US LUA

US LHC Users Association

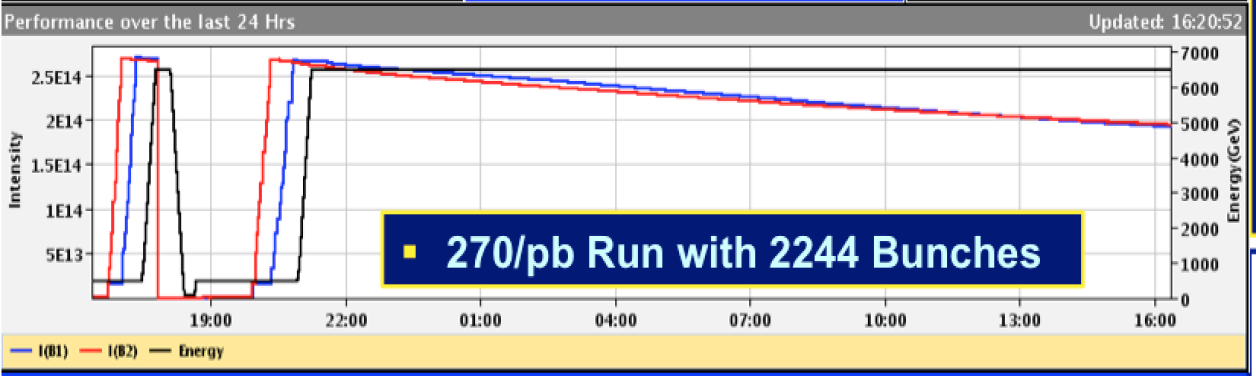
LHC At 13 TeV: Impressive Progress

Climbing a Steep Learning Curve

01-Nov-2015 16:20:52 Fill #: 4560 Energy: 6500 GeV I(B1): 1.92e+14 I(B2): 1.94e+14

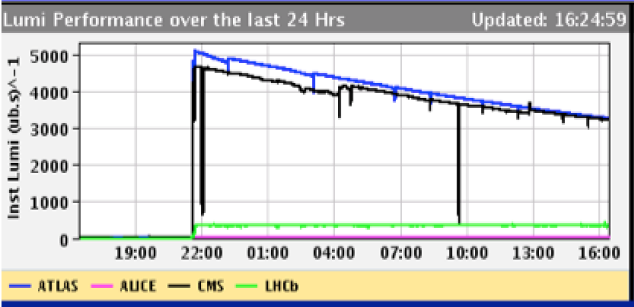
	ATLAS	ALICE	CMS	LHCb
Experiment Status	PHYSICS	PHYSICS	PHYSICS	PHYSICS
Instantaneous Lumi [(ub.s)^-1]	3282.966	5.255	3236.461	333.857
BRAN Luminosity [(ub.s)^-1]	3373.7	4.2	2864.3	140.2
Fill Luminosity (nb)^-1	268436.906	339.287	259194.938	22781.402
Beam 1 BKGD	0.000	1.970	0.087	0.525
Beam 2 BKGD	0.000	0.243	0.078	0.112

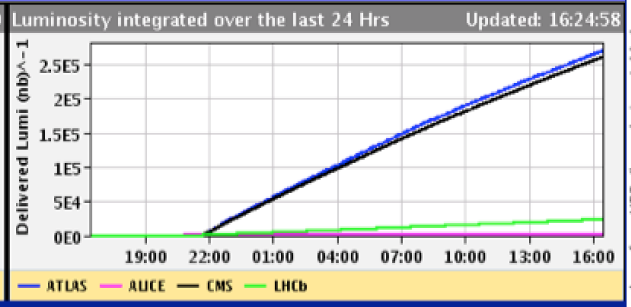
LHCb VELO Position IN Gap: -0.0 mm STABLE BEAMS TOTEM: STANDBY



- 270/pb Run with 2244 Bunches

01-Nov-2015 16:24:58 Fill #: 4560 Energy: 6500 GeV I(B1): 1.92e+14 I(B2): 1.94e+14



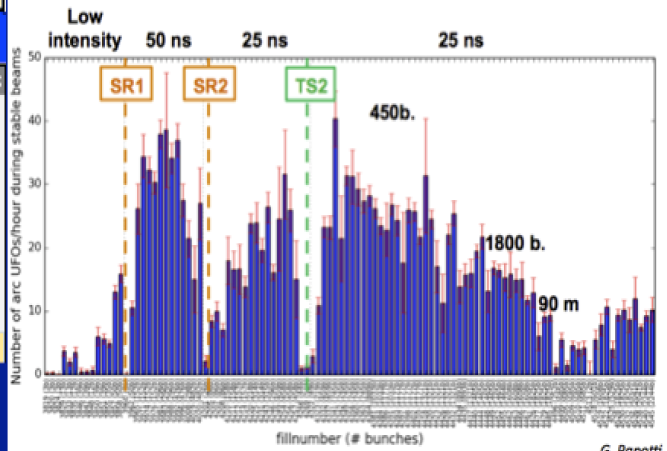


Luminosity Lifetime 48 Hours

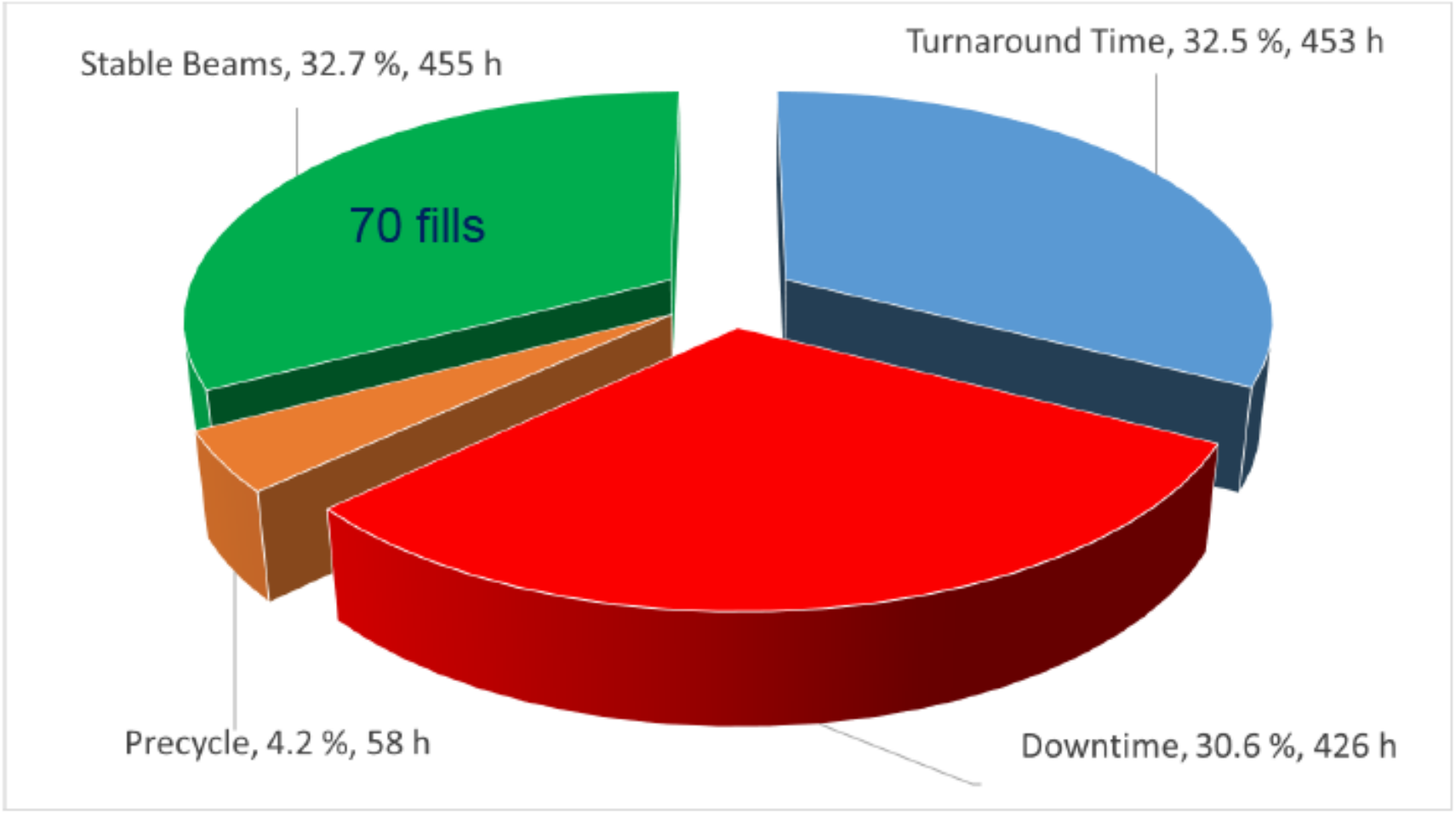
- Dealing with
- 25 ns Electron Cloud new filling schemes
- Heating at Injection
- UFOs: Declining with Sustained Running
- ULO: Steering

➡ Very Effectively

UFOs 2015



Availability for Physics – 25 ns Run

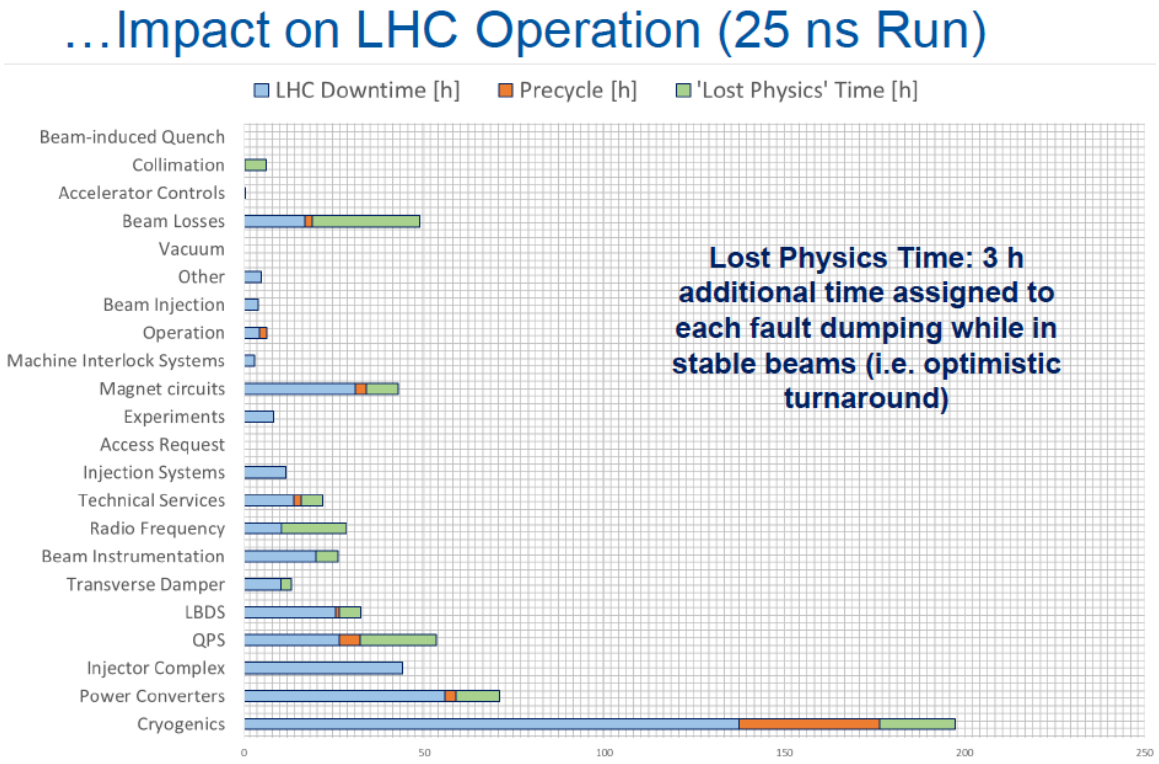


- 22 End Of Fill, 48 dumped due to faults
- Fraction of premature dumps: 48/70 = 68.6 %
- Average turnaround (per SB) = 453/70 = 6.5 h
- Average Fault time (per SB) = 426/70 = 6 h

Andrea APOLLONIO

Availability

- 65.3 % availability during 25 ns Run (close to 2012)
- Remarkable availability during Ion Run – 81 %!
- Cryogenic system is the biggest contributor to LHC unavailability (~ 25 % as ‘child’ due to quench recovery)

