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The potential application of MHD simulation to PWNe/SNRs in LHAASO project

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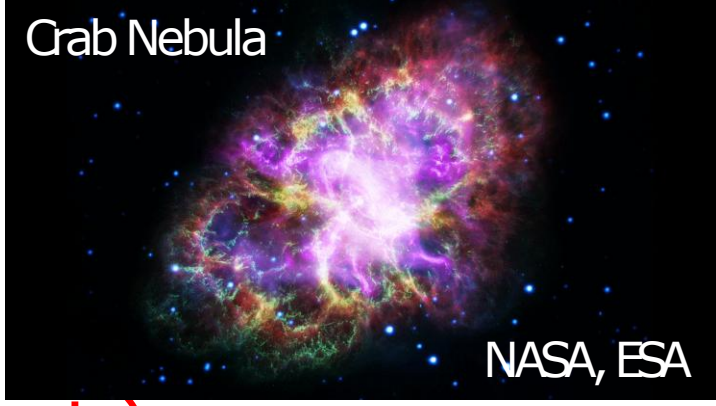
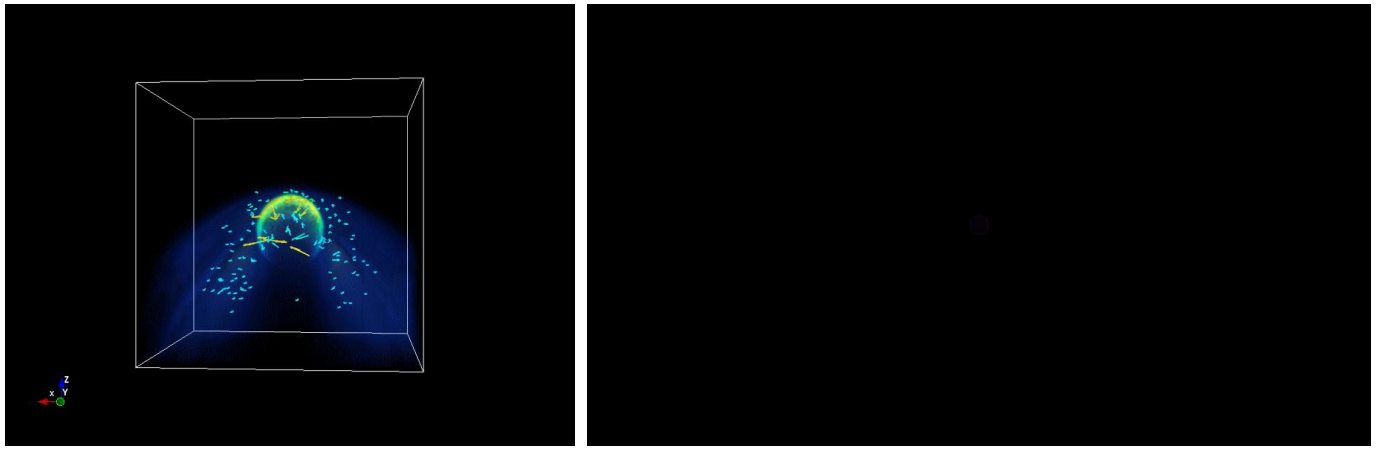
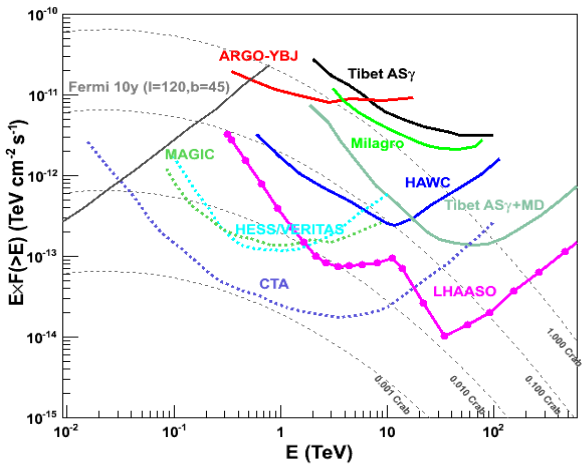
Introduction

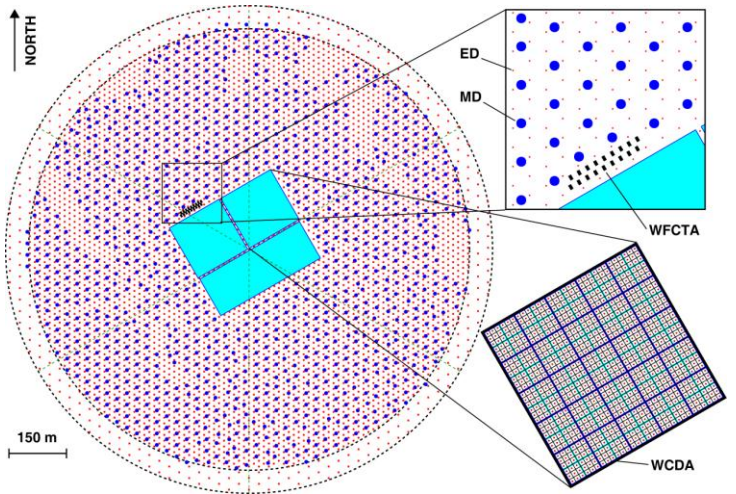


- PWNe(Pulsar Wind Nebulae)/SNRs(Supernova Remnants)
  1. Multi-wavelength
  2. Original places of CRs
- MHD simulation
  1. 3D patterns
  2. Evolution details
- LHAASO project
  1. Sensitivity
  2. KM2A, WCDA
  3. Resolution



