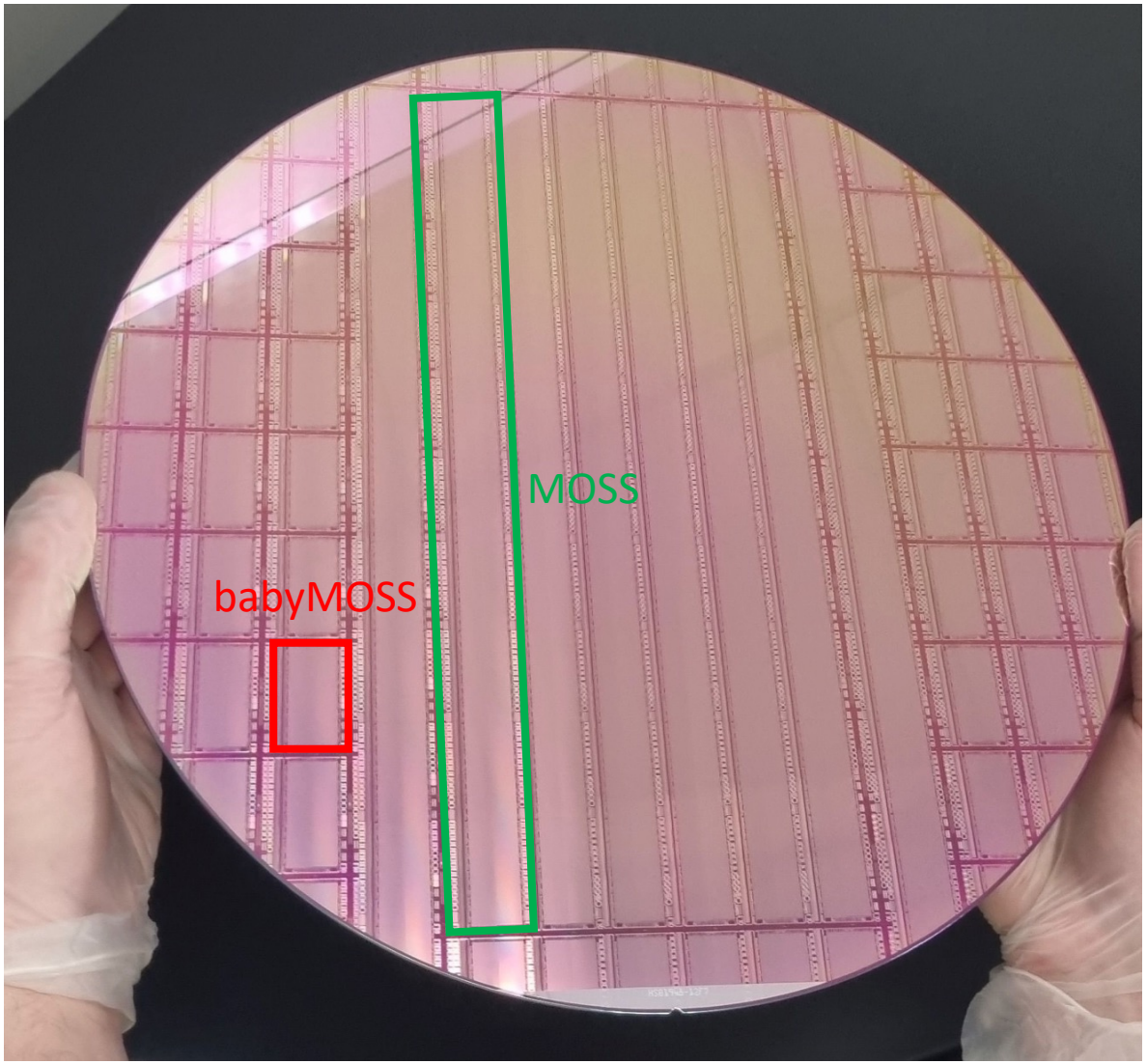
ER1 BabyMOSS Tests by LBL/UCB

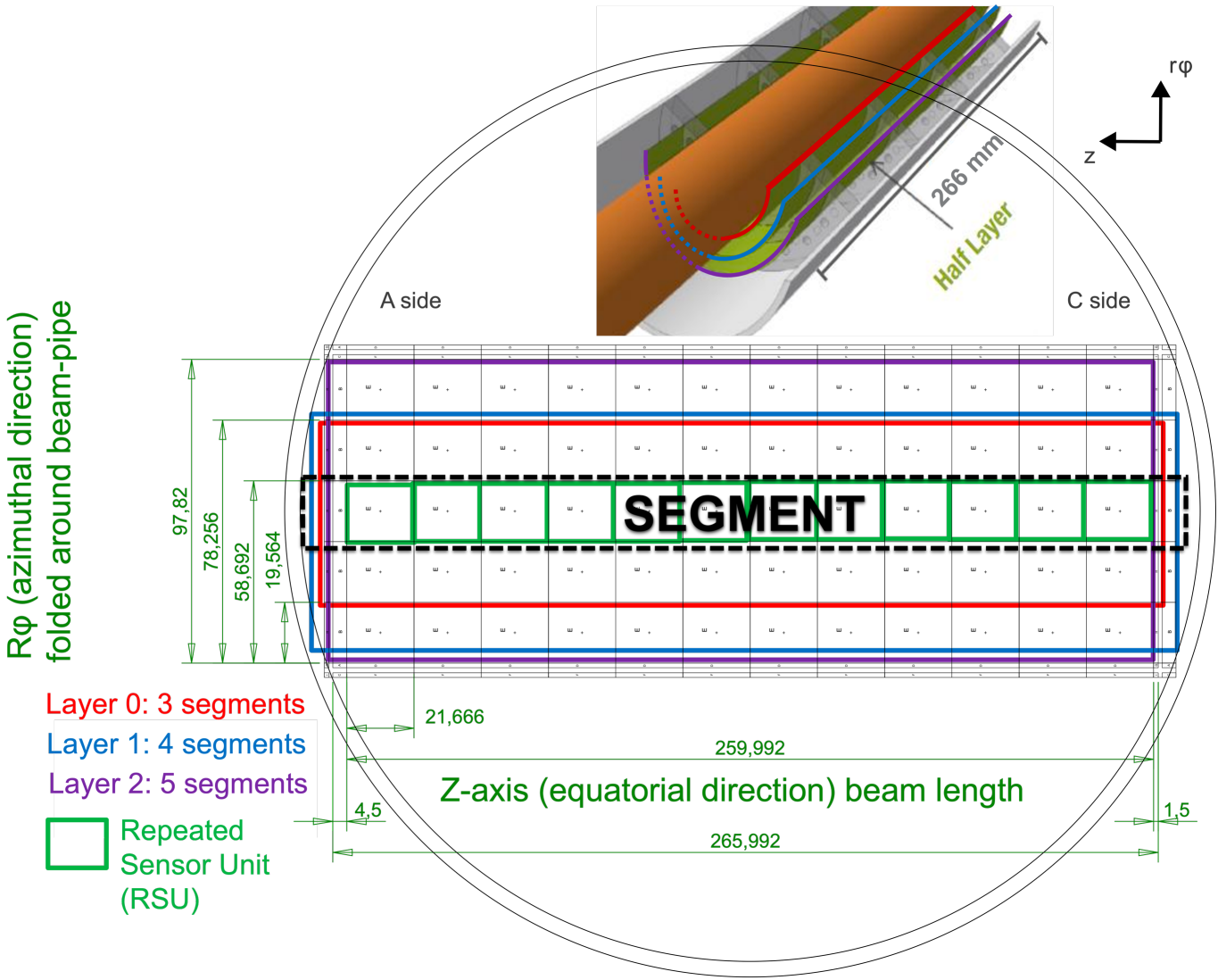
- Beam Tests at FTBF and BASE -

