Apr 24 2019
EEE Weekly Meeting

Detector Simulation Working Group (DeSi-WG)

EEE telescope simulation an update on model validation

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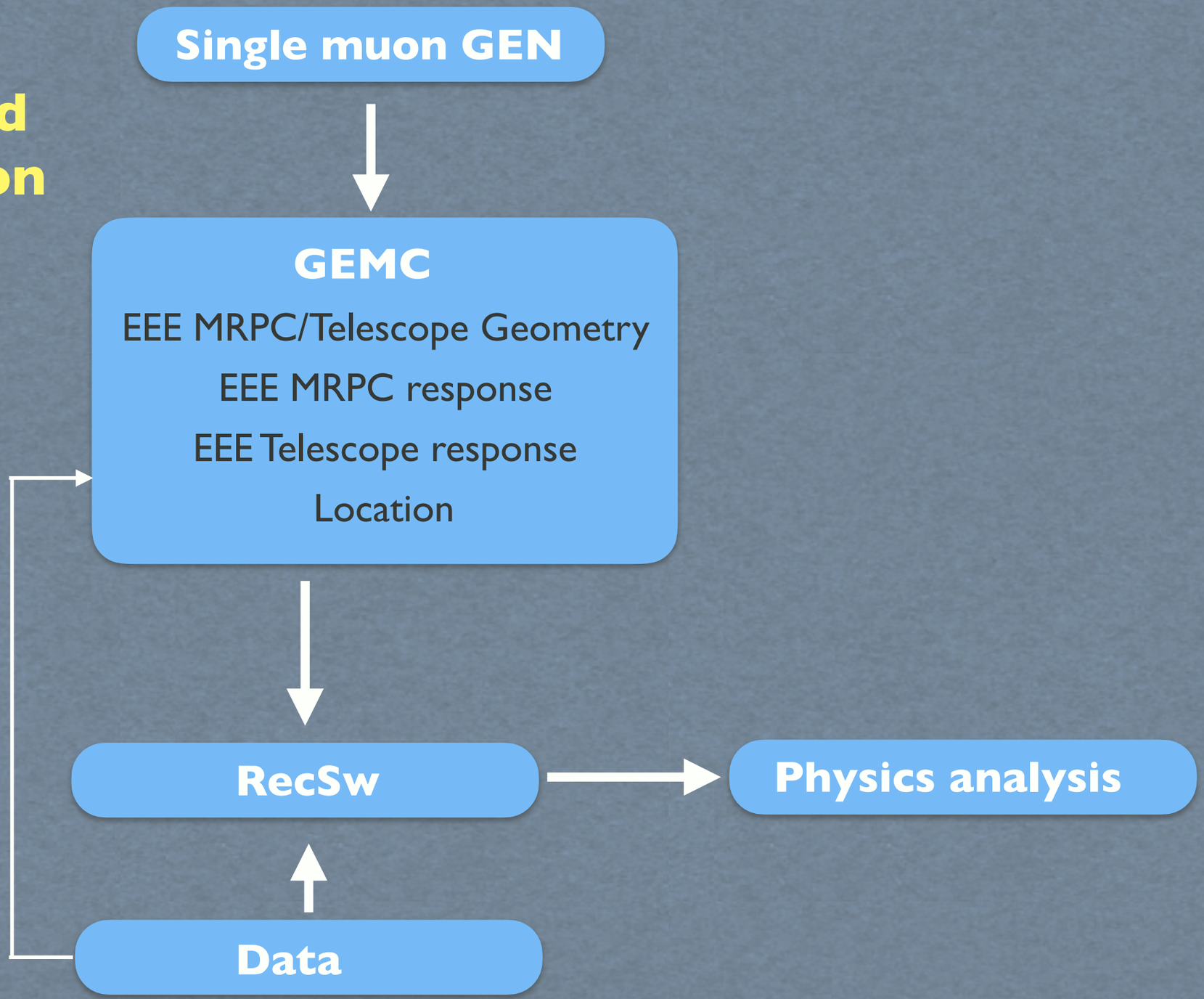
DEtector**SI**mulation**-WG**

Goal: generate pseudo data using GEANT4 to track CORSIKA generated particle

Test and validation of the whole chain



Ingredients entering into simulation validation: SIM & DATA

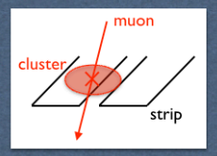
EEE-MRPC response to cosmic rays in GEANT4

- MRPC geometry: material, size, …
- MRPC response (parametrized)
- Telescope response: geometry, trigger, …
- Telescope location: effect of roof, walls, surrounding materials, …
- Telescope: muon rates for different multiplicities
- Multi-telescopes: coincidence rates
- Single/multiple telescope(s) studies: bottom-up muons, …

✳ **EEE MRPC response**

✳ No avalanche simulated in details

✳ Effective hit process:
- Sample XY (and Z) muon hit on on bottom strip plane
- Assume both strips and gaps are active
- Apply a spread to account for multiple hits and spread position resolution X and Ynand T

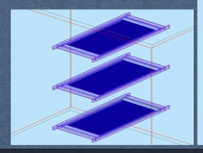


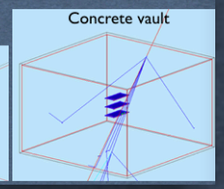
✳MRPC parameters
- 90x160 active area
- Active: 2.5cm x 24 strips + 0.7cm x (24-1) gaps
- Time spread: σ = 238ps
- Cluster size: σ_X = 9.2 mm
- Cluster size: σ_Y = 15 mm
- Light speed: 15.8 ns/cm
- HIT_{XY} is gaussian-spread and projected on the sensitive area to derive strip multiplicity

Ref: JINST13(2018)P08026

✳Telescope parameters
- 3 chambers
- -50/0/+50 cm apart
- placed in a concrete box wall on all sides (140cm concrete)

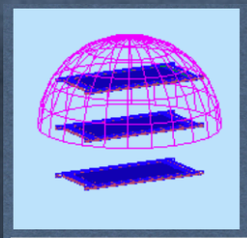
Ref: GENO-01





SIM: detector microscopic description

- Checked varying microscopic parameters: TOF, X-Y resolution, …
- Multiplicity can be better matched (by-hands)



