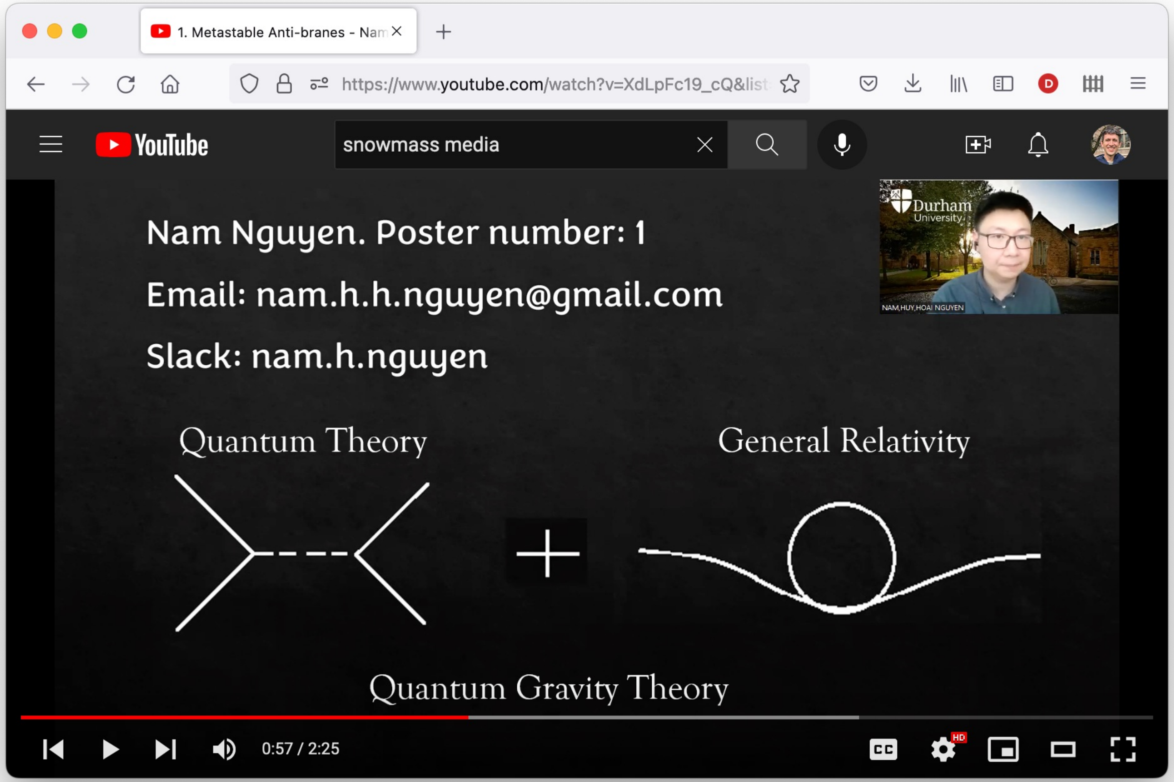
Snowmass 2022 Poster Awards

Jason Detwiler, UW

July 25, 2022

Thank you to all participants for a successful hybrid poster session!

- 75 in-person and 15 remote presenters
- In-person session at last Monday’s reception was well-attended!
- Most presenters provided a video. Those are available as a [YouTube playlist]



Poster Awards

- 4 awards in total, $300 each, for early-career presenters
- 3 sponsored by the journal Universe
- 1 sponsored by the journal Symmetry
- Special thanks to our sponsors!

universe
an Open Access Journal by MDPI

symmetry
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Poster Judging Committee

- 1 judge from each frontier put in many hours of work. Big thank you to our judges!
  - Accelerator Frontier: **Michiko Minty**, Brookhaven National Laboratory
  - Cosmic Frontier: **Alex Drlica-Wagner**, Fermi National Accelerator Laboratory / University of Chicago
  - Community Engagement Frontier: **Ken Bloom**, University of Nebraska, Lincoln
  - Computational Frontier: **Peter Boyle**, Brookhaven National Laboratory
  - Energy Frontier: **Isobel Ojalvo**, Princeton University
  - Instrumentation Frontier: **Petra Merkel**, Fermi National Accelerator Laboratory
  - Neutrino Physics Frontier: **Erin O'Sullivan**, Uppsala University
  - Rare Processes and Precision: **Robert H Bernstein**, Fermi National Accelerator Laboratory
  - Theory Frontier: **Marc Sher**, William and Mary
  - Underground Facilities Frontier: **John Orrell**, Pacific Northwest National Laboratory

