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Status Report on the start-up activities (injectors and LHC) and outlook

Council

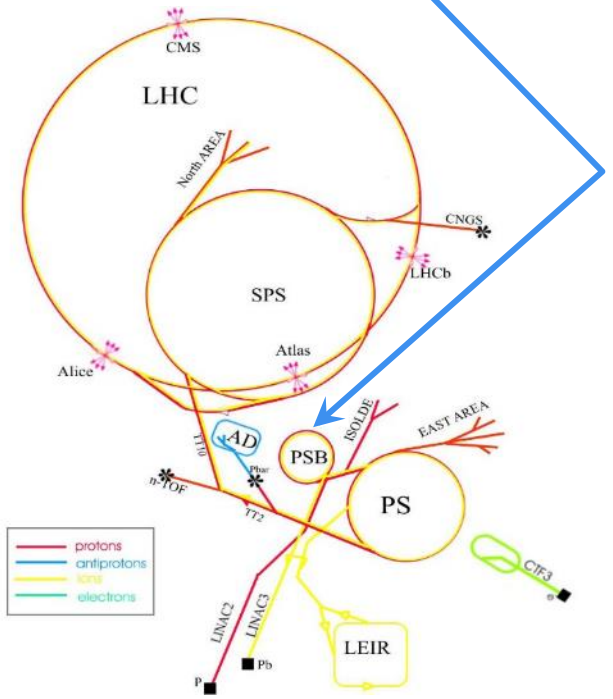
Frédérick Bordry

18th June 2015

PS Booster: Fixed-Target Beams June 2015

ISOLDE beams	status
NORMGPS	OK up to ~3.6 10^{13} ppp
NORMHRS	OK up to ~3.6 10^{13} ppp
STAGISO	OK in specs

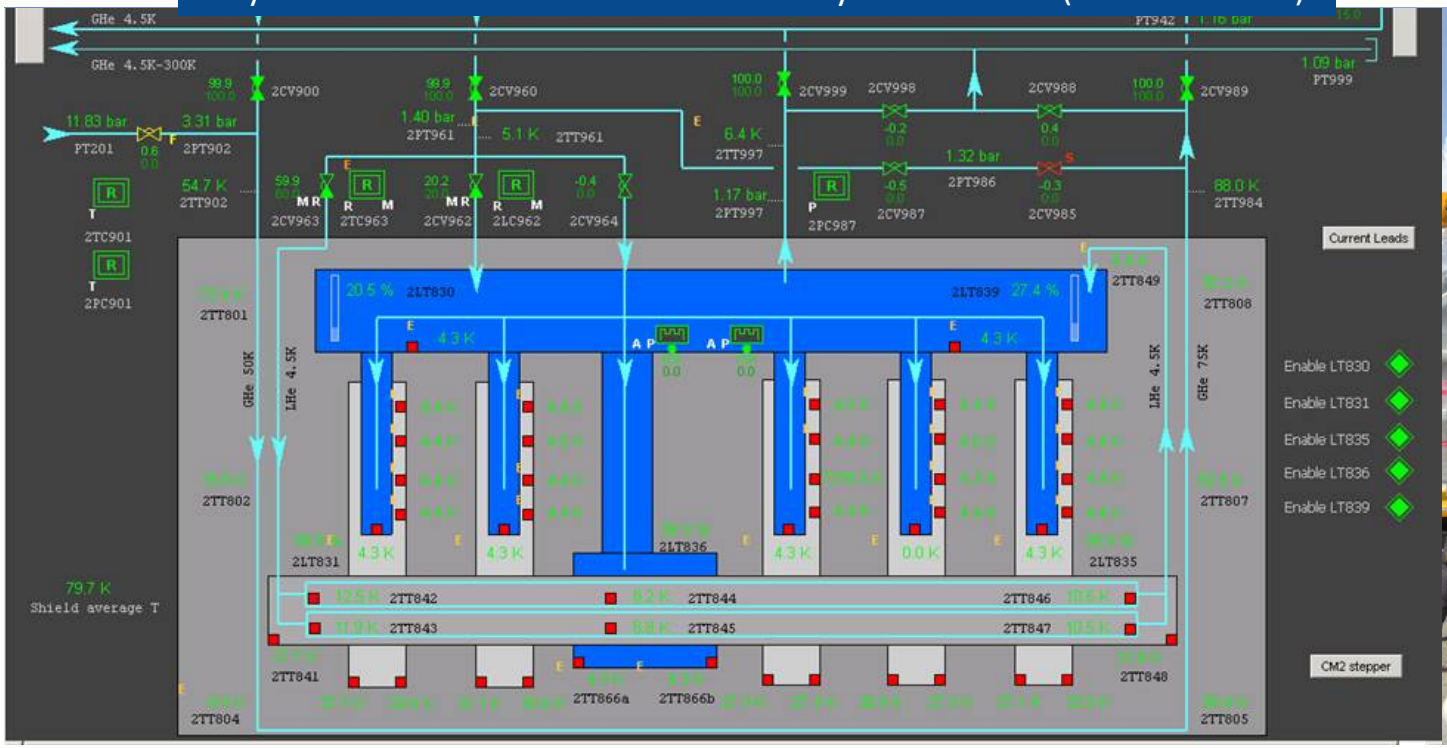
Fixed target beams	status
EAST	OK in specs
SFTPRO	OK in specs
TOF	OK in specs
AD	OK in specs



➢ good progress made in pushing ISOLDE intensity

HIE-ISOLDE cryo-module status

"Cryomodule of HIE Isolde is in nominal cryo conditions" (17th June 2015)



PS Booster: LHC-type and Scrubbing Beams - June 2015

LHC type beams	status
LHC 25ns DB	OK in specs
LHC 50ns DB	OK in specs
BCMS 25ns DB	OK in specs
LHCPROBE	OK in specs
LHCINDIV	OK in specs
LHCF_INDIV	OK in specs

scrubbing beams	status
high-intensity 25 ns	OK in specs
high-intensity BCMS	OK in specs
high-intensity doublet	being checked

- scrubbing beams successfully delivered to SPS

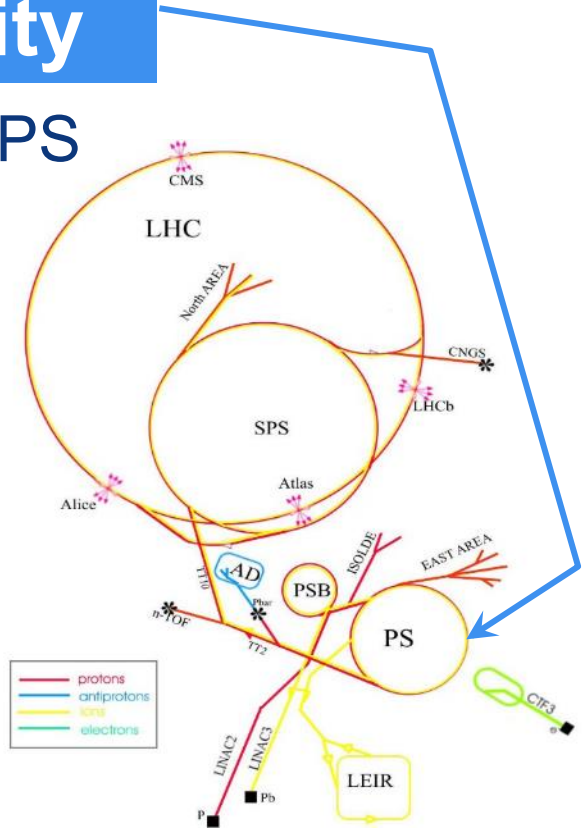
Courtesy Klaus Hanke

PS Machine: Beam Availability

- Very good beam availability out of the PS

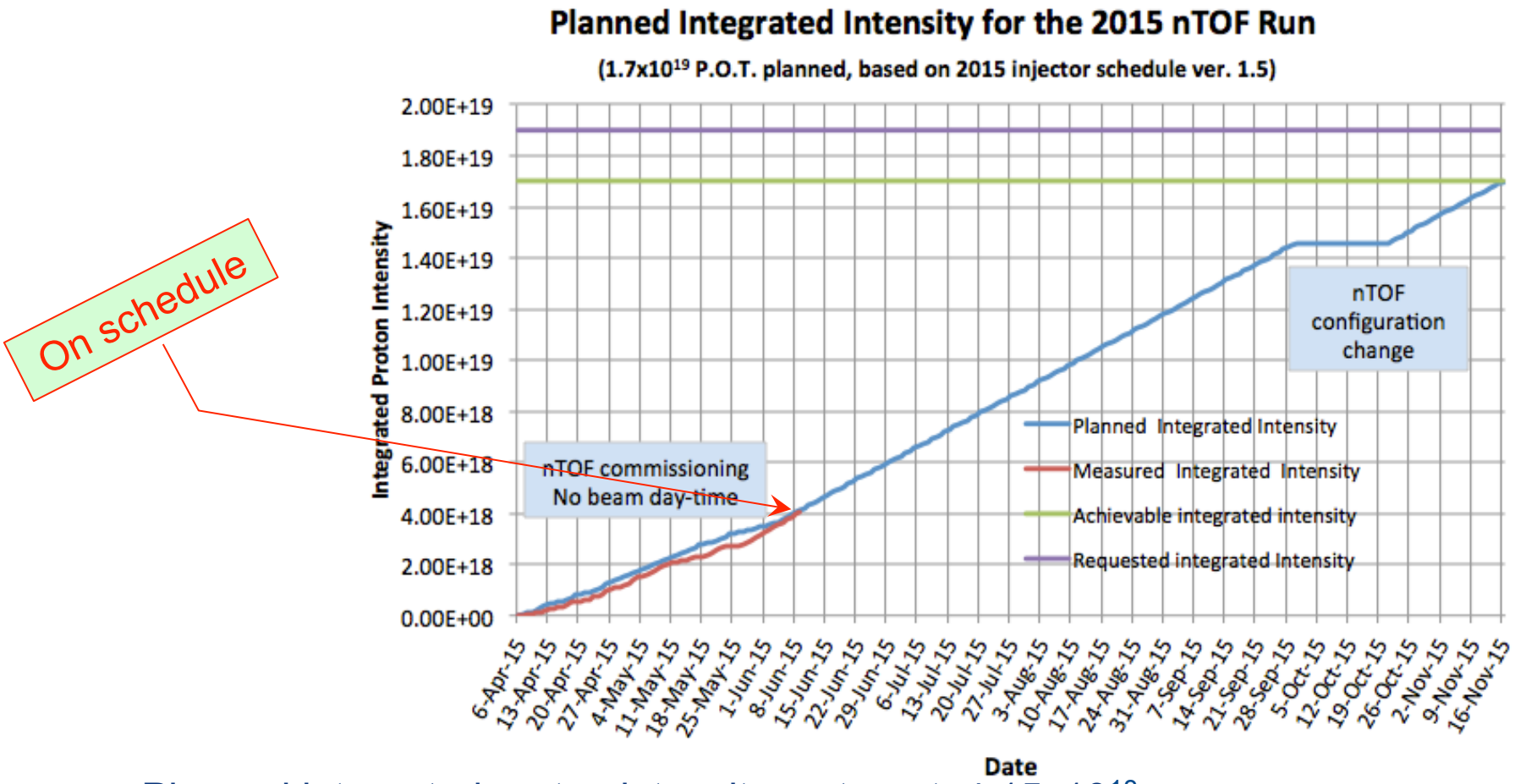
Beam to:	Beam Availability
SPS for Fixed Target	93%
nTOF	89%
East Area	95%
SPS for LHC	91%

Since start Proton run April 2015



- The 2014 run allowed to fully recover following all modifications made during LS1
- PS is in a good shape to deliver the LHC beams, but also the fixed target beams

Good progress for the nTOF beam (09-06-2015)



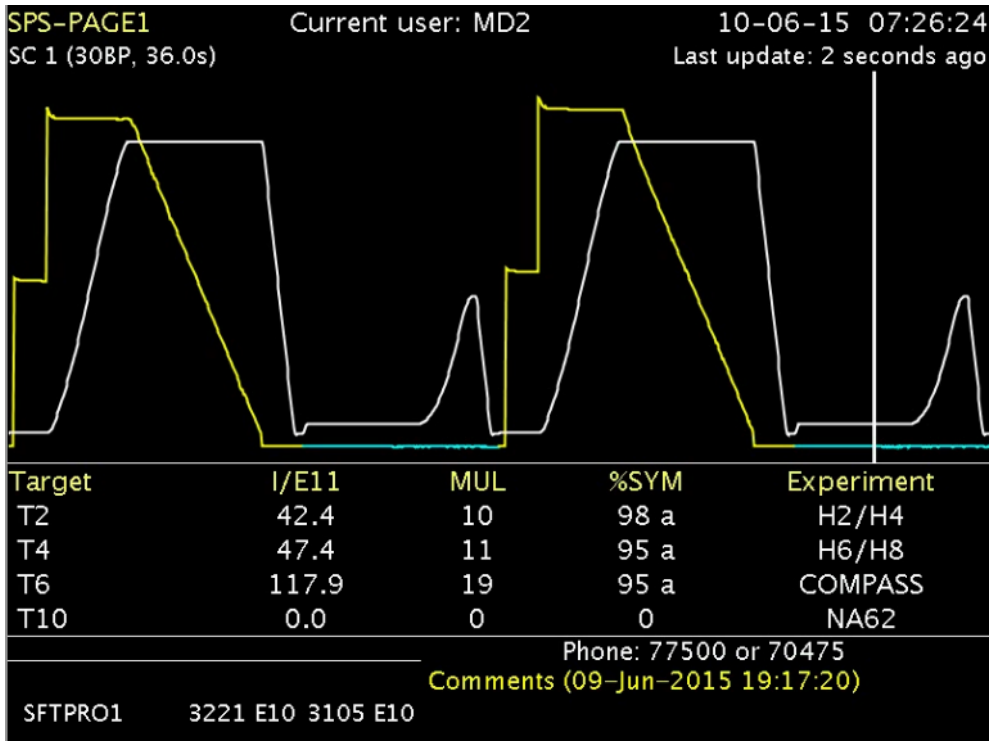
- Planned integrated proton intensity on target: 4.15×10^{18}.
- Achieved integrated proton intensity on target: 4.06×10^{18}.
- This is 98% w.r.t. scheduled and 24% of the total forecasted for 2015

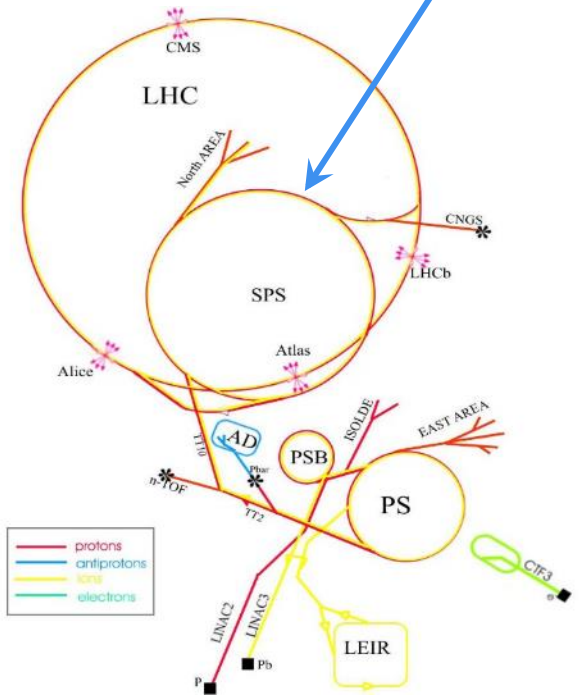
PS : Intense Machine Development Program

