First Results of High-Rate Proton Irradiation Test of MDT Chambers

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Outline

Goal:

Study detector performance at high rates of highly ionizing particles.

Effects of the irradiation:

- Muon hits can be masked from background hits due to the electronics' dead time.
- Highly ionizing irradiation causes space charge in the MDTs
  - $\Rightarrow$ Drop of the gas gain
    - $\Rightarrow$ Signal amplitudes can drop below the discriminator threshold.

Both effects cause a drop in the efficiency.

Experimental Setup

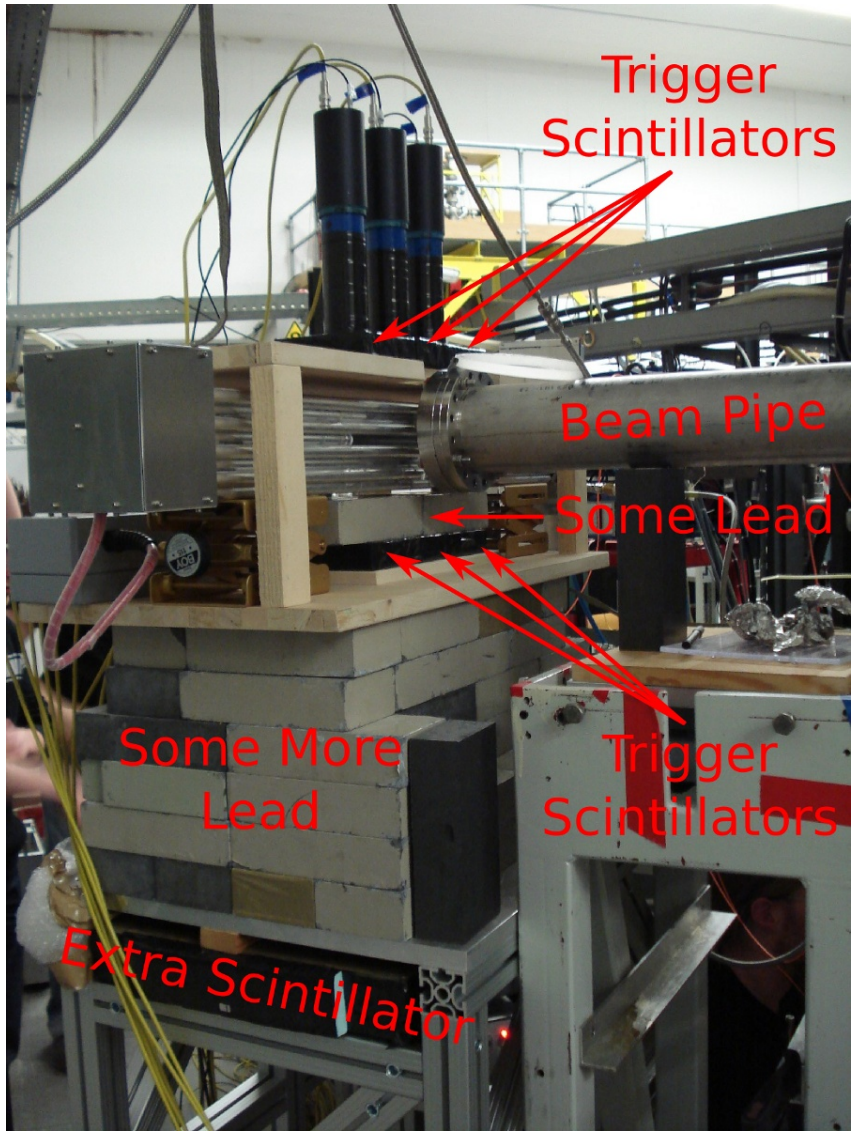
Beam:

- $\approx$ 20 MeV protons
- beam spot: $\approx$ 20 mm $\times$2 mm
- wobbler frequency: 300–900 Hz