Poster Judging Criteria

- **Content** (40 points)
  - Objectives stated
  - Significance/relevance stated
  - Project design and execution explained
  - Interpretation of results and/or current progress included
- **Display** (20 points)
  - Clarity of illustrations, graphics, figures, photos, etc.
  - Spelling, grammar, sentence structure, lack of excessive jargon
  - Ability to be understood by general audience without comment
  - Accessibility
- **Recorded Presentation** (20 points)
  - Clarity of presentation
  - Effective use of materials
- **In-person posters** (40 points)
  - Ability to provide explanations and answer questions
  - Effective use of materials

- Two awards were based on just the first 3 categories (both remote and in-person presenters were eligible)
- The other two awards took into account all 4 categories
- There were so many great posters, the decision was very difficult!

Without further ado, our winners are…

Annika Gabriel, SLAC

universe

an Open Access Journal by MDPI

Community Summer Study
SNOWMASS
2022 July 17 - 26 Seattle

CERTIFICATE

UNIVERSE POSTER AWARD

This certificate is given to

Annika Gabriel

SLAC National Accelerator Laboratory
"Reshaping THz Near-Fields for Efficient Particle Acceleration"
in recognition of winning the Poster Award sponsored by the open access journal *Universe*
Presented at the Snowmass Community Summer Study Workshop
July 17–26, 2022 | University of Washington, Seattle, USA

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Basel, July 2022

Jason Detwiler
Chair of the Poster Judging Committee

Dr. Shu Kun Lin
President & Publisher, MDPI

SLAC NATIONAL ACCELERATOR LABORATORY

Temporal and Spatial Characterization of Ultrafast Terahertz Near-Fields for Particle Acceleration

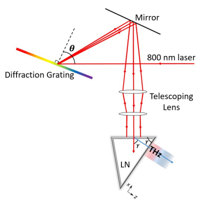
Annika E. Gabriel†, Mohamed A. K. Othman, Matthias C. Hoffmann, Emilio A. Nanni
†angabrie@slac.stanford.edu

Abstract

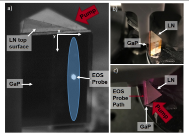
- We have measured the THz near-field in order to inform the design of improved THz-frequency accelerating structures.
- THz-frequency accelerating structures could provide the accelerating gradients needed for next generation particle accelerators with compact, GV/m-scale devices
- A better understanding of the THz near-field source properties is necessary for the optimization of THz transport and coupling into accelerator structures
- We have developed a technique for detailed measurement of the THz near-fields
- Analysis of the results from this measurement will inform designs of novel structures for use in THz particle acceleration.

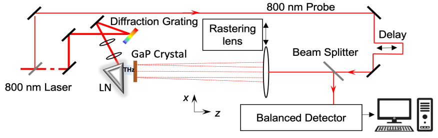
Methods

- THz generation by optical rectification in LN:
  - Requires tilted pulse front to achieve velocity matching



- THz detection:
  - Electro-optic sampling in GaP and balanced diode detection
  - Series of images yield the full temporal 3D THz near-field

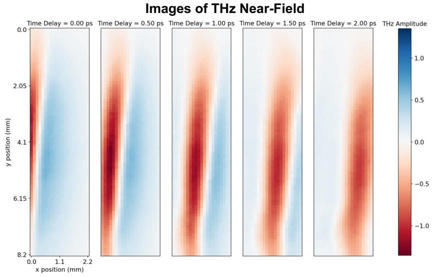




THz Near-Field Results

- 2D images of THz near-field:
  - A series of 2D images of the THz near-field were reconstructed from grid scans of the GaP crystal
    - 5 representative images are shown at right
    - Our results show a temporal delay in the emission of the pulse as a function of lateral delay on the LN surface
    - Temporal delay can be seen as movement of the THz pulse peak in the *x* direction

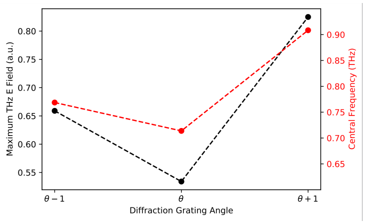
Images of THz Near-Field



Varying Diffraction Grating

- Series of 1D scans varying the diffraction grating angle within the tilted pulse front setup by $\pm1°$ from the ideal angle θ
- Results were analyzed to yield the maximum THz E-field amplitude, central frequency, and change in lateral motion of the pulse.