M. F, Zhang et al. 2017, 2018





H. H, He 2018

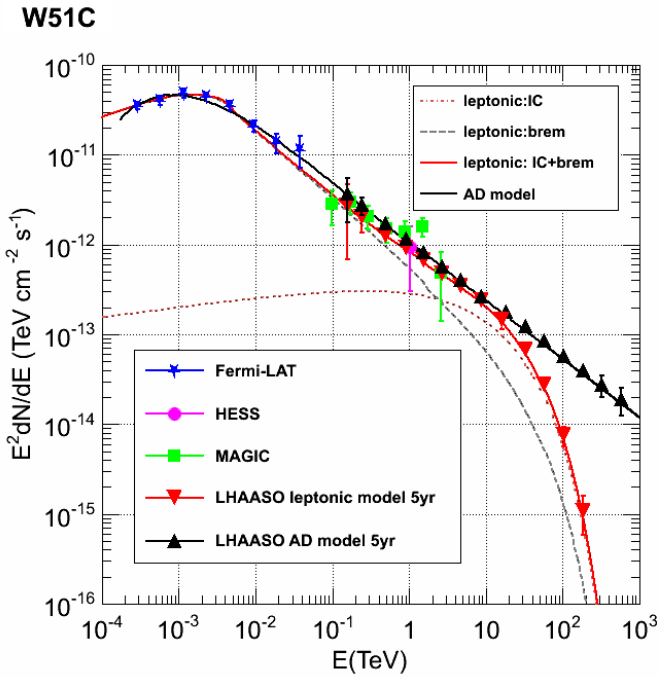
A proposal?

$$F = A(E/E_0)^{-\alpha} e^{-(E/Ec)}$$

- Aims

1. The acceleration and propagation of CRs; 2. radiation mechanism

- Detectability → GeV-TeV data! → Estimated spectrum →

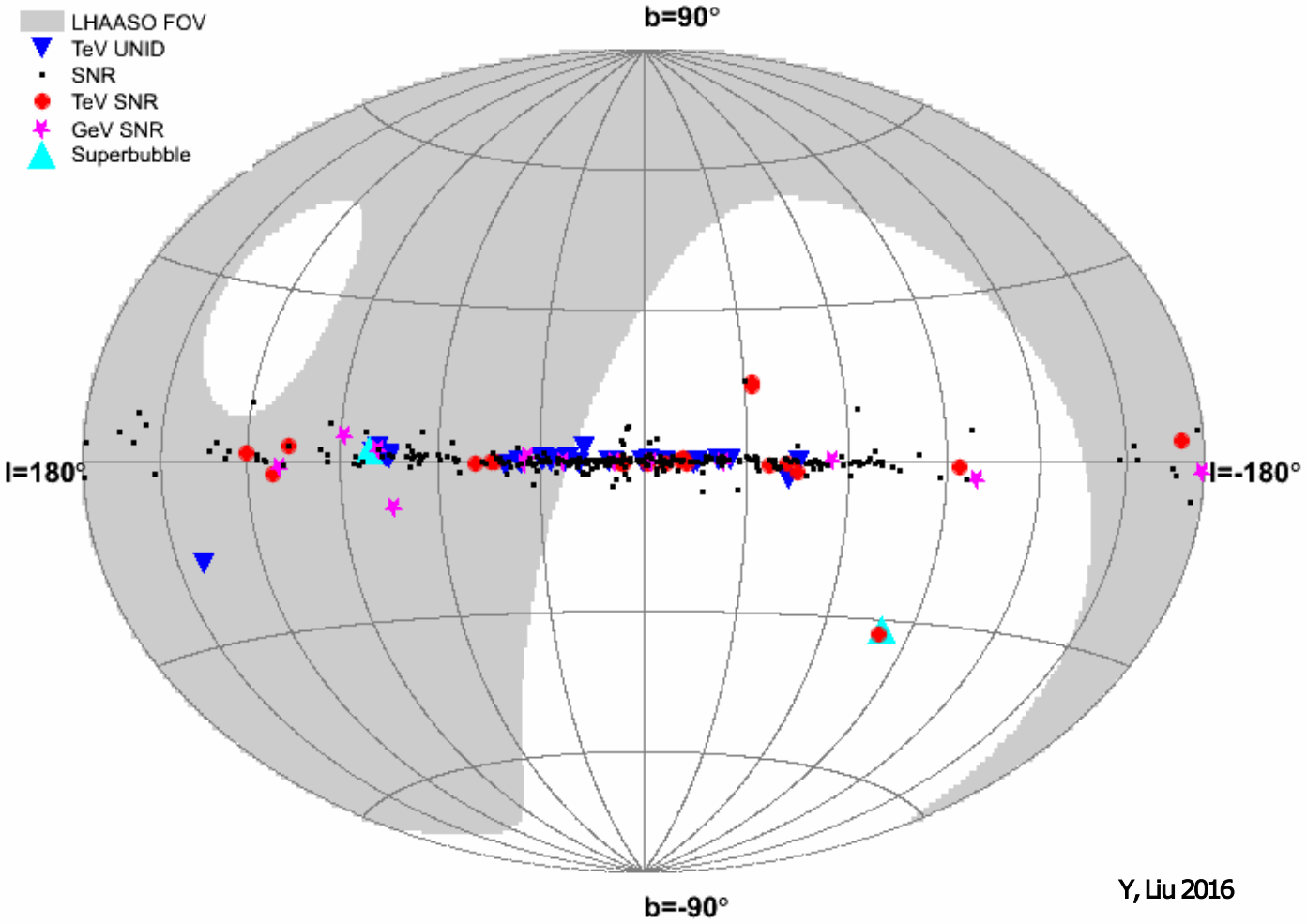


Y, Liu 2016

Resolution at different bands

	WCDA			KM2A		
	0.5TeV	1TeV	10TeV	10TeV	30TeV	100TeV
Effective Area	3,000m^2	10,000m^2	50,000m^2	0.3km^2	0.8km^2	0.9km^2
Resolution	0.6°	0.4°	0.2°	0.86°	0.5°	0.3°

In the FoV: 92 radio SNRs !



Which one should we try to detect?
Multiwavelength SED? (radio + X-ray => TeV?)

Only SED?

