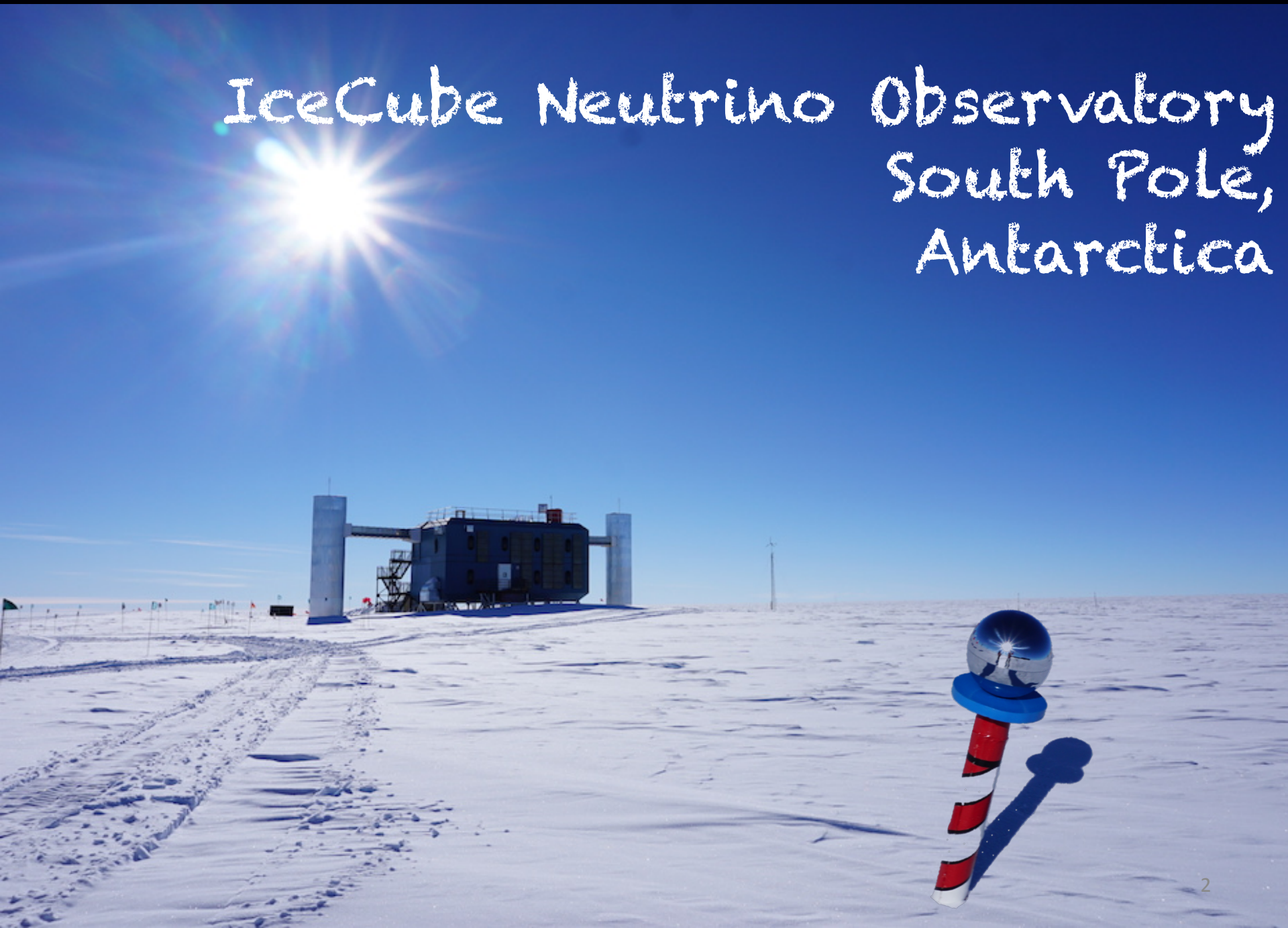
IceCube

Search for GeV neutrinos associated with solar flares

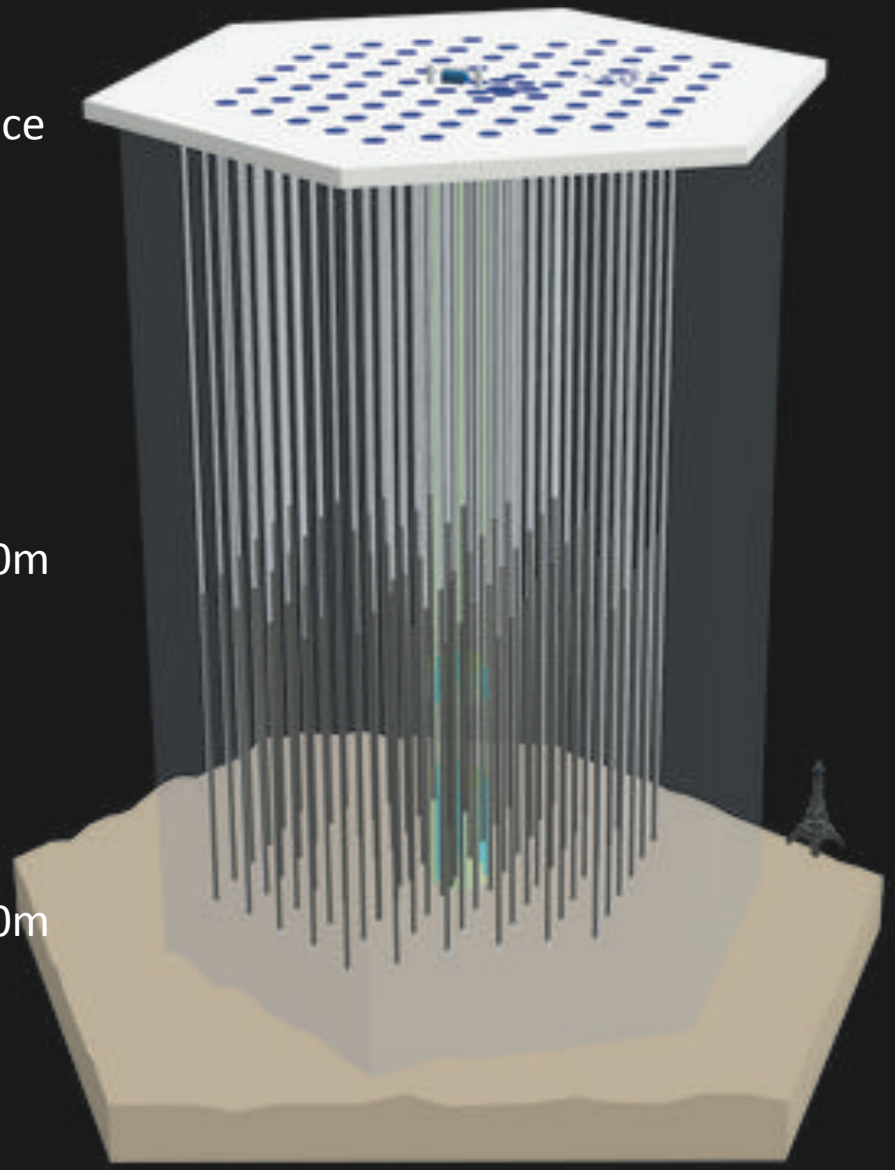
VRIJE UNIVERSITEIT BRUSSEL

Gwenhaël de Wasseige
for the IceCube Collaboration
https://icecube.wisc.edu

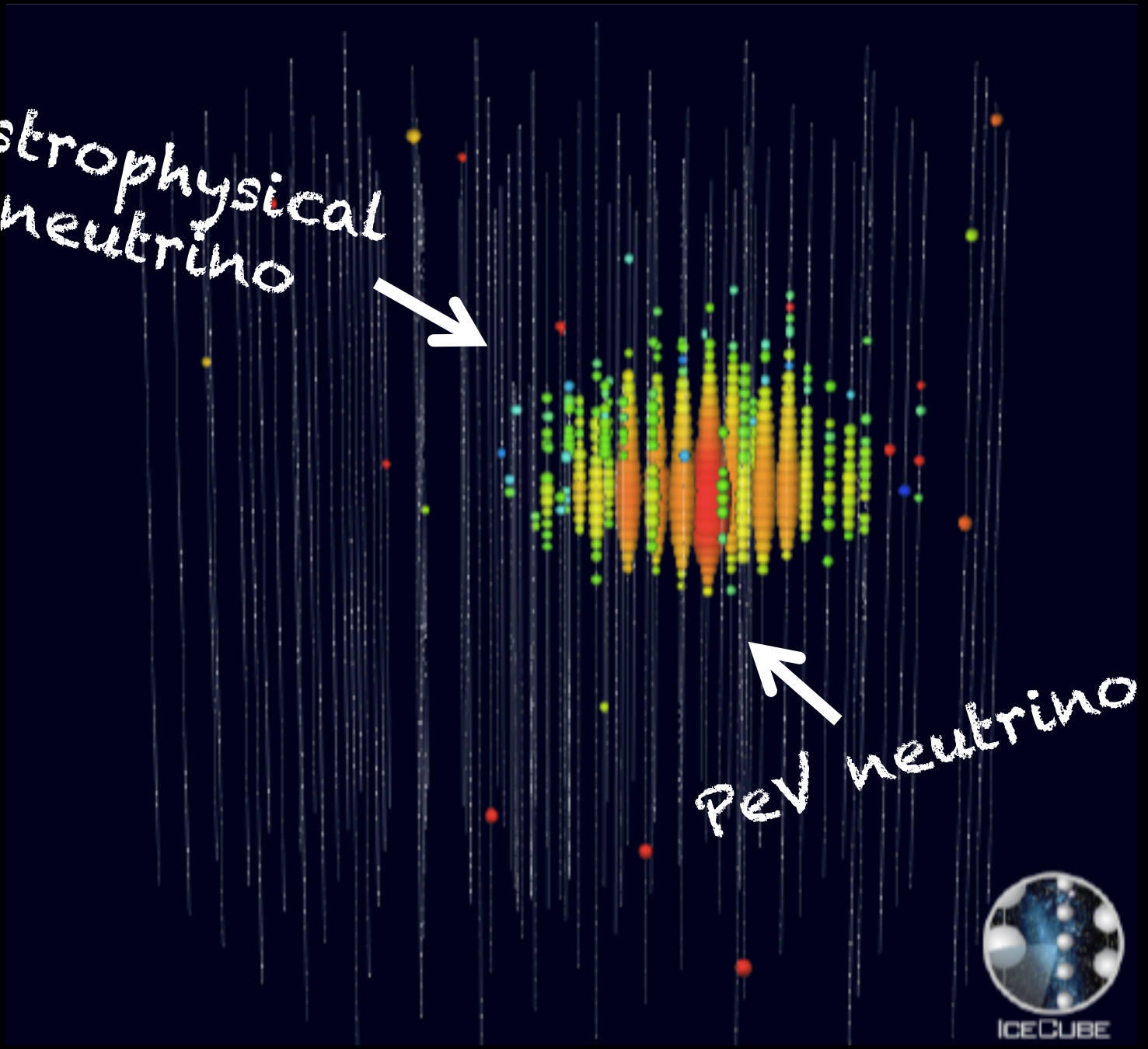
IceCube Neutrino Observatory South Pole, Antarctica

