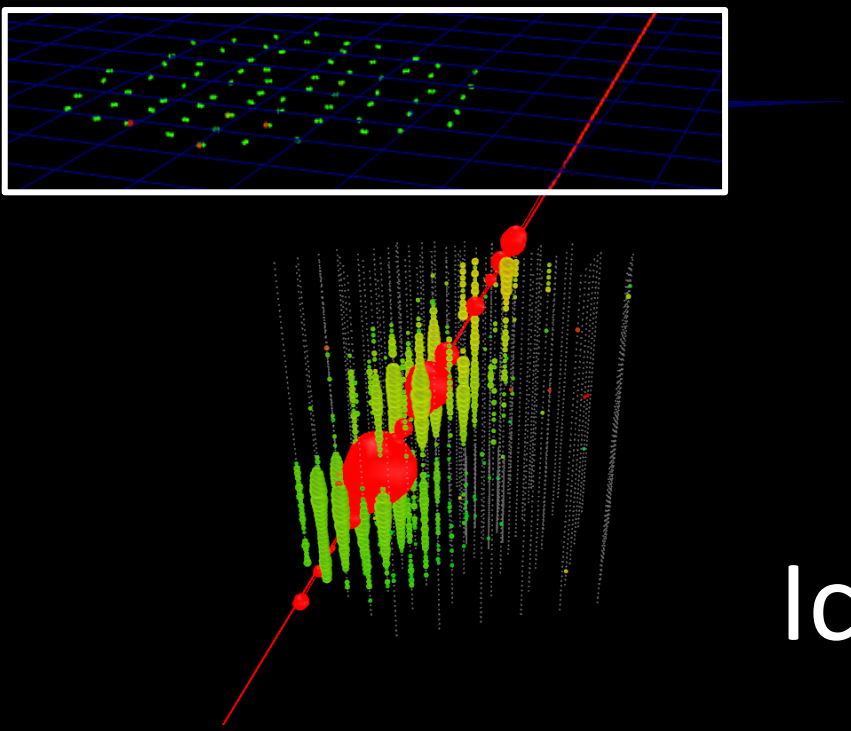
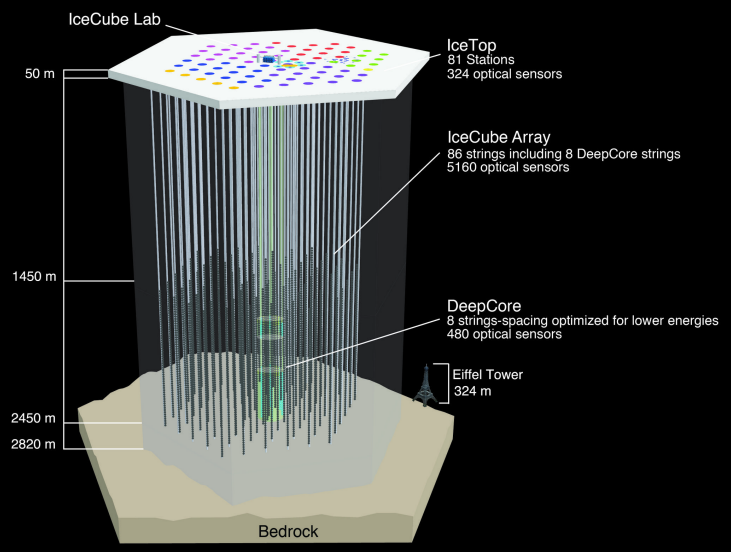


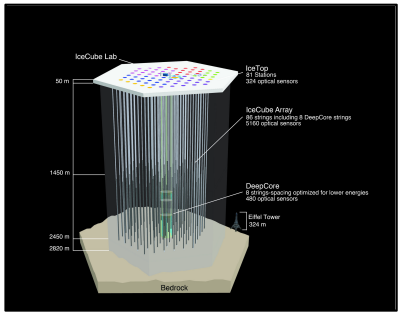


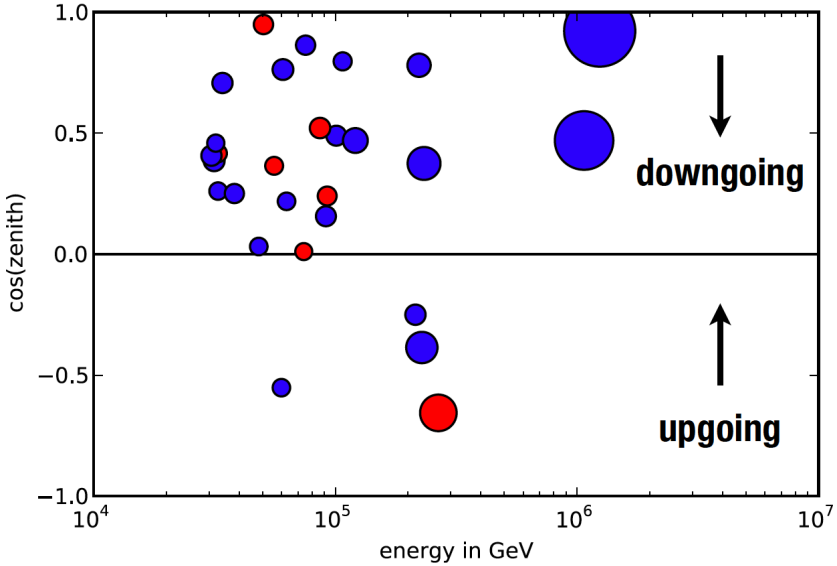
IceVeto

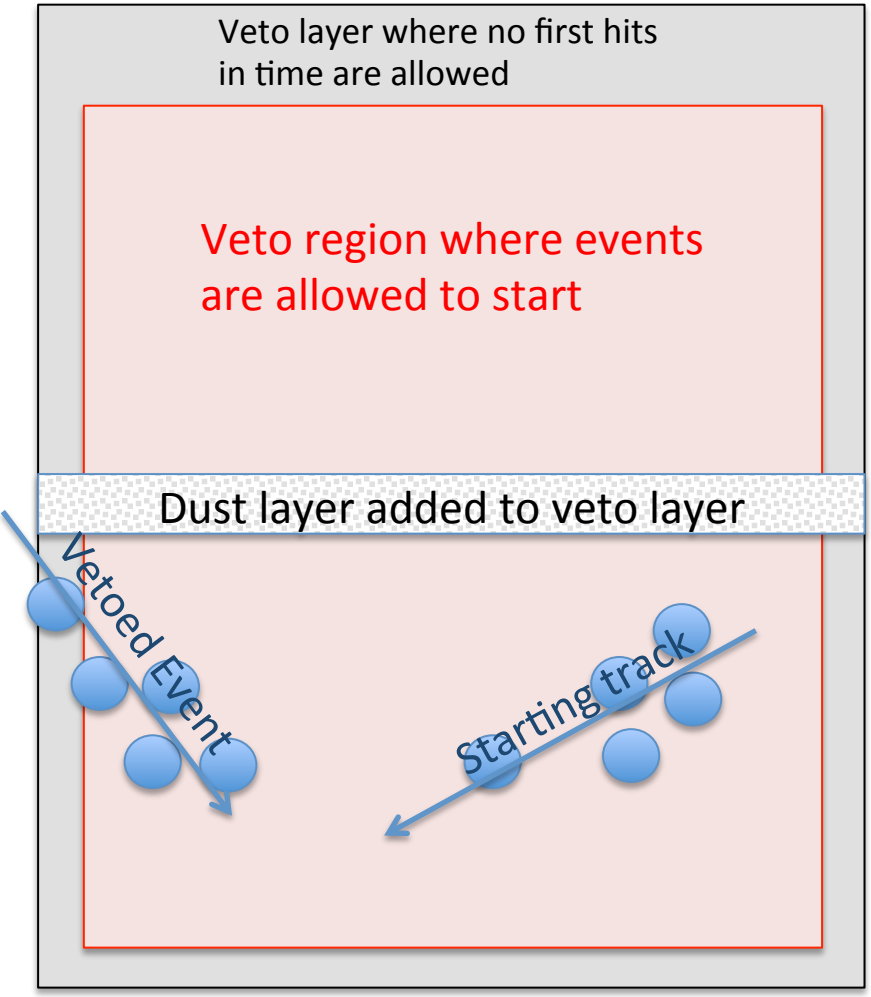
An extension for IceTop to veto CR induced signals

