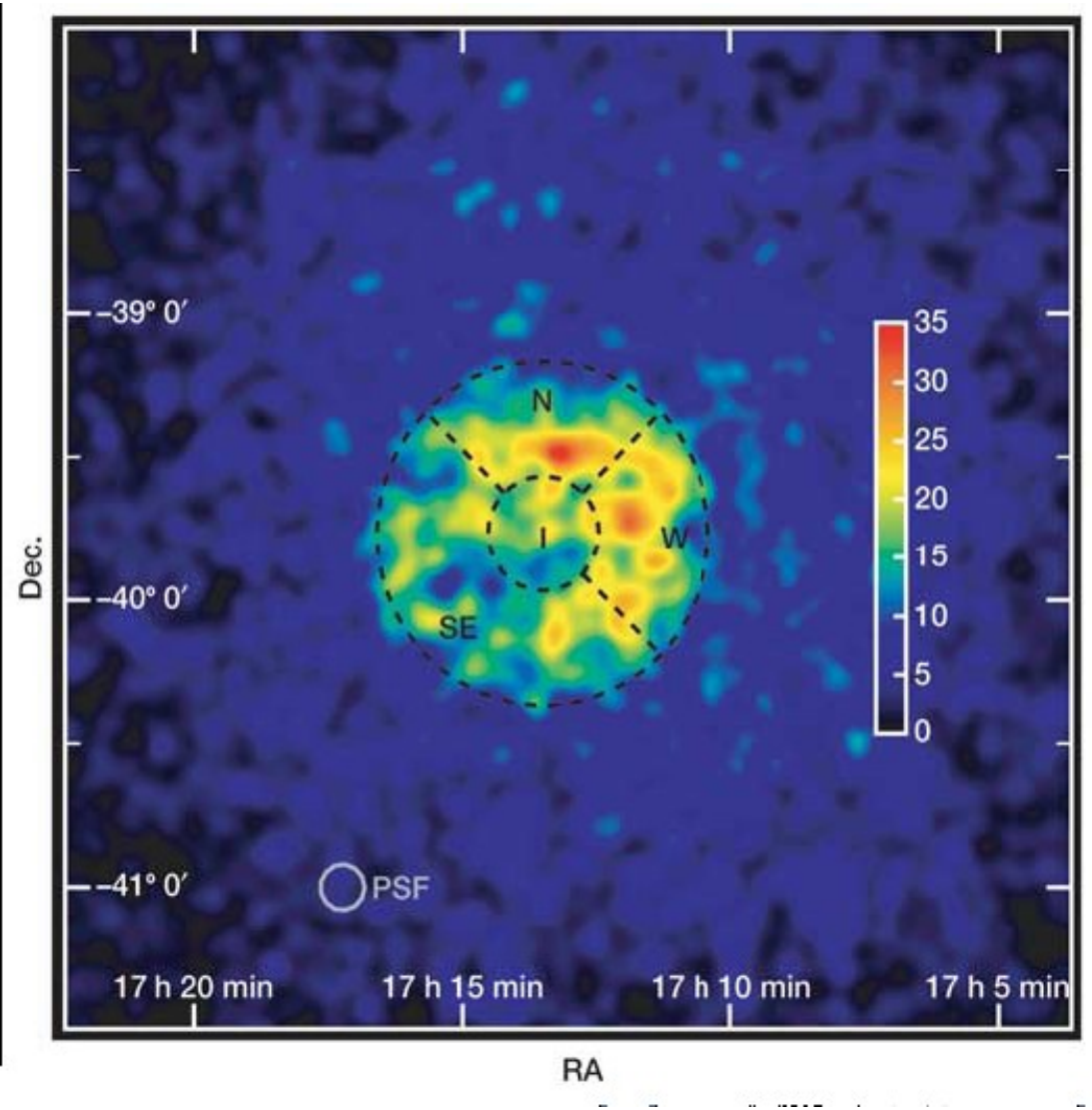
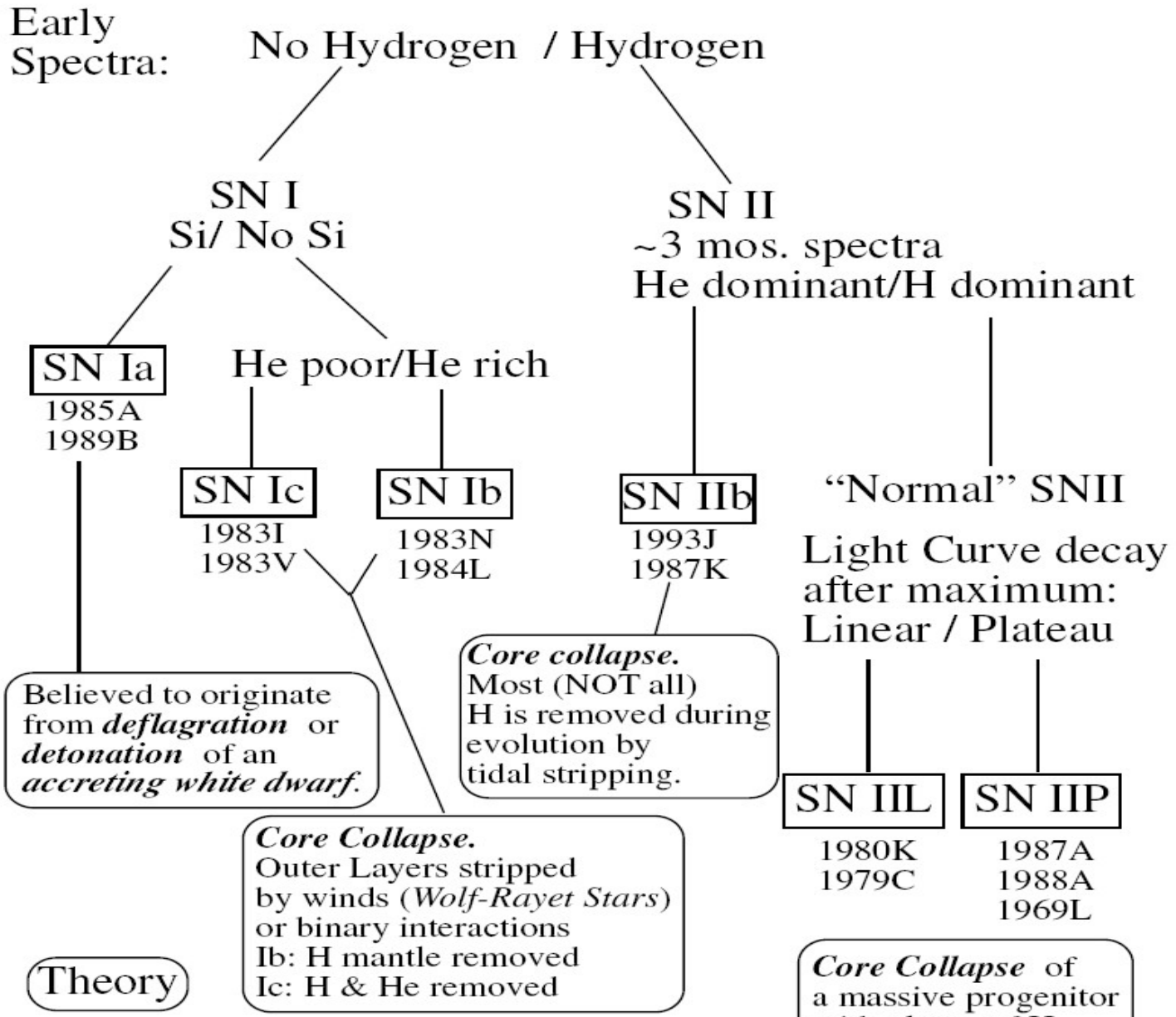
The SNR RX J1713-3946

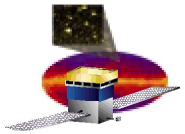


- **HESS *preliminary* observation of this SNR proves imaging capabilities in TeV range**
- **EGRET saw a signal in this direction (more later)**
- **Extensive literature on this SNR, with the central question:**

  Can we prove this SNR accelerates nuclei (protons)?
- **Obviously, a very interesting target for GLAST!**
  - **Detecting π^0 photons?**
  - **Resolving the SNR in GeV?**

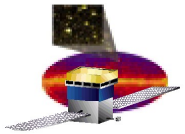
Classification of Supernovae





Types of Supernova Remnants

- **Shell-type remnants**:
  - Vast majority
  - shock wave ploughs through space, heats and stirs up ISM, producing a big shell of hot material in space.
  - Limb brightening => ring structure
- **Crab-like remnants**: also "plerions" (Crab like)
  - Like shell-type, but a pulsar blows out jets of very fast moving material. These remnants look more like a "blob" than a "ring."
- **Composite Remnants**:
  - shell-like, crab-like depending what part of spectrum
  - 2 kinds : thermal and plerionic.
    - Thermal : shell-type in the radio (synchrotron radiation). Crab-like in X-ray (but with spectral lines)
    - Plerionic : crab-like in both radio and X-ray, but with shells. No X-ray lines in shell but not in center
- **Fourth type? Mixed Morphology** (Rho & Petre 1998)
  - shell-type in radio, but the X-ray morphology centrally peaked.
  - X-ray emission from ISM, not the ejecta making up the SNR.
  - no prominent, central, compact source in radio or X-ray bands.



"Canonical" Evolution of SNR

- **Free Expansion :**
  - **Velocity very large with respect to ambient medium**
  - **Swipe up large fraction of the medium**
- **Sedov Phase :**
  - **Expansion driven by conversion of of internal energy into kinetic energy**
- **Radiative Phase :**
  - **Energy loss due to radiative cooling**
  - **Shock becomes isothermal**
  - **Shell moves with constant radial momentum**
- **Merging Phase :**
  - **Speed of expansion < speed of sound**
  - **SNR dissolves into ISM**

All this assumes isotropic, homogeneous, plus plenty other caveats...

What to expect for a shell type SNR?

