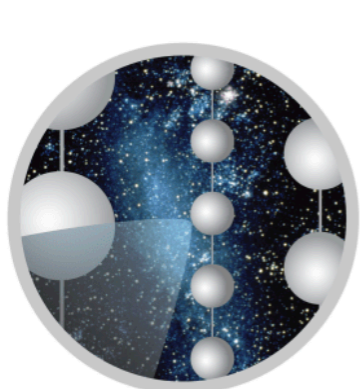


Low-energy astrophysical neutrino searches in IceCube

Presented by Per Arne Sevle Myhr
on behalf of the UCLouvain neutrino group

Belgian Physical Society meeting — Brussels 2024
Fundamental interactions session — Wednesday, May 29th



ICECUBE
NEUTRINO OBSERVATORY



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UCLouvain

Why low-energy neutrino astronomy?

Feasibility with gigaton detectors

ELOWEN — “first light” at GeV energies

HitSpooling — A novel approach

Why low-energy neutrino astronomy?

High-energy astrophysical neutrinos confirmed

Low-energy counterparts

Higher flux

Other interaction channels (pp, pn, β)

Transient sources

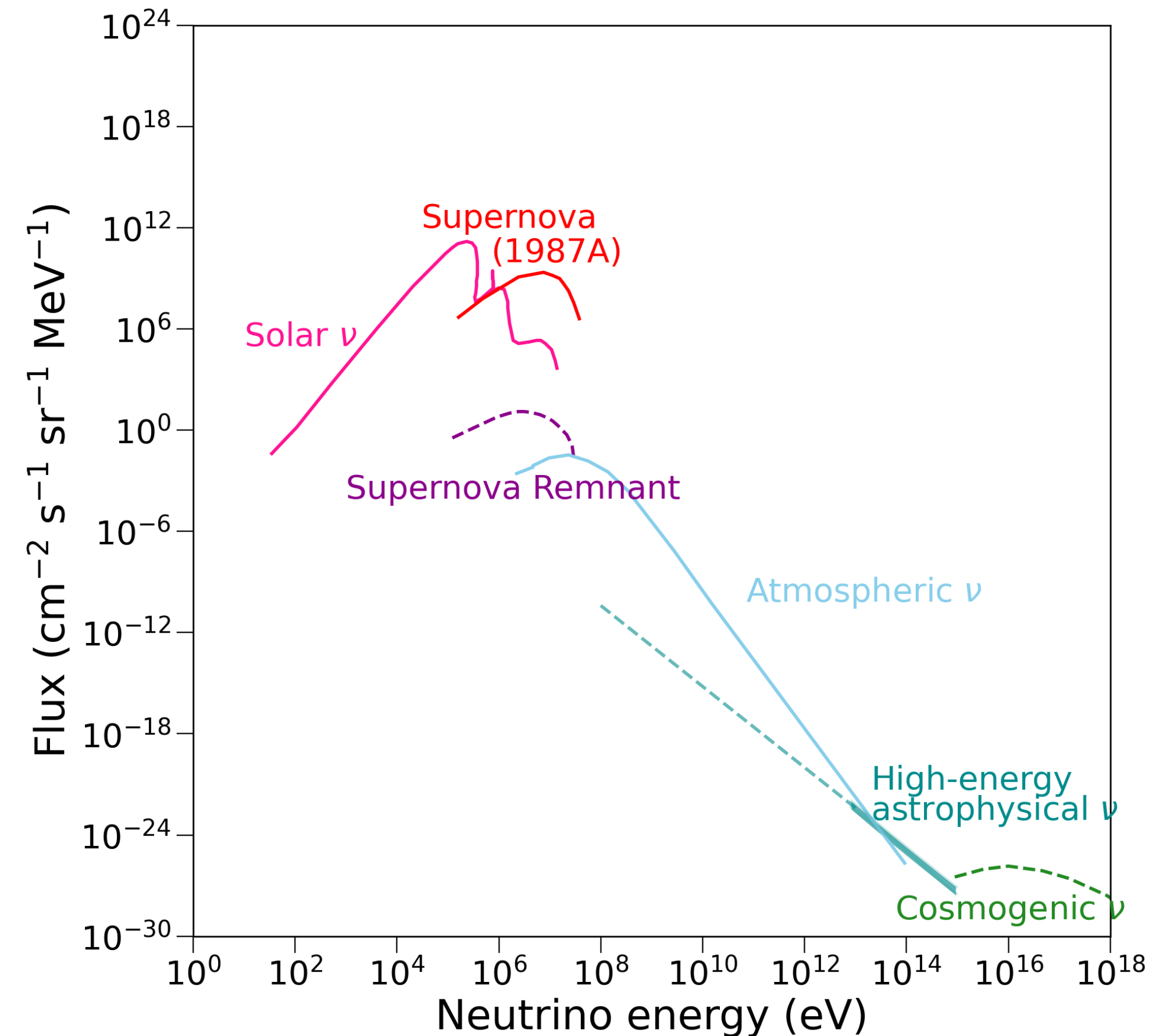
Gamma-ray bursts (GRBs)

Compact binary coalescences (CBCs)

Flares (solar, astrophysical)

Tidal disruption events (TDEs)

