Initial Commissioning to Stable Beams

Belen Salvachua

On behalf of the LHC Team with MANY input from Ph.Baudrenghien, Ch.Bracco, E.Bravin, W.Hofle, G.Iadarola, M.Lamont, Th.Lefevre, S.Redaelli, M.Solfaroli, J.Wenninger, H.Timko, R.Tomas

Outline

- Assumptions for next year
- Commissioning Phases
- System and Measurement requirements
- 2016 Schedule
- Scrubbing
- Intensity ramp-up

Assumptions for 2016

Beam Parameters for 2016	
Intensity per bunch	1.2×10^{11} p/b
Bunch spacing	25 ns
Max. bunches per train	288
Tune (H/V) at injection	0.275 / 0.295
Chromaticity at injection	15 / 15
Machine cycle for operation (see Matteo Solfaroli's talk)	
Injection	Same as 2015
Ramp and Squeeze (IP1/IP2/IP5/IP8)	3m/10m/3m/5m
Squeeze (IP1/IP2/IP5/IP8)	0.4m/10m/0.4m/3m
Collisions	Adjusted to new beta

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Commissioning Phases

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HW Commissioning

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4 weeks

Beam Commissioning

Stable Beams

Commissioning Phases

HW Commissioning

4 weeks

Beam Commissioning

Stable Beams

1 weeks

Scrubbing

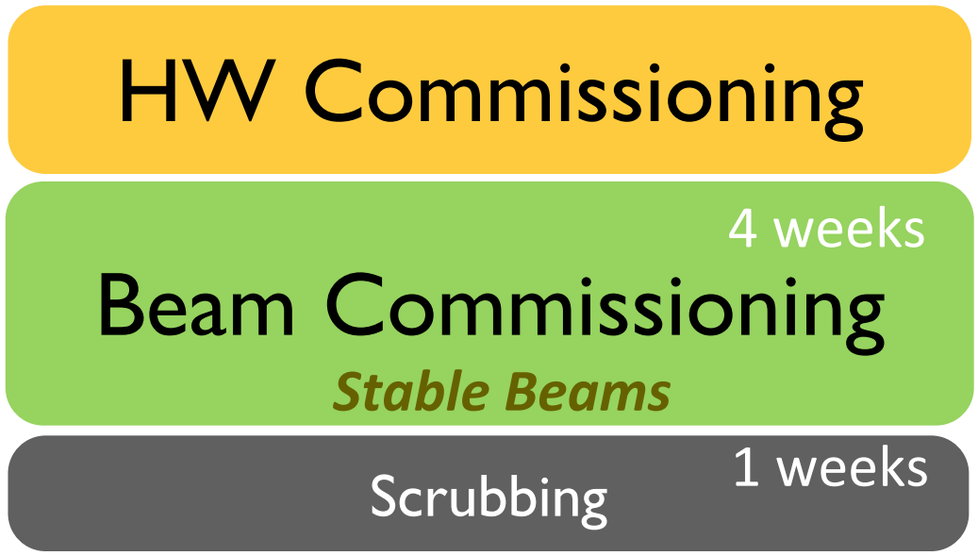
Commissioning Phases

Setup and Validate all relevant systems. MP Test.

Measurements to asses final beam parameters.

Established the new cycle and low intensity Stable Beam conditions

Prepare machine for high intensity beam. Setup of trains. Ramp up: goal 2800b



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Beam Commissioning

Stable Beams

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Ramp & Squeeze:

- First pass with probes, feedforward corrections from MD. OFB and QFB on, flat orbit, optic measurements.
- Second pass with RF modulation, feedforward tune, flat orbit...
- Ramp with bumps (probes)
- Ramp with bumps (nominals)

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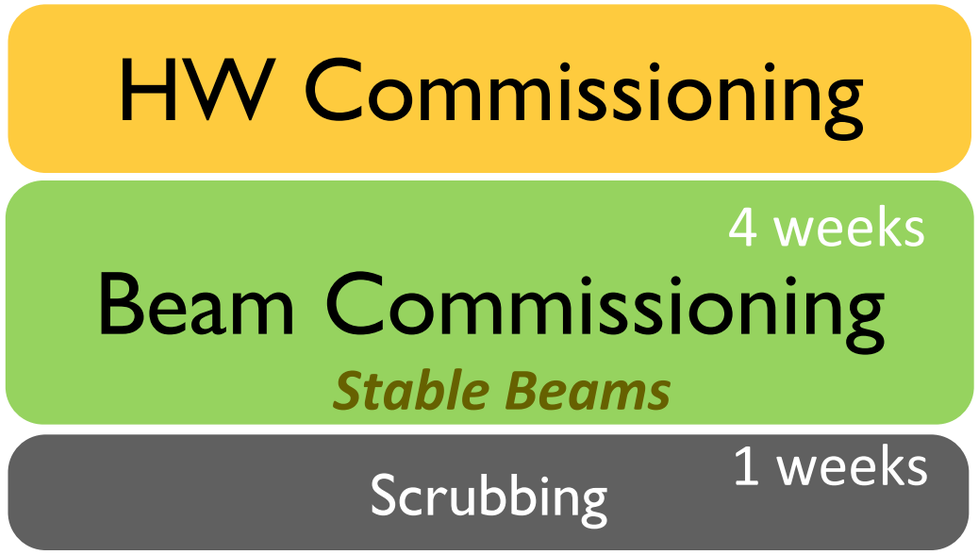

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Squeeze:

- First pass in steps, probes and optics measurements
- Squeeze in steps with probes, optics corrections
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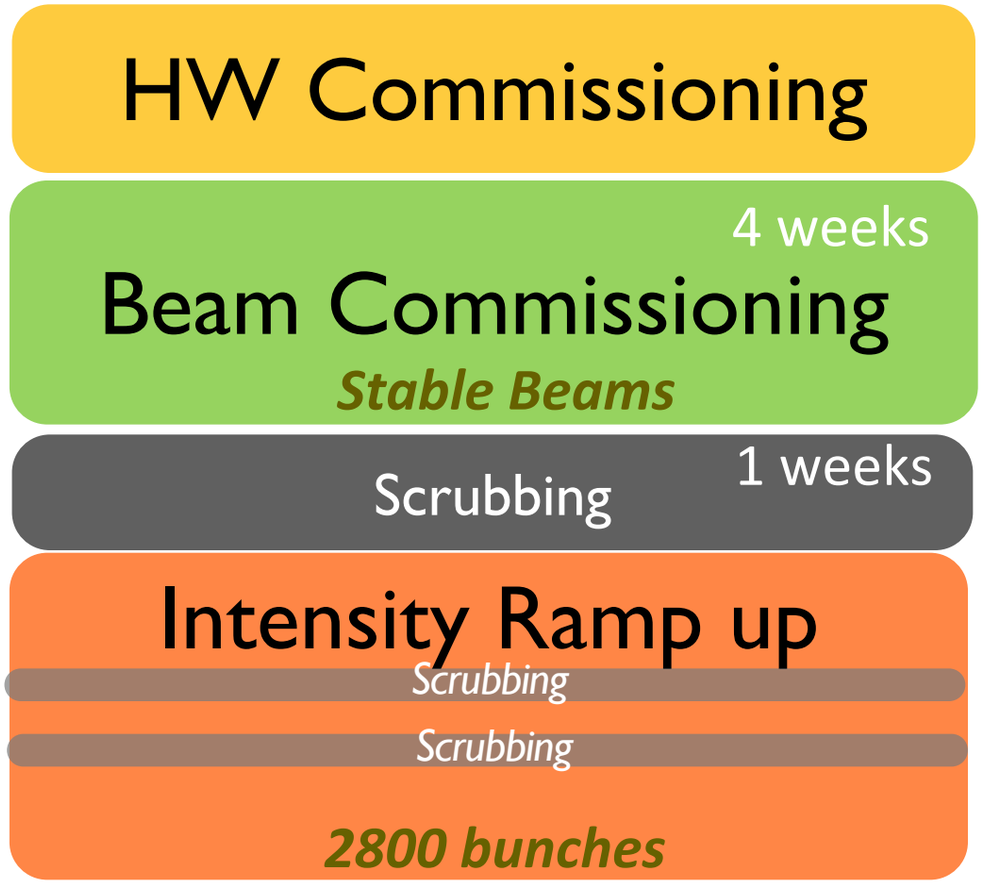

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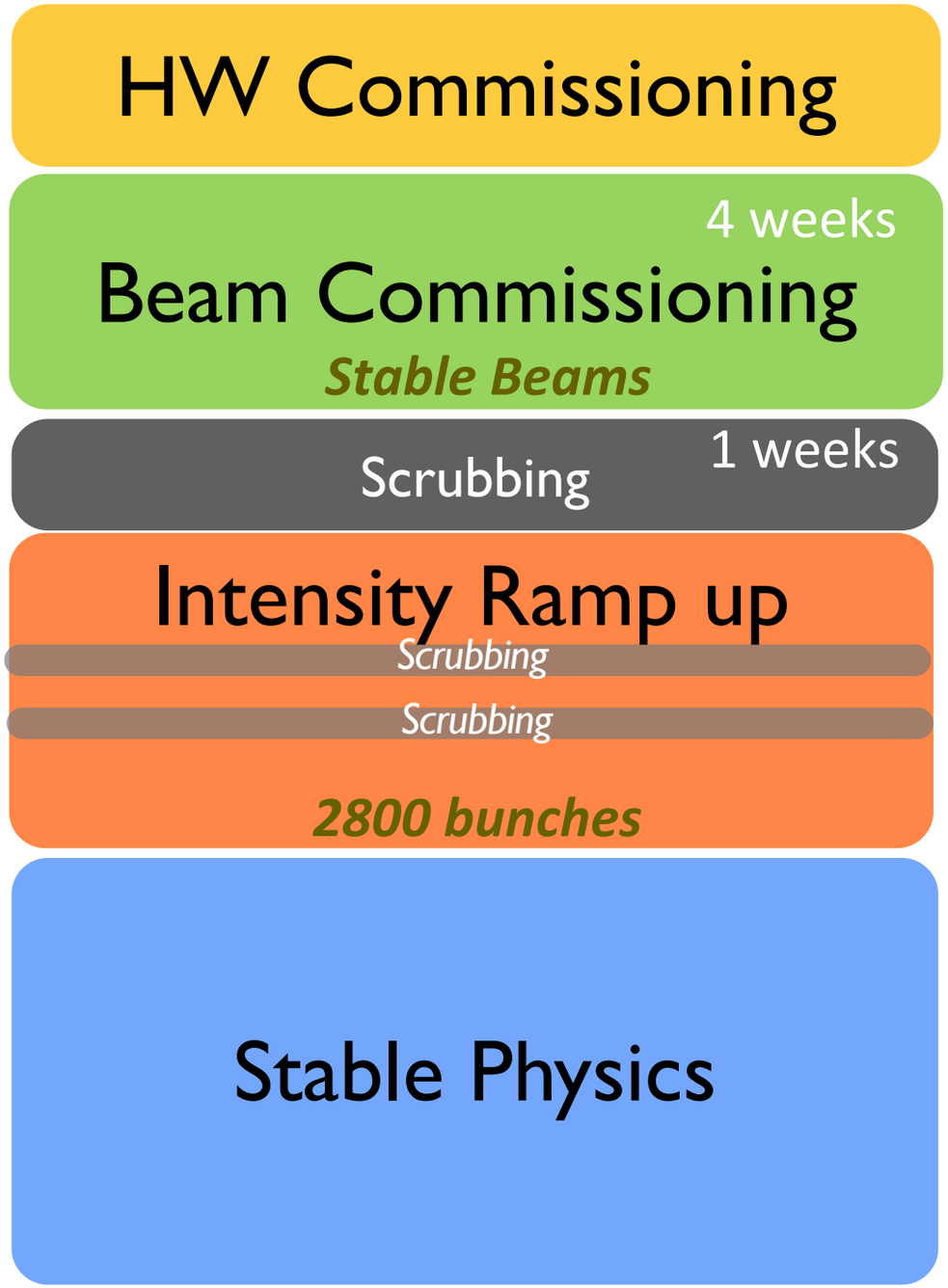

