



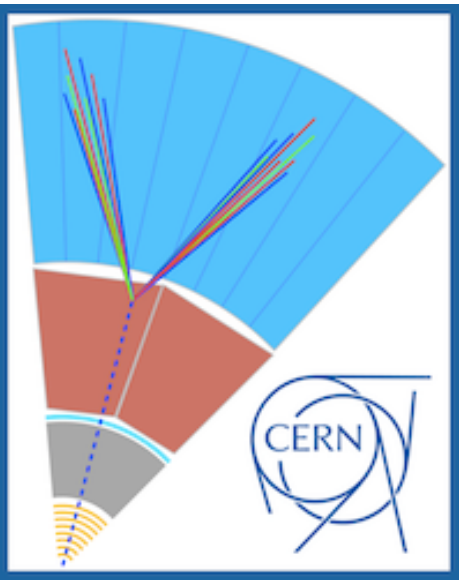
Status of the FASER Experiment

Eric Torrence

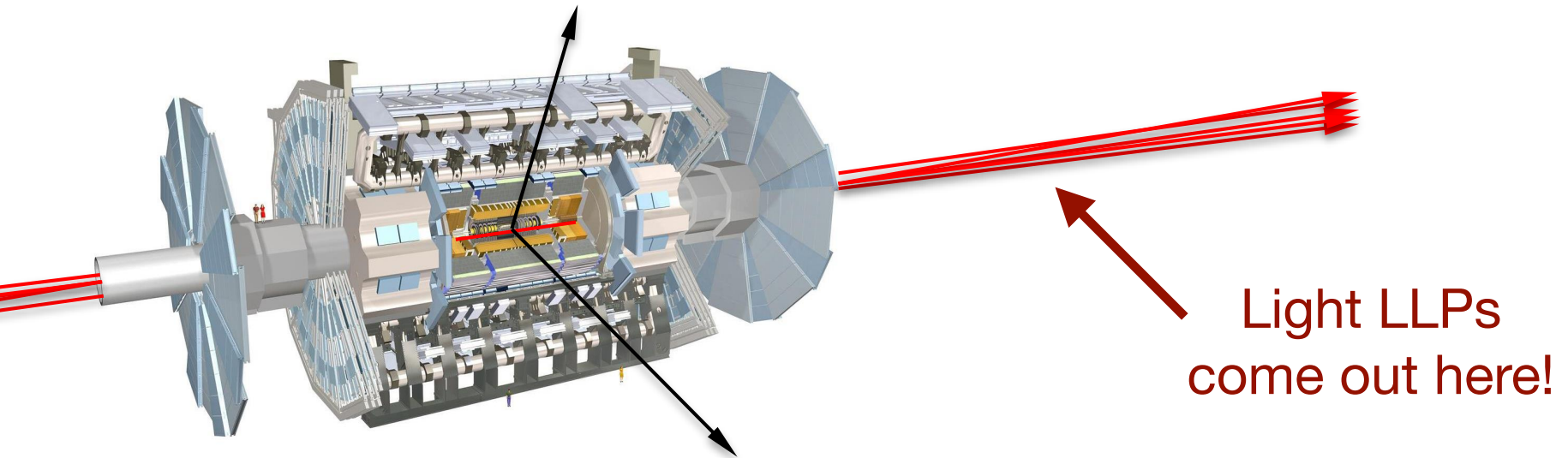
**University of Oregon
for the FASER Collaboration**