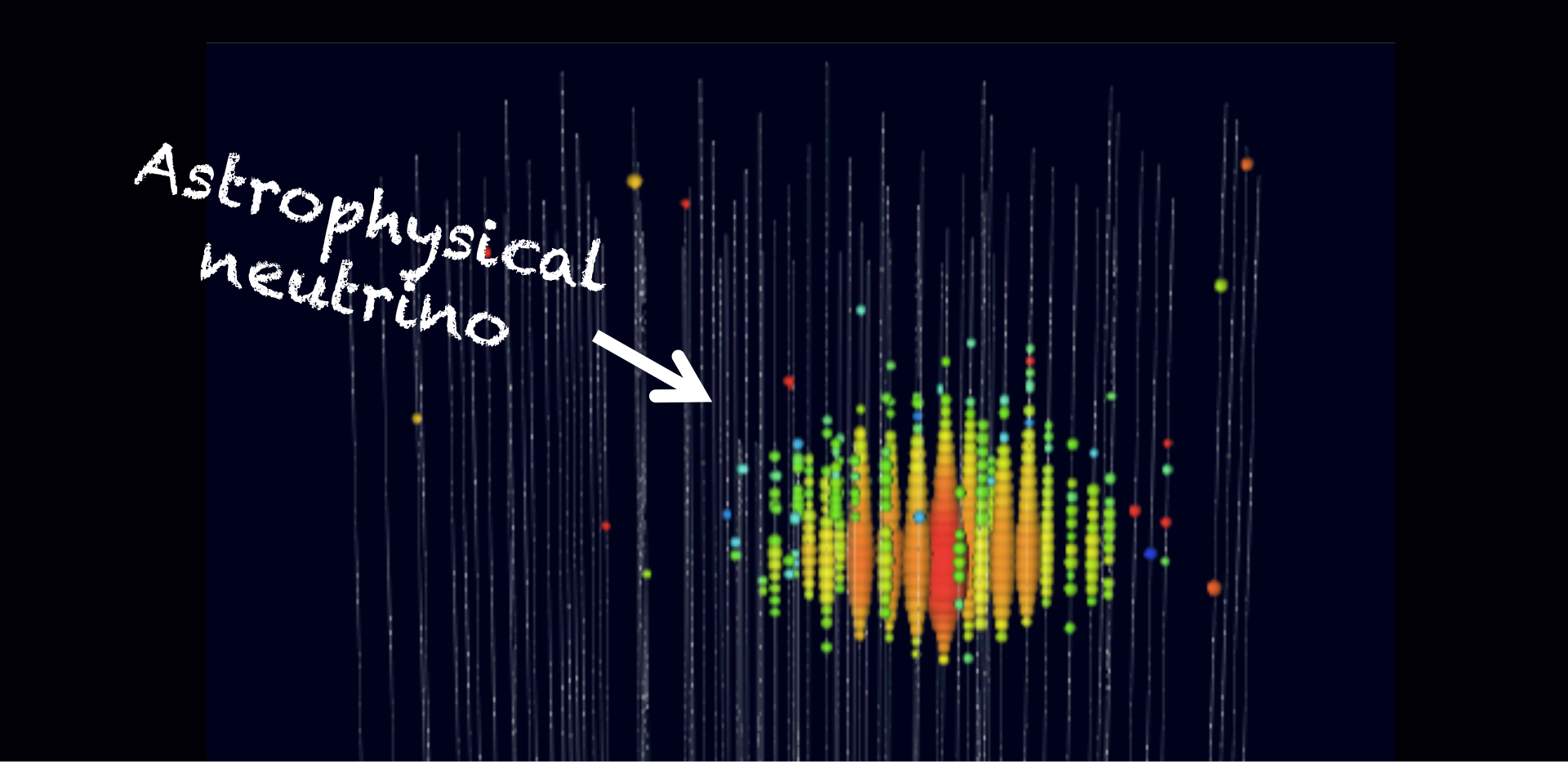


IceCube



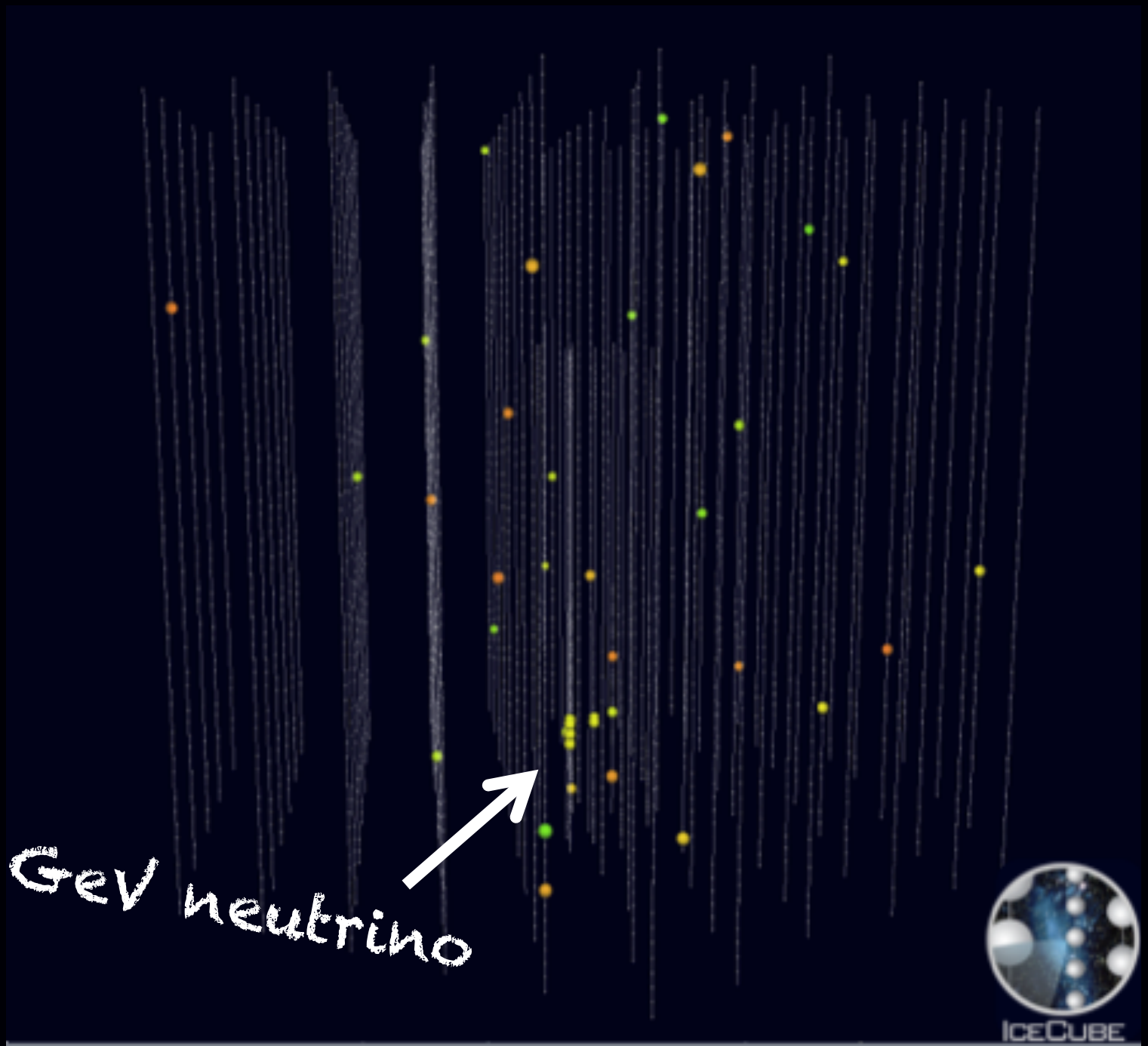
- $1km^3$ of instrumented ice
- 1.5km below the South Pole surface
- 5160 optical modules
- Modules detecting Cherenkov radiation
- Completed in 2010


Astrophysical neutrino
PeV neutrino
IceCube



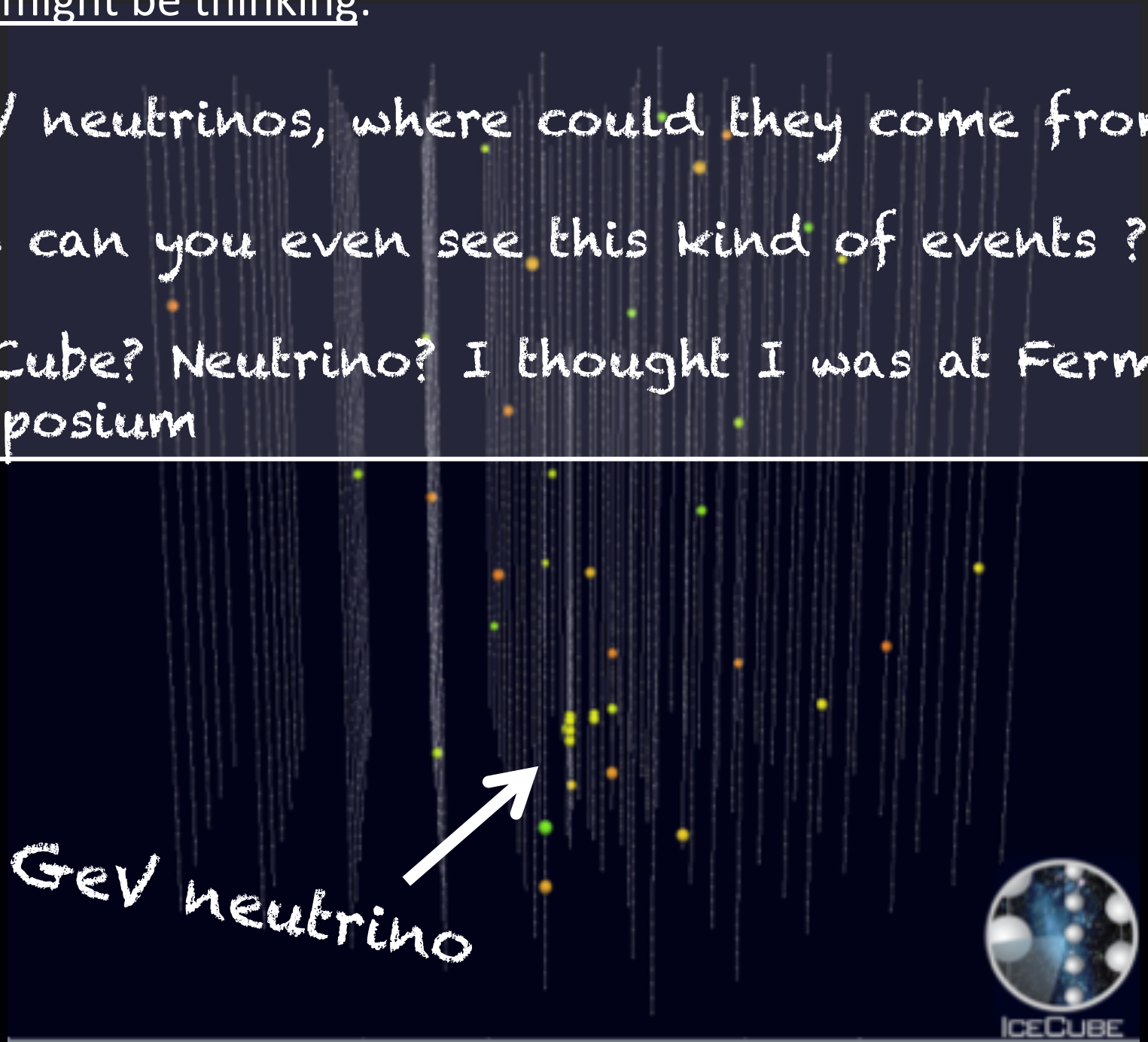
Since 2013, we kept pushing the detection limits, with e.g.:

- **sterile neutrino** limits
- **WIMP-nucleon cross section** limits
- **neutrino oscillation** measurements
- **multimessenger** and **realtime** analyses


GeV neutrino
IceCube

You might be thinking:

- GeV neutrinos, where could they come from ?
- How can you even see this kind of events ?
- IceCube? Neutrino? I thought I was at Fermi Symposium



