The Colorado Shallow Underground Research Facility at the Edgar Experimental Mine

RISQ Workshop 2024

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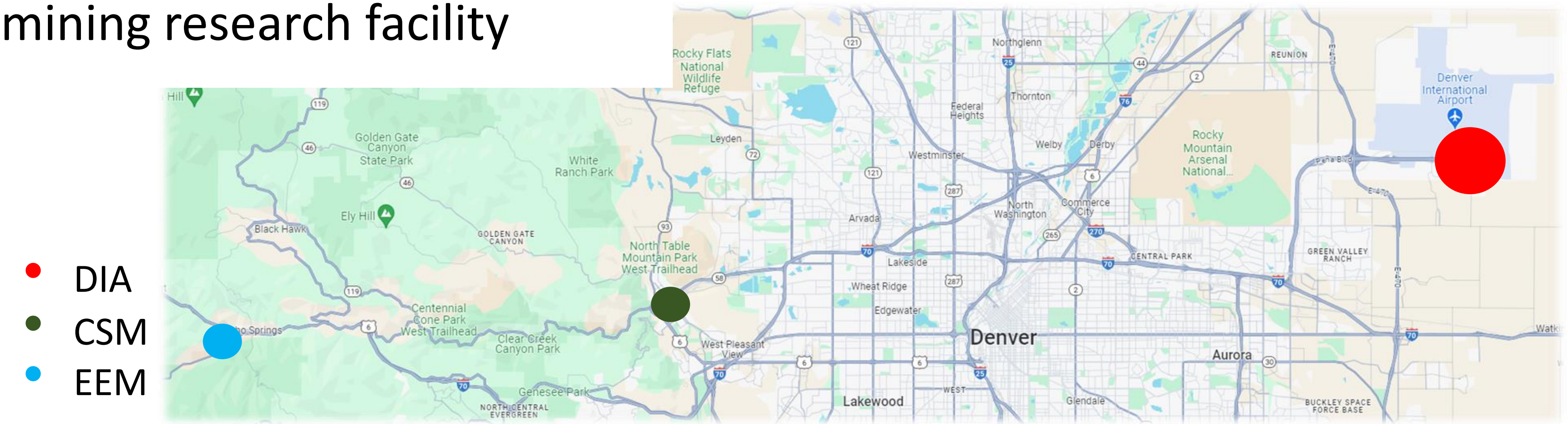
supported by NSF

History and Background

- Located in Idaho Springs, CO (2400m elevation)
- Approx. 1 hr. drive from DIA
- Approx. 30 min from CSM (Golden, CO)
- Active producer of silver and gold in the 1870’s
- Acquired by CSM in 1921 for use as an underground classroom for engineering education and as a mining research facility



