cherenkov telescope array

INFN PADOVA
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LST Crab campaign results

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INFN Analysis meeting

Fellini
Fellowship for Innovation at INFN

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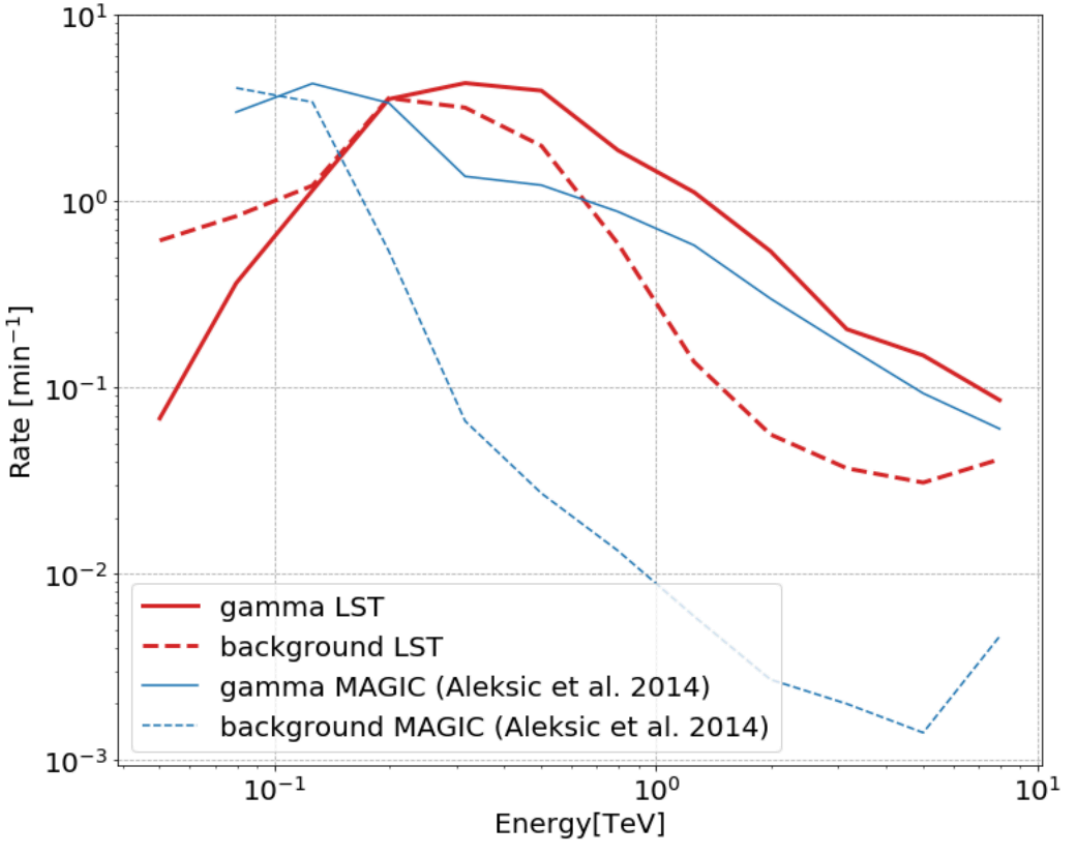
General words on the analysis

- Very preliminary results obtained with recently processed data.
  - Room for improvement in cleaning (not optimized yet), MC, signal extraction…
- Most of the results shown here use source-dependent analysis
  - Data from January/February campaign.
  - To match the Data to the MC performance, I introduced an overall 1.5 factor on the intensity (at the DL1 level) to account for:
    - ~20% difference between signal integration in MC and Data (will be solved in the next lstchain release).
    - additional ~20% difference between the optical efficiency of the current, non-tuned MC and that derived from analysis of muon real data.
  - No different cleaning applied between MC and Data -> would improve MC/Data agreement due to the above light intensity mismatch.
  - Total of **~ 14 hours** included in the analysis

