



LHC re-commissioning

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Outline

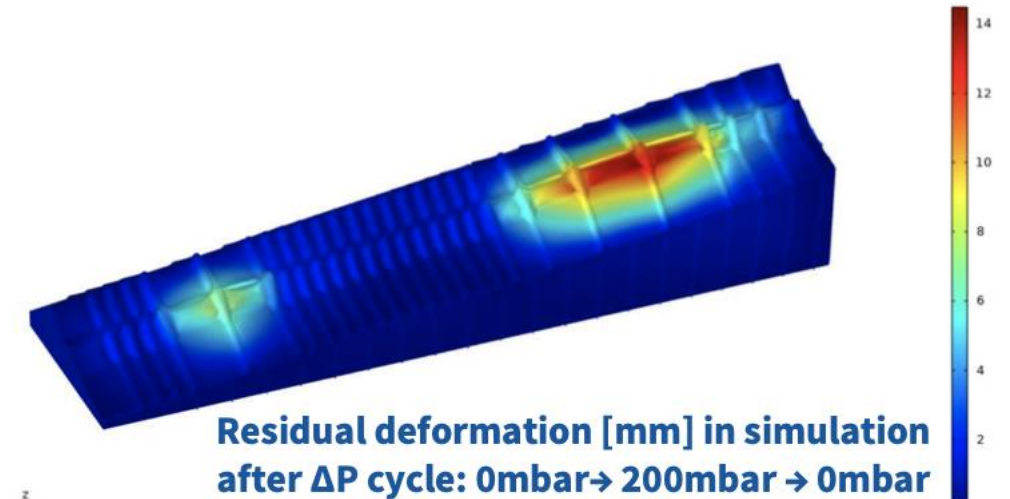
- A few updates from the YETS period
- 2023 operation and re-commissioning plan
- Info on 2023 run

LHCb VELO incident

The evaluation of the **impact** of the VELO vacuum incident on the LHC machine and VELO operation is **still in progress**

Current status:

- The **deformation should not be a problem** for beam injection (aperture)
 - Aperture checks around IR8 to be done with beam for confirmation
- No problem expected in terms of **impedance and heating**
- To define **limits on VELO closure**, the edge of VELO must be reconstructed with beam tomography, possibly completed by beam aperture scans
 - LHCb is investigating what can be determined parasitically to beam operation using SMOG



