Observations of Supernova Remnants with H.E.S.S.

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Outline

- Galactic Observations
  - Pulsars & pulsar nebulae
    - Crab nebula
    - PSR B1706
    - Vela
    - PSR B1259
  - Supernova remnants
    - SN1006
    - RX J1713-46
  - Galactic centre
The H.E.S.S. Experiment

- **Array of Cherenkov Telescopes**
  - Situated in Namibia, southern Africa
  - 4 telescopes, 120 metre separation

- **Telescope Structures**
  - 4 x 10^6 m^2 reflector dish area
  - 15 metre focal length

- **Camera**
  - 960 photomultiplier tubes
  - Fast electronics
  - Wide field of view (5°)

- **Performance**
  - 100 GeV energy threshold
  - Sensitivity 1% of Crab flux in 25 hours
  - Energy resolution ~16%
Data analysis with H.E.S.S.

- **Raw data**
  - Pixel calibration A
  - Pixel calibration B

**Data prep.**

- Select image pixels
  - determine
  - Hillas parameters

  - **Shower reco**

**Shower parameters**

- Shower parameters from fit of pixel intensities

**Spectral data points**

- MC A
- MC B

- **Spectral fit**

**Spectrum**

- Likelihood fit to deconvolute spectrum
Comparison with Monte Carlo

- Good agreement
  - MC simulations
  - $\gamma$ ray excess events
- Narrow PSF
  - $< 0.1^\circ$
Data quality checks

PMT currents check
pointing better than 20"

Imaging & absolute calibration:
muon rings
Crab Nebula

- **Observations in 2003**
  - 2.8 hours of data
  - 3 telescope stereo data
  - 46° Zenith Angle
  - 350 GeV energy threshold

- **Strong detection**
  - $6.68 \gamma$/min., 53 $\sigma$
  - Flux, spectrum consistent with other measurements
  - Consistent with point source
SN 1006

CANGAROO

3.8 m telescope
+ conference proceedings
SN 1006

H.E.S.S.

18 hours 2 Telescope data, 2003
No signal seen
RXJ 1713.7-3946

CANGAROO

Kifune ICRC 2003

H.E.S.S.

18 hours 2 telescope data 2003

>20σ, clearly extended
Hard cuts, no background subtraction

18 h 2003 data
RX J1713 Spectrum

Index 2.2$\pm$0.07$\pm$0.1

Index 2.84$\pm$0.15$\pm$0.20

preliminary
TeV gamma rays from GC

17 hours 2 telescope data
> 10σ
Point source (size < 3' or 7 pc)
Best guess (?)
Sgr A East SNR
\[ \rho \sim 10^3 / \text{cm}^3 \]

Sgr A East
Chandra & Radio
NASA/G.Garmire (PSU)
F.Baganoff (MIT)
Yusef-Zadeh (NWU)
Galactic center spectra

- **CANGAROO**
  - Slope $-4.6 \pm 0.5$
  - Flux $\sim 1$ Crab!
  - H.E.S.S. should see it in minutes

- **H.E.S.S.**
  - Slope $-2.2 \pm 0.09$
  - Flux 6% Crab

- **Whipple**
  - Flux marginally consistent

![Graph showing energy spectra with data points for CANGAROO, H.E.S.S., and Whipple.]
PSR B1259-63

Model: Ball & Kirk 2000

Complex time dependence depending on alignment of pulsar and stellar wind

CANGAROO
Kawachi et al. 2004

Integral flux (>1 TeV) (ph/cm²/sec)

Days from the periastron
PSR B1259-63

H.E.S.S. preliminary

- Strong detection
  - ~ 9σ pre-periastron
  - ~ 6σ post-periastron
  - Flux ~5% Crab
  - Spectral Index 2.8±0.3 (stat)

oversampled skymap

~ 10 days before periastron (Feb./March)
- **New unidentified TeV source**
  - 39 hours, >13 $\sigma$ detection
  - Looks extended at 0.2$^{\circ}$ level, steady flux
  - Index $\sim$2.2, $\sim$10% Crab
## Galactic sources with H.E.S.S.

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<td>&gt; 50 $\sigma$</td>
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<td>10 $\sigma$, 5% Crab</td>
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<td>VHE J1303</td>
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<td>13 $\sigma$, 10% Crab</td>
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PSR 1706-44

- Detected by Durham and CANGAROO-I,II
  - Kifune et al. 1995
  - Chadwick et al. 1998
  - Kushida et al., ICRC 2003

- H.E.S.S.
  - 14 h 2-telescope data
    - Commissioning phase
  - No signal seen
    - Upper limit 3% of Crab flux

Diagram showing integral flux vs. energy with Durham, Cangaroo, and Crab Flux data points and an upper limit of 3% of Crab flux for H.E.S.S. assuming a point source.
- CANGAROO source 0.13° off pulsar
- H.E.S.S. limits similar for both CANGAROO and pulsar location

**Integral Flux**

- Durham Chadwick et al. 2000
- CANGAROO Yoshikoshi et al. 1997
- H.E.S.S. 2004 assuming point source
Galactic center: PMT currents