The Interlocked BPMs of the LHC in Pt.6

- Issues
- Modification proposals
- Commissioning plan

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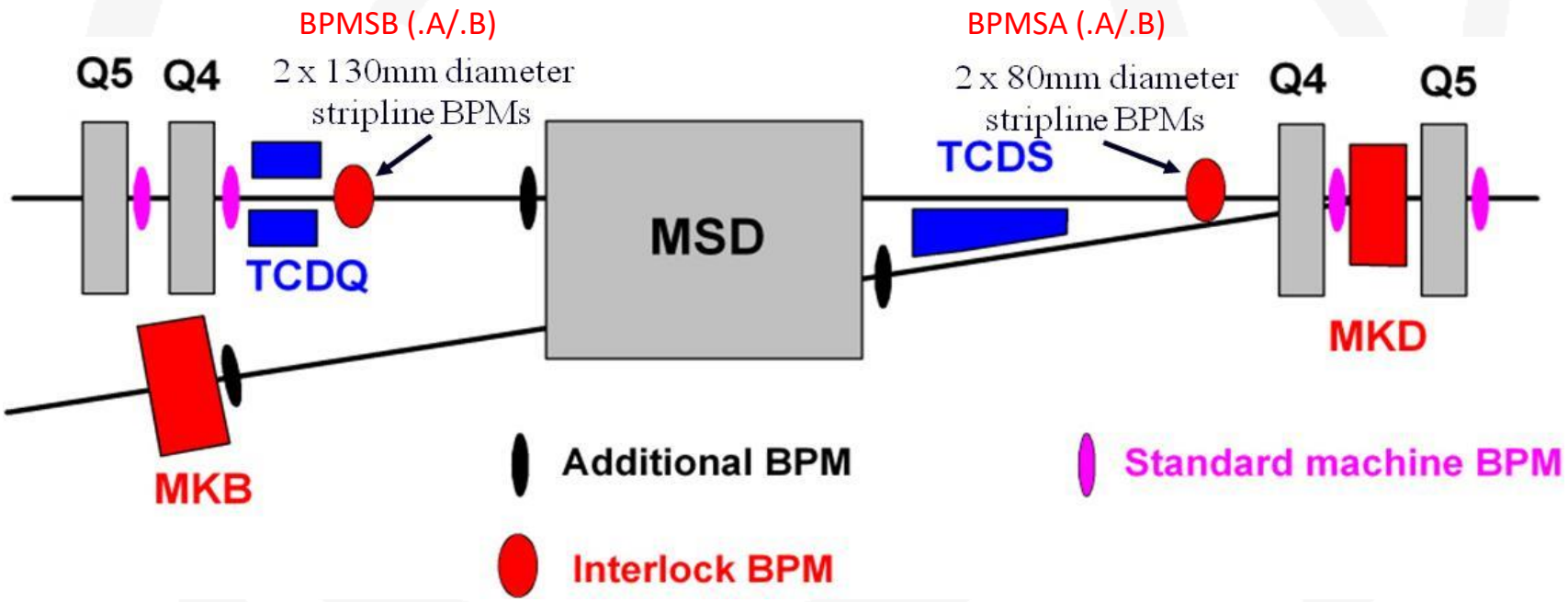
Introduction - Layout