- The spectral index at radio waveband

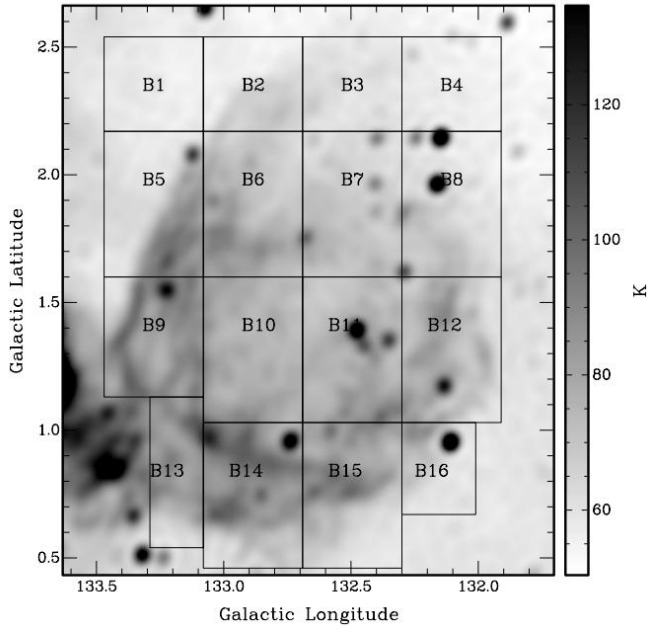
Tycho spectral index:

1.95 in 2011 (Acciari), 2.92 in 2015 (Park)

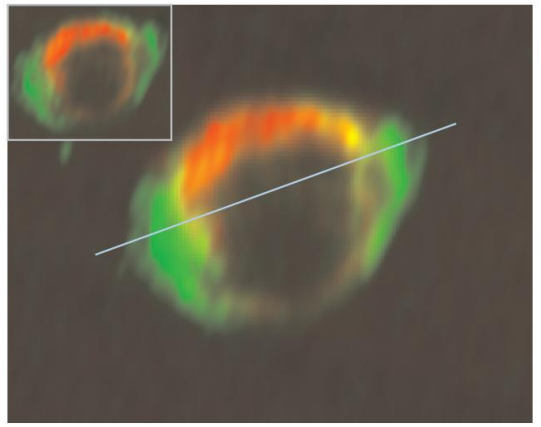
- SNR at radio and X-ray (G1.9)

- PWN(G16.7)

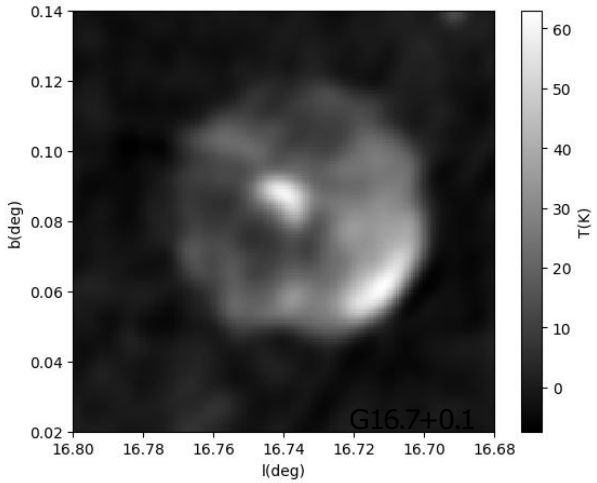
Sp. index	α	α	α
Area No.	Including compact sources	Compact sources subtracted	Compact sources removed
B1	0.06 ± 0.50	0.03 ± 0.73	0.07 ± 0.49
B2	0.29 ± 0.07	0.29 ± 0.07	0.29 ± 0.07
B3	0.12 ± 0.21	0.18 ± 0.23	0.18 ± 0.14
B4	0.46 ± 0.09	0.30 ± 0.20	0.28 ± 0.14
B5	0.51 ± 0.06	0.54 ± 0.06	0.55 ± 0.05
B6	0.43 ± 0.06	0.46 ± 0.08	0.45 ± 0.08
B7	0.52 ± 0.05	0.43 ± 0.07	0.31 ± 0.09
B8	0.45 ± 0.04	0.31 ± 0.05	0.25 ± 0.02
B9	0.12 ± 4.15	0.05 ± 4.10	0.11 ± 0.79
B10	0.12 ± 0.10	0.09 ± 0.10	0.09 ± 0.10
B11	0.60 ± 0.12	0.39 ± 0.12	0.40 ± 0.07
B12	0.45 ± 0.06	0.41 ± 0.07	0.36 ± 0.04
B13	0.10 ± 0.14	0.07 ± 0.13	0.05 ± 0.13
B14	0.45 ± 0.02	0.38 ± 0.04	0.45 ± 0.01
B15	0.29 ± 0.02	0.32 ± 0.03	0.29 ± 0.02
B16	0.25 ± 0.03	0.25 ± 0.03	0.23 ± 0.02



