

**Highlights of Conference  
on “Astrophysical Sources  
of  
High-Energy Particles and Radiation”**

Torun, Poland  
19-24 June 2005

## General Remarks

- ❑ I would like to first make some general remarks (*but don't worry, Jean-Pierre, I'm not giving the after dinner talk...*)
- ❑ Meeting was superbly organized – everything has gone very smoothly
- ❑ Program was carefully thought out and talks covered all important topics
- ❑ Importance of personal relationships is often under appreciated in science – they provide the foundation and the fabric of our enterprise
- ❑ Organizers are therefore to be commended for providing generous lunch breaks during which so many wonderful scientific and social conversations have taken place

## General Remarks (Continued)

- ❑ Torun – with its small size and many restaurants – also contributed to the special intimacy and warmth of this meeting
- ❑ I appreciated the efforts that the organizers made to provide funds so that young scientists from many countries could attend this conference – and I greatly enjoyed meeting and talking with many of them
- ❑ All of this made for a wonderfully successful meeting – everyone was very amiable
- ❑ Only one problem: it left me longing for a few sharp exchanges – or just some “sparking” – that I could use as “fodder” for this wrap-up talk
- ❑ Well, maybe two problems: so much was covered so well in this meeting that it is truly impossible to cover all of the highlights

## General Remarks (Continued)

- ❑ I did make a valiant effort to rectify the situation: I asked the organizers to give me 200 minutes, instead of 20, for this talk
- ❑ But they were firm in saying that I must keep to the scheduled time (I noticed yesterday, when Tomek announced the bus schedule, that they had moved up the time of departure by  $\frac{1}{2}$  hour, just to make sure...)
- ❑ Well, maybe three problems: At my hotel this morning, I asked for schnapps...wine...even a beer, but no luck – so I find myself at a great disadvantage compared to Jean-Pierre last night (*but don't worry, Jean-Pierre, I'm not giving the after dinner talk...*)

## General Remarks (Continued)

- ❑ Jean-Pierre's wonderful remarks last night brought back memories of my own – of course, I am much younger than him, so I can only remember a time when there were 3 gamma-ray photons and 3 sources... okay, 2 gamma-ray photons and 2 sources (*but don't worry, Jean-Pierre, I'm not giving the after dinner talk*)
- ❑ Over the course of my scientific career as a theorist, I have observed that “observations repel theory” (as Trevor Weekes commented) – and I have felt that repelling force myself!
- ❑ However, as with all aphorisms, the opposite is also true: observations attract theory – observational discoveries drive theory

## Observations Attract Theory

- ❑ *Chandra*
- ❑ *XMM-Newton (Wilms)*
- ❑ *Integral (Walter)*
- ❑ *Swift (Nousek)*
- ❑ *H.E.S.S. (Hermann)*
- ❑ *MAGIC (Mannheim)*
- ❑ *Astro-E2, GLAST, NuST (Madejski)*
- ❑ *Auger (Giller)*

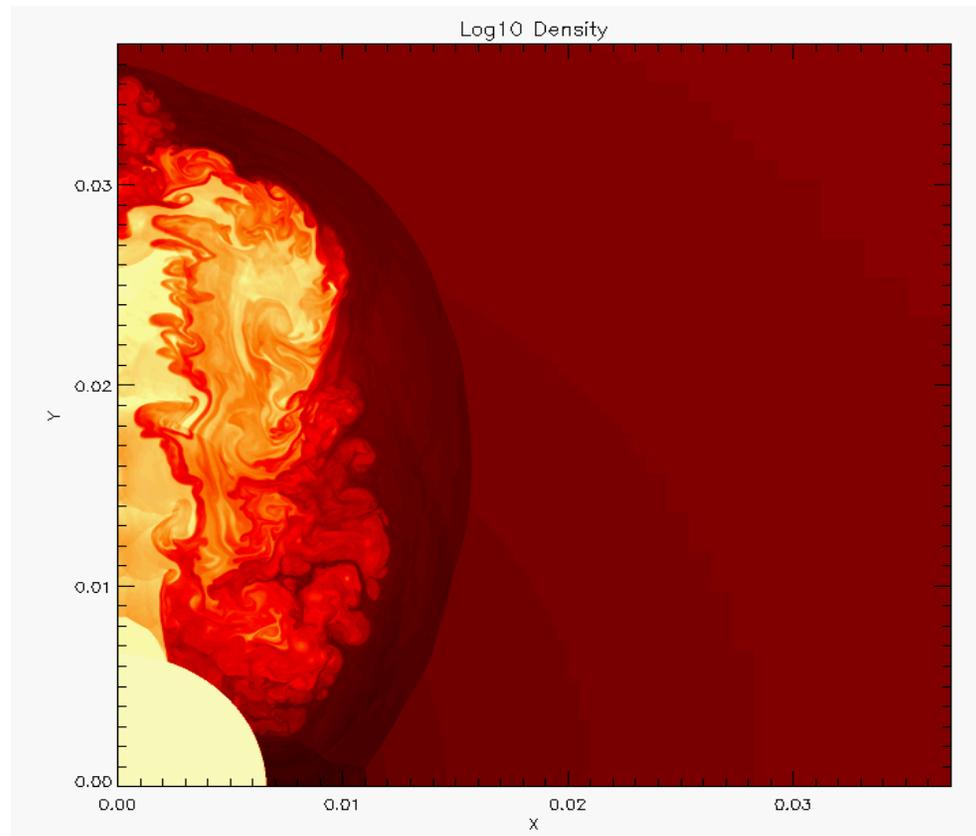
## Diffuse Backgrounds Eventually Become Point Sources

