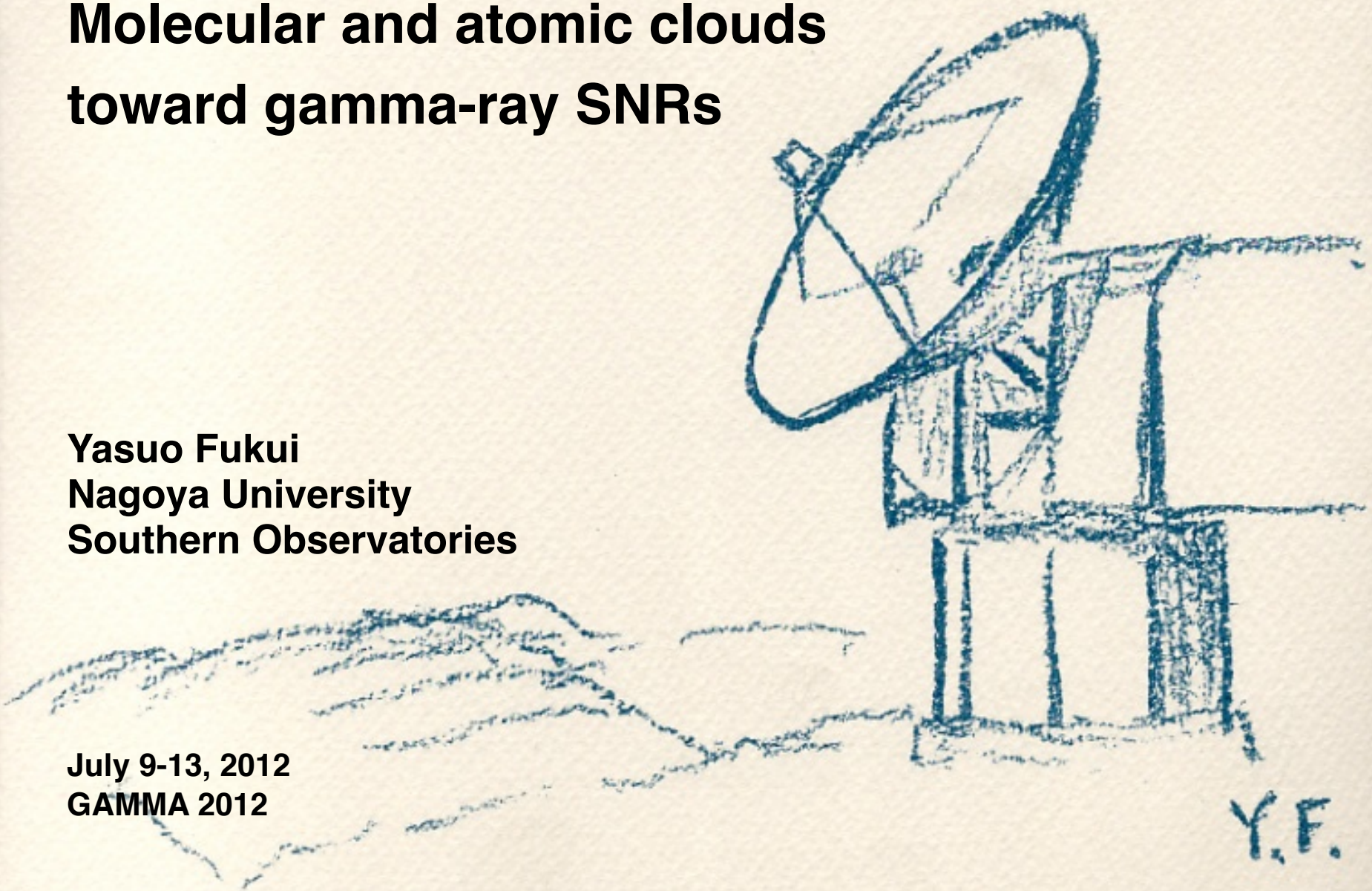
Molecular and atomic clouds toward gamma-ray SNRs



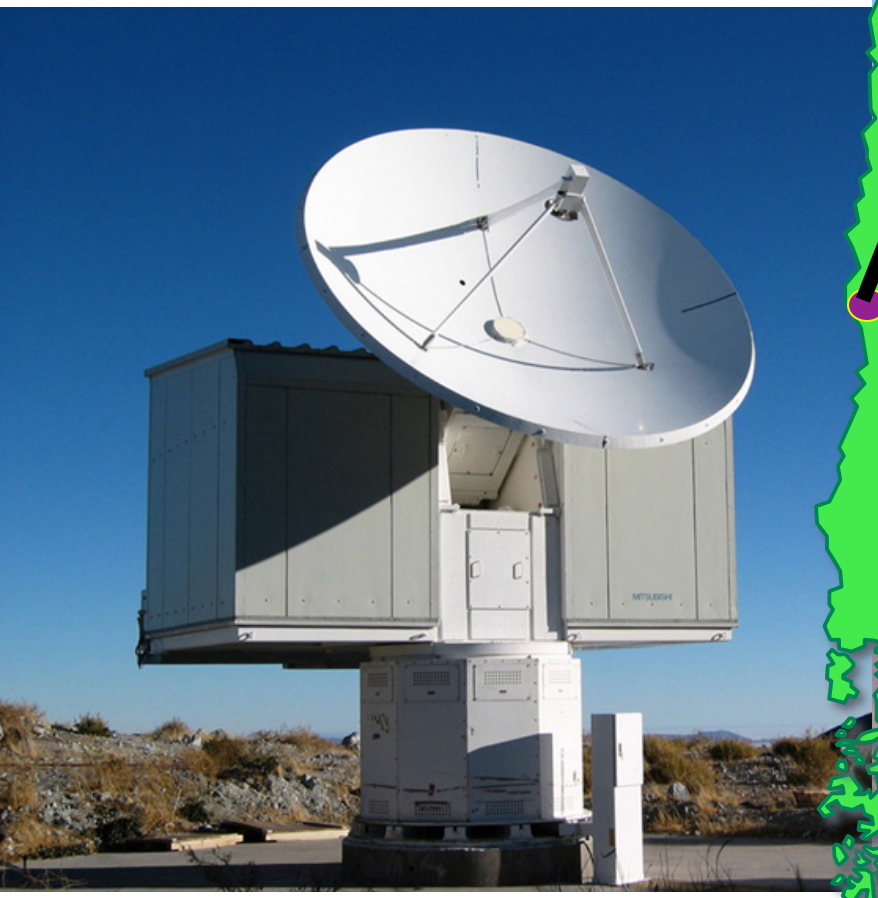
Yasuo Fukui
Nagoya University
Southern Observatories

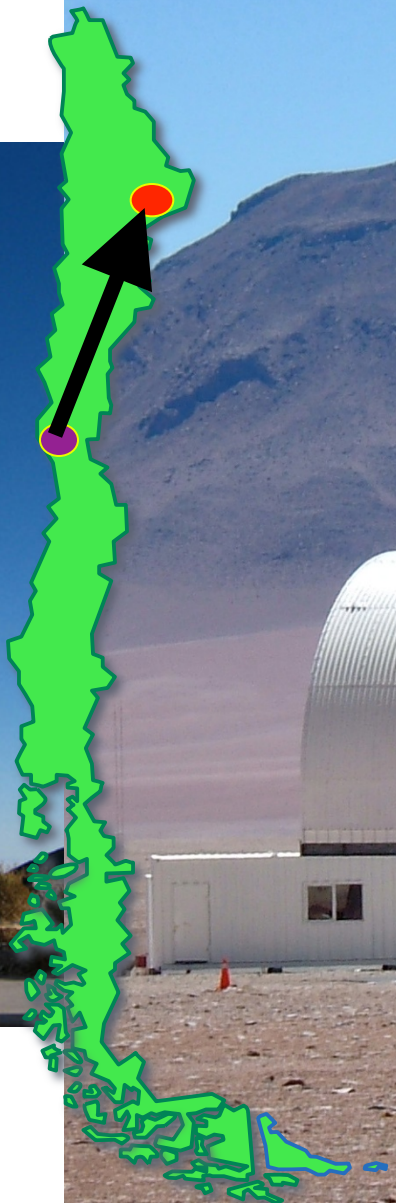
July 9-13, 2012
GAMMA 2012

Origin of γ−rays in RX J1713 and RX J0852

- Hadronic or leptonic?
  - ISM protons vs. γ−rays
    show good spatial correspondence
  - γ−rays vs. X rays;
    correspondence breaks at higher resolution
  - conclusion: Hadronic
- Future prospects
  - Higher angular resolution by CTA, ALMA…

