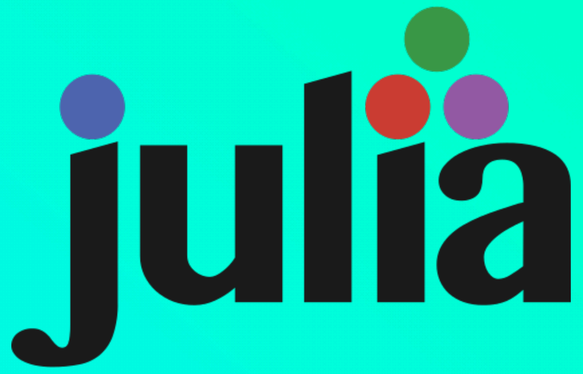
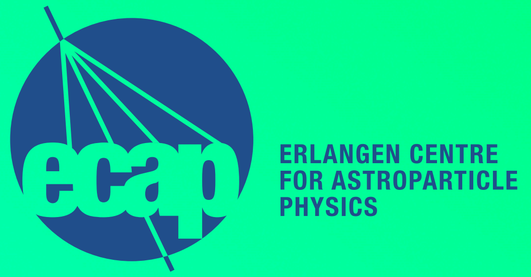




3D Neutrino Event Display RainbowAlga.jl

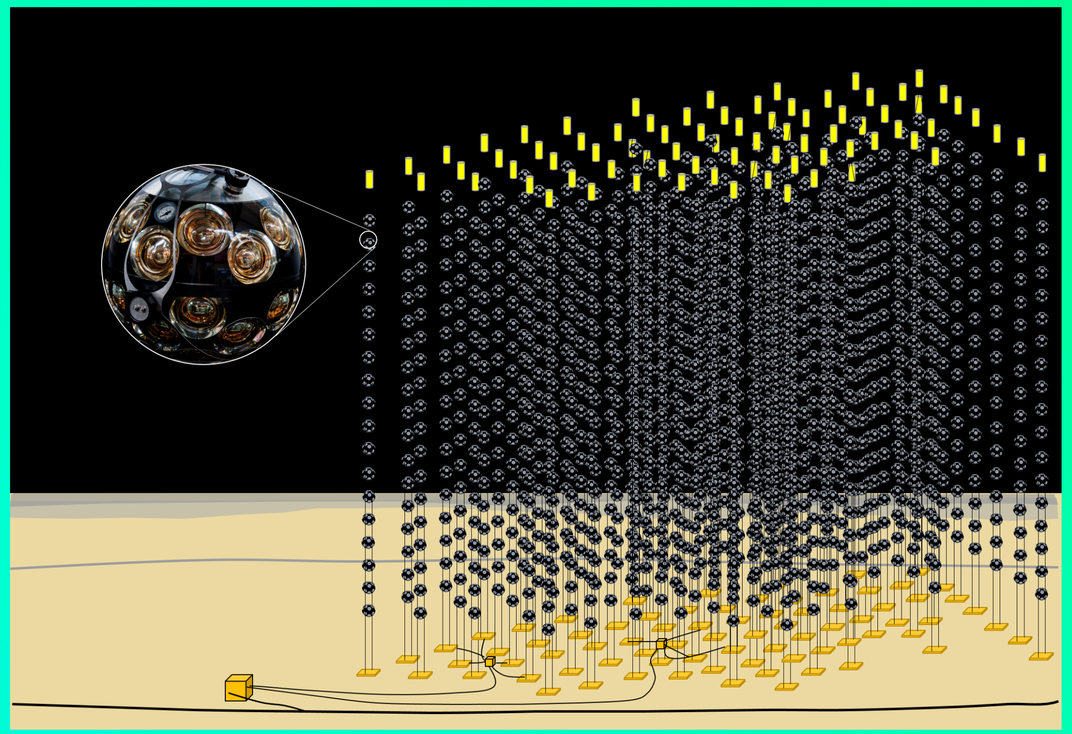
JuliaHEP 2024 - CERN
1. October 2024

Tamas Gal – Erlangen Centre for Astroparticle Physics

https://indico.cern.ch/event/1410341/contributions/6143182/

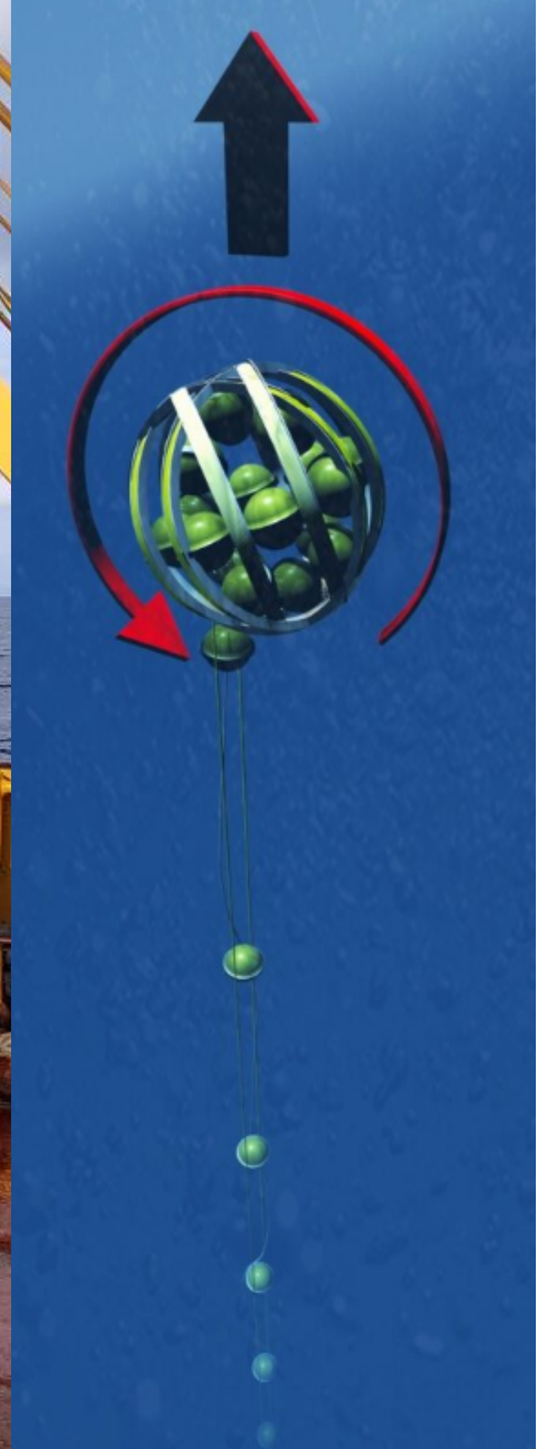
What is KM3NeT?

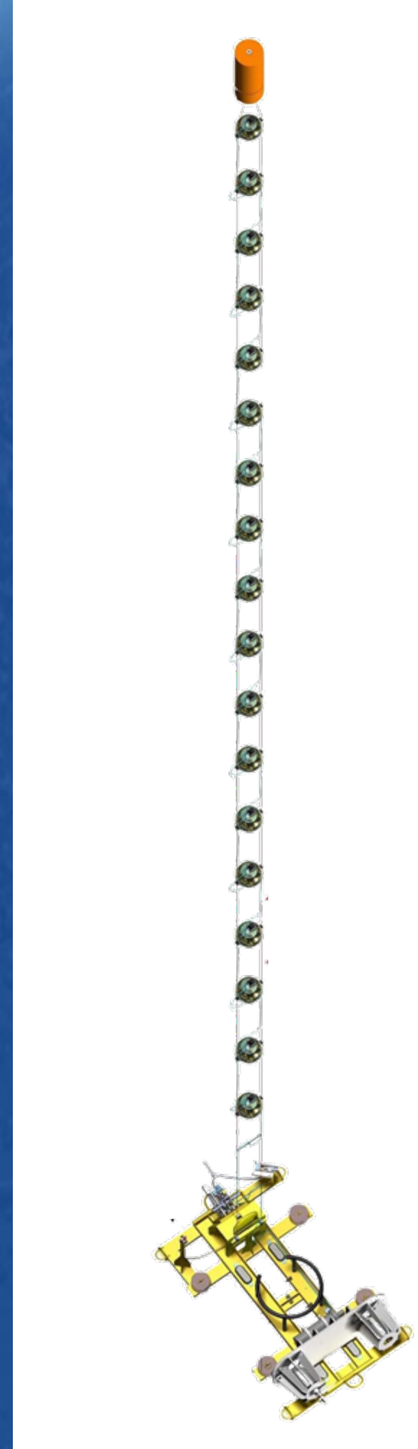
- A **Cherenkov-based neutrino telescope**
- Located in the deepest seas of the Mediterranean (up to **3.5km deep**)
- Once completed, the telescope will have detector **volumes** of several **cubic kilometres** of clear sea water
- Per detector block **115 vertical strings** (up to 800m long) holding **18 digital optical modules** (DOMs) containing **31 photomultiplier tubes** (PMT) each
- A total of **64170 PMTs per detector block]**
- Sub-nanosecond time-resolution of photons
- Down to **1 milliradian** (~0.05 degrees) **angular resolution** for reconstructed events