Different novae



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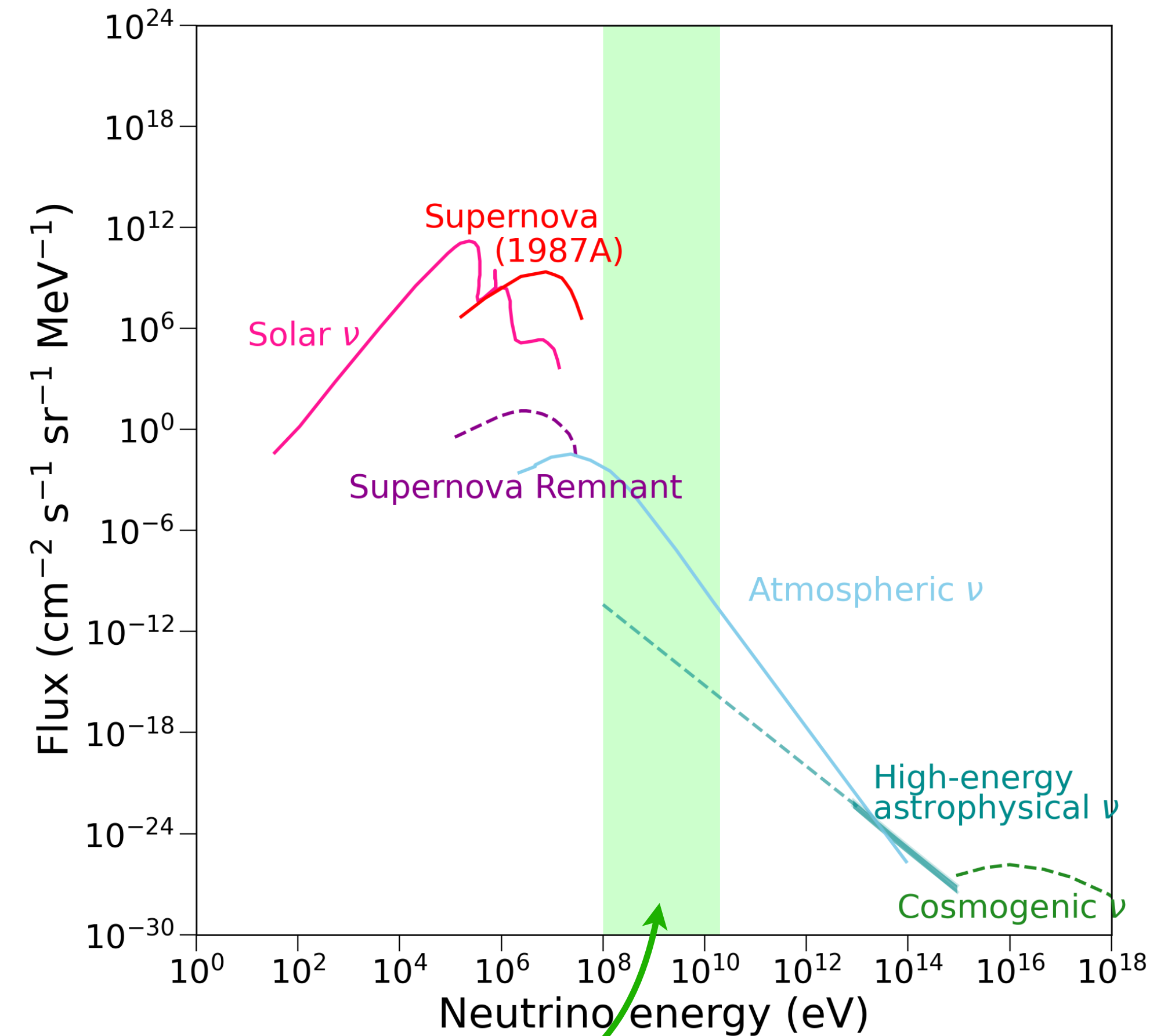
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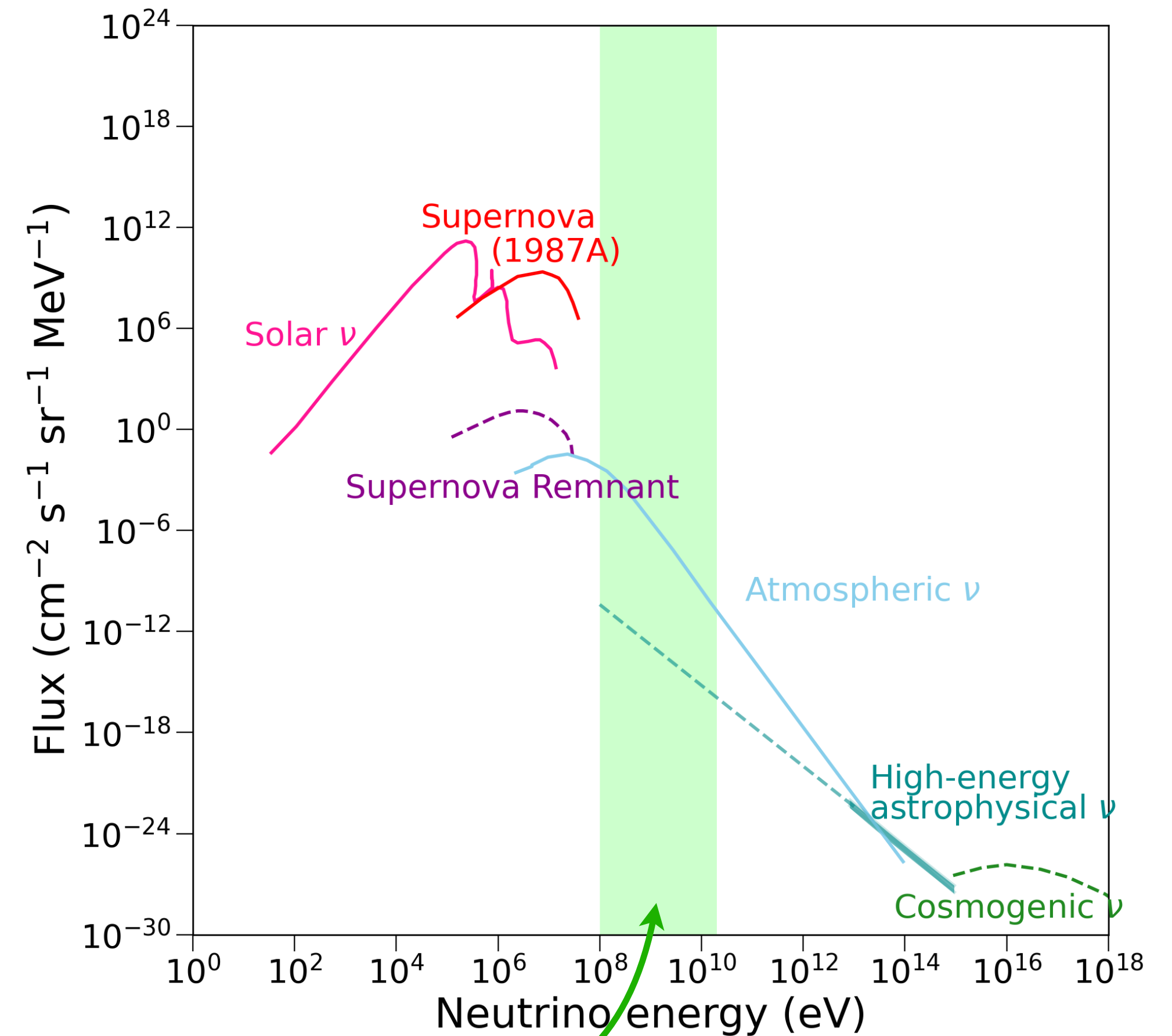
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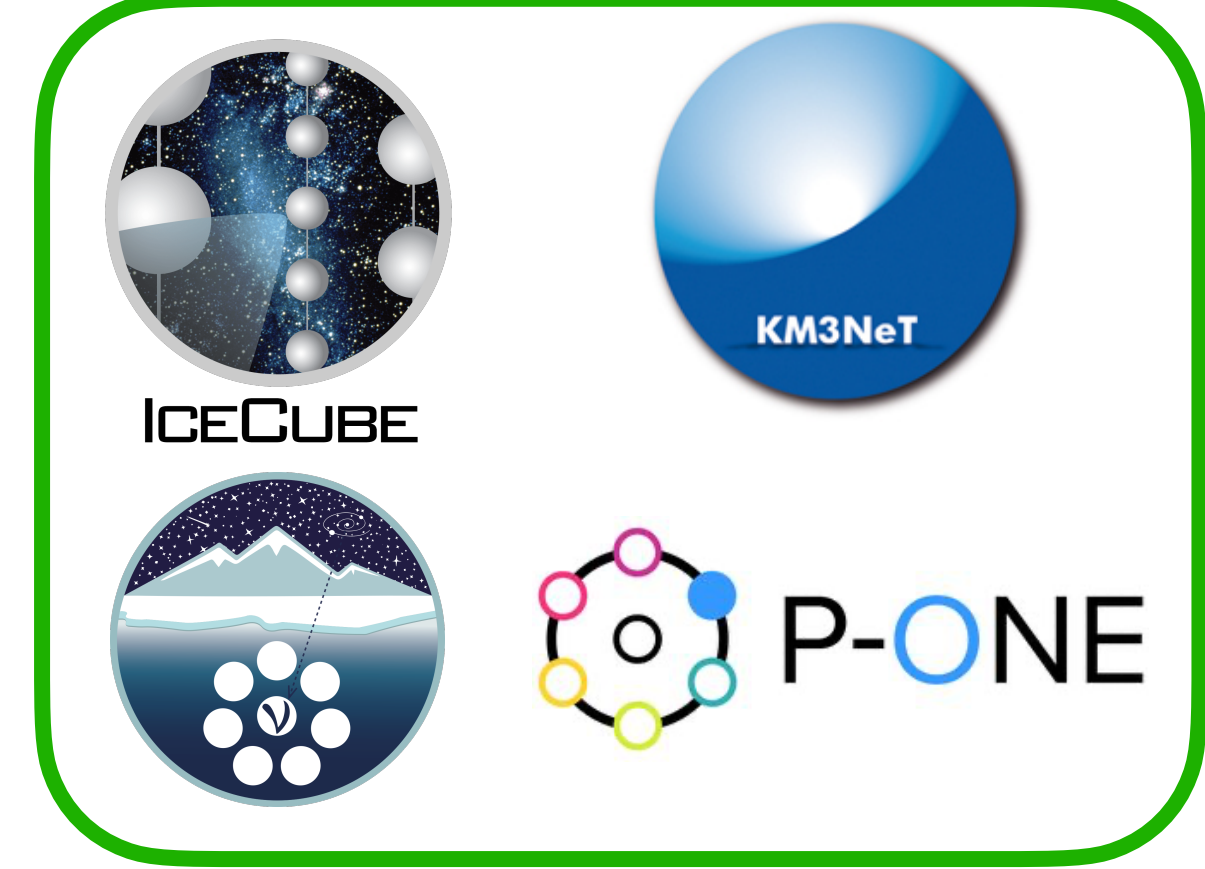
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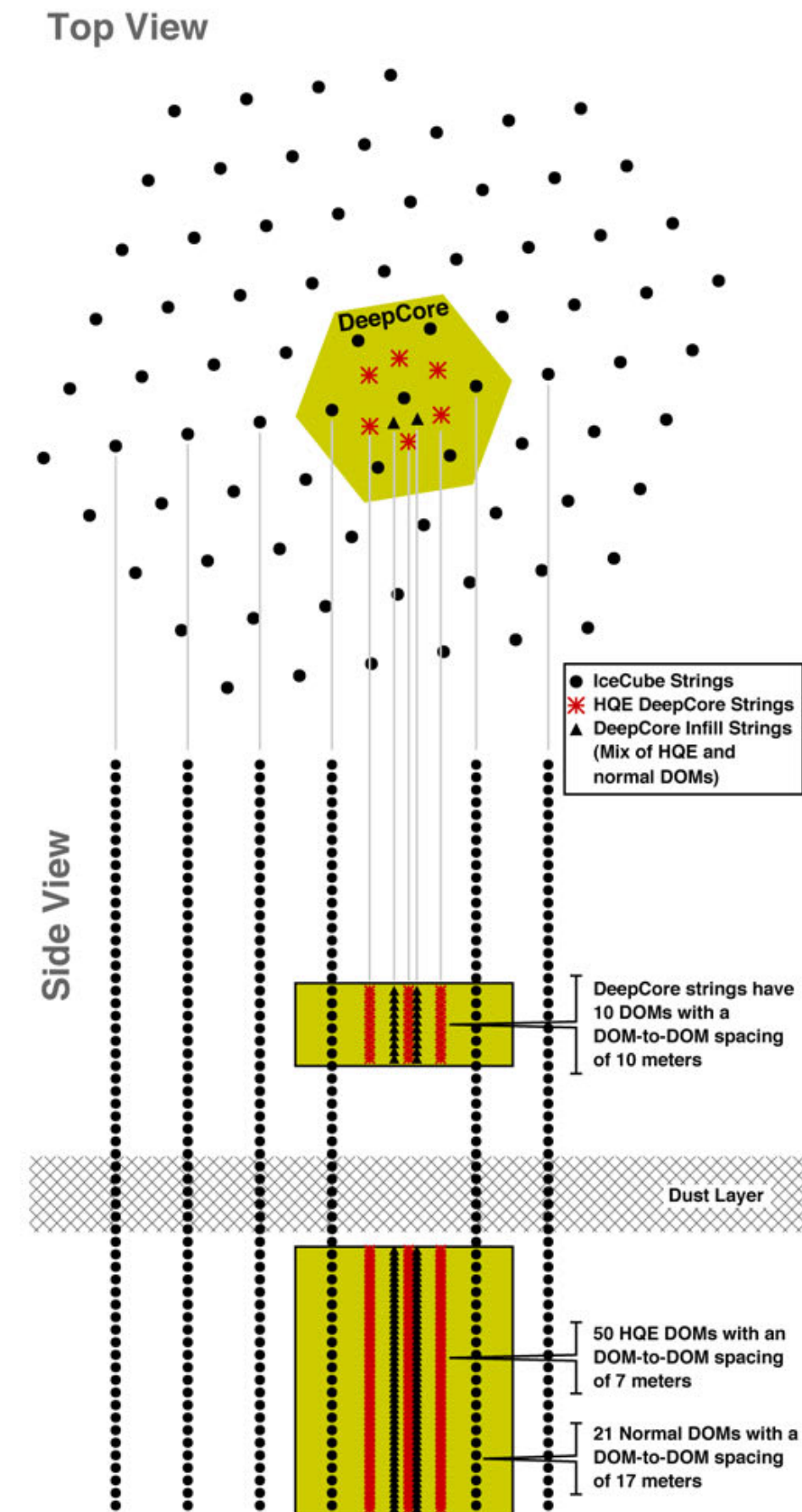
IceCube (and friends) are built for TeV+ neutrinos

— “Always on”