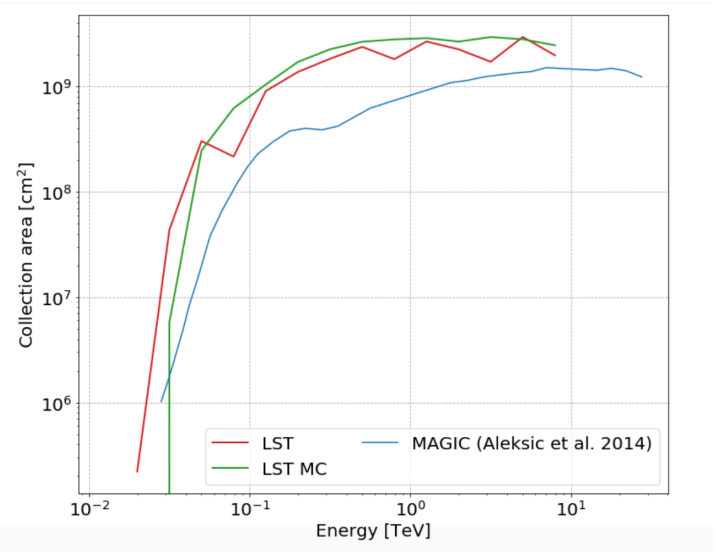
Rates

- Analysis performed using real data
  - Gamma rate corresponds to Crab excess.
- Rates at expected ballpark
  - The rates shown in the figure have been calculated using cuts to assure MC and Data matching.
  - Fixed cut in intensity > 200 phe due to MC/Data mismatches on trigger, image cleaning...

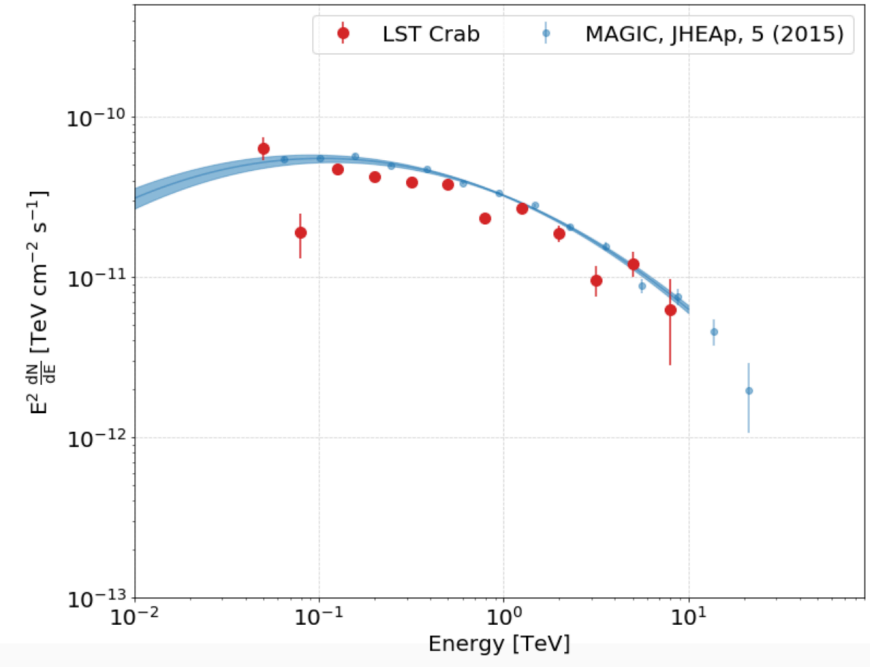


Spectrum

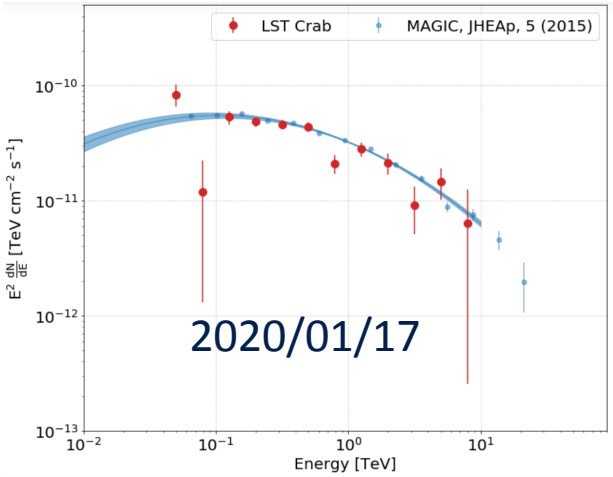
- **Very loose cuts** also applied to the collection area calculation to assure MC and Data matching.
- Collection area from MC and that derived from Crab Nebula observations.

