R2E test campaign at IRRAD

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SY-STI-BMI - R2E Project

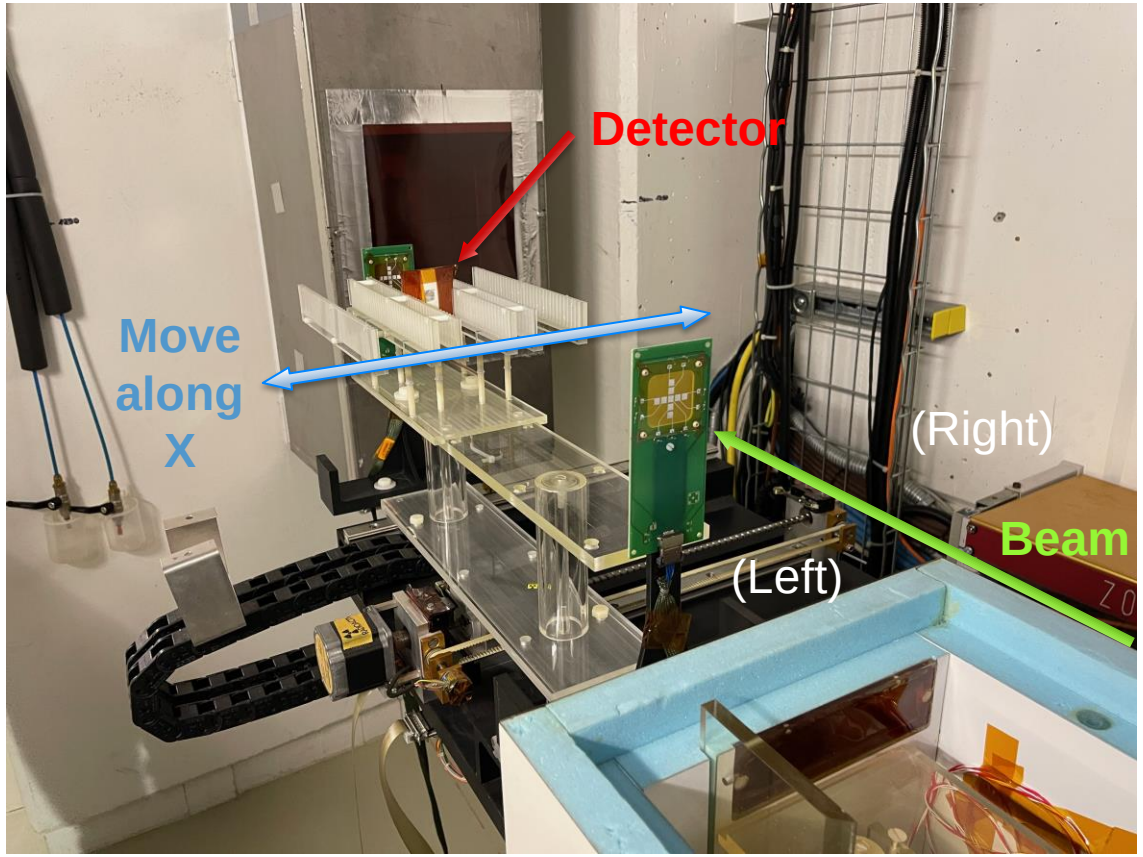
December 1st, 2021

Test campaign summary

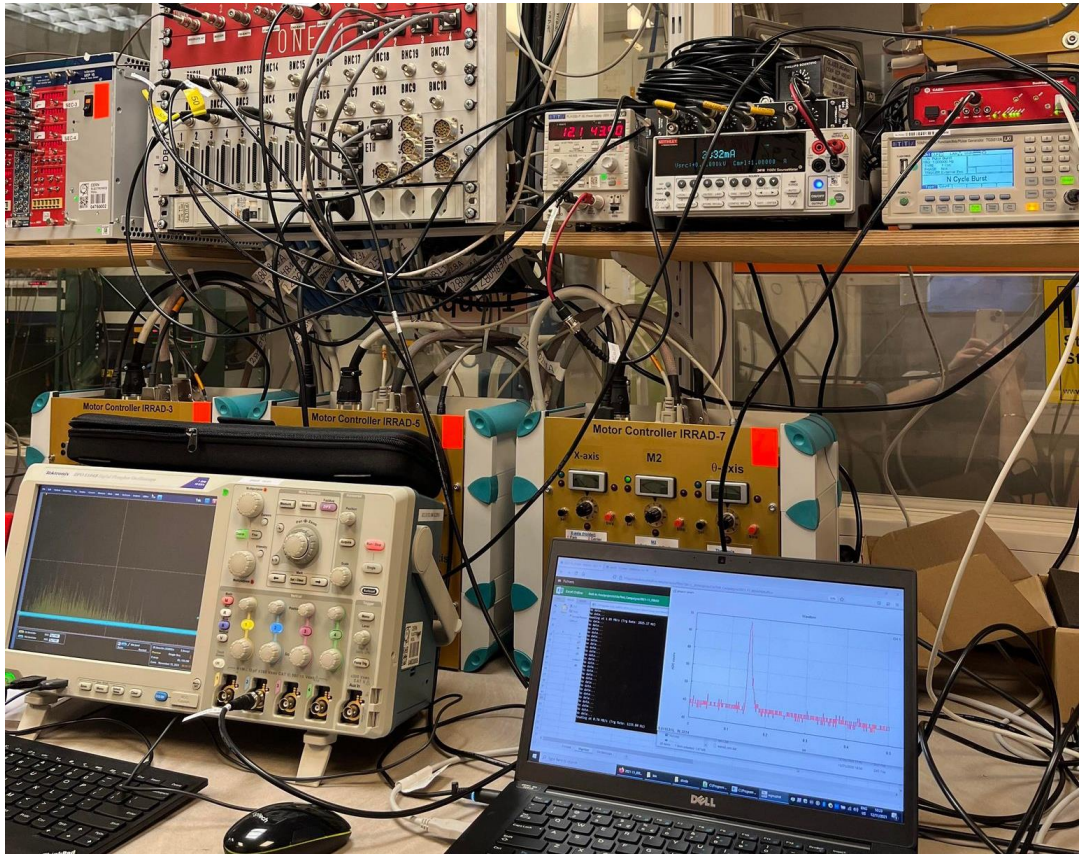
- **Where:** IRRAD @ CERN
- **When:** November 3rd – 14th, 2021
- **Particles:** 24 GeV protons
  5 GeV/n Pb^{82+} ions
- **Detector:** Silicon diode
- **Objective:** Time structure of the proton beam
  Heavy ions on T8 for CHIMERA

