H.E.S.S. Observations of the Large Magellanic Cloud

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for the H.E.S.S. Collaboration

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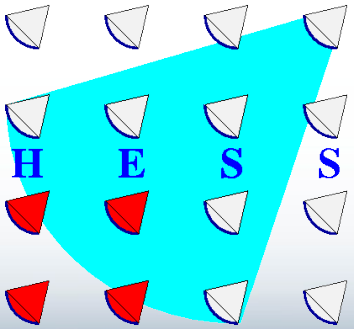
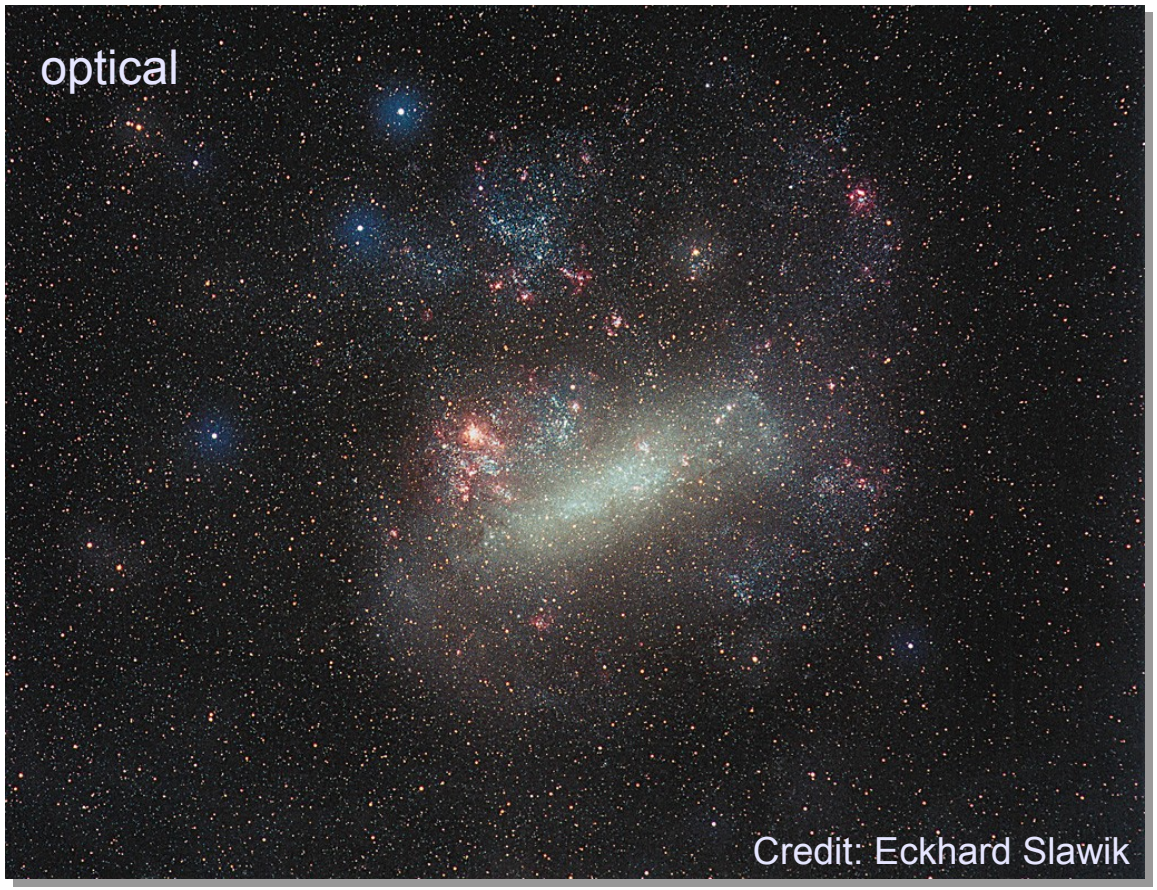
saclay



Motivation

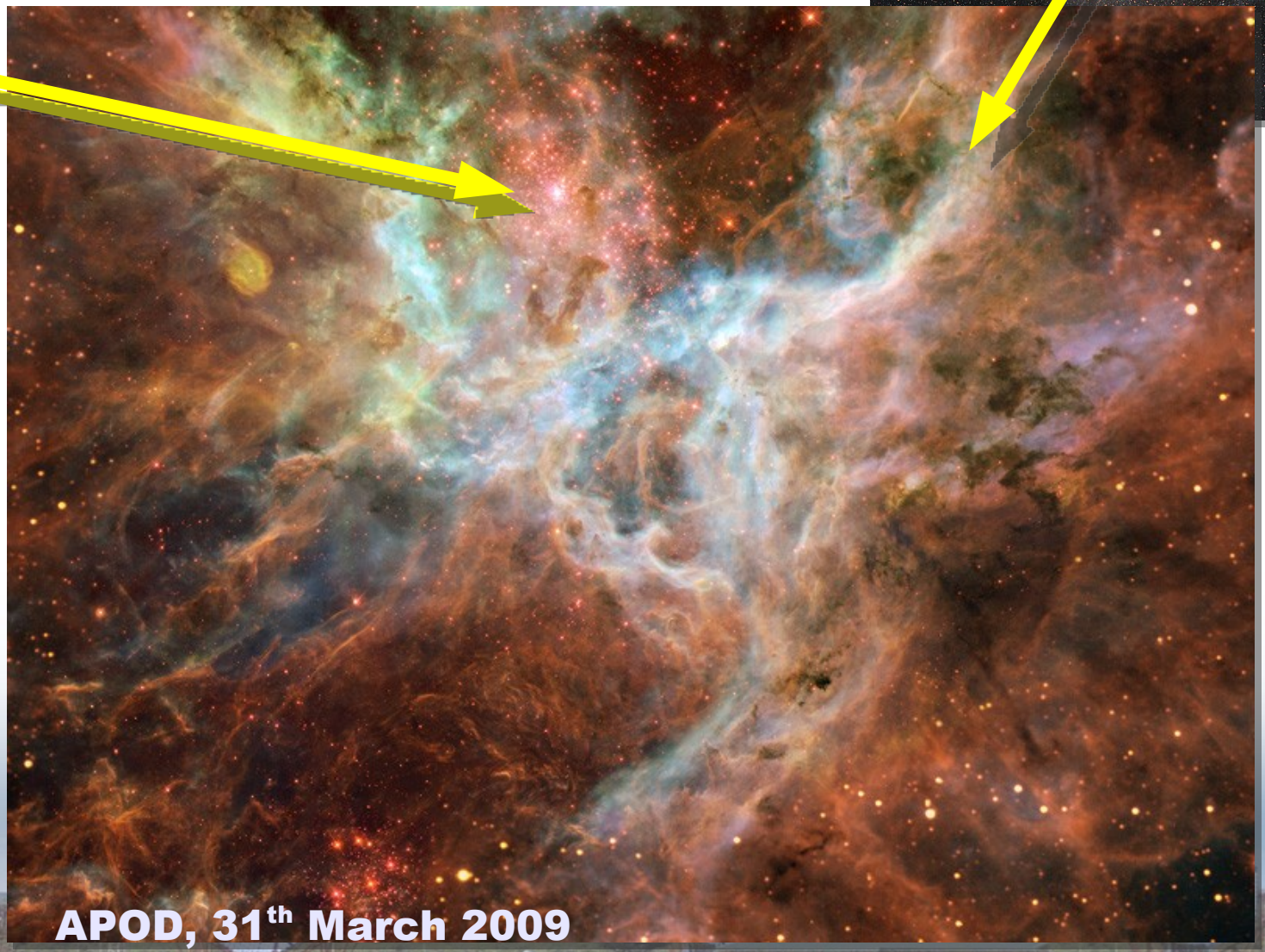


- satellite spiral galaxy
  - ~ 10º extension
  - distance 48 kpc
  - inclined, nearly face on
  - off the Galactic plane
    → not obscured
- many interesting objects
  - site of recent and closest supernova: **SN 1987A**
  - most powerful pulsar wind nebula (PWN) **PSR J0537-6910**
  - massive star forming region (MSFR) **30 Dor C**