Muon generation

✳ Single-muon generation

✳ Semi-sphere generation such as to obtain a flat distribution on a plane surface

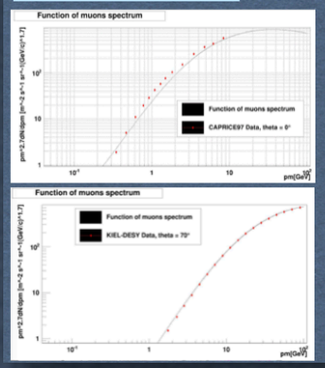
✳ Improved Gaisser parametrization for Flux(E_μ,Θ) to include Earth curvature (all latitudes) and low energy muons (<100GeV)

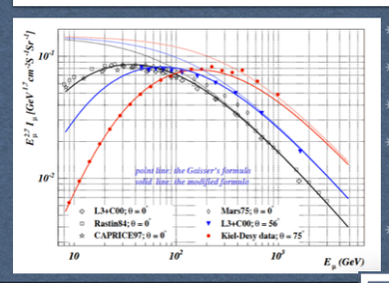
$$\frac{dI_\mu}{dE_\mu} = 0.14\left[\frac{E_\mu}{GeV}\left(1+\frac{3.64GeV}{E_\mu(\cos\theta^*)^{1.29}}\right)\right]^{-2.7}\left[\frac{1}{1+\frac{1.1E_\mu\cos\theta^*}{115GeV}}+\frac{0.054}{1+\frac{1.1E_\mu\cos\theta^*}{850GeV}}\right]$$

$$\cos\theta^* = \sqrt{\frac{(\cos\theta)^2+P_1^2+P_2(\cos\theta)^{P_3}+P_4(\cos\theta)^{P_5}}{1+P_1^2+P_2+P_4}}$$

P_1	P_2	P_3	P_4	P_5
0.102573	-0.068287	0.958633	0.0407253	0.817285

arXiv:1509.06176





✳ good agreement with previous data

✳ low/high energies, small/large angles

✳ our implementation checked on data

✳ Generation split in 3 E_μ intervals:
- [0.2 GeV - 2 GeV]
- [2GeV-10 GeV]
- [10GeV-100 GeV]

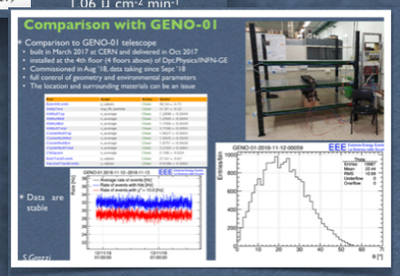
✳ Normalization factor for absolute flux:
1.06 μ cm^{-2} min^{-1}

SIM: muon generation

- Flux(E_μ,θ_μ) parametrization and implementation cross checked with existing measurements
- Extrapolation in region with no data
- Accuracy~10% (overall)

SIM: environment description

- GENO-01 requires accuracy in location description
- Back to the simplest locations
  - ✳ TORI-03
  - ✳ TRIN-01
  - ✳ SAVO-01
  - ✳ CERN-01

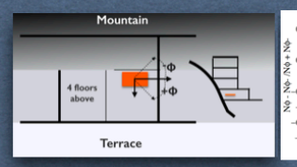


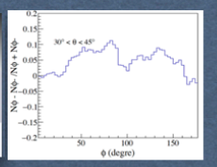
GENO-01

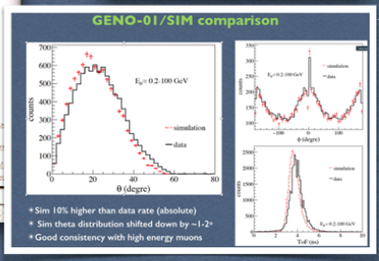
✳First test: comparison to GENO-01

✳The complicated location prevented a straightforward comparison

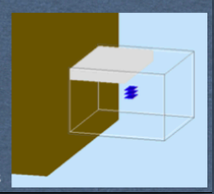
✳Data shows an anisotropy in PHI difficult to correctly implement in simulation





