TeV Observations of the Binary System PSR B1259-63/LS 2883 with H.E.S.S. around the 2010/2011 Periastron Passage

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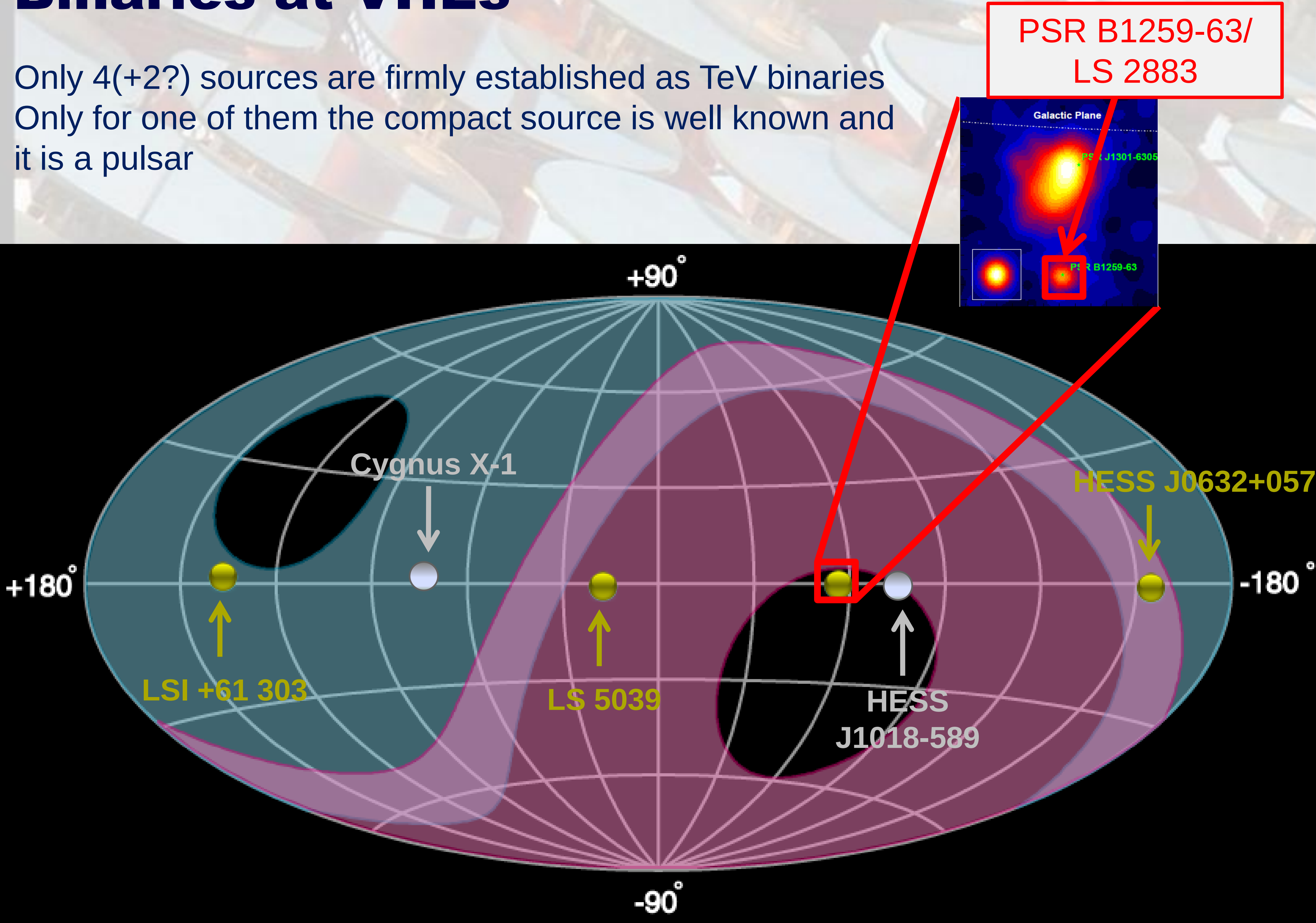
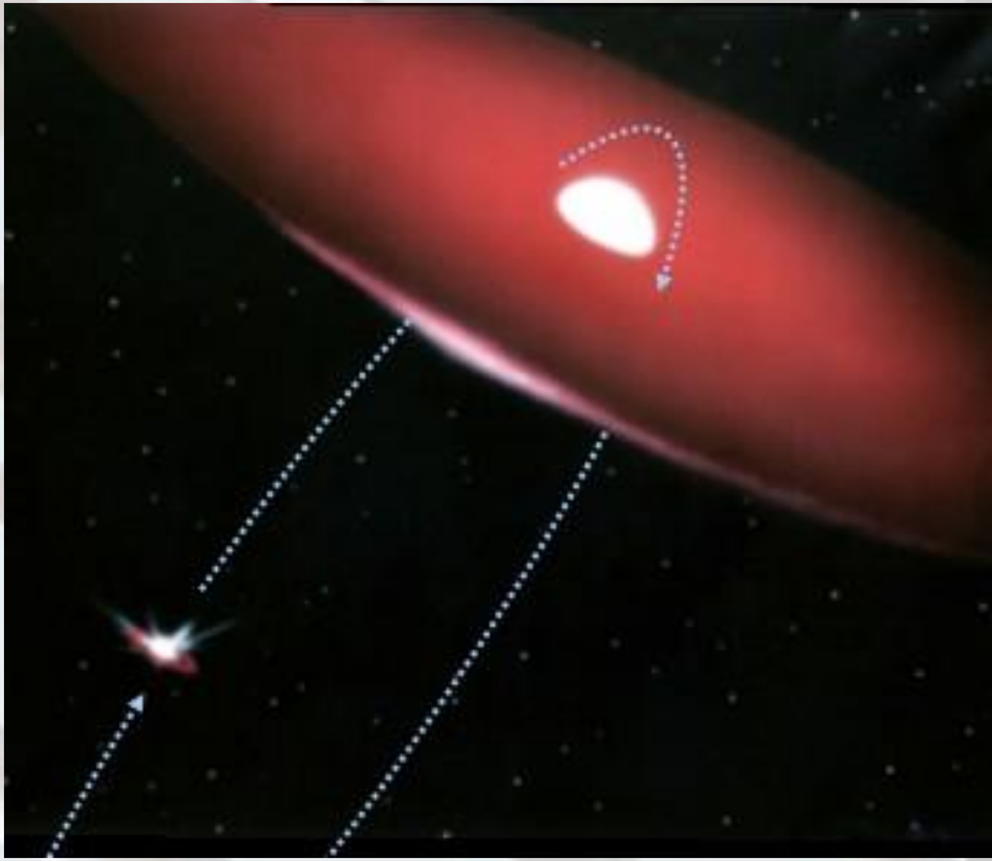
Binaries at VHEs

Only 4(+2?) sources are firmly established as TeV binaries
Only for one of them the compact source is well known and it is a pulsar



PSR B1259/LS2883

- PSR B1259−63
  - P = 48 ms
  - L_{SD} = 8 × 10^{35} erg/s
  - t_c =3.3 × 10^5 years
  - P_{orb} = 3.4 years
  - Eccentricity = 0.87
- LS 2883
  - Be star
  - Highly inclined circumstellar disk
  - L_{star} = 2.3×10^{38} erg/s
  - T = 27500 – 30000 K
  - M ≈ 31 M_{sun}
  - R = 8.1 – 9.7 R_{sun}
  - D = 2.3 kpc



PSR B1259/LS 2883: across the spectrum

Radio:

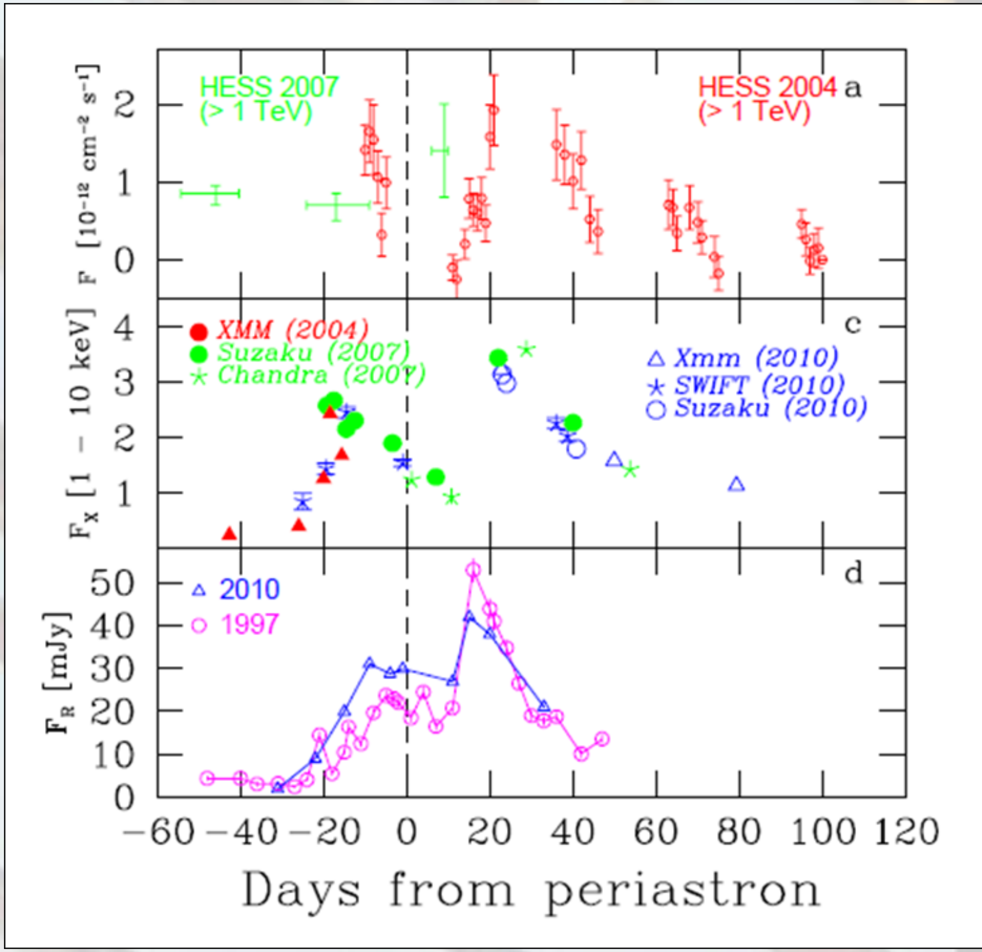
- The eclipse of the pulsed emission lasts from about 20 days before the periastron to about 15 days after
- In this period the unpulsed emission appears which features two peaks

