MAGIC observations of Dragonfly Nebula at TeV Energies using the Very Large Zenith Angle Technique

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Outline

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Dragonfly nebula at TeV energies

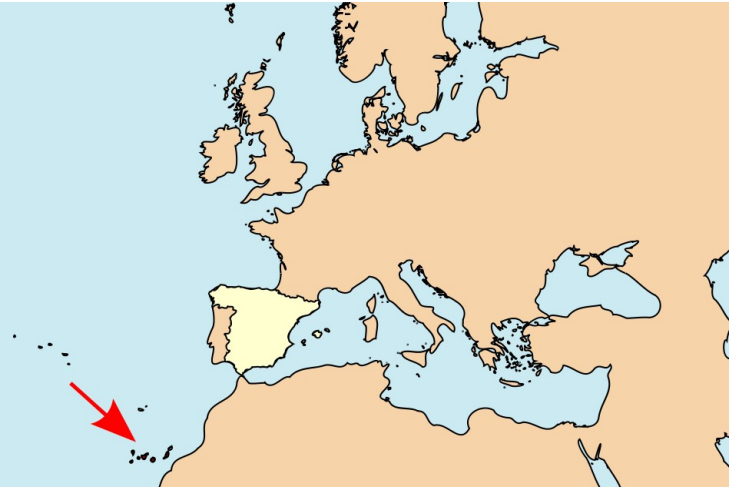
- MGRO J2019+37: brightest Milagro gamma-ray source in the Cygnus region
  - 80% of the Crab Nebula flux above 12 TeV
- In 2014 VERITAS resolved MGRO J2019+37 into:
  - point source VER J2016+371
  - extended source VER J2019+368
- VER J2019+368 cause for majority of MGRO J2019+37 emission

Aim of these observations

- Domain above several tens of TeV has not been deeply studied
  - Perform spectral measurements in that domain
- Hard spectrum of VER2019+368 published by VER in ’14 (~1.75)
  - good candidate for obervations
- Interesting to measure the maximum energy of the emission particles

MAGIC telescopes

- System of two Imaging Atmospheric Cherenkov Telescopes
- Observing the very high energy gamma-ray sky
- Dish diameter 17m
- Located at La Palma, Canary islands
- 2200 m a.s.l



