Report from LTD25

BULLKID Collaboration Meeting Ferrara 1-2/07/2025

Tommaso Lari

LOW TEMPERATURE DETECTORS CONFERENCE 2025

TOPICS

- Low Temperature Detector Physics and Technology
- Signal Read-out Electronics, Digital Data Acquisition and Analysis
- Sub-Kelvin Refrigeration and Space Cryogenics
- Detectors for X-Rays, Gamma Rays, and UV to IR photons Spectroscopy
- Detectors for Dark Matter, Neutrino Physics, and Rare Nuclear Decays
- Detectors for Atomic, Nuclear and Heavy Ion Physics
- Bolometers for Cosmology, Astrophysics, and Astronomy.

LTD2025

21st International Conference on
Low-Temperature Detectors
Santa Fe, New Mexico
June 1st - 6th, 2025

1. Better **understand the field**: context, key experiments, and trends.
2. **Stay updated** on the latest detector technologies, innovations, and results.
3. **Present our work** and receive a feedback from the community.
4. Return with plenty of **useful insights for our project.**

Outline of the presentation:

1. BULLKID Experiment at LTD25

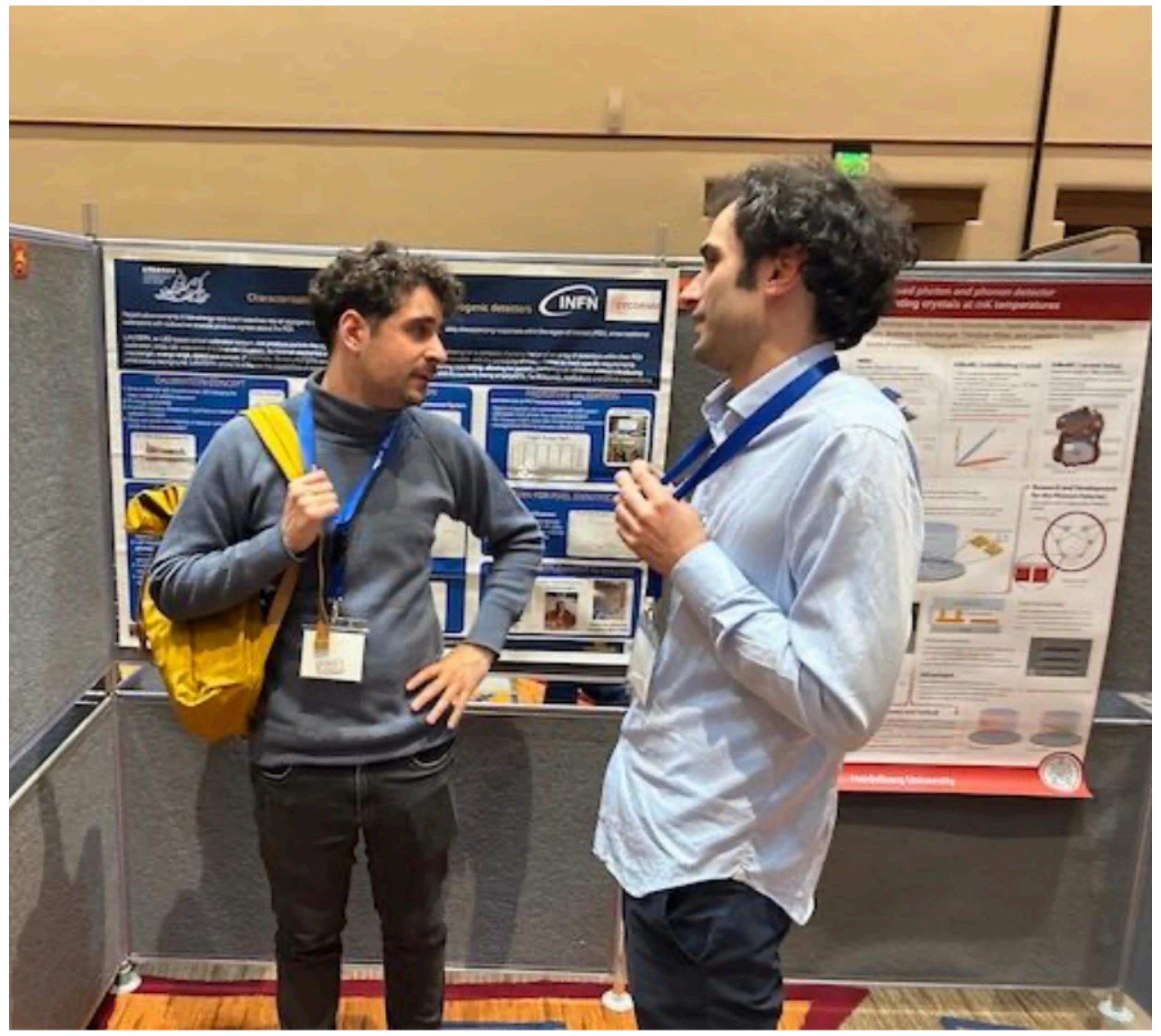
2. Dark Matter: General trends and notable presentations

3. MKID Detectors: General trends and notable presentations

4. Highlights from LTD Talks and Posters: Useful insights gathered from various sessions

- LTD did not upload presentation slides.
- Once the proceedings are published, I will upload the selected articles to the BULLKID wiki.

BULLKID @ LTD25



Daniele Delicato: [BULLKID-DM: searching for light WIMP with monolithic arrays of detectors]

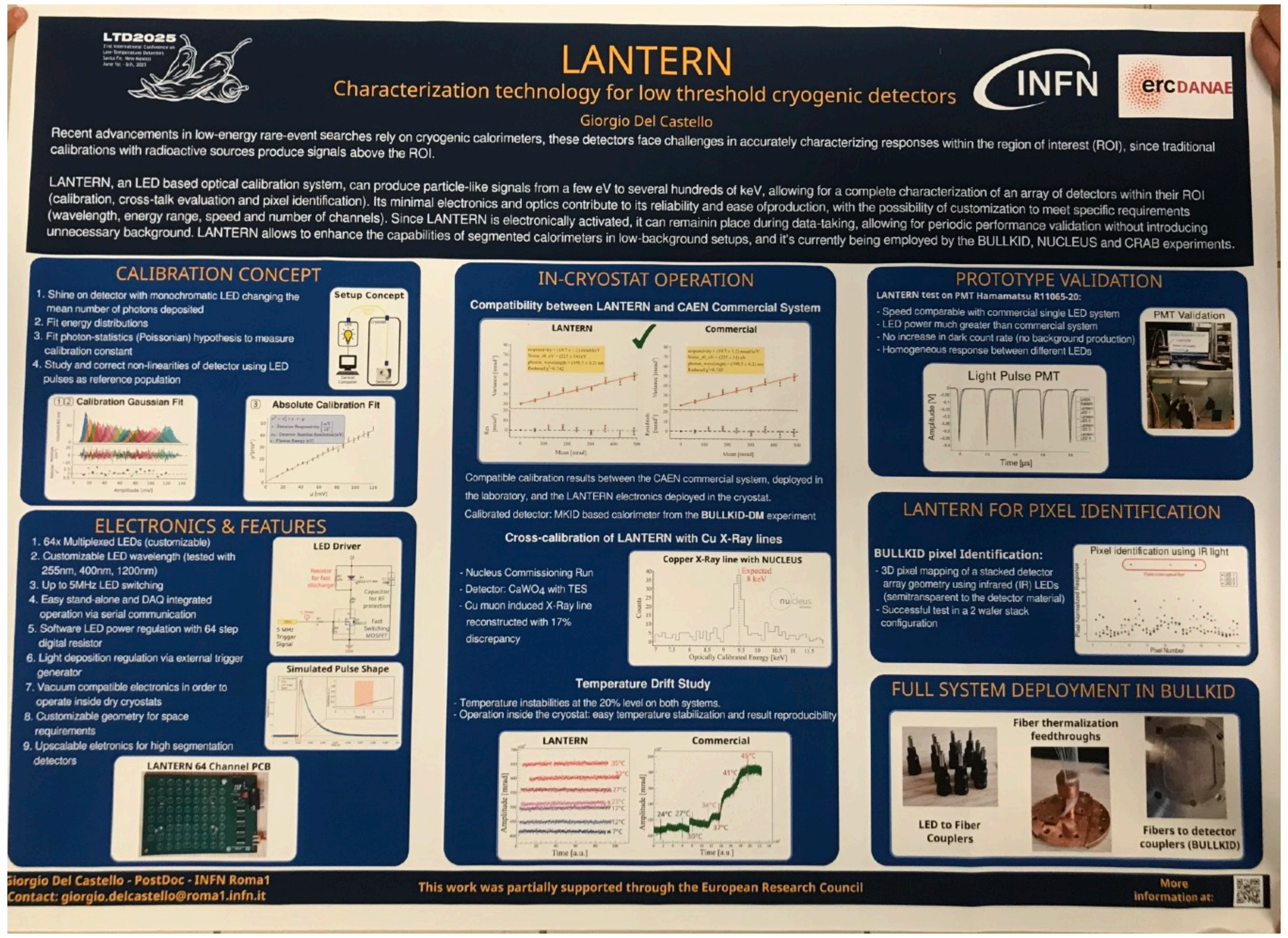
Timo Muscheid [Real-Time Readout System Design for the BULLKID-DM Experiment: Enhancing Dark Matter Search Capabilities]

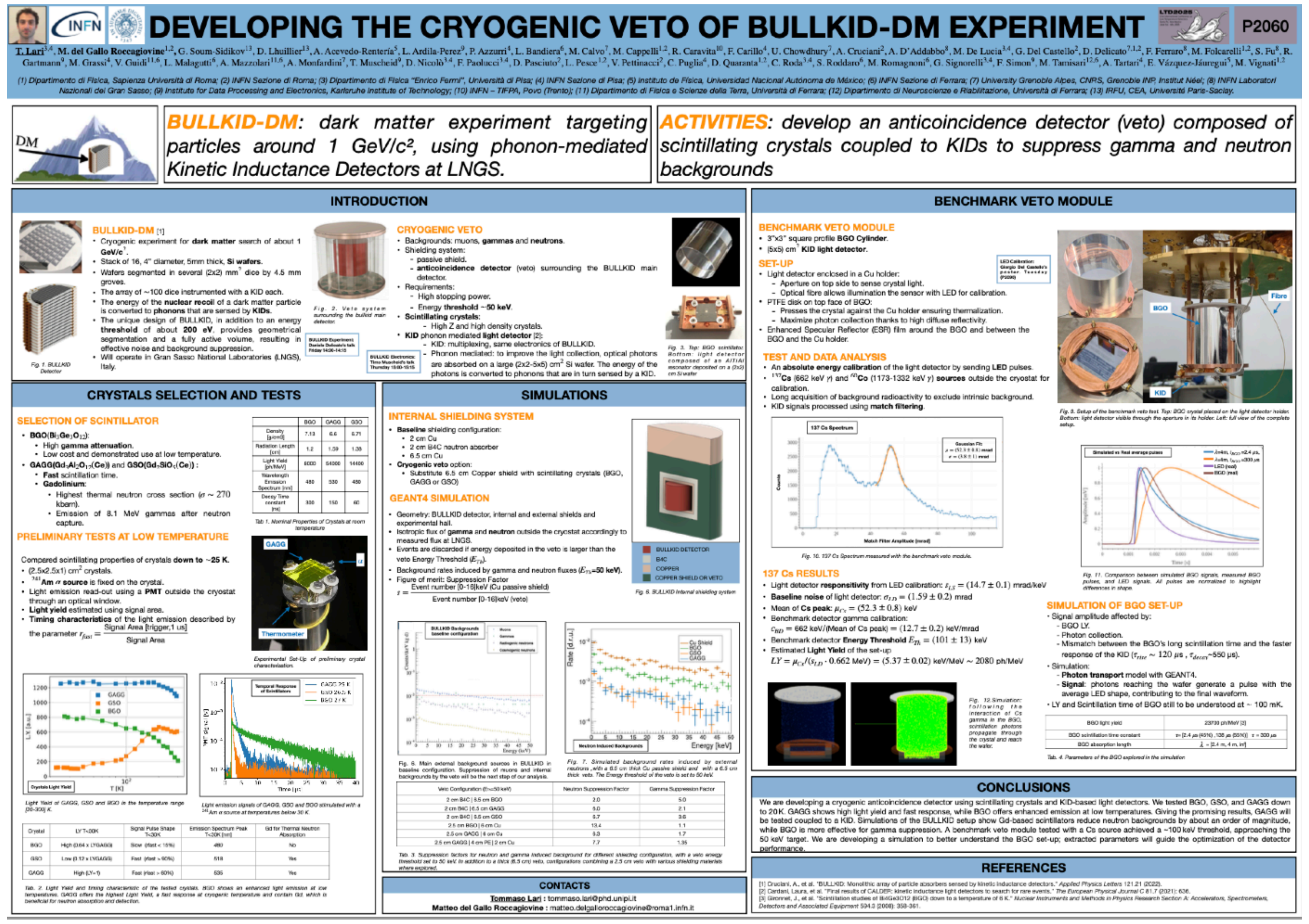
Talk:

1. **Daniele Delicato**: Presentation of BULLKID experiment and latest results.
2. **Timo Musheild**: BULLKID Electronics

Poster:

3. **Giorgio Del Castello**: LANTERN LED Calibration.
4. **Tommaso Lari**: Veto R&D by Pisa group and M. Del Gallo.

