Searches for PeV Gamma Rays with IceCube

Andrea Parenti and Ioana C. Mariș (Université Libre de Bruxelles)

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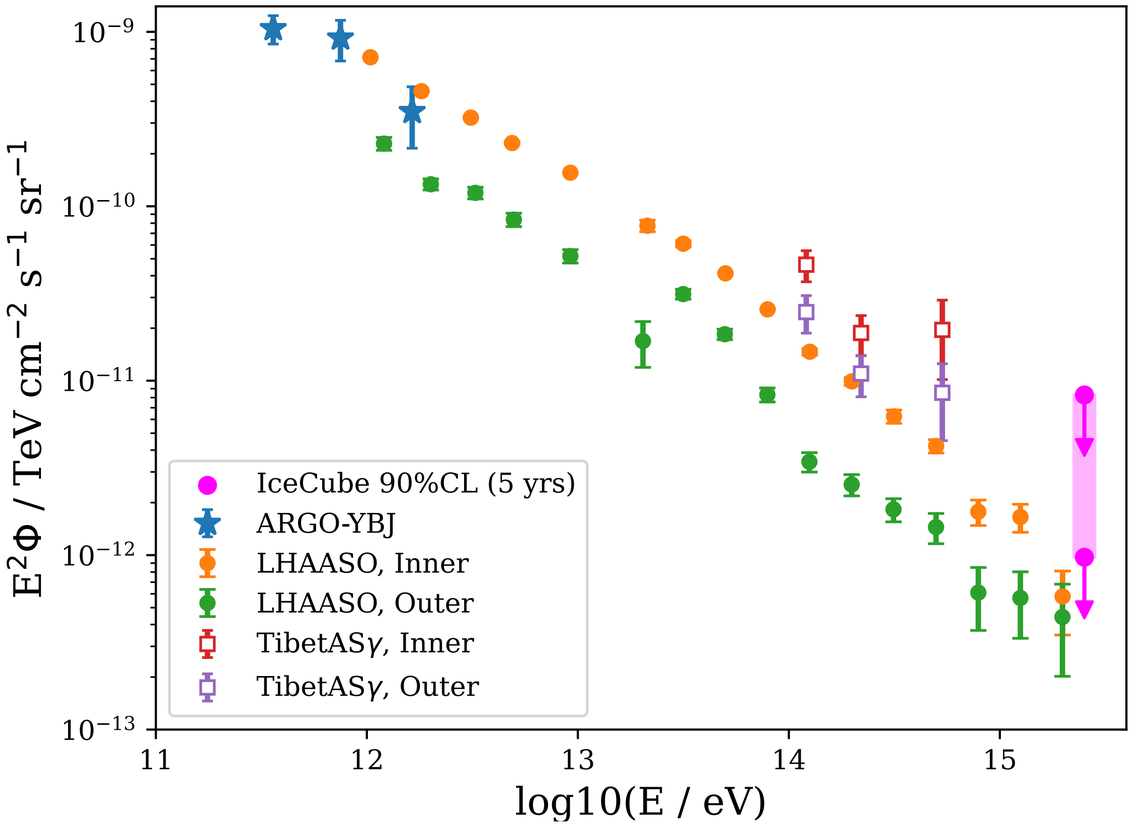
IceCube searches for PeV gamma-rays