- LHC Injector Upgrade Studies
  - Space charge studies
  - LHC beam performance studies
- Preparation scrubbing runs in SPS and LHC
  - Special doublet beam developed
- Commissioning Multi-turn Extraction (MTE) for SPS fixed target beam
  - Optimises the PS machine performance also for operational beams
  - Reduces PS radiation levels

SPS: Fixed-Target Beams

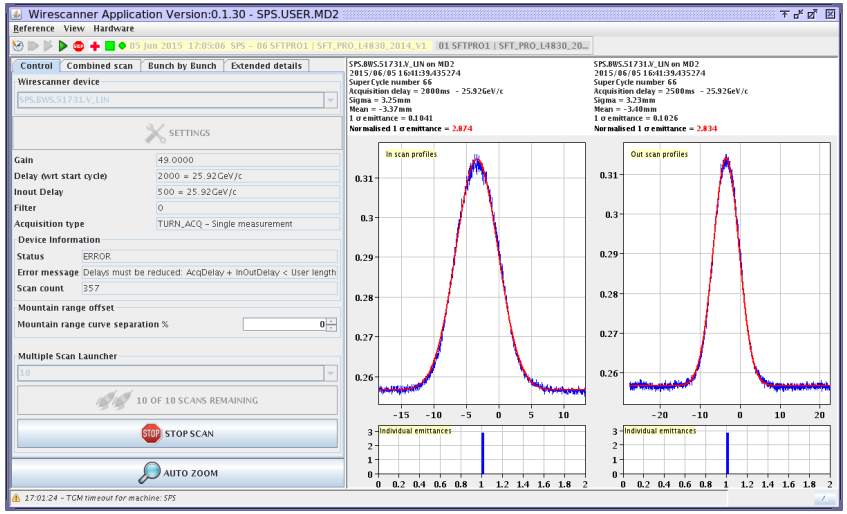
- Fixed target
  - Stable running with 2 10^{13} p/cycle, 85% availability
  - New spill control gives better stability for TT20 steering.
  - NA62 will start on June 22nd.



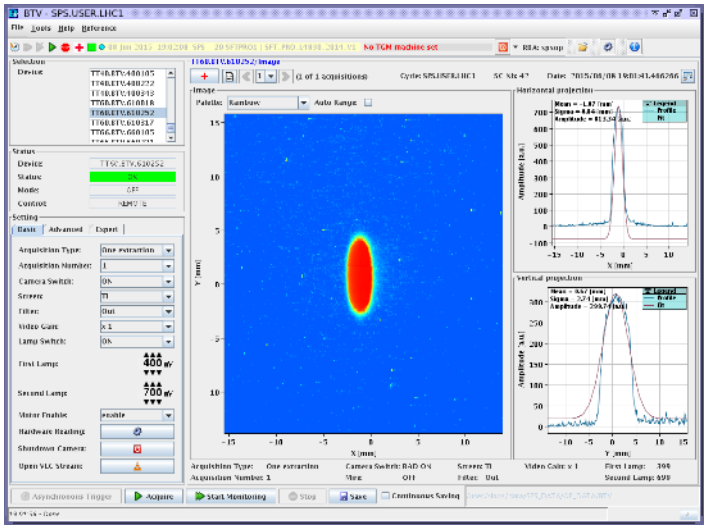


SPS: LHC-type and Scrubbing Beams

- LHC
  - Pilot, Indiv, and 50nsec (6 bunches of 1.2 10^{11} protons, 1.6 μm emittance) injected in LHC.
  - Nominal 25 nsec 1.2 10^{11}, 3 μm emittance is ready and was used by HiRadMat.
  - Doublet beam : Train of 12 bunches extracted to first TED.

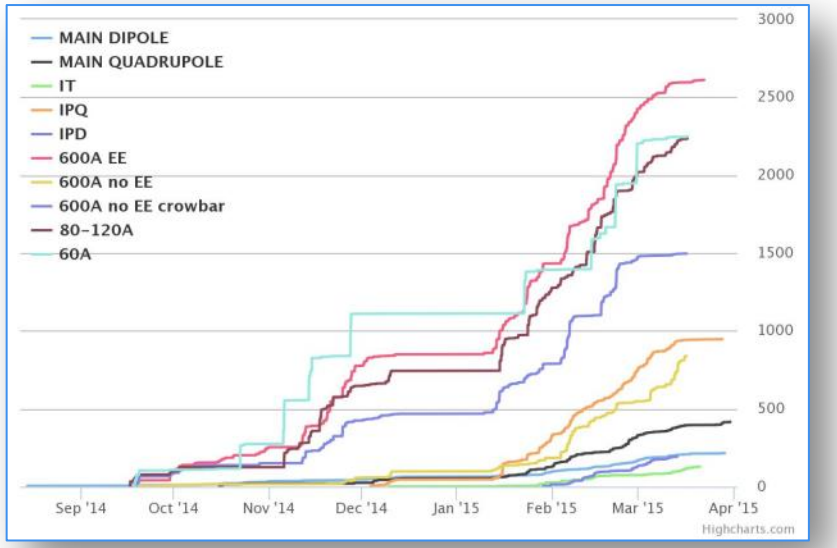


Profile of beam prepared for Vandermeer scan

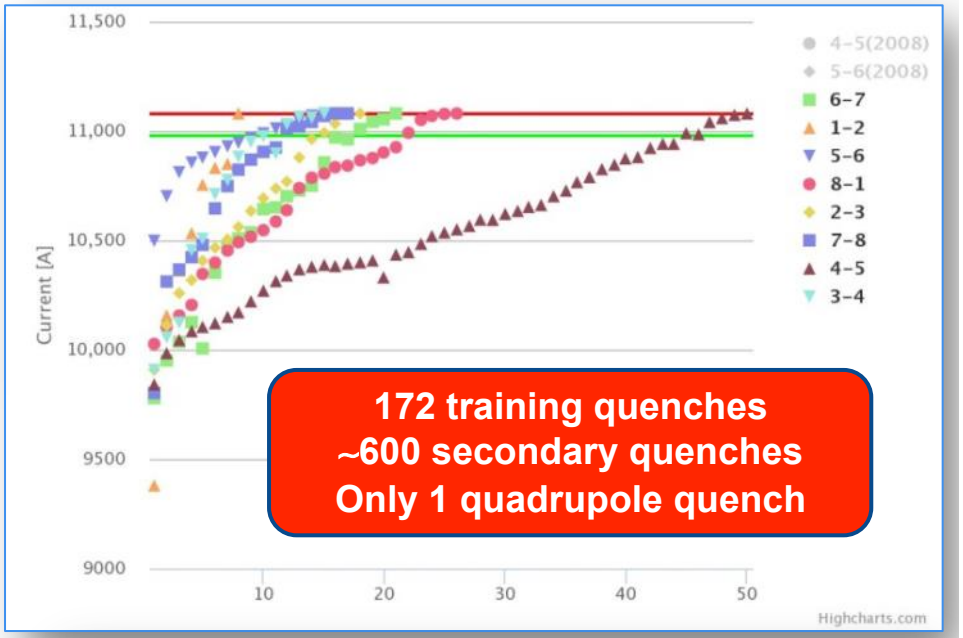


Doublet beam on screen infront of TEDin TT60

The LHC powering tests overview



Powering tests were completed at 8 am on Friday 3rd April 2015



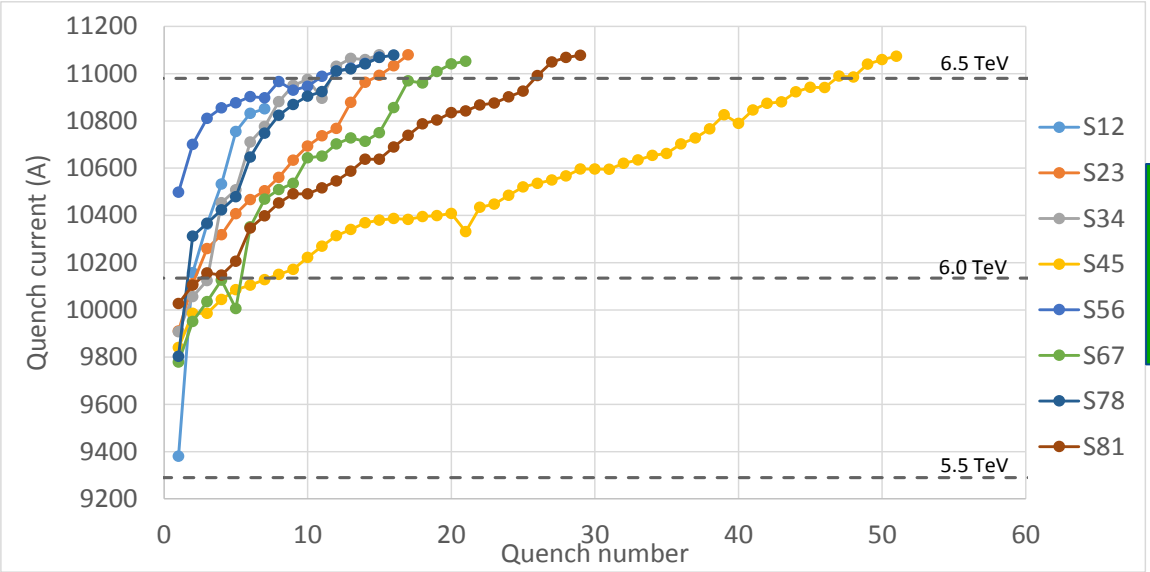
172 training quenches
~600 secondary quenches
Only 1 quadrupole quench

Since September 15th 2014:

1566 superconducting circuits commissioned through execution and analysis of **more than 10.000 test steps** (~13.800 test steps including re-execution)

Circuit	Status	#M Firm 1	#M Firm 2	#M Firm 3	#MQ Firm 1	#MQ Firm 2	#MQ Firm 3	#MQ total	#CQ total
RB.A12	11080 A reached	50	95	9	2	1	4	7	7
RB.A23	11080 A reached	56	58	40	0	2	15	17	17
RB.A34	11080 A reached	44	81	29	1	7	8	16	16
RB.A45	11080 A reached	48	44	62	-	3	48	51	49
RB.A56	11080 A reached	28	42	84	0	0	18	18	17
RB.A67	11080 A reached	57	36	61	0	1	21	22	21
RB.A78	11080 A reached	53	40	61	2	10	7	19	19
RB.A81	11080 A reached	64	24	66	0	3	26	29	26

Dipole Training Campaign



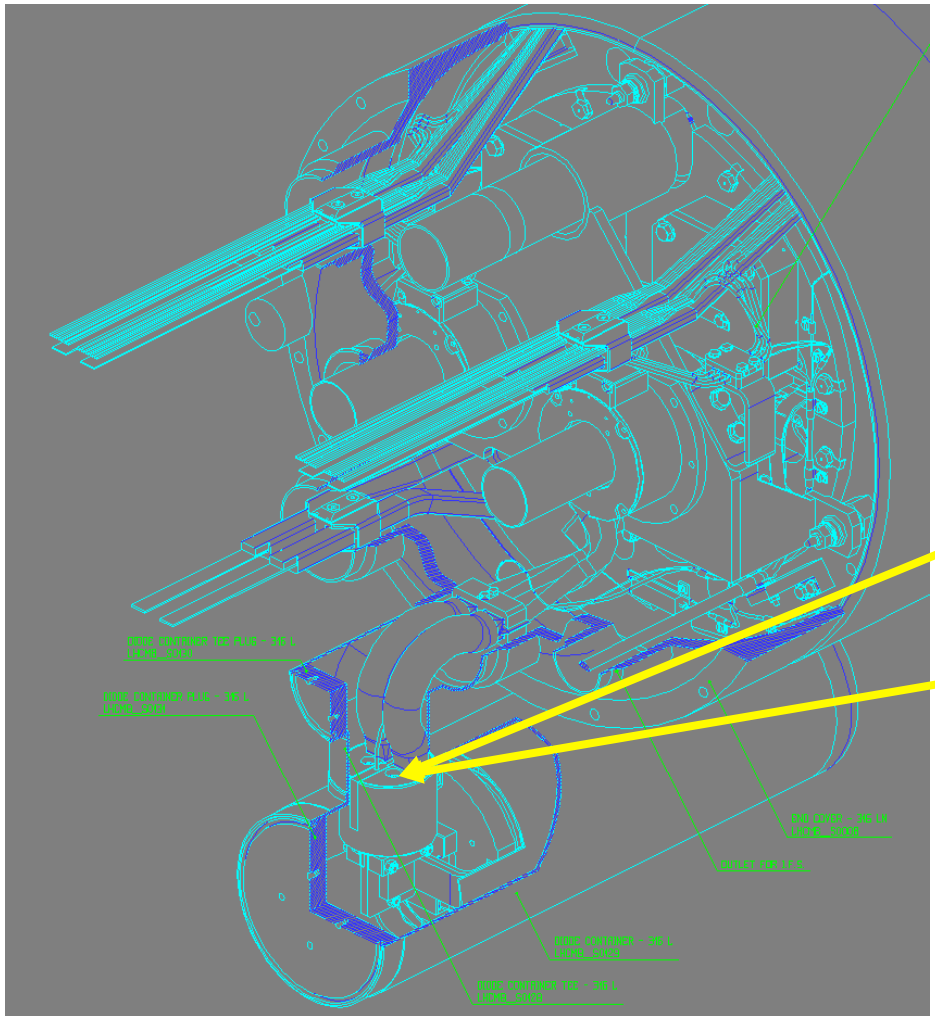
Each Sector Trained to 6.55TeV (11080A)
(100 A above the operational field)

Sector	# Training quench	Flattop quenches
S12	7	0
S23	17	0
S34	15	1
S45	51	0
S56	18	3
S67	22	1
S78	19	3
S81	29	0
Total	171	8

Large variation in number of training quenches per sector

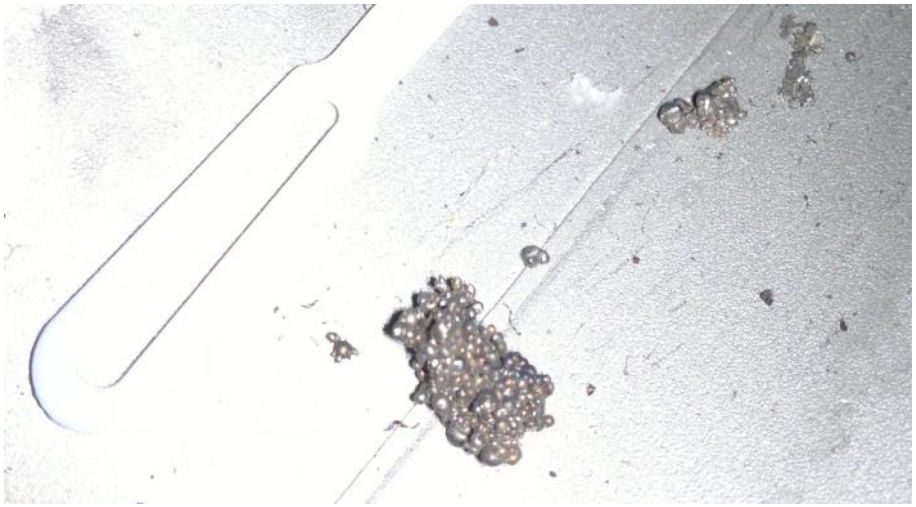
Detailed Analysis in Progress!