30 Dor C / Tarantula Nebula

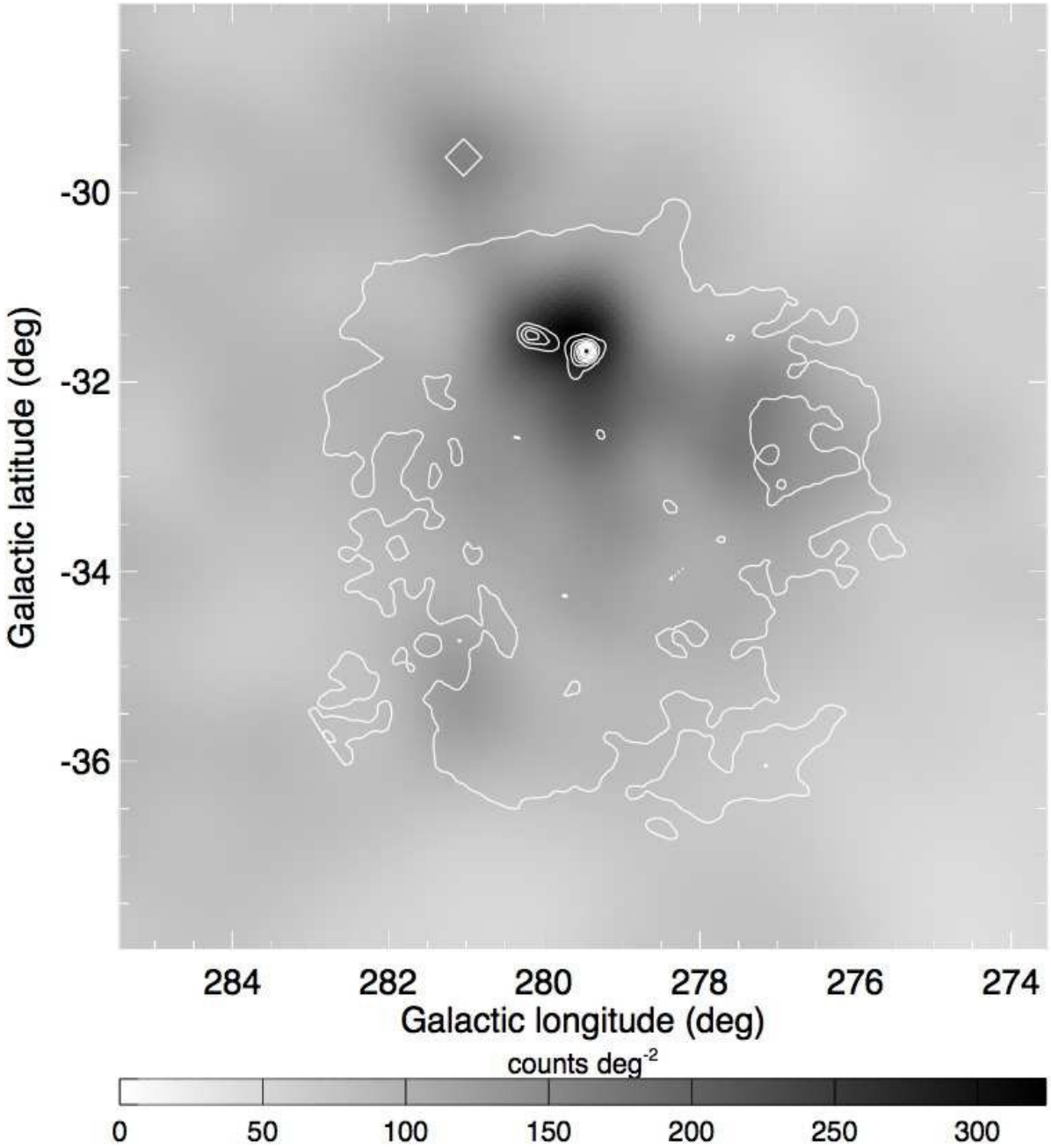
- most massive star forming region known
- (more, non-LMC, will follow at the end of the talk)

star cluster
RMC 136



Fermi Observations of the LMC

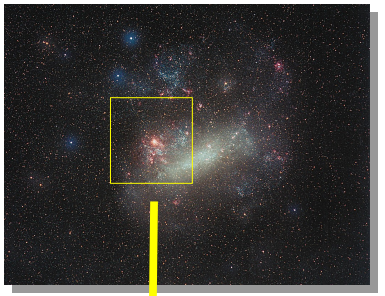
- [Fermi, ICRC 2009]
- large, extended emission Ø ~4º
- contours: extinction map [Schlegel et al. 1998] tracing gas
- maximum of emission close to RMC 136
- emission connected to 30 Dor C



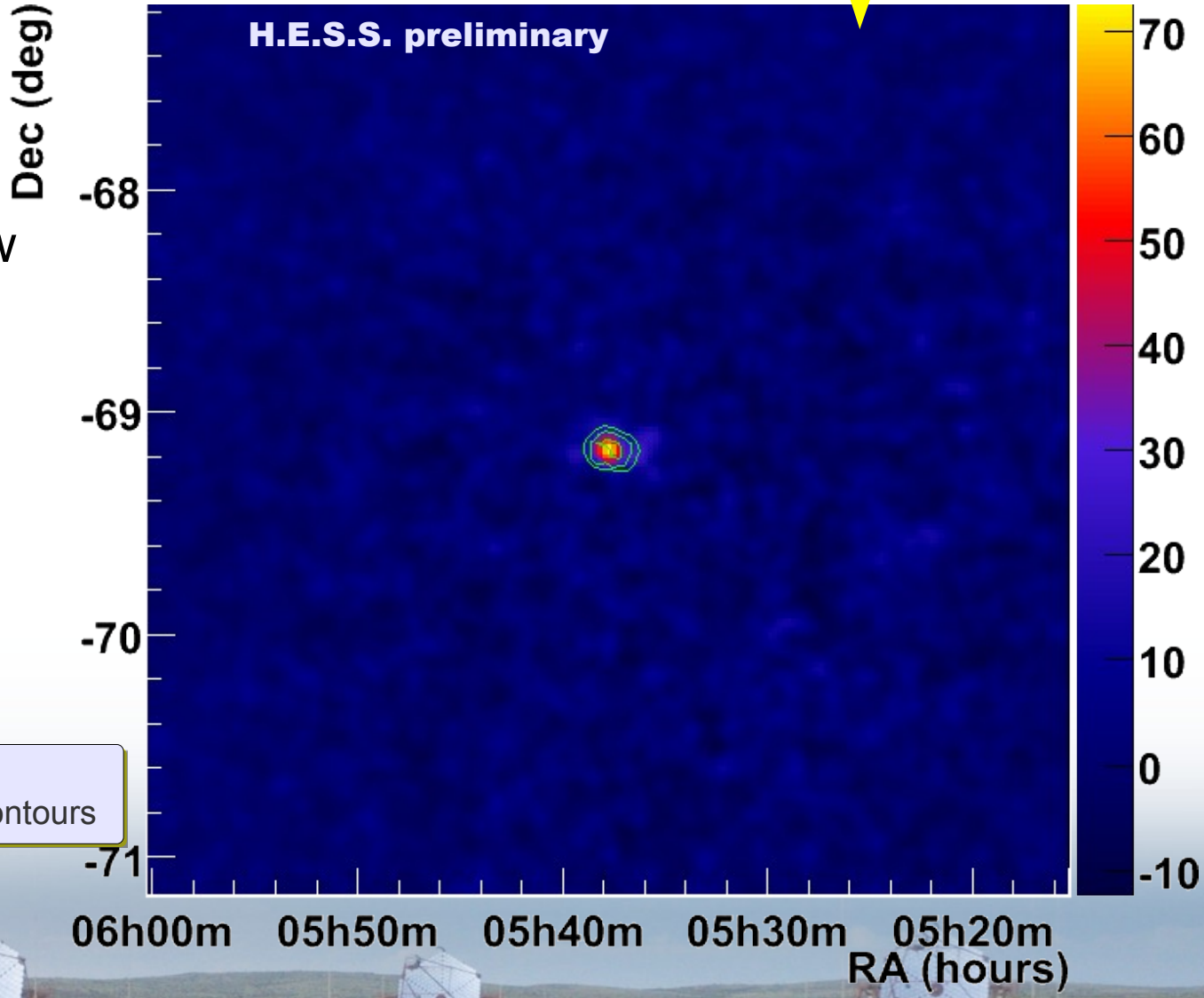
H.E.S.S. Observations

- observations since 2003, centered on SN 1987A
- currently 100 runs, 44h exposure of ongoing campaign
- large zenith angle → $E_{\text{threshold}}$ ~ 500 GeV
- rainy season → affects systematics