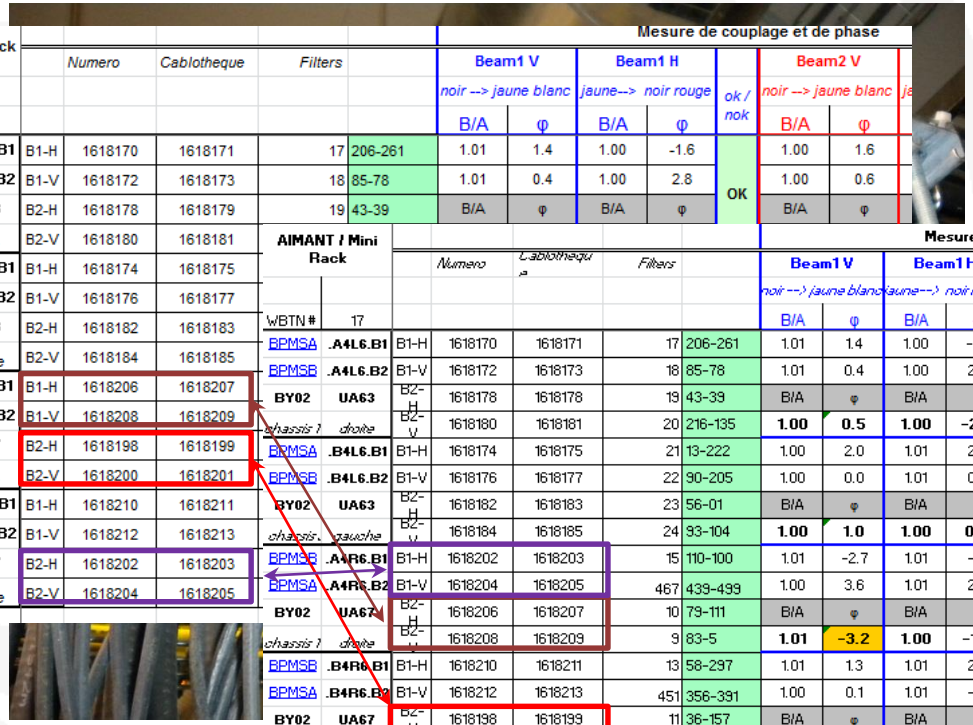
System Constraints

- **Due to integration constraints, these pick-ups have very large diameters (80mm & 130mm) and long cables to reach the front-end electronics.**
- **The electronics consist on the standard LHC BPM front-ends, BUT with a particular FPGA firmware in the digital acquisition part.**
  - The analogue part works in 2 sensitivity modes
    - High sensitivity from 2×10^{9} to 5×10^{10}
    - Low sensitivity from 5×10^{10} to 2×10^{11}
  - The input levels are matched to the electronics by attenuators, taking into account the cable losses.
  - Chamonix – decided to lower low sensitivity threshold to give more margin
    - Led to issues with probes visible at injection, triggering system when injection cleaning on.

The attenuators issue

Attenuators are placed in each of the 44 cables, attached on the top of the rack, with very difficult access.

AIMANT / Mini Rack			Numero	Cablotheque	Filters		Mesure de couplage et de phase: Beam1 V (noir --> jaune blanc) B/A	Beam1 V φ	Beam1 H (jaune--> noir rouge) B/A	Beam1 H φ	ok / nok	Beam2 V (noir --> jaune blanc) B/A	Beam2 V φ
WBTN #	17												
BPMSA	.A4L6.B1	B1-H	1618170	1618171	17	206-261	1.01	1.4	1.00	-1.6		1.00	1.6
BPMSB	.A4L6.B2	B1-V	1618172	1618173	18	85-78	1.01	0.4	1.00	2.8	OK	1.00	0.6
BY02	UA63	B2-H	1618178	1618179	19	43-39	B/A	φ	B/A	φ		B/A	φ
chassis 1	droite	B2-V	1618180	1618181									
BPMSA	.B4L6.B1	B1-H	1618174	1618175									
BPMSB	.B4L6.B2	B1-V	1618176	1618177									
BY02	UA63	B2-H	1618182	1618183									
chassis 2	gauche	B2-V	1618184	1618185									
BPMSB	.A4R6.B1	B1-H	1618206	1618207									
BPMSA	.A4R6.B2	B1-V	1618208	1618209									
BY02	UA67	B2-H	1618198	1618199									
chassis 1	droite	B2-V	1618200	1618201									
BPMSB	.B4R6.B1	B1-H	1618210	1618211									
BPMSA	.B4R6.B2	B1-V	1618212	1618213									
BY02	UA67	B2-H	1618202	1618203									
chassis 2	gauche	B2-V	1618204	1618205									