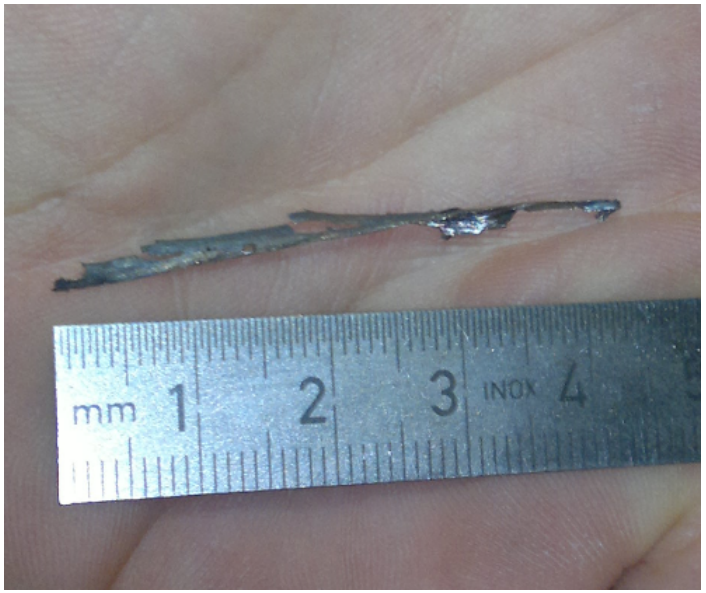
Not everything is plain sailing! *One example… sector 3-4*



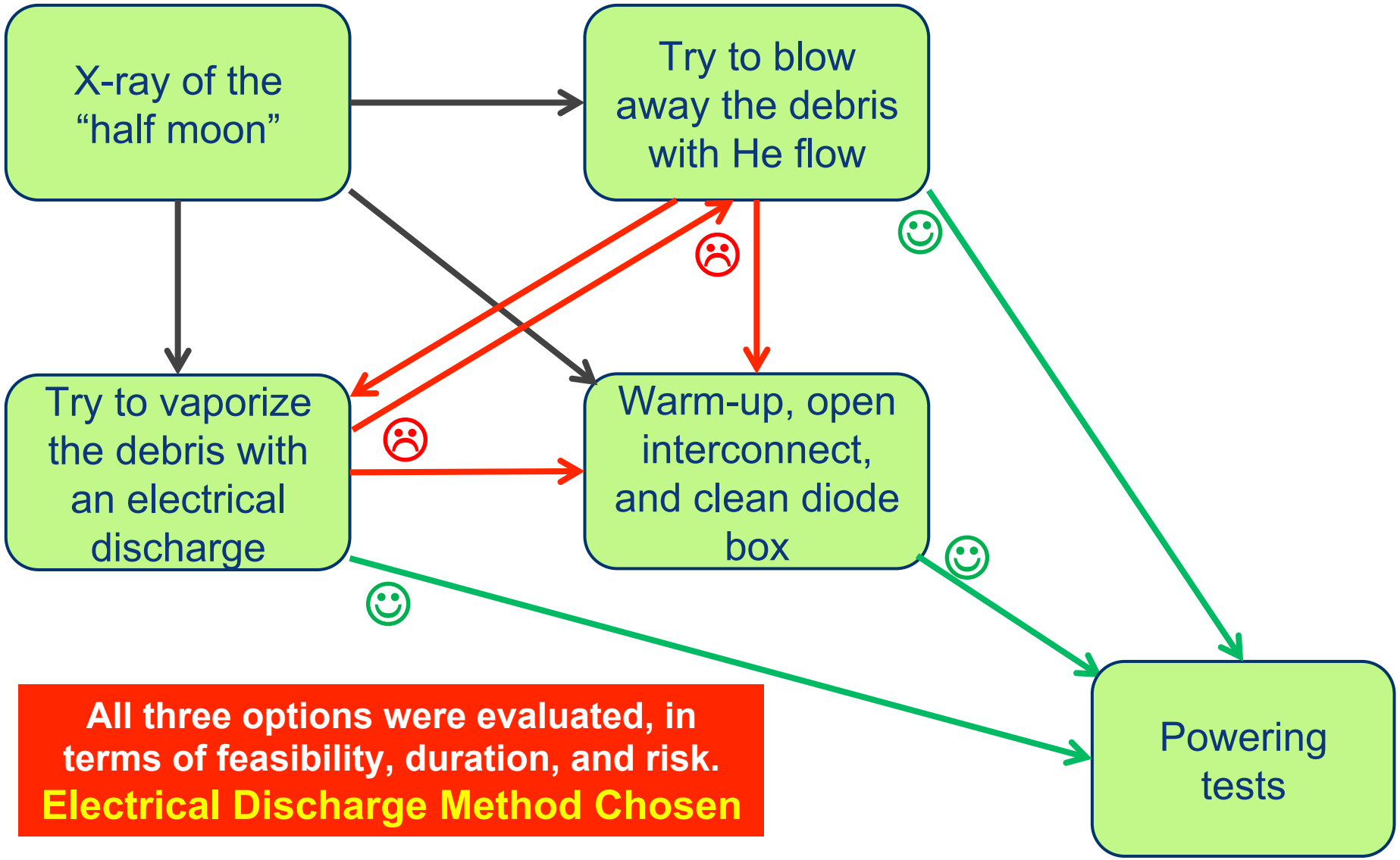
Unfortunately can not see the debris in the affected magnet

Metal chips and pieces found in the past



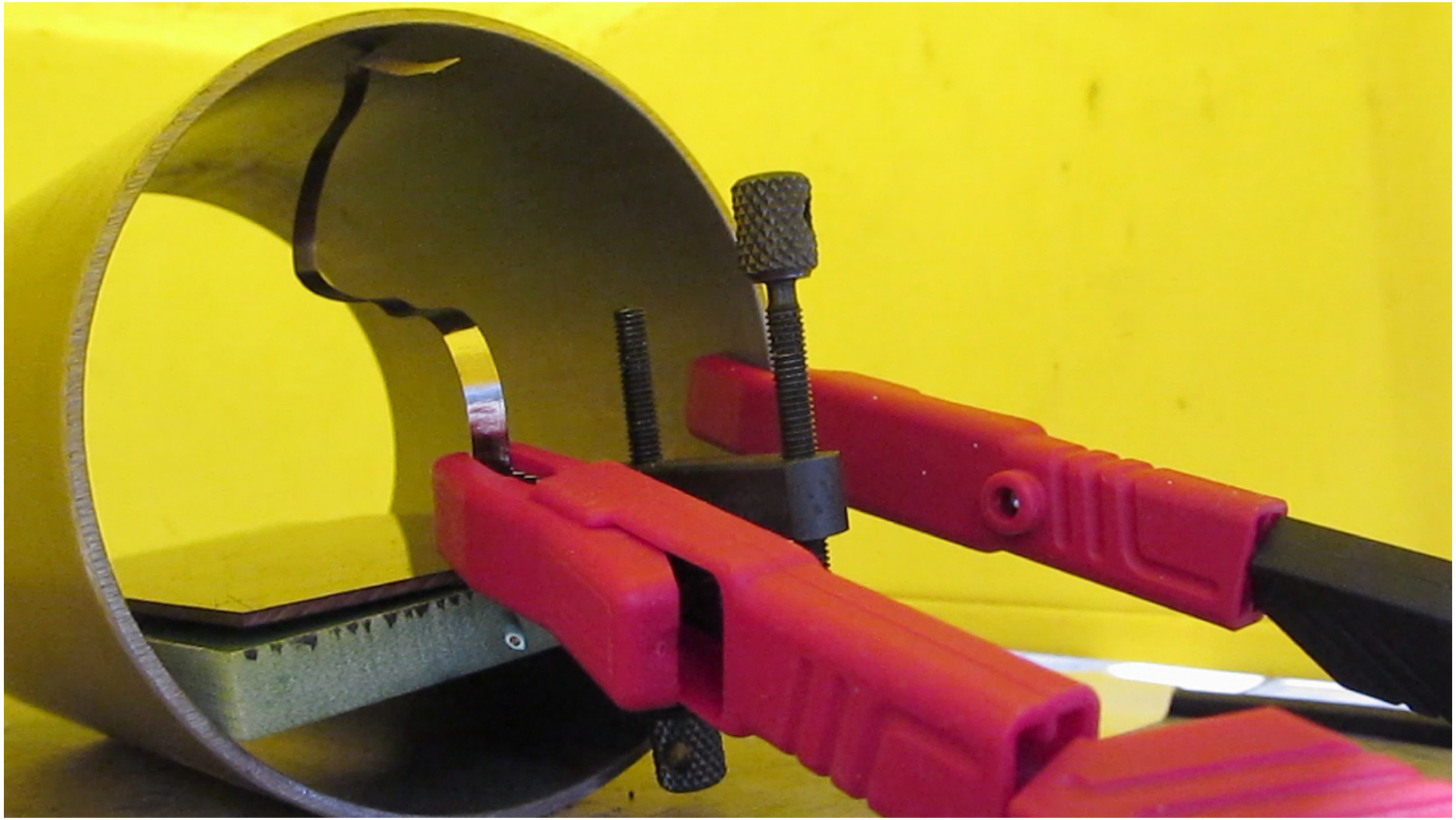


Three options were evaluated



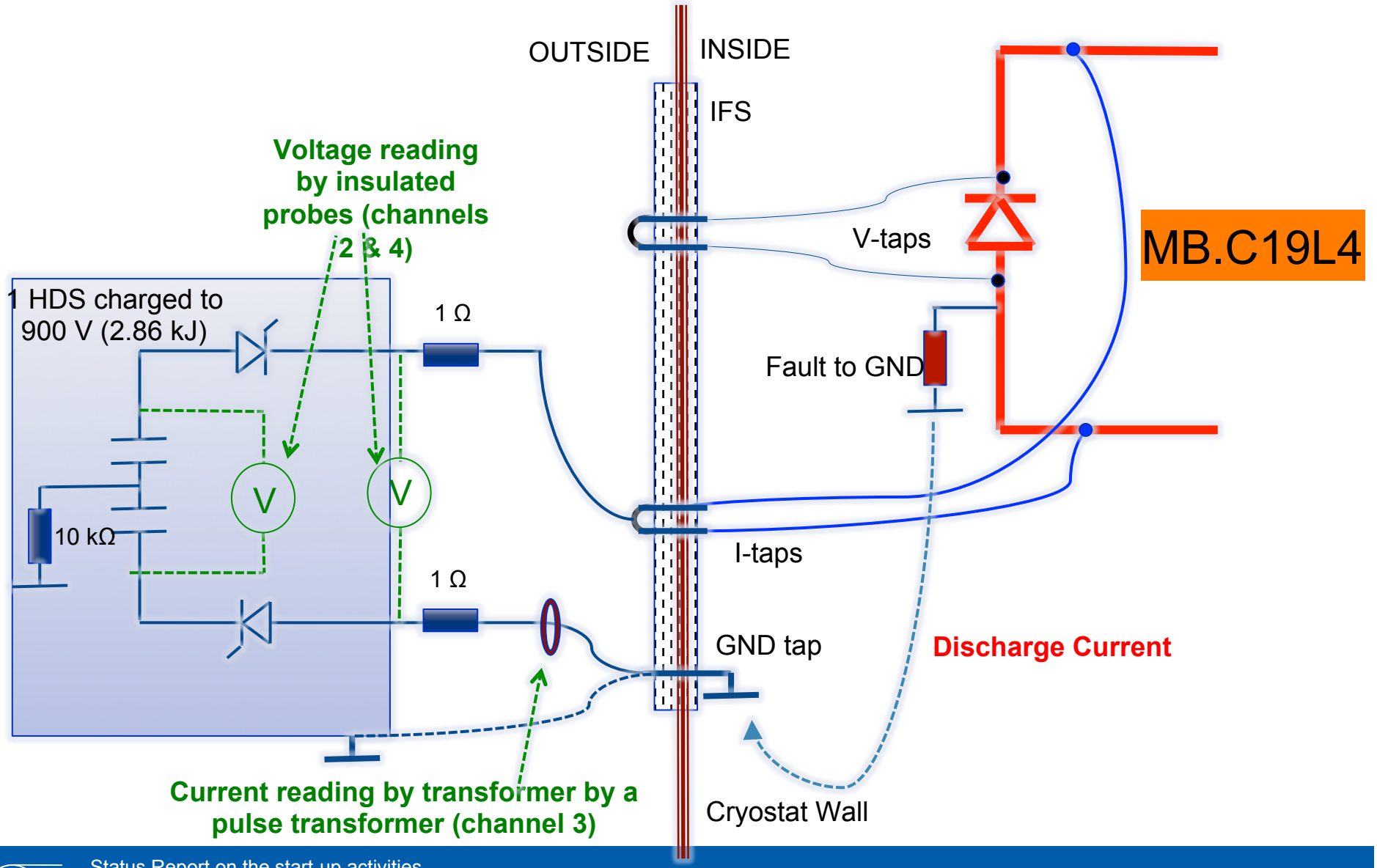
All three options were evaluated, in terms of feasibility, duration, and risk.
Electrical Discharge Method Chosen

