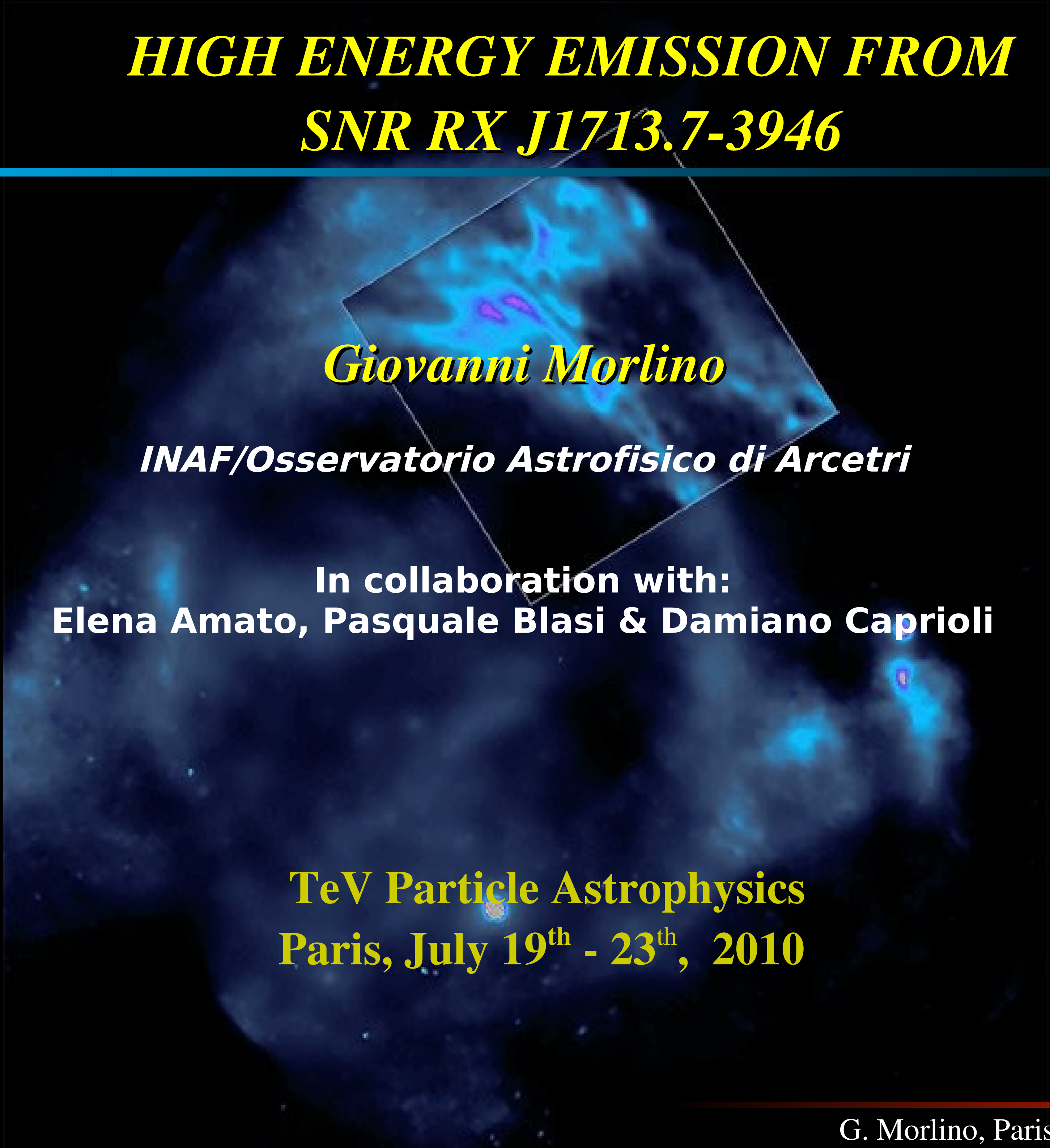
HIGH ENERGY EMISSION FROM SNR RX J1713.7-3946



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TeV Particle Astrophysics
Paris, July 19th - 23th, 2010

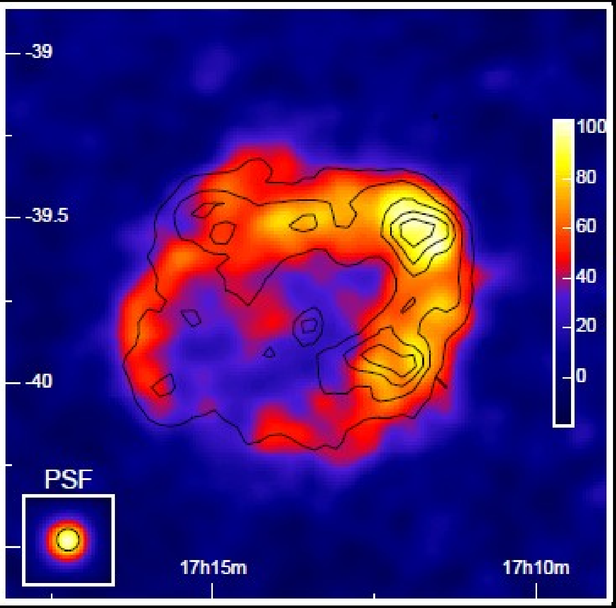
TeV Emission: Hadronic or Leptonic Origin?