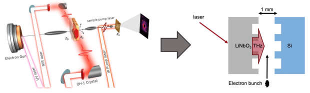
Diffraction Gating Angle	Lateral Motion (mm/ps)
θ-1°	0.73± 0.06
θ	0.85±0.04
θ+1°	0.99± 0.05



- THz near-field results show that:
  - Lateral delay of the pulse can be tuned by varying the diffraction grating angle
  - Could allow for synchronous motion with an electron bunch for particle acceleration
  - THz pulse amplitude and central frequency can be changed for different beam manipulation applications

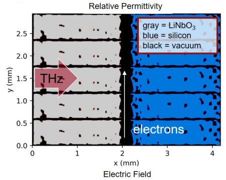
Integrated THz Generation and Electron Acceleration

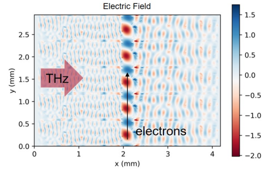
- THz generation and acceleration within one structure:
  - Removes losses from beam transport and coupling
  - Allows for longer THz interaction length



M. A.K. Othman, E. C. Snively, A. E. Gabriel, *et al.* arXiv:2104.05691 (2021).

- Preliminary simulations of THz generation and electron acceleration structure:
  - 0.5 THz CW incident from left side
  - Shunt impedance: 13 MΩ/m





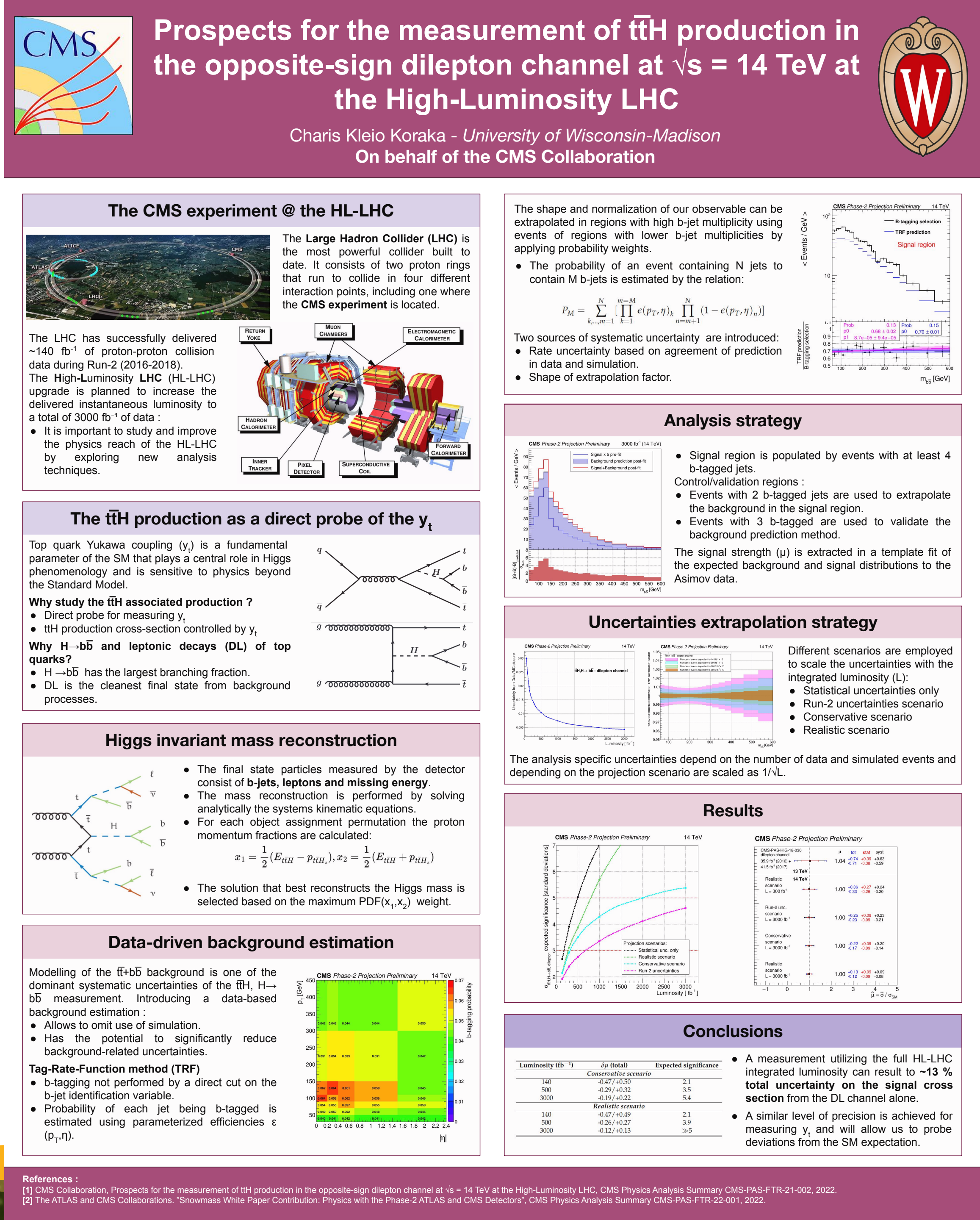
A. E. Gabriel, *et al.* IPAC'21.