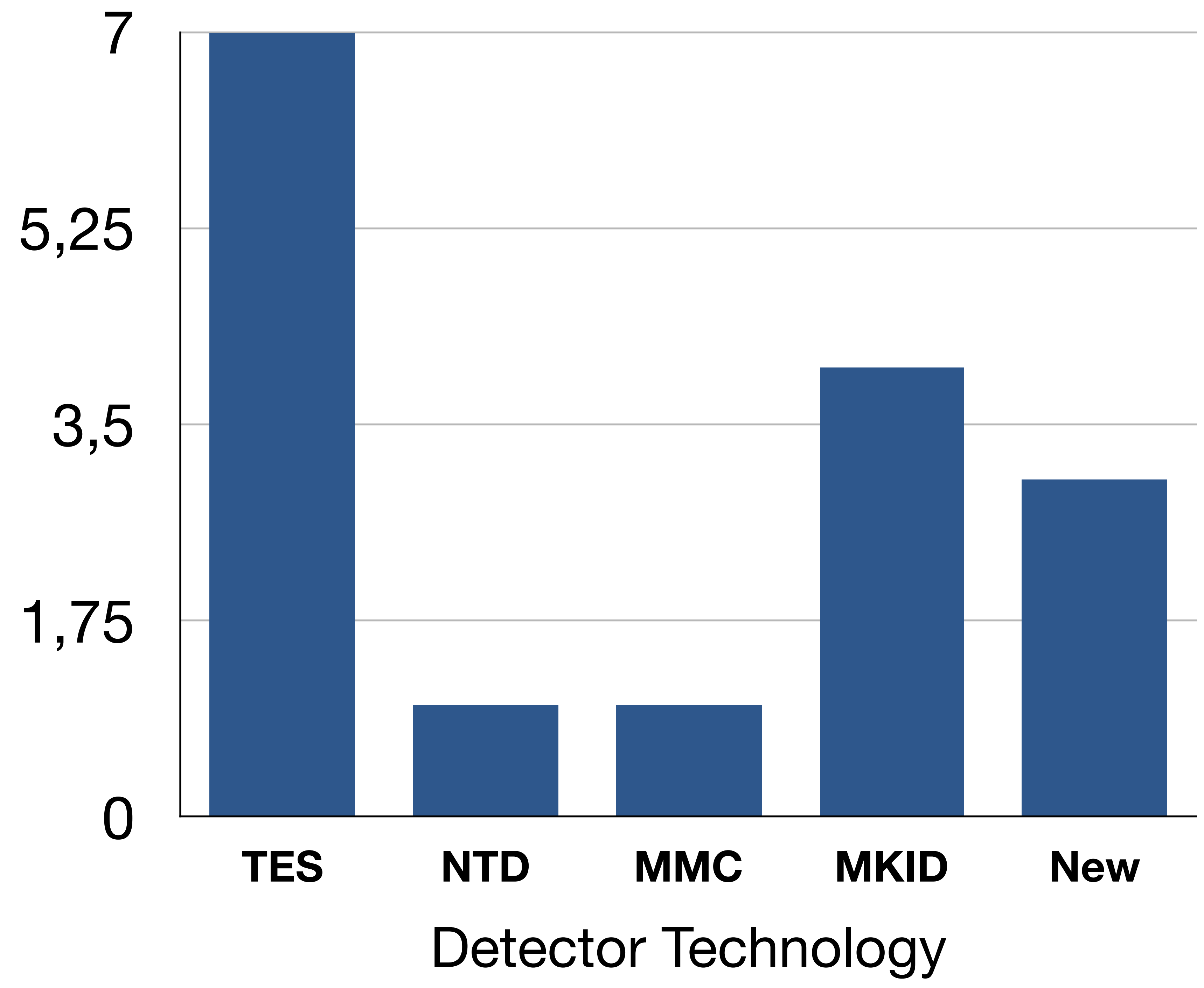


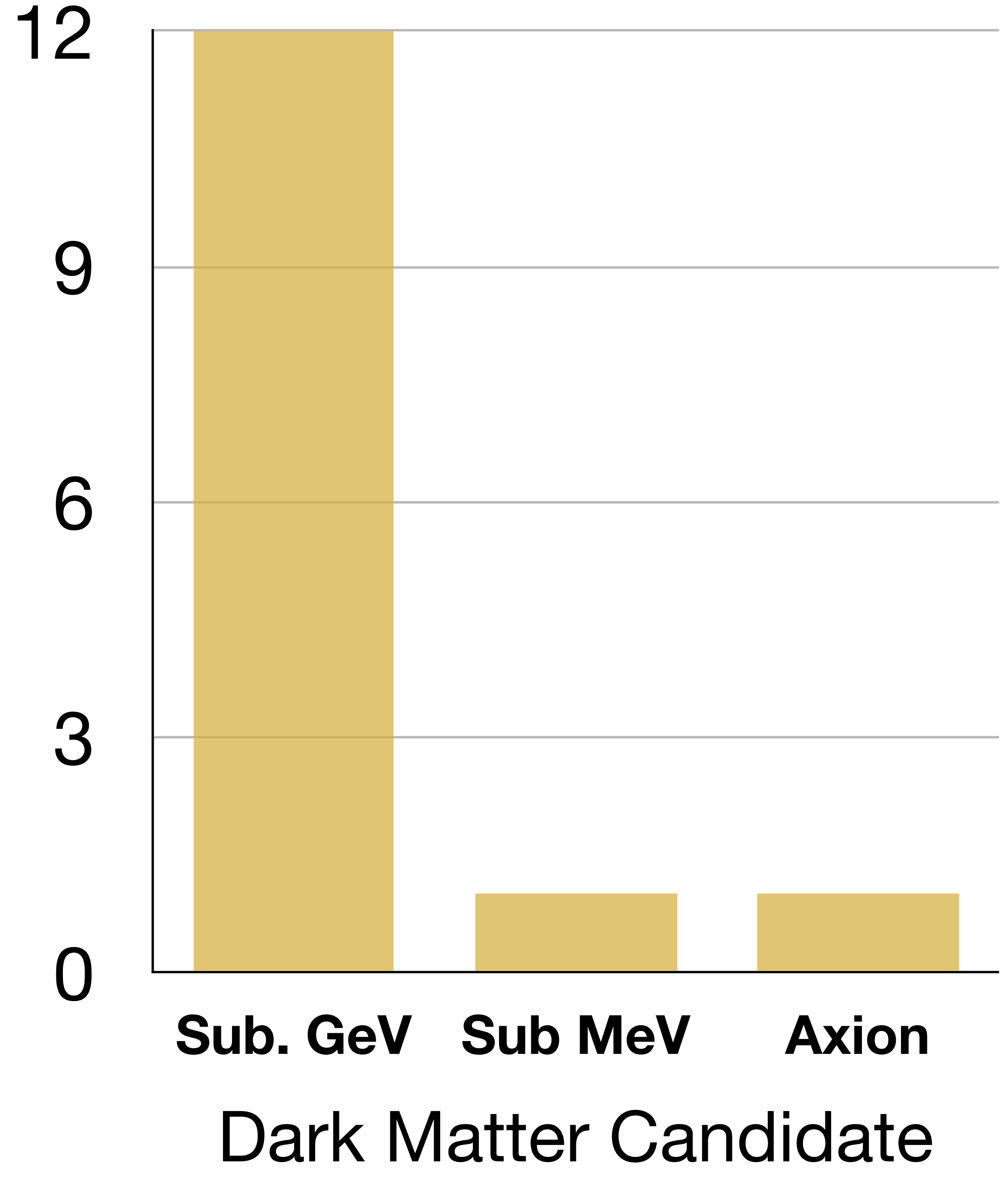


Dark Matter Talks: general trends

	Author	Title (link to abstract)	DM Candidate	Detector
1	Francesca Pucci	Optimisation of TES design for the CRESST experiment	Sub. GeV DM	TES
2	Zoe Smith	Characterizing Position-Dependent Phonon Efficiency in KIPM Detectors Using Cryogenic MEMs Mirrors	Sub. GeV DM	MKID
3	Tali Figueroa	Searching for Rare Events and New Physics with LTDs	-	-
4	Stefanos Marnieros	Heat-only background rejection with the CRYOSEL high-impedance TES detector	Sub. GeV DM	NTD, TES
5	Jadyn Anczarski	Novel Materials and Precision Charge Measurement to Advance Dark Matter Detection	Sub MeV DM	HEMT based amplifier for novel superconductor
6	Hannah Magoon	Characterization of the First Superconducting Quasiparticle Amplifying Transmon (SQUAT) Sensors	Sub. GeV DM	SQUAT
7	Giovanni Benato	Detecting Dark Matter and Neutrinos using RES-NOVA Pb-based cryogenic detectors	Sub GeV DM	TES
8	Victor Rollano	Development of Superconducting Kinetic Inductance Detectors for Dark Matter axion detection	Axion	KID
9	Dylan Temples	The KIPM Detector Consortium	Sub. GeV DM	MKID
10	Kyle Kennard	Latest Results from the SuperCDMS-HVeV Program	Sub. GeV DM	TES (NTL)
11	Michael Williams	Progress and Results from the TESSERACT Dark Matter Experiment	Sub. GeV DM	TES
12	Michele Mancuso	Mitigating the Low-Energy Excess in Cryogenic Detectors for low-mass dark matter searches: Advances from the CRESST Experiment	Sub. GeV DM	TES
13	Sebastian Kempf	Direct Search Experiment for Light Dark Matter (DELight): Motivation, status and future perspectives	-	MMC (superfluid He)
14	Aviv Simchony	SuperCDMS HVeV on Carbon-Based Substrates: TES Development on SiC and Diamond	Sub. GeV DM	TES (NTL)
15	Dan Baxter, Margarita	Summary of the workshop on EXCESS backgrounds observed in low-threshold dark matter and CEvNS experiments	Sub. GeV DM	-
16	Daniel Delicato	BULLKID-DM: searching for light WIMP with monolithic arrays of detectors	Sub. GeV DM	MKID

Dark Matter Talks: general trends

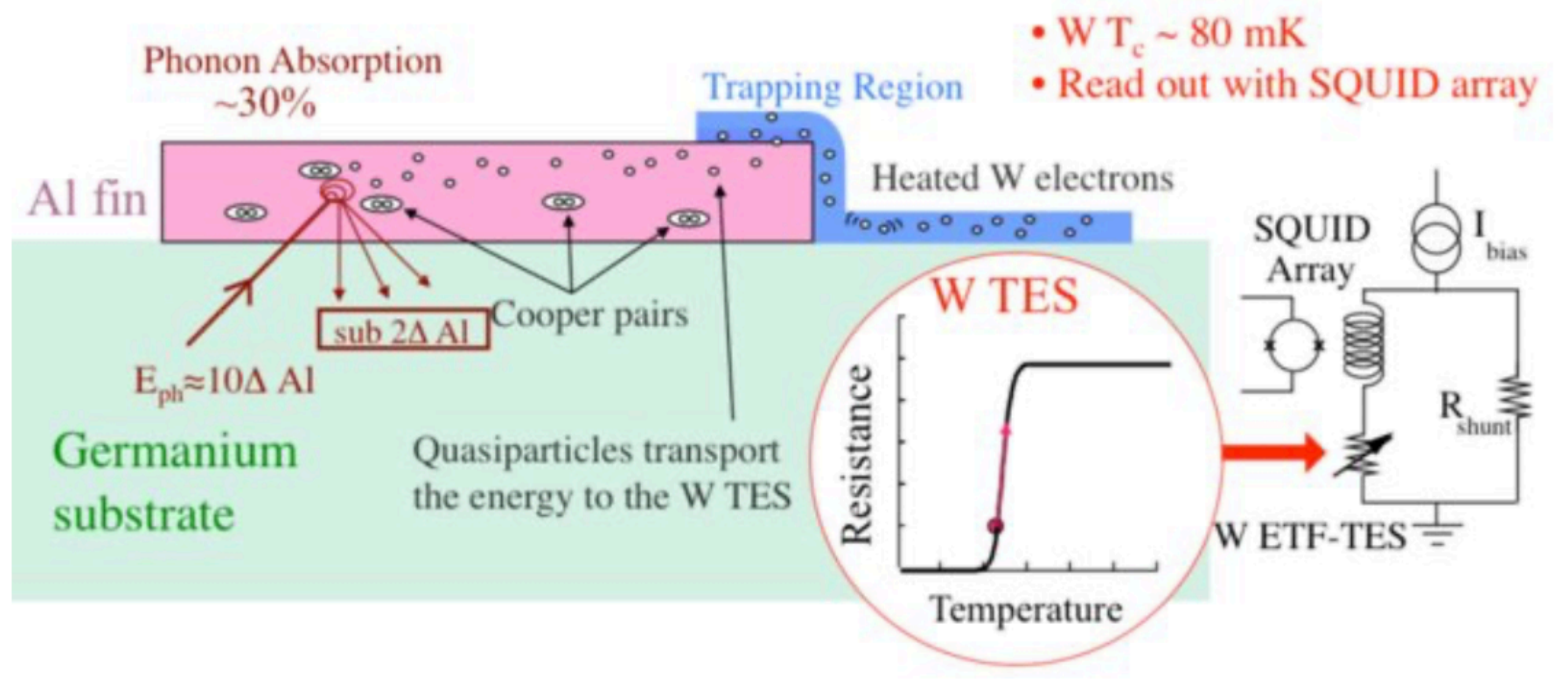




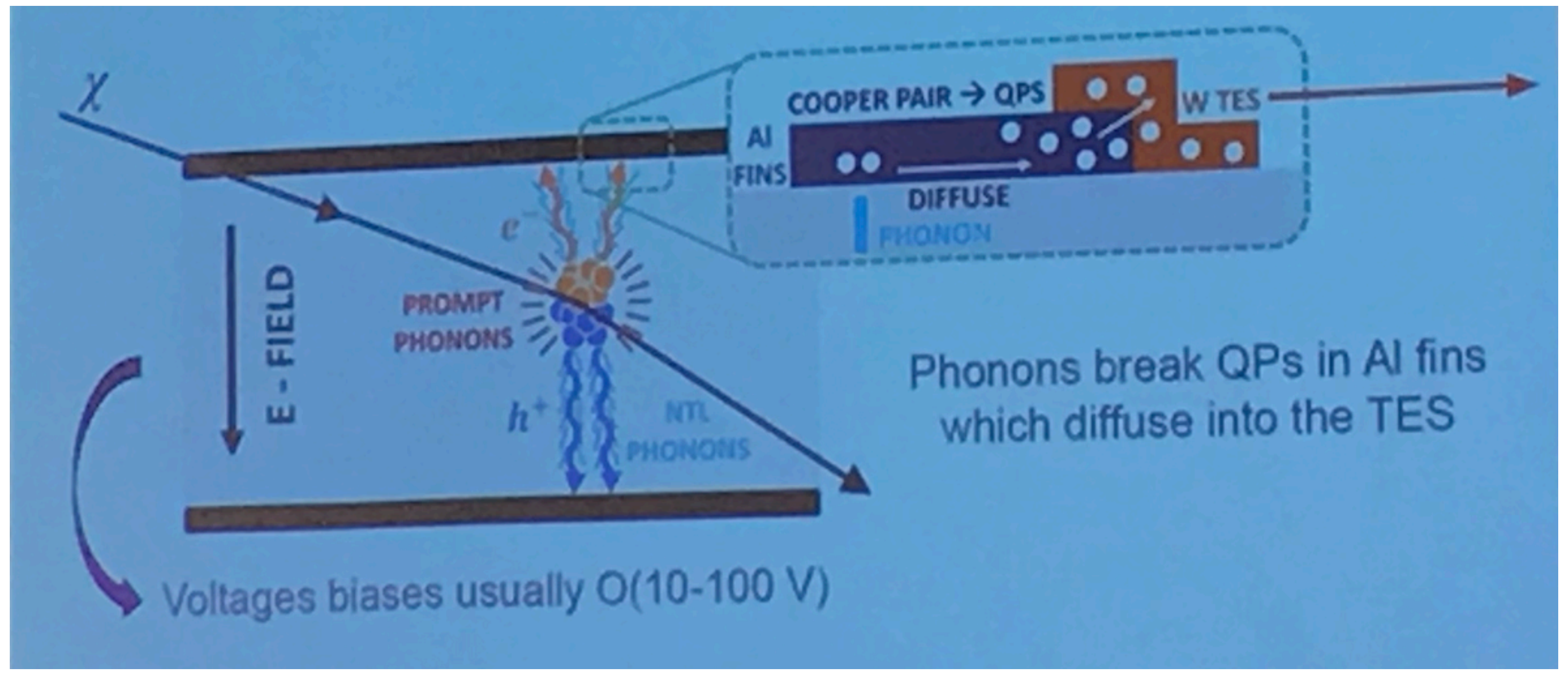
TES	1,4,7,11,12
TES(NTL)	10,14
NTD	4
MMC	13
MKID	2,8,9,6
New	13,6,5

Sub GeV	1,4,7,11,12
Sub MeV	10,14
Axion	4

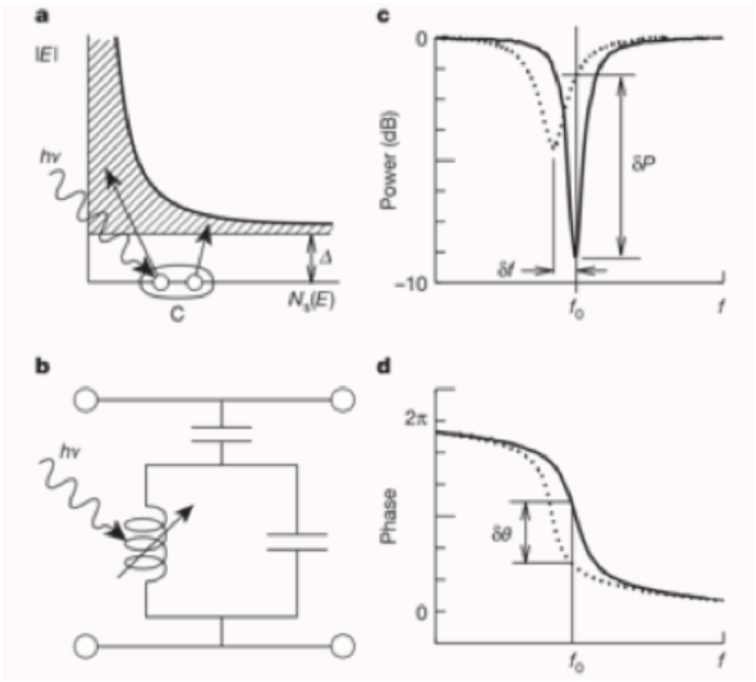
TES



TES (NTL)

