

RADiCAL

RADiCAL at CERN

October 1 - October 9 on the H6 beam line

JAMES WETZEL on behalf of the RADiCAL Collaboration - October 2024

RADiCAL Collaboration

IOWA

Caltech



COE COLLEGE



UNIVERSITY OF
NOTRE DAME



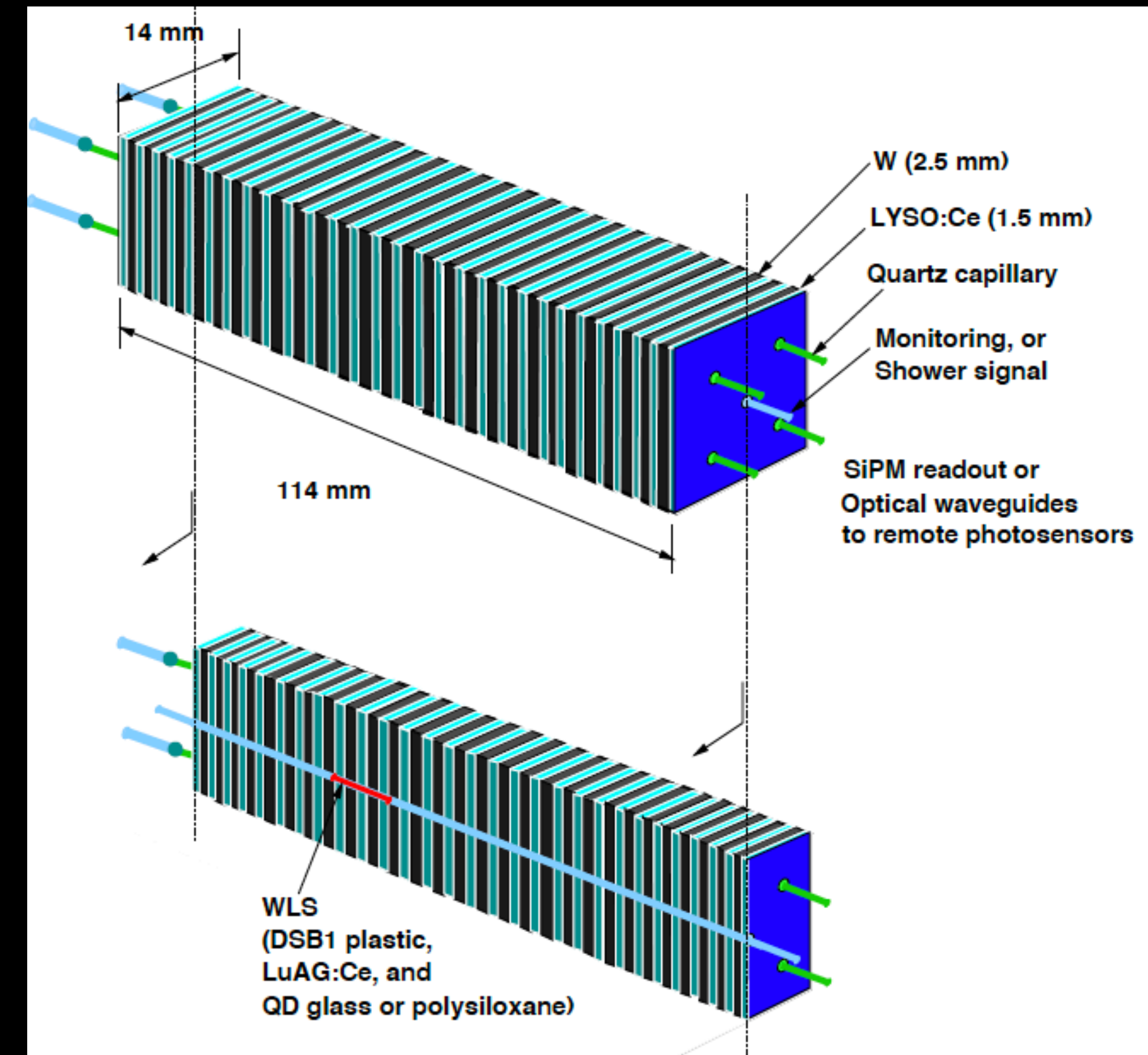
What is the RADiCAL?

Radiation hard ultra compact EM calorimeter



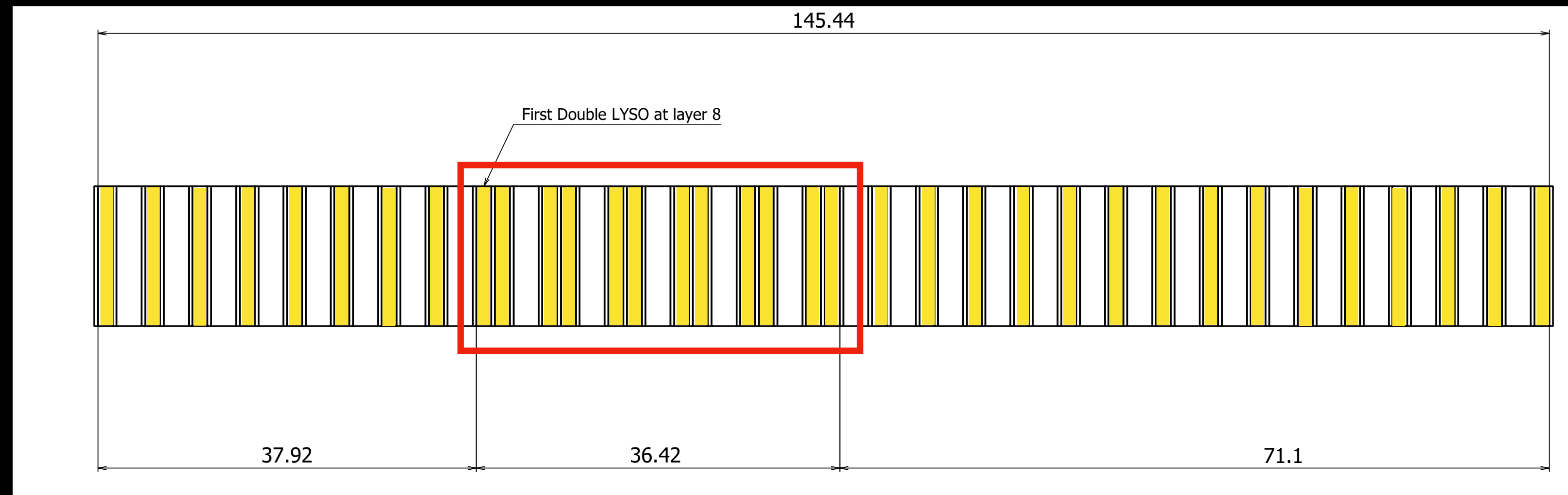
A RADiCAL Module

- Quartz capillaries act as light-guides to pipe information about when shower max occurs with a currently measured precision approaching 17 picoseconds.
- Our aim with this beam test was to get that number as close to 10 picoseconds as possible by improving light yield at shower max.
- Existing modules have been constructed by alternating layers of LYSO with Tungsten.



Experiment Strategy

- We know that the time precision of the module improves with increasing light yield.
- In this run, LYSO tiles were doubled up near shower max to increase light yield in that region.
- We also cranked the SiPM bias on our 'high gain' channels to sharpen wave pulses.