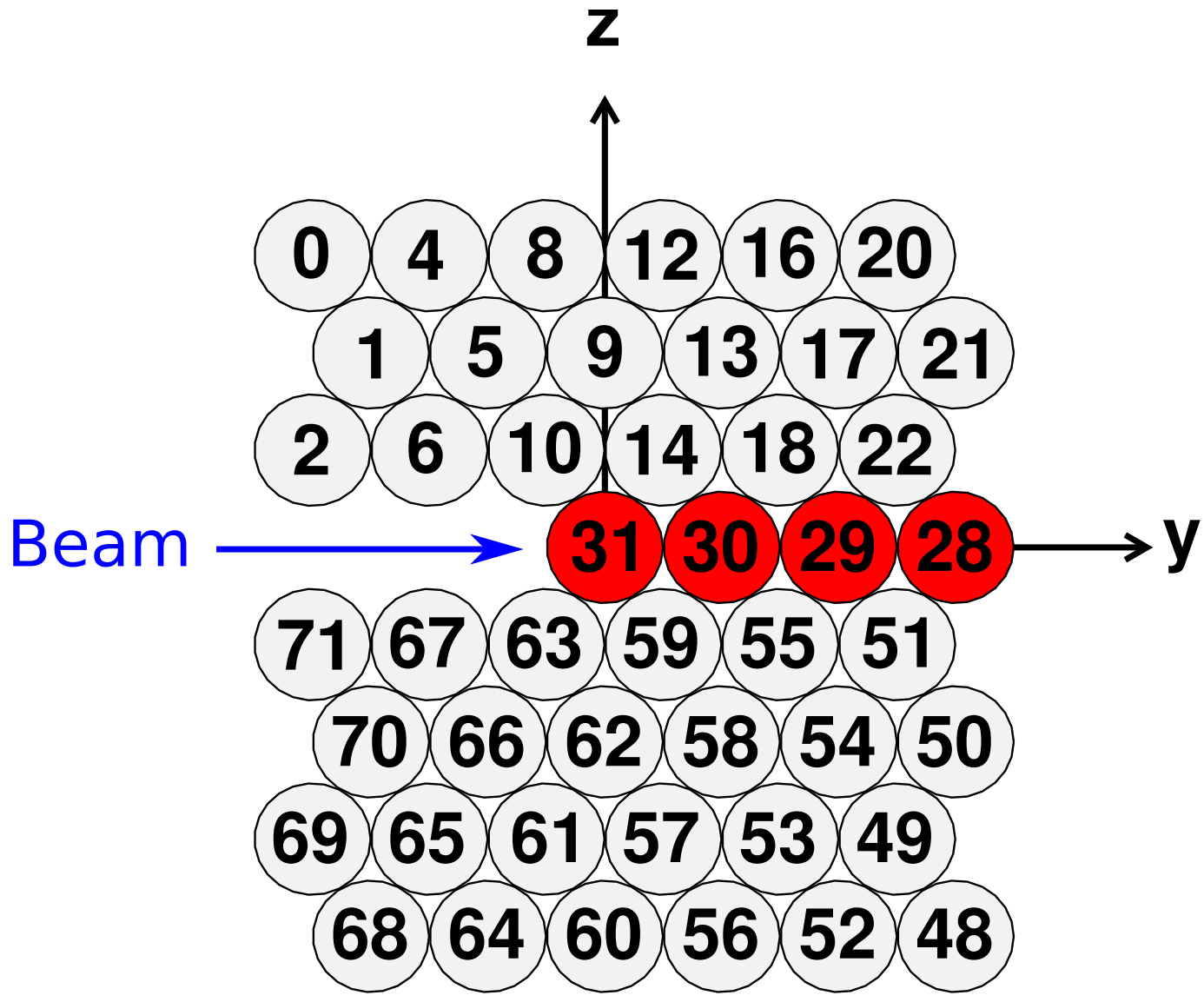
$\Rightarrow$ total beam width: 7 cm

Trigger:

- 2 layers of 3 scintillators each form the cosmic trigger
- the 2 central scintillators cover the irradiated area
- 1 extra scintillator paddle for optional energy hardening of the cosmic muons



