Configuration and Schedule for the Heavy Ion Run

John Jowett

Thanks to B. Auchmann, A. Lechner, P. Hermes, S. Redaelli, R. Alemany, M. Schaumann, T. Mertens, J. Wenninger, M. Lamont, D. Manglunki, W. Hofle, D. Jacquet, …

Topics

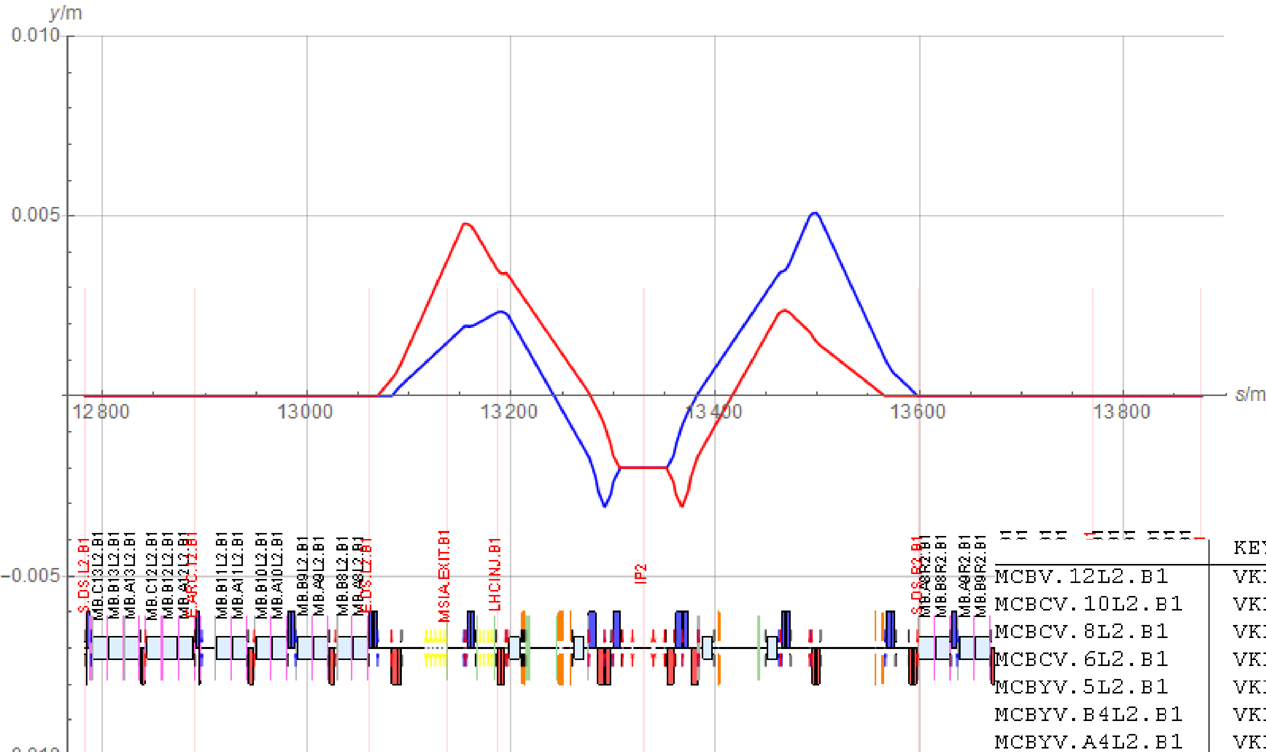
- ALICE crossing scheme with vertical displacement of IP
  - (LMC action)
- BLM thresholds
- Schedule
  - Commissioning and transition to Pb-Pb data-taking around p-p reference run
  - Interruptions to Pb-Pb data taking (MDs, VdM, etc)
- Injectors and filling scheme issues
- Performance, levelling

  - Optics, squeeze: LMC 16 Sep 2015 LMC 2 Sep 2015
  - BFPP mitigation etc: LMC 20 May 2015 LMC 2 Sep 2015
  - MD requests during Pb-Pb run LMC 19 Aug 2015

ALICE Vertical Displacement

- Request for downwards vertical shift of the collision point to re-centre in detector
  - Detector and beam pipe have moved by ~-5 mm but a compensating vertical shift of the IP -2 mm would be adequate
  - Solution for proton run: LMC 17 June 2015
  - Bump in unsqueezed optics was OK for p-p physics this year
- Need new version for squeezed HI optics
  - Constrained by need to avoid shadowing of spectator neutrons on ALICE ZDCs by injection elements (TCLIA)
  - Would need to reduce crossing angle to 35 μrad for one spectrometer polarity to maintain usual situation.
  - New ALICE Monte Carlo done and showed that ZDC data degradation acceptable $\Rightarrow$ we can keep ±60 μrad

ALICE Vertical displacement bump for HI2015



Somewhat different from p-p bump

	KEYWORD	KICKPERCENTMIN	KICKPERCENTMAX
MCBV.12L2.B1	VKICKER	0.	0.
MCBCV.10L2.B1	VKICKER	0.	0.
MCBCV.8L2.B1	VKICKER	0.	0.
MCBCV.6L2.B1	VKICKER	-35.287	35.287
MCBYV.5L2.B1	VKICKER	31.364	-31.364
MCBYV.B4L2.B1	VKICKER	0.	0.
MCBYV.A4L2.B1	VKICKER	28.619	-28.619
MCBXV.3L2	VKICKER	-20.368	20.368
MCBXV.2L2	VKICKER	16.764	-16.764
MCBXV.1L2	VKICKER	16.764	-16.764
MBXWT.1L2	VKICKER	0.	0.
MBWMD.1L2	VKICKER	0.	0.
MBAW.1R2	VKICKER	0.	0.
MBXWT.1R2	VKICKER	0.	0.
MCBXV.1R2	VKICKER	-16.042	16.042
MCBXV.2R2	VKICKER	-16.042	16.042
MCBXV.3R2	VKICKER	19.01	-19.01
MCBYV.4R2.B1	VKICKER	39.399	-39.399
MCBCV.A5R2.B1	VKICKER	38.431	-38.431
MCBCV.B5R2.B1	VKICKER	0.	0.
MCBCV.7R2.B1	VKICKER	-24.23	24.23
MCBCV.9R2.B1	VKICKER	0.	0.
MCBV.11R2.B1	VKICKER	0.	0.
MCBV.13R2.B1	VKICKER	0.	0.