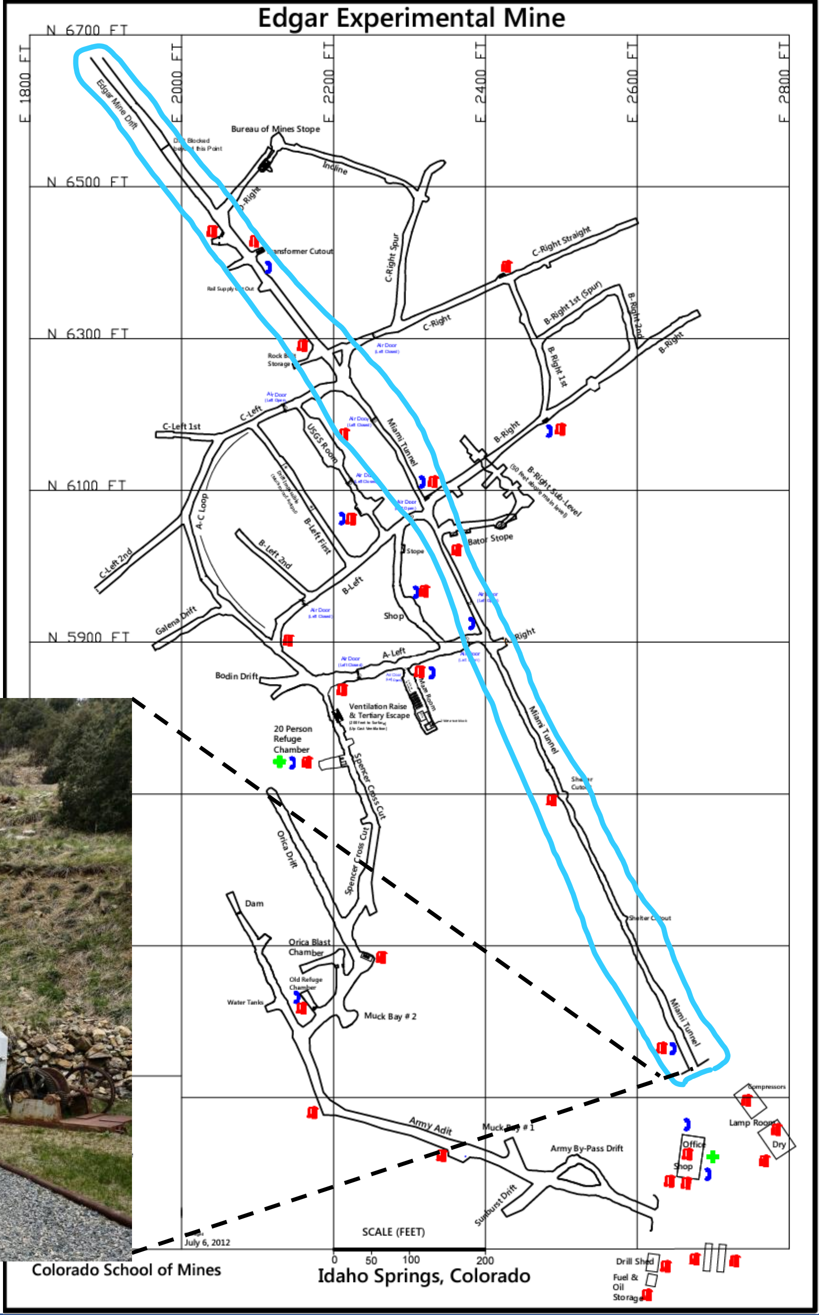
Facilities and Access

- Divided into 2 sections: Army tunnel and Miami tunnel
- Surface level, horizontal access
- Over 2000m of rail driven tunnels
- Near constant year-round temp. ~ 12 C

Available Facilities:

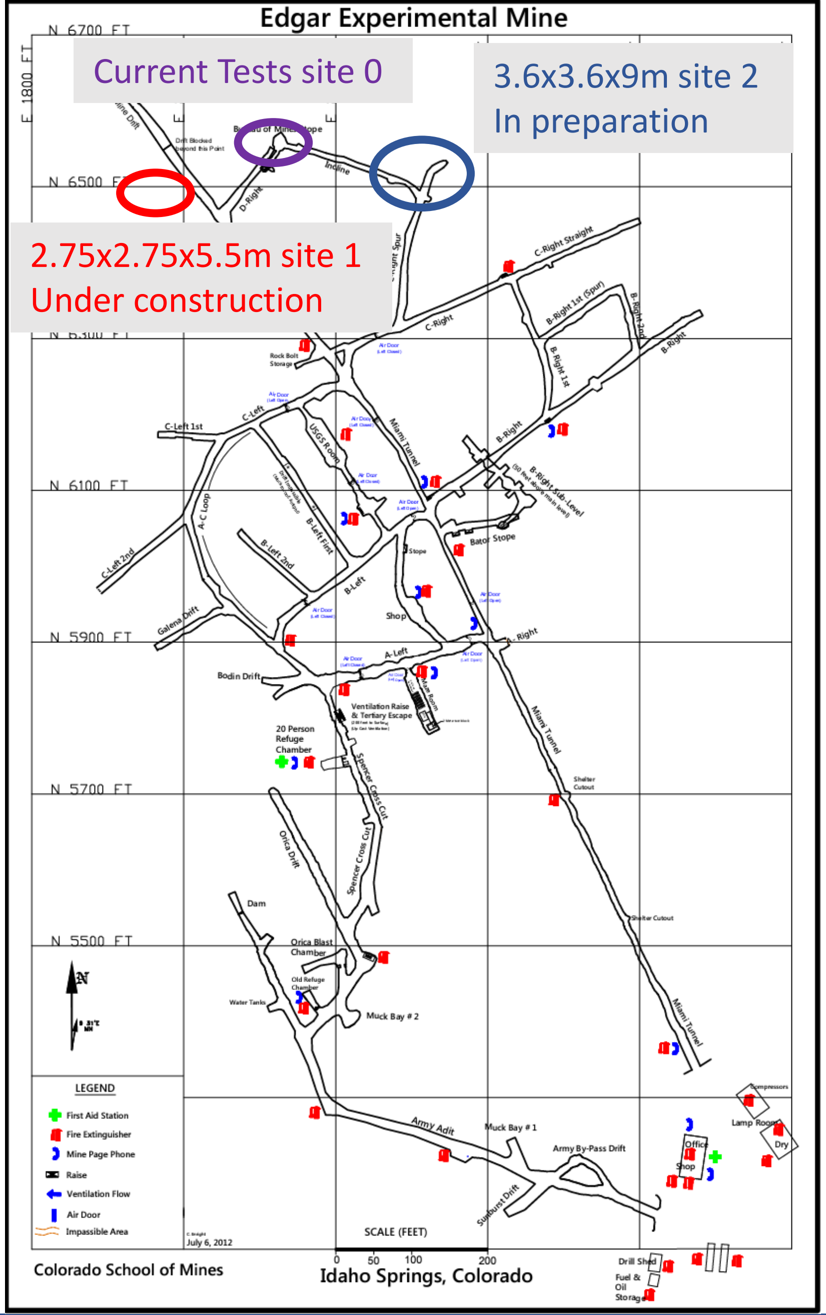
- single phase – 110V and 3 phase – 440V power
- Compressed air and water sources
- 1275 m^3/min exhausting silencer equipped fan for ventilation
- High-speed Wi-Fi

