Summary of p-Pb tests and Preparation of p-Pb run

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with support from OP, RF, BI, injectors, ABP, … during MDs

Introduction (1/3)

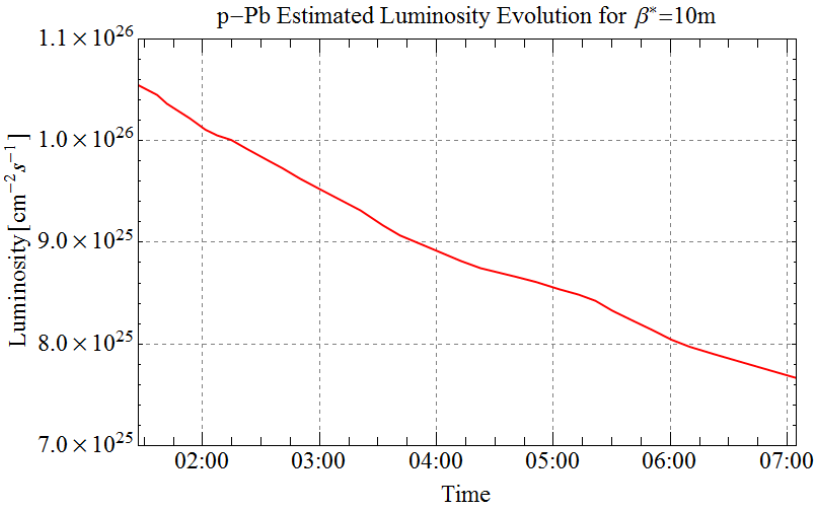
This presentation focuses on the experience from tests done in Week 37.

- p-p rephasing test successful at 450 GeV.
- p-Pb pilot run very successful, $L_{peak} \approx 1 \times 10^{26}$ $cm^{-2}.s^{-1}$.
  - start at 16:00 on 09/12,
  - collisions at 23:30,
  - loss maps at 00:45,
  - STABLE BEAMS at 01:27,
  - IP shifted by -0.5 m at 06:25,
  - IP shifted by +0.5 m at 07:55.
- p-Pb intensity limit MD not done
  - canceled in 2011 due PS septum failure,
  - rescheduled on 09/10, interrupted after 6 hours due WS leak,
  - rescheduled on 09/14, interrupted after 13 hours due to BPMs interlocks in IR6 dumping the proton low intensity beam.

Introduction (2/3) – Pilot physics run

Parameter	Units	Expected	Reached
Filling scheme	Single_15b_8_8_8_pPb_2non_coll		
Beam Energy	*Z* TeV	4	4
Colliding bunches		8	8
β*	m	10/11	10/11
p / bunch	10^{10}	1.15	~ 1.2
Pb / bunch	10^{8}	1.2	~ 0.73
$\gamma_p \varepsilon_p$	μm.rad	1.5	~ 1.7
$\gamma_{Pb} \varepsilon_{Pb}$	μm.rad	1.5	H: 1.4 V: 1
σ_{Pb}(β*=10 m)	μm	~94	H: 91 V: 77
Bunch length	cm	~7	~ 11
Initial luminosity	10^{25} cm^{-2}.s^{-1}	1-10 (max)	~ 12

Luminosity evolution during p-Pb pilot run, from measured beam parameters



Two additional non colliding bunches were injected and used for the loss maps. Parameters are given at start of Stable beams.

Introduction (3/3)

Chamonix'12 estimate of luminosity was

$L_{peak} \approx 8\ 10^{28}\ cm^{-2}.s^{-1} \approx$ 800 L_{peak}(pilot run), but:

- Will start with $\beta^* = 0.8$ m (conservative for aperture),
- Could maybe increase proton beam intensity (effect of moving encounters?),
- Filling scheme to be determined, $n_b \approx 320$ b,
- Smaller proton emittances.

Main choice:	Units	200 ns
Beam energy/(Z TeV)	$\mathcal{Z}$ TeV	4
Colliding bunches		356
β^*	m	0.6
Emittance protons	μm	3.75
Emittance Pb	μm	1.5
Pb/bunch	10^8	1.2
p/bunch	10^{10}	1.15
Initial Luminosity L_0	10^{28} cm^{-2} s^{-1}	**8.3**
Operating days		**24**
Difficulty (subjective)		**1**
Integrated luminosity	nb^{-1}	**22.4**
Nucleon-nucleon	pb^{-1}	**4.7**

Parameters estimates presented in Chamonix'12 (J. Jowett)

To be addressed before the run in January 2013:

- BPMs interlocks in IR6,
- Timing problem for Pb injection,
- Collimation for off-momentum operation,
- Emittance measurements,
- Intensity test? + Allow different BPMs' sensitivities for B1 and B2,
- Establish the commissioning plan,
- Check on the luminosity lifetime from the pilot run.

