

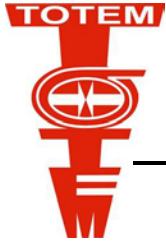


# TOTEM experience with radiation levels in the LHC tunnel during 2010 run

Federico Ravotti (PH/TOT)

ALFA Technical Meeting

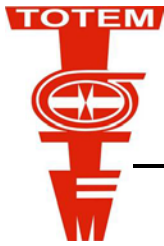
26 January 2011



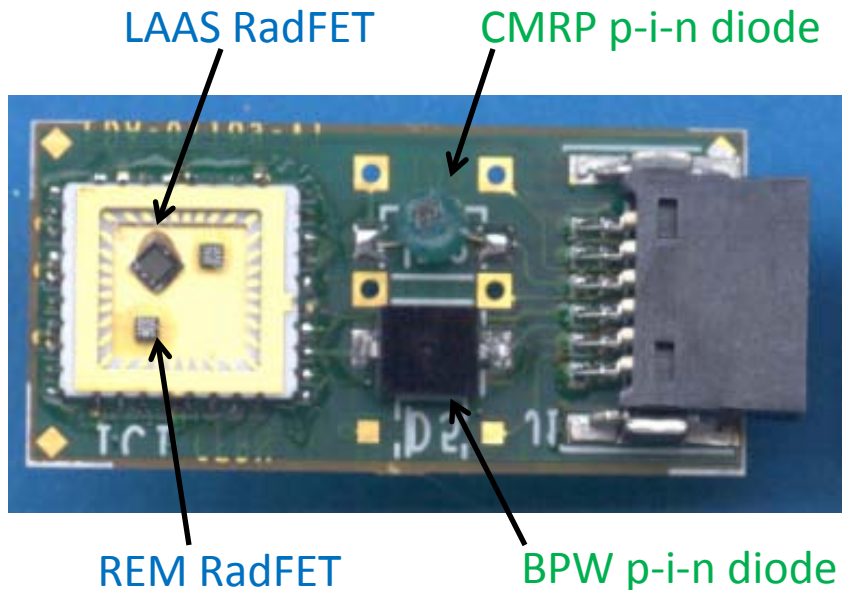
# Contents

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- Radiation Monitors: types/layout in the Tunnel
- TID @ TOTEM Roman Pots
  - Measurements vs. RAMSES/LHC-RADMON/simulations
- NIEL @ TOTEM Roman Pots (vs. simulations)
- Predictions of radiation levels for 2011 run
- Conclusion



# Active Radiation Monitors

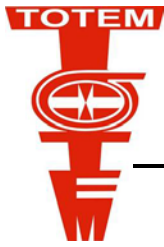


## Integrated Sensor Carrier (ISC)

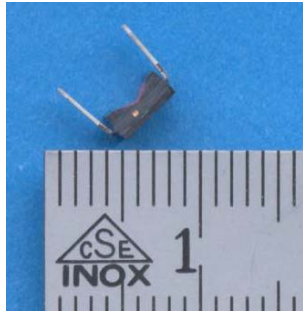
“RadMon for LHC Experiments”

Ravotti, Glaser, Moll, “Sensor Catalogue—Data compilation of solid-state sensors for radiation monitoring”, CERN TS-Note-2005-002.

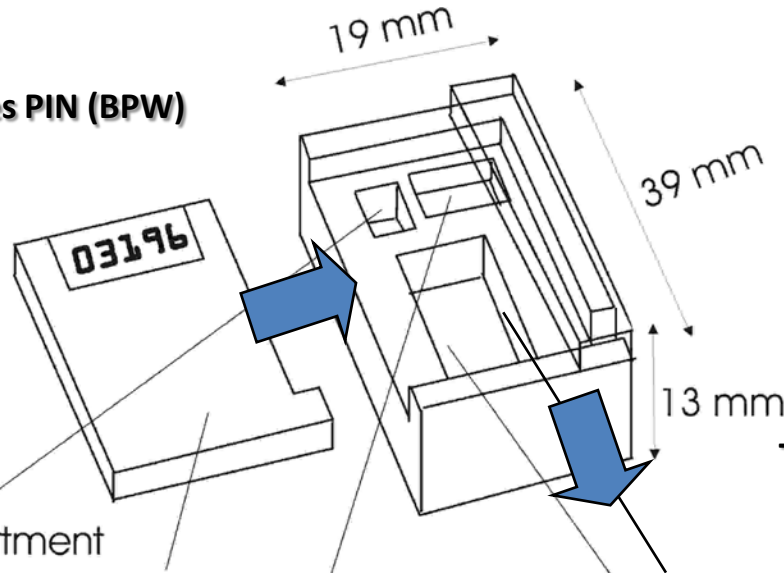
- Survey of cumulative radiation damage
- RadFETs: Ionizing Dose – IEL (Gy)
  - $\gamma / e / ch. had. / \underline{NO} \underline{n}$
  - LAAS (high sensitivity)
  - REM (broad dynamic range)
- p-i-n diodes: NIEL ( $n_{[1\text{MeV eq.}]}/\text{cm}^2$ )
  - $\underline{n} / ch. had. / e / \underline{NO} \gamma$
  - CMRP (high sensitivity)
  - BPW (broad dynamic range)
- Readout over 6-wires (including NTC)