Miami tunnel entrance



Facilities and Access

- 3 sites of current interest
  site 0 (BOM Stope/purple): currently testing here
  site 1 (red): under construction (1-2 months from completion)
  site 2 (blue): in preparation (6-8 months from completion)
- ~ 400 horizontal meters into Miami tunnel
- Openings to sites vary from 1.8x1.8m to 4.5x4.5m
- ~200m vertical rock overburden



Facilities and Access

Current Status of Site 1 →

- Concrete floor
- Shotcrete walls
- Cinder block entrance wall
- Door ready to be installed

← Site 2 to receive same renovations

Cosmogenic Muon Background

Simulations

Daemonflux [1] + MUTE [2]

- Daemonflux: combines primary flux model Global Spline Fit (GSF) and interaction model Data-Driven Model (DDM)
- MUTE: uses outputs from Daemonflux with PROPOSAL
- Allows for propagation of systematic errors from the models (detailed in [1])

[1] J. P. Yanez and A. Fedynitch Phys. Rev. D **107**, 123037 (2023)

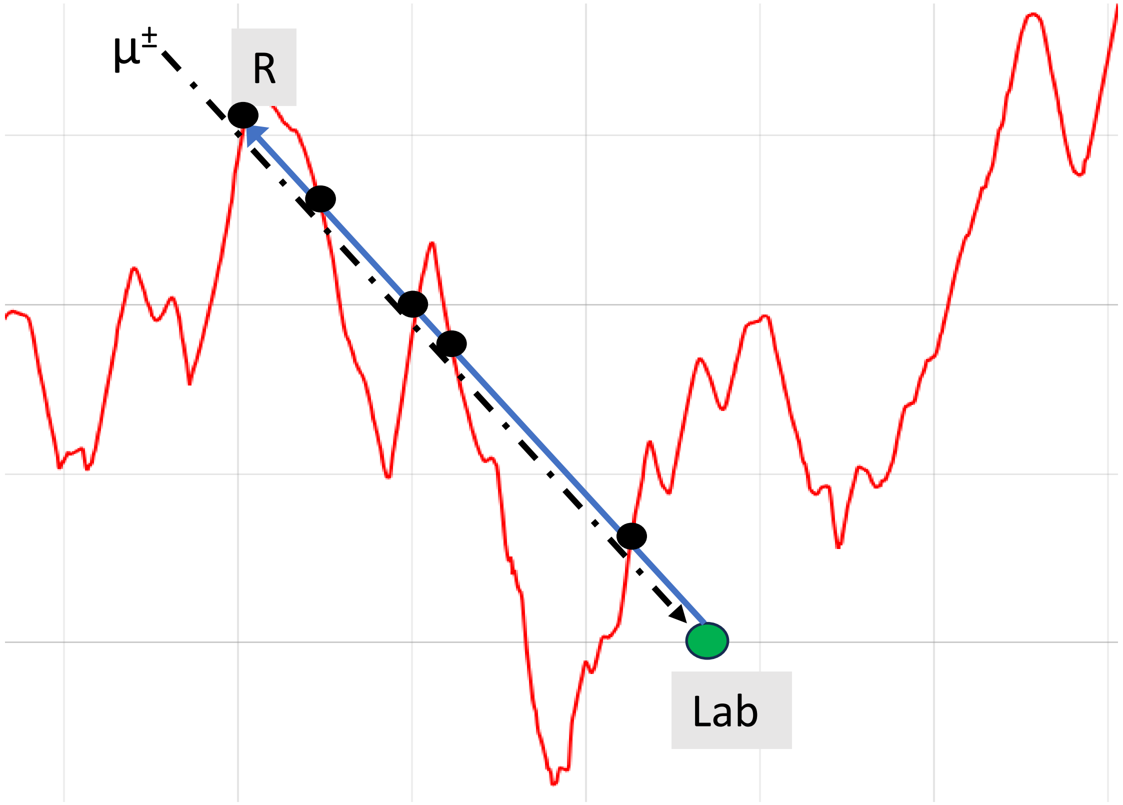
[2] A. Fedynitch *et al* 2022 *ApJ* 928 27

Mountain Profiles

- Custom mtn. profile for each site using QGIS (USGS lidar data)
- X-Y ~ 1m accuracy
- Z ~ 13.57cm accuracy
- Spatial errors negligible compared to geological systematics
- Two main issues: air gaps and rock density

