Collimation set-up for ion commissioning: initial studies

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Stage I: From start to first collisions of Early Ion Beam

		Ring factor	Total Time [days] both rings	Comments
I1	Injection and first turn	2	0.25	Magnetically identical to protons; 1 bunch/beam.
I2	Circulating beam	2	0.25	Magnetically identical to protons. Synchronisation of transfer lines and RF capture at -5 kHz frequency shift. Check lifetime in particular (IBS?).
I3	450 Z GeV initial commissioning	2	0.25	Beam instrumentation slightly different. Optics OK.
I4	450 Z GeV optics measurements	2	.5	Magnetically identical to protons but do minimal check.
I6	450 Z GeV - two beams	1	.5	>0.4 nominal bunch intensity, otherwise magnetically identical to protons.
I7	Collisions at 450 Z GeV	1	1 ?	If interesting. Performance to summarise.
I8	Snapback and ramp	2	0.5	Single and then two beams, Magnetically identical to protons. Check beam dump at various energies
I9	7 Z TeV flat top checks	2	0.5	Single beam initially, performed f… …ful ramp
I12	Commission experimental magnets			Included already since d…
I10	Setup for collisions - 7 Z TeV	1	0.5	
	Physics un-squeezed	1	-	Zero cr… …n CMS & ATLAS. LHCb s…
	TOTAL to first collisions		6	
I11	Commission squeeze	2		…e of ALICE to same as presently achieved …TLAS (with ATLAS and CMS unsqueezed). May …started with protons. Check separation. …de CMS & ATLAS squeeze depending on time.
I5	Increase intensity	2		Increase bunch number to 62 (Early Scheme).
	Set-up physics - partially squeezed.	1	2	
	Pilot physics run			Parasitic measurements during physics (BLMs, ...) of great interes

J Jowett, Feb 2009
To be updated!!!

Early ion beam parameters:

		Injection	3.5TeV collisions
Lead ion energy	GeV	36900	287000
Energy/nucleon	GeV	177.4	1380
Rel gamma		190.5	1482
N. ions/bunch		7E7	
N. bunches		62	
Transverse norm. emittances	μm	1.5	1.5
Stored energy	MJ	0.0256	0.1993

$$Ql = 2\times10^{8}\left[\frac{E}{TeV}\right]^{-1.64} \text{ p/m/s [B.Dehning]}$$

~ 14 W/m

Energy [GeV/u]	Quench limit [W/m]
177	53.4
800	20.35
1450	13.90
2100	10.97
2760	9.21

Injection optics:
zero crossing angles, zero separation bumps, on_alice:=2;on_lhcb:=0; ???

β^*(IP1) =11m β^*(IP2) = 10m β^*(IP5) = 11m β^*(IP8) = 10m

Collision optics:
zero crossing angles, zero separation bumps, on_alice:=2;on_lhcb:=0;

1) β^*(IP1) =2m β^*(IP2) = 2m β^*(IP5) =2m β^*(IP8) = 10m

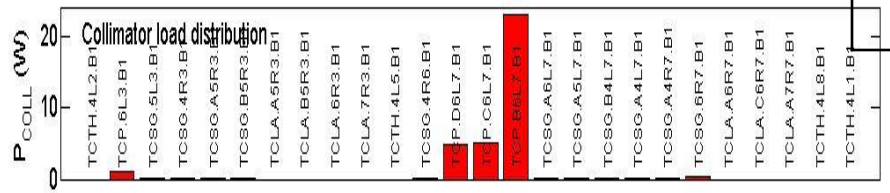
2) β^*(IP1) = 3.5m β^*(IP2) = 3.5m β^*(IP5) = 3.5m β^*(IP8) = 10m

Minimal changes from machine ‘proton’ configuration: transparent switch – as much as possible!

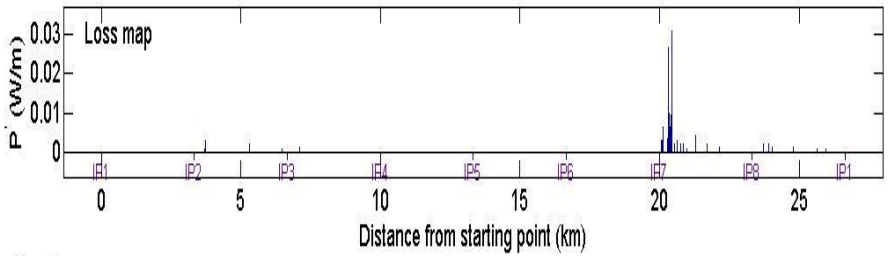
First setup:

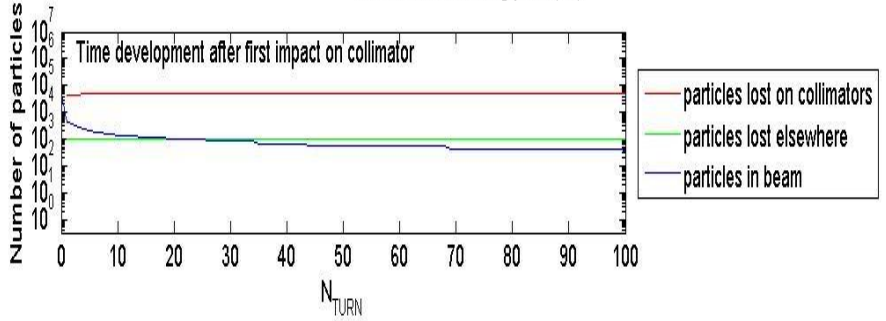
Beam1, betatron collimation
Injection 450GeV/A, 12min lifetime

