

The slide features a decorative layout with blue lines and corner ornaments. A vertical line on the left and a horizontal line at the top intersect at the top-left corner, with a small blue circle at the intersection. A horizontal line at the bottom and a vertical line on the right intersect at the bottom-right corner, also with a small blue circle at the intersection. The main title is centered in a large, bold, purple font.

Collimator and beamline heating

External Review of the LHC Collimation Project

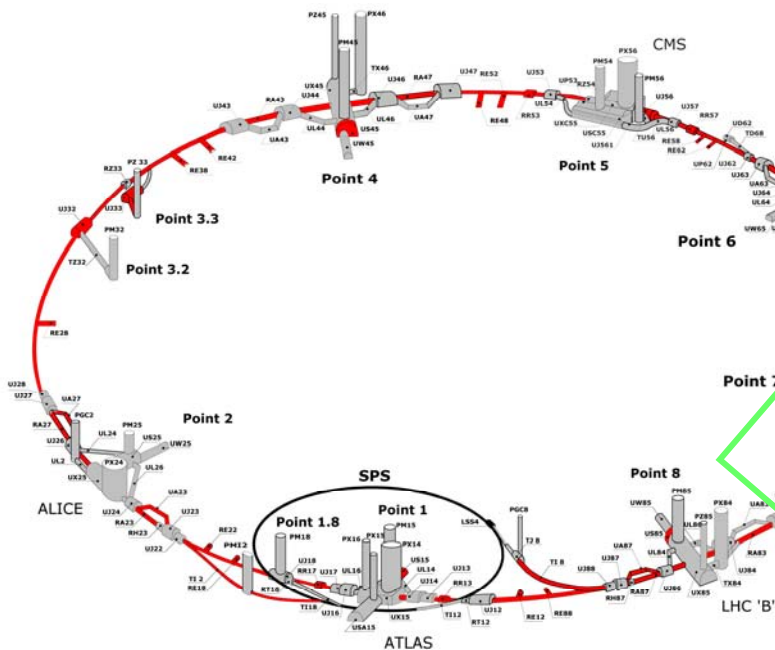
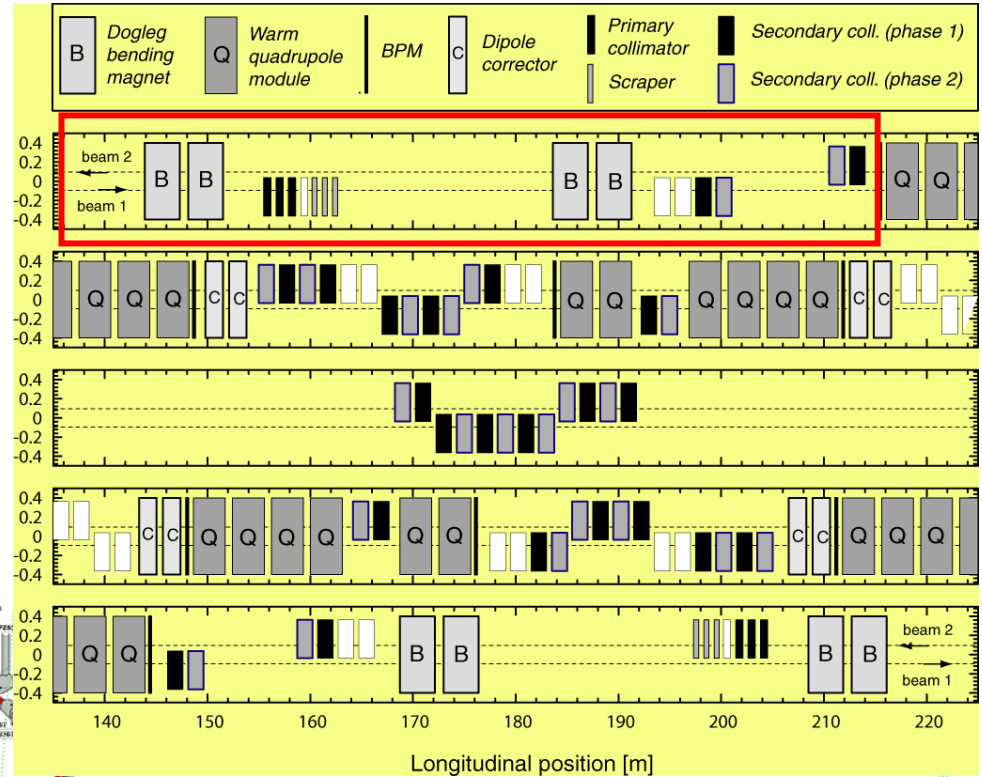
Vasilis.Vlachoudis@cern.ch

CERN Wed 30/6/2004

Description

- FLUKA Simulation of a 100m section of the IR7 region (betatron cleaning)
- Normal operation
0.2 hours beam life time
⇒ 4×10^{11} p/s for 10 s
- Energy deposition from cross talk of collimators

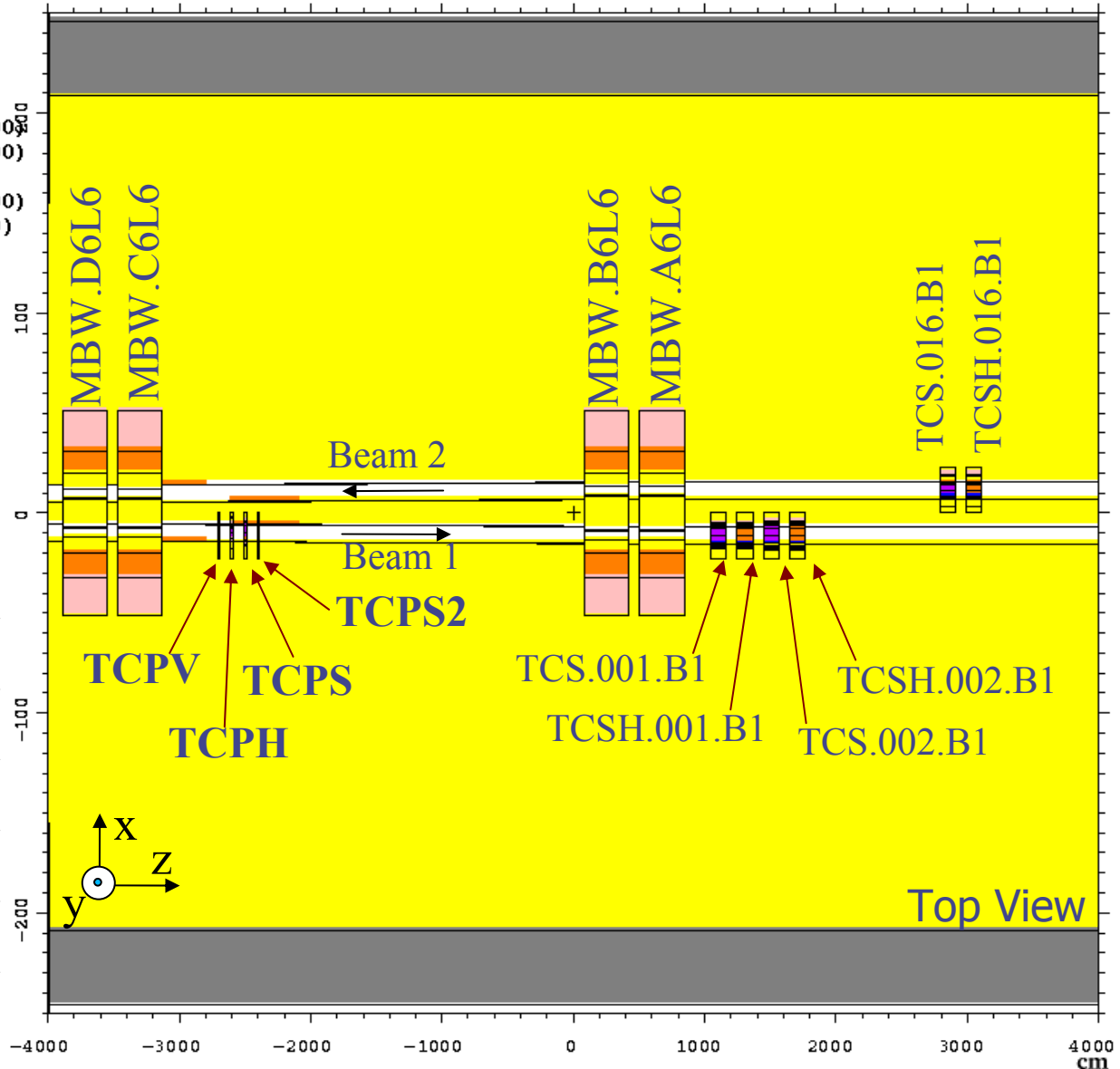
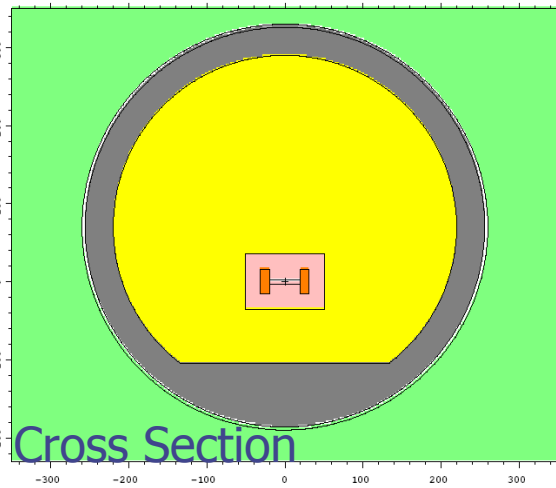
IR7 Layout



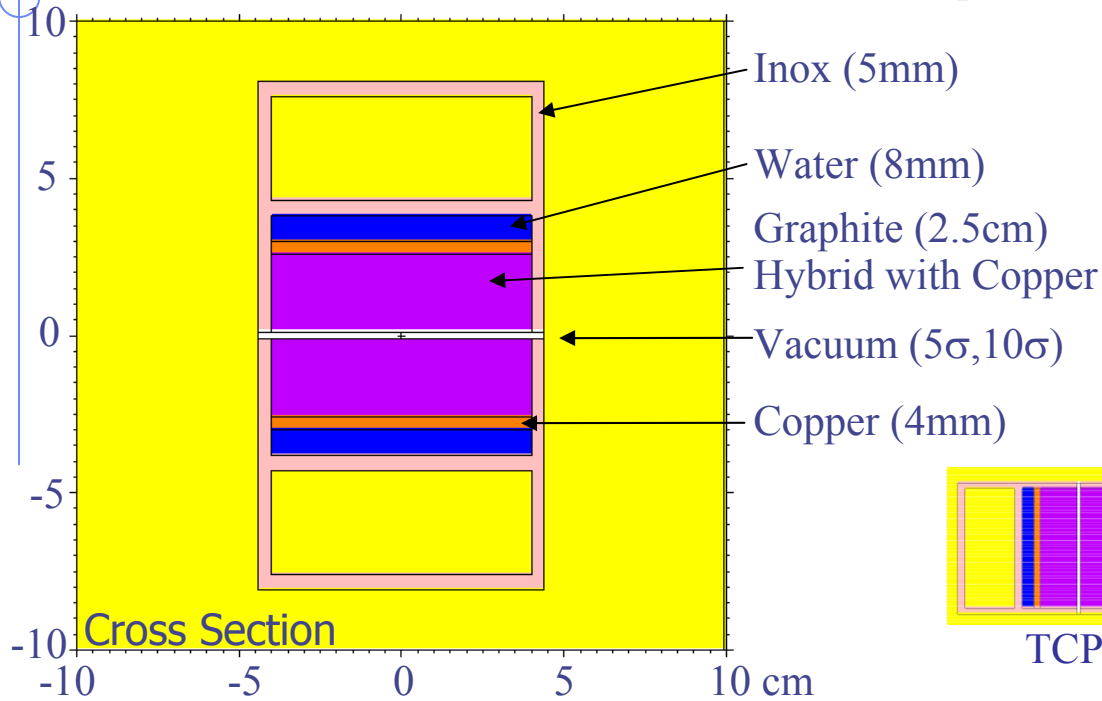
IR7 Geometry

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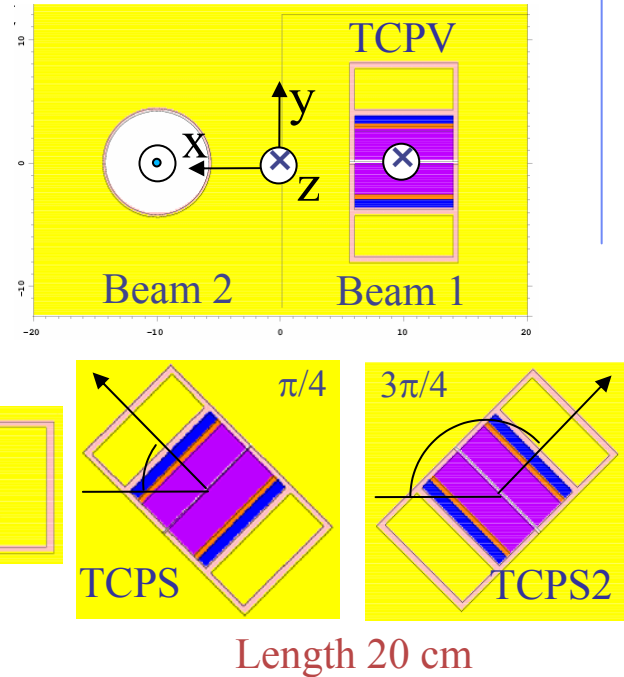
01/05/04 11:39:28
IR7 LHC Collimator - energy
deposition on secondary
collimators
