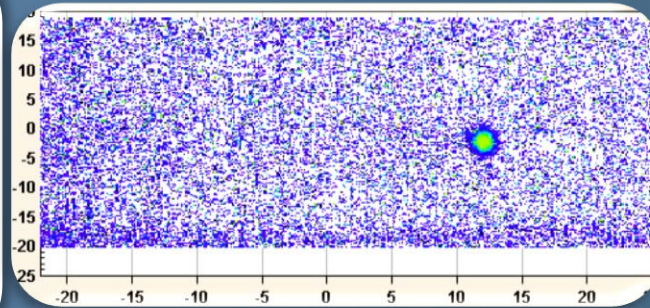
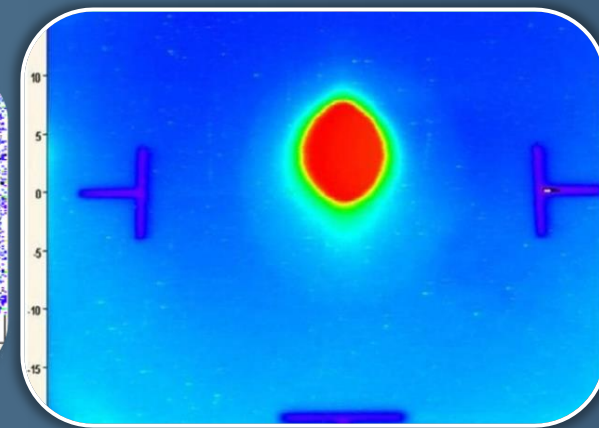




TI8: 23rd Oct 2004



TI8: 2005 The first hole



TI2: Autumn 2007

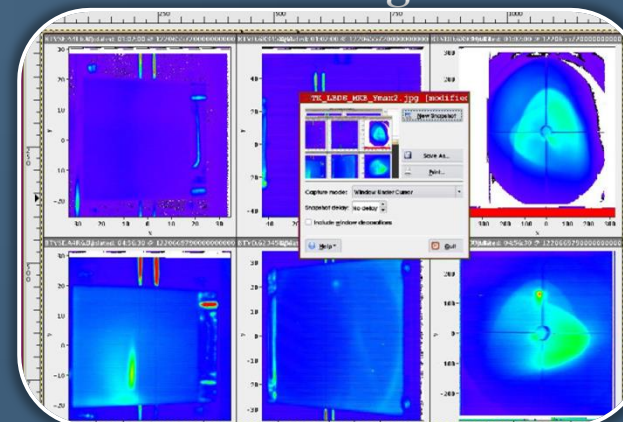
LHC TRANSFER LINES AND SECTOR TESTS

2014-2015

First: credits → CO, ABT, ABP, ASR, BI, OP, RF, CV, EPC, MPE, VSC, MEF, ALICE, LHCb, CMS, ATLAS



TI8: 22nd Aug 2008



S7826LBDS: 5th Sep 2008

Verena Kain
Reyes Alemany

during LS1



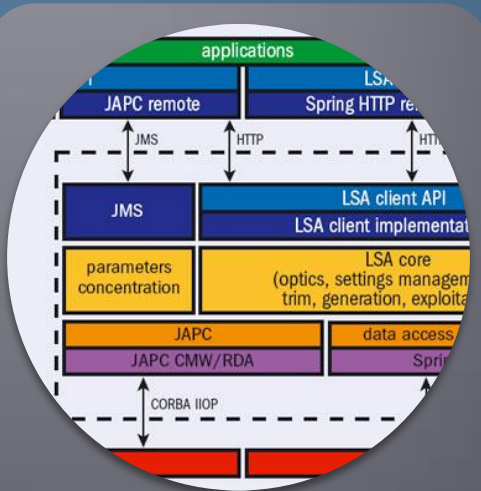
after LS1



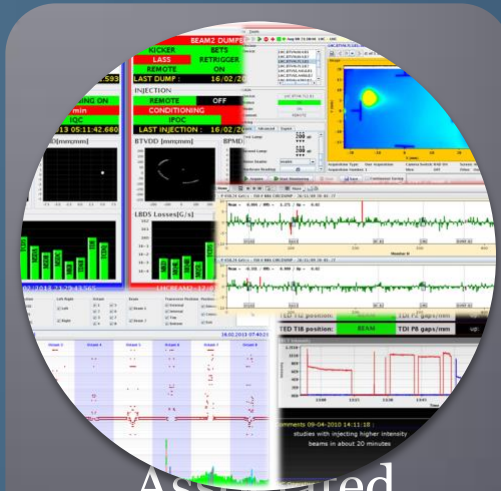
Motivation



Machine sub-systems operational

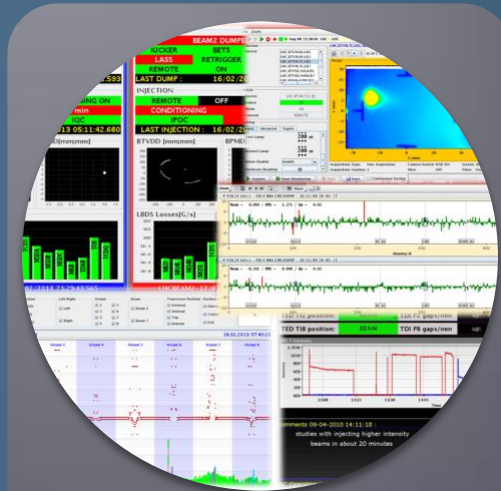
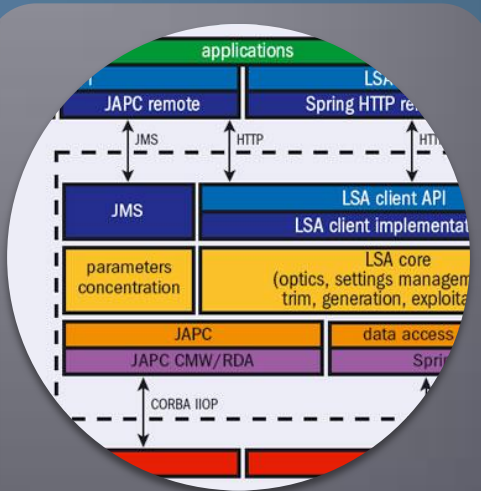


Fully integrated into the control system



Associated application software and cycle management available

Motivation



- SPS-LHC Injection & Dump synchronization & Timing
- BLM, BTV, BPM Commissioning
- Linear Optics and Dispersion (TL+Ring matching)
- BPM & MAGNETS POLARITY
- First probe of the APERTURE

