Beam test analysis and plans for the August test

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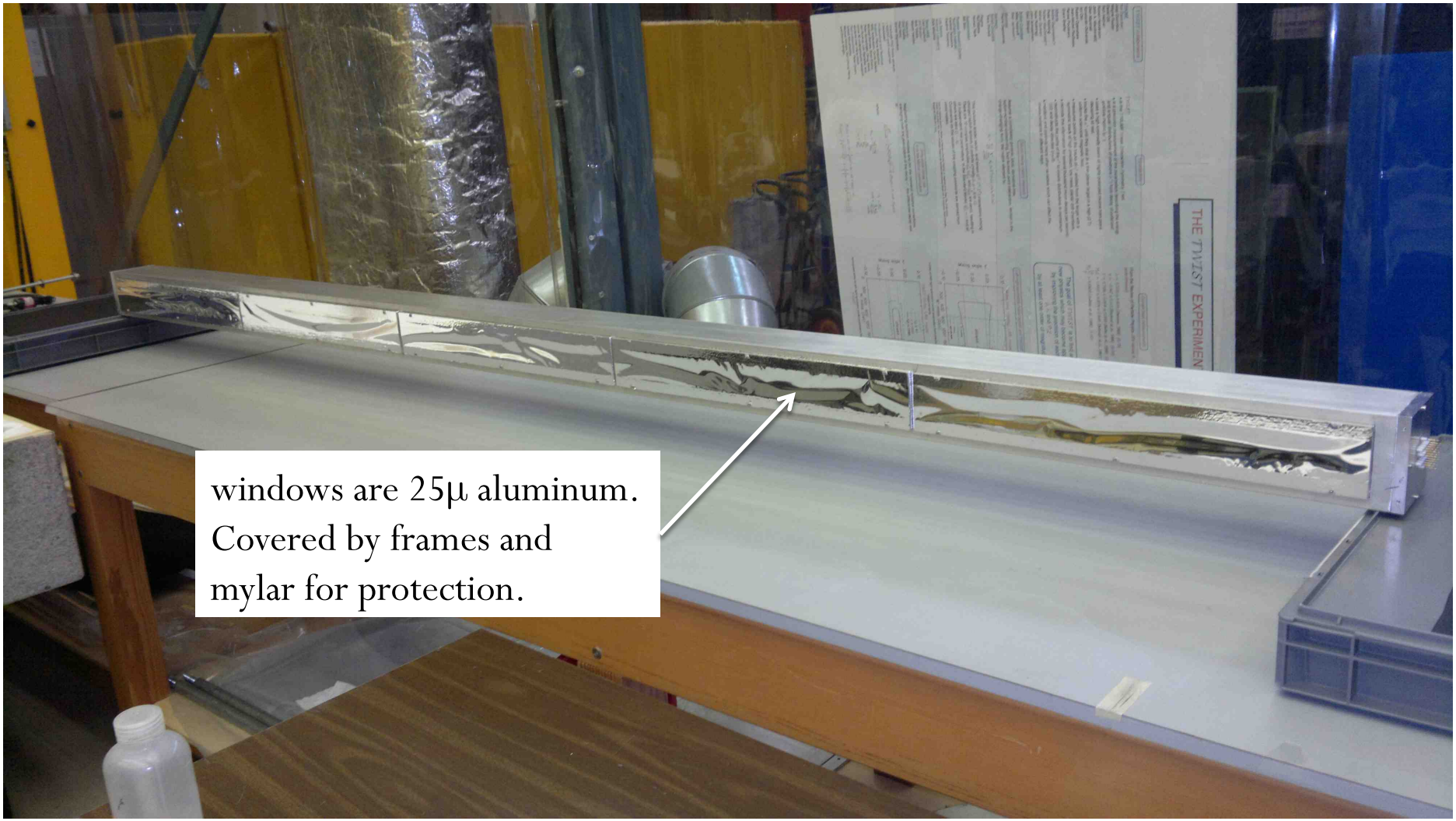
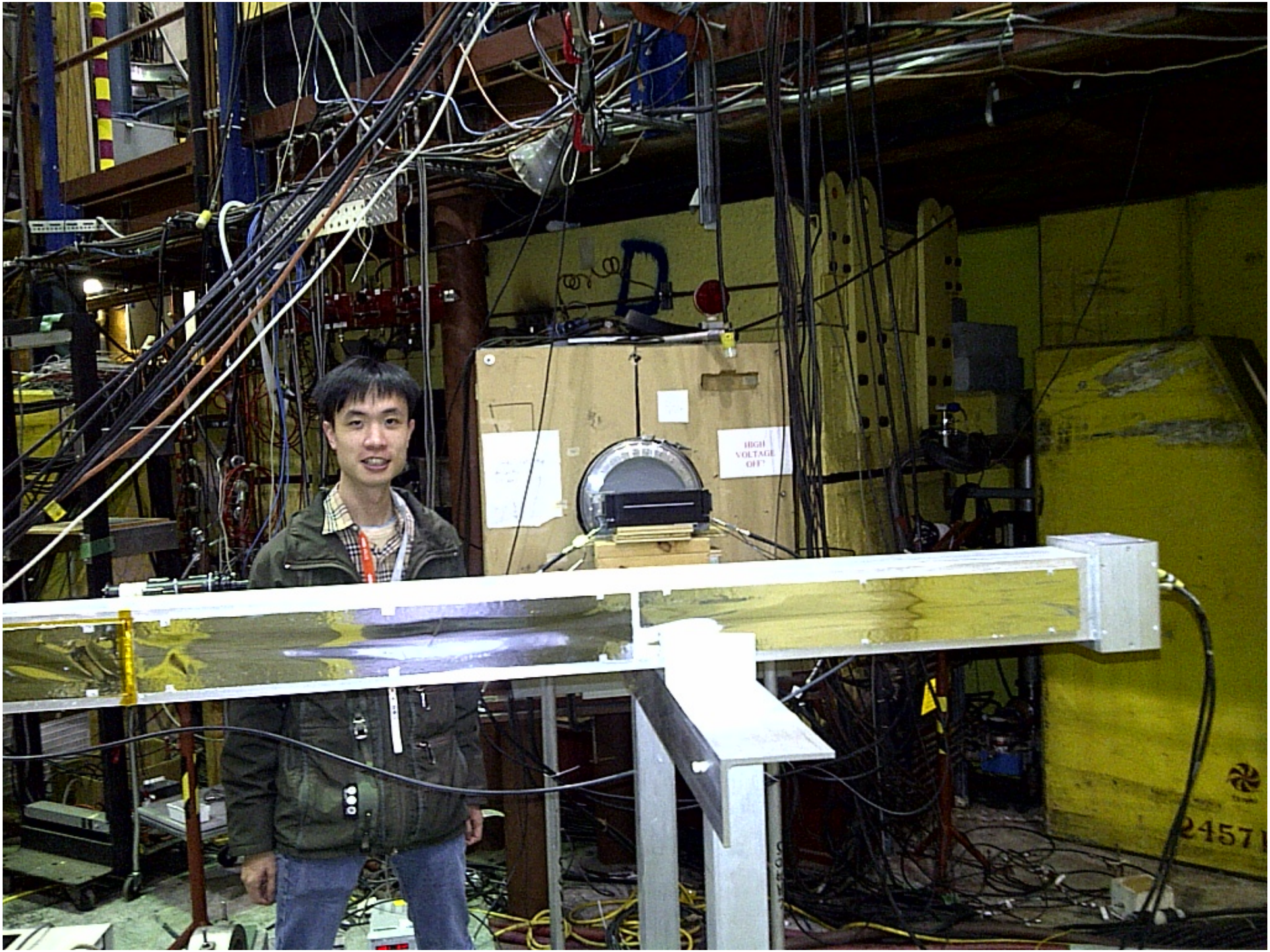
