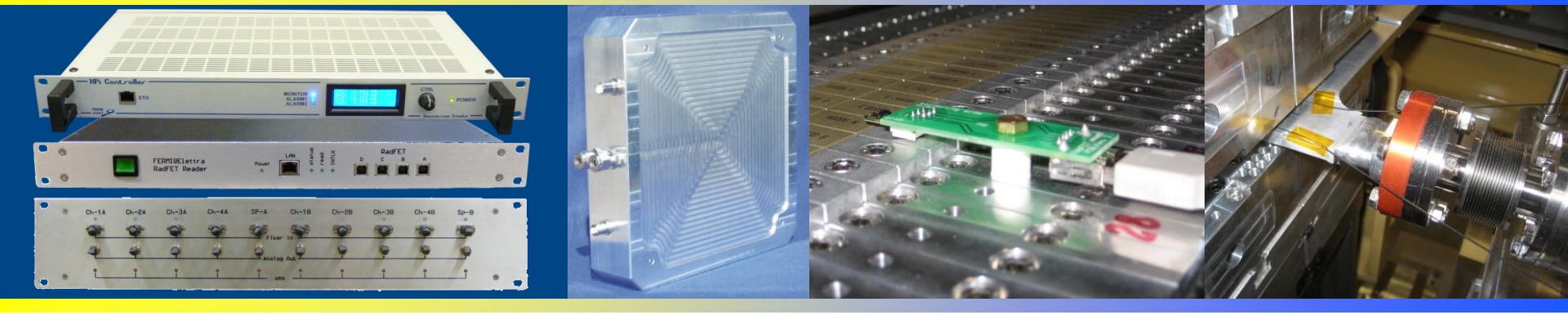
The FERMI@Elettra MPS



L. Fröhlich, A. I. Bogani, K. Casarin, G. Cautero, G. Gaio,
F. Giacuzzo, D. Giuressi, A. Gubertini, R. H. Menk, E. Quai,
G. Scalamera, A. Vascotto (Sincrotrone Trieste, Basovizza, Italy)
L. Catani (INFN, Rome, Italy), D. Di Giovenale

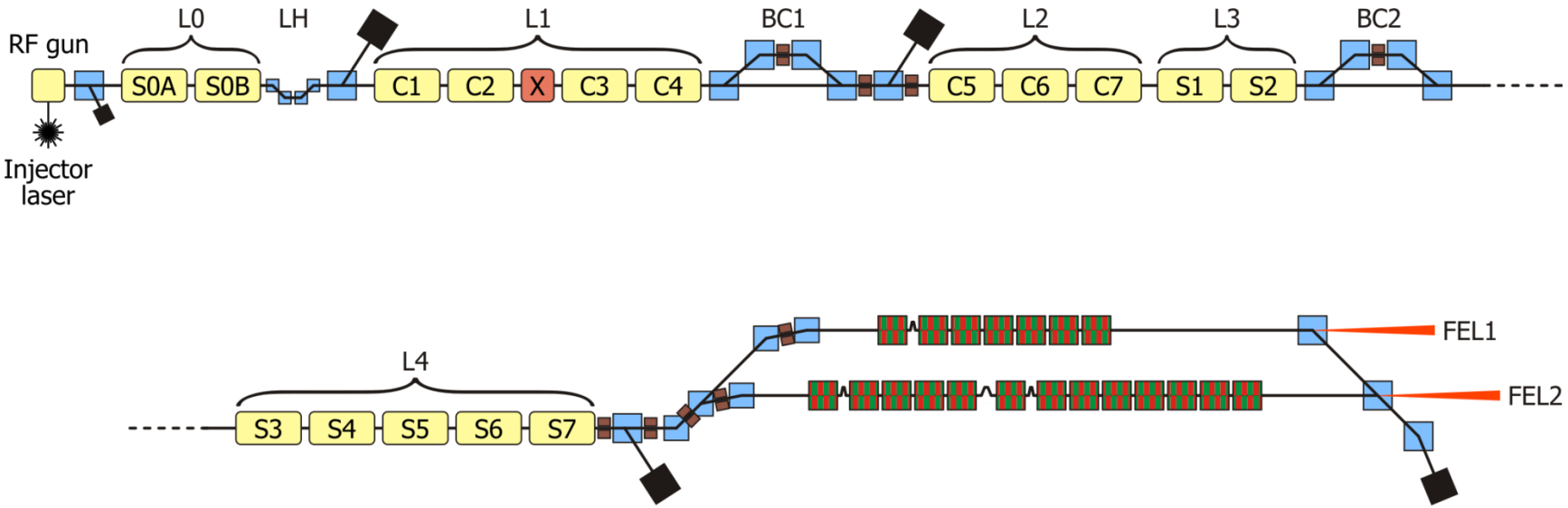
Overview

- FERMI@Elettra
- MPS architecture
- General features

- Subsystems:
  - Ionization chamber BLMs
  - RADFET online dosimetry

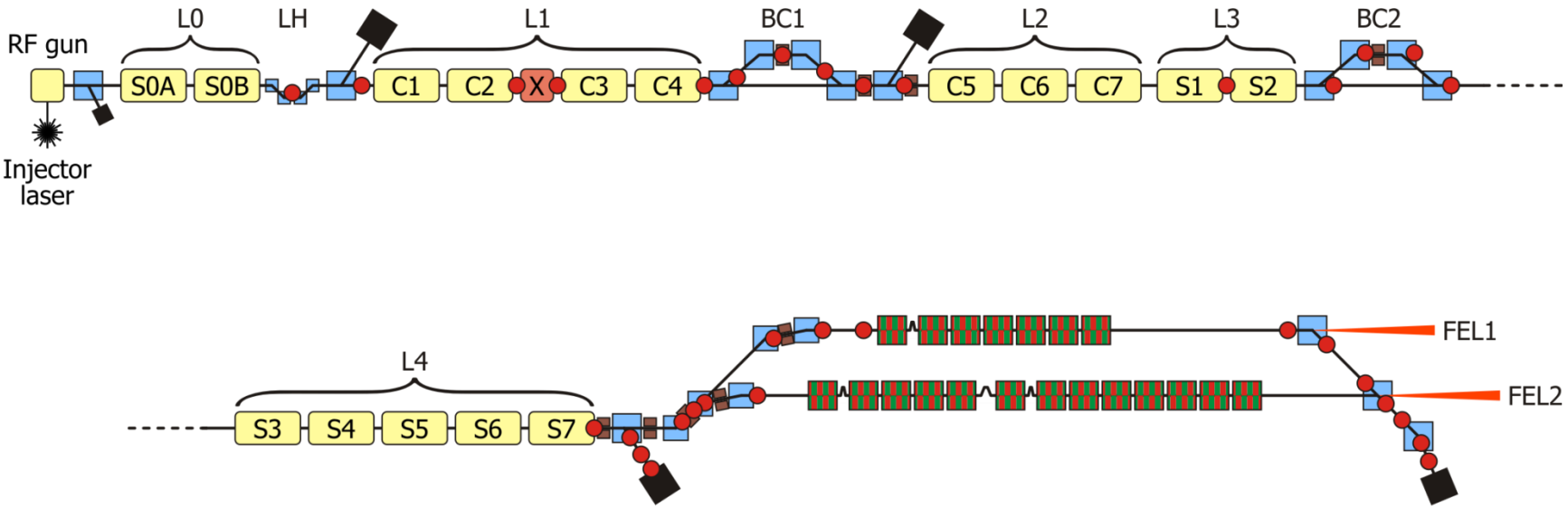
Elettra & FERMI

FERMI@Elettra



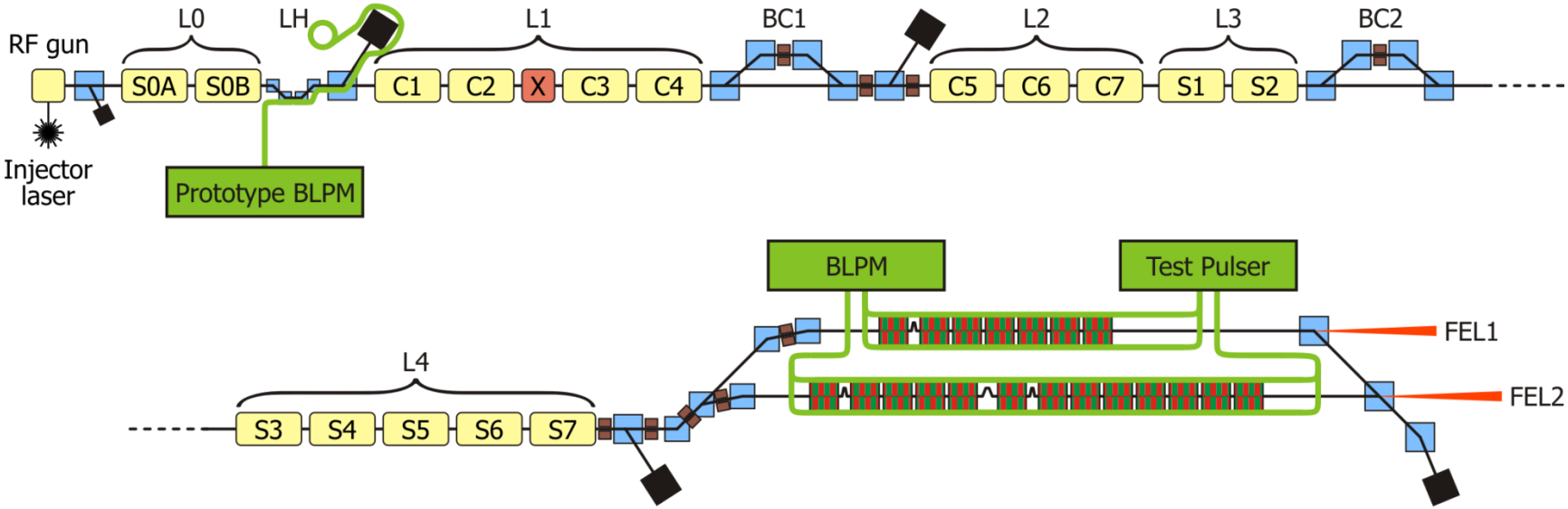
	Energy	Bunch Charge	Repetition Rate	Beam Power
Typical	1.2 GeV	350 pC	10 Hz	4.2 W
Design	1.5 GeV	1 nC	50 Hz	75 W