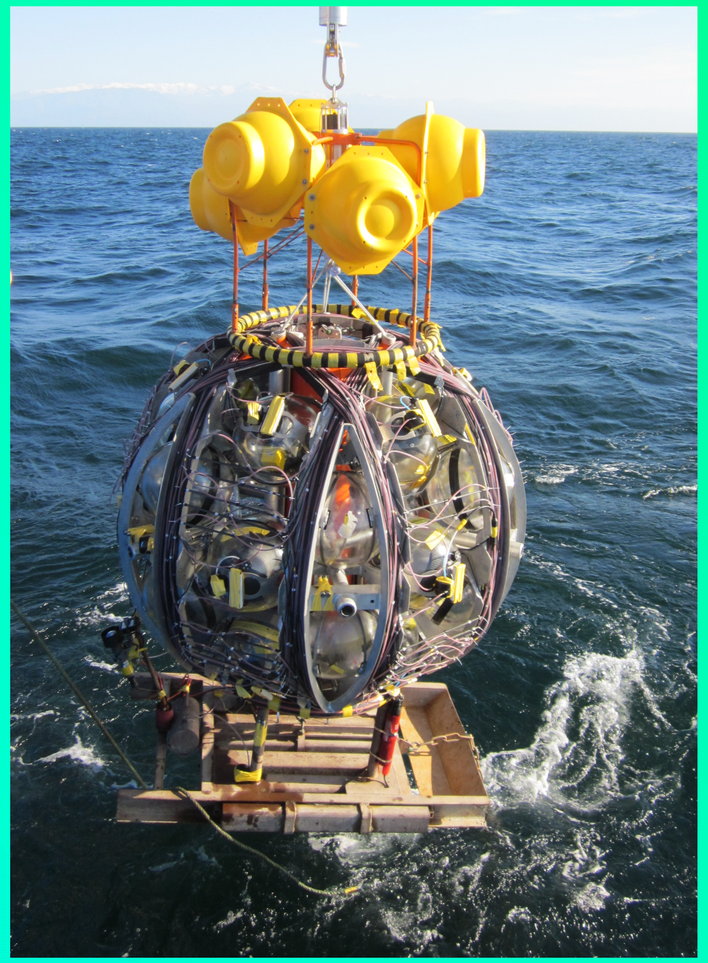
	ORCA	ARCA
String spacing	23m	90m
Vertical spacing of DOMs	9m	36m
Depth	2470m	3500m
Building Blocks (Strings)	1 (115)	2 (230)

Lagoon nebula picture copyright: **Nishesh Chaudhary** (Astrobiscuit Discord)

