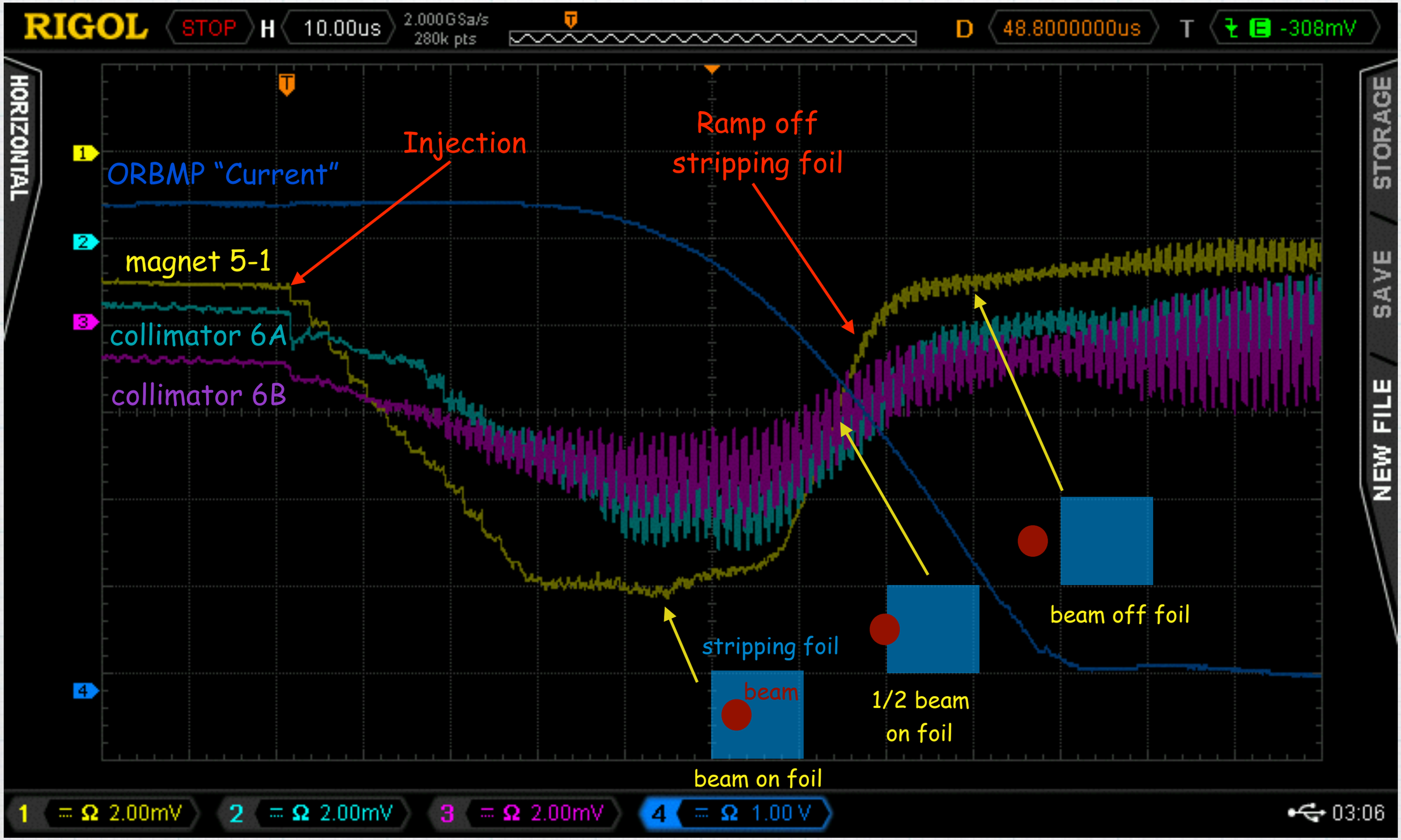
A "Non-Invasive" Beam Profile Measurement for the Booster

R.J. Tesarek

4/6/16

Fun with Fast Loss Monitors



Extracting a Beam Profile from Losses

Procedure:

- Take counter and ORBMP magnet current data with oscilloscope.
- Use oscilloscope to signal average over "N" booster cycles.
- Save 'scope trace data to memory stick for offline analysis
- Analyze data using Excel

Details:

- Trigger 'scope on ORBMP current down ramp.
- Record up to 3 counters (at least 2 locations)
- Typically average over 256 consecutive booster cycles (independent of booster event)
- Tests with averages over fewer cycles

First Look at Data

Raw Data:

- 1,400 points (V,t) from each 'scope trace
- 100 ns between points
- Average peak counter signal ~8mV
- Not optimized.

