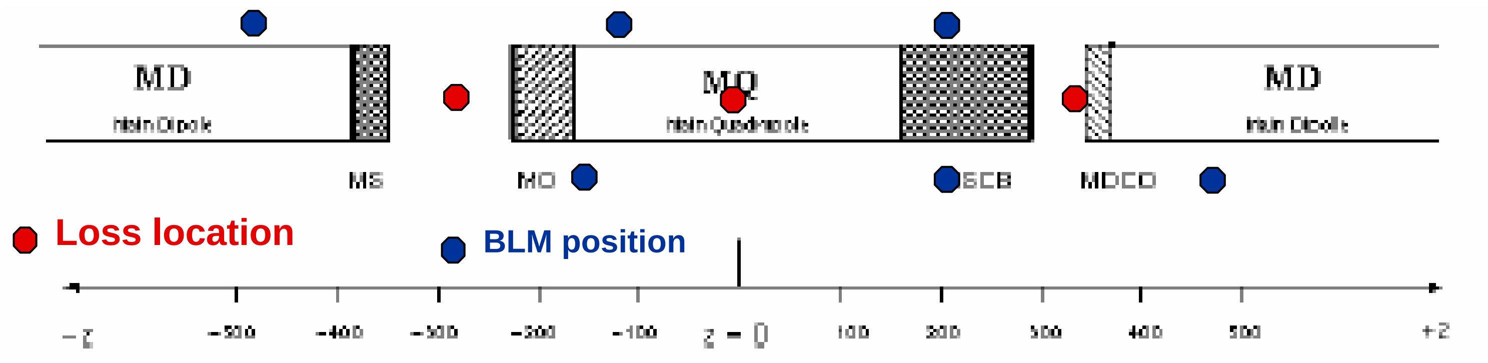
Beam Loss Monitors

B. Dehning

BLM Locations in the Arcs

- **3 loss locations simulated: shower development in the cryostat, GEANT 3 & 4.**
- **The positions of the BLMs are chosen to:**
  - minimize crosstalk
  - reduce difference between inside and outside loss



Location of Loss Detectors at IP8

left

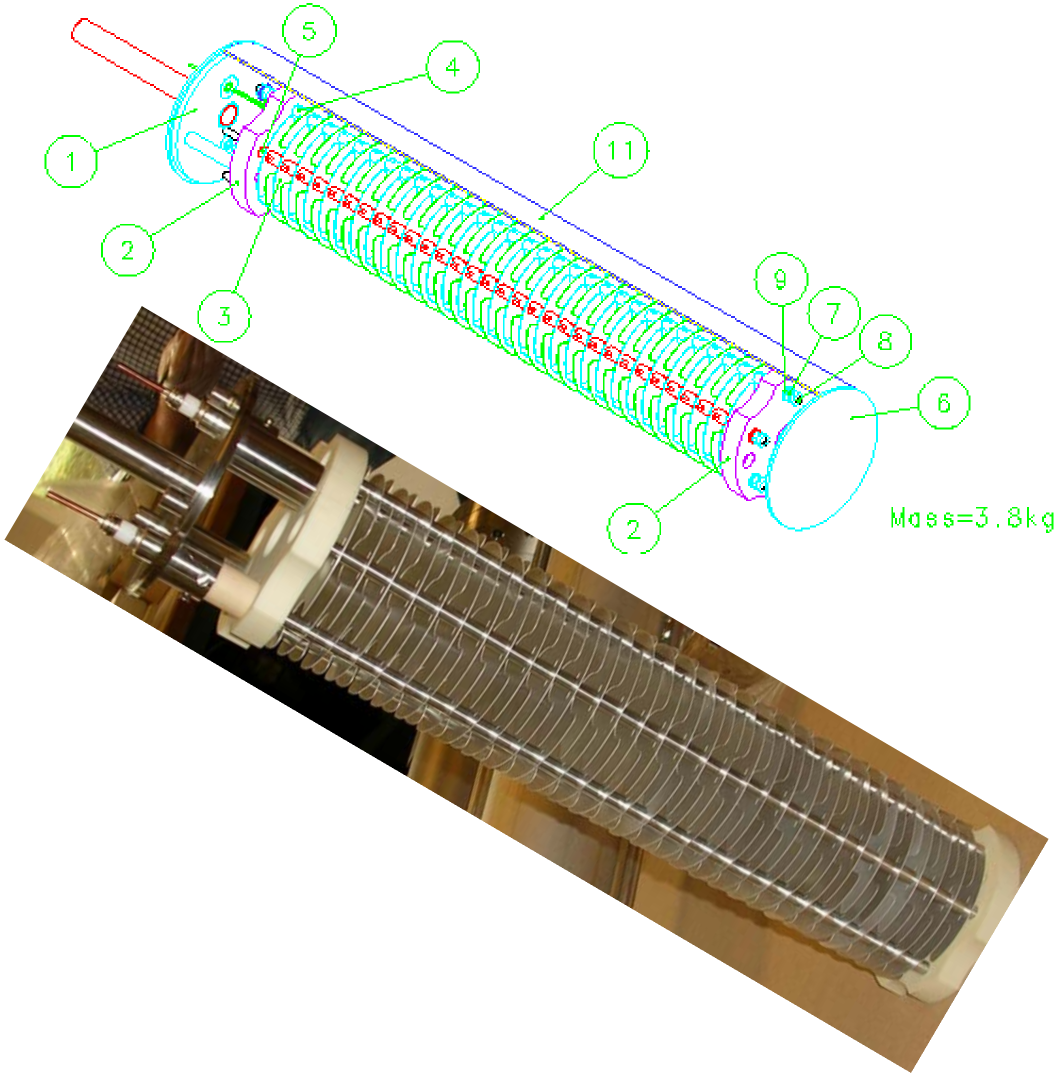
N.	Location	IC	SEM
1	BPMSW.1L8	1	1
2	MQXA.1L8	6	
3	MQXB.A2L8	6	
4	MQXA.3L8	6	
5	TCTV.4L8.B1	1	1
6	TCLIA.4L8.B2	1	1
7	TCTH.4L8.B1	1	1
8	MBRC.4L8	1	1
9	MQY.A4L8	6	
10	MQM.A5L8	6	
11	TCLIB.6L8.B2	1	1
12	MQML.6L8	6	
13	MQM.A7L8	6	
14	MBA.8L8	6	
	MBA.8L8		6
15	MQML.8L8	6	
16	MQM.9L8	6	
17	MQML.10L8	6	
18	MBA.11L8	6	
	MBA.11L8		6
19	MQ.11L8	6	
20	MQ.12L8	6	
21	MQ.13L8	6	
22	MQ.14L8	6	
23	MQ.15L8	6	
24	MQ.16L8	6	

