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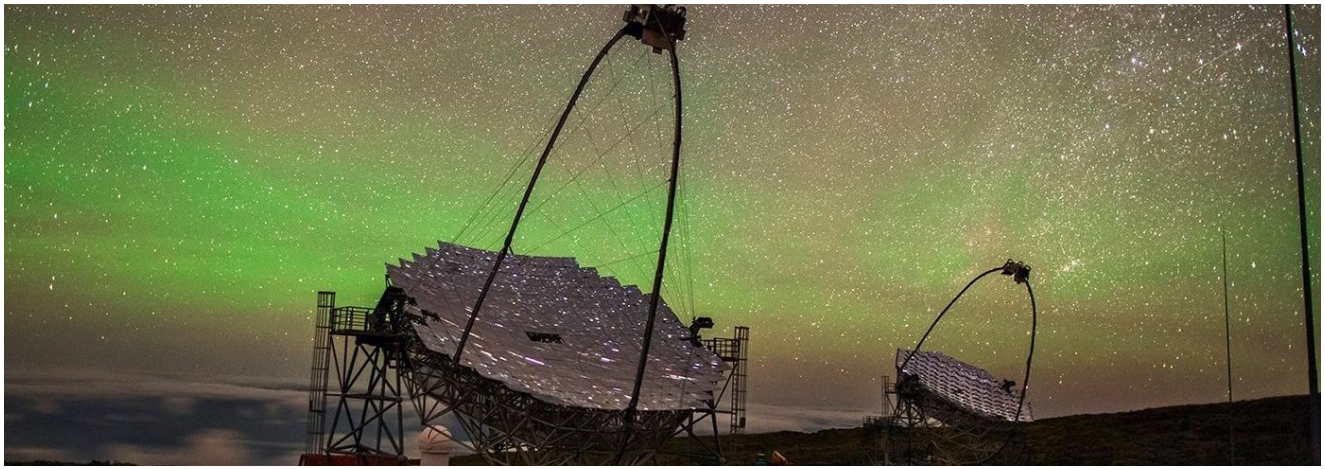

# Estimation of the observation time for the MAGIC telescopes on the basis of *Fermi* data

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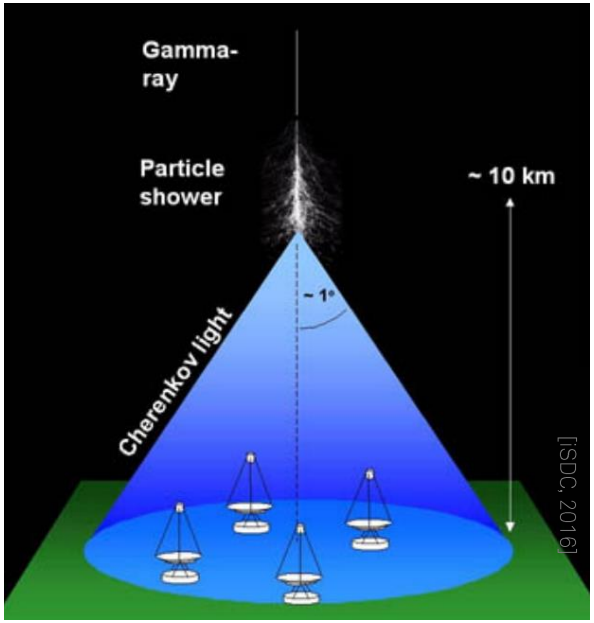
Experimental Physics 5 - TU Dortmund
Astroparticle school Obertrubach 2016

# MAGIC Telescopes

Major
Atmospheric
Gamma-Ray
Imaging
Cherenkov

- Energy range: 10 GeV – 30 TeV
- Field of View: 3.5°
- Effective collection area: >100000 m²




# Motivation

- Measurement of Cherenkov light
  → Need of dark light conditions
- Need of long observation times for detection
- Small Field of View
  → Measurement of one very high energetic gamma source per time

