RPL dosimeter at CERN

M. Fuerstner[+], I. Brunner[+], F. Jaquenod [‡], N. Liaudet [‡] ,
S. Pernecker [‡], M. Tognolini [‡], G. Triscone [‡], H. Vincke[+]

[+] CERN

[‡] Ecole d'ingenieurs de Geneve

Overview

- Principles
- New RPL reader
  - Principle
  - Components
  - Software
- RPL Dosimeter China
- Experiments

RPL Dosimeter

Material: Silver activated metaphosphate glass

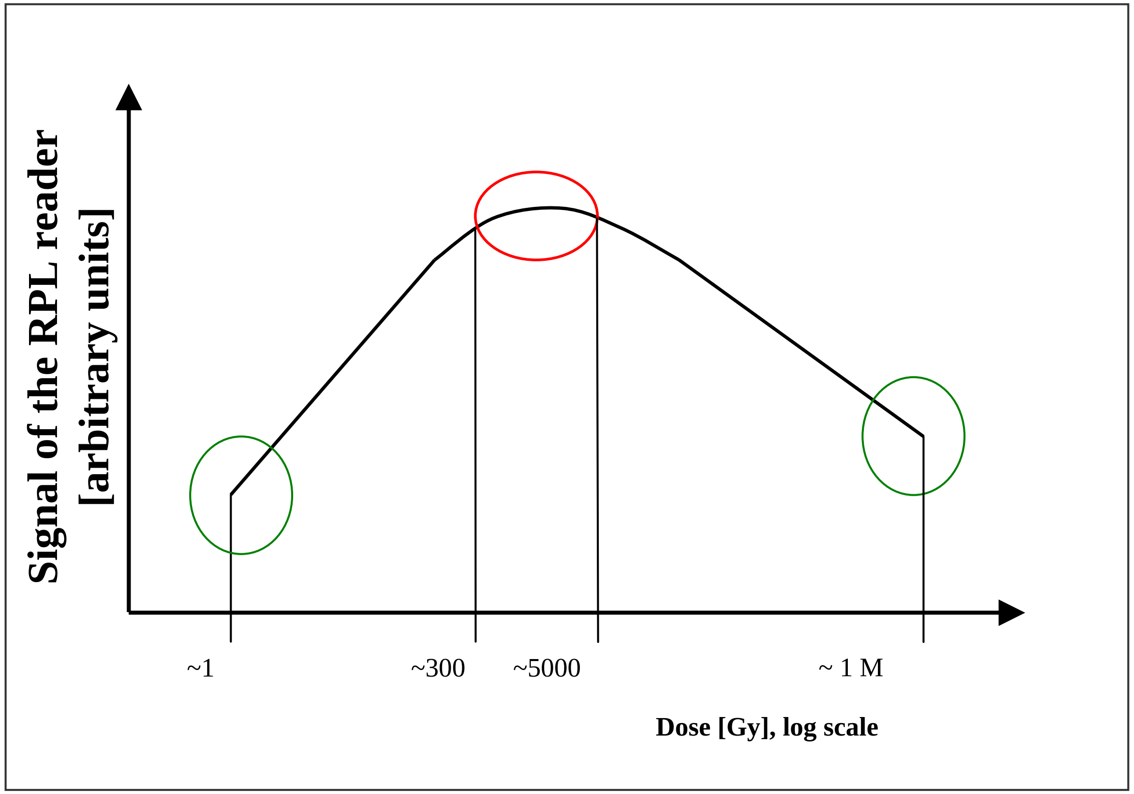
Effect:

- Ionizing radiation creates radio-photoluminescence centers
- Colorization

Analysis:

- Luminescence intensity after UV-light exposure
- Optical density

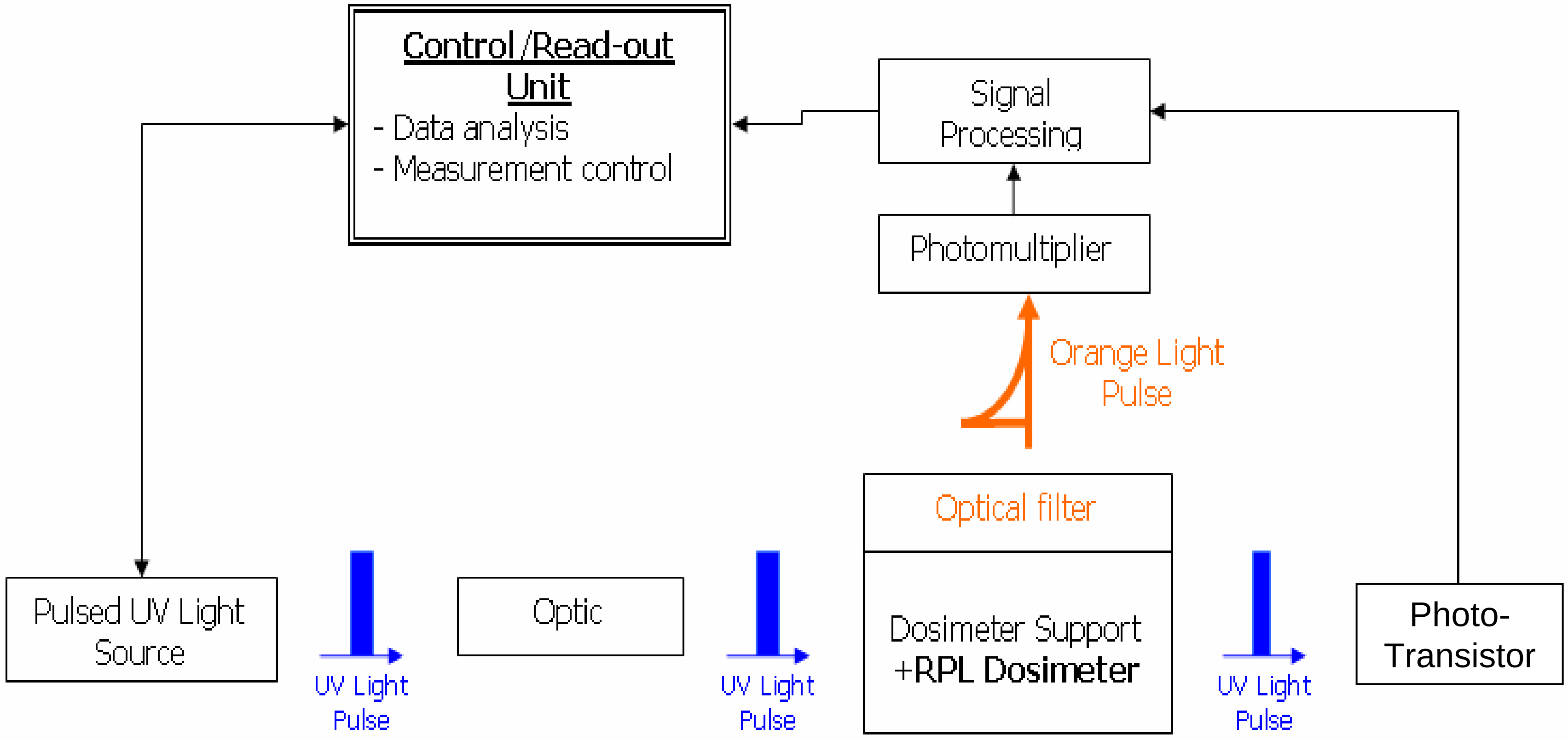
Dosimeter characteristics



Increasing the precision

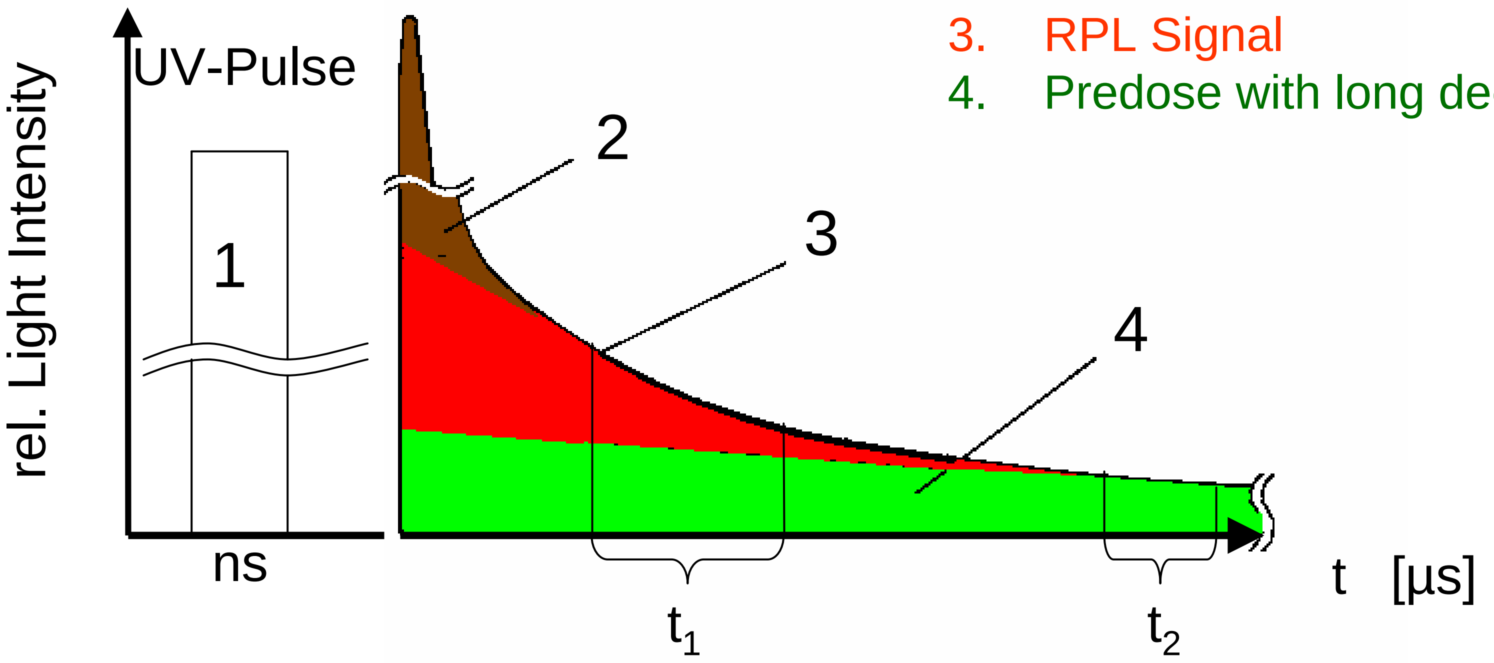
New RPL Reader

Schematic


Control/Read-out Unit
- Data analysis
- Measurement control
Signal Processing
Photomultiplier
Orange Light Pulse
Optical filter
Dosimeter Support +RPL Dosimeter
Pulsed UV Light Source
UV Light Pulse
Optic
UV Light Pulse
UV Light Pulse
Photo-Transistor

Luminescence

1. UV pulse
2. Chemo-luminescence
3. RPL Signal
4. Predose with long decay



Dose ✪ $A(t_1) – f(A(t_2))$

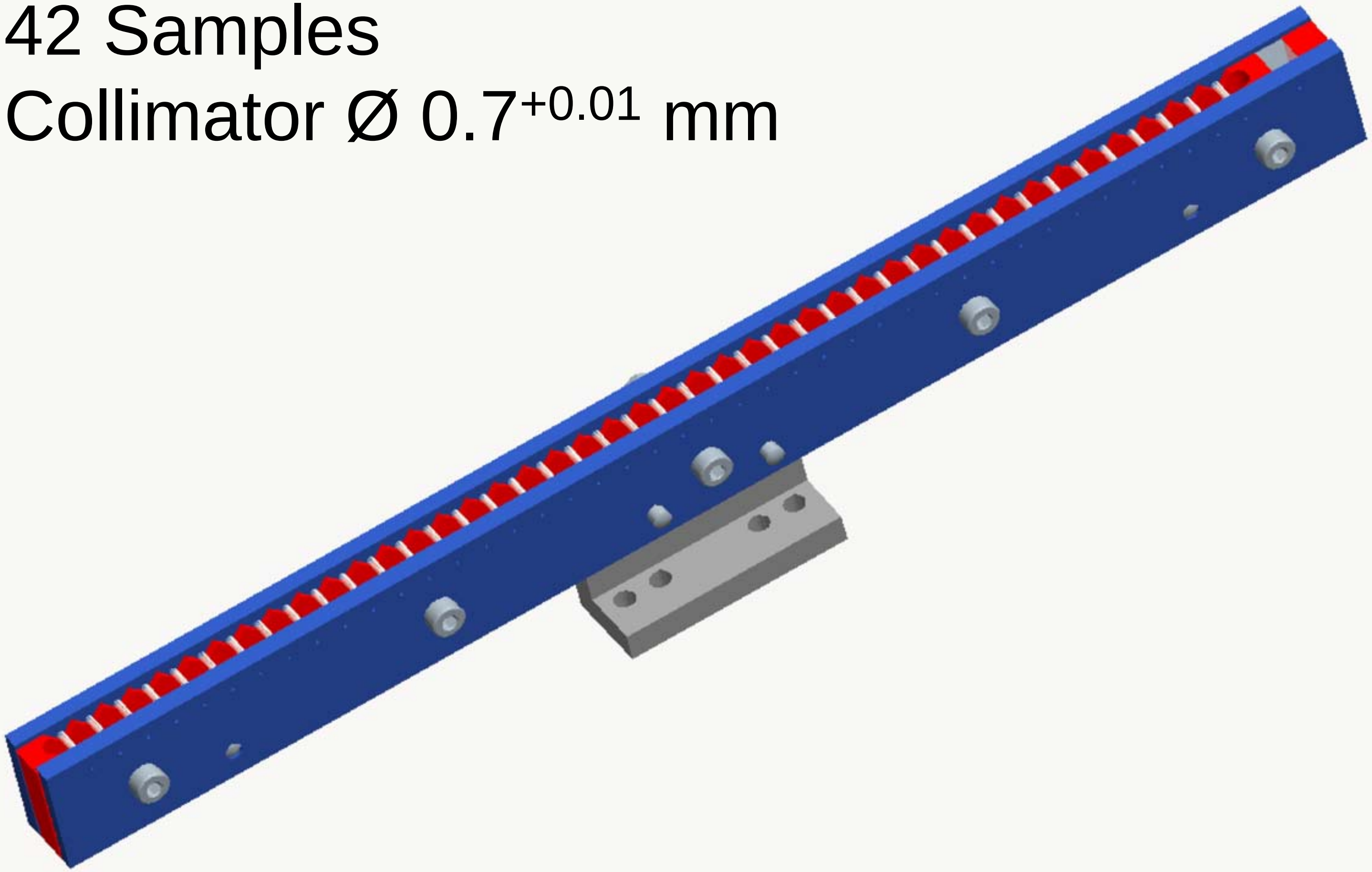
RPL Components

- Nitrogen Laser
  - Spectra Physics VSL-337ND-S
  - Pulse energy: 300 µJ
  - Pulse duration: 4 ns
- X-Table
  - Zaber T-LLS 260
  - Resolution: 0.16 µm
  - Repeatability: < 0.5 µm
- DAQ card
  - Acqiris DP308
  - Resolution: 12 bit
  - Sample rate: 200 MS/s