right

N.	Location	IC	SEM
1	BPMSW.1R8	1	1
2	MQXA.1R8	6	
3	MQXB.A2R8	6	
4	MQXA.3R8	6	
5	TCDD.4R8	3	3
6	TCTV.4R8.B2	1	1
7	TDI.4R8	3	3
8	TCTH.4R8.B2	1	1
9	MBRC.4R8	1	1
10	MQY.A4R8	6	
11	MQY.A5R8	6	
12	MSIA.A6R8	3	3
13	MSIB.A6R8.	3	3
14	MQM.6R8	6	
15	MQM.A7R8	6	
16	MBA.8R8	6	
	MBA.8R8		6
17	MQML.8R8	6	
18	MQM.9R8	6	
19	MQML.10R8	6	
20	MBA.11R8	6	
	MBA.11R8		6
21	MQ.11R8	6	
22	MQ.12R8	6	
23	MQ.13R8	6	
24	MQ.14R8	6	
25	MQ.15R8	6	
26	MQ.16R8	6	

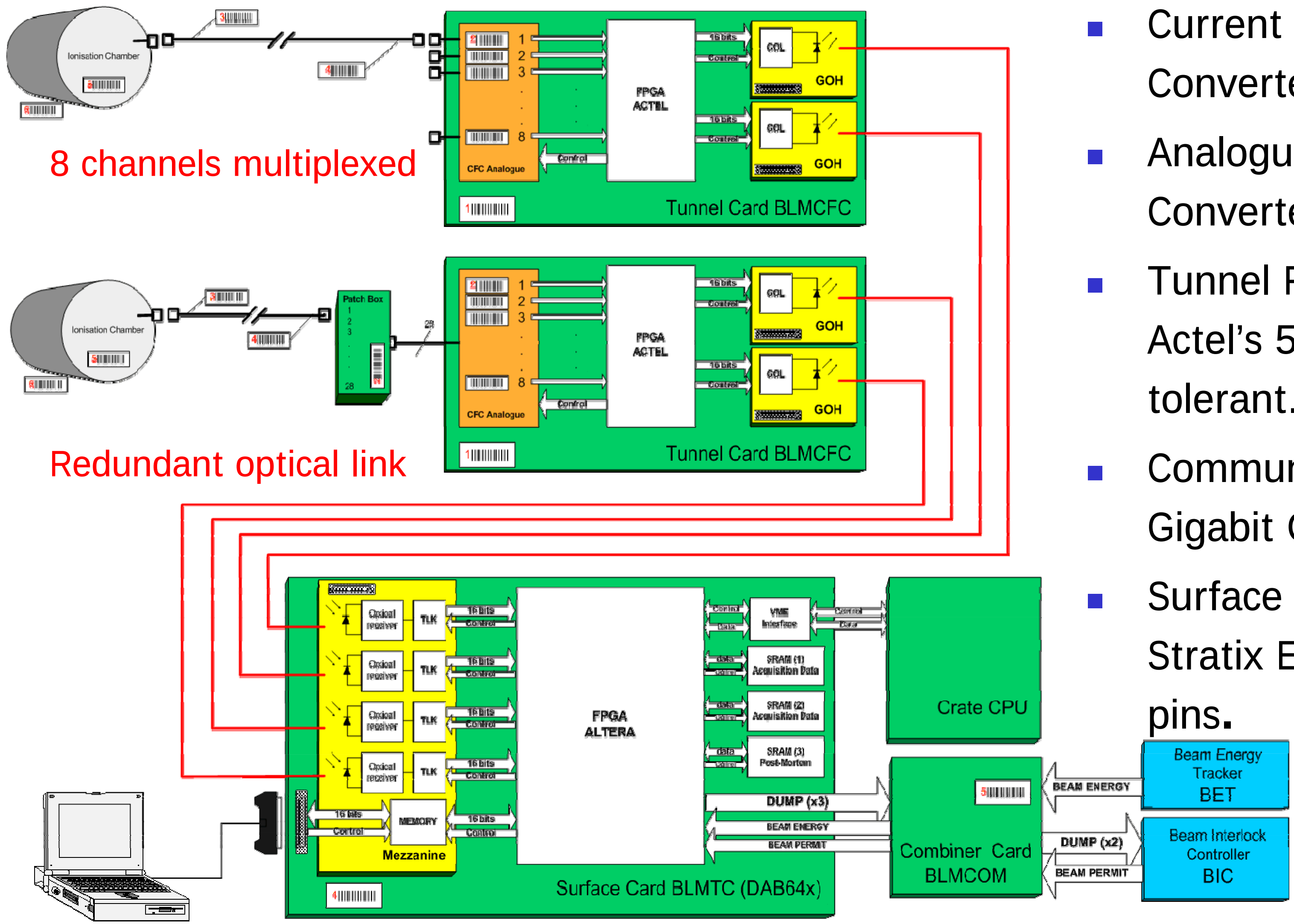
- At every element several detectors mounted on:
  - cryostat
  - support
- Detectors:
  - Ionisation chambers
  - Secondary emission

Ionisation chamber LHC



- Stainless steal cylinder
- Parallel electrodes separated by 0.5 cm
- Al electrodes
- Low pass filter at the HV input
- N_2 gas filling at 100 mbar over pressure
- Diameter 8.9 cm
- Length 60 cm
- Sensitive volume 1.5 l
- Voltage 1.5 kV
- Ion collection time 85 us