Pb and proton injection problems

- Problem injecting Pb into the right bucket unless a given SPS super-cycle was used.

  Seemed to be solved for the MD on 09/14, but should check it also works for reversed beams, i.e. Pb in B1.

- BPMs need to be operated in high sensitivity range due to "pilot" intensity bunches.

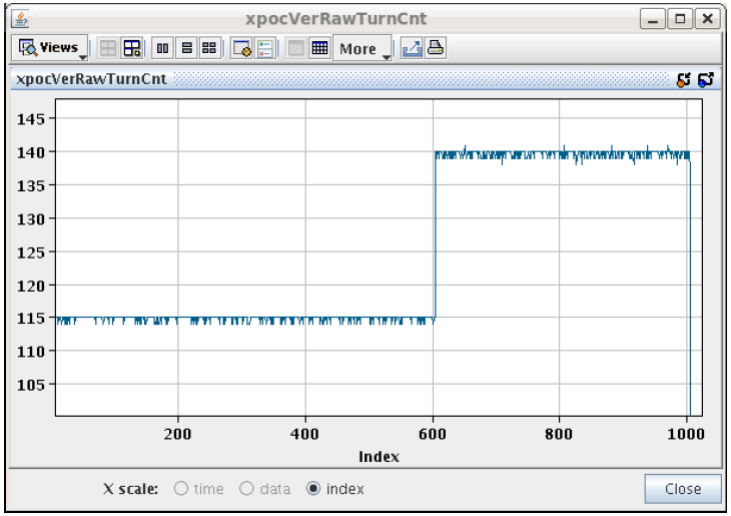
  Experience of tests in Week 37:

  - BPMs behavior OK with single "pilot" bunches (~1.2×10^{10} charges)
  - Beam dump after ~ 200 turns while trying to inject a first batch of 24 b
  - Fluctuating counting of the number of bunches.

  Not due to:

  - bunch spacing,
  - too high bunch intensity,
  - to satellites,

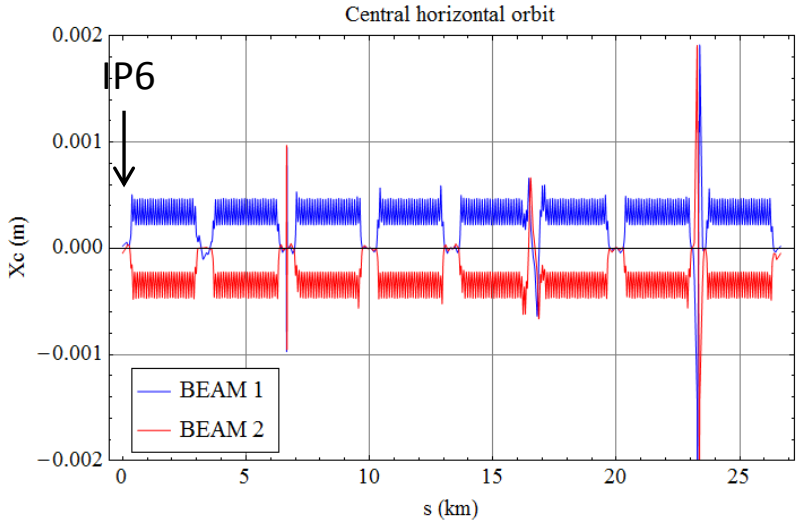
  Still prevents from injecting trains of "pilot" intensity bunches.



Ex. of miscounting: XPOC data from BPMSA.A4L6.B1, vertical channel.