25 May, 2021

**9th Workshop of the
LLP Community**

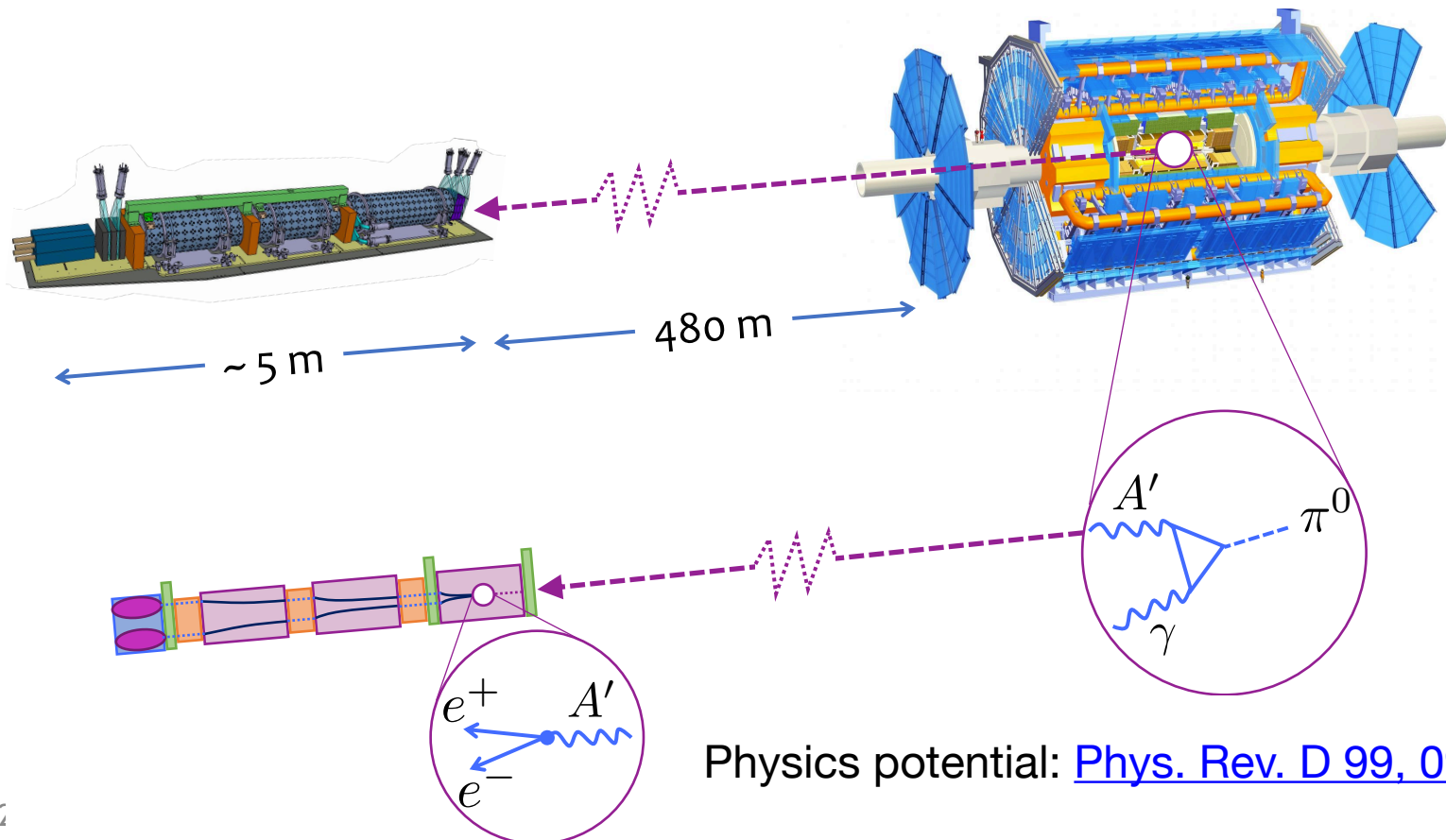


UNIVERSITY OF
OREGON

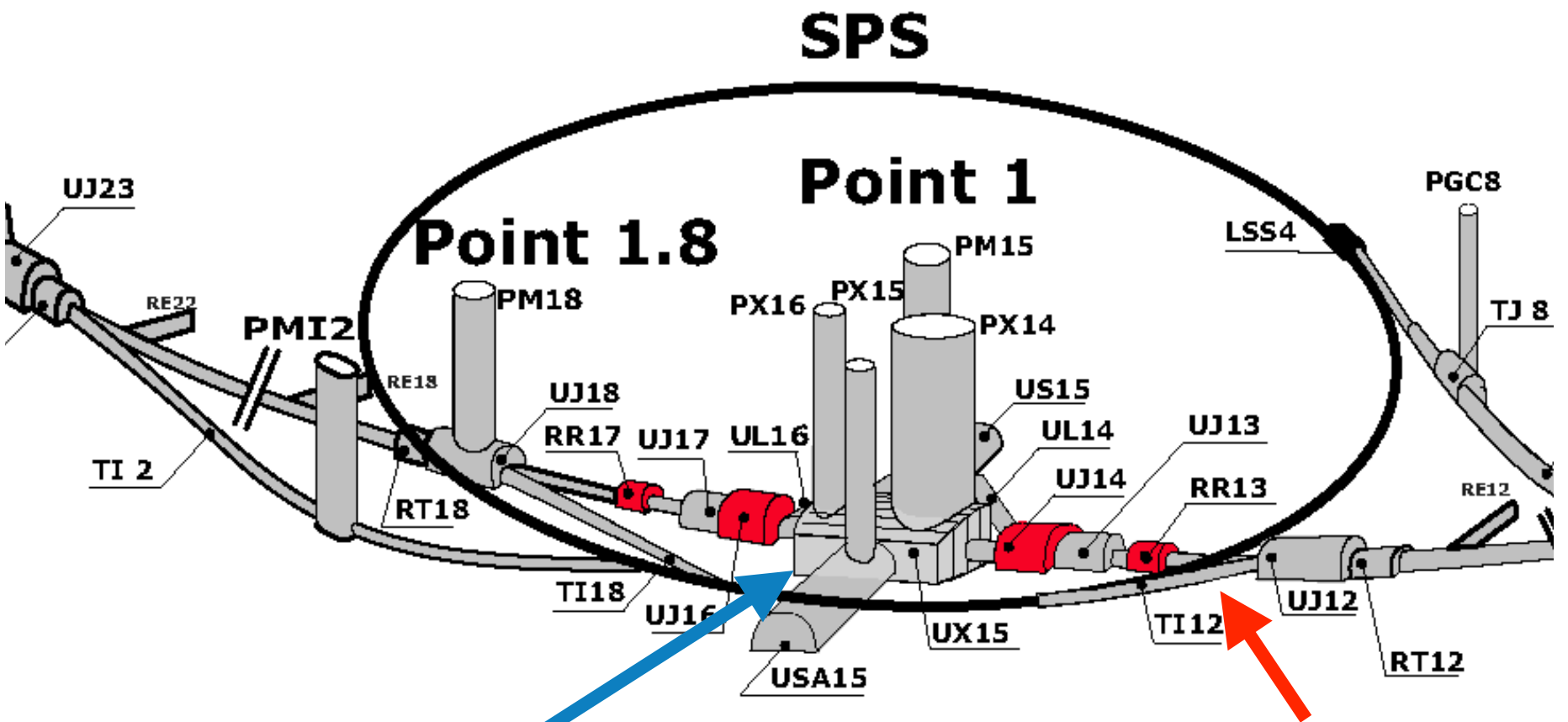


- Search for LLPs in far-forward pp collisions
 - Ideal for lighter (10-100 MeV) weakly-coupled particles
- Exploit huge rate in collimated beam
 - Inelastic pp cross-section: ~ 0.1 barns, $N \sim 10^{16}$ at Run3
 - Very forward production: $\theta \sim \Lambda_{\text{qcd}} / E \sim \text{mRad}$
 - Decay length: ~ 100 m for $m \sim 10\text{-}100$ MeV, $\epsilon \sim 10^{-5}$
- Put small detector on line-of-sight collision axis

- Benchmark physics process: Dark Photons A'
- Produced via kinetic mixing from e.g. π^0 decays
- Detected in decay to e^+e^- in FASER decay volume
- Sensitive to other LLPs and decay modes as well



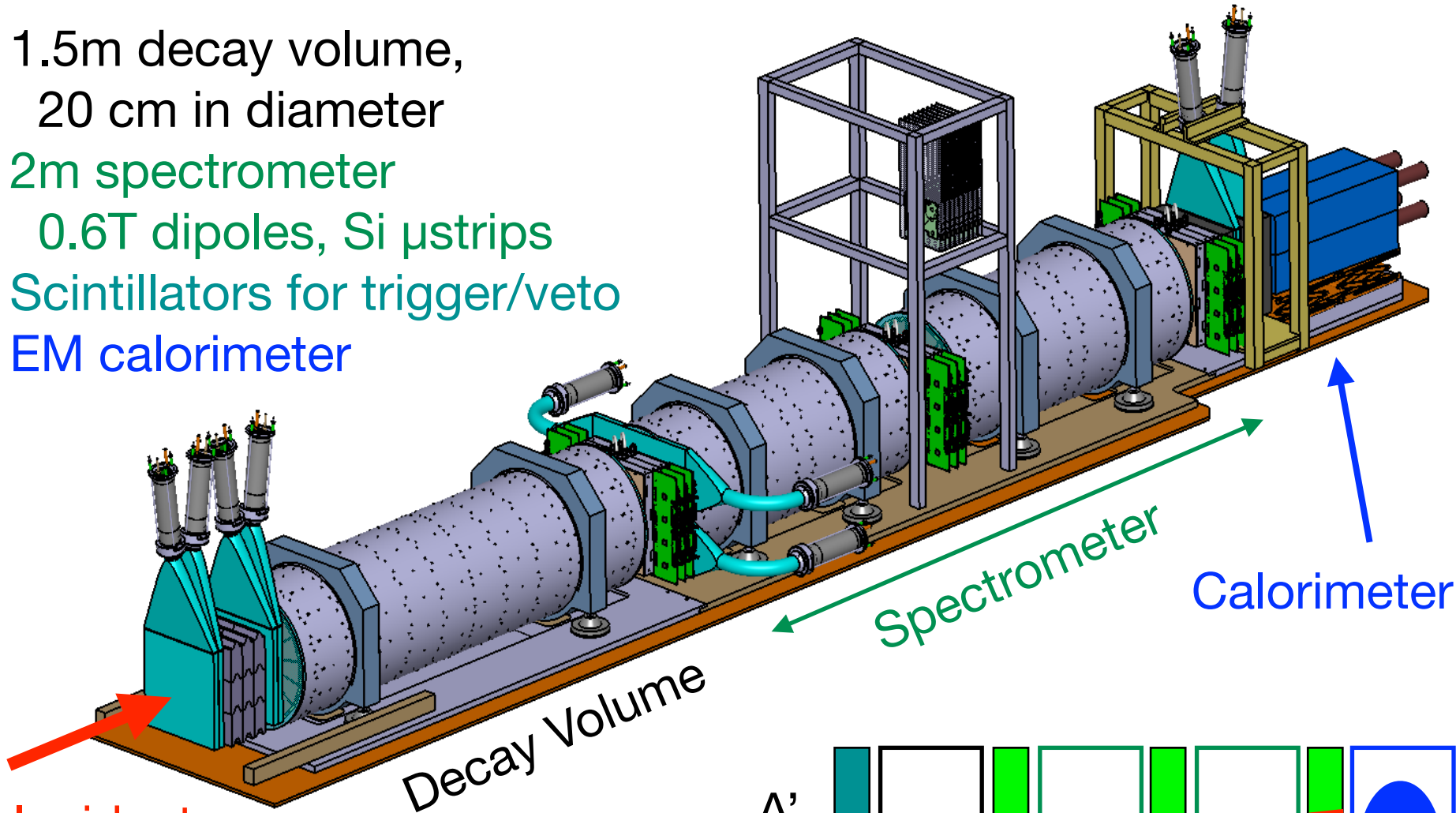
Physics potential: [Phys. Rev. D 99, 095011](https://arxiv.org/abs/1808.07248)



480m downstream of IP1
 including 10m concrete, 90m rock
 Quiet background environment



- 1.5m decay volume,
20 cm in diameter
- 2m spectrometer
- 0.6T dipoles, Si μ strips
- Scintillators for trigger/veto
- EM calorimeter



