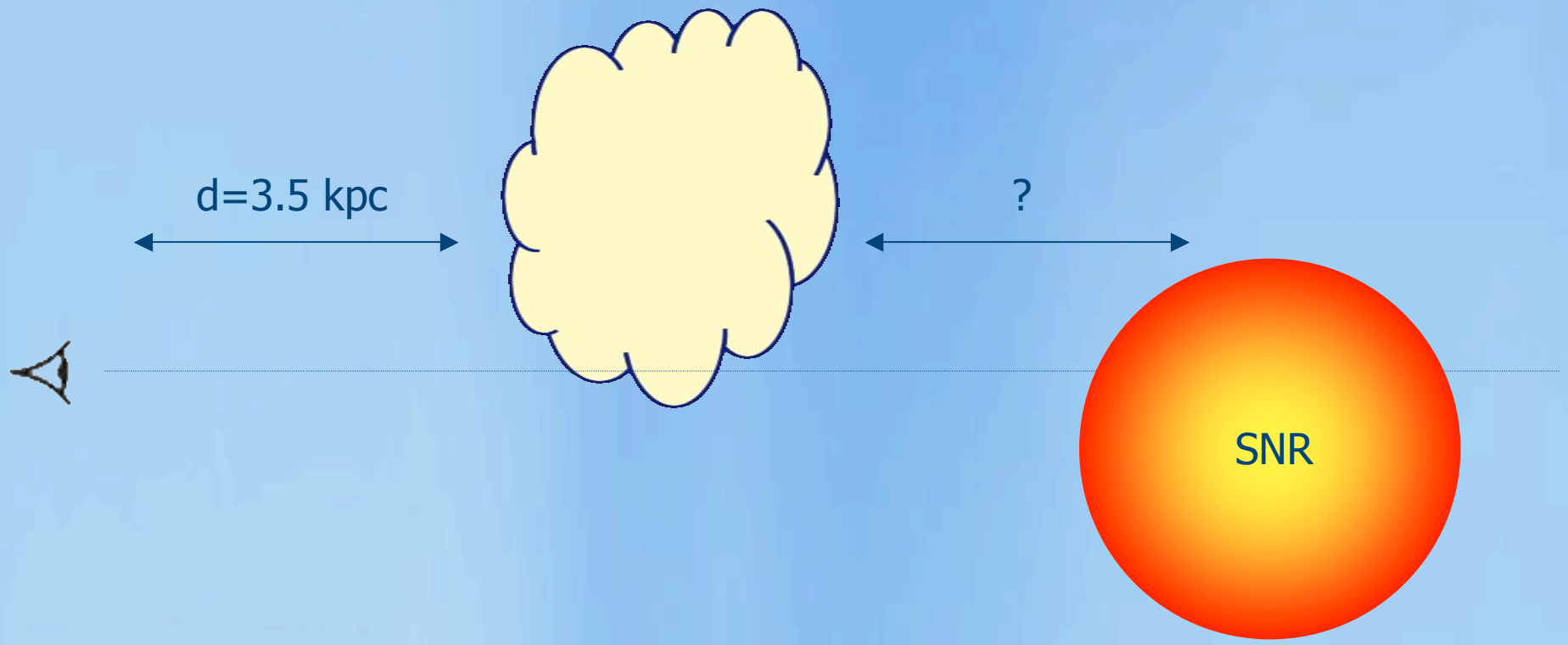


Galactic Rotation : Fich et al. 89

Lower Limit of 3.5 kpc

Errors of +/- 0.5 kpc using different Galactic rotation Models.

Cartoon



J1731 : Conclusion

- Gamma-ray Morphology suggesting a shell like remnant
  -> Recent observations will hopefully confirm this
- Shell structure seen in radio and X-rays
- First shell SNR discovered based on Gamma observations !!!
- J1731 could join the club of RX J1713, Vela Jr, RCW 86 and SN 1006
- No cutoff in spectrum (Aharonian 08)
  -> Recent observations will test the spectrum with better statistics
- Molecular Cloud in the vicinity

-> Direct/Diffusive/no interaction

Conclusion

- Looking for a methodology to detect emission from MC

-> Look around young SNR

-> Cutoff in the spectrum's SNR is a proof of escaping CRs

-> Specific spectrum shape

- RX J1713 -> Good example but nothing seen so far

- New interesting candidate -> HESS J1731
  -> MC in the vicinity

Thank you !