Updates on FLUKA simulations of TCDQ halo loads at IR6

FLUKA team & B. Goddard

Summary

- Brief recall from last presentation
- Analyzed cases
- Normalization factors
- Simulation results
- TCLA implementation
- Statistical uncertainties
- Conclusions

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Where did we leave...

8th May 2006 presentation:

- Heat load on Q4 for **nominal cleaning** at injection and top energy;
- Horizontal and vertical losses considered, **but** horizontal slightly worse, so vertical neglected;
- Sensitivity to the magnetic field in the MCBY;
- Comparison with beam 1 in case of nominal cleaning --> factor 100 difference, due to asymmetry in the LHC collimation betatron cleaning system (IR7).

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Analyzed cases

- **Cleaning without secondary collimators**
- **One sided cleaning**
- **Nominal cleaning (again) with an additional shielding for the Q4**

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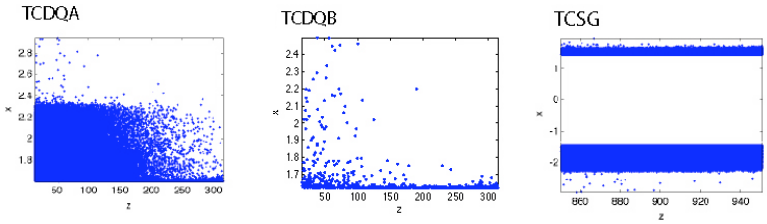
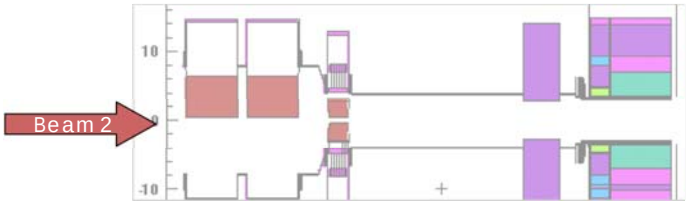
Analyzed case: Secondary collimators retracted

Injection

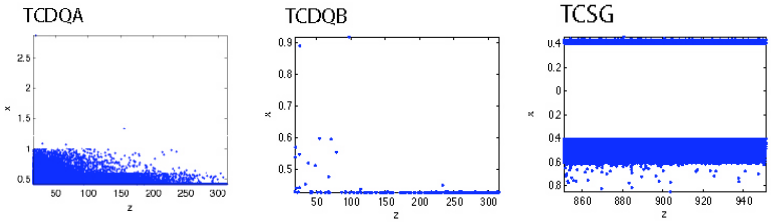
TCDQA	209227
TCDQB	1390
TCSG	280480
Total	491097





Top Energy

TCDQA	83115
TCDQB	502
TCSG	59730
Total	143347



Thanks to the extensive simulations of C. Bracco

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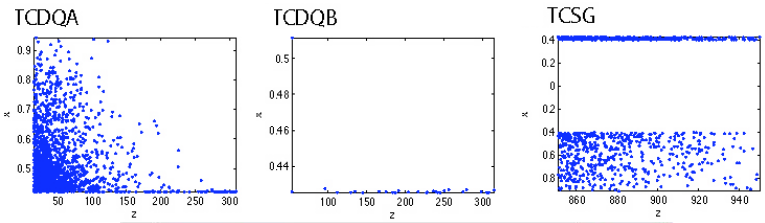
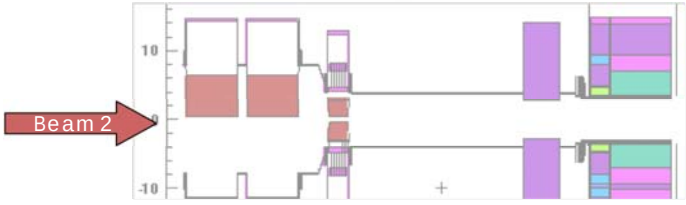
Analyzed case: One sided collimation

Top Energy

TCDQA	3226
TCDQB	29
TCSG	1006
Total	4261





Thanks to the extensive simulations of T. Weiler

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Normalization factors

- Number of particles tracked (and hypothetically absorbed in all the machine) in Sixtrack simulations: **ALL-tracked**
- Number of particles intercepted by the elements of interest (TCDQA/B and TCSG in this particular case): **COLL-imp**
- COLL-imp / ALL-tracked ==> % of particles lost on "my" collimators, has to be scaled to the loss rate of the machine in nominal operation conditions
- **Loss rate**:

$$\frac{dN}{dt} = \frac{ppb \times \#b}{t}$$

ppb particles per bunch, 1.15 10^{11}
#b number of circulating bunches, 2808
} Nominal intensity 3.4 10^{14} p^+

t beam lifetime, time for the beam to reduce by a factor '*e*' :
0.1 h, injection
0.2 h, top energy

N_f = Loss rate * COLL-imp / ALL-tracked [p/s]