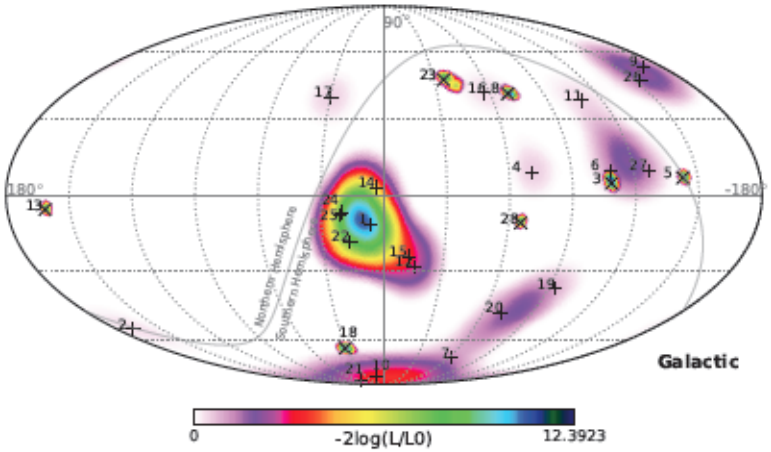
Jan Auffenberg

Motivation I

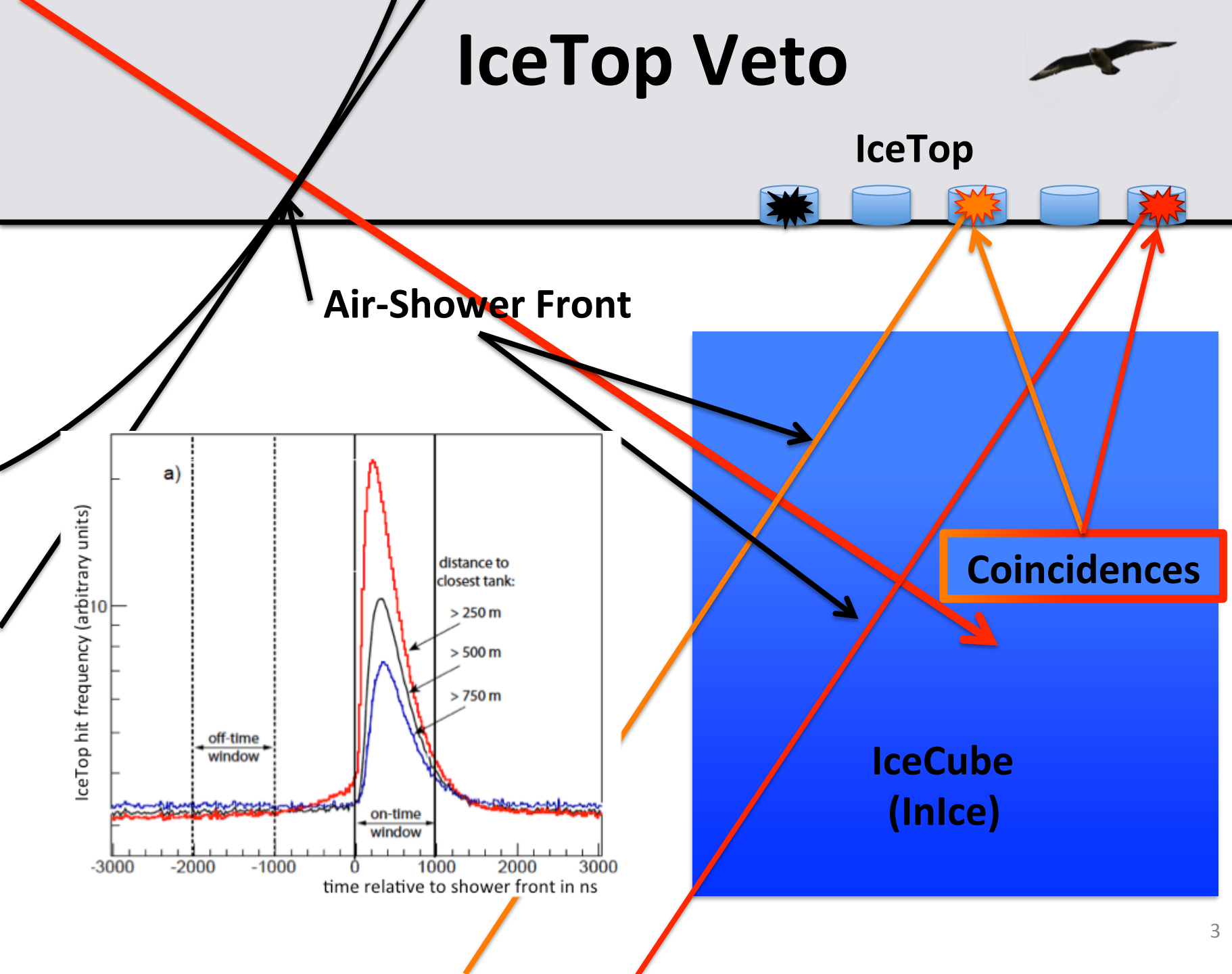




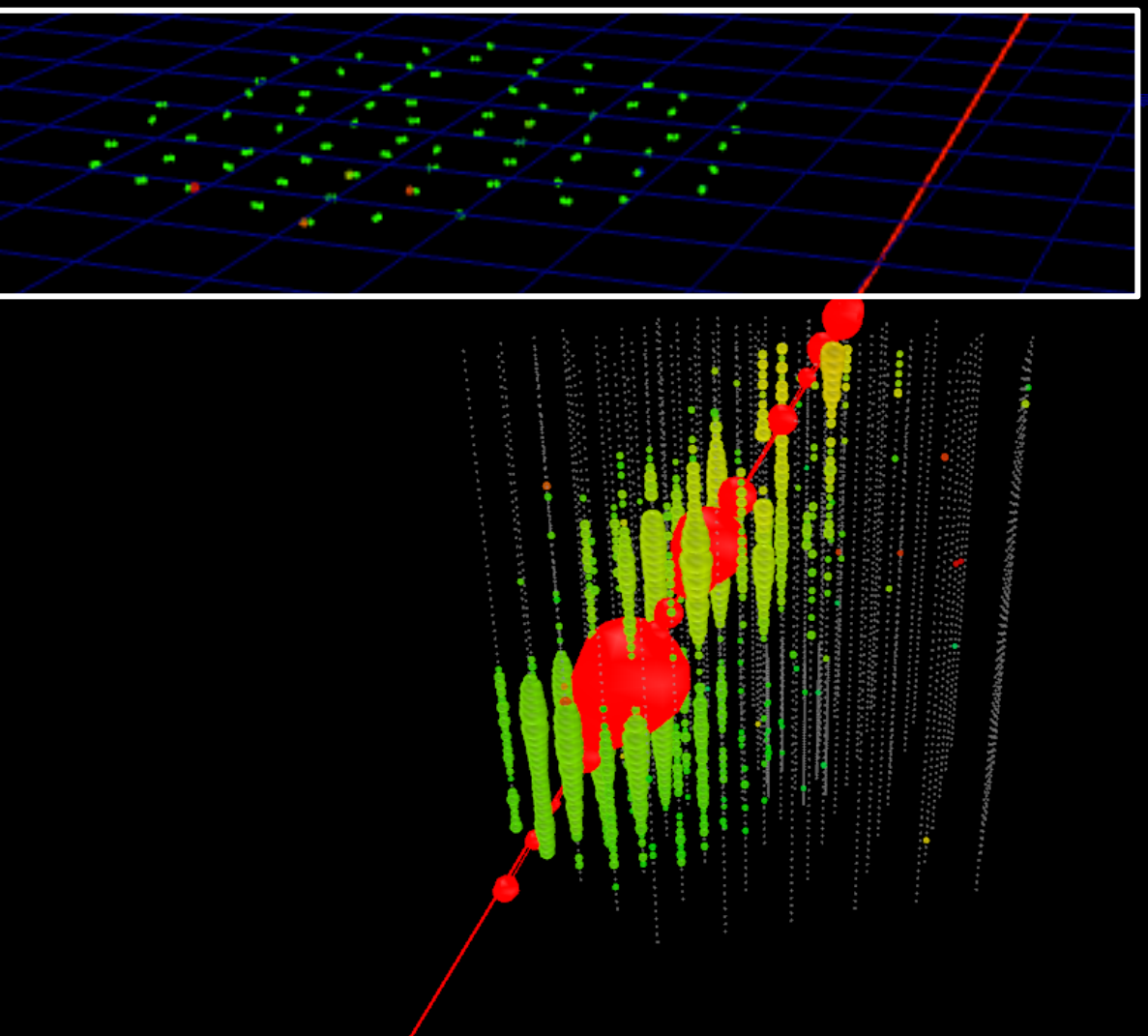




IceTop Veto

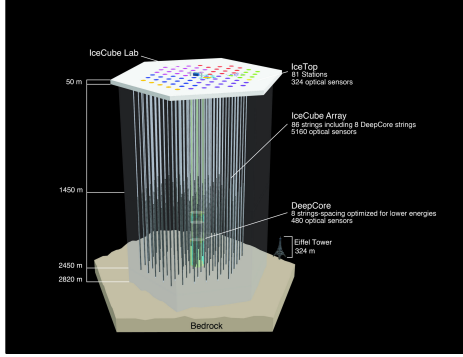

IceTop
Air-Shower Front
Coincidences
IceCube
(InIce)
a)
IceTop hit frequency (arbitrary units)
10
distance to
closest tank:
> 250 m
> 500 m
> 750 m
off-time
window
on-time
window
-3000
-2000
-1000
0
1000
2000
3000
time relative to shower front in ns

Motivation II

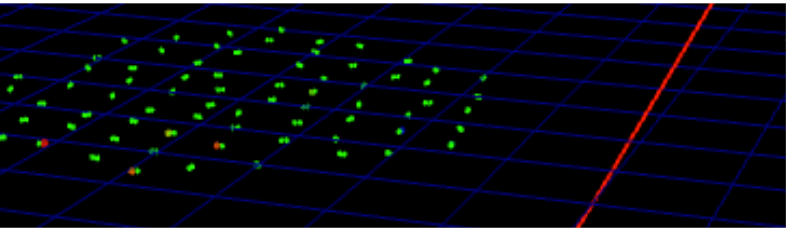


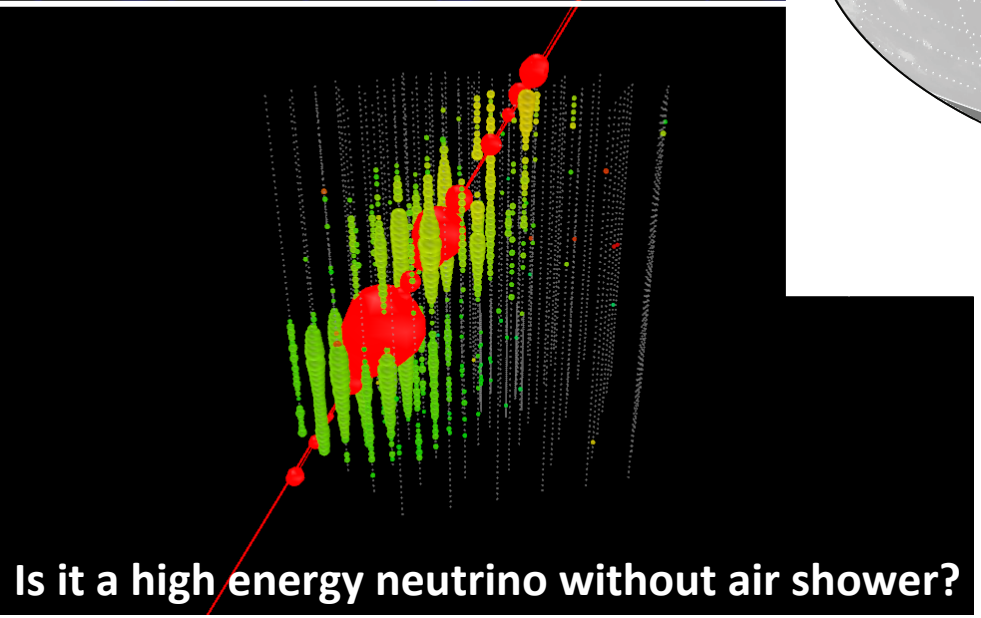
IC79 burn-sample data
(Max_Event)
dE/dx ~ 1PeV
No coincident IceTop hit
Closest tank ~400m away

Single Neutrino induced muon tracks

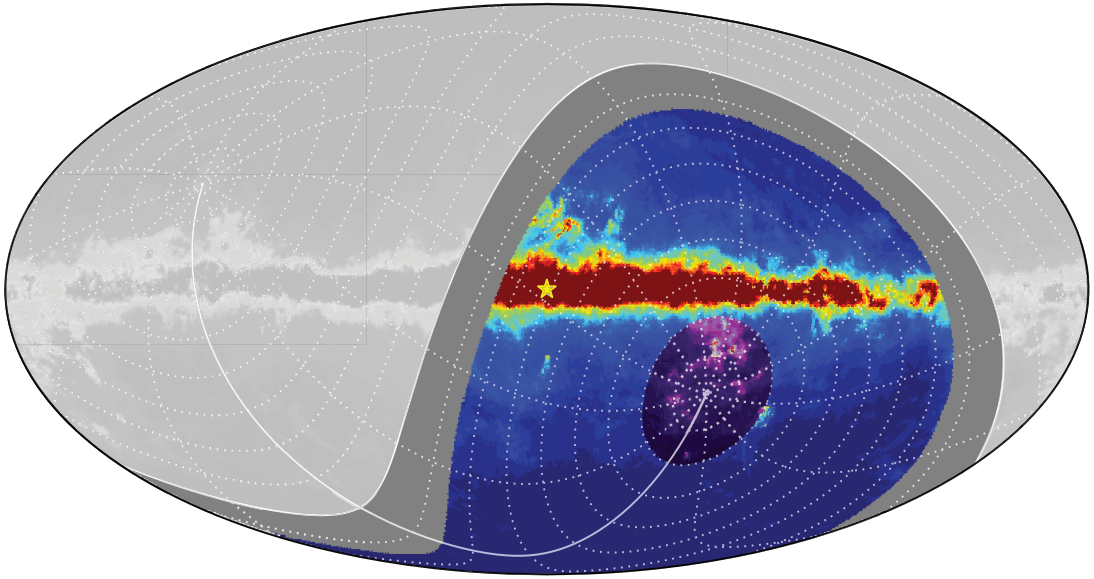


Tracks point much better to their source than cascades!



