TRIUMF beam test overview and outlook

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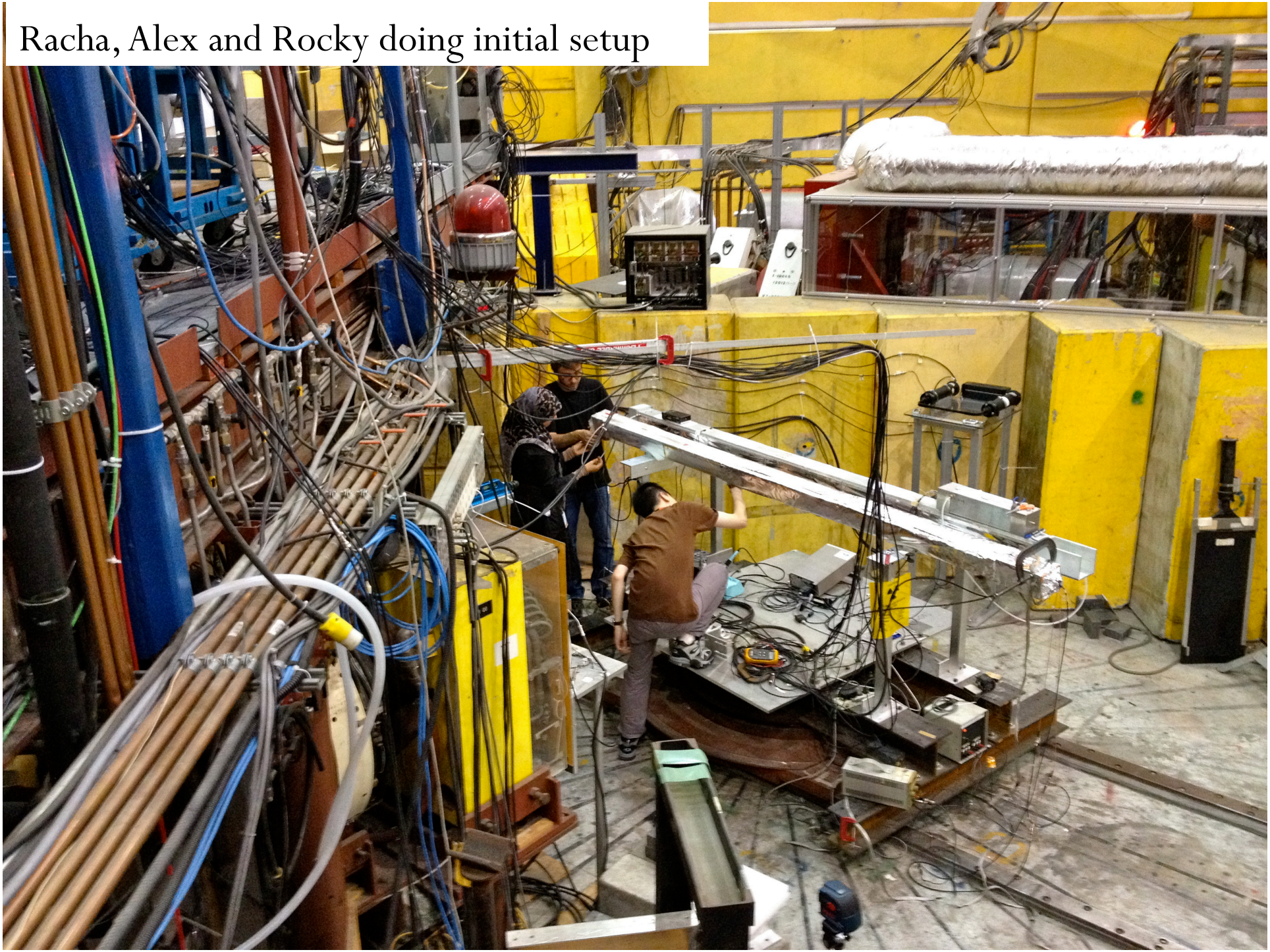
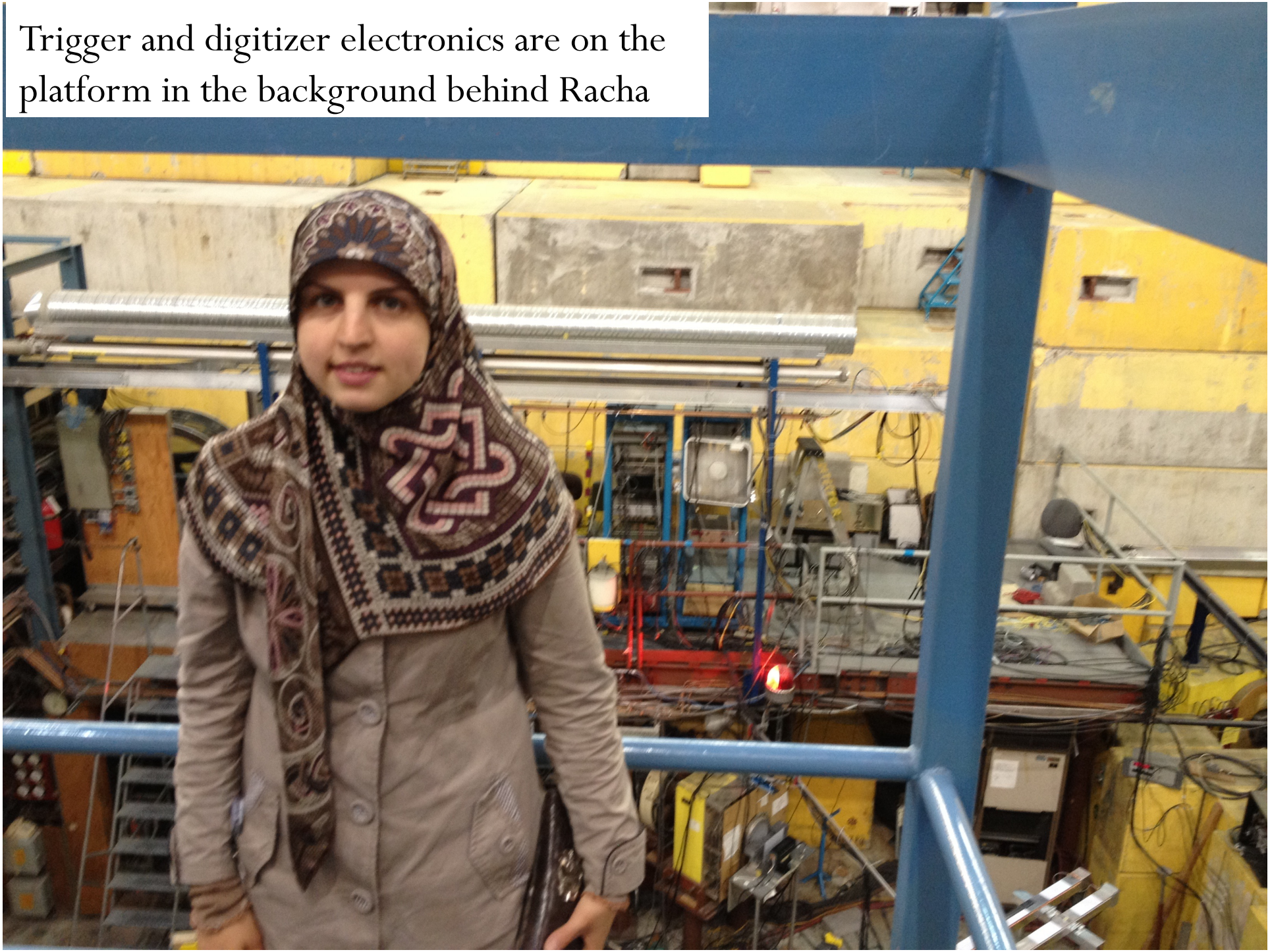
TRIUMF M11 beam line

