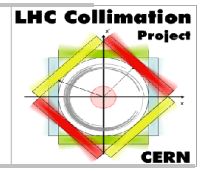
Status of energy deposition studies at IR7

Collimation Meeting
17-07-2006



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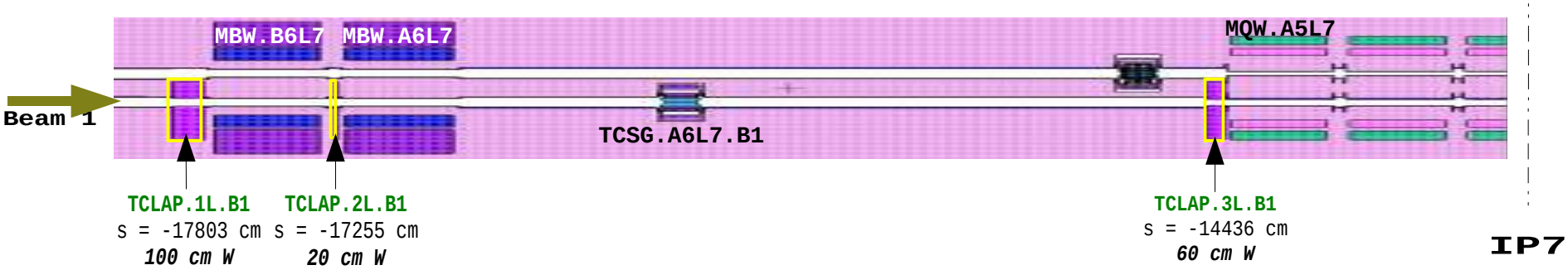
Outline

- Update on the simulations of the warm section of IR7
  - Dose in MBW's and MQW for horizontal and vertical beam losses at 7000 GeV
  - Heat density in the PA for several scenarios.
- Update on the simulations of the cold arc of IR7
  - Scenarios: Injection/top energy, all TCS off/nominal, vertical/horizontal loss...
  - Heat density in the MB's and MQ's
- Energy balance
  - Distribution of heat losses
  - Particles escaping the system
  - Remaining particles in the beam
- Ongoing/starting tasks
  - Phase space individual events for BLM's
  - Heat in support of MBW's

Simulations of the warm section of IR7

New scenarios: injection, TCS off, vertical losses

Layout:



Studied variables: Beam energy, Loss scenario, TCS.

Surveyed magnitudes:

- Power density in PA.
- Dose in MBW and MQW coils.

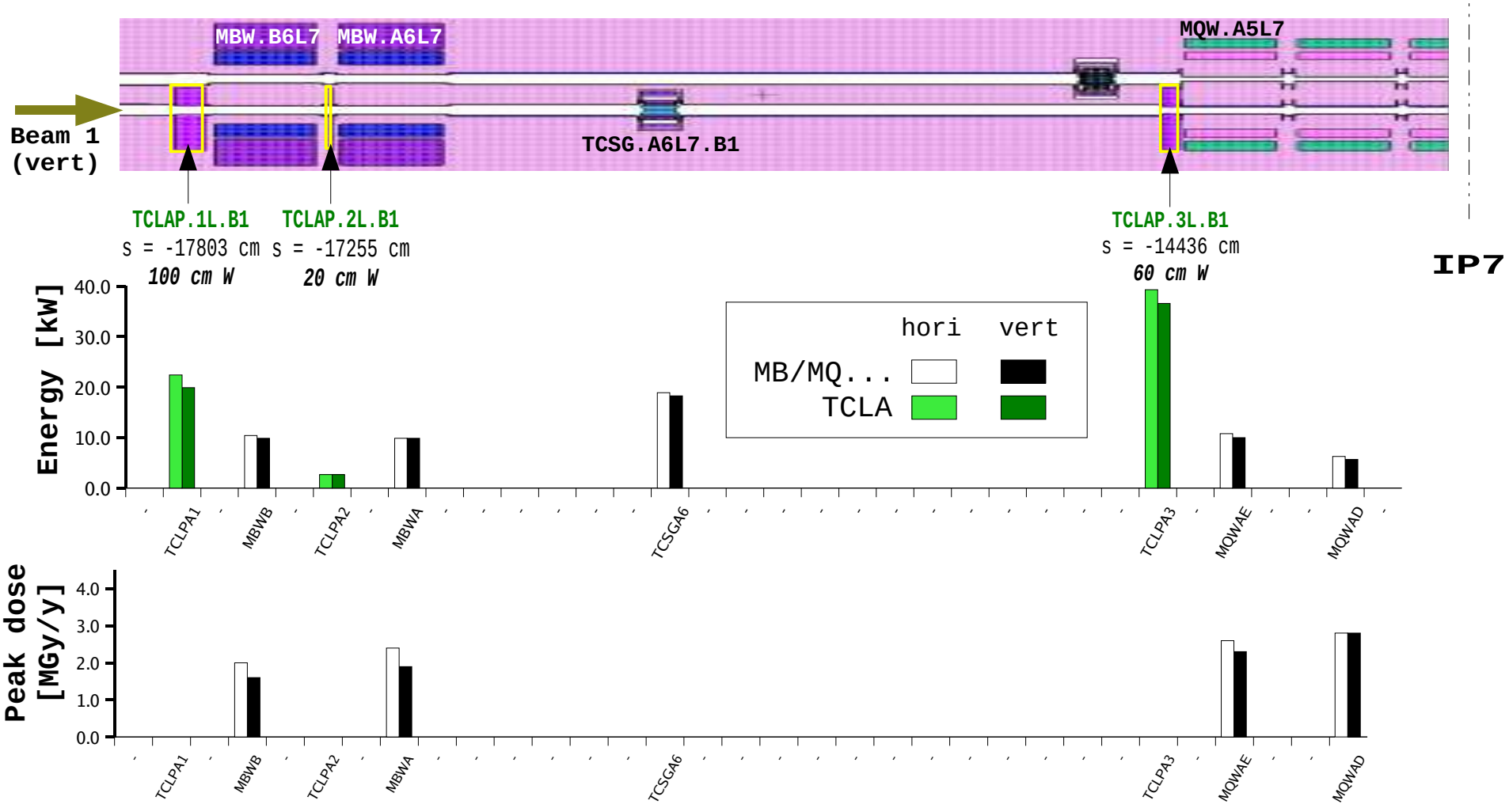
Conditions:

- Beam 1: 7000 or 450 GeV, 2E16 p/y, 4E11 p/s losses
- 60 cm long TCP at 6 sigma.
- 100 cm long TCS at 7 sigma (nominal) or all off.
- W passive absorbers, 100 cm, 20 cm and 60 cm long.

Simulations: Sixtrack (C.Bracco)+FLUKA: 2x2x2 = 8 sets

IR7 Warm section simulations

MBW and MQW's: vertical vs. horizontal losses, update.



IR7 Warm section simulations

Power deposition in the PA for several scenarios 1/2

Results:

22.4	90
kW	W/cm^3

		Horizontal						Vertical					
TCS	E	TCLPA1		TCLPA2		TCLPA3		TCLPA1		TCLPA2		TCLPA3	
nominal	lwb	22.4	*90*	2.7	*19*	39.3	*212*	19.9	*92*	2.8	*24*	36.5	*188*
	inj	1.8	*2.3*	0.05	*0.15*	0.35	*0.61*	2.5	*2*	0.04	*0.1*	0.56	*0.85*
accident	lwb	29.3	*119*	3.8	*34*	48.7	*194*	22	*100*	3	*27*	48.1	*174*
	inj	2.3	*2.9*	0.06	*0.2*	0.54	*0.67*	2	*2.8*	0.05	*0.15*	0.57	*0.67*

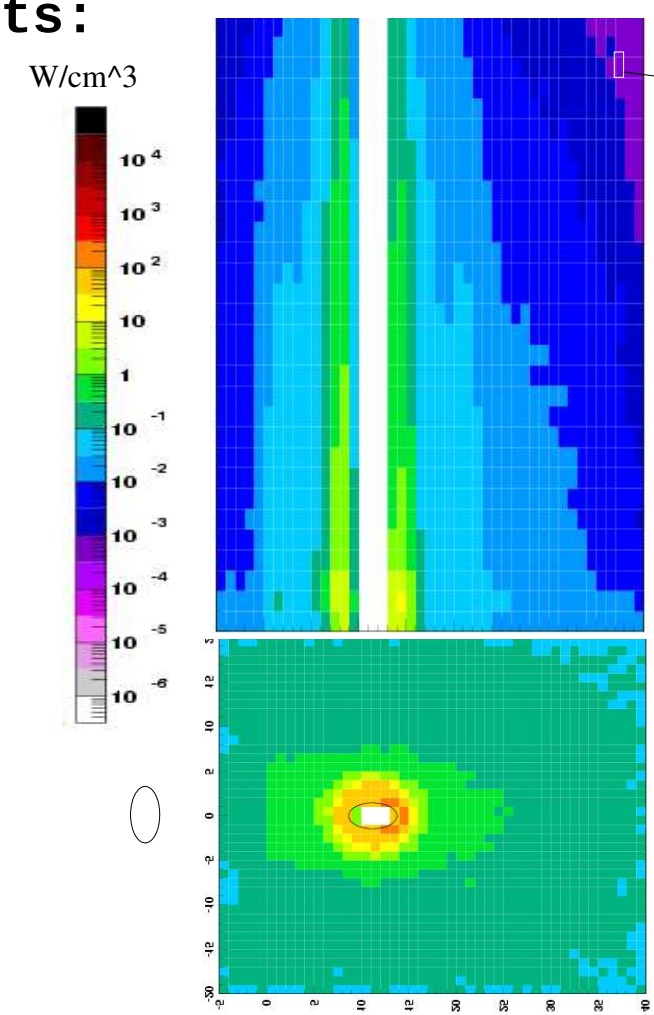
Conclusions:

- The absorbers need cooling. 3^{rd} > 1^{st} > 2^{nd}
- The power densities/total powers for vertical and horizontal losses are very similar.
- The peak power densities at injection are from 40 to 200 times lower than those for top energy.
- In the failure mode the TCS is not showering, but the TCP produce more showers --> more irradiation of the absorbers.

IR7 Warm section simulations

Power density in the PA for several scenarios 2/2

Results:



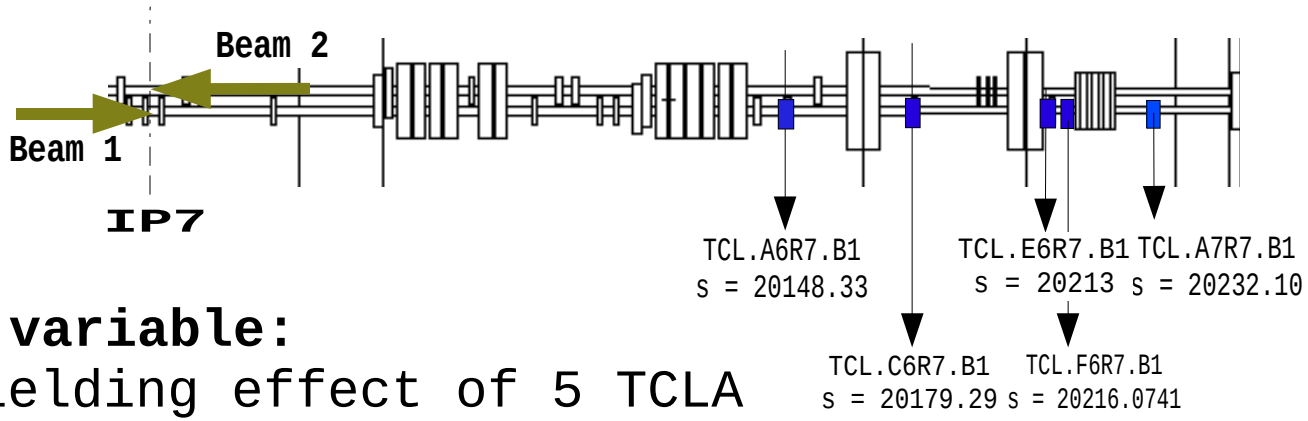
Conclusions:

- The peak power density is at about 20 cm z-depth, in the mid plane, close to the beam pipe.
- Power maps are available for all three absorbers and for every scenario.

New simulations of the cold arc

Effect of the TCLA, update 1/2

Layout:



Studied variable:

- Shielding effect of 5 TCLA

Conditions:

- Beam 1, horizontal losses
- 60 cm long TCS and TCP
- TCP and TCS all in
- Passive absorbers in

Simulations:

- Sixtrack: (Chiara Bracco)
- FLUKA: 3500000 lost protons

New simulations of the cold arc

Effect of the TCLA, update 2/2

Results:

E [GeV/b]	7000	7000
	Hori	Hori
TCL TCS	*OFF* ON	ON ON
MQ6	370	1.4
MQ7	34.000	0.400
MBA8R MBB8R	12.000 14.000	0.200 0.200
MQ8	7.000	1.000
MBA9R MBB9R	4.000 1.500	0.600 1.000
MQ9	1.400	1.800
MBA10R MBB10R	0.500 0.010	0.400 0.030
MQ10	1.000	0.500
MBA11R MBB11R	1.700 0.900	0.900 1.000
MQ11	8.000	5.000

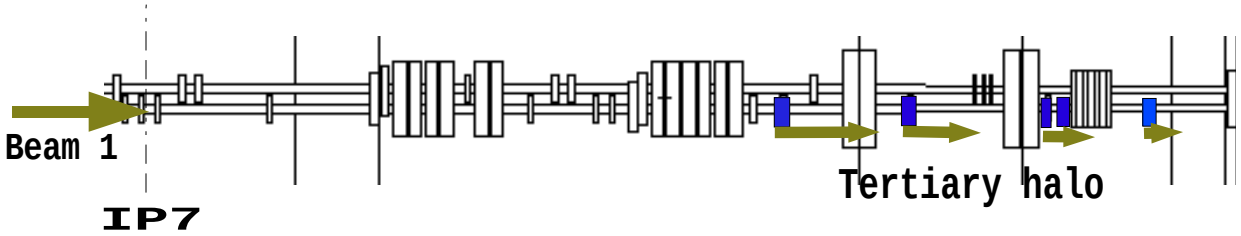
Conclusions:

- The 5 TCLA reduce the peak dose by a factor 370/1.4 > **260**
- In absence of the 5 TCLA, the first 5 magnets are taking the role of “absorbers”
- The shielded structure is 'only' close to quench at MQ11.