- **Plasma (ISM or stellar wind) heated by the shock:**

  $E \sim NkT = M/m_p * kT$ with $E \sim 10^{51}$ ergs

  with $N \sim M/m_p$ and M~a few M_{sol}

  -> kT~10 keV X-ray

- **Ionized medium : emission lines (in X as well)**

- ***If diffusive shock acceleration correct* :**
  - **Synchrotron emission from accelerated electrons in the shell:**

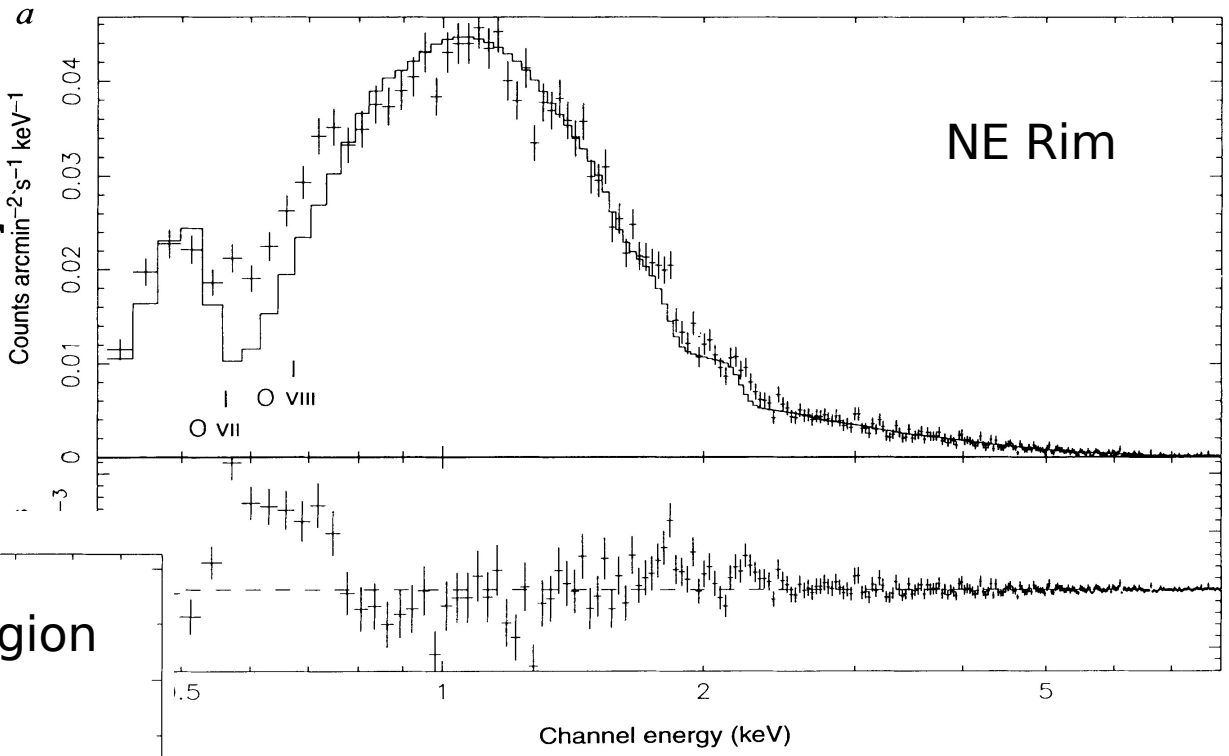
$$E_e \approx \frac{300\ \mathrm{TeV}}{B_{\mu G}^{1/2}} \left(\frac{E_X}{1\ \mathrm{keV}} \right)^{1/2} .$$

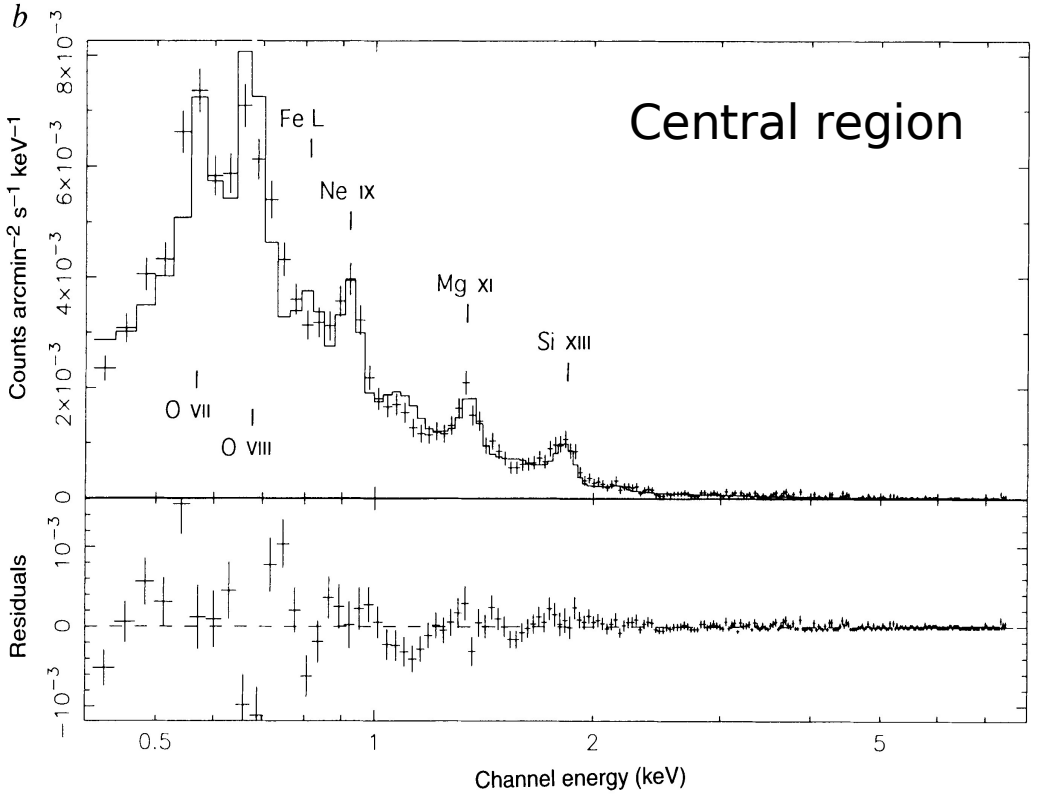
  - **Nuclei (protons) as well!**

    CR spectrum up to the knee…. or almost

SN1006 (Koyama et al. 1995, ASCA)

- **Historical SN**
- **Expected thermal comp.+lines in the center**
- **Strong Si line : SNIa?**



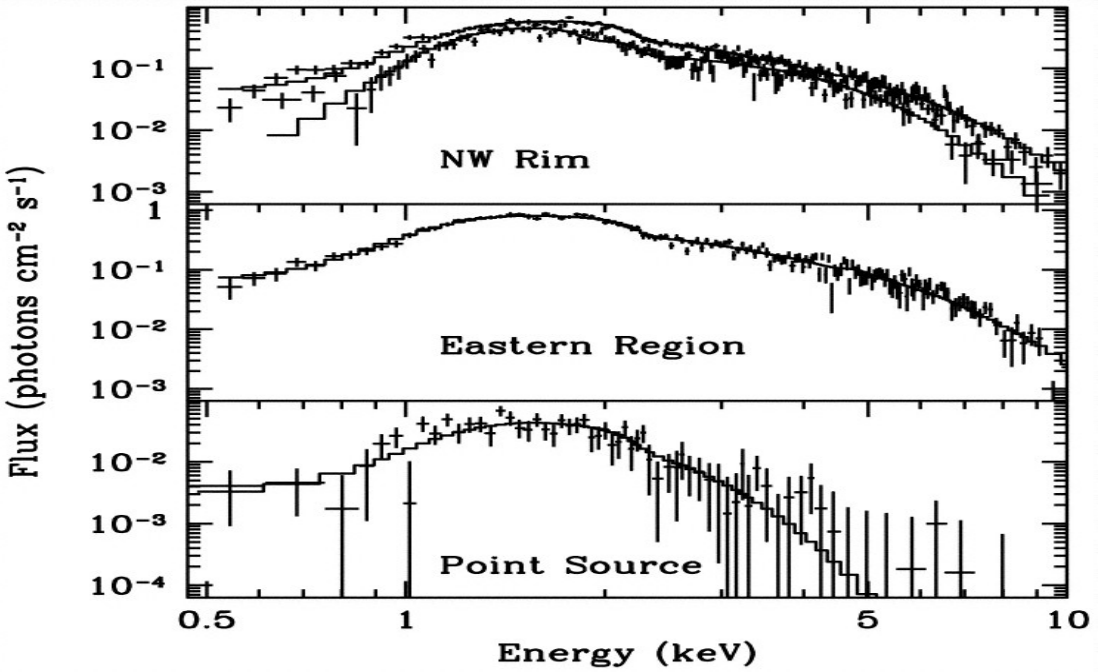


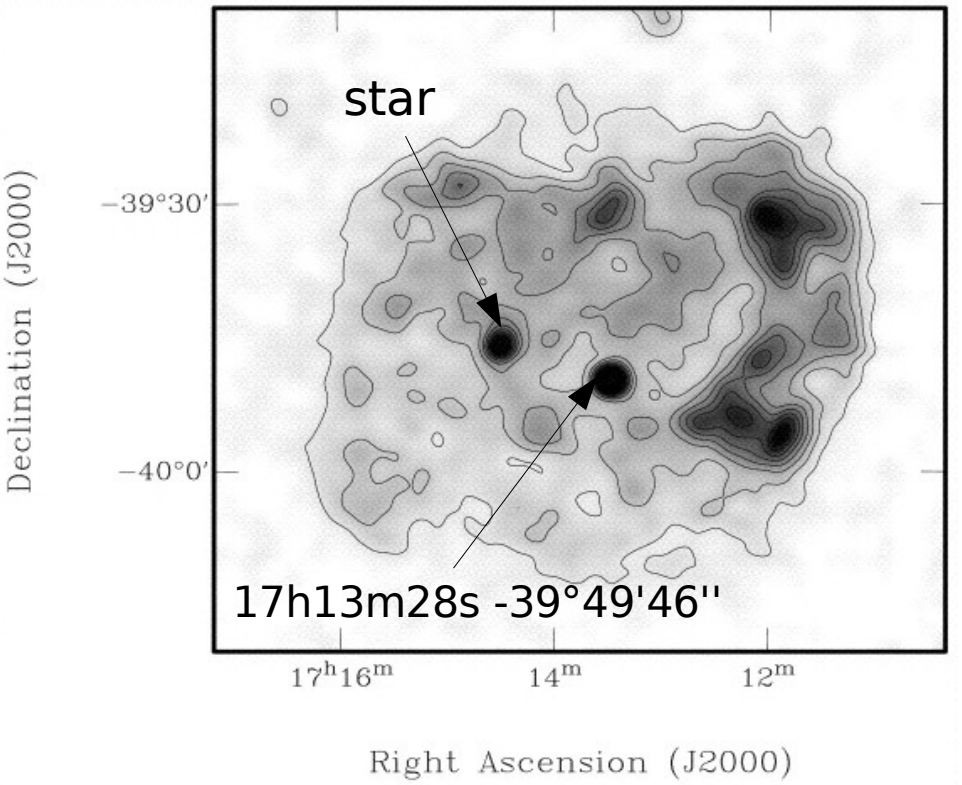
- **Non thermal dominant component in the NE shell**
- **First case for Synch. photons from accelerated electrons up to 200TeV!!!**

