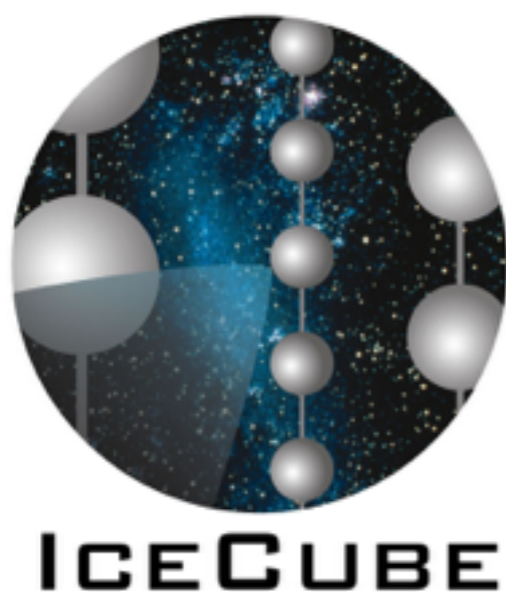


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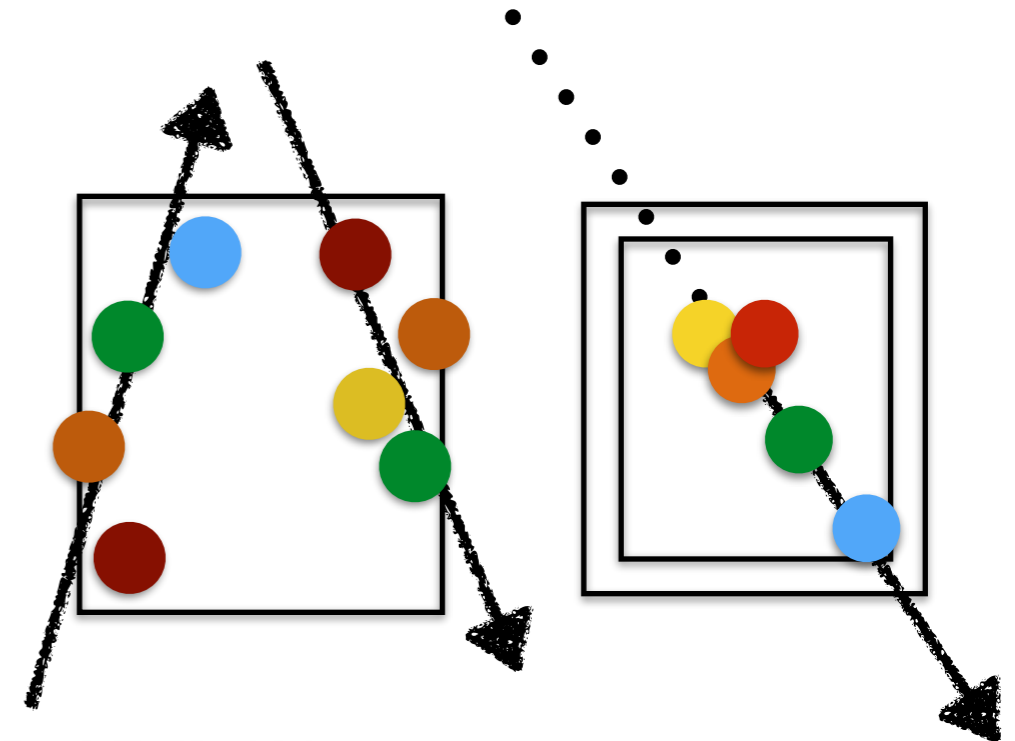
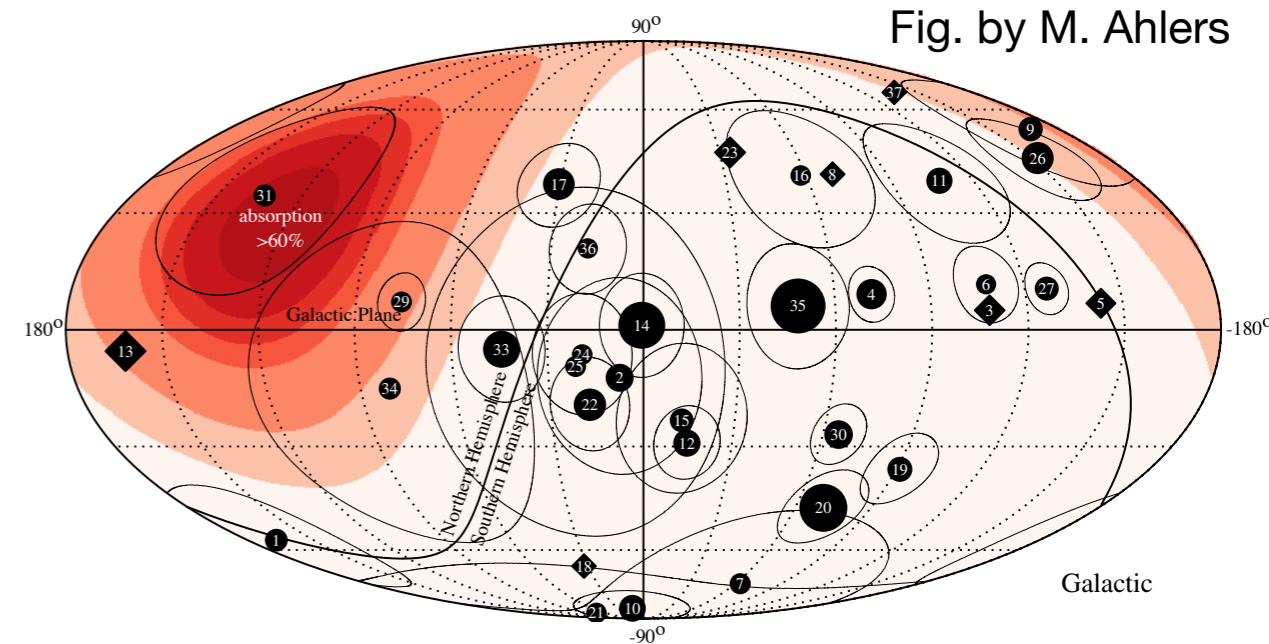
IceCube-Gen2 Point Source Sensitivity

2015-01-28

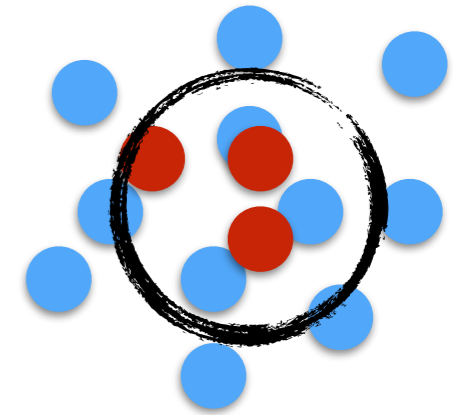
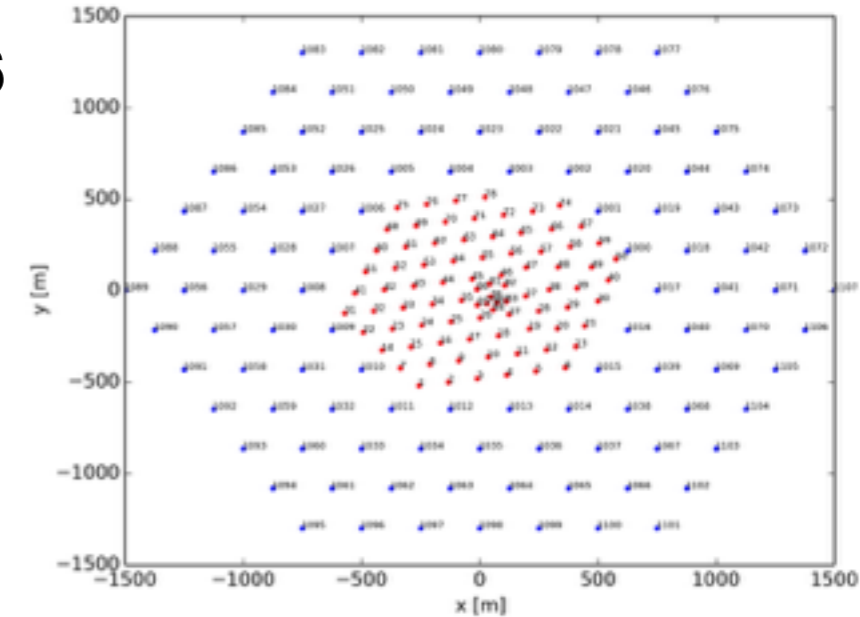
Stefan Coenders, Elisa Resconi
IceCube-Gen2 Workshop, Madison



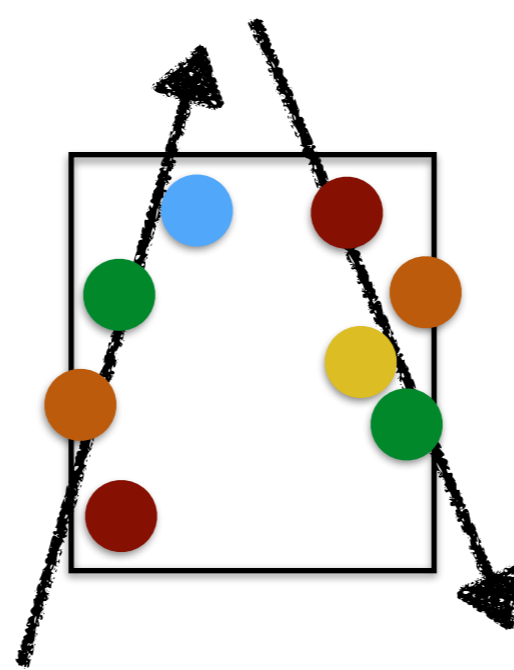
- Clear detection of astro-physical component in IceCube
 - Cascades
 - Up-going muon component
- What is the origin of these neutrinos?
- *IceCube-Gen2* point source capabilities
 - Through-Going searches
 - Starting event searches