# Passive Radiation Monitors



**Diodes PIN (BPW)**

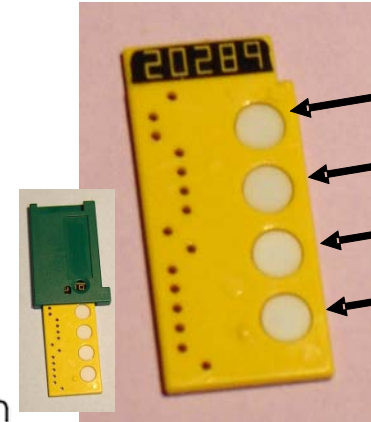
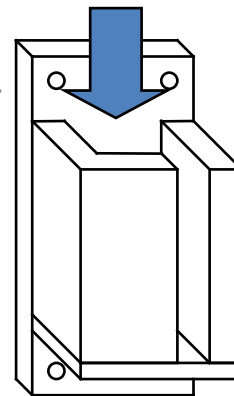


p-i-n  
compartment

ALNOR  
TLD holder

alanine compartment

RPL compartment



MTS-N  $^{na}LiF:Mg,Ti$

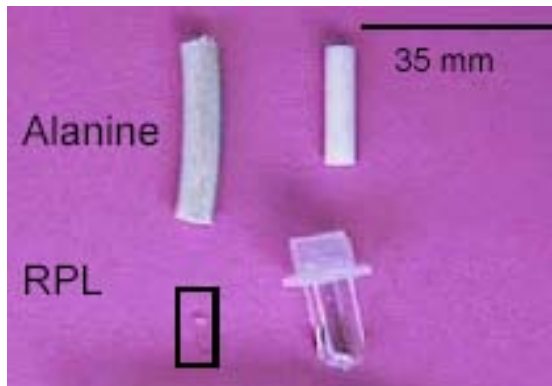
MTS-7  $^7LiF:Mg,Ti$

MCP-7  $^7LiF:Mg,Cu,P$

MCP-7  $^7LiF:Mg,Cu,P$

**Thermo-Luminescent Dosimeters (TLDs)**

**Polymer Alanine  
Dosimeters (PADs)**



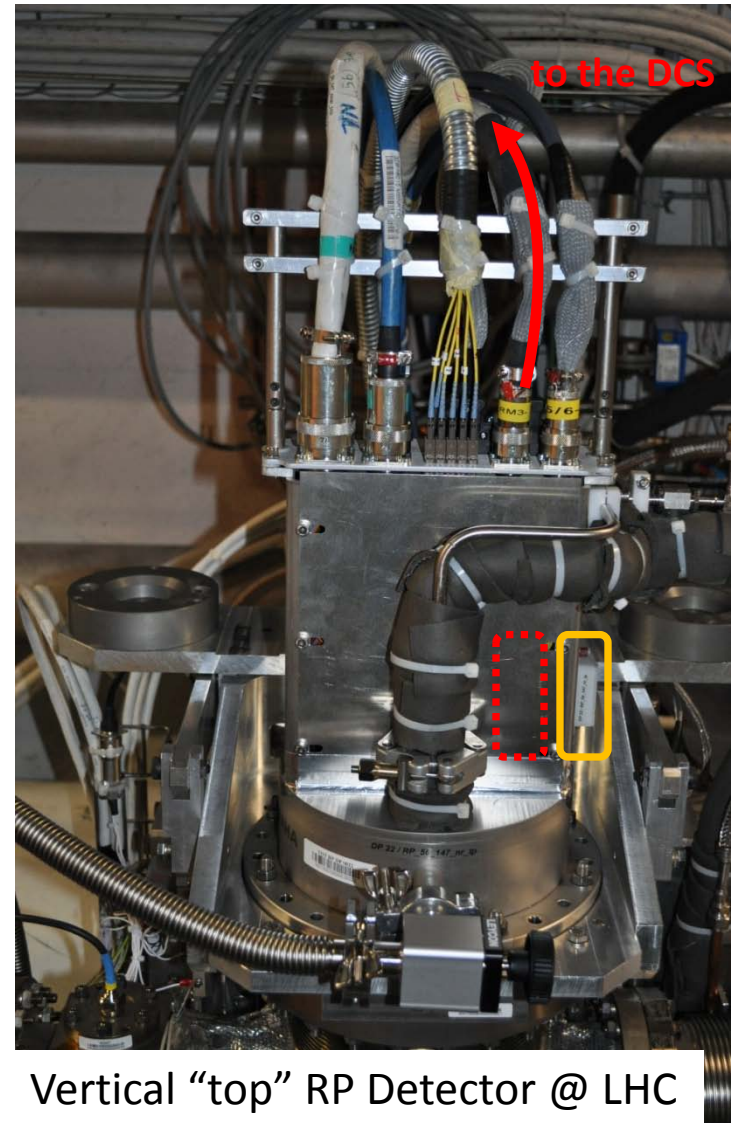
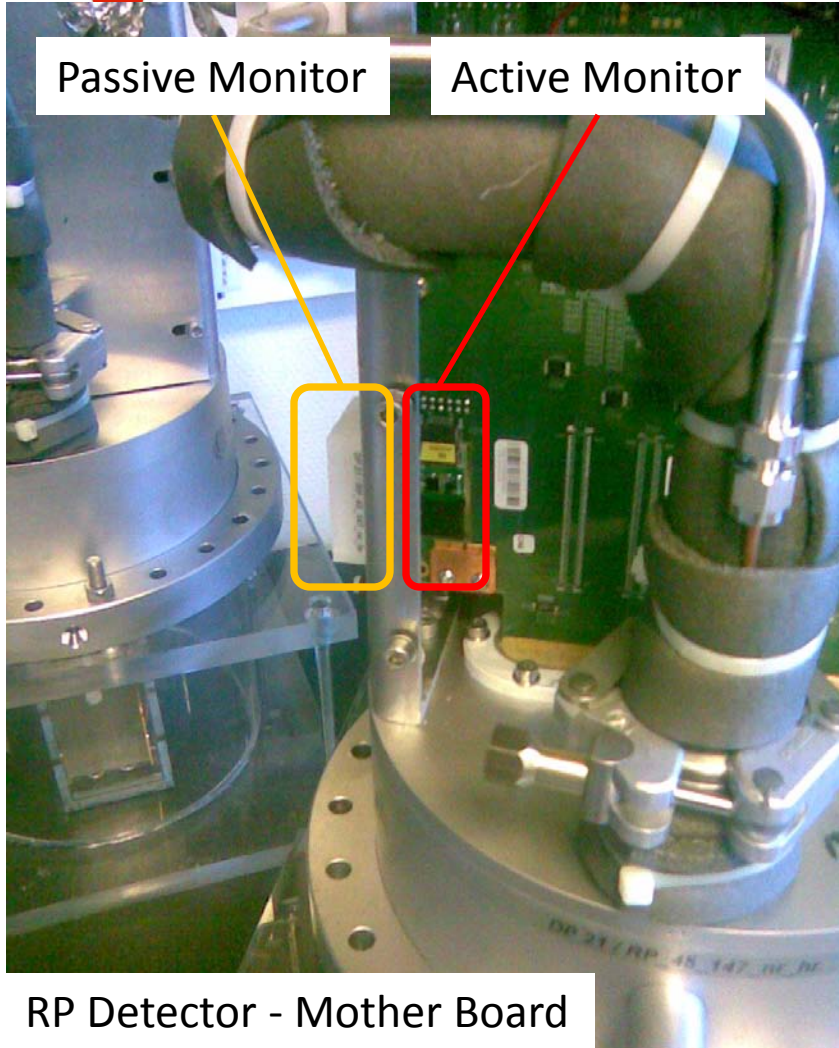
**Radio-Photo  
Luminescent  
(RPL) dosimeters**