Test Setup

Experimental area (zone1)



IRRAD Control room

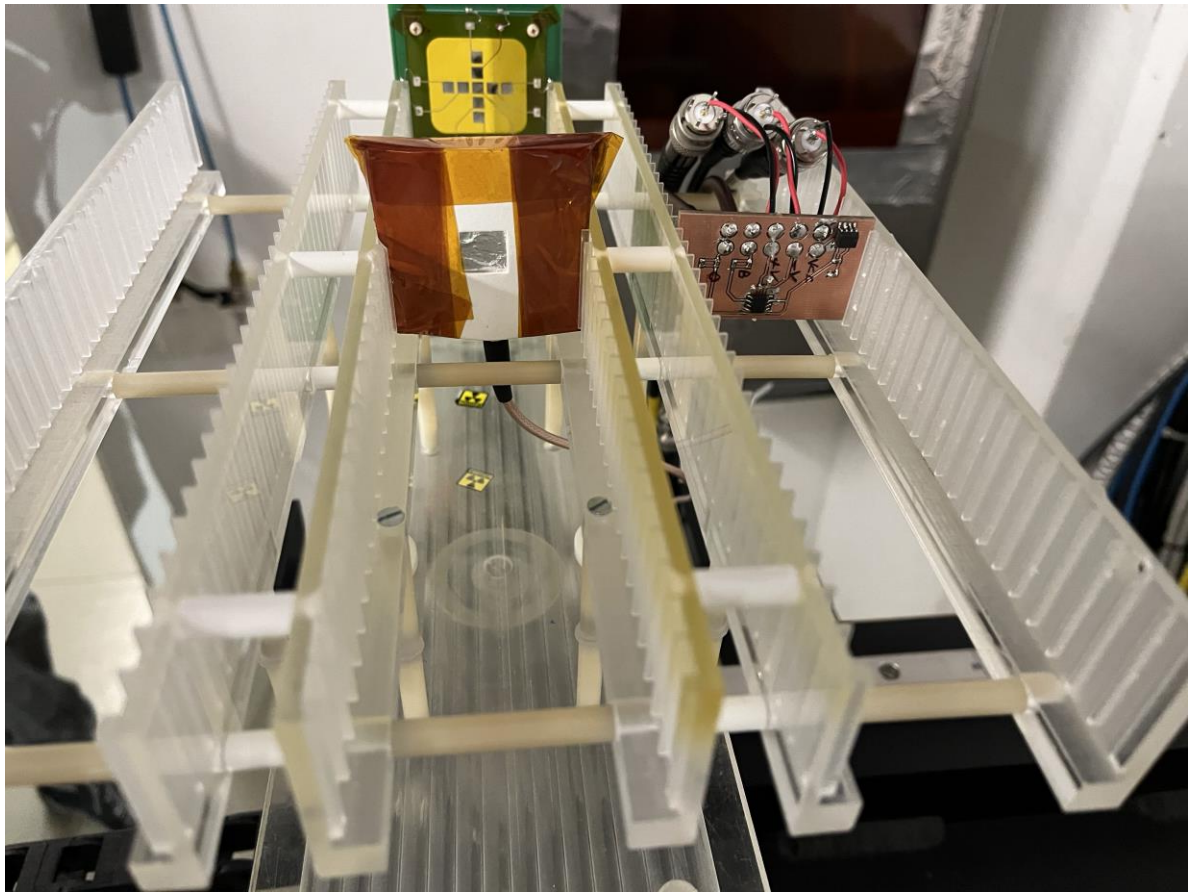


Test Setup

In the middle of the test campaign,
on November 10th, 2021:

- Installation of the optocoupler setup next to the diode
  → see Rudy's presentation

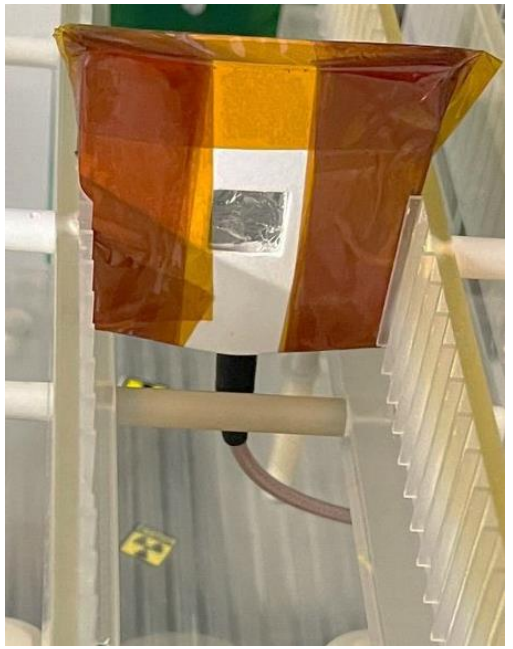
- Both setups move at the same time.