RXJ1713

Discovered by ROSAT all sky survey (Pfeffermann & Aschenbach 1996)

- **Shell type, ~70' wide**
- **Strong enhancement on western rim**
- **F(0.1-2.4 keV)=4.4 10^{-10}erg $cm^{-2}s^{-1}$**
- **No thermal component at all!**





ASCA : Slane et al.1999

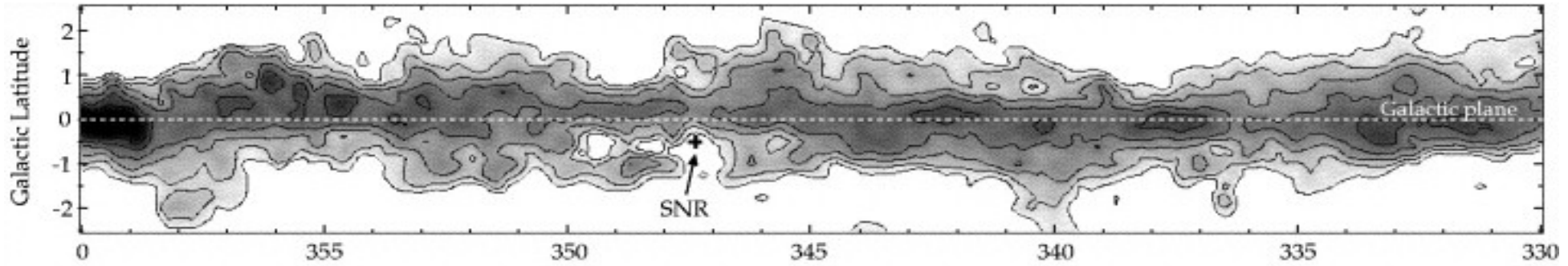
About the CCO : Lazendic et al.(2003), Cassam-Chenai et al.(2004)

- **no pulsation and no long term flux variability**
- **XMM spectral fit studies show global agreement with other data**
- **N_h compatible with the SNR. So, Type II/Type Ib-c very likely**

CO Observations

- **CO molecule strongly polarized, contrary to H_2**
  - **mm-wave rotational transitions observable**
  - **H_2 tracer (condition for one = condition for the other)**
- **Mapping of the radial velocity (via Doppler shift)**
  - **Correlation with galactic curve : estimation of distance**
  - **Correlation with CO/H2 conversion factor : Constraint on N(H2)**

Slane et al. 1999

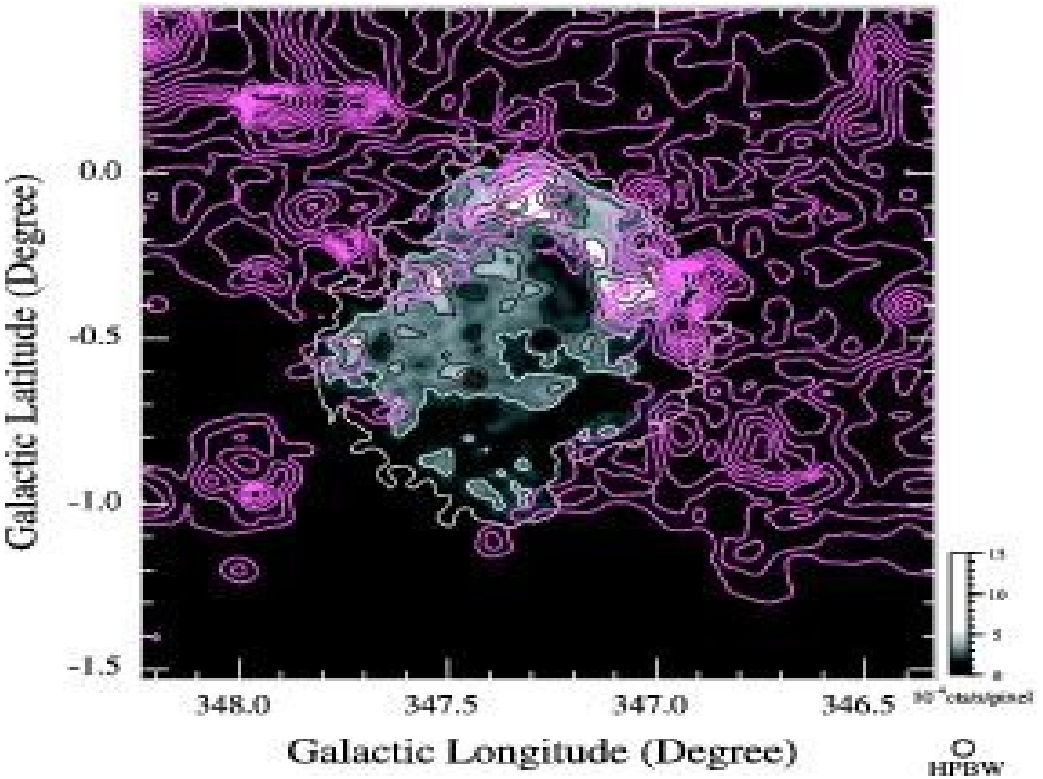


Total molecular column density, contours are logarithmically spaced at 34, 60, 107, 190, 224, and 600 × 10^20 molecules cm-2

- **How to prove that the SNR is in the vicinity of the cloud?**
  - **Morphology**
  - **Compatibility with N(H2) from X ray spectral fit**
  - **CO(2->1)/CO(1->0) enhancement**

CO observation : Distance Estimation

- **First estimate (Slane et al. 1999, Butt et al. 2001) : D~6 kpc**
- **Refined CO survey + XMM reanalysis : D~1 kpc**