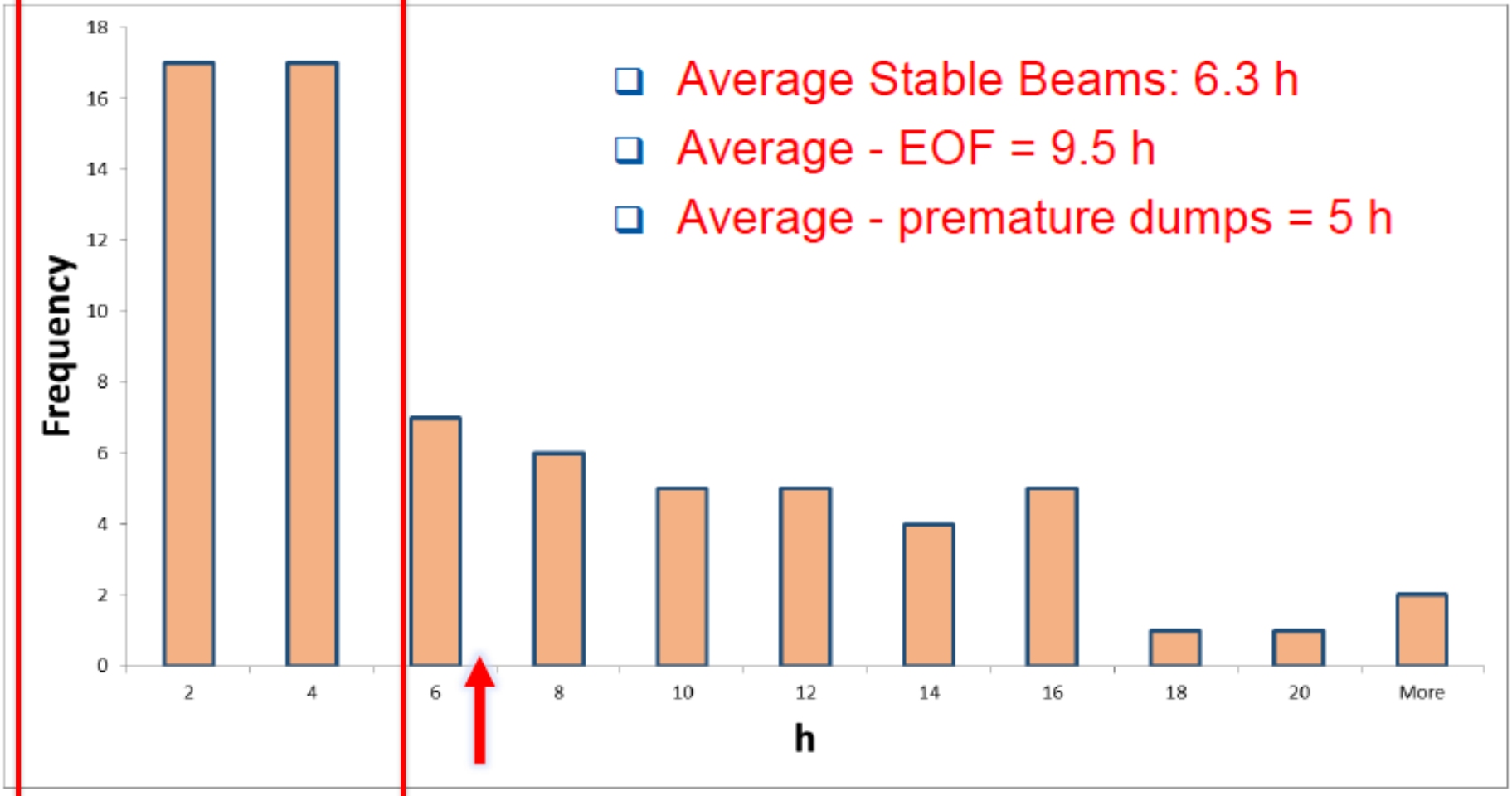


Availability

"If you can not measure it, you can not improve it." Kelvin

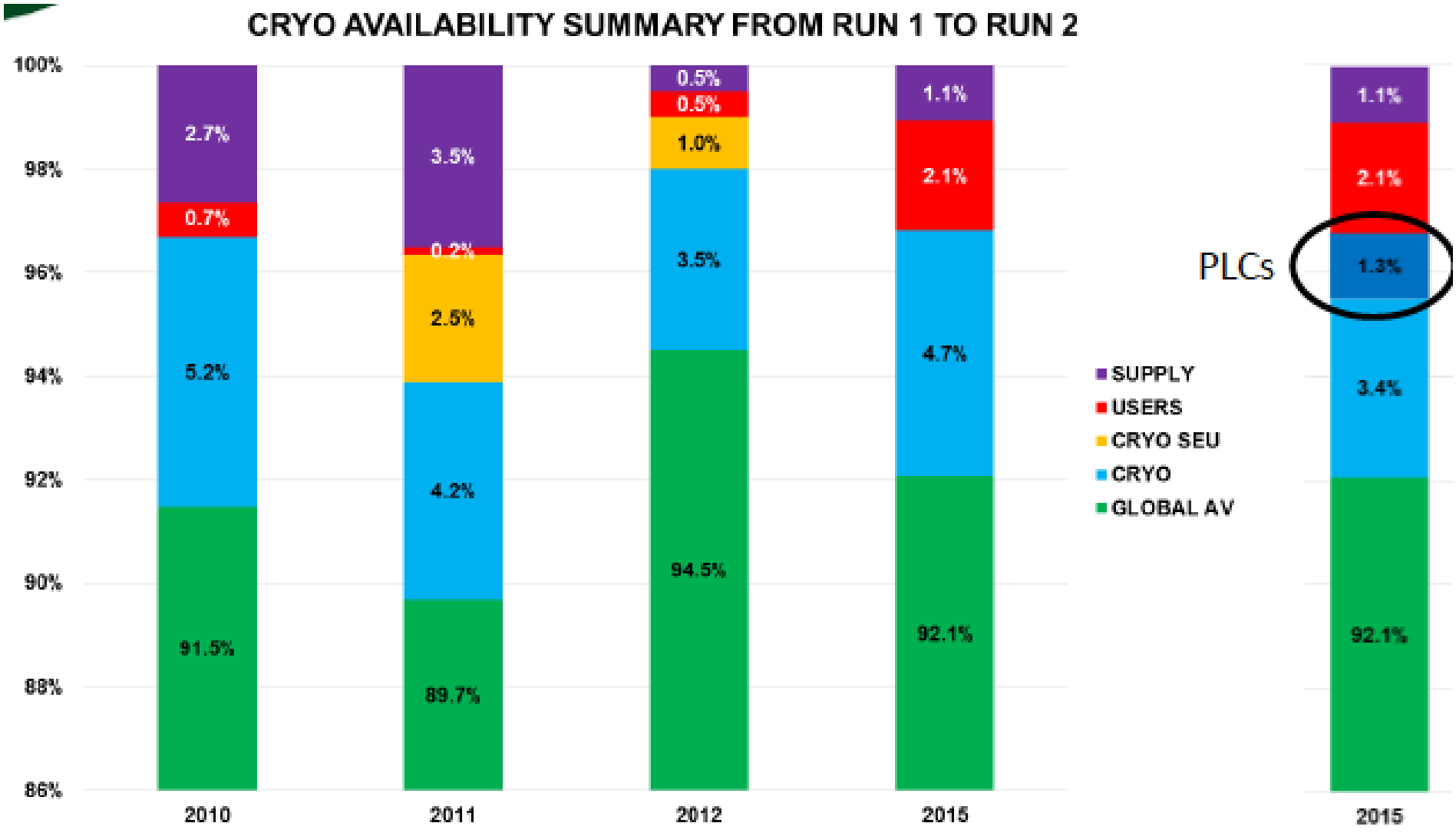
- QPS – looking good
  - excellent after card replacement
  - comms issue to be resolved
  - possible usability issues to be targeted
- R2E – is it still an issue? YES!
  - Major success all round
  - no room for complacency (only 4 fb^{-1} in 2015)
  - power converters – 24 dumps per 35 fb^{-1} year
- RF – mature system – 300 kW in 2016

Stable Beams Distribution – 25 ns Run



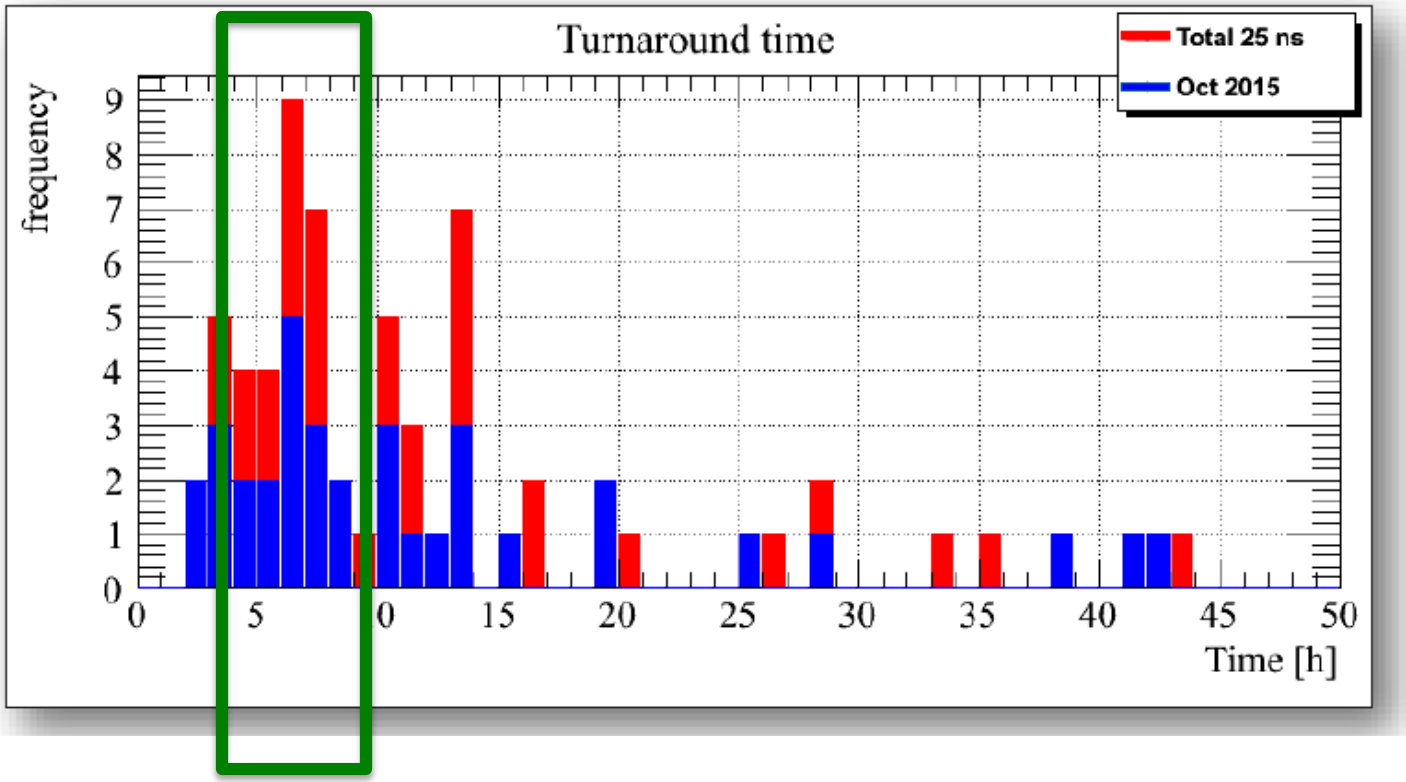
Cryogenics

- Cryogenic Run2 (2015) was a success with CM availability at 92.1 %
- New configuration was applied and validated – room for modifications exists
- Main failure – 4.5 K refrigerator – to be repaired in January 2016 plus other stuff
- LS1 consolidations visibly helped
  - (bravo all and R2E!, 0 SEU cases declared in 2015)
- e-cloud thermal effect pushed the LHC cryo to the limits of capacity (over originally installed capacity foreseen for 4.5 - 20 K)
- Triplet movement in 8 – plans?