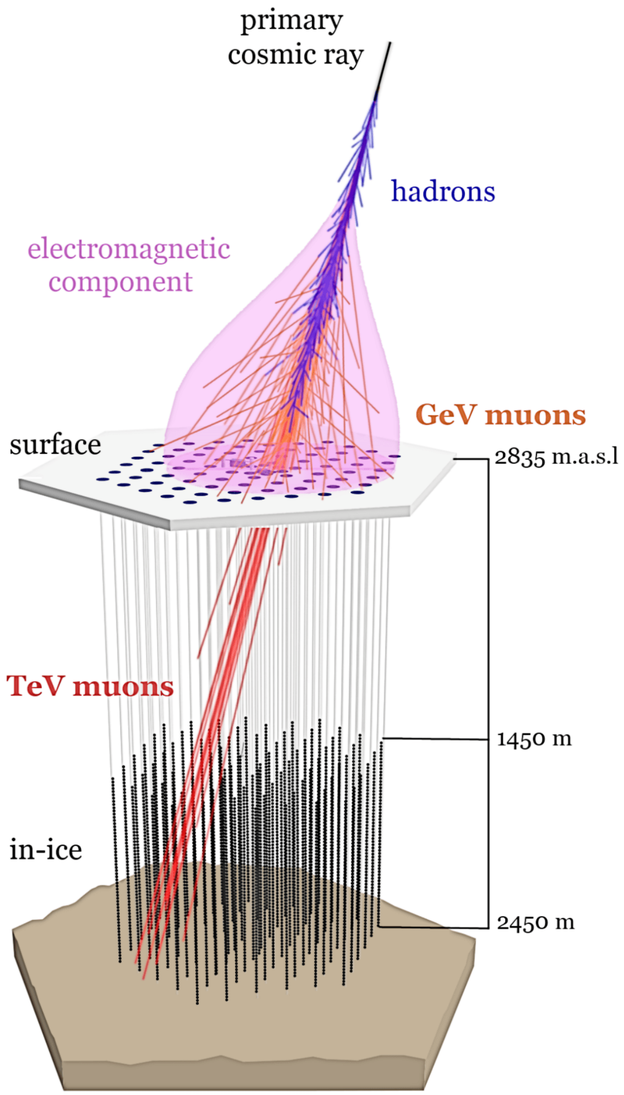
https://arxiv.org/abs/1908.09918

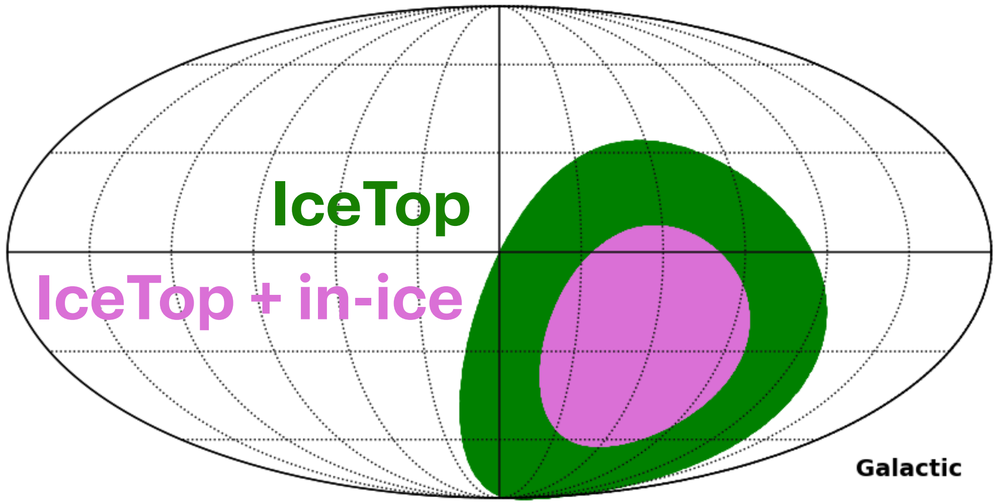
- Unique view of the Southern Sky
- Publication in 2020, using 5 years of IceCube data from 2011 to 2015
- No significant point-like source, upper limit on the diffuse gamma-ray flux at 2 PeV

Go from upper limit to measurement:

- 10+ years of data
- Lower energy threshold
- Better gamma/hadron separation
- Updated hadronic interaction model Sibyll2.3d

Detection strategy





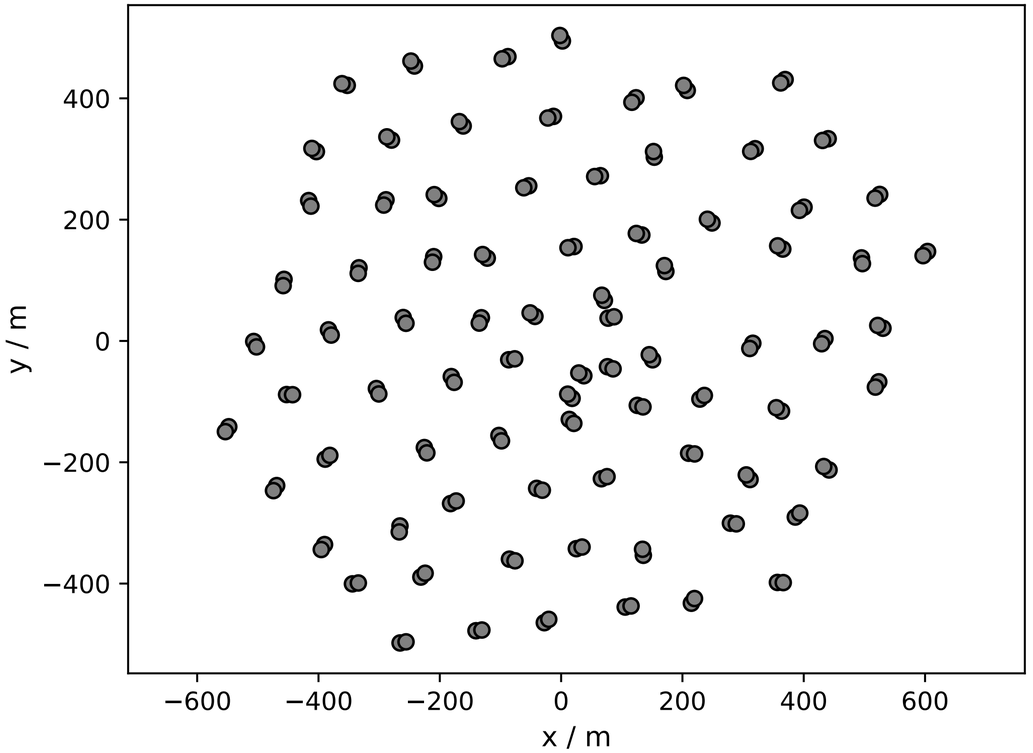
Use IceTop surface detector to reconstruct shower direction and energy