probid = 01/05/04 11:39:26
basis:
( 0.000000, 0.000000, 1.000000)
( 1.000000, 0.000000, 0.000000)
origin:
( 0.00, 0.00, 37000.00)
extent = ( 4000.00, 250.00)
    
```



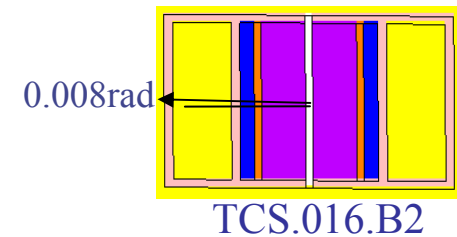
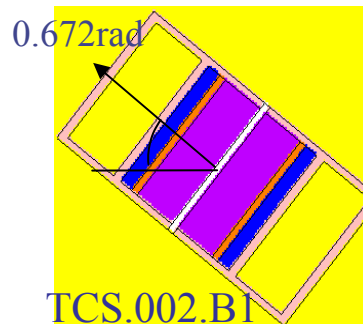
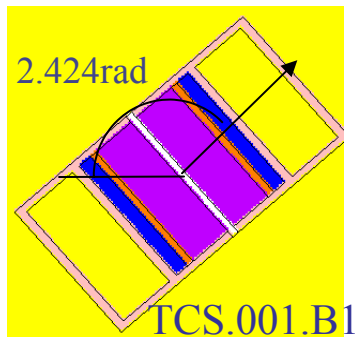
Collimator Geometry



Primary Collimators



Secondary Collimators



Length 120 cm

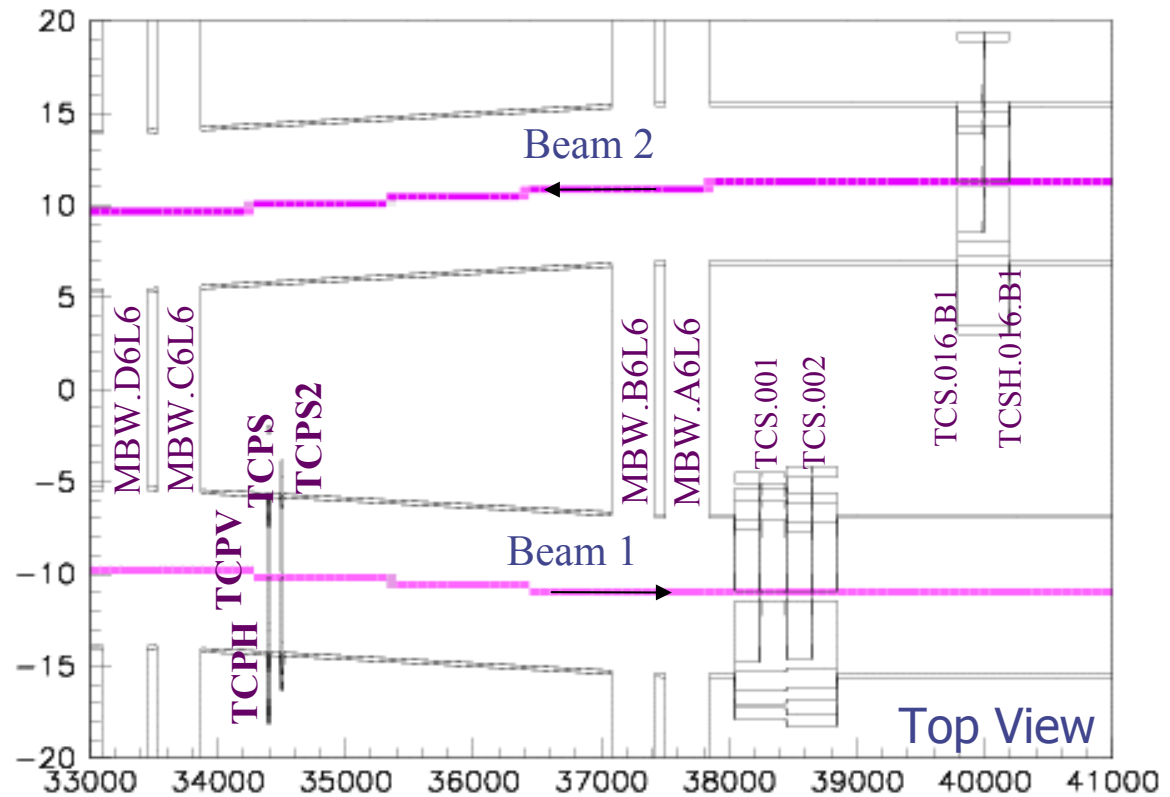
Other items

● Beam Tube

- Material: Copper
- Inner radius: 4.2 cm
- Outer radius: 4.4 cm
- Inside MBW
 - ◆ R_{in} : 2.2 cm
 - ◆ R_{out} : 2.4 cm

● Dogleg Bends

- Modules: 4
 - ◆ MBW.A6L7
 - ◆ MBW.B6L7
 - ◆ MBW.C6L7
 - ◆ MBW.D6L7
- Dimensions: 1.00 x 0.7 x 3.4 m³
- Aperture: 52mm
- Magnetic Field: 1.287 T
- Kick angle: 0.38 mrad



Cases Studied

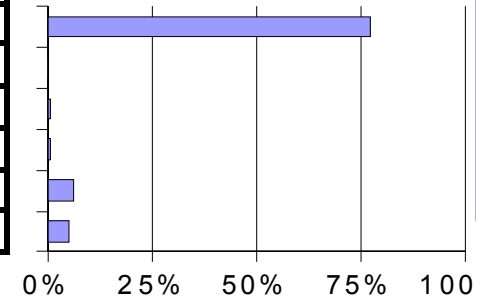
- Proton beam:
 - Momentum 7 TeV/c
 - Impact parameter: 200 nm
 - Pencil-beam on Primaries 1cm before the end (misaligned $\sim 25 \mu\text{rad}$)
 - Pencil-beam on Secondaries at the front face (perfectly aligned)
- 1st phase system (no hybrid collimators)
 - Results are weighted with the loss maps provided by R.Assmann assuming multiple traversals of the beam.