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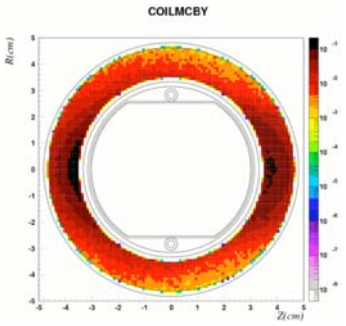
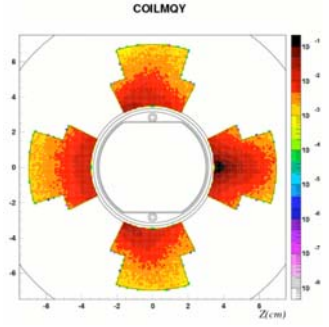
Simulation results





TCS retracted

Local Peak

	COIL MCBY	COIL MQY
	7 TeV	
$J/cm^3/p$	$1.3 \cdot 10^{-11}$	$1.9 \cdot 10^{-11}$
mW/cm^3	150.0	220.0
	450 GeV	
$J/cm^3/p$	$2.6 \cdot 10^{-13}$	$2.0 \cdot 10^{-13}$
mW/cm^3	18.3	14.0

Total deposited power

	COIL MCBY	COIL MQY
	7 TeV	
J/p	$4.7 \cdot 10^{-9}$	$1.8 \cdot 10^{-8}$
W	52.9	200.0

One sided losses

Local Peak

	COIL MCBY	COIL MQY
	7 TeV	
$J/cm^3/p$	$1.4 \cdot 10^{-11}$	$1.9 \cdot 10^{-11}$
mW/cm^3	5.3	7.2

To be compared to a typical **quench limit** of:

5 mW/cm^3
Localized

20 W Total

TCLA implementation

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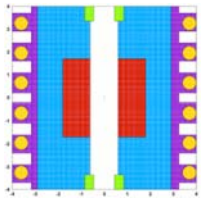
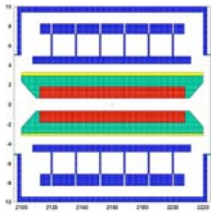
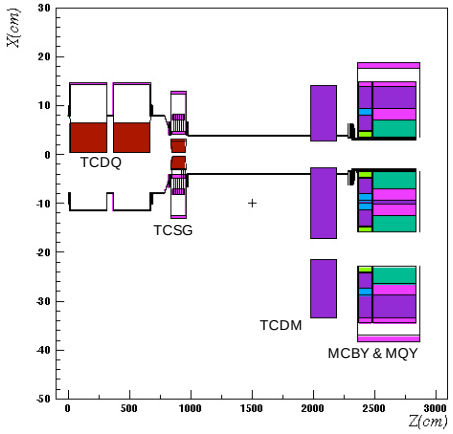
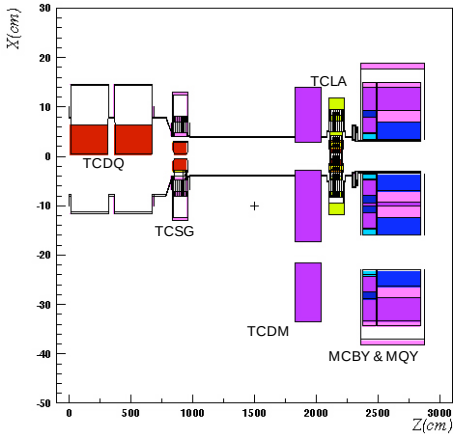
To reduce the local peak of energy on the magnets, an absorber has been implemented in the geometry. A 'test' simulation has been run with the nominal cleaning halo load.





$TCLA_{halfgap}$ = 10 s { 0.6 cm @ 7 TeV ; 2.5 cm @ 450 GeV





TCLA implementation: Results

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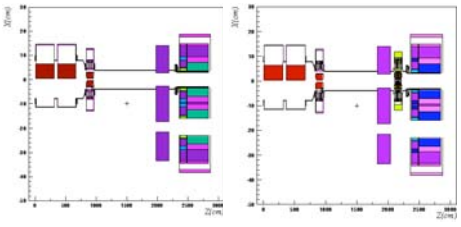
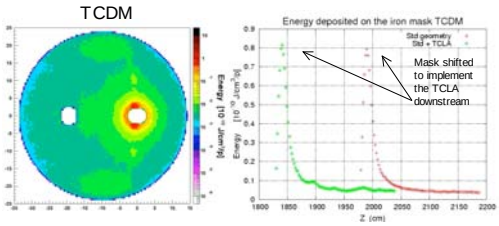