Dosimeter holder

42 Samples

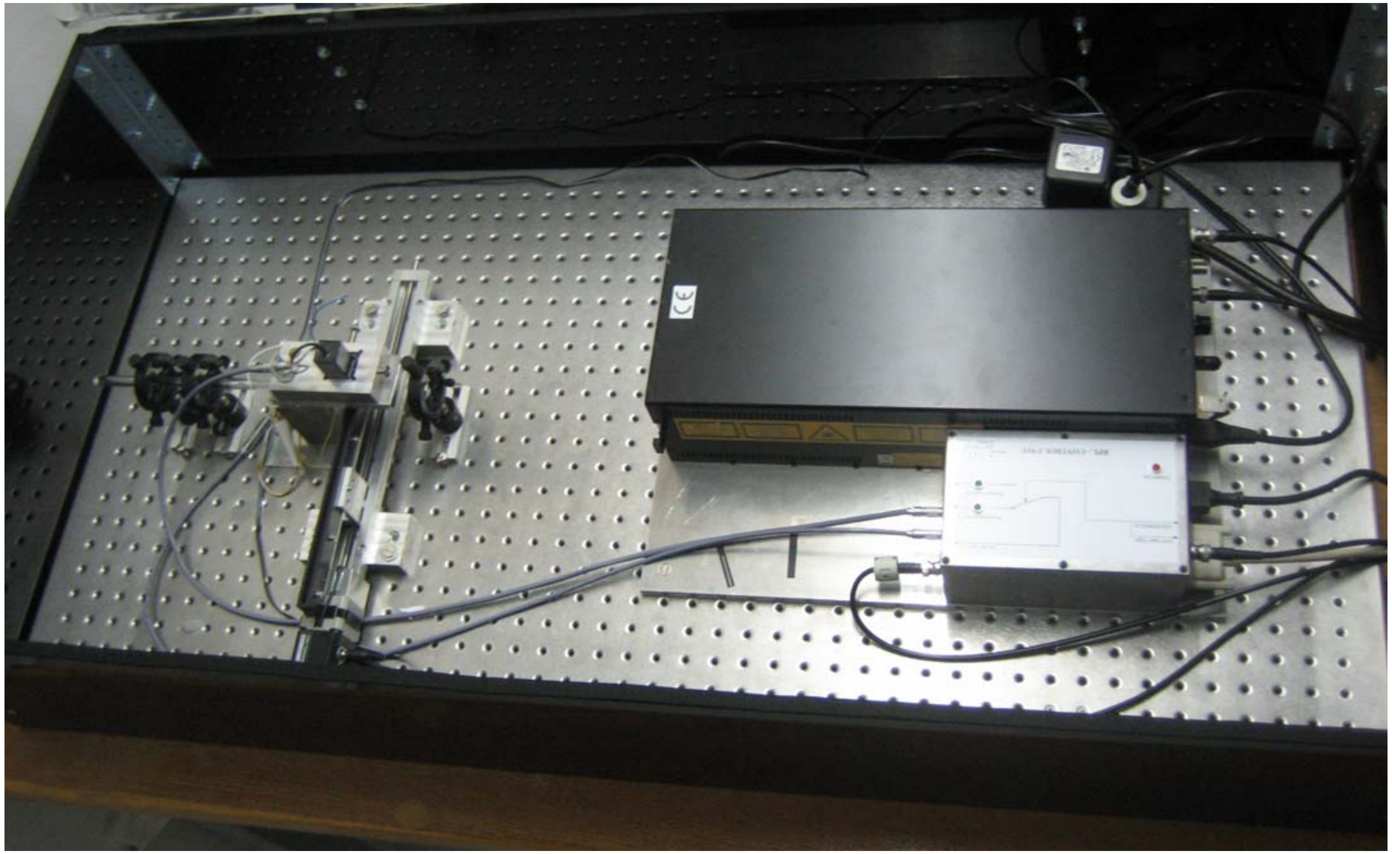
Collimator Ø $0.7^{+0.01}$ mm



RPL control unit

- Fast amplifier (420MHz bandwidth) build at EIG Geneve
- Tailored to our needs

RPL reader



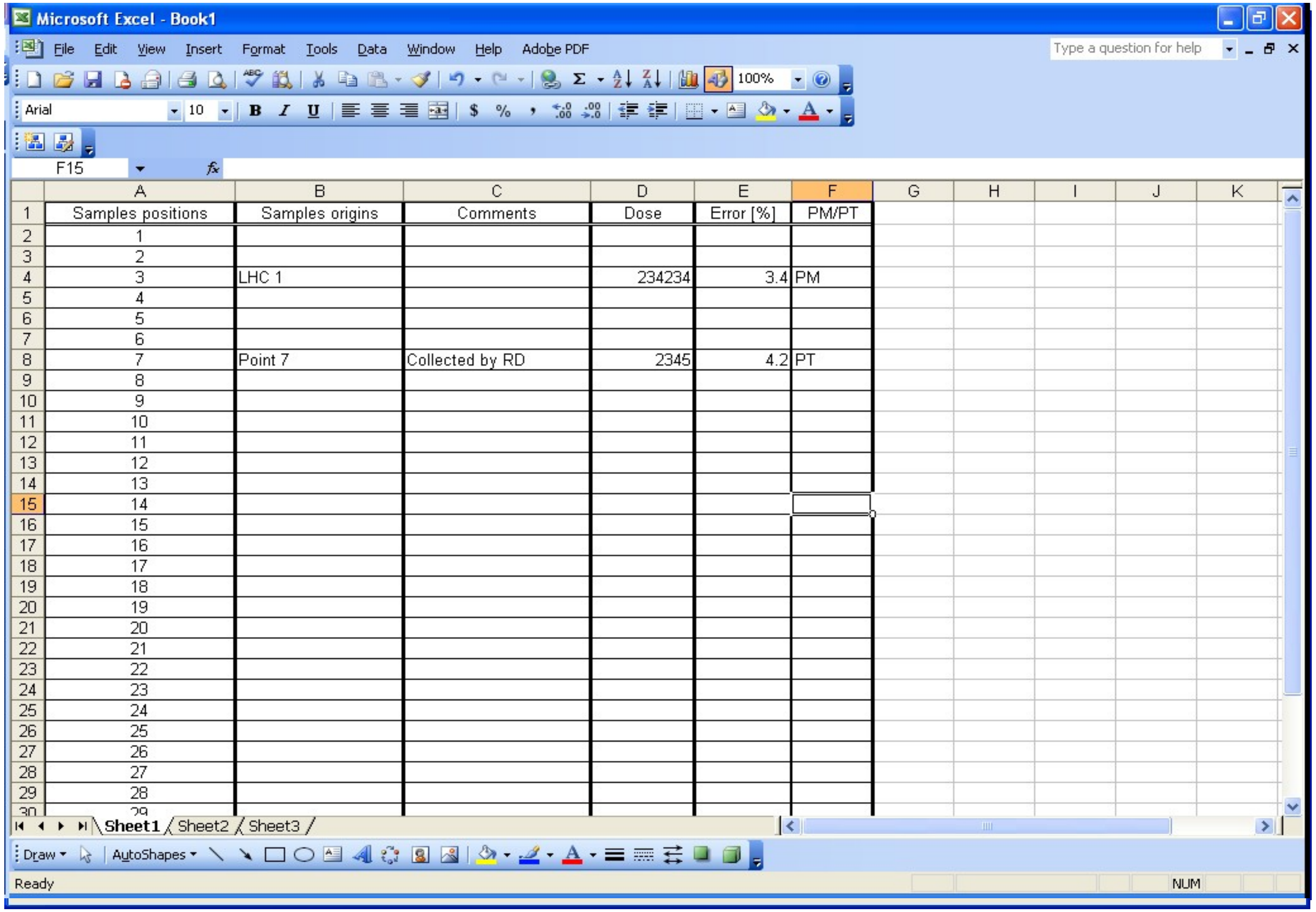
Control Software

- User friendly GUI
- Measurement instructions via Excel sheet
- The measured curves are stored automatically
- Tracing the efficiency of the System

$$\varepsilon_{PM} = \frac{\int_{I_{PM}} PM_{ref}\,dt}{\int_{I_{PM}} PM_{cal}\,dt} \qquad \varepsilon_{PT} = \frac{\int_{I_{PT}} PT_{ref}\,dt}{\int_{I_{PT}} PT_{cal}\,dt}$$

