Cherenkov Fiber Beam Loss Position Monitors at FERMI@Elettra

- General considerations
- Installation at FERMI@Elettra
- MPPC Frontend
- Data Acquisition & Signal Processing
- Transverse Information

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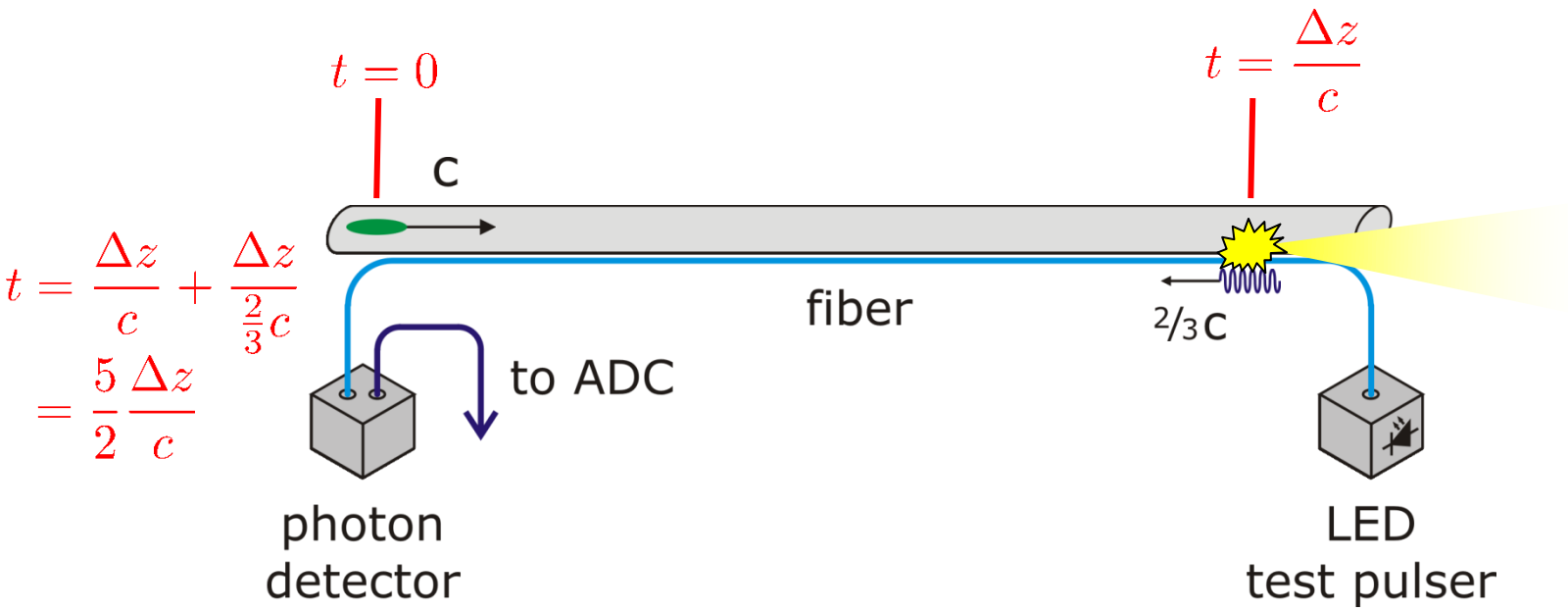
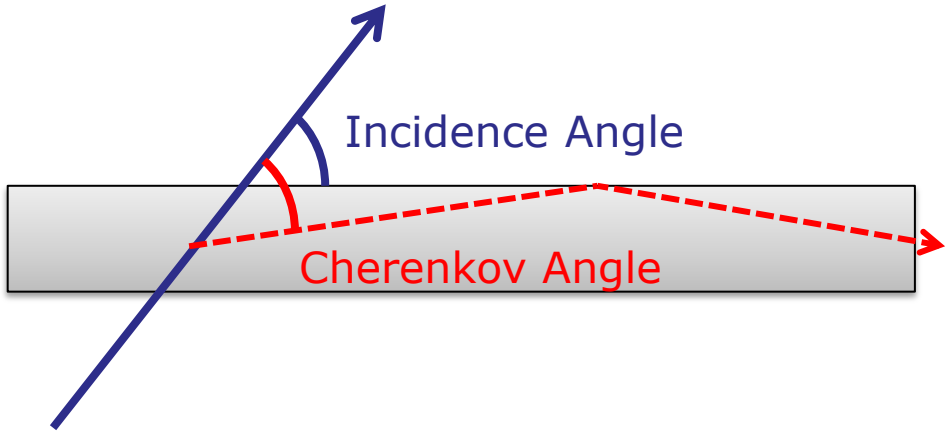
Cherenkov Fiber Beam Loss Position Monitor (BLPM)