NANTEN & NANTEN2



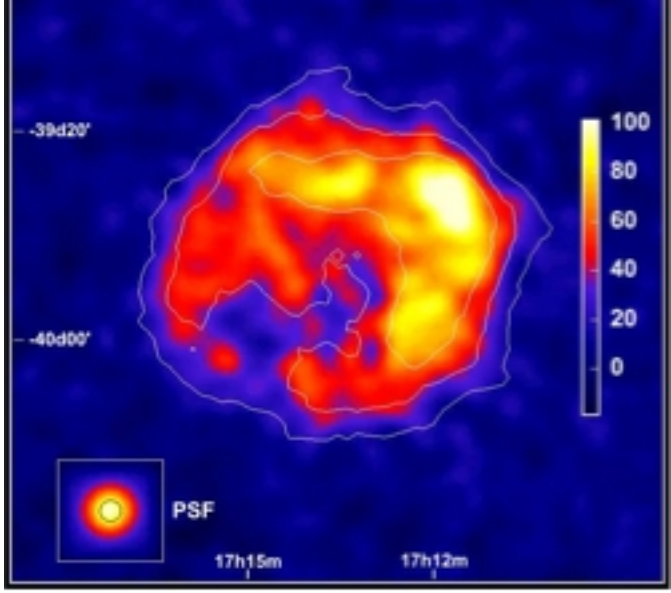


@Las Campanas, alt.2400m

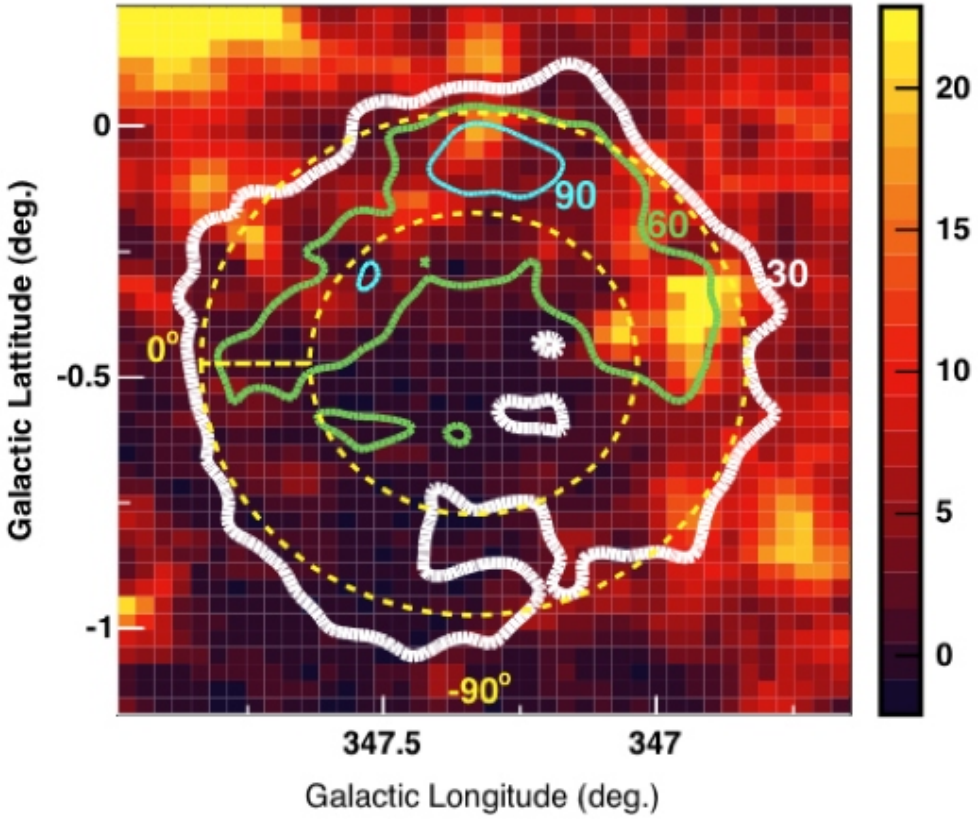
@Atacama, alt.4800m

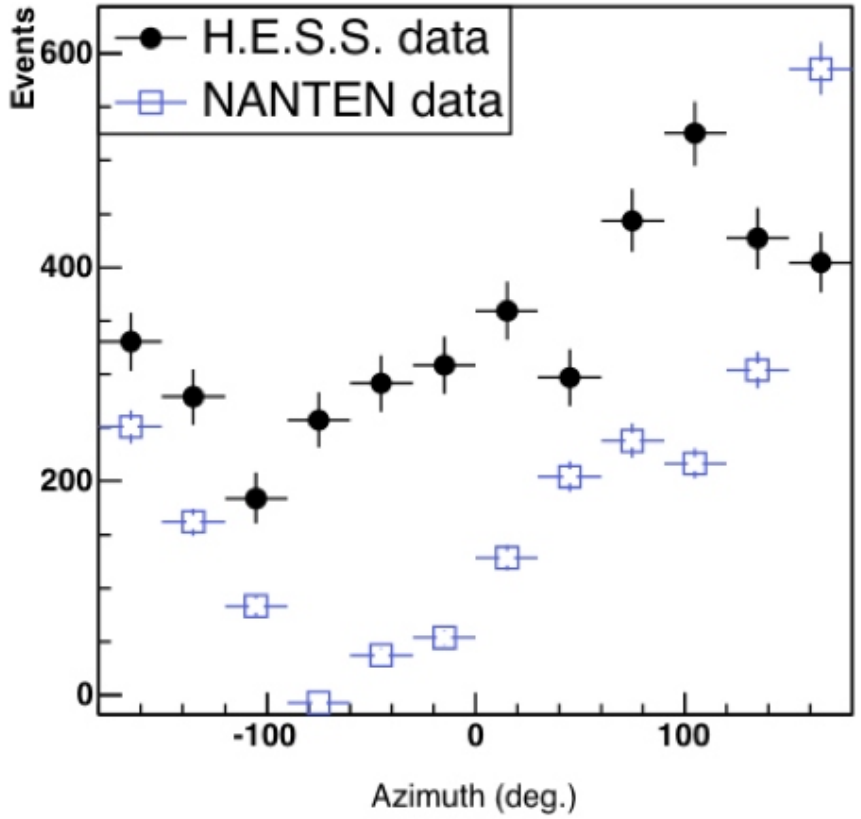
SNR G347.3-0.5 (RX J1713.7-3946)

- Shell-like structure: similar with X-rays
- No significant variation of spectrum index
  across the regions
- spatial correlation with surrounding molecular gas