FERMI@Elettra

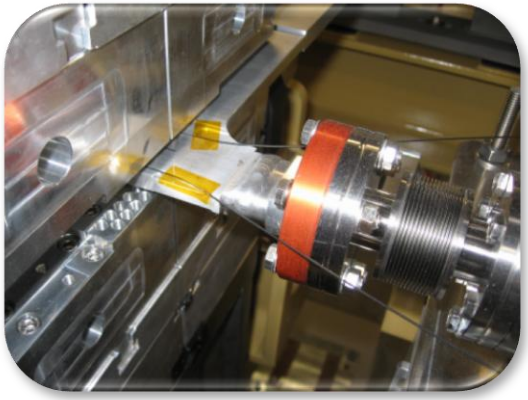


PIN diode BLMs

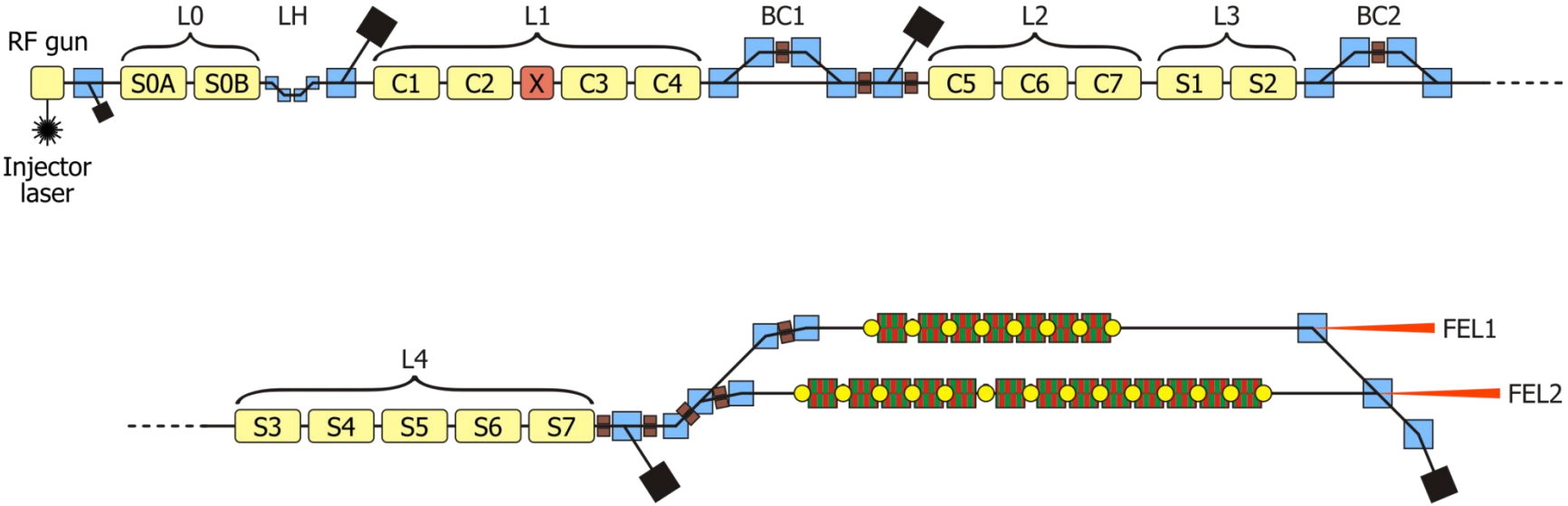
K. Casarin, E. Quai,
S. Sbarra, A. Vascotto



Cherenkov Fiber Beam Loss Position Monitors (BLPMs)

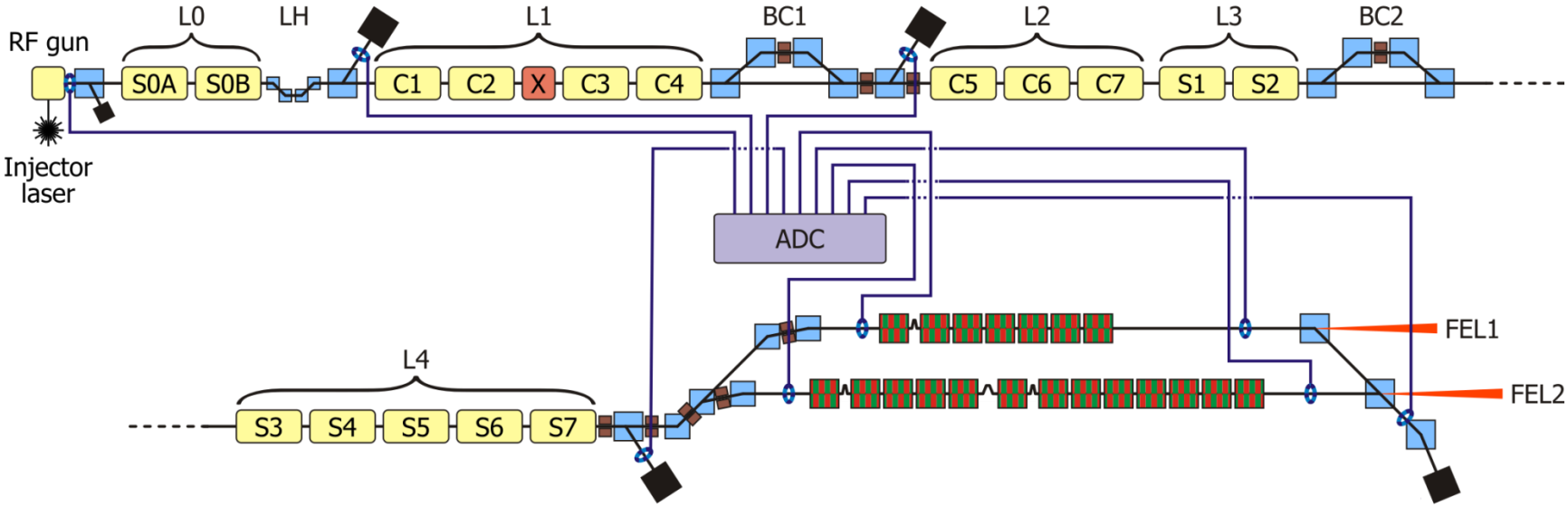


FERMI@Elettra

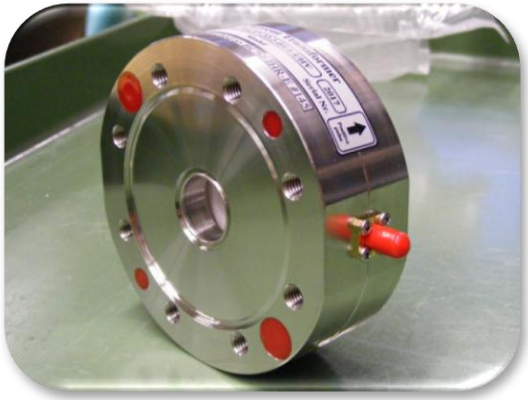


Ionization Chamber Beam Loss Monitors (BLMs)

FERMI@Elettra



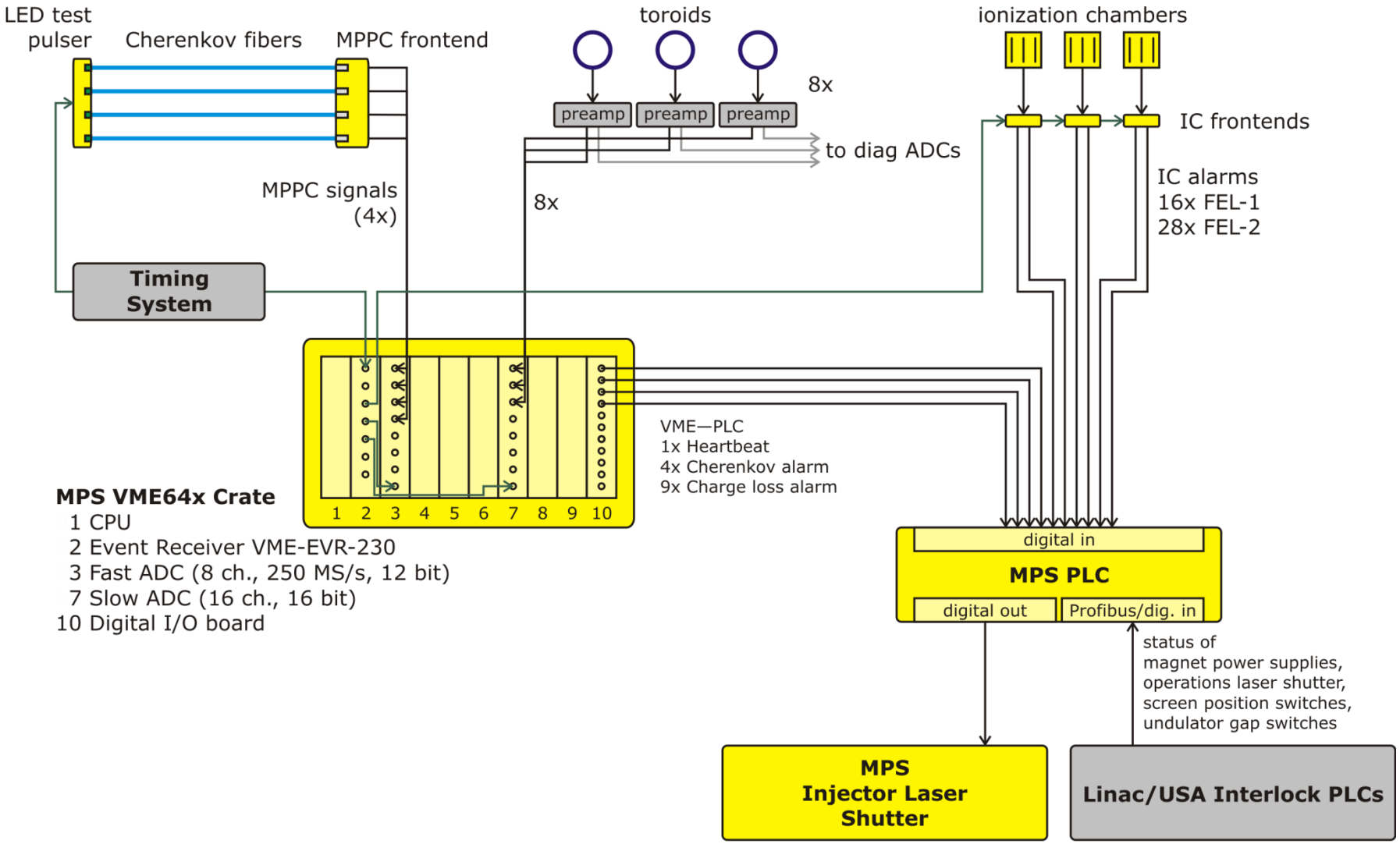
Charge Monitors



S. Bassanese

MPS Architecture & General Features

MPS Overview



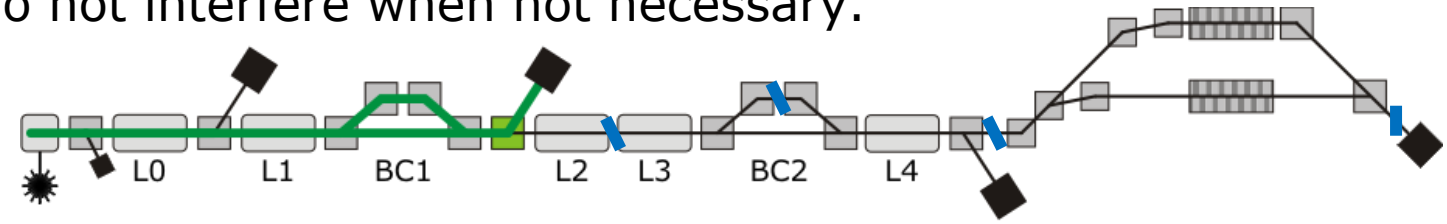
Screens + Dipole Magnets

Screen Interlock

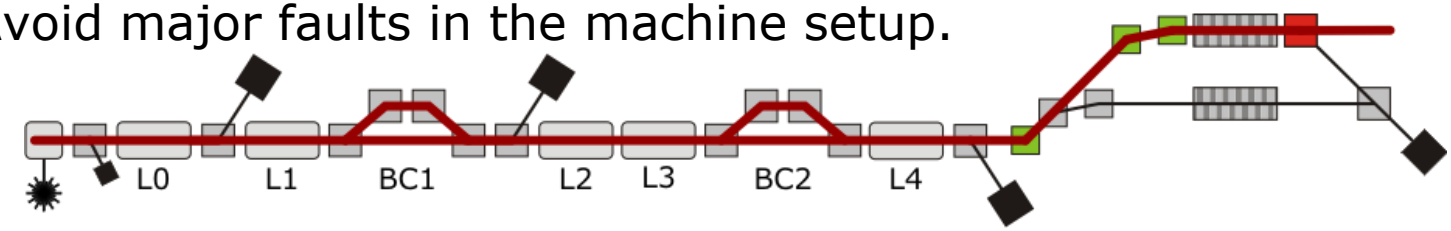
- Inhibits electron beam when:
  - Screens moving or in undefined/forbidden position
  - Linac screen inserted when in FEL-1 or FEL-2 mode
- Only active for screens in current beam path