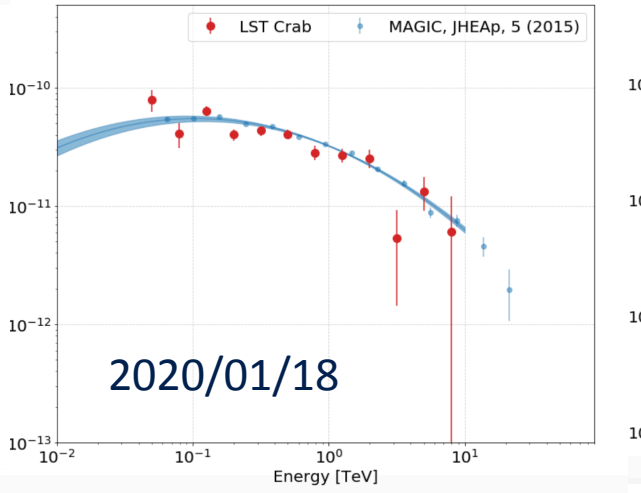


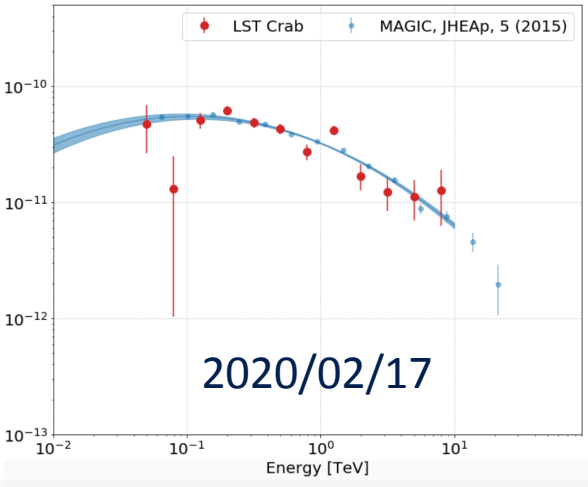
Coll. Area using very loose cuts to assure MC/Data matching