View in VHE Gamma Rays

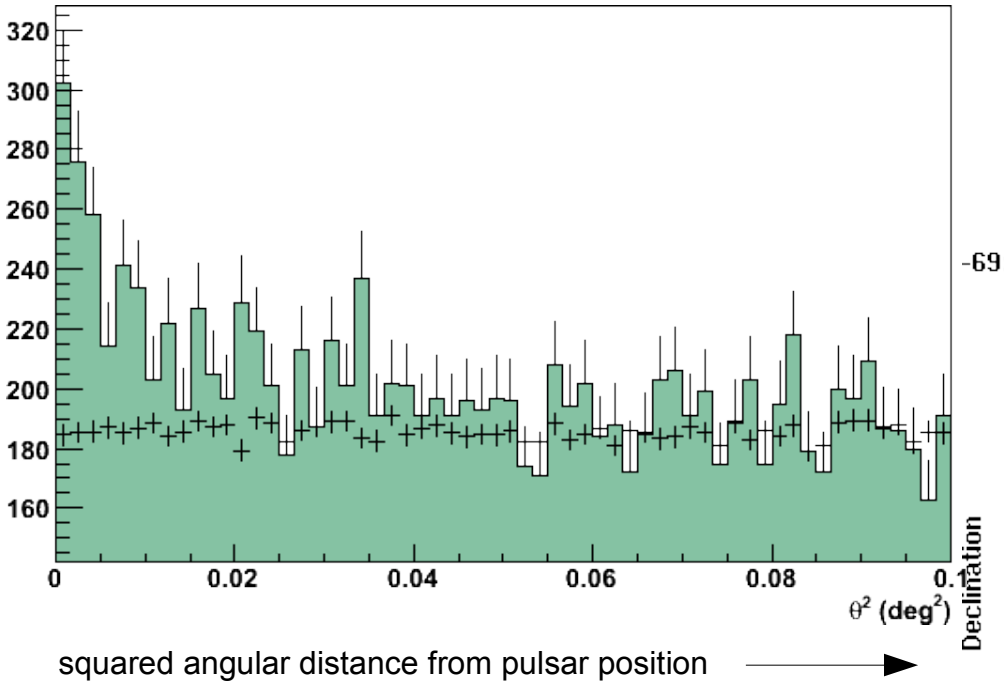


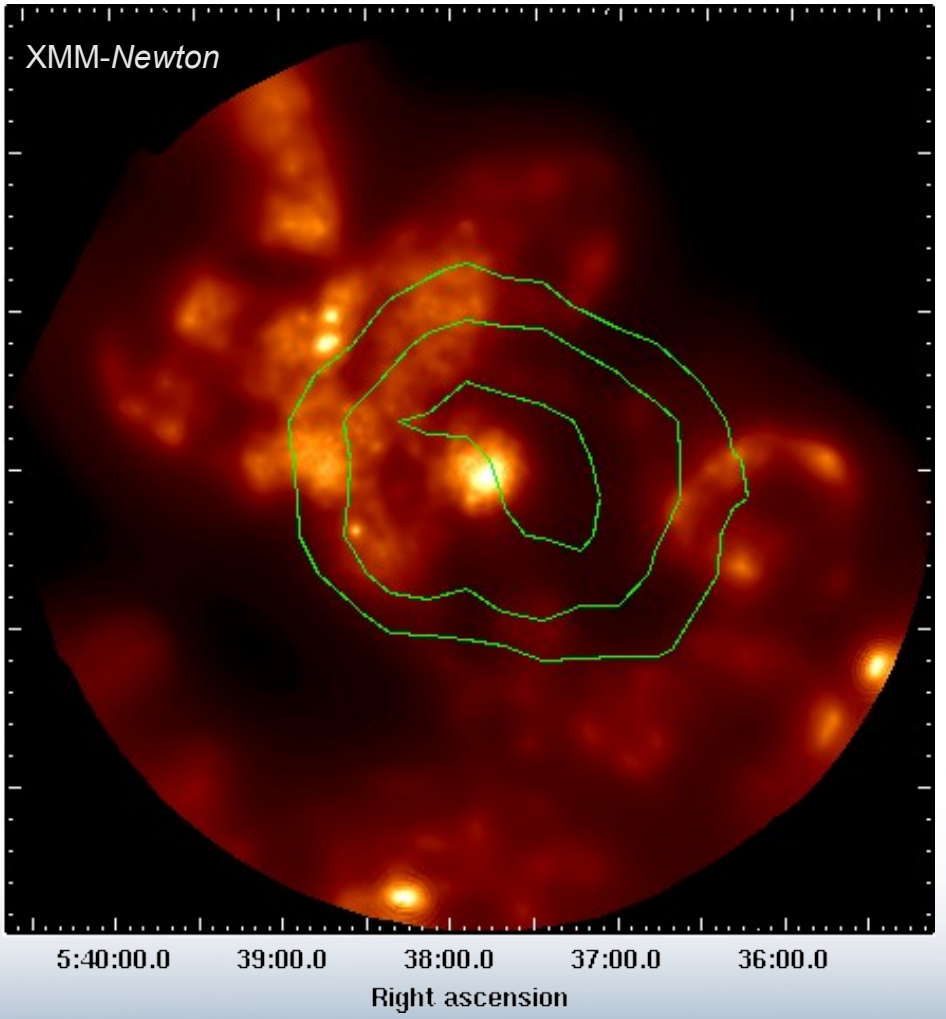
- target of observations: direction of SN 1987A
- roughly 5º x 5º field of view
- discovery of one, small VHE gamma-ray source



smoothed gamma-ray excess
6, 8.5, 11 sigma significance contours

Detection of N157B

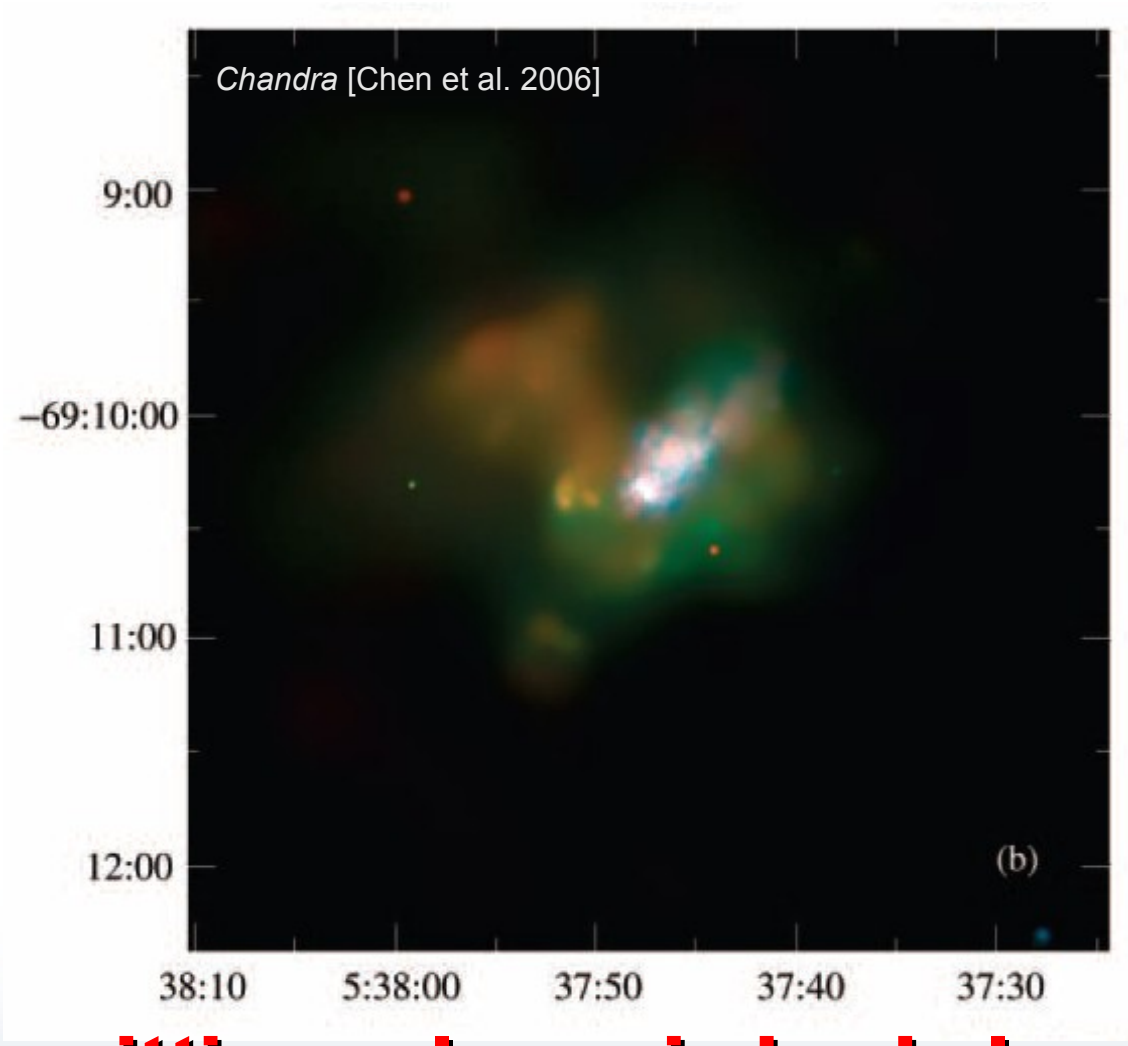




- within 0.1° of the pulsar (standard point-source cut):
  - 440 excess events
  - 11σ significance
- consistent with composite SNR N 157B / PSR J0537-6910