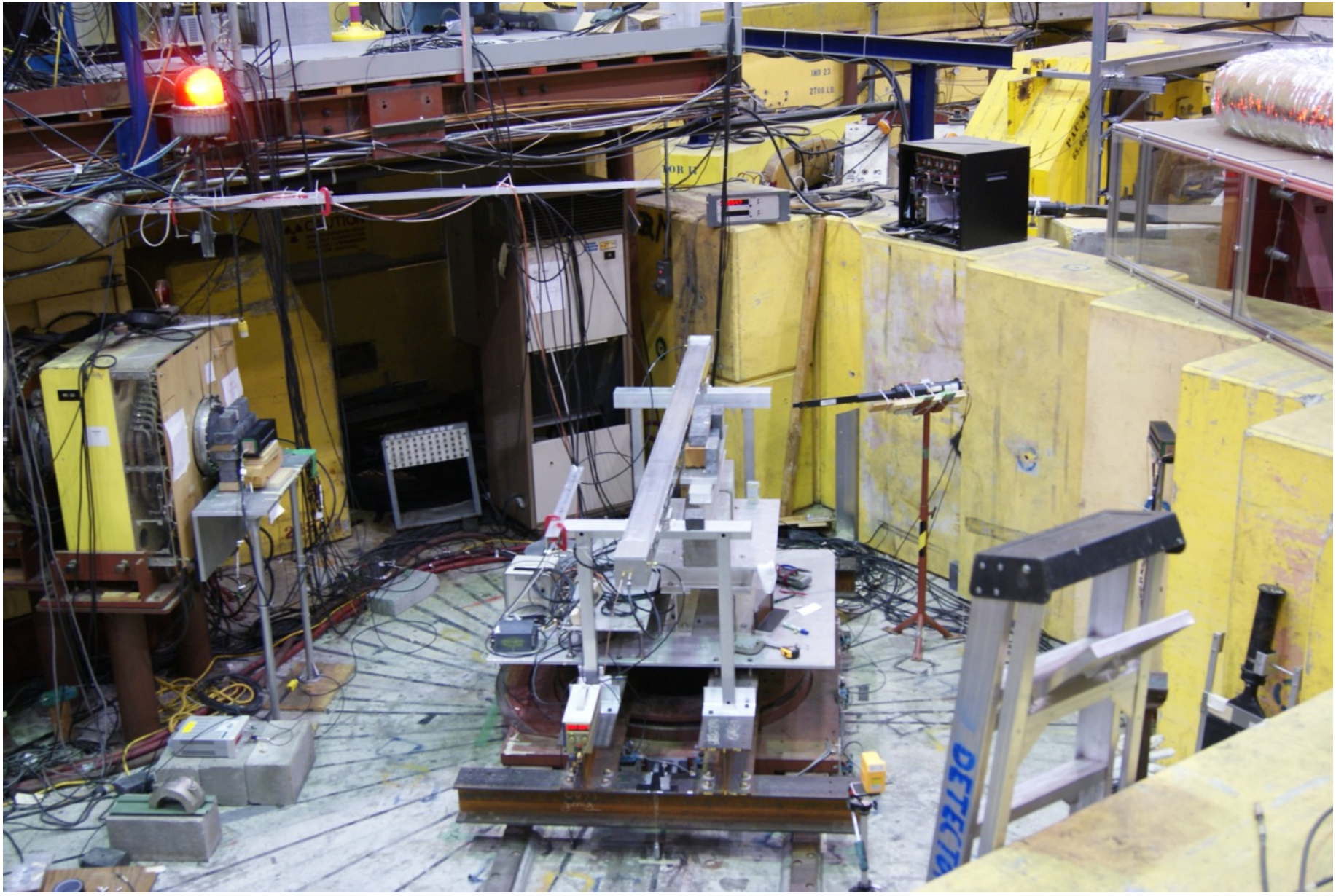
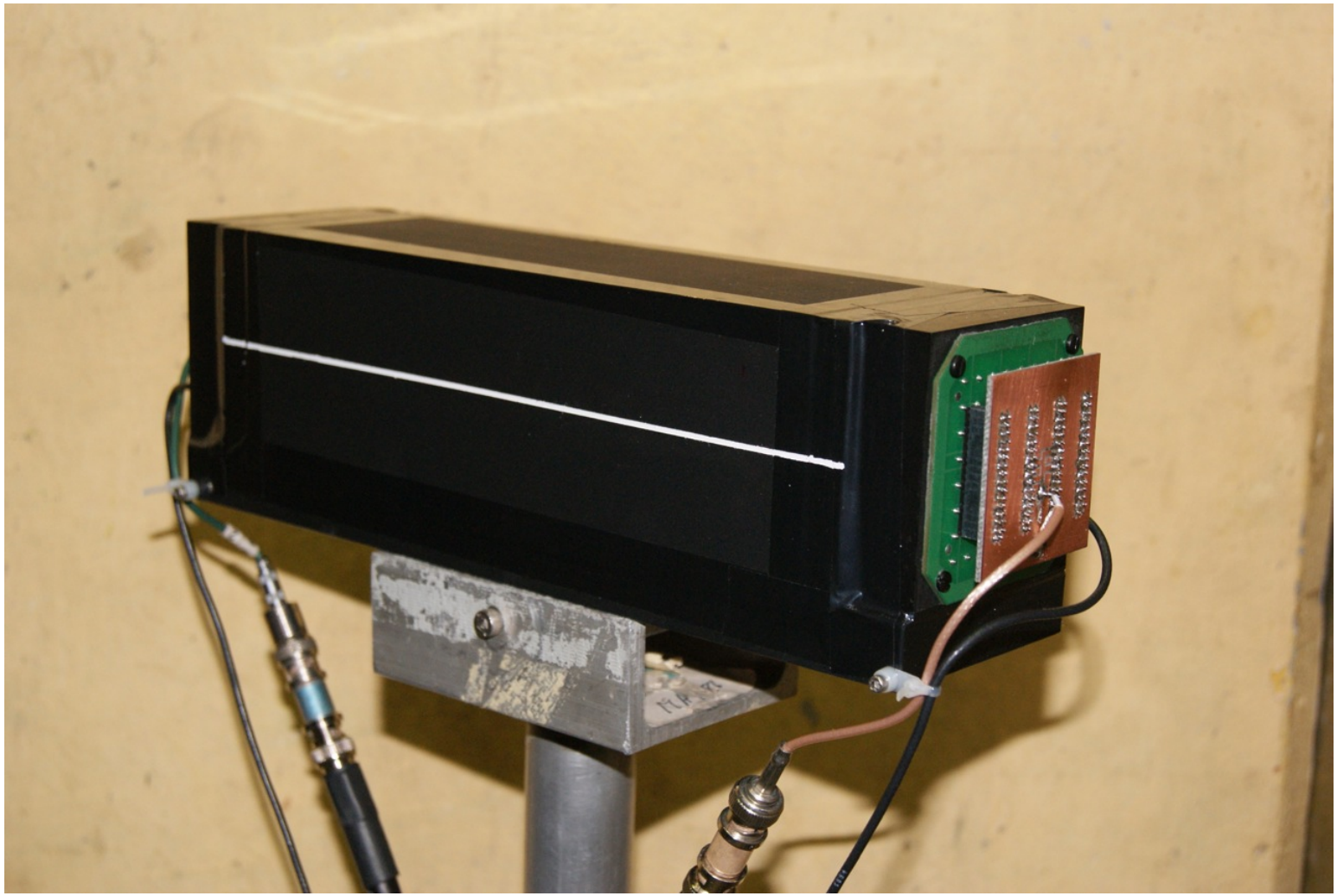
Recap of November 2011 test