- **Aim**

  Investigating whether the SNR RX J1713.7-3946 can be an efficient Cosmic Rays accelerator, studying the origin of TeV γ-ray emission

- **Method**

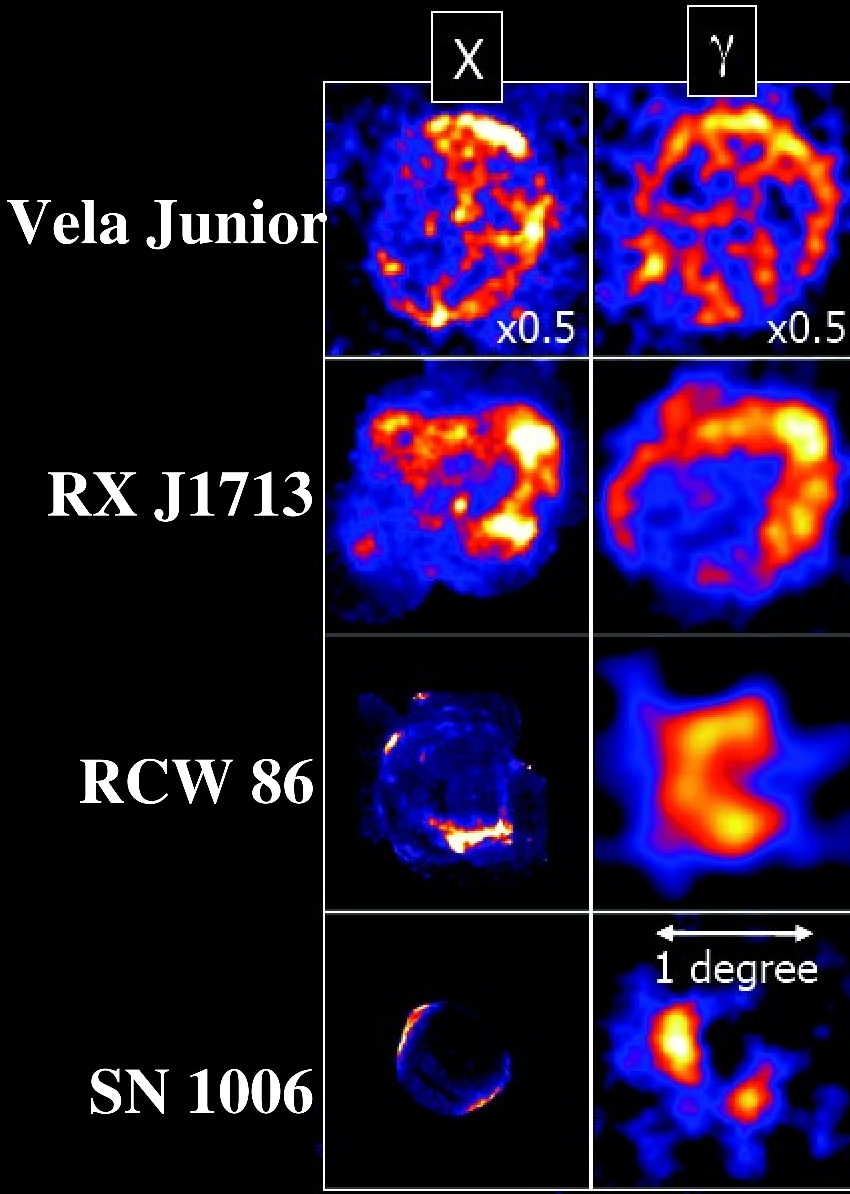
  We use the nonlinear diffusive shock acceleration theory coupled with resonant magnetic field amplification to compute the nonthermal particle population and the associated photon emission



SNRs in TeV γ-Rays

- **RX J1713.7 is one of 4 shell-like SNRs observed in TeV band**

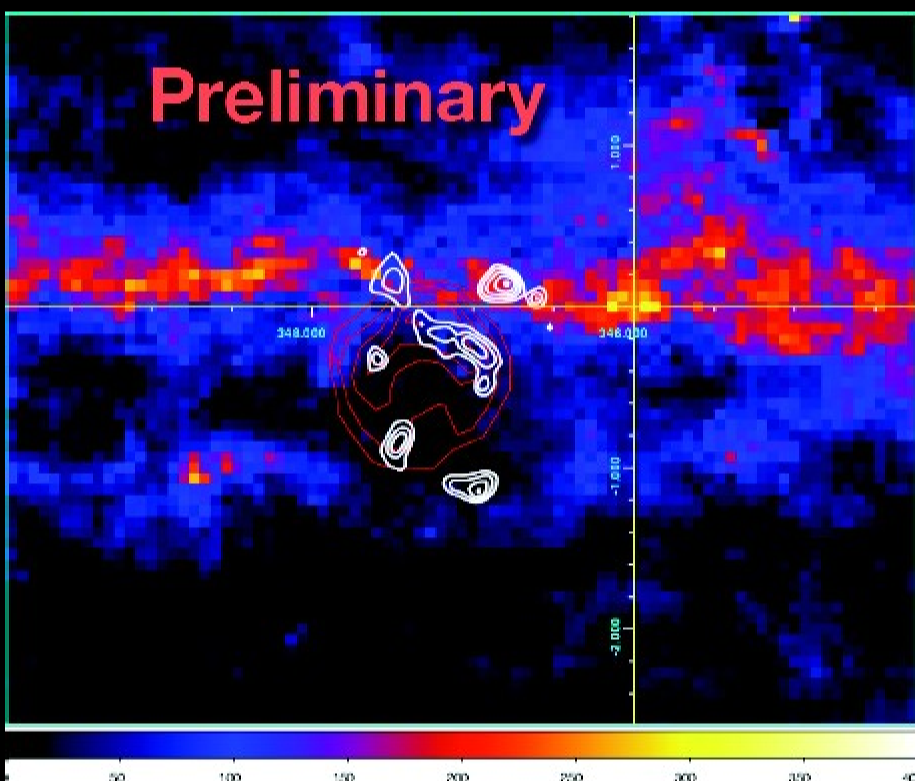
- **All show correlation with non-thermal X-ray**