Test Setup – Experimental area

❖ **Detector = silicon diode**

- Model: Canberra
- Active area: 50 mm^2
- Thickness: 300 µm
- Bias voltage: + 110 V
- Leakage current — before: 14 µA
  — after: 28 µA



- Wrapped with1 layer of 300 µm Al foil
- Placed between 2 carton holders with square cut-out
- Placed on a movable table - x axis range = [25cm (left) – 8cm (right)]

Test Setup – Experimental area

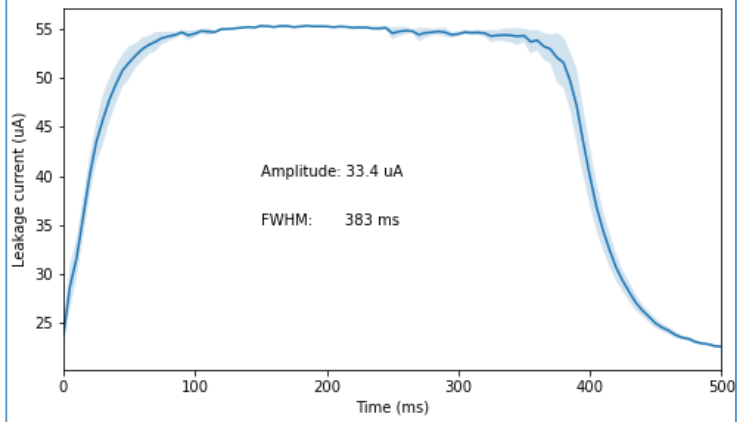
❖ Preamplifier

- Model: Cividec C1HV0089
- Certified gain: 21.9 dB
- Bandwidth: 1 MHz – 2 GHz
- Output saturation: > 1 V
- Output impedance: 50 Ω

- AC coupled, bipolar, inverting.
- Needed to bias the diode.

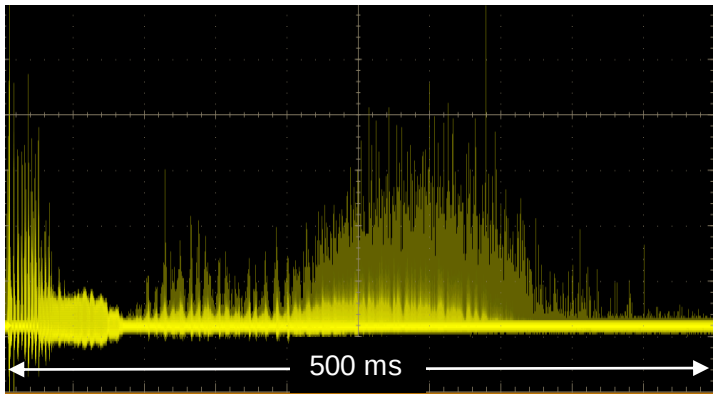
Test Setup – Acquisition modes

SMU current



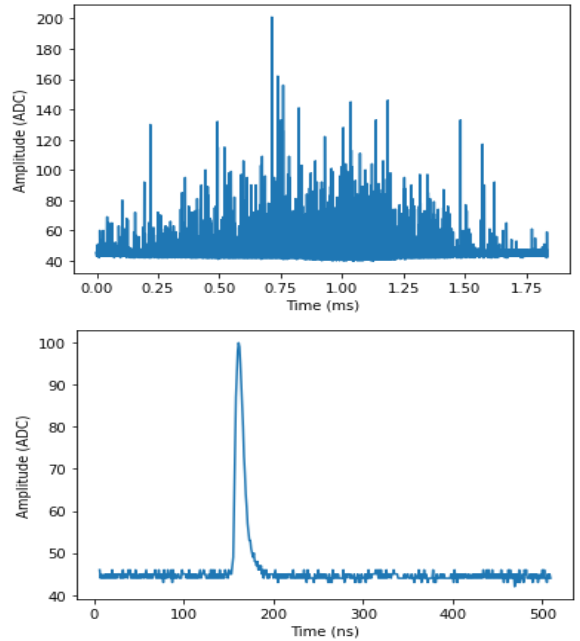
- No trigger
- Acquiring one or several spills
- Sampling frequency: **200 S/s**

Oscilloscope



- IRRAD trigger
- Acquiring one full spill per run
- Sampling frequency: **200/500 MS/s**

Digitizer (ADC)



- Delayed IRRAD trigger / self trigger
- Long (1.835 ms) / short (500 ns)
- Sampling frequency: **1 GS/s**