→ Estimation of observation time

→ Useful for observation proposals and schedules

# Estimation tool: Overview

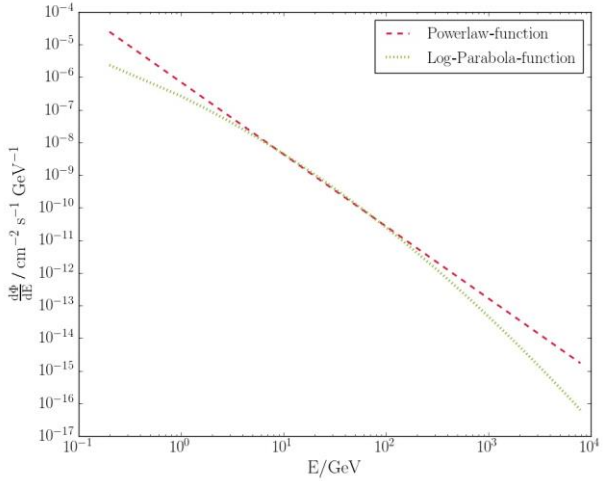
Differential flux

EBL absorbed flux

Signal rate

Significance

# Estimation tool: Basis




Differential flux

$$\frac{d\Phi}{dE}(E) = K \cdot \left(\frac{E}{E_0}\right)^{-\alpha}$$

$$\frac{d\Phi}{dE}(E) = K \cdot \left(\frac{E}{E_0}\right)^{-\alpha-\beta\cdot\ln\left(\frac{E}{E_0}\right)}$$

EBL absorbed flux


Signal rate

Significance

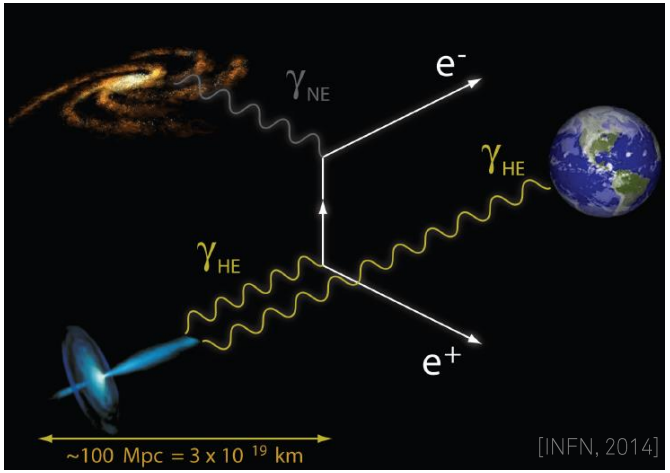
Extragalactic Background Light

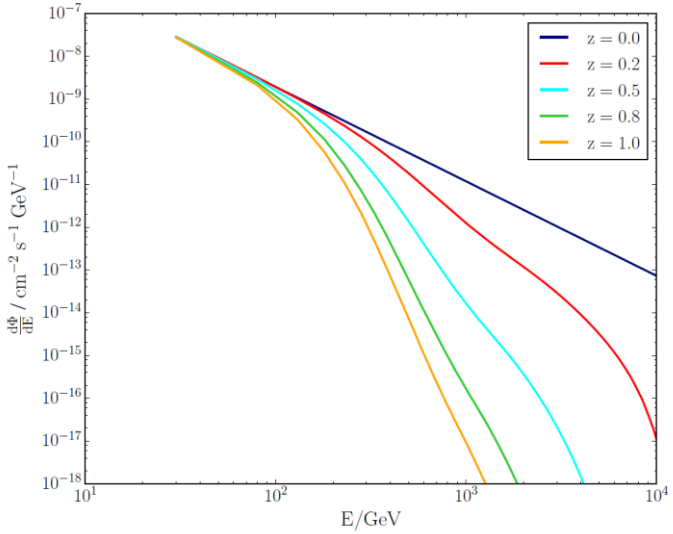
# Absorption by EBL

- Pair production of VHE photons and LE photons from EBL
- Exponential attenuation of intrinsic flux

$$\left(\frac{d\Phi}{dE}\right)_{measured} = \left(\frac{d\Phi}{dE}\right)_{intrinsic} \cdot e^{-\tau(E,z)}$$