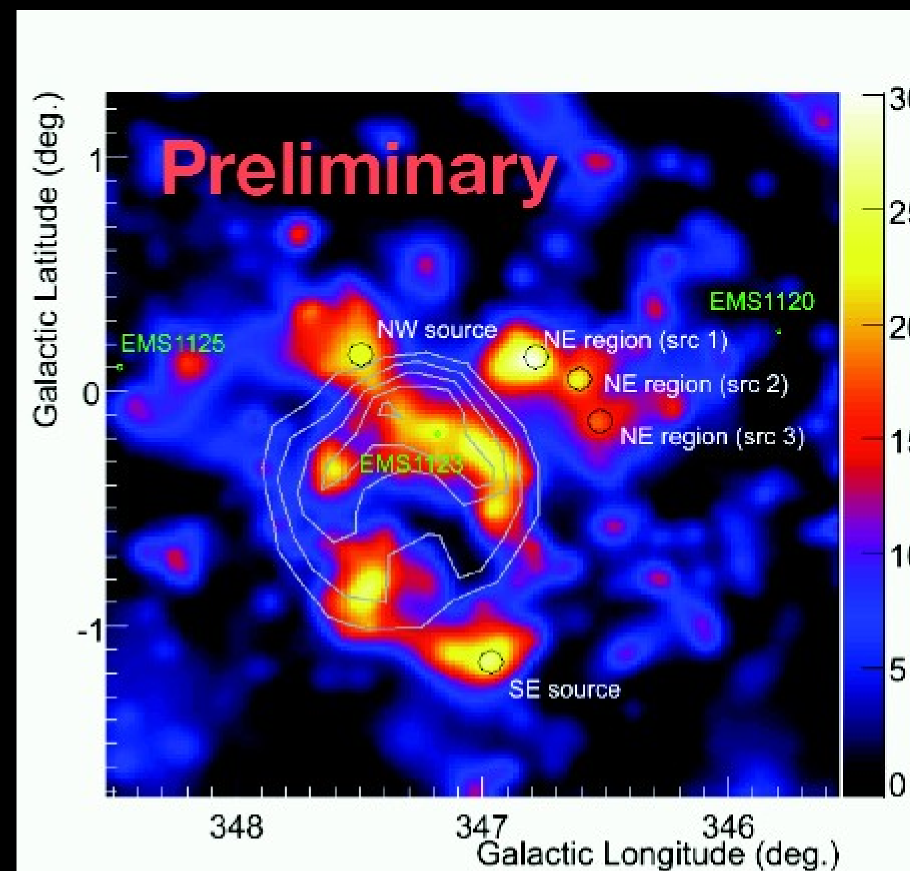


Fermi-LAT view of RX J1713.7-3946

RX J1713 has been detected by Fermi-LAT in GeV band:

- **Faint source in a complicated region**
- **Extended source**





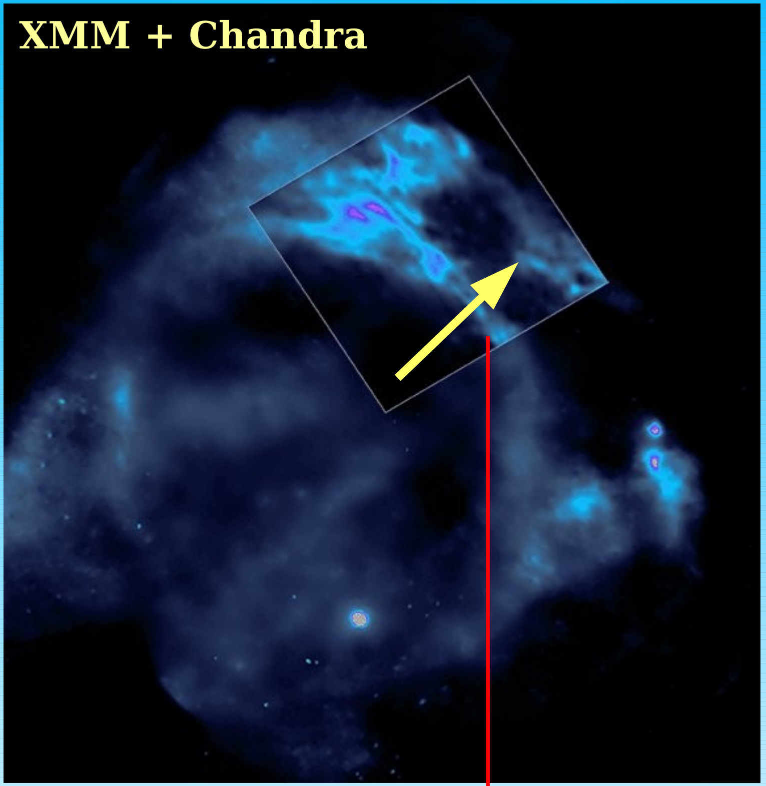
[Figures from Funk (2009)- Fermi Symposium II]

X-ray Observations and Magnetic Field

The magnetic field is a key parameter to understand the TeV emission

Assuming that the thickness of X-ray rims is due to sever synchrotron losses, we can infer the magnetic field ~ 100 μG

[Lazendic et al.(2004)]