Shows additional strength contributions for this bump alone

Physics configurations – corrector strengths

Spectrometer ON_ALICE=-7/6.37

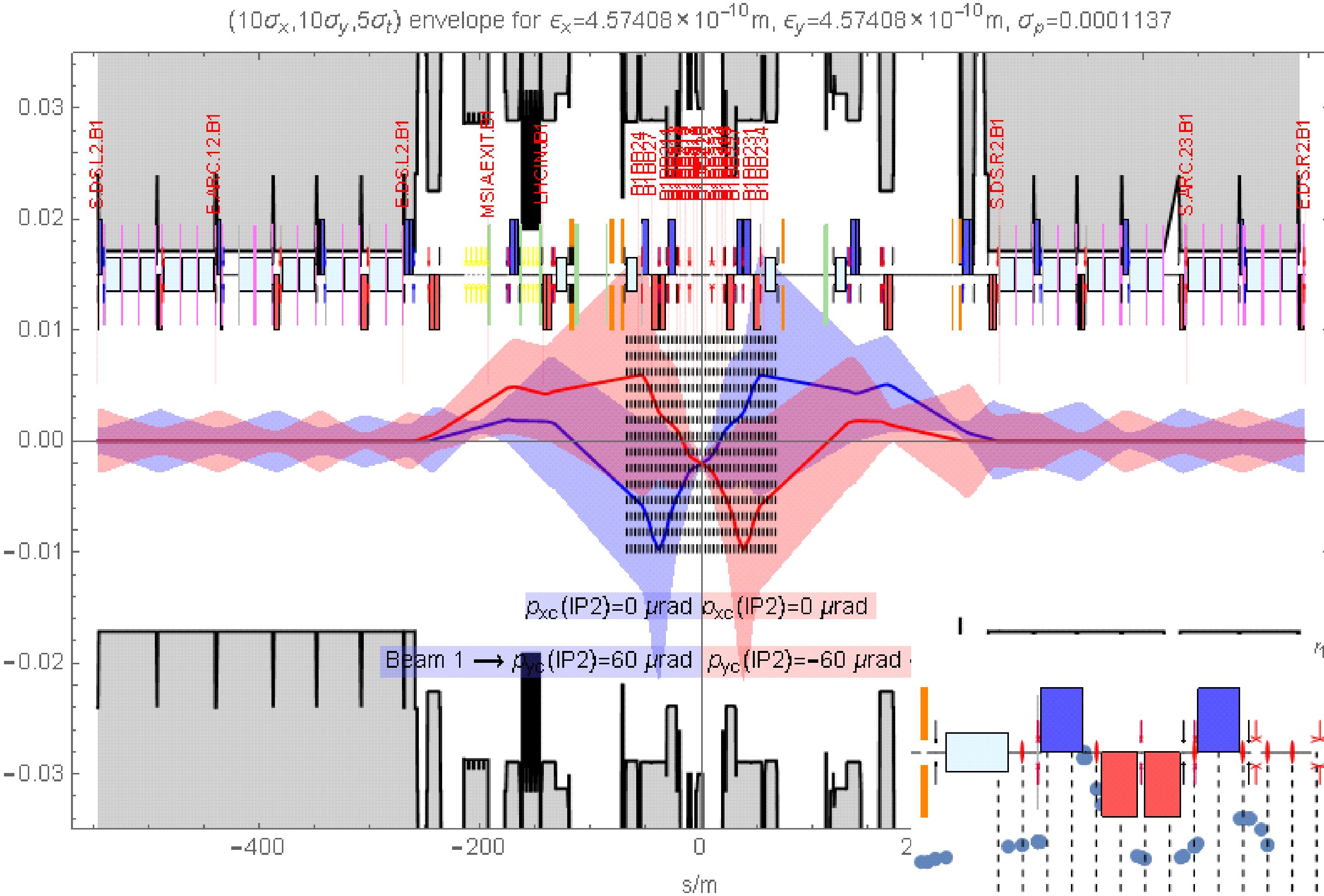
	KEYWORD	KICKPERCENTMIN	KICKPERCENTMAX
MCBV.12L2.B1	VKICKER	0.	0.
MCBCV.10L2.B1	VKICKER	0.	0.
MCBCV.8L2.B1	VKICKER	0.	0.
MCBCV.6L2.B1	VKICKER	-35.287	35.287
MCBYV.5L2.B1	VKICKER	46.688	-46.688
MCBYV.B4L2.B1	VKICKER	0.	0.
MCBYV.A4L2.B1	VKICKER	61.842	-61.842
MCBXV.3L2	VKICKER	-32.186	32.186
MCBXV.2L2	VKICKER	4.9459	-4.9459
MCBXV.1L2	VKICKER	4.9459	-4.9459
MBXWT.1L2	VKICKER	2807.3	70.182
MBWMD.1L2	VKICKER	-3574.2	-98.325
MBAW.1R2	VKICKER	-101.11	101.11
MBXWT.1R2	VKICKER	-2309.1	-57.726
MCBXV.1R2	VKICKER	-4.2234	4.2234
MCBXV.2R2	VKICKER	-4.2234	4.2234
MCBXV.3R2	VKICKER	30.829	-30.829
MCBYV.4R2.B1	VKICKER	29.039	-29.039
MCBCV.A5R2.B1	VKICKER	4.112	-4.112
MCBCV.B5R2.B1	VKICKER	0.	0.
MCBCV.7R2.B1	VKICKER	-24.23	24.23
MCBCV.9R2.B1	VKICKER	0.	0.
MCBV.11R2.B1	VKICKER	0.	0.
MCBV.13R2.B1	VKICKER	0.	0.