Emission from Pulsar Wind Nebula

- X-rays
  Chen et al. 2006 [*ApJ* **651**:237]
  - non-thermal emission from PWN
  - thermal emission from shell
- HESS source:
  - → IC emission from PWN
  - flux (1-10 TeV) ~ 10^{-12} erg cm^{-2} s^{-1}
- most powerful pulsar known
  - $\dot{E}$ = 4.9 10^{38} erg s^{-1}
  - age ~5000 years
  - apparent efficiency 0.01% $\dot{E}$

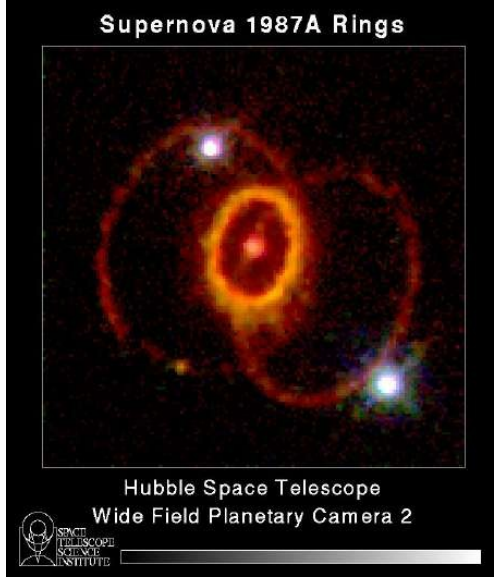


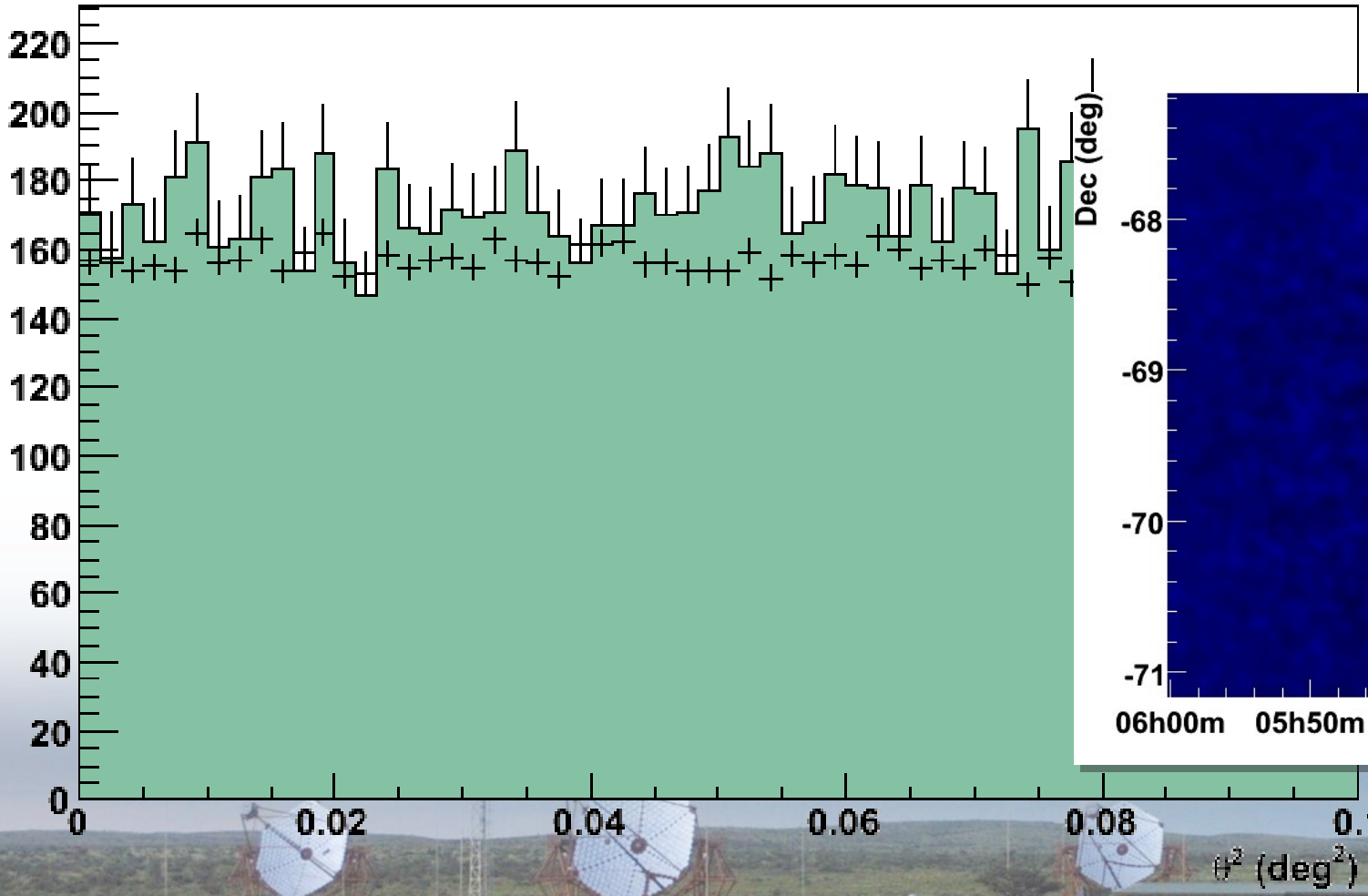
most distant gamma-ray emitting pulsar wind nebula
first extra-Galactic TeV gamma-ray source
which is not a Galaxy

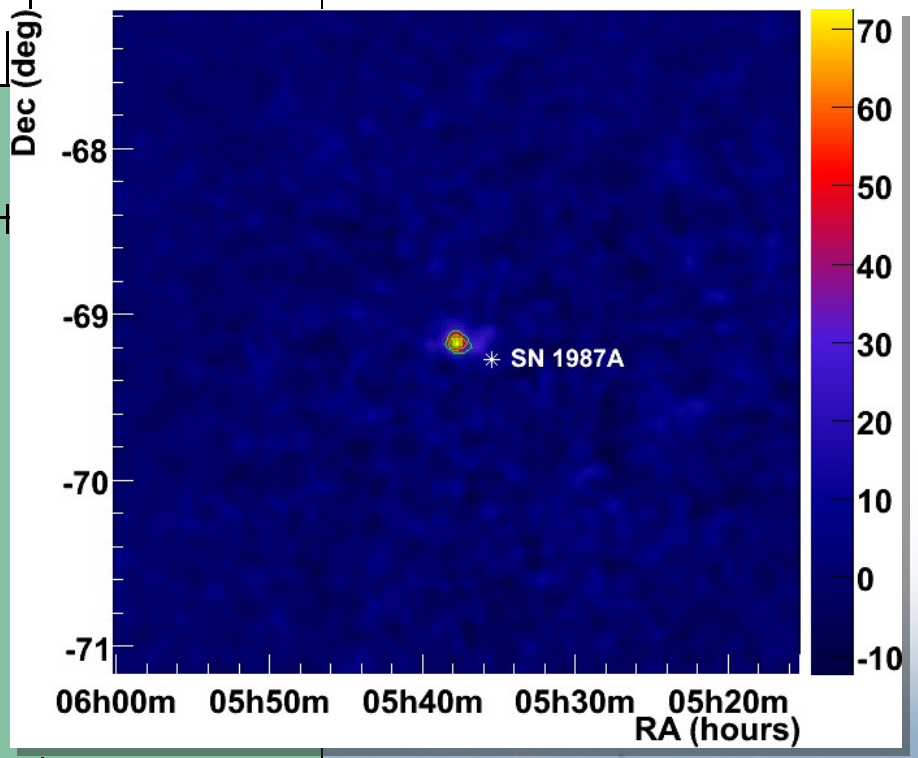
SN 1987A

- most recent and closest supernova explosion
- not detected in H.E.S.S. data set
- upper limit on energy flux for spectral index 2

$F(> 1\ \mathrm{TeV}) < 6\ 10^{-13}\ \mathrm{cm}^{-2}\ \mathrm{s}^{-1}$ (99% C.L.)