New simulations of the cold arc

Effect of the tertiary halo, update 1/2

Layout:



Studied variable:

- Contribution of tertiary halo to heat in cold arc

Conditions:

- Beam 1, horizontal losses
- 60 cm long TCP, 100 cm long TCS
- TCP, TCS *and* TCLA all in
- Passive absorbers in

Simulations:

- Sixtrack: (Chiara Bracco)
- FLUKA: 2 sets of simulations filtered to TCLA

New simulations of the cold arc

Effect of the tertiary halo, update 2/2

Results:

E [GeV/b]	7000	7000	7000
	Hori	Hori	Hori
TCL	*OFF*	ON	*Passive*
TCS	ON	ON	ON
MQ6	370	1.4	0.77
MQ7	34.000	0.400	0.460
MBA8R	12.000	0.200	0.100
MBB8R	14.000	0.200	0.320
MQ8	7.000	1.000	0.880
MBA9R	4.000	0.600	0.600
MBB9R	1.500	1.000	0.540
MQ9	1.400	1.800	0.350
MBA10R	0.500	0.400	0.080
MBB10R	0.010	0.030	0.004
MQ10	1.000	0.500	0.160
MBA11R	1.700	0.900	0.370
MBB11R	0.900	1.000	0.380
MQ11	8.000	5.000	2.560

Conclusions:

- The contribution of the tertiary halo ranges from a factor 1 to 5, typically being ~2
- The effect of the tertiary halo is critical in MQ11 (factor2), where the dose was already high.

New simulations of the cold arc

Effects of the beam energy & loss scenario and TCS 1/3

Studied variables:

- Beam energy: injection (450) or top (7000 GeV)
- Beam loss scenario: horizontal / vertical
- Commissioning case: TCS off

Conditions:

- Beam 1, 450 *or* 7000 GeV, horizontal *or* vertical beam losses.
- 60 cm long TCP at 6 sigma.
- 100 cm long TCP at 7 sigma (nominal) *or* all retracted.
- 5 TCLA at 10 sigma.
- 3 Passive absorbers in.
- Tertiary halo tracked.

Simulations:

- 2 (Energy) x 2 (scenario) x 2 (TCS) = 8 sets
- Sixtrack: (Chiara Bracco)
- FLUKA: ~ 500000-750000 particles per set.

New simulations of the cold arc

Effects of the beam energy & loss scenario and TCS 2/3

Results:

E [GeV/b]	7000				450			
	Hori	*Vert*	Hori	*Vert*	Hori	*Vert*	Hori	*Vert*
TCL	ON		ON		ON		ON	
TCS	ON		*OFF*		ON		*OFF*	
MQ6	1.4	0.3	29.9	39.3	0.1	0.02	2.5	5.7
MQ7	0.400	0.100	2.400	2.600	0.010	0.005	0.300	0.400
MBA8R	0.200	0.500	1.700	2.600	0.090	0.002	0.100	0.050
MBB8R	0.200	0.100	0.500	1.000	0.010	0.006	0.050	0.020
MQ8	1.000	0.010	0.400	5.000	0.030	0.002	0.050	0.030
MBA9R	0.600	0.350	0.800	1.500	0.020	0.007	0.030	0.030
MBB9R	1.000	0.500	1.000	1.500	0.010	0.006	0.030	0.050
MQ9	1.800	0.400	2.400	1.700	0.010	0.004	0.030	0.030
MBA10R	0.400	0.030	0.300	0.500	0.010	0.000	0.020	0.030
MBB10R	0.030	0.300	0.100	0.020	0.001	0.000	0.020	0.030
MQ10	0.500	0.300	0.160	0.020	0.010	0.000	0.030	0.030
MBA11R	0.900	0.200	1.300	1.800	0.005	0.000	0.020	0.000
MBB11R	1.000	0.600	1.020	2.000	0.005	0.000	0.020	0.000
MQ11	5.000	3.500	3.800	7.000	0.020	0.000	0.030	0.000

New simulations of the cold arc

Effects of the beam energy & loss scenario and TCS 3/3

Conclusions:

- In *nominal* conditions, the horizontal case is worse than the vertical one. The contrary is true for failure conditions.
- The *failure* scenario would quench MQ6 in all cases except horizontal-injection.
- The hottest magnet is MQ6 at injection and *also* MQ11 at top energy.
- The *highest* power densities in *nominal* conditions are between 1 and 5 mW/cm^3

Notes:

- All results concerning injection energy are pending from a verification of FLUKA setup optics for that energy.

