



cherenkov
telescope
array

MAGIC + LST simulations: plans and perspectives.

F. Di Pierro

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1. First production (2019)
 - i. expected sensitivity of combined observations
 - ii. used also for LST-SiPM studies
2. Next production (> July 2020)
 - i. more realistic LST simulation
 - ii. Focused on LST-1 analysis, MAGIC included



1. Goals of the production

- i. To estimate the performance of combined MAGIC and LST1 observations
 - Check the simulation and analysis pipelines comparing these results and MAGIC known performance
- ii. To test cross-calibration strategies (MAGIC – LST1)

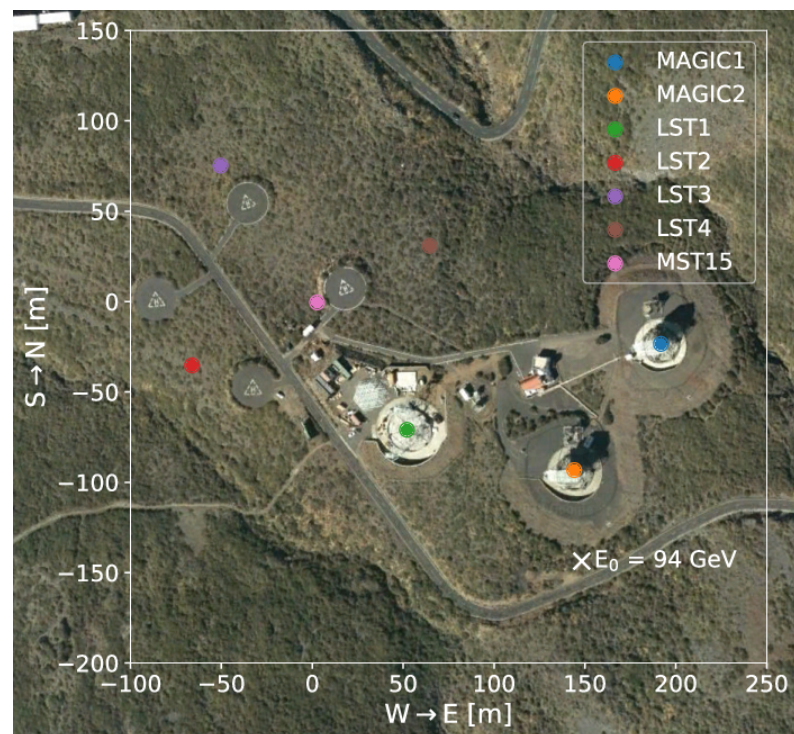
2. Redmine issue, to follow the task:

- i. <https://forge.in2p3.fr/issues/35807>

3. Production (corsika, simtel) and Analysis (chimp/mars) using **Dirac** on CTA VO resources

1. Layout (4 LSTs, 2 MAGIC, central MST)
2. Zenith angle, THETAP = 20°
3. Azimuth, PHIP = $0^\circ - 180^\circ$ (pointing S and N)

