The impact of clouds on image parameters in IACT at very high energies

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Outline

- Motivation!
- Monte Carlo simulations
- The longitudinal distribution
- The lateral distribution
- Examples of average image
- DIST distributions
- LENGTH distributions
- WIDTH distributions
- Conclusions

MC simulations

- Corsika ver. 6.99
- Interaction models: UrQMD and QGSJET-II for low and high energy
- La Palma site: 2200m a.s.l., Geomagnetic Field, NSB level
- Reyleigh and Mie scattering was taken into accout
- I set of simulations to get longitudinal and lateral distributions
- II set of simulations to get angular distributions of the Cherenkov photons

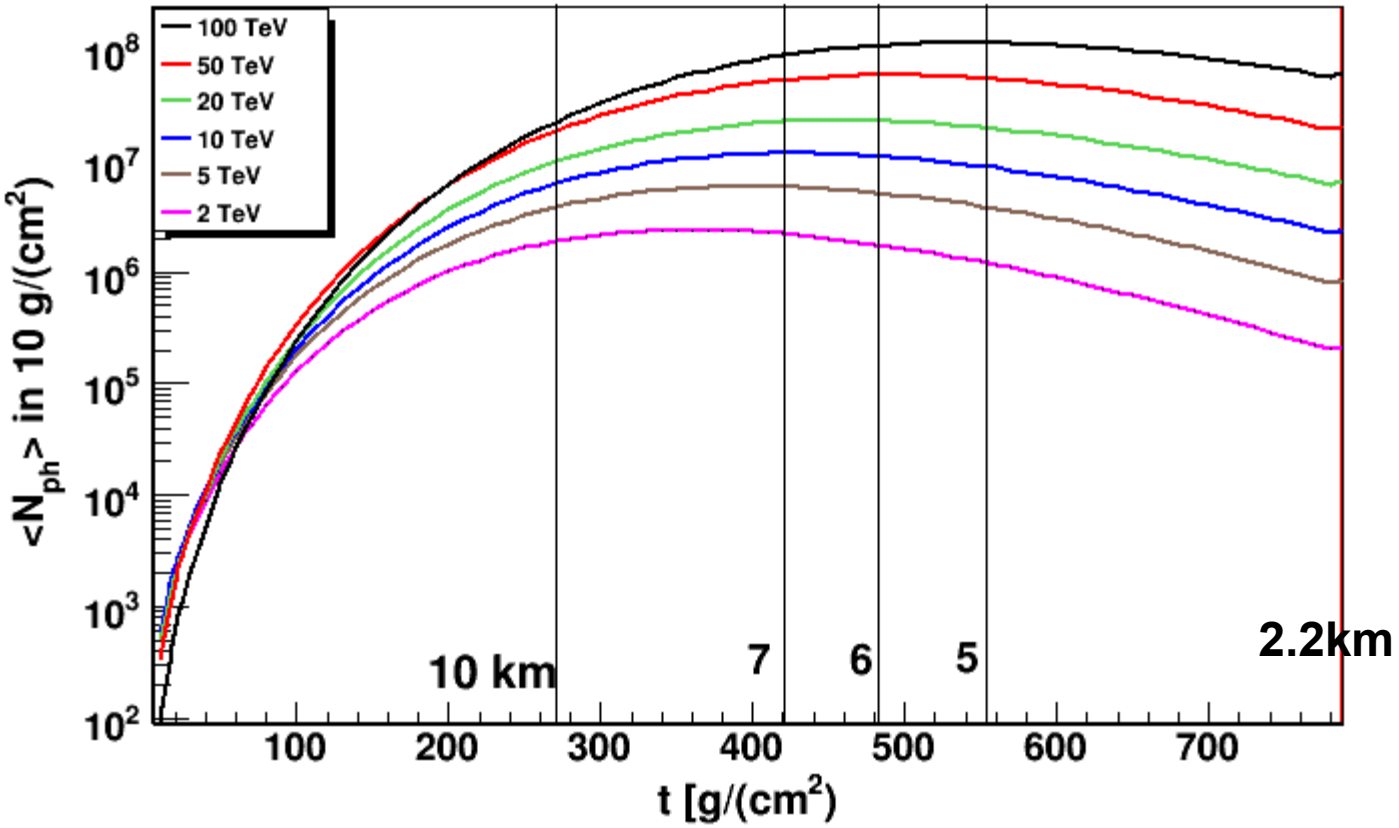
II set of the MC simulations

- Vertical showers
- Detectors: 15m x 15m located along x-axis at 8th distances from the shower core (32.5, 72.5, …, 312.5m)
- Output file: 2-dimensional angular distributions of the Cherenkov light – images
- Histogram ranges: (-1deg; 14 deg) in x-direction (-7.5deg; 7.5deg) in y-direction
- Bining: 0.1deg in both directions

II set of the MC simulations

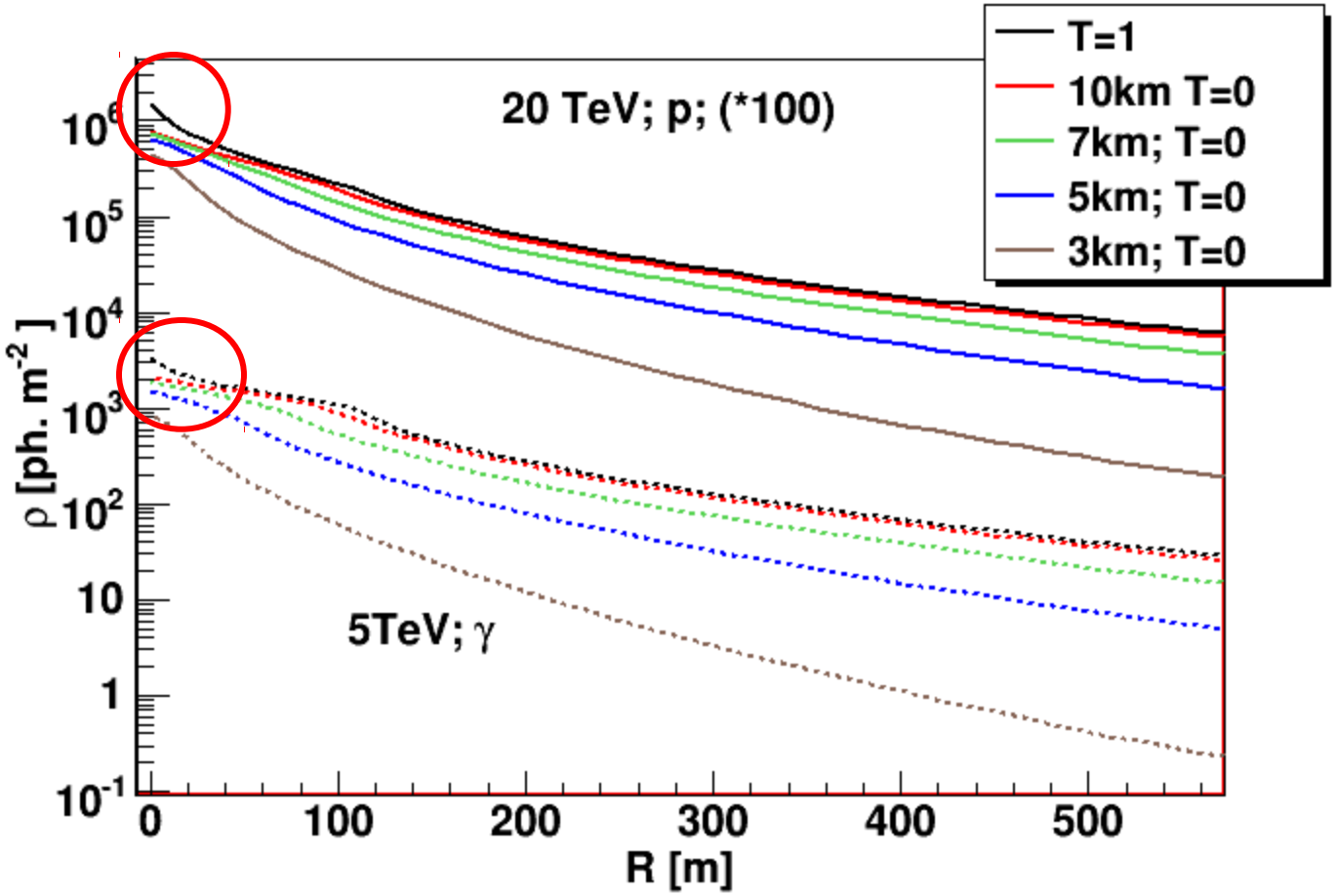
- Clouds model – black or grey disc on the chosen altitude. Additional absorption with probability equal cloud transmission (only photons created above cloud)
- Altitudes of clouds: 10, 7, 6 and 5 km a.s.l.
- Transparencies of clouds:1, 0.8, 0.6, 0.4, 0.2 and 0
- Simulated primary energies:
  - Gamma-ray :2, 5, 10, 20, 50, 100 TeV
  - Protonic events: 10, 20, 50, 100, 200 TeV
- Numbers of simulated events: 1000
- 500 events for gamma 100 TeV and proton 200 TeV