Energy balance 1/5

energy share (horizontal losses)

Basic Balance [kW] (0.2 h accident case):

- Input energy: 4.0E11 p/s x 7TeV/p = **449** (100%)

- Scored energy:	327	(~73%)	327
- Energy escaping the system:	107	(~24%)	434
- Energy lost from nuclear models:	13	(~3 %)	447
- Energy converted to mass (recoils):	2	(0.4%)	**449**

Scored energy [kW] Table obtained for all (sub)objects

- TUNCVC1	48	48	- MBWB6	12	209
- TCLQA5	44	92	- TCSGA5	12	221
- TUNBVC1	26	118	- MBWA6	11	232
- TCLPA5	26	144	- MQWAE4	9	241
- TCSGA6	23	167	- MQWAD5	7	248
- TCPB6	18	185	- MQWAC5	6	254
- MQWAE5	12	197	- remain	73	*327*

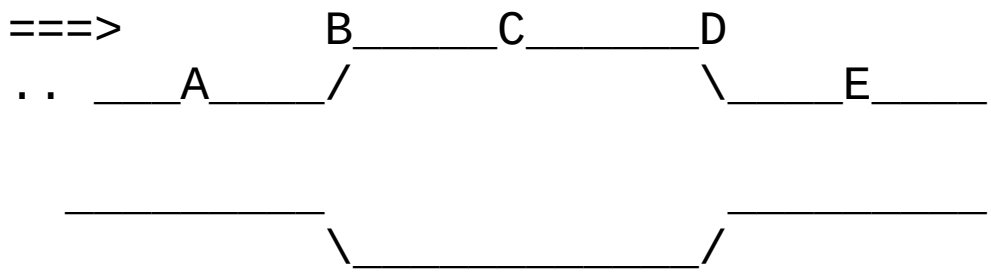
Energy balance 2/5

escaping energy (horizontal losses)

Energy escaping the system [kW] (~24%) single number in FLUKA output file.

- Tunnel concrete (tunnel)
- RR's, UJ's
- End of IR7 section --> ?

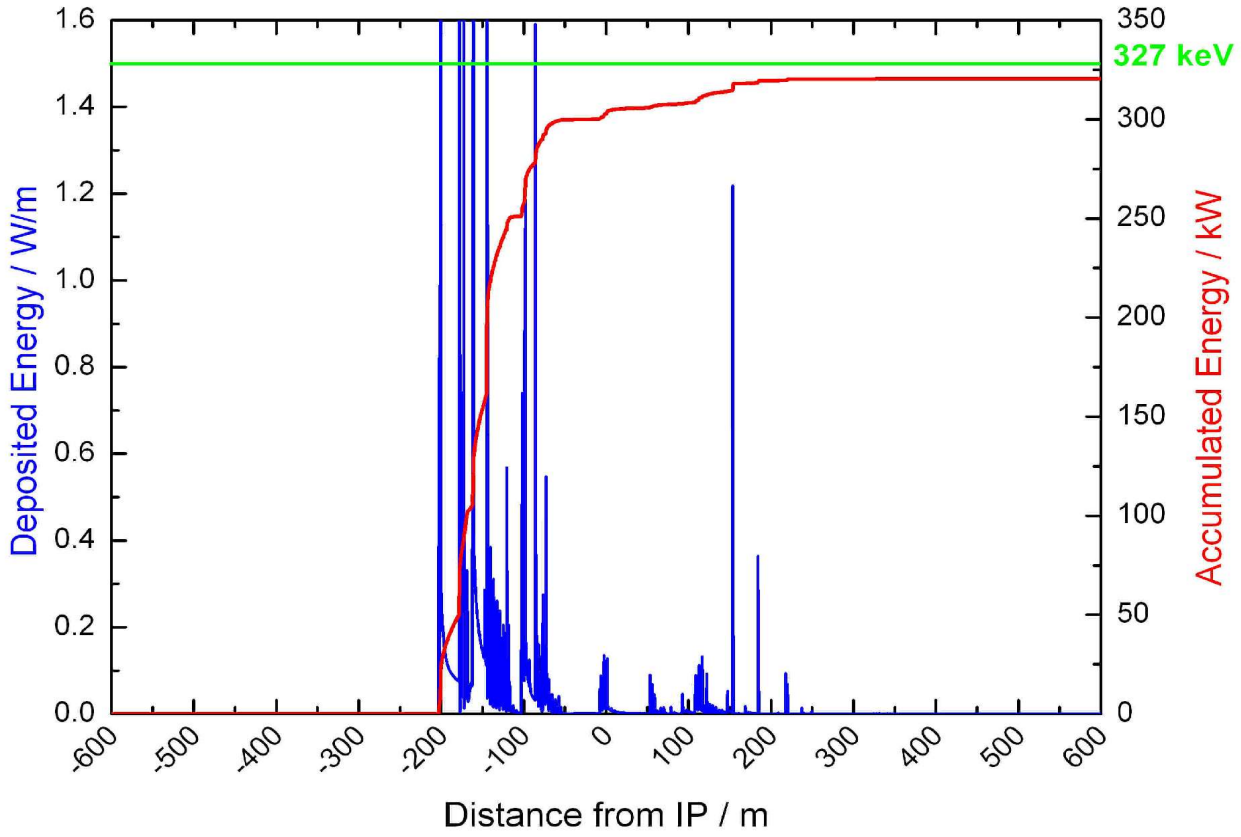
Energy at the end of IR7. Power deposited in the pipes:



A: ~0
B: 26 kW
C: 48 kW
D: 0.07 kW
E: 0.002 kW

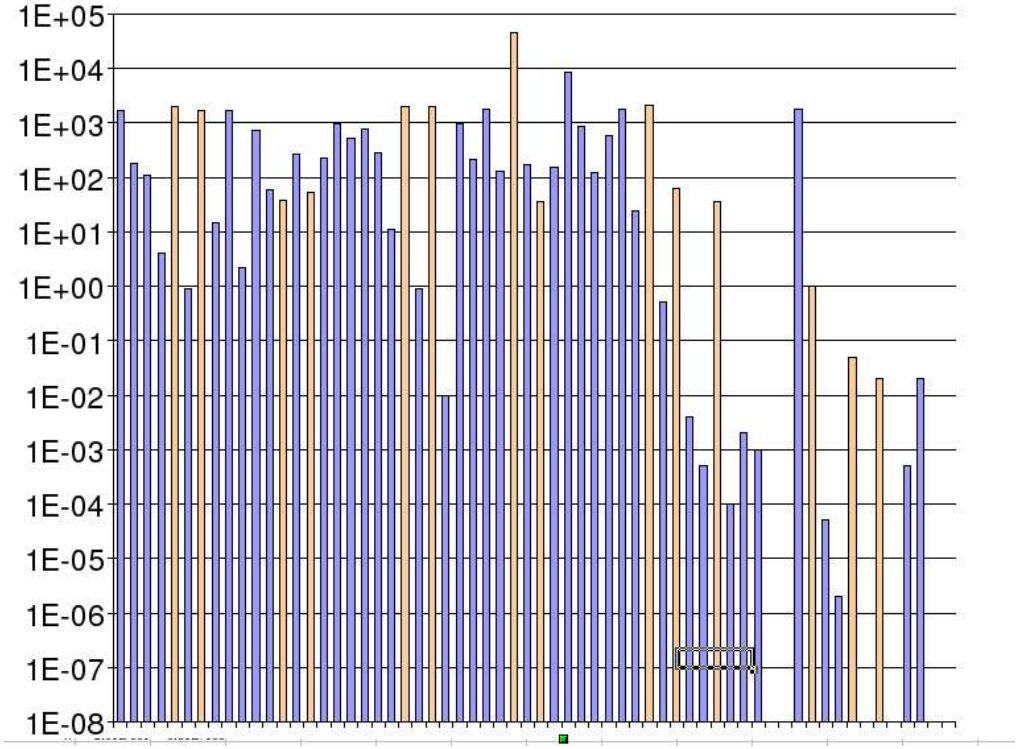
Energy balance 3/5

escaping energy



Energy balance 4/5

escaping energy: energy in cold part



Energy balance 5/5

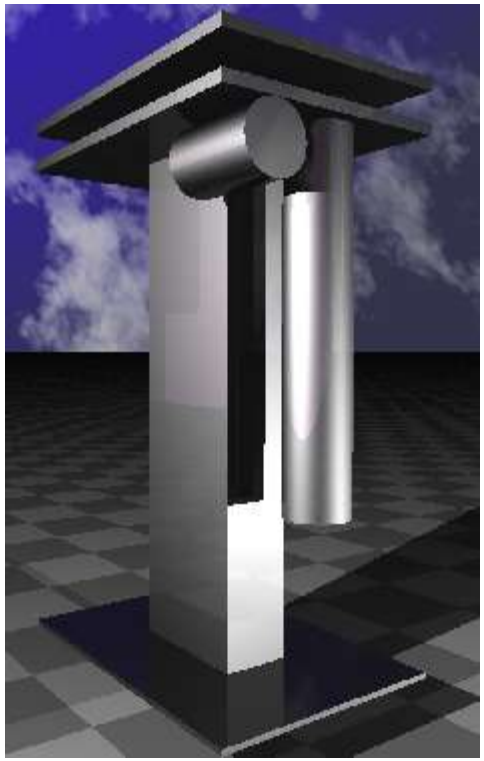
ongoing simulations

Flow measurement at different pipe cross sections at the end of the cold section

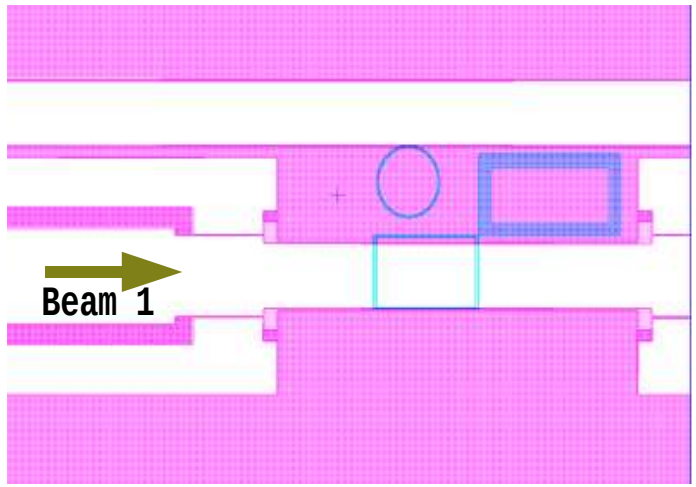
- Ideally Energy spectra for different particles.
- Problem: Statistics is too low
- Simulations now running!
- First results estimated on 20/07/06

Ongoing/starting tasks: BLM's

OLD SETUP for BLM simulations



- BLM blocks **after each collimator** (TCP/TCS), **below** the beam line plane
- BLM twiss file created
- Each BLM contains **2 detectors**



- Each detector measures:
  Fluence: protons, neutrons, photons, muons (+/-), e-e+, pions
  Energy deposition
- Each measurement made for a different beam source (loss in collimators)

Ongoing / Starting tasks: BLM's

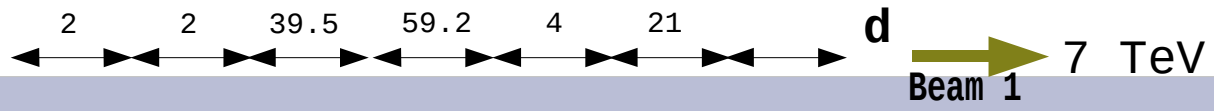
OLD RESULTS: Cross-talk *M*atrices (vertical detector)

Horizontal beam loss scenario

	L1								R1	
	C6	B6	A6	B5	A5	D4	B4	A4	A4	B5
*TCP*C6	0.991 7	0.693 5	0.307 4.7	0.068 9.9	0.046 8.3	0.013 12	0.007 17	0.009 18	0.019 18	0.065 40
*TCP*B6	0.009 14	0.307 5	0.386 5.6	0.054 8.2	0.053 12	0.014 14	0.008 25	0.008 18	0.015 24	0.106 63
*TCP*A6	0 5	1.4E-5 96	0.308 3.9	0.223 7.3	0.159 4.5	0.053 7.6	0.044 16	0.032 16	0.057 26	0.029 43
*TCSG*B5	0 5	0 3	0 2.5	0.653 7.3	0.6 3.7	0.344 5.8	0.29 11	0.266 11	0.254 11	0.101 38
*TCSG*A5	0 5	0 3	0 2.5	0.002 76	0.141 3.7	0.576 4.9	0.65 5.6	0.685 14	0.655 6.7	0.699 53