DeepCore — Infill with denser detection units

“Historically” used for oscillations

We use it for astrophysical transient



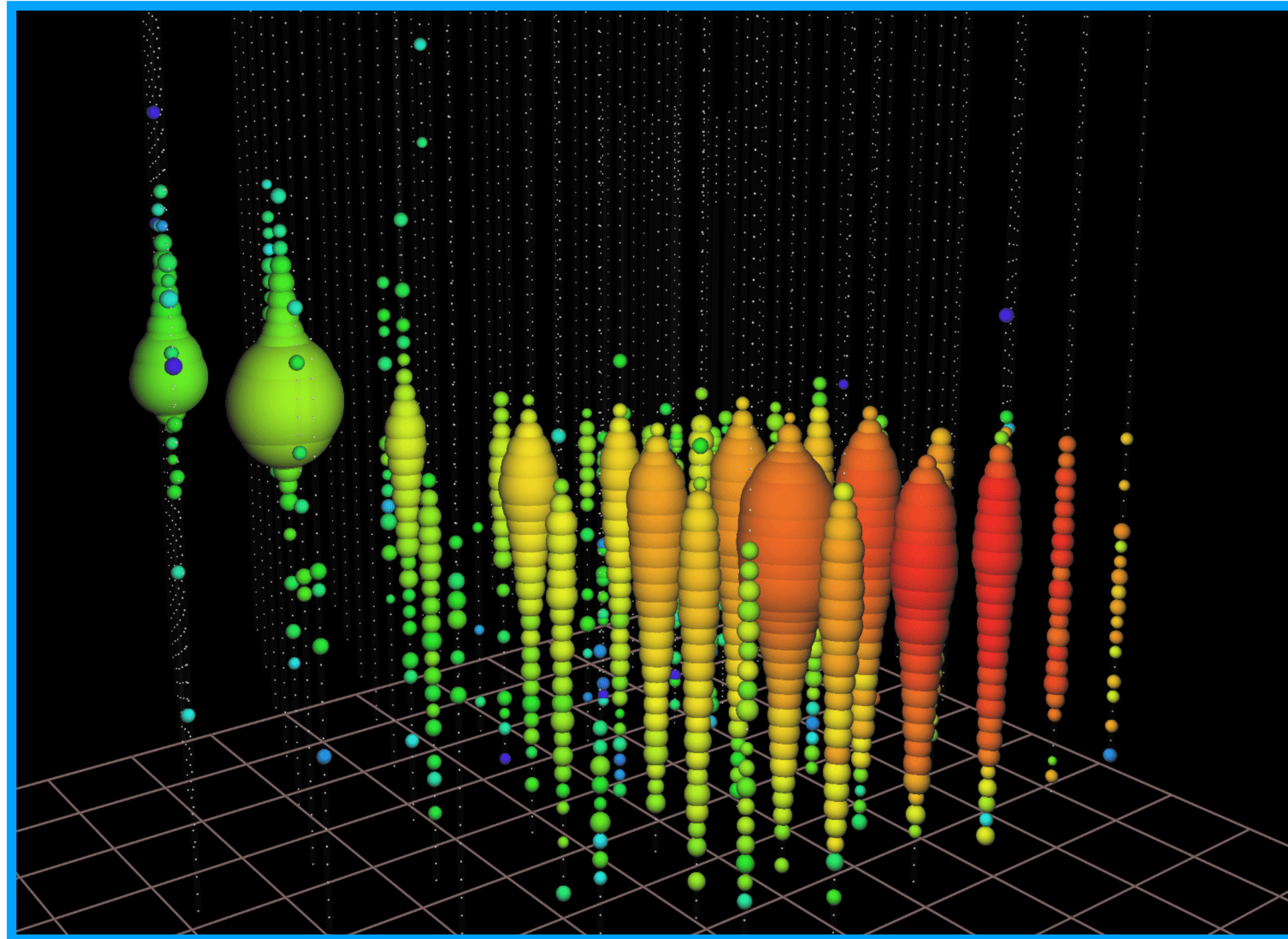
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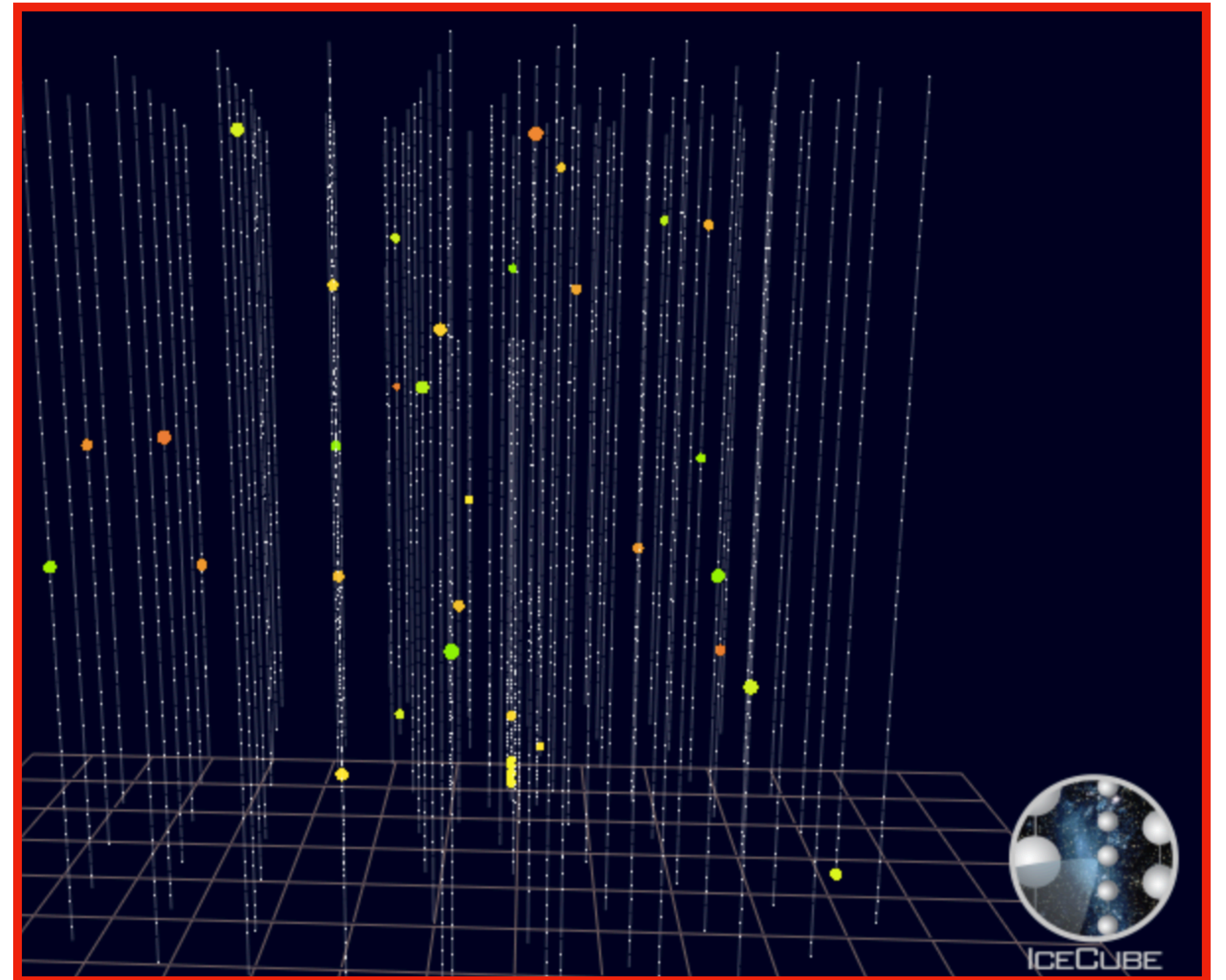
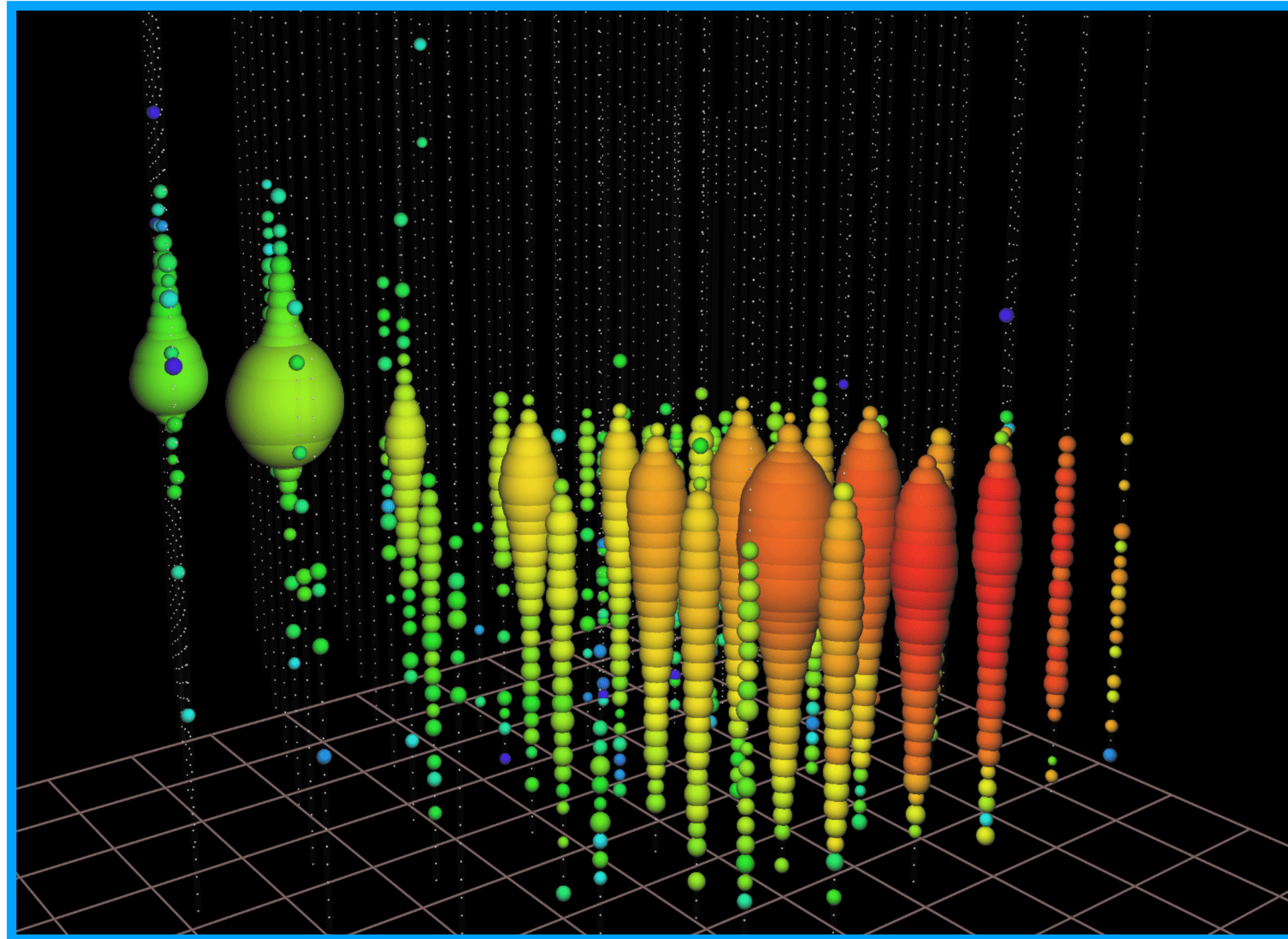
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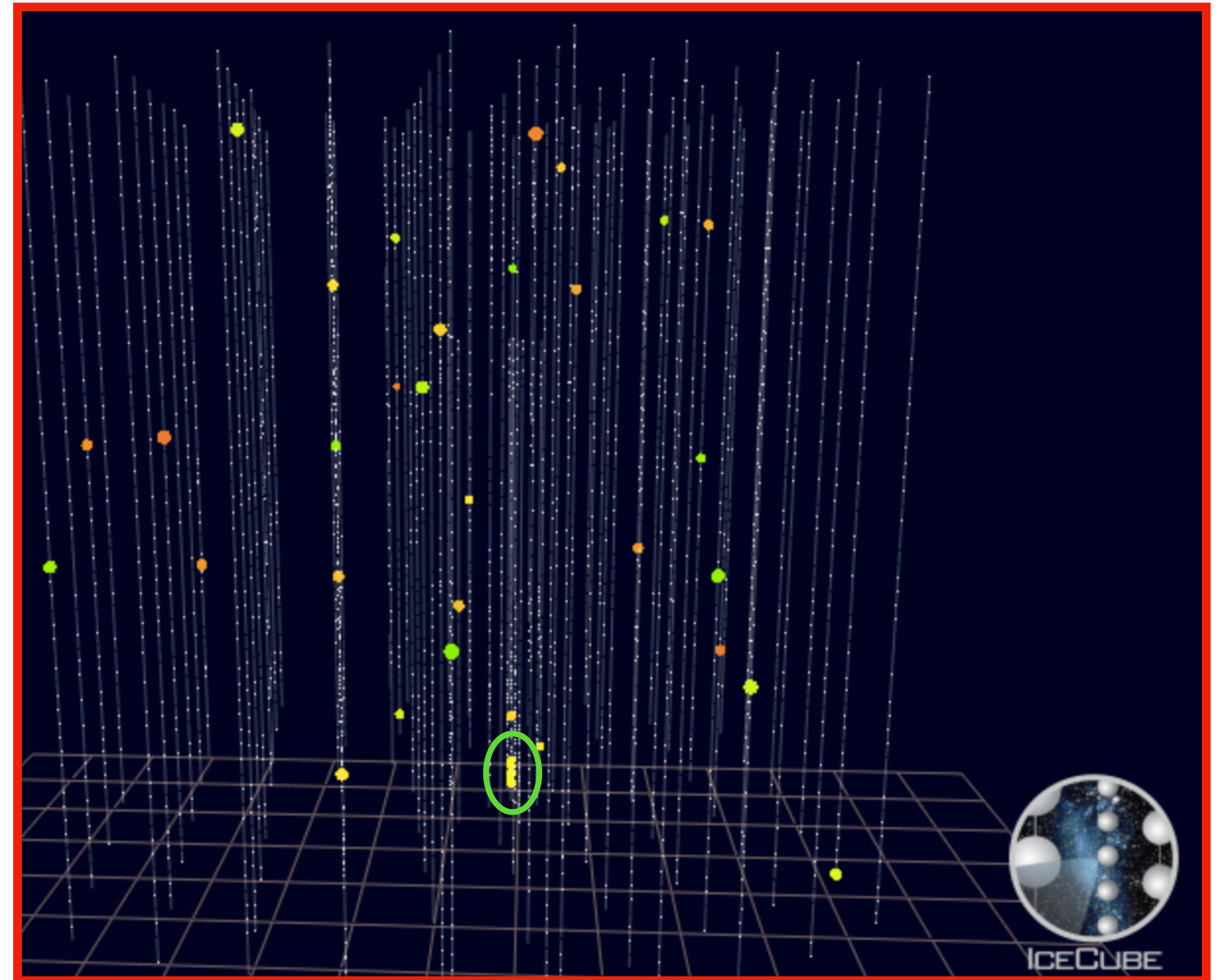
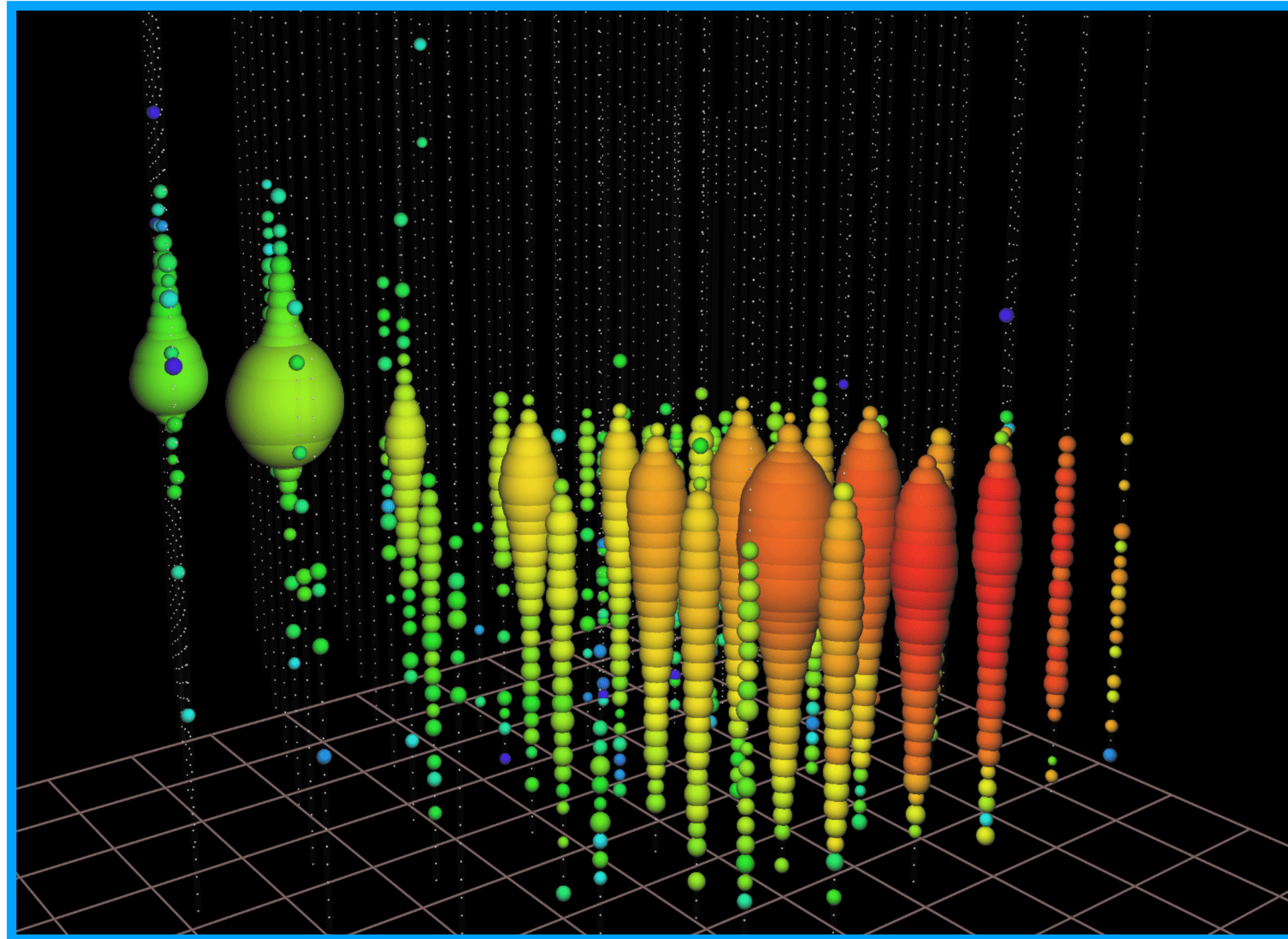
High-energy event