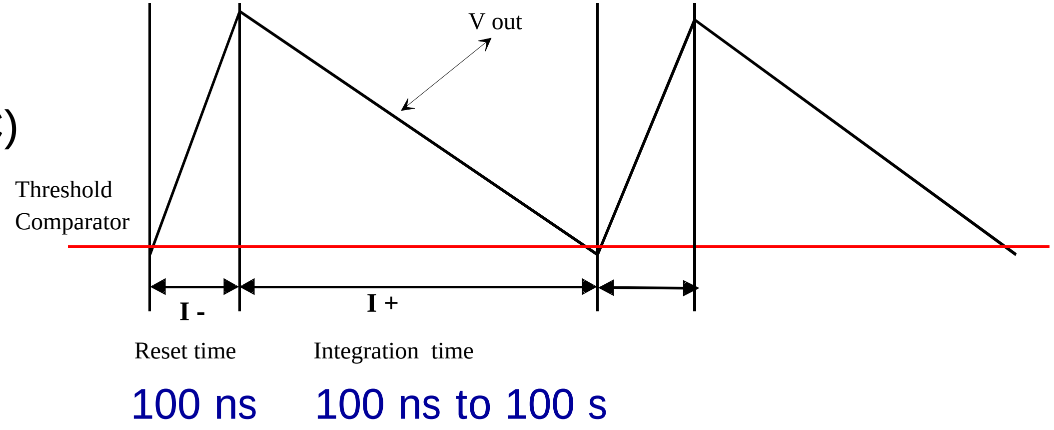
LHC acquisition board

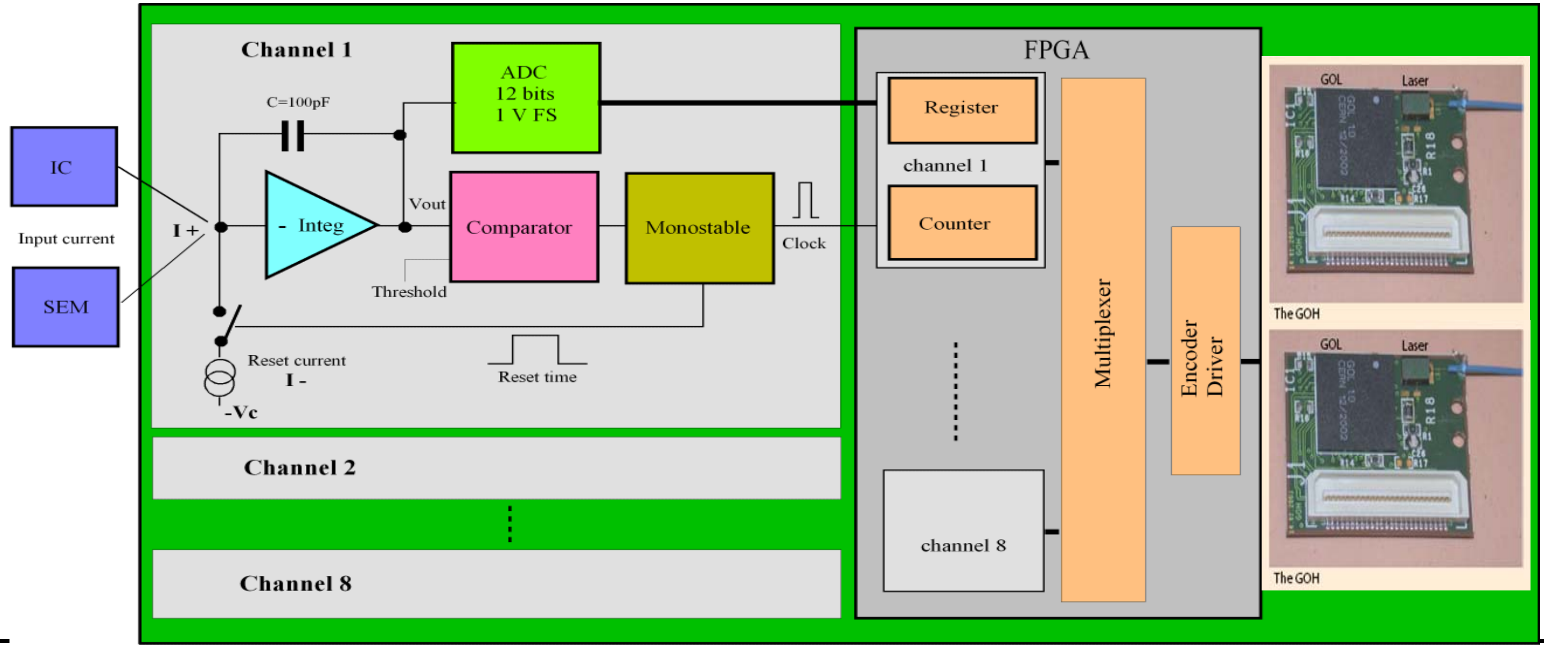


- Current to Frequency Converters (CFCs)
- Analogue to Digital Converters (ADCs)
- Tunnel FPGAs: Actel's 54SX/A radiation tolerant.
- Communication links: Gigabit Optical Links.
- Surface FPGAs: Altera's Stratix EP1S40 with 780 pins.