- We had two blocks of time this summer in the M11 beam line, July 13 – Aug 3 (3 weeks) and Sept 6 – 9.
  - includes set up time
- 140 – 350 MeV/c e^+, μ^+, and π^+
- Shifts mostly taken by students, with some help from Mike and me.
  - Jean-Francois Caron (UBC)
  - Rocky So (UBC)
  - Wyatt Gronnemose (high school student)
  - Sam DeJong (Victoria)
  - Alex Beaulieu (Victoria)
  - Racha Cheaib (McGill)

Racha, Alex and Rocky doing initial setup



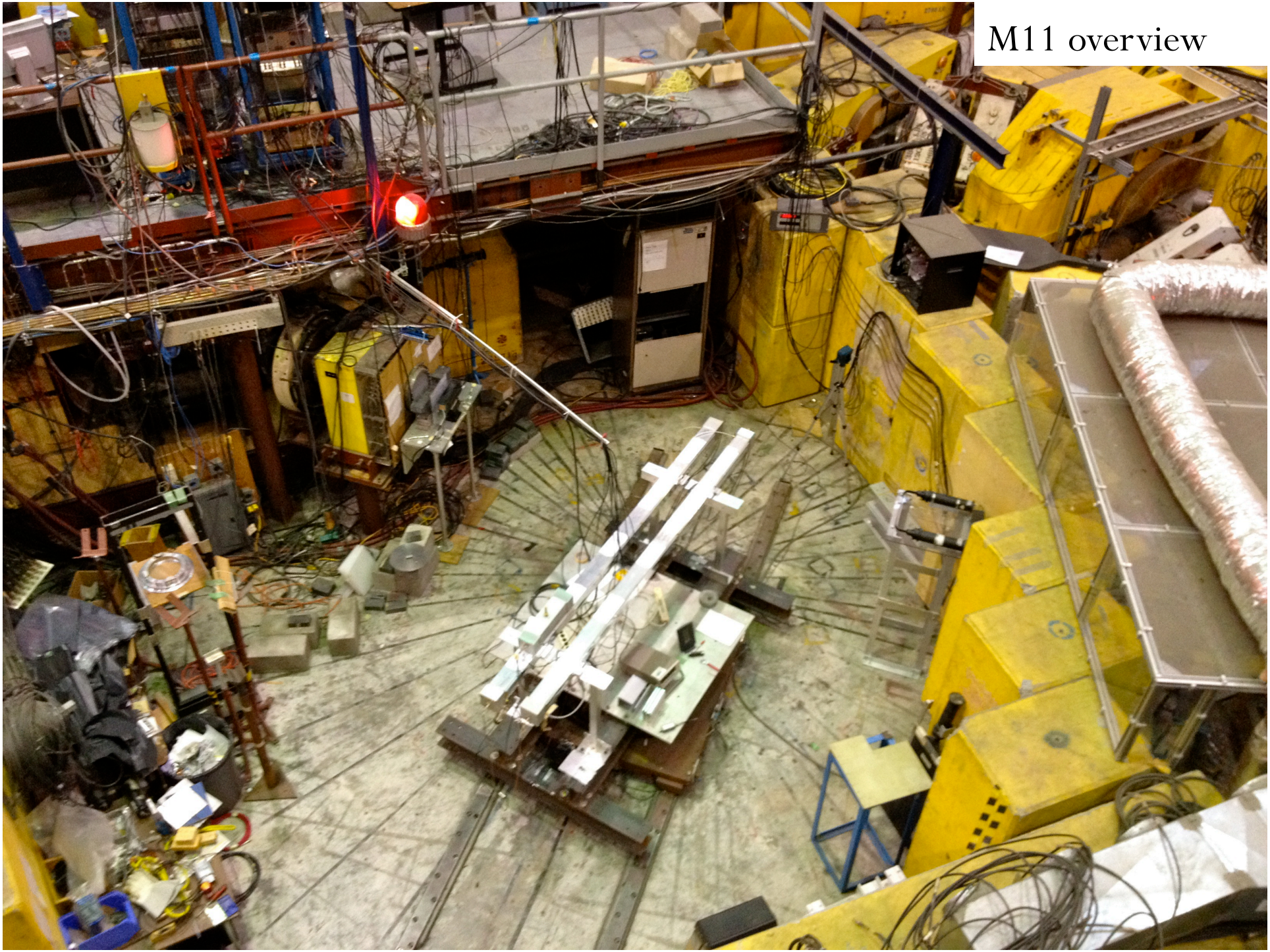
Trigger and digitizer electronics are on the platform in the background behind Racha