Collimation (1/2)

- New settings needed as beams will be off-centered before the squeeze,



$\delta = \pm 2\ 10^{-4}$,

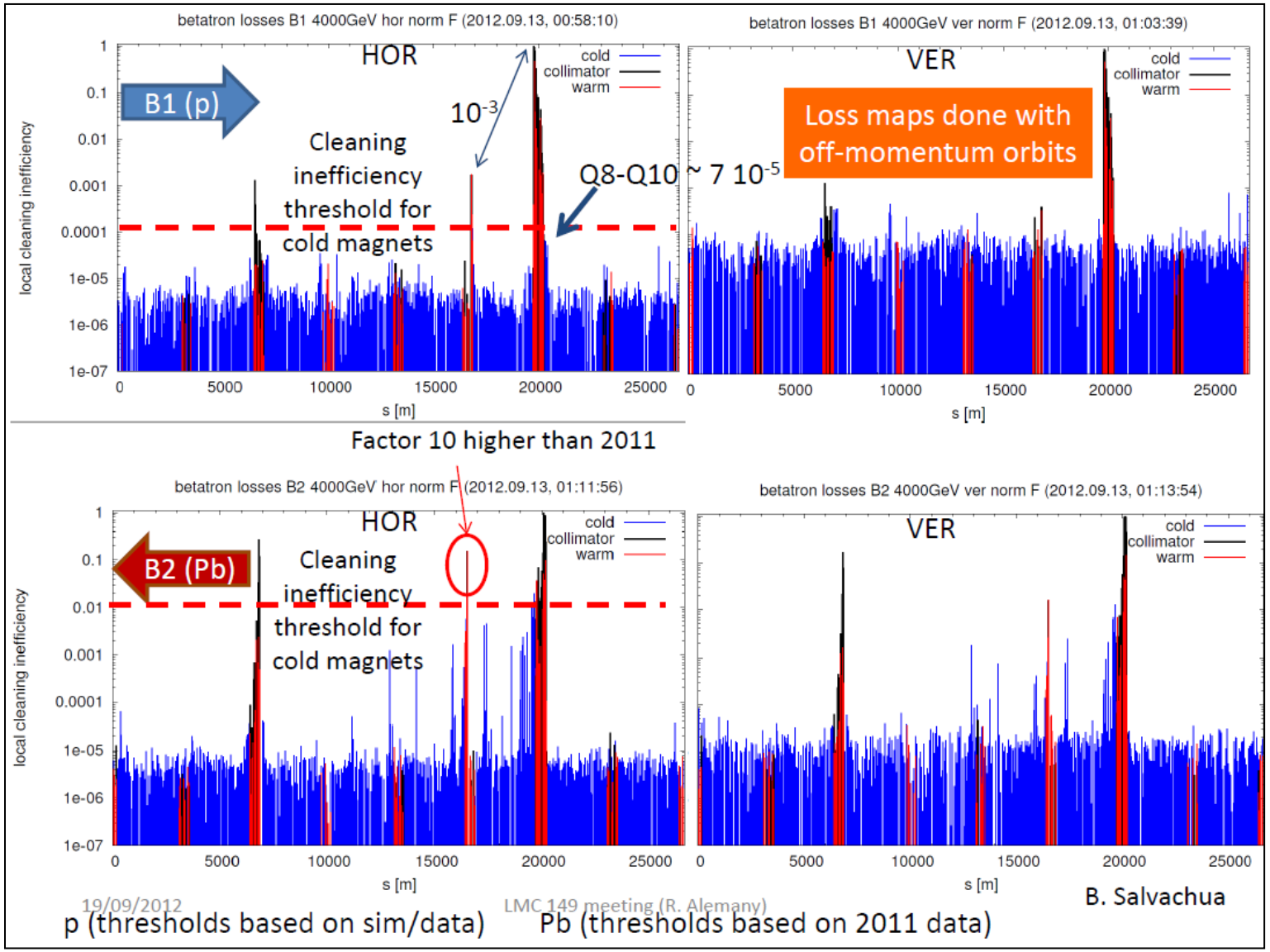
$x_{c,max} \approx \pm 0.5$ mm in the arcs

Ensure consistent settings and thresholds for new ramp and squeeze.

- Loss maps done off-momentum on 09/12 were compared to:
  - data from March 2012 for B1 (p), on-momentum and tight settings,
  - 2011 data for B2 (Pb), on-momentum, 3.5 *Z* TeV and relaxed settings.

  Factor of 10 in cleaning inefficiency w/r 2011 for B2 in IR6 to be analyzed.