- ❑ AGN + galaxies are X-ray background at  $E < 6$  keV; likely also at  $\text{keV} < E < 8$  keV (*Worsley*)
- ❑ Galactic X-ray sources are 90% of galactic ridge (*Walter*)
- ❑ Universe is transparent to gamma-rays → discovery of absorbed sources possible (pulsars, AGN, GRBs)

## Gamma-Ray Bursts

- ❑ Collapsars produce jets (*MacFadyen*)
- ❑ Extreme populations can severely constrain models: XRFs (*DQL*); very hard GRBs outside *Integral* FOV (*Marcinkowski*)
- ❑ *Swift* discovery of spectacular (x 1000!) flares in X-ray afterglows (*Nousek, Zhang*)
- ❑ GRBs as “standard candles” for cosmology – determine properties of dark energy (*Ghirlanda*)
- ❑ GRBs as probe of very high redshift ( $z > 5$ ) universe: moment of “first light;” star formation, metallicity, reionization history of universe (*Hartmann*)

# Relativistic Jets in GRBs

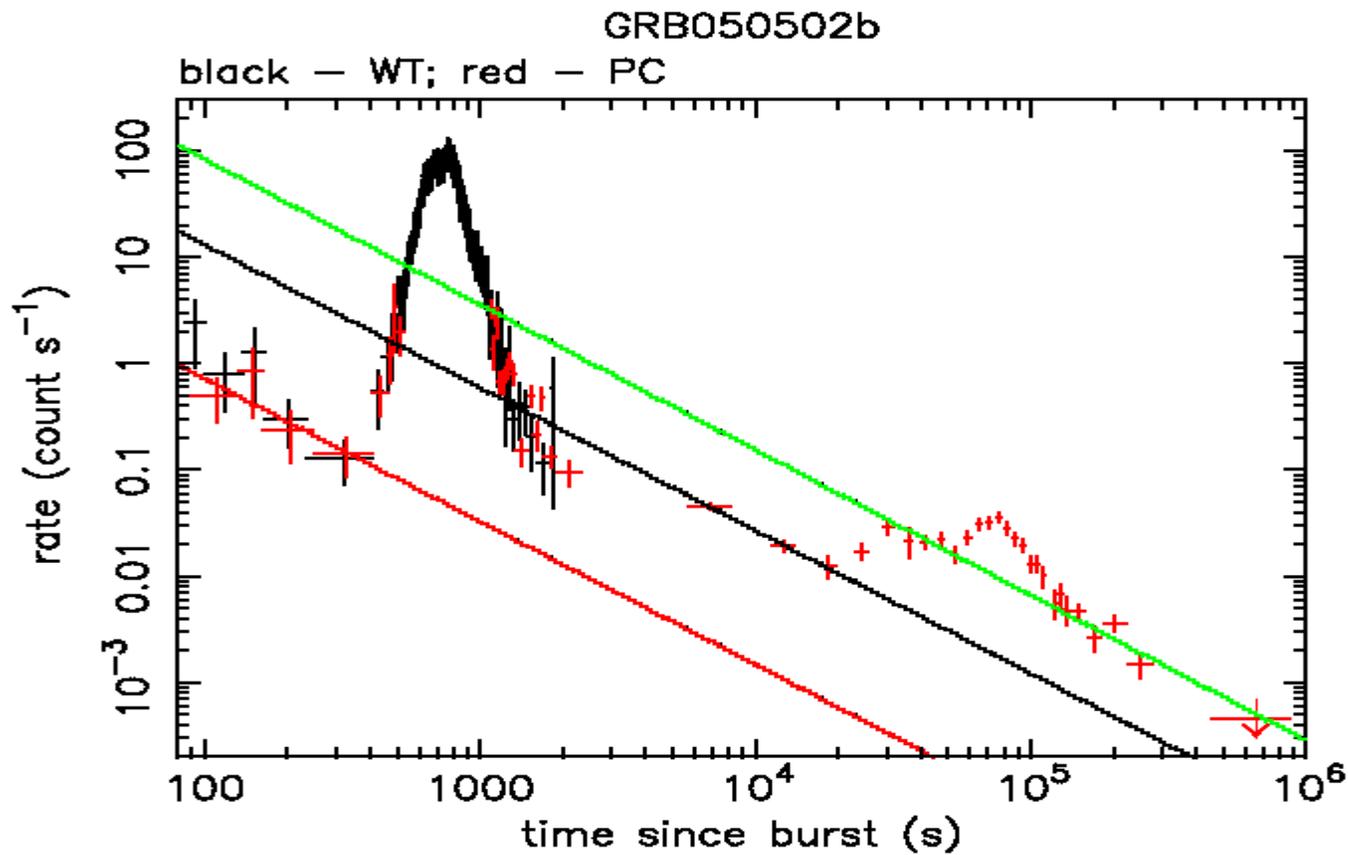


*MacFadyen (2005)*

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# Giant X-ray Flare: GRB050502b