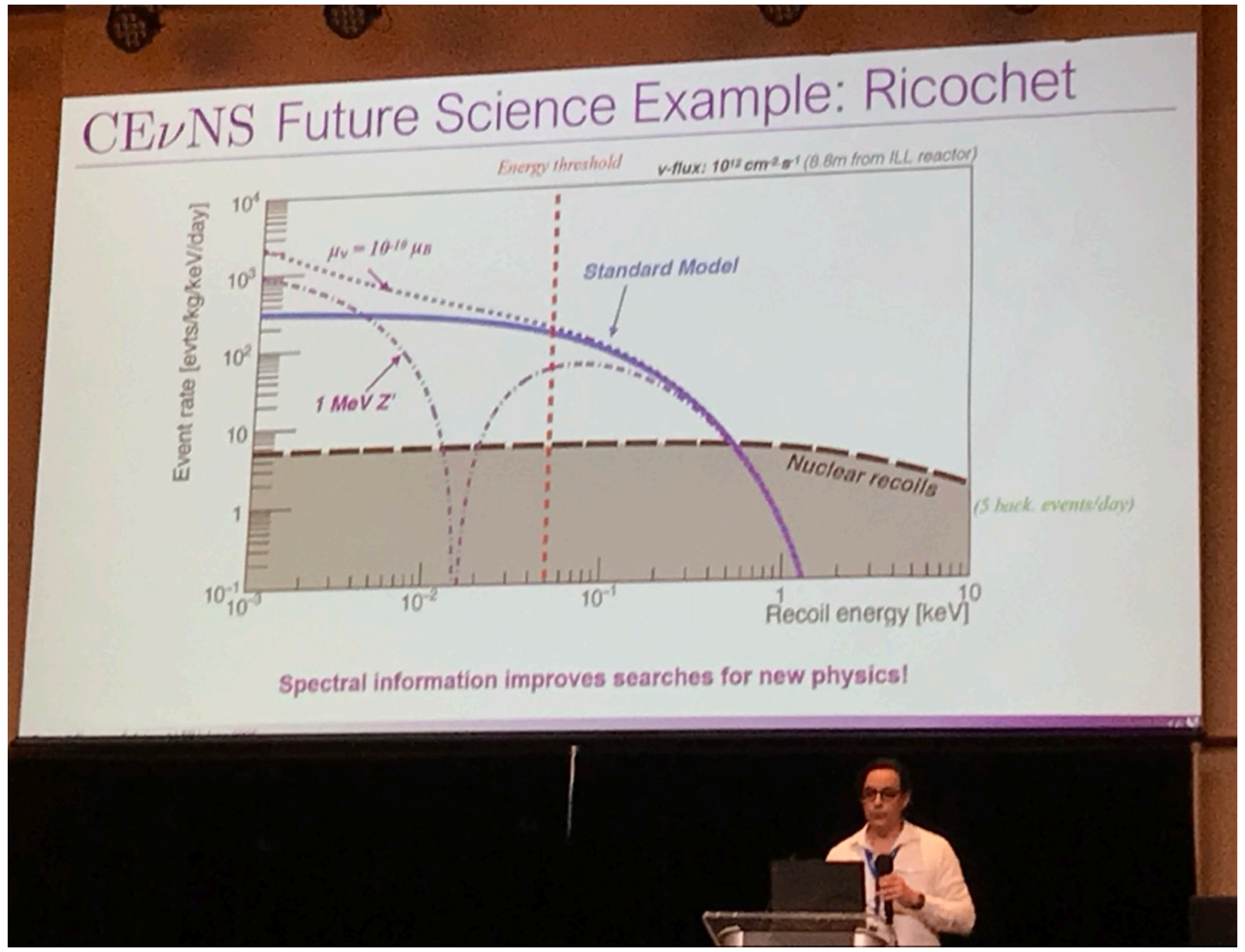


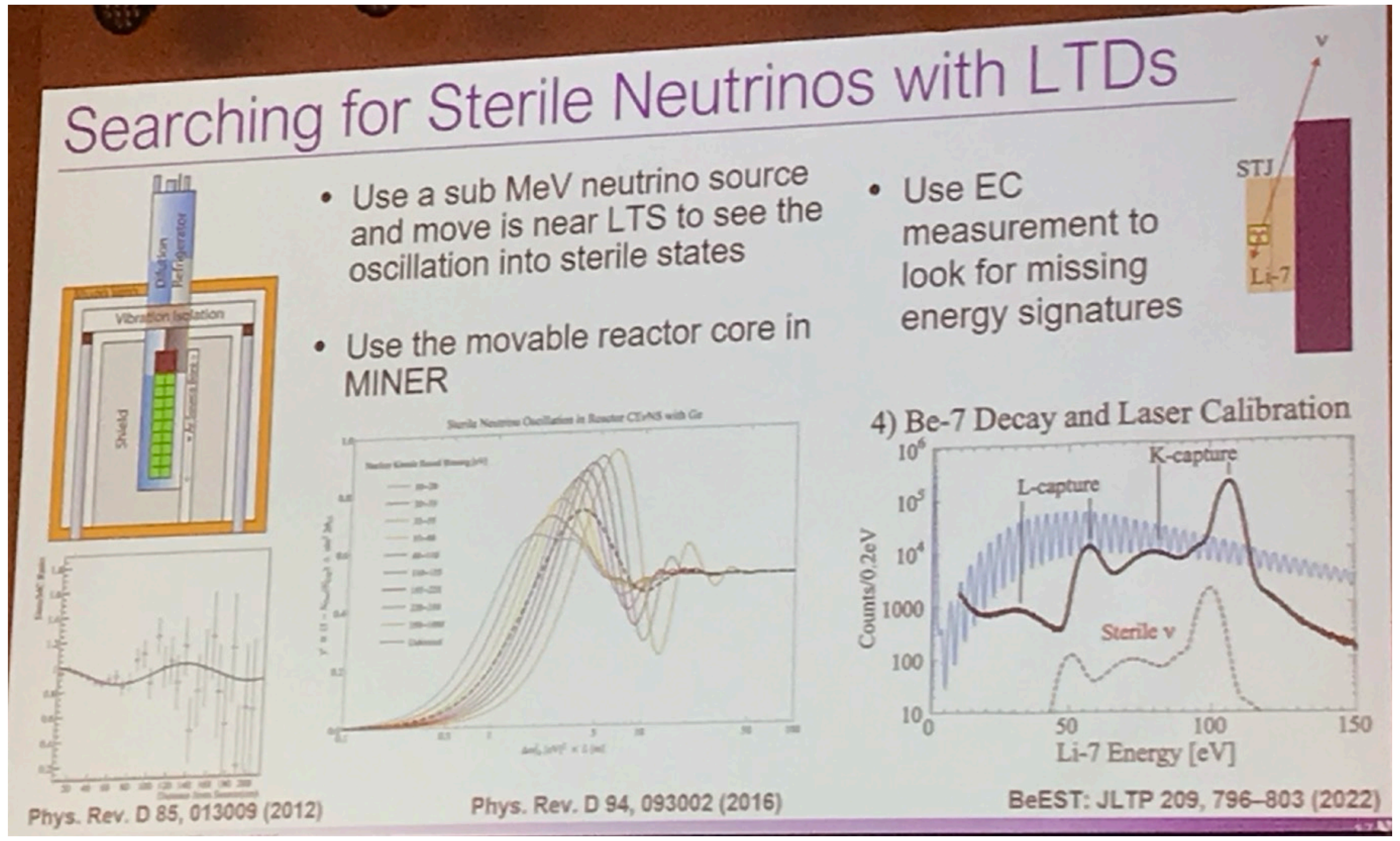
MKID

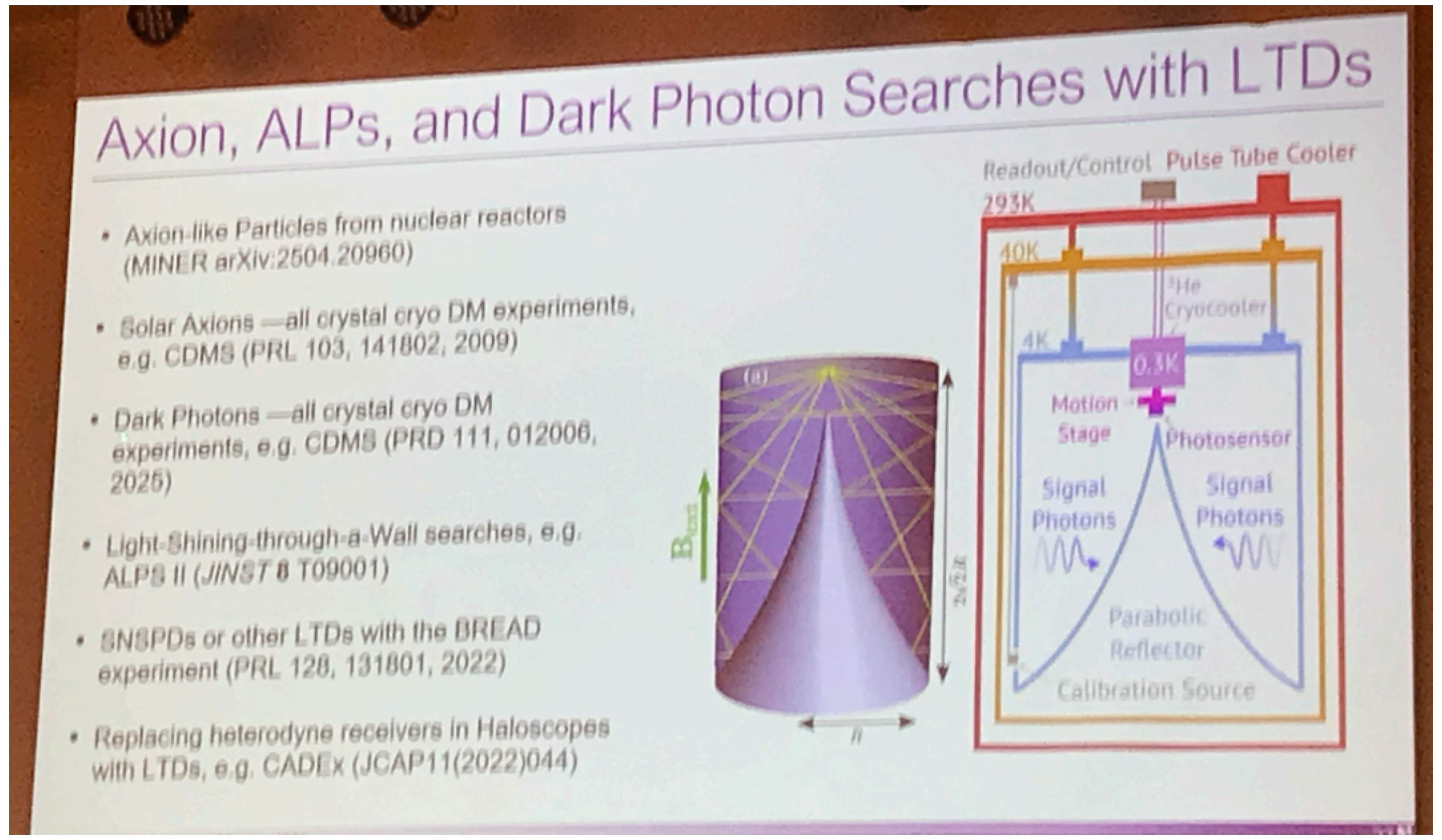


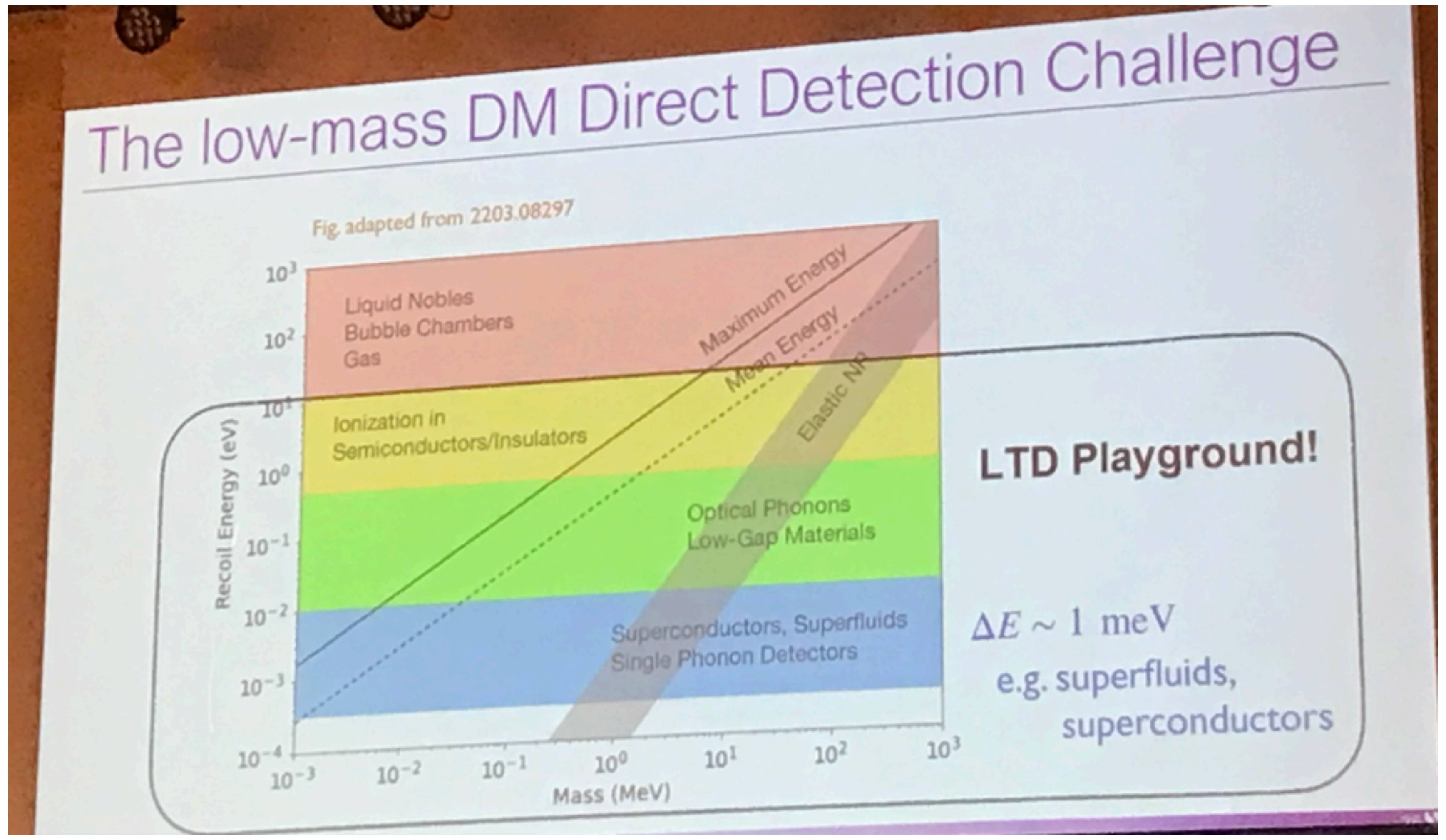
Dark Matter Talks: notable presentations

Tali Figueroa: [Searching for Rare Events and New Physics with LTDs]







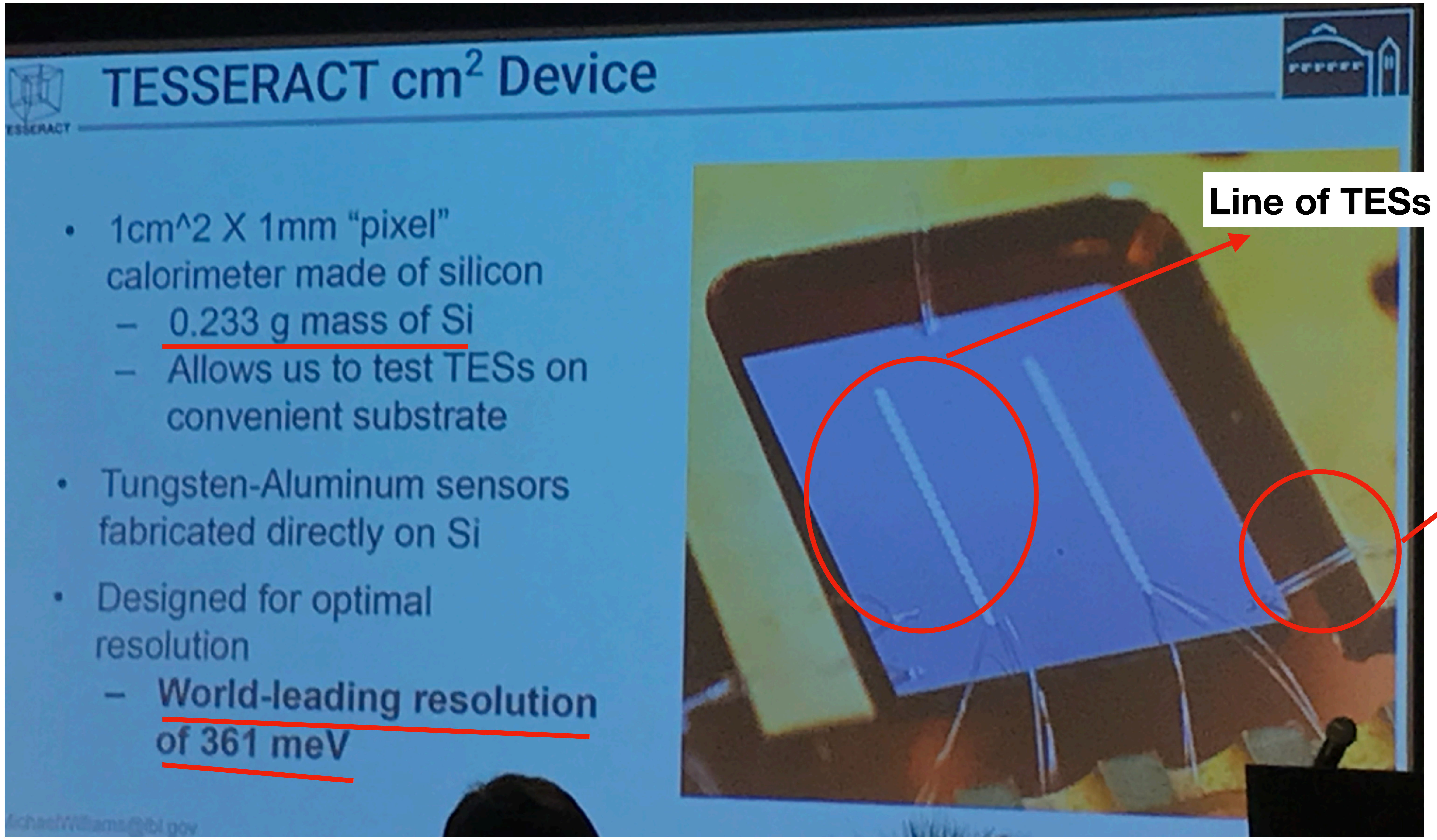


Key points:

- A very interesting overview of **LTD applications in particle physics**
- Clear, systematic, and well-structured — a great **introduction to the field**
- Hope the slides or proceedings become available soon

Dark Matter Talks: highlights

Michael Williams: Progress and Results from the TESSERACT Dark Matter Experiment



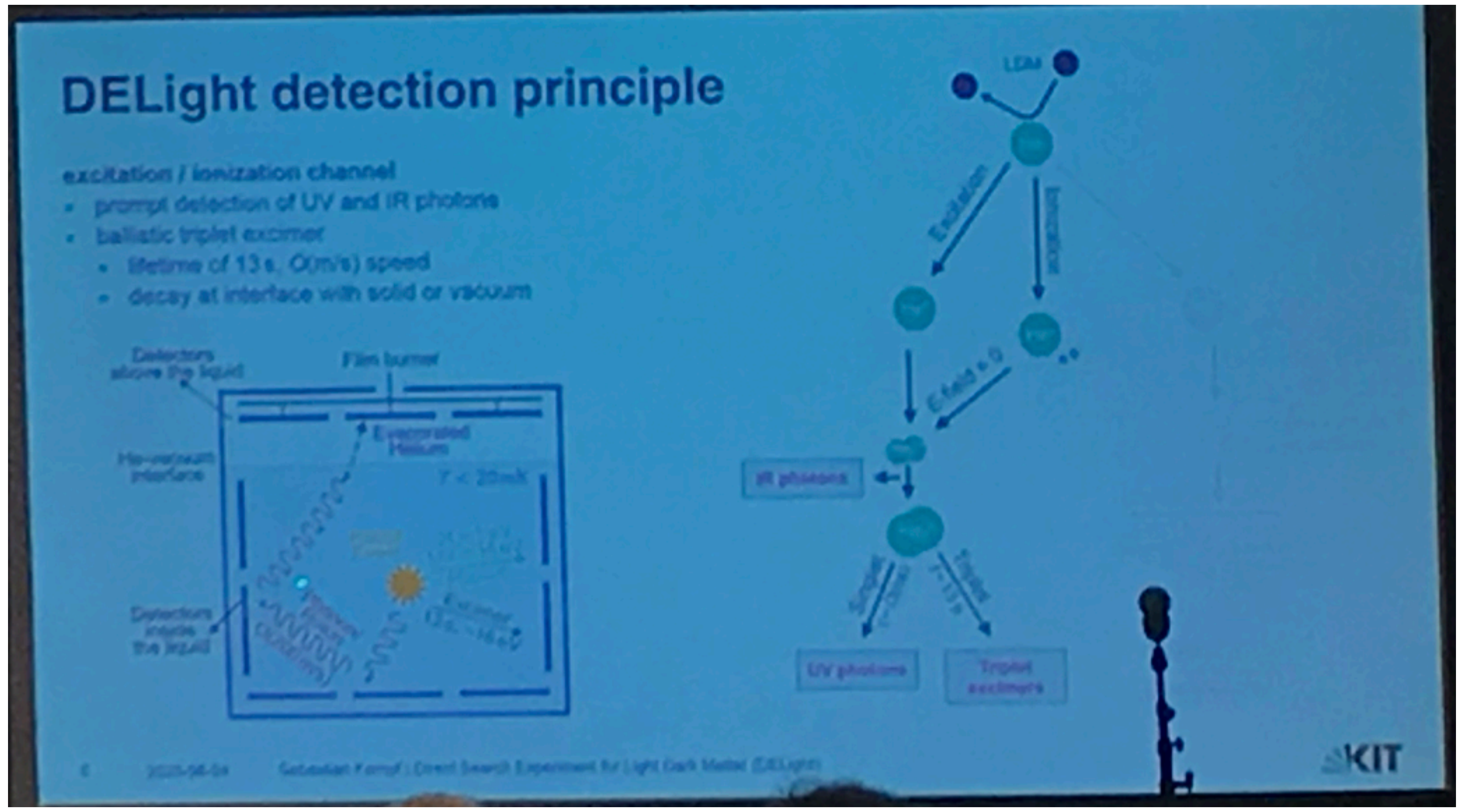
Wire bonding suspension

Key Points:

- Record **energy resolution**
- **Innovative solution**

Dark Matter Talks: highlights

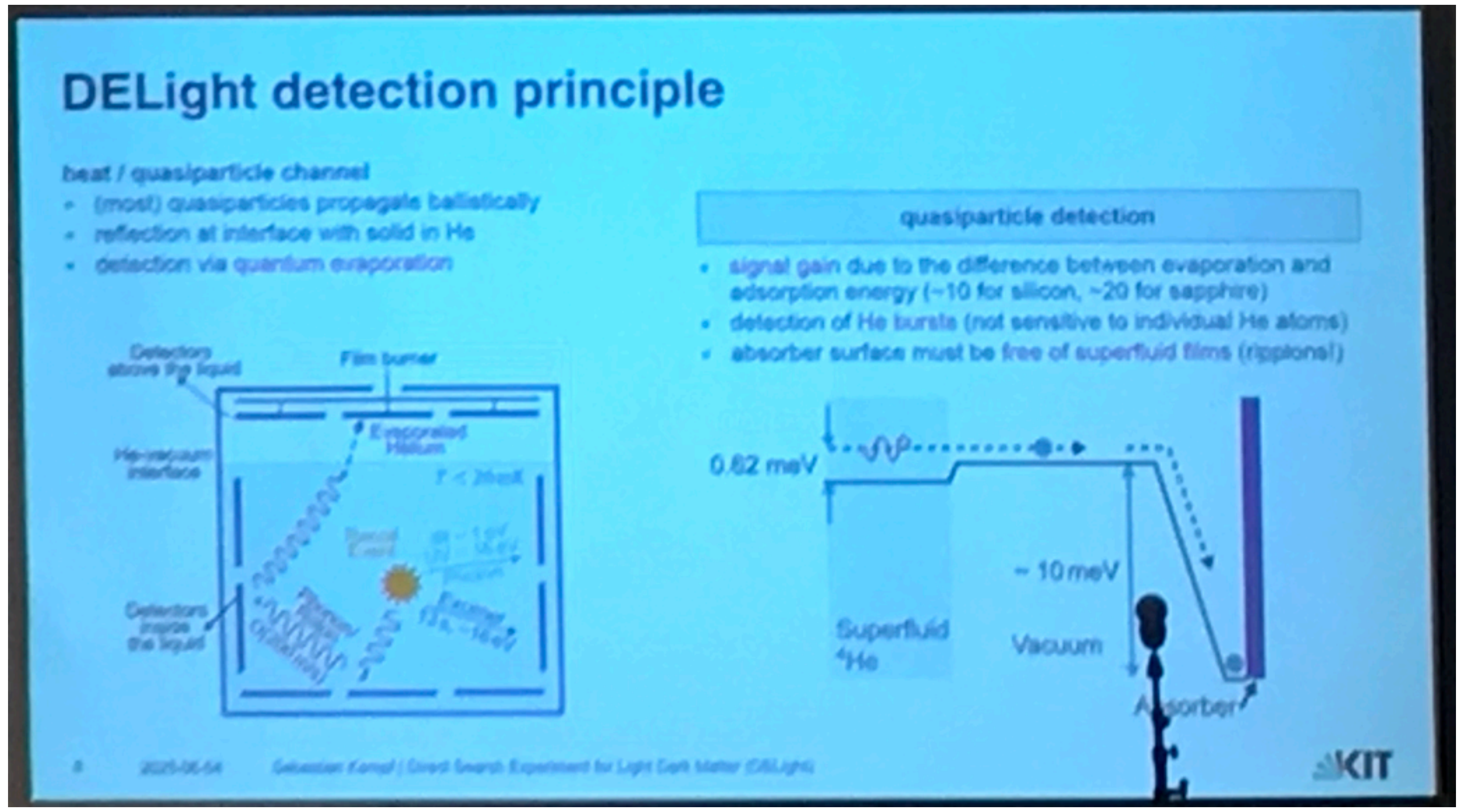
Sebastian Kempf: [Direct Search Experiment for Light Dark Matter (DELight): Motivation, status and future perspectives]

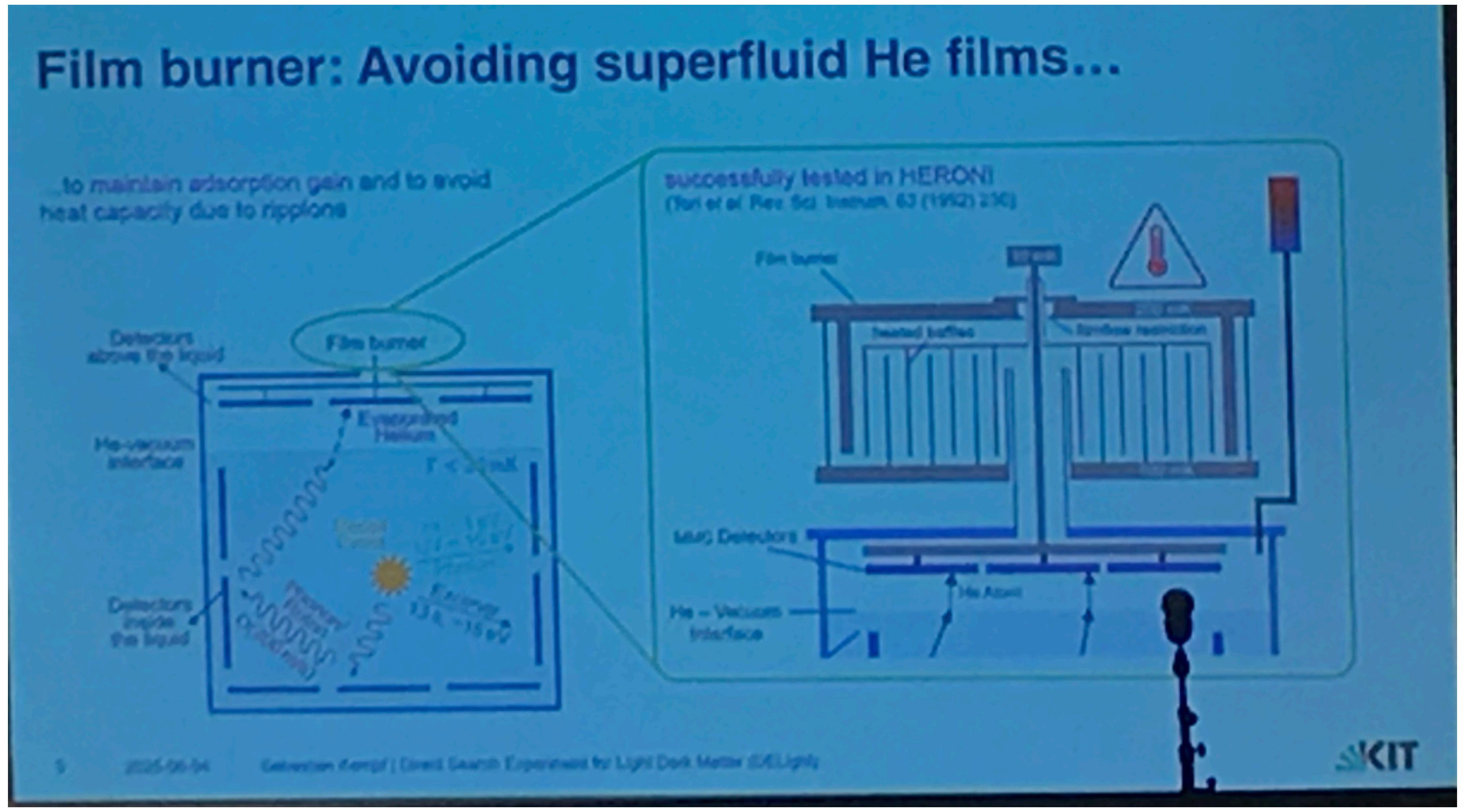


Superfluid He target instrumented with MMCs:
Exploit the rich physics of superfluid helium to detect low-mass dark matter.

Key Points:

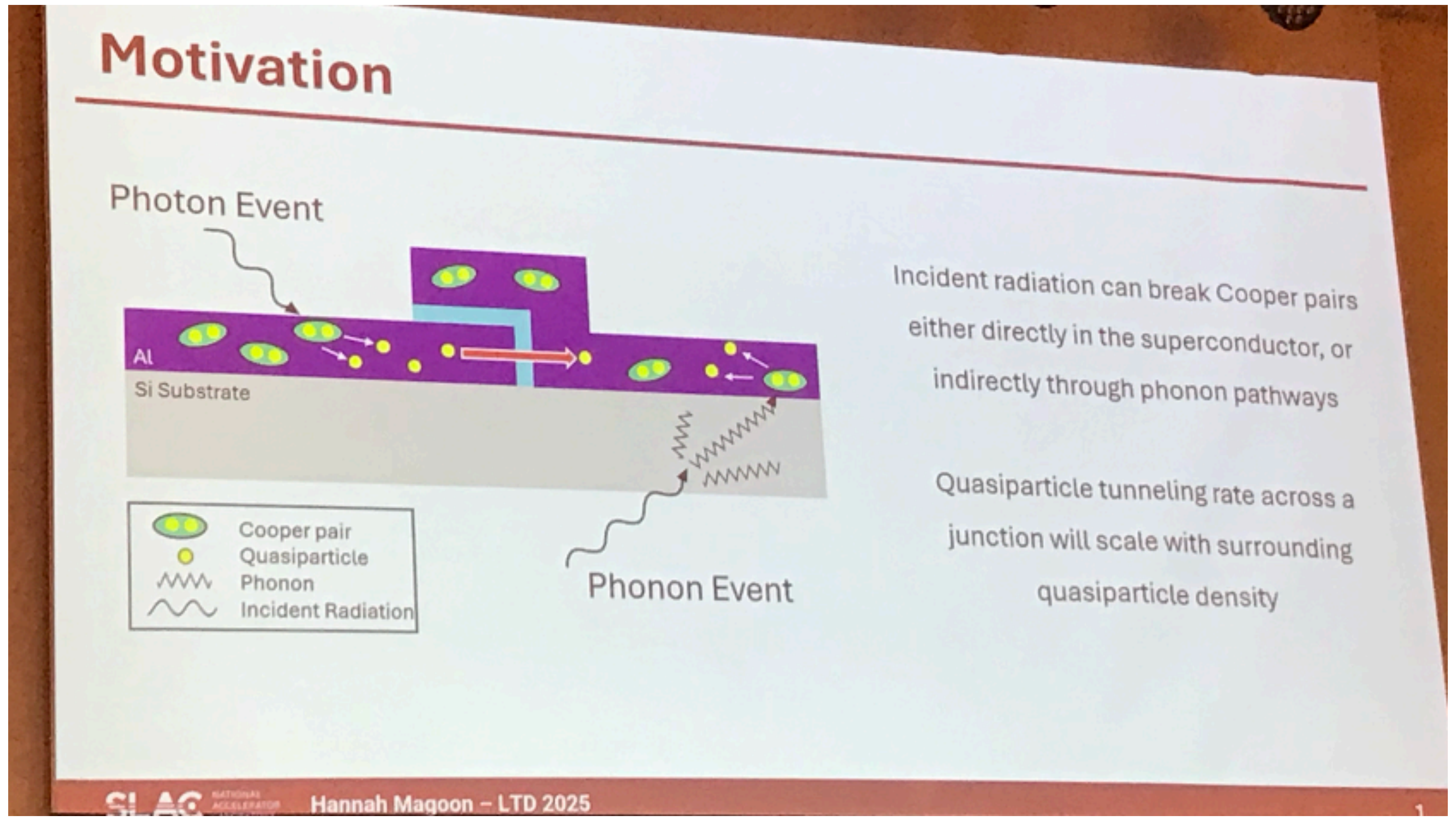
- Novel detection principle

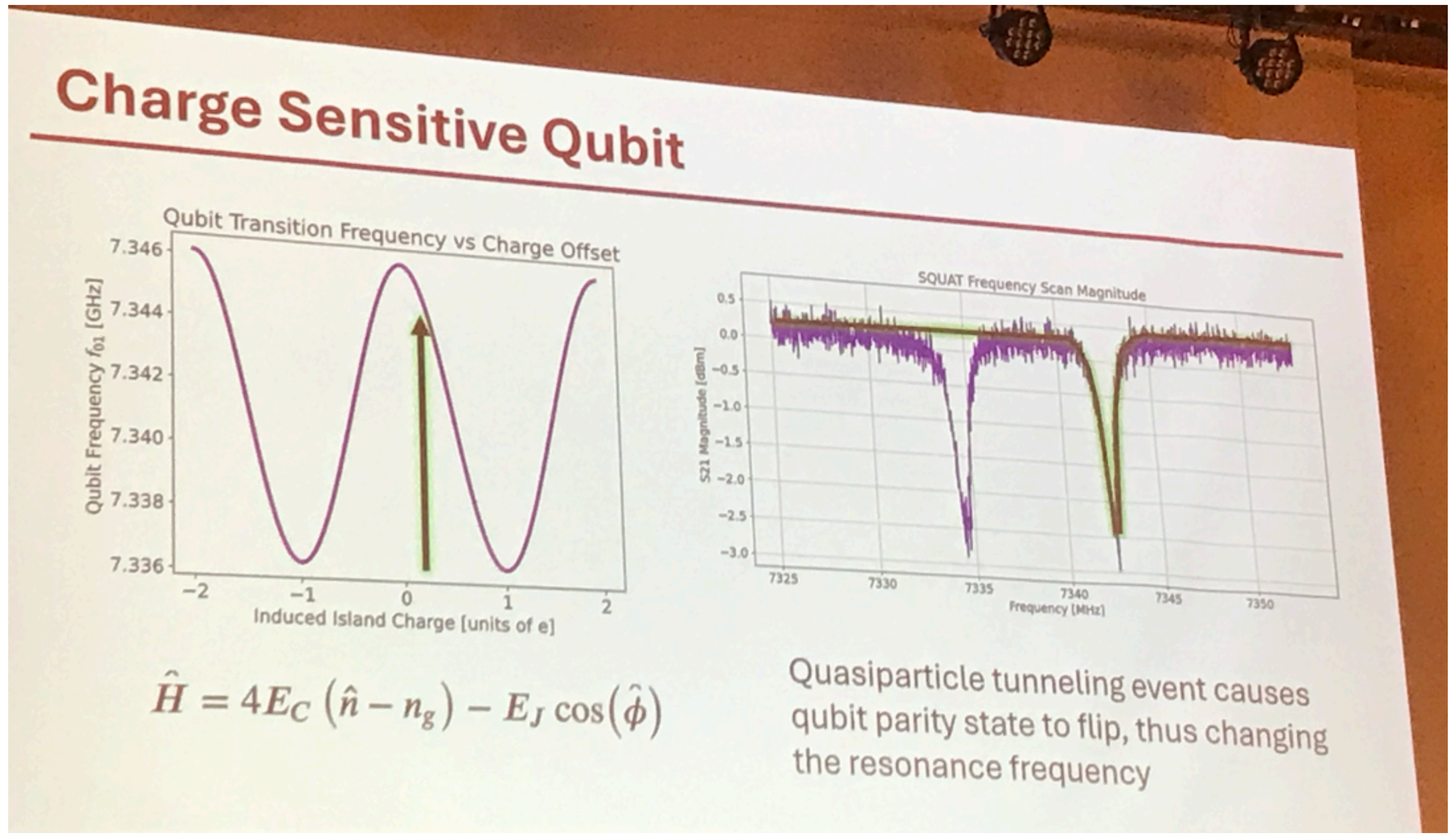


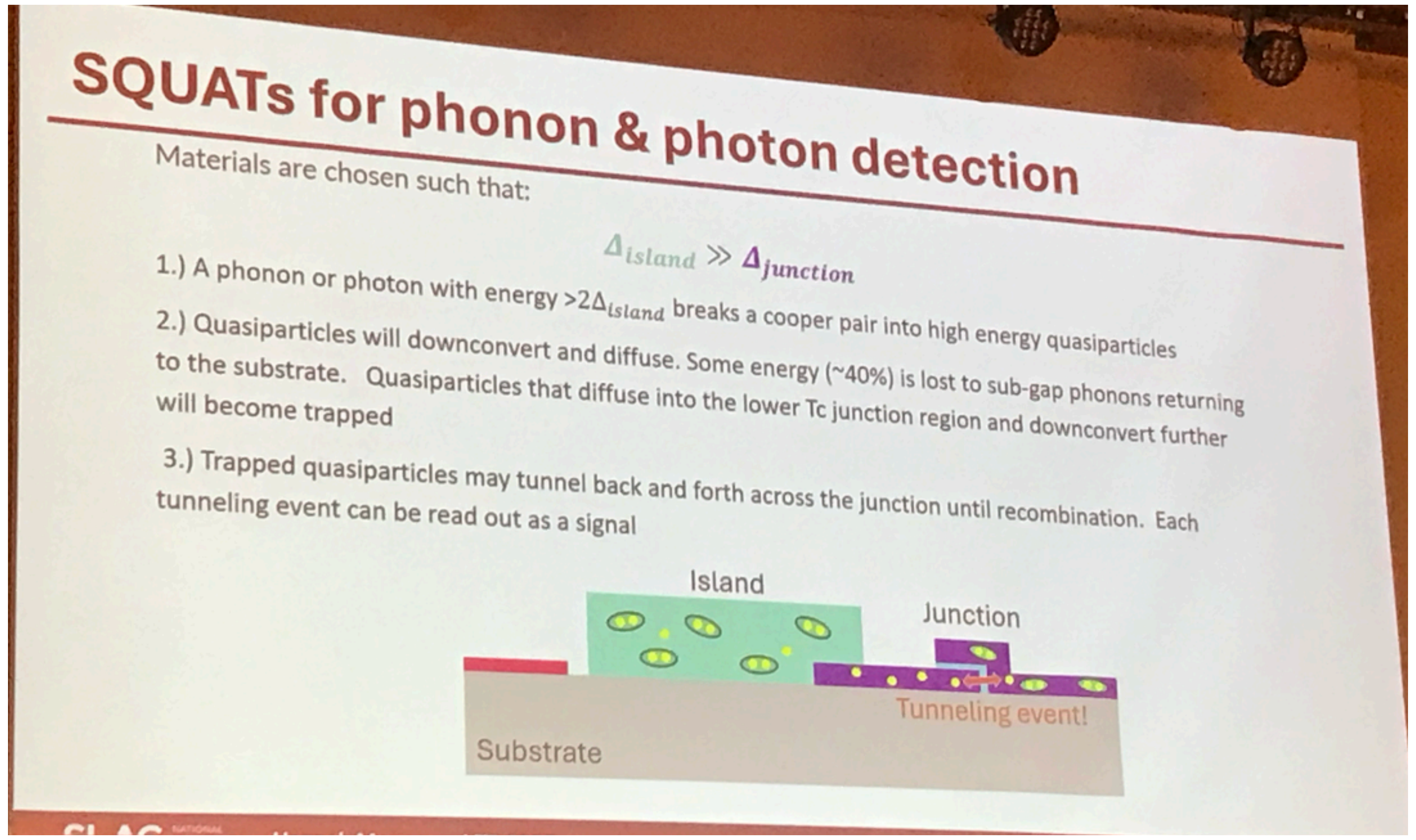


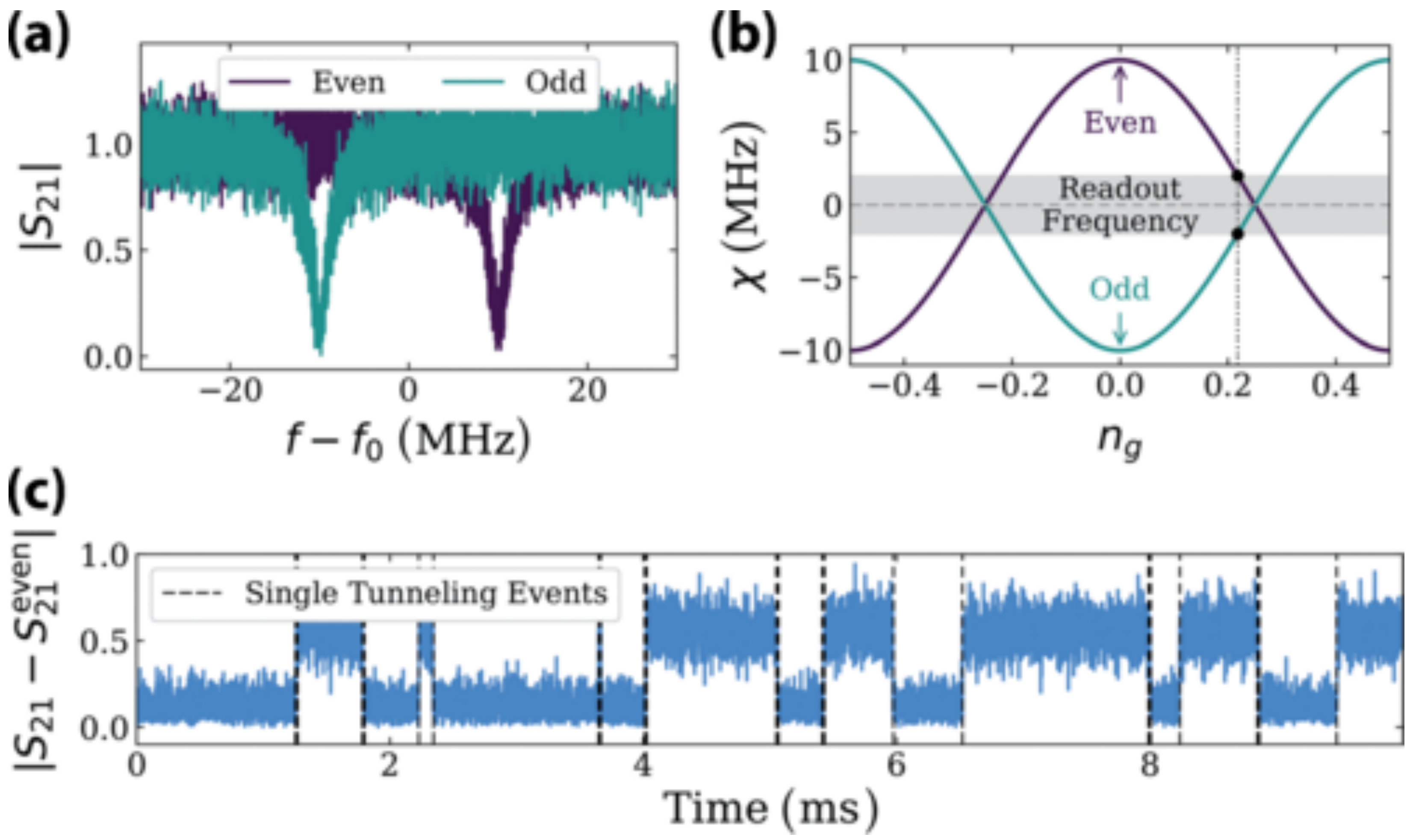
Dark Matter Talks: highlights

Hannah Magoon: [Characterization of the First Superconducting Quasiparticle Amplifying Transmon (SQUAT) Sensors]









Key Points:

- Innovative detector

MKID Talks: general trends

	Author	Title (link to abstract)	Science Case
1	Akira Endo	DESHIMA 2.0: Ultra-wideband Submillimeter-wave Astronomical Observations with an Integrated Superconducting Spectrometer	Astrophysics/Cosmology (Line Intensity Mapping)
2	Sarah Steiger	Wavefront Sensing and Control with Superconducting Detectors for the Habitable Worlds Observatory	Astronomy (Exoplanets)
3	Sean Bryan	KID Detector Readout Electronics Development for Habitable Worlds Observatory	Astronomy (Exoplanets)
4	Aled Cuda	Fabricating a Hafnium Airbridge MKID Array. https://custom.cvent.com/B6DBF01384AB4E1CB4B0C6F97B77BDB2/files/event/22930724c2e84b3b93f62c7170746141/5ef75daf37814a07a627027fb61a128c.pdf	Astronomy (Exoplanets)
5	Anna Katariina Vaskuri	CCAT: Aluminum MKID Arrays for EoR-Spec Line-Intensity Mapping from 210 GHz to 420 GHz	Astrophysics Cosmology(Line intensity Mapping)
6	Wilbert Ras-Vinke	Strongly reduced frequency scatter in Optical KID arrays	Astronomy/Astrophysics (Optical)
7	Victor Rollano	Development of Superconducting Kinetic Inductance Detectors for Dark Matter axion detection	Dark Matter
8	Zoe Smith	Characterizing Position-Dependent Phonon Efficiency in KIPM Detectors Using Cryogenic MEMs Mirrors	Dark Matter
9	Chris Albert	Far Infrared Photon Counting Kinetic Inductance Detectors	Astrophysics/Cosmology(Far Infrared)
10	Nicolas Reyes	Early results from the AMKID camara at APEX	Astronomy/Astrophysics
11	Austin Stover	The Vertical Integrated Spectrometer (VIS), an architecture for millimeter wave integral field units for intensity mapping	Astrophysics/Cosmology(Line Intensity Mapping)
12	Kevin Kouwenhoven	Boosting the Quantum Efficiency of VIS-NIR Kinetic Inductance Detectors	Astrophysics
13	Christopher Woodhead	Fabricating LEKID arrays from High Power Impulse Magnetron Sputtering grown TiN superconducting films. https://custom.cvent.com/B6DBF01384AB4E1CB4B0C6F97B77BDB2/files/event/22930724c2e84b3b93f62c7170746141/3606bfe823934ce79de97f35f6dd17f6.pdf	KID Physics/Fabrication
14	Jordan Shroyer	Laboratory Measurements of Horn-Coupled Multi-Chroic Microwave Kinetic Inductance Detector Arrays for Cosmic Microwave Background Polarimetry	Astrophysics/Cosmology
15	Pieter de Visser	Quasiparticle recombination in disordered superconductors	MKID Physics

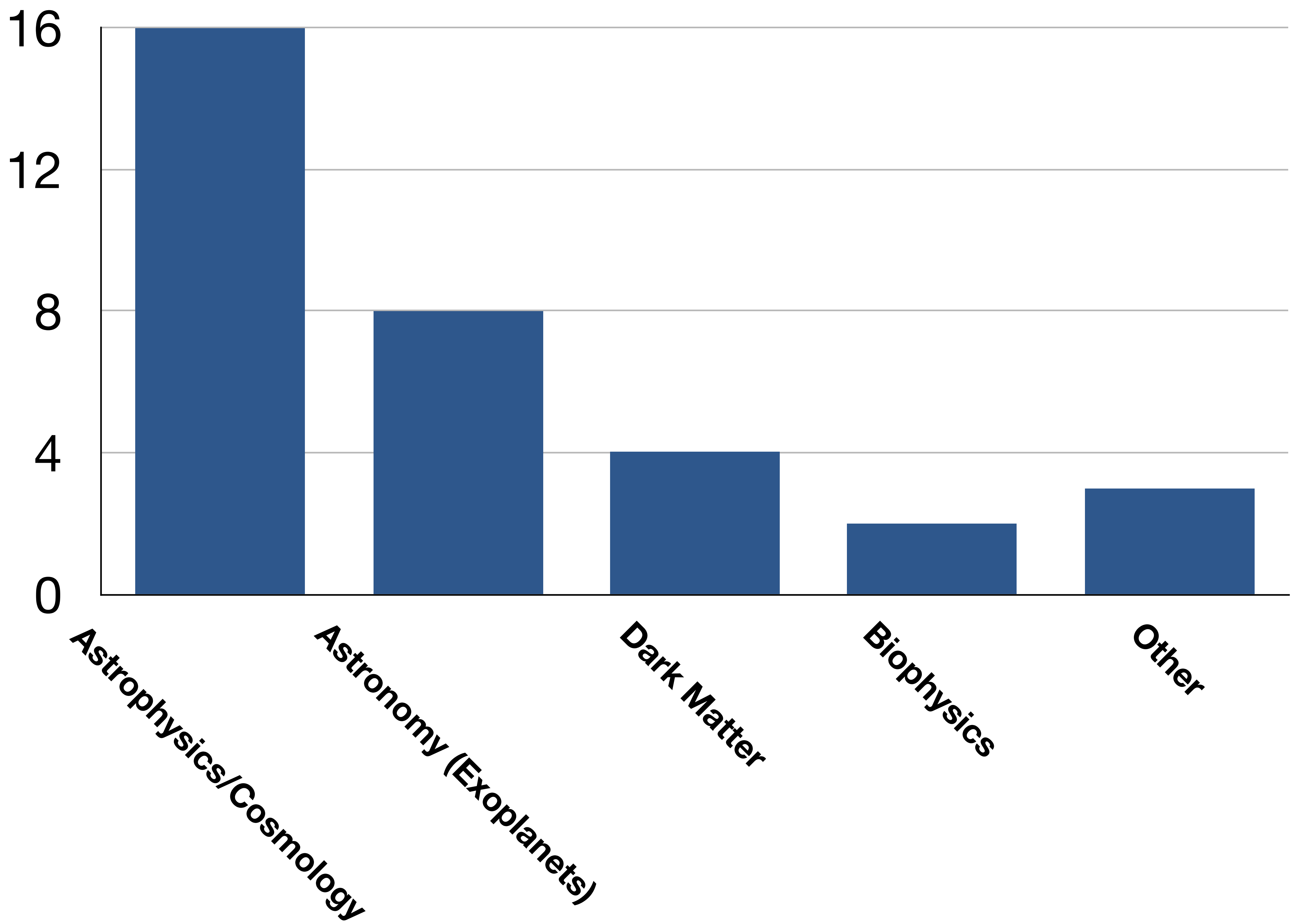
MKID Talks: general trends

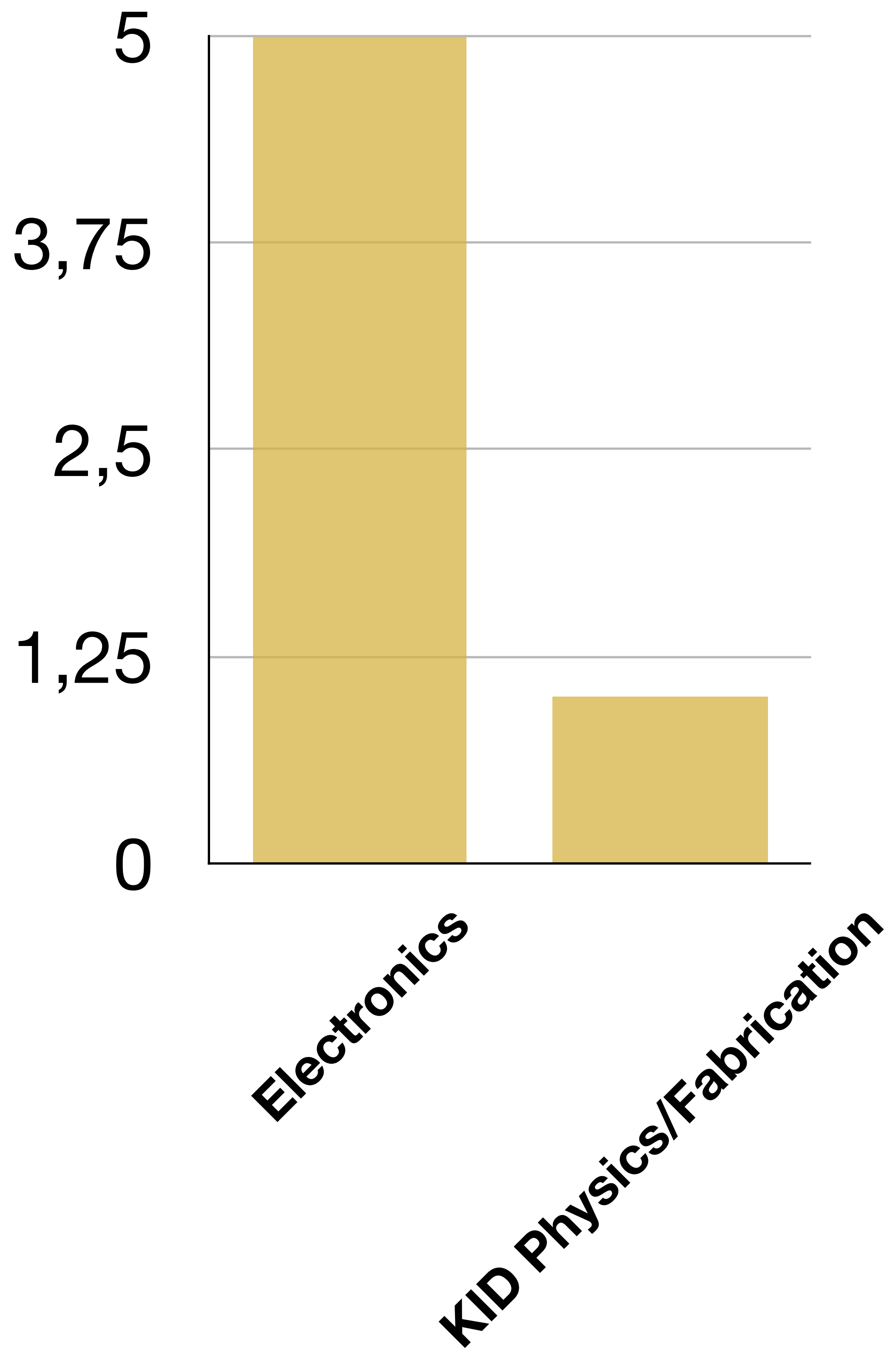
	Author	Title (link to abstract)	Science Case
16	Ian Fogarty Florang	Thermal kinetic inductance detector physics: understanding devices through measurements of position dependence and first-principles models	keV-MeV Charged particles
17	Ben Mazin	MKIDs: What Not To Do	All
18	Sean Bryan	KID Detector Readout Electronics Development for Habitable Worlds Observatory	Astronomy (Exoplanet)
19	Thomas Rao	Progress developing thermal kinetic inductance detectors for charged particle detection in neutron beta decay experiments	Neutron beta decay
20	Jianyang Fu	Cryogenic Receiver Development and Characterization for the Terahertz Intensity Mapper (TIM)	Astrophysics/Cosmology (Line Intensity Mapping)
21	Maclean Rouble	Electro-quasiparticle feedback: in-situ resonant frequency tuning and control for kinetic inductance detectors via active readout current modulation	Electronics
22	Joshua Montgomery	Signal processing improvements to the CRS platform for KIDs readout: electro-quasiparticle feedback and synchronized high-bandwidth transient captures	Electronics
23	Dylan Temples	The KIPM Detector Consortium	Dark Matter
24	Mike Niemack	CCAT: the Mod-Cam and Prime-Cam instruments with 10^4 and 10^5 KIDs	Cosmology
25	Sam Rowe	Mitigating intermodulation distortion in multi-tone resonator readouts via frequency rounding	Electronics/readout
26	Will Clay	A Characterization of High Yield, Kilopixel, Beta-Ta MKID Arrays with Anti-Reflection Coatings	Exoplanets/Biophysics
27	Sumit Dahal	Spaceflight KID Readout Electronics Development for PRIMA	Astrophysics/Cosmology (Far Infrared)
28	Daan Roos	Lens Absorber coupled Microwave Kinetic Inductance Detectors at 7 THz for Space based Far infra-red Astronomy	Astrophysics/Cosmology (Far Infrared)
29	Oketa Basha	A Design Methodology for an FPGA-based Polyphase Filterbank for Microwave Kinetic Inductance Detector (MKID) Readout Systems	Electronics/readout

MKID Talks: general trends

	Author	Title (link to abstract)	Science Case
31	James Burgoyne	CCAT: LED Mapping for Lithographic Corrections in an 850 GHz TiN MKID Array	Cosmology
32	Timo Muscheid	Real-Time Readout System Design for the BULLKID-DM Experiment: Enhancing Dark Matter Search Capabilities	Electronics
33	Joseph Redford	Bioimaging with Optical Microwave Kinetic Inductance Detectors	Bioimaging
34	Daniel Delicato	BULLKID-DM: searching for light WIMP with monolithic arrays of detectors	Dark Matter
35	Usasi Chowdhury	Hyper-Spectral Device based on Kinetic Inductance Detectors (HYPKID) for 2 mm atmospheric band	Astrophysics/Cosmology (Line Intensity Mapping)
36	Yuri Nishimura	TIFUUN: THz Integral Field Unit with Universal Nanotechnology https://custom.cvent.com/B6DBF01384AB4E1CB4B0C6F97B77BDB2/files/event/22930724c2e84b3b93f62c7170746141/3835936df7564cbe88050cbd44a18115.pdf	Astrophysics/Cosmology (Line Intensity Mapping)
37	Louis Marting	TIFUUN: Design of Higher-Order Directional Filters for Sunyaev-Zel'dovich Effect Observations, Cosmic Microwave Background Polarimetry and Line-Intensity Mapping	Astrophysics/Cosmology (Line Intensity Mapping)

MKID Talks: general trends





Astrophysics Cosmology	1,5,6,9,10,11,12,20,27,28,35,36,37,14,24,31
Astronomy Exoplanets	2,3,4,10,12,18,6,26
Dark Matter	7,8,9,34
Biophysics	26,33
Other	16,17,19

Astrophysics/Cosmology:

- **Line Intensity Mapping**:
  - **Bolometers.**
  - **Telescope focal plane** populated with pixel arrays, each consisting of an **antenna**, **filter bank**, and **MKID array.**
  - **MKID meander** structure can as the **antenna** in some designs.
- **CMB:**
  - **Bolometers** with **polarization** sensitivity.
  - **Thermal KIDs** used to detect sub-gap radiation.
- **Far IR:**
  - **Photon Counting**.
  - Large format arrays.