Systems and Measurements

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Systems

- Injection
- LDBS
- Collimation
- RF and ADT
- B. Instrumentation

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Measurements

- Orbit
- Optics
- Aperture
- Impedance
- Magnetic Reproducibility
- MP and Loss maps Validation
- Setup of trains

Systems and Measurements

New LHC Cycle: Ramp-squeeze and Squeeze to 0.4 m

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Injection & LBDS

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Injection

- **SPS extraction (link to YETS modifications):**
  - MKE4 waveform: beam on downstream TED (4hours)
  - Extraction aperture (0.5 hours/beam)
- **Transfer Lines**
  - TCDI setup and validation (2hours/beam)
- **Injection Protection Collimators**
  - TDI, TCLIA, TCLIB setup and validation (8 hours / beam)

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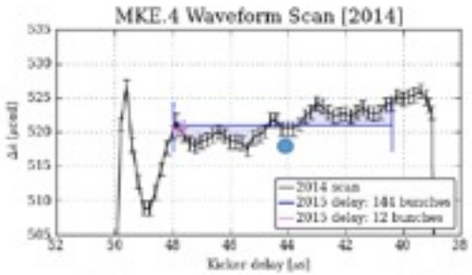
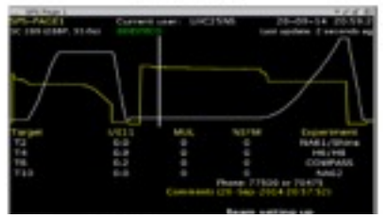
Transfer line commissioning

- Establish the transfer line references with pilot
- Procedure improved for the pilot trajectory to be more representative of the nominal :



Kickers delays changed for the MKEs and the MKIs so that the pilot is positioned at the middle of the waveform



In the SPS pilot on the nominal cycle for comparable magnetic history

Chiara Bracco

Injection & LBDS

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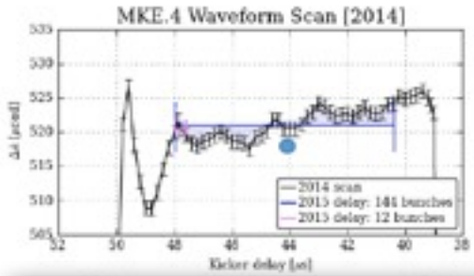

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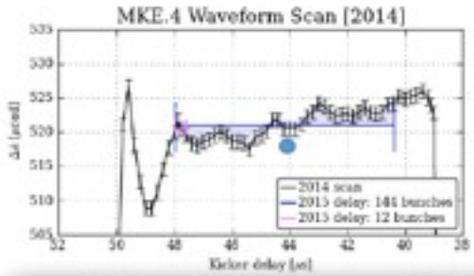

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- **Calibration measurements for Async. BD (link)**
  - ➡ Aperture measurements IP6 (2 hours / beam)
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- **Validation of BPMS (BI)**
- **Final validation with Async. BD test**

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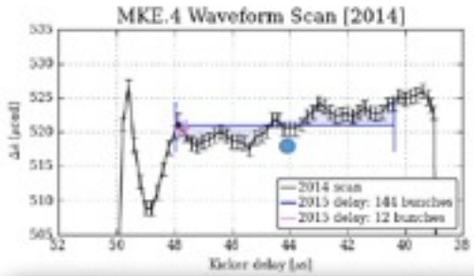

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Build a reference of conditions before an asynchronous beam dump happens.

Collimation

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Commissioning plans for 2016

- Require usual alignments + validation at 4 points in the machine cycle (injection, ramp, squeeze, collisions).
  - ➡ 3 shifts for alignments + 3 shifts for validation
- Don't plan major changes to the control software, so we will only repeat a subset of MP tests that ensures that each IP is tested.
- For the embedded BPM collimators, with the final DOROS electronics software in place since TS2, will have to repeat several tests with beam (*1 - 2 shifts*):
  - ➡ BLM vs BPM alignment cross-checks
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- **Alignment (3x8h)**
- **BPMs at collimators (1-2 x 8 h):**
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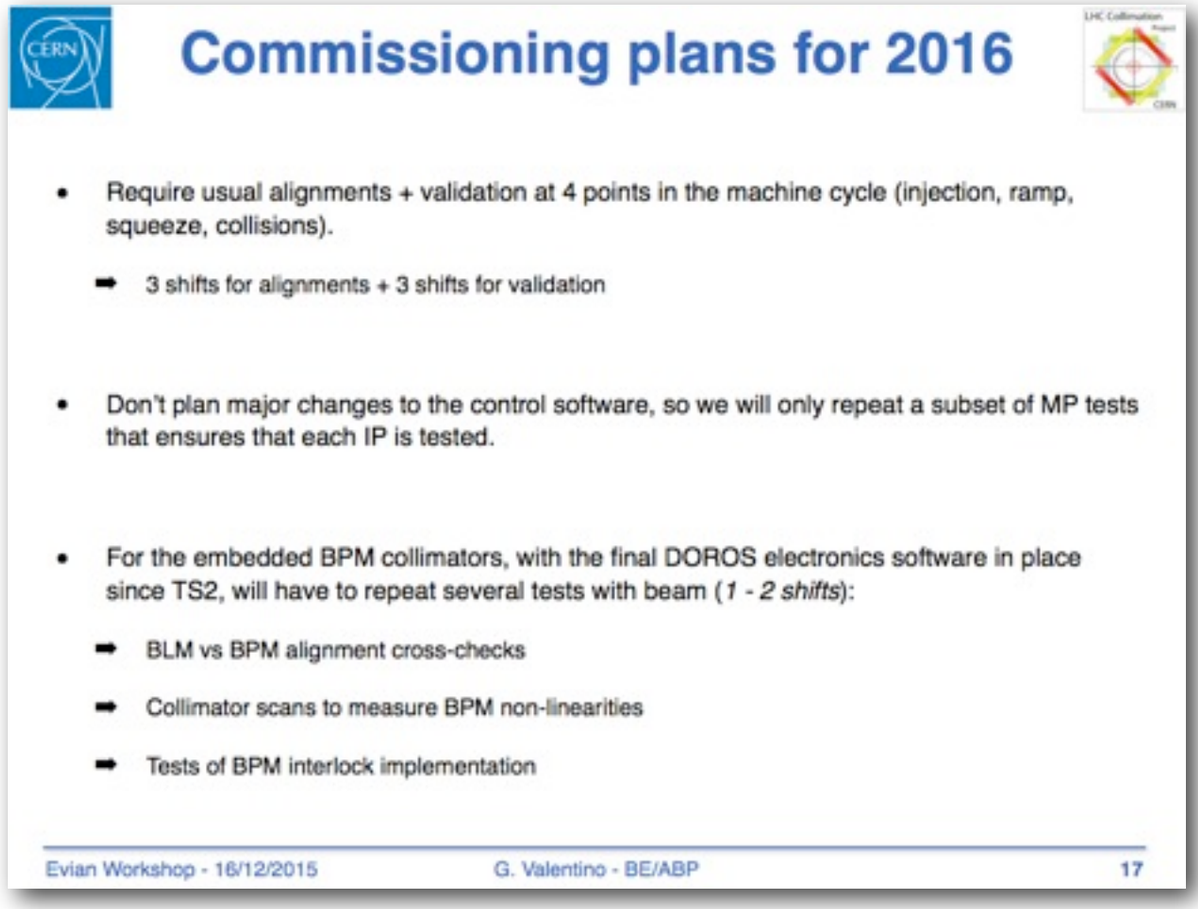

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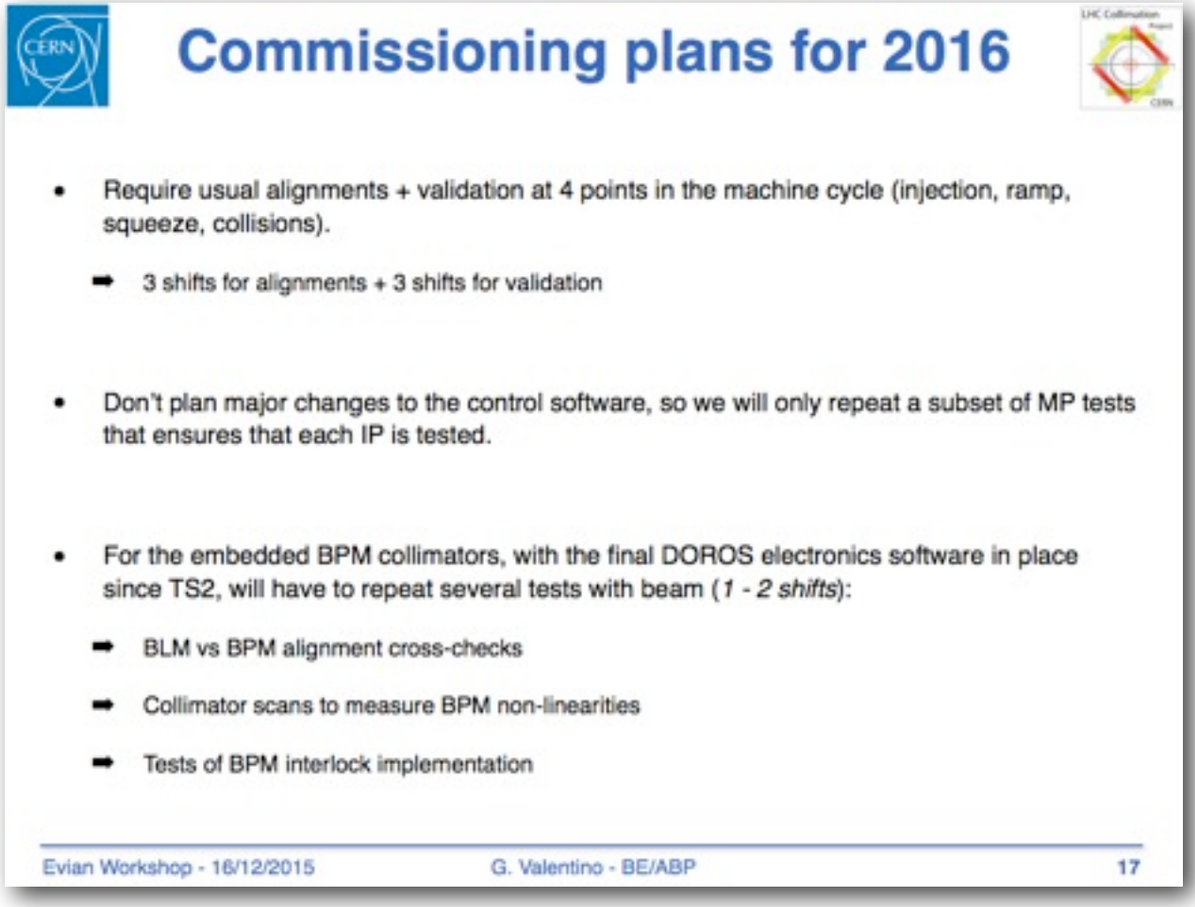