 - 3 cases: Impact at TCPV, TCPH, TCPS
- 2nd phase system (with hybrid collimators)
- Results are given for 0.2 hours beam life time:
Loss rate = 4×10^{11} p/s for 10 s

Loss Maps

TCP 1 $\theta = \pi/2$

Div.x = 0 μ rad
 Div.y = 17 μ rad
 Aperture = 1.22 mm

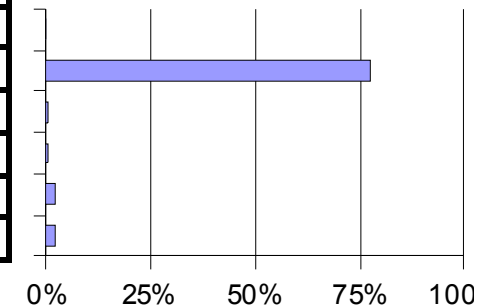
Collimator	# Absorbed	Fraction
Total Abs.	597493	
TCPV	462179	77.35%
TCPH	94	0.02%
TCPS	2079	0.35%
TCPT	2573	0.43%
TCS.001.B1	33867	5.67%
TCS.002.B1	29276	4.90%



TCP 2 $\theta = 0$

Div.x = -22.44 μ rad
 Div.y = 0 μ rad
 Aperture = 1.63 mm

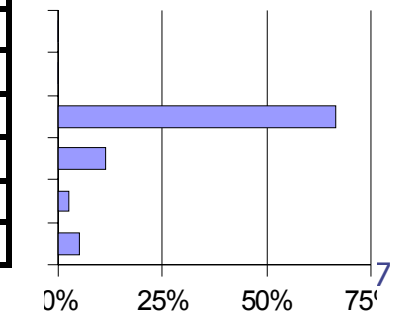
Collimator	# Absorbed	Fraction
Total Abs.	582142	
TCPV	106	0.02%
TCPH	449885	77.28%
TCPS	3980	0.68%
TCPT	3641	0.63%
TCS.001.B1	12518	2.15%
TCS.002.B1	11719	2.01%



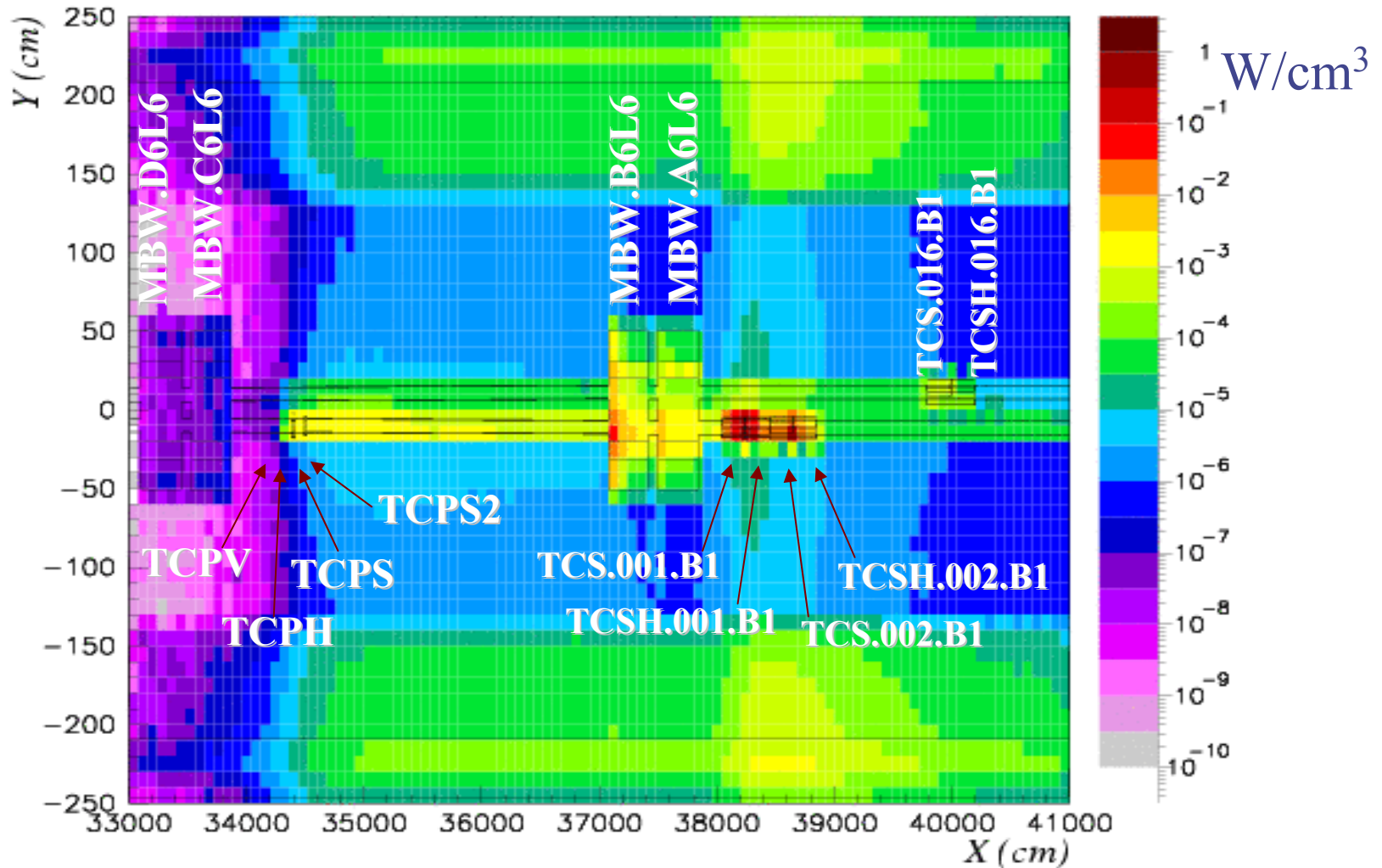
TCP 3 $\theta = 3\pi/2$

Div.x = -15.79 μ rad
 Div.y = 12.39 μ rad
 Aperture = 1.44 mm

Collimator	# Absorbed	Fraction
Total Abs.	460088	