X-ray:

- No pulsed emission
- Non-thermal unpulsed emission behaves similar to radio unpulsed emission showing two peaks at -20 and +20 days with respect to periastron

TeV gamma-rays:

- Observed with H.E.S.S. around 2004 and 2007 periastrons
- Show a hint of two-peak structure, similar to radio and X-ray



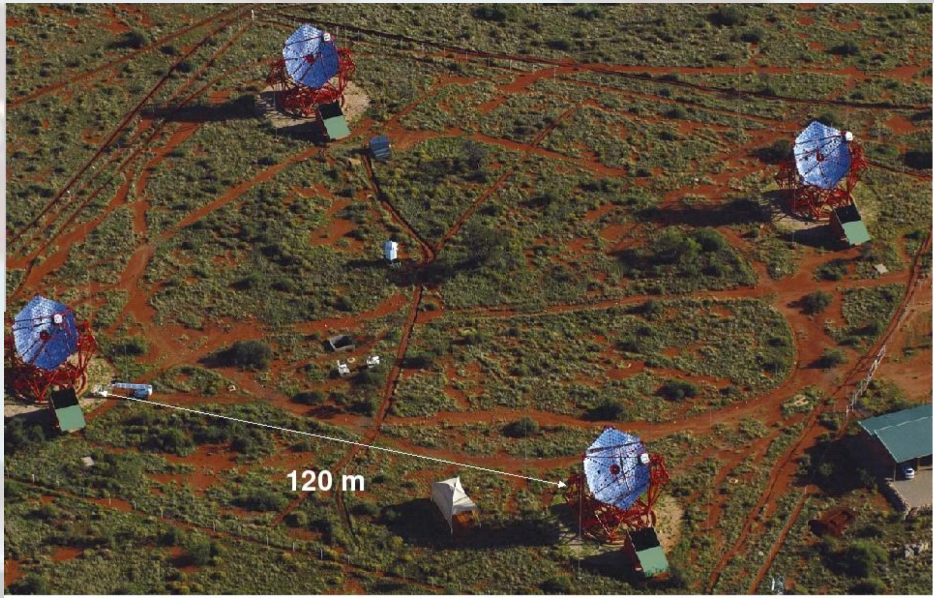
Abdo et al. 2011

2010/2011 periastron passage.

H.E.S.S. observations

- Periastron on 15th December 2010
- Unfortunately not visible before and at the periastron
- We proposed 59 h of obervations after the periastron from January to March
- The proposal was fully accepted

But…



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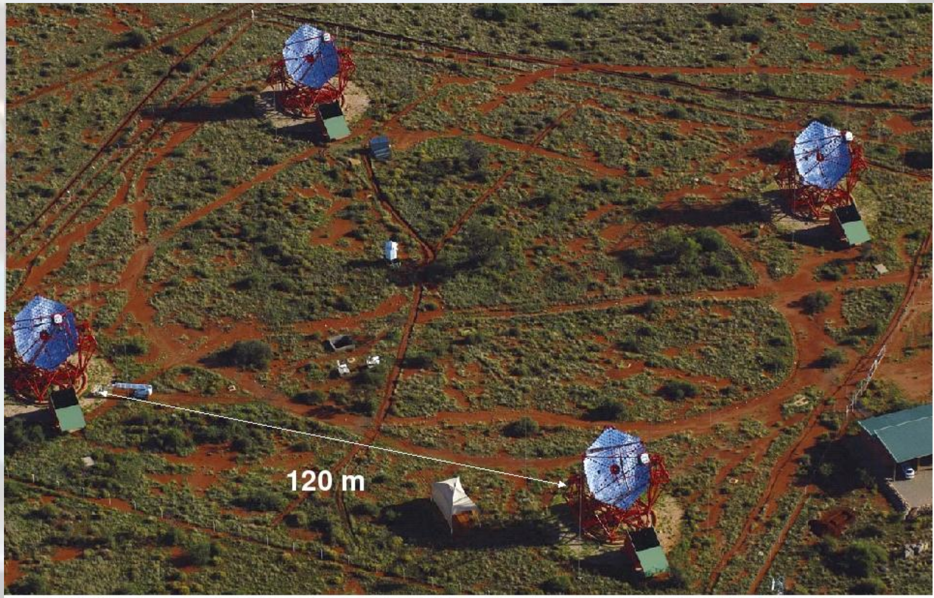
Rainy season in Namibia spoiled almost everything…



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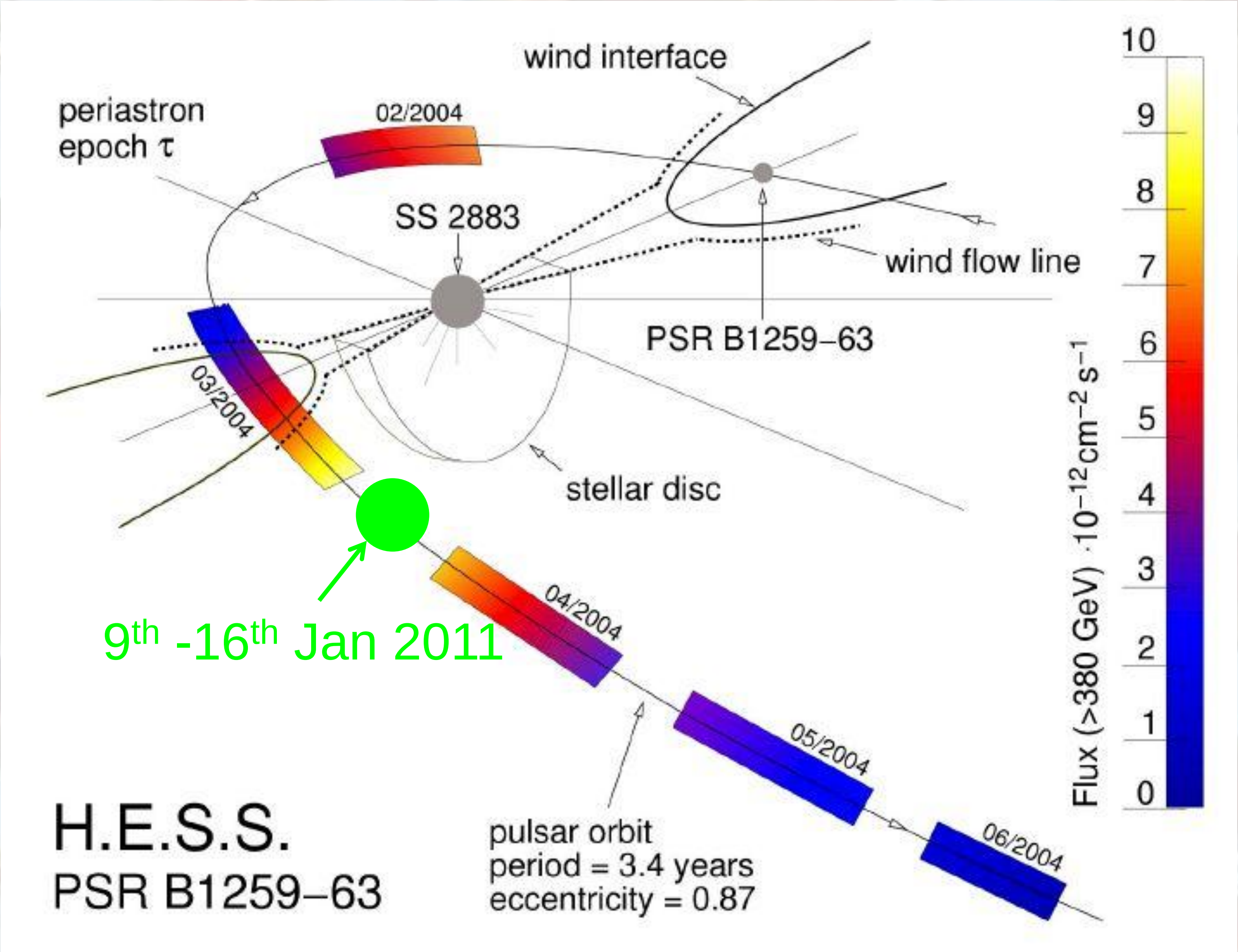
Even Spider-Man couldn’t help…

2010 periastron passage.