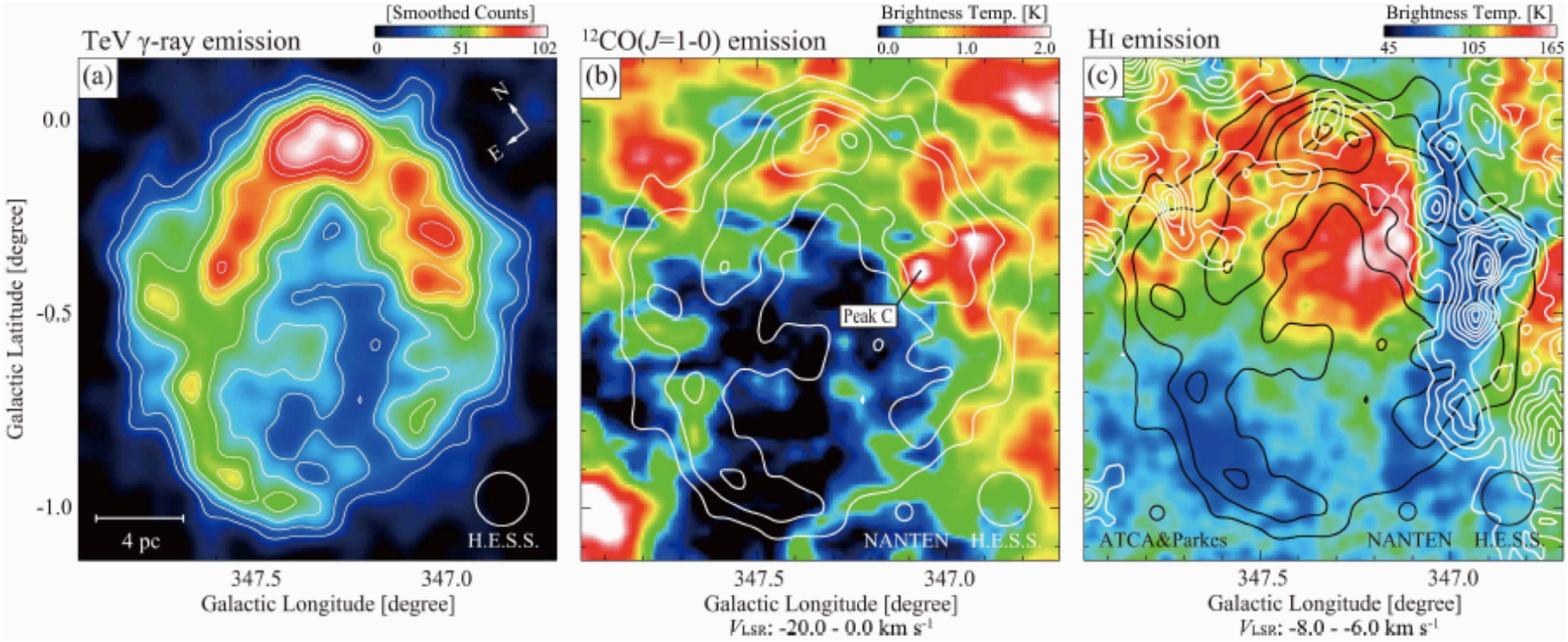


Aharonian et al. 2005



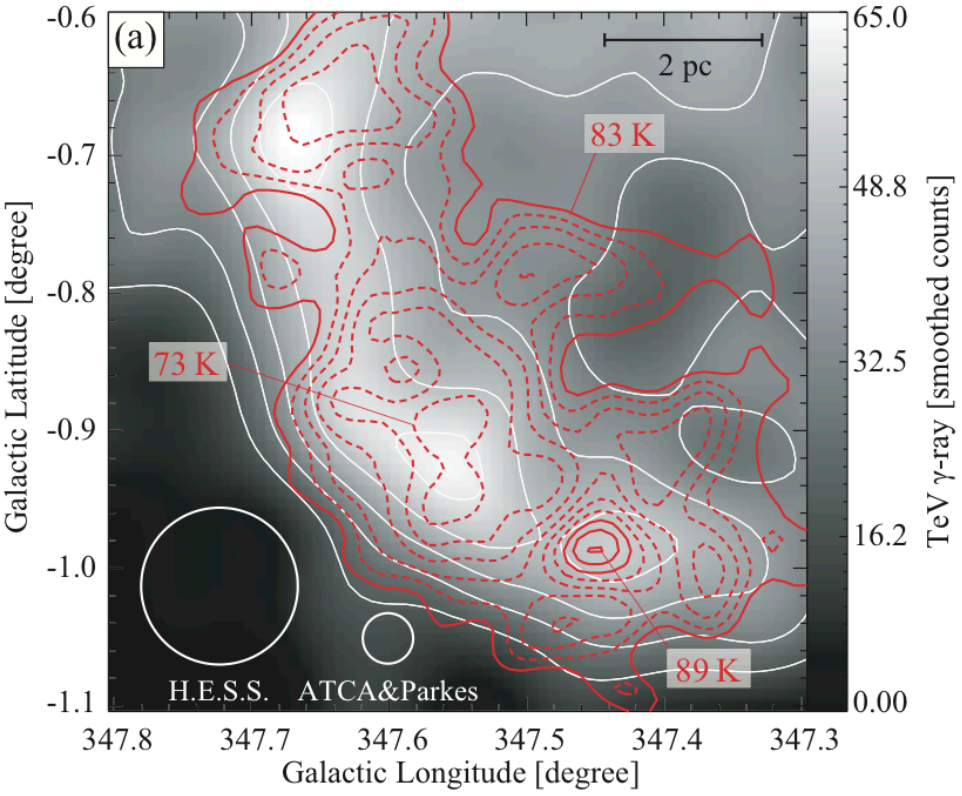


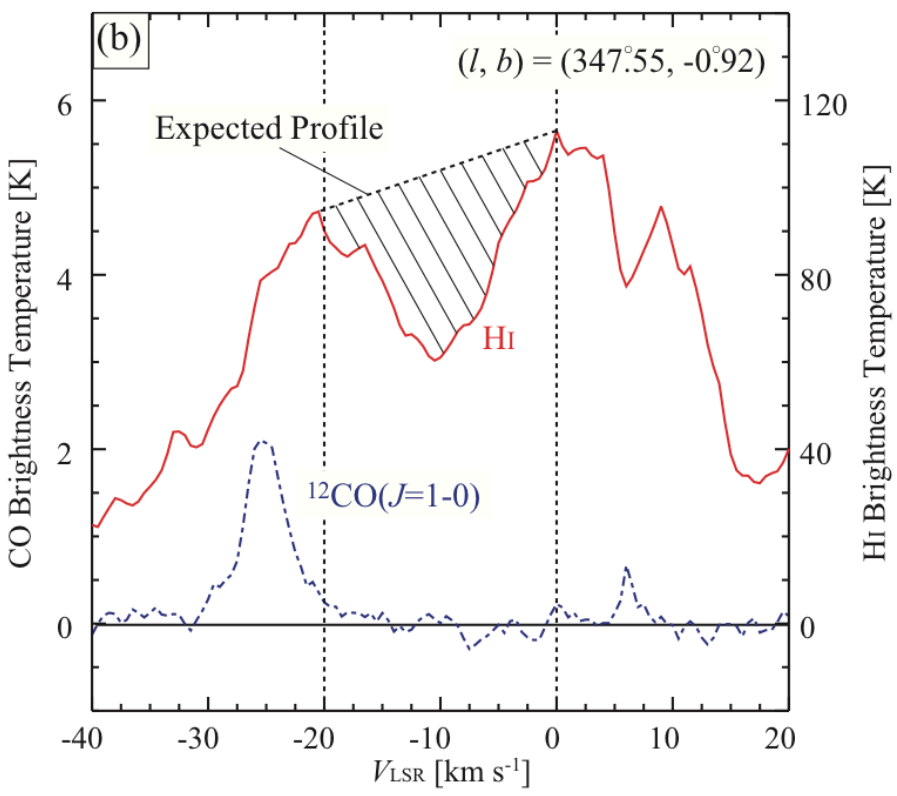
TeV γ−ray SNR RX J1713.7-3946



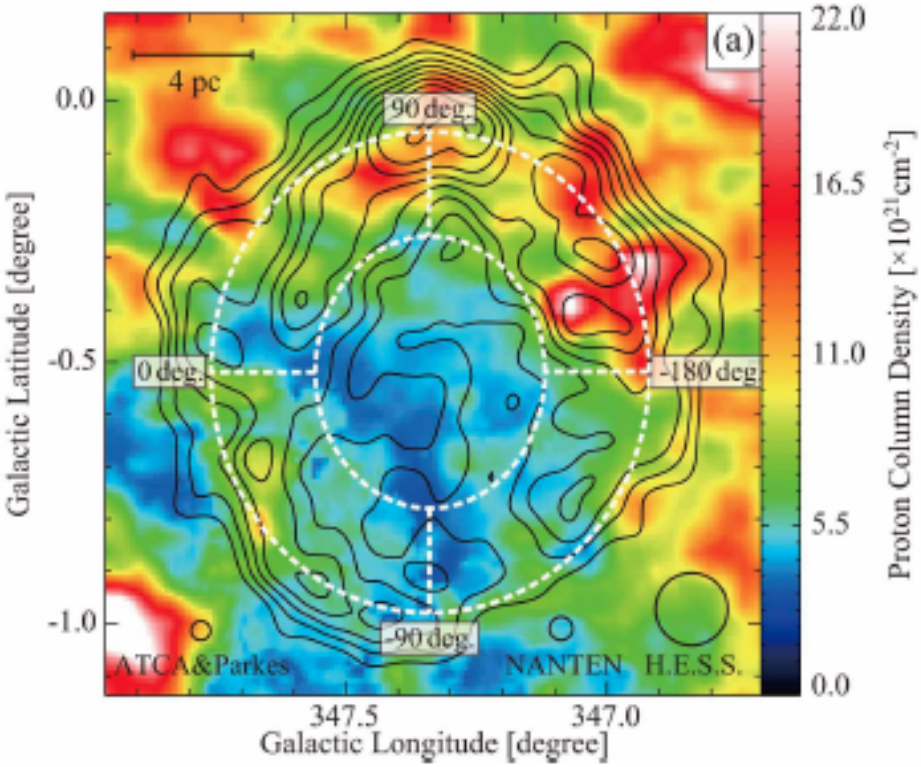
Fukui et al. 2012, ApJ, 746, 82

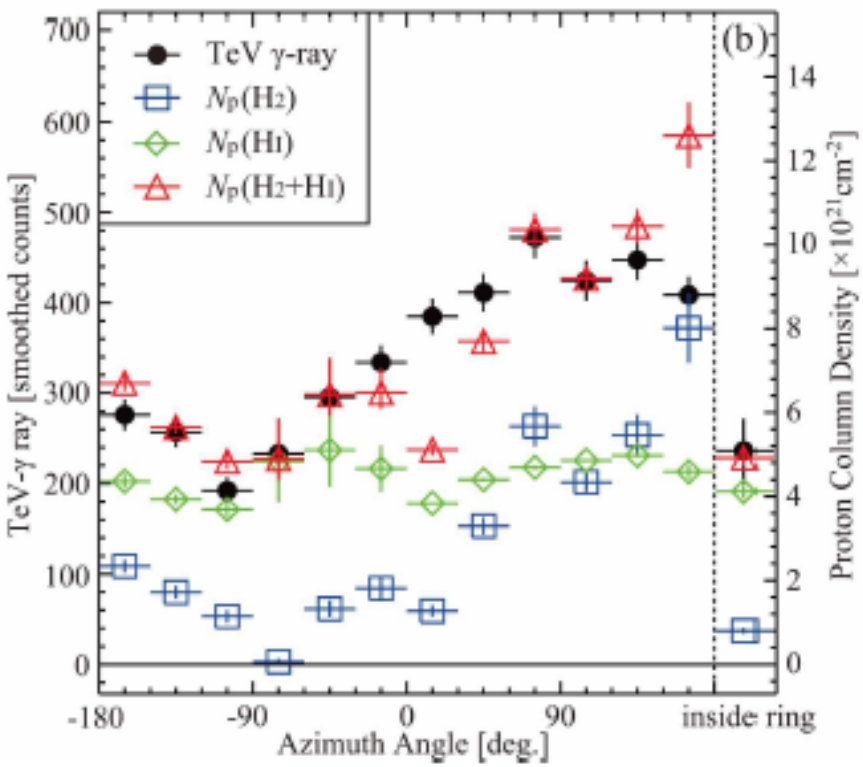
Dark HI SE Cloud (Self-Absorption)