Conclusions

- We have measured the THz near-field generated via optical rectification in $LiNbO_3$ with excellent spatial and temporal resolution
- Measurements show a temporal delay in the emission of the pulse as a function of lateral position on the LN surface
- The temporal delay could be tuned by varying the diffraction grating angle
- We also show a change in maximum THz amplitude and central frequency with change in diffraction grating angle
- These measurements will inform new designs of an integrated THz generation and electron acceleration structures

Acknowledgement: This work was supported by Department of Energy contract DE-AC02-76SF00515.

Charis Kleio Koraka, UW Madison



Christina Wang, Caltech

Award accepted by Christina's PhD advisor, Maria Spiropulu

universe

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Community Summer Study SNOWMASS 2022 July 17 - 26 Seattle

CERTIFICATE

UNIVERSE POSTER AWARD

This certificate is given to

Christina Wang

California Institute of Technology
"Search for Neutral Long-lived Particles Decaying in the CMS Endcap Muon Detectors"
in recognition of winning the Poster Award sponsored by the open access journal *Universe*
Presented at the Snowmass Community Summer Study Workshop
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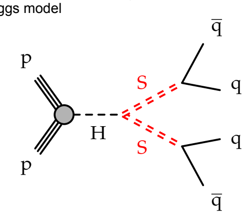
Search for Neutral Long-lived Particles with CMS Endcap Muon Detectors

Christina Wang (Caltech)
on behalf of the CMS Collaboration

Long-lived Particles

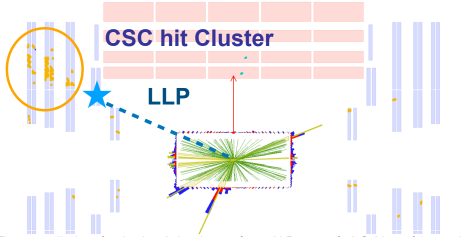
- Long-lived particles are common in SM as well as BSM theories
- Well motivated and predicted in many BSM models: SUSY, Heavy neutral leptons, twin Higgs model



Feynman diagram of the twin Higgs model (S is long-lived)

CMS Muon System

- Covers decays far away from interaction point (sensitive to large $c\tau \sim$ m)
- Excellent **background suppression** from shielding materials → unique to CMS
- Steel interleaved with cathode strip chambers (CSCs) → **sampling calorimeter**
- LLP decay will result in particle shower detected with a large hit multiplicity

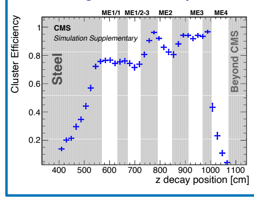


The event display of a simulated signal event for an LLP mass of 40 GeV, $c\tau$ of 1m, and $S \to b\bar{b}$ in rz-plane. The LLP decayed in the muon system (indicated by the blue start) and produced a **CSC hit cluster with 711 hits (orange dots)**. The **green lines** represent the tracks. The **yellow lines** represent jets. The **red arrow** represents the MET direction. The **red** and **blue** cones represent the ECAL and HCAL energy deposits, respectively.