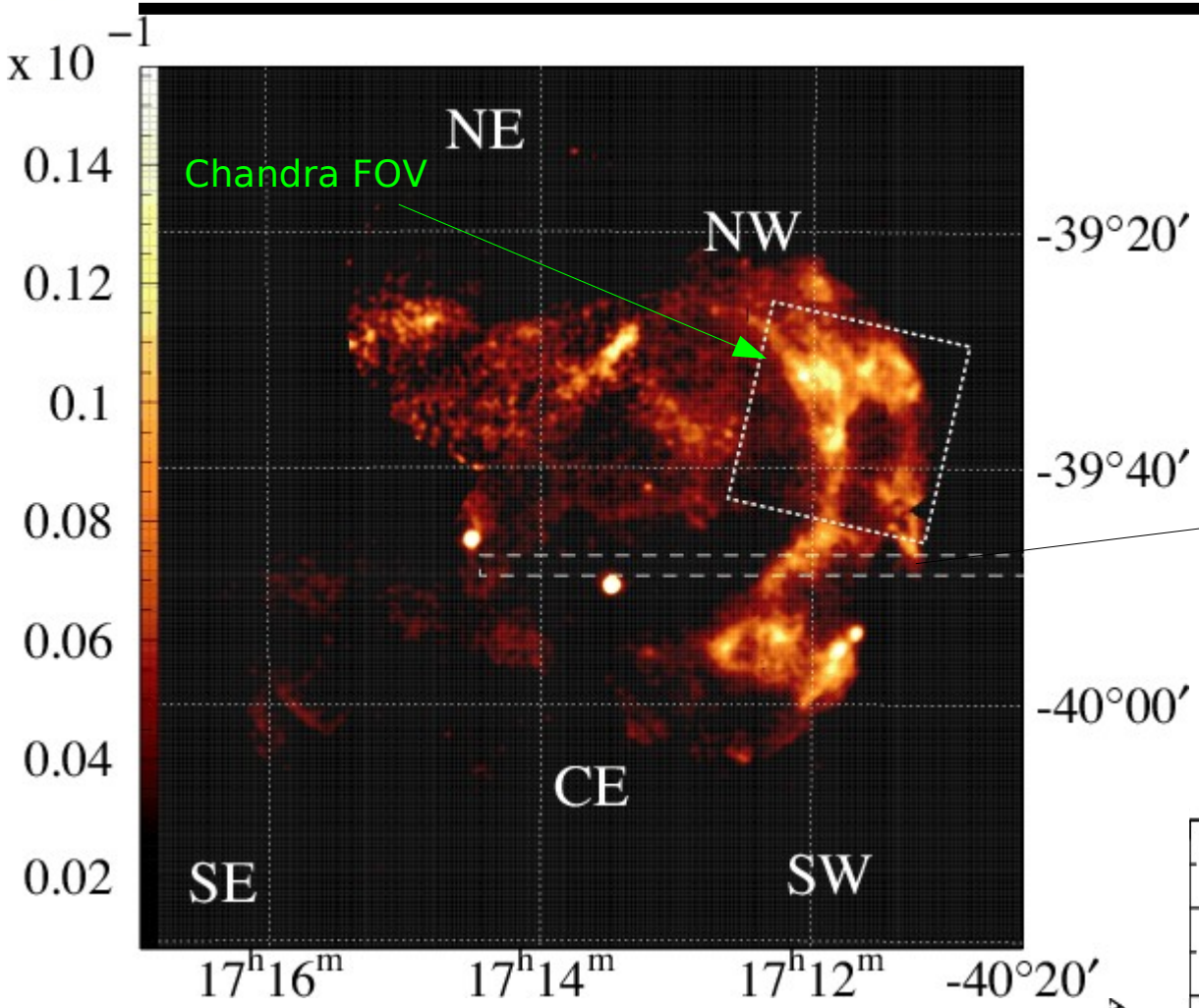


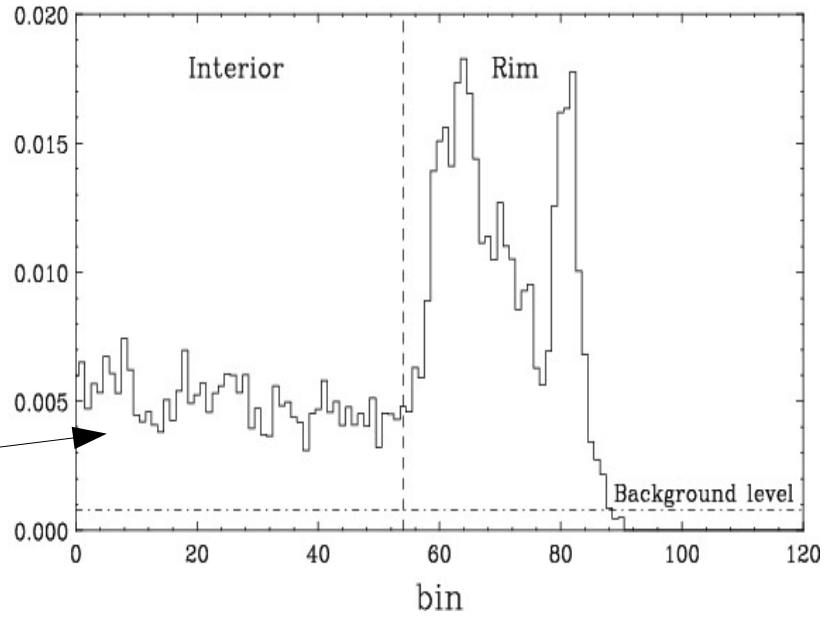
Cassam-Chenai et al. 2003

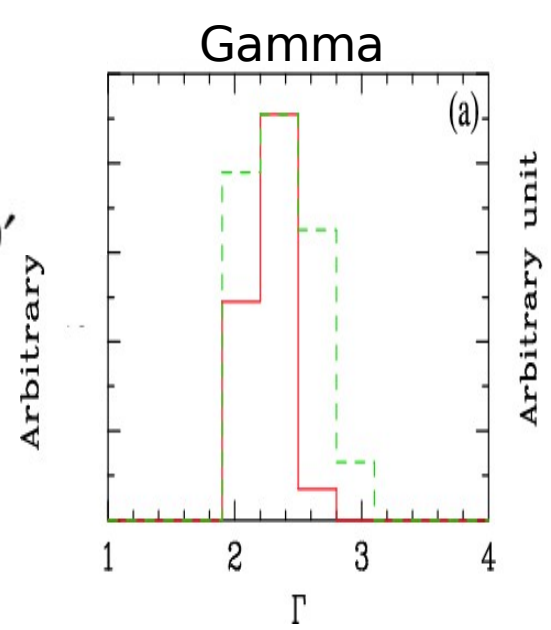
V_{LSR} (km s^{-1})	D (kpc)	N_H (10^{22} cm^{-2}) NW	SW	CE
–0.4	0.14	0.43	0.50	0.38
–3.0	0.58	0.52	0.60	0.48
–5.6	**0.98**	**0.62**	**0.71**	**0.56**
–8.2	**1.33**	**0.74**	**0.83**	**0.65**
–10.9	**1.67**	**0.89**	**0.97**	**0.76**
–13.5	1.97	1.03	1.12	0.85
–16.0	2.24	1.14	1.22	0.92
–18.6	2.50	1.21	1.28	0.97
–21.2	2.74	1.27	1.33	1.01
–23.8	2.96	1.35	1.37	1.05
–26.5	3.17	1.44	1.42	1.08

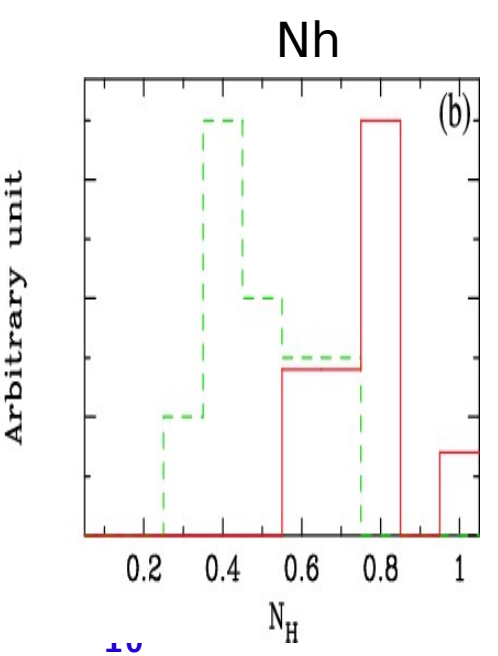
- **Global coincidence of a CO hole at a degree scale with the X-ray SNR obtained by ASCA (Koyama et al. 1997; Slane et al. 1999) and ROSAT (Pfeffermann, Aschenbach 1996)**
- **Detailed correspondence of the CO peaks on an arc-min scale with the X-ray data of XMM (J. Hiraga et al. 2005)**
- **Existence of a velocity-shifted CO component apparently associated with one of the X-ray peaks.**

Some more XMM-Newton (Hiraga et al. 2005)