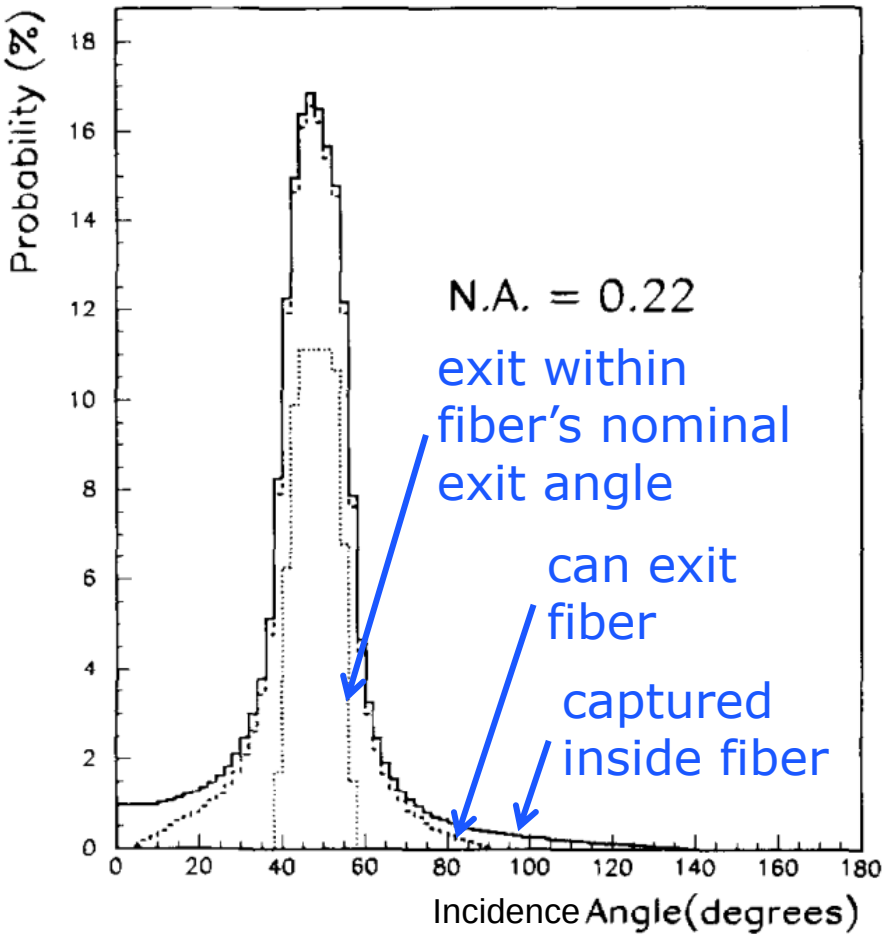


250 MS/s ADC → longitudinal resolution ~50 cm

Capturing Cherenkov Photons

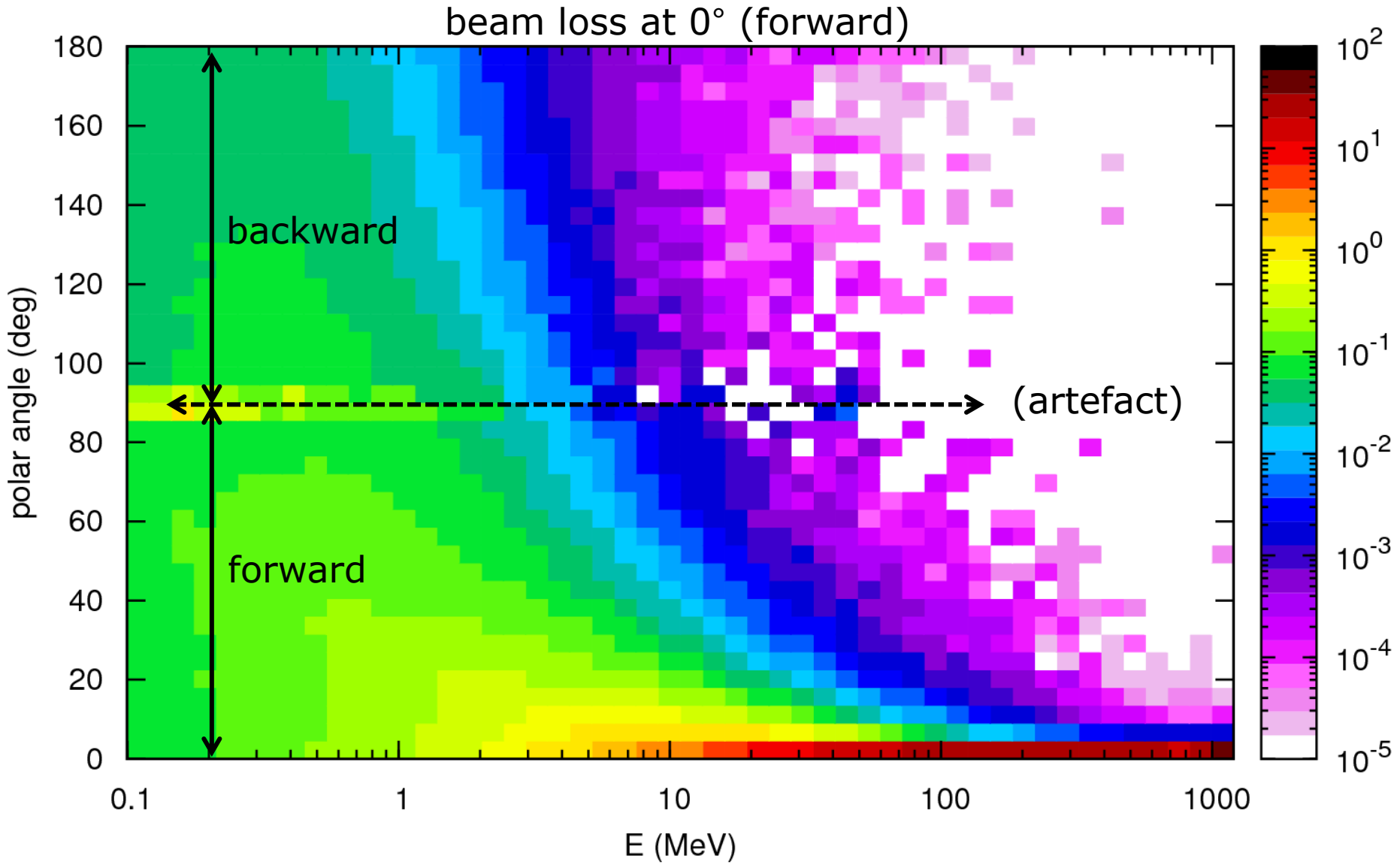
- An electron crosses a fiber at some *incidence angle.*
- It generates one Cherenkov photon.
- What are the photon's chances of making it to the end of the fiber?





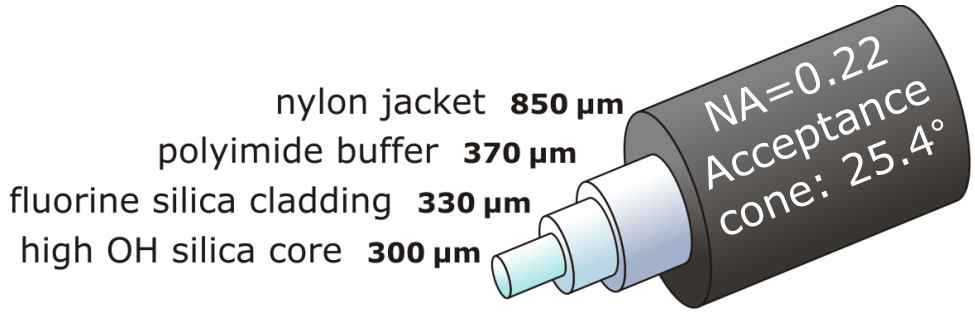
P. Gorodetzky et al.,
"Quartz fiber calorimetry",
Nucl. Instr. and Meth. A 361,
pp. 161–179, 1995.

