

Exploring the lifetime and cosmic frontier with MATHUSLA

MATHUSLA

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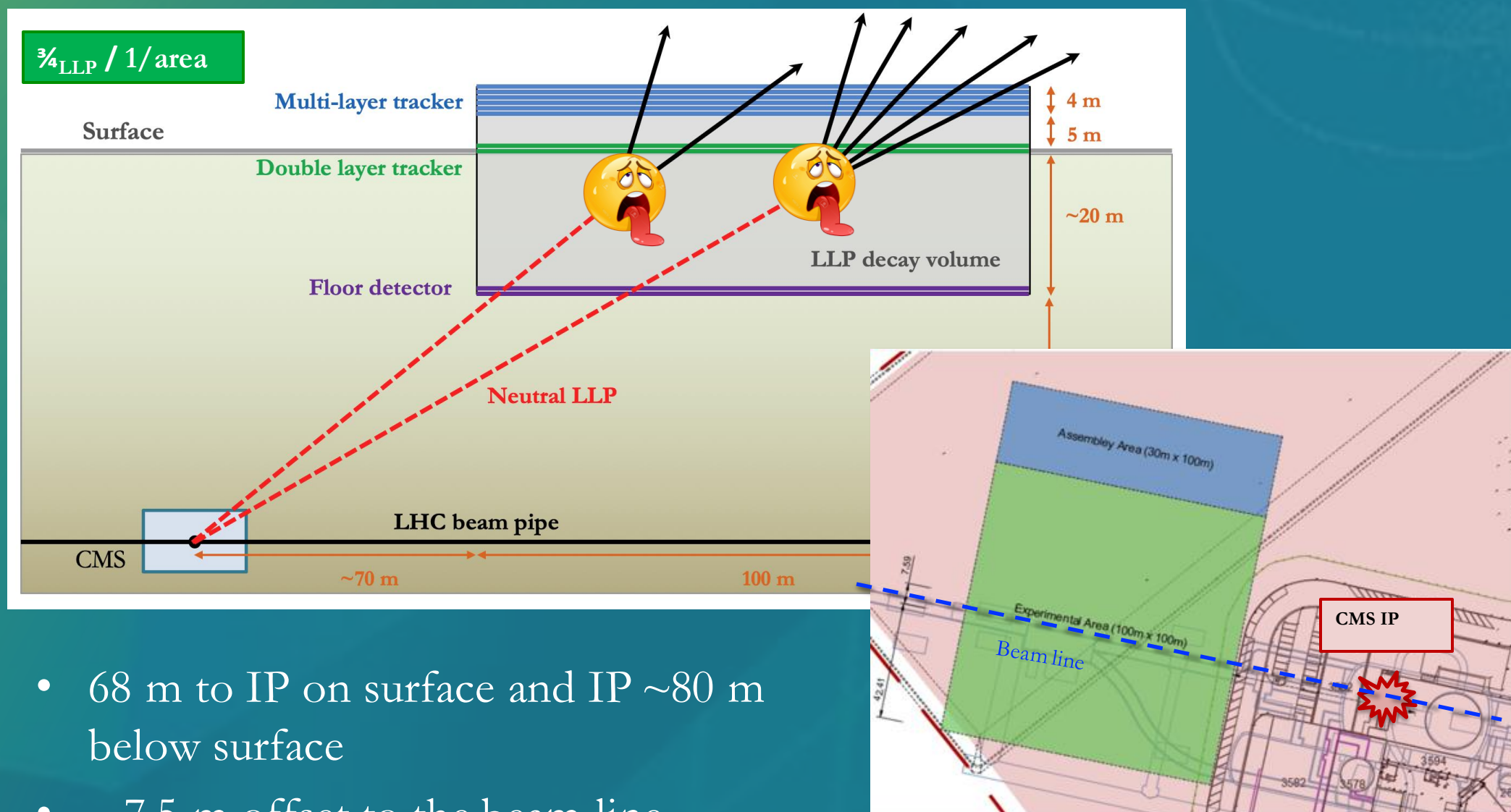
on behalf of the MATHUSLA Collaboration