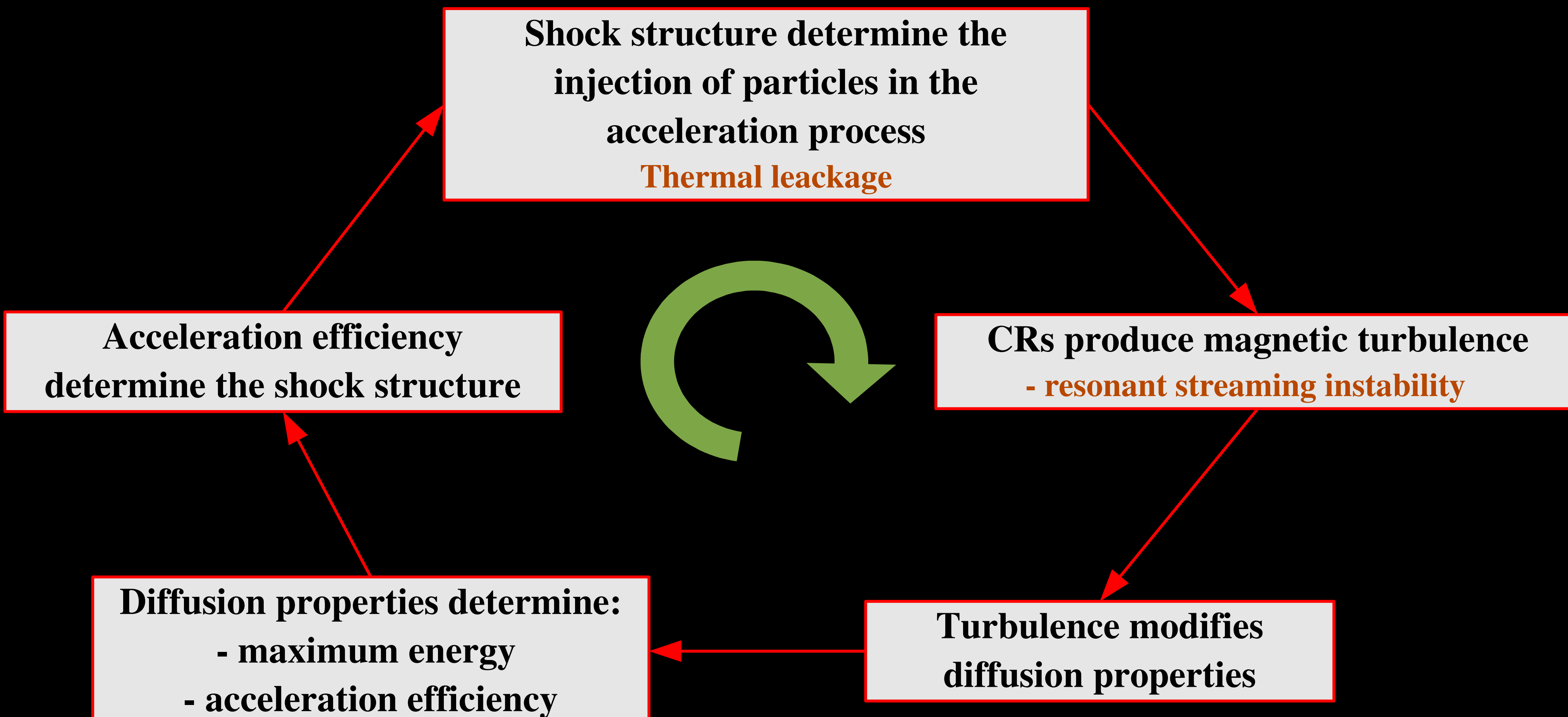


$$\Delta R_X = \frac{2 \; D_2/u_2}{\sqrt{1+4 D_2/u_2^2 \tau_{syn}} - 1}$$

$$B_2 \sim 100 \, \mu G$$

Basic Features of NLDSA model

If acceleration is efficient CRs modify the shock structure in a complicated way. We need a nonlinear theory able to describe how all elements feedback on all others ➔ we use an iterative method



Basic Features of NLDSA model

We use the model described in
Blasi (2002), Blasi et al. (2005), Amato & Blasi (2006)
Results are presented in Morlino, Amato & Blasi (2009)

- **Solution of stationary transport equation in a plane shock geometry**
- **Bohm-like diffusion coefficient in the local amplified magnetic field**
- **Particle injection according to the thermal leakage model**

