Status of Interlock BPM

LHC BPM team

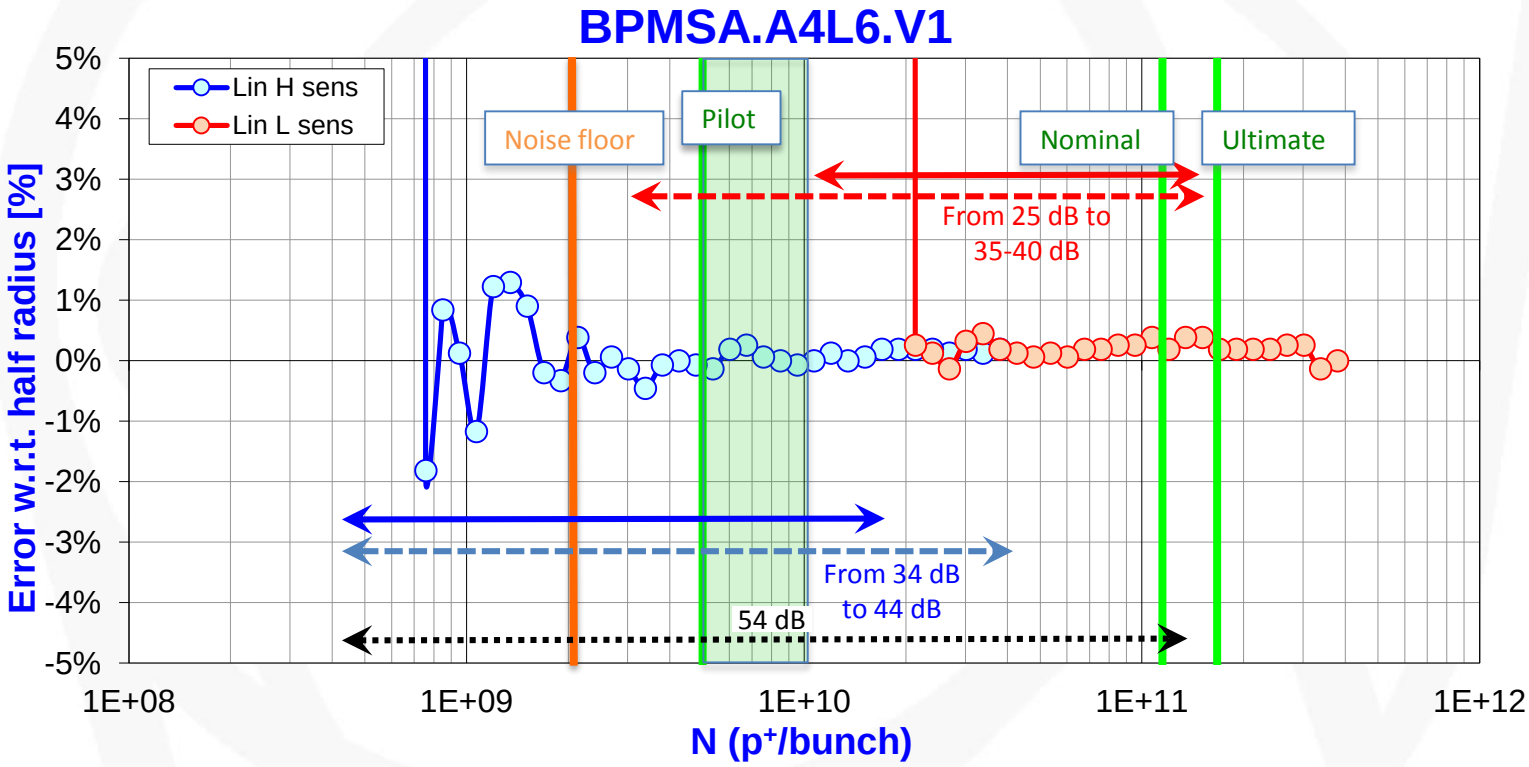
Outline

- **Re-commissioning of the system with beam**
  - New dynamic range
  - Modifications of the Post-mortem freeze
  - New diagnostic tools / Post-mortem data
- **Modifications for next TS ?**
  - Do the Dynamic ranges in place now fit all your needs (MPP/OP)
- **Update on Doublet bunches**

Hardware Modifications : LS1

- Improving the dynamic range of the BPM: Avoid dumping on false BPM readings when beam intensity decreases: Limiting signal reflection
  - Replaced shorted strip-lines with 50 Ω termination
  - Added absorptive filter at strip-line output (100 MHz)
- Better stability with thermal controlled racks
  - No statistic yet – but will improve the long term reliability of the system
- Better monitoring/processing of Interlock data
  - Separated orbit and interlock functions (2 DABs)
  - Larger memory for interlock acquisition channel to store B/B data over 154turns
  - A daisy chain to trig all BPM channels synchronously

New dynamic ranges



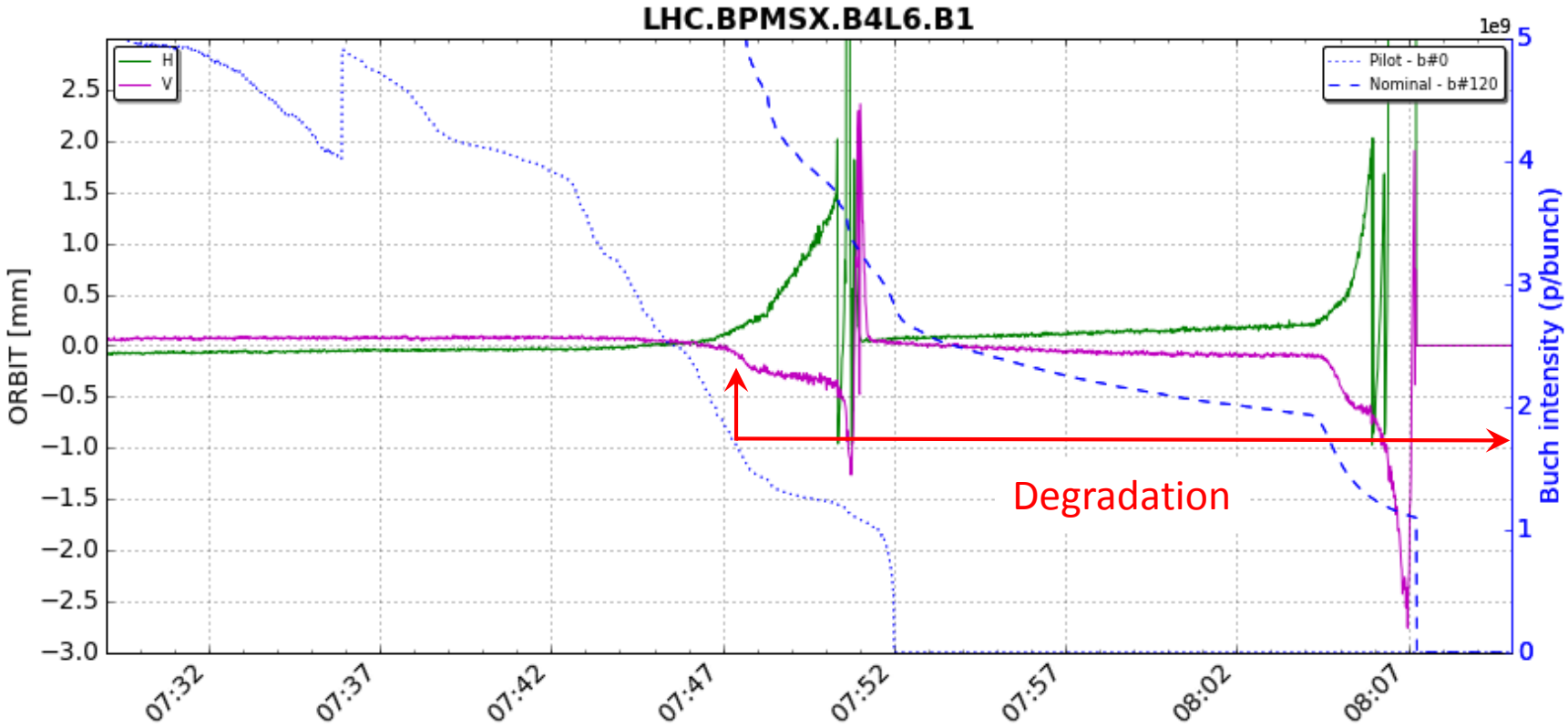
	Before	Now
High Sens.	1.5E9 – 3E10	1.5E9 - >1.3E11

Dynamic range improved by more than 10dB

Low Sens.	*2E10 - > 2E11*	*1.5E10 - > 2E11*
Unchanged now but		*?? - > 2E11*

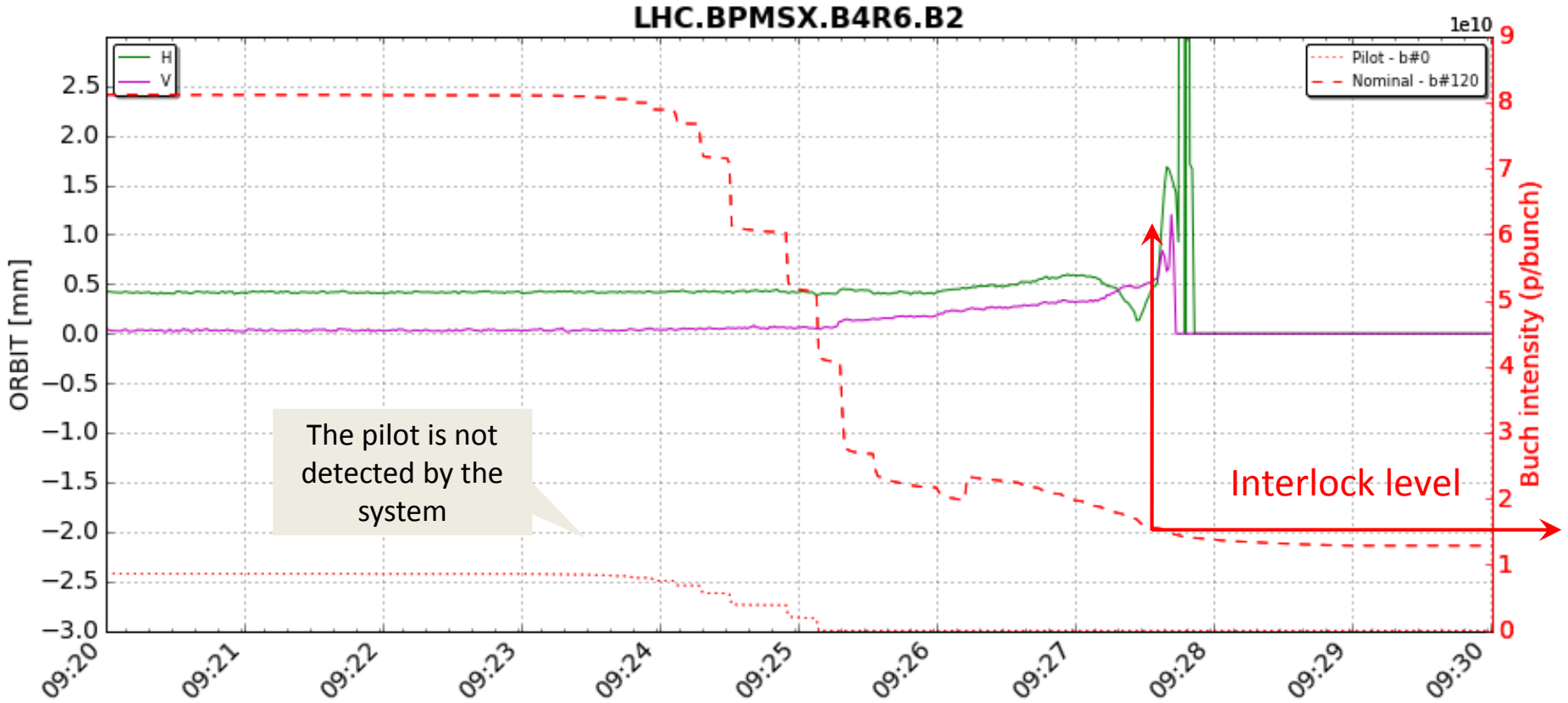
Re-commissioning

Scrapping one Pilot and one Nominal in **High sensitivity** mode



Re-commissioning

Scrapping one Pilot and one nominal in **low sensitivity** mode



Ongoing activities

- Observed a discrepancy of 0.5mm in between the limit set by MPP and the one calculated by FE
  - Error found in the software.. Should be corrected now
- New interlock Capture data (B/B position over the last 154 turns) not available on the post-mortem buffer : working on it

Hardware changes during TS

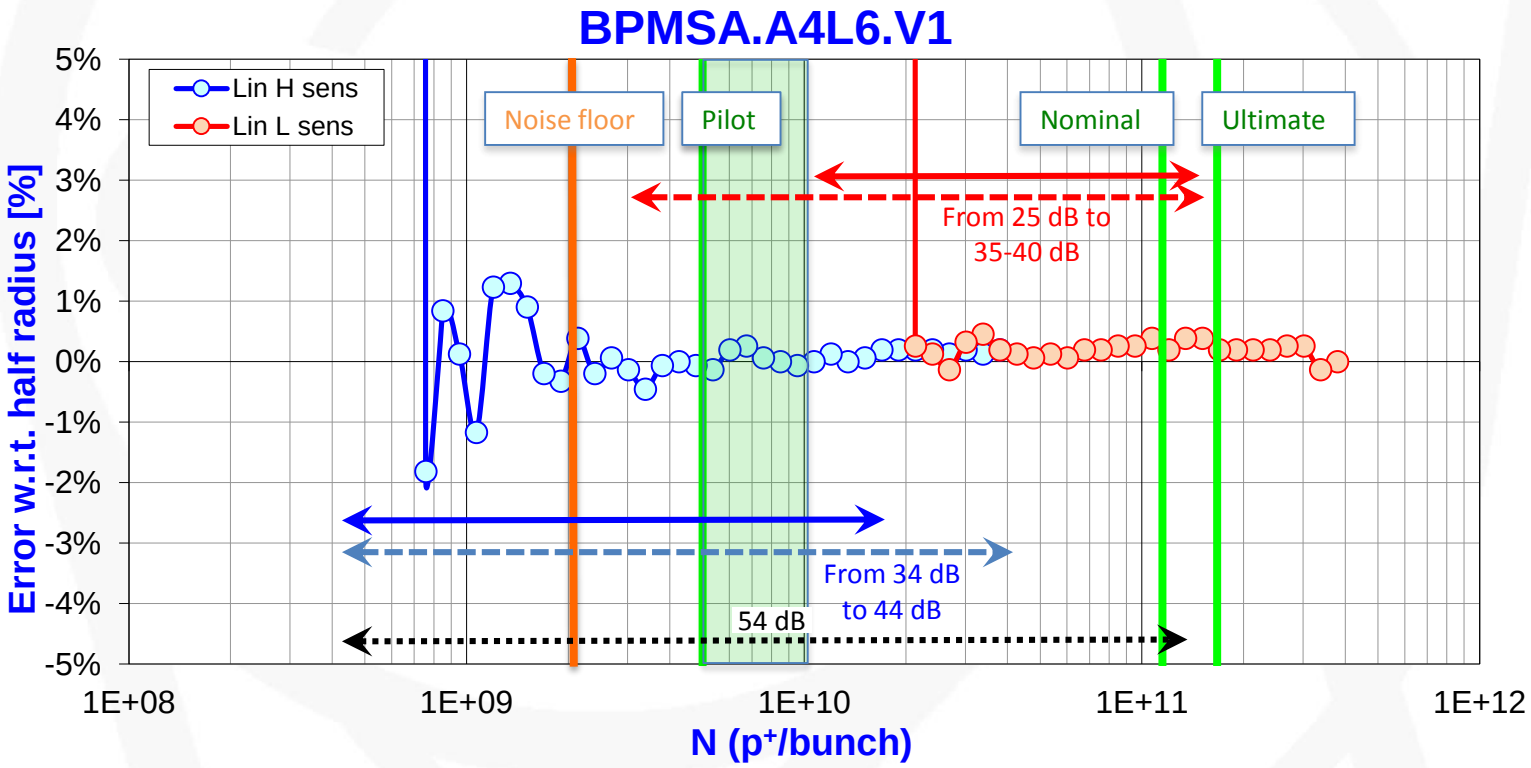
Do we keep the the Dynamic ranges as such ?
Limit during physics and scrubbing ?

- Ions-Ions or Ions-P fills using High Sensitivity Mode
  - Problem solved - Should not have any limitation in using any requested proton bunch intensity: however the limit may come now from the regular BPM system which do not have the extended dynamic range.
- P-P fills using Low Sensitivity Mode
  - Now at 1.5E10 but can go down if requested (need acces to UA)
  - Issue with Pilot bunch intensities : It should be seen by the BPM: What can be done to make sure that the Pilot bunches has always bunch population smaller than 5E9
    - Pilot Cleaning or Scrapping before injecting nominal bunch intensities ?

Doublet bunches

Spare Slides

Old / New situation



- HS mode will still dump beams for bunch population < 1E9
- Dumping beam from signal reflections in HS for Bunch population >3E10
- Dumping beam in LS mode for bunch population < 2E10 : to be defined

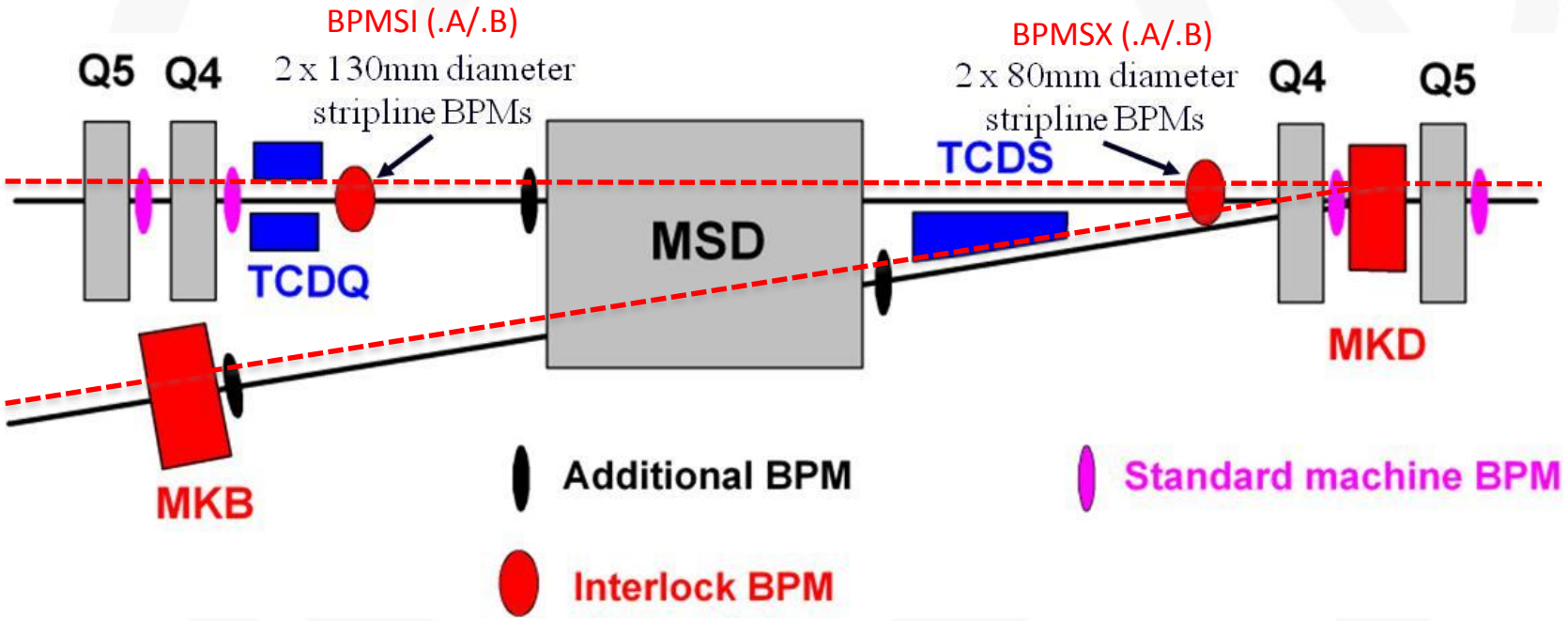
New situation

- Ions-Ions or Ions-P fills using High Sensitivity Mode
  - Should not have any limitation in using any requested proton bunch intensity: The limit may come now from the regular BPM system which do not have the extended dynamic range.