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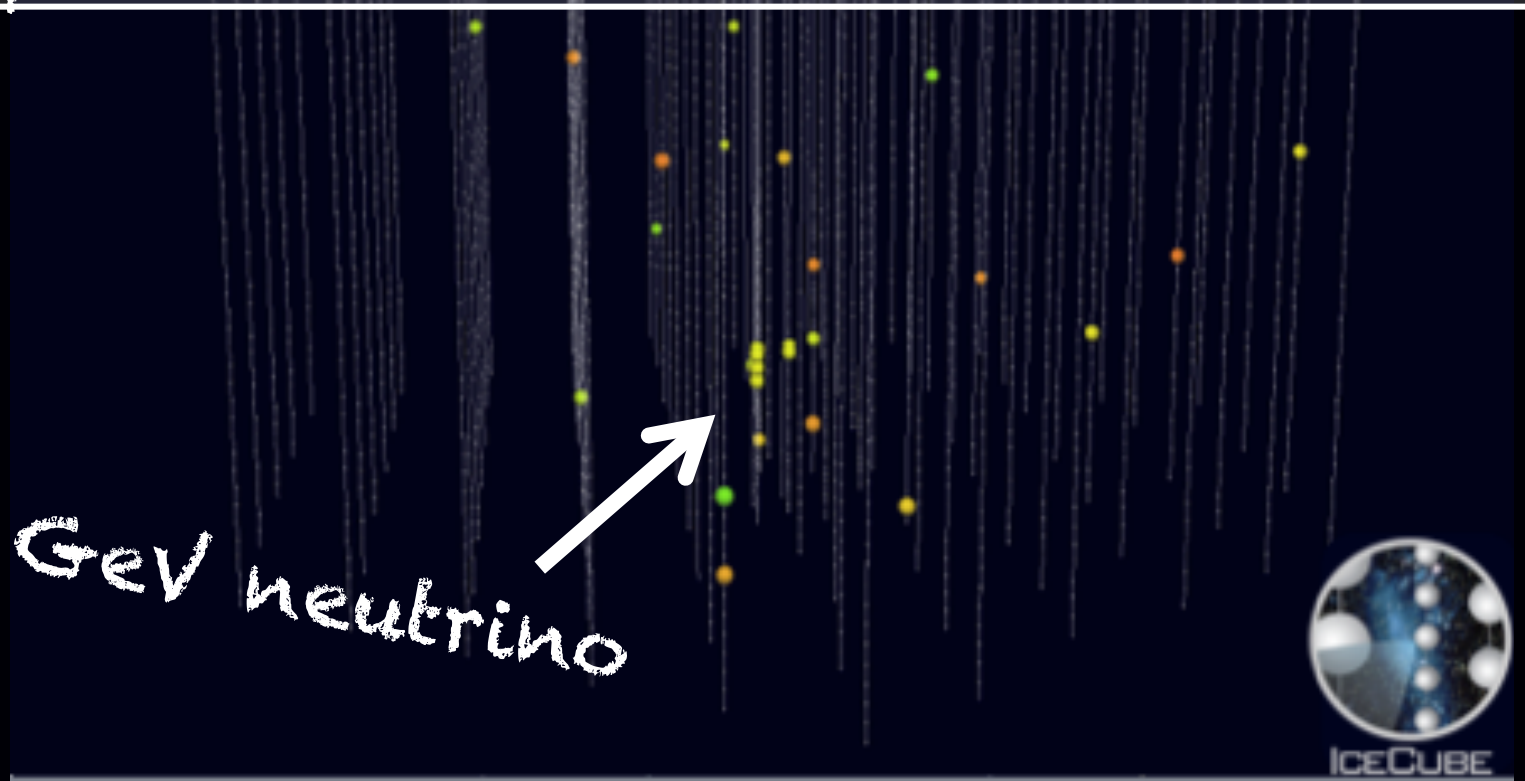
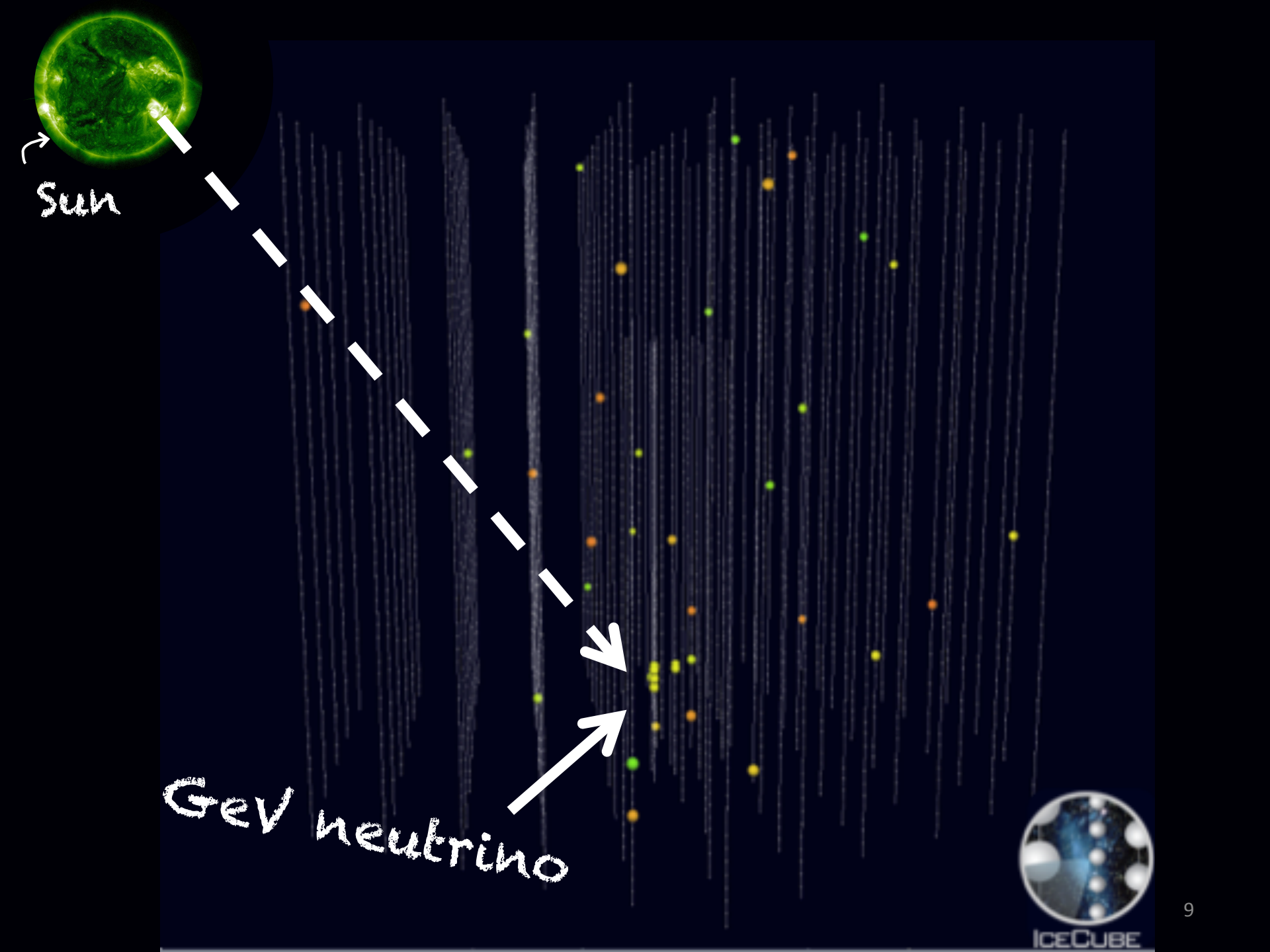
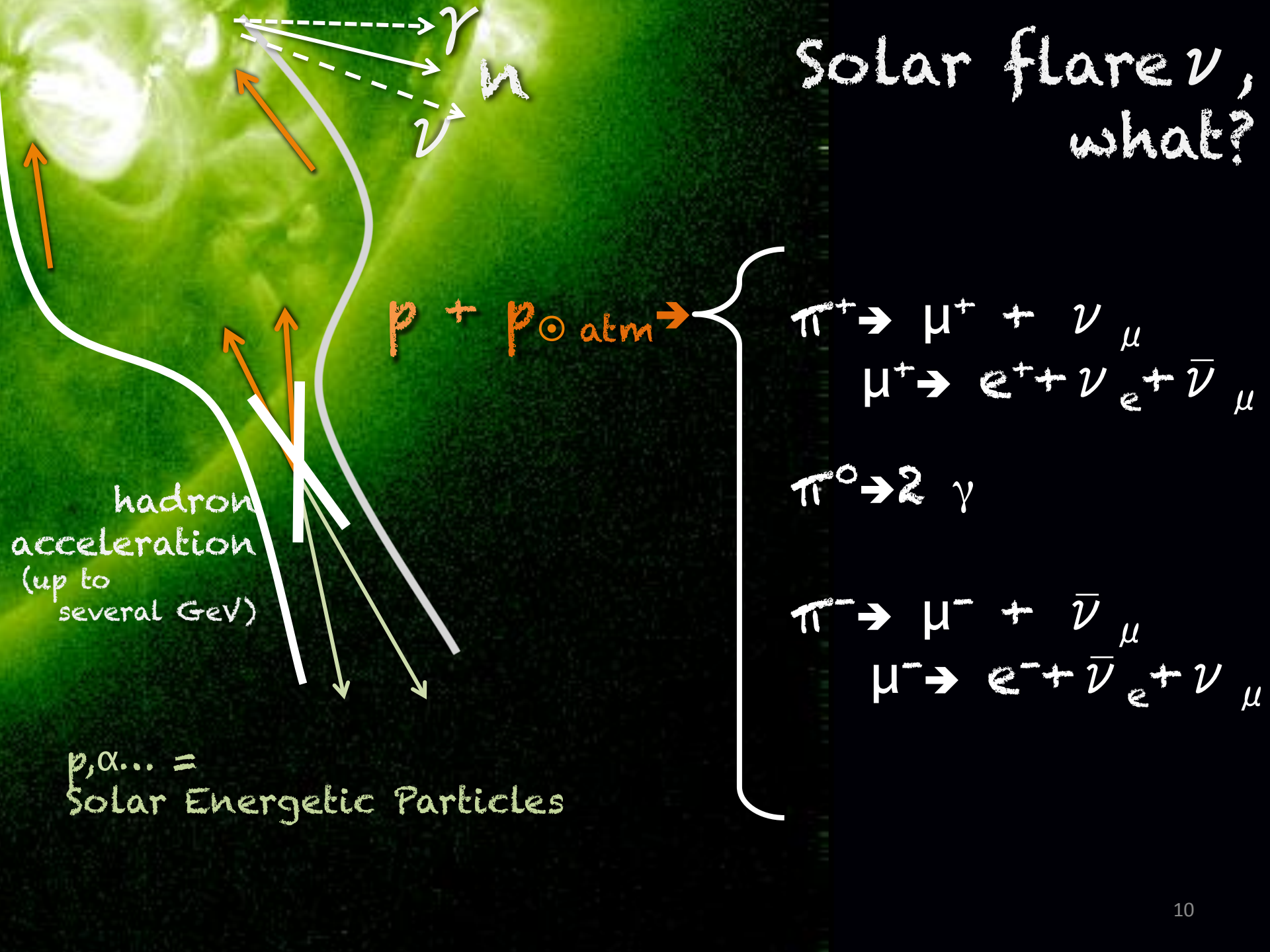



Sun
GeV neutrino
IceCube



Solar flare ν, what?

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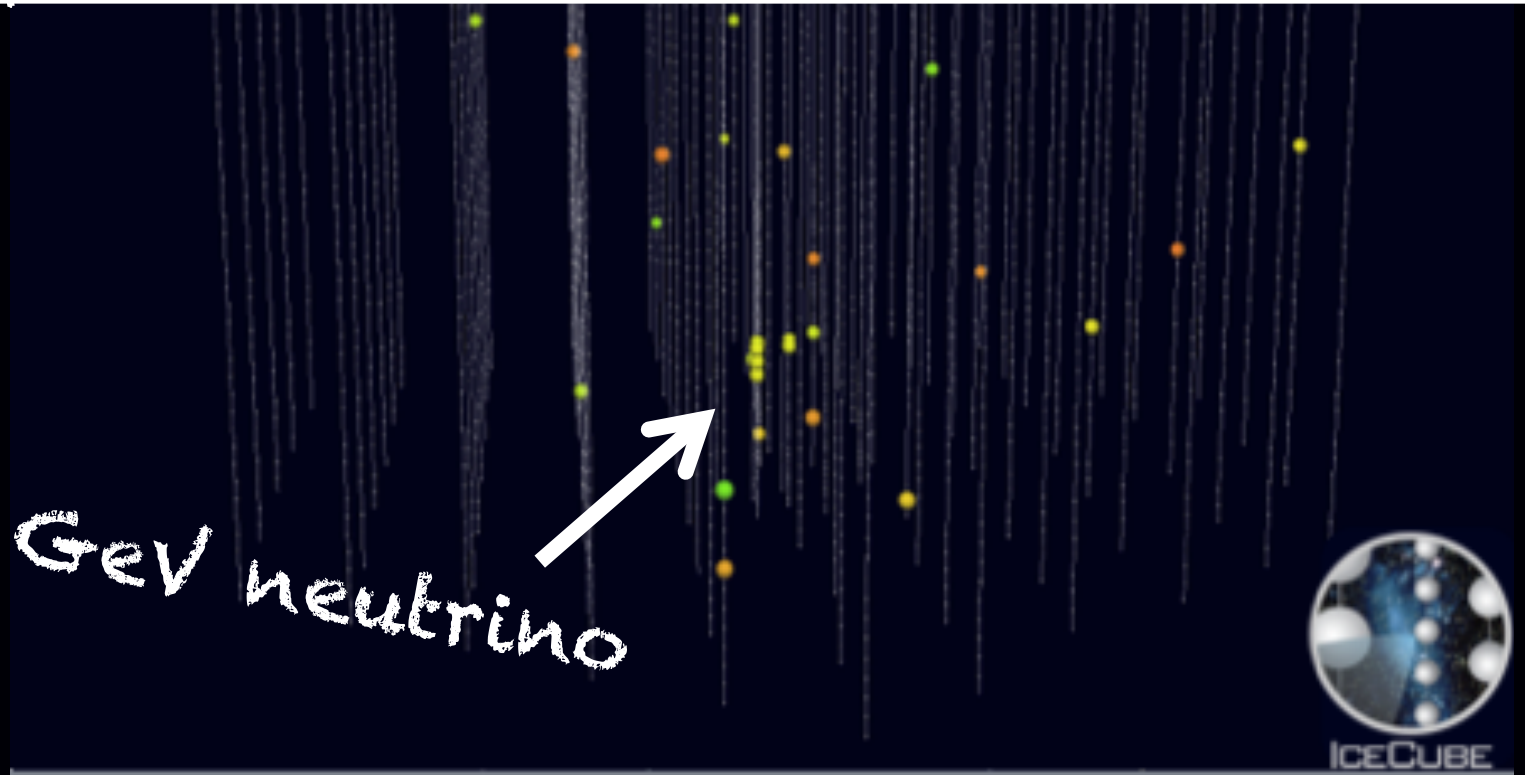
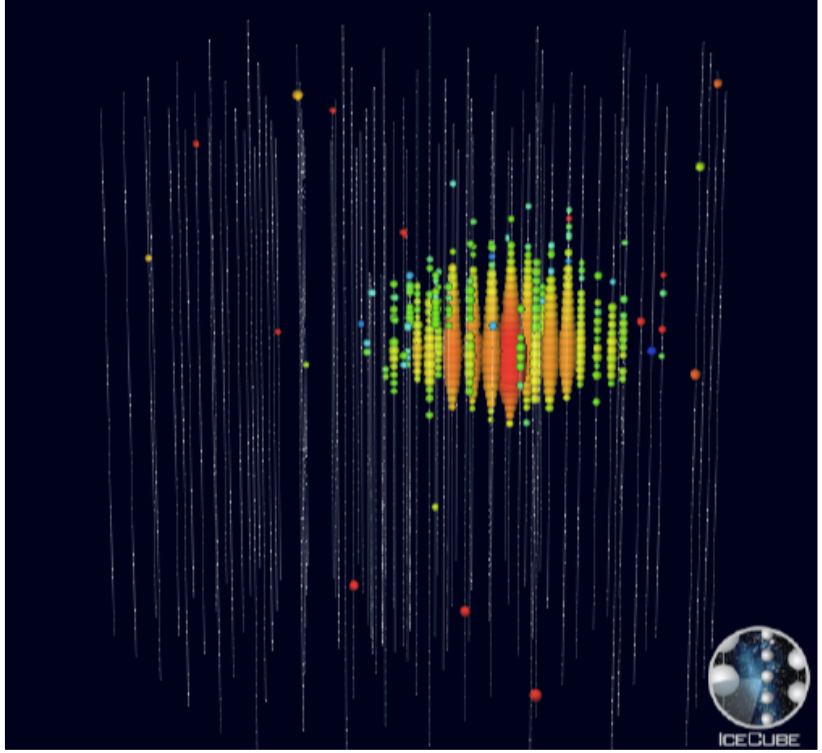
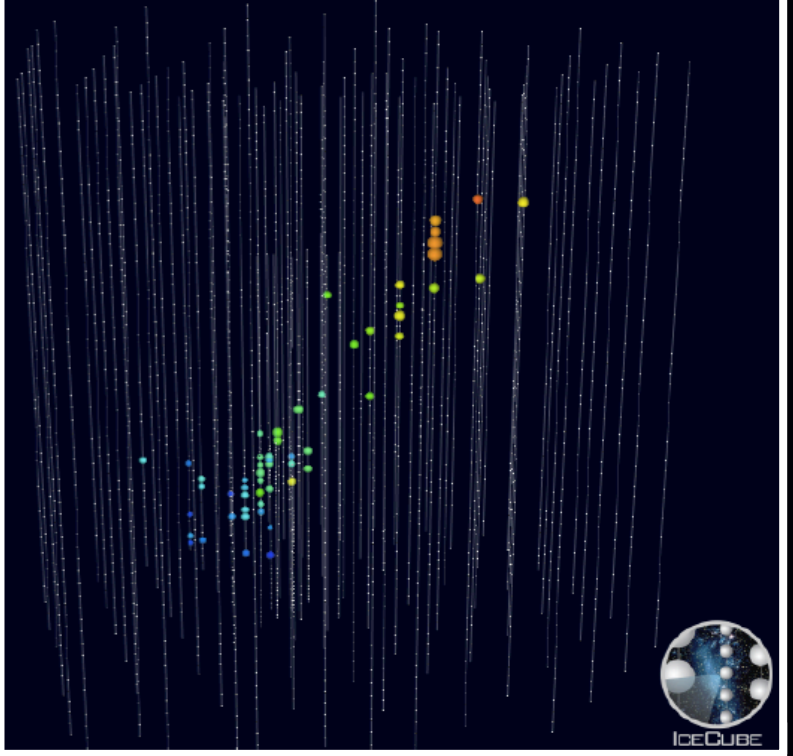



