Discovery of a non-thermal X-ray shell coincident with the γ-ray source HESS J1731–347

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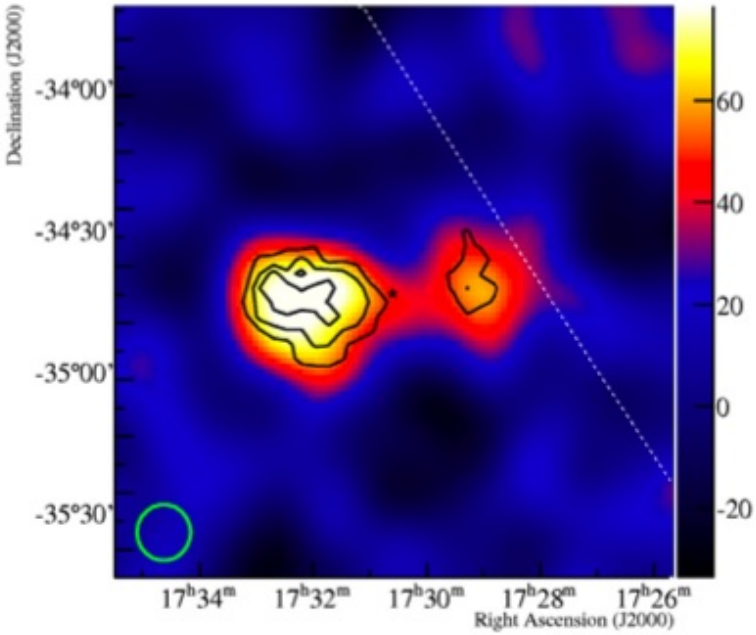
SNRs and PWNe in the Chandra Era
Boston, July 9, 2009

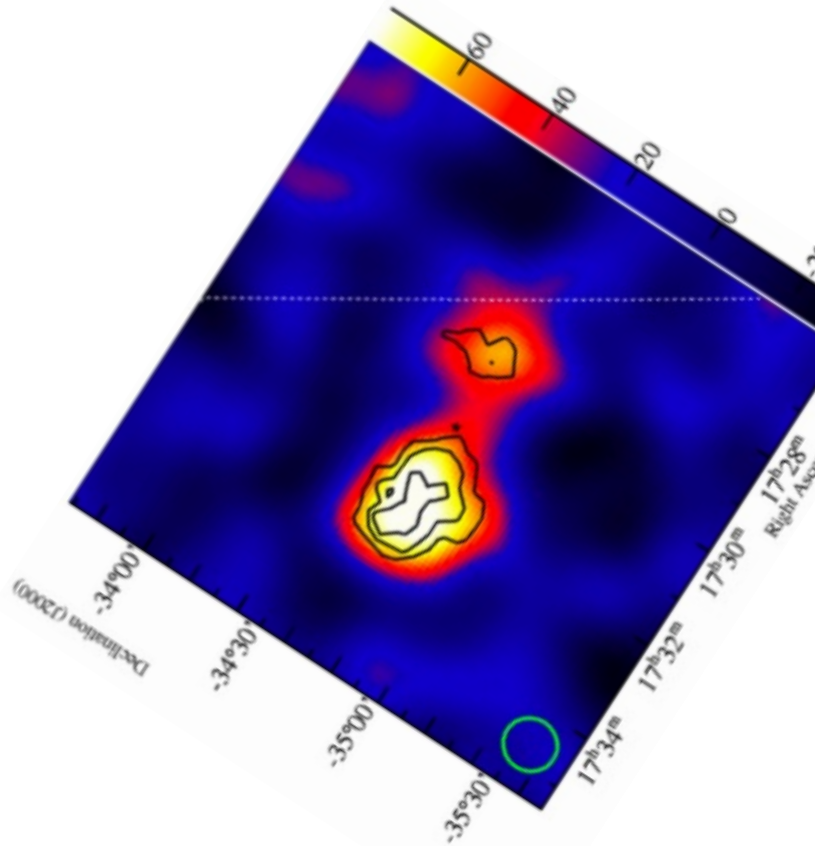
see also : Acero et al. 2009, to appear in proceedings of the ICRC (arXiv:0907.0642)