TCPV	193	0.04%
TCPH	424	0.09%
TCPS	307274	66.79%
TCPT	51799	11.26%
TCS.001.B1	11050	2.40%
TCS.002.B1	23888	5.19%

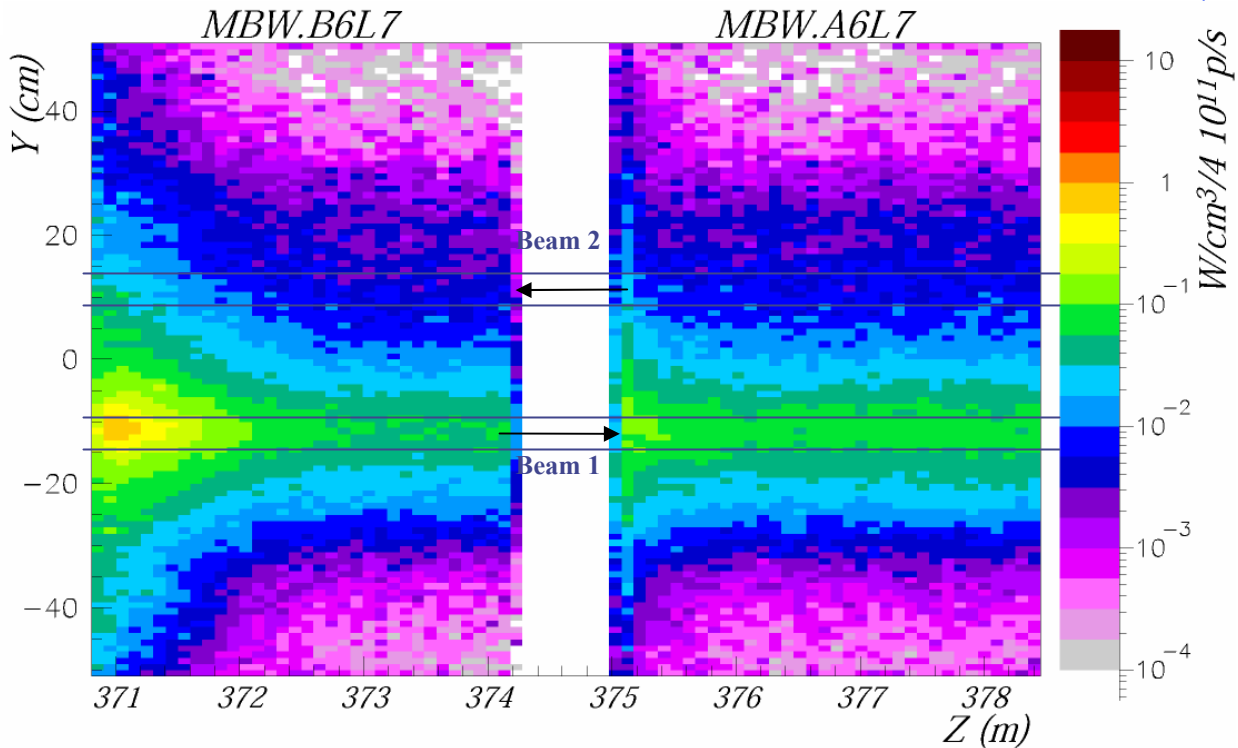
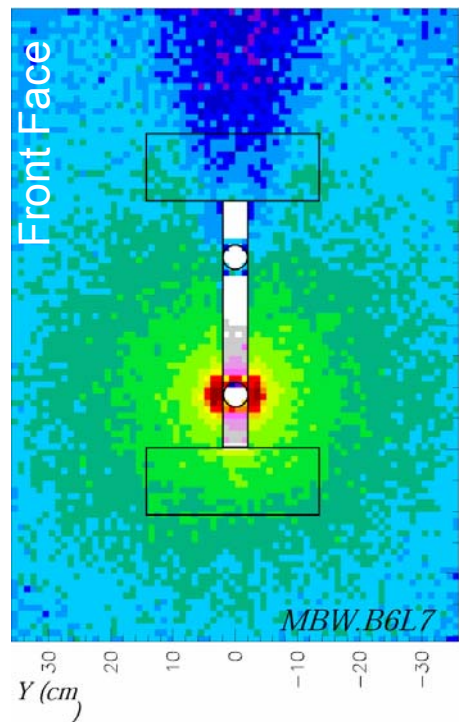


TCPV - Energy deposition



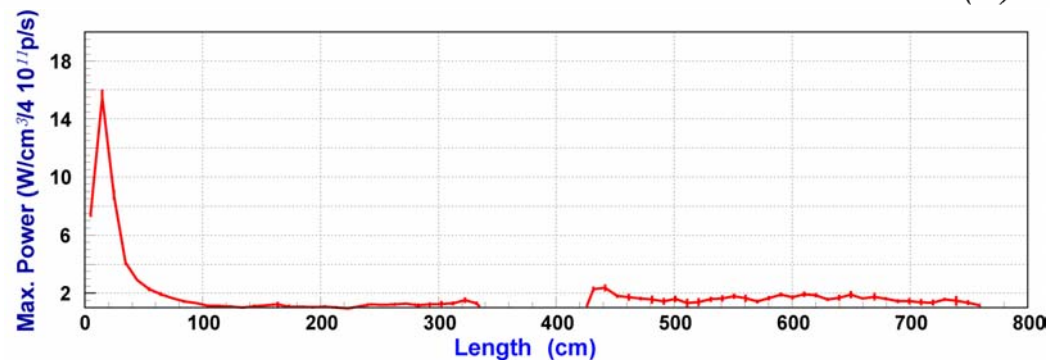
Average energy deposition per 4×10^{11} p/s on tunnel and beam elements for $-1 < Y < 1$ m

Dogleg Bending Magnets (MBW)



Max. Energy deposition for MBW.B6L7

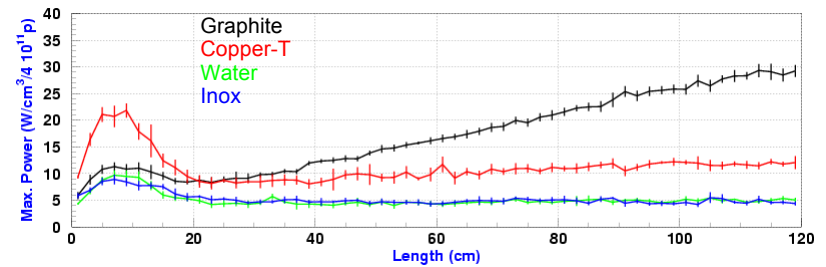
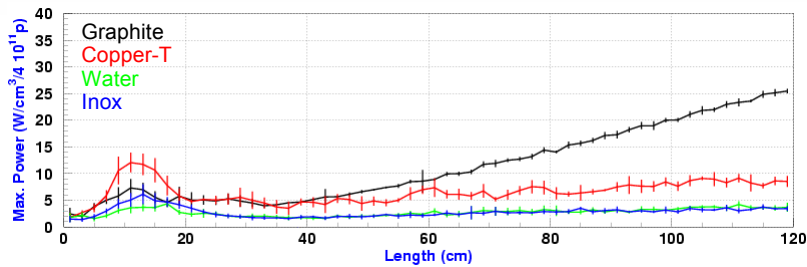
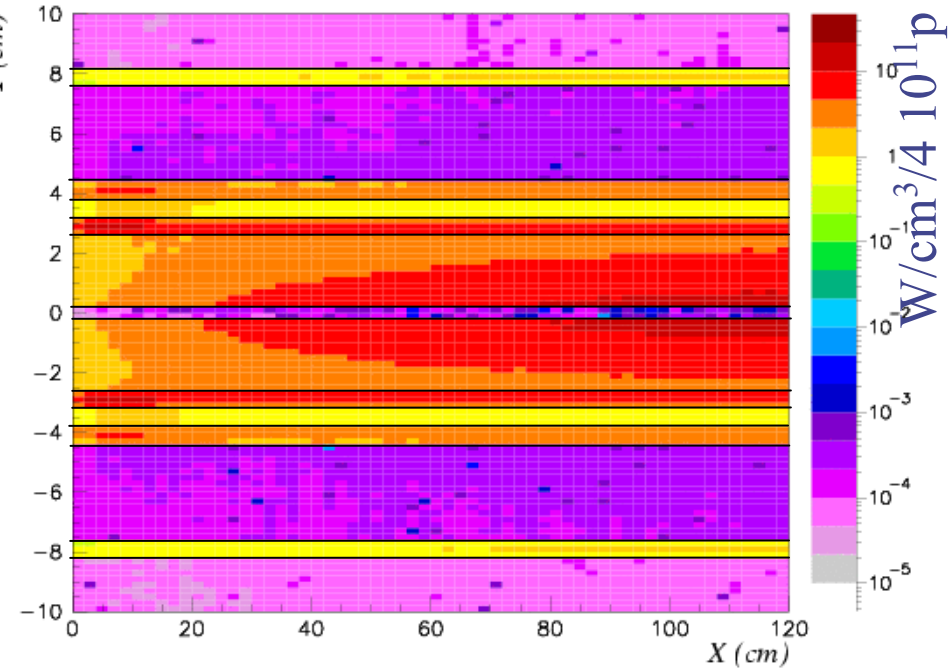
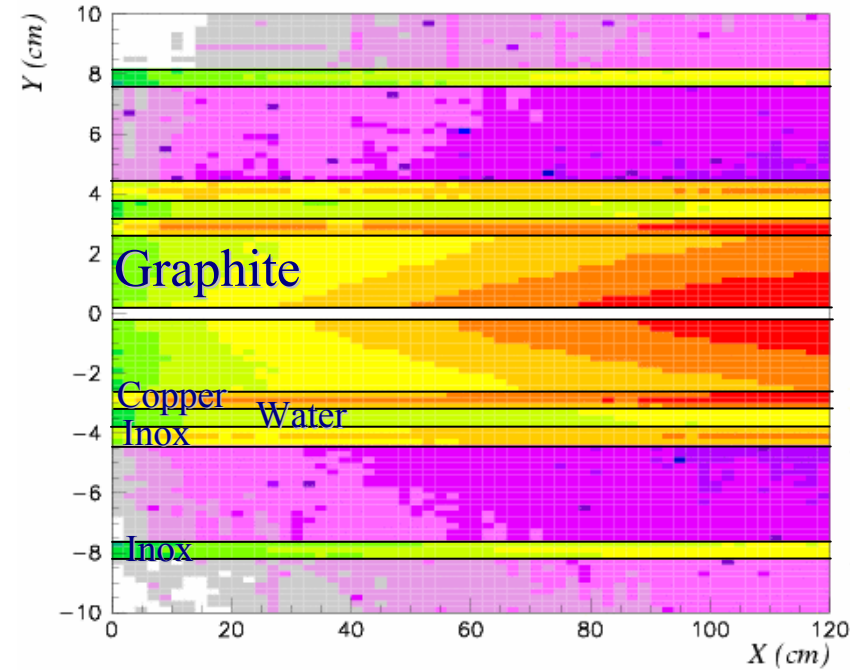
$16 W/cm^3/4 \cdot 10^{11} p/s$



Phase #1: Case TCP1 (TCPV)

TCS.001.B1

TCS.002.B1

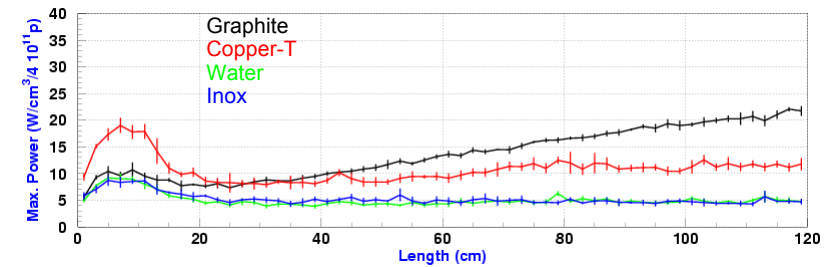
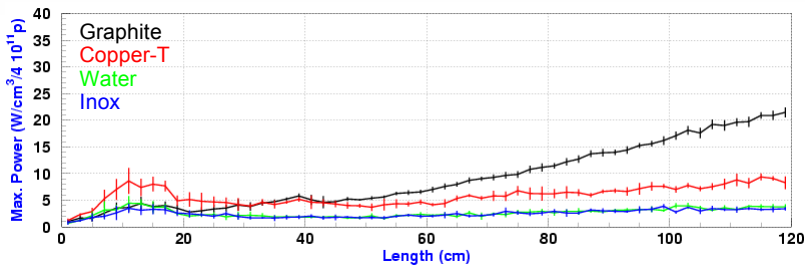
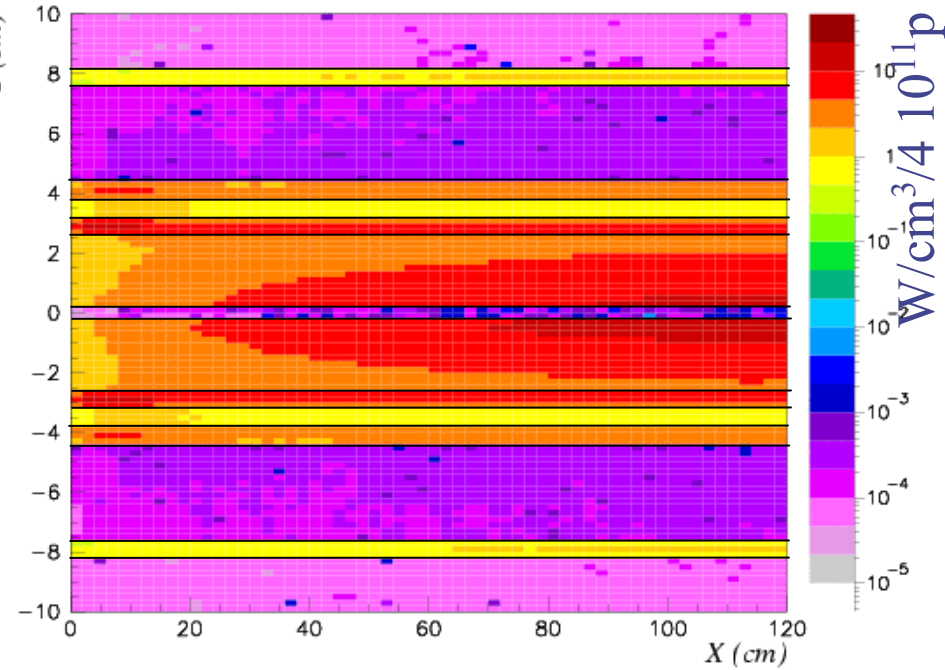
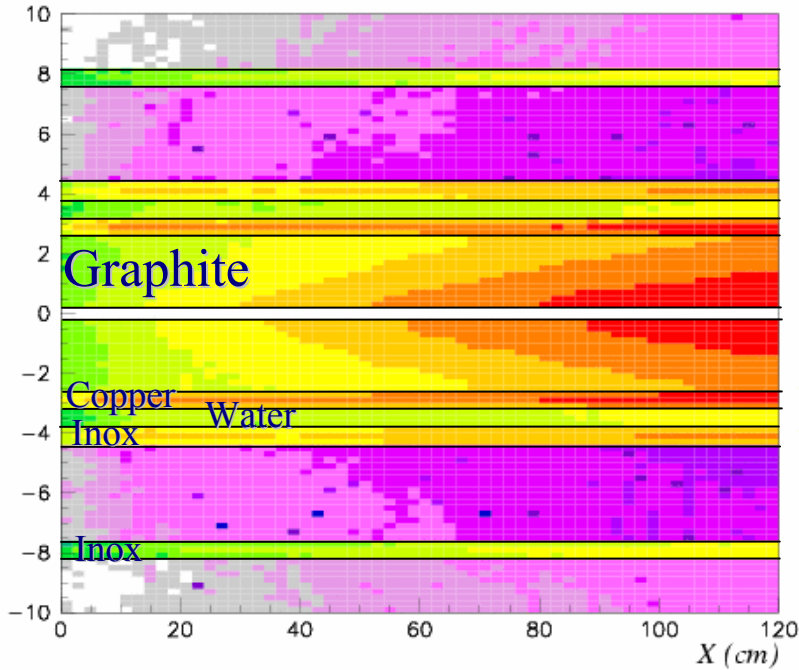


Maximum Energy deposition per 4×10^{11} p/s (0.2 hours beam life time)
on secondary collimators