- P-P fills using Low Sensitivity Mode
  - The system is capable to go down to 5E9 as lower threshold
  - But the set of the threshold is part of the tuning of the card and cannot be controlled remotely
  - Need to choose a threshold for which the pilot bunch will not be seen by the system: 1E1O or even smaller which may be better if we runin physics with ecloud.
  - What can be done to make sure that the Pilot bunches has alays bunch population smaller than 5E9
    - Pilot Cleaning ?

Spare Slides

Dump Channel



The main aim of these BPMs is to avoid large orbit offsets leading to high losses on the septum protection during a dump

Interlocked BPMs

- Strip line pick-ups installed in IR6 just after Q4 (BPMSX was BPMSA) and just before the TCDQ (BPMSI was BPMSB)
- Prevent beam on TCDS
- Acquisition is based on the LHC BPM design with dedicated firmware
- Two operational ranges used (high and low sensitivity modes)

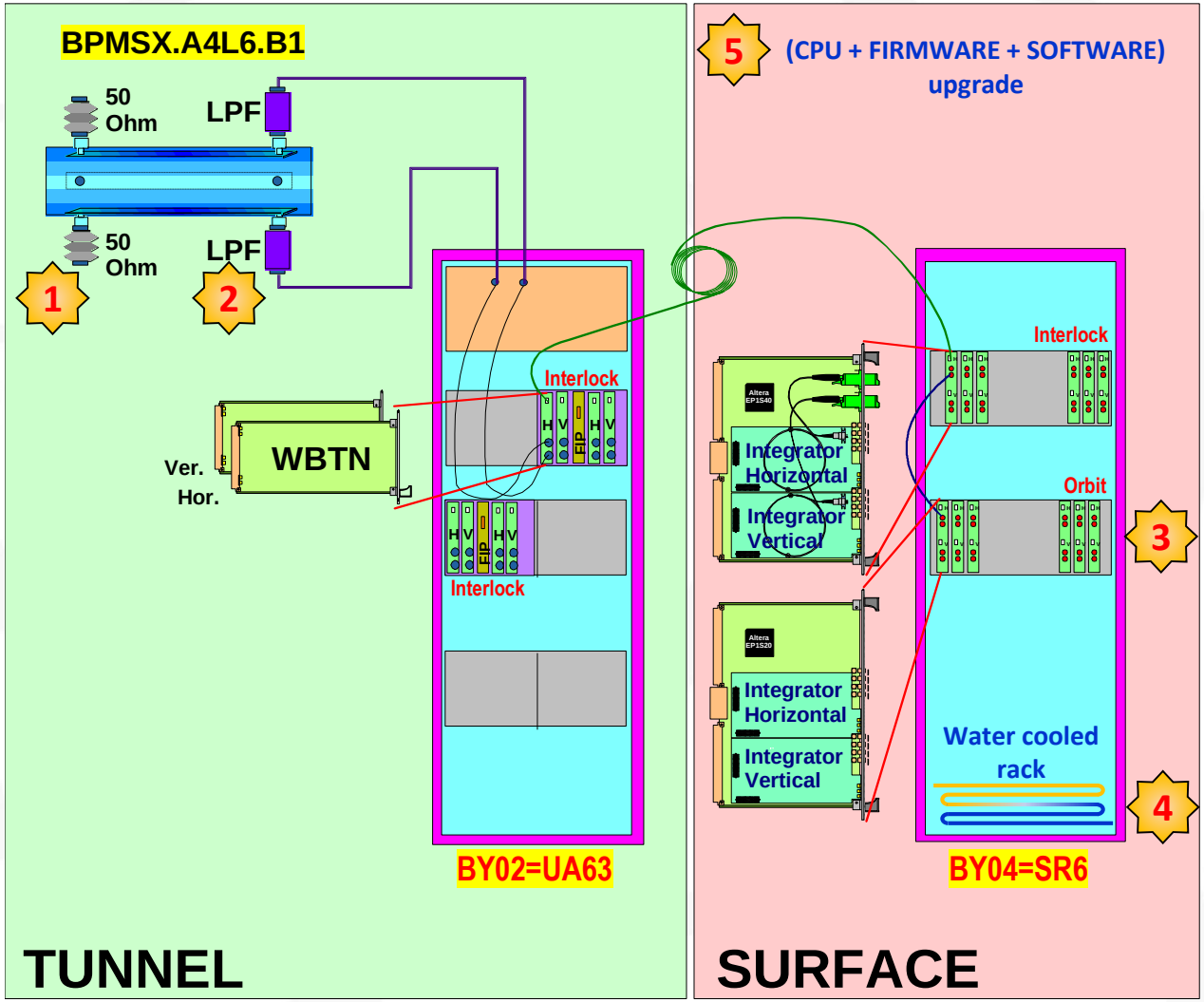
Interlock Mechanism

- Two separate trigger logics
  - 70 reading in the last 100 turns out of limits (a single bunch can trigger the dump)
  - 250 reading in the last 10 turns out of limits (response to fast orbit changes)
- Limits set to ~±3mm
- The whole chain from readout to beam dump trigger is in hardware (and firmware)
- Interlock signal connected to a maskable channel of the BIS

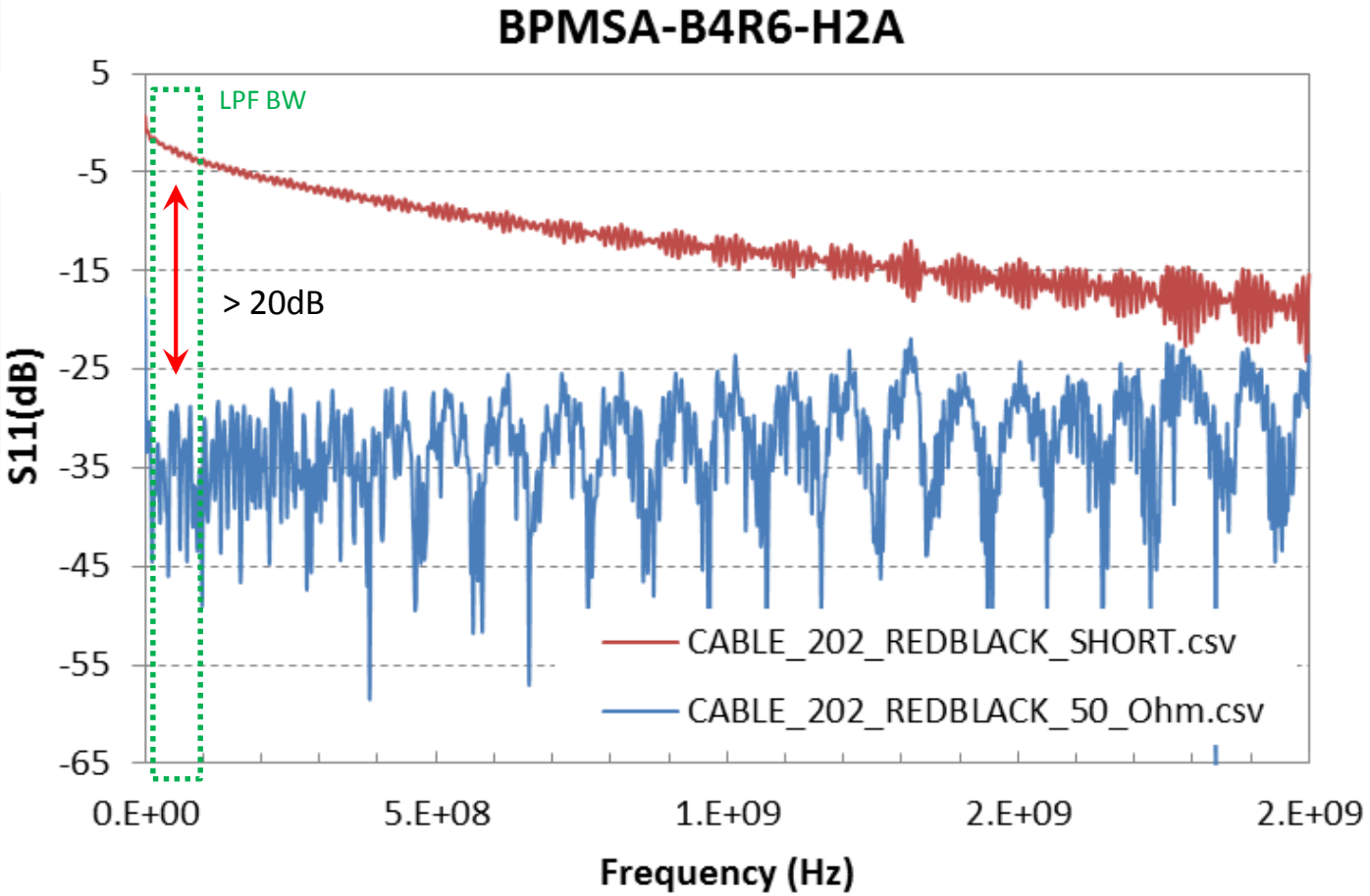
New BPM-int setup

The BPMs have been renamed (LHC-BP-EC-0002)