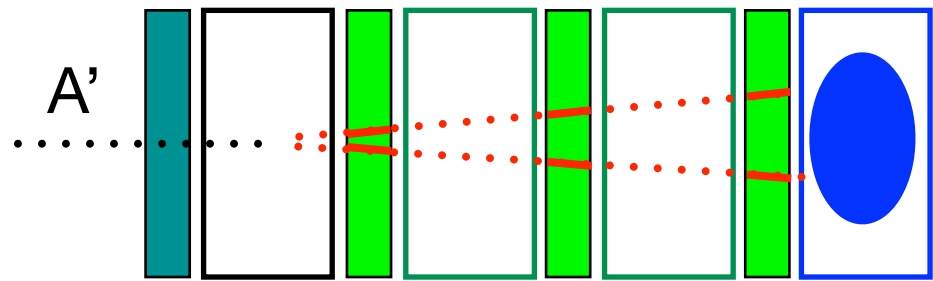
Incident Beam

Charged Particle Veto

Decay Volume

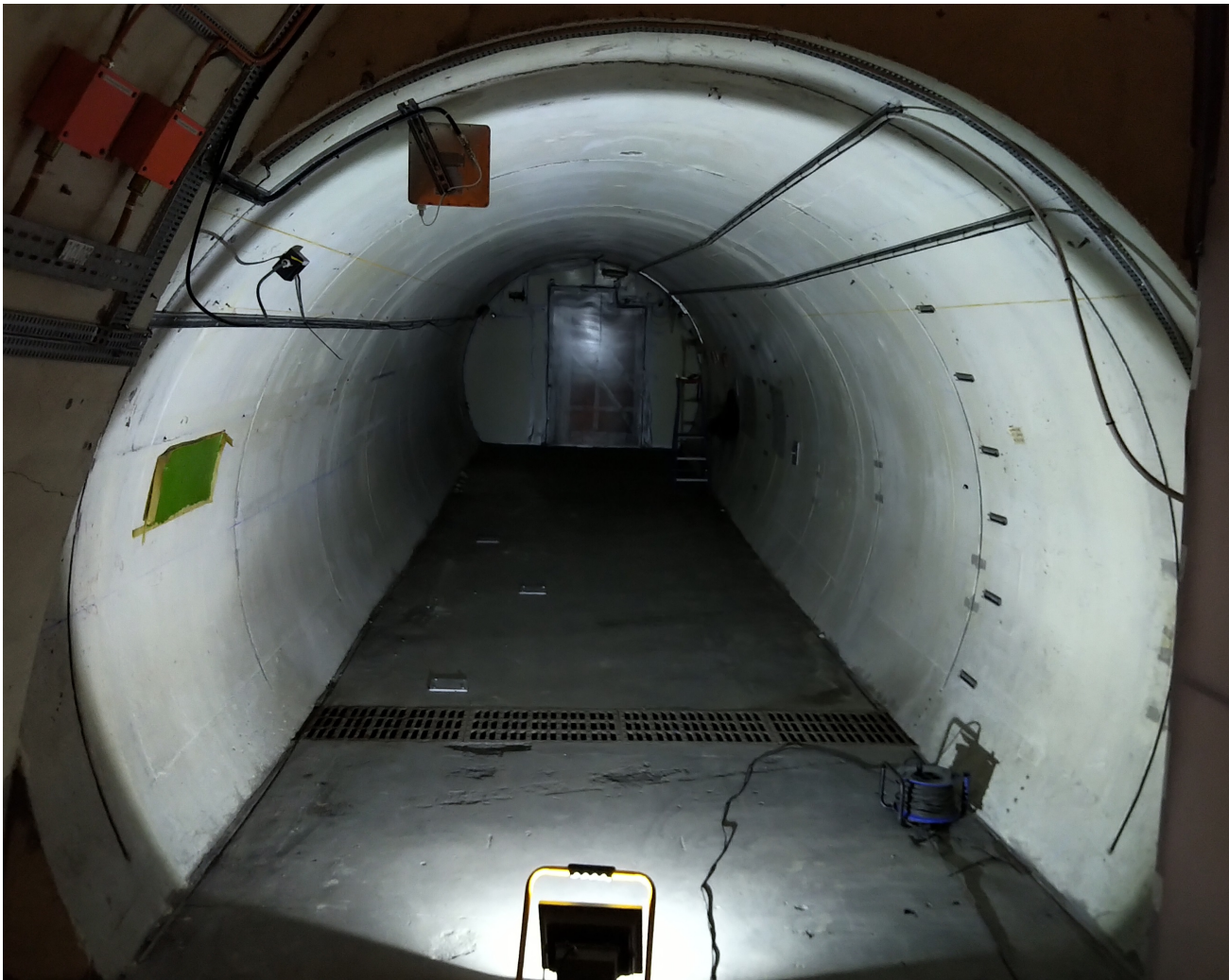
Spectrometer

Calorimeter

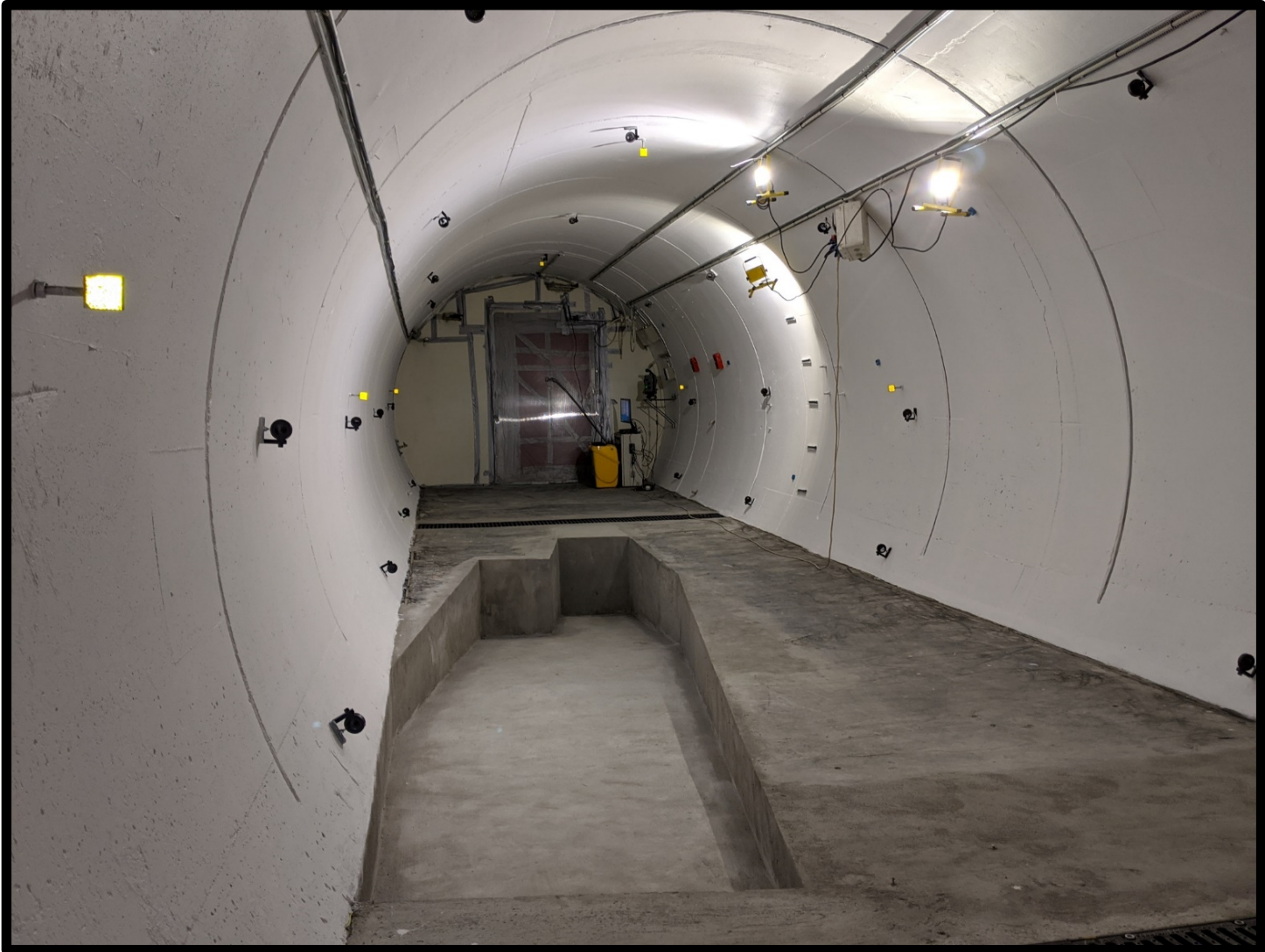




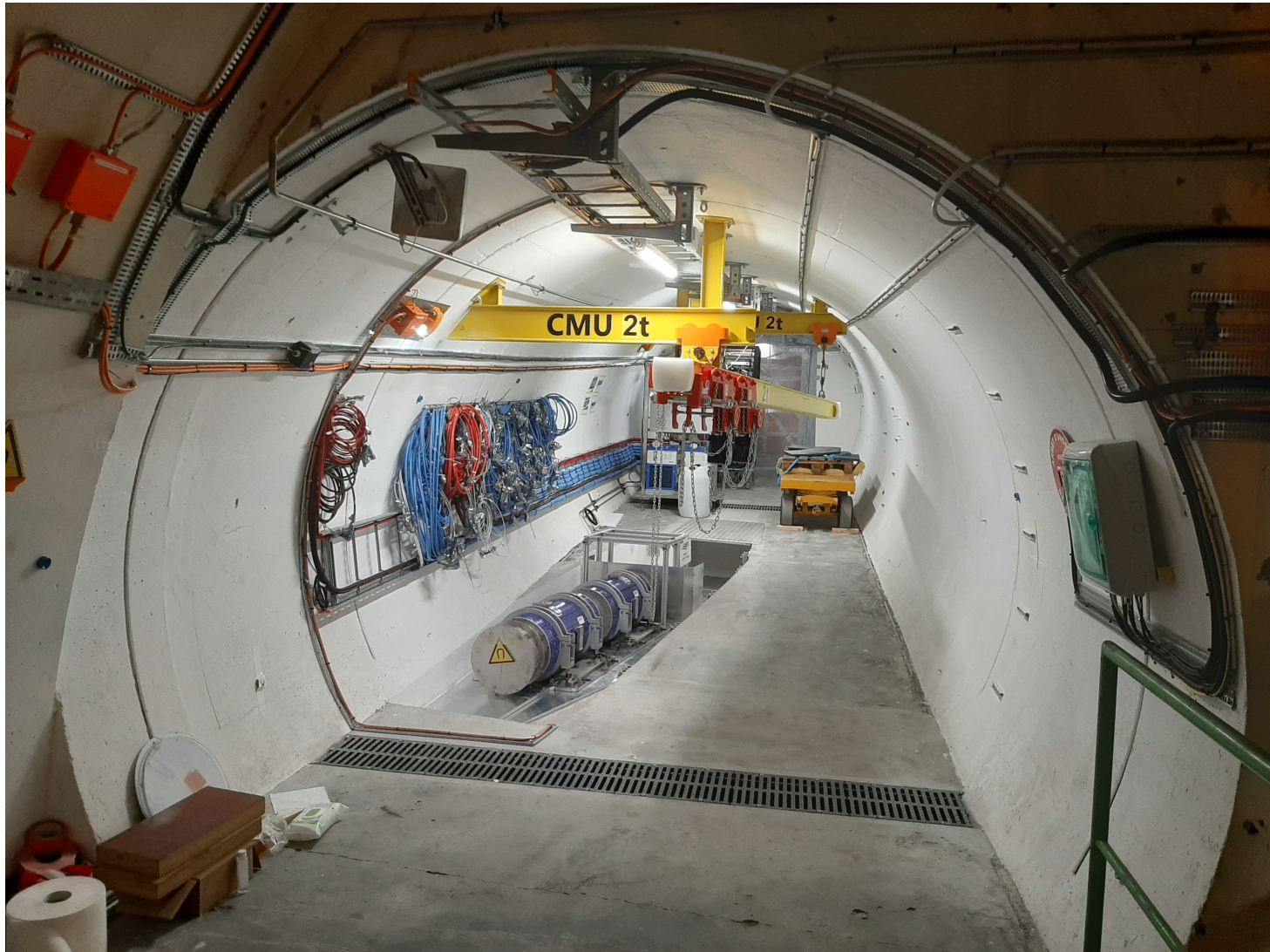
August 2018 - old LEP transfer line



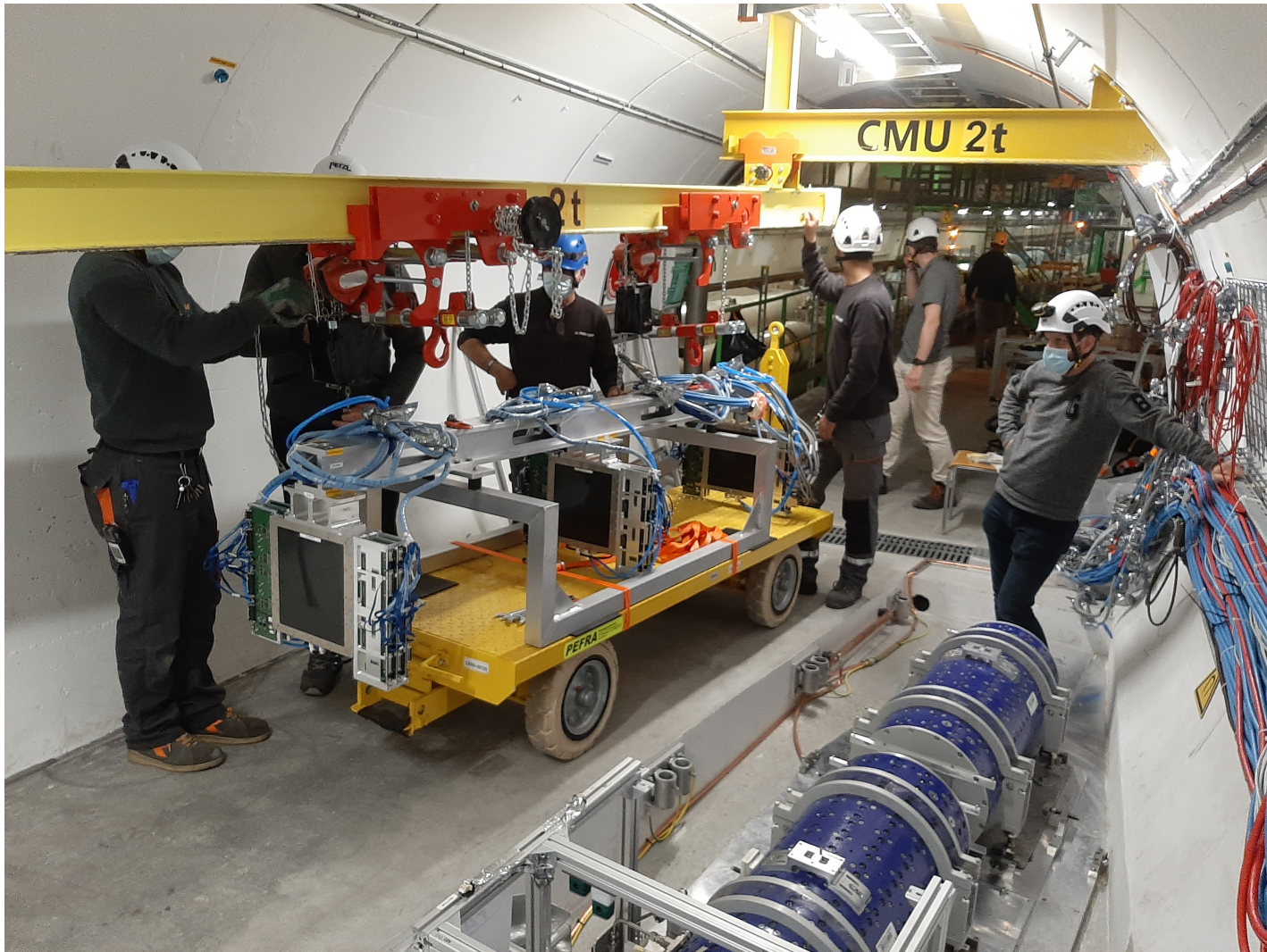
August 2019 - tunnel cleaned out



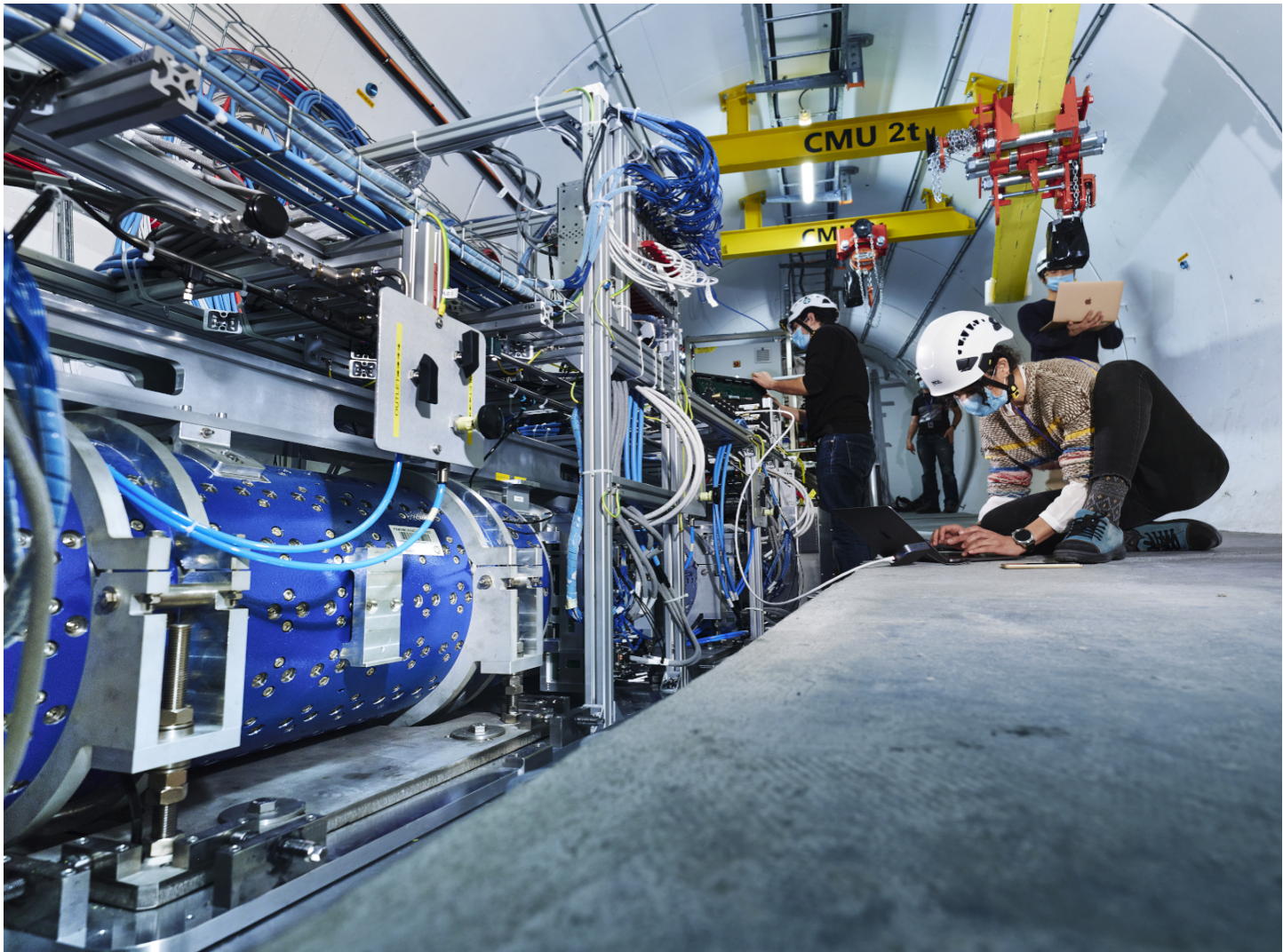
April 2020 - civil engineering complete



Nov. 2020 - infrastructure and magnets installed



