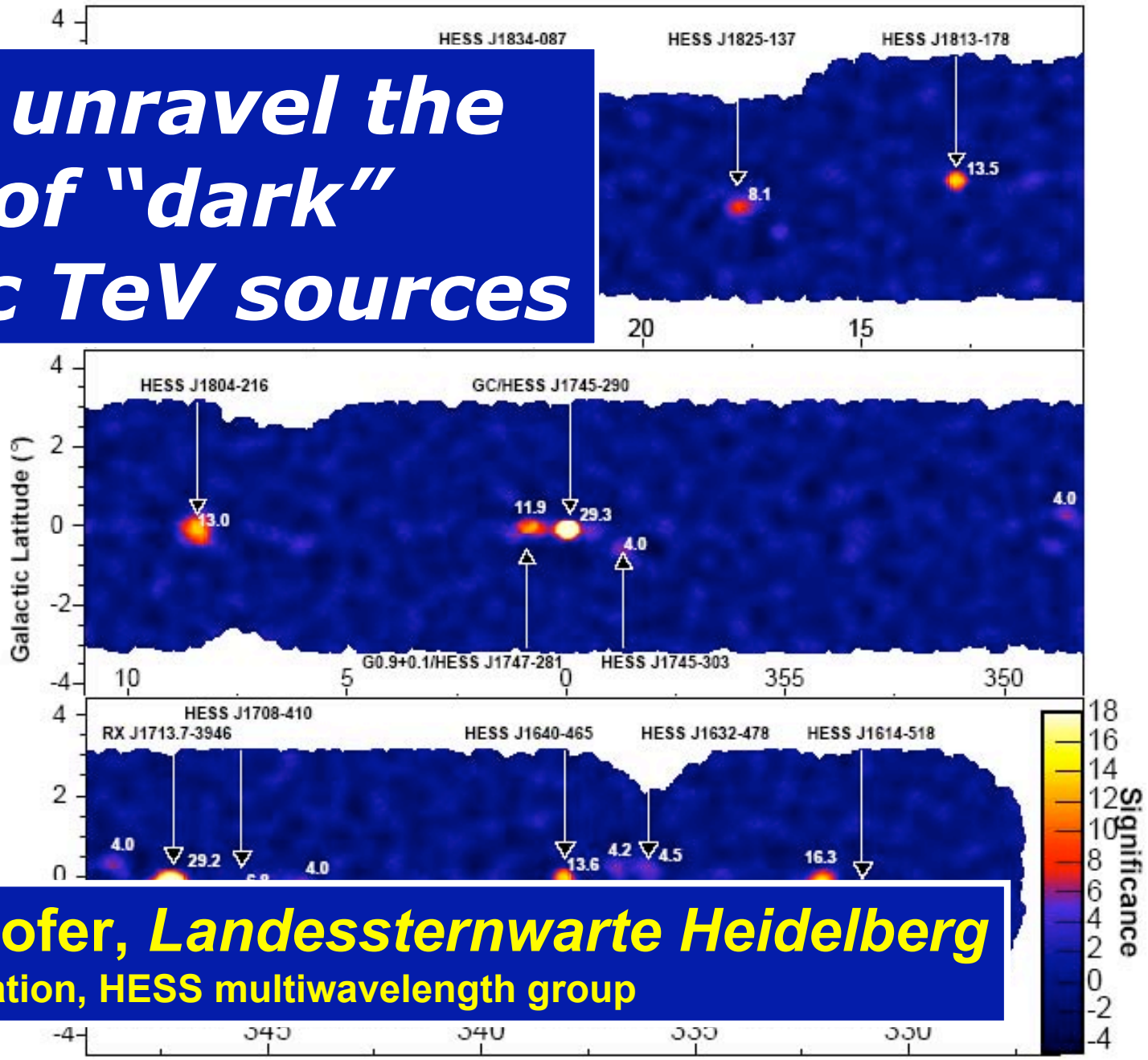
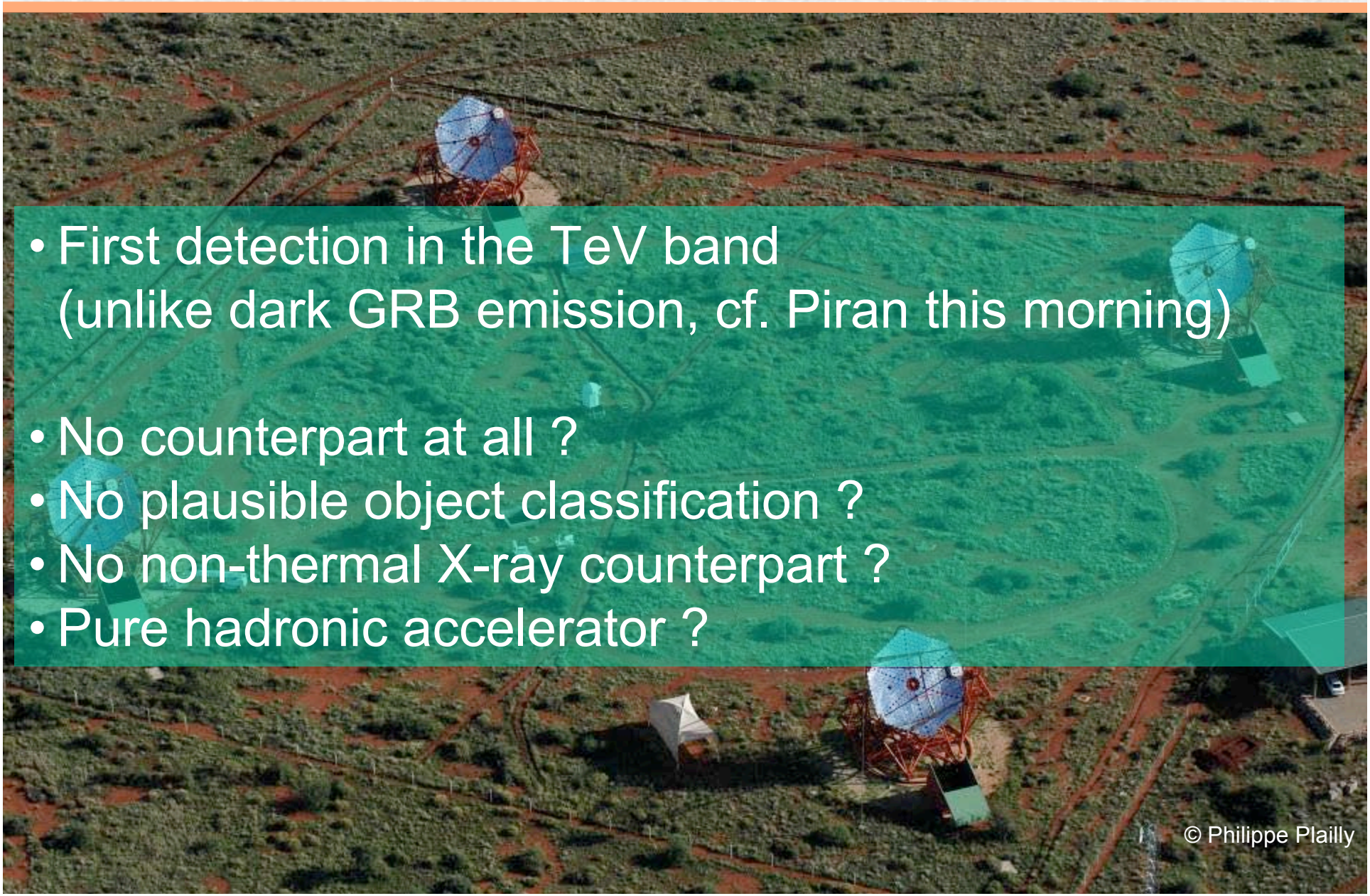
How to unravel the nature of "dark" Galactic TeV sources