- 2 weeks of running, 120 – 220 MeV/c μ, π, e
- 3 gas mixtures
- prototype amplifier from Jean-Pierre JP-1
- single cell chamber, full length.
- DAQ was CAEN switched capacitor array, 2 GS/s


windows are 25μ aluminum.
Covered by frames and
mylar for protection.


HIGH
VOLTAGE
OFF

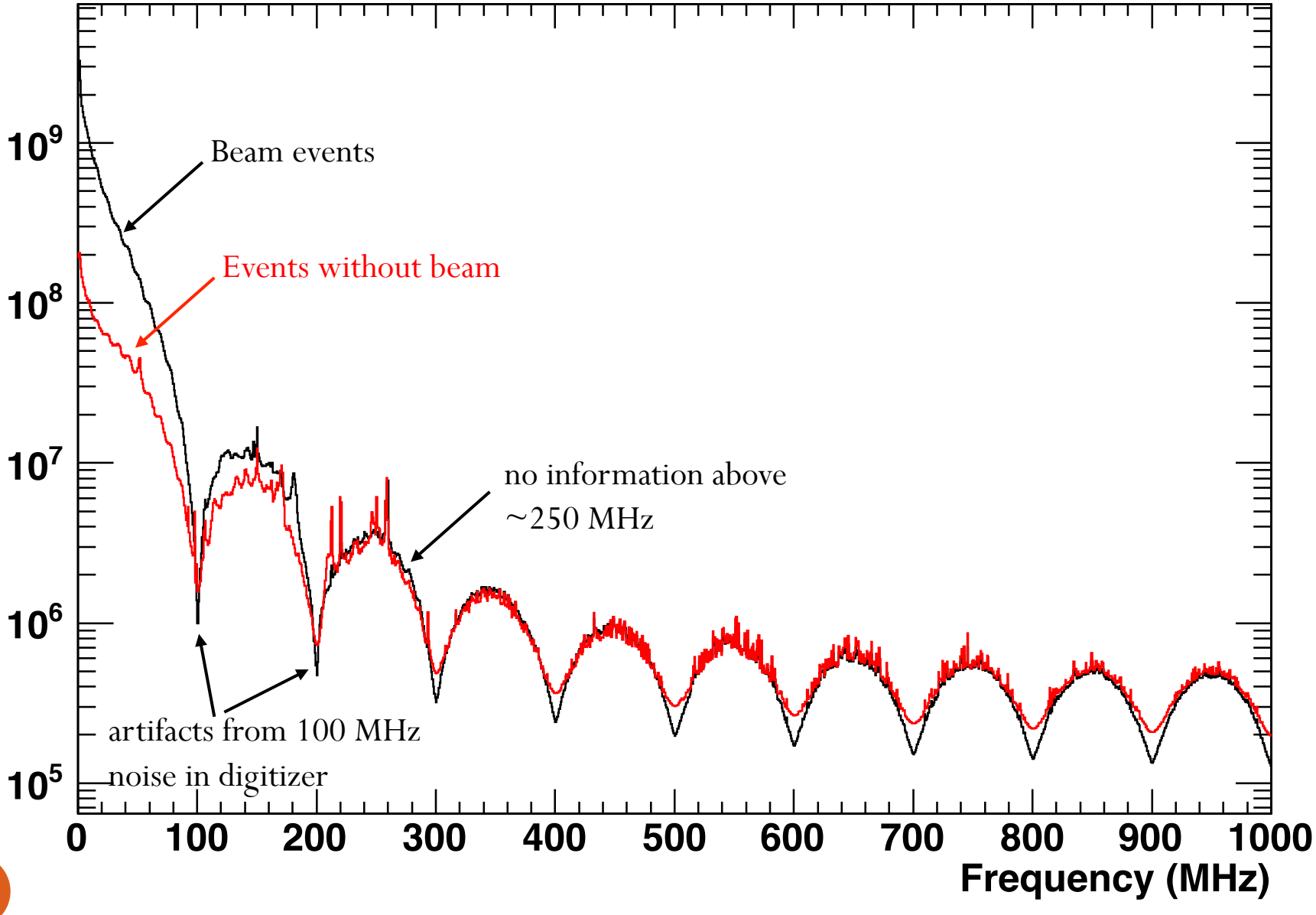




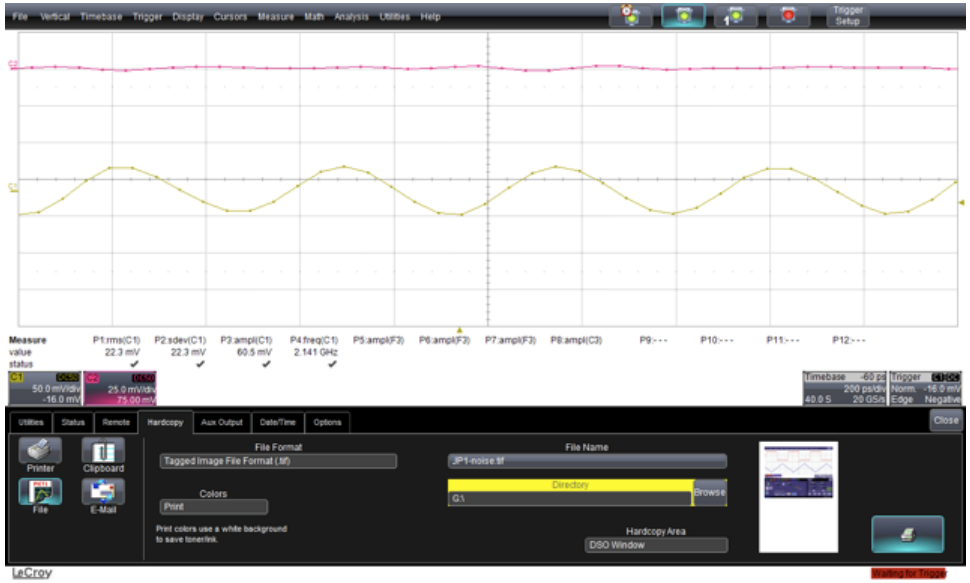
Earlier results

- Bandwidth of DAQ was limited to ~300 MHz
- JP-1 amplifier had high-frequency oscillation, causing excess noise even with 300 MHz cutoff.