Longitudinal distributions – primary gamma



Cloud altitudes above and below the shower max

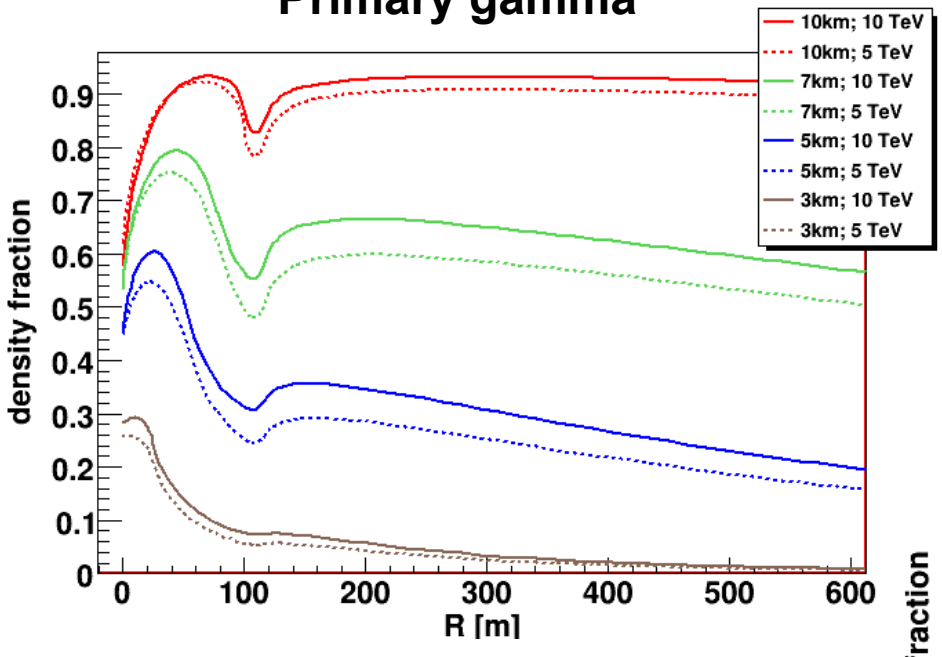
Densities in the presence of fully opaque clouds



Significant differences between T=1 and the cloud at 10km are close to the core only!

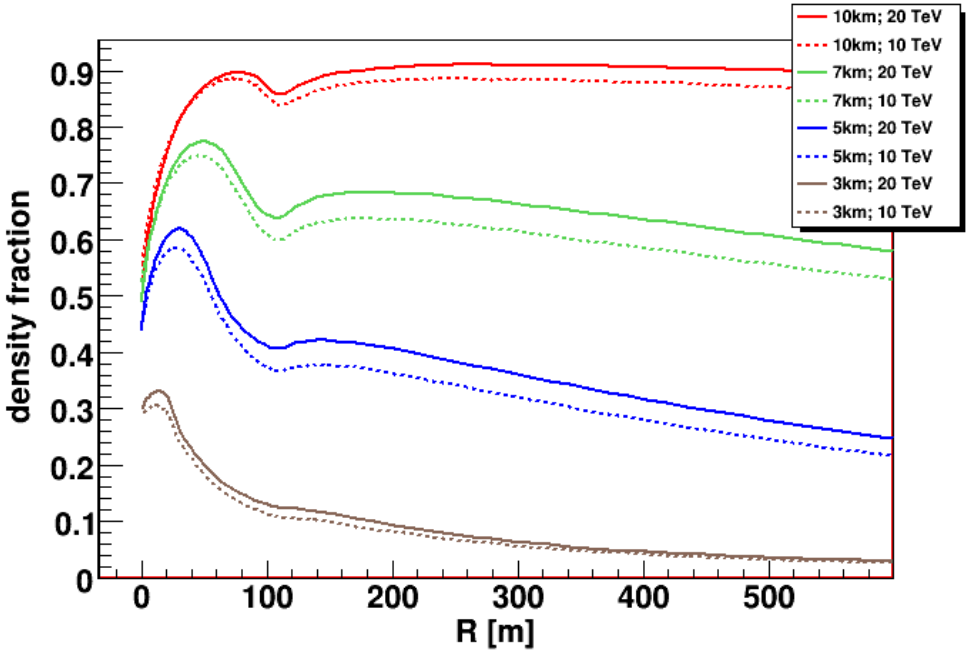
Density fraction (fully opaque clouds)