Zhenyu Ye

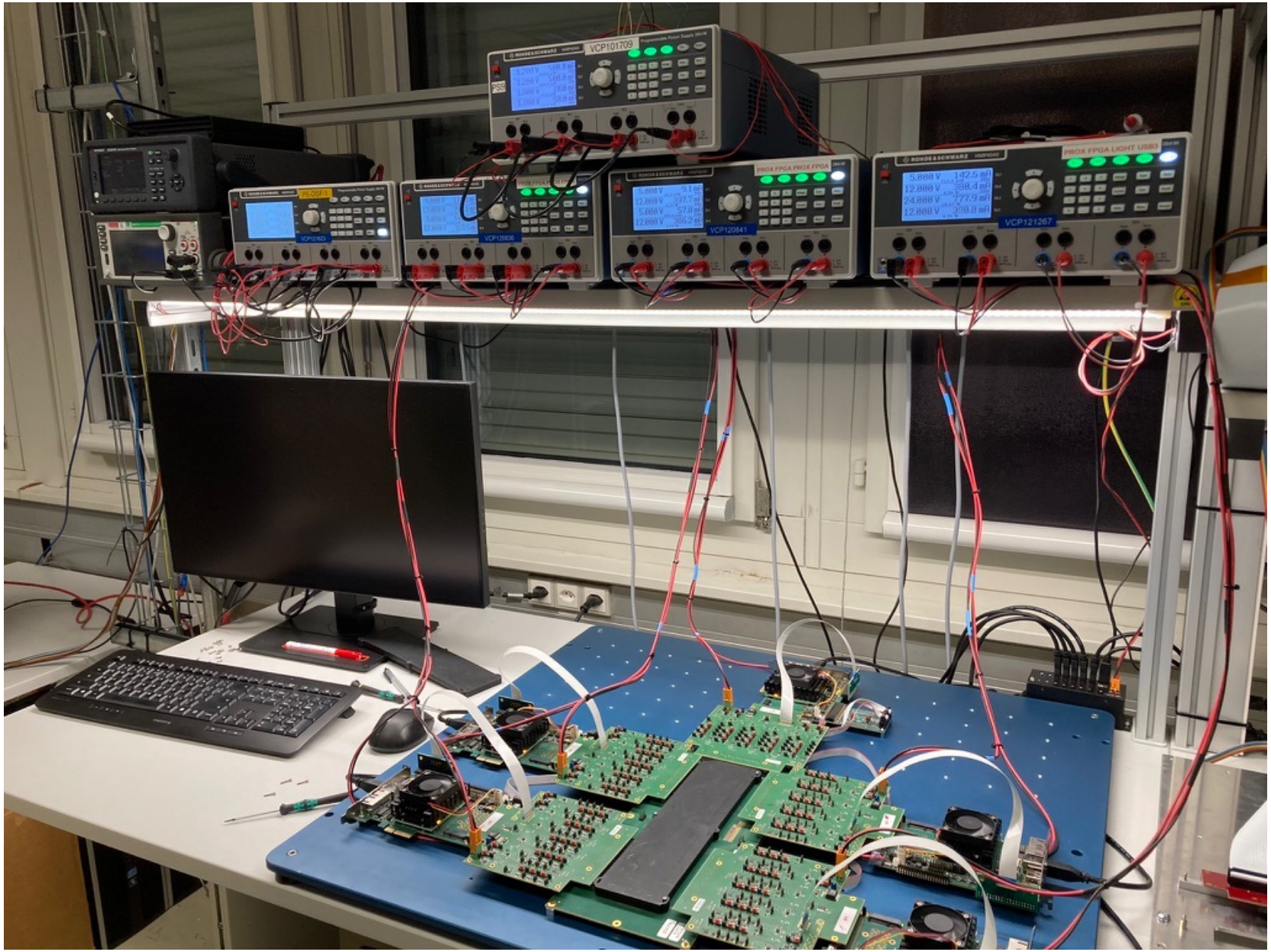
LBL

ALICE ITS3 ER1 – MOSS and BabyMOSS Sensors



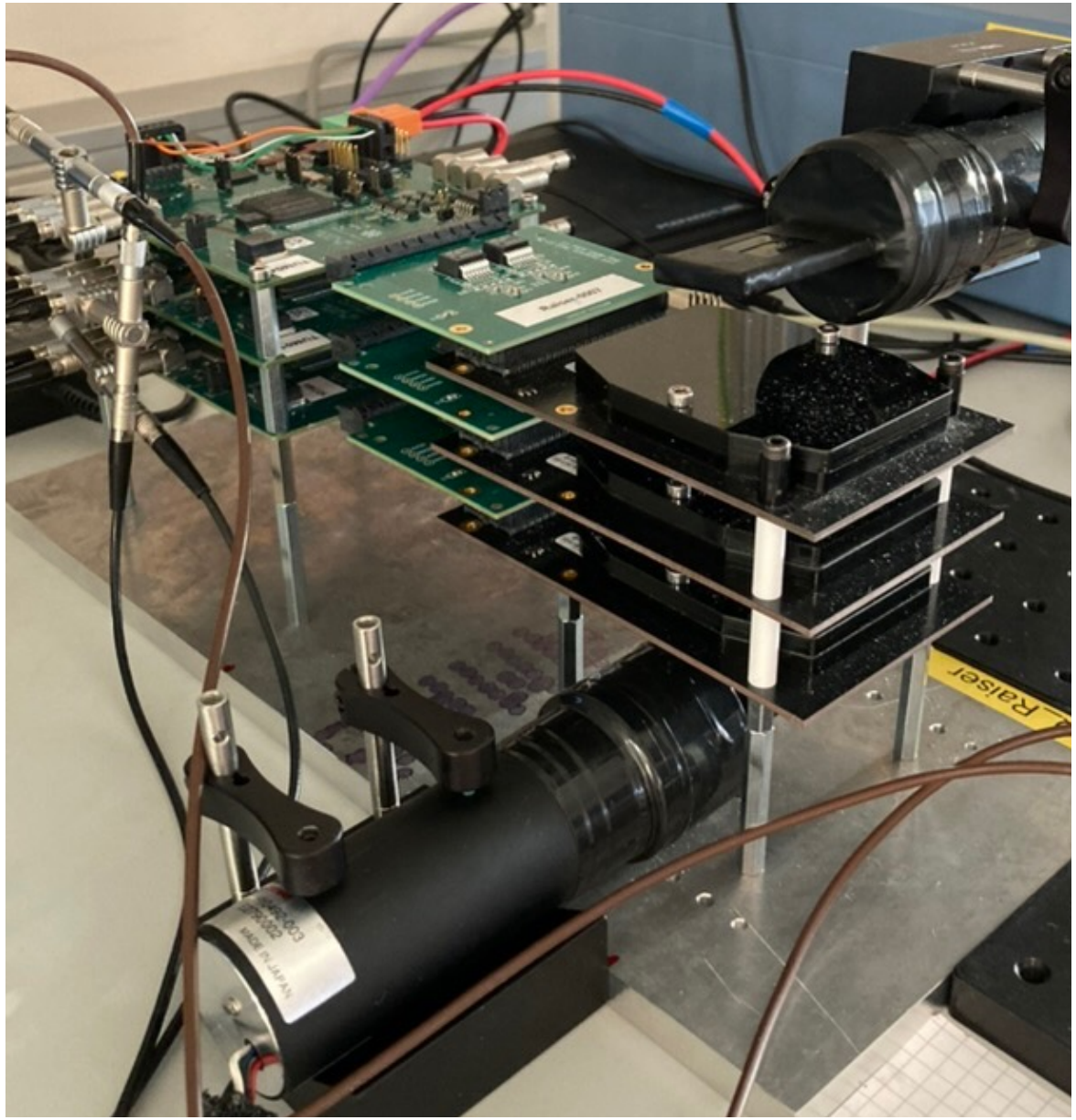