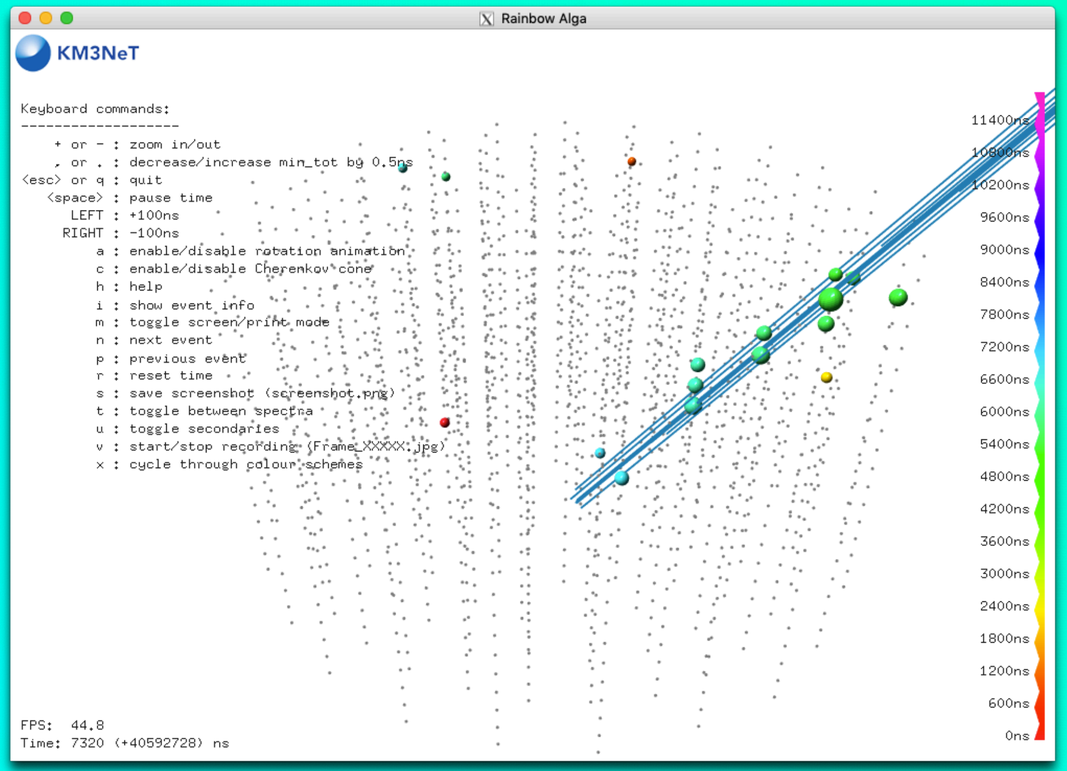




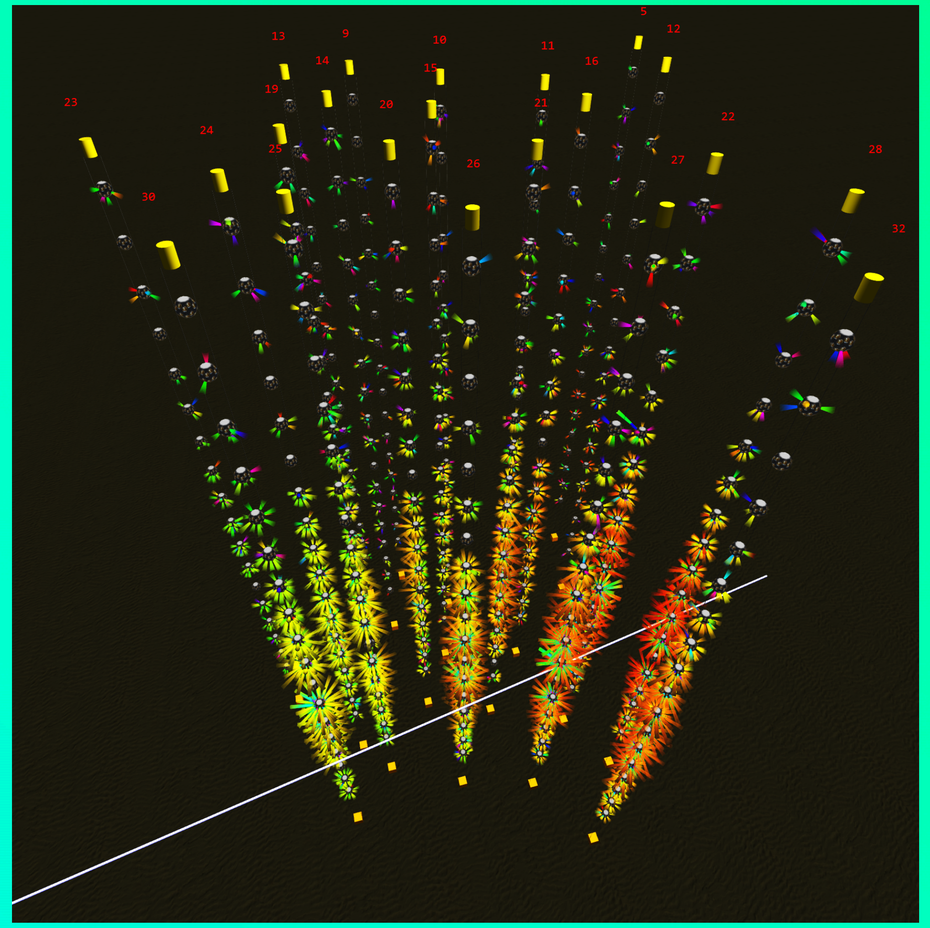
What is KM3NeT?



3D Displays in KM3NeT

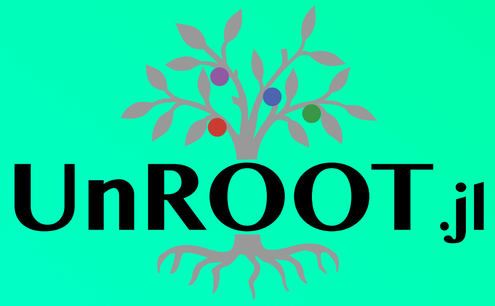


Written in pure Python, based on PyOpenGL
Slow, limited functionalities, not scriptable.