Gerd Pühlhofer, *Landessternwarte Heidelberg*
H.E.S.S. collaboration, HESS multiwavelength group

H.E.S.S Galactic Plane Survey

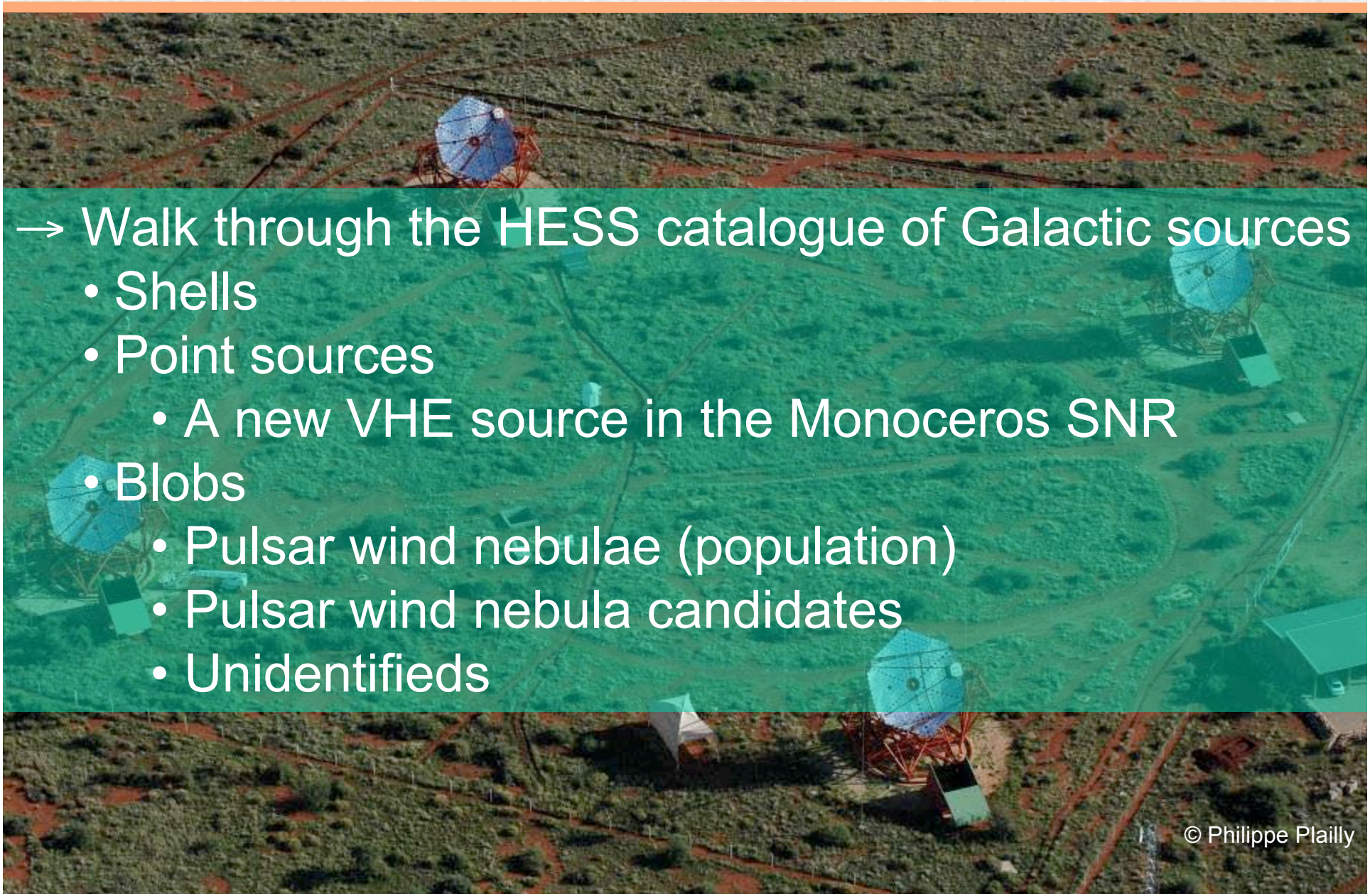
What is a “dark” TeV source?



- First detection in the TeV band
  (unlike dark GRB emission, cf. Piran this morning)

- No counterpart at all ?
- No plausible object classification ?
- No non-thermal X-ray counterpart ?
- Pure hadronic accelerator ?

Outline



→ Walk through the HESS catalogue of Galactic sources

- Shells
- Point sources
  - A new VHE source in the Monoceros SNR
- Blobs
  - Pulsar wind nebulae (population)
  - Pulsar wind nebula candidates
  - Unidentifieds

The HESS catalogue of Galactic sources

l = +65º

l = ± 30° published in ApJ 636, 777, 2006

l = 295º

HESS GP survey

RX J1713-3946

Shell-type SNR

Easy identification through morphology

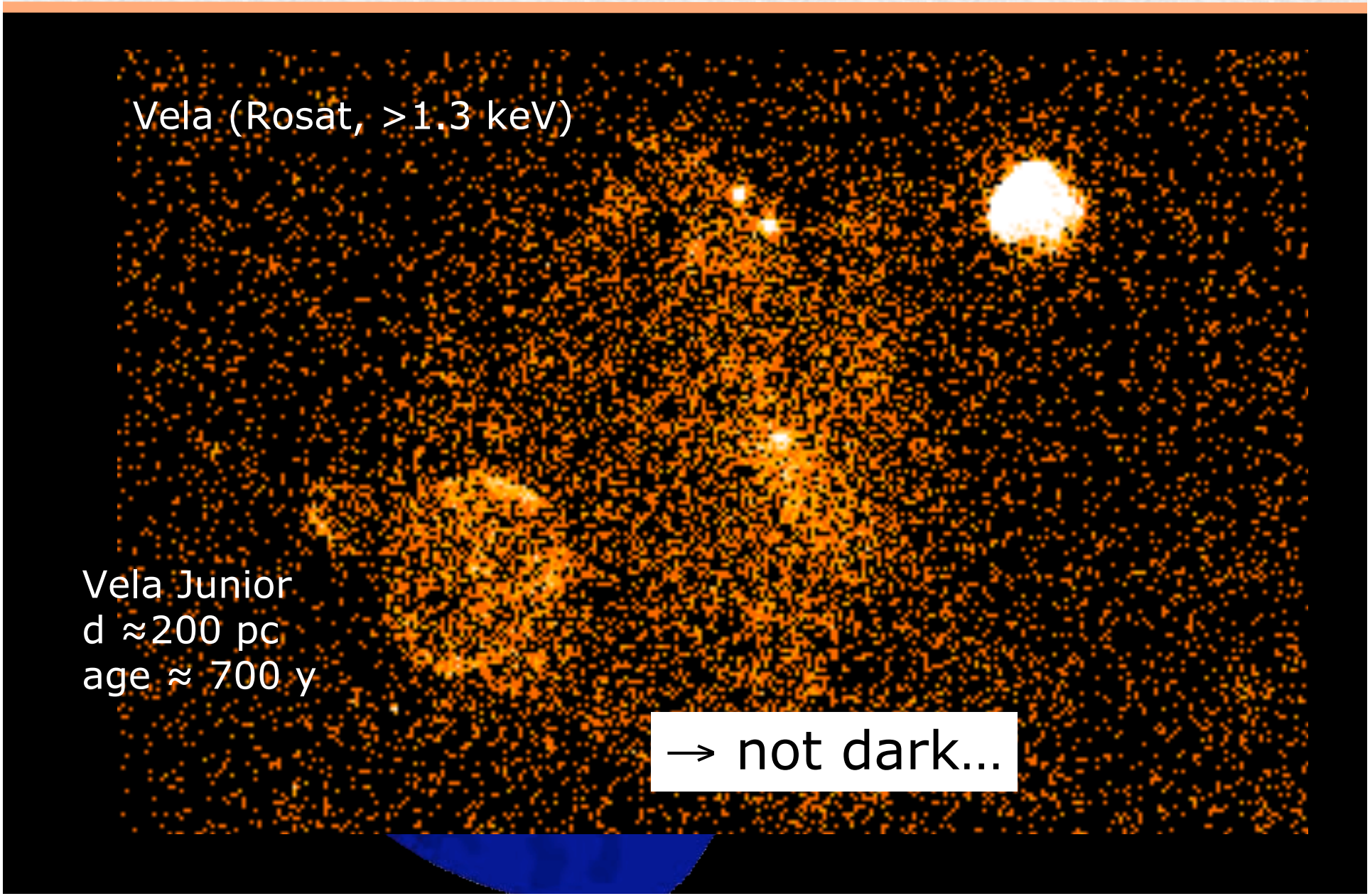
(VHE alone, but better with X-rays)