ALICE ITS3 ER1 - MOSS



Baby Moss Telescope

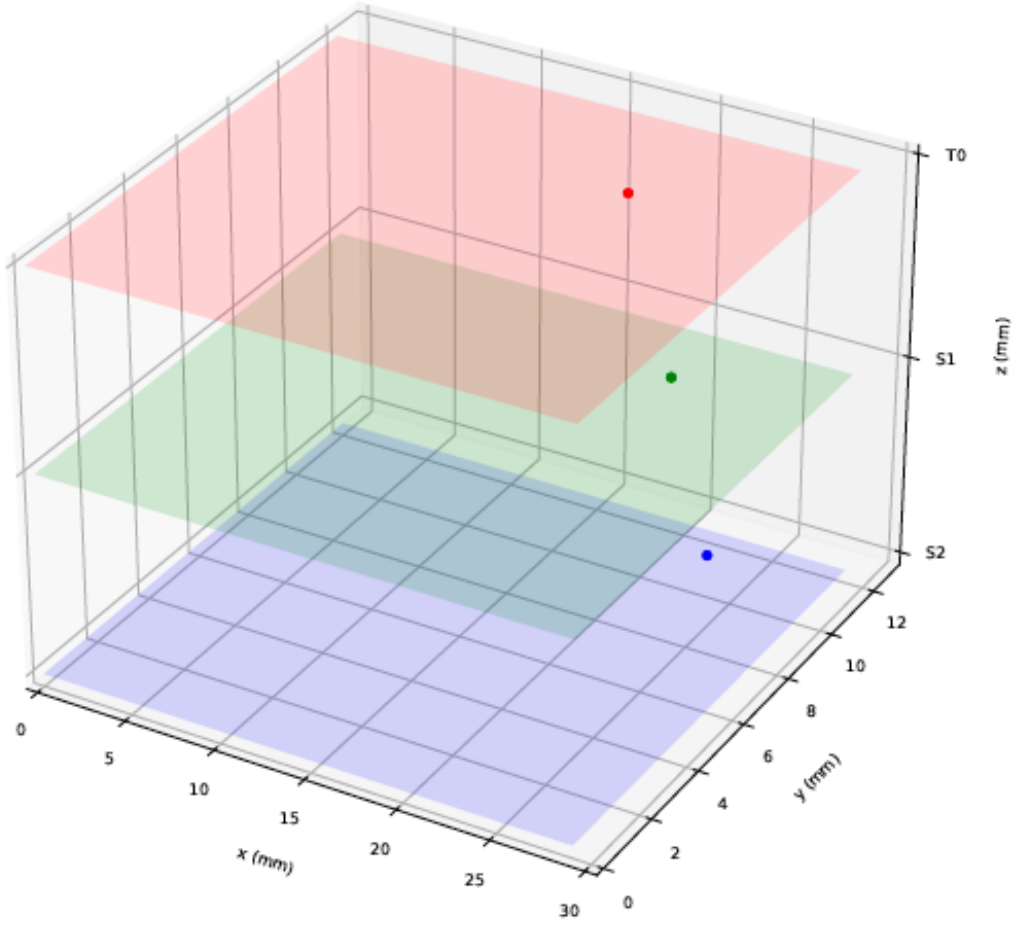
Iaroslav Panasenko (Lund), Zhenyu Ye (Berkeley)

