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AGILE AND SNRs W44 & W28

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on behalf of the AGILE team

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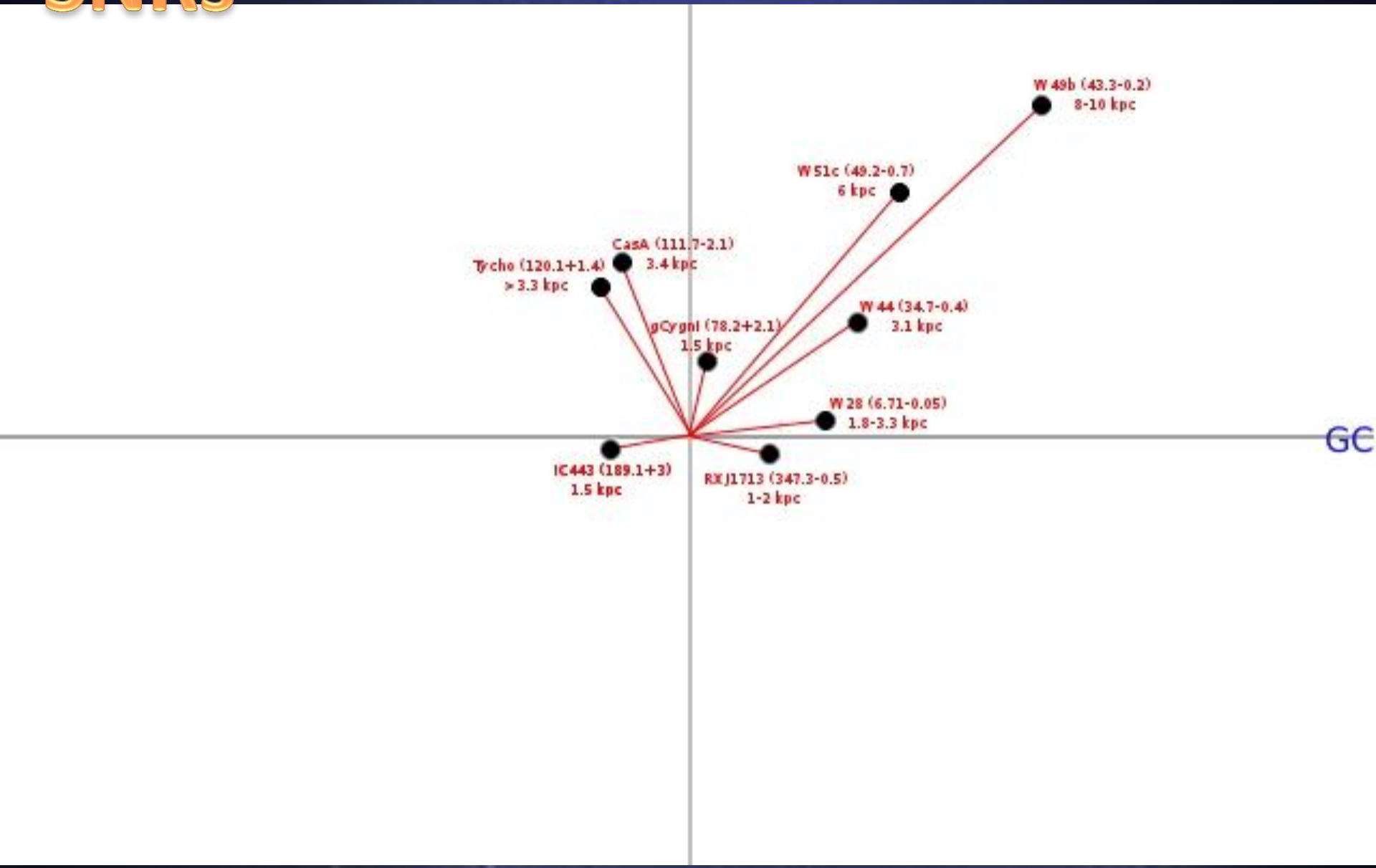
- SNR/CR main issues:
  - *Low Energy cut-off*
  - *High energy spectral steepening*
- Comparing W44 & W28:
  - *Morphology*
  - *Models*
- Conclusions

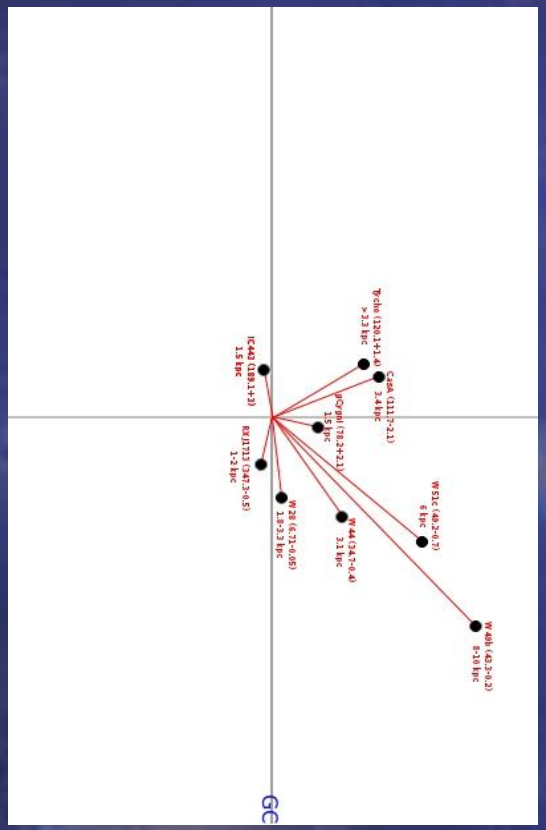
SNRs

SNR (l,b)	distance	AGILE	Fermi-LAT	age[yrs]	MC detect.	TeV
CAS A (111.7,-2.1)	3.4 kpc	no	yes	~300	yes	Veritas, MAGIC
Tycho (120.1,+1.4)	>3.3kpc	no	yes	~440	yes	Veritas
SN 1006 (327.6,+14.6)	2.2	no	no	~1,000	-	HESS
RXJ1713 (347.3,-0.5)	1-2 kpc	no	yes	~1,600	yes	HESS
W49B (G43.3-0.2)	8-10kpc	no (we see it)	yes	1,000-4,000	no (W49a yes)	HESS
γ-Cygni (78.2,+2.1)	1.5 kpc	in prep.	no	~7,000	yes(?)	Veritas
W44 (34.7,-0.4)	3.1 kpc	yes	yes	~20,000	yes	HESS
W51 (49.2,-0.7)	6 kpc	no (we see it)	yes	>20,000	yes	MAGIC, HESS
IC443 (189.1,+3)	1.5 kpc	yes	yes	20,000-30,000	yes	Veritas, MAGIC
W28 (6.71,-0.05)	1.8 - 3.3 kpc	yes	yes	35,000-45,000	yes	HESS