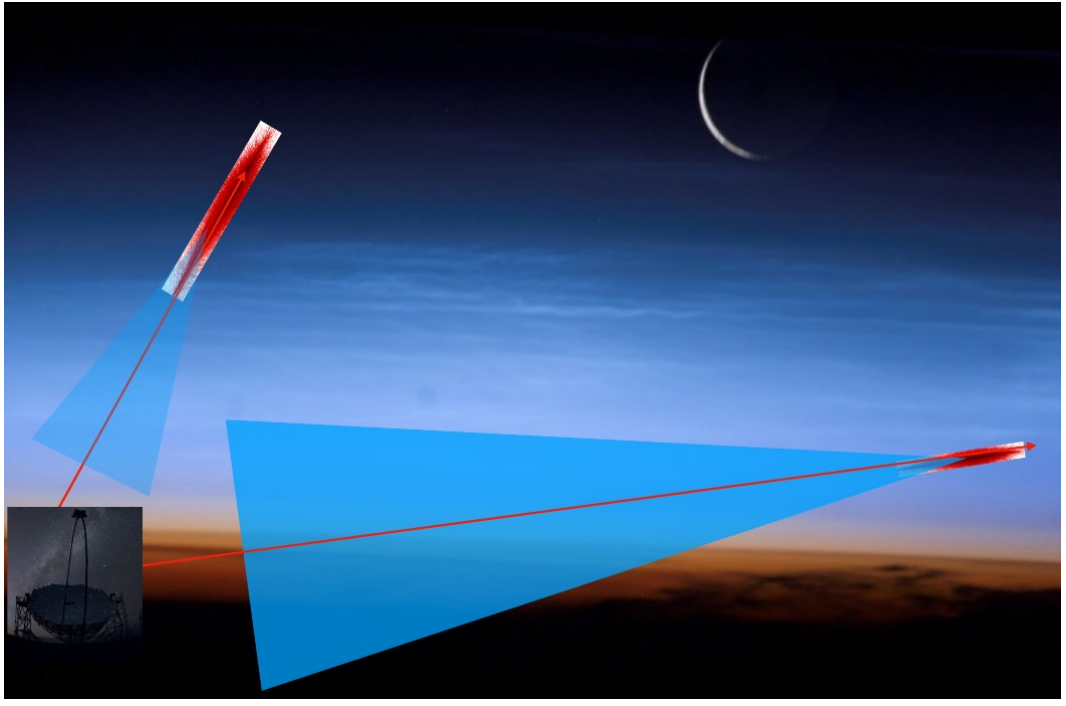
Observing the high energy spectrum

- Observations of very high energy gamma rays
  - Flux decreases rapidly → low count rates
- Solution: increase observation time or increase the collection area
- To increase collection area:
  - Build bigger telescope arrays
  - Observing with Very Large Zenith Angles

Very Large Zenith Angle Observations

- Observations above ~60° zenith
- Increase in collection area ~1km^2
- Energy threshold ~1 TeV
- Careful analysis of atmosphere required

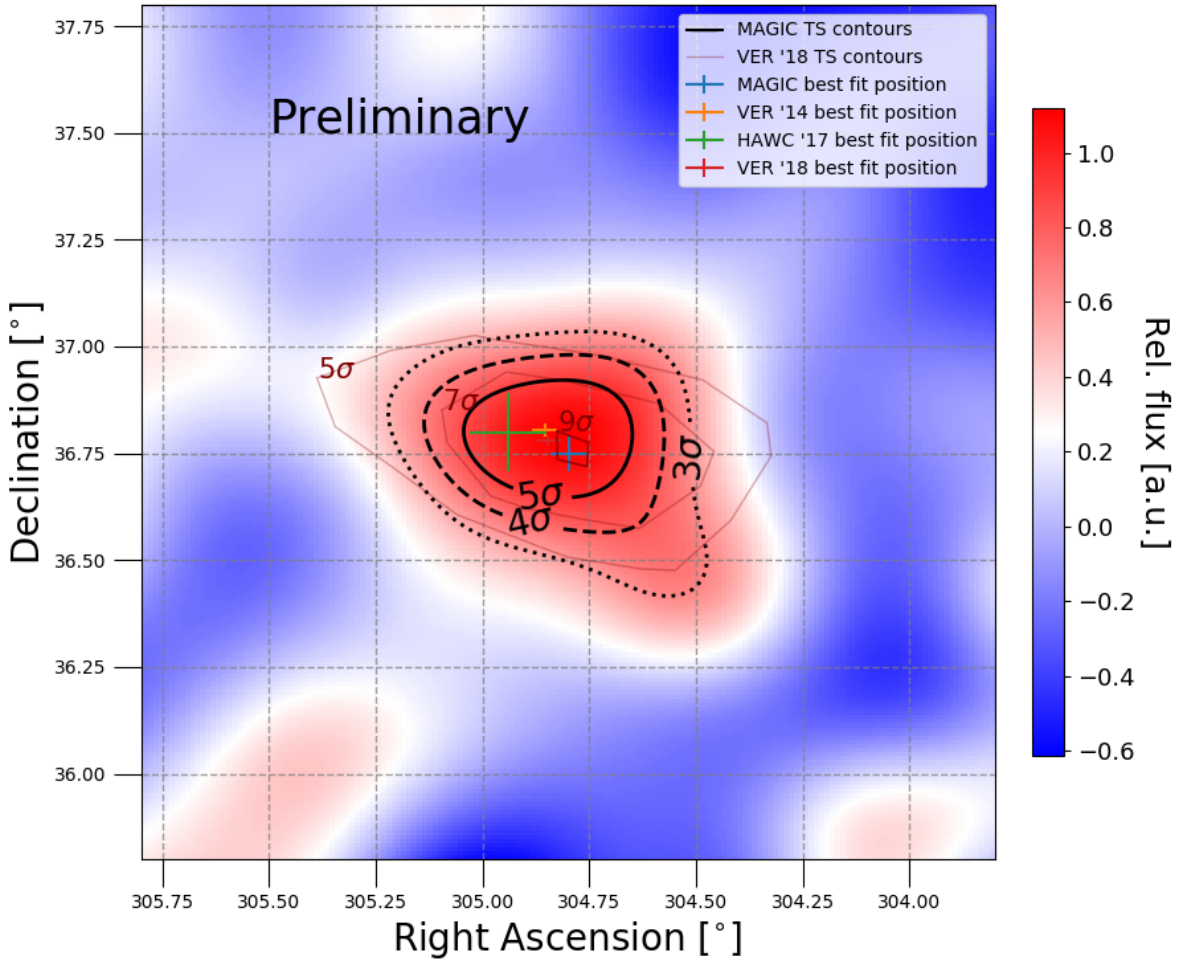
- For details on the method see poster on the VLZA Technique by Martin Will
- GAI Poster Session 3
- PoS(ICRC2019)828