- These two items made it difficult to evaluate cluster counting performance.
  - Rocky has showed some interesting dE/dx results at the last meeting.

Fast Fourier Transform of 140 MeV/c beam event waveforms and events without beam



JP-1 Oscillation



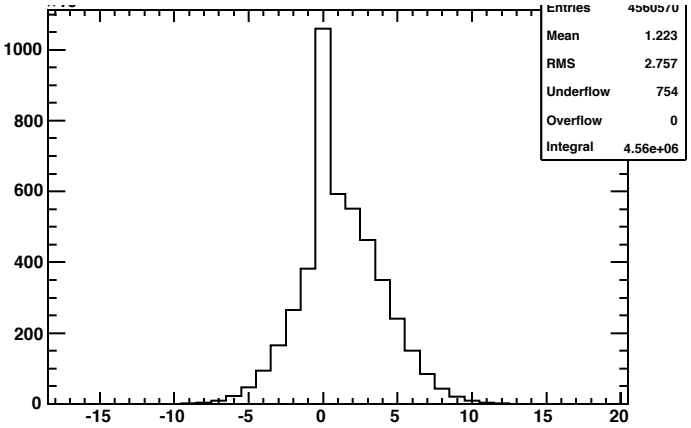
- 2.17 GHz, 250 mV peak to peak.
- RMS vs bandwidth is the same whether chamber is terminated or not:
  - 4 GHz 94 mV
  - 1 GHz 18.5 mV
  - 200 MHz 0.3 mV