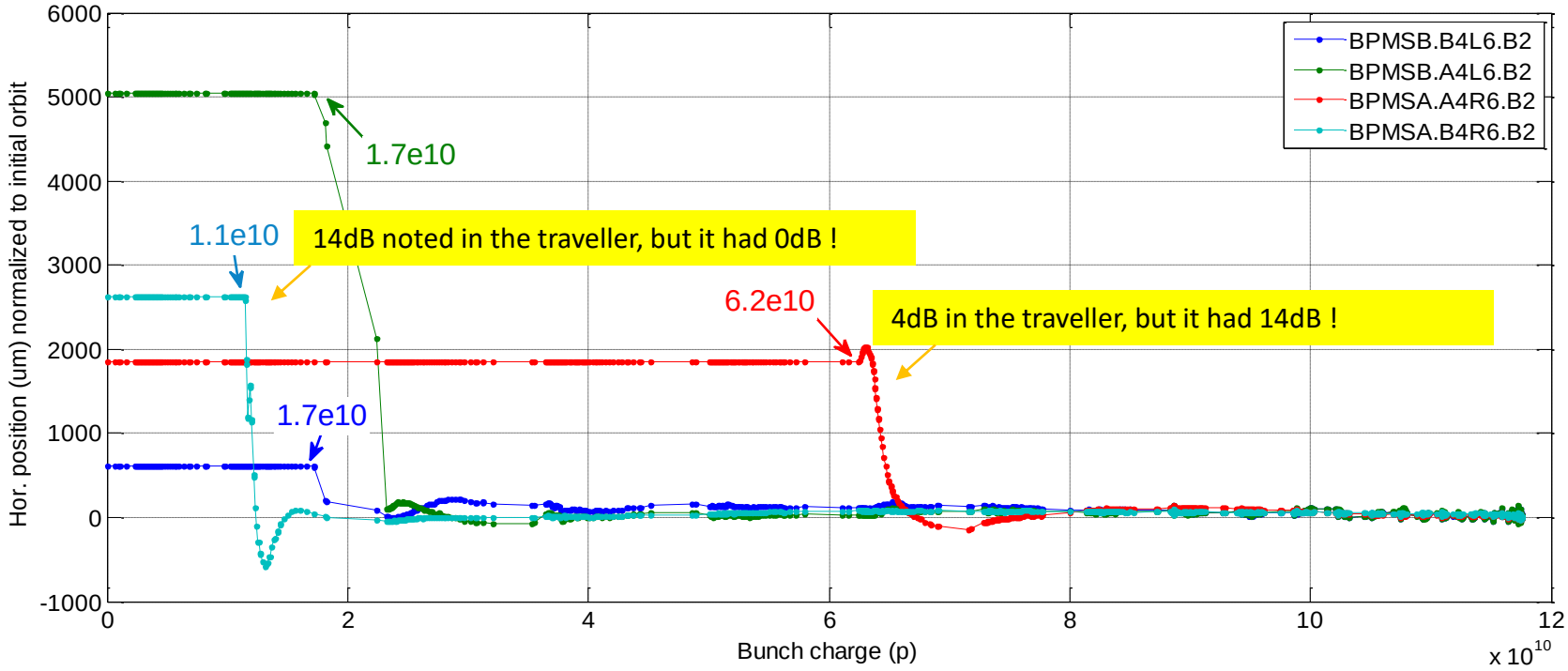


AIMANT / Mini Rack			Numero	Cablotheque	Filters		Mesure de couplage et de phase: Beam1 V (noir --> jaune blanc) B/A	Beam1 V φ	Beam1 H (jaune--> noir rouge) B/A	Beam1 H φ	ok / nok	Beam2 V (noir --> jaune blanc) B/A	Beam2 V φ
WBTN #	17												
BPMSA	.A4L6.B1	B1-H	1618170	1618171	17	206-261	1.01	1.4	1.00	-1.6		1.00	1.6
BPMSB	.A4L6.B2	B1-V	1618172	1618173	18	85-78	1.01	0.4	1.00	2.8		1.00	0.6
BY02	UA63	B2-H	1618178	1618178	19	43-39	B/A	φ	B/A	φ	OK	B/A	φ
		B2-V	1618180	1618181	20	216-135	**1.00**	**0.5**	**1.00**	**-2.2**		**1.00**	**0.5**
BPMSA	.B4L6.B1	B1-H	1618174	1618175	21	13-222	1.00	2.0	1.01	2.2		1.01	-2.2
BPMSB	.B4L6.B2	B1-V	1618176	1618177	22	90-205	1.00	0.0	1.01	0.7	OK	1.01	4.3
BY02	UA63	B2-H	1618182	1618183	23	56-01	B/A	φ	B/A	φ		B/A	φ
		B2-V	1618184	1618185	24	93-104	**1.00**	**1.0**	**1.00**	**0.8**		**1.00**	**-3.3**