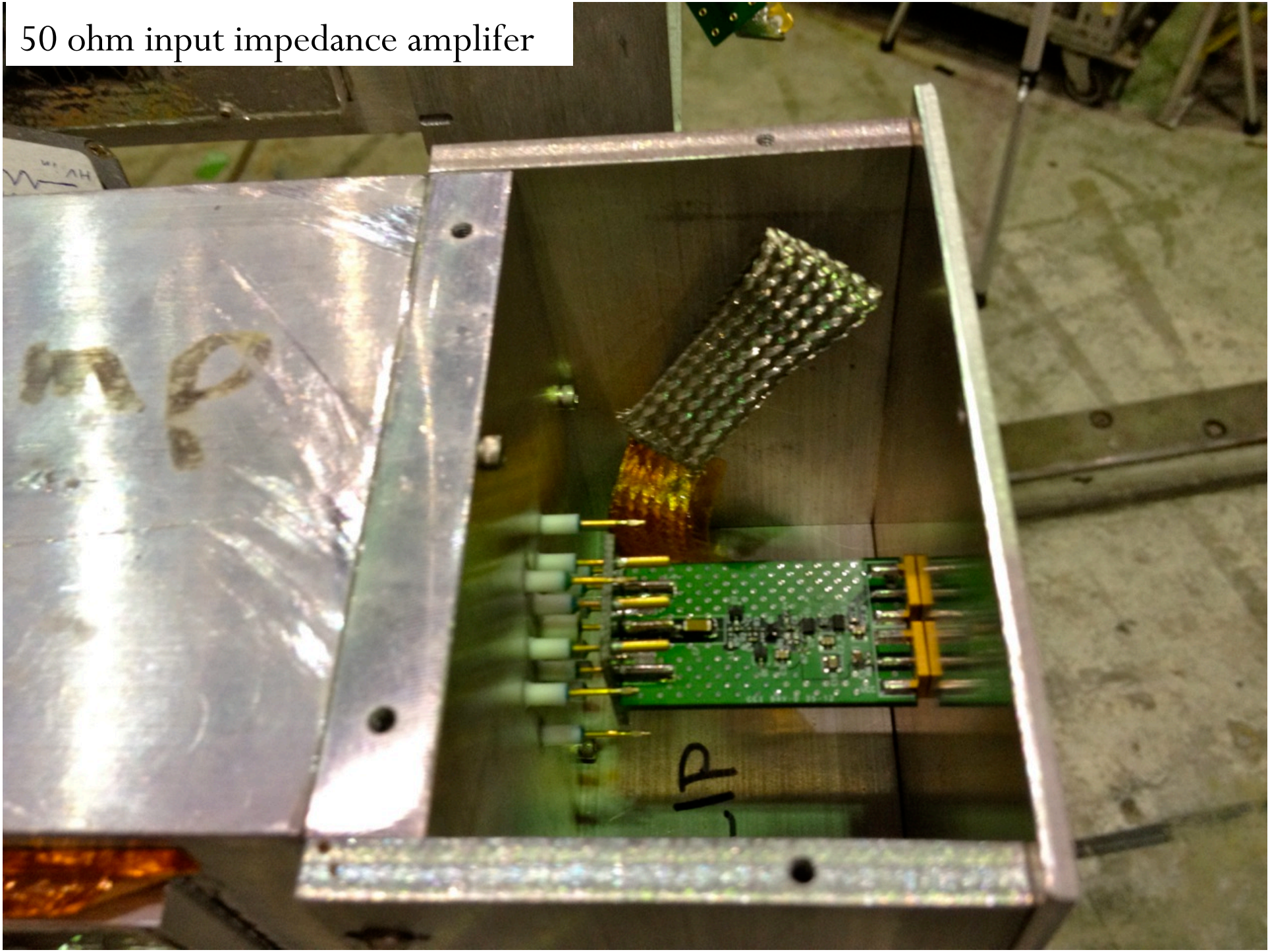
Sam, Rocky, Wyatt

Rocky and Alex switching amplifiers

M11 overview



50 ohm input impedance amplifer



Goals

- Study performance of amplifier prototypes (JP Martin) under realistic conditions.
- Study impact of various design choices on particle ID performance.
  - sense wire diameter
  - analog signal cable between the amplifier and digitizer (five different 75 ohm cables)
  - connectors on this cable
  - bandwidth
  - termination
- Data for student theses.

Not goals

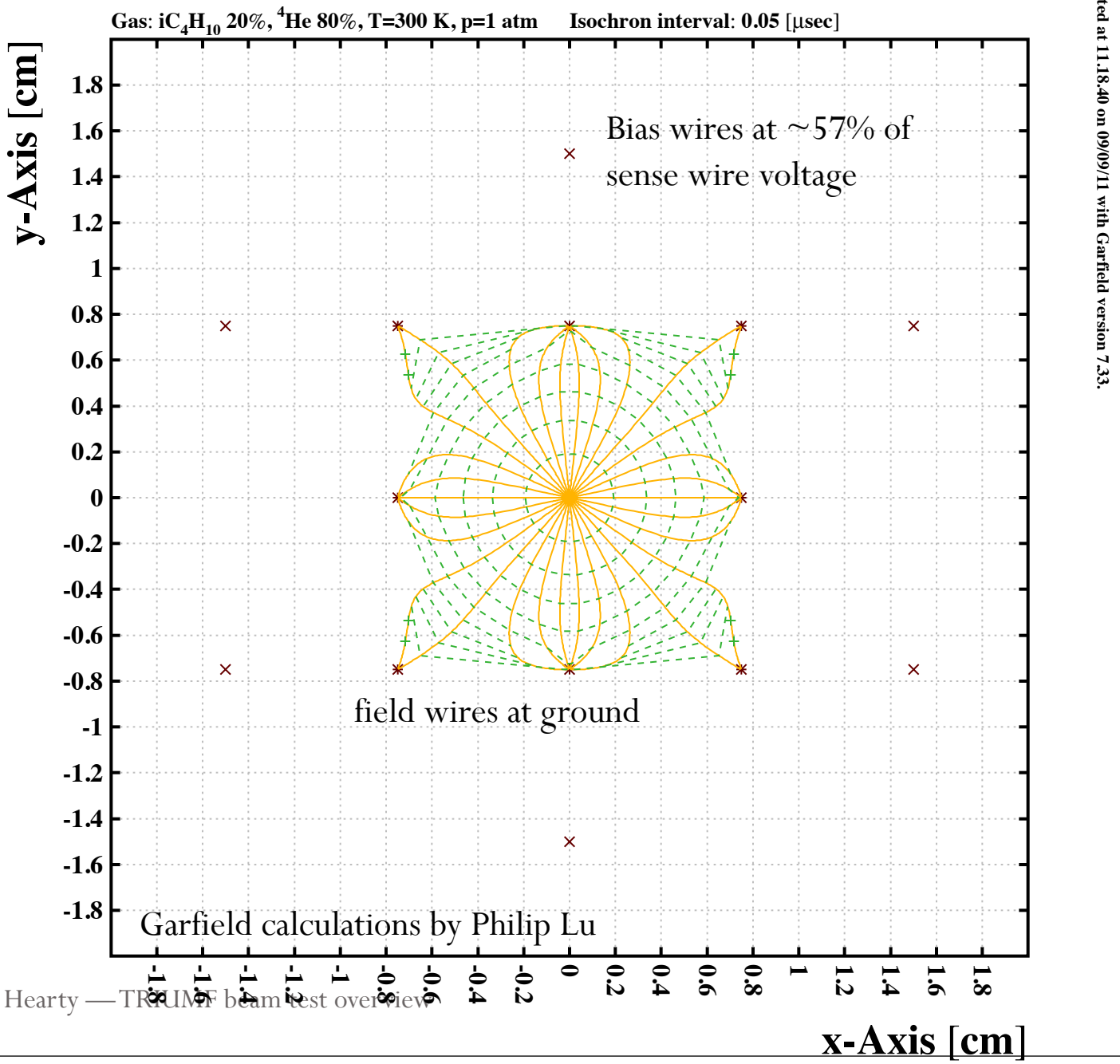
- We did not study:
  - Different gas mixtures (all data was 90:10 He: Iso)
  - Tracking