Astronomy (Exoplanets):

- Camera with an **array of ~10^3 KIDs.**
- **Single-photon** resolution in the **optical band.**

Dark Matter:

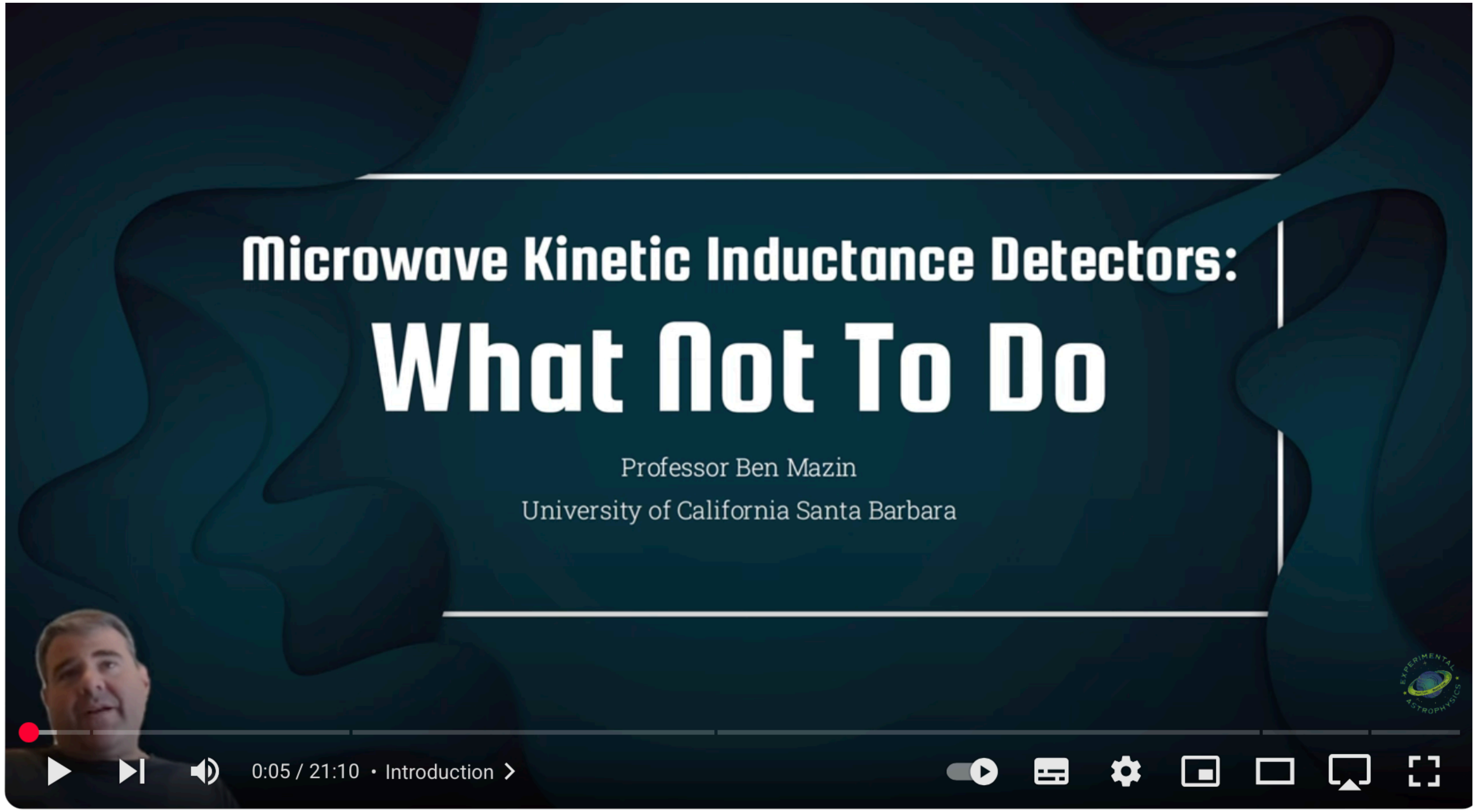
- **Phon mediated KID.**

Electronics	21,22,25,29,32
MKID Physics/ Fabrication	15,13

MKID Talks: notable presentations

Ben Mazin: [MKIDs: What Not To Do]

One of the failings of science is that we almost never publish what doesn't work, because it often isn't that interesting, and we often can't either reproduce or take the time to really understand what went wrong. This leads to people wasting time repeating mistakes. Given the large number of new people entering field, I designed this talk to discuss some of these mistakes we've make in the hope of helping you avoid them.



https://www.youtube.com/watch?v=wU43qqCz0yw

Key Points:

- A very interesting **overview** from one of the father of MKID technology.
- Shares past errors to help newcomers avoid them.

Insights for BULLKID:

- **Substrate**: Si (good), Al2O3 (top), Everything else is terrible.
- **Electronics**: Do not underestimate it.

MKIDS Talks: highlights

Aled Cuda [Fabricating a Hafnium Airbridge MKID Array]

SORRY NO PICTURE

Fabricating a Hafnium Airbridge MKID Array (UE1)
In this talk we present a Hafnium airbridge process used to make hybrid Hafnium α-Tantalum MKIDs with suspended inductors. By using a suspended inductor we create a vacuum barrier between the light absorbing inductor and the substrate; thereby significantly limiting hot phonon escape. By making the capacitor and wiring out of a high SC (superconducting) gap material and the inductor out of a low SC gap material we hope to demonstrate the energy resolving enhancement provided by trapping quasi-particles in the inductors. We plan to use this process to develop a 20 kpixel array with resolving power approaching the Fano limit to upgrade the MEC camera at the Subaru telescope.

Key Points:

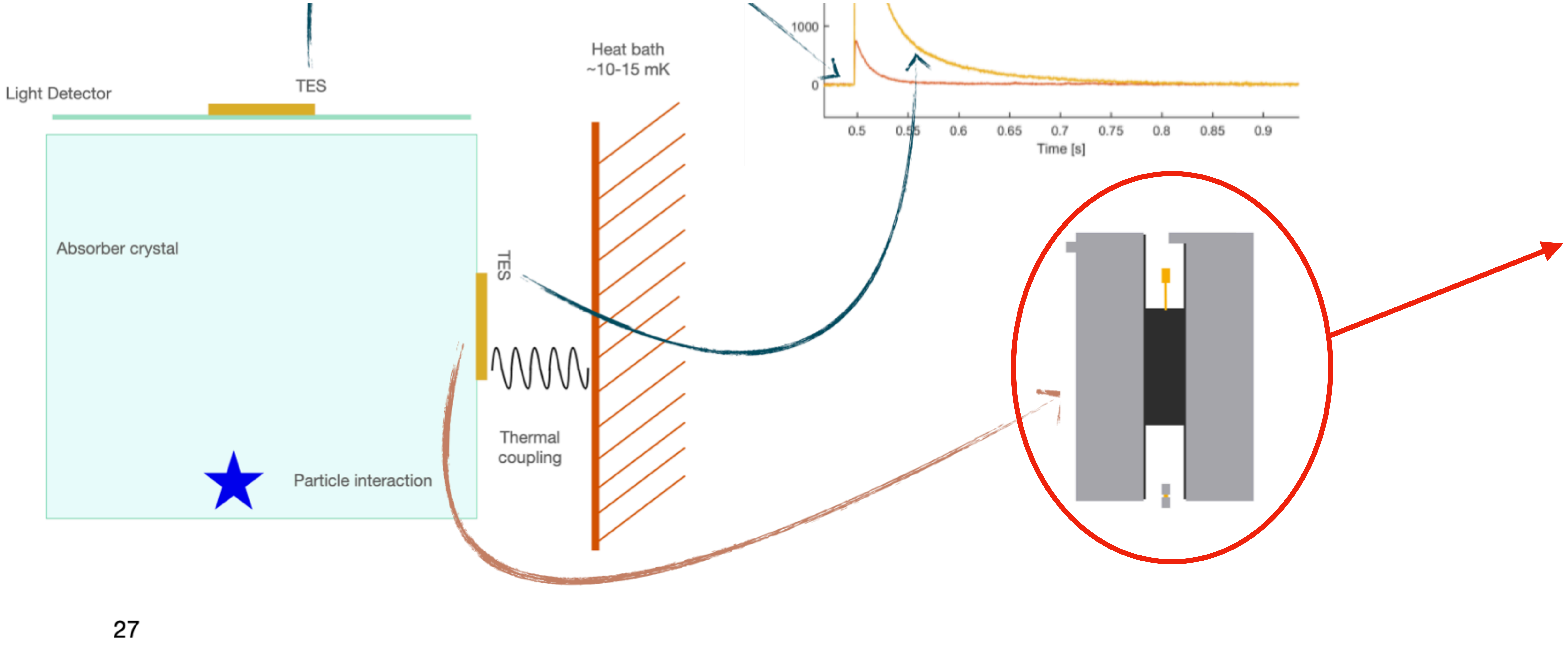
- Hafnium- α Tantalum MKIDs

Insights for BULLKID:

- R&D on low Tc material to increase sensitivity

Highlights from LTD Talks and Posters

Francesca Pucci: [Optimisation of TES design for the CRESST experiment]



Key Points:

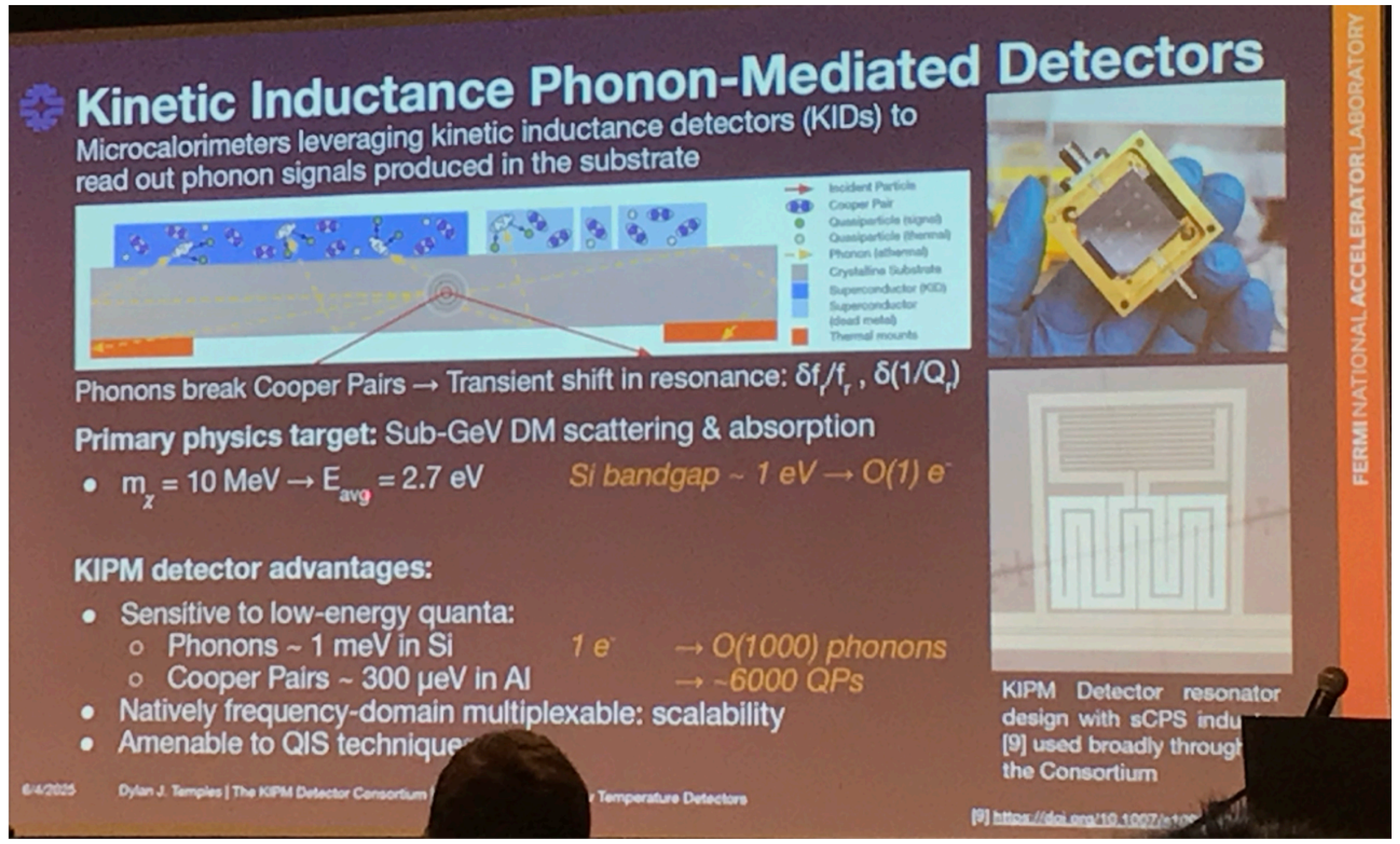
- CRESST: cutting edge dark matter experiment.

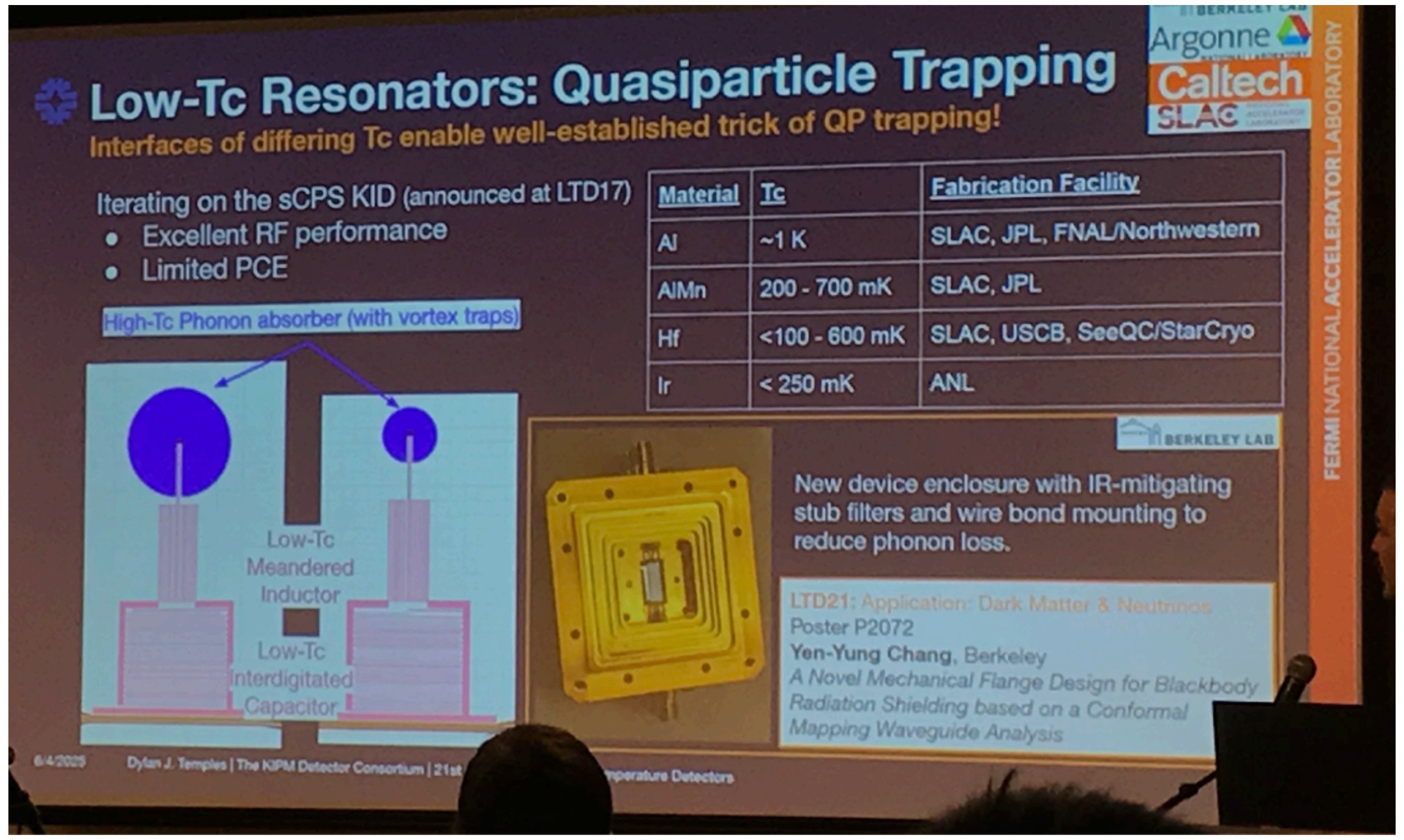
Insights for BULLKID:

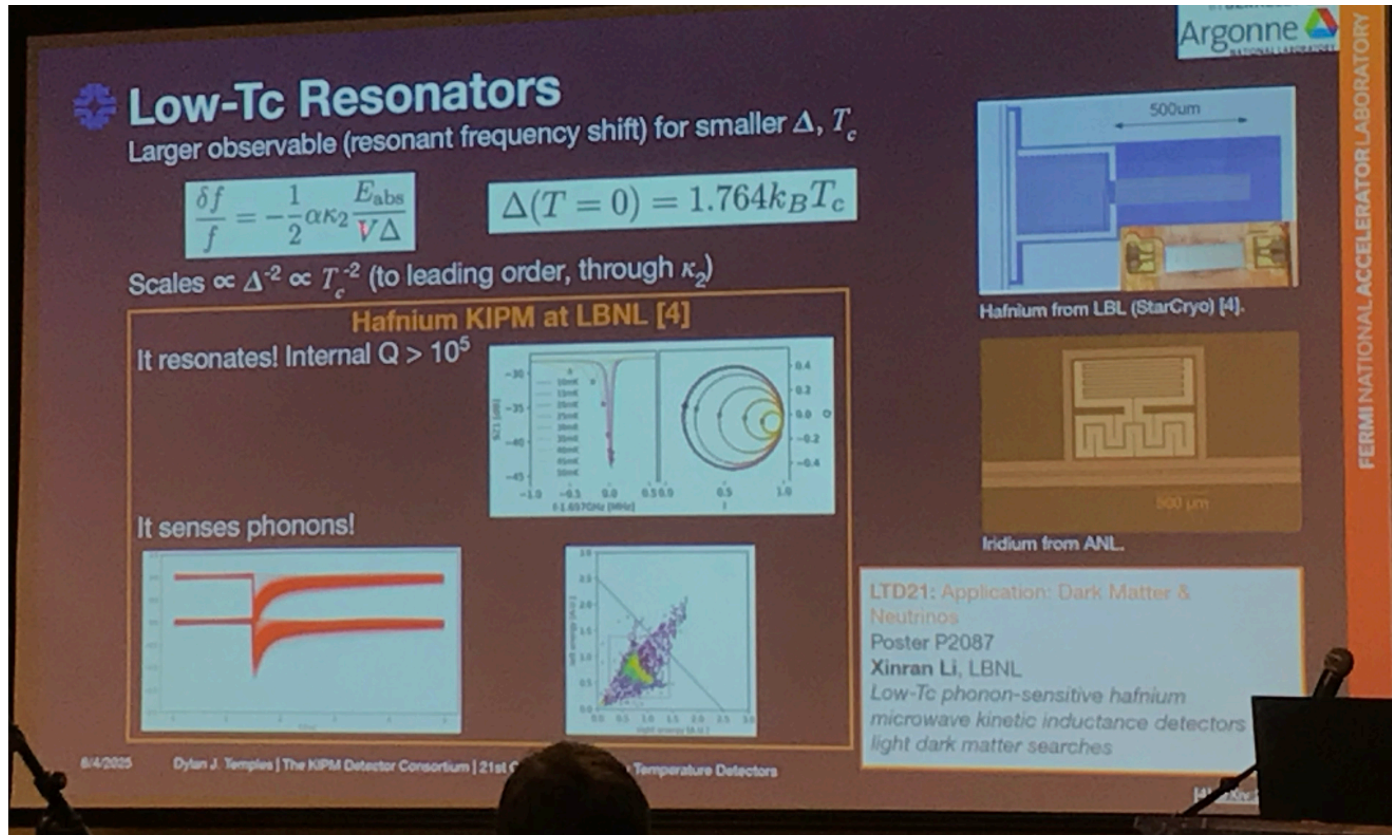
- **Optimization of Al phonon collector:**
  - tuning thickness and geometry of Al film to increase phonon absorption.