Beams

Protons

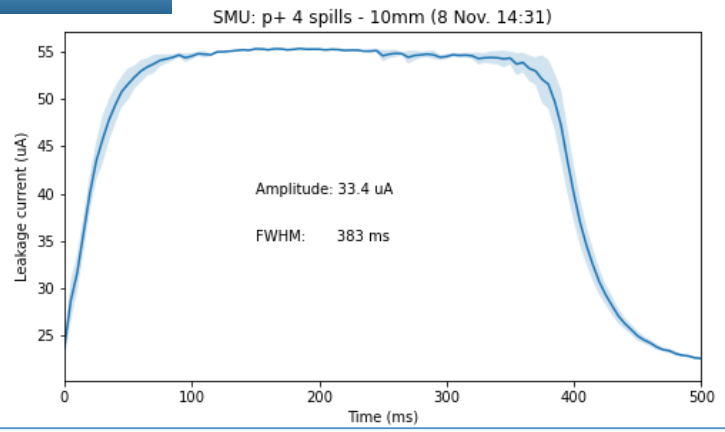
- **Fast extraction:**
  - Signal too high → saturation
  - Could not be measured at all.
- **Slow extraction:**
  - Signal still high → no measurements possible directly in the beam
  - Measuring at different lateral distances from the beam center → beam halo or secondary particles
  - Closest position: 10 mm (diode center – beam center)
  - But it caused significant increase in leakage current → radiation damage

Heavy ions

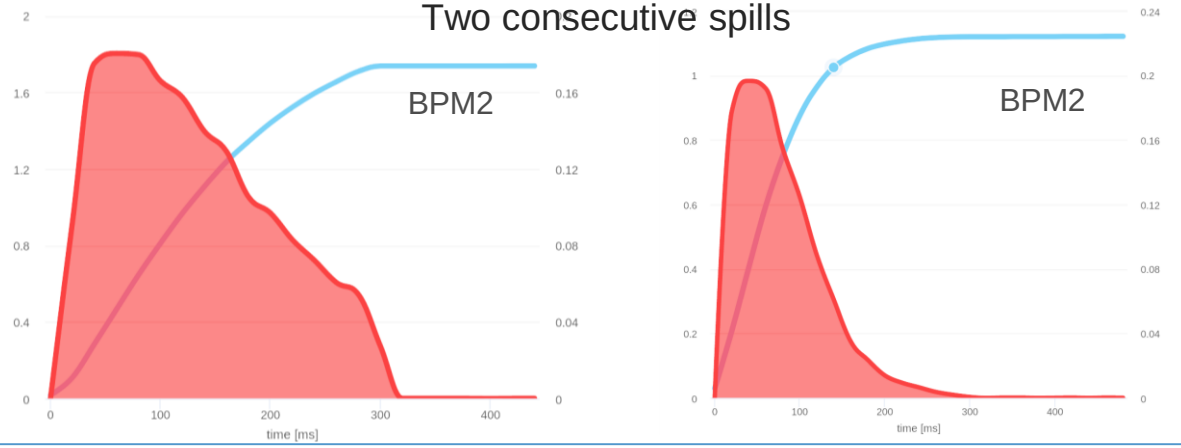
- **Fast extraction:**
  - Measured with the oscilloscope and SMU
  - But too much pile up for the digitizer
  - And slow and fast extraction in the same super cycle → trigger signal aligned with slow.
- **Slow extraction:**
  - With low intensity could be measured with the diode in the beam
  - Had to find the beam center experimentally (BPMs off)
  - Intensity ramp up