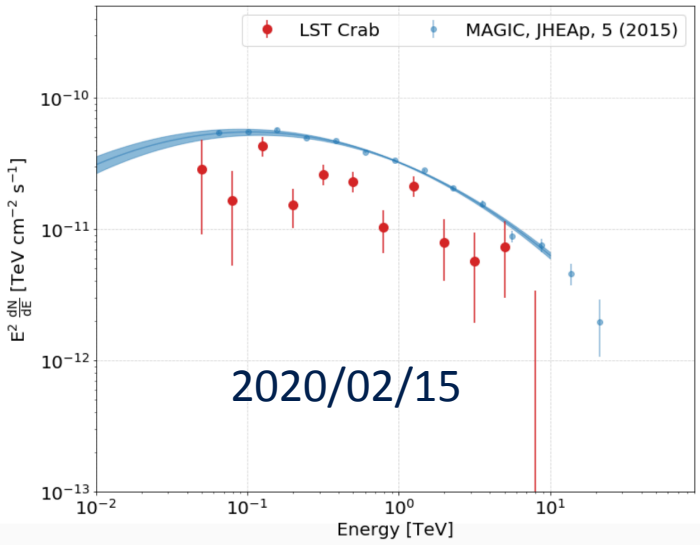


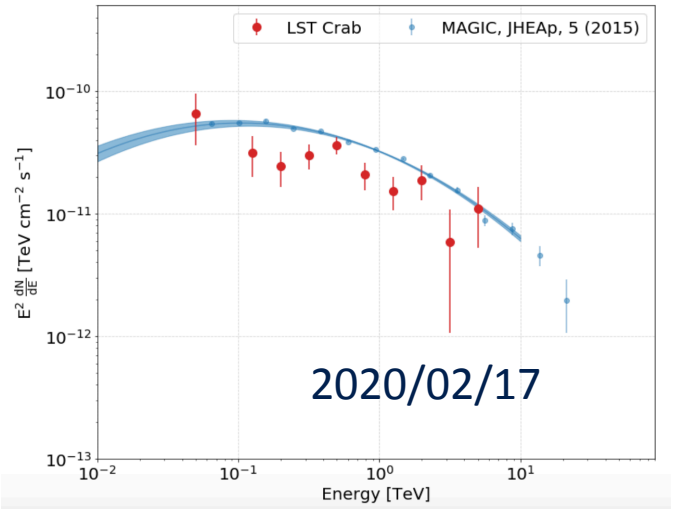
Spectra for days with ~few runs







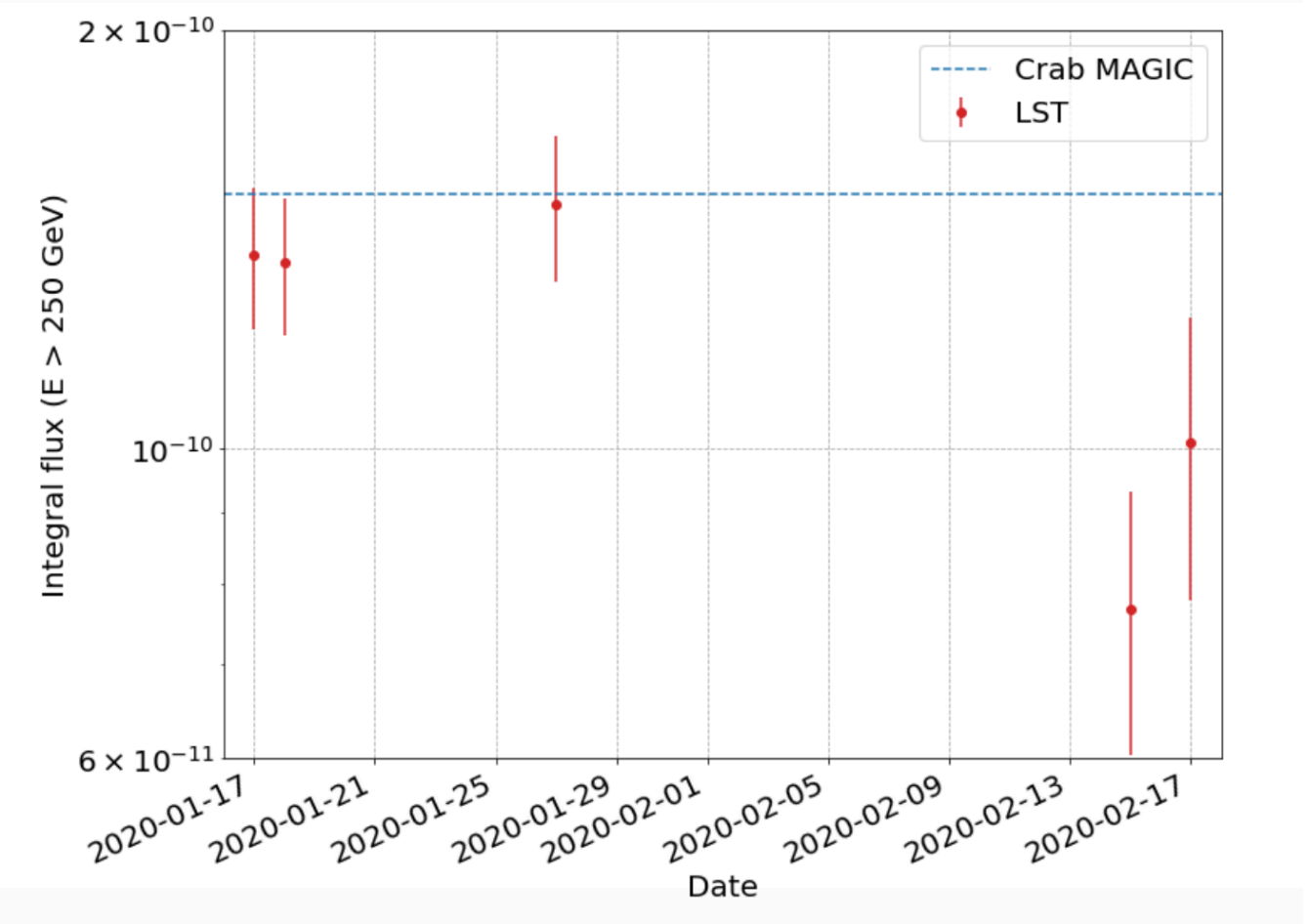




Stable spectra over time