- Automatically adjustment of the DAQ input range

Control Software



	Samples positions	Samples origins	Comments	Dose	Error [%]	PM/PT
2	1					
3	2					
4	3	LHC 1		234234	3.4	PM
5	4					
6	5					
7	6					
8	7	Point 7	Collected by RD	2345	4.2	PT
9	8					
10	9					
11	10					
12	11					
13	12					
14	13					
15	14					
16	15					
17	16					
18	17					
19	18					
20	19					
21	20					
22	21					
23	22					
24	23					
25	24					
26	25					
27	26					
28	27					
29	28					

Conclusion

- The Reader is designed to be user friendly
- All components were chosen to guaranty high precision
- The dosimeter holder is produced in high accuracy and installed
- The control and analysis software is written

Outlook

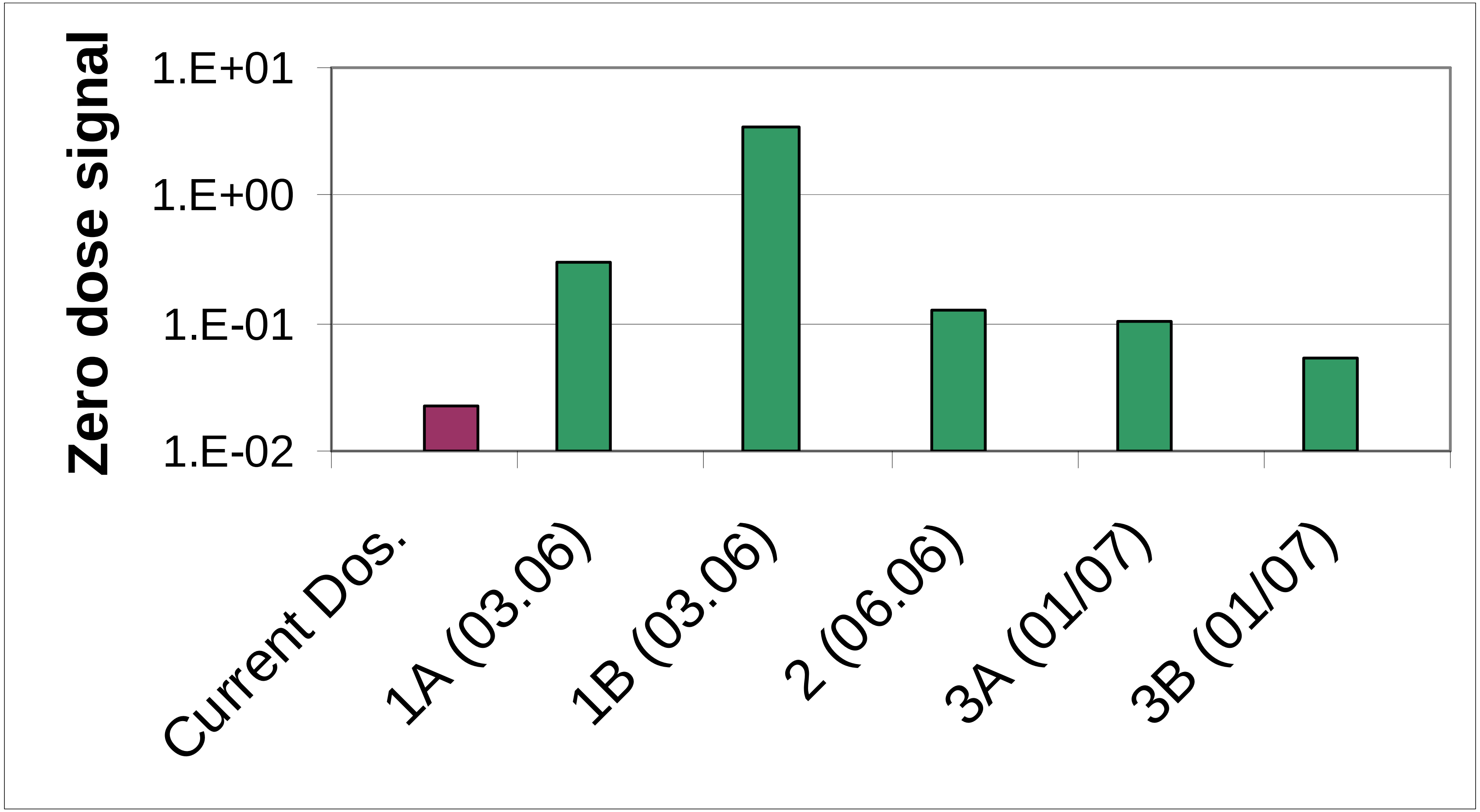
- Comprehensive tests are foreseen to ensure that the Reader is working stable
- The laser has to be exchanged, since the pulse energy stability does not comply with the specifications given by the company

RPL dosimeter

RPL dosimeter production

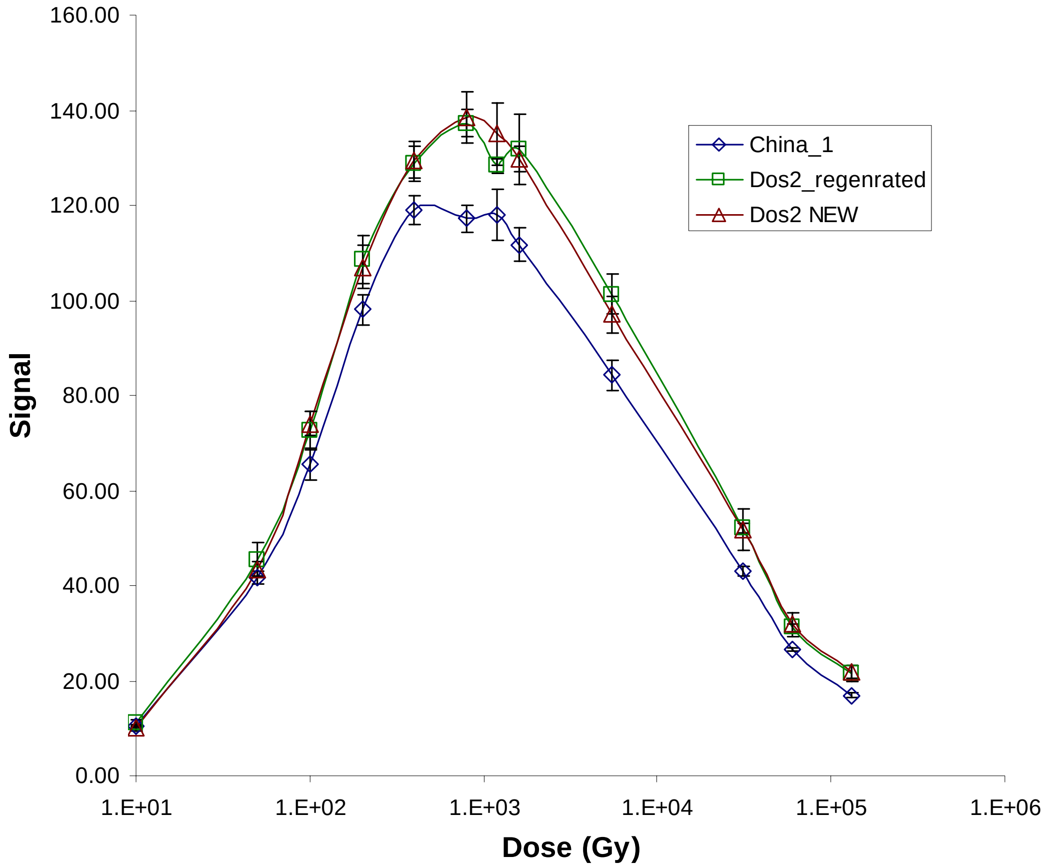
- Cooperation:
  The Laboratory for laser glass
  Shanghai Institute of Optical and Fine Mechanics
  Chinese Academy of Sciences
- Adjusting:
  - Melting Temperature and duration
  - Cooling time
  - Base components
  - Predose

Predose



Zero dose signal
1.E+01
1.E+00
1.E-01
1.E-02
Current Dos.
1A (03.06)
1B (03.06)
2 (06.06)
3A (01/07)
3B (01/07)