l = 295º

Vela Jr

l = 165º

Shell-type SNR



The HESS catalogue of Galactic sources

l = +65º

l = ± 30° published in ApJ 636, 777, 2006

l = 295º

HESS GP survey

LS 5039

G0.9+0.1

GC ?

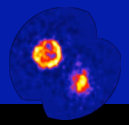
PSR B1259-63

VHE point sources

position + variability

VHE position + size limit, SED

A new VHE source in the Monoceros/Rosette Nebula complex



l = 295º

HESS J0632+058

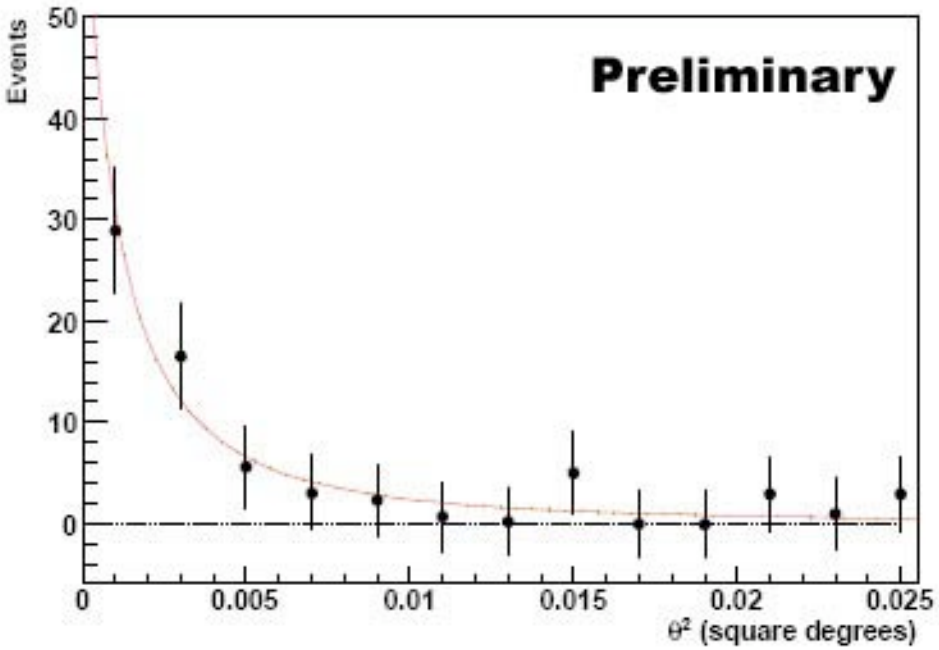
l = 165º

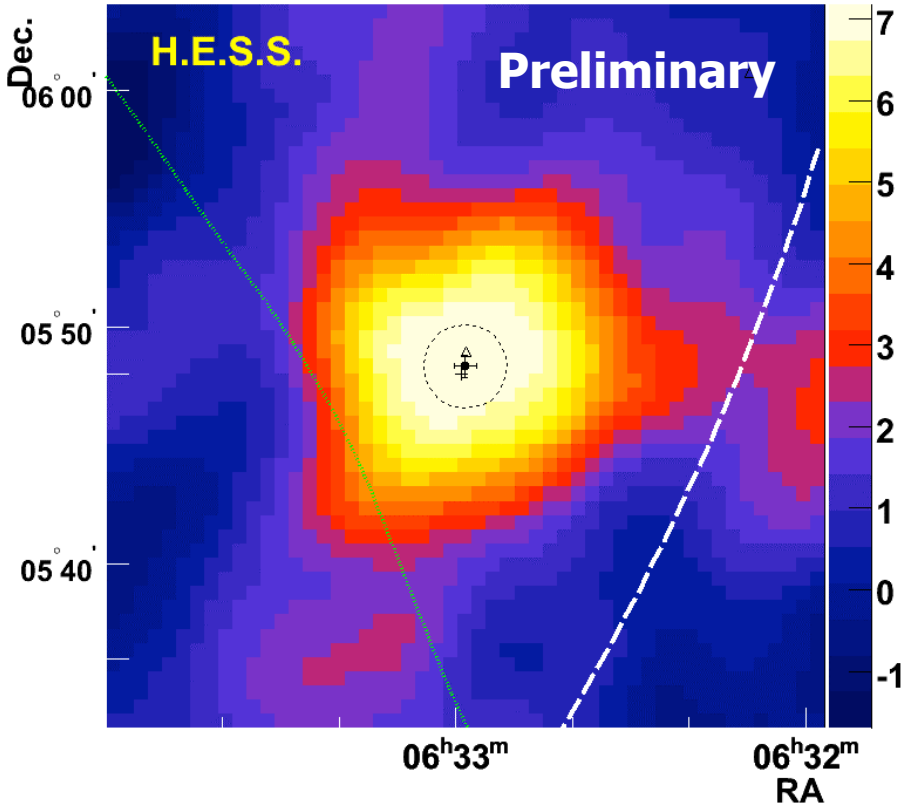
Crab

HESS J0632+057

- 7.1σ, 5.3σ post-trial
- 2.6% Crab Flux
- Point-like source
- Limit on rms size of emission region: 2’

