

Muon calibration for SST-1M telescope

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Small Size Telescope – Single Mirror (SST-1M)

- 4m diameter class, single mirror Davies-Cotton design telescope
- 18 mirror segments (78cm flat-to-flat, 5.6m focal length) – 9.48m² total area, 7.54m² after shadowing
- coating: AlSiO₂ (av. 300-500nm – 91%), AlSiO₂HfO₂ (av. 95%) + additional filter on camera window
- effective mirror area (after shadowing and reflectance) 6.86m²-7.16m² (req. >4.5m²)



SST-1M – DigiCam camera

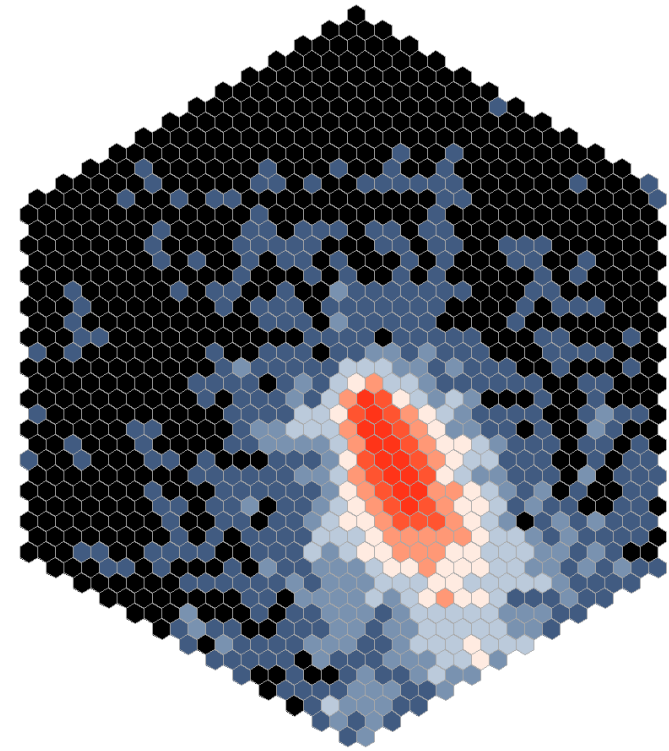
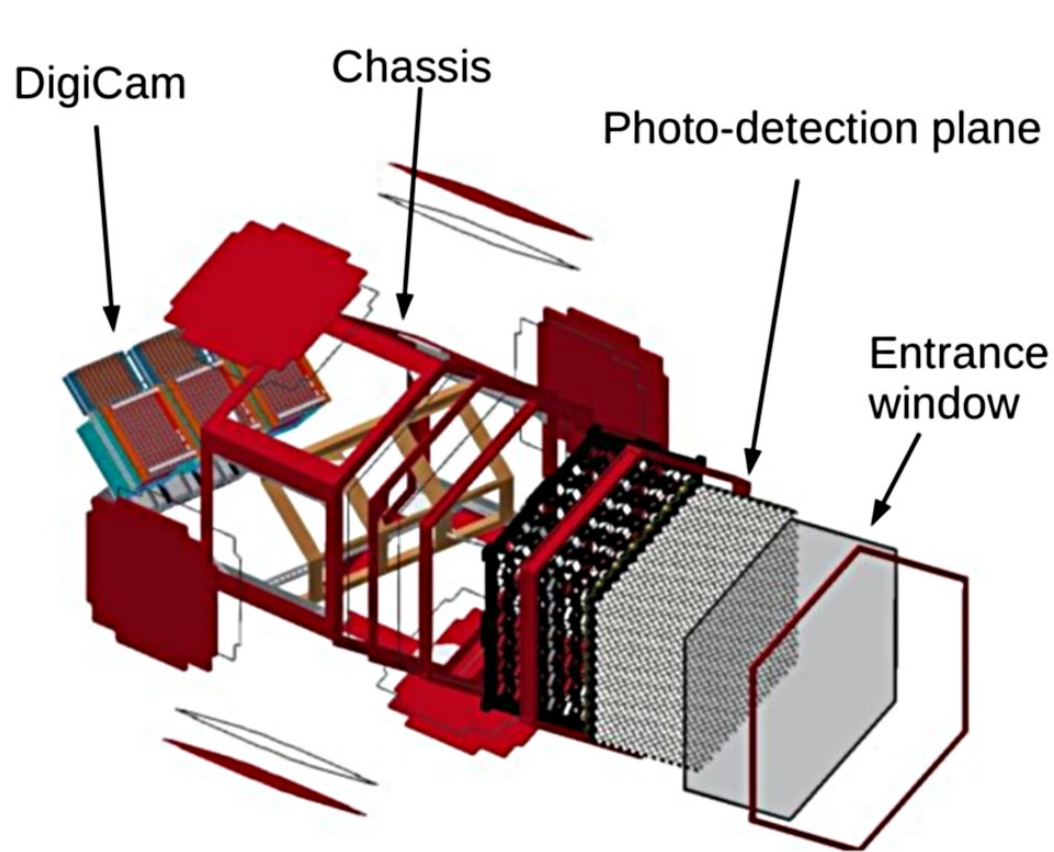
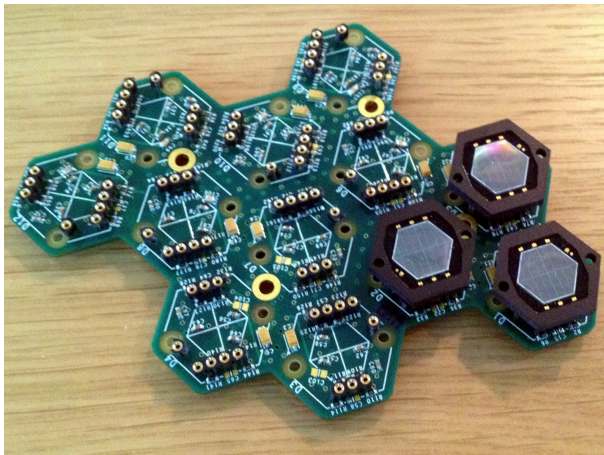
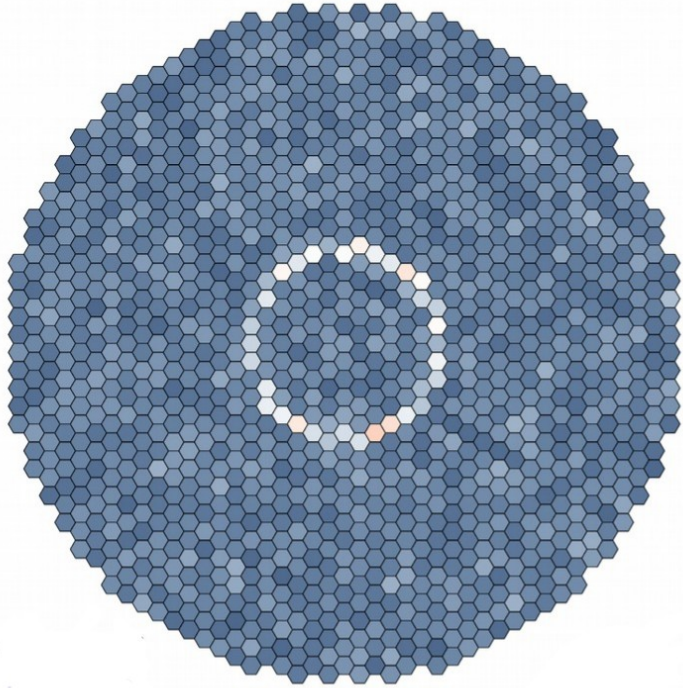


Fig. 3 Exploded view of the CAD drawing of the SST-1M camera.