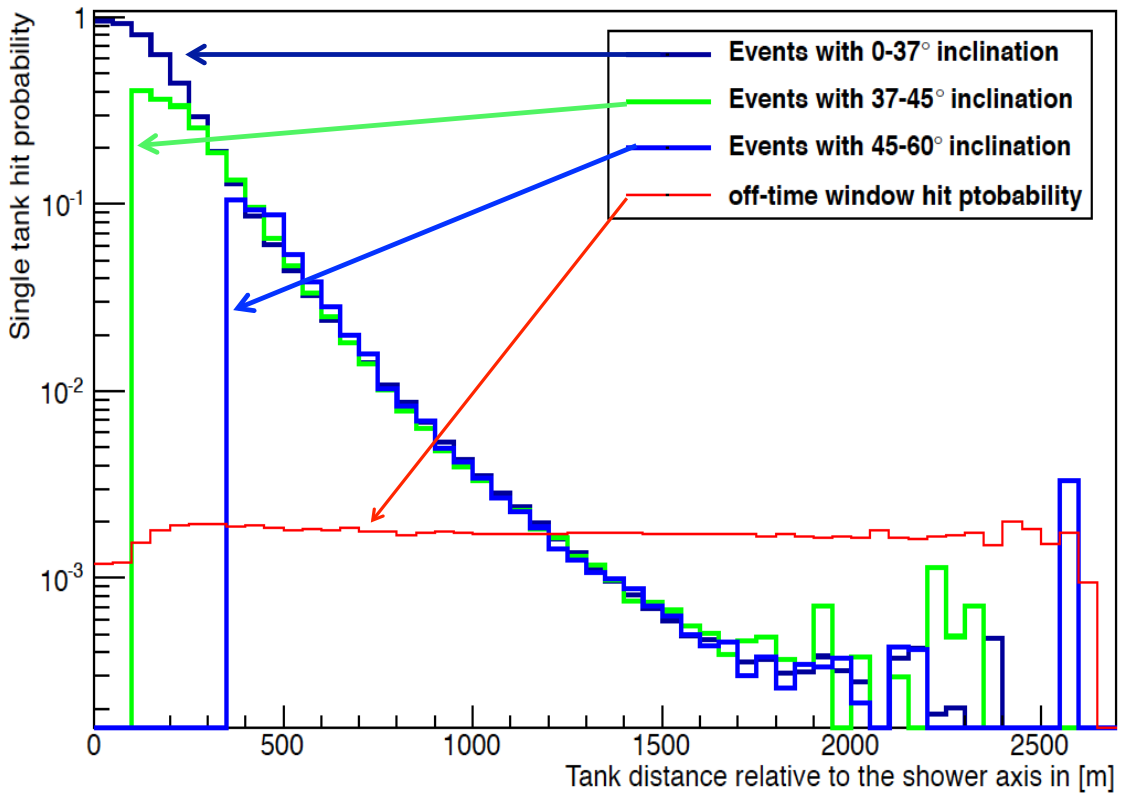


Is it a high energy neutrino without air shower?



- **Open the southern sky for Neutrino induced muon tracks without air shower in an extended detector Volume**

Single IceTop tank hit probability (real data)



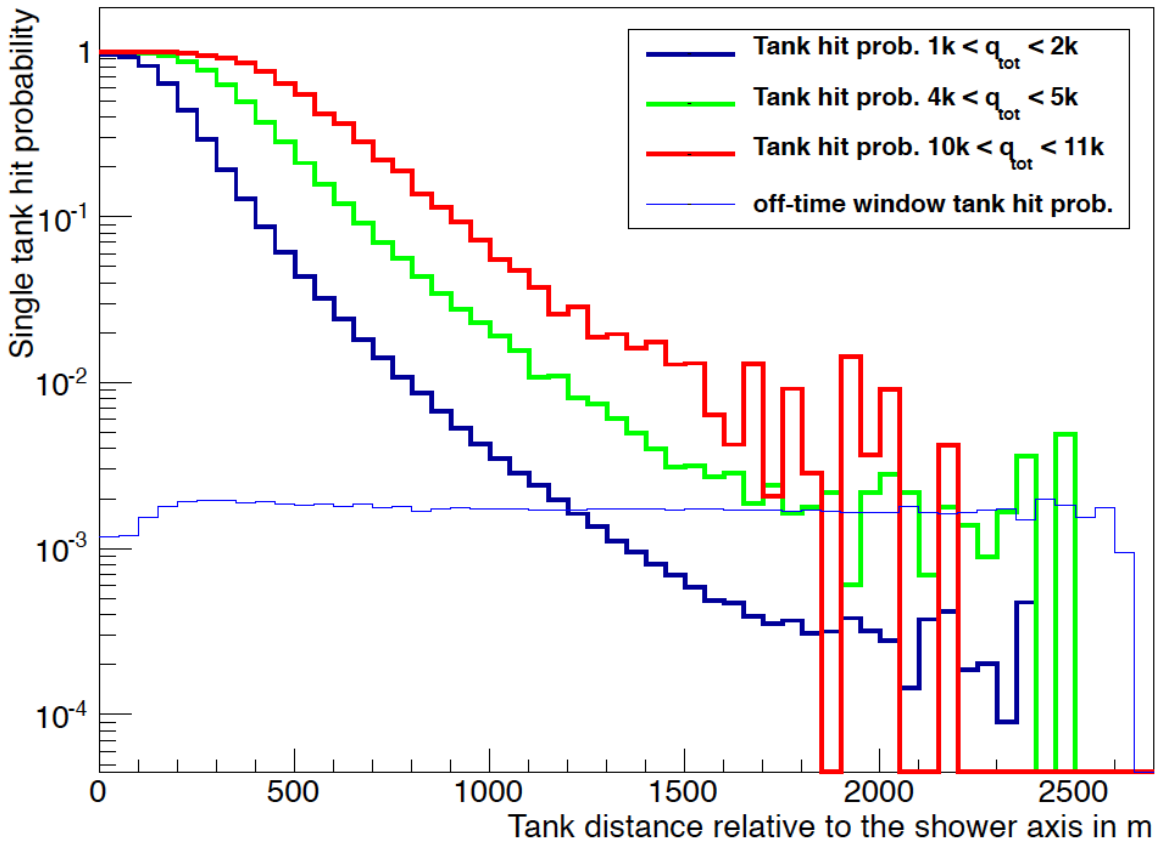
For constant NPE in the deep detector:

Tank hit probability is independent from inclination.

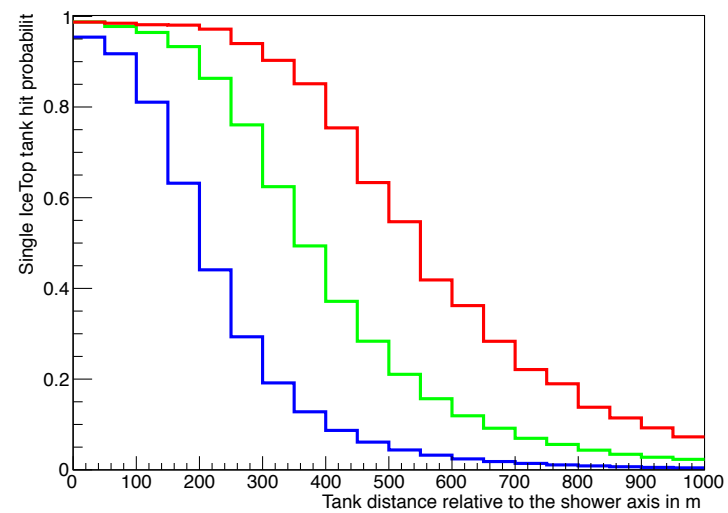
Note:
Tanks further away than ~500m have negligible hit probability

Background hit probability dominates at distances > 1200m

Single IceTop tank hit probability (real data)



Tank hit probability increases with increasing NPE in the deep detector

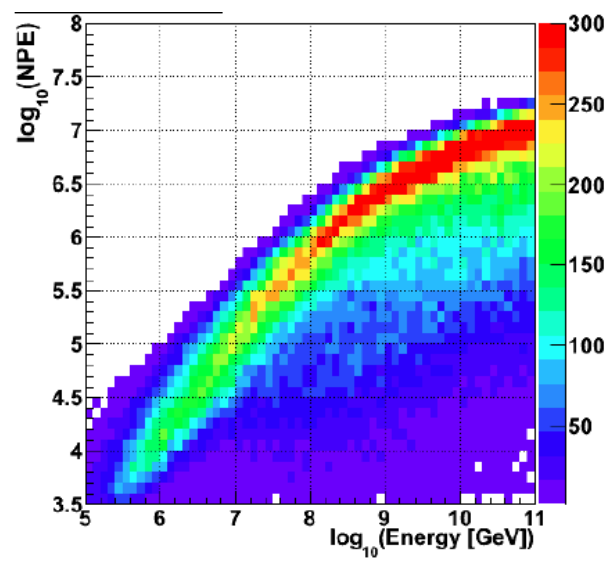


MC simulation (based on real data)

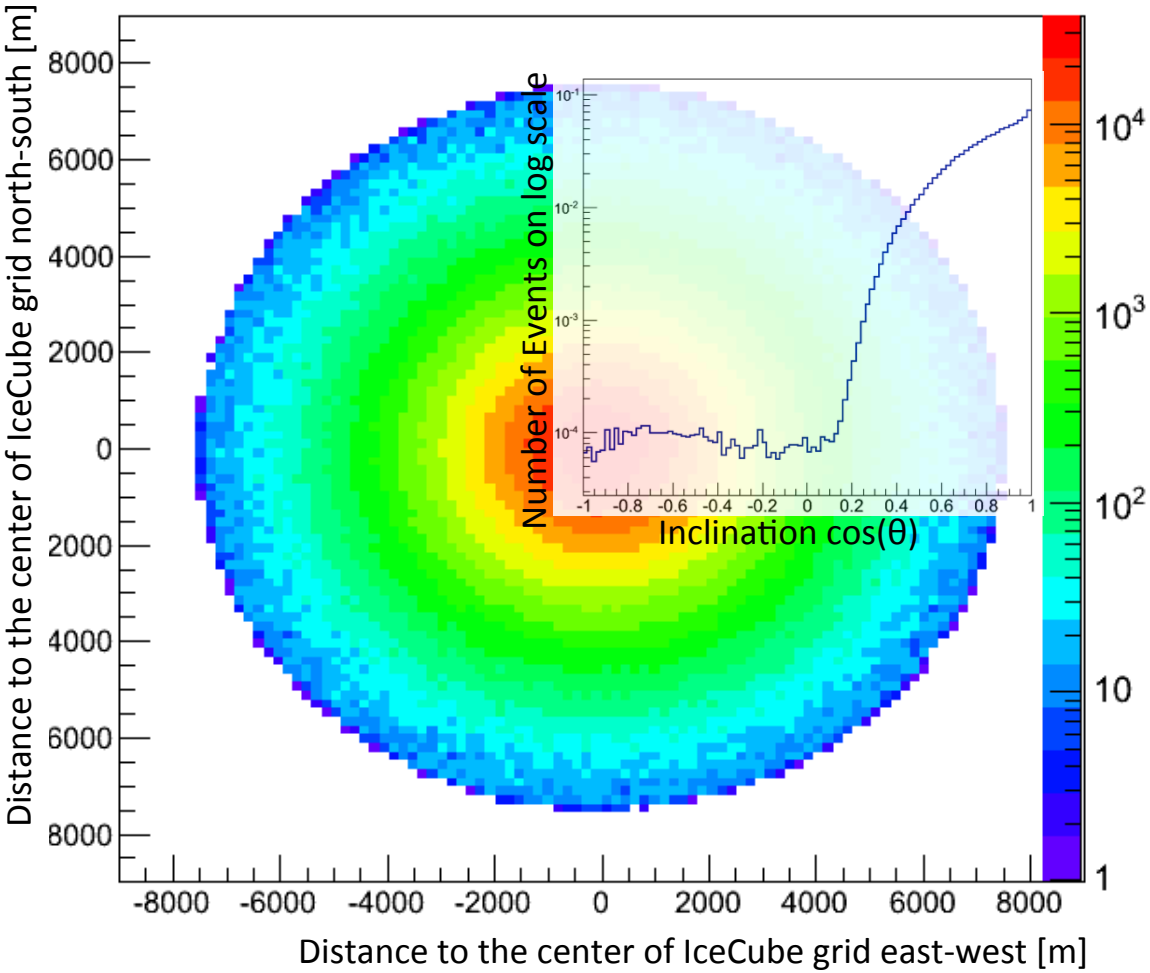
Assumptions:
IceVeto detection module acts as a CR Veto similar to an IceTop tank.