Data Analysis:

- Calculate derivatives as ratio of differences:

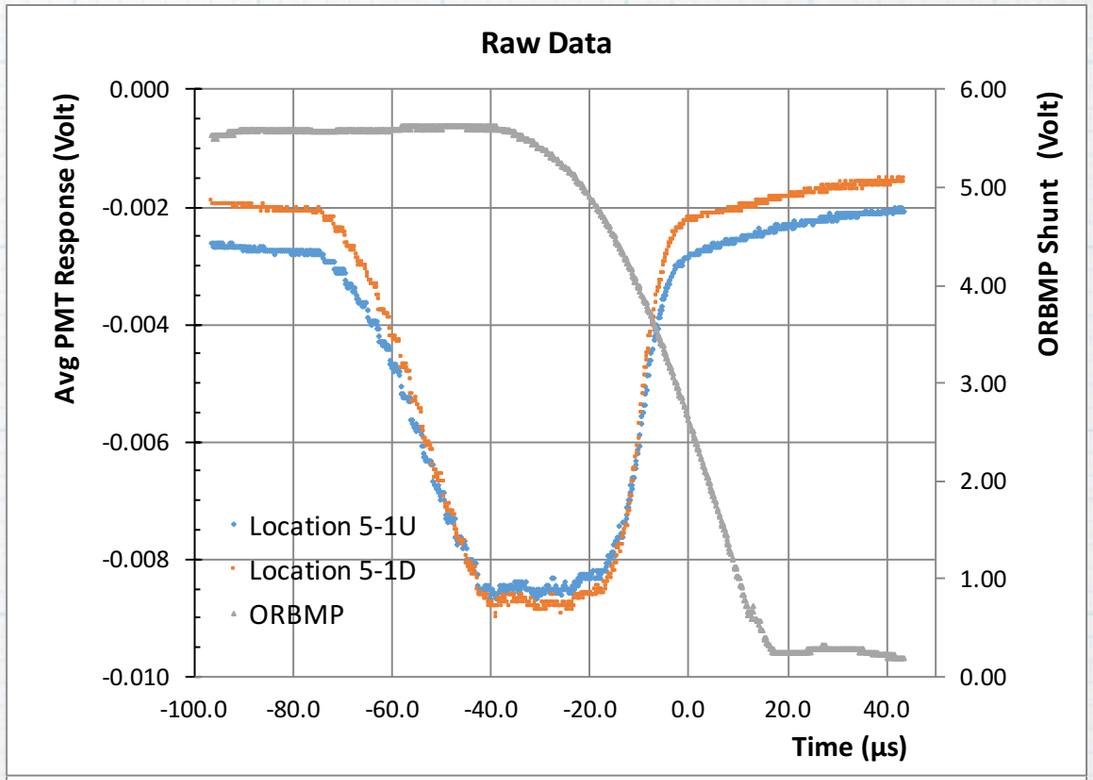
$$\frac{dV}{dt} = \frac{V_{i+1} - V_i}{t_{i+1} - t_i}$$