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MATHUSLA

Dedicated detector sensitive to neutral long-lived particles with lifetime up to the Big Bang nucleosynthesis limit (10^7 - 10^8 s) [arXiv:1606.06298v1]

- Propose a large surface detector located above CMS
- Air decay volume with tracking chambers



- 68 m to IP on surface and IP ~80 m below surface
- ~7.5 m offset to the beam line
- Need robust tracking and excellent background rejection
- Extruded scintillators + SiPM considered for tracking

No LHC background but...

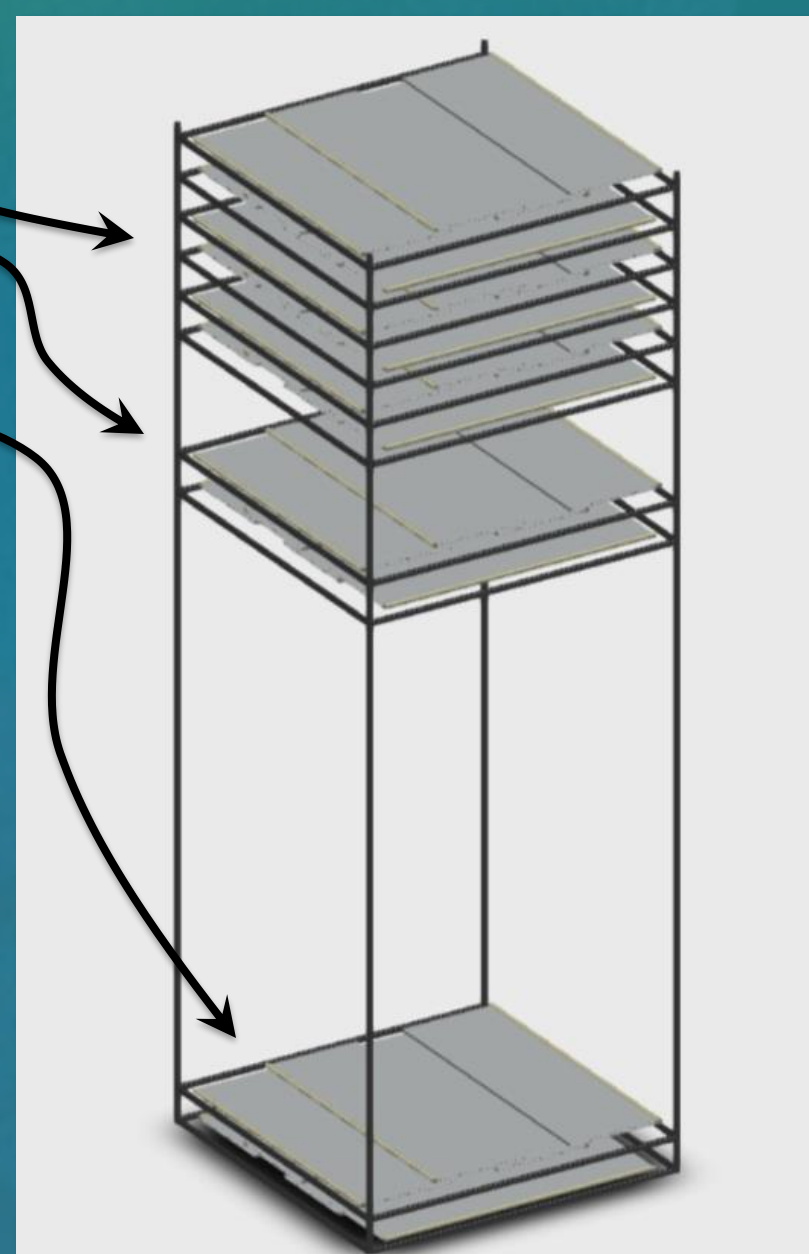
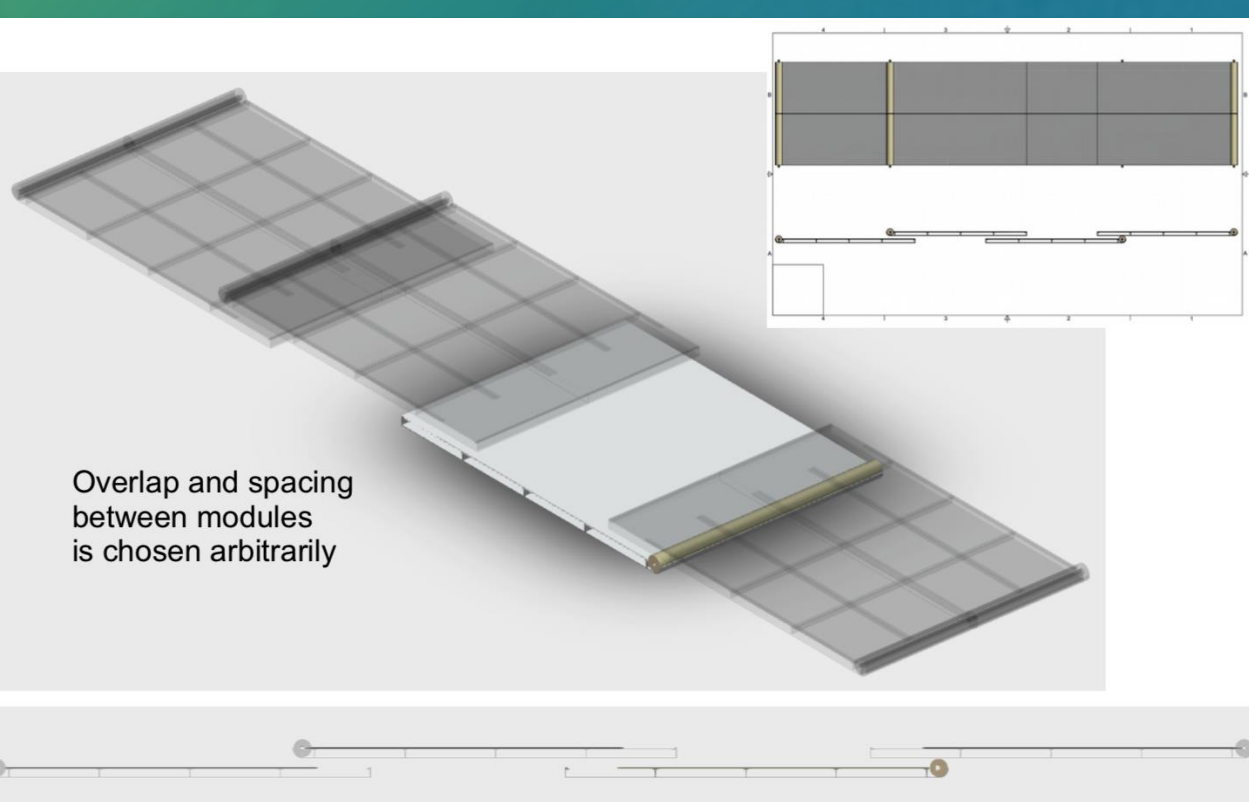
- Upward atmospheric neutrinos interacting in the detector: ~ 10-100/year
- Cosmic muons (~ 10^6 Hz) and LHC muons (~ 10 Hz)
- Developed a GEANT simulation of backgrounds

→ Goal is a background-free MATHUSLA!