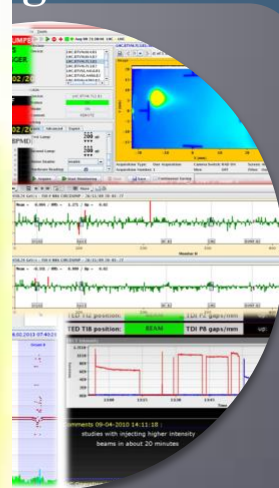
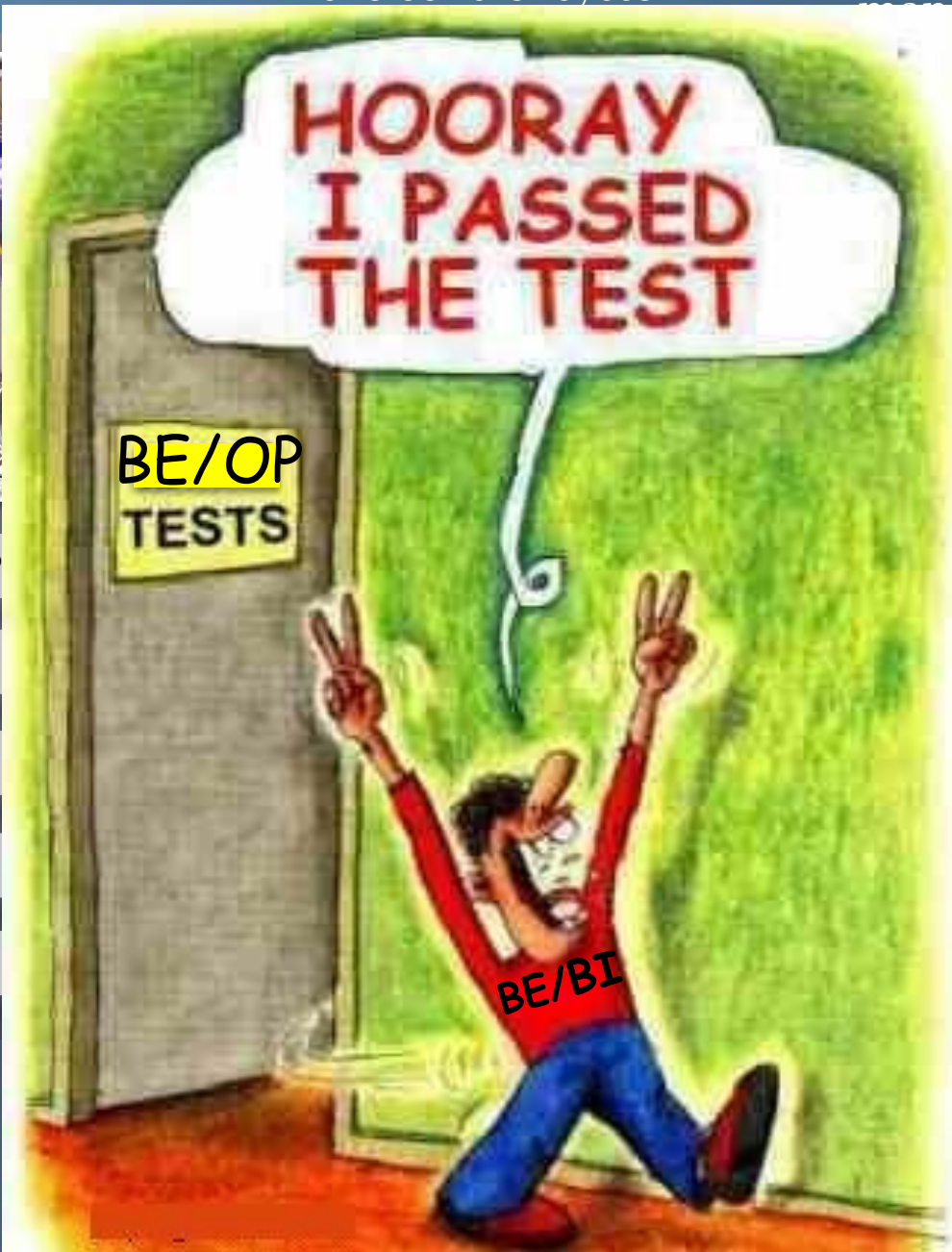
BLM: Beam Loss Monitors
BTV: Beam screens
BPM: Beam Position Monitors
TL: Transfer Line

Motivation

Machine sub-systems operational

Fully integrated into the control system

Associated application software and cycle management



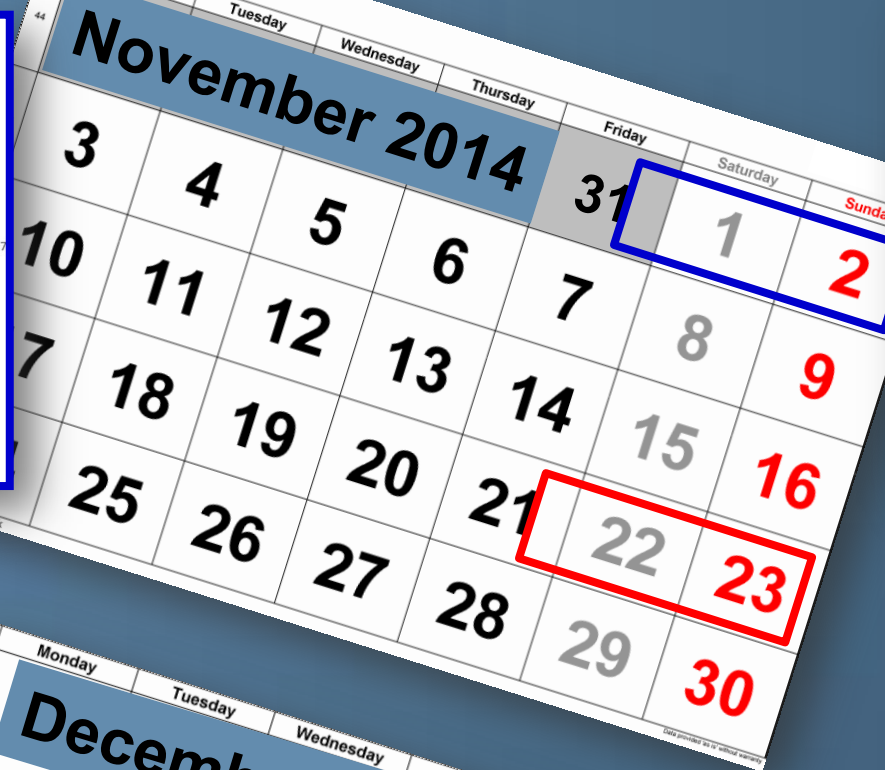
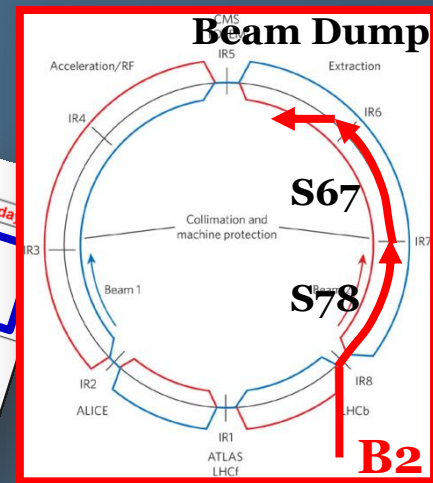
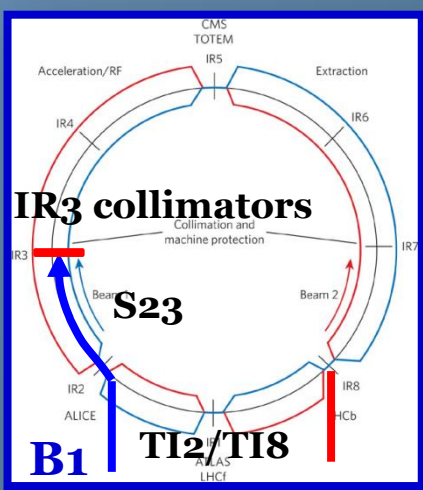
SP

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hing)

BE/BI

Schedule

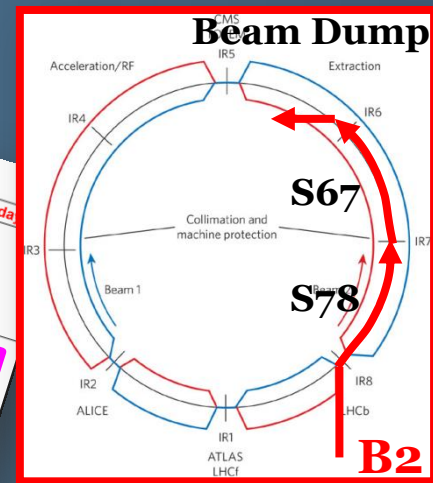
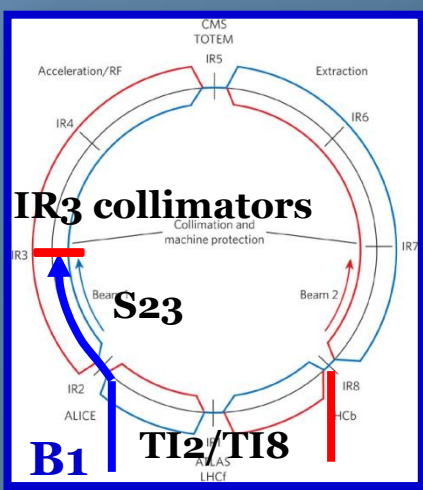