Attenuation

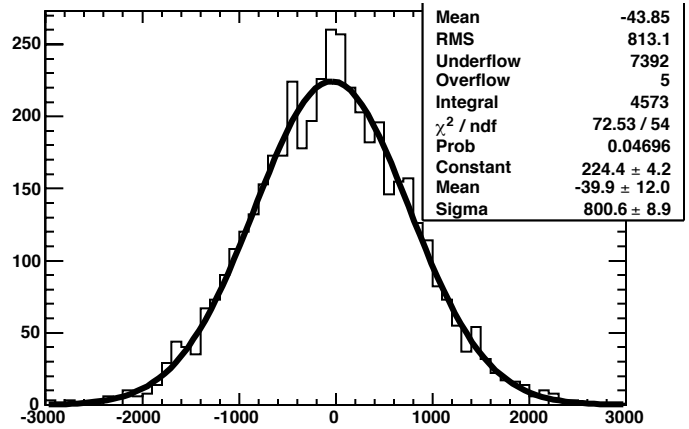
- Use integrated signal to study measured charge vs location along wire.
  - He:Iso 90:10, 0° dip angle, 3 momenta, far end terminated.
- Fit crystal ball to histogram of charges after pedestal subtraction.
- Also look at unterminated data for 140 MeV/c

Some plots for 140 MeV/c

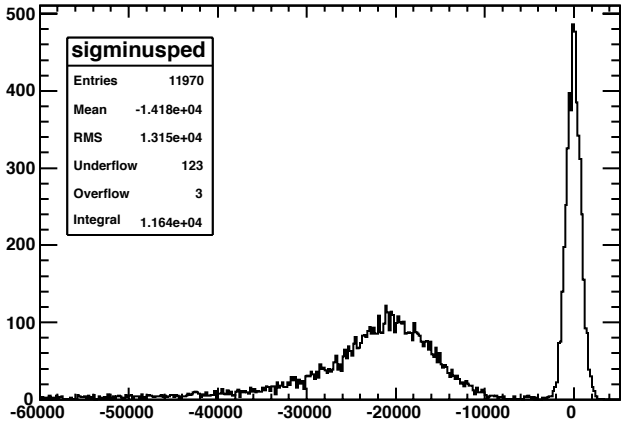
single sample pedestal peak (counts)



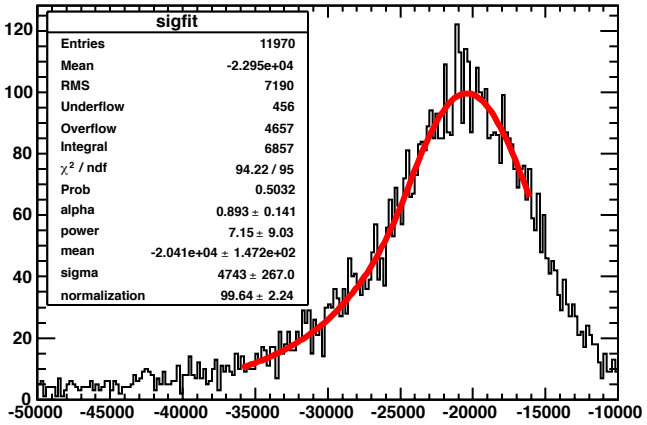
integrated signal pedestal peak (counts)