SMU current measurement vs. BPM2

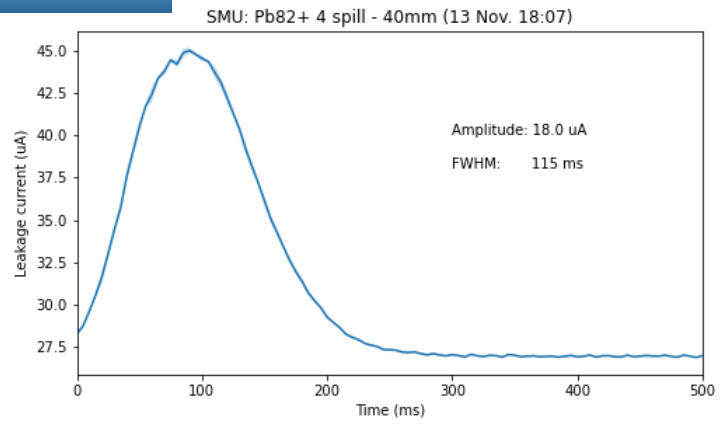
Protons

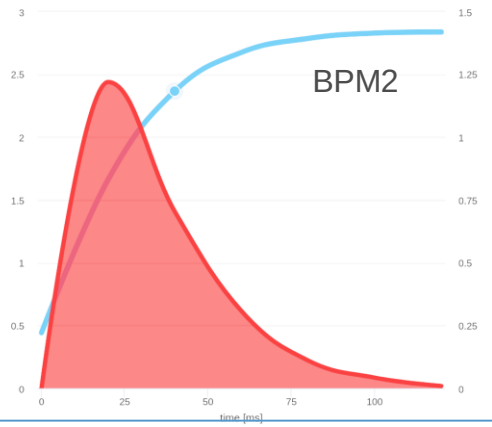


Two consecutive spills



Heavy ions

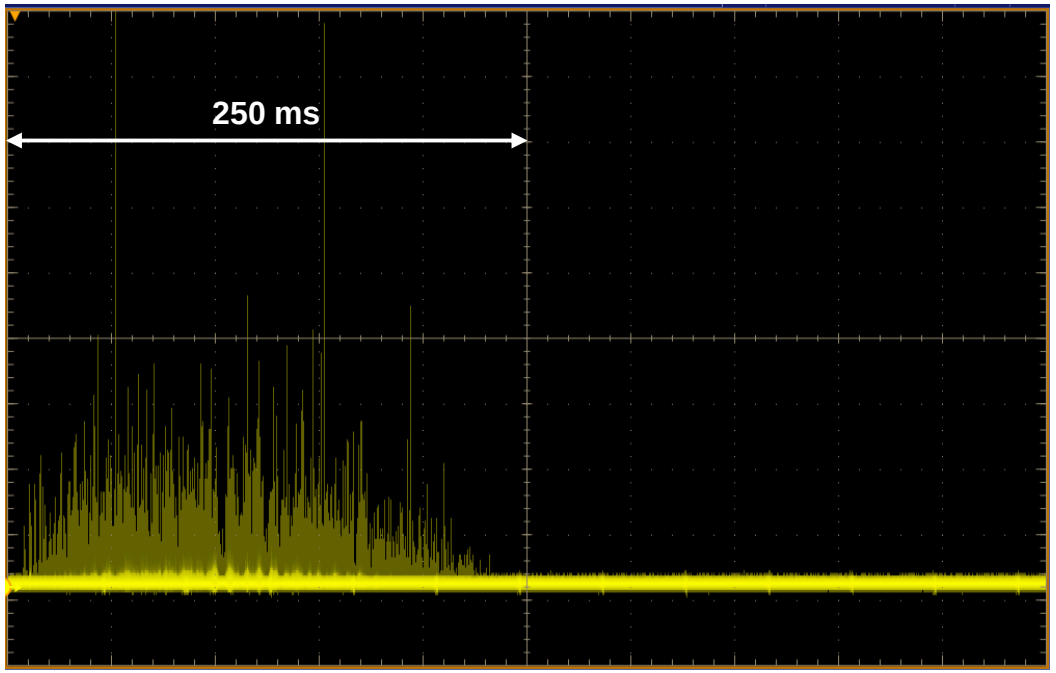




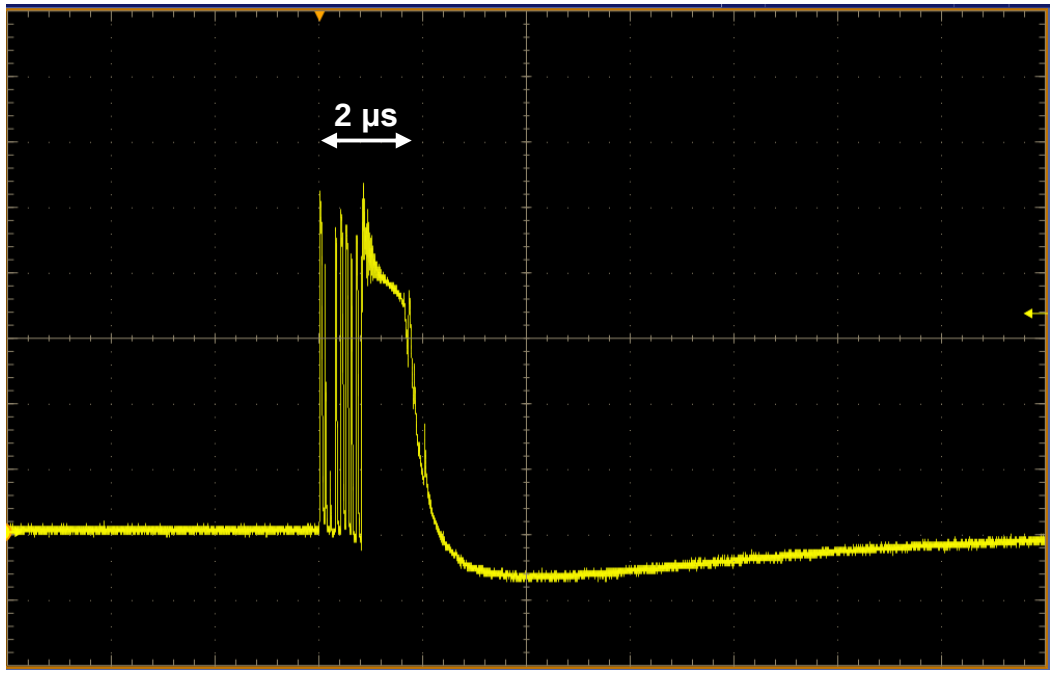
- Similar shape
- Different width

Heavy ions: Slow vs. Fast extraction

Slow extraction



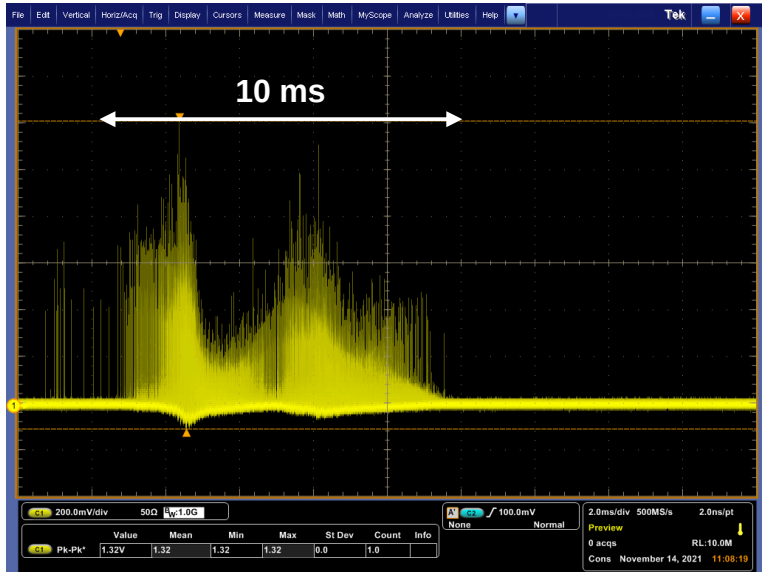
Fast extraction



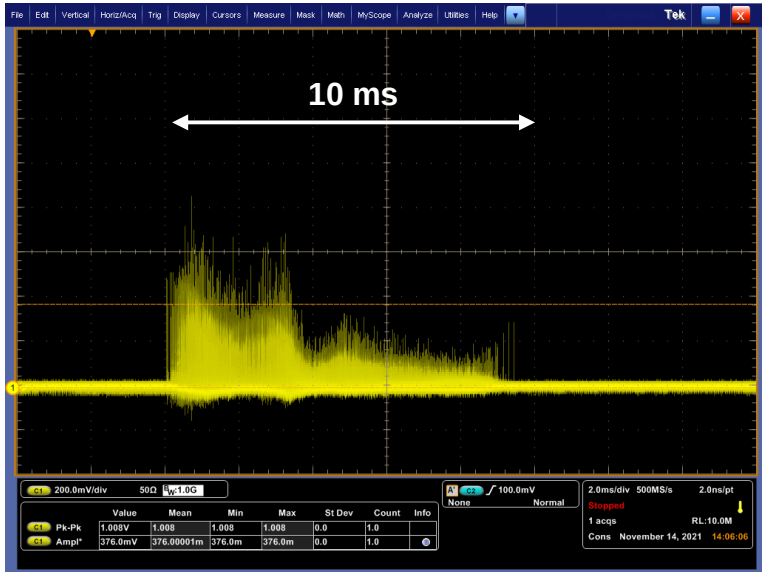
- Beam intensity: 5e10
- Distance from beam center: 10.5 cm