Elowen-energy event



Elowen-energy event



Elowen — “first light” at GeV energies

ELOWEN — Extremely LOW ENergy

Most sensitive IceCube analysis below 10 GeV

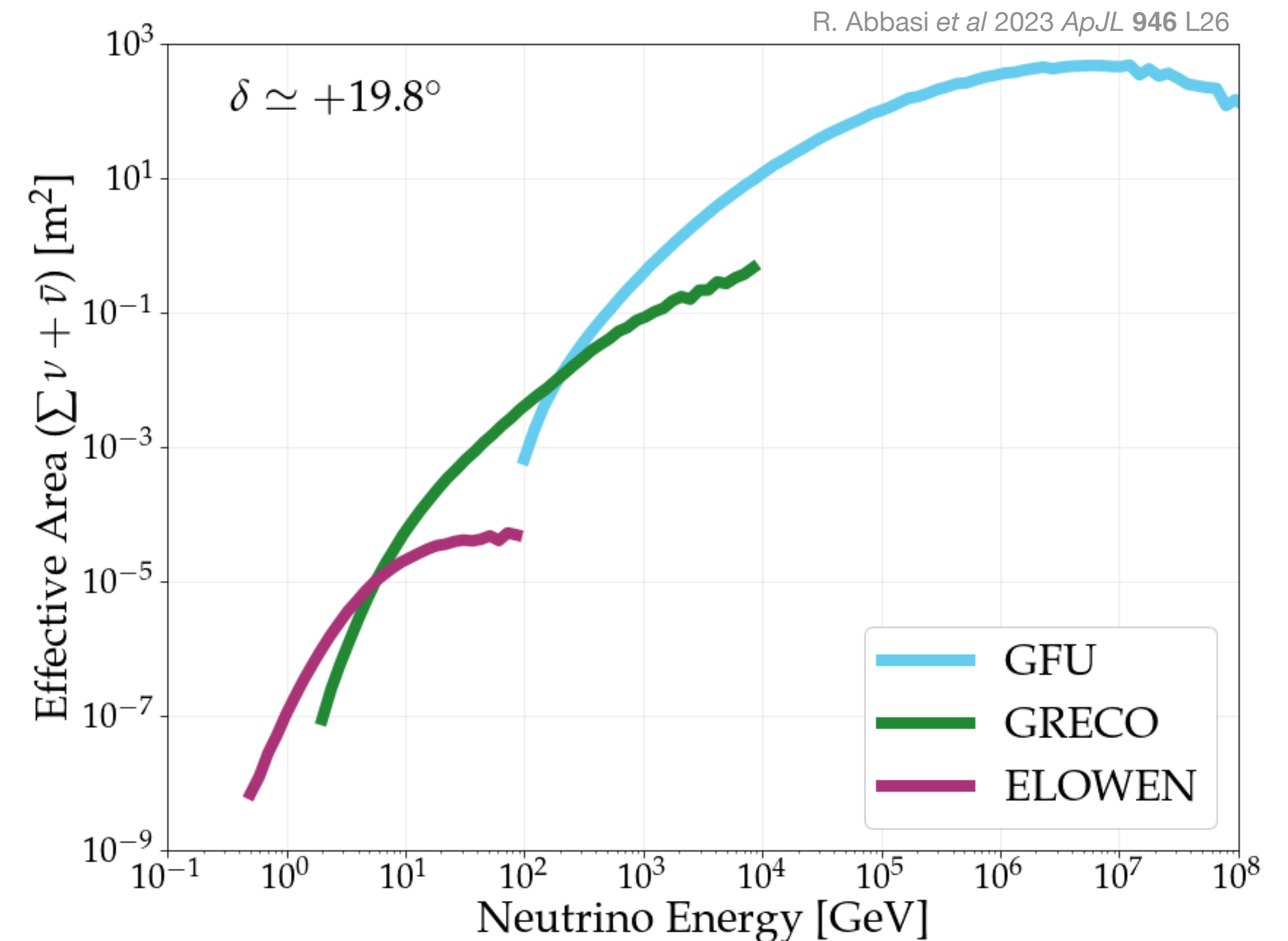
Sensitive for $E_\nu \in [0.5, \sim 100]$ GeV

Originally developed for solar flare neutrinos

Used for other transients:

*LIGO-Virgo-KAGRA (LVK) follow-up

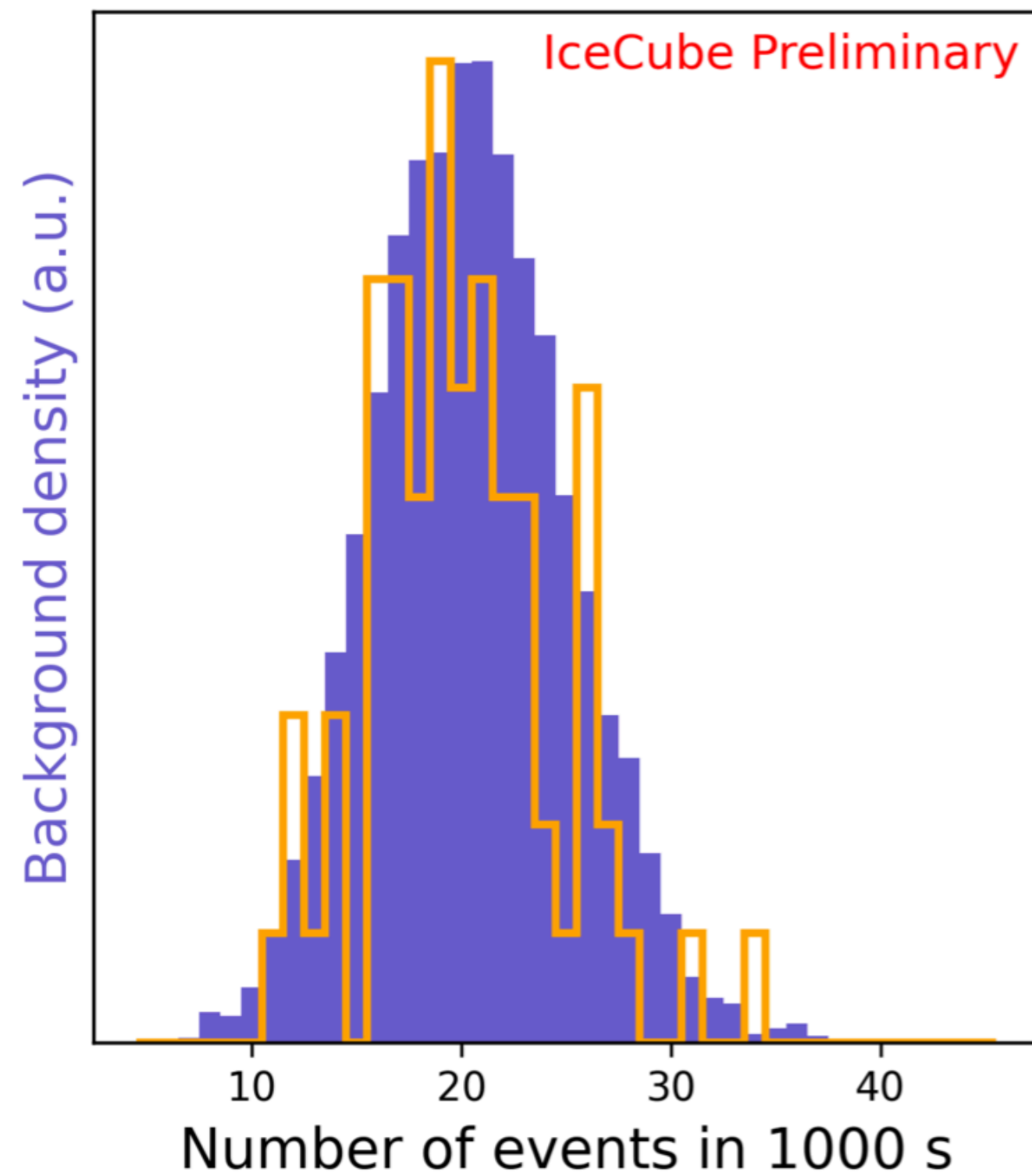
*GRB221009A



Elowen — GW followup & GRB221009A

O4a follow-ups

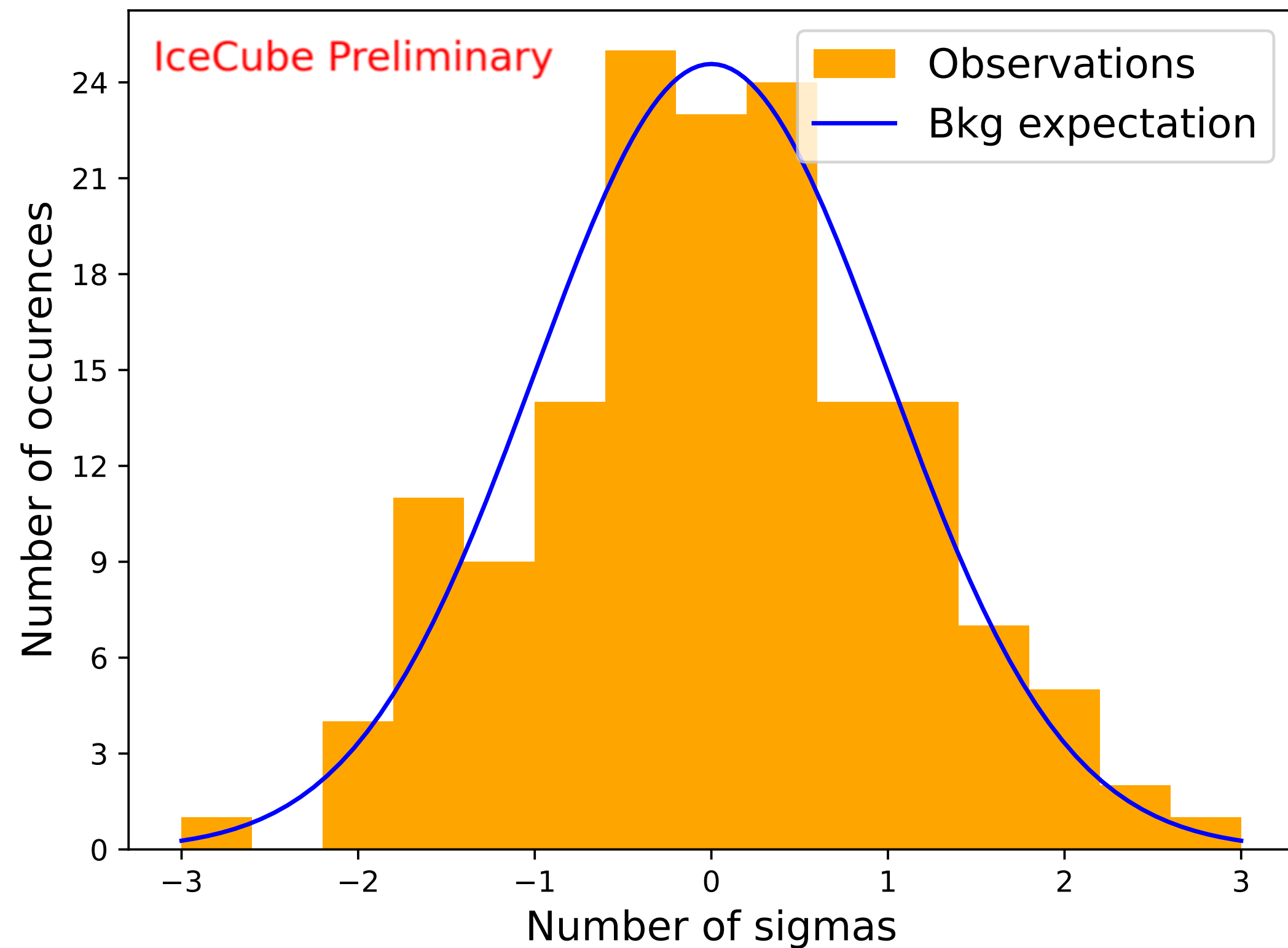
Contribution to GRB221009A



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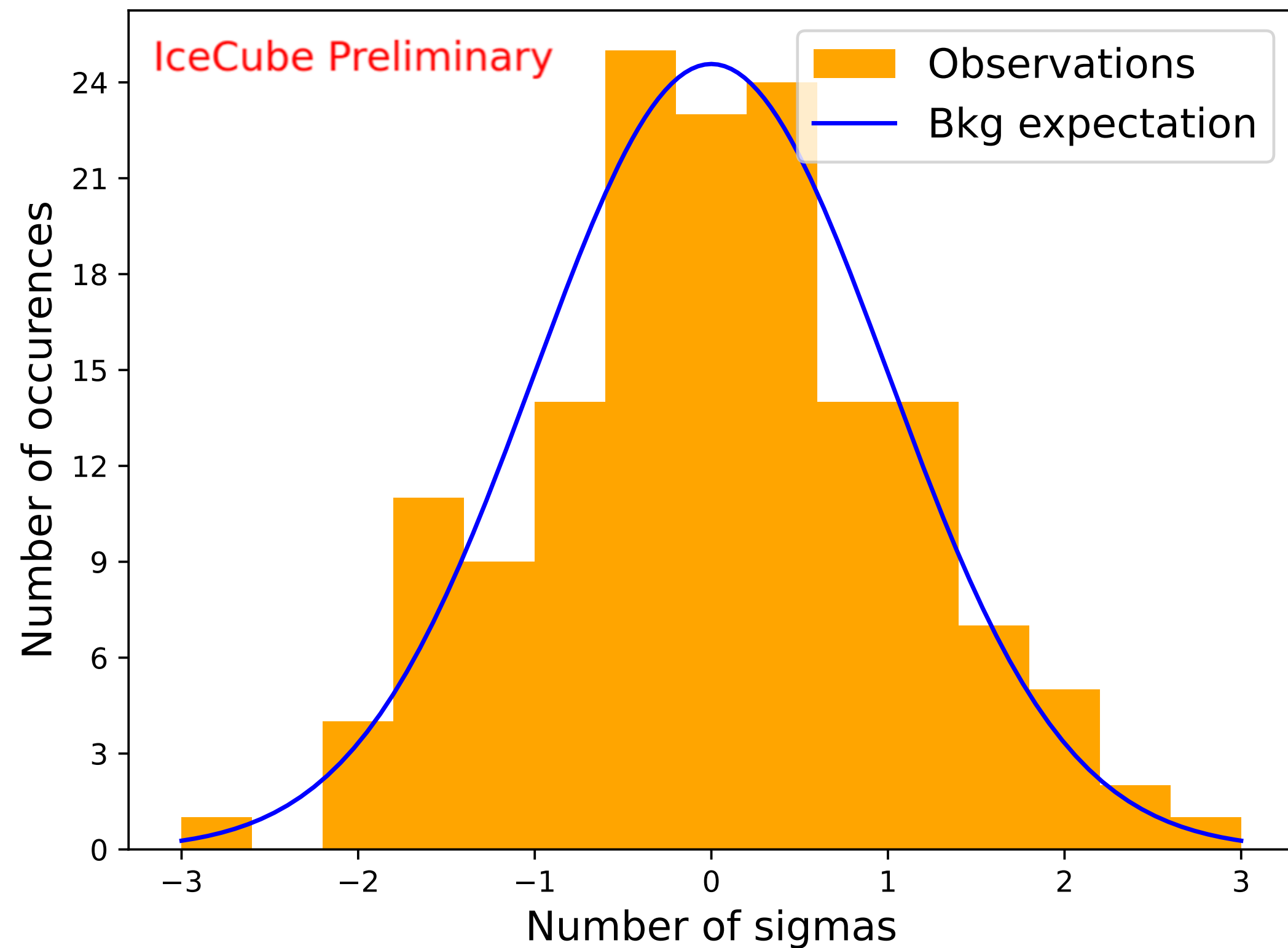