- Interpolation of given $\tau$-values



# Estimation Tool: Effective collection area

Differential flux

Redshift z

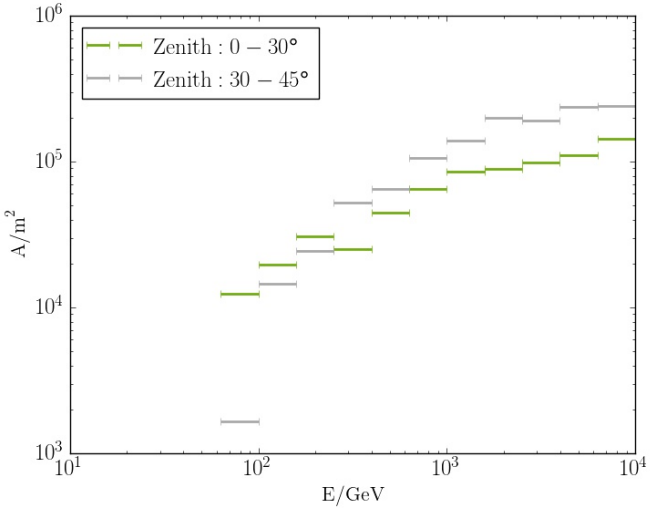
EBL absorbed flux

$$g = \int_{E_1}^{E_2} \frac{d\phi}{dE} A(E) dE$$

Effective collection area

Signal rate

Significance



# Estimation Tool: Rates

Differential flux

Redshift z ⇒ ⇓

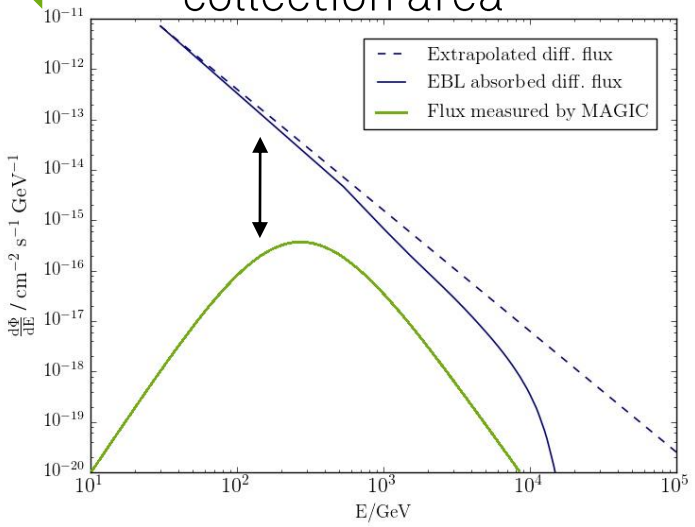
EBL absorbed flux

⇓ ⇐ Effective collection area

Signal rate

Background rate ⇒ ⇓

Significance

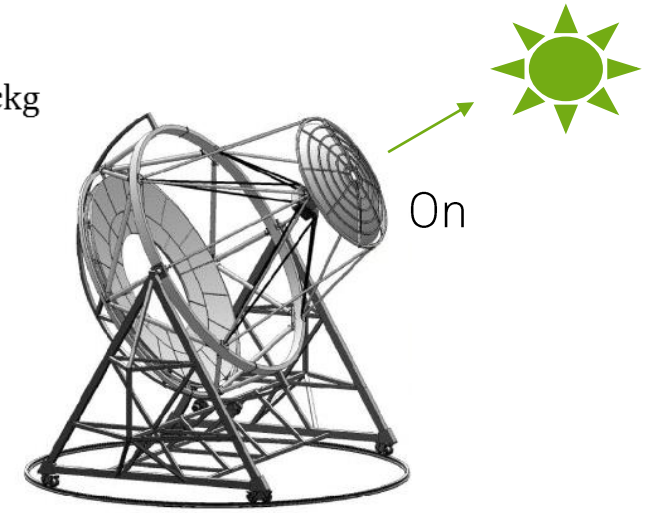


# Significance

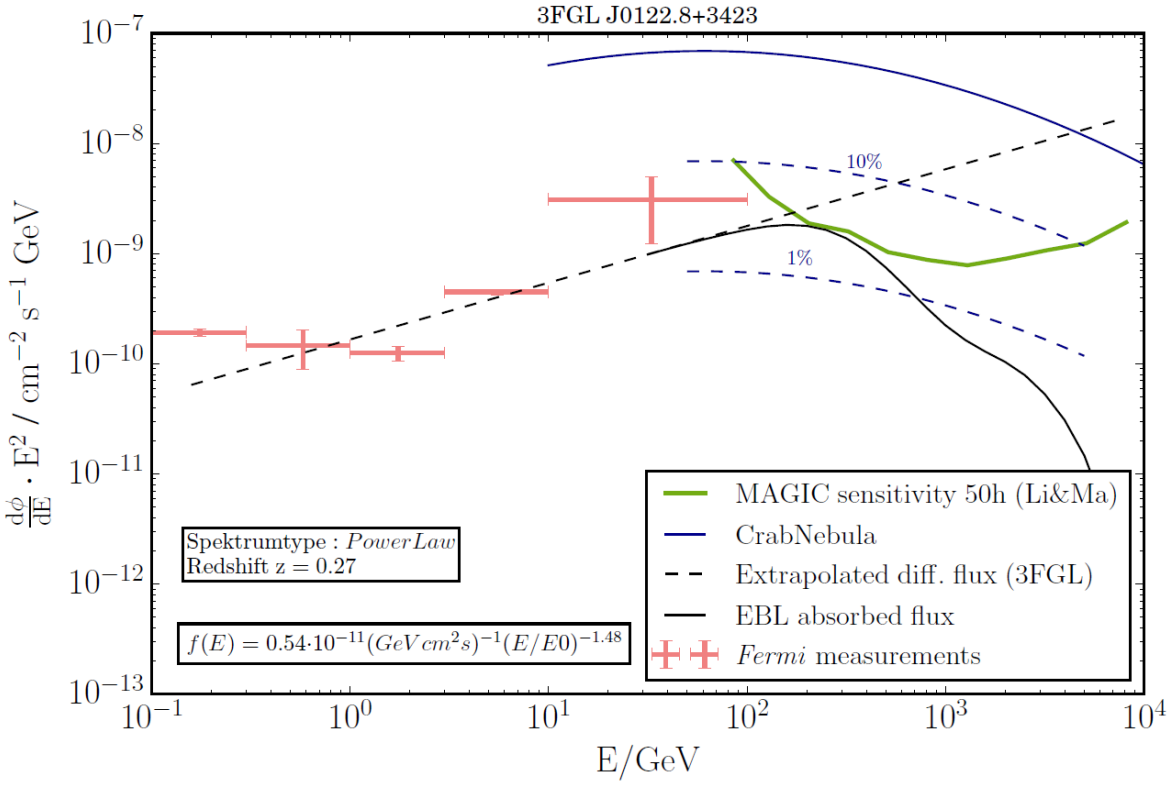