Mar. 2020 - installation of detector components

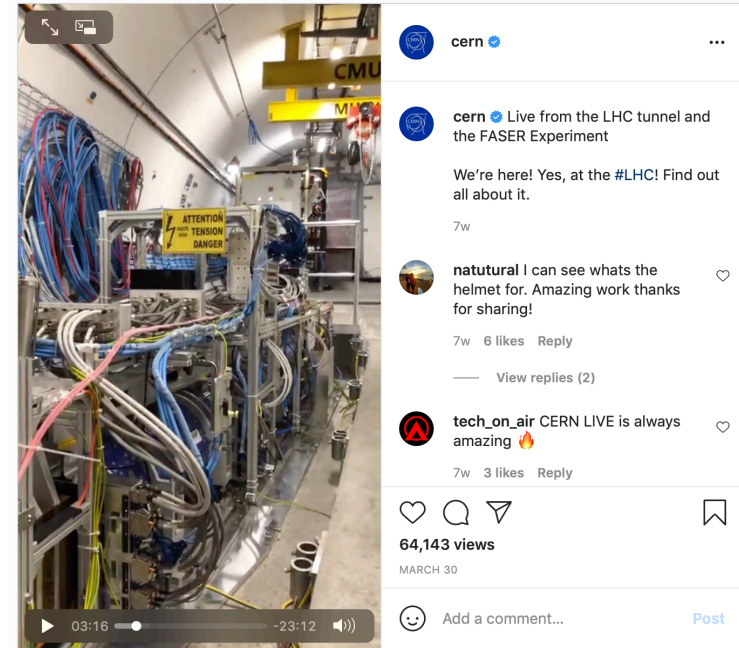
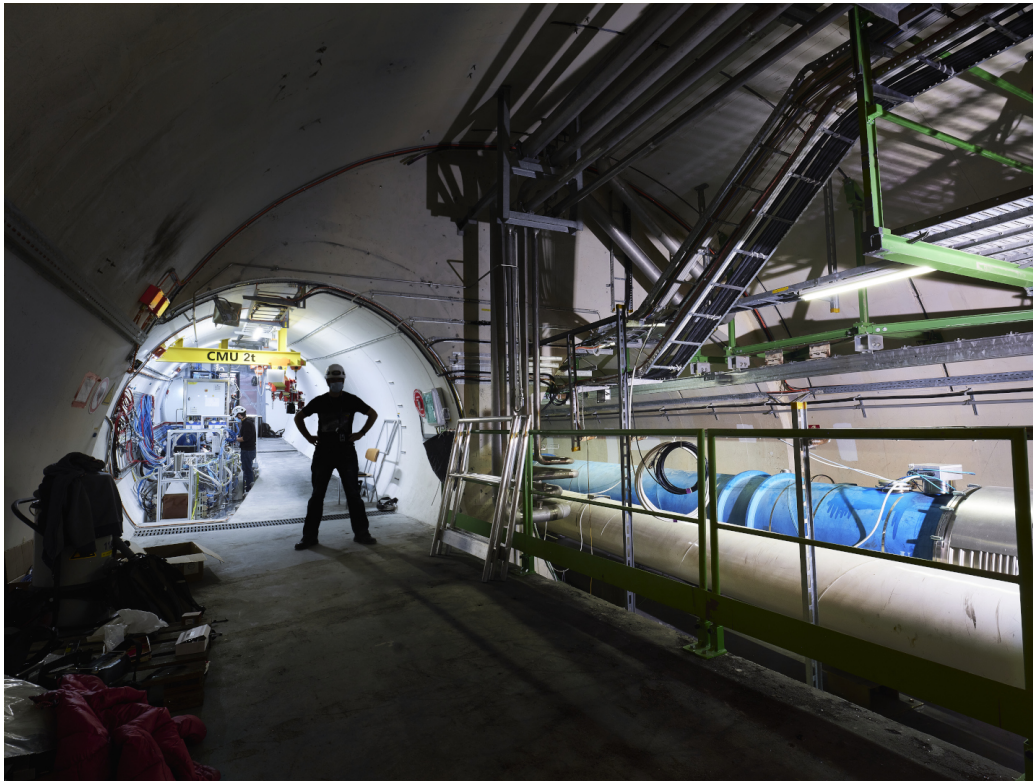


March. 2020 - and cables!



April. 2020 - fully installed detector
CERN safety sign-off

- [Instagram Tour](#) with Michaela Queitsch-Maitland
- Official CERN photoshoot [here](#) and [here](#)



- Time-lapse videos on CDS [here](#)



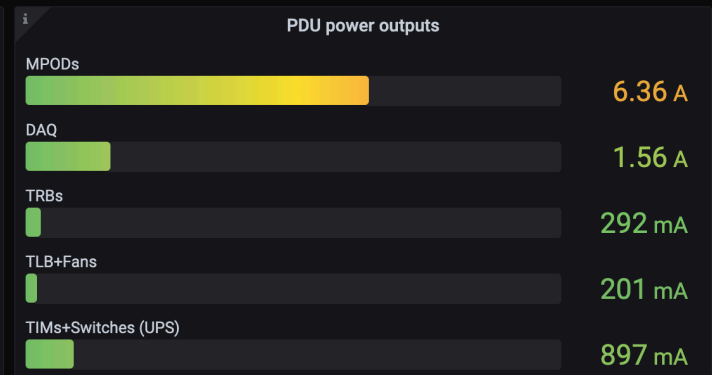
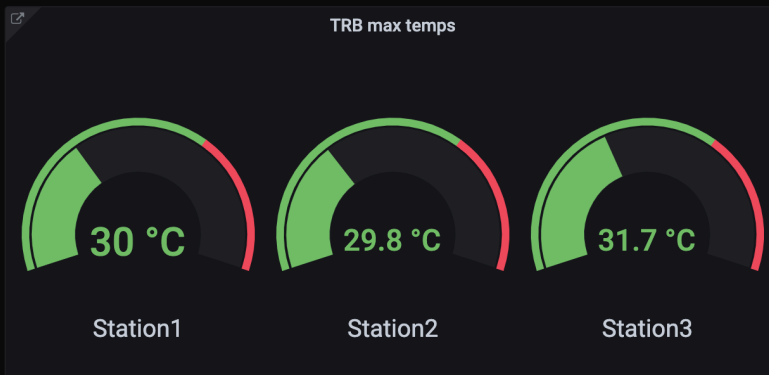
Commissioning

DCS / DCS Overview

Last updated
2021-05-11 12:58:34

PMT High Voltage