- Limited study of
  - variation of performance with entrance angle (most data at 10 deg. dip angle)
  - variation of performance with momentum. Most data at 210 MeV/c, with smaller sets at 140 MeV/c (for comparison with November) and 180 – 230 MeV/c

Prototypes

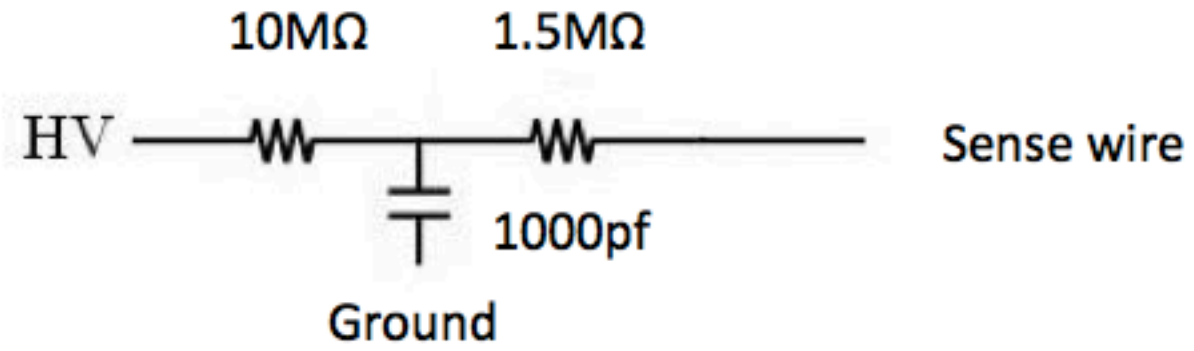
- We had two single-cell prototypes, each 2.7m long.
- 15 mm × 15 mm square cell.
- One had 20 micron sense wire, the other had 25 micron (most data) or 30 micron (last few days).
- five large windows (both entrance and exit) with either 25 micron or 18 micron aluminum.
- terminated at 390 ohms at non-amplifier (HV) end.

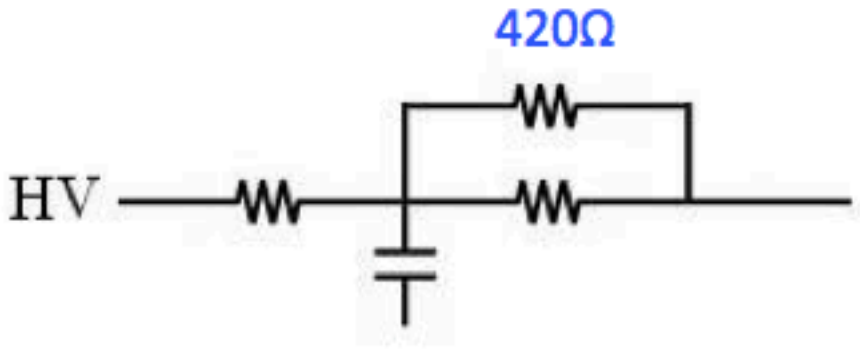
Positron drift lines from a wire



Prototype under construction, showing the five windows

Not terminated (signal can bounce)