EEM extent

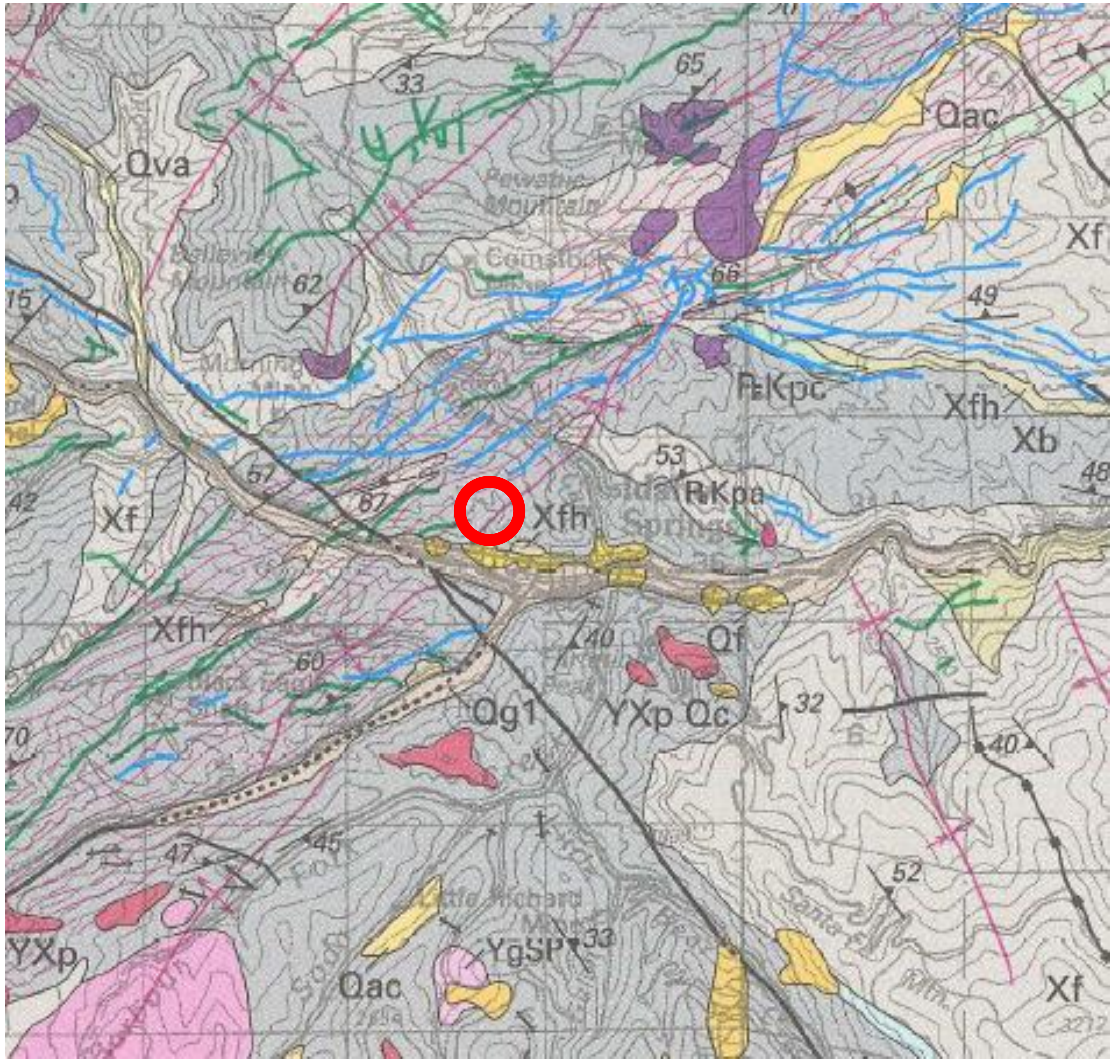
Mountain Profiles



Air gaps

- Would incorrectly overestimate slant depths
- Projected zenith (θ) and azimuthal (ϕ) angles onto narrow column
- Swept 2π sr
- Checked for repeated R values (radial distance from lab) for given (θ , ϕ)
- Computed new R based on even/odd frequency criteria
- ~ 1-2% difference from previous flux simulation values

