UPPSALA UNIVERSITET

HEX Surface Veto Toy MC

based on lateral distribution functions

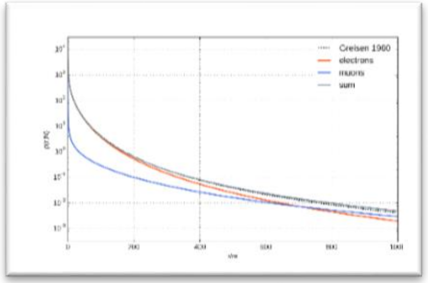
Sebastian Euler

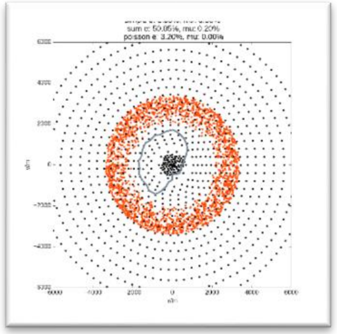
IceCube Gen2 Workshop

26 January 2015

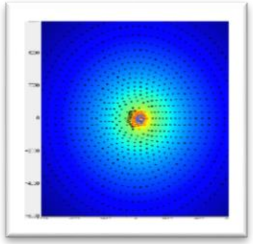
Contents

- Introduction / Reminder
  - What is a lateral distribution function?
  - How does the toy MC work?

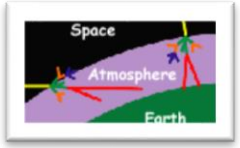


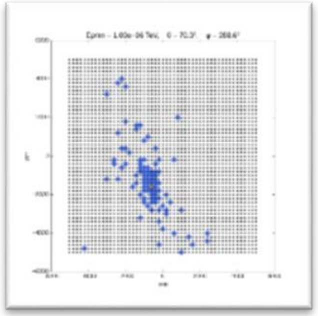


- Status end of last year (last surface extension call)