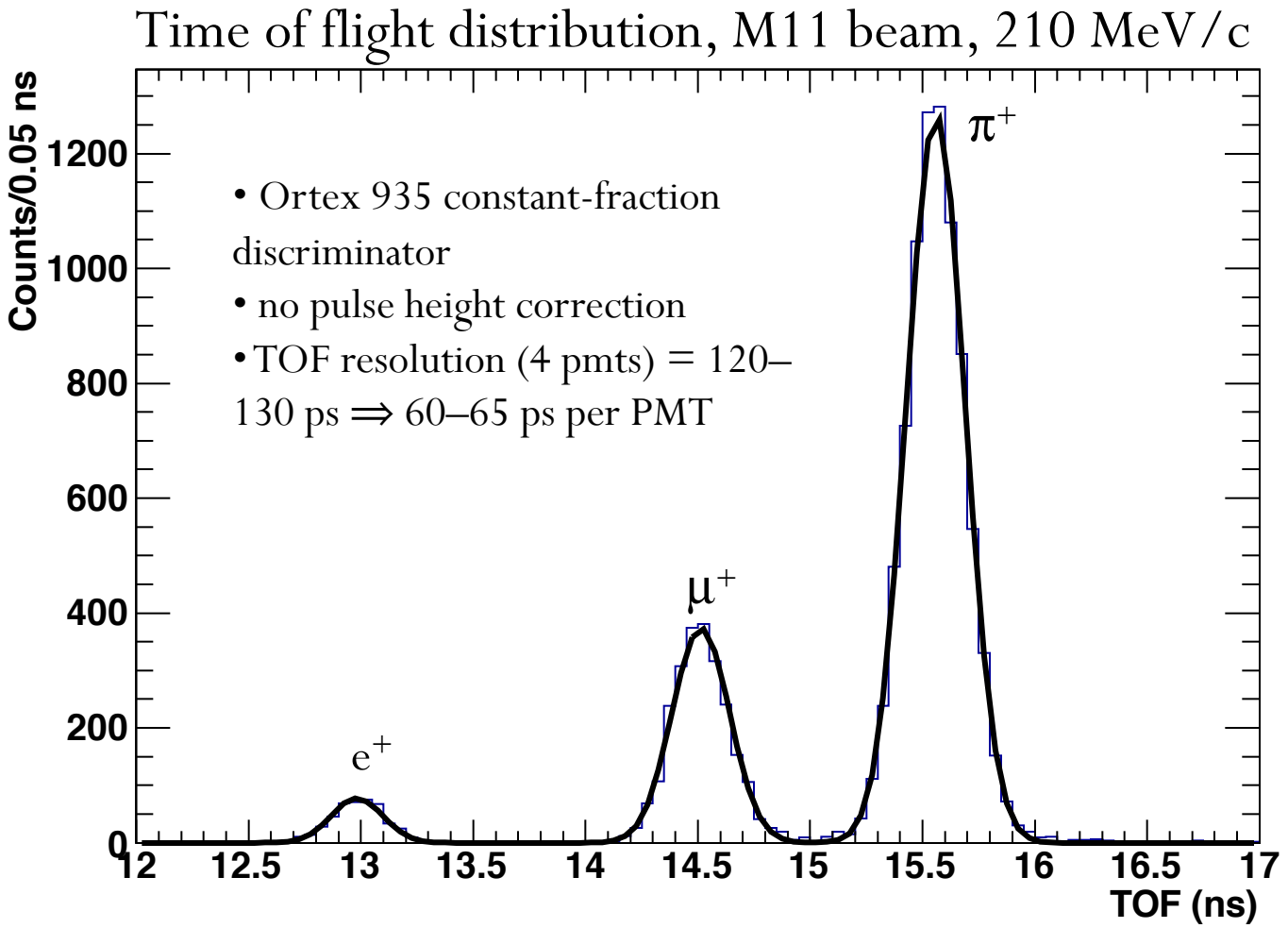


Terminated (signal can't bounce)

The chambers were terminated for almost all data

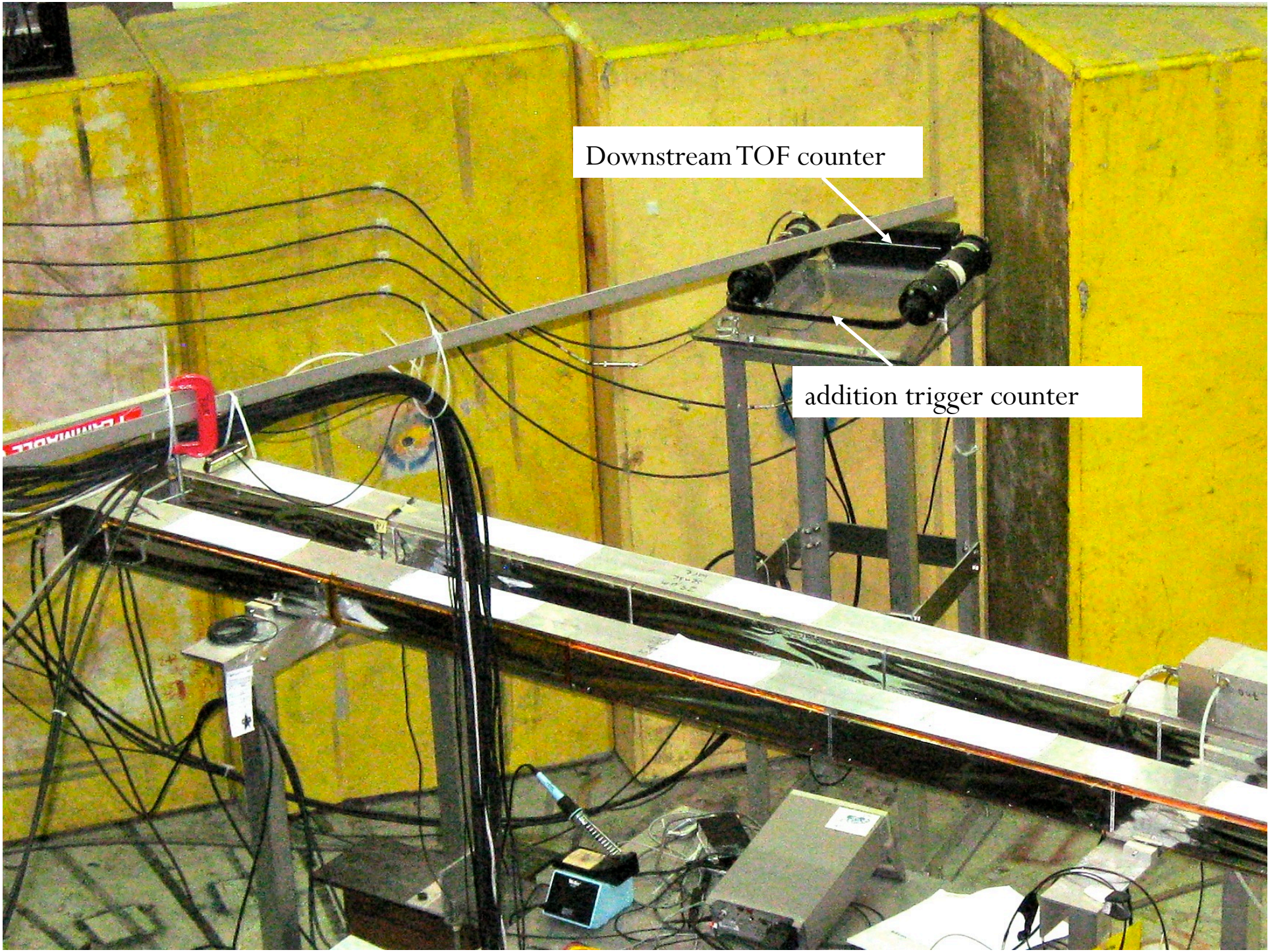
Time of flight

- Two time-of-flight counters, separated by 3.9m.
- Scintillator is $12.7 \times 12.7 \times 220$ mm
  - close to the beam size
- Each counter read by two Burle 64 channel micro channel plates (25 micron pores). We gang together the center four channels (each channel 6×6 mm)
  - on loan from Jerry Va'vra.
- Also have a pickoff signal from the proton beam just before the target, but have not yet used it in the TOF calculation. Not really needed, given the achieved performance.


Time of flight distribution, M11 beam, 210 MeV/c
Counts/0.05 ns
1200
1000
800
600
400
200
0
12
12.5
13
13.5
14
14.5
15
15.5
16
16.5
17
TOF (ns)
• Ortex 935 constant-fraction discriminator
• no pulse height correction
• TOF resolution (4 pmts) = 120–130 ps ⇒ 60–65 ps per PMT
e+
μ+
π+

Trigger

- Added a third thin (3 mm) counter to reduce events in which the particle scatters and hits both TOF counters but misses the chamber. Not clear it helped much.
- Coincidence rate is tens of Hz.
- Also included asynchronous triggers (i.e. trigger on clock)