IceCube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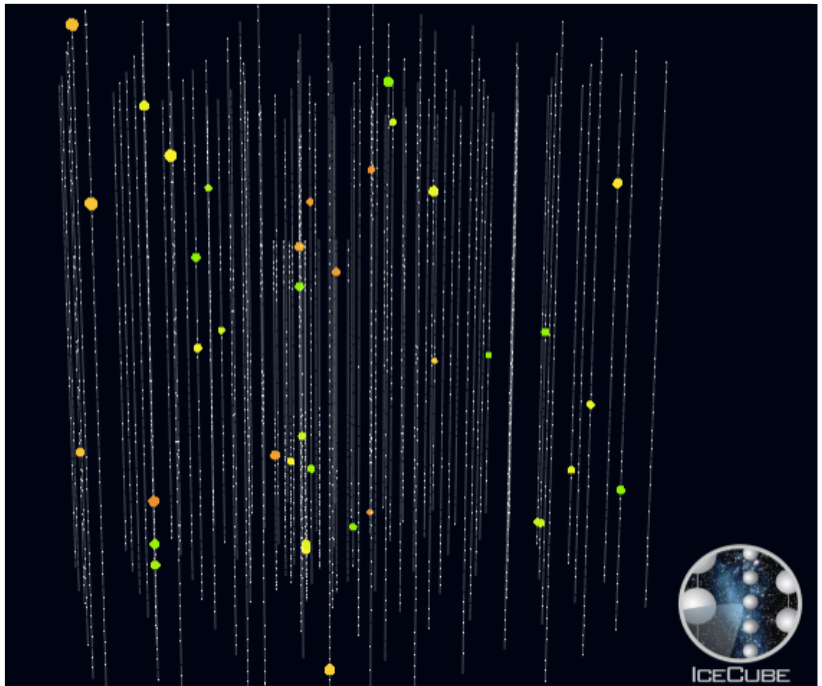
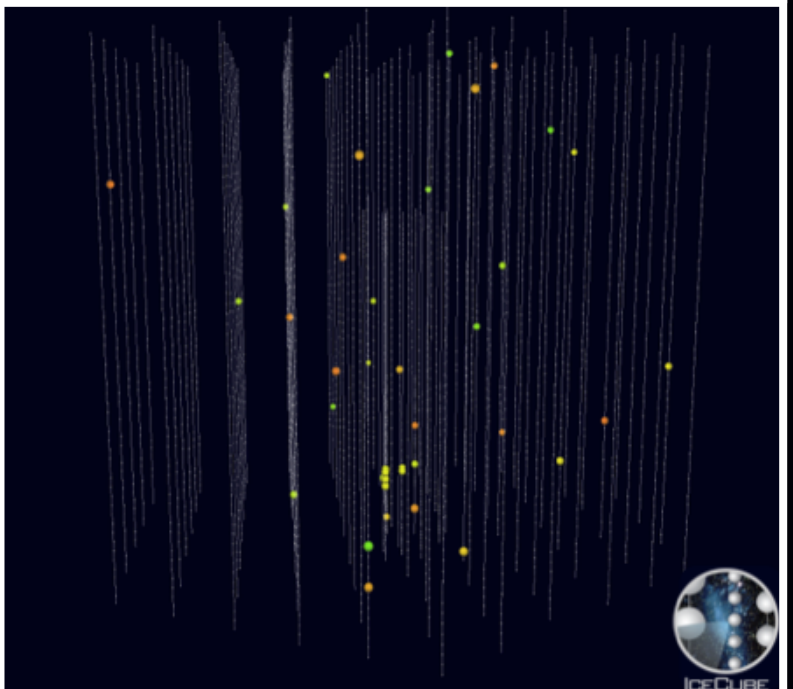
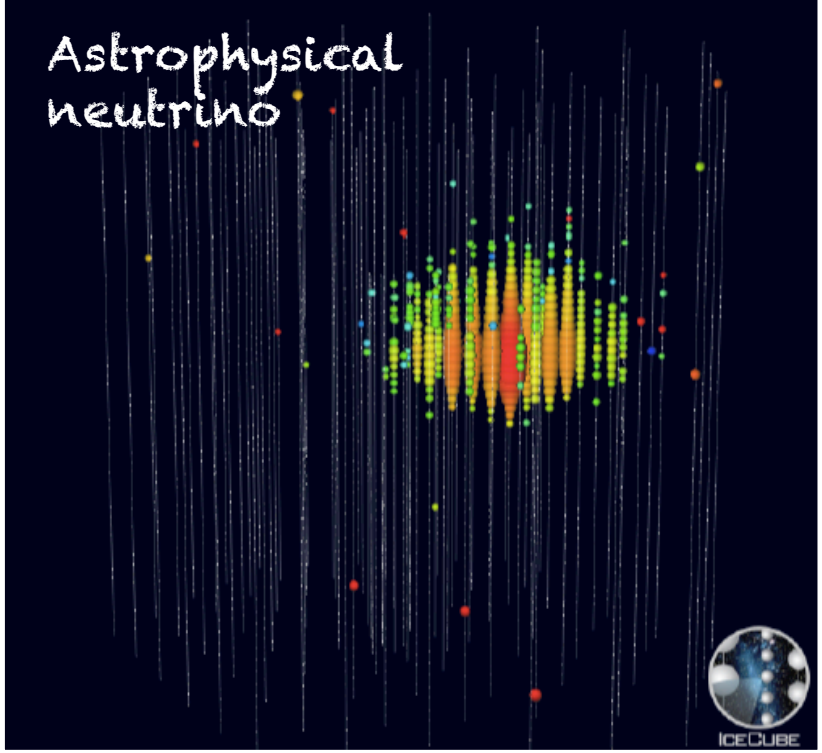
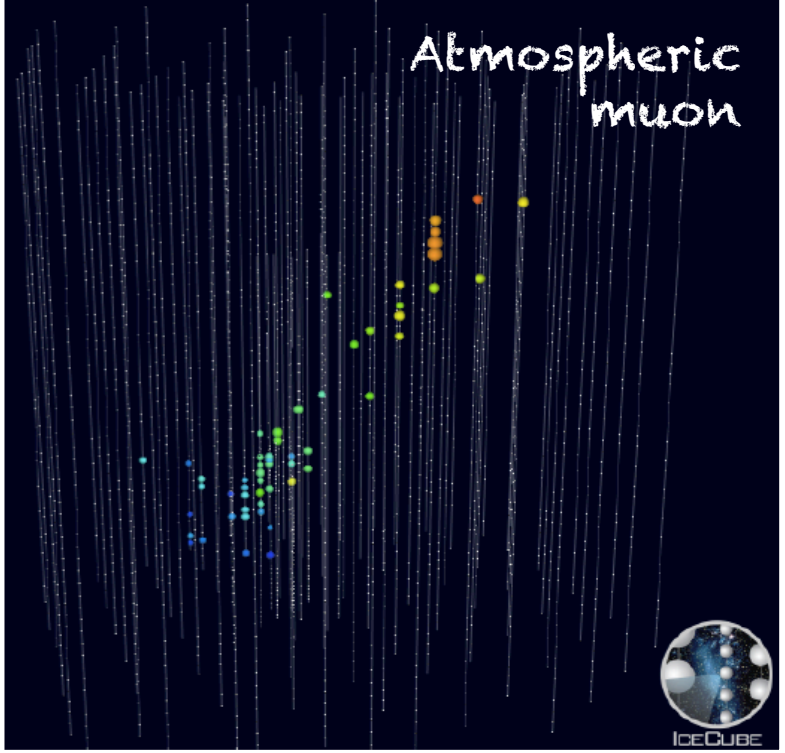
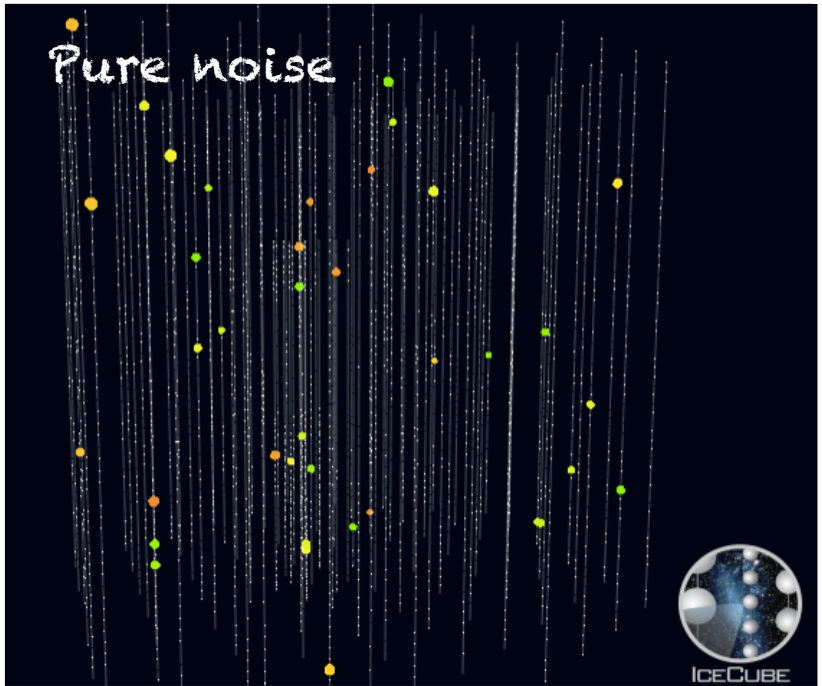
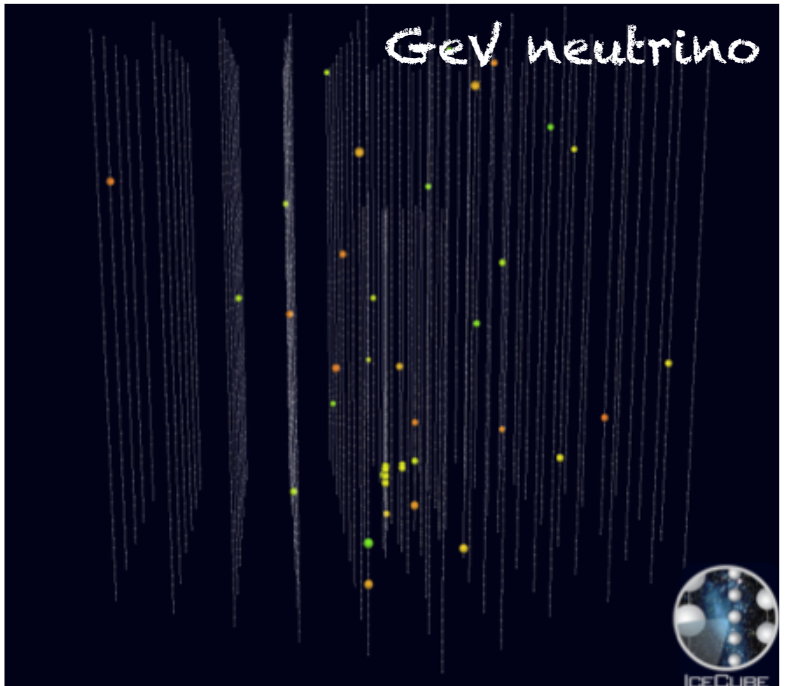