The Interlock and orbit systems have been separated

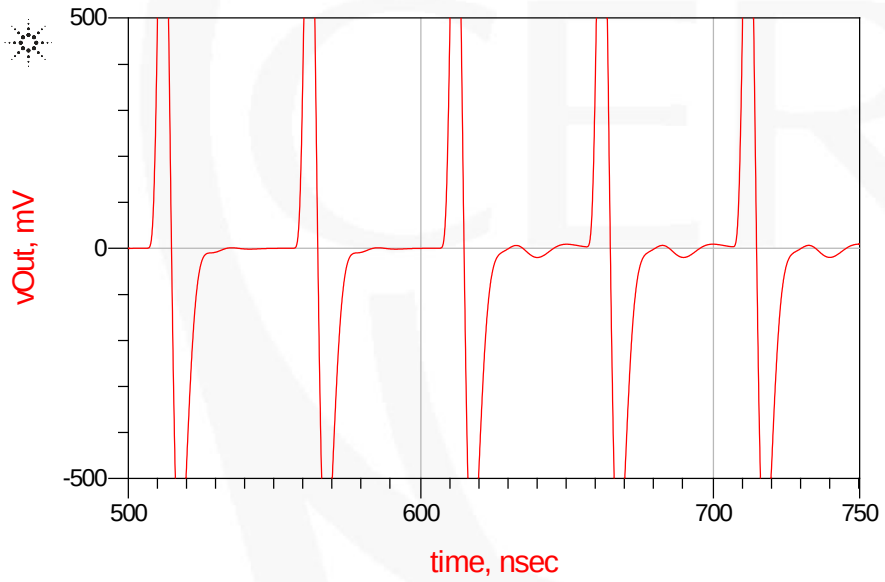


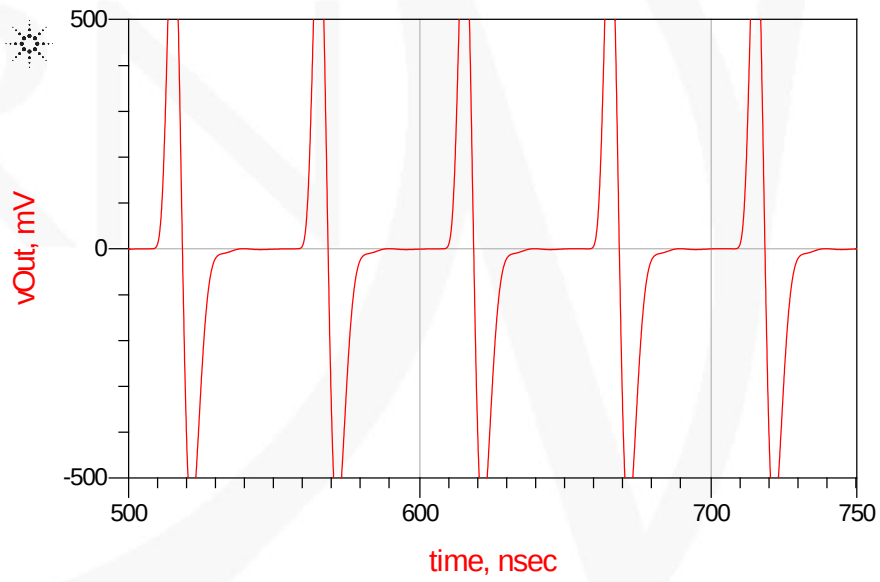
BPMs Reflections



More than a factor 10 improvement on the Pick-up

Reflections in time domain

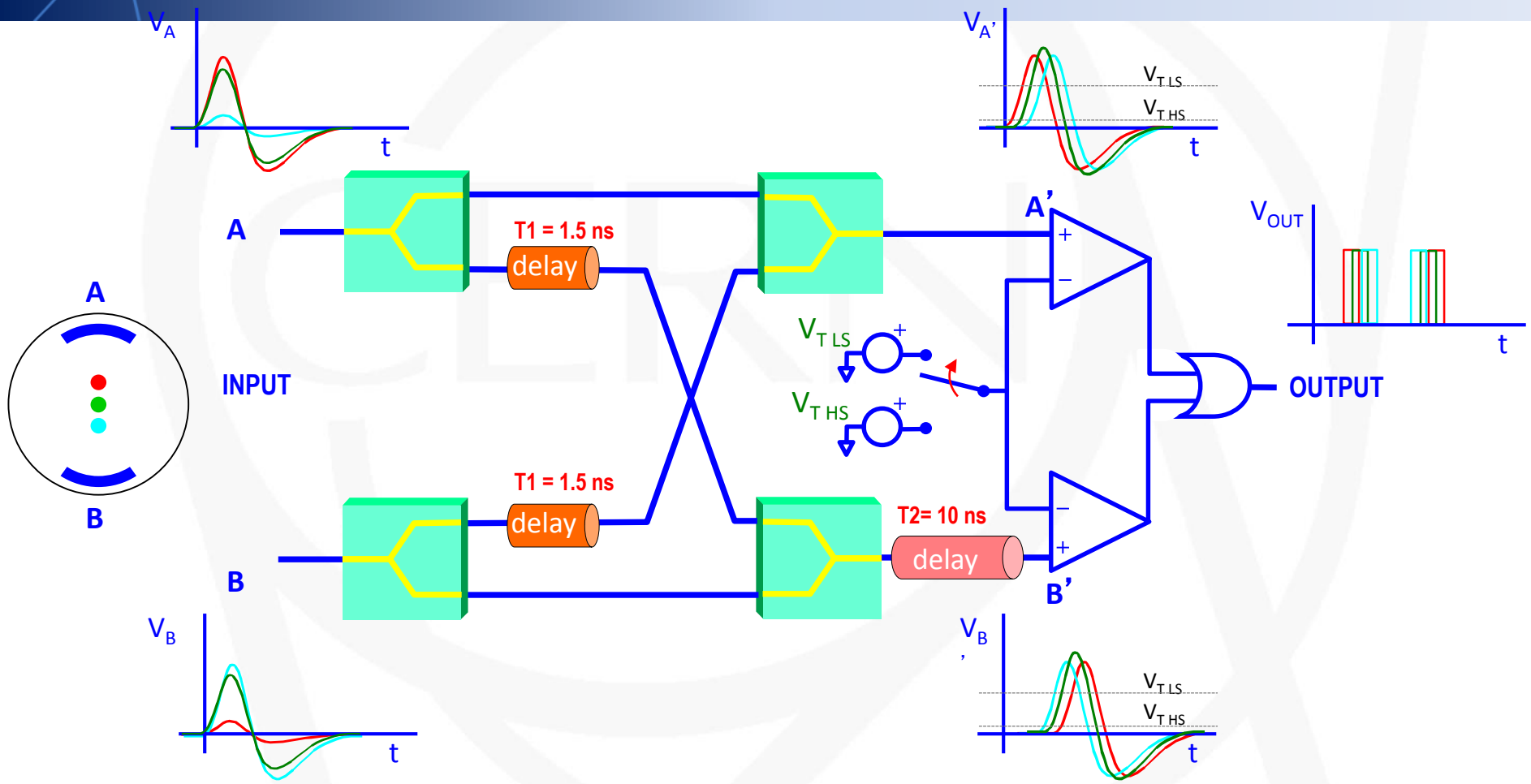




Shorted strip-lines reflections
Measurement: -27 dB
Simulation: -34 dB

Terminated strip-lines with LPF:
Simulations: <-46 dB

The WBTN principle

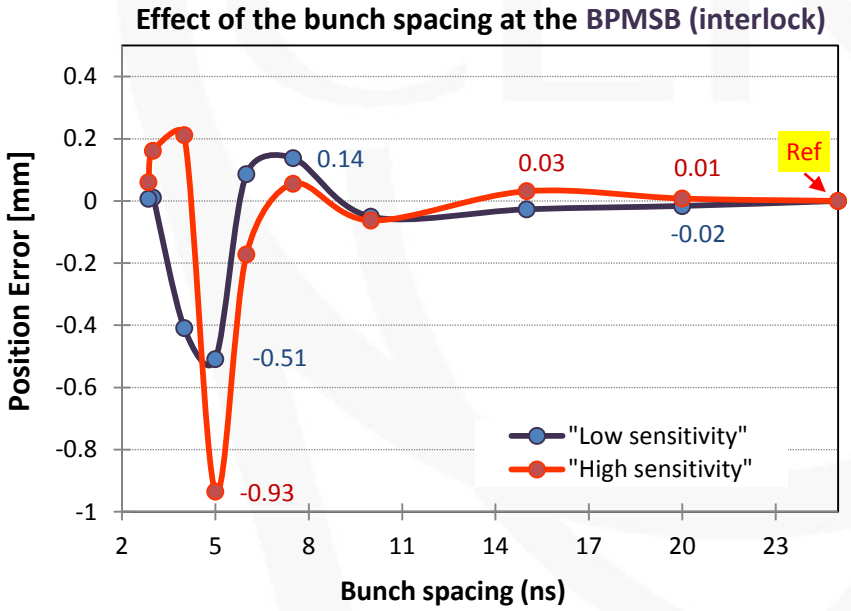


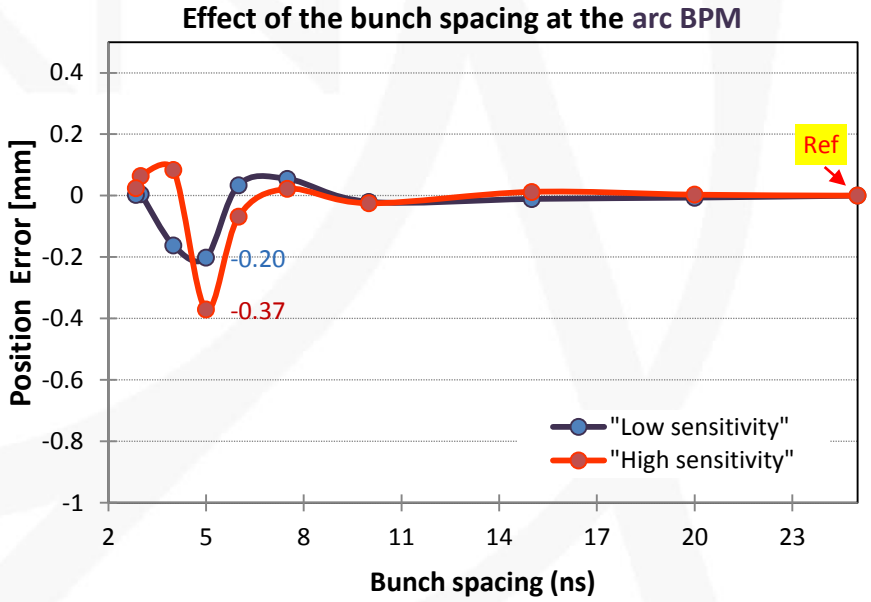
Amplitude modulation

Time modulation

Scrubbing doublets

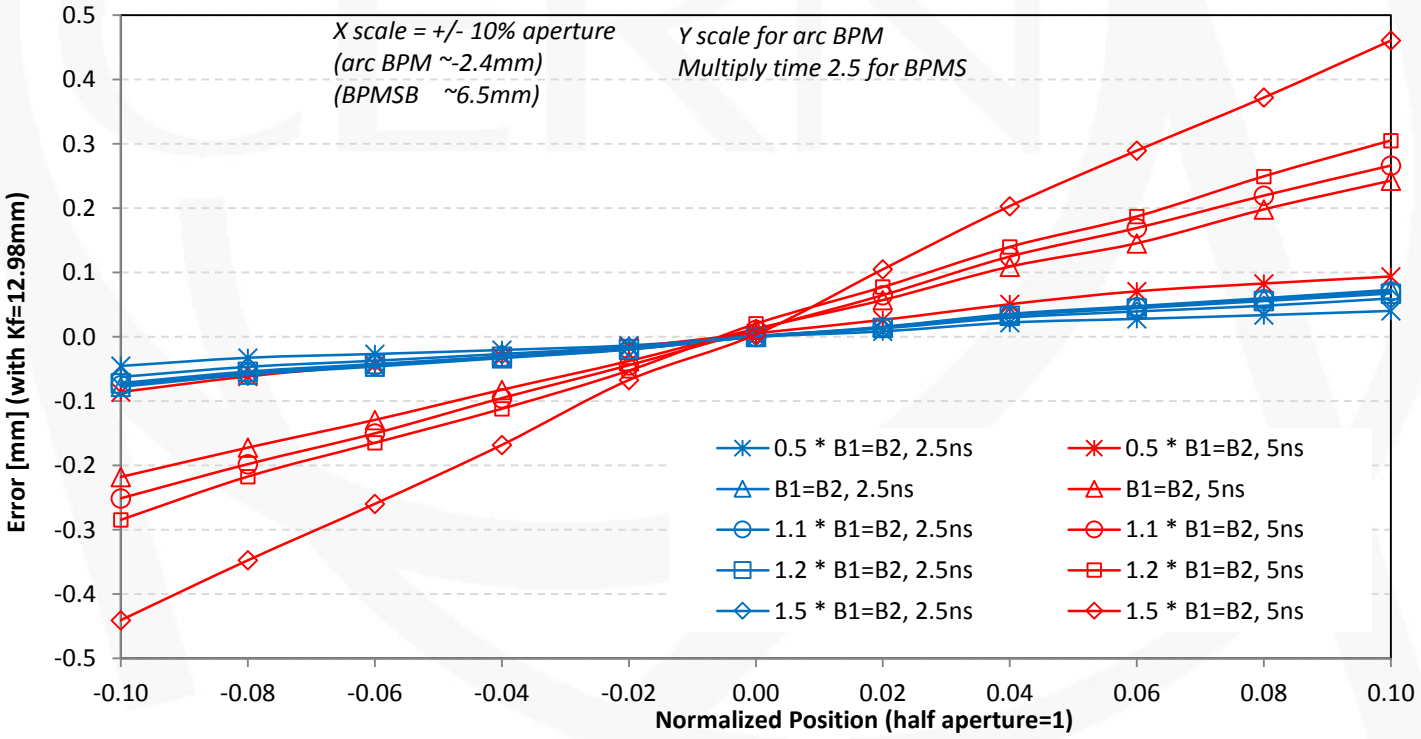
Beam “simulator” tests (beam signal replaced by pulse generator)
May be possible to test on SPS with beam





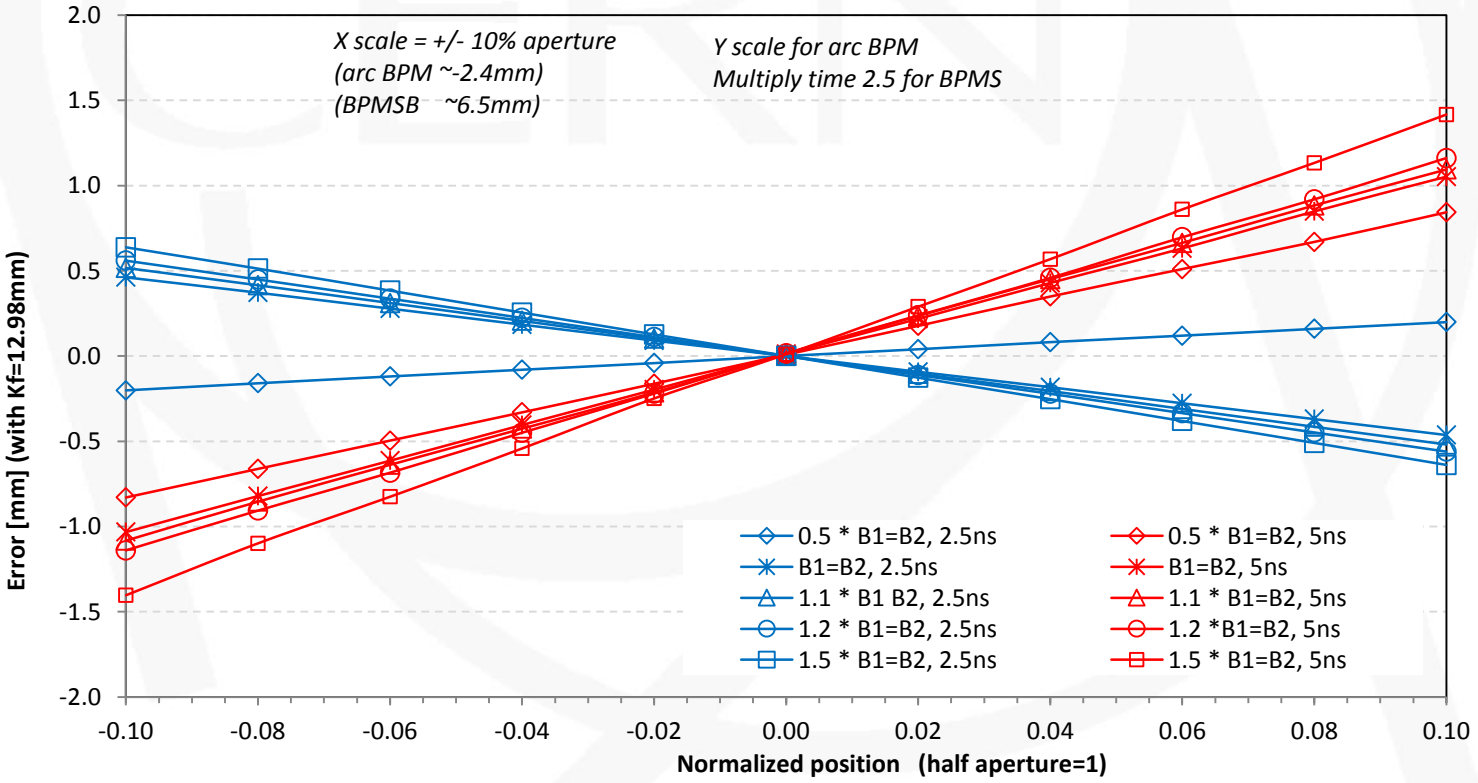
Doublets simulations 1

Bunch 1 and bunch 2 with same position

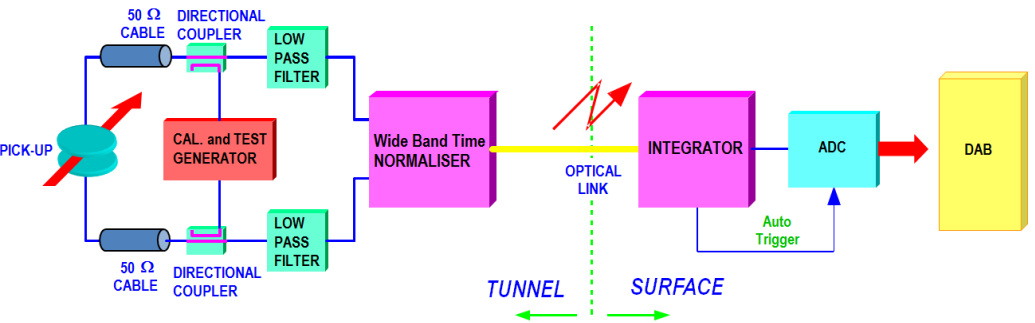


Doublets simulations 2

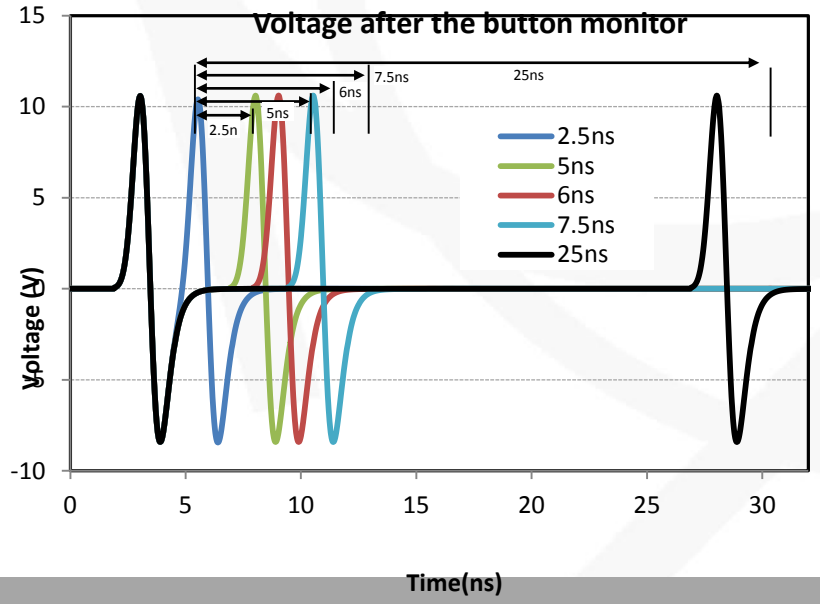
Bunch 2 always centred

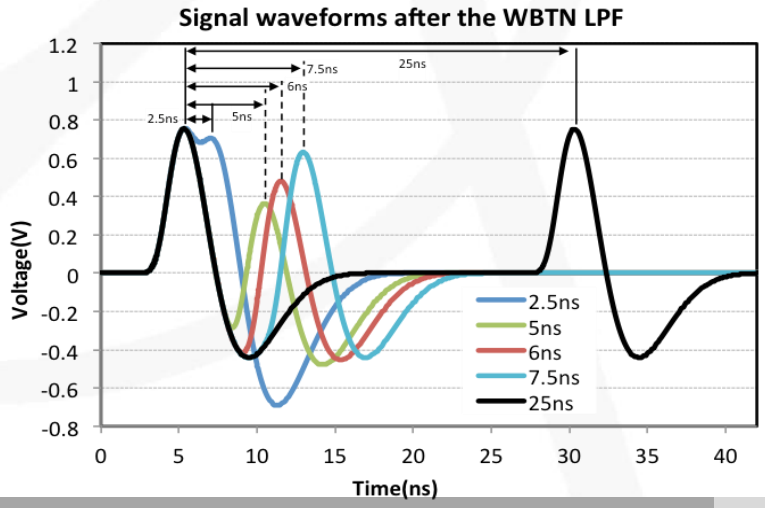


LHC BPM - WBTN



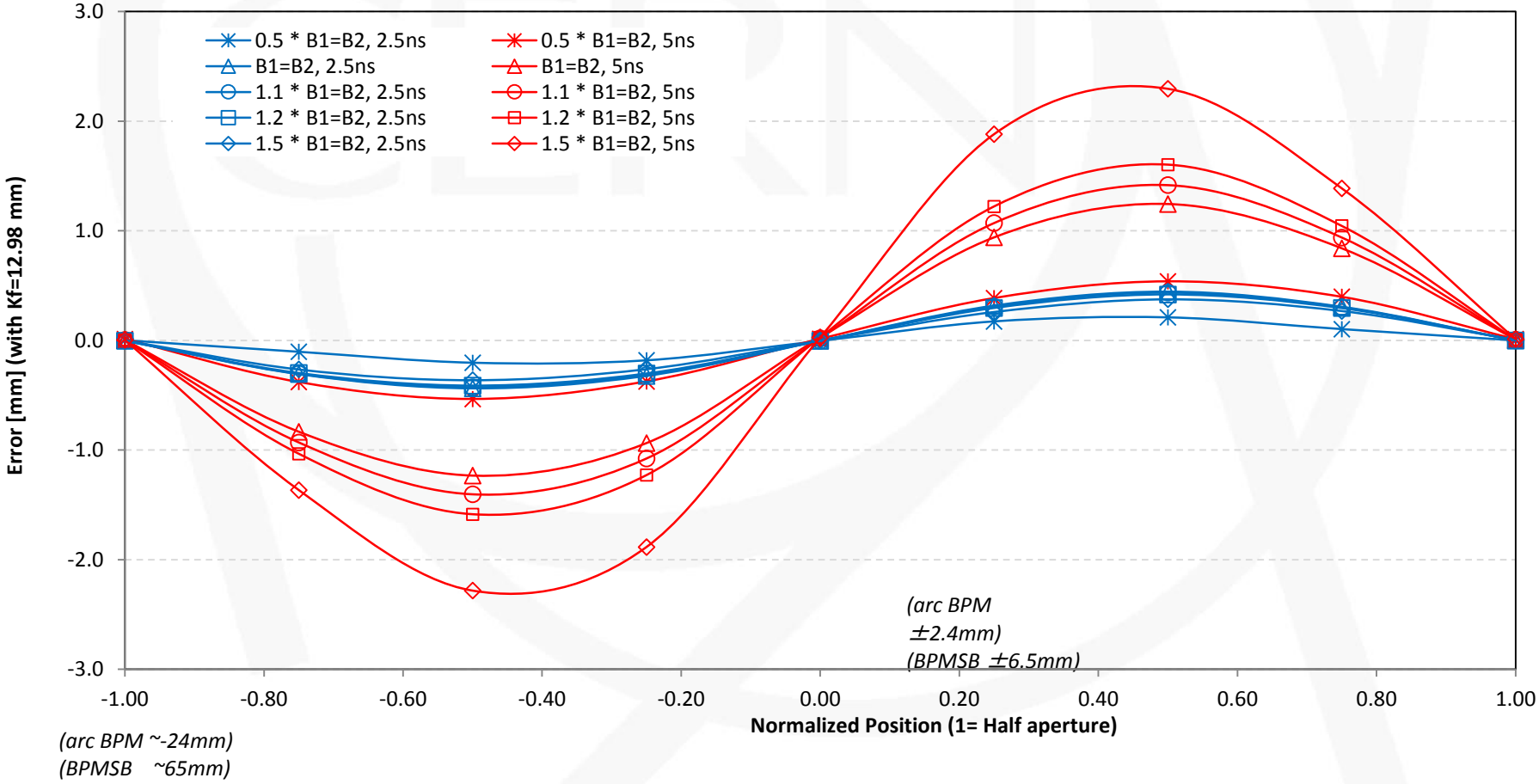
- Amplitude to Time conversion
- 70MHz LPF at the input of the electronic (bunch length independent)
- Depending on the bunch spacing , the signal will overlap in different ways.
- The system will provide a single measurement for bunches which are spaced by less than ~20ns.





Simulations with Pspice

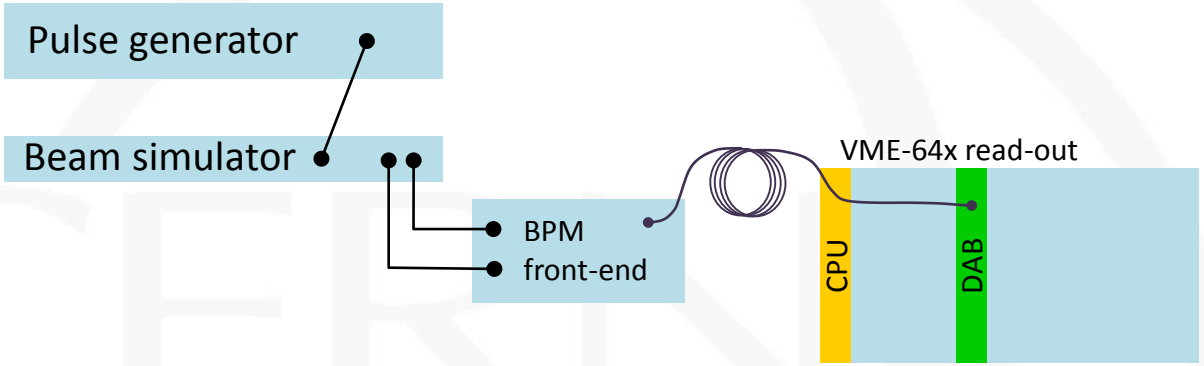
- **Bunch 1 and 2 can have different intensities : ‘(Un)Balanced Doublet’**
- Normalizer model circuit and signals are “ideal”
- Realistic Bunch length



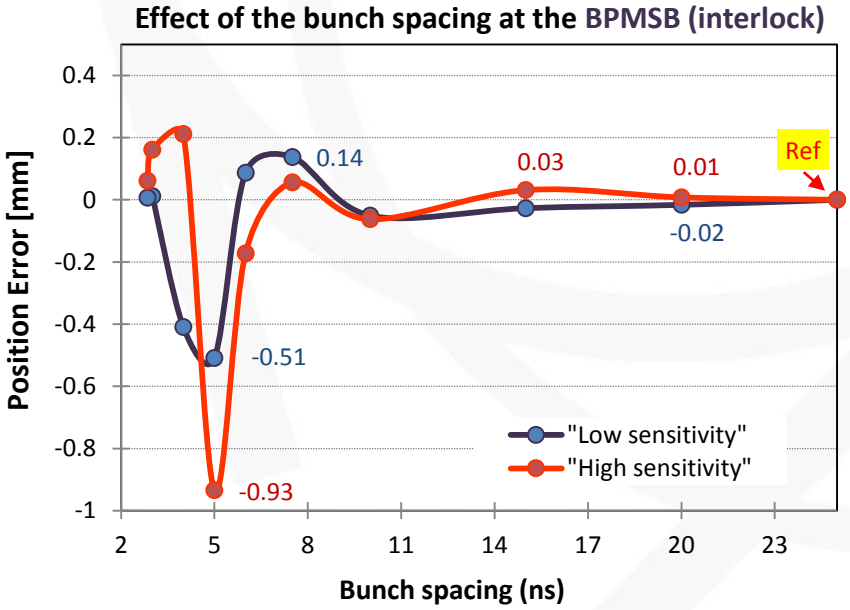
(arc BPM ~-24mm)
(BPMSB ~65mm)

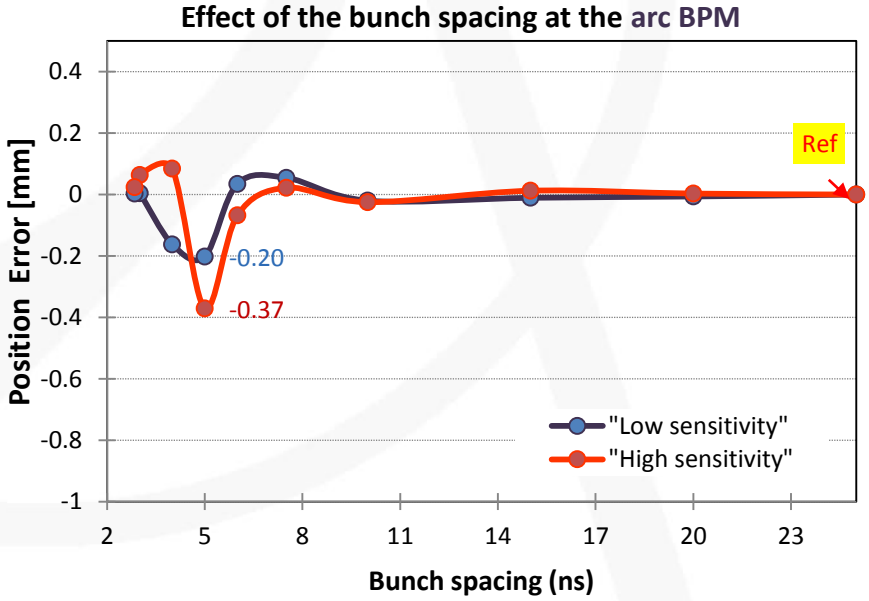
Note : Half Aperture of arc BPM = 24mm
Half Aperture of BPMSB = 65 mm