Mountain Profiles



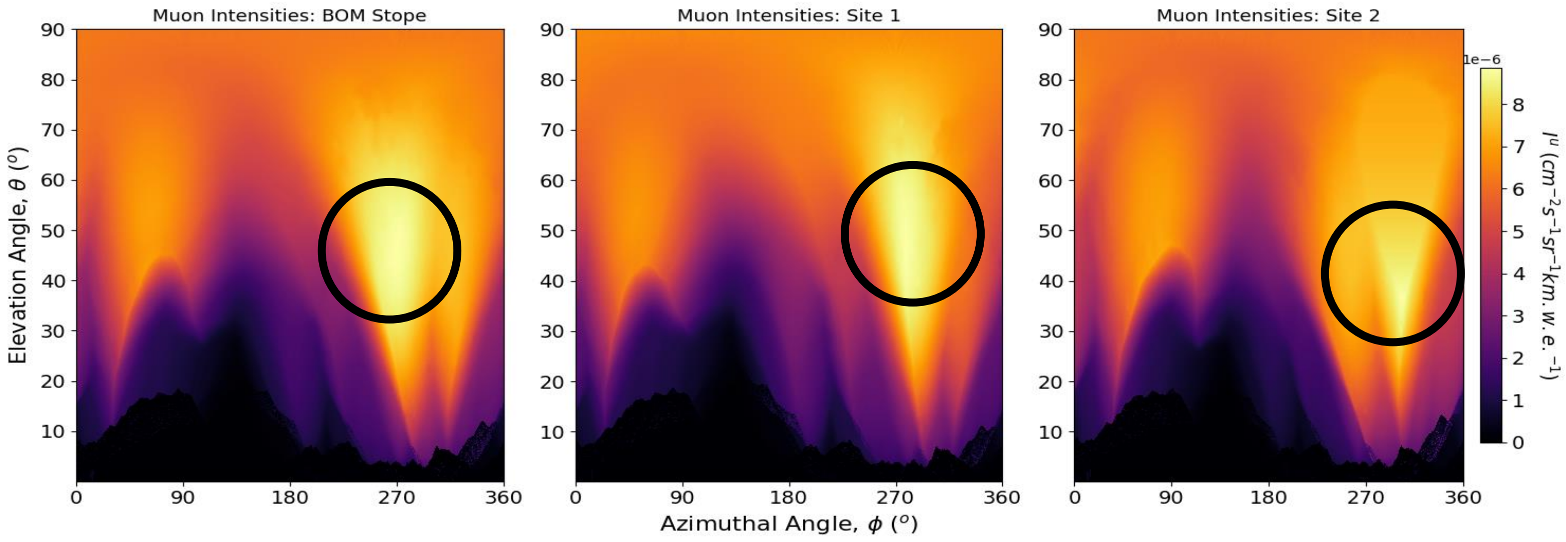
Rock density

- Used USGS geologic survey and rock composition data
- Created worst case, simple average, and azimuthal average density profiles
- Ran simulations to compare profiles
- Concluded simple average was sufficient
  $\langle\rho\rangle = 2.7685\ \mathrm{g/cm^3}$
- Expect < 5% effect to total muon flux, directional experiments to validate