CRYO AVAILABILITY SUMMARY FROM RUN 1 TO RUN 2
100%
98%
96%
94%
92%
90%
88%
86%
2.7%
0.7%
5.2%
91.5%
3.5%
0.2%
2.5%
4.2%
89.7%
0.5%
0.5%
1.0%
3.5%
94.5%
1.1%
2.1%
4.7%
92.1%
2010
2011
2012
2015
SUPPLY
USERS
CRYO SEU
CRYO
GLOBAL AV
PLCs
1.1%
2.1%
1.3%
3.4%
92.1%
2015

Operations

Turnaround = time from SB to SB



- **What?**
- Ramp, squeeze, collide – clockwork
- Combined ramp & squeeze recommended
- Injection – biggest scope for improvement

Injection

Incisive critical analysis from Delphine

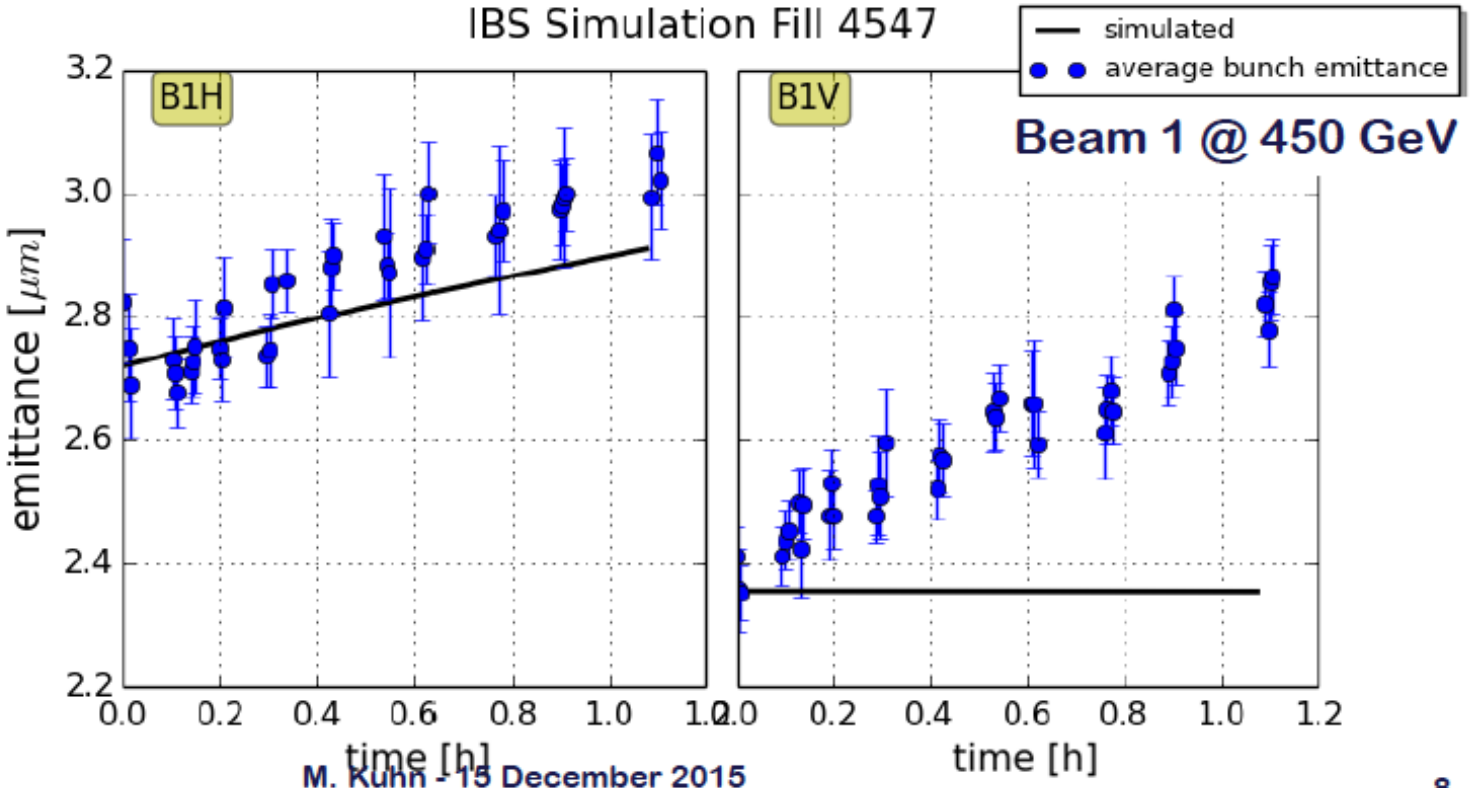
- IQC has lost its credit
  - warning levels – long discussion – who's responsible?
- Steering while feeling – 50% of the time
- SPS BQM rejects 20% of nominal
- Wrestle with
  - Cryogenics, TDI.B2, MKI.B2, ADT diagnostics

- Injection is the part of the turnover where we can really gain time
  - Optimize the SPS supercycle length
  - Improve the compatibility between LHC needs and SPS daily operation to allow more setting-up time before beam is requested
  - Optimize the filling schemes to reduce the number of SPS supercyle change, reduce the number of injections and allow for steering while filling.
  - Optimize the time spent for beam measurement

- Feedbacks
  - Good progress – critical – a lot more robust
  - Team work!
- Tune and b3 decay
  - Interesting, interesting…
  - Do we need a pre-cycle?
  - Supplementary question – what can we get away without pre-cycling?

OMC get any beam time they ask for OK.

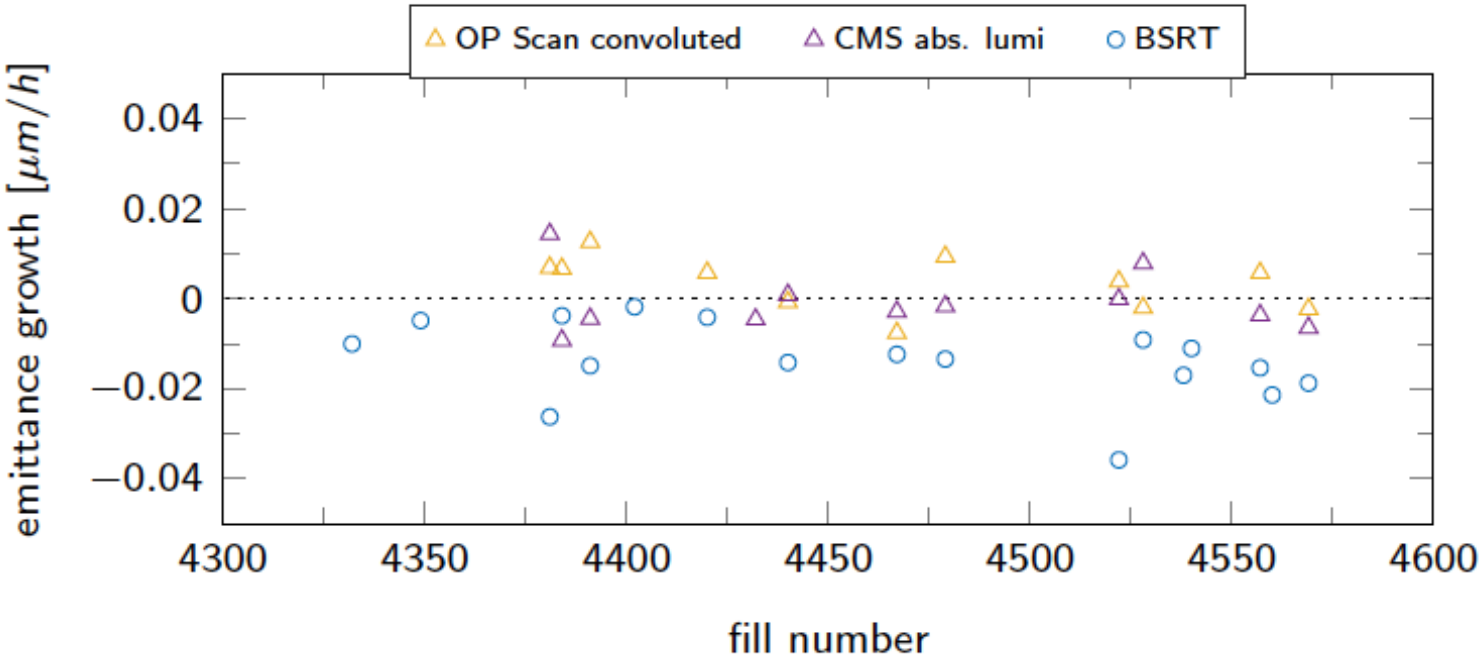
Wire scanner measurements versus MADX IBS simulations.



Maria Kuhn

emittance evolution in collisions

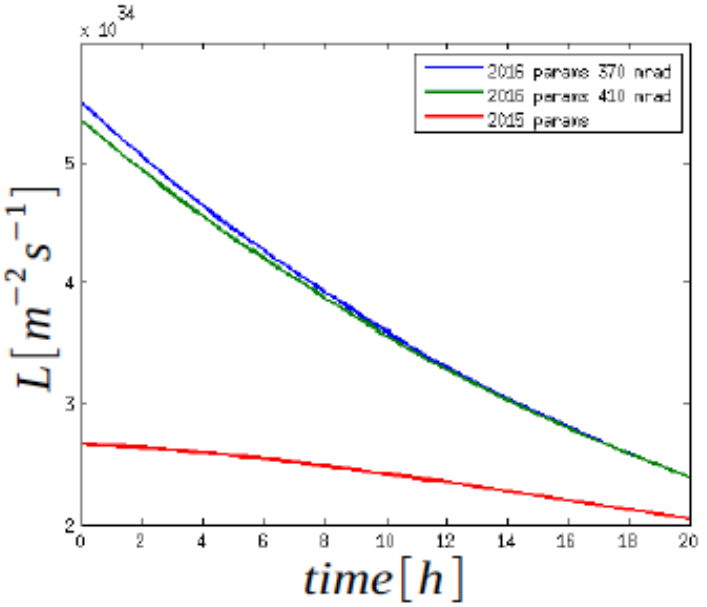
- emittance evolution for fills with at least 2 OP scans
- horizontal emittance growth, ~0.03 μm/h (crossing plane uncertainty)
- vertical emittance shrinkage, ~0.02 μm/h
- convoluted emittance: constant within error bars
  - BSRT sees small shinkage, difference in horizontal plane

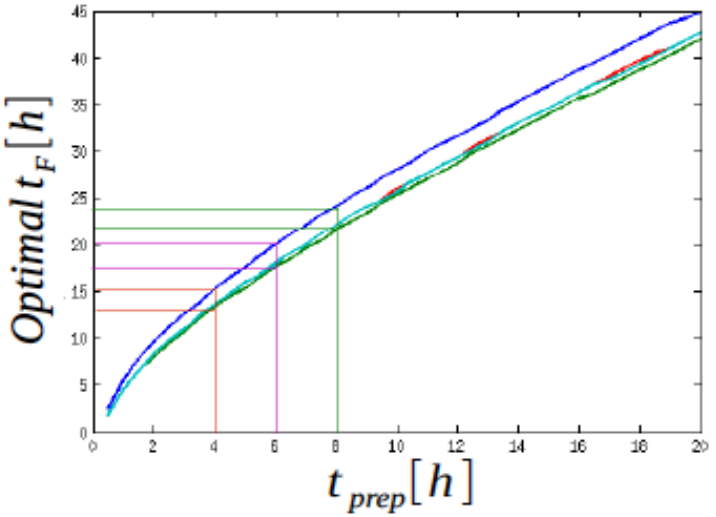


* excluded CMS points for fills with magnet off or ramping

Optimal Fill times for 2016

- 2016 proposed parameters:
  - β*=40 cm in IP1/5
  - 410 μrad (11 σ) or 370 μrad (10 σ) in IR1 and 5
  - Similar bunch brightness and bunch length as in 2015 (1.2e11, 3μm, 1.3ns)
- Most probable turnaround time (based on 2015) of 6-8h (see M. Solfaroli)
- Using different emittance evolution scenarios (based on 2015 observations)
  - Long Fills are favorable
  - For 6h prep. Time: 18-20h
  - For 8h prep. Time: 22-24h
  - For 4h prep. Time: 13-15h

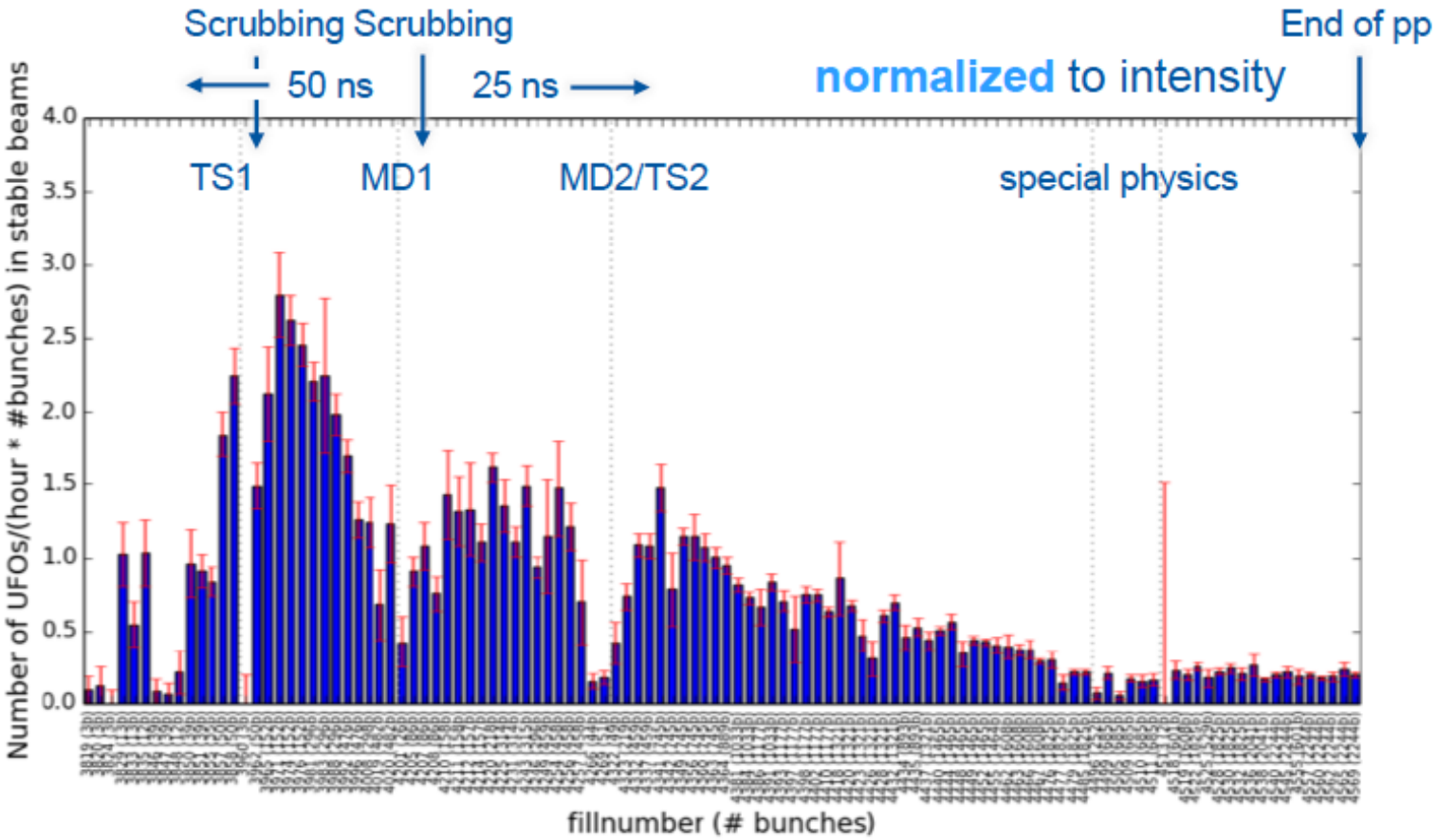




Bernhard Auchmann

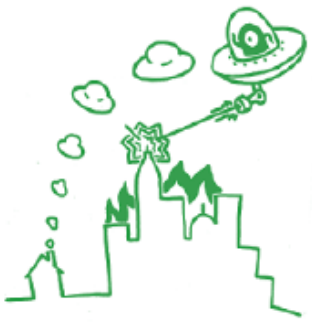
UFO Rates 2015 pp Run

Rates of registered UFOs in Arcs and DSs at 6.5 TeV.