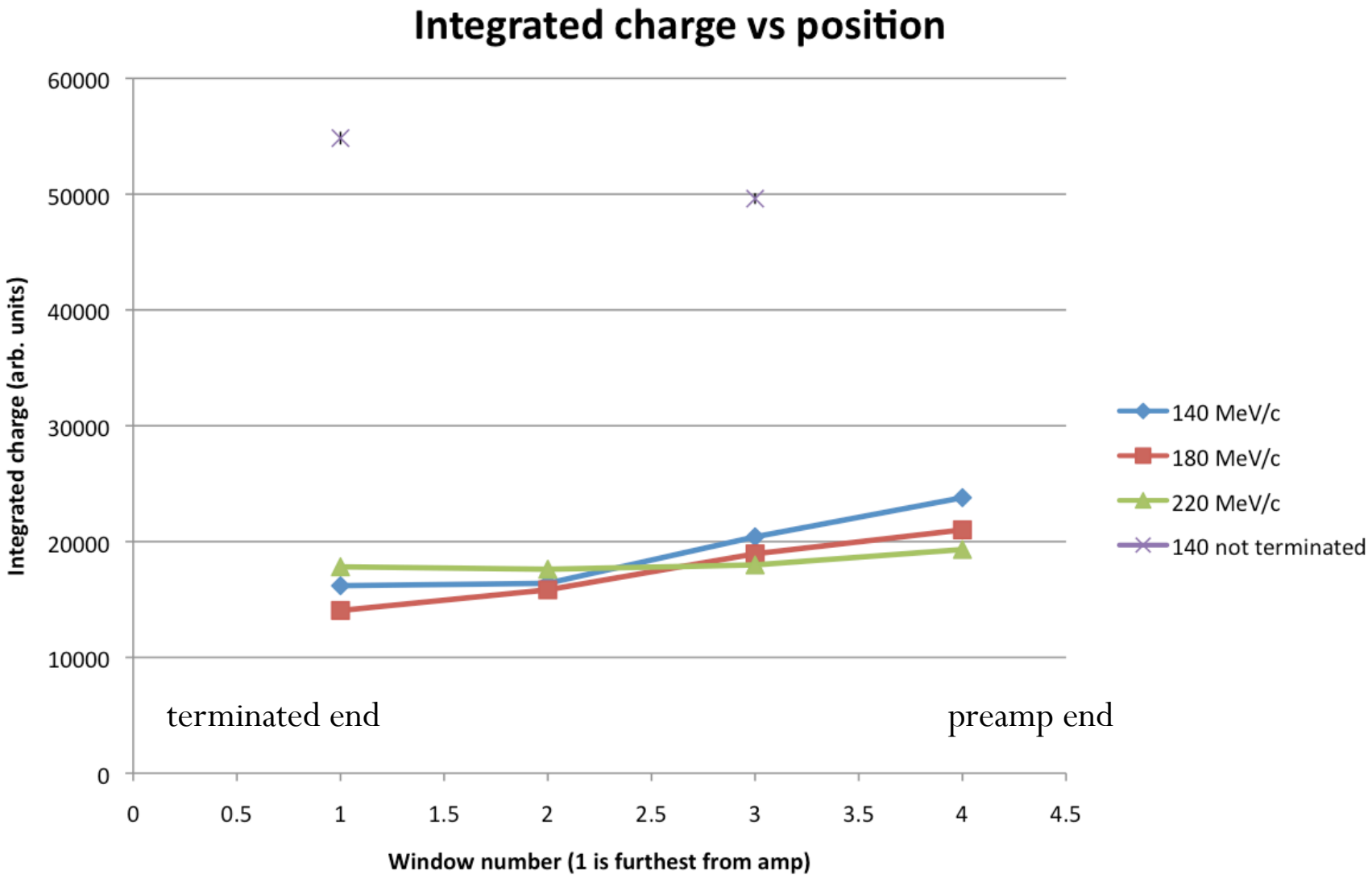


-1 × integrated signal (counts)



fit to integrated signal (counts)




Integrated charge vs position
60000
50000
40000
30000
20000
10000
0
Integrated charge (arb. units)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Window number (1 is furthest from amp)
terminated end
preamp end
140 MeV/c
180 MeV/c
220 MeV/c
140 not terminated

Interpretation

- From the variation in signal vs momentum, it is clear that the relative gain from run to run was not controlled to better than 15 – 20%.
  - consistent with what Rocky sees in the aging chamber before correction.
  - temperature reading was unfortunately useless.
- Attenuation along the wire ~25%.
  - could be different with higher bandwidth readout.
- Unterminated signal is 3× larger than terminated signal. If termination and input impedance were correct, shouldn't this be a factor of 2?

Next beam test at TRIUMF

- M11 is available July 11 – Aug 24. We are nominally scheduled Aug 9 – Aug 24, and T2K July 11 – July 30. However, they doubt that they will be ready in time and would like to trade for some time in August.
  - we are planning on borrowing their DAQ…

Goals

- Establish whether or not amplifier prototypes provided by Jean-Pierre satisfy the requirements for cluster counting.
- Quantify the benefits of cluster counting wrt dE/dx
- Impact of sense wire diameter on PID performance
- Impact of analog cable choice on PID performance
- Impact of cable connectors on PID performance
- Impact of termination on PID performance
- Impact of gain on PID performance
- Normalization of current draw for aging calculations
- dE/dx data for Rocky's thesis