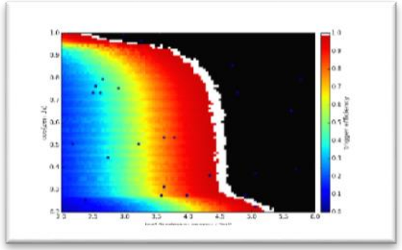


- Deficiencies in old version
  - Bugfixes and new features



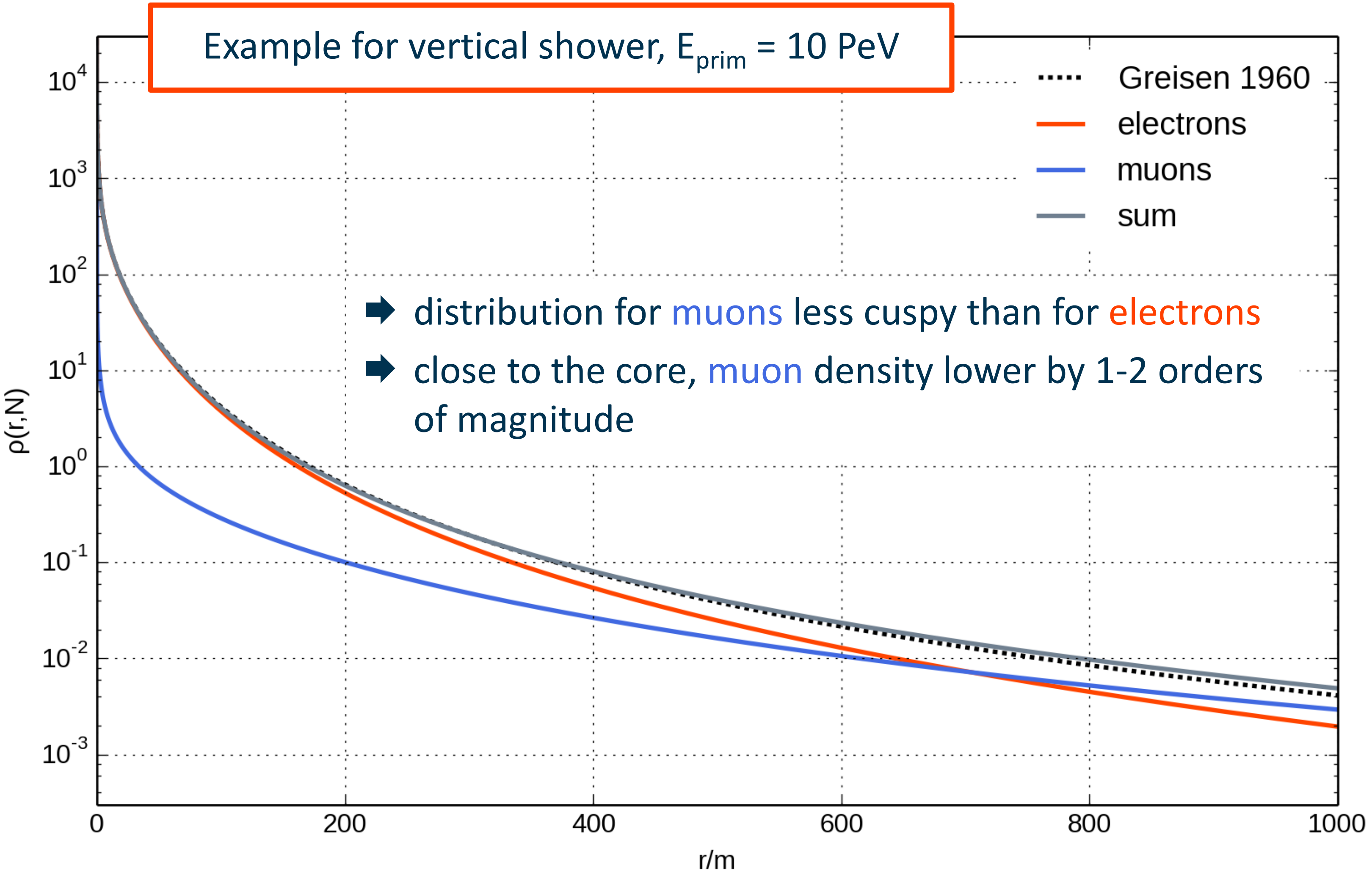


- New results



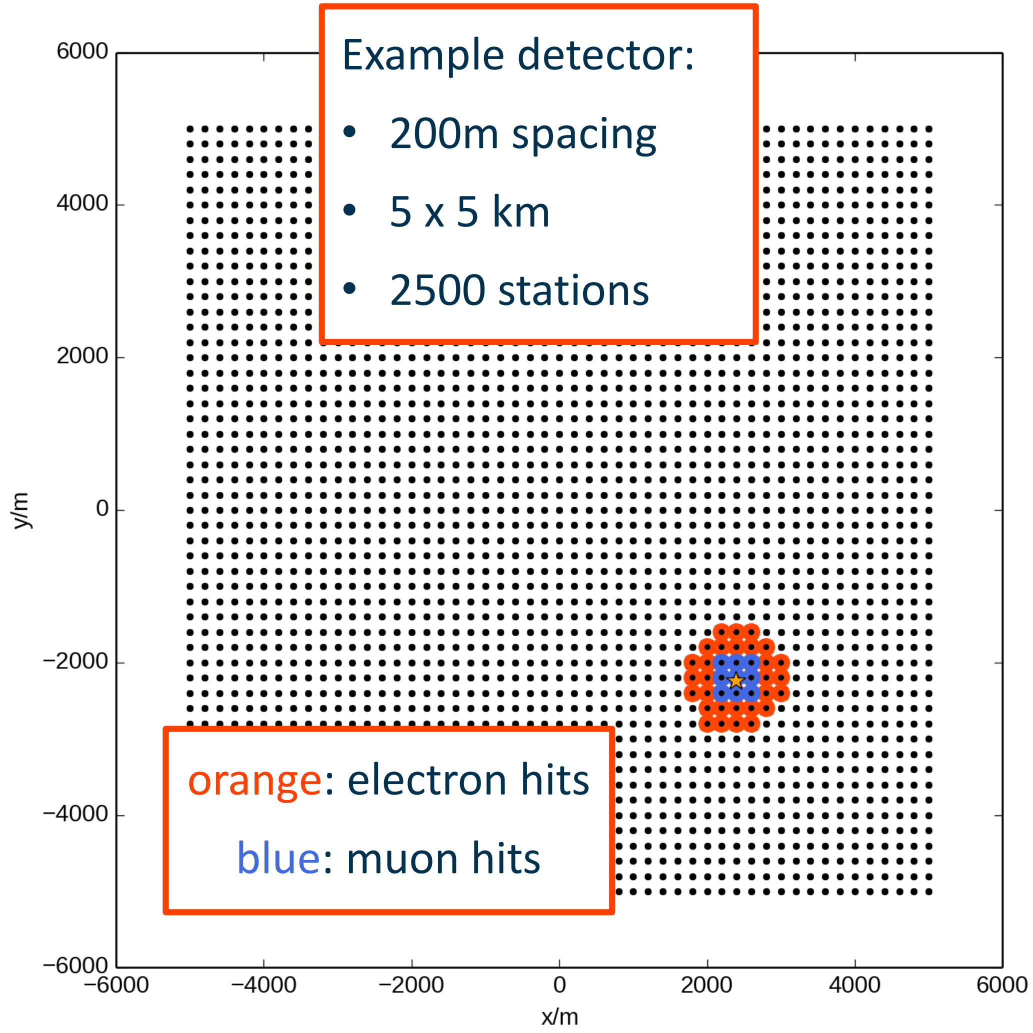
Lateral Distribution Functions

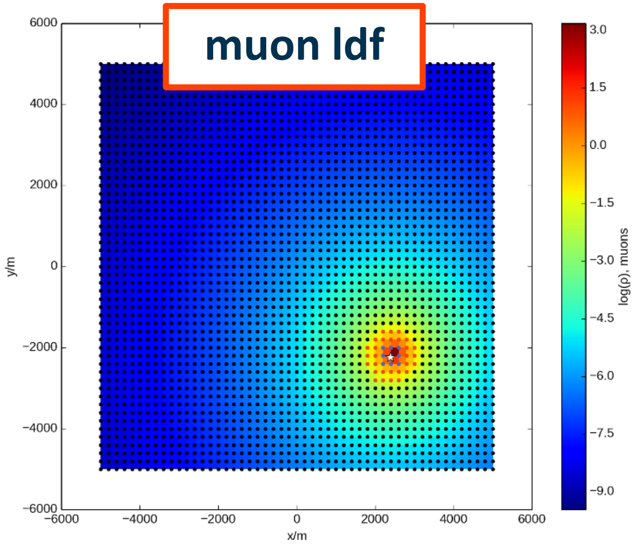
- phenomenological functions
- describing particle density in an air shower
- function of lateral distance to the shower core
- available for electrons and muons
- REMEMBER: if you want to detect electrons, better be above snow!