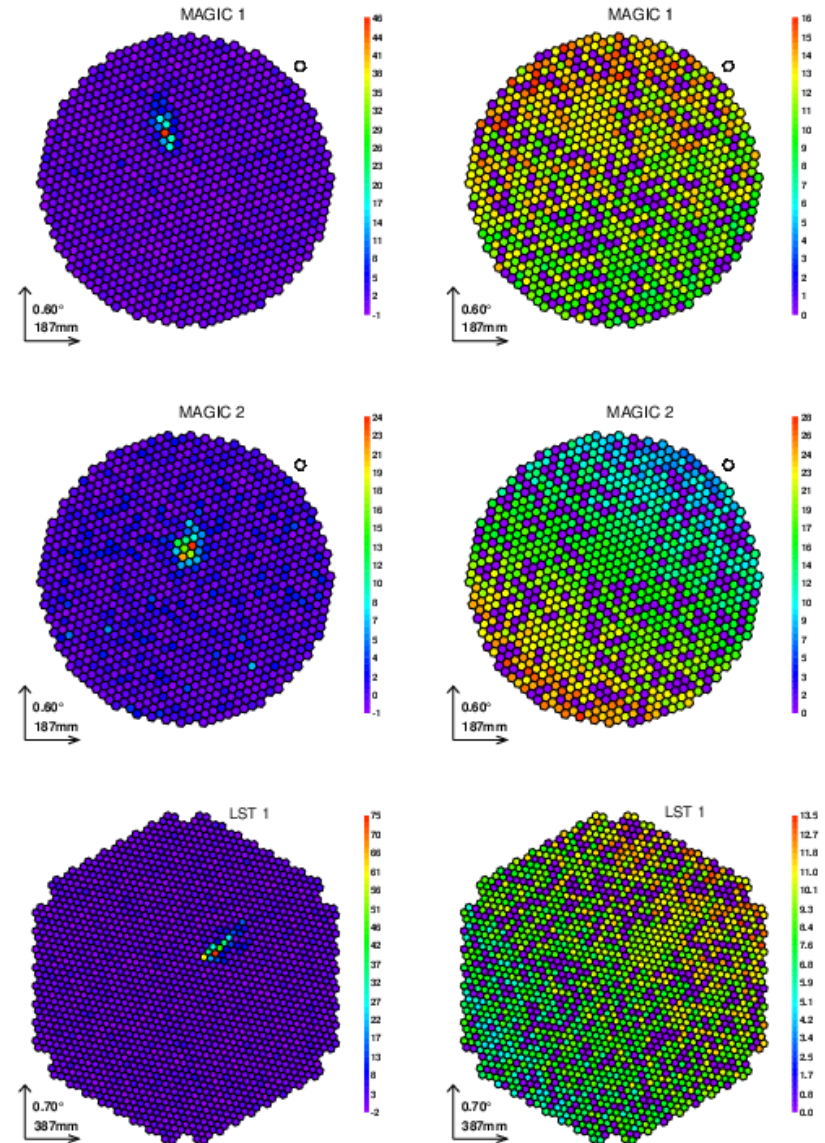
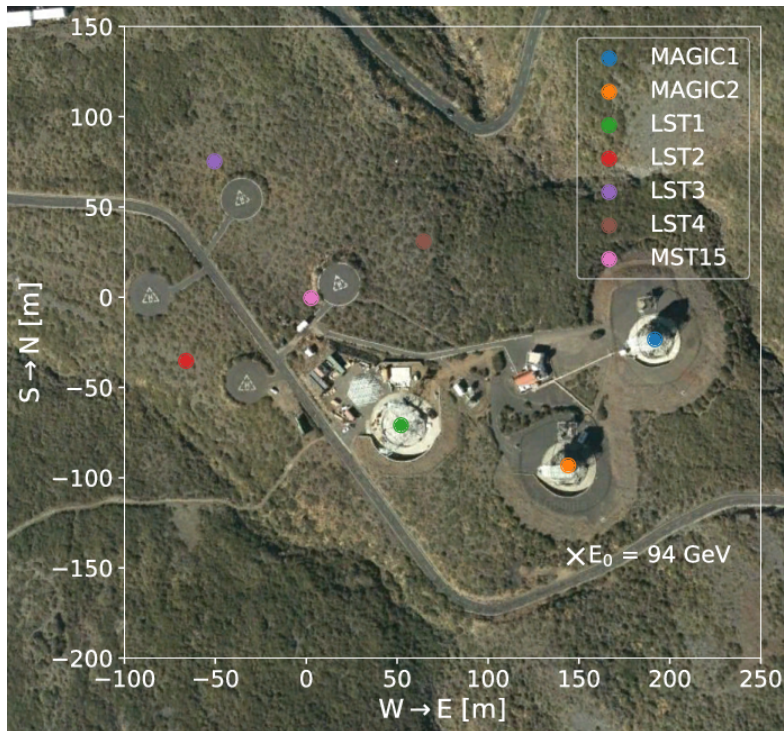
| Primary | Gamma | Proton | Electron |
|------------------------|-------|--------|----------|
| E _{min} [GeV] | 3 | 4 | 3 |
| E _{max} [GeV] | 330E3 | 600E3 | 330E3 |
| Eslope | -2 | -2 | -2 |
| CSCAT [m], radius | 700 | 1000 | 1000 |
| NSCAT | 5 | 10 | 10 |
| Viewcone [deg], radius | 0 | 6 | 6 |
| Nshow/job | 5E4 | 1E5 | 1E5 |
| Jobs | ~2200 | ~12000 | ~10000 |