Comparison of China w. Dos2



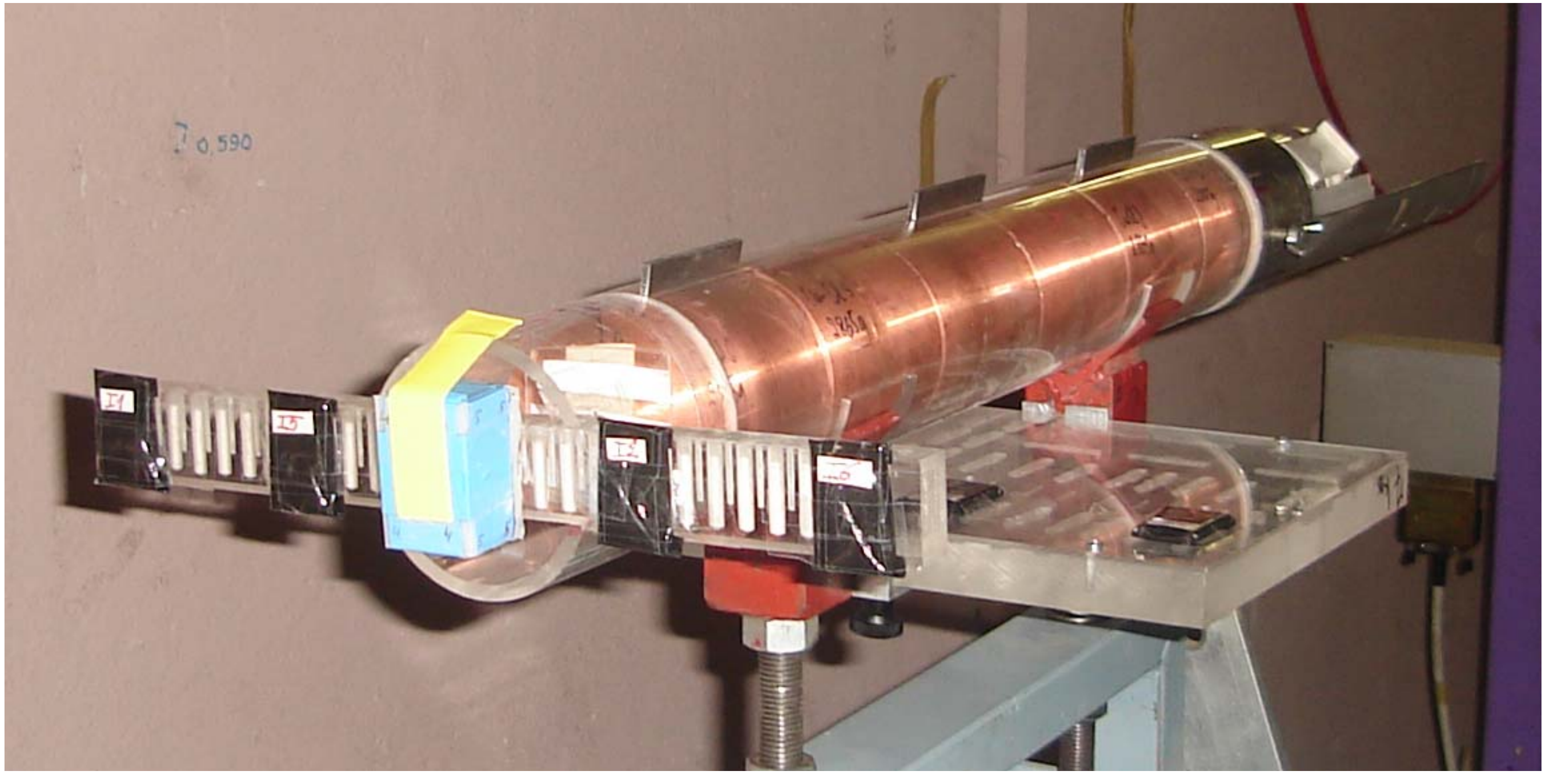
Conclusion

- The present Chinese dosimeter are already acceptable for CERN
- ... Nevertheless we push for further improvements

Experiments

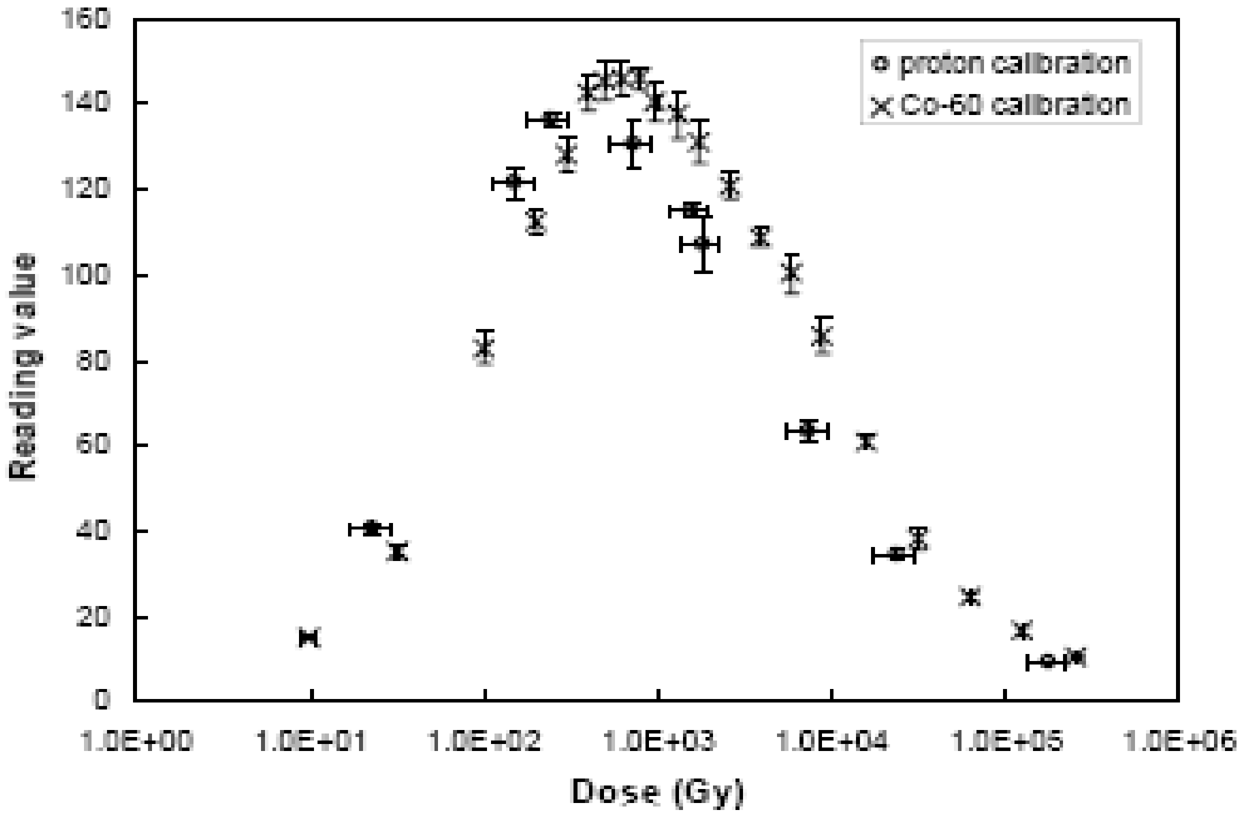
- CERF 2003 ✓
- CERF 2004 ✓
- p^+ Calibration Curve (IRRAD1) ✓
- Radiation Source TT40 Beam dump
- CNGS
- CERF 2006