Operation Mode

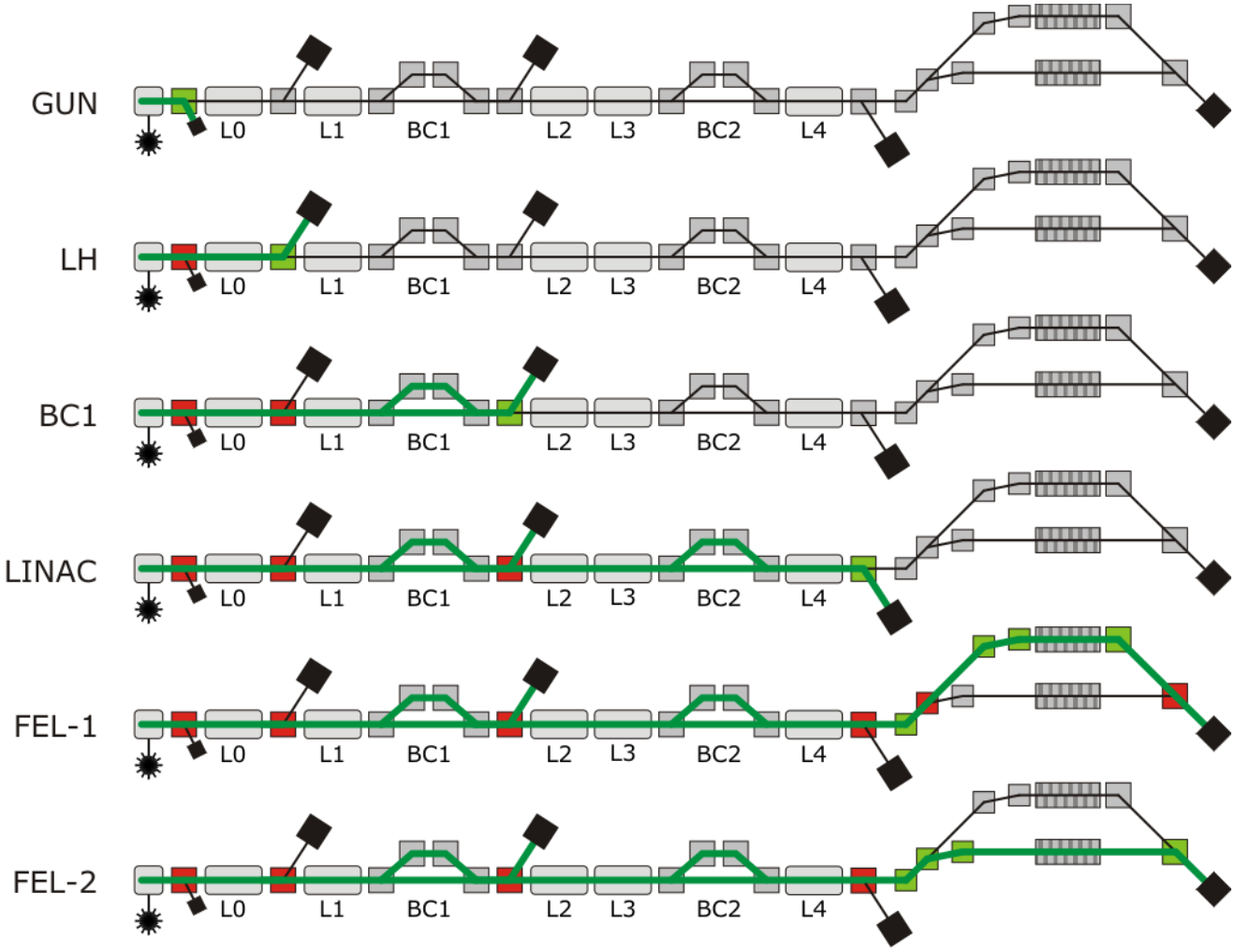
Purpose 1: Do not interfere when not necessary.



Purpose 2: Avoid major faults in the machine setup.

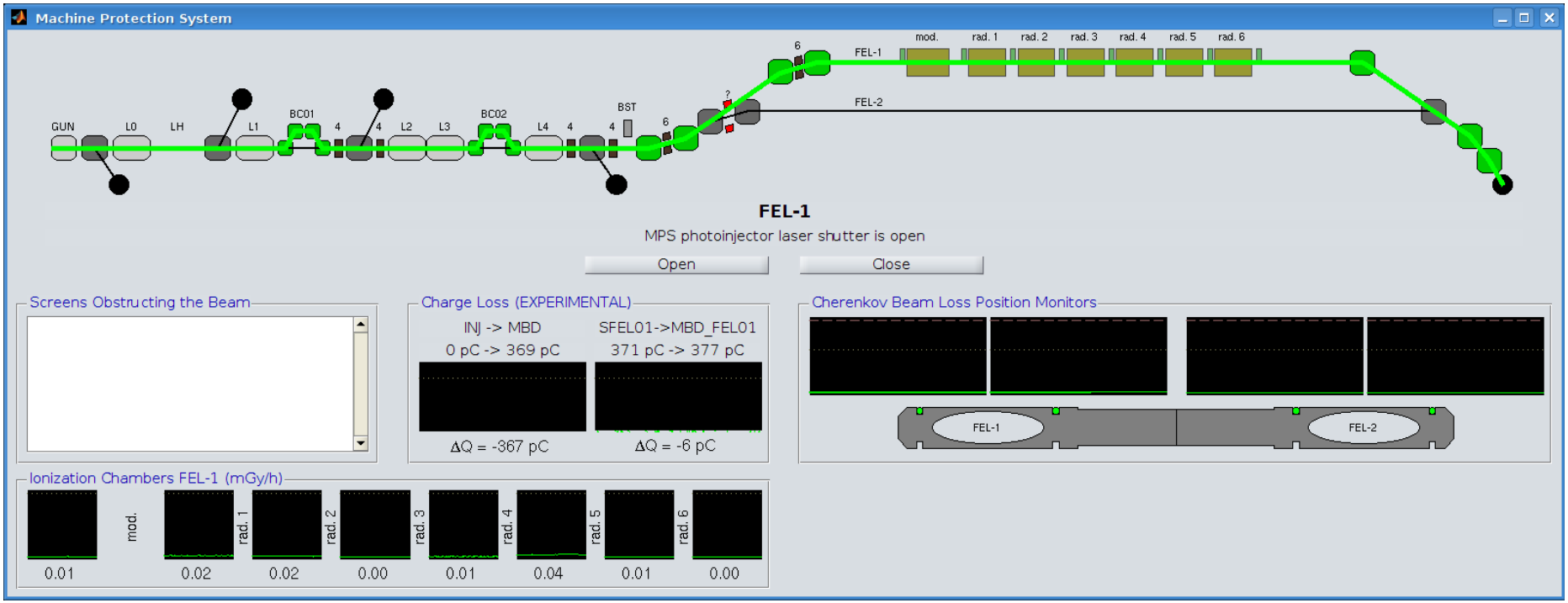


Operation Modes



Dipole currents monitored via DCCT and analog PLC input.

MPS Panel

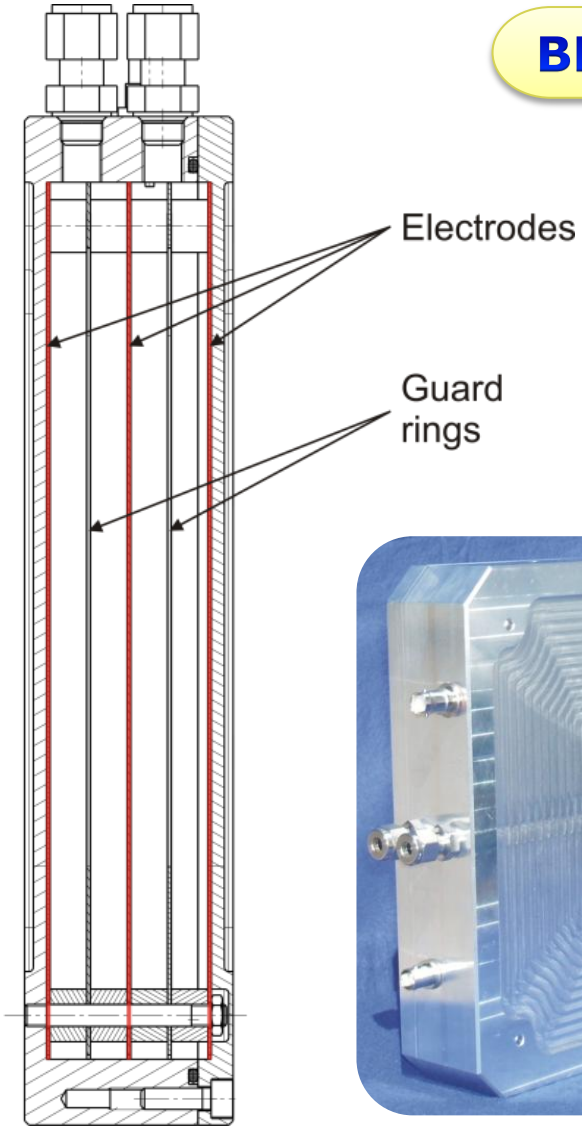

Machine Protection System
GUN
L0
LH
L1
BC01
L2
L3
BC02
L4
BST
FEL-1
FEL-2
mod.
rad. 1
rad. 2
rad. 3
rad. 4
rad. 5
rad. 6
FEL-1
MPS photoinjector laser shutter is open
Open
Close
Screens Obstructing the Beam
Charge Loss (EXPERIMENTAL)
INJ -> MBD
0 pC -> 369 pC
SFEL01->MBD_FEL01
371 pC -> 377 pC
ΔQ = -367 pC
ΔQ = -6 pC
Cherenkov Beam Loss Position Monitors
FEL-1
FEL-2
Ionization Chambers FEL-1 (mGy/h)
mod.
rad. 1
rad. 2
rad. 3
rad. 4
rad. 5
rad. 6
0.01
0.02
0.02
0.00
0.01
0.04
0.01
0.00