One week of intense preparation



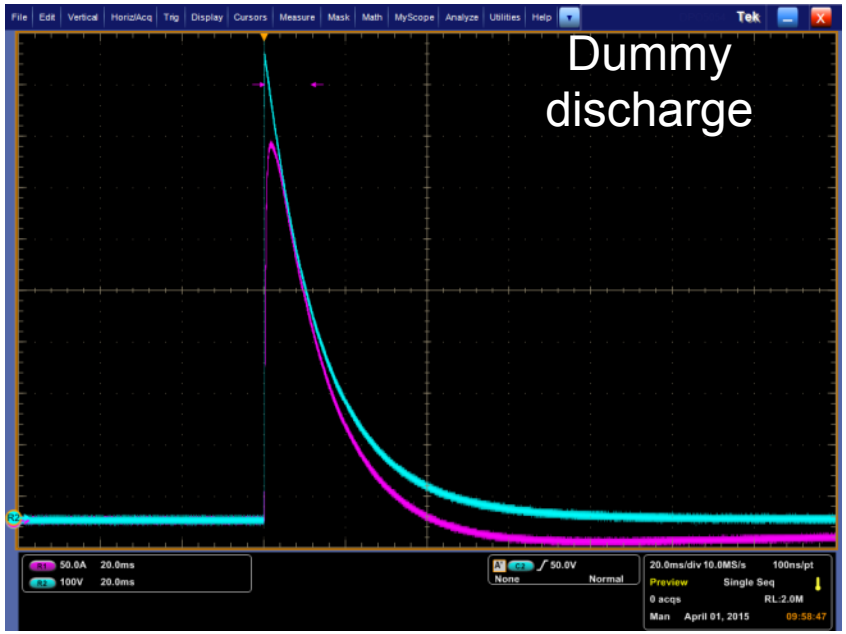
Courtesy Andrzej Siemko

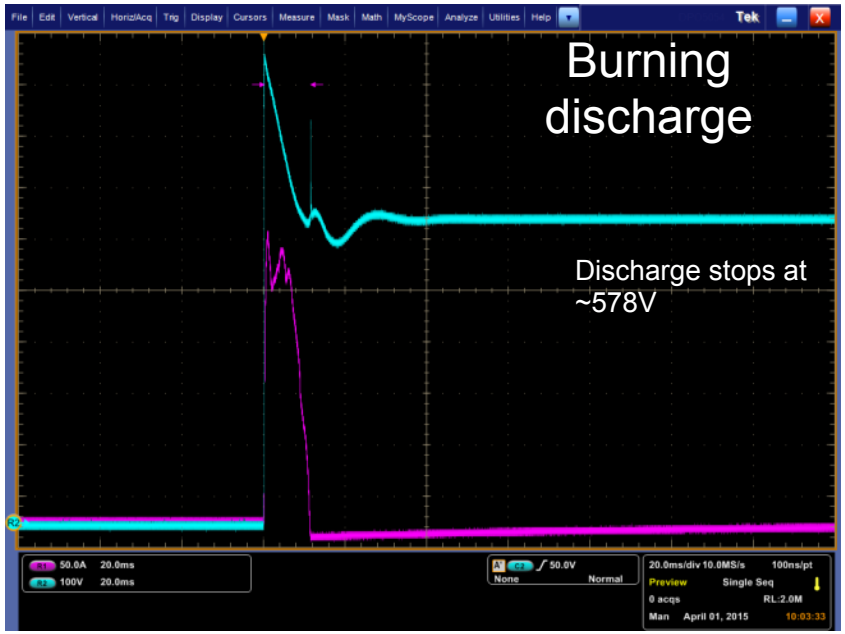
Discharge Set-Up

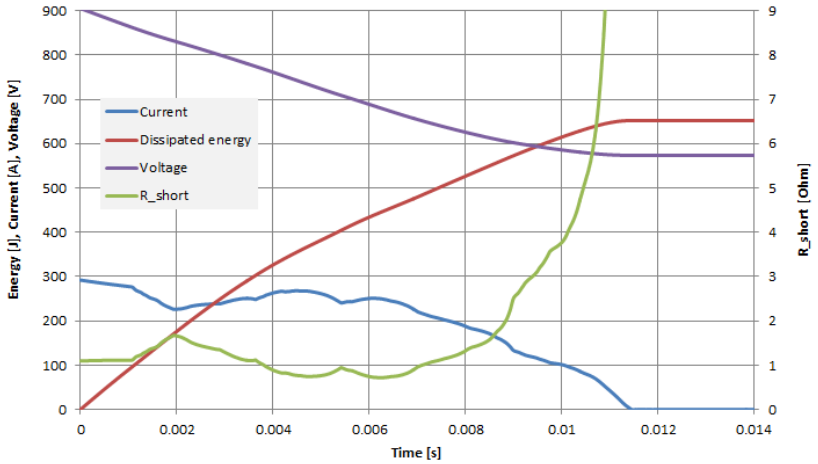


How it worked ?

and 11ms instead of 2 month
(10 days of thinking and preparation)

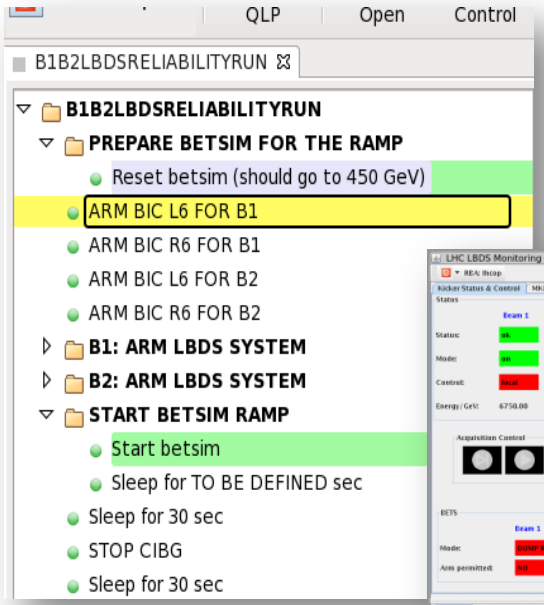






Discharge time:	~11.5ms
Discharge voltage:	906V to 578V
Dissipated energy:	~1.5kJ
Balancing resistors:	2x1Ohm
Short resistance:	~1 Ohm
Energy dissipated in short:	~500J

Beam dump system: Dry Runs

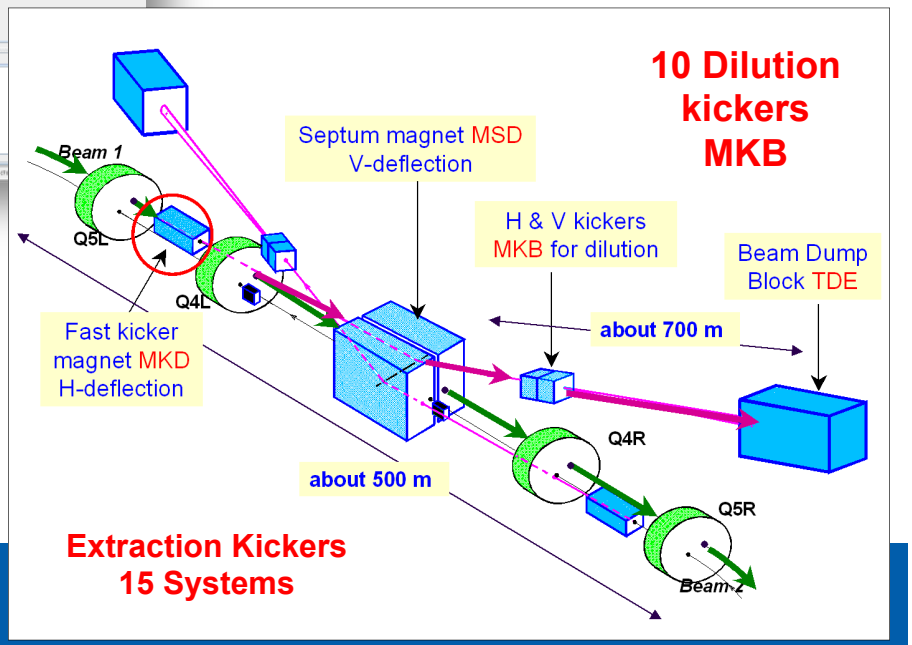


Beam dump reliability run

Early test campaigns of operational procedures by OP team from the control room

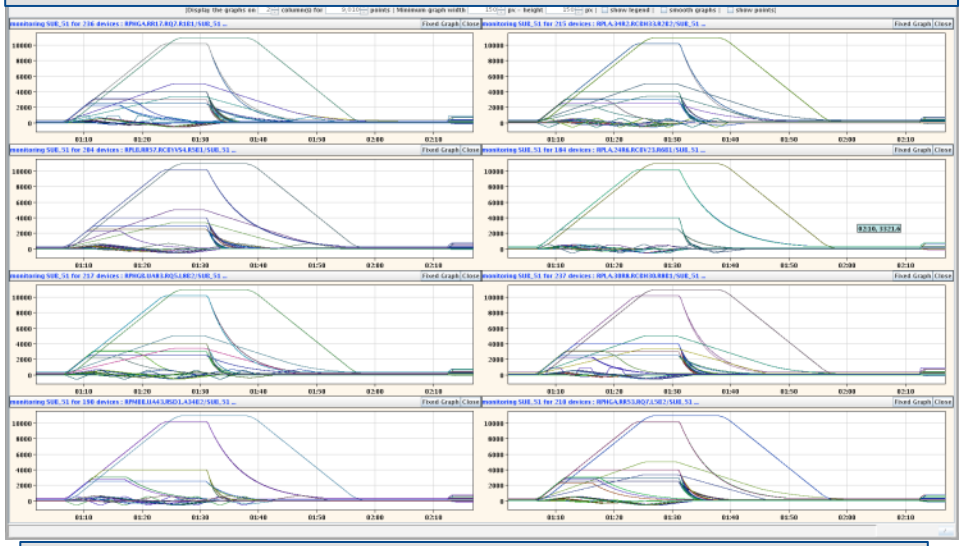
Remote reliability run:

- New arming sequence
- With local Beam interlock loop
- Energy ramp with energy tracking simulator
- Sequence to arm/ramp/dump that was played in a loop for several weeks.

