BLM thresholds for MQW magnets

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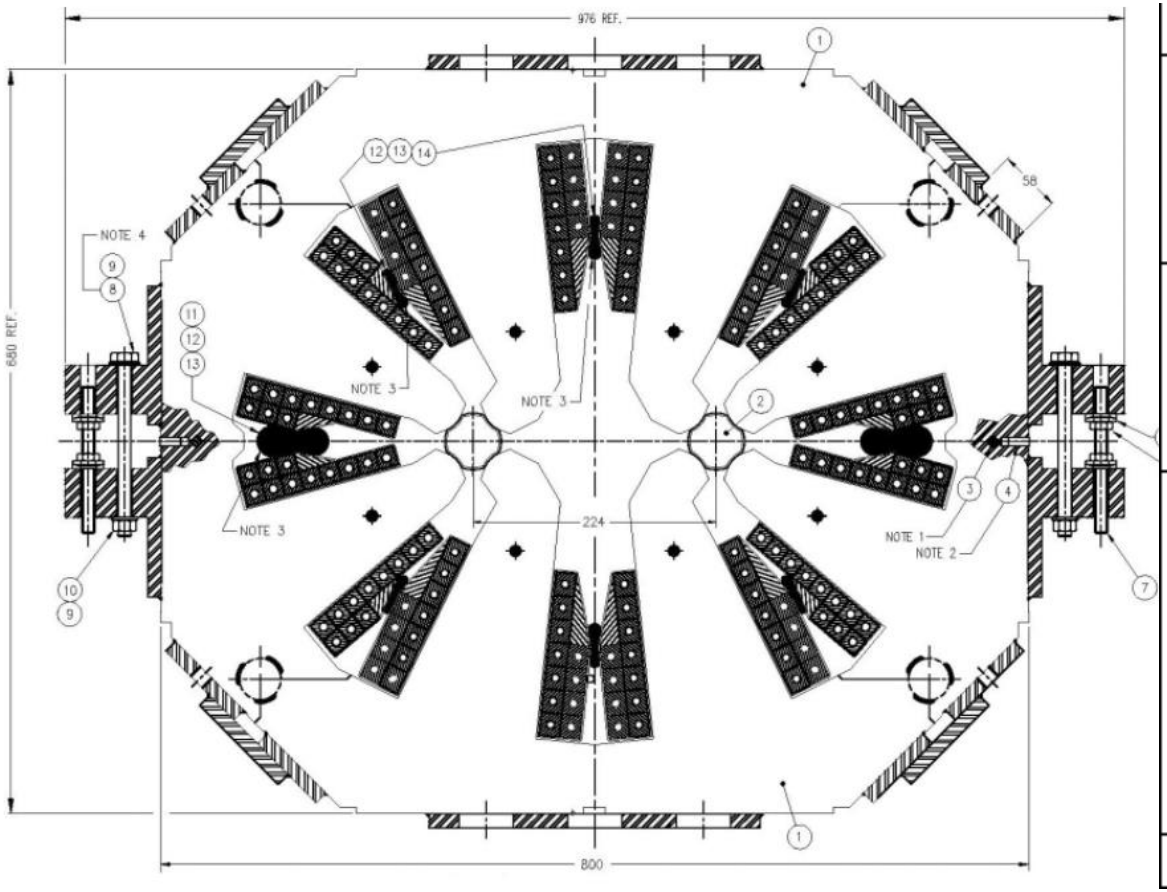
MQW normal conducting quadrupole magnet



Magnet type	MQWA	MQWB
Magnetic length	3.1 m	
Beam separation	224 mm	
Aperture diameter	46 mm	
Operating temperature	< 65° C	
Nominal gradient	35 T/m	30 T/m
Nominal current	710 A	600 A
Inductance	28 mH	
Resistance	37 mΩ	
Conductor X-section	20.5 x 18.0 mm² inner poles 17.0 x 17.0 mm² outer poles	
Cooling hole diameter	7 mm inner poles, 8 mm outer poles	
Number of turns per magnet	8 x 11	
Minimum water flow	28 l/min	
Dissipated power at I_{nom}	19 kW	14 kW
Mass	11700 kg	