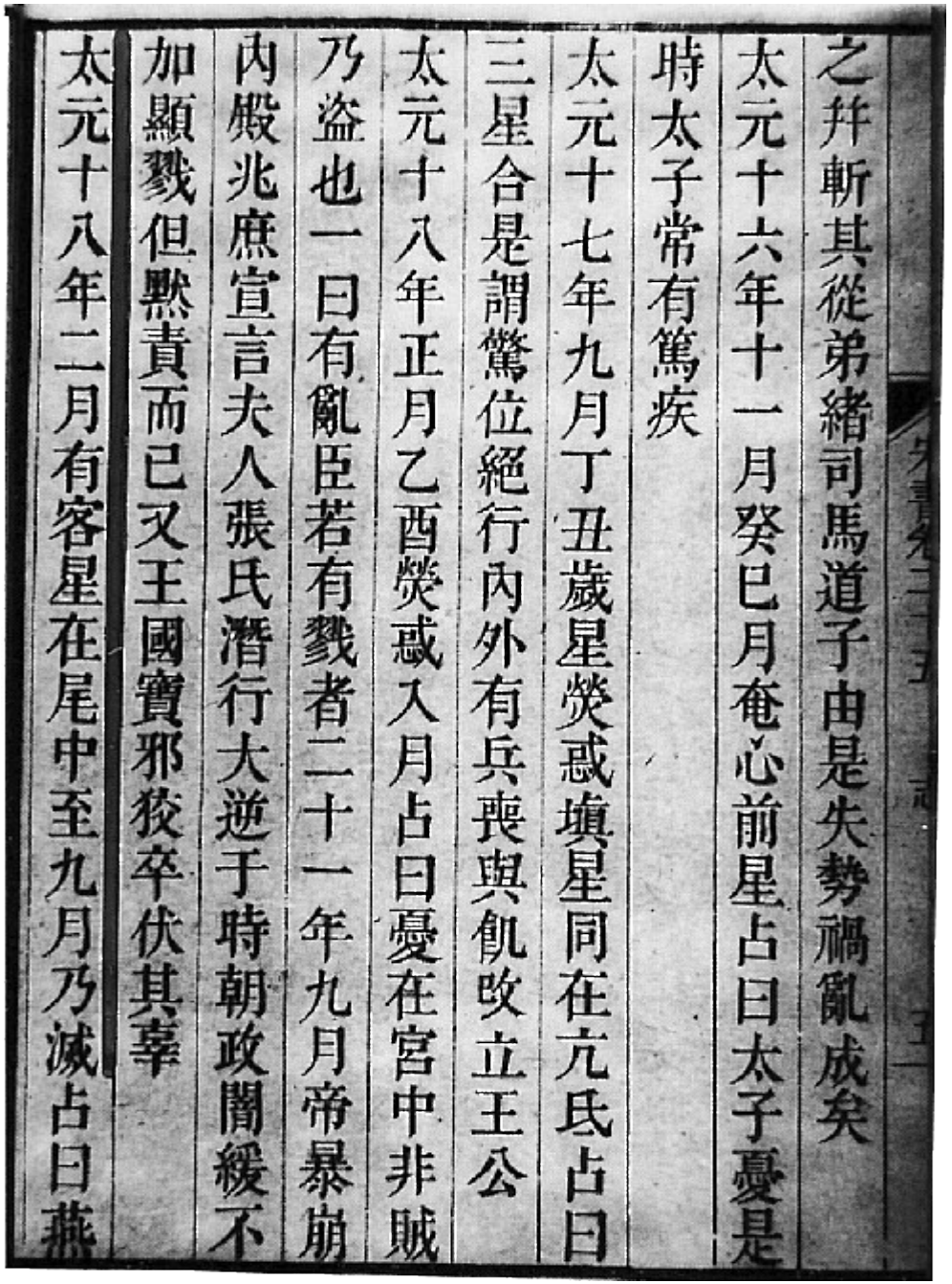






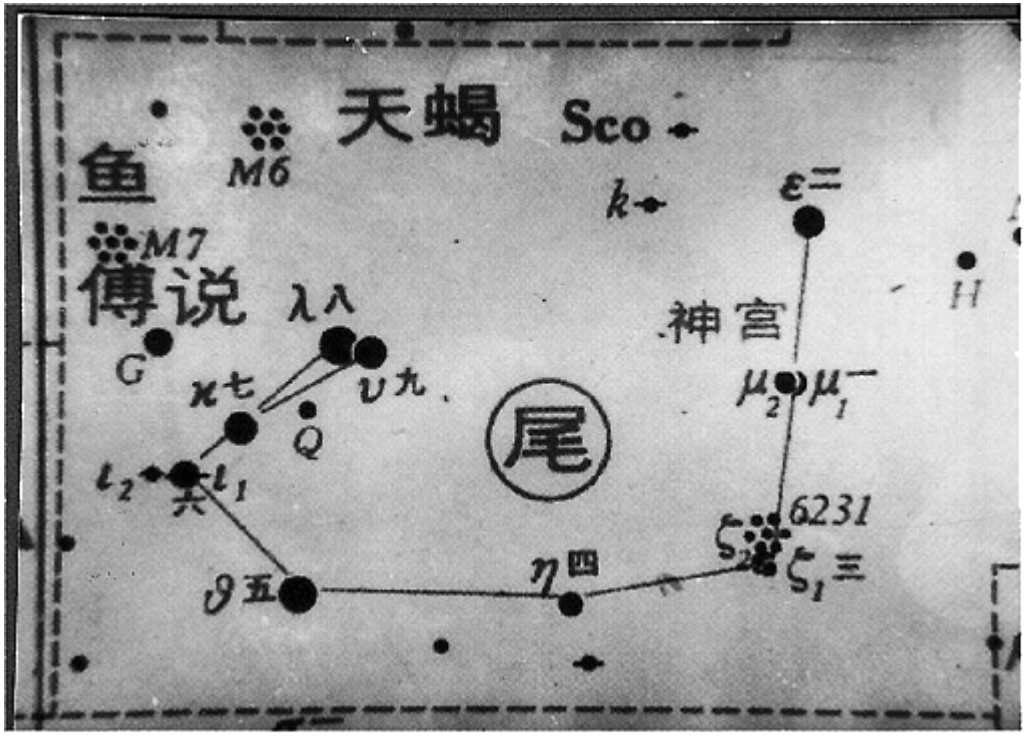
XMM analysis seems to favor
D~1 kpc
aka 1000-2000 years...

A Historical Remnant? AD 393 (Wang et al. 1997)

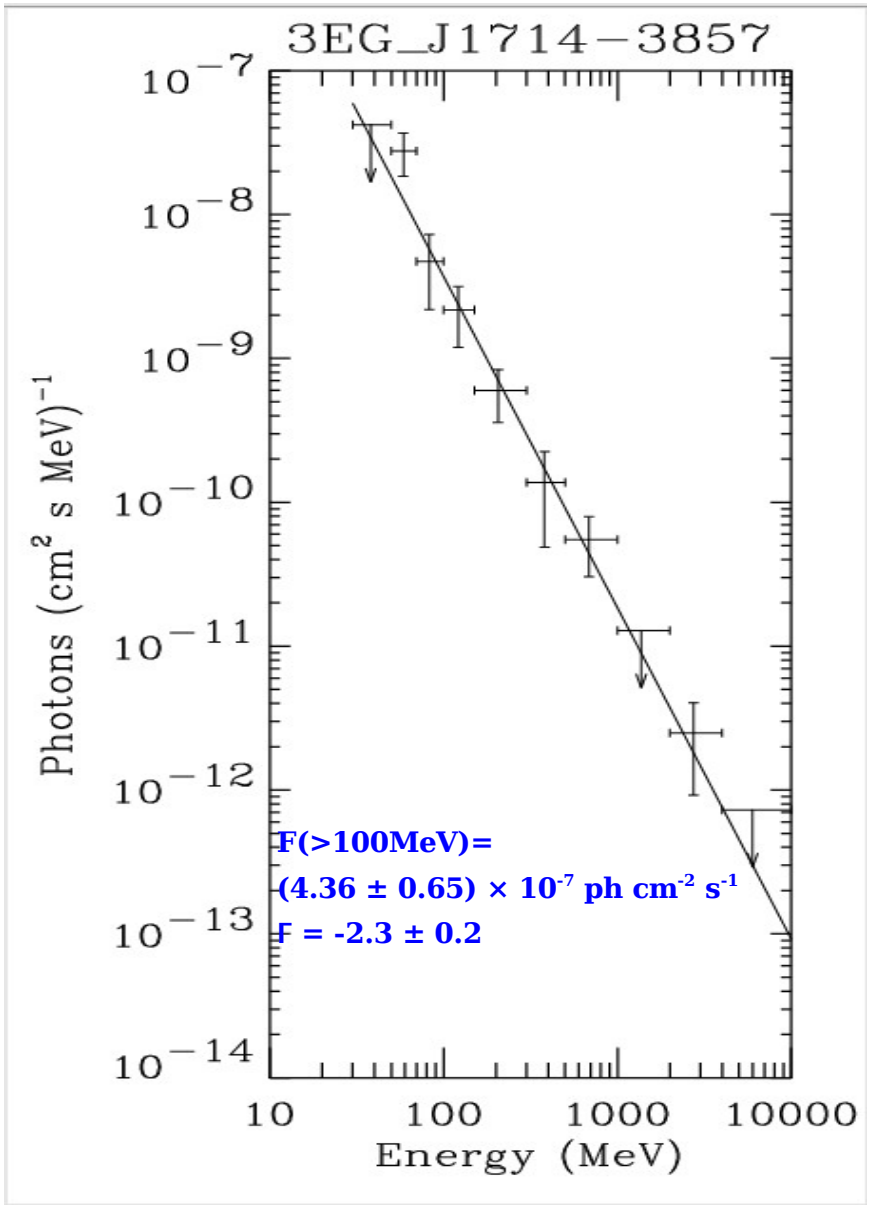


之幷斬其從弟緒司馬道子由是失勢禍亂成矣
太元十六年十一月癸巳月奄心前星占曰太子憂是
時太子常有篤疾
太元十七年九月丁丑歲星熒惑塡星同在亢氐占曰
三星合是謂驚位絕行內外有兵喪與飢改立王公
太元十八年正月乙酉熒惑入月占曰憂在宮中非賊
乃盜也一曰有亂臣若有戮者二十一年九月帝暴崩
內殿兆庶宣言夫人張氏潛行大逆于時朝政闇緩不
加顯戮但黙責而已又王國寶邪狡卒伏其辜
太元十八年二月有客星在尾中至九月乃滅占曰燕

"A guest star appeared within the asterism Wei during the 2nd lunar month of the 18th year of the Tai-Yuan reign period (February 27 - March 28, AD393), and disappeared during the 9th lunar month (October 22 - November 19, AD393)."



EGRET Detection (3rd Catalog)