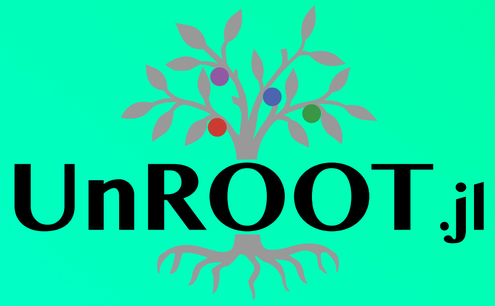
JavaScript (WebGL), has a nice GUI but not easy to use.
Requires ROOT -> JSON conversion, not scriptable.

RainbowAlga.jl



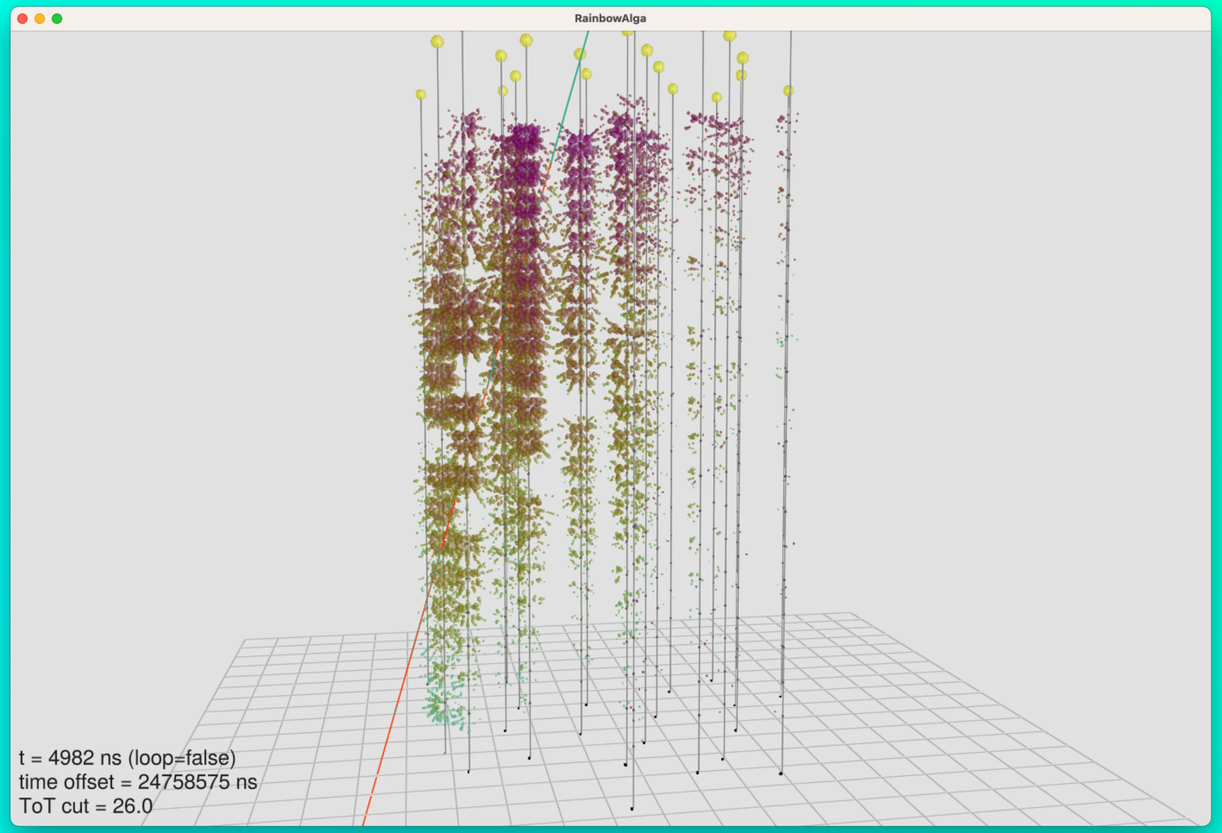
- A **pure Julia** package based on **(GL)Makie.jl** and **GLFW.jl** to visualise events in 3D in an interactive way
- **Currently only** working with **KM3NeT** data (several ROOT formats and custom detector geometry and calibration dataformats)
- Can **easily be modified** to work with other **similar experiments** like IceCube, P-ONE, Antares, Baikal(-GVD), TRIDENT, NEON etc.
- The aim is to give the user full programmatic access to the actual scene
- **https://git.km3net.de/tgal/RainbowAlga.jl**
  (mirror on https://github.com/tamasgal/RainbowAlga.jl if you want to collaborate)
- Special **thanks to Simon Danisch** (main developer) for support :)