MDT Chamber Layout



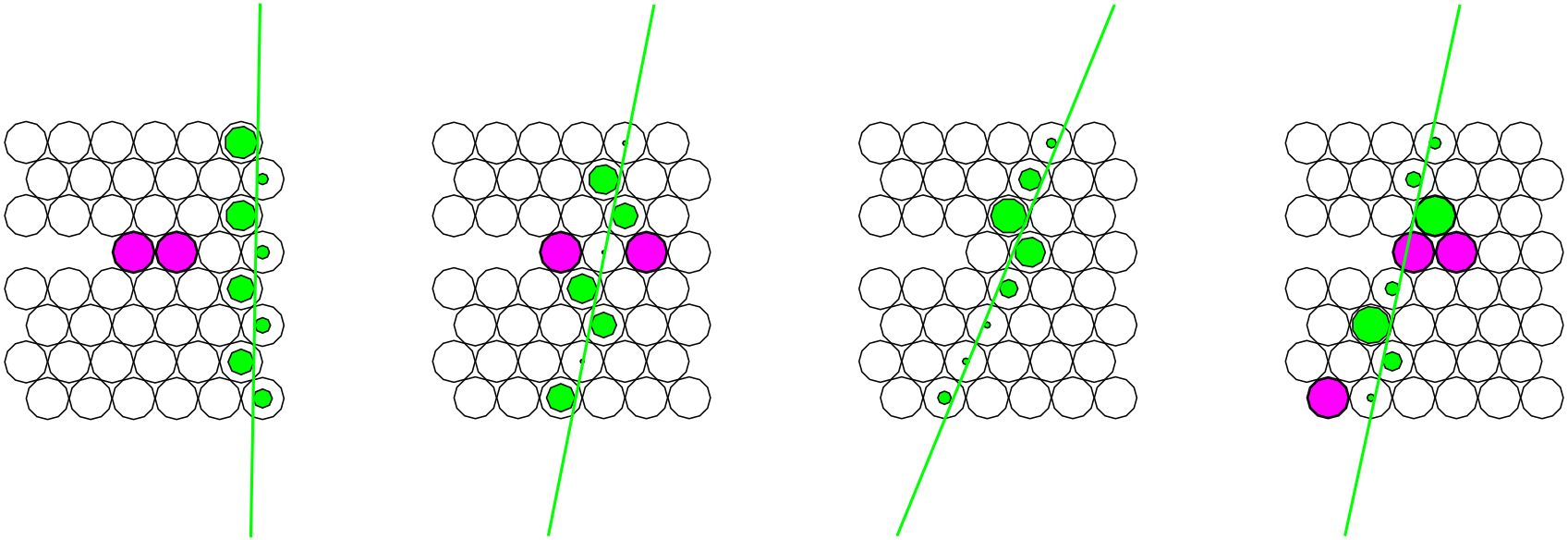
HW channel mapping

Run Overview

tandem__2011_04_28__20_02_26__beam_current_0
tandem__2011_04_30__00_59_00__beam_current_2.1nA
tandem__2011_04_30__09_12_50__beam_current_2.1nA_2
Ion source unstable $\Rightarrow$ New source installed
tandem__2011_05_03__00_38_27__beam_current_5nA
tandem__2011_05_03__18_34_02__beam_current_1.5nA
Source breakdown
tandem__2011_05_04__03_41_20__beam_current_0nA
New source installed
tandem__2011_05_04__13_46_35__beam_current_2.5nA
Source breakdown
tandem__2011_05_04__15_49_26__beam_current_0nA
New source installed
tandem__2011_05_05__00_05_23__beam_current_1.3nA
tandem__2011_05_05__19_22_15__beam_current_1.3nA

