Study of the response of ionization chambers in HiRadMat

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Acknowledgments: N. Charitonidis.

Outlook

- Motivation
- The Experiment:
  - Setup
  - FLUKA simulations (N. Charitonidis)
  - Observations
- Complementary measurements at PSB
- Summary and conclusions

Motivation

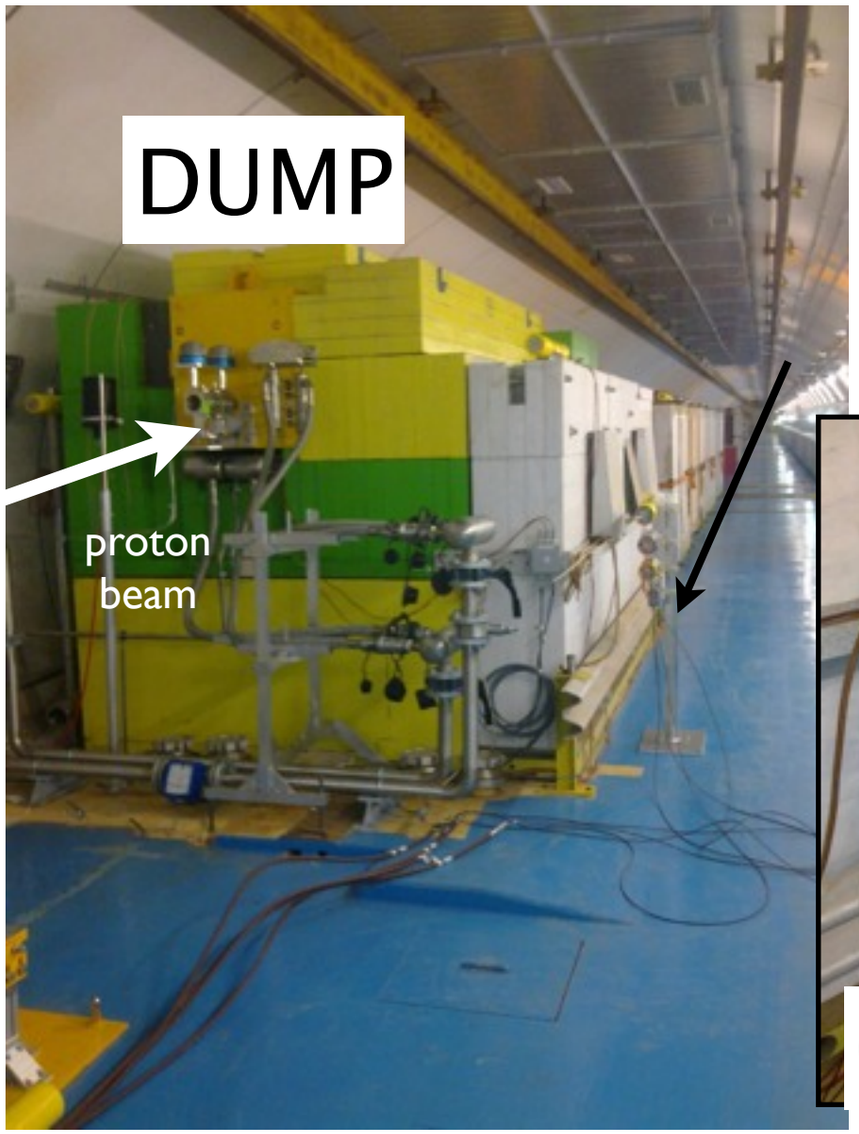
- Motivation: In certain regions of the LHC the Ionization chambers (BLMs) produce such high signals that saturate the electronics making the system blind. The reduction of active volume and filling pressure will reduce the number of charges produced, decreasing the sensitivity. Chambers tested:
  - LHC Ionization Chamber. Active vol 1.5l, filling pressure 1.1 bar.
  - Little Ionization Chambers (LIC). Active vol 0.05l, filling pressure 1.1bar.
  - Little Ionization Chamber (LIC). Active vol 0.05l, filling pressure 0.4 bar
  - Flat Ionization Chambers (FIC). Active vol 0.05l, filling pressure 0.1 bar.

- Study of the signal linearity and response against high voltage variations.