Spectrometer ON_ALICE=+7/6.37

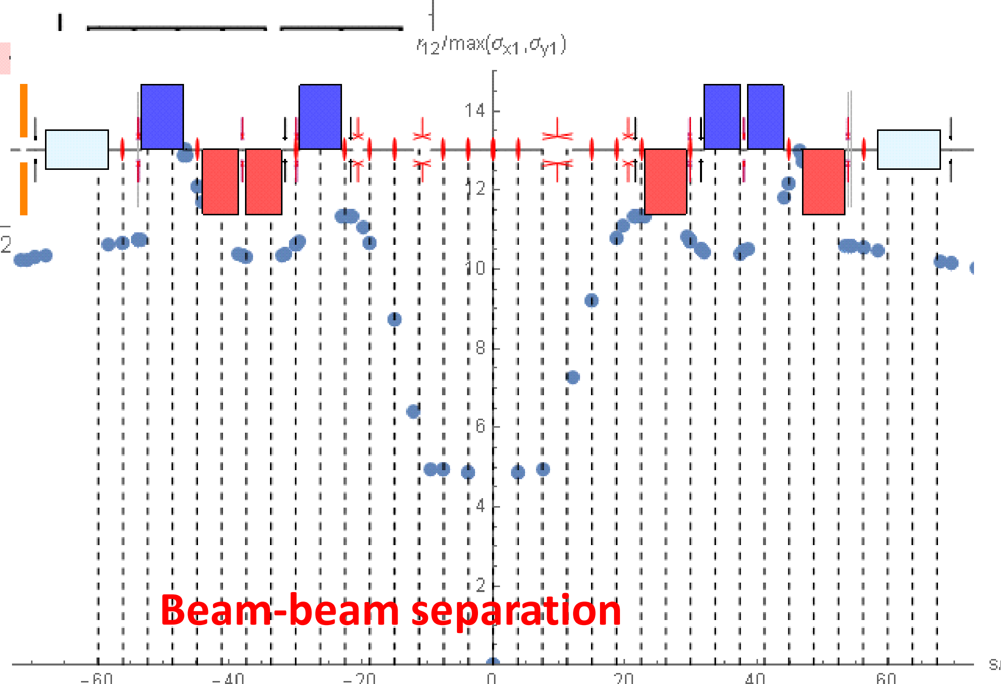
	KEYWORD	KICKPERCENTMIN	KICKPERCENTMAX
MCBV.12L2.B1	VKICKER	0.	0.
MCBCV.10L2.B1	VKICKER	0.	0.
MCBCV.8L2.B1	VKICKER	0.	0.
MCBCV.6L2.B1	VKICKER	-35.287	35.287
MCBYV.5L2.B1	VKICKER	16.04	-16.04
MCBYV.B4L2.B1	VKICKER	0.	0.
MCBYV.A4L2.B1	VKICKER	-4.6049	4.6049
MCBXV.3L2	VKICKER	-8.5498	8.5498
MCBXV.2L2	VKICKER	28.583	-28.583
MCBXV.1L2	VKICKER	28.583	-28.583
MBXWT.1L2	VKICKER	-2807.3	-70.182
MBWMD.1L2	VKICKER	3574.2	98.325
MBAW.1R2	VKICKER	101.11	-101.11
MBXWT.1R2	VKICKER	2309.1	57.726
MCBXV.1R2	VKICKER	-27.86	27.86
MCBXV.2R2	VKICKER	-27.86	27.86
MCBXV.3R2	VKICKER	7.1919	-7.1919
MCBYV.4R2.B1	VKICKER	49.76	-49.76
MCBCV.A5R2.B1	VKICKER	72.749	-72.749
MCBCV.B5R2.B1	VKICKER	0.	0.
MCBCV.7R2.B1	VKICKER	-24.23	24.23
MCBCV.9R2.B1	VKICKER	0.	0.
MCBV.11R2.B1	VKICKER	0.	0.
MCBV.13R2.B1	VKICKER	0.	0.

IP displacement bump will be added at the end of the beam process, after squeeze, together with manipulations of external crossing angle, before collision.
ALICE being levelled, so separation will not be completely collapsed.

Spectrometer ON_ALICE=-7/6.37 (start of Pb-Pb run)