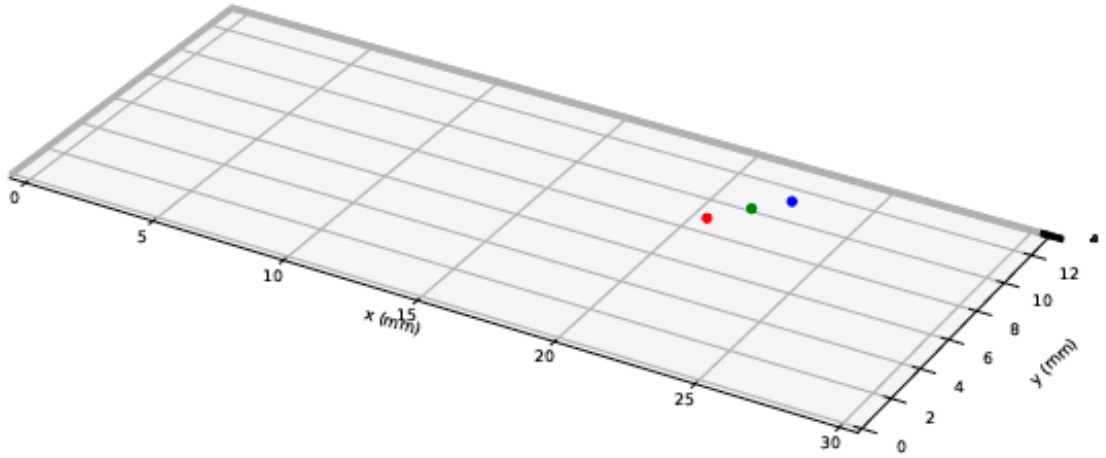


- Changes to the baby-moss FW (and SW) to fix DAQ hanging problem with high trigger rate
  - The trigger module output is enabled only when busy is low
  - Also added a control register to the trigger module to enable/disable output
  - When event FIFO is full, raise the busy signal until FIFO is empty
- The system was tested ok with triggers from a pulse generator at 2 kHz (in prep. for beam)
- Assembled a baby-moss telescope for cosmic
  - 1 trigger board, 3 sets of baby-moss sensor + DAQ + raiser boards separated by ~2.3 cm each, 2 scintillators on top and below for triggering
  - The trigger and busy lines of the DAQ and trigger boards are daisy-chained together
  - Recorded ~4k events at ~1.1 Hz over the weekend, ~10% having hits in all 3 sensors