Data Taken with the Module ~10 million events

Beam Energy	125 GeV		Beam Energy	100 GeV		Beam Energy	75 GeV
Cap Config	DSB1		Cap Config	DSB1		Cap Config	DSB1
Total Events	1,530,000.00		Total Events	1,530,000.00		Total Events	1,530,000.00
Events per Spill	7,000		Events per Spill	7,000		Events per Spill	7,000

Beam Energy	50 GeV		Beam Energy	25 GeV		Beam Energy	10 GeV
Cap Config	DSB1		Cap Config	DSB1		Cap Config	DSB1
Total Events	1,590,000.00		Total Events	1,080,000.00		Total Events	510,000.00
Events per Spill	7,000		Events per Spill	7,000		Events per Spill	5,000

Beam Energy	5 GeV		Beam Energy	125 GeV
Cap Config	DSB1		Cap Config	LuAG:Ce
Total Events	120,000.00		Total Events	1,530,000.00
Events per Spill	300		Events per Spill	300

CERN Prévéssin Facilities Crew

Professional, responsive, accommodating

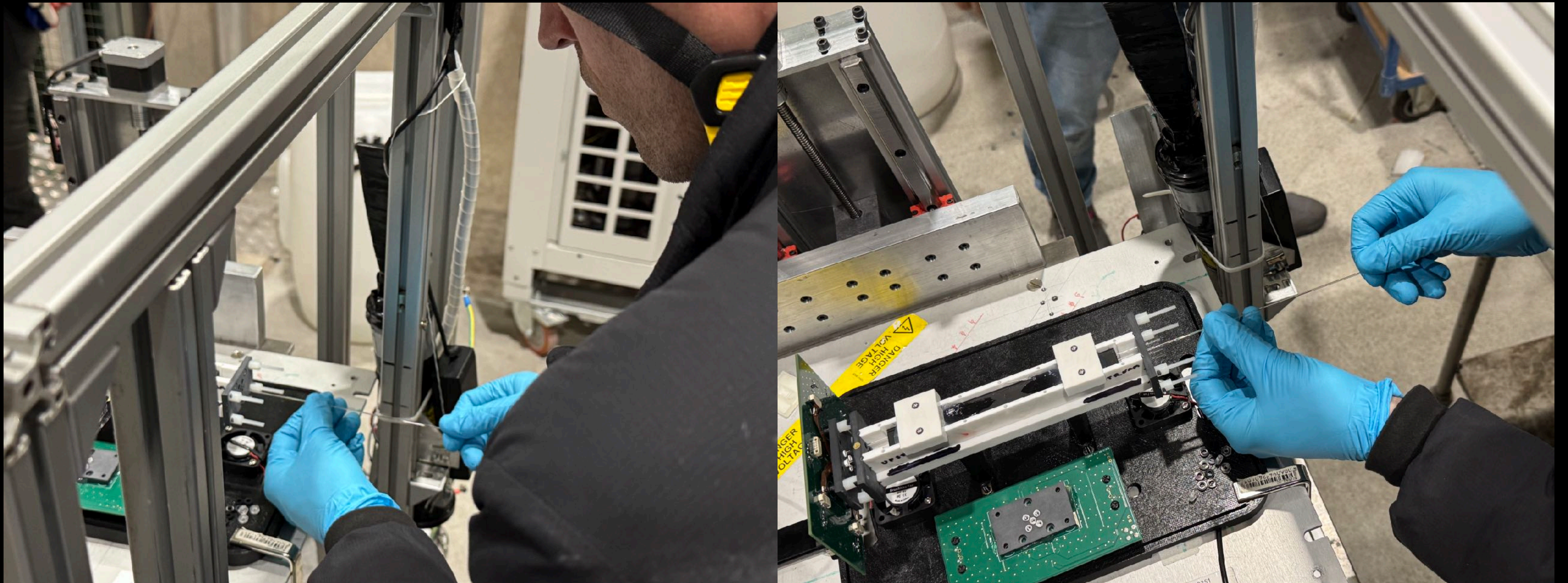
- Here we see the DESY motion table being moved at our request



Installation

Straightforward - no issues

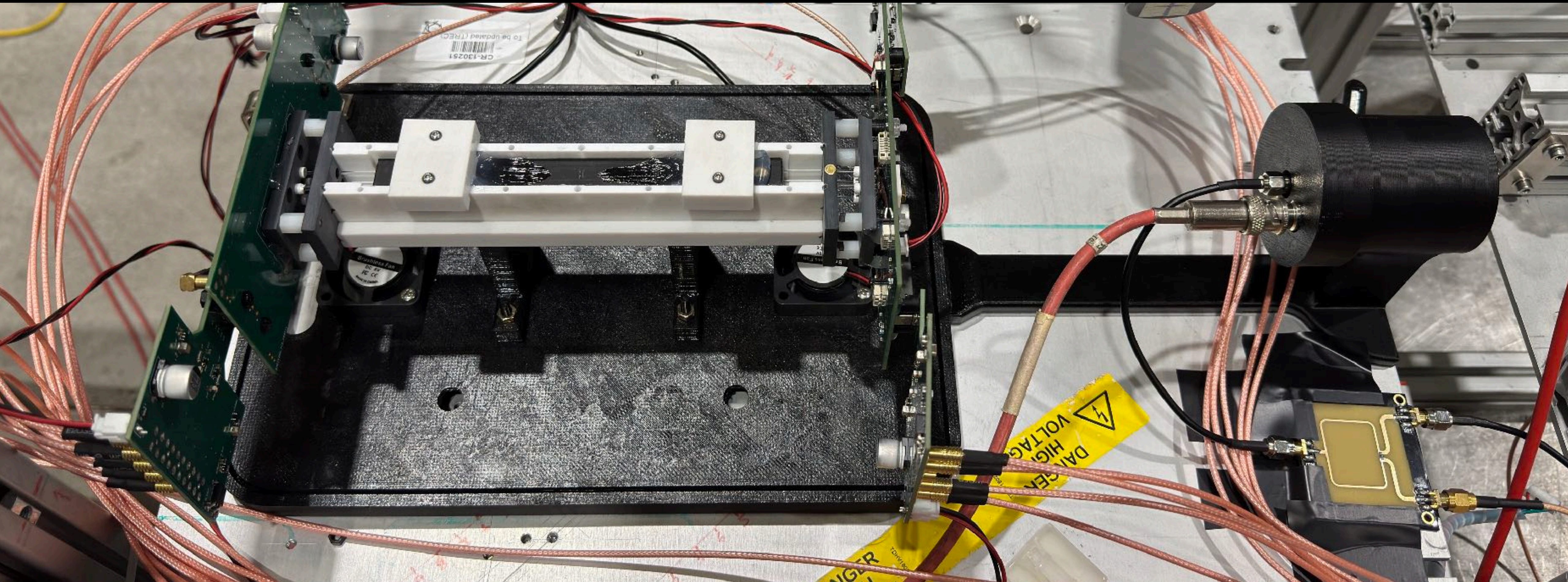
- Here we see Wetzels installing quartz capillaries into the RADiCAL



Installation

Straightforward - no issues

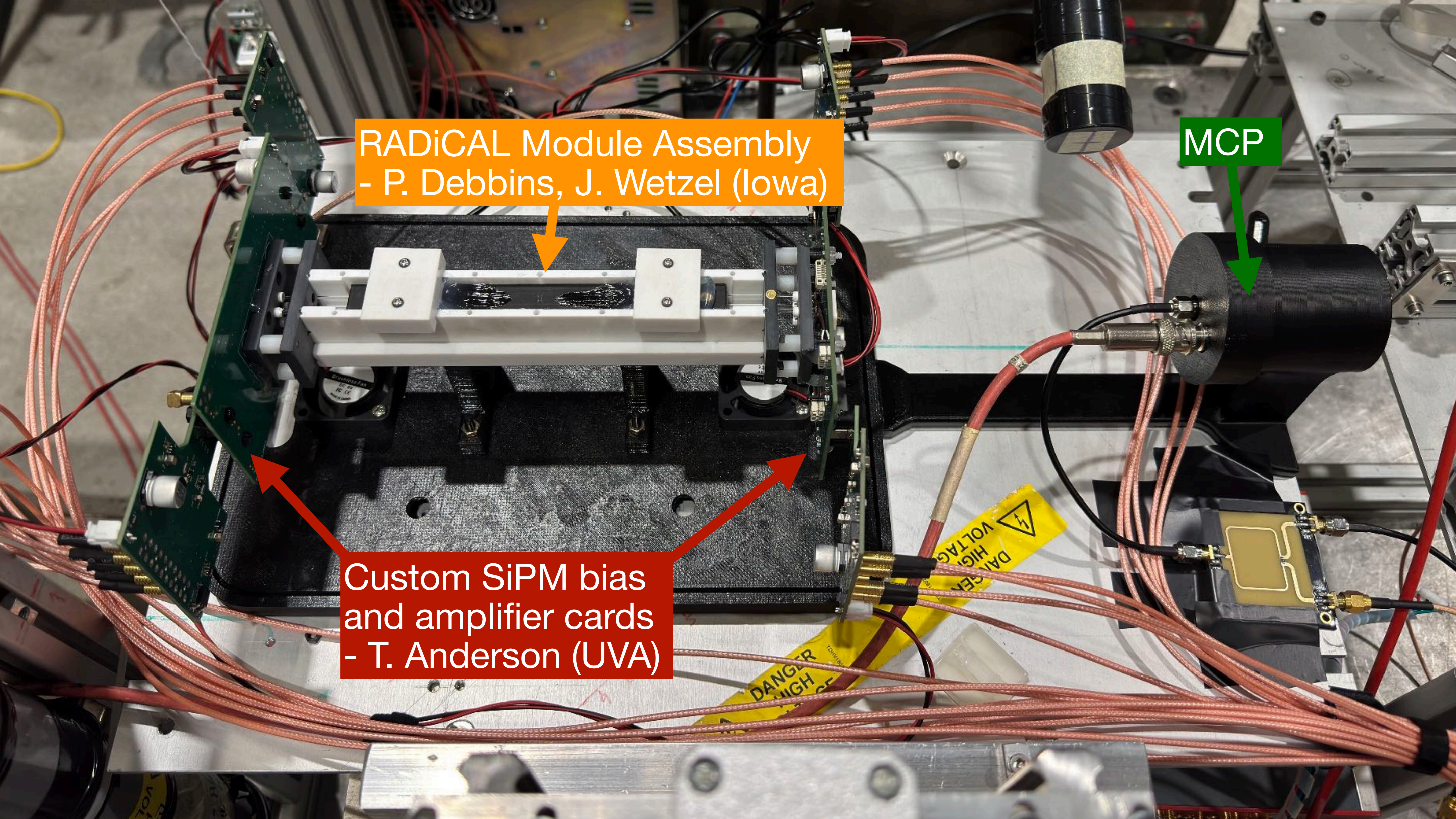
- Seen here and on the next slide is the RADiCAL experimental setup on the DESY table