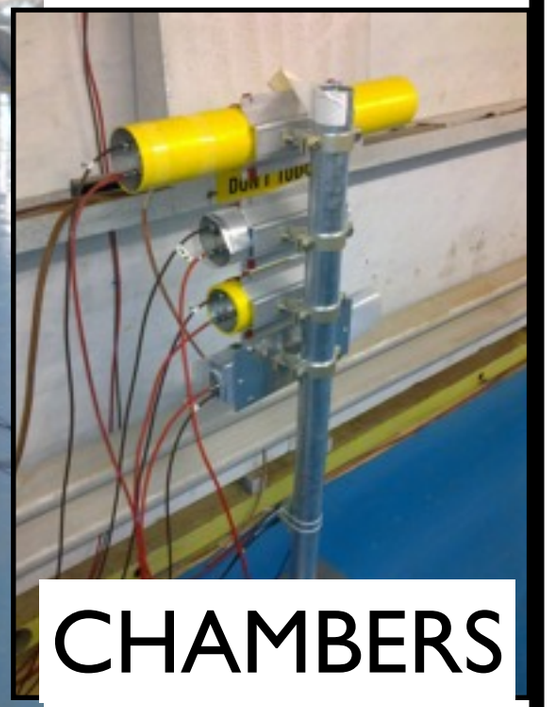
Experimental Setup

- Direct beam onto the dump and observe secondary showers

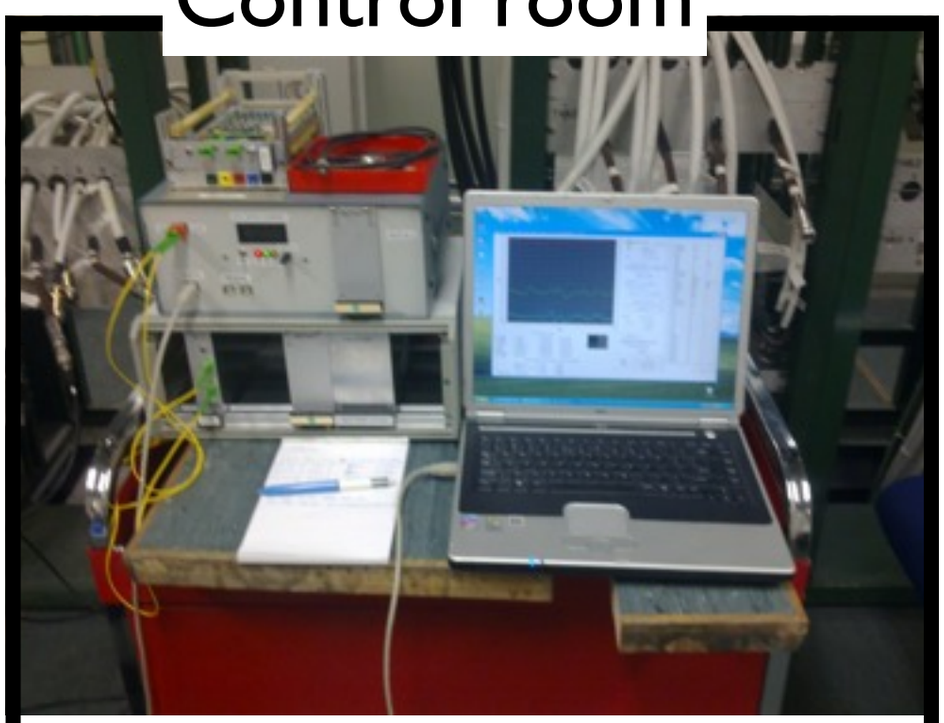
Tunnel

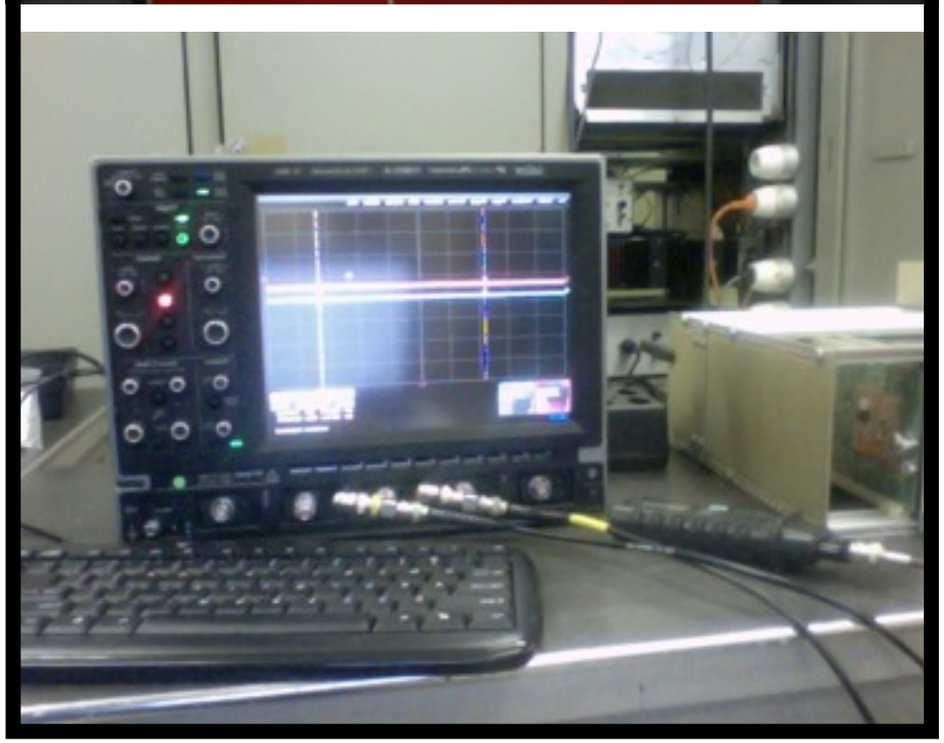


LHC-IC
LIC 1.1 bar
LIC 0.4 bar
FIC

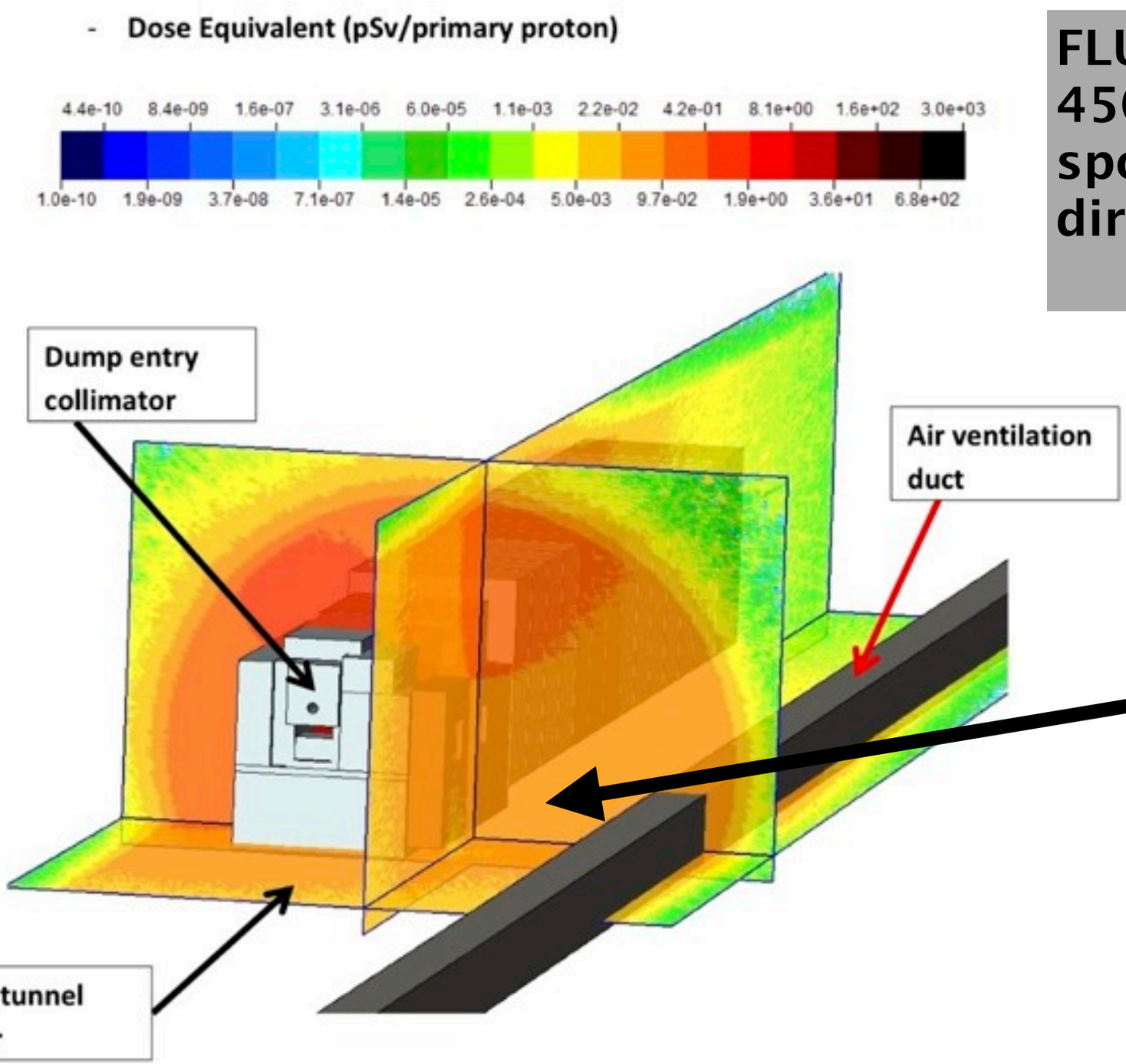


Control room





FLUKA simulation

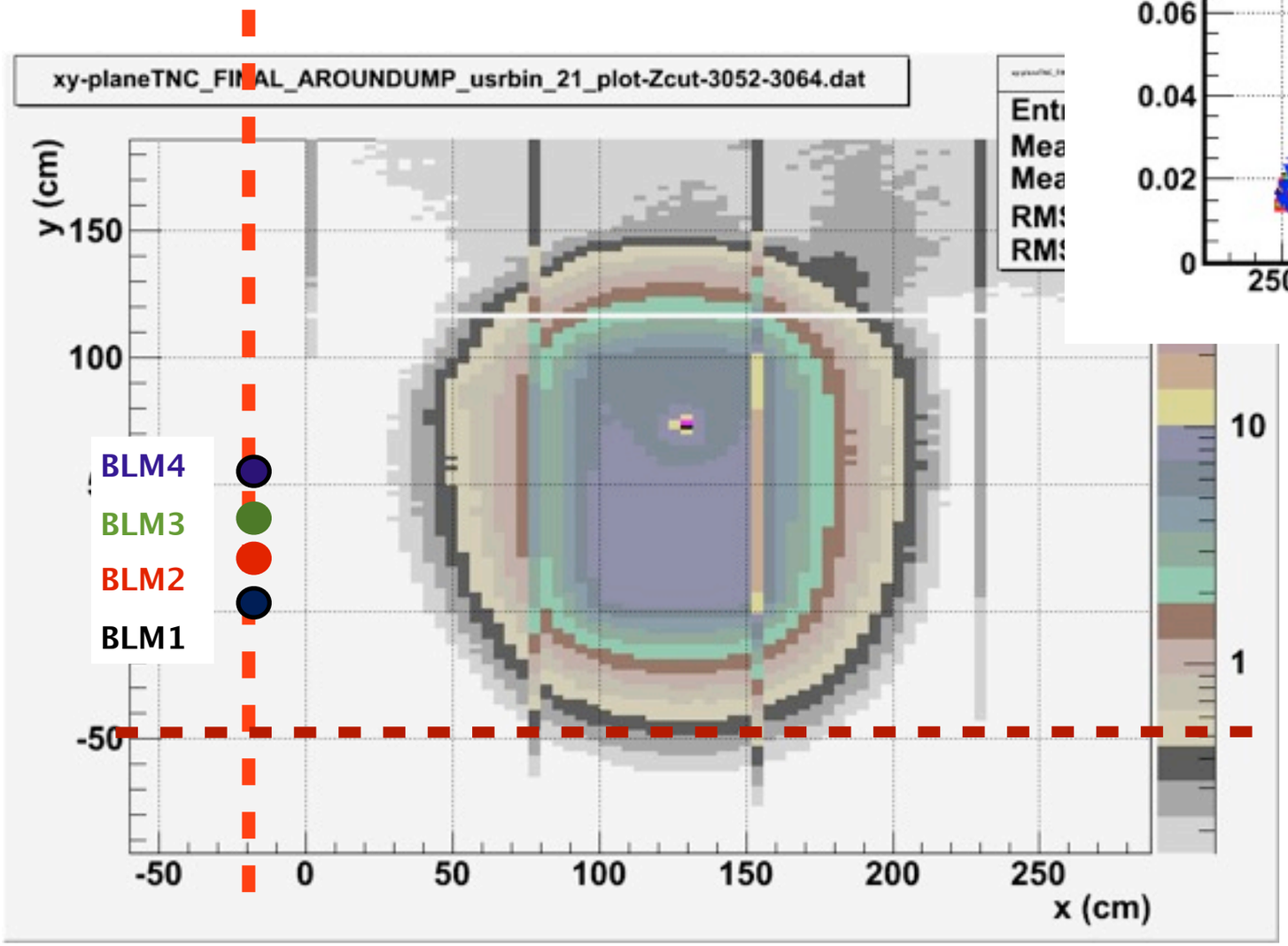


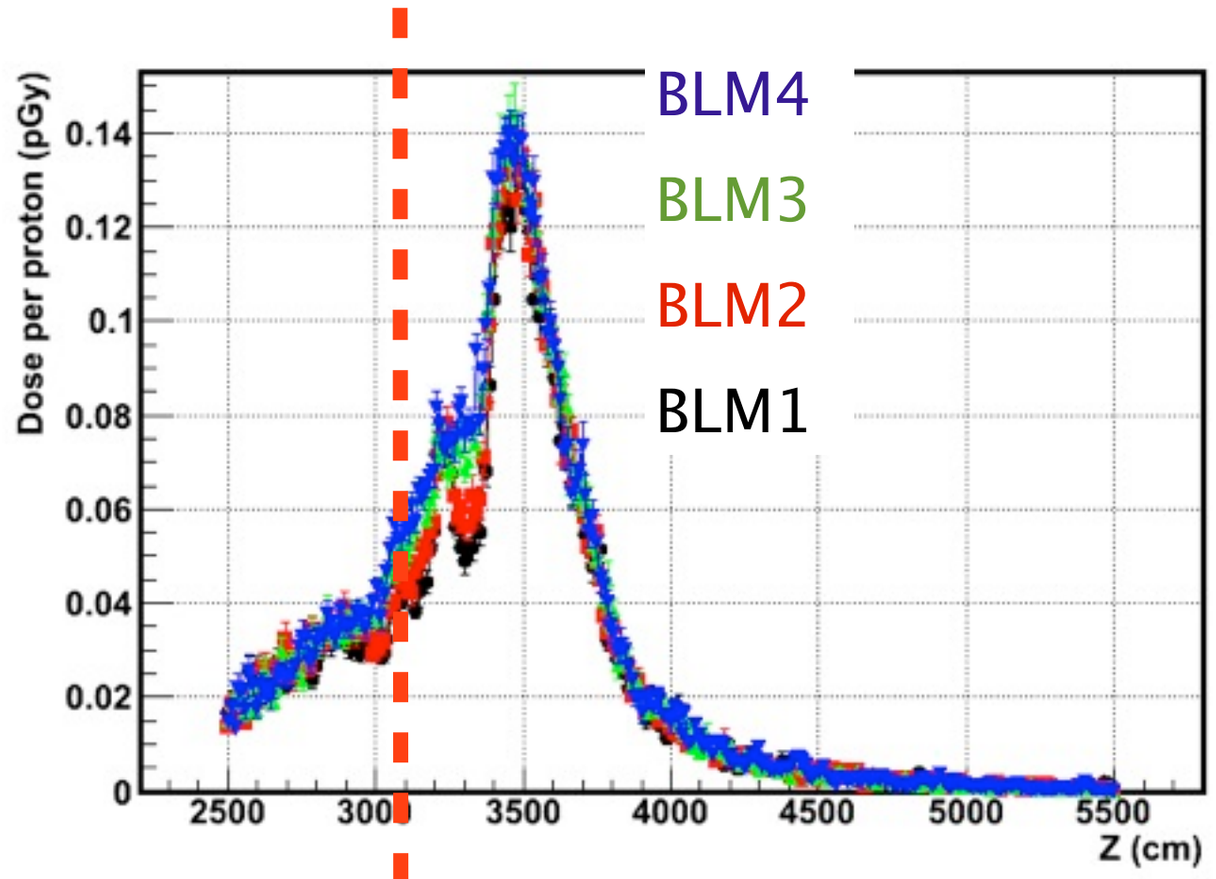
FLUKA (Nikos Charitonidis)
450 GeV p beam
spot size ~2mm
directly hitting beam dump

foreseen detector location

FLUKA simulation

- Total dose per primary proton in 2x4x12 cm3 volumes

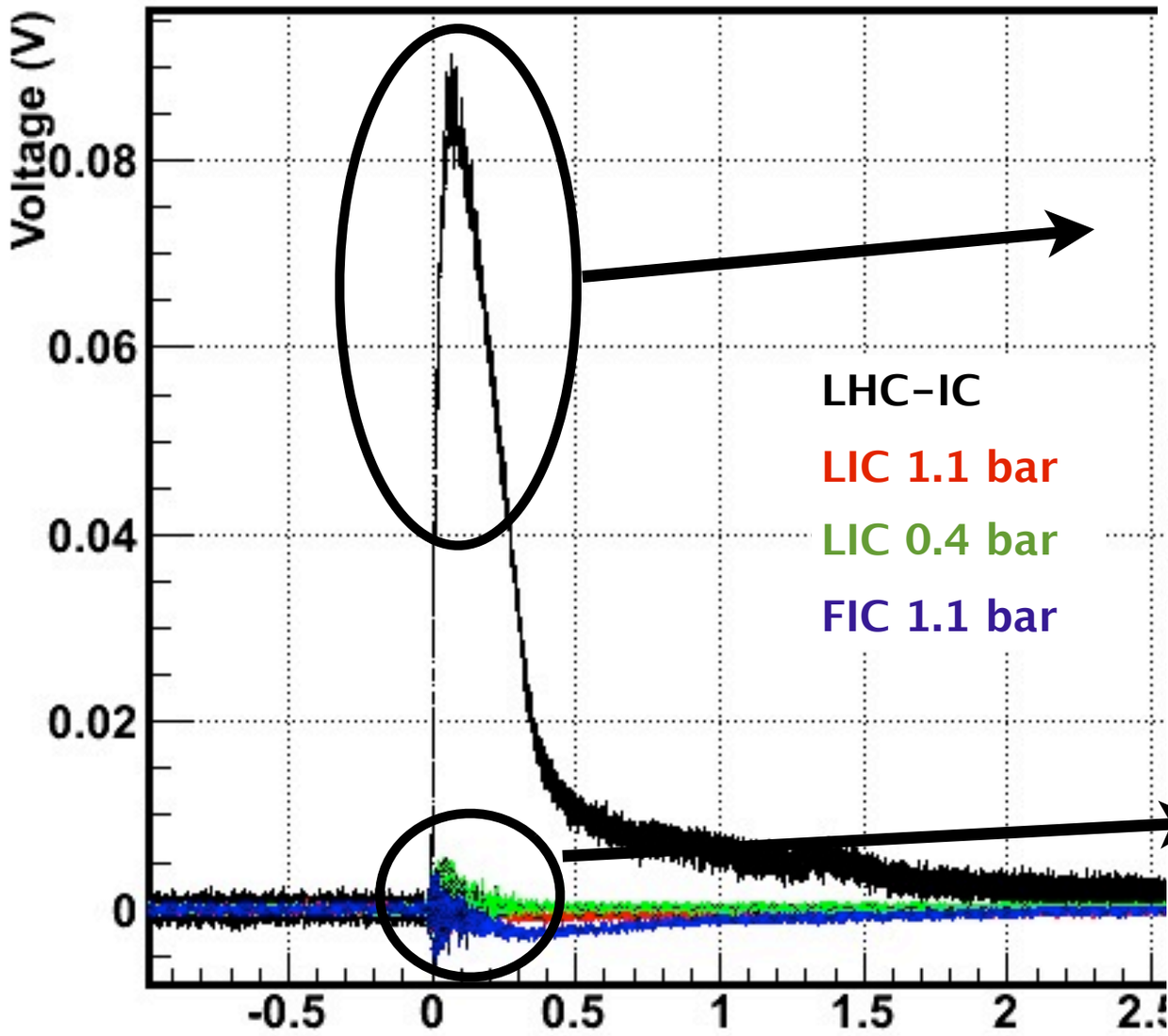


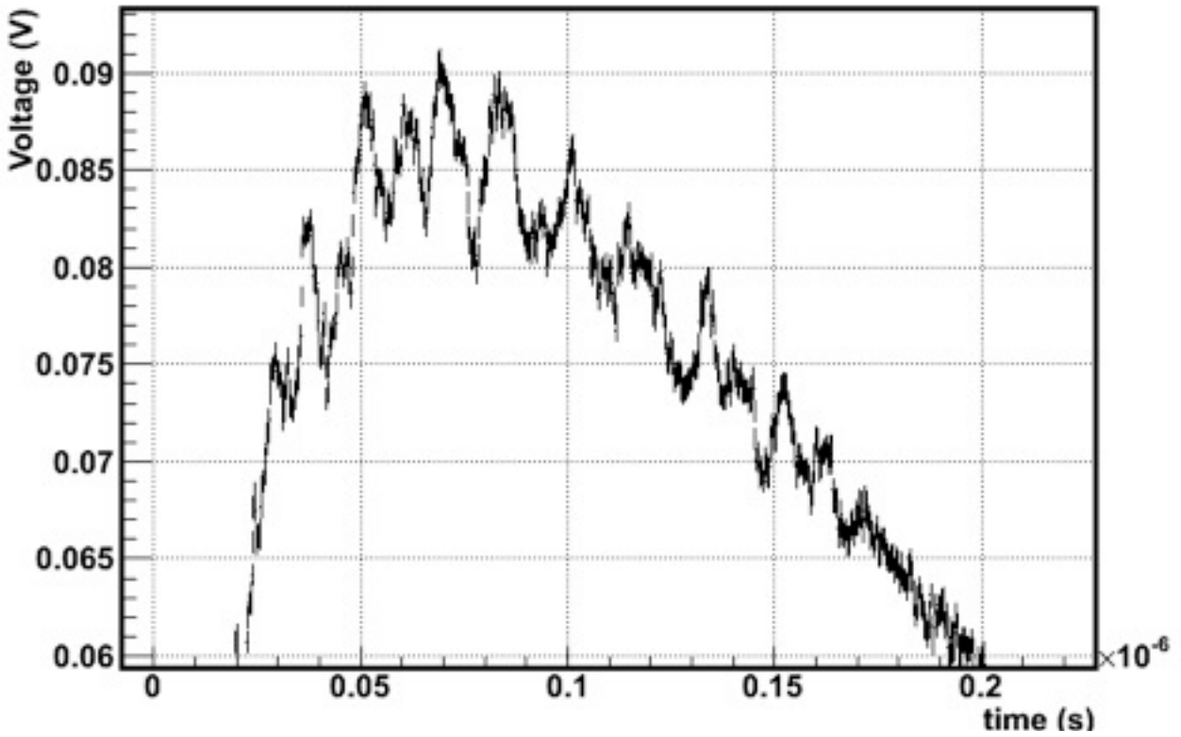


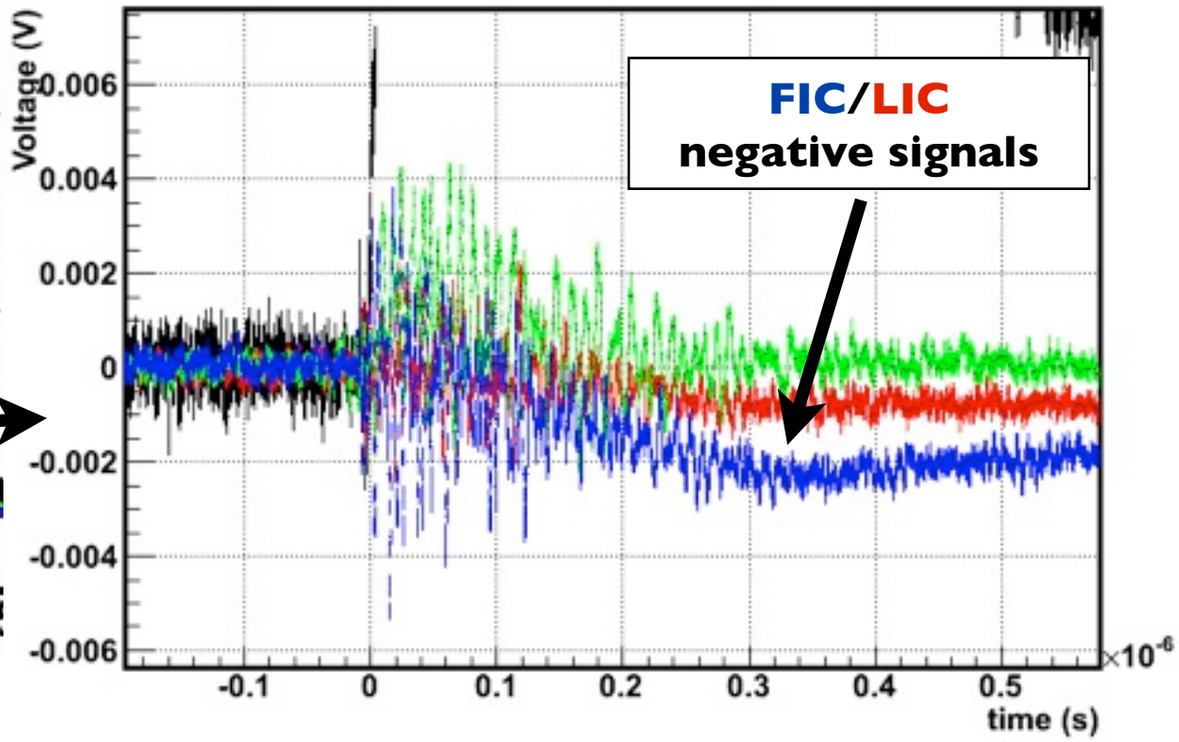
- At the location of BLMs the dose is ~independent of the vertical position (within statistical error).