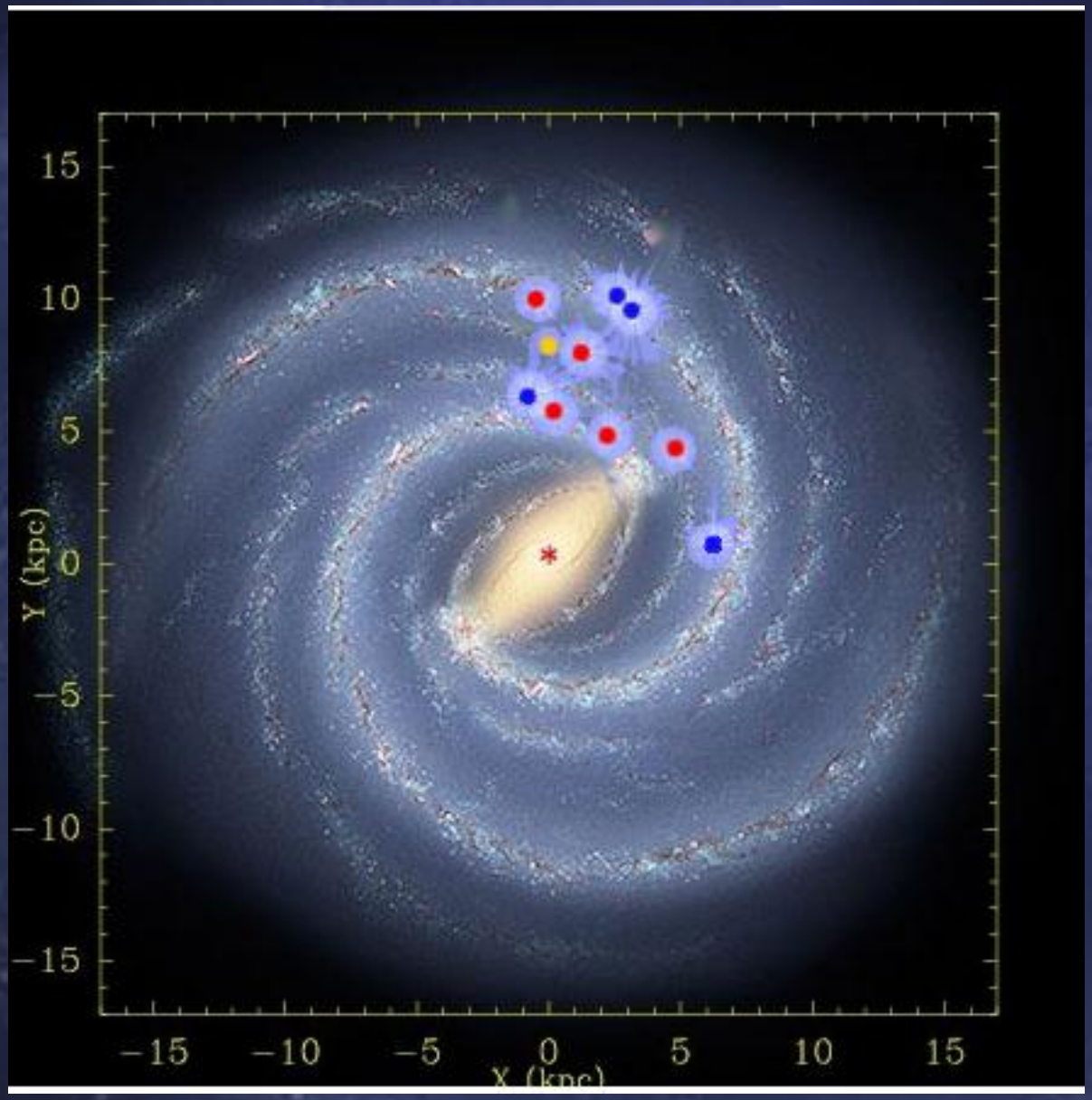
SNRs


W 49b (43.3-0.2)
8-10 kpc
W 51c (49.2-0.7)
6 kpc
CasA (111.7-2.1)
3.4 kpc
Tycho (120.1+1.4)
>3.3 kpc
W 44 (34.7-0.4)
3.1 kpc
gCygnI (78.2+2.1)
1.5 kpc
W 28 (6.71-0.05)
1.8-3.3 kpc
GC
IC443 (189.1+3)
1.5 kpc
RXJ1713 (347.3-0.5)
1-2 kpc

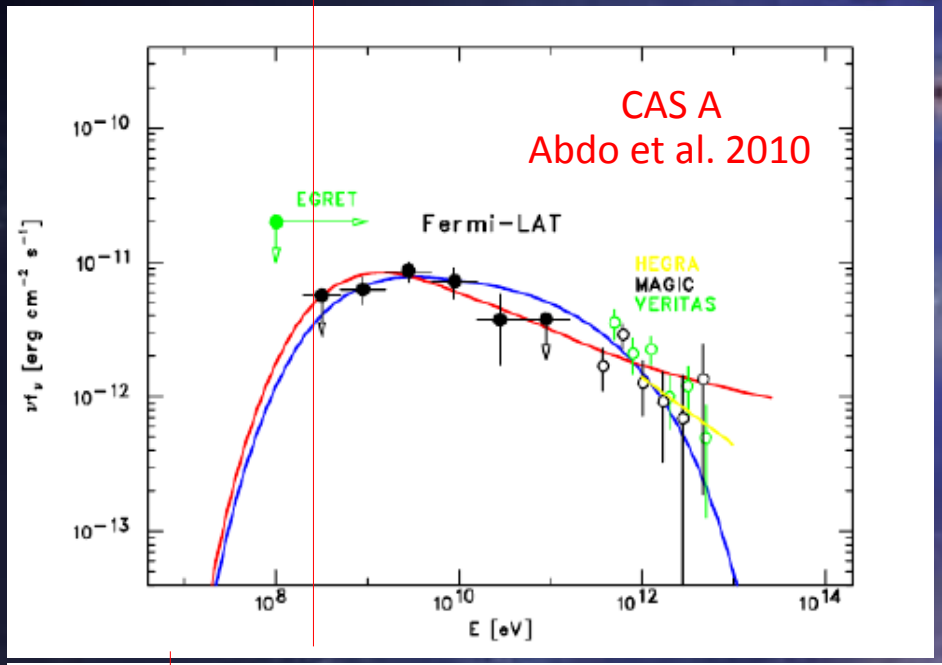
SNRs

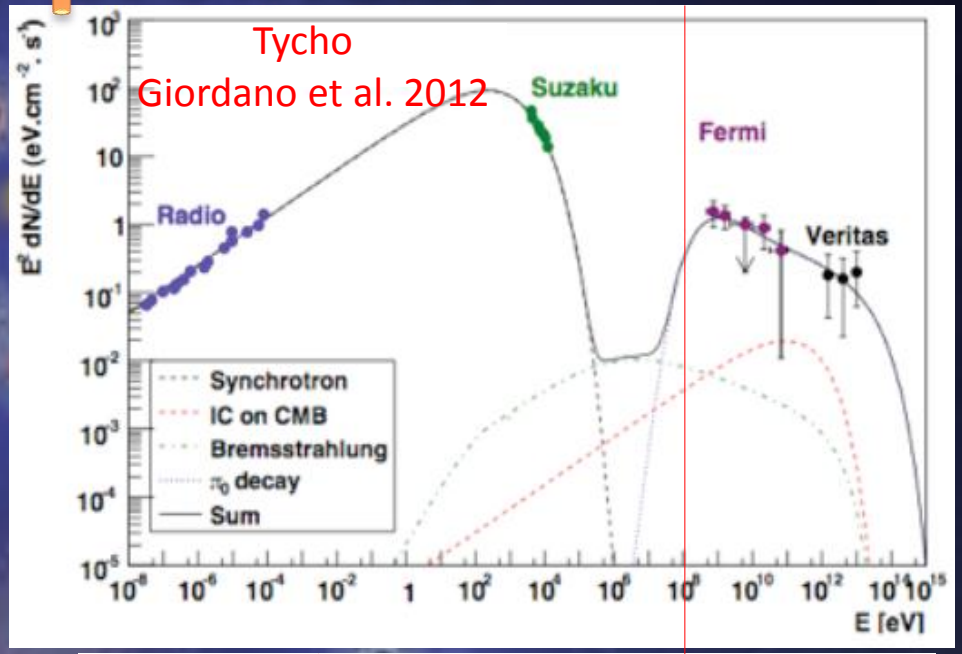

Tycho (130.1+1.4)
> 3.3 kpc
G-ook (111.7-2.1)
3.4 kpc
pO'qpbi (78.2+2.1)
1.5 kpc
IC443 (189.1+3)
1.5 kpc
RXJ1713 (347.3-0.5)
1-2 kpc
W28 (6.5+0.05)
1.9-2.3 kpc
W44 (34.7+0.4)
3.1 kpc
W51C (49.2-0.7)
6 kpc
W-ooh (42.3-0.2)
8-10 kpc
GC