Test in the lab



- Pulse generator creates 2 pulses with bunch spacing ranging from 2.5 up to 25ns
- Generator produces wider pulses than the beam will do, but this effect is minimized by the LPF at the WBTN input.
- The present set-up only simulate bunches with same intensities and same position

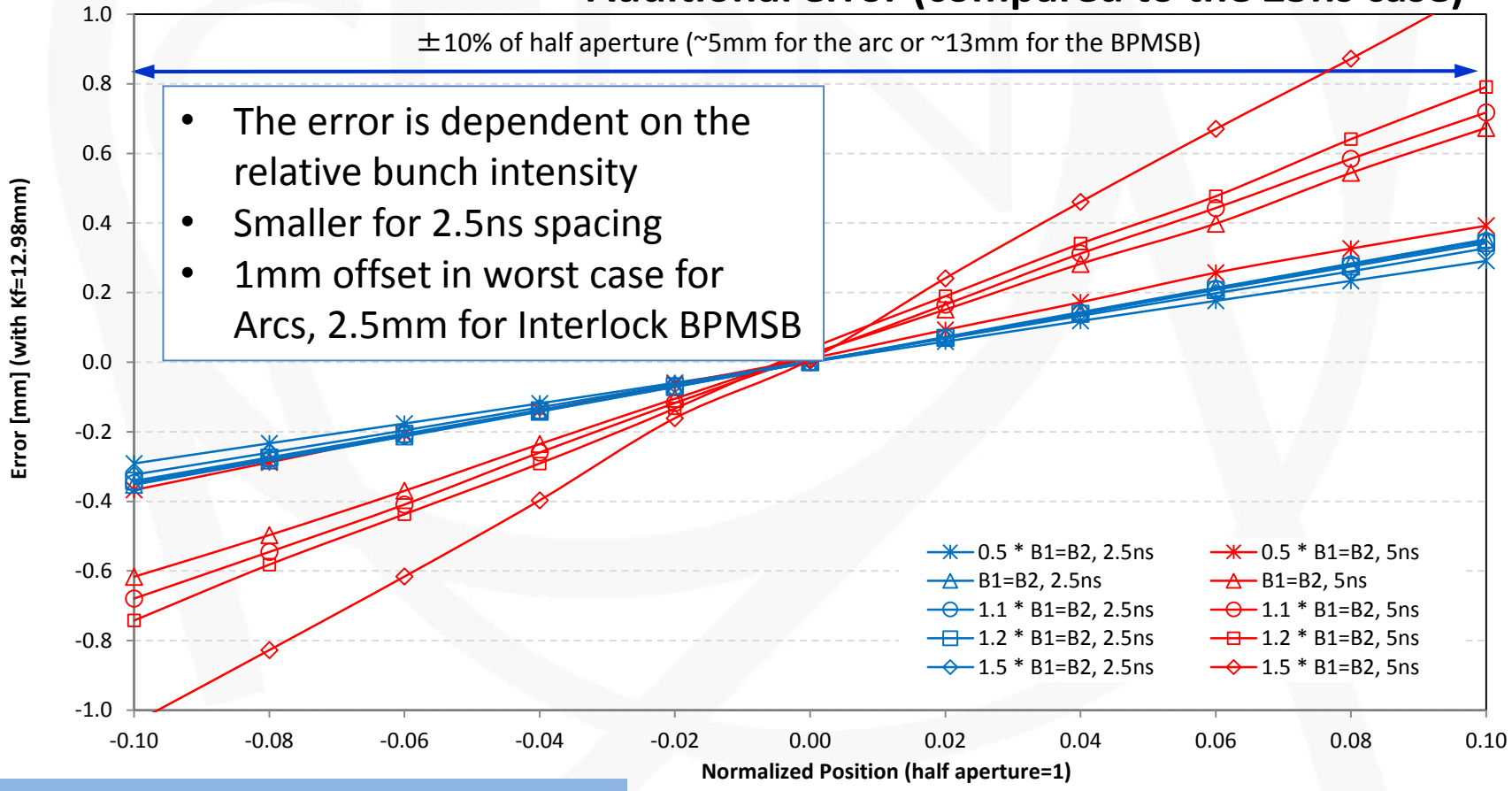




Simulations with Pspice

- **Bunch 1 and 2 have different intensities (50%) : 'unbalanced Doublet'**
- Normalizer model circuit and signals are "ideal"
- Realistic Bunch length

Additional error (compared to the 25ns case)



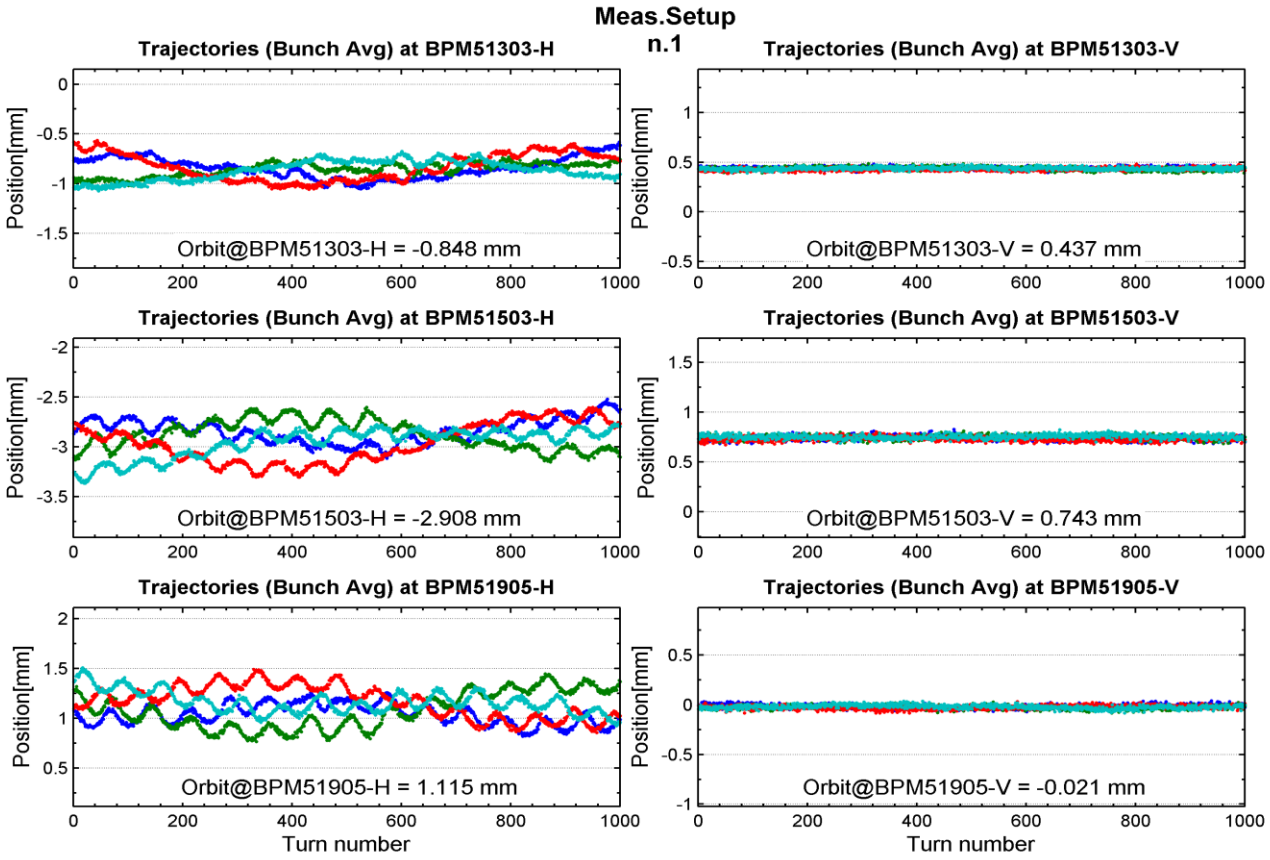
Note : Half Aperture of arc BPM = 24mm, Kf= 12.98
Half Aperture of BPMSB = 65 mm, Kf = 32.75 (2.5 bigger error!)

Beam tests on SPS

- **Test done on 3 button BPMs 'BPMB': 513, 515 and 519**
  - BPMB aperture 83mm : 34mm Button diameter
  - Resolution in b/b mode: 90um/bin
- **Using a train of bunches with 25ns spacing**
- **Always acquiring reference measurements with nominal bunches (b/b over 1000 turns)**
- **Switching to Doublets**
  - Tests at both injection and flat top
  - Tests with 'centered' beam and using orbit bump at flat bottom
  - Comparing the orbit offset with respect to nominal bunches (extrapolated for all BPMs in LHC) and measuring the b/b fluctuations/noises relevant for LHC interlock BPMs

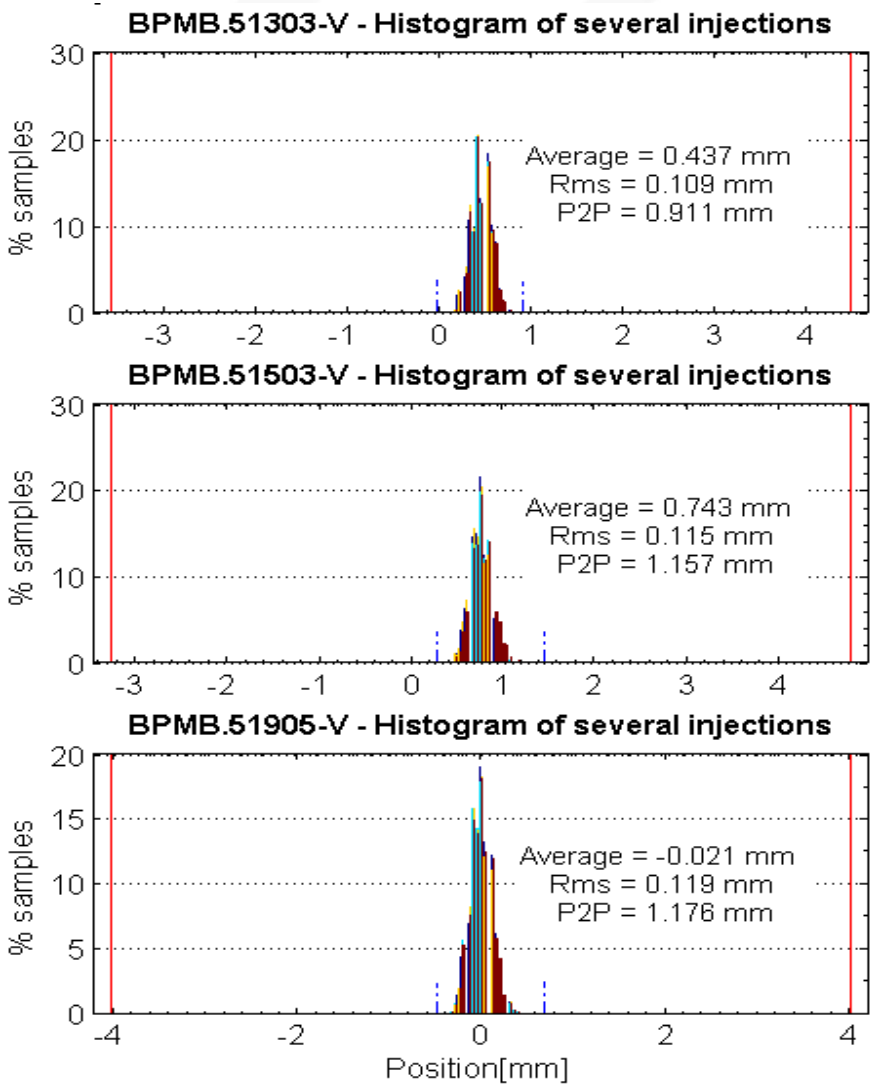
Nominal bunches at injection

- At 26GeV - 72 nominal bunches @ 25ns
- 1000 turns acquisition 560ms after injection – Turn-by turn data averaging all bunches over one turn



- *Oscillations/variations quite strong in horizontal plane*
- *Presenting only results in the vertical plane to get better resolution*

Nominal bunches at injection



- At 26GeV – 72 nominal bunches @ 25ns
- Histogram of B/B positions over 1000 turns
- BPM in Low sensitivity

	BPMB.51303-V			BPMB.51503-V			BPMB.51905-V		
	Orbit	Rms	P2P	Orbit	Rms	P2P	Orbit	Rms	P2P
Inj. N.1	0.443	0.107	0.864	0.740	0.107	0.915	-0.015	0.116	1.029
Inj. N.2	0.436	0.109	0.864	0.748	0.117	0.915	-0.024	0.120	1.127
Inj. N.3	0.430	0.110	0.815	0.732	0.113	0.867	-0.024	0.119	1.128
Inj. N.4	0.438	0.110	0.911	0.754	0.121	1.157	-0.020	0.120	1.078
AVERAGE	0.437	0.109	0.863	0.743	0.115	0.963	-0.021	0.119	1.090

- *Good fill to fill orbit stability of +/-10um*
- *b/b r.m.s variation around 100um (close to resolution limit of 90um)*
- *peak to peak variation over 1000 turns around 1mm (due to few bunches with larger variation)*

Nominal bunches at injection

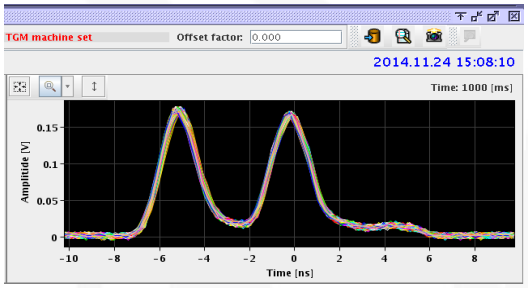
- At 26GeV – 72 nominal bunches @ 25ns
- Several measurement taken during the day over 6h period

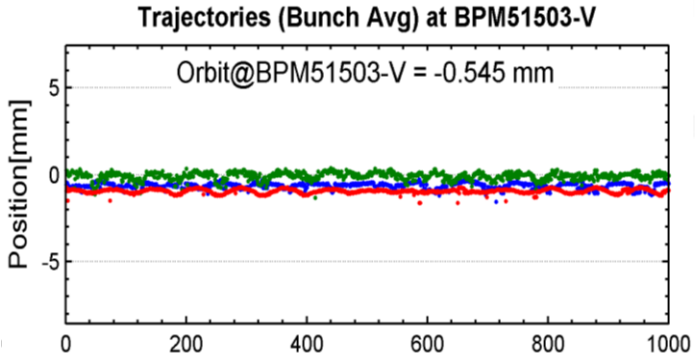
	Orbit during Setup #1	Orbit during Setup #4	Observed drift
BPMB.51303-V	0.437 mm	0.467 mm	0.030 mm
BPMB.51503-V	0.743 mm	0.755 mm	0.012 mm
BPMB.51905-V	-0.021 mm	-0.008 mm	-0.013 mm

Good reproducibility with very small orbit drift observed over 6h !

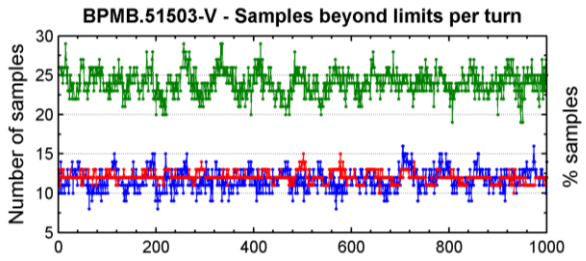
Doublet bunches at injection

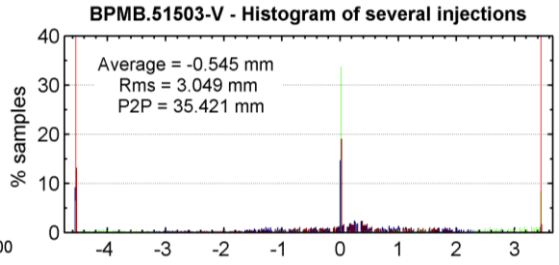
- At 26GeV – 72 Doublet bunches @ 25ns
- 1000 turns acquisition 560ms after injection
- BPM in Low sensitivity





	BPMB.51303-V			BPMB.51503-V			BPMB.51905-V		
	Orbit	Rms	P2P	Orbit	Rms	P2P	Orbit	Rms	P2P
Inj. N.1	-0.597	2.702	**35.225**	-0.628	2.804	**34.995**	-2.557	4.709	**32.387**
Inj. N.2	-2.893	7.277	**35.726**	-0.068	3.129	**35.201**	-2.274	6.683	**28.255**
Inj. N.3	-0.434	2.590	**35.140**	-0.939	3.138	**28.878**	-1.907	4.220	**33.254**
AVERAGE	-1.308	4.190	**35.364**	-0.545	3.023	**33.025**	-2.246	5.204	**31.299**



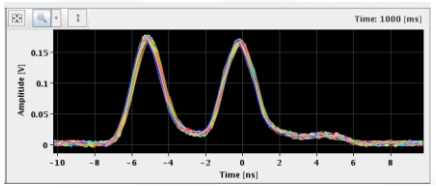


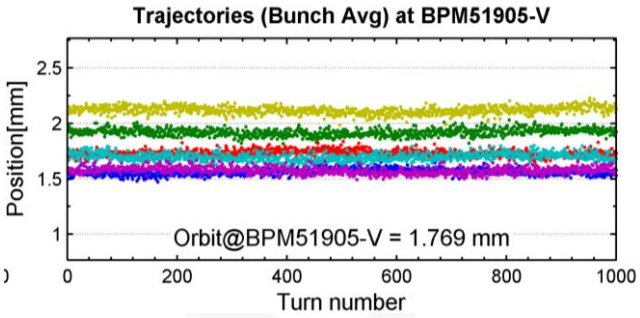
- *Not reproducible Orbit offset*
- *Very large r.m.s b/b variation*
- *Out of range Peak to peak variation*
- *High number of bunches measured outside the position limit (+/-4mm)*

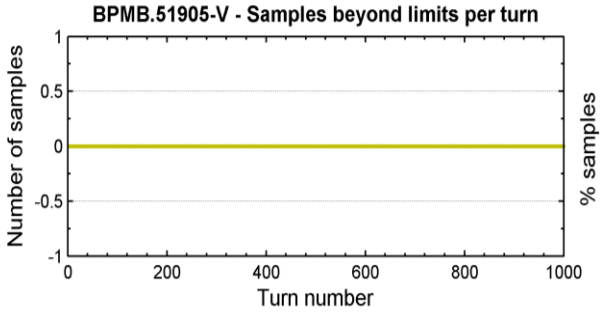
With doublet bunches - Low sensitivity mode is not functioning anymore – (pulse length issue)

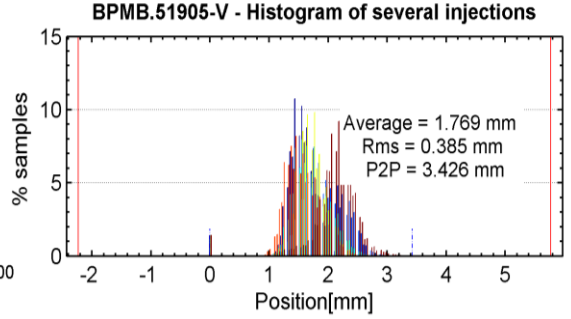
Doublet bunches at injection

- At 26GeV – 72 Doublet bunches @ 25ns
- 1000 turns acquisition 560ms after injection
- BPM in High sensitivity









	BPMB.51303-V			BPMB.51503-V			BPMB.51905-V		
	Orbit	Rms	P2P	Orbit	Rms	P2P	Orbit	Rms	P2P
Inj. N.1	1.664	0.185	2.434	1.384	0.156	1.114	1.563	0.272	2.517
Inj. N.2	1.773	0.208	2.728	1.580	0.213	1.649	1.922	0.405	3.072
Inj. N.3	1.664	0.175	1.309	1.419	0.180	1.358	1.732	0.289	2.147
Inj. N.4	1.709	0.186	2.434	1.455	0.172	1.405	1.700	0.308	2.719
Inj. N.5	1.595	0.163	1.308	1.319	0.164	1.259	1.577	0.291	1.996
Inj. N.6	1.839	0.221	1.841	1.732	0.234	1.940	2.120	0.392	3.426
AVERAGE	1.707	0.190	2.009	1.481	0.186	1.454	1.769	0.326	2.646

- *Reproducible Orbit offset*
- *(Reasonable) r.m.s b/b variation (0.3mm)*
- *No bunch measured outside the position limit (+/-4mm)*

Open question – **What is due to electronic** / what is linked to quality of doublet beam ?