Observations (Noise)

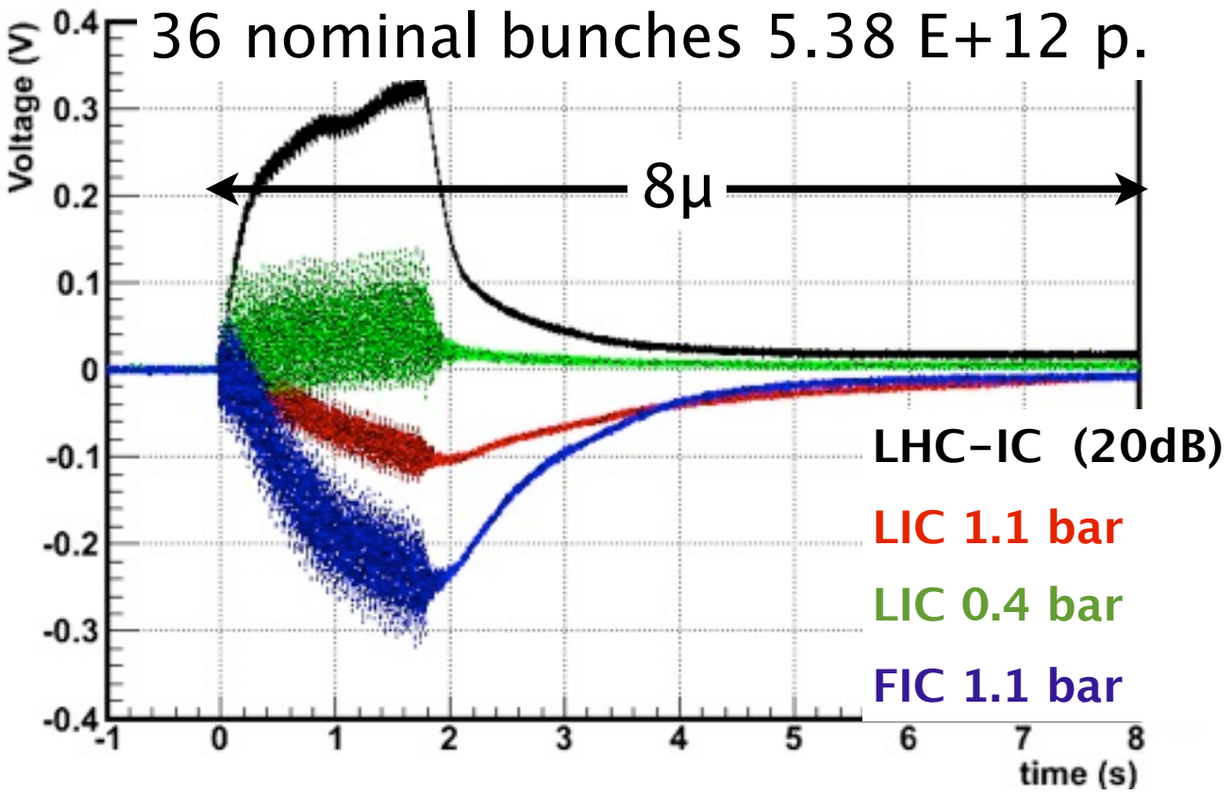
- Probe bunch 2.77E+10 p
- High frequency noise also during a few ~100ns.