All GW follow-ups

Contribution to GRB221009A

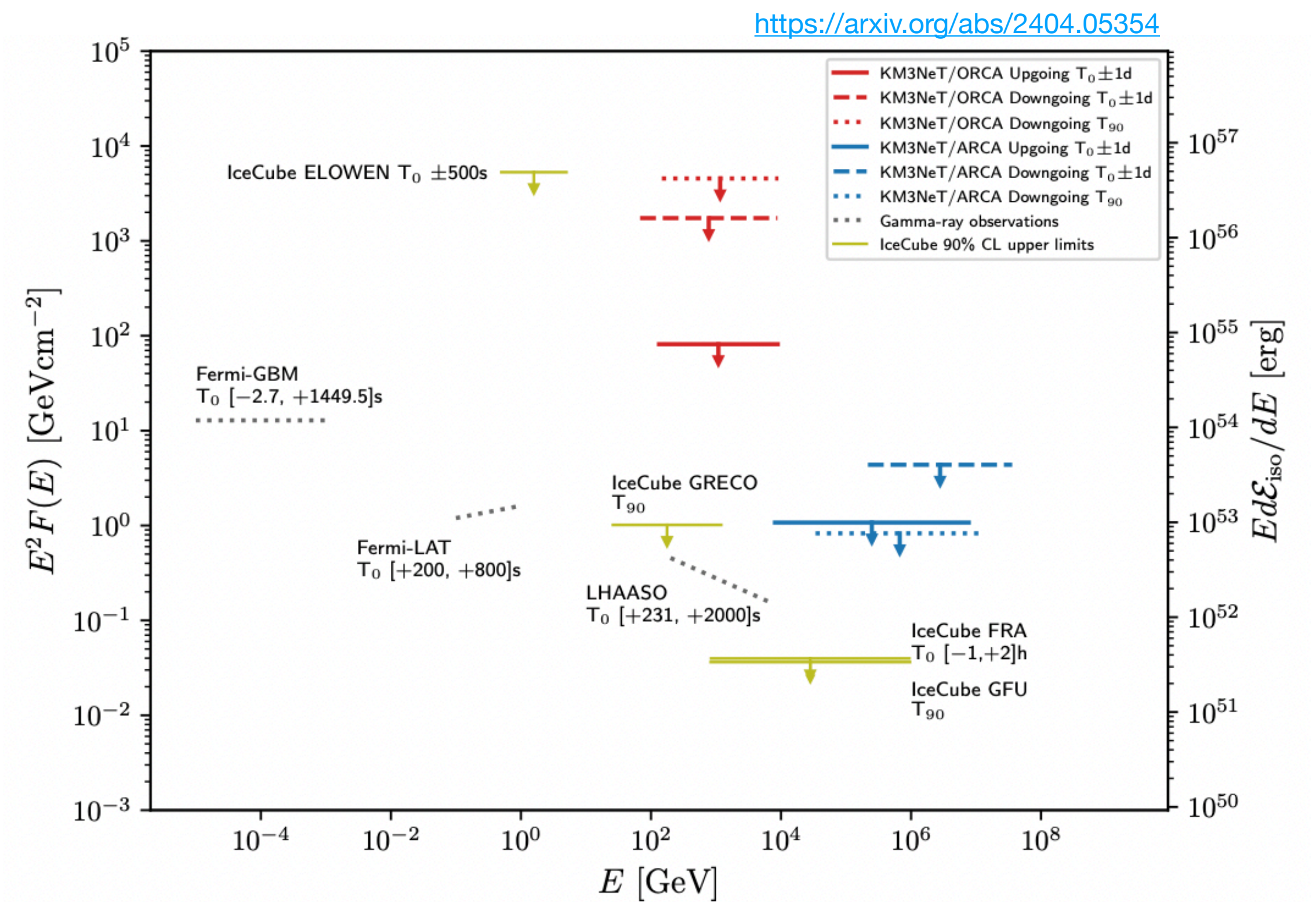


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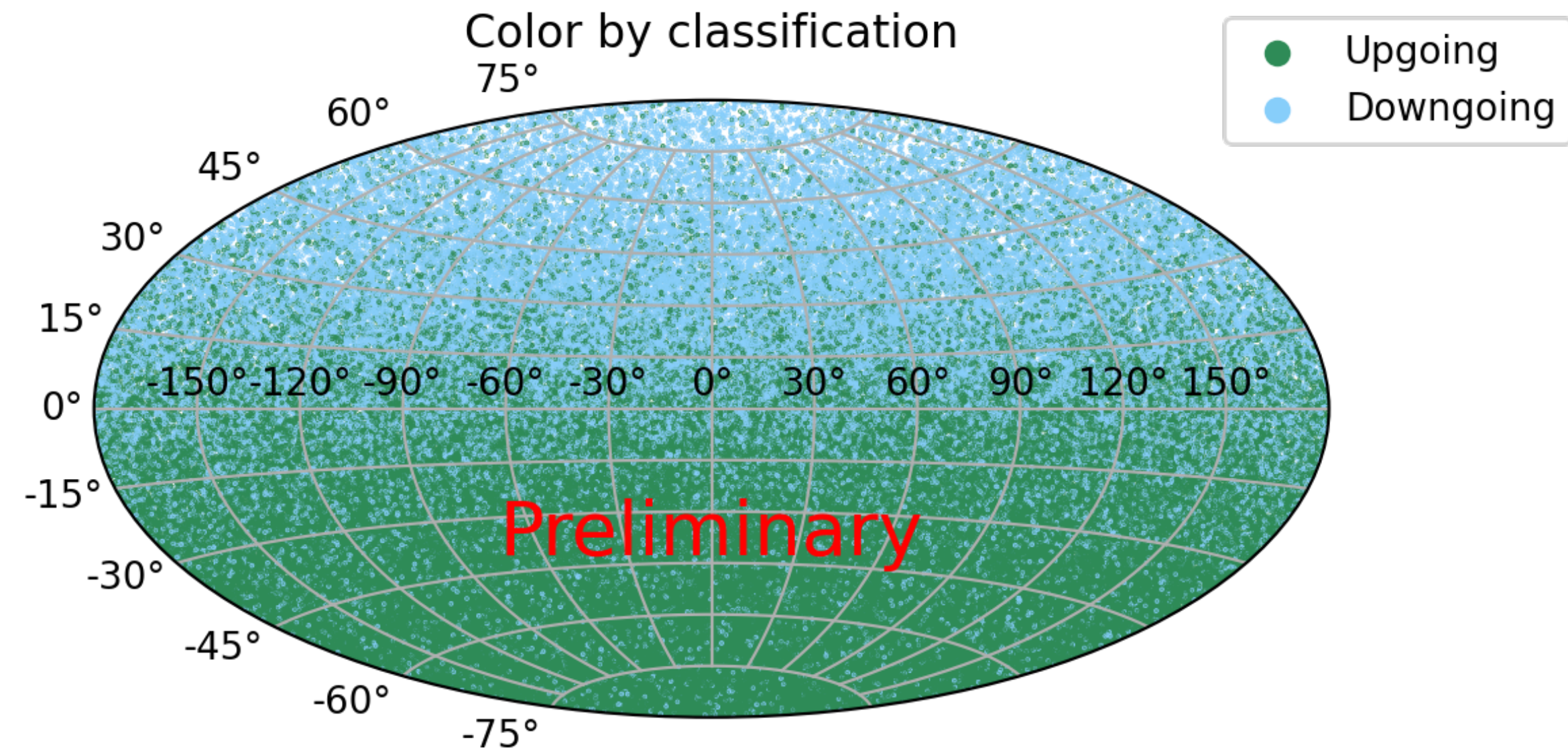
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Elowen 2.0