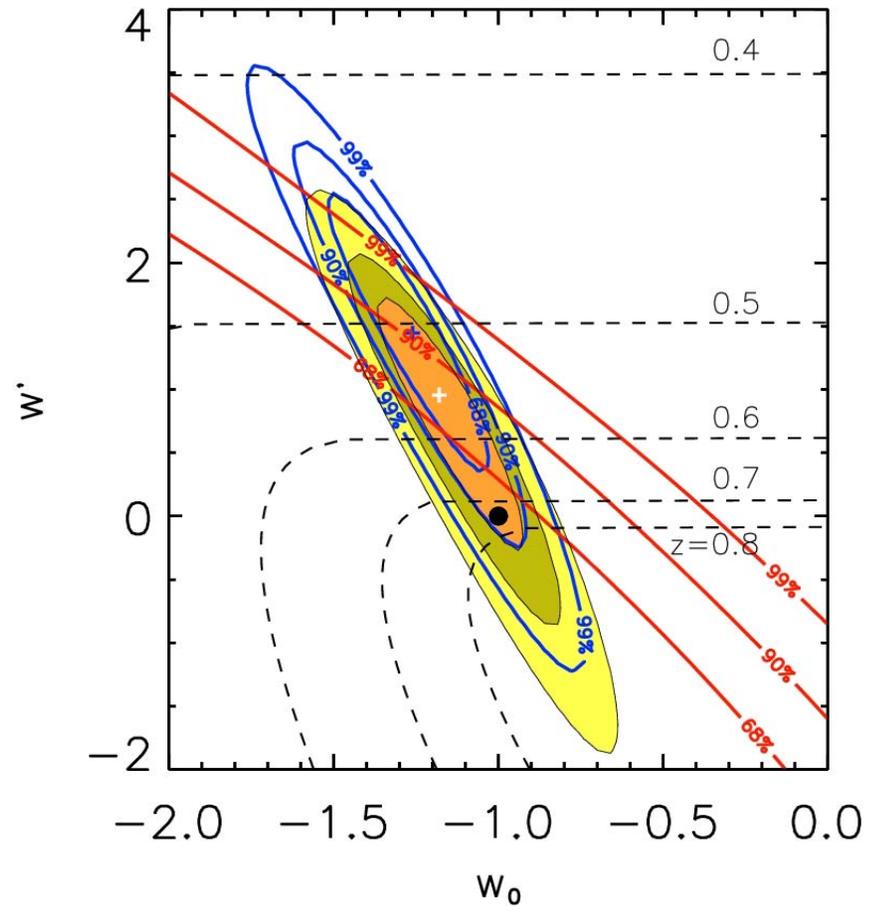
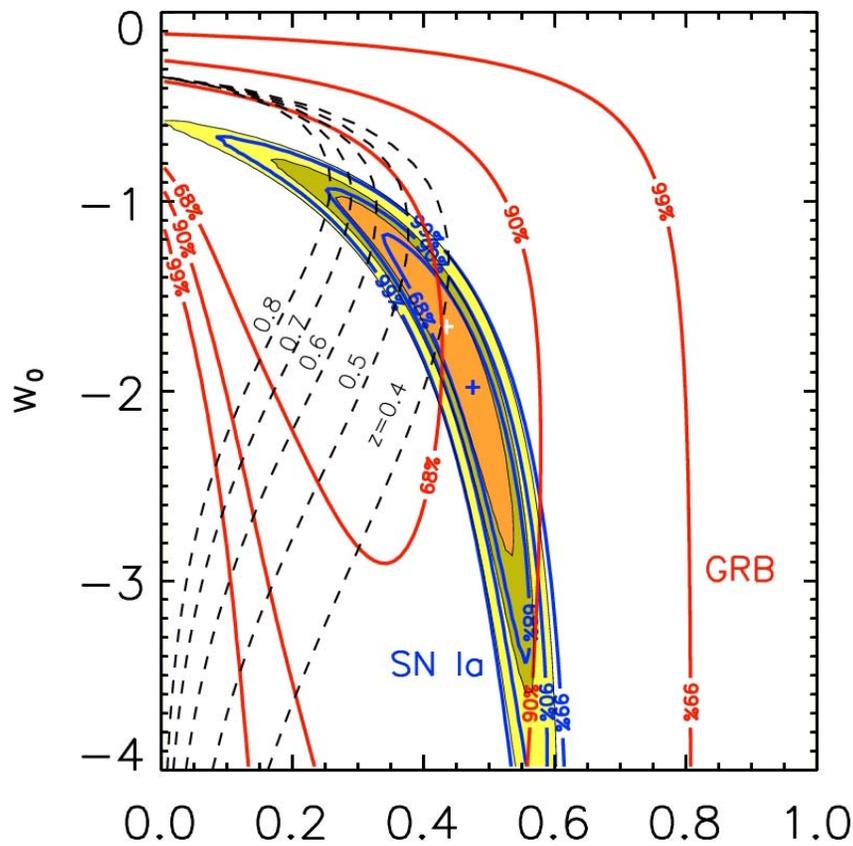