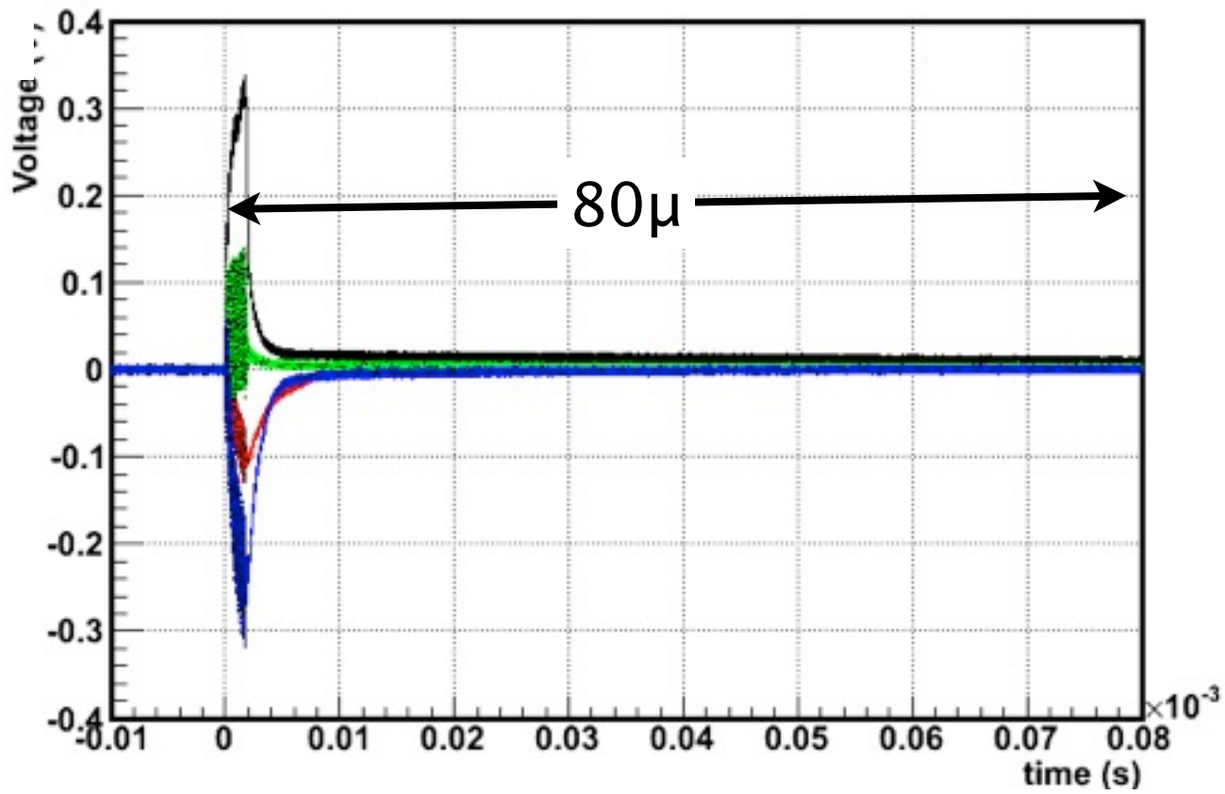


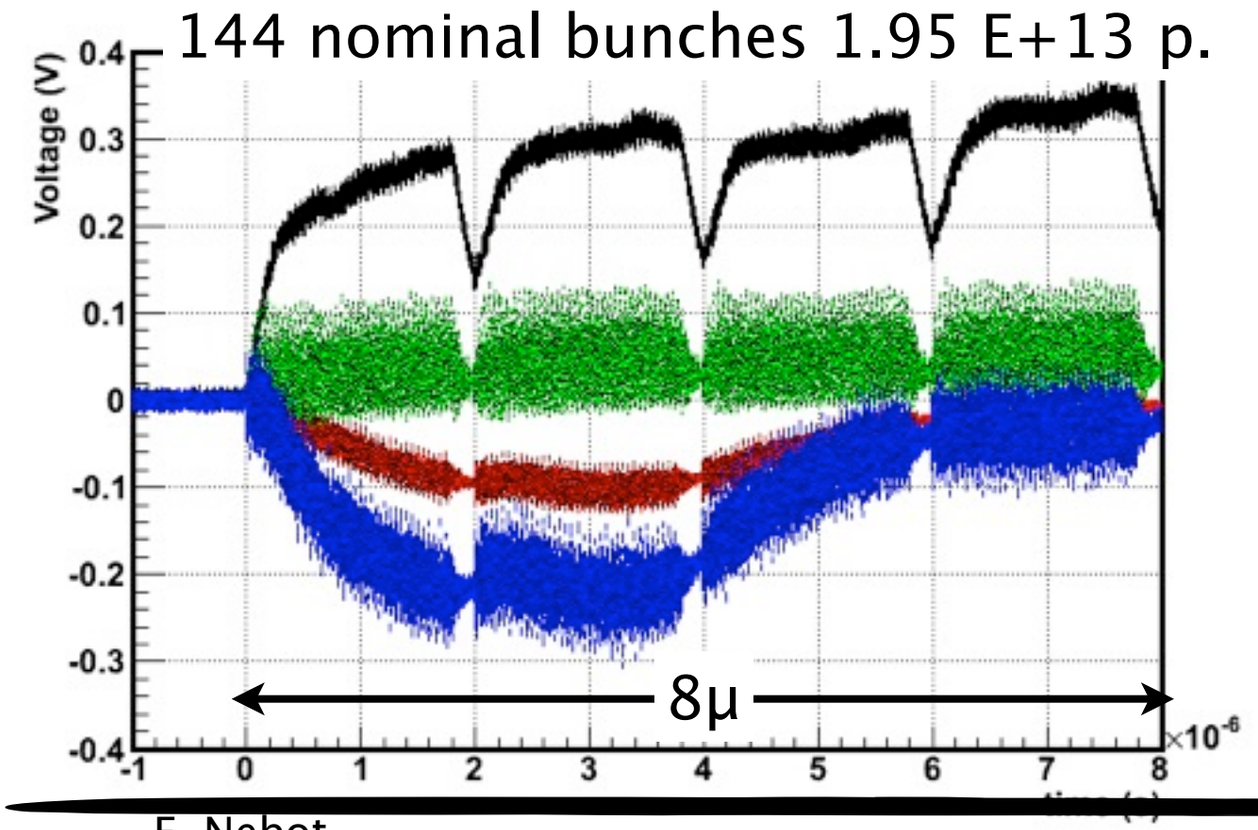


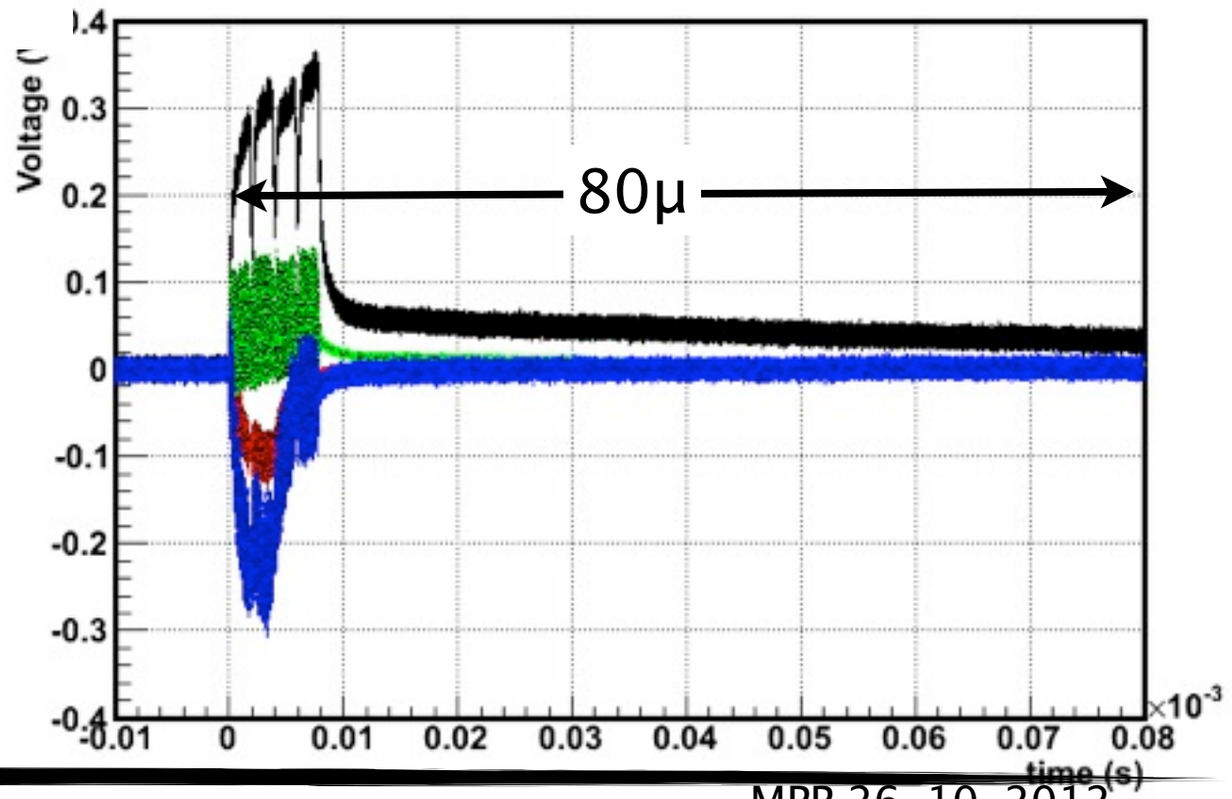


Observations

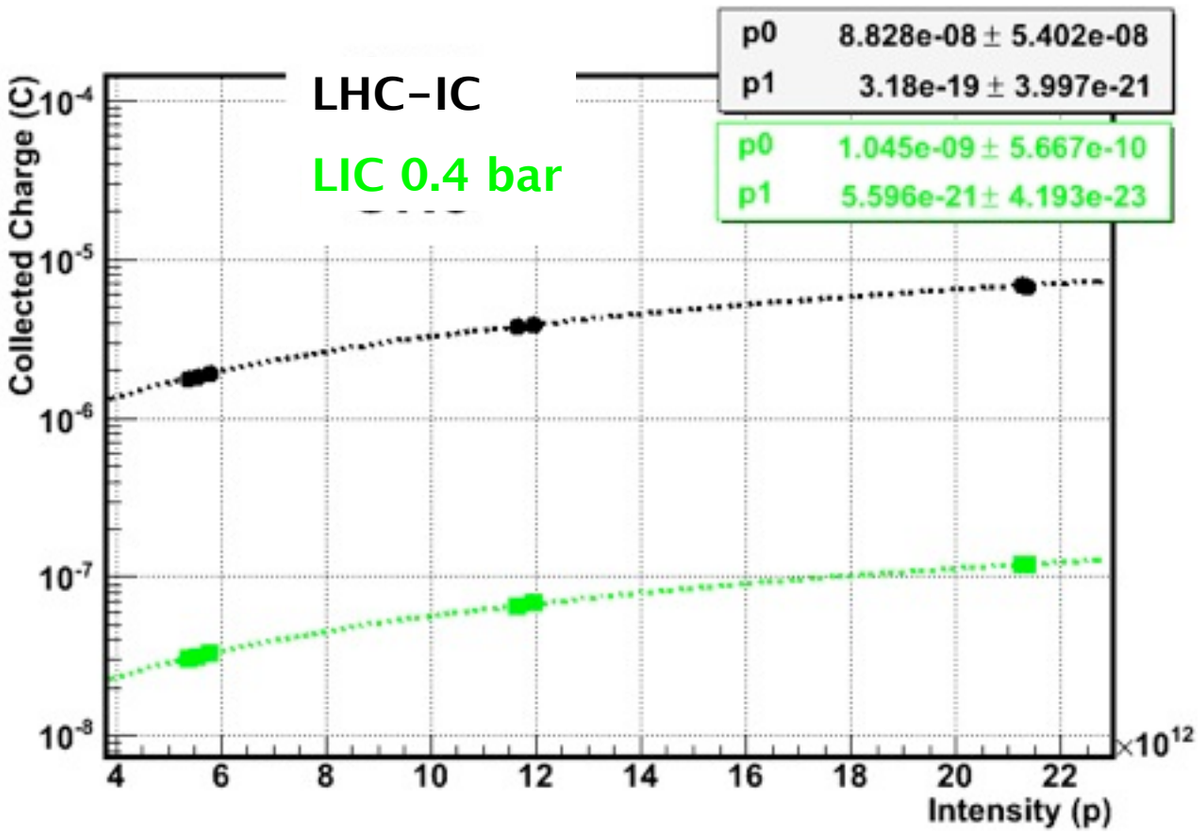




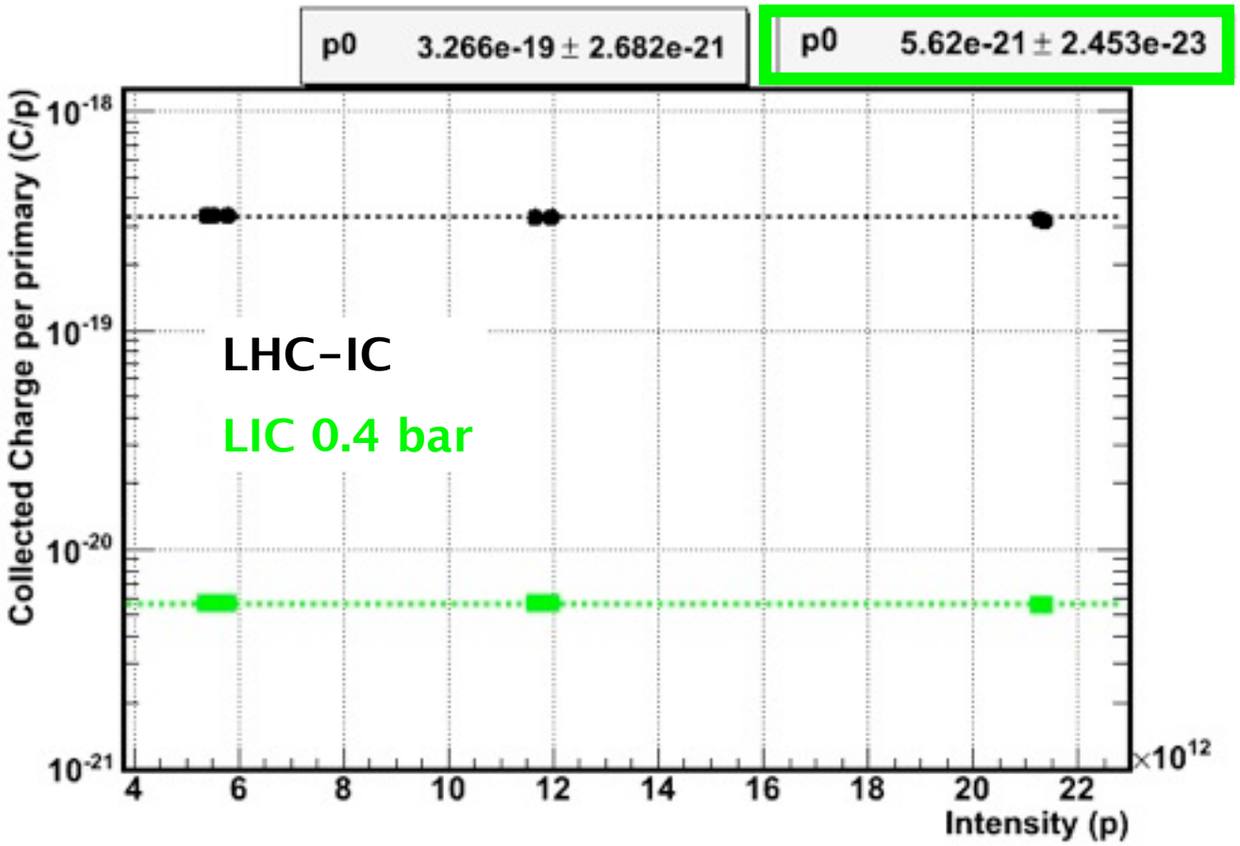




Observations



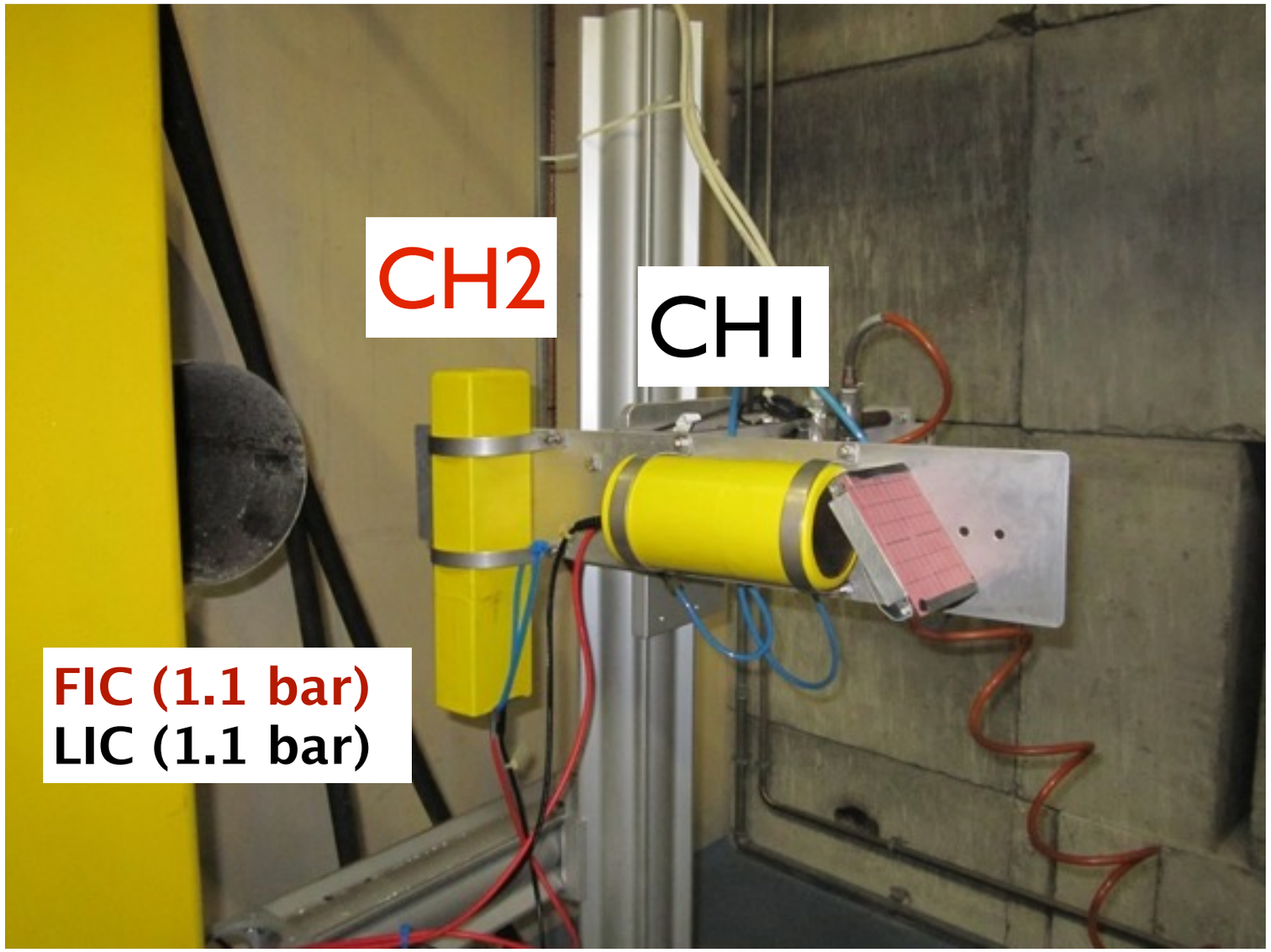
- Signals integrated with LHC electronics (1.3 s) **LHC-IC** and LIC 0.4 bar.
- Linear dependence with intensity found in both chambers.



- Constant (within 3-1 %) normalized signal vs intensity (small space charge effect)
- S_{IC}/S_{LIC} = 58 (similar to previous measurements).

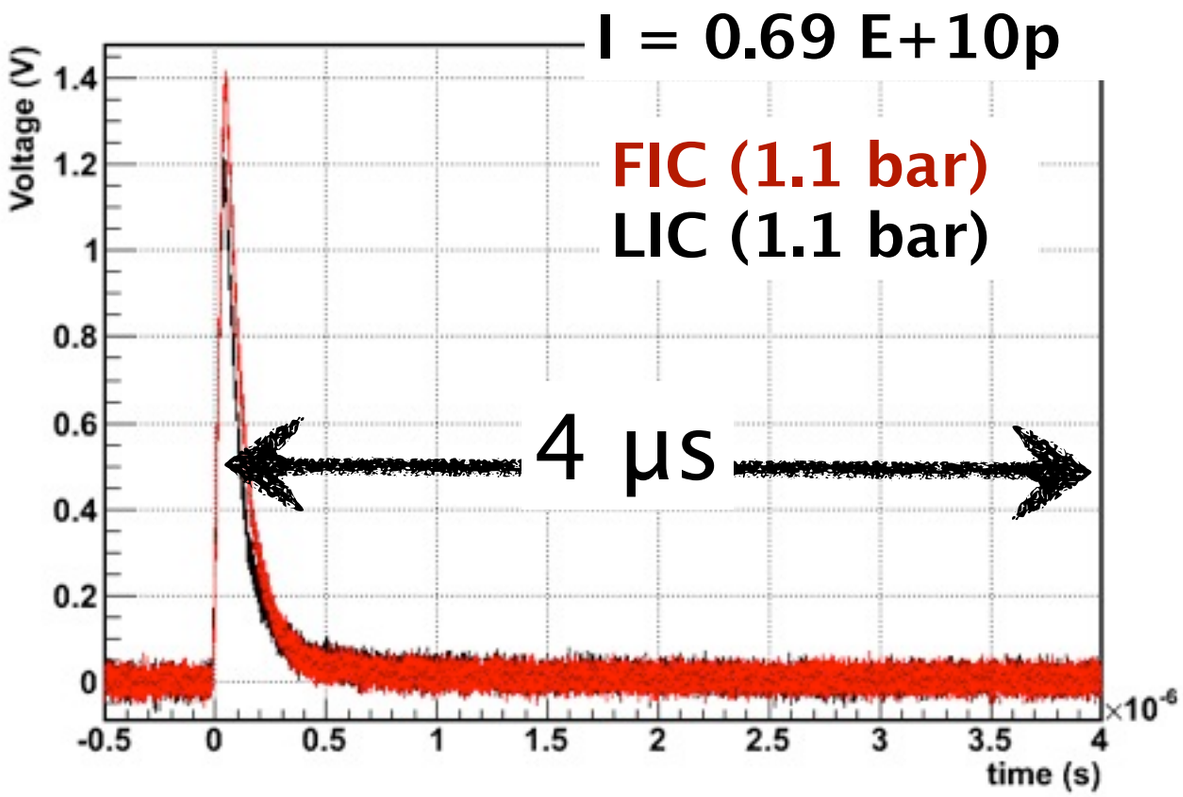
More measurements at PSB

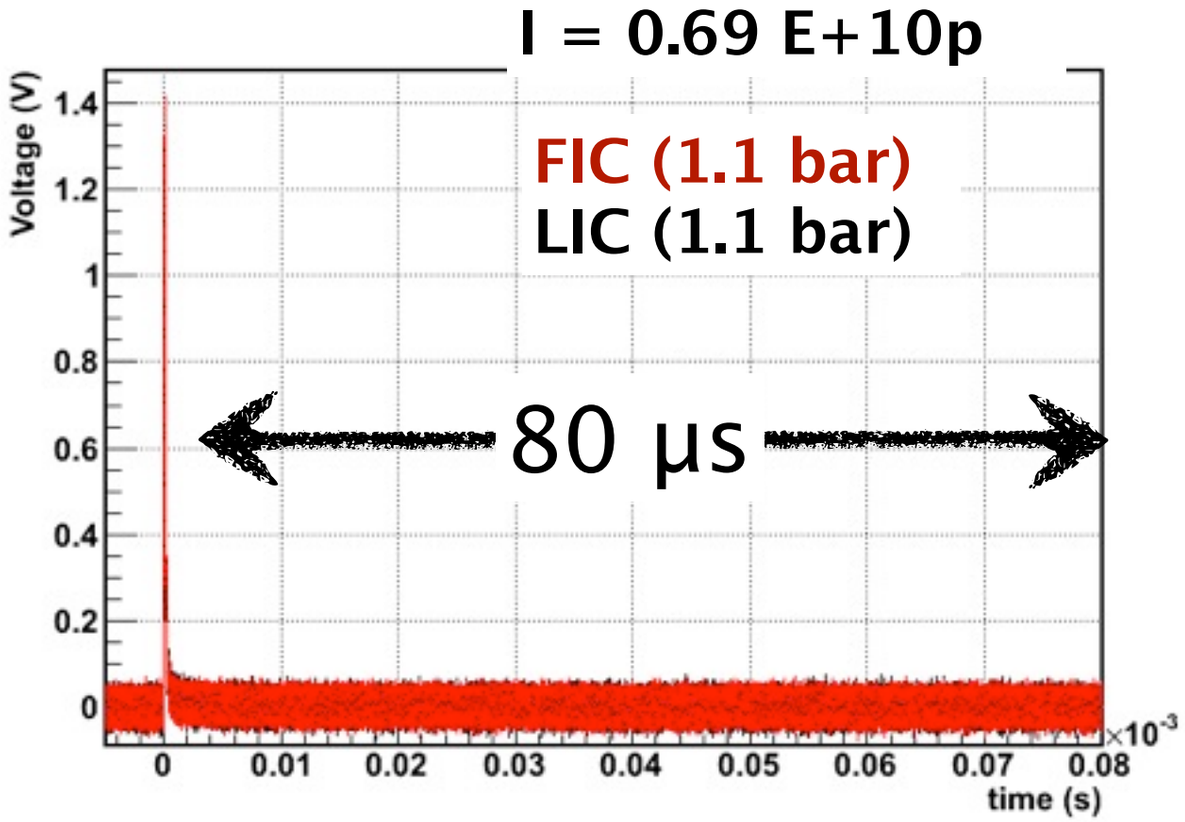
- Same LIC-FIC detectors corrected (Capacitor on HV input) and installed in PSB dump line.
- Beam conditions: 1.4GeV protons, ~1.0 E+10 p/bunch.
- Lenght ~60ns. Size ~ 1 mm.