BPMSB	.A4R6.B1	B1-H	1618202	1618203	15	110-100	1.01	-2.7	1.01	-1.1		1.01	-2.3
BPMSA	.A4R6.B2	B1-V	1618204	1618205	467	439-499	1.00	3.6	1.01	2.3	OK	1.01	3.8
BY02	UA67	B2-H	1618206	1618207	10	79-111	B/A	φ	B/A	φ		B/A	φ
		B2-V	1618208	1618209	9	83-5	**1.01**	**-3.2**	**1.00**	**-1.7**		**1.00**	**-3.1**
BPMSB	.B4R6.B1	B1-H	1618210	1618211	13	58-297	1.01	1.3	1.01	2.3		1.01	4.8
BPMSA	.B4R6.B2	B1-V	1618212	1618213	451	356-391	1.00	0.1	1.01	-1.1	OK	1.00	-3.9
BY02	UA67	B2-H	1618198	1618199	11	36-157	B/A	φ	B/A	φ		B/A	φ
		B2-V	1618200	1618201	12	46-132	**1.01**	**0.6**	**1.00**	**1.7**		**1.01**	**4.4**

An error in the documentation reporting the cabling numbering was the cause that the attenuator changes during first part of the year produced so strange behaviour.
Additionally, details like the the complicated naming, does not facilitate locating the channels (error-prone)