Phase #1: Case TCP2 (TCPH)

TCS.001.B1

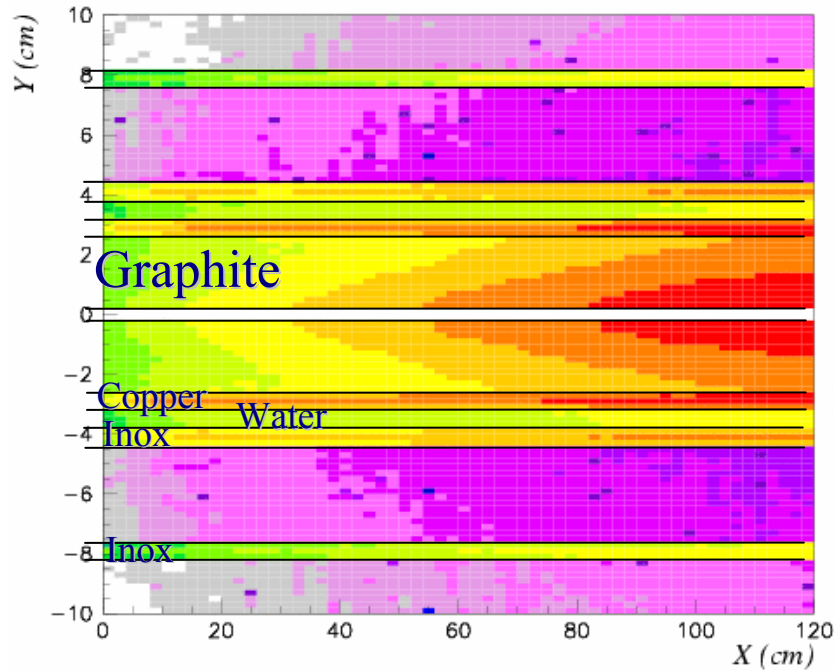
TCS.002.B1



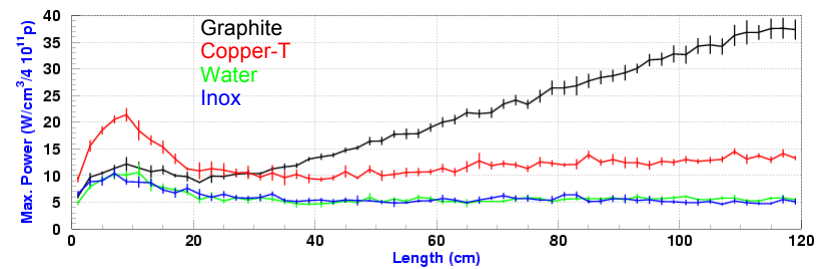
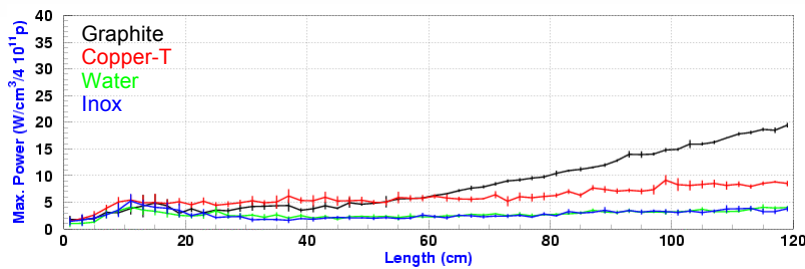
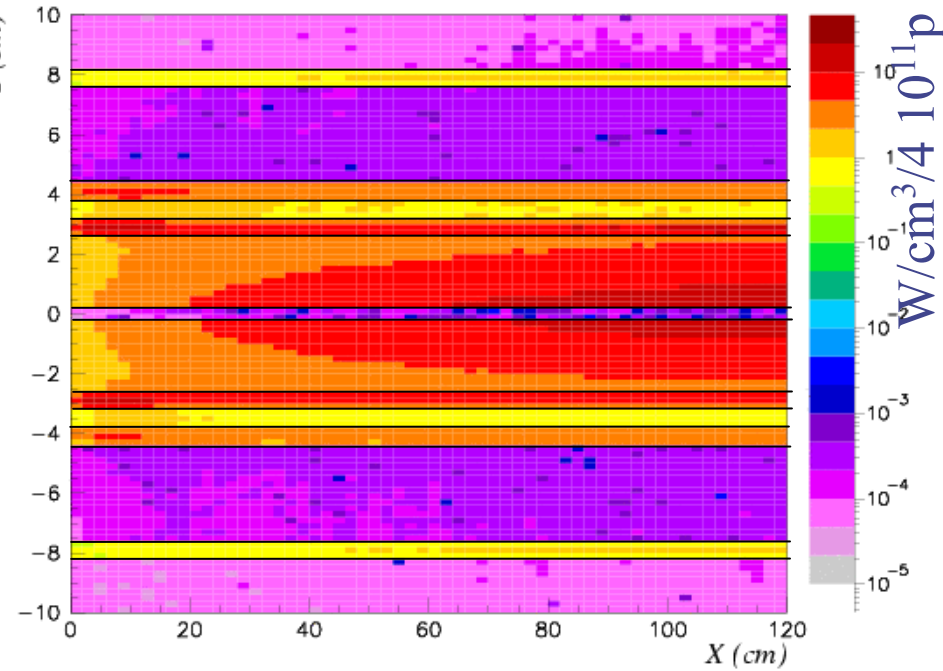
Maximum Energy deposition per 4×10^{11} p/s (0.2 hours beam life time)
on secondary collimators

Phase #1: Case TCP3 (TCPS)

TCS.001.B1

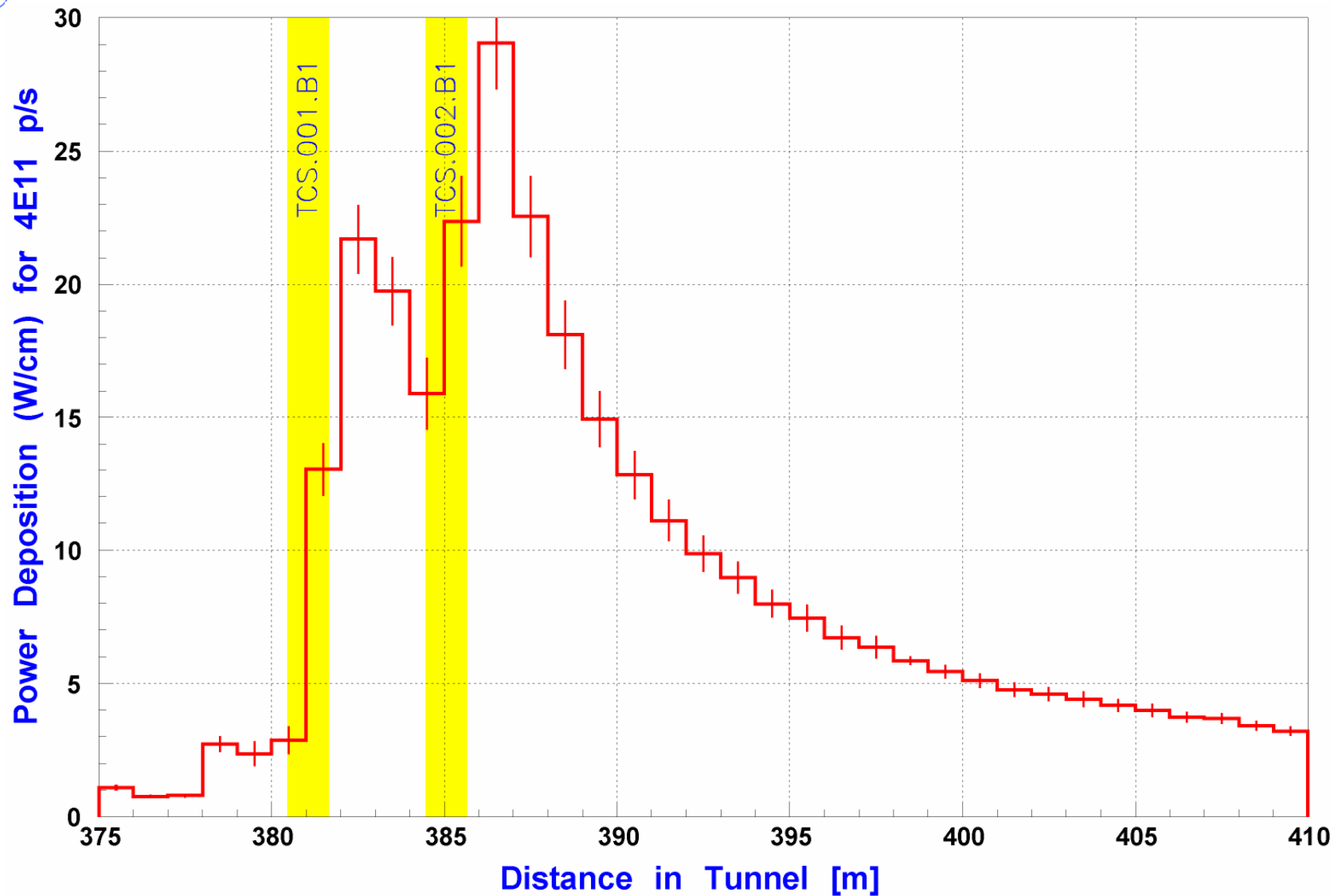


TCS.002.B1



Maximum Energy deposition per 4×10^{11} p/s (0.2 hours beam life time)
on secondary collimators

Phase #1: Beam tube



Phase #1: Power Deposition

		TCP #1		TCP #2		TCP #3	
Collimator	Element	kW/4e11 p	Total	kW/4e11 p	Total	kW/4e11 p	Total
TCS.001.B1	Graphite	6.20	12	6.13	11	6.20	12
	Copper-T	2.26		2.18		2.25	
	Water	0.42		0.41		0.48	
	Inox	2.68		2.66		2.73	
TCS.002.B1	Graphite	17.06	29	17.50	29	18.43	31
	Copper-T	5.00		5.03		5.36	
	Water	1.02		1.05		1.13	
	Inox	5.70		5.76		6.10	
TCS.016.B2	Graphite	0.00	0	0.00	0	0.08	0