CMS radial IP shift

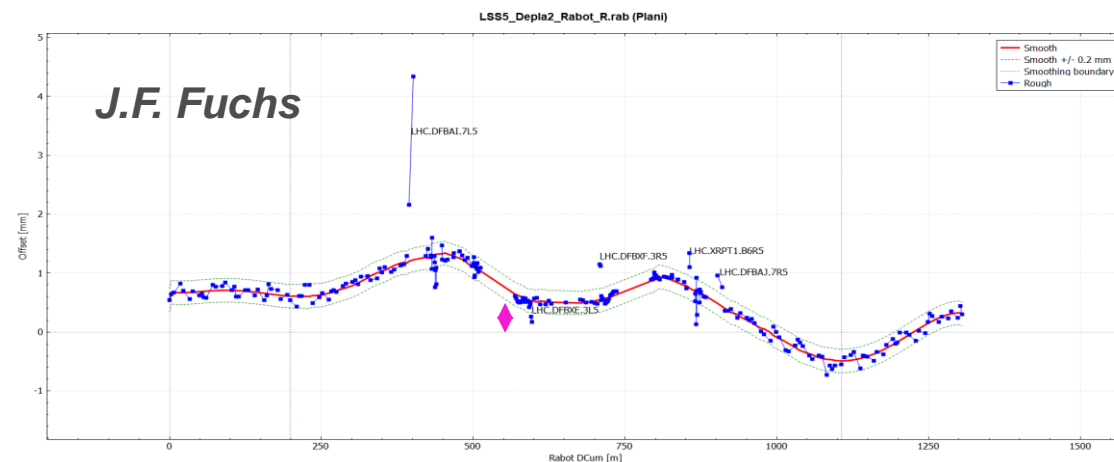
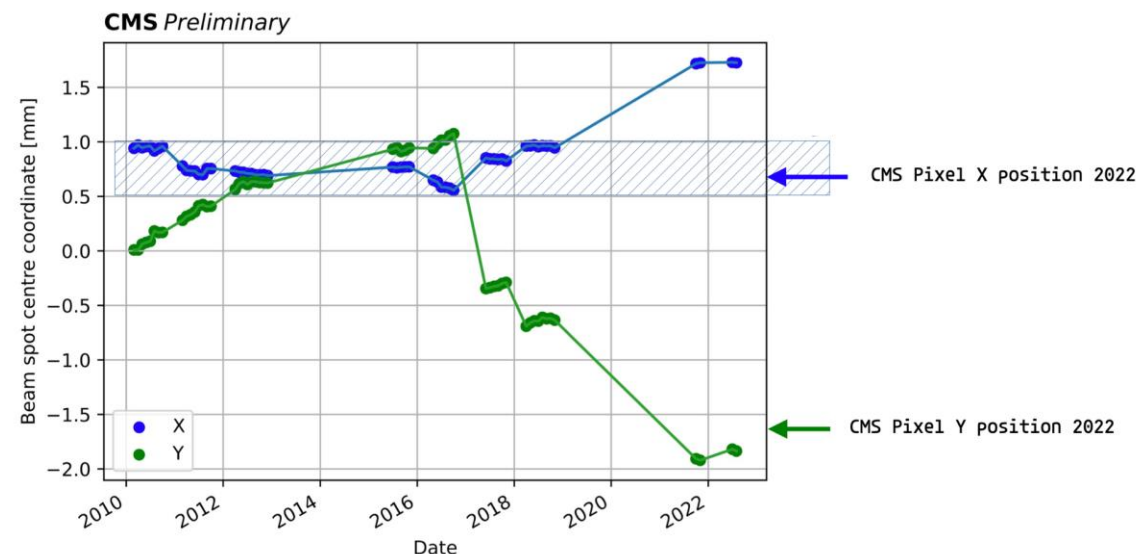
At the end of 2022 run, CMS requested a **radial shift** of the beamline by **1.1 mm** to center the beam spot within the CMS pixel.

In order to **limit the mechanical stress** on the HW components, it was decided to separate the correction:

- 50% by **beam line movement**
- 50% by introduction of a **magnetic bump**

Today:

- LSS5 beam line was shifted by **0.5 mm radially**
- It was estimated that the magnetic bump would induce **~10% increase** of radiation to the triplet magnets → IT task-force recommended to **not apply** this correction



ATLAS luminosity scale

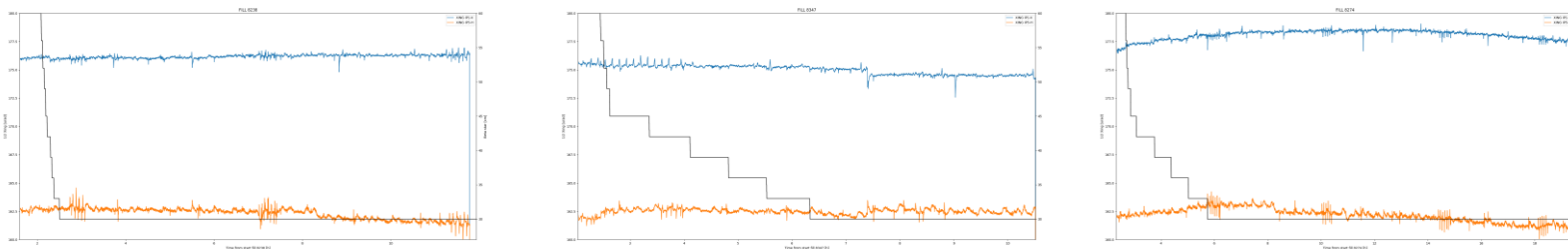
ATLAS recently corrected their 2022 luminosity scale **down by 5.4%**