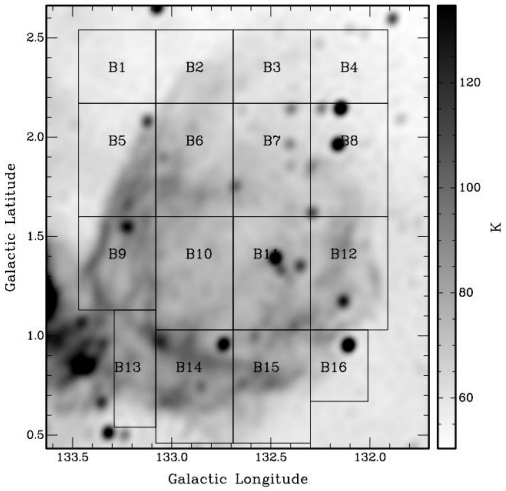
W. W, Tian 2005



Reynolds 2008

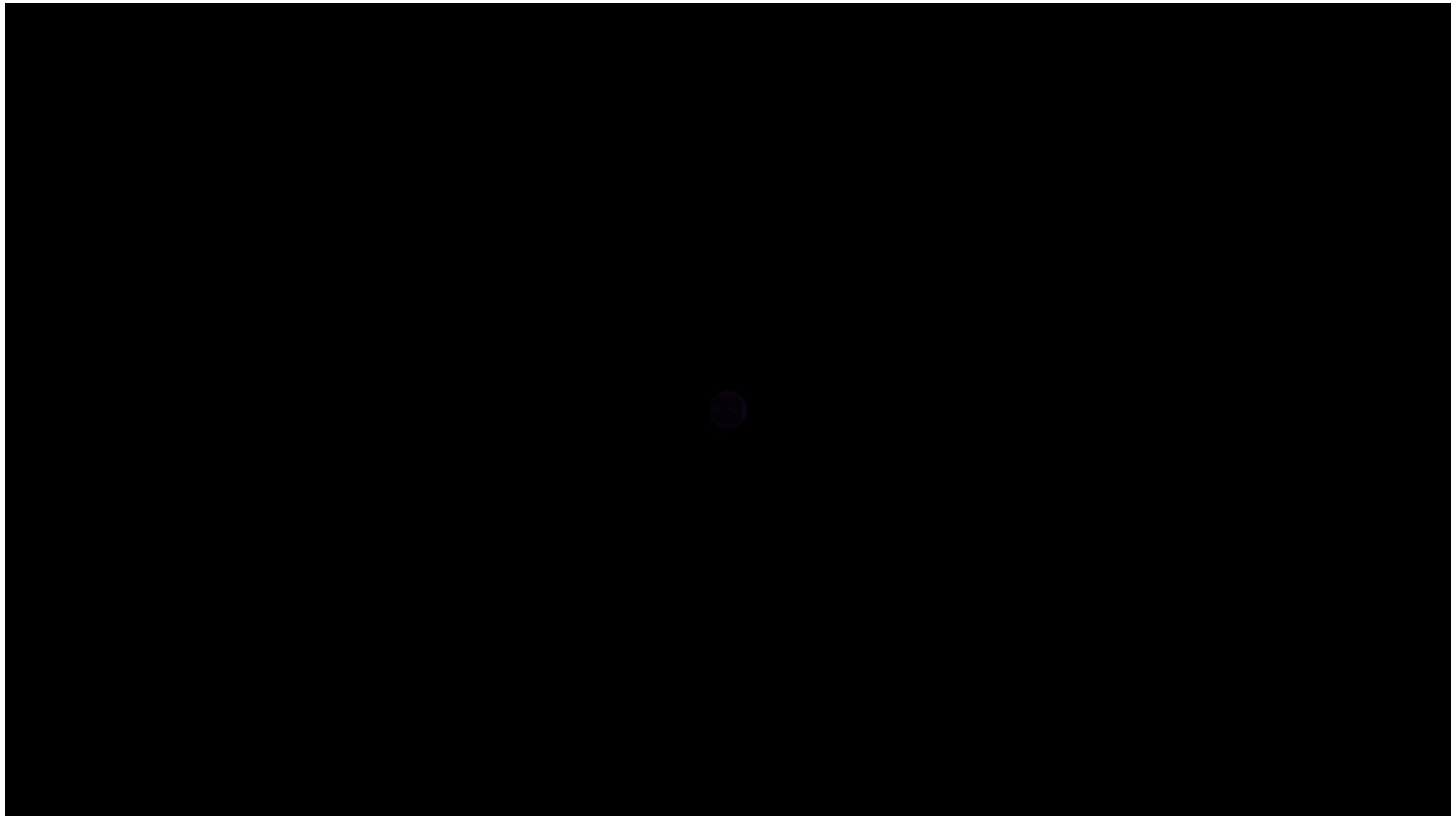


MHD + SED !

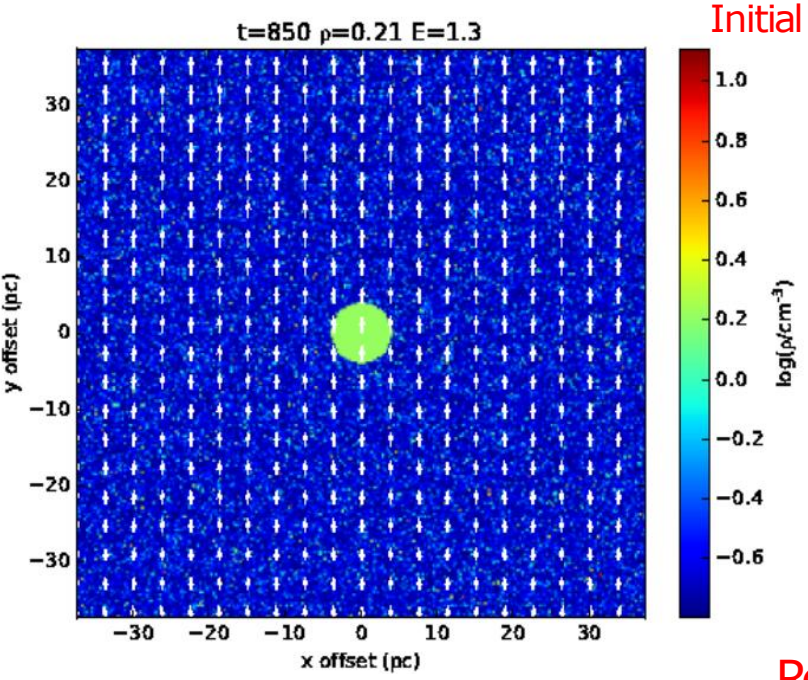


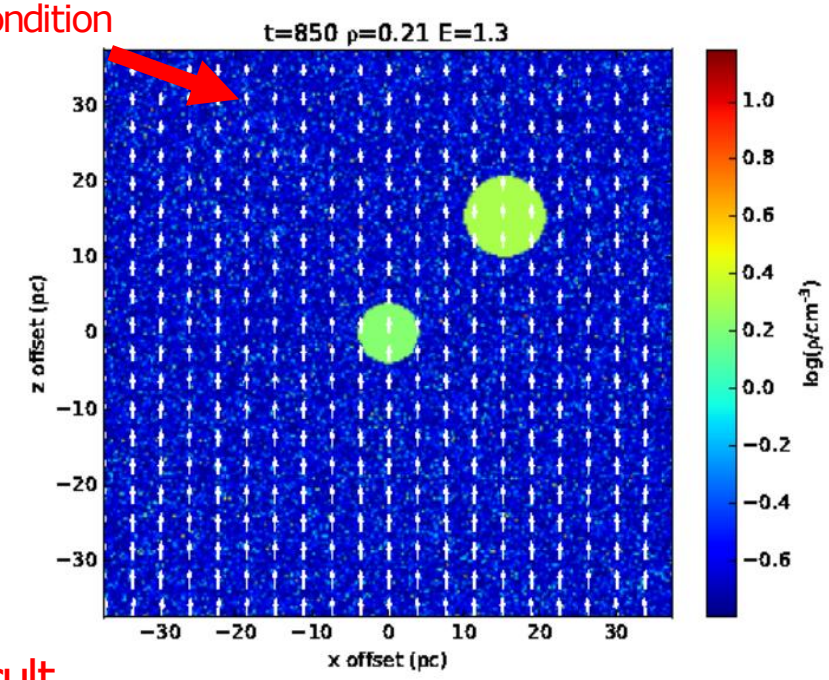
- The spectral index at radio waveband :