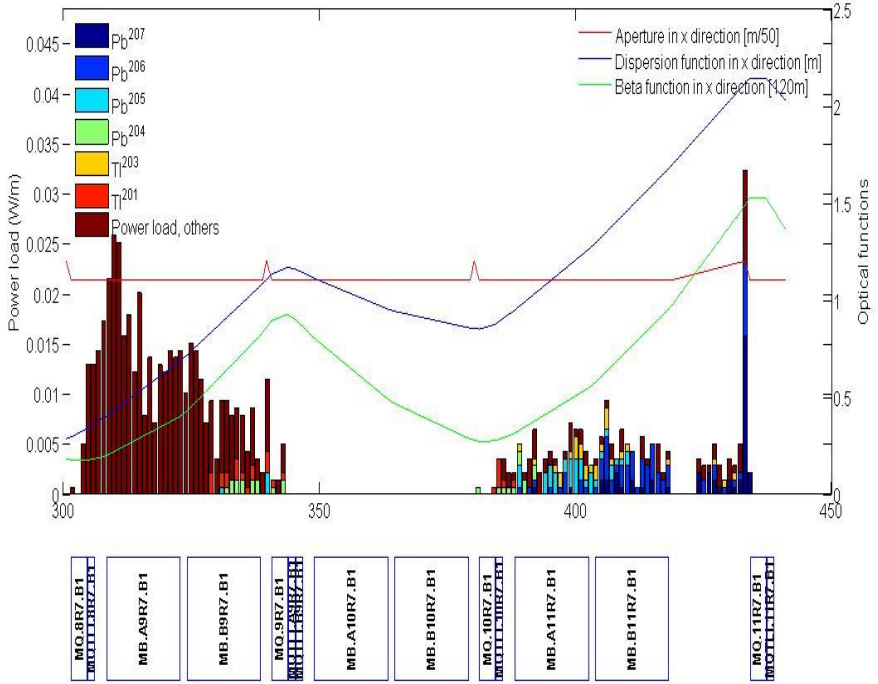
TCP IR7	5.7 σ	TCP IR3	8 σ
TCSG IR7	6.7 σ	TCSG IR3	9.3 σ
TCLA IR7	10 σ	TCLA IR3	10 σ
		TCTs	15/25 σ



Some losses distributed outside IR7 DS, < 0.05 W/m level
Max load on TCP.B6L7.B1 = 22.8W







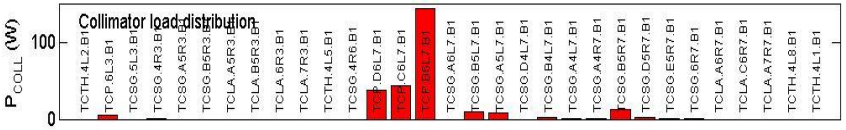
η= Σ aperture hits/Σ collimator hits= 0.022

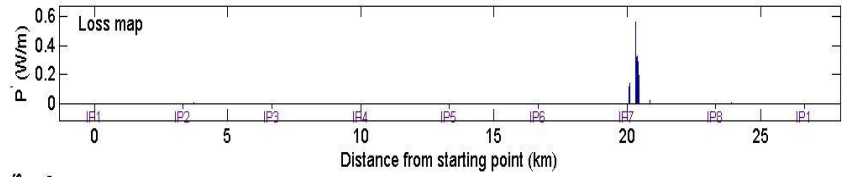
First setup:

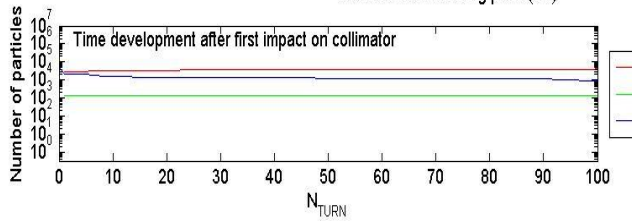
Beam1, betatron collimation

E=3.5TeV/A, β^* =2m, 12min lifetime

TCP IR7	6 σ	TCP IR3	15 σ
TCSG IR7	8.8 σ	TCSG IR3	18 σ
TCLA IR7	INJECTION	TCLA IR3	INJECTION
		TCTs	12.8 σ

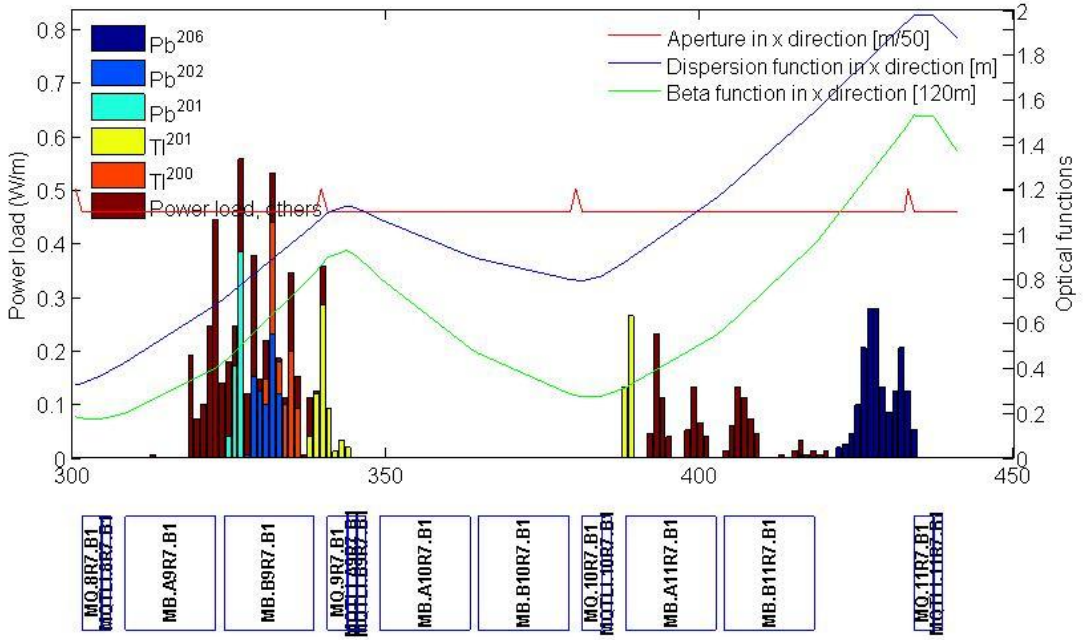






No losses outside IR7 DS

Max load on TCP.B6L7.B1=120W



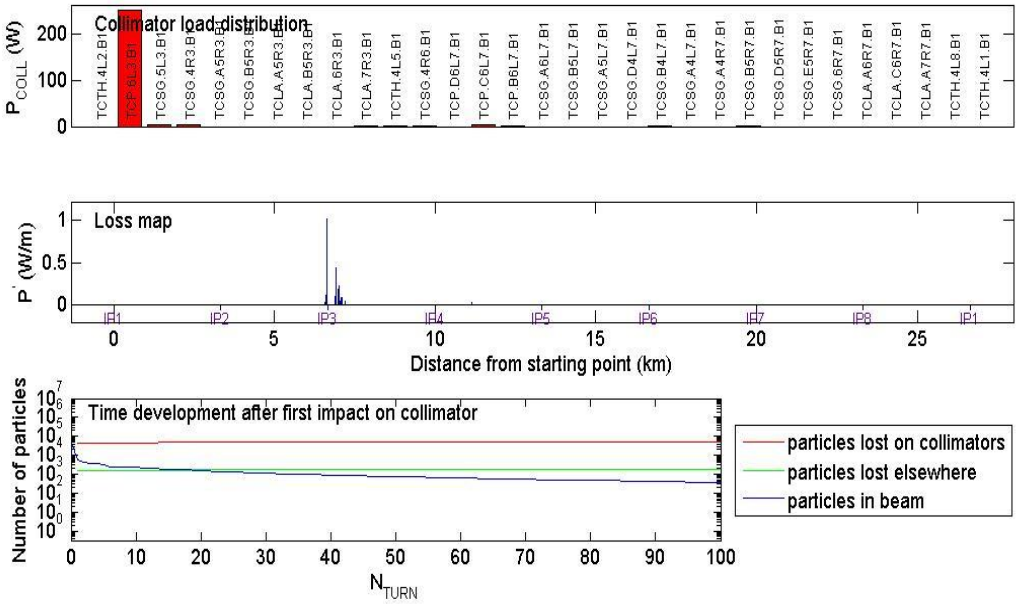
DS aperture: <1W/m losses

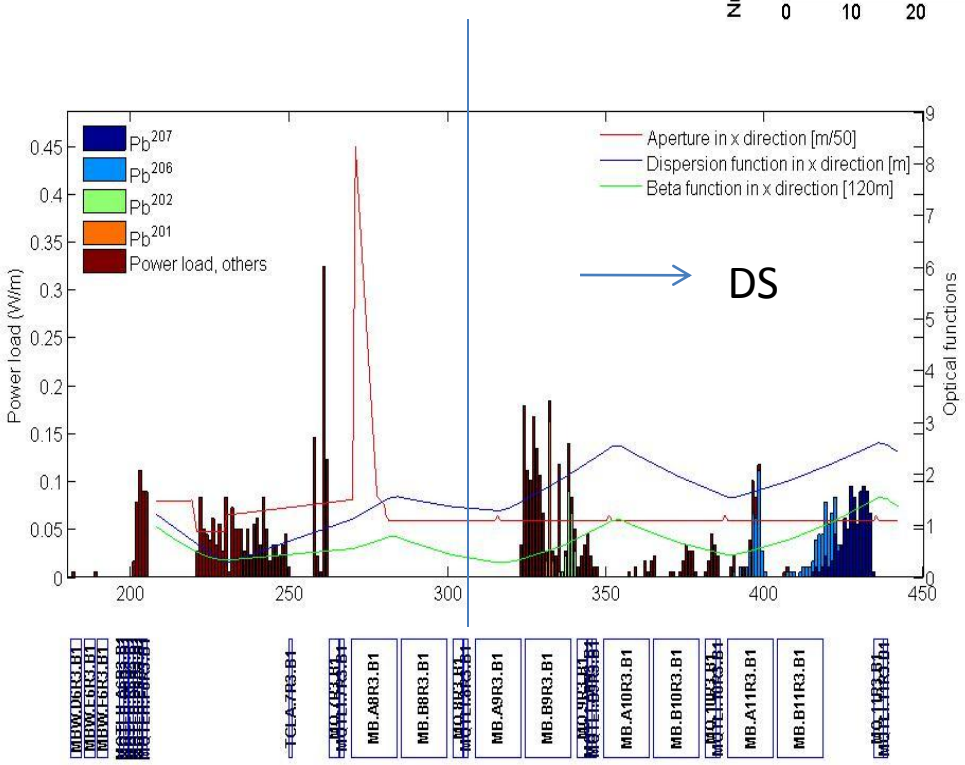
$\eta = \Sigma$ aperture hits/Σ collimator hits= 0.035