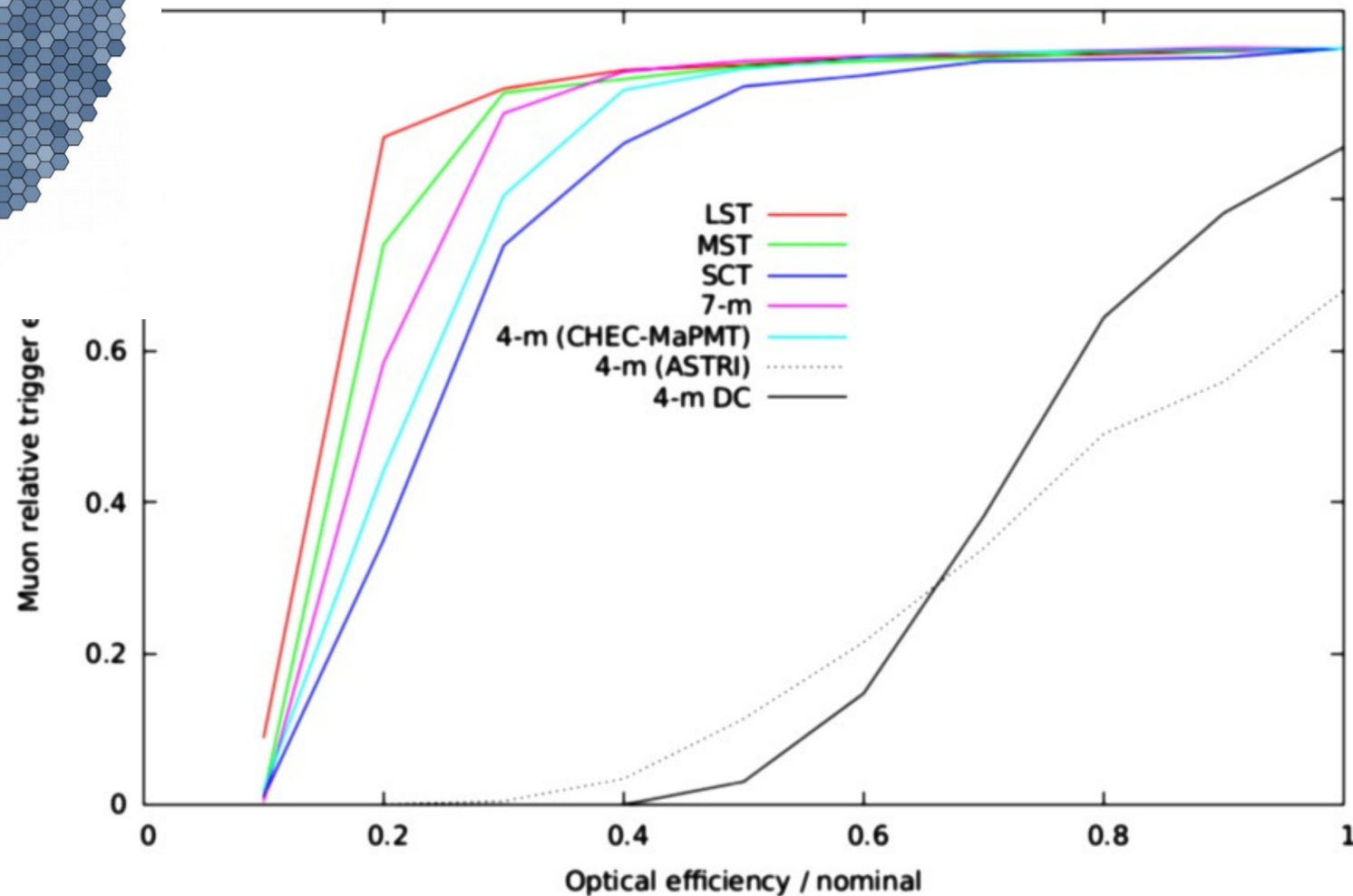


- 1296 pixels (0.25deg), 9.1deg FoV
- hexagonal G-APD detector from Hamamatsu
- optical filter with cut-off wavelength of 540nm (opt. eff >18% - req. 11%; esig/sqrt(ebg)>38% - req. 30%)
- dark sky NSB level 41MHz

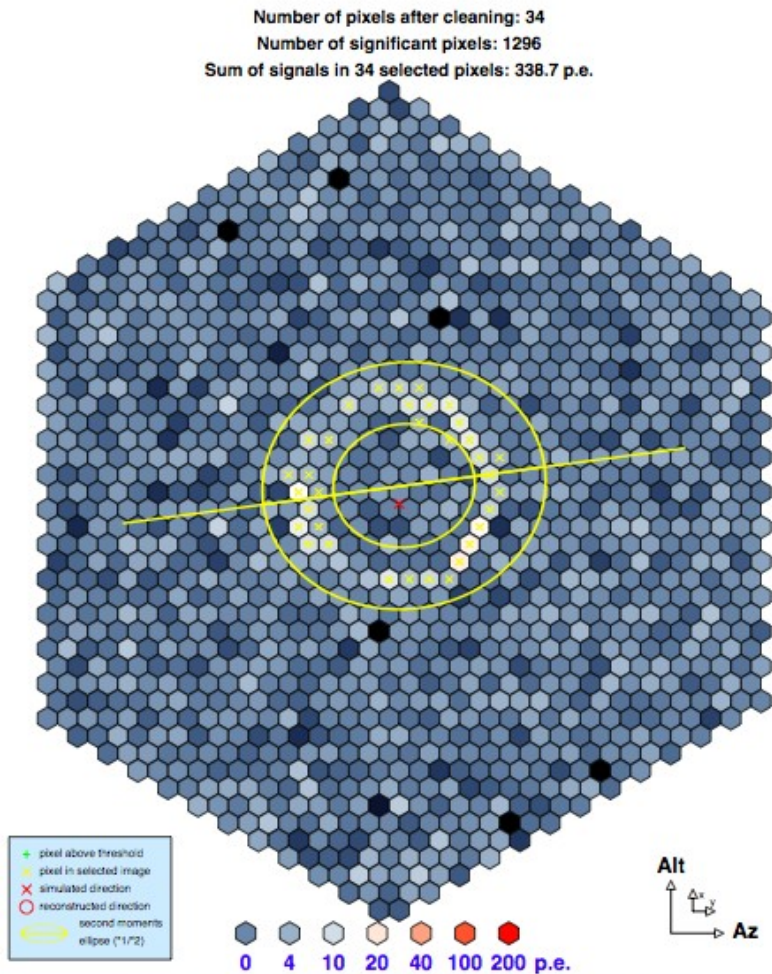
SST-1M – muon simulations



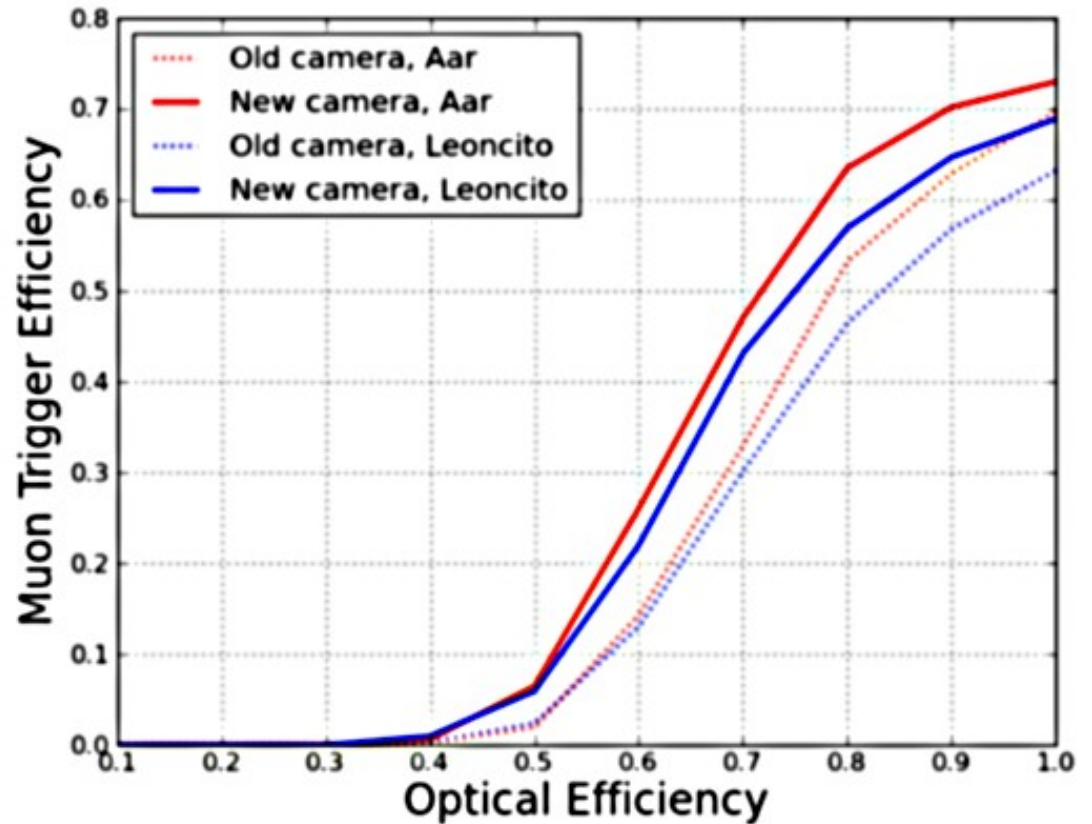
- Konrad's simulations of muons for all Prod-2 telescopes:
 - each telescope can trigger on muons
 - SST-1M shows strong dependence of muon trigger efficiency on optical efficiency which may bias the optical throughput calibration