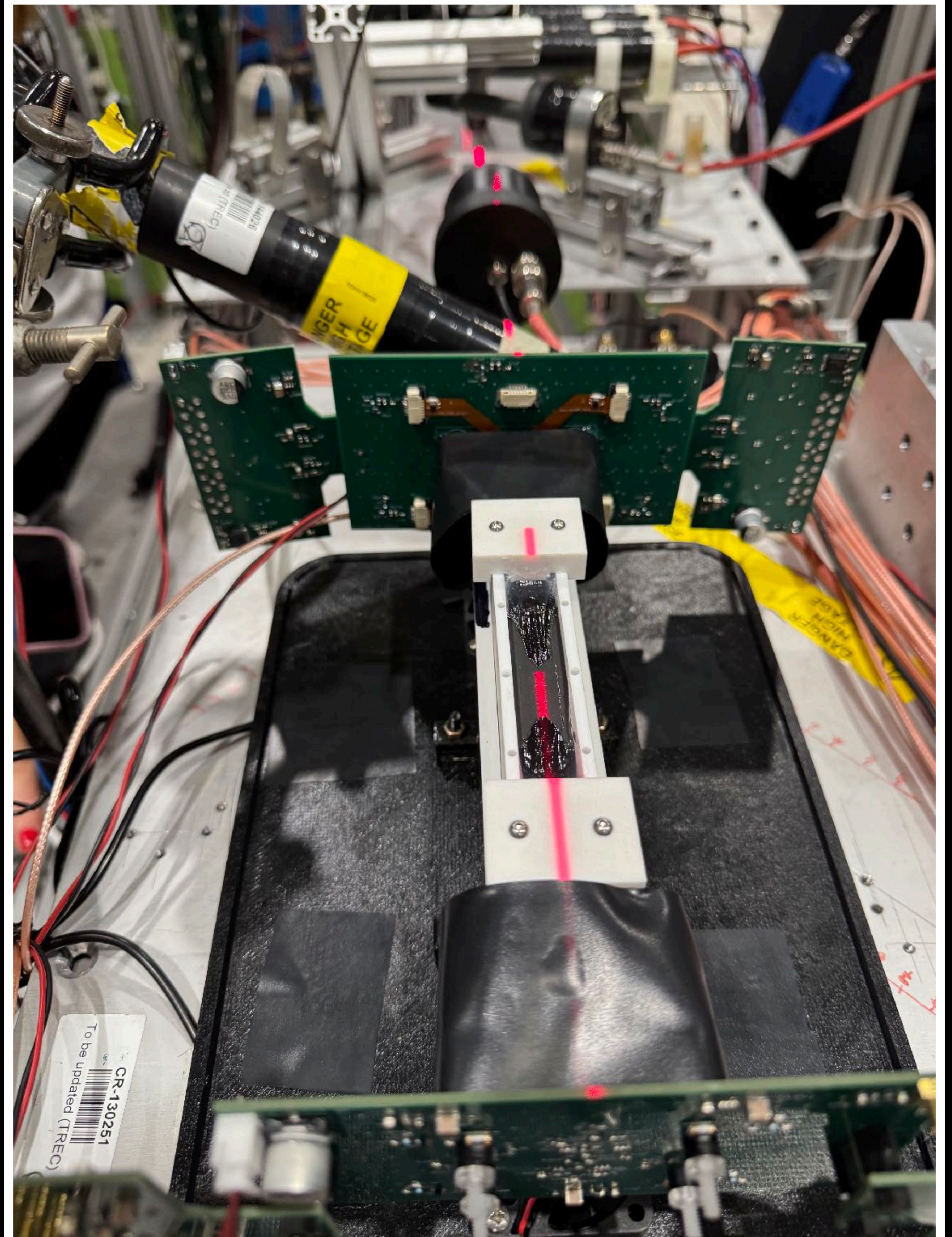
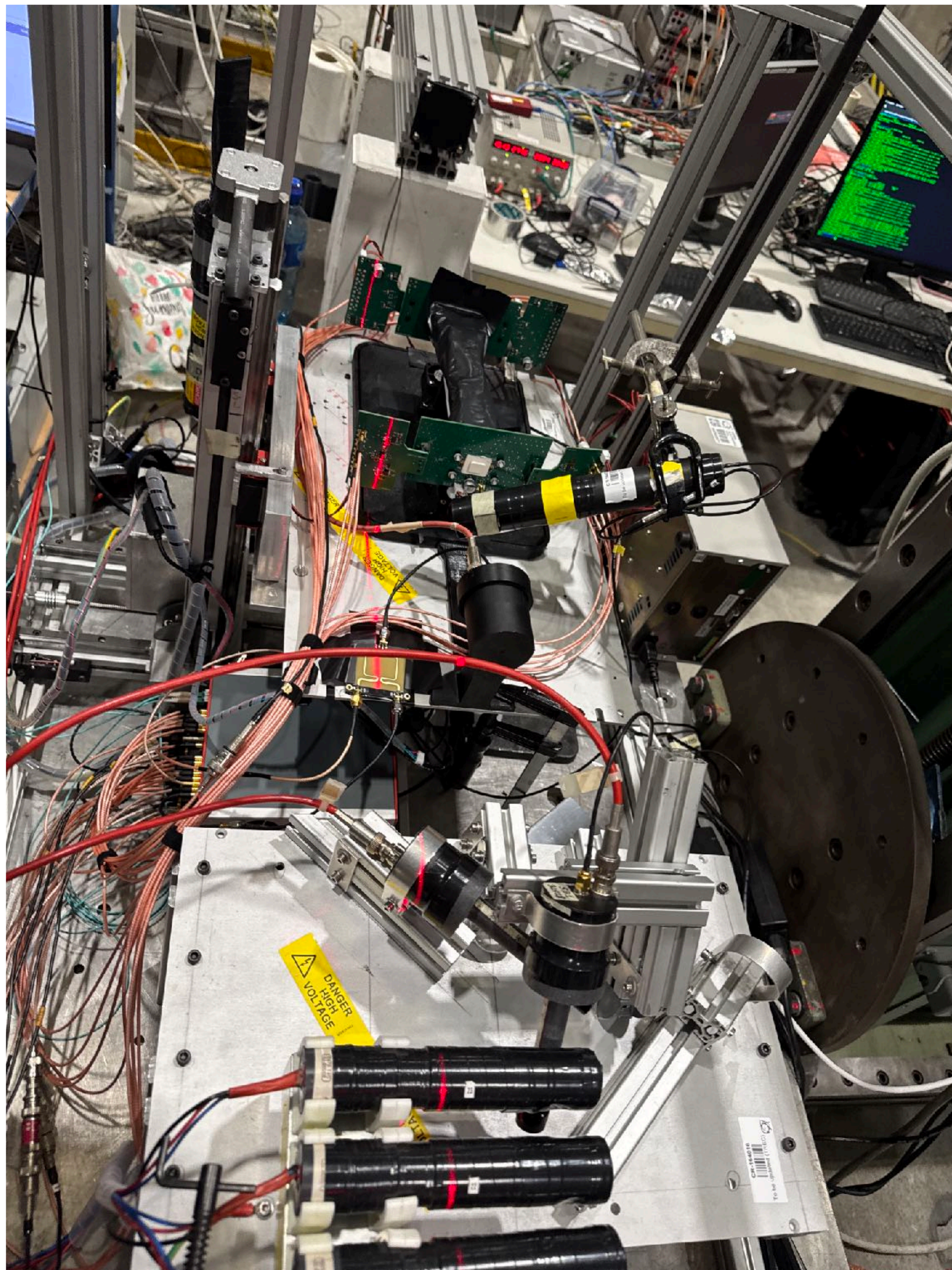