Cross-section of the MQW twin aperture normal conducting matching quadrupole

BLM Threshold for Slow losses

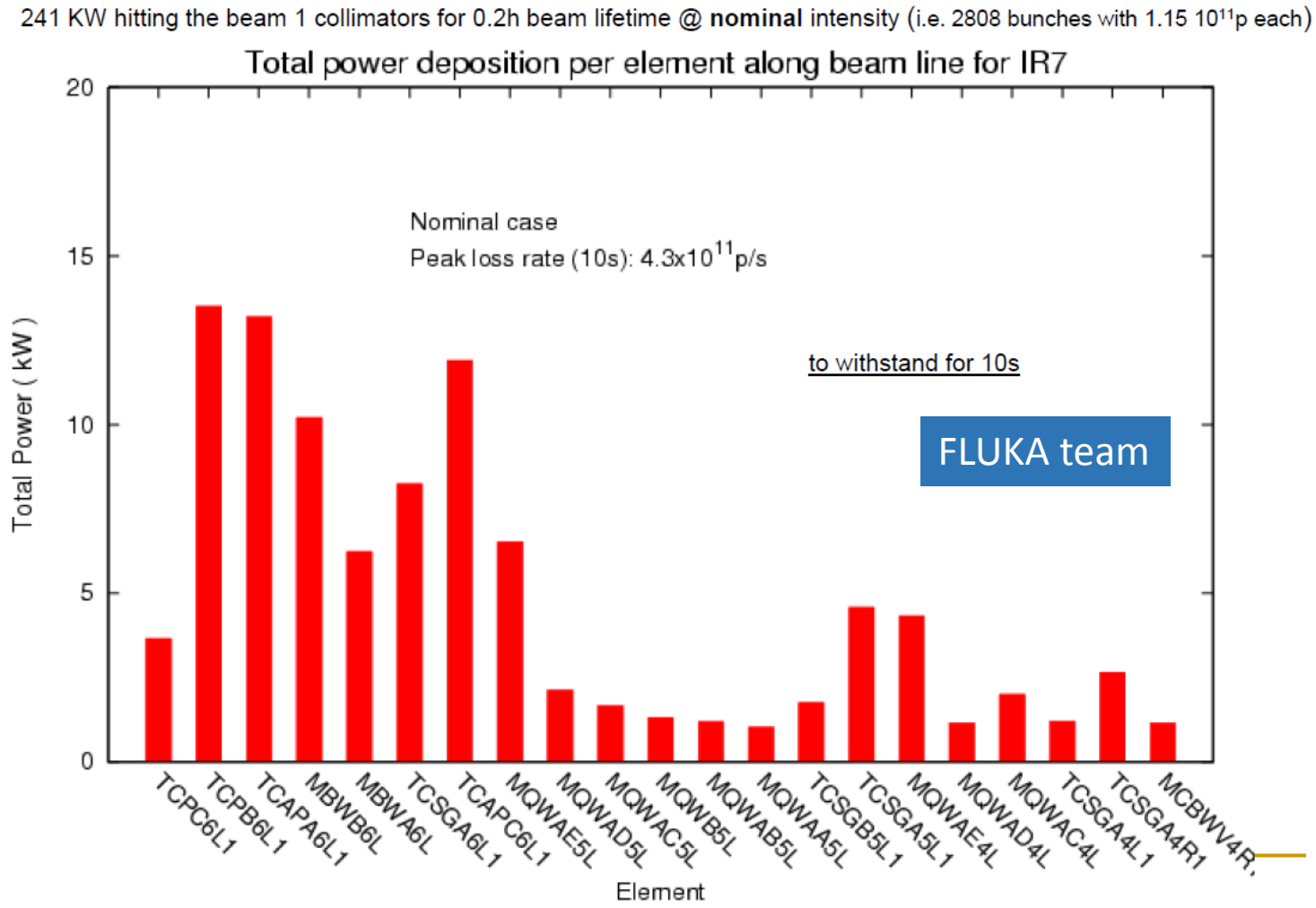
Scenario: 3.5 TeV vertical orbit bump on the lower part of the beam pipe 1 meter upwards the middle of the MQWA.E5R7

- **Coils Temperature** < 65 °C (Thermo-switch to protect the coils)
- Water Cooling has to cope with **Dissipated power, Collimation losses** and **Orbit bump losses**

Normal Cleaning Scenario at 3.5 and 7 TeV

- **Study done at 3.5 TeV:** Update for 7 TeV required.