Beam1, momentum collimation
E=3.5TeV/A, β* =2m, 12min lifetime

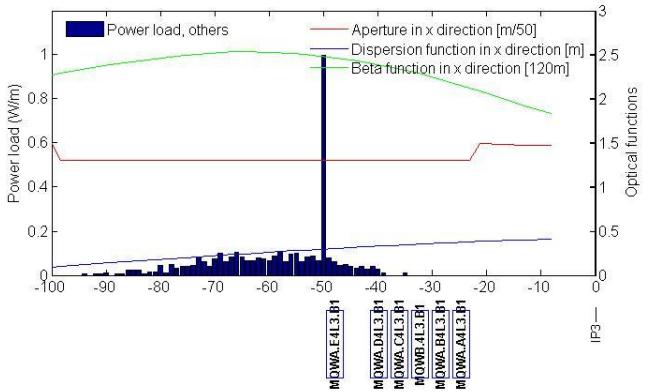
Max load on TCP.6L3.B1=250W

Σaperture hits/Σ collimator hits= η= 0.038



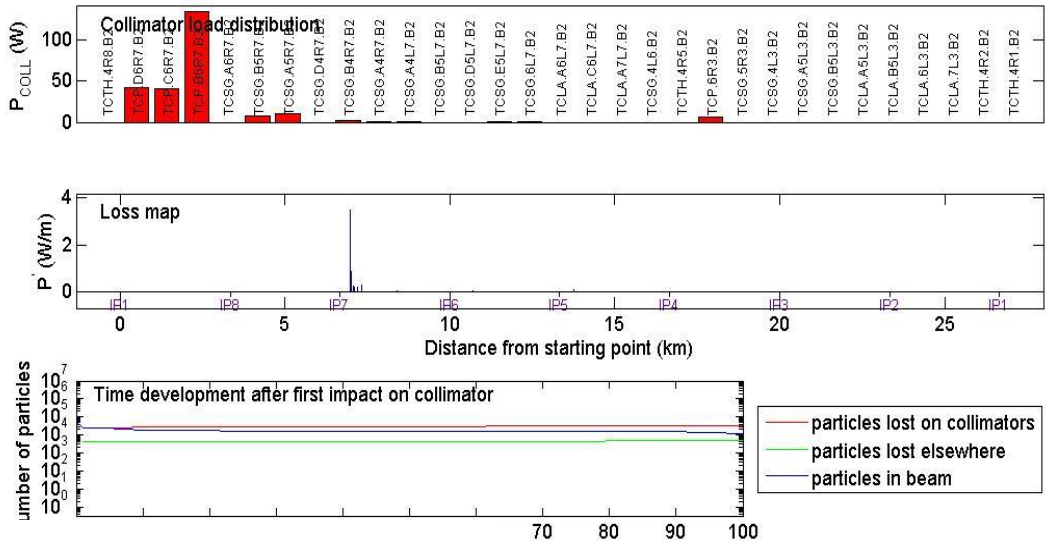


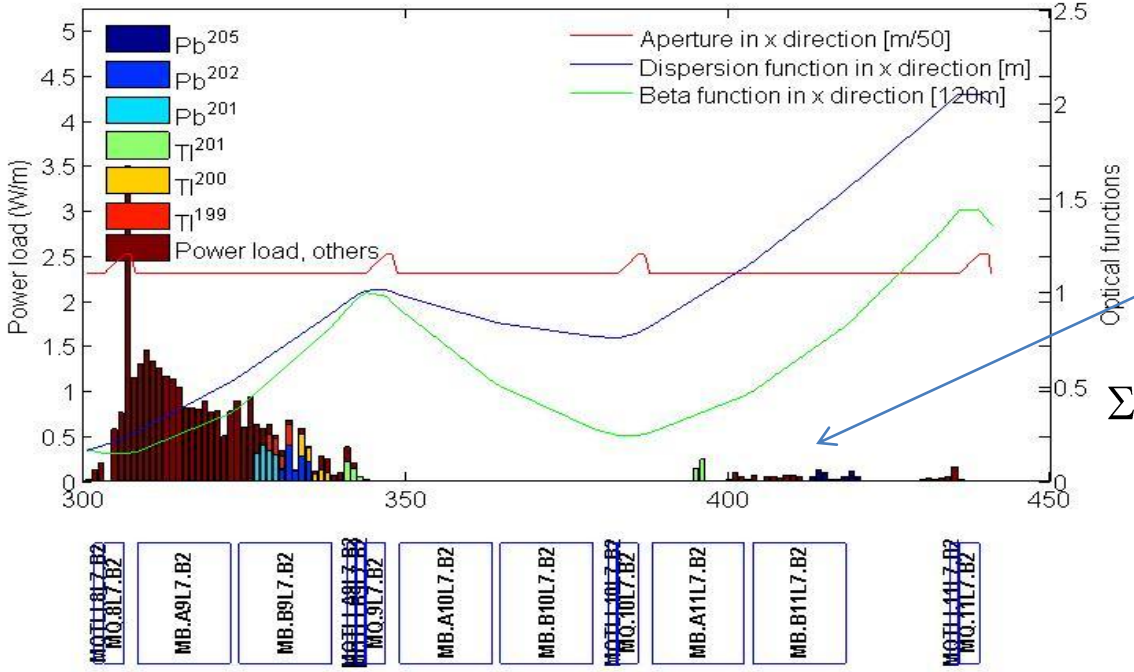
Losses before IP3



Beam2, betatron collimation
E=3.5TeV/A, β* =2m, 12min lifetime