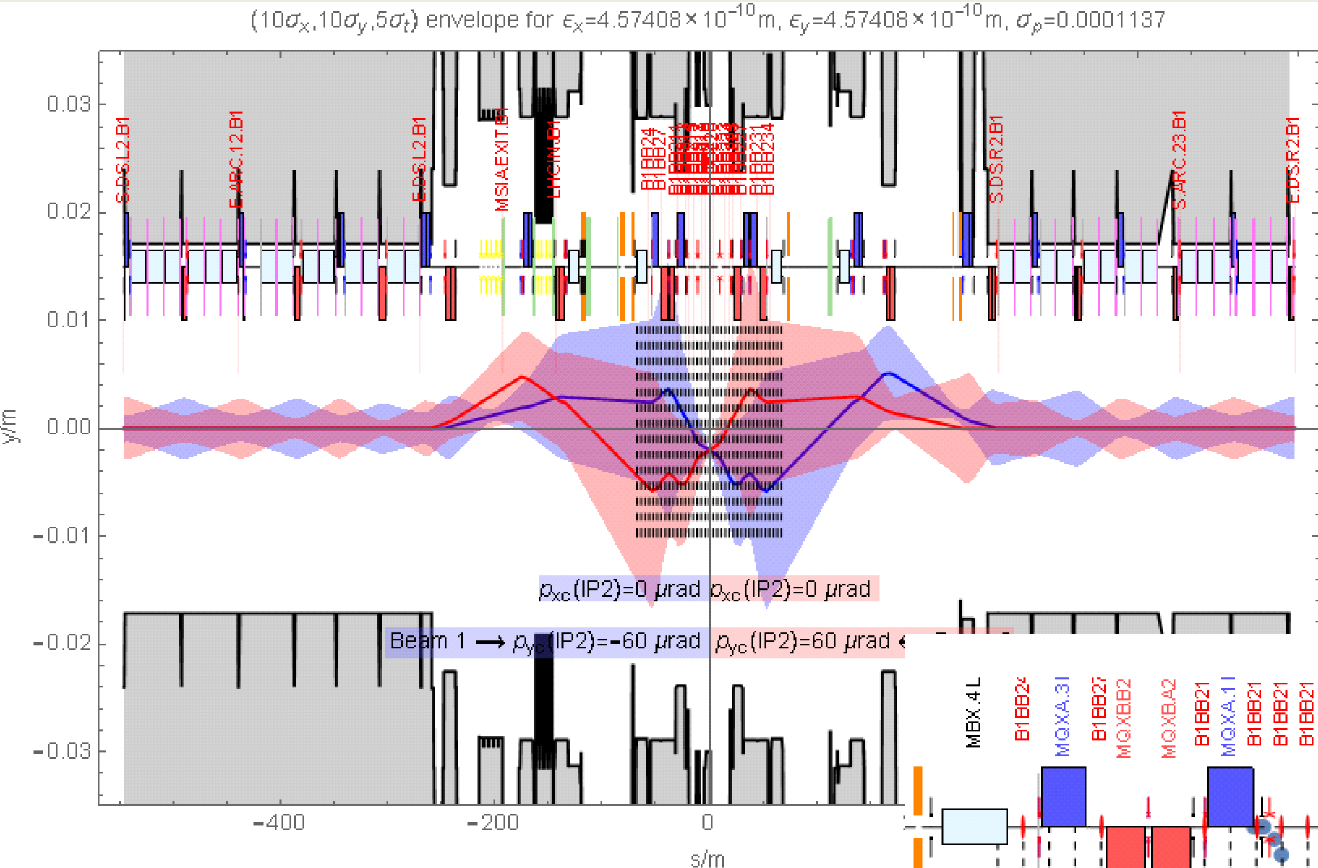


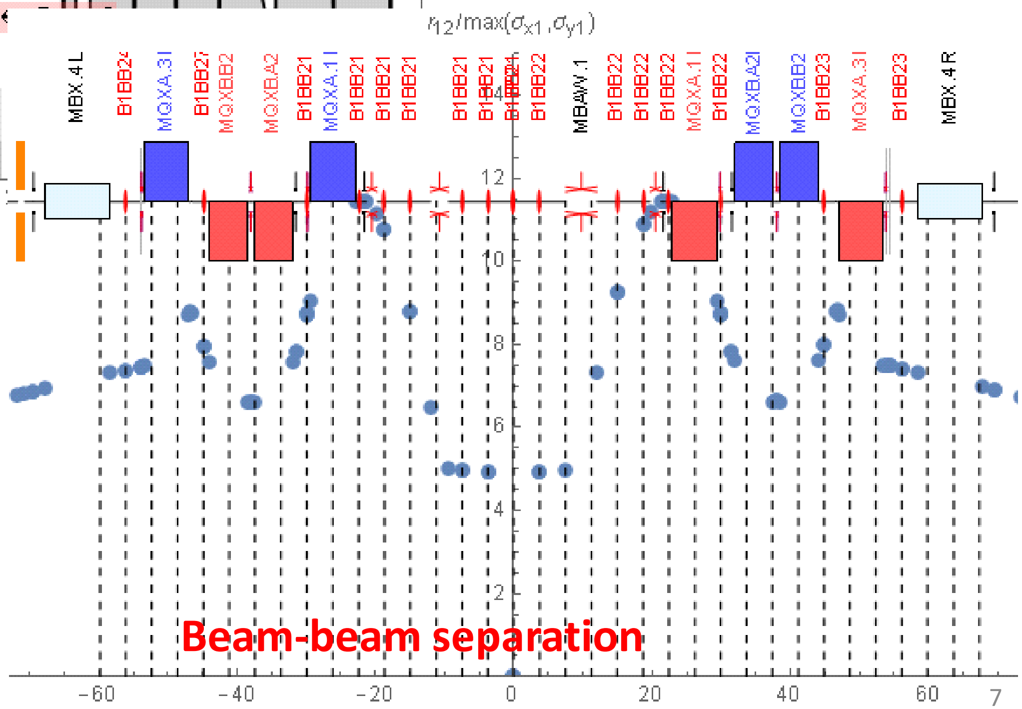
May constrain ALICE β* for rest of Run 2 (important to fix in LS2). To be studied



Spectrometer bump angle -77 μrad, external bump +137 μrad for Beam 1.

Spectrometer ON_ALICE=+7/6.37 after reversal





BFPP-Scenario BLM Thresholds

FLUKA simulations by A. Lechner.

Red ... loss distribution without orbit bump.