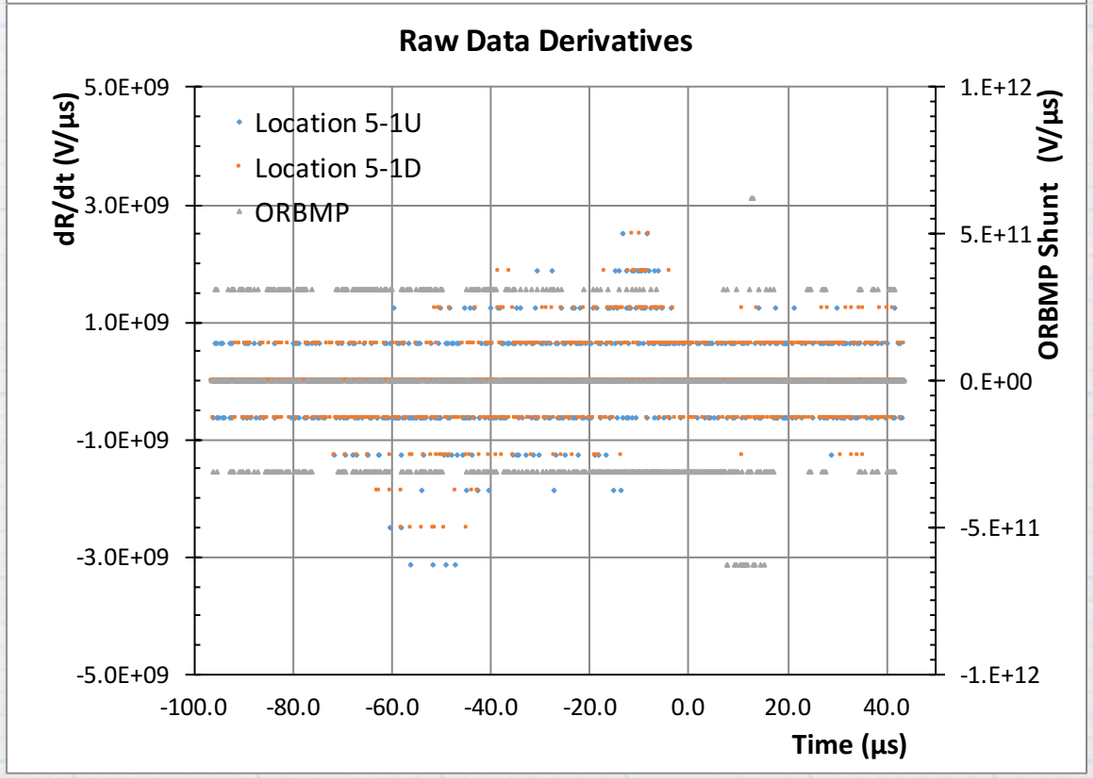
- Plot derivatives vs time

NOTES (sample analysis):

- 2 counters at same location (small gain diff.)
- Oscilloscope uses 8 bit ADC
- 'Scope average done with 8 bit precision (0-255 scale)

➡Need higher precision data to extract beam profile.





2nd Analysis Same Data

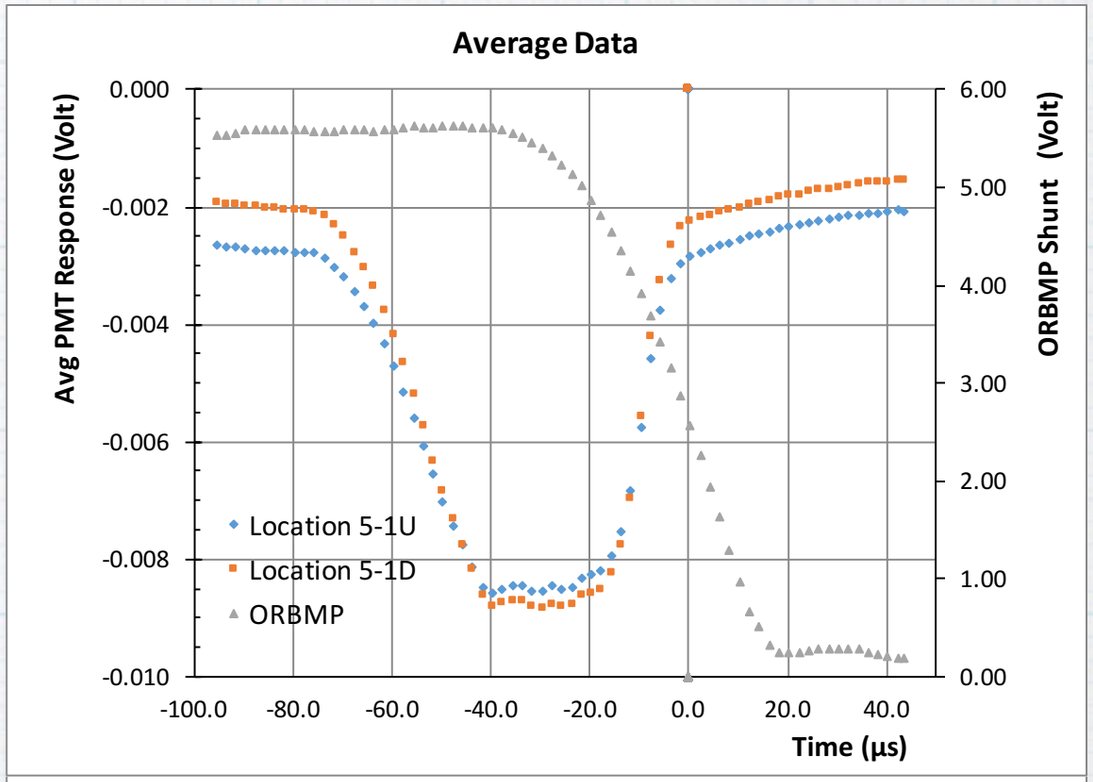
Average consecutive points:

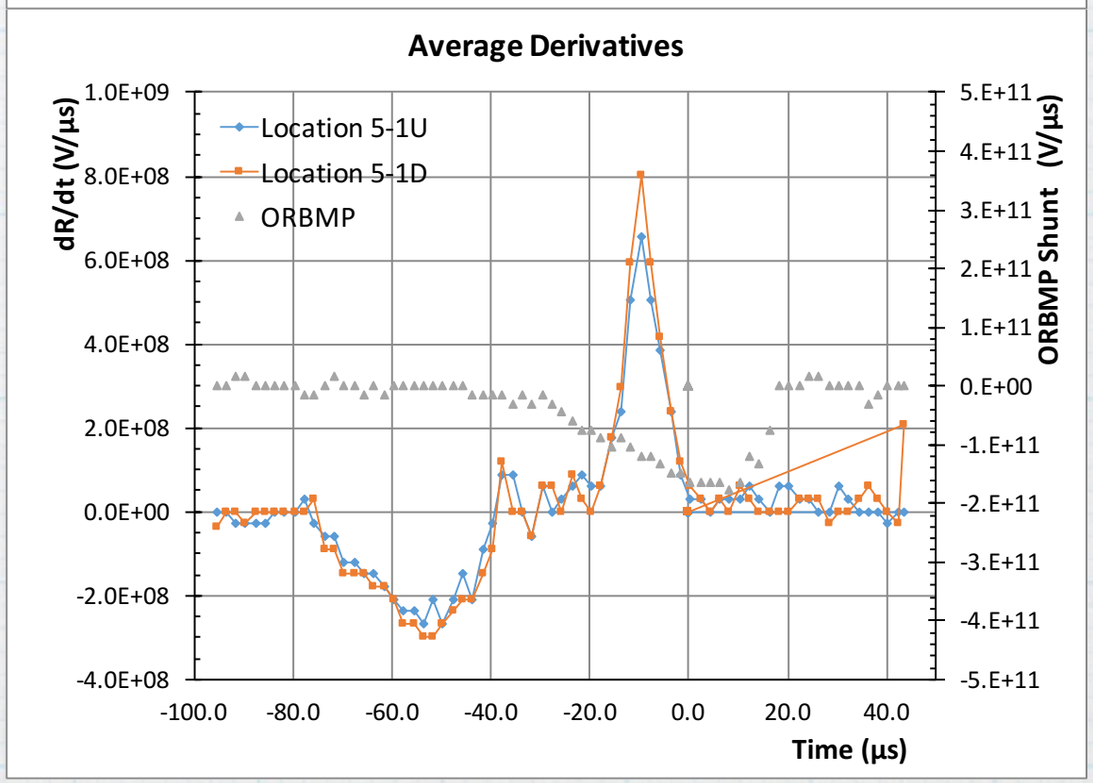
- "N" (V,t) points in an average (N variable).
- Example uses N=20
- Use computer to calculate average (64 bit precision),
- Plot raw data and derivatives as on previous slide.

