MDs for 2018

let's start discussing

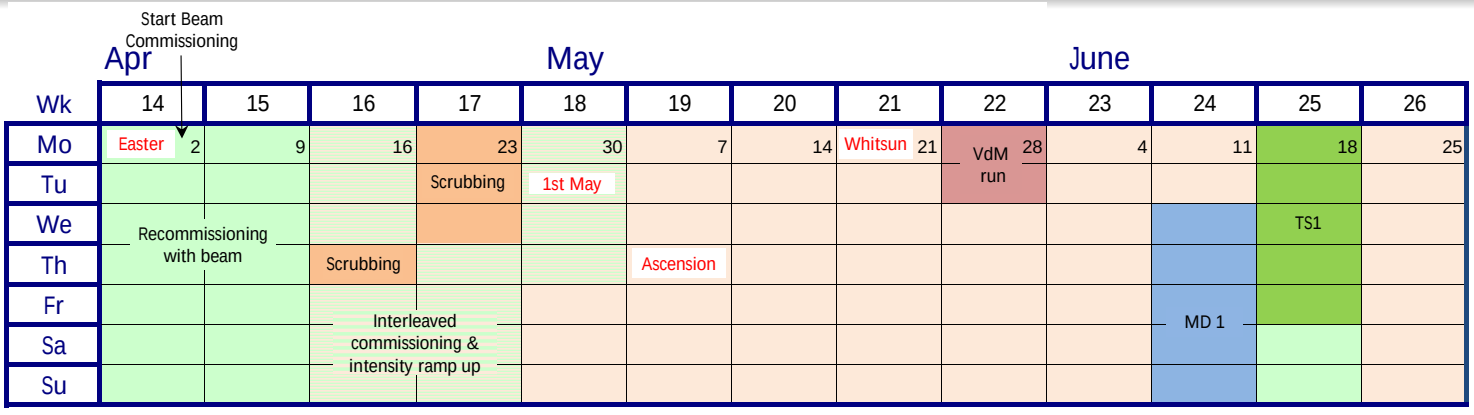
MD Coordinators: M. Solfaroli, R. Tomás and J. Uythoven

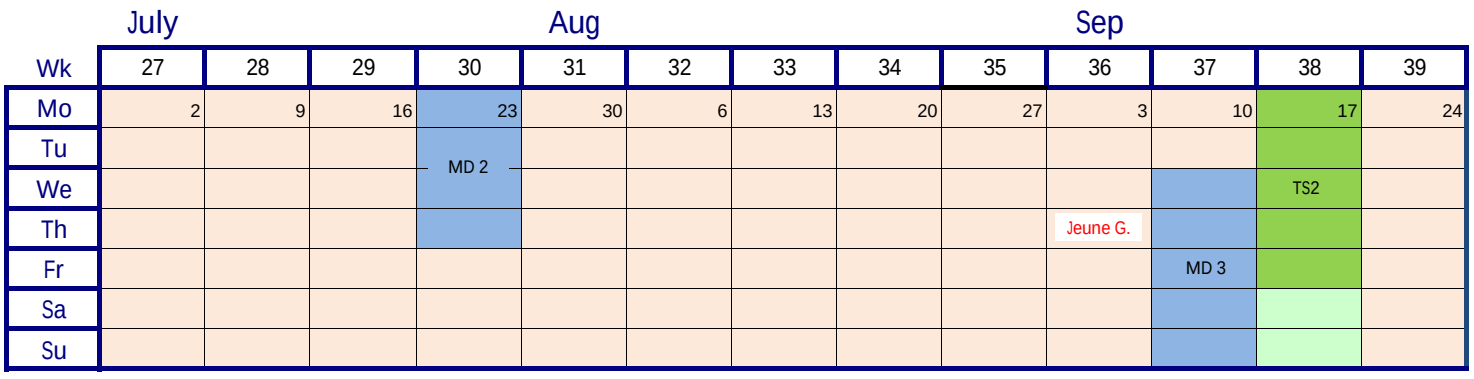
Thanks to MD users and many others

https://md-coord.web.cern.ch

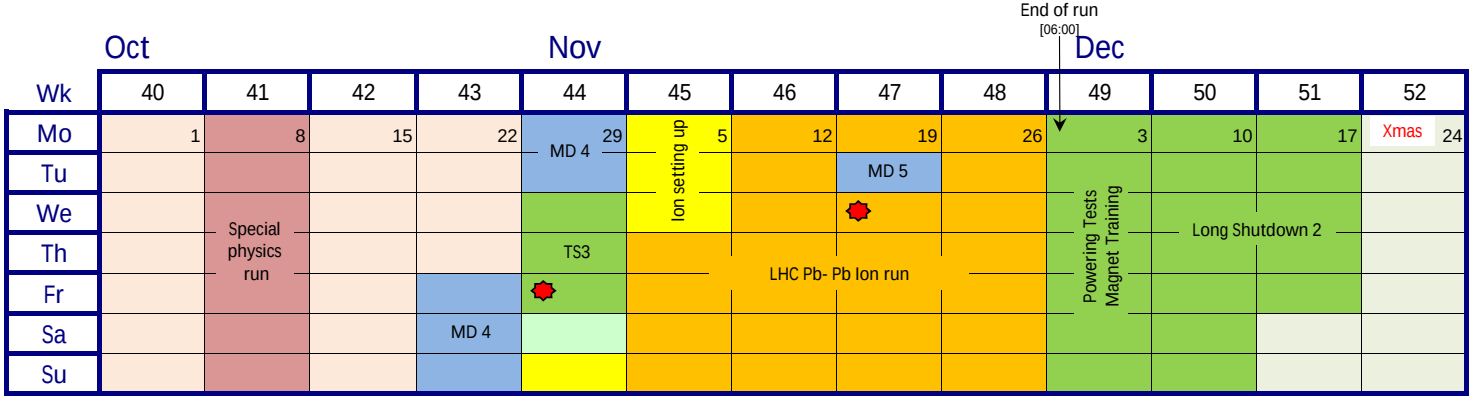
December 13, 2017

2018 schedule





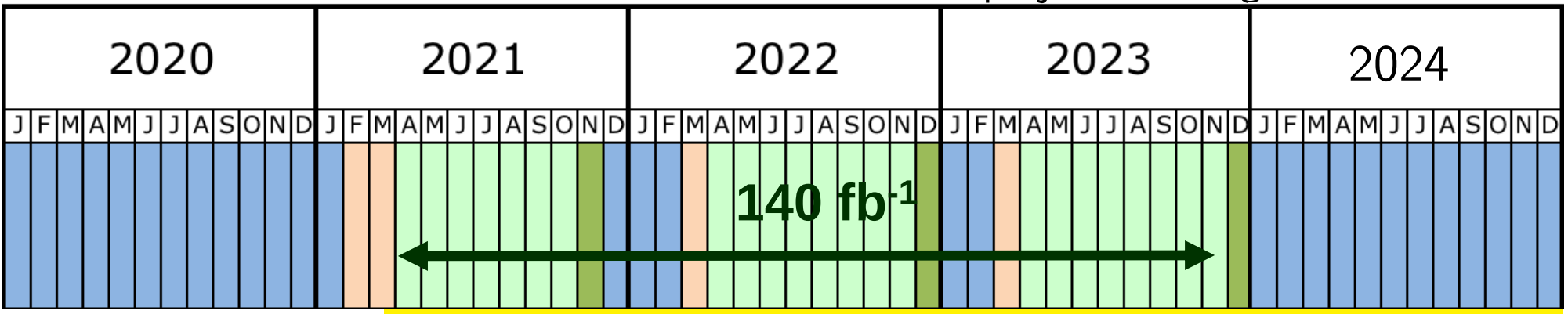
19+1 MD days
(1 ion MD day)