Skymap

- ~45 hours of data taken in 2018
- Between 62°- 80° zenith

- Source shape asymmetric
- No indication of 2 candidate sources comprising VER 2019+368 in MAGIC data yet



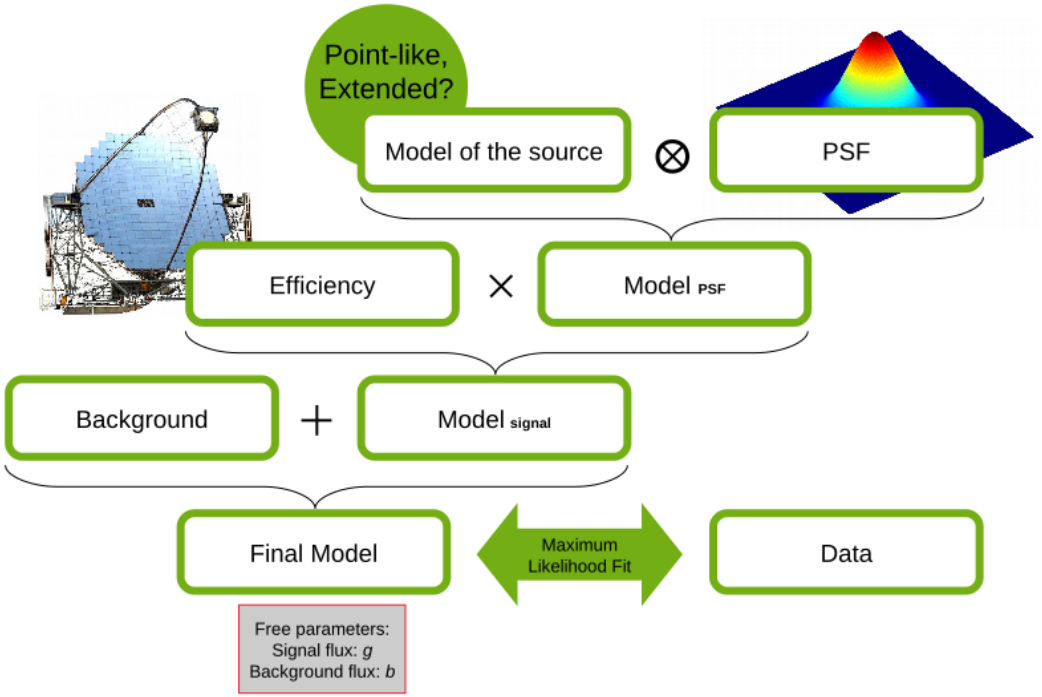
Source modeling

- Standard IACT analysis uses source and background control region to extract spectral parameters
  - Usually only suitable for point like sources
- New analysis tool in MAGIC: Maximum likelihood fit of the source model to the sky image

1. $\underbrace{\text{Model} \otimes \text{PSF}}$
2. $\underbrace{\text{Model}_{PSF} \times \text{Exposure}}$
3. $\underbrace{\text{Model}_{Excess} + \text{Background}}$
4. $\text{Complete Model} \Leftrightarrow \text{Data}$

Vovk et al., A&A 619, A7 (2018)

- Source modeled as an asymmetric 2D Gaussian with a power law spectrum
- Background modeled as isotropic with LogParabolaCutOff