CERF 2006

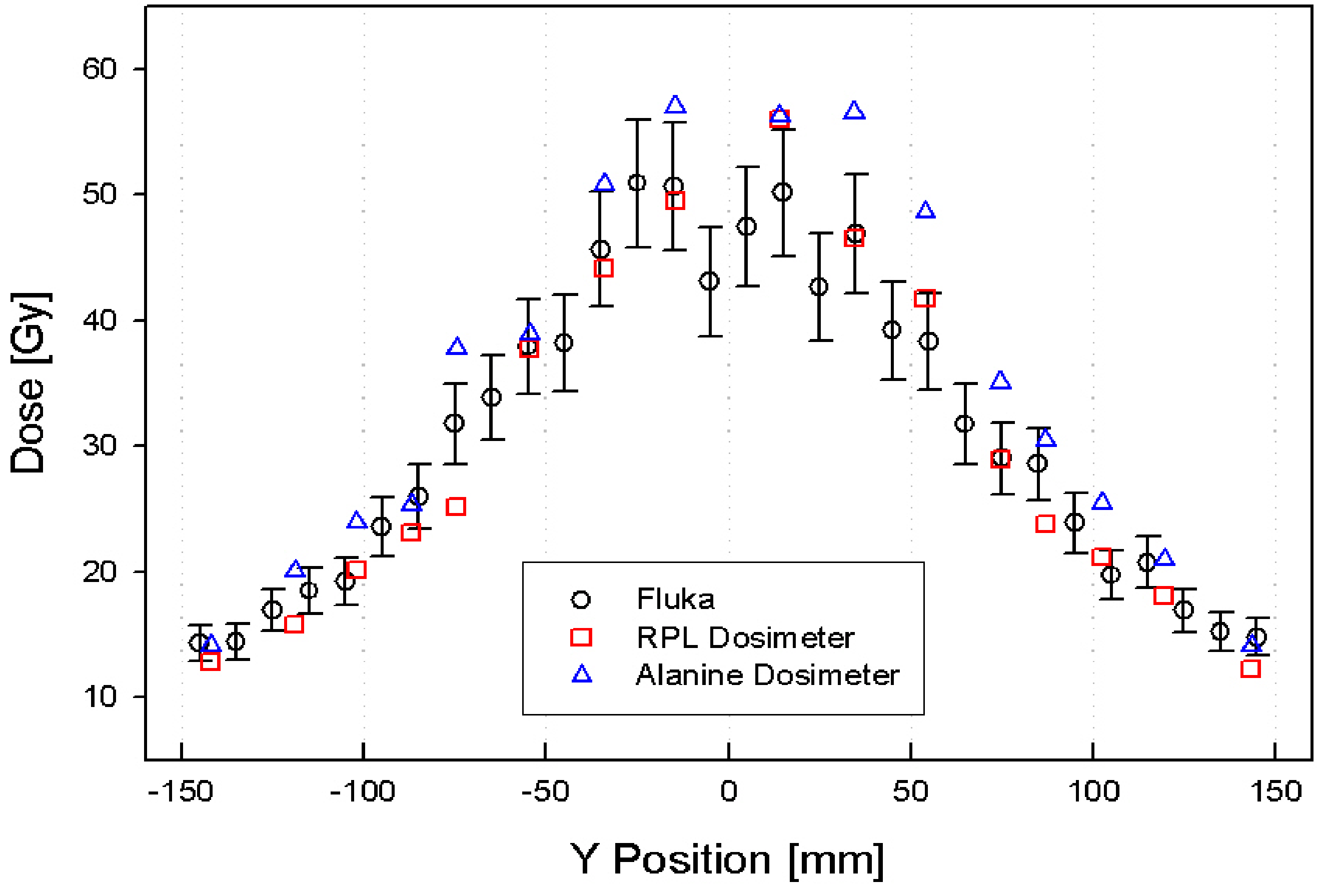


IRRAD 1

24 GeV/*c* proton beam



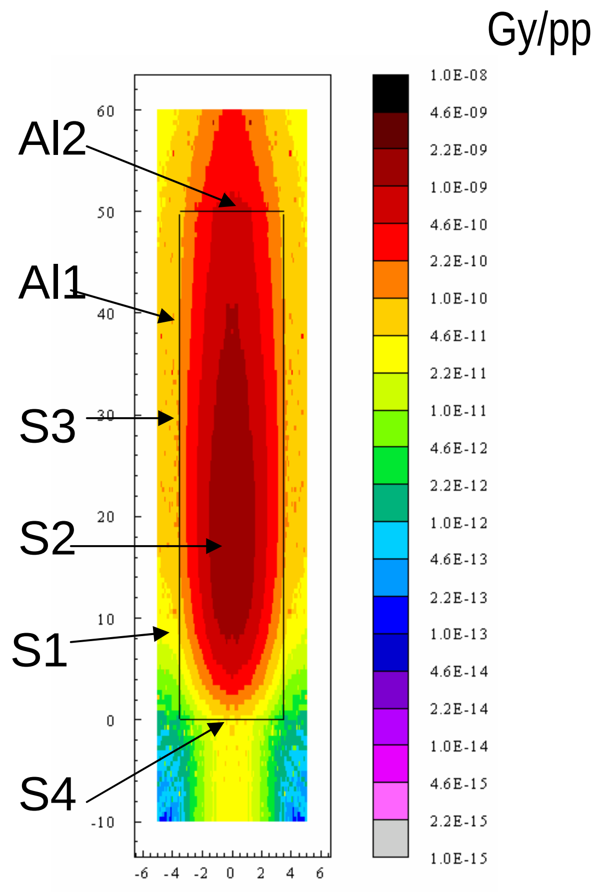
CERF 2004 (preliminary)



CERF 2003

Simulation results give Gy in air

	Simulat -ion	Stat. σ	measured	Measure- ment σ	Sim/ Meas
RPL 1	30.3	4.4	29	1	1.04
RPL 2	168	5	182	6	0.92
RPL 3	169	4	183	6	0.92
RPL 4	75	7	76	2	0.99
Al1	130	10	127	7	1.02
Al2_a	724	15	854	40	0.85
Al2_b	862	17	879	40	0.98
Al2_c	958	21	879	40	1.09
Al2_d	861	17	789	40	1.09