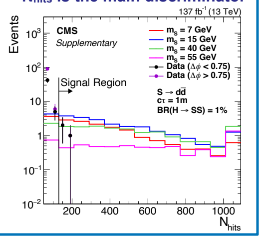
Search Strategy

- Trigger with high MET due to lack of dedicated trigger (~1% efficiency)
- Look for 1 CSC hit cluster with high multiplicity (>130 hits) isolated from jets and muons

High cluster reconstruction efficiency throughout the muon system



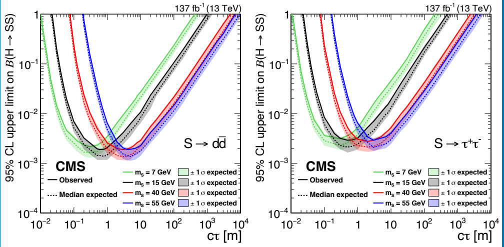
N_{hits} is the main discriminator



Result

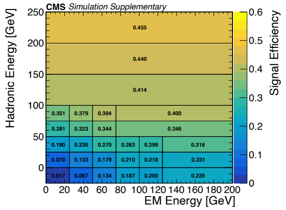
- 3 events observed (2 ± 1 expected)
- Analysis sensitivity is **independent of LLP mass** → only sensitive to LLP energy
- Achieve first sensitivity to τ decay mode at $\mathrm{BR}(H \to SS) \sim 10^{-3}$

Phys. Rev. Lett. 127, 261804



CMS Detector Response Function

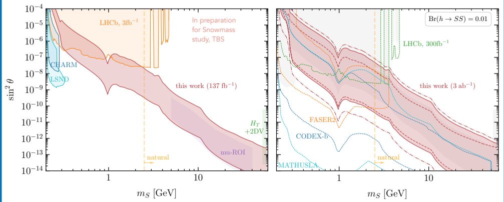
- Cluster-level detector response parameterized in generator-level LLP energy and decay position (HEPData entry)
- Fast simulation of CSC cluster object has been validated and integrated into official Delphes framework
- Allow for reinterpretation to any models



Cluster efficiency in one region of the muon system as a function of generator-level LLP EM and hadronic energy.

Phenomenology

- In collaboration with Caltech theorists Michele Papucci and Andrea Mitridate, we recasted the CMS Run 2 result and projected sensitivity for Phase 2
- We explored several models: dark scalar, dark photon, axion-like particles, inelastic dark matter, and hidden valley models (more coming)
- For most models, the analysis covers previously unconstrained regions of the parameter space and complements the reach of dedicated LLP detectors



Constraints on light scalars produced in Higgs decays for $\mathrm{BR}(H \to SS) = 0.01$.
Left: Comparison of our current reach (red region) with existing limits.
Right: Projections of our constraints for a luminosity of $3\ \mathrm{ab}^{-1}$(red region). The three red contours correspond to three search strategies considered for Phase 2 (Solid line: same analysis strategy and simply scale the result by luminosity; Dot-dashed line: increase N_{hits} cut until 0 background is achieved; Dotted line: remove MET cut and require 2 CSC clusters)

Kelly Stifter, Fermilab

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2022 July 17 - 26 Seattle

CERTIFICATE
SYMMETRY POSTER AWARD

This certificate is given to

Kelly Stifter

Fermi National Accelerator Laboratory
"Low energy calibration and characterization of novel dark matter detectors with a scanning laser device"
in recognition of winning the Poster Award sponsored by *Symmetry*
Presented at the Snowmass Community Summer Study Workshop
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Jason Detwiler
Chair of the Poster Judging Committee