INNOVATIVE ELEMENTS

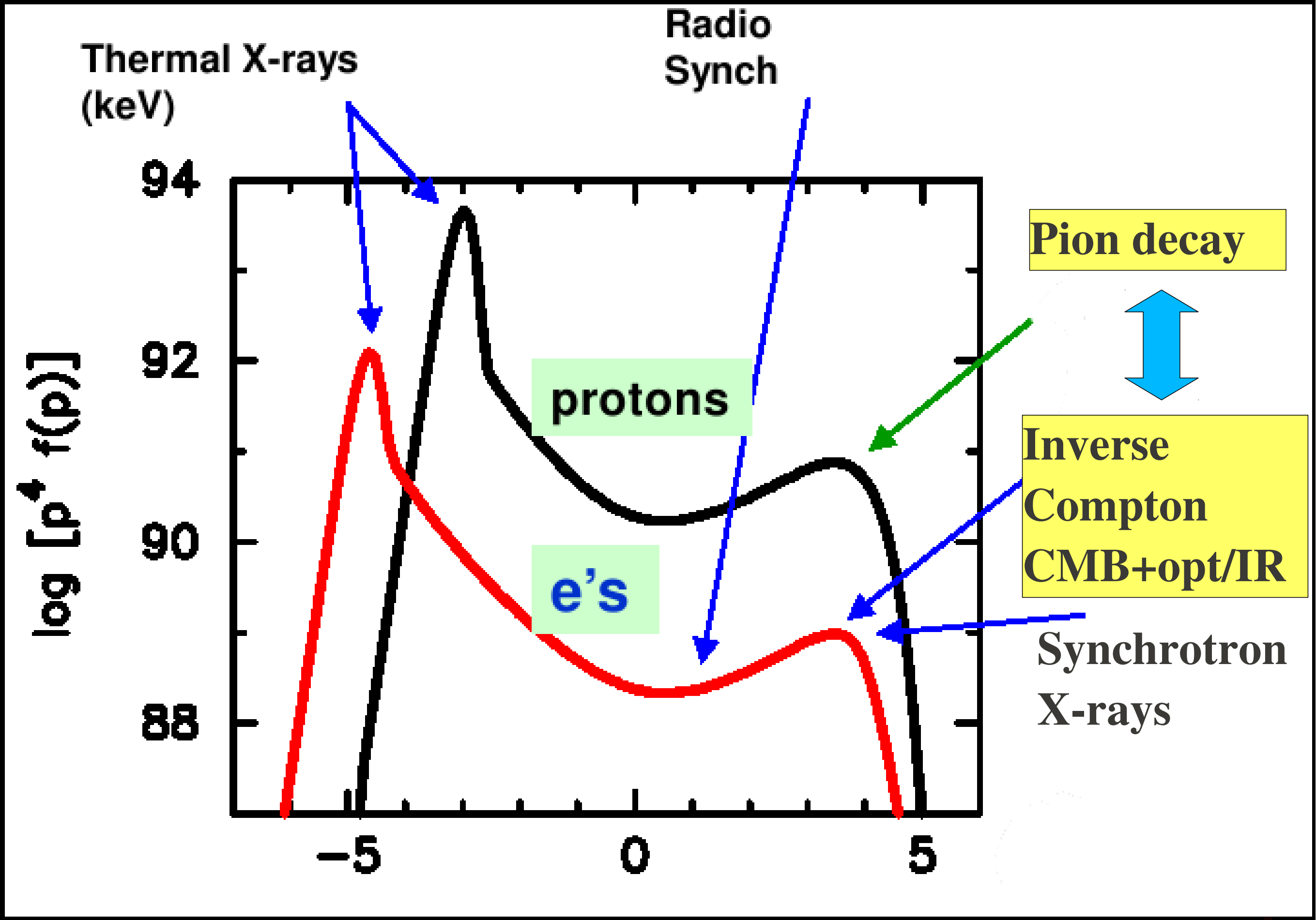
- **Resonant magnetic field amplification and compression**
- **Inclusion of dynamical reaction of amplified magnetic field onto the shock**

Basic Features of NLDSA model

Age ~ 1600 yr
Distance ~ 1 kpc

Model Parameters

- T_0 Temperature (10^6 K)
- U_{sh} shock speed
- n_0 upstream density
- B_0 upstr. magnetic field ~2-4 μG
- ξ acceleration efficiency
- K_{ep} injected e/p ratio



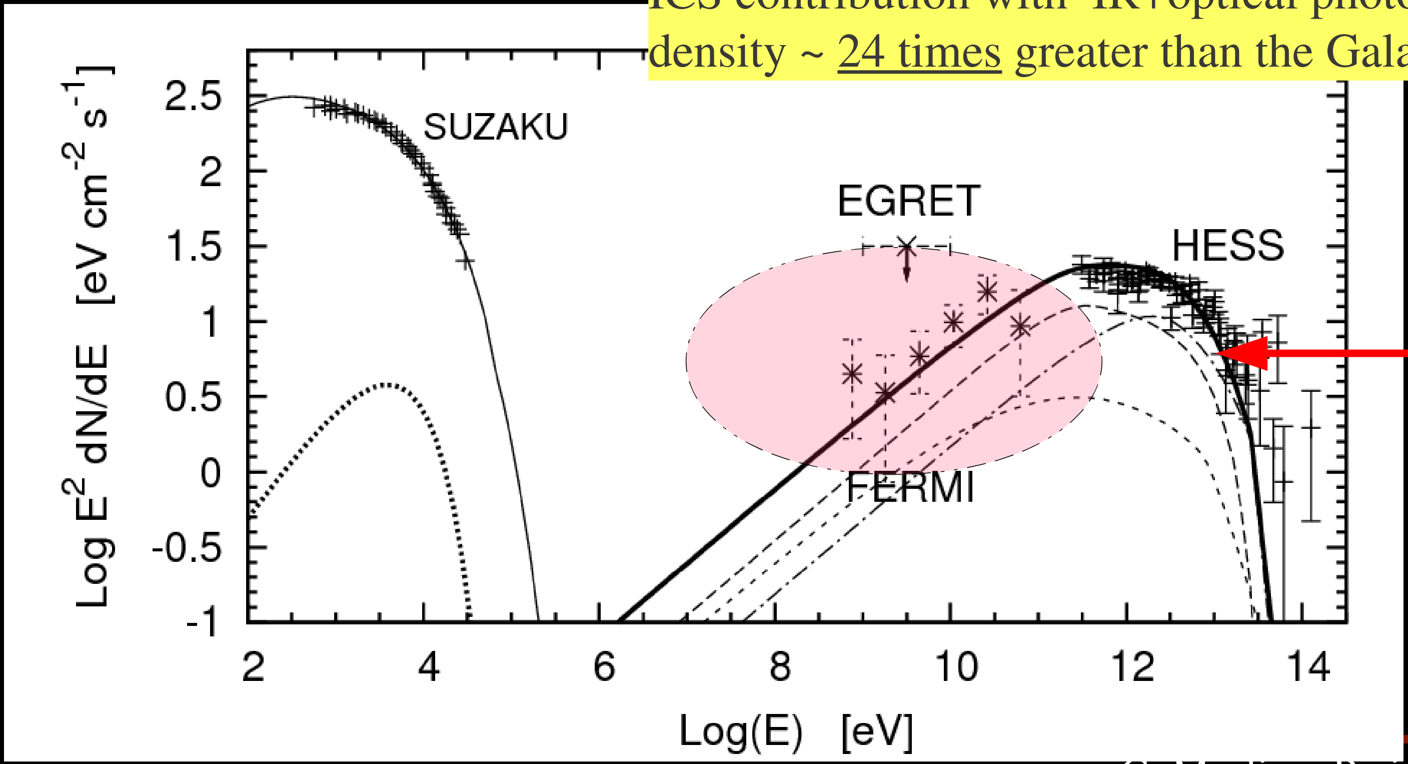
Maximum energy of both electrons and protons are computed consistently using nonlinear theory in the amplified magnetic field