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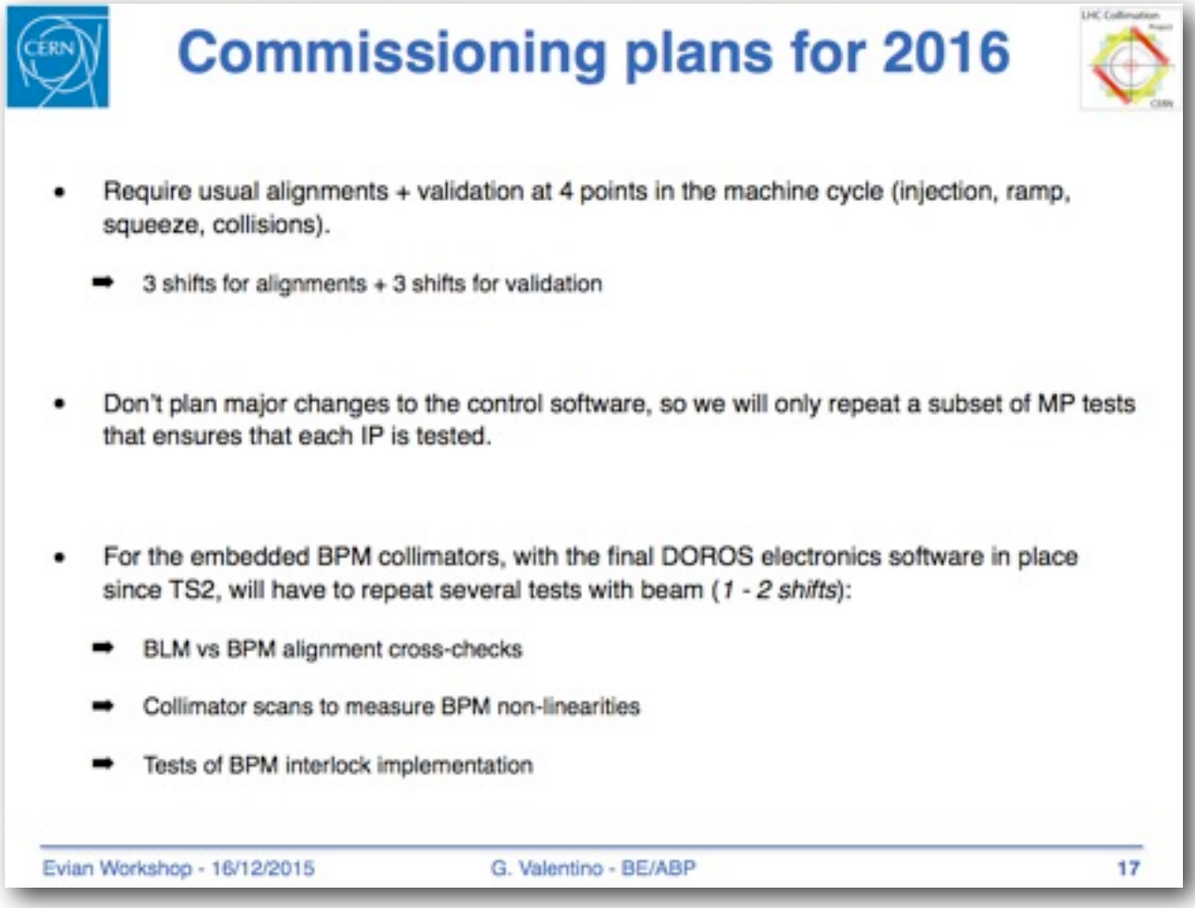

- **Alignment of Roman Pots (TOTEM for low beta)**

Collimation

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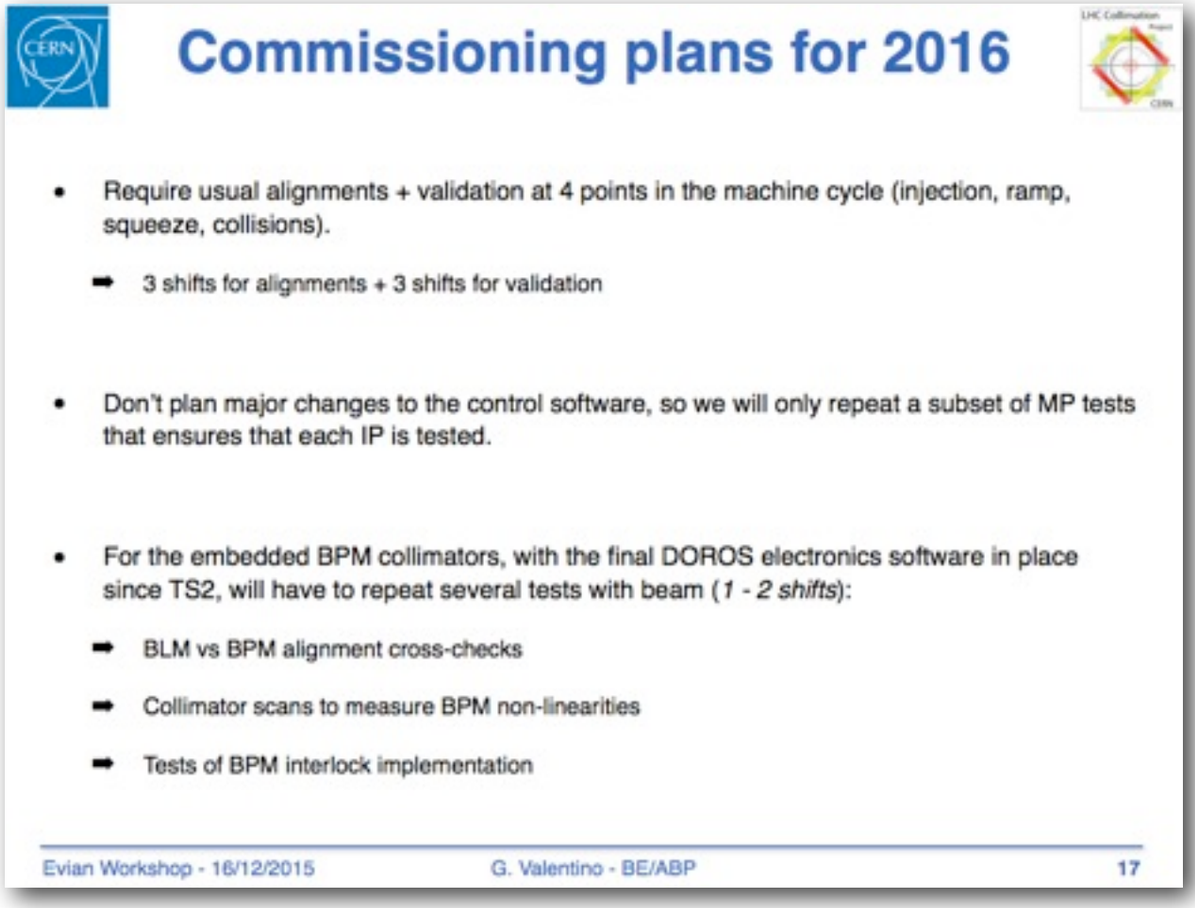

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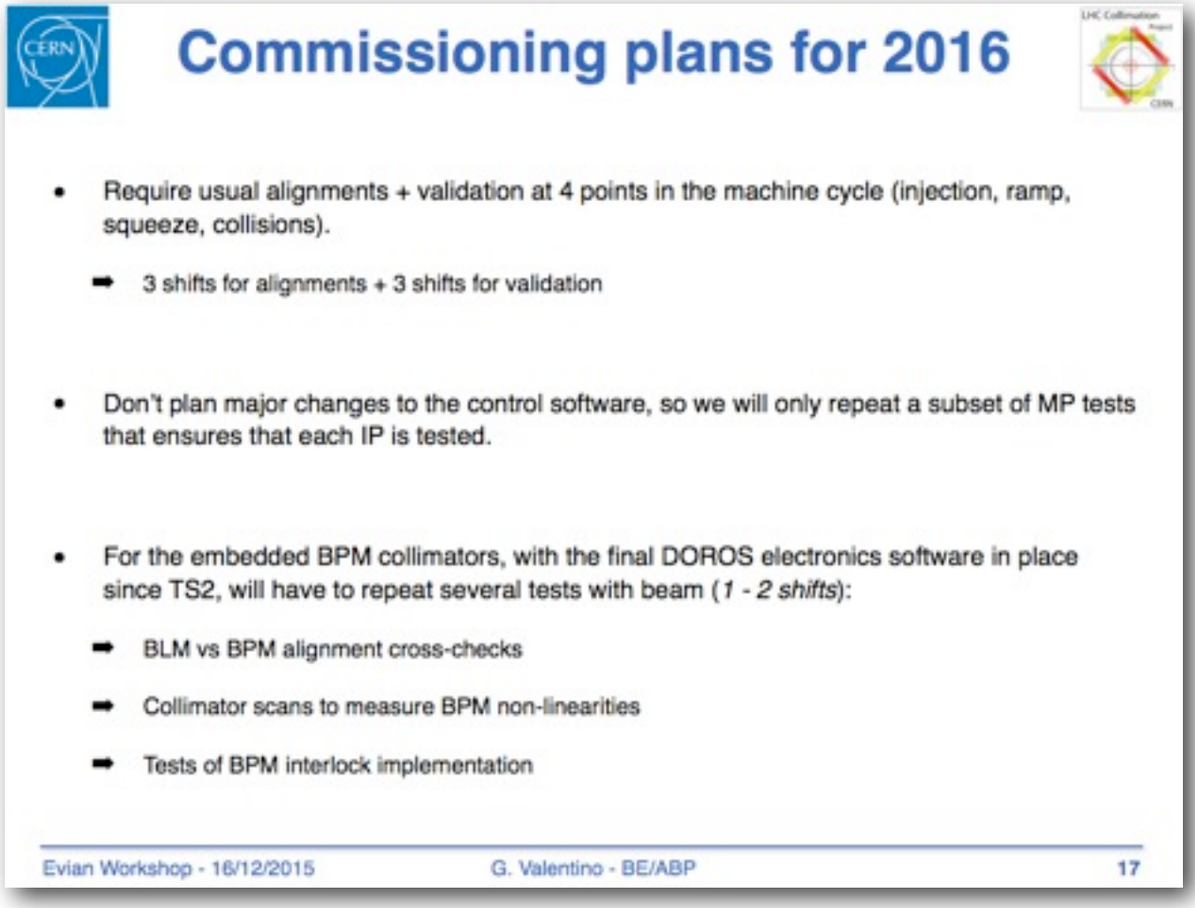

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- **Validation: (4 x 8 h)**
  - ➡ Standard Loss maps

Collimation

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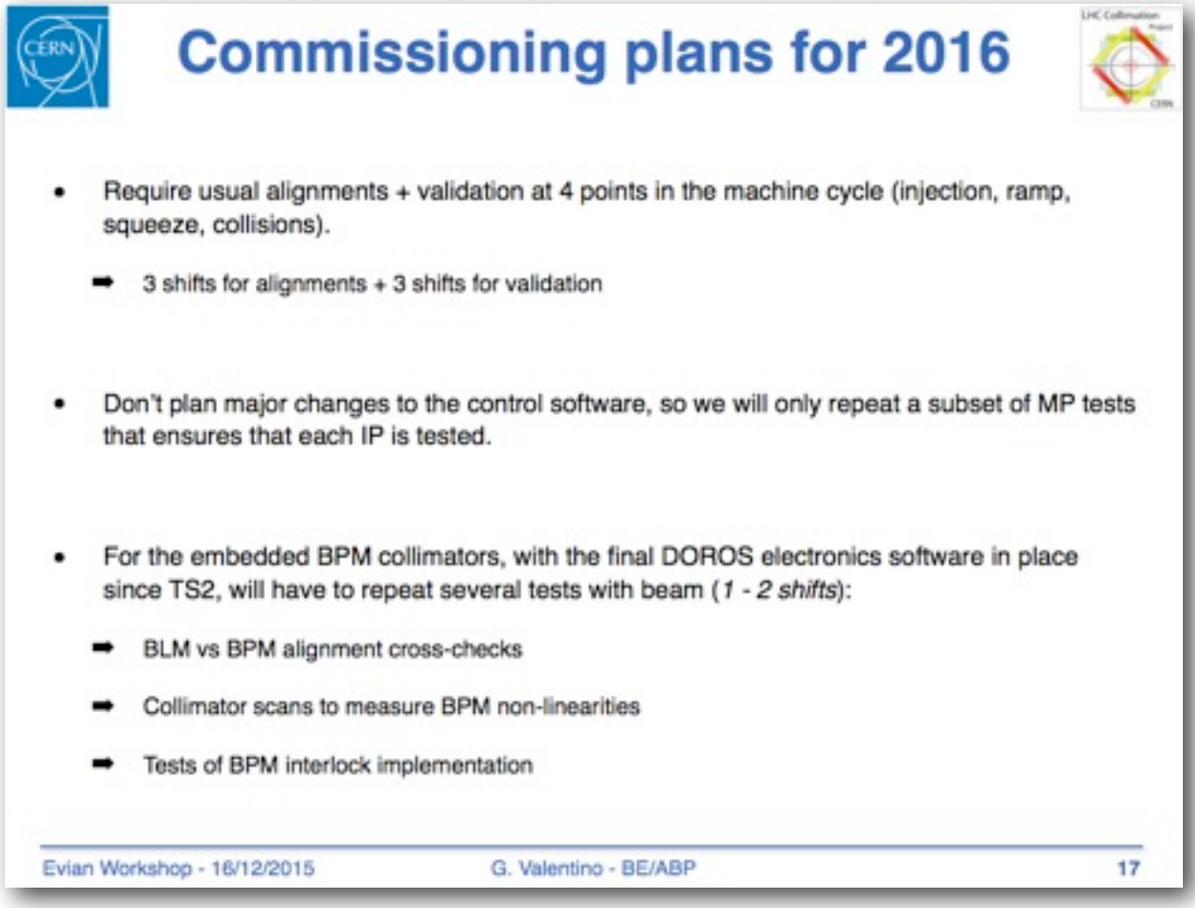