RADiCAL Module Assembly
- P. Debbins, J. Wetzel (Iowa)

MCP

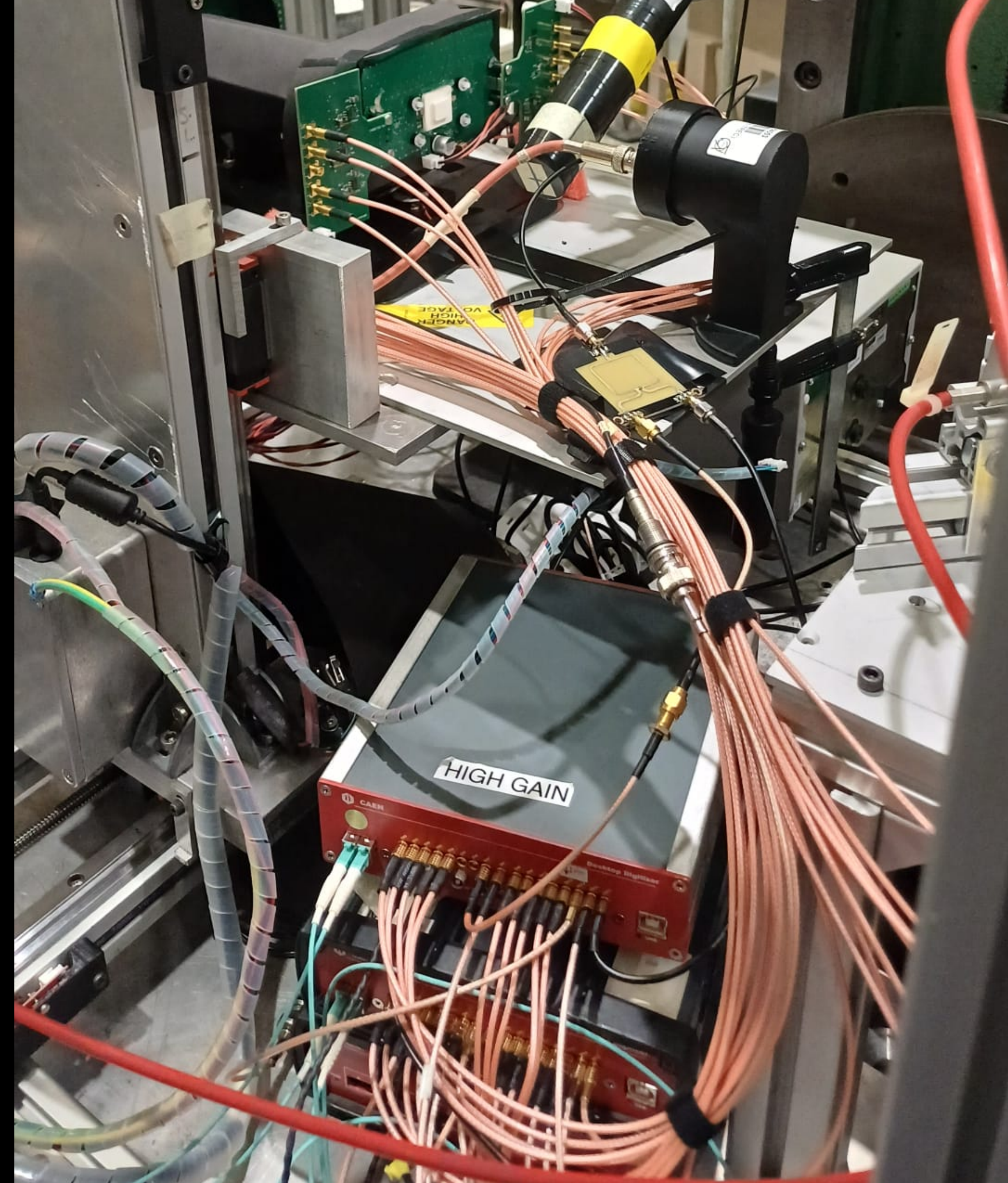
Custom SiPM bias
and amplifier cards
- T. Anderson (UVA)