SST-1M – muon simulations - new camera



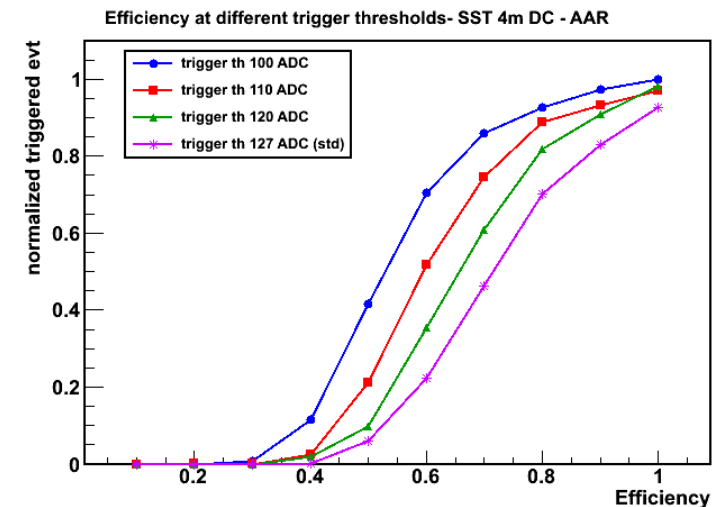
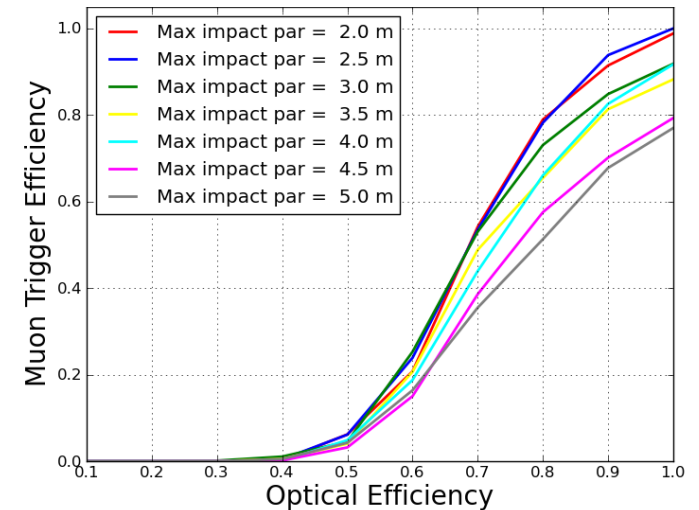
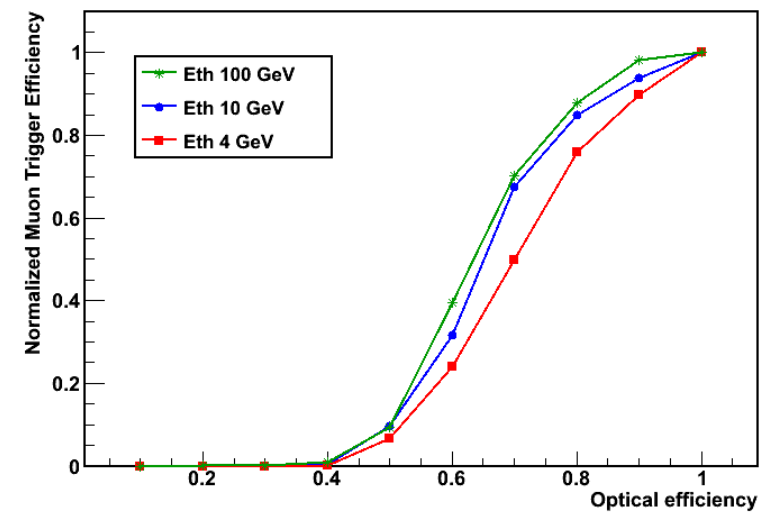
Primary: muon of 0.014 TeV energy at 0 m distance



- with new camera still a strong dependence of muon trigger efficiency on optical efficiency

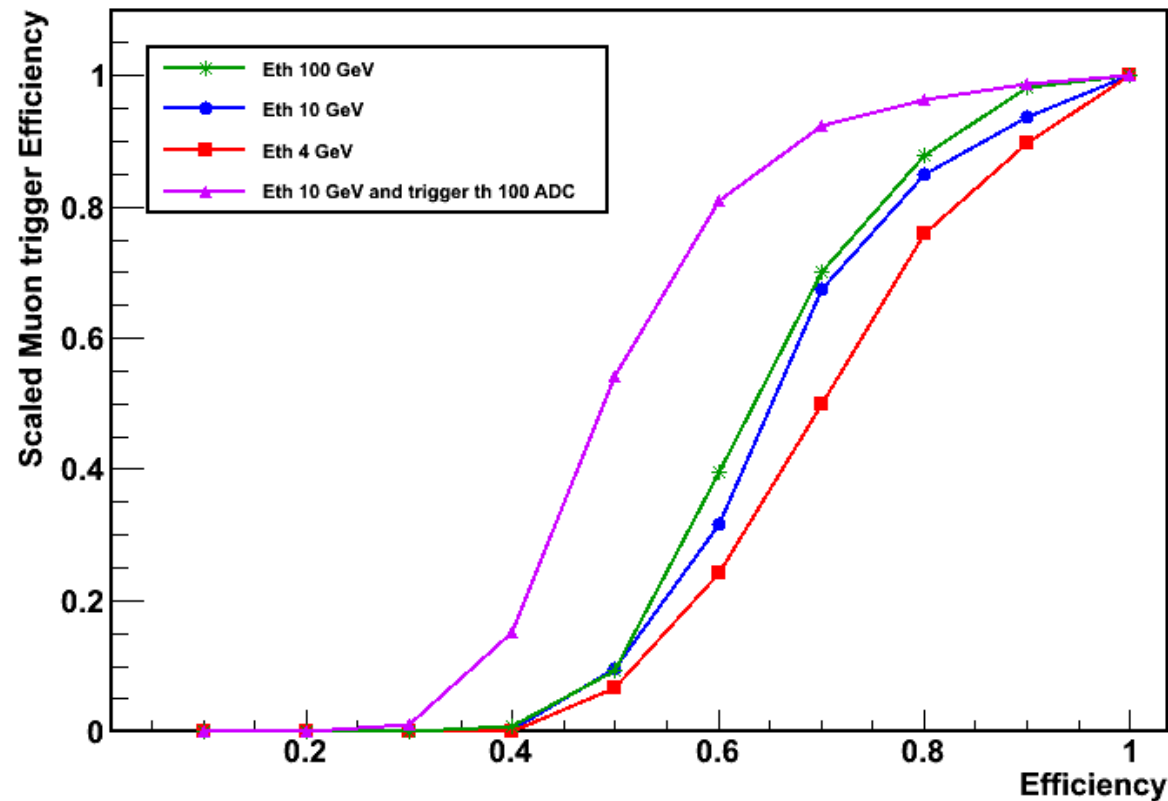
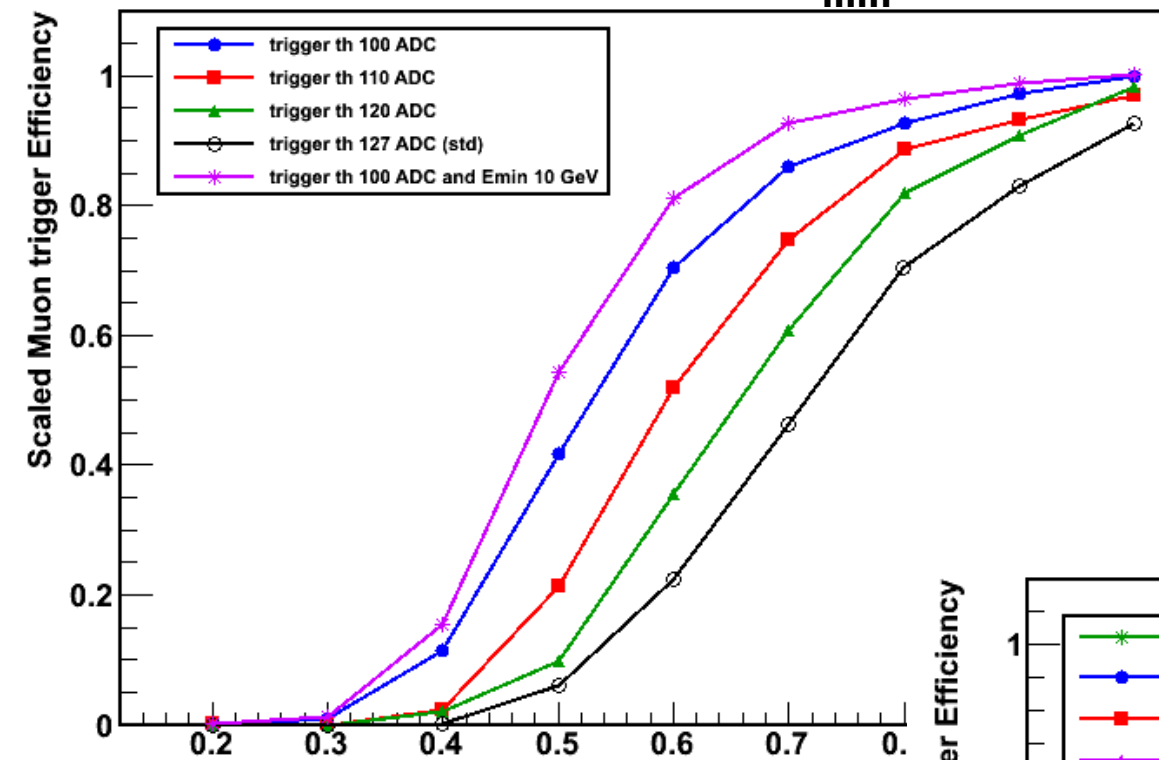
SST-1M – muon simulations

- **energy cut** - simulated muons with E_{\min} 10GeV and 100GeV and rate compared to that of muons with E_{\min} 4 GeV
- influence of the **impact parameter** to take into account partial rings
- **lower trigger threshold**:
 - standard “safe” threshold of 25.4 PE (127 ADC) – incident rate <100 Hz
 - 120 ADC (24 PE) – incident rate ~100 Hz
 - 110 ADC (22 PE) – rate 1 kHz
 - 100 ADC (20 PE) – rate 10kHz(camera can sustain 13 kHz trigger rate; trigger – digital sum of 7 pix sector)