*Swift* XRT

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# GRBs as “Standard Candles” for Cosmology

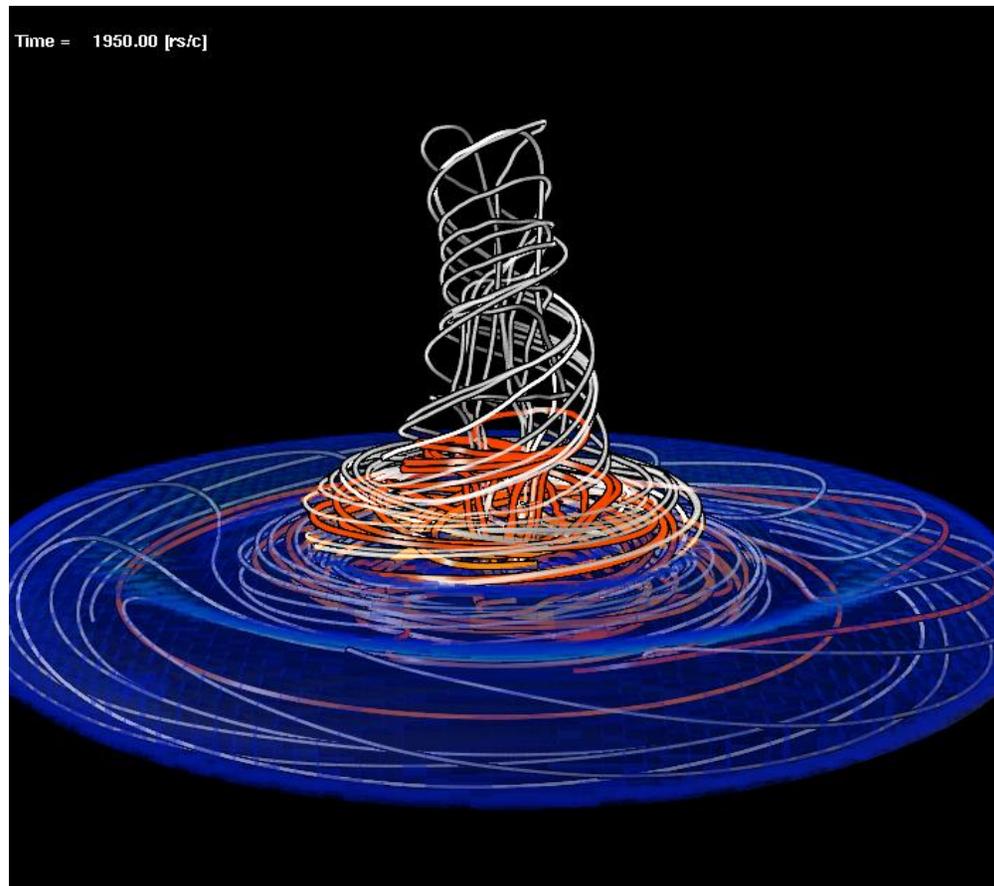


*Firmani, Ghisellini, Ghirlanda & Avila-Reese, (2005)*

## Similarities and Differences Between AGN, Microquasars, and GRB Jets

- ❑ Accretion flows produce MHD jets in AGN (*Mineshige, Nishikawa*); GRBs (?)
- ❑ Are AGN (GRB) jets matter or Poynting flux-dominated (*Sikora*)
- ❑ Polarization studies can provide insights into jet structure and magnetic fields in both AGN and GRBs (*Lazzati*)
- ❑  $K\alpha$  emission lines can provide probe of GR spacetime near black hole – but most AGN and QSOs do not show such lines (*Wilms*)
- ❑  $\Gamma < 20$  in AGN and micro-quasars,  $\Gamma > 300$  in GRBs; why? (latter are low-entropy jets, but why?)