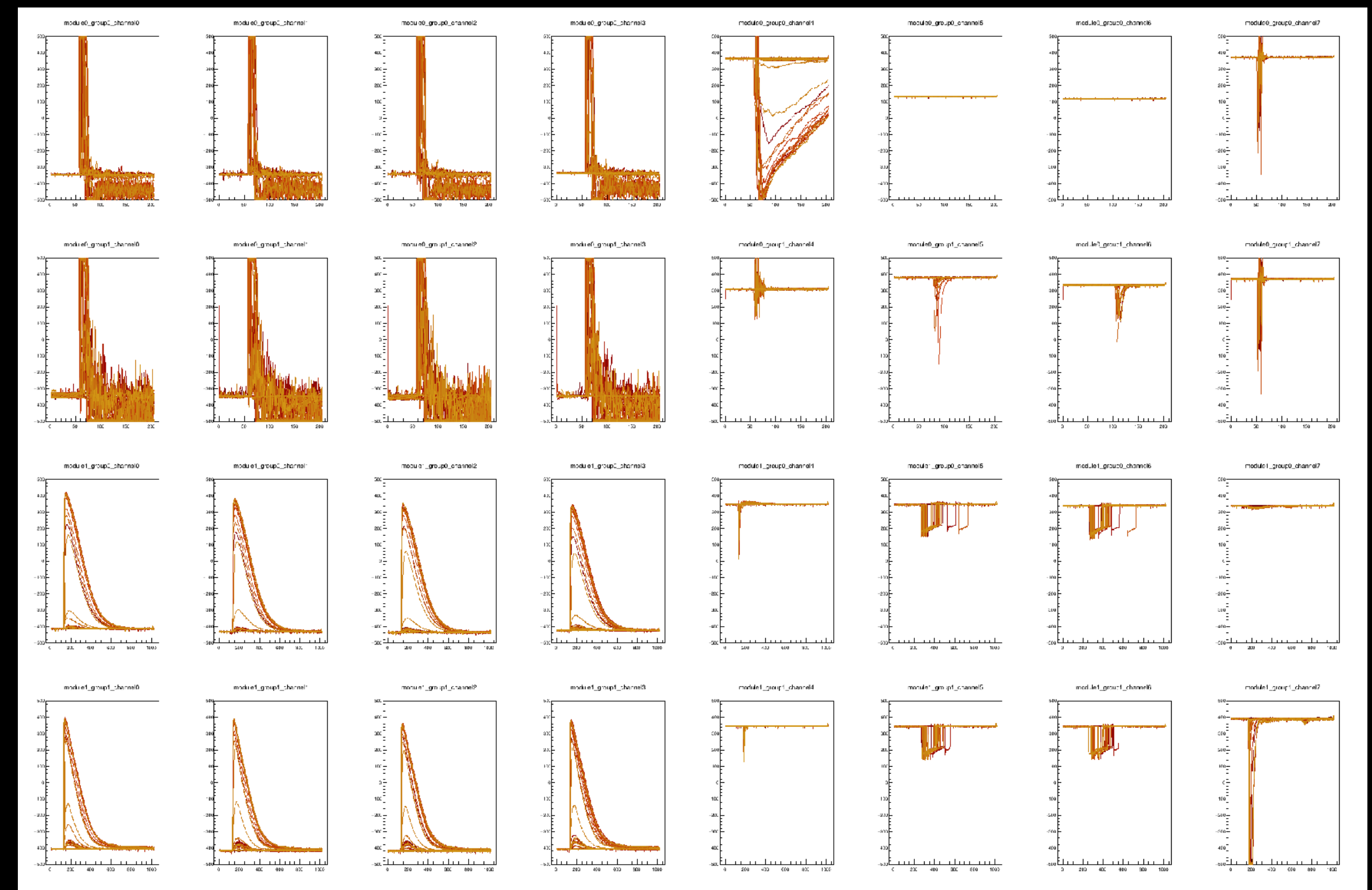
RADiCAL DAQ

- The RADiCAL has 5 capillaries read out from both ends, for a total of 10 channels.
- However, each channel has two amplifiers: high gain for timing and low gain for energy.
- Thus, a total of 20 channels are read out of a single module.
- Two CAEN DT5742 modules synchronized via a clock module were used to digitize SiPM waveforms, seen right.
- Additional channels included the MCP, 1x1 and 2x2 scintillator counters, wire chambers, and a Pb Glass calorimeter, all digitized for a single event.



RADiCAL DAQ

- The custom RADiCAL DAQ software was written by Carlos Perez-Lara (FNAL) for a previous CERN test beam and re-used here in October.
- Laurent Forthomme came by to say hi and ended up producing a ‘quick look’ data viewer to speed up our commissioning process, seen right.
- The top left 8 channels are high gain, the 8 channels lower left are low gain. Try to guess the others :)
- Thank you Laurent!



Safety Review

Professional, fast, on time

- Here we see the safety crew with RADiCAL members Selbi Hatipoğlu (IU Undergraduate) and Alexi Mestvirishvili (Iowa). The safety crew understood the setup well and was quickly approved.

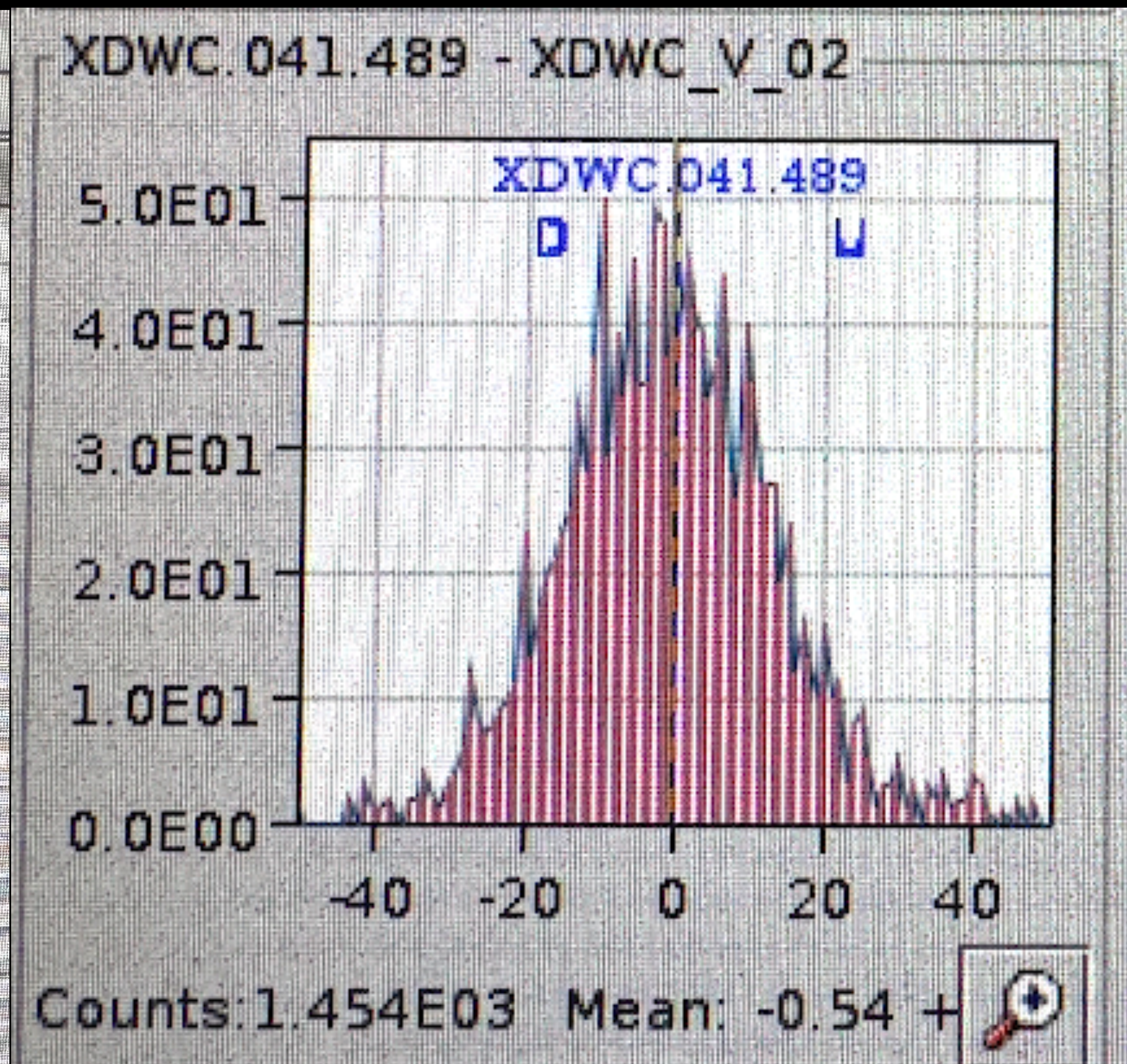


Beam File Setup

Absolutely perfect and frictionless

- Laurie Nevay produced flawless profiles for the requested beam energies, and showed us in person how to tune the beam. They really were perfect.