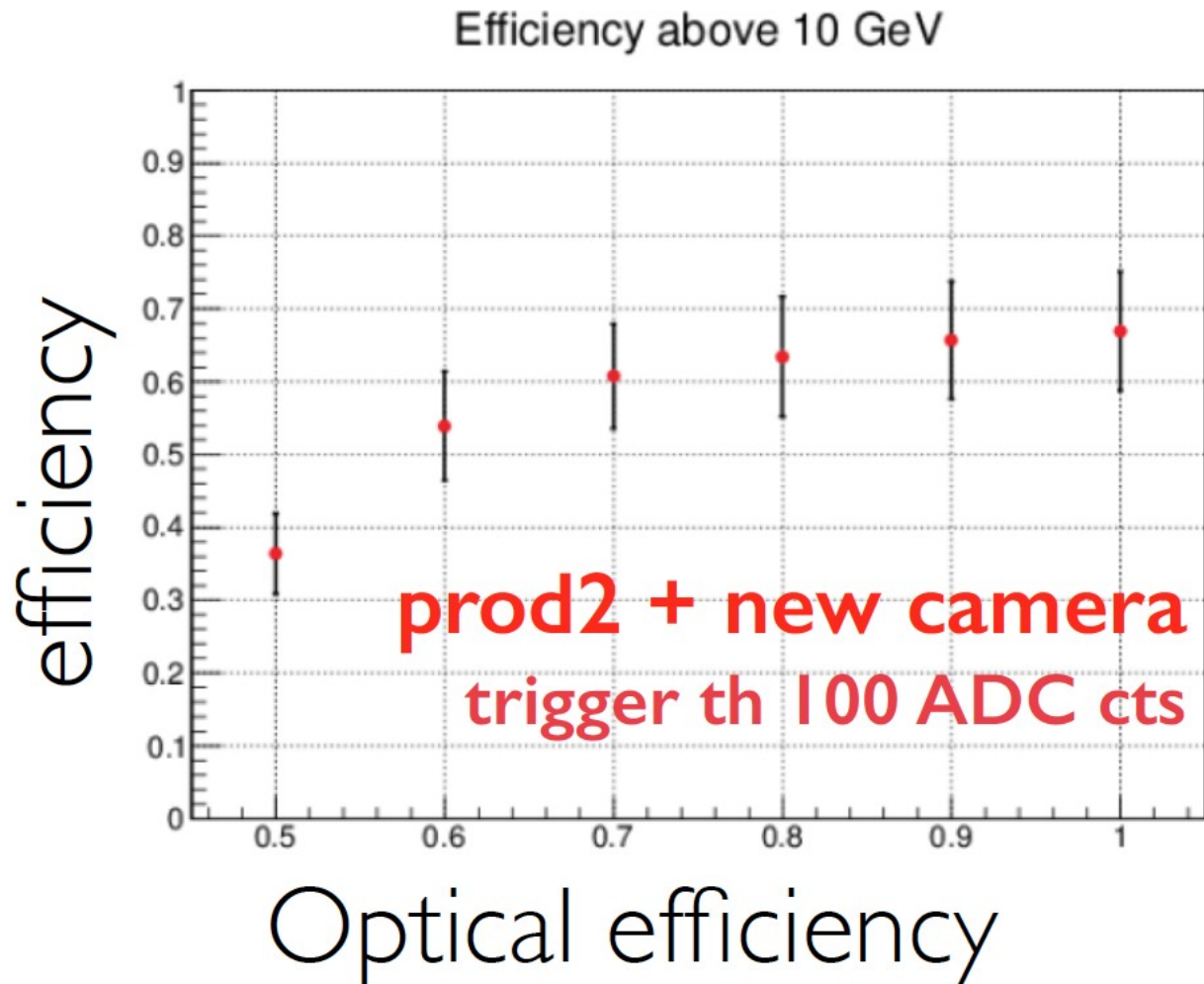


SST-1M – muon simulations

combined effect of E_{\min} cut and lower trigger threshold



SST-1M – muon simulations – ring analysis

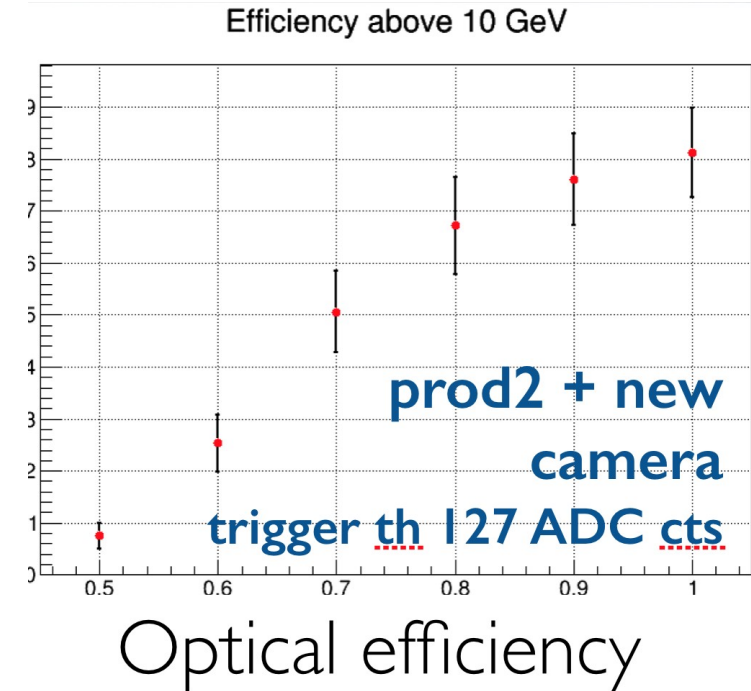
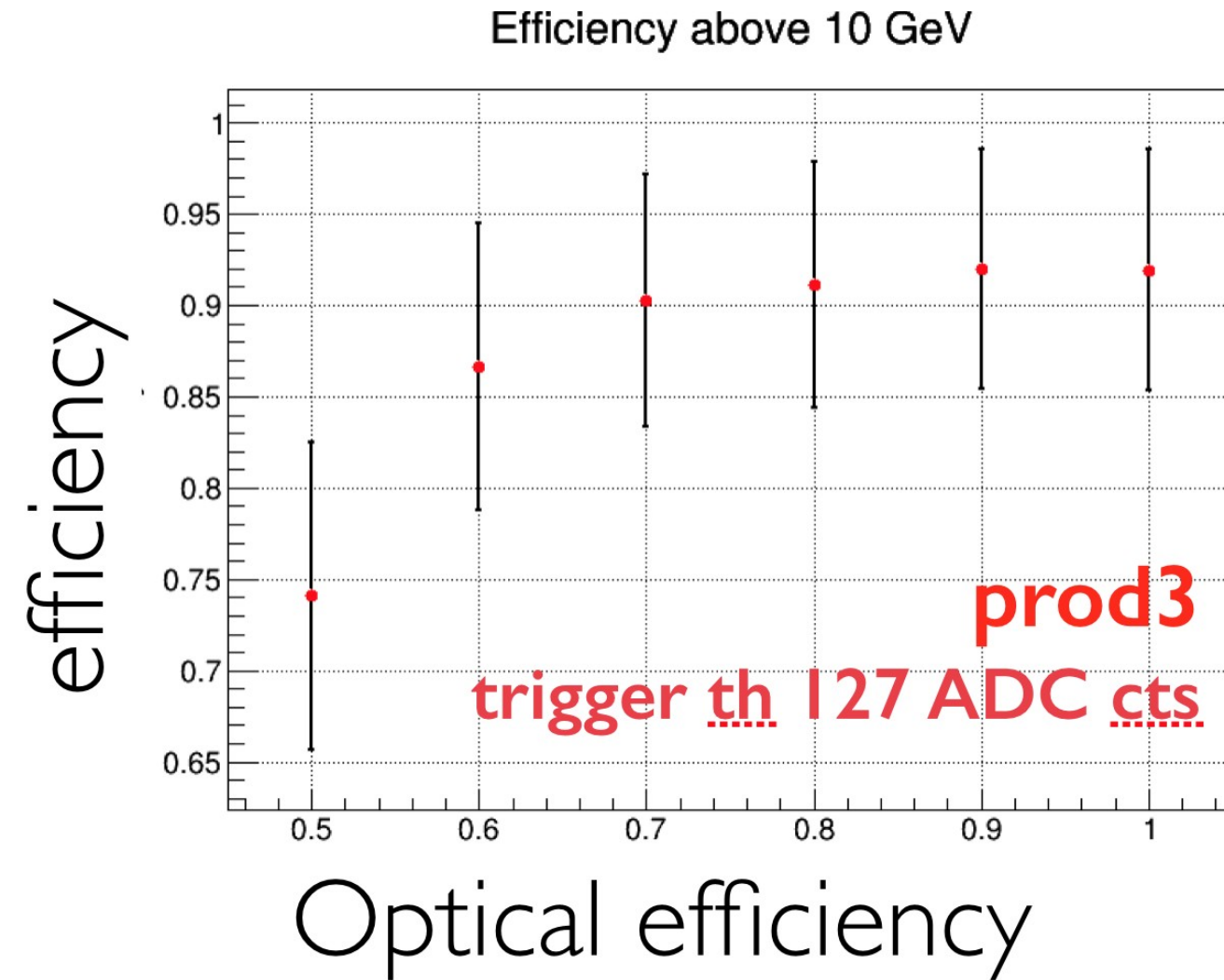


simulations with E_{\min} cut and lower

energy threshold reconstructed with MARS with additional cuts:

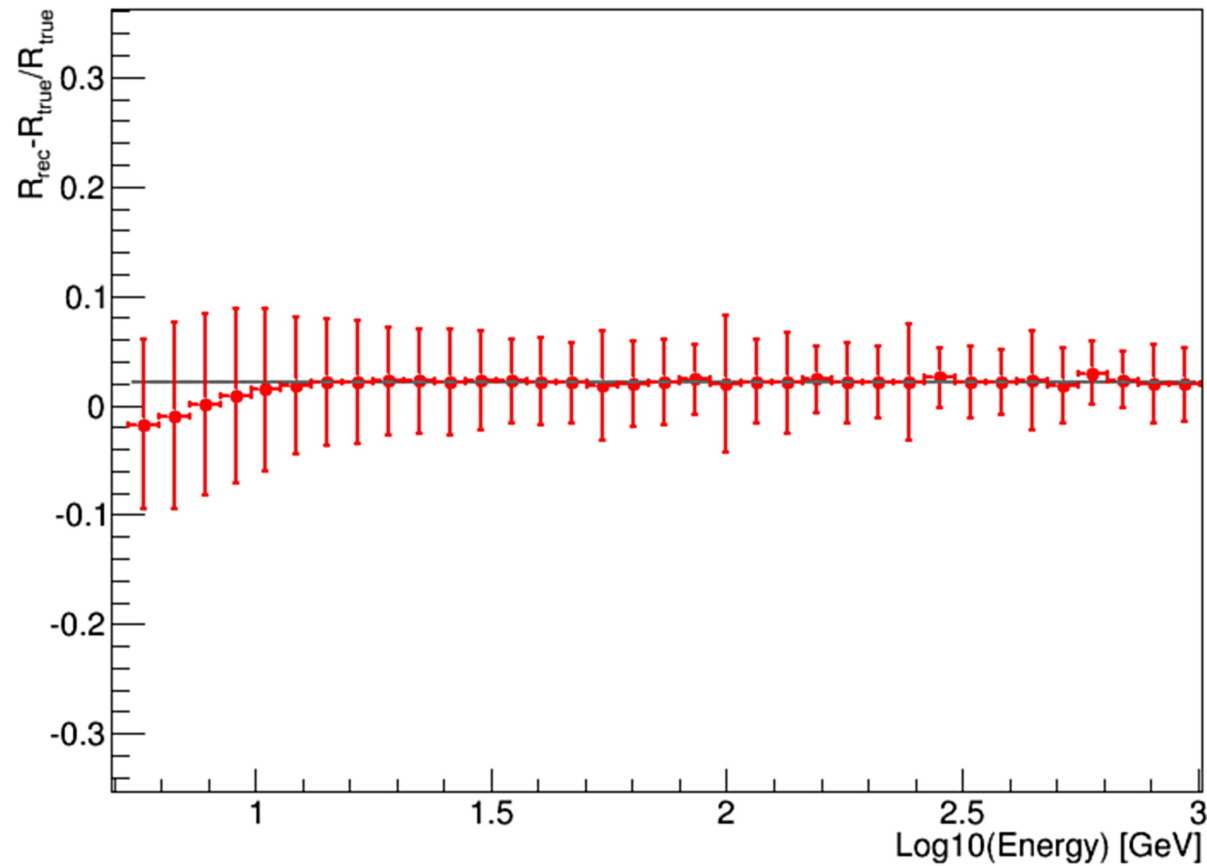
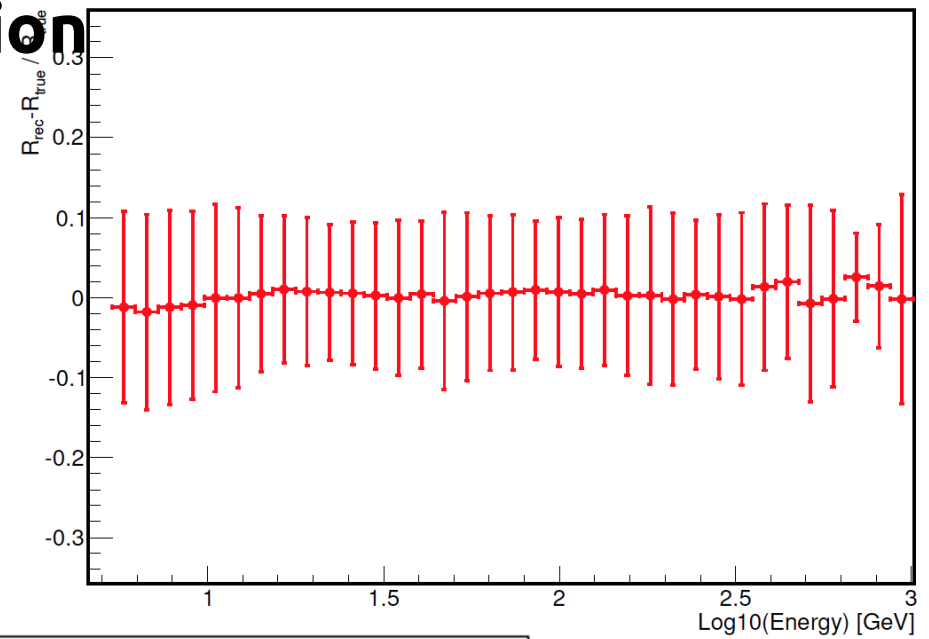
- muon ring fully contained in the camera,
- the reconstructed radius should be between 0.5 and 1.5 degrees,
- the projected ring width along the ring radius should have a gaussian shape (reduced chi square of the arc-width < 2)
- the csi parameter (ring fit goodness) should be smaller than 2

SST-1M – muon simulations with Prod-3 parameters



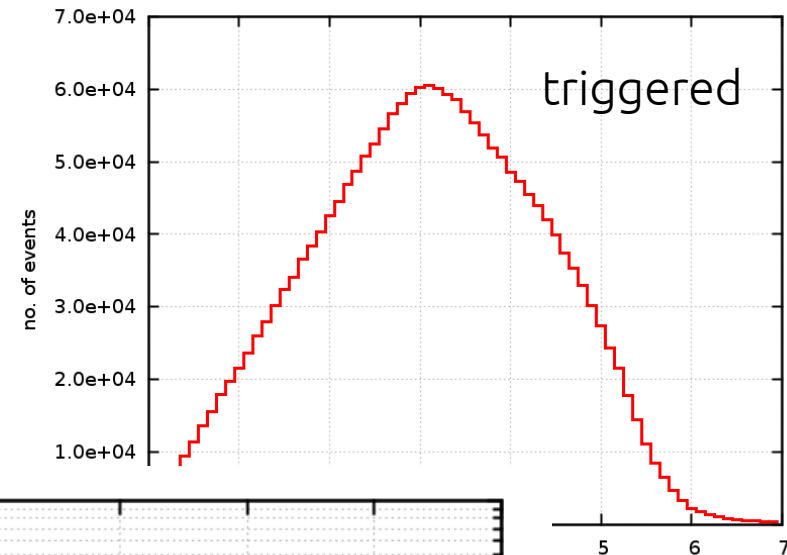
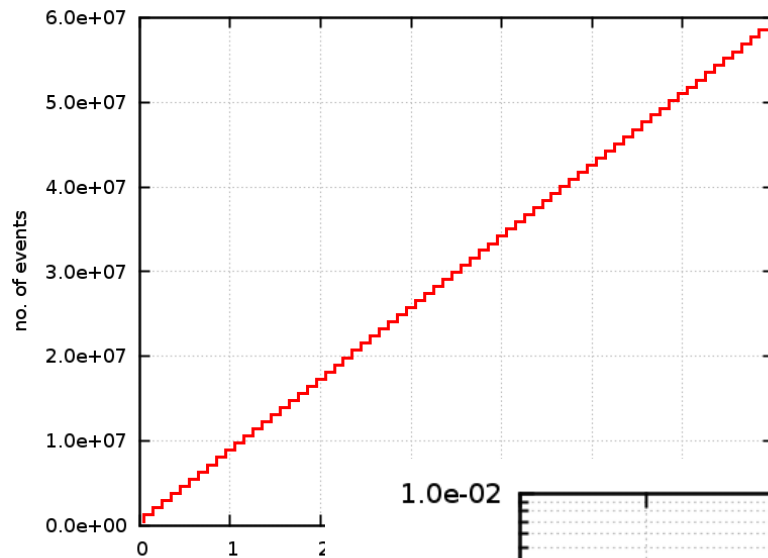
SST-1M – ring radius reconstruction

- bias on ring radius reconstruction $\sim 2\%$
- impact parameter (IP) reconstruction still in progress