Use in-ice detector as veto

Gamma / hadron separation based on the muon content of the shower

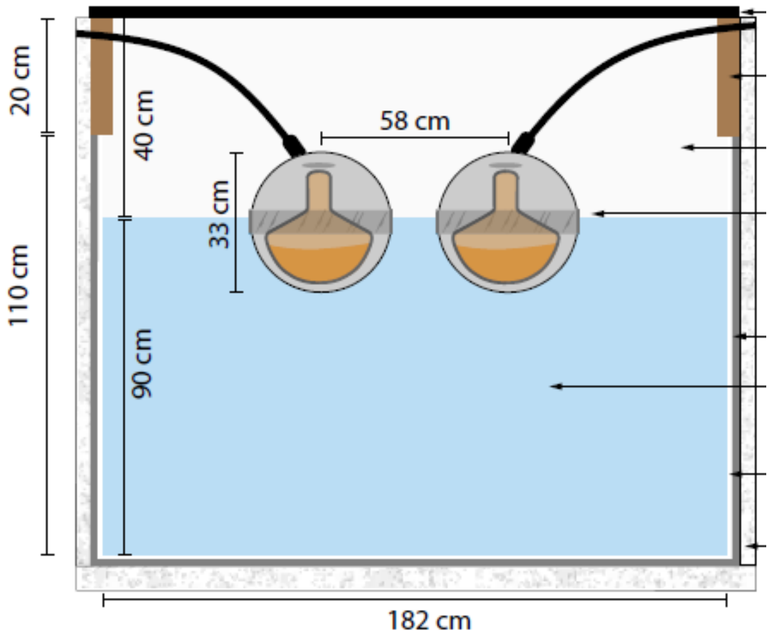
IceTop: the air shower detector

1 km^2 array at 2835 m a.s.l.



81 stations, with two ice Cherenkov tanks each, equipped with two DOMs per tank

IceTop detector is always changing with time due to snow accumulation on top of the tanks



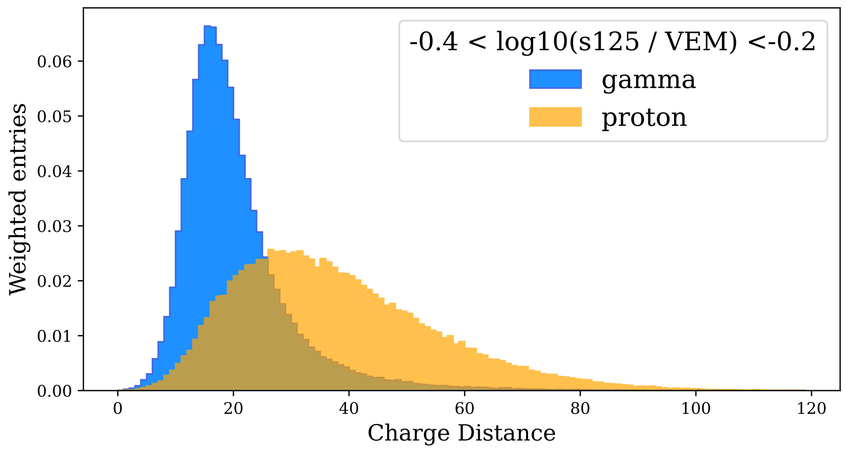
HLC: two tanks of a station have at least one DOM over threshold

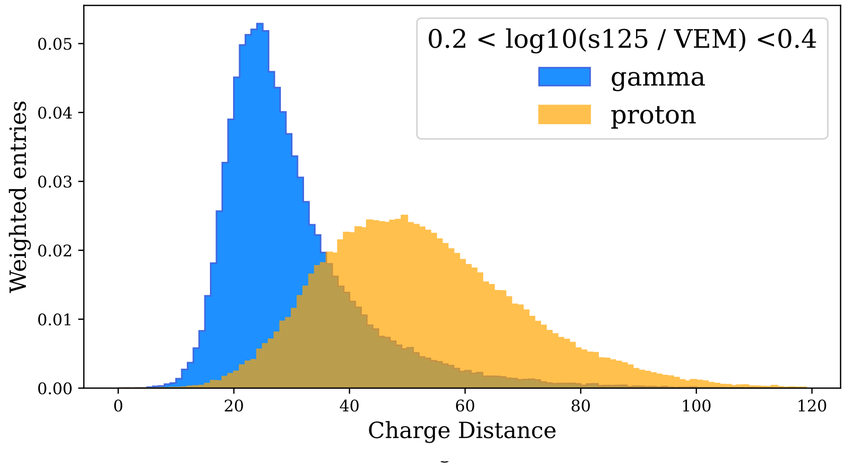
SLC: only one tank in the station has a DOM over threshold