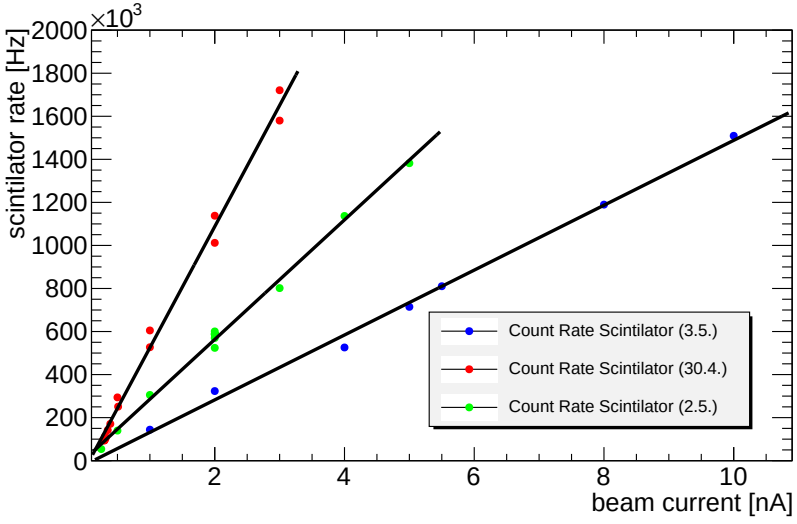
Unfortunately, with each new source we have a different beam geometry.