Primary gamma



Impact parameter

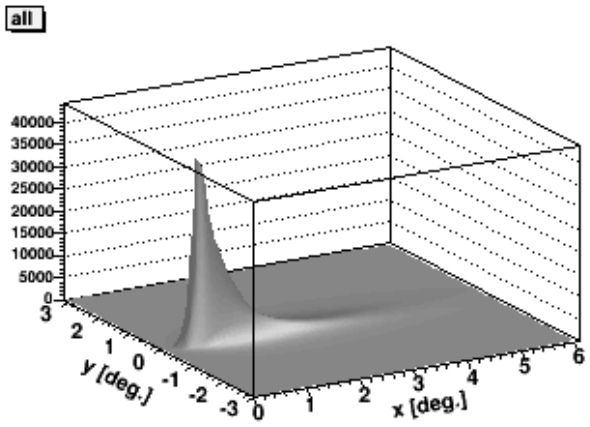
Primary proton

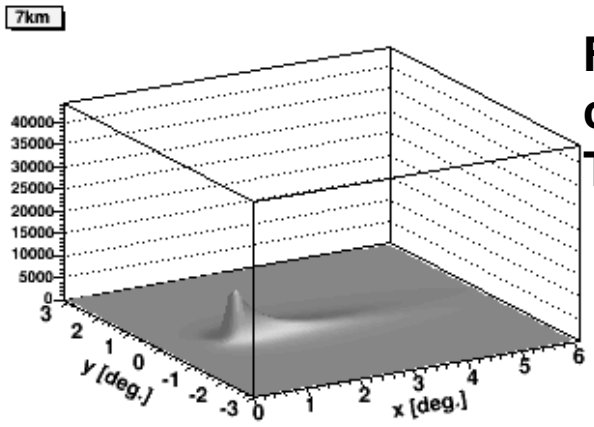


The lower cloud the larger effect
The lower energy the larger effect

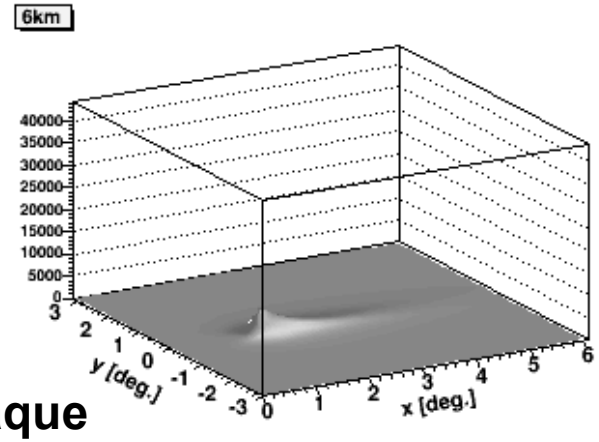
Average image : R=110 m, gamma, 20TeV

Clear sky
T=1

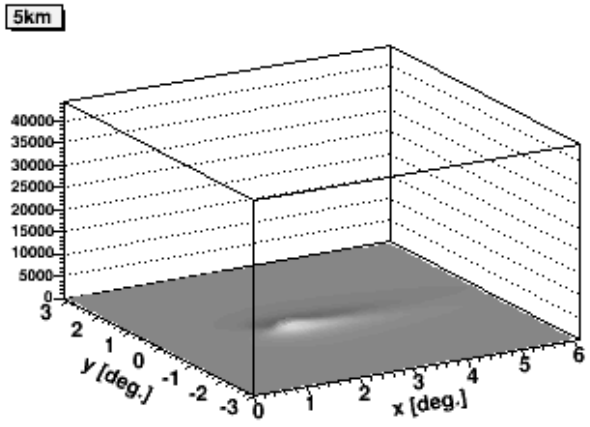




Fully opaque
cloud at 7km
T=0



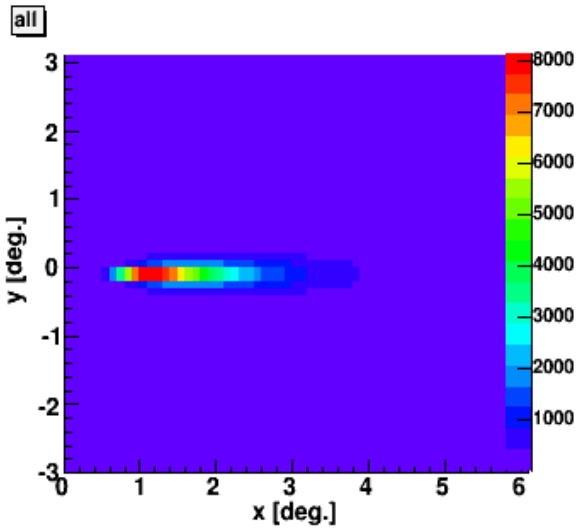
Fully opaque
cloud at 6km
T=0

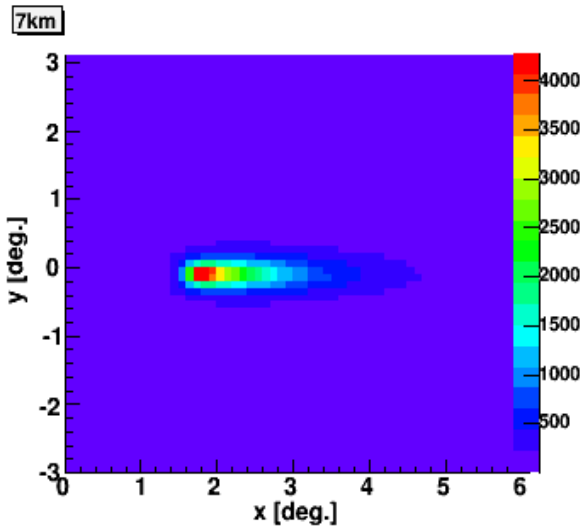


Fully opaque
cloud at 5km
T=0

Gamma; 20 TeV, R=150m

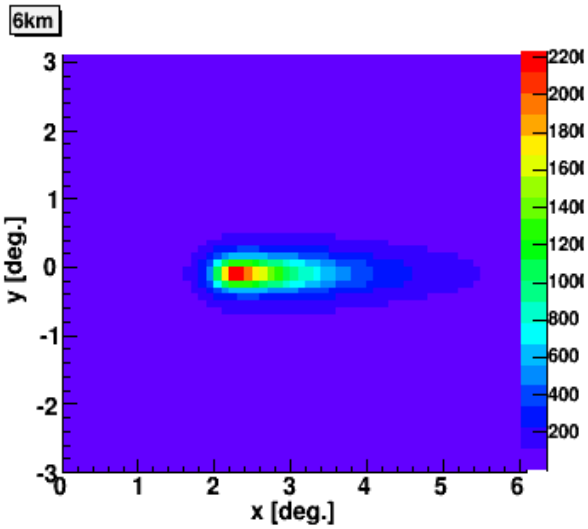
T=1

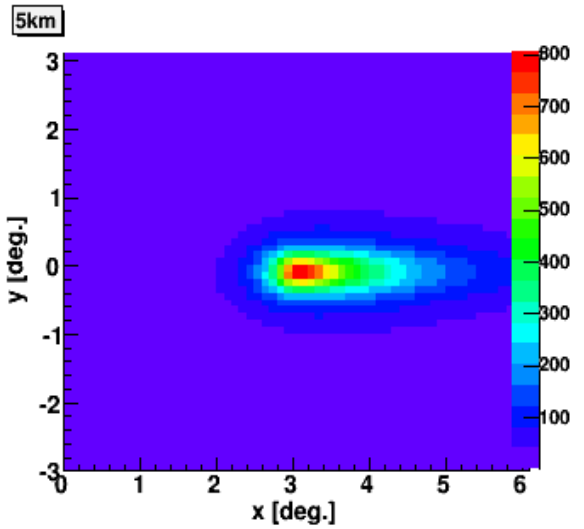




T=0
7km

T=0
6km