In 2016 and 2017 we had 21 and 18 MD days

Run 3 LHC and injector plans

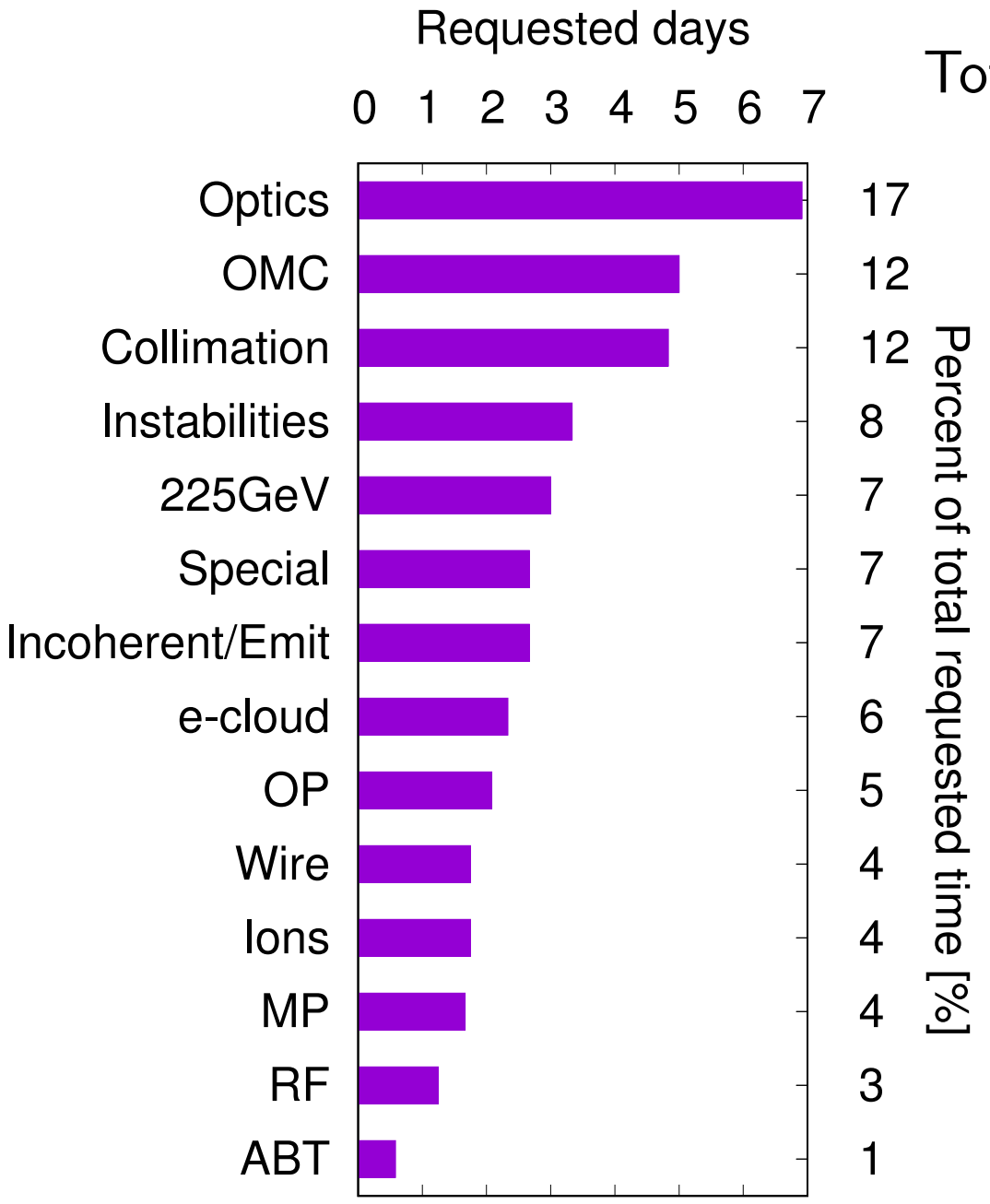
HL-LHC project meeting 2017, Madrid



Injectors p/b: $1.3 \cdot 10^{11}$ $1.8 \cdot 10^{11}$ $2.1 \cdot 10^{11}$ $2.3 \cdot 10^{11}$

with desired brightness in 25ns

Preliminary requested MDs for 2018



Total requested = 40 days

in calendar time
(rampdown & availability)
this needs **57** days

300% overdemand!

Link to all requests

2018 primary MD goals

- ★ Define Run 3 optics and operational modes for improved performance.
- ★ Fully demonstrate HL-LHC optics (linear & non-lin) and operational modes.
- ★ Guarantee that LHC can take LIU beams in Run 3 MDs: instabilities, octupole strength & beam-beam. Understand discrepancies to predictions and cures.
- ★ Understand e-cloud & heat-load, demonstrate its back-up for HL (8b4e) and mitigations (doublets).
- ★ Quantify luminosity gain from BBLR wire.
- ★ Finalize demonstration of crystal ion collimation.
- ★ Understanding emittance blow-up, sources, noise sources and cures.

Requests for new optics

MD request	Hours	Prio.
Flat (with BBLR, leveling, etc)	60	1
Ramp+A**T**S-squeeze	40	1
Half integer	24	2
Telescopic de-squeeze	10	2
IR4 beta enhancement†	8	2
Alternatives to suppress MS14 resonances†	8	2
IP8 ramp & squeeze to 1.5m†	8	2
Lower β^* at injection	8	2

High β runs request 32h that traditionally come from physics: Ramp & de-squeeze, High β^* at injection.

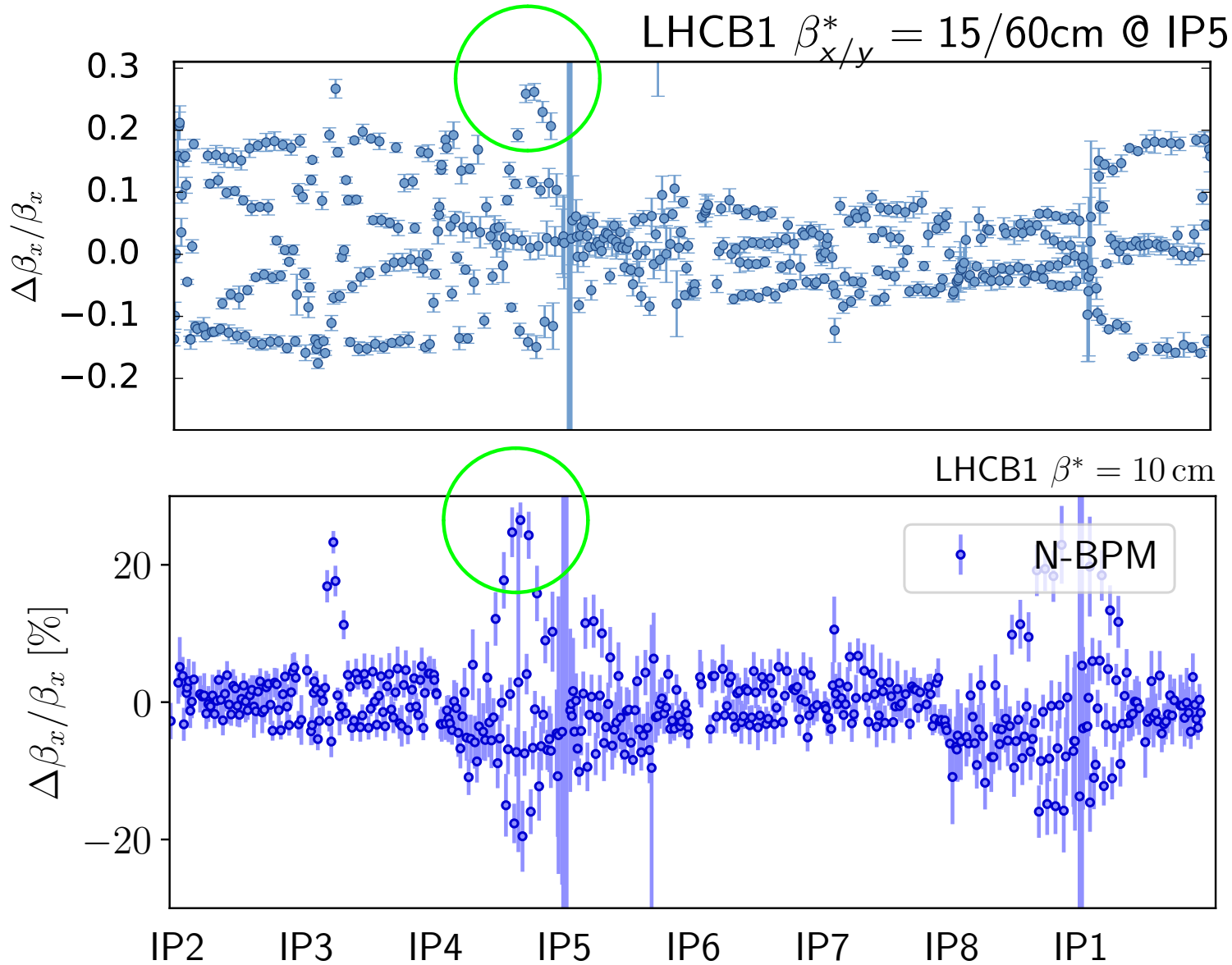
† Possibly combined

Why flat optics?

- ★ Can give about 5% more integrated lumi than round $\beta^* = 25$ cm
- ★ Can also give more performance in HL-LHC
- ★ It is the HL-LHC back-up scenario in case crab cavities do not work.