IceCube

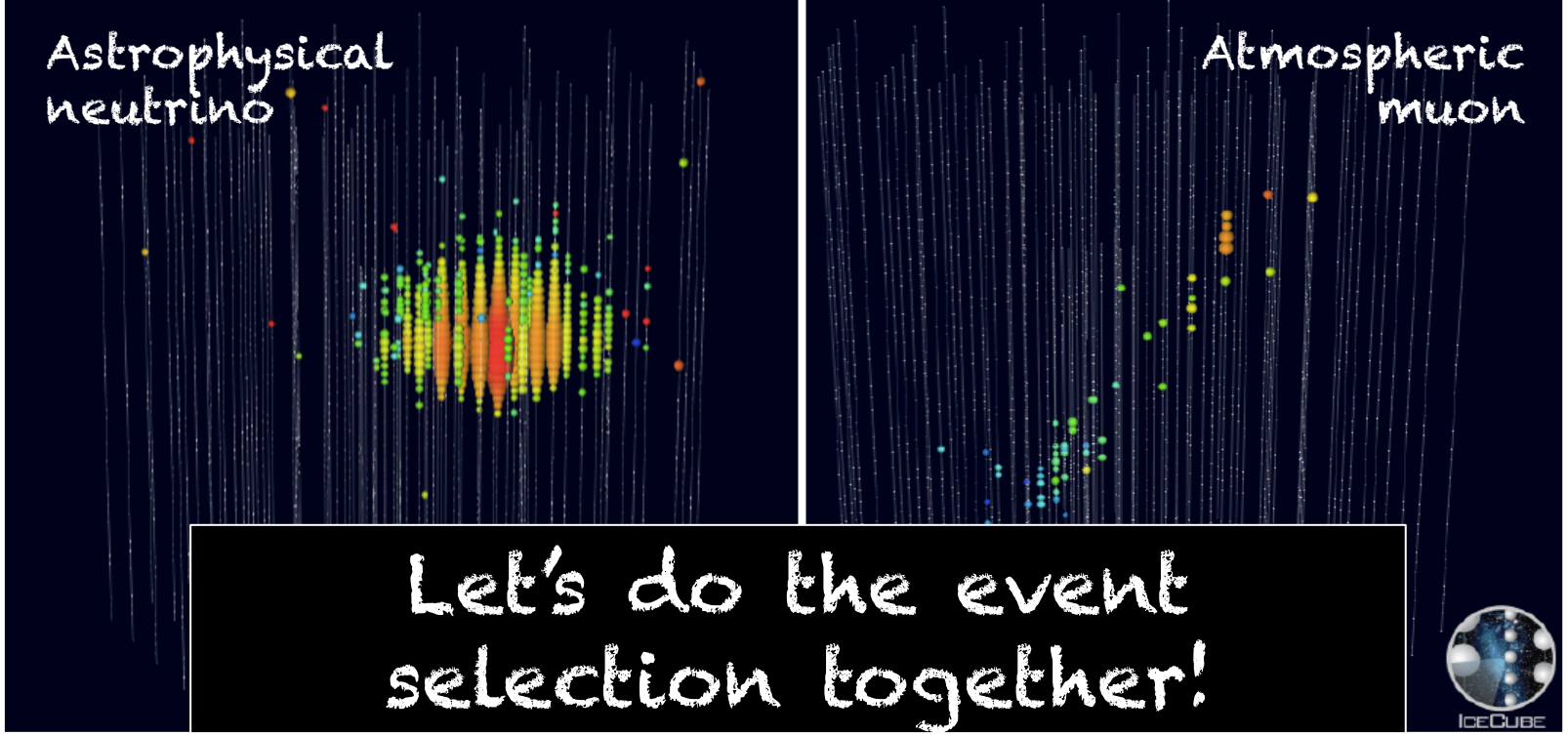

IceCube

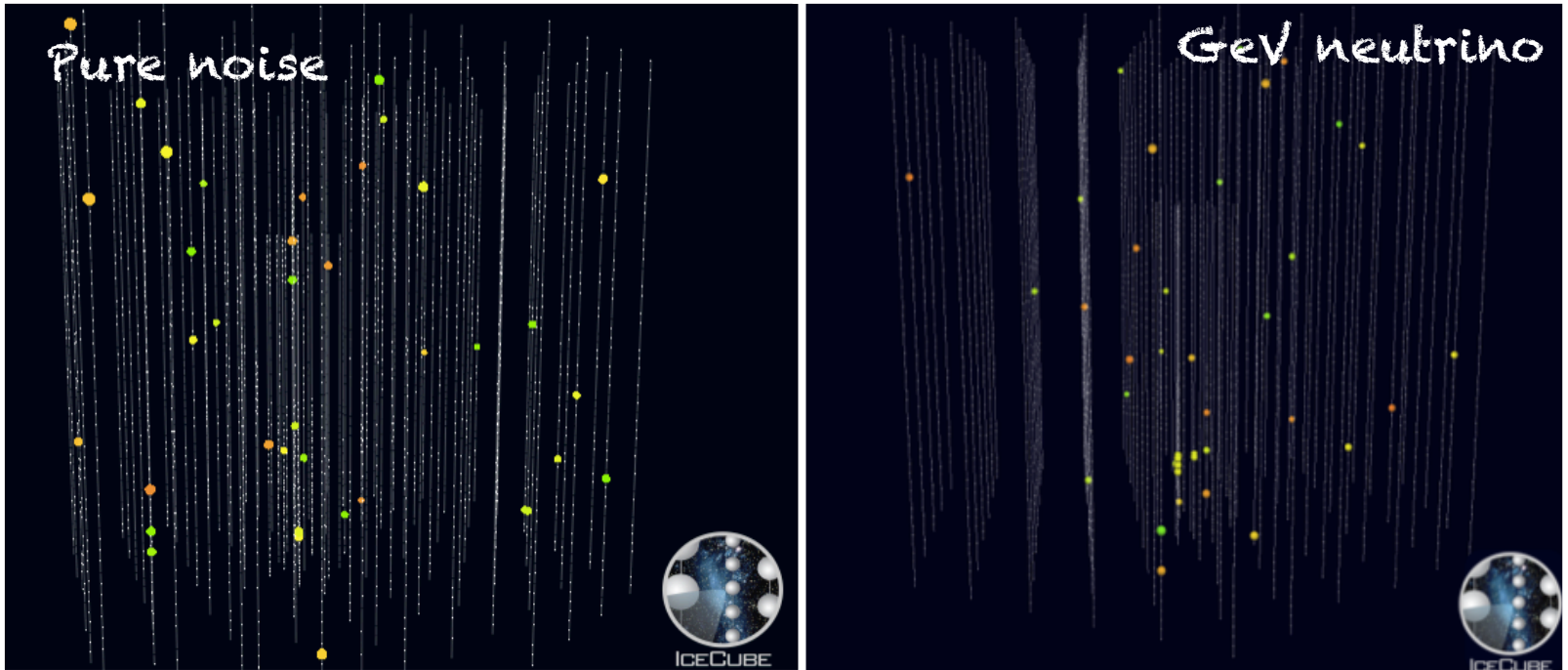

Astrophysical
neutrino
IceCube

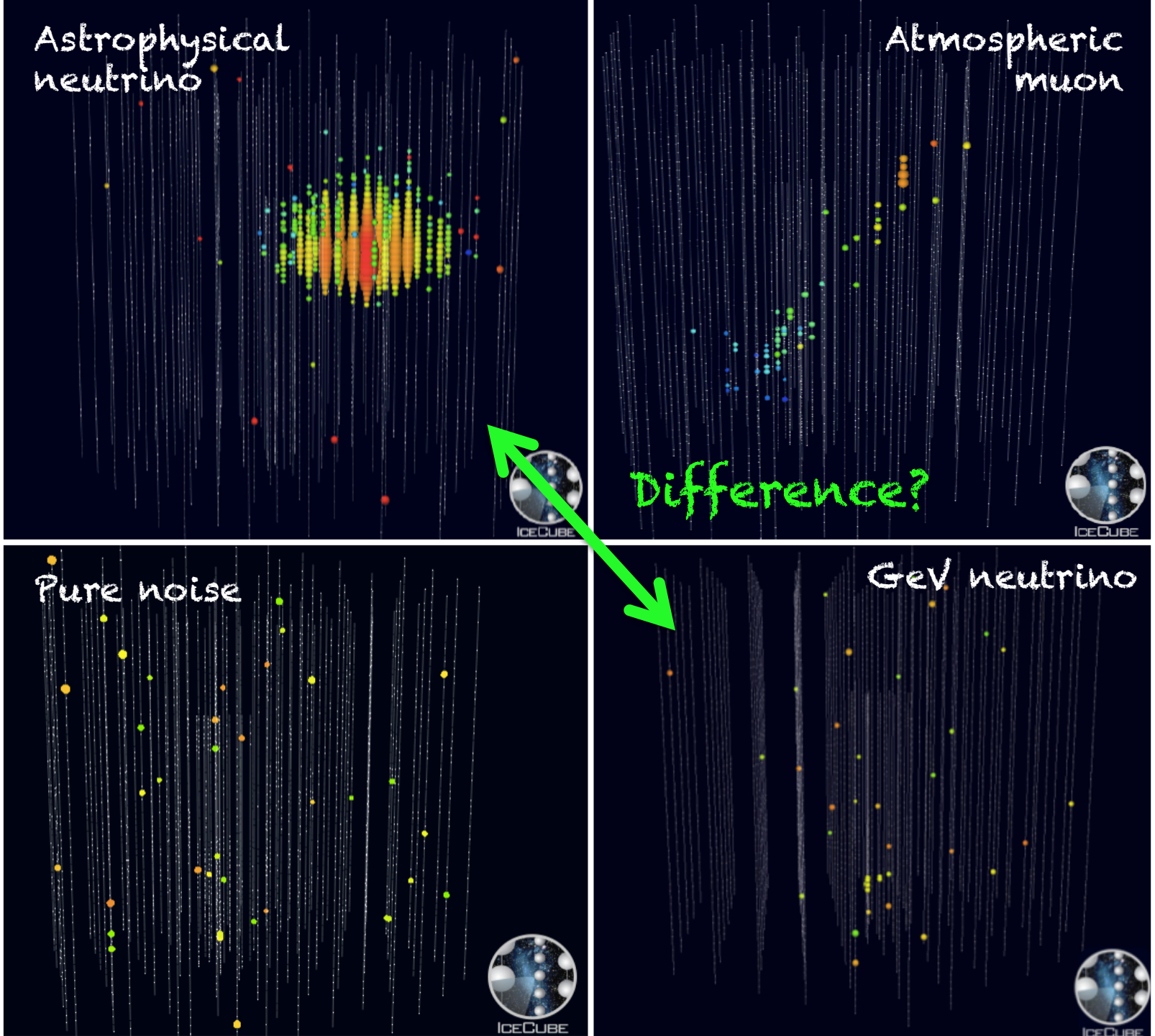

Atmospheric
muon
IceCube

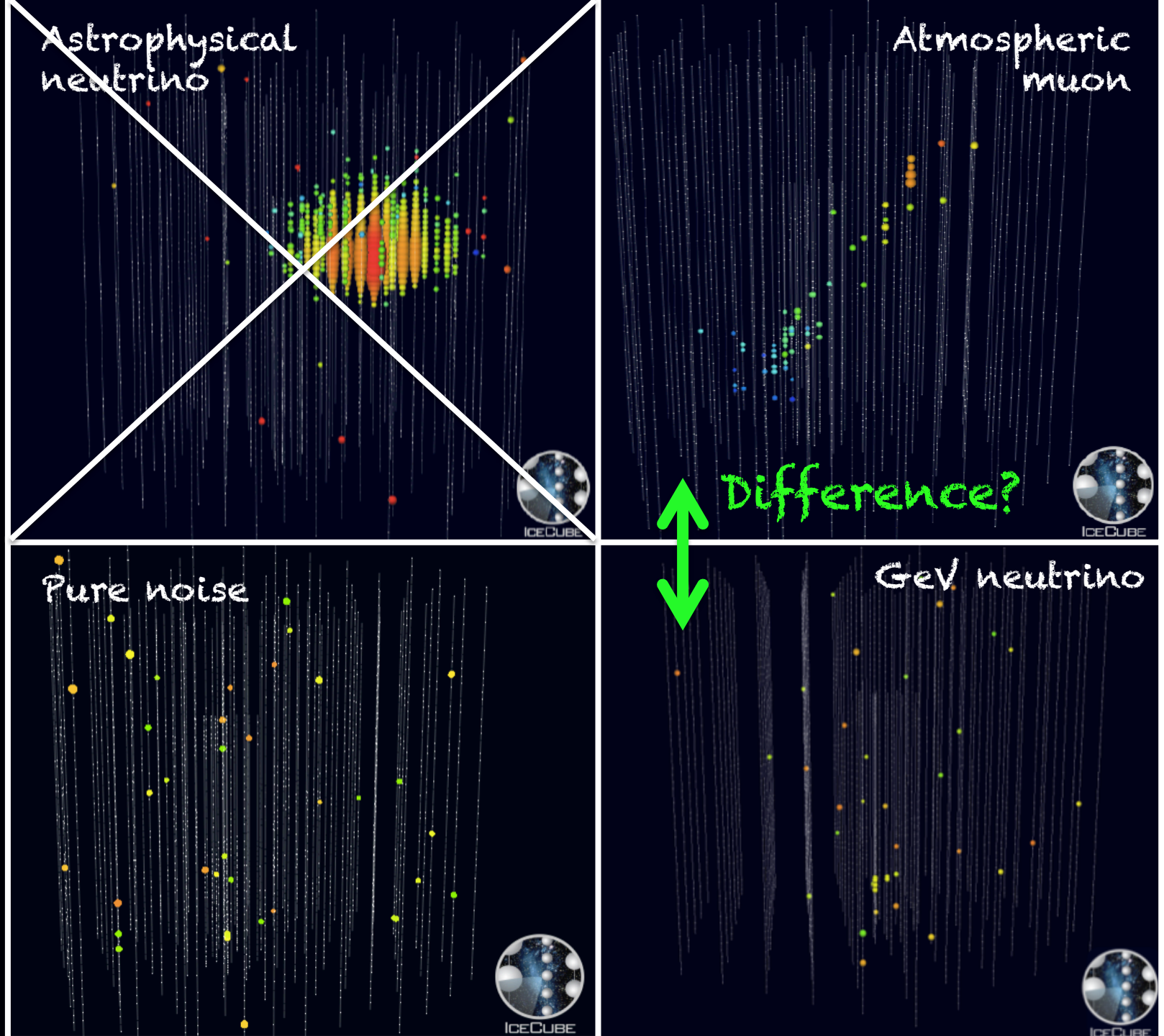

Pure noise
IceCube


GeV neutrino
IceCube


Astrophysical neutrino
Atmospheric muon
Let's do the event selection together!
IceCube


Pure noise
GeV neutrino
IceCube
IceCube


Astrophysical neutrino
Atmospheric muon
Difference?
Pure noise
GeV neutrino
IceCube
IceCube
IceCube
IceCube