Ionization Chambers

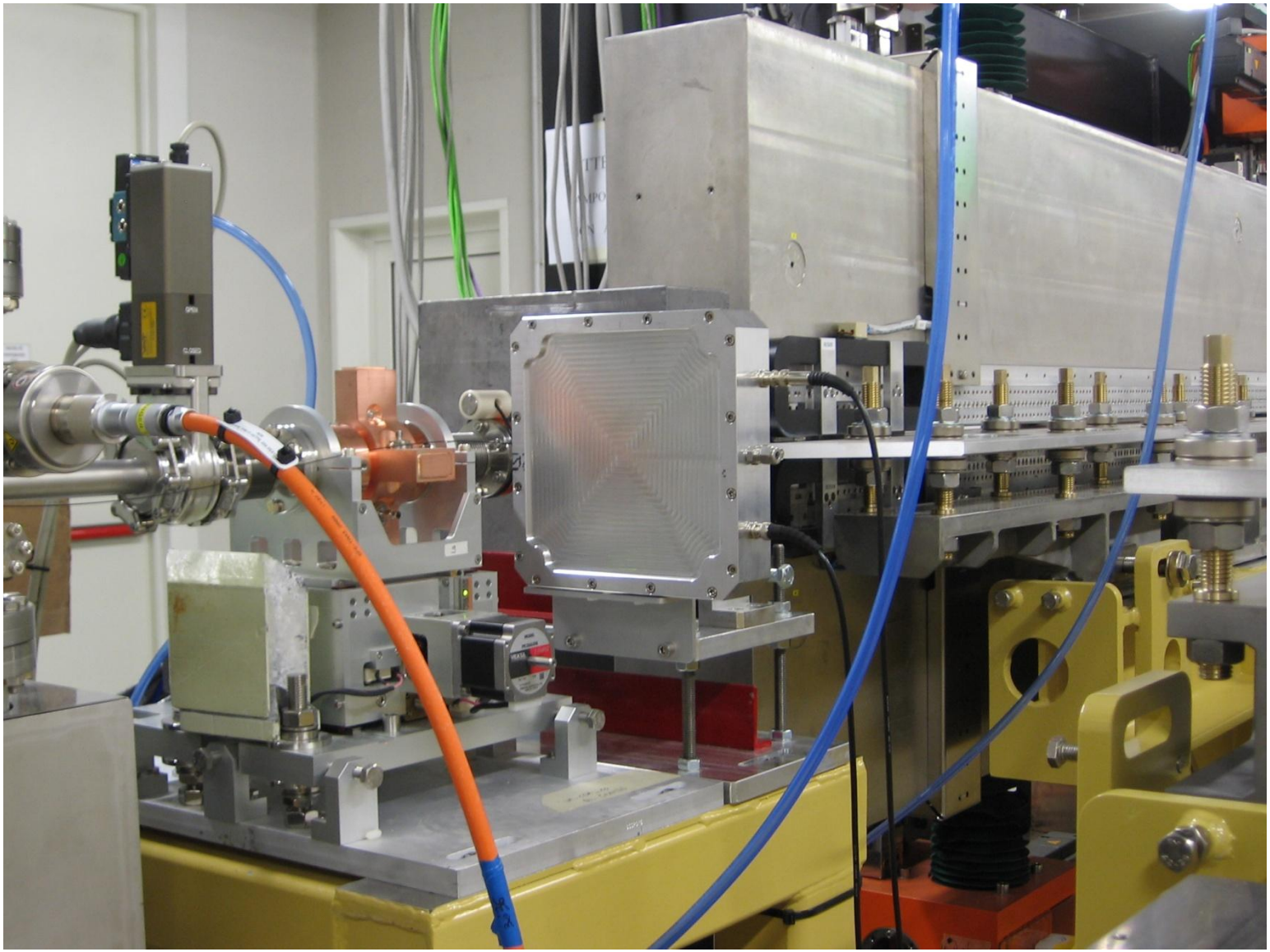
Ionization Chambers

BLM–IC02

- Milled aluminum enclosure
- Electrodes: printed circuit boards
- Use in air or with gas flux
- Volume:
  1.3 l
- Voltage:
  up to 1000 V
- Sensitivity (air):
  ~46 µC/Gy
- Leakage current:
  ≪ 200 fA (at 1000 V)
- Fermi:
  1 ionization chamber in air
  per undulator segment (19 total)



Ionization Chambers



Ionization Chamber Frontend

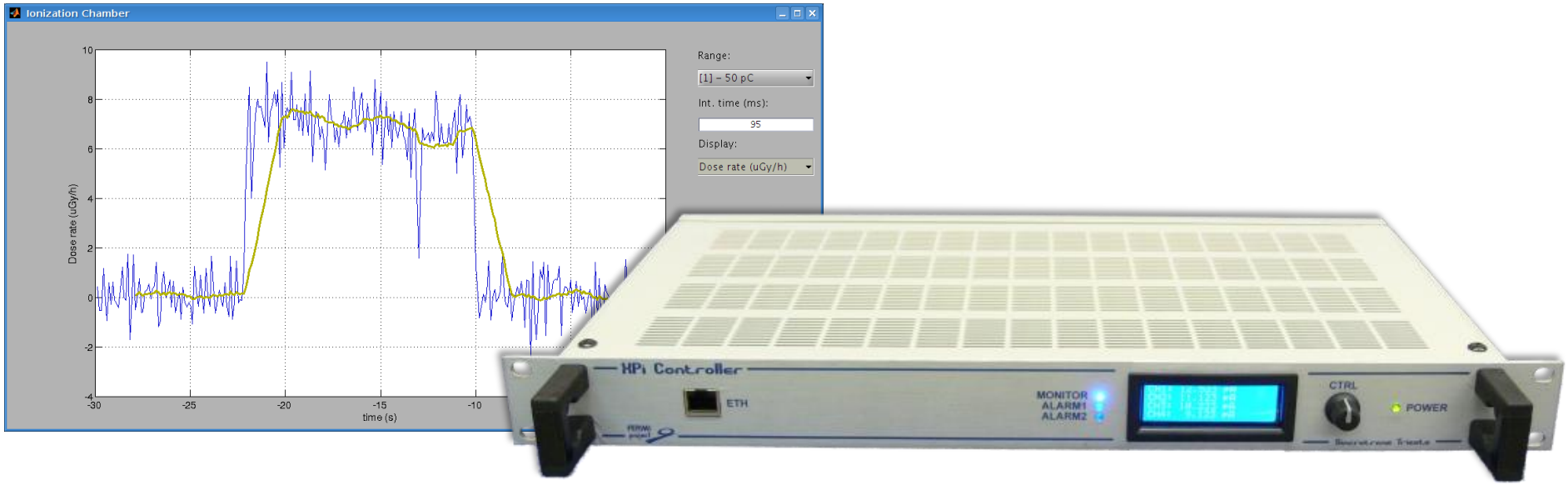
- 19” XPi modular data acquisition system
- Microprocessor controlled
- Ethernet interface
- 1× HV generation up to 2000 V (power ≤ 1 W)
- 4× Charge-integrating amplifier and 20-bit ADC

XPi DAS

Ionization Chamber Frontend

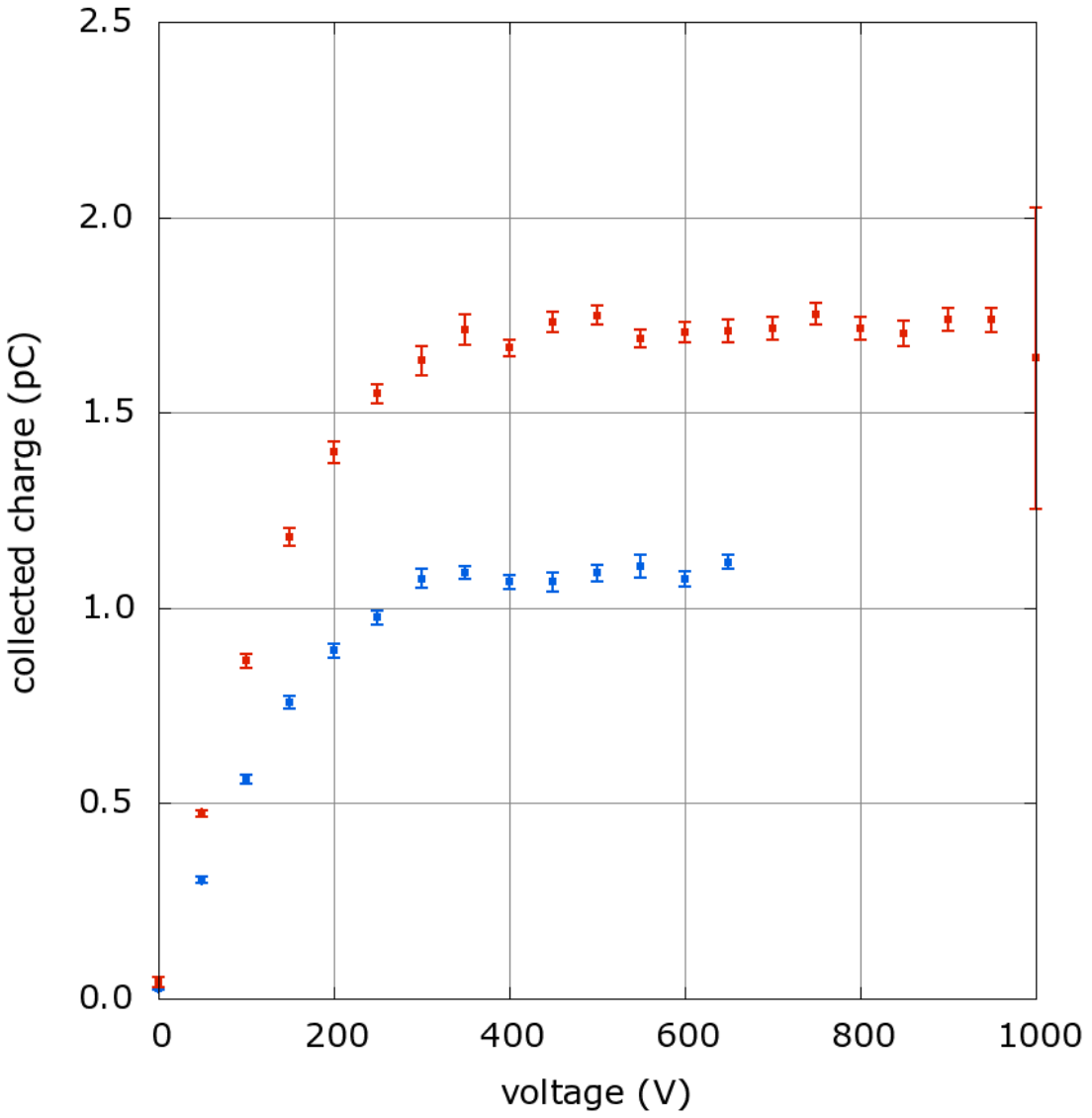
XPi DAS

- Full charge range:
  0…50 pC — 0…1.8 nC
- Integration time: 1 ms – 1 s
- 2 programmable alarm outputs
- Noise floor (with Fermi chamber):
  <0.4 µGy/h (rms)
- Tango server
- Data acquisition tested up to 50 Hz



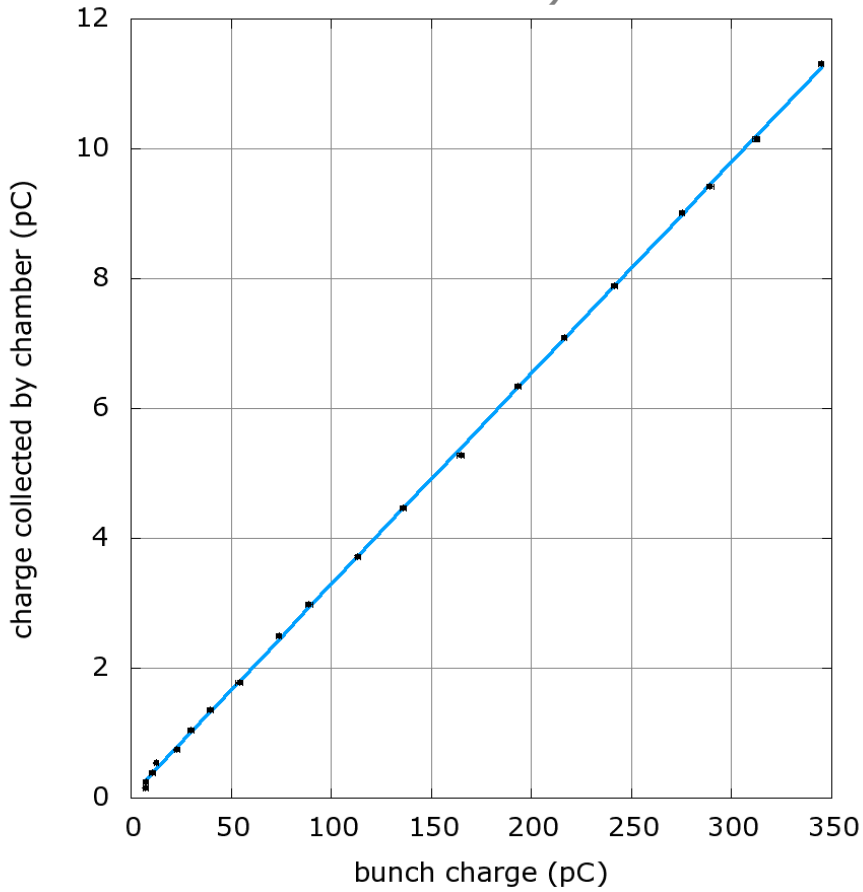
Collection Efficiency

- Air filled chamber
- Charges collected:
  - Electrons
  - Oxygen ions (O_2^-)
  - Positive ions (N_2^+ etc.)
- Integration time: 3 ms (2 ms sufficient to collect all charges)