Downstream TOF counter
addition trigger counter

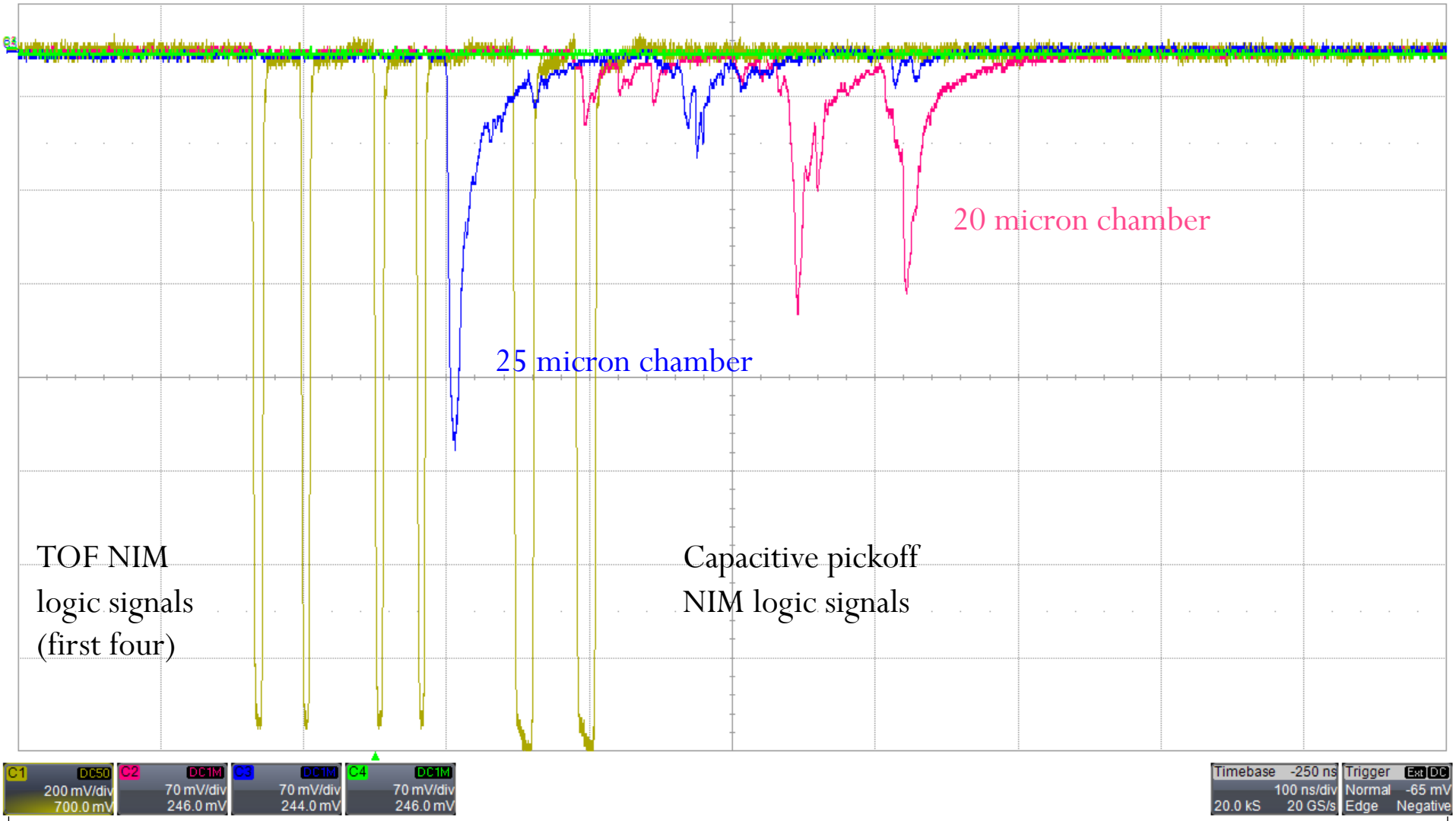
Other items

- Helium:isobutane 90:10 mixed using mass-flow controllers. Generally 200 cc/min; 400 cc/min for some runs.
- Monitoring chamber with Fe55 source, picoammeter readout.
- Added polypropylene absorber before the first TOF counter to range out protons (6.3 mm at 210 MeV/c)
- Mechanical stand can translate and rotate about the y axis
  - i.e. we could vary the dip angle, not entrance angle
  - could not reach the window closest to the amplifier.

DAQ

- Biggest change from November test.
- November: CAEN V1729 SCA used as digitizer with MIDAS (PSI/TRIUMF) DAQ. Bandwidth ~250 MHz.
- This time, used a 4 GHz bandwidth LeCroy scope as the digitizer.
- Not really a production system. Windows Vista operating system. Writes one file per trace per event (=120,000 files per hour). Quickly breaks file structure.
- ~12 Hz to disk.

