

MAGIC + LST simulations

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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)

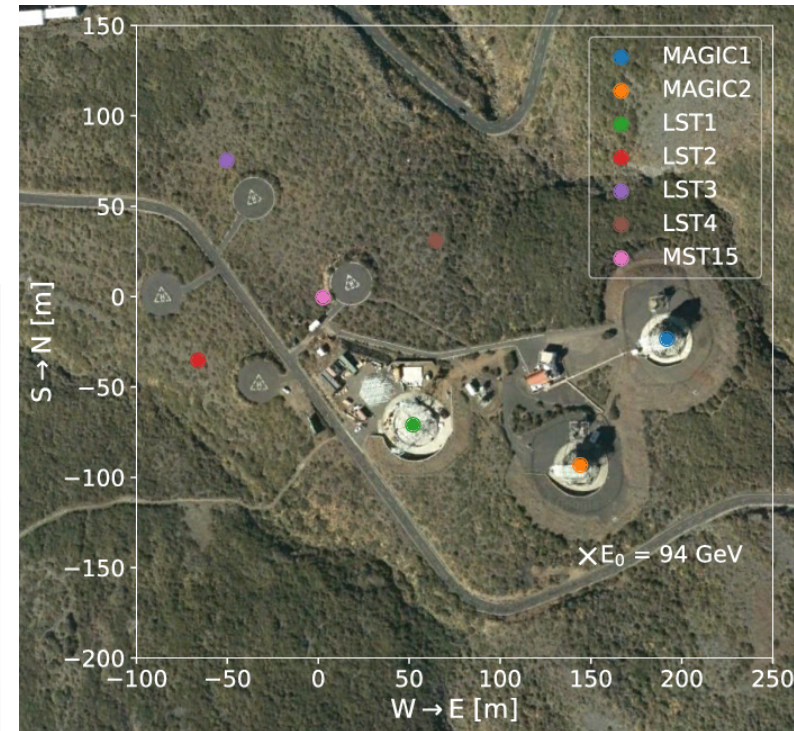
2. Redmine issue, to follow the task:

- 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° - 180° (pointing S and N)

| Primary | Gamma | Proton | Electron |
|------------------------|-------|--------|----------|
| Emin [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 |



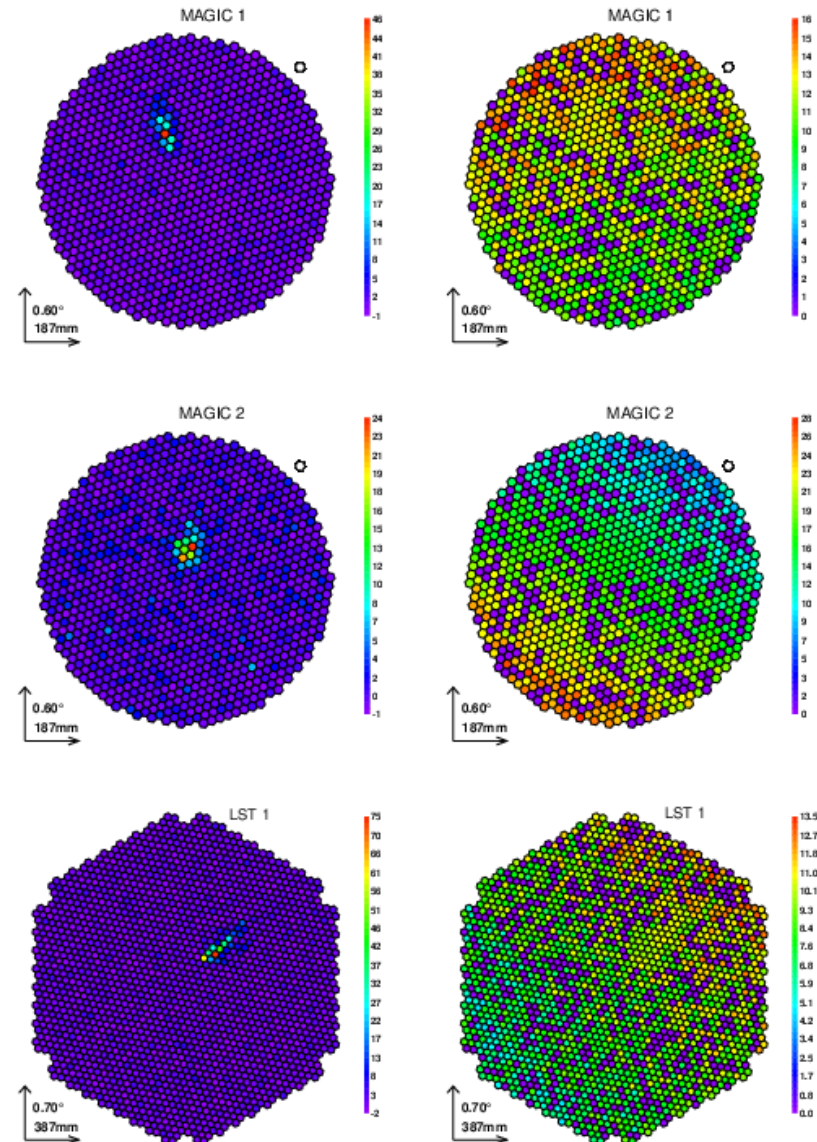
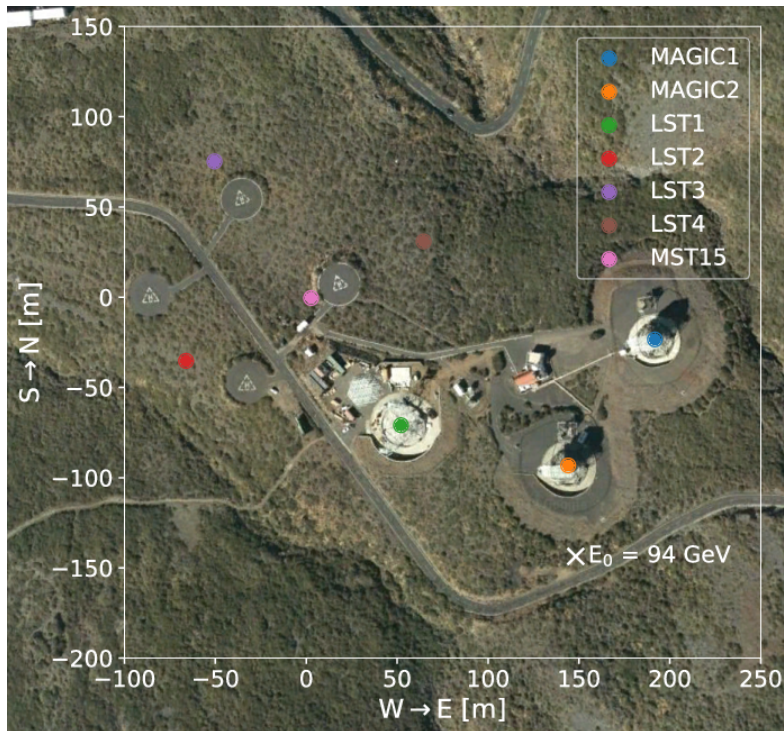
- Files can be found here: [/vo.cta.in2p3.fr/MC/PROD4/LaPalma/](https://vo.cta.in2p3.fr/MC/PROD4/LaPalma/)
- Occupied Disk Volume: ~280 TB (all files, 2 pointings, gamma-diffuse)

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.).

See Sasa's slides for the details:
https://forge.in2p3.fr/attachments/download/62474/LST_Analysis_Bootcamp_2018_Micanovic.pdf
 - iii. Central MST: CTA-ULTRA6-MST-NectarCam.cfg
3. **Trigger:** all mono triggers (possible cross-checks with cta-lstchain)
4. Files are here:
 - i. /vo.cta.in2p3.fr/user/f/fdipierro/simtel/

sim_telarray

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):