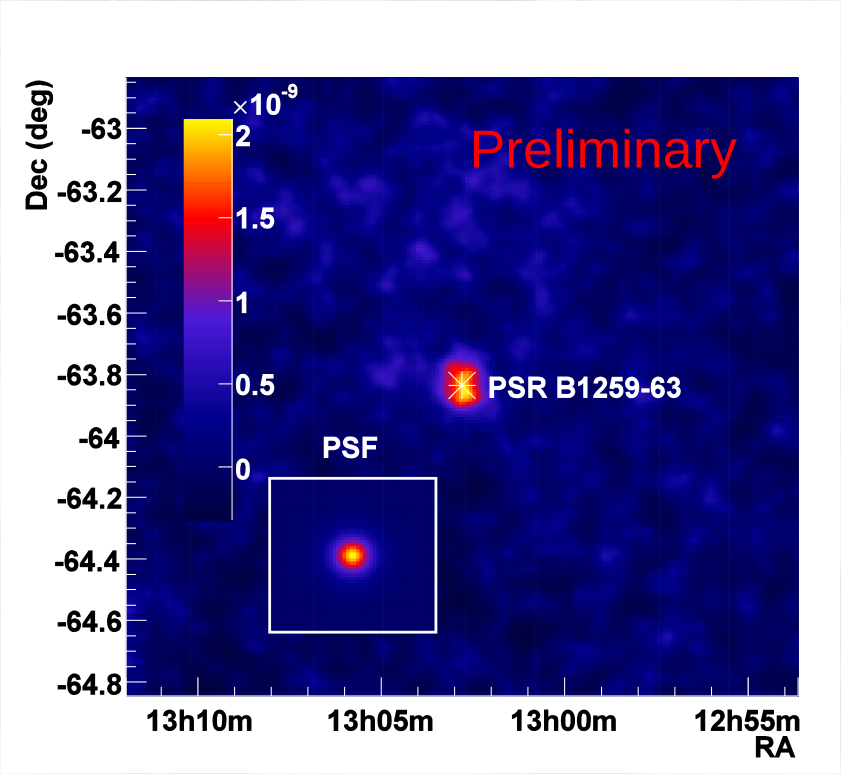
H.E.S.S. observations

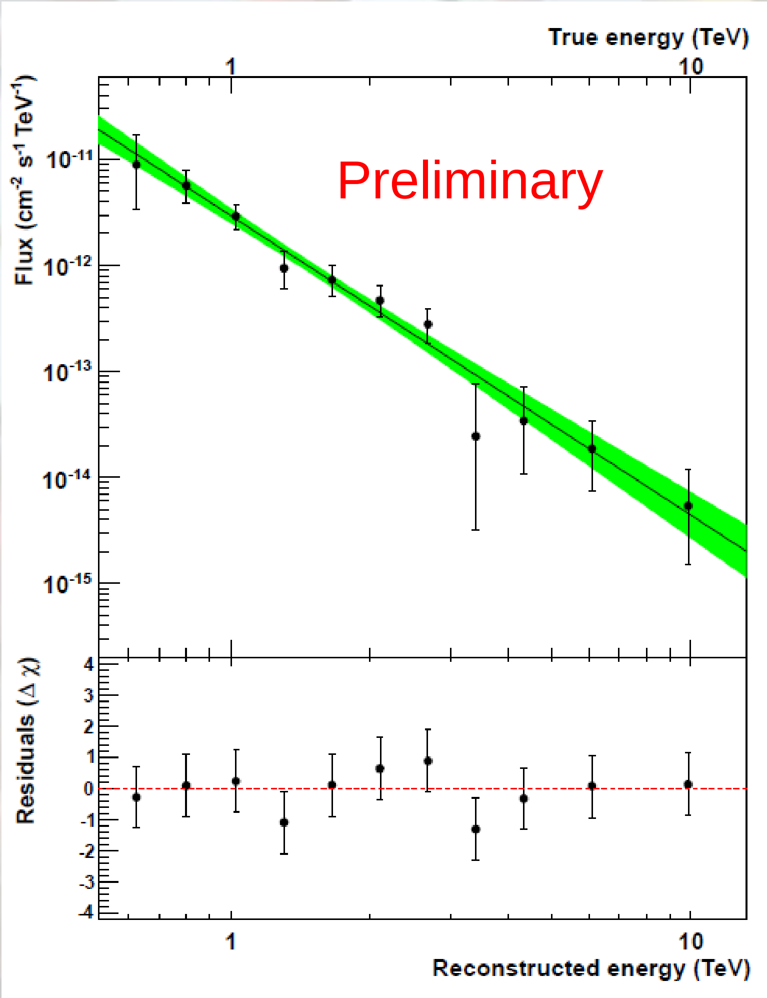


Aharonian et al. 2005

Observation results

- Livetime: 6.2 h
- Excess: 124
- Significance: 13.5 σ

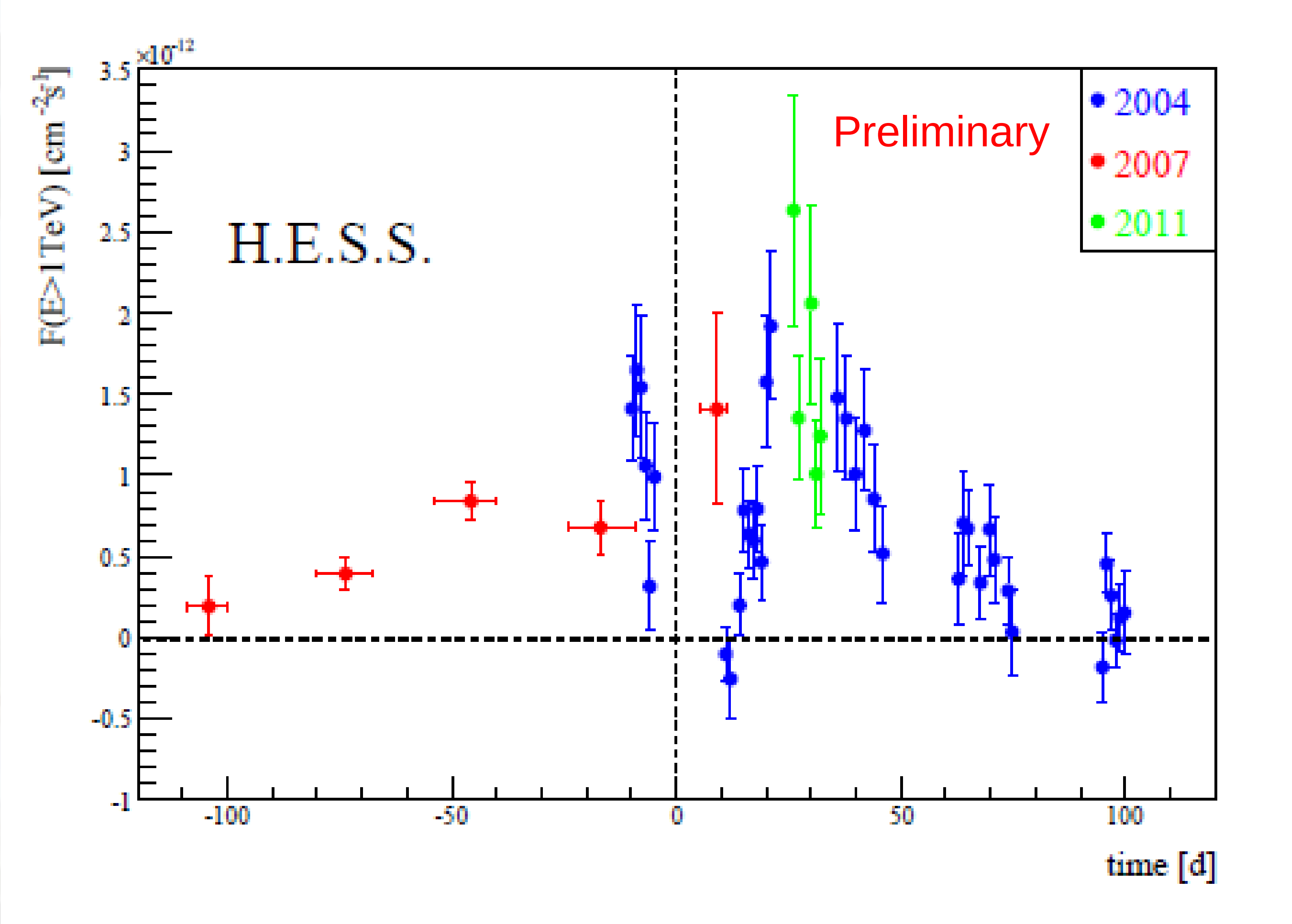




- $\Gamma = 2.82 \pm 0.26$
- $F(E>1\ \text{TeV}) = (1.61 \pm 0.22)\times10^{-12}$ $cm^{-2}\ s^{-1}$
- $N_0(1\ \text{TeV}) = (2.94 \pm 0.49)\times10^{-12}$ $TeV^{-1}\ cm^{-2}\ s^{-1}$
- Chi2/NDF = 5.7/4
- Prob = 0.22