- Instrumented volume increased by more than a factor of 6 with respect to IceCube
- Quick thoughts from cut & count perspective
 - Background locally uniform
 - Signal source delta function smeared with reconstruction uncertainty
 - Search window size comparable to angular resolution σ
- For starting events, large increase in fiducial volume with high background rejection power ϵ



$$\text{Improv.} \propto \sqrt{A_{\text{eff}}} \times \frac{1}{\sigma} \times \sqrt{\epsilon}$$



Through-going searches

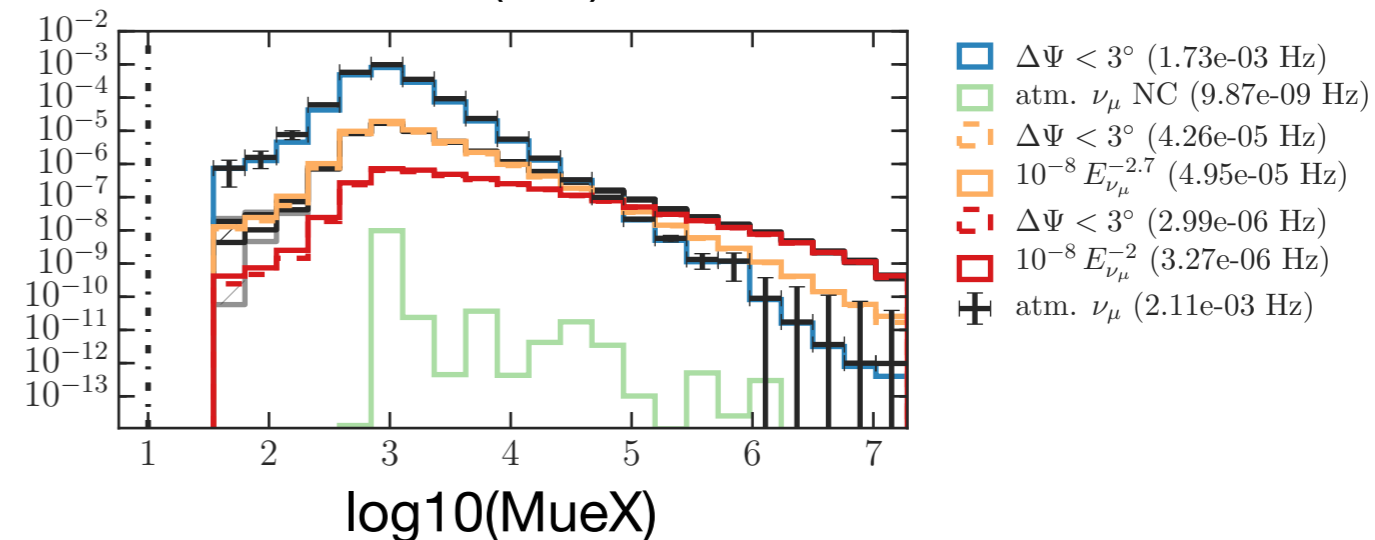
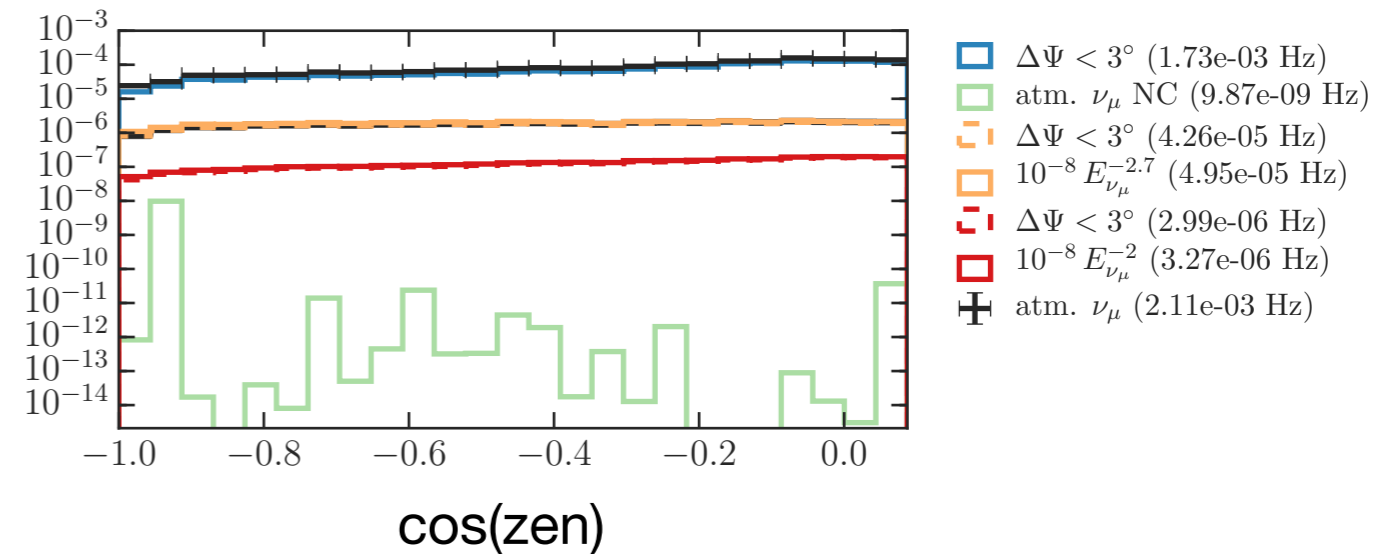
- Based on simulation done by Christian Haack

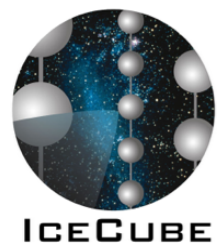
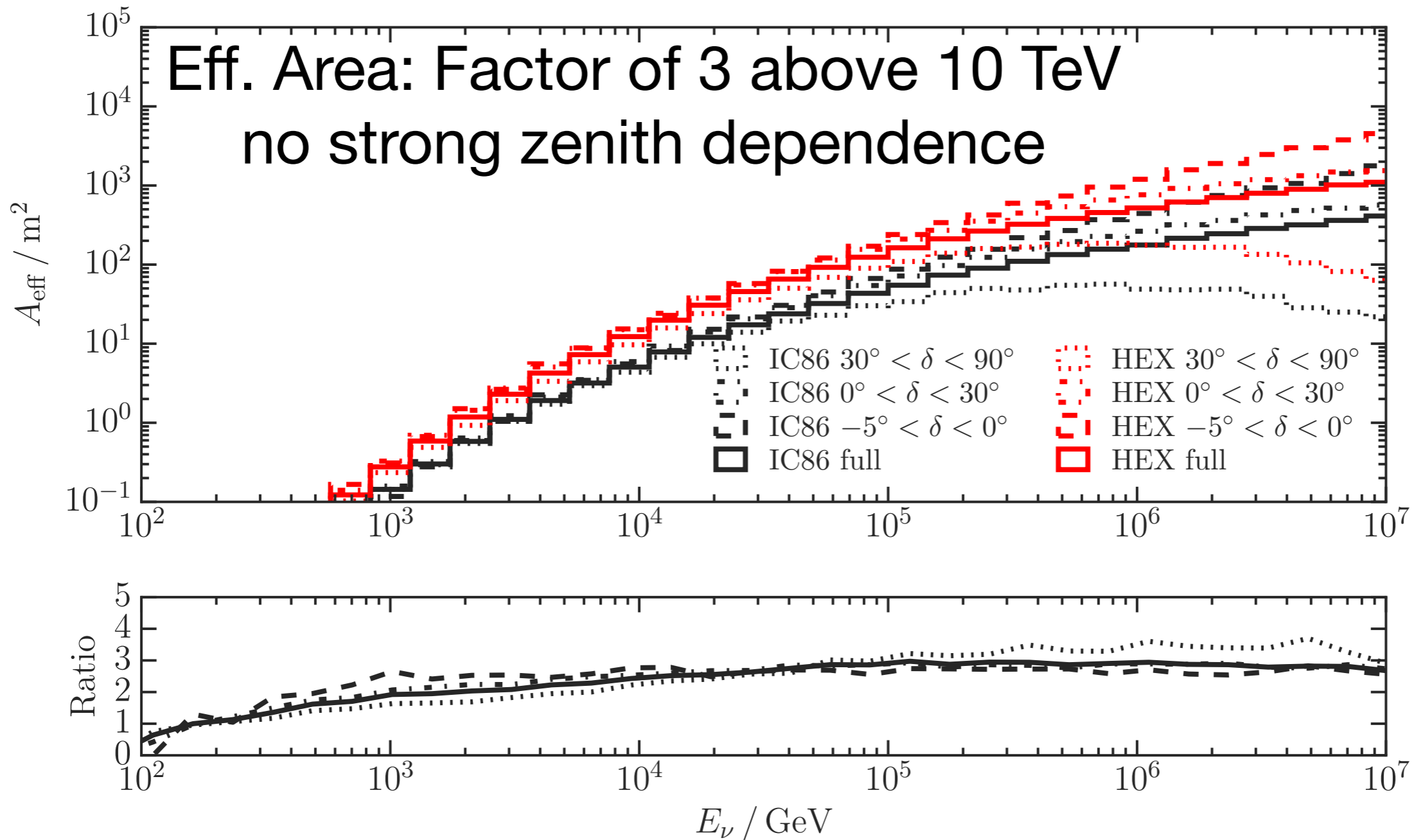
- Up-going NuGen simulation
- CORSIKA missing for DG studies

- Create a typical PS sample

- 3 strings hit
- 6 direct hits
- Paraboloid successful and < 2 deg
- COG at center (no corner-clippers)