Min voltage	-965 v
Max voltage	-1655 v
Max current	-411 μ A



Tracker Status for Station1

Max Bias Voltage	150 v
Min Bias Voltage	150 v
Max Bias Current	3.30 μ A
Max analog current	1.05 A
Max digital current	484 mA
Max module temperature	28.4 °C
Dewpoint	-31 °C

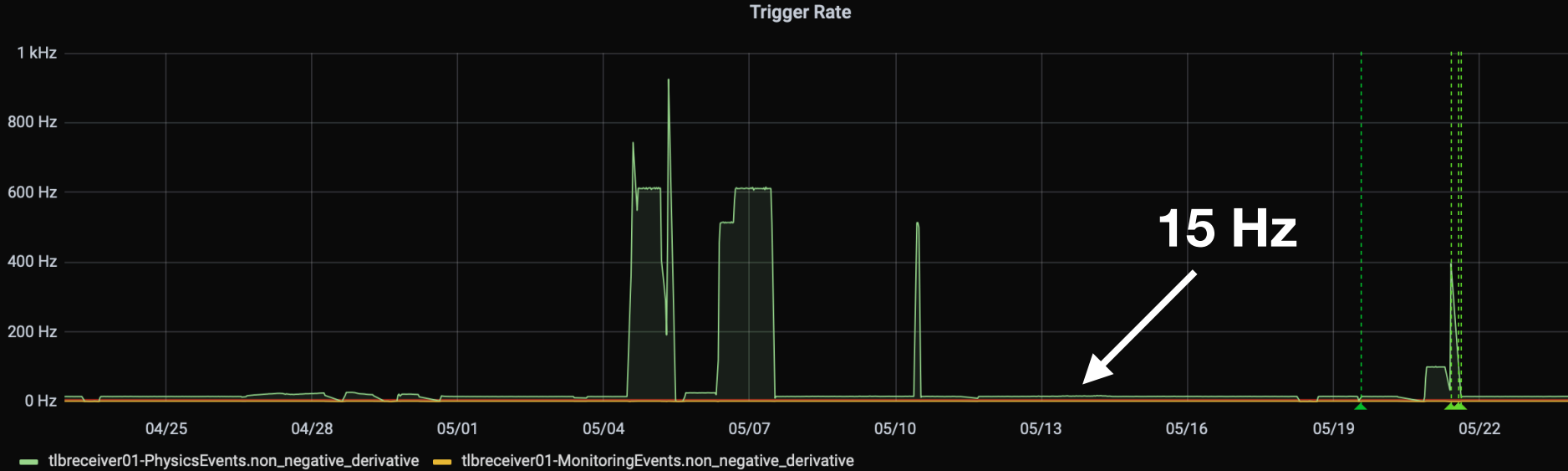
Tracker Status for Station2

Max Bias Voltage	150 v
Min Bias Voltage	150 v
Max Bias Current	2.89 μ A
Max analog current	1.03 A
Max digital current	484 mA
Max module temperature	28.9 °C
Dewpoint	-36 °C