- **Fast extraction → Saturation in amplitude → no measurements closer than 10 cm from the beam, no digitizer**

Heavy ions: Slow extraction & Intensity

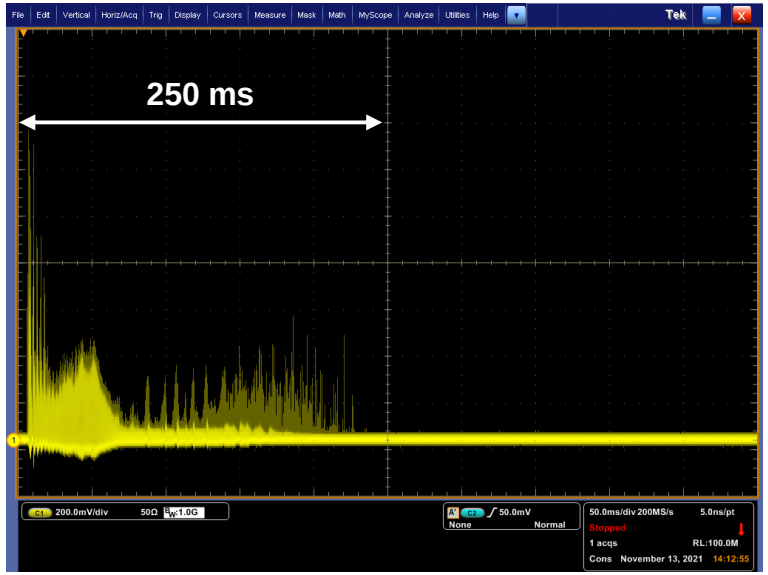
1.6e10



2.5e10



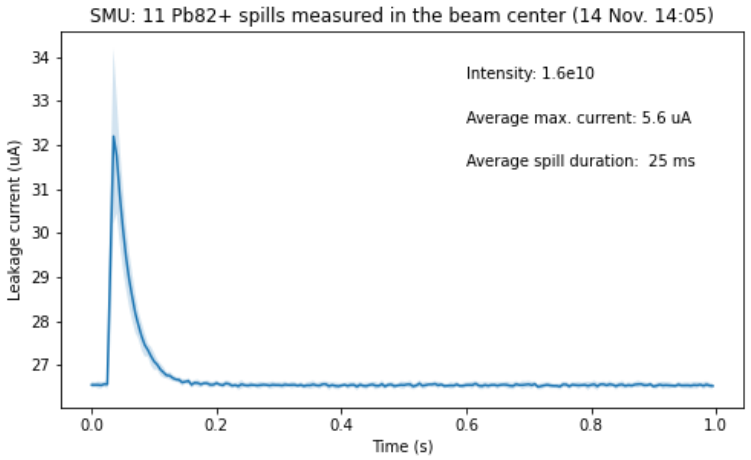
5e10



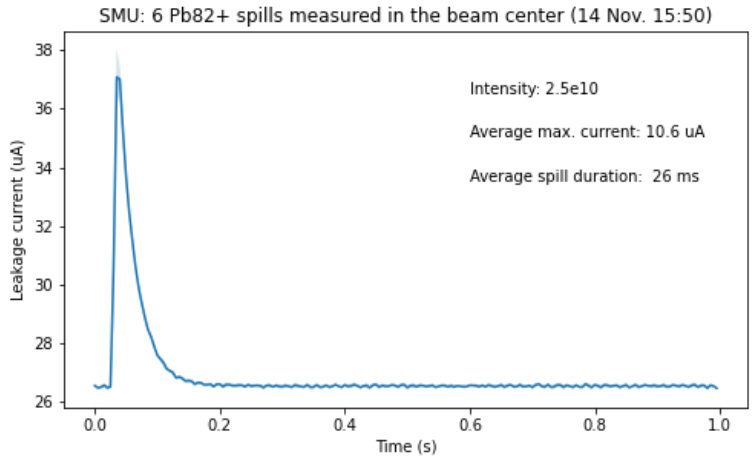
- Distance from beam center: 3 cm
- Same vertical scale for all → No obvious difference in amplitude.
- **Lower intensity → Shorter spill, but similar amplitude.**