- Files can be found here: [/vo.cta.in2p3.fr/MC/PROD4/LaPalma/](https://vo.cta.in2p3.fr/MC/PROD4/LaPalma/)
- Occupied Disk Volume: ~280 TB (all files, 2 pointings, gamma-diffuse)

1. **Version:** /vo.cta.in2p3.fr/software/corsika_simhessarray/2018-11-07/
2. **Configurations:**
 - /vo.cta.in2p3.fr/user/f/fdipierro/mycfg_simtel_magic_lst_test.tar.gz
 - i. LST: CTA-ULTRA6-LST-40ns.cfg (same as prod3 CTA-ULTRA6-LST.cfg, but with fadc_sum_bins = 40 instead of 30 [ns])
 - ii. MAGIC1 and MAGIC2 (CTA-PROD4-MAGIC1.cfg and CTA-PROD4-MAGIC2.cfg, produced by Sasa, Yoshiki, Yusuke, levgen, Julian, et al.).
3. **Trigger:** all mono triggers (used also for mono-analysis)
4. Files are here:
 - i. /vo.cta.in2p3.fr/user/f/fdipierro/simtel/

1. Camera displays for an event (gamma, $E_0 = 94$ GeV)
2. Pixel Charge (left), Pixel Timing (right)



1. Versions: /cvmfs/cta.in2p3.fr/software/sl6-gcc44/simulations/mars/2019-04-19/

i. ROOT: 5.34.38

ii. MARS: V2-19-3

iii. Chimp: current CVS version + small modification (MAGIC calibration scale):

/vo.cta.in2p3.fr/user/f/fdipierro/Software/CChimp_20190419.tar.gz

2. Chimp (calibration, image cleaning, conversion to root)

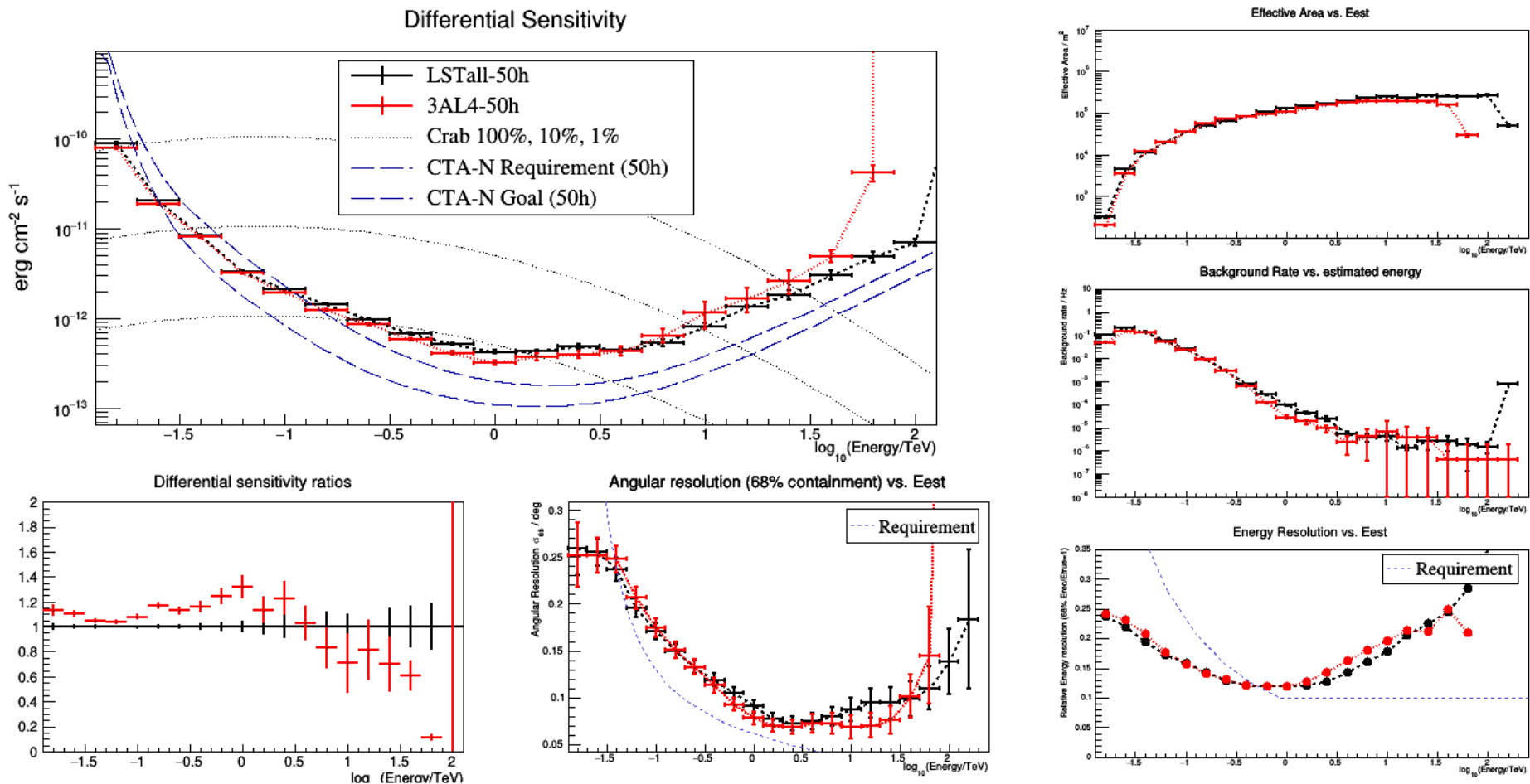
i. final_clean_levels: MAGIC (6,3), LST (4,2) (*LST calib scale unchanged, same as prod3b)