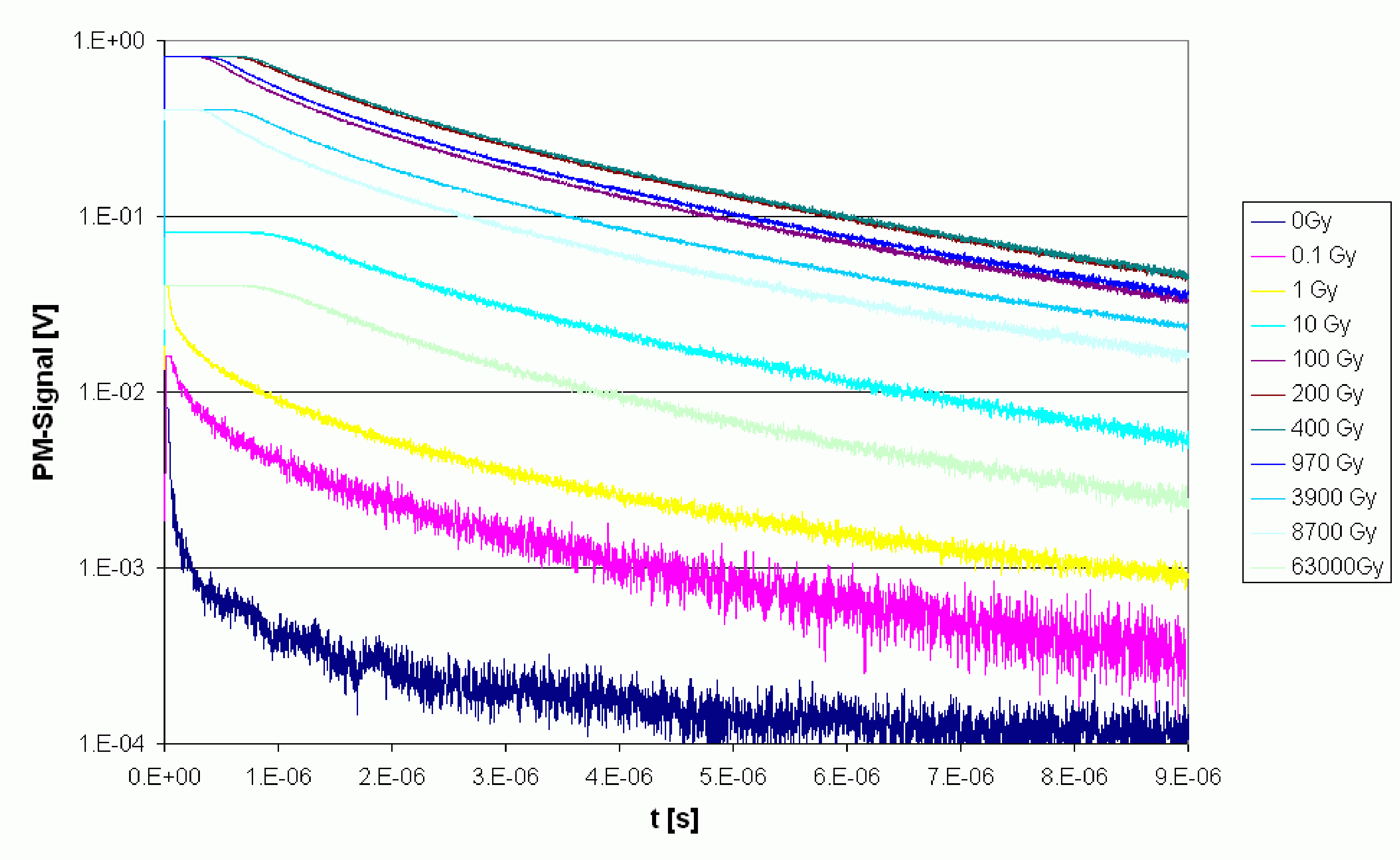


Conclusion

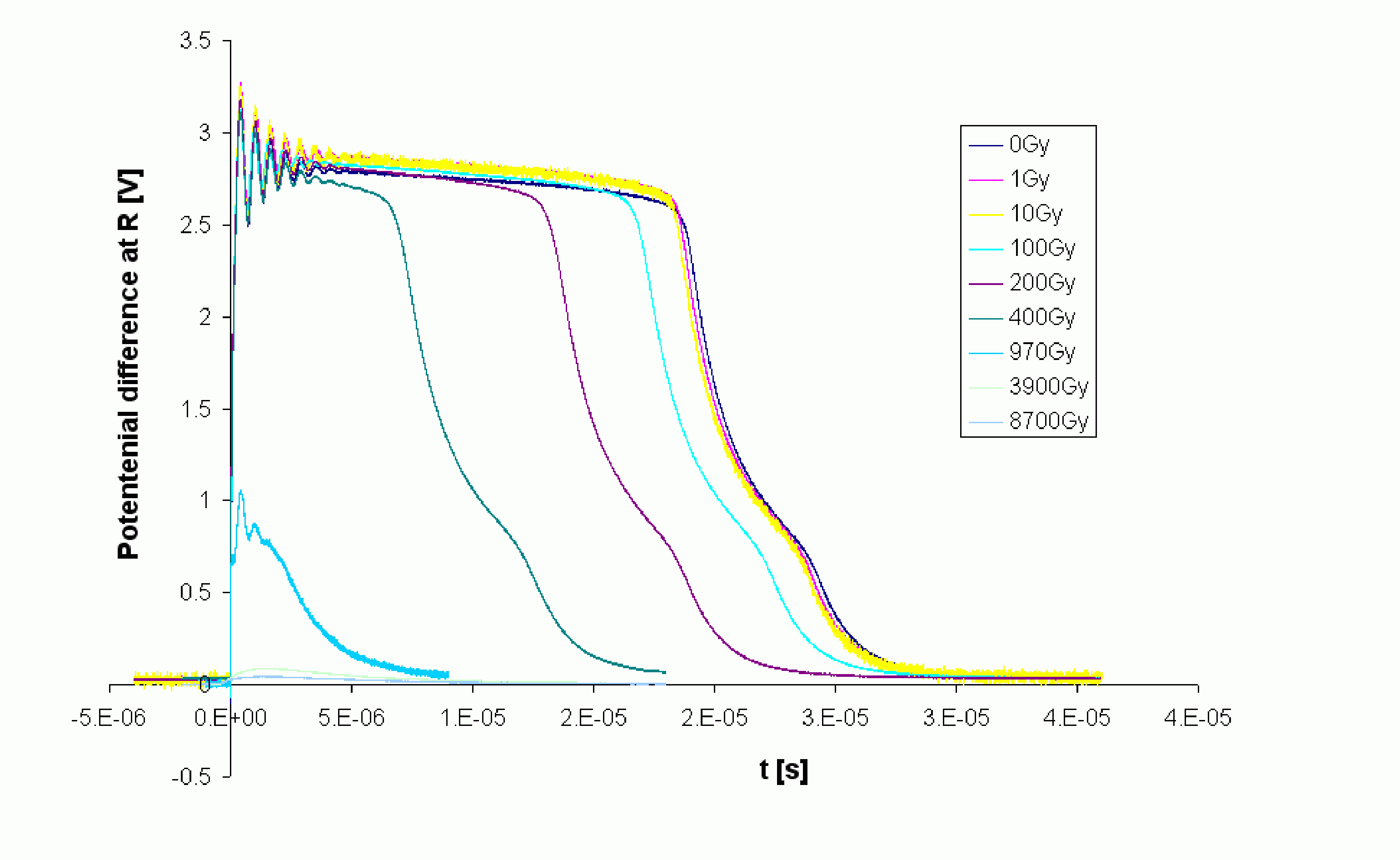
- Various measurement campaigns in mixed high-energy radiation fields were performed in order to improve the knowledge of the HLD systems.
- Simulations were performed allowing a better understanding of the behavior of the HL dosimeters in mixed radiation fields
- Further analysis of the measurements and simulations are under way.
- Results and preliminary results look very promising.
- RPL and Alanine dosimeter are well suited for High Level Dosimetry at CERN .

Thank you very much for you attention…

PM response


1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
PM-Signal [V]
0.E+00
1.E-06
2.E-06
3.E-06
4.E-06
5.E-06
6.E-06
7.E-06
8.E-06
9.E-06
t [s]
0Gy
0.1 Gy
1 Gy
10 Gy
100 Gy
200 Gy
400 Gy
970 Gy
3900 Gy
8700 Gy
63000Gy

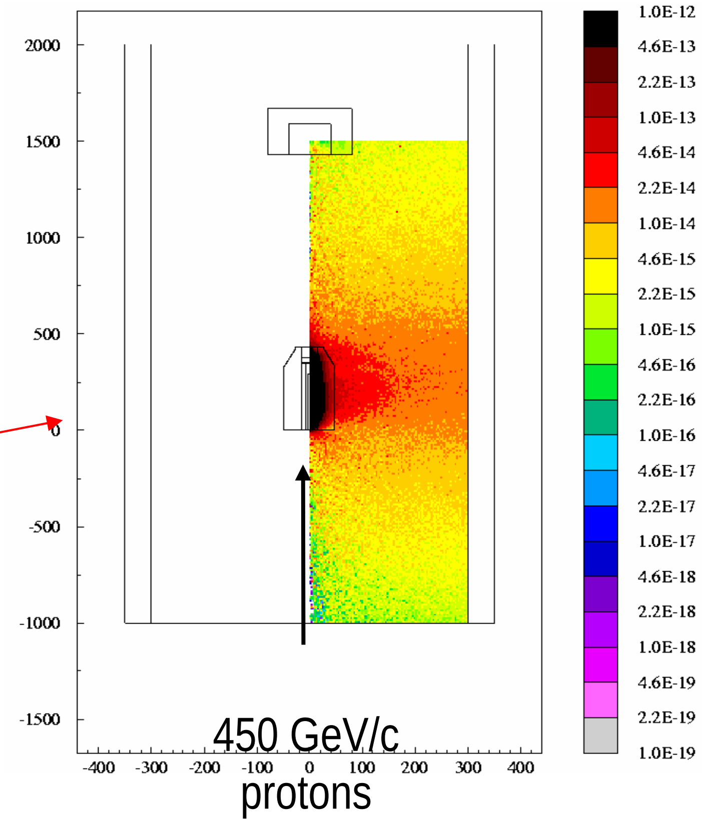
PT response



Potentenial difference at R [V]
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-5.E-06
0.E+00
5.E-06
1.E-05
2.E-05
2.E-05
3.E-05
3.E-05
4.E-05
4.E-05
t [s]
0Gy
1Gy
10Gy
100Gy
200Gy
400Gy
970Gy
3900Gy
8700Gy