Is a ratio of 10 UFOs/hr already the asymptote?

- *Luck seems to be a factor* when it comes to surviving a UFO attack.



Post-YETS Changes

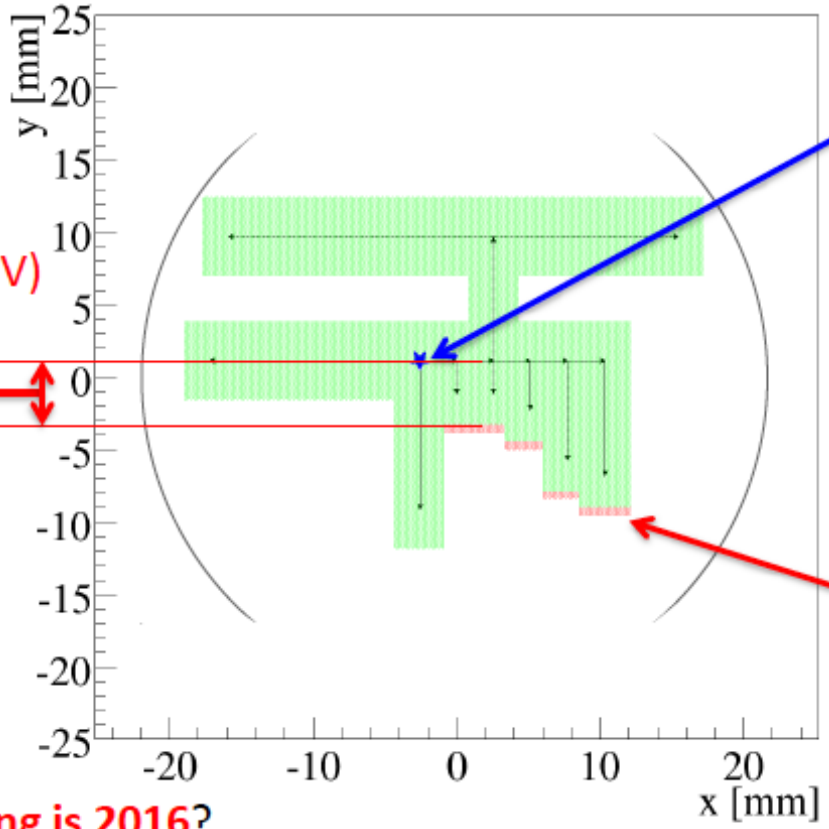
BLMTWG proposes to

- increase the short Running Sums (RS 1-6) by another factor 2, while reducing the longer Running Sums to conservative values.
  - Monitor factor (MF) from current 0.5 to 0.2.
  - RS 1-6 Master Threshold increase x5.
  - (Possible decrease of long Running Sums in Master Table due to BFPP quench-test result. See Matti Kalliokoski's presentation.)
- use conservative thresholds next to magnets with heater problems.
- keep this setting (or even increase the MF) provided that UFOs cause no more than ~15 quenches per year.
  - 15 quenches is comparable to expected flattop training, much lower in terms of heater firings than spurious QPS triggers (resets, etc.).
- in short: avoid dumping on UFOs all-together as a strategy to maximize availability.

ULO restriction now?

- Local aperture **scan repeated** with protons **(15/11)** and lead beams **(10/12)**

  → Consistent results obtained: *vertical dimension increased*



- What if it keep **growing is 2016**?

  ✓ **Still room** to have at least **10σ** in both planes (@ 450 GeV)

  ✓ Possible best **new bump** to be decided based on **actual situation**

Maximum shifts:
H = -6mm
V = +3.5mm

Lee Carver

Instabilities

- Transverse instabilities regularly observed during operation.
- ADT gain, Chromaticity and Octupole current increased to mitigate blowup. By the end of November, instabilities were able to be suppressed routinely.
- BCMS fill showed that at injection and during the squeeze, we are quite close to the limit of stability.
- ADT ObsBox will be able to provide more detailed bunch-by-bunch information which will allow us to understand some of the instabilities better.

- Instability measurements show good agreement for operational chromaticities. Further studies required for small and negative chromaticities.
- Threshold was increased by a factor of 5 for bunch train in strong presence of e-cloud. High intensity physics scrubbed the machine at flat top, thereby reducing e-cloud levels and reverting to single bunch instability thresholds.

- Will be challenging again in 2016… defenses very nicely described by Kevin
- Important to continue to validate model and improve understanding…

Scrubbing: Gianni's proposal for the 2016 start-up

- Arcs will be kept under vacuum → **scrubbing should be at least partially preserved** during the YETS
- Scrubbing **requirements for 2016**:
  - **4 days scrubbing run** should be reasonable to recover high intensities at 450 GeV
  - A few **"refresh" scrubbing fills during first 1-2 weeks of intensity ramp up** in physics (to avoid problems with deconditioning)
  - Accumulate **further scrubbing in physics:**
    - → **"aggressive" filling scheme**, with up to **288b. per injection**, should be used until we hit again limitations from cryo
  - **Doublet test** to be performed when **SEY is sufficiently low** (e.g. after recovering the 2015 situation) to check whether good beam quality can be preserved
    - → In case of positive outcome, **first scrubbing stores with doublets**

And please guys – no more sleeping on the job

Beam-beam

- Message
  - We’re in happy place – lower HO, lower LR
  - So happy that high Q’, high oct – not a problem
  - 10 sigma (**nominal emittance**) is good
  - 370 microrad in 1&5 for beta* = 40 cm
  - 400 urad in ALICE, 2*250 in LHCb

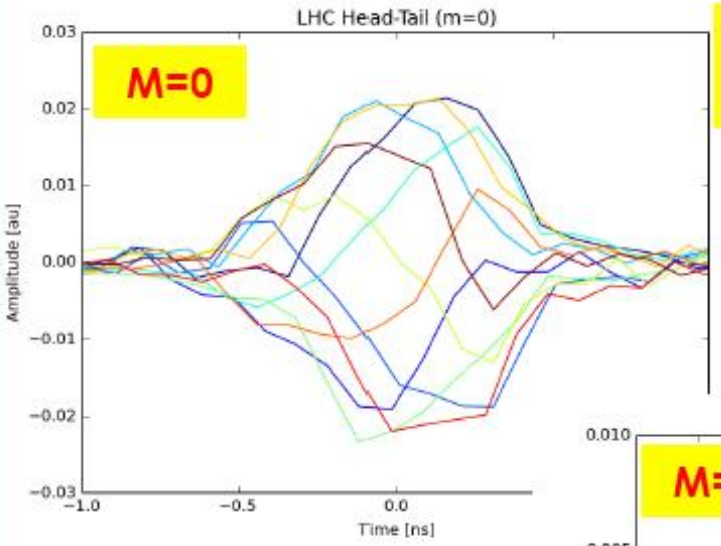
Outgassing TDIs should not longer be a problem

Thanks Anton

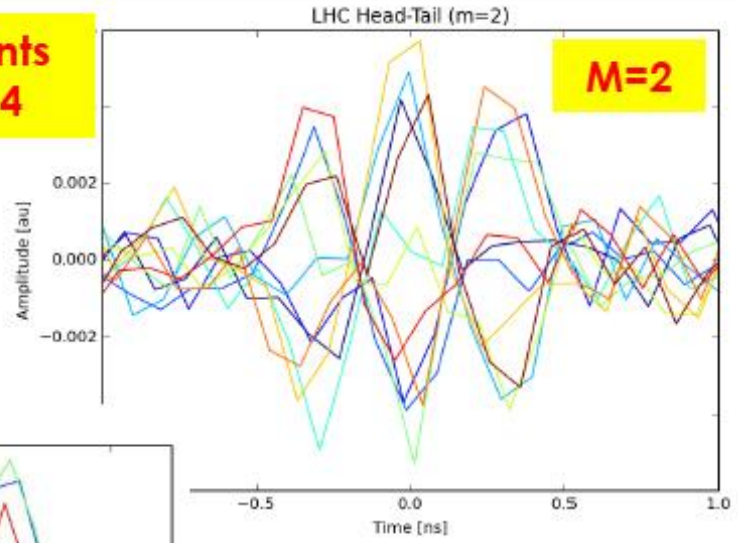
Hi Benoit,
we have been doing the endoscopy to TDI8 and the surfaces of the HbN are all spoiled, basically there is some spot left of Ti coating. Moreover there are bubbles on the copper coated holder. The contacts and foils look fine.
Here the picture/video: https://espace.cern.ch/be-ice-impedance/Measurements/TDI8%20Endoscopic_2015_12_16.zip
Tomorrow we are going to see TDI2 as it will be available.
With Antonio we preliminary planned the measurements for the first week of January (from 5/01 on).
Ciao