Slight decrease in some days in February may be due to bad weather

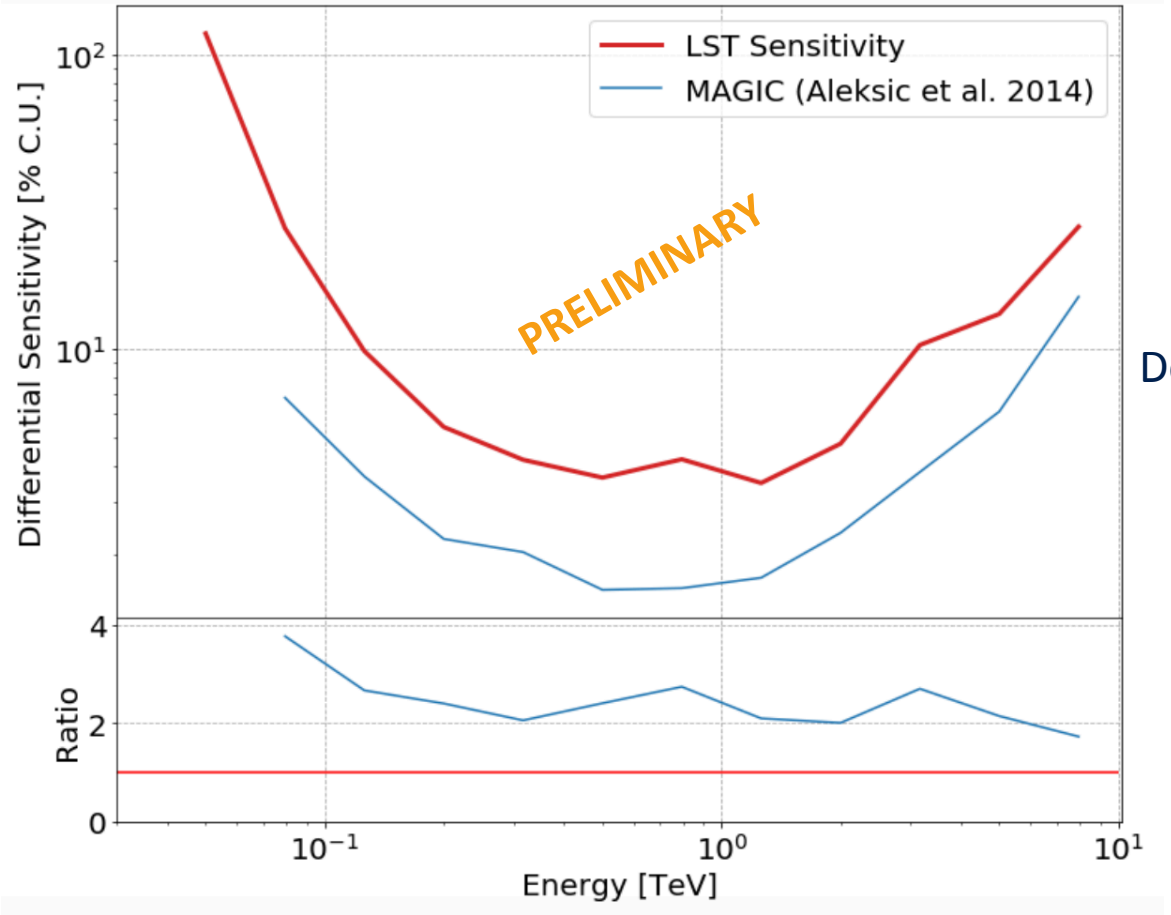
Integral flux



- Integral flux vs time at roughly the expected level if we take into account non-perfect-weather data