Initially



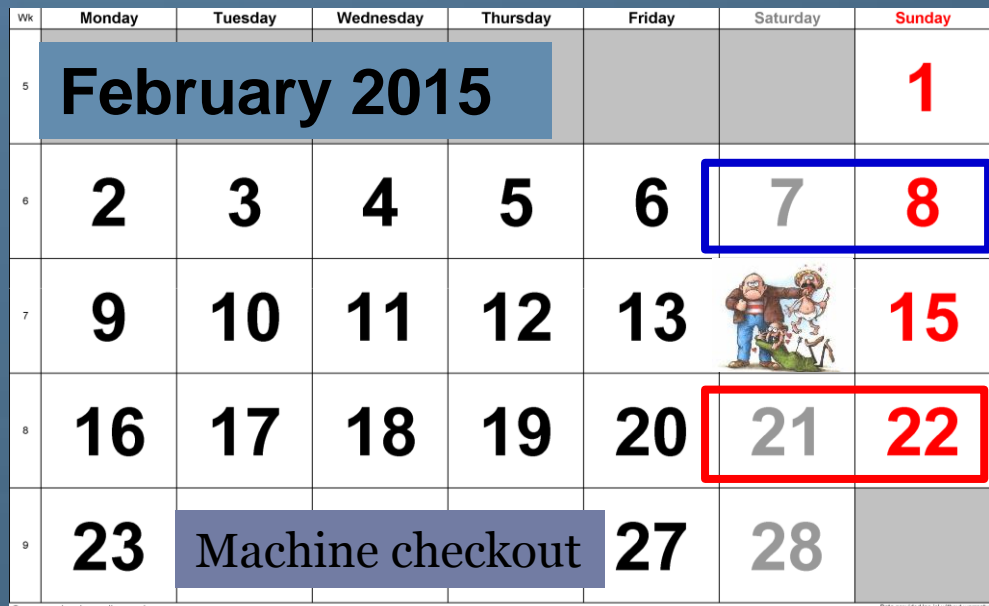
+ Contingency weekend

Schedule



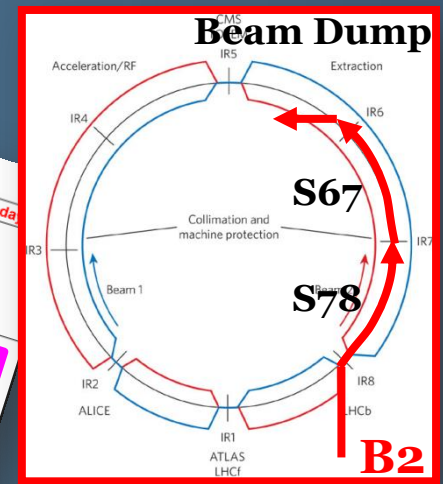
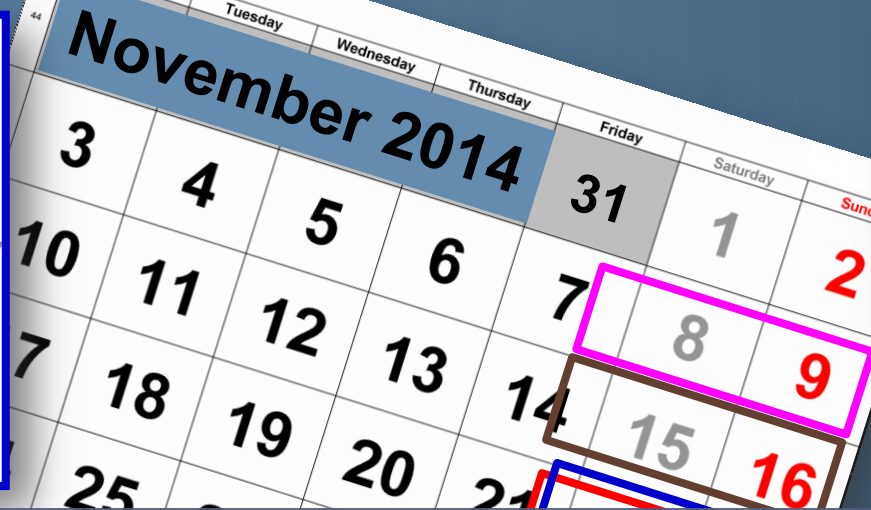
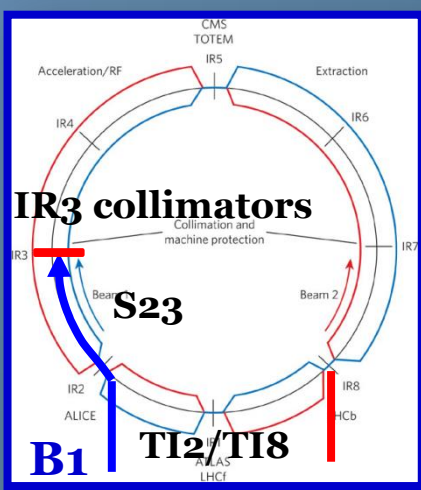
Access system commissioning
DSO test

Transfer Line
Test TI2&TI8,
LHC MKI
synchronization,
LBDS inject and
dump

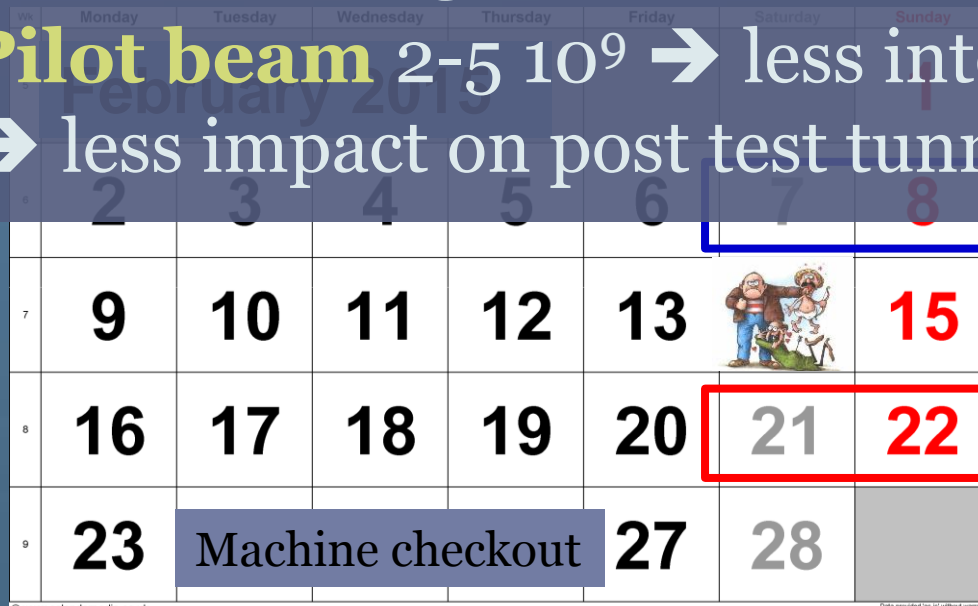


S23
S67-s78-LBDS

Machine checkout



- Test scheduled **weekends** to minimize the inconvenience to the experiments and hardware commissioning
- **Pilot beam** $2-5 \cdot 10^9$ → less intensity → less radiation → less impact on post test tunnel activities