Doublet bunches at injection

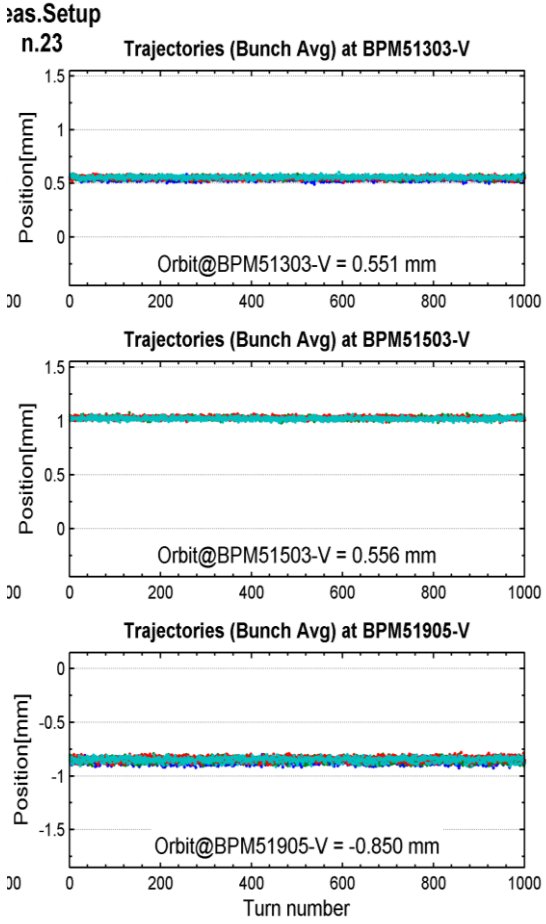
- At 26GeV – 72 Doublet bunches @ 25ns
- 1000 turns acquisition 560ms after injection
- BPM in High sensitivity

	V. Orbit during Nominal	V. Orbit during Doublet	Drift due to doublet (balanced) beam
BPMB.51303-V	0.467 mm	1.707 mm	1.240 mm
BPMB.51503-V	0.755 mm	1.481 mm	0.726 mm
BPMB.51905-V	-0.008 mm	1.769 mm	1.777 mm

- *Averaged offset of 1.1mm with large variation for the different pick-up (not clear why but BPM519 electronic is noisier)*
- *b/b variation larger up to 3mm (factor 3 more than with nominal bunches)*

Nominal bunches at Flat top

- At 450GeV – 72 nominal bunches @ 25ns
- 1000 turns acquisition 28.3s after injection
- BPM in Low sensitivity



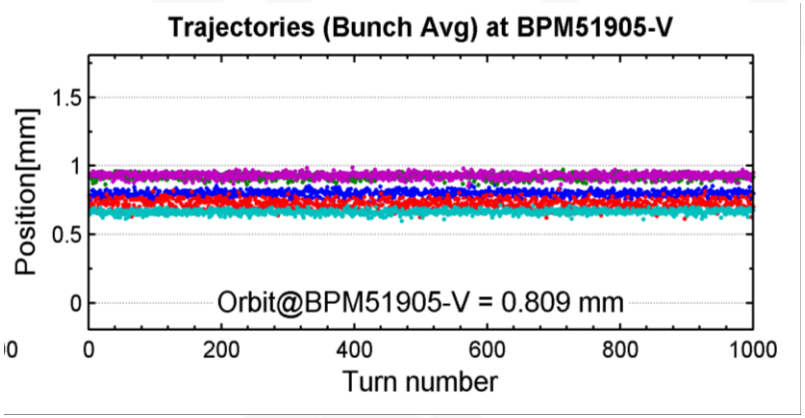
	BPMB.51303-V			BPMB.51503-V			BPMB.51905-V		
	Orbit	Rms	P2P	Orbit	Rms	P2P	Orbit	Rms	P2P
Inj.N.1	0.539	0.112	0.912	1.029	0.106	1.117	-0.863	0.142	1.117
Inj.N.2	0.553	0.109	0.912	1.031	0.106	0.966	-0.851	0.143	1.068
Inj.N.3	0.554	0.112	0.912	1.033	0.108	0.966	-0.839	0.148	1.068
Inj.N.4	0.557	0.111	1.009	1.024	0.108	0.966	-0.847	0.148	1.165
AVERAGE	0.551	0.111	0.936	1.029	0.107	0.966	-0.85	0.145	1.105

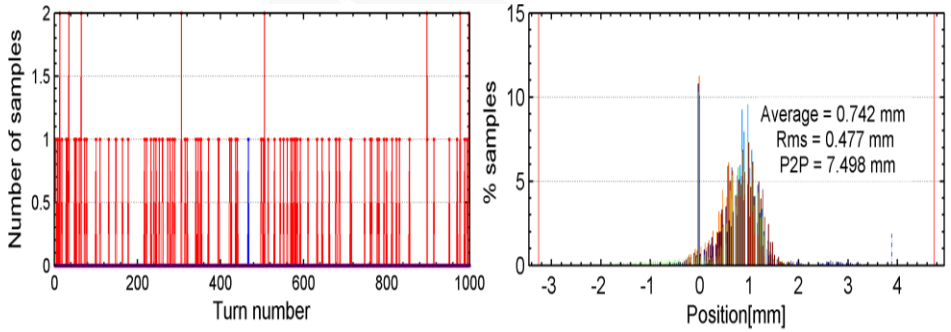
- *Good to fill orbit stability of +/-10um*
- *b/b r.m.s variation around 100um (close to resolution)*
- *peak to peak variation over 1000 turns around 1mm (few bunches)*

Doublet bunches at Flat top

- At 450GeV – 72 Doublet bunches @ 25ns
- 1000 turns acquisition 28.3s after injection
- BPM in High Sensitivity

	BPMB.51303-V			BPMB.51503-V			BPMB.51905-V		
	Orbit	Rms	P2P	Orbit	Rms	P2P	Orbit	Rms	P2P
Inj. N.1	1.750	0.325	2.184	1.867	0.428	4.014	0.800	0.526	4.677
Inj. N.2	1.862	0.184	1.649	2.007	0.182	1.654	0.922	0.257	2.172
Inj. N.3	1.790	0.362	6.610	1.975	0.448	8.830	0.725	0.581	6.081
Inj. N.4	1.705	0.288	2.532	1.798	0.288	2.090	0.666	0.365	2.618
Inj. N.5	1.858	0.248	2.728	1.995	0.235	1.607	0.93	0.301	1.979
AVERAGE	1.793	0.281	3.140	1.928	0.316	3.639	0.809	0.406	3.505

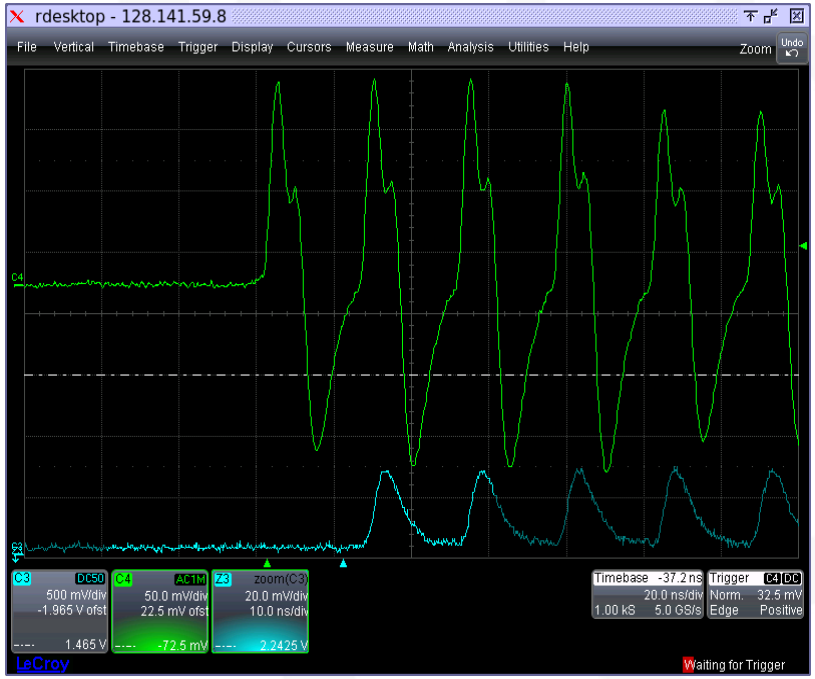


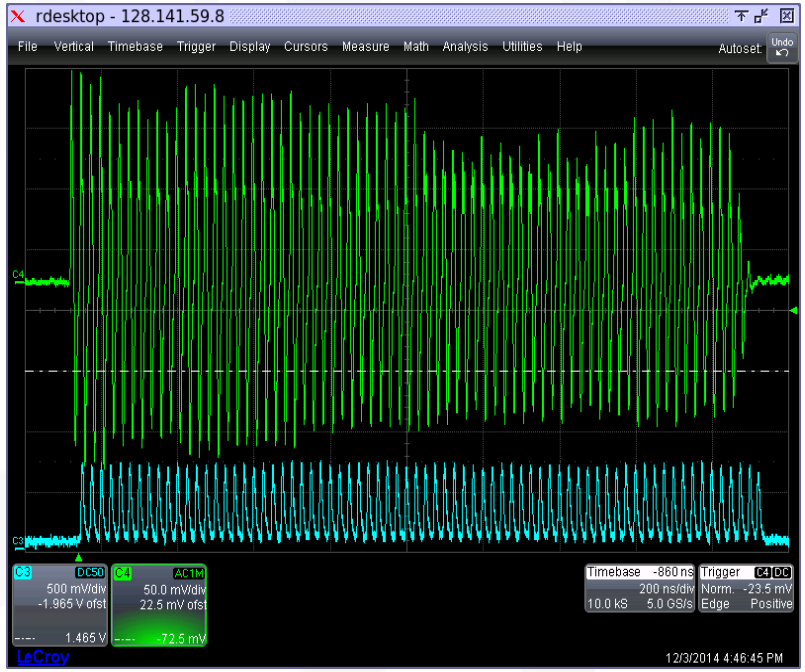


- *Reproducible Orbit with offset similar to the one observed at injection*
  - *No effect due to bunch shortening*
  - *Somehow expected due to 70MHz filter*
- *Slightly larger r.m.s b/b variation than at injection*
- *few bunch measured outside the position limit (+/-4mm)*
  - *Possibly due to ecloud / instabilities*

Doublet bunches at Flat top

Shape of the Signal measured at the entrance of the Normaliser

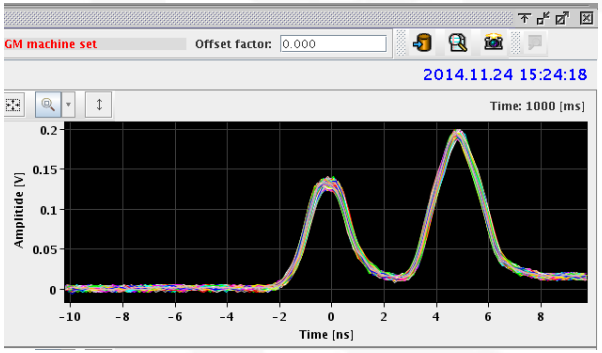




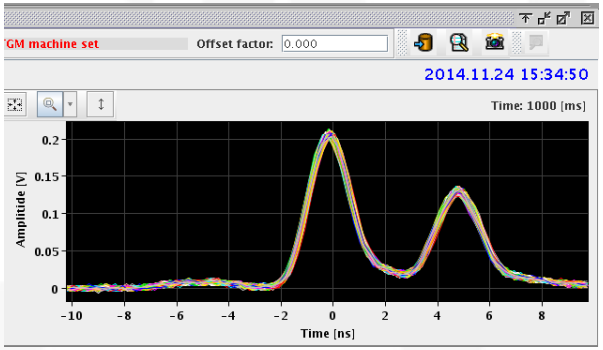
Some 10-30% fluctuations in the doublet bunch intensities over the train

Unbalanced Doublet bunches

- At 26GeV – 72 Doublet bunches @ 25ns
- 1000 turns acquisition 560ms after injection
- BPM in High sensitivity
- Tests done with and without vertical bump in 515



Unbalanced -/+

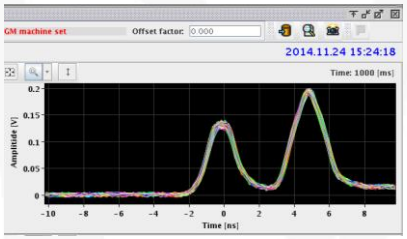


Unbalanced +/-

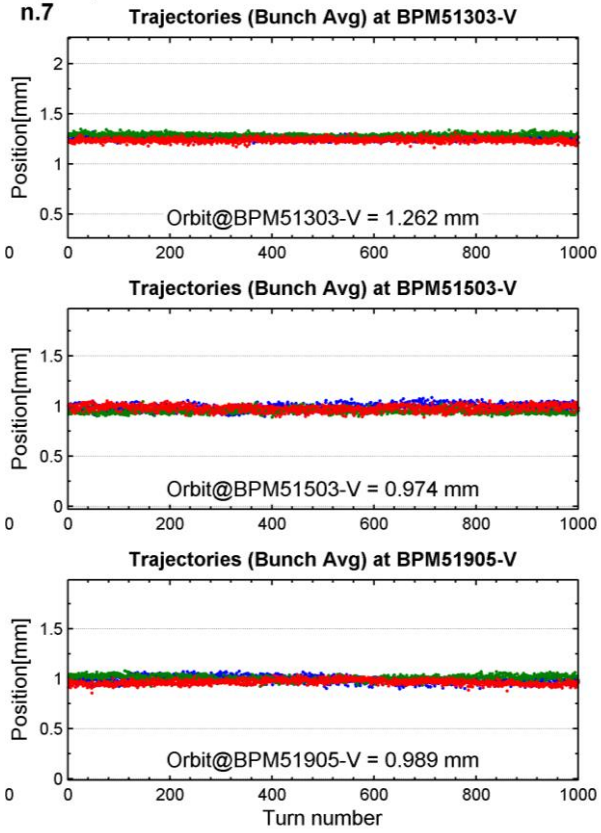
Doublet bunches at injection

- At 26GeV – 72 Doublet bunches @ 25ns
- 1000 turns acquisition 560ms after injection
- BPM in High sensitivity

Unbalanced -/+

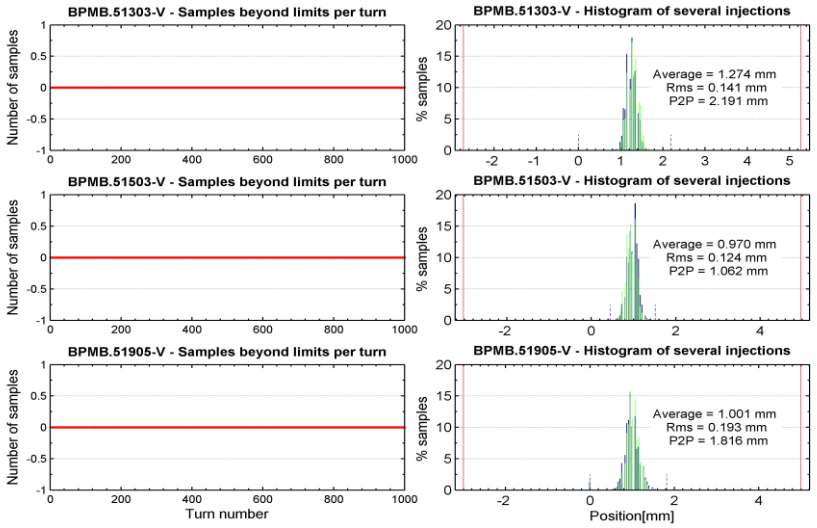


as.Setup n.7



	BPMB.51303-V			BPMB.51503-V			BPMB.51905-V		
	Orbit	Rms	P2P	Orbit	Rms	P2P	Orbit	Rms	P2P
Inj. N.1	1.260	0.127	2.093	0.989	0.123	0.966	0.994	0.198	1.766
Inj. N.3	1.287	0.152	2.191	0.951	0.122	1.062	1.008	0.187	1.816
Inj. N.4	1.239	0.165	2.093	0.981	0.129	1.110	0.966	0.221	1.816
AVERAGE	1.262	0.148	2.126	0.974	0.125	1.046	0.989	0.202	1.799

Meas.Setup n.7

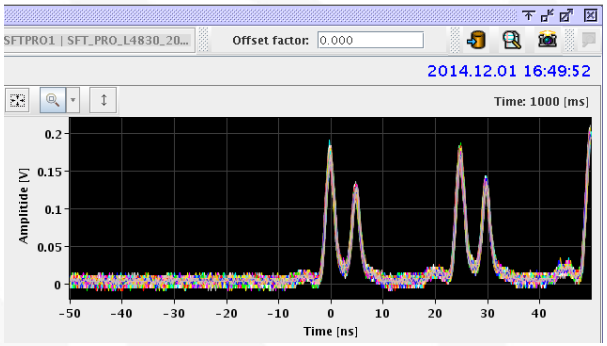


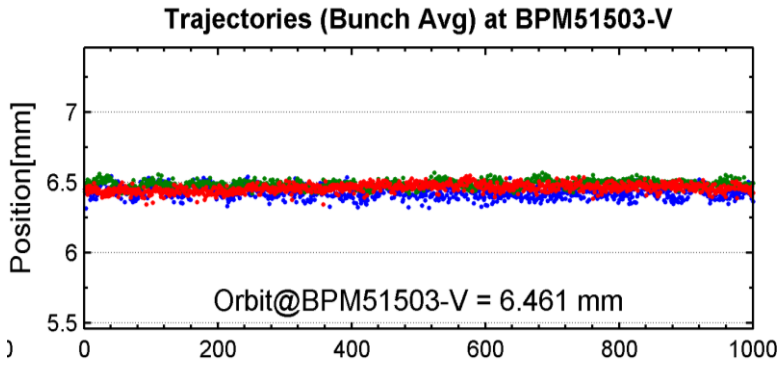
Smaller Offset, r.m.s and P2P variations as expected