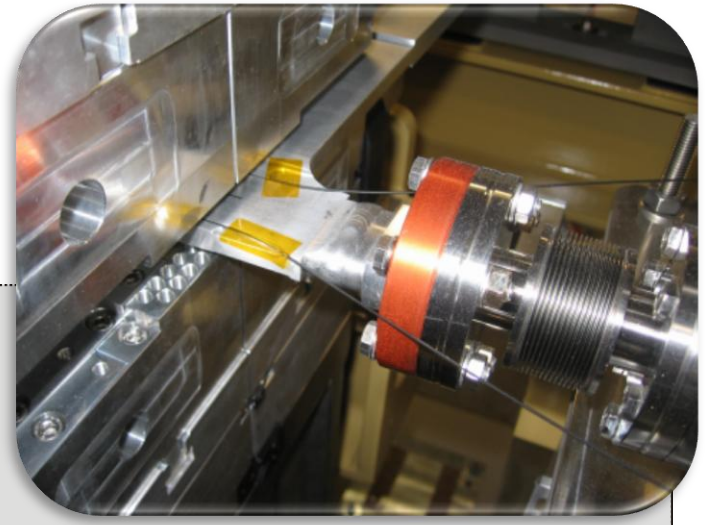
e^+/e^- Fluence within Fiber

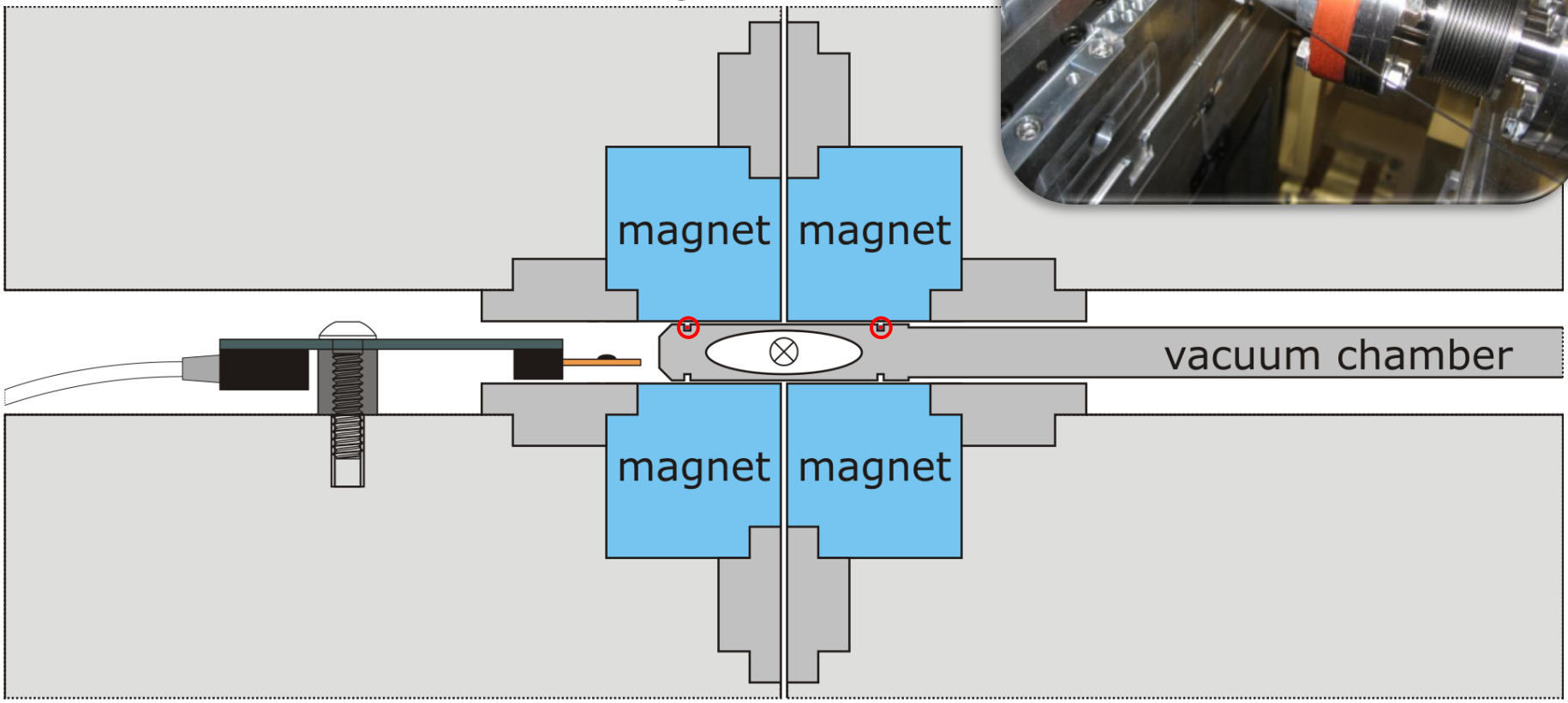


Fiber Installation

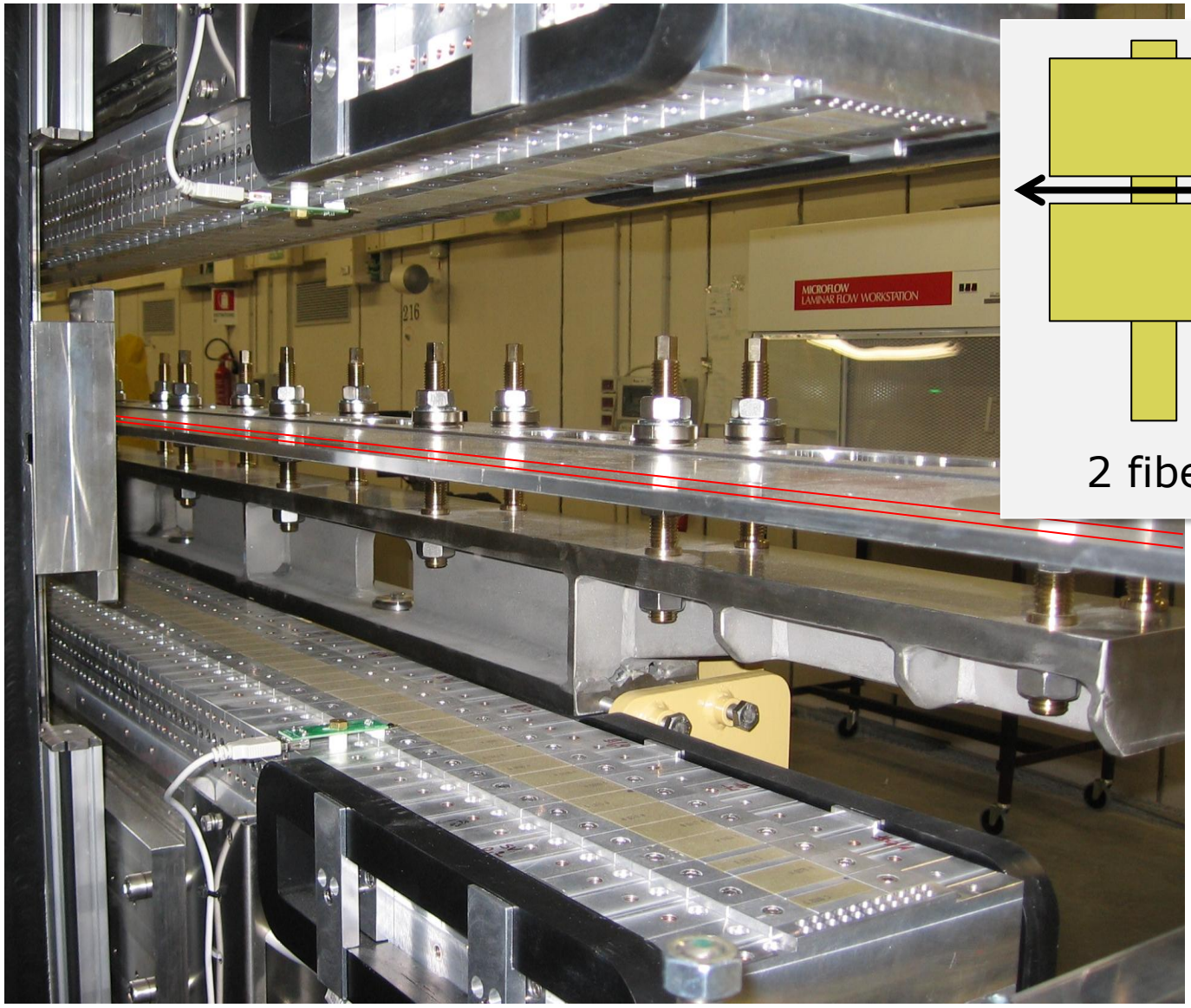
Undulator Cross Section

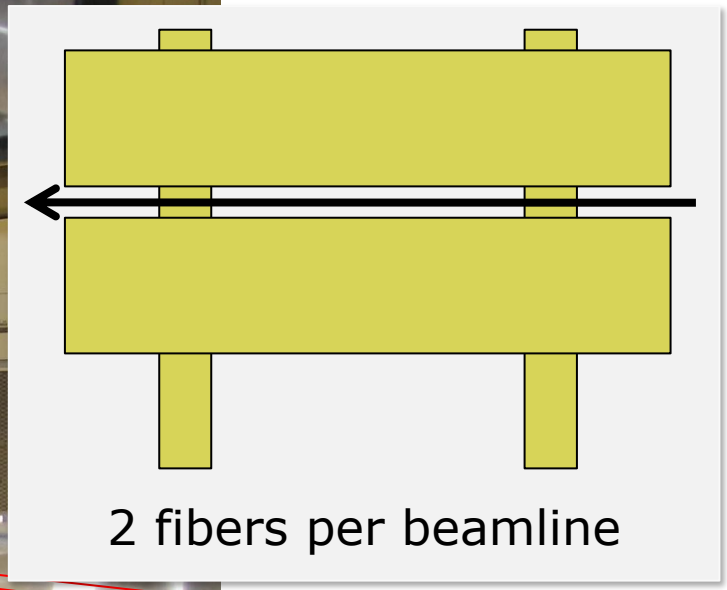






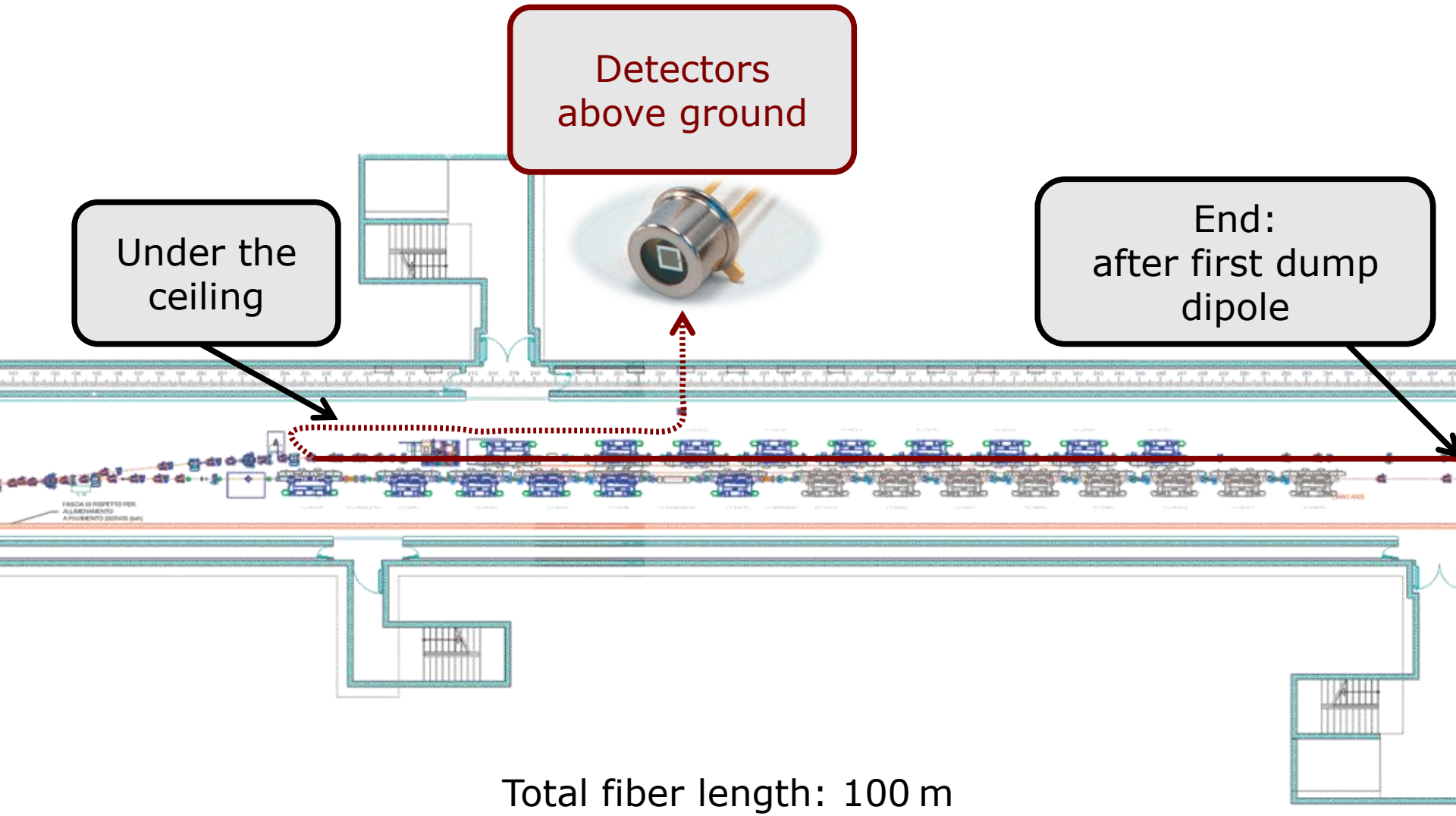
Undulator with Open Gap





2 fibers per beamline

Fiber Position in the Tunnel

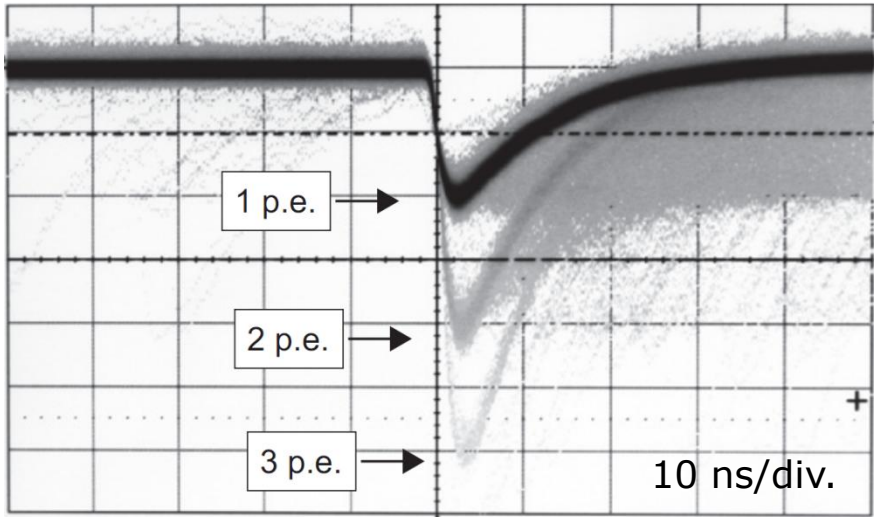