# Roman Pot Stations 220m





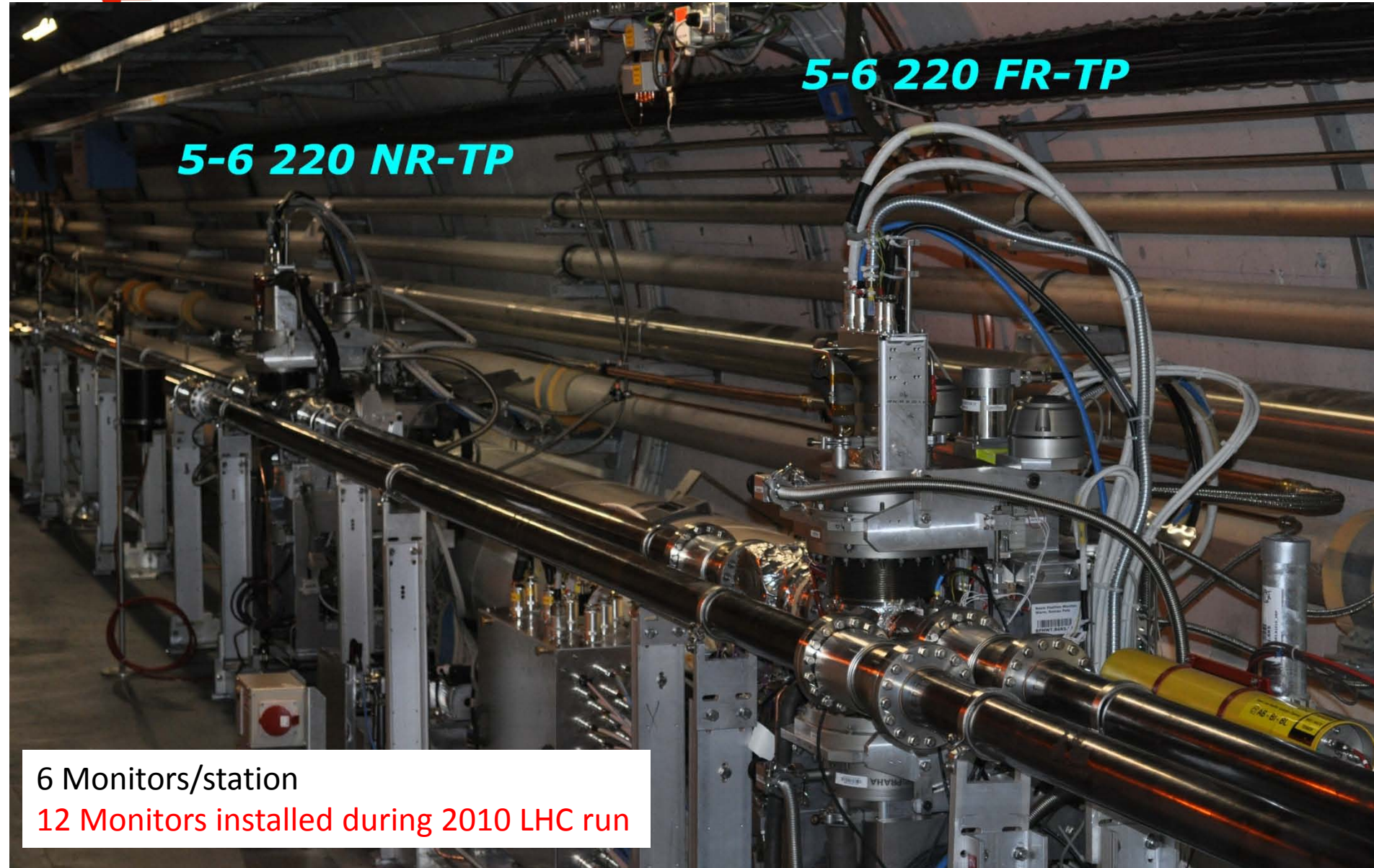


# Roman Pot Stations 220m

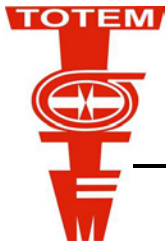
**5-6 220 NR-TP**

**5-6 220 FR-TP**

6 Monitors/station  
12 Monitors installed during 2010 LHC run





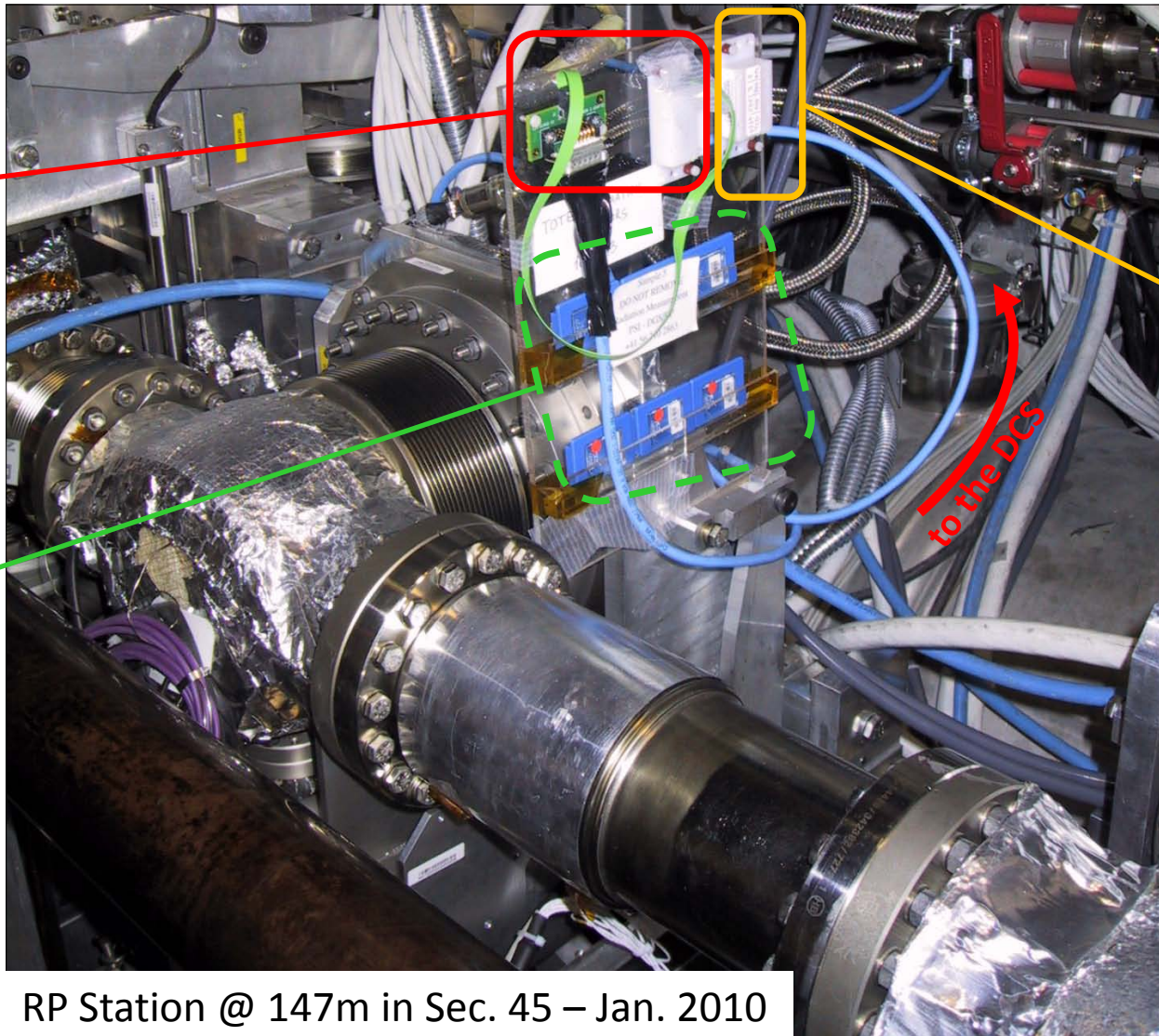


# Roman Pot Station 147m

Active  
Radiation  
Monitor  
(1 unit)

CR-39  
neutron  
dosimeters  
from  
DGS/RP  
(6 units)

Passive  
Radiation  
Monitor  
(1 unit)