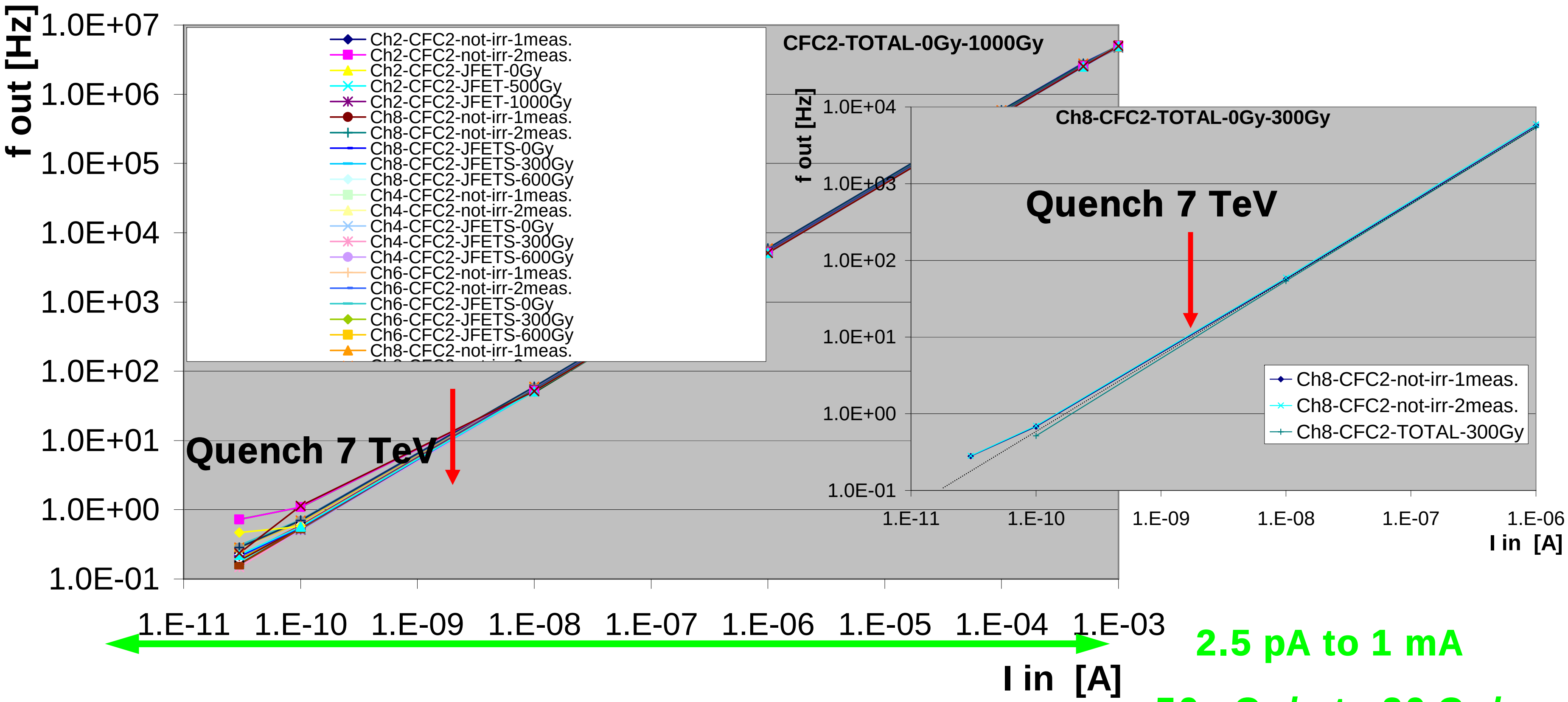
LHC tunnel card

- Not very complicated design: "simple"
- Large Dynamic Range (8 orders)
  - Current-to-Frequency Converter (CFC)
  - Analogue-to-Digital Converter
- Radiation tolerant (500 Gy, 1 10^{12} p/cm^{2})
  - Bipolar
  - Customs ASICs
  - Triple module redundancy





Current to Frequency Converter and Radiation



2.5 pA to 1 mA

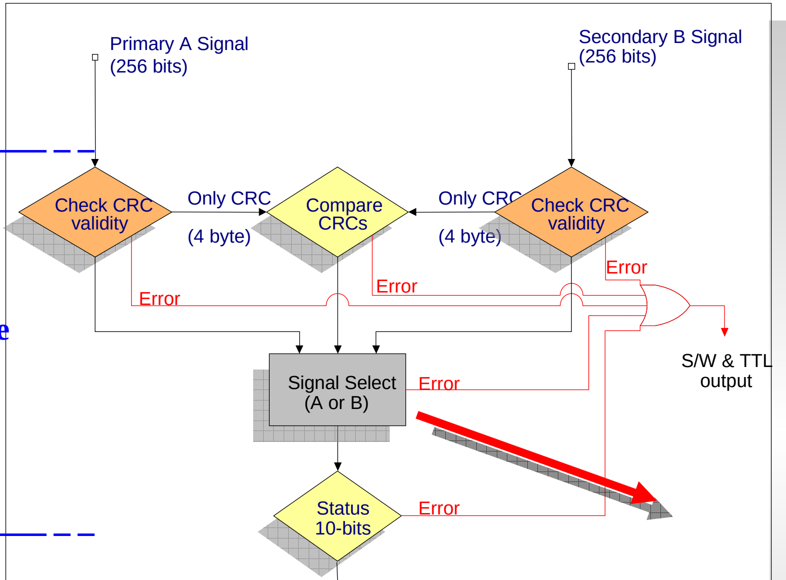
50 nGy/s to 20 Gy/s

- Variation at the very low end of the dynamic range
- Insignificant variations at quench levels
- Radiation caused offset by DAC induced current compensation