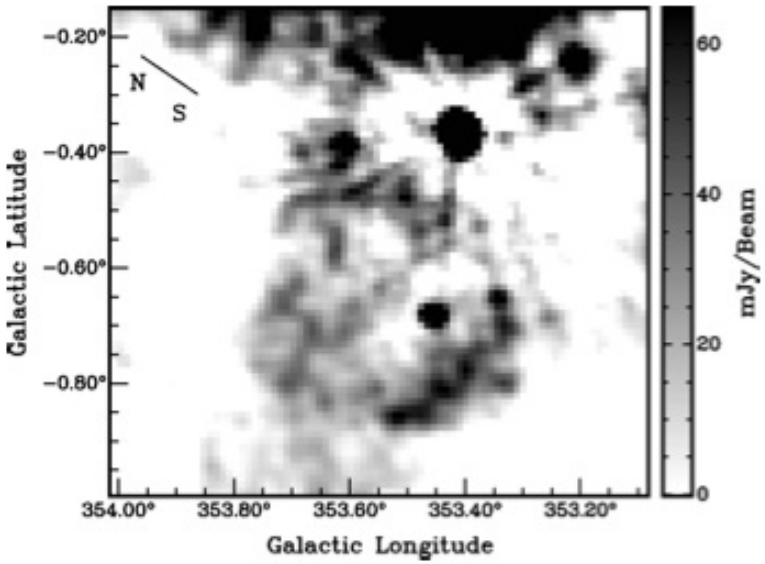
HESS J1731–347



- discovered in TeV γ-rays in the ongoing H.E.S.S. survey of the Galactic plane
- no identified counterpart (Aharonian et al. 2008)

HESS J1731–347 and SNR G 353.6–0.7

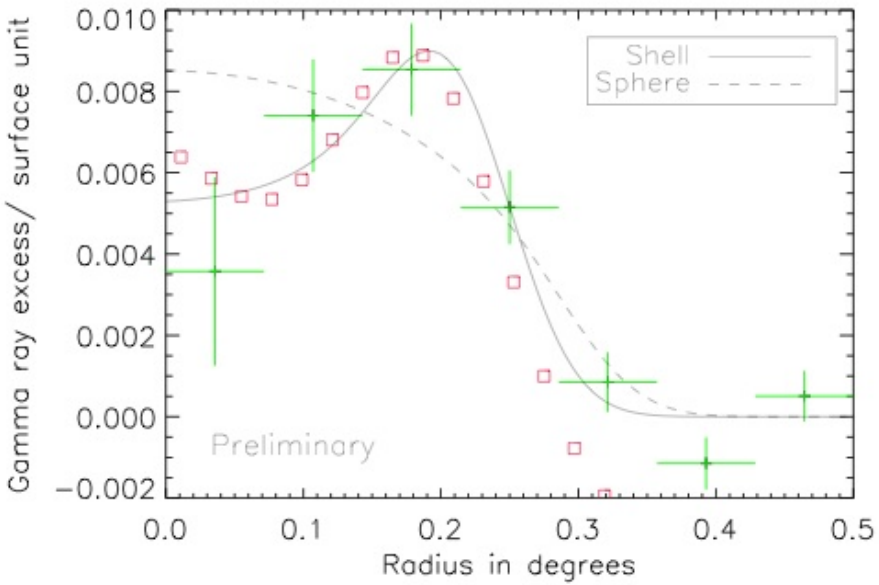




- discovered in TeV γ-rays in the ongoing H.E.S.S. survey of the Galactic plane
- no identified counterpart (Aharonian et al. 2008)
- coincident with a radio shell discovered with ATCA data: G 353.6–0.7 (Tian et al. 2008)