Implementation

- Three single-wire chambers with 20, 25, and 30 μm gold-coated Moly sense wires.
- Three different amplifier prototypes (three copies of each)
- Use 4 GHz bandwidth scope for DAQ
  - three channels for the chambers plus one for the TOF system
- Move Rocky's monitoring chamber to M11 to correct for pressure and temperature. Separate DAQ.
- Add third trigger counter to clean up triggers
- Add random trigger

Cables to test

- We have 10 m samples of four different cables for the sense wire readout. All are 75Ω.
  - We will use the 1855A for most runs

	Cable	impedance (ohms)	diameter (mm)	db/10m at 1 GHz	
→	179DT	75	2.54	7.1	Sub-Miniature RG-59/U
	C1156	50	2.62	11.3	General Cable RG 174
→	1281R	75	2.9	5.3	75 Ohm Miniature Coax
→	1865A	75	3.81	4.6	Sub-Miniature RG-59/U
→	1855A	75	4.03	3.5	Sub-Miniature RG-59/U
	HVS	75	4.03	3.8	Holland Electronics mini coax
	7806	50	4.95	3.7	RG-58
	LMR-400-UF	50	10.29	1.7	Times Microwave Used in test beam

Connectors

- The connectors are also important at high frequency.
- Wayne has installed BNC on cables.
- We will also take runs with a header connector in line.
  - Real RF connectors are big and expensive

RF connector for Belden 179DT; 7.8mm diameter

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Mouser Part #:	523-282103-75
Manufacturer Part #:	282103-75
Manufacturer:	Amphenol Connex
Description:	RF Connectors 75Ohm 1.0/2.3 DIN Pl Belden 179DT Cable
Lifecycle:	NEW **New Product:** New from this supplier.

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RF Series:	1.0/2.3	☐
Gender:	Plug (Male)	☐
Contact Plating:	Gold	☐
Shell Plating:	Nickel	☐
Termination Style:	Crimp	☐
Body Style:	Straight	☐
Cable Type:	Belden 179DT	
Connector Type:	Push-Pull Crimp Plug	
Maximum Frequency:	3 GHz	

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Running conditions

- In November we varied the gas mixture and the beam momentum quite a lot. I think that this time we should stick to He:Iso 90:10 only, and use fewer momenta.
- Most of the issues can be studied at single momentum, which I would propose to be 200 MeV/c.
  - μ/π separation at 200 MeV/c ~ π/K separation at 2 GeV/c
  - we had previously said that 140 MeV/c was like 2 GeV/c, but we were confusing momentum and kinetic energy in the comparison.
- We can run the beam through all three chambers at the same time; extra material is negligible for purposes of PID.

Clusters per cm (Garfield) for various momenta

	muon	105.7	pion	139.6	Kaon	493.7	pi - mu	pi - K
p MeV/c	T MeV	clu/cm	T MeV	clu/cm	T MeV	clu/cm	clu/cm	clu/cm
140	70	17.2	58	21.1	19		3.9	
180	103	15.5	88	17.7	32		2.2	
200	121	15.2	104	16.9	39		1.7	
350	260	13.9	237	14.2	111		0.3	
400	308	13.9	284	13.9	142		0.0	
2000	1897		1865	15.5	1566	13.8		1.7

Running conditions II

- I propose two dip angles per window, 0 deg and "nominal"
  - nominal = the appropriate angle at that *z* for a track from the beam spot
  - should we actually use 10 deg instead of 0 deg? I am thinking about saturation.
- We should probably generally run at a higher gain than we did previous. In November, with 25 micron sense wire in 90:10 gas we used 1800 V.

Nominal running conditions

- He:Iso 90:10
- 2× gas gain compared to November
- terminated
- 1855A cable
- BNC connectors
- 200 MeV/c

A sketch of a run plan I

- Setup:
  - 2 days installation
  - 1 day beam tuning/trigger/TOF
  - 1 day matching gains, checking the three amplifiers
- For each amplifier [20 runs $\times$ 3 amplifiers]
  - 7 runs (4 windows, 2 dip angles)
  - 7 runs different cable/connectors (window 3)
  - 2 runs different gas gains (window 3)
  - 4 runs unterminated (one per window)

Run plan II

- Runs for Rocky's thesis [25 runs]
  - dip = {0, 10, 20, 30, 40} x p = {180, 190, 200, 210, 220} window 3, selected amplifier
- Minimum ionizing to normalize aging calculations. Uses monitoring chamber plus picoammeter.
  - will require some modifications to trigger / setup
  - could also collect minimum ionizing data with the three chambers if there is an interest.
- Total = 4 days + 85 runs + MIP running.
  - we recorded ~100 runs in November.
  - don't yet know the maximum trigger rate with the scope.