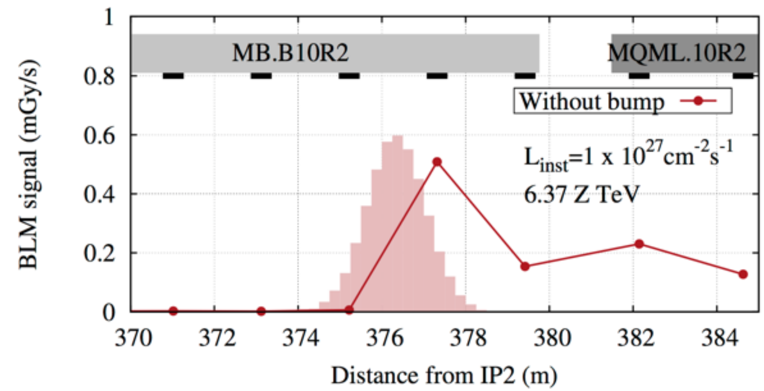
Blue ... loss distribution with orbit bump.

Quench levels from QP3 corresponds to those used for UFO scenario in Arc and DS.

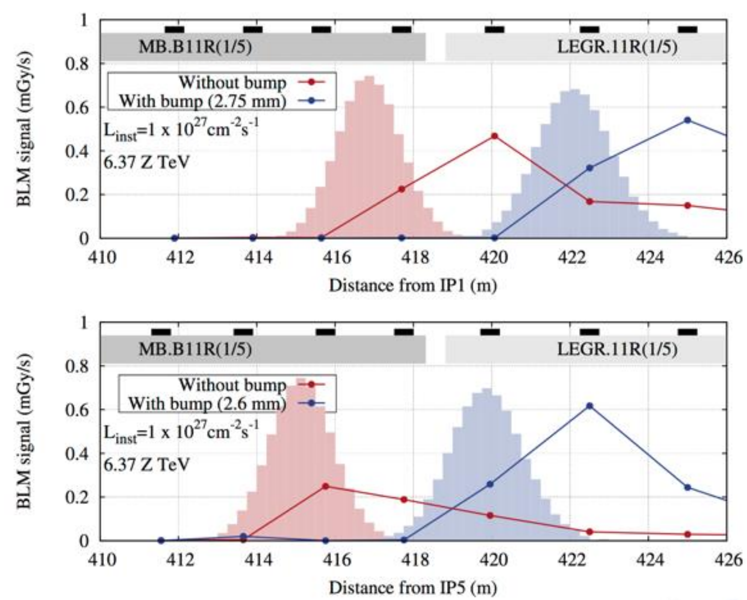
More information on:

http://indico.cern.ch/e/blmtwg24,
http://indico.cern.ch/e/blmtwg23,
http://indico.cern.ch/e/blmtwg19.

ECR in circulation



IR 2



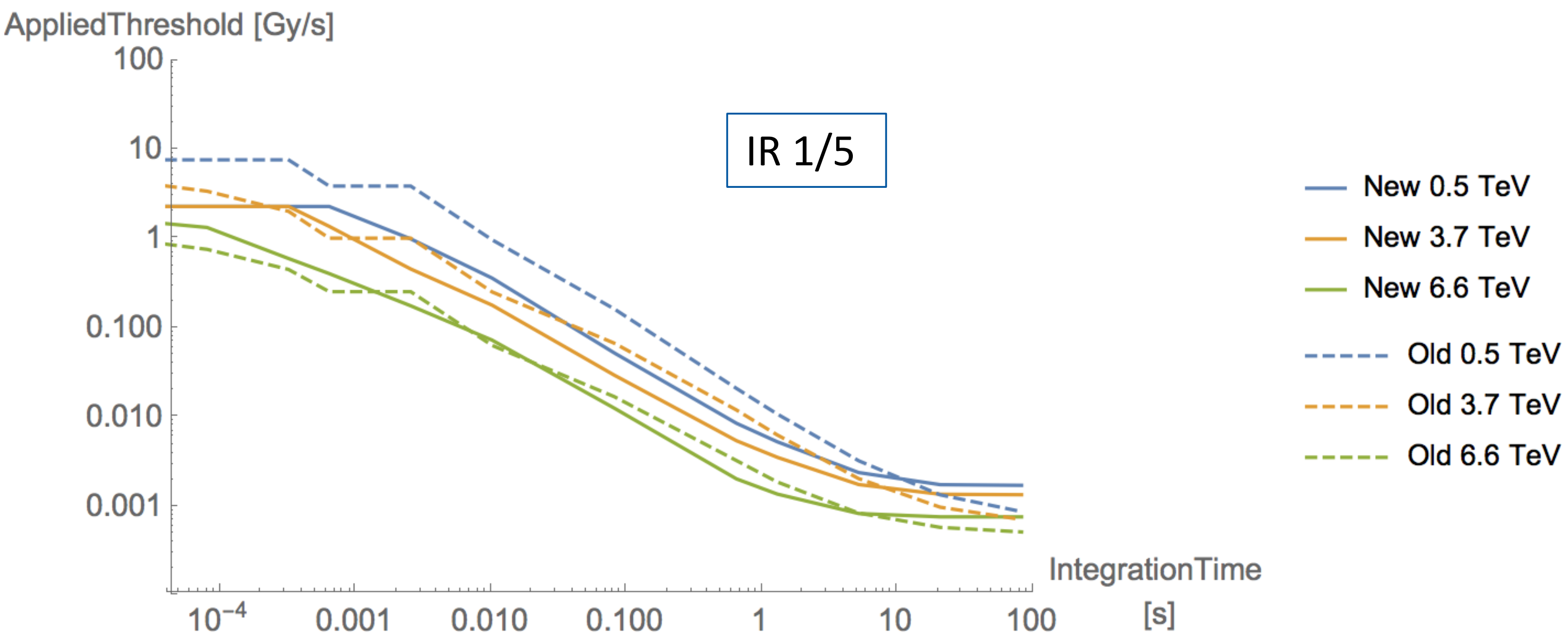
IR 1/5

From B. Auchmann

Master Thresholds

Calculated master thresholds are scaled x2 to allow thresholds 6x above conservative quench levels during quench tests.