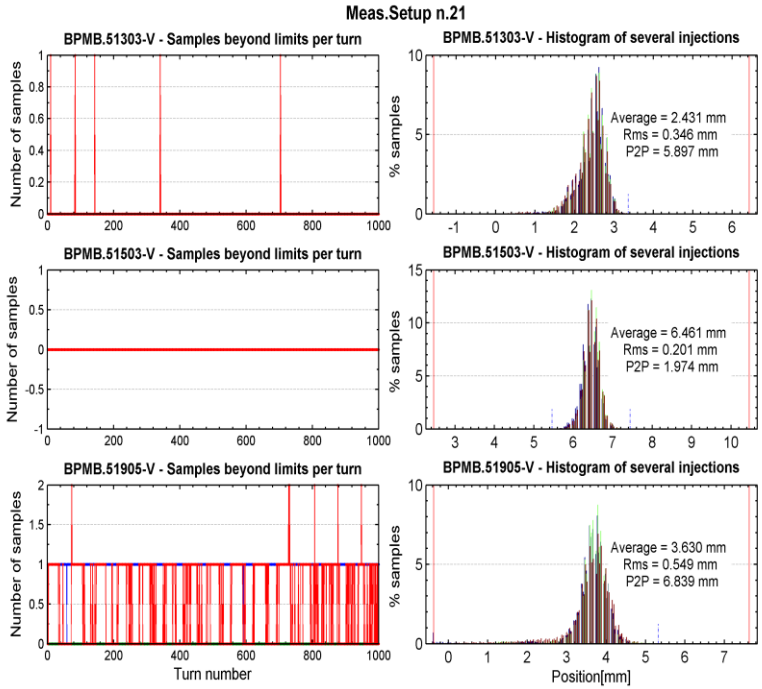
Doublet bunches at injection

- At 26GeV – 72 Doublet bunches @ 25ns
- 1000 turns acquisition 1s after injection
- BPM in High sensitivity
- Vertical offset in 515

Unbalanced +/-





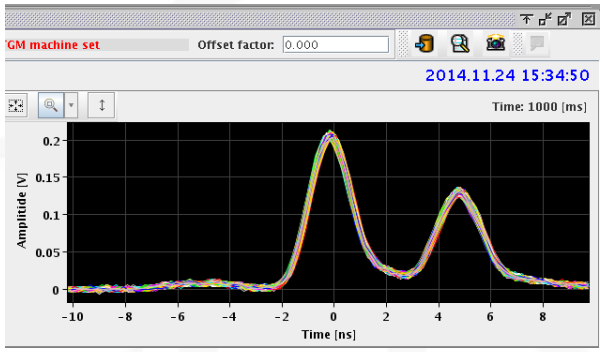


	BPMB.51303-V			BPMB.51503-V			BPMB.51905-V		
	Orbit	Rms	P2P	Orbit	Rms	P2P	Orbit	Rms	P2P
Inj. N.1	2.449	0.337	3.106	6.434	0.206	1.821	3.627	0.591	6.685
Inj. N.2	2.448	0.317	2.288	6.487	0.186	1.723	3.672	0.408	4.547
Inj. N.3	2.396	0.379	5.897	6.461	0.207	1.923	3.592	0.621	6.247
AVERAGE	2.431	0.344	3.764	6.461	0.200	1.822	3.630	0.540	5.826

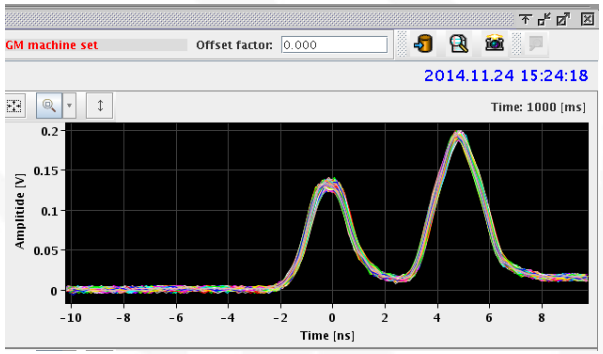
Larger Offset, r.m.s and P2P variations as expected

Doublet bunches at injection

Unbalanced +/-



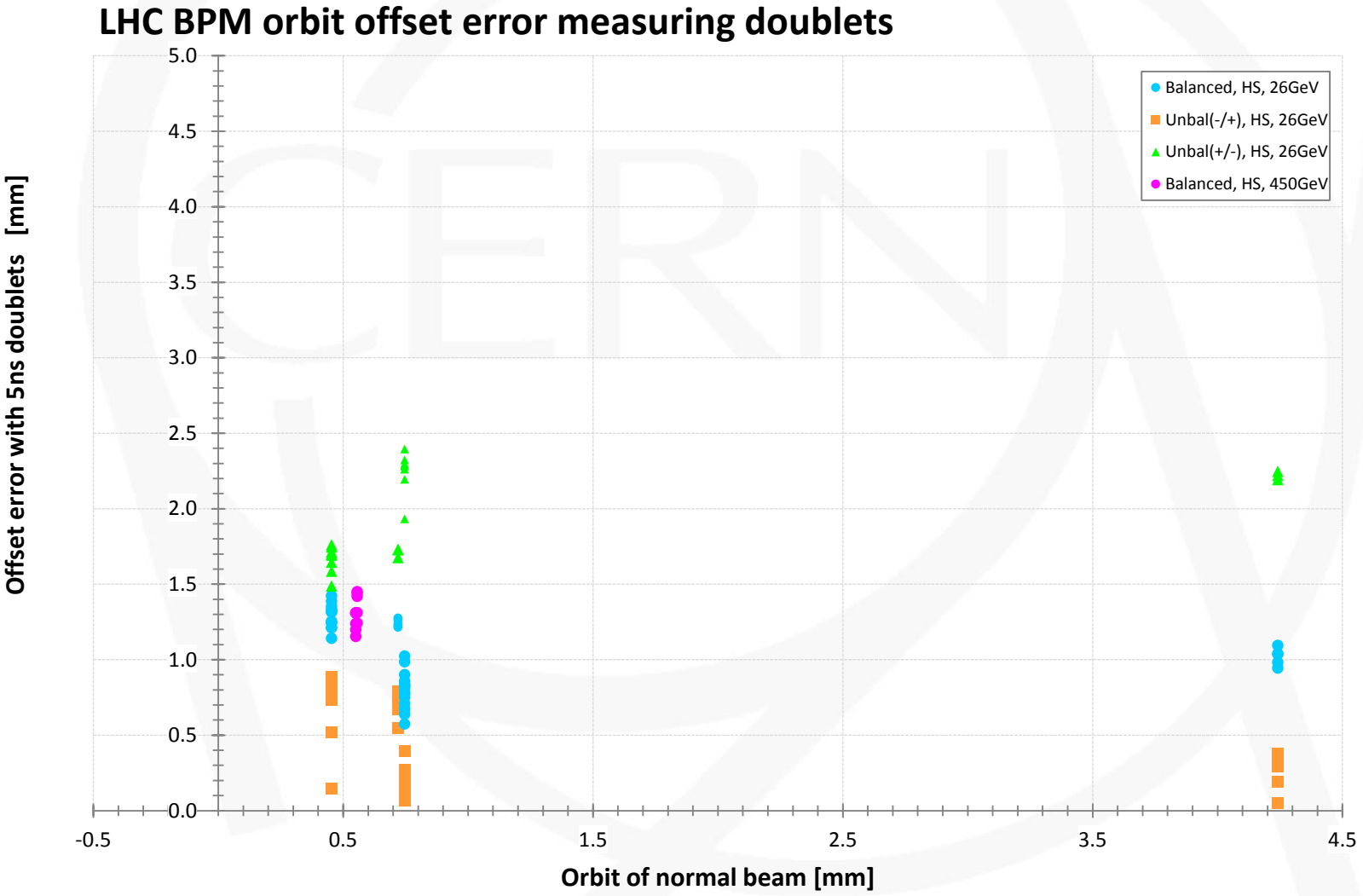
Unbalanced -/+



	Drift due to doublet	Drift due to doublet
	Unbalanced beam (1st >> 2nd)	Unbalanced beam (1st << 2nd)
BPMB.51303-V	1.686 mm	-0.807 mm
BPMB.51503-V	2.183 mm	-0.215 mm
BPMB.51905-V	3.263 mm	-1.009 mm

- *Offset similar to what was simulated*
- *Larger noise for unbalanced Doublet +/-*
  - *More sensitive due to the shape of the signal*
  - *Unbalanced Doublet -/+ gives lower fluctuations than normal Doublet*

Summary plot



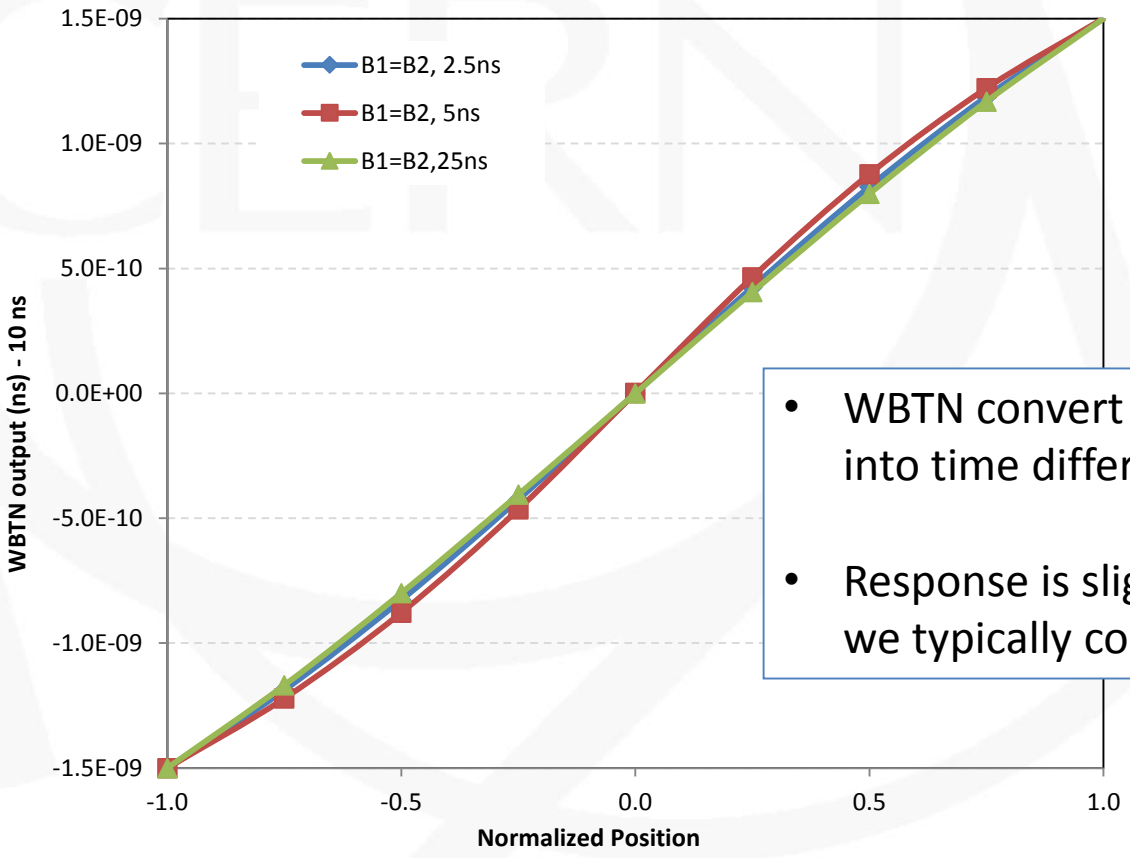
Conclusions

- **Offset similar to the one simulated has been confirmed on SPS**
  - Up to 2mm orbit offset observed using doublet bunches
  - It can be measured and compensated for as a fixed offset
- **B/B fluctuations are enhanced using Doublets from 1 to 3mm**
  - A fraction of it can be linked to the Doublet beams themselves
- **No observable change for different bunch length**
  - Bunch length fluctuations are almost suppressed in the electronic by the 70MHz input filter
- **Unbalanced doublet affects the measurements both the offset and the fluctuation/noise**
  - Unbalanced doublet -/+ showed smaller fluctuations and smaller offset: Is that an option ?
- **Issue with interlock BPMs**
  - Can you tolerate larger offsets/fluctuations: almost double to the 3-4mm triggering limit

Thanks

Simulating WBTN with Pspice

- **Bunch 1 and Bunch 2 with similar intensity and position**
- Normalizer model circuit and signals are “ideal”
- Realistic Bunch length

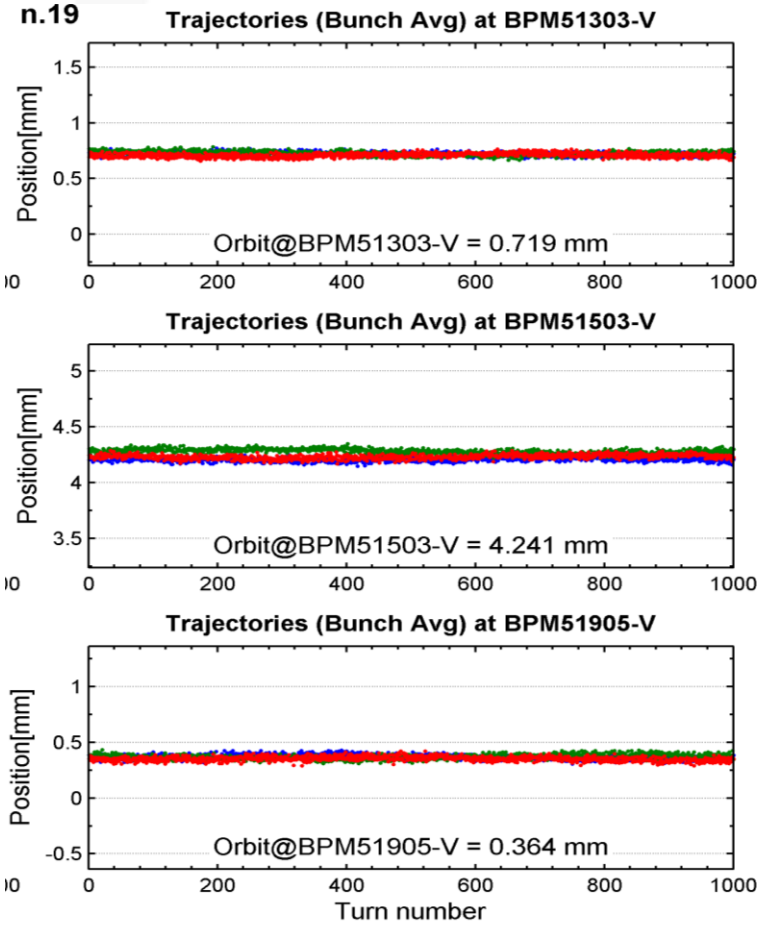


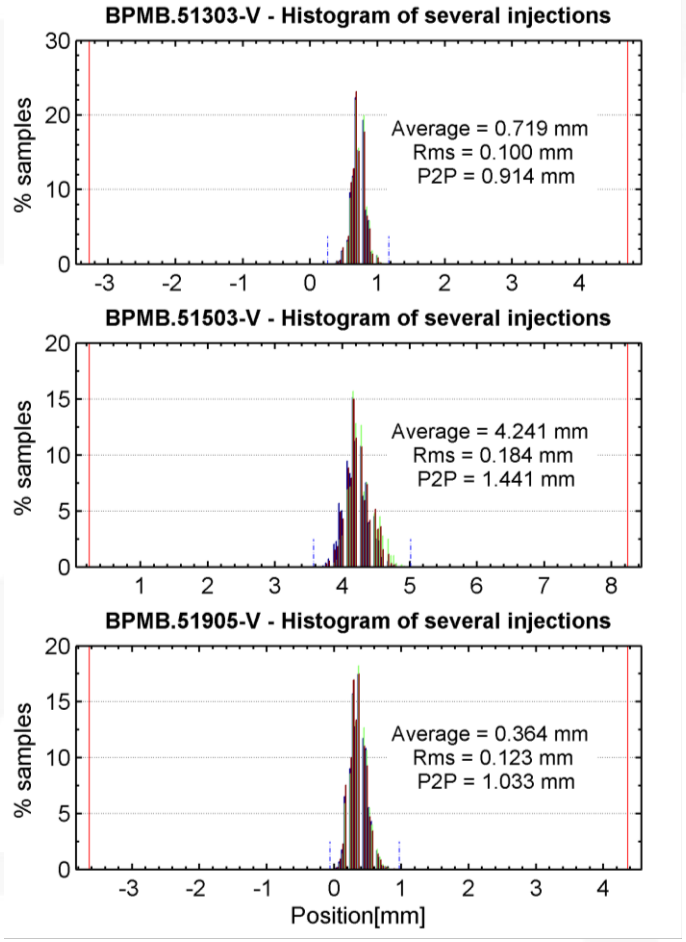
- WBTN convert voltage difference into time difference
- Response is slightly non linear but we typically compensate for that

Note : Half Aperture of arc BPM = 24mm
Half Aperture of BPMSB = 65 mm

Nominal bunches at injection

- At 26GeV – 72 nominal bunches @ 25ns
- Vertical Orbit Bump on BPM515

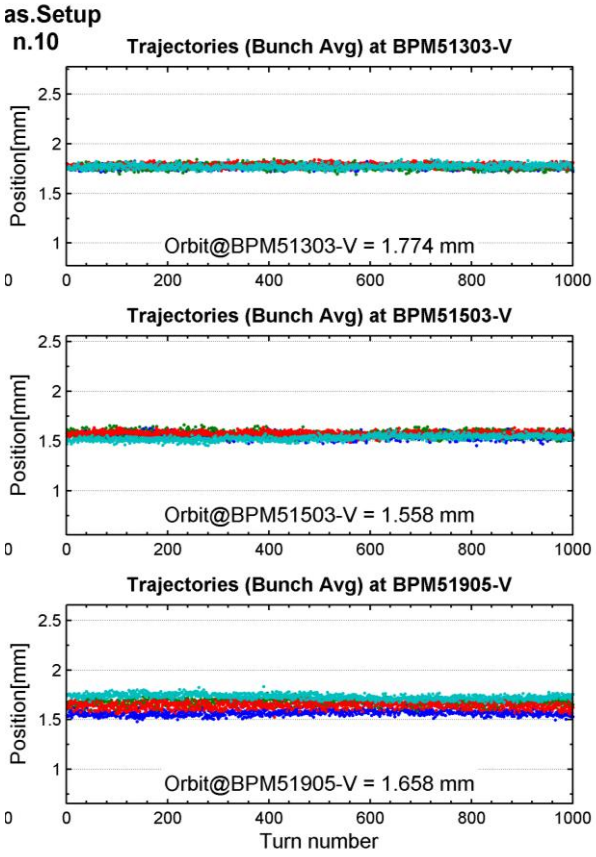


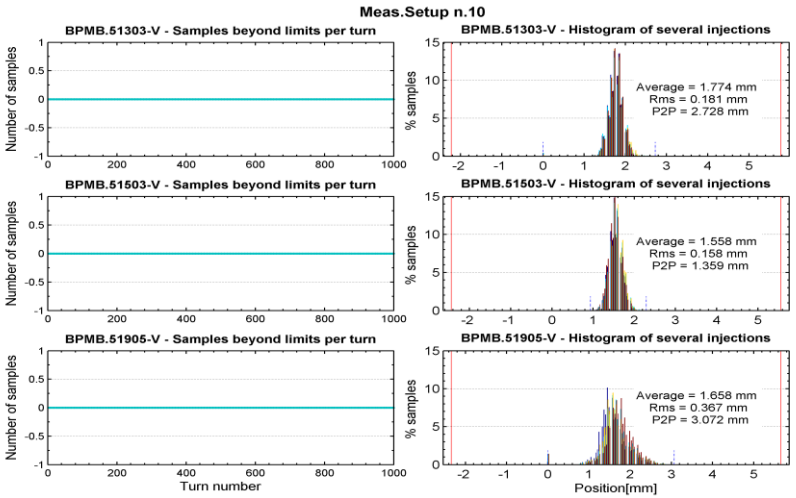


Doublet bunches at injection

- At 26GeV – 72 Doublet bunches @ 25ns
- 1000 turns acquisition 1s after injection
- BPM in High sensitivity