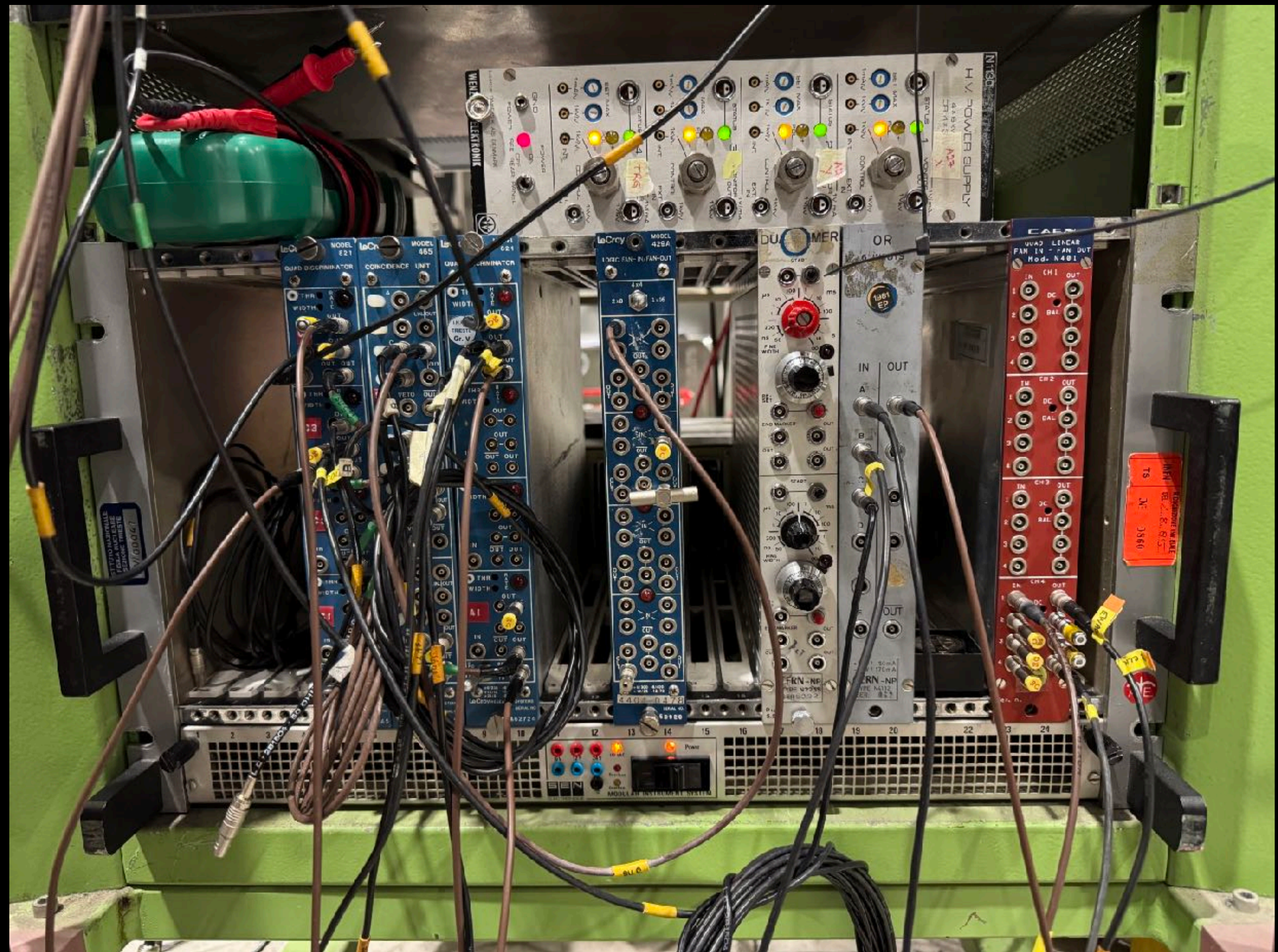
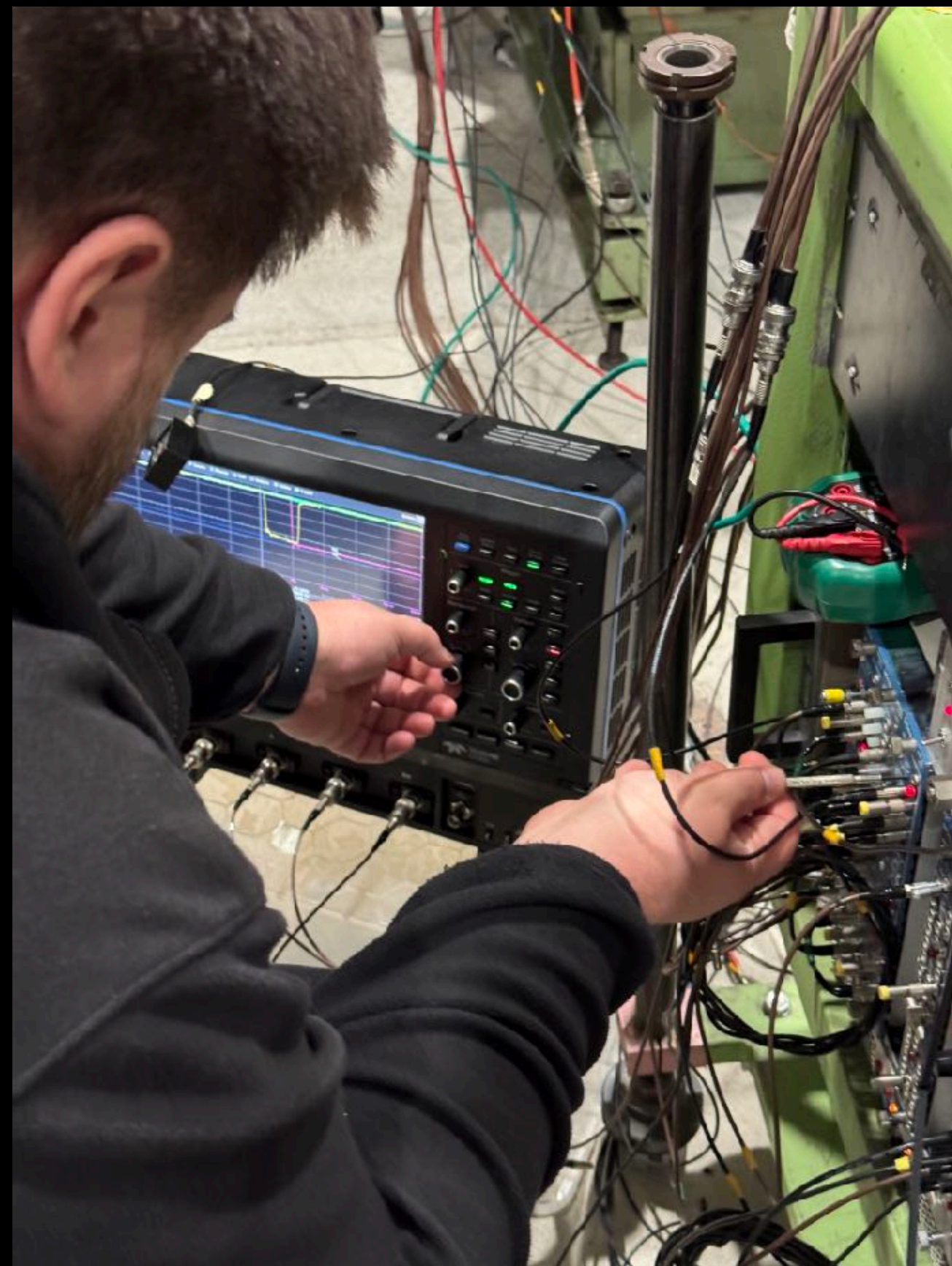
RADICAL	Comment
H6A.RADICAL.000	2024 +10 e+ [+180/+120]
H6A.RADICAL.001	2024 +20 e+ [+180/+120]
H6A.RADICAL.002	2024 +25 e+ [+180/+120]
H6A.RADICAL.003	2024 +50 e+ [+180/+120]
H6A.RADICAL.004	2024 +75 e+ [+180/+120]
H6A.RADICAL.005	2024 +100 e+ [+180/+120]
H6A.RADICAL.007	2024 +120 mu+ [+180/+120]
H6A.RADICAL.008	2024 -120 mu- [-300/-120]
H6A.RADICAL.009	2024 -5 e- [-300/-120]
H6A.RADICAL.010	2024 -10 e- [-300/-120]
H6A.RADICAL.011	2024 -20 e- [-300/-120]
H6A.RADICAL.012	2024 -25 e- [-300/-120]
H6A.RADICAL.013	2024 -50 e- [-300/-120]
H6A.RADICAL.014	2024 -75 e- [-300/-120]
H6A.RADICAL.015	2024 -100 e- [-300/-120]
H6A.RADICAL.016	2024 -125 e- (from -140) [-300/-180]