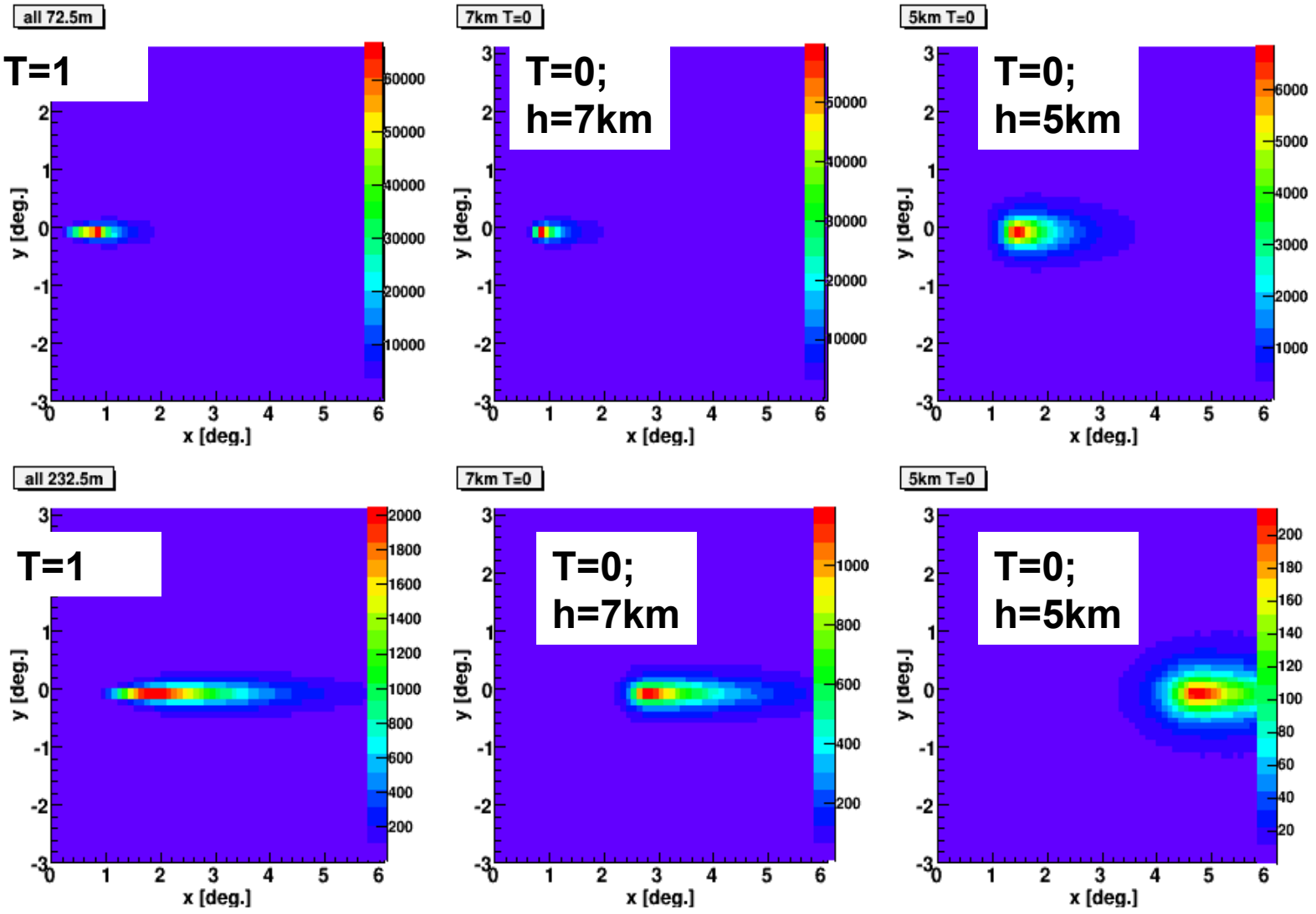




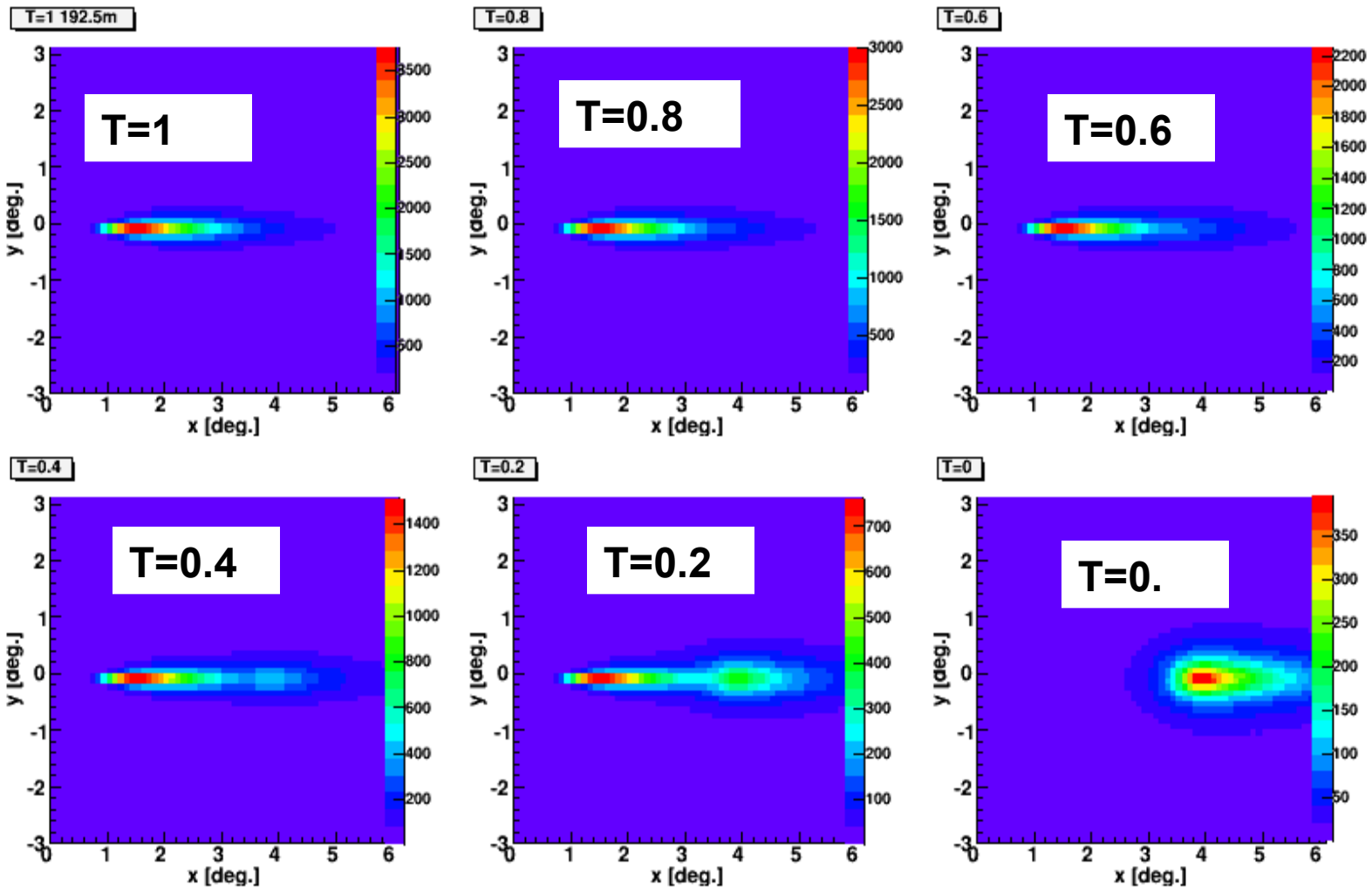
T=0
5km

Z- direction - different scale

Gamma, 20 TeV, 70 m (top) and 230 m (botton)

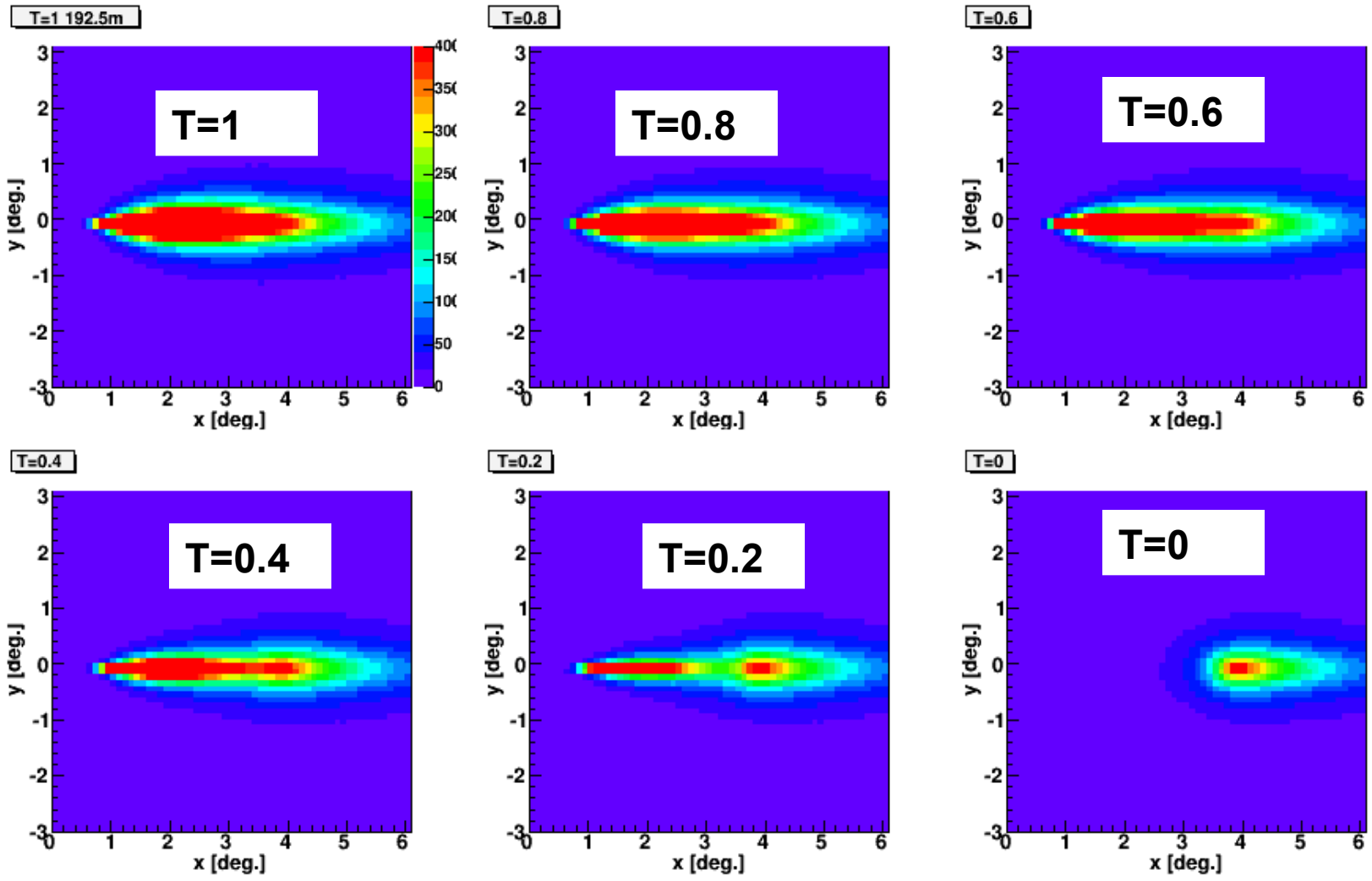


Gamma; 20 TeV, 190 m, h=5km, different cloud transparencies



Z- direction - different scale

Gamma; 20 TeV, 190 m, h=5km different T



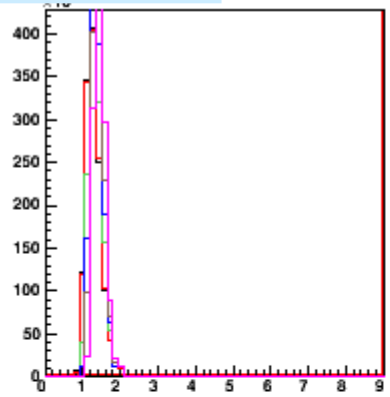
Z- direction - the same scale

Image parametrs

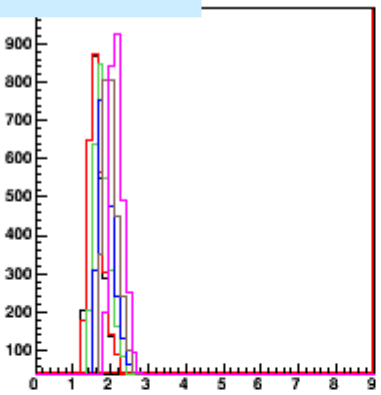
- Randomly add NSB
- Clean images – important cleaning level
- Make a distribution for each impact parametr

DIST, gamma, 50 TeV,h=6km, colors indicate clouds transparency (black T=1, pink T=0)