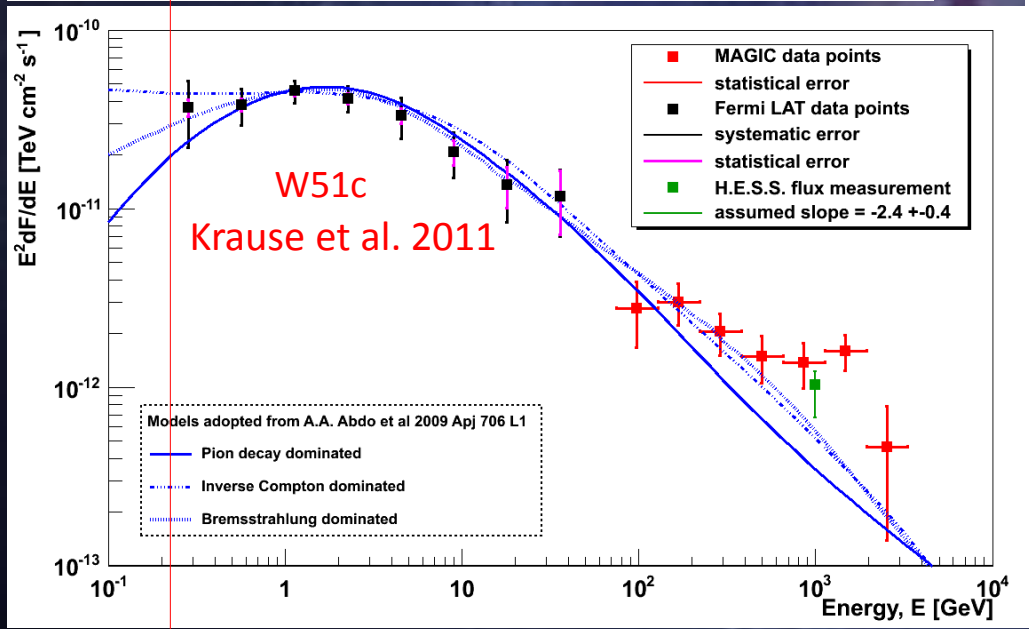
SNRs

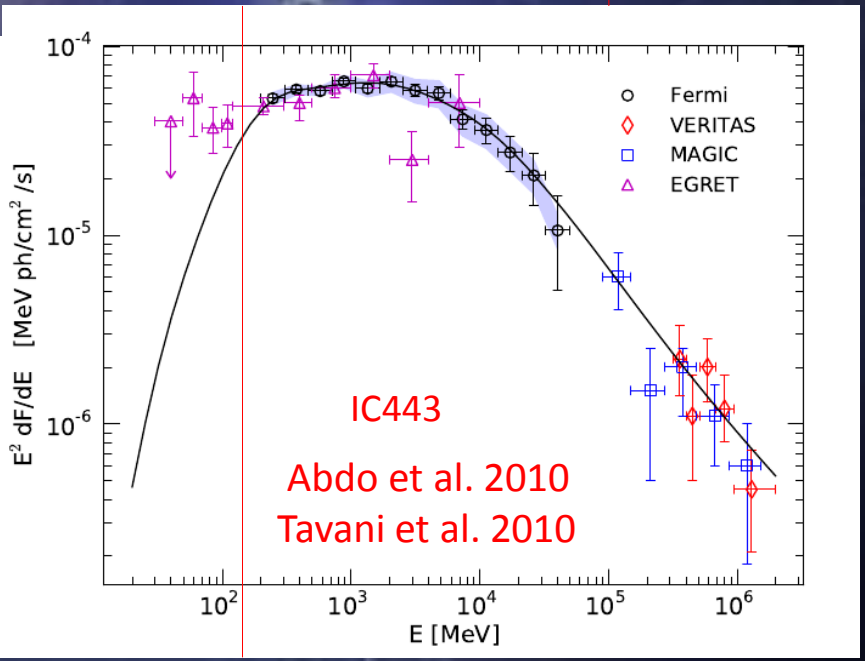


SNRs: low-energy problem









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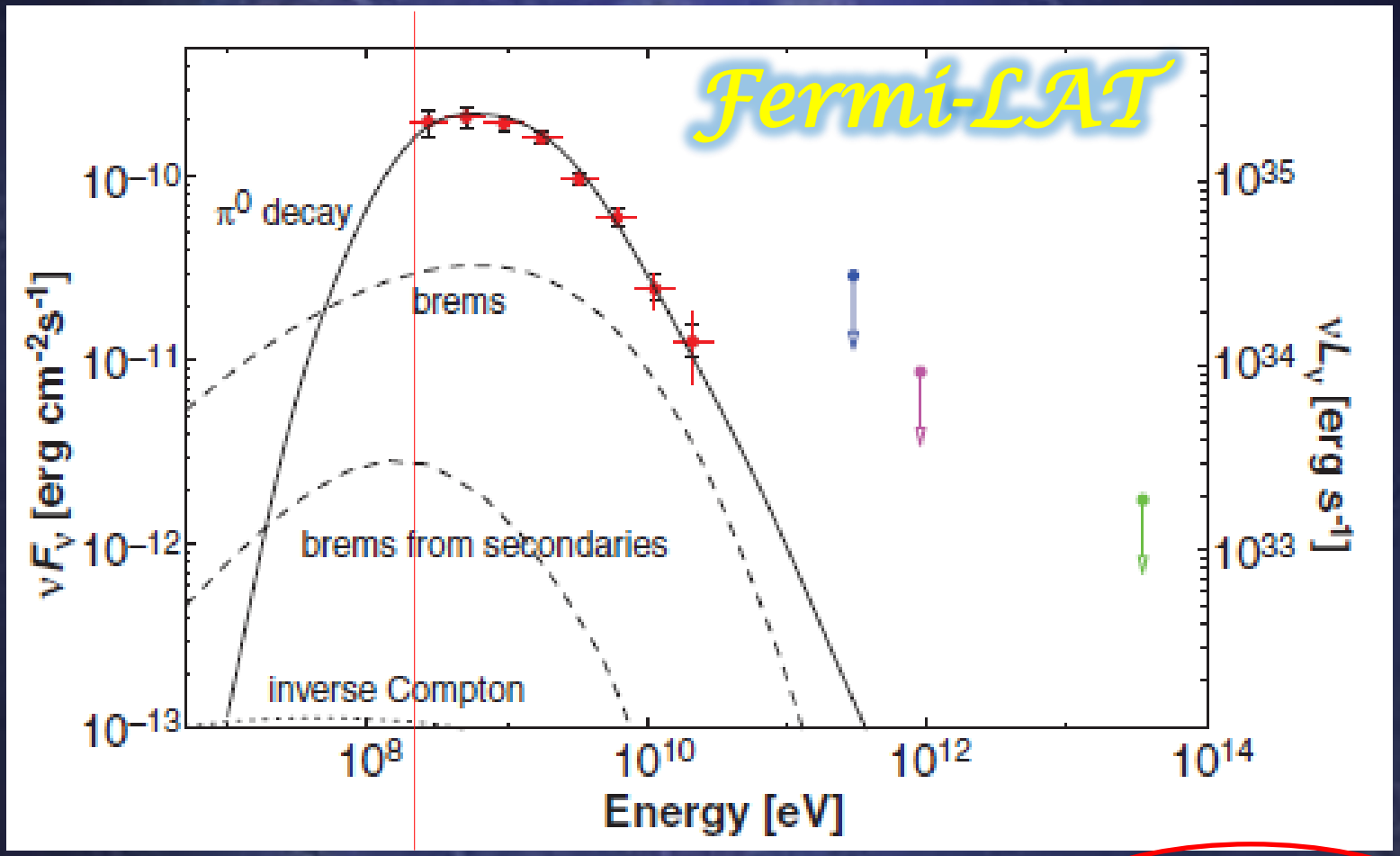
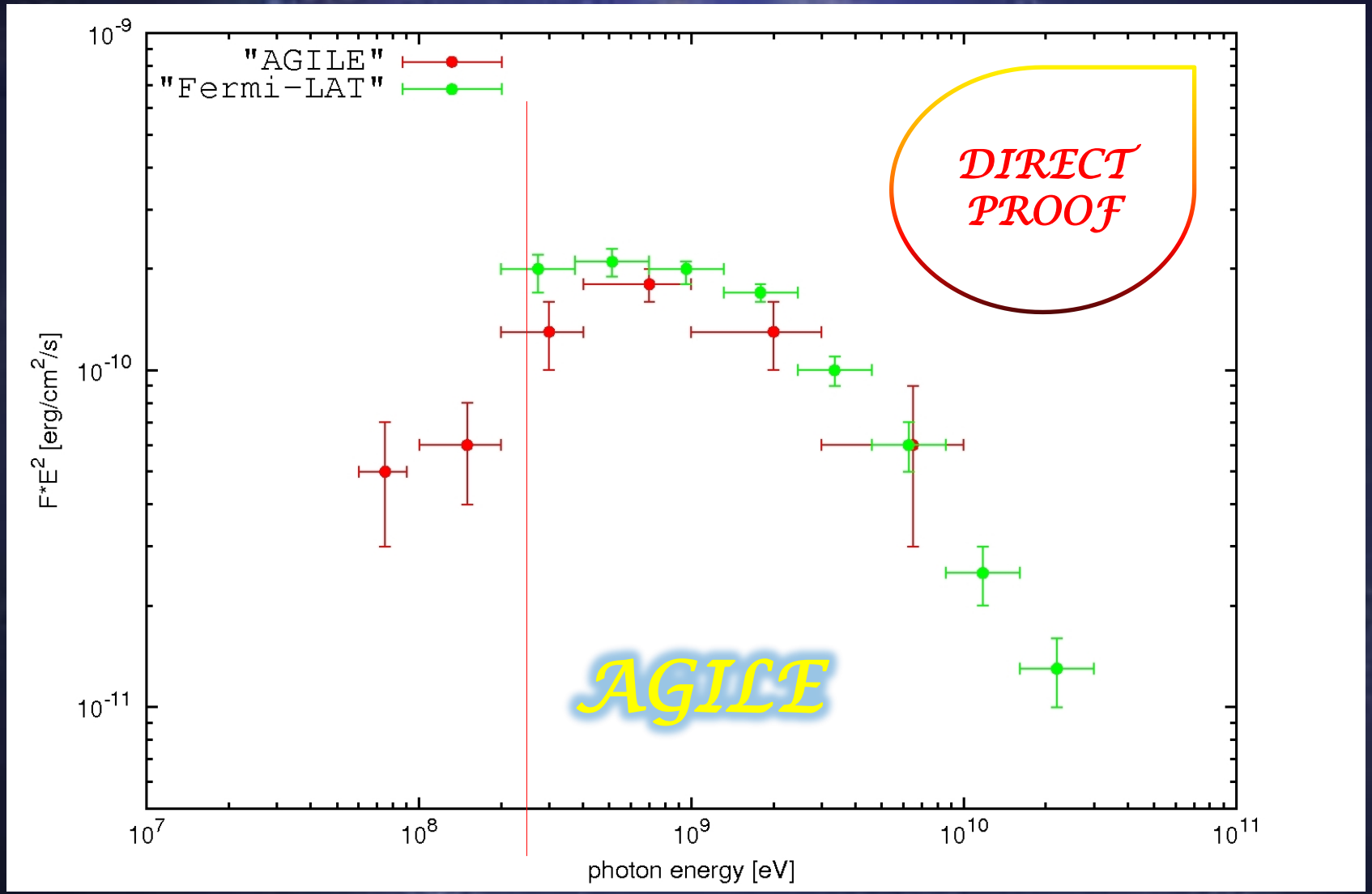


In Abdo et al (2010)
Bremsstrahlung is excluded as dominant contribution assuming n~10^2 and K_{ep}~10^{-2}→ B~$70\mu G$