Simulation Results

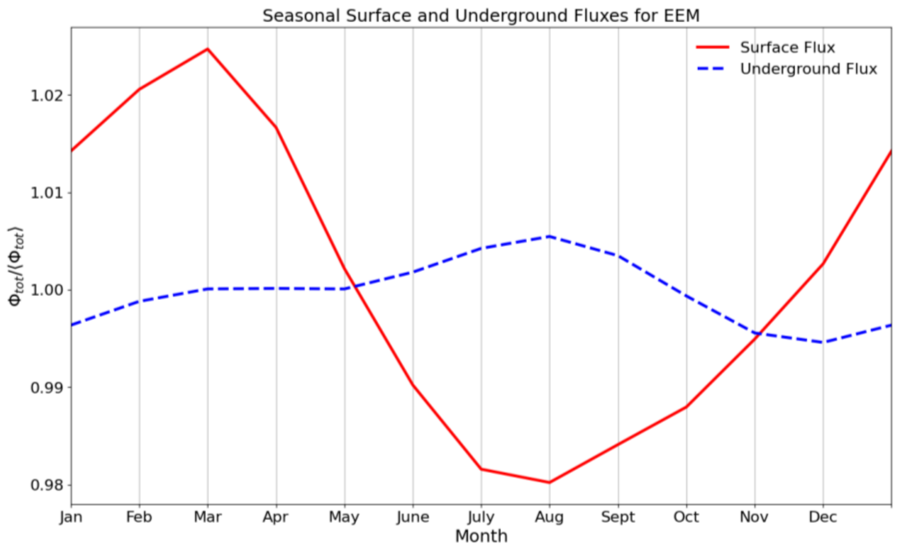
Underground Intensities

- Highest intensities (black) come from S/SE
- Mean underground energy ~ 100 GeV



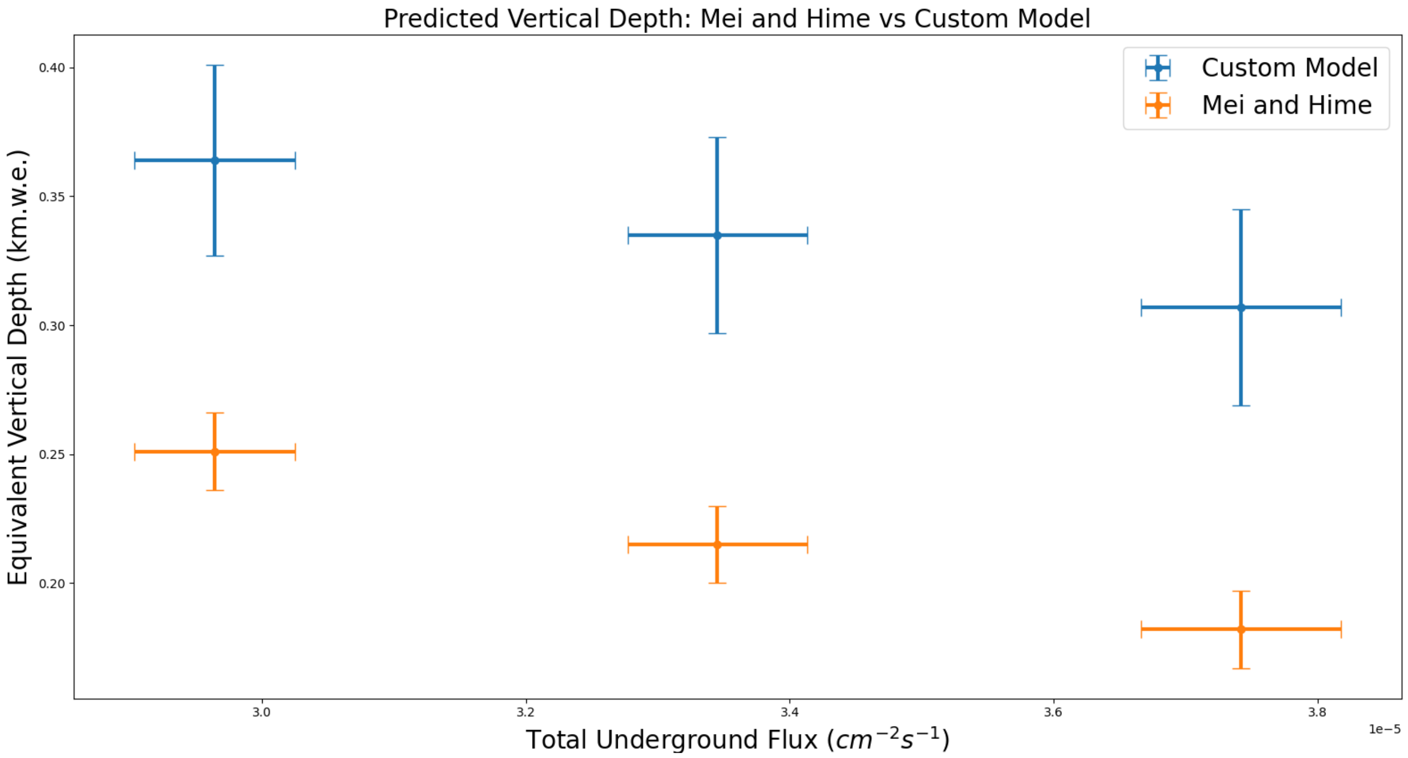
Seasonal Fluxes (NRLMSISE-00)

- Surface fluxes vary ~ 5%
- Underground (200m) fluxes vary ~ 1%



Simulation Results

	Flux (10^-5)*[3]	Mei and Hime [4] (km.w.e.)	Custom Model (km.w.e.)
Site 0	3.345(68)	0.215(15)	0.335(38)
Site 1	2.964(61)	0.251(15)	0.364(37)
Site 2	3.742(76)	0.182(15)	0.307(38)



- **~ 500x reduction compared to sea level**
- Created custom model to predict equivalent vertical depth, since [4] only spans [1, 10] k.m.w.e
- Disagreement between models at these shallow depths
- Custom model to be experimentally cross-validated

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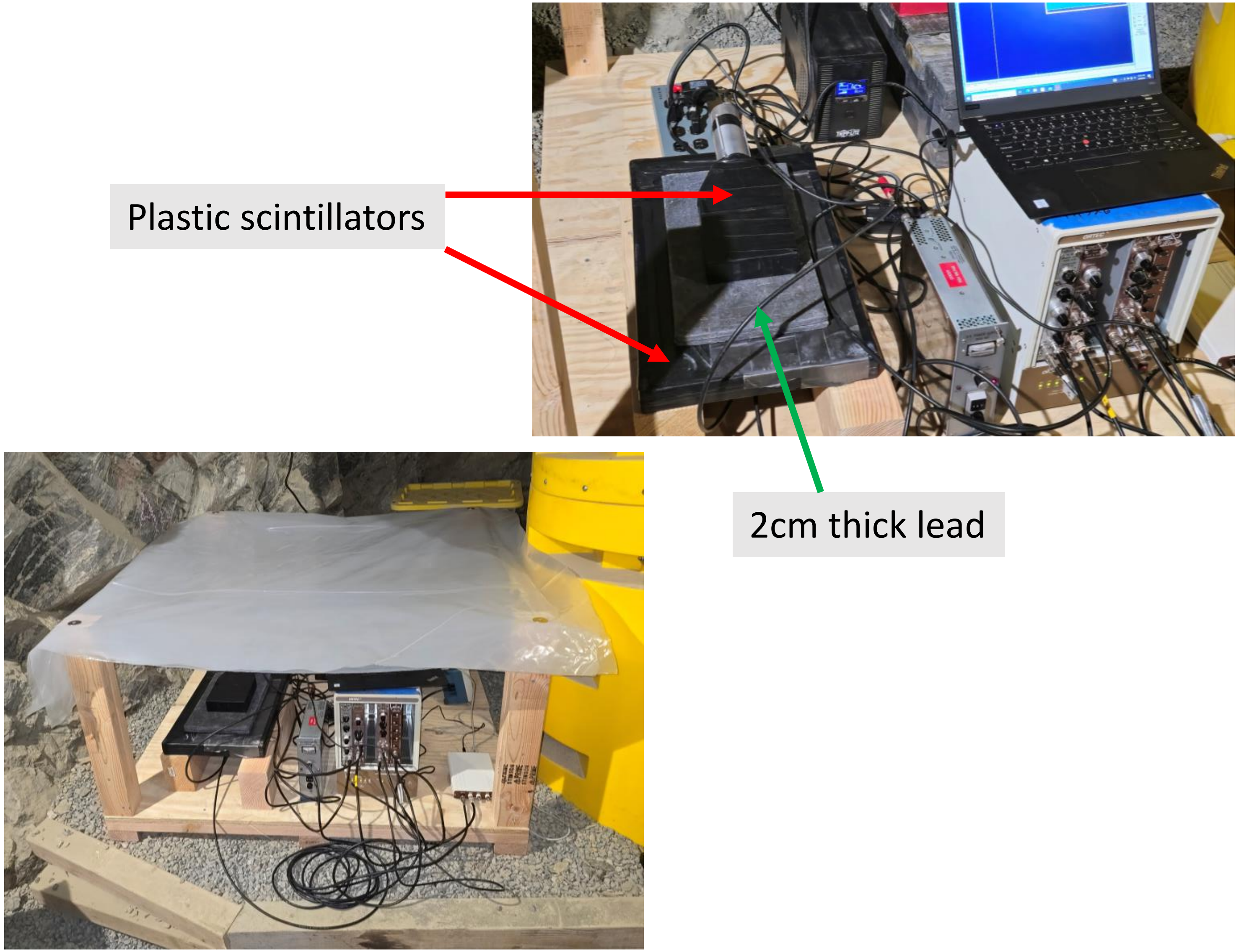
*after surface flux correction applied
[3] J. F. Ziegler, Terrestrial Cosmic Rays