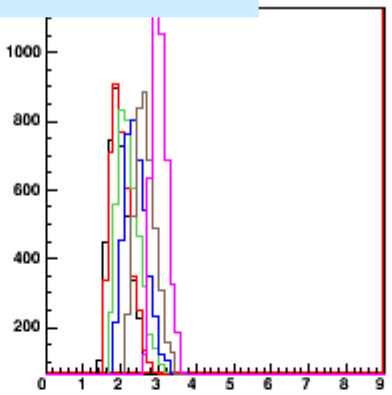
R=32.5m



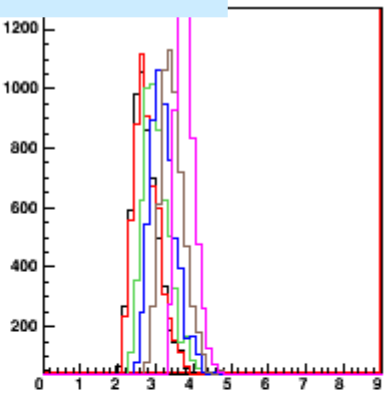
R=72.5m



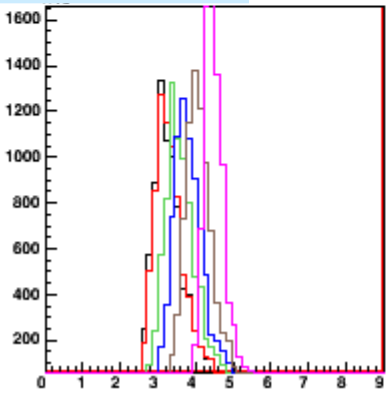
R=112.5m



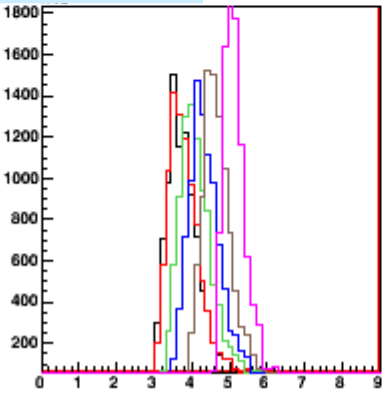
R=152.5m



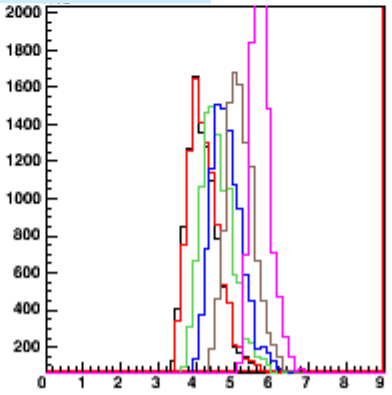
R=192.5m



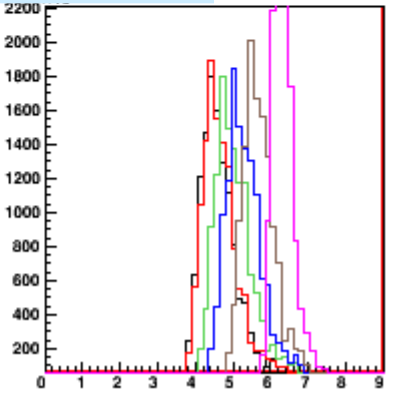
R=232.5m



R=272.5m



R=312.5m



Expected distributions for impacts between ~ 20. and ~320. m

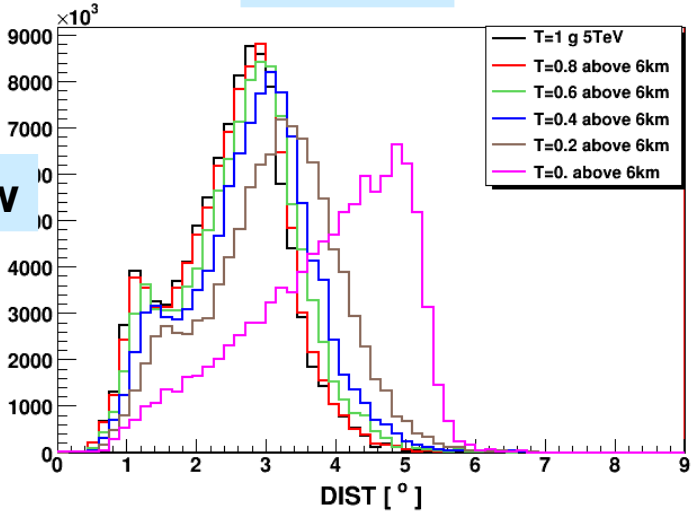
- Add 7 additional detector position between those simulated
- For additional detectors: calculate averages from neighbouring detectors and make parameters distributions
- Sum of 15th scaled distributions. Scaling factors proportional to the area of the corresponding rings