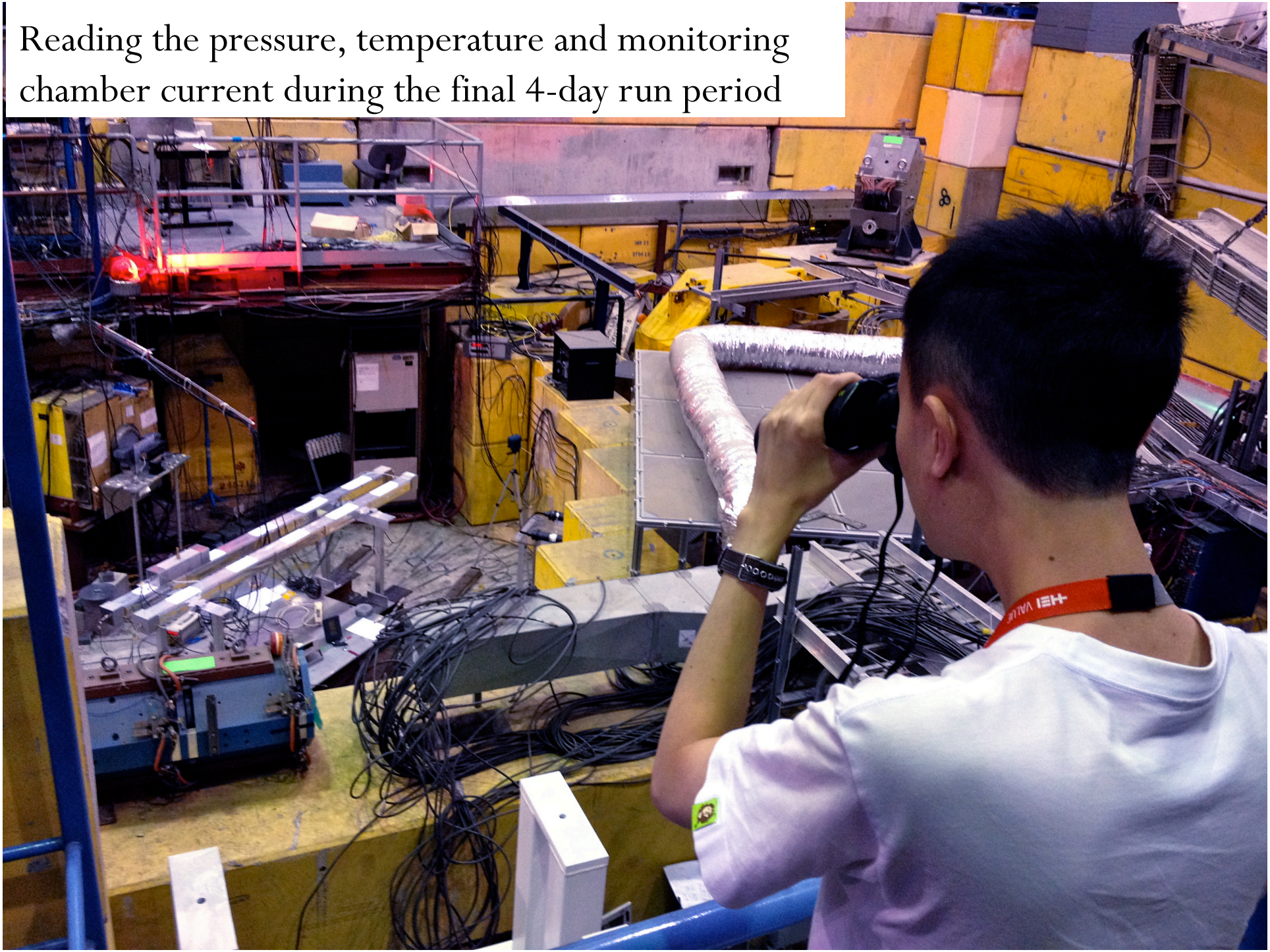
LeCroy WavePro 740Zi 4 GHz bandwidth


20 micron chamber
25 micron chamber
TOF NIM
logic signals
(first four)
Capacitive pickoff
NIM logic signals
C1 DC50 200 mV/div 700.0 mV
C2 DC1M 70 mV/div 246.0 mV
C3 DC1M 70 mV/div 244.0 mV
C4 DC1M 70 mV/div 246.0 mV
Timebase -250 ns 100 ns/div 20.0 kS 20 GS/s
Trigger Ext DC Normal -65 mV Edge Negative

Conditions monitoring

- Used MIDAS to asynchronously record temperature, atmospheric pressure, and monitoring chamber current during the primary run.
  - We used a simpler system for the short run at the end

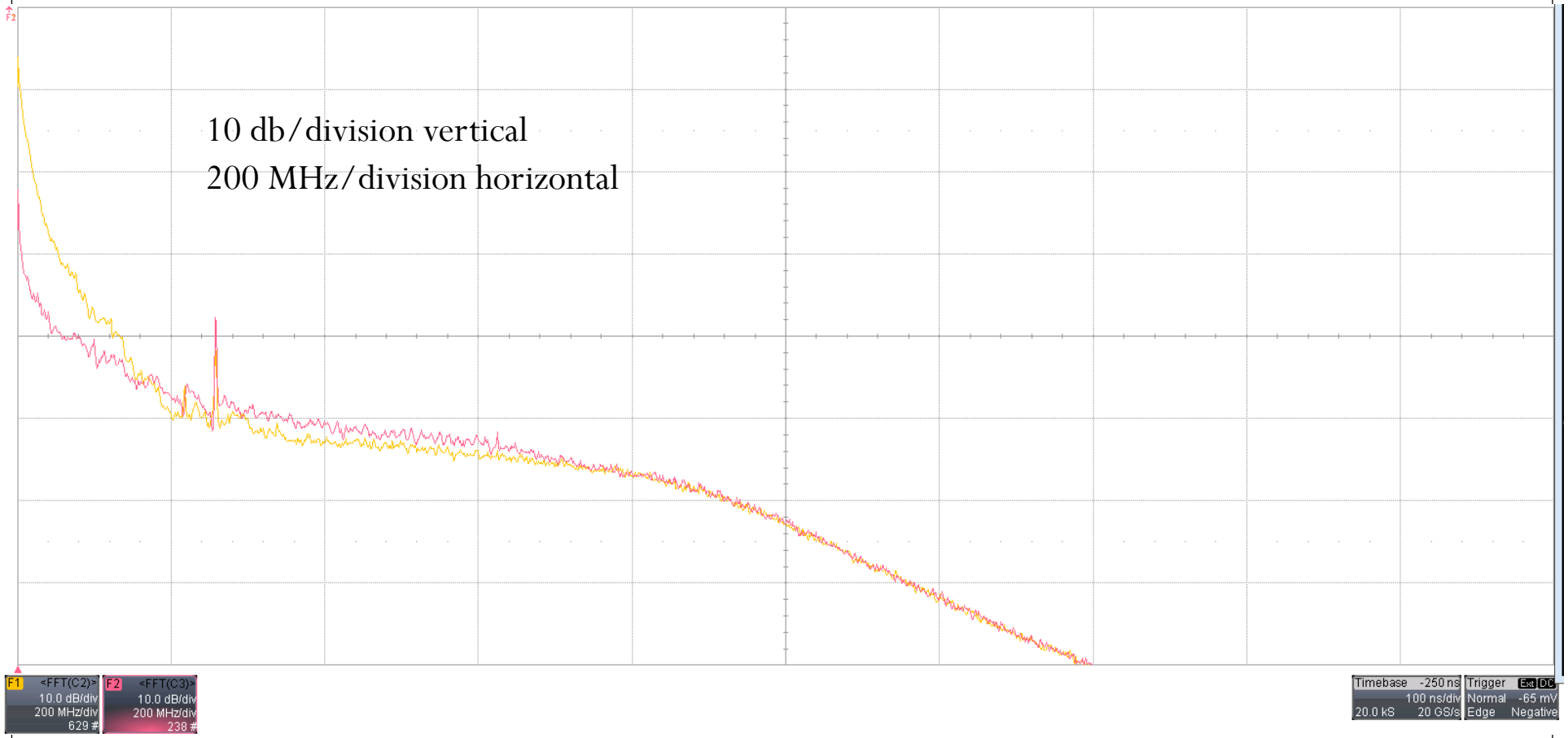
Reading the pressure, temperature and monitoring chamber current during the final 4-day run period



Data collected

- ~200 good runs collected using five different amplifier designs. Each run is typically 30k events, including 15% asynchronous triggers and 10% empty events.
  - google docs
- Jean-Francois has converted the ~120,000 files from each run into a single root file.
- Stored on the Victoria Mercury cluster.
- Also recorded FFTs and scope traces (random trigger and beam trigger) for each amplifier / chamber combination.
  - This was mostly what we did in the short run at the end.