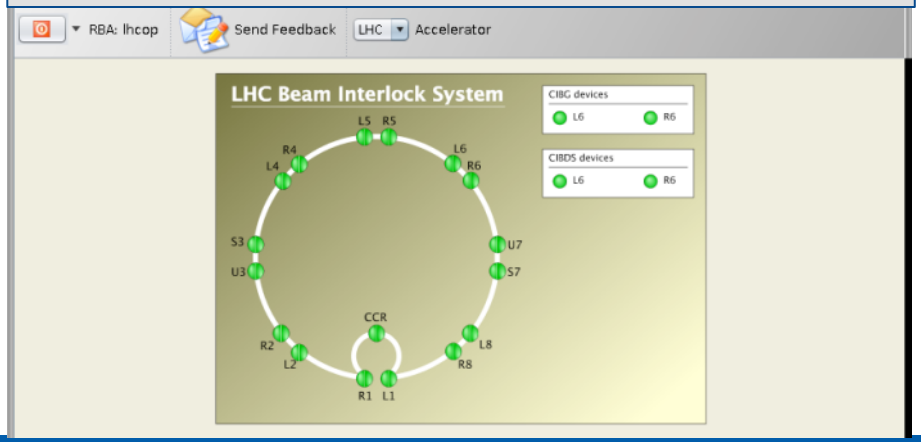


Final Preparations: Cold Checkout

First Cycle of the Complete Machine

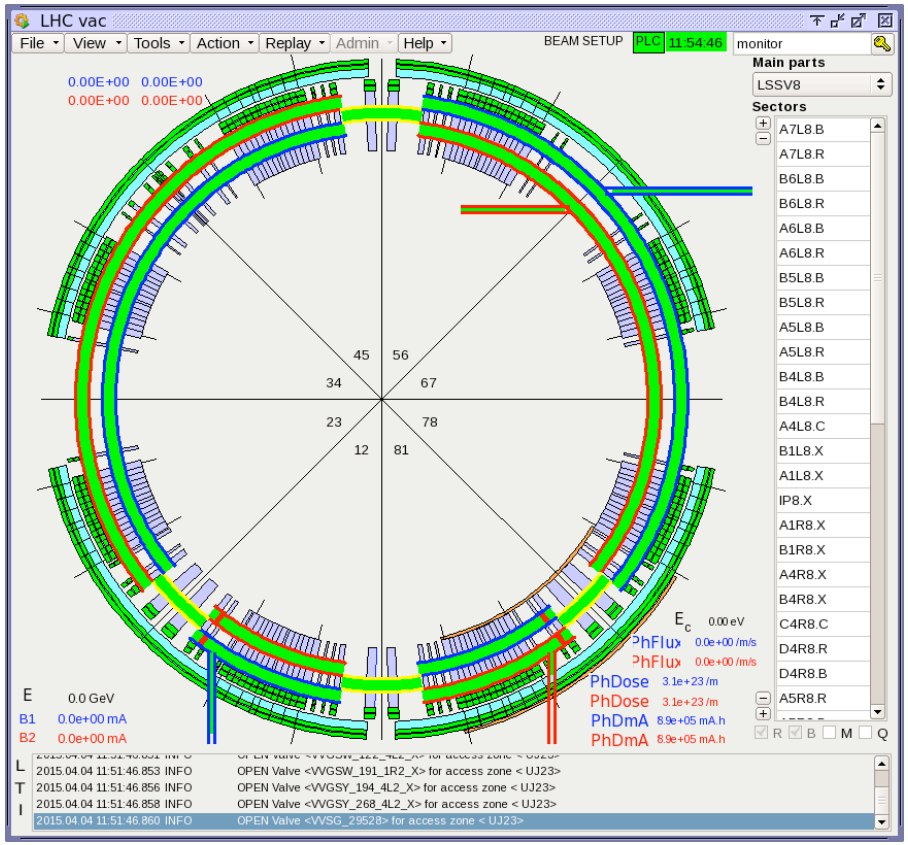


Beam Interlock Loop Closed



… all ready on Saturday 4th April

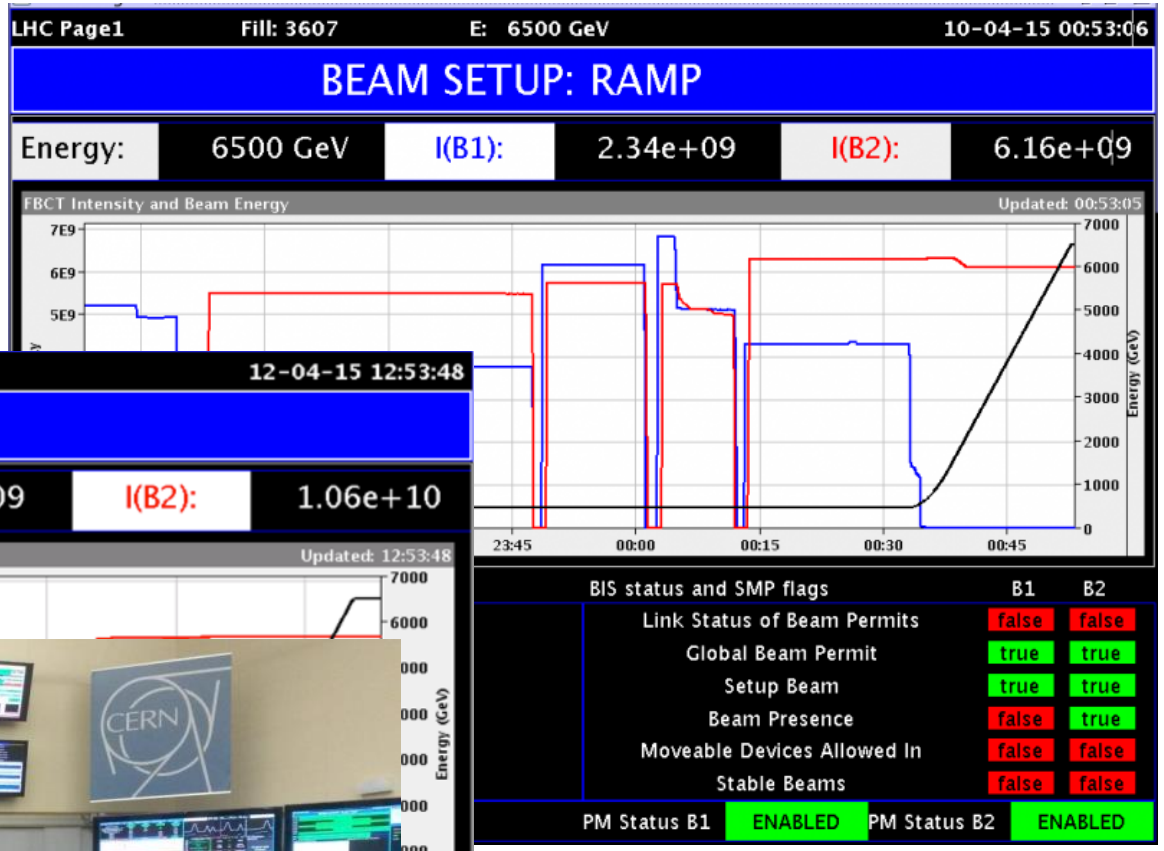
Vacuum Valves Open

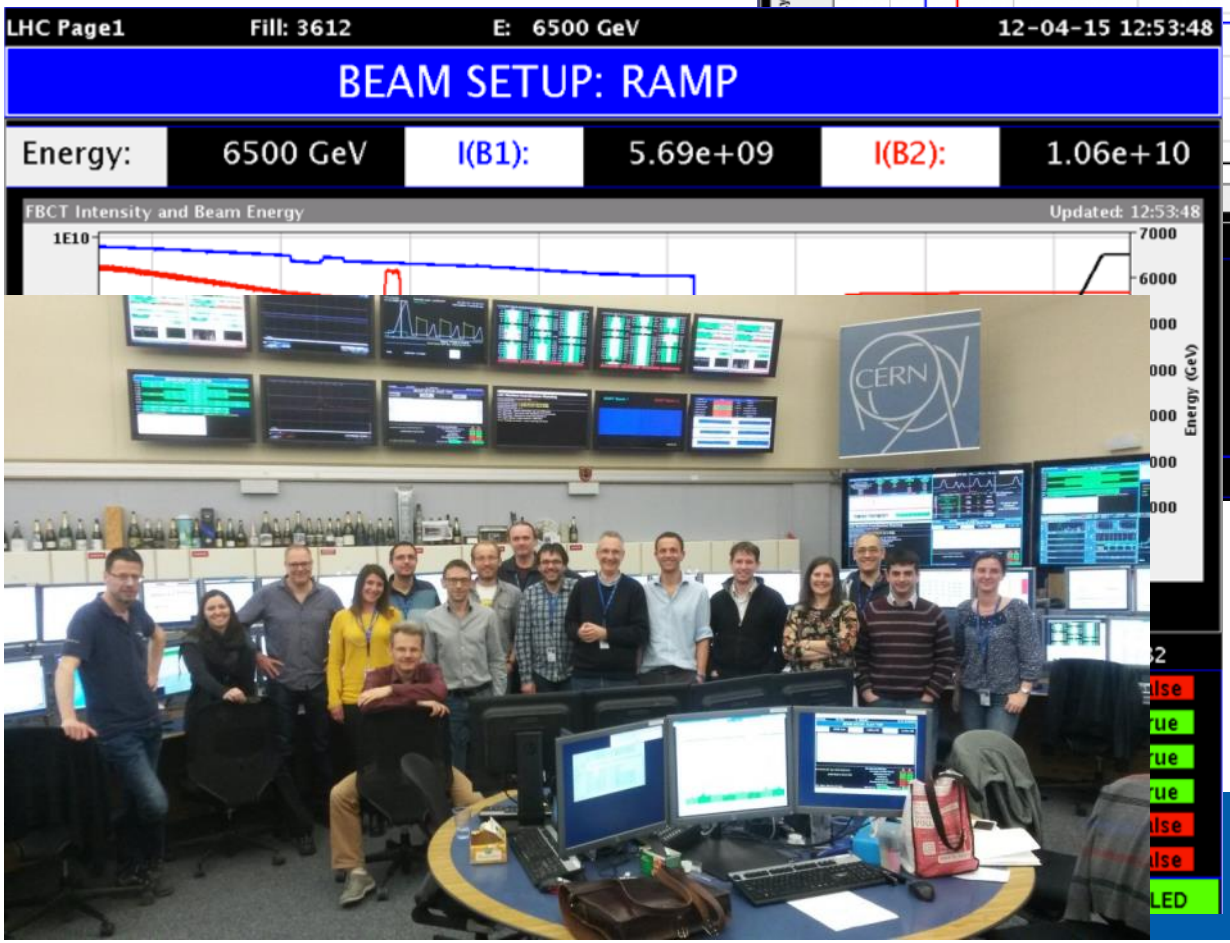


First circulating beams in LHC on Easter Sunday

5th April 2015

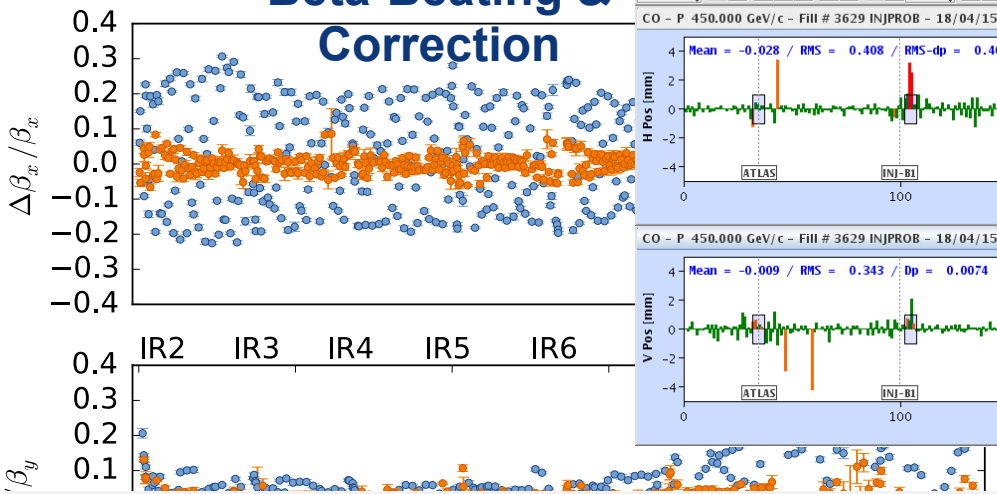
First beamS at 6.5 TeV! (12th April)



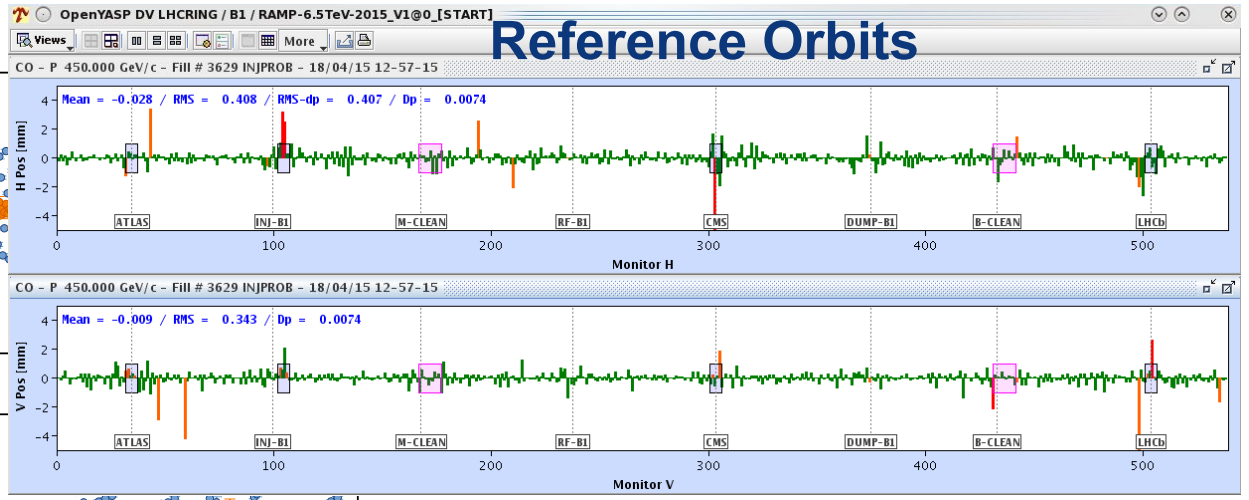


Beam Commissioning

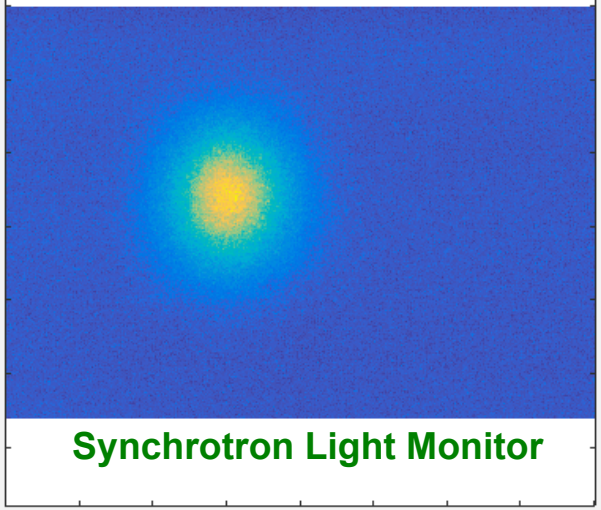
Beta-Beating & Correction



Reference Orbits

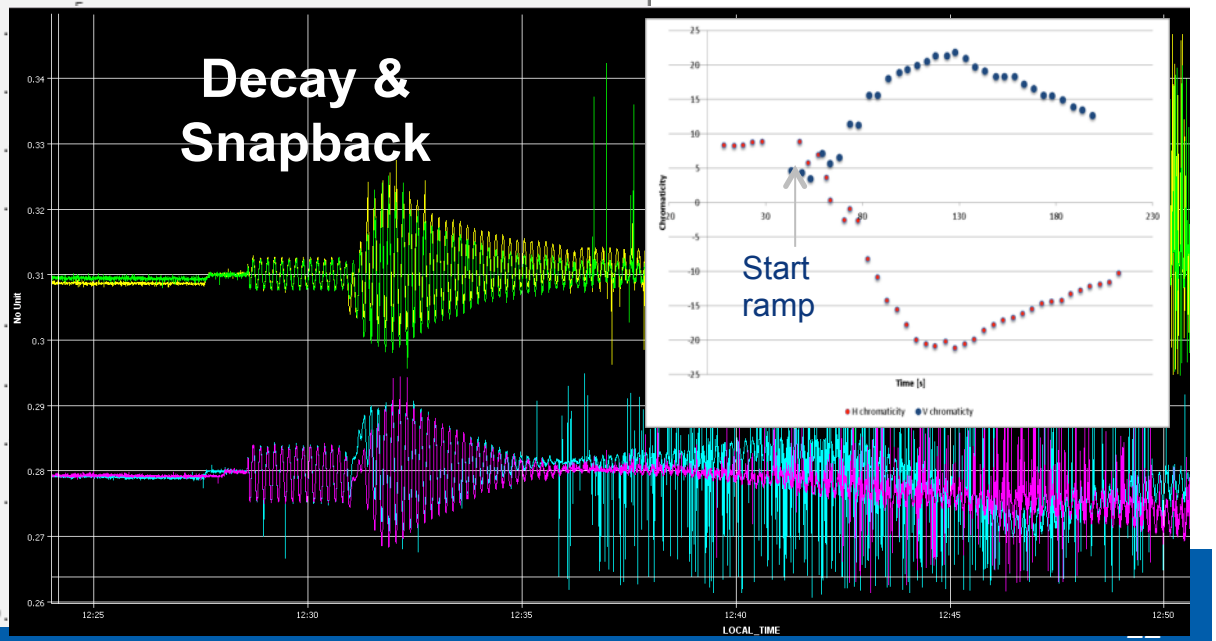


Beam Instrumentation



Synchrotron Light Monitor

Decay & Snapback



Beam Commissioning Roadmap

- **System commissioning with beam**
  - Collimation
  - Beam dump
  - Feedbacks
  - Beam instrumentation
  - Machine protection
  - RF
  - Transverse damper
  - Injection
- **Machine characterization**
  - Optics measurement and correction
  - Magnetic machine
- **Operations**
  - High intensity injection
  - Ramp to 6.5 TeV
  - First squeeze tests
  - Debugging
  - Squeeze
  - Collision