Recorded Cosmic Events

More can be found under cosmic_event.pdf

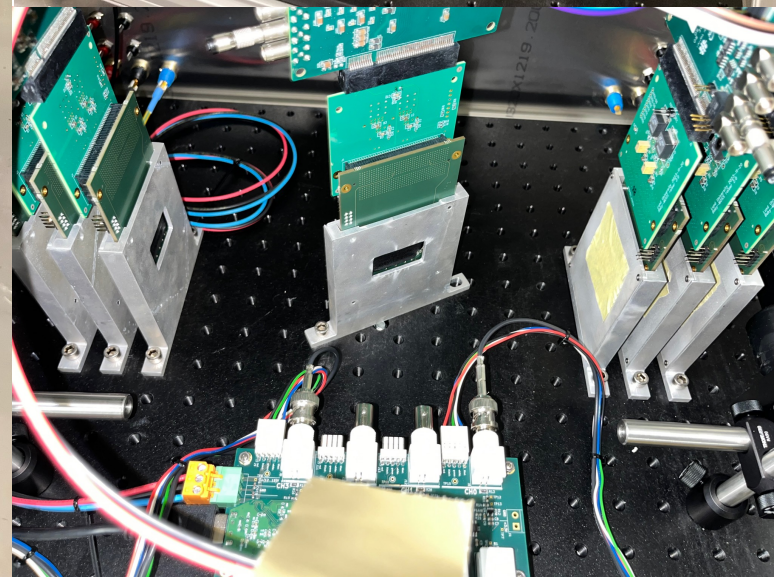


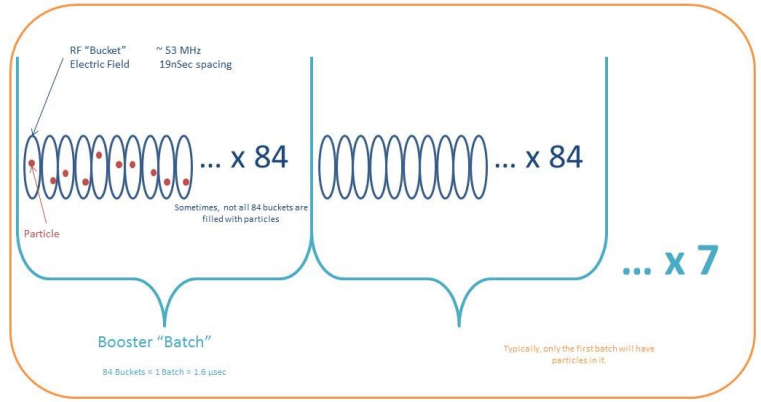


Very first event with hits in all 3 planes recorded on Feb 16, 2024

BabyMOSS Telescopes

Beam Telescope at FTBF



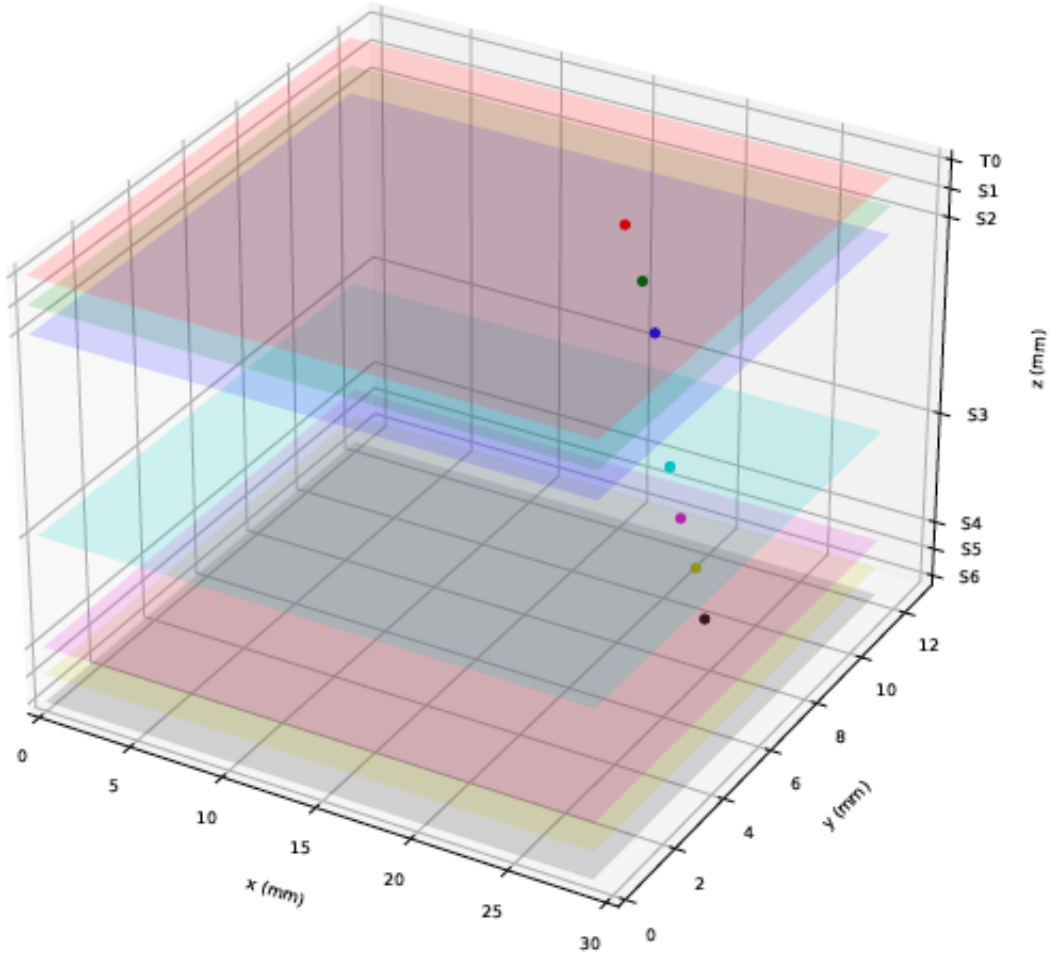


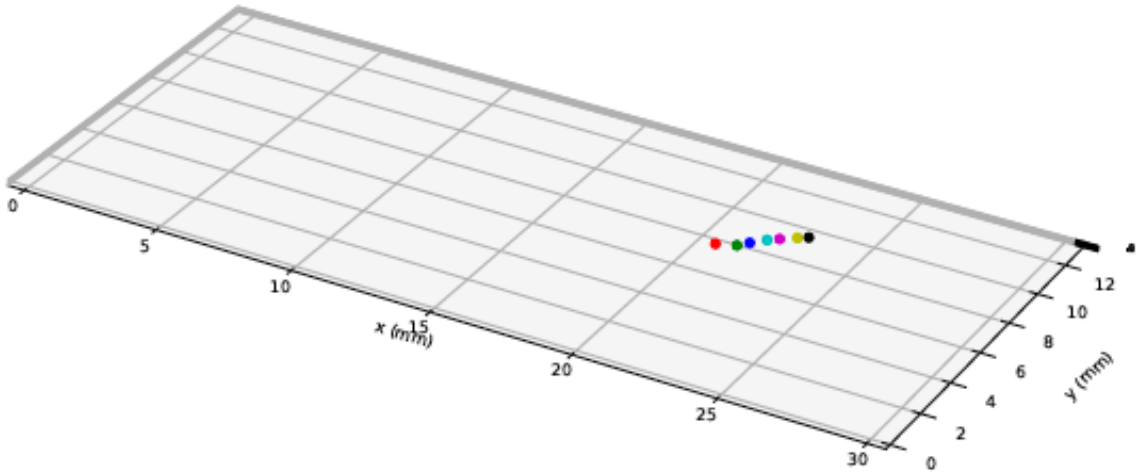
7 Batches = 1 MI Cycle = 11.2 microSec

- 19 nanoseconds = 1 RF bucket (53 MHz)
- 1.6 microseconds = size of booster (84 RF buckets), called a "batch"
- 11.2 microseconds = size of Main Injector cycle (7 Batches)
- 4.2 seconds = 1 spill (375k MI cycles)
- 60 seconds = approximate rep rate of spill

only one particle per Main Injector RF bucket would be extracted per rotation, but for intensities up to 100 kHz, double occupancy occurs 35% of the time and two particles are extracted instead. This percentage can increase at higher intensities.