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- **Validation: (4 x 8 h)**
  - ➡ Standard Loss maps
  - ➡ Loss maps during the Ramp/Squeeze (parasitically during the first test ramp with nominals)

ADT and RF

RF

- **For nominal parameters:** *1.2x10^{11}p/b, 25 ns, 6.5TeV*
  - ➡ RF synchro and capture (8h)
  - ➡ 1.25 ns and 10-12 MV
- **If bunch intensity above nominal:**
  - ➡ Condition the klystrons at 300 kW (HW commissioning)
  - ➡ Preparation of phase modulation scheme to cope with double bunch intensity (MD time). *IPAC12, MOPPC015*

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ADT

- **Standard setup (8h)** *LBOC 2014*
  - ➡ bunch intensity, tunes, Abort gap cleaning, injection cleaning, loss maps
- **Automatic intensity settings and protection (4 h)**
- **Setup of trains**

- ***New pickups Q8/Q10 will be commissioned mid 2016***

Beam Instrumentation

preliminary list...

Beam Instrumentation

- **BLM (11h + ramp up)**
  - ➡ Interlock functionality check (3h)
  - ➡ Latency check (2h)
  - ➡ direct BLM tests with beam dumping system (4h)
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  - Connectivity tests using kick response and with RF trimming (3h) - polarity inversion and faulty channels.
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- **BSRT (4h + 4h and 2 ramp-ups)**
  - ➡ One week of parasitic data taking and tuning
  - ➡ Machine validated for INDIV. Calibration with beam (2h + 2h and a ramp up)
  - ➡ Repeat calibration few days later after HW adjustments (2h + 2h and a ramp up)

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- **BSRT (4h + 4h and 2 ramp-ups)**
  - ➡ One week of parasitic data taking and tuning
  - ➡ Machine validated for INDIV. Calibration with beam (2h + 2h and a ramp up)
  - ➡ Repeat calibration few days later after HW adjustments (2h + 2h and a ramp up)
- **BCTs, BSRL, BBQ, BTV etc.**

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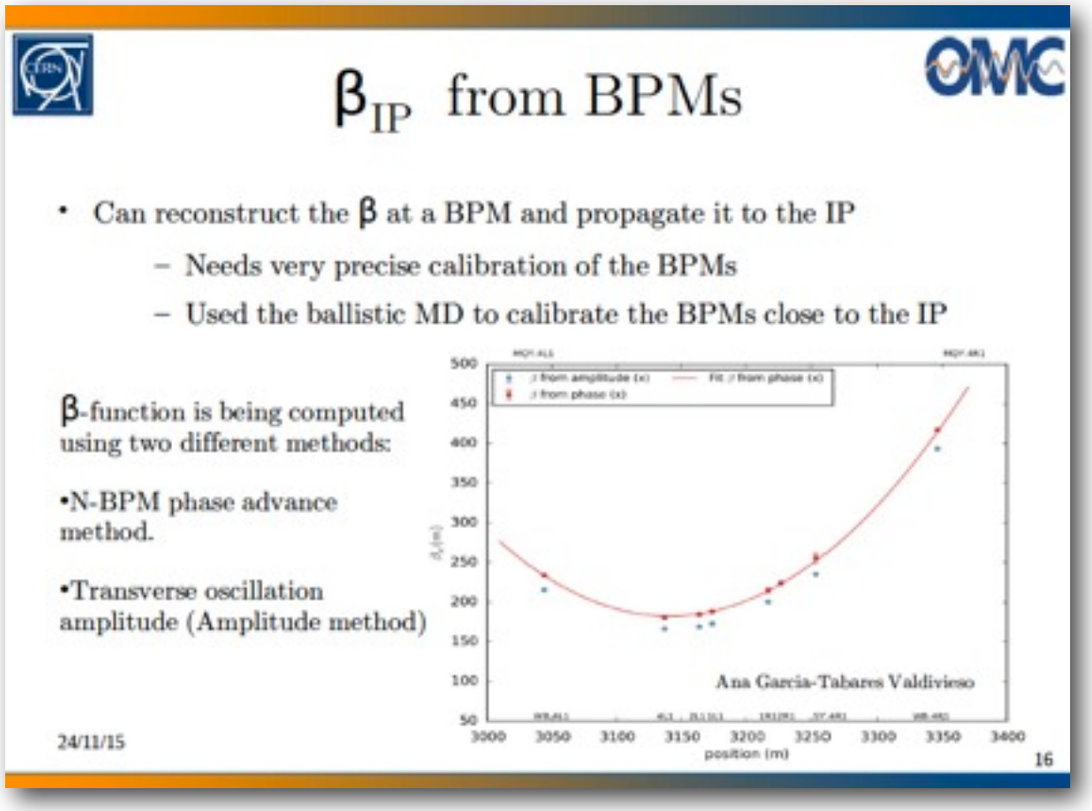

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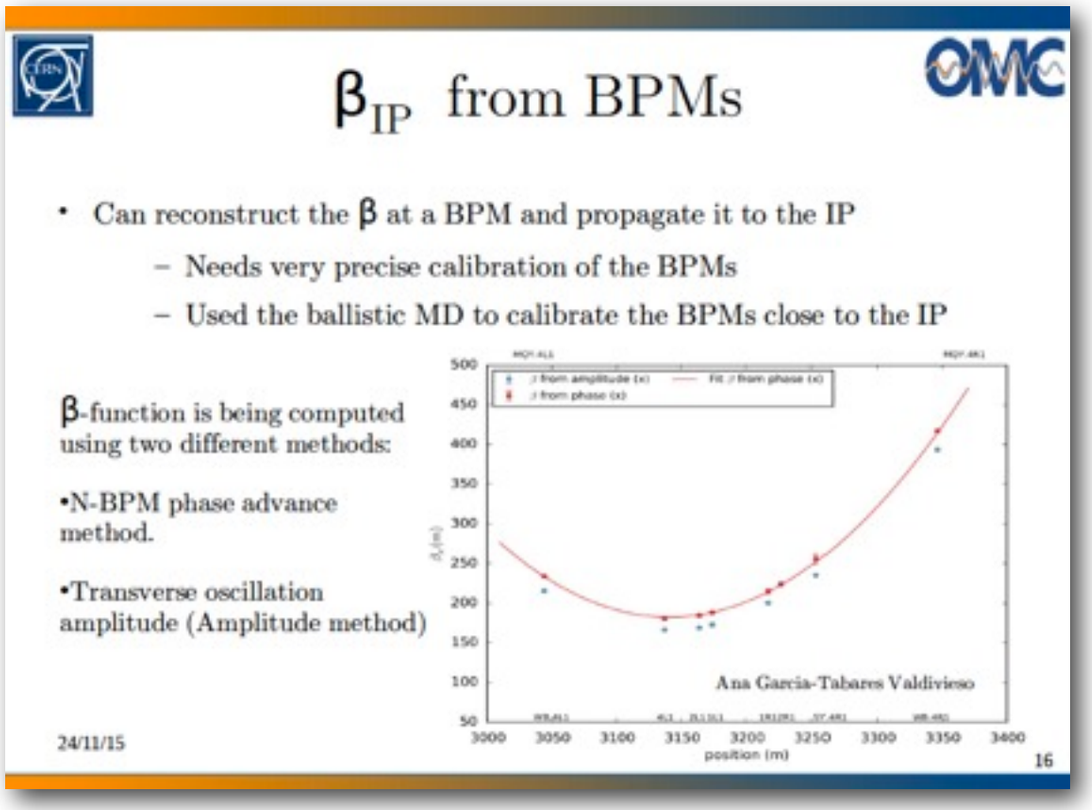

- **Ramp-Squeeze (1 shift)**
  - ➡ Optics measurements during the ramp
- **40cm beta-star (3 shifts)**
  - ➡ Optics and aperture, crossing angles
- **non-linearity corrections (2 shifts)**

Commissioning Phases

Recap from previous commissioning periods

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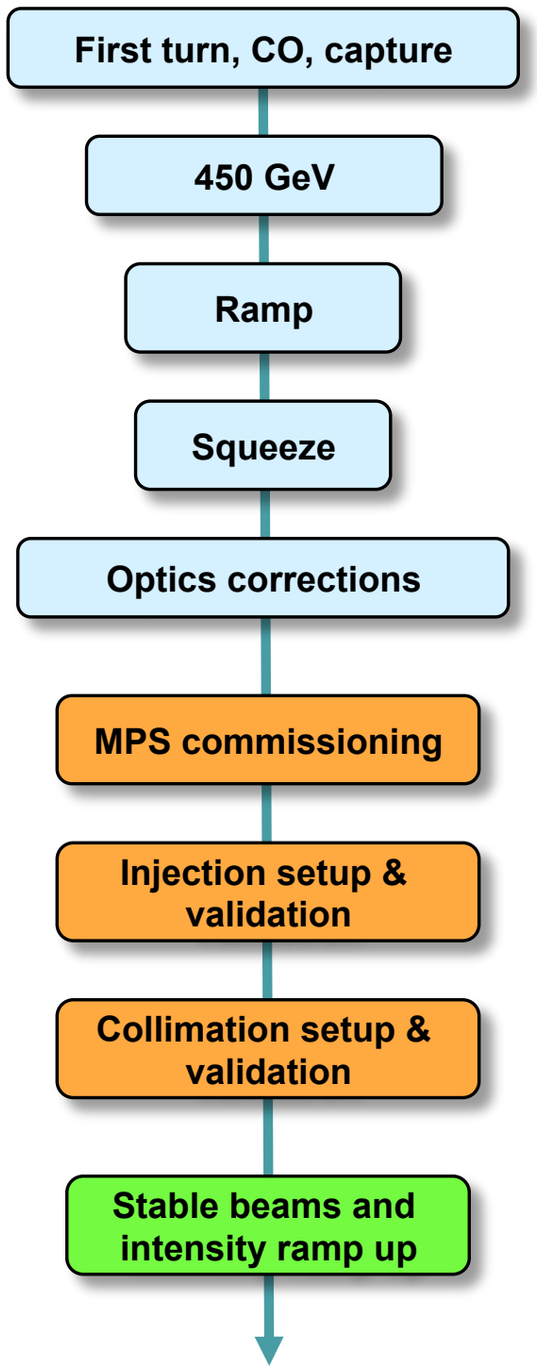


Commissioning Phases

Recap from previous commissioning periods

- First turn, CO, capture
- 450 GeV
- Ramp
- Squeeze
- Optics corrections
- MPS commissioning
- Injection setup & validation
- Collimation setup & validation
- Stable beams and intensity ramp up

Injection

- Transfer line setup
- Injection steering
- Injection protection
- Transfer line collimation
- Injection protection validation

Collimation

- Collimation 450 GeV
- Ramp settings
- Collimation 4 TeV FT
- Tertiary setup squeeze & collisions
- Squeeze settings
- Loss maps