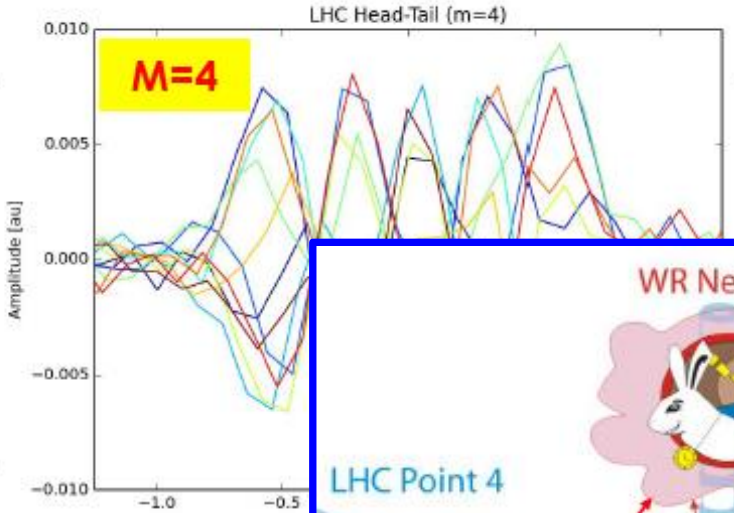
Nicolò and Na

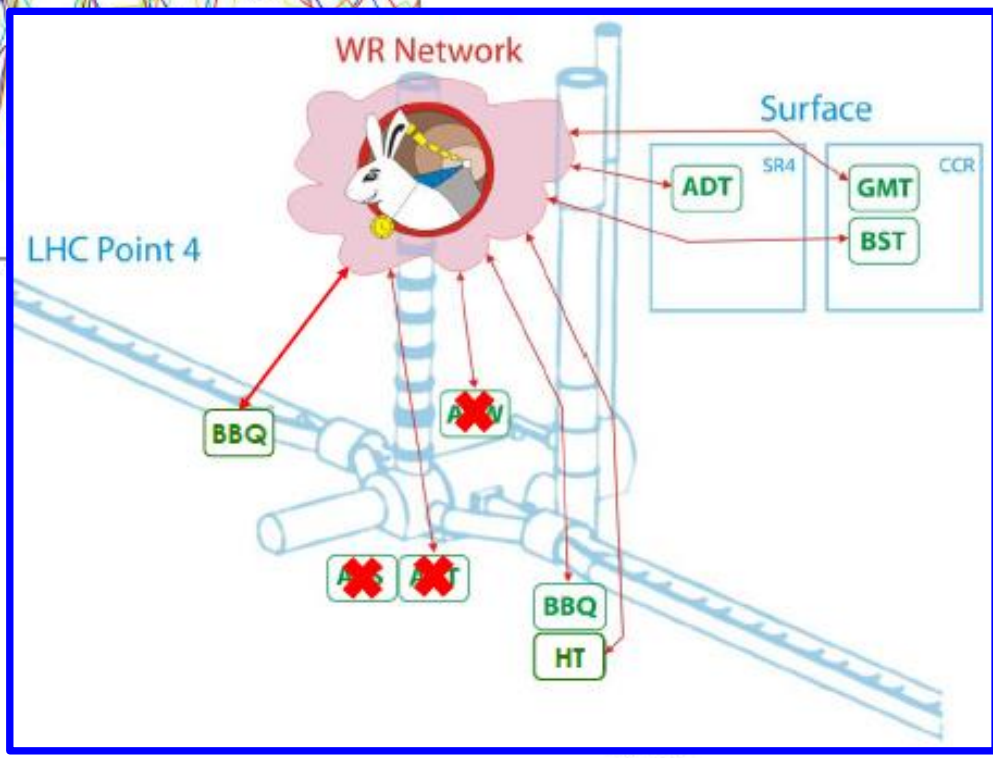
Gerd Kotzian



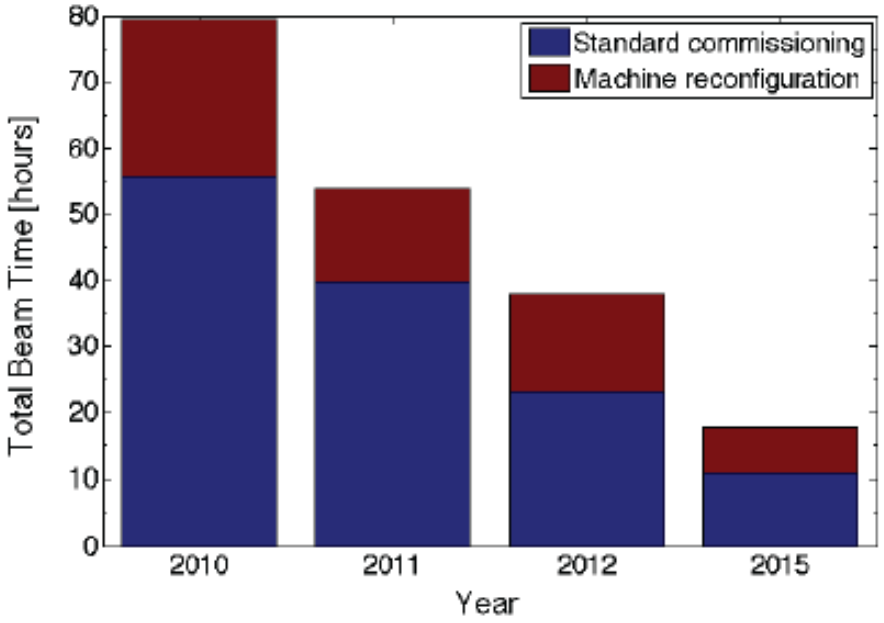
MD measurements saw modes 0...4

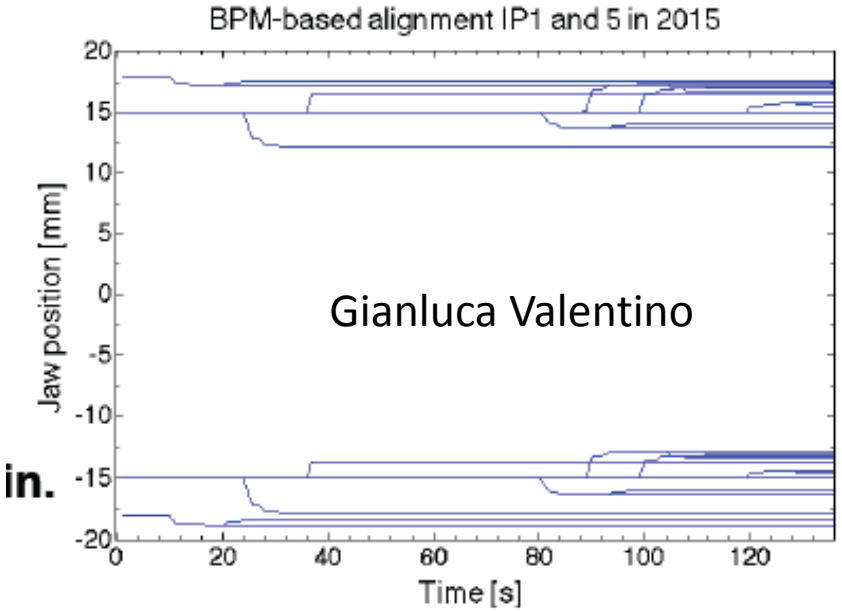






Beautiful - has to be a solution for data storage and robust software solution to exploit the combined systems





Gianluca Valentino

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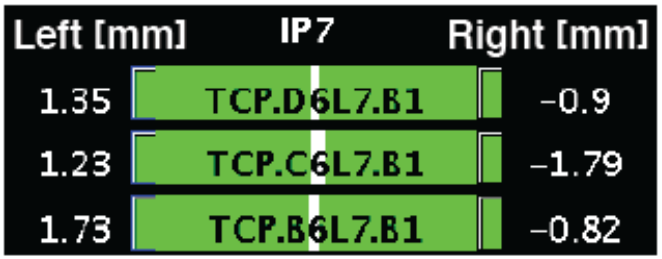
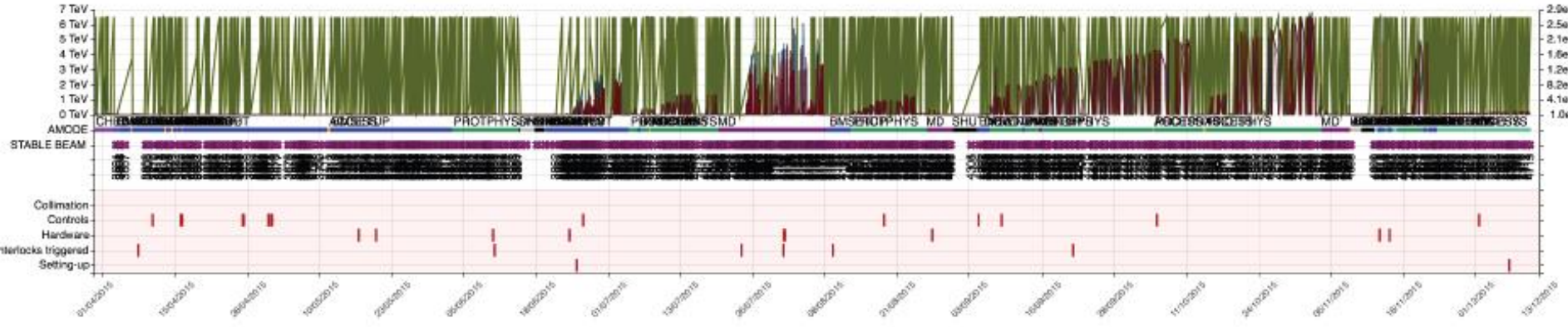
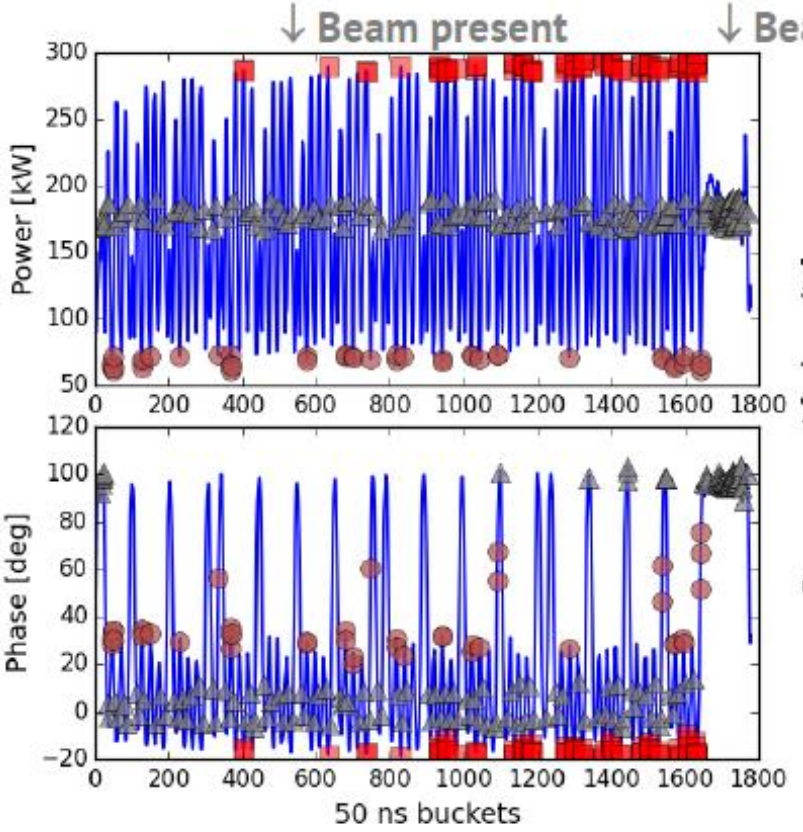


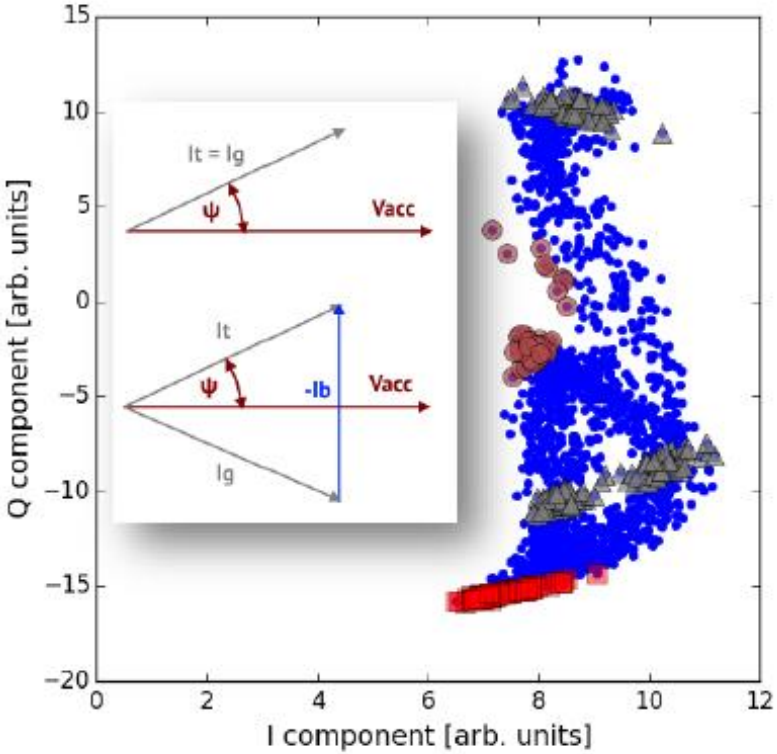
down to 2.2 mm gap in IR7!



Half-detuning (1)

Power transients with a full machine (2244 bunches, fill 4565, 2nd November)





← Beam absent

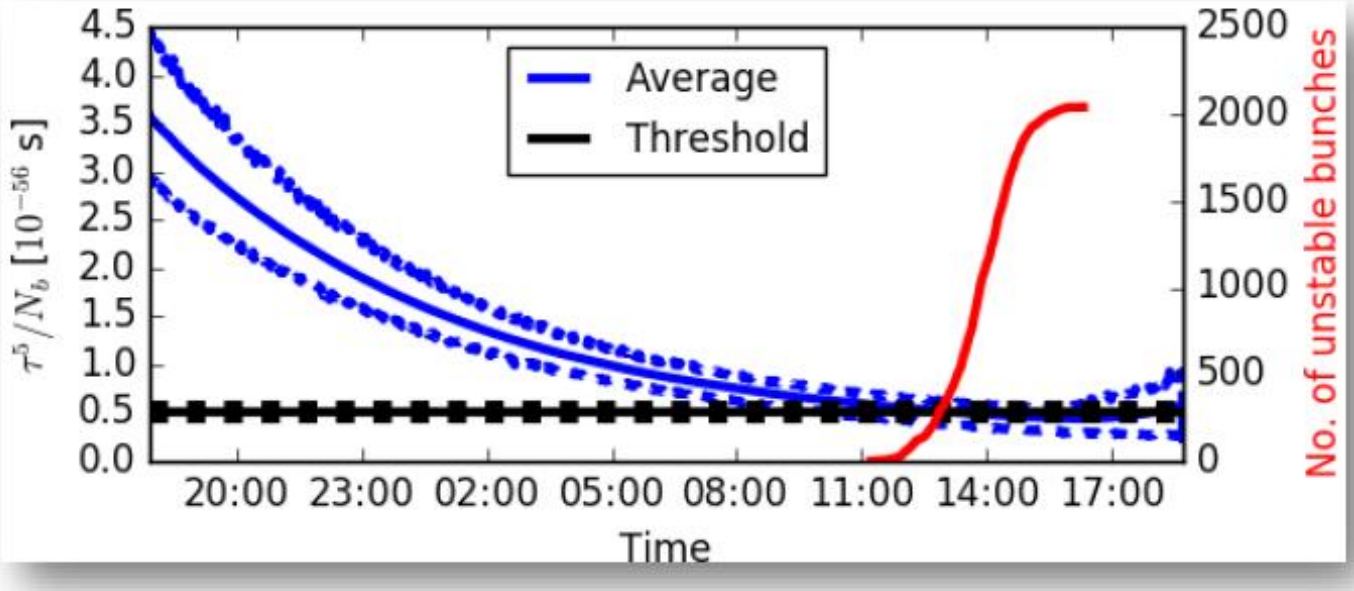
← Beam present

Longitudinal beam stability (2)