Check out HESS source of the month Feb ‘07





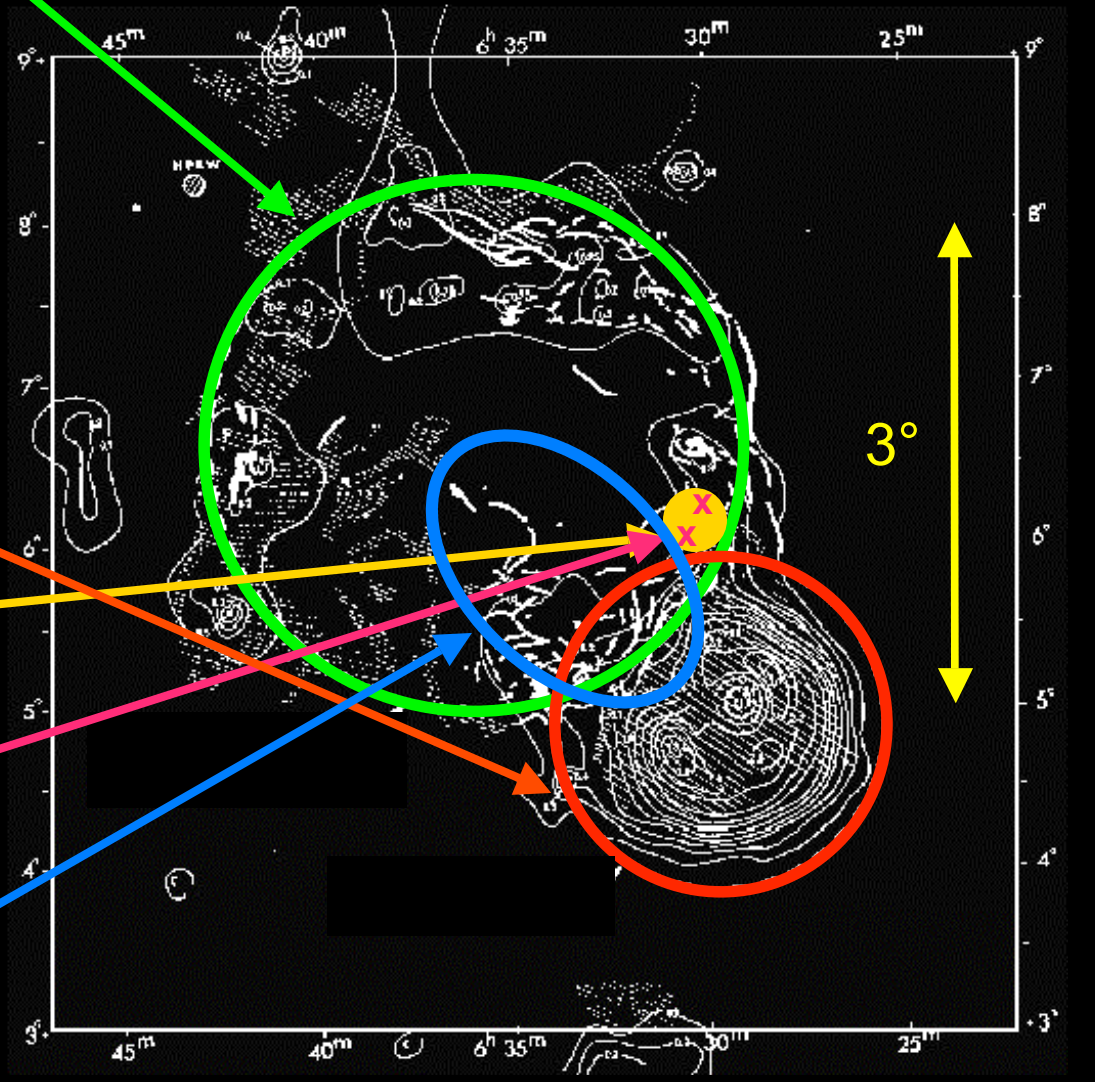
The Monoceros Loop SNR

- 3° diameter ring seen in Hα
- 30-150 kyrs old
- Distance ~1.5 kpc
- Interaction with the Rosette nebula?

- HESS J0632+058

- weak RX source
- Be Star

- 3EG J0634+057

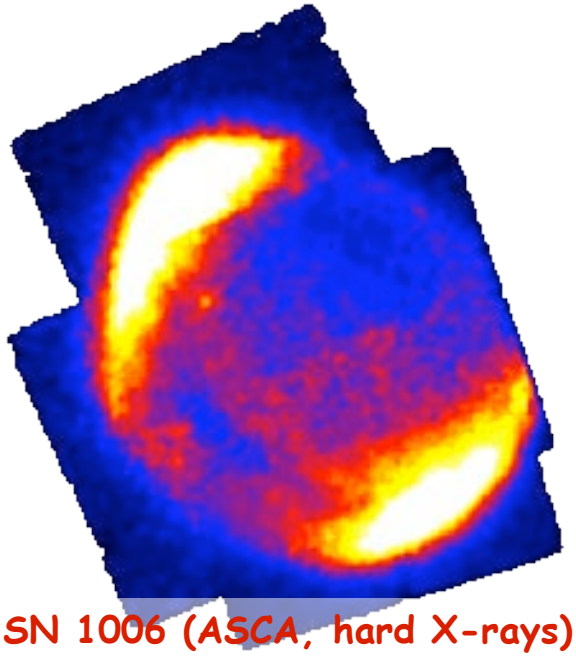


→ Dark? Identified? At least: no confirmed source type

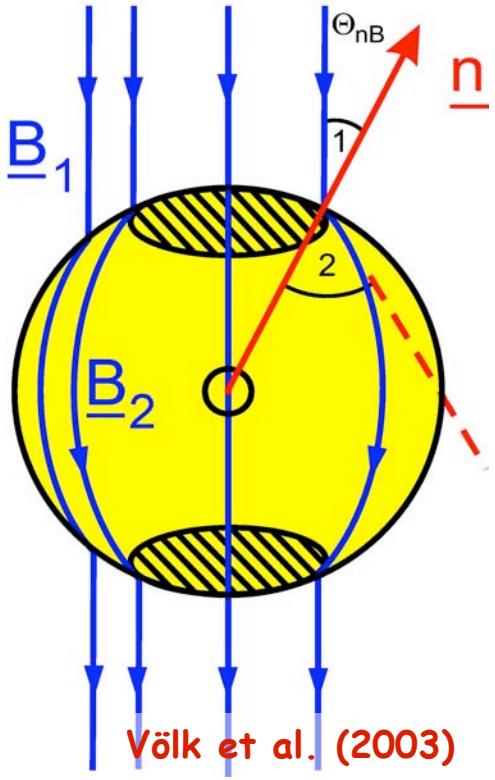
What about VHE blobs in radio SNR shells?

- Several extended HESS sources coincident with radio SNR shells
- VHE morphology does not quite match shell morphology
- No energetic radio pulsars (yet) detected

→ Partial injection of particles into shell?

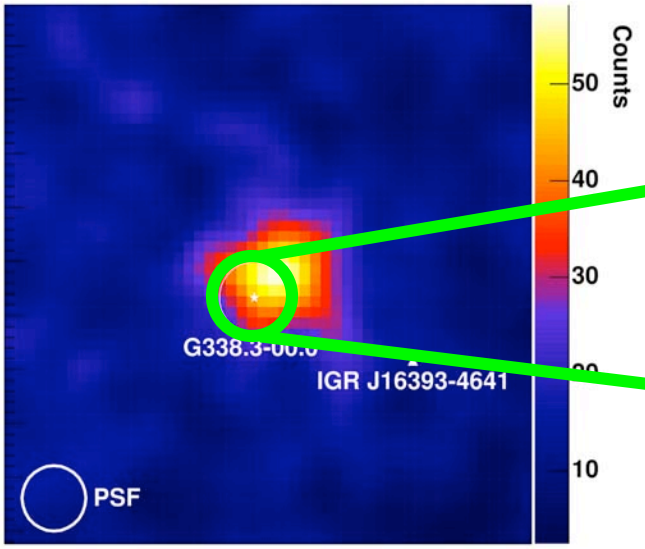


SN 1006 (ASCA, hard X-rays)