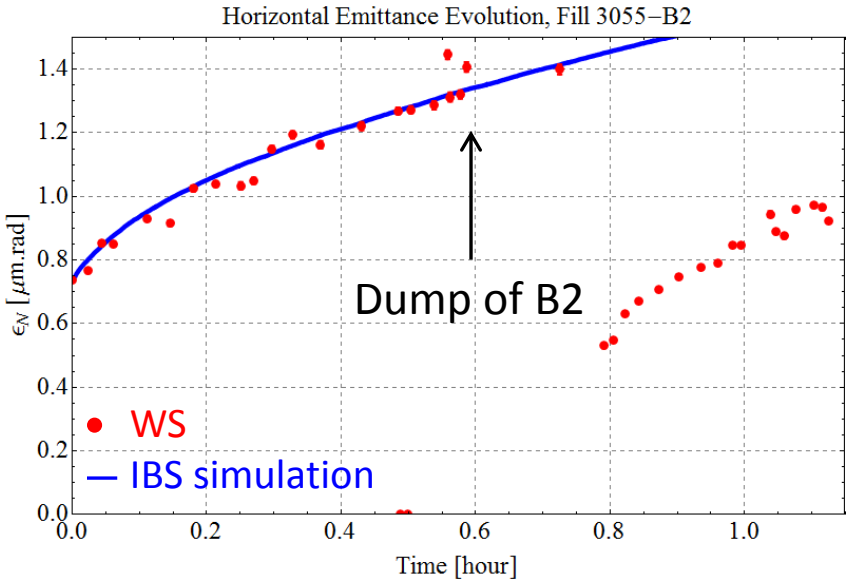
Collimation – loss maps (2/2)

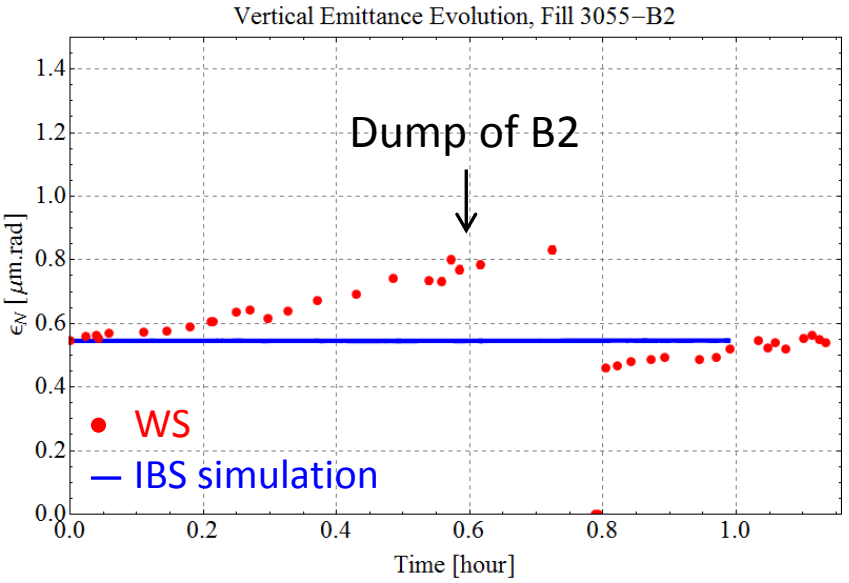


Emittance measurements

- Monitoring beams' emittances is essential as we can expect effect from IBS, moving encounters, colliding beams of different transverse dimensions...

B2 WS data at injection – 09/12/2012





- BSRTs needed for p, also at injection for Pb?
- BGIs for both beams as they will be reversed?
- WS will probably be beyond intensity limit to scan all bunches.
- Calibration.

MD on p-beam intensity limit

- Experience from MD in 2011:
  - approx. 300 b (spacing 100 ns) were injected,
  - injection in wrong buckets forced to stop half way of the full filling scheme.
- Could we re-schedule MD on p-beam intensity (late Nov.?) not to have to face other possible problems at the beginning of the run?
  - still did not ramp many p-bunches against few Pb-bunches,
  - still did not investigate the effect of moving encounters,
  - could help defining (upgrade?) p-beam intensity for the run,
  - would require Pb bunches, fix for low intensity p-injection and ~6h beam time,
- If the p-intensity can be increased, as we hope, implementation of the algorithm for different stripline BPM sensitivity ranges for B1 and B2 will be necessary.
- Beam-beam separation may have to be increased at injection and ramp – would substantially modify commissioning strategy.