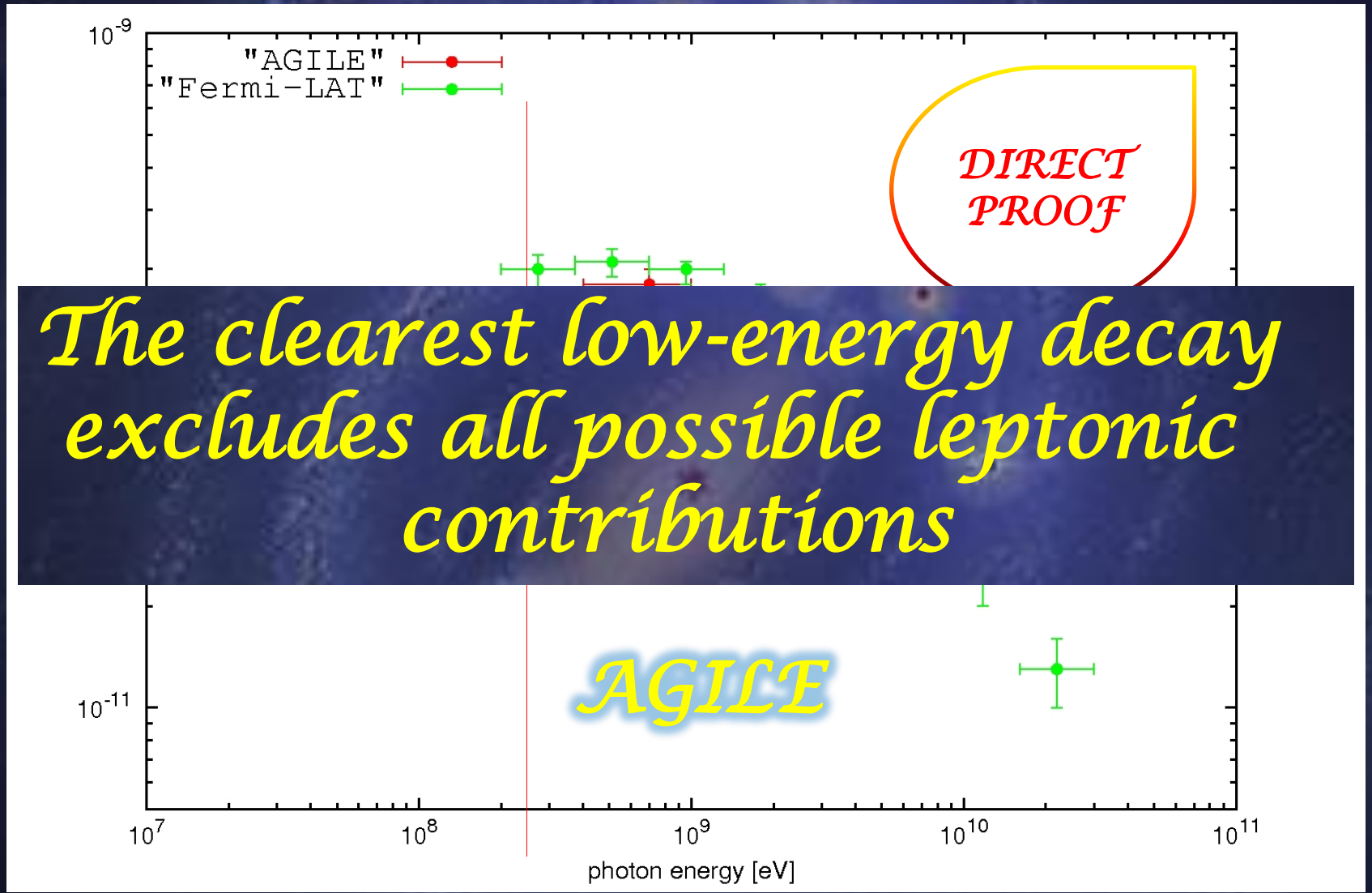
Parameter combinations

SNRs: low-energy problem



Giuliani, Cardillo, Tavani et al .(2011)