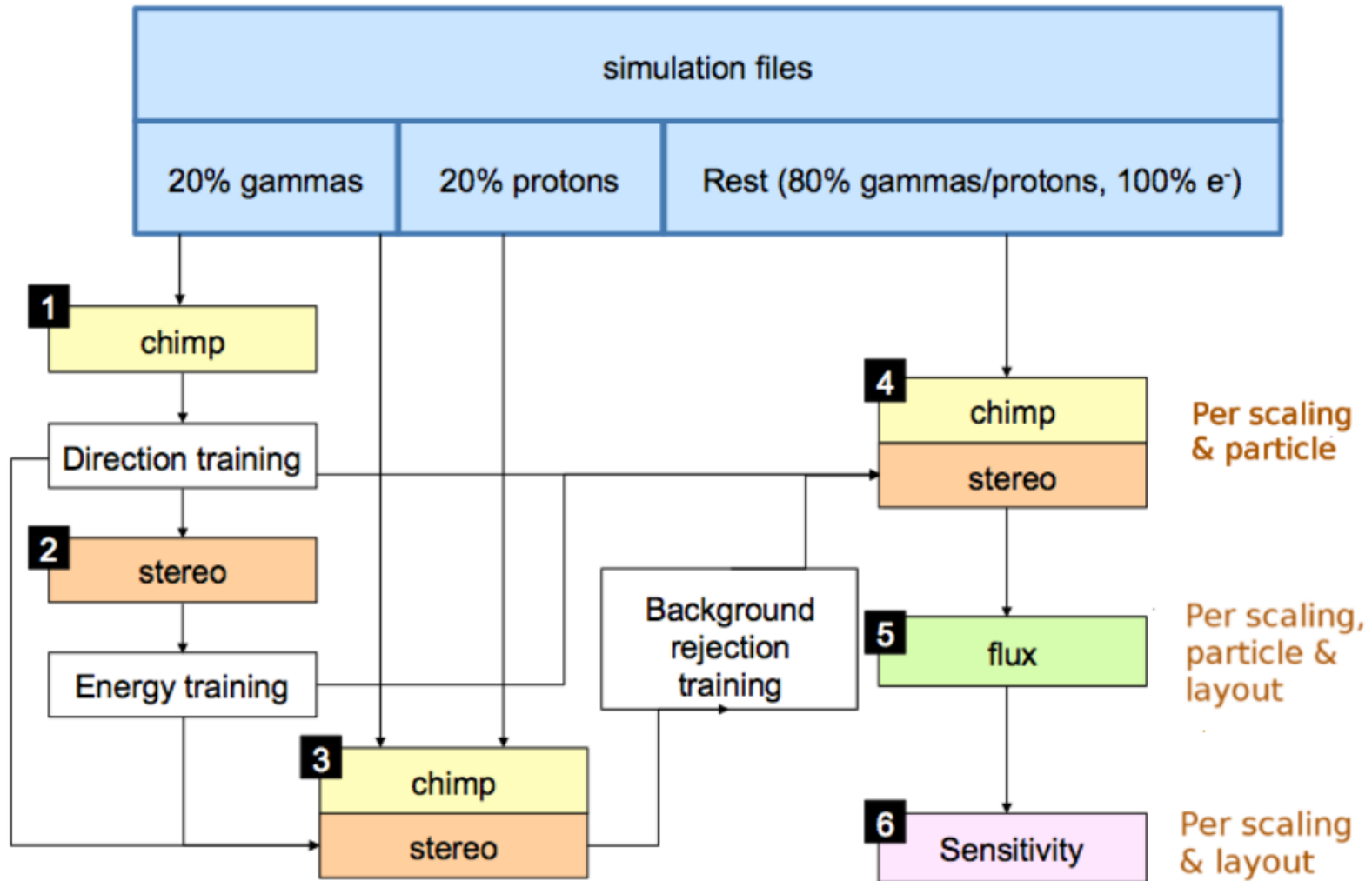
`/vo.cta.in2p3.fr/user/f/fdipierro/Software/CChimp_20190419.tar.gz`

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/`

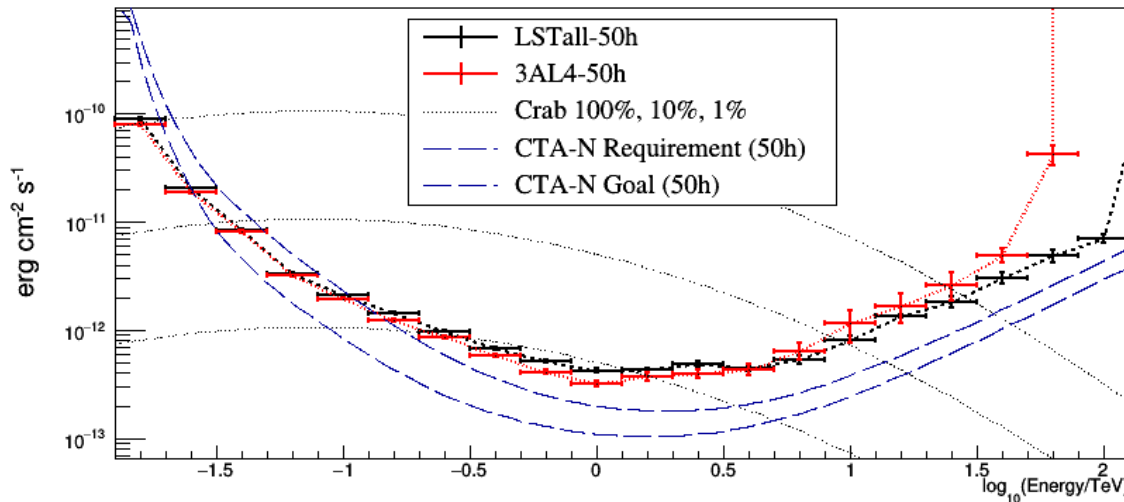


- i. Several sublayouts (e.g.: M1 + M2, 2-3-4 LSTs, **2 MAGIC + LST1**, MAGIC+LST1-2, 2 MAGIC + MST, All,...)

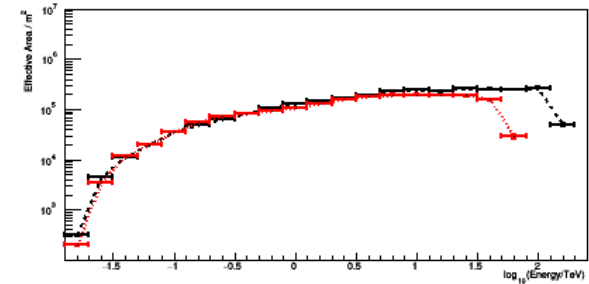
1. Shown for “average” pointing
2. Comparison with prod3b results
3. Comparison of MAGIC simulated sensitivity with measured one
4. Combined MAGIC-LST1 observations’ performance
 - i. Two different triggers studied: “any 2 out of 3” (hardware intervention needed); “both MAGIC tels” (combined events using 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