- After update of the visible X-section from vdm scans

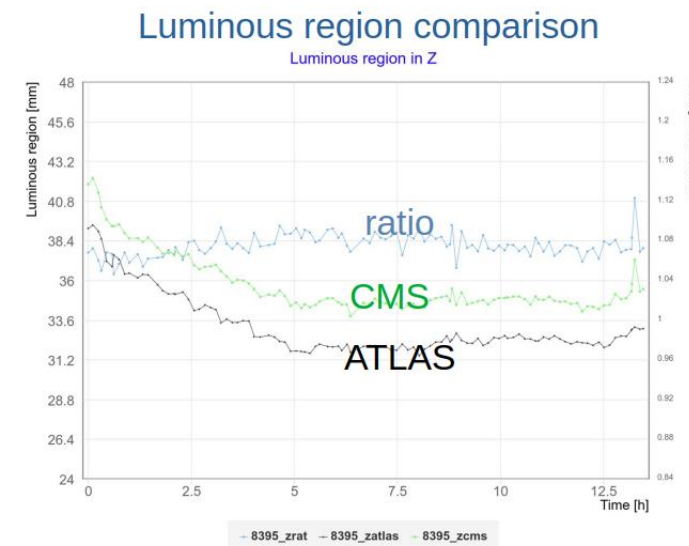
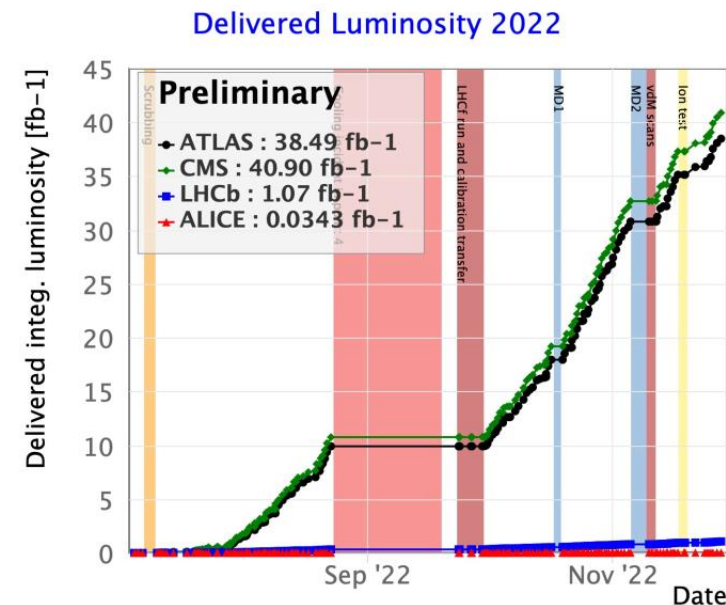
The **lower ATLAS lumi** is in agreement with the observed **difference of luminous region**. This could be explained by a **~10 microrad** larger half-Xing angle in ATLAS than in CMS

- Some indications of such a difference visible on the DOROS BPM data, but it's at the edge of the BPM accuracy

We will feed this information **into the 2023 setup** → Collisions at injection might be used to reconstruct the luminous regions to **guide the machine setup at 6.8 TeV**