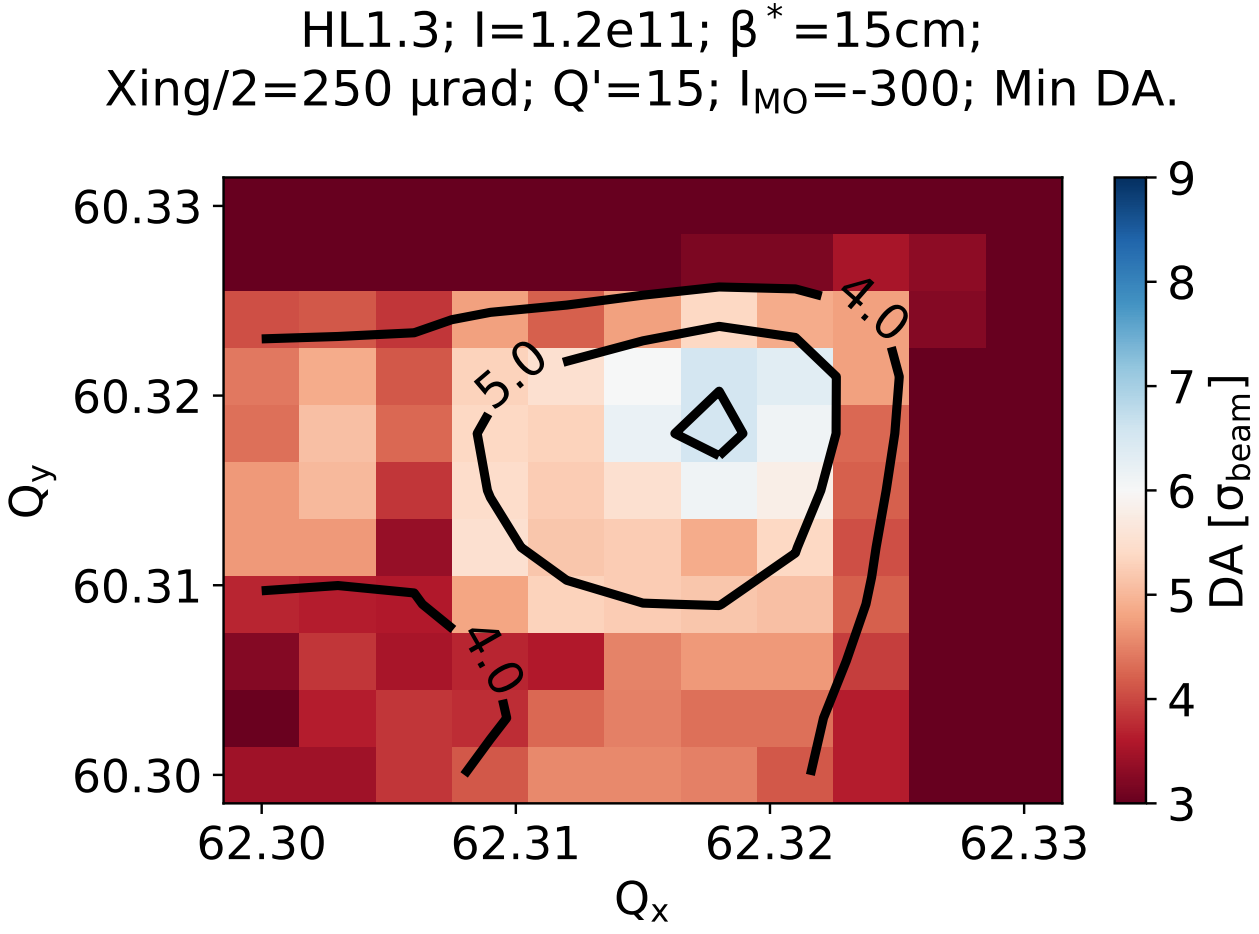
Operation with flat beams requires demonstration, starting from optics correction...

Flat and round ATS optics ($\beta_{arc} \times 4$)



$\Delta\beta/\beta$ not under control for ATS large β_{arc}

Why half integer? HL-LHC DA



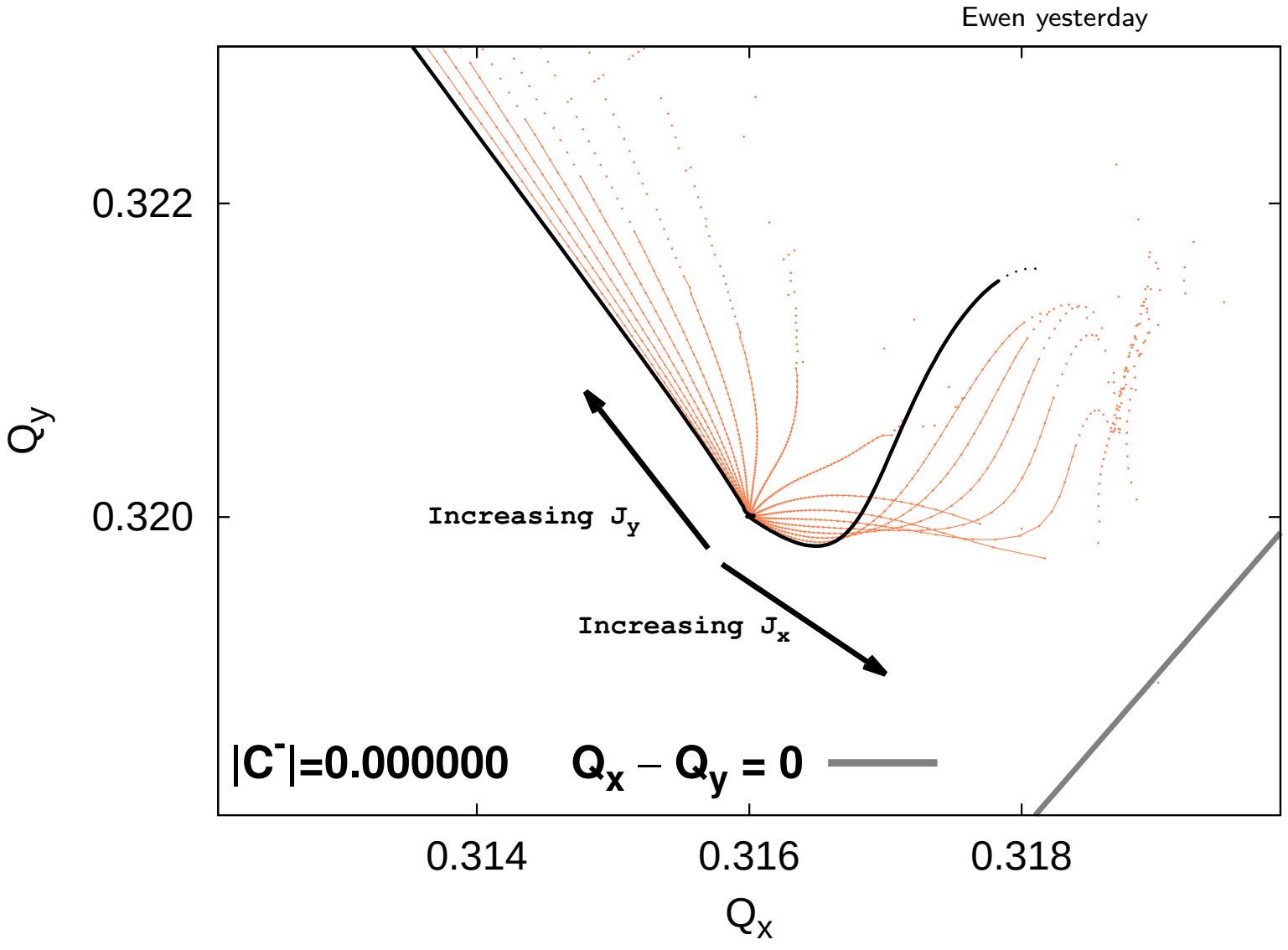
DA OK in a tiny region close to $Q_x = Q_y$. Tune and coupling control become critical. Half integer offers more space.