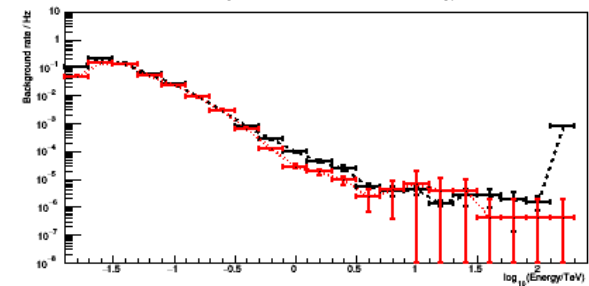
Differential Sensitivity



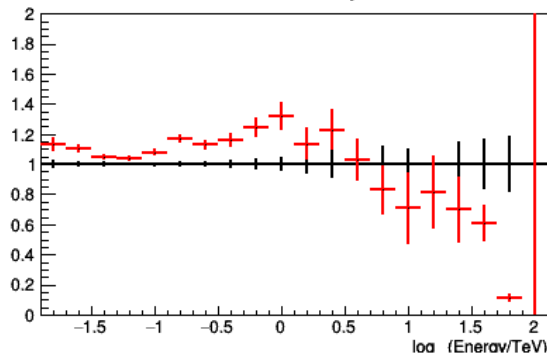
Effective Area vs. Eest



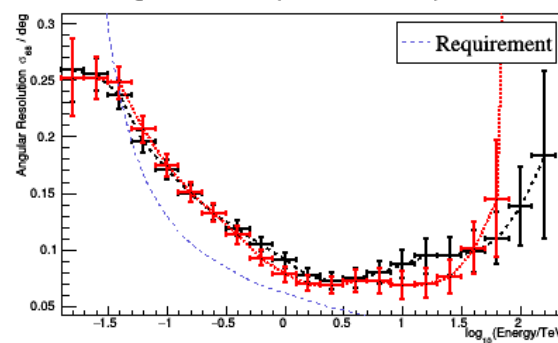
Background Rate vs. estimated energy



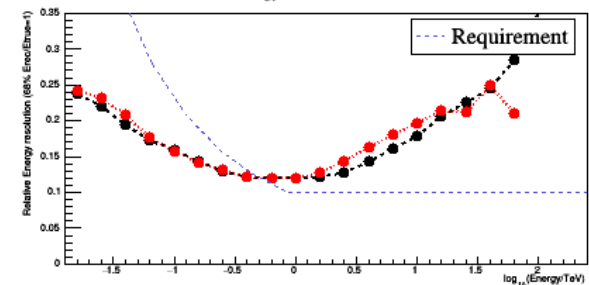
Differential sensitivity ratios



Angular resolution (68% containment) vs. Eest



Energy Resolution vs. Eest



● LSTall = this produciton

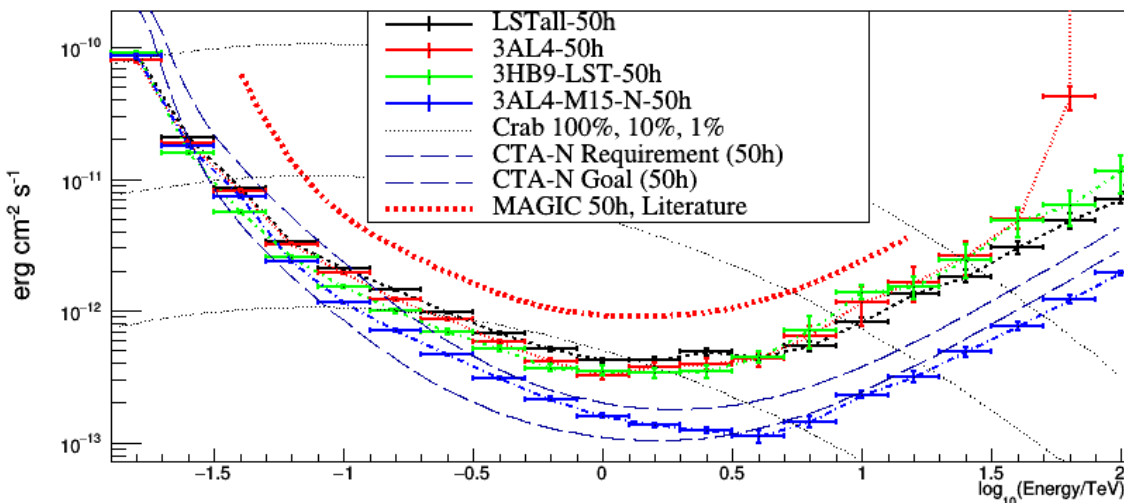
● 3AL4 = prod3b

New production has slightly better sensitivity at HE

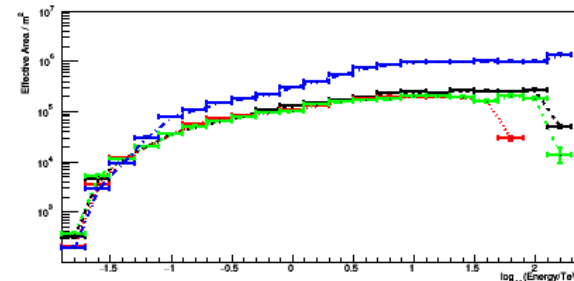
Comparison with prod3b and CTA-S



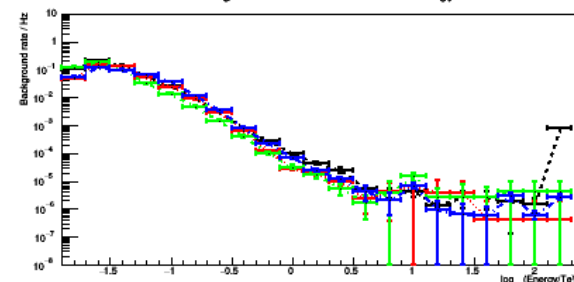
Differential Sensitivity



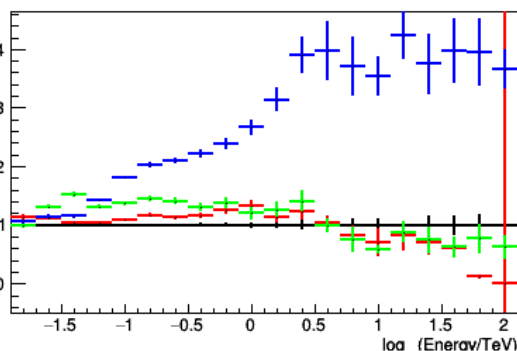
Effective Area vs. Eest



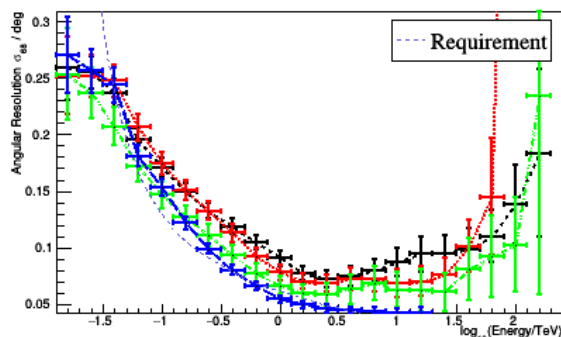
Background Rate vs. estimated energy



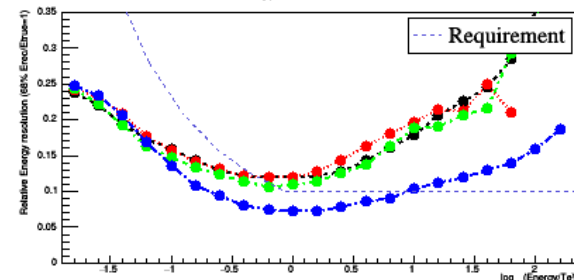
Differential sensitivity ratios



Angular resolution (68% containment) vs. Eest



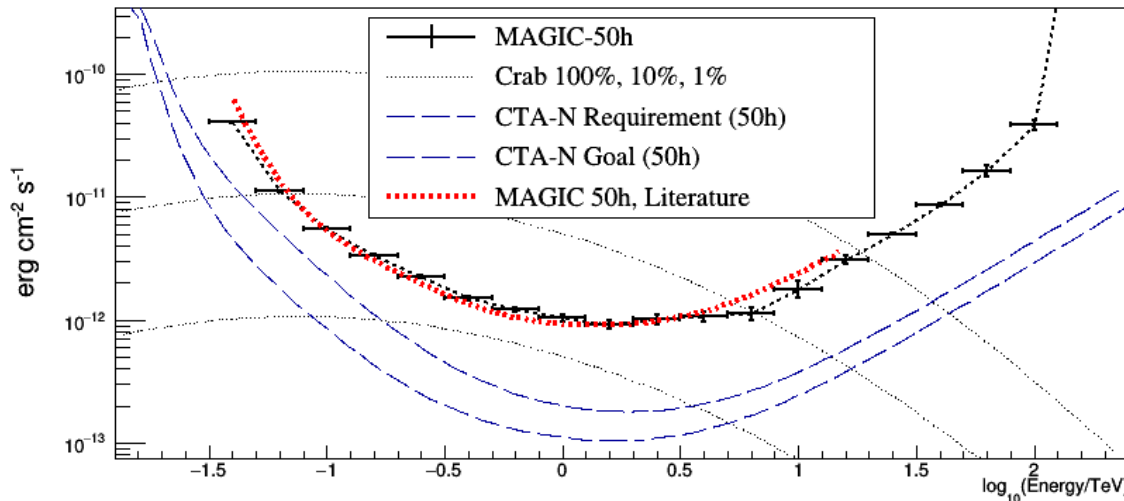
Energy Resolution vs. Eest



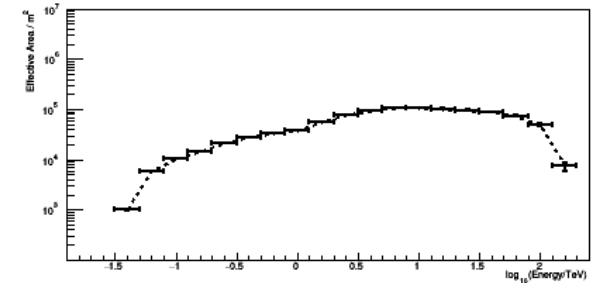
- LSTall = this produciton
- 3AL4 = prod3b
- 3HB9-LST = prod3 Paranal
- 3AL4-M15-N = prod3b CTA-North (all: MARS analysis)