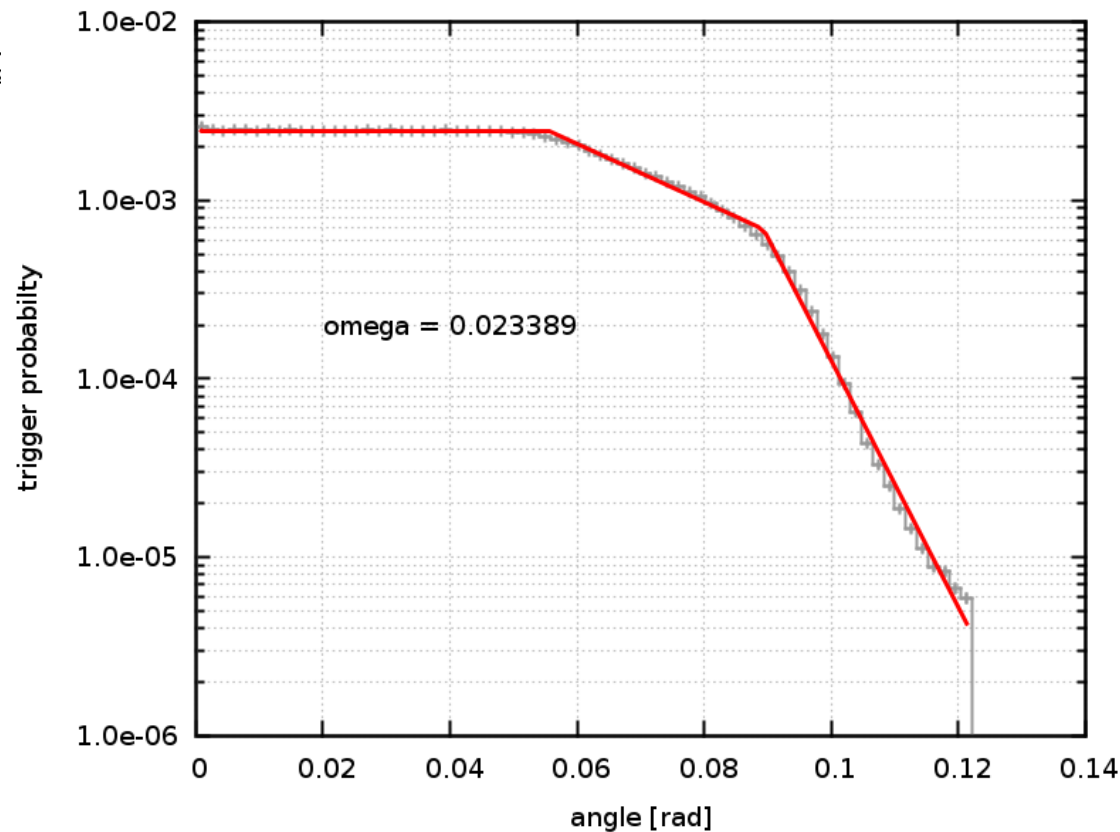
SST-1M – muon rate

simulations for the “Paranal” site



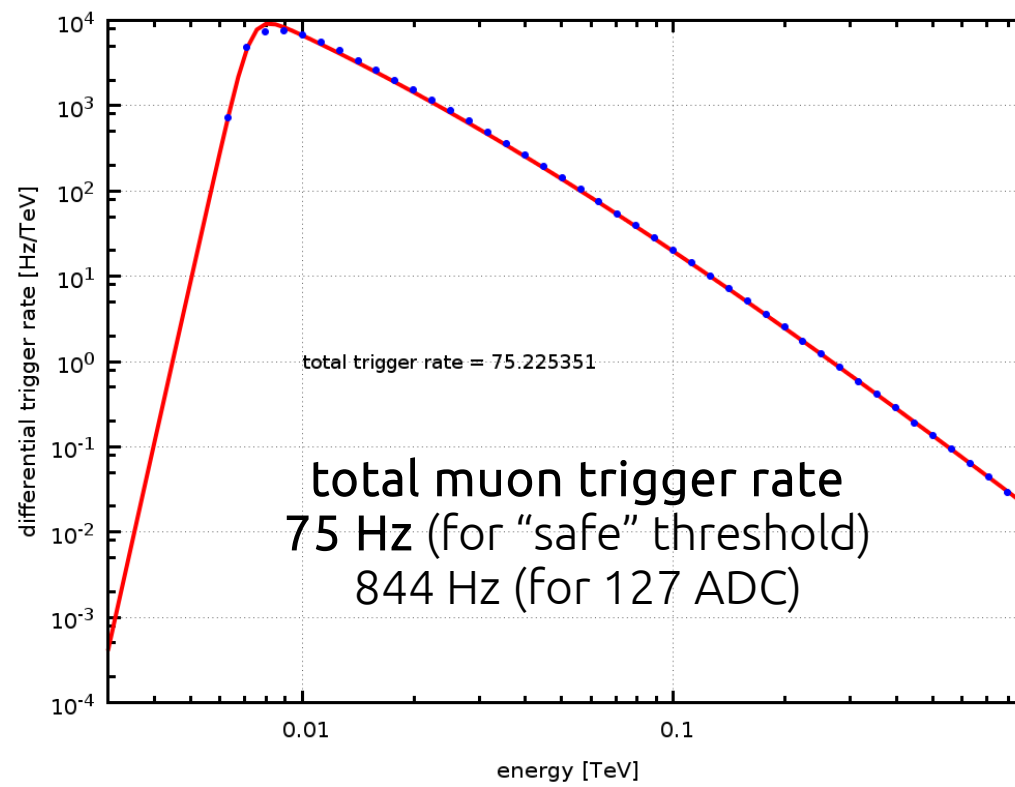
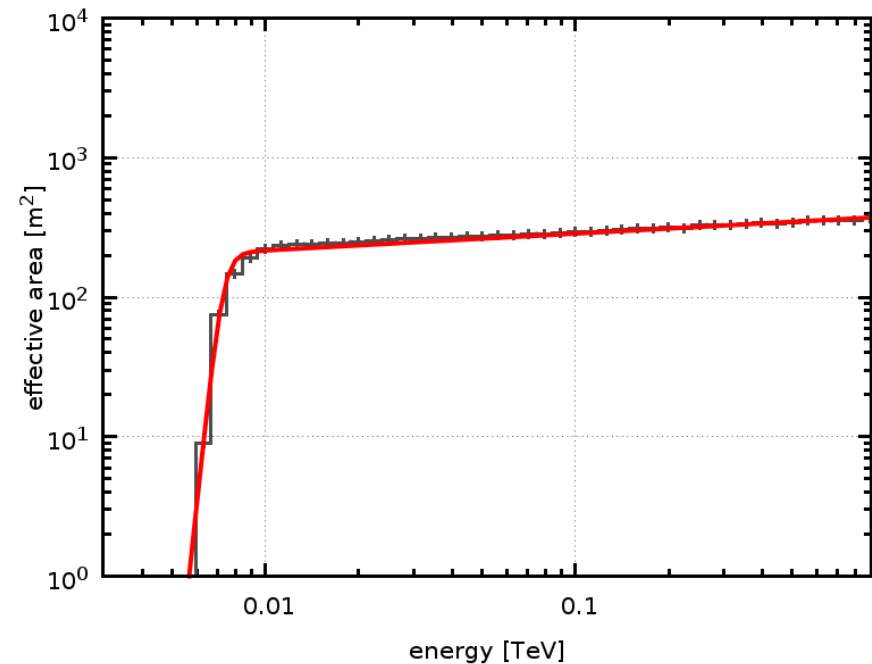
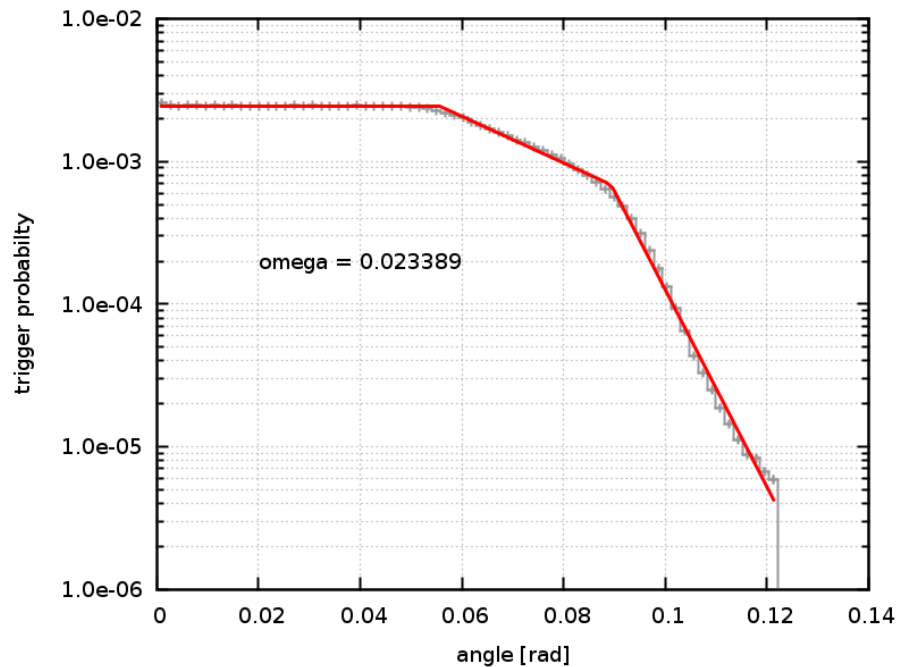
simulated muons with

```
NSHOW 1.0e9  
VIEWCONE 0. 7.  
CSCAT 10 200e2 0  
FIXCHI 100.
```



angular profile
FoV=2x0.023
srad (~17.5 deg)