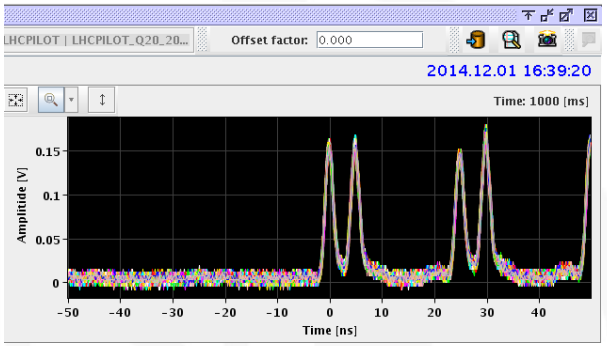
	BPMB.51303-V			BPMB.51503-V			BPMB.51905-V		
	Orbit	Rms	P2P	Orbit	Rms	P2P	Orbit	Rms	P2P
Inj. N.1	1.768	0.164	2.630	1.556	0.155	1.213	1.572	0.349	2.870
Inj. N.2	1.771	0.209	2.630	1.570	0.163	1.359	1.679	0.370	3.072
Inj. N.3	1.784	0.187	2.728	1.575	0.154	1.213	1.647	0.371	2.971
Inj. N.4	1.774	0.162	1.261	1.530	0.157	1.213	1.734	0.359	3.021
AVERAGE	1.774	0.180	2.312	1.558	0.157	1.250	1.658	0.362	2.983

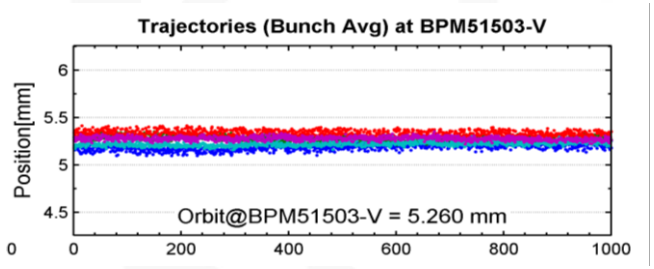




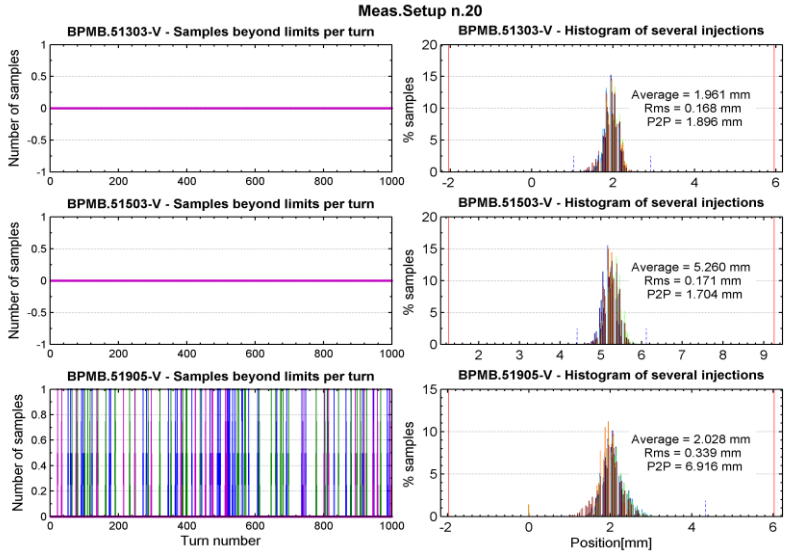
Doublet bunches at injection

- At 26GeV – 72 Doublet bunches @ 25ns
- 1000 turns acquisition 1s after injection
- BPM in High sensitivity
- Vertical offset in 515





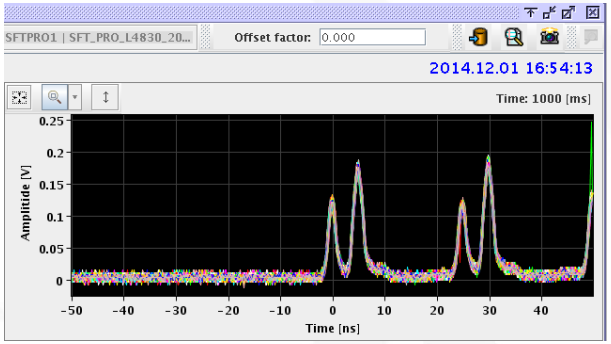
	BPMB.51303-V			BPMB.51503-V			BPMB.51905-V		
	Orbit	Rms	P2P	Orbit	Rms	P2P	Orbit	Rms	P2P
Inj. N.1	1.954	0.158	1.456	5.185	0.159	1.403	2.079	0.316	6.405
Inj. N.2	1.944	0.156	1.409	5.279	0.172	1.555	2.078	0.335	6.868
Inj. N.3	1.995	0.154	1.167	5.335	0.161	1.254	2.072	0.352	3.173
Inj. N.4	1.979	0.157	1.166	5.223	0.147	1.252	1.939	0.302	2.819
Inj. N.5	1.932	0.204	1.896	5.279	0.174	1.654	1.971	0.359	5.694
AVERAGE	1.961	0.166	1.419	5.26	0.163	1.423	2.028	0.333	4.992

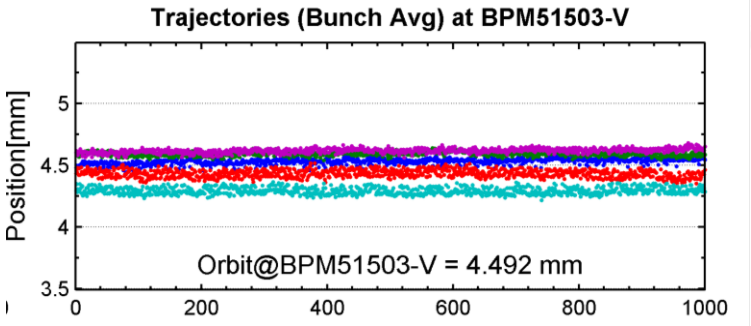


Doublet bunches at injection

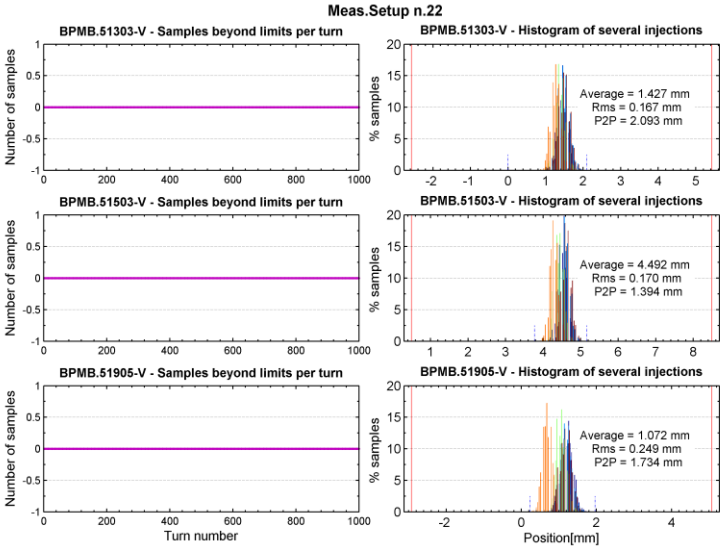
- At 26GeV – 72 Doublet bunches @ 25ns
- 1000 turns acquisition 1s after injection
- BPM in High sensitivity
- Vertical offset in 515

Unbalanced -/+





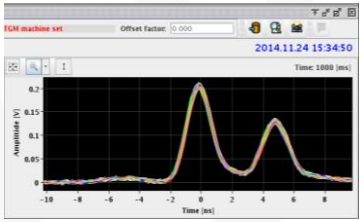
	BPMB.51303-V			BPMB.51503-V			BPMB.51905-V		
	Orbit	Rms	P2P	Orbit	Rms	P2P	Orbit	Rms	P2P
Inj. N.1	1.466	0.143	2.093	4.531	0.12	1.046	1.236	0.159	1.291
Inj. N.2	1.51	0.14	1.114	4.592	0.124	1.046	1.196	0.152	1.29
Inj. N.3	1.392	0.138	1.258	4.431	0.123	1.144	1.071	0.137	1.19
Inj. N.4	1.267	0.132	1.112	4.291	0.117	0.994	0.686	0.124	1.037
Inj. N.5	1.498	0.148	1.21	4.617	0.121	1.047	1.172	0.159	1.39
AVERAGE	1.427	0.14	1.358	4.492	0.121	1.055	1.072	0.146	1.24

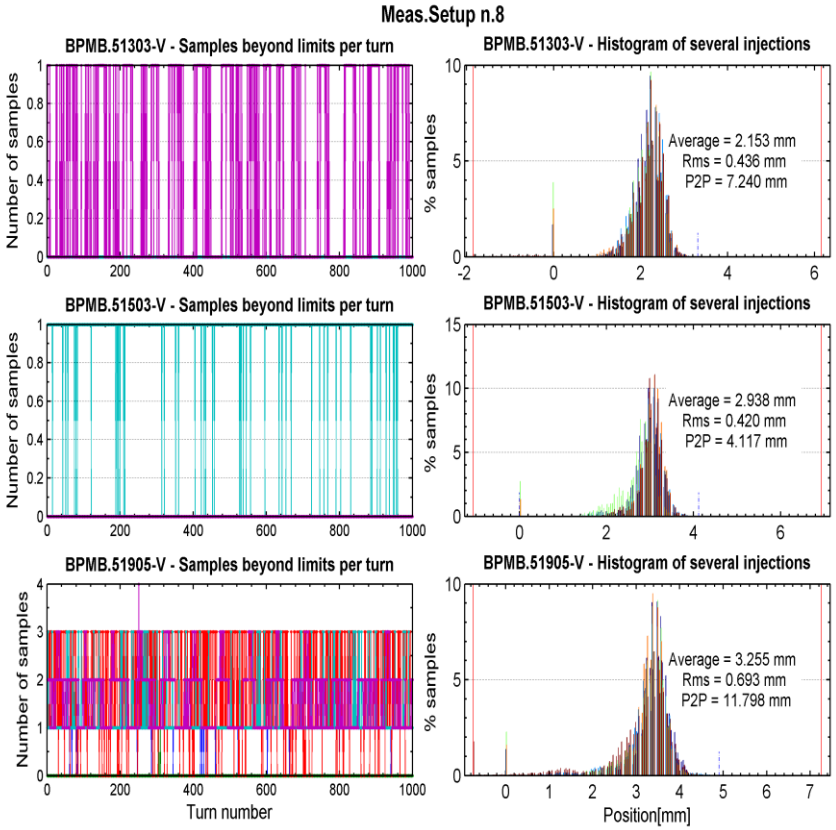


Doublet bunches at injection

- At 26GeV – 72 Doublet bunches @ 25ns
- 1000 turns acquisition 1s after injection
- BPM in High sensitivity

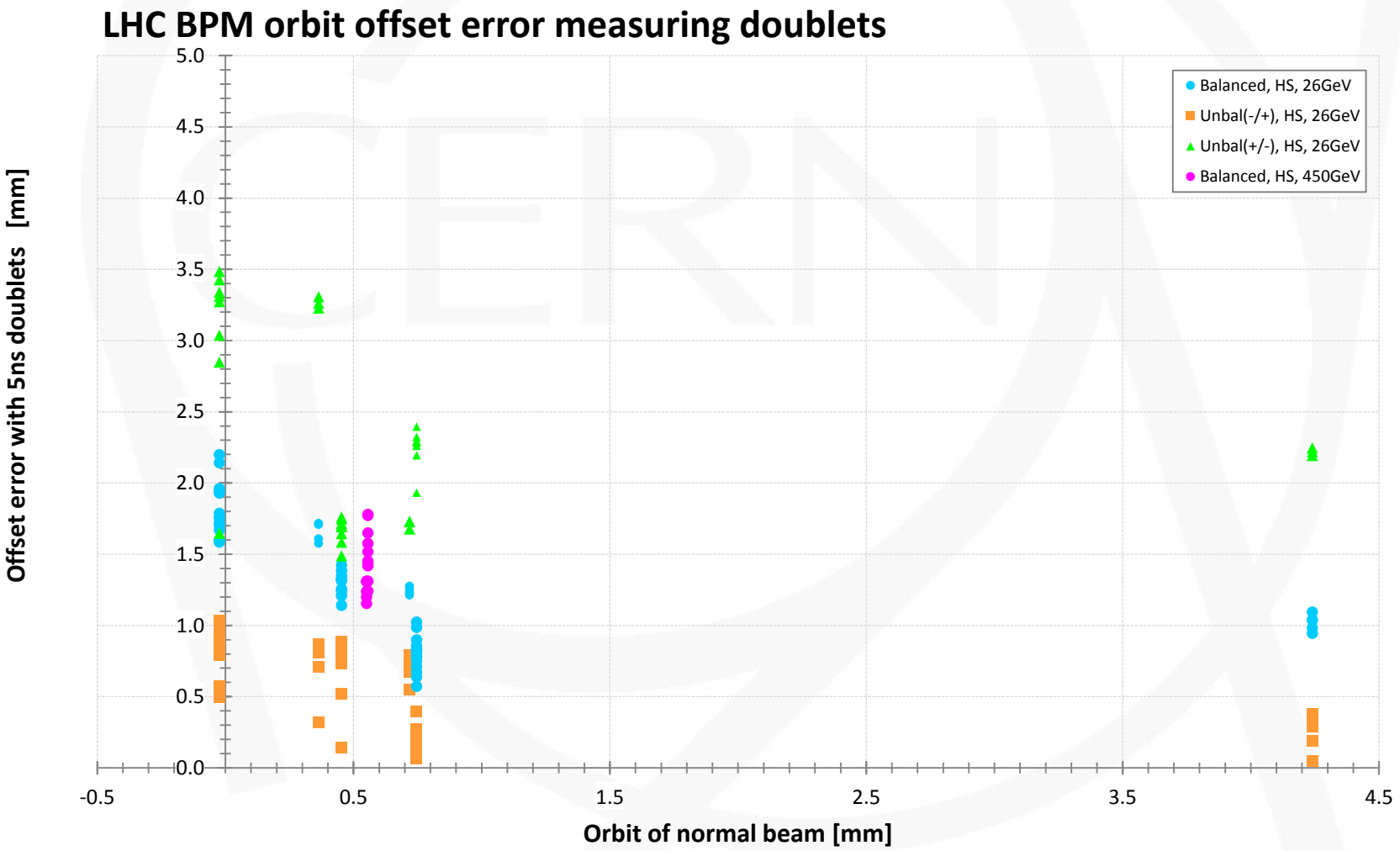
Unbalanced +/-
Some cavity tripping



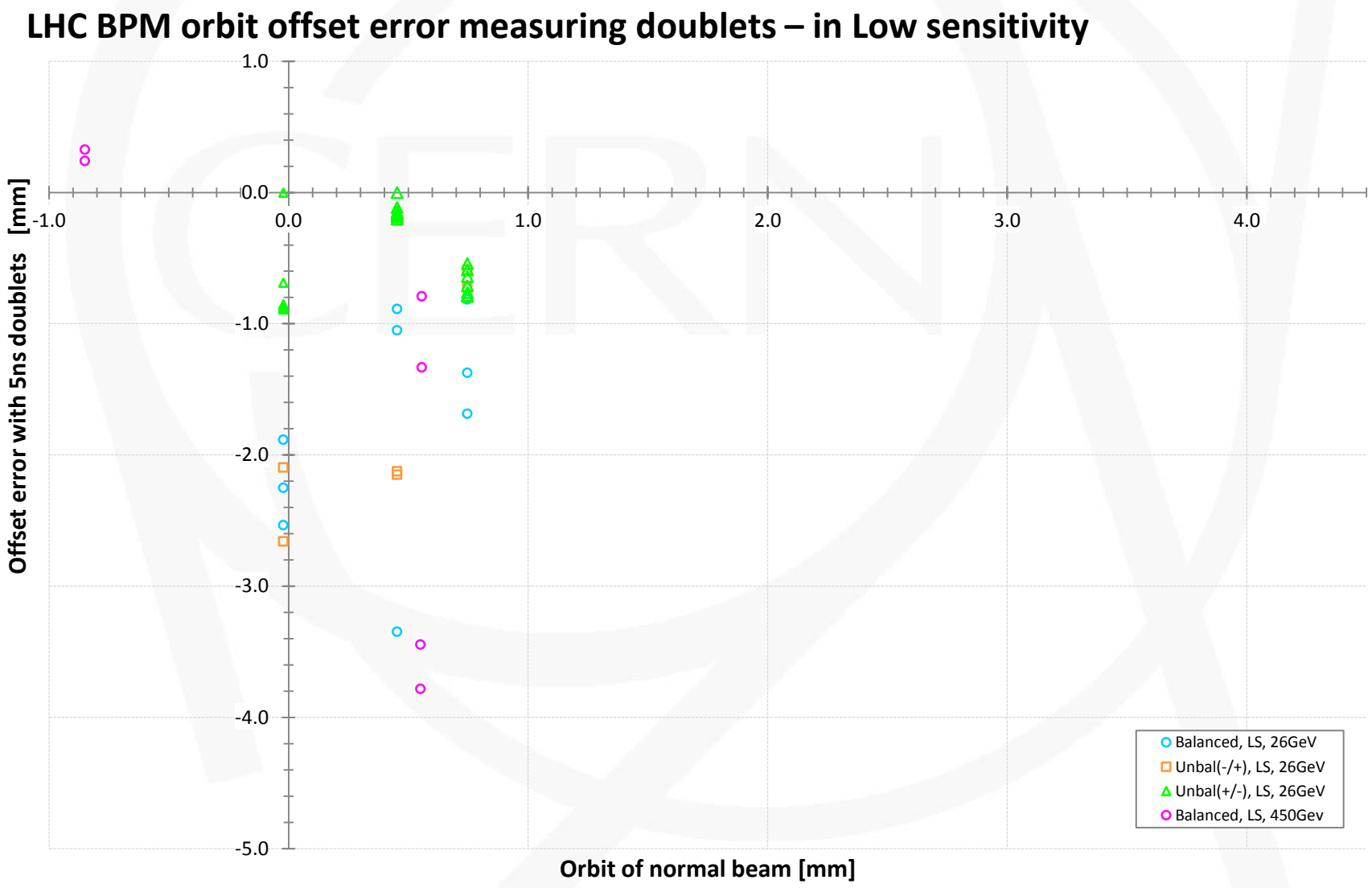


	BPMB.51303-V			BPMB.51503-V			BPMB.51905-V		
	Orbit	Rms	P2P	Orbit	Rms	P2P	Orbit	Rms	P2P
Inj. N.1	2.168	0.388	3.267	2.941	0.300	3.819	3.404	0.500	4.651
Inj. N.2	2.200	0.319	3.120	3.008	0.342	2.890	3.288	0.484	4.774
Inj. N.3	2.099	0.500	3.316	2.678	0.585	4.017	3.252	0.627	4.754
Inj. N.4	2.146	0.470	3.267	3.031	0.413	3.968	3.317	0.510	4.548
Inj. N.5	*2.152*	*0.473*	**7.141**	*3.03*	*0.270*	*2.406*	*3.015*	**1.087**	**11.644**