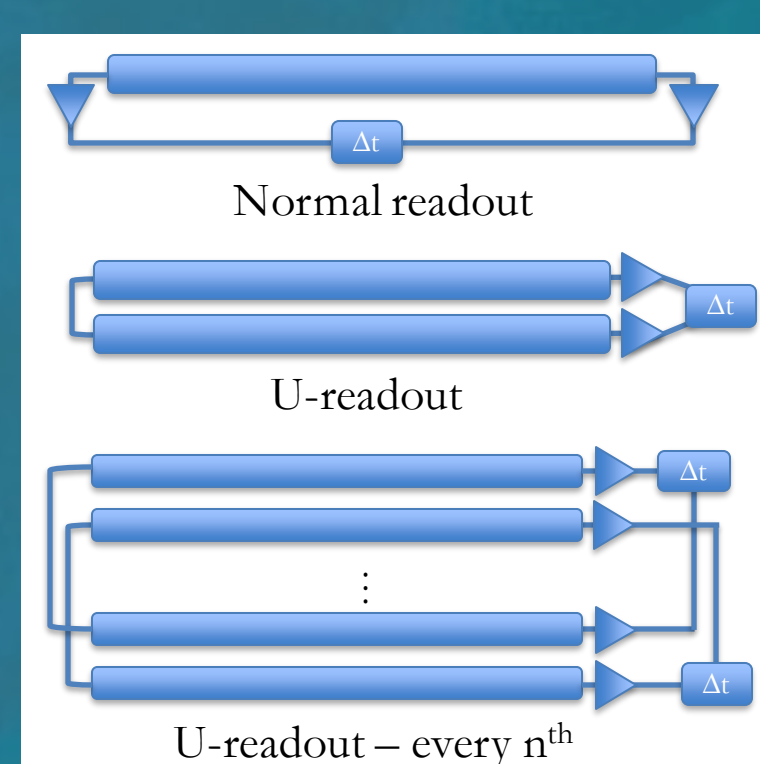
Detector Layout

Modular concept allows to stage the construction (scalable detector)

- 6 layers of tracking/timing detector separated by 80 cm
- Additional double layer 5 m below
- Double layer floor detector (to veto charged particles from LHC)