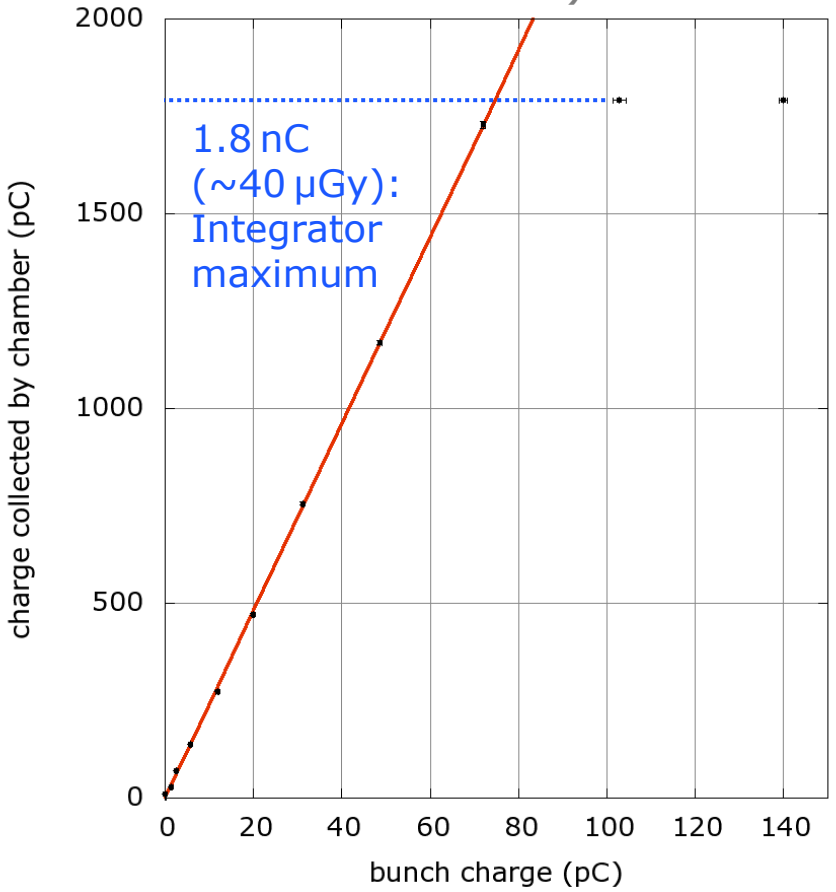


Linearity at 1000 V

Low dose rates
(~20 cm downstream of screen)

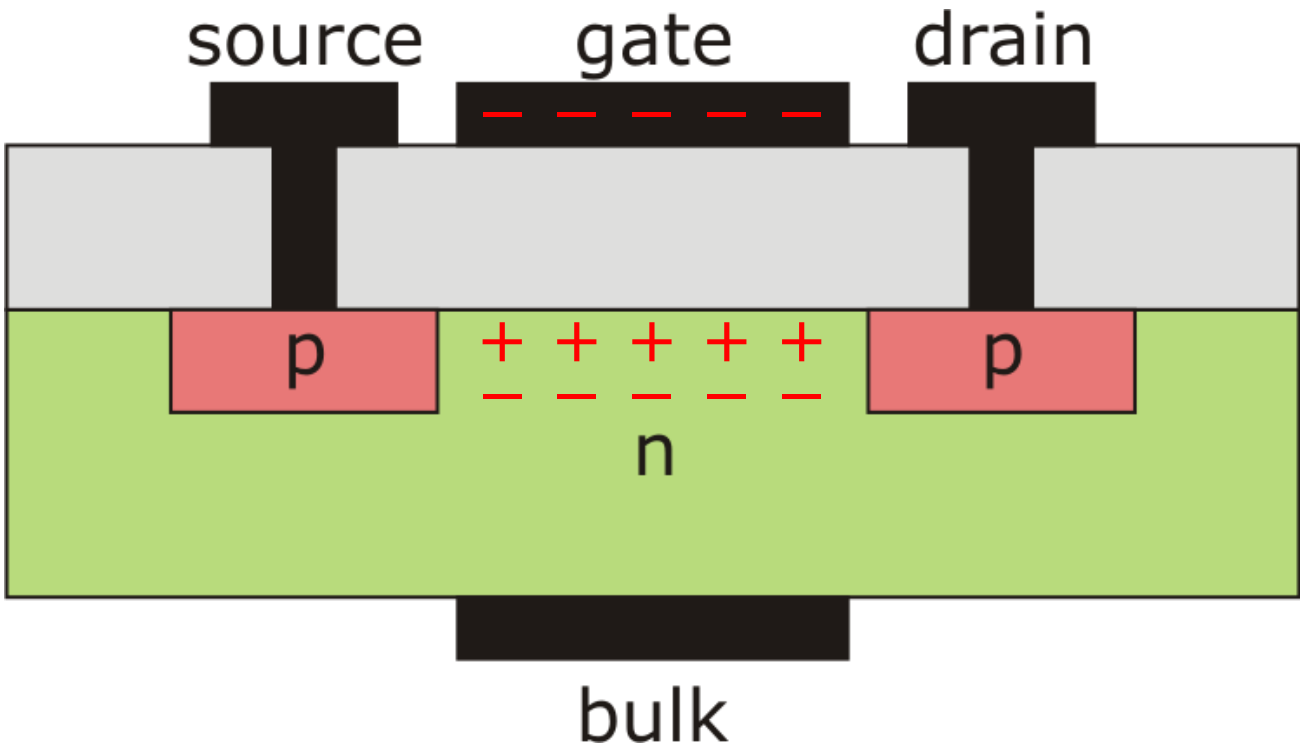


High dose rates
(~4 m downstream of screen)



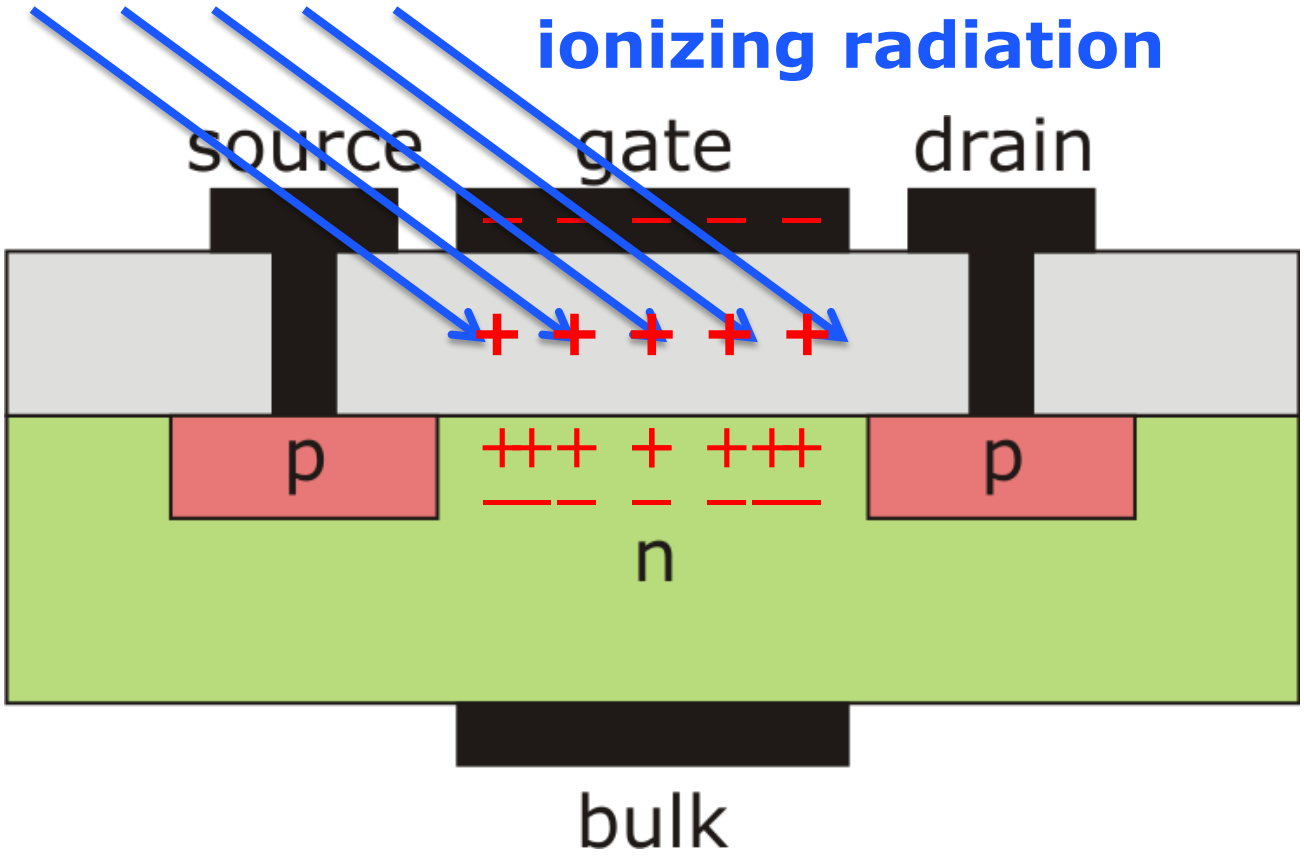
Online Solid-State Dosimetry

P-channel MOSFET



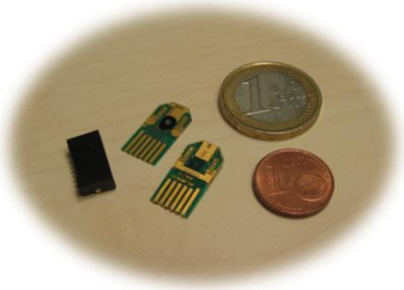
negative gate potential → conductive inversion layer

P-channel MOSFET



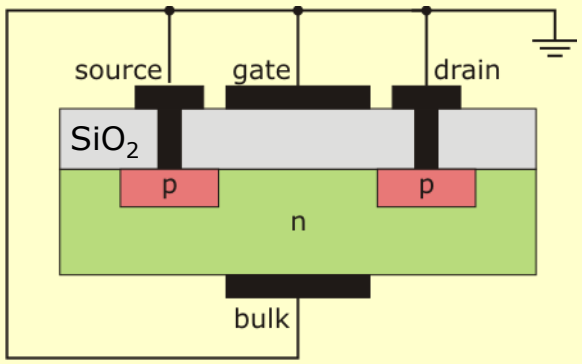
ionizing radiation → stationary charges in insulation layer

RADFET Dosimeters

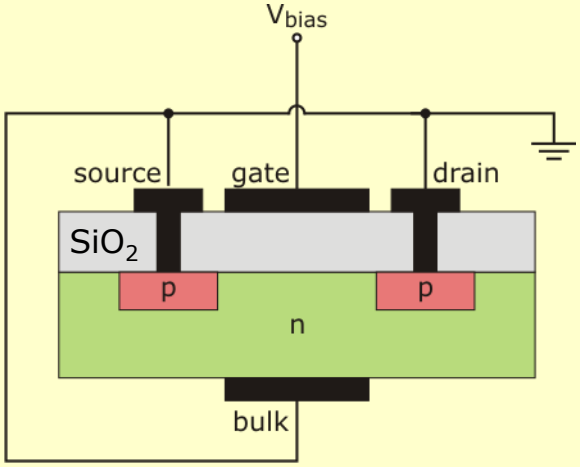


- REM Oxford Ltd. RADFET RFT-300-CC10G1
- Chip contains 2 p-channel MOSFETs with 300 nm insulator layer

exposure "zero bias"