Max load on TCP.B6R7.B1=103W





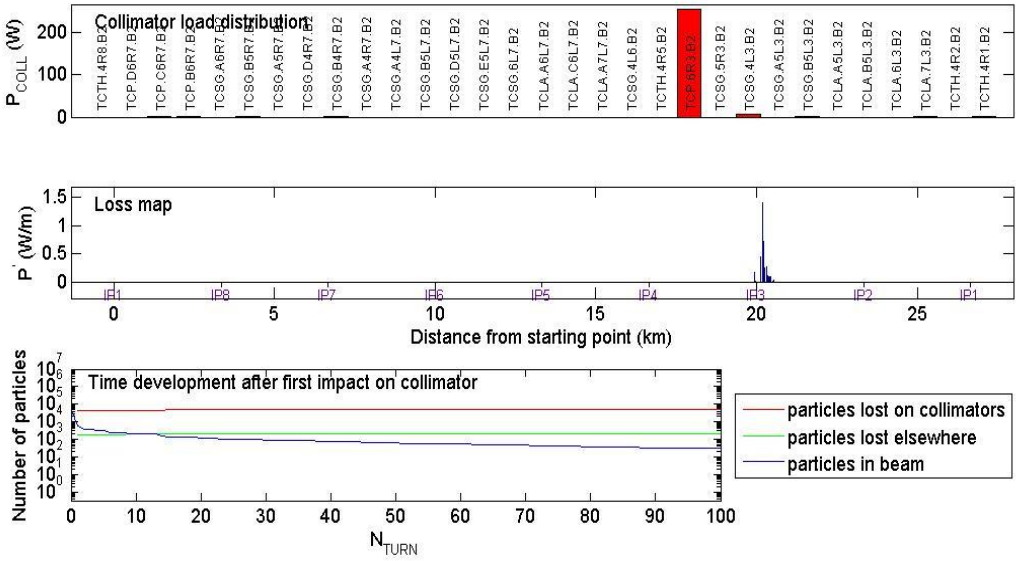
Near zero dispersion at TCPs

Σaperture hits/Σ collimator hits=
η= 0.14

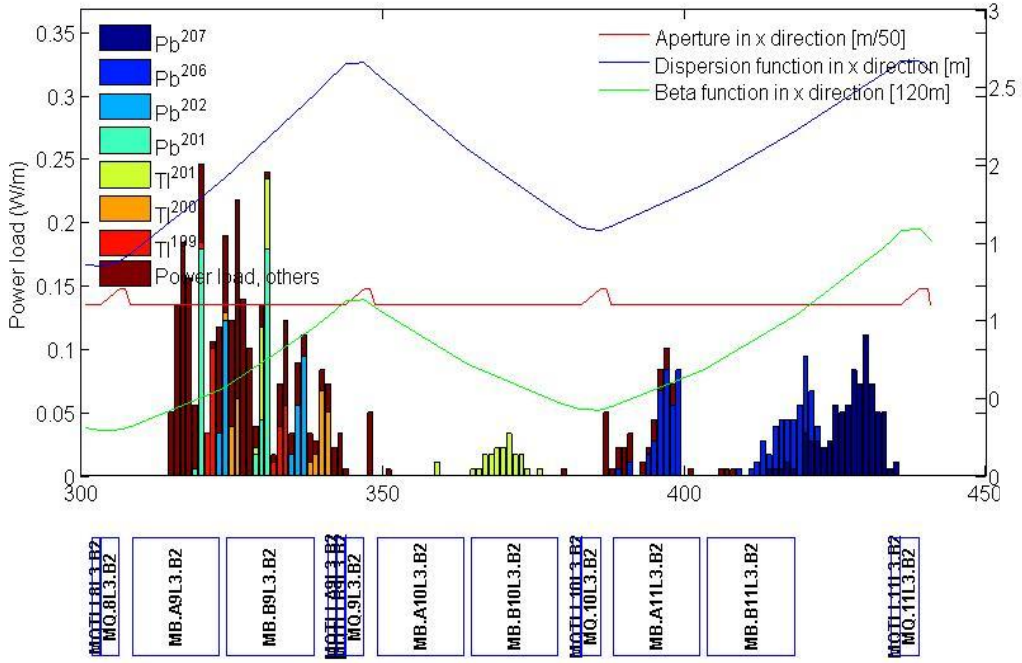
Beam2, momentum collimation
E=3.5TeV/A, β* =2m, 12min lifetime

Max load on TCP.6R3.B2=254W

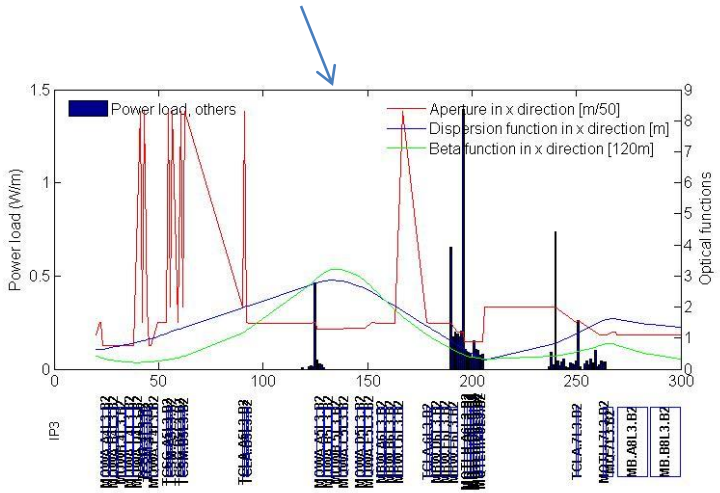
Σaperture hits/Σ collimator hits=
η= 0.045