Heavy ions: Slow extraction & Intensity

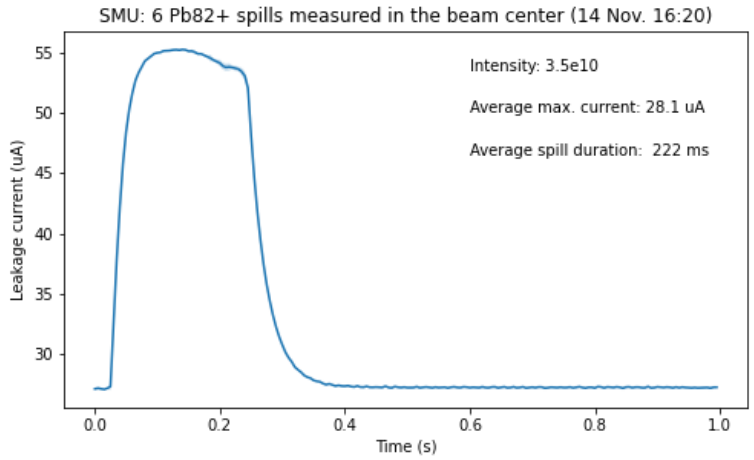
1.6e10



2.5e10



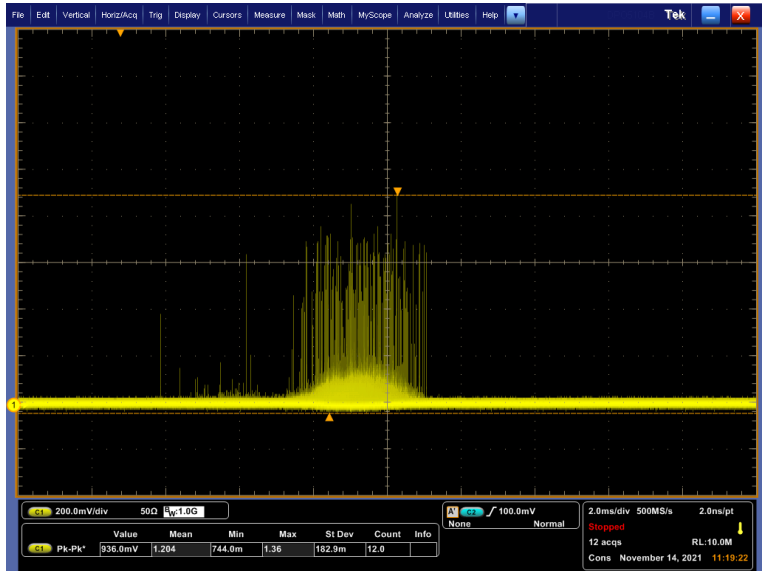
3.5e10



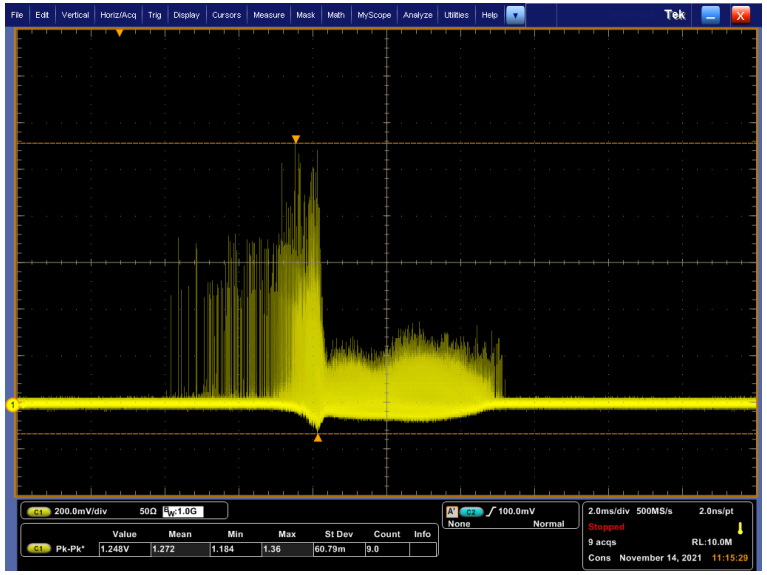
- Distance from beam center: 2.5 cm
- Same observation confirmed by the SMU current measurement as well.

Heavy ions: Slow extraction & Position

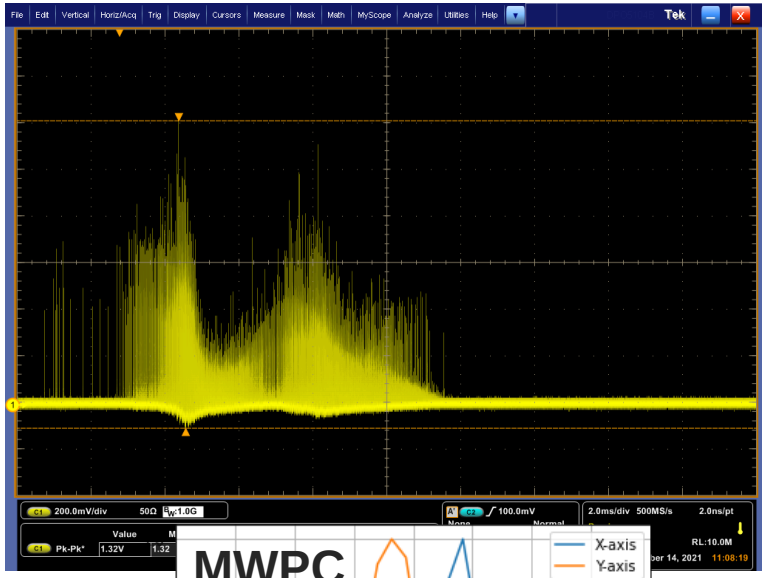
3 cm (left side)