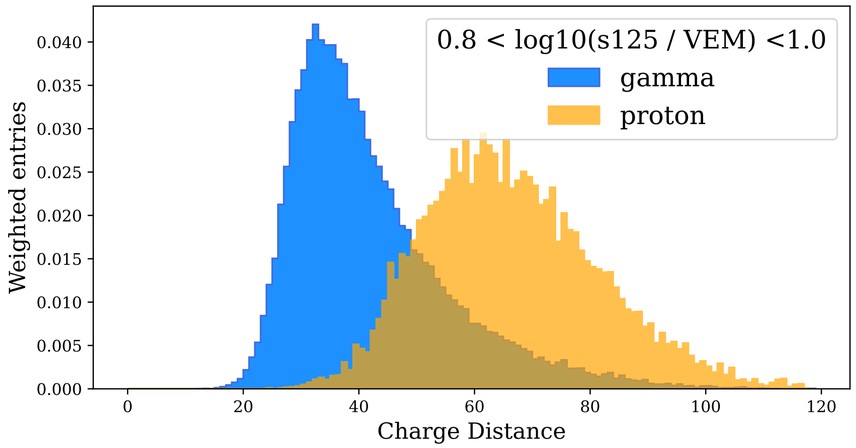
Gamma / hadron separation with IceTop

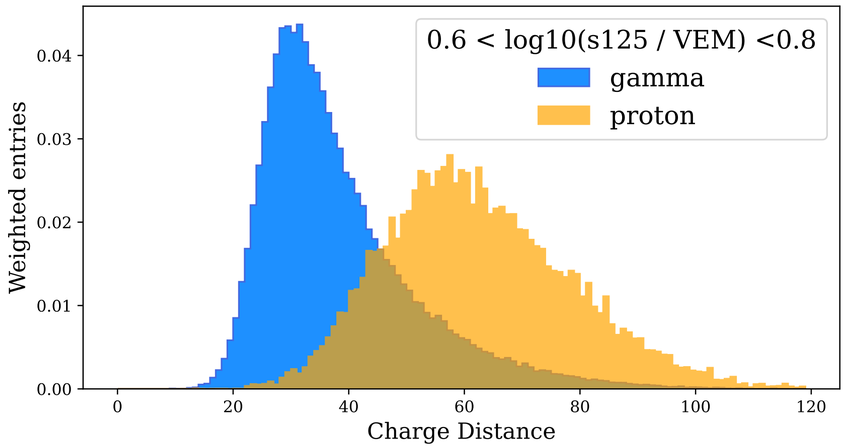
Proton MC 2012
Gamma MC 2012

$$\text{Charge-Distance} = \log_{10}\left[\sum_i \left(\frac{q_i^{\text{SLC}}}{0.1\text{VEM}}\right)^{\frac{R_i}{10\text{ m}}}\right]$$