	Copper-T	0.00		0.00		0.08	
	Water	0.00		0.00		0.00	
	Inox	0.17		0.16		0.17	

Phase #1: Power Distribution

- Total power intercepted **233 kW (52%)** +Tunnel Remaining 48% energy escapes downstream

130 kW (30%) on beam elements

- MBW
 - Iron: **21 kW**, 9.5 kW
 - Copper **6 kW**, 1.5 kW
- Beam Tubes
 - Beam1: **34 kW**
 - Beam2: 2.4 kW

- Primary Collimators

- TCPV: 10 W
- TCPH: 290 W
- TCPS: 700 W
- TCPS2: **1.7 kW**

- Secondary Collimators

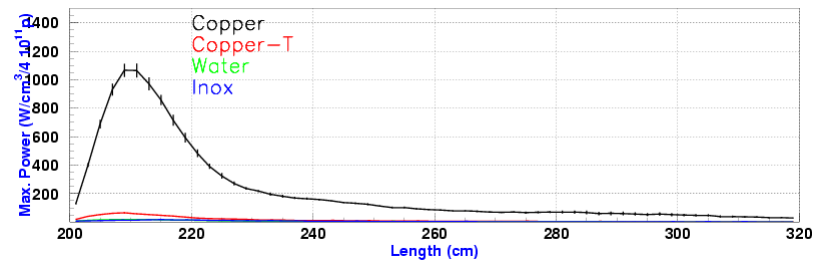
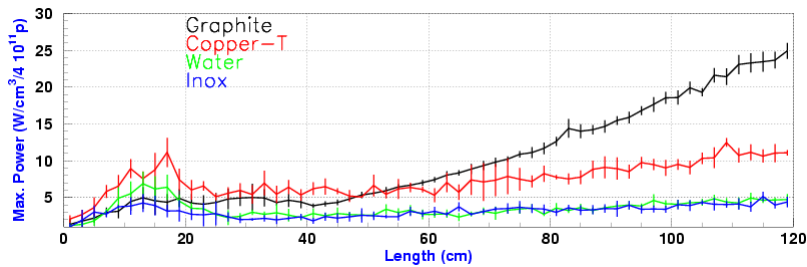
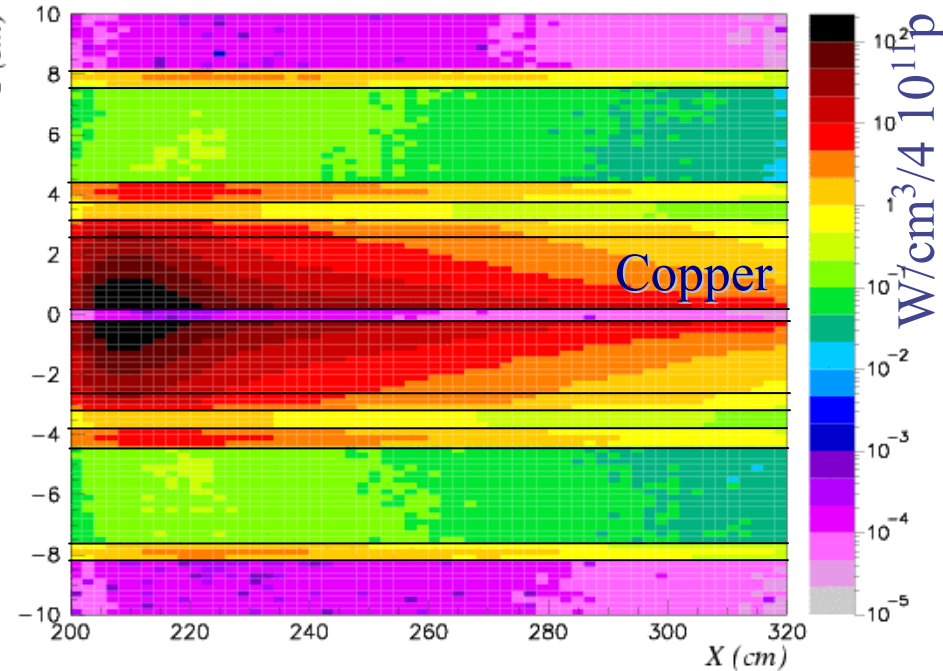
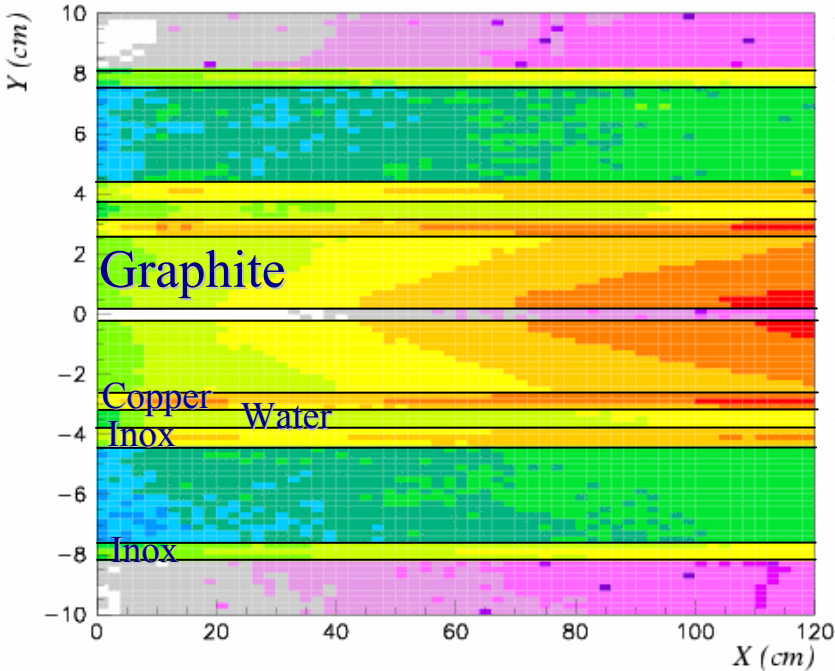
- TCS.001.B1 12 kW
- TCS.002.B1 **27 kW**
- TCS.003.B1 245 W

- Motors < 200 W

Phase #2: With Hybrid

TCS.001.B1

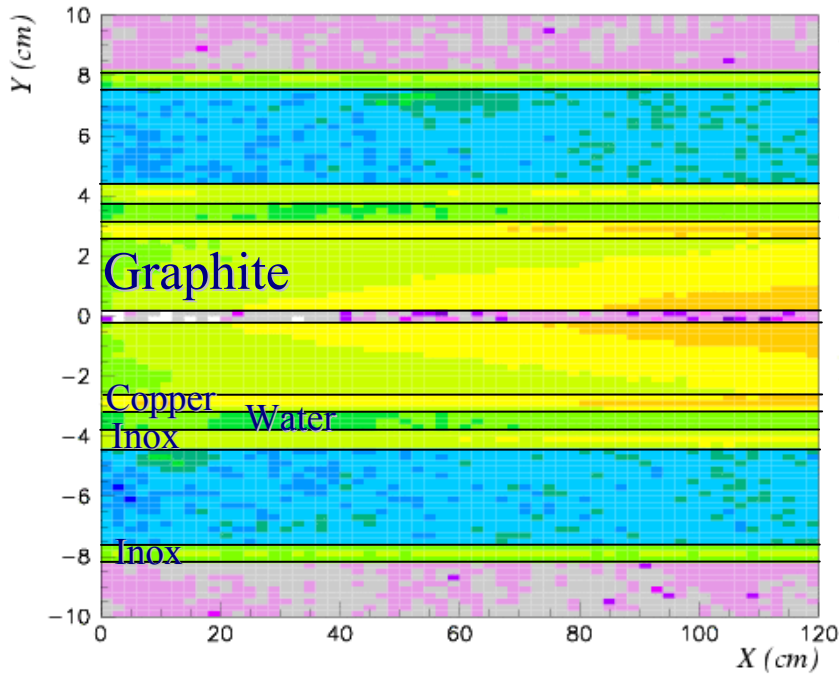
TCSH.001.B1



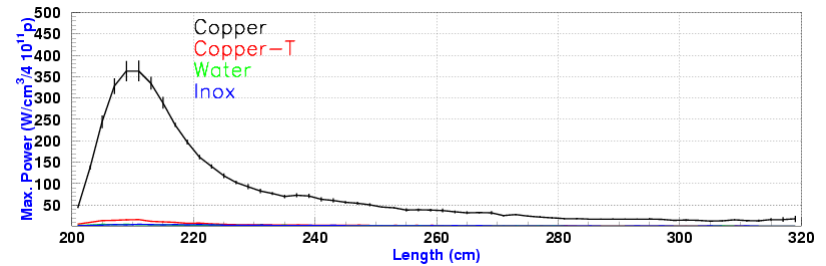
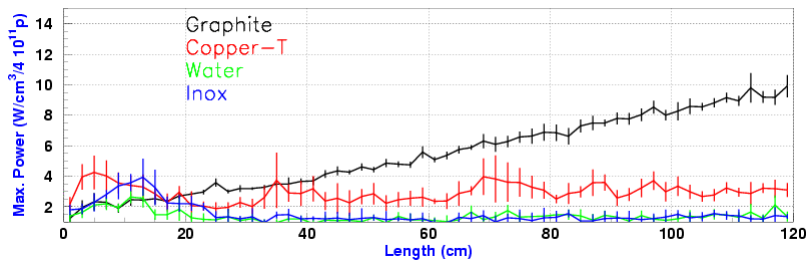
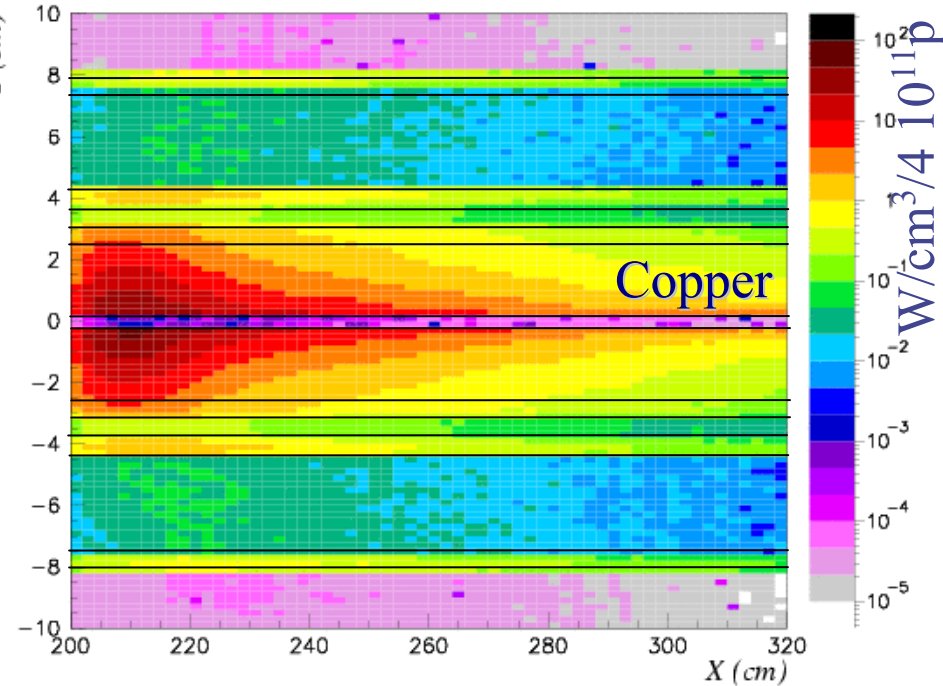