Beam tests on SPS

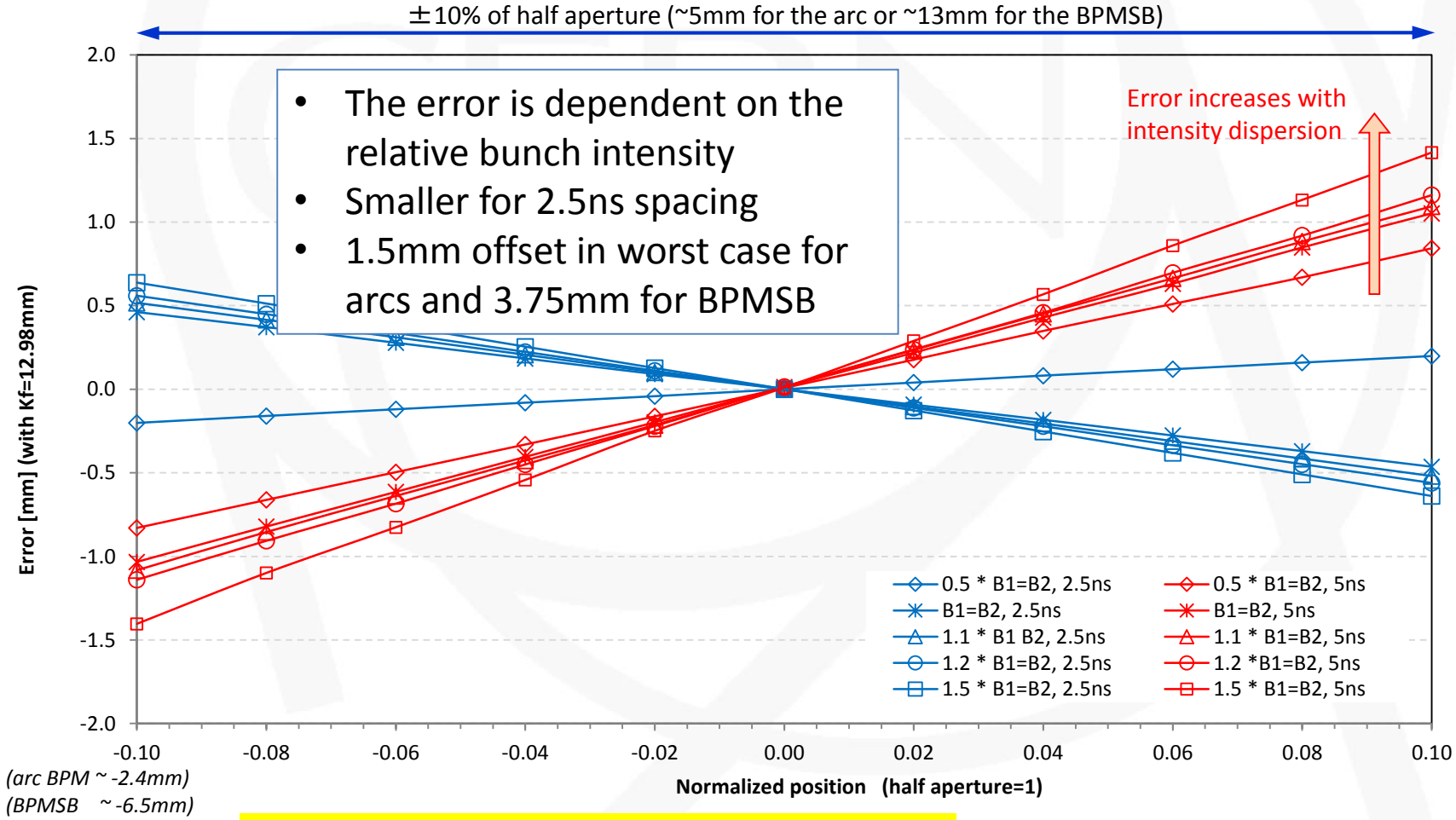


Beam tests on SPS



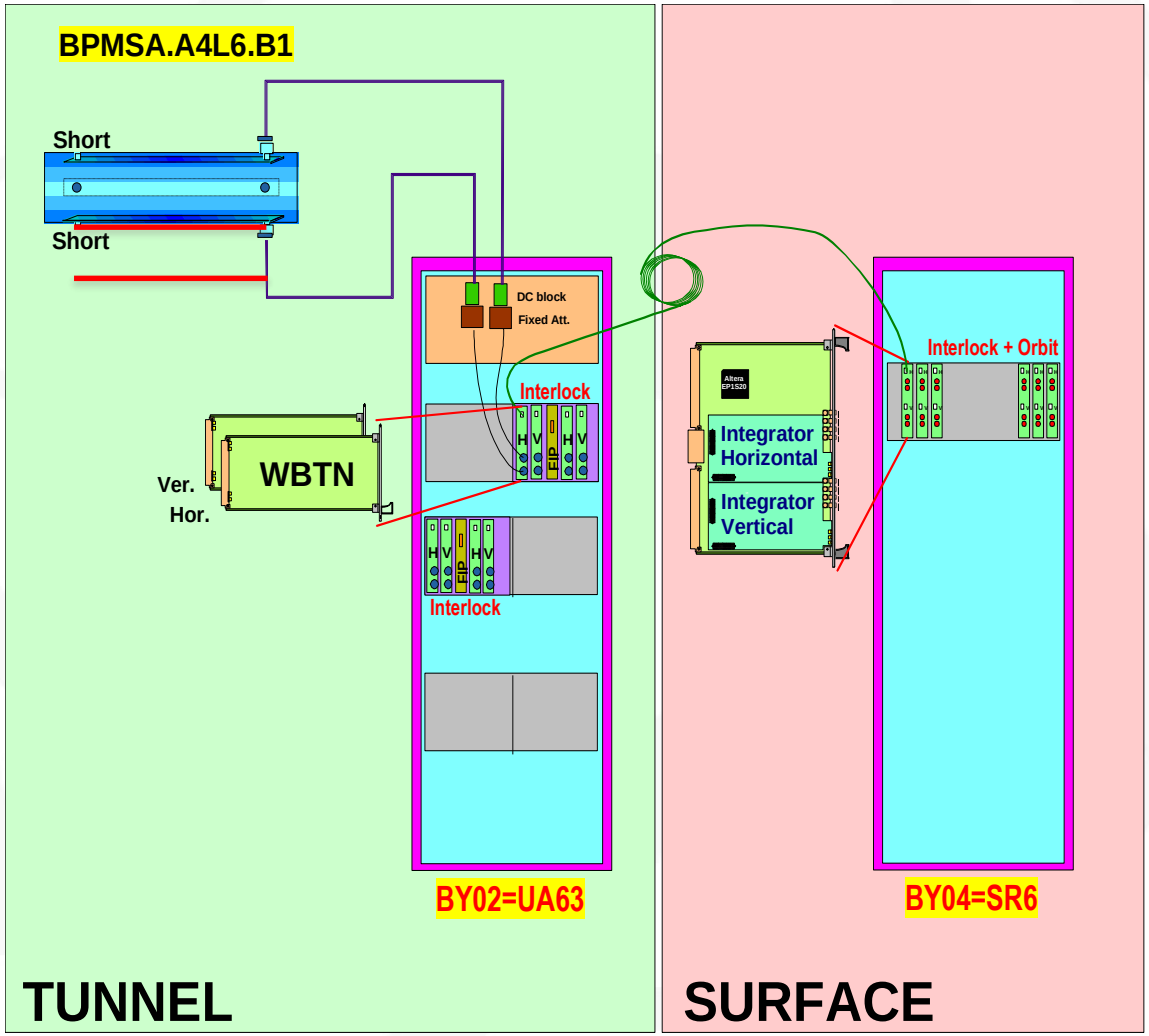
Simulations with Pspice

- Bunch 1 has a position which varies ±10% of half the aperture, while bunch 2 is centred
- Error was calculated w.r.t. the average position of both bunches.
- Bunch intensities vary about ±50%.



Note : Half Aperture of arc BPM = 24mm, Kf= 12.98
Half Aperture of BPMSB = 65 mm, Kf = 32.75 (2.5 bigger error!)

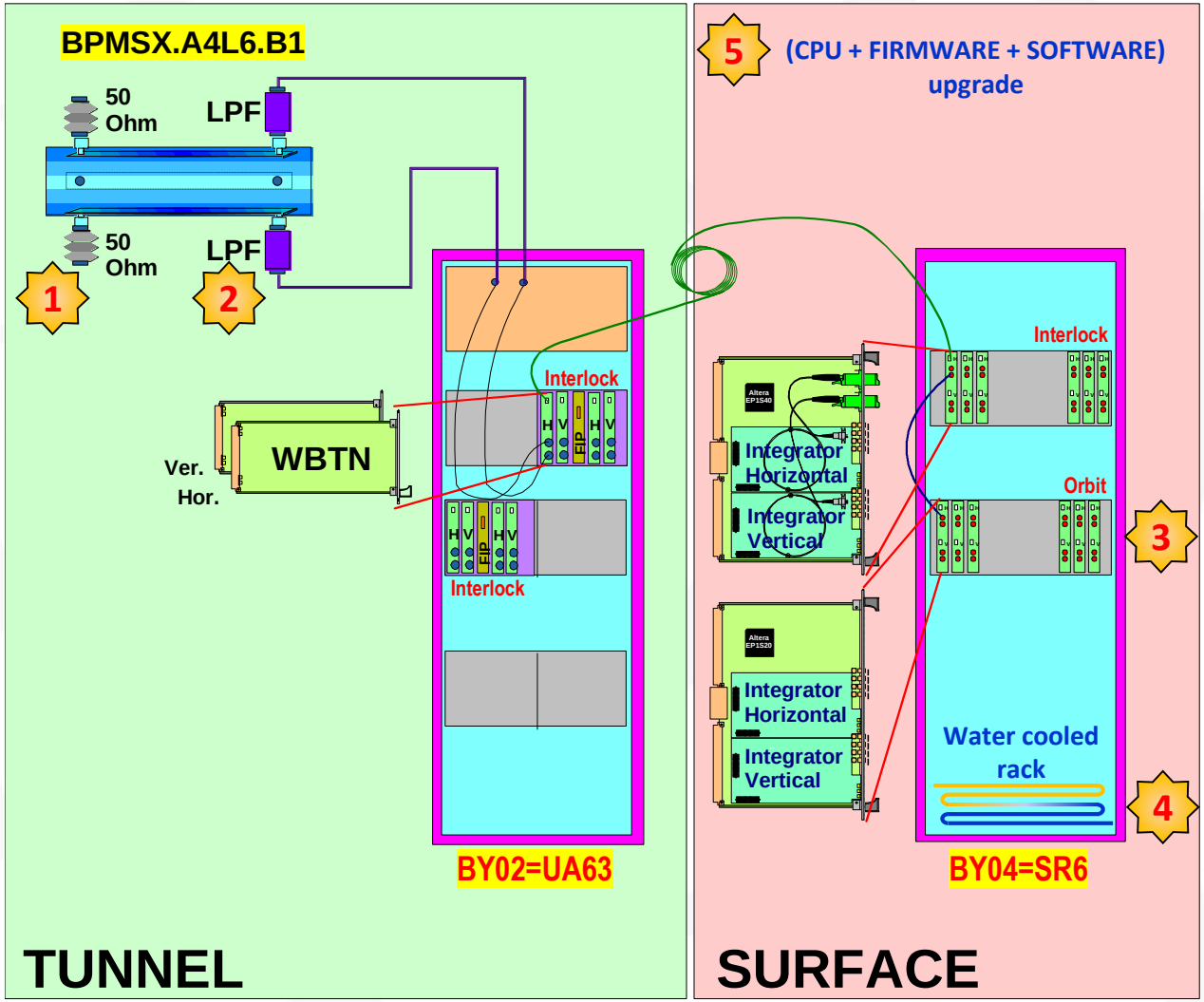
Old BPM-int System



New BPM-int setup

The BPMs have been renamed (LHC-BP-EC-0002)

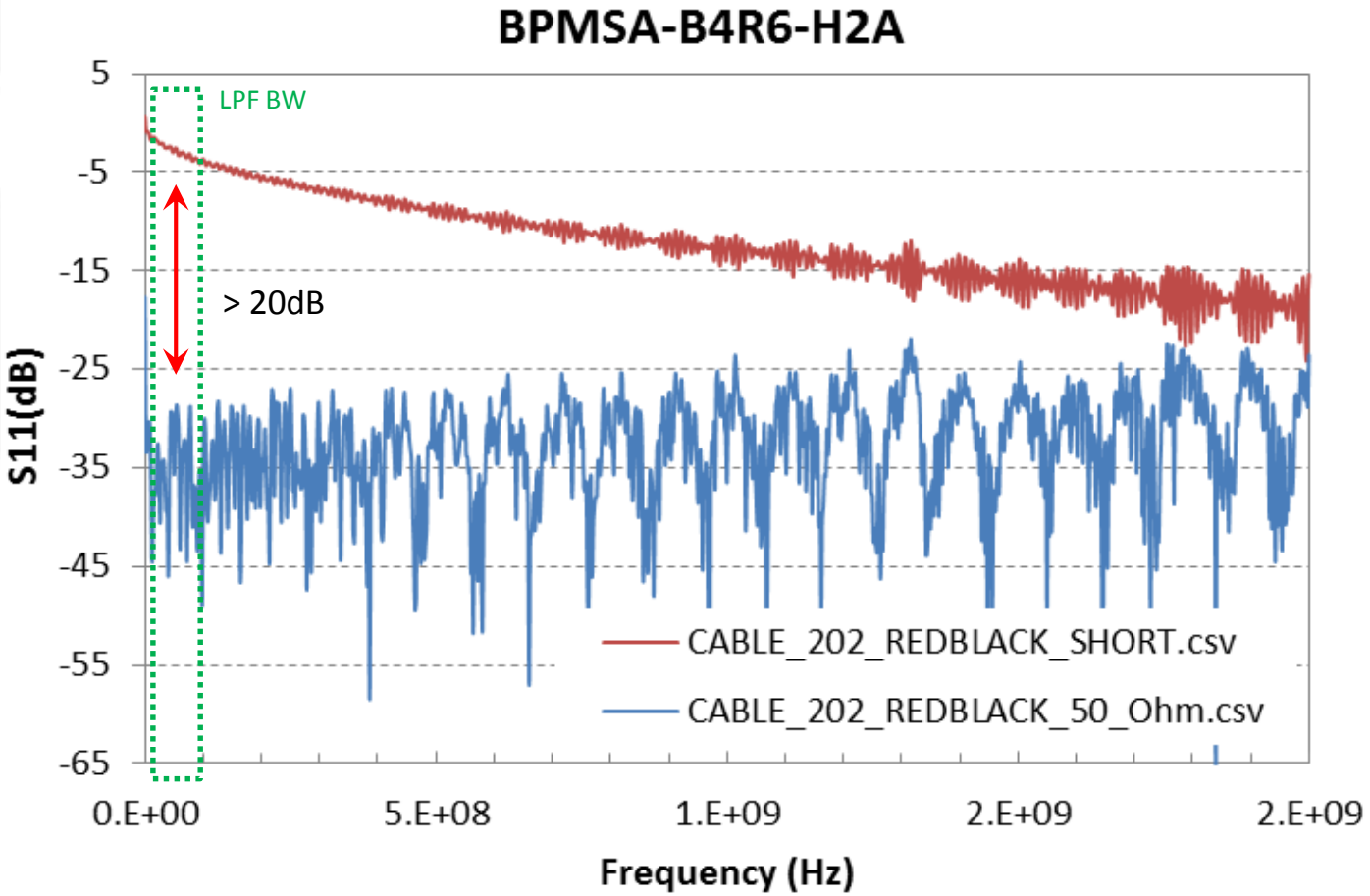
The Interlock and orbit systems have been separated



Hardware Modifications

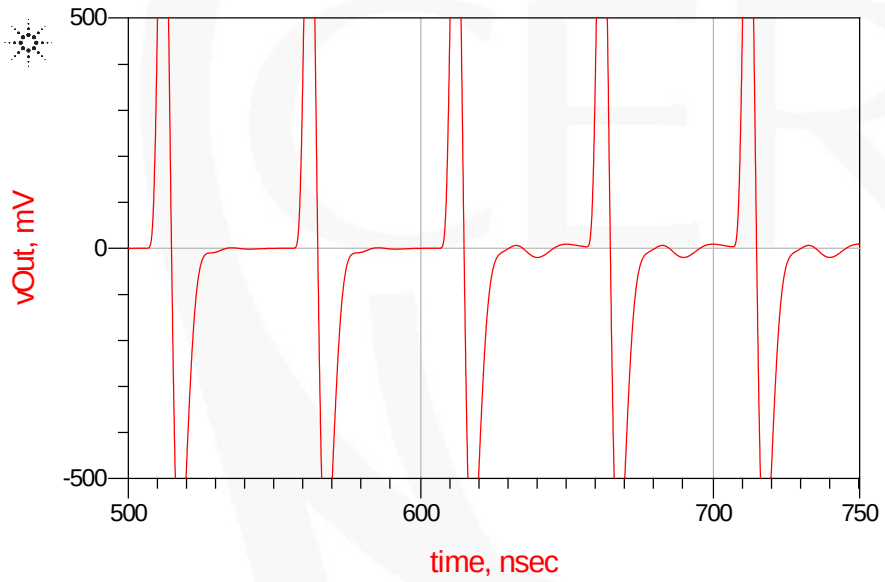
- Limiting signal reflection
  - Replaced shorted strip-lines with 50 Ω termination
  - Added absorptive filter at strip-line output (100 MHz)
- Better stability with thermal controlled racks
- Better monitoring/processing of Interlock data
  - Separated orbit and interlock functions (2 DABs)

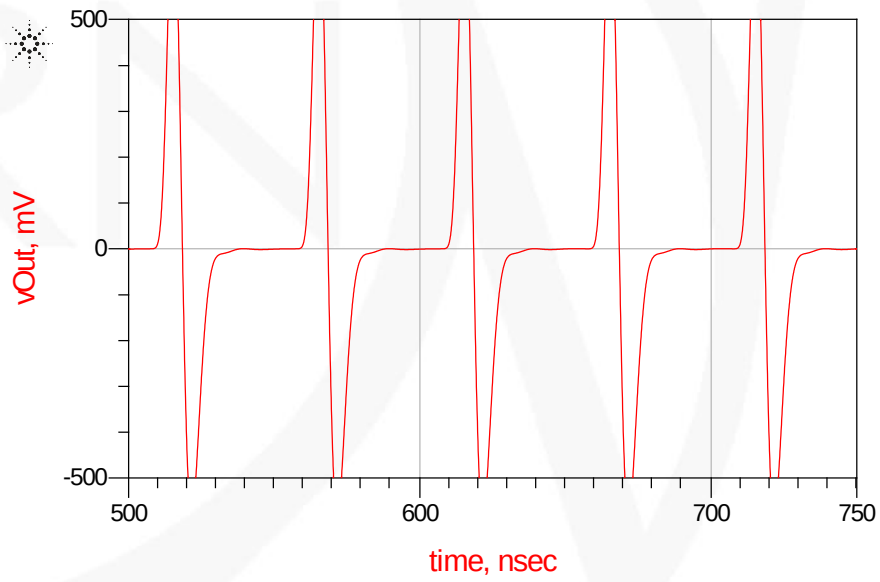
BPMs Reflections



More than a factor 10 improvement on the Pick-up

Reflections in time domain





Shorted strip-lines reflections
Measurement: -27 dB
Simulation: -34 dB

Terminated strip-lines with LPF:
Simulations: <-46 dB

Firmware/Software Modifications

- New interlock functions running dedicated DAB
  - Interlock processes remains as before
  - bunch-by-bunch interlock post-mortem data (3564 slots x 294 turns)
- FESA adapted to new firmware (and new CPUs)
- New GUI for the interlock post-mortem t.b.d. (BI/OP)

Firmware/Software Modifications

- The new interlock firmware will keep the old turn by turn “interlock data” summary:
  - Number of valid bunches (H & V) outside dump limits
  - Number of valid bunches (H & V) outside alarm limits
  - Max and min values (H & V) at every turn.
  - Number of ADC out of range samples (H & V)
- Add. Registers to follow in ‘real time’ the number of bunches outside limits and the number of errors during the time windows pre-defined.
- Modify the synchronous Post-Mortem data
  - The turn-by-turn data(last 1024 sync. orbits, and last 1024 sync. Trajectories), has been removed, since they do not permit to diagnose the reason of the dump. These information will still be available in the orbit DAB running the old firmware.
  - Provide B/B data (3564 slots) for the last 294 turns.
  - Add. Fields - the number of errors per turn and turn flags
- New functionality – A channel triggers a dump it also freezes the others (H//V – B1/B2) in order to get comparable data for both planes and both beams