Commissioning

No problems of note

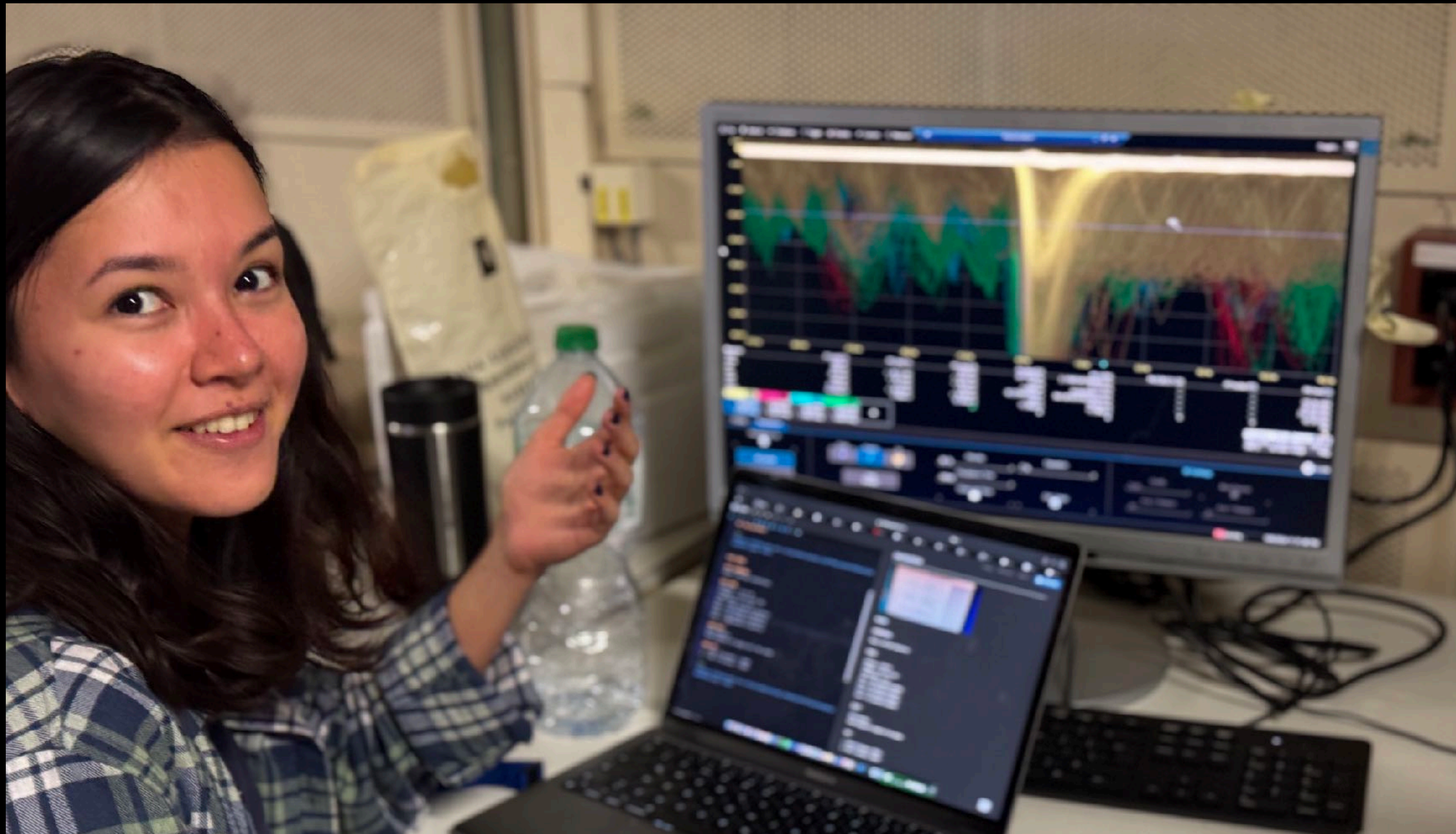
- Berkan Kaynak (IU) seen tuning the trigger (left) with the trigger setup (right).



Commissioning

No problems of note

- Selbi Hatipoğlu (IU) showing clear signals from the detector on the oscilloscope.



Commissioning

Help from friends

- Seen here are Laurent Forthomme (2nd from right) with (L to R) Selbi, Onur Potok, Berkan, and Eda Erdogan working through dinner to assist us with developing a 'quick look' data parser. Many thanks again to Laurent for taking the time to help us.