IR3 DS

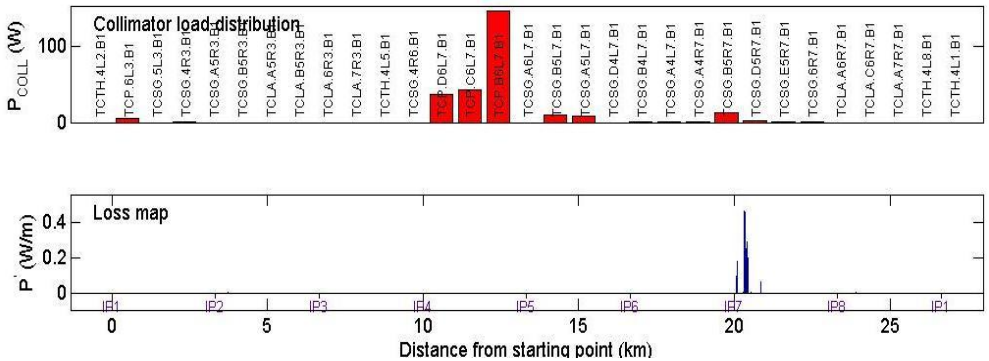


Losses near IP3



Beam1, betatron collimation
E=3.5TeV/A, β* =3.5m, 12min lifetime

TCP IR7	5.7 σ	TCP IR3	12 σ
TCSG IR7	8.5 σ	TCSG IR3	15.6 σ
TCLA IR7	17.7 σ	TCLA IR3	17.6 σ
		TCTs	15 σ

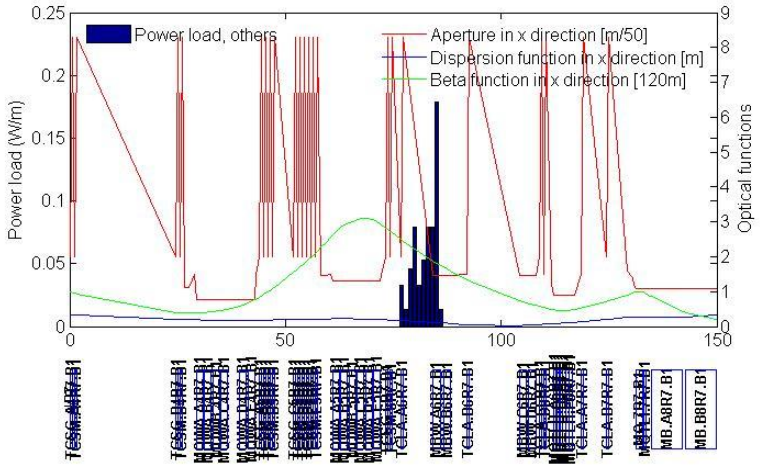


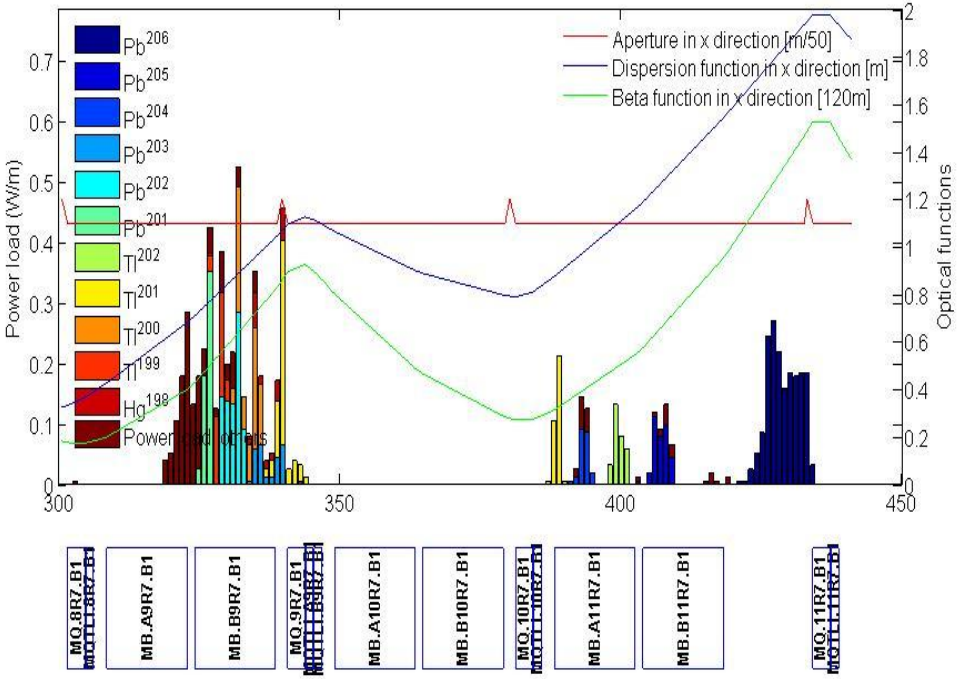
Σ aperture hits/Σ collimator hits= η= 0.033