Injection - probe

Ramp - probe

Flat-top - probe

Squeeze - probe

Injection - nominal

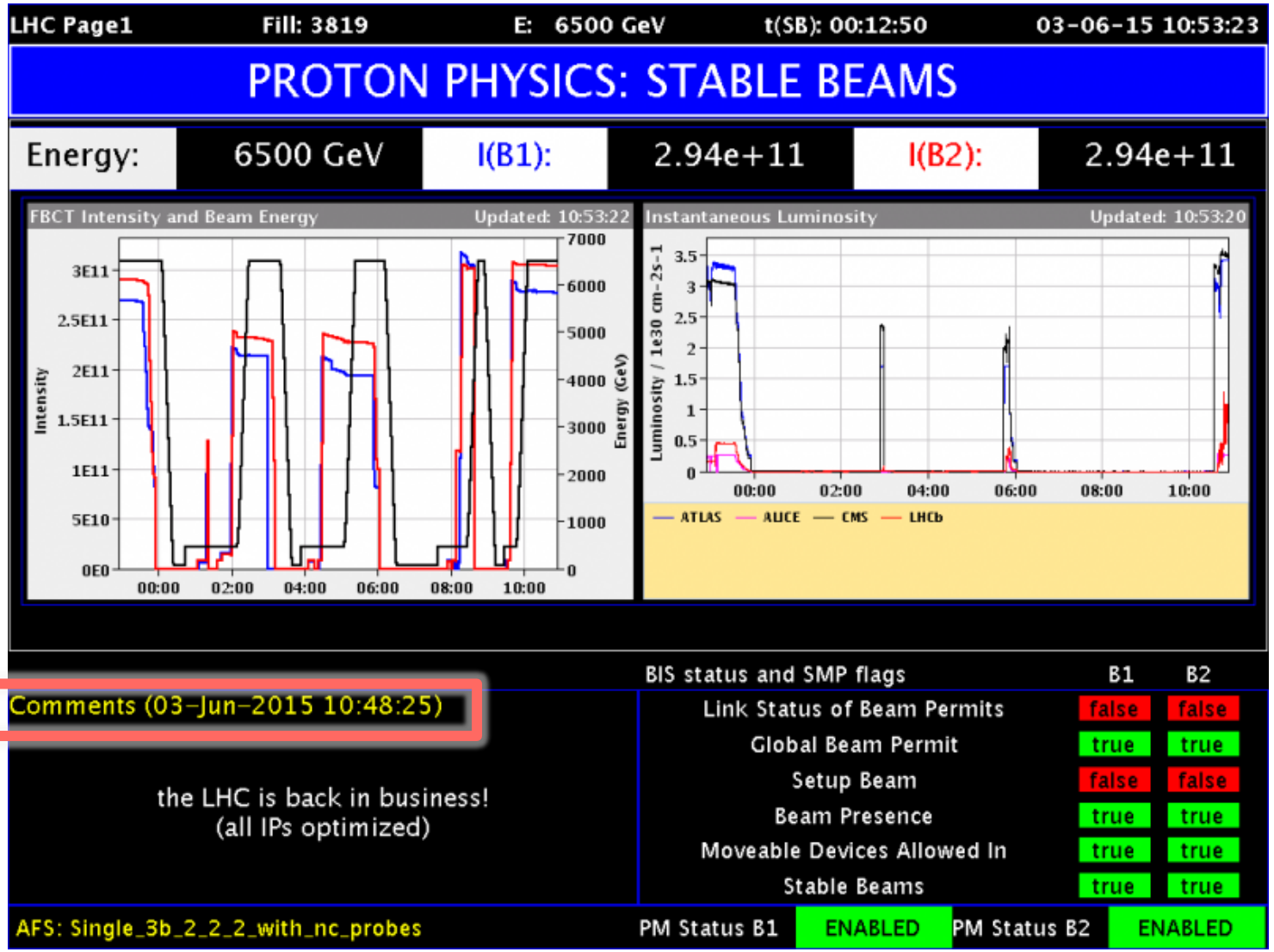
Ramp - nominal

Flat-top - nominal

Squeeze - nominal

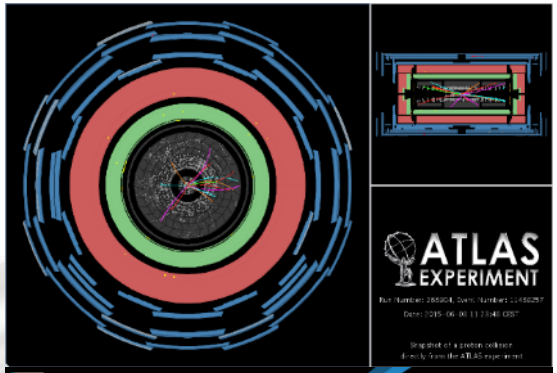
Collide & validation

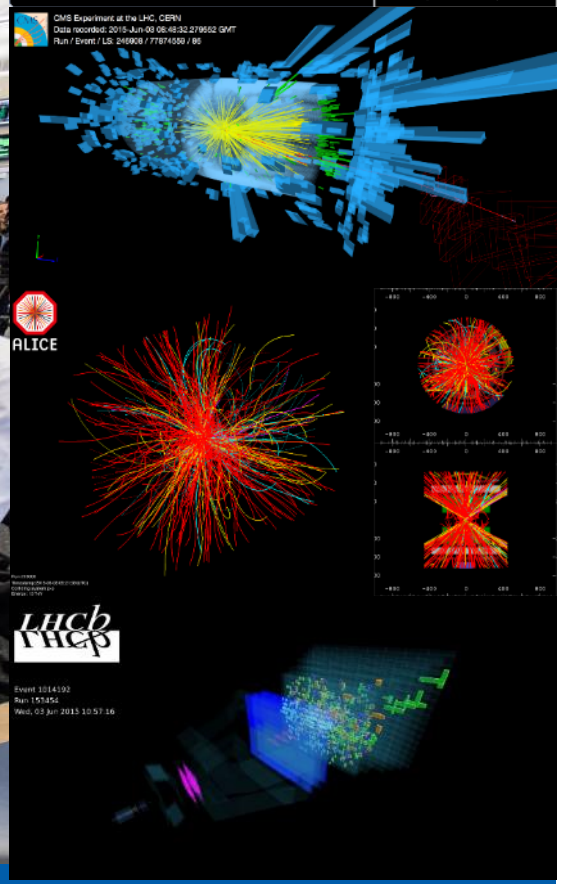
First stable beams in LHC: 3rd June 2015



LHC experiments are back in business at a new record energy **13 TeV**

3rd June 2015





Beam commissioning in two months ☺ 13 TeV

- **A lot of lessons learnt and experience from Run 1**
- Excellent and improved system performance **(LS1)**
  - Beam Instrumentation
  - Transverse feedback
  - RF
  - Collimation
  - Injection and beam dump systems
  - Vacuum
  - Machine protection
- Improved software & analysis tools **(LS1)**
- Magnetically reproducibility
- Optically good, corrected to excellent
- Behaving well at 6.5 TeV
  - One additional training quench so far
- Operationally well under control
  - Injection, ramp, squeeze, de-squeeze

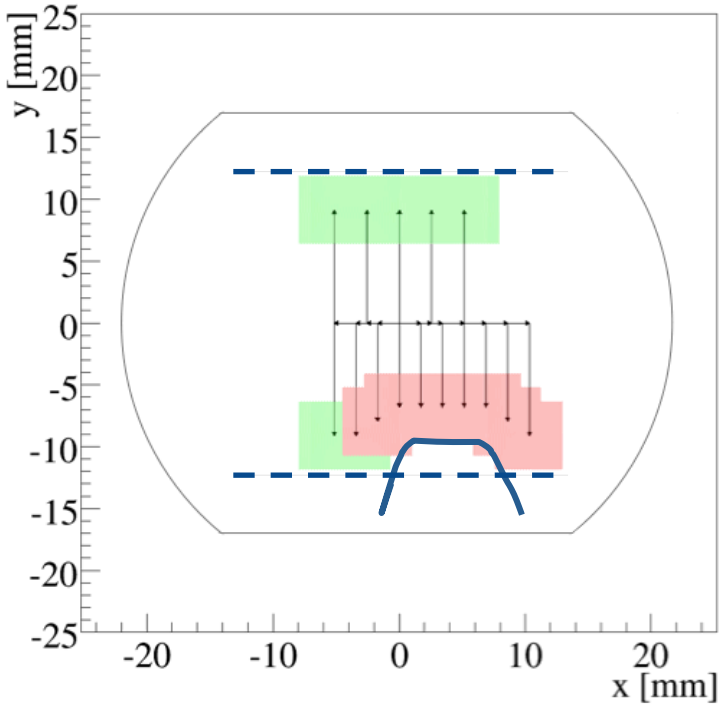
One cloud in the sky: Aperture in 15R8 : MUFO => ULO

Aperture restriction:

- **Measured at injection and 6.5 TeV**
- **UFO stopped after 2nd beam screen warm-up**
- **Reference orbit is bumped by +1mm in V and -3mm in H at 15R8.**
- **Probably not a limiting aperture for operation**
- **But stability of the object remains a concern**

…to come

- **How does it behave with higher intensities? bunch trains? …**

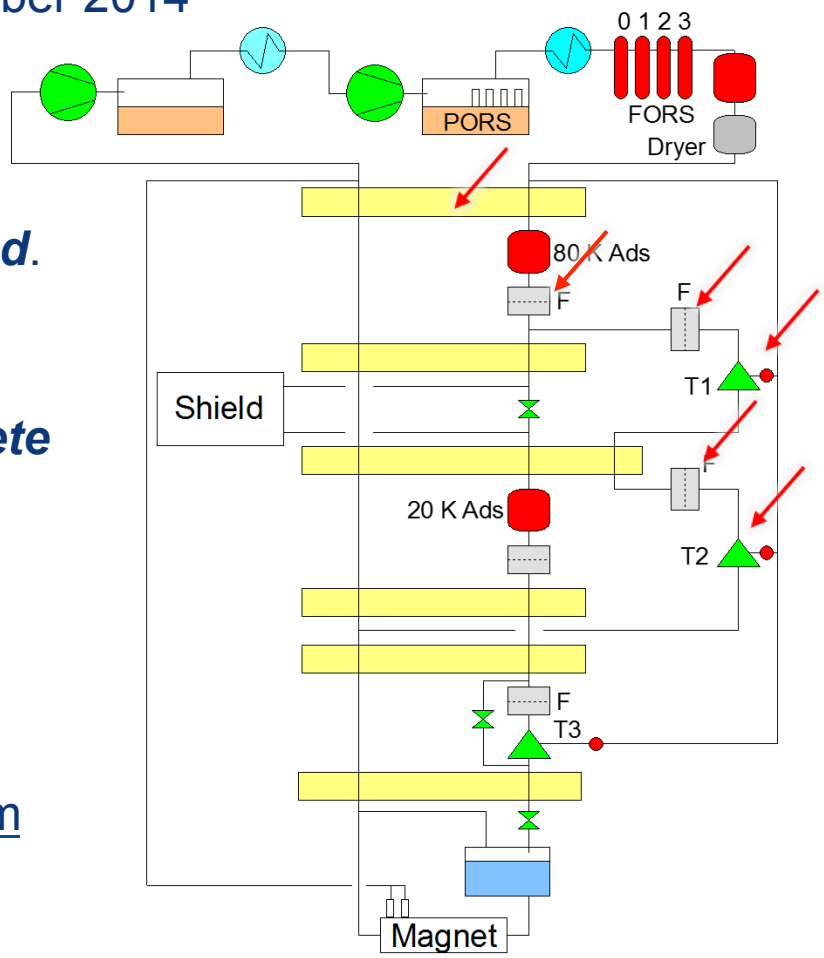


Still have to face the intensity ramp-up

- UFOs, e-cloud, beam induced heating, instabilities,… especially 25 ns
- **ULO (Unidentified Laying Objects)**

CMS Cold-Box Contamination
Summary of events (1/2)

- CMS refrigerator has been re-started in November 2014 after the LS1 maintenance;
- Mid March first sign of contamination, at that moment blamed on air / water-pollution. ***Procedures applied: sub-system regenerated***.
- Beginning of May contamination identified at three different points. ***Procedures applied: System stopped, samples taken and complete regeneration***.
- After re-start of system almost **immediate contamination measured** at same points. Confirmed by result analysis of samples. ***Procedures applied: System stopped.***
- Analyse shows compressor oil (Breox) milligram (mg) traces.



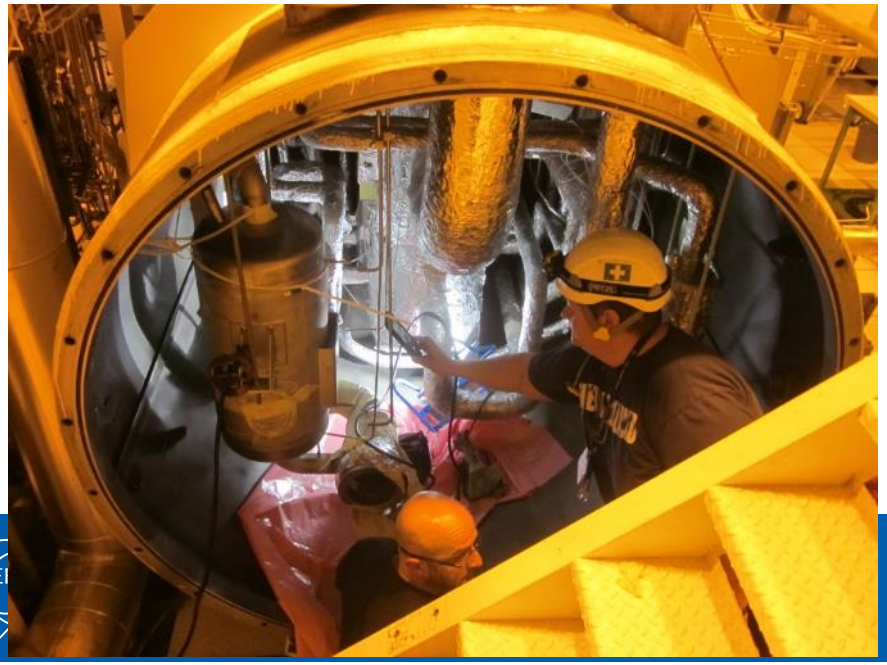
Courtesy Miguel Jimenez

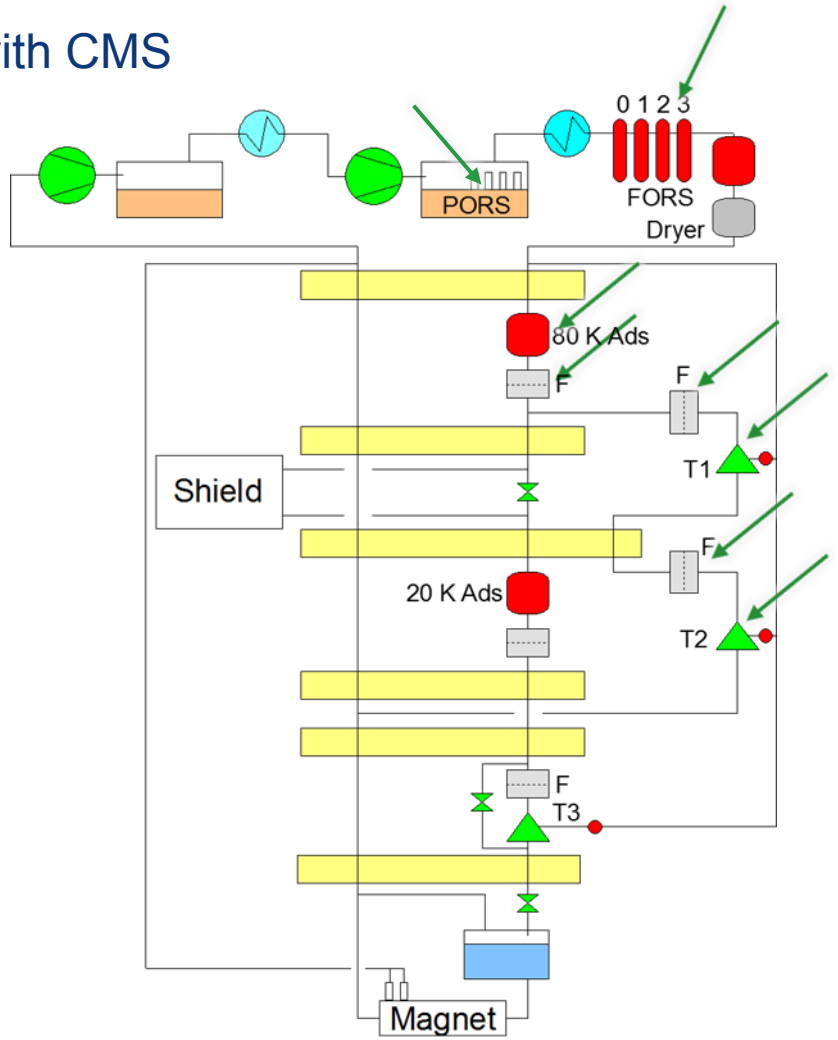
CMS Cold-Box Contamination
Summary of events (2/2)

Major intervention launched in agreement with CMS

1. Evaluate the oil removal system (one “loose” coalescer in oil-separator, replacement of several coalescers).

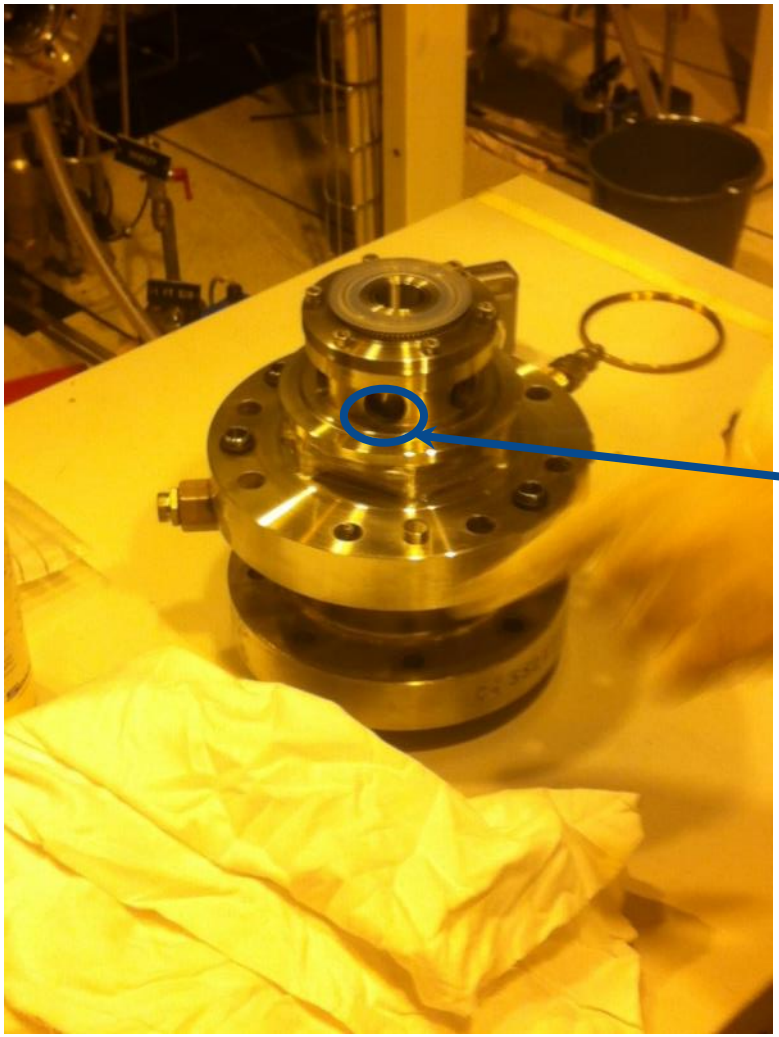
2. Dismount 80 K absorber, replace the active charcoal, clean the vessel and remount it, replace its outlet filter.