Comparison with previous observations

	2011	2007	2004
Spectral index Γ	2.8 pm 0.3	2.8 pm 0.2	2.7 pm 0.2



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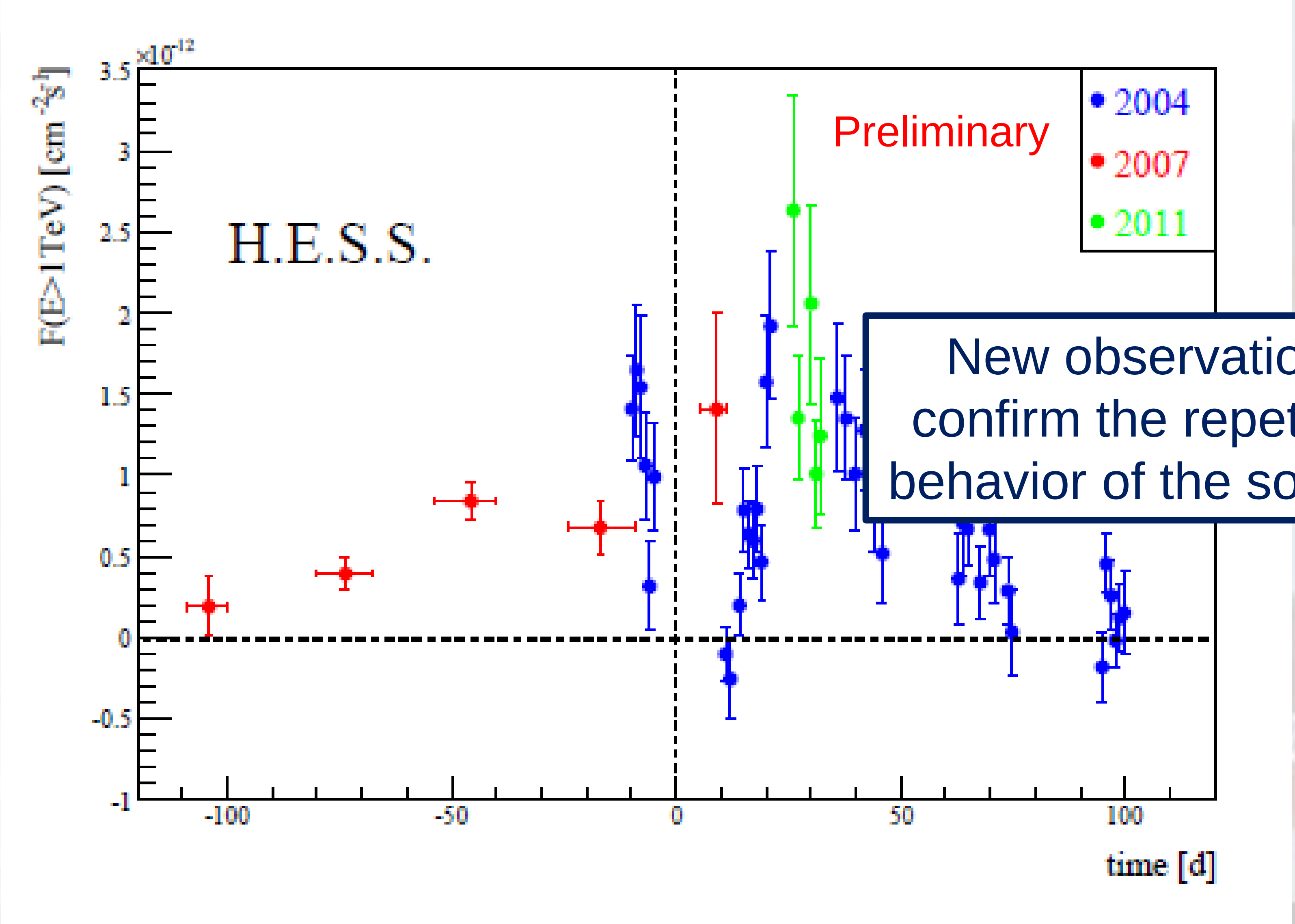
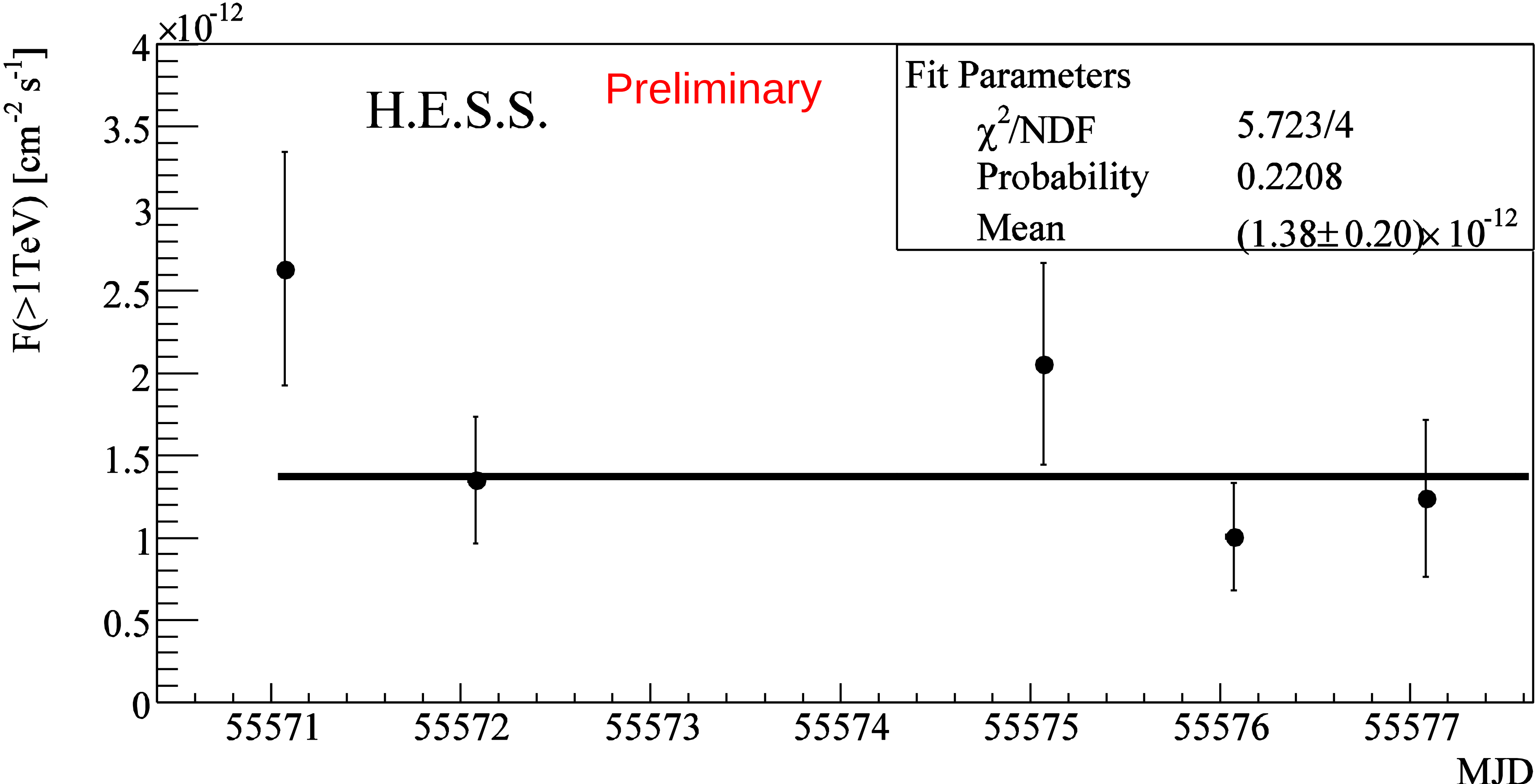


New observations confirm the repetitive behavior of the source!

Lightcurve (2011 data)

No hint of variability!



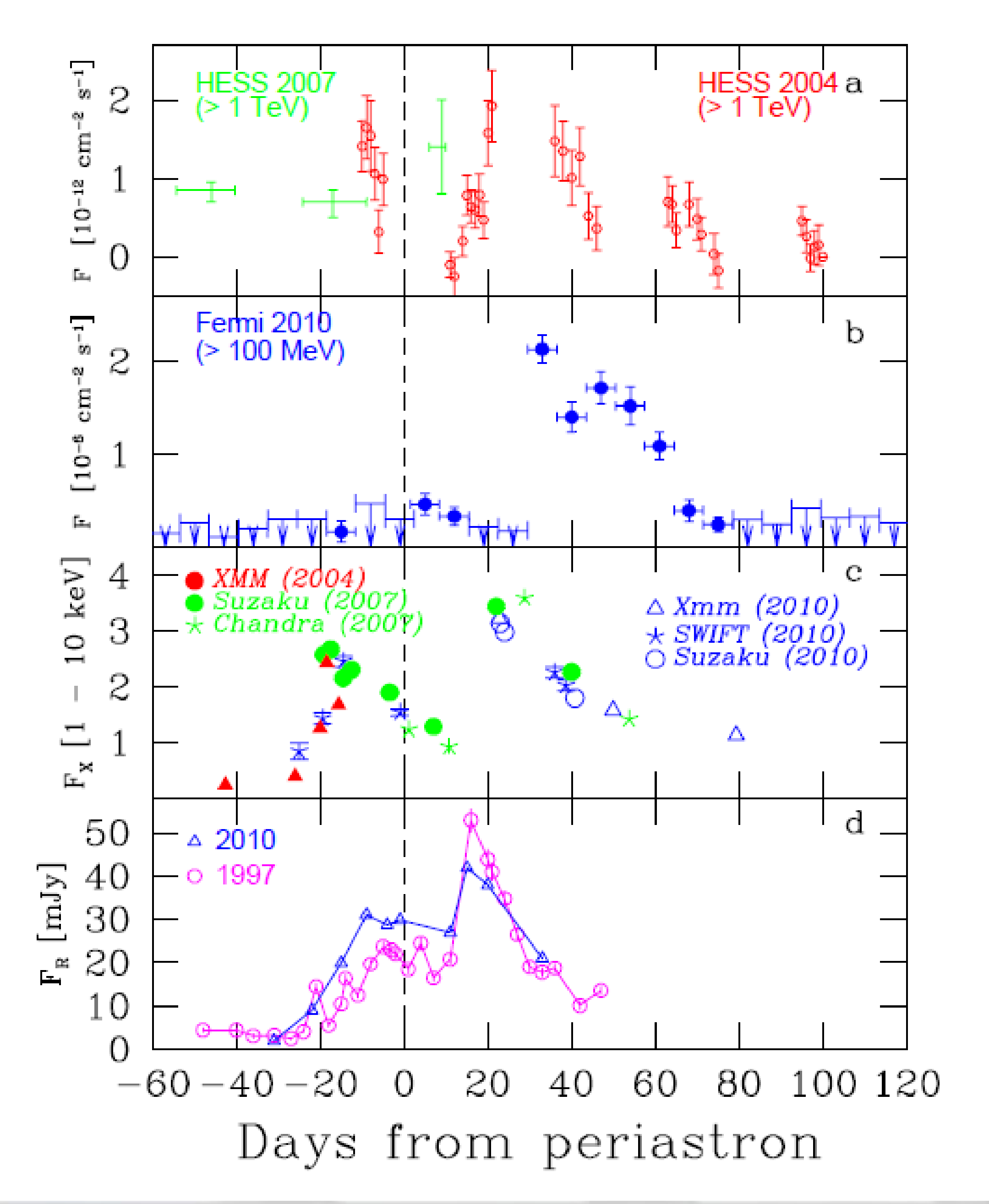
2010/2011 periastron passage
MWL campaign