ISM protons in RX J1713.7-3946

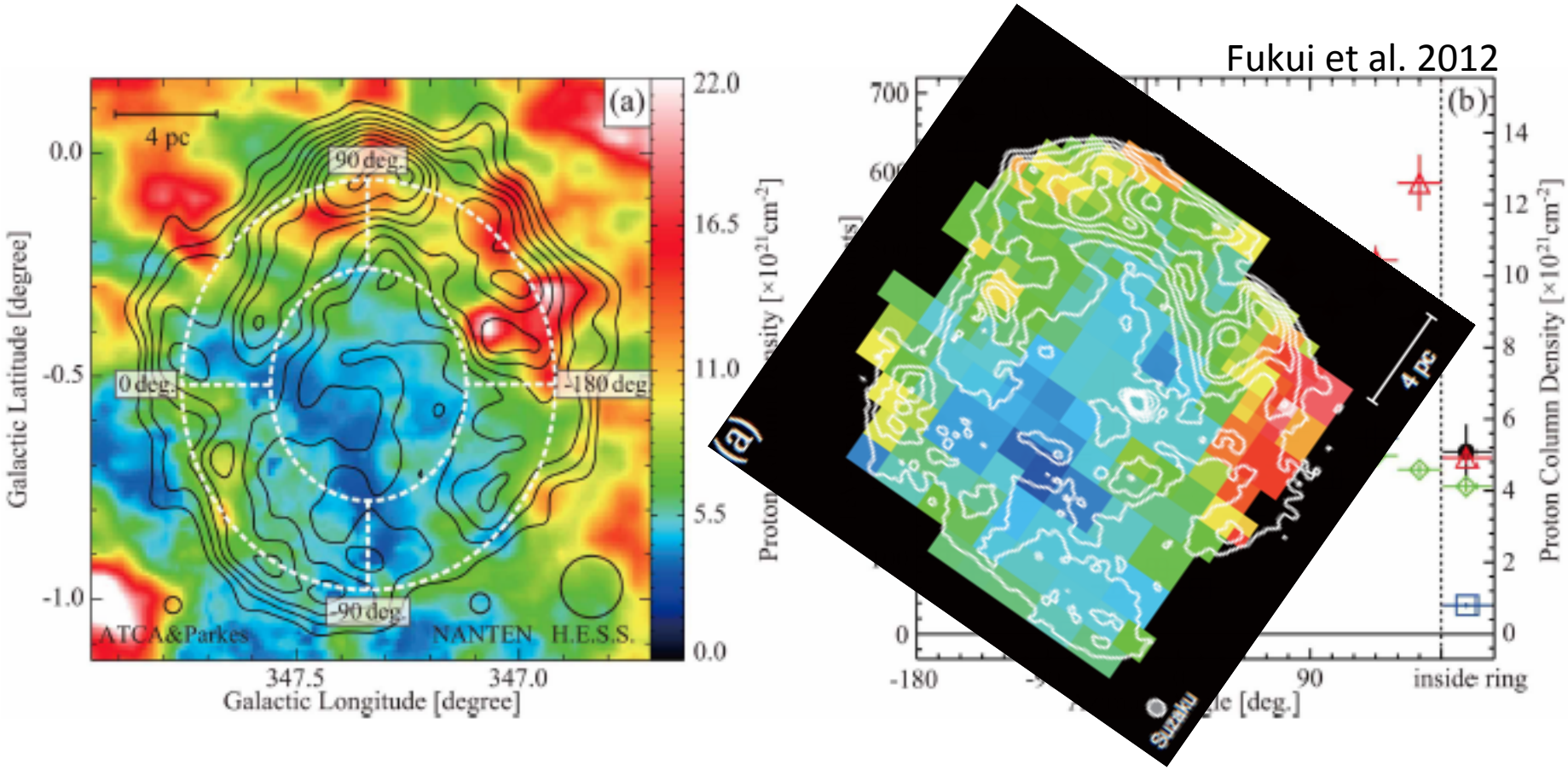




HI + 2H2

Fukui et al. 2012

Fukui et al. 2012



Posters

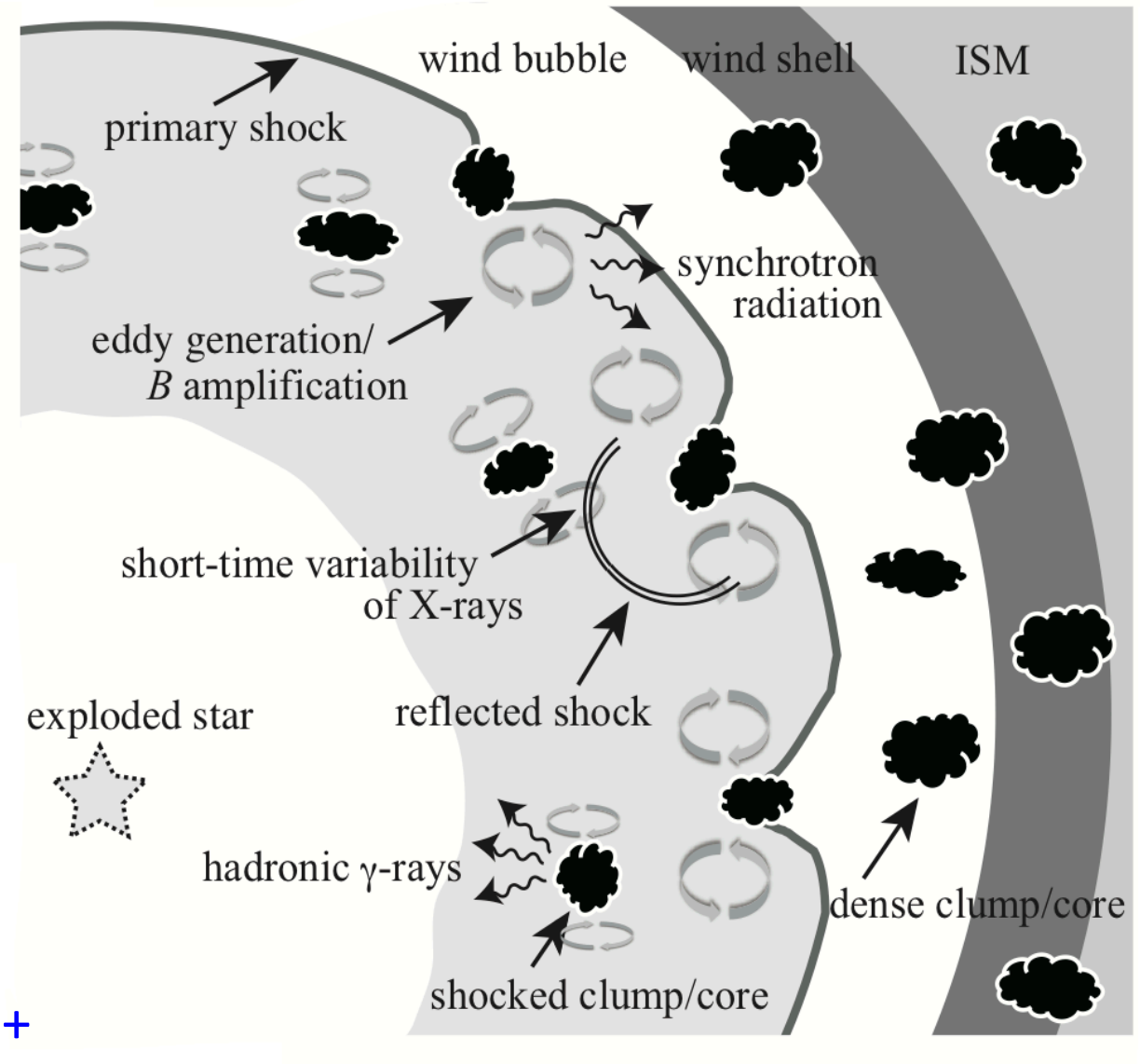
P5-11 Fukui+

P5-12 Sano+

Suzaku

X ray absorption column density

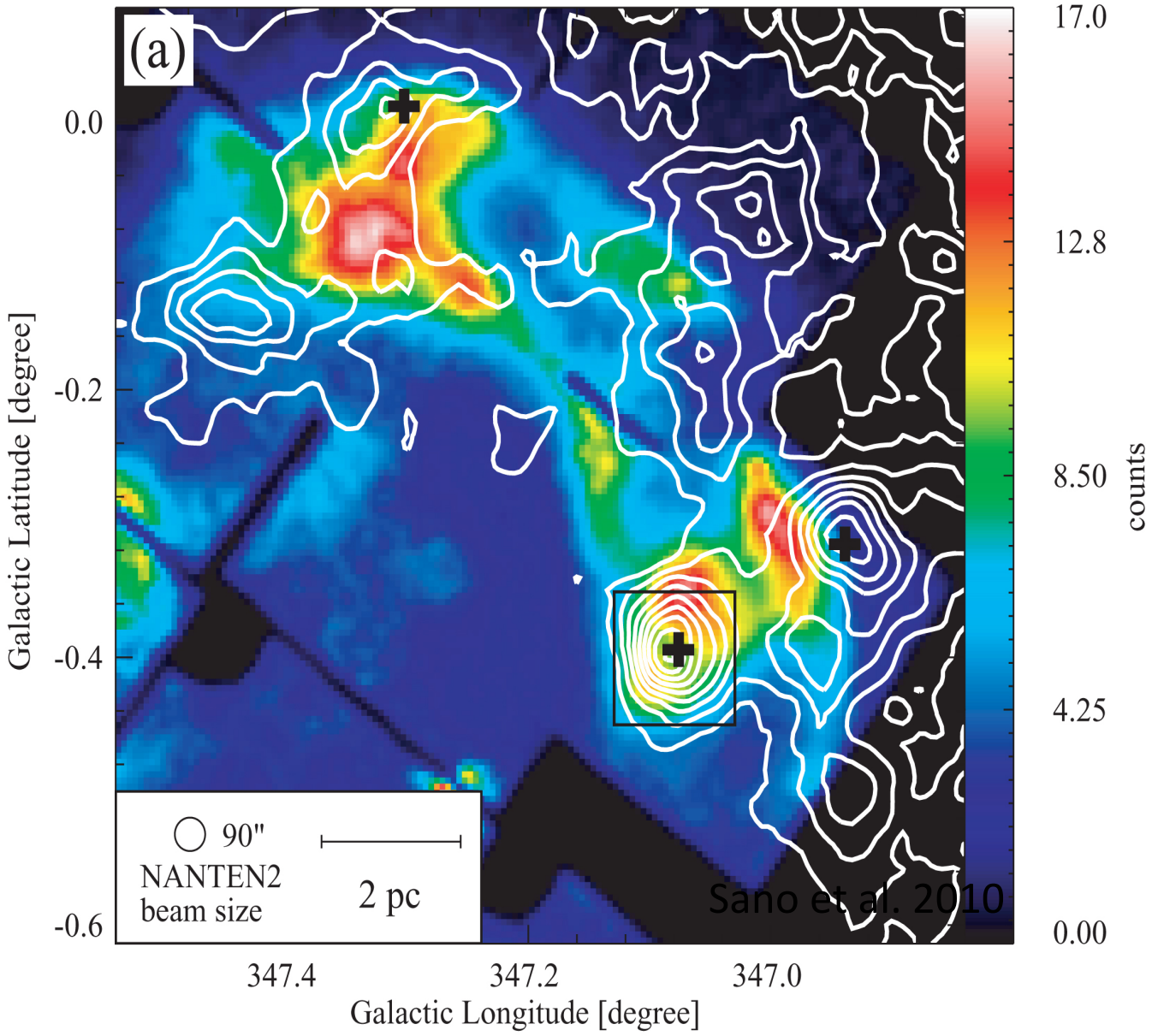
Sano+ 2012



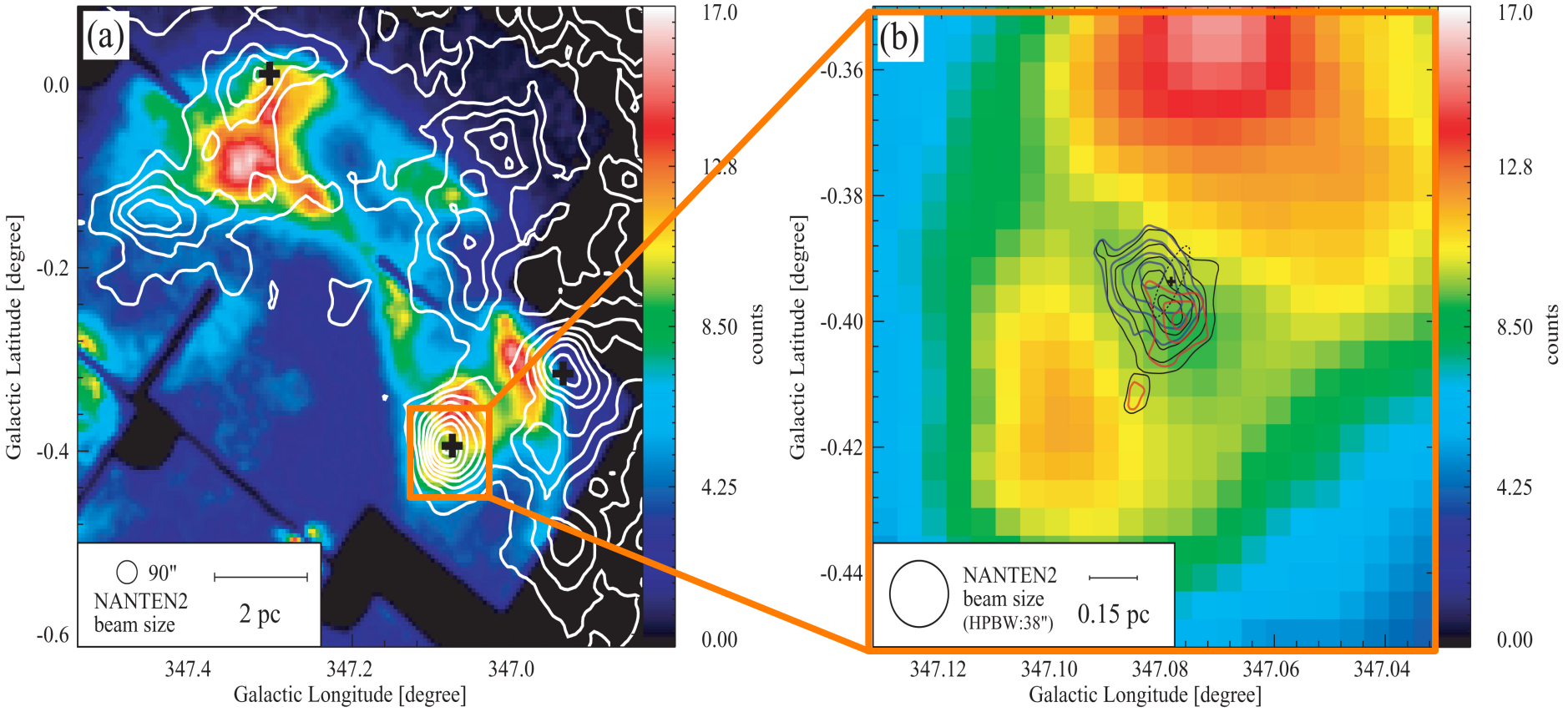
Poster
P5-2
Yamazaki+

Inoue, Yamazaki, Inutsuka, Fukui 2012, ApJ, 744, 71

Shock propagation into dense gas



Shock propagation into dense gas



n : density of clump