At the end of long physics fills, Landau damping was lost

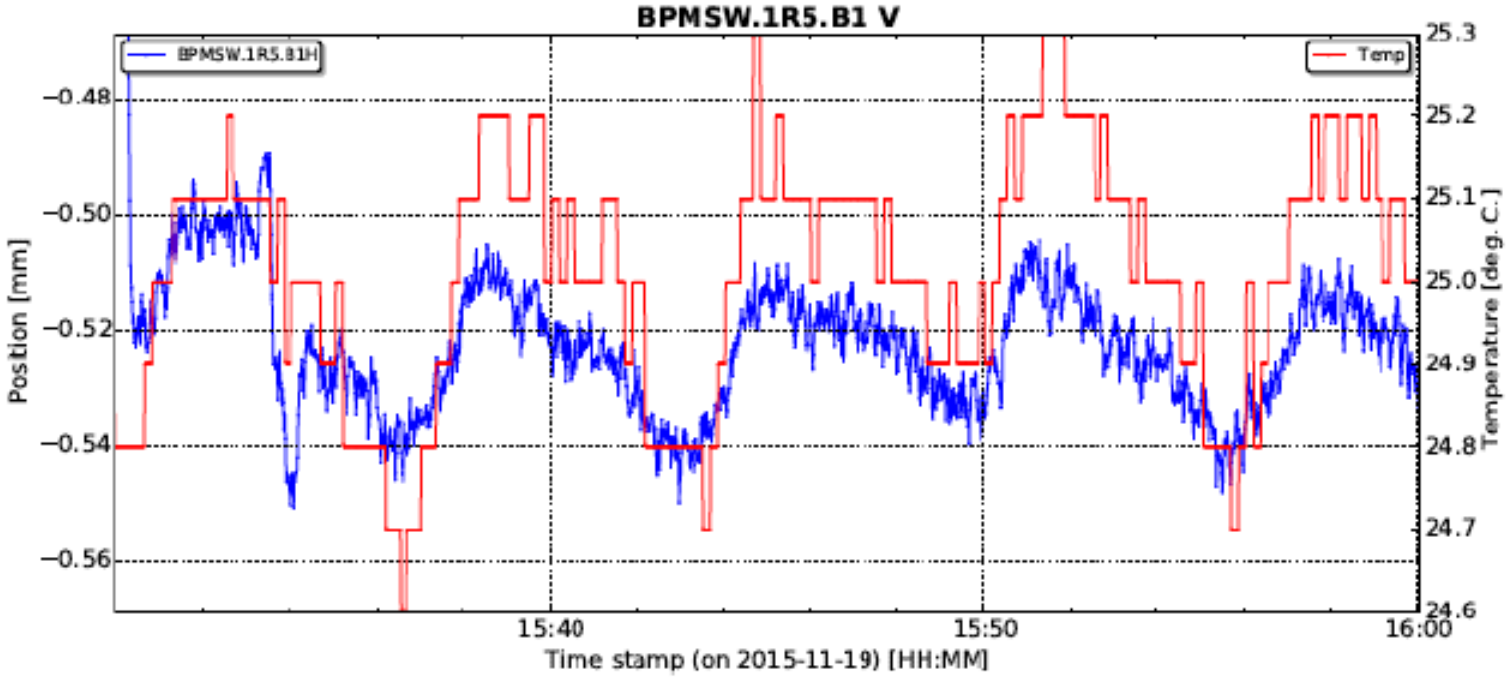
- With 2015 end-of-fill beam parameters, coupled-bunch instability not observed, only single bunch instability

  Bunch flattening can be used as a mitigation if needed



Loss of Landau damping in the longest fill of the year.

Single-bunch threshold obtained in MDs.



- Very successful year for the beam instrumentation
- Many changes during LS1 requiring some debugging during 2015
- Instrumentation ready for the upcoming production years
- Still a lot of challenges for the R&D systems
- BI can now focus toward HL-LHC

You can not be serious!

Summary

❑ WS:

Deep understanding/investigation of the measurement precision in Run II.
Undergoing software improvements will improve even more the system.
Accuracy of the beam size measurement (absolute value) is <3 %
Precision of the beam size measurement (spread around absolute value) <9 %

❑ BSRT:

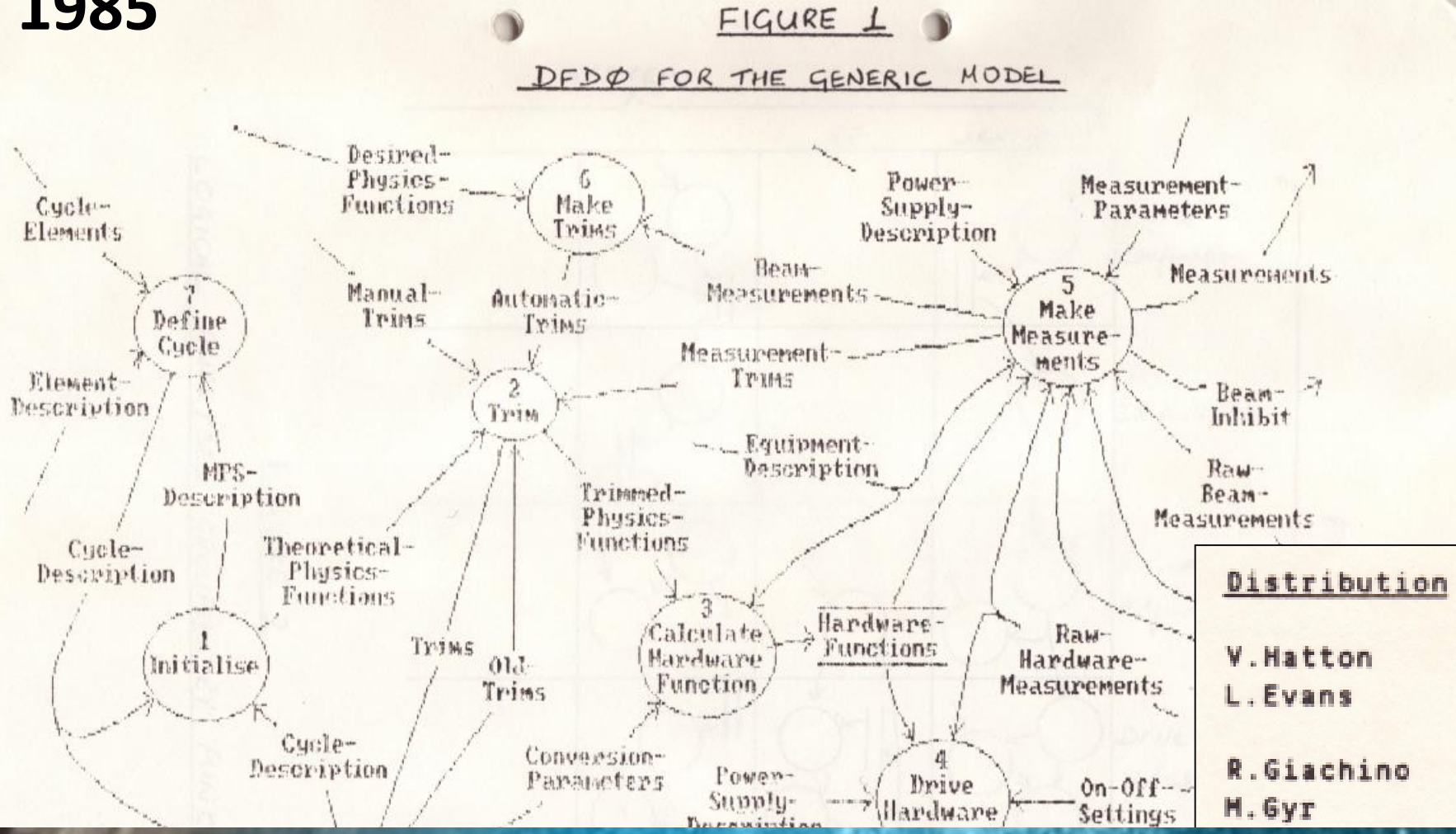
Ope
- Acc
  Pre
- At i
  => Spare OP time, however would be nice to have routine (monthly) checks at injection (<20 min).
- Dedicated MD time (often confused with "Calibration") for development will be crucial for Hi-Lumi.

Lovely talk including timely reminder about the difference between accuracy and precision.

❑ BGI & BGV:

2016 will still be a commissioning year for both instruments.