Vertical beam loss scenario

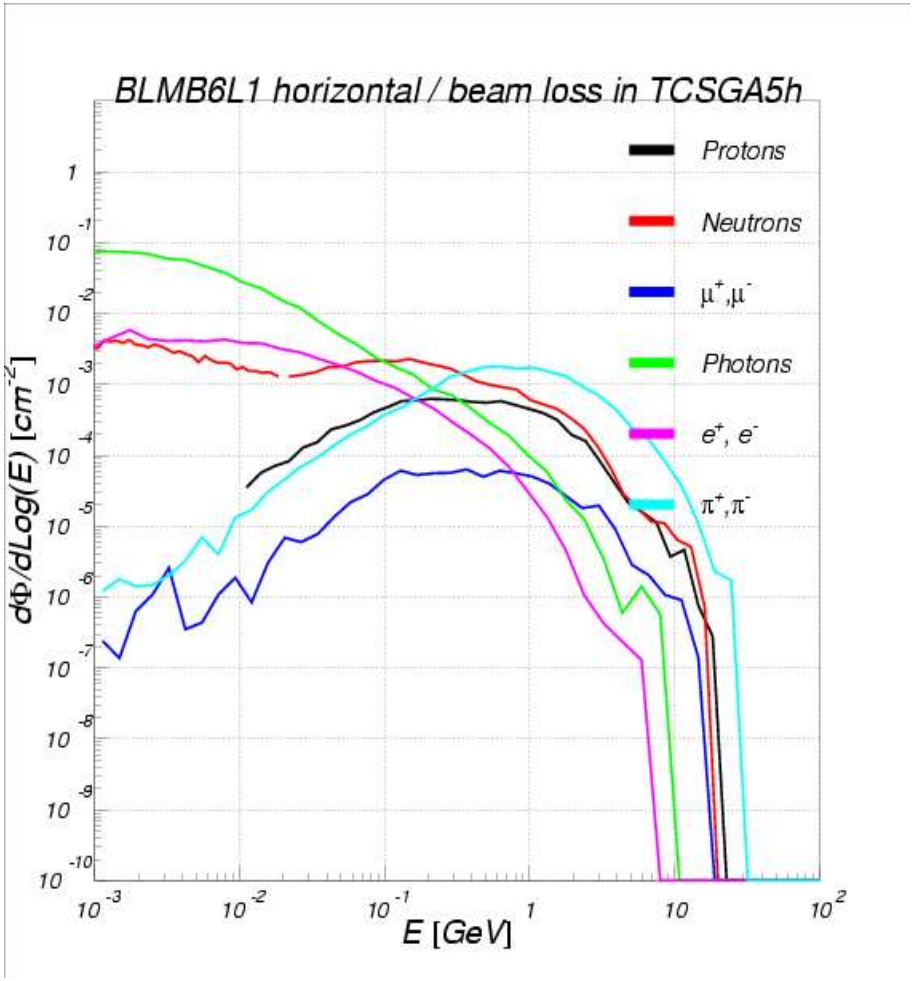
	L1								R1	
	D6	C6	B6	A6	B5	A5	D4	B4	A4	A4
TCPD6	0.962 8.3	0.578 4.9	0.338 5	0.247 7.7	0.071 12	0.054 7.3	0.017 21	0.037 71	0.015 23	0.026 28
*TCP*C6	0.038 13	0.419 4.9	0.499 5.8	0.22 6	0.036 11	0.028 8.3	0.008 25	0.003 29	0.073 94	0.003 20
*TCP*B6	5.5E-4 39	0.003 10	0.163 5.8	0.292 7.7	0.066 16	0.041 7.3	0.013 16	0.004 18	0.007 22	0.020 41
*TCP*A6	0 5.8	0 2.9	0 3	0.241 6.8	0.204 7.6	0.144 4.5	0.053 14	0.039 41	0.052 52	0.034 15
*TCSG*B5	0 5.8	0 2.9	0 3	0 3.2	0.622 8.4	0.595 3.6	0.322 5.9	0.258 8.5	0.252 12	0.23 8.3
*TCSG*A5	0 5.8	0 2.9	0 3	0 3.2	3.6E-4 26	0.139 4.5	0.588 8.3	0.659 7	0.6 13	0.681 9.9



- Cross talk ~ 1/d --> big cross-talk between primaries
- Little backscattering
- Similar picture for horizontal and vertical beam
- Similar cross-talk for the 2 detectors
- Loss estimation $L=(M^{T}M)^{-1}M\ R$

Ongoing / Starting tasks: BLM's

OLD RESULTS: Predicted response of every BLM



- Detected particles
  - Protons
  - Neutrons
  - Muons (+/-)
  - Photons
  - Electrons/positrons
  - Pions (+/-)
- Loss scenarios (7TeV)
  - Horizontal
  - Vertical
  - Full losses
- 2 detectors/BLM
- *Injection Energy not analyzed*

Ongoing / Starting tasks: BLM's

NEW SIMULATIONS: Phase space of individual particles

- Rearrangement of BLM detectors: **DONE**
- Customization of routines: **DONE**, **under test**
- Simulations: **NOT running yet**.
- WARNING: Results {x,y,z,K,vx,vy,vz,W,par}
  will contain the STATISTICAL weight W of the particle...
  Can this be easily handled?
  Does it make sense to do these (CPU-demanding) calculations?

Ongoing/Starting tasks.

- Simulation of energy deposition in supports of MBW's
  - Could you provide exact geometry?
  -
- Flux at end of IR7
  - Setup tested and running
  - First results on 20/07/06
- BLM individual phase-space counts
- Upgrade of Commissioning simulations
  - Need revised beam loss maps
  - To be launched when CPU's are available