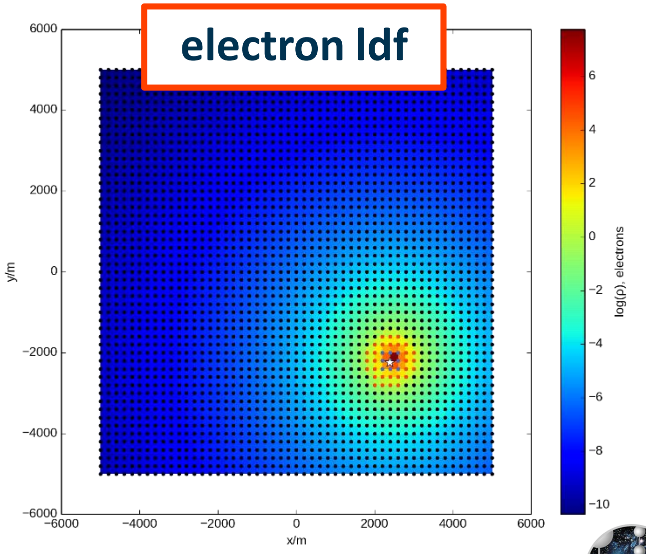


Toy MC simulation based on LDFs

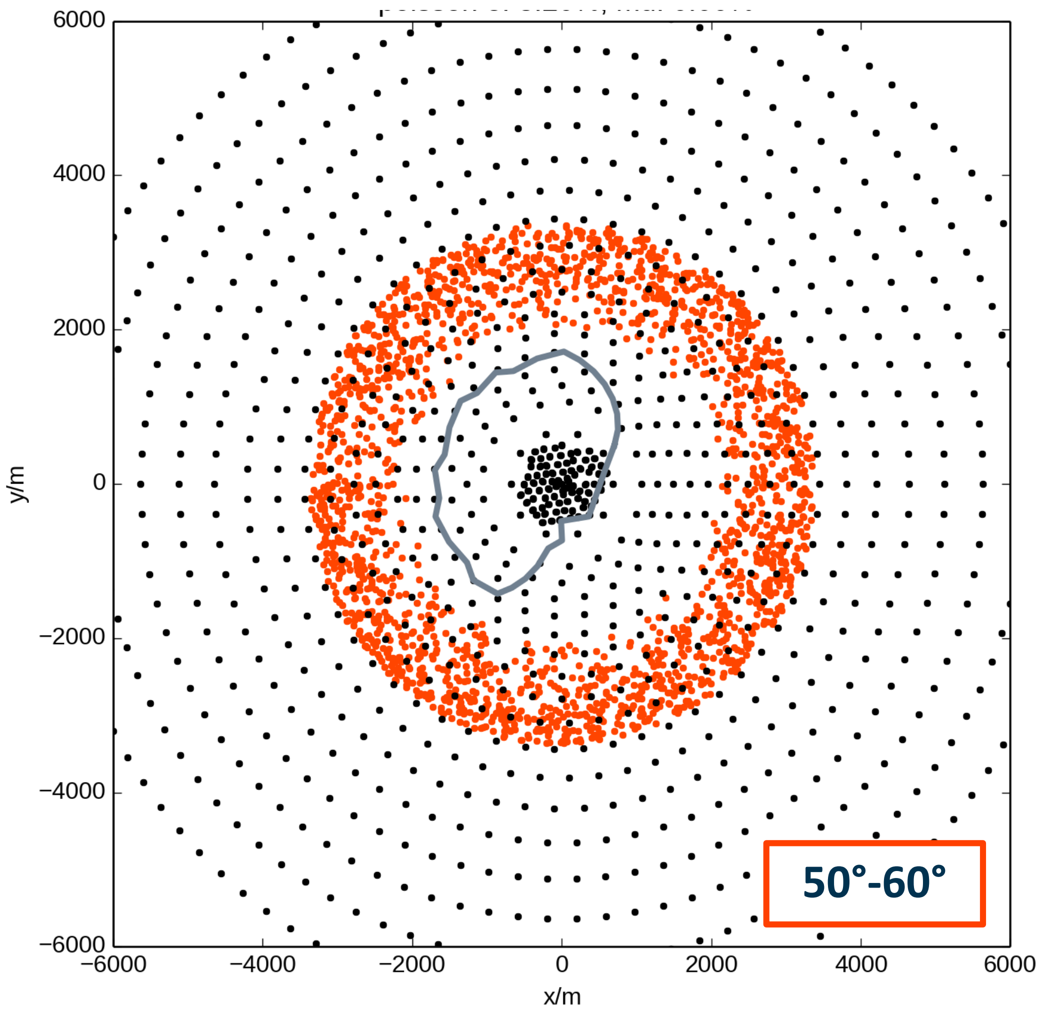
- create detector geometry
  - regular grid
  - IceTop
  - Jan Auffenberg's IceVeto (baseline)
- one detector station at each position (black dots)
- evaluate LDFs at these positions
- for each station, calculate from particle density the Poisson probablity to see a hit
- consider size of the station