Maximum Energy deposition per 4×10^{11} p/s (0.2 hours beam life time)
on secondary collimators

Phase #2: With Hybrid (cont)

TCS.002.B1

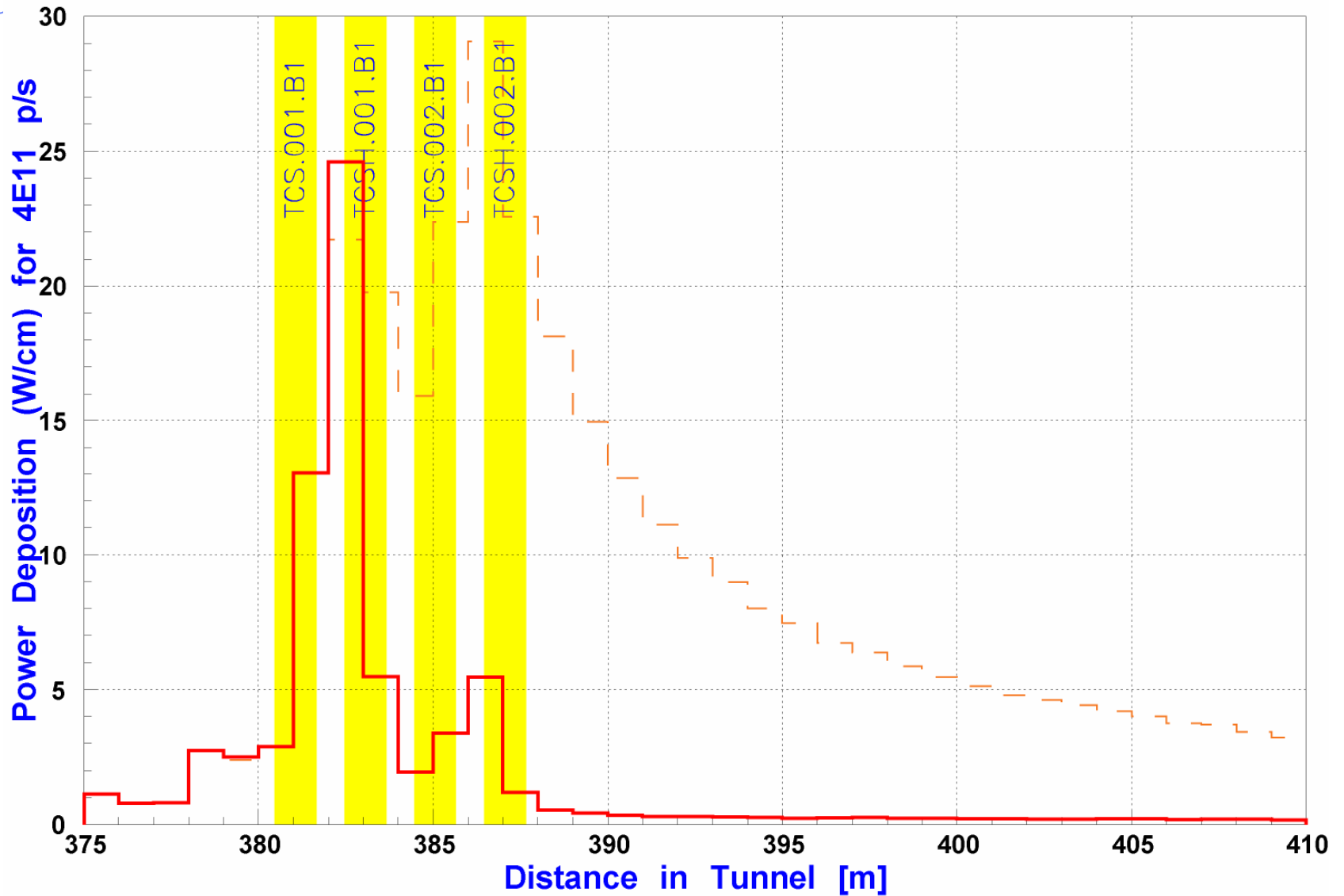


TCSH.002.B1



Maximum Energy deposition per 4×10^{11} p/s (0.2 hours beam life time)
on secondary collimators

Phase #2: Beam tube



Phase #2: Power Deposition

- Total power intercepted **363 kW (81%)** + Tunnel Remaining 19% energy escapes downstream

247 kW (55%) on beam elements

- Beam Tubes
 - Beam1: **14 kW**
 - Beam2: **1.8 kW**

Collimator	Element	GeV/p	%	kW/4e11 p	Total
TCS.001.B1	Graphite	2.77	0.54	7.50	14
	Copper-T	1.01	1.41	2.70	
	Water	0.2	1.69	0.50	
	Inox	1.22	0.77	3.30	
TCSH.001.B1	Copper	42.97	0.69	116.60	130
	Copper-T	1.71	0.50	4.70	
	Water	0.41	0.79	1.10	
	Inox	2.73	0.52	7.40	
TCS.002.B1	Graphite	1.06	1.98	2.90	5
	Copper-T	0.32	2.00	0.90	
	Water	0.07	1.29	0.20	
	Inox	0.44	1.42	1.20	
TCSH.002.B1	Copper	9.83	2.64	26.70	30
	Copper-T	0.35	1.90	1.00	