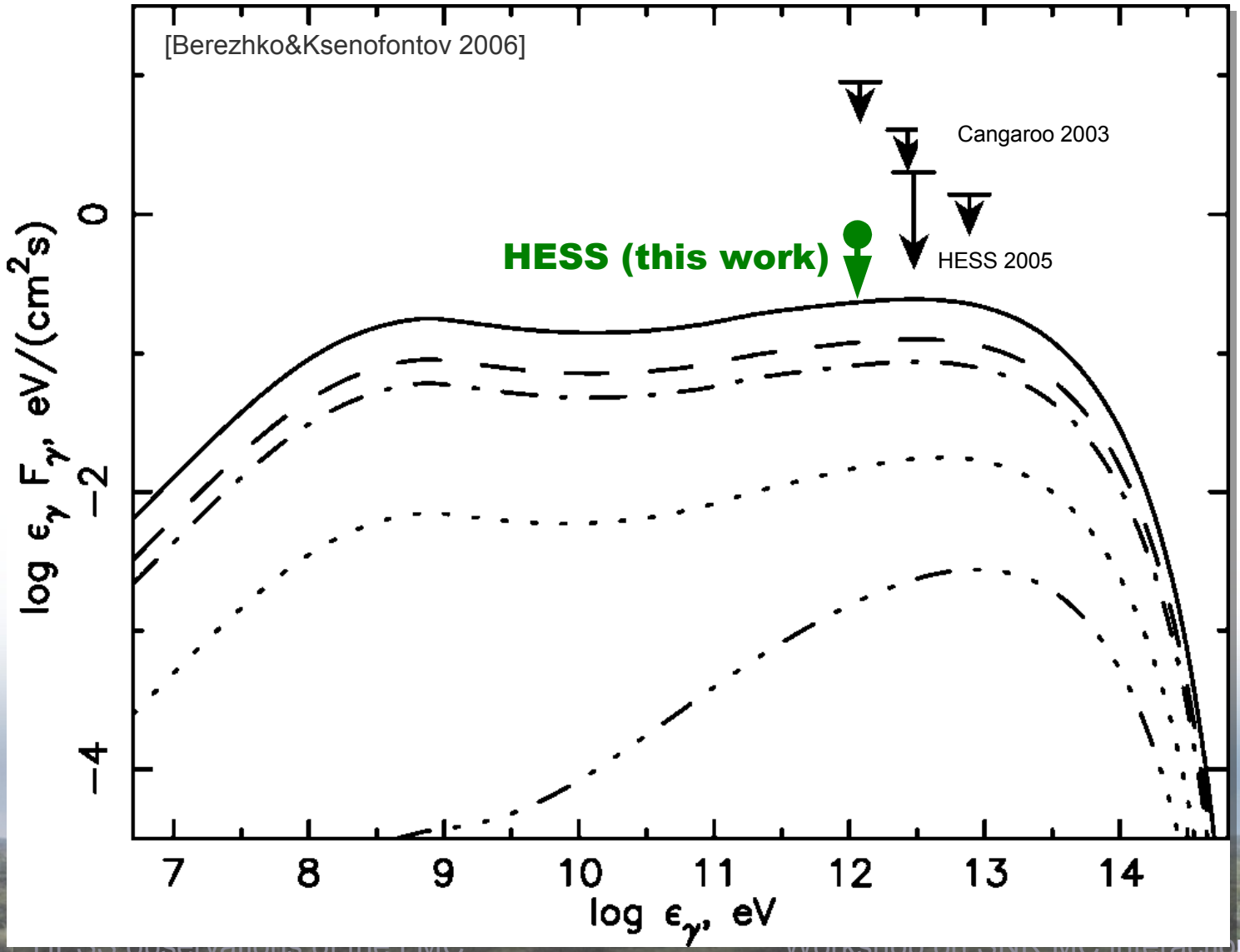






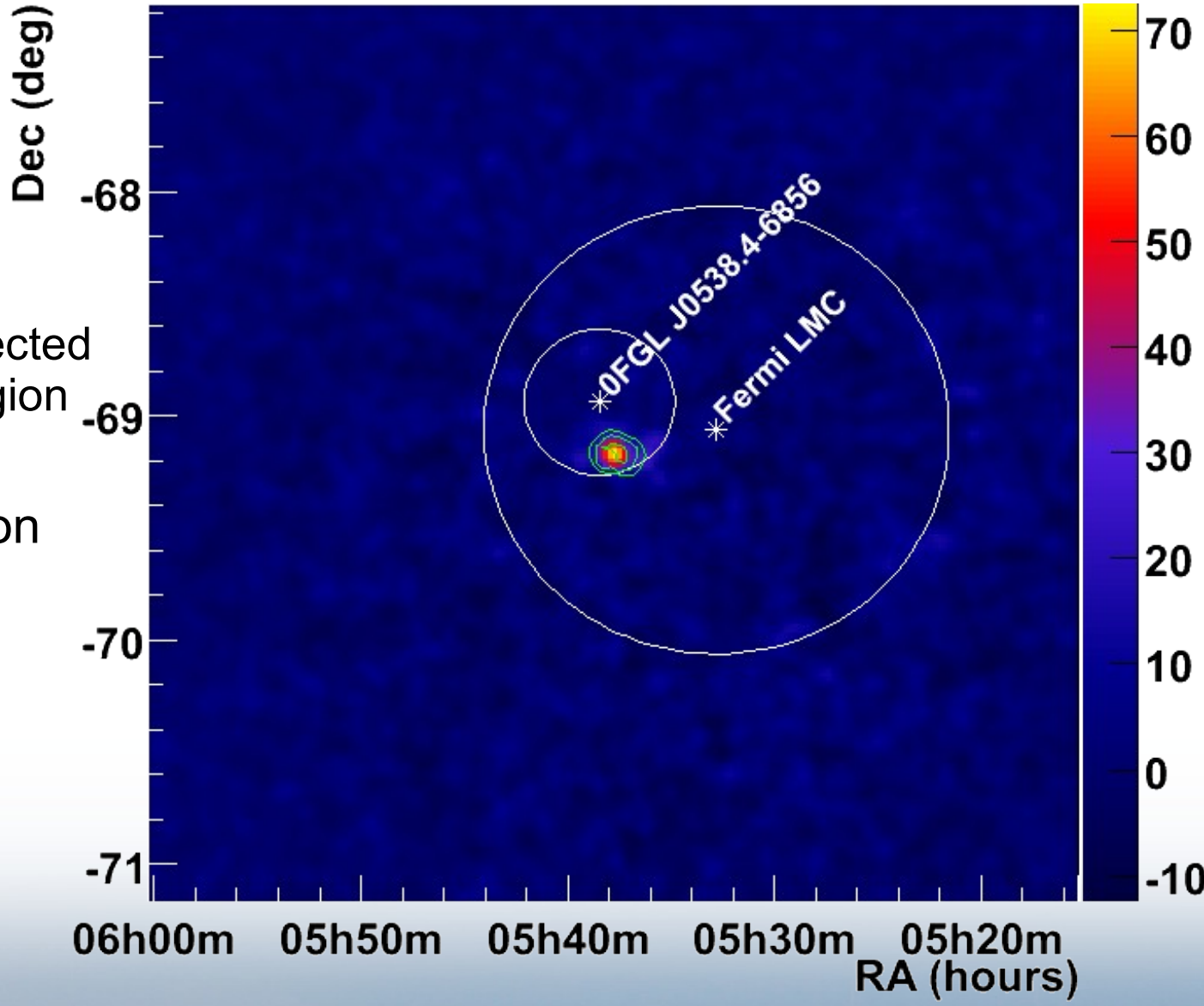
Gamma-Ray Emission from SN 1987A

- Berezhko & Ksenofontov 2006 [*ApJ* **650**:L59]
  - prediction of gamma-ray emission from π^0 decay
  - ~ 2 x 10^{-13} erg cm^{-2} s^{-1} (2006), doubles within 4 years