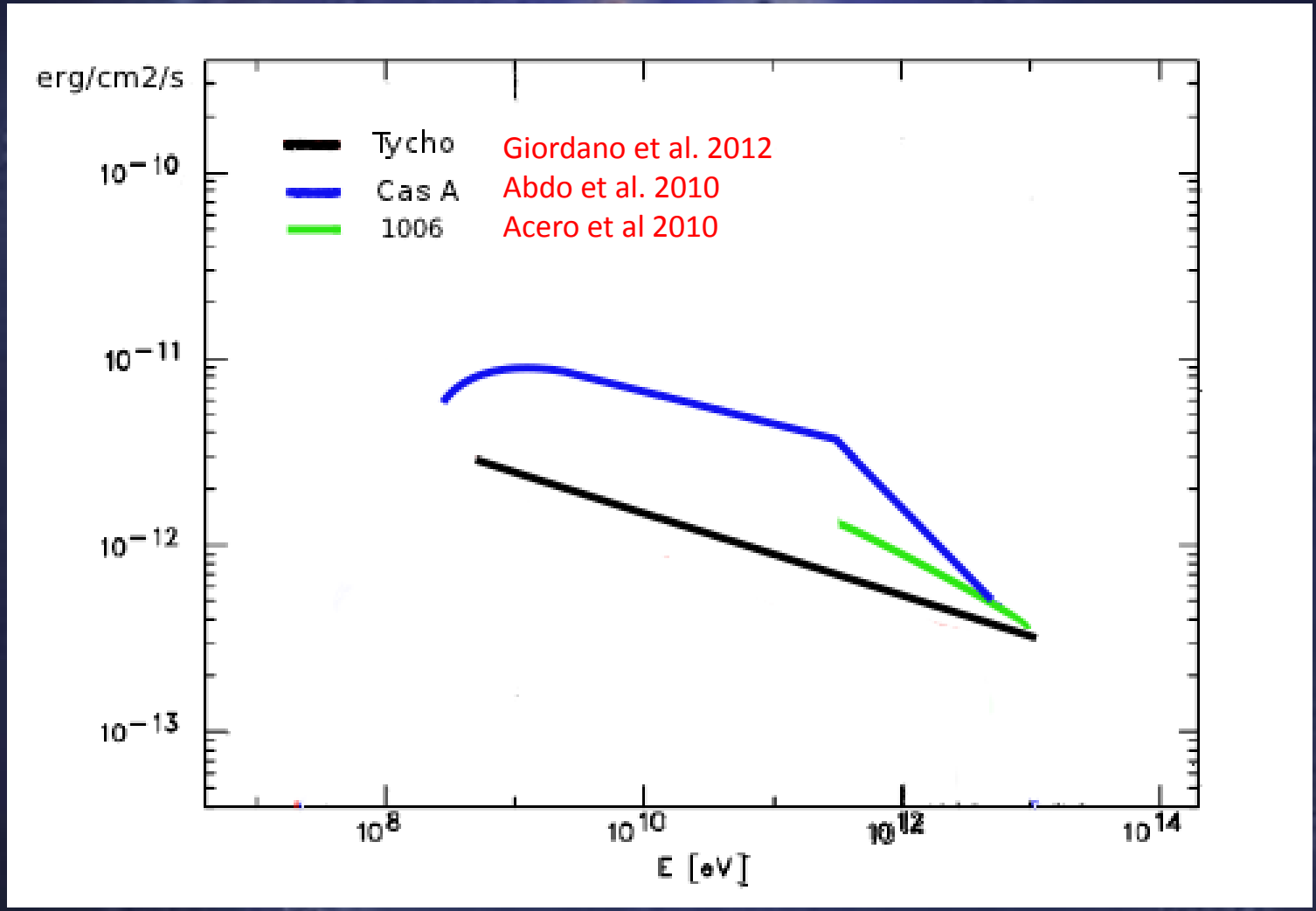
SNRs: low-energy problem



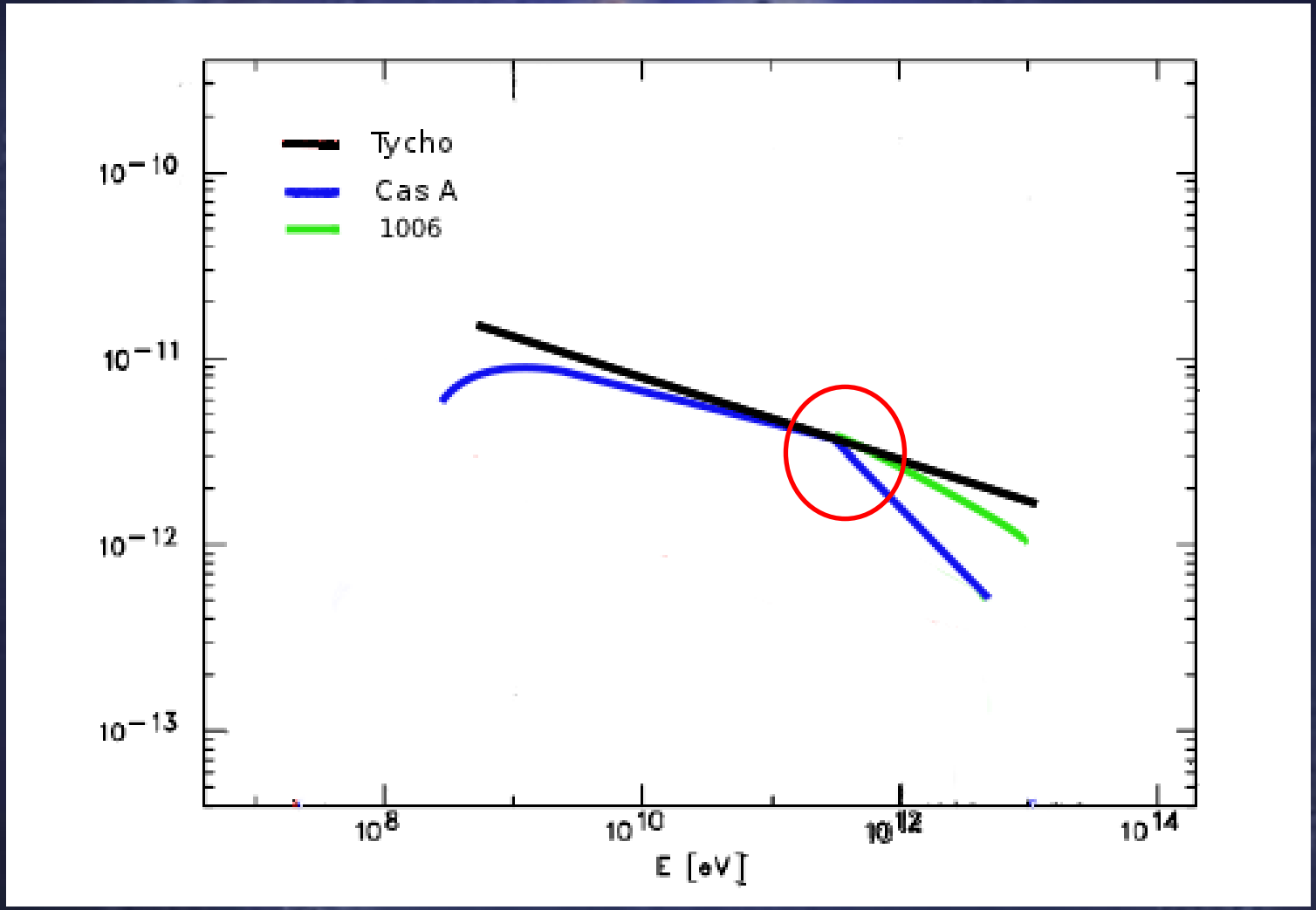
The clearest low-energy decay excludes all possible leptonic contributions

Giuliani, Cardillo, Tavani et al .(2011)

SNRs: steepening problem → young



SNRs: steepening problem → young



SNRs: steepening problem → young

Spectral Steepening

All young SNRs have an index steeper than 2:

$\alpha \sim 2.3$

Neutrals leakage from downstream to upstream and lower compression ratio (Blasi et al., 2012; Ohira et al., 2012) ?

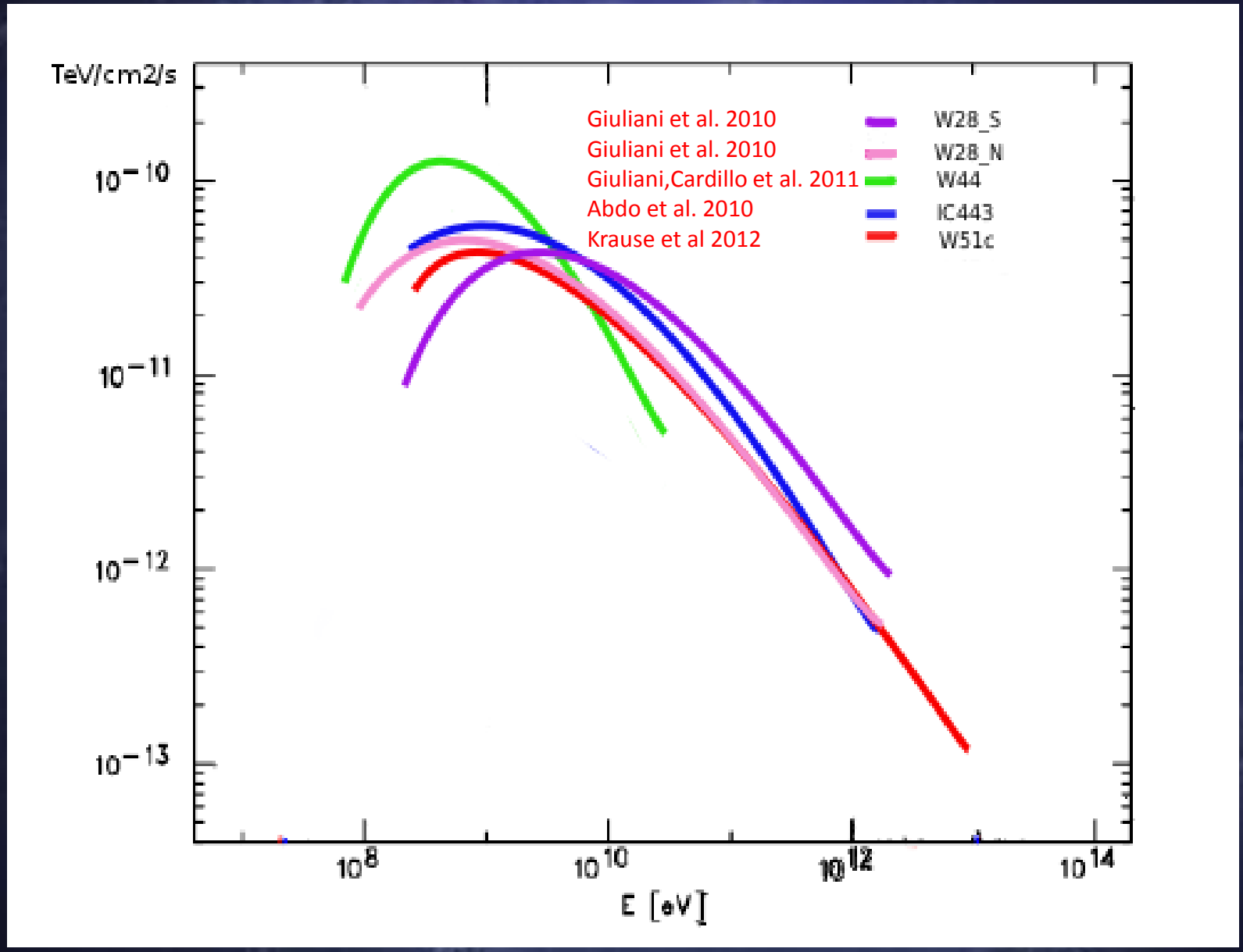
CasA problem

"A priori" models for young SNRs provide a hard photon spectrum from CR acceleration mechanisms → why does CasA seem to have a cut-off at high energies?

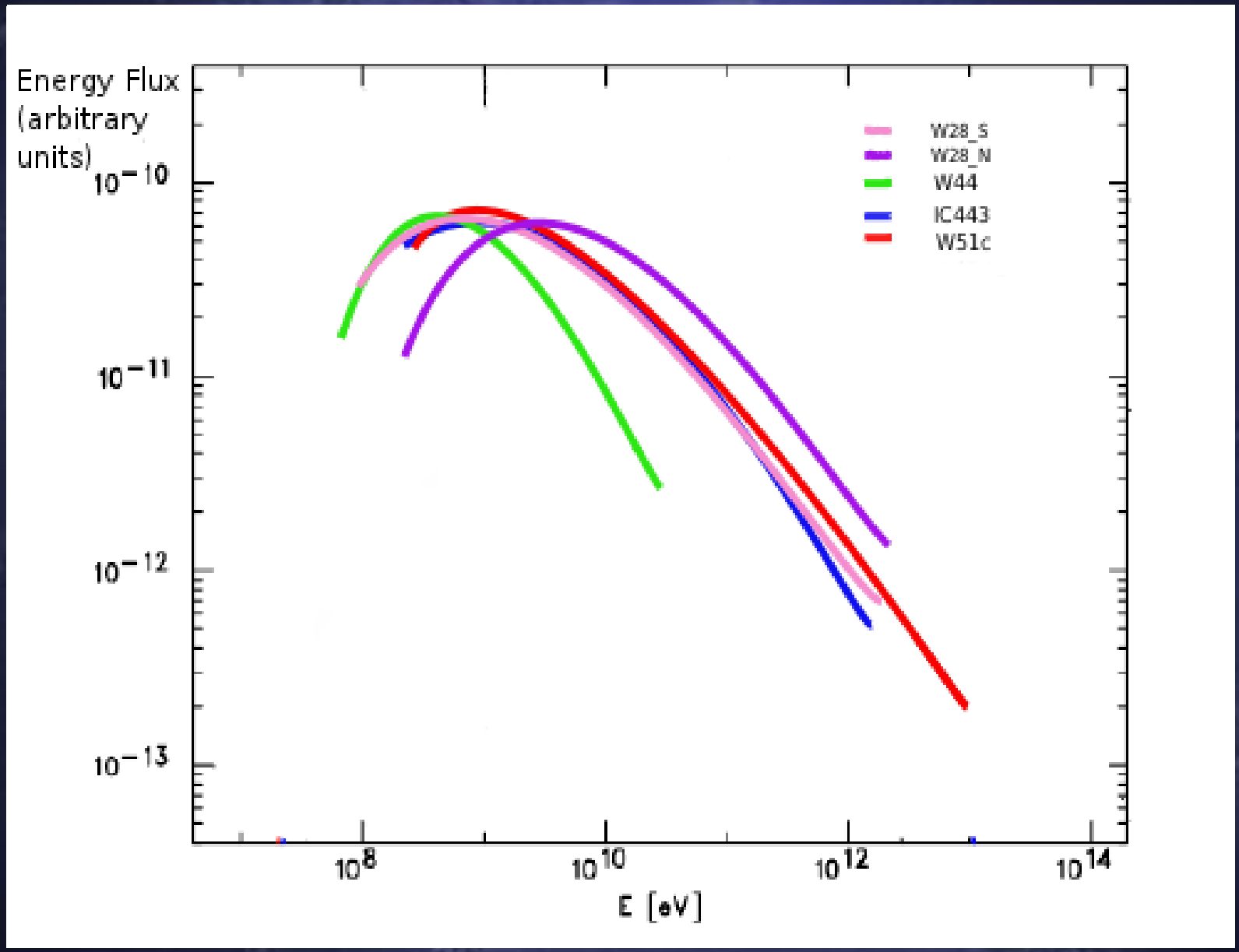
Maybe did it evolve in its progenitor wind ?