Differential Sensitivity

- Cuts optimized per energy bin in loose grid of alpha/gammaness



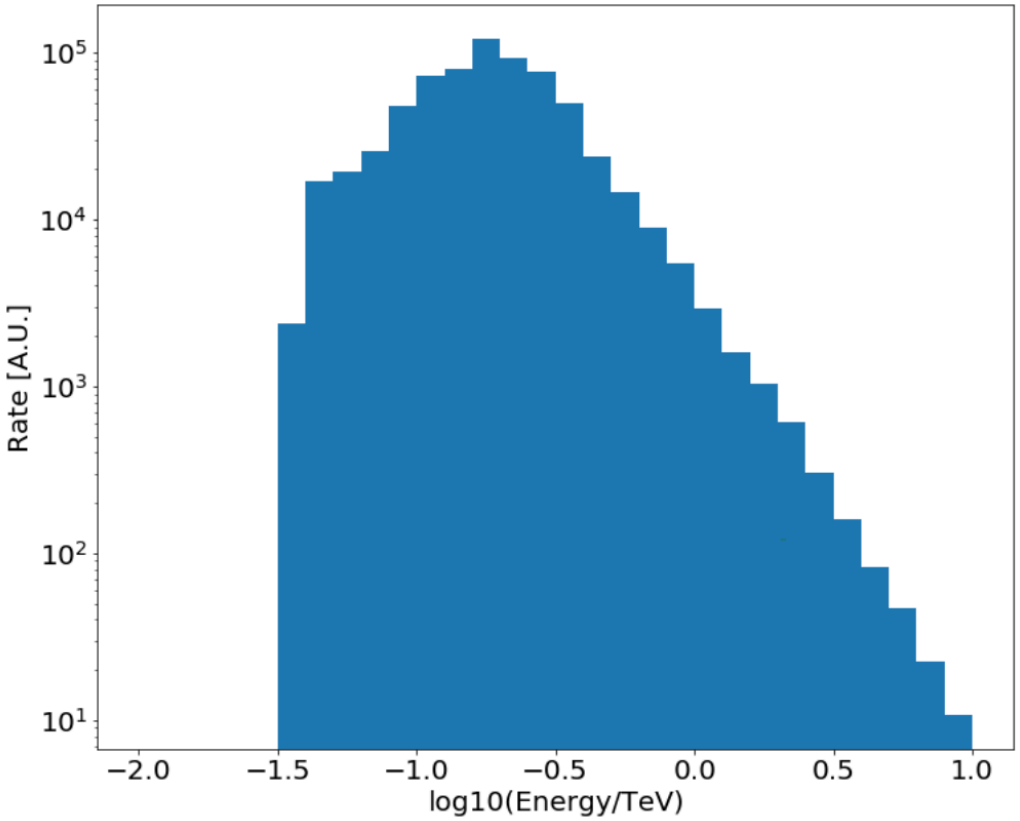
- Sensitivity goes:
  - Parallel to that of MAGIC Stereo at high energies and a factor ~2.5 worse
  - Diverges at low energies because of the worst background rejection due to observations performed in single-telescope mode

Definition

  - 50 hours of observation
  - Excess matching 5 sigma significance
  - 5 energy bins per decade
  - At least 10 gammas per bin after 50 hours.
  - Exposure ratio ON/OFF = 0.2
  - Excess > 5% Background (per energy bin)