Parameter optimisation

Directional reconstruction



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Below 0.5 GeV requires a different approach

Subthreshold — below triggering conditions

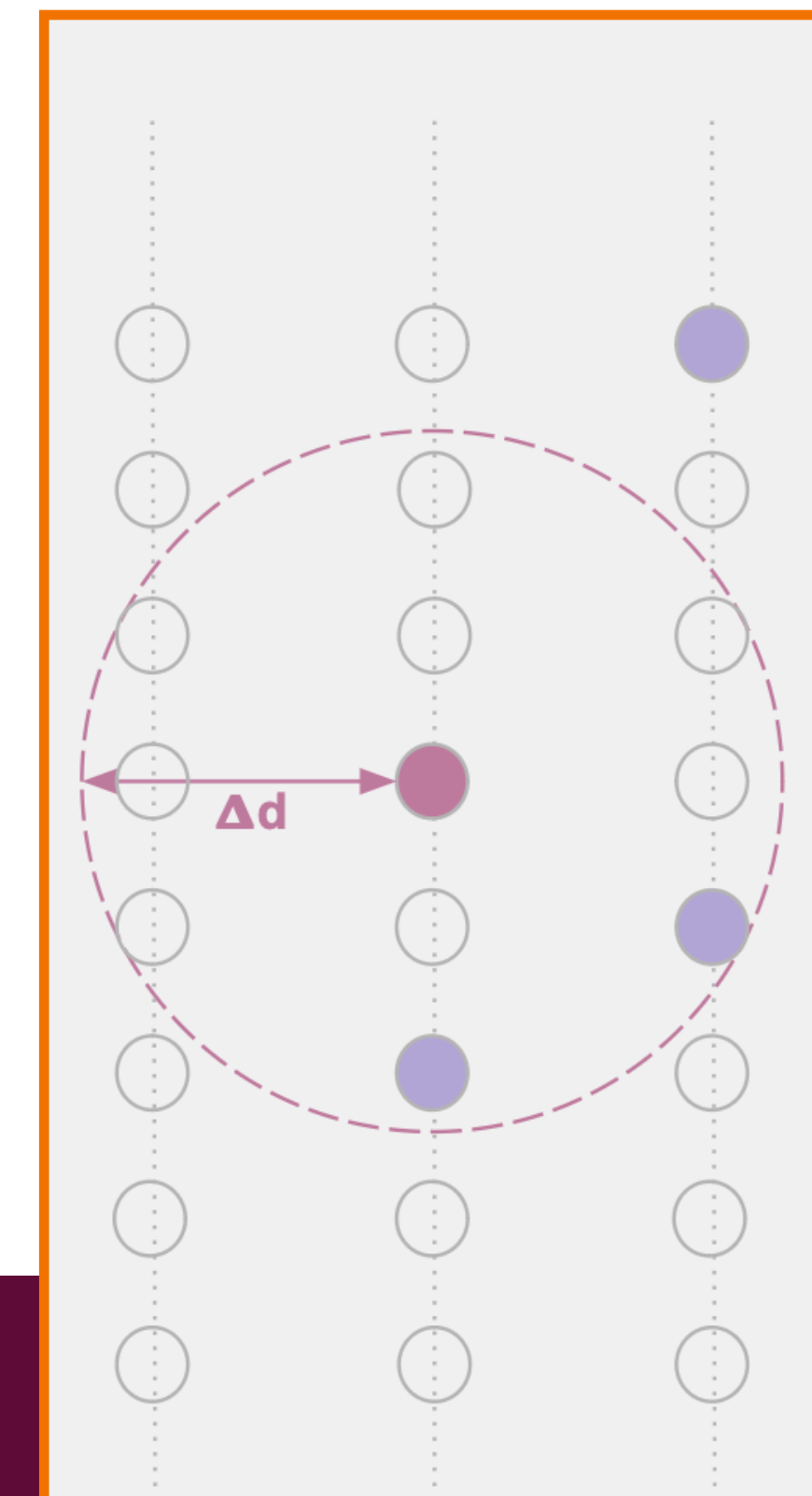
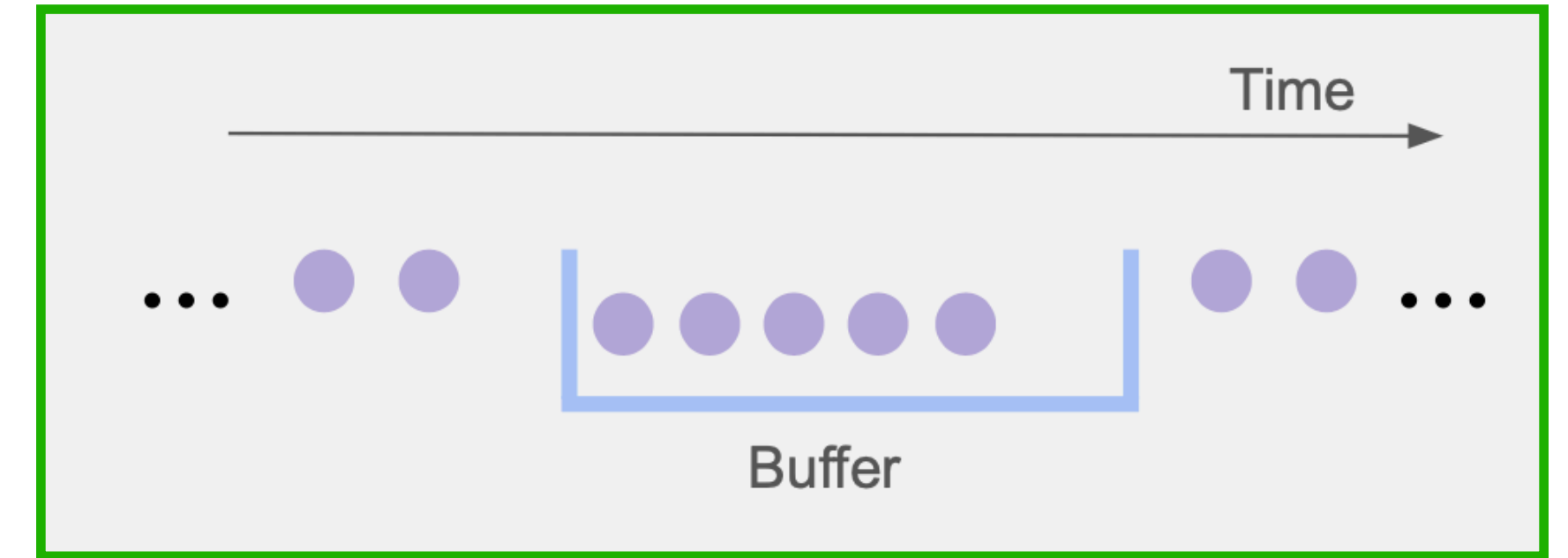
HitSpool

Temporary full detector **buffer**

New processing & analysis pipelines

“Burst” search

Correlated, subthreshold interactions



HitSpooling — Preliminary results

Bursts -> List of correlated hits

Highly noise-dominated

Three steps:

- Additional parametrisation

- Principal component analysis (PCA)

- t-SNE (non-linear)