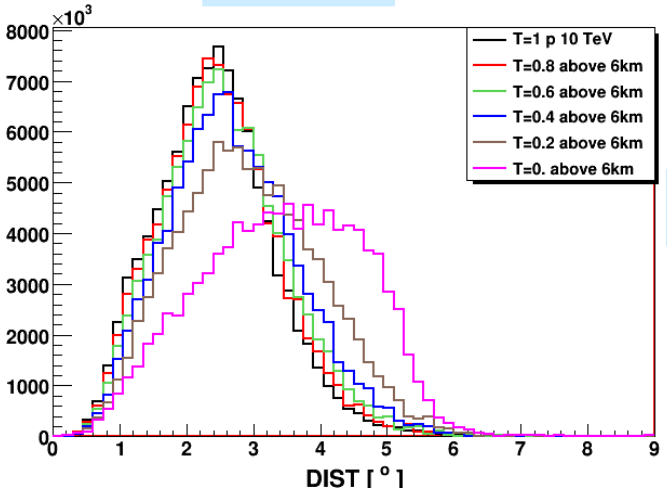
DIST, h=6km, dependence on T

Gamma

Proton

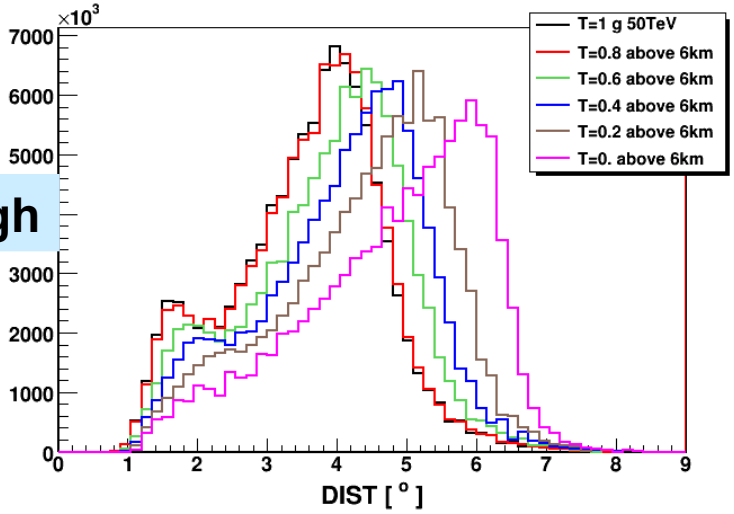
low

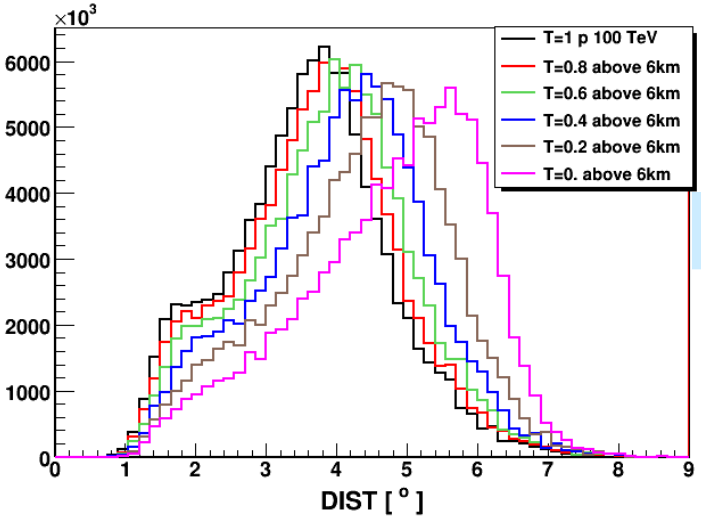




low

high





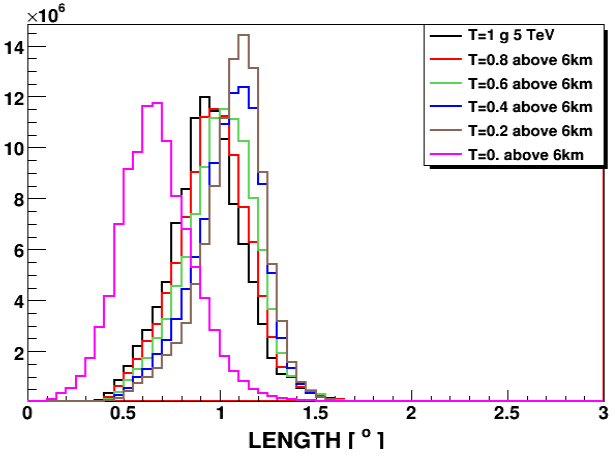
high

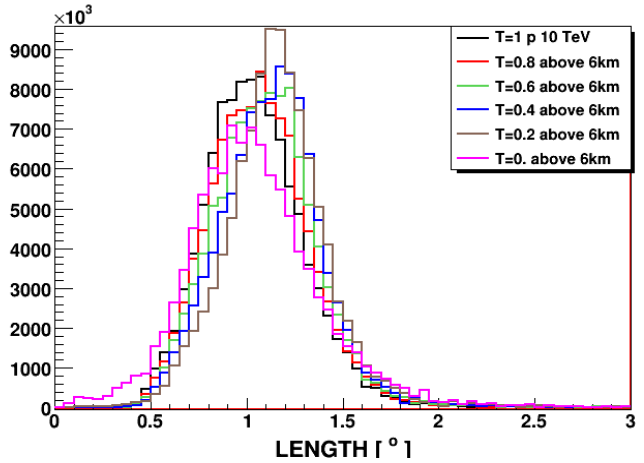
LENGTH, h=6km, dependence on T

Gamma

Proton

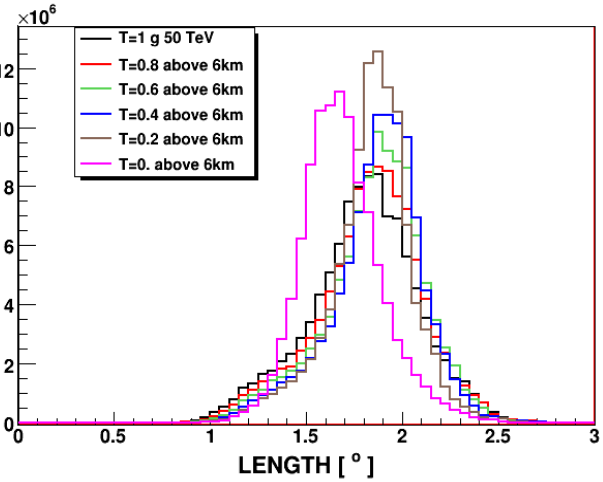
low

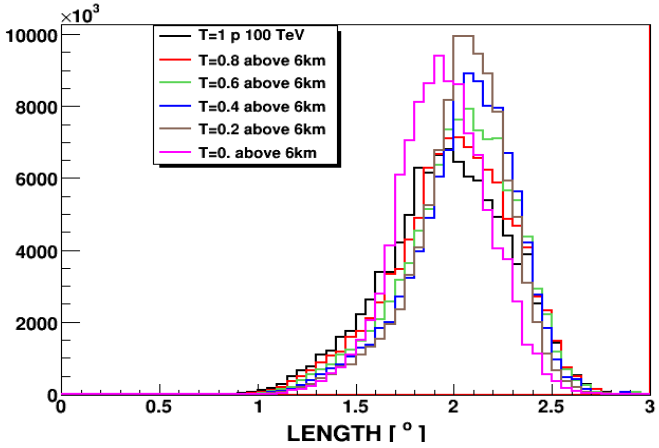




low

high





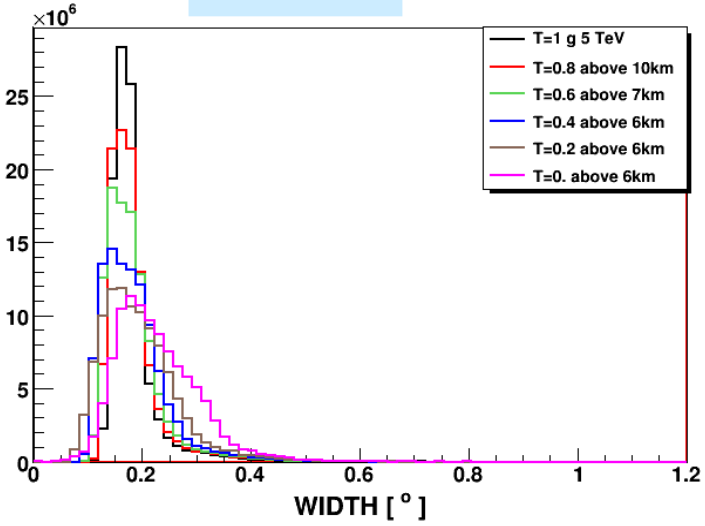
high

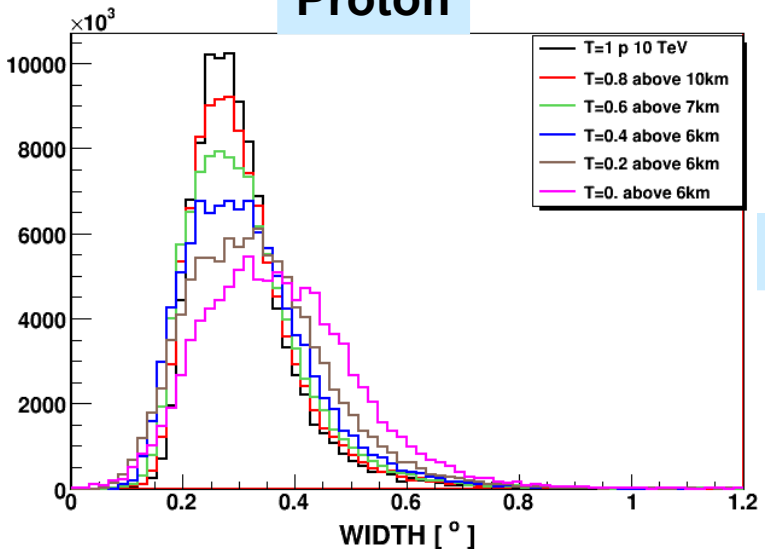
WIDTH, h=6km, dependence on T

Gamma

Proton

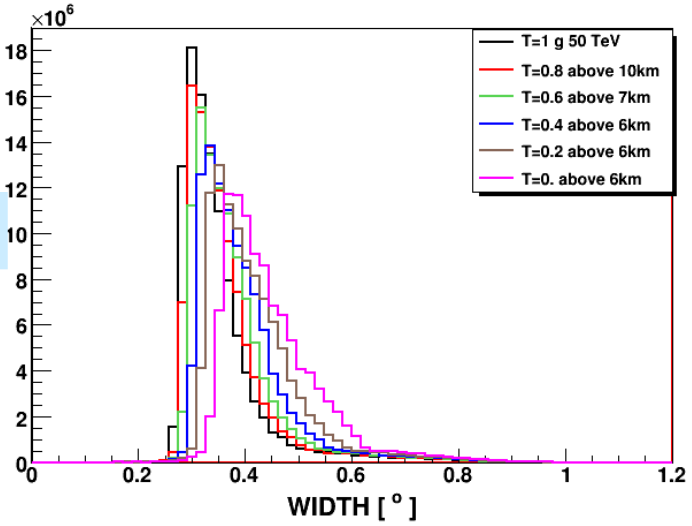
low

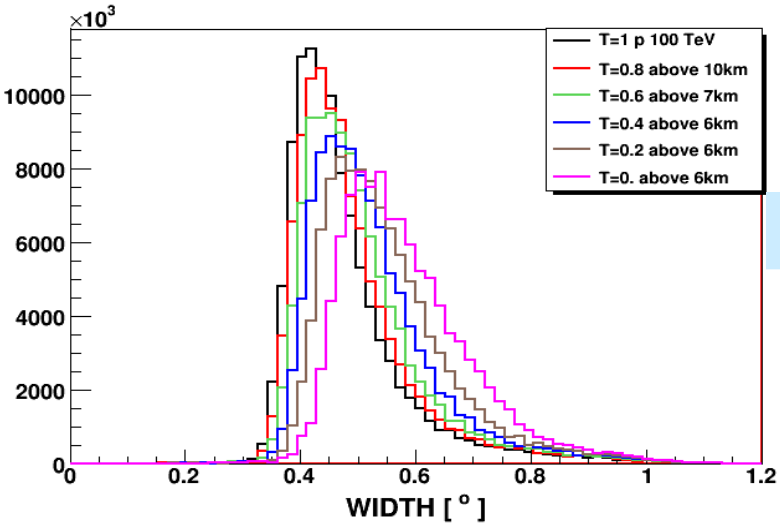




low

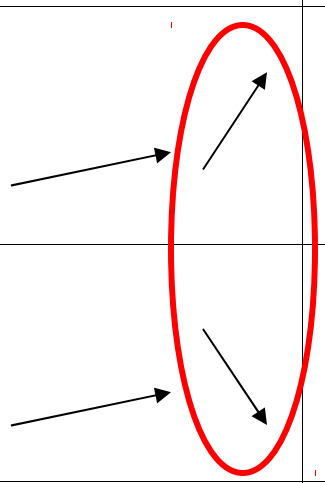
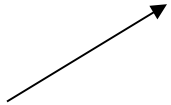
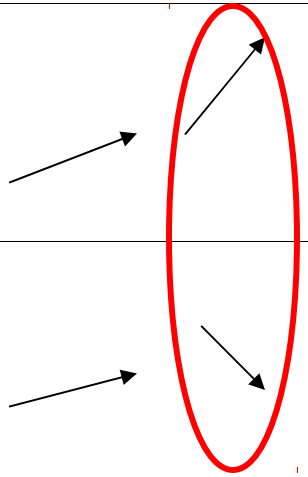
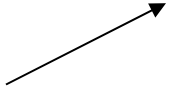
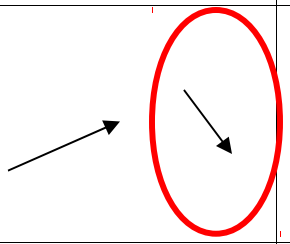
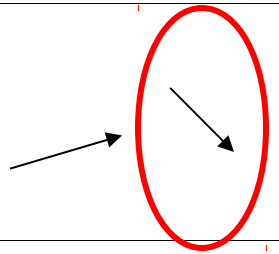
high





high

Summary – fix altitude (with decreasing of the transparency)