LHC transmission check

Reception

Tx Check & Signal Choice

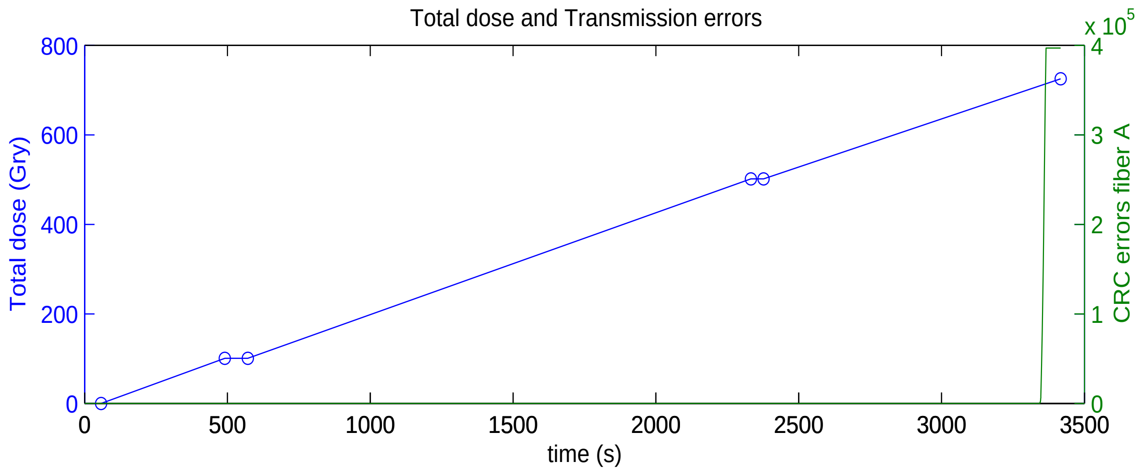


Signal Select Table				
CRC32 check		Comparison of 4Byte CRCs	Output	Remarks
A	B			
Error	**Error**	**Error**	Dump	**Both signals have error**
Error	**Error**	OK	Dump	**S/W trigger (CRCgenerate or check wrong)**
Error	OK	**Error**	Signal B	**S/W trigger (error at CRC detected)**
Error	OK	OK	Signal B	**S/W trigger (error at data part)**
OK	**Error**	**Error**	Signal A	**S/W trigger (error at CRC detected)**
OK	**Error**	OK	Signal A	**S/W trigger (error at data part)**
OK	OK	**Error**	Dump	**S/W trigger (one of the counters has error)**
OK	OK	OK	Signal A	By default (both signals are correct)

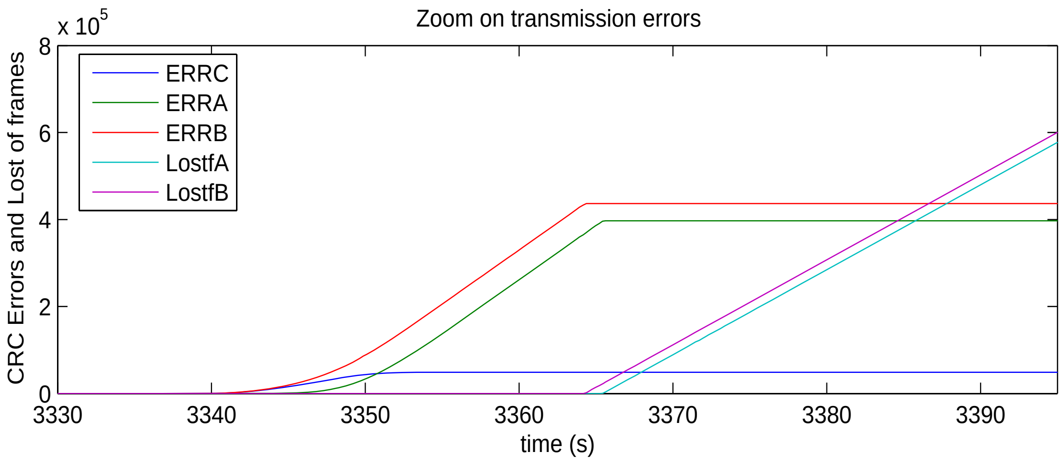
At the Surface FPGA:

- Signal CRC-32
  - Error check / detection algorithm for each of the signals received.
  - Comparison of the pair of signals.
  - Select block
  - Logic that chooses signal to be used
  - Identifies problematic areas.
- Tunnel's Status Check block
  - HT, Power supplies
- FPGA errors
  - Temperature

Beam on FPGA, SEU & Transmission Errors check



- Stop of transmission at 700 Gy (3 10^8 proton/s/cm^2)



1. CRC errors on opt link B (red)
2. CRC A & B not equal (blue)
3. CRC A errors (green)
4. Loss of transmission B, A (violet, blue)

Test Procedure of Signal Chain

- Basic concept: Automatic test measurements in between of two fills
  - Measurement of 10 pA bias current at input of electronic
  - Modulation of high voltage supply of chambers
    - Check of components in Ionisation chamber (R, C)
    - Check of capacity of chamber (insulation)
    - Check of cabling
    - Check of stable signal between a few pA to some nA (quench level region)
  - Not checked: the gas gain of chamber (in case of leak about 50 % gain change, signal speed change – to be checked)