Astrophysical neutrino
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GeV neutrino
IceCube
IceCube
IceCube
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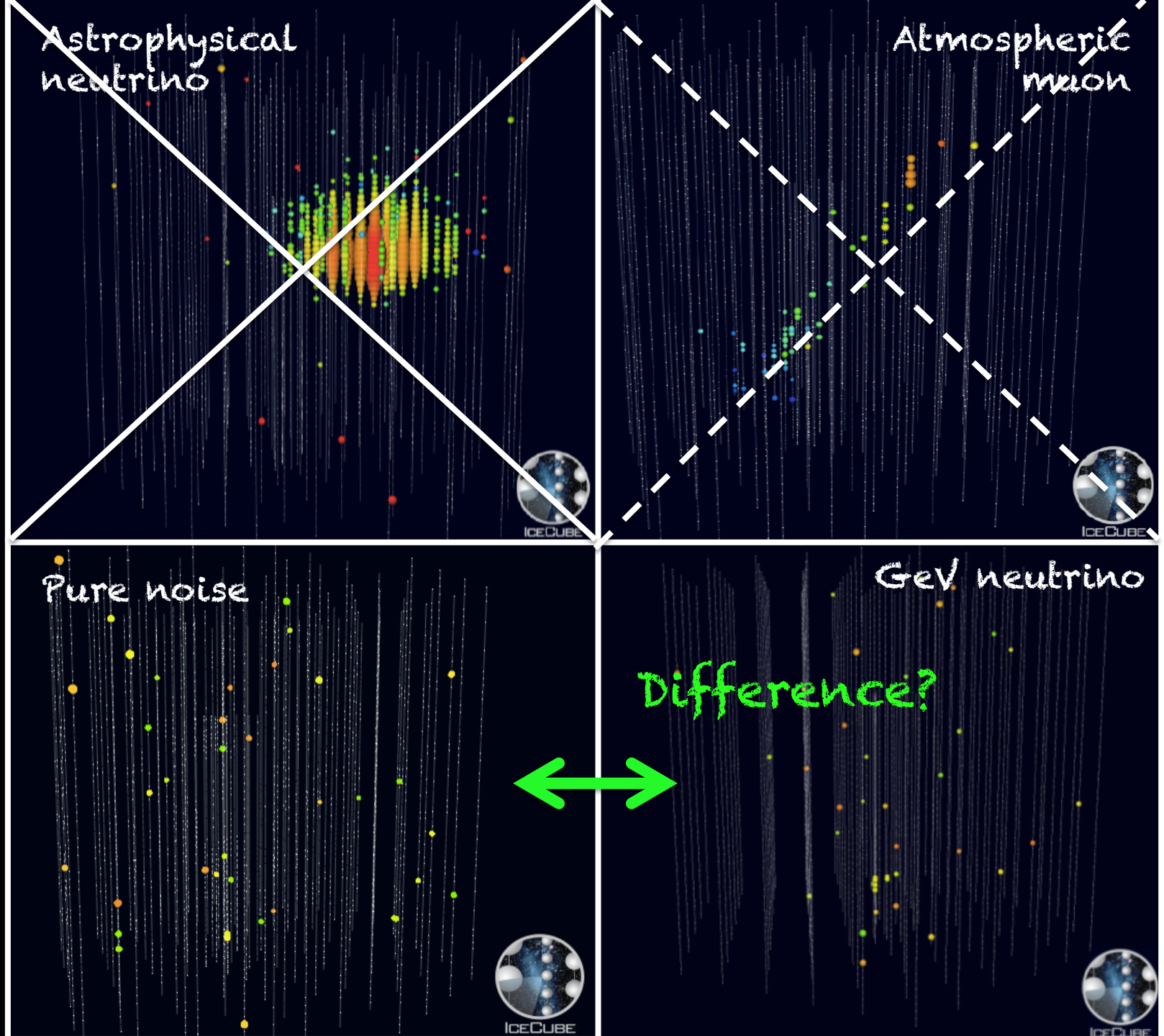
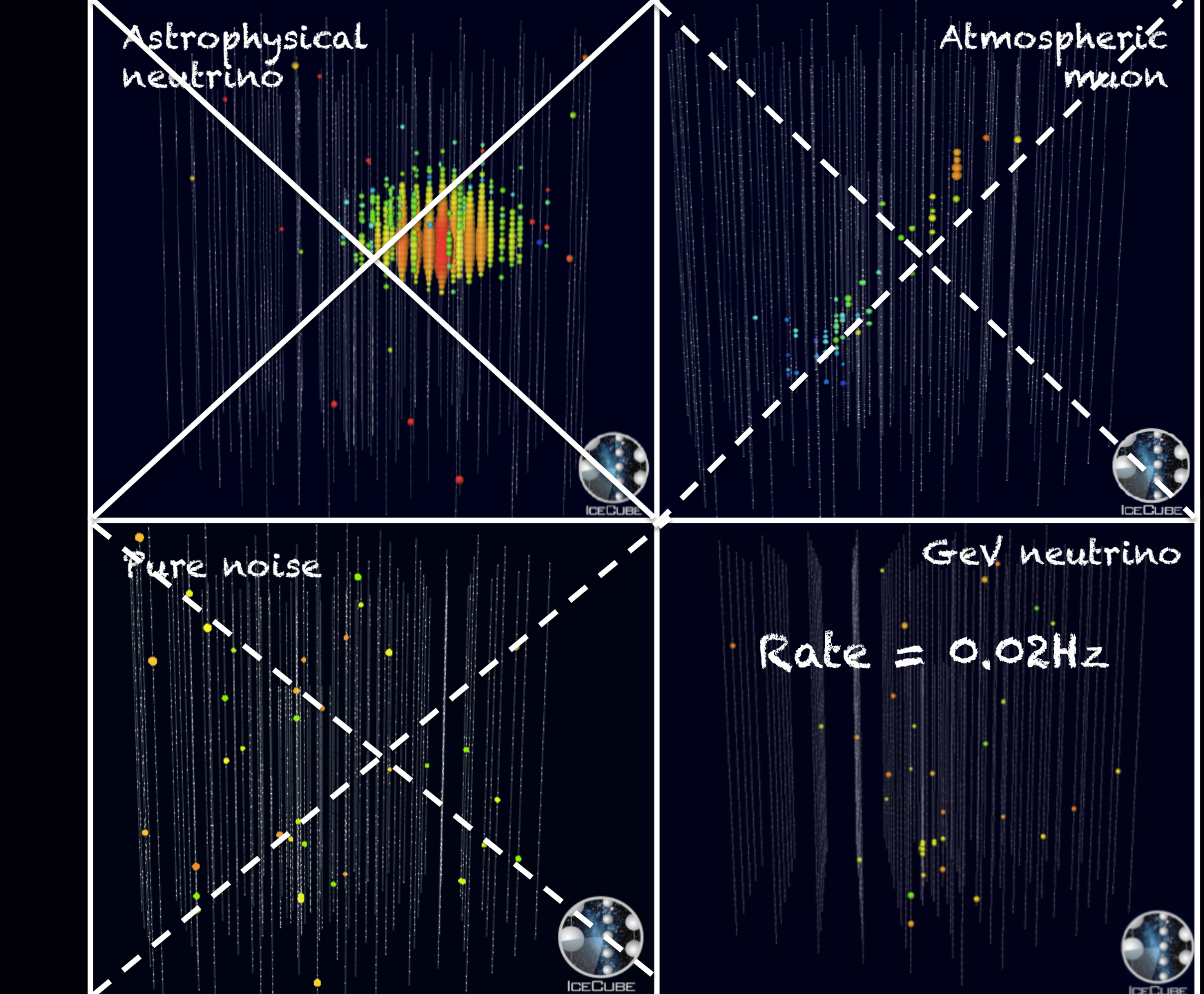

Astrophysical neutrino
Atmospheric muon
Pure noise
GeV neutrino
Difference?
IceCube
IceCube
IceCube
IceCube


Astrophysical neutrino
Atmospheric muon
Pure noise
GeV neutrino
Rate = 0.02Hz
IceCube
IceCube
IceCube
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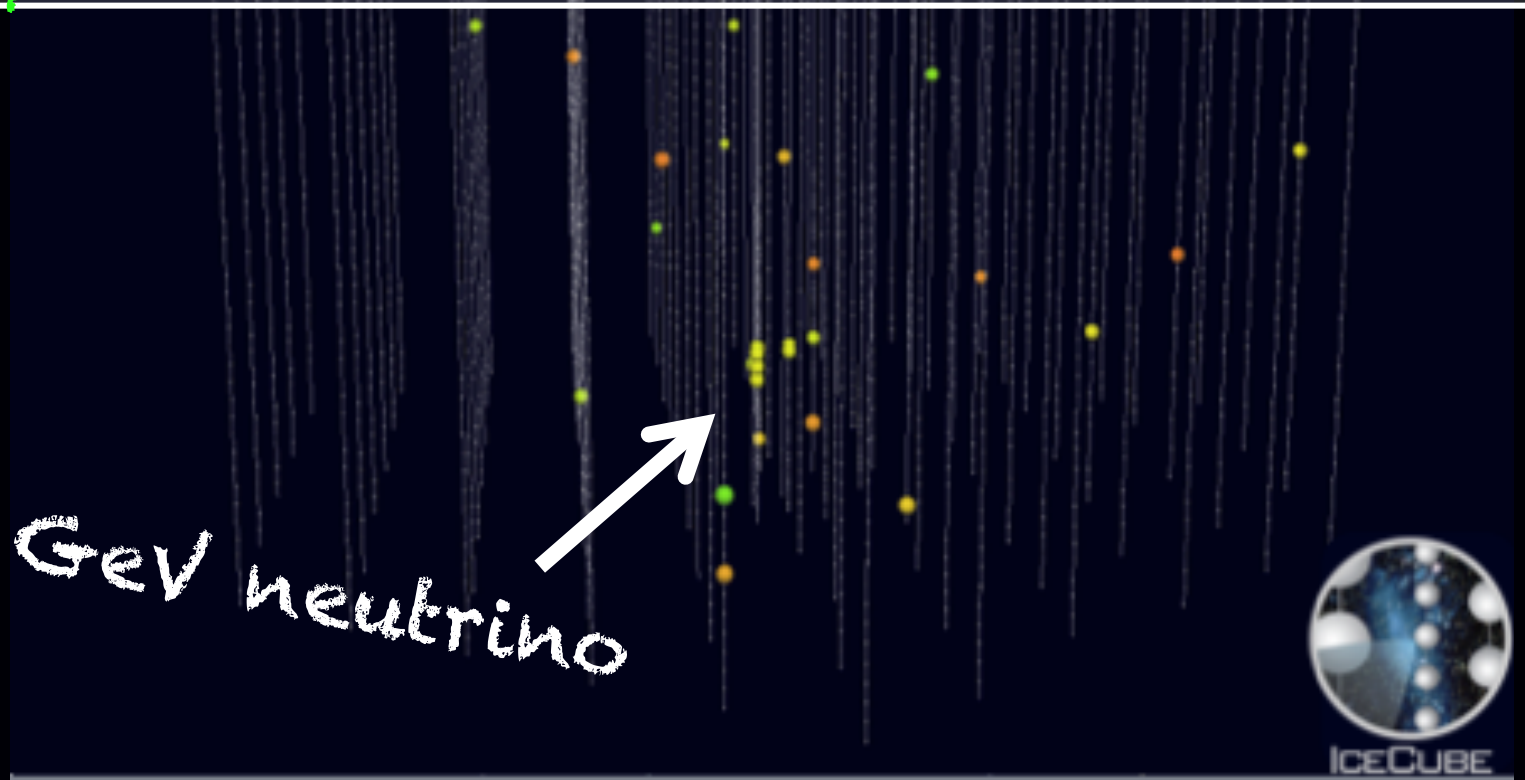


Solar flare ν, what?

$p + p_{\odot\,atm} \rightarrow$

$\pi^+ \rightarrow \mu^+ + \nu_\mu$

$\mu^+ \rightarrow e^+ + \nu_e + \bar{\nu}_\mu$

$\pi^0 \rightarrow 2\,\gamma$

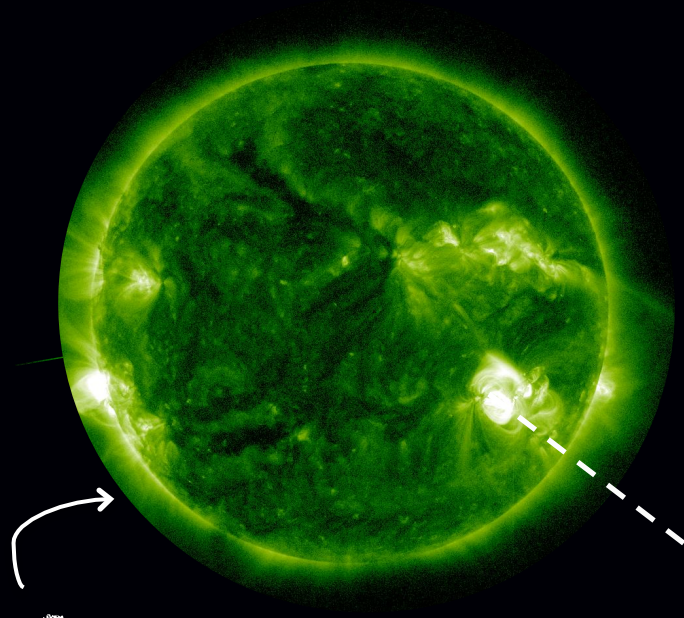
$\pi^- \rightarrow \mu^- + \bar{\nu}_\mu$

$\mu^- \rightarrow e^- + \bar{\nu}_e + \nu_\mu$

hadron acceleration (up to several GeV)

p,α... = Solar Energetic Particles

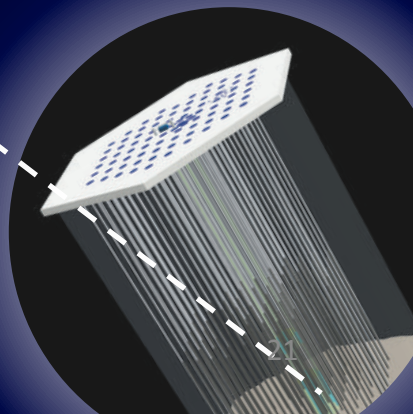
Solar flare ν, how?