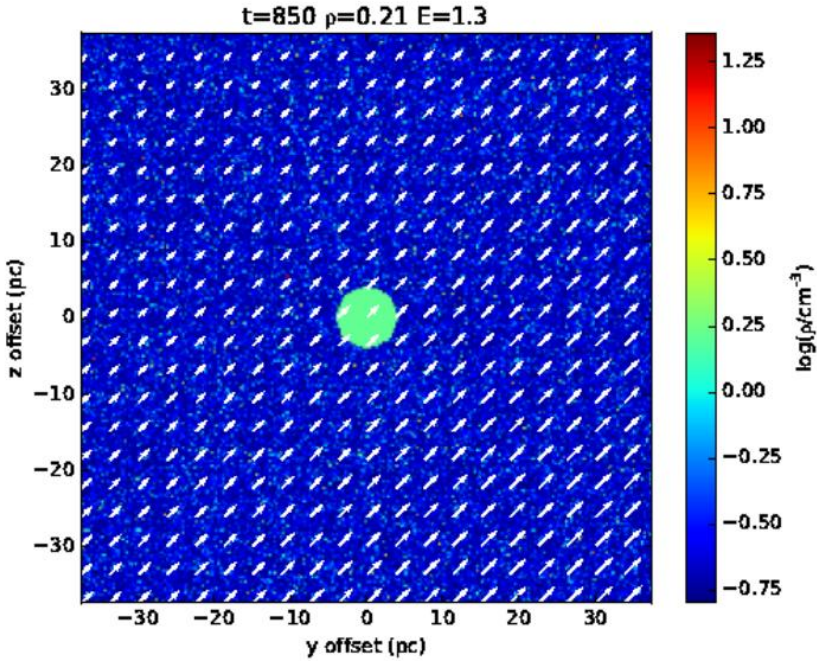
  index deviation -> ISM density distribution