Comparison MAGIC sim. result and literature sensitivity

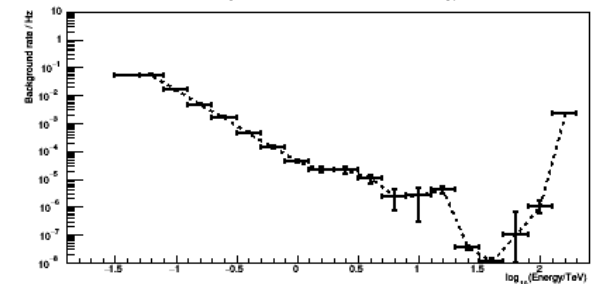
Differential Sensitivity



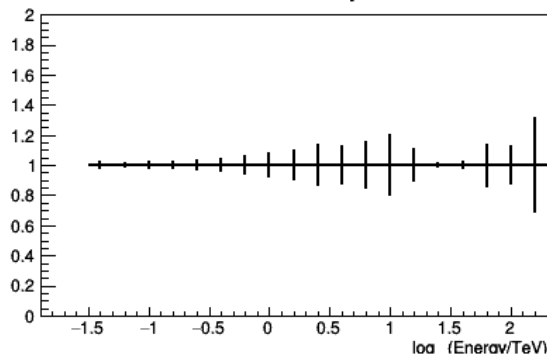
Effective Area vs. Eest



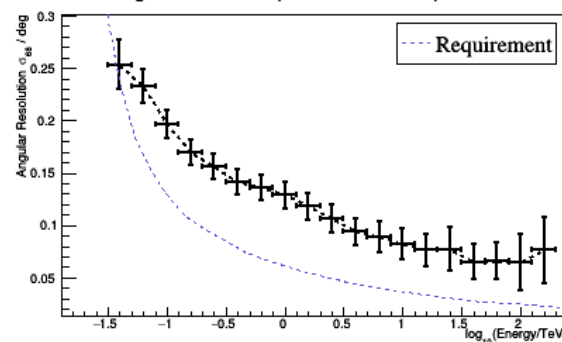
Background Rate vs. estimated energy



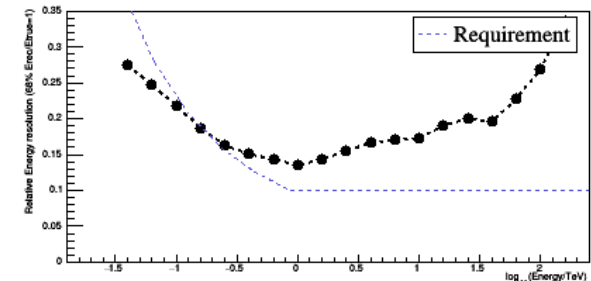
Differential sensitivity ratios



Angular resolution (68% containment) vs. Eest



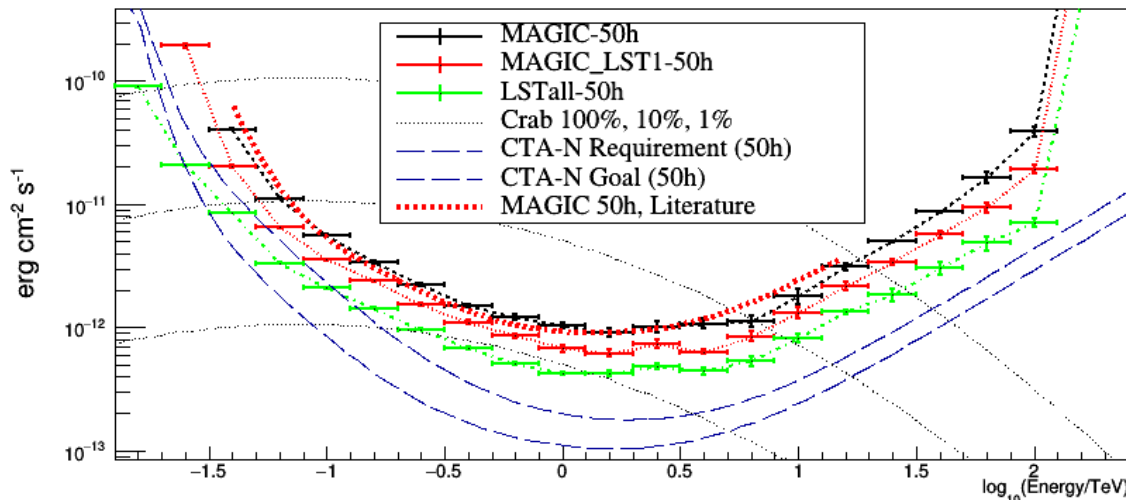
Energy Resolution vs. Eest



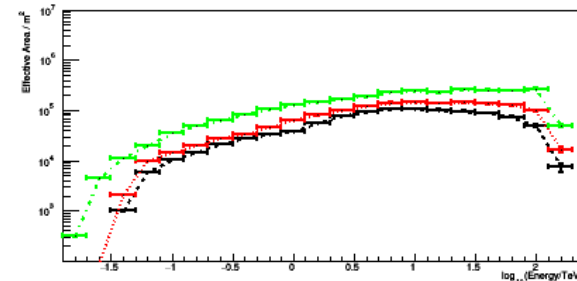
- First MC production including MAGIC: good independent validation of MC pipeline. Implemented MAGIC simulation is reliable.

Combined MAGIC-LST1 performance

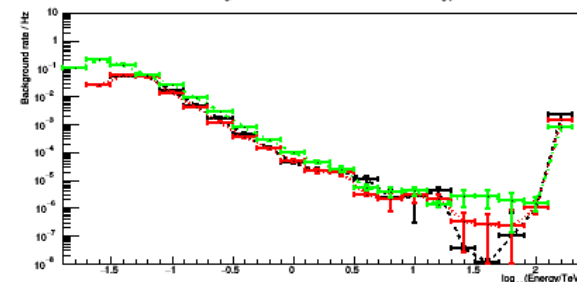
Differential Sensitivity



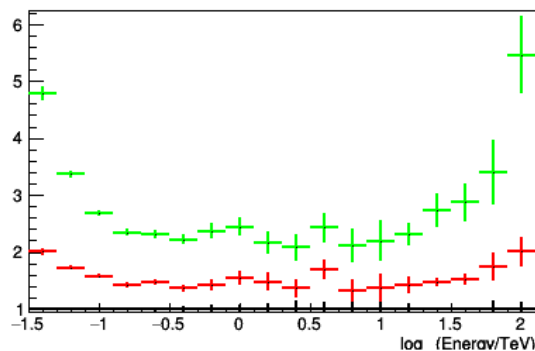
Effective Area vs. Eest



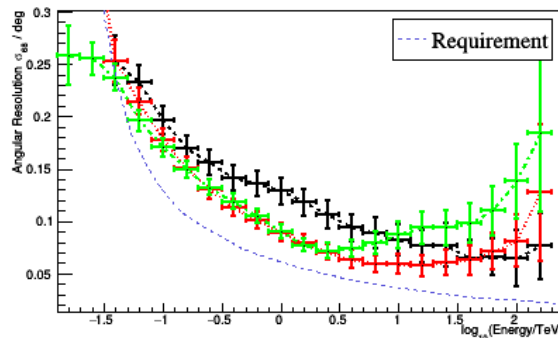
Background Rate vs. estimated energy



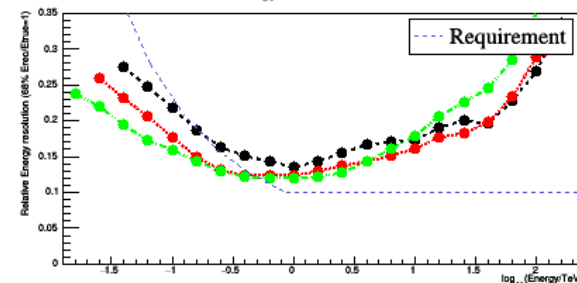
Differential sensitivity ratios



Angular resolution (68% containment) vs. Eest



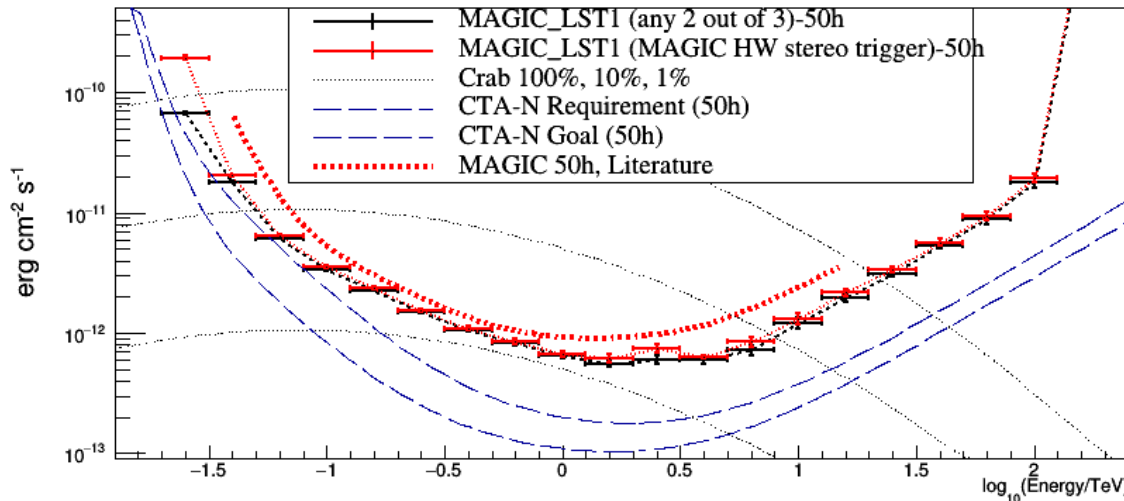
Energy Resolution vs. Eest



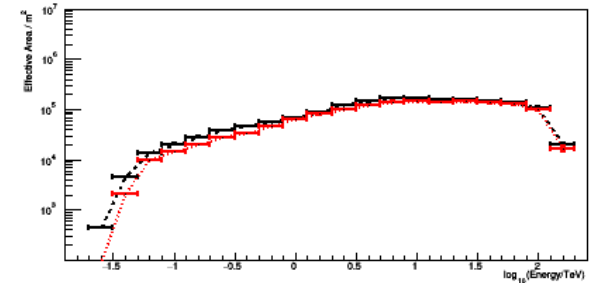
- **MAGIC + LST1** have significantly better sensitivity than MAGIC alone (on average factor ~ 1.5 better)
- **MAGIC + LST1** simulated including MAGIC HW trigger