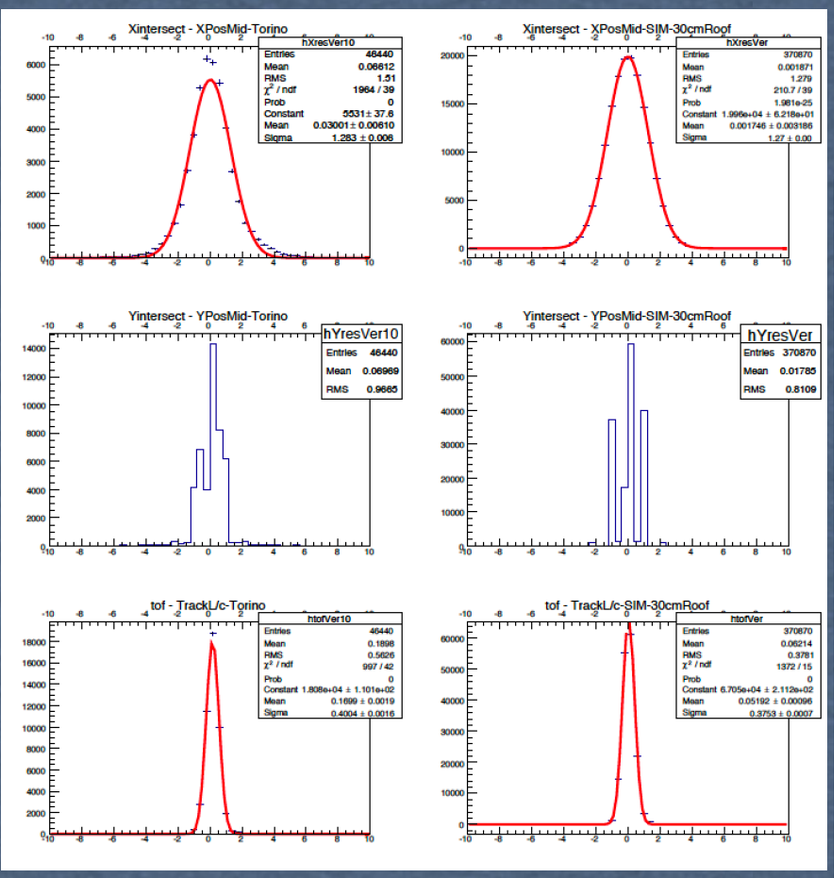


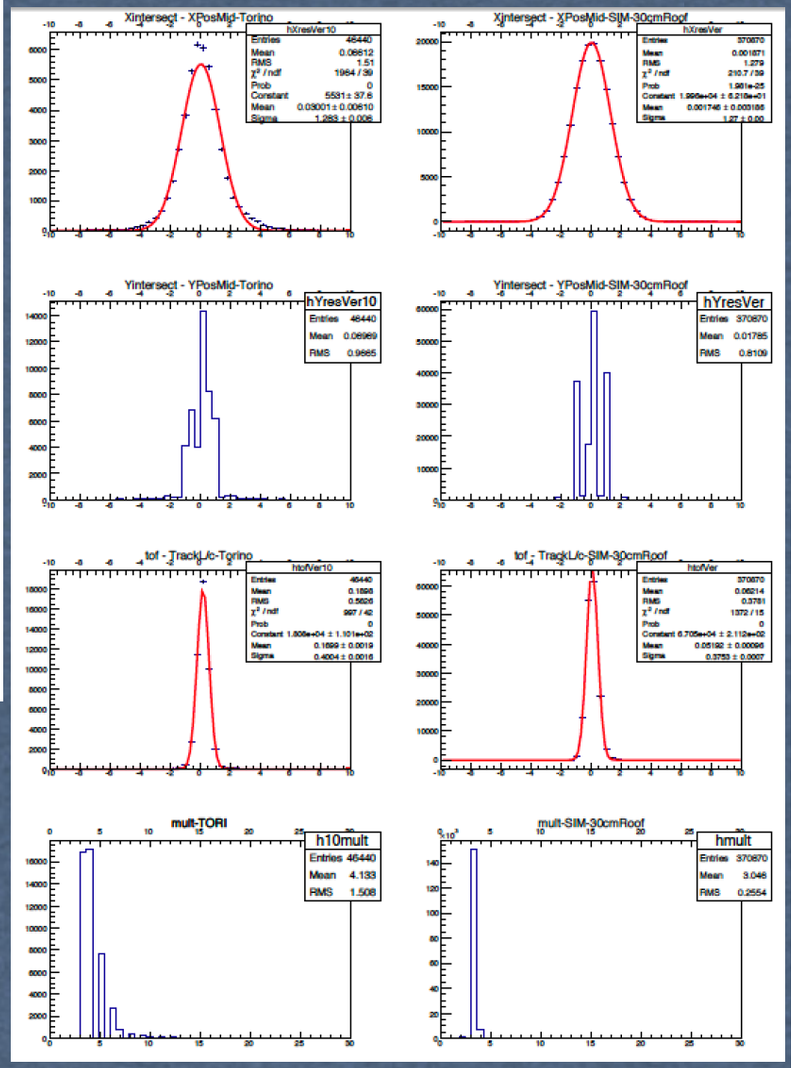
✳Reasonable agreement but not optimal



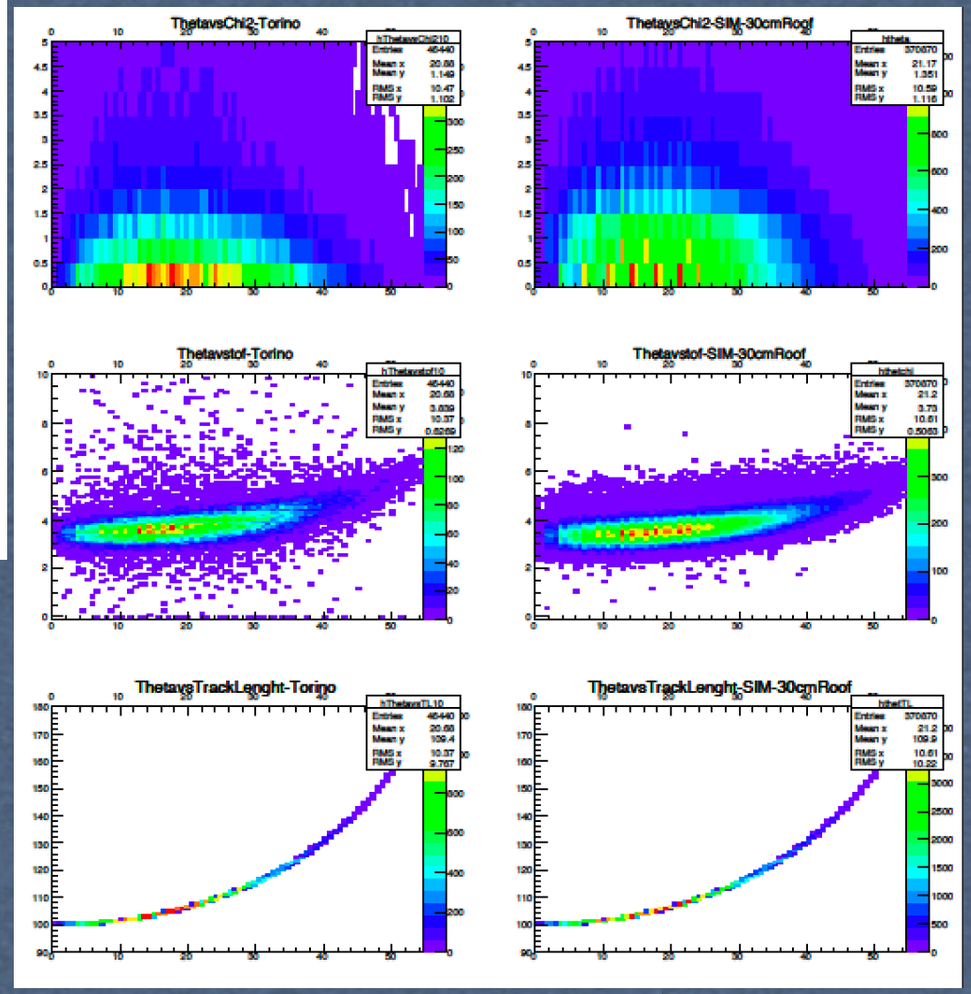
✳ Still working to implement a more realistic geometry of surrounding materials