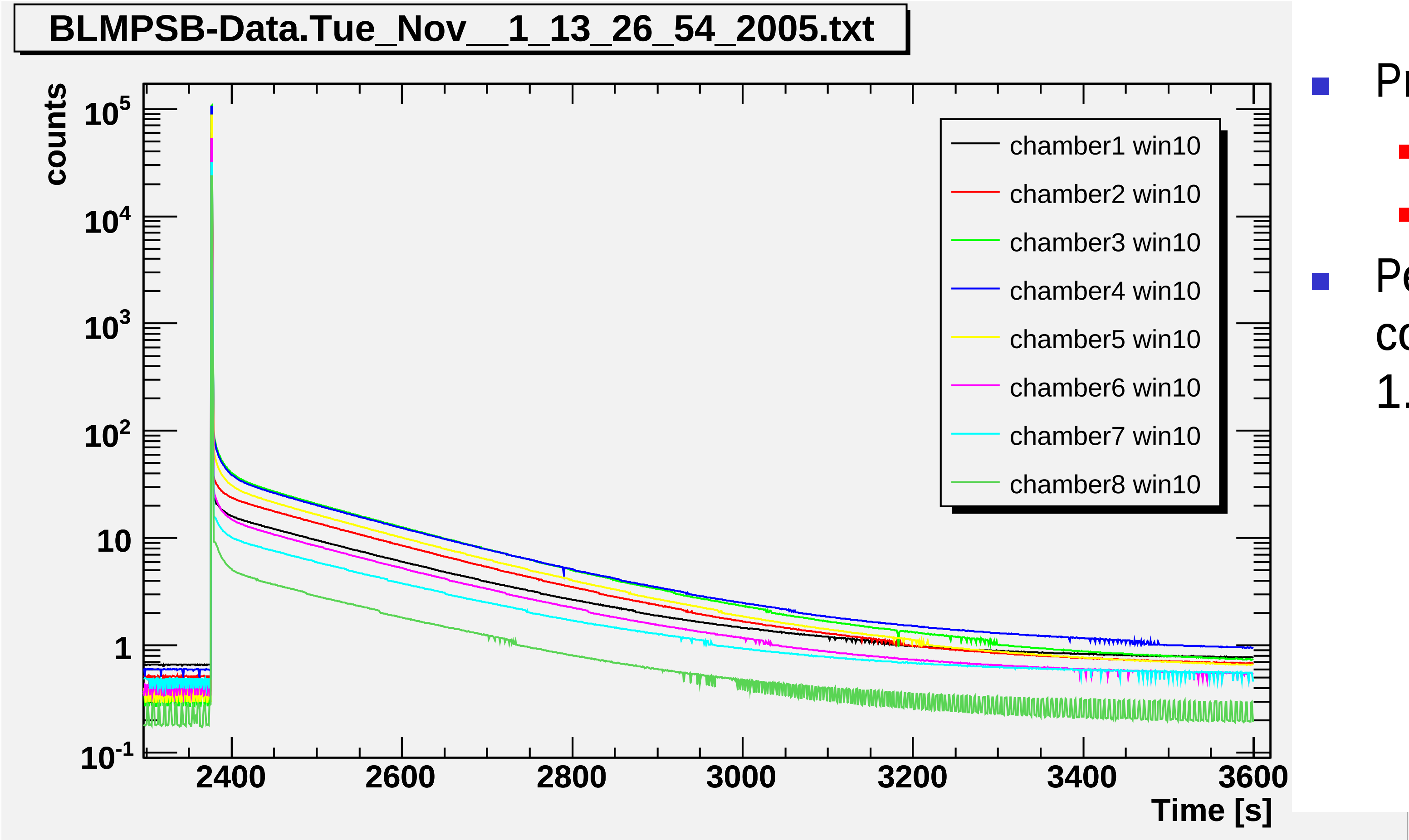
Some Specification Requirements

- DATA FOR THE CONTROL ROOM AND THE LOGGING SYSTEM
  - Loss rates normalized quench level, (energy and integration time-independent) (units need still to be defined)
  - Updated every second
  - Allow frequency spectrum analysis
  - Long term summation for comparisons with dose detectors
- POST-MORTEM ANALYSIS
  - Stored data: 100 - 1000 turns before post mortem trigger
  - Average rates: a few seconds to 10 minutes before a beam-dump
- False dumps
  - less than one per month (about 2 to 3 per month, simulations)
- BEAM 1/BEAM 2 DISCRIMINATION
  - If possible, higher tuning efficiency
- A set of movable BLM's

Beam Dump at HERA

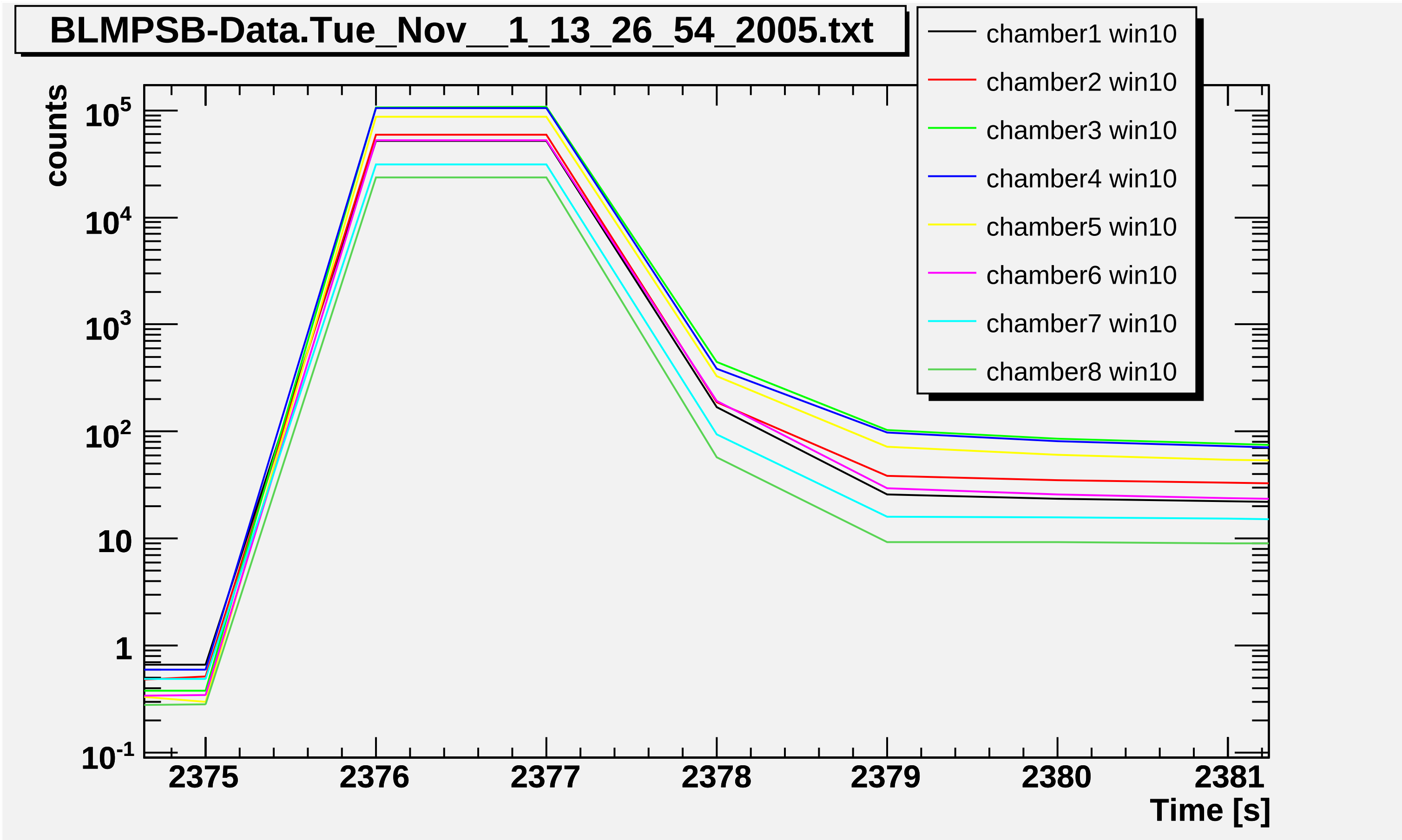
- Aim of setup
  - BLM system test
  - Verification of Geant simulation
  - Beam losses dynamic observations
- LHC measurement setup
  - 6 chambers in top of internal dump
  - 1 before and 1 after the dump