Dump

- Setup 450 GeV
- Setup 4 TeV
- Dump protection
- Dump protection validation

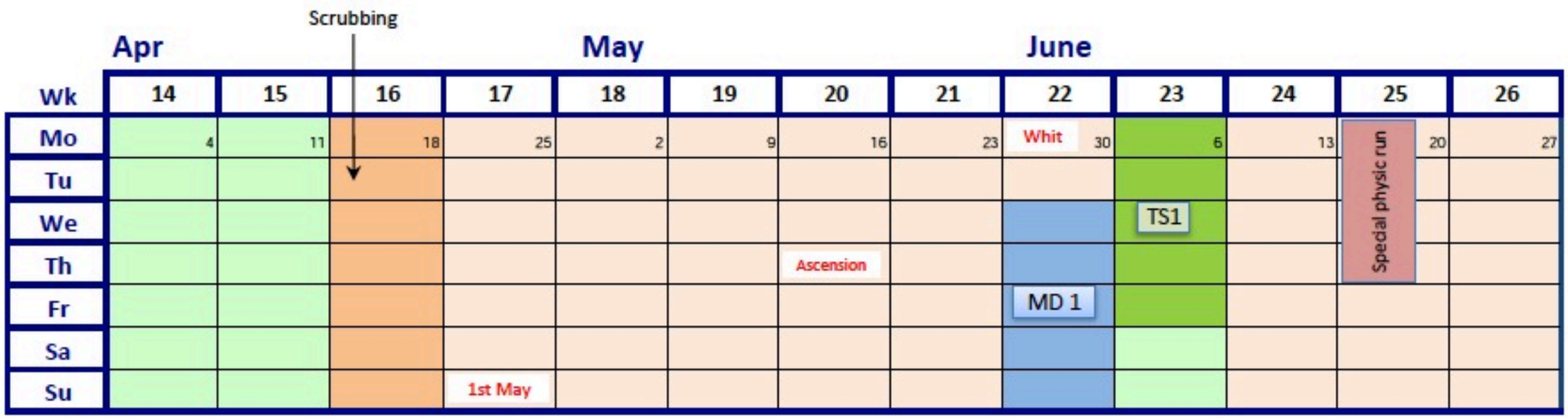
Planning outline - I

Work in progress...

Shift-by-Shift		
Day	Time	Activity
1	8	Injection, first turn B1&B2
1	8	Closed orbit and capture B1&B2
2	4	Instrumentation - orbit, Q, Q', wire scanner
2	4	Dispersion, coupling, Q, Q', C-measure and correct
2	8	RF capture, delay buckets and ADT first setup with probe
2	4	Feedbacks - recommissioning at injection (Q, orbit, radial)
3	4	Beta beating measurements and correction @ 450 GeV
3	8	Dump check-out
3	8	Ramp-squeeze (1st fill): feed forward corrections from MD, tune feedback on, nc
3	0	End previous fill with MP test: BLM ?
3	4	BLM: Transmission time, MPS functionality @ 450 GeV
4	8	Ramp-squeeze (2nd fill): chroma measurement, no tune feedback
4	12	Ballistic optics
4	4	SIS MP test
5	8	Squeeze to 0.4 m
5	8	Squeeze to 0.4 m - Optics measurements
5	8	Reference orbit with probe
6	8	Injection correction and TI2/8 reference trajectories
6	8	Pre-cycle or ramp (no beam) - decay measurements at 450 GeV
6	8	BI shift
7	8	Injection of nominal bunch
7	4	Flat reference orbit at injection with nominal bunch
7	4	ADT setup for nominal bunch - test excitation, abort gap, lossmaps
7	4	ADT setup for nominal bunch - test excitation, inj. cleaning
7	4	Ramp-squeeze (3rd fill): Feed forward, measure chroma, no feedback
8	8	ULO measurement at injection
8	8	Ramp-squeeze (4th ramp): optics measurements along ramp
8	8	Squeeze to 0.4 m - Optics measurements and corrections
9	8	Aperture at 6.5 TeV squeezed

2016 schedule

[Link to 2016 schedule]



Intensity ramp up

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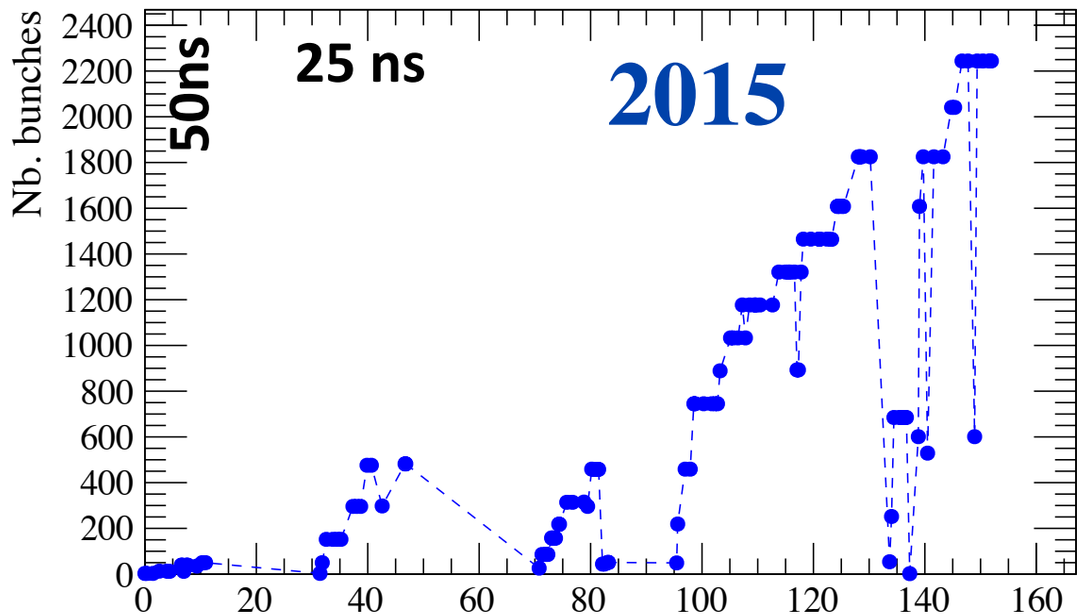

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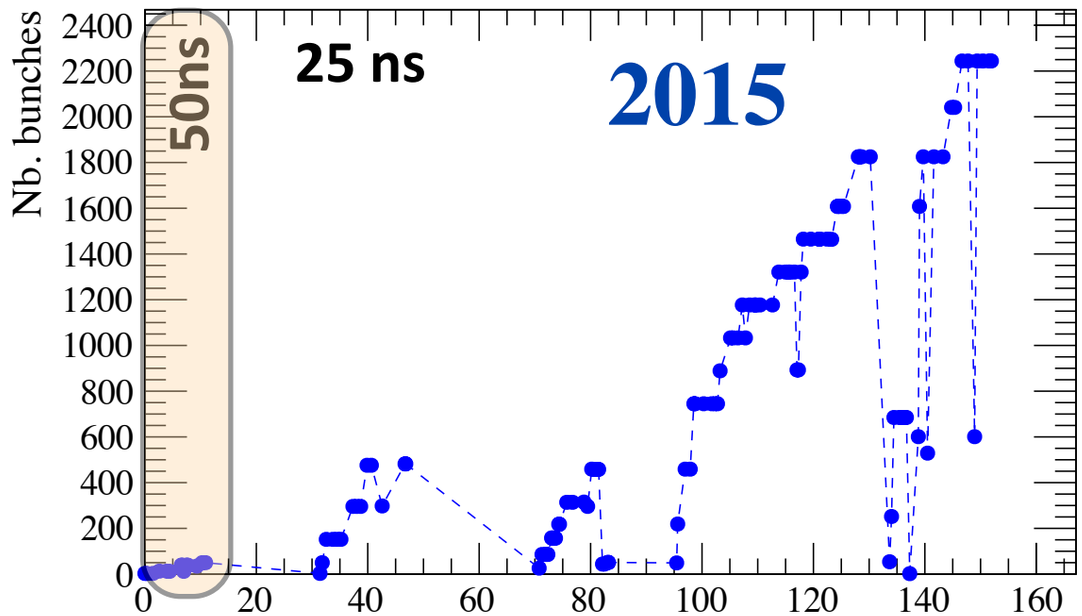

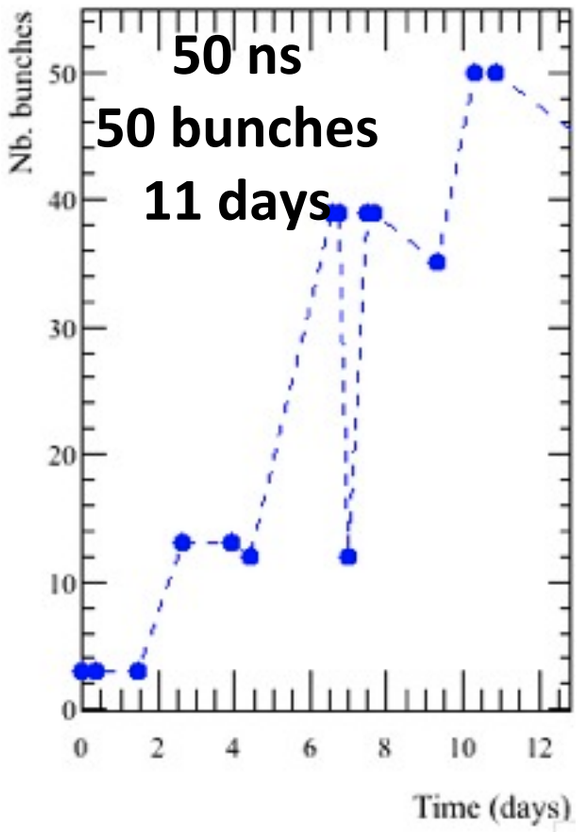

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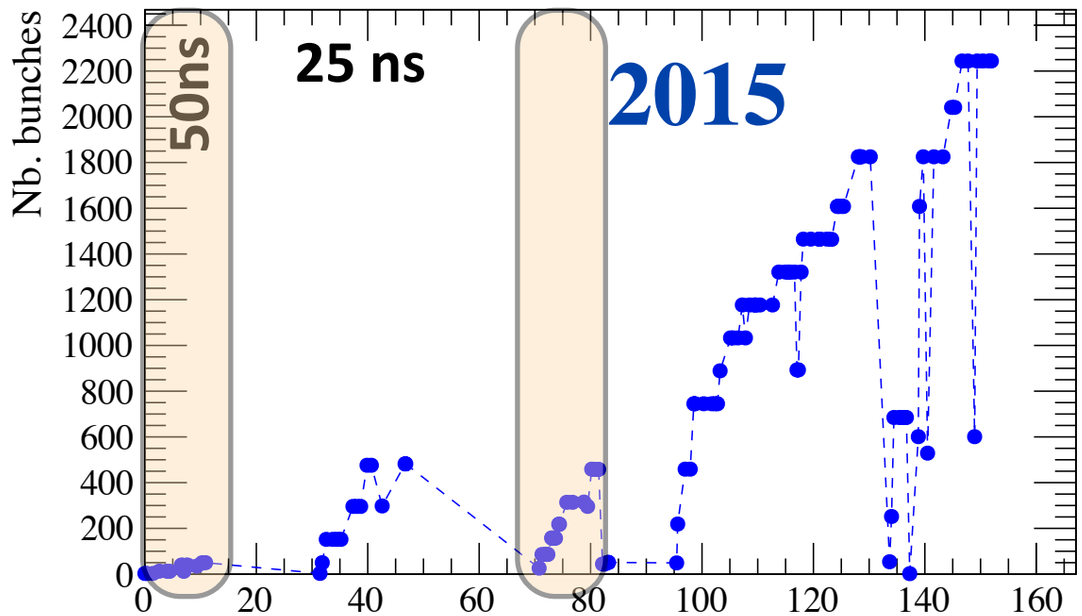