About the commissioning plan

P-Pb commissioning scheduled in 4 days from 01/14/2013 to 01/17/2013.

To be addressed:

- Squeeze procedure:

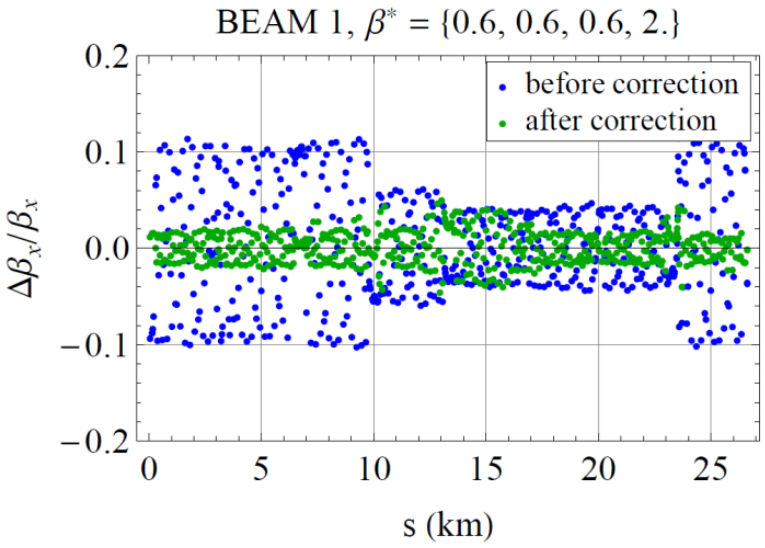
  - Simultaneous squeeze of IP1/IP2/IP5 down to 0.8 m and to 0.6 m, and probably of IP8 to 2 m (well advanced in OP, could be tested with protons before Christmas),

  - Implementation of intrinsic beta-beating correction as a knob,

  - Crossing angle in ALICE (60 µrad),

  - Collimation setup,

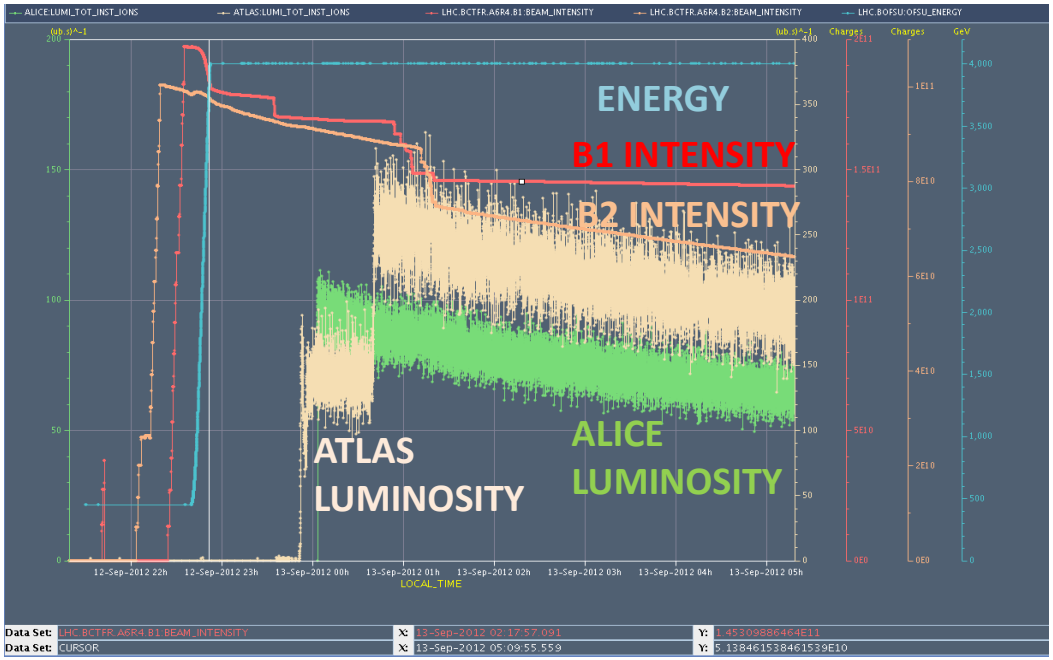
- Filling scheme,
- Strategy for reversing beams,
- Strategy for ALICE polarity reversal.