NOTES:

- Points drawn larger to be visible.
- Sparser points, but same vertical/horizontal scale as previous slide.

➡Derivative shows beam profile like structure but time is horizontal axis.





Beam Profile

Convert ORBMP 'scope voltage to beam position:

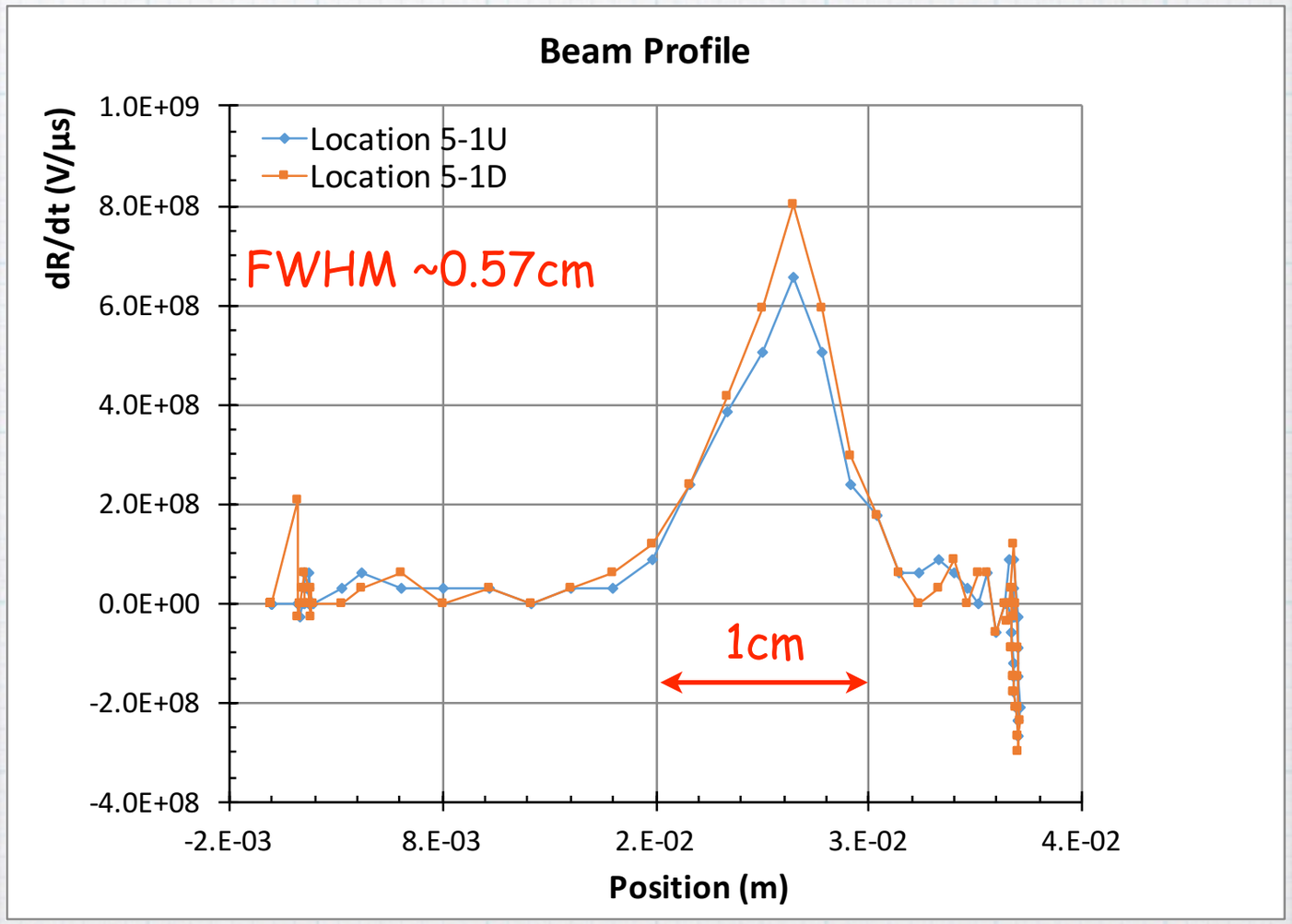
- Voltage to shunt current: 2000 (A/V)*
- Current to position: 3.115 e-6 (m/A)**