	Gamma low	Gamma high	Proton low	Proton high
DIST				
LENGTH				
WIDTH	wider distrb. 		wider distrb. 	

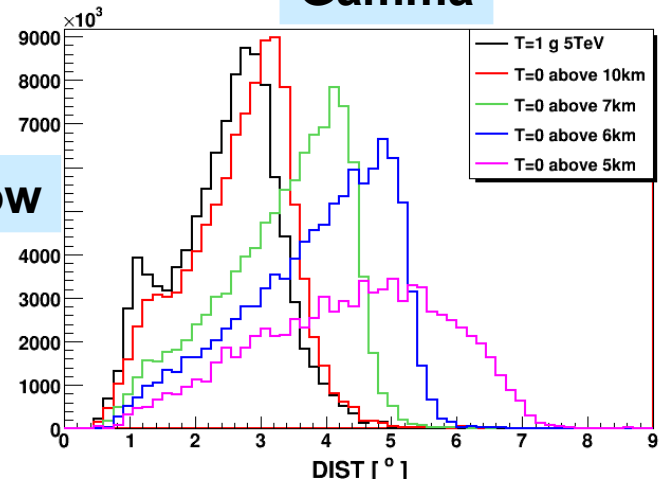
Geometrical effect at T=0

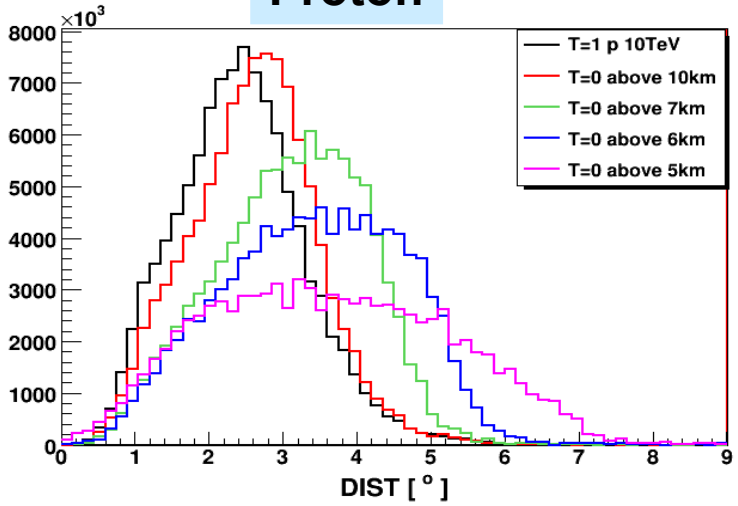
DIST, T=0, h=10,7,6 and 5 km a.s.l.

Gamma

Proton

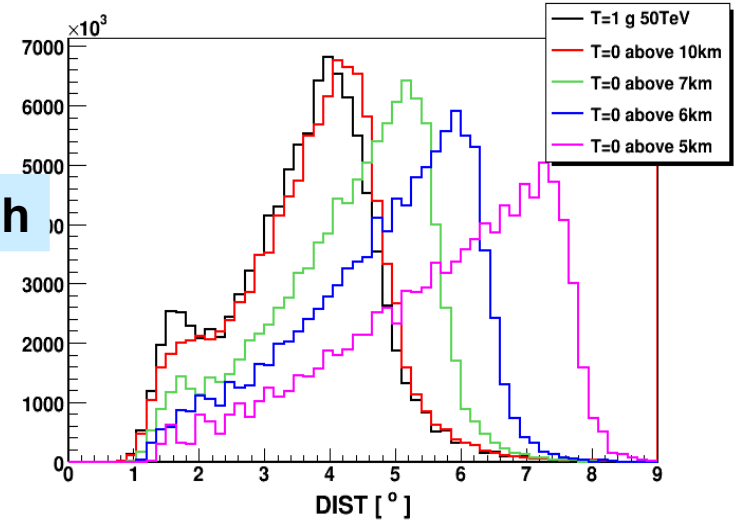
low

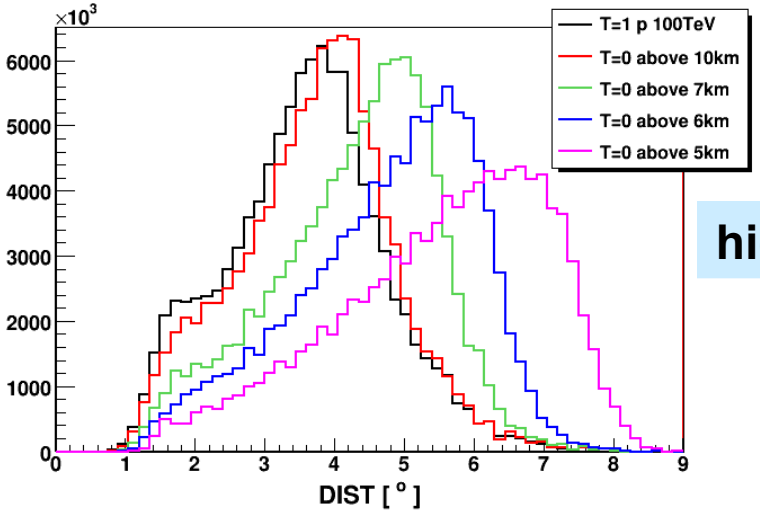




lo
w

high





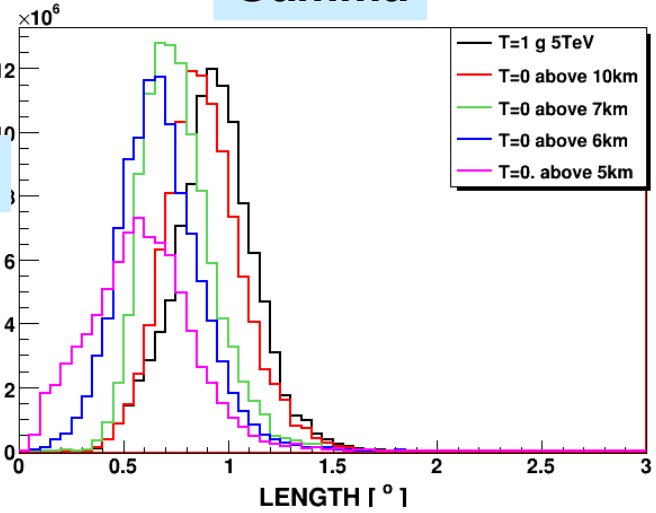
high

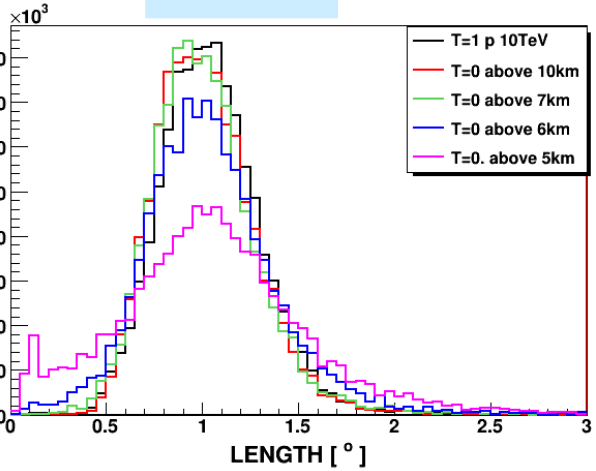
LENGTH, T=0, h=10,7,6 and 5 km a.s.l.