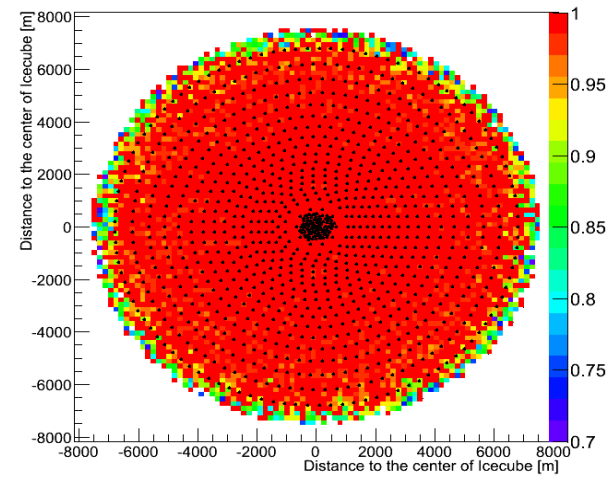
Input parameters:
-Veto efficiency for events with reconstruction between 0-75° inclination with 1000 pe light deposit in the detector with >99.9% .
-IceVeto tanks are forced on rings around IceTop.

Input from real data:
-IceTop tank hit probability as function of pe.
-Geometrical event distribution.

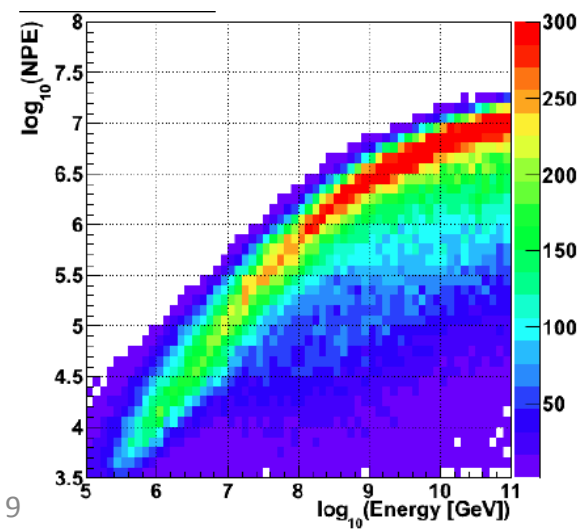


Event distribution

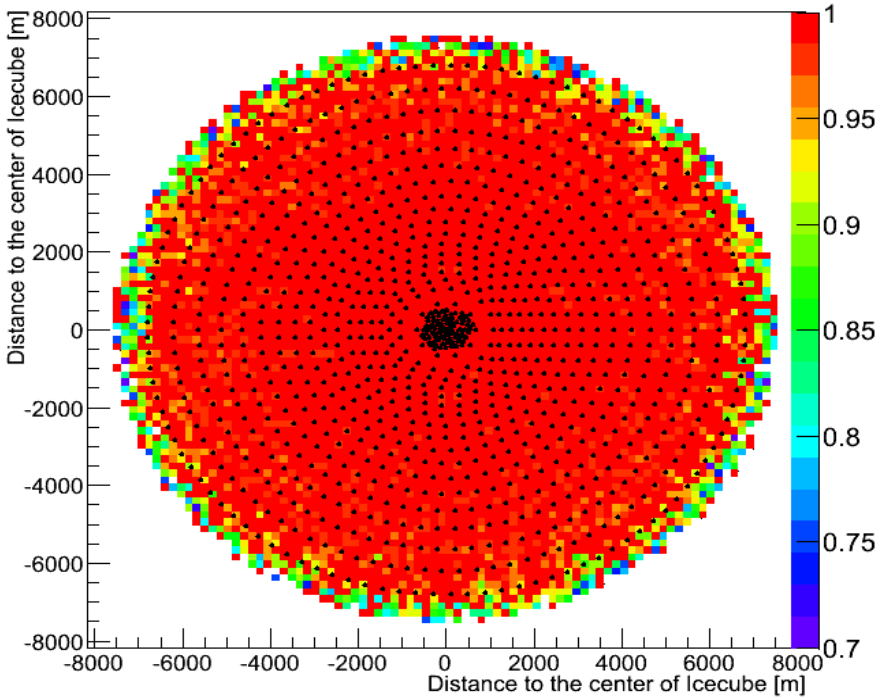




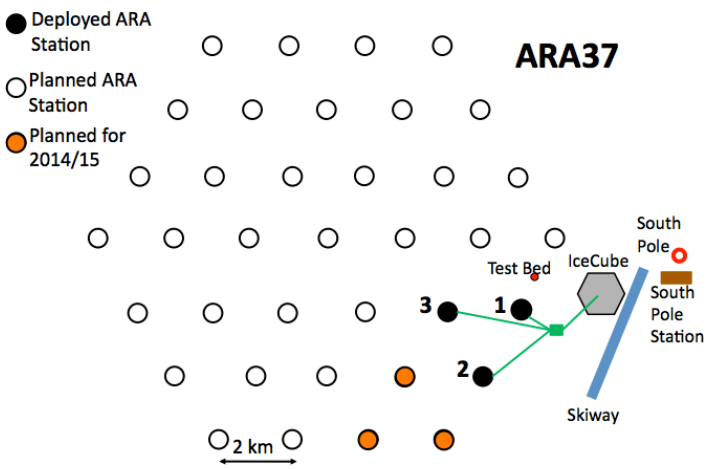
99.999% Veto efficiency for NPE > 4000



Simulation results



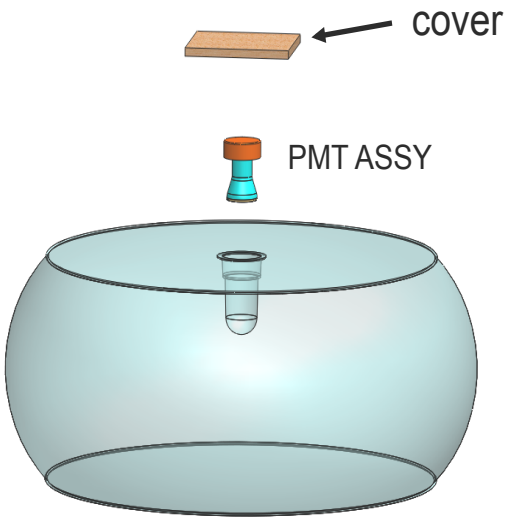
- **Efficient to 72° inclination**
- **943 Modules on the surface**
- **6.7 km radius around IceCube (dimensions like ARA)**
- **Veto efficiency of 99.999% at 4000 PE**



Simulation Weaknesses:

Air Showers with low number of Particles (charm?) could mimic signal. Needs special Corsika simulations

Technical ideas for IceCube



- Simple IceTop tank like

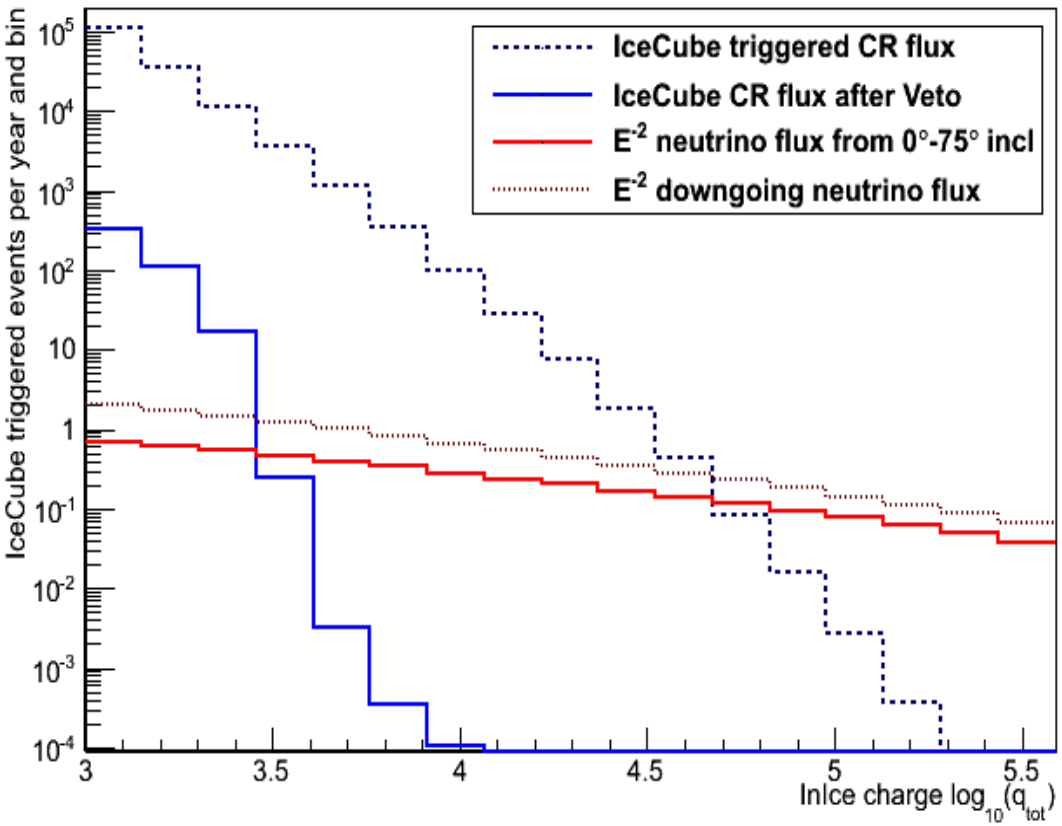
Cherenkov light-ice detector-modules
Large Volume but no degased ice.

- Only min ionizing particle detection.
- No Energy or multiplicity measurement

Advantage: Single small (3 inch?) PMT
Low Power consumption
Disadvantage: Less powerful for CR physics

- Power and signal transmission with cables (like ARA)
- Digitizing at detection point (like IceCube) (only binary number transmission?)

Diffuse muon neutrino flux



Based on current IceCube Simulations for 79 string configuration And current IceCube diffuse neutrino flux limits integrated up to 10 PeV.