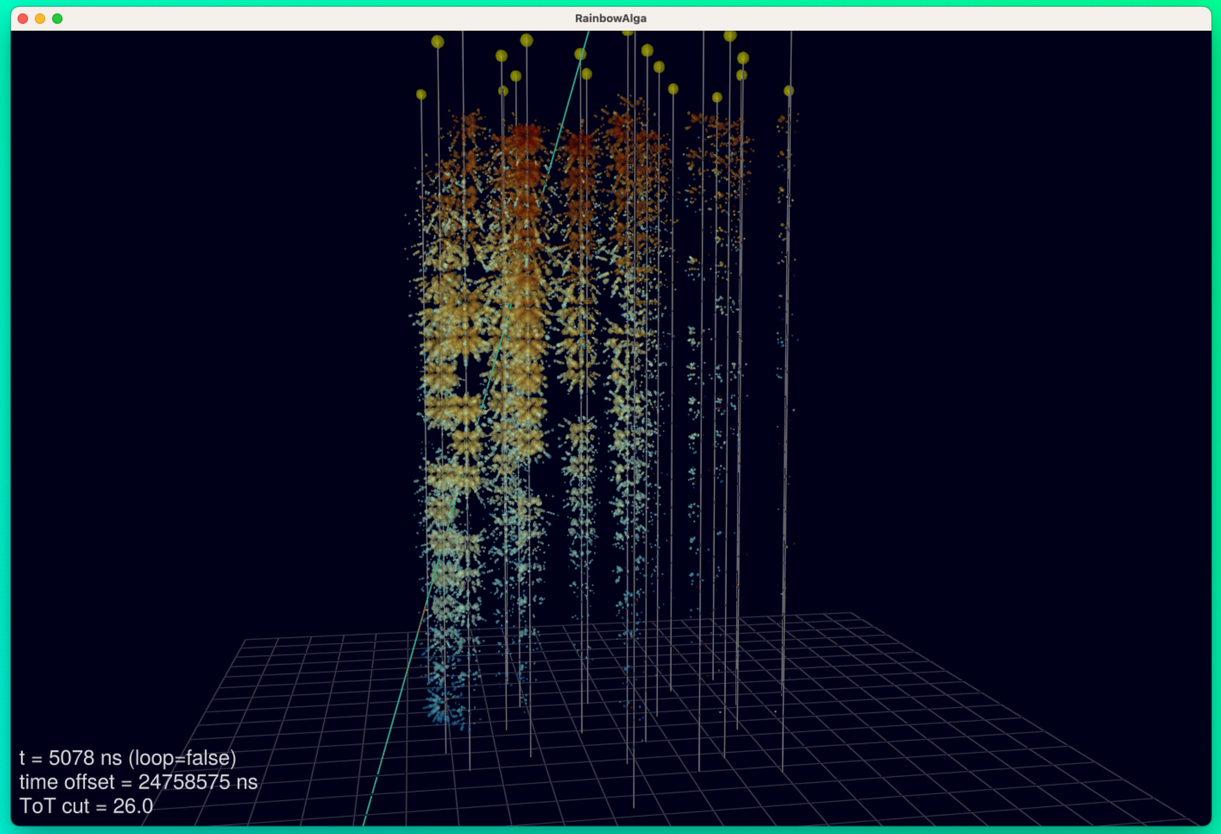
RainbowAlga.jl



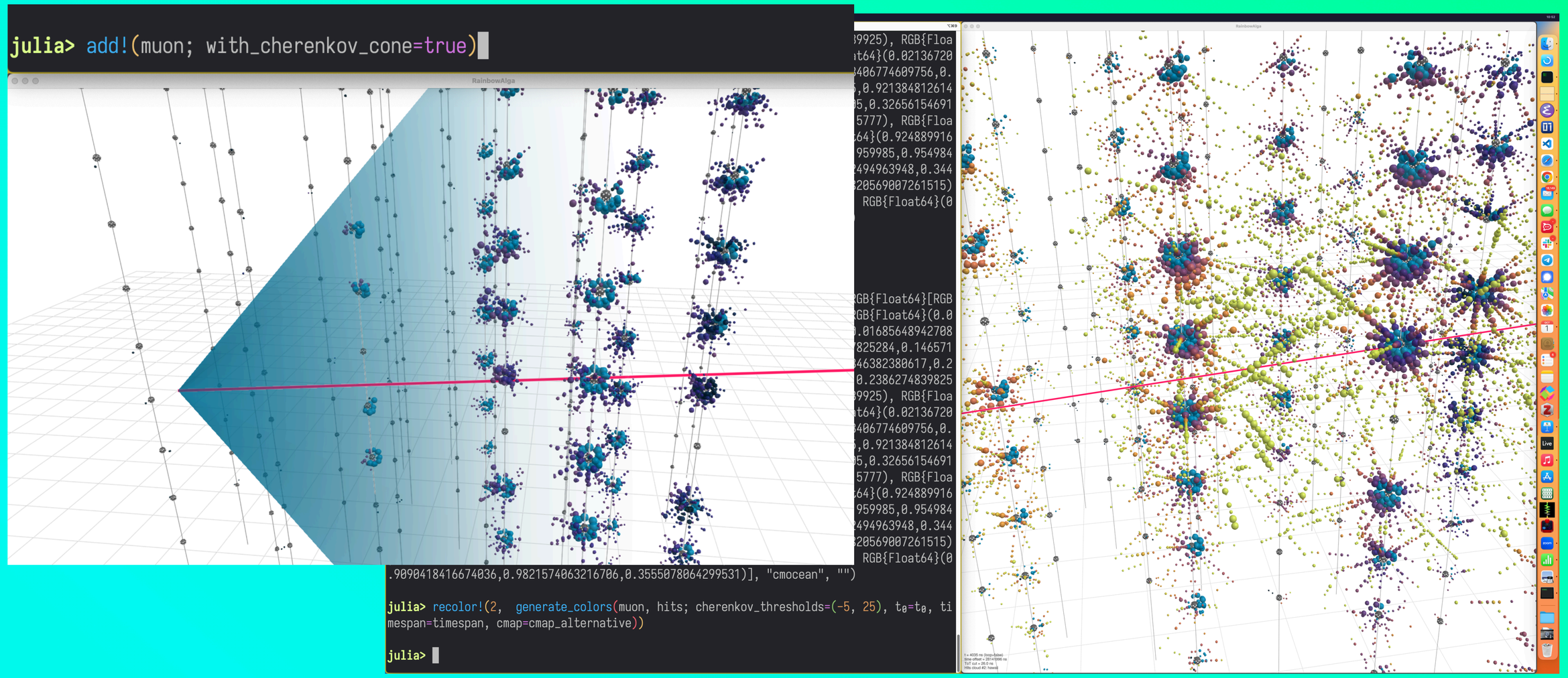
- Animations use a **global clock** (time in nanoseconds) and FPS is limited manually
- **Current implementation** of the main loop is **managing GLFW manually** (buffer swapping, event polling, rendering etc.)
- As **Simon Danisch** pointed out: **GLMakie.jl is capable** of doing it more efficiently using the **render_tick** method
  - I still have some issues making it work correctly
  - Main problems: performance and REPL interactivity
  - Work in progress...
- **Exporting screenshots (and videos) of the scene is not working correctly**
  - The images have wrong depth information and a very low resolution with messed-up colouring
  - Simon helped to debug but we could not figure out what's happening
  - Luckily, one can easily take screenshots using built-in OS functionalities