(Vink 2012)

SNRs: steepening problem → old



SNRs: steepening problem → old



SNRs: steepening problem → old

We can conclude that all the old SNRs known until now have a photon index in a range

$$2.6 < \alpha < 3$$

Which are the mechanisms that make CR photon spectrum so steep? We need to consider SNR enviroinment, magnetic field, MHD and non-linear DSA processes.

SNRs: steepening problem → old

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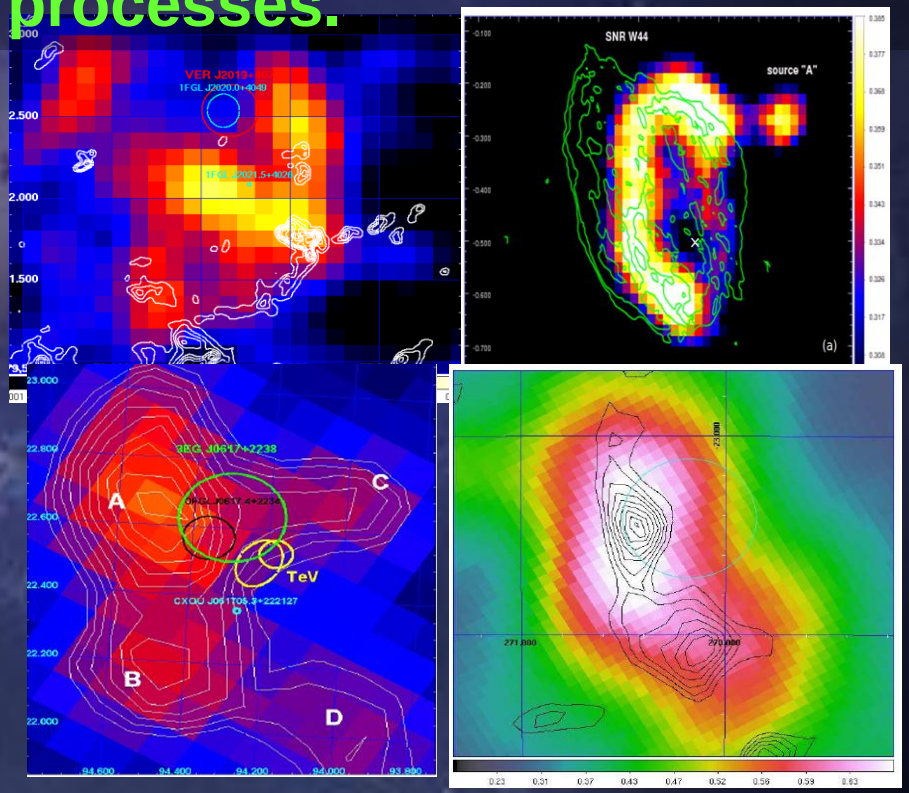
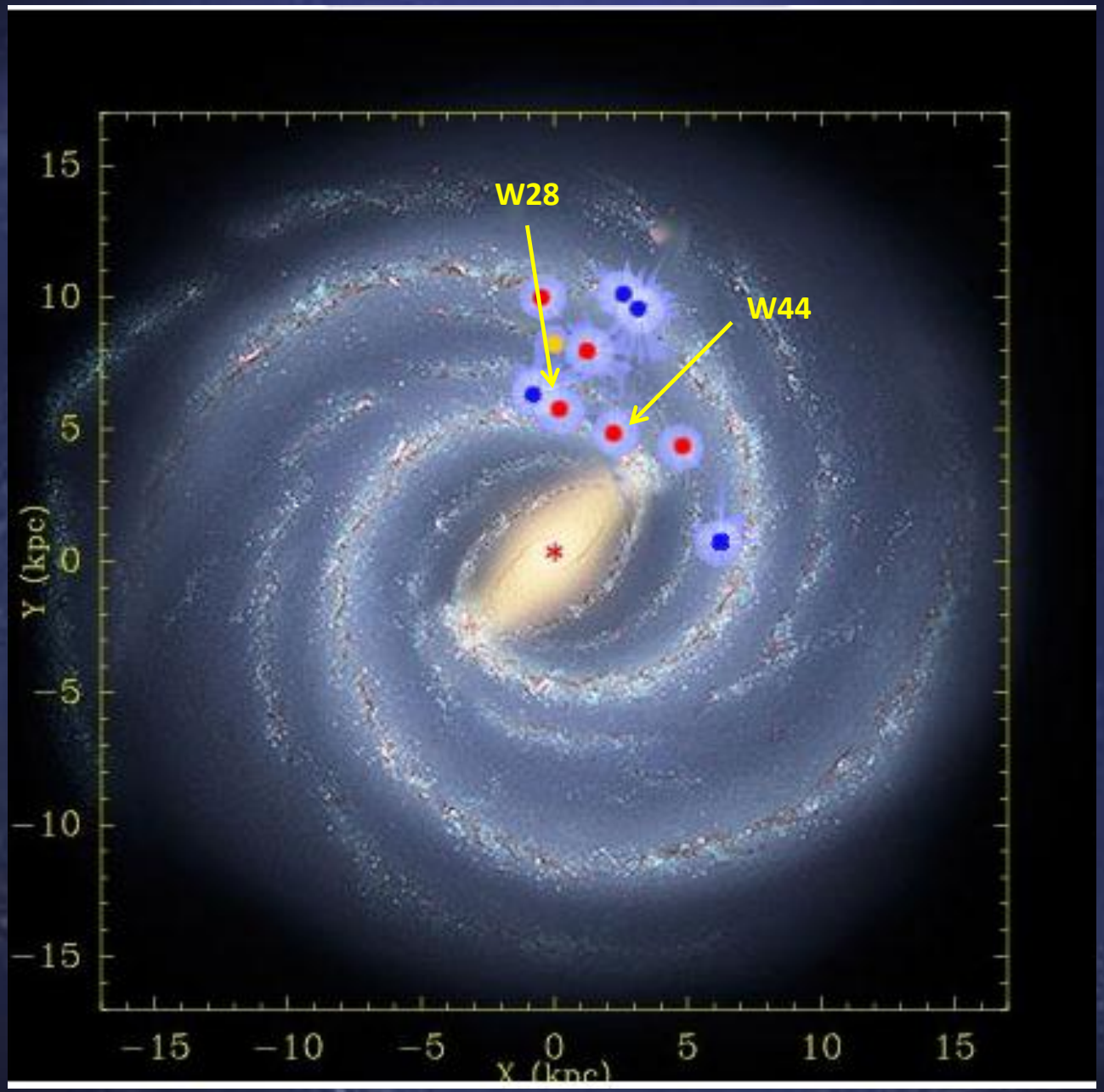
A comparison of all SNR multiwavelength emissions.