N scope trace average: 256
Npts average: 20

- *Calibration from D.Dick
- ** Calibration from J.Lackey

NOTES:

- Detectors ~100m from stripping foil
- Detector gain can be raised ~16x comfortably

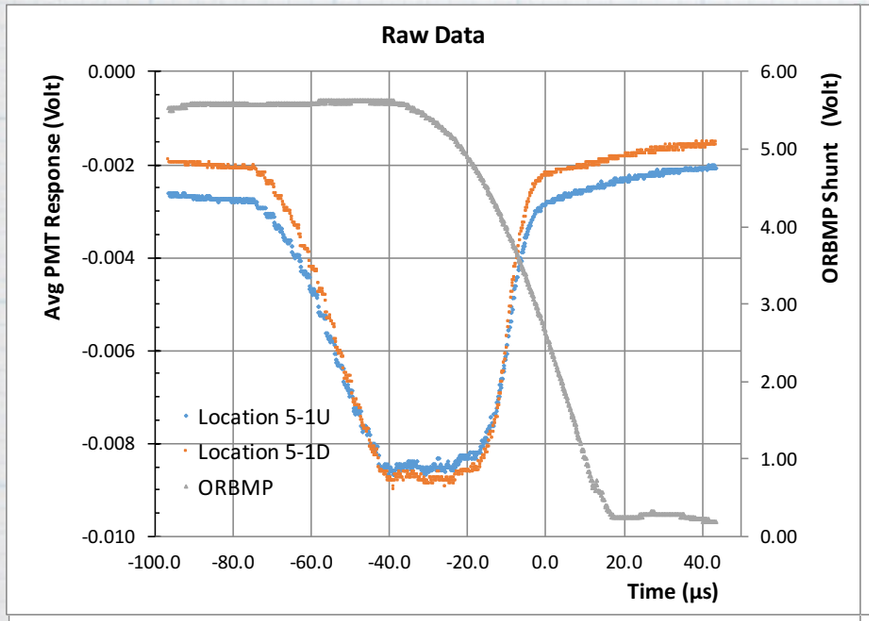