- **By extrapolation at 7 TeV:** 500 kW hitting primary collimators. Highest heat load on first MBW (~20 kW) and MQW (~15 kW).



Orbit bump scenario

At **3.5 TeV**, values normalized per impacting proton on the beam pipe

- BLM Signal: **7.4844e-14 Gy**
- Integrated Energy Deposition in the whole magnet: **261.4 GeV**
- Integrated Energy Deposition in the most impacted coil (Lower one both cross sections) : **6 GeV**

At **7 TeV**, scale value by a factor 2

Orbit bump scenario – Loss rate / BLM signals

	Whole MQW magnet				Most exposed coil	
	3.5 TeV		7 TeV		3.5 TeV	7 TeV
Scenario including collimation losses	No	Yes	No	Yes	No	No
Max Power [kW] *	49	41	35	20	6.1	4.3
Max. Loss rate [p+/s] *	1.17 E12	9.87E11	4.18E11	2.39E11	6.35 E12	2.27E12
Corresponding BLM signals [Gy/s]	**8.73E-02**	**7.39E-02**	**6.25E-02**	**3.57E-02**	**4.75E-01**	**3.40E-01**

* Max power deposit into magnet and/or coil and loss rate to keep T_{coil} < 65 °C with nominal cooling

- Actual master threshold 7E-02 Gy/s

- Scenario including collimation losses, BLM signals due to collimation losses not included (input from FLUKA needed)

Fast losses on vacuum pipe and coils

Copper properties: Cp = 0.385 J/(g K) ; ρ = 8.96g/cm3

- Melting point (ΔT~1040°C, T~1100 °C) => ΔE = 3.6 kJ cm^{-3}

- From TT40 Experiment (1.32 10^{12} protons @450 GeV,~500 °C) used as input for the Setup Beam Flag and Peak energy deposition in the orbit bump case (4.5 GeV/cm^{-3} @3.5 TeV)
  => ΔE = 1.9 kJ cm^{-3} , BLM signal 0.2 Gy (2.64E+12 p+ @3.5 TeV, 1.32E+12 p+ @7 TeV)

- Copper at T=100 °C (ΔT=60 °C)
  => ΔE = 0.21 kJ cm^{-3}, BLM signal 0.02 Gy (2.9E11 p+ @ 3.5 TeV; 1.5 E11 p+ @ 7 TeV)

For 100 °C and 500 °C, BLM signal above maximum threshold until 2.56 ms integration time

Old vs. New inputs for BLM Thresholds

Input for Old Thresholds:	3.5 TeV	7 TeV
BLM Response [Gy/p+]	5.33E-12	1.00E-11
Fast Loss [p+]	5.40E+11	1.00E+10
Steady-state Loss [p+/s]	5.40E+10	1.00E+09
Fast Loss Threshold [Gy]	2.88E+00	1.00E-01
Steady-state Loss Threshold [Gy/s]	2.88E-01	1.00E-02

Input for New Thresholds:	3.5 TeV		7 TeV			
BLM Response [Gy/p+]	7.48E-14		1.50E-13			
Fast Loss [p+]	2.91E+11	2.64E+12	1.46E+11	1.32E+12	100 C	500 C
Steady-state Loss [p+/s]	1.17E+12	9.87E+11	4.18E+11	2.39E+11	w/o collim	with collim
Fast Loss Threshold [Gy]	2.18E-02	1.97E-01	2.18E-02	1.97E-01	100 C	500 C
Steady-state Loss Threshold [Gy/s]	8.73E-02	7.39E-02	6.25E-02	3.57E-02	w/o collim	with collim