3. Files are:

i. /vo.cta.in2p3.fr/user/f/fdipierro/chimp/

1. Shown for “average” pointing
2. Comparison with prod3b results
3. Comparison of MAGIC simulated sensitivity with measured one
4. Combined MAGIC-LST1 observations’ performance
 - i. Two different triggers studied: “any 2 out of 3” (hardware intervention needed); “both MAGIC tels” (combined events using time tag)
 - ii. Analysis cut: $n \text{ images} \geq 2$, image c.o.g within $0.8 \times \text{camera radius}$, image size $> 50 \text{ pe}$

Comparison with prod3b

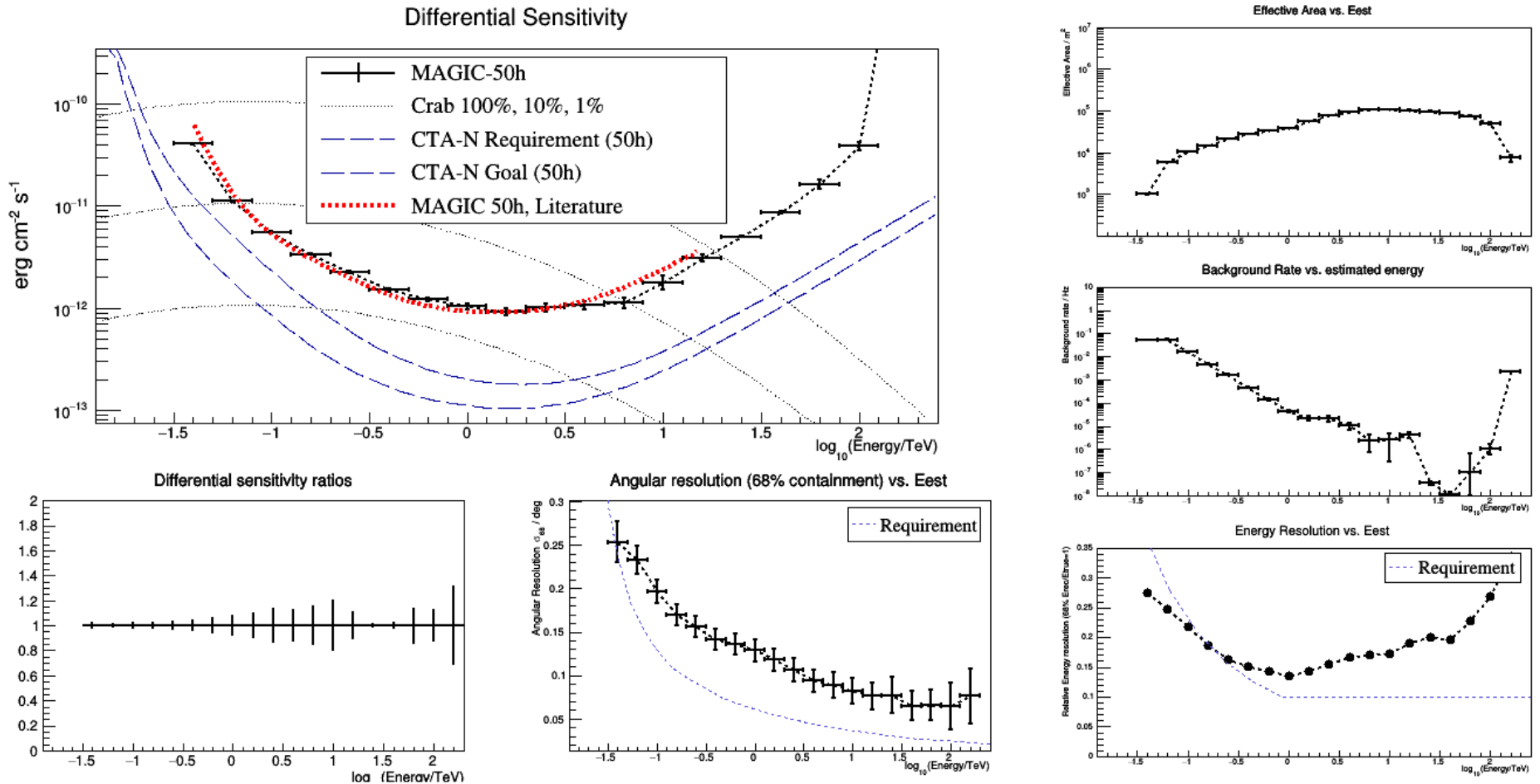


● LSTall = this production

● 3AL4 = prod3b

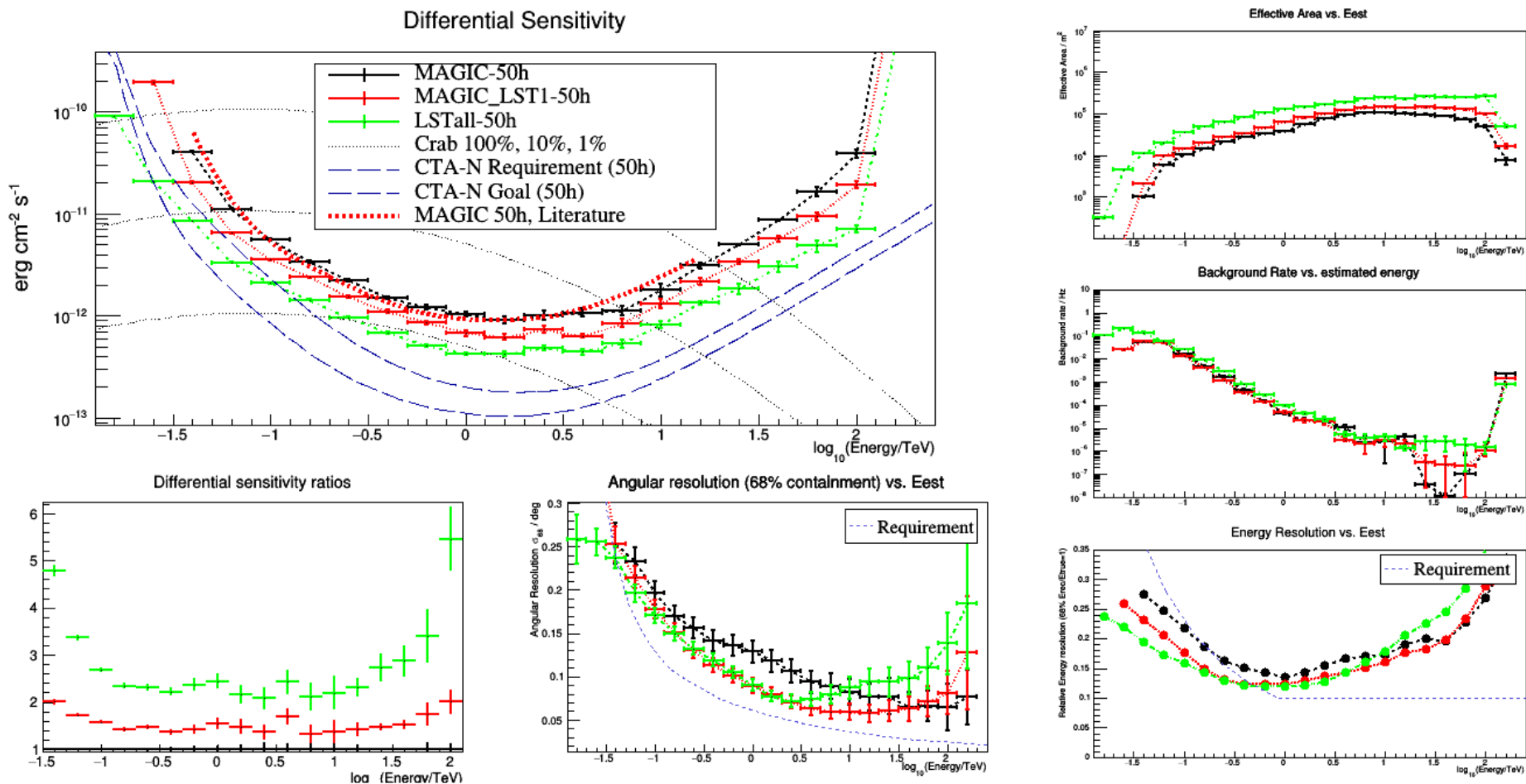
New production has slightly better sensitivity at HE