Recorded FTBF Events



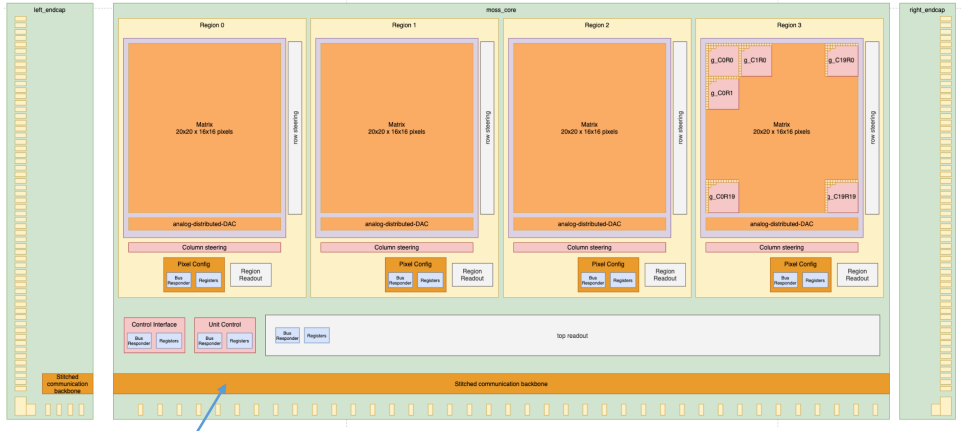


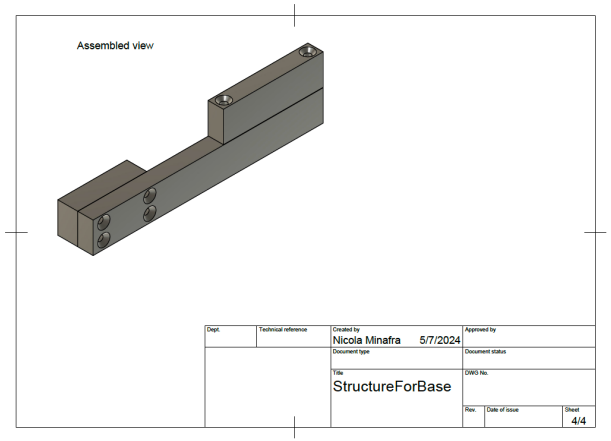
BabyMOSS at Fermilab Test Beam Facility

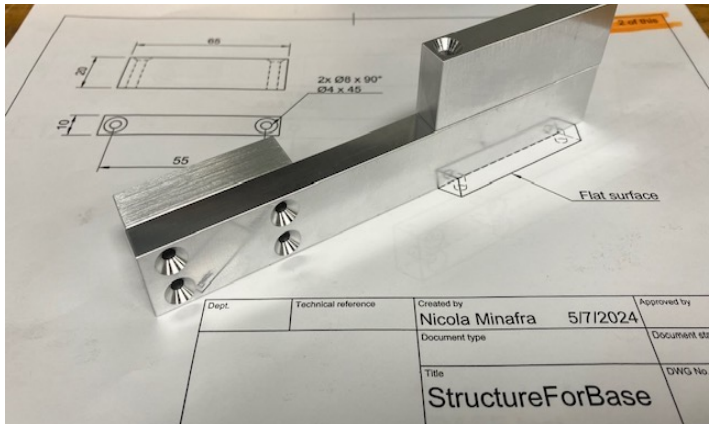
- **LBL/UCB: Tucker Hwang, Zhenyu Ye; UIC: Danush Shekar**
- **Schedule**
  - ✓ **4/15-4/16: initial check at CERN (Iaroslav, ZY)**
    - ✓ **Verified the status of babyMOSS's**
  - ✓ **4/29-5/1: check at LBL**
    - ✓ **Verified the status of babyMOSS, DAQ and raiser boards, trigger board, PMTs and scintillators, PS, DAQ PC**
  - ✓ **5/2-5/7: assemble the telescope**
    - ✓ **Received the telescope box from UIC machine shop**
    - ✓ **Assembled babyMOSS and trigger detectors**
    - ✓ **Verified all the parts are in-hand and working**
  - ✓ **5/8-5/21: install and commission telescope at FTBF**
    - ✓ **Using standalone codes**
  - ✓ **5/22-5/28: take and analyze data as primary user**
    - ✓ **Efficiency, fake rate, spatial resolution**
    - ✓ **Cluster size as a function of incident angle**
  - **6/26-7/2: take data as primary user**
    - **Add LGAD+ETROC2 planes as timing reference for future beam tests**

BabyMOSS SEL Test at BASE - Objectives

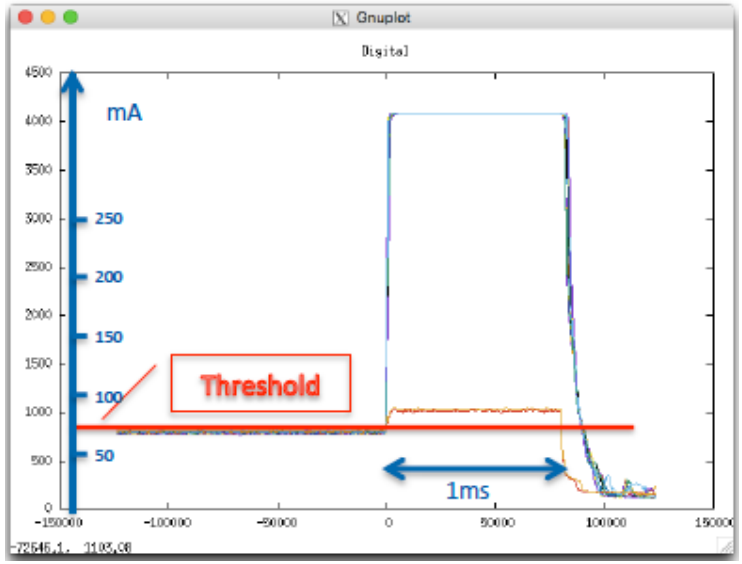
- Identify SEL-sensitive areas on the babyMOSS using motion-controlled collimators