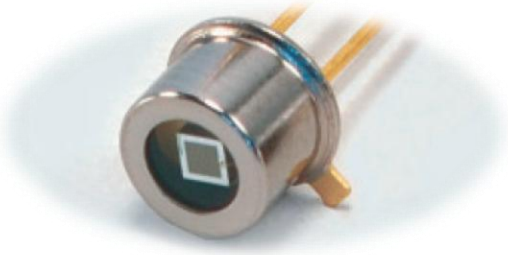
Total fiber length: 100 m

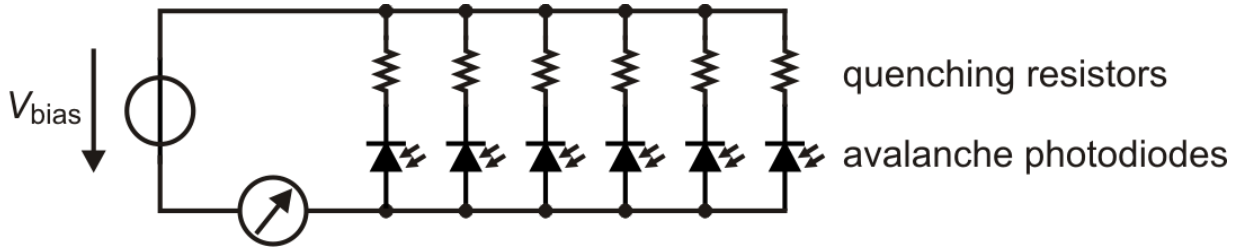
Light Detection

Multi-pixel Photon Counters (MPPCs)

- Array of avalanche photodiodes (APDs) connected in parallel
- Reverse bias → photon causes APD breakdown
- Photomultiplier-like gain
- Dynamic range limited by number of APDs
- Rise time: some 100 ps
- Hamamatsu S10362-11-050U: 400 APDs at ~70 V reverse bias