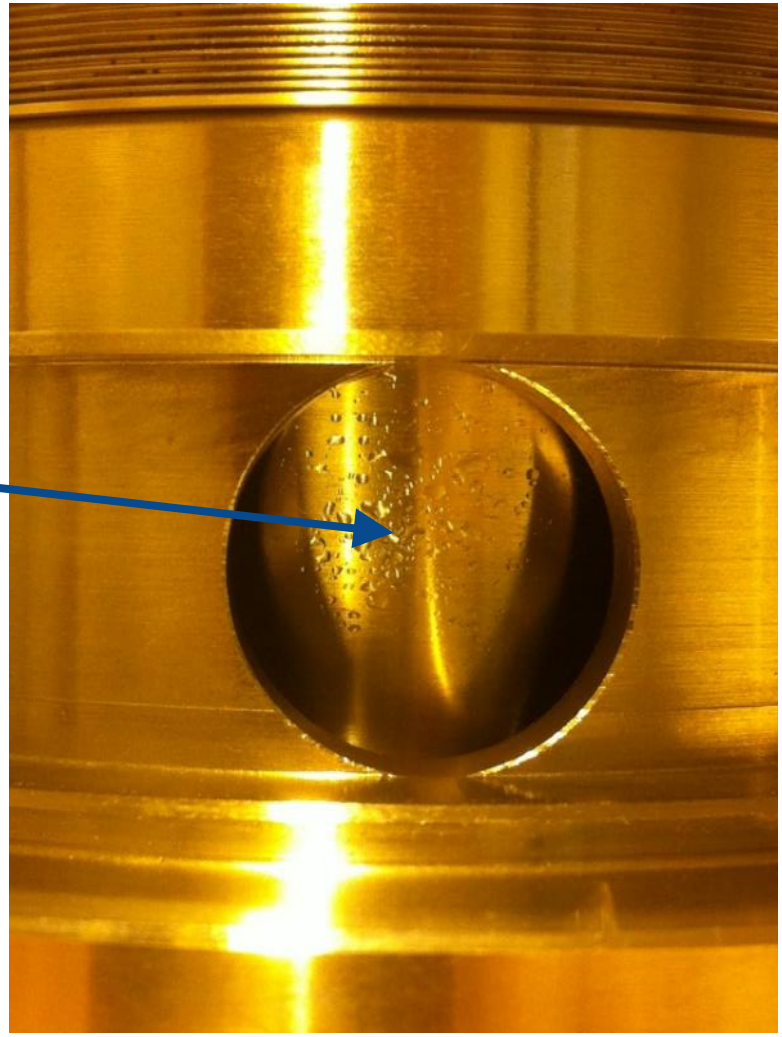




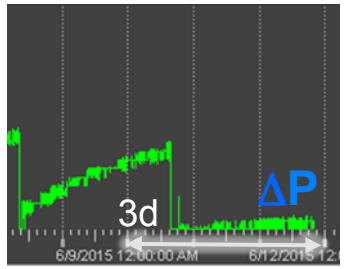
Courtesy Miguel Jimenez

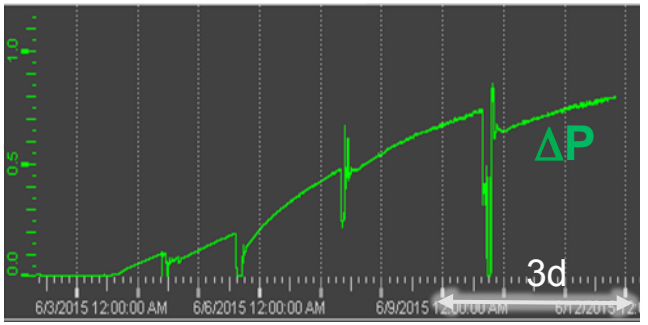
Turbine 1 dismounted: oil droplets





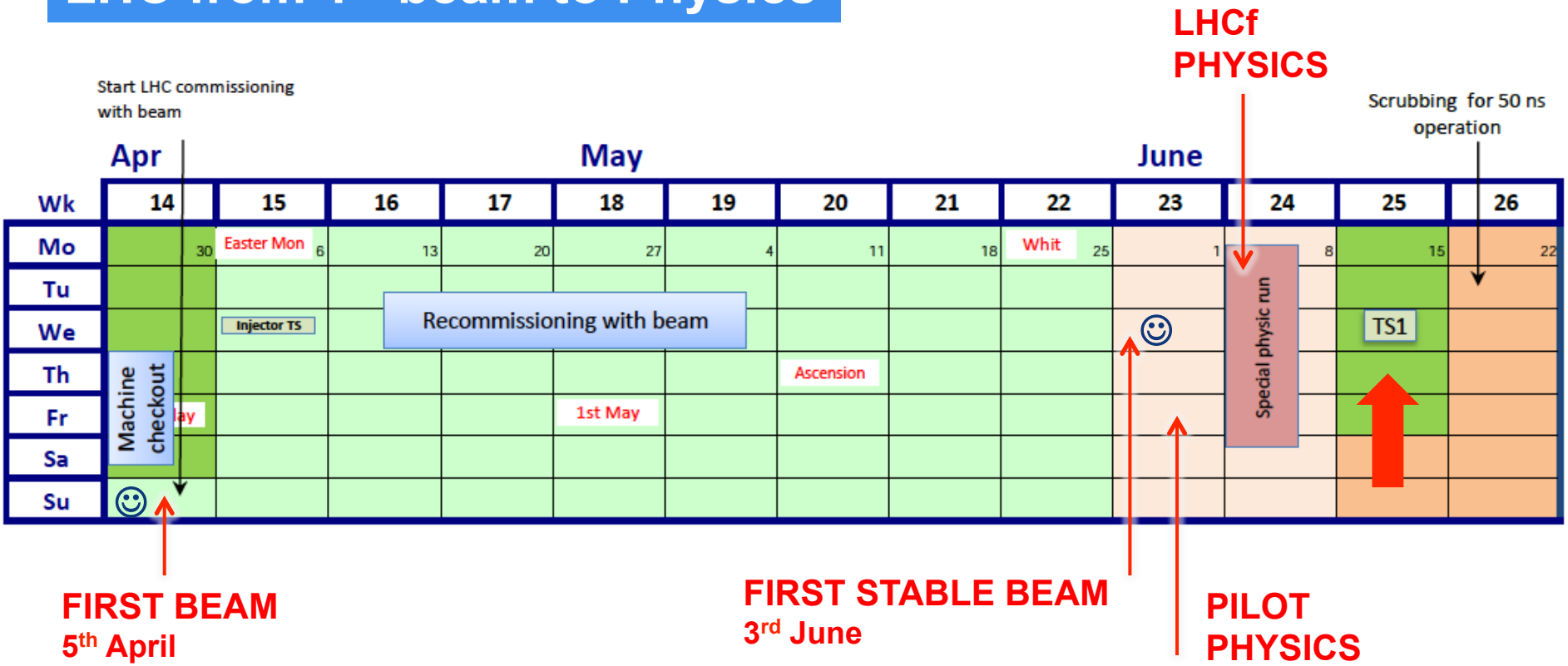
CMS Cold-Box Contamination
Perspectives





1. All checks had positive outcomes:
   - ΔT @ exchanger remains stable;
   - Negligible clogging (ΔP) of the newly installed T1 filter, Charcoal dust contamination was observed;
   - ΔP over the 80K absorber outlet filter is showing a clear tendency to saturation;
   - No leak found;
   - No gas contamination found (online chromatography).
2. Agreed schedule:
   - Friday 12th, proceed with cool down of thermal screen
   - Sunday 14th, warm up of the Cold-Box;
   - Monday 15th, flushing of 80 K absorber charcoal and filter exchange;
   - Wednesday 17th, resume cool down of Cold-Box;
   - Thursday 18th, Cold-Box ready to be connected to CMS Magnet.
3. CMS planning:
   - Friday 19th June, Cold-Box fully released for operation.
   - Sunday 21st June, Start cool down of CMS magnet: 5 days needed.
   - Friday 26th June, CMS ready for powering of the magnet.
   - Sunday 28th June, CMS Fully operational (magnet powered)

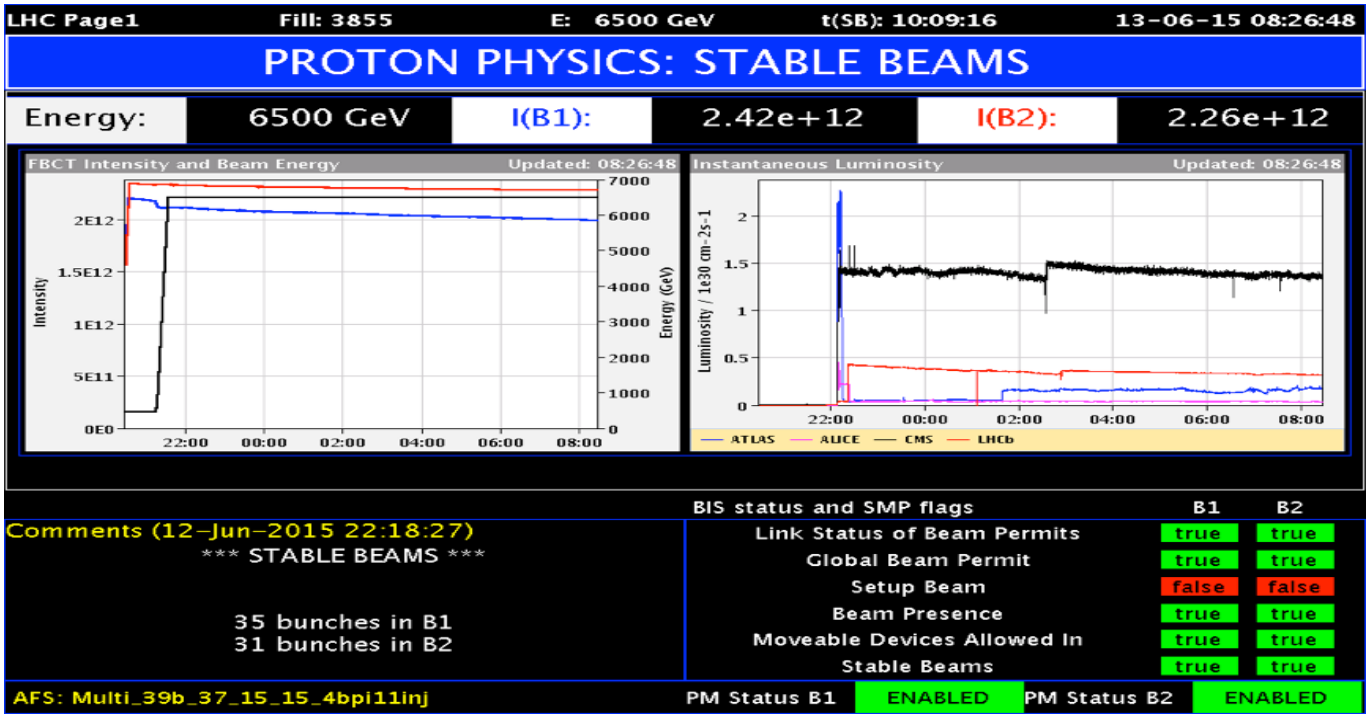
LHC from 1st beam to Physics



- 8 weeks beam commissioning
- Pilot physics – up to ~40 bunches per beam
- 5 days special physics at beta* = 19 m LHCf, (VdM, TOTEM & ALFA - postponed)
- Start technical stop – 15th June