Leptonic Scenario: Inefficient Acceleration

n_0[cm^{-3}]	T_0 [K]	B_0[μG]	u_0[km/s]	ξ	K_{ep}
0.01	10^6	1.5	4300	4.1	0.013

ε	η_{ing}	R_{sub}	R_{tot}	B_1/B_0	B_2[μG]	T_2 [keV]	$p_{p,max}$ [GeV]	t_{acc} [yr]
1.6 %	7.7×10^{-7}	3.96	4.03	4.0	23	23	9.3×10^4	1600

ICS contribution with IR+optical photons energy density ~ 24 times greater than the Galactic mean value



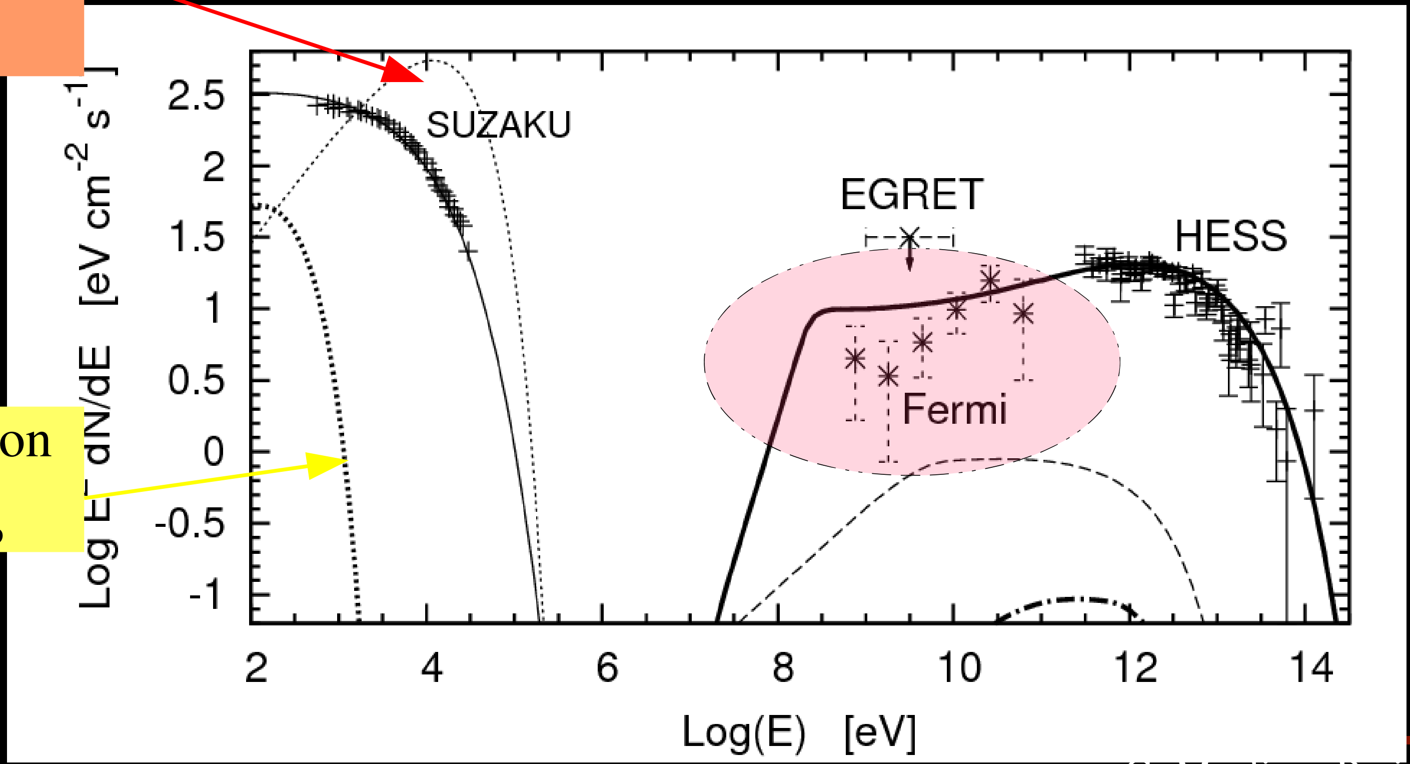
Hadronic Scenario: Efficient Acceleration

n_0[cm^{-3}]	T_0 [K]	B_0[μG]	u_0[km/s]	ξ	K_{ep}
0.12	10^6	2.6	4300	3.8	8×10^{-5}

ε	η_{ing}	R_{sub}	R_{tot}	B_1/B_0	B_2[μG]	T_2 [keV]	$p_{p,max}$ [GeV]	t_{acc} [yr]
26 %	6.5×10^{-5}	3.95	5.35	25.5	100	19.5	1.25×10^5	780