- Layout of a detector unit with U-readout

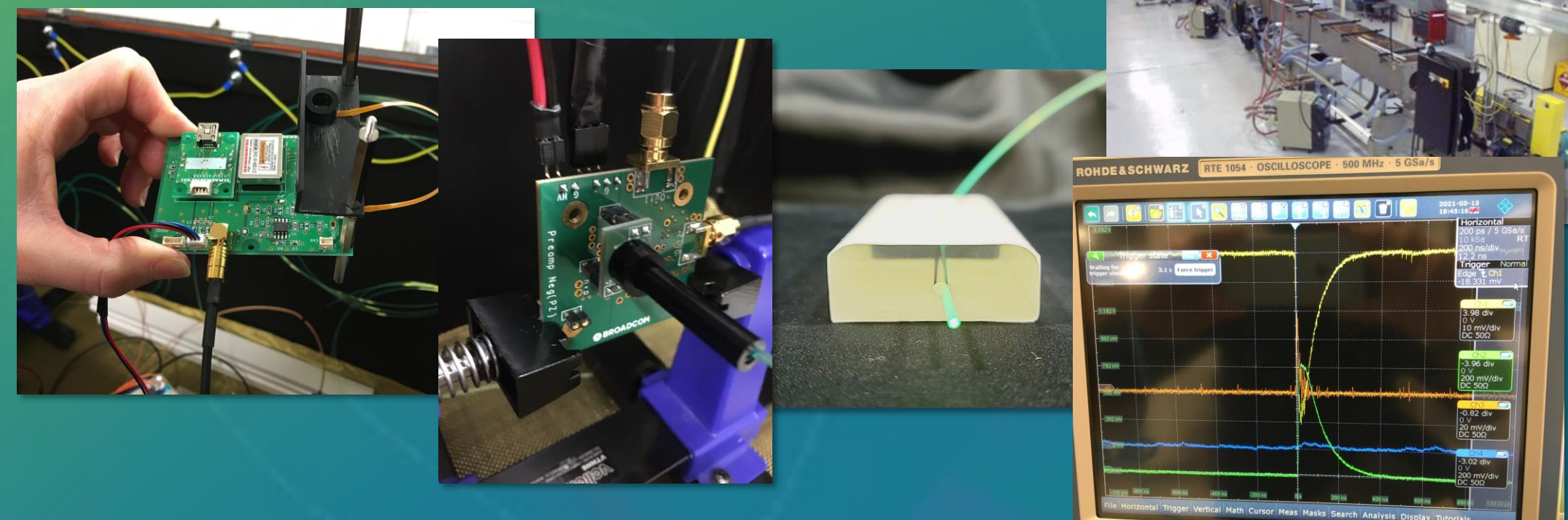


- SiPMs on same side simplify DAQ readout
- ...but require protective cover on WLS fibers / more delicate assembling

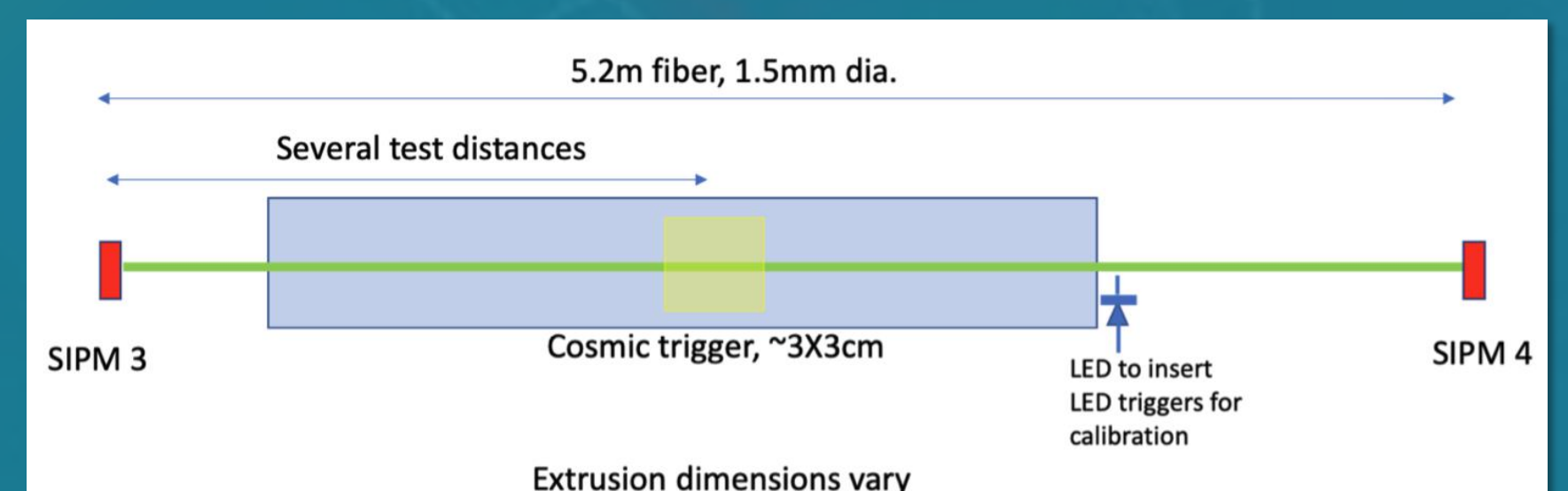
Scintillator/SiPM R&D

Extruded scintillator bars with wavelength shifting fibers coupled to SiPM are very competitive (timing resolution competitive with RPC)

- Extruded scintillator facility at Fermilab
- Target timing resolution of 1 ns with >15 PE