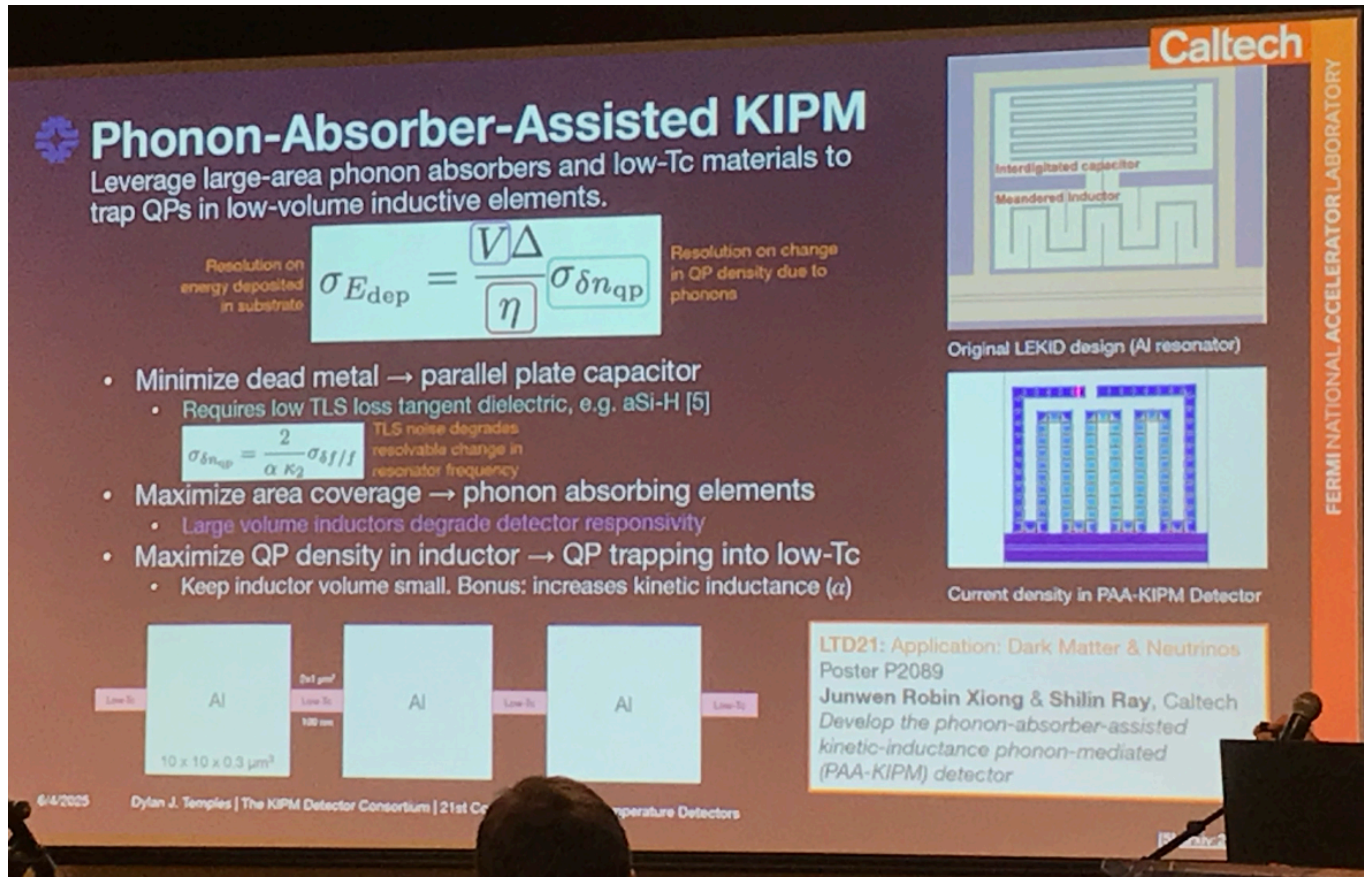
Highlights from LTD Talks and Posters

Dylan Temples: [The KIPM Detector Consortium]









Key Points:

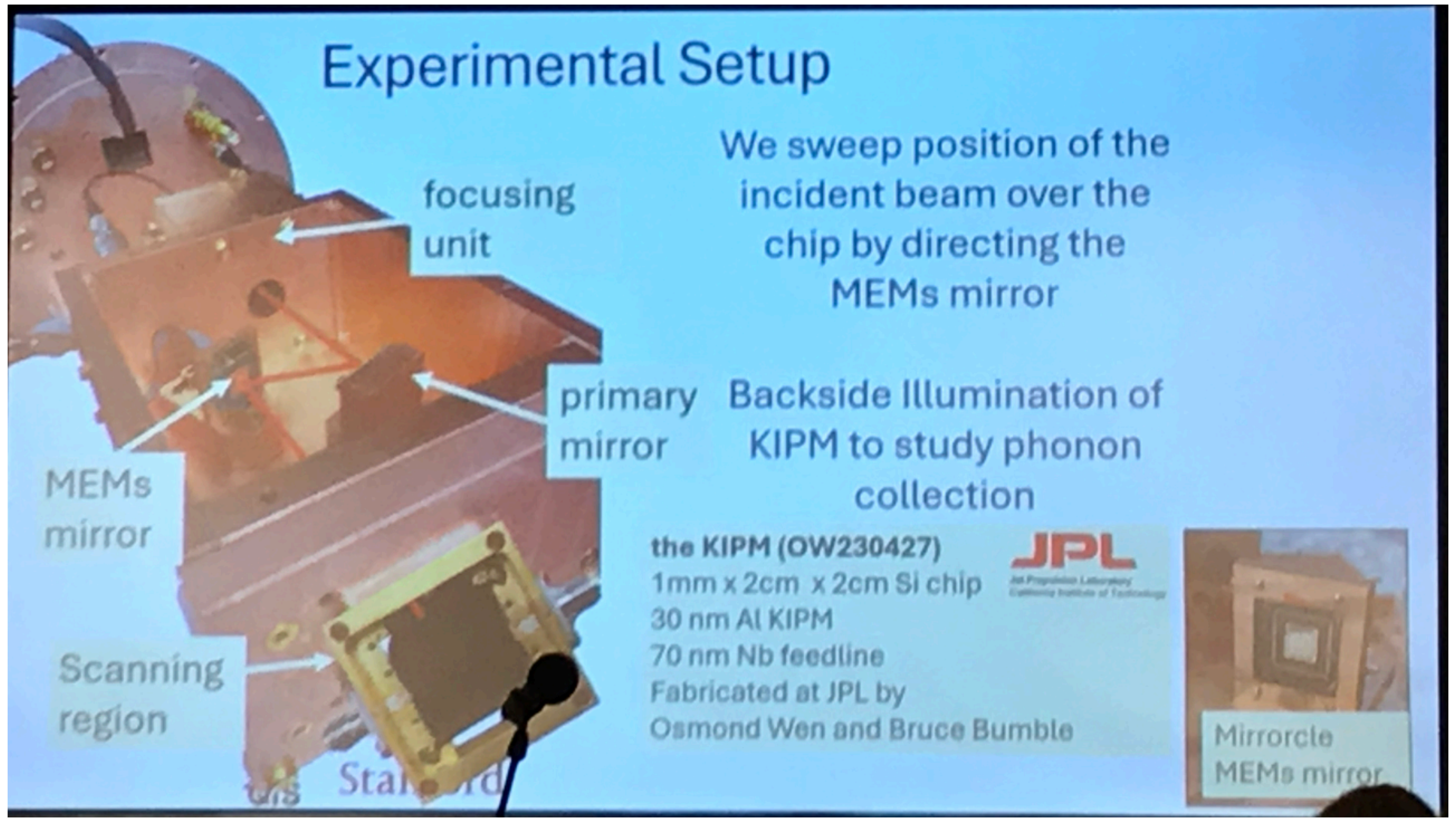
- **Sub GeV Dark Matter**
- **Kinetic inductance Phonon Mediated detector:** very close to bullkid concept

Insights for BULLKID:

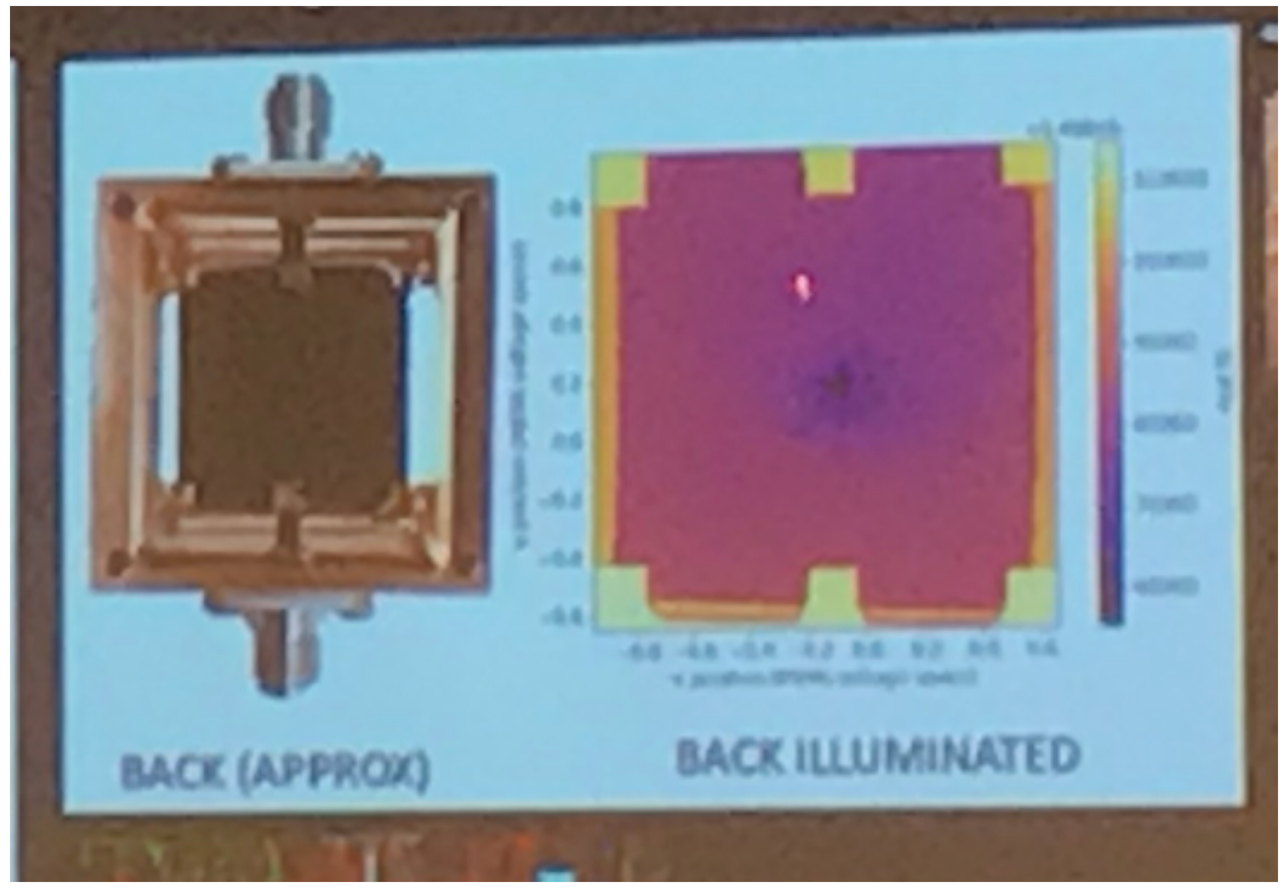
- Low Tc resonator
- Quasiparticle trap
- New interesting design

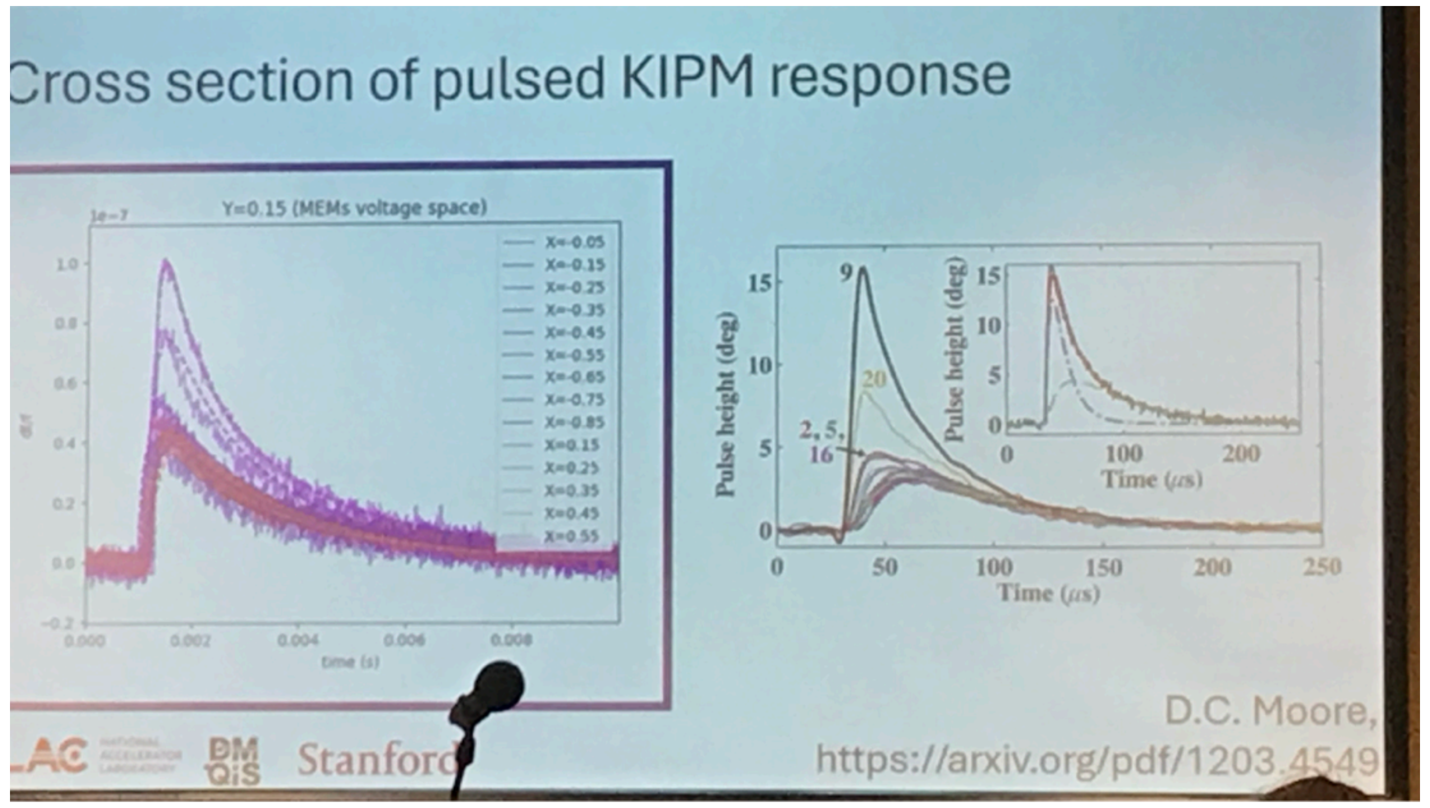
Highlights from LTD Talks and Posters

Zoe Smith: **Characterizing Position-Dependent Phonon Efficiency in KIPM Detectors Using Cryogenic MEMs Mirrors**



MEMS (micro-electromechanical systems) is the technology of microscopic devices incorporating both electronic and moving parts.