SIM: detector microscopic description





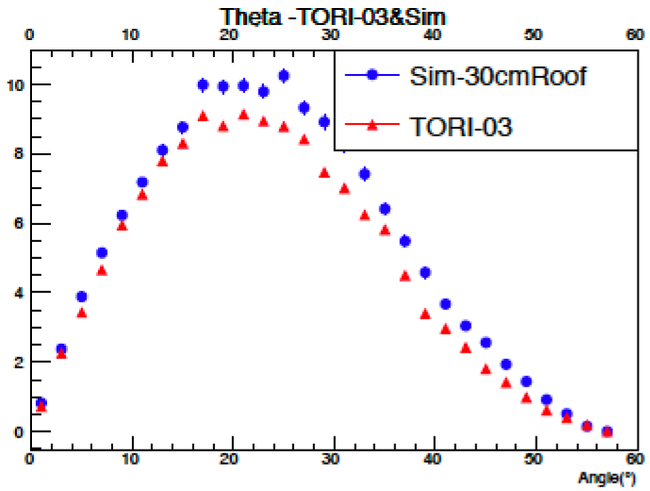
TORI-03

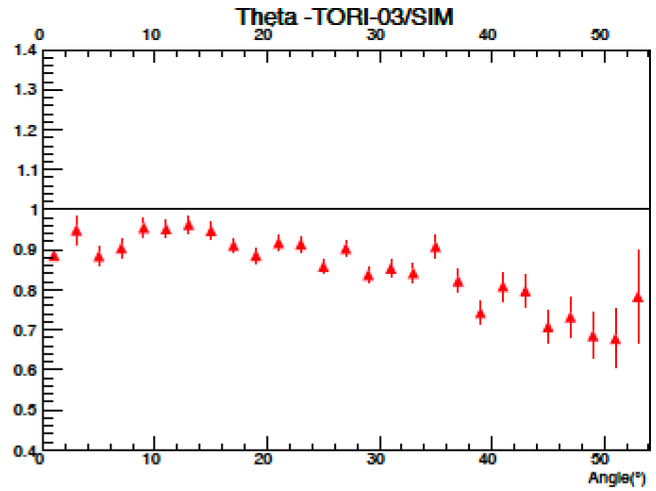


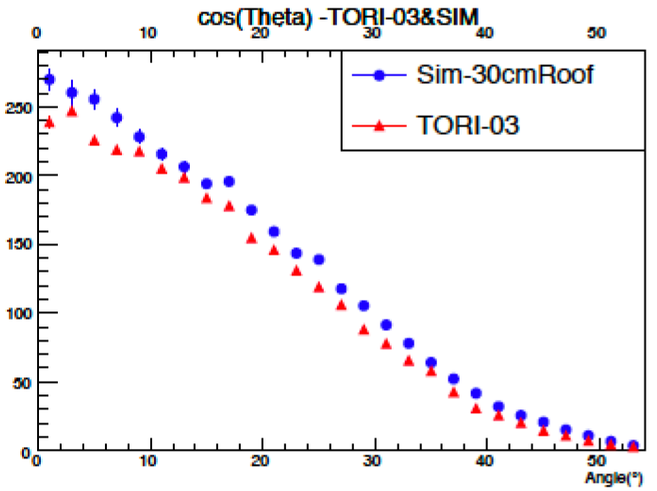
- Multiplicity is different but can be easily adjusted

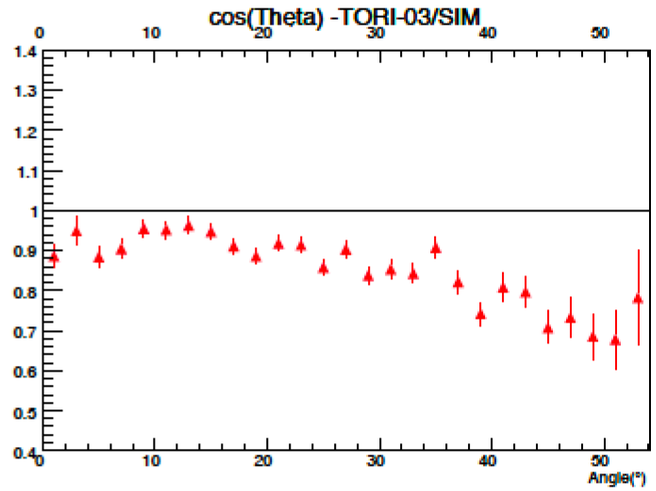
- Comparison of microsopic quantities: good agreement