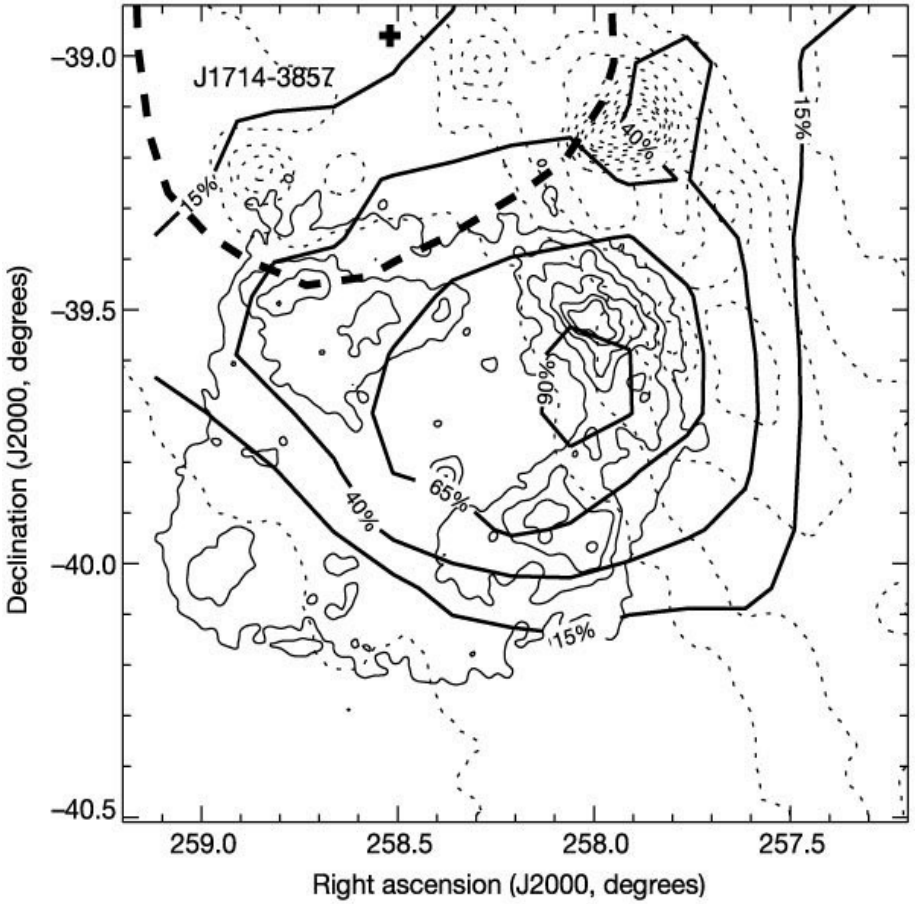


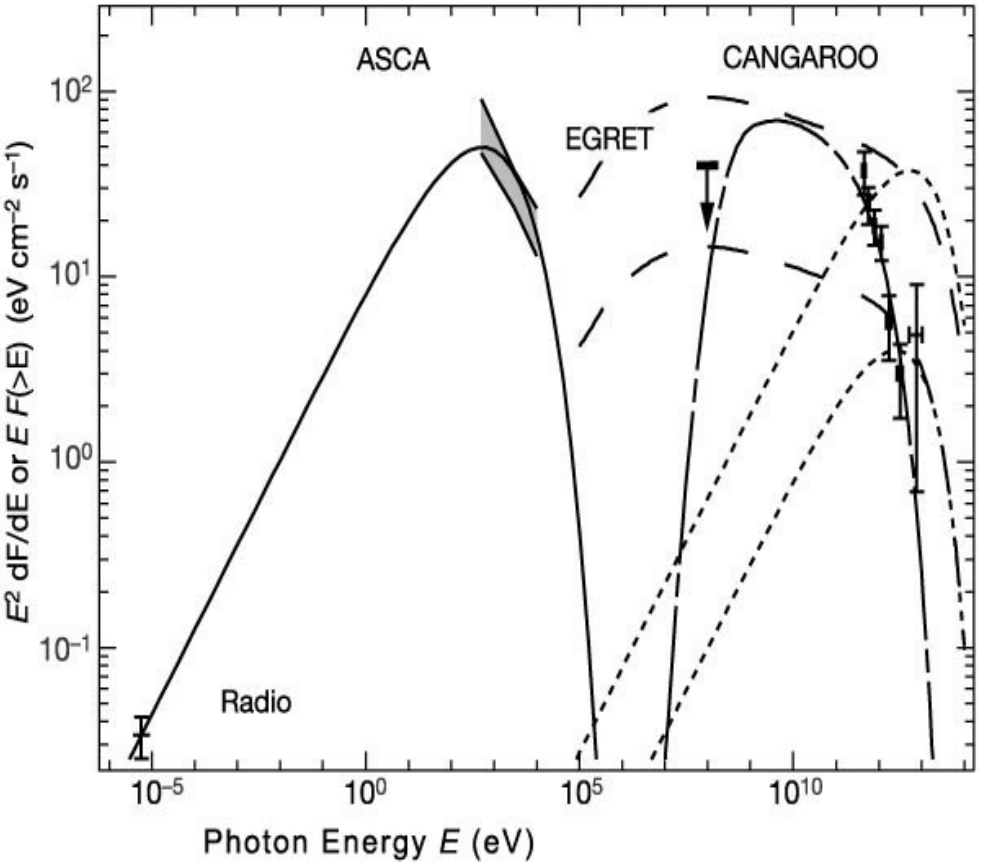

```
3EG J1714-3857,258.52,-38.96,348.04, -0.09,0.51 ,  43.6, 6.5,   2.30 ,   797,   7.0, P1234  ,  ,  ,  em
               ,  38.0,15.4,  +-0.20,   117,   2.6,   5.0  ,  ,  ,  C
               ,  61.6,22.6,        ,   104,   2.9,  16.0  ,  ,
               ,  70.5,    ,        ,    32,   0.0,  23.0  ,  ,
               ,  72.9,32.8,        ,    57,   2.4,  27.0  ,  ,
               , 150.2,    ,        ,    20,   0.0,  35.0  ,  ,
               , 154.2,    ,        ,    34,   0.8,  38.0  ,  ,
               , 103.6,    ,        ,    30,   0.0, 210.0  ,  ,
               ,  82.3,44.7,        ,    32,   2.0, 214.0  ,  ,
               ,  98.6,    ,        ,    35,   0.0, 223.0  ,  ,
               , 108.0,27.8,        ,   133,   4.2, 226.0  ,  ,
               ,  79.9,24.4,        ,   126,   3.5, 223.+  ,  ,
               , 155.4,    ,        ,    68,   1.6, 229.+  ,  ,
               ,  74.6,20.9,        ,   143,   3.8, 232.0  ,  ,
               , 102.6,    ,        ,    80,   1.5, 302.3  ,  ,
               ,  43.3,21.3,        ,    76,   2.1, 323.0  ,  ,
               , 124.7,    ,        ,    36,   0.5, 324.0  ,  ,
               ,  55.0,    ,        ,    39,   0.0, 330.+  ,  ,
               , 194.3,53.0,        ,    79,   4.2, 334.0  ,  ,
               ,  84.7,39.6,        ,    54,   2.3, 336.5  ,  ,
               , 123.6,    ,        ,    70,   1.4, 421.0  ,  ,
               , 119.6,    ,        ,    82,   1.8, 422.0  ,  ,
               , 101.1,    ,        ,    75,   1.3, 423.0  ,  ,
               ,  68.4,    ,        ,   136,   1.7, 421.+  ,  ,
               , 119.4,    ,        ,    74,   1.6, 423.5  ,  ,
               ,  37.4,10.9,        ,   237,   3.5,    P1  ,  ,
               ,  64.0,13.4,        ,   302,   5.0,    P2  ,  ,
               ,  48.3,12.6,        ,   222,   4.0,    P3  ,  ,
               ,  38.0,17.2,        ,    99,   2.3,    P4  ,  ,
               ,  48.1, 8.5,        ,   532,   5.9,   P12  ,  ,
               ,  44.0,10.2,        ,   317,   4.5,   P34  ,  ,
```

TeV Detection with CANGAROO

Muraishi et al. 2000 &Enomoto *et* al. 2002:

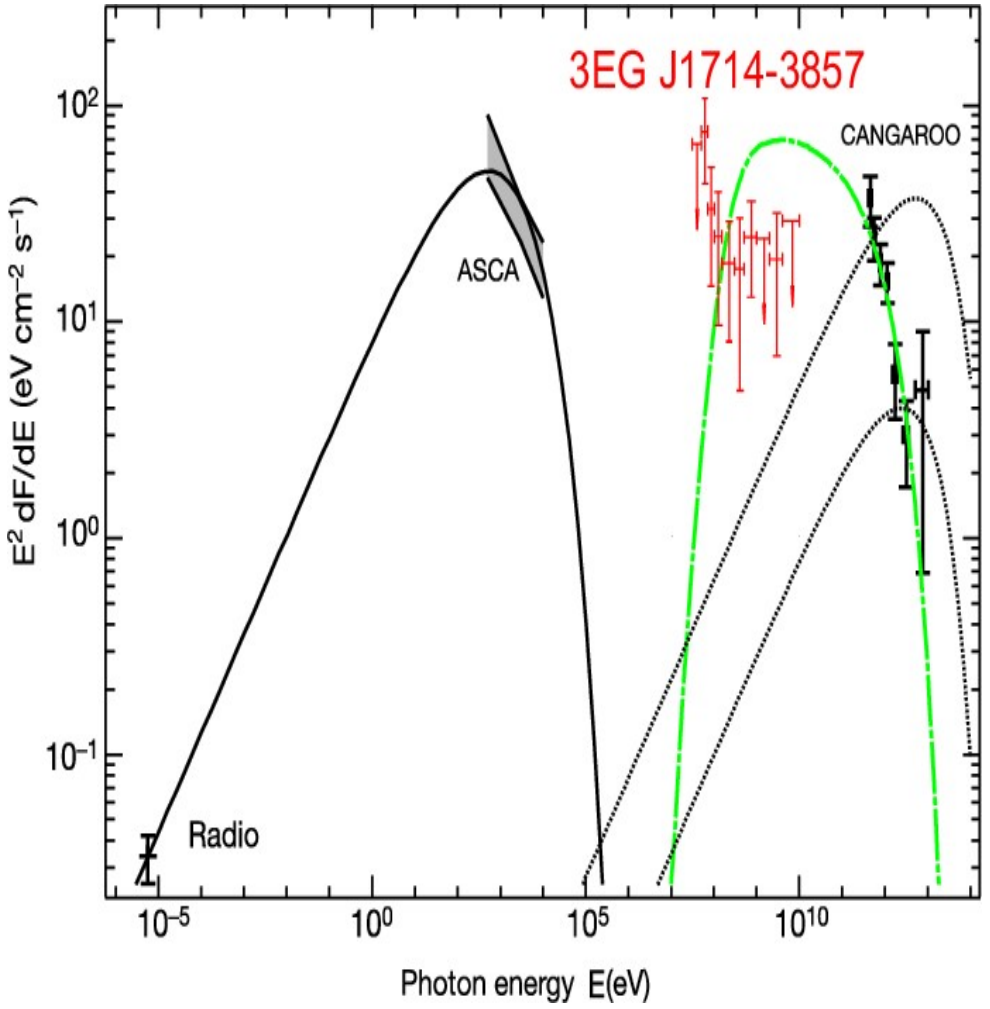
$$dF/dE = (1.63 \pm 0.15 \pm 0.32) \times 10^{-11} E^{-2.84 \pm 0.15 \pm 0.20}$$ cm-2 s-1 TeV-1