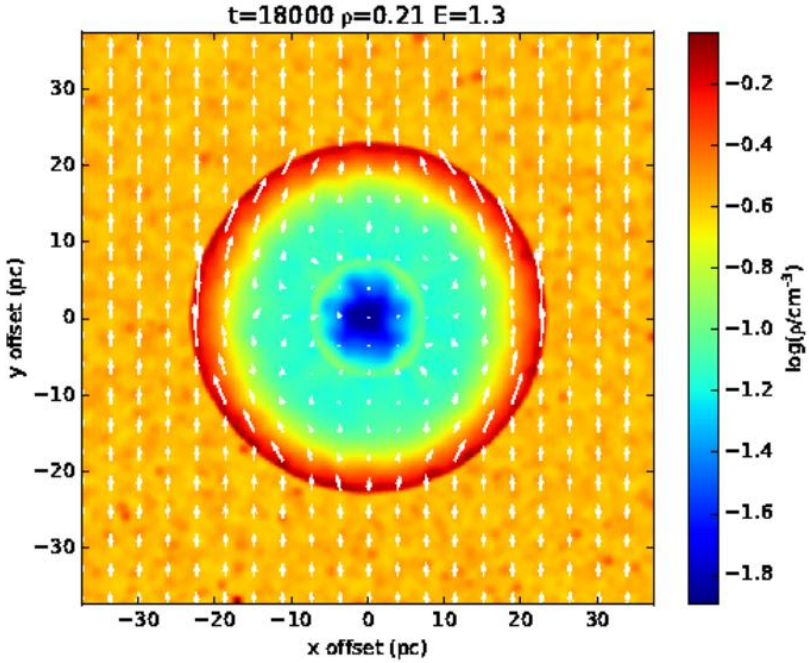
Initial condition

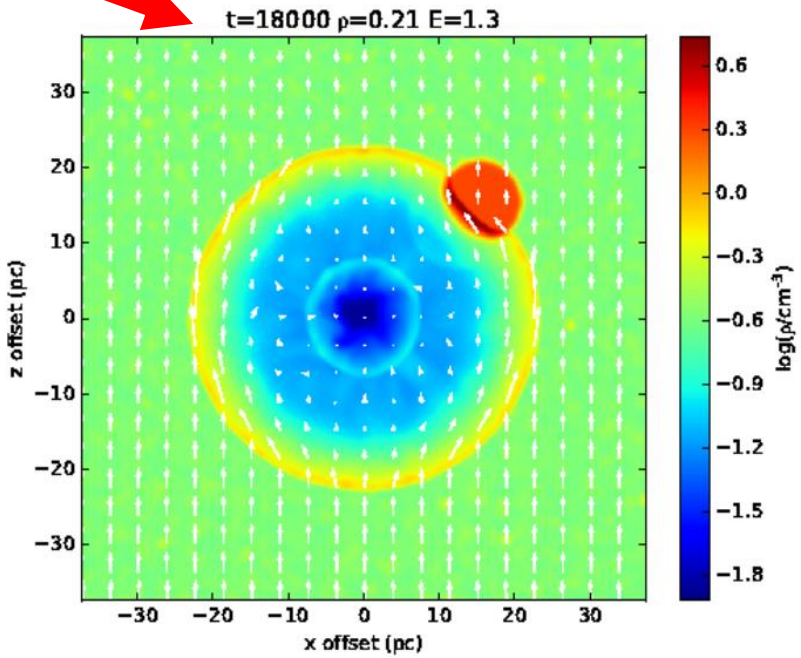


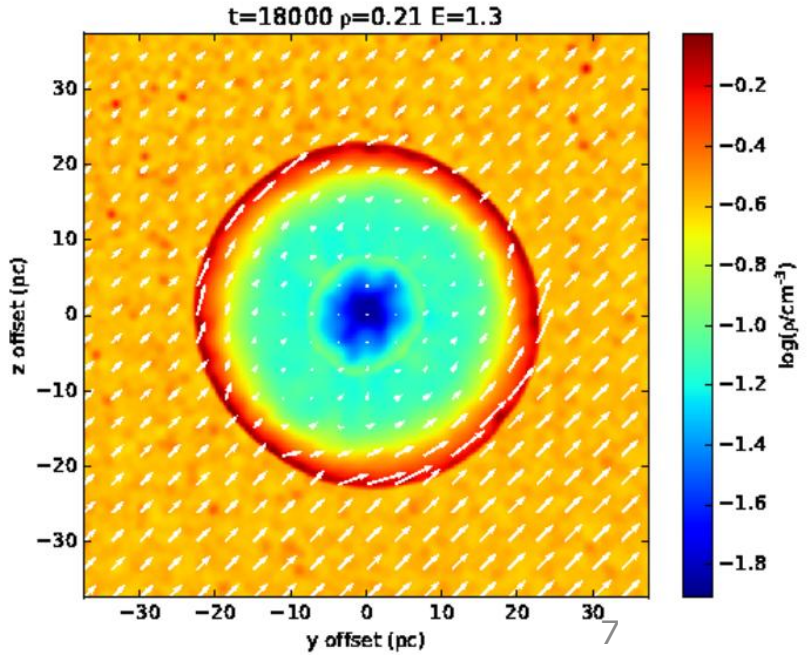




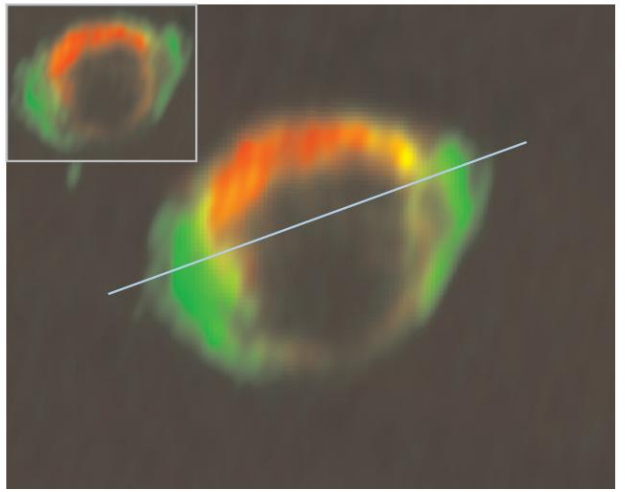
Result



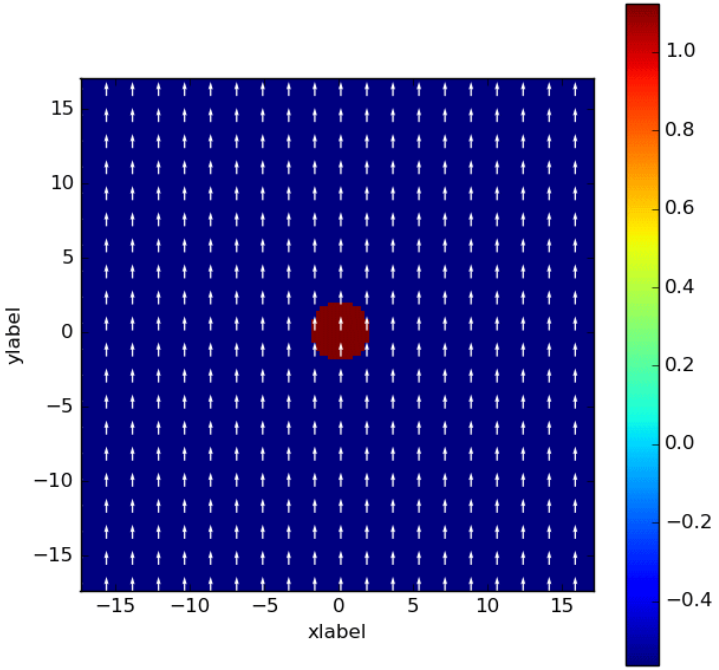


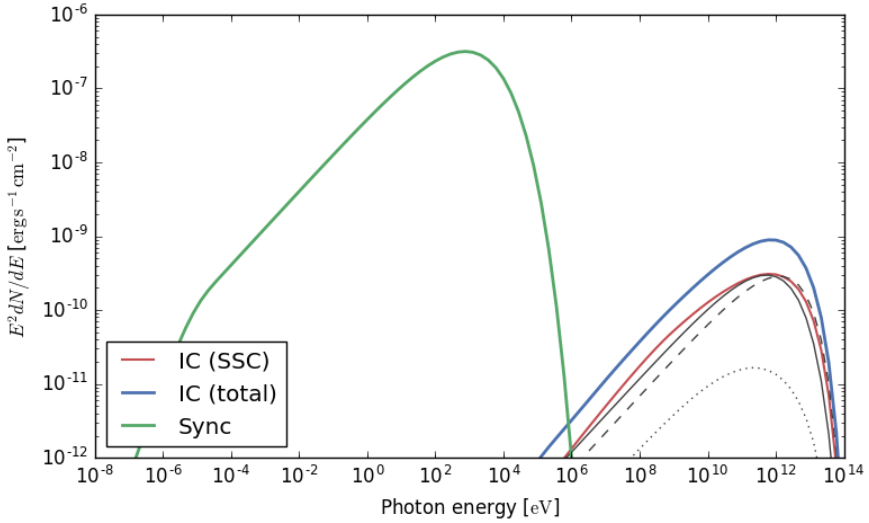


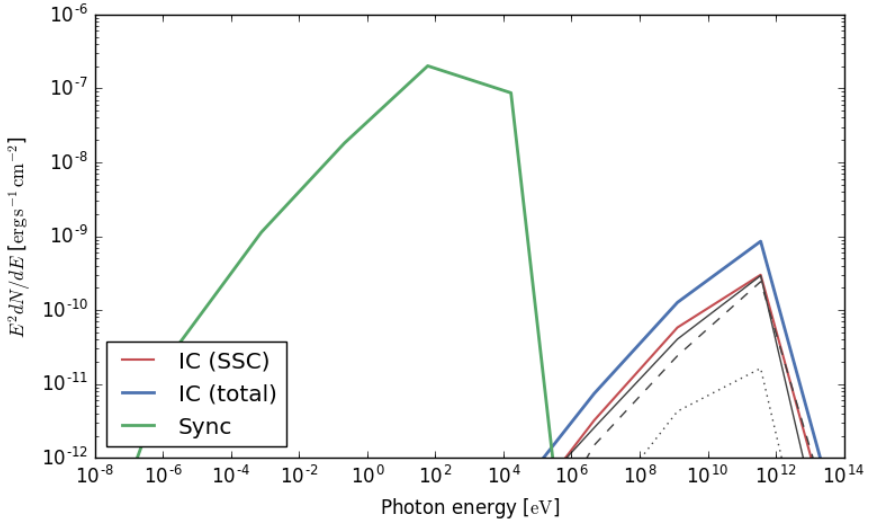
MHD + SED !