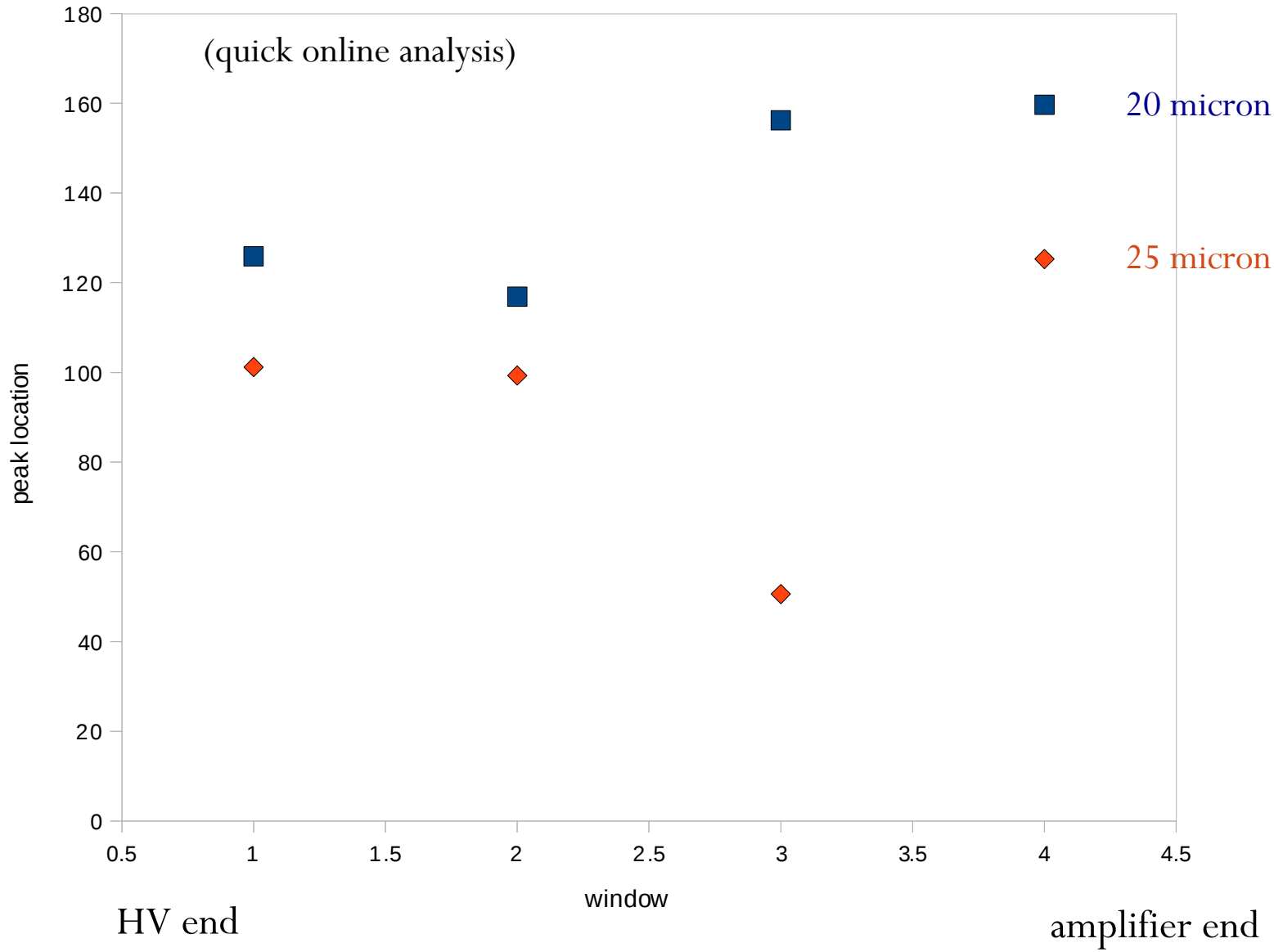
Sample FFT; two difference 370 ohm input impedance amplifiers



Problems

- Much of the data in the long block was recorded with almost no gas flow because we forgot to close the bypass valve.
  - actually, the data still looks OK
- The 25 micron chamber clearly showed a problem in the central window.
  - wire tensions were all OK.
- Restrung it with a 30 micron sense wire for the final runs; don't yet know if this fixed the problem.

Peak of charge distribution vs location along wire, 210 MeV/c



HV end

amplifier end

Wayne and Rocky restringing the prototype with 30μ sense wire

Problems continued

- Monitoring chamber showed rapid decline in gain. Total integrated charge is only ~1% of what Rocky has done with his aging chamber.
- Monitoring chamber was his normalization chamber, so it was not generally exposed to the hot source.
- Both monitoring and aging chambers are BaBar cell design. Aging chamber has gold-coated field wires; monitoring chamber uses bare aluminum.
- Under investigation.

Problems continued

- We did not collect data to address the issues of cables, connectors, and wire diameters using the amplifiers with the best performance.

November beam test

- We have been assigned M11 for 12 days, Nov 21 – Dec 3, with possibly another day or two for setup.
- Plan is to run 24 hours /day (vs ~15 hours/day in the summer). Nevertheless, a short run.
  - outside of normal working times, we are supposed to have two people present when working in the beam area. (It is OK to work alone in the control room).

Questions

- Is the existing trigger / TOF system adequate?
  - Note that with the scope (50 ps LSB) we got 60–65 ps resolution per PMT. Our TDC (CAEN V1190B) has 100 ps LSB, so resolution will be slightly worse.
  - We could probably modify TOF counters to be twice as tall (25 mm). This would take planning, since other groups are using them for their beam tests.
- What about mechanical? Existing structure plus something to allow rotation about chamber axis? What about height adjustment? Shall we design something? Or does something already exist?

More questions

- What gases do we want? Anything other than He:Iso?
- Amplifiers? HV boards?
- There is a CAEN SY2527 HV system in M11. (Although we used Bertans for the single-cell prototypes).

DAQ

- CAEN VX1742 as digitizer? There is a VME system with MIDAS readout in M11, but the DAQ group will need to develop and check code for the VX1742 if we are going to use it.
  - I believe they would be quite interested in working with one of these.
- Do we need anything other than existing temperature/pressure/current monitoring?
  - we are building a new monitoring chamber.

Single-cell chamber in November

- I will see if we can get some time to do more tests with the single cell chambers prior to the run in November. If not, I would like to explore running it parasitically with the large prototype in November.

Some practical issues for visiting TRIUMF

- Book a room at the TRIUMF guest house as soon as possible; it fills up.
- There are forms. It is faster to complete them before you arrive; I will send around an email.
- You will need safety shoes to work in the M11 area. If you don't have any, TRIUMF will pay for them.
  - in practice, this is mostly for the installation and disassembly periods.