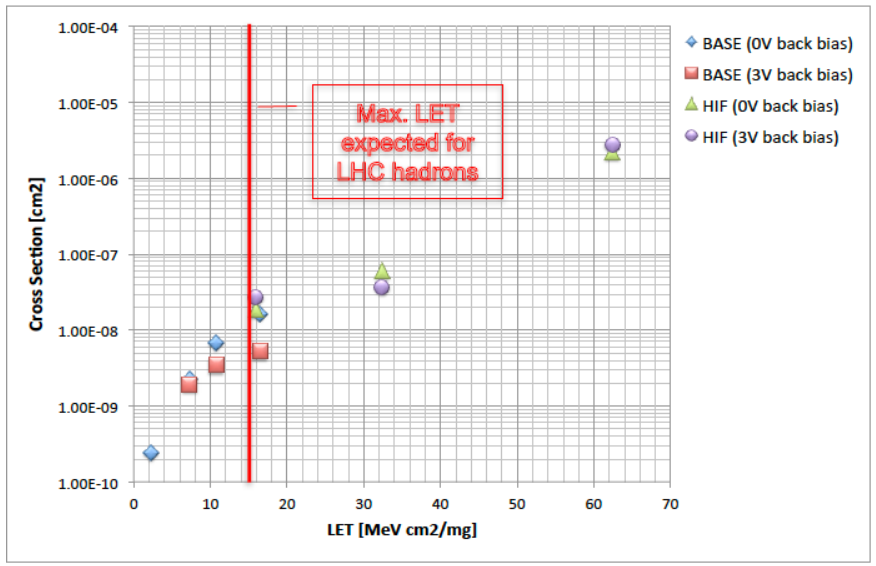






- Measure SEL cross-section as a function of linear energy transfer (below are measurements done on ALPIDE)