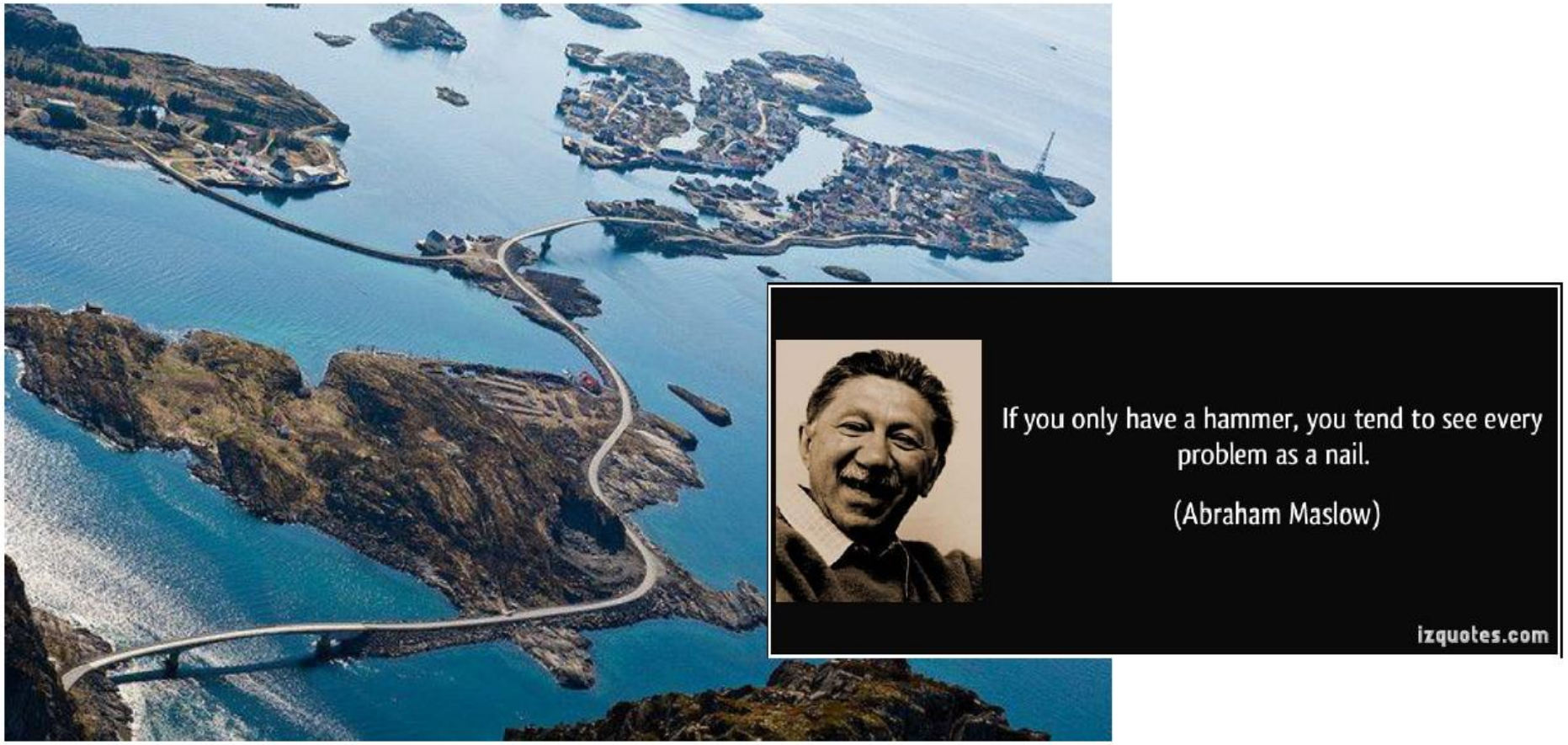
1985



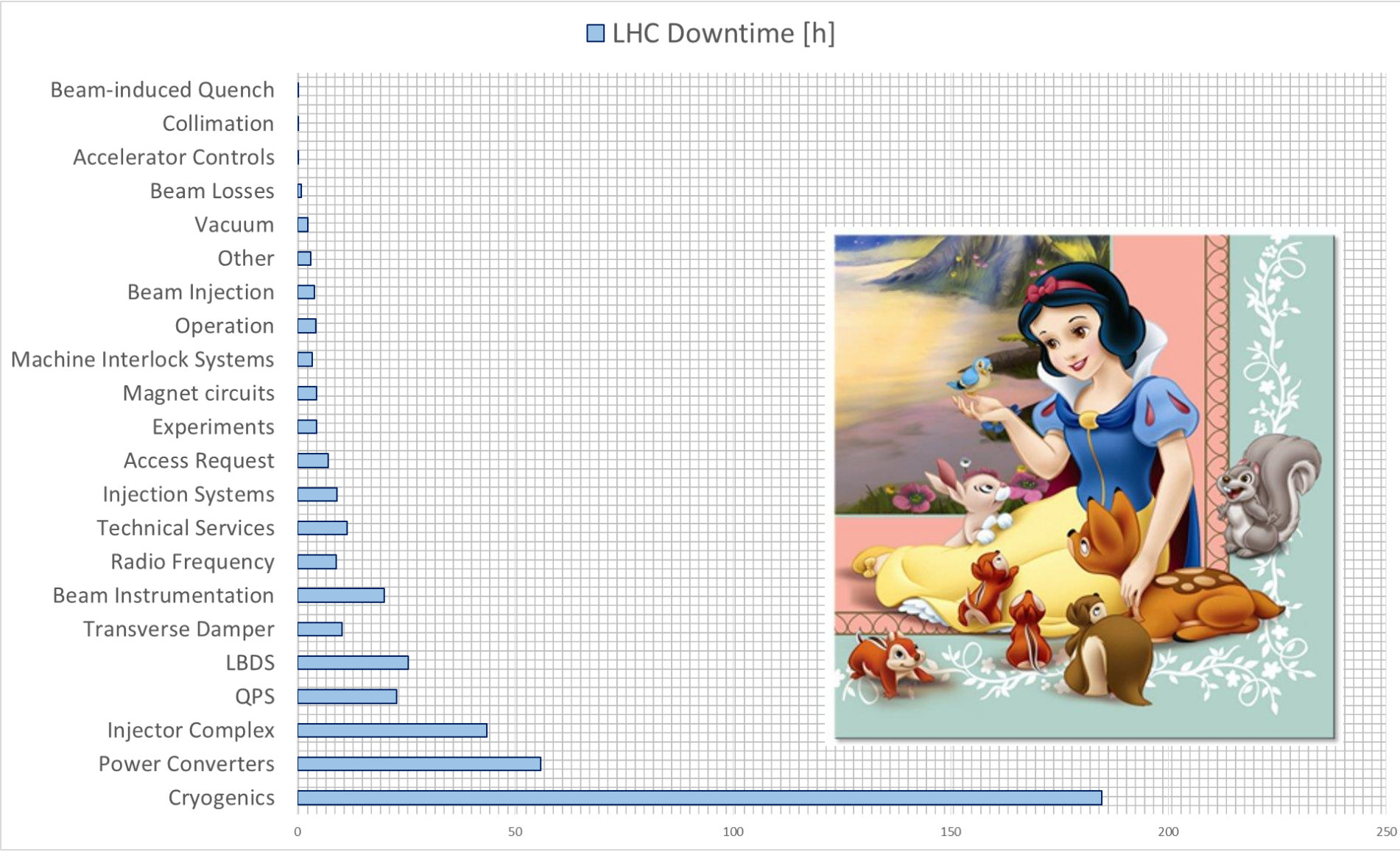
Careful evolution to drive CERN's accelerators safely into the future


We’ve come some way since LEP

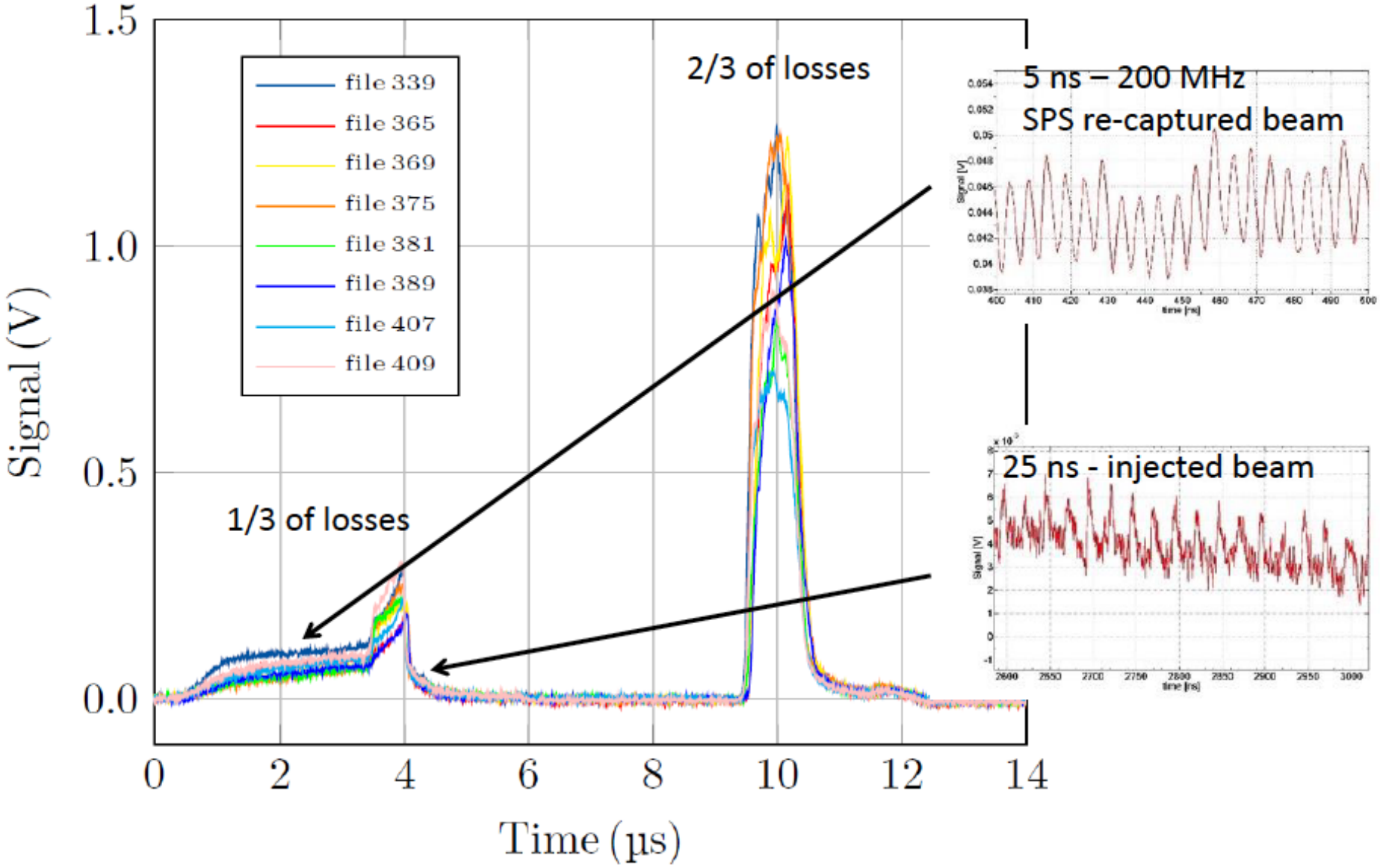
Kajetan: let’s build some bridges



Controls


LHC Downtime [h]
Beam-induced Quench
Collimation
Accelerator Controls
Beam Losses
Vacuum
Other
Beam Injection
Operation
Machine Interlock Systems
Magnet circuits
Experiments
Access Request
Injection Systems
Technical Services
Radio Frequency
Beam Instrumentation
Transverse Damper
LBDS
QPS
Injector Complex
Power Converters
Cryogenics
0
50
100
150
200
250

Losses @ TDI for 144b B1



MPS ensured safe operation with up to **~280 MJ** stored beam energy in 2015

"The condition upon which God hath given liberty to man is eternal vigilance."

Daniel Wollmann

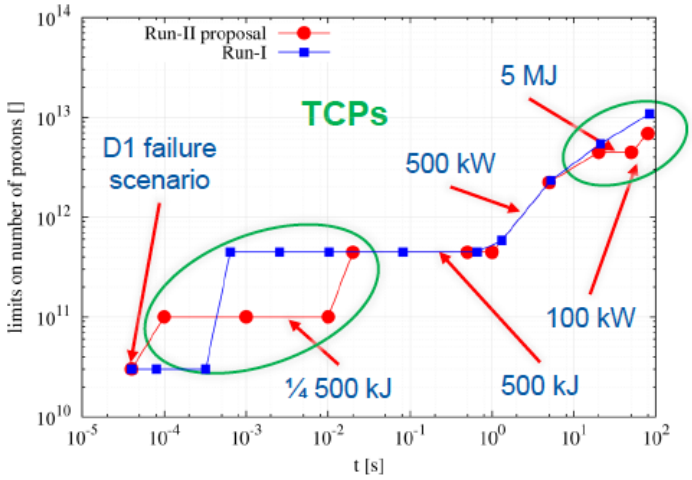
BLM Thresholds Evolution And 2016 Proposal

M. Kalliokoski, B. Auchmann, B. Dehning, E. Effinger, J. Emery, V. Grishin, E.B. Holzer, S. Jackson, B. Kolad, A. Lechner, A. Mereghetti, E. Nebot Del Busto, O. Picha, C. Roderick, M. Sapinski, E. Skordis, M. Sobieszek, C. Xu and C. Zamantzas

BLM Thresholds and Damage Limits for Collimators

R. Bruce, E. B. Holzer, M. Kalliokoski, *A. Mereghetti*, S. Redaelli, B. Salvachua Ferrando

- Overview of BLM thresholds deployed in 2015, and their updates (debris / operational scaling in IR7 / UFO events in experimental IRs);
- 2016: review of BLM thresholds at collimators:
  - New curve of proton limits at TCPs and scaling factors for non-TCP collimators (already available);
  - Analysis campaign for proton-to-signal conversion factors – focus on metallic collimators and energy dependence (and ions);
  - Lessons learnt from 2015 will be taken into account;

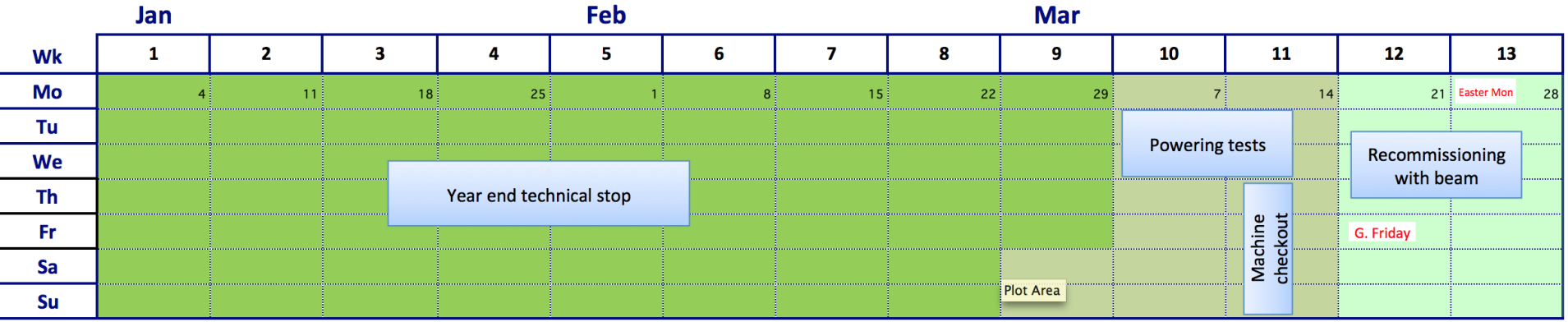


BI for Machine Protection

- Interlock BPMs (IP6)
- Abort Gap Monitoring
- Beam Current Change Monitor : dI/dt

T. Lefevre on behalf of the people involved in
BI and MPE groups

2016


Jan
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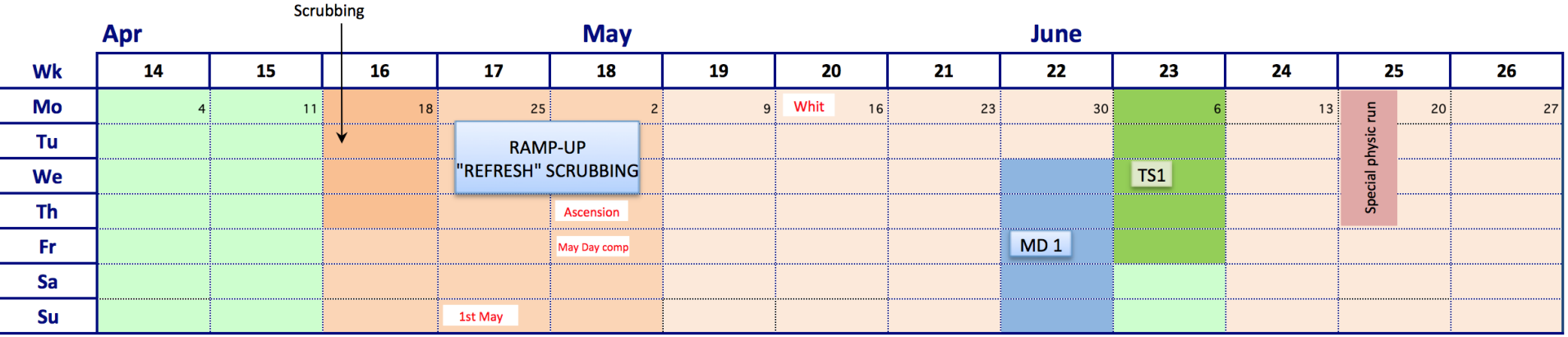
28
Easter Mon
Year end technical stop
Powering tests
Recommissioning with beam
Machine checkout
G. Friday
Plot Area