The monitor factor for operation (ion and proton) outside of quench tests is 0.1 (moderately conservative).



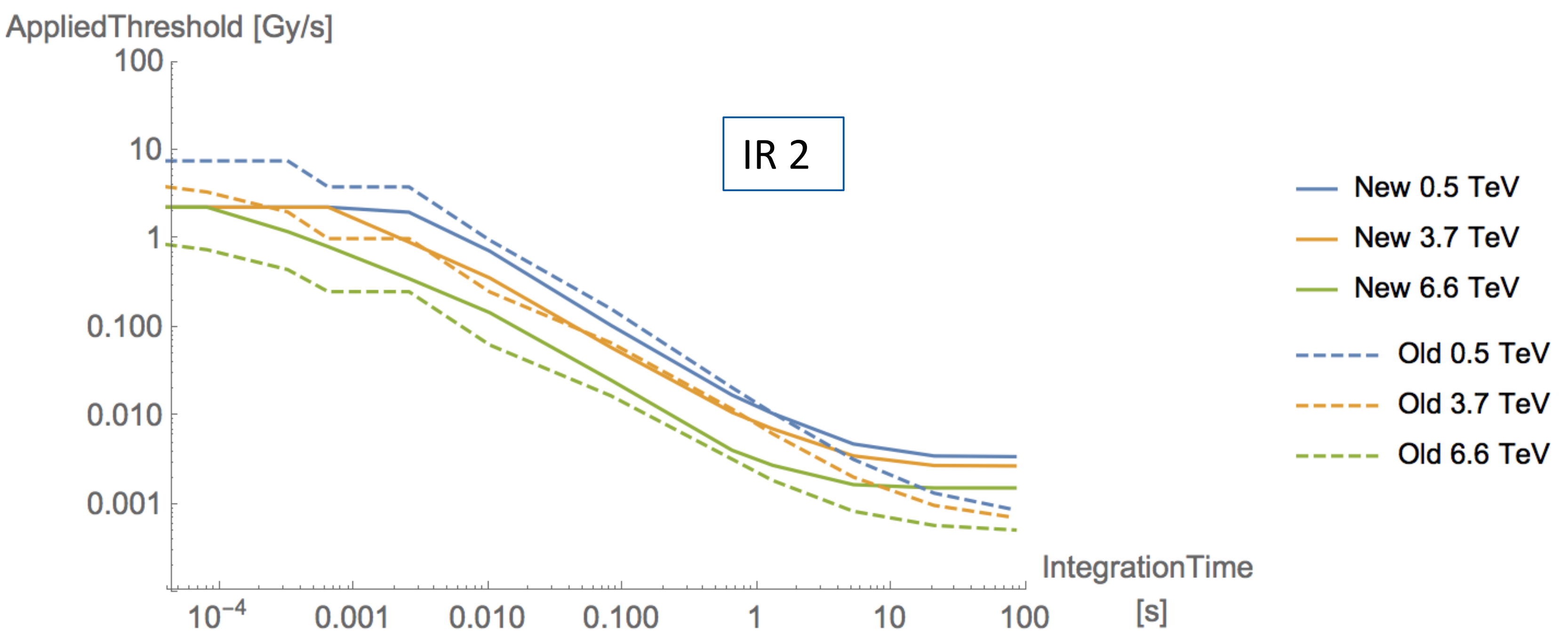
From B. Auchmann

Master Thresholds

Calculated master thresholds are scaled x2 to allow thresholds 6x above conservative quench levels during quench tests.

The monitor factor for operation (ion and proton) outside of quench tests is 0.1 (moderately conservative).

From B. Auchmann



New thresholds at flattop comparable or higher than old ones.

Commissioning Schedule – first weekend up to p-p ref

Start time		Shift		Beam	Cycle	Activity	Time	Teams	Comments
Slot-in			4 hrs	protons	25 ns	Slot-in: Reference heat load run at 450 GeV			Gianni & co. - demote to lowe
						Slot-in: Checking/setting injection orbit			
									refill on 13/11/201
14/11/2015 08:00	Sat	M	Full cycle						of the squeeze, st
14/11/2015 16:00	Sat	A	Full cycle						of the squeeze, st
15/11/2015 00:00	Sun	N							r computation of c
15/11/2015 08:00	Sun	M							ions not ready yet.
15/11/2015 16:00	Sun	A		protons	ion	Squeeze in steps flat, apply optics corrections and check	shift	ABP,OP	One shift may be too short (b
16/11/2015 00:00	Mon	N		protons	ion	Squeeze flat in steps, clean up tunes, coupling, Q' etc	shift	OP	Clean up possibble now that
16/11/2015 08:00	Mon	M	Full cycle	Pb	ion	Set-up with ions, transfer lines, RF capture, injection	shift	ABP,OP	Switch to ions mandatory
16/11/2015 16:00	Mon	A	Full cycle	Pb	ion	Set-up with ions, clean squeeze through cycle, first squeeze with bumps on and in one step, establish collisions, keep for 1 h	shift	ABP,OP	3 bunches/beam to make co
17/11/2015 00:00	Tue	N							Global measurement should
17/11/2015 08:00	Tue	M							
17/11/2015 16:00	Tue	A							Nominally to 4 m

Note: agreement from Machine Protection that optics measurement and correction studies can continue with Pb beams.

Slot-ins and catch-up during time when optics corrections are being computed.

Details will certainly be adapted as we go along so need flexibility from all experts.