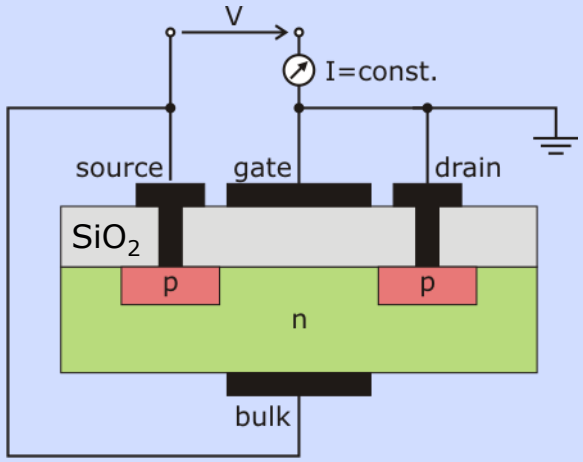
exposure with bias voltage



$V_{bias} > 0$: more sensitive

$V_{bias} < 0$: more linear

read-out



Track voltage for constant current (490 µA) between source and drain

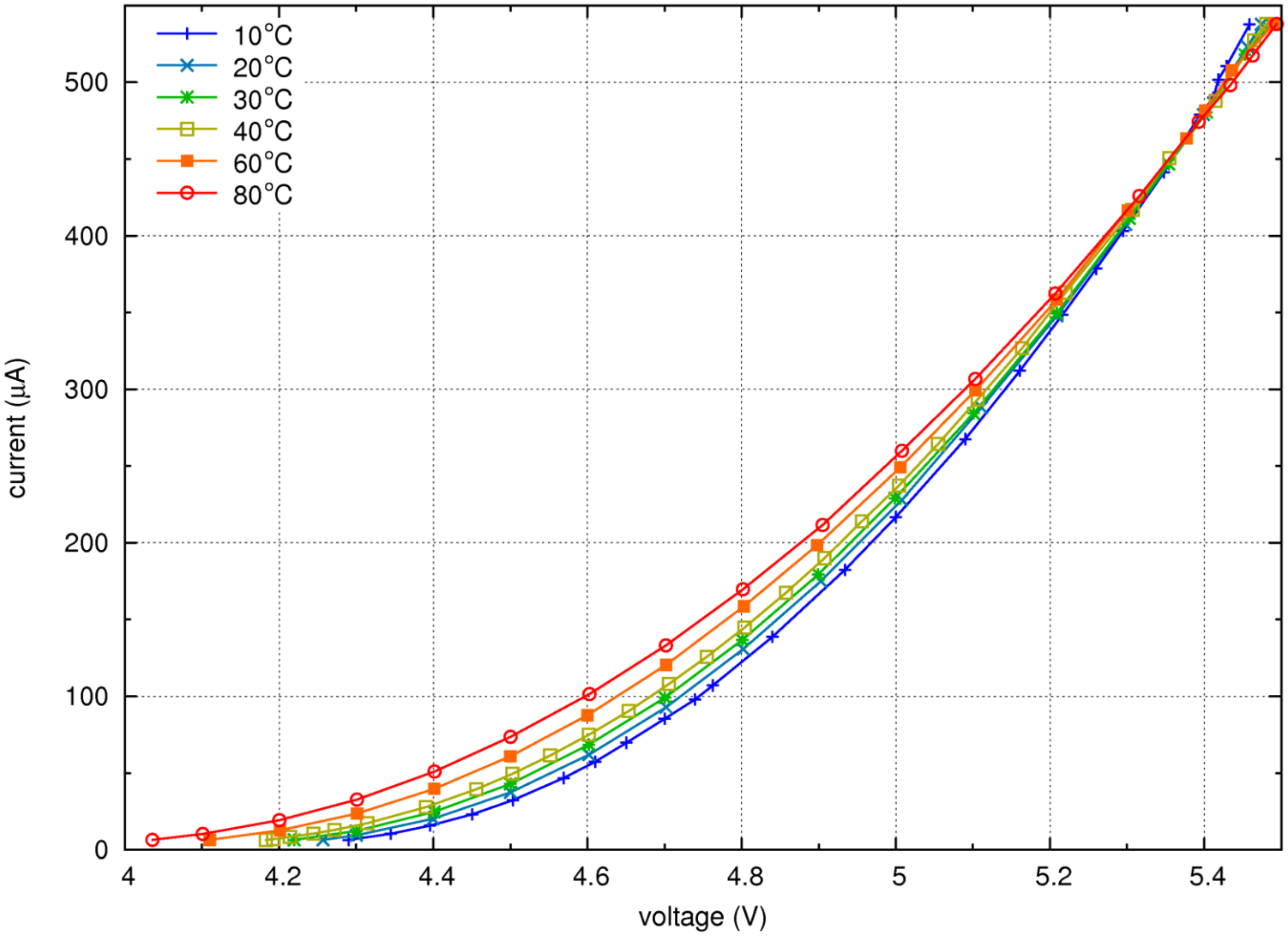
Dosimeter Reader

- Microprocessor controlled
- Ethernet connection
- 4 RADFET channels
- Fixed read-out current: 490 µA
- Voltage read-out: 24 bit ADC, up to 25 V
- Programmable interlock output
- Uses standard USB cables