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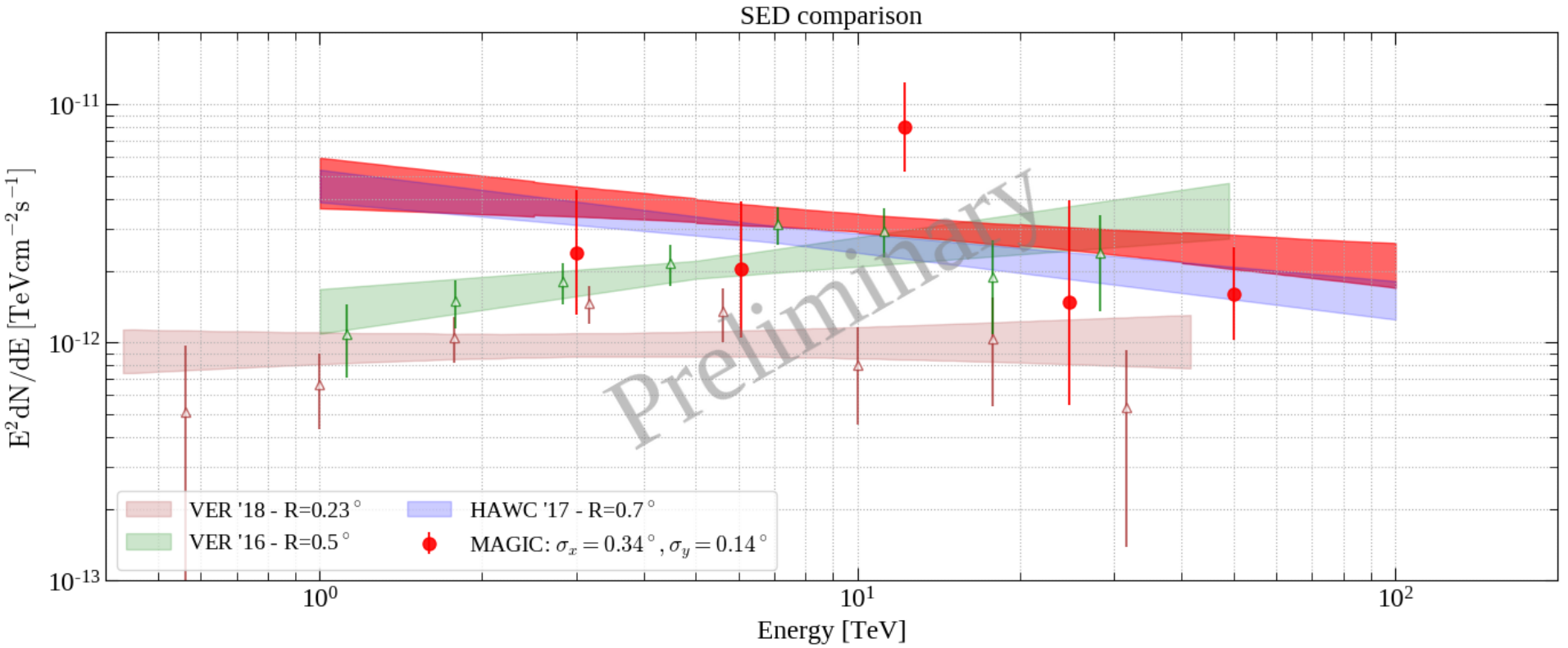
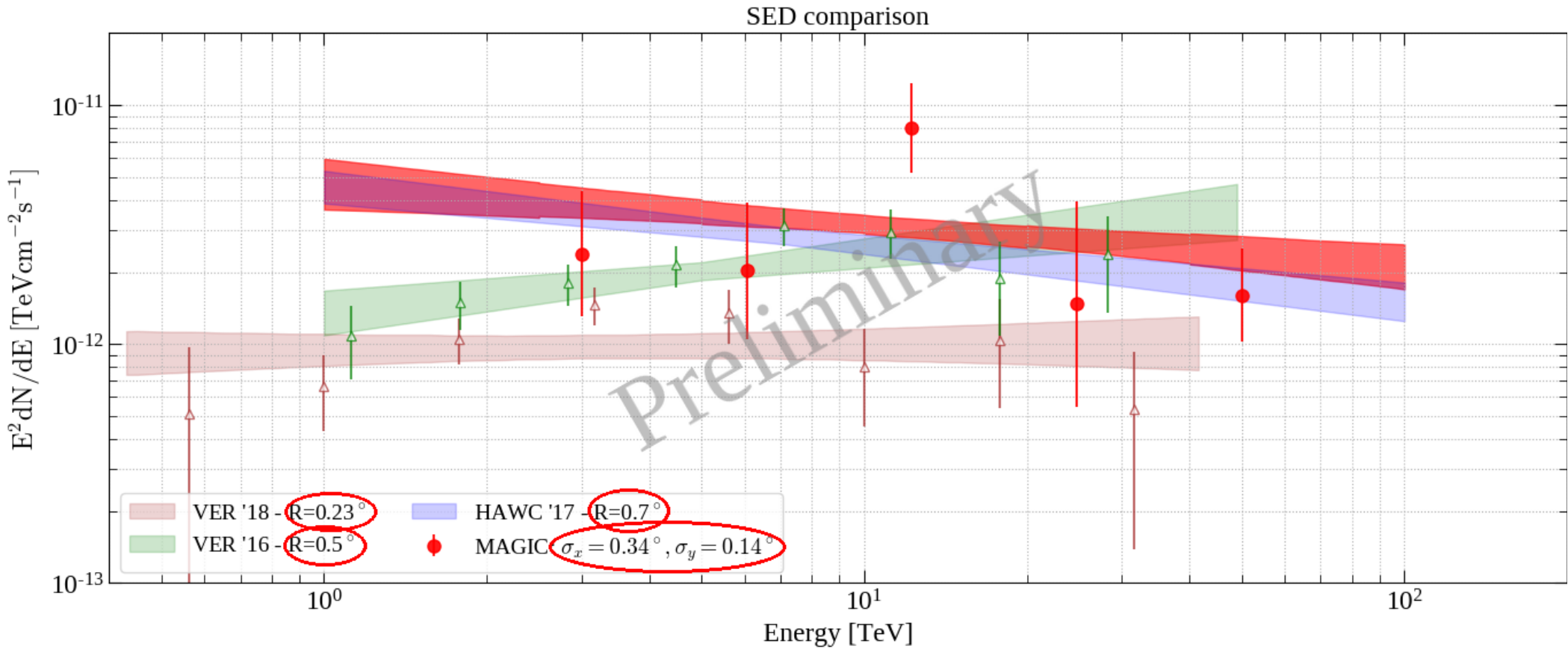