RP Station @ 147m in Sec. 45 – Jan. 2010

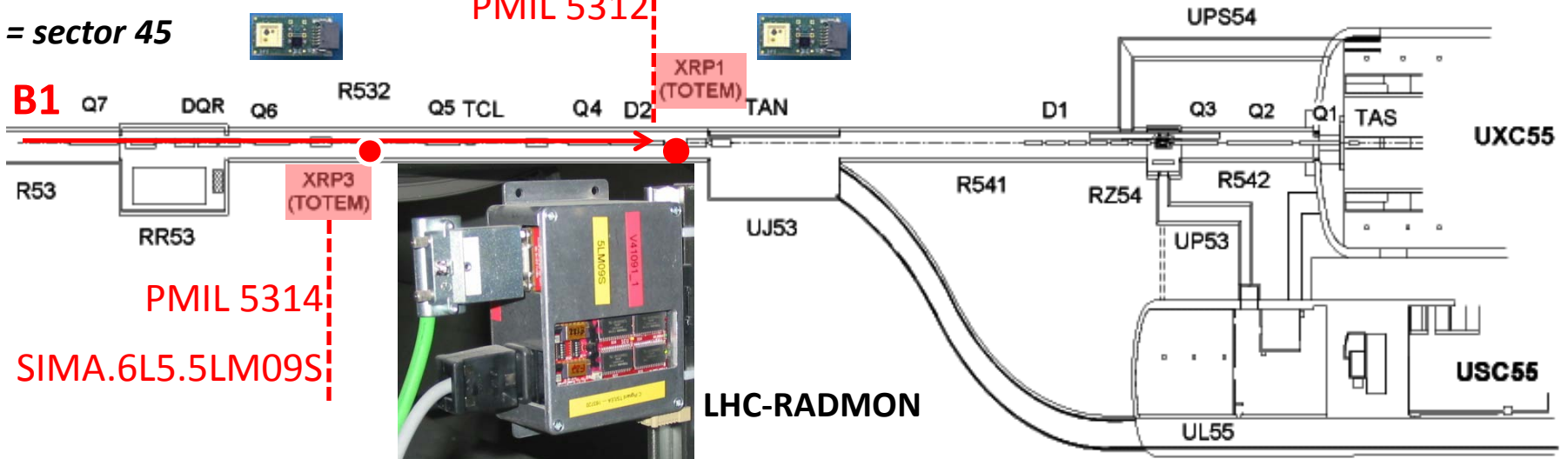


# Radiation Monitors Layout

L = sector 45

PMIL 5312i

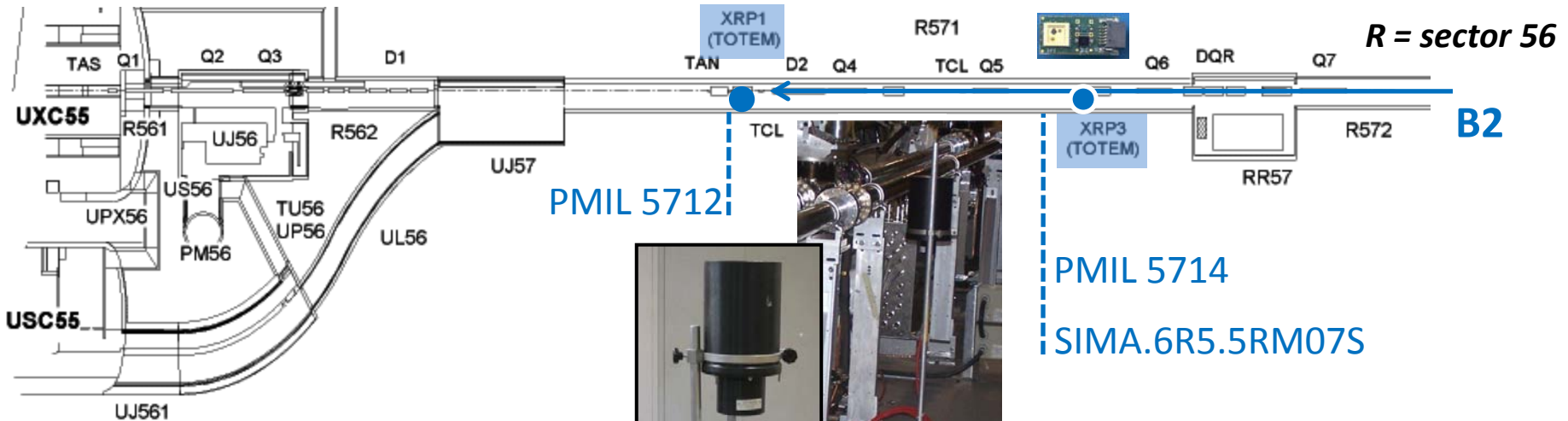
B1



PMIL 5314

SIMA.6L5.5LM09S

LHC-RADMON



R = sector 56

PMIL 5712i

PMIL 5714

SIMA.6R5.5RM07S

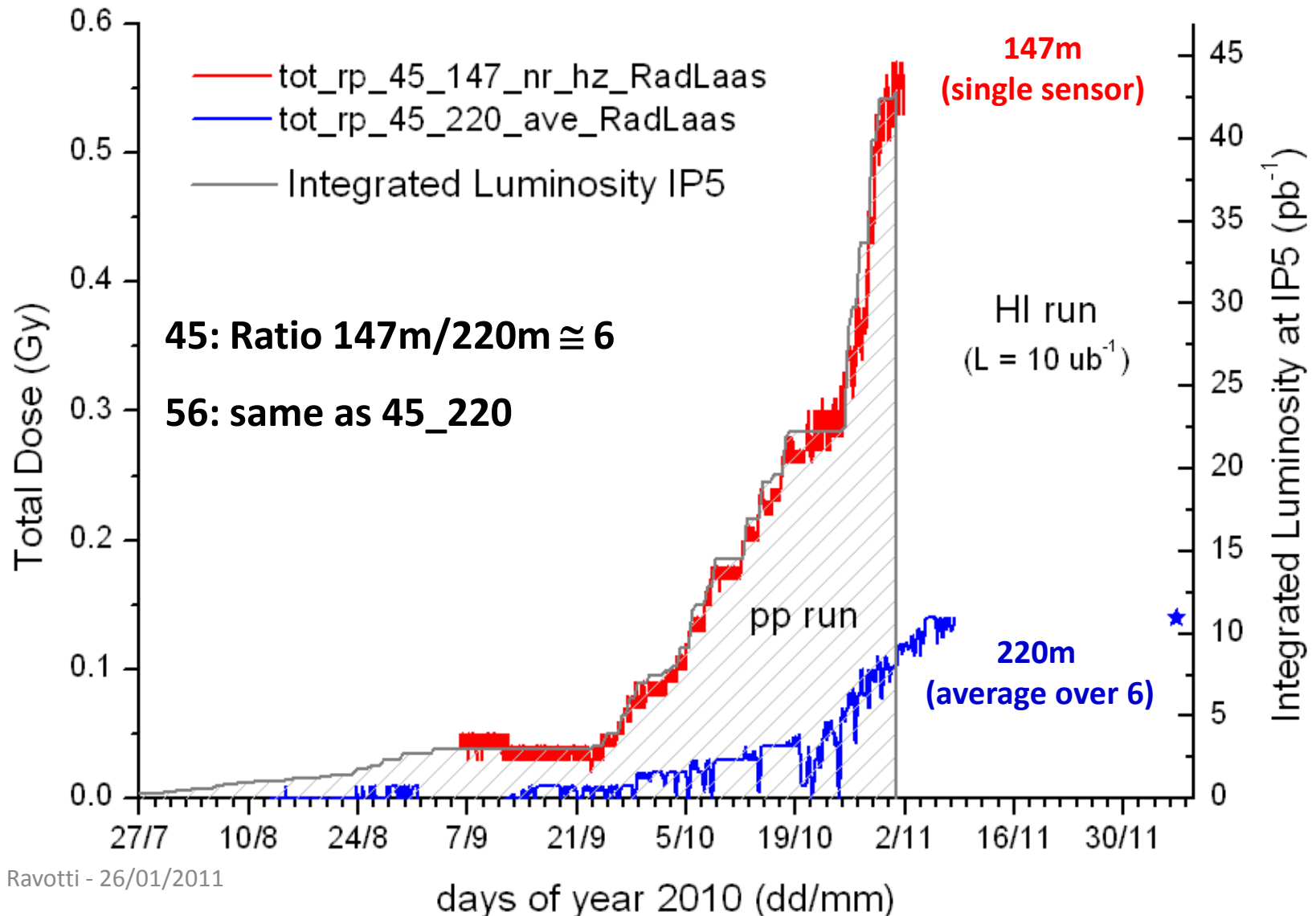