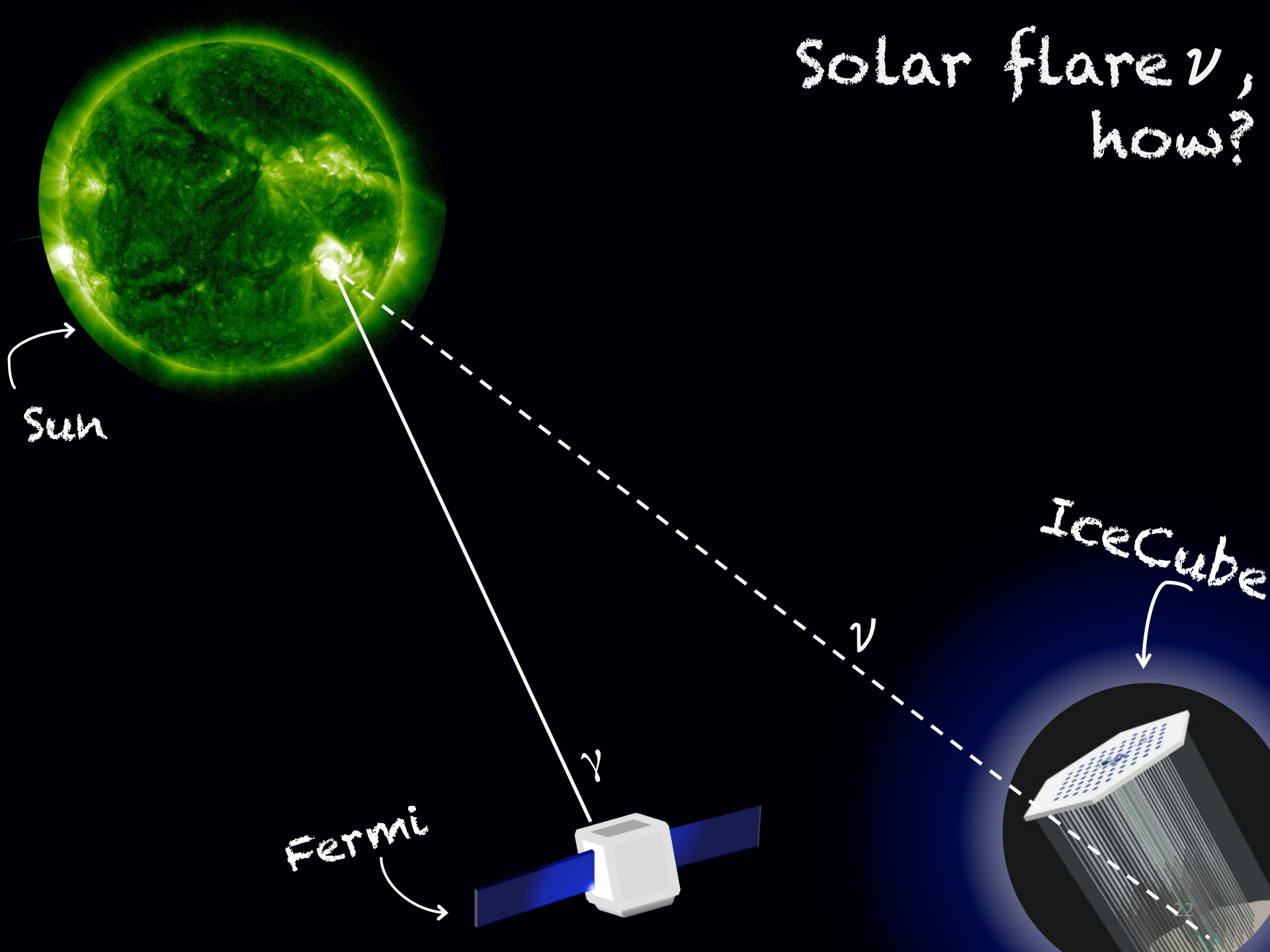


Sun

ν

IceCube




Solar flare ν, how?
Sun
IceCube
ν
γ
Fermi

2 possible approaches:

1. Use IceCube archival data (2011-now) and study solar flares seen by Fermi-LAT

2. Trigger IceCube based on realtime Fermi observations

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1. Use IceCube archival data (2011-now) and study solar flares seen by Fermi-LAT
   - Mar 7th 2012
   - Feb 25th 2014
   - Sep 1st 2014
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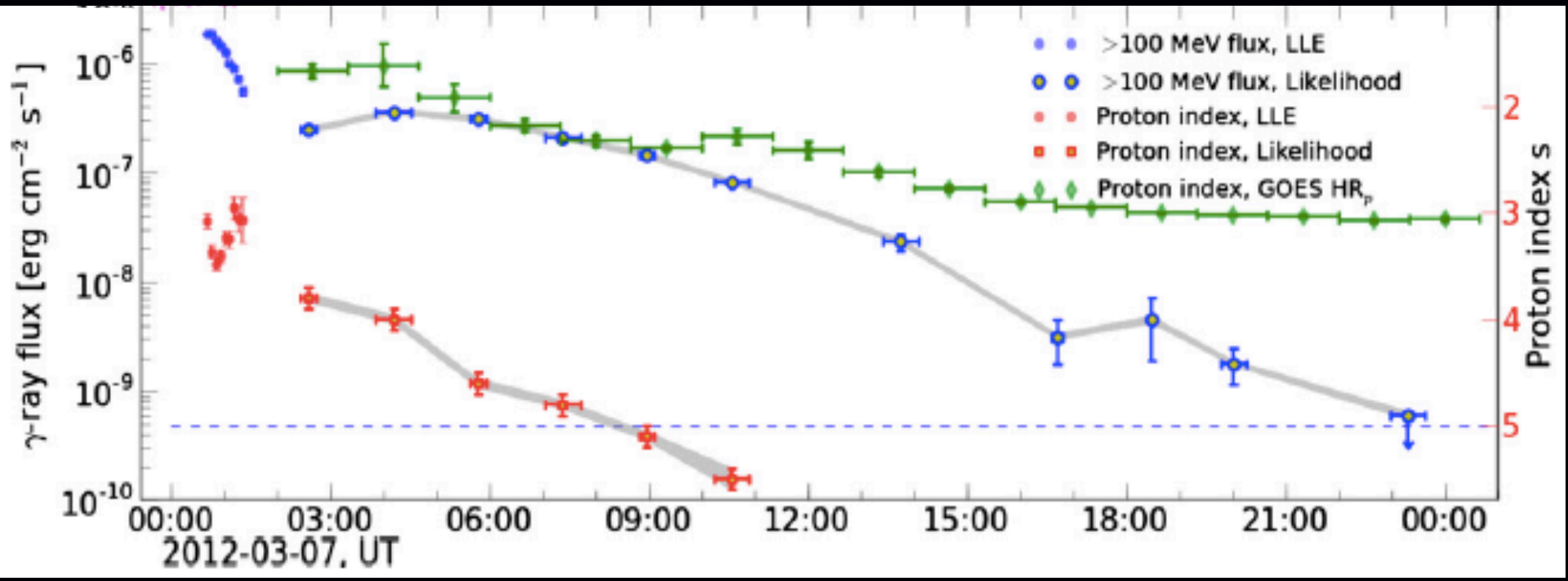
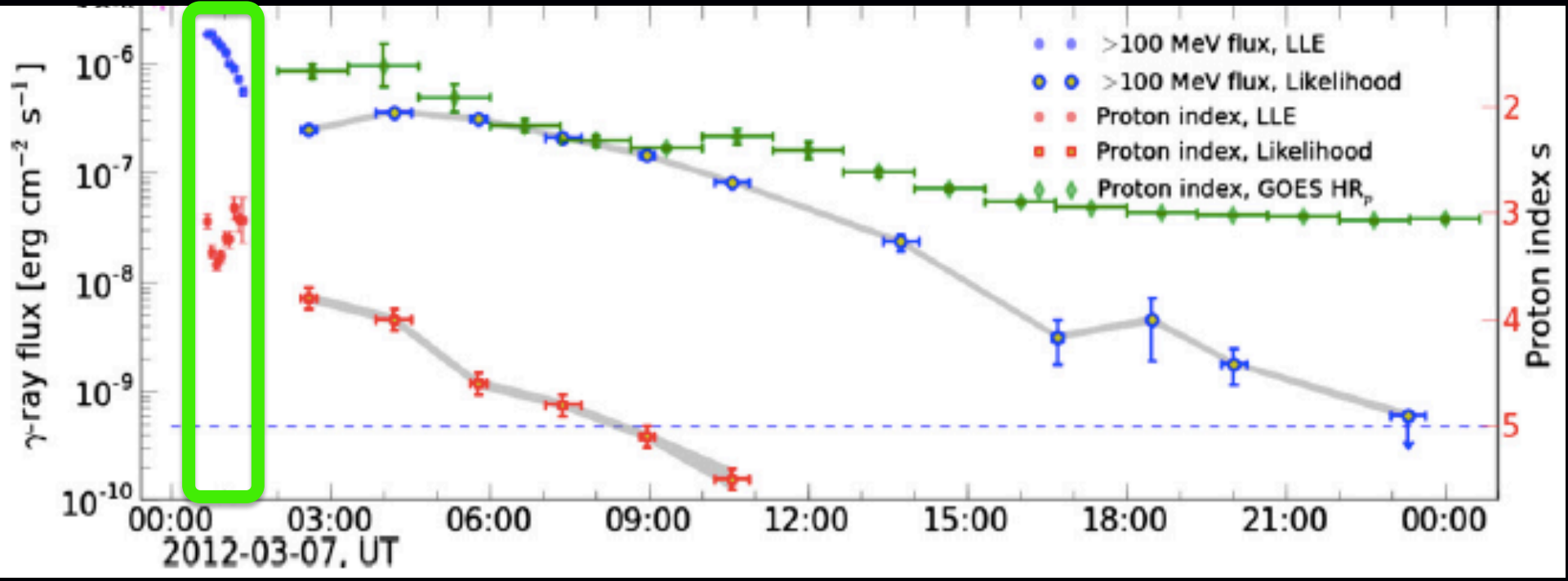
Solar flare ν, how?



Fermi light curve for March 7th, 2012
Ajello et al., 2014

Solar flare ν, how?

20 minutes



Fermi light curve for March 7th, 2012
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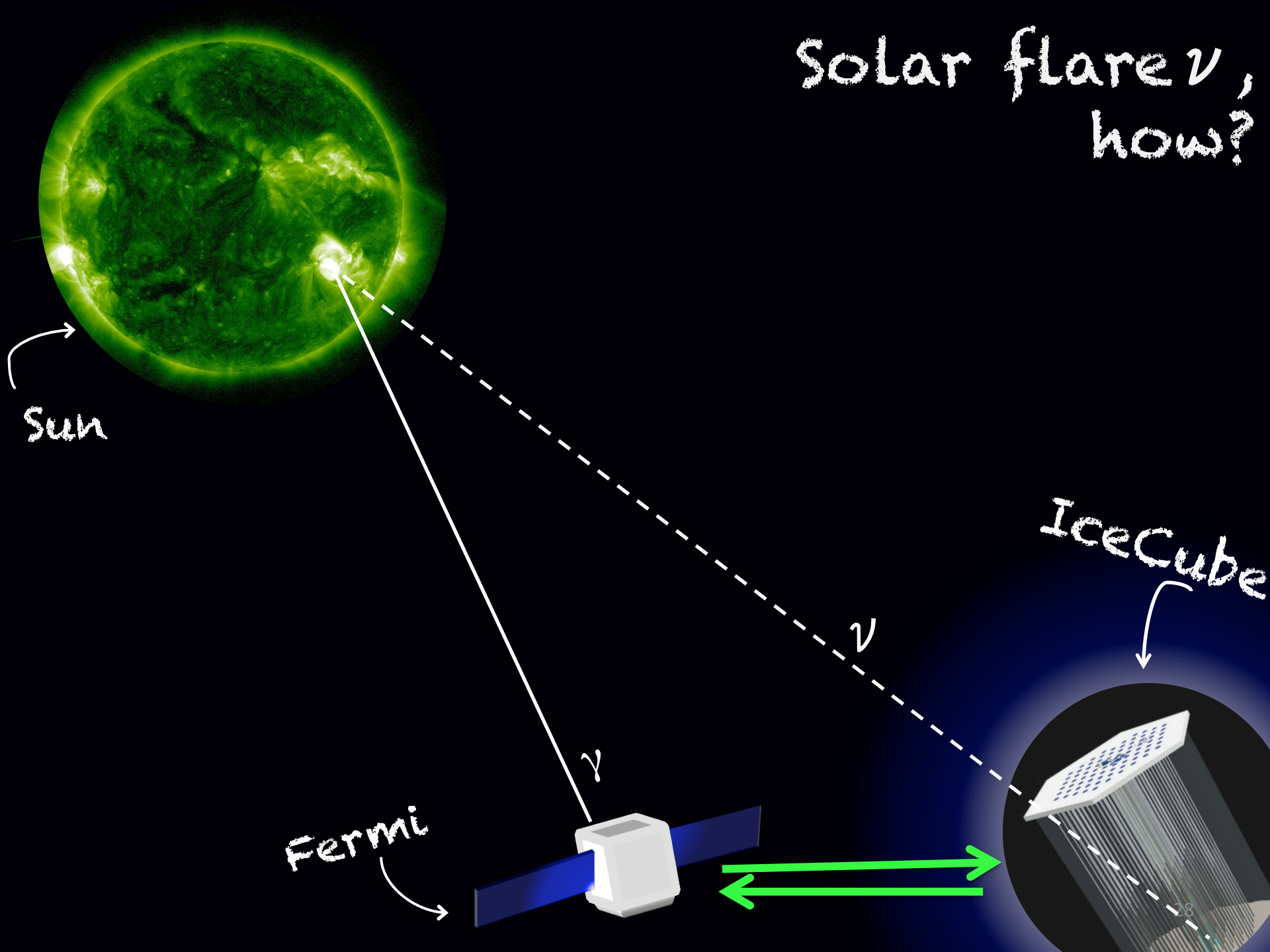
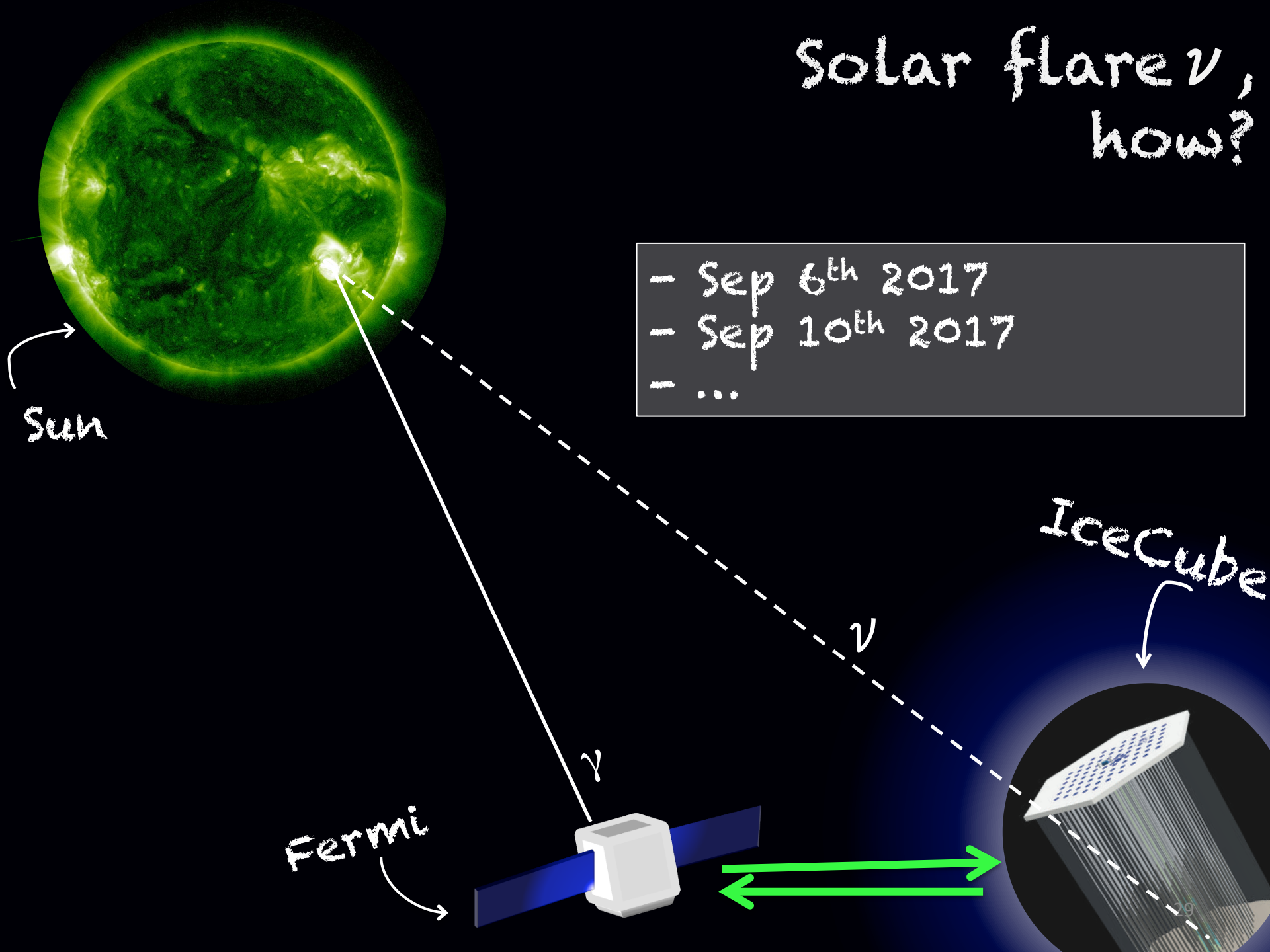
   - HitSpool data -> SFNews