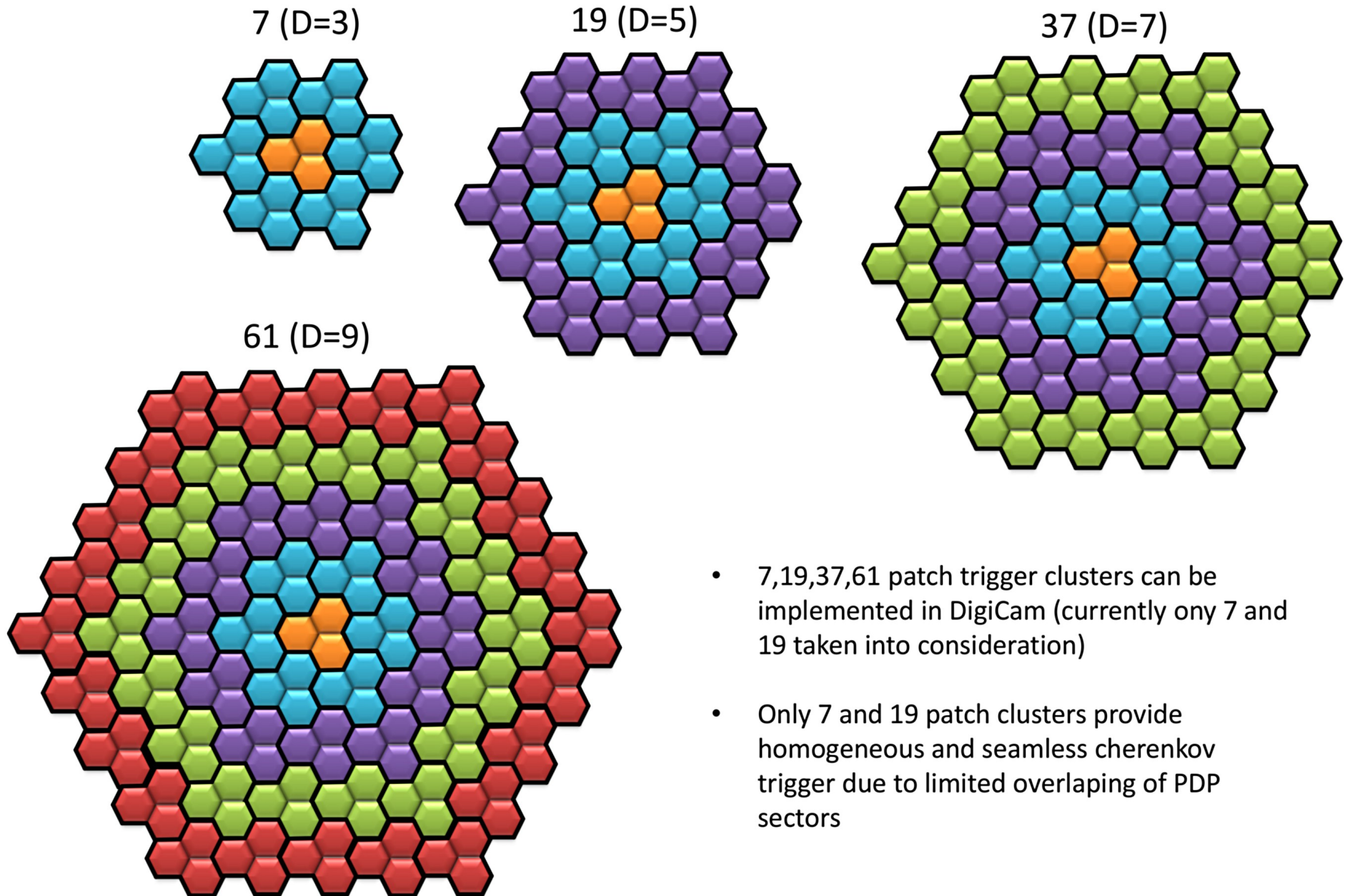
SST-1M – muon rate



SST-1M – muon preselection

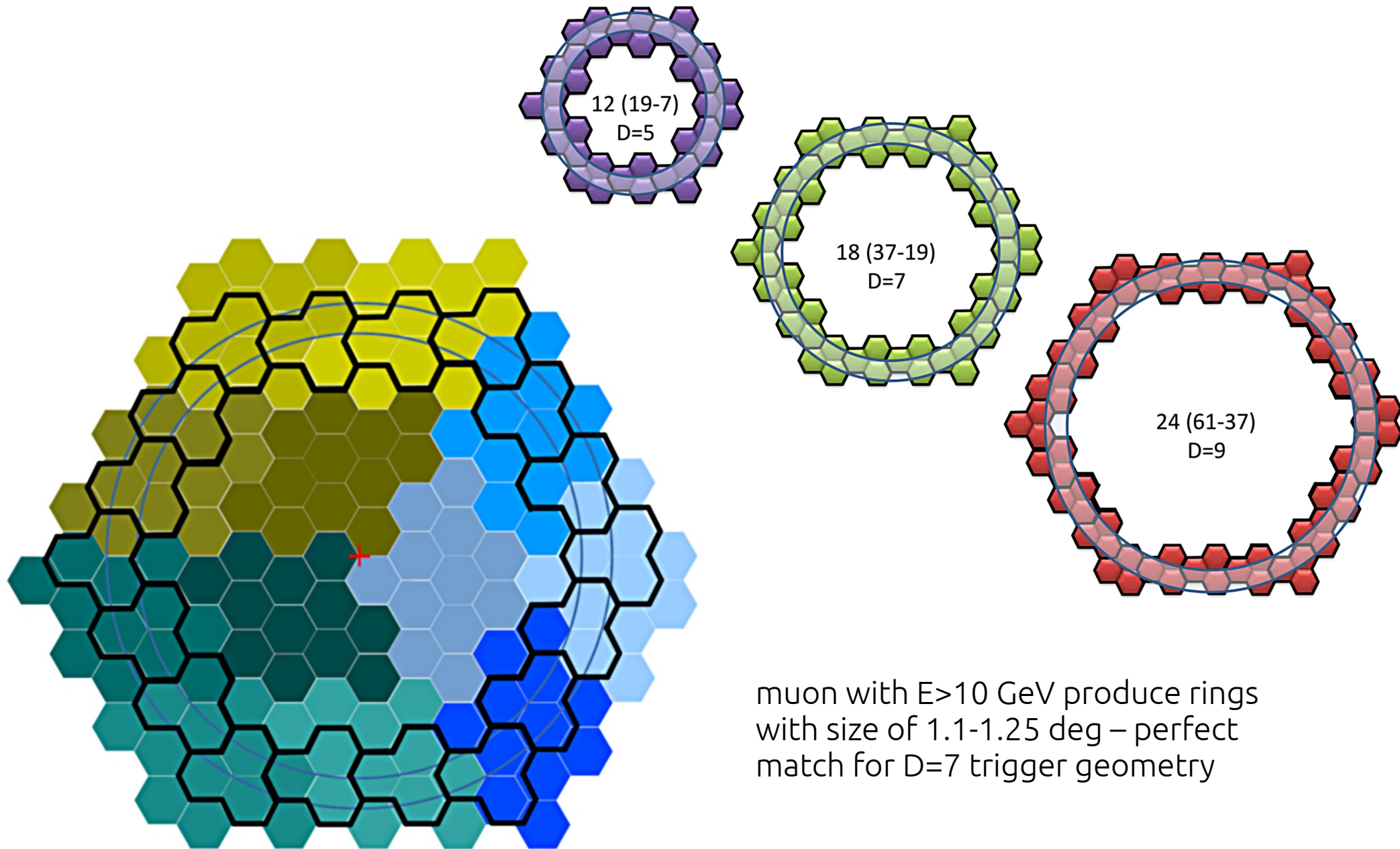
- standard rate of ~ 75 Hz not a problem – reconstruction can be done off-line during data analysis (only “mono” event facility required from central trigger)
- if lower energy threshold required muon trigger rate may be too high, so pre-selection required
- pre-selection can be done:
 - in the camera itself with **dedicated trigger** (“hollow” trigger)
 - in the camera server with **fast analysis** (Hough transform)

SST-1M – “hollow” trigger (with K. Ziętara and P. Rozwadowski)

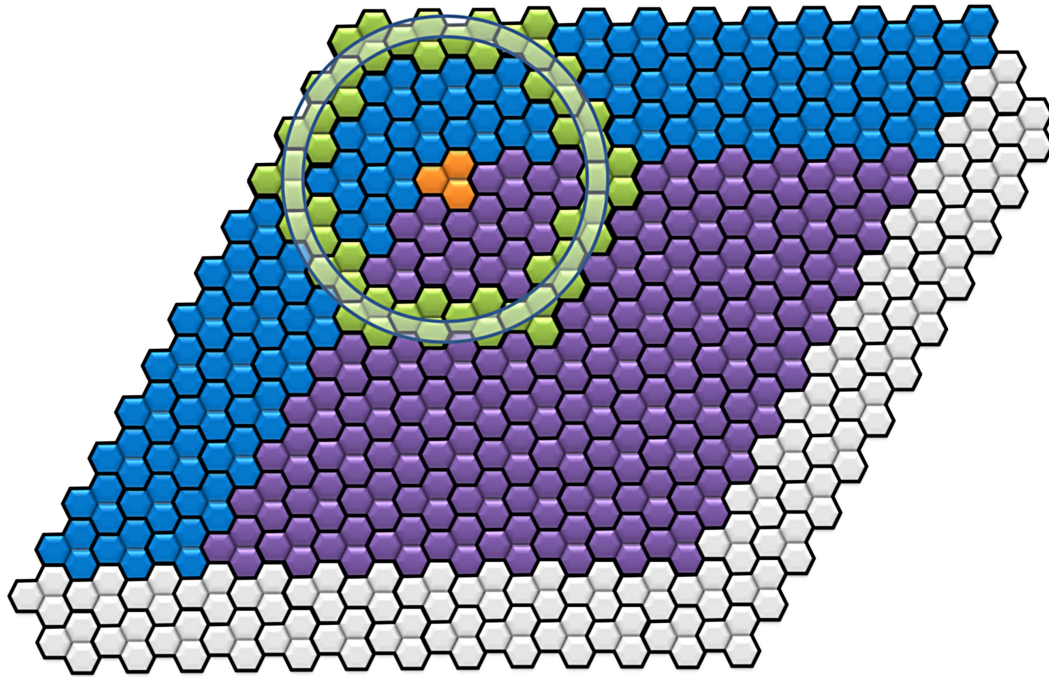


- 7,19,37,61 patch trigger clusters can be implemented in DigiCam (currently only 7 and 19 taken into consideration)
- Only 7 and 19 patch clusters provide homogeneous and seamless cherenkov trigger due to limited overlapping of PDP sectors

SST-1M – “hollow” trigger (with K. Ziętara and P. Rozwadowski)