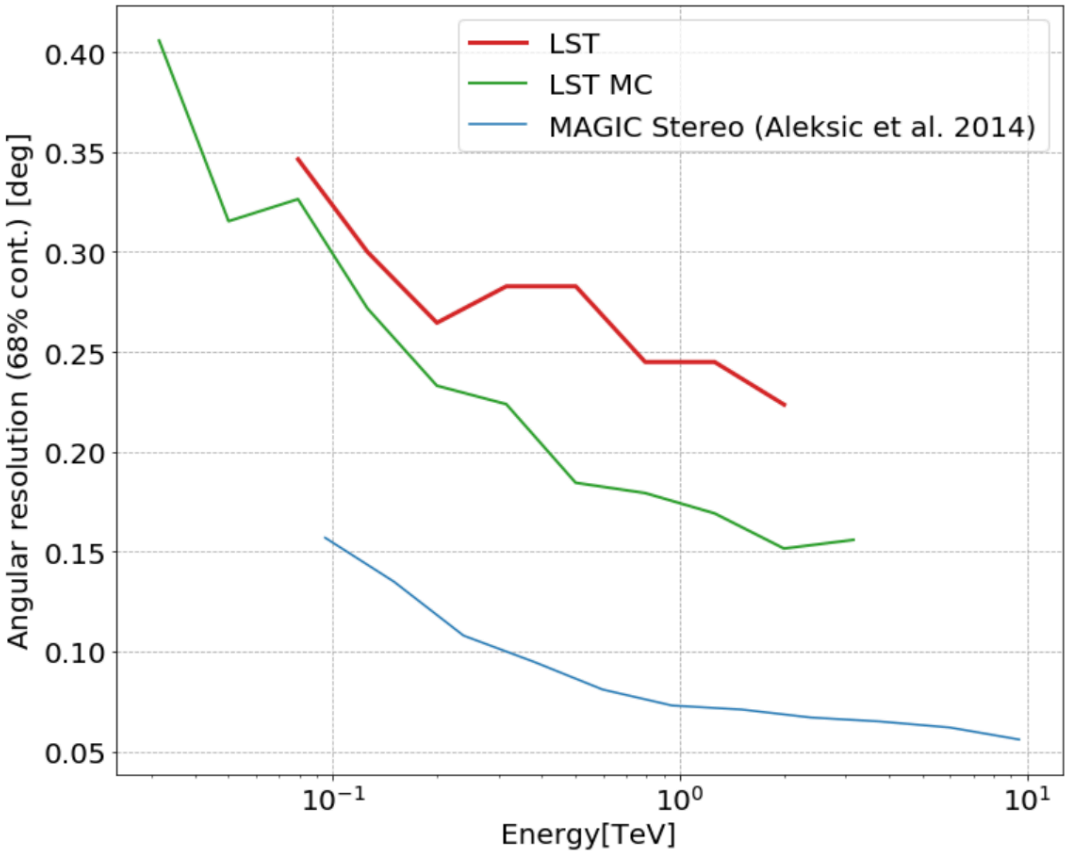
Energy threshold

- Using sensitivity cuts we reach a threshold of ~150 GeV
  - Relaxed cuts as those used for spectral calculation lead to much lower energy thresholds -> in the tens of GeV energy range



Angular resolution

- Angular resolution derived from data follows the trend expected from MC, still some Data/MC mismatch.
  - Results are also expected to be improved with optimized cleaning and usage of interleaved information



Crab Nebula

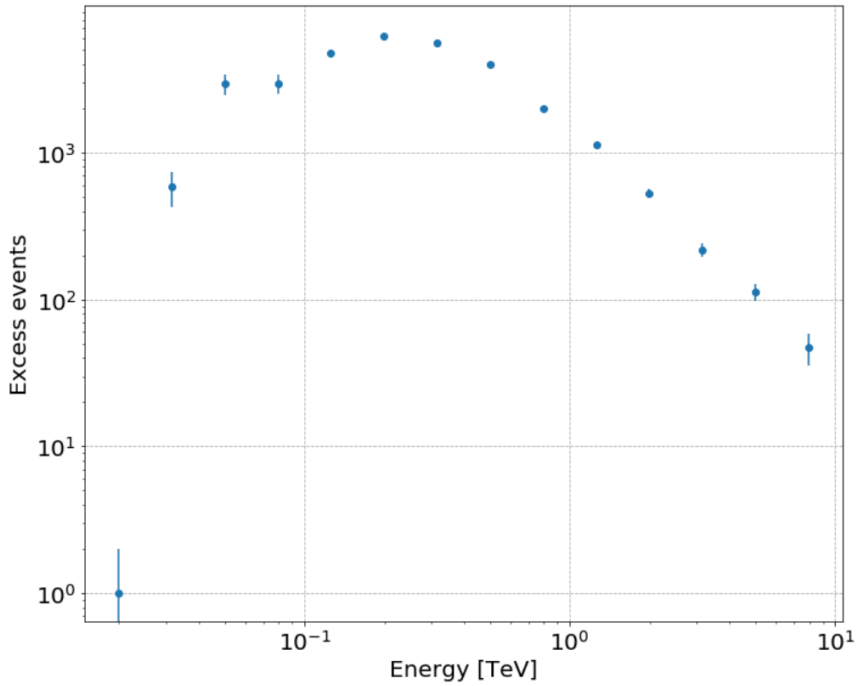
Crab Nebula …and pulsar

Timing fixed in v0.5

- Should give a good enough tagging precision to perform pulsar studies.
- PINT software (https://github.com/nanograv/PINT)
  - Tested on data from other IACTs with similar results to TEMPO2 software
  - Slight time and phase shifts because of 0-phase definition that can be easily corrected.
- Data selection:
  - Ruled out:
    - Bad weather runs (Runs 1999, 2000, 2002, 2003).
    - Moon runs (2020/02/01 - 2020/02/02).
    - After storm due to tests being performed (2020/02/27 - 2020/02/28).
    - Bad timing (Run 1814, 1887, 1888).
    - Total time = 11.4 hours