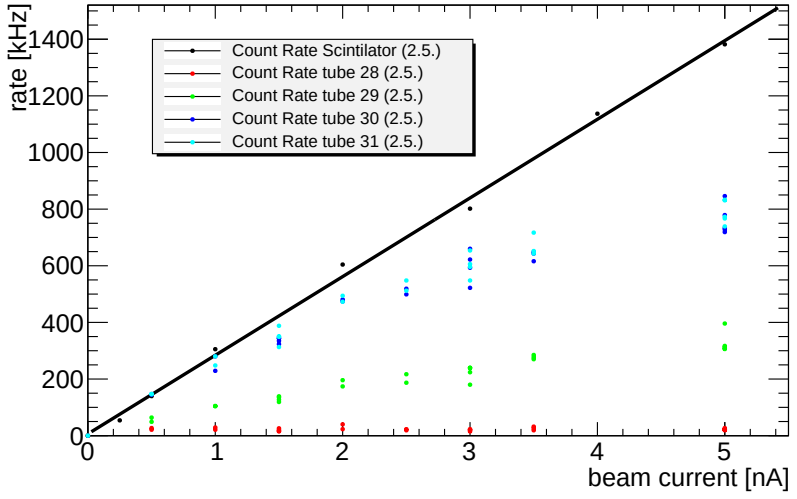
Some Event Displays

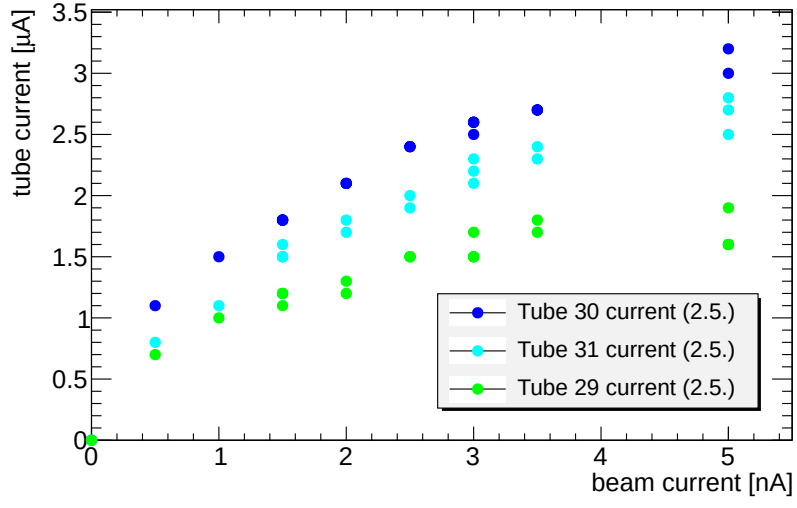


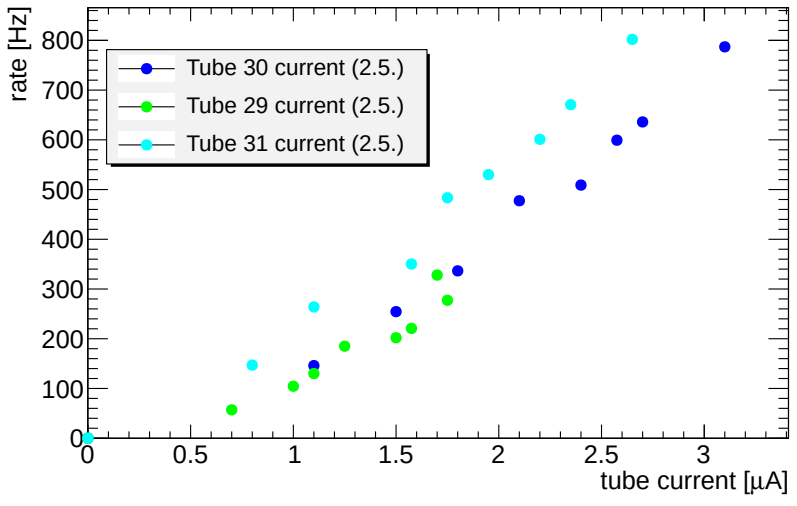
- Low noise rate
- Good trigger acceptance
- $\approx 75\,\%$ tracking efficiency

Measurement of the Proton Rate







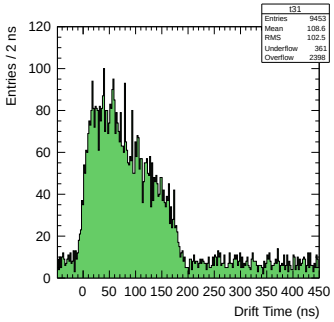


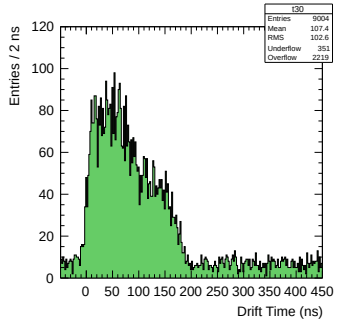
Some saturation effect for rates above $\approx 300\,\text{kHz}$.

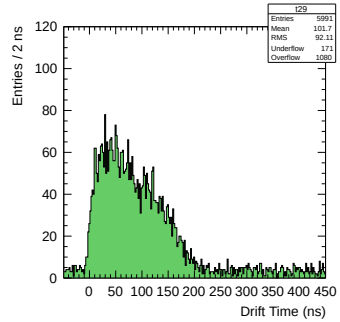
Rates should be save for electronics $\Rightarrow$ Drop of gas gain