- Similar sample for point sources as for IC86-I

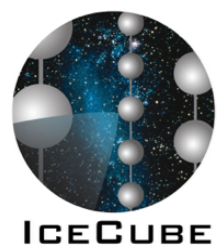
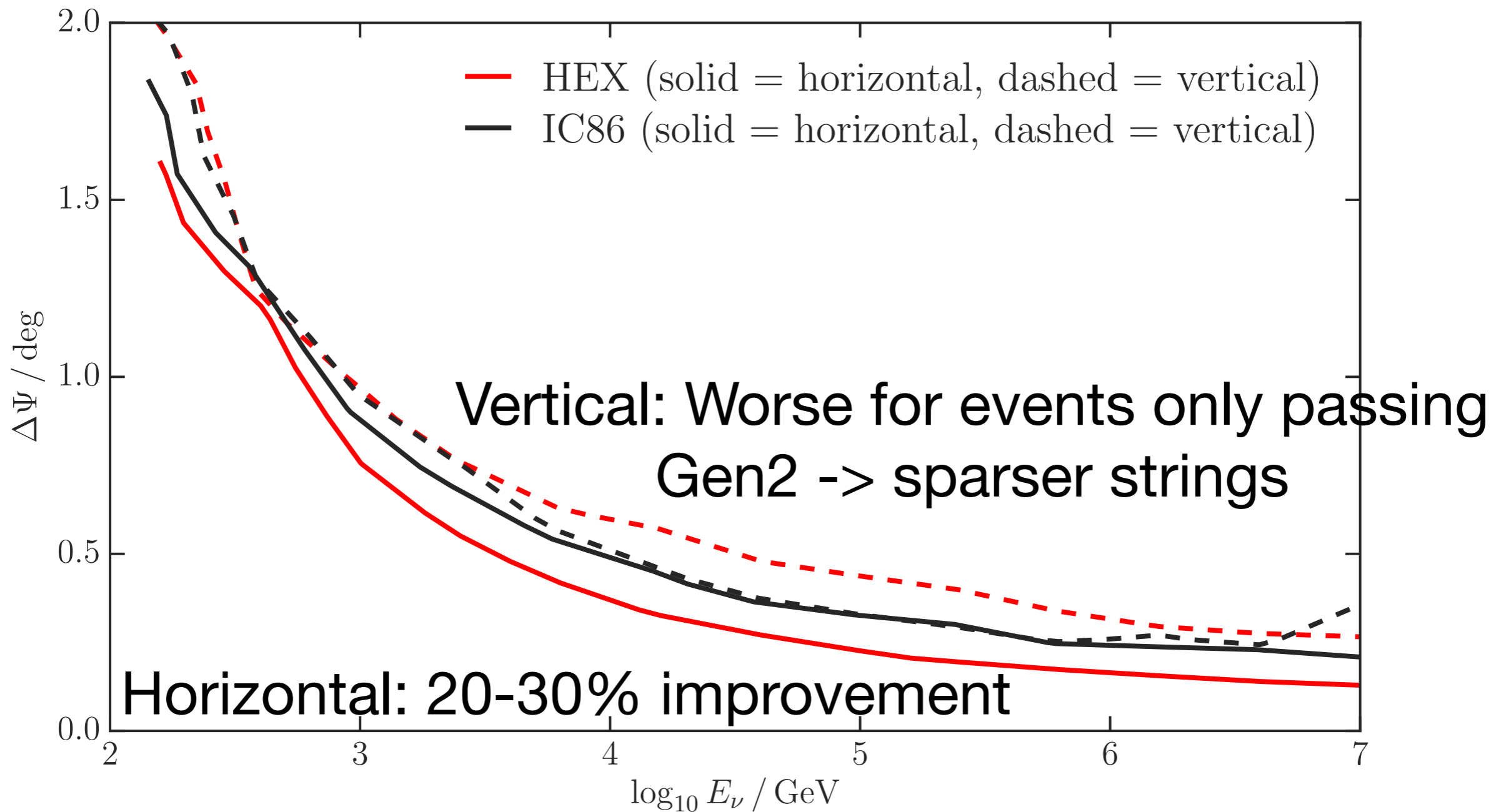




$$\text{Improv.} \propto \sqrt{A_{\text{eff}}} \times \frac{1}{\sigma} \times \sqrt{\epsilon}$$

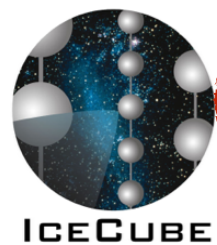
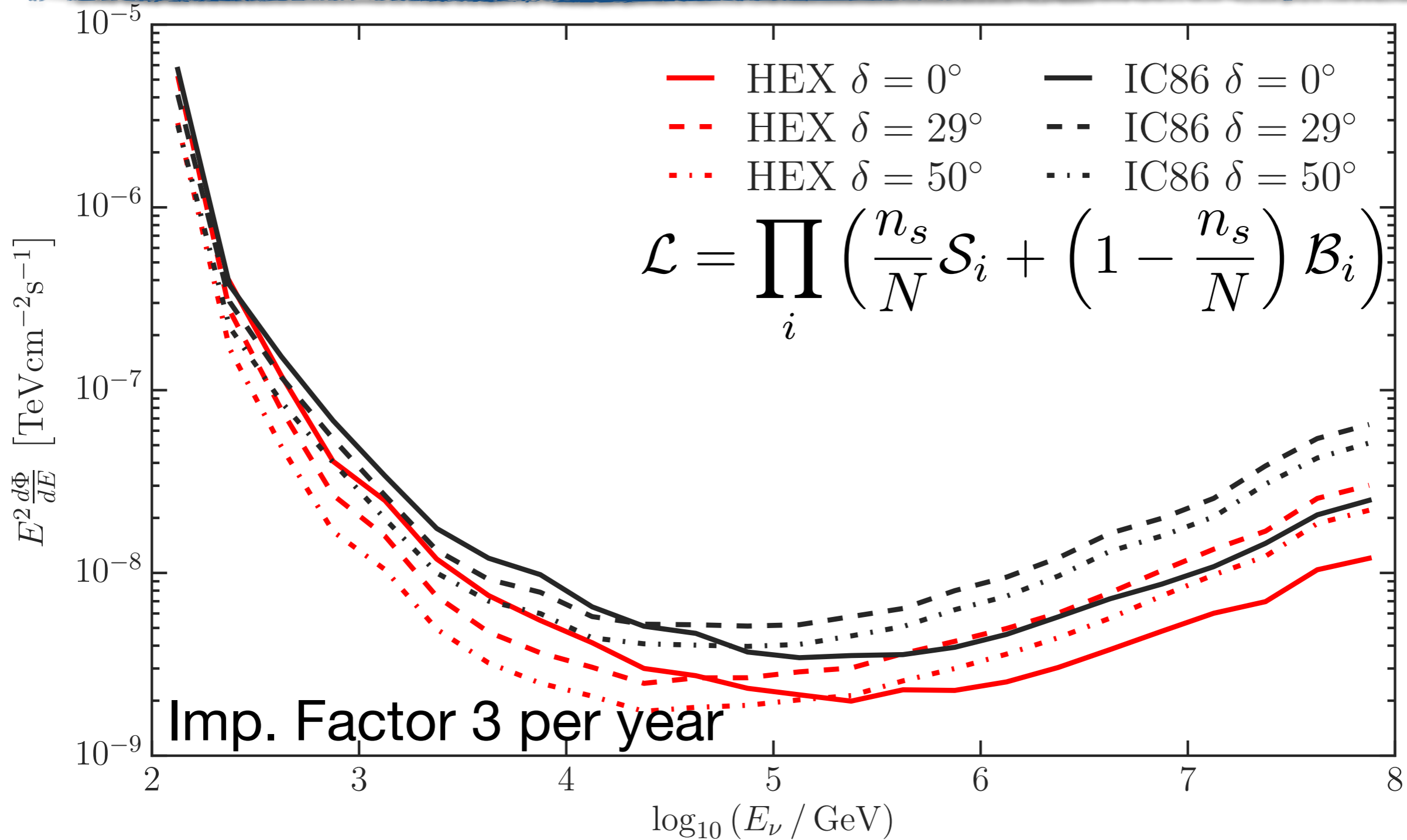
Stefan Coenders
2015-01-28
Gen2 Workshop, Madison





$$\text{Improv.} \propto \sqrt{A_{\text{eff}}} \left\langle \frac{1}{\sigma} \right\rangle \sqrt{\epsilon}$$



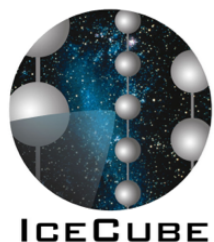


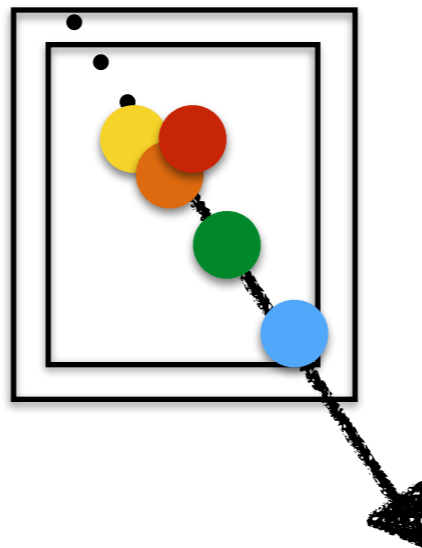
Improv. $\propto \sqrt{A_{\text{eff}}} \times \frac{1}{\sigma} \times \sqrt{\epsilon}$

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 Gen2 Workshop, Madison



- Increasing IceCube in size results in performance gain
 - Bigger effective Area
 - Better reconstruction
- Using current methods, a net gain of 3 is achieved
- Possible gain: Better reconstruction, veto capabilities