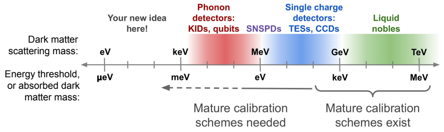
Low energy calibration of novel dark matter detectors with a scanning laser device

QUANTUM SCIENCE CENTER

Kelly Stifter, Cosmic Physics Center, Fermi National Accelerator Laboratory July 2022

Near-threshold calibration is required for novel dark matter detectors:

Motivation: Growing interest in low-mass dark matter requires novel, low-threshold detectors

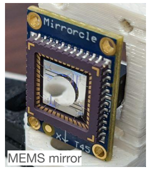


To enable discovery, we need to calibrate near threshold for this wide variety of devices.

Outcome: We have developed a calibration setup that

- Delivers photons over an energy range of 60meV - 5eV
- Scans over full area of device with <100μm precision
- Produces time-resolved, low-intensity pulses
- Operates *in situ* (cryogenic, no parasitic backgrounds)
- Is device independent, flexible, and modular
- Is relatively inexpensive

Careful design and technology choices allow for desired operating specifications:



MEMS mirror

Challenge: cryogenic movement
Solution: modified MEMS mirrors for use at 10mK (upper left)

- Dissipates <nW of power on average

Challenge: small beam spot size at many wavelengths
Solution: homebrew reflective focusing mechanism

- Reflective collimator (center left) + off-axis parabolic mirror (lower left)


Reflective collimator


Off-axis parabolic mirror

Target technical specifications:

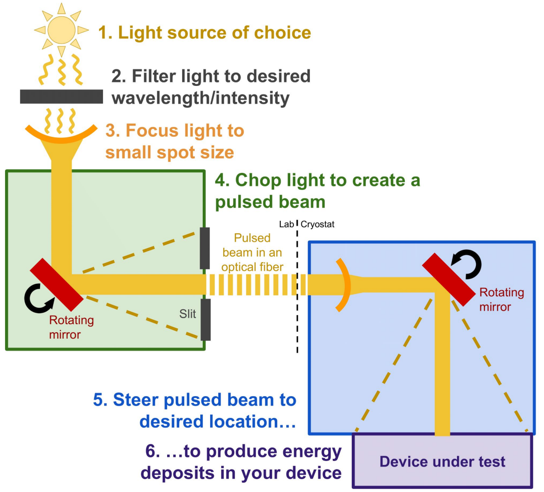
- ~1.5" x 1.5" scanning area
- <100μm spot size
- ~10μm position resolution
- O(100)Hz scanning speed
- O(μs) pulse width
- Operating temperature as low as 10mK

Collaborators: Hannah Magoon (Tufts), Anthony Nunez (Stanford), Noah Kurinsky (SLAC), Israel Hernandez (IIT), Daniel Baxter (FNAL), Lauren Hsu (FNAL), Adam Anderson (FNAL)

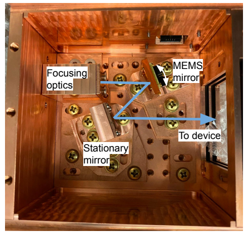
Funding: This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics. This work is funded in part by the U.S. Department of Energy, Office of Science, High-Energy Physics Program Office as well as the Quantum Science Center (QSC) Thrust 3 and the QSC Postdoc Research Award (QPRA).

FERMILAB-POSTER-22-084-PPD

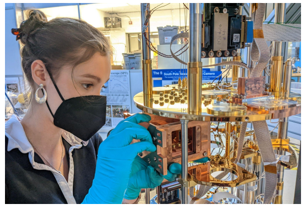
Pulsed, scanning laser device concept:



Current status: First 100mK scanning test imminent



Upper left: Final design of scanning device, machined in copper
Lower left: Full ~1.5" x 1.5" scanning area can be targeted with arbitrary pattern of laser light
Below: H. Magoon installing scanning device into dilution refrigerator



Early science goals of testing program:

- Functionality demonstration of modified MEMS mirrors at 100mK
- Investigation of MKID detector position sensitivity
- Measurement of phonon transport and collection to inform simulations of variety of quantum devices and detectors
- Study of quasiparticle poisoning in qubits

Thank you!

- To our poster presenters
- To our sponsors
- To our judges and the LOC
- To all the participants!

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