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

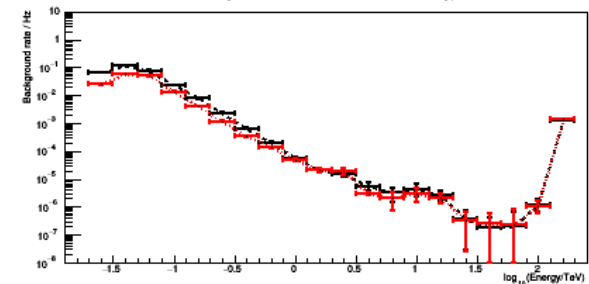
Differential Sensitivity



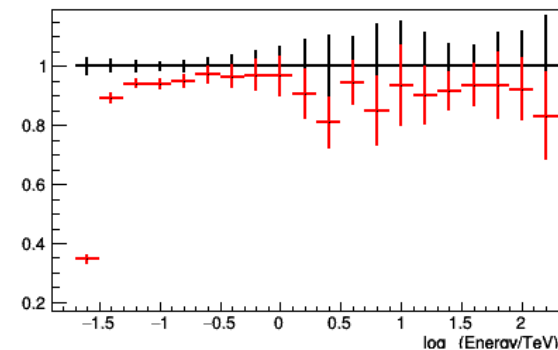
Effective Area vs. Eest



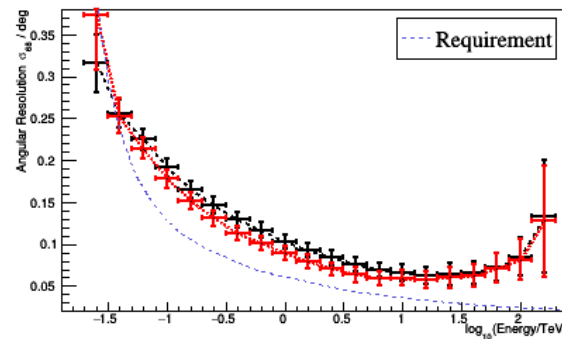
Background Rate vs. estimated energy



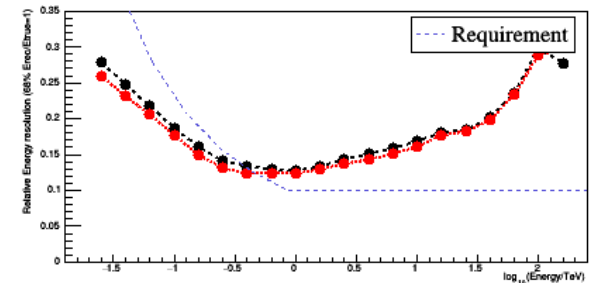
Differential sensitivity ratios



Angular resolution (68% containment) vs. Eest



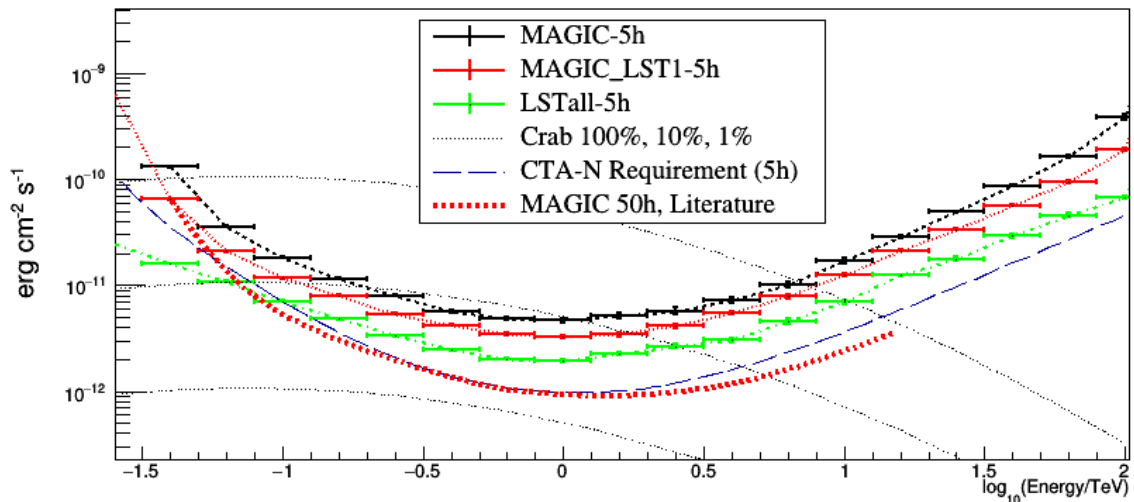
Energy Resolution vs. Eest



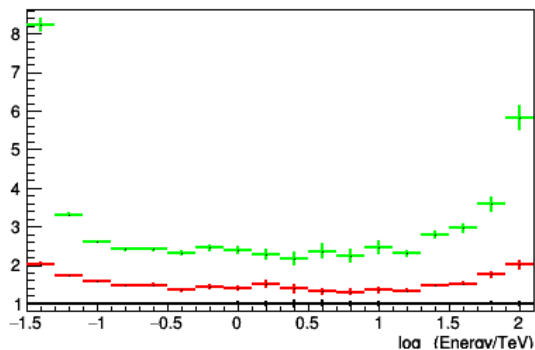
- MAGIC HW-stereo trigger (so sw-combined with LST1)
- ANY 2 out of 3 telescopes (so hw-combined with LST1)

Shorter Observations (5h)

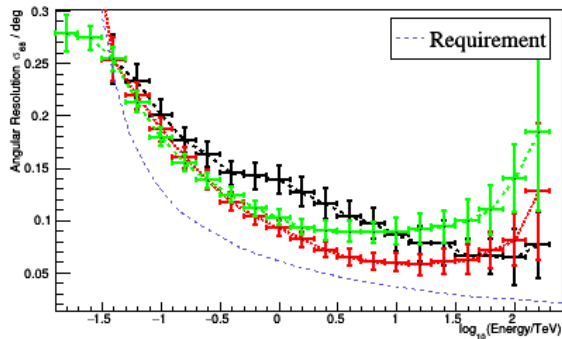
Differential Sensitivity



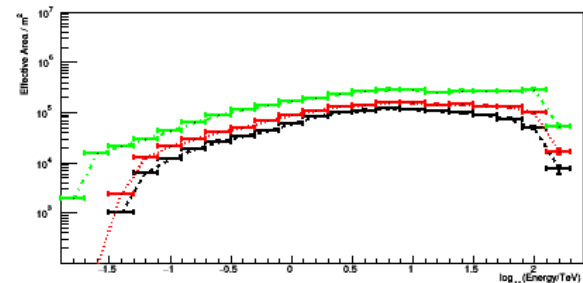
Differential sensitivity ratios



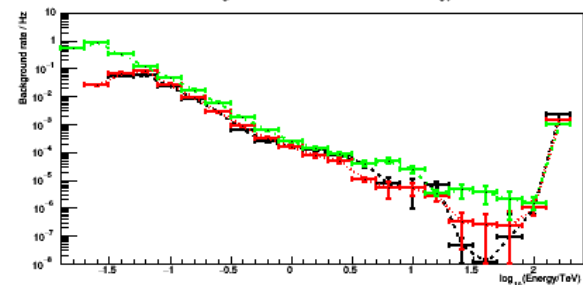
Angular resolution (68% containment) vs. Eest