Gamma Cygni (Piano et al. in preparation)	W44 (Giuliani, Cardillo, Tavani et al. 2011)
IC443 (Tavani et al., 2010)	W28 (Giuliani et al., 2010)

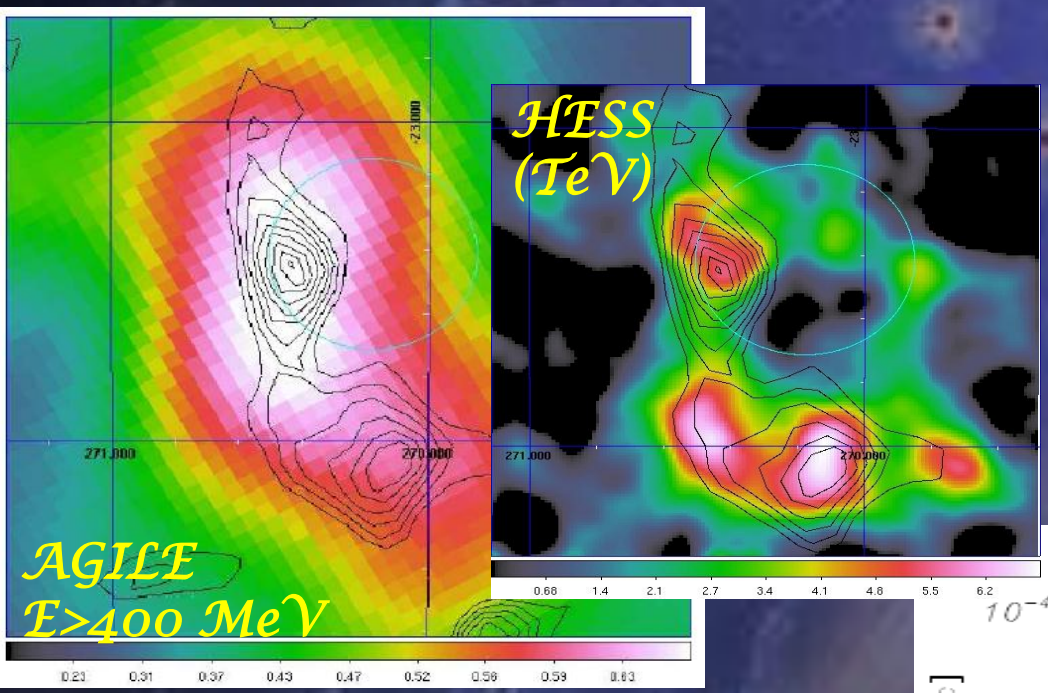


W44 & W28



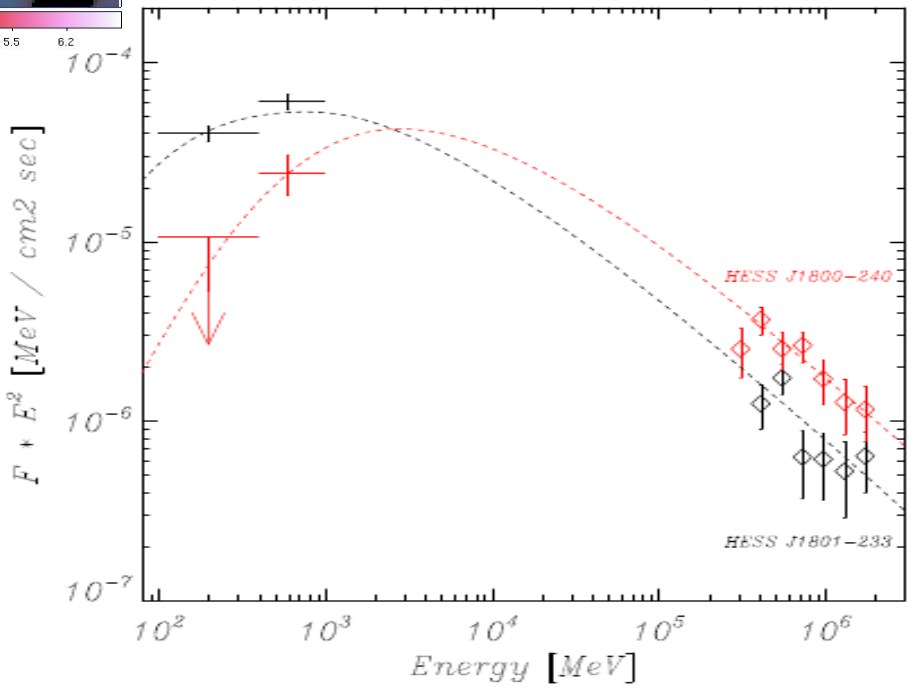
W28

Giuliani et al. 2010



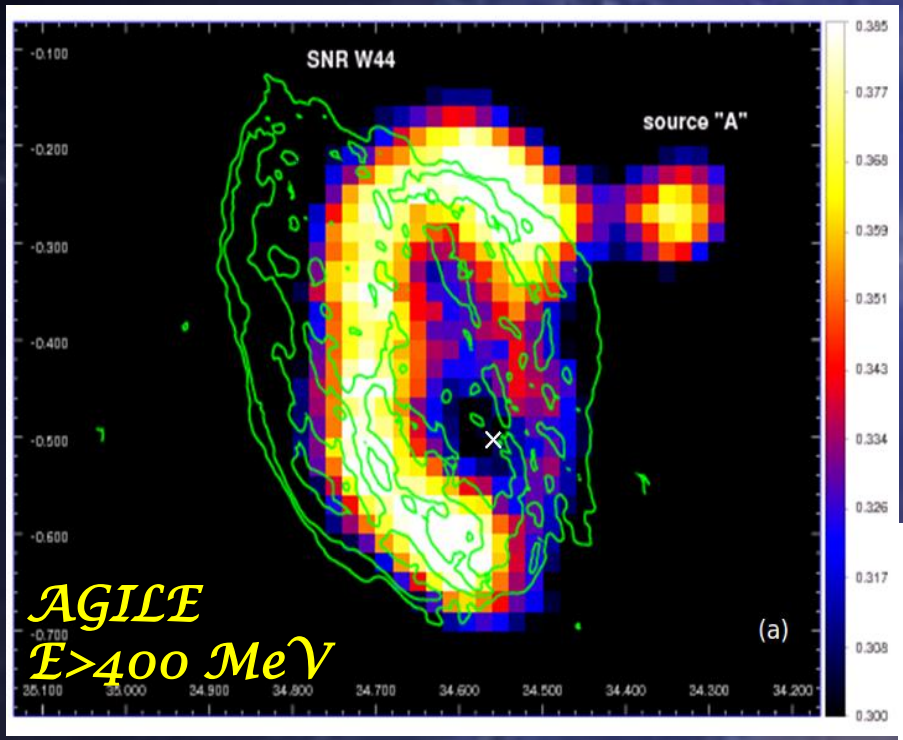
- Galactic Plane
- 1.8-3.3 kpc
- 3.5×10^4 yrs
- Mixed morphology

- Spectral index for E>1 GeV → α=2.7
- Linear DSA model

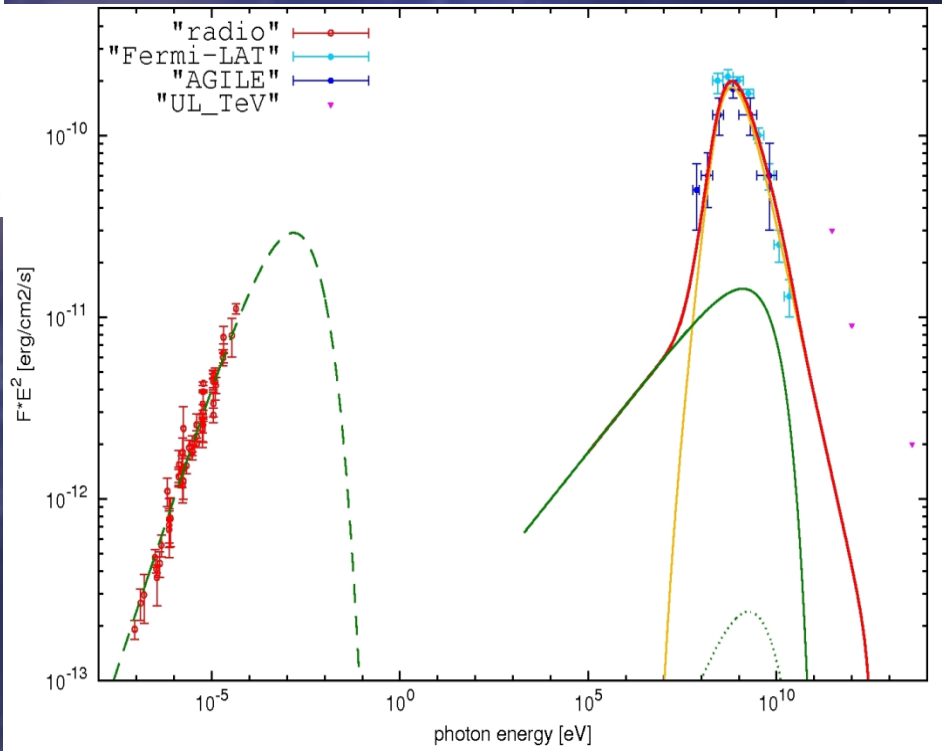


W44

Giuliani, Cardillo, Tavani et al .(2011)