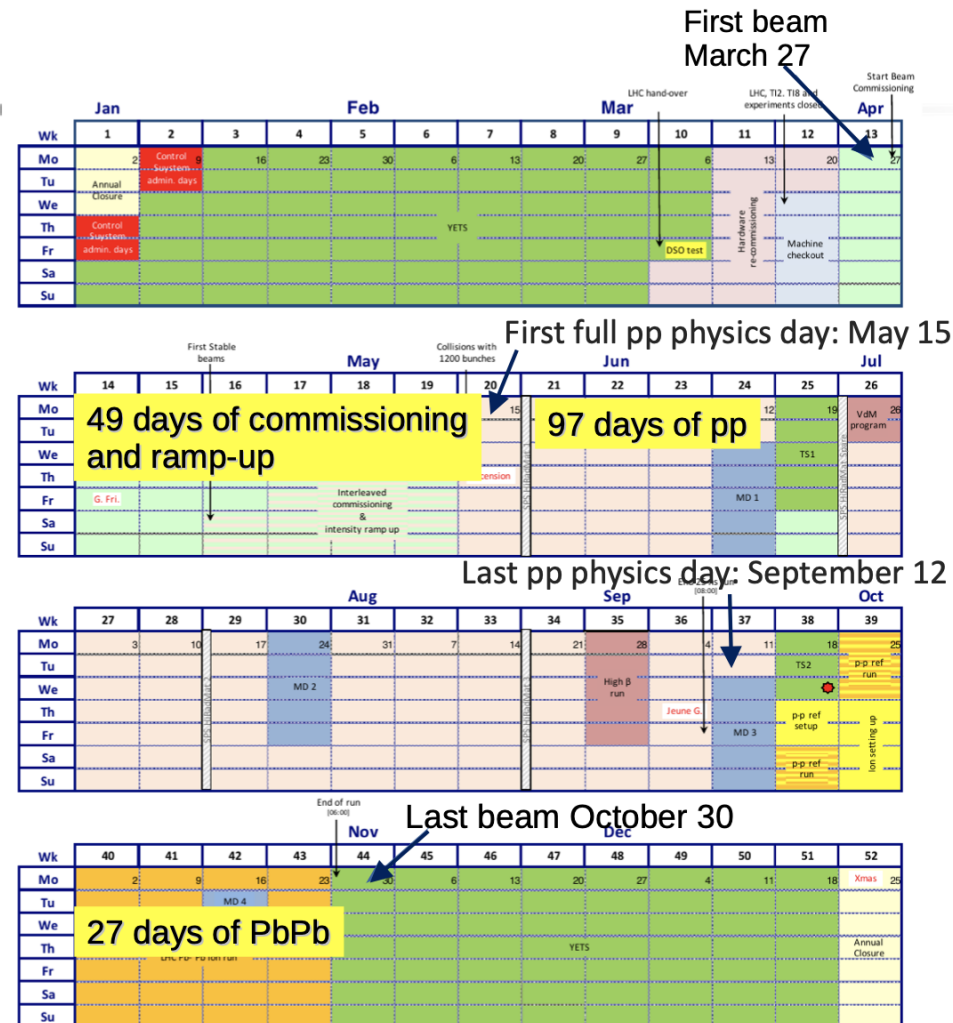
Examples of reconstruction of Xing angle with DOROS BPM data



2023 plan

- 2023 is a short year due to early EYETS:
 - 13.5 weeks of pp physics
 - 4 weeks of ion physics
 - + 1 week for pp reference run

Activity	Duration [days]	Ratio [%]
Beam Commissioning & Intensity ramp-up	47	21.7
Scrubbing	2	0.9
25 ns physics (>1200 bunches)	97	44.7
Special physics runs (incl. setting-up)	7	3.2
Pb-Pb ions & p-p ref. setting-up	6	2.8
Pb-Pb ions physics & p-p ref. run	32	14.7
Technical stop	8	3.7
Technical stop recovery	2	0.9
Machine Development blocks (incl. floating MDs)	16	7.4
Total:	217	100%