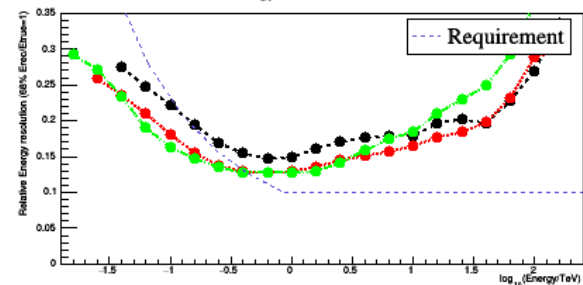
Effective Area vs. Eest



Background Rate vs. estimated energy



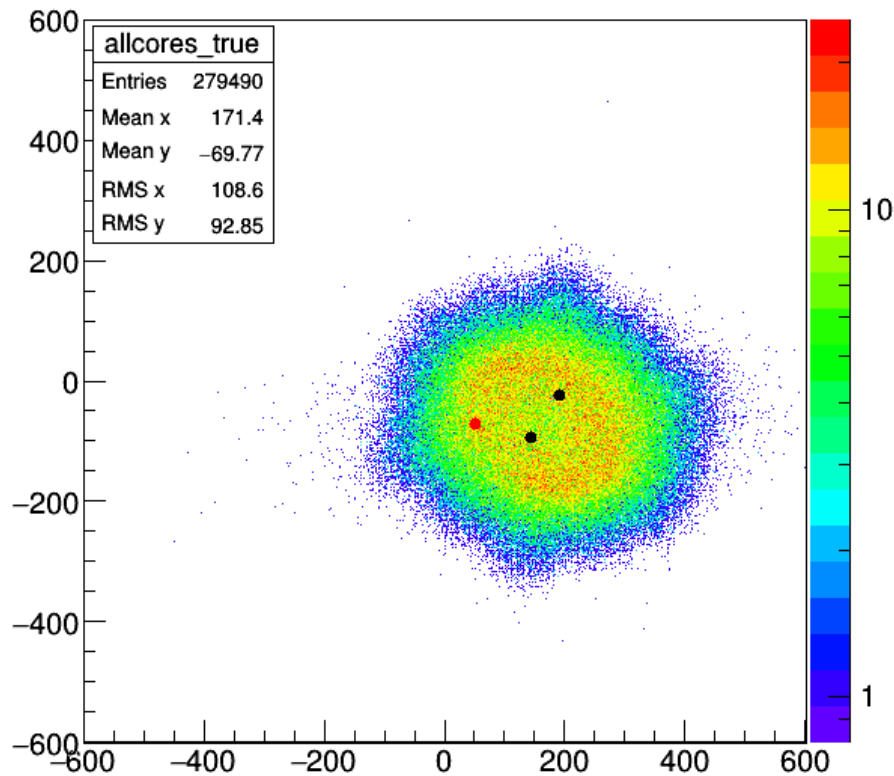
Energy Resolution vs. Eest



Core distribution: MAGIC, MAGIC-LST1

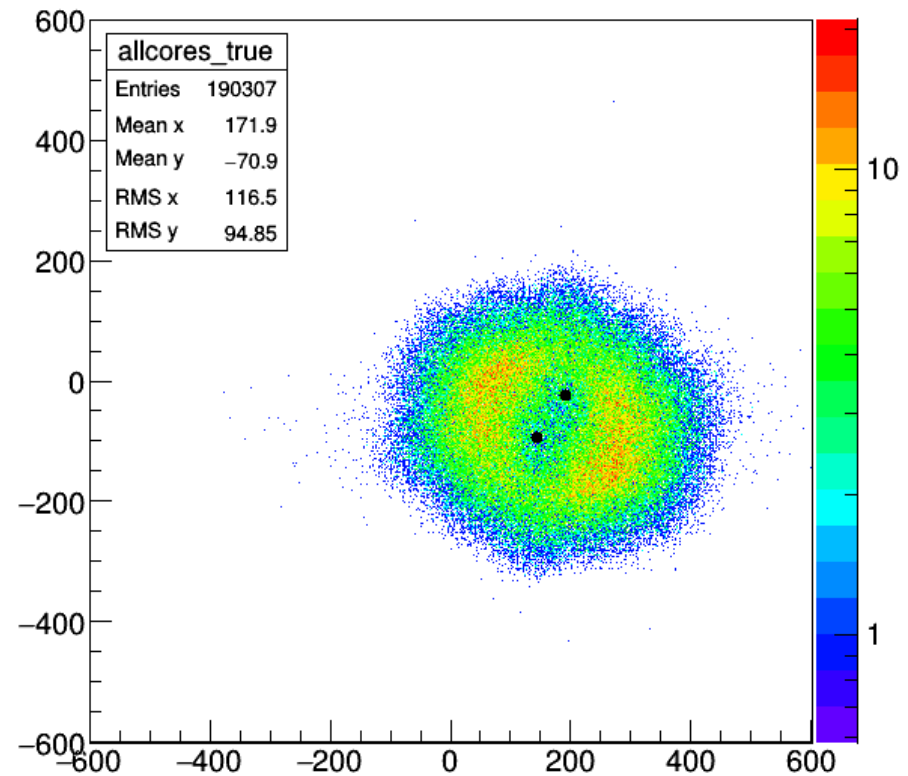
MAGIC+LST1 (Magic HW trigger)

True Core, all events



MAGIC

True Core, all events

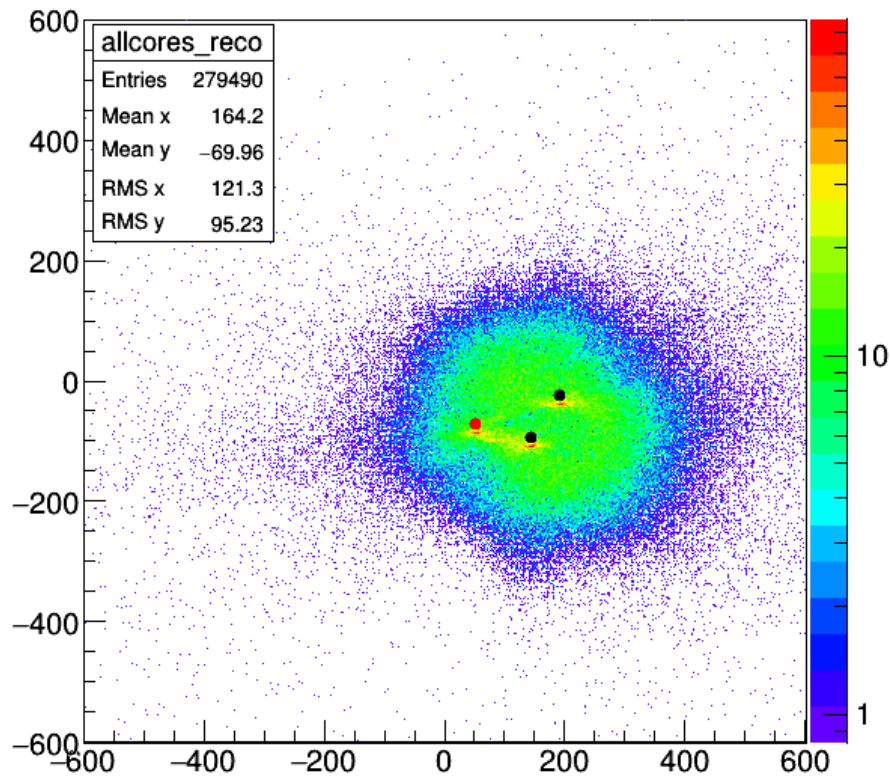


- True core positions (events passing trigger and image quality cuts)

Core distribution: MAGIC, MAGIC-LST1

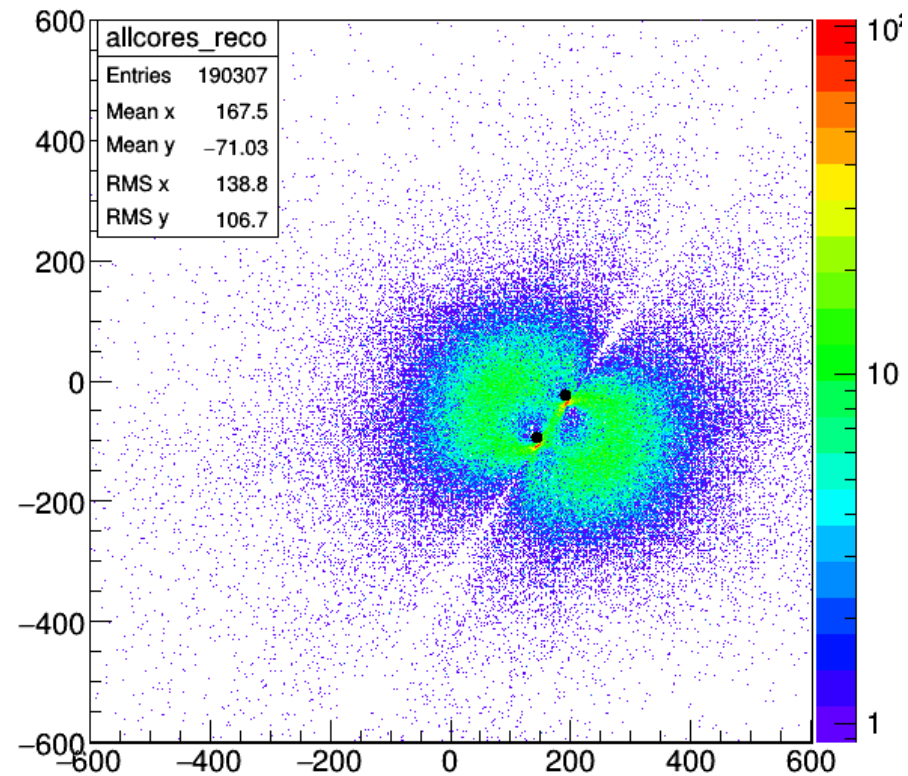
MAGIC+LST1 (Magic HW trigger)

Reco Core, all events



MAGIC

Reco Core, all events

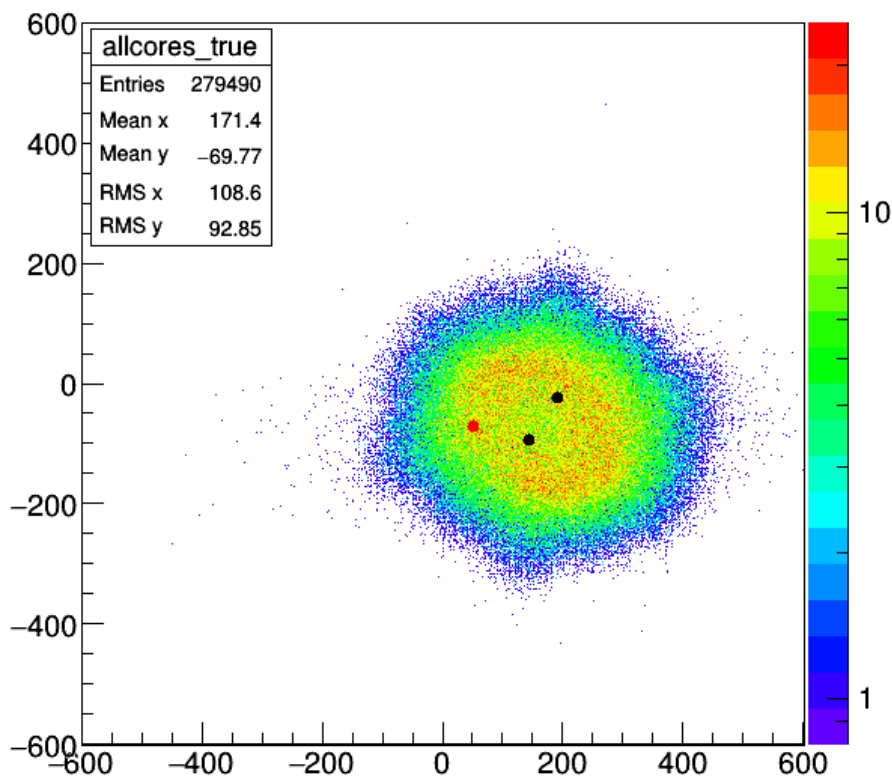


- Reconstructed core positions (events passing trigger and image quality cuts)