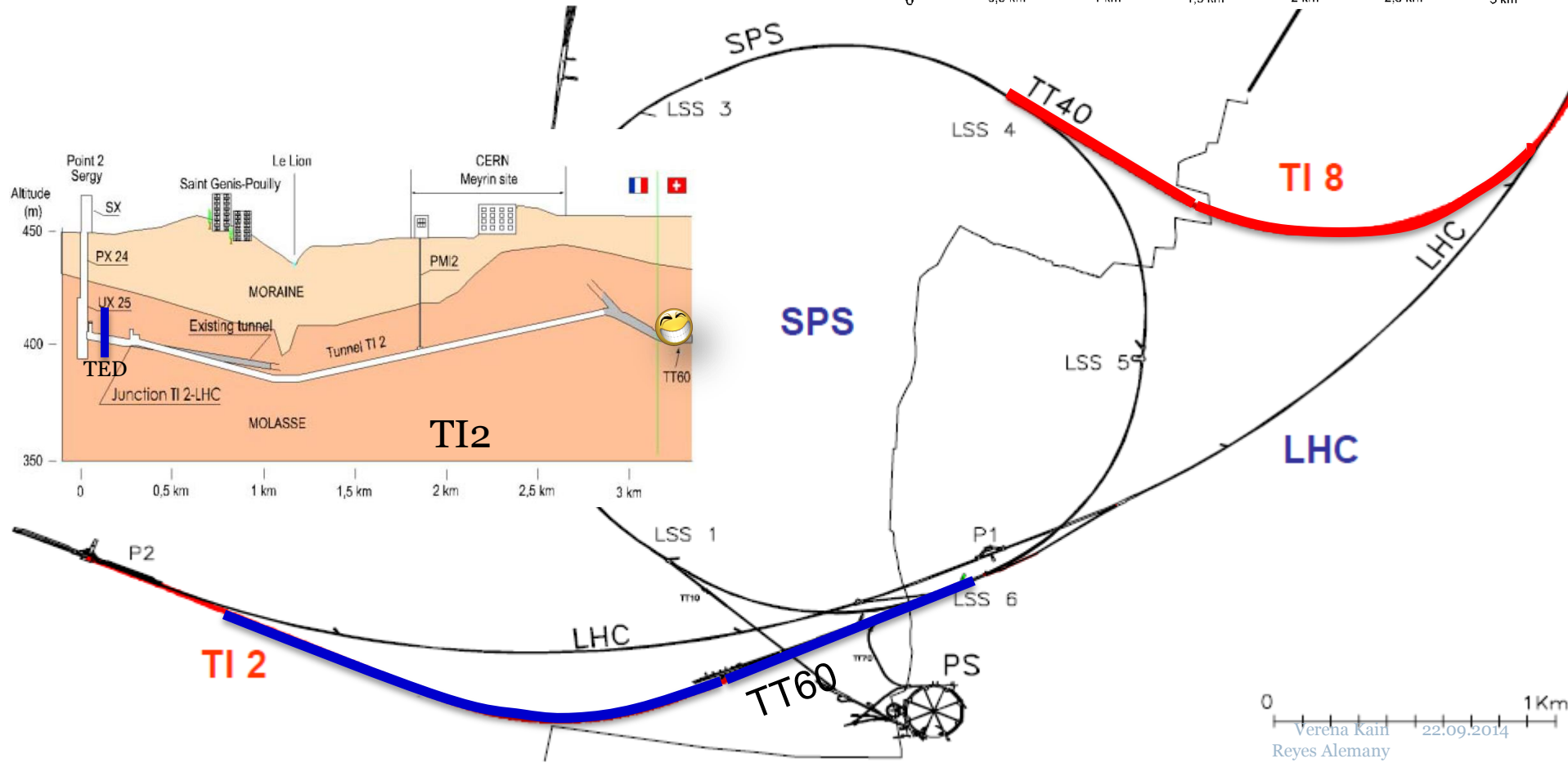
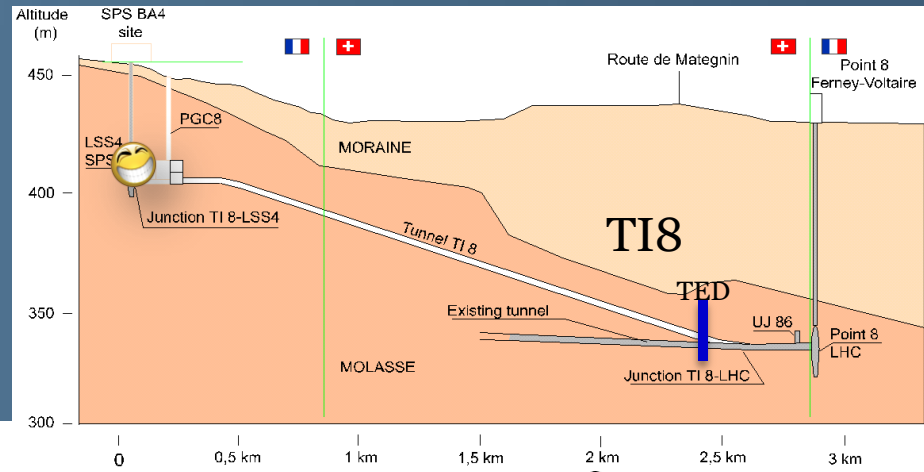
S67-s78-LBDS

TRANSFER LINE TESTS

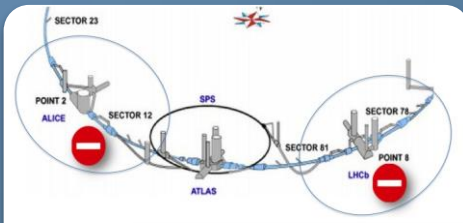
Strategy

TRANSFER LINE TEST:

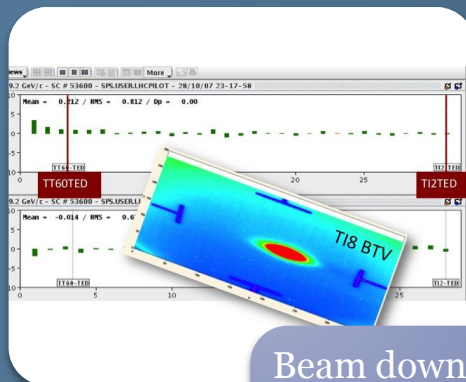
- Setting up of TT60/TT40 extraction (before sector test, date to be defined)
- Beam down to TI₂/TI₈ TED



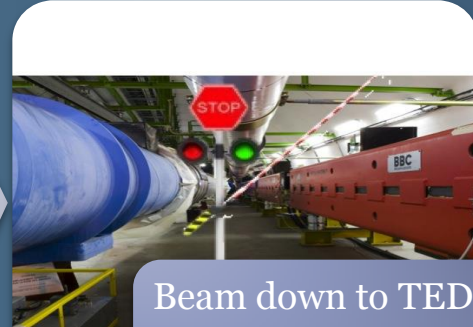
Objectives



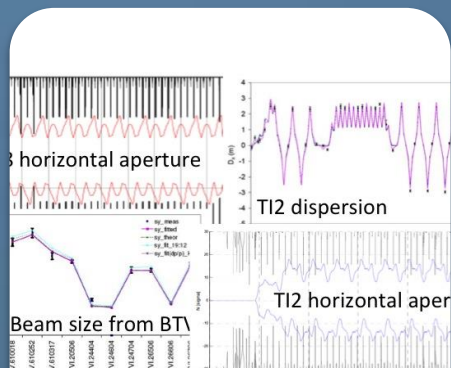
- Patrol and closure
- S12-S23-ALICE
 - S81-S78-LHCb
 - TT40/TT60 extraction



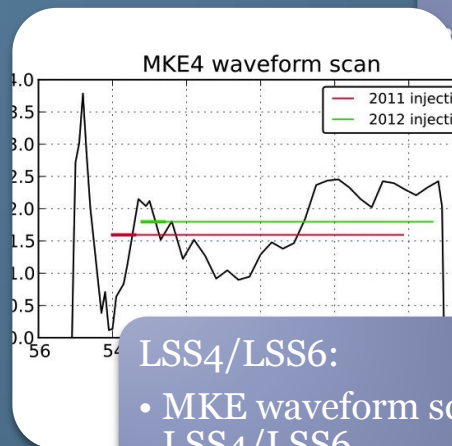
- Beam down to TED with SPS mastership
- Threading/steering
 - BI commissioning
 - BIC commissioning
- SPS-TI2 energy match/acceptance