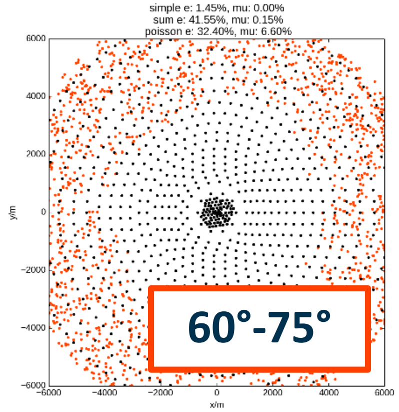


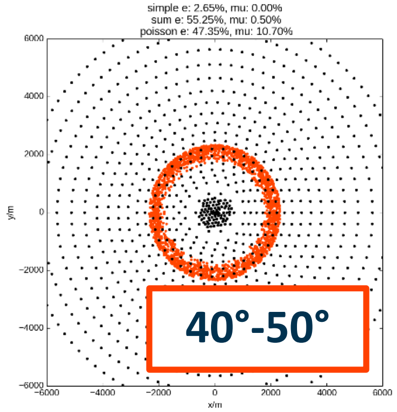


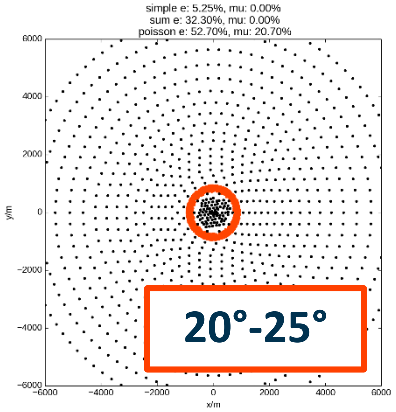
Trigger efficiency from Toy MC



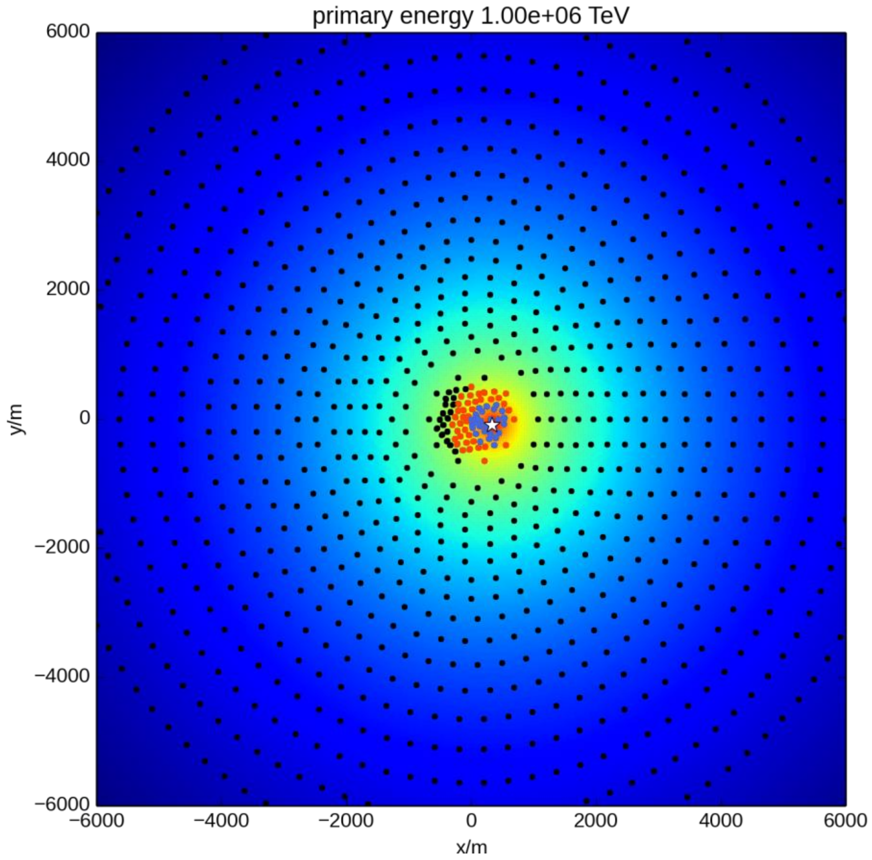
- example here: IceVeto geometry
- simulate thousands of showers for different zenith angles and primary energies
- force showers to cross IceCube
  - radial distance chosen according to zenith angle
  - azimuth angle points towards center







Conclusions (as of last year)