Core distribution: MAGIC-LST1 (sw-hw trigger)

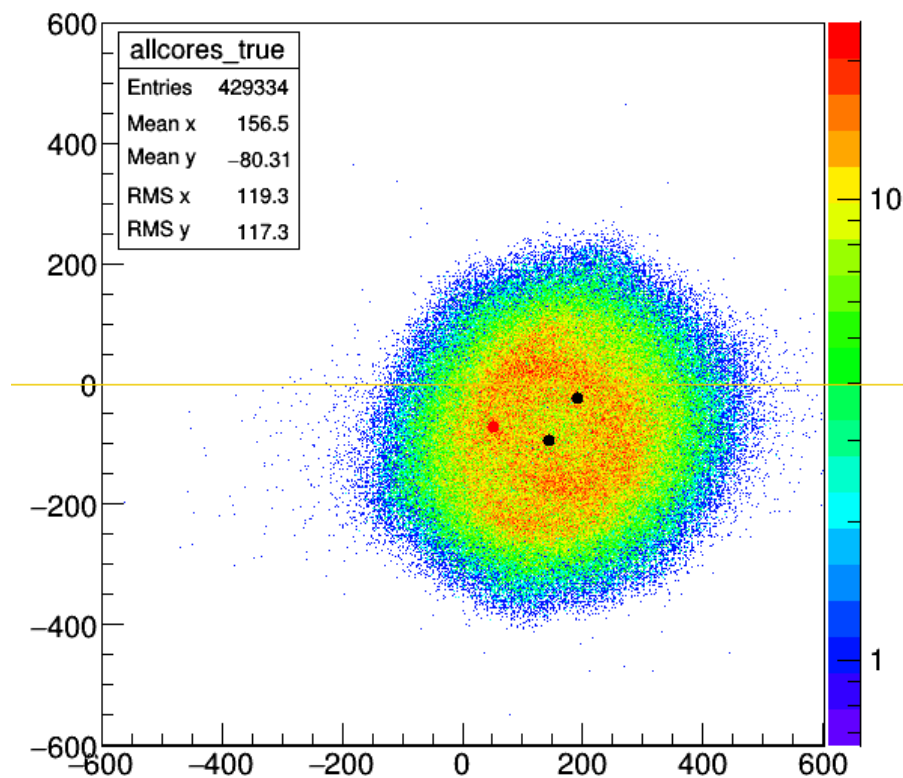
MAGIC+LST1 (Magic HW trigger)

True Core, all events



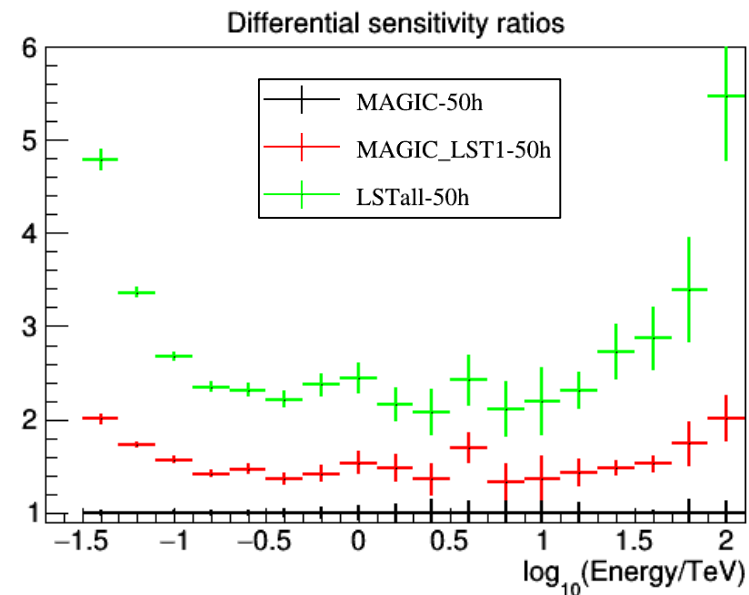
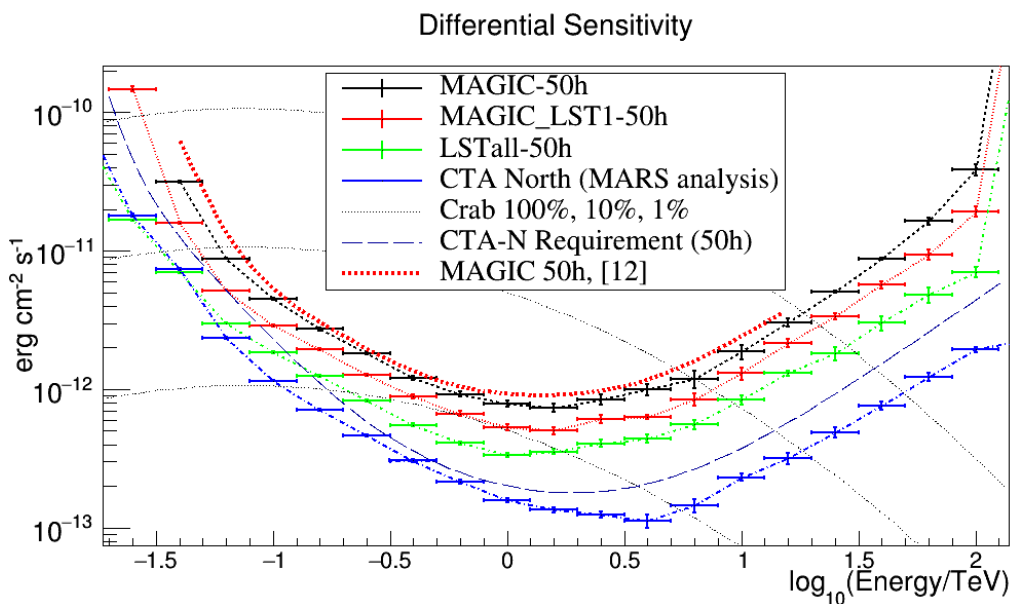
MAGIC+LST1 (any 2/3)

True Core, all events



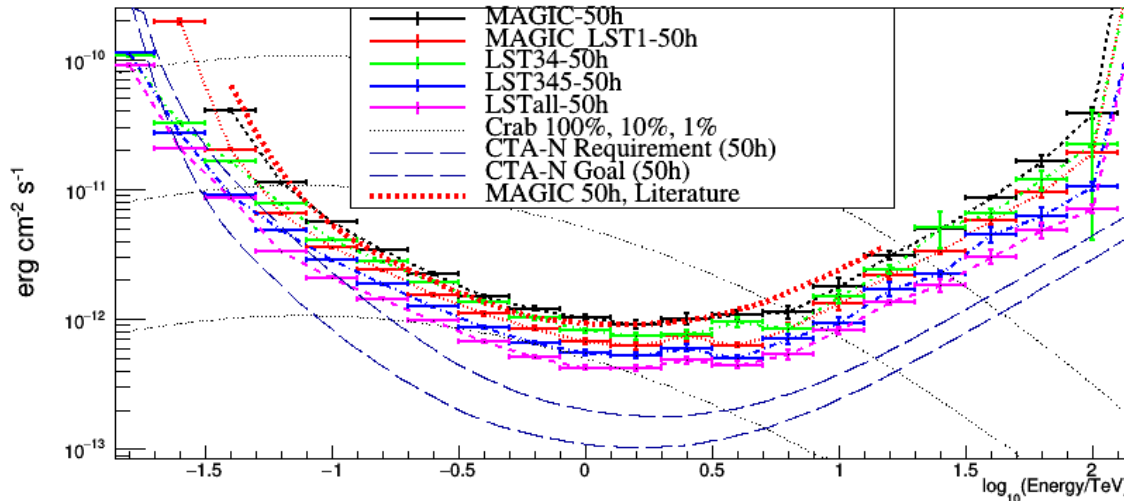
- True core positions (events passing trigger and image quality cuts)

1. MARS analysis of MAGIC+LSTs production: done
2. Cross-checks (prod3b, MAGIC literature): successful
3. Combined MAGIC+LST1 performance: estimated
 - i. both for sw (time tag) trigger and for really combined (2/3) trigger.