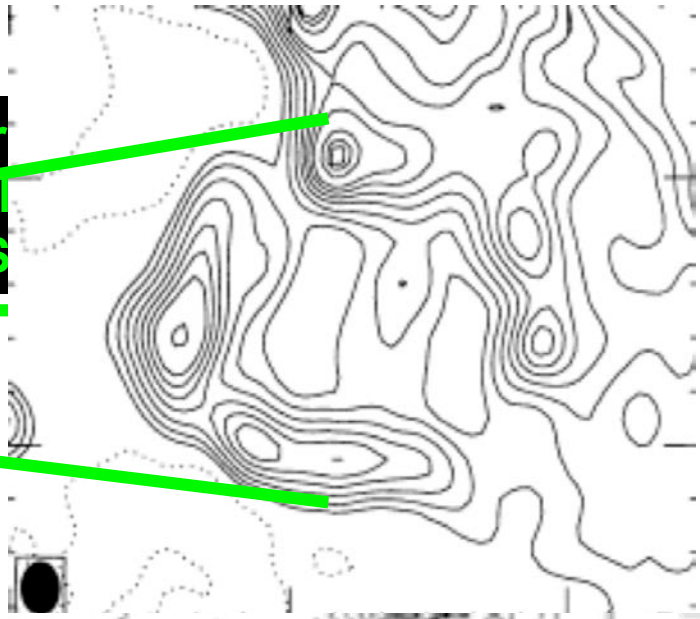


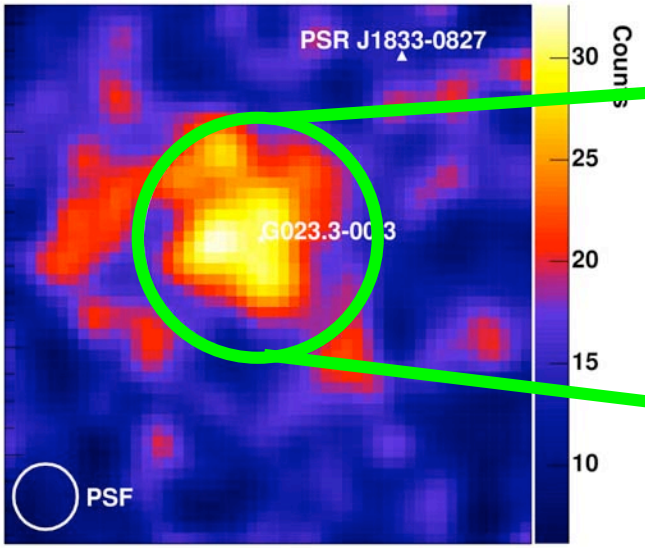
Völk et al. (2003)

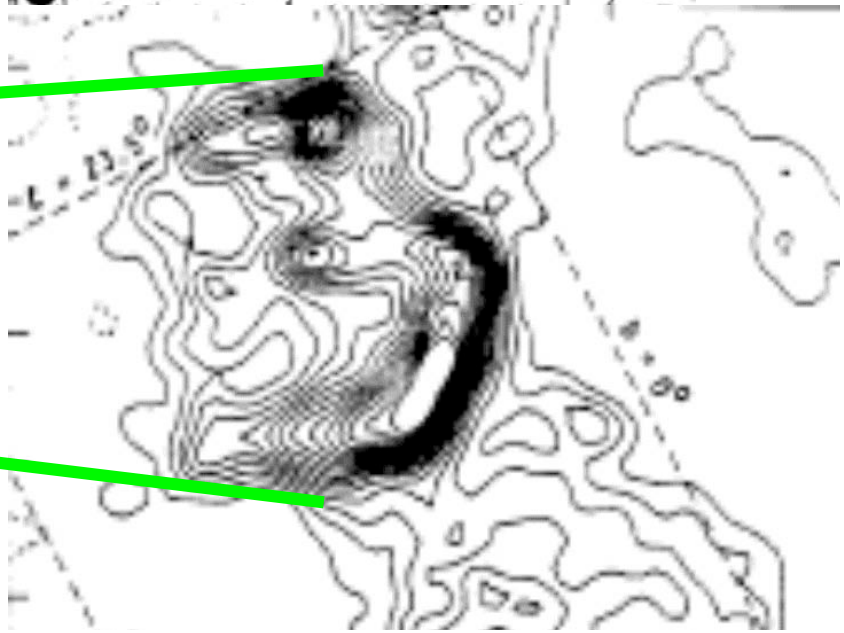
HESS sources at SNR shells



- Was "dar
- SNR publ
  after HES







X-ray follow-up program on unidentified H.E.S.S. sources

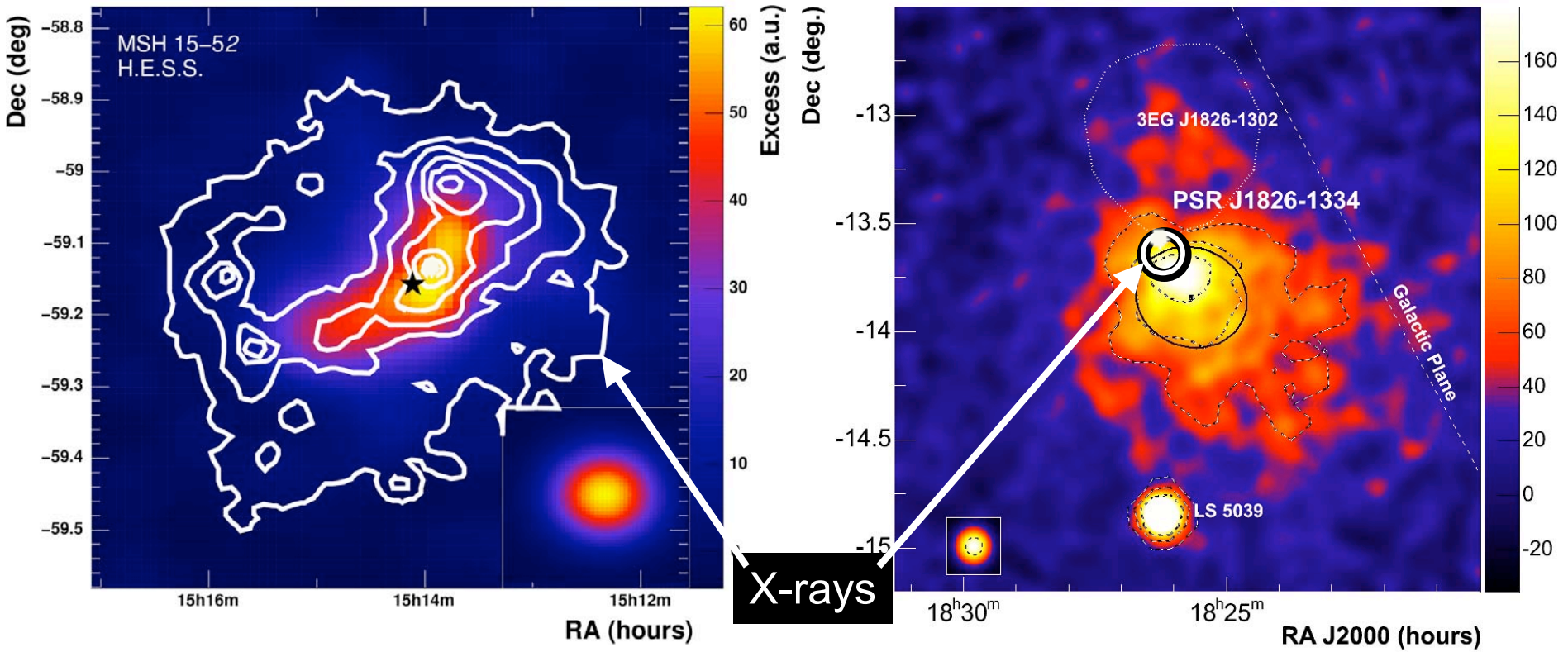
- Aim: identification of "dark" sources and sources with yet unclear positional coincidences
- Since XMM AO 4 (2004), 15 proposals accepted for XMM-Newton, Chandra, and Suzaku
- Program carried out by H.E.S.S. multiwavelength group

X-ray results for VHE blobs at SNR shells

- No evidence for X-ray SNR shell emission
- X-ray PWN candidates (morphology, spectrum)
- Without radio pulsars (yet)