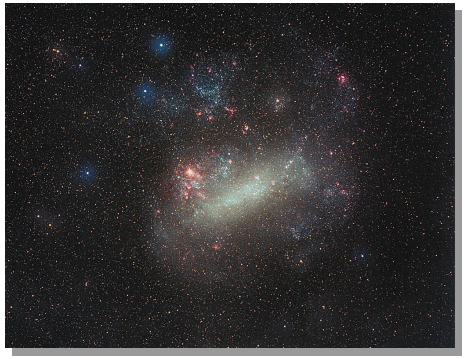
Comparison with Fermi/LAT Results

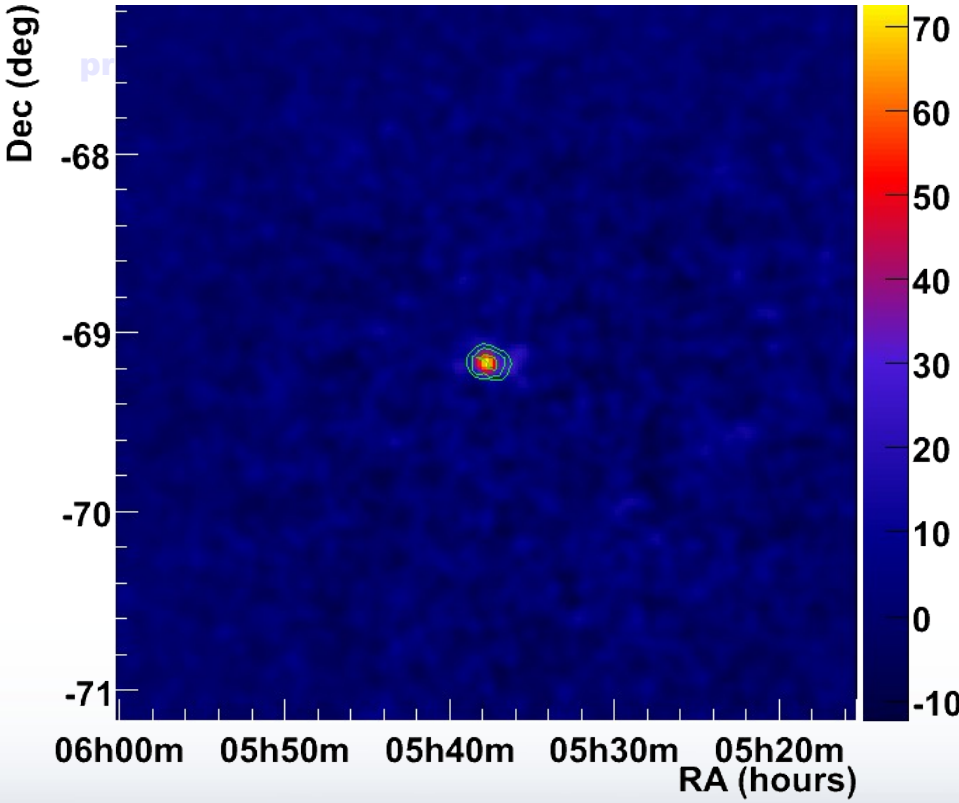
- Fermi/LAT observations
  - 0FGL J0538.4-6856
    Fermi Bright Source List
    [2009 *ApJS* **183**:46]
    - fit of point-like source
  - extended emission connected to 30 Dor star forming region [Fermi, ICRC 2009]
- no apparent TeV emission
  - large extension makes detection difficult



Summary LMC

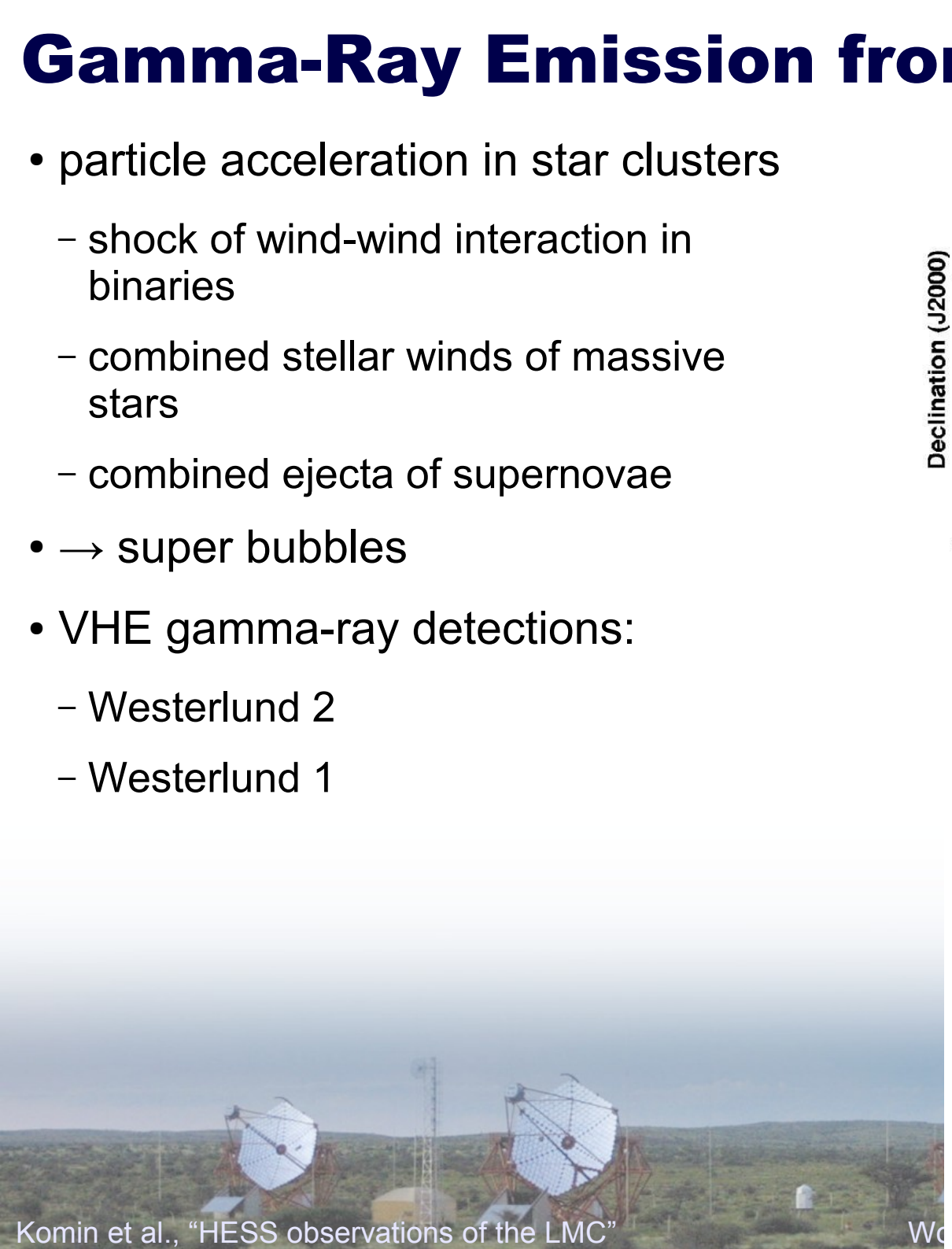
- detection of one TeV gamma-ray source
  - most distant gamma-ray emitting PWN
  - first non-AGN extra-Galactic TeV source
- non-detection of gamma-rays from SN 1987A
- no further obvious source
  - no connection to MCs (they exist)
  - no emission from MSFR