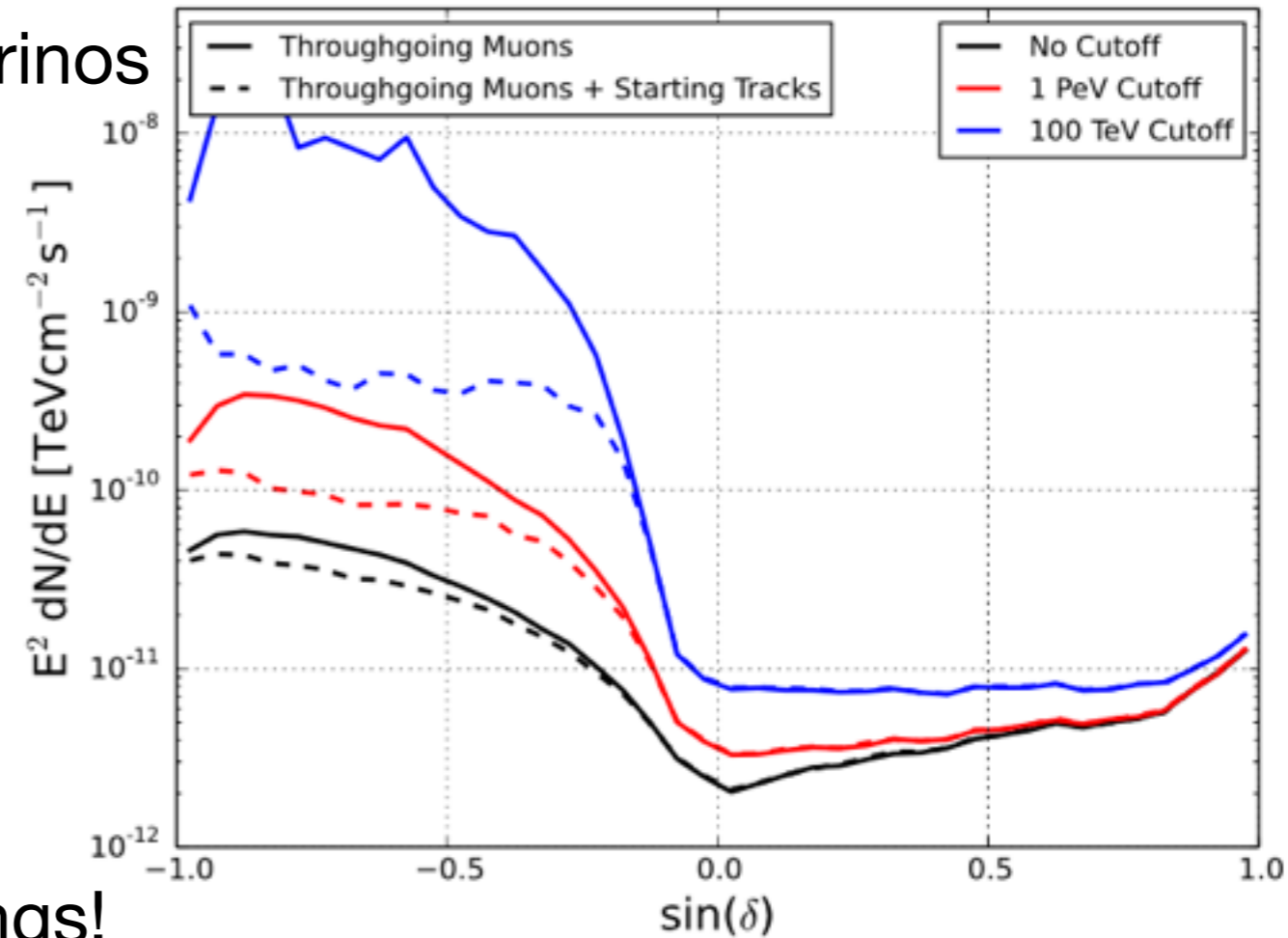
Vetoing atm. Events

$$\text{Improv.} \propto \sqrt{A_{\text{eff}}} \times \frac{1}{\sigma} \times \sqrt{\epsilon}$$

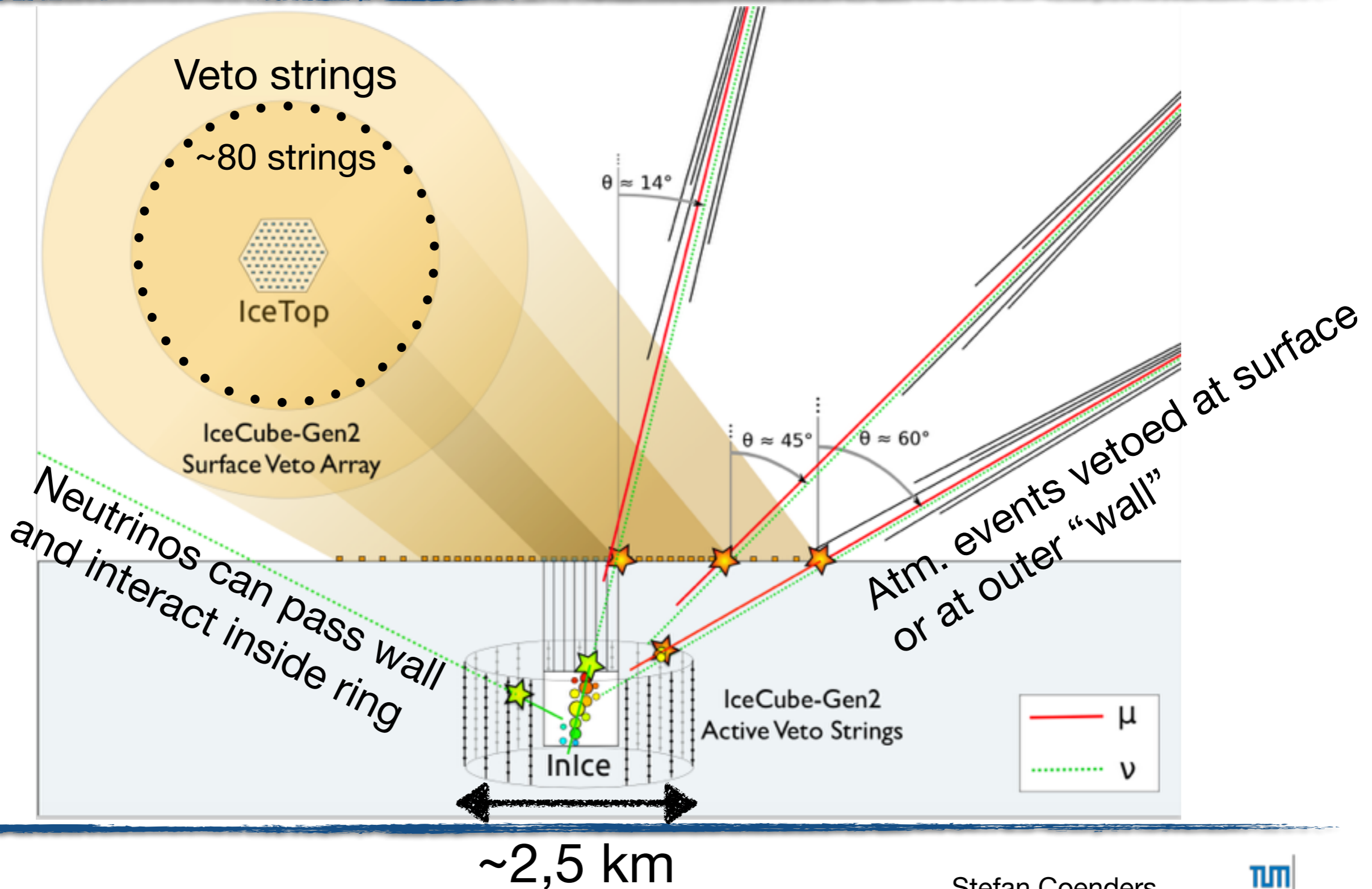
Increasing sample
purity

- Down-going neutrino induced tracks buried under vast background
- Starting events as indicator for neutrinos
- MESE
 - ~500 events in 3 years
 - fiducial volume ~50% IceCube
 - smaller lever arm
- Gen2: IceCube plus active veto strings!