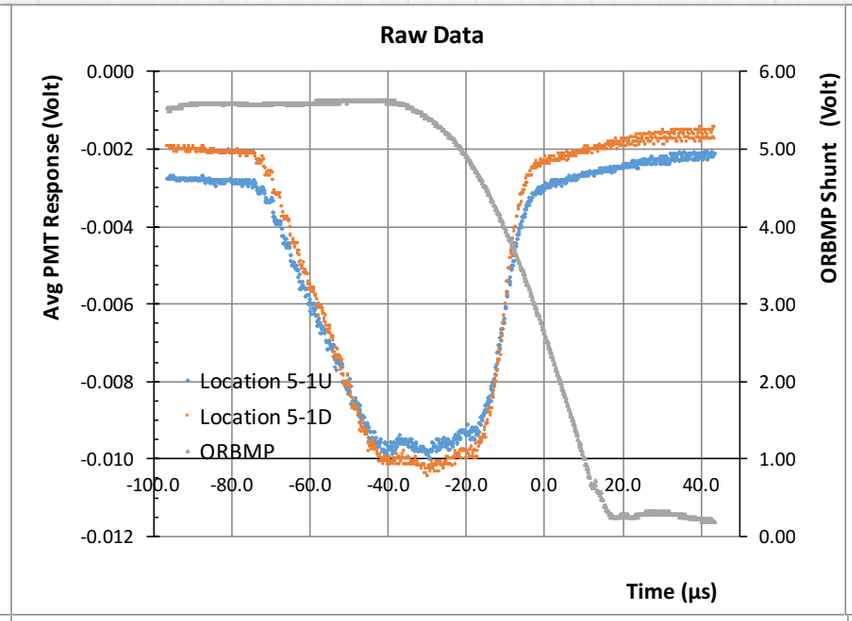
Scope Trace Averages

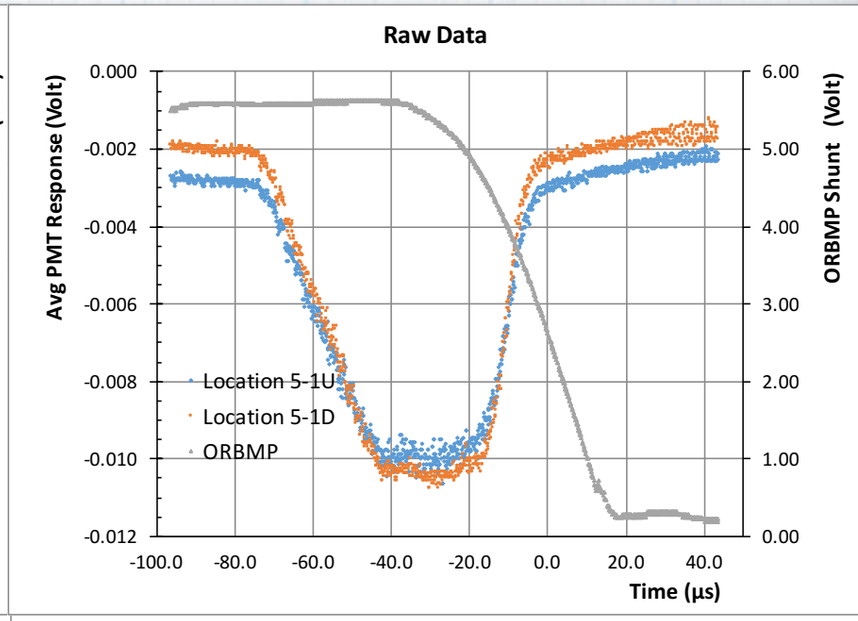
N scope trace average: 256
Npts average: 20

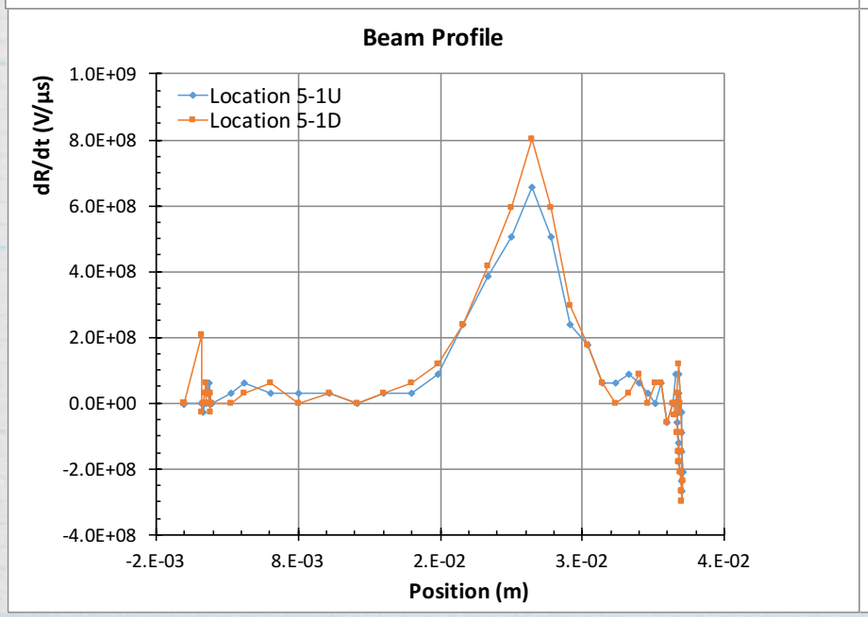
N scope trace average: 64
Npts average: 20