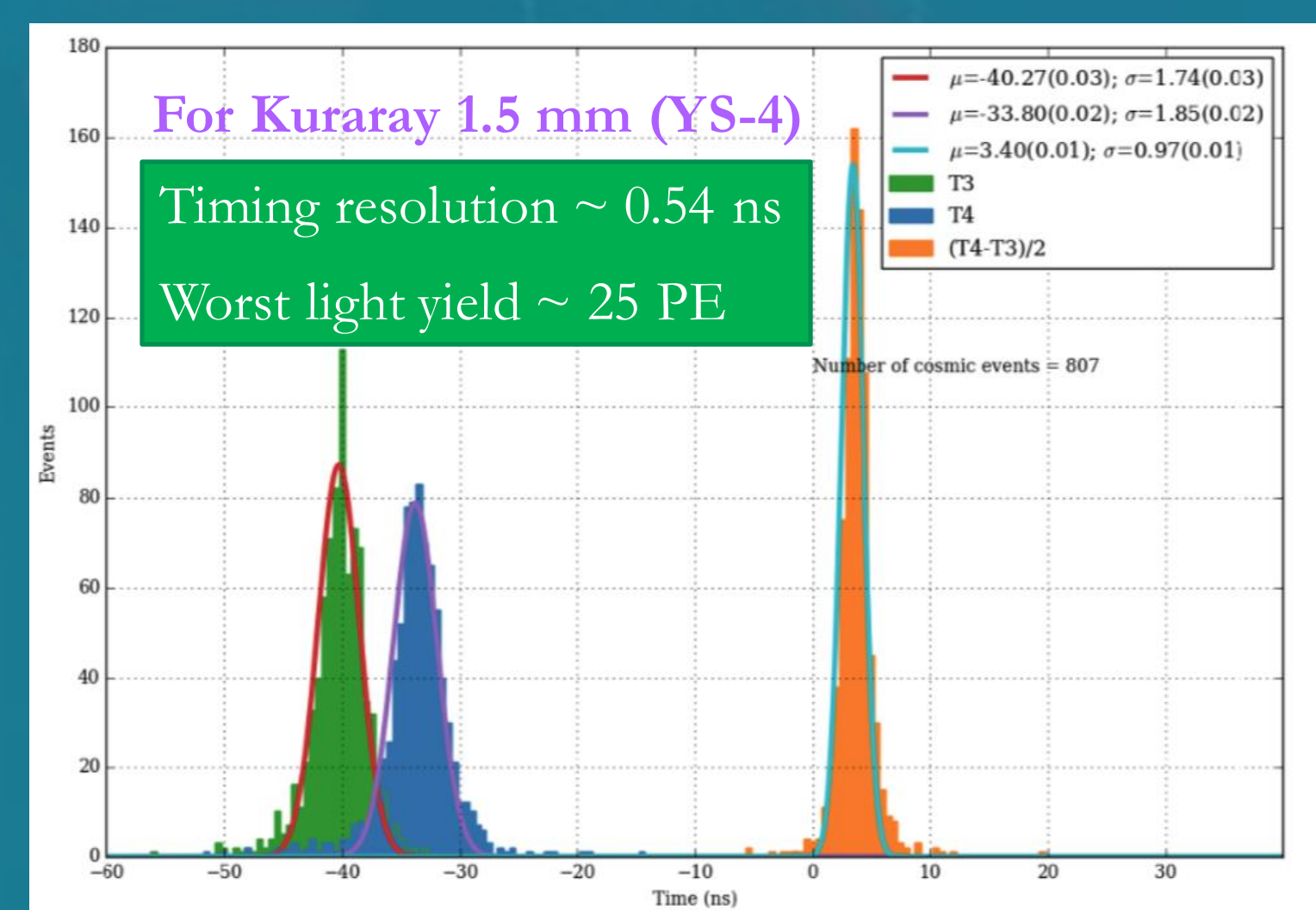


- Timing measurements using cosmic rays for a 5 m long fiber through a 2.5 m extrusion located at the center of the fiber



Better performance than the target requirement!