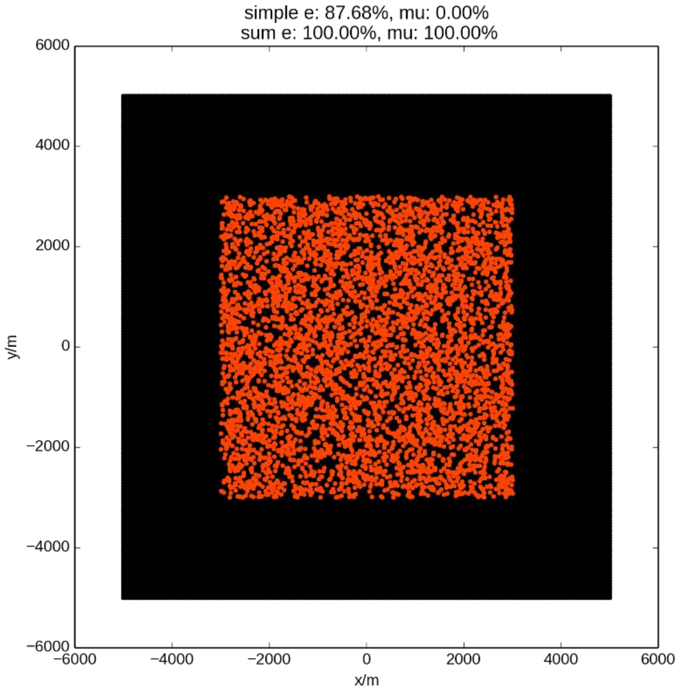
IceVeto efficient for E_{prim} > 10 PeV

surface veto efficient at 100 TeV requires much denser spacing

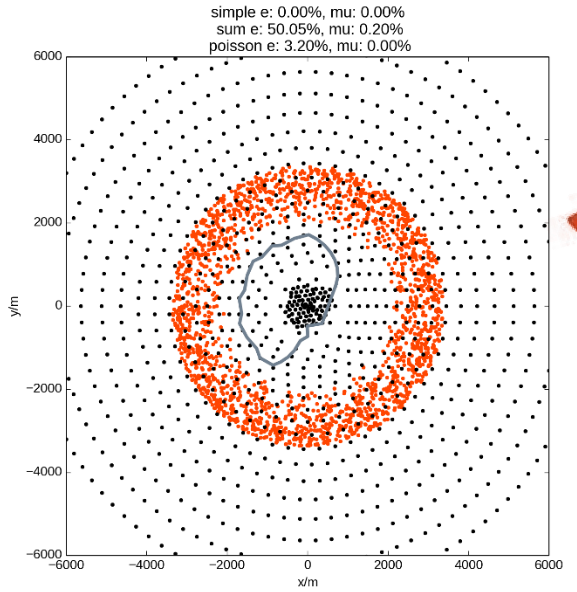
➡ example: 100000 stations

1 m^2 each

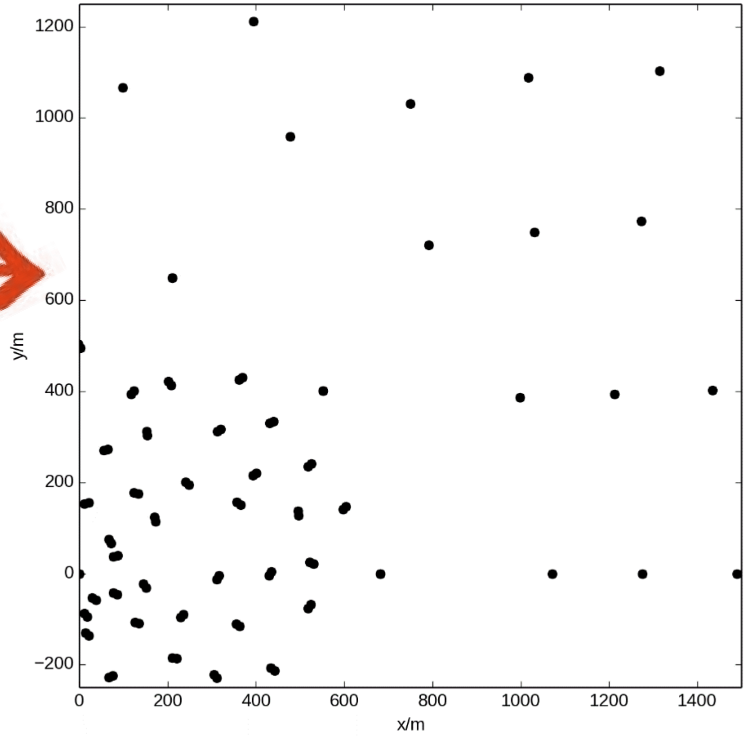
30 m spacing

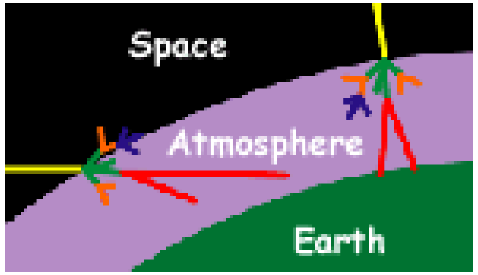


Deficiencies (last year)



- **unequal shower density:** fixed
- **larger size of IceTop tanks not considered:** fixed
- **required two hits for trigger:** changed to one hit

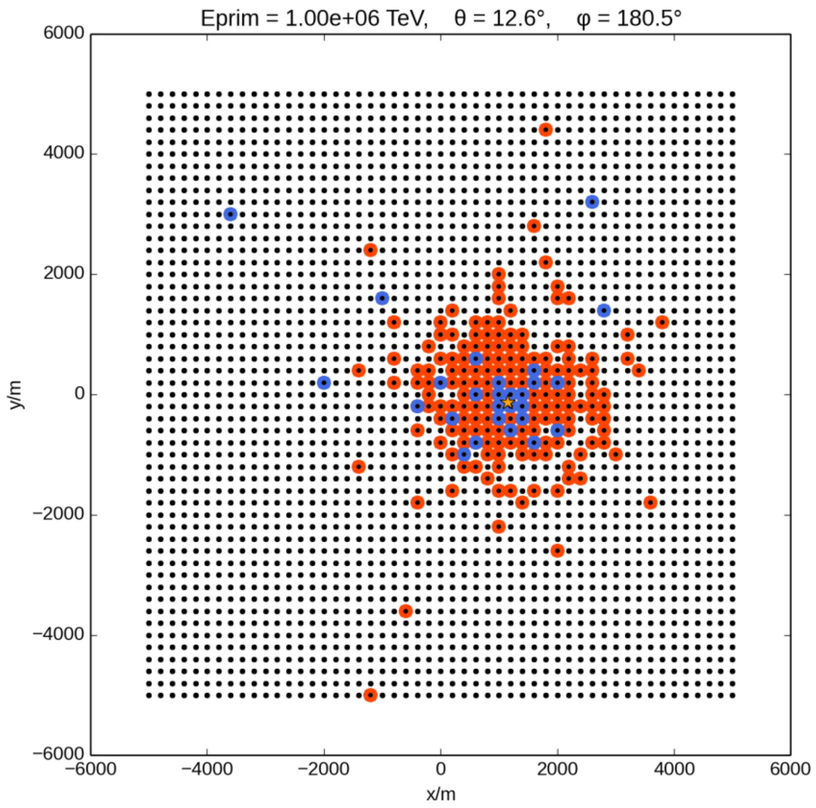




- **slant depth not taken into account:** implemented by Ben Roberts (summer student in Christchurch, NZ)

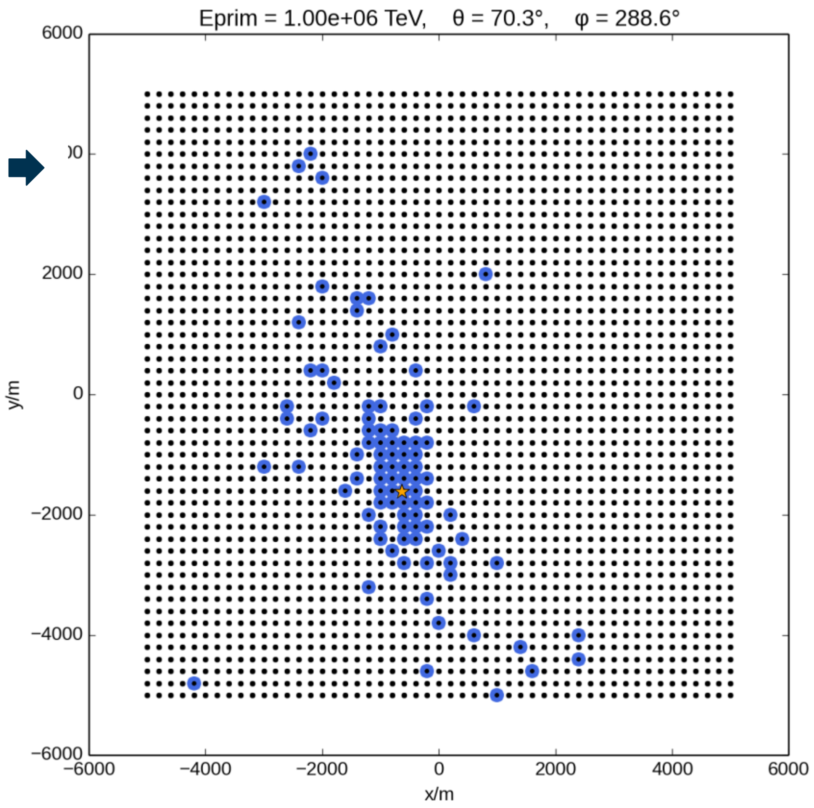
New: inclined showers

- electromagnetic component dies out for large inclinations
- currently, no slant depth correction for muon component
- plots show example showers with E_{prim} = 1 EeV