Commissioning Schedule – back to Pb-Pb after p-p ref

Might start sooner if p-p ref goes very well or so badly (not time for VdM) that it is abandoned.

22/11/2015 08:00	Sun	M					pp ref nominal physics		OP	
22/11/2015 16:00	Sun	A			protons	pp	pp ref nominal physics		OP	VdM scans to be slotted in
23/11/2015 00:00	Mon	N			protons	pp	End of protons at 06:00 (unless ...)		OP	Protons can stop sooner if
23/11/2015 08:00	Mon	M		Full cycle	Pb	ion	Re-establish collisions, optimise BFPP bumps around A		ABP,OP	BFPP bumps included in p
23/11/2015 16:00	Mon	A			Pb	ion	TCT alignment, loss maps at end of squeeze, separated, off energy loss maps and async dump (if necessary		ABP,OP,COLL	Collimation to decide on a
24/11/2015 00:00	Tue	N			Pb	ion	Continued			
24/11/2015 08:00	Tue	M			Pb	ion	Ramp two beams, squeeze, checks, Stable Beams		OP,ABP	
24/11/2015 16:00	Tue	A			Pb	ion	Inject trains for physics		OP,ABP	
25/11/2015 00:00	Wed	N			Pb	ion	Full filling scheme			
25/11/2015 08:00	Wed	M			Pb	ion	Definitive end of protons at 06:00!!!			
25/11/2015 16:00	Wed	A			Pb	ion	Pb-Pb physics 3 bunches			
26/11/2015 00:00	Thu	N			Pb	ion	Pb-Pb physics 50 bunches			
26/11/2015 08:00	Thu	M			Pb	ion	Pb-Pb physics 200 bunches			
26/11/2015 16:00	Thu	A			Pb	ion	Pb-Pb physics			
27/11/2015 00:00	Fri	N			Pb	ion	Pb-Pb physics Full 400 bunches			
27/11/2015 08:00	Fri	M			Pb	ion	Crystal collimation MD (up to 12h)			Revert to physics ASAP
27/11/2015 16:00	Fri	A			Pb	ion	Pb-Pb physics			

Proposed dates for interruptions to Pb-Pb data-taking

- Crystal collimation
  - Up to 12 h starting 08:00 Fri 27 Nov
- Van der Meer
  - 08:00 Mon 30 Nov
- Ion source oven refill
  - 08:00 Tue 1 Dec (coupled with UA9 in SPS …)
- ALICE spectrometer reversal
  - To be decided, preferably in shadow of source refill
- BFPP quench test
  - 4-8 h, 08:00 Thu 10 Dec, rever to physics if no quench
- Collimation quench test in IR7
  - 16 h from 08:00 Fri 11 Dec
  - Leaves last weekend for Pb-Pb physics

Injectors, filling scheme

- We have long been planning to use an alternating 100/225 ns filling scheme
- Learned yesterday afternoon that SPS injection kicker is not presently capable of 225 ns spacing between injected batches from PS
- Proposal from B. Goddard (*for discussion?*):
  - start with 250 ns (i.e. as is, compatible with p+), we then reconfigure to 225 for tests before 24th Nov, and we also check whether reconditioning to 53 kV to use only the first 3 magnets is feasible.
- $\Rightarrow$ Preparing two sets of filling schemes for LHC
  - Some luminosity loss with 100/250 ns scheme
  - New filling scheme solutions to optimise burn-off (level ALICE longer) will also avoid close parasitic encounters around ALICE because of LHCb.

Pb beam status in SPS (from D. Manglunki)

- Still a long way away from being able to measure the intensity variation along the 12 ×2 Pb bunch train for the LHC.
- So far we have only had about 11 hours of dedicated time to set up the LHC Pb filling beam, we estimated at least 20 hours needed.
- The rest of the setting up will have to be done in parallel with fixed target physics, either proton or Pb.