[arXiv:2203.08126]

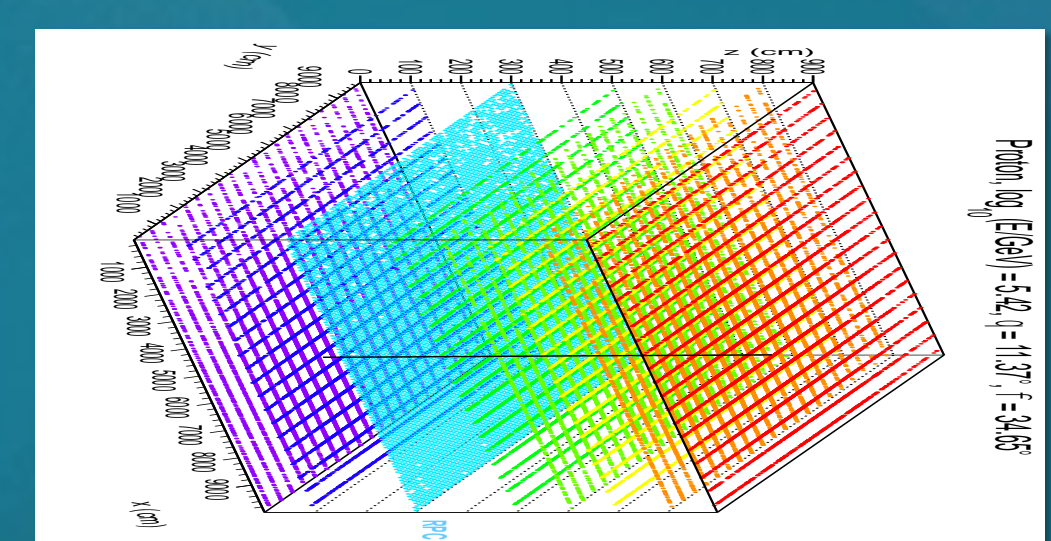
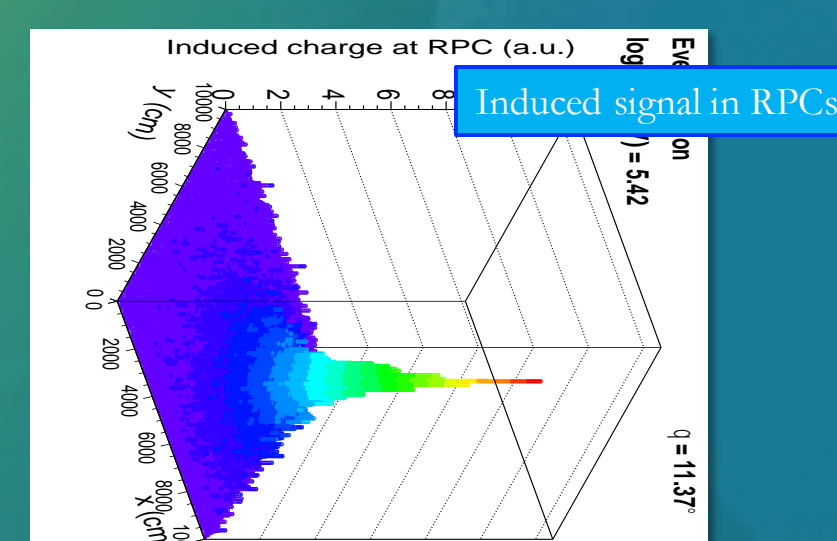


- Currently testing different extrusion thicknesses and vendors (e.g. Uniplast), fiber diameters and lengths, fiber vendors (e.g. Saint-Gobain shows similar performance)
- Ongoing studies on dark count rates and a possible SiPM cooling system

Cosmic Ray Studies

MATHUSLA (standalone or in combination with CMS) can provide more detailed studies of the air showers core structure around the “knee”

- Studying the physics case for adding a layer or RPCs to measure vertical air showers (analog/digital readout)



- Current RPC layout

- ✓ 1-mm gap (2.2×0.9) m² with 2 gas inlets / 2 outlets at the corners
- ✓ 80 longitudinal strips 2.2 m long with 11.2 mm pitch (FE boards located at each end to interpolate the position along the strip)
- ✓ “Big pads” for analog read-out of 1.1×0.9 m²
- ✓ FE electronics embedded in the detector Faraday cage
- ✓ Mechanical support structure: honeycomb panels 1 cm thick