Scrubbing
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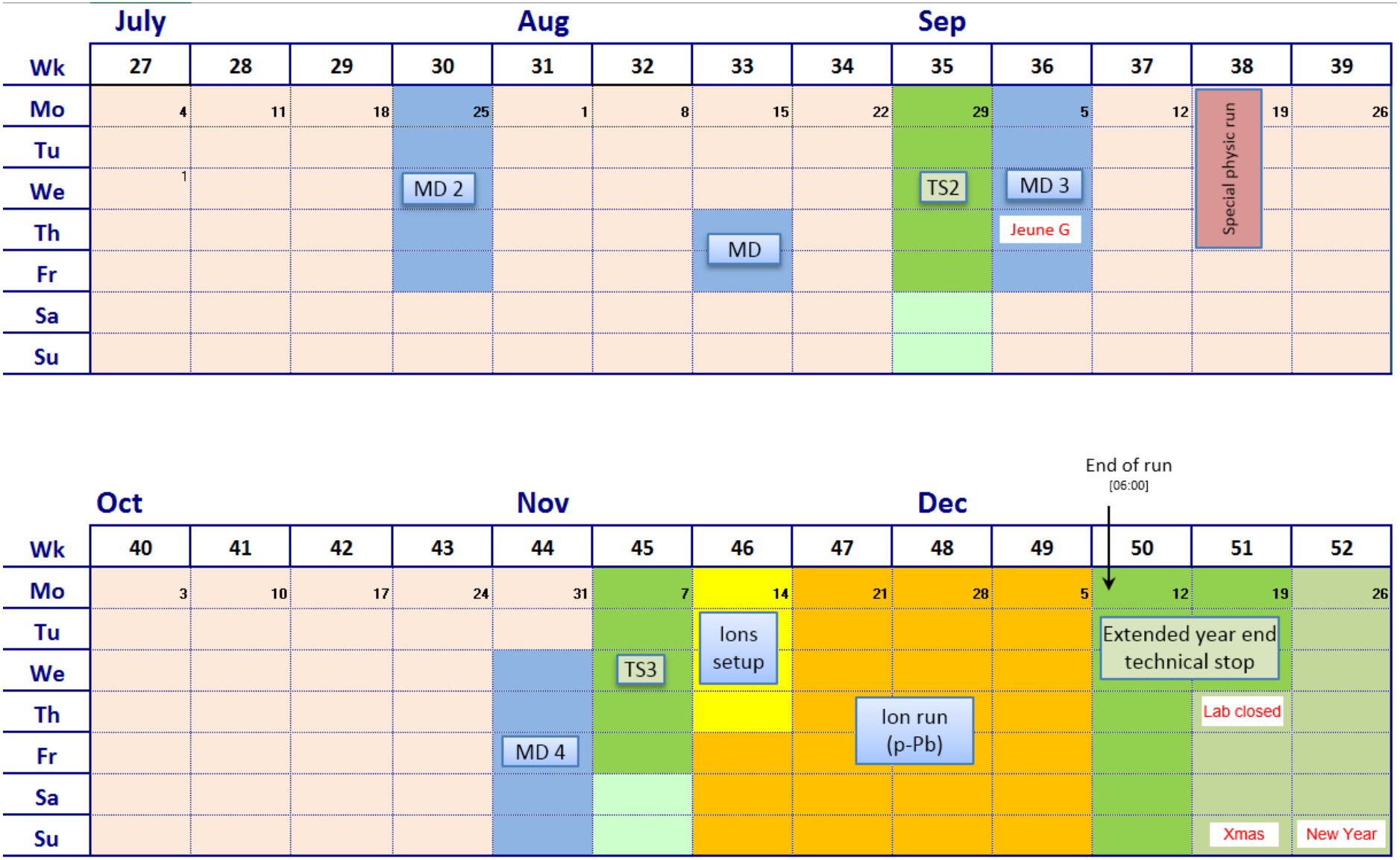
27
RAMP-UP
"REFRESH" SCRUBBING
Ascension
May Day comp
1st May
TS1
MD 1
Special physic run

2016 Q3/Q4 (v1.0)



2016 version 1.0

Phase	Days
Initial Commissioning	28
Scrubbing: 4 days initially and then as required during ramp-up	7
Proton physics 25 ns	**152**
Special physics runs (**high beta*; 90 m; VdM (19 m)**	8
Machine development	22
Technical stops	15
Technical stop recovery	6
Ion setup/proton-lead run	4 + 24
Total	**266 days (38 weeks)**

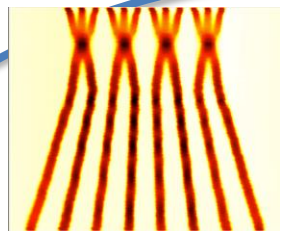
Can we get to β*=40 cm?

*Provided aperture stays good

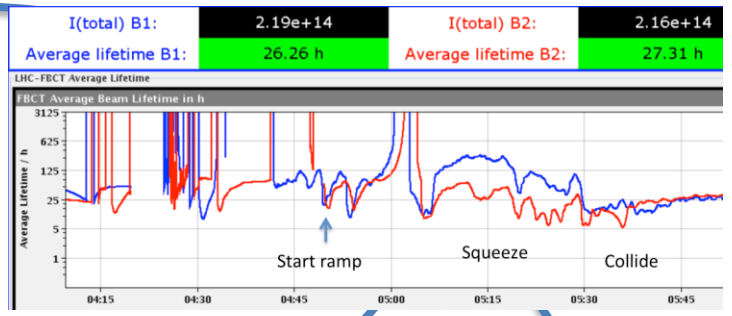
LHC Eightfold Path

Teamwork

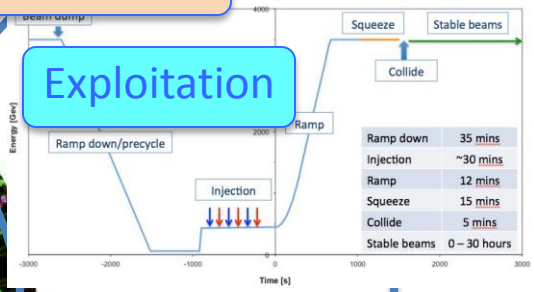
Beam from injectors



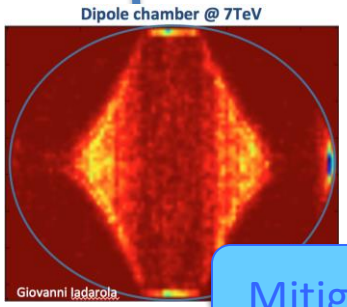
Beam performance



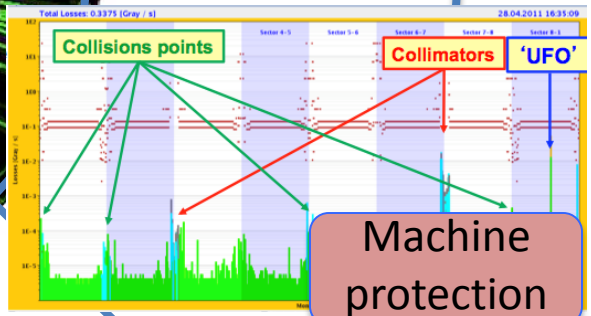
Exploitation



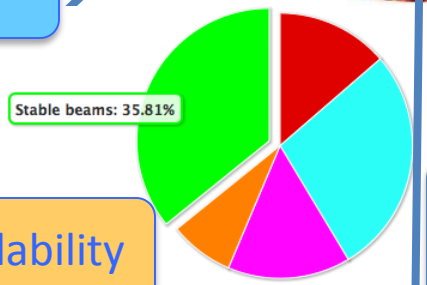
Mitigation



Machine protection



System performance



Availability

RF, power converters, collimators, beam dumps, injection, magnets, vacuum, transverse feedback, machine protection, magnets, magnet protection, beam instrumentation, beam based feedbacks, controls, databases, high level software, cryogenics, survey, technical infrastructure, access, radiation protection

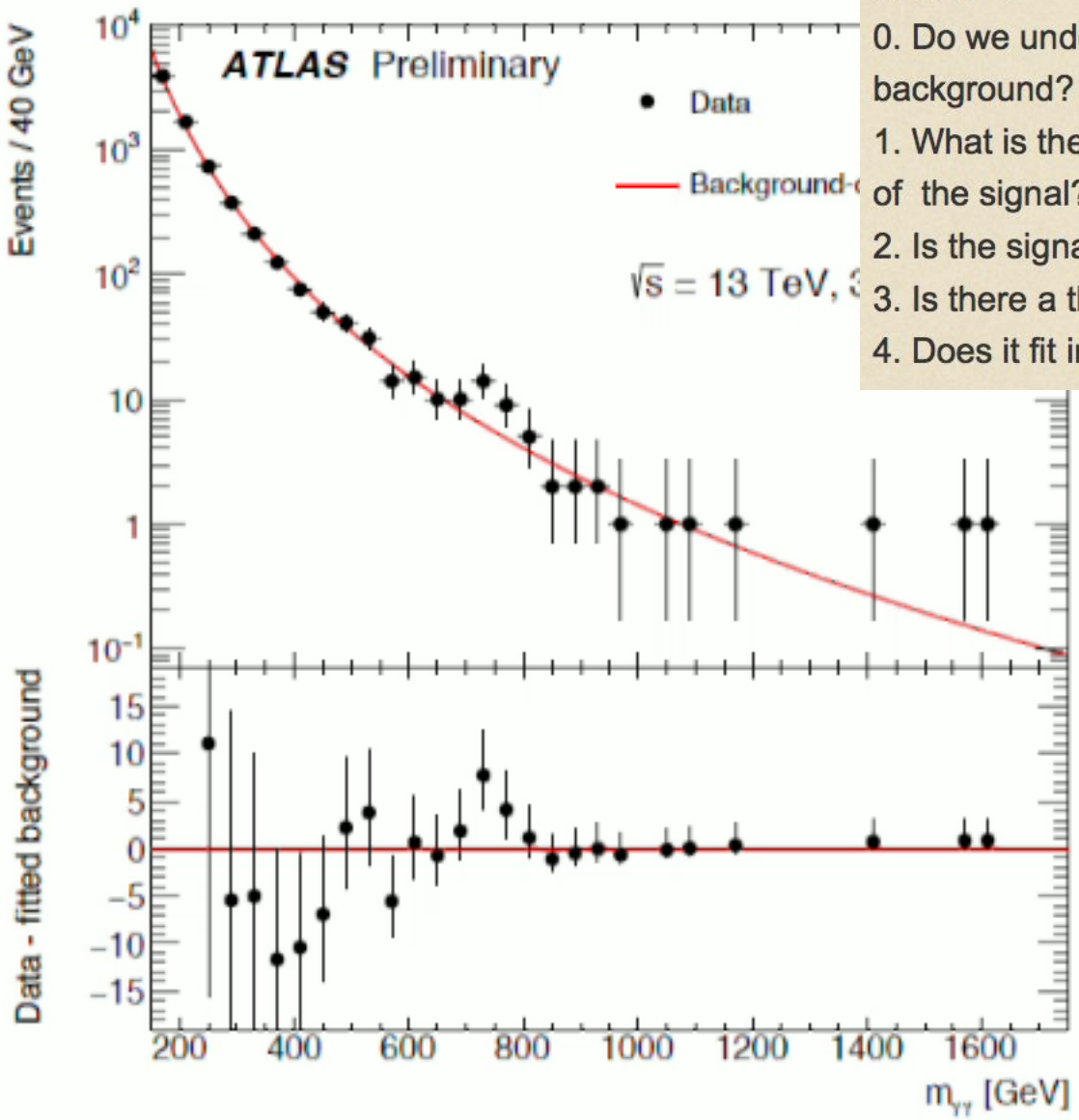
Phenomenal

- **In a new place – end of first year of operations after a long stop after Run 1.**
  - **Having got over the hangover…**
- Benefits of the feed in of experience gained showing very clearly
- Professionalism, understanding, exquisite level of detail, sophistication, maturity of tools
- Harnessing of 21 century technology
- Resources, talent, imagination and YOOF!!!

Many, many thanks…

- Organization
  - Everything: Sylvia
  - Everything else: Malika & Brennan
  - Technical coordination: Hervé
  - Proceedings: Brennan and Sylvia
- Session chairs – brilliantly done
- Speakers - excellent set of talks!
- Jamie

Happy Christmas!



~~0. WTF ?~~

0. Do we understand the background?

1. What is the statistical significance of the signal?

2. Is the signal consistent with other data sets?

3. Is there a theoretical framework to describe it?

4. Does it fit in a bigger scheme of new physics?