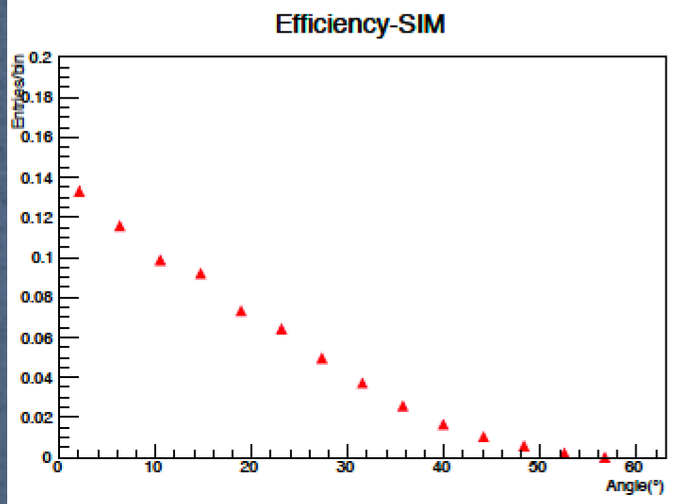
TORI-03





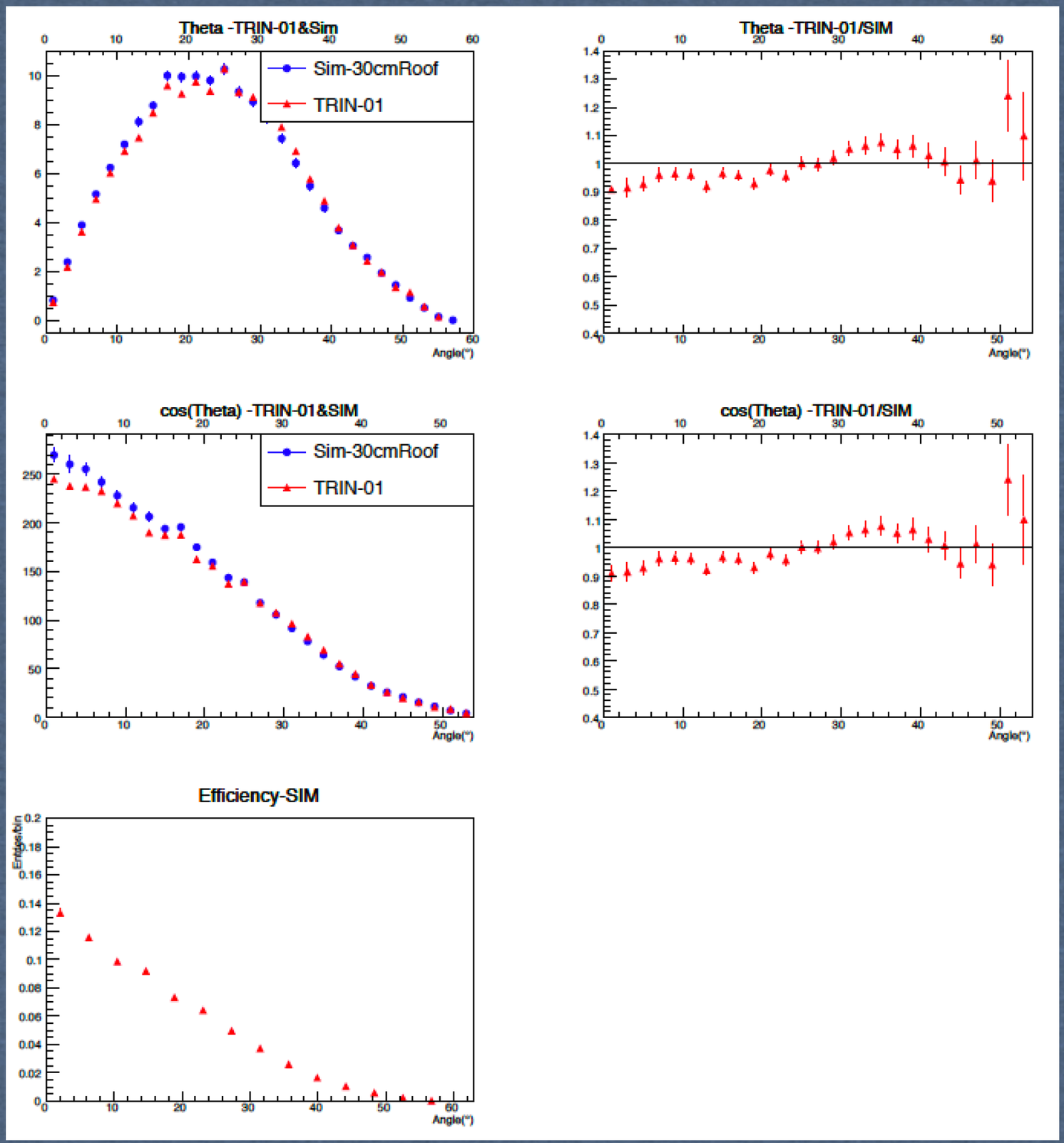






- Good agreement between data and simulation (world-data parametrization) both for absolute and angular behaviour
- Data are 10% lower with a reasonably smooth and constant ratio
- The region where the agreement is less good corresponds to large angles where the efficiency drops by a factor of ten
- Can have a better agreement in selected kinematics regions?