# MHD Jets from Accretion Disks



*Mineshige et al. (2005)*

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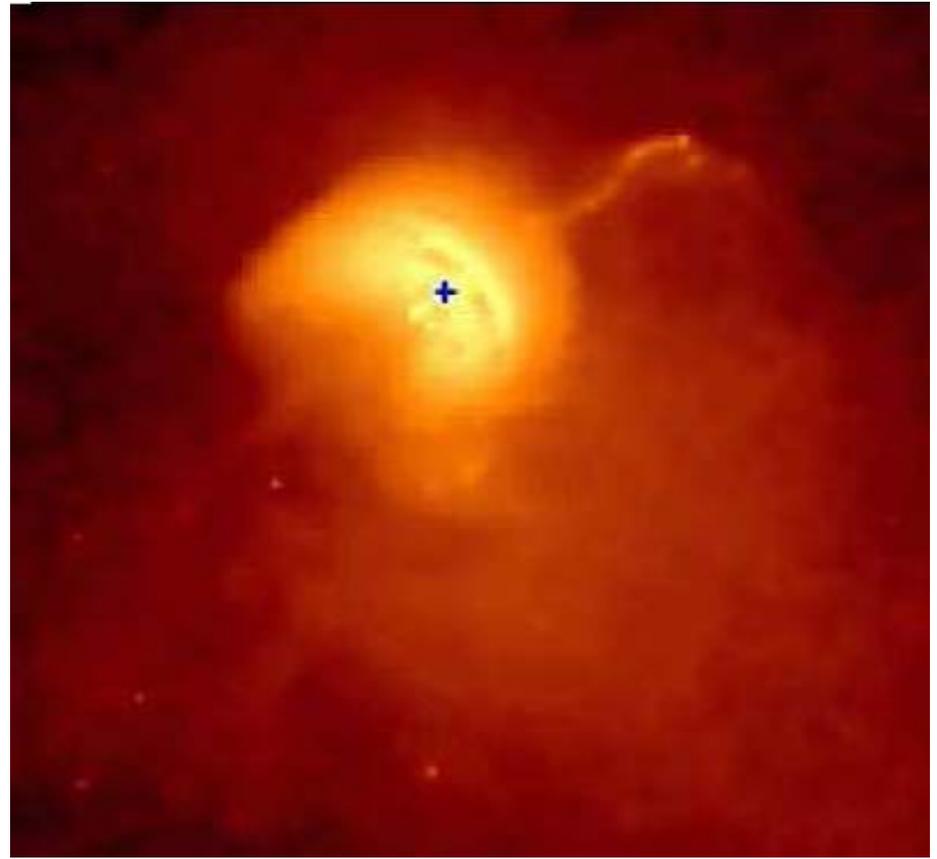
## Rotation-Powered Pulsars and Isolated Magnetic Neutron Stars

- ❑ Bewildering complexity of observed behavior in rotation-powered pulsars (*e.g.*, *Slowikowska*)
- ❑ Increase in complexity of theory required in order to “keep up” (*Harding, Dyks, Hirotani, Petrova, Petri*)
- ❑ Younger generation has new tools (*e.g.*, *Rossi XTE, XMM-Newton*, more powerful computers for numerical simulations) and new courage to tackle this difficult problem (*e.g.*, *Spitkovsky*)

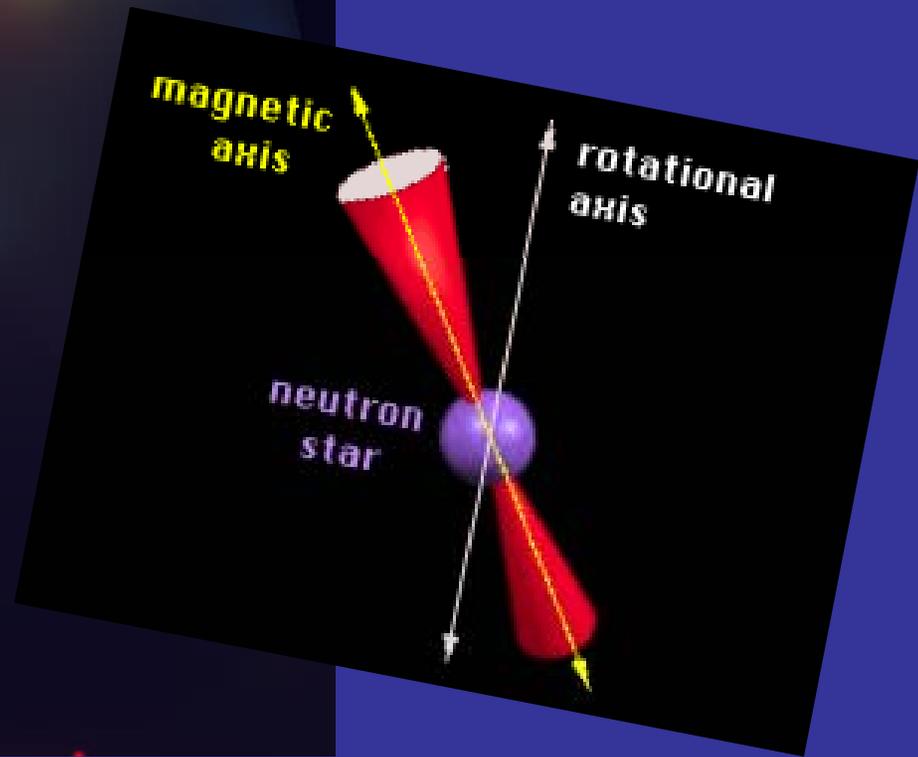
## Rotation-Powered Pulsars and Isolated Magnetic Neutron Stars