→ See S. Funk's talk at the end of this session

TeV PWN: MSH 15-52 vs. HESS J1825-137



MSH 15-52

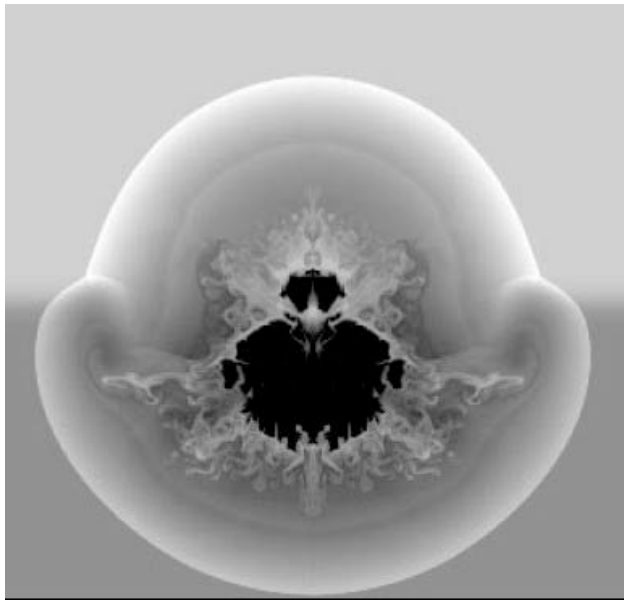
HESS J1825-137

TeV-Xray identification based mostly on morphology (and SED)

TeV-Xray identification based to a large extend on TeV spectral imaging!

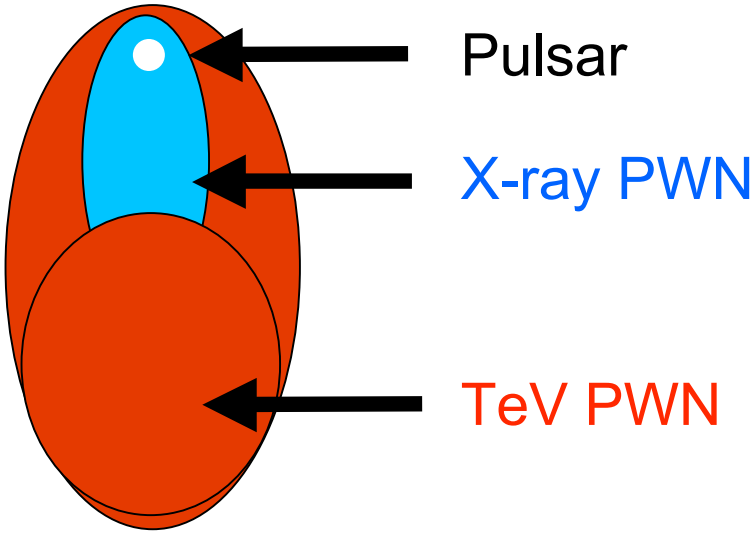
Asymmetric TeV Pulsar Wind Nebulae

"Crushed Plerions"



Blondin et al., 2001

Offset TeV PWN



+ IC electron lifetime larger than synchrotron lifetime
+ larger particle injection efficiency in the past

Or pulsar proper motion?

Electrons far off the acceleration site
→ X-ray detectability?

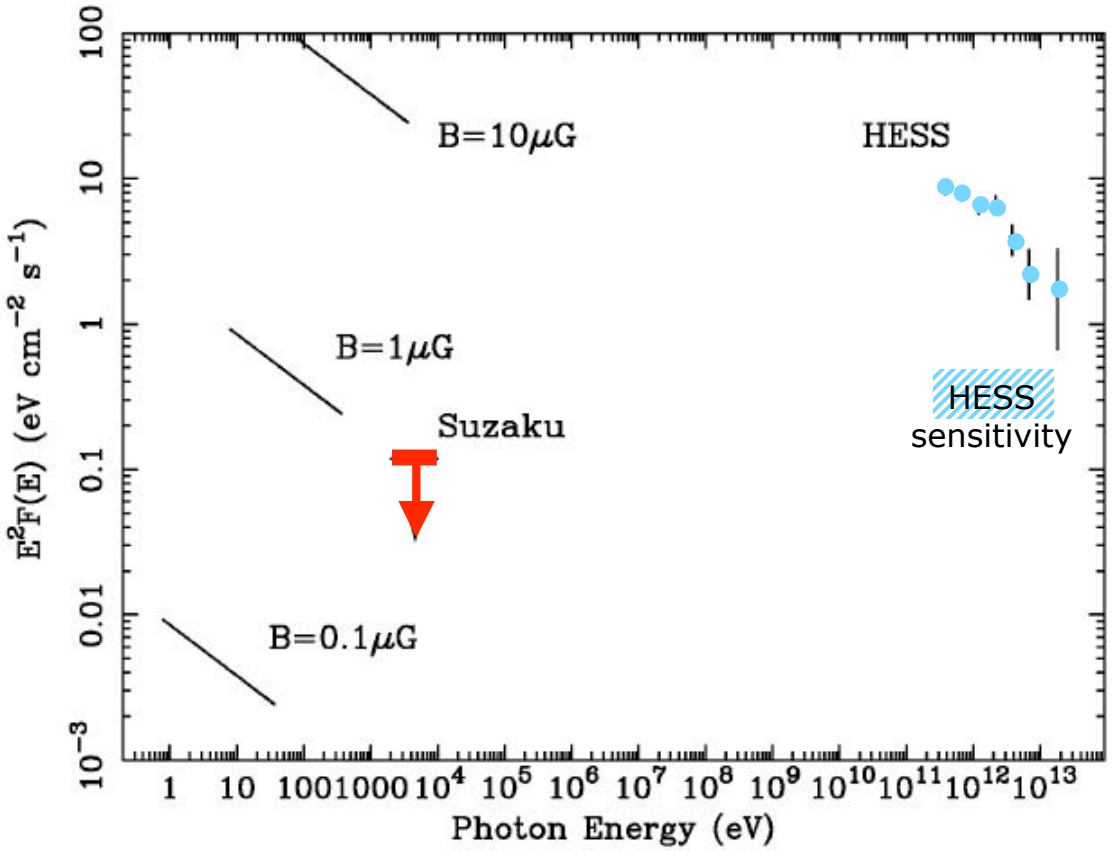
Without X-rays?

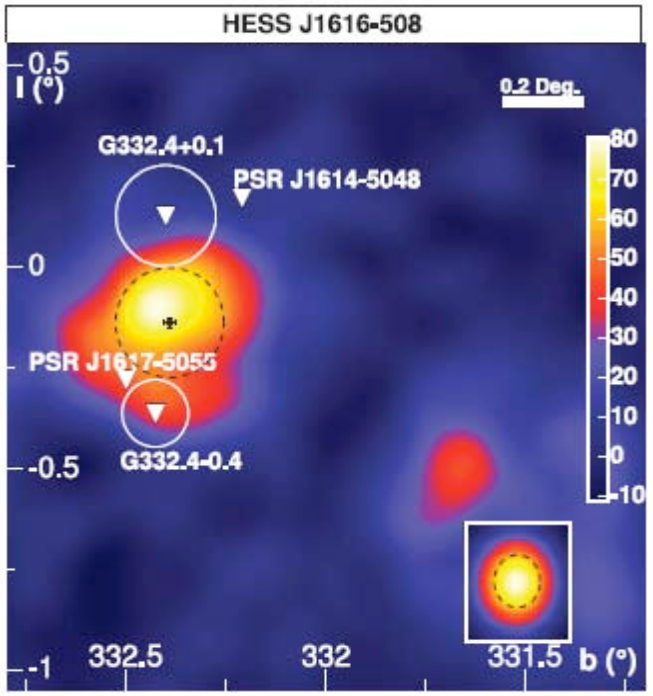
- Few cases with likely TeV-source / pulsar association (no X-ray PWN yet)
- Individual source identifications need confirmation through multiwavelength picture

→ What X-ray sensitivity do we need to detect

  - the PWN at the pulsar candidate?
  - the offset TeV PWN (low B-field)?