TRIN-01

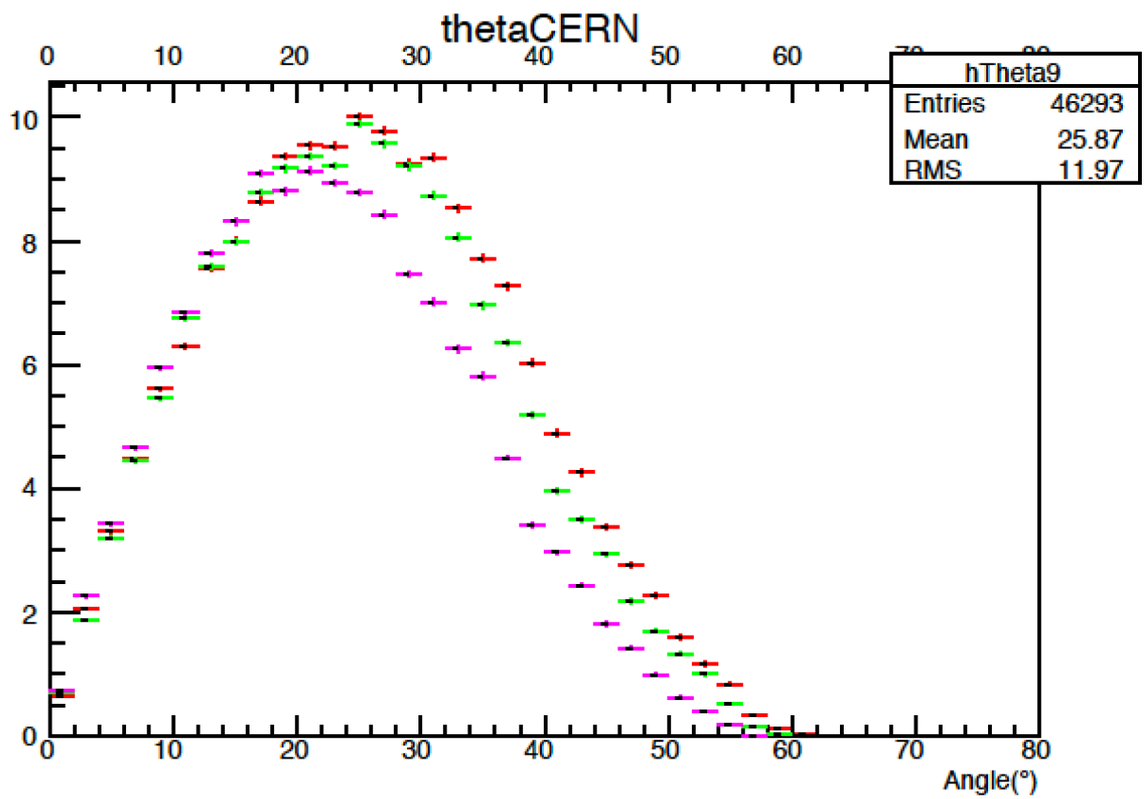


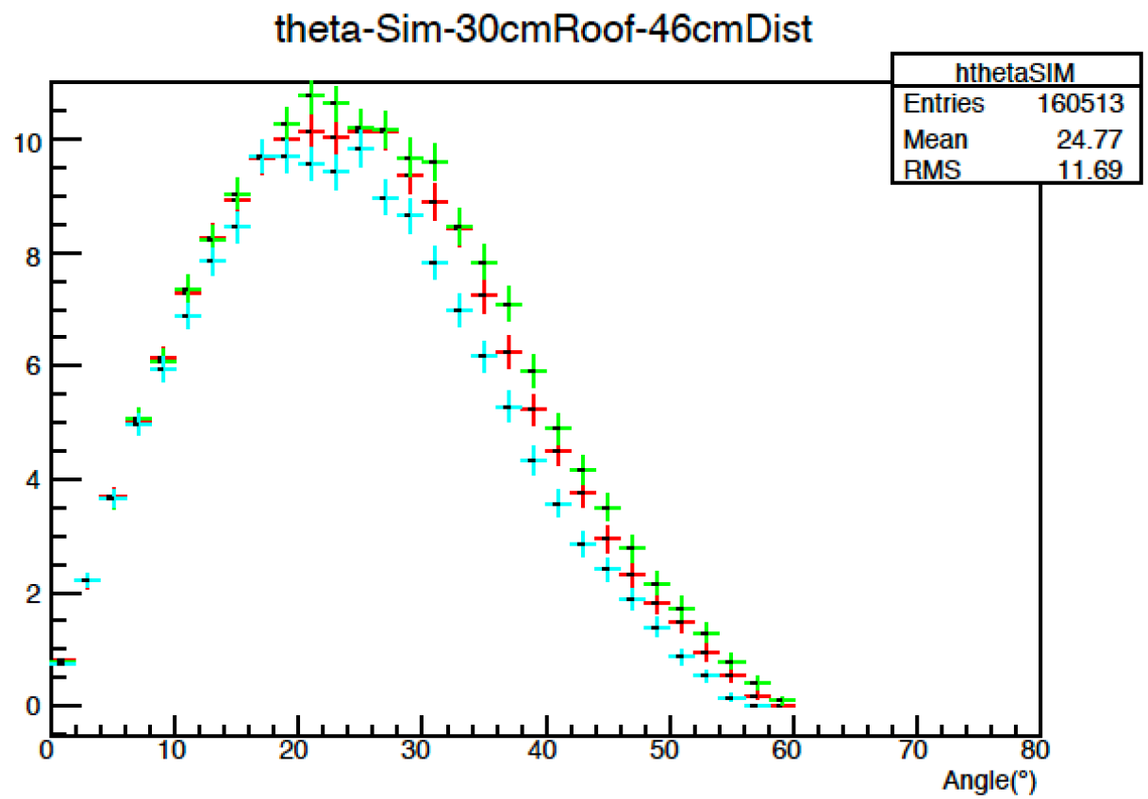
- As a cross check we analysed a stable telescope , same distance between the chambrers (+/- 50cm) in similar environmental conditions (30cm walls room)