n_0 : ambient density (=1 cm^{-3})

$$V_{\rm sh} \sim 3000 \ {\rm km\ s^{-1}} \Big/ \sqrt{n/n_0}$$

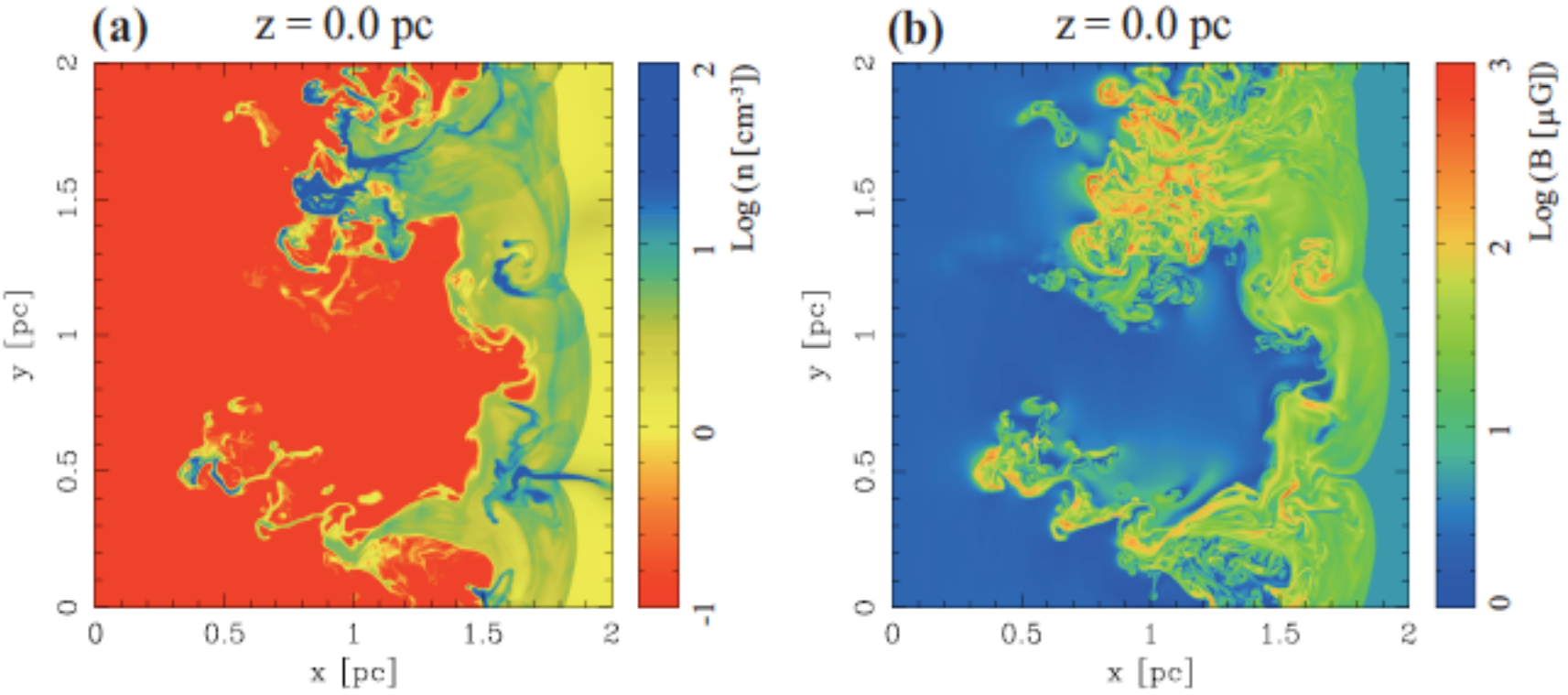
10^4 cm^{-3}, t~1000yrs

Penetrating Depth = 0.03 pc

Sano et al. 2010

MHD simulation of shock-cloud interaction

density vs. magnetic field



Inoue, Yamazaki, Inutsuka, Fukui 2012, ApJ, 744, 71

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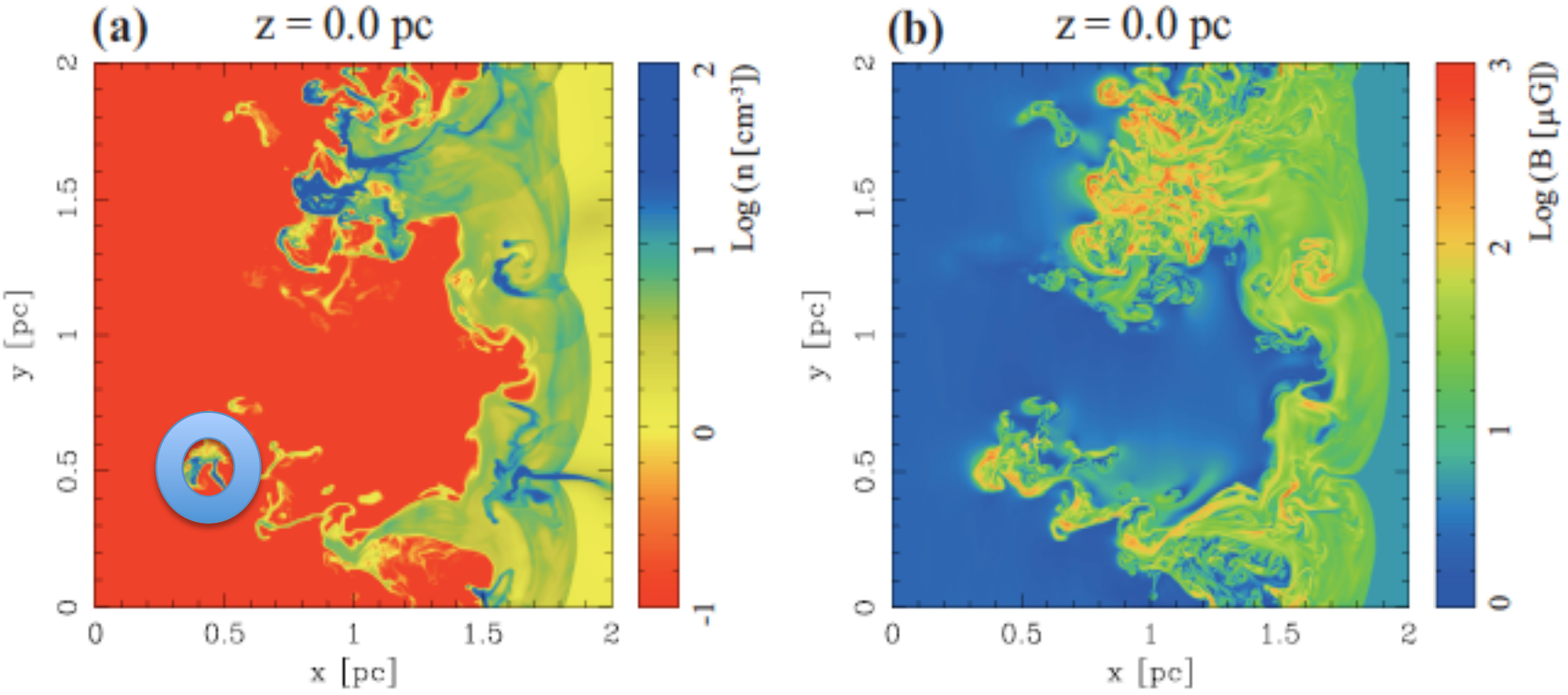
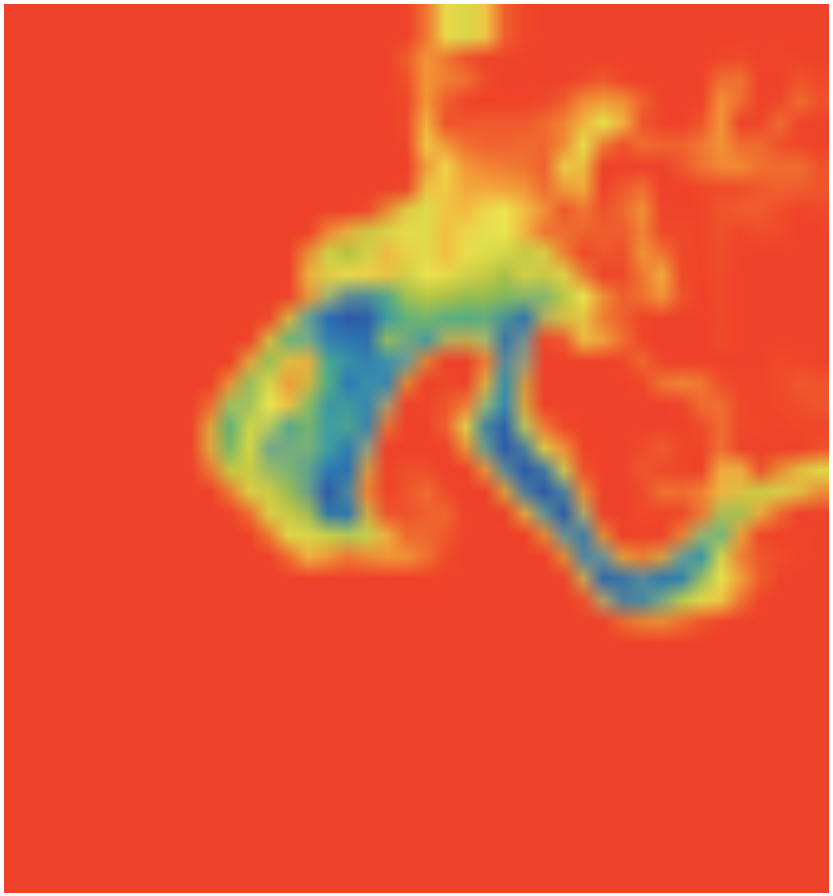
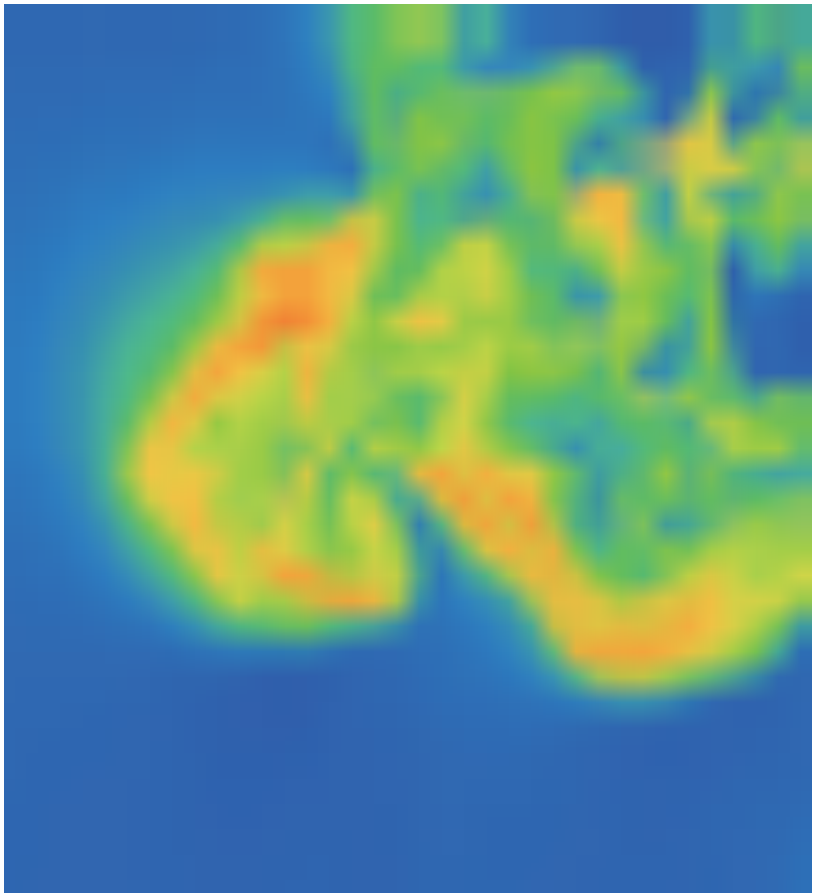