Tracker Status for Station3

Max Bias Voltage	150 v
Min Bias Voltage	150 v
Max Bias Current	2.82 μ A
Max analog current	1.02 A
Max digital current	511 mA
Max module temperature	28.5 °C
Dewpoint	-39 °C

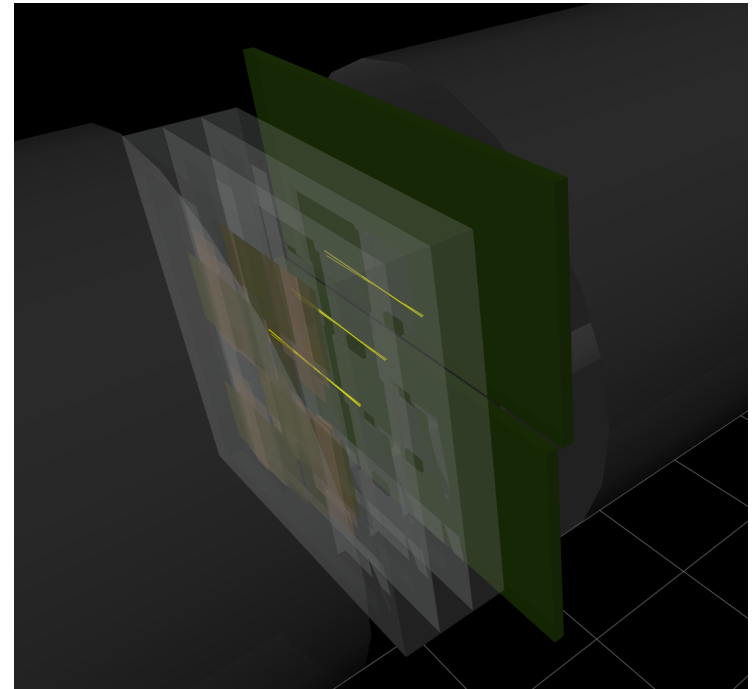
- First cosmic run with full detector on March 23rd
- Have been running the system almost continuously since then to test remote operation and monitoring



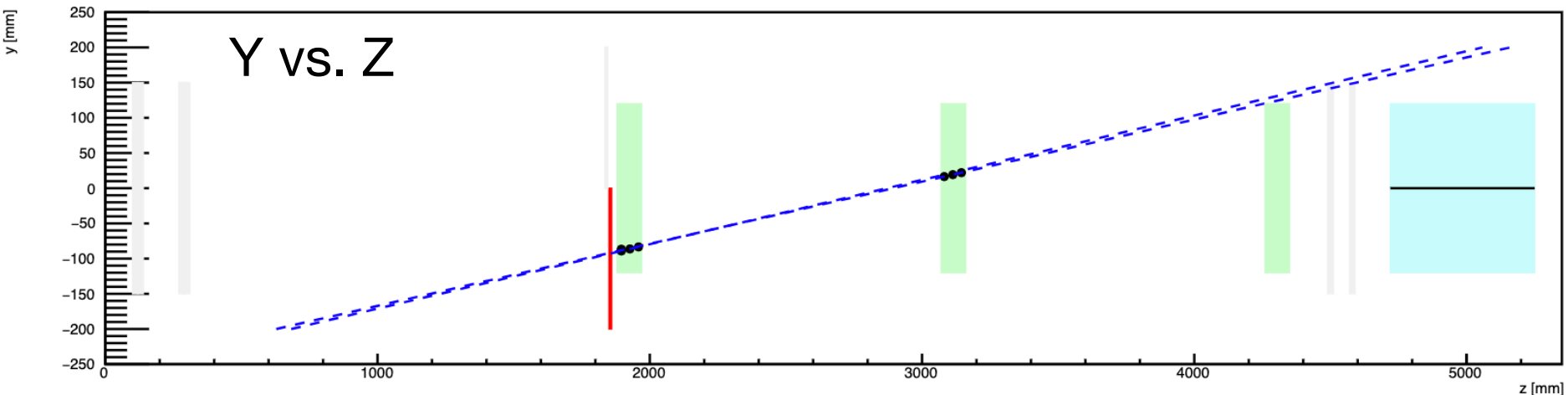
← Last Month →

- 10-15 Hz trigger rate requiring 2-scintillator coincidence
 - Also 1 Hz rate of random triggers
- Very long runs (days) achieved with few problems
- Extended “High rate” tests (~600 Hz) also successful

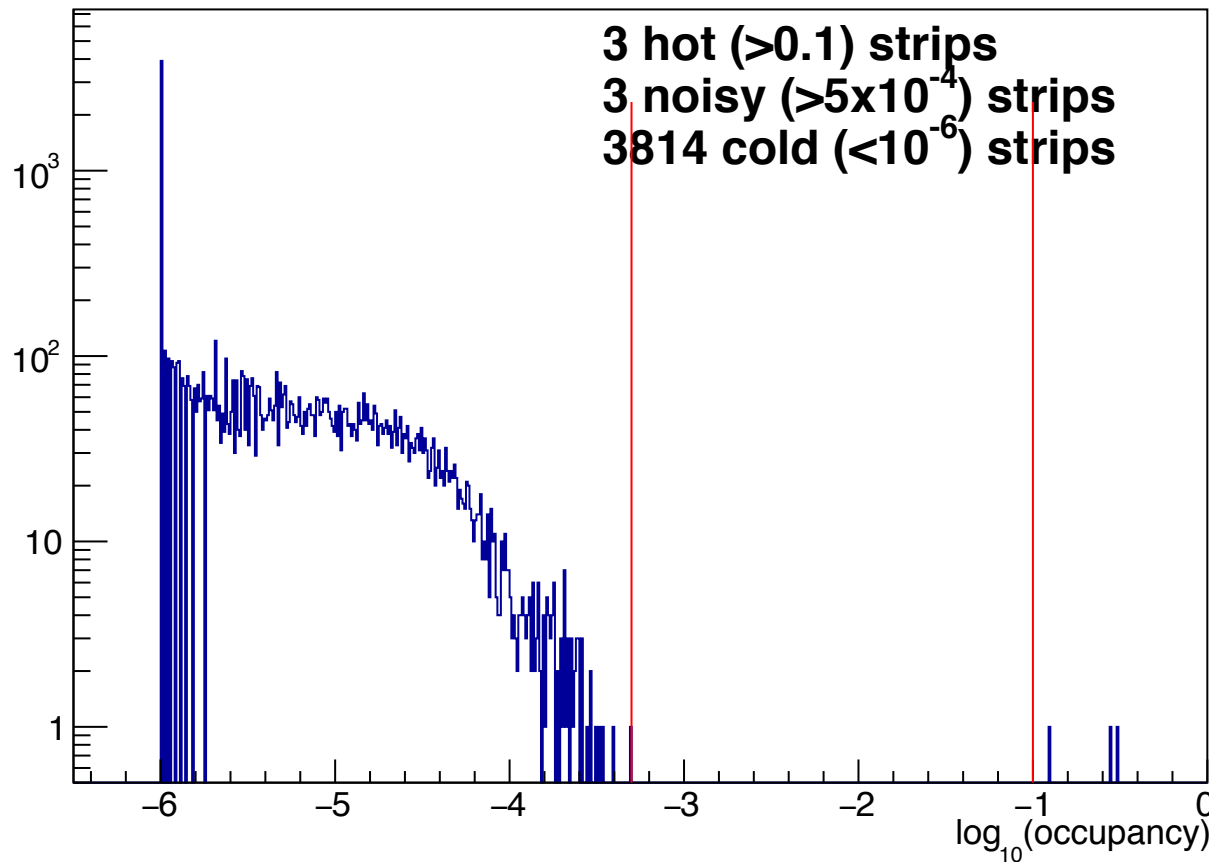
- Tracks observed in single station (3 layers)
 - triggered by nearby scint.
 - Rate about 1 every minute
- Double station hits seen
 - few times per day
- No 3-station tracks yet
 - expected to be very rare