Fig. by J. Feintzeig

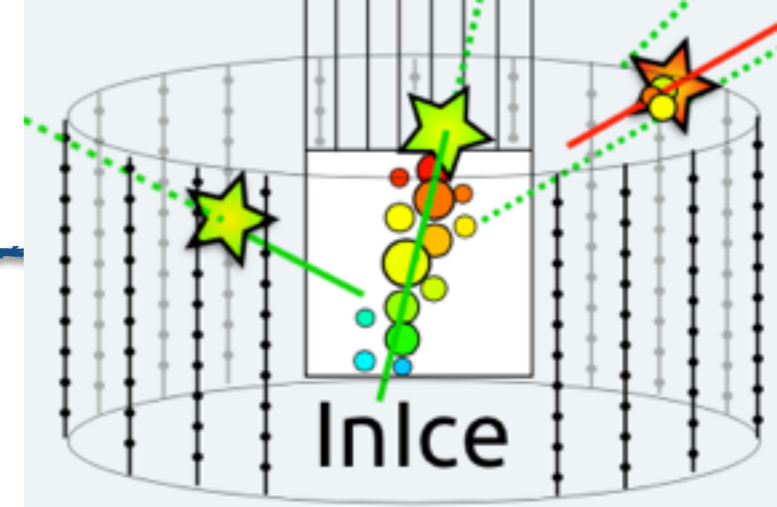


Effectively veto events for IceCube

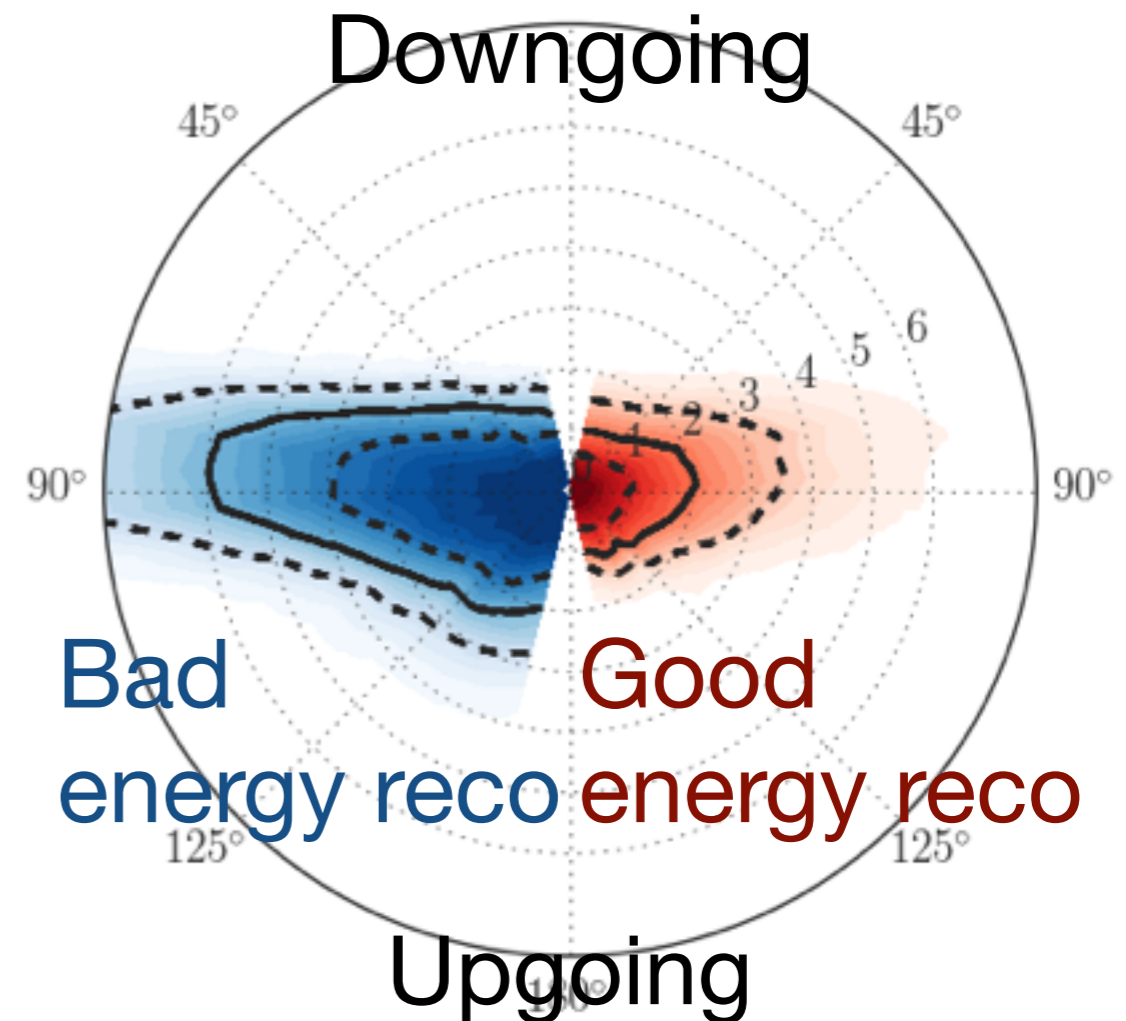


Effectively veto events for IceCube

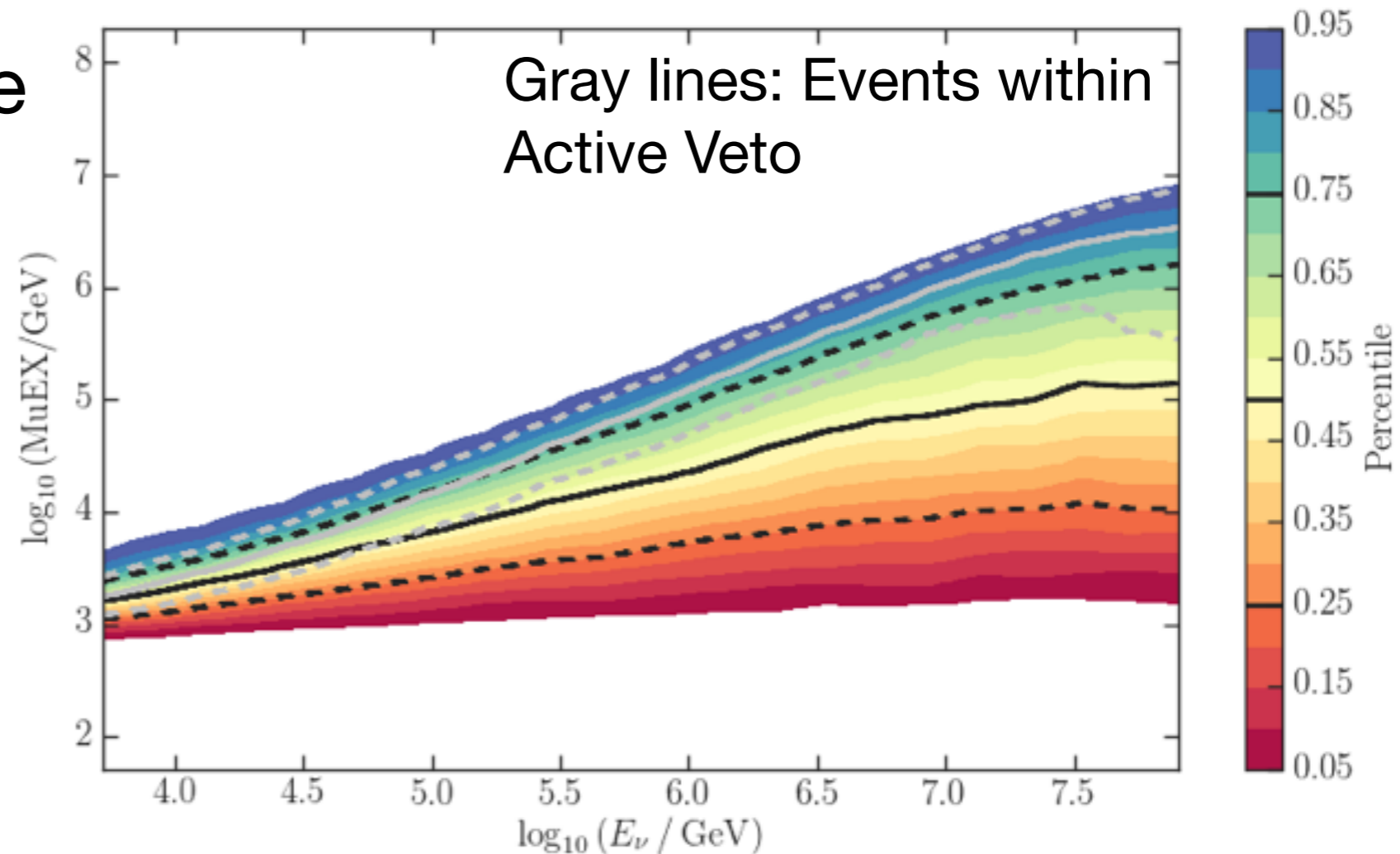
- IceCube detector unchanged
- similar angular reconstruction as IceCube
- Veto reduces atm. background - purity increase
- Collect through-going tracks that started inside of the volume!
- Better neutrino energy reconstruction for events close to IceCube



$$4.2 < \log_{10} (E_\nu / \text{GeV}) < 5.0 \quad (33.8\% E^{-2.3})$$



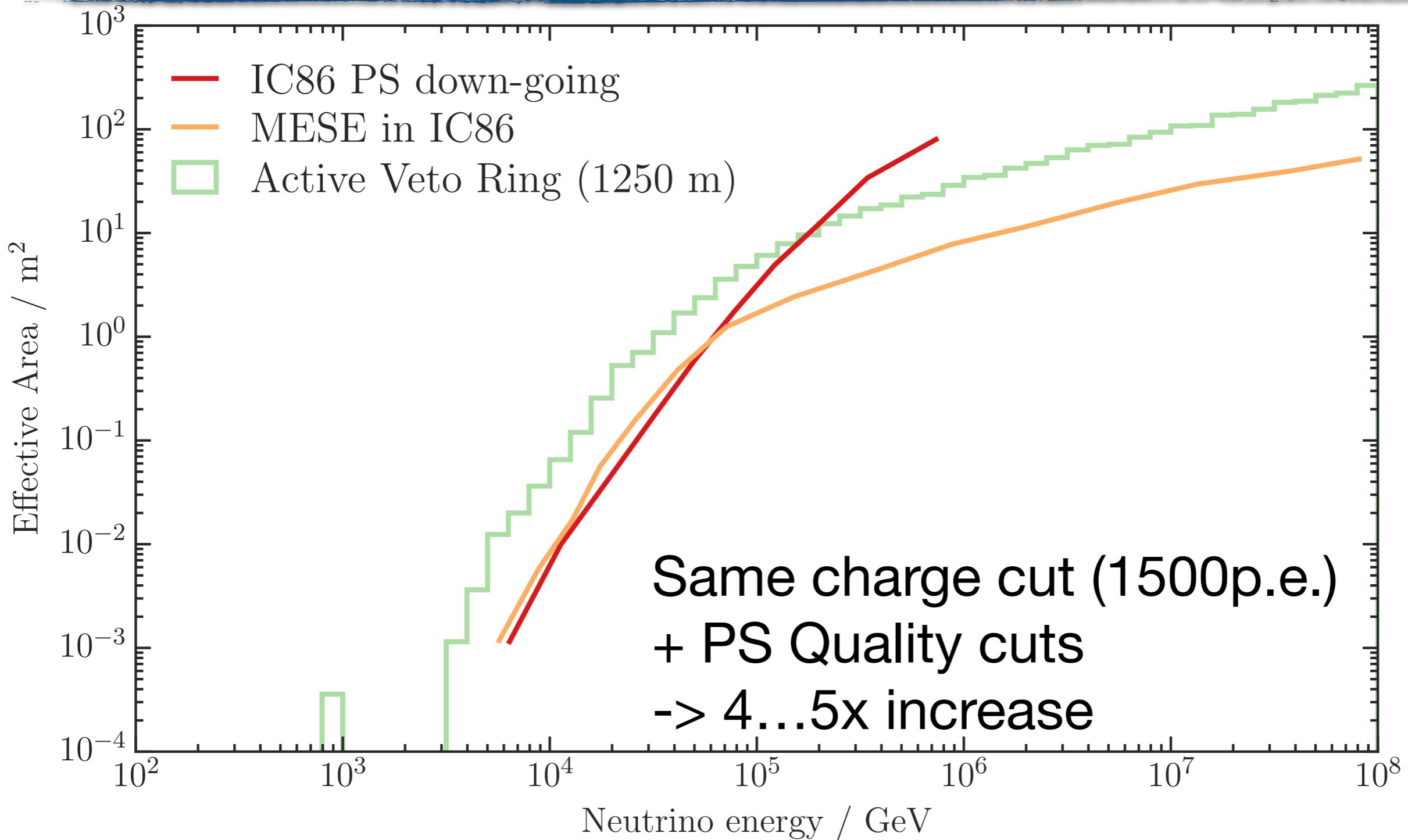
- Large distance between IceCube and neutrino vertex gives large bias in energy reconstruction
- Events within active veto show better correlation
- Potential gain in unbinned LLH formalism