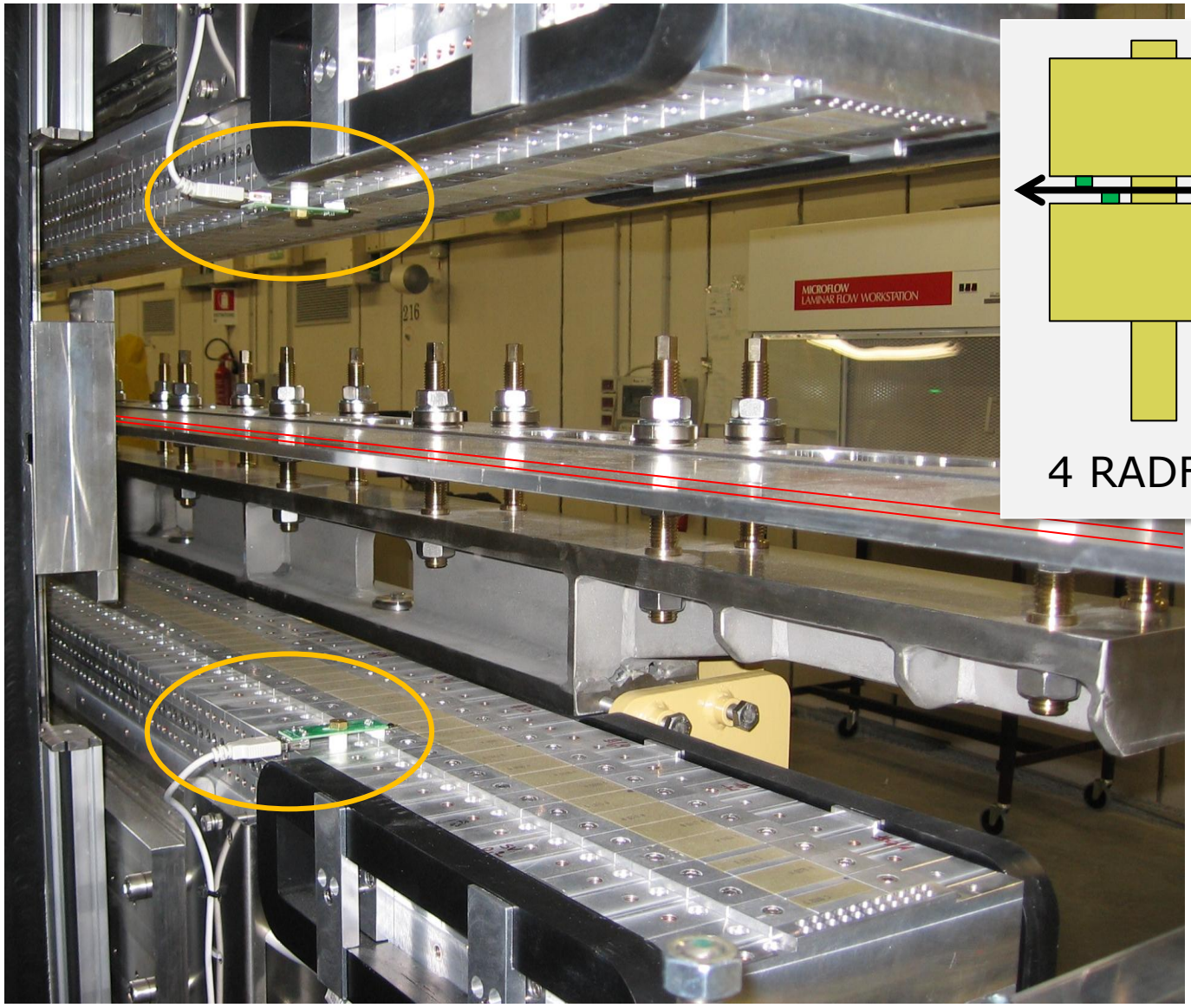
L01-DOSFET

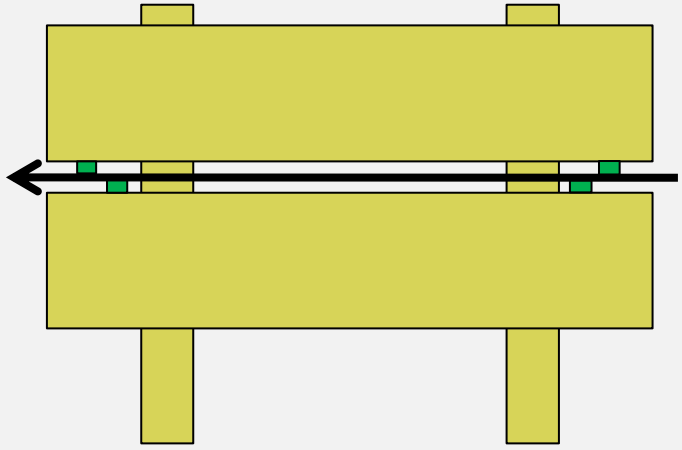
Photo: M. Peloi

Temperature Dependance



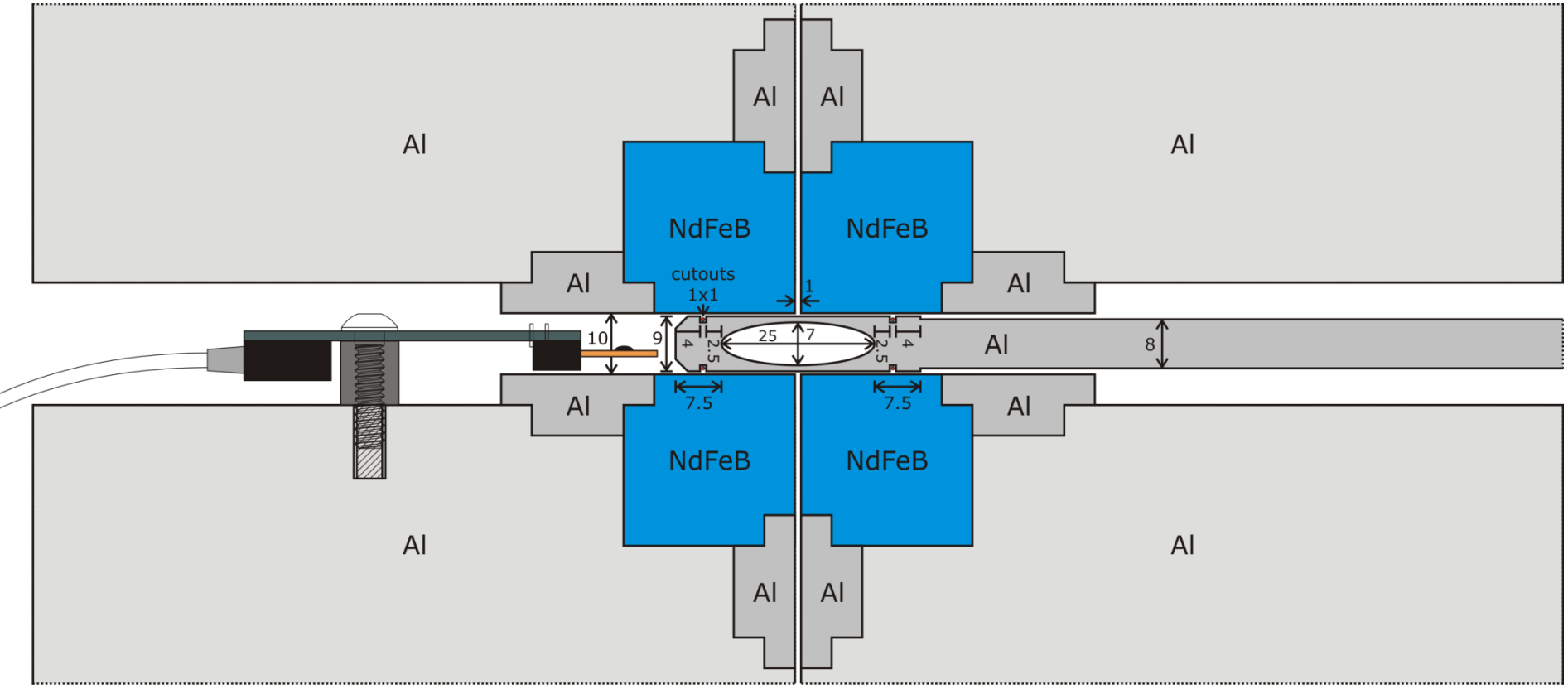
Undulator with Open Gap



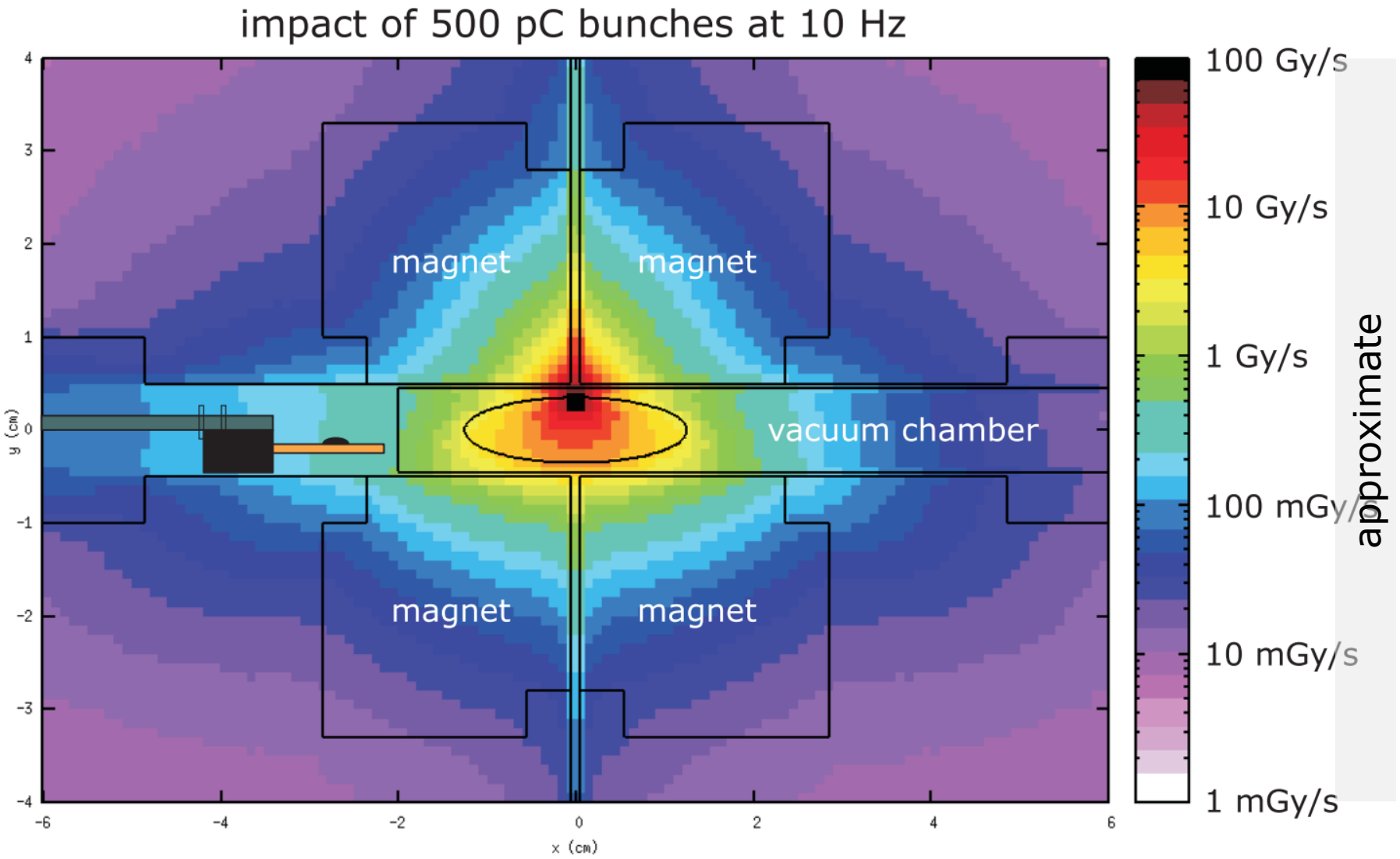


4 RADFETs per undulator

Undulator Cross-Section



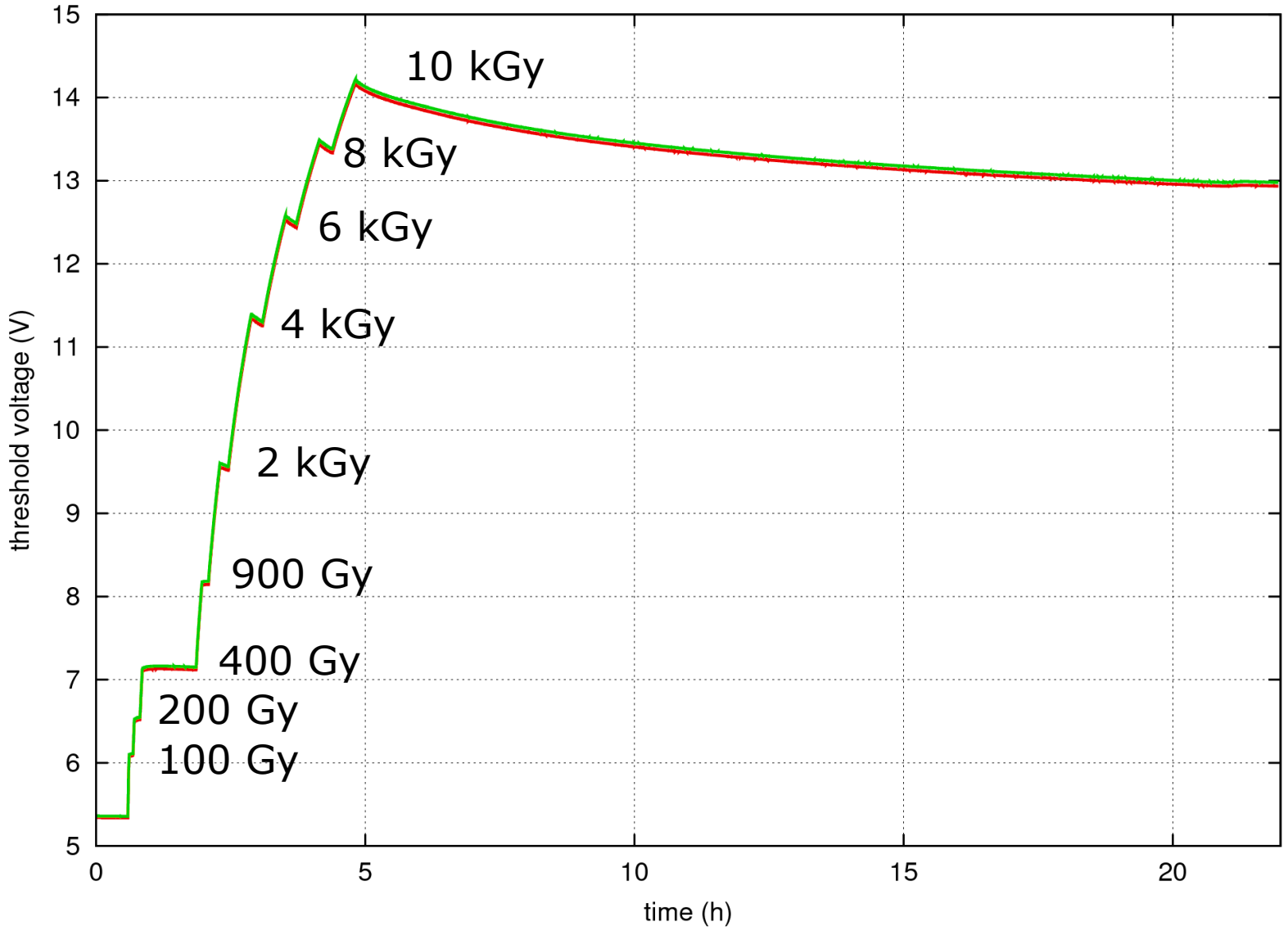
Dose Rates


impact of 500 pC bunches at 10 Hz
magnet
magnet
vacuum chamber
magnet
magnet
100 Gy/s
10 Gy/s
1 Gy/s
100 mGy/s
10 mGy/s
1 mGy/s
approximate
y (cm)
x (cm)
4
3
2
1
0
-1
-2
-3
-4
-6
-4
-2
0
2
4
6