losses < 0.5 W/m

Max load on TCP.B6L7.B1=122W

Some losses before DS



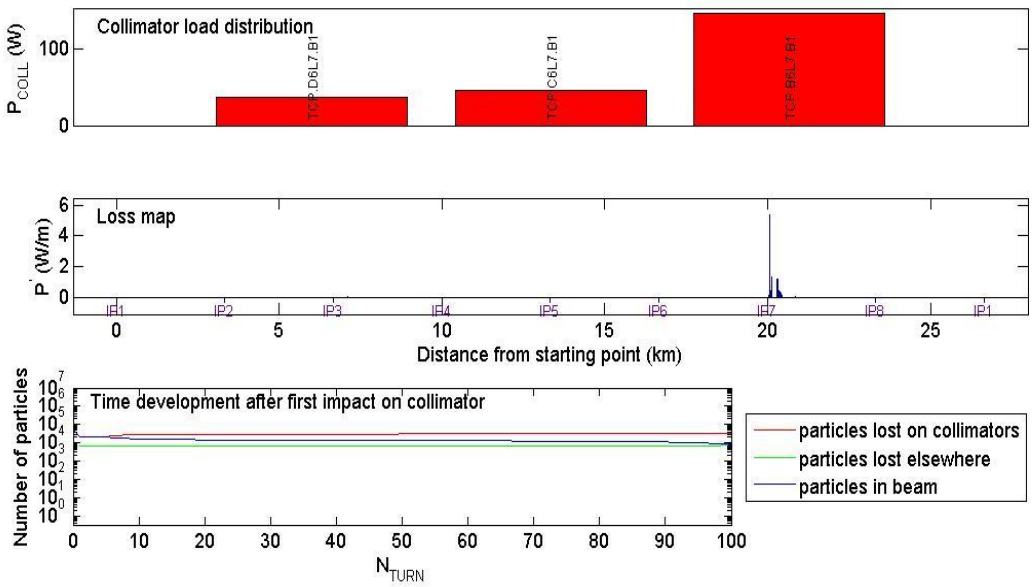


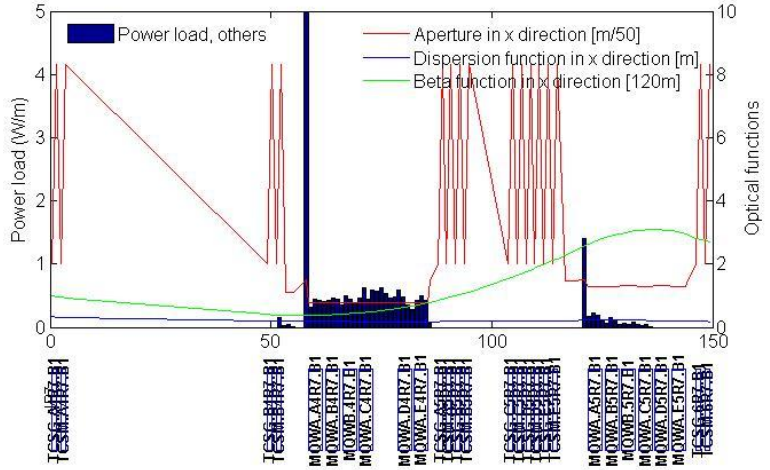
only TCPs at 5.7 σ

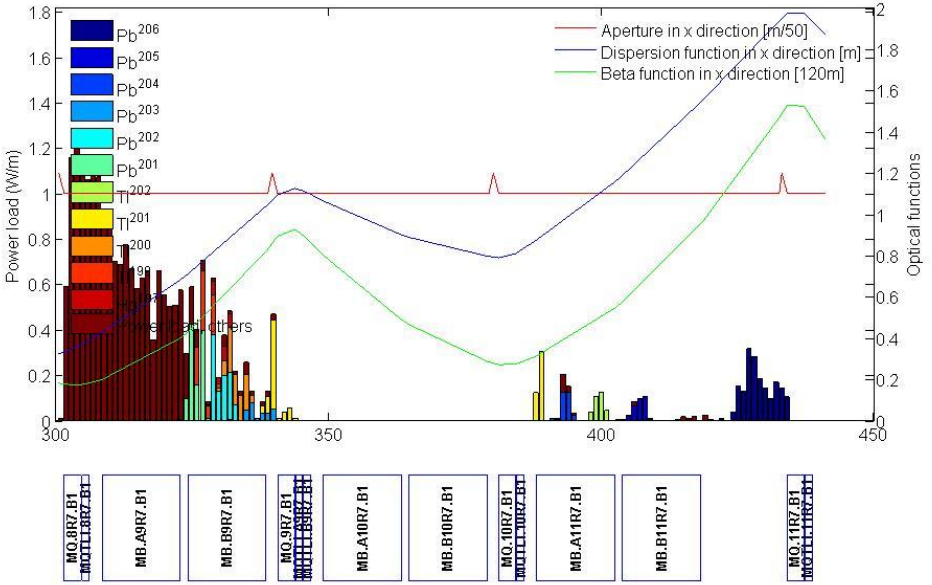
Beam1, betatron collimation
E=3.5TeV/A, β* =3.5m, 12min lifetime