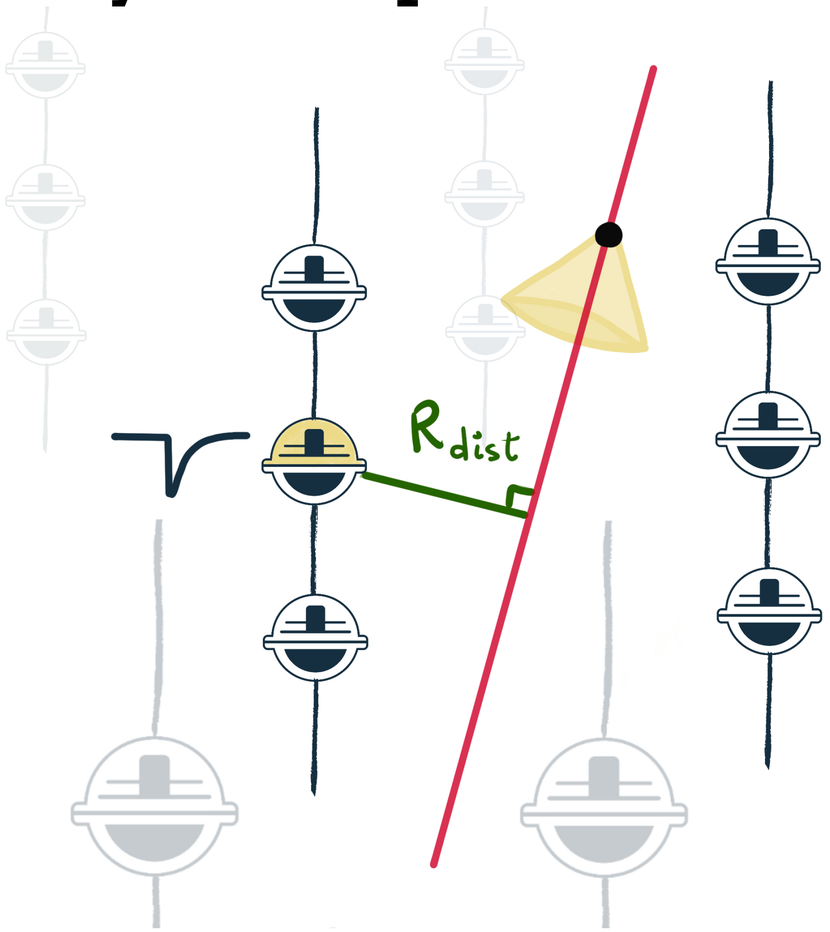




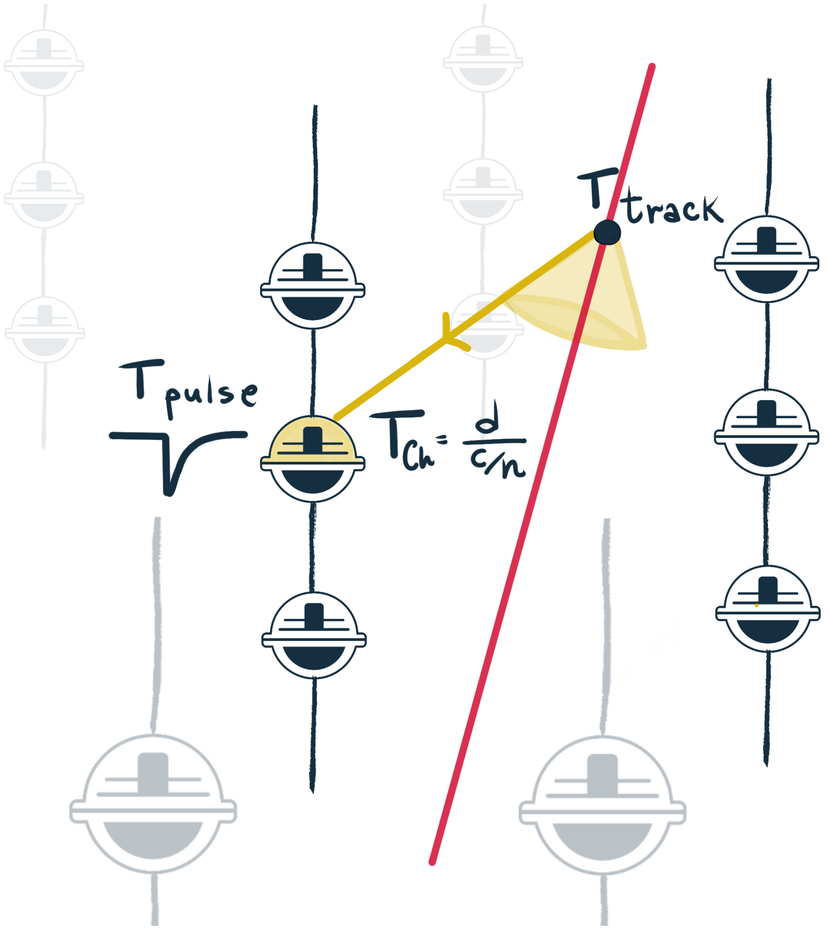




Identify in-ice pulses correlated with air-shower muons



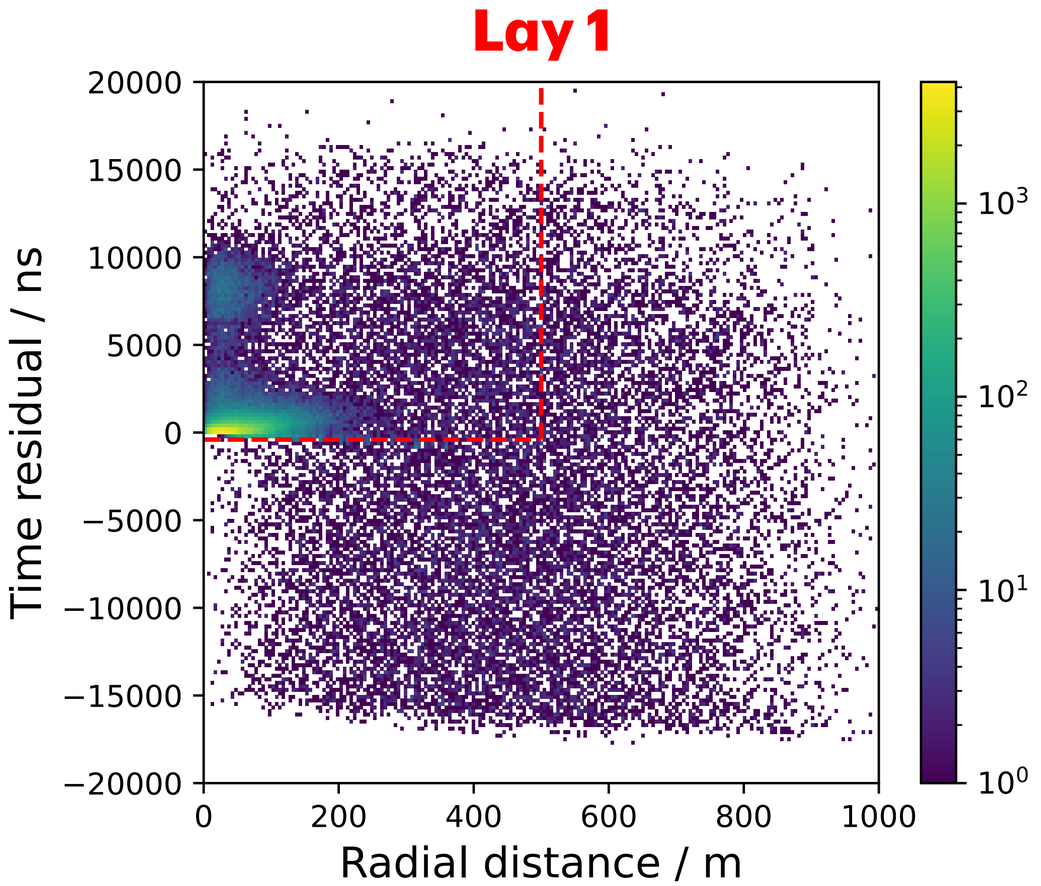
Radial distance



Time residual :

$$T_{pulse} - (T_{track} + T_{Ch})$$

Gamma / hadron separation with the in-ice array



Proton MC 2012
log10(E_{MC} /eV) = [15.1, 15.2]