Side-view - Run-001551, event 304486

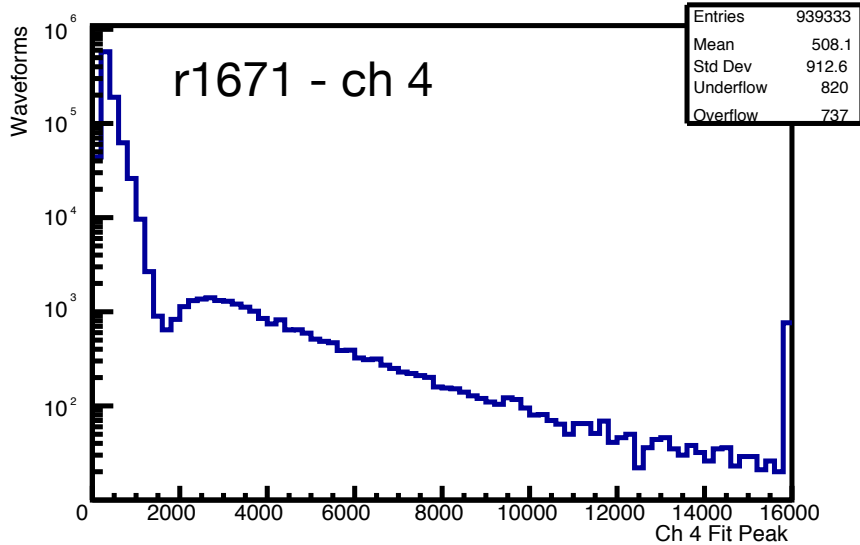


Strip occupancy - layer 0

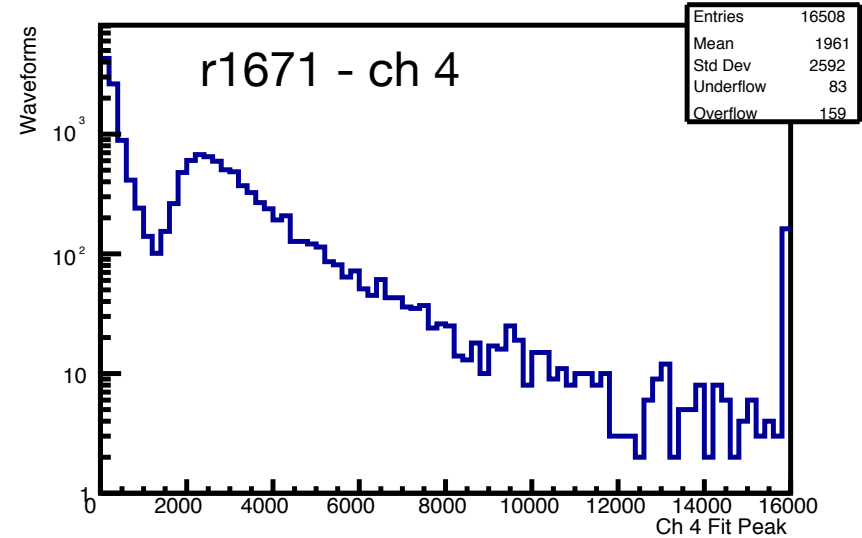


- Strip occupancy in tunnel matches measurements on surface
- Worst layer has 19 hot ($>10\%$ occ.) strips out of 3820
- Setting up automated hot strip finding and DQ/monitoring

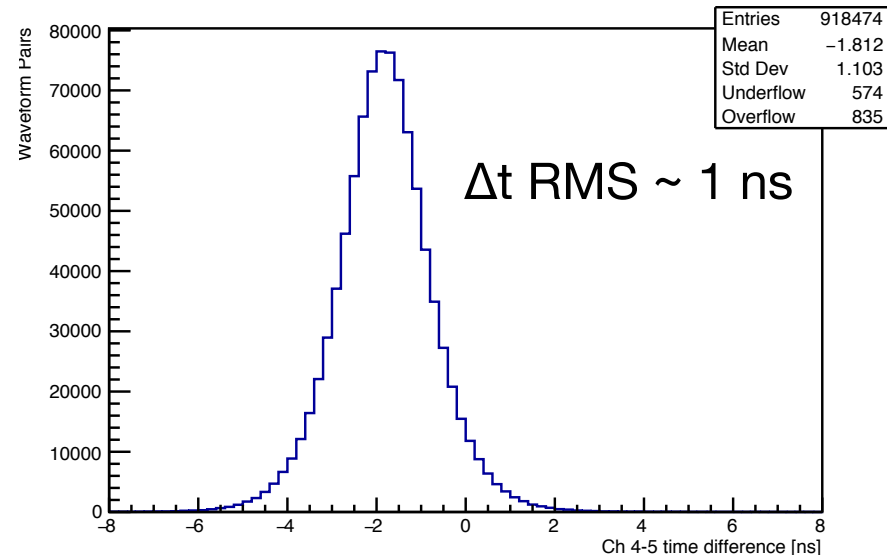
Veto counter - all triggers



Veto counter - quad coinc.

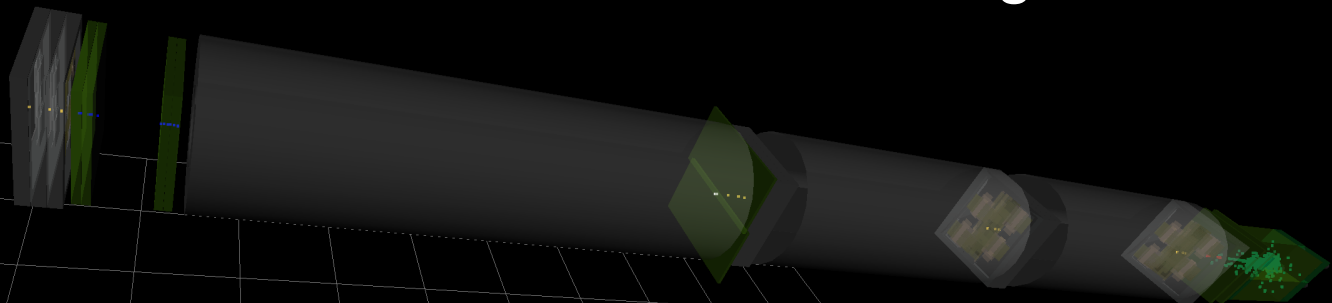


- Scintillators show MIP peak above noise
- Time resolution as expected from surface studies ~ 1 ns
- Can see expected correlations with track segment positions

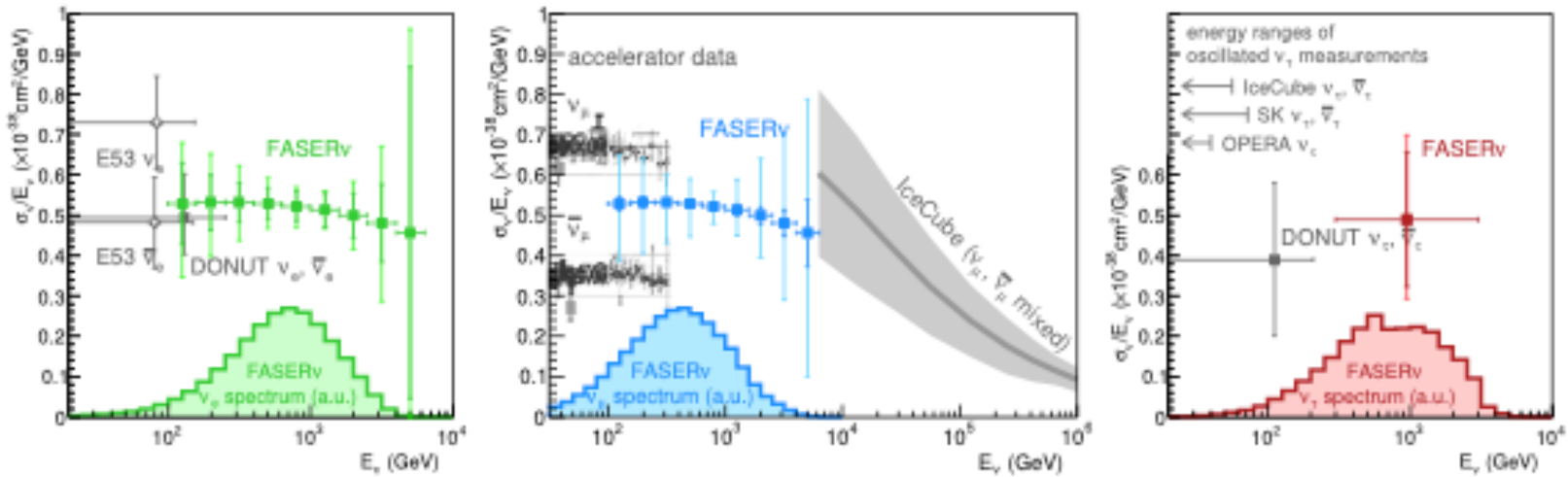


- Detector simulation well advanced
 - Recently added cosmic generator
 - FaserNu detector geometry included
- Reconstruction code development
 - ACTS-based tracking code making progress
 - Fast segment finder for cosmics also developed
- Automated production system
 - Implementing light-weight job scheduling with Redis rq
 - Submission of calibration jobs, reco, monitoring, streaming