Plan to re-start

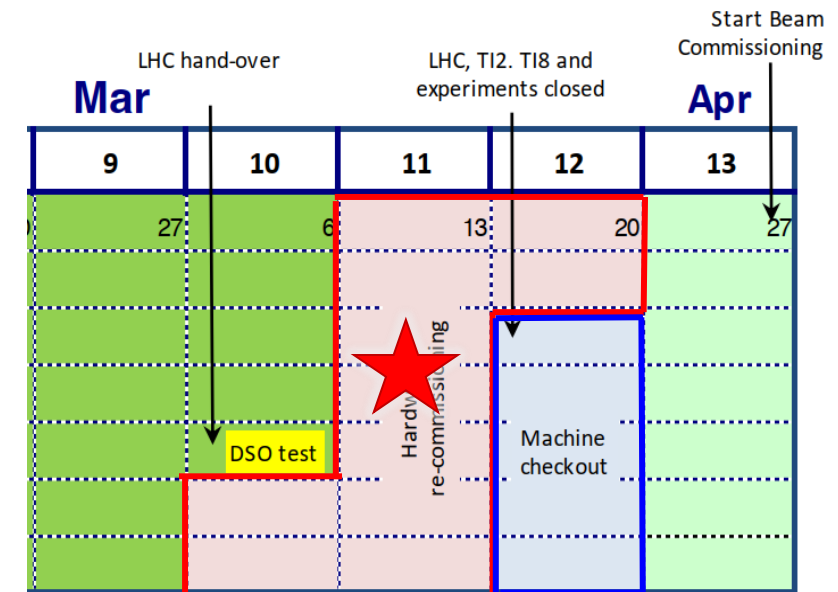
With the Departmental Safety Officer (DSO) tests, **BE-OP** takes over **LHC machine coordination** from EN-ACE on **March 10th**

DSO tests

- Global safety tests, including access system and EiS (*Element Important de Securite*)
- Preparation for the tests on **Thursday 9th** end of the day - LHC and experimental caverns **closed & patrolled @4pm**
- Full day tests on **Friday 10th** - LHC and experimental caverns **closed & patrolled until completion**

Powering tests

- **10512 tests** to prepare sc circuits for 6.8 TeV operation
- First low current tests **6th - 9th March** – **evenings only**
- 11 days period bet **11th – 22nd March** – **NO access in LHC, access possible in the experimental caverns**
- Start **individual equipment checkout** in parallel to powering tests



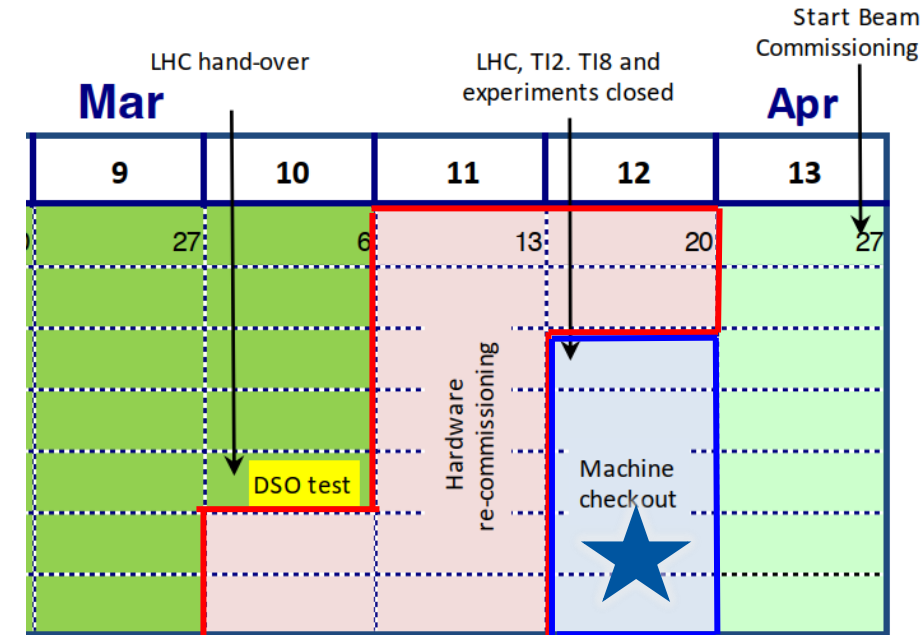
Plan to re-start

5-day period of **global machine checkout**

- Start **delayed** by 24-36 hours (LHCb) → **23rd March**
- LHC machine and experimental caverns **patrolled & closed on 22nd March 2023**
- If delay **limited to 24 hours** and **no issue encountered**
 - Three days should be sufficient (provided powering test are completed)
 - → we should be able to stay on track to get beam during weekend **25th – 26th March**

At the end of check-out we plan a **Transfer Lines test**:

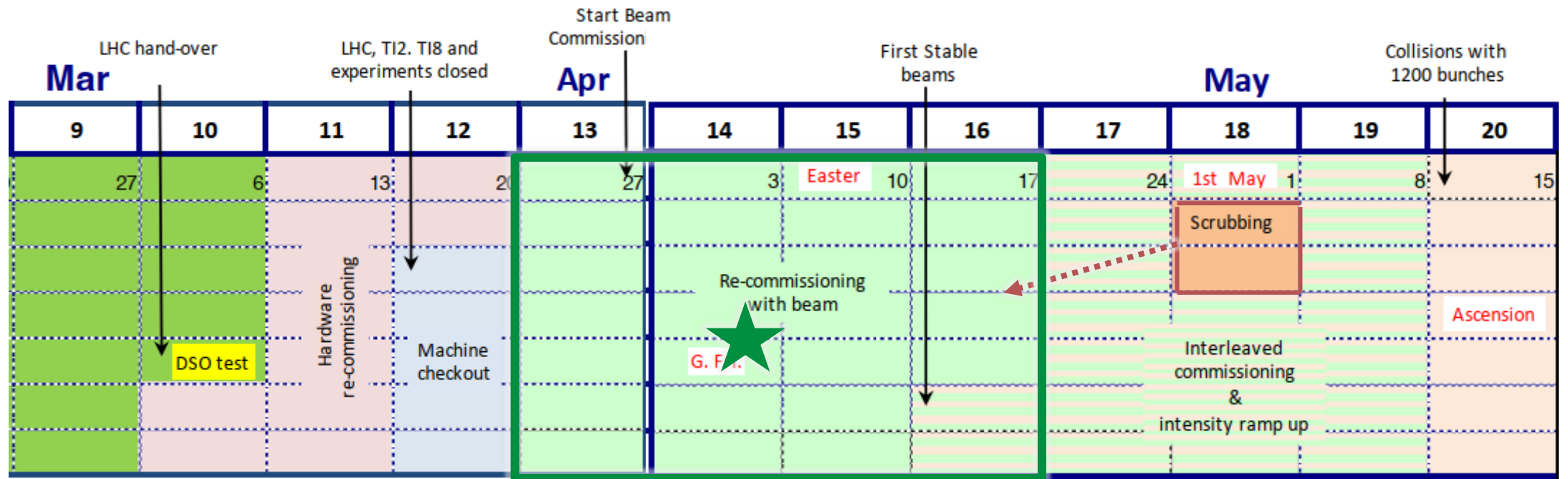
- **Beam extraction** from SPS until downstream dumps at the end of the TI2 and TI8 transfer lines
- **Fundamental activity** that allows testing the full extraction chain, anticipating problems
- Tentatively scheduled on **Friday 24th March** in the evening



Beam commissioning

3.5 weeks of re-commissioning with beam

- Mostly **commissioning on machine side**, in preparation for physics production
- Some **activities concerning experiments** will also be carried out (next slides)
- 2-3 days allocated for reconditioning of the vacuum chamber for e-cloud (**scrubbing**) - advanced wrt schedule (place-holder): **end of week 16, beginning of week 17**