Further H.E.S.S. Observations in 2008

arXiv:0907.0642



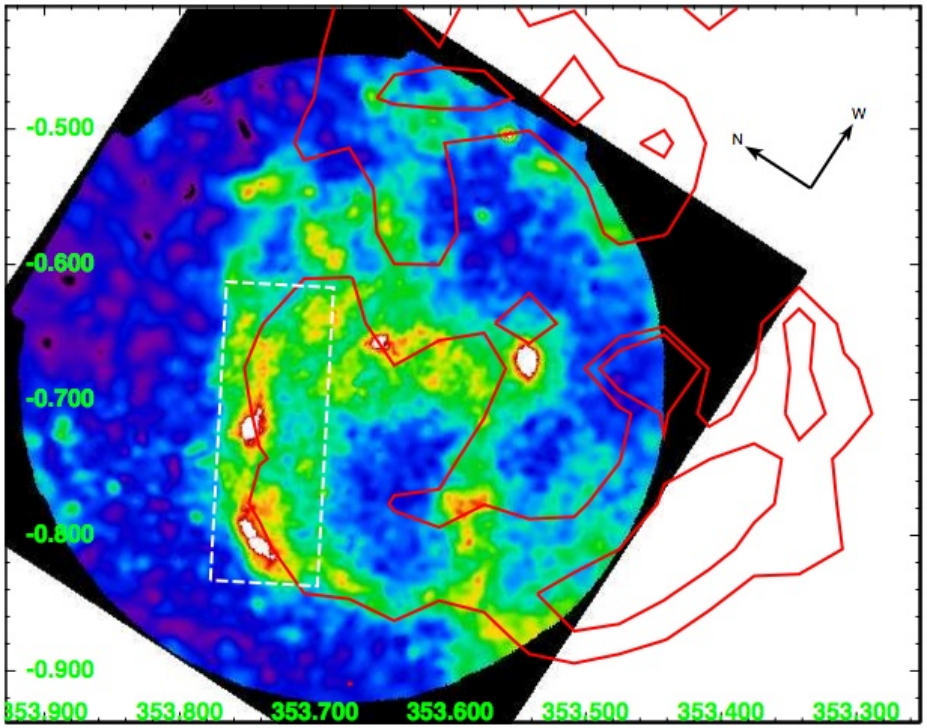
- suggestion of limb-brightened morphology, but limited ($\sim 2\sigma$) statistical significance (more H.E.S.S. observations in 2009)

A New SNR with TeV Shell-Type Morphology?

- would join the class of G 347.3–0.5, G 266.2–1.2 (Vela Jr), SN 1006 and (probably) RCW 86
- these shells all show prominently non-thermal X-ray emission

X-ray Observations

XMM MOS, 0.5-4.5 keV



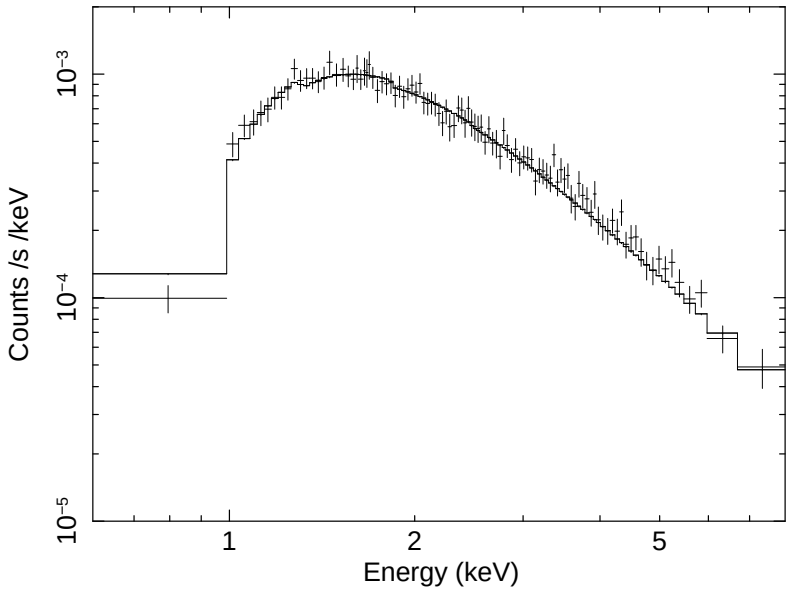
- *Suzaku* : 20 ks
- *XMM-Newton* : 23 ks
- *Chandra* : 30 ks