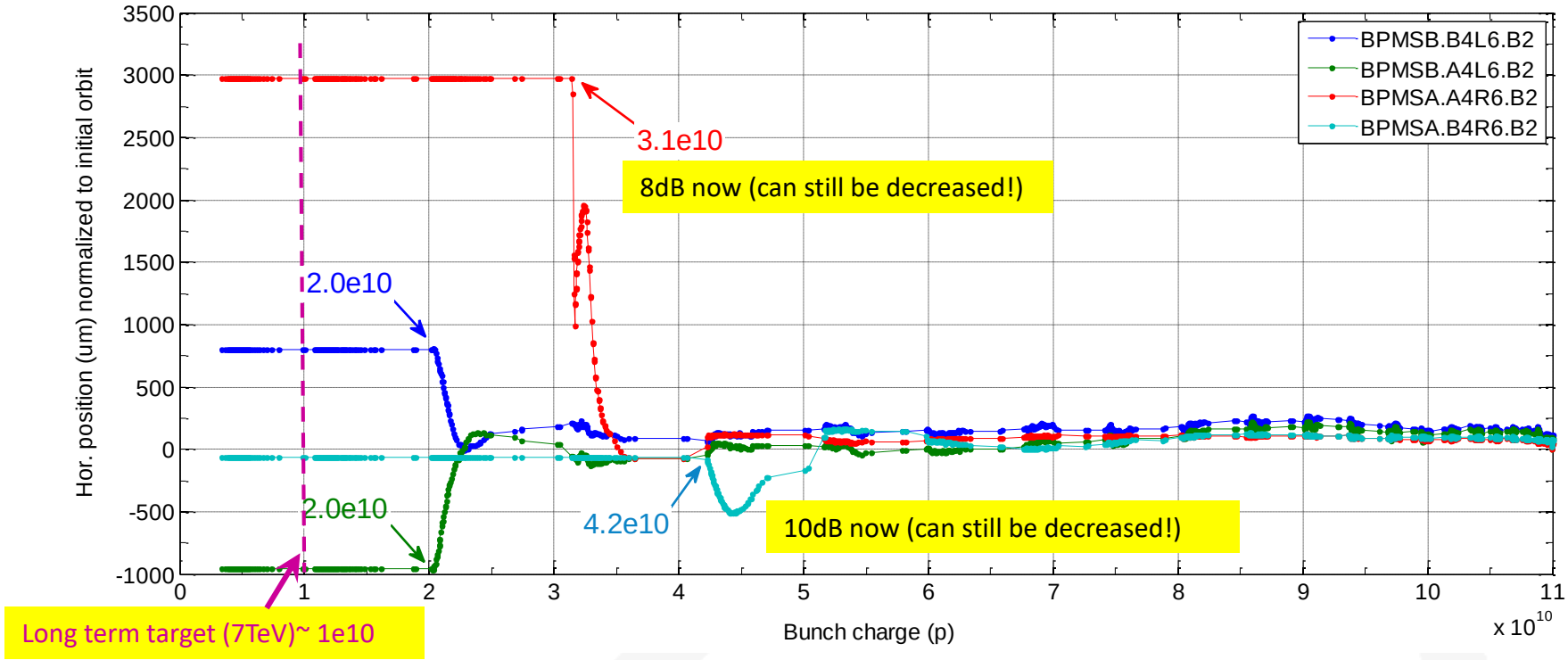
Observations

- **Changes in attenuation**
  - Attenuation increased for BPMSA.B4R8 twice to counter injection issues
  - A scrapping on 24/5 showed attenuation had been increased on wrong channel
    - Explained both continued problems at injection & higher intensity limit for B2