[4] D.-M. Mei and A. Hime
Phys. Rev. D **109**, 019901 (2006)

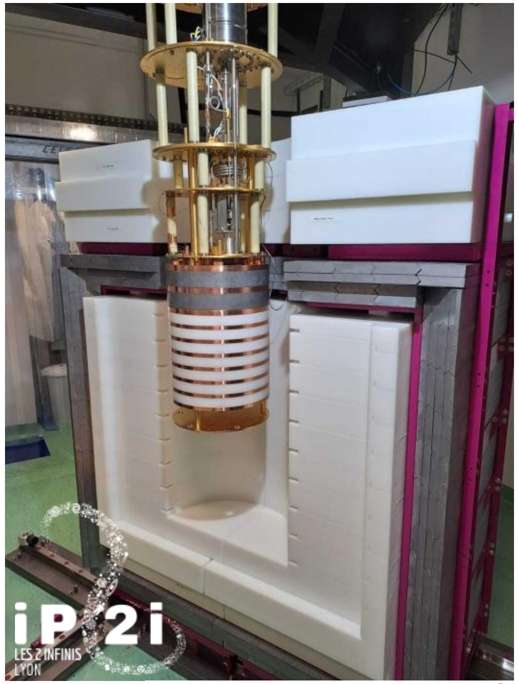
Preliminary Experimental Results

- Conducted in Site 0 (has no dedicated shielding)
- Lead burger scintillator setup
- Running coincidence counts, gating against gamma background
- Prelim results suggest 0.312(37) $m^{-2}s^{-1}$
- Good agreement with simulation
- Values in-line with similar sites



mK Testing Platform

- mK platform built around dilution fridge
- Surrounded by scintillators for active muon veto
- Layered shell of lead and borated polyethylene for gamma and neutron reduction
- Inside of fridge to have cryogenic muon veto, additional lead shielding, and superconducting magnetic shielding
- Thermometry and advance sensors off well-understood noise environment
- Quantum-limited MW amplifiers will read out devices under development



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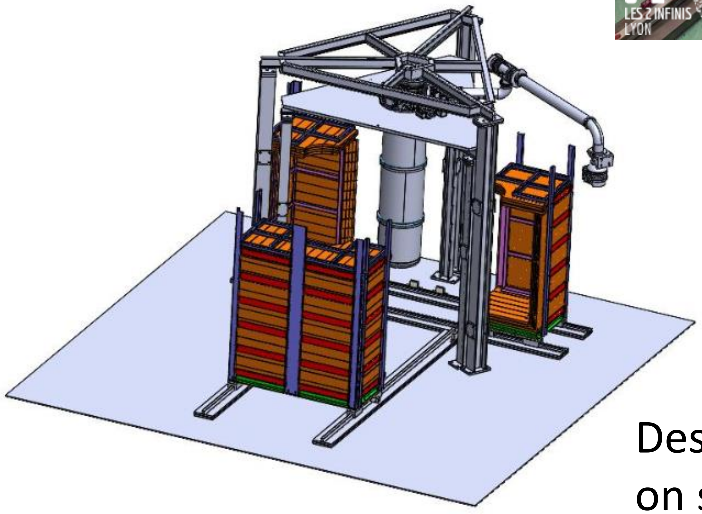