Requests for Optics Measurements & Corrections

MD request	Hours	Prio.
HL-LHC DA	16	1
IR b6 correction for HL-LHC	16	1
Tune jitter measurements at 6.5 TeV	6	1
Resonance driving terms based corrs.	8	1
Reaching the 10^{-4} coupling	8	1
Correction of spurious dispersion	8	2
Amplitude dependent ΔQ_{min}: a4, ac dip	6	2
ADT large free kicks	8	2
...		2

See Optics Measurement and Correction Challenges for HL-LHC CERN-ACC-2017-0088

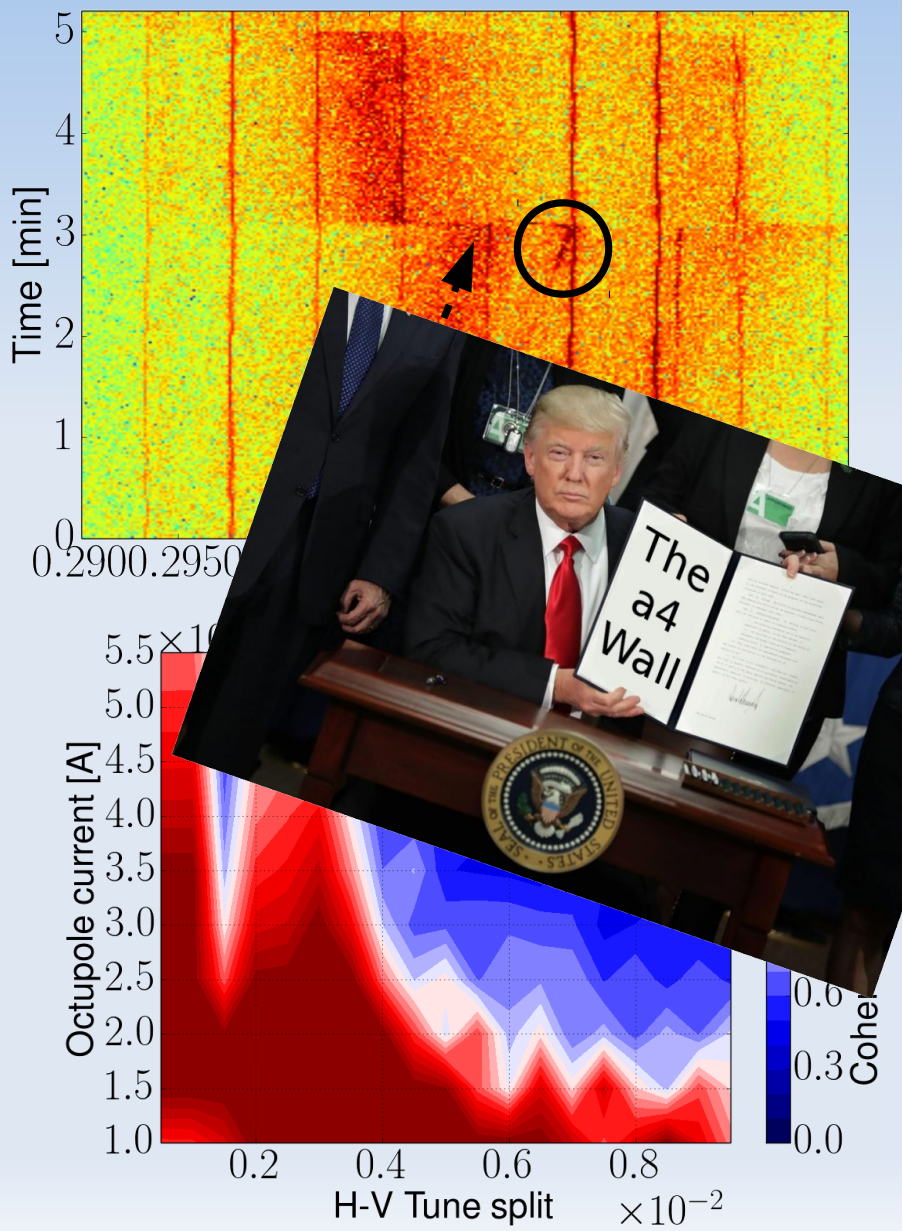
IR skew octupoles, a4, are mind-blowing



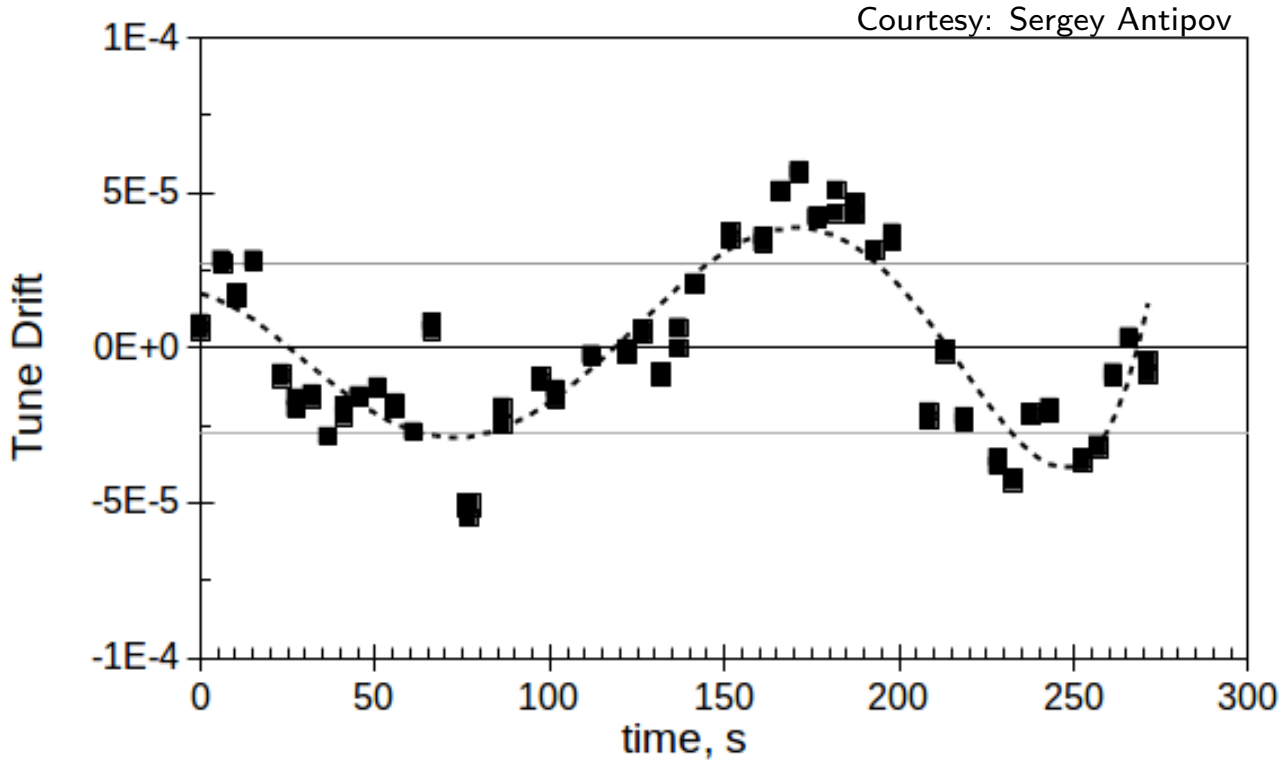
The impact of lattice imperfections

- Reducing the tune separation for lifetime optimisation or reduction of loss spikes should no longer be a concern thanks to online linear coupling corrections
  - Instabilities were observed in ADJUST after the reduction of β* from 40 to 30cm (1 dump)
  - Non-linear errors (e.g. a4) can have similar impact on the beam stability with reduced tune separation (See E. Maclean)

    → Requires correction
- The measured lattice non-linearities do not explain the discrepancy with the octupole threshold at flat top