Abdo et al. 2011

- Various instruments from radio to VHEs
- Radio and X-ray observations showed similar results to previous periastrons
- For the first time it was observed by Fermi LAT

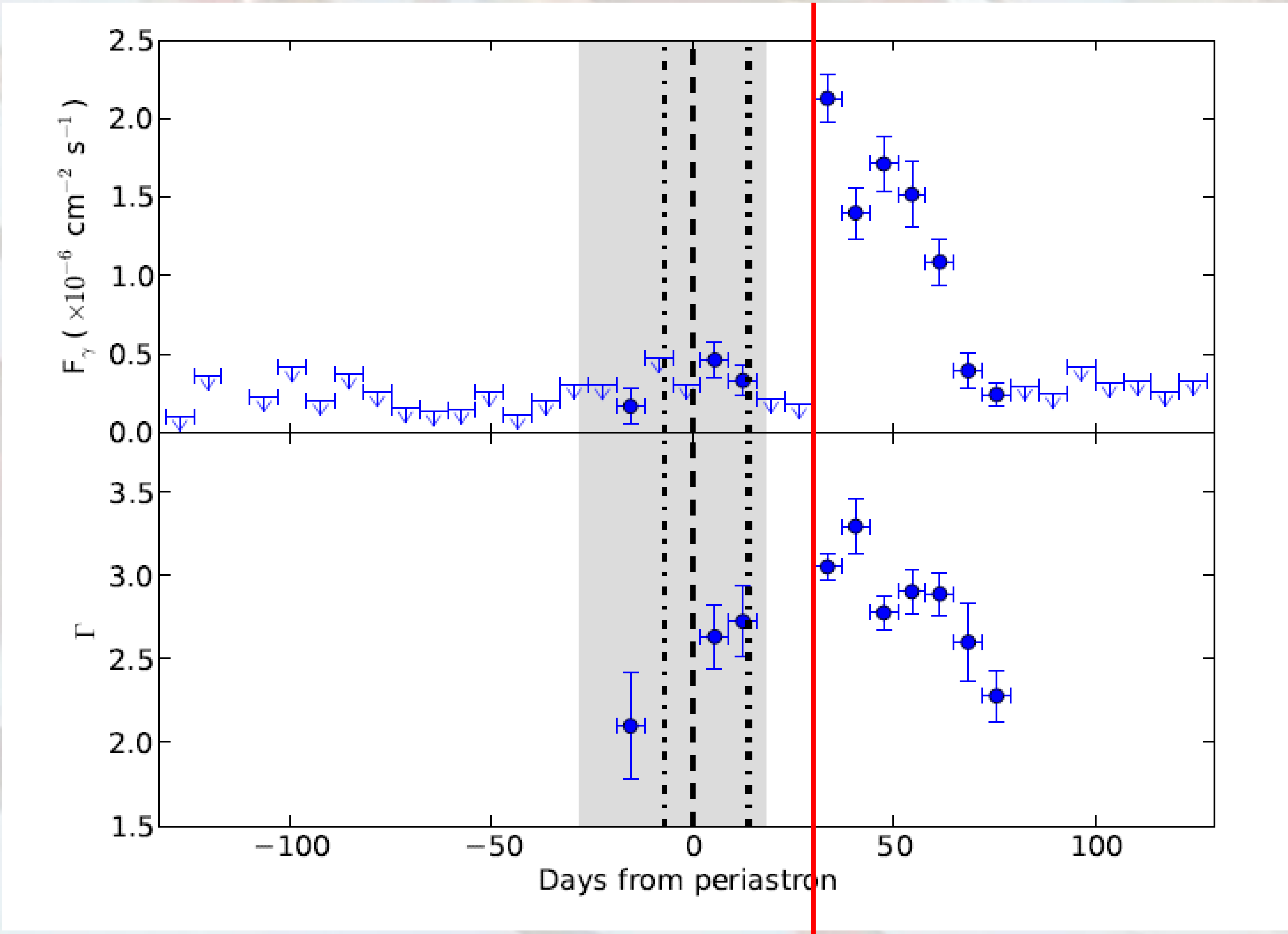
Fermi observations:

- Tiny emission close to the periastron
- Spectacular flare 30 days after the periastron
- GeV flare displaced with respect to the post-periastron peak at other energies



Fermi flare

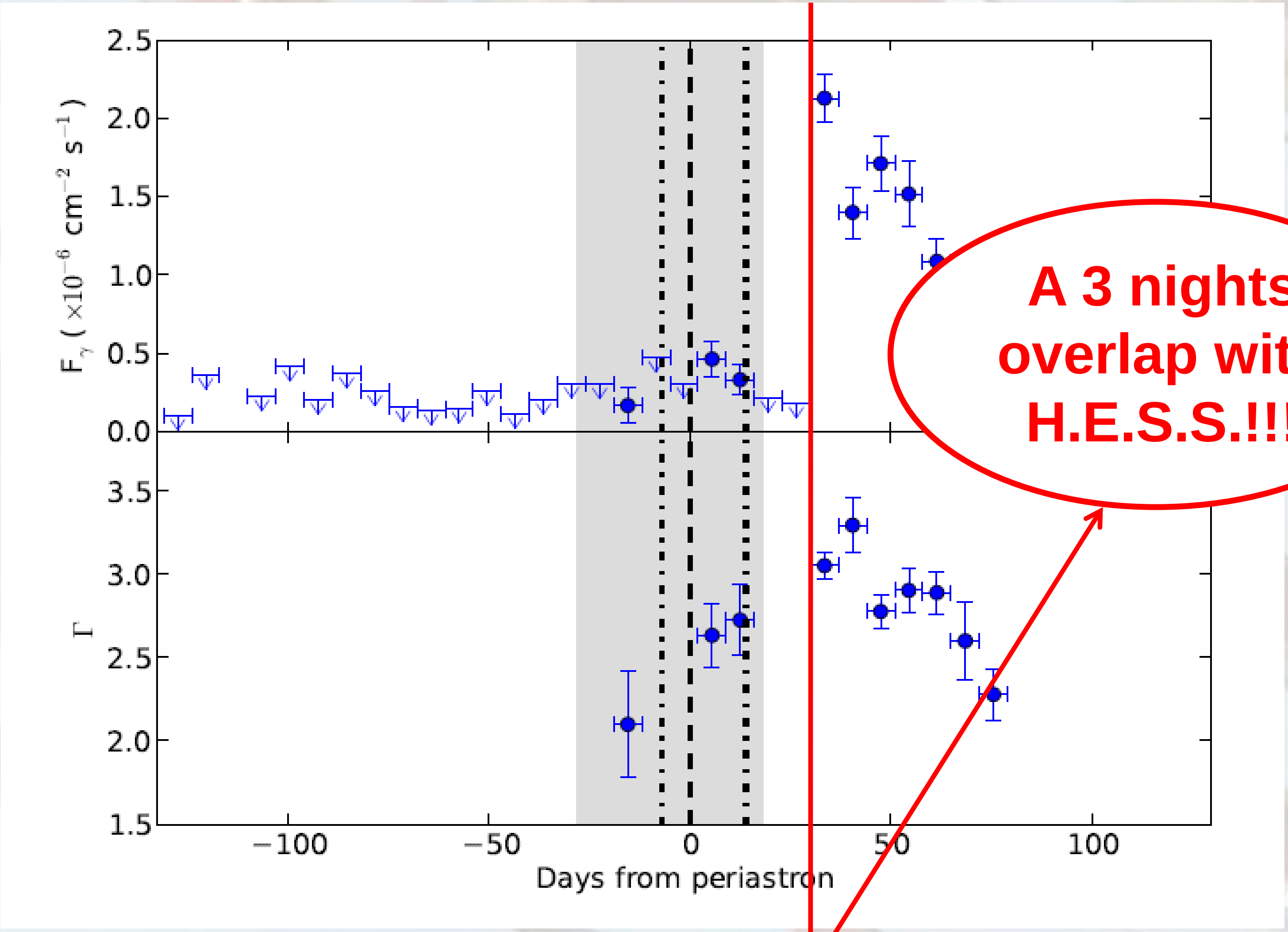
Abdo et al. 2011



30 days after periastron
14th of January

Fermi flare

Abdo et al. 2011



A 3 nights overlap with H.E.S.S.!!!