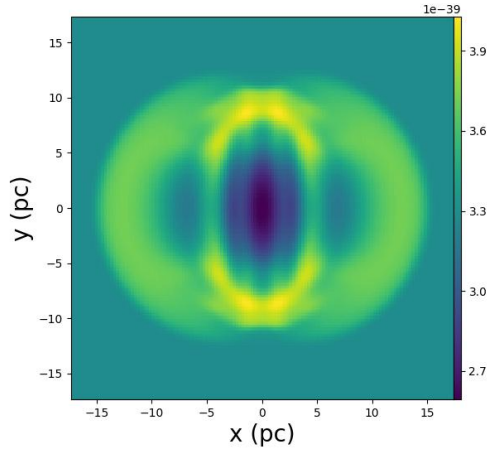
- SNR at radio and X-ray (G1.9) :
  strong magnetic field (1 mG)!

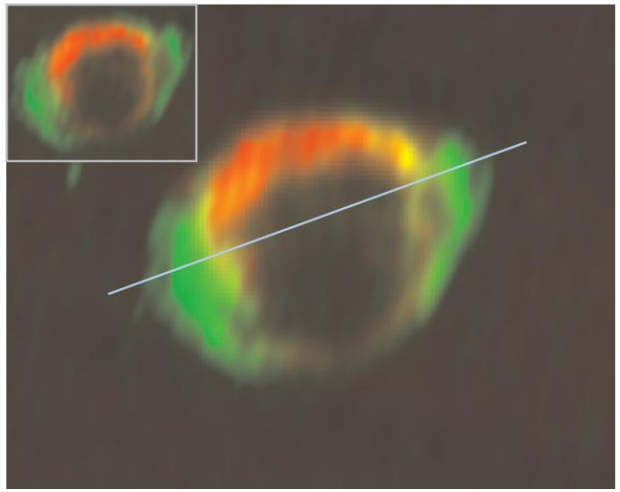






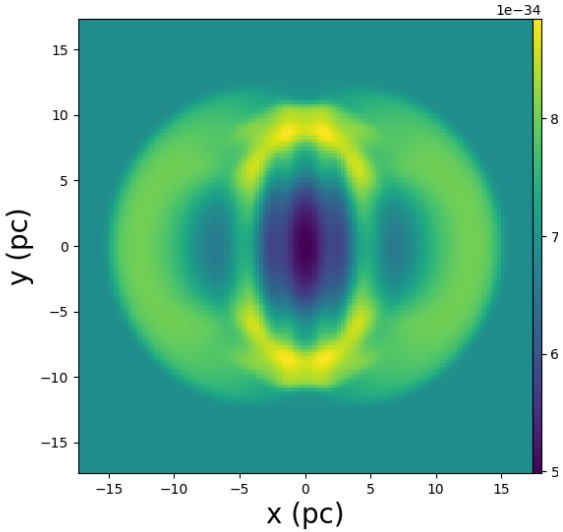
MHD + SED !



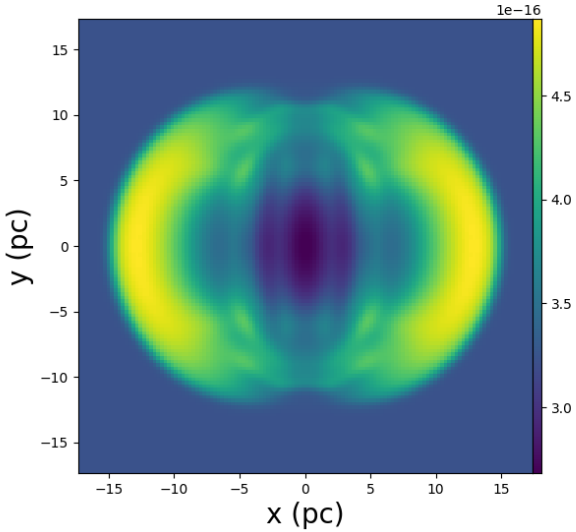


- SNR at radio and X-ray (G1.9) : strong magnetic field (1 mG)!