LHCf physics

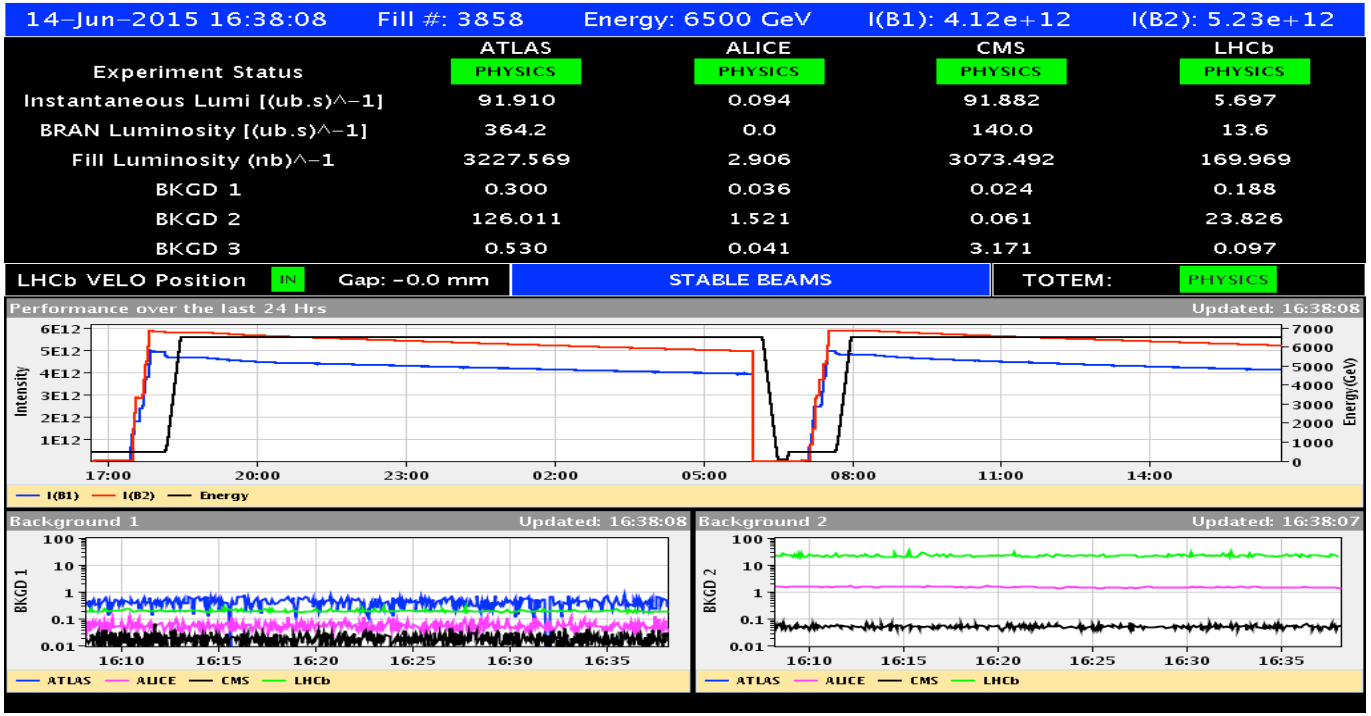
Request: 10 nb^{-1}



fill	Stable beams	nb^{-1}	bunches
3846	1h55m	0.1	39 pilots
3847	2h16m	0.28	39 pilots
3848	2h42m	0.91	12 nominal
3850	2h49m	1.95	39 nominal
3851	11h13m	6.81	39 nominal
3855	14h15m	6.49	39 nominal

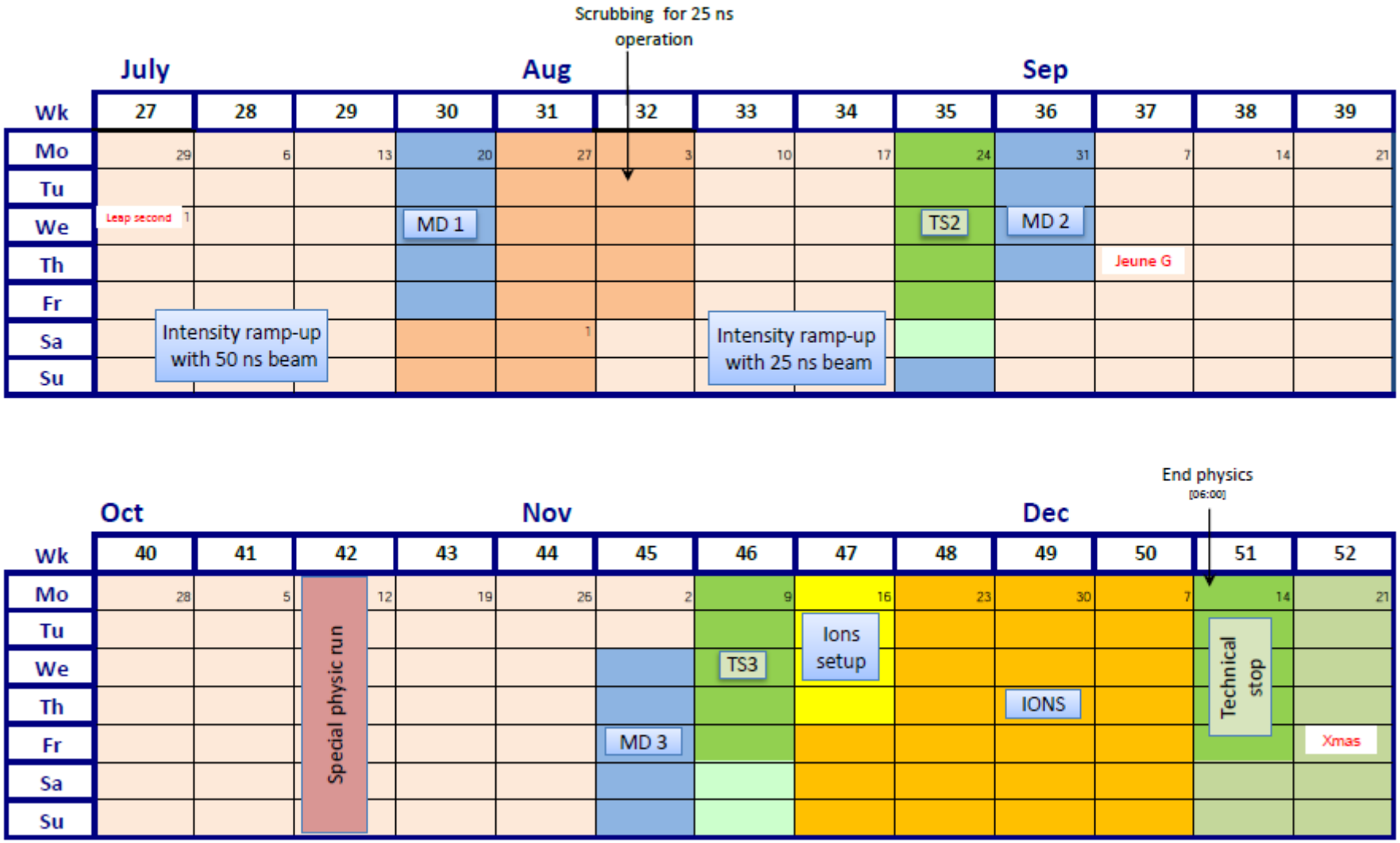
$\Sigma > 16\ nb^{-1}$

Last Weekend: start of intensity ramp-up 50 bunches



Number of bunches	**50**
Number of colliding bunches (ATLAS/CMS)	**38**
Peak luminosity	**1.45 x 10^{32} $cm^{-2}s^{-1}$**
Integrated luminosity	**3.8 + 3.5 pb^{-1}**
Peak <Events>/BX	**~27**

LHC 2015 – Q3/Q4



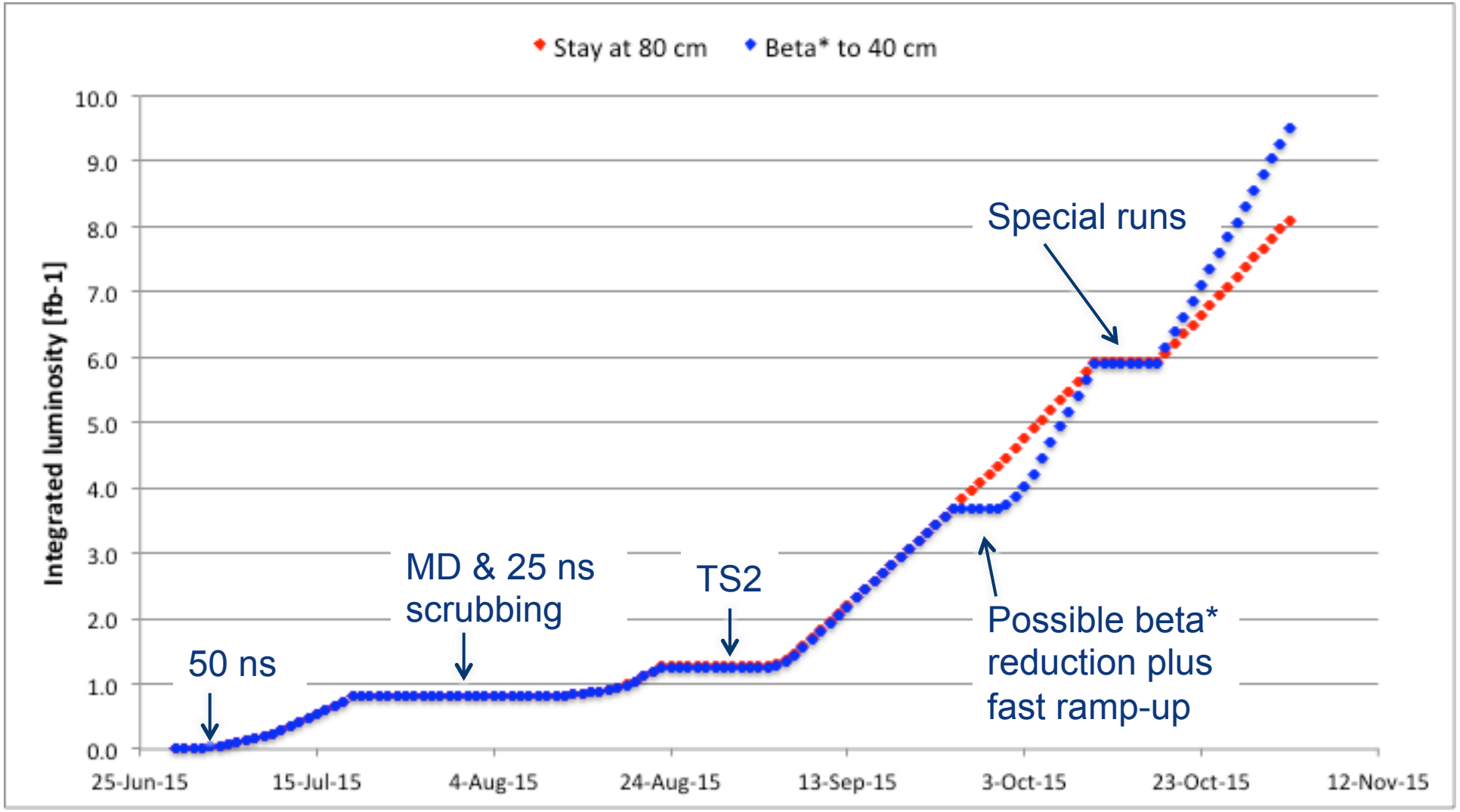
LHC schedule 2015: latest schedule

Phase	Days
Initial Commissioning	57
Scrubbing	23
Special physics run 1 (LHCf/VdM)	5
Proton physics 50 ns	**9 + 21**
Proton physics 25 ns	**70**
Special physics run 2 (TOTEM/VdM)	7
Machine development (MD)	15
Technical stops	15
Technical stop recovery	3
Ion setup/Ion run	4 + 24
Total	**253 (36 weeks)**

Four weeks delay from:
- Powering tests/quench training overrun
- Earth fault resolution (sector 3-4)

LHC 2015: projection

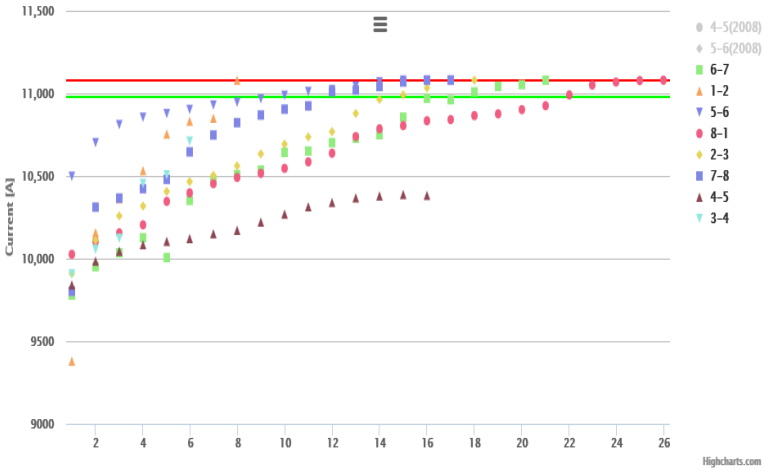
Including intensity ramp-ups and steadily increasing physics efficiency



Courtesy Mike Lamont

Conclusion (March 2015)

Safety First,
Quality Second,
Schedule Third.

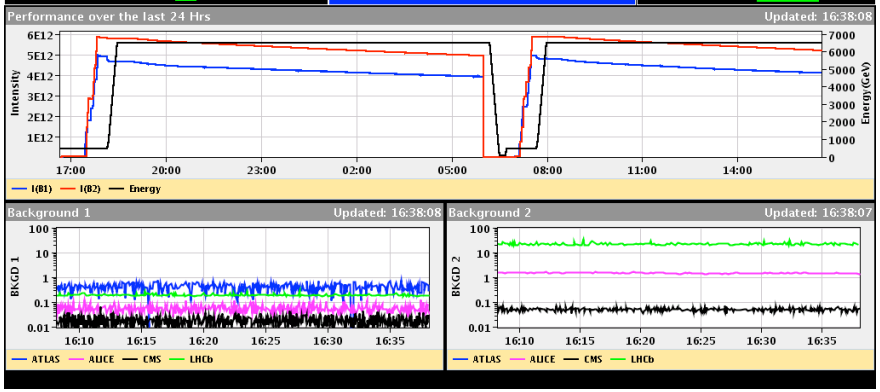


Conclusion (June 2015)

KEEP CALM BECAUSE WE DID IT

Safety First, Quality Second, Schedule Third.

14-Jun-2015 16:38:08	Fill #: 3858	Energy: 6500 GeV	I(B1): 4.12e+12	I(B2): 5.23e+12
	ATLAS	ALICE	CMS	LHCb
Experiment Status	PHYSICS	PHYSICS	PHYSICS	PHYSICS
Instantaneous Lumi [(ub.s)^-1]	91.910	0.094	91.882	5.697
BRAN Luminosity [(ub.s)^-1]	364.2	0.0	140.0	13.6
Fill Luminosity (nb)^-1	3227.569	2.906	3073.492	169.969
BKGD 1	0.300	0.036	0.024	0.188
BKGD 2	126.011	1.521	0.061	23.826
BKGD 3	0.530	0.041	3.171	0.097
LHCb VELO Position: IN	Gap: -0.0 mm	STABLE BEAMS	TOTEM: PHYSICS	



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2015: ATLAS and CMS performance

- Beta* = 80 cm, possible reduction later in year (count 4 days plus fast intensity ramp up)
- Nominal bunch population for 50 and 25 ns
- Reasonable emittance into collisions
- Assume slightly worse machine availability than in 2012
- TDI limit:144 bunches/injection – colliding bunches for 25 ns down to 2376
- If things go well… (recall 2012 – 1 fb^{-1}/week with ~7e33 $cm^{-2}s^{-1}$)

	Nc	β*	ppb	EmitN	Lumi [$cm^{-2}s^{-1}$]	Days (approx)	Int lumi	Pileup
50 ns	1300	80	1.2e11	2.5	4.8e33	21	< 1 fb^{-1}	25
2015.1	2376	80	1.2e11	3.1	7.0e33	35	~5 fb^{-1}	21
2015.2	2376	40	1.2e11	3.1	1.2e34	30	~4 fb^{-1}	35

GPD Integrated luminosity target for the year was 10 fb^{-1}
(after Chamonix workshop Oct. 2014)

Now on the challenging side – 5 to 10 fb^{-1}