Thermal emission for $T_e = T_p$

Thermal emission for $T_e = 0.01\ T_p$



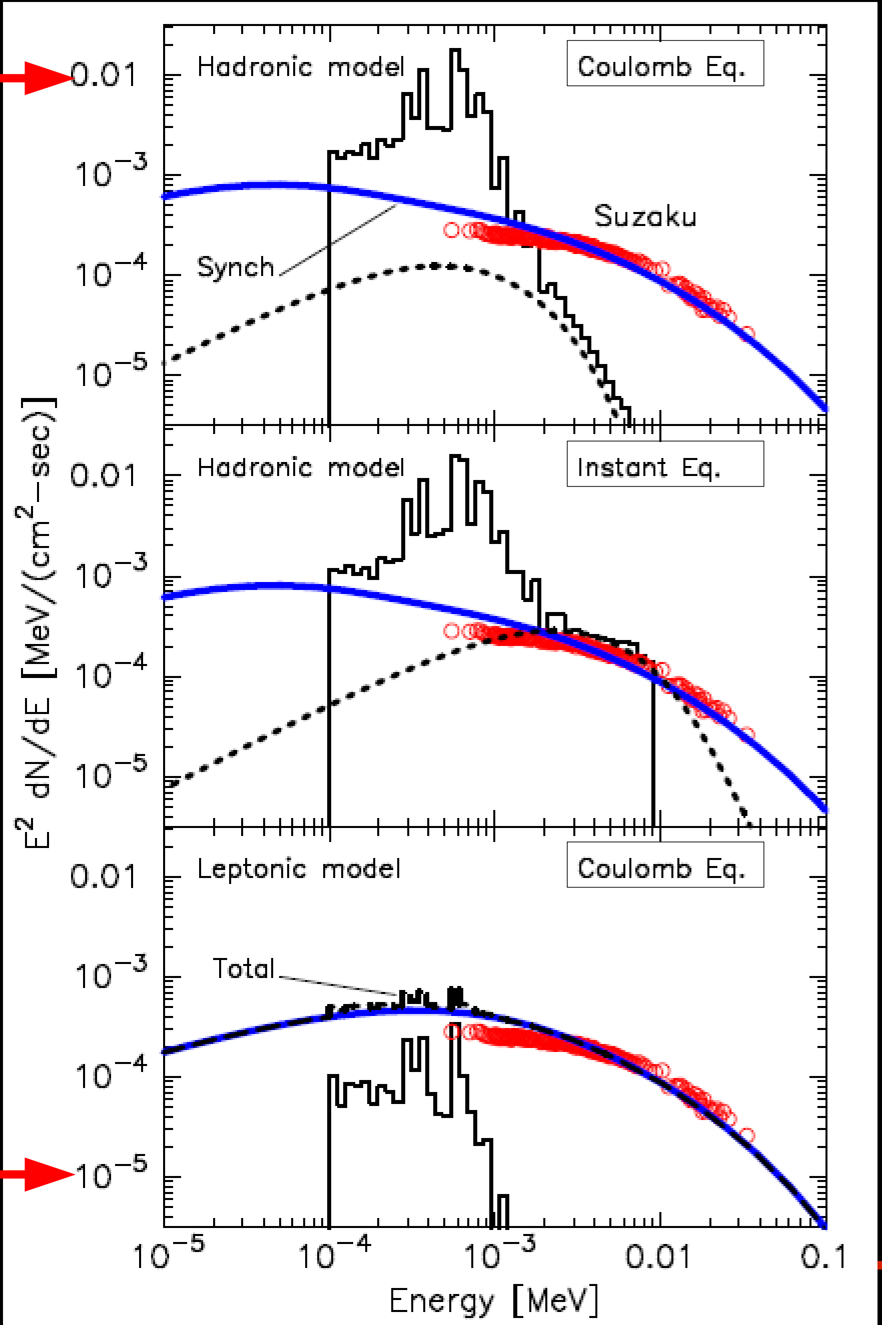
Thermal X-ray lines: is the Hadronic Scenario ruled out?

$n_0 = 0.2\ cm^{-3}$

Ellison et al. (2010) showed that

If ISM density ~ 0.1 cm^{-3}
→ Coulomb collisions can heat electrons enough to produce observable X-ray lines above the Suzaku observed flux

$n_0 = 0.05\ cm^{-3}$



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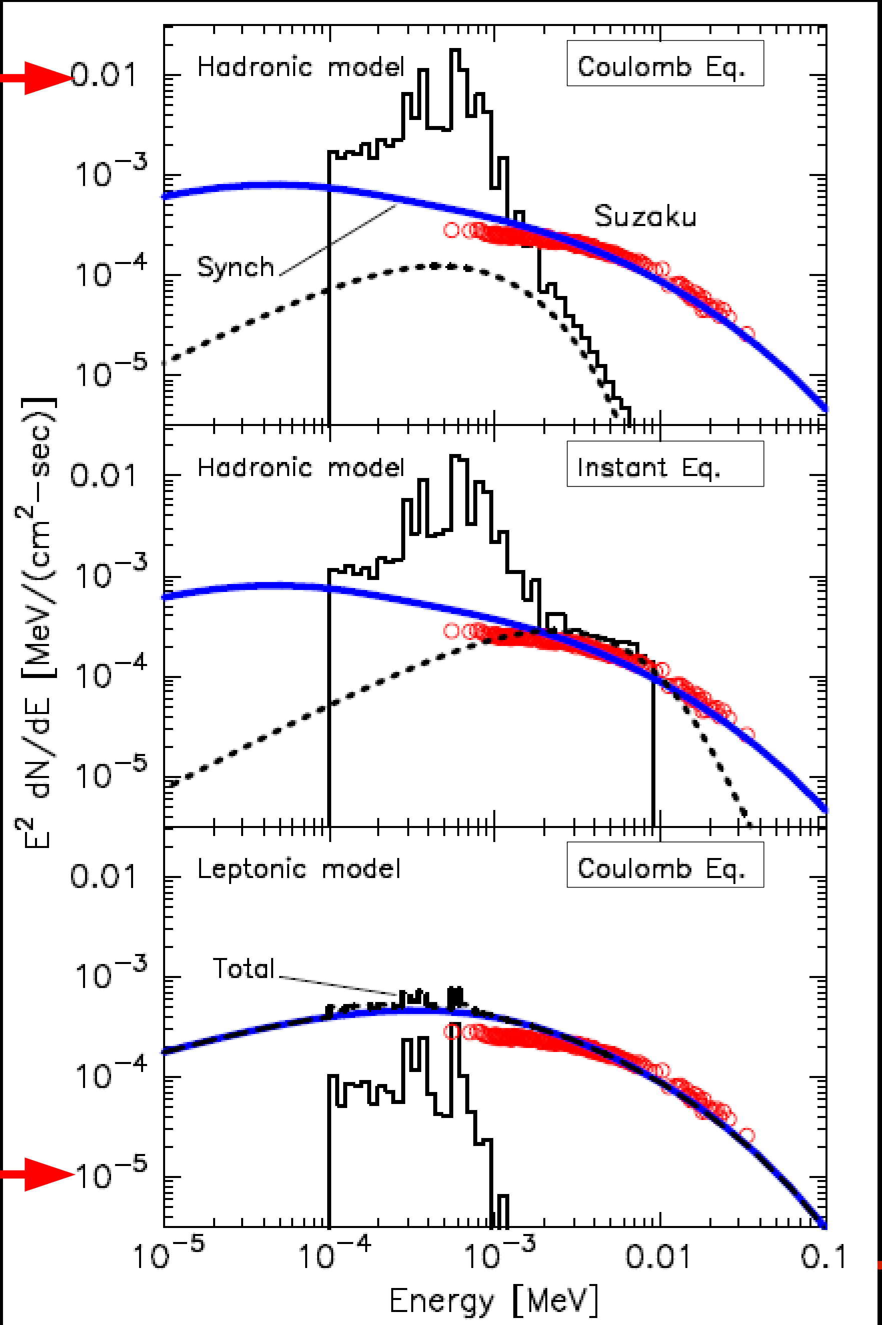
<u>Possible caveats:</u>