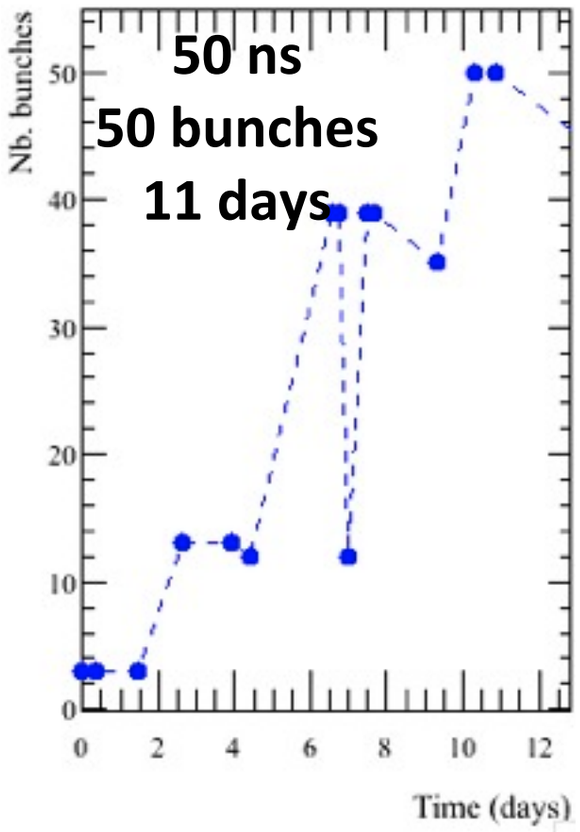

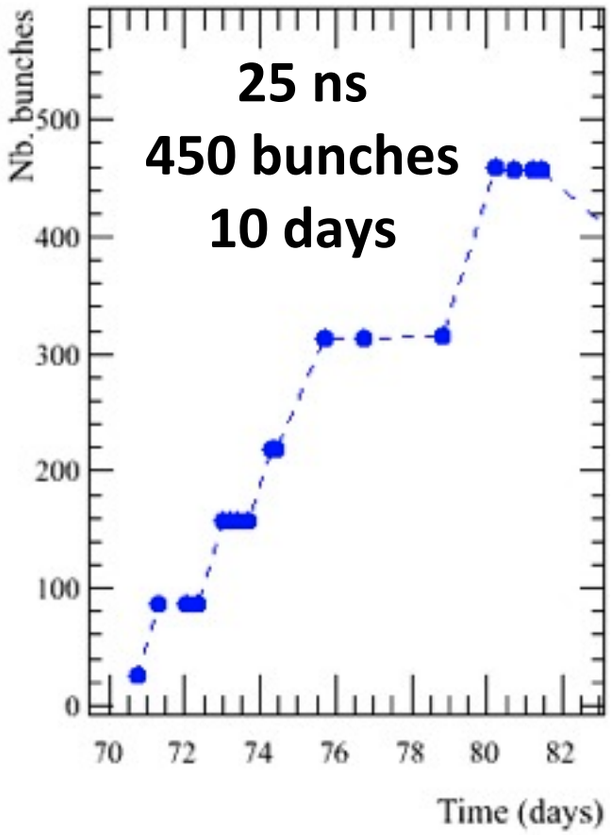

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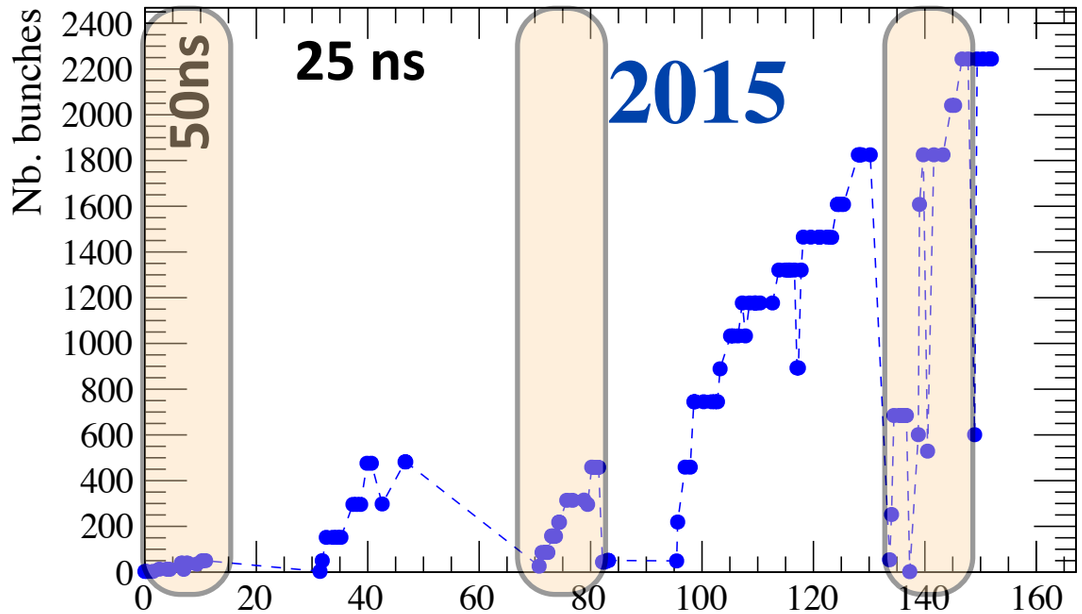

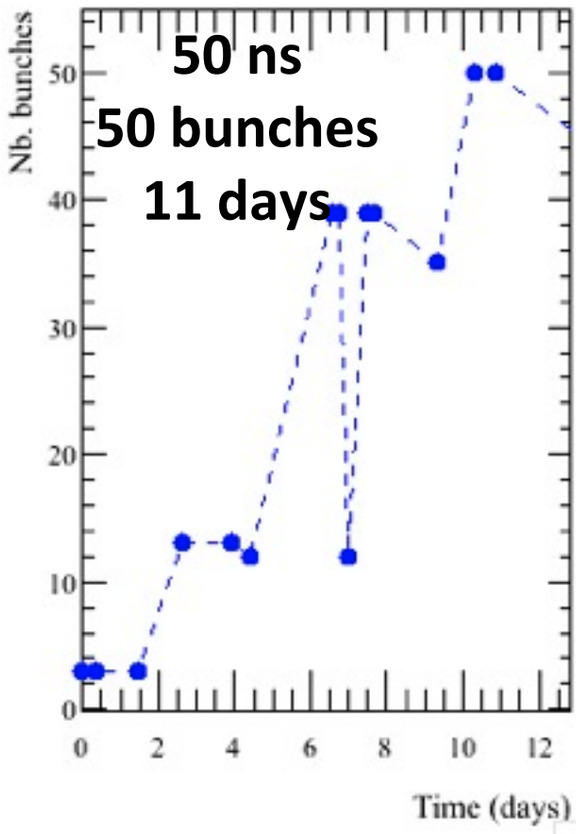

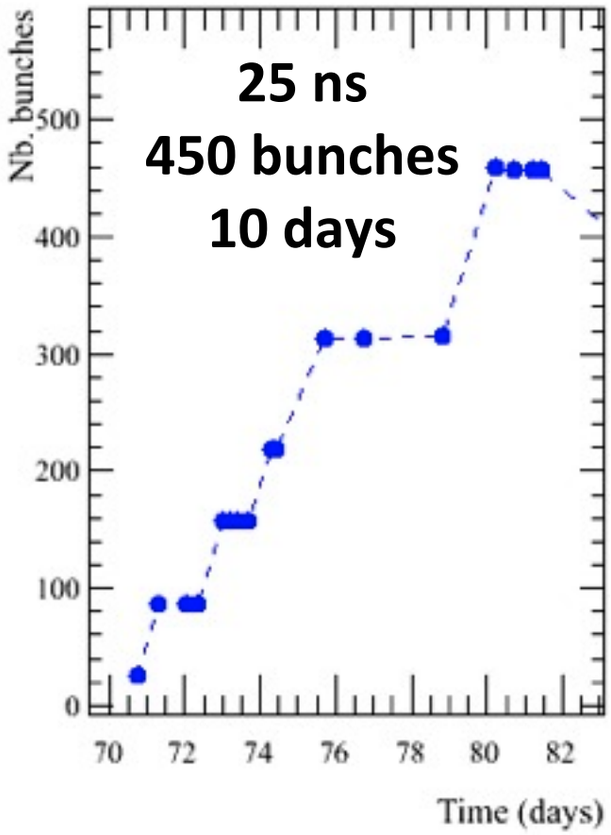

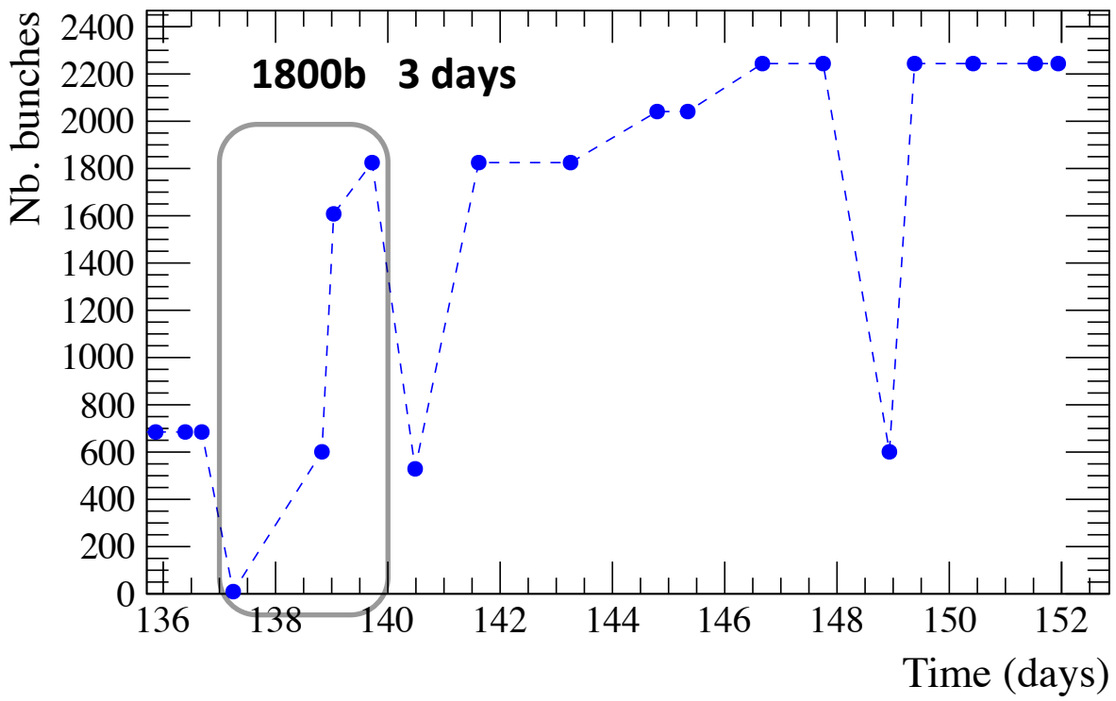

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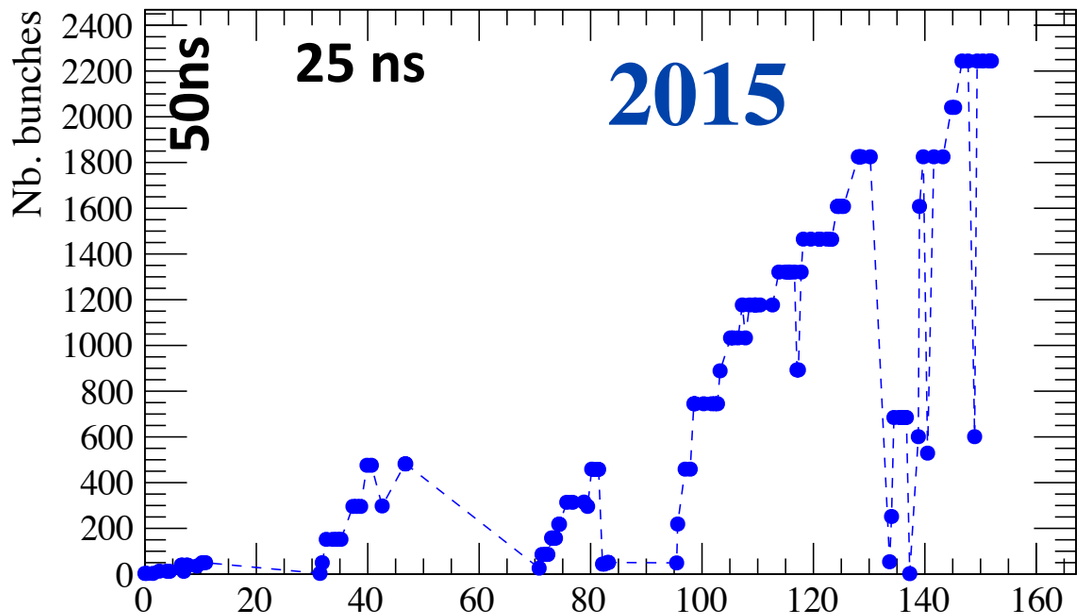