Σ aperture hits/Σ collimator hits=
η= 0.205

Max load on TCP.B6L7.B1=122.5W



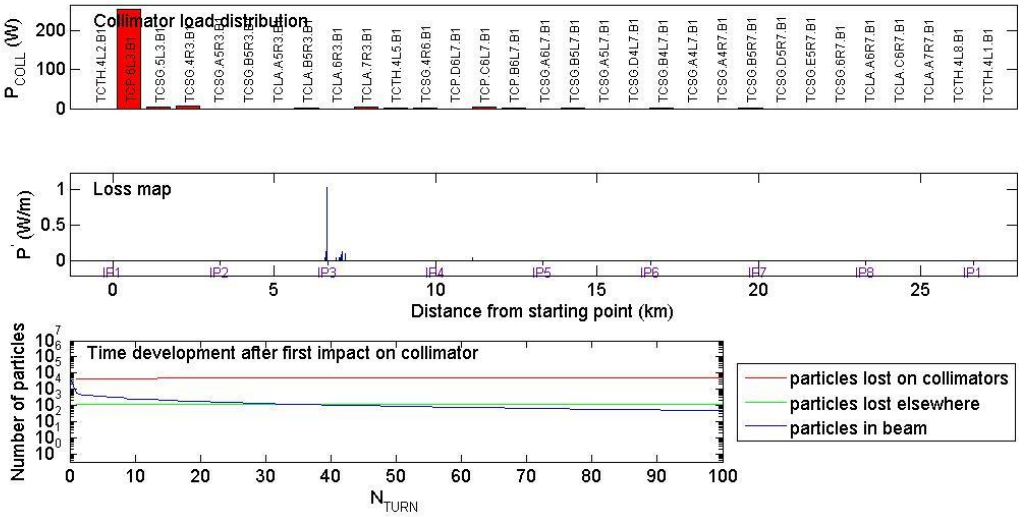


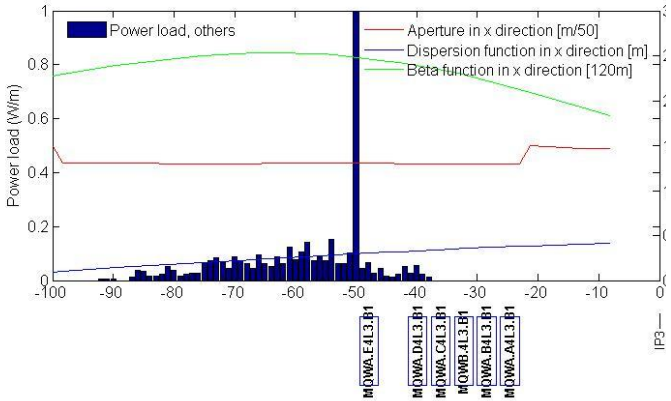


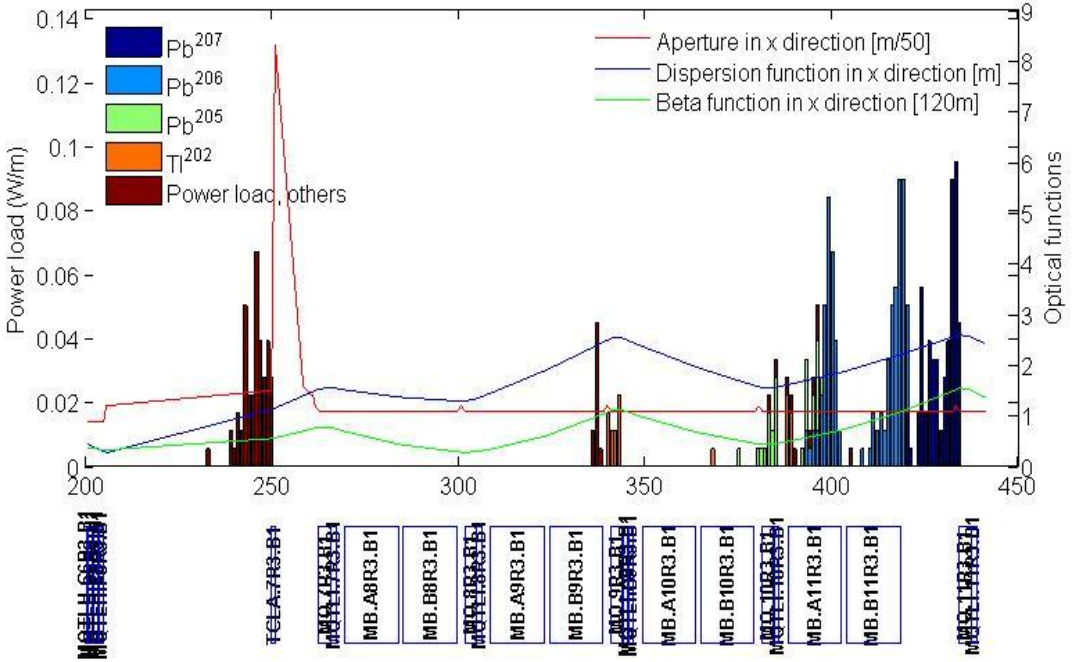
Beam1, momentum collimation
E=3.5TeV/A, $\beta^* = 3.5$m, 12min lifetime

Max load on TCP.6L3.B1=250W

Σaperture hits/Σ collimator hits= η= 0.025







Beam-based ion collimation commissioning:

single nominal bunch at 3.5TeV/A - reference orbit

verify cleaning and protection with provoked beam losses (IR3 and IR7)

Different (broken) hierarchy from protons → what strategy for collimation setup?

BLM thresholds

other risk scenarios to be studied?