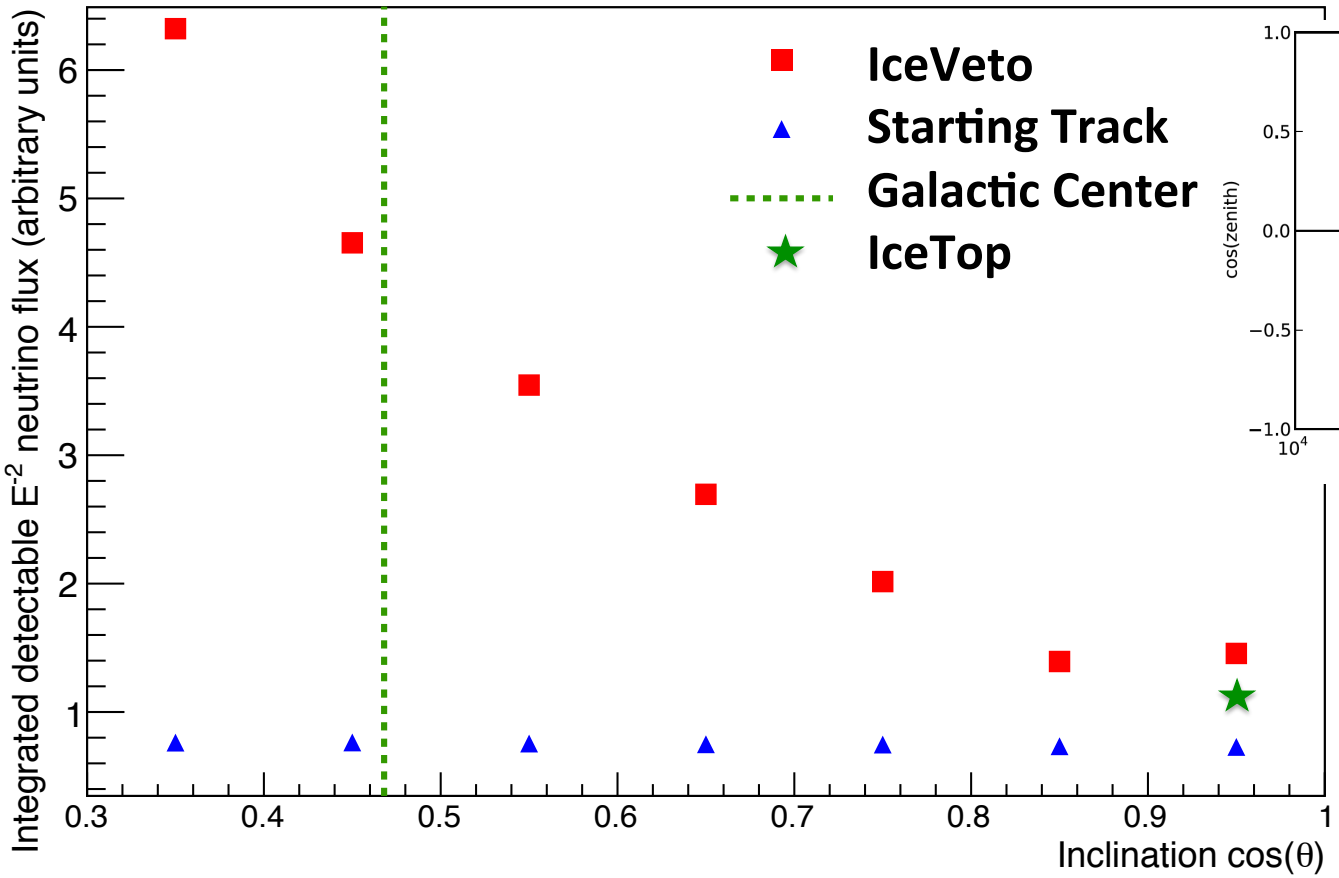
IceVeto would lead to 2.6 events detected on 0.06 background per year!

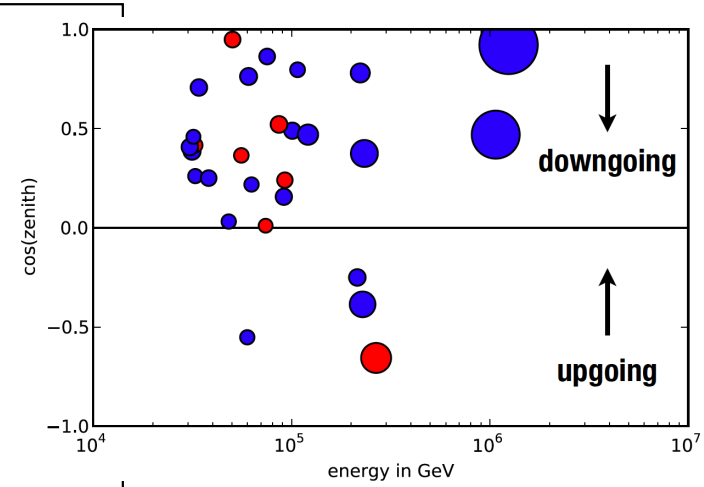
>5σ significance (without systematic errors) after one year.

The strongest argument remains pointing

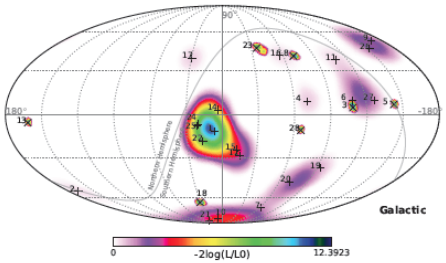
Remember:
The applied Veto efficiency is calculated with simulations that base on real data.

Many more tracks compared to starting track analyses





Only the red dots are tracks



5.5 times more neutrino induced muon tracks at the Galactic Center between 30 TeV -5 PeV based on an E^{-2} neutrino flux.

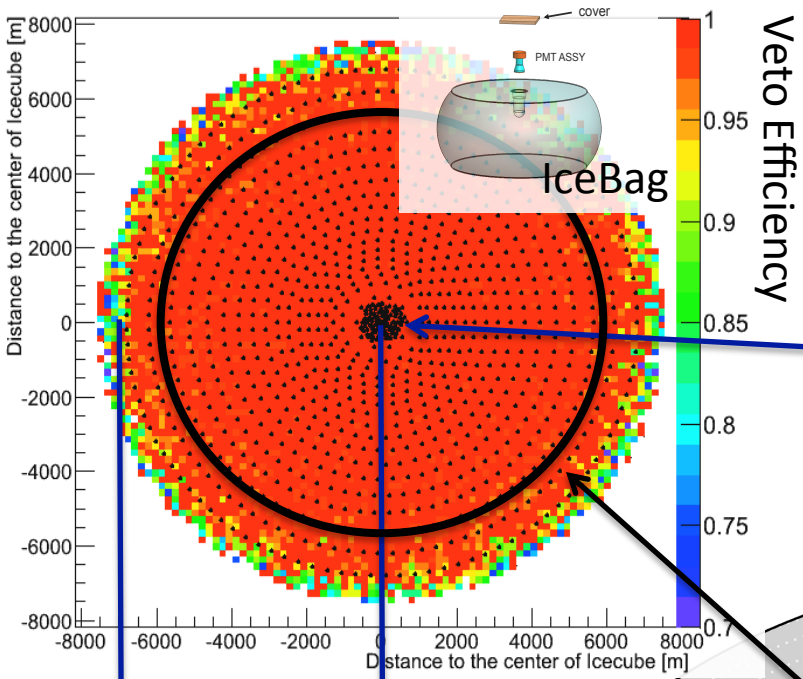
What about KM3NET?

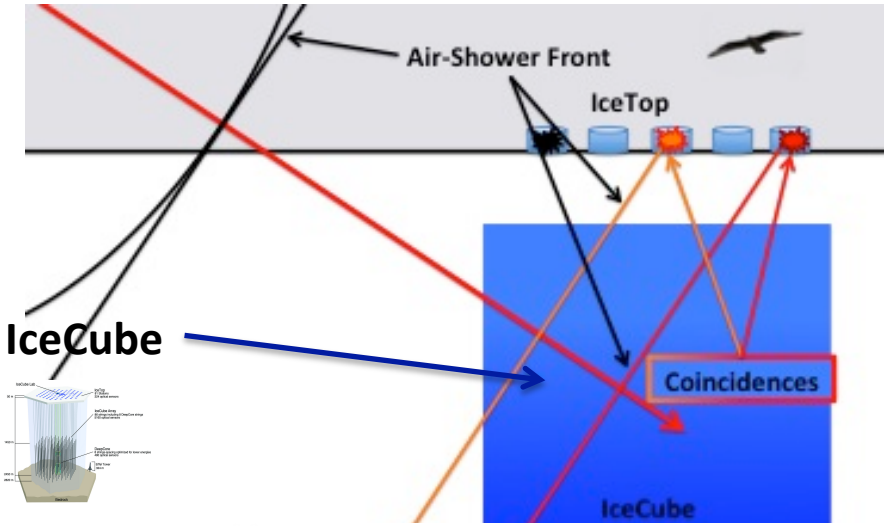
- KM3NET has the same potential for a surface Veto.
- A deeper detector needs a larger surface Veto area.
- No high precision positioning for surface Veto modules (buoy?) necessary.

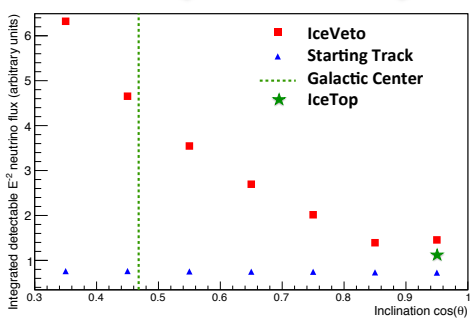
Summary

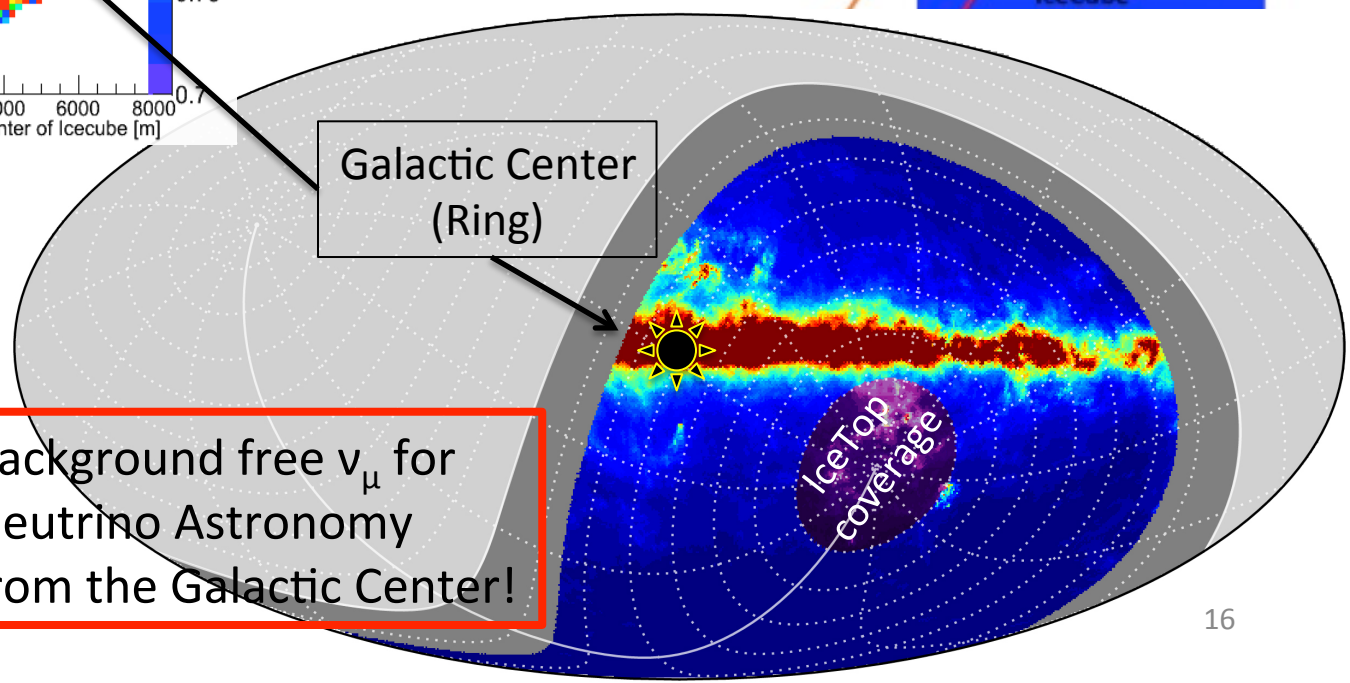
- Less than 1000 simple surface CR detection modules seem sufficient for a surface Veto for **background free** through-going astrophysical muon neutrino detection above ~50TeV.
- 5.5 time more muon neutrino tracks from the direction of the galactic center.
- Tracks have excellent pointing
- 2.6 diffuse muon neutrinos with >5σ from the southern hemisphere per year for an E^{-2} flux from 30TeV-10PeV (IC59 limit).
- Maybe also useful for KM3NET