⬅ **θ = 12.6°**

θ = 70.3° ➡

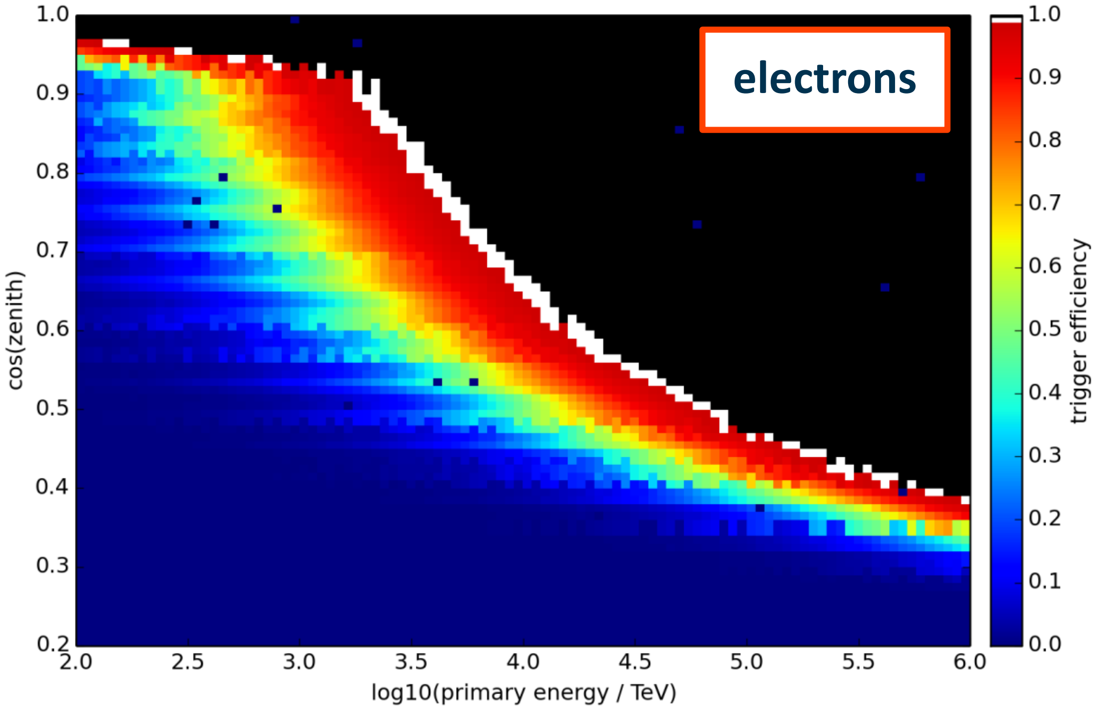


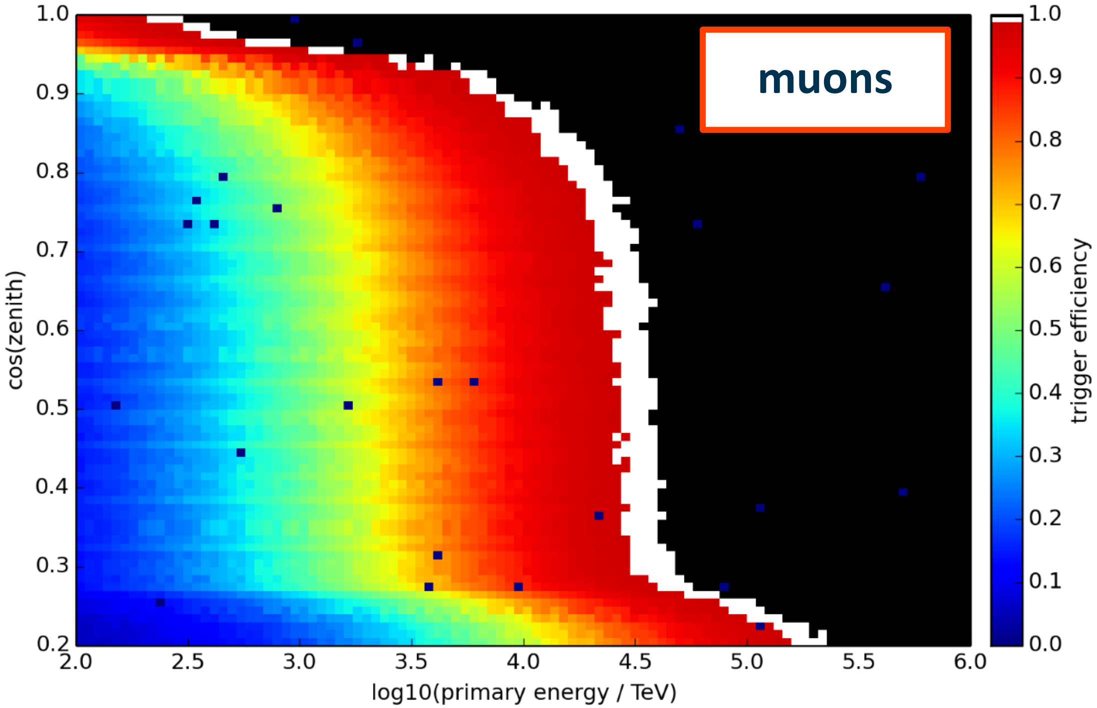
orange: electron hits

blue: muon hits

New results: IceVeto trigger efficiency

- plots show trigger efficiency for IceVeto geometry
- run 10000 showers for each bin in E_{prim} and $\cos(\theta)$
- white: > 99% , black: > 99.99%
- dark blue bins: crashed or unfinished jobs, disregard