Use in-ice array as a veto

Define phase space of DOM pulses correlated with the high energy muons

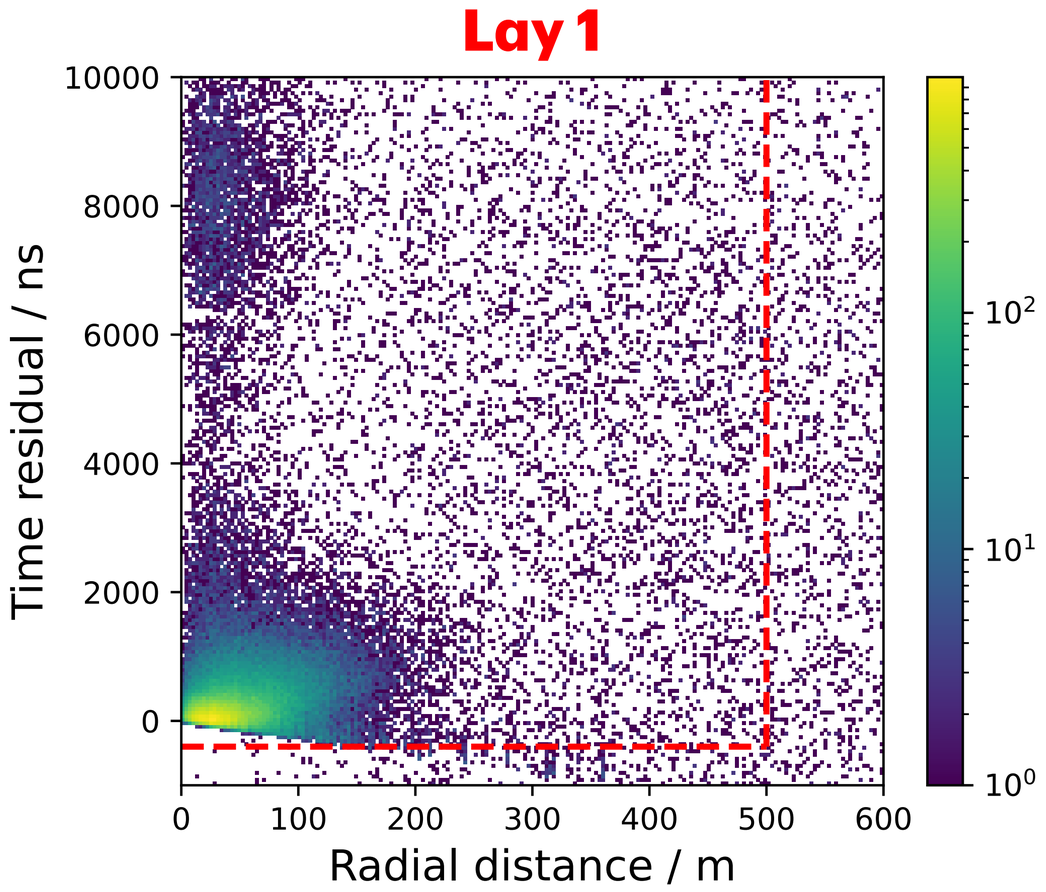
$$N_{lay} = 1,2,3,4$$

$$R < 500 \text{ m}$$

$$\Delta T > -400 \text{ ns}$$

If there is any charge deposit in the veto region, reject the event

Gamma / hadron separation with the in-ice array



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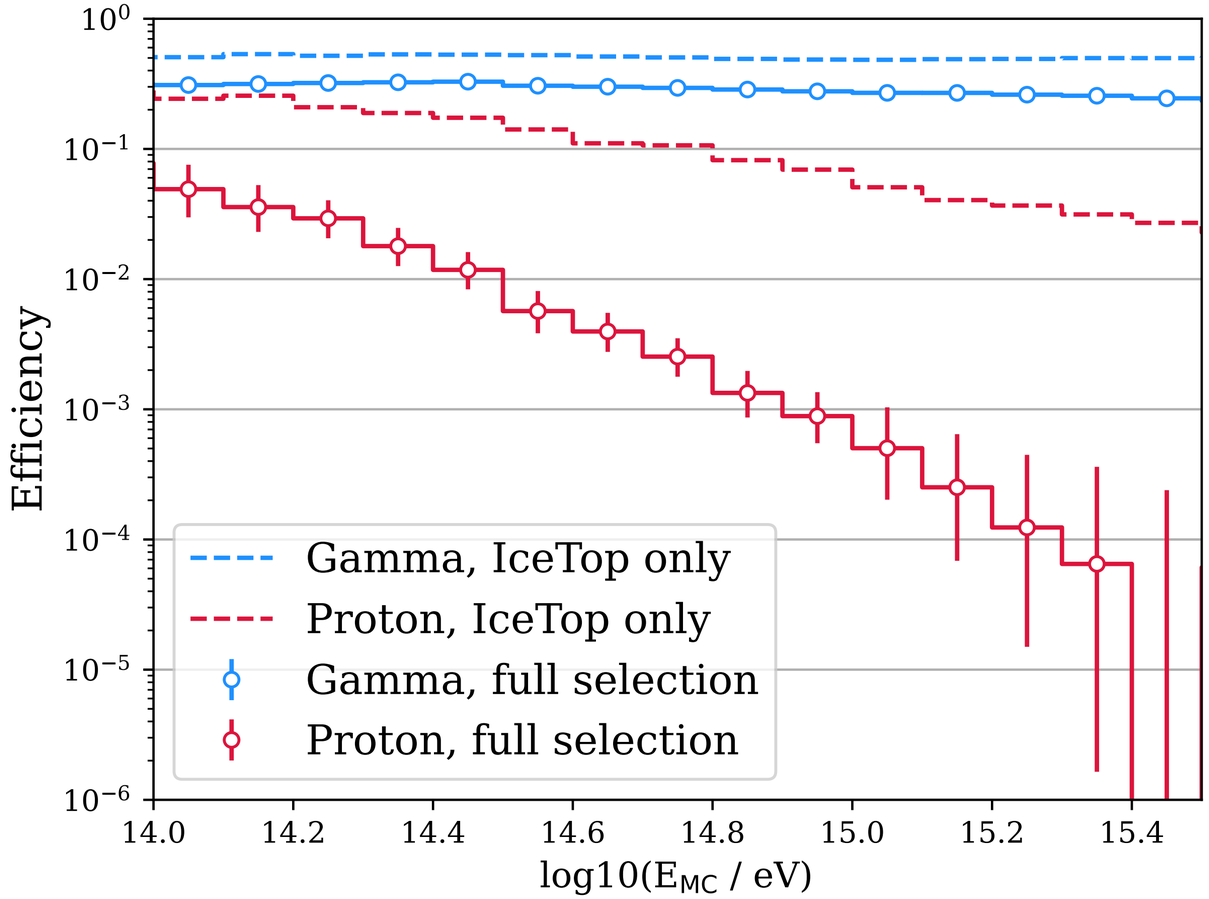
Gamma / hadron total separation