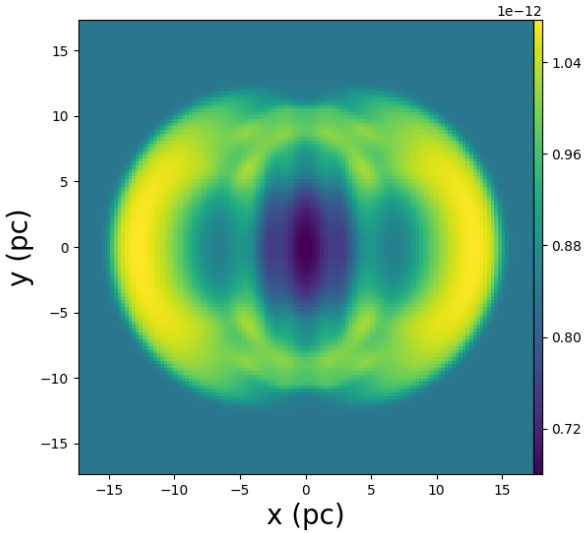
670MHz



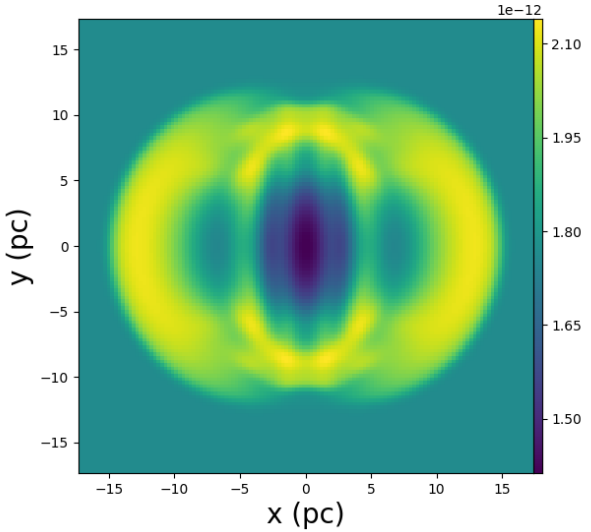
20 nm



16 keV



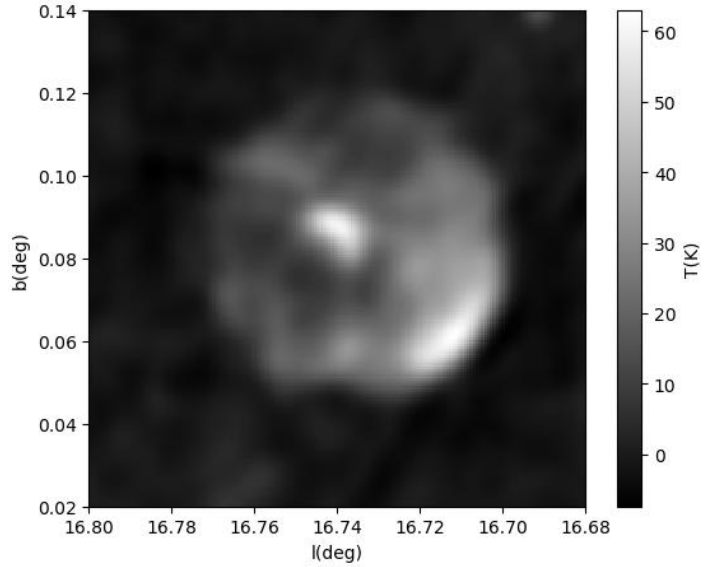
100 TeV



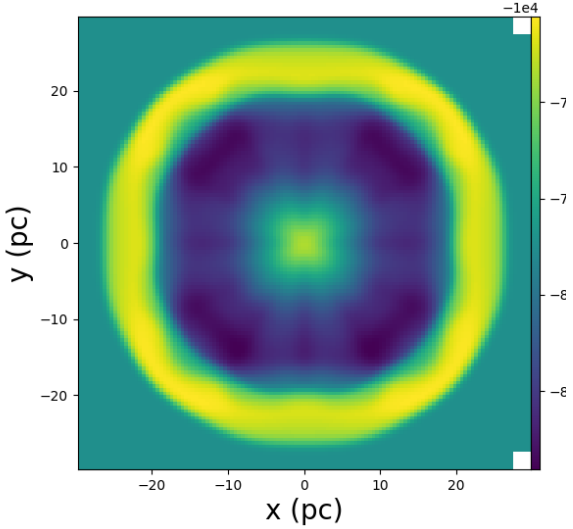
MHD + SED !

- PWN(G16.7) :

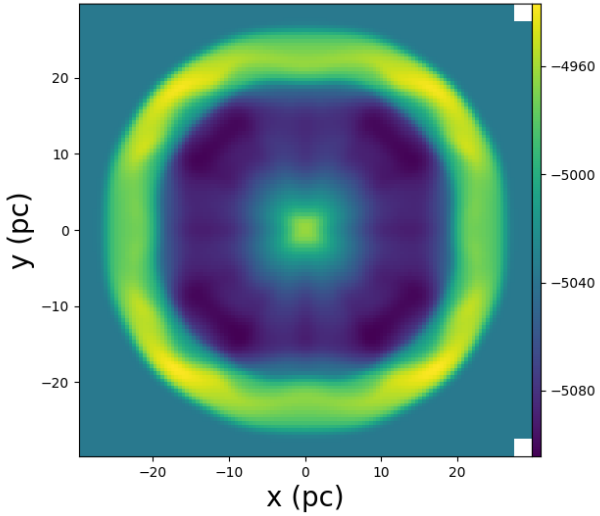
  pwn + canonical magnetic field (9 uG)!



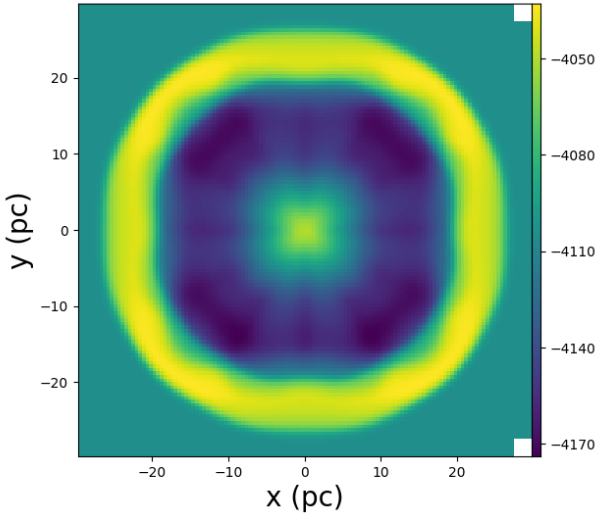
670MHz



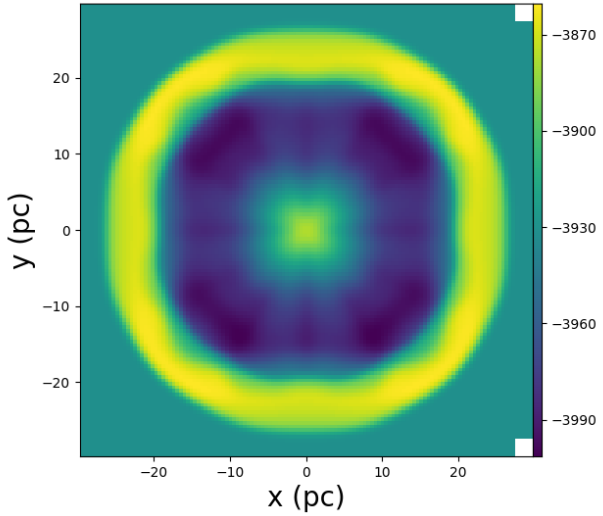
20 nm



16 keV



100 TeV



Other advantages

- **Magnetic field amplification**

1. Important in explaining the CRs around the knee
2. Cooling energy (1mG, Inoue 2012) $E_c \sim 10(B/\mu G)^{-2}(T/10^3 yr)^{-1}$ PeV

- **TeV -> radio**

Most of the unidentified TeV sources are located in the Galactic plane and could be potential SNRs.

- **Acceleration rate**

MHD simulation can be used to estimate the acceleration rate directly.

Thank you!