30 days after periastron
14th of January

The search of the flare in H.E.S.S. data

If we assume that the GeV and TeV emission is created by the same mechanism – we should expect the flare of the same power at TeV energies

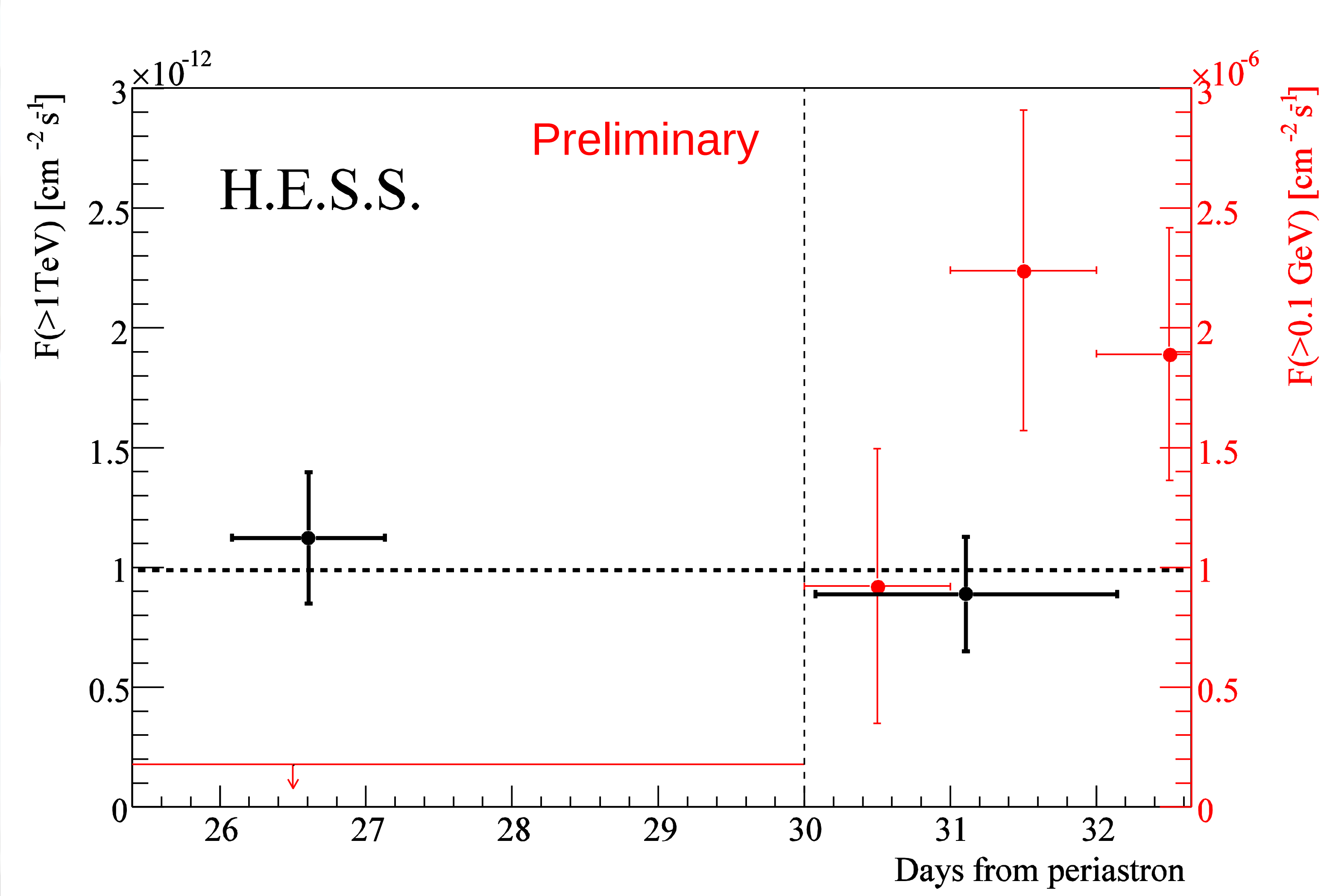
The dataset was divided into two periods: “preflare” and “flare”

	pre-flare	flare
Livetime [h]	2.7	3.7
excess	34.4	50.5
significance	7.5σ	7.3σ
Flux($E > 1$ TeV) $[10^{-12}\ \mathrm{cm^{-2}s^{-1}}]$	1.13 ± 0.28	0.89 ± 0.24
Γ	$3.08 \pm 0.53_{stat} \pm 0.2_{syst}$	$3.22 \pm 0.55_{stat} \pm 0.2_{syst}$

The search of the flare in H.E.S.S. data

No hint of variability

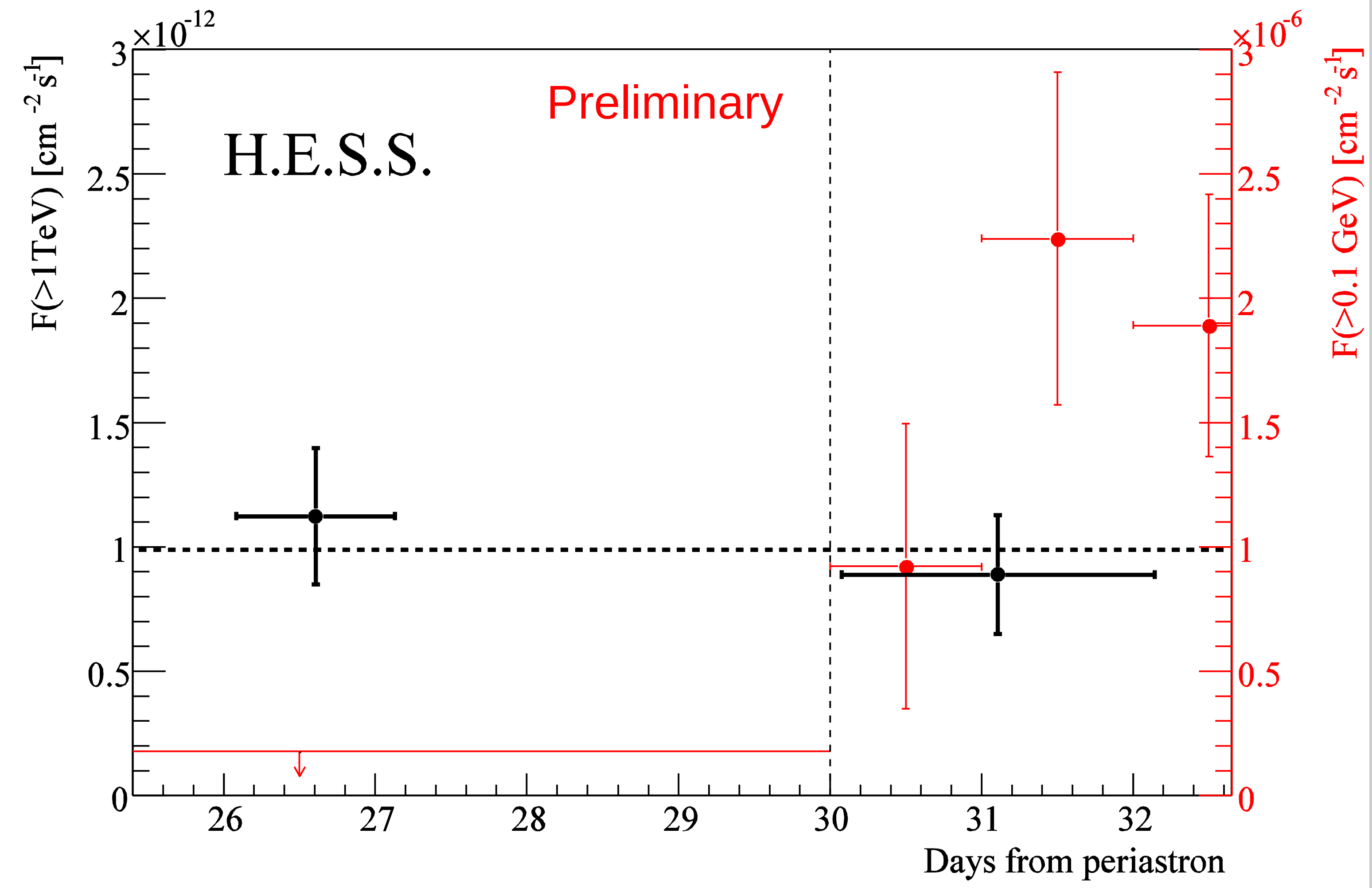
Const fit:
Chi2/NDF = 0.42/1
Prob = 0.52



The search of the flare in H.E.S.S. data

Flare coefficient $k = F_{flare}/F_{preflare}$ => $k_{Fermi} \geq 9.2$

Upper limit on k_{HESS}?