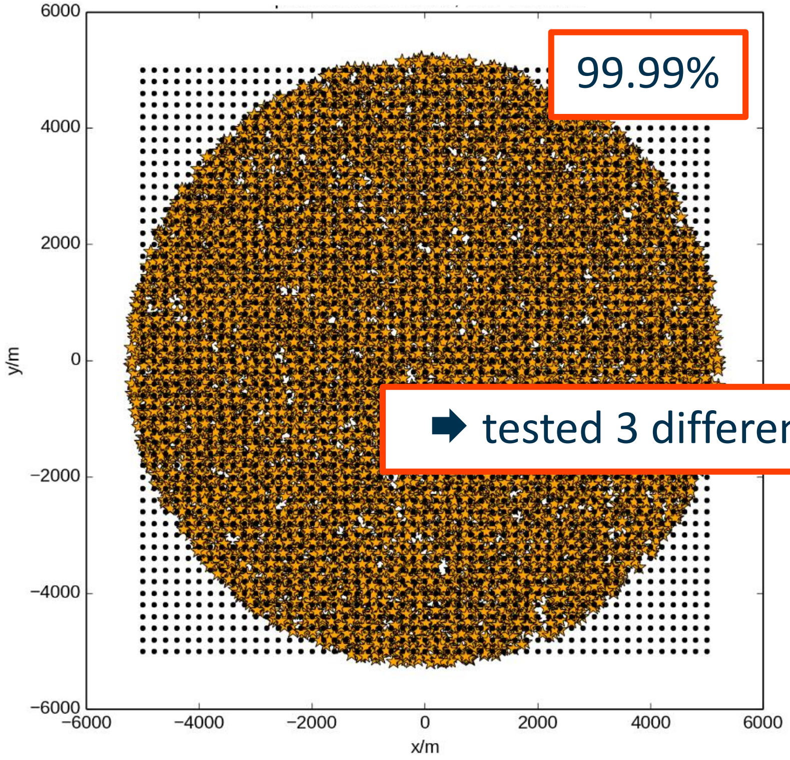
Geometry efficient at 100 TeV

„need 1000 m^2 active detector area per km^2 to get an efficient veto at 100 TeV E_{prim}" (Dave Seckel)