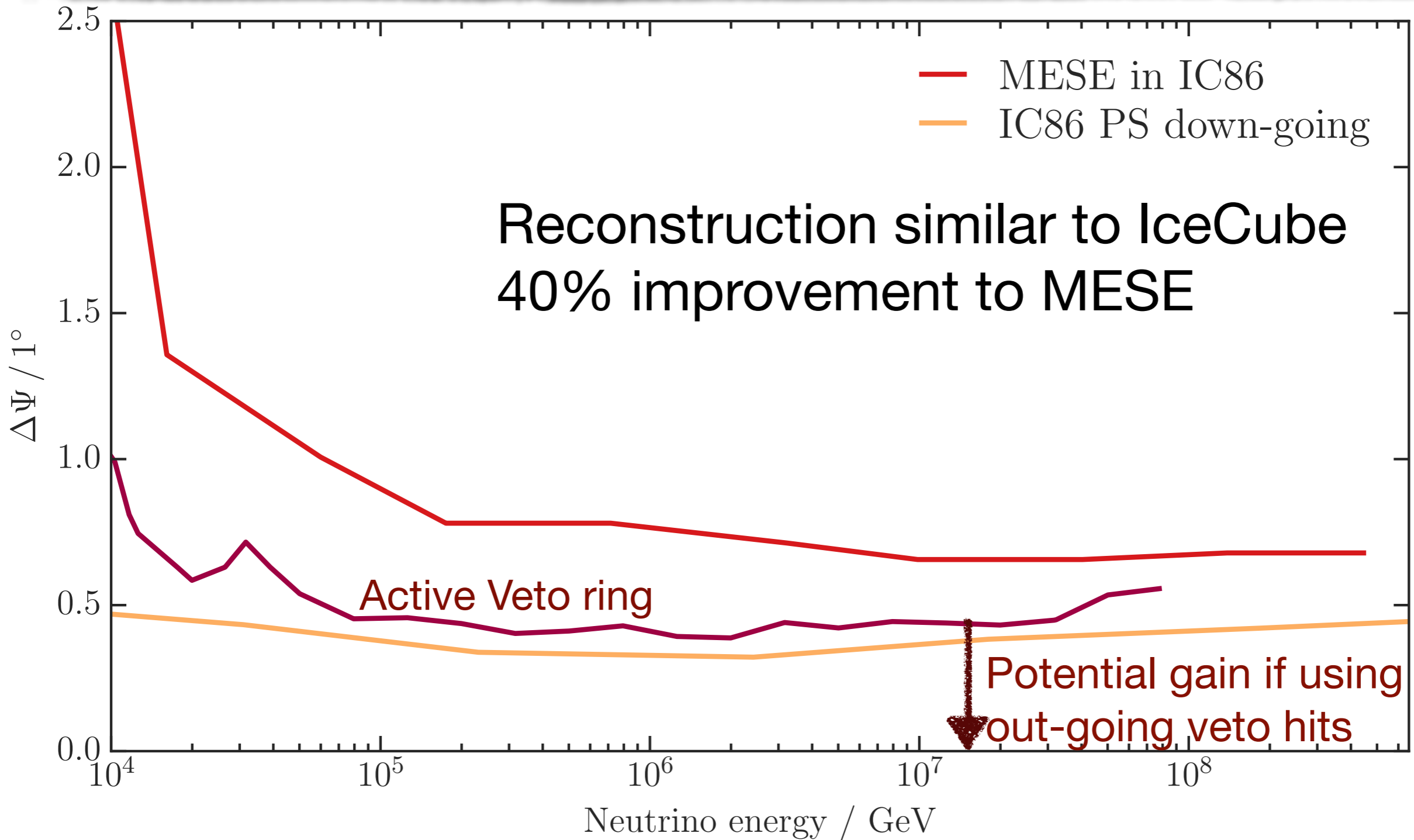


- What does this mean for Point Source searches
- MESE-type analysis using active veto string layer
 - veto-power as MESE analysis
 - better angular reconstruction (full IceCube performance)
- significantly larger fiducial volume with respect to HESE/MESE

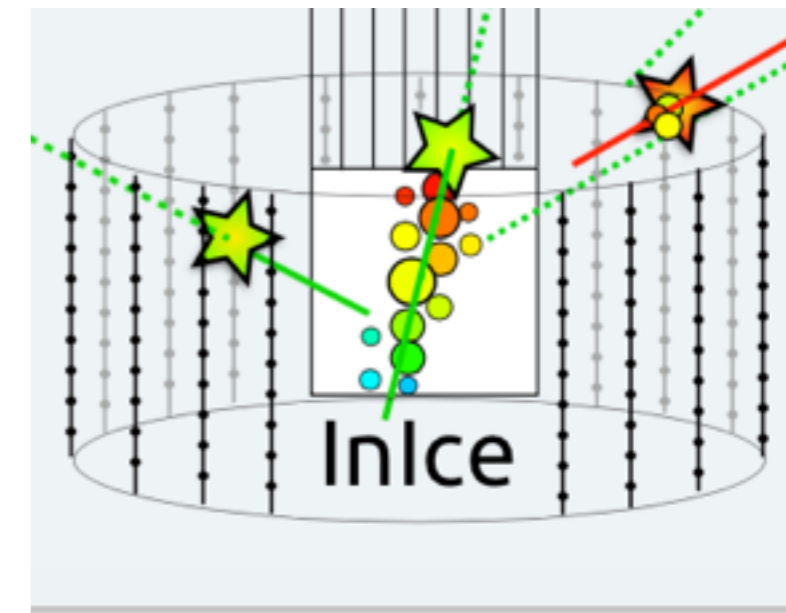


Collection Volume



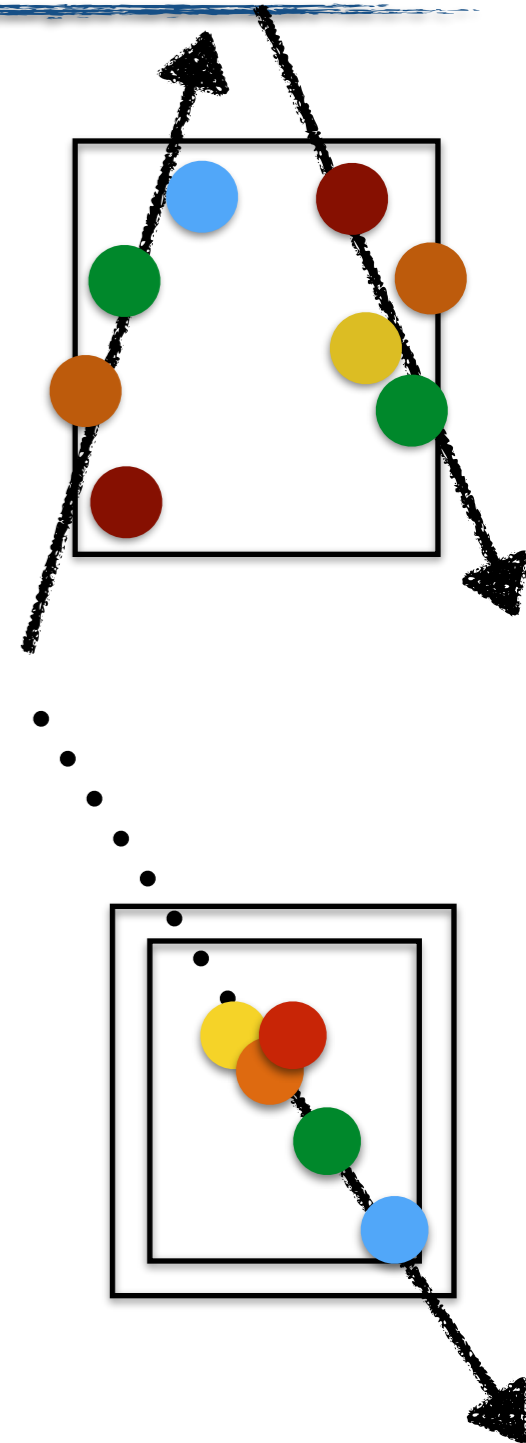


- Adding one layer of IceCube-style strings as an active veto
 - MESE like point source search with increased collection Volume
 - 4x eff Area, 2x incr. ang. reconstruction
 - Improvement ~ 4 per year to MESE, $>10x$ to IceCube
- Uncertainties
 - Veto power for surface events?
 - Energy proxy in unbinned LLH analysis
 - Background simulation needed for detailed future studies