Correction of B1H using all MQTs except MQTLs

Luminosity lifetime (1/2)

- A factor ~100-1000 on peak luminosity is to be gained with respect to the pilot run,
- p-Pb pilot run's luminosity lifetime was about 8 hours,
- Luminosity burn-off component will be multiplied by a factor ~10 after squeeze, but burn-off lifetime was > 250 h during the pilot run,

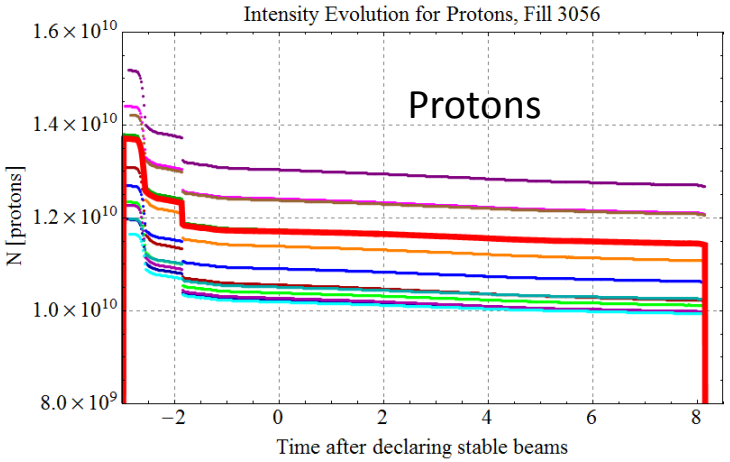


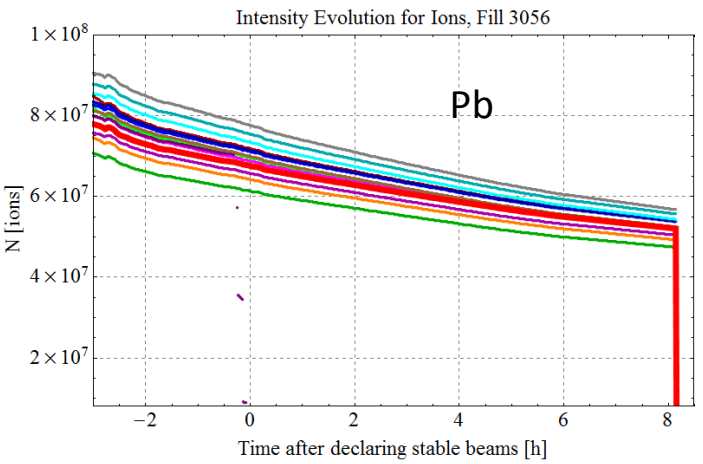
- Unidentified source of emittance growth was observed, also on non-colliding bunches.

Luminosity lifetime (2/2)

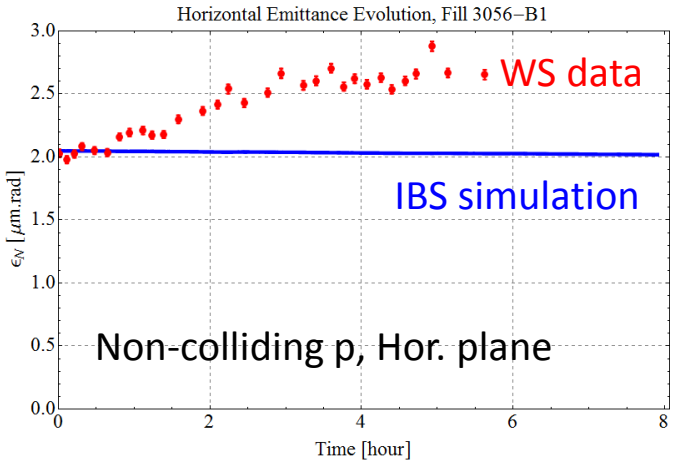
- Non colliding bunch data vs IBS simulation (M. Schaumann, study is on-going):