Comparison MAGIC sim. result and literature sensitivity



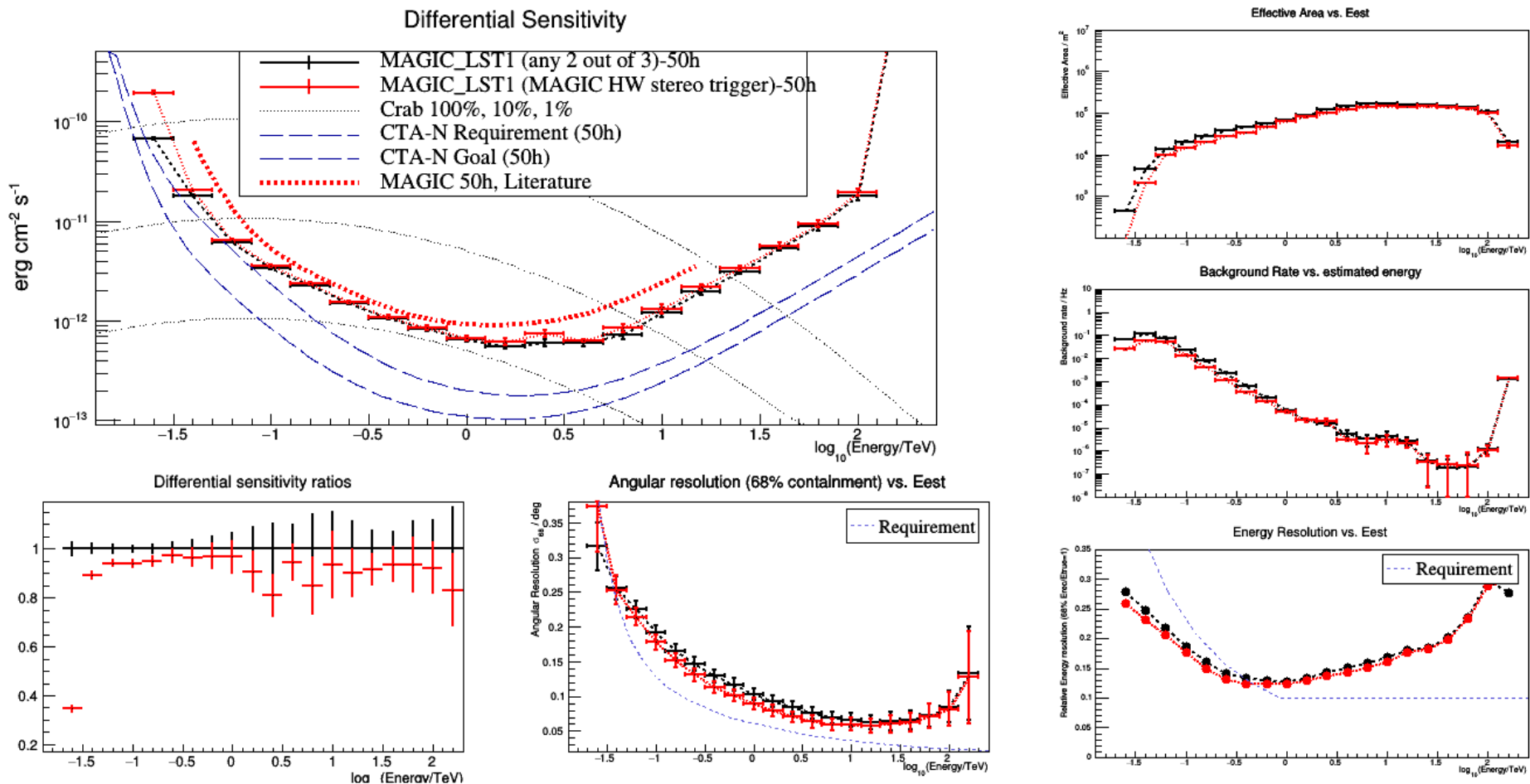
- First MC production including MAGIC: good independent validation of MC pipeline. Implemented MAGIC simulation is reliable.