- FOVs only covering (NE) part of shell

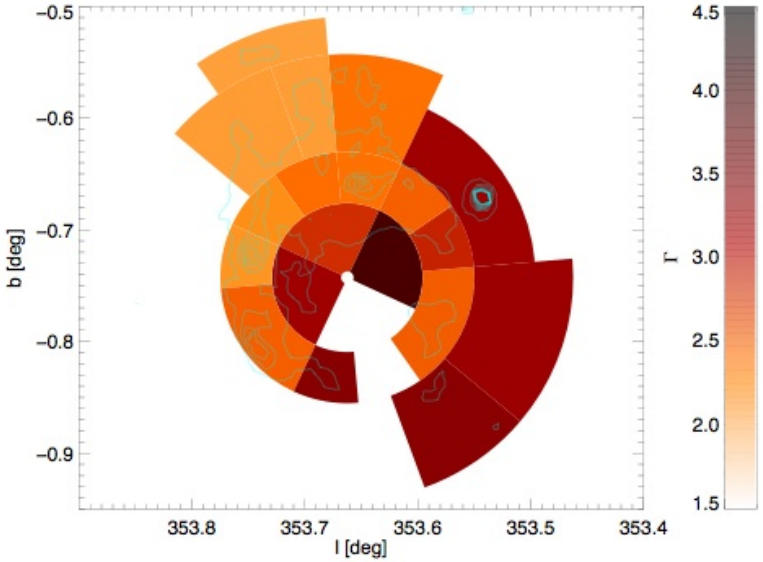
- rims or filaments of emission seen within radio shell
- nature of apparent "inner ring"?
  - different, overlapping SNR? Unlikely if similar spectrum
  - inhomogeneities of expansion into surrounding medium?

Non-Thermal Emission

XMM MOS2 : bright rim



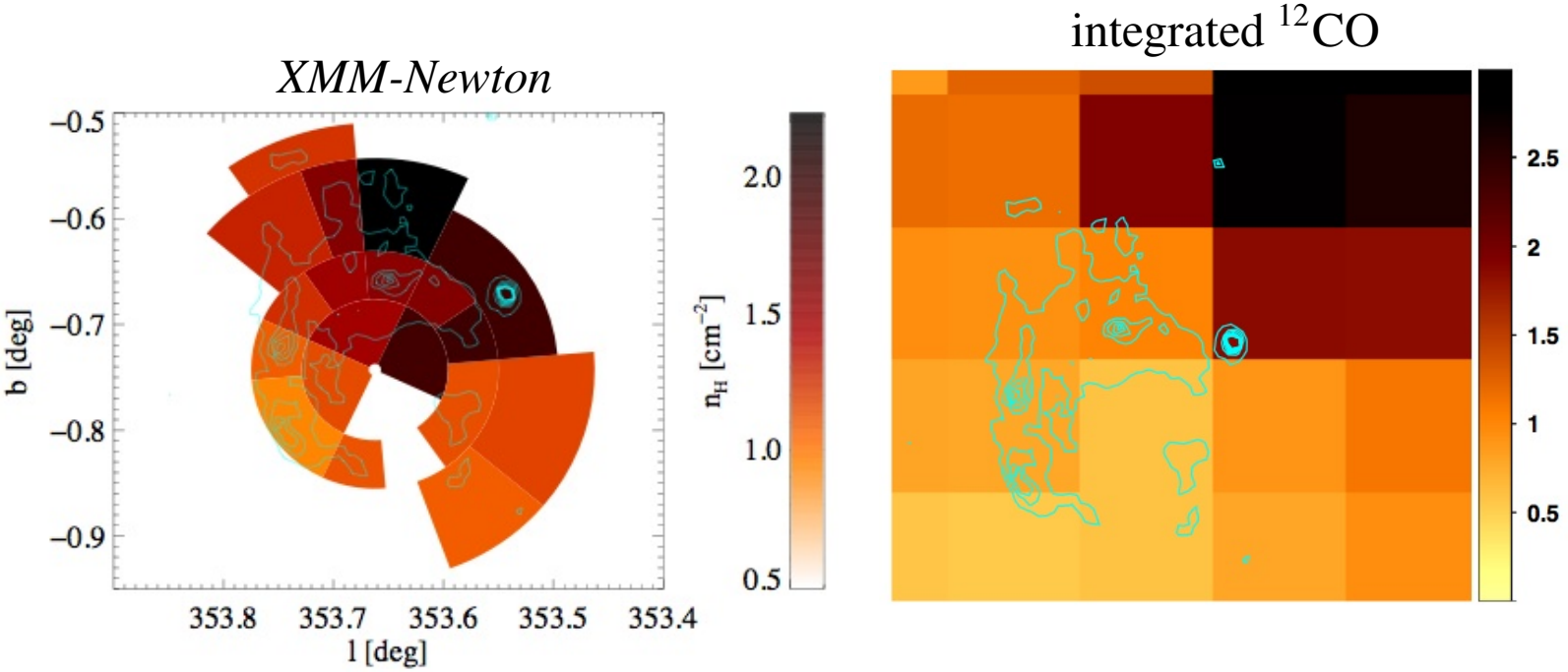
- all filaments well fit by absorbed power-law
- no evidence for thermal (line) emission