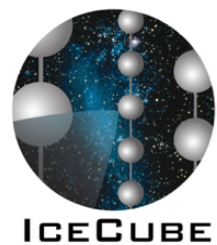


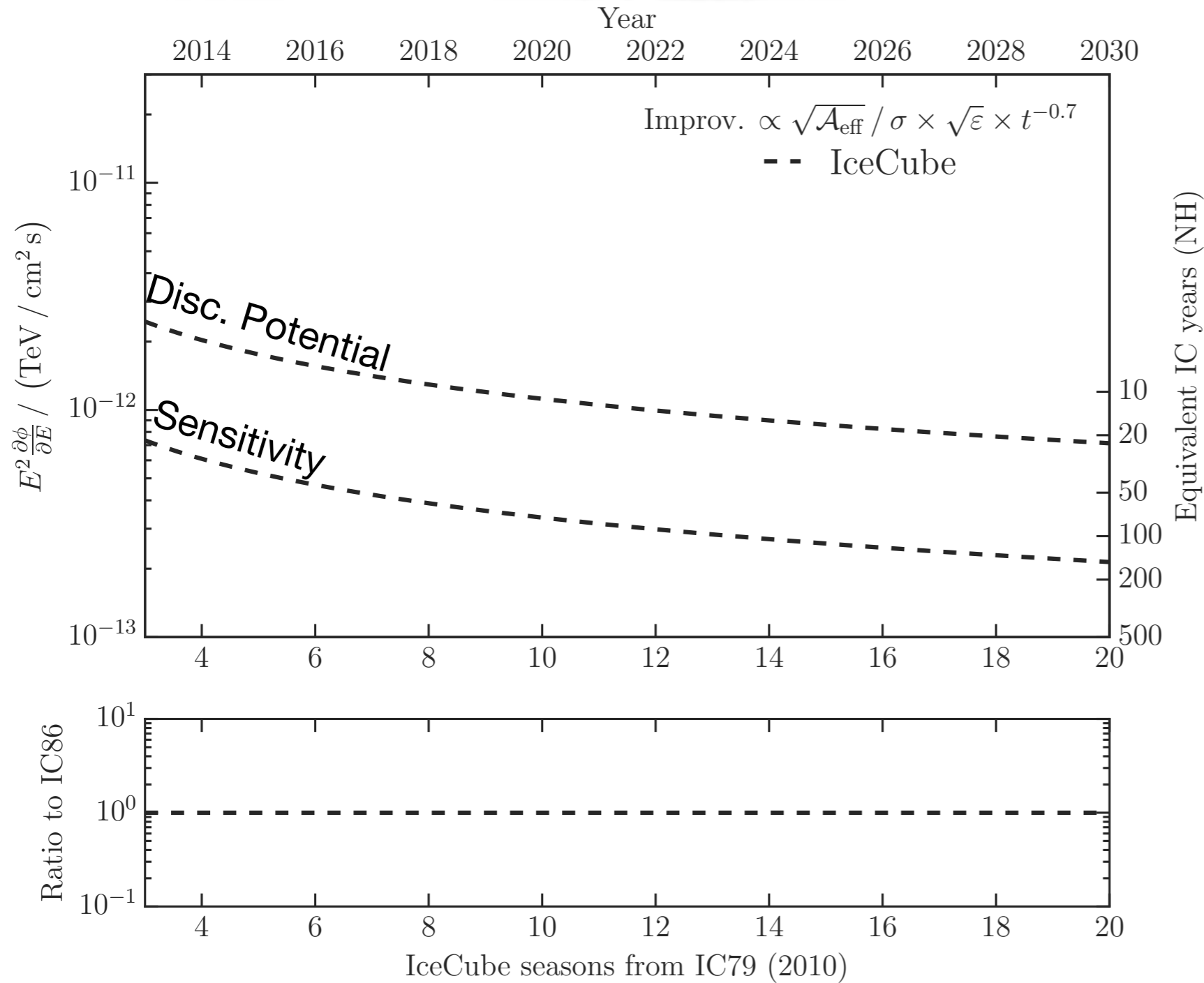
$$\text{Improv.} \propto \sqrt{A_{\text{eff}}} \times \frac{1}{\sigma} \times \sqrt{\epsilon}$$

- IceCube-Gen2
 - effective Area + angular reconstruction improvement
 - ~2.5 times better sensitivity per year
- Active Veto with normal IceCube inside
 - IceCube performance with higher purity (MESE veto)
 - 4 times MESE performance , >10 standard IceCube performance