RAMSES

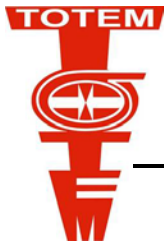




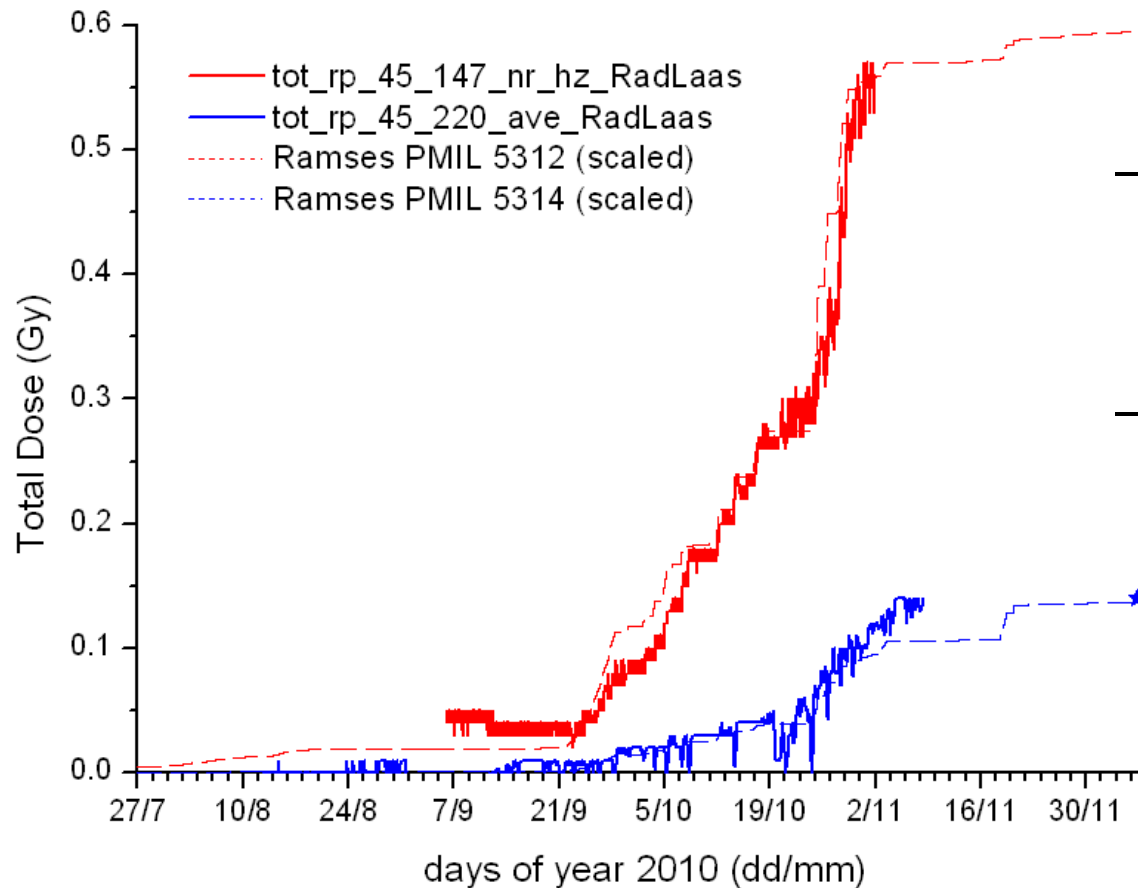
# RP Total Ionizing Dose

Data from *sensitive RadFETs (LAAS)*, maximum  $\Delta V \sim 250$  mV

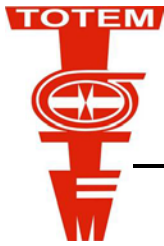




# RadFETs vs. RAMSES

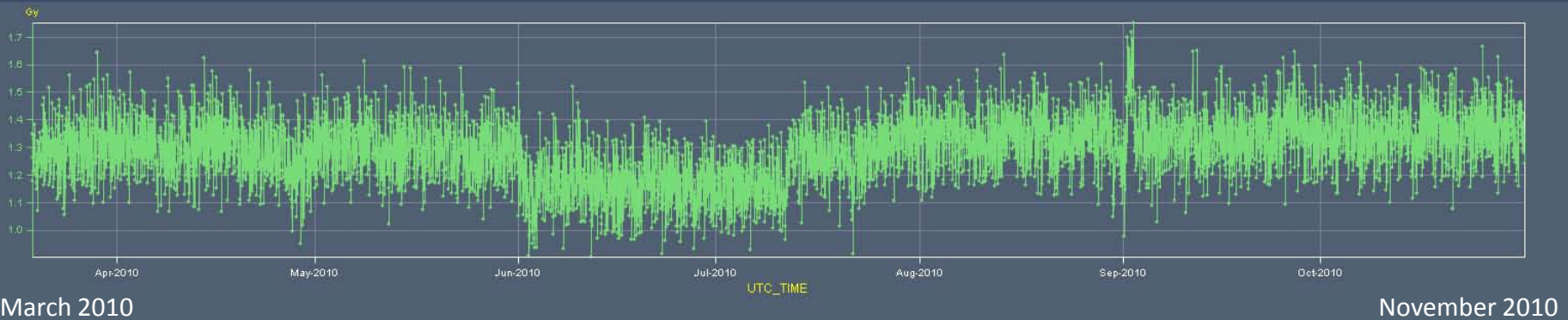


- Low intensity beams  
→ comparison it is possible
- PMIL data scaled with  $F = 1.8$   
→ Ratio 147m/220m confirmed
- Agreement within  $F = 2$  is a good results taking into account:
  - different position ( $r$ )
  - different calibration cond. (Kerma vs. absorbed dose)
  - different energy response
  - ...