RainbowAlga.jl





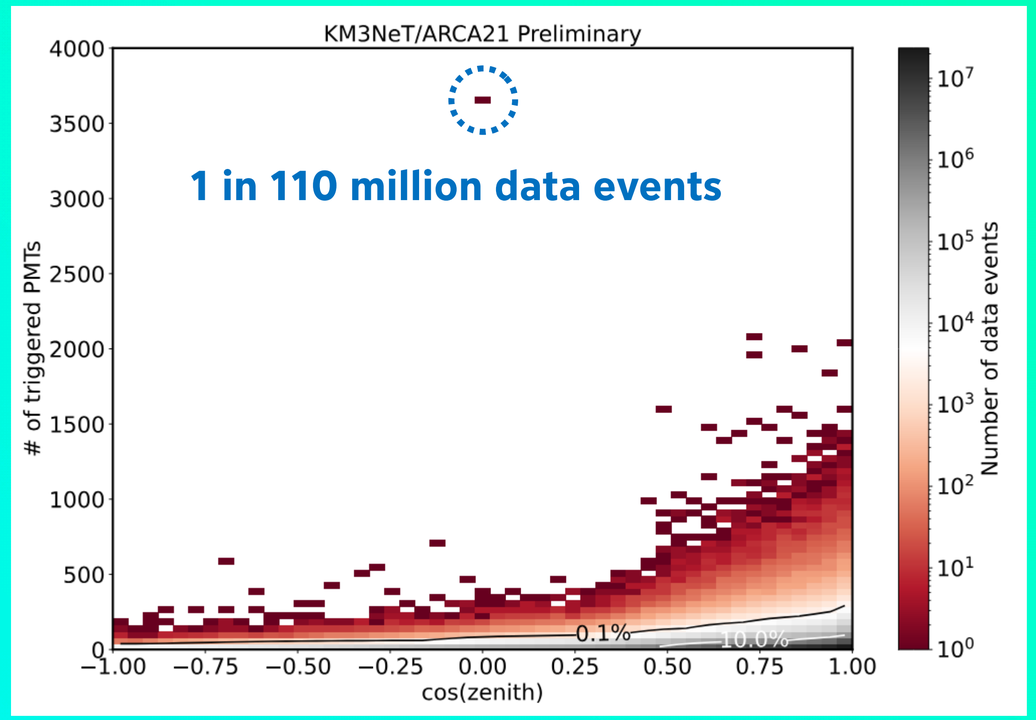
RainbowAlga.jl – REPL Interactivity

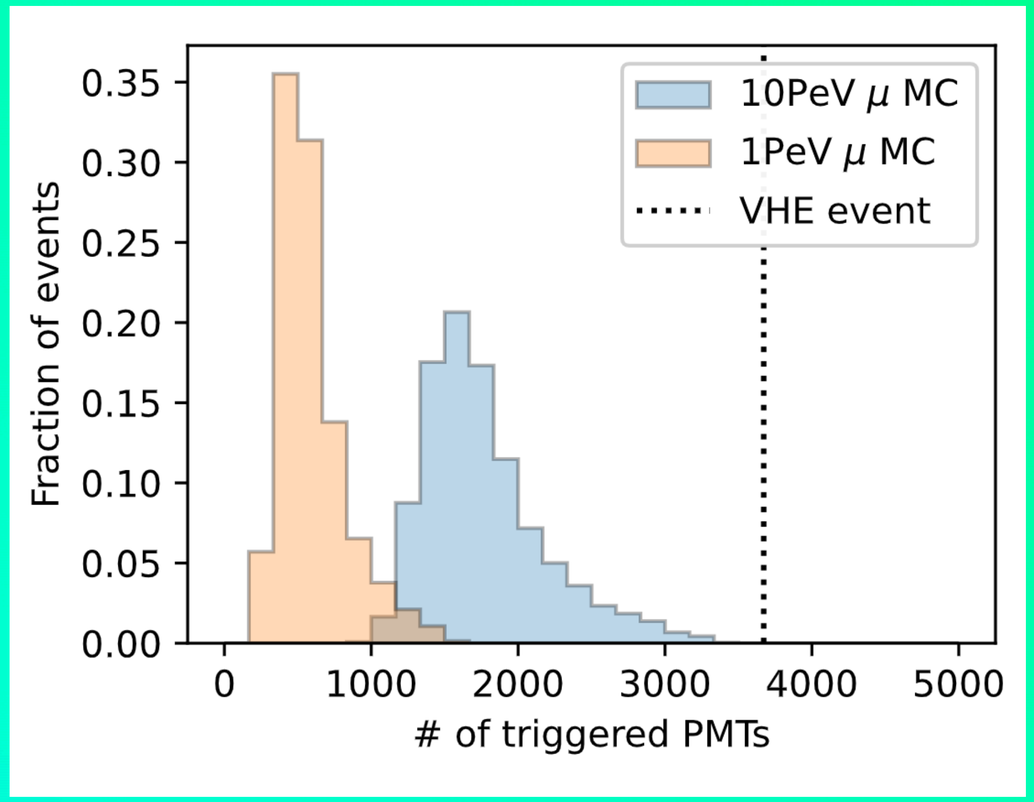


demo

Very High Energy Event detected with KM3NeT/ARCA

- **Significant event observed with huge amount of light**
- Horizontal event (**1° above horizon**) as expected since earth opaque to neutrinos at PeV scale
- **3672 PMTs (35%)** were triggered in the detector
- Muons simulated at 10 PeV almost never generate this much light
- **Likely multiple 10's of PeV**





First figure in the upcoming Nature paper is made with RainbowAlga.jl ;)

Friedrich-Alexander-Universität
Erlangen-Nürnberg

KM3NeT

ECAP ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

FAU

Thanks!

"People are very open-minded about new things —
as long as they're exactly like the old ones." -
Charles F. Kettering