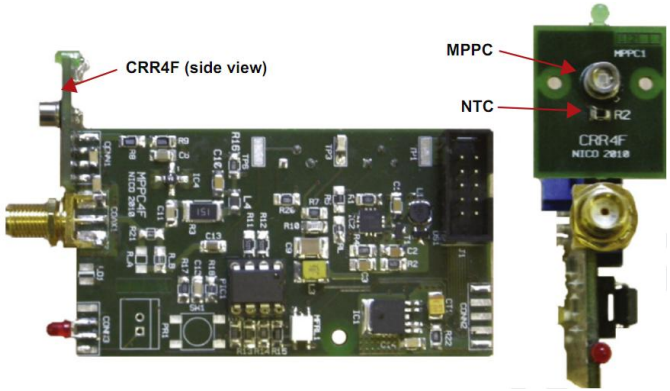


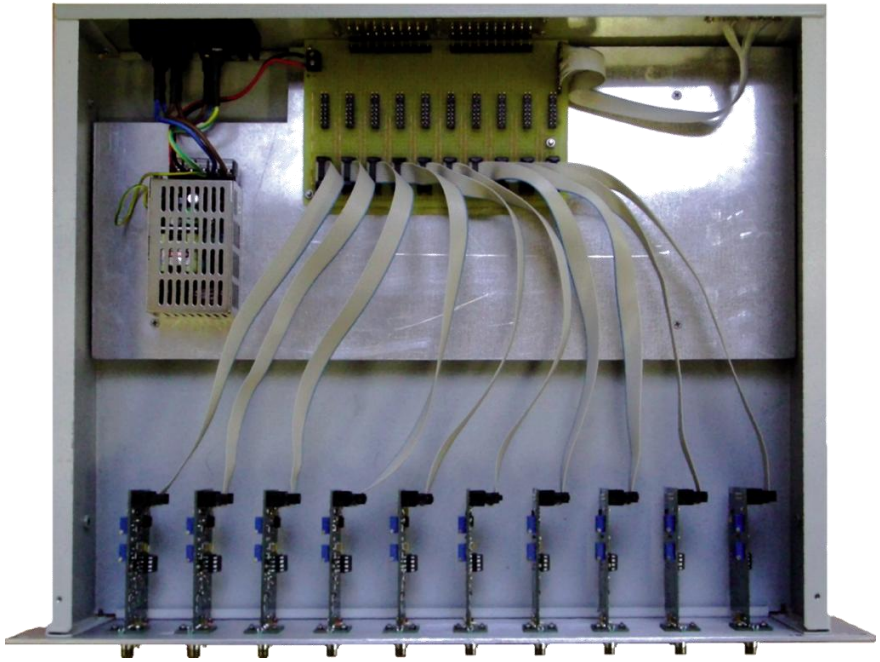
MPPC Signal Histogram

Measured dark count: ~8×10^5 breakdown events per second

MPPC Frontend

- Modular electronics
- Temperature-compensated gain
- Voltage output (50 Ω)
- Configurable alarm thresholds

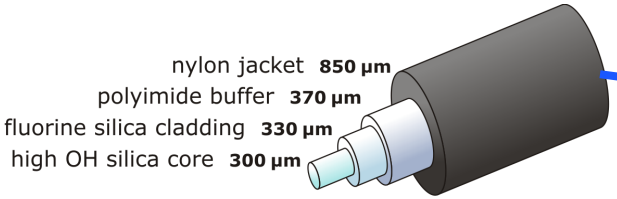


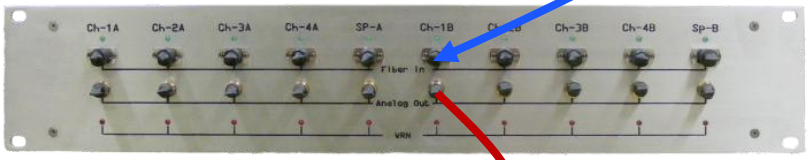


Electronics: D. Di Giovenale

Data Acquisition & Signal Processing

Data Acquisition





VME Crate

ADC 250 MS/s, 12 bit

CPU, Linux w/ realtime extensions

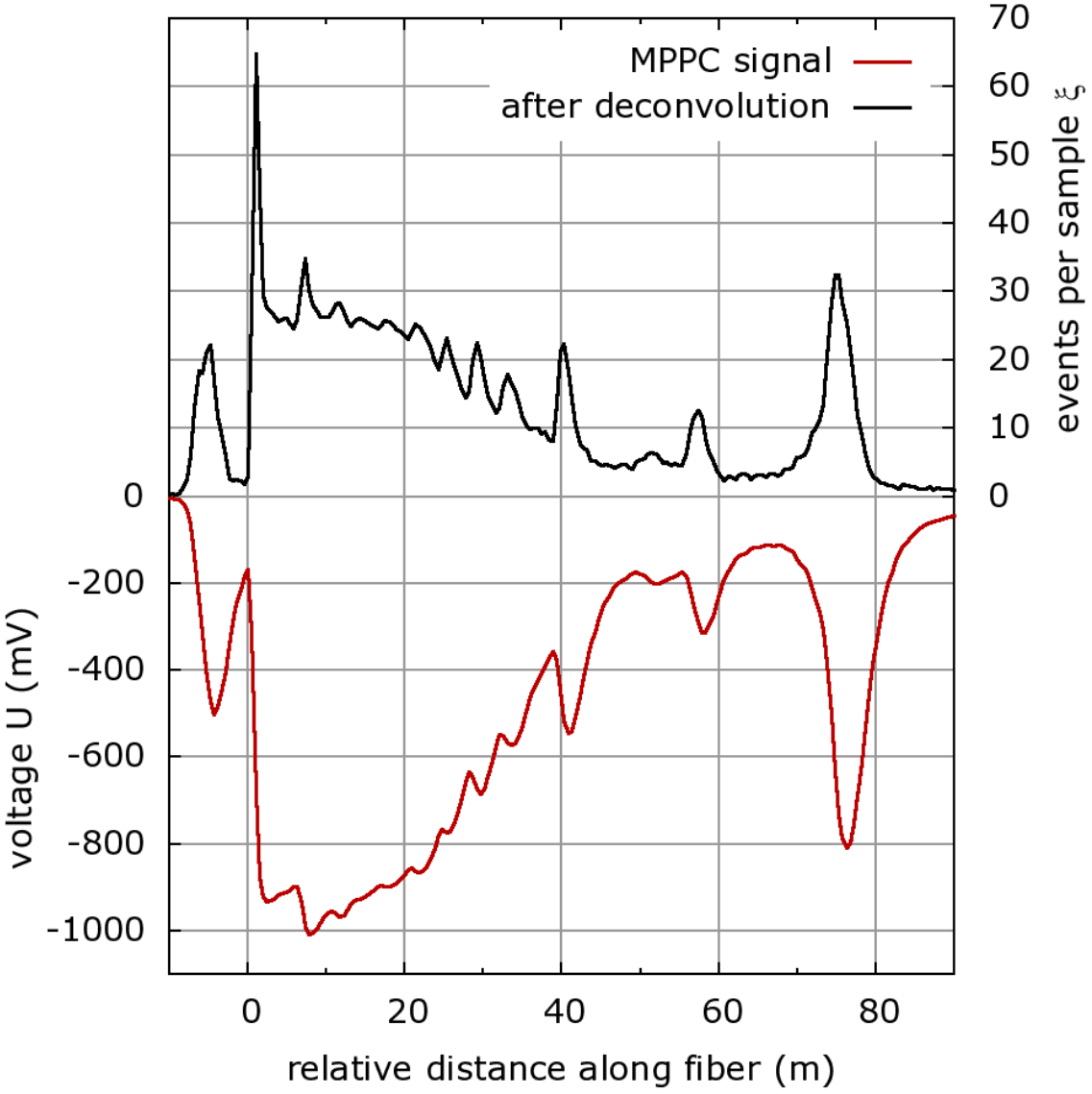
device driver

realtime kernel module

TANGO control system

Digital I/O board (MPS alarms)