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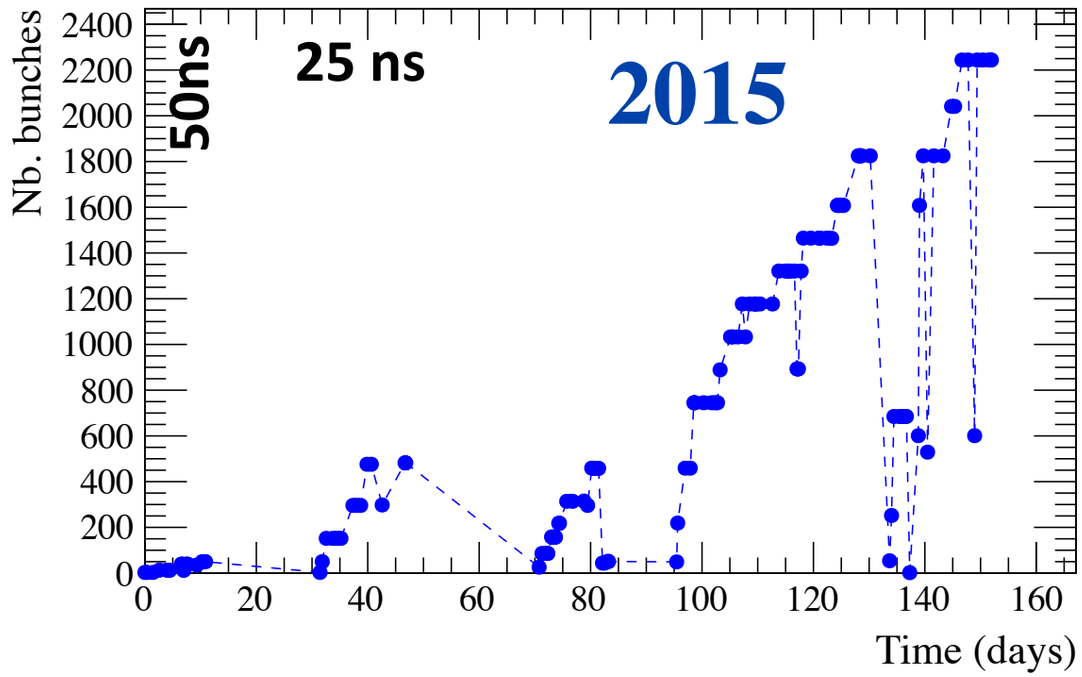

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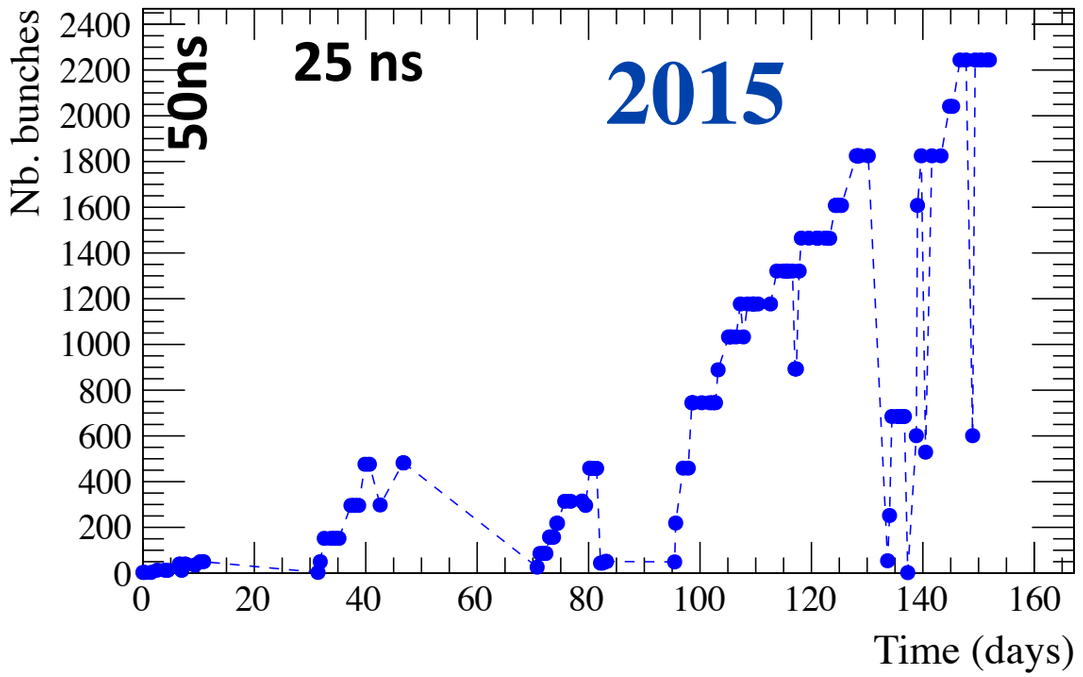

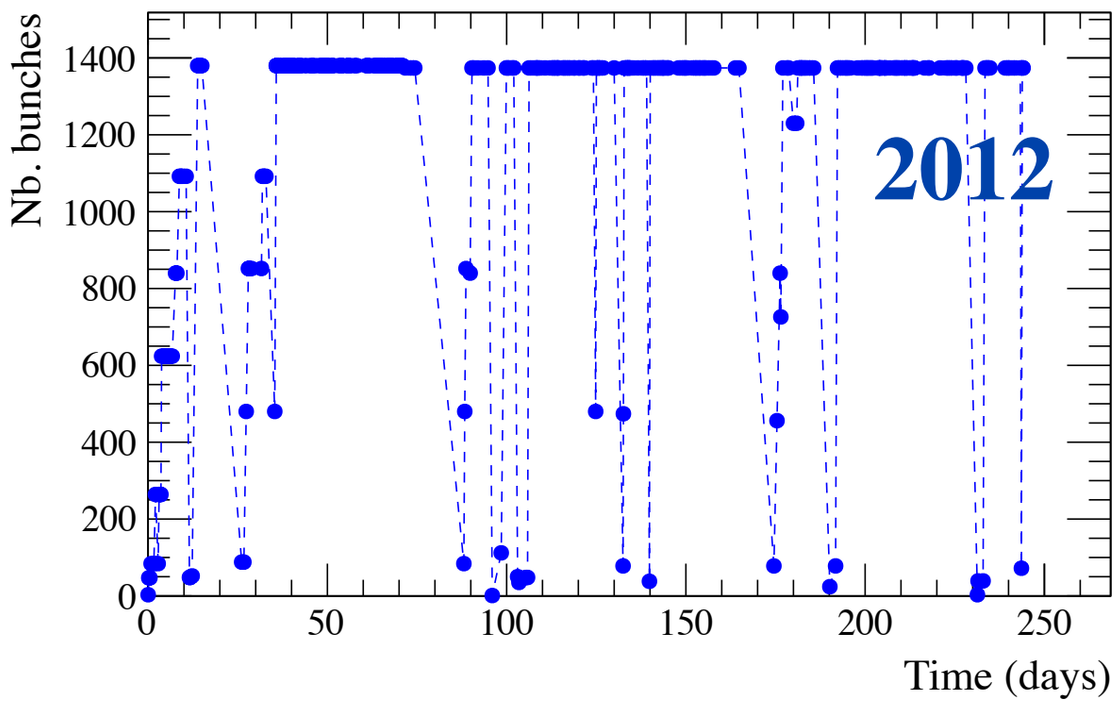

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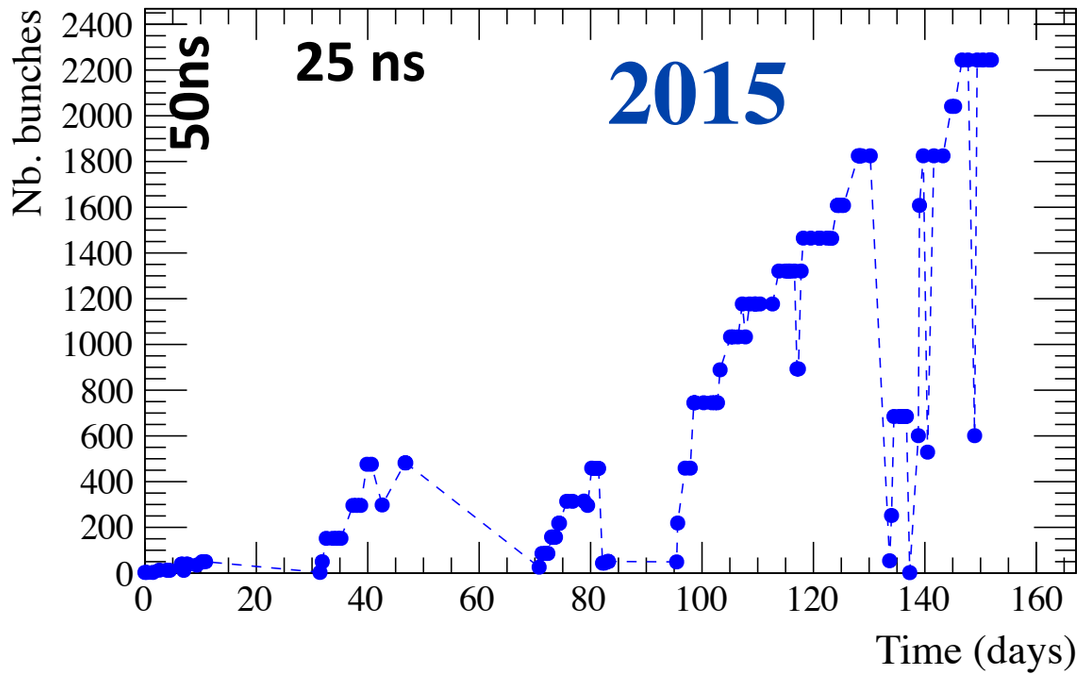

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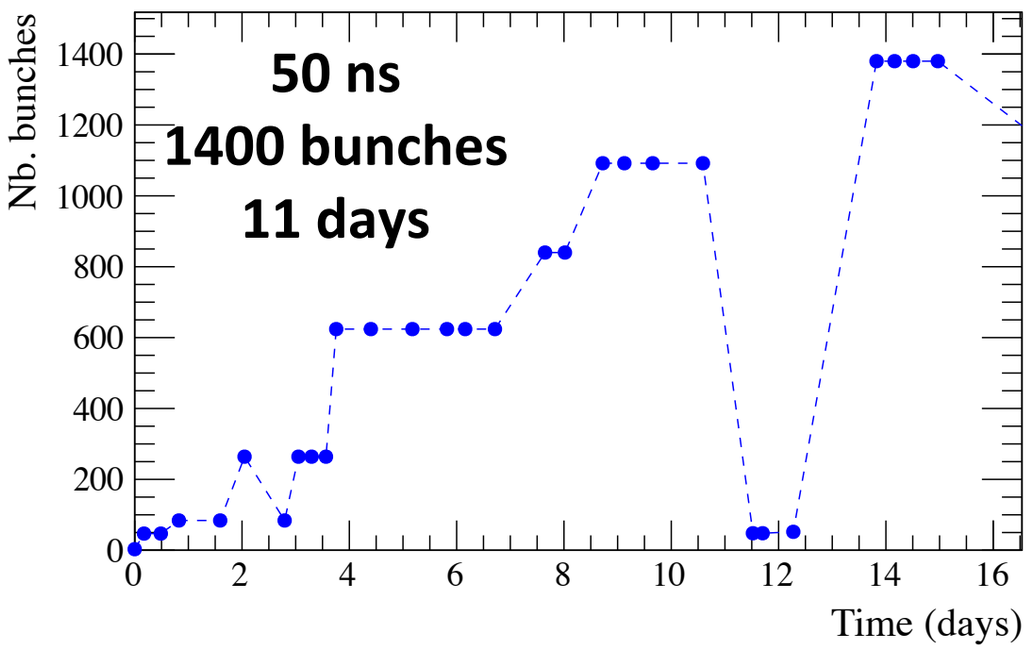