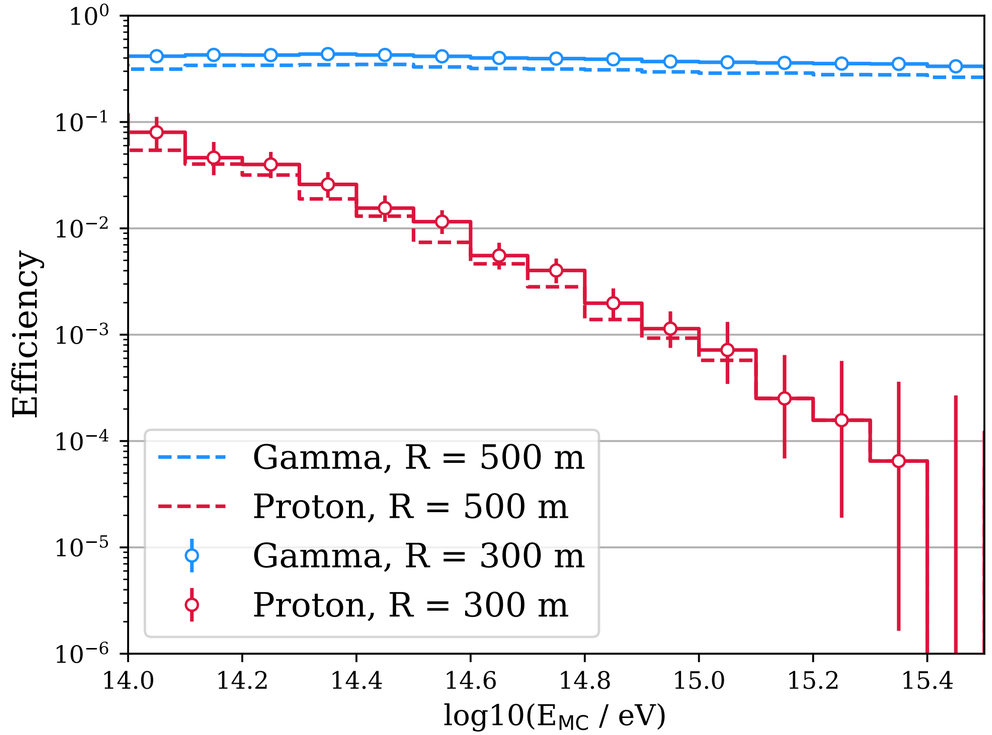


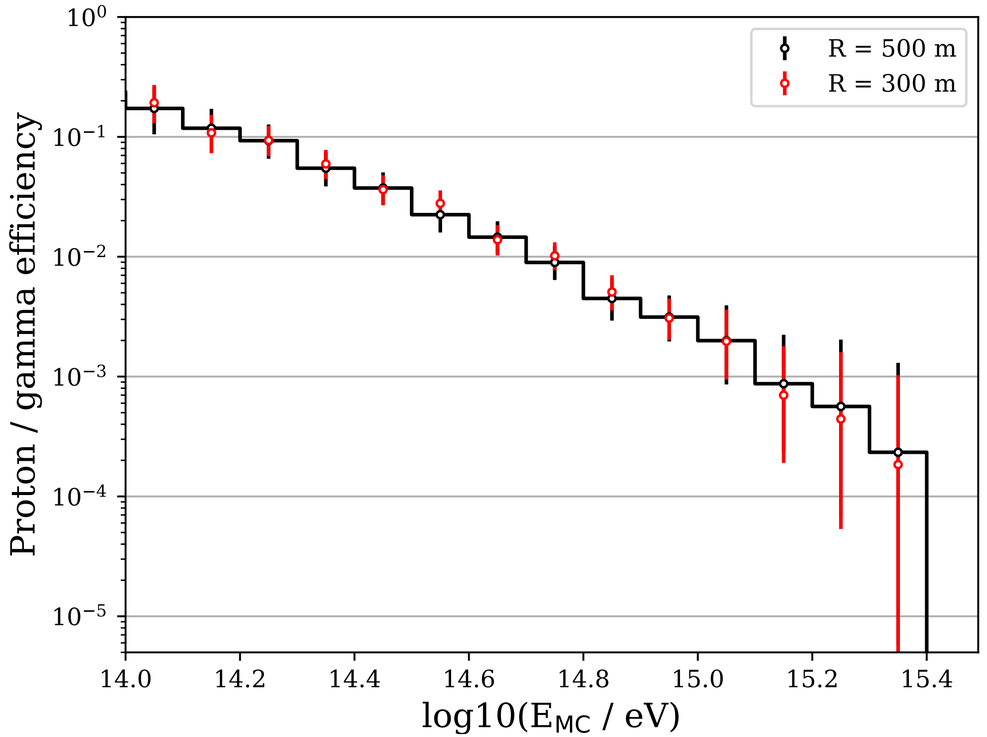
Proton rejection: charge-distance + in-ice veto

With the in-ice veto request, selection is complete

Achieved proton rejection is better than 10^3 above PeV

Gamma / hadron total separation



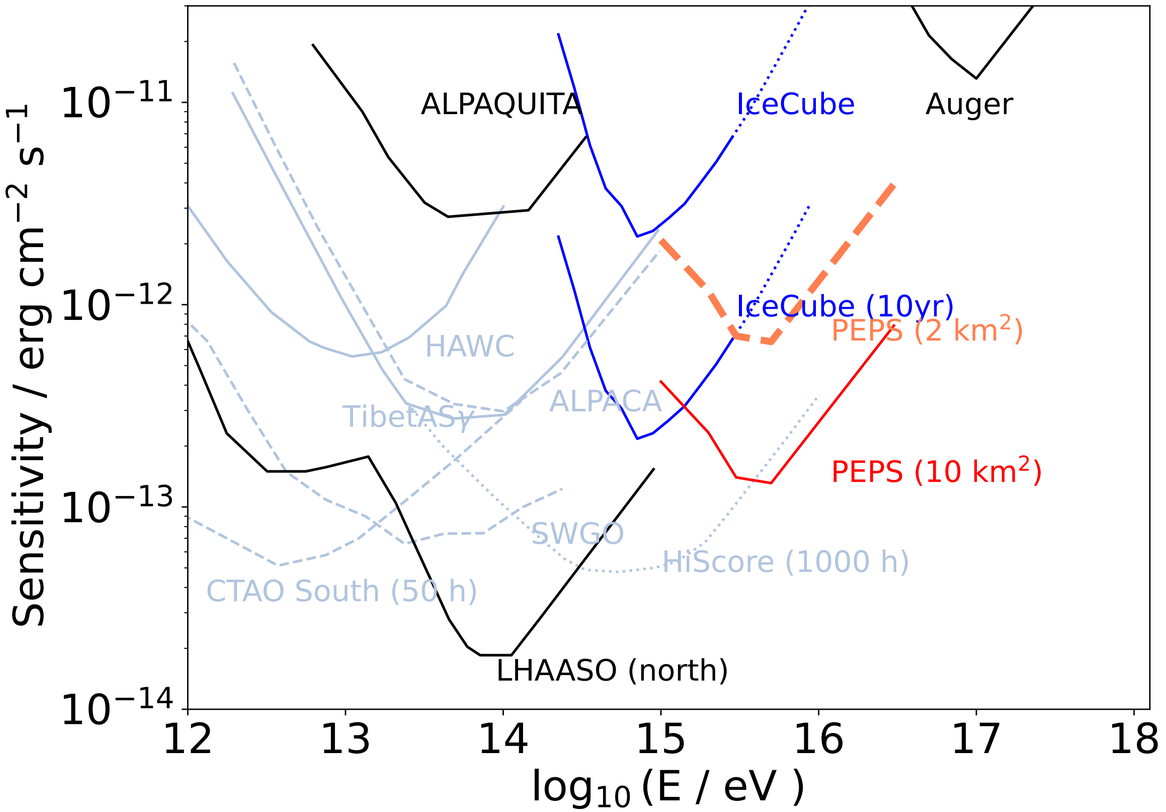


Restricting veto region to R < 300 m increases the gamma efficiency from 30% to 40%

Gamma - hadron separation remains at the same level

Conclusions

Preliminary IceCube 1yr sensitivity to point like source



- Unique view of the Southern Sky in the PeV regime
- Promising perspective with full 10+ years dataset
- Improved gamma / hadron separation

Outlook:

- Produce simulations for different years
- Tune in-ice veto region to increase gamma-ray efficiency