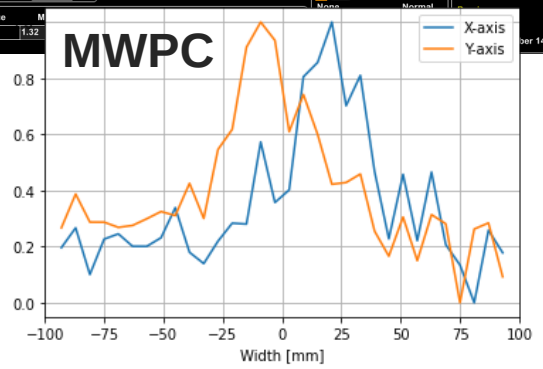


0 cm (nominal center)



3 cm (right side)





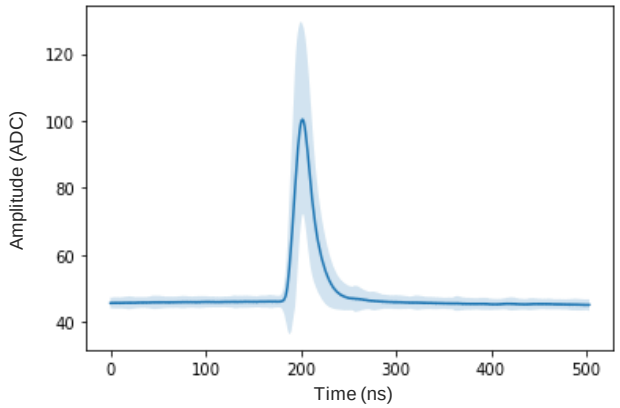
- Beam intensity: 1.6e10 (lowest possible)
- Amplitude & time scale same for all 3
- **The real beam center towards the right side** (confirmed by MWPC)

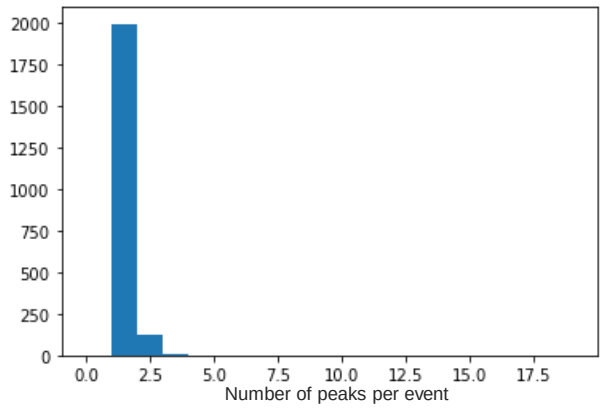
Heavy ions: Digitizer data

High intensity - far from the beam

- Beam intensity: 5e10
- Position: 10.5 cm

98% of frames are single pulses

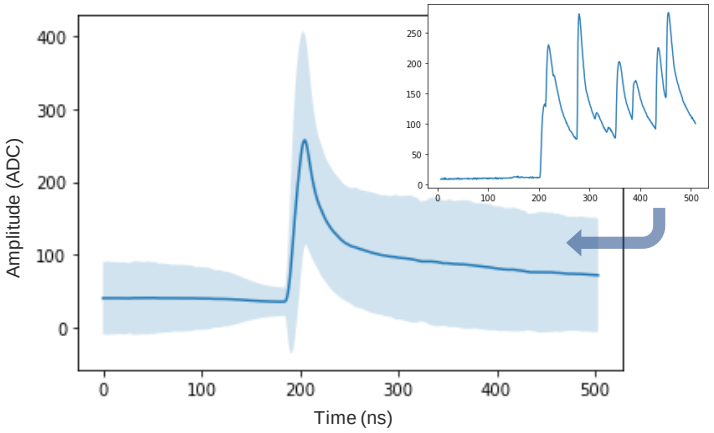


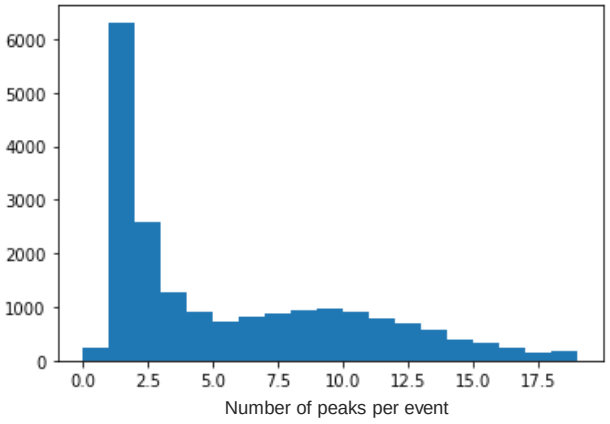


Low intensity - in the beam

- Beam intensity: 1.6e10
- Position: 2.5 cm (actual center)

Only 33% of frames are single pulses
→ pileup





Thank you for your attention!