Measured tune jitter in collimator impedance MDs

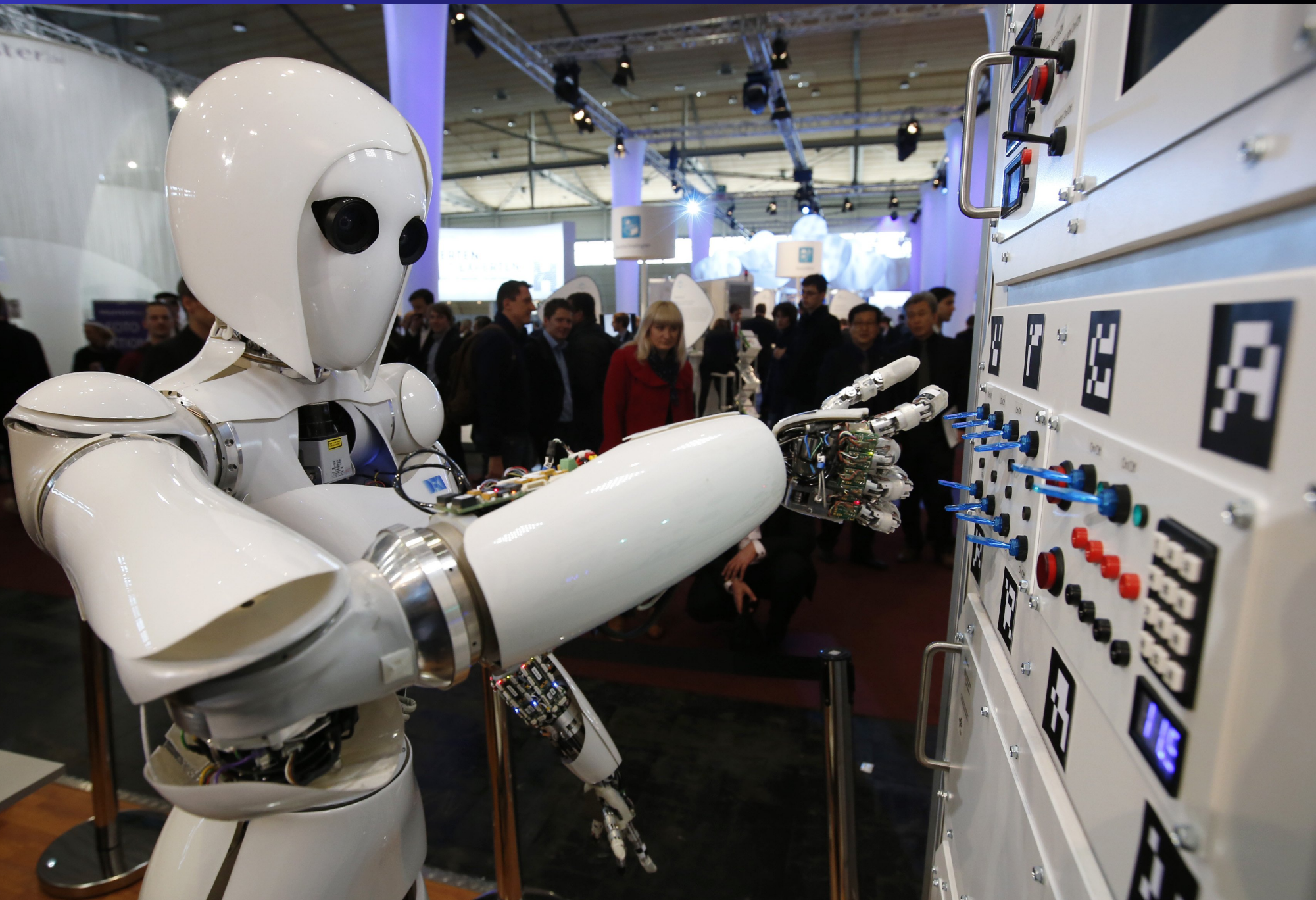


What is this 100s oscillation? How large will it be in HL-LHC? It could impair β^* measurements with K-modulation.

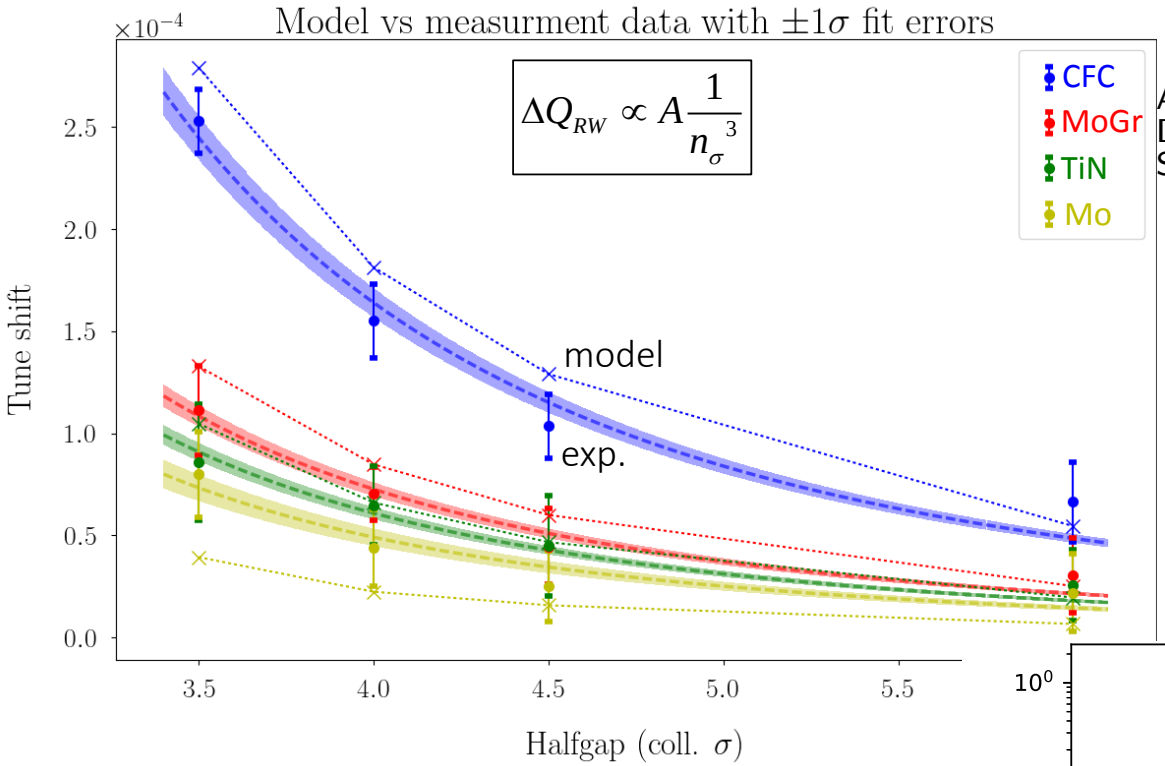
Requests for collimation

MD request	Hours	Prio.
Test of collimator coating robustness	8	1
Impedance measurements and hierarchy	8	1
Crystal collimation tests with protons	16	1
Halo population by collimation scraping	8	1
Asymmetric coll settings in IR7	8	1
Collimation quench tests with proton	8	1
Coll. alignment + machine learning	16	1
Halo control, colored noise	10	2
Collimators with wire for halo control	8	2
Aperture: lower β^* and CMS bump	8	2
...		2