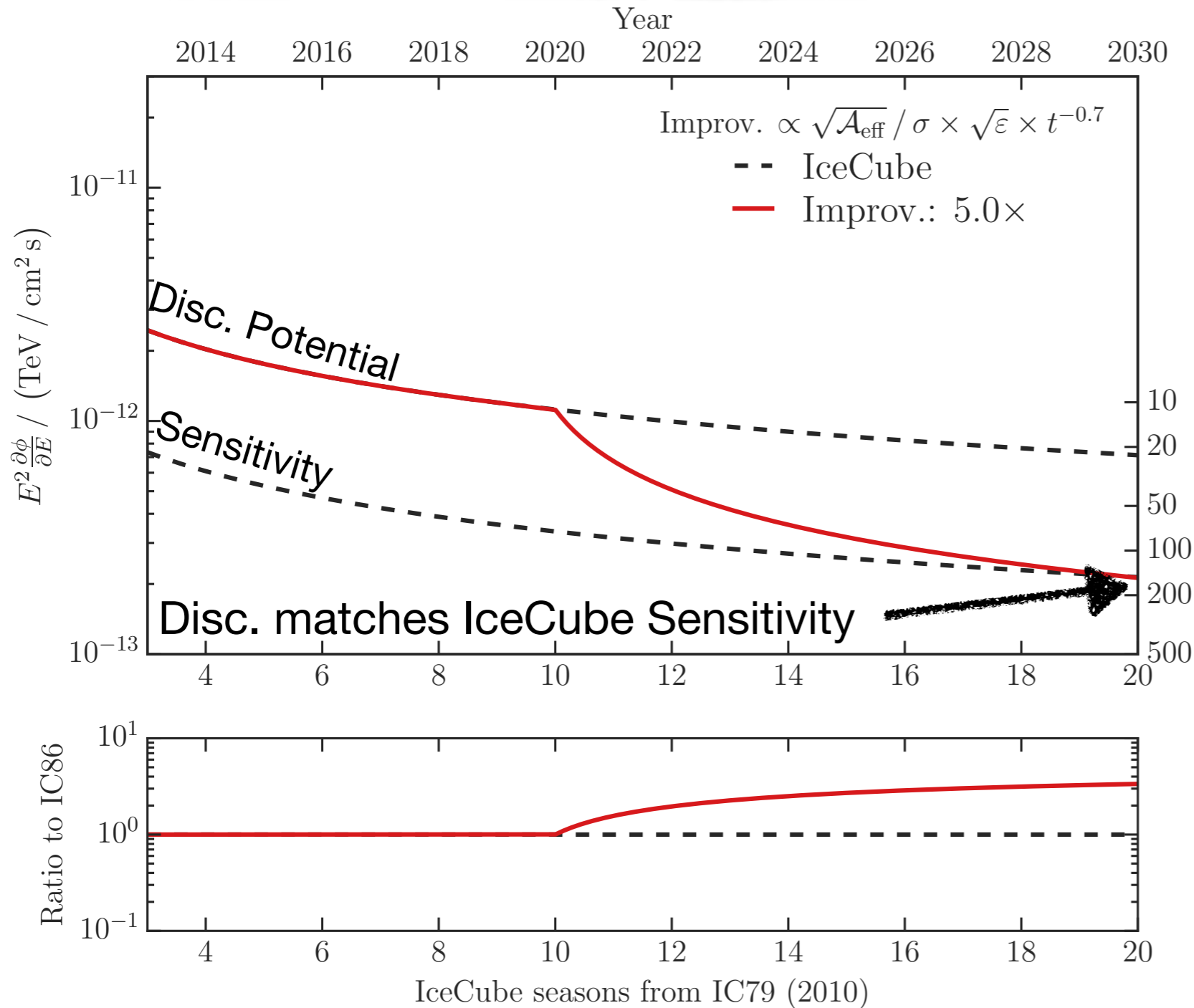


Putting everything together



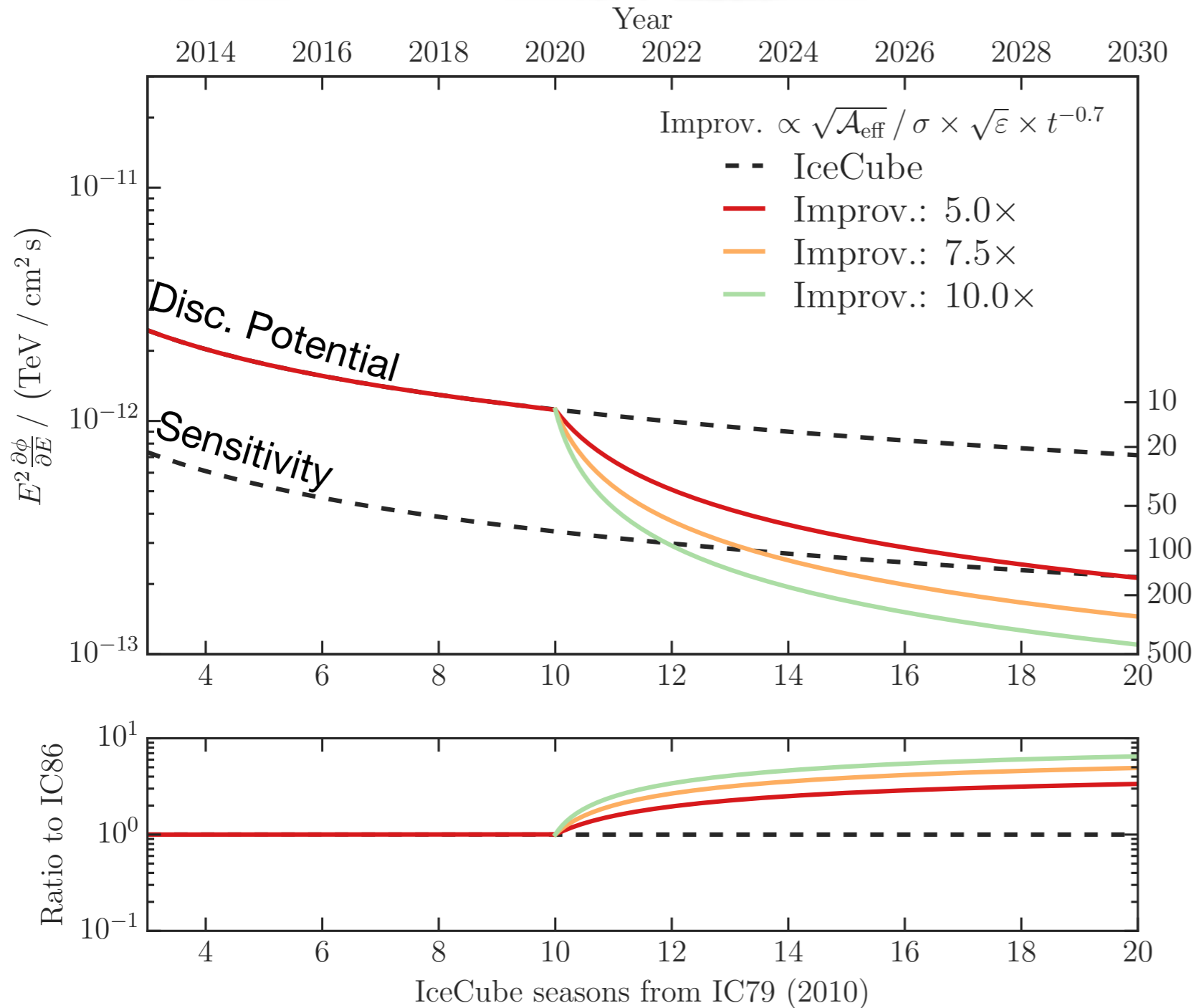


- unbinned LLH calculation suggests $\sim t^{-0.7}$ increase with time

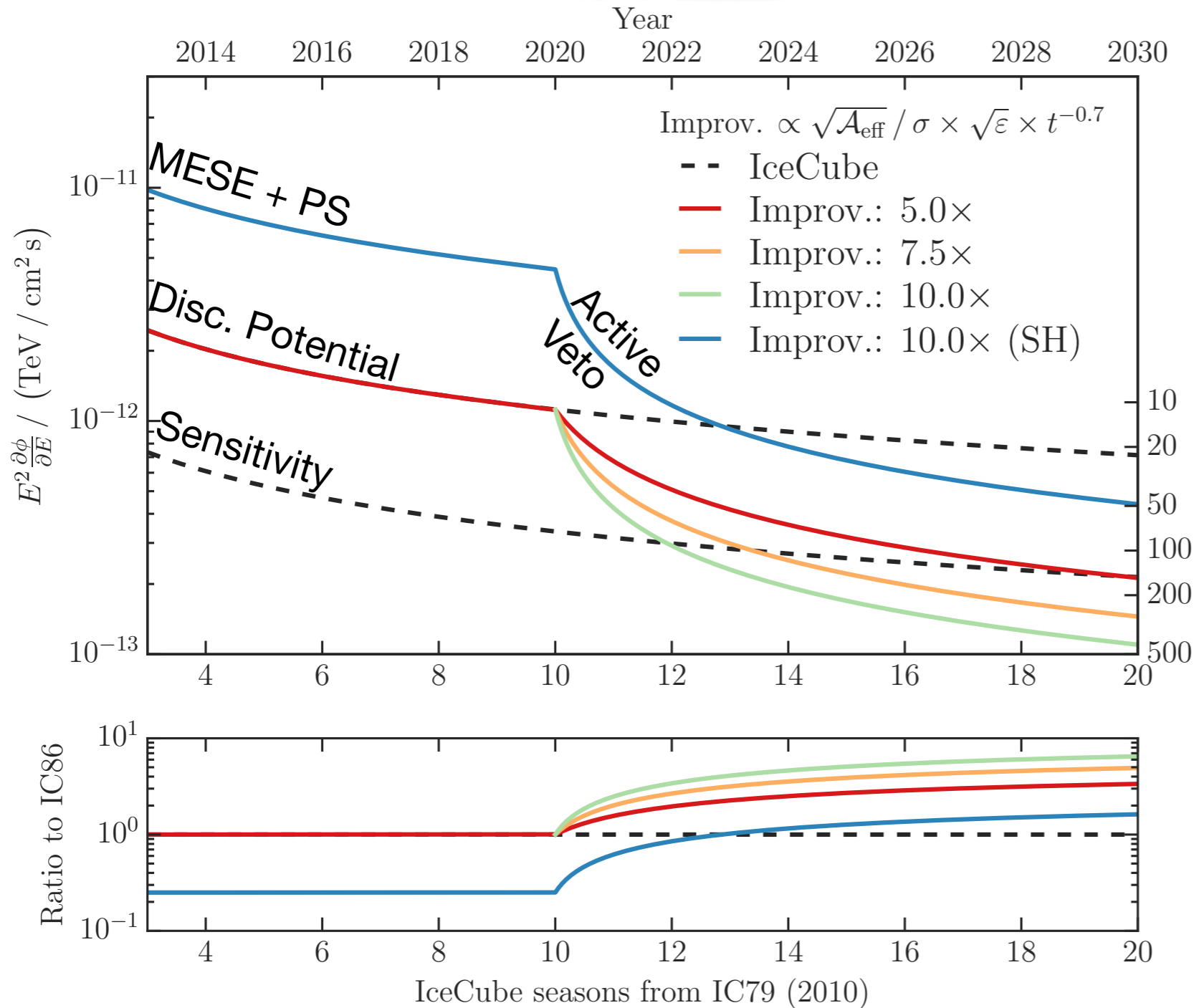


- unbinned LLH calculation suggests $\sim t^{-0.7}$ increase with time
- IceCube-Gen2 operation at 2020

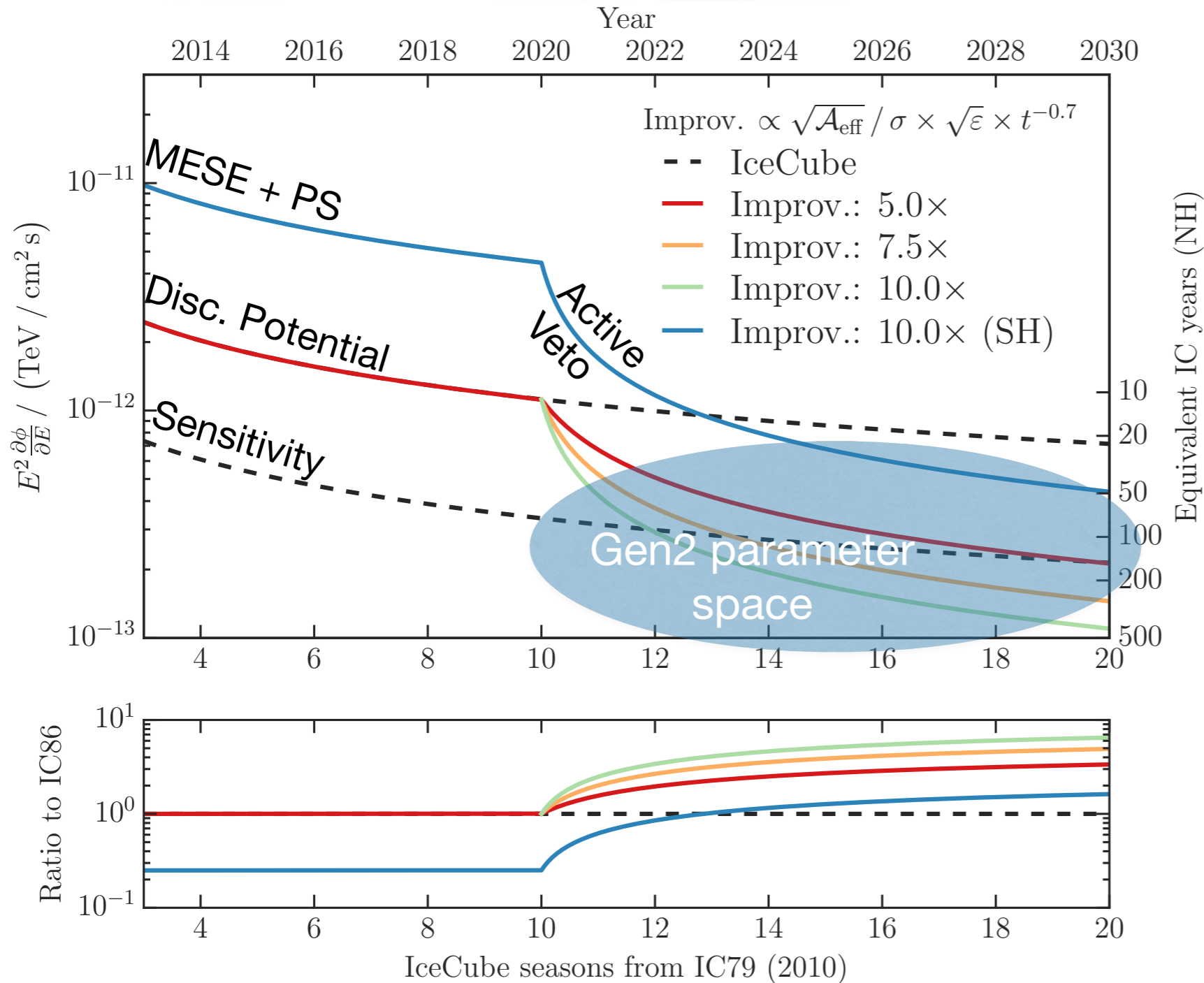




- unbinned LLH calculation suggests $\sim t^{-0.7}$ increase with time
- IceCube-Gen2 operation at 2020
- Better reconstructions and geometries boost sensitivity



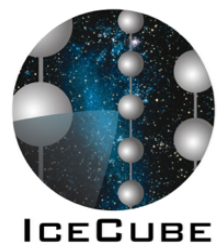
- unbinned LLH calculation suggests $\sim t^{-0.7}$ increase with time
- IceCube-Gen2 operation at 2020
- Better reconstructions and geometries boost sensitivity
- Active Veto
 - Boost Down-Going
 - Southern Hemisphere surpasses Northern Hemisphere (IceCube) after ~3 years



- IceCube-Gen2 can access parameter space that IceCube will never reach in 50 years of operation

Internal
Report at
[LINK](#)

Thank You!



Vertex position of events

- Good reconstructed events close to IceCube
- 50% within 2km