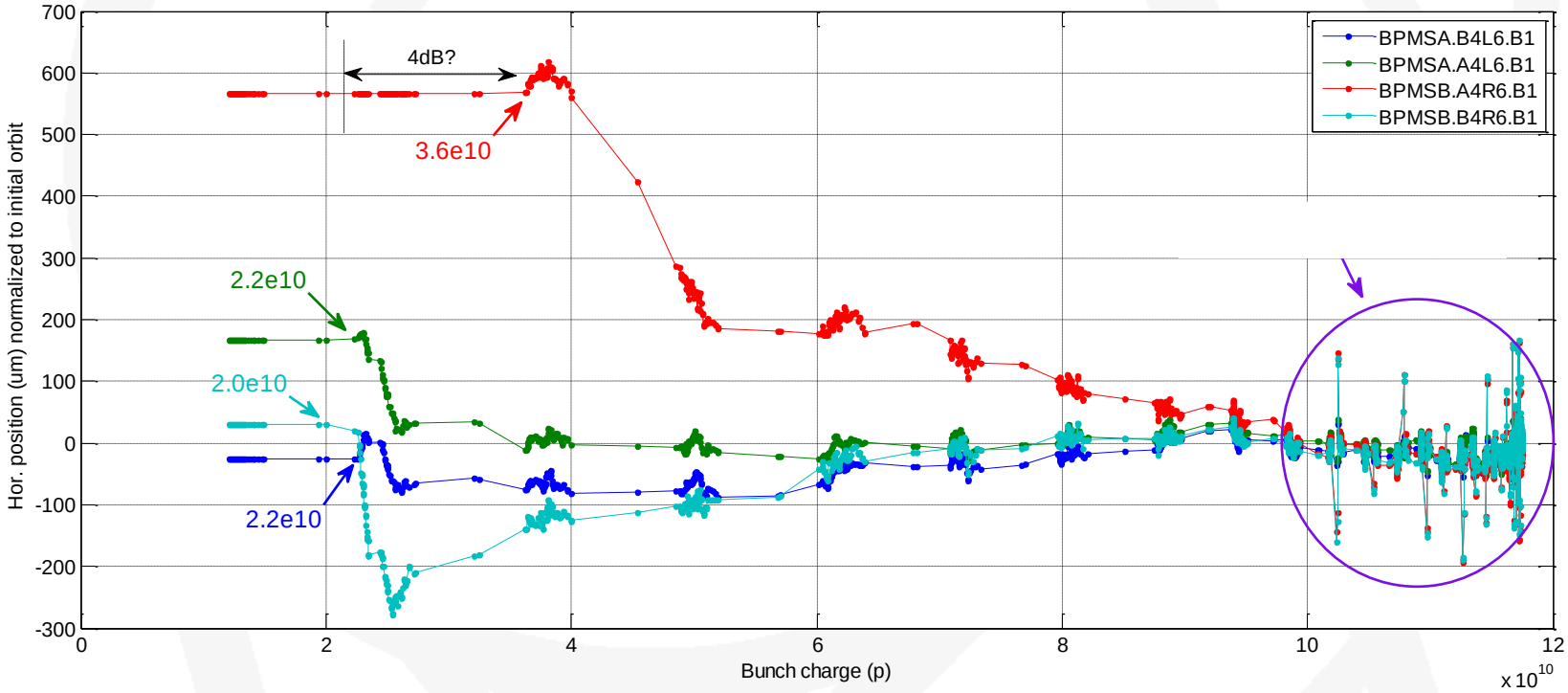
Status and changes justification

- **Today's status**
  - Attenuation modified on 25/05 for B2 BPMSAs – limit now at 4.2e10
  - Both beams can be further optimised
  - **Aim is to align all interlock BPMs to limit around 2e10 – 3e10**



Status and changes justification (cont.)

B1 (status at 24/5/2012)



Suspected there are 4dB instead of the 0dB noted in the traveller in BPMSB.A4R6.B1

Now that the cause of the successive problems is understood, "there is no risk" for optimising the system.

Improving the System…

- **Current settings (MCS)**
  - The BPM interlock firmware compares the ADC output of every single bunch measured with a defined threshold.
  - Currently if 70 readings out of limits over 100 turns triggers the system (i.e. 1 bunch)
  - Second window with 250 out of limits over 10 turns to quickly catch fast orbit change
  - Errors currently counted as “out of allowed window”
    - Intentionally implemented in this way to guarantee correct operation of the system
    - It’s typically on errors that we trigger the system when bunch intensity drops to threshold levels
- **Firmware/Software upgrades:**
  - The attenuator change and the filling scheme change (no private IR8 collisions) has avoided that we trigger the interlock during the last weeks.
  - The new firmware can separate badly acquired bunches from real measurements.
    - This will provide additional post mortem data
      - to distinguish between weak bunches not correctly measured or oscillating bunches.
    - Should make the system more accommodating to specific operational scenarios without compromising protection functionality
      - by allowing different trigger thresholds for the oscillating bunches than for the number of weak bunches.