Inoue, Yamazaki, Inutsuka, Fukui 2012, ApJ, 744, 71

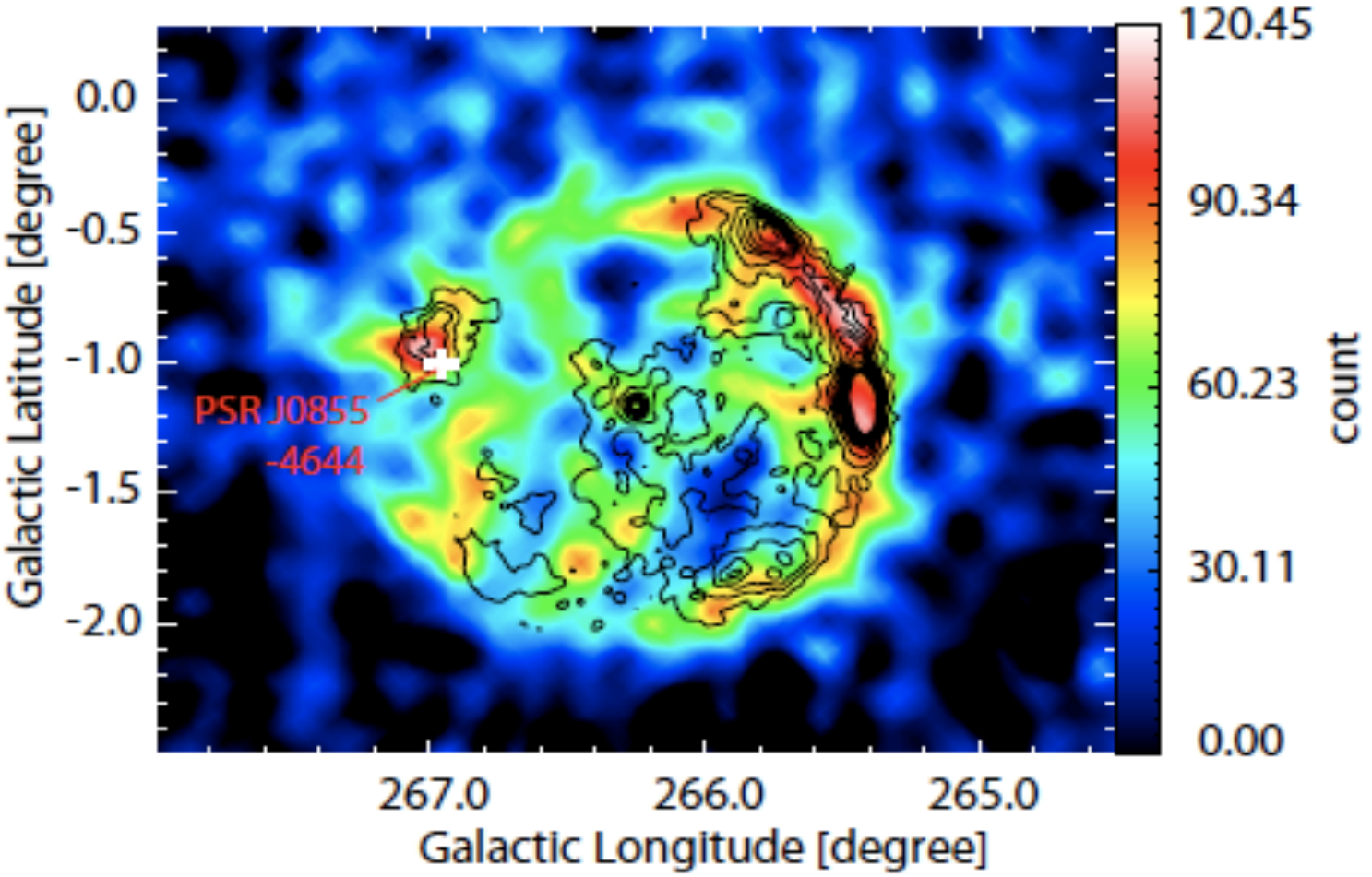
density vs. magnetic field [sub-pc scale]





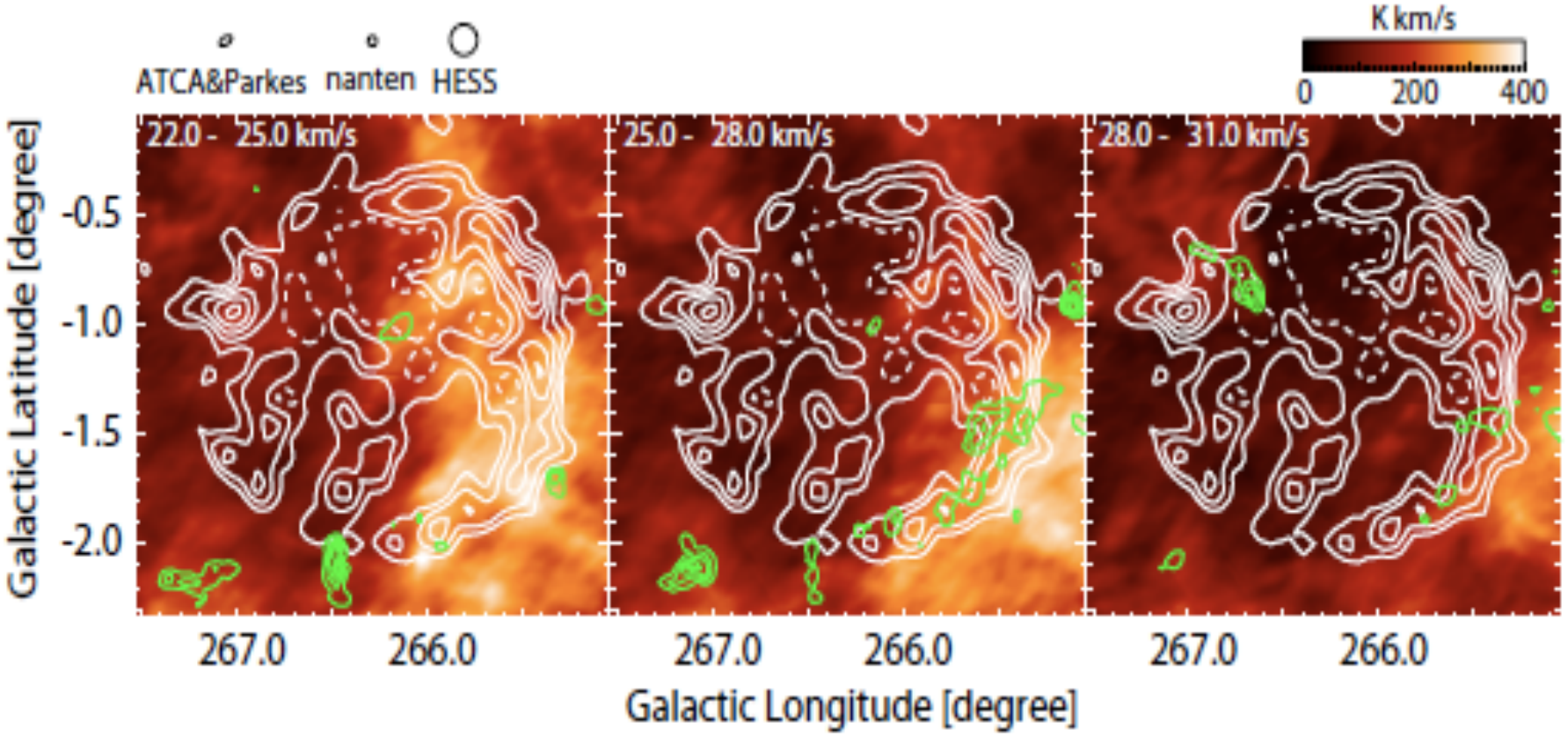
Inoue, Yamazaki, Inutsuka, Fukui 2012, ApJ, 744, 71