Machine learning for the CCC

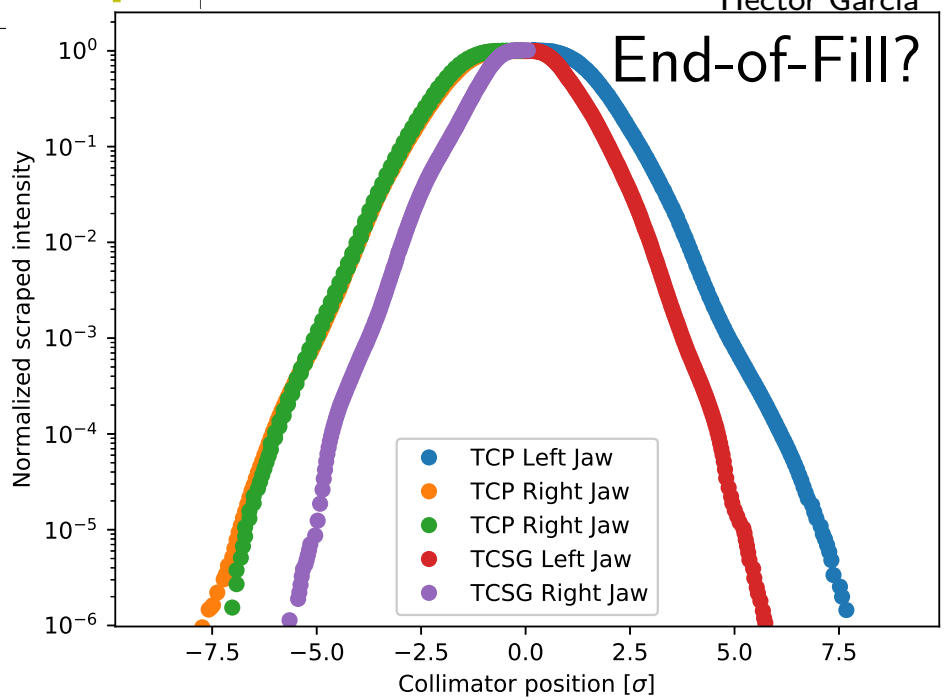


HL: Collimator impedance and halo



A. Merghetti in LSWG
D. Amorin
S. Antipov

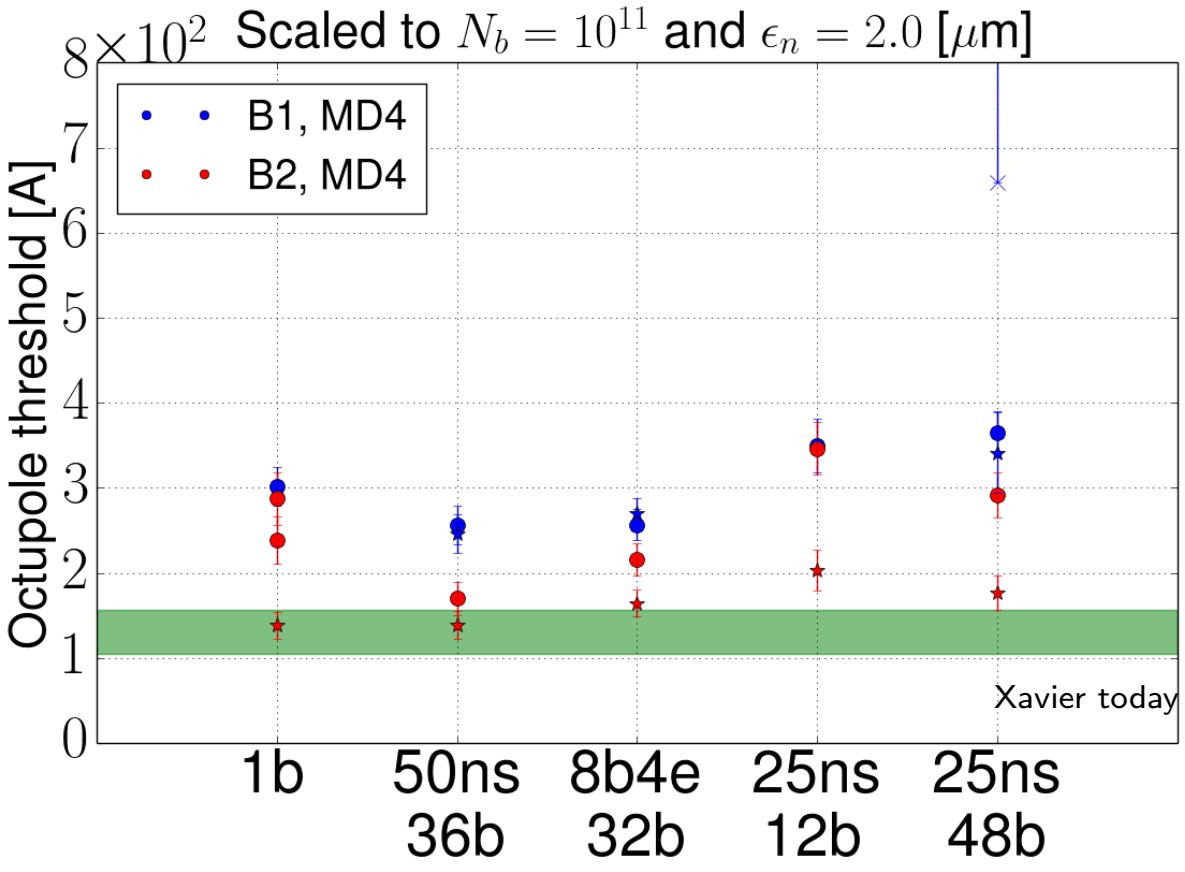
Hector Garcia



Requests for Instabilities

MD request	Hours	Prio.
Train instability versus brightness	8	1
Stability margin with ADT (low noise)	8	1
Real tuneshift & growth time	8	1
Instabilities with low chromaticity	8	1
Instabilities with low ADT gain	8	1
Ramp+A**T**S (Counted as optics)	0	1
Landau damping with BBLR & LOF$<$0	8	1
...		2

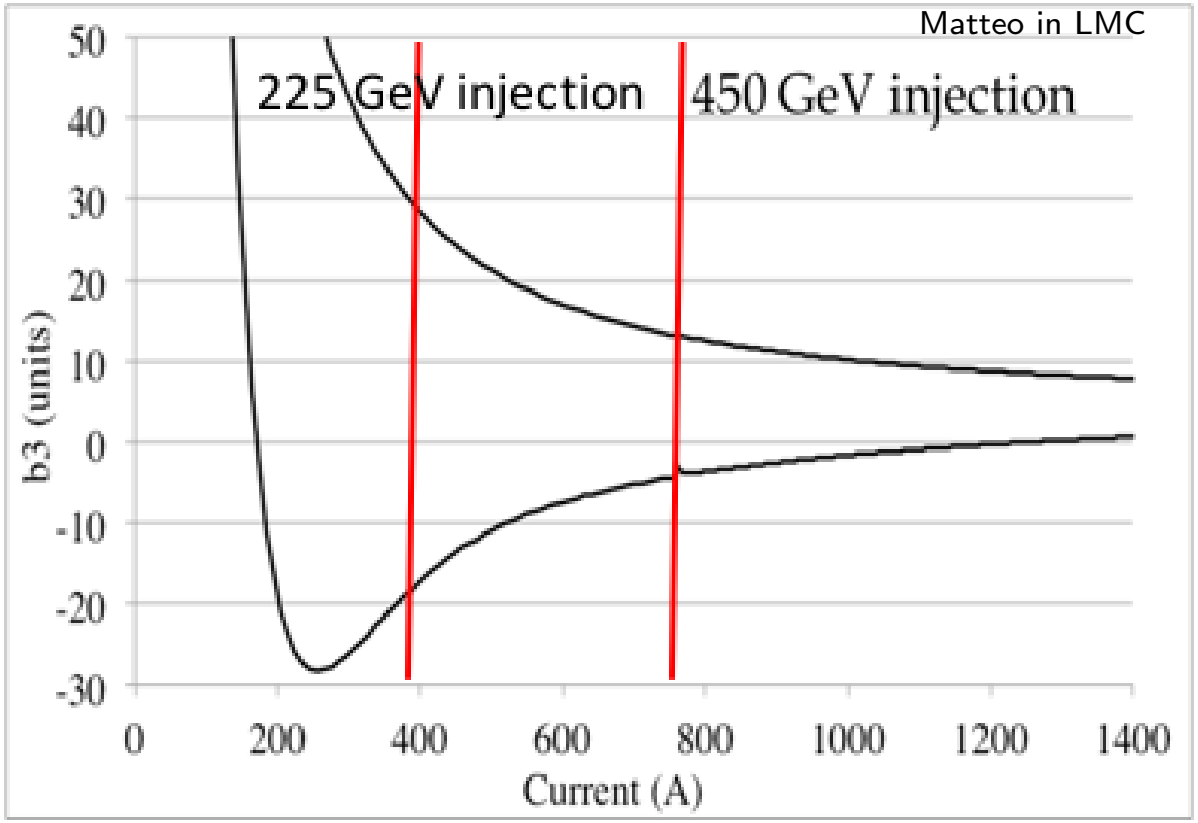
Required octupole current - LIU beams?



Required octupole current always larger than expected. Why? LIU beams would not make it into the LHC in Run 3. Possible cure is Ramp+A**T**S.

225 GeV Injection and ramp

3 days to demonstrate a factor 30 in the energy swing by injecting at 225 GeV and ramp for FCC and HE-LHC:



Preliminary assigned priority is 2.