Dose Measurements at the HERA Beam Dump

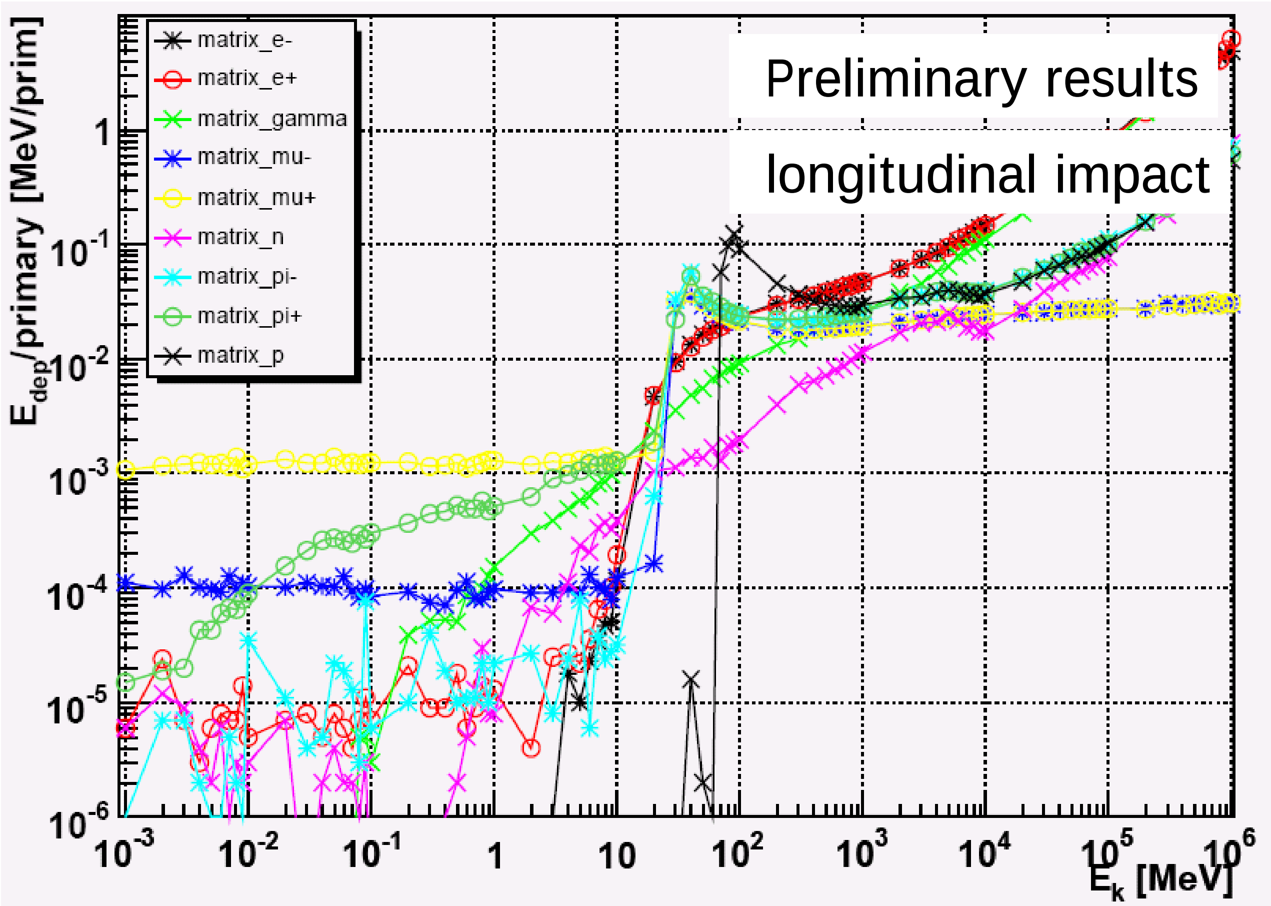


- Protons:
  - 1 10^{13}
  - E = 920 GeV
- Peak corresponds to 1.5 Gy

Dose Measurements at the HERA Beam Dump, zoom



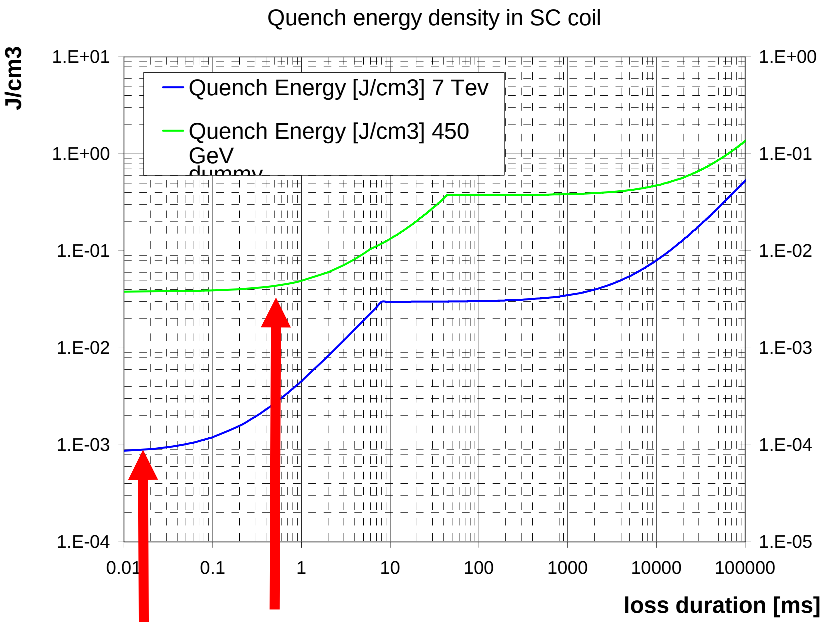
SPS Ionisation Chamber Spectrum Response