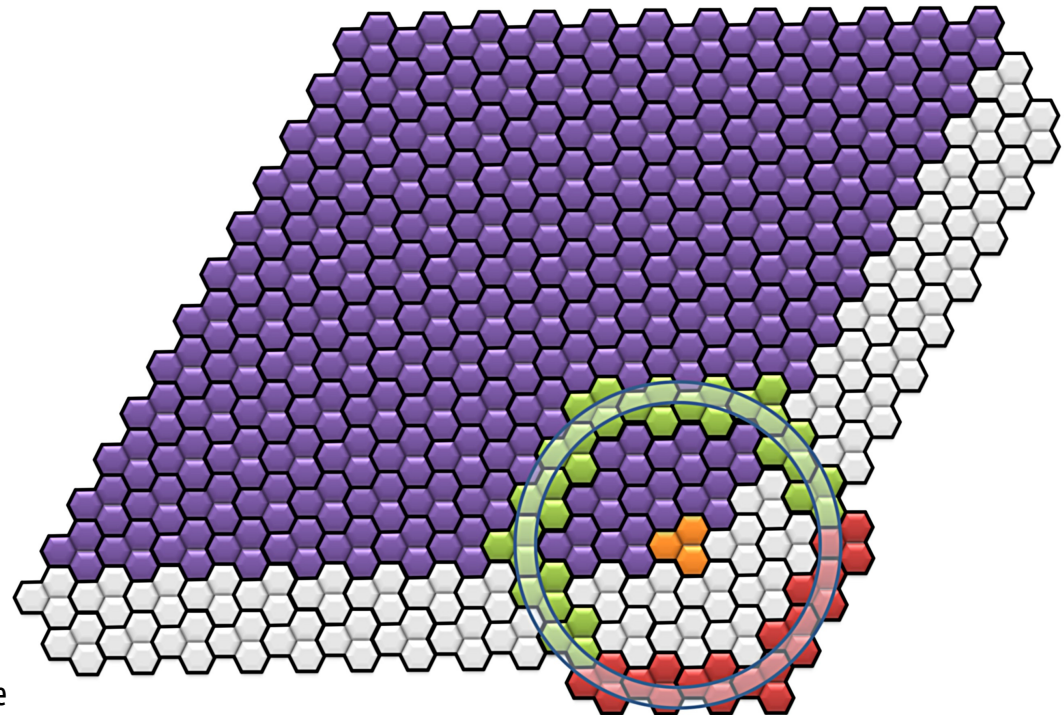


SST-1M – “hollow” trigger (with K. Ziętara and P. Rozwadowski)

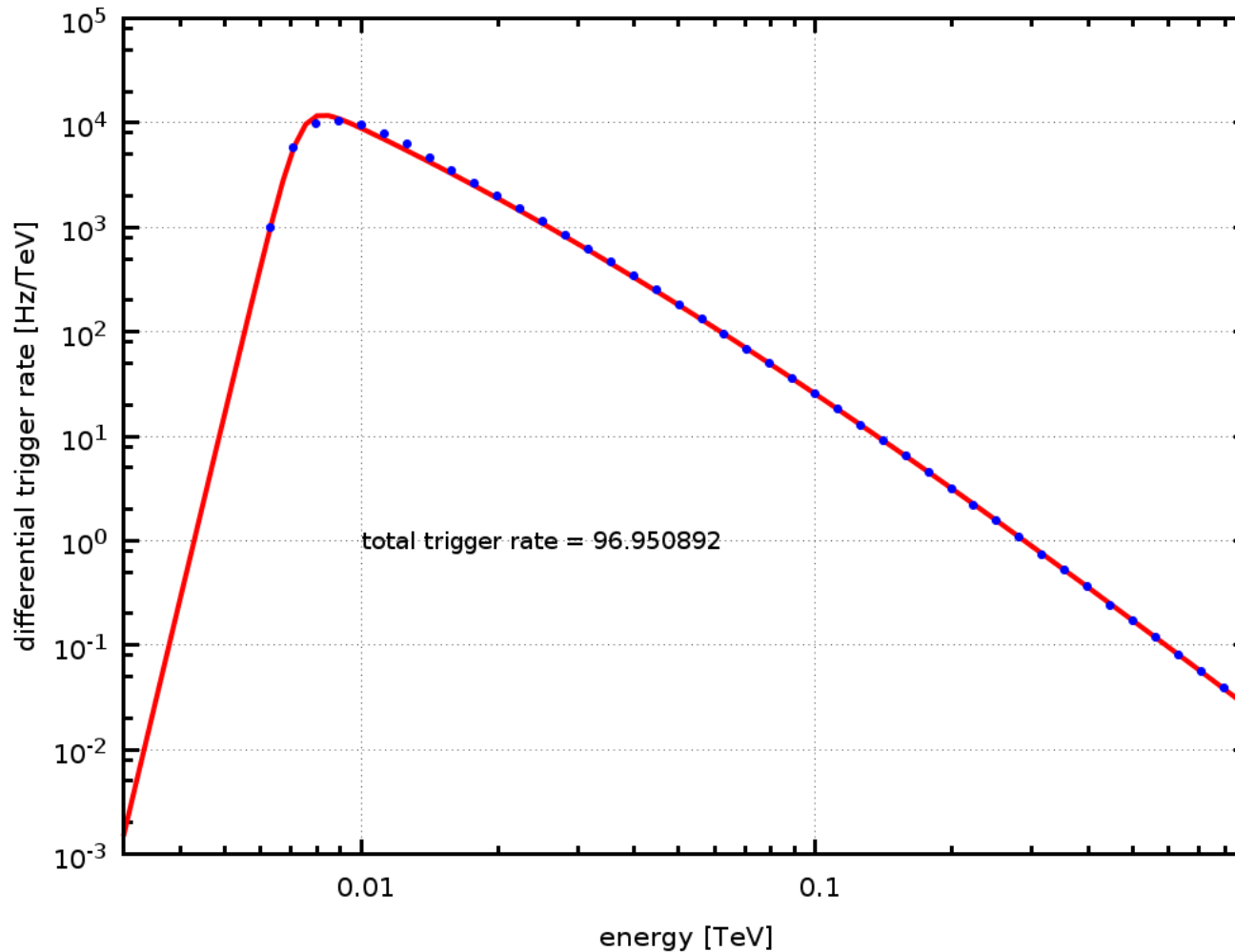


not the full ring on the edge of
the camera

not the full ring due to
limited information
exchange between camera
sectors



SST-1M – “hollow” trigger (with K. Ziętara and P. Rozwadowski)



- for “safe” threshold (in case of hollow D=7 trigger “safe” means ~50 PE (1000 PE)) muon trigger rate is

~ 97 Hz

- trigger homogeneity needs to be investigated

SST-1M – pre-selection in camera server (with E. Lyard))

- use Hough transform to detect circles in the camera image (Tyler et al. for the VERITAS Collaboration “Muon Identification with VERITAS using the Hough transform”)

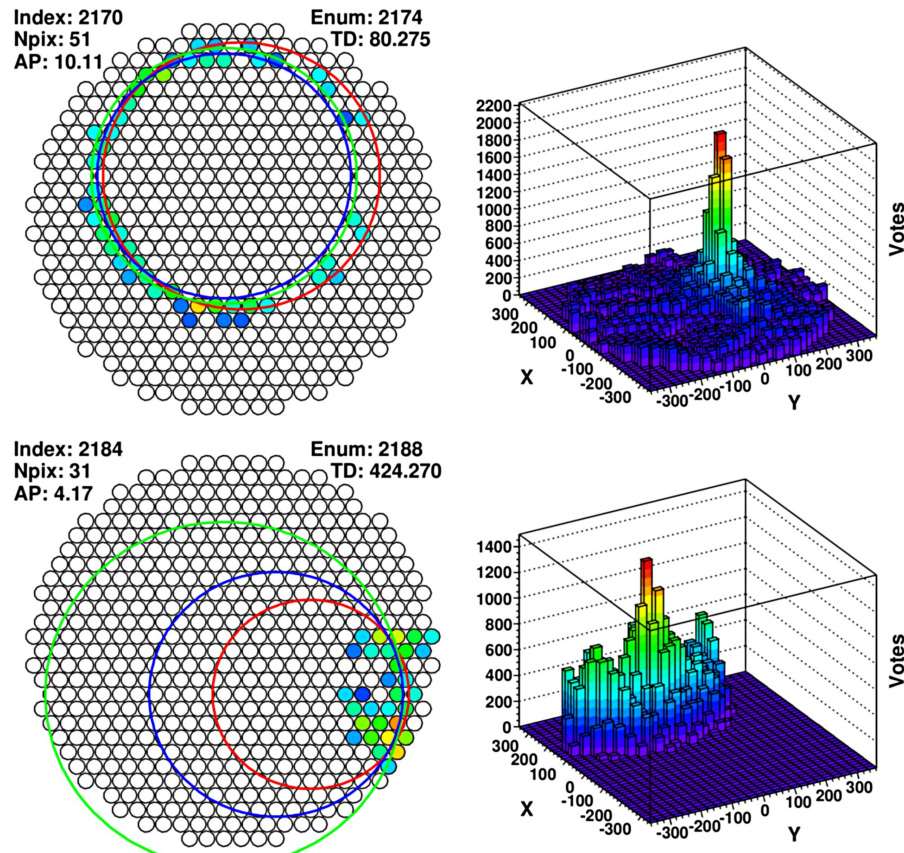


Fig. 4: Pixel patterns and accumulator array projections for two events seen by VERITAS. Top: a muon event. Bottom: a non-muon event.

Conclusions

- SST-1M muon group in the process of transferring tasks to different people
- “hollow” trigger under investigation for homogeneity and muon flagging efficiency
- Hough transform still considered as valuable solution on the camera server, but detailed cut parameters need to be investigated