Combined MAGIC-LST1 performance



- **MAGIC + LST1** have significantly better sensitivity than MAGIC alone (on average factor ~ 1.5 better)
- **MAGIC + LST1** simulated including MAGIC HW trigger

Combined MAGIC-LST1: trigger any2/3 or MAGIC stereo



- MAGIC HW-stereo trigger (so sw-combined with LST1)
- ANY 2 out of 3 telescopes (so hw-combined with LST1)

MC studies in a LST equipped with SiPMs

L. David M. Miranda, Yves Renier, Andrii Nagai, Cyril Alispach, Matthieu Heller, Luca Foffano, D. Della Volpe, T. Montaruli



**UNIVERSITÉ
DE GENÈVE**

FACULTY OF SCIENCE
Department of Nuclear and
Particle Physics

Simulations of LSTs

- Evaluated performance for 3 configurations

- LST with **1-inch PMT** and **LST nominal window** (PMMA window)
- LST with **SiPM** and **LST nominal window** (PMMA window)
- LST with **SiPM** and **SST-1M filter** (Borofloat window)

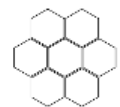


- 7420 **SiPM** pixels (simulated with **LCT5** photo-detection efficiency (PDE) at 4.4 V over-voltage)
- 1 GHz** sampling rate (same as the nominal LST)
- Same **trigger logic** as the nominal LST. However, **28 pixels** per trigger cluster (4 SiPM pixels for each PMT)

- SST-1M** light cones
- Individual gain (no more gain selection)
- MUSIC ASIC measured pulse shapes :**



SiPM cluster



PMT cluster

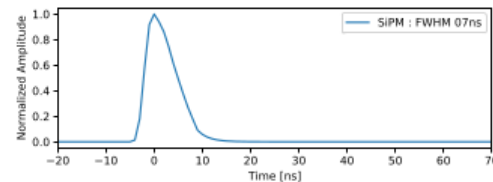
- 4 channels summed-up, 1 channel connected to one quadrant of the SiPM
- LCT2 sensor used** due to unavailable hexagonal LCT5 sensor
- Pole zero cancellation optimized experimentally

- Shorter pulse : 7 ns FWHM (but too noise to measure SPE)
- SPE obtained using a 12 ns FWHM pulse
- Noise/Gain from 12 ns FWHM SPE