Key Points:

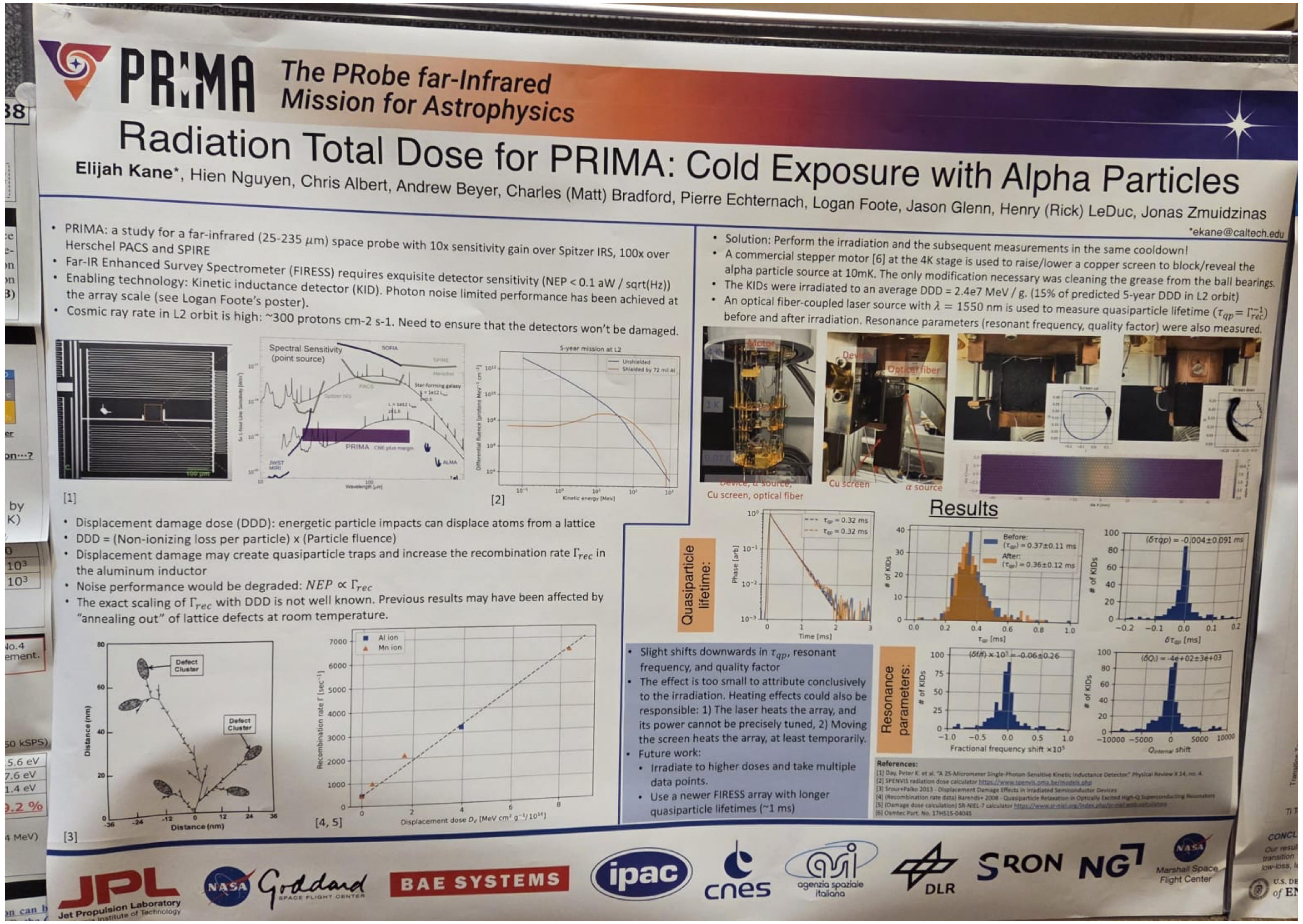
- Cryogenic **MEMS mirrors** system to optically interrogate KIPM detectors

Insights for BULLKID:

- **Calibration:** move beam to investigate position dependent effect.
- **Phonon collection optimization**:
  1. Niobium feed lines
  2. Evaluate phonon loss using meds mirror setup
  3. How Si wafer is fixed to Cu holder?

Highlights from LTD Talks and Posters

Elijah Kane: Radiation Total Dose for PRIMA: Cold Exposure with Alpha Particles



Key Points:

- **Dose test of MKID array**

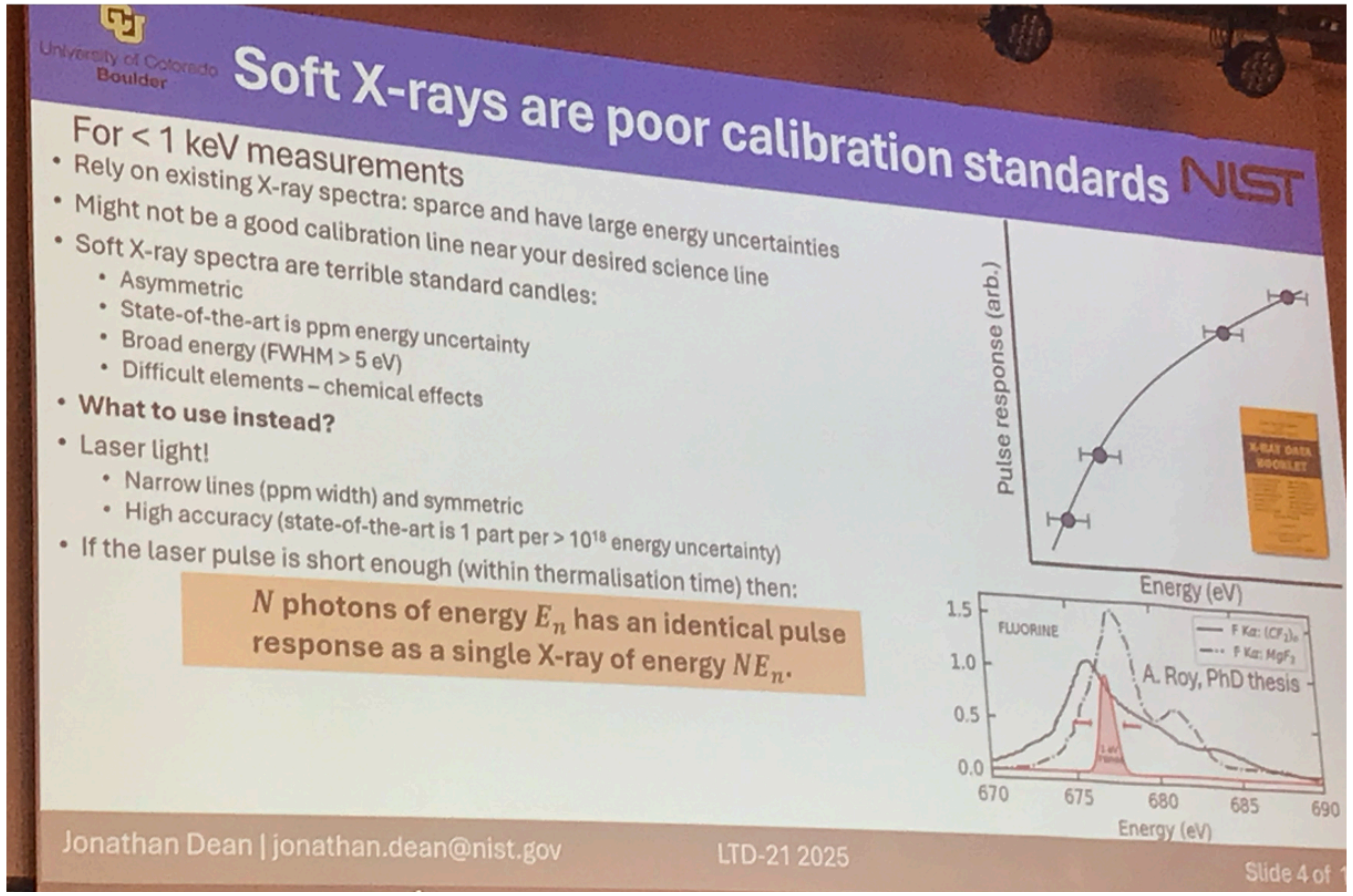
Insights for BULLKID:

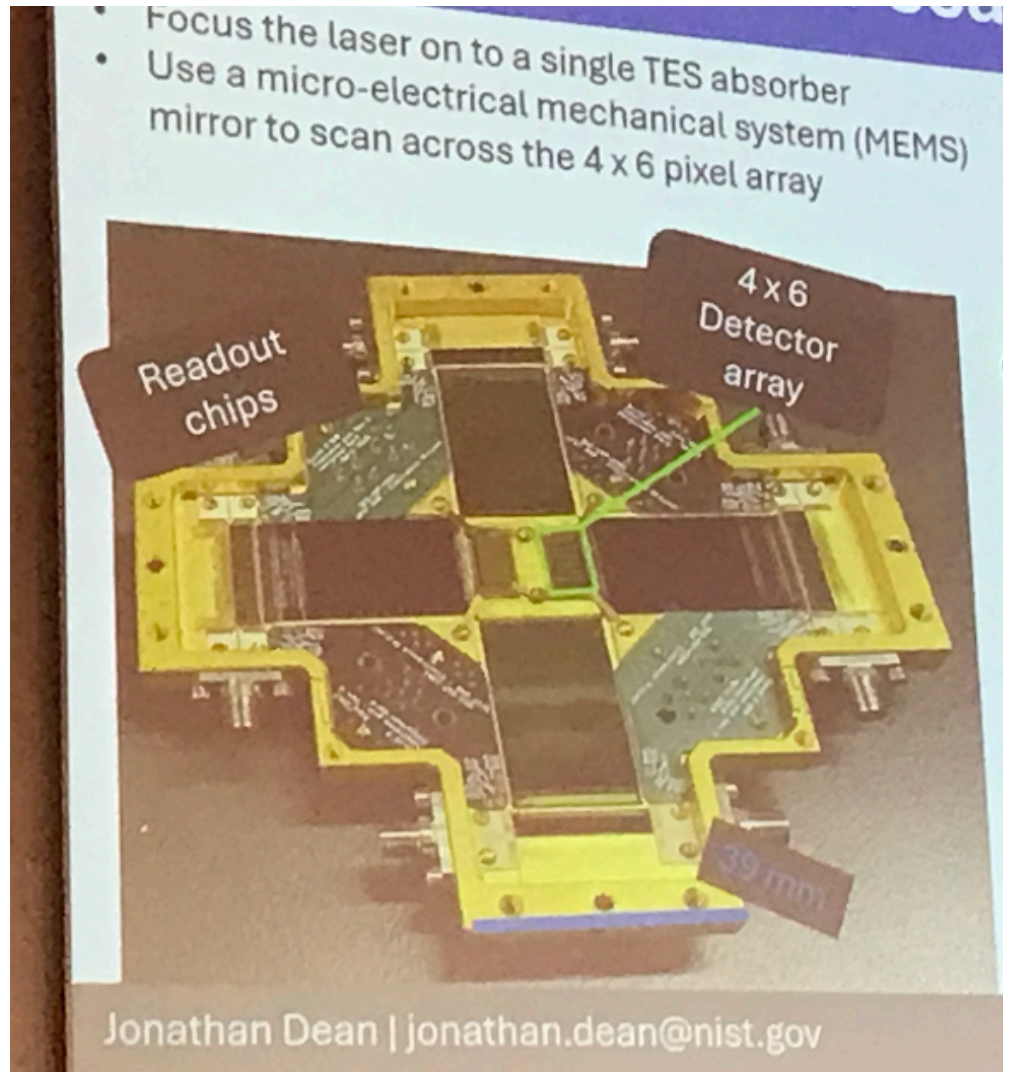
- Calibration.
- Alpha source screened by a **movable Cu shield at 4K**.
- **Commercial stepper motor** move the Cu shield: the only modification necessary was cleaning the grease from the ball bearings

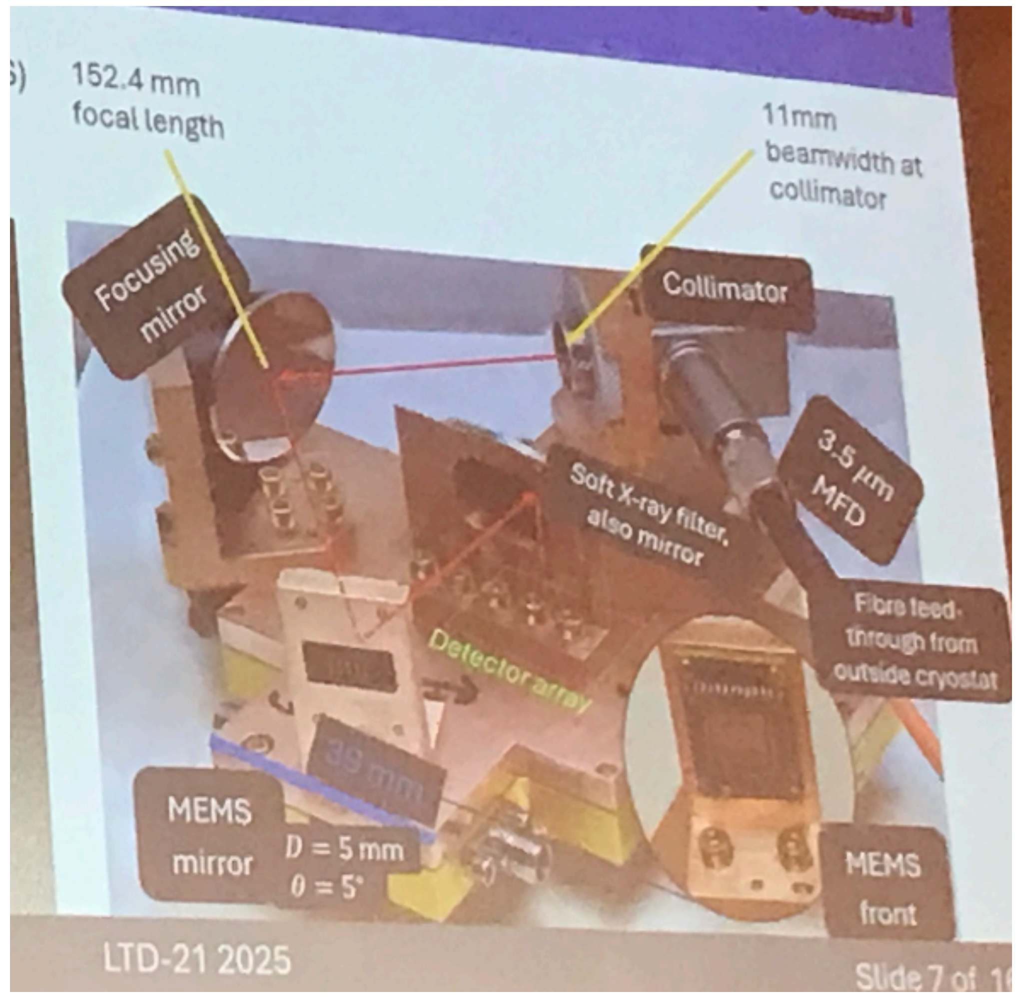
See Donato Niccolò Calibration Talk

Highlights from LTD Talks and Posters

Jonathan Dean: [Cryogenic beam-steering for transition-edge sensor calibration]







Key Points:

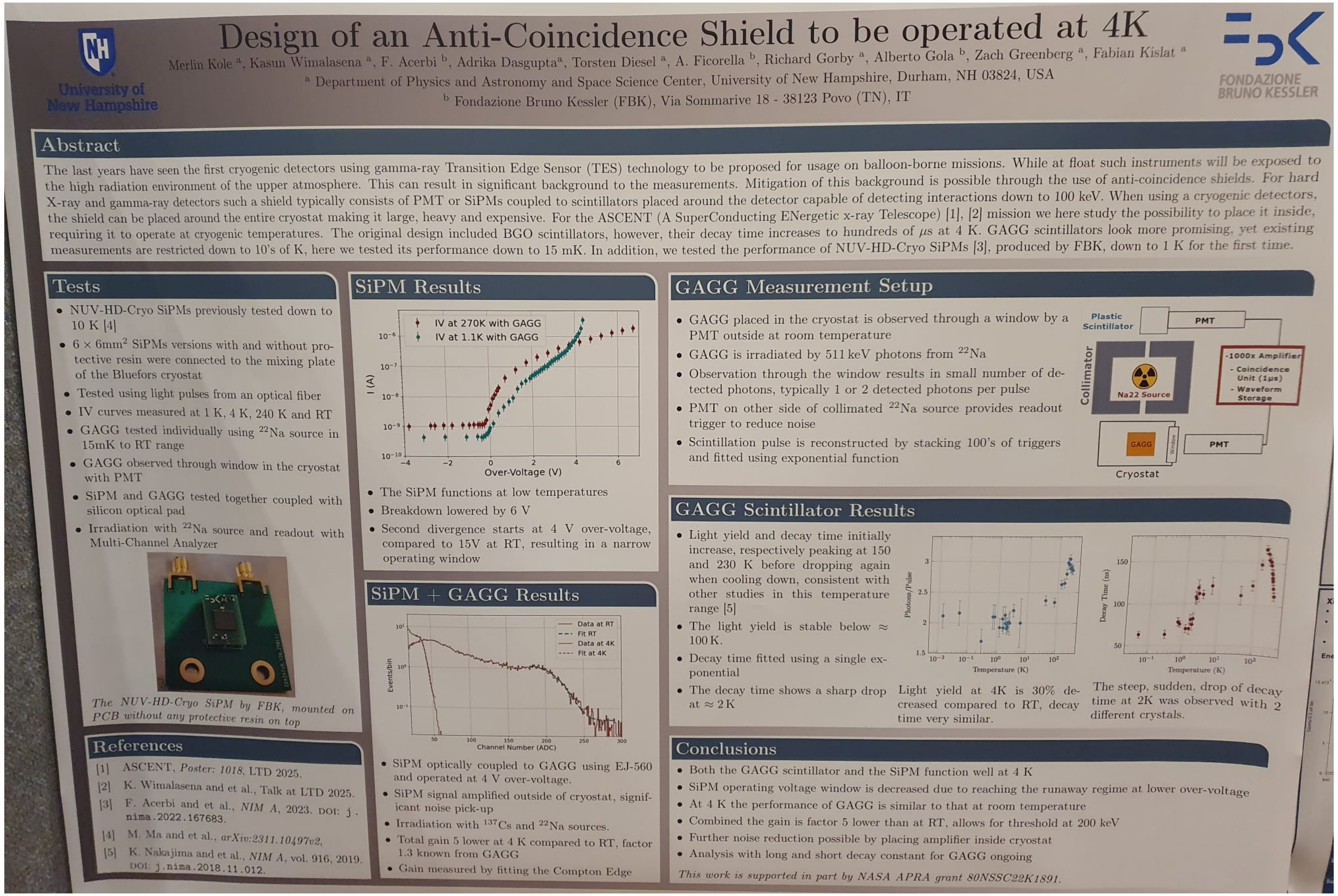
- **Calibration of Xray TES calorimeter array.**

Insights for BULLKID:

- **Calibration:**
  1. **Soft Xray are poor calibration standard**
  2. **Better optical calibration**

Highlights from LTD Talks and Posters

Merlin Kole: Design of an Anti-Coincidence Shield to be operated at 4K



Link; https://custom.cvent.com/B6DBF01384AB4E1CB4B0C6F97B77BDB2/files/event/22930724c2e84b3b93f62c7170746141/cf57e34b79b442aea3265e2f55c9c597.pdf

Key Points:

- **Anti coincidence shield at 4K**

Insights for BULLKID:

- **Veto: GAGG**
- Wait for the proceeding (if any) for further detail and insights.

Thank you for your attention