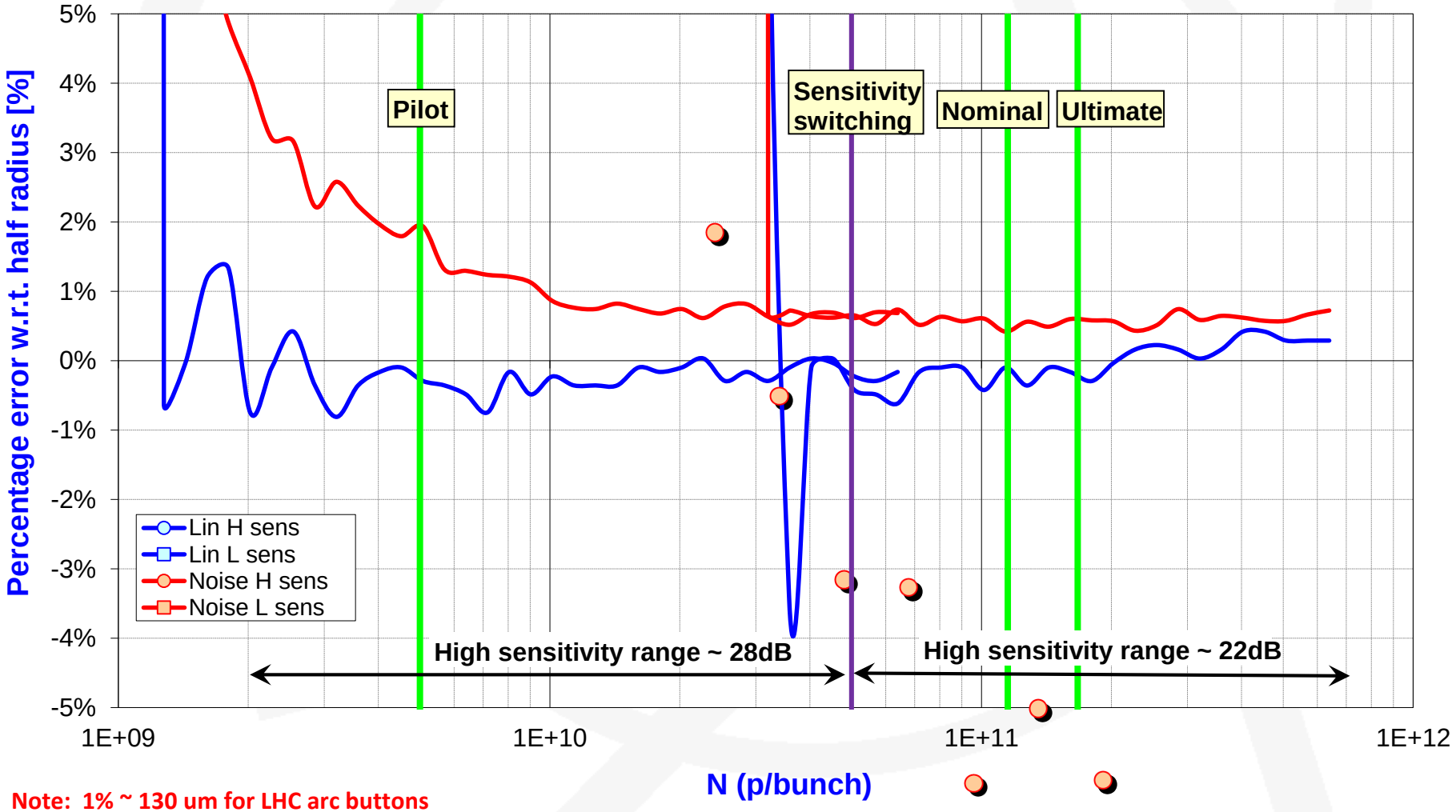
Commissioning Plan

- **Sunday, during BI MD : Test the new firmware functionality**
  - Deployment of the new firmware and FESA versions.
  - Set up one BPM interlocked crate to trigger the interlock if 3-4 bunches are too weak to be correctly acquired. (To prove that protection functionality is not compromised).
  - Setup the second crate in order not to trigger the interlock with only 3-4 weak bunches.(To prove flexibility)
- **During the TS: Include the temperature correction coefficients and test their efficacy by modulating the crate fan speed.**
- **During TS: Replace the attenuators of BPMSA.A4R6.B2 , BPMSA.B4R6.B2 and BPMSB.A4R6.B1.**
- **After TS : Verification of the attenuator change**
  - B1 and B2 scrapping (~30 minutes)
  - "Bump test": make trigger all the channels through bumps, and compare the position when triggering with the defined threshold. (~1h?). The comparison between the levels found last time and the new ones should give an indication about any included offset.
- **Collimator alignment campaign in IR6 to verify the BPM offsets.**

Thanks

Spares

Linearity error vs bunch charge



Note: 1% ~ 130 um for LHC arc buttons