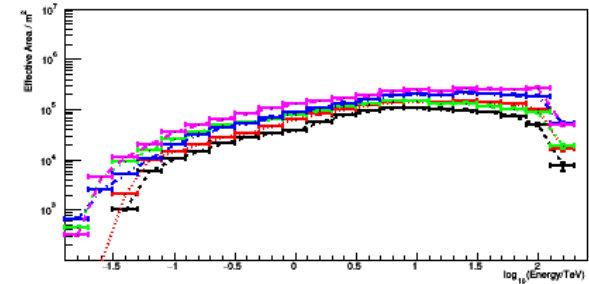


Combined MAGIC-LST1 performance

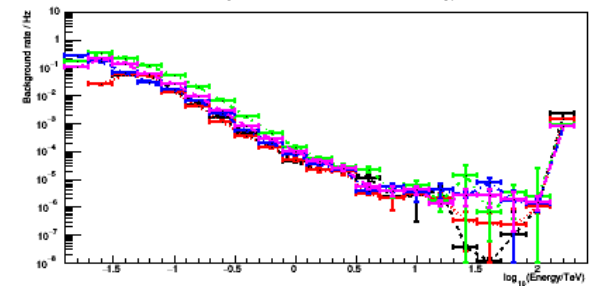
Differential Sensitivity



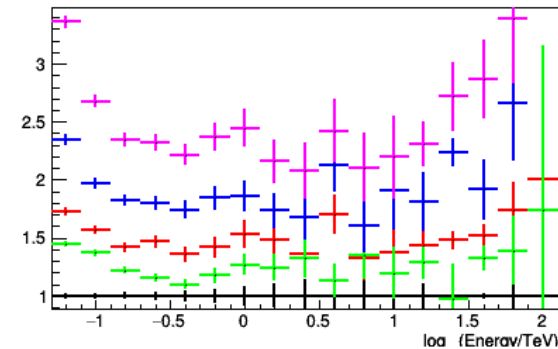
Effective Area vs. Eest



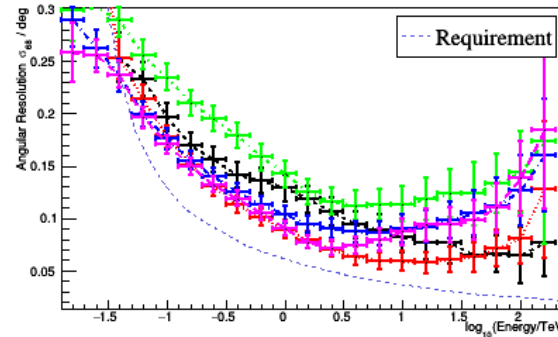
Background Rate vs. estimated energy



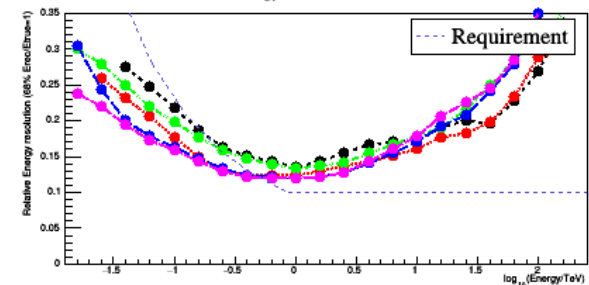
Differential sensitivity ratios



Angular resolution (68% containment) vs. Eest



Energy Resolution vs. Eest

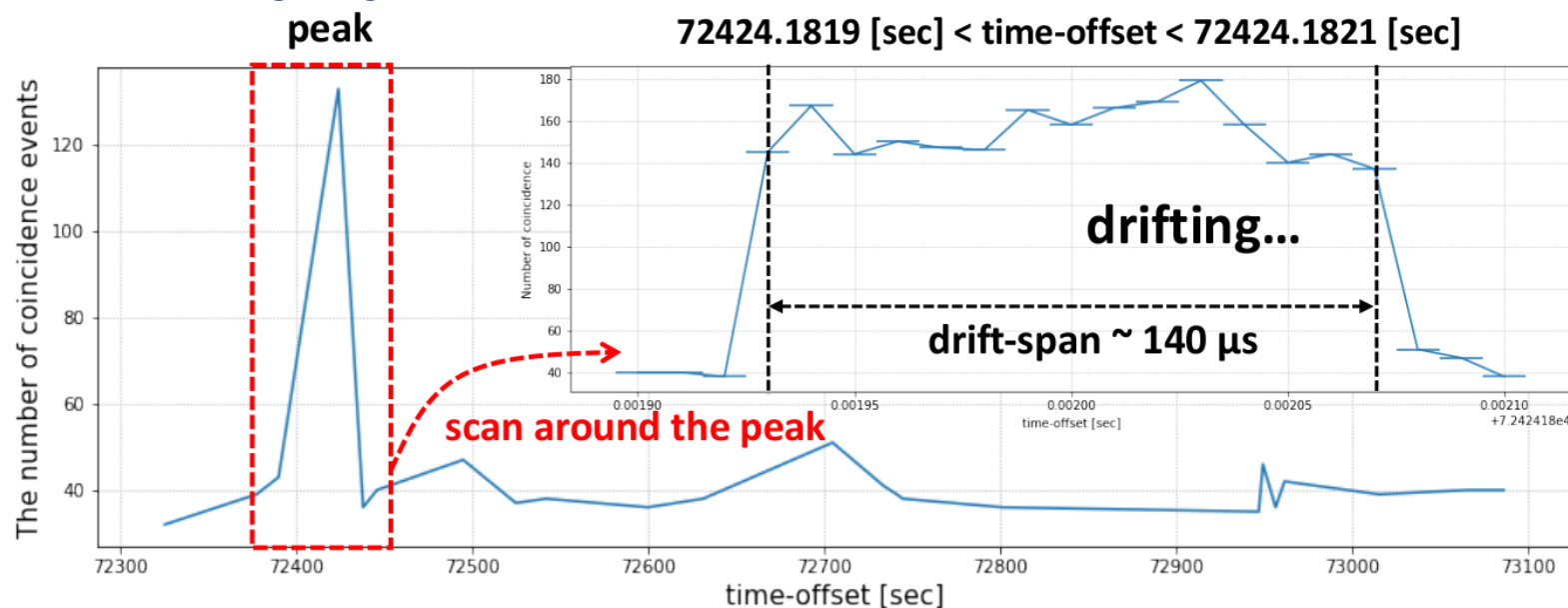


- The number of telescopes is the key factor (as expected), 2 LSTs have better sensitivity than MAGIC, 3 LSTs better than MAGIC+LST1

Towards MAGIC-LST Real Data



1. Mrk 501 joint observations in August: coincidences from event time stamps at ~ 50 Hz
 - i. By Yoshiki Ohtani. Found a time drift between MAGIC and LST1 timing (new GPS going to be installed at LST1)



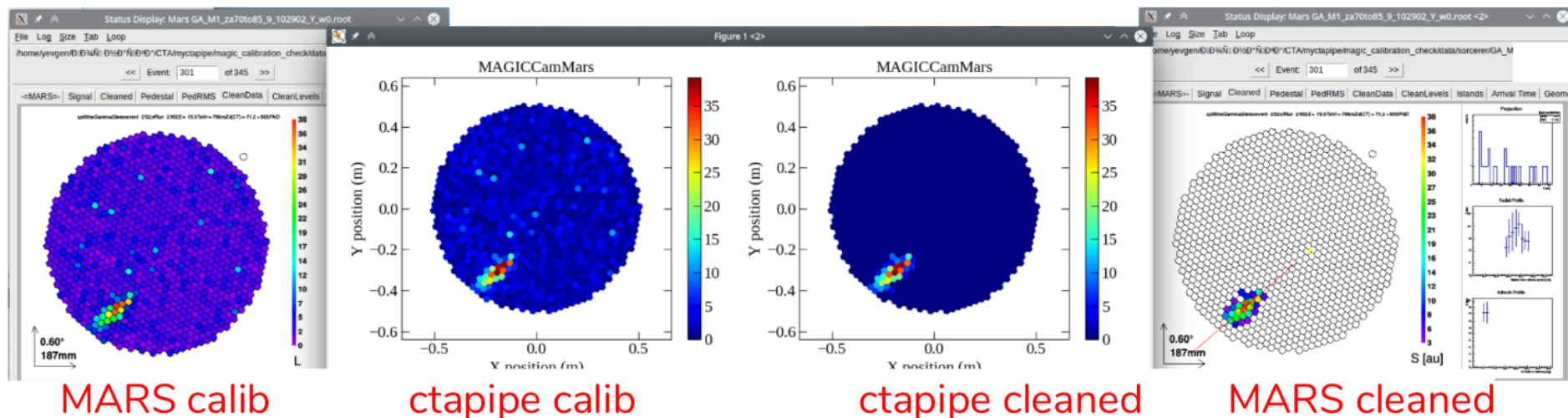
2. **Crab Campaign** starting in the next days

Towards MAGIC-LST Real Data

1. What we are doing now:

i. Analyzing **MAGIC real data with ctapipe/protopipe**

- Converter MAGIC calibrated data to ctapipe-compliant format developed by levgen Vovk



ii. Protopipe: new pipeline for stereo analysis, based on ctapipe, developed by Michele Peresano

1. What we are doing now:

- i. Analysing LST1 data with cta-lstchain
- ii. Data at IT-container (then transferred to PIC and CNAF)

2. Next steps

- i. MAGIC - LST1 cross-calibration
- ii. To merge MAGIC - LST1 data, to analyze them for combined analysis with protopipe.

1. 2020 allocated resources: 1.5 PB , 5296 TB Disk, 400 TB tape.
2. Working at CNAF (**see Vincenzo's talk**)
 - Request account: <https://www.cnaf.infn.it/utenti-faq/>
 - Support: user-support@lists.cnaf.infn.it
 - Disk for “farm” users (~80 TB): `/storage/gpfs_data/ctalocal/`
 - Disk for “GRID” users: `/storage/gpfs_data/ctadisk/`
 - Common sw: `/opt/exp_software/cta/`
3. CNAF as OFFSITE Data center for LST-1 (**see Lisa's talk**)
4. New mailing list: computing-info@cta-observatory.org
5. Next CTA Meeting: CTAO Archive Workshop, Desy, 27-29 January 2019