IceVeto: A CR Veto detector for neutrino astronomy at the southern sky

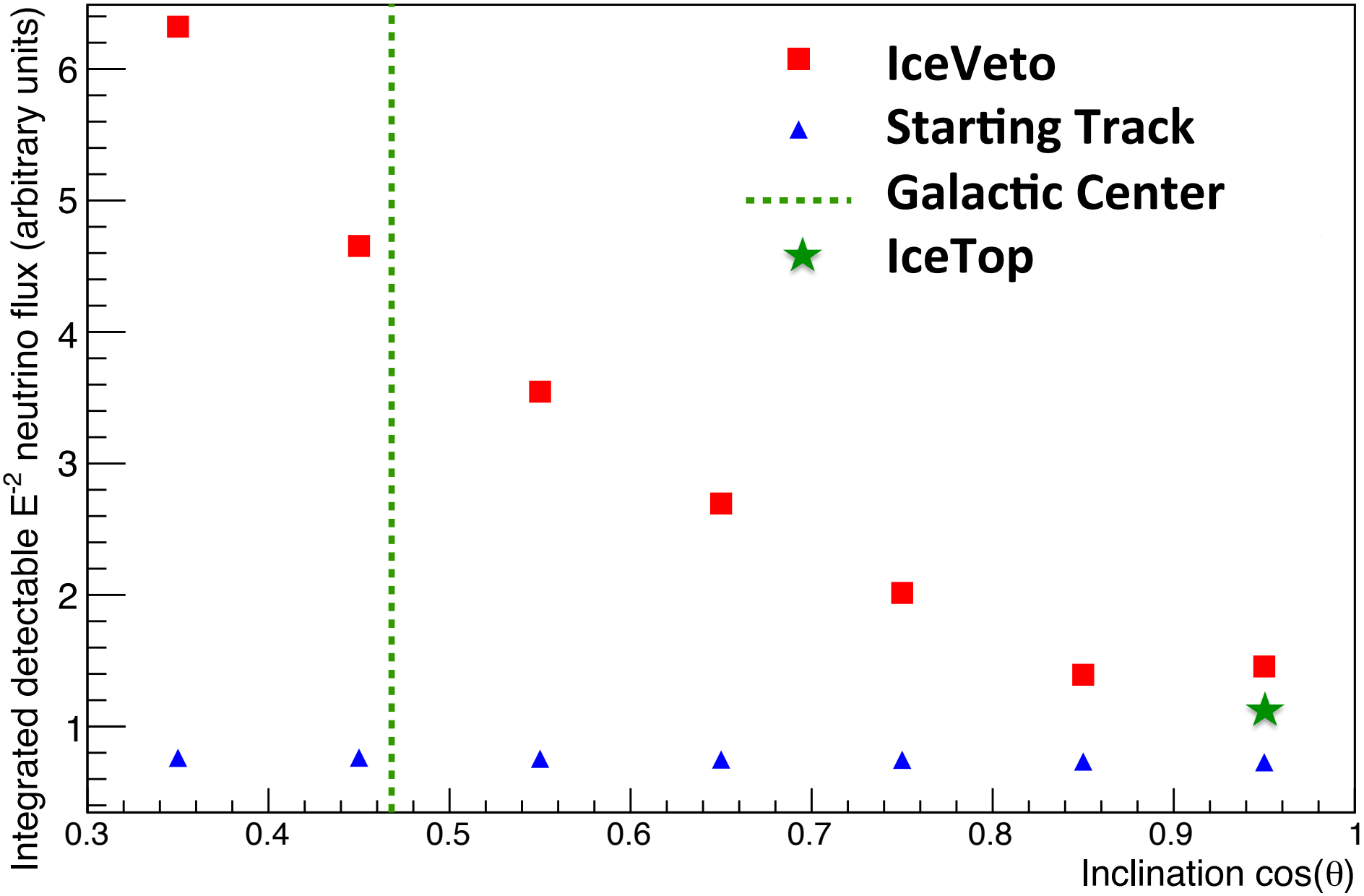


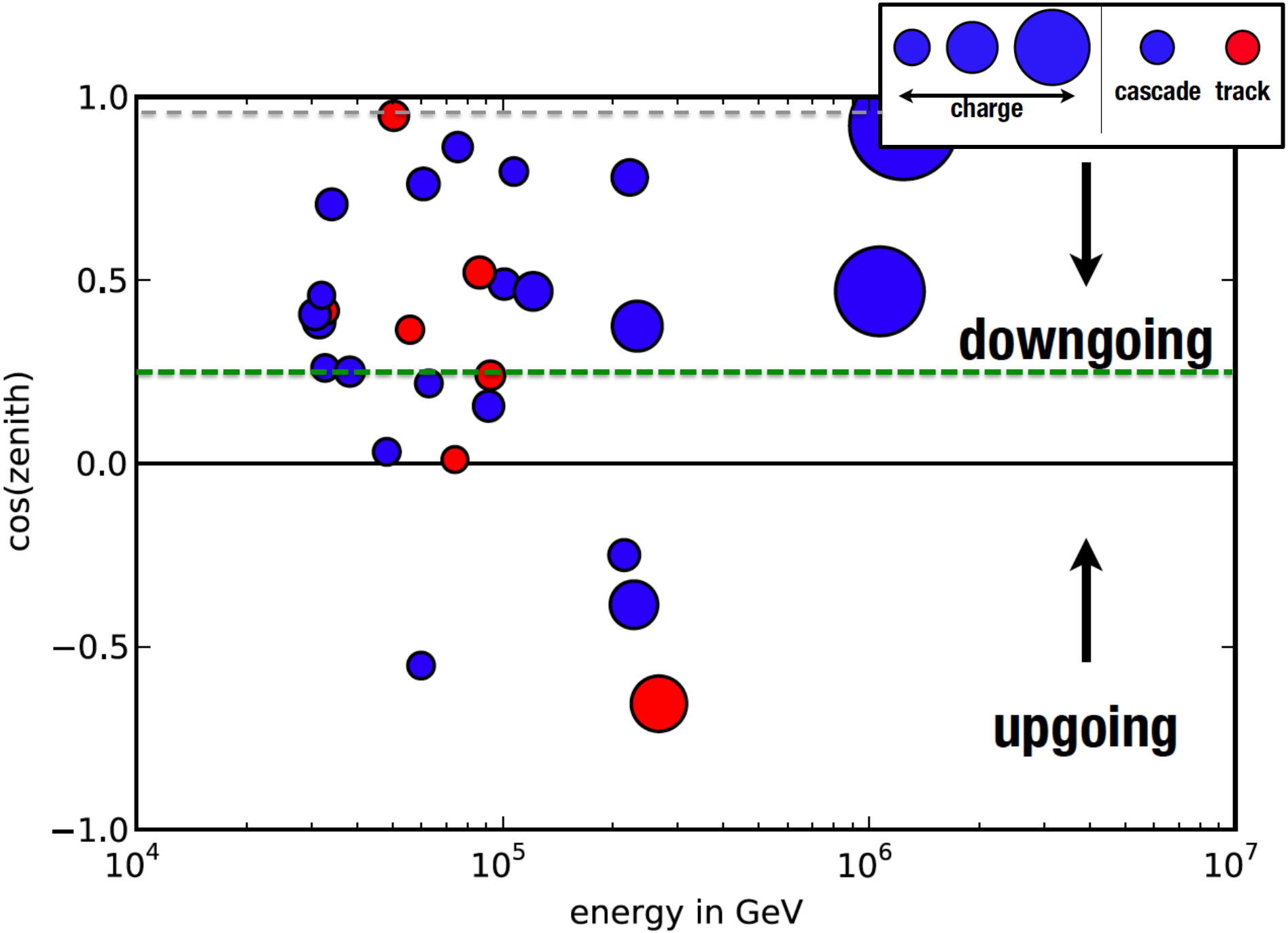


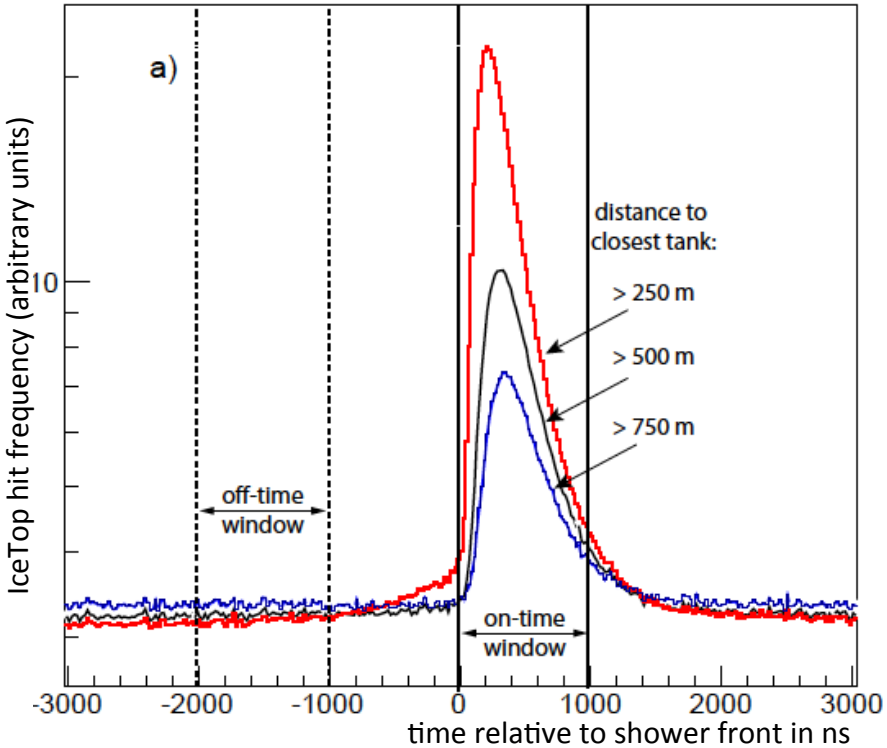


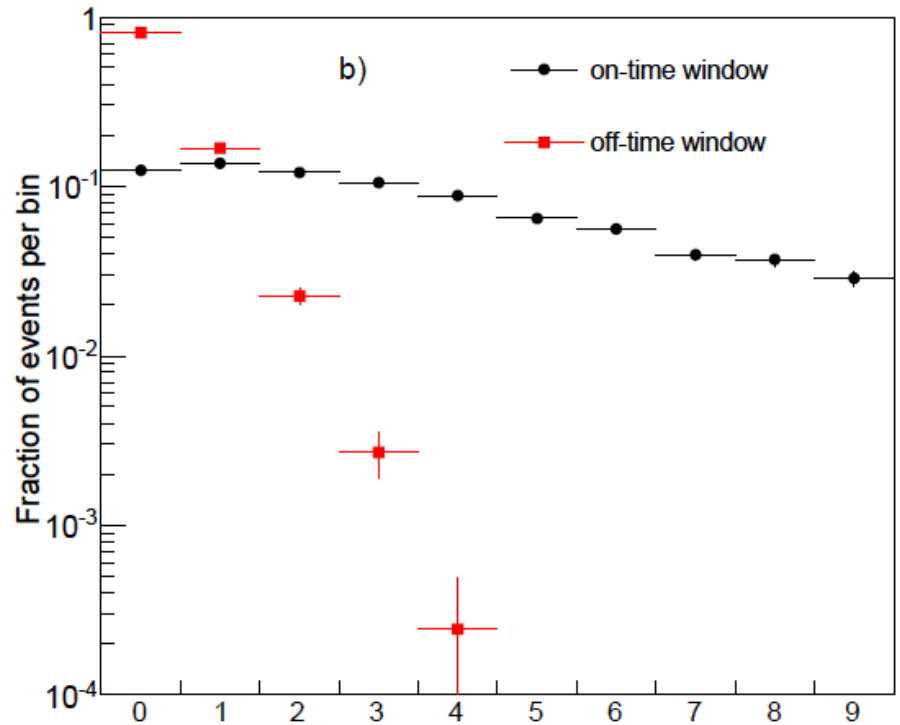


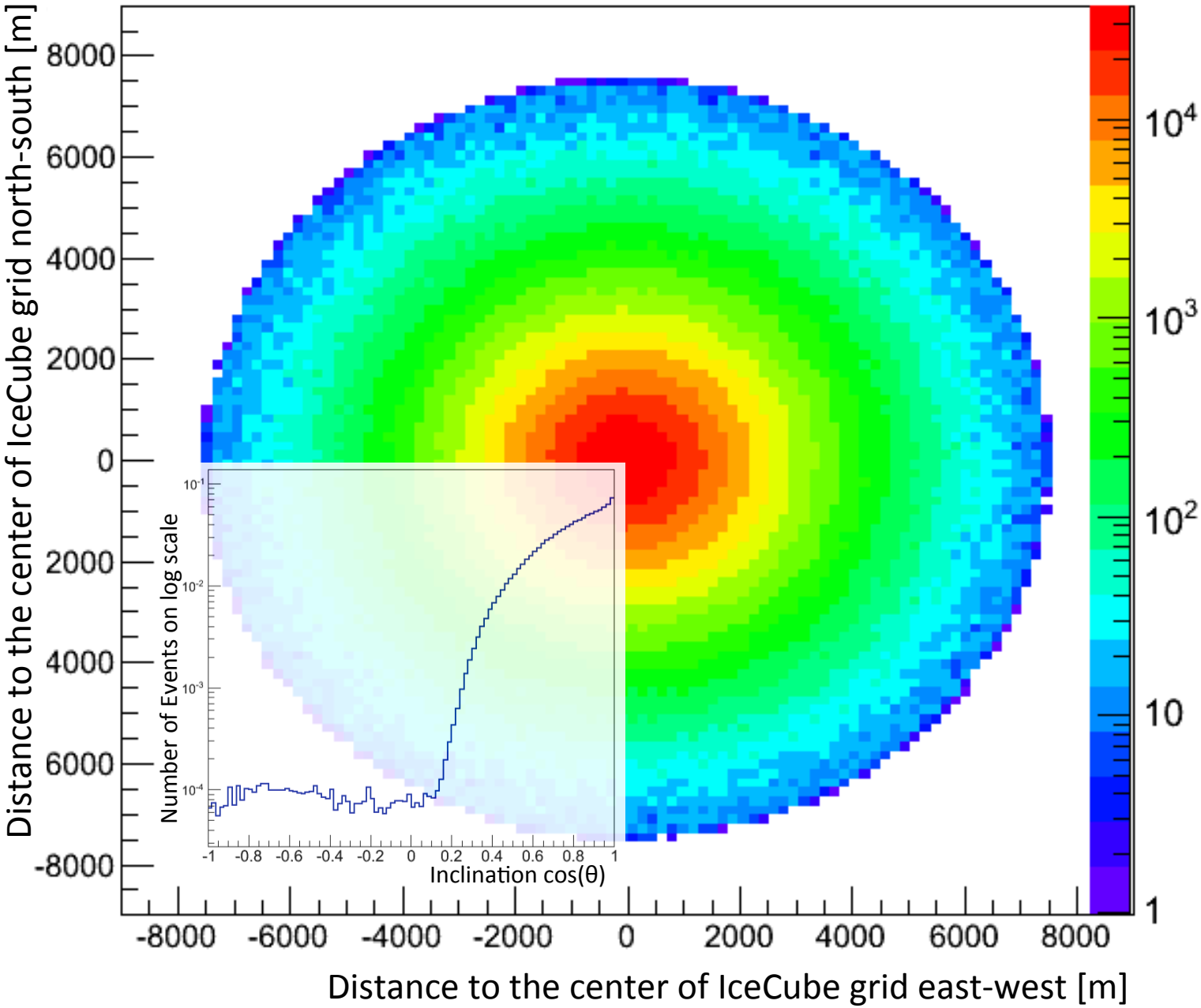
Background free ν_μ for Neutrino Astronomy from the Galactic Center!

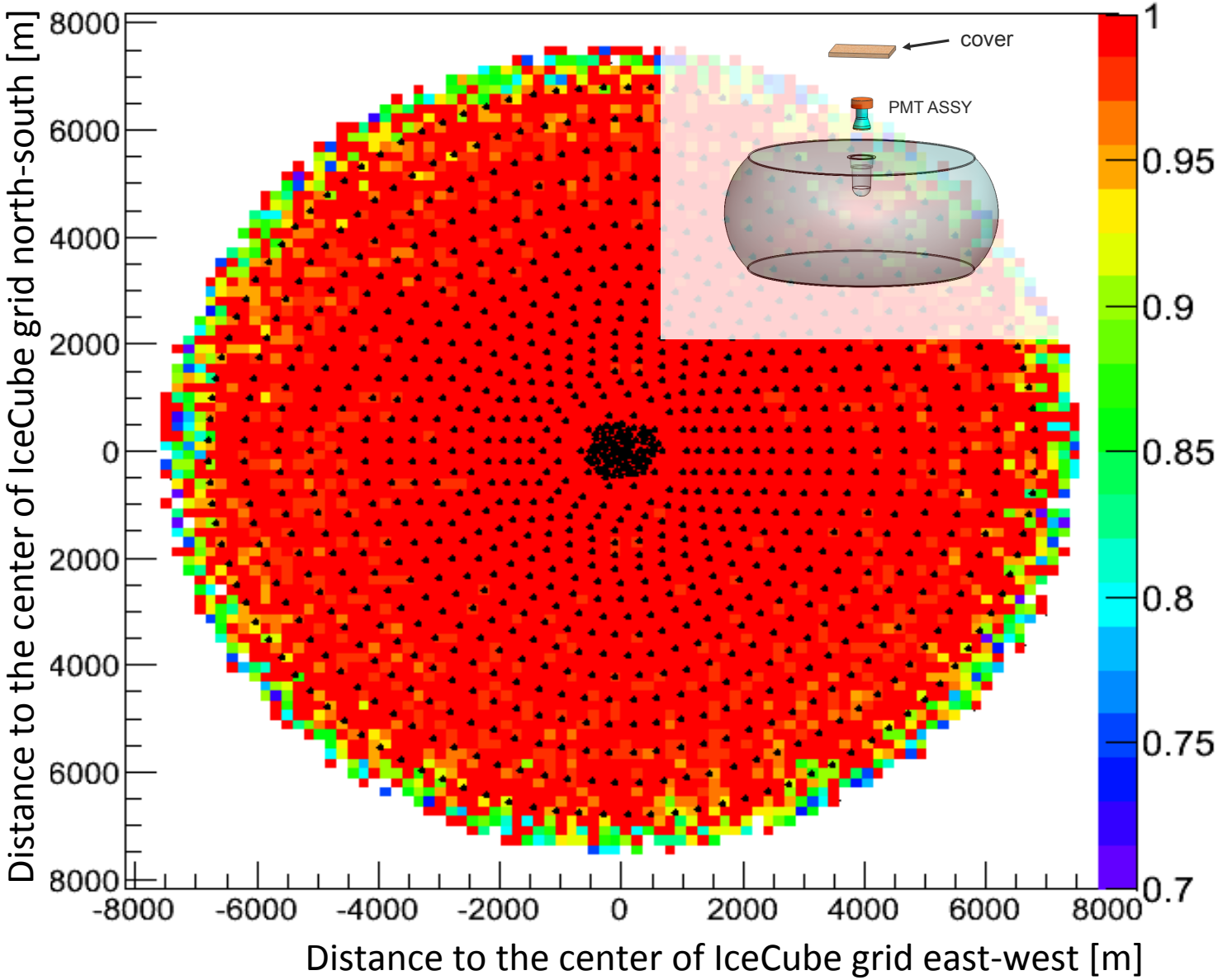

IceVeto
Starting Track
Galactic Center
IceTop
Integrated detectable E^{-2} neutrino flux (arbitrary units)
Inclination cos(θ)
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1
2
3
4
5
6


charge
cascade
track
downgoing
upgoing
1.0
0.5
0.0
−0.5
−1.0
cos(zenith)
10^4
10^5
10^6
10^7
energy in GeV


a)
IceTop hit frequency (arbitrary units)
10
distance to
closest tank:
> 250 m
> 500 m
> 750 m
off-time
window
on-time
window
-3000
-2000
-1000
0
1000
2000
3000
time relative to shower front in ns


b)
on-time window
off-time window
Fraction of events per bin
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0
1
2
3
4
5
6
7
8
9


Distance to the center of IceCube grid north-south [m]
8000
6000
4000
2000
0
2000
4000
6000
-8000
-8000
-6000
-4000
-2000
0
2000
4000
6000
8000
Distance to the center of IceCube grid east-west [m]
10^4
10^3
10^2
10
1
Number of Events on log scale
10^{-1}
10^{-2}
10^{-3}
10^{-4}
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
Inclination cos(θ)


cover
PMT ASSY
Distance to the center of IceCube grid north-south [m]
Distance to the center of IceCube grid east-west [m]
8000
6000
4000
2000
0
2000
4000
6000
8000
-8000
-6000
-4000
-2000
0
2000
4000
6000
8000
1
0.95
0.9
0.85
0.8
0.75
0.7