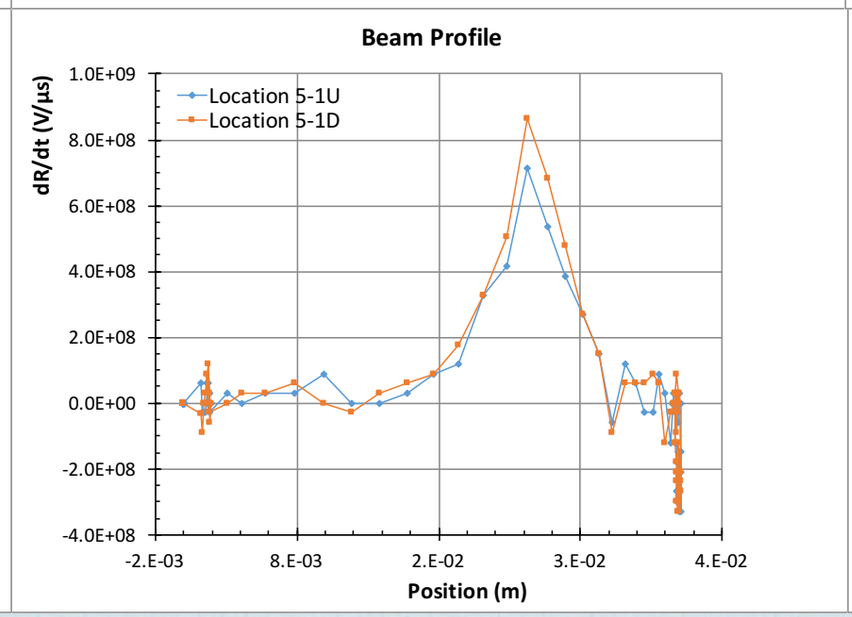
N scope trace average: 16
Npts average: 20

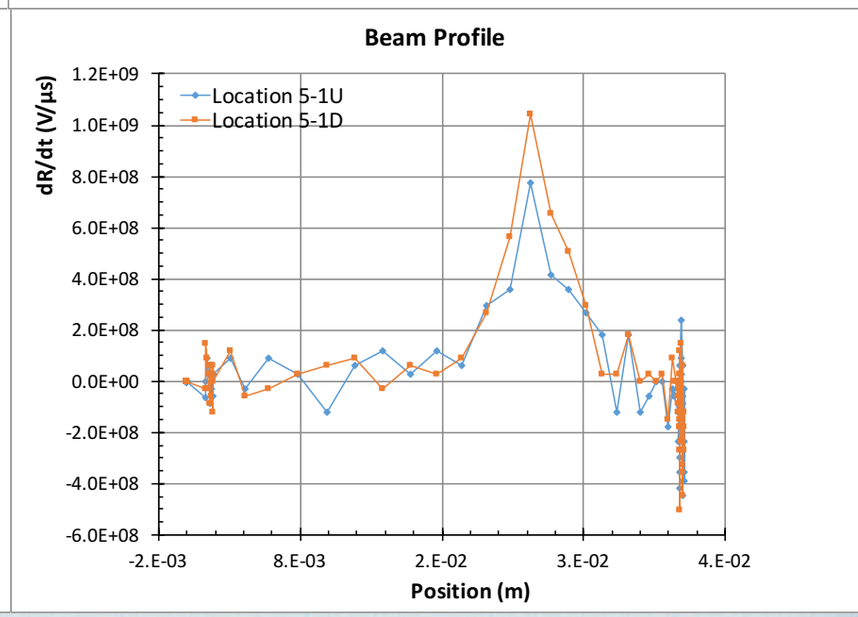












Summary, Next Steps

Use losses from stripping foil to infer horizontal beam profile at injection

- Measure beam width ~ 0.57cm FWHM (0.24cm sigma)
- Proof of principle with non-optimized detector configuration
- Self normalizable (measurement independent of reasonable detector performance)
- Update frequency ~1Hz possible!

Next Steps:

- Construct passive splitter to send copy of ORBMP magnet current to W. Booster tower
  - calibration of signals = 0.5*present calibration
  - Simultaneous use of signal in 2 locations (MCR, W.Booster tower)
- Additional study time
  - Measure profile with wire at injection foil
  - Measure profile with stripping foil only
- Write up results
- Summer student to further studies