- ❑ Double pulsar is providing spectacular laboratory for study of GR, pulsar emission properties, neutron star EOS (*Possenti*)
- ❑ Isolated neutron stars are providing new laboratory for study of physics of strong magnetic field (*Lai, Niemi*)
- ❑ Beautiful *Chandra*, *Integral*, and H.E.S.S. images of pulsar wind nebula – have led to confirmation of many theoretical ideas and important new insights (*Hermann, Hermsen, de Jager*)

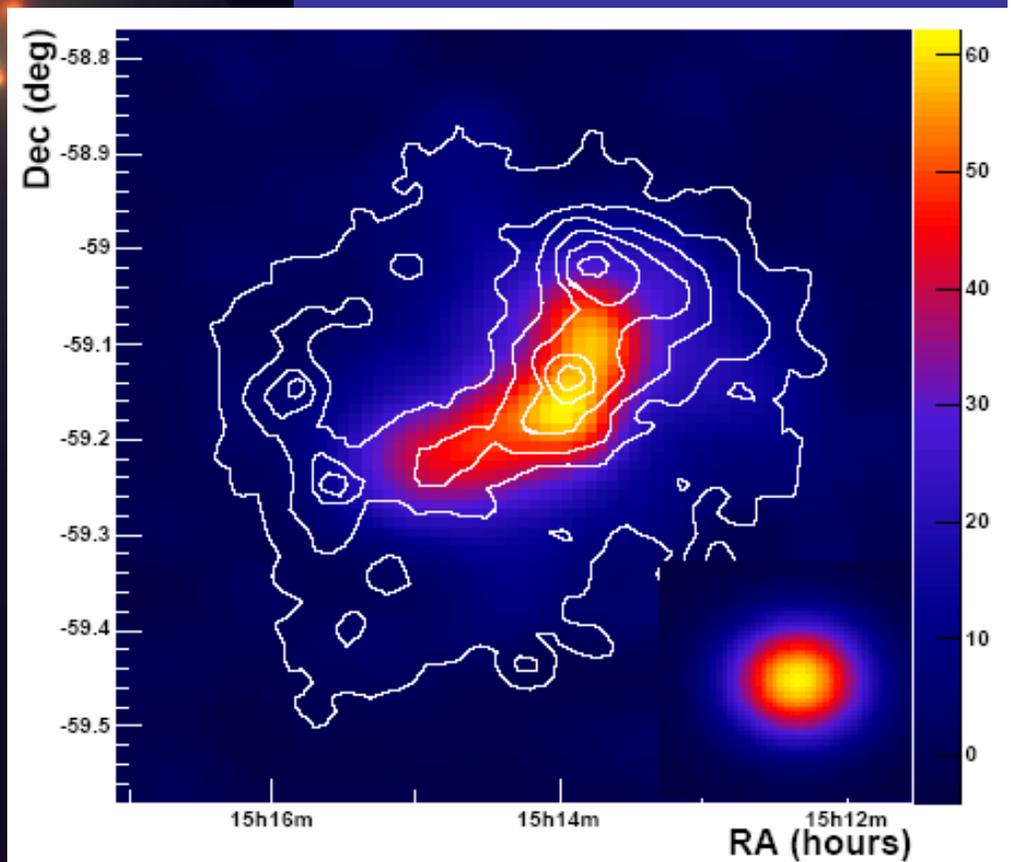
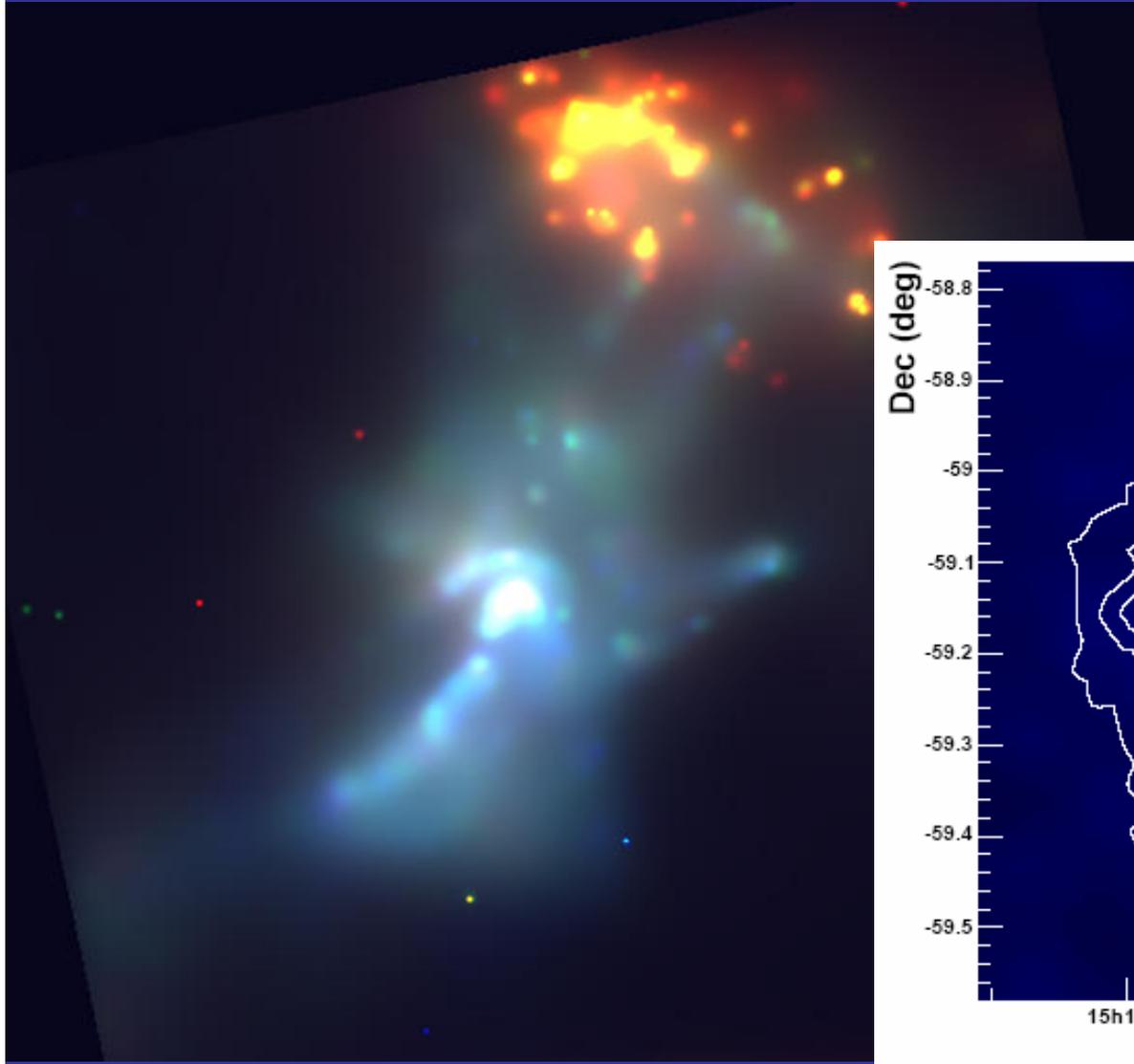
## Crab and Vela PWN