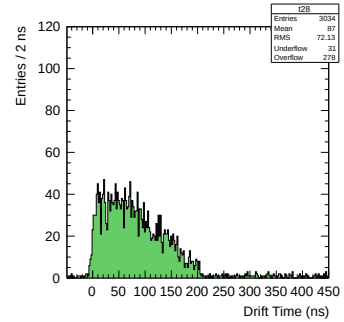
Drift Time and ADC Spectra

low rate drift time

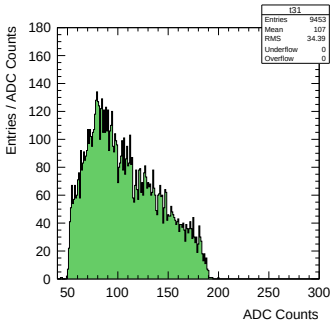


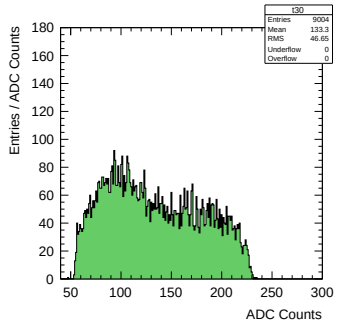


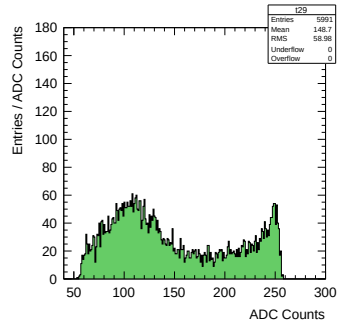


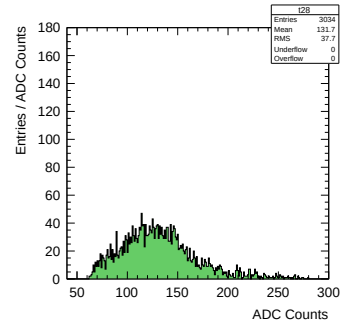


low rate ADC

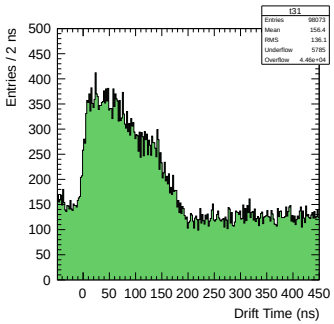


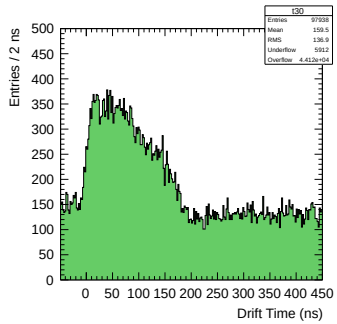


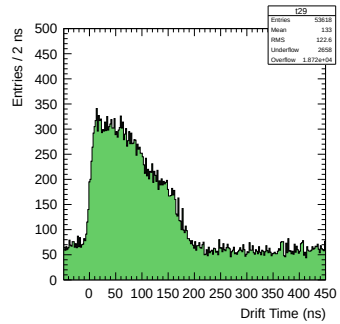


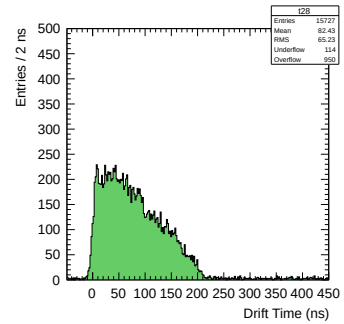