SED comparison
Preliminary
$E^2 dN/dE$ [TeVcm^{-2}s^{-1}]
10^{-11}
10^{-12}
10^{-13}
10^0
10^1
10^2
Energy [TeV]
VER '18 - R=0.23°
VER '16 - R=0.5°
HAWC '17 - R=0.7°
MAGIC: $\sigma_x = 0.34°$, $\sigma_y = 0.14°$

Best fit results comparison

- All results fit by a power law spectrum:

$$\frac{\mathrm{d}F}{\mathrm{d}E} = F_0 \left(\frac{E}{\mathrm{E}_0} \right)^{-\Gamma}$$

	VERITAS 2014	HAWC 2017	VERITAS 2018	MAGIC preliminary
Γ	1.75 ± 0.08	2.24 ± 0.04	1.98 ± 0.09	2.14 ± 0.08
F_0 [$TeV^{-1}cm^{-2}s^{-1}$] x 10^{-14}	8.1 ± 0.7	5.8 ± 0.5	10.2 ± 1.1	8.2 ± 0.7
E_0 [TeV]	5	7	3.11	7
Integration region	R=0.5°	R=0.7°	R=0.23°	σ_x= 0.34° σ_y= 0.14°



HAWC ‘17 extraction region ≈ 95% containment of the MAGIC extraction region

Summary

- Spectrum more inline with 2017 HAWC survey results
- 50 TeV emission, new limit by IACTs of VER2019+368
- Need more data to test the candidate sources possibly composing VER J2019+37

Thank you for your attention!