HESS J1616-508: a "dark" TeV source?

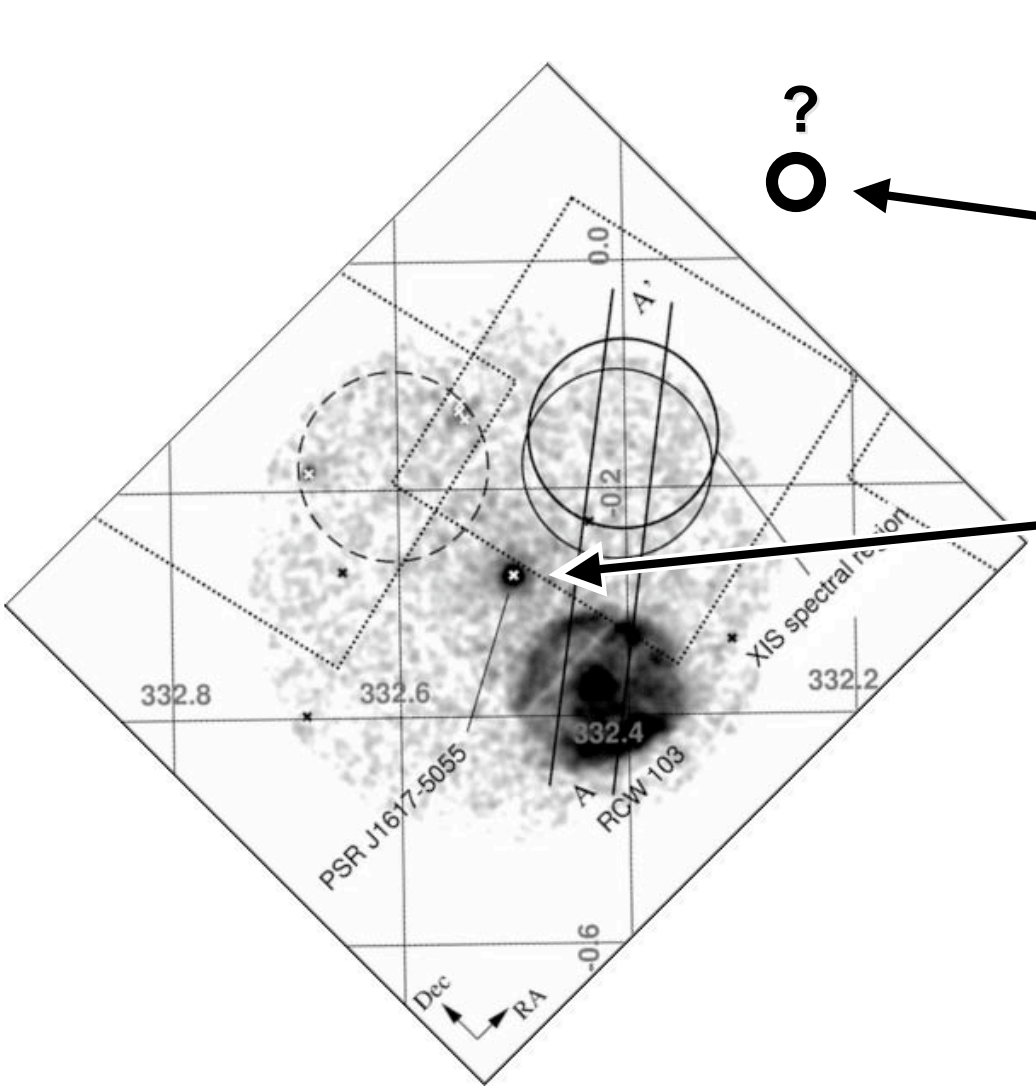




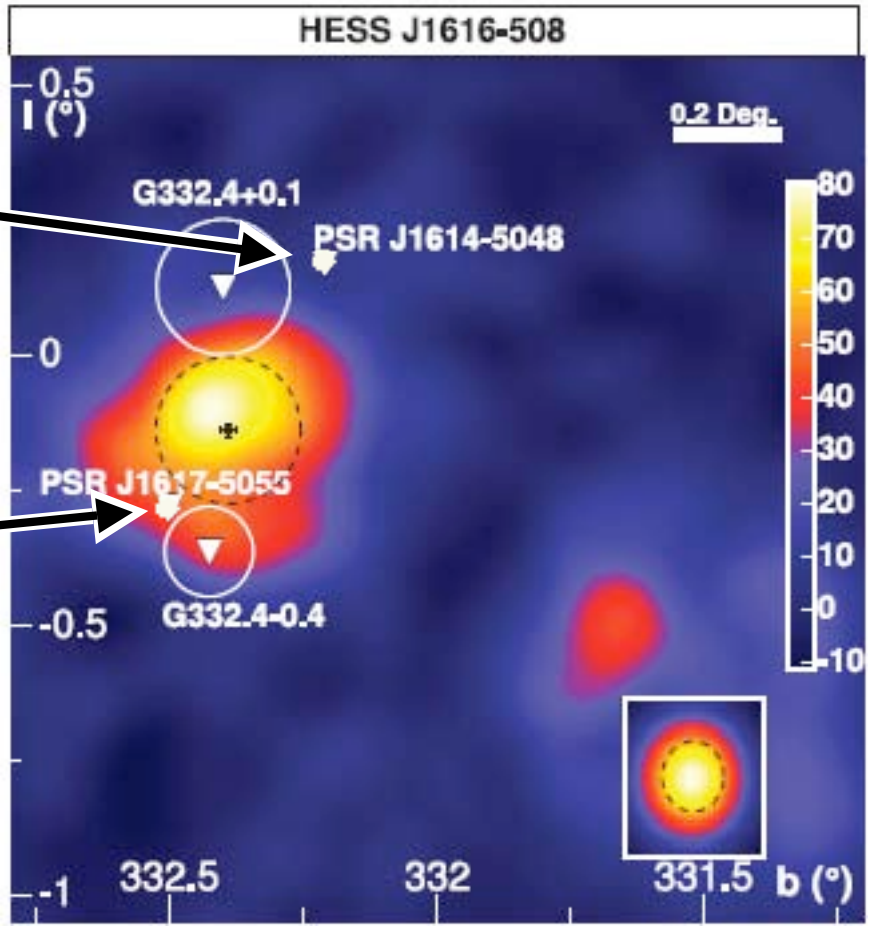
"Evidence for a dark particle accelerator"

Matsumoto et al., astro-ph/0608475

HESS J1616-508 : a “dark” TeV source?