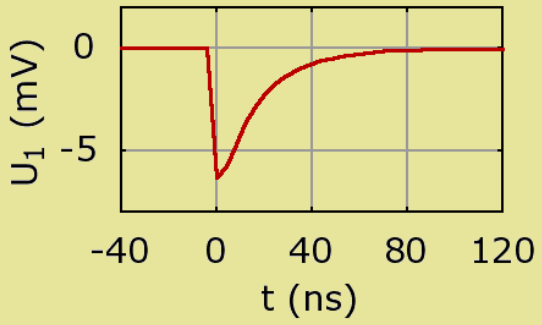
Signal Processing



number of photodiode breakdowns

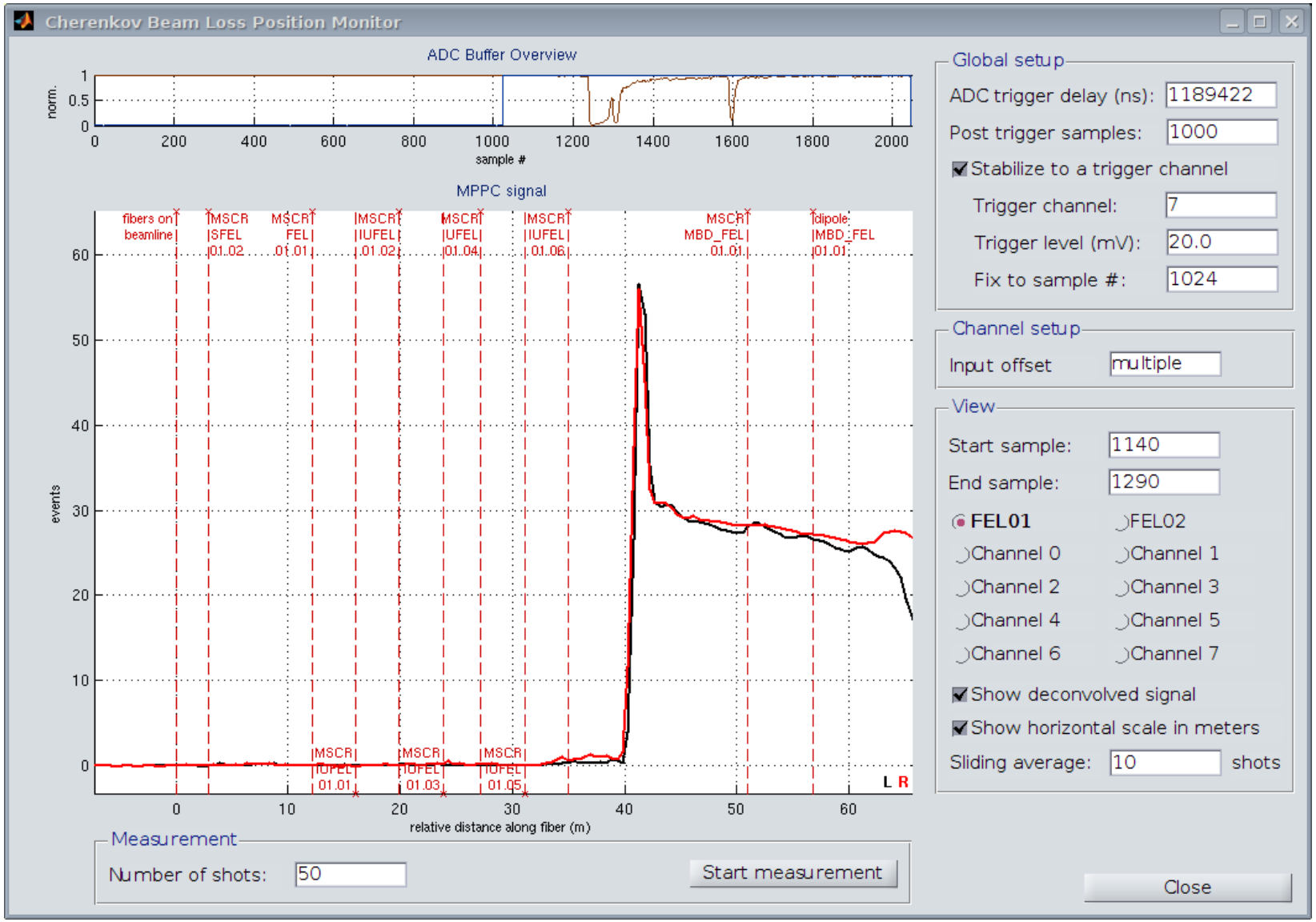
deconvolution

$$\xi(t) = \mathcal{F}_\nu^{-1}\left[\frac{\mathcal{F}_t[U(t)]}{\mathcal{F}_t[U_1(t)]}\right]$$