TeV γ-ray SNR RX J0852.0-4622



Color TeV γ ray contour X ray

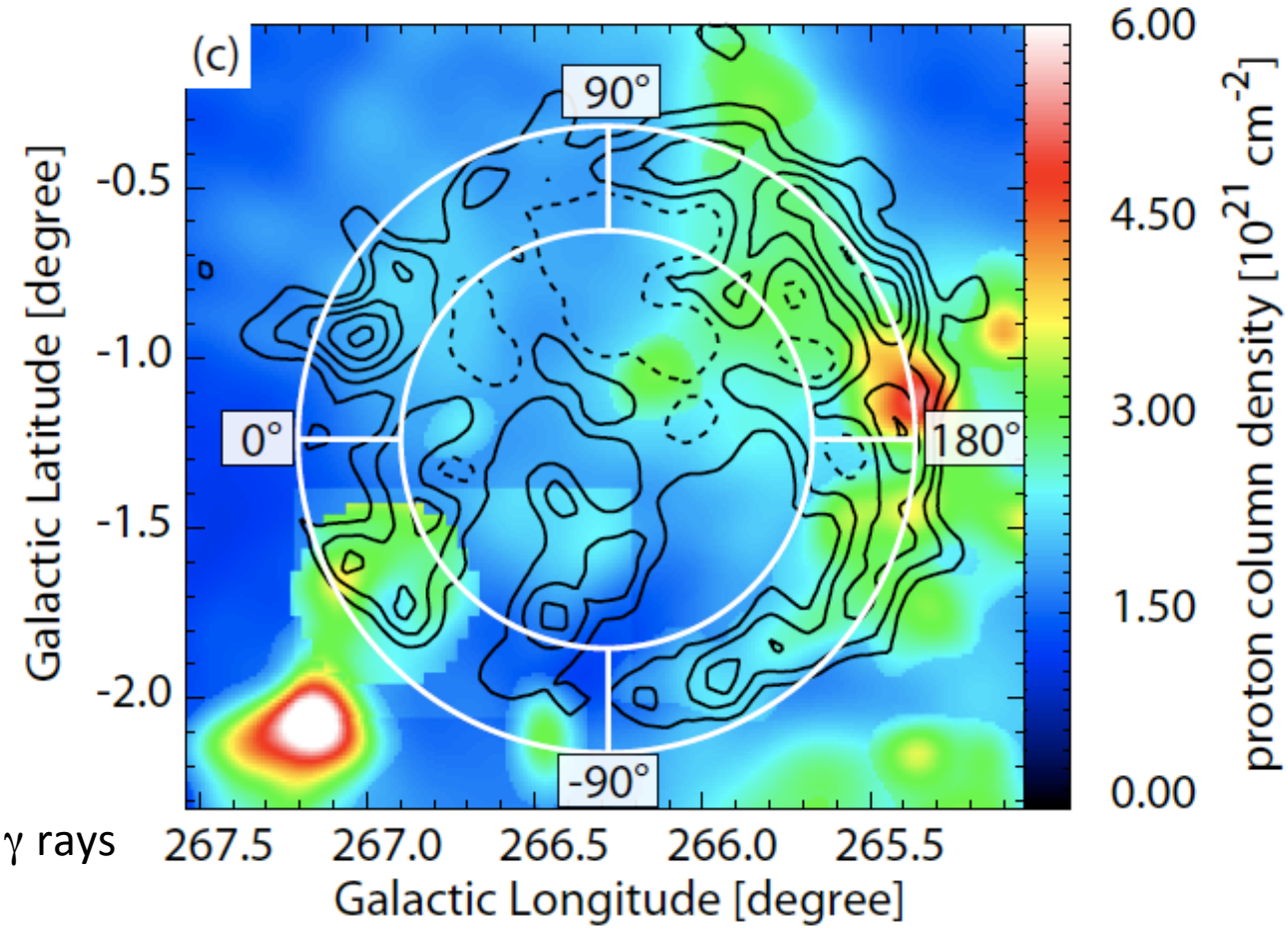
HI and CO in RX J0852.0-4622



Green CO Orange HI

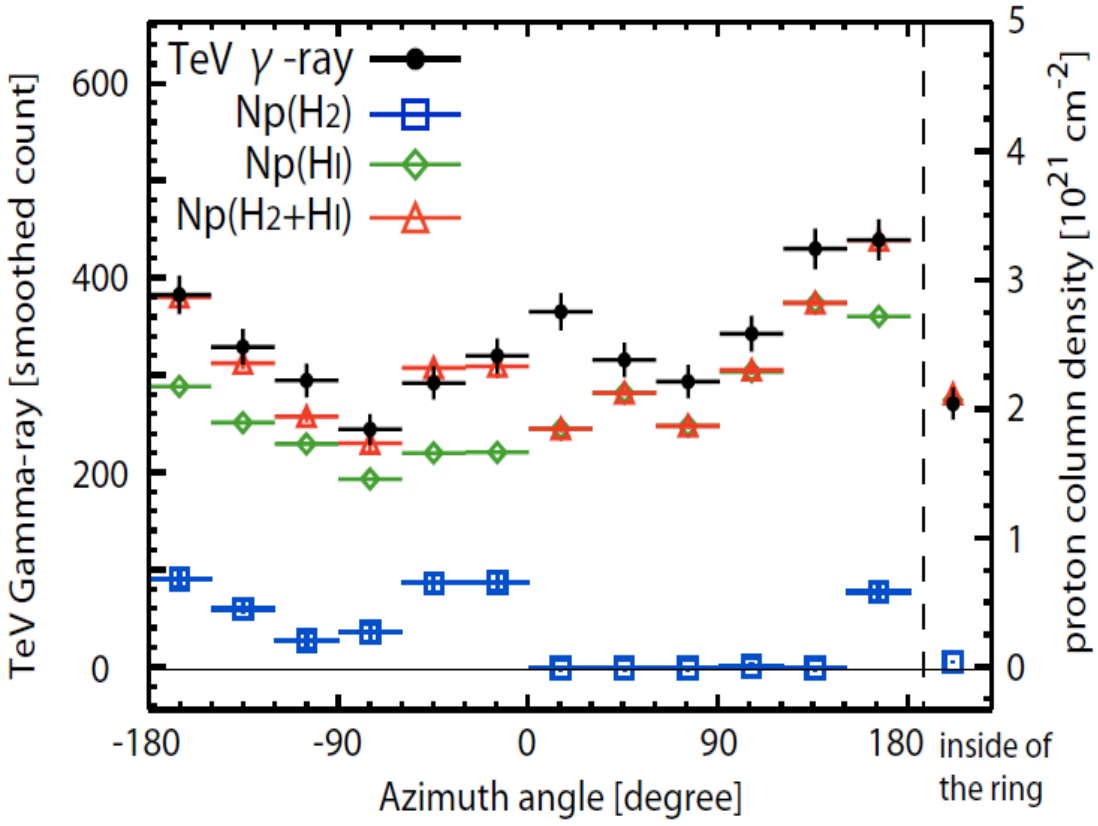
TeV γ-ray SNR RX J0852.0-4622
ISM Proton Column Density Distributions

Fukui et al. 2012, in prep.