The search of the flare in H.E.S.S. data

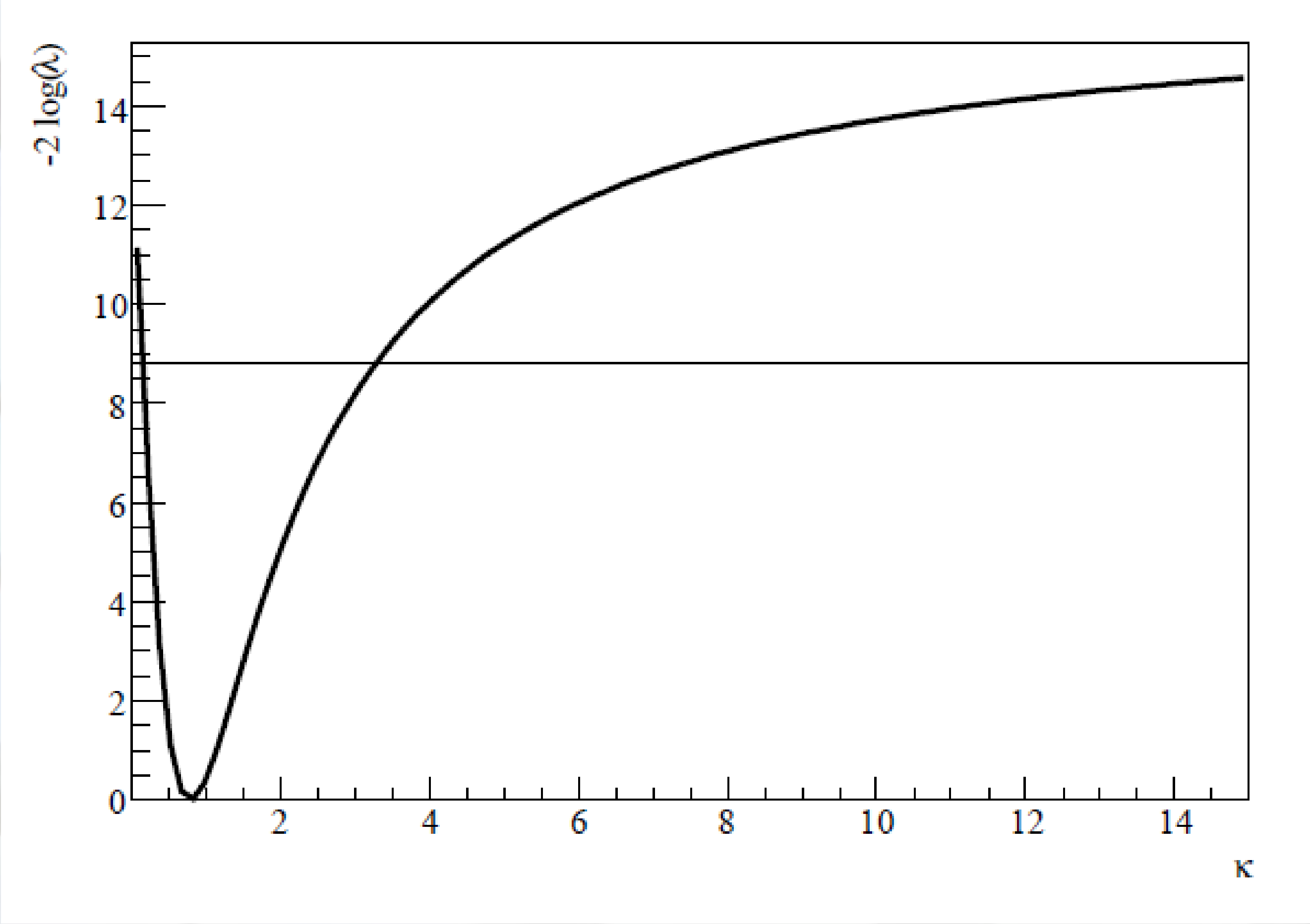
$k_{Fermi} = F_{flare}/F_{preflare}$

$$\lambda(\kappa) = \frac{L(\hat{\hat{\phi}}_1, \kappa | \phi_1, \phi_2)}{L(\hat{\phi}_1, \hat{\kappa} | \phi_1, \phi_2)}$$

$k_{Fermi} \geq 9.2$

Profile likelihood: $-2log(\lambda)$

follow the chi-squared distribution with 1 df



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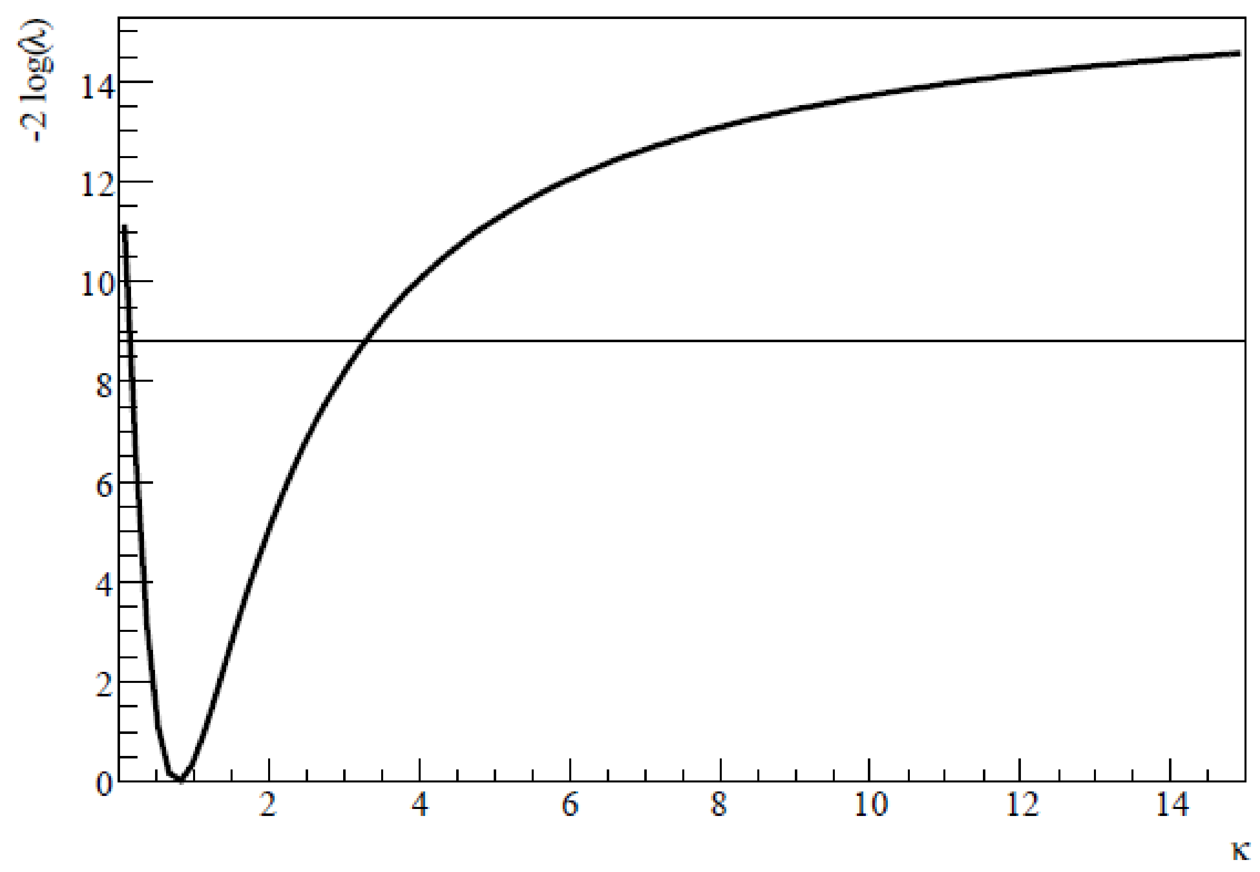
0.3% percentile is 8.8

99.7 % CL UL is k<3.3

GeV and TeV emissions come from different mechanisms

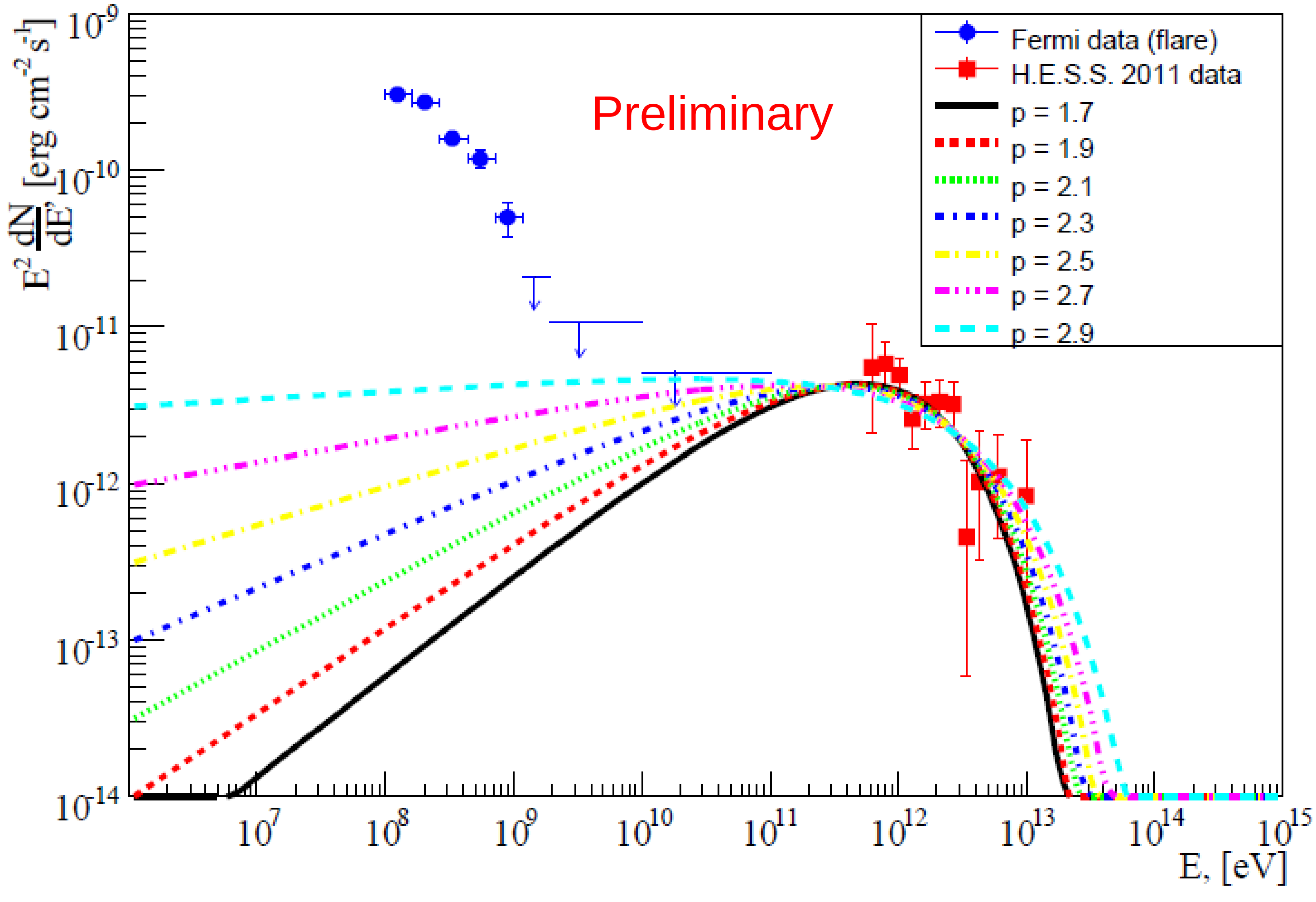


TeV emission modeling

$$\frac{dN_e}{d\gamma} = K_e \gamma^{-p} e^{-\frac{\gamma}{\gamma_{max}}}$$

electron energy distribution

Electrons accelerated at the shock
Electrons are assumed to be distributed isotropically
IC scattering on the stellar photons