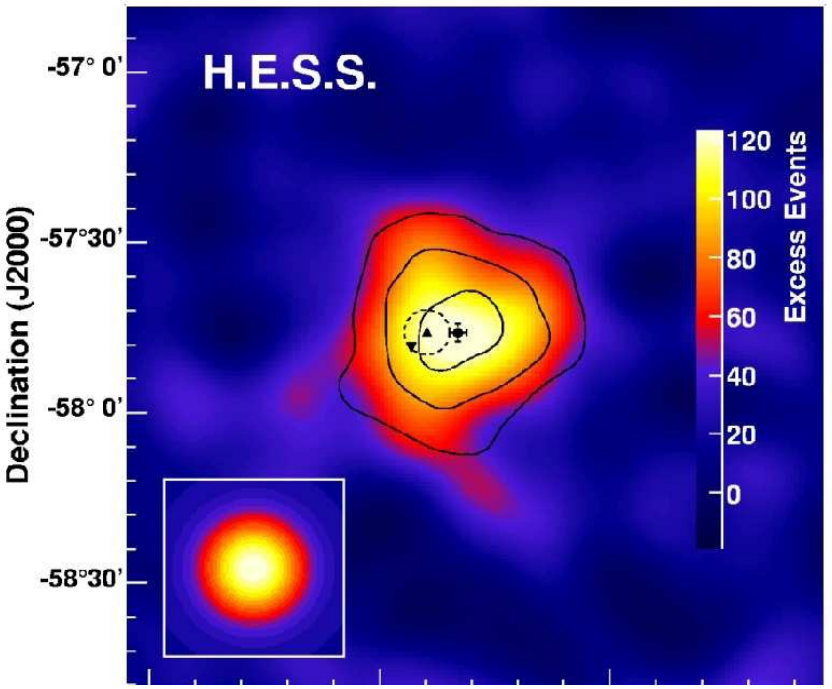


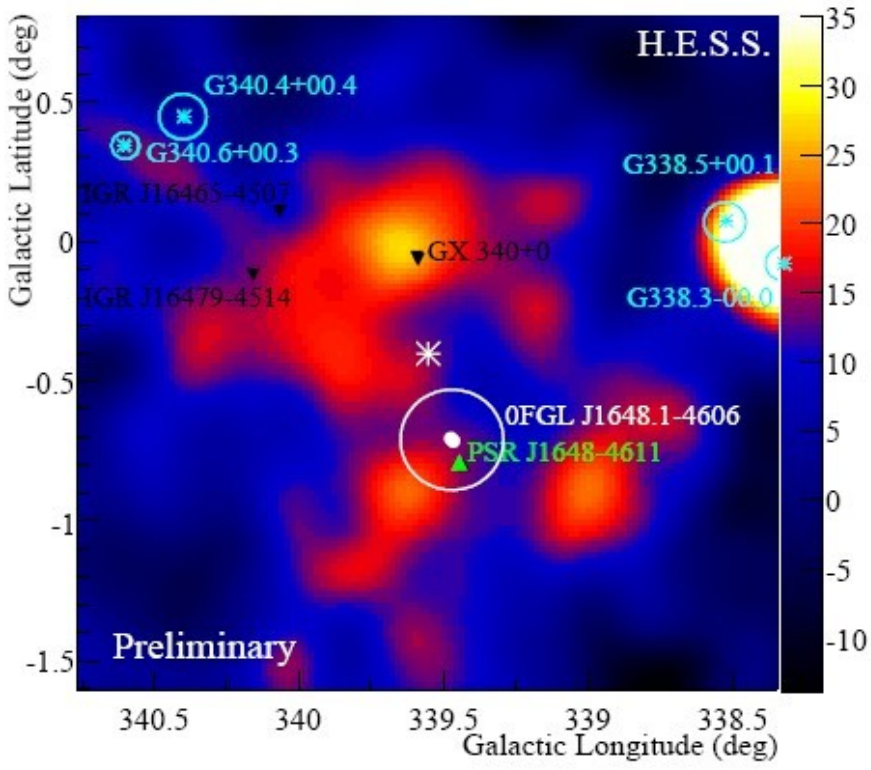


Gamma-Ray Emission from Star Clusters

- particle acceleration in star clusters
  - shock of wind-wind interaction in binaries
  - combined stellar winds of massive stars
  - combined ejecta of supernovae
- → super bubbles
- VHE gamma-ray detections:
  - Westerlund 2
  - Westerlund 1

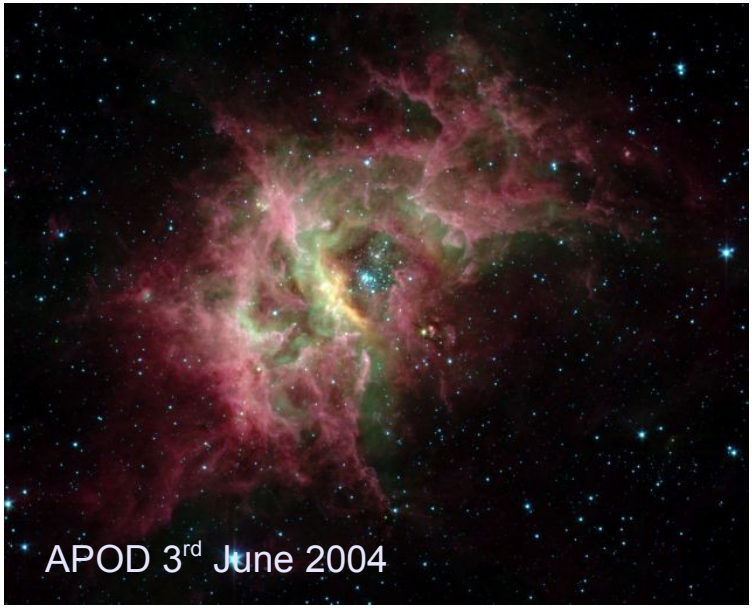


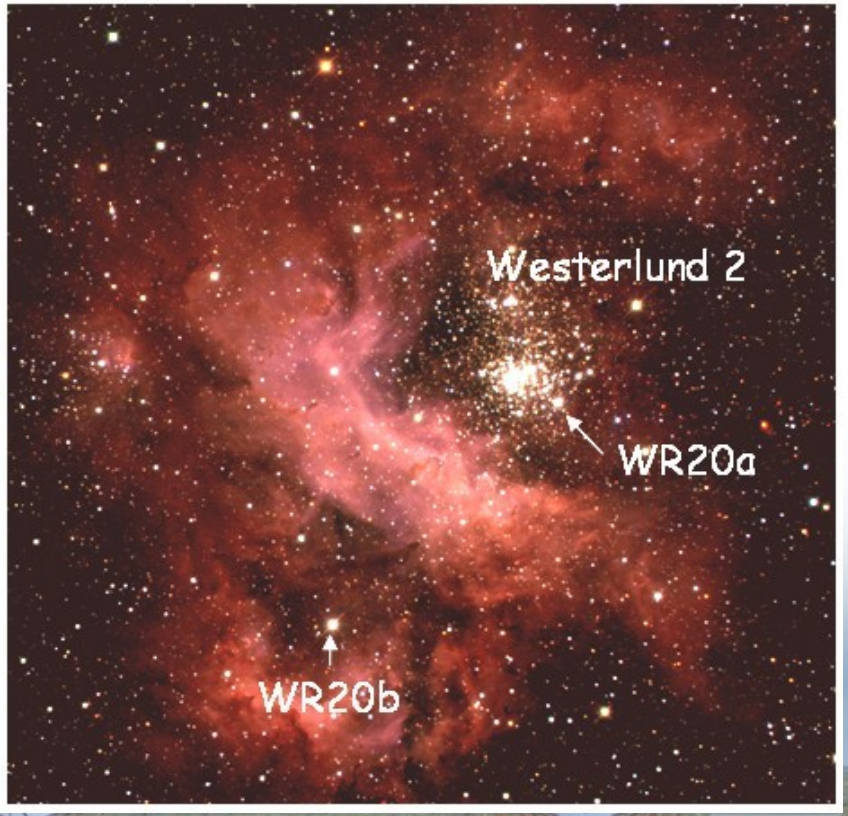




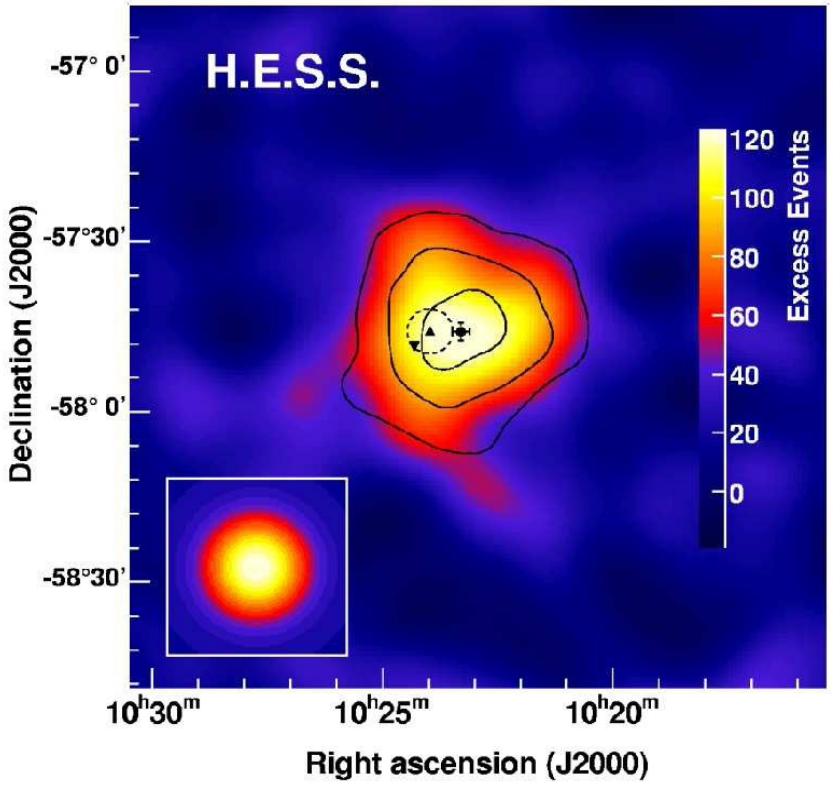
Westerlund 2

- star forming region RCW 49
- stellar cluster Westerlund 2
- Wolf-Rayet stars: Wd20a, Wd20b
- Wd20a: close WR binary
  - orbit 3.7 days
- wind-blown bubbles visible in IR
- → promising target for gamma-ray observations