- Calculation with likelihood ratio test
- Dependence on On- and Off measurements

$$S = \sqrt{2} \cdot \sqrt{N_{on} \cdot \ln\left(\frac{1+\alpha}{\alpha} \cdot \frac{N_{on}}{N_{on}+N_{off}}\right) + N_{off} \cdot \ln\left(\frac{1+\alpha}{1} \cdot \frac{N_{off}}{N_{on}+N_{off}}\right)}$$

- $N_{on} = N_{excess} + N_{Bckg}$




# **Example:** 1ES0120+340 (z=0.272)




Full energy range:

11.7 σ

EBL

3.5 σ

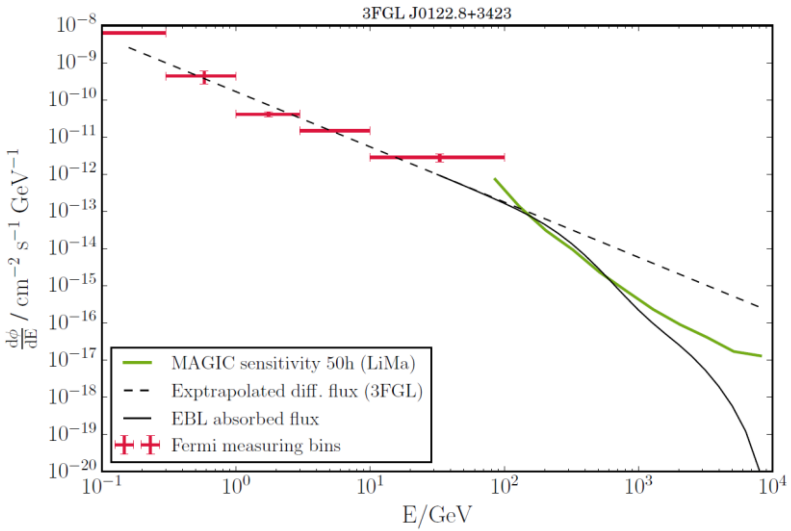
*Differential sensitivity*: flux of a source giving significance = 5 after 50 h of effective observations time