Crab pulsar analysis

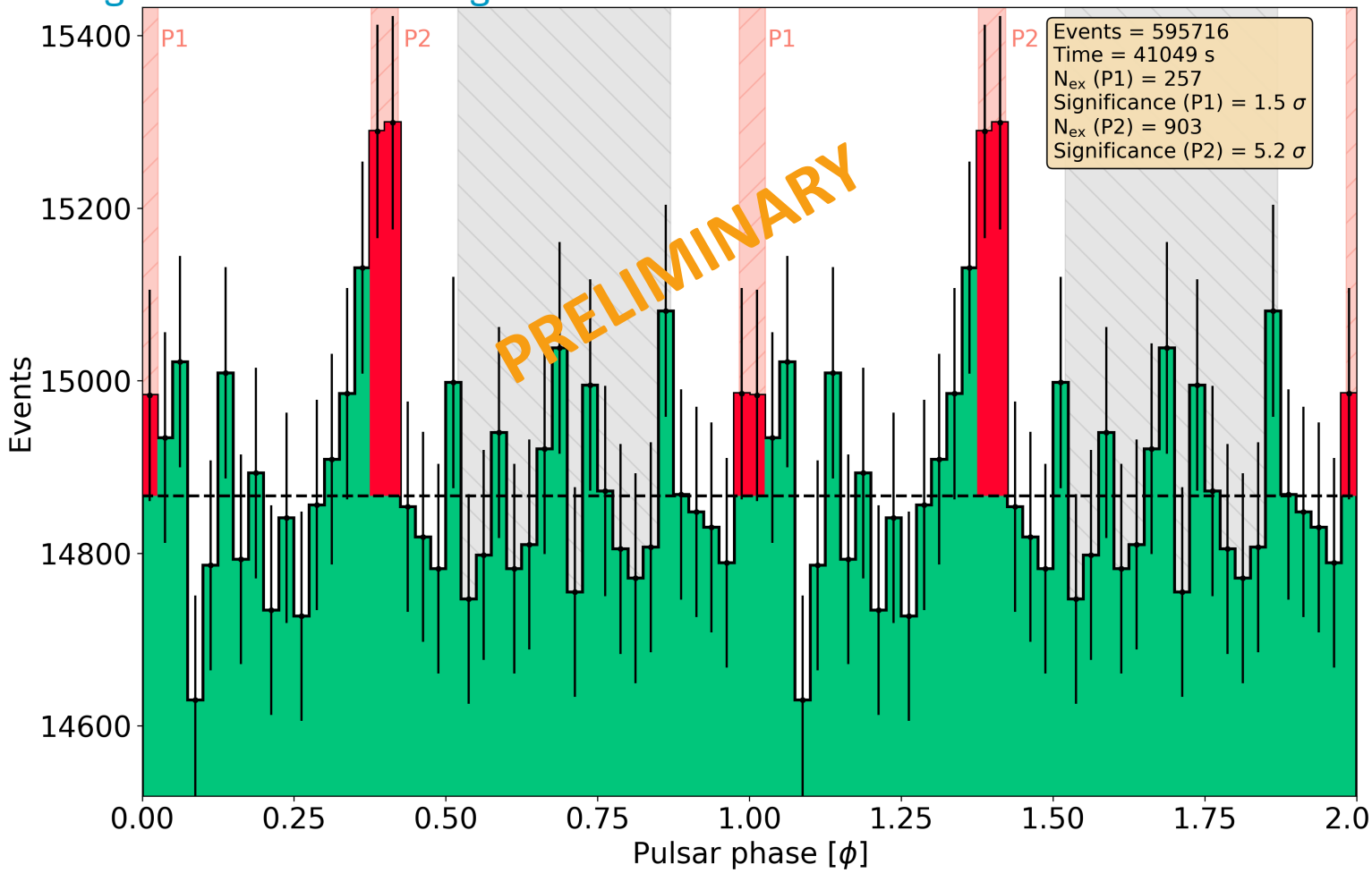
- Analysis characteristics
  - Source-Dependent analysis to improve the performance at the lowest energies.
  - ON/OFF region defined by the Aleksic et al. 2011:
    - P1: [0.983, 0.026]
    - P2: [0.377, 0.422]
    - OFF: [0.520, 0.870]
  - Loose cuts not to cut away low energy photons.
    - gammaness > 0.7
    - alpha < 8
    - E_reco > 25 GeV



Excess events of the Nebula + Pulsar

Crab pulsar detection

- Ephemeris using data from Jodrell Bank observatory (thanks to G. Ceribella)
- P2 clearly detected with significance 5.2 σ
- P1 significance is still marginal.



Conclusion

- LST1 gradually approaching expectations in terms of performance
  - Improving results thanks to all the software team.
  - Already several of the performance figures of merit match ballpark MC expectations. -> need a fine-tuned MC to properly assess it.
  - Room for improvement in the analysis, specially at the lowest energies:
    - Match MC and Data overall efficiencies -> in the following data productions.
    - Optimize image cleaning.

- Even only using commissioning data, already:
  - Crab pulsar detected in 11.4 hours of data.
  - First pulsar detected with a prototype telescope of CTA.
  - Signal significance ~ 1.5 σ * sqrt(Time/h)

Crab pulsar movie