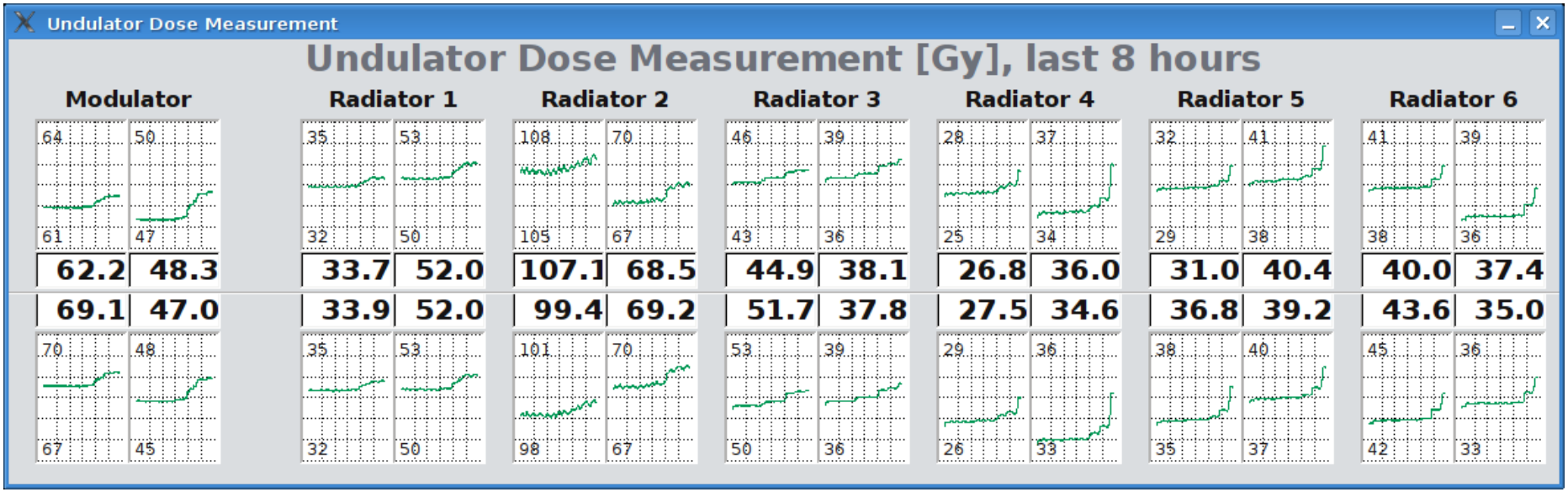
Calibration

unpublished data

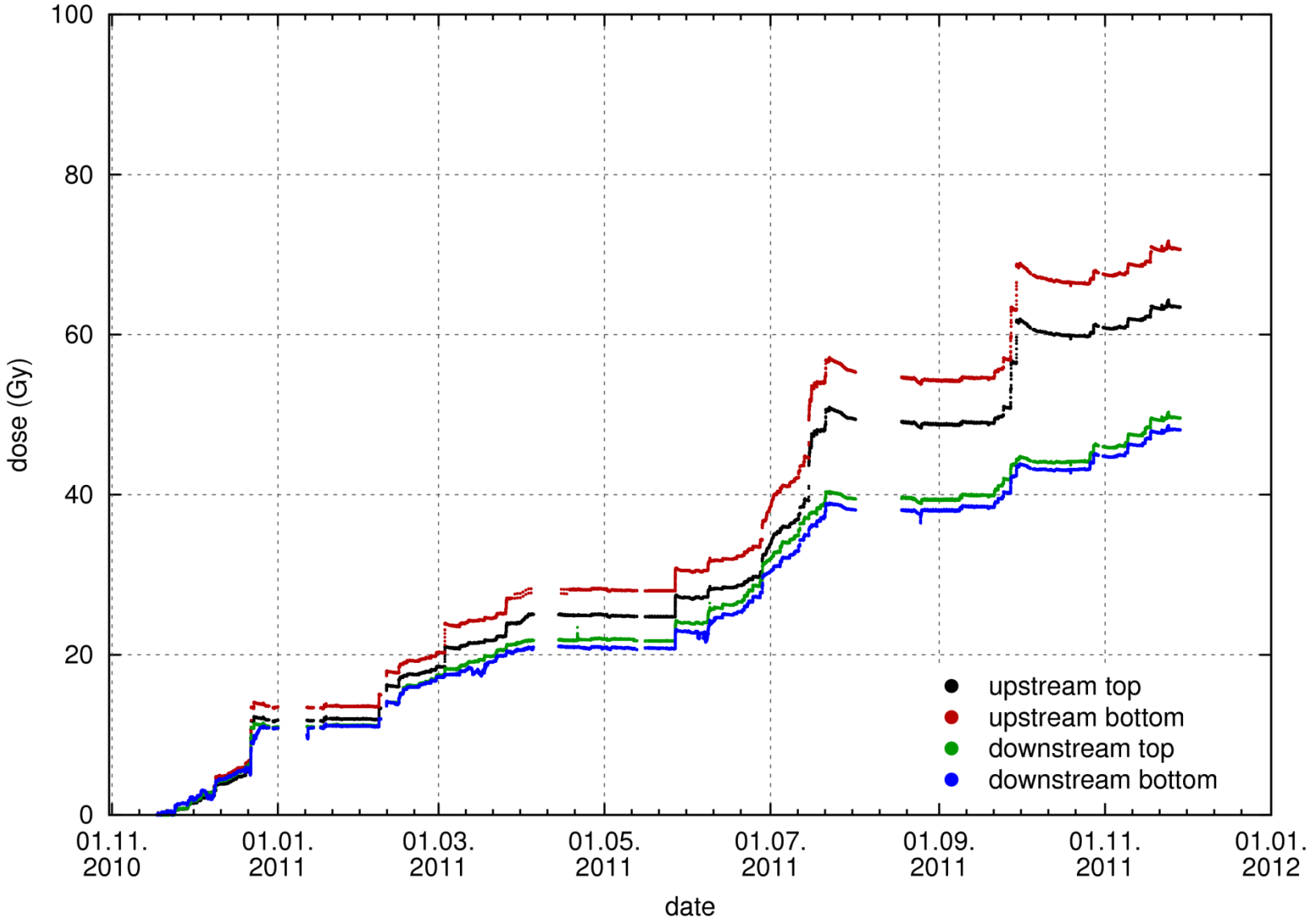
Irradiation and Fade



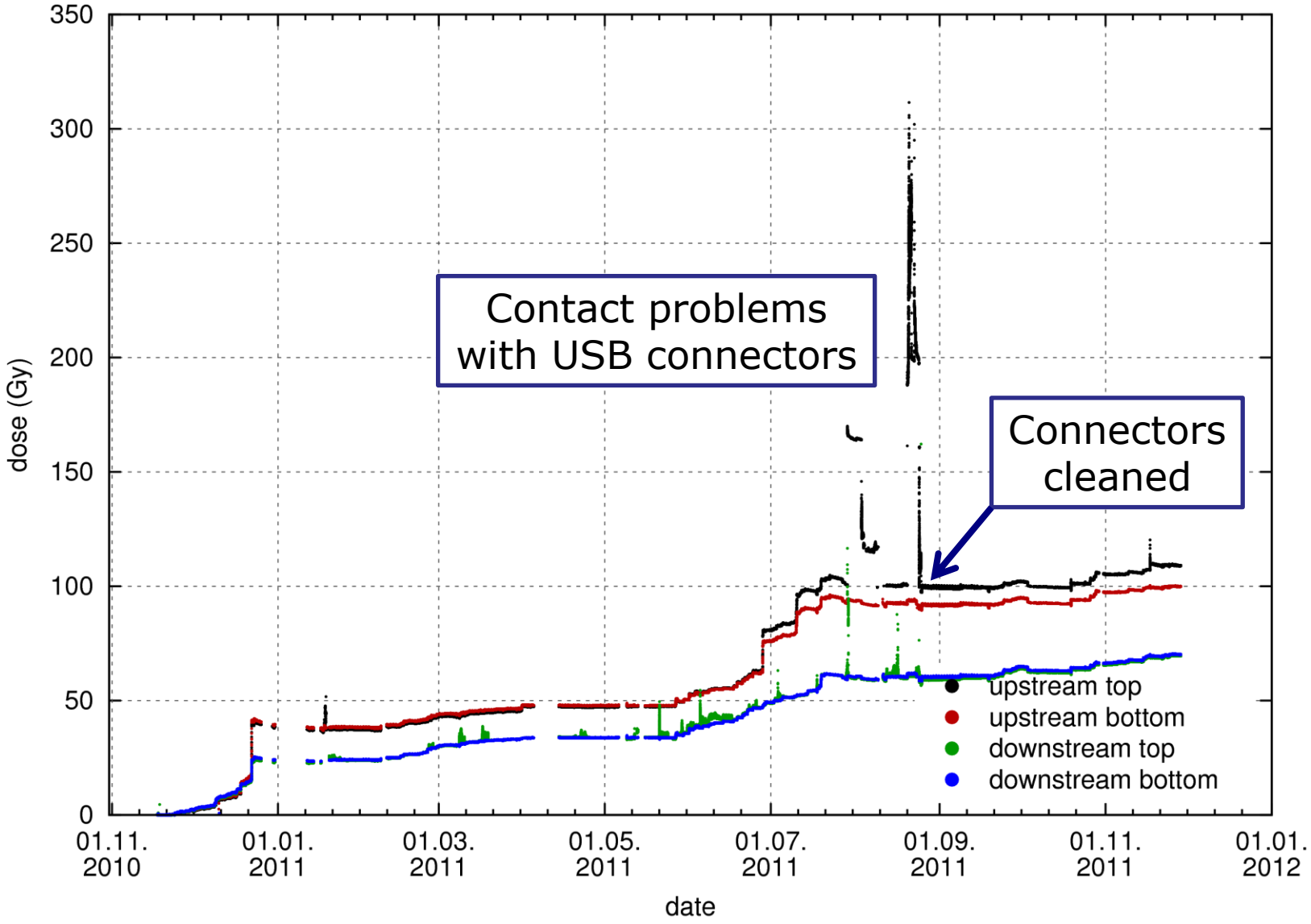
Control Panel



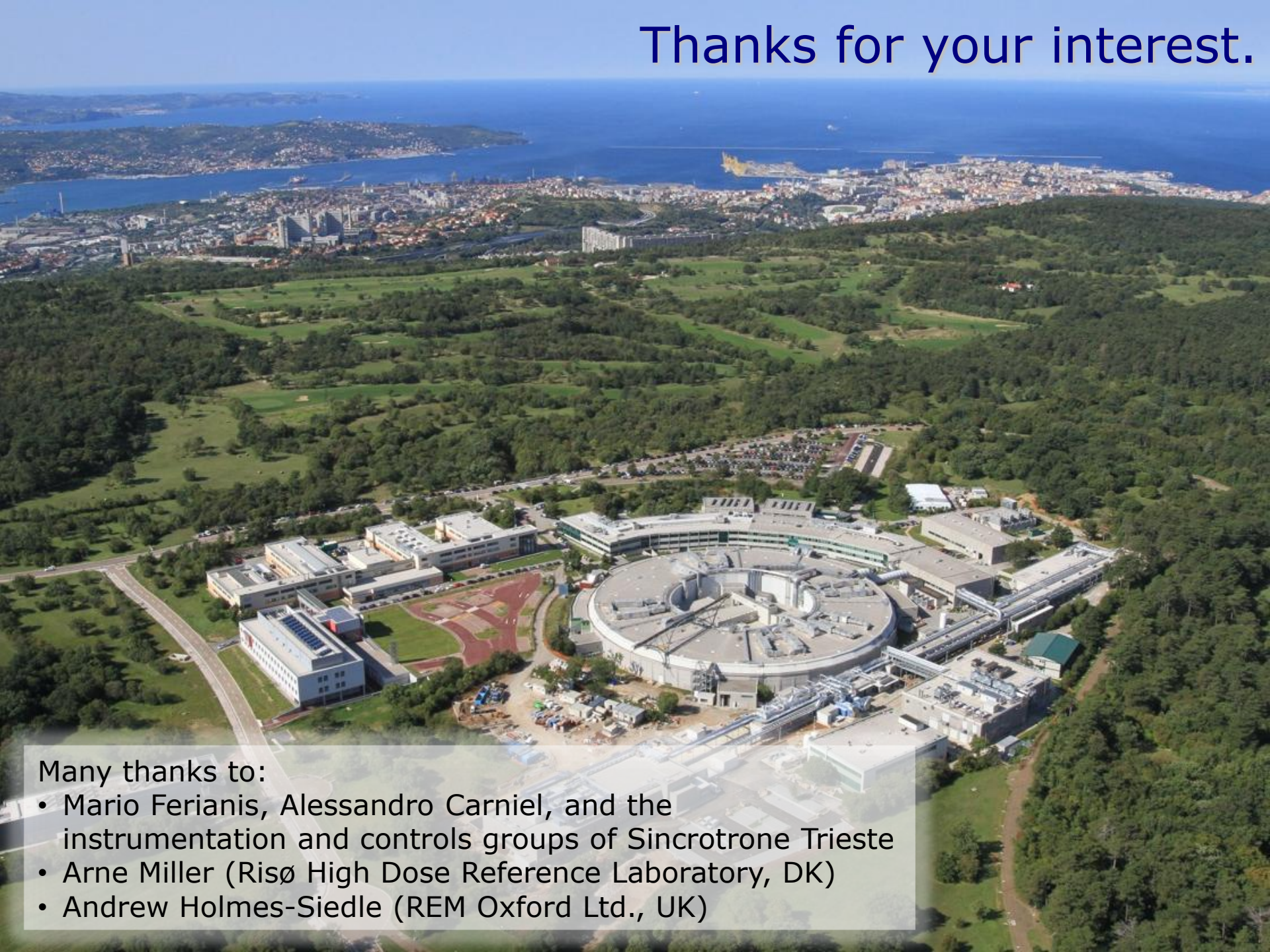
Dose History Modulator FEL-1



Dose History Radiator 2 FEL-1



Thanks for your interest.



Many thanks to:
- Mario Ferianis, Alessandro Carniel, and the instrumentation and controls groups of Sincrotrone Trieste
- Arne Miller (Risø High Dose Reference Laboratory, DK)
- Andrew Holmes-Siedle (REM Oxford Ltd., UK)