Design to be based on schematic

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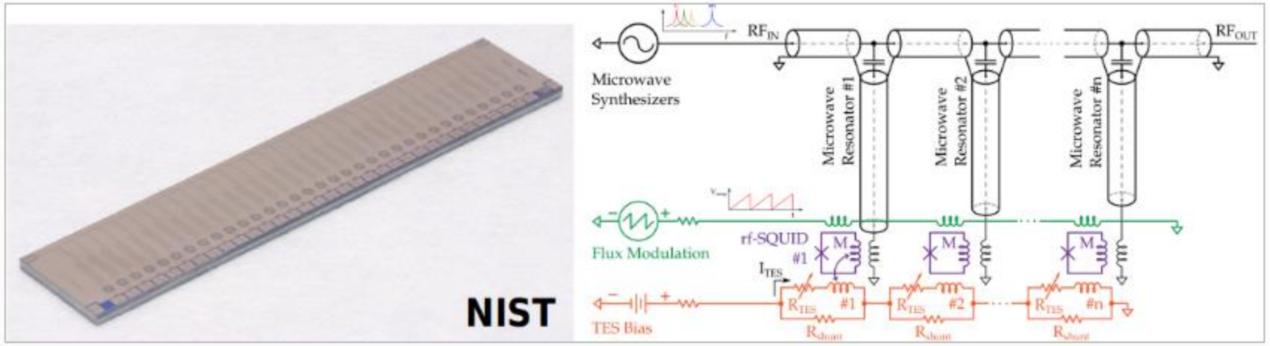
Future Plans

- Active monitoring of magnetic (and vibrational) noise using SQUIDs
  initial measurement done with [5]: ~ 77 µT
- Planning initial gamma measurement using HPGe detector
- Monitoring of gammas with TES-based detectors (NIST)
- Simulation and measurement of µ-induced (and total) neutron background
- Actively monitor/veto muons with scintillator arrays and/or SNSPDs
- Host superconducting sensing experiments using radioisotopes



Advantages

- Relatively low operating/construction costs
- Will have virtually no wait time to run experiments
- Freedom in choosing experiments to host
- Will have electric locomotive to haul heavy equipment

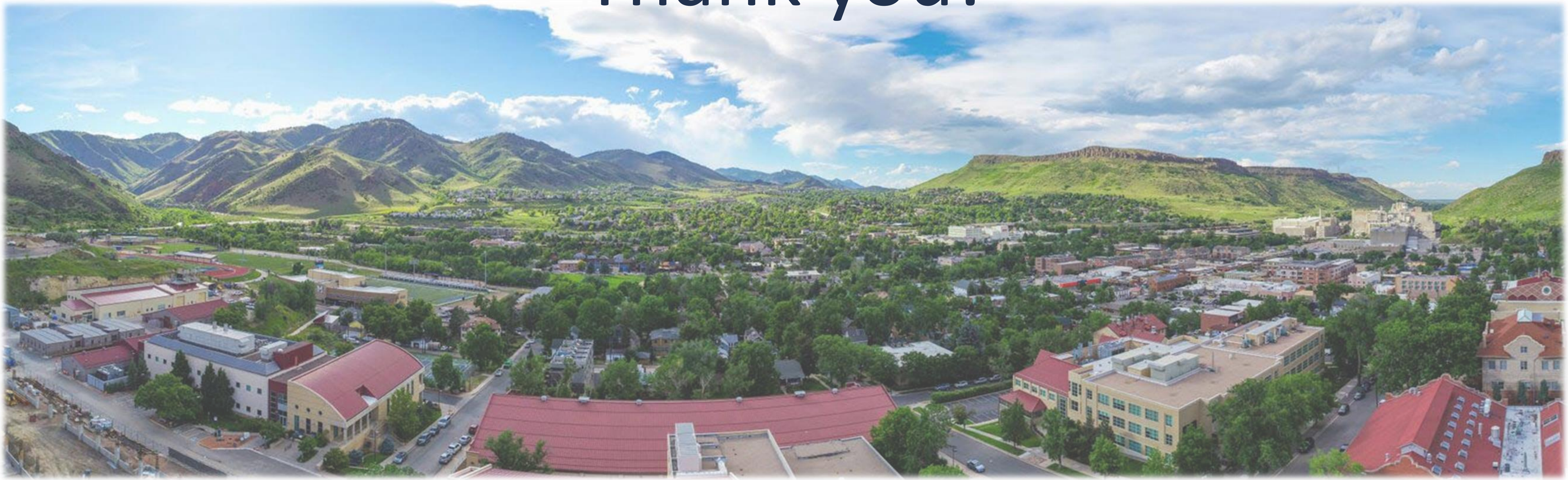
To Consider

- New facility, lots of work to be done
- Must consider vibrational noise (from rock blasting, mining equipment, etc.)
- In process of acquiring clean room

Summary

- Unique opportunity for CSM to create new shallow underground research facility
- Owning and operating significantly reduces operational and expansion costs and time, and we are actively converting sections into usable physics space
- Preliminary muon background measurements suggest ~500x reduction in muon flux
- Active monitoring of backgrounds will enable studying of the sensitivity of the devices under test for different types of noise using coincidence or noise cross-correlation.
- **Many more opportunities for interested groups!**

Thank you!



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This material is based upon work supported by the National Science Foundation Graduate Research Fellowship under Grant No. (DGE-2137099).