Gamma

Proton

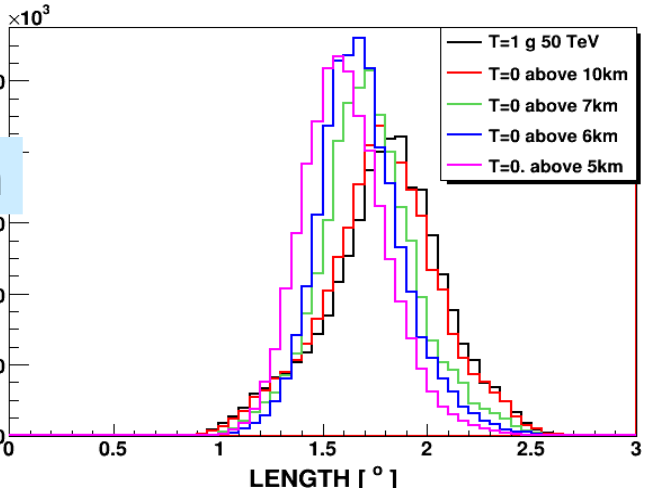
low

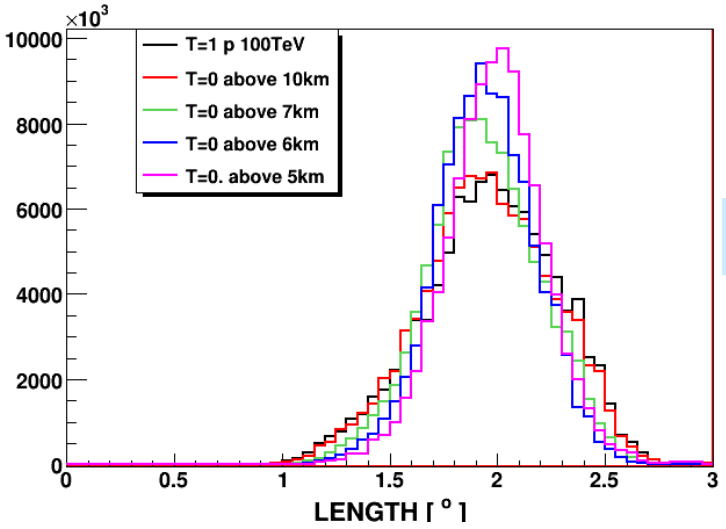




low

high



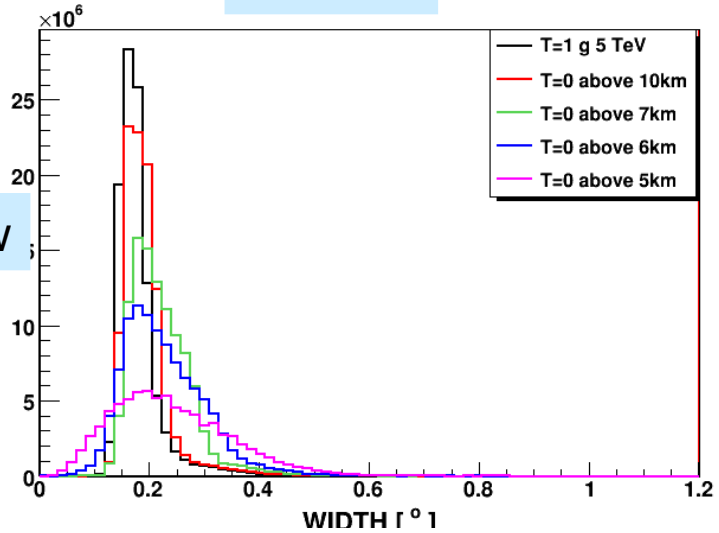


high

WIDTH, T=0, h=10,7,6 and 5 km a.s.l.

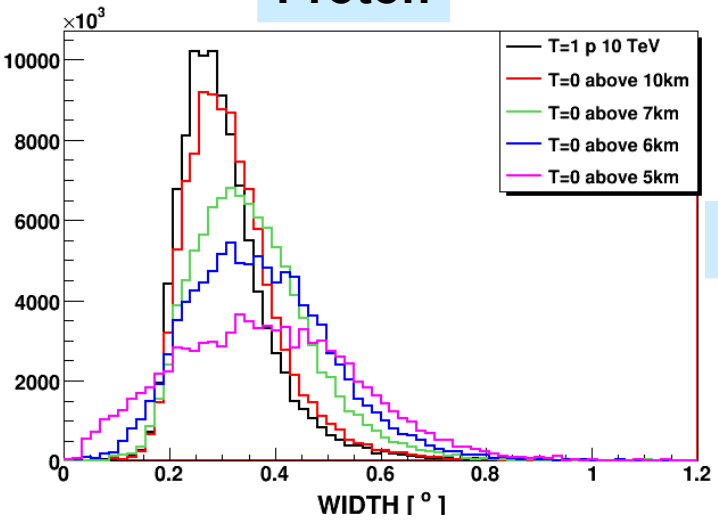
Gamma

low

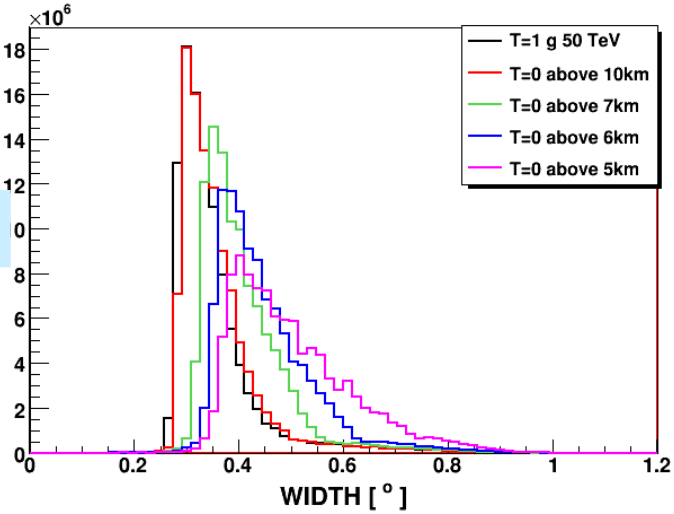


Proton

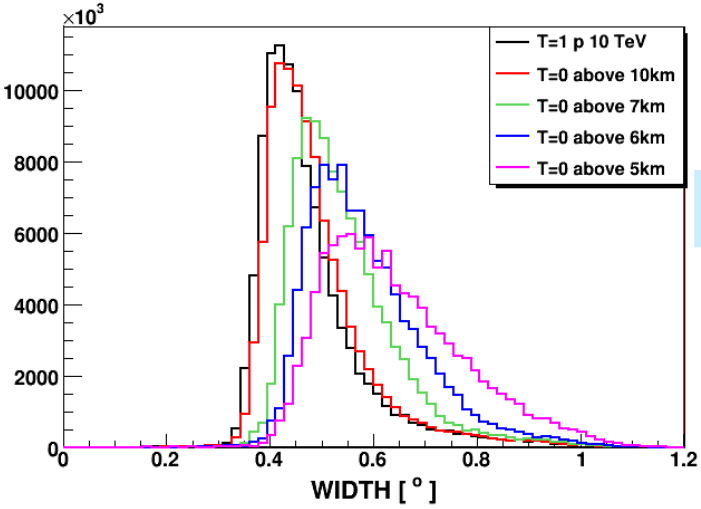
low



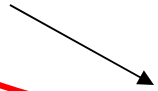
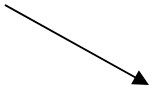
high



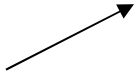
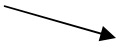
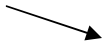
high



Summary II - for T=0 (with decreasing h)

	Gamma low	Gamma high	Proton low	Proton high
DIST				
LENGTH				
WIDTH	wider distr. 		wider distr. 	

Summary II – fix T (example T=0.4); (with decreasing h)

	Gamma low	Gamma high	Proton low	Proton high
DIST				
LENGTH	Wider (5) 		Wider (5) 	
WIDTH	 wider distr.		 wider distr.	

Summary III - for fix h and T (with increasing energy)

	Gamma	Proton
DIST		
LENGTH		
WIDTH		

Conclusions

- There is a deformation of the image caused by additional absorption and it looks like images are „shifted” in the camera plane. LARGE CAMERA FOV IS NEEDED
- The changes of the image parameters depend on: the impact parameter, the transparency and the altitude of cloud
- The expected DIST, LENGTH and WIDTH increase with the cloud absorption (except T=0).
- For fully opaque clouds DIST, and WIDTH increase with decreasing of the cloud altitude. LENGTH decreases for gamma-ray and slightly increases for proton.

Conclusions

- Clouds influence on parameters of the gamma-ray and proton in similar way (not for T=0)
- Clouds on the level 10 km a.s.l. or higher have negligible impact on the images
- Large telescope with large camera FOV can be used for observation of the very high energy gamma-rays