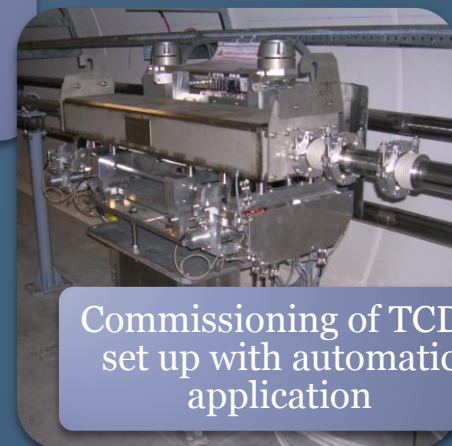
- Beam down to TED
- LHC mastership commissioning
 - MSI-MKI-beam synchronization



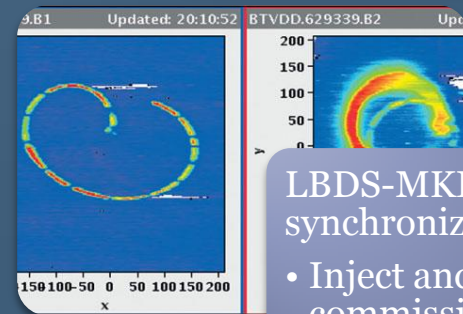
- Beam measurements:
- BPM and orbit corrector polarity and gain checks
 - Rough linear optics and dispersion checks
 - Trajectory stability



- LSS4/LSS6:
- MKE waveform scan
 - LSS4/LSS6
 - Extraction region aperture scan

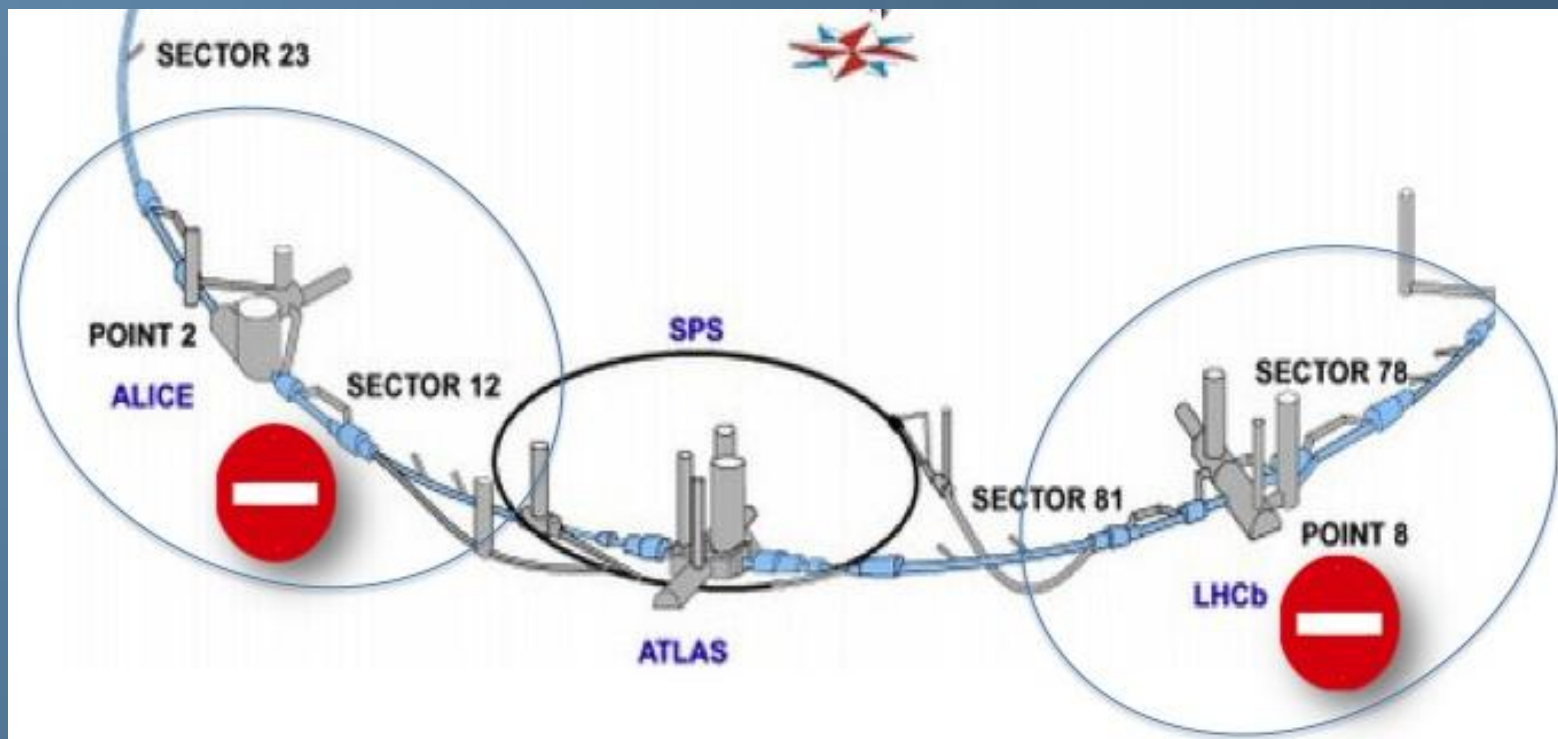


Commissioning of TCDI set up with automatic application



- LBDS-MKI synchronization
- Inject and dump commissioning

LHC Partially closed



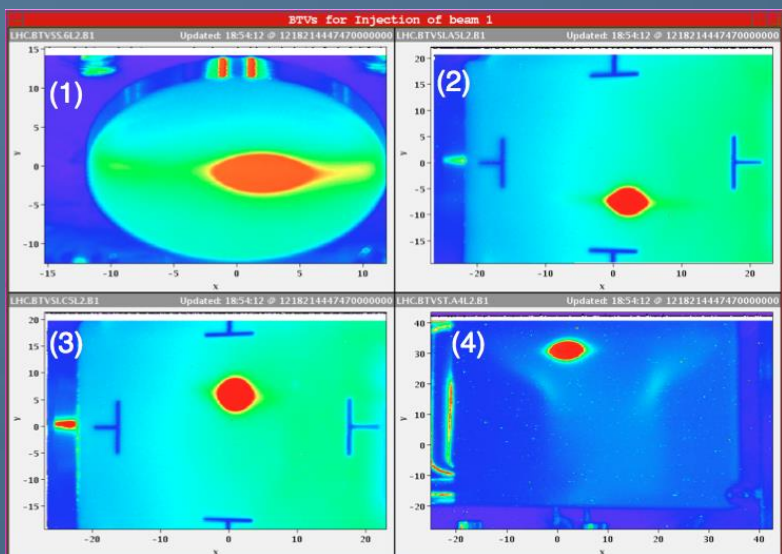
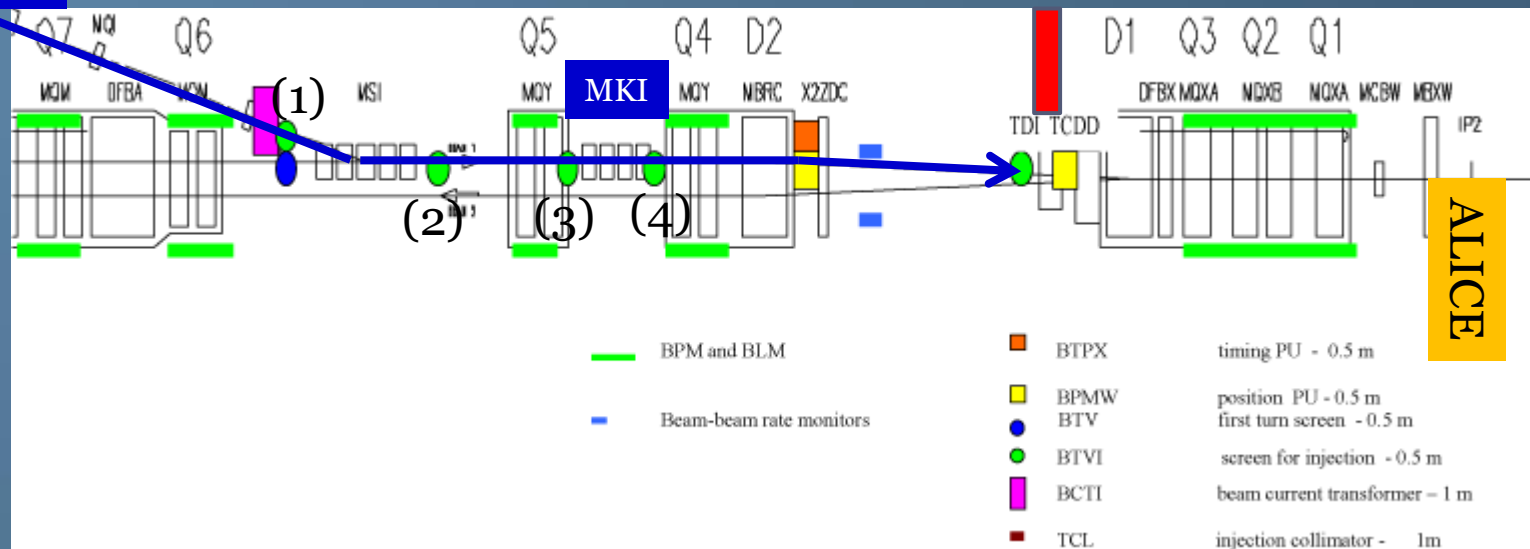
- ATLAS and CMS not concerned
- But other sectors might be closed for powering test