Ref: Hartmut Hillemanns @ CERN
LHC Radiation Effects Symposium 2018

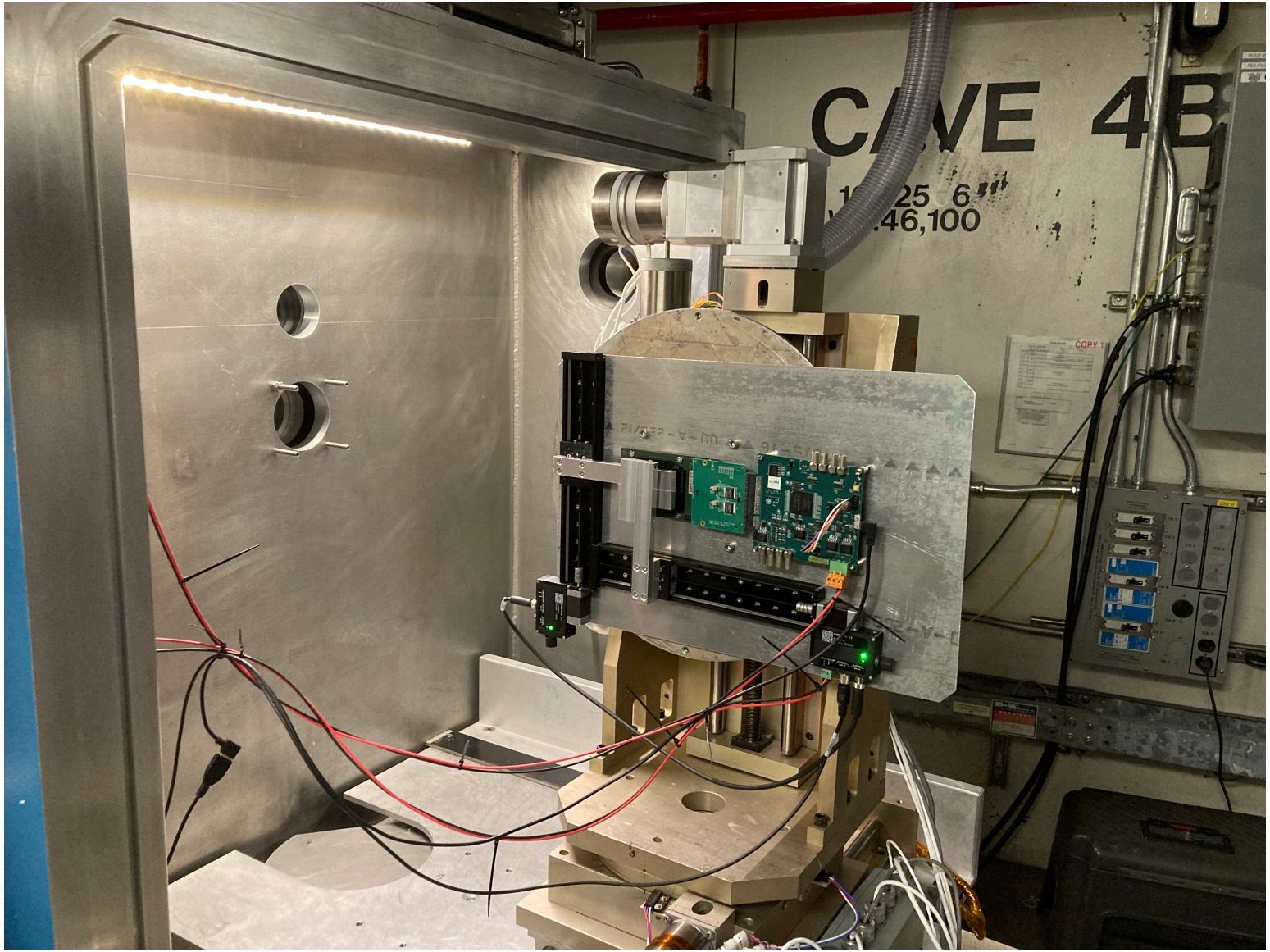
Berkeley Accelerator Radiation Facility

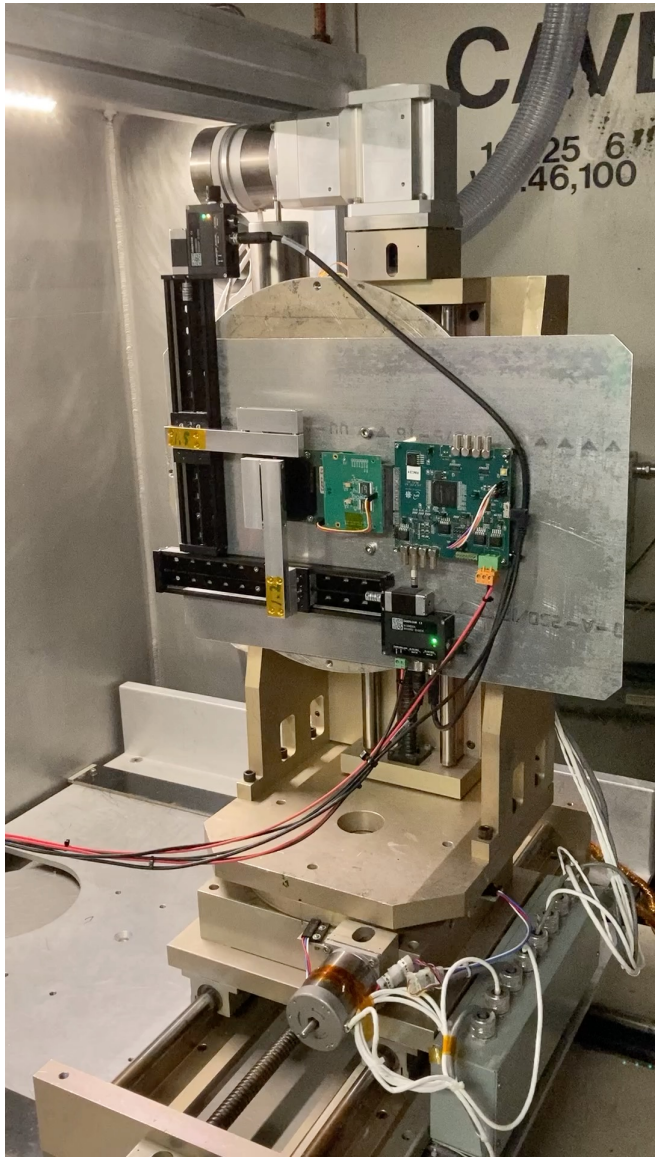
- Berkeley Accelerator Space Effects Facility, LBNL https://cyclotron.lbl.gov/base-rad-effects
  - Heavy ions with fluxes up to 10^7 $cm^{-2}s^{-1}$ and LET between 1-100 MeV/(mg/cm^2)

Ion	**Cocktail** (AMeV)	**Energy** (MeV)	**Z**	**A**	**LET (Entrance)** (MeV/mg/cm2)	**Range in Si (Max)** (μm)
B	**10**	44.90	5	10	**1.65**	78.5
N	**10**	67.44	7	15	**3.08**	67.8
Ne	**10**	89.95	10	20	**5.77**	53.1
Si	**10**	139.61	14	29	**9.28**	52.4
Ar	**10**	180.00	18	40	**14.32**	48.3
V	**10**	221.00	23	51	**21.68**	42.5
Cu	**10**	301.79	29	63	**29.33**	45.6
Kr	**10**	378.11	36	86	**39.25**	42.4
Y	**10**	409.58	39	89	**45.58**	45.8
Ag	**10**	499.50	47	109	**58.18**	46.3
Xe	**10**	602.90	54	136	**68.84**	48.3
Tb	**10**	724.17	65	159	**77.52**	52.4
Ta	**10**	805.02	73	181	**87.15**	53.0

  - Proton and neutron beams are also available for SEE, TID, and NIEL studies

BabyMOSS SEL Tests at BASE – Setup





BabyMOSS SEL Tests at BASE - Schedule

- **LBL/UCB: Anjali Nambrath, Barak Schmookler, Barbara Jacak, Emma Yeats, Zhenyu Ye**
- **CERN: Hartmut Hillemanns; KU: Nicola Minafra**
- **Schedule:**
  - **May 22**
    - 07:00-16:00 installation and commissioning
  - **May 23-24**
    - 08:00-11:30 beam tuning
    - 11:35-11:50 $4x10^3$ $cm^{-2}s^{-1}$ Xe beam with maximum intensity limited by contaminations
    - 12:10-16:40 Y beam with intensity up to $2x10^5$ $cm^{-2}s^{-1}$
    - 17:30-08:30 Xe beam with intensity up to $4x10^5$ $cm^{-2}s^{-1}$
      - 17:30-03:00 scan in X-Y with 1.5-mm collimator gap in X and 1.2-mm collimator gap in Y
      - 03:00-04:30 reduce the collimator gap sizes
      - 04:30-08:30 scan in X-Y with 0.2-mm collimator gap in X and 0.2-mm collimator gap in Y
  - **July 1**
    - 12:00-16:00 installation and beam tuning
    - 16:00-20:00 measure SEL cross-section as a function of LETs with different ion beams
    - 20:00-24:00 scan in X-Y with 0.2-mm collimator gap in X and 0.2-mm collimator gap in Y with Xe beam

Summary and Outlook

- **Beam Tests at Fermilab Test Beam Facility**
  - Commissioned a 7-plane babyMOSS telescope and took data with 120 GeV protons at FTBF
    - Spatial resolution consistent with expectation
    - Studied cluster size dependence on incident angle
  - Next steps:
    - Finish data analysis and report the findings
    - Prepare for 2nd beam test on June 26-July 2 with the addition of DC-LGAD+ETROC2 planes
    - (AC-LGAD) Test beam in the Fall – options at DESY, FTBF, Jlab being considered

- **SEL Tests at Berkeley Accelerator Space Effects Facility**
  - Searched for SEL-sensitive areas on babyMOSS with motion-controlled collimators
  - Next steps:
    - Finish data analysis and report the findings
    - Complete the X-Y position and LET scans on July 1 (~8 hours)