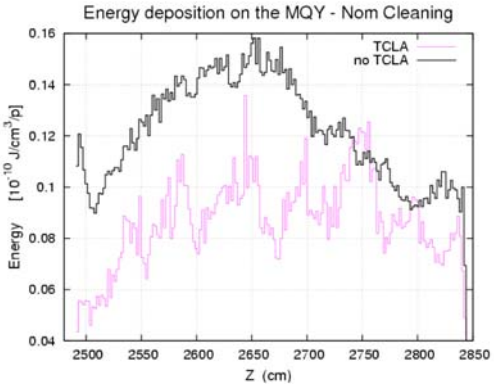


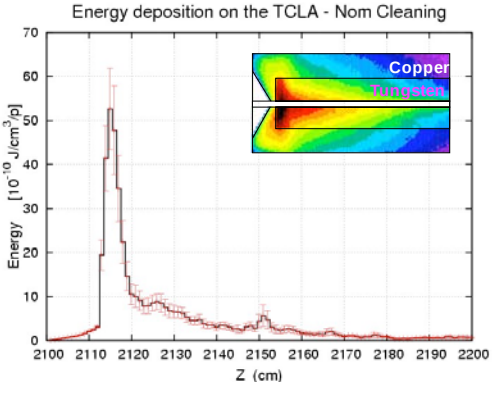
Local Peak

	COIL MCBY	COIL MQY
	7 TeV	
$J/cm^3/p$	$3.7 \cdot 10^{-12}$	$1.1 \cdot 10^{-11}$
mW/cm^3	0.6	1.8

Total deposited power

	COIL MCBY	COIL MQY
	7 TeV	
J/p	$1.7 \cdot 10^{-9}$	$6.5 \cdot 10^{-9}$
W	0.28	1.07





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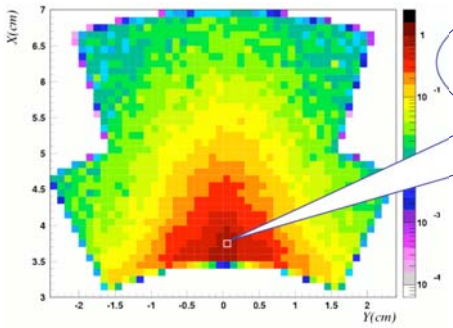
Statistical uncertainties

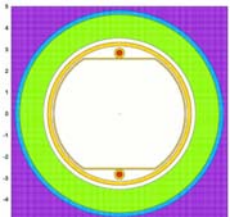
Results shown in the tables **to be *handled* carefully**:



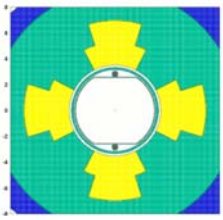
The bins' size used to score the energy deposition in the coils is 1 mm^2 over 2 cm length.

The error in the bin with the **maximum** value is ~20%.

The error in the energy deposited on the **total coil** is less than 10%.



MCBY: 115 cm



MQY: 350 cm

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Conclusions

- Asymmetry between beam 1 and beam 2 due to LHC layout
- Expected power load on the Q4.L6 coil with nominal LHC cleaning collimation 3.1 mW/cm^3 (less than factor 2 below the quench limit); one sided cleaning case 7.2 mW/cm^3, about 50% higher than quench limit.
- TCDQ system for beam 2 risks being an operational limit once the LHC intensities are above about half nominal.
- The implementation of a TCLA absorber could reduce the power in the Q4 coils by a factor 2.
- In case of operation with all secondary collimators retracted the huge increase in the number of secondary halo protons impacting the TCDQ system limits this scheme to low intensities:
  - increase in number of protons factor 76
  - to respect the 5 mW/cm^3 limit in the Q4 coil, the total beam intensity must be limited to a factor of 50 below nominal (6 10^{12} p^+) corresponding to a possible operation with 156 bunches of 4 10^{10} p^+.

(see R. Assman, *Beam commissioning of the LHC collimation system*, Proceedings LHC Workshop Chamonix 06, 2006)

New data about onesided cleaning

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L.Sarchiapone et al.,
5th March 2007

Old input data

	Protons absorbed				
	Total LHC	TCDQA	TCDQB	TCSG	tot
FOR IDEAL MACHINE					
Side of **pos.** jaw	2.24×10^6	544	0	364	908
Side of **neg.** jaw	5.11×10^6	3226	29	1006	4261
INCLUDING ENERGY SPREAD					
Side of **pos.** jaw	3.68×10^6	845	1	492	1338
Side of **neg.** jaw	4.32×10^6	2218	19	655	2892

New (corrected) input data

	Protons absorbed				
	Total LHC	TCDQA	TCDQB	TCSG	tot
FOR IDEAL MACHINE					
Side of **pos.** jaw	2.24×10^6	154	0	364	518
Side of **neg.** jaw	5.11×10^6	1623	29	1005	2657
INCLUDING ENERGY SPREAD					
Side of **pos.** jaw	3.68×10^6	239	1	491	731
Side of **neg.** jaw	4.32×10^6	1128	17	654	1799

The old value of 7.2 mW/cm^3 was obtained scaling the results to the old input data - ideal machine - side of negative jaw.

In the new input data the 'fake' impacts seen by the collimators are removed.

New results

		COIL MCBY	COIL MQY
		7 TeV	
$J/cm^3/p$		$1.4 \cdot 10^{-11}$	$1.9 \cdot 10^{-11}$
FOR IDEAL MACHINE			
mW/cm^3	Side of **pos.** jaw	1.5	2.0
	Side of **neg.** jaw	3.3	4.4
INCLUDING ENERGY SPREAD			
mW/cm^3	Side of **pos.** jaw	1.2	1.7
	Side of **neg.** jaw	2.6	3.5