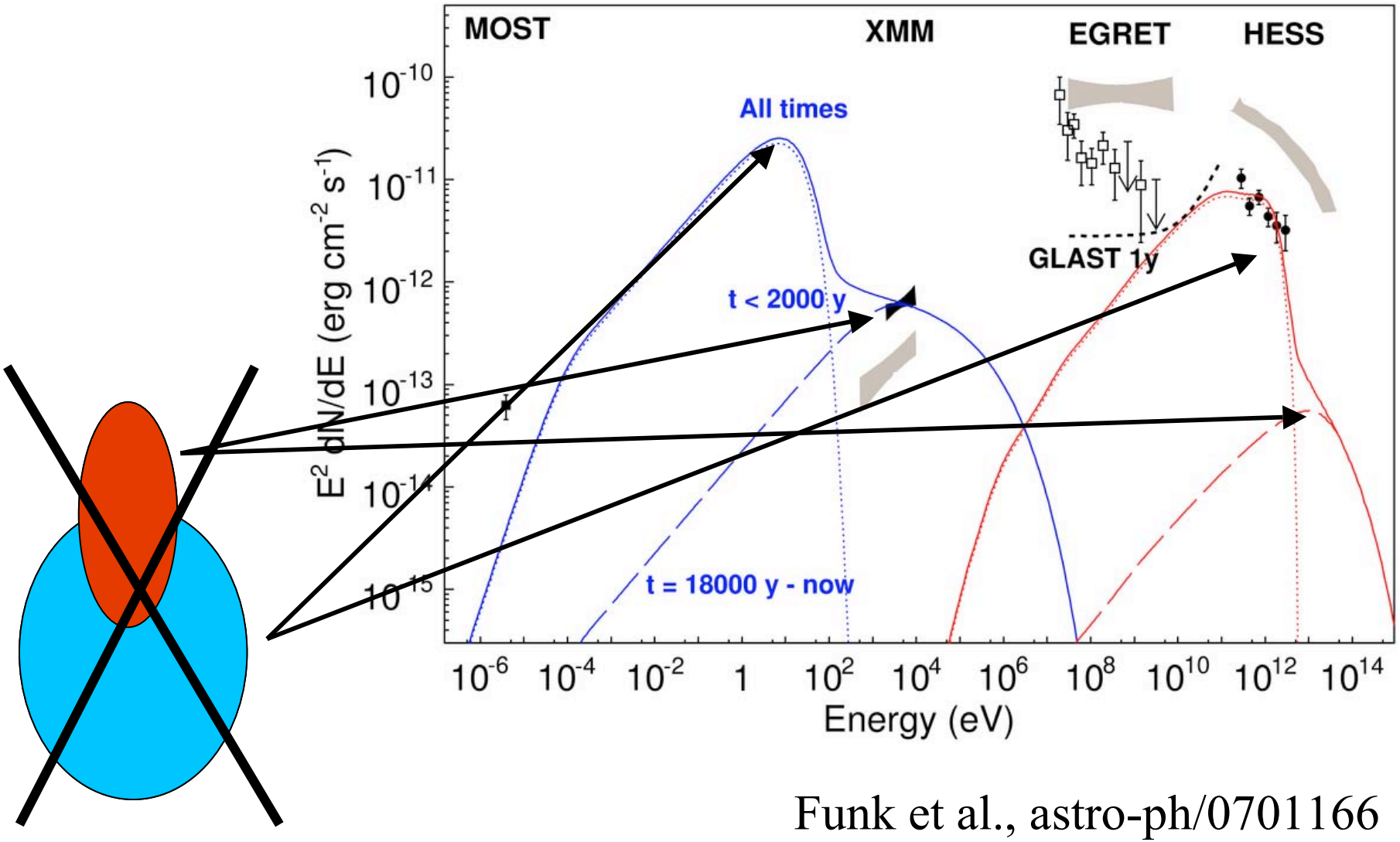
?



Matsumoto et al., astro-ph/0608475

Multiple association, needs to be tested

HESS J1640-465, a similar case?

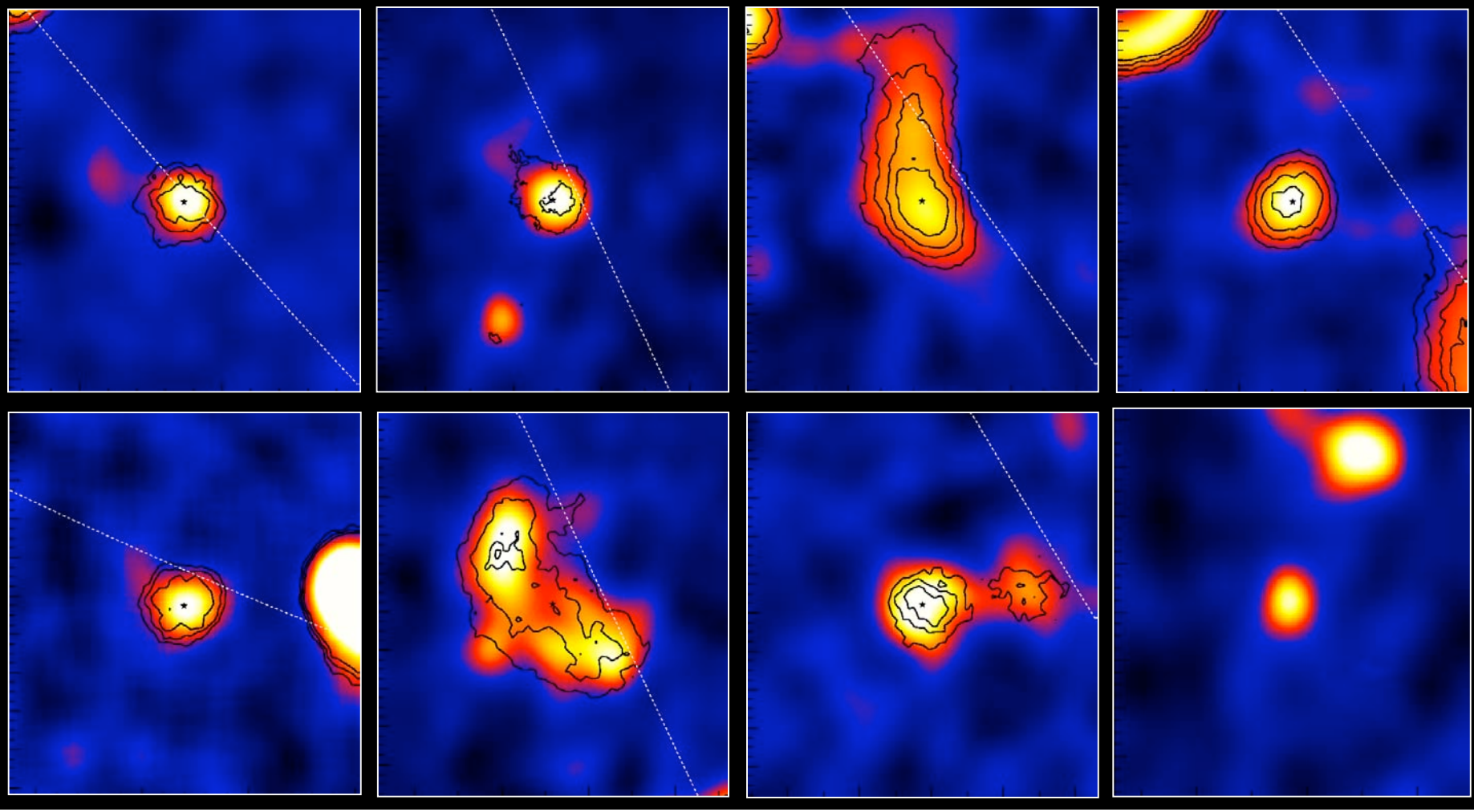


Funk et al., astro-ph/0701166

And the rest?

Besides shells, easy (?) point sources and PWN candidates:

What about all the other blobs?



HESS J1303-631: the first dark TeV source or PWN with distance problem?

PSR J1303-6305:

d=15.8 kpc
(Taylor & Cordes 1993)

d=6.6 kpc
(using NE2001, Cordes & Lazio 2002)

initial spin-down power:
few 10^{38} erg/s

characteristic spin-down time:
500-1000 years

d=6.6 kpc
-> $E_{electrons} \sim 1.5\ 10^{47}$erg
< $E_{total,pulsar}$

Summary

- The H.E.S.S. Galactic plane survey has revealed lots of so far unidentified TeV sources
- Identification of these sources using X-ray detectors is promising (but consider B-field distribution)
- Are there “dark” sources (i.e. w/o non-thermal emission in lower wavebands)? Perhaps many of them are PWN
- Finding these sources first with TeV imagers seems reasonable (B-field low, $F_{TeV}/F_X >> 1$)
- Not covered in this talk:
  - “Pure” hadronic accelerators: search for CO matches (cf. Galactic center region)
  - HESS J1023-575: gamma rays from stellar winds ?