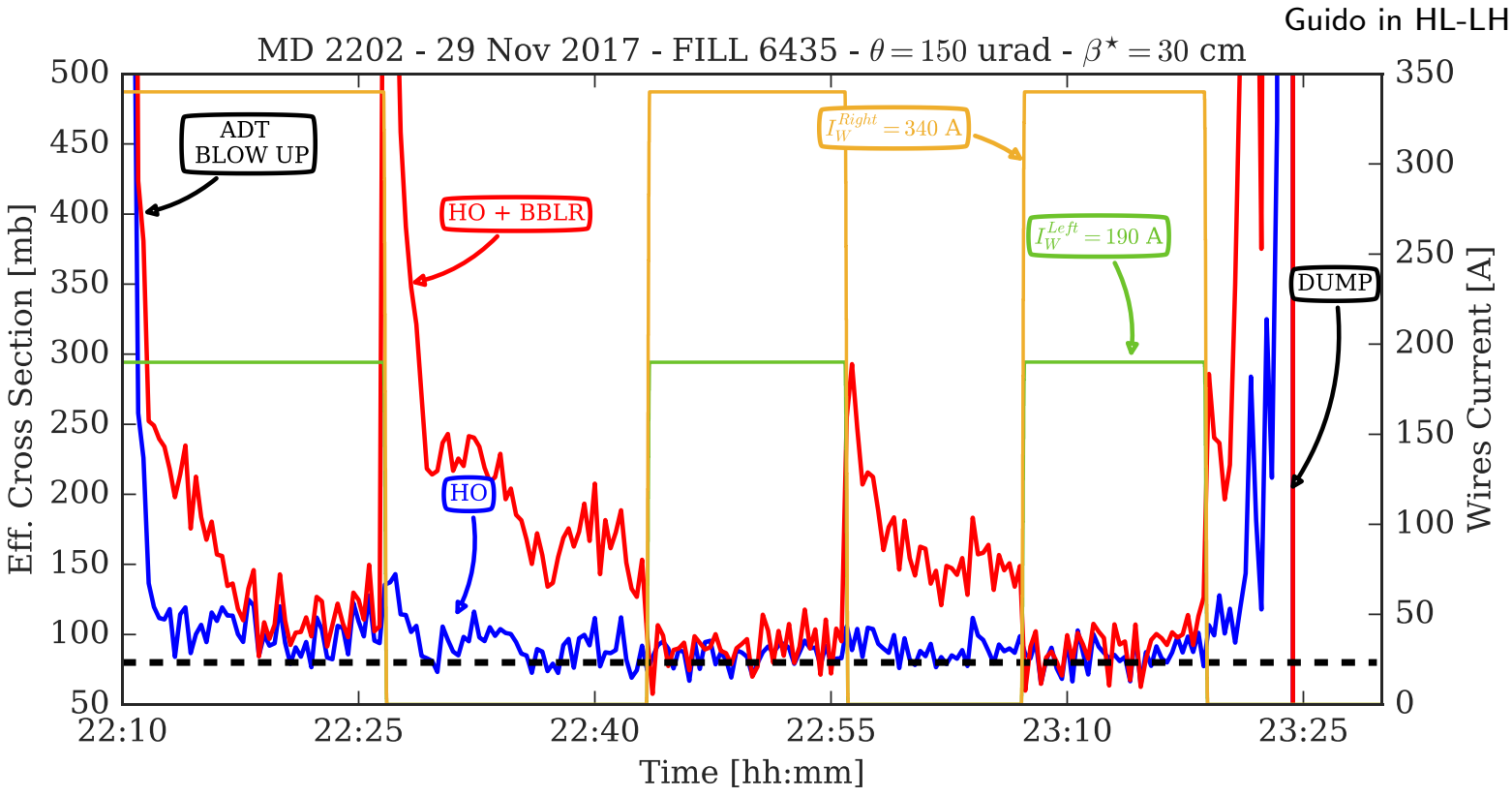
OP

MD request	Hours	Prio.
β^* leveling	16	1
β-beating free Full Ramp&Squeeze	8	1
Beam losses during adjust	10	1
Cross-calibration of emittance monitors	16	1

Incoherent effects, emitt. and BBLR wire

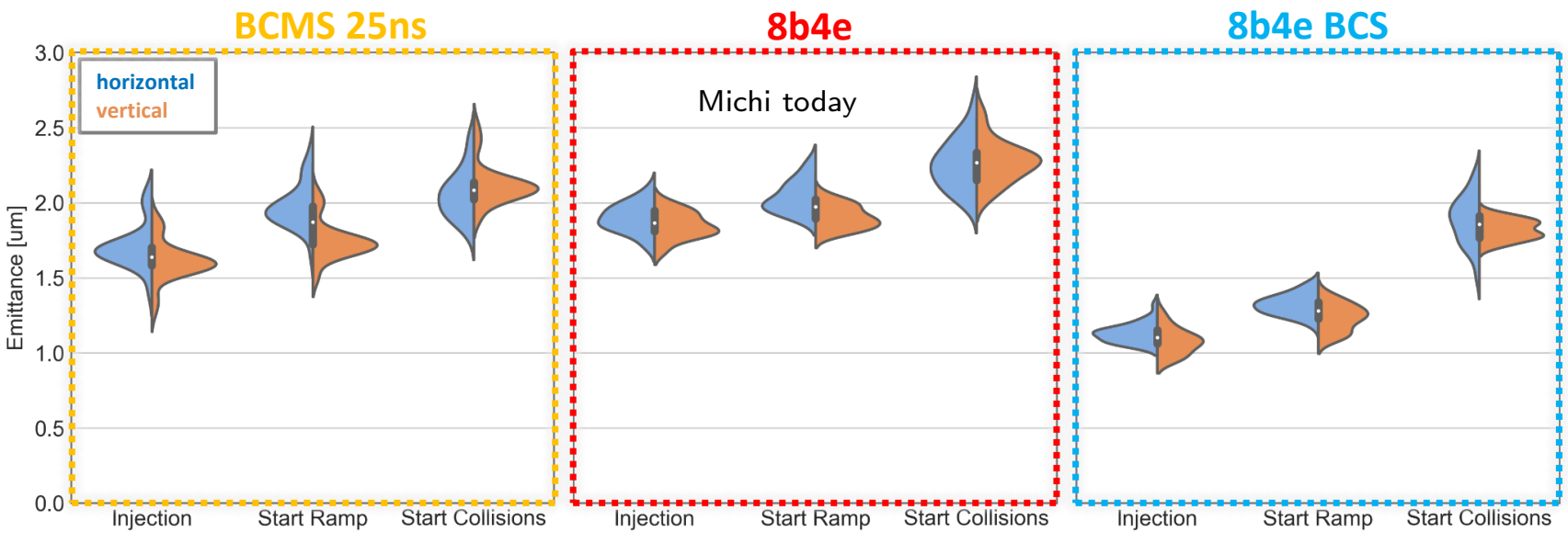
MD request	Hours	Prio.
Emittance growth sources	8	1
Incoherent emittance blow-up	8	1
BBHO limit and high/low freq. noise	16	1
BBLR limits at β^* =25cm	8	1
Wire: Various optics & leveling	42	1
Beam-beam and optics	8	2

Wire



Benefitial effect of single-IP BBLR wire compensation clearly observed in 2017. Use of more wires and quantifying the gain for HL-LHC in 2018.

Emittance blow-up in 2017



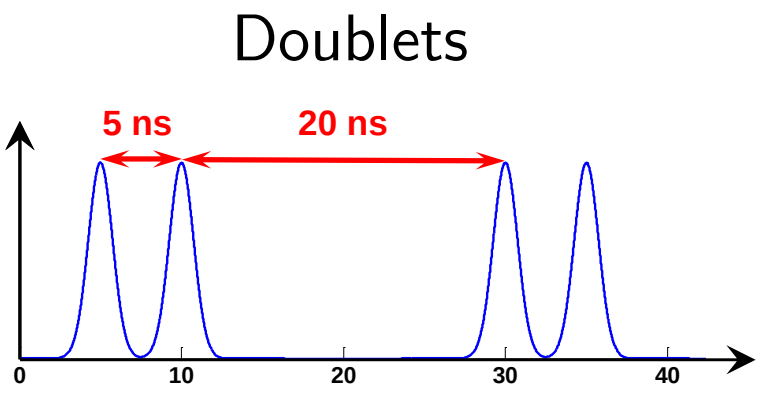
Nikos in LMC 29/11/2017

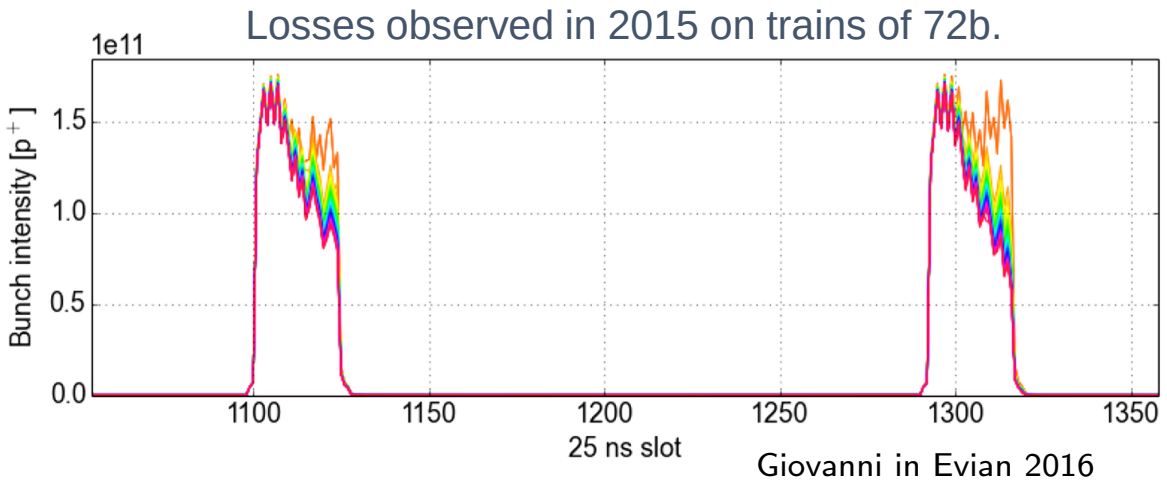
BCMS	B1H [%]	B1V [%]	B2H [%]	B2V [%]
Flat Bottom	13.1	9.3	15.9	7.9
RAMP	32.5	26.8	14.1	22.0
Injection-SB	39.9	37.8	33.1	27.3

We are loosing lots of luminosity here!
HL-LHC assumes 10% blow-up!

e-cloud

MD request	Hours	Prio.
High intensity 8b+4e	16	1
Doublets MD2456	24	1
e-cloud in 25ns beams	16	1





Ions

MD request	Hours	Prio.
Crystal collimation for ions	16	1
BFPP quench test	10	1
Collimation quench tests with Pb	8	2
Optimized IR7 settings	8	2
during proton run:		
Pb80+ Lifetime and losses†	16	2
Pb81+ Lifetime and losses†	16	2

Request 2 ion MD days while only 1 day scheduled.