Muon simulated through full detector

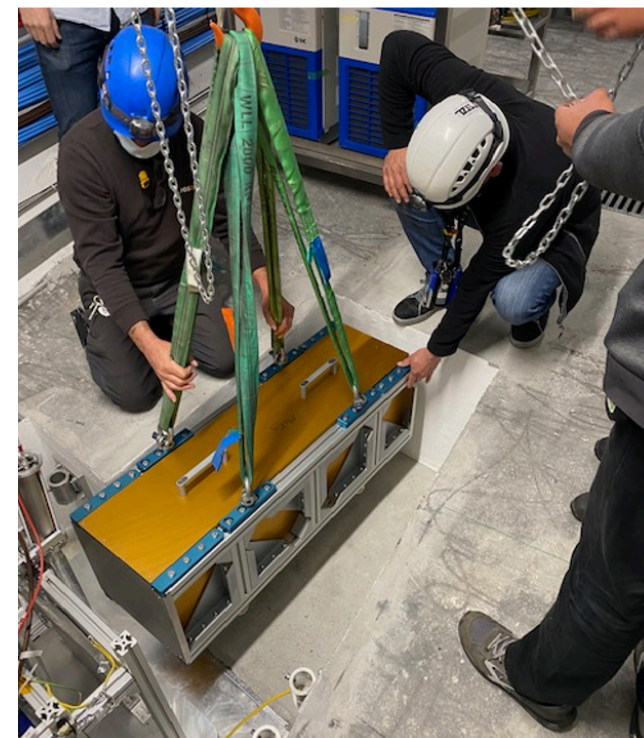


- Standard Model produces copious amounts of weakly interacting, long-lived, light particles: **neutrinos**
- FASER ν is 1.1m long, 1.1 ton tungsten-emulsion stack at front of FASER designed for ν detection
- Goal to measure neutrino cross-section for all species in collider-energy range (100 GeV - few TeV)
- 4th tracking station to be added between FASER ν and rest of FASER - measure muon charge (detect ν_μ vs $\bar{\nu}_\mu$)



Neutrino physics: [EPJC 80, 61 \(2020\)](#)
 Tech. Proposal: [CDS](#)

- Dry run of FASERv installation/removal on Apr. 29
 - Empty box, full-weight test scheduled for Oct/Nov
 - Some modifications needed to make this easier
 - Stack will be swapped during each technical stop, must be efficient!



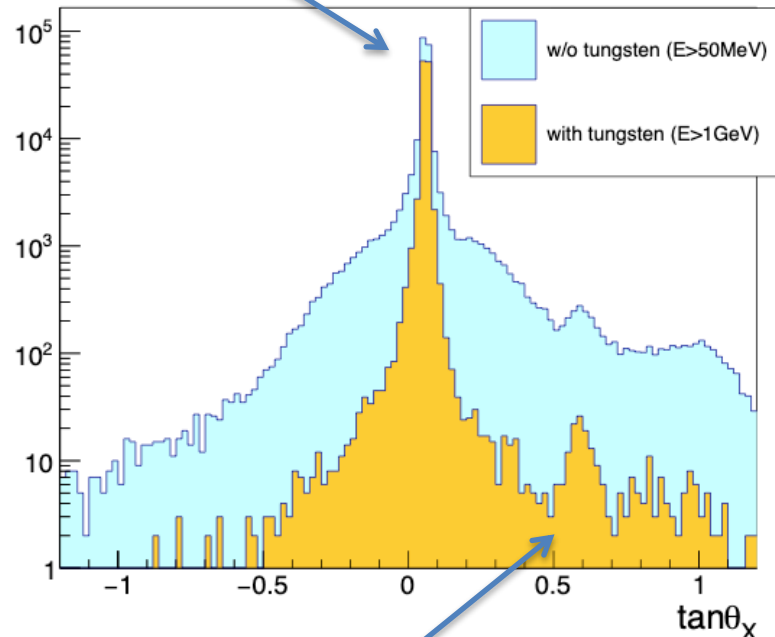
- Emulsion and Timepix detectors exposed to 12 fb^{-1} in 2018
- Primary goal was to verify muon flux and backgrounds in T112 & T118 tunnels
- **Secondary goal was to look for neutrinos...**

30 kg Emulsion Detector in T118



particles from IP1

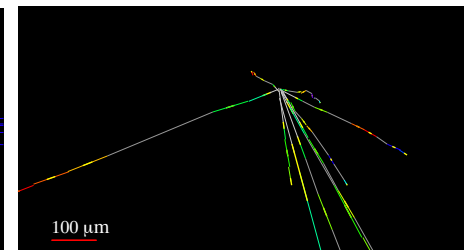
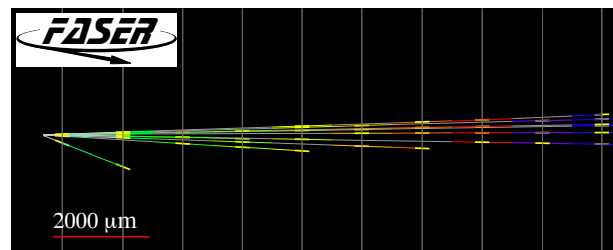
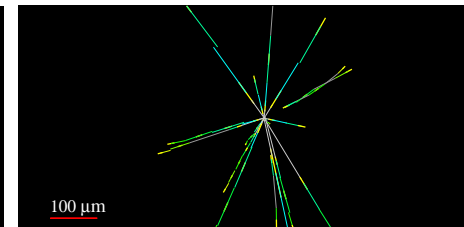
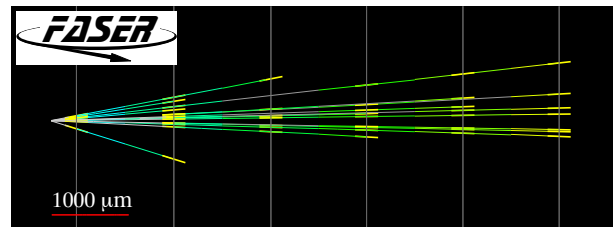
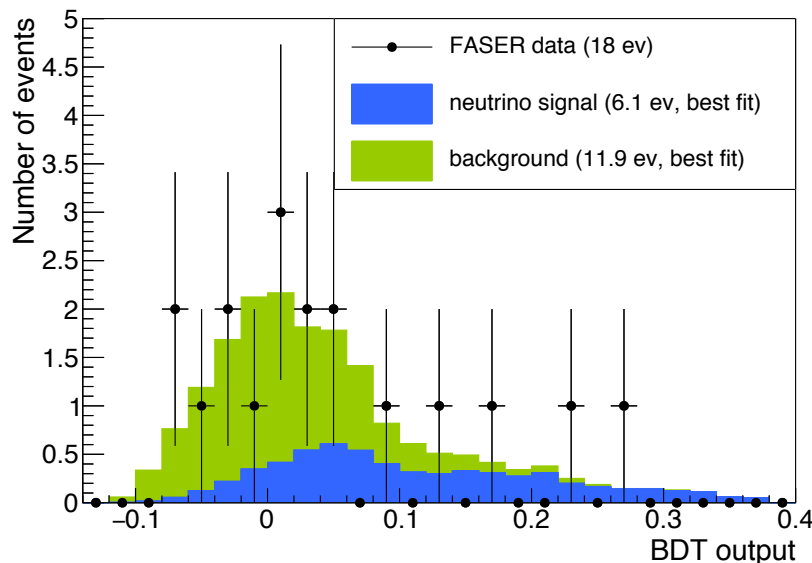
Rates in T112



particles from LHC beam line

Measured angle in emulsion detector

- Neutrino analysis from Pilot run available
- “First neutrino interaction candidates at the LHC” submitted to journal: <https://arxiv.org/abs/2105.06197>
- 11kg fiducial mass target, 12.2 fb⁻¹ of exposure
- BDT selection based on 5 neutral vertex attributes
- Observe 6 signal events (2.7σ excess) over μ-induced neutral hadron background (mostly n and K) consistent with expected neutrino rate of 3.3^{+1.7}_{-0.9}



The FASER Collaboration has ~70 members from 19 institutes in 9 countries



<http://faser.web.cern.ch/>

The FASER Collaboration gratefully acknowledges our funding agencies for their continued support:



HEISING-SIMONS
FOUNDATION

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Along with the tremendous institutional support from



- FASER has been installed in the LHC tunnel
- Initial commissioning in tunnel has gone smoothly
- Work on offline reconstruction, dataflow, calibration, alignment, etc. ongoing
- First physics result from neutrino pilot run submitted for publication

Looking forward to first LHC collisions of Run3!