Solar flare ν, how?
Sun
IceCube
ν
γ
Fermi

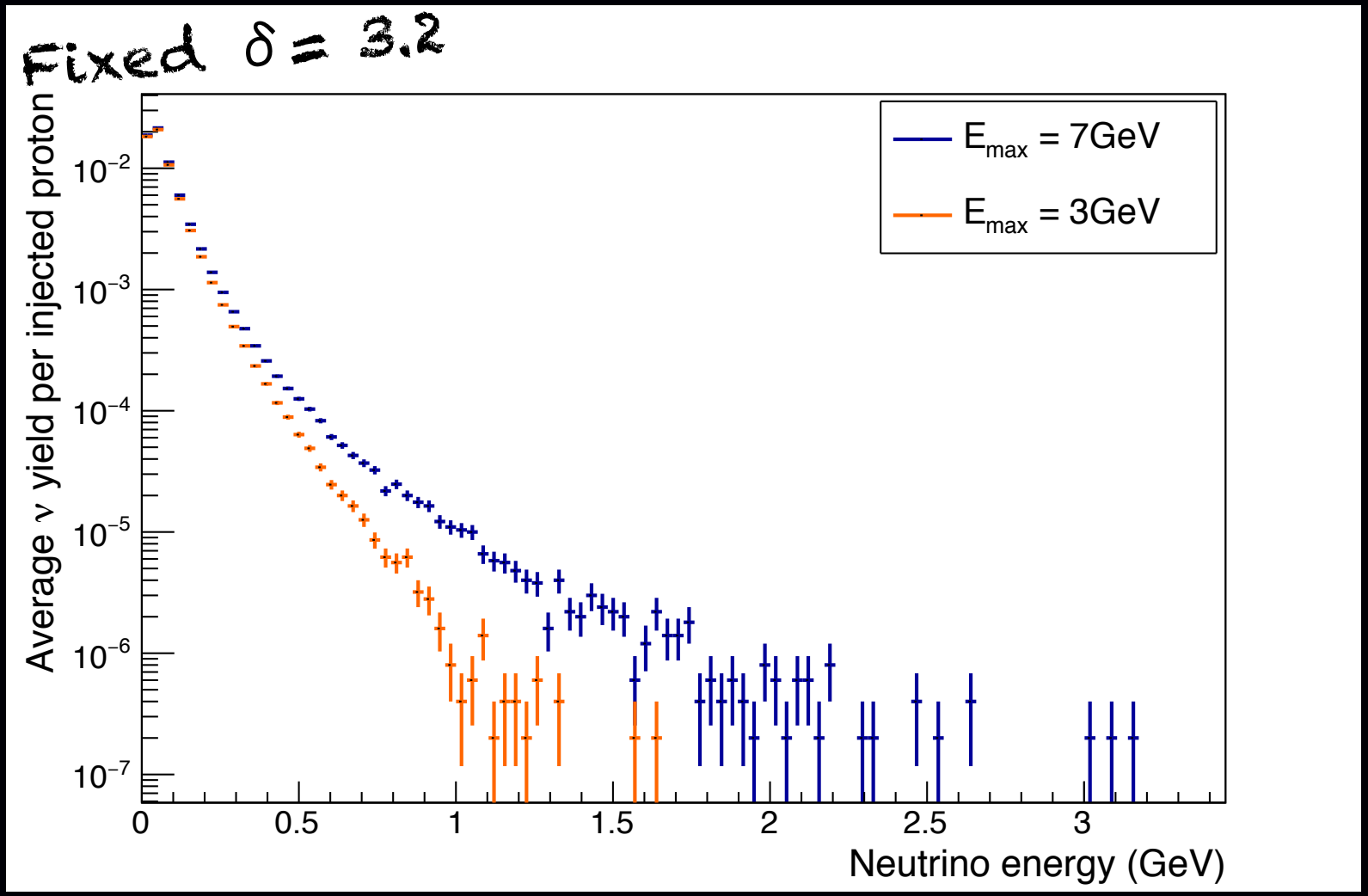
Solar flare ν, how?

- Sep 6th 2017
- Sep 10th 2017
- ...



Beam of protons: $F(E) = A\,E^{-\delta}\,H(E_{max} - E)$

A and δ derived from observations



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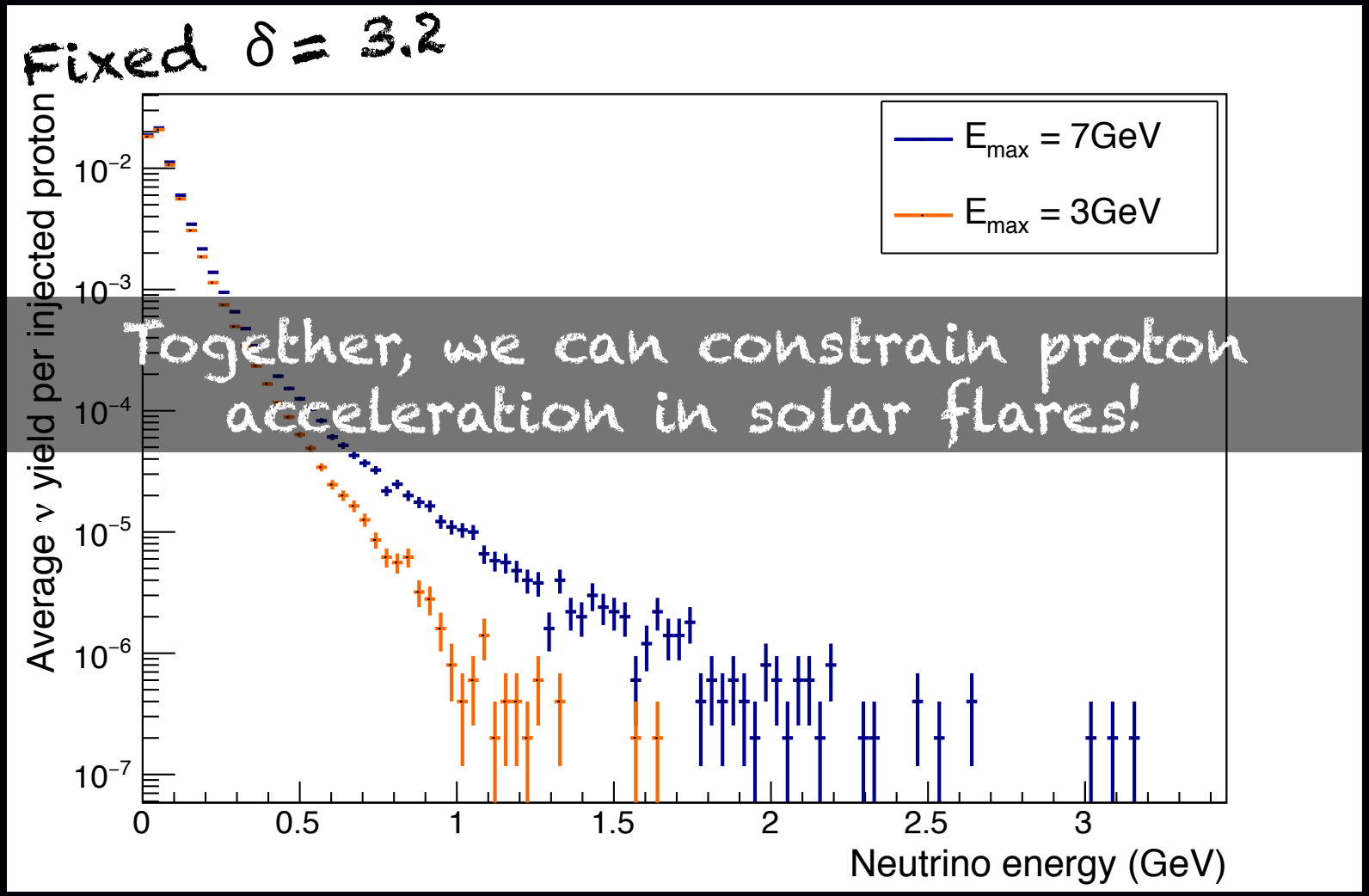
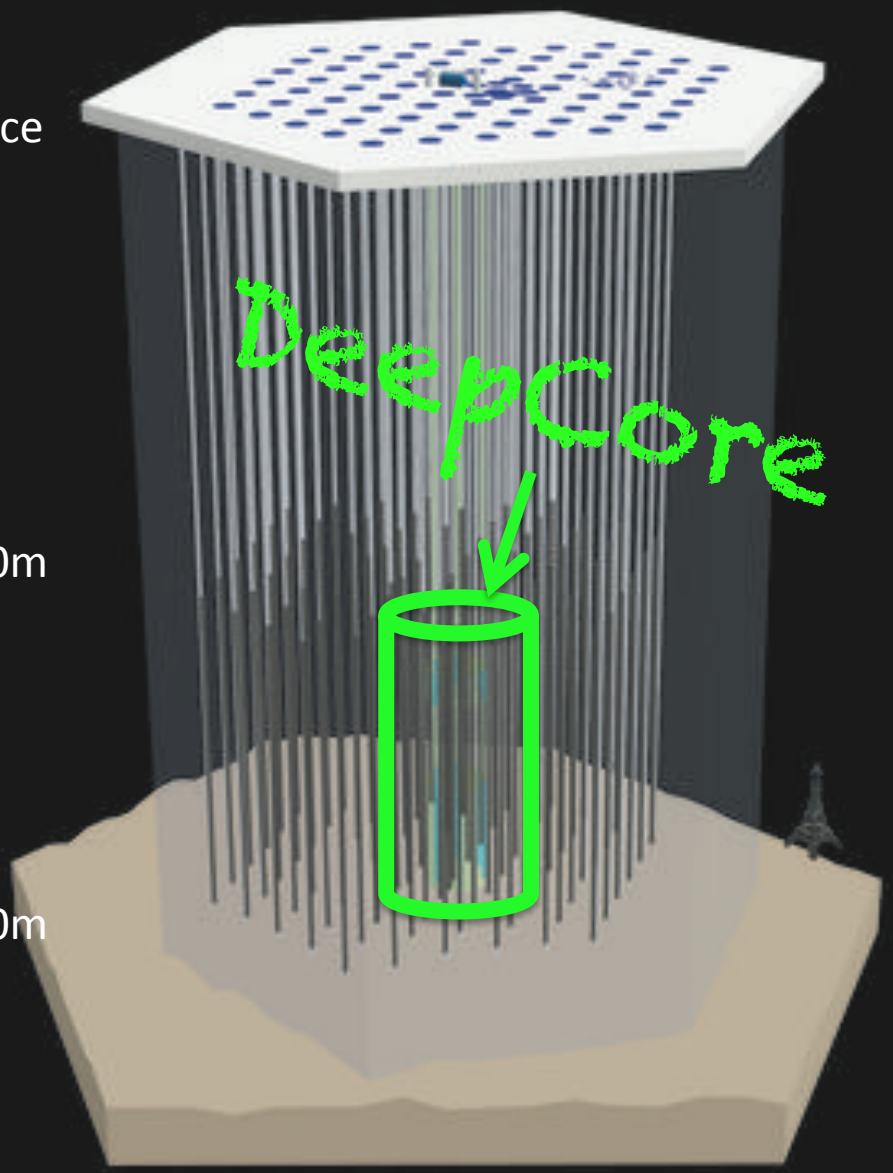


Take-home messages

- IceCube is sensitive to GeV neutrinos from transient sources
- Fermi is an essential partner in this search
- Together, we can constrain solar flare physics and much more!

Thanks!

IceCube



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