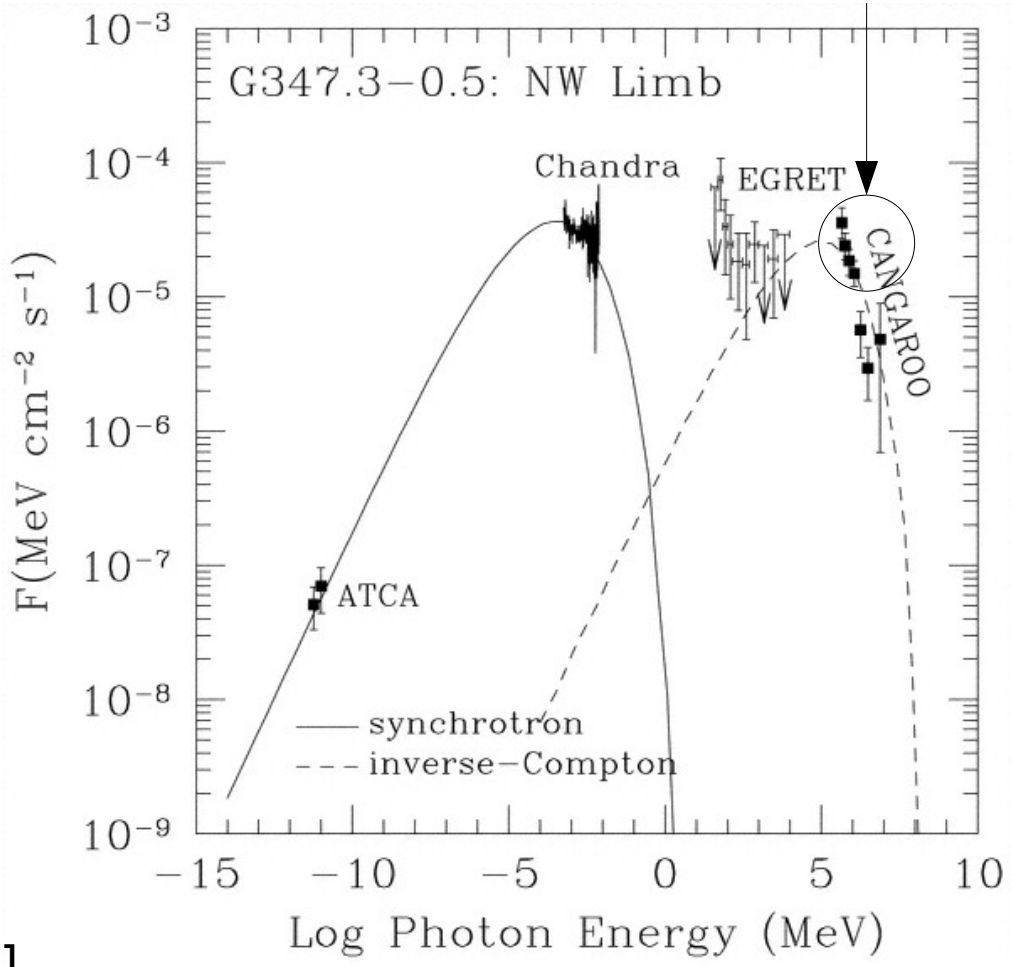


Proton Acceleration... or not

Reimer & Pohl (2002) : "3EG J1714-3857 is either associated with the SNR or an upper limit to the gamma-ray emission of the SNR."



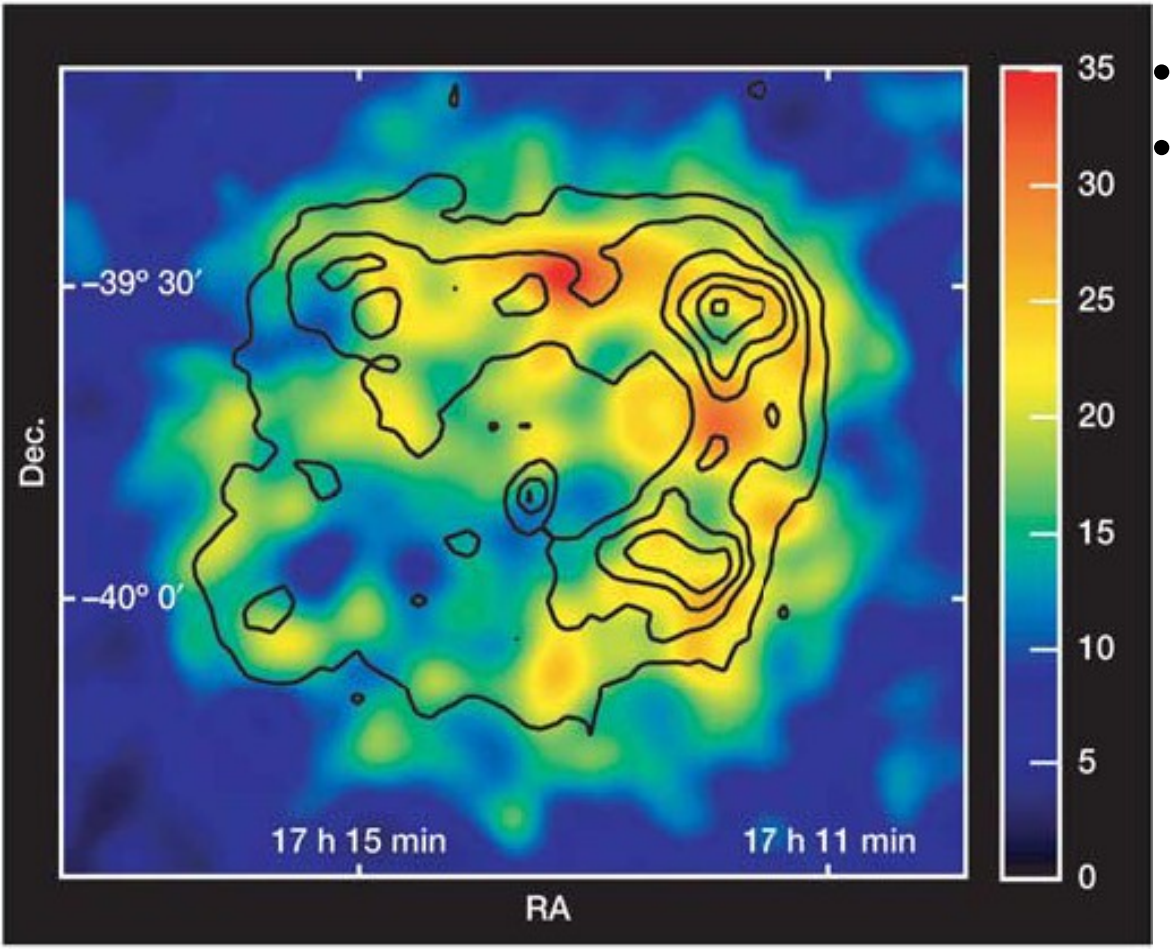
No flattening at 1 TeV



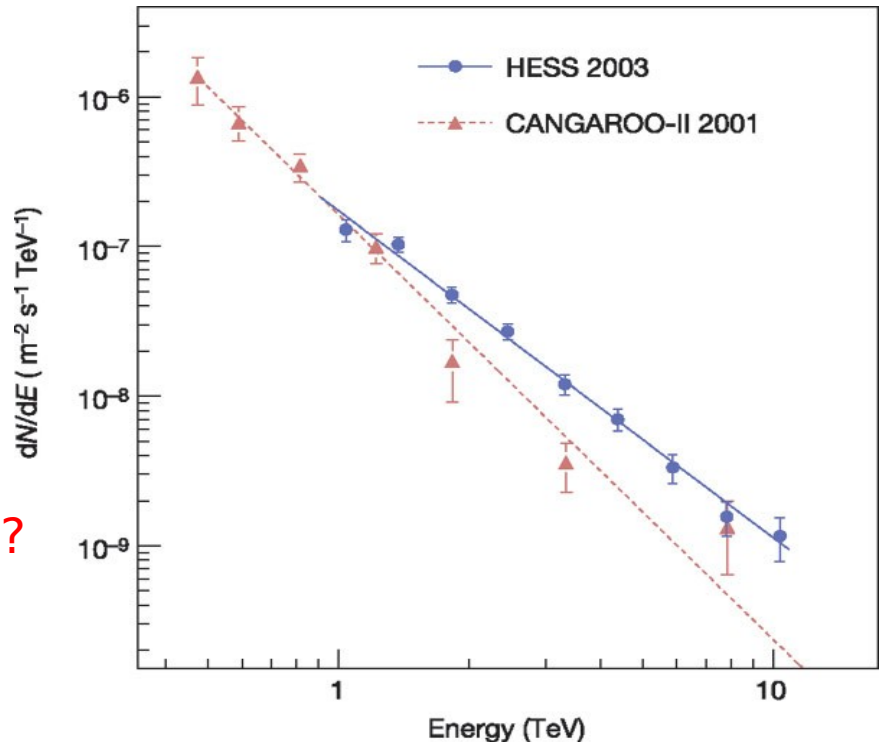
From Tune's talk in Heidelberg: GLAST
$E^2dN/dE(\text{MeV cm}^{-2}\text{s}^{-1}) = 10^{-6}$ in [500MeV-5GeV]