# Conclusion

- Development of estimation tool:
  - Extrapolation of *Fermi* measurements
  - Consideration of EBL absorption
  - Adaptable to zenith ranges, background rates and energy distribution
- First usage during MAGIC observations

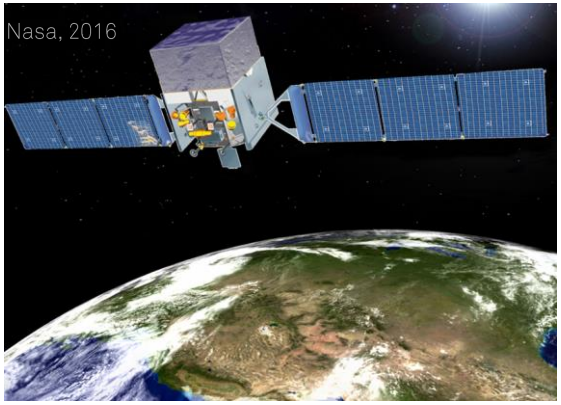
# Outlook

- Dependence on day of observation
- Release of the tool



# Backup

# Parameters from 3FGL




- Large Area Telescope on *Fermi* satellite:
  → Gamma-ray observation on 20 % of the sky
- Cataloging after detection:
  → 3FGL catalog with 3033 sources and 50 characteristics
- Given in 3FGL: slope, curvature, scaling + Integral flux

| | name | bii | spectrum_type | powerlaw_index | spectral_index | beta | flux_100_300_mev |
|---|---|---|---|---|---|---|---|
| 4 | 3FGL J0046.7-8419 | -32.8070 | PowerLaw | 2.8206 | 2.82062 | NaN | 1.121860e-08 |
| 5 | 3FGL J2202.4-8339 | -31.7347 | LogParabola | 2.4700 | 2.42962 | 0.1962 | 3.435640e-08 |
| 6 | 3FGL J2237.5-8326 | -32.5373 | PowerLaw | 2.4337 | 2.43369 | NaN | 1.365850e-08 |

# Data from MAGIC performance paper

| N | $E_1$ in GeV | $E_2$ in GeV | $\gamma-\text{Rate}_{0\text{-}30^\circ}$ in 1/min | UG-$\text{Rate}_{0\text{-}30^\circ}$ in 1/min | $\gamma$-$\text{Rate}_{30\text{-}45^\circ}$ in 1/min | UG-$\text{Rate}_{30\text{-}45^\circ}$ in 1/min |
|---|---|---|---|---|---|---|
| 0 | 63 | 100 | 3,01 | 4,060 | 0,40 | 2,920 |
| 1 | 100 | 158 | 4,29 | 2,410 | 3,18 | 2,890 |
| 2 | 158 | 251 | 3,37 | 0,540 | 2,76 | 0,540 |
| 3 | 251 | 398 | 1,36 | 0,066 | 2,86 | 0,305 |
| 4 | 398 | 631 | 1,22 | 0,027 | 1,76 | 0,088 |
| 5 | 631 | 1000 | 0,88 | 0,013 | 1,44 | 0,038 |
| 6 | 1000 | 1585 | 0,58 | 0,006 | 0,94 | 0,019 |
| 7 | 1585 | 2512 | 0,30 | 0,003 | 0,67 | 0,011 |
| 8 | 2512 | 3981 | 0,17 | 0,002 | 0,32 | 0,009 |
| 9 | 3981 | 6310 | 0,09 | 0,001 | 0,20 | 0,004 |
| 10 | 6310 | 10000 | 0,06 | 0,005 | 0,10 | 0,005 |