	Water	0.09	2.31	0.20	
	Inox	6.05E-001	2.03	1.60	
TCS.016.B2	Graphite	8.23E-003	8.45	0.00	0
	Copper-T	8.44E-003	9.38	0.00	
	Water	2.20E-003	4.92	0.00	
	Inox	2.14E-002	6.76	0.10	
TCSH.016.B2	Copper	1.66E-002	16.13	0.00	0
	Copper-T	2.94E-003	5.80	0.00	
	Water	1.13E-003	6.93	0.00	
	Inox	1.23E-002	4.03	0.00	

Results

- Collimators intercept the largest fraction of the energy
 - For hadron-nucleon interaction at these energies one expect a $P_t=350$ MeV/c
 - For hadron-nucleus interaction we have $P_t=400-500$ MeV/c thus $P_t/P=100$ μrad (4 mm at 40m)
 - Structural elements (i.e. MBW, flanges...) around the beam tube do not affect much the development of the shower
- Phase #1 (no hybrid)
 - Results are weighted with the loss map
 - TCS.002.B1 ~ 30 kW
 - No significant difference between the various cases
 - Energy deposition on beam pipe peaks ~ 30 W/cm
- Phase #2 (with hybrid)
 - TCSH.001.B1 130 kW!
 - Pending: Loss map weighting