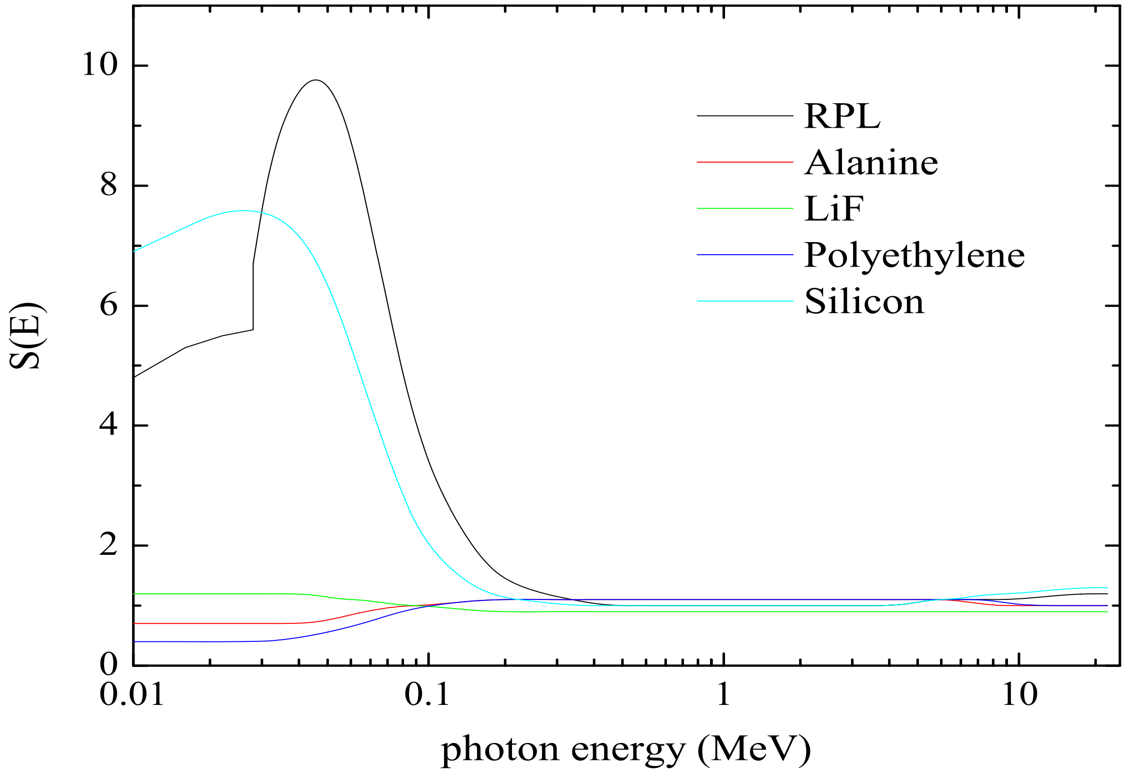
TT40

- More than two hundred dosimeters (RPL and alanine) were installed on various positions on the dump (TED).
- Analysis of the read out results is ongoing.
- Preliminary simulations were performed.
- Accurate simulations will be performed in order to evaluate the various field components at the given detector positions.
- Measurements will be compared with simulations in order to improve the knowledge of the detector response in mixed fields



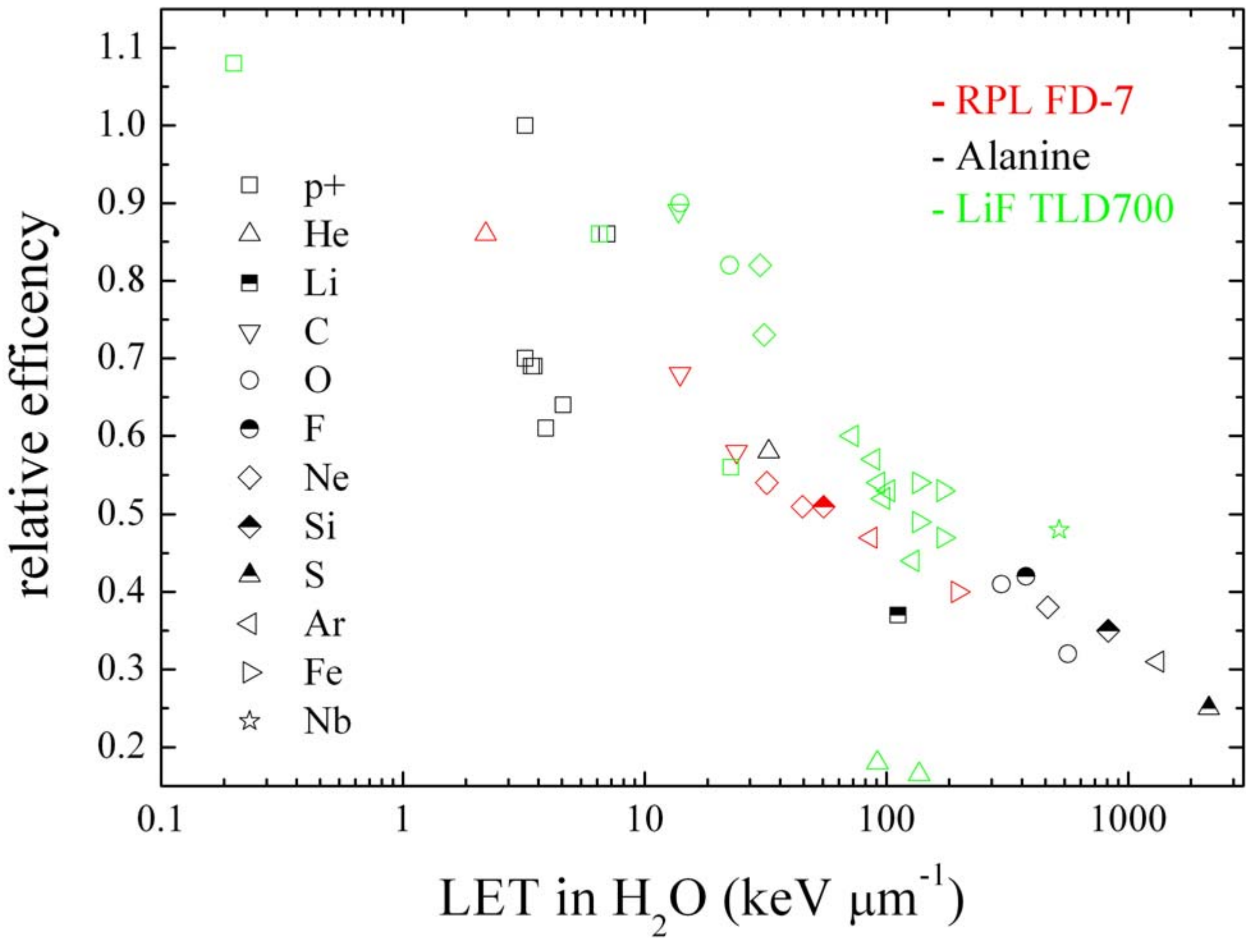
Photon Response

$$S(E) = \frac{\left(\frac{\mu}{\rho}\right)_m}{\left(\frac{\mu}{\rho}\right)_{air}}$$



LET response

$$\varepsilon = \left. \frac{D_\gamma}{D_P} \right|_{R(\gamma)=R(P)}$$



Neutron response