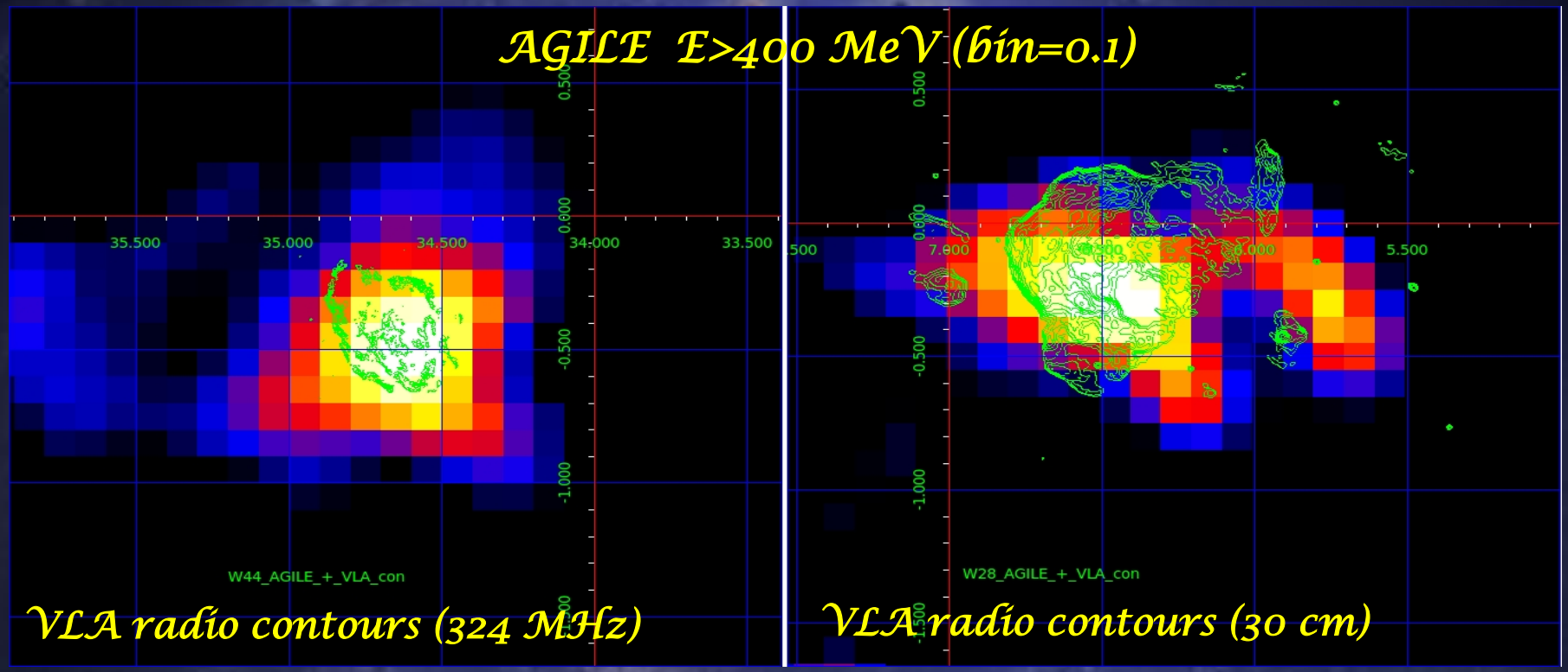


- Galactic Plane
- 3.1 kpc
- 2×10^4 yrs
- Mixed morphology



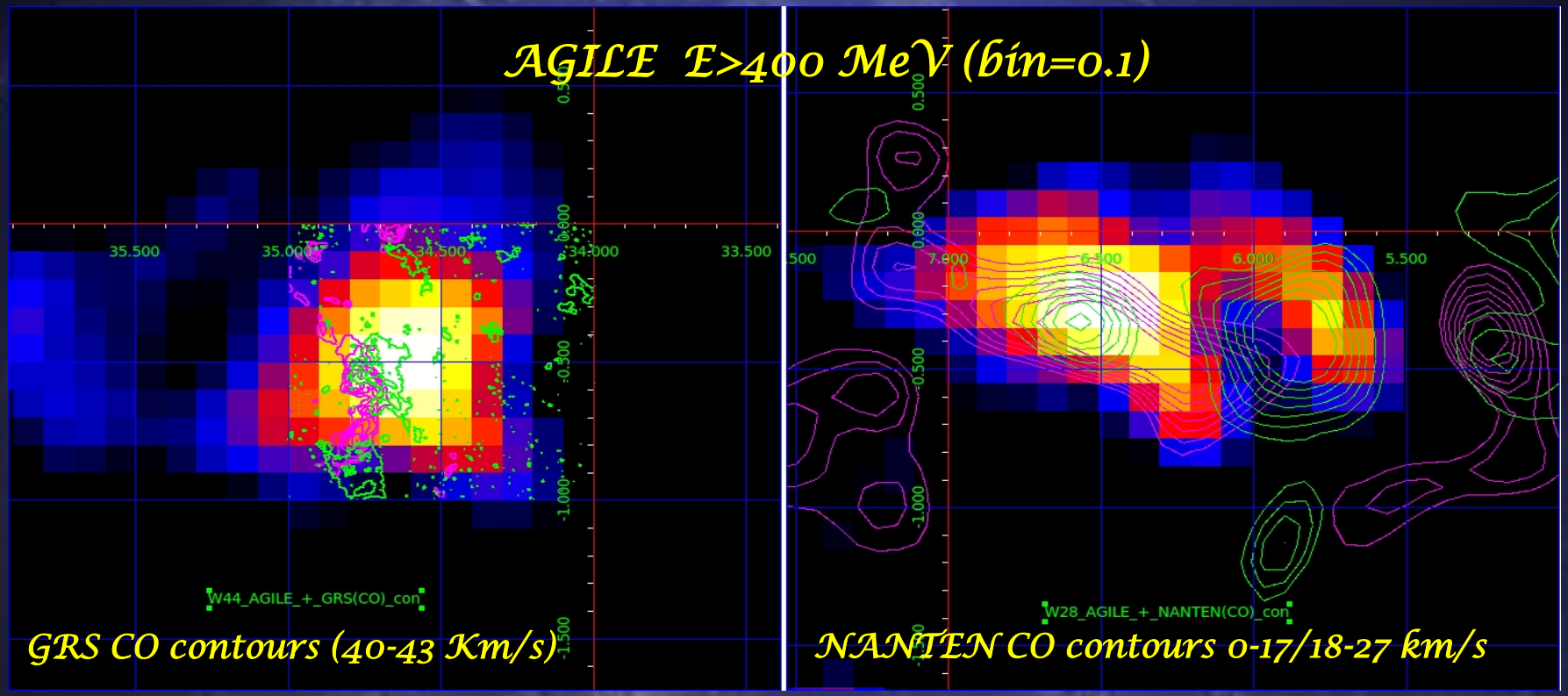
- Spectral index for E>1 GeV → α=3
- Linear DSA fails

W44 & W28: gamma-ray vs radio



W44: radio contours are embedded in gamma-ray emission
→ inner shell?
W28: correlation with radio emission is no evident

W44 & W28: gamma-ray vs CO



W44: MC complex (40-43 km/s) is in the SE part of the remnant
W28: good correlation with CO emission (3-27 km/s), in anti-correlation with the TeV one

W44 & W28

Linear DSA

$$D(E) = D_0 \left(\frac{E}{E_0}\right)^{\delta}$$

↓

Diffusion → shell or cloud?

↔

Non linear mechanisms

↓

Alfvèn damping (ion/neutrals collisions) (Malkov et al. 2011 and therein)

Better understanding of SNR environiment differences:

- MC structure → density behaviour and clumpiness
- X-ray filaments → shock nature

Conclusions

Two main problems in CR/SNRs context:

low-energy spectrum and spectral steepening

- **AGILE find that W44 has the clearest low-energy decay →**

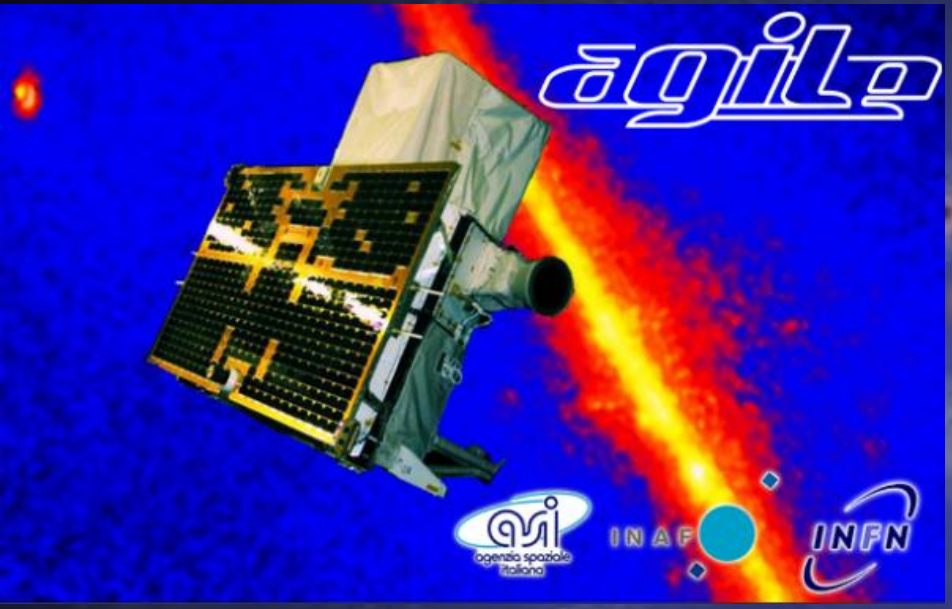
Gamma-ray satellites with a substantial improvement of AGILE and Fermi-LAT PSF and sensitivities at low-energies are the only way to have confirmation of CR acceleration by other SNRs (Gamma Ligth, G400)

- **Challenges for all theoretical mechanisms:**

importance of SNR enviroinment → deeper multiwavelenth analysis

- **W44 and W28:**

Possibility for understanding mutual effects between linear and non linear mechanisms → extension to other SNRs, IC443, Gamma-Cygni and W51c



THANKS TO ALL!