Data for quench tests exist, really high priority?

†ep collisisions with Pb80+ not strongly requested by detectors (yet)

Motivation for physics beyond colliders.

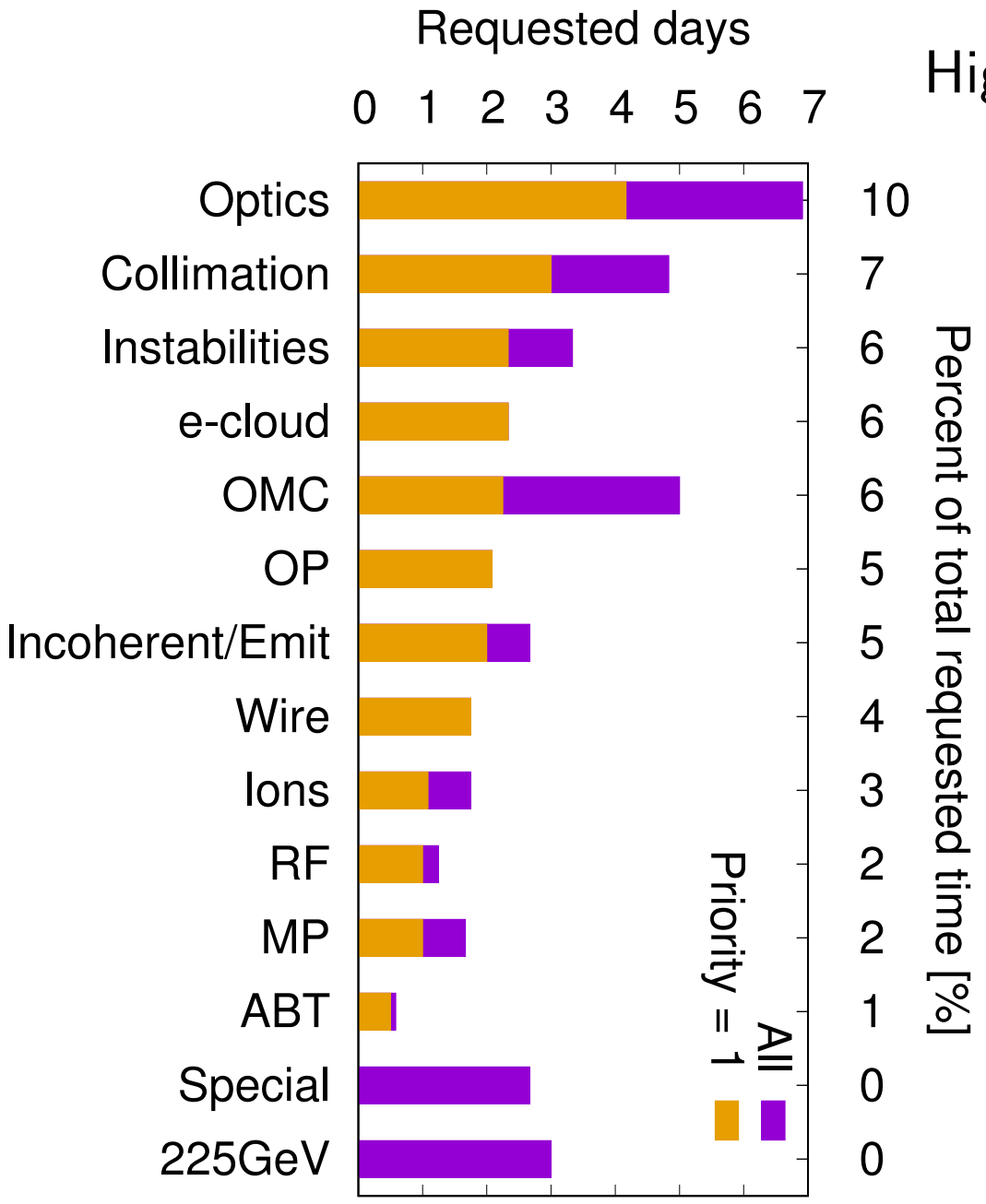
Machine protection

MD request	Hours	Prio.
Orbit bump to measure IP6-TCT margins	8	1
Quench heater kick	10	1
CCs failures with ADT-crabbed beams	6	1
Beam-gas induced instabilities (with BGI)	8	2
Triggering UFOs at the ULO	8	2

RF and ABT

MD request	Hours	Prio.
Divergence of controlled emitt. blow-up	8	1
Instabilities and minimum voltage at inj.	8	1
Coupled-bunch stability	8	1
Uncontrolled noise (bunch distribution)	6	2
80b + injection kicker ripple	4	1
Beam loss during asynch dump	8	1
Beam angle measurements with short coll.	2	2

Prioritized requested MD time



High priority = 24 days

in calendar time
this needs **34** days

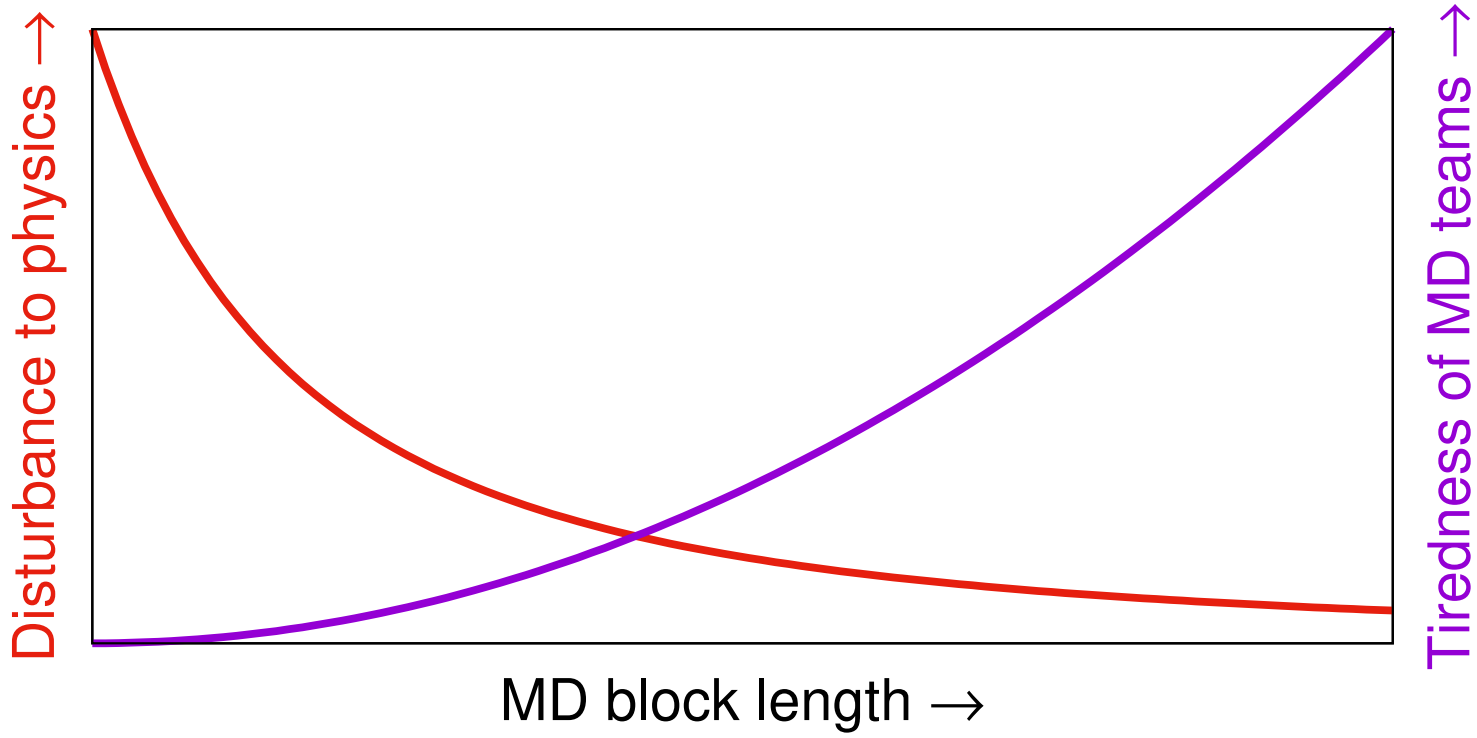
170% overdemand for high priority MDs!

Summary & outlook

- ★ There is little time for many great ideas
- ★ LHC MDs promise to stay at the forefront of accelerator physics and technology

THANKS!

Back-up: MD block length



Sweet spot for the MD block length seems to be between 3 and 5 days.