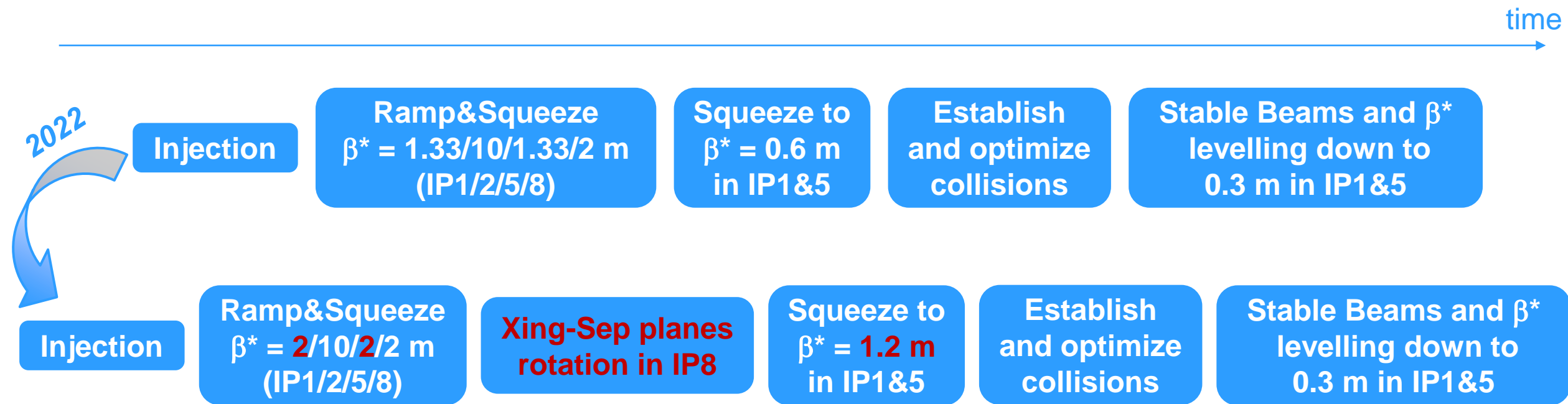


Beam commissioning - experiments

Some activities have been **agreed with LPC**:

- **Dedicated splashes** around day 3-4 of beam commissioning
- **First stable beams at injection**, planned to happen before Easter weekend
- A **few stable beams** shifts during Easter weekend to help cover the 4-day long weekend
- ATLAS request for **horizontal muons** → after Easter, before first stable beams at 6.8 TeV
- Gas injection in IP8 (**LHCb SMOG**) to perform parasitic VELO foil tomography
- **First stable beams at 6.8 TeV**: expected on schedule **during week 17**

Machine configuration for pp production



Main differences for experiments between 2022 and 2023 cycles:

- **IP8 rotation** to provide same full crossing angle for any LHCb polarity – confirmed by LHCb
- **Much longer β^* levelling** from 1.2 m to 0.3 m (2022: 60-30cm) to maximise integrated luminosity - Tuned for bunch intensities of $1.8E^{11}$ ppb

Machine configurations for special runs & ions

In **parallel to setting up** the nominal pp configuration, we hope to use beam commissioning periods (mostly nights and week-ends) to **pre-commission** other 2022 configurations

Vdm: based on 2022 settings

- Expect a **quick recommissioning**, mainly orbit and collision point optimization

High-beta 120m, high beta 6km: brand new de-squeezes

- Bring probe beams to end of de-squeezes, if time permits first look at optics

Ions: energy has been defined to be 6.8Z TeV, **optics available**

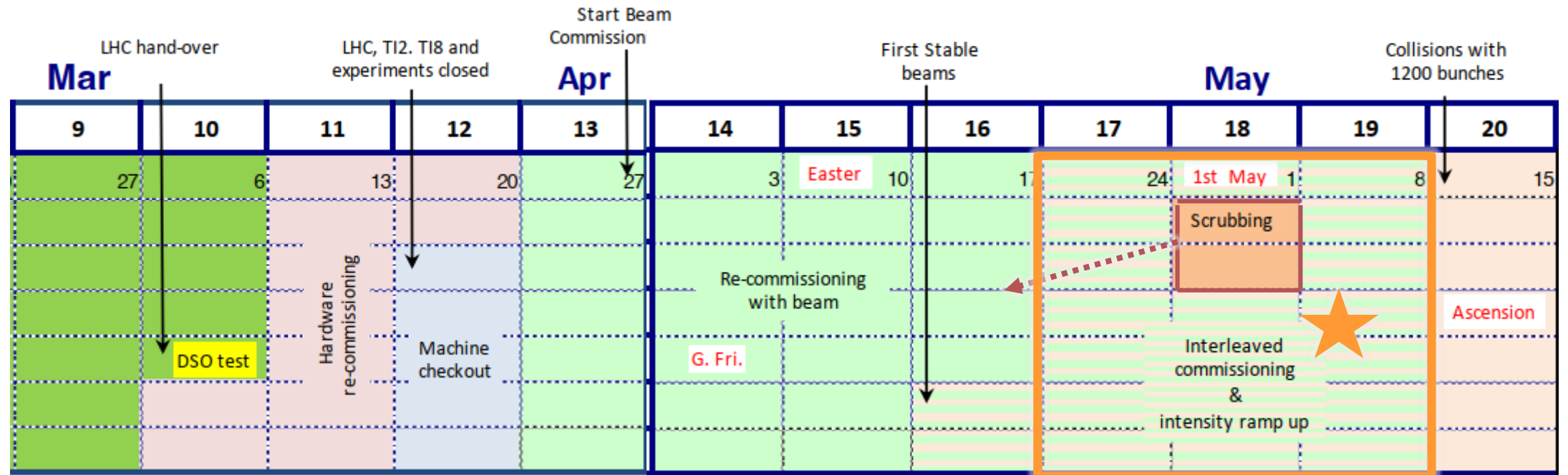
- If time permits, bring probe beams to end of squeeze, first look at optics