More measurements at PSB

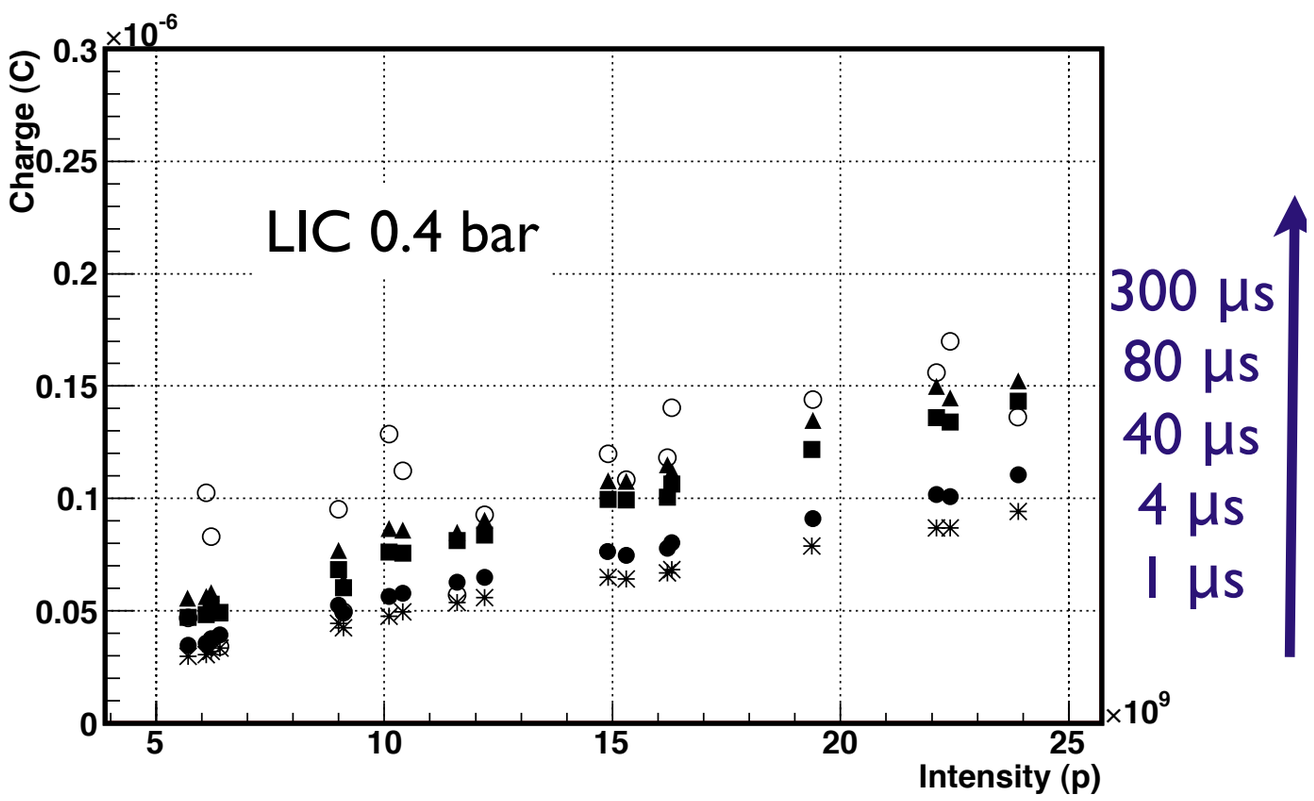
- Typical pulse shapes observed:
- raise time ~50 ns. Fwhm ~ 80 ns
- Electron pulse duration



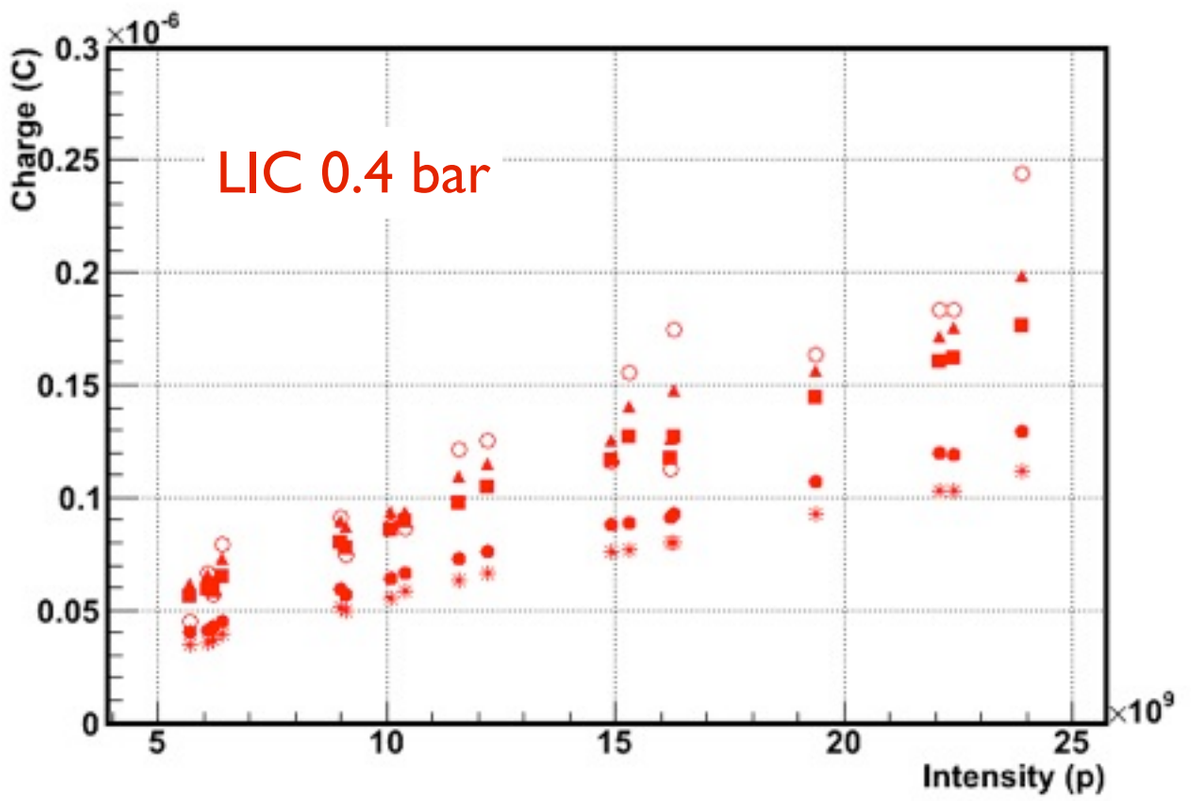


Intensity scan. Integration windows

- Integration windows Δt = 1μs , 4μs , 40μs , 80μs and 320μs
- Electron/ion collection time ~ 100ns/100μs
- During the first two integration windows the charges are mostly due to the electron collection.

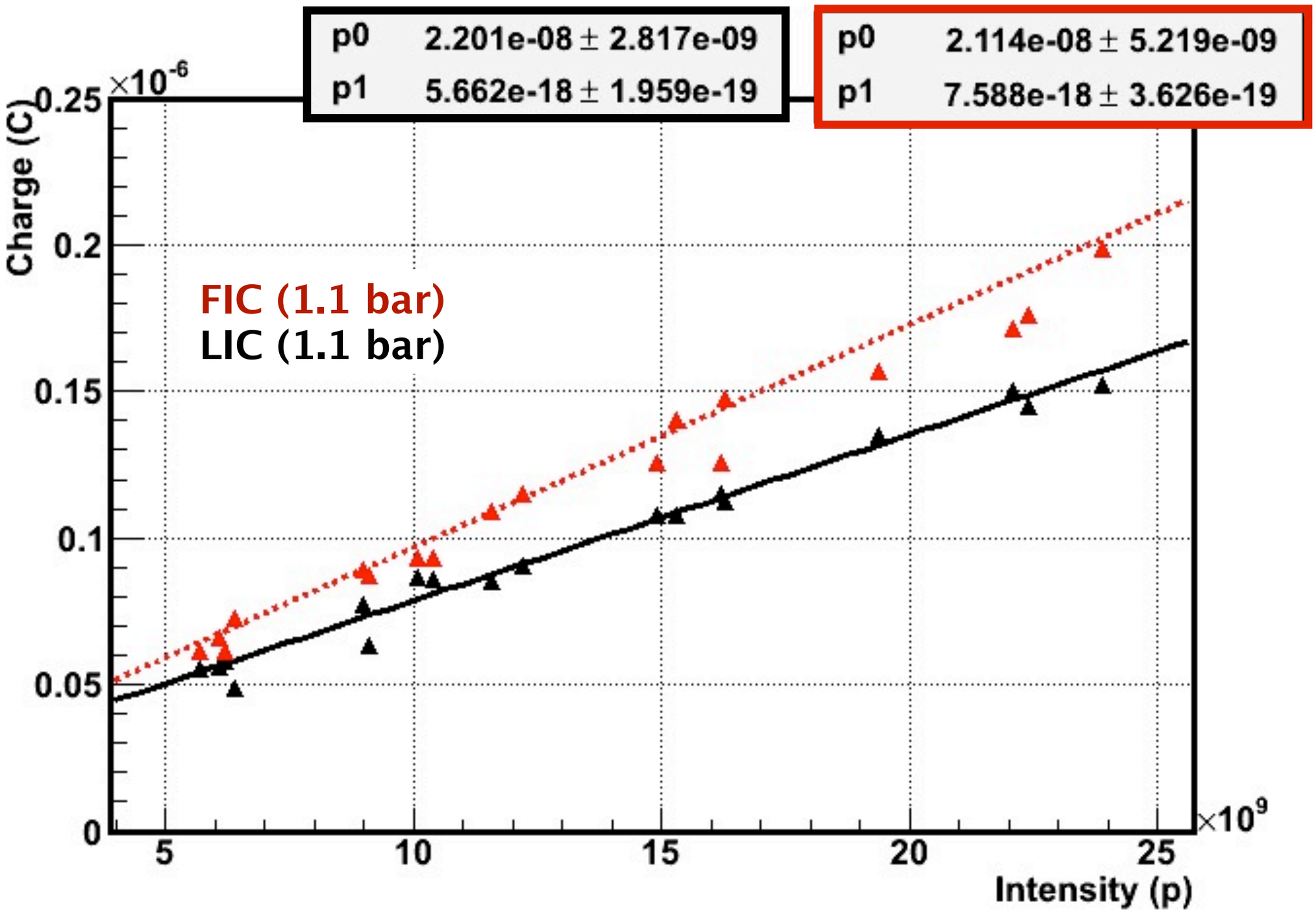


300 μs
80 μs
40 μs
4 μs
1 μs



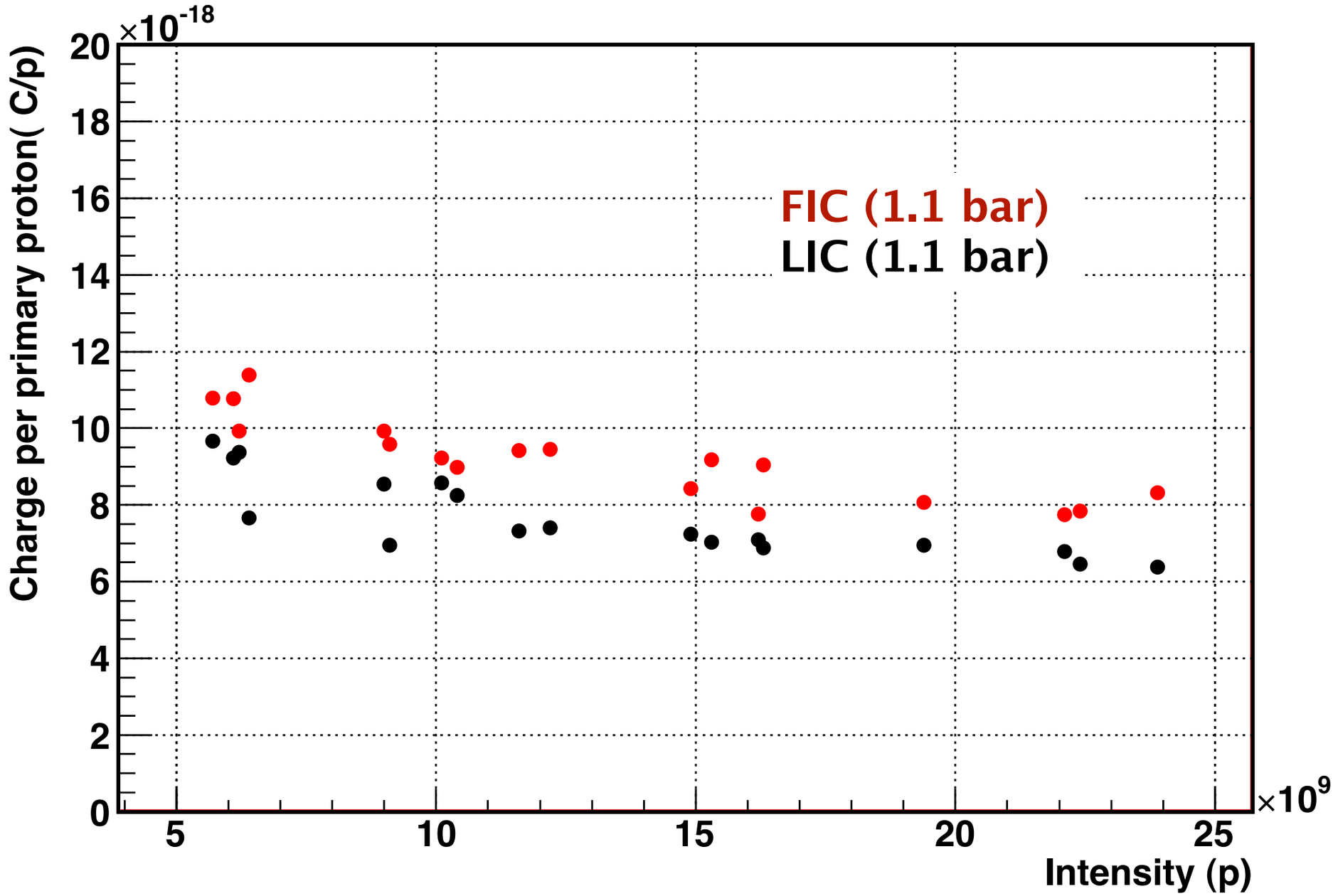
Intensity scan.