SECTOR TESTS

SECTOR TEST:

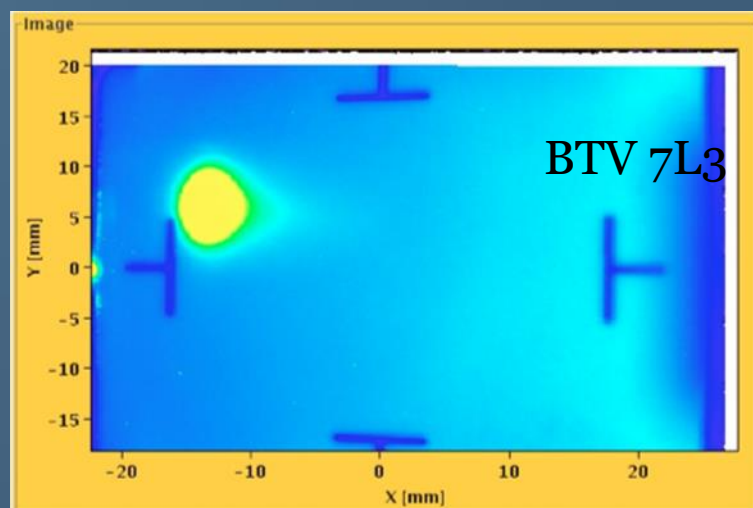
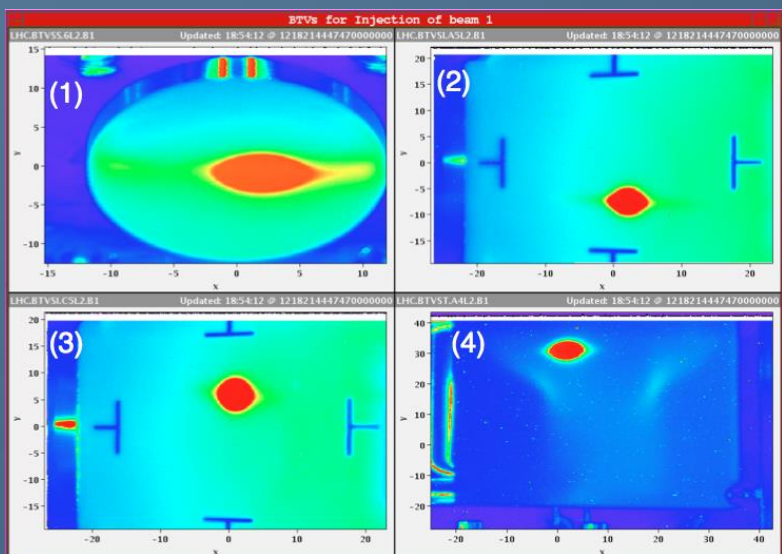
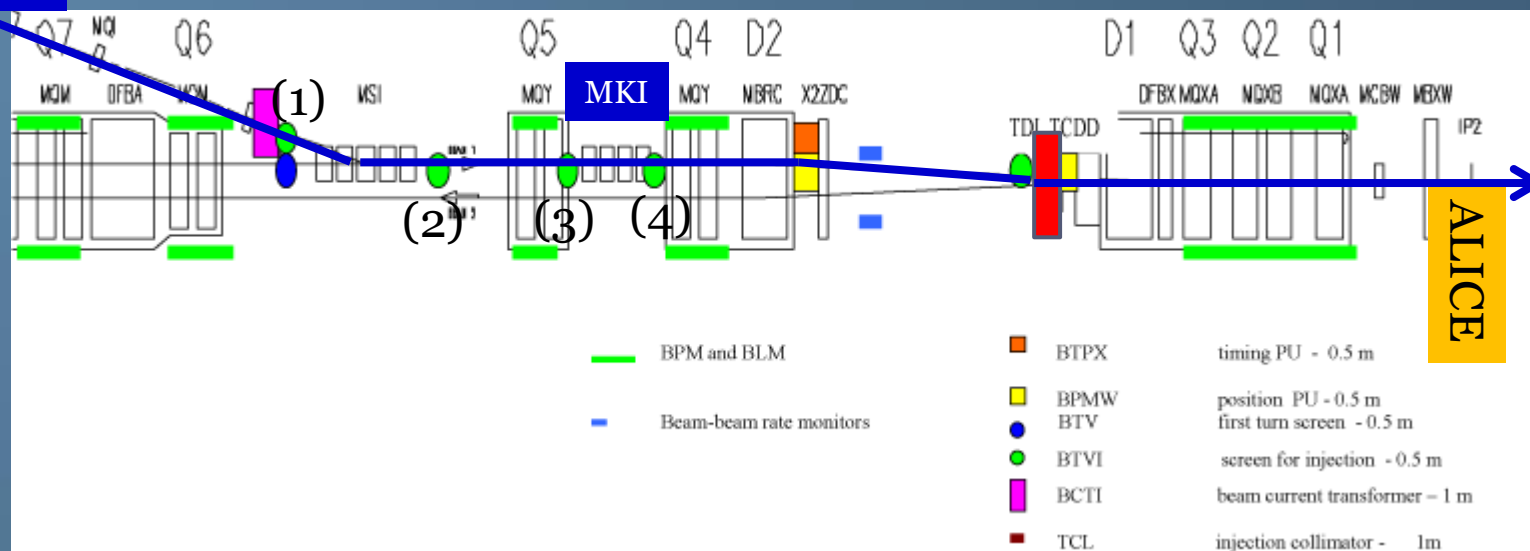
- Transfer line set up
- Beam to TDI with MKI OFF (TI2 TED out)
- Beam to TDI with MKI ON