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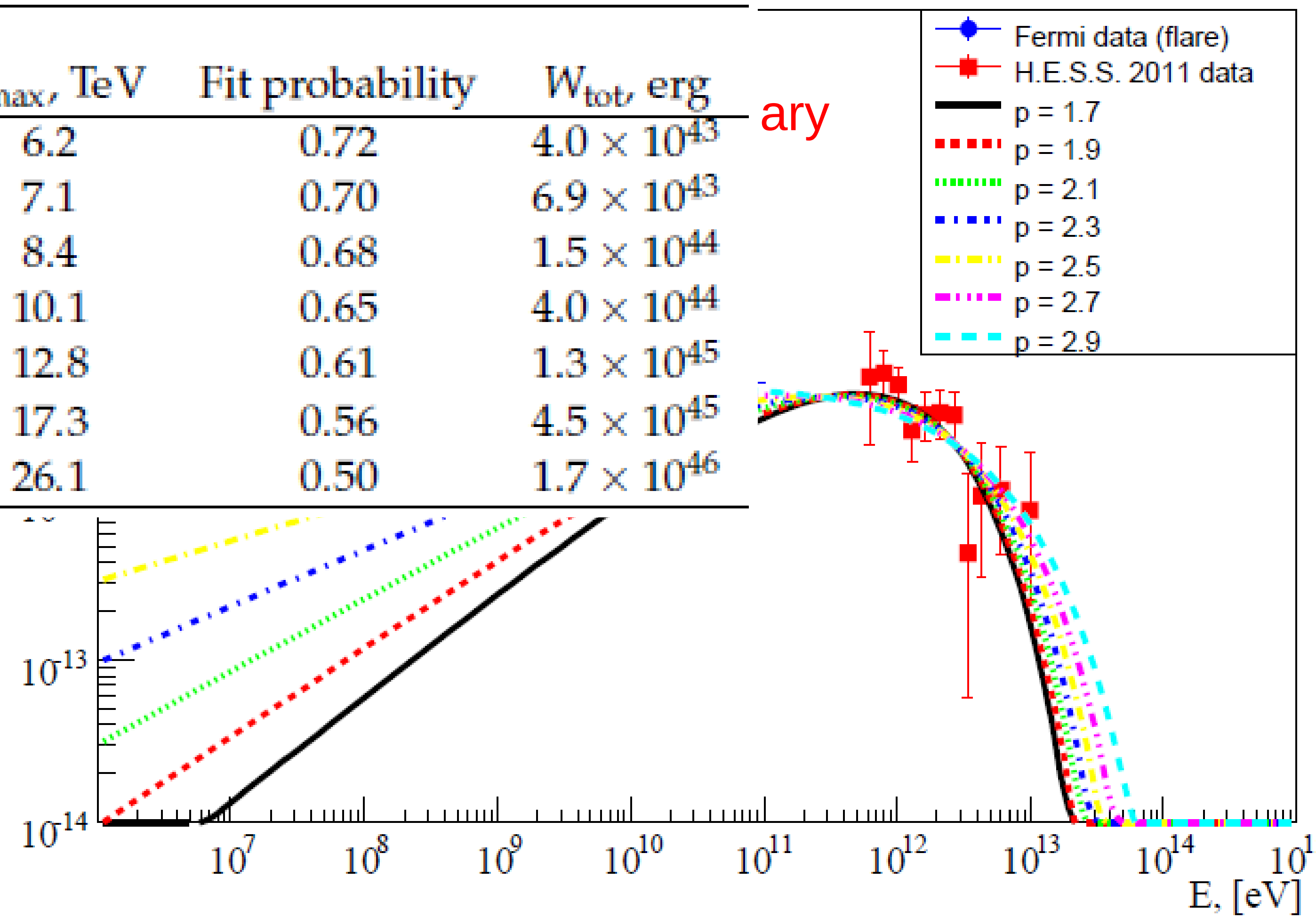
p	$K_e/(4\pi D^2)$, cm^{-2}	E_{max}, TeV	Fit probability	W_{tot}, erg
1.7	2.2×10^2	6.2	0.72	4.0×10^{43}
1.9	5.0×10^3	7.1	0.70	6.9×10^{43}
2.1	1.1×10^5	8.4	0.68	1.5×10^{44}
2.3	2.6×10^6	10.1	0.65	4.0×10^{44}
2.5	5.8×10^7	12.8	0.61	1.3×10^{45}
2.7	1.3×10^9	17.3	0.56	4.5×10^{45}
2.9	2.9×10^{10}	26.1	0.50	1.7×10^{46}



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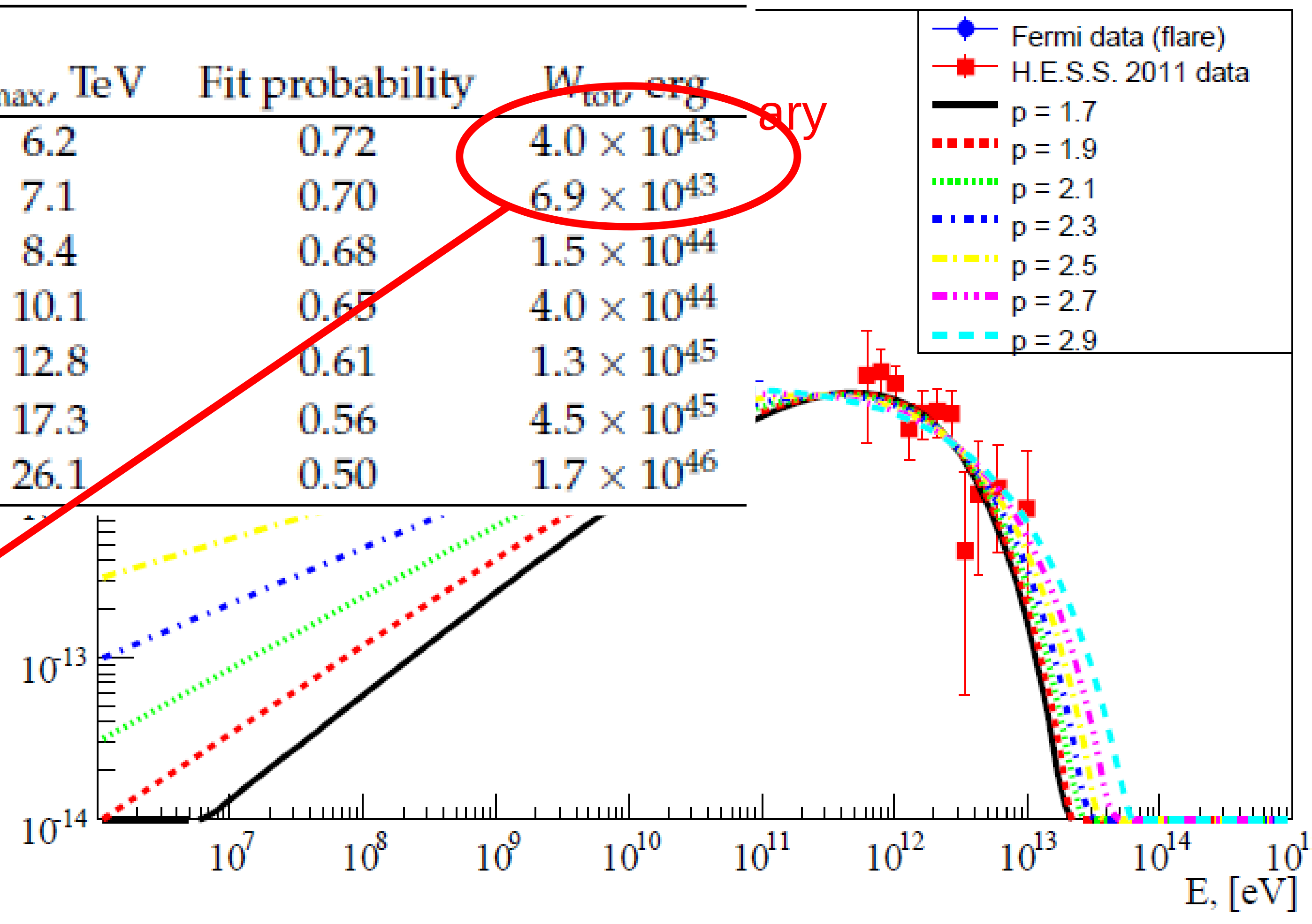

Less than 3.4 years needed

Summary

- Confirmation of previous observation results
- Confirmation of the repetitive behavior of the source
- No signs of time variability in flux at TeV energies on the 7 days timescale
- The spectacular GeV flare is not accompanied by a flare at TeV energies
- Different mechanisms responsible for GeV and TeV emission