Integrated charge (80 µs)



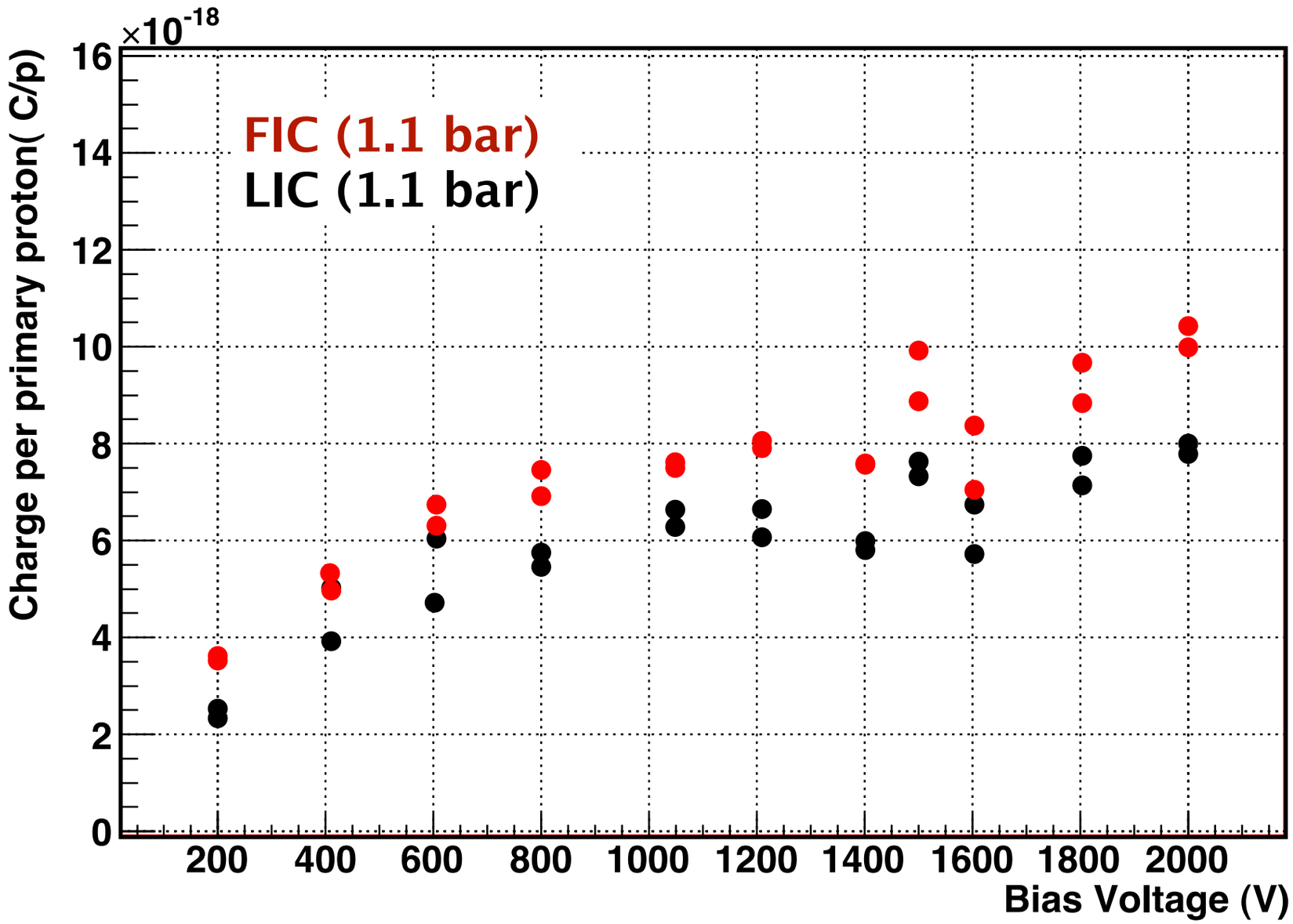
Integrated signals. I scan

Integrated signals (80 µs) per primary proton.
Decreasing tendency attributed to space charge



HV scan

Integrated signals (80 µs) per primary proton.
Roughly flat response between 800 and 1600 V



Summary and conclusions

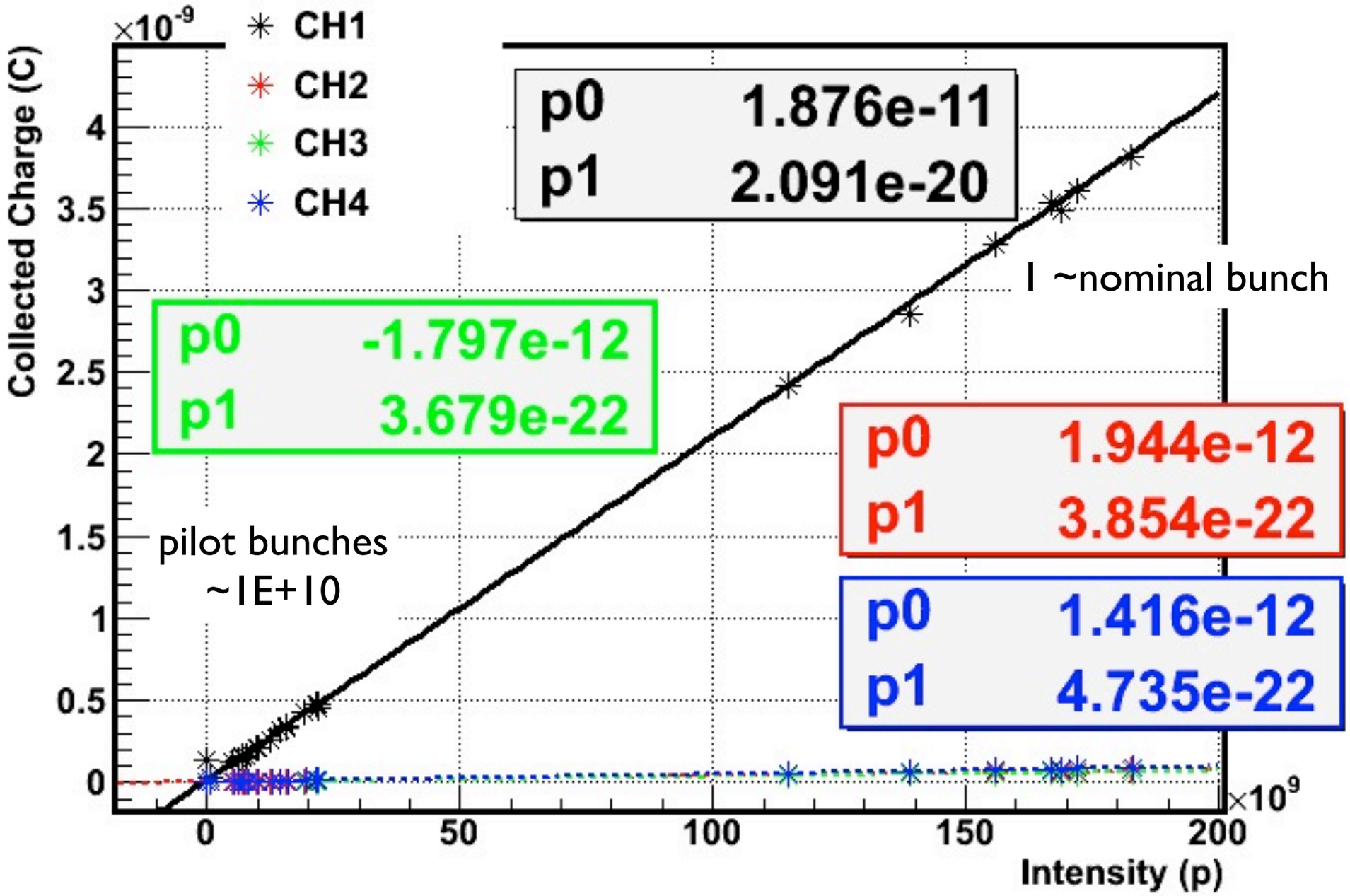
- Chambers were tested in two different conditions:
  - Hiradmat. Up to 144 bunches (1.5 E+11 p/bunch) of 440GeV protons at 50 ns bunch spacing. Pulse durations ~ 7μs. LIC (0.4 bar)/IC showed behaviour as previously measured. FIC/LIC
  - PSB dump line. Single bunch. Pulse duration ~ 70 ns. Intensities from 5E+9 to 2.0E+10 protons. Linearity with intensity observed after correction of HV input.
- Installation of these two new devices in the LHC. Preferred location at TDI (replace existing SEM detectors)

BLM name	DCum
BLMEL.04L2.B1E10_TDI.4L2.B1	3251.027
BLMES.04L2.B1E10_TDI.4L2.B1	3251.027
BLMEI.04L2.B1E20_TDI.4L2.B1	3254.727
BLMES.04L2.B1E20_TDI.4L2.B1	3254.727

Extra slides

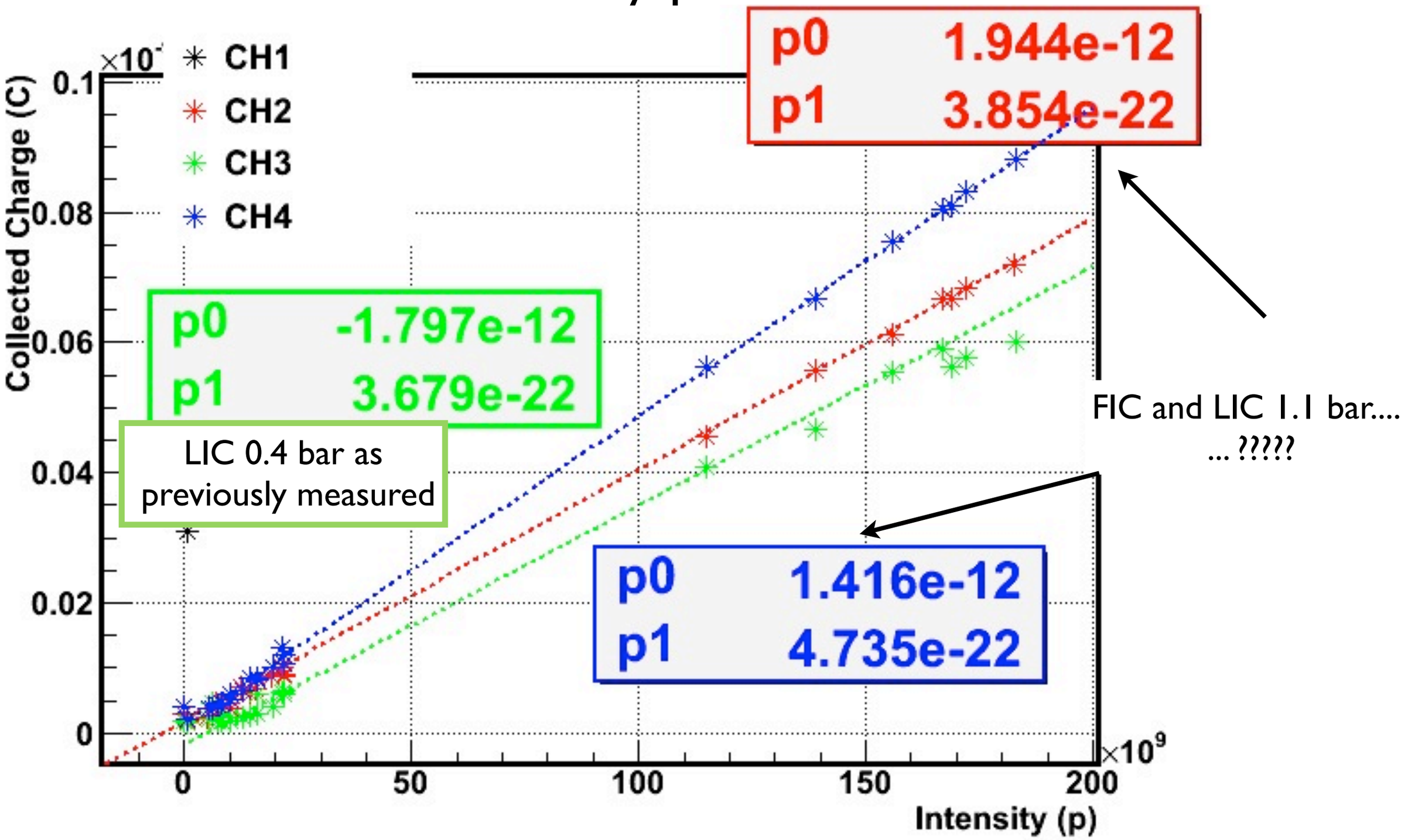
Signal (40us) vs Intensity

HiRadmat. Low intensity phase



Signal (40us) vs Intensity (ZOOM FIC/LIC)