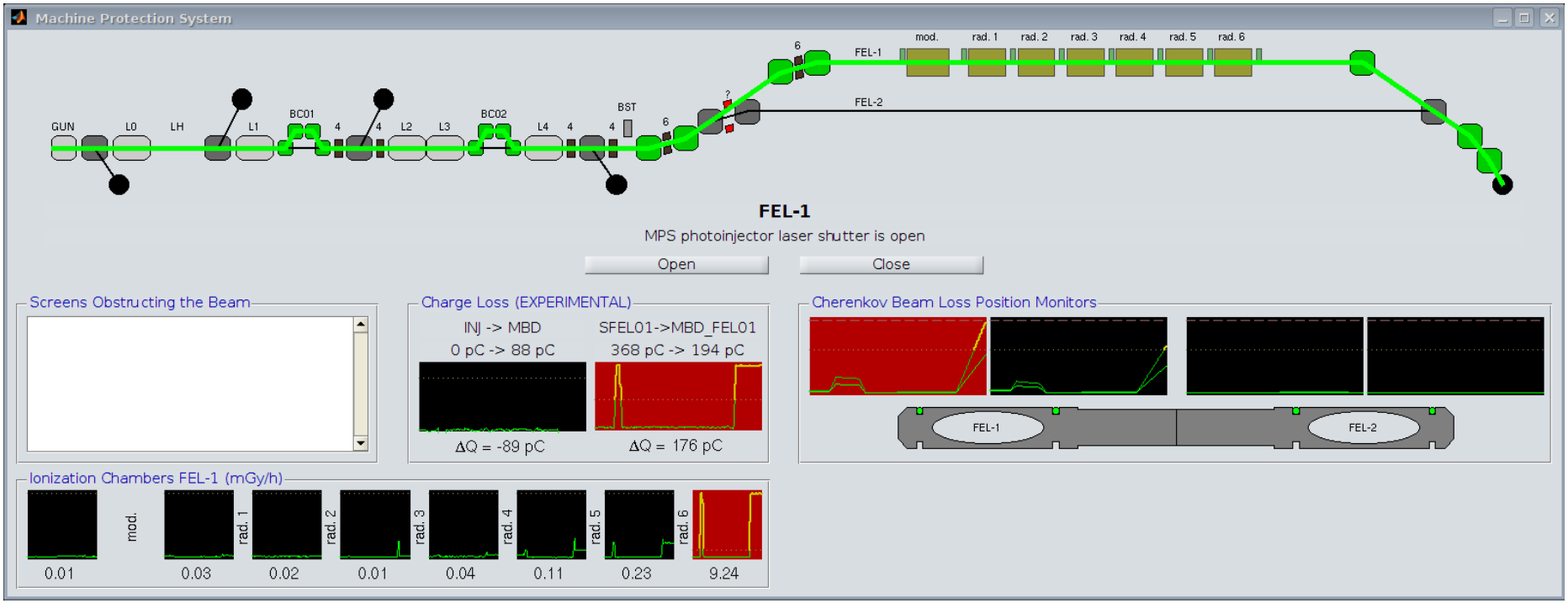


MPPC output signal

Viewer Application

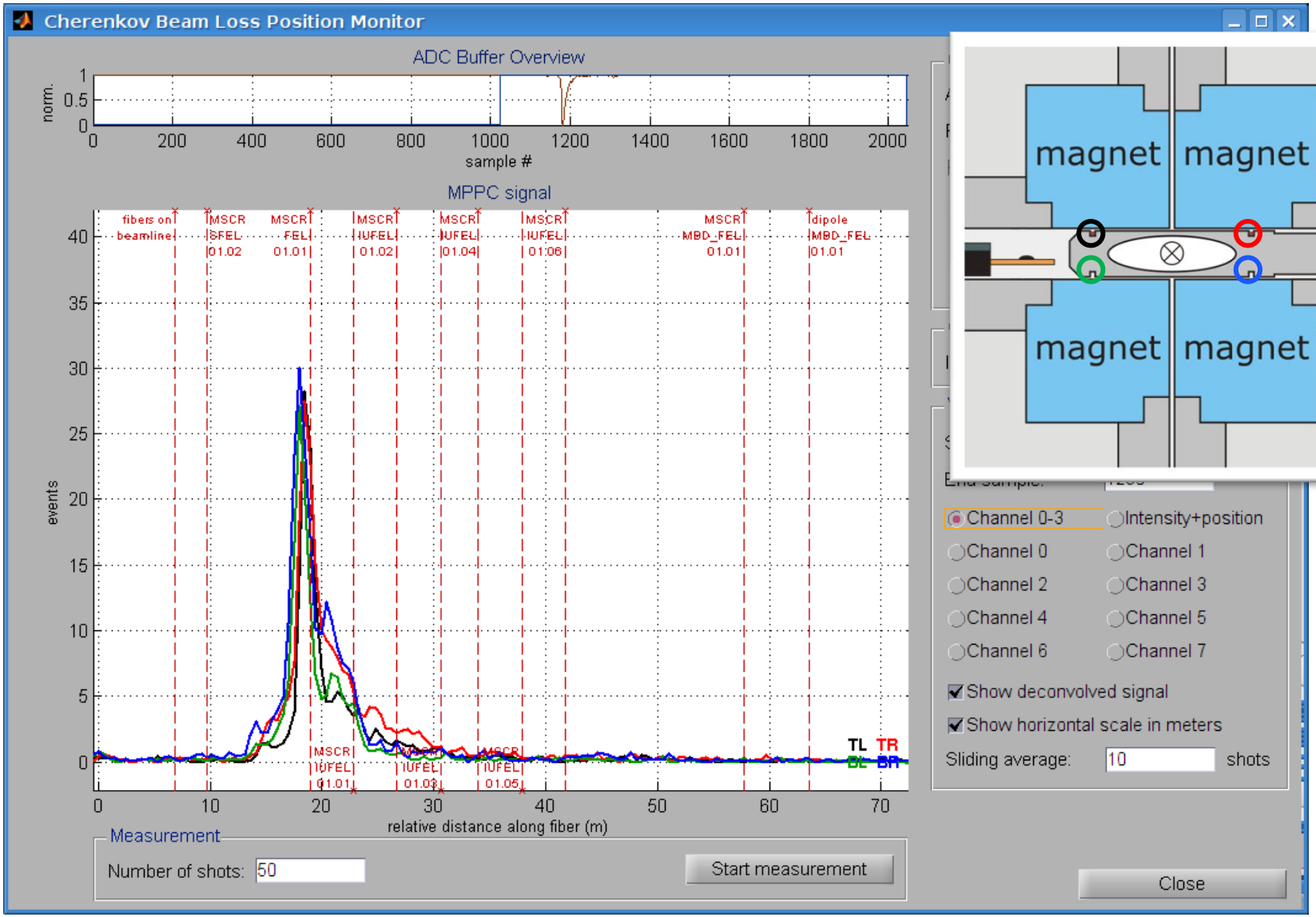


MPS Overview

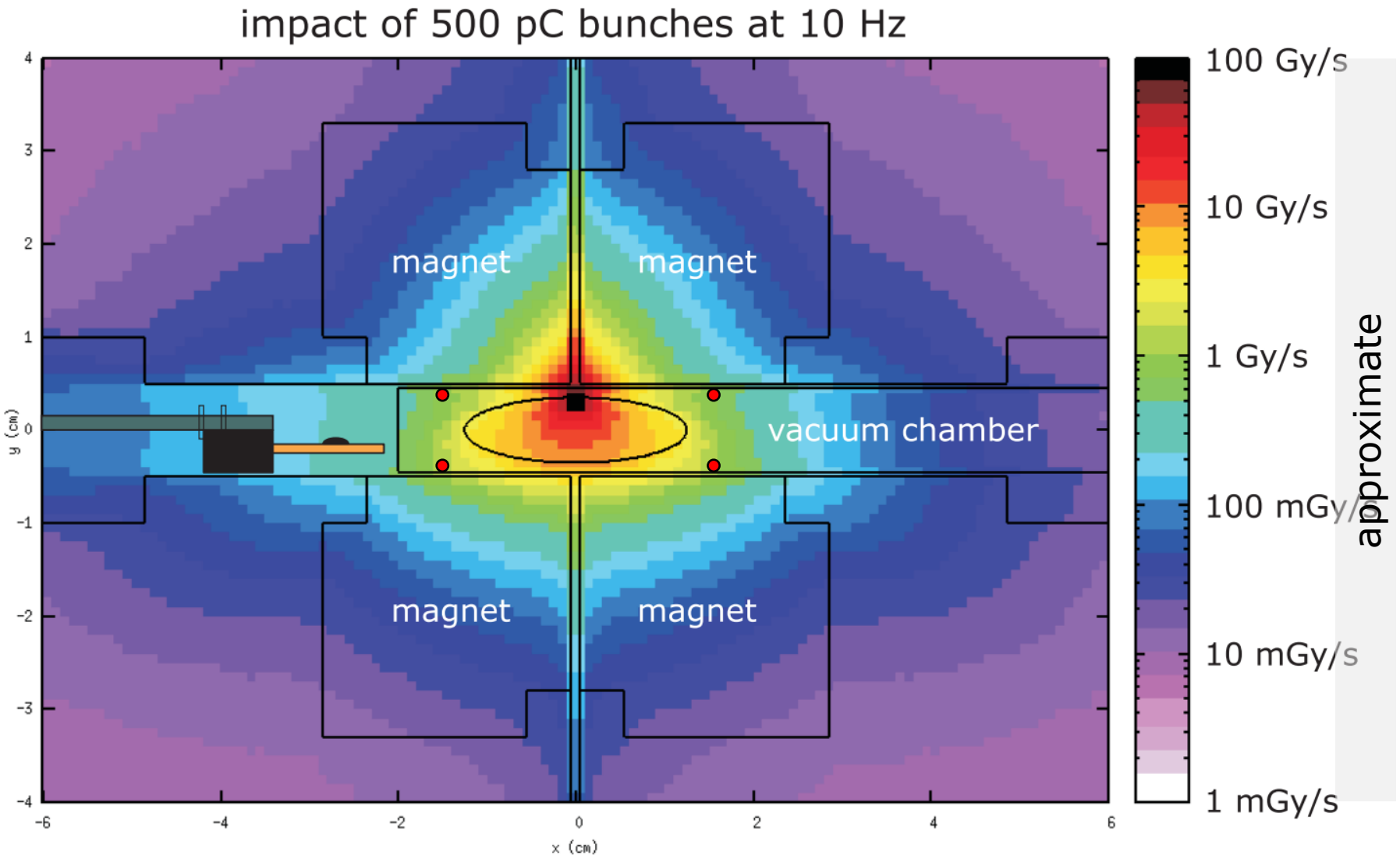


Transverse Information

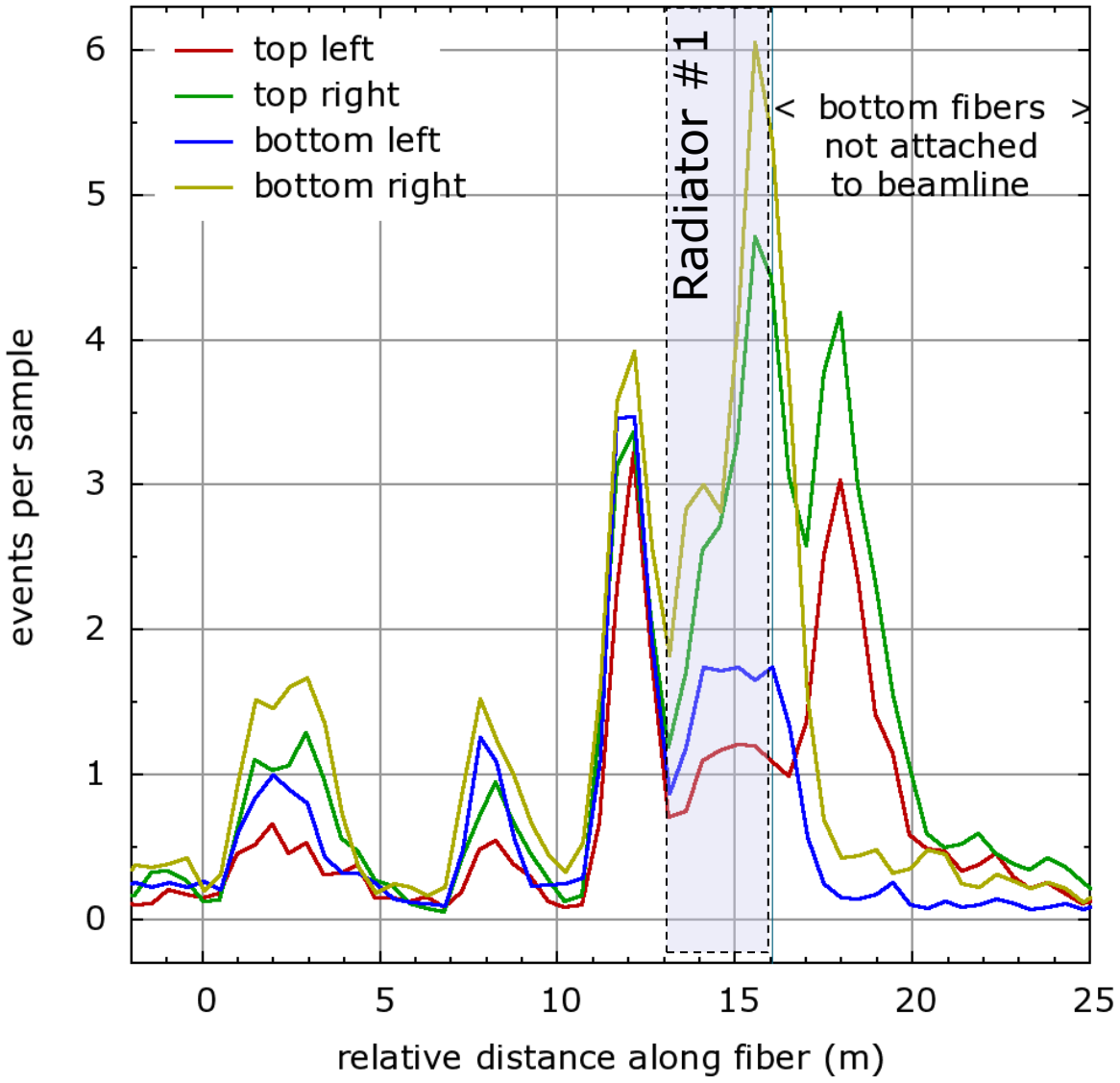
Four Fibers


Cherenkov Beam Loss Position Monitor
ADC Buffer Overview
norm.
sample #
MPPC signal
fibers on beamline
MSCR SFEL 01.02
MSCR FEL 01.01
MSCR IUFEL 01.02
MSCR IUFEL 01.04
MSCR IUFEL 01.06
MSCR MBD_FEL 01.01
dipole MBD_FEL 01.01
MSCR IUFEL 01.01
MSCR IUFEL 01.03
MSCR IUFEL 01.05
TL TR
BL BR
events
relative distance along fiber (m)
Measurement
Number of shots: 50
Start measurement
magnet
magnet
magnet
magnet
Channel 0-3
Intensity+position
Channel 0
Channel 1
Channel 2
Channel 3
Channel 4
Channel 5
Channel 6
Channel 7
Show deconvolved signal
Show horizontal scale in meters
Sliding average: 10 shots
Close