## PSR B1509-58...



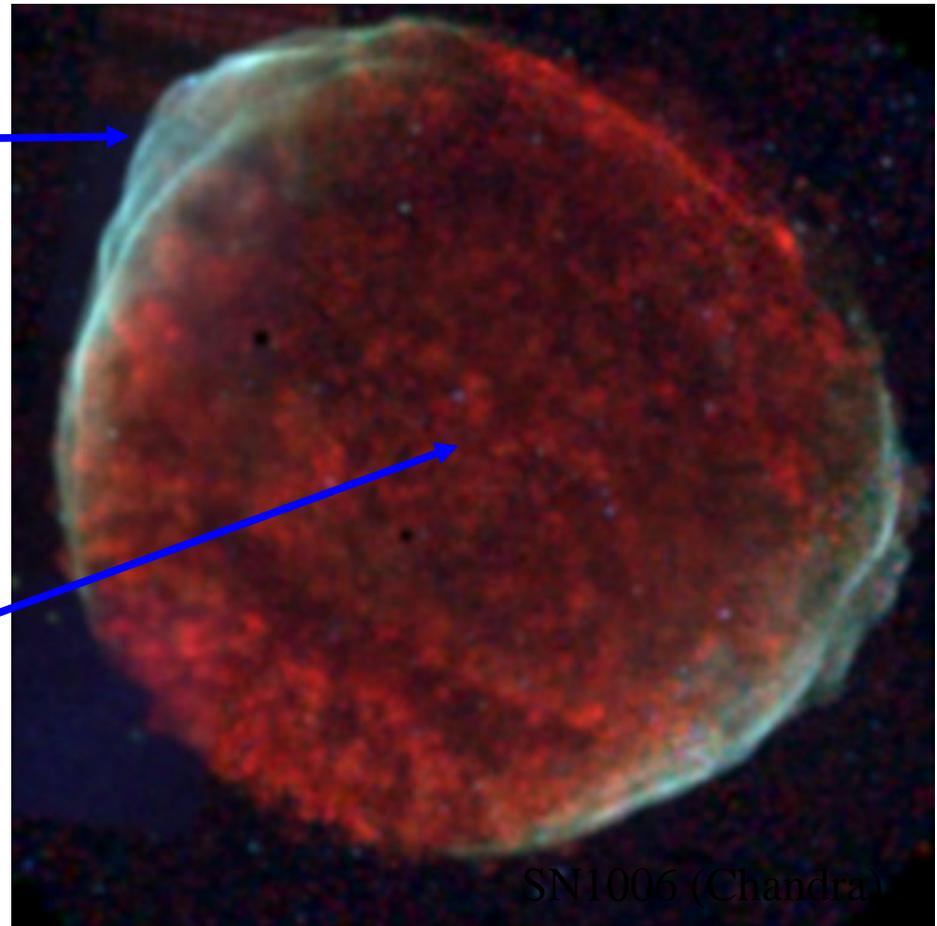
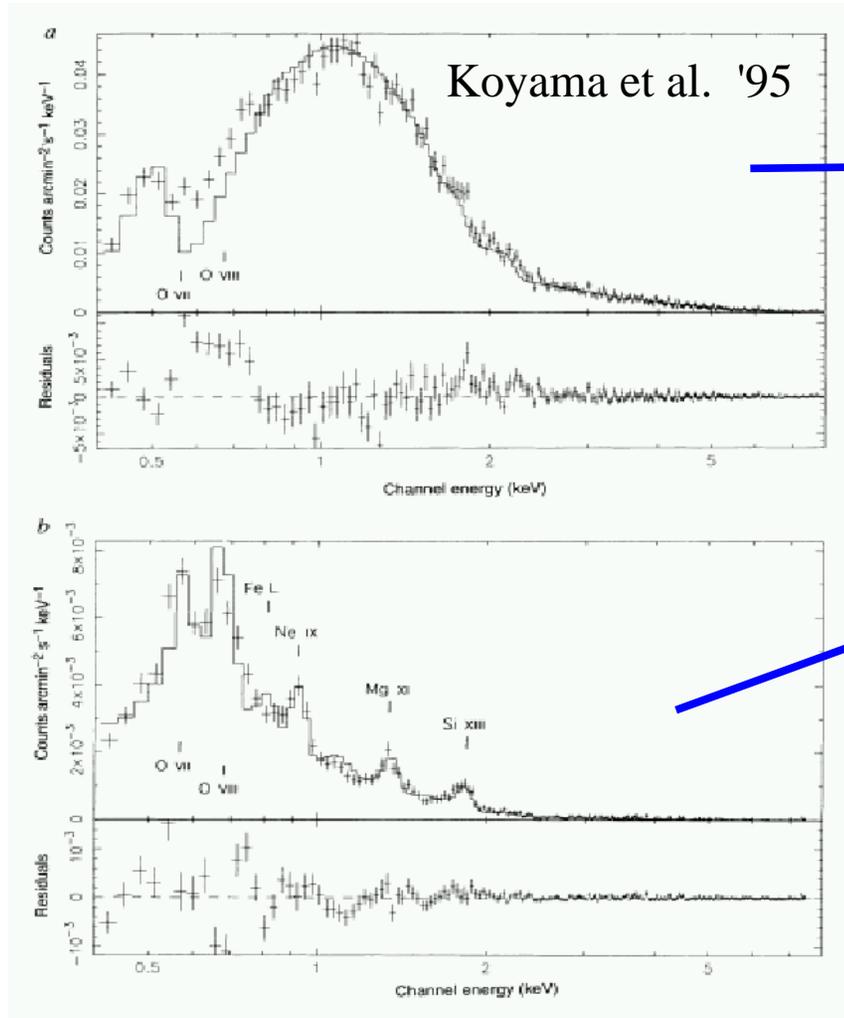
## ...Jet Dominated Flow



## Particle Acceleration in Astrophysical Shocks

- ❑ Important features of particle spectrum are robust – thank goodness! (*Ellison*)
- ❑ Theoretical progress is continuing (e.g., PIC numerical simulations), but fully self-consistent models not yet achieved (*Ellison, Rieger, Gabici*)
- ❑ Relativistic jets (e.g, GRBs) pose daunting problems (*Ellison, Spitkovsky*)
- ❑ *Chandra* images have provided new insights into particle acceleration in SNRs (*Vink, Drury*)

# Evidence for Efficient CR Acceleration



## Thank You

- ❑ Local Organizing Committee:
  - ❑ Tomasz Bulik
  - ❑ Michal Frackowiak
  - ❑ Bronislaw Rudak (chair)
  - ❑ Agnieszka Slowikowska
  - ❑ Janusz Ziolkowski
  
- ❑ Nicolaus Copernicus Astronomical Center, Torun
- ❑ Faculty of Mathematics and Computer Science,  
Nicolaus Copernicus University
- ❑ City of Torun

# Thank You

## – and Please Invite Us to Come Back Soon!

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