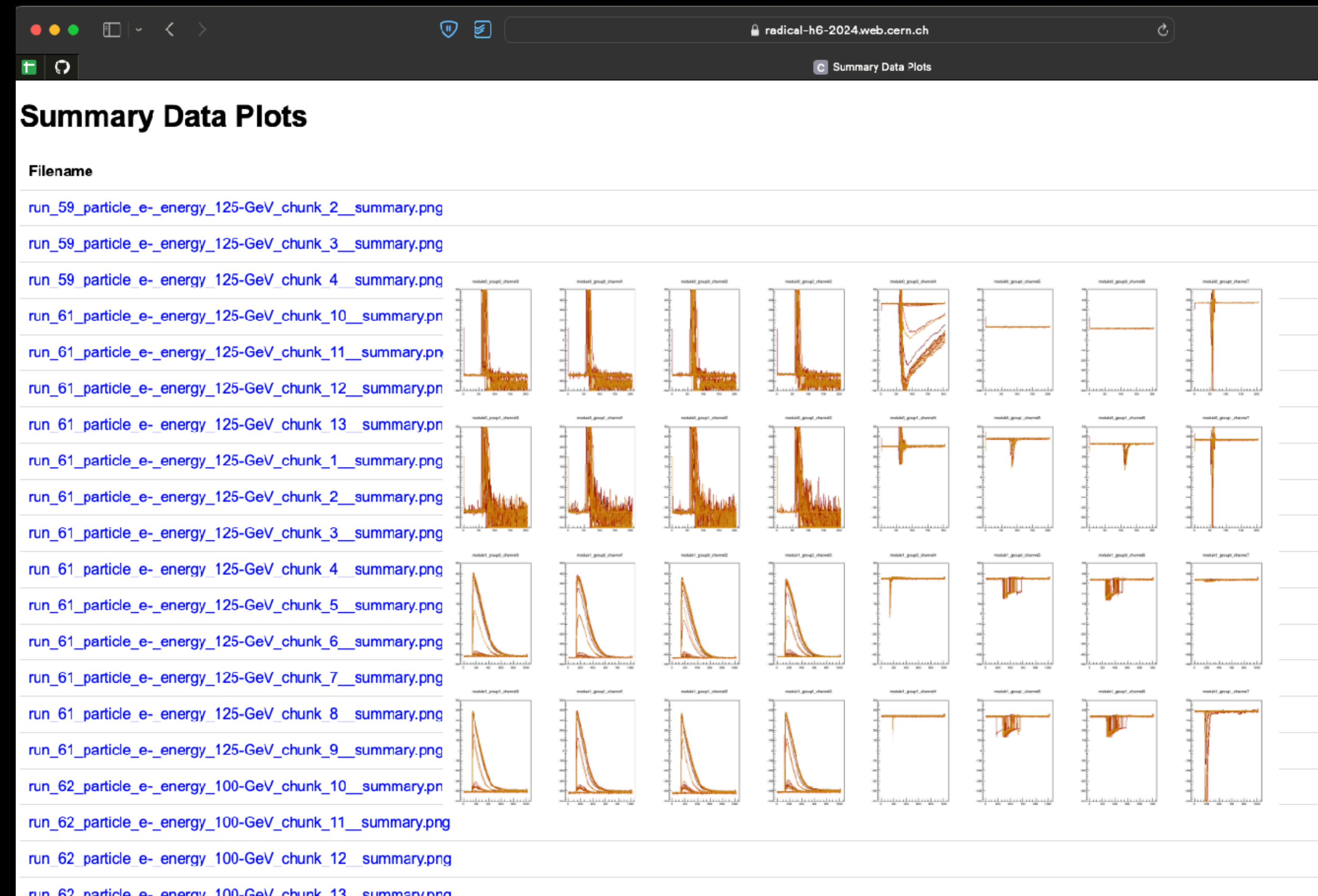


Commissioning

Help from friends

<https://radical-h6-2024.web.cern.ch/>

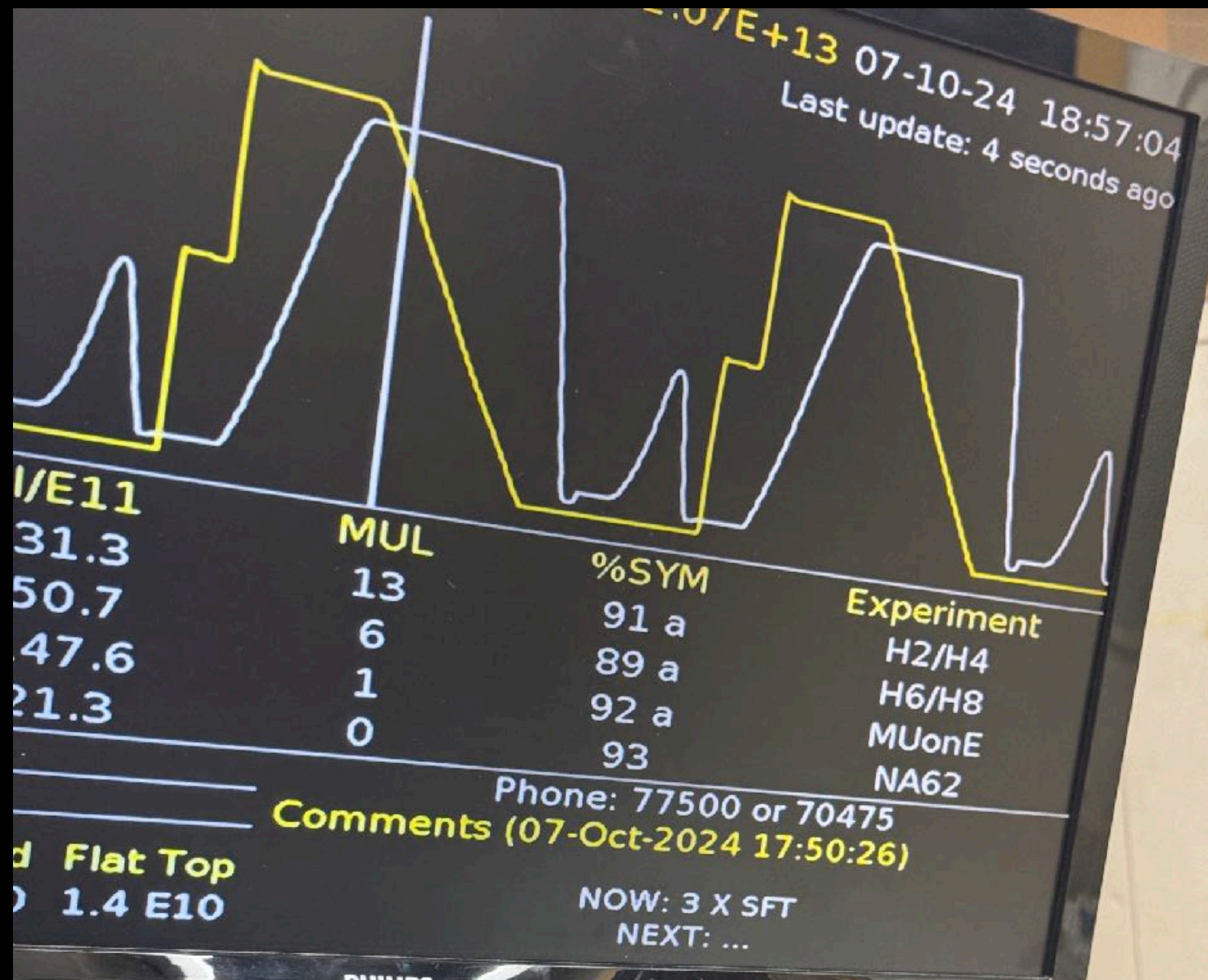
- Laurie pointed Wetzel to CERN's web publishing service, which allowed us to get back to CERN's roots and immediately serve our quick-look plots to the whole world!
- This allowed everyone to quickly glance at the data as it was collected to make sure we were collecting what we needed.
- From his home in Arizona USA, Randal Ruchti used these plots to request SiPM bias adjustments.
- Tim Berners-Lee would be proud!



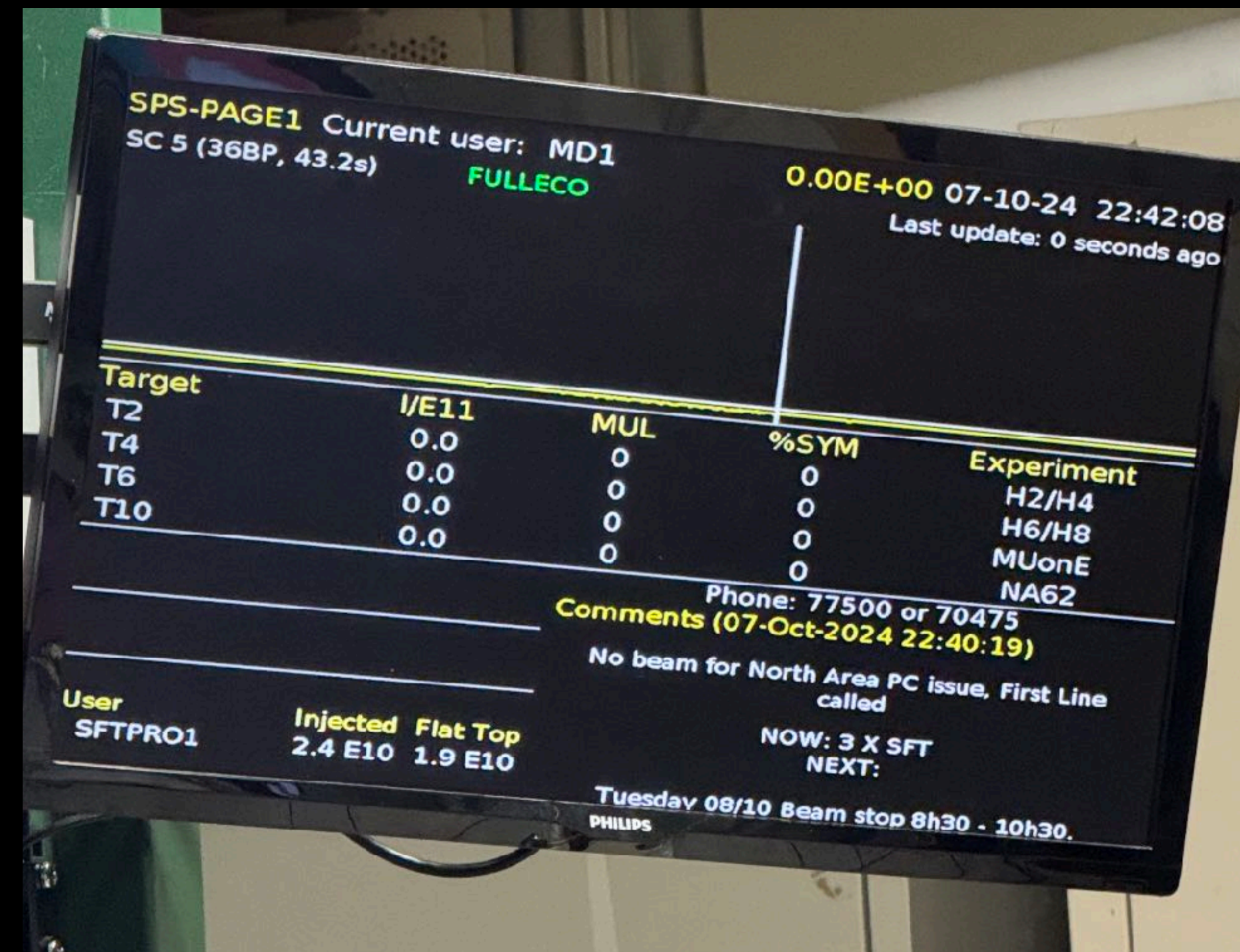
Beam Uptime

Beam drops were rare

- There were a handful of short duration beam drops, none of which interrupted our program. Each lasted only as long as a much needed coffee break.



Common



Rare

Post Run: Rad Safety

Straightforward

- Seen here is a Rad safety label attached to a piece of our equipment exposed to the beam, with no activation of any installed gear observed.
- Everything exposed to the beam must be tagged, measured, and tracked in TREC.



Post Run: Cleanup

Loading dock and available pallets + pallet jack made cleanup easy

- Berkan seen here delivering equipment to the loading dock



RADiCAL Personnel Involved

***Subset of the RADiCAL collaboration**

- Onsite at CERN:
 - U. Iowa - Alexi Mestvirishvili, James Wetzel (Also Coe College), Aldo Penzo
 - Istanbul University - Suat Ozkorucuklu, Berkan Kaynak, Onur Potok, Selbi Hatipoğlu, Eda Erdogan
- Assisted Remotely:
 - Notre Dame: Randal Ruchti
 - U. Virginia: Thomas Anderson, Alexander Ledovskoy

Summary of Recent RADiCAL Test Beams

- Fermilab -
 - June 2022
 - Measured timing resolution of 45 ps @ 28 GeV
- CERN -
 - May 2023
 - Measured timing resolution of 25 ps @ 150 GeV, with limiting resolution of 17.5 ps
 - NIM A: Study of time resolution measurements and prospects for energy resolution of an ultra-compact sampling calorimeter (RADiCAL) module at EM shower maximum over the energy range 25 GeV 150 GeV
 - <https://www.sciencedirect.com/science/article/pii/S0168900224006636>
 - Oct 2024 - Analysis underway

Special thanks to CAEN

- CAEN staff made available at no cost a much needed second DT5742 module.



Electronic Instrumentation

Fin.