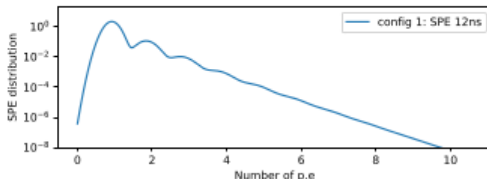


Not perfect, but far more realistic than using a PMT's pulse shape and SPE

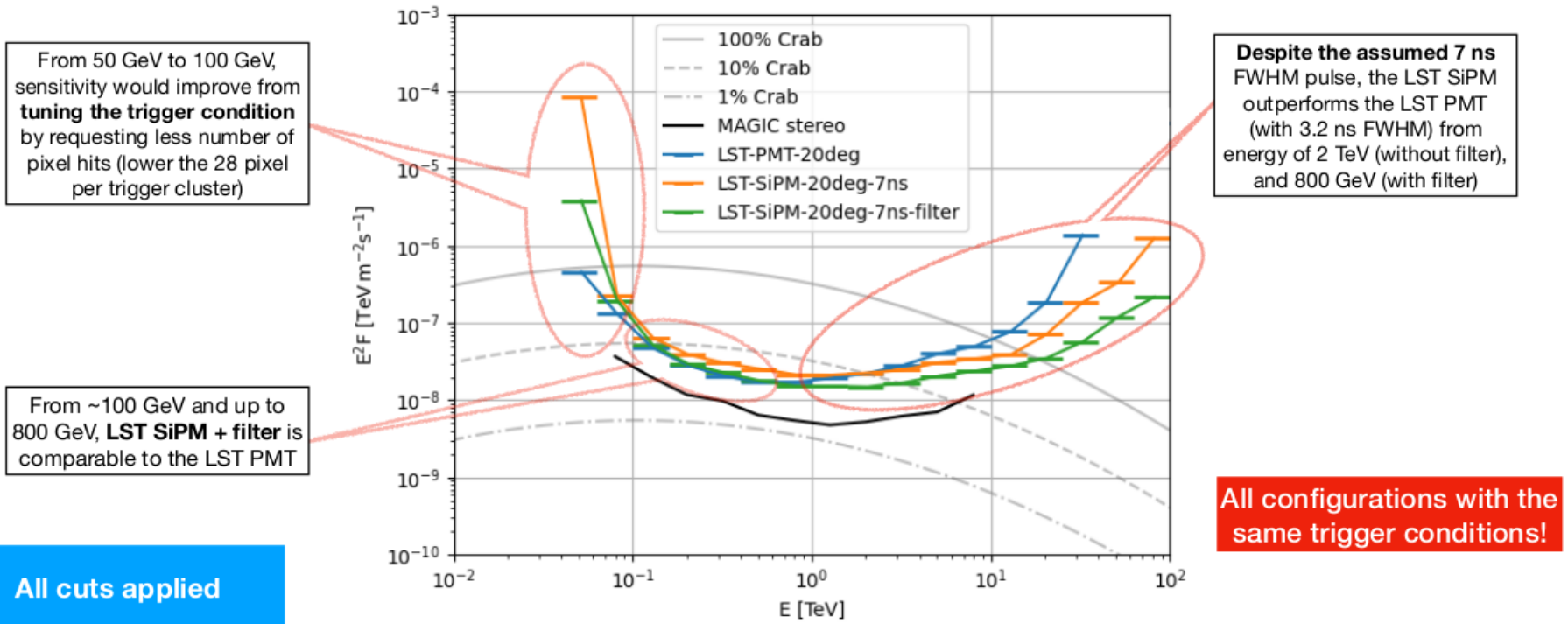
Measured 7ns template (MUSIC ASIC + SCOPE)



Simulated SPE obtained from a 12 ns template measurement



Results : Sensitivities with 1 LST



Other analysis, same corsika + simtel production



1. possibile tests for **magic-cta-pipe**...see Alessio's talk
 - i. with real data, 3 telescopes analysis not yet implemented

1. Updated LST MC configurations shown by Yusuke at last LST GM

Introduction

- A lot of inputs from the LST1 commissioning and labs since Prod3b
- Next full CTA MC production (Prod5) will start in July
 - sim_telarray, CORSIKA v.7.7100, $Z_d = (20, 40, 60)$ deg
 - LST MC model description: [LST.pdf](#)
- Several calls between the CTA-MC and LST teams and discussions in [Redmine](#)
- Due to the pandemic, some planned measurements could not be done in time
- Will show what we will use in Prod5 (some may change after Prod5)

1. Updated LST MC configurations shown by Yusuke at last LST GM
 - i. for CTA ASWG Prod5
2. A team (Yusuke, Yoshiki, Marcel and levgen) is forming to carry on a new production
 - i. will include new LST config
 - ii. will include MAGIC
 - iii. will cover different Z_d (similarly to low, medium, high zenith produced for MAGIC)
 - iv. will run at IT Center in LP
 - v. will be used to analyse combined observations
 - vi. Details and contributions under discussion