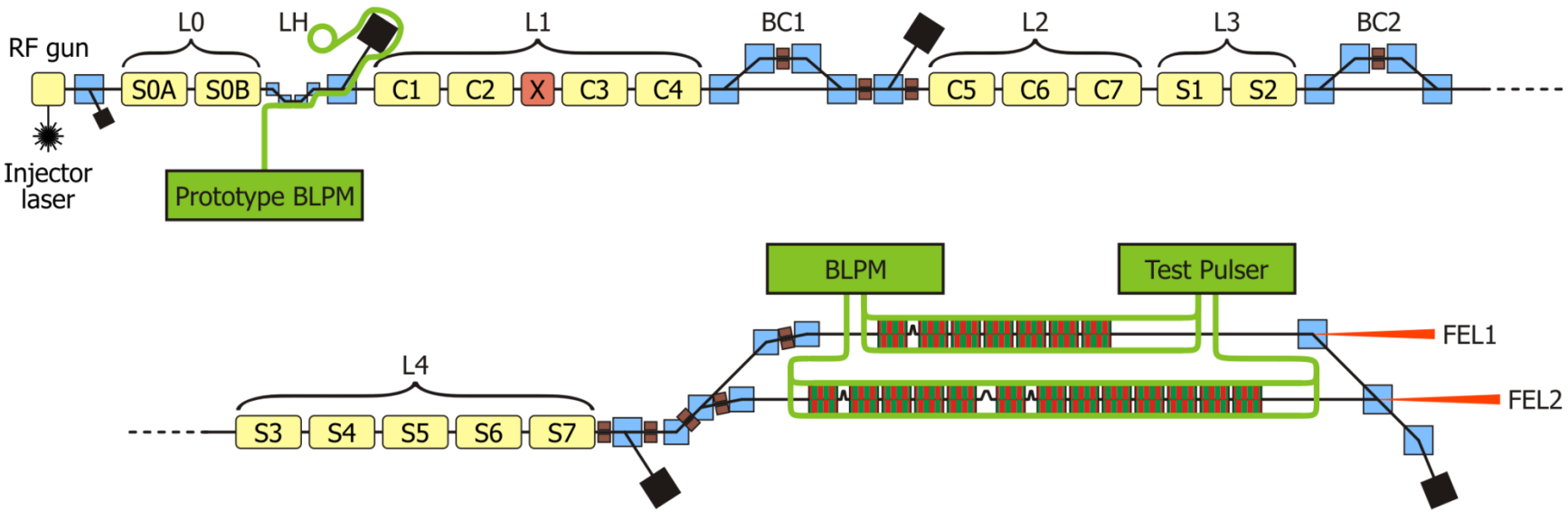
Dose Rates


impact of 500 pC bunches at 10 Hz
magnet
magnet
vacuum chamber
magnet
magnet
y (cm)
x (cm)
100 Gy/s
10 Gy/s
1 Gy/s
100 mGy/s
10 mGy/s
1 mGy/s
approximate

Four Fibers


top left
top right
bottom left
bottom right
Radiator #1
< bottom fibers >
not attached
to beamline
events per sample
relative distance along fiber (m)
0
1
2
3
4
5
6
0
5
10
15
20
25

Wish List



Beam losses:

- ☑ Reliable detection (no blind spots)
- ☑ Magnitude *(qualitative)*
- ☒ *Quantitative* measurement (lost charge/dose rate/particle flux)
- ☑ Longitudinal position
- ? Transverse position/direction

La fine.

More information:

D. Di Giovenale, L. Catani, L. Fröhlich, “A read-out system for online monitoring of intensity and position of beam losses in electron linacs”, Nucl. Instr. & Meth. A (2011), http://dx.doi.org/10.1016/j.nima.2011.11.038