B1

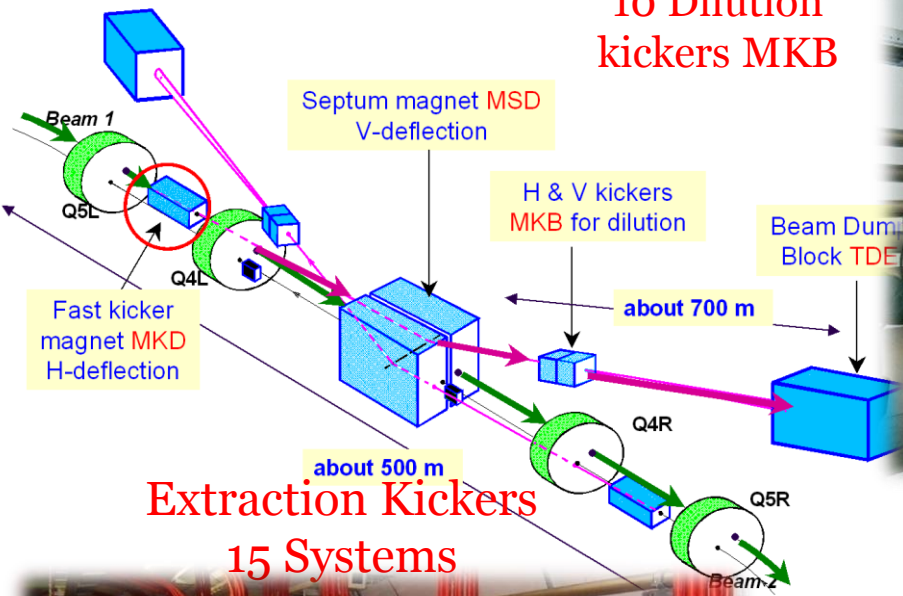


- Beam to TDI with MKI OFF (TI₂ TED out)
- Beam to TDI with MKI ON
- Beam to IR₃ (TDI out)

B1



10 Dilution kickers MKB



Extraction Kickers 15 Systems



+ beam instrumentation: BTV, BLM, BCTs ...
+ Inject and dump (with beam)

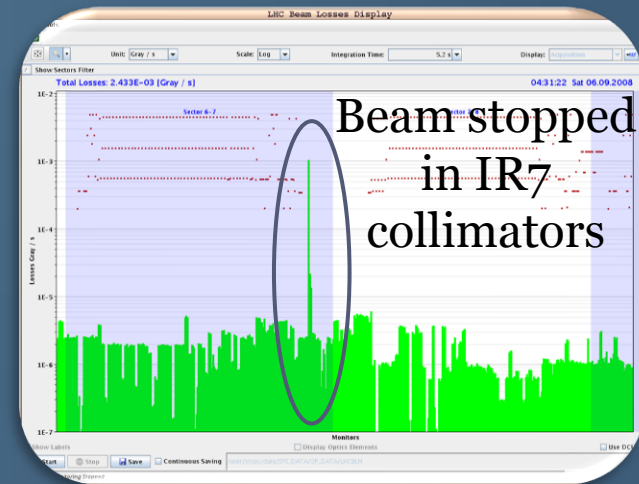
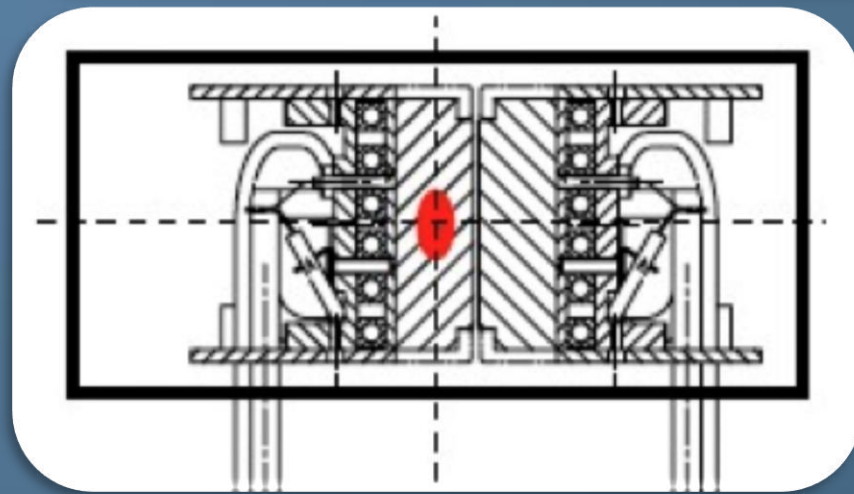
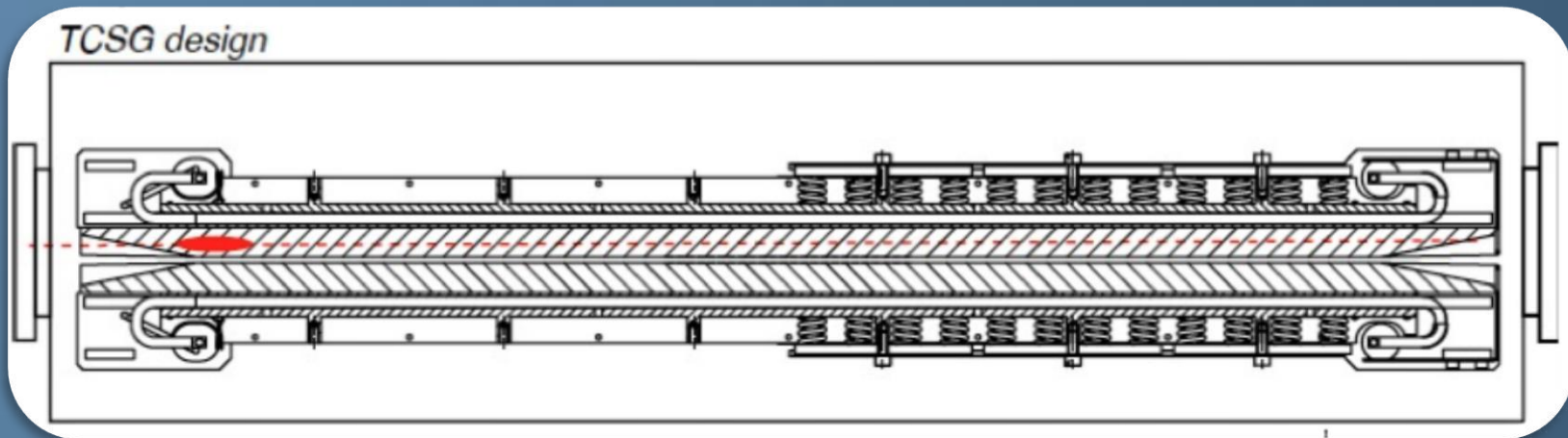
SECTOR TEST B2

Pre-requisites

- IST + HWC
- Powering test
- Dry runs
- Access system
- DSO
- Machine checkout



How to stop the beam



- Collimators with minimum gap on anti-collision switches = 0.5 mm
- 5 mm overshoot across nominal orbit
- Possible to tilt collimator to leave NO clearance

SECTOR TEST S23

INJ 1	CIB.SR2.INJ1.1	CIB.SR2.INJ1.2
	LHC Beam1	Nothing needed
	Permit	
	Operator switch	
	MKI2 status	
	Vacuum	
	MKI2 erratic	
IR2 (B1)	CIB.UA27.R2.B1	L2.B1
	MKI	BLM
	Vacuum	Vacuum
	ALICE detector	
IR3 (B1)	CIB.UJ33.U3.B1	CIB.SR3.S3.B1
	ACCESS_SB ⁽²⁾	BLM
	WIC ⁽²⁾	