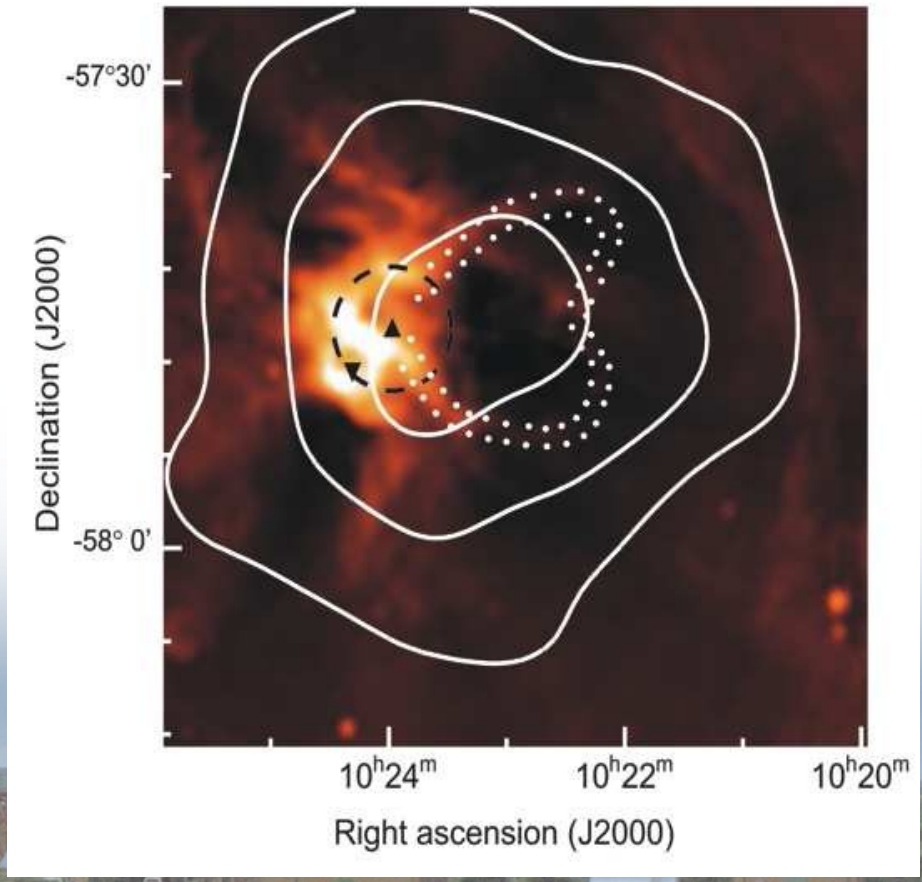
HESS J1023–575



- [A&A 467, 1075-1080 (2007)]
- extended gamma-ray emission
- no flux variability
- → binary origin unlikely

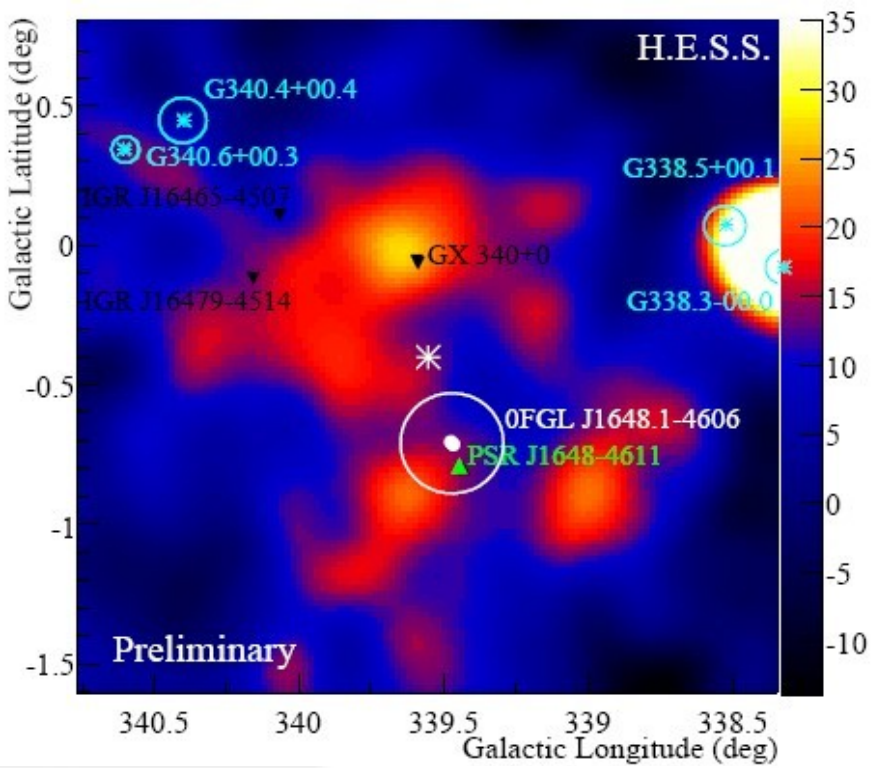
- gamma-ray emission consistent with radio “blister”
- bubble opens into low density ISM

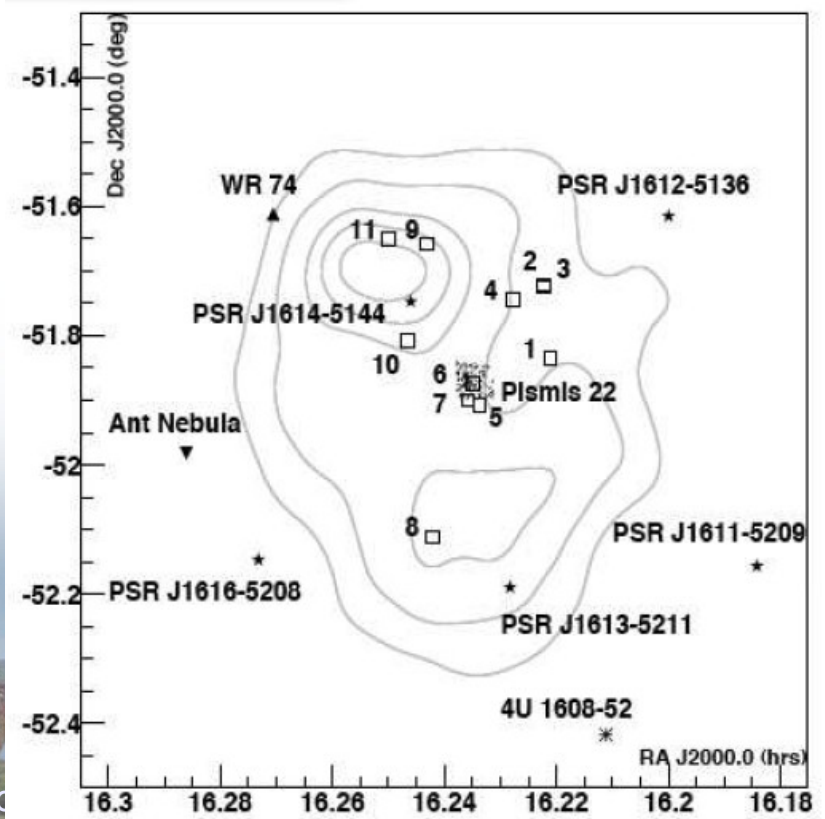
stellar clusters as new gamma-ray source class



Westerlund 1

- HESS J1614–518
  - one of the brightest unidentified sources in Galactic Plane scan
  - large extended source $r \sim 1^{\circ}$ → most extended TeV source
  - [Ohm et al., Jaen, February 2009]
- massive and young cluster
  - large number of massive stars: hypergiants, supergiants, WR stars,...
  - → may have evolved into SNe
- counterparts:
  - PWNe: not powerful enough
  - Wolf-Rayet star: WR 74
  - open cluster Pismis 22





Summary Star Clusters

- star clusters / massive star forming regions established gamma-ray sources
- Westerlund 2, Westerlund 1 (, W43 yesterdays talk by Karl)
- acceleration (binaries, combined stellar winds, supernova ejecta) not yet clear