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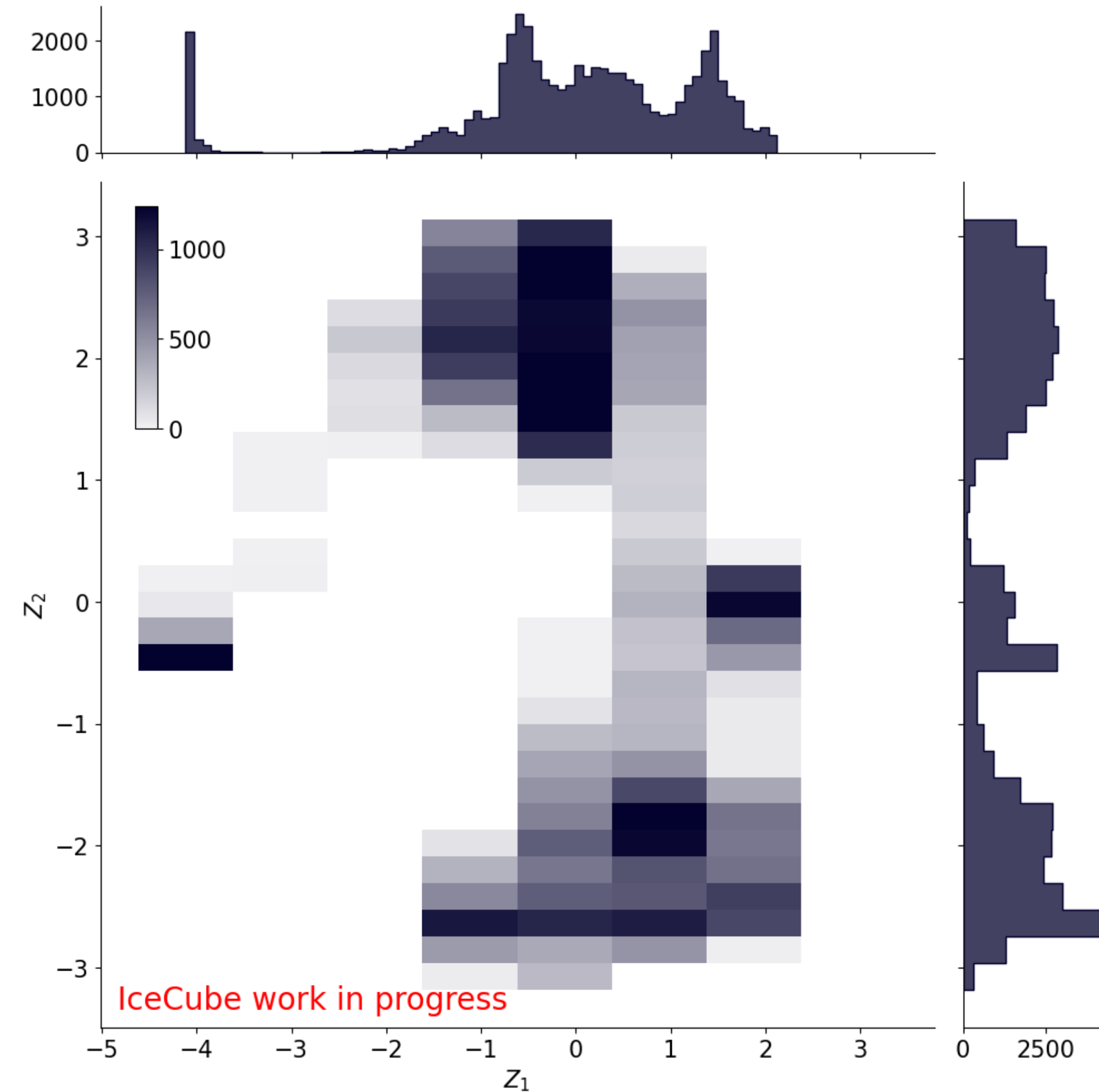
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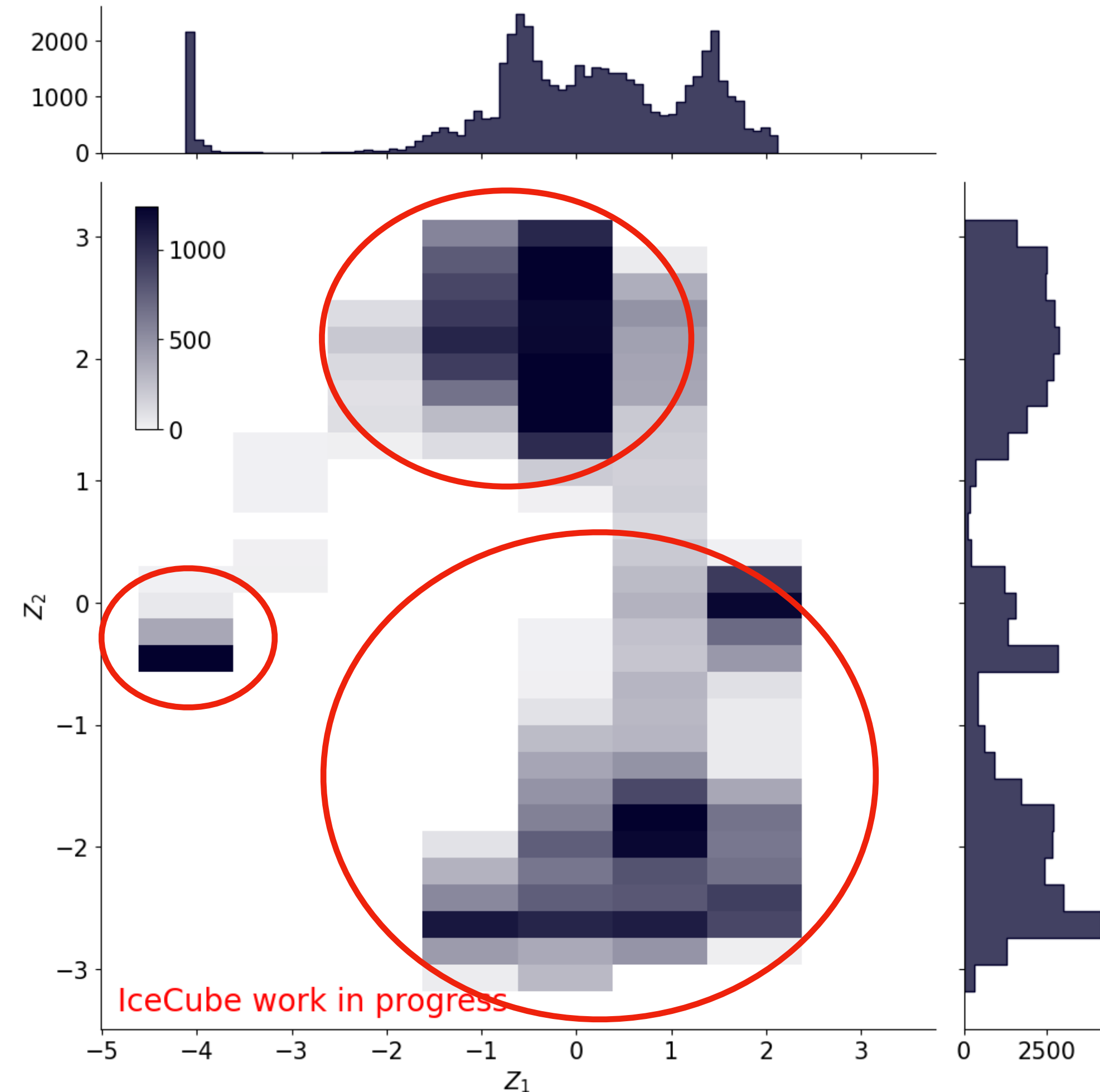
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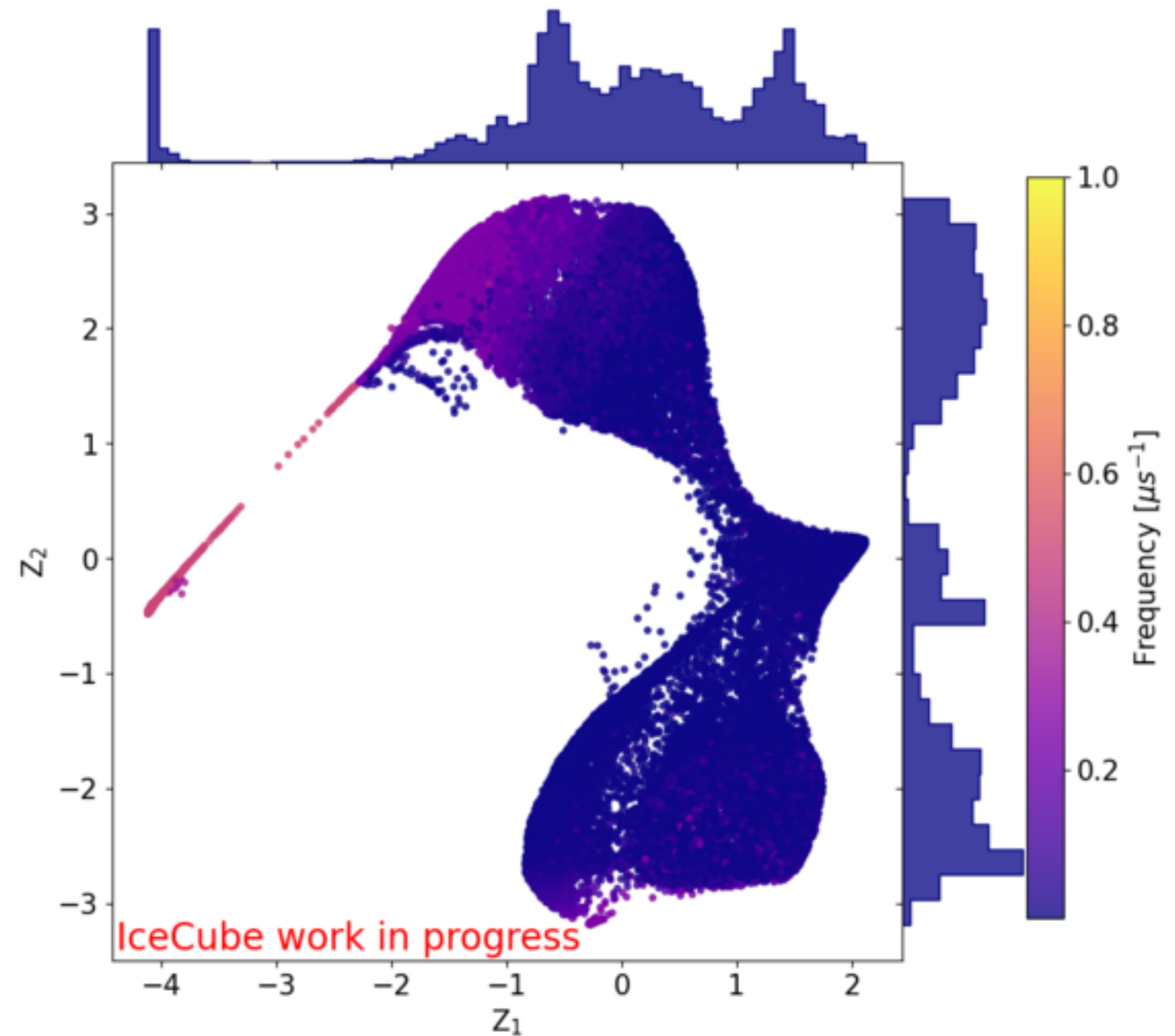
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Take-home multi-messages

(sub-)GeV neutrino astronomy with gigaton detectors is thriving!

I have focused on **IceCube**, but we are also heavily involved with **KM3NeT**.

With ELOWEN, we are doing **multi-messenger follow-ups** and improving the analysis.

Pushing to **even lower energies** with novel approaches.

There is a **clear structure** to subthreshold interactions in IceCube.

Thank you!