Such strategy proved to be **very effective** in the past to prevent diverting some shifts of pp production to those tasks and to timely identify possible issues

Intensity ramp up

Intensity ramp up (to ~1200 bunches) during ~3 weeks

- Similar steps to 2022, possible optimization is under discussion
- Start with ~**1.5E¹¹ ppb** (bunch intensity used in operation at end of 2022)
- Insert **8b4e train** early on, from ~300-600b



Filling scheme and PU options for 2023

Luminosities predicted for various filling schemes and PU scenarios

Luminosity gains for 2023 wrt. 2022?

1) Can **gain ~8%** by going from 36b scheme @ $I_b = 1.5 \times 10^{11}$ ppb to hybrid filling scheme @ $I_b = 1.8 \times 10^{11}$ ppb

2) Additional luminosity gains by **increasing PU**:

PU = 60	+ 7%	wrt. PU=54
65	+ 6%	wrt. PU=60
70	+ 5%	wrt. PU=65

Pure 8b4e not available in 2023

		8b4e	Hybrid 36b	Hybrid 48b	36b	48b
	I_b [10^{11} ppb]	2.1	1.8	1.7	1.5	1.2
	#IP1/5 bunches	1967	2380	2440	2484	2740
$\mu=54$	$L_{\text{peak,IP1/5}}$	1.5	1.81	1.86	1.89	2.08
	$L_{\text{int.,day}}$ [fb^{-1}]	1.06 (-6%)	1.21 (+8%)	1.20 (+7%)	1.13	0.97 (-14%)
$\mu=60$	$L_{\text{peak,IP1/5}}$	1.66	2.01	2.06	2.10	2.32
	$L_{\text{int.,day}}$ [fb^{-1}]	1.14 (+2%)	1.30 (+15%)	1.28 (+14%)	1.18 (+4%)	0.98 (-14%)
$\mu=65$	$L_{\text{peak,IP1/5}}$	1.8	2.17	2.23	2.27	
	$L_{\text{int.,day}}$ [fb^{-1}]	1.21 (+7%)	1.36 (+21%)	1.34 (+19%)	1.22 (+8%)	
$\mu=70$	$L_{\text{peak,IP1/5}}$	1.94	2.35	2.41	2.45	
	$L_{\text{int.,day}}$ [fb^{-1}]	1.27 (+13%)	1.42 (+26%)	1.39 (+23%)	1.25 (+11%)	

Max bunch intensity for a given scheme (heat load+TCDS)

Reference (~2022)

Target for 2023?

CONFIRMED

Note actual gain will depend a lot on how availability changes with bunch intensity and longer optimal fill length



Conclusions

- An intense phase of **re-commissioning** of the LHC for 2023 run is about to start
 - BE/OP will take over the LHC activity coordination on coming Friday 10th March
- All activities are on schedule and **NO showstopper** is identified
- **First Stable Beams @6.8 teV** planned to happen sometimes in week 17