Check with some other telescopes

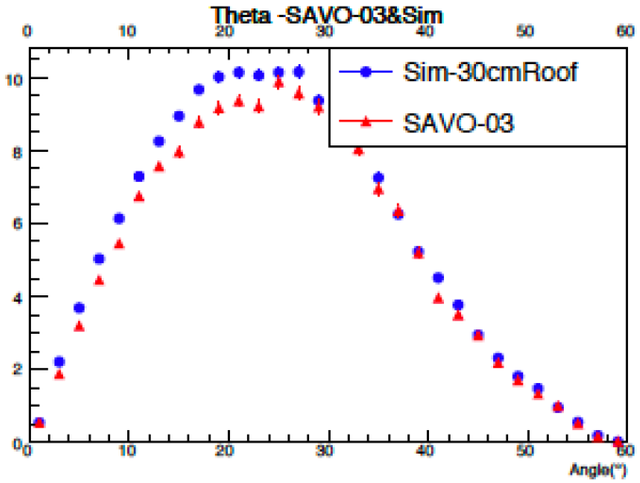
CERN-01: distance between chambers 44cm

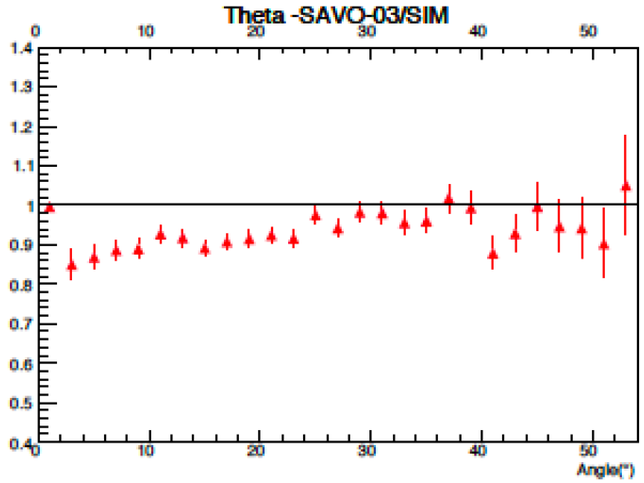
SAVO-01: distance between chambers 46cm

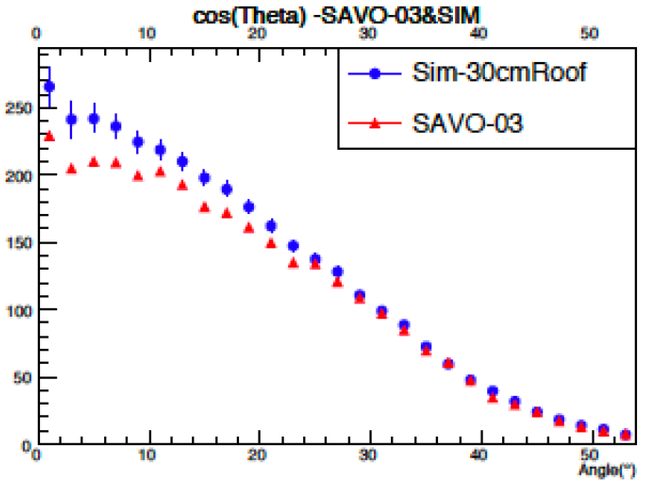


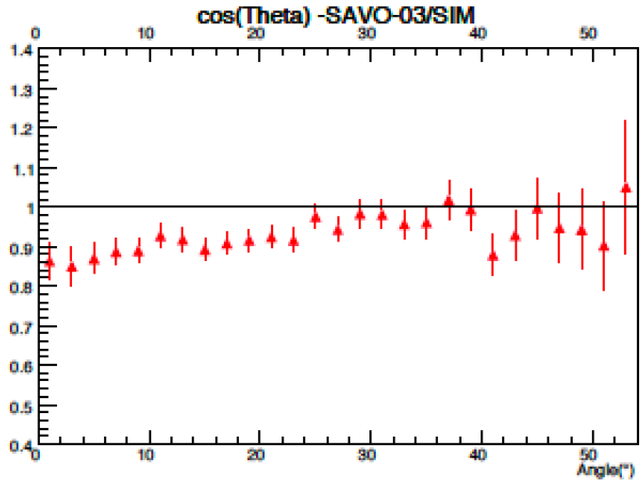


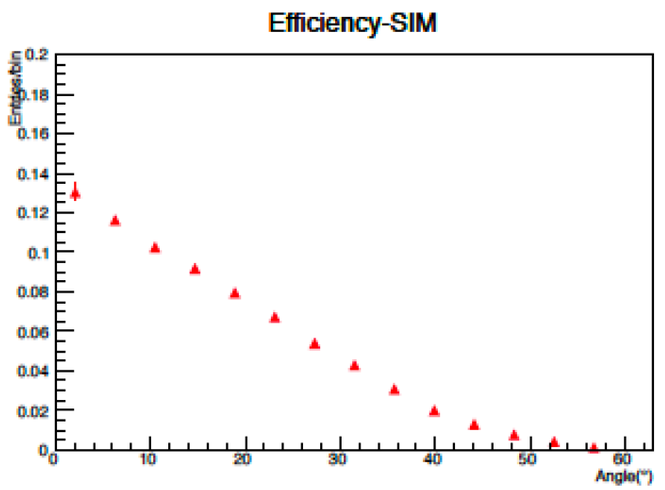
SAVO-01


Theta -SAVO-03&Sim
Sim-30cmRoof
SAVO-03
Angle(°)

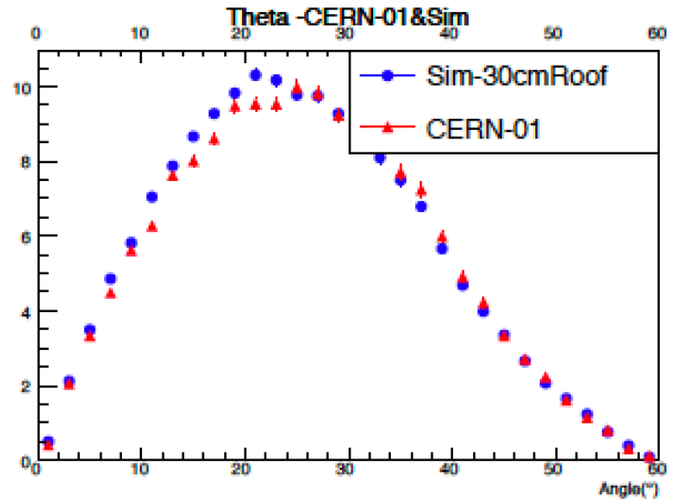

Theta -SAVO-03/SIM
Angle(°)

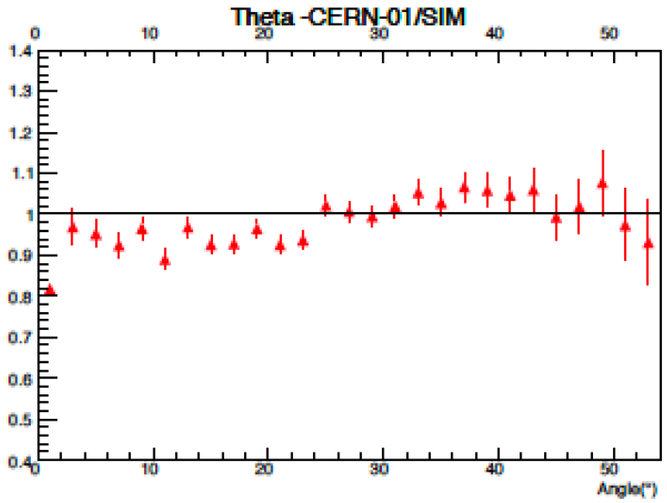

cos(Theta) -SAVO-03&SIM
Sim-30cmRoof
SAVO-03
Angle(°)