- Chemical composition of circumstellar medium different from the assumed solar one
- Non uniform circumstellar medium

[see Zirakashvili & Aharonian 2009]

$n_0 = 0.05\ cm^{-3}$



Conclusions

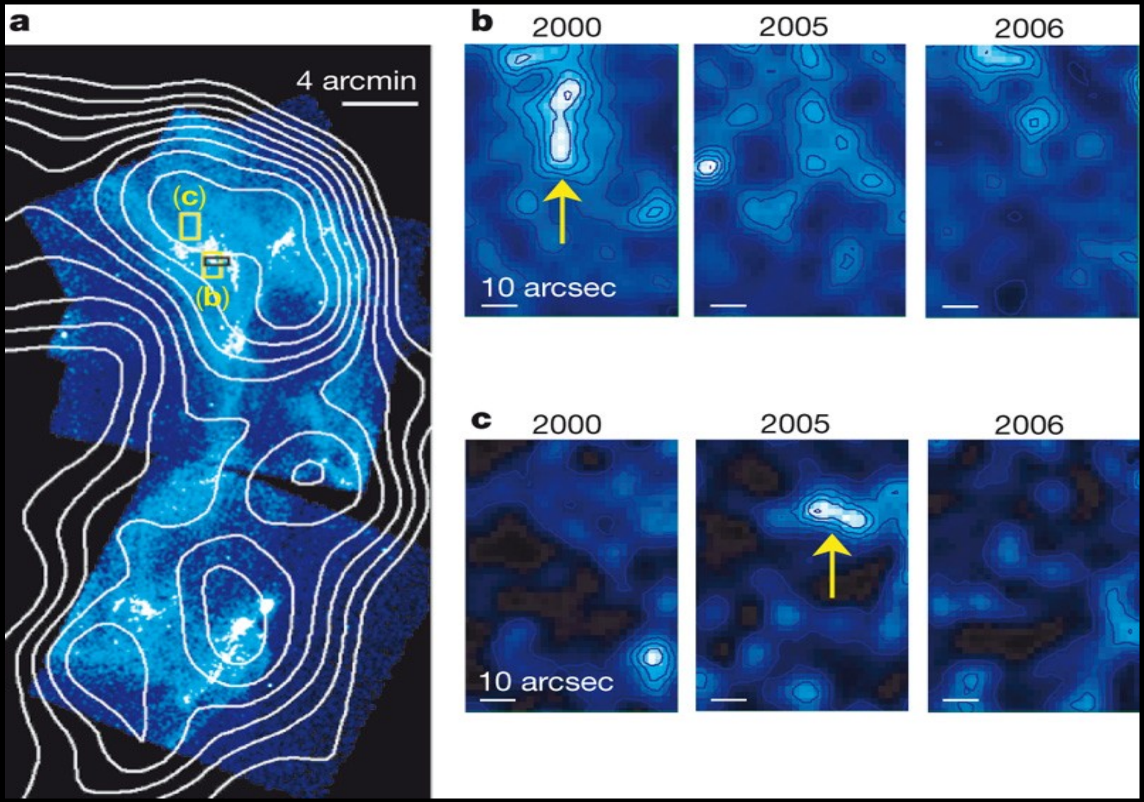
The dispute between Hadronic vs Leptonic scenario
is still not solved

	Non-thermal X-ray	Thermal X-ray	GeV (Fermi-LAT)	TeV	X-ray filaments
HADRONIC (efficient acceleration)	GOOD	BAD	NOT SO GOOD	GOOD	GOOD
LEPTONIC (inefficient acceleration)	GOOD	GOOD	GOOD	BAD	BAD

X-rays variability

Uchiyama et al.(2008) observed whit CHANDRA rapid variations of single X-ray spots of order ~1 year

Assuming that this is due to synchrotron losses they infer a magnetic field ~mG observing



Predictions from other Authors