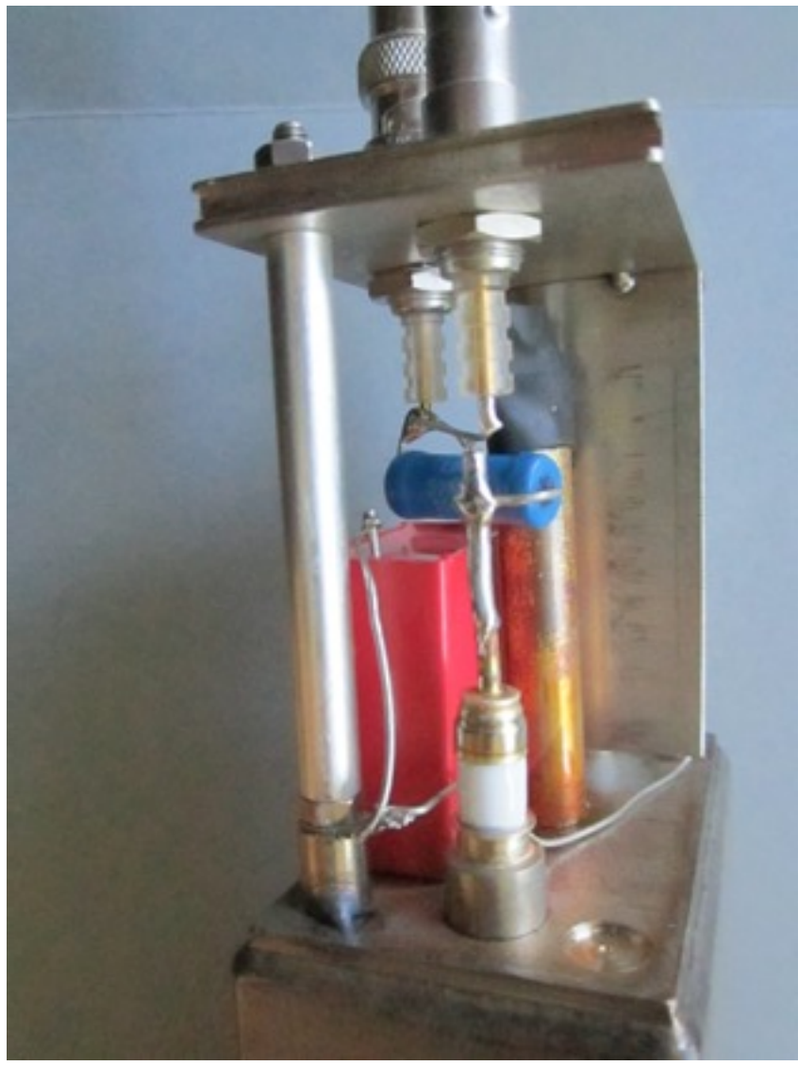
HiRadmat. Low intensity phase

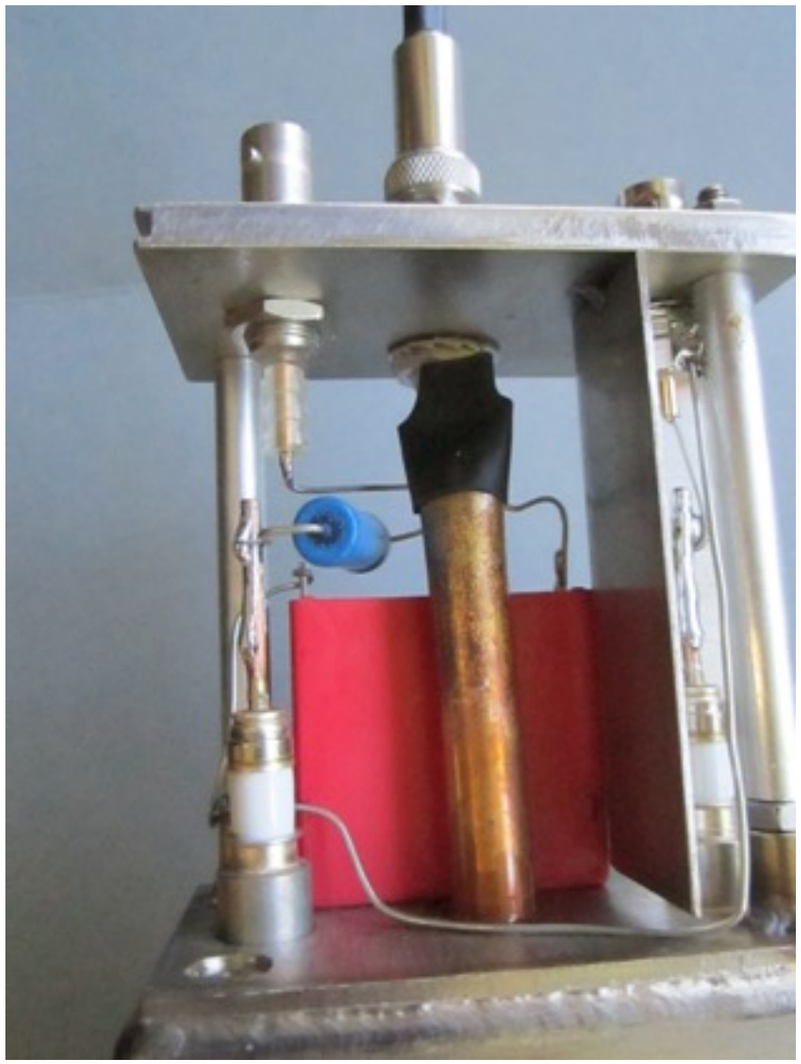


Post-hiradmat lab test

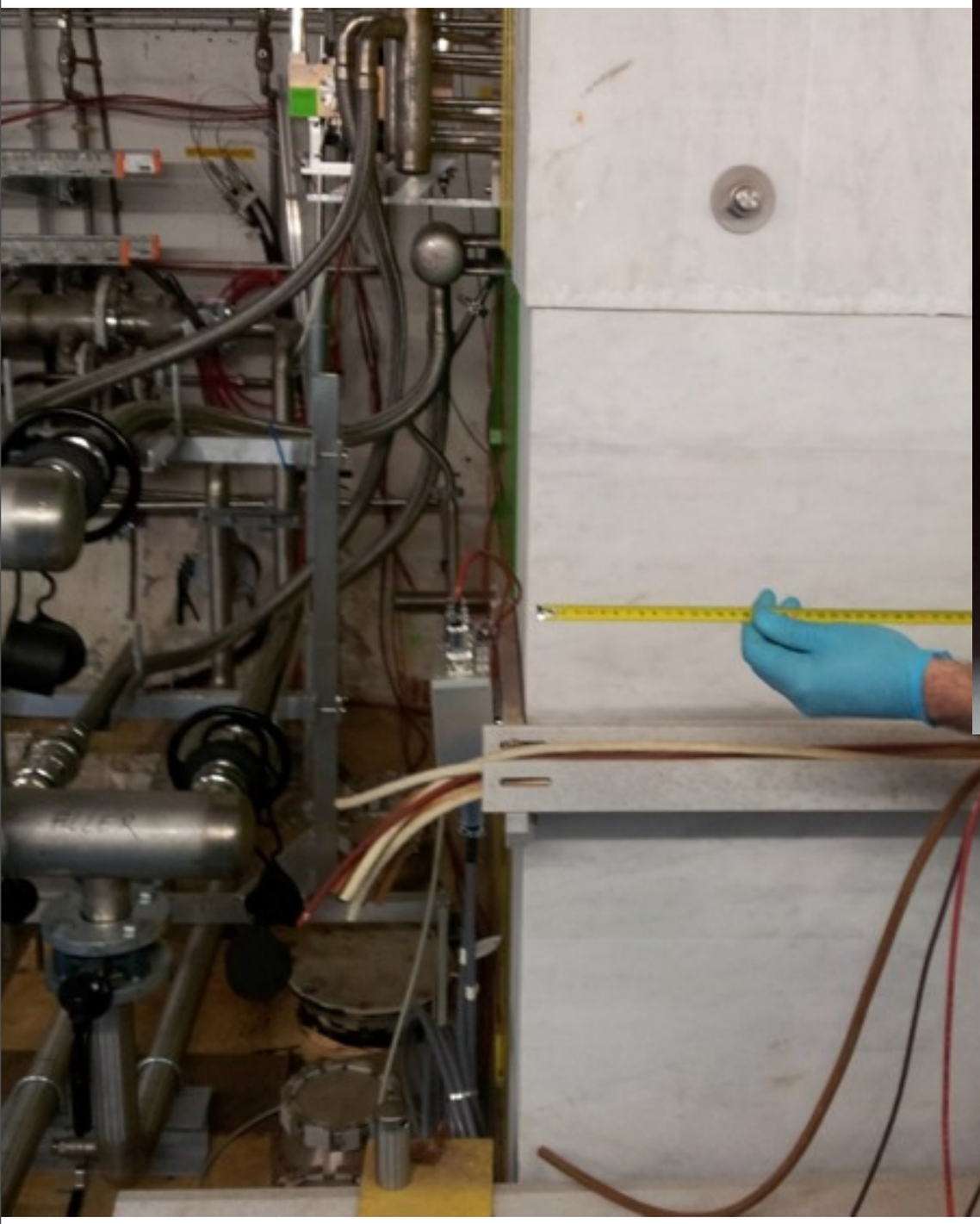
- Under modulation test, SEM and LIC detectors present the same behaviour.
- Modulation test showed that both LIC-FIC behaved as SEM without filter.
- Electrical box was open to find a wrong connection of Capacitor and resistance in both detectors.

Some photos of the opened FIC

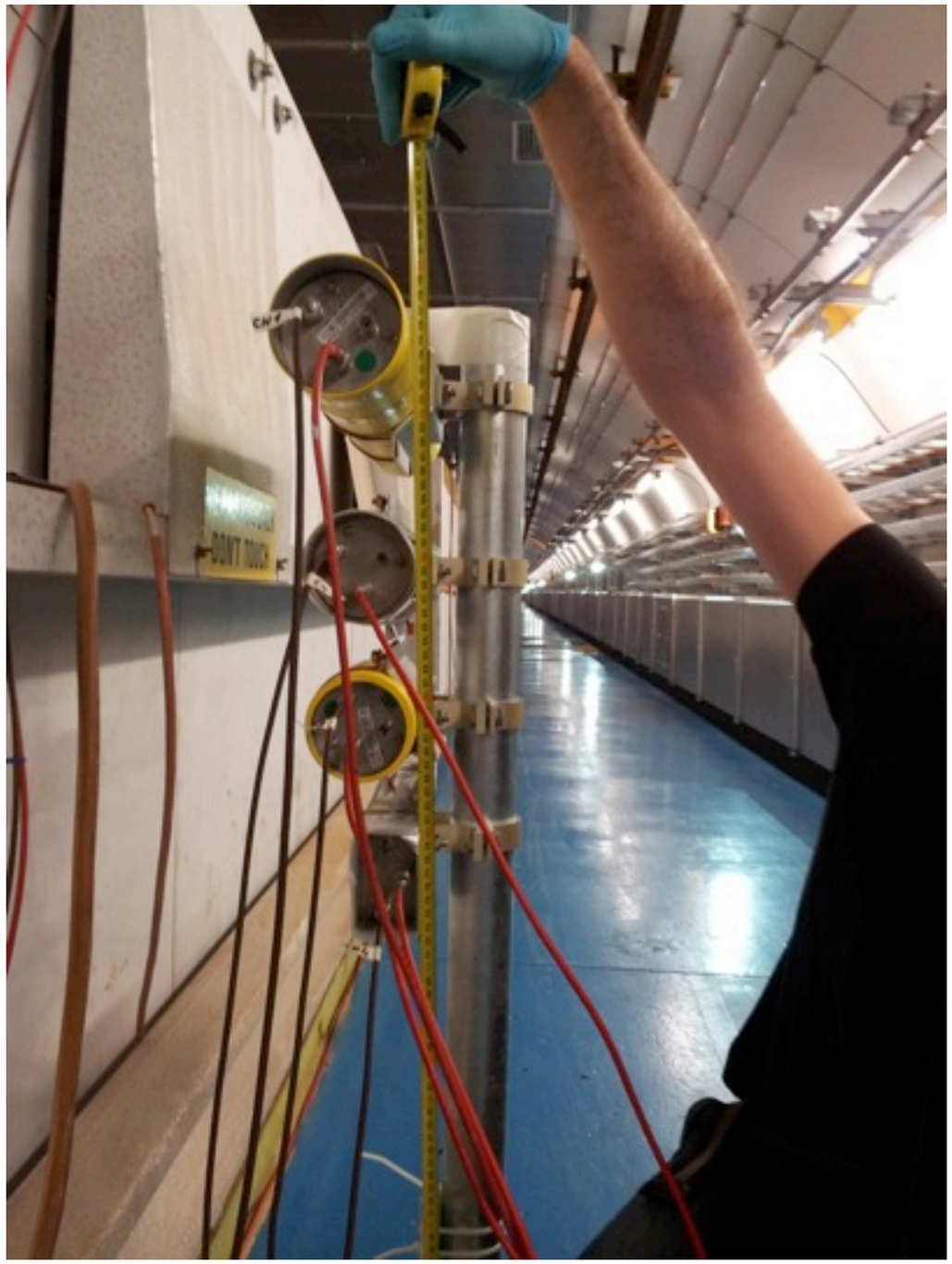


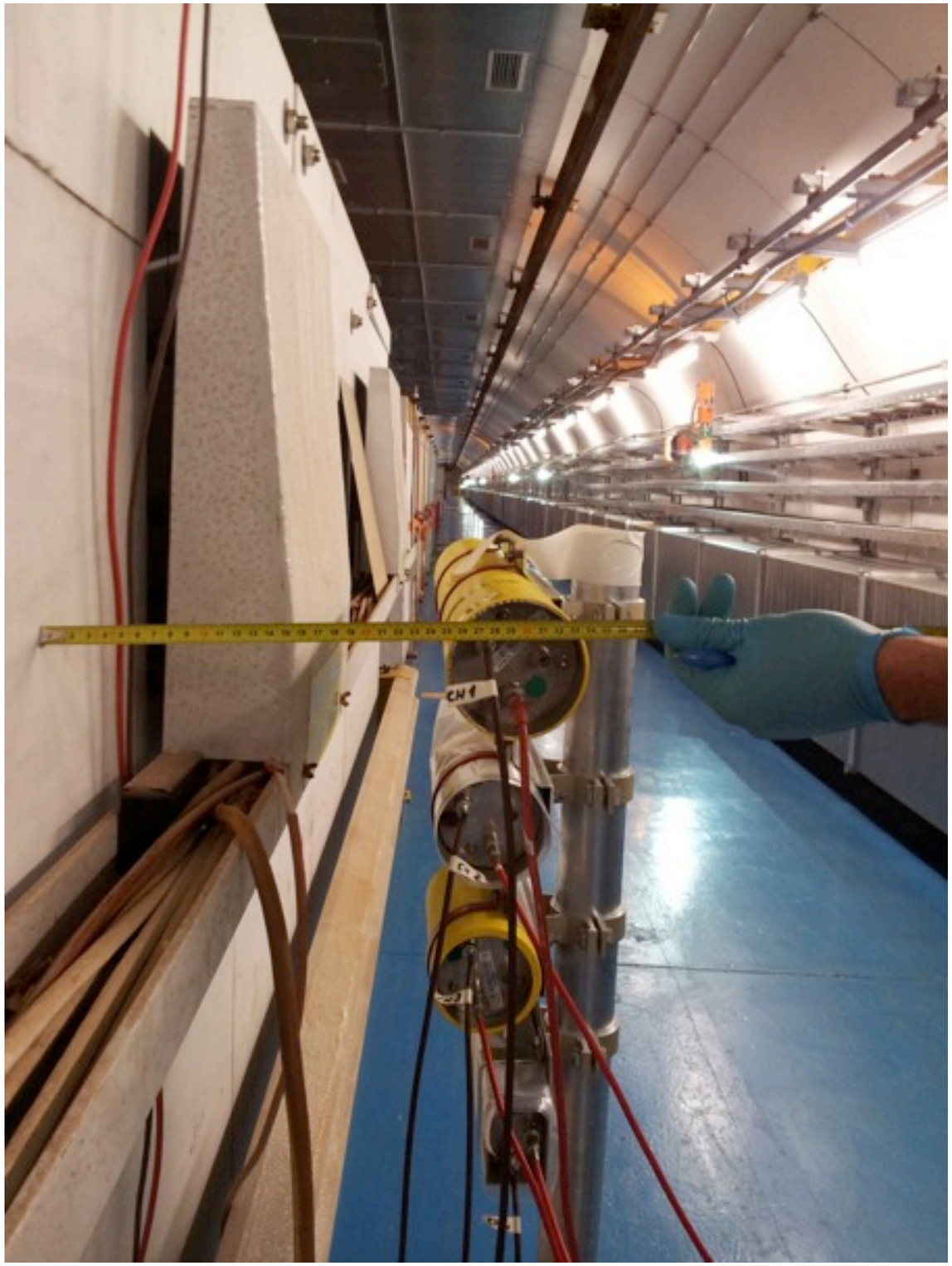


HiRadMat Experiment



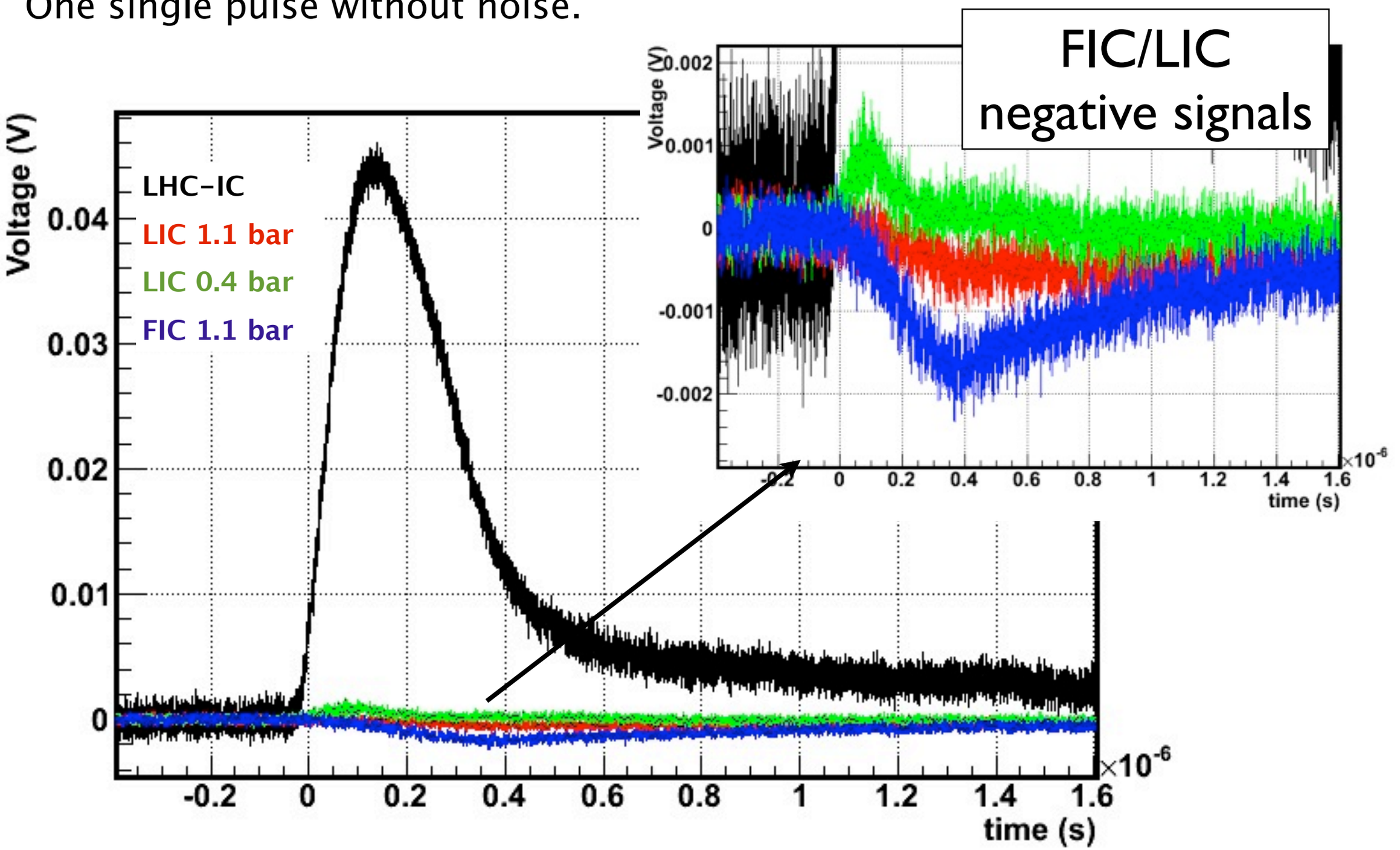
HiRadMat Experiment





Observations (Noise)