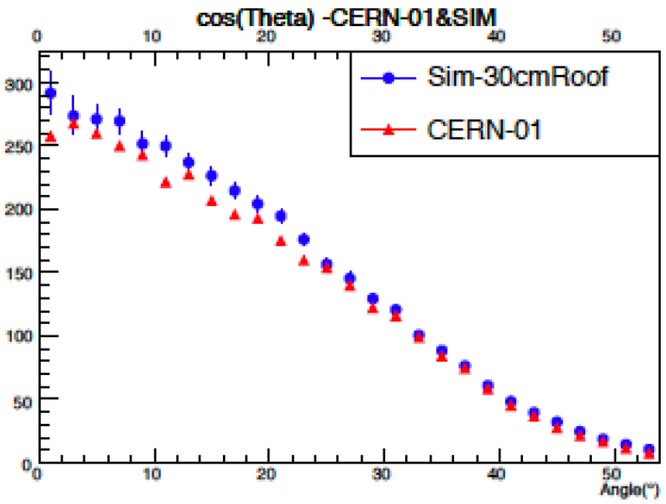

cos(Theta) -SAVO-03/SIM
Angle(°)

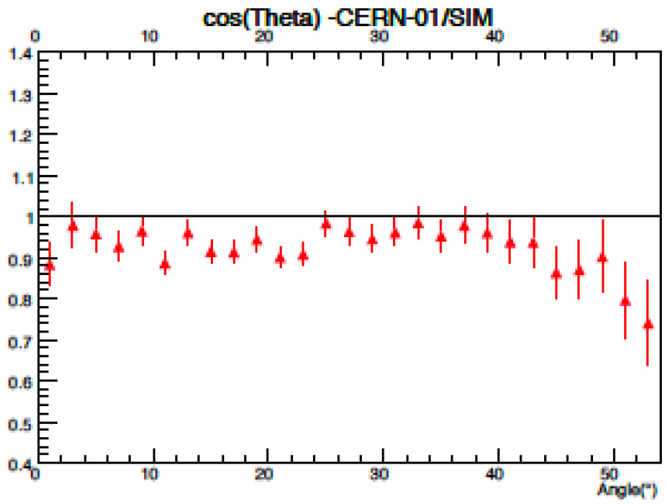

Efficiency-SIM
Entries/bin
Angle(°)

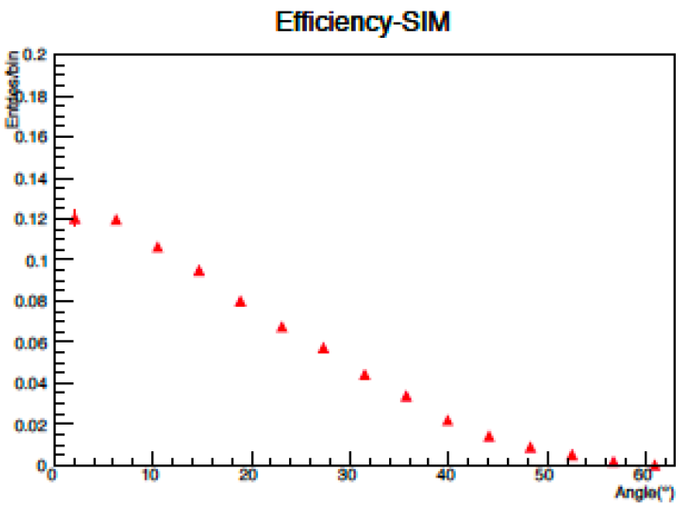
CERN-01


Theta -CERN-01&Sim
Sim-30cmRoof
CERN-01
Angle(°)


Theta -CERN-01/SIM
Angle(°)

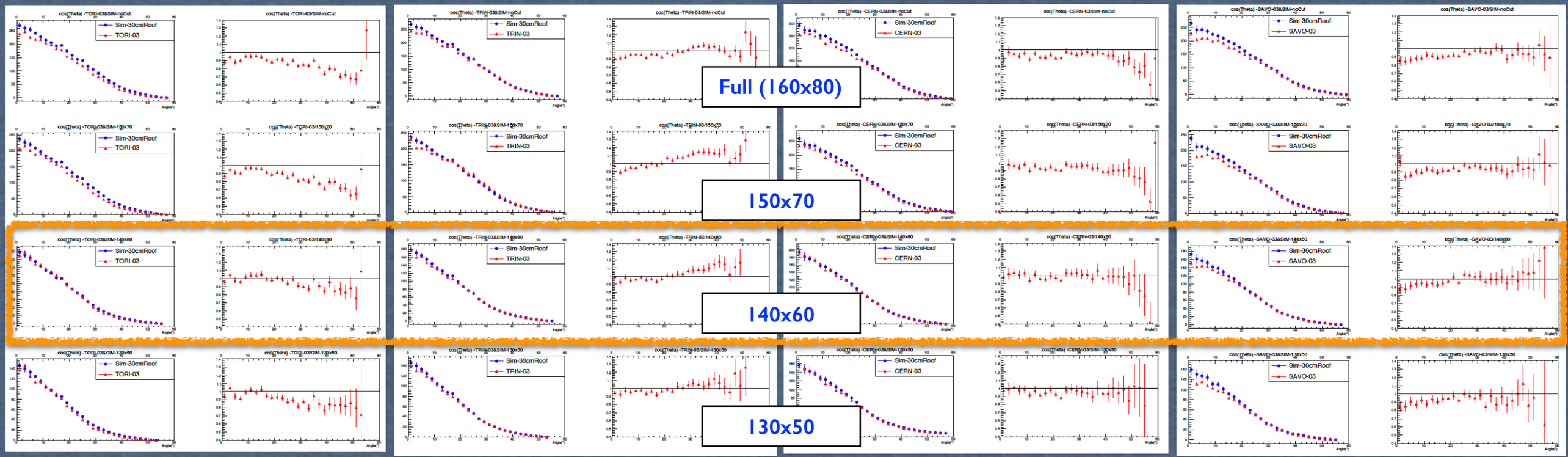

cos(Theta) -CERN-01&SIM
Sim-30cmRoof
CERN-01
Angle(°)


cos(Theta) -CERN-01/SIM
Angle(°)


Efficiency-SIM
Entries/bin
Angle(°)

Fiducial volumes

TORI-03 | TRIN-01 | CERN-01 | SAVO-01



✳ Best agreement for a fiducial volume of 140x60 (excluding 20x20cm external)

DATA/SIM comparison

Limited data/sim agreement calls for a thorough DQ assessment

- ✳ Measure detection efficiency directly from the detector (StefanoG/FrancescoN)
- ✳ Check stability in time (StefanoB et al.)
- ✳ Check uniformity in space (GiuseppeM et al.)