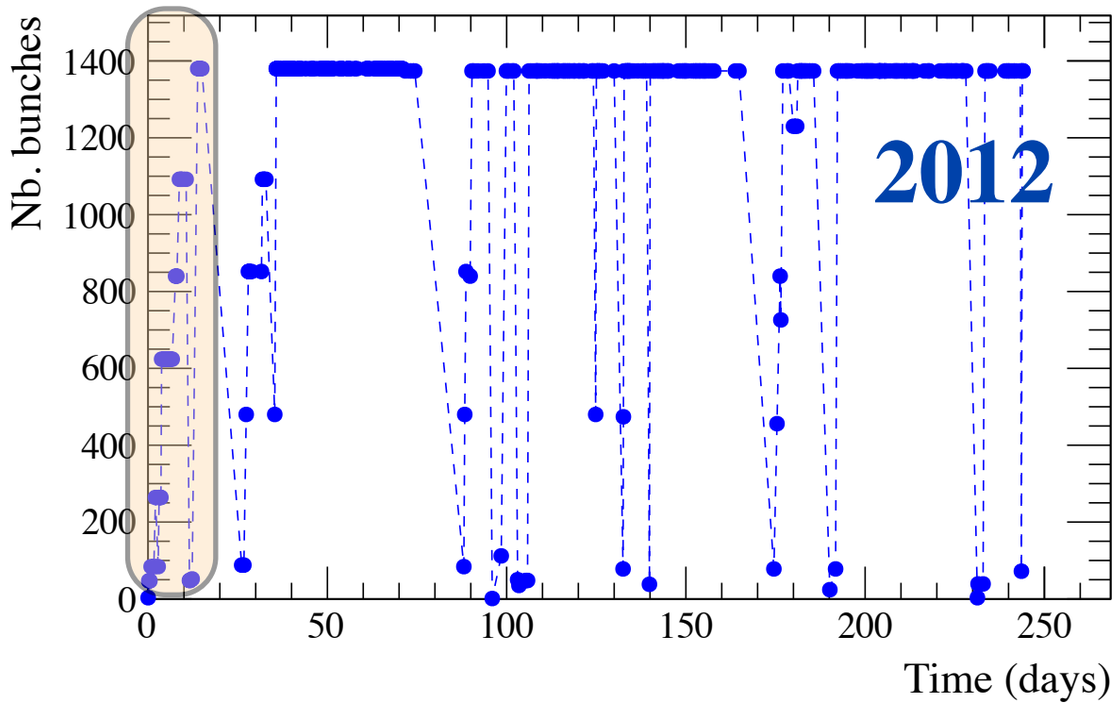

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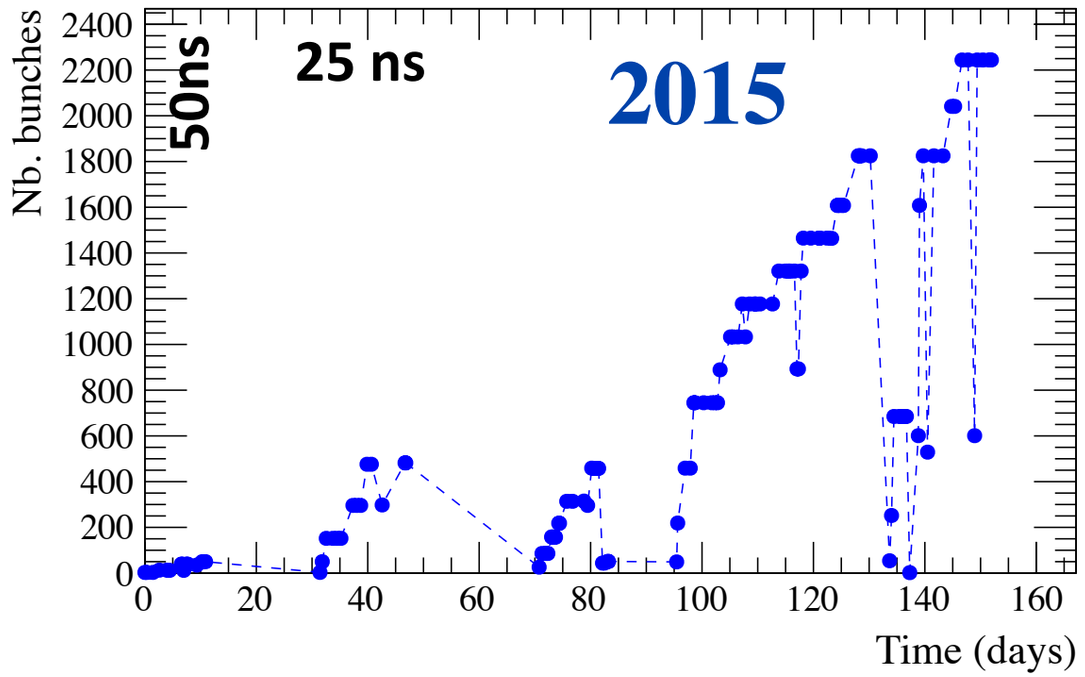

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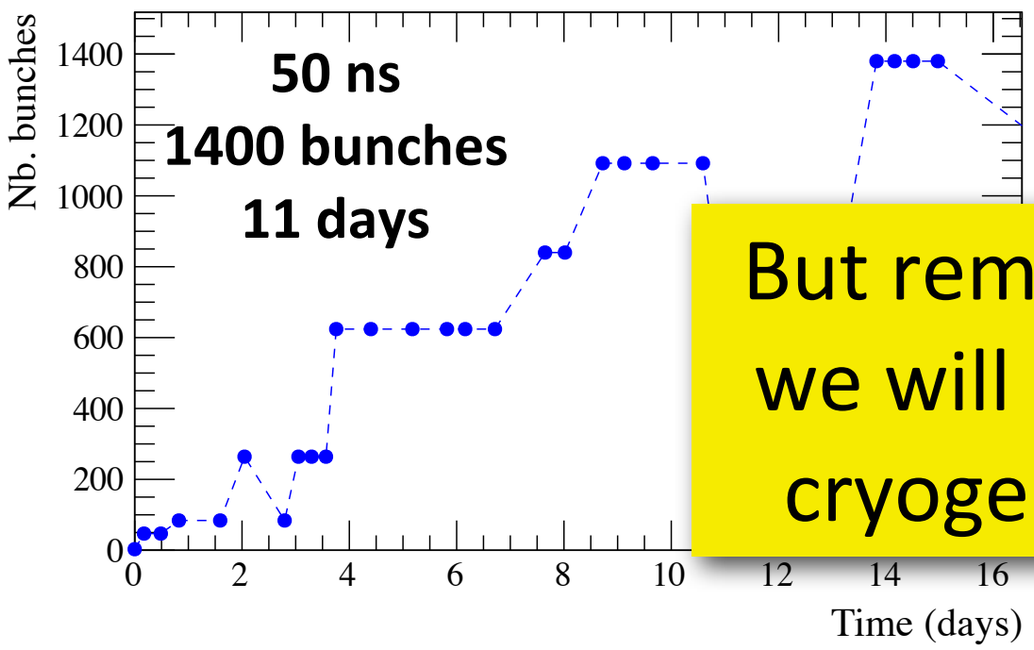

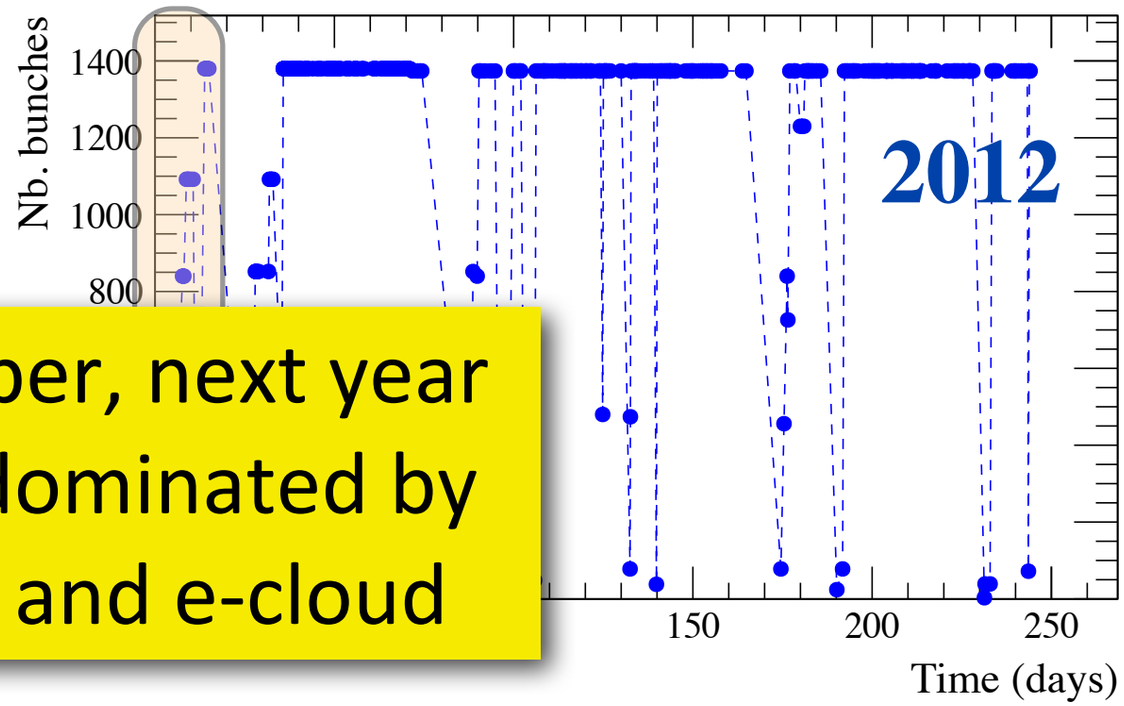

But remember, next year we will be dominated by cryogenics and e-cloud

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"Mini" intensity steps, 1 train 288 each time but 1-2 fills with reasonable physics.

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Keep this approach until 500 bunches in order to validate machine configuration and optics, allow time to post analyze the fills. Then "mini" steps of 1 extra train with 1 fill in SB without problems.

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- ***Similar bunch intensities as end of last year:***
  - ➡ *1.2(5)x10^{11} p/b (try 1.3x10^{11} when heat load permits)*
  - ➡ *Only 25ns configuration*
  - ➡ *Priority to setup 288 bunches*

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- **2016 should be a production year**
  - ➡ Shorter time for commissioning: 4 weeks
  - ➡ Prepare machine for high intensity: 7 days of scrubbing
  - ➡ Commissioning of new optics with the goal of 40cm beta-star, measurements and aperture checks will be the decision points for the final beta-star.

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  - ➡ Commissioning of new optics with the goal of 40cm beta-star, measurements and aperture checks will be the decision points for the final beta-star.
- **Intensity Ramp up with the goal to 2800b**
  - ➡ Keep the strategy of previous years of 3 fills /20 hours, this works well to spot problems during the ramp up.
  - ➡ Machine Protection encourages to keep this approach up the injection of 500 bunches
  - ➡ Then we will probably be limited by e-cloud and cryogenics
  - ➡ After 500 bunches we could envisage to continue with “mini”-steps of intensity (only 1 fill per step) adding 1 train 288 each time.