high rate drift time

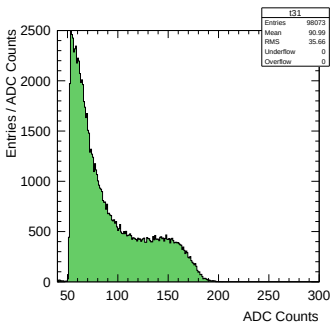


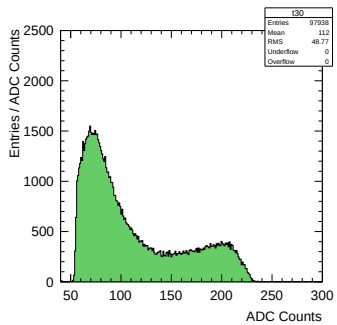


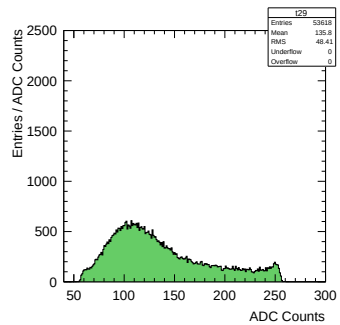


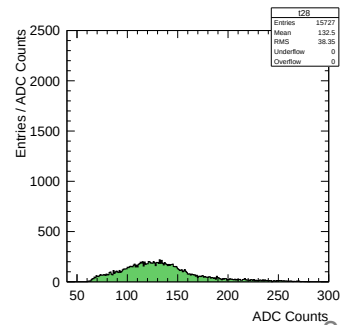


high rate ADC

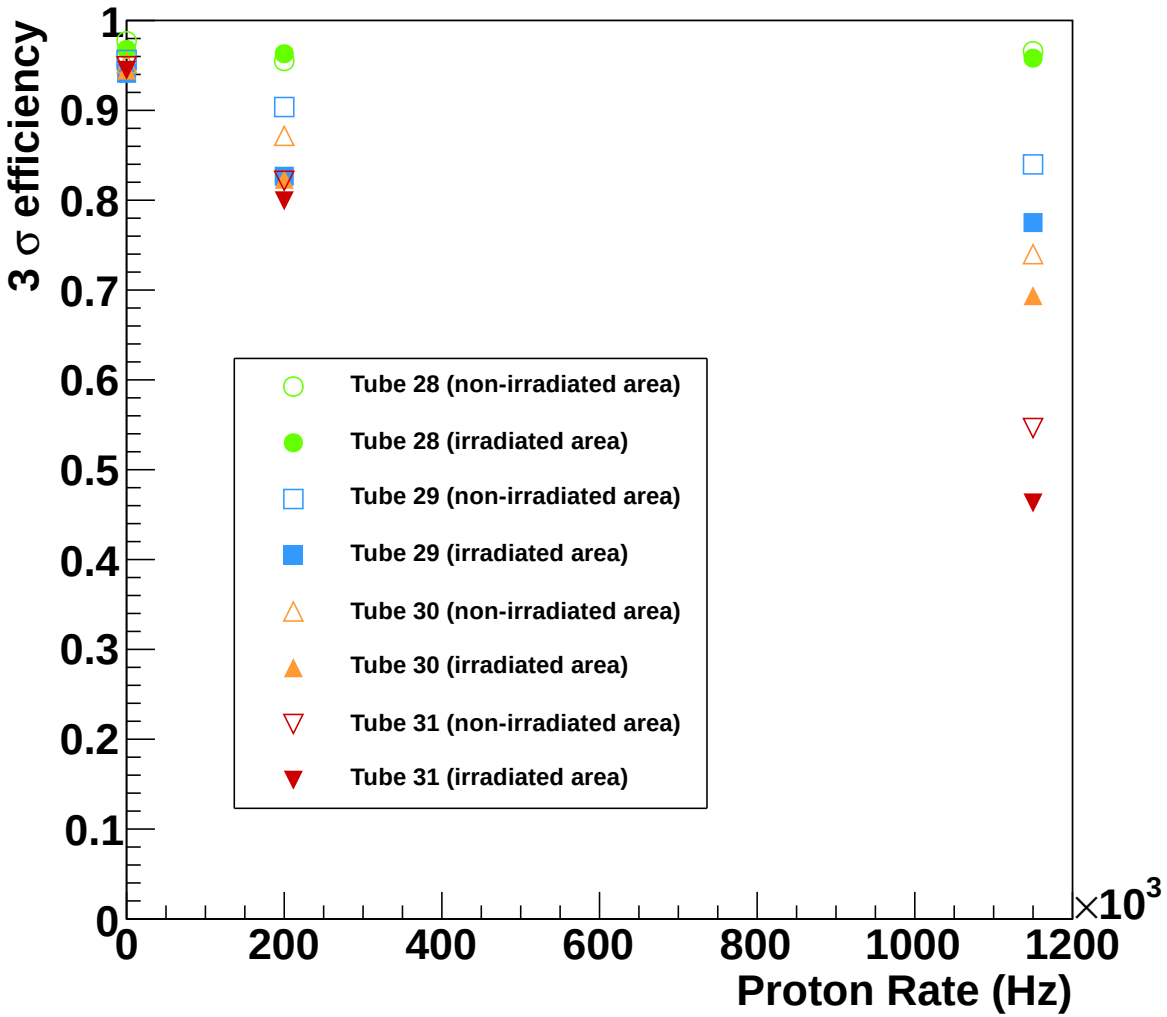








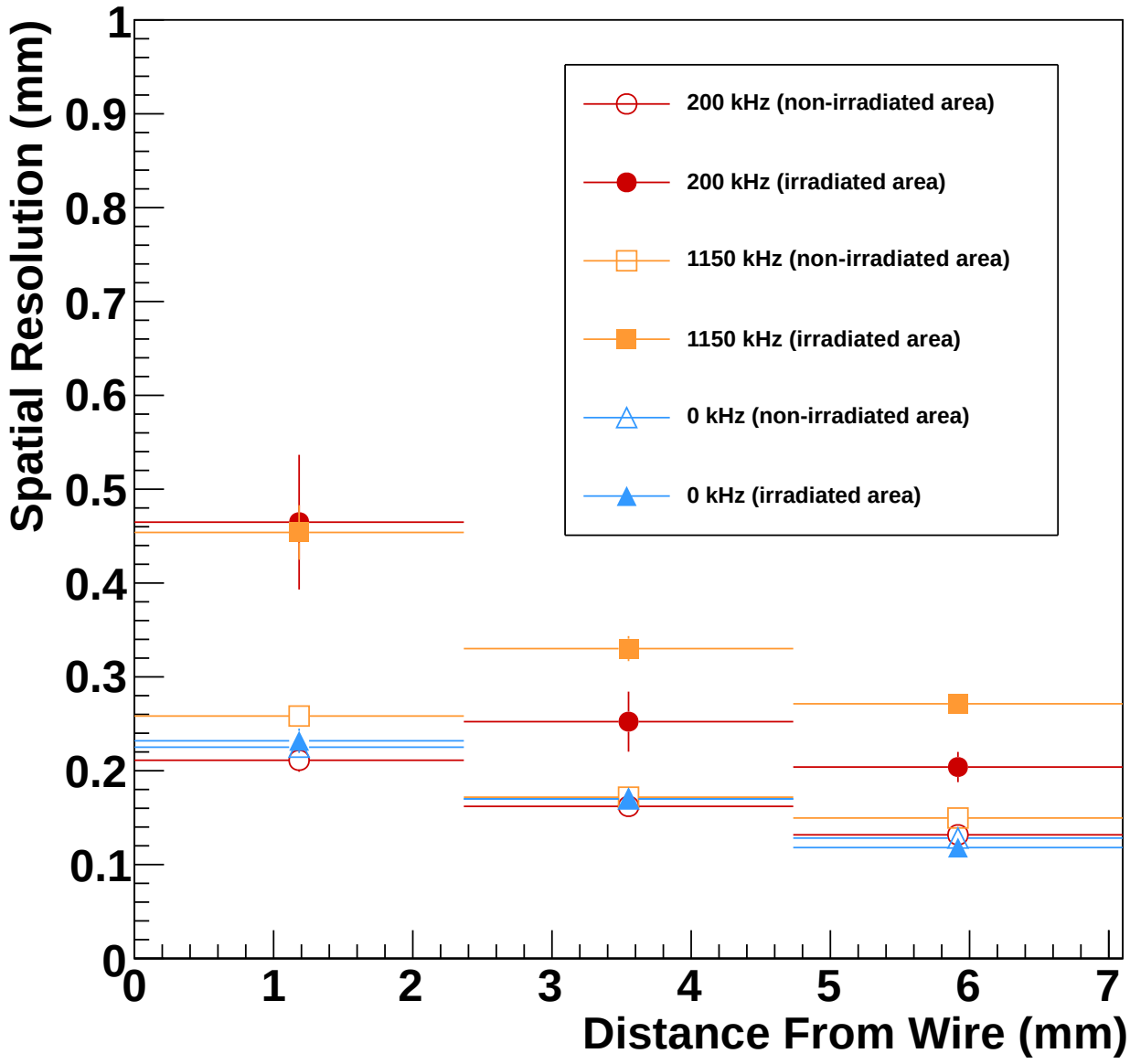
Efficiency



Two effects:

- Masking of muon hits due to the high (proton) rate.
- Additional drop of efficiency due to space charge effects in the irradiated area.

Spatial Resolution



Summary

- MDT chamber performed very well. No HV trips, low noise . . .
- Accelerator performed unfortunately not that well. Three ion sources died.

$\Rightarrow$ Different beam geometry in many of the runs.

- Measured rates and shift of ADC spectra not yet fully understood.
- Efficiency seems to be compatible with the measurements in the GIF.
- Space charge effects should be studied (simulation?).