Color: HI+2H_2
Contour : TeV γ rays

TeV γ-ray SNR RX J0852.0-4622
ISM Proton and TeV γ-ray Distributions



γ rays
ISM protons
good correspondence

ISM protons
as targets for cosmic ray protons

RXJ0852.0-4622
Fermi LAT

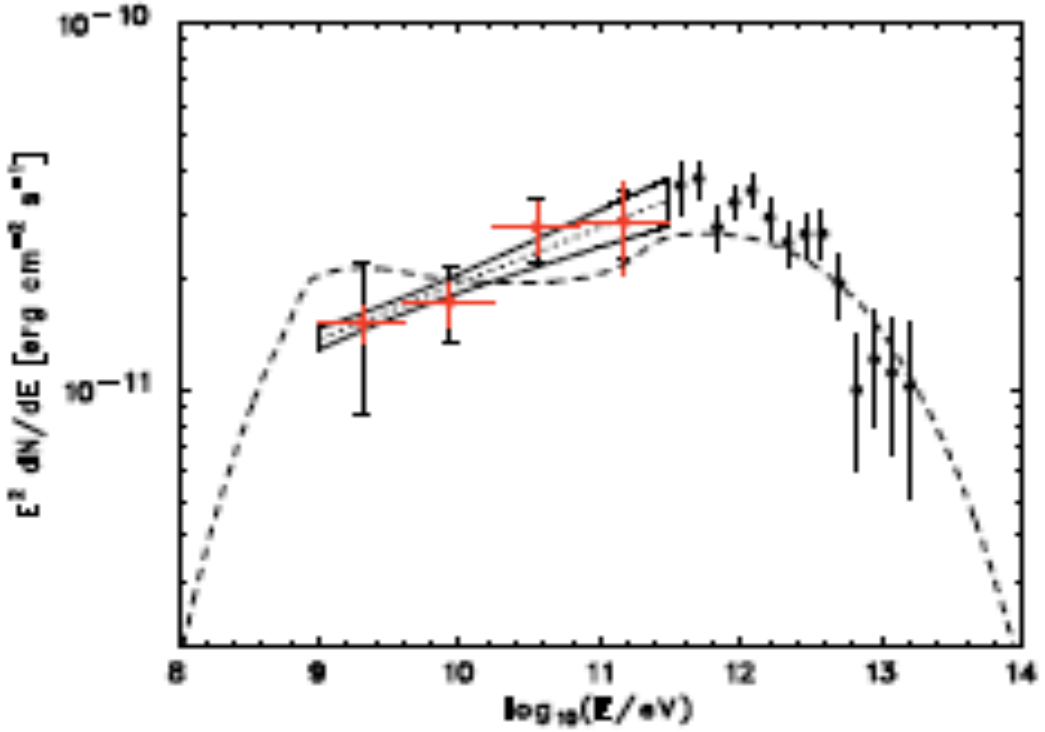
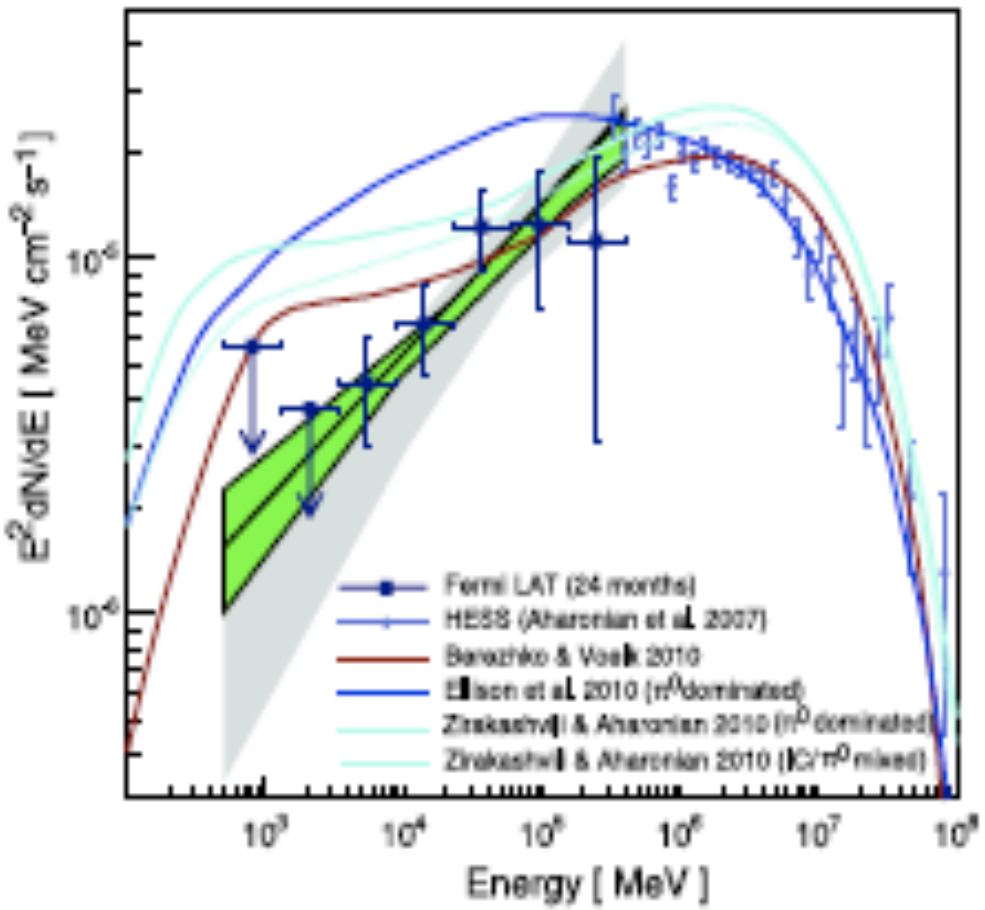


Figure 2. *Fermi* LAT spectral energy distribution (SED) in 1–300 GeV with the H.E.S.S. SED by Aharonian et al. (2007b) plotted together. For the *Fermi* LAT points, the vertical red lines and the black caps represent statistical and systematic errors, respectively. The dotted line indicates the best-fit power law obtained from the maximum likelihood fit for the entire 1–300 GeV band. The butterfly shape shows the 68% confidence region. The dashed curve is the π^0-decay spectrum by Berezhko et al. (2009).

γ-ray spectrum of RXJ1713.7-3946

Abdo et al. 2011



The hard spectrum is not unique to the leptonic scenario

The hard spectrum is explained by energy dependent penetration of CR protons into dense molecular gas.

ISM/γ-ray comparison

- RXJ1713.7-3946

  -Dense molecular rich/clumpy

  $M(H_2)=10^4 Mo$, $M(HI)=10^4 Mo$

  -Hard γ-ray spectrum

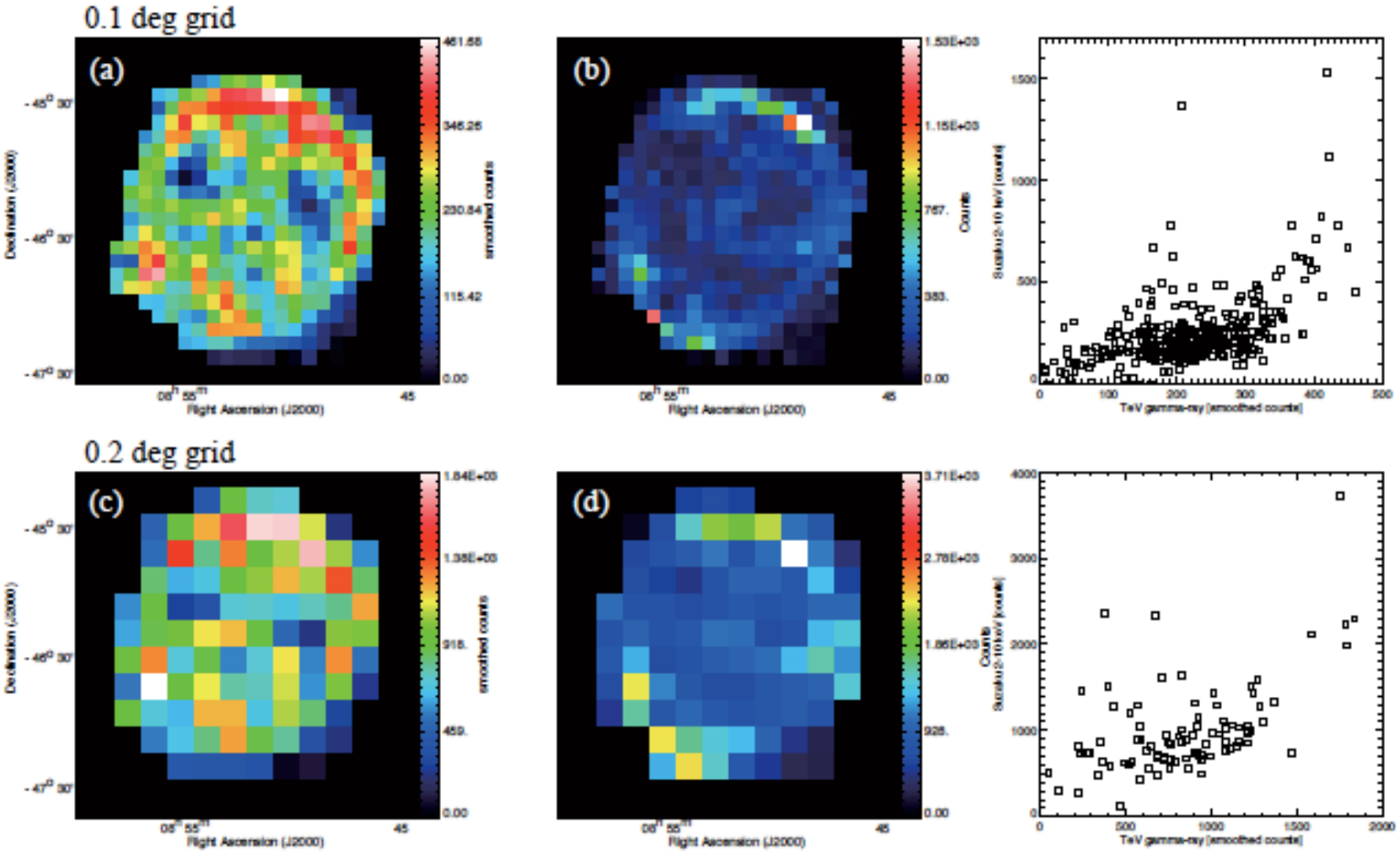
- RXJ0852.0-4622

  -Diffuse atomic rich/uniform

  $M(H_2)=10^3 Mo$, $M(HI)=10^4 Mo$

  -Soft γ-ray spectrum

RX J0852.0-4622 TeV gamma-rays vs. X-rays



(a) and (c): TeV gamma-rays, (b) and (d) X-rays (2-10 keV)

Origin of γ−rays in RX J1713 and RX J0852

- Hadronic or leptonic?
  - ISM protons vs. γ−rays
    show good spatial correspondence
  - γ−rays vs. X rays;
    correspondence breaks at higher resolution
  - conclusion: Hadronic
- Future prospects
  - Higher angular resolution by CTA, ALMA…

The origin of cosmic ray protons in TeV γ-ray SNRs

Hadronic vs. leptonic (electron's inverse Compton etc.)
Hadronic $p + p \Rightarrow \pi^0 \Rightarrow 2\gamma$ promising

Two young TeV γ SNRs, 1600-2000yrs:
RXJ1713.7-3946, brightest HESS source
RXJ0852.0-4622 [Vela Jr.]

If hadronic, target ISM protons corresponds to γ rays.
If leptonic, non-thermal X rays corresponds to γ rays.

Collaborators
- HESS team: F. Aharonian, G. Rowell +
- HI: N. McClure-Griffiths +
- MHD: T. Inoue, S. Inutsuka +