2500 stations

200 m spacing

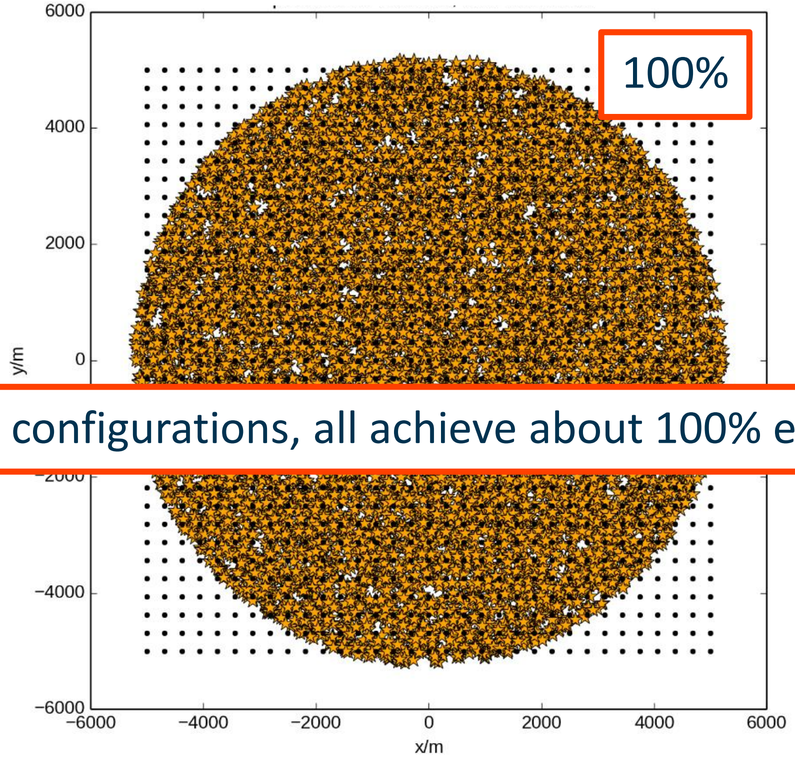
40m^2 per station



1000 stations

312 m spacing

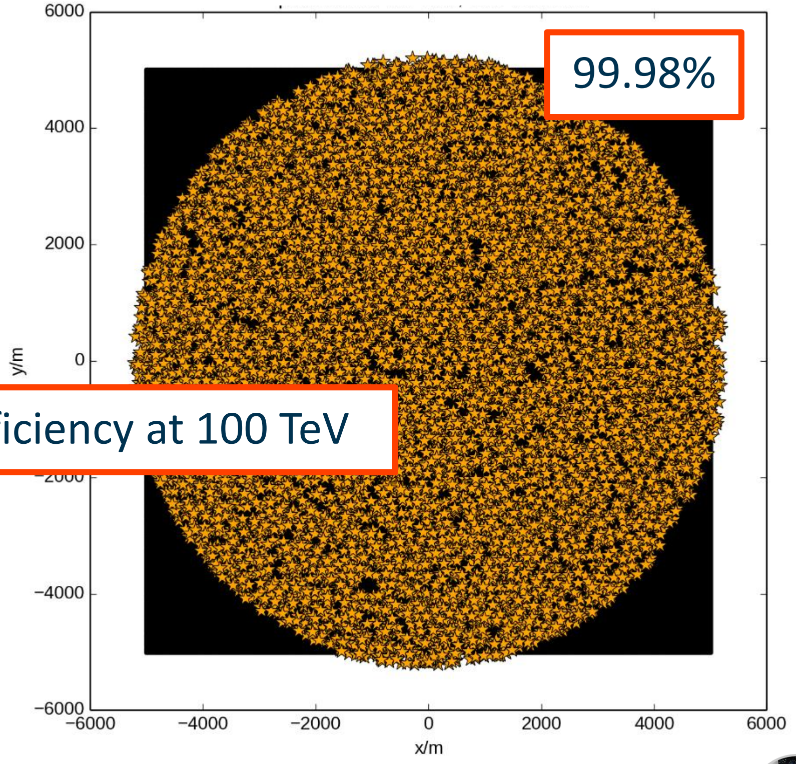
100m^2 per station



100000 stations

31 m spacing

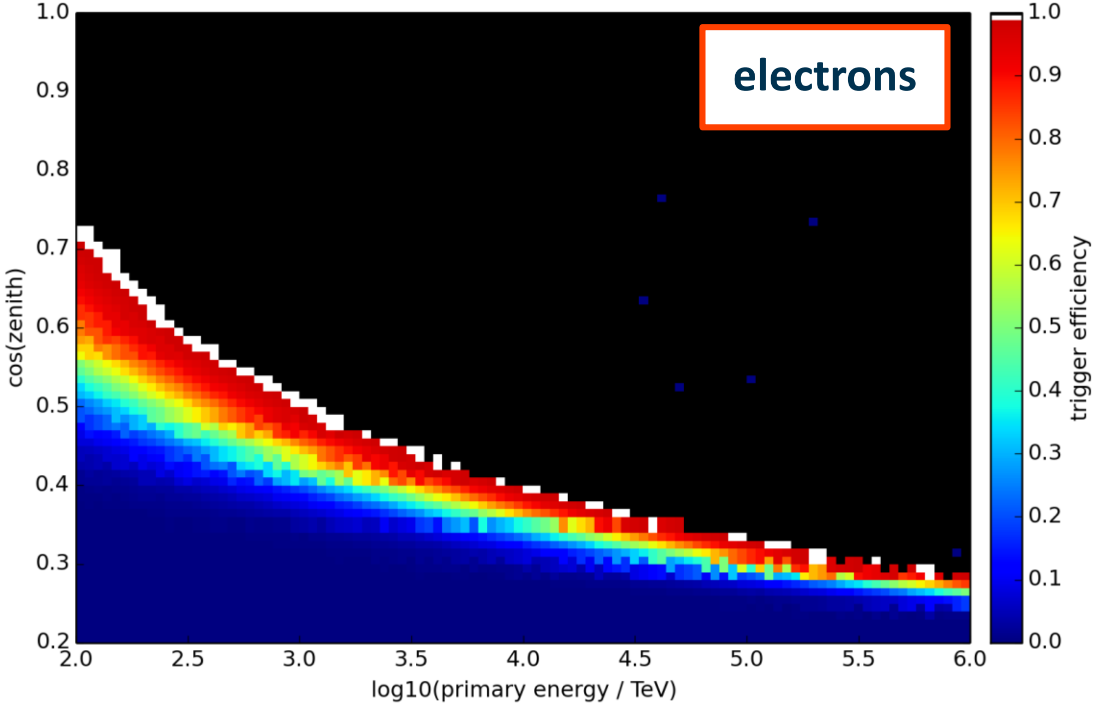
1m^2 per station

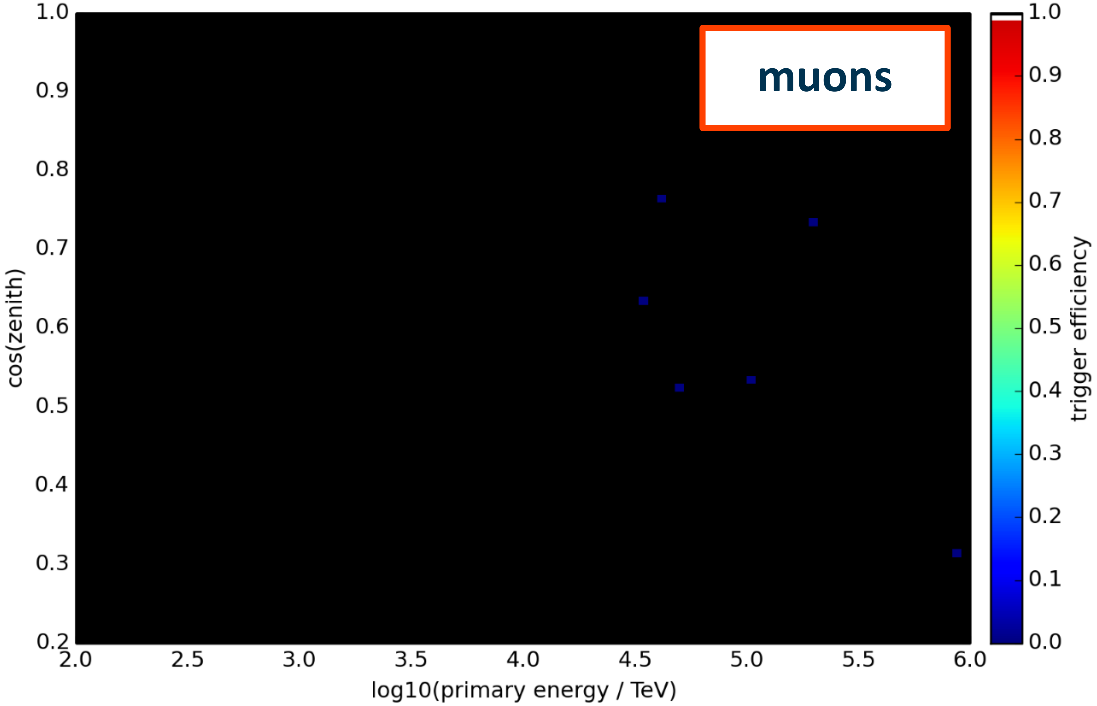


➡ tested 3 different configurations, all achieve about 100% efficiency at 100 TeV

Trigger efficiency for 200m grid

- trigger efficiency for grid geometry with 1000m² / km² (4900 stations w/ 40m2 each, 200m spacing)
- run 10000 showers for each bin
- white: > 99% , black: > 99.99%
- dark blue bins: crashed or unfinished jobs, disregard





Conclusions & Next steps

- toy MC is a great tool to quickly evaluate performance of different detector configurations
- bugs fixed, corrections (slant depth) implemented ➡ don‘t expect major changes in the results
- IceVeto geometry is an efficient surface veto for PeV neutrinos
- a „low-energy“ surface veto requires denser spacing (➡ more $$)

- make sure lateral distribution functions describe reality ➡ compare to data and CORSIKA simulations
- compare with Jan Auffenberg‘s original IceVeto studies ➡ get relation between E_{prim} and in-ice q_{tot}
- write ICRC paper (together with Javier Gonzalez)