Lazendic et al. 2004

HESS Observation

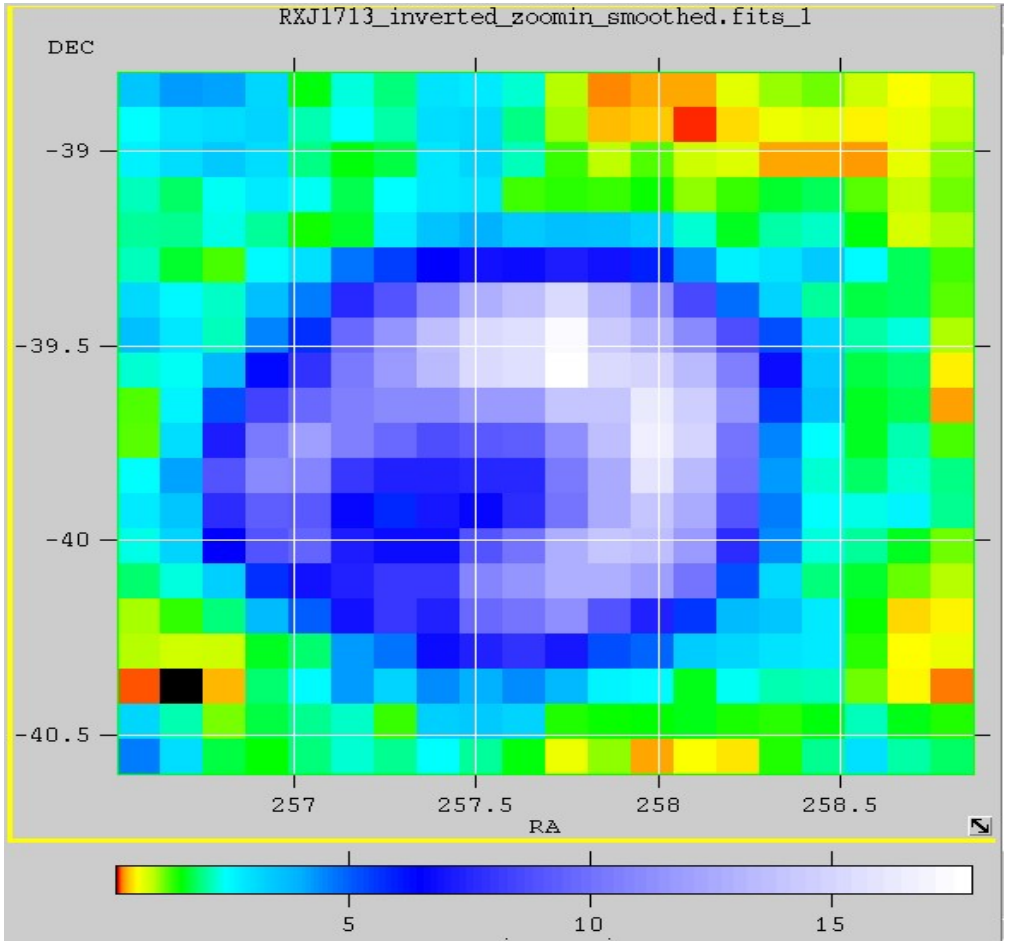


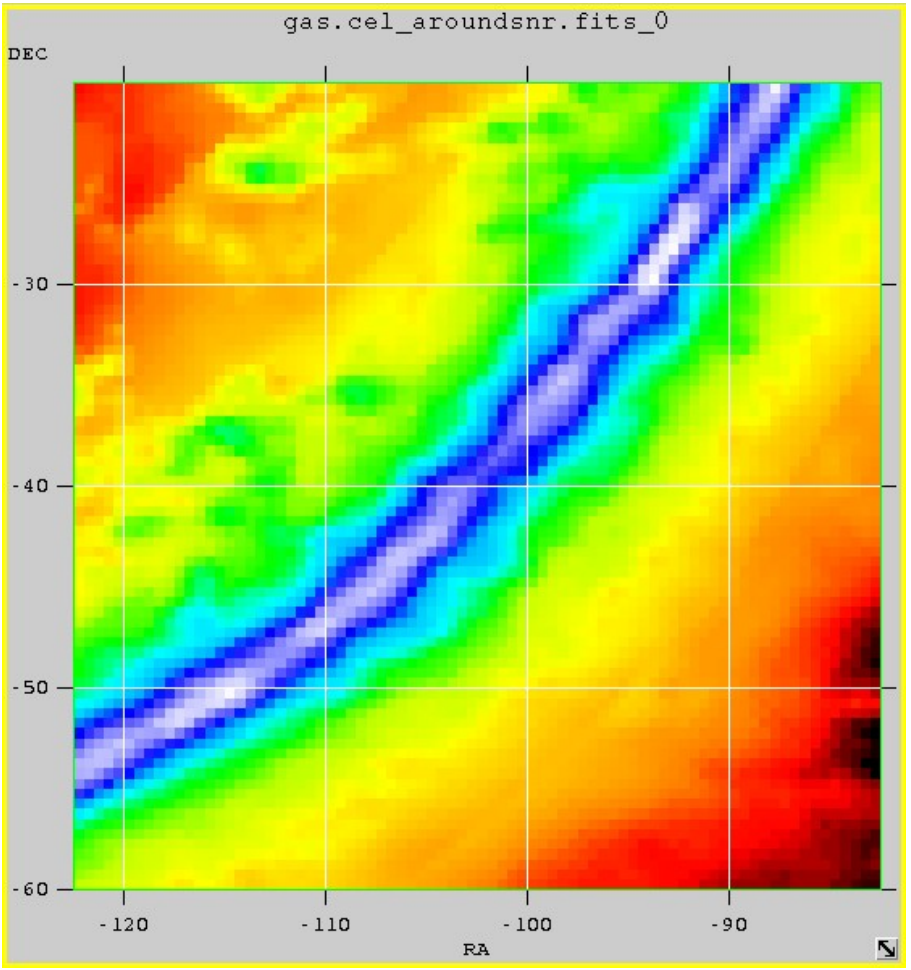
- Γ = 2.19± 0.09± 0.15
- F(>1TeV) = (1.46 ± 0.17 ±0.37) 10^{-7} photons m^{-2} s^{-1}



Anti-correlation between ASCA and HESS hot spots?

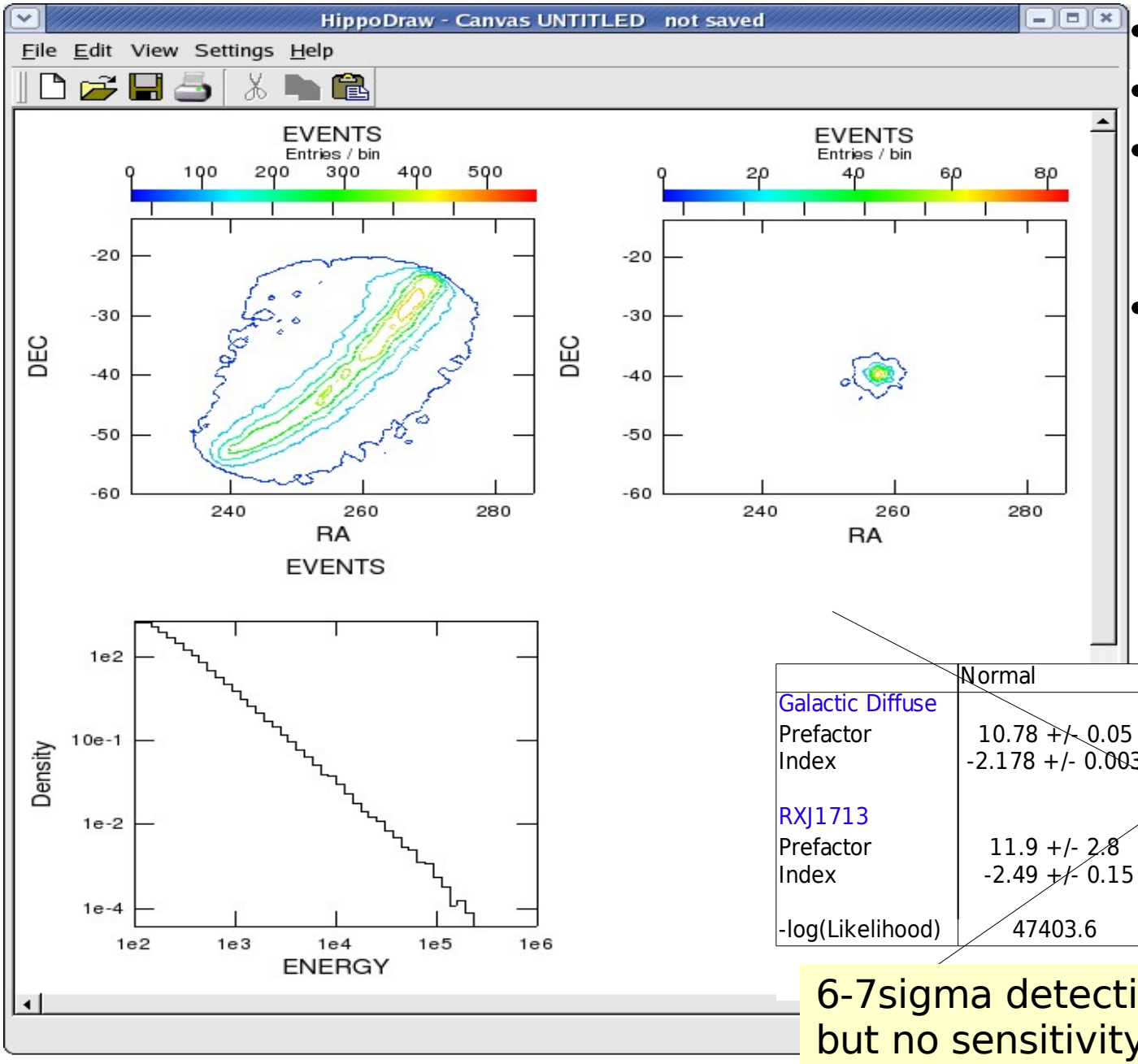
A shot at simulating the SNR





- **HESS countmap (bck subtracted) from Berrie**
- **Ad Hoc Prescription : total flux and photon index from EGRET**
- **EGRET diffuse model with photon index=2.2, in the neighborhood of the SNR (total flux in the map 0.66 $m^{-2}s^{-1}$)**

A shot at simulating the SNR

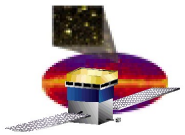


- **Disclaimer, etc....**
- **But there is hope!**
- **Note that Binned Likelihood still being implemented**
- **Will work on unbinned next**

	Normal	Diffuse only	Point source
Galactic Diffuse			
Prefactor	10.78 +/- 0.05	10.85 +/- 0.05	10.76 +/- 0.05
Index	-2.178 +/- 0.003	-2.178 +/- 0.003	-2.175 +/- 0.003
RXJ1713			
Prefactor	11.9 +/- 2.8		6.4 +/- 1.4
Index	-2.49 +/- 0.15		-3.02 +/- 0.16
-log(Likelihood)	47403.6	47428.8	47412.1

TS value: 36.7192

6-7sigma detection seems possible,
but no sensitivity to extension in 1 mth data



Conclusion

- Improving EGRET signal
- Detecting gamma rays from the SNR
- Constraining hadronic photon emission processes
- A gamma-ray pulsar? Who knows.....

For another GLAST lunch:

- Image resolution with GLAST
- Shock acceleration in SNR for dummies
- More on the simulated source detection

"The SNR RX J1713.73946 is perhaps the best natural laboratory available today for studying the acceleration and diffusion of cosmic-rays. The unique combination of a relatively close SNR and a group of well defined molecular clouds in its surroundings, ~~none of them in front of the remnant itself,~~ makes this source a priority target for the forthcoming generation of high-energy instruments such as HESS, AGILE, INTEGRAL, and GLAST, as well as for infrared, radio, mm and sub-mm observatories."

(Torres et al. 2003)