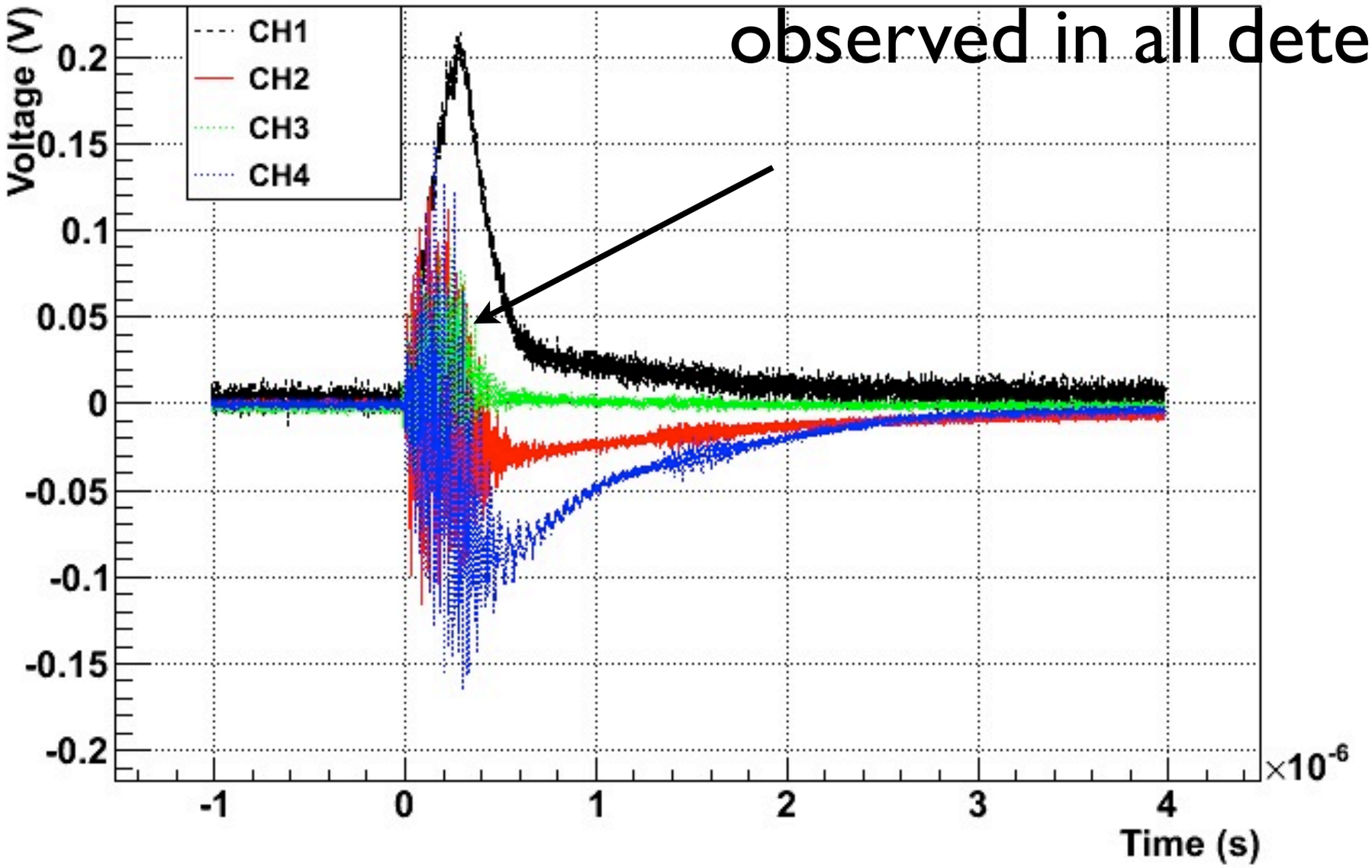
- Probe bunch 1.64 E+10 p.
- One single pulse without noise.



Wave pulses. 6 nominal bunch

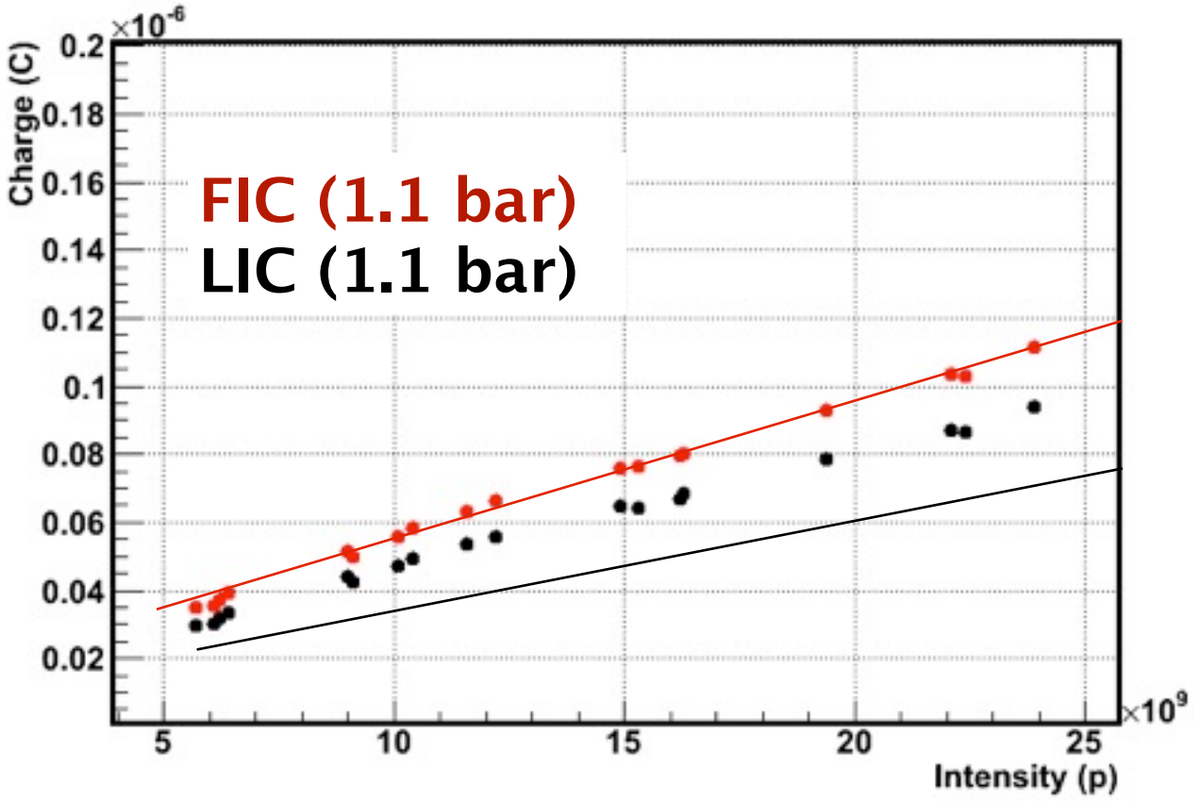
20dB attenuation in IC

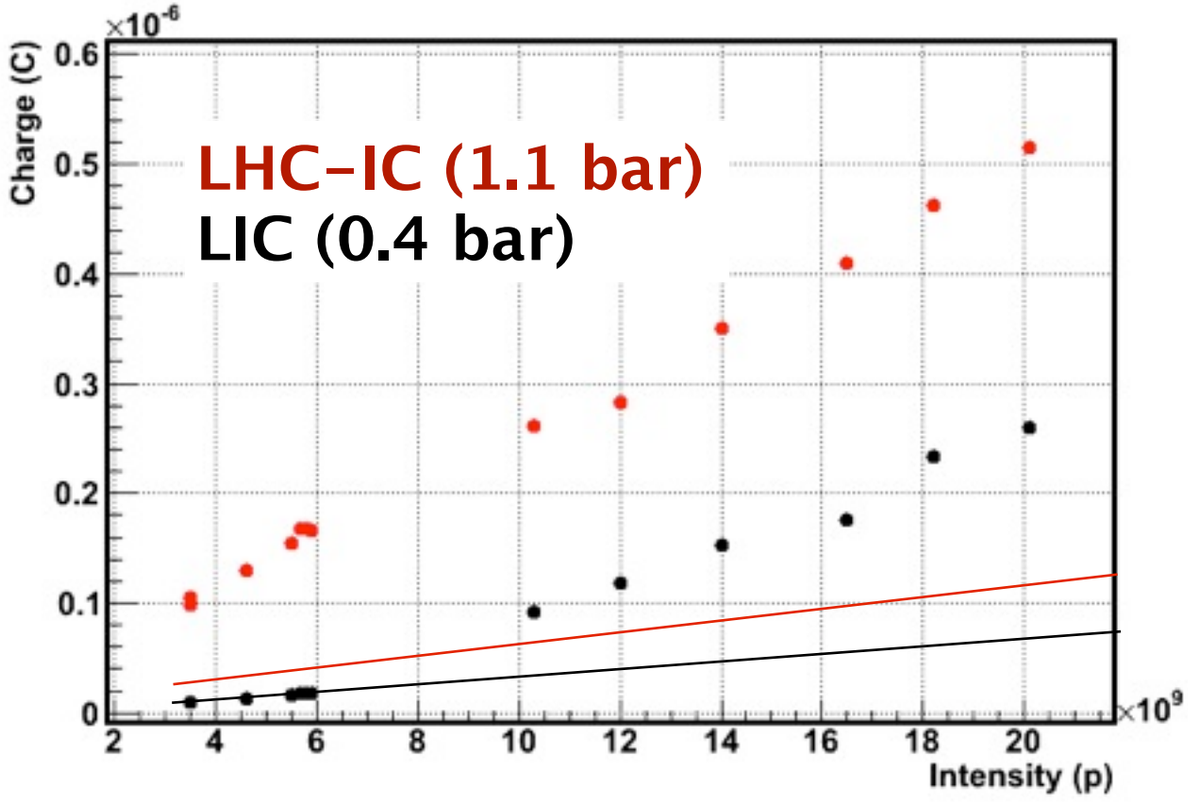
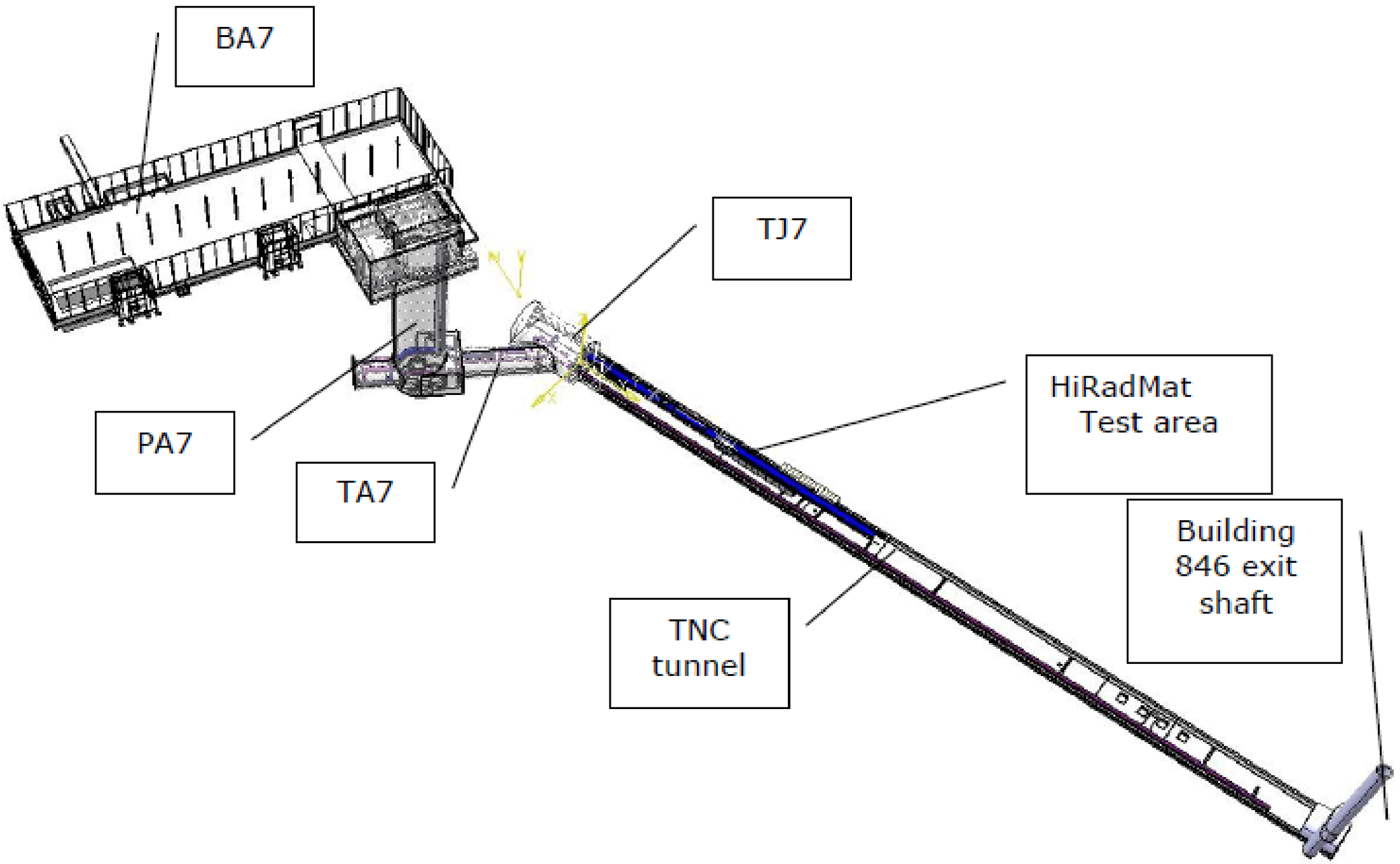
High frequency noise (~100MHz) observed in all detectors



Intensity scan

Comparison with previous test
Integrated charge (1 μs)
Unexpected behaviour for LIC 0.4 bar for I > ~7.0 E+10





HiRadMat. Layout