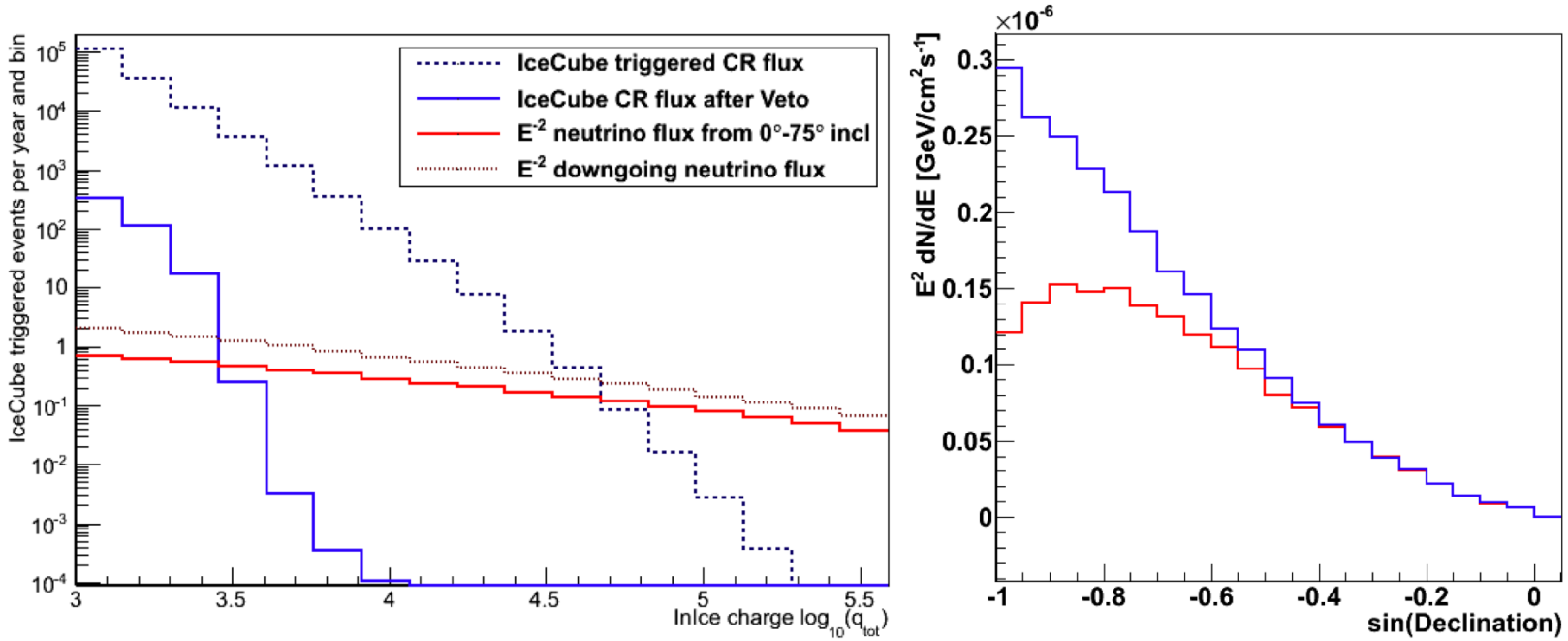
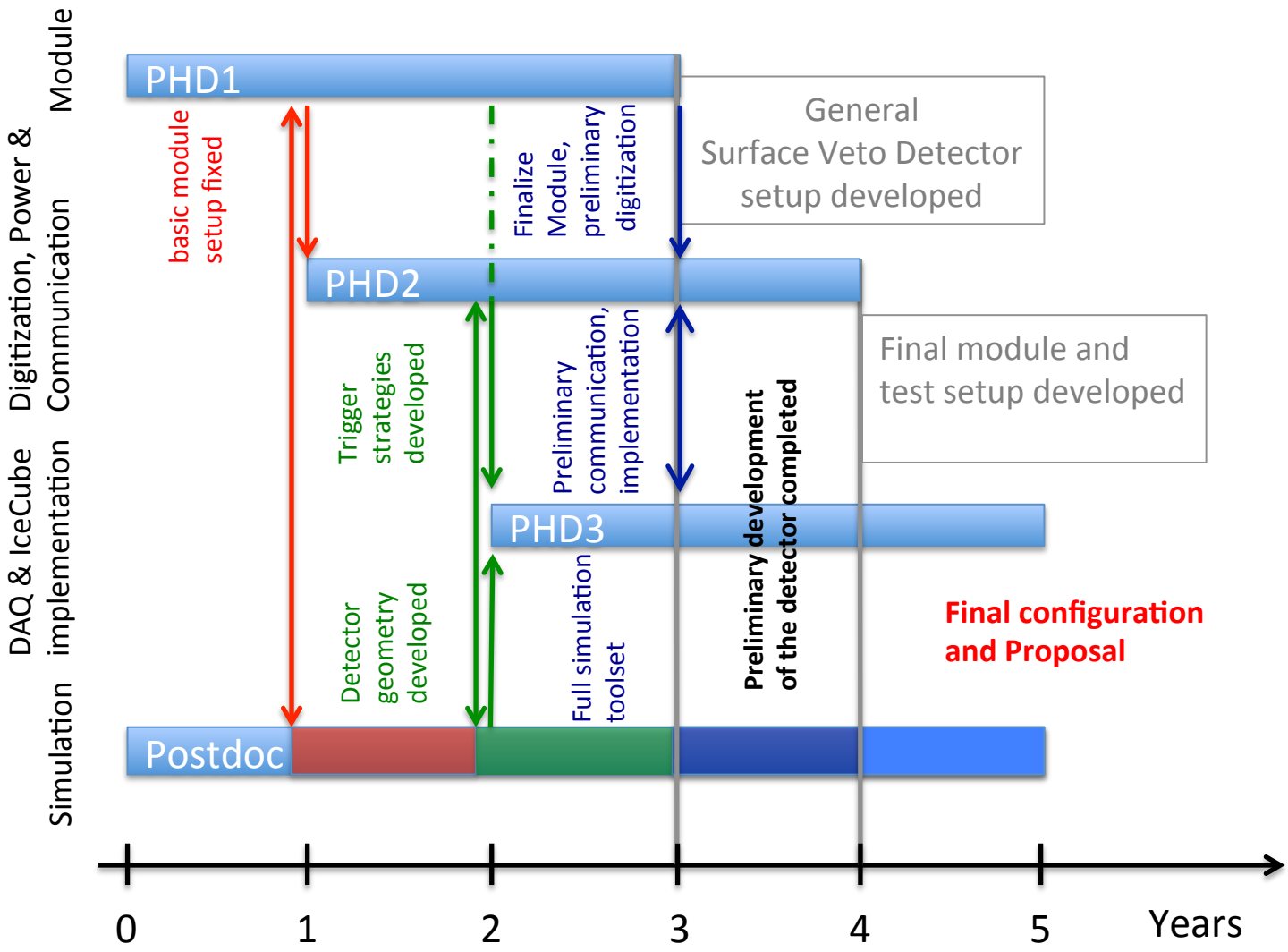
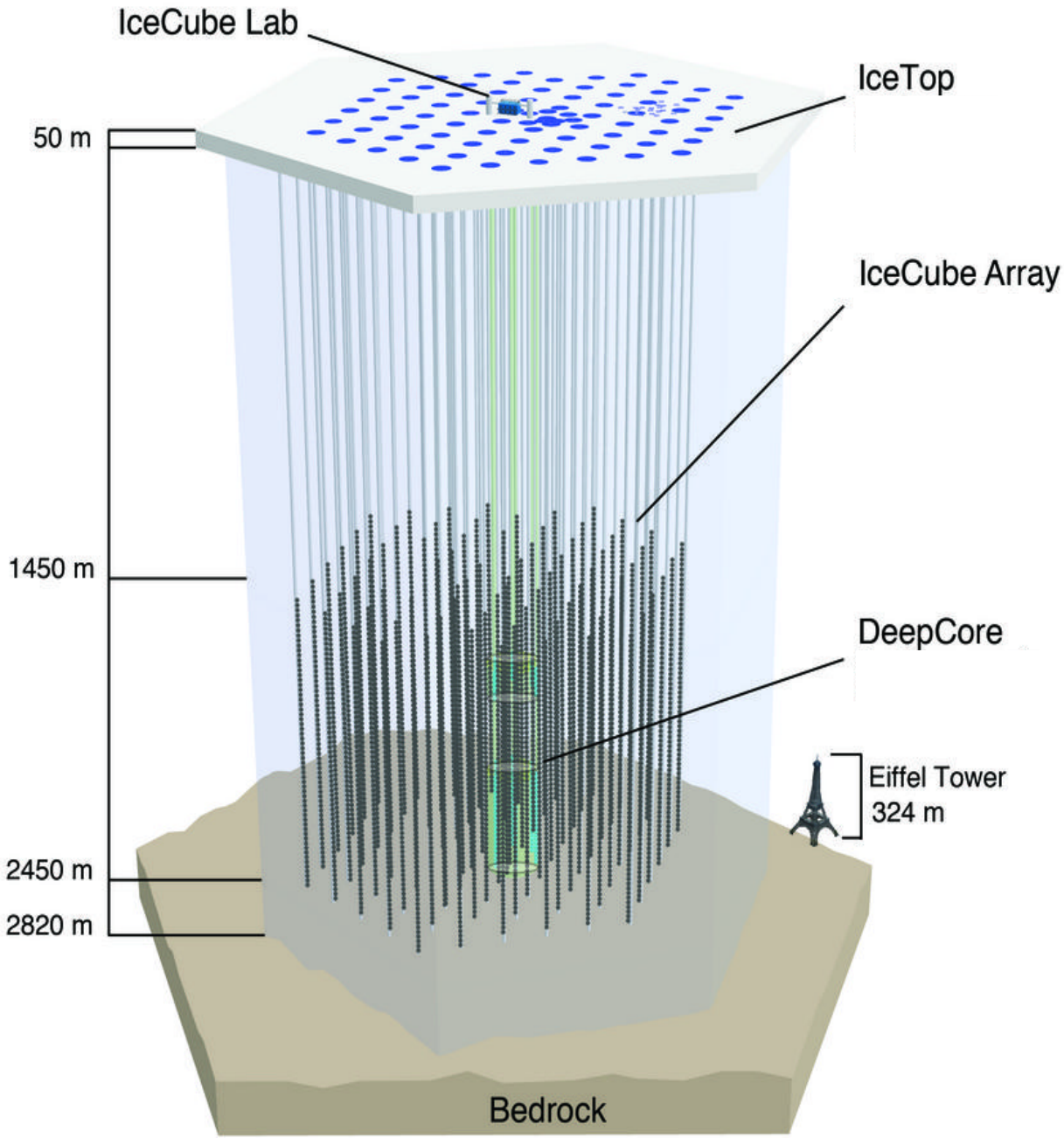


Figure 7a: the dashed blue line shows the expected CR background taken from simulation. The solid blue line is the flux after applying the Surface Veto Array with 0°-75° inclination. The dotted red line is an astrophysical E^{-2}


Module
Digitization, Power &
Communication
DAQ & IceCube
implementation
Simulation
PHD1
basic module
setup fixed
Finalize
Module,
preliminary
digitization
General
Surface Veto Detector
setup developed
PHD2
Trigger
strategies
developed
Preliminary
communication,
implementation
Final module and
test setup developed
PHD3
Preliminary development
of the detector completed
Final configuration
and Proposal
Detector
geometry
developed
Full simulation
toolset
Postdoc
0
1
2
3
4
5
Years


IceCube Lab
IceTop
50 m
IceCube Array
1450 m
DeepCore
Eiffel Tower
324 m
2450 m
2820 m
Bedrock