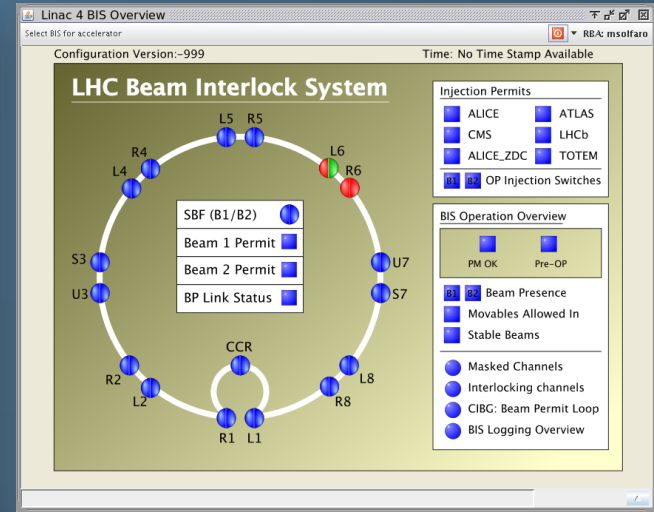
SECTOR TEST S78-S67-LBDS

INJ 2	CIB.SR8.INJ2.1	CIB.SR8.INJ2.2
	LHC Beam2	LBDS.B2
	Permit	
	Operator switch	
	MKI8 status	
	Vacuum	
	MKI8 erratic	
IR6 (B2)	CIB.UA67.R6.B2	CIB.UA63.L6.B2
	Vacuum	Vacuum
	LBDS (TSU)	WIC (septa)
	LBDS (PLC)	BLM
	CIBDS B2	
IR7 (B2)	CIB.SR7.S7.B2	CIB.TZ76.U7.B2
	BLM	Vacuum
		WIC ⁽²⁾
IR8 (B2)	CIB.UA87.R8.B2	L8.B2
	Vacuum	Vacuum

B1&B2 need to be commissioned

(1) Should be tested @DSO test; if there are issues could have a jumper.
 (2) Covered by SIS; if doesn't work could have a jumper.

1. PIC is covered by SIS
2. The unmaskable inputs not needed for the Sector and will be disabled.
3. The maskable inputs if not commissioned and operator will have a jumper.



450 GeV

450 GeV

Beam Energy Tracking will get the energy from the BETSimulator

Or the main bends IF READY

Start Time 14:04:43.308	Data 450	Start Time 14:04:43.308	Data 450
Time Index 0	Voltage 0.582	Time Index 0	Voltage 0.582
Enable <input checked="" type="checkbox"/>	DAC 0.585	Enable <input checked="" type="checkbox"/>	DAC 0.585
	ADC 0		ADC 0

The tests were undoubtedly an essential precursor to the successful start of LHC Beam Commissioning

2004 TI8 test

2005 TI8 test (high intensity beam)

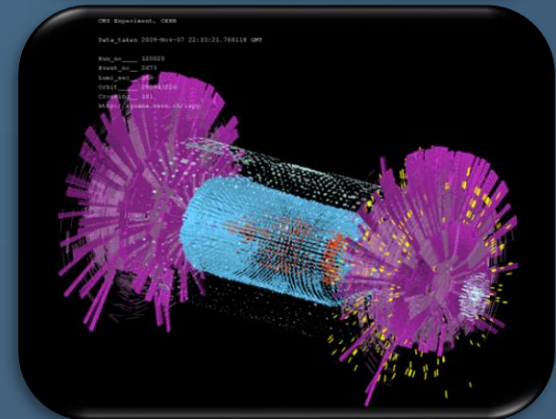
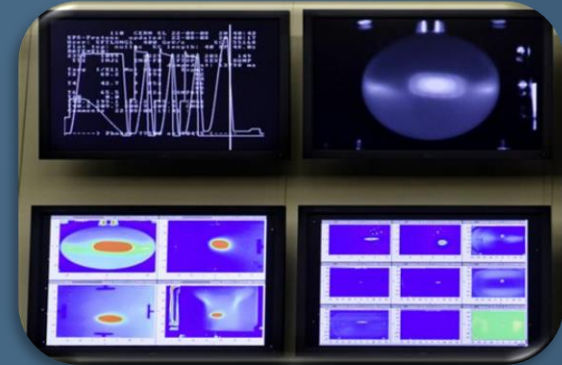
2007 TI2 test

2008 5 injection tests

1. S23
2. S78, S23
3. S78-S67, S23-S34-S45
4. S23-S34-S45
5. Whole ring

2009 2 injection tests

1. TI2, S23, first ions in LHC
2. TI2/TI8, S23, S78-S67-S56



(Following plots → ref: M. Lamont et al. “The LHC Injection Tests”, LHC Performance Note 2008-10-21)

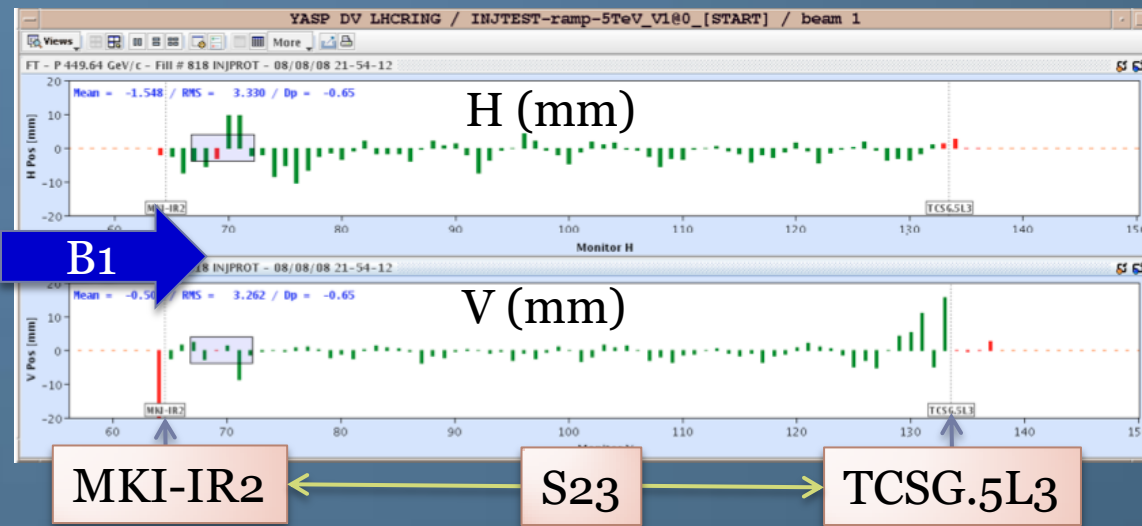
A bit of History

First trajectory

BPMs triggered at the first passage (async mode)

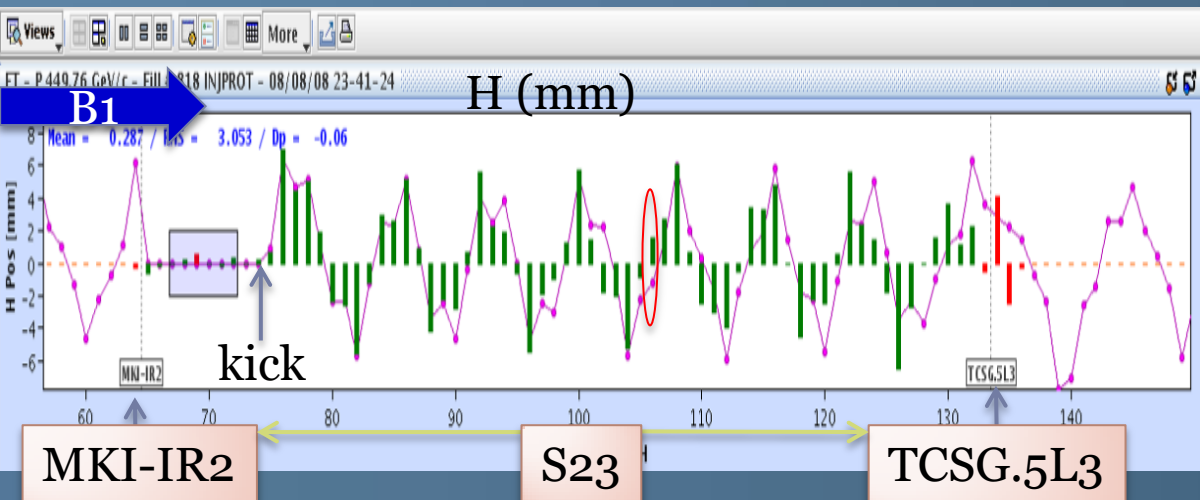
Orbit correction to **+/- 10 mm H/V within few shots**

First corrected trajectory: **+/- 3 mm** (LHC design specs: +/- 4 mm)