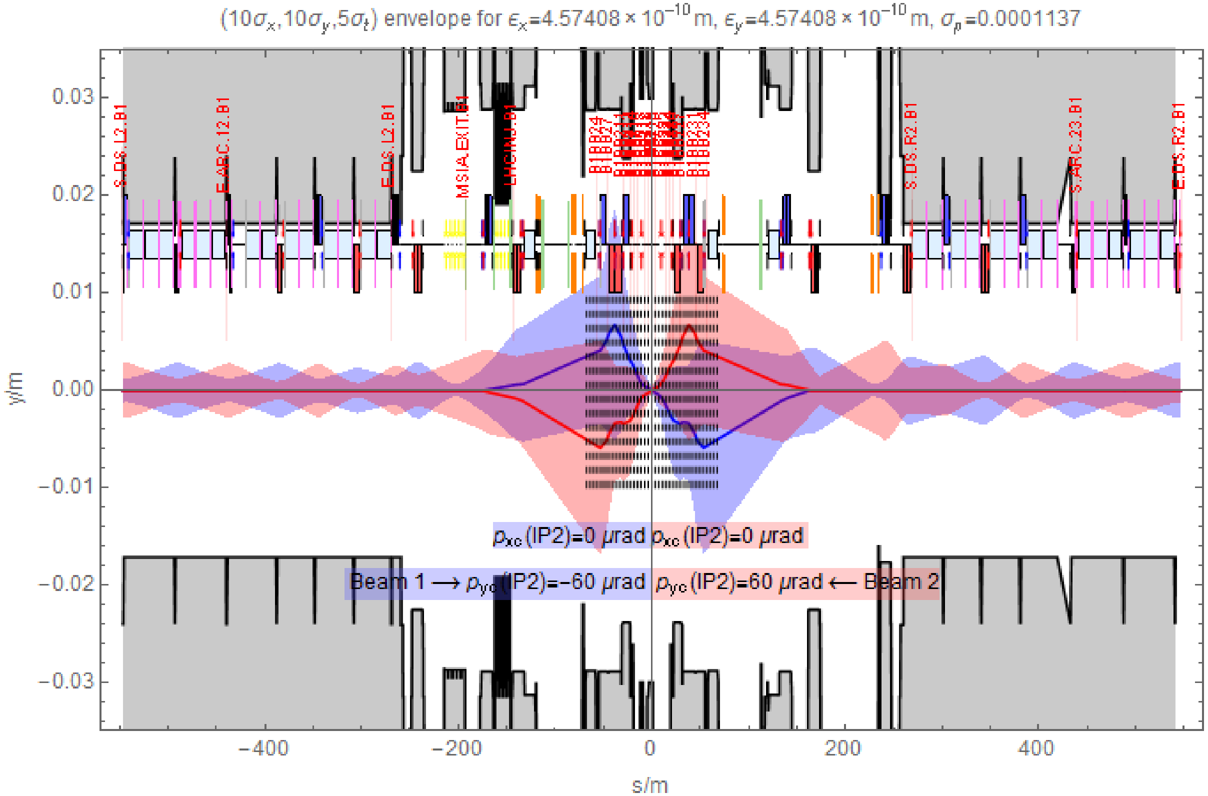
- *Trains not needed until 24 Nov*

Summary

- This Pb-Pb run is more complicated than the last one in 2011.
- Time is also shorter with p-p ref, MDs, etc.
- Much depends on intensities available from injectors which we do not yet know.
  - SPS injection kicker issue
- Schedule is fairly clear but may well be adapted.
- Hoping for good availability.

BACKUP SLIDES

ALICE optics if we had no vertical displacement



Crossing angle small (as in previous runs) in order to avoid shadowing of spectator neutrons by limited aperture injection elements in IR2.

LHC MD304: Collimation quench tests for ions at 6.5 Z TeV

- **MD Contact persons:** P. Hermes, B.Salvachua, S. Redaelli
- **Participants:** Collimation team with BE/BI (BLM), ADT, magnet and MP teams.
- **Time required (hours):** 16
- **Merit:** This study aims at evaluating the quench limits in dispersion suppressor and arc magnets due to Pb ion collimation losses around the betatron cleaning insertion, at assessing maximum intensity reach for RunII, RunIII and HL. These tests also have the immediate outcome of allowing more optimized settings for the operational BLM thresholds. Specifically for ions, important upgrade choices like the production of 11T dipoles depend on the results of such tests.
- **MD procedure link:** See procedure followed in the ion quench tests in 2011: https://espace.cern.ch/be-dep/Lists/IPAC13_new/ Attachments/184/THPEA045.pdf and http:// epaper.kek.jp/HB2012/papers/mop245.pdf. The corresponding MP note is also available.
- **Species:** Ions
- **Category:** Normal MD
- **Beam:** Either
- **OP contact person:**
- **Description:**Collimation quench tests for ions are performed by inducing very large beam losses on the primary collimators of IR7 with collimation settings as in standard high-intensity fills for physics. The procedure for ion beams follows what has been already achieved for protons, as in https://cds.cern.ch/record/1708365/files/ CERN-ACC-NOTE-2014-0036.pdf?. Note that in 2011, the ion quench test was performed by exciting the beams with the tune resonance method while we now propose to use the controlled ADT excitations instead.
- **Beam energies:**Flat top

May benefit from previous experience with corresponding proton MD, should be done near end of run.

LHC MD672: Crystal collimation with ion beams

- **MD Contact persons:**
- Stefano Redaelli
- **Participants:**
- **Time required (hours):** 8
- **Merit:**Crystal collimation is a promising option to improve the betatron cleaning for ion beams. A successful demonstration of this concept might have important implication for CERN in terms of defining a strategy for the 11T dipole deployment in IR7.
- **MD procedure link:**
- **Specie:** Ions
- **Category:** Normal MD
- **Beam:** Beam 1
- **OP contact person:**
- **Description:**With IR7 nominal settings, H and/or V crystals are approached to the circulating beams until they become the primary machine restriction. In this conditions, angular scans are performed while monitoring beam losses close to the crystal and at a collimator that intercept channeled particles. Once channeling is found, secondary collimators are opened one at a time until we achieve a reduced collimation system that, in presence of crystal collimation, is expected to provide improved cleaning than the present system that uses all secondary collimators. The test is ended with loss maps to measure the cleaning. Similar procedures are applied at injection and top energy. We propose to test the crystal channeling and ion efficiency with Pb ion beams at 6.5TeV. Ideally, ion tests would follow successful validation of the crystal installation in IR7 done with proton beams.
- **Beam energies:**Flat top

Discussed by S. Redaelli at LMC 5/8/2015.
May benefit from previous experience with corresponding proton MD.

LHC MD844: BFPP Quench Limit

- **MD Contact persons:** John Jowett
- **Participants:** Michaela Schaumann, Tom Mertens, Anton Lechner, John Jowett
- **Time required (hours):** 4
- **Merit:** Determine the Pb-Pb luminosity at which the BFPP beam induces a quench, important for planning upgrades for HL-LHC. Only necessary if quenches have not already occurred in operation. If quenches still do not occur, the fill can be converted into a physics fill and the time cost will be small.
- **Description:** The operational set up for Pb-Pb physics will include bumps designed to mitigate the risk of quenches. If no quenches occur in operation, we will set up as for a maximum luminosity physics fill and collide in either IP1 or IP5 only (in ADJUST mode). Then we will reduce the bump on L and/or R until a quench occurs. If no quench occurs, it should be possible to repurpose the fill as a physics fill.
- **Species:** Ions
- **Category:** Normal MD
- **Beam:** Both
- **OP contact person:** R. Alemany

Perform near end of run when peak luminosity should be highest.