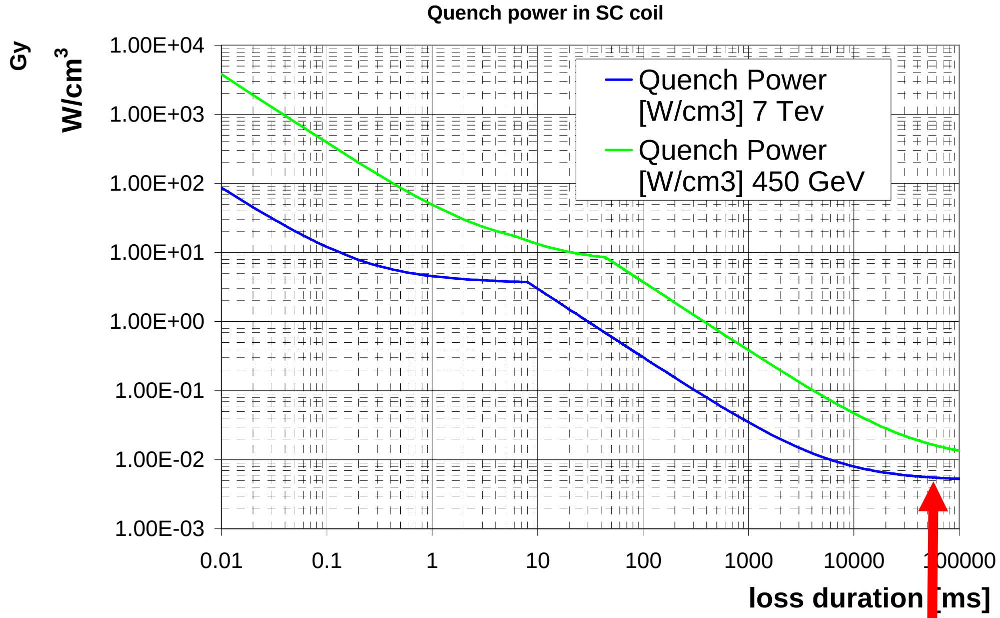


- Ionisation chambers:
  - H6 line measurements
  - HERA Dump
  - Response to mixed radiation field (chambers outside cryostat)
  - Comparisons with simulations (shown by H. Vincke)
  - Thesis M.Stockner
- SEM
  - Same procedure as for ion. ch.
  - BOOSTER
  - PSI
  - Thesis D. Kramer

Reserve Slides

LHC Bending Magnet Quench Levels,
LHC Project Report 44





38 mJ/cm3 = 5 mJ/g

5 mW/cm3 = 0.6 mW/g

0.8 mJ/cm3 = 0.09 mJ/g

(RHIC=2 mJ/g, Tevatron=0.5mJ/g)

(RHIC = 8 mW/g, Tevatron = 8mW/g)

Systematic Uncertainties at Quench Levels

	relative accuracies	Correction means
Electronics	< 10 %	Electronic calibration
Detector	< 10 – 20 %	Source, sim., measurements
Radiation & analog elec.	about 1 %	
fluence per proton	< 10 - 30 %	sim., measurements with beam (sector test, DESY PhD)
Quench levels (sim.)	< 200 %	measurements with beam (sector test), Lab meas., sim. fellow)
Topology of losses (sim.)	?	Simulations

Loss Levels and Required Accuracy

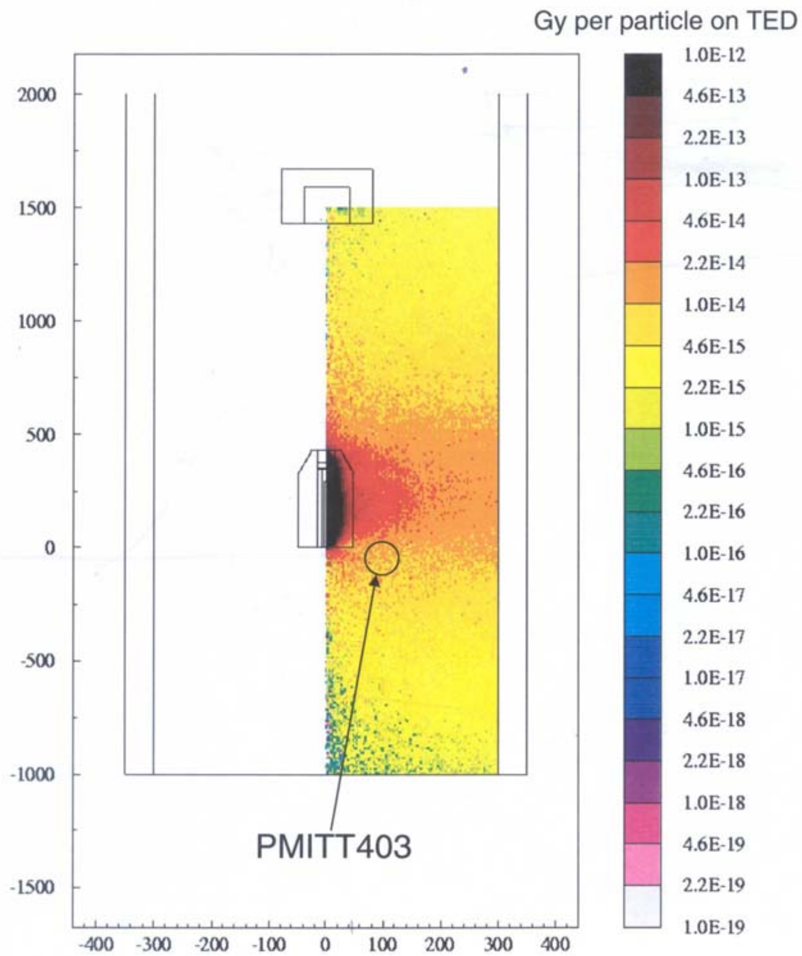
Relative loss levels		
	450 GeV	7 TeV
Damage to components	320/5 ***tran./slow***	1000/25 ***tran./slow***
Quench level	1	1
Beam dump threshold for quench prevention	0.3	0.3/0.4 ***tran./slow***
Warning	0.1	0.1/0.25 ***tran./slow***

Specification:

Absolute precision (calibration)	< factor 2 initially: < factor 5
Relative precision for quench prevention	< 25%

Accurately known quench levels will increase operational efficiency

TT41 Beam DUMP



- Beam Dump design similar to HEARA dump
- Dose for impact of 450 GeV protons