XMM (preliminary)

- evidence for spectral index variations
- $\Gamma = 2.1 - 2.5$ in bright parts, fainter regions appear steeper

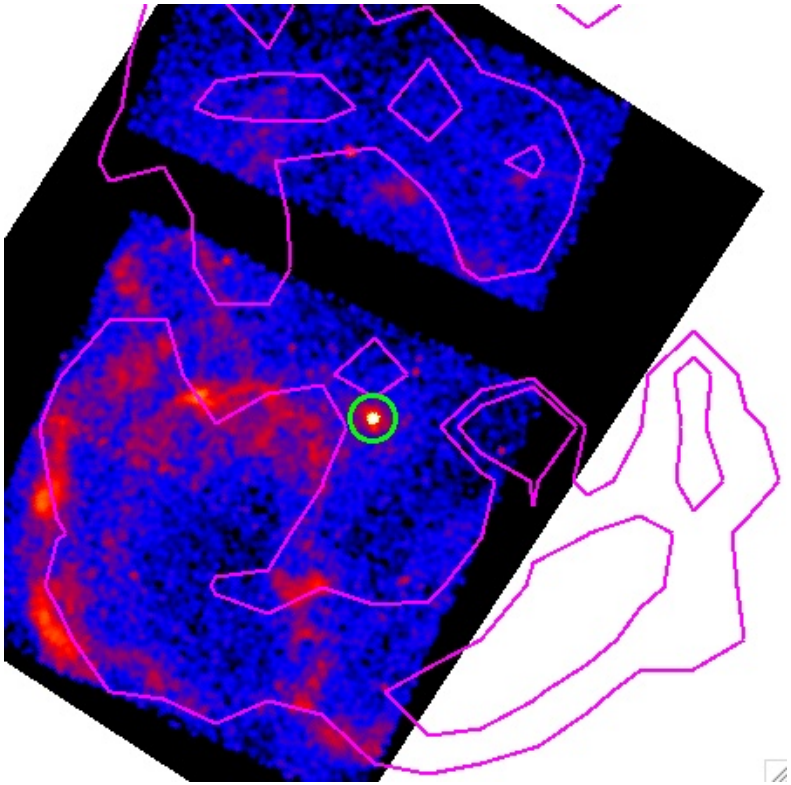
Absorption Column, CO and Distance



- strong gradient in fitted N_H across object $\Rightarrow$ intervening cloud?
- cloud with appropriate morphology and column density found around $v_{LSR} = -17$ km/s in CfA CO survey data
- lower limit on distance : **3.5 kpc** $\Rightarrow$ $R_{SNR} \geq 15$ pc
- assuming Sedov phase, remnant age $\geq 5\,\mathrm{kyr}\left(\frac{n_{ISM}}{0.1\,\mathrm{cm}^{-3}}\right)^{1/2}$

A Central Compact Object in G 353.6–0.7

Chandra, 1.3–5 keV



- well fit by an absorbed blackbody ($kT \approx 0.5$ keV)
- $N_H \sim 1.4 \times 10^{22}$ cm^{-2}, compatible with (local) shell
- no evidence for surrounding nebula, e.g. with *Chandra*
- consistent with steady flux in *XMM*, (piled-up) *Chandra* and *Suzaku* observations
- no evidence for pulsations (*XMM* pn : $\Delta t = 73$ ms)

- close to geometrical center of radio shell, compatible N_H
- $\Rightarrow$ discovery of a likely CCO associated with G 353.6–0.7

- upper limit on distance if emission from whole surface: 15 kpc

Summary and Outlook

Summary

- HESS J1731–347 matches position and extension of radio shell SNR G 353.5–0.7; suggestion of limb-brightening in γ-rays
- X-ray observations of reveal purely non-thermal filaments of emission in observed part of the shell, and CCO at shell center
- would join class of TeV-emitting SNRs with non-thermal X-ray shells: G 347.3–0.5, Vela Jr, SN 1006, RCW 86, Cas A, ...

Outlook

- additional X-ray pointings needed to study whole of radio shell (nature of asymmetry, possible overlapping SNR?)
- X-ray/radio studies of TeV sources can reveal **new** (pulsar wind nebulae and) **non-thermal shells**: strong Galactic accelerators