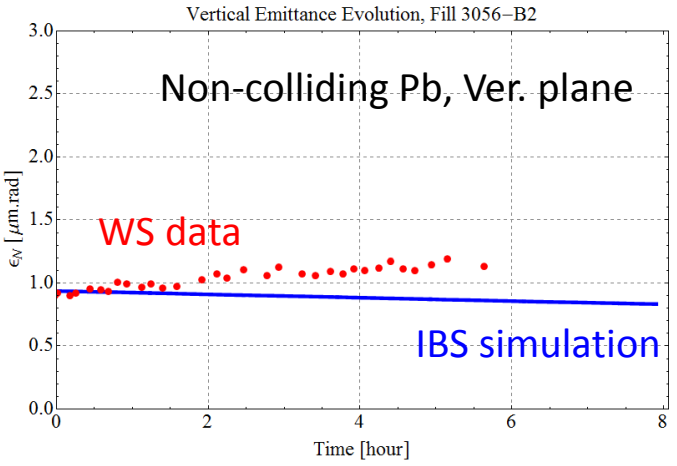
Bunch intensities, non colliding bunch is in thick red.





Unexplained emittance growth for B1H and B2V.

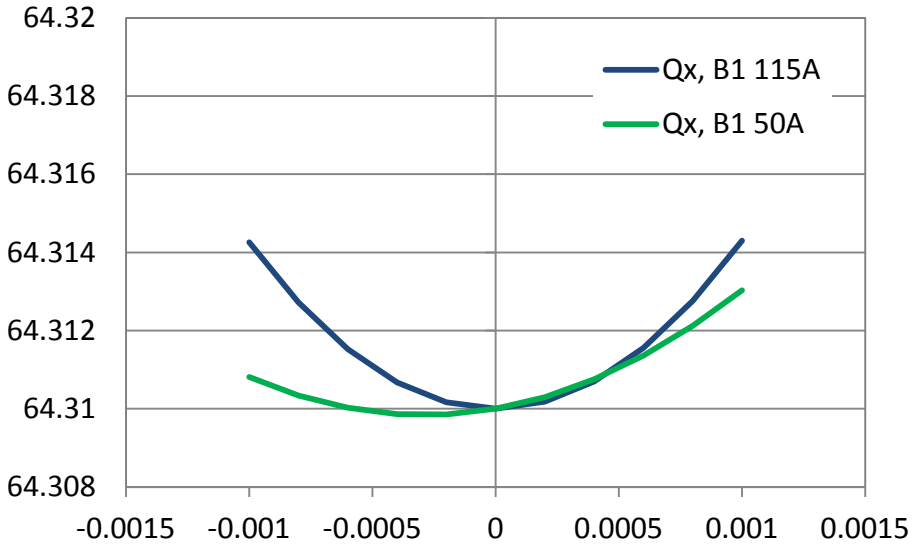


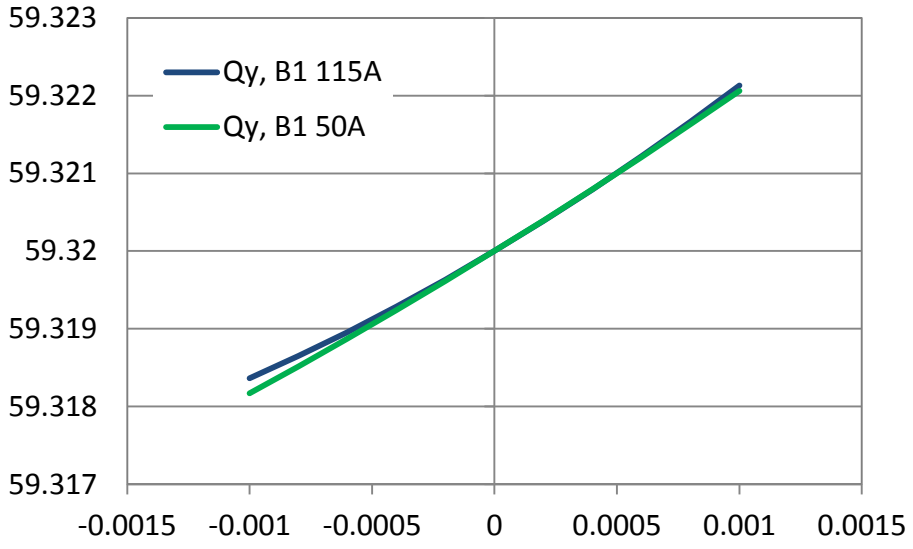


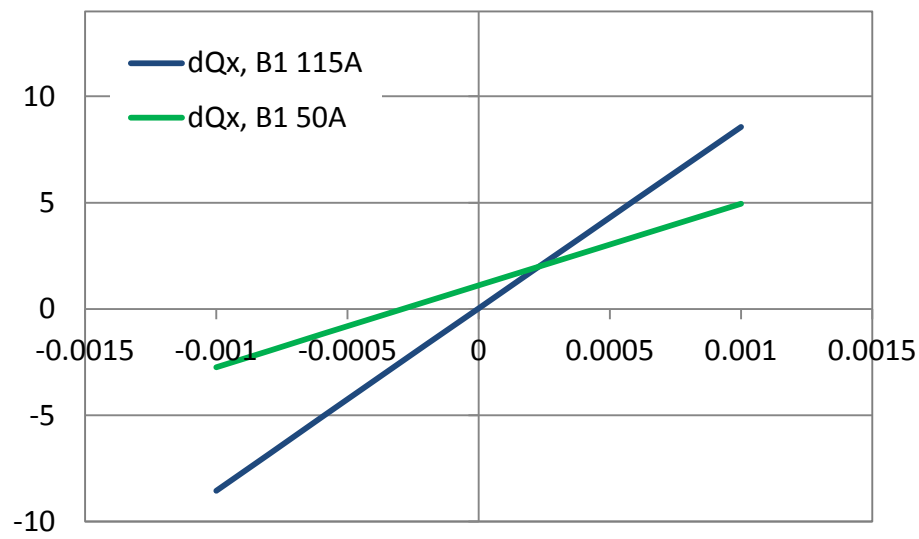
Conclusion

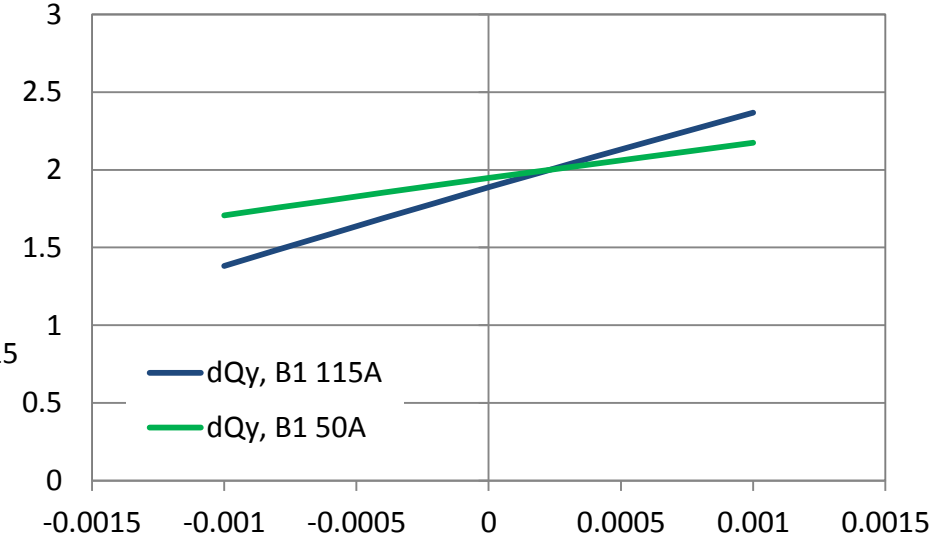
- p-Pb pilot run was very successful. Injected, ramped 15x15 bunches, locked the RF using the new procedure, made loss maps and got to stable beams in 9.5 h.
- BPMs' interlock problem in IR6 has to be fixed. Without hardware intervention, in case tests could be re-scheduled before Christmas?
- No new results about p-intensity limit. If injection and ramp tests not re-scheduled in Nov-Dec, will have to be done during the run.
- Significant setup of collimation off-momentum will have to be done, for p and Pb with tight settings for squeezed beams.
- Emittance measurements are very important. Increase observed during the pilot run may reduce the luminosity lifetime.
- If possible the proton beam intensity may be increased, which would require the implementation of the algorithm for different stripline BPM sensitivity ranges for B1 and B2.
- The commissioning plan details are to be discussed, and the final choice of the filling scheme to be made with Steve and Django.

B1 – Tune and Chromaticity vs. δ_p for I_{oct} = 50 A and 115 A, chroma. matched for δ_p=+0.00023









B2 – Tune and Chromaticity vs. δ_p for I_{oct} = 50 A and 115 A, chroma. matched for δ_p=-0.00023