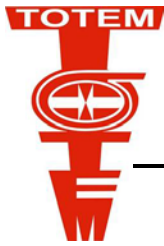
# RadFET vs. LHC-RADMON

SIMA.6L5.5LM09S – Sensitive RadFET (data from Timber)



- Based on same technology of sensors / different types
- Measurements do not scale with Luminosity
- Sensors located downstream with respect to the 220m RP stations
  - relocation in order to have better comparison during 2011 run (under discussion)

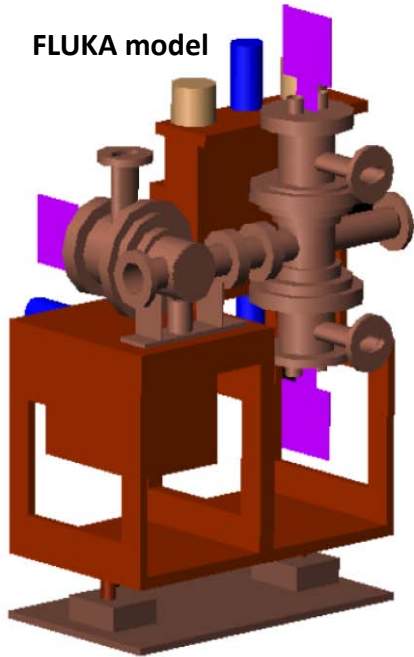




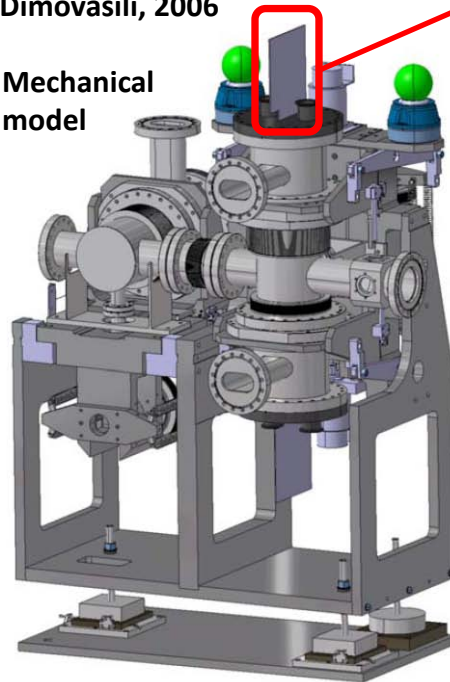
# RadFET vs. simulations

Dose Calculations for TOTEM  
Roman Pots, E. Dimovasili, 2006

FLUKA model

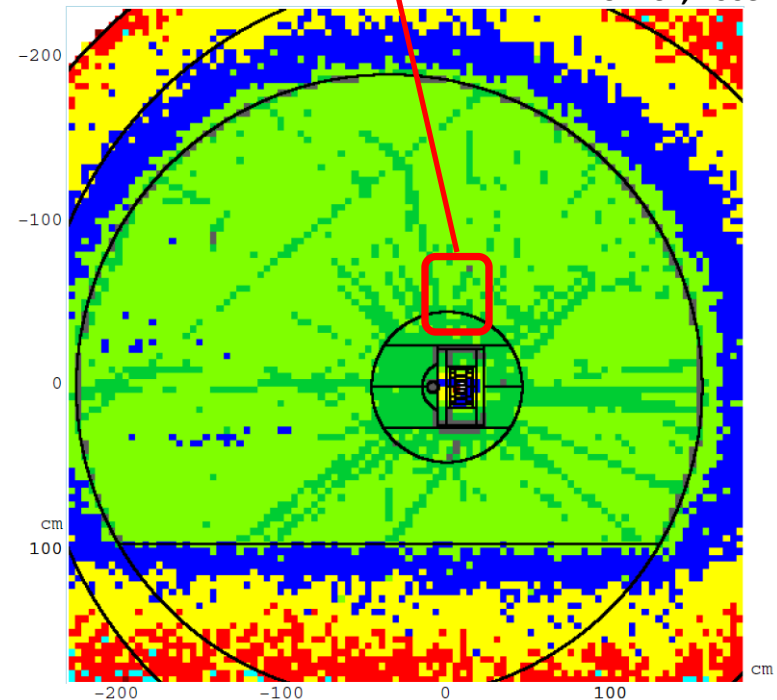


Mechanical model



RP MotherBoard (RPMB) region

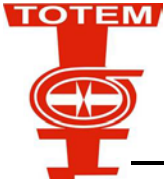
Simulations for XRP1  
LHC-ProjRep-633,  
N. Mokhov, 2003



8.5e+05  
10<sup>5</sup> 10<sup>4</sup> 10<sup>3</sup> 10<sup>2</sup> 10<sup>1</sup> 10<sup>0</sup> 10<sup>-1</sup> 10<sup>-2</sup> 10<sup>-3</sup> 0.0e+00

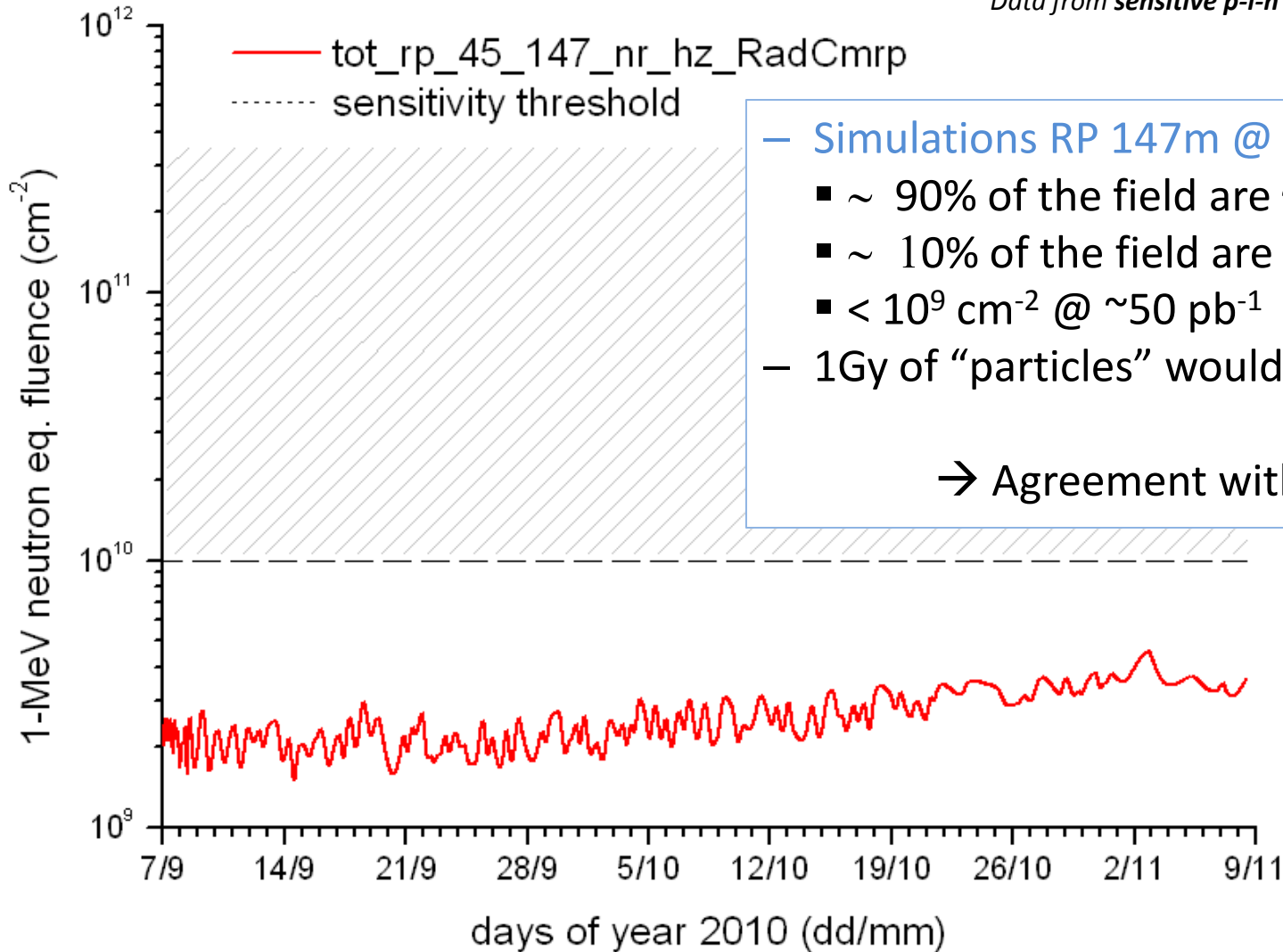
Accumulated Dose (Gy/yr) at 10<sup>34</sup> cm<sup>-2</sup> s<sup>-1</sup>

- RP 147m @ RPMB:  
10<sup>4</sup> Gy @ nominal  $L \rightarrow \sim 1$  Gy @  $\sim 50$  pb<sup>-1</sup>
- RP 220m @ RPMB:  
10<sup>3</sup> Gy @ nominal  $L \rightarrow \sim 0.1$  Gy @  $\sim 50$  pb<sup>-1</sup>

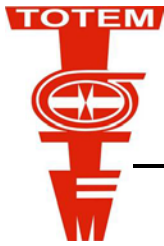


# RP NIEL vs. simulations

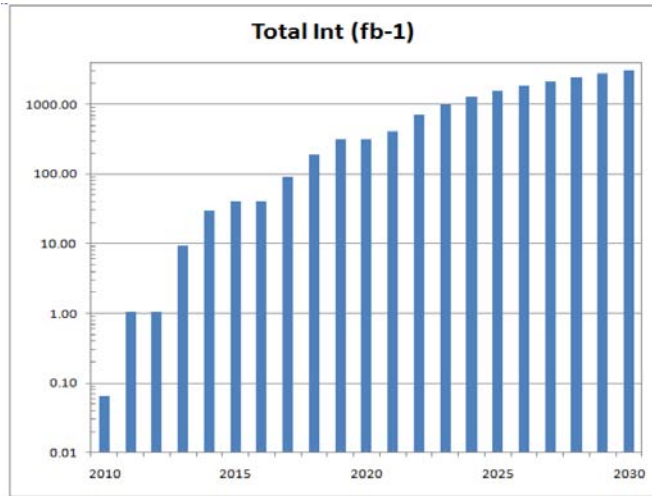
Data from *sensitive p-i-n diode (CMRP)*,  $\Delta V$  a few mV



- Simulations RP 147m @ RPMB:
    - ~ 90% of the field are  $\gamma$
    - ~ 10% of the field are  $\underline{n} / e / ch. had.$
    - $< 10^9 \text{ cm}^{-2}$  @  $\sim 50 \text{ pb}^{-1}$
  - 1Gy of “particles” would means  $\sim 10^{10} \text{ cm}^{-2}$
- Agreement with CMRP data



# Scenario for 2011 run



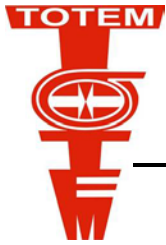
“Reasonable” numbers for the 2011 run of LHC (M. Lamont – Dec. 2010):

**200 days of proton physics → 2.2 fb<sup>-1</sup>**

S. Myers  
(ICHEP 2010)

	~ 50 pb <sup>-1</sup> (measurement 2010)		2200 pb <sup>-1</sup> (prediction 2011)	
	TID	NIEL (1MeV-n <sub>eq</sub> )	TID	NIEL (1MeV-n <sub>eq</sub> )
RP stations 220m	0.1 Gy	< threshold	~ 5 Gy	< 1x10 <sup>10</sup> cm <sup>-2</sup> (*)
RP stations 147m	0.6 Gy	< threshold	~ 30 Gy	~ 1x10 <sup>10</sup> cm <sup>-2</sup> (*)
plus side	45 Gy	9x10 <sup>10</sup> cm <sup>-2</sup>	~ 2k Gy	~ 4x10 <sup>12</sup> cm <sup>-2</sup>
T2 minus side		7x10 <sup>11</sup> cm <sup>-2</sup>		~ 3x10 <sup>13</sup> cm <sup>-2</sup>





# Conclusions

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- Radiation measurements @ TOTEM RPs:
  - good agreement with other data/simulations (level & composition)
  - enabled prediction of the radiation levels for 2011 run
  - waiting for data from passive dosimeter samples
- Radiation Levels @ TOTEM RPs were “low” in 2010 and so they will remain for 2011 run
- Need to assess the radiation damage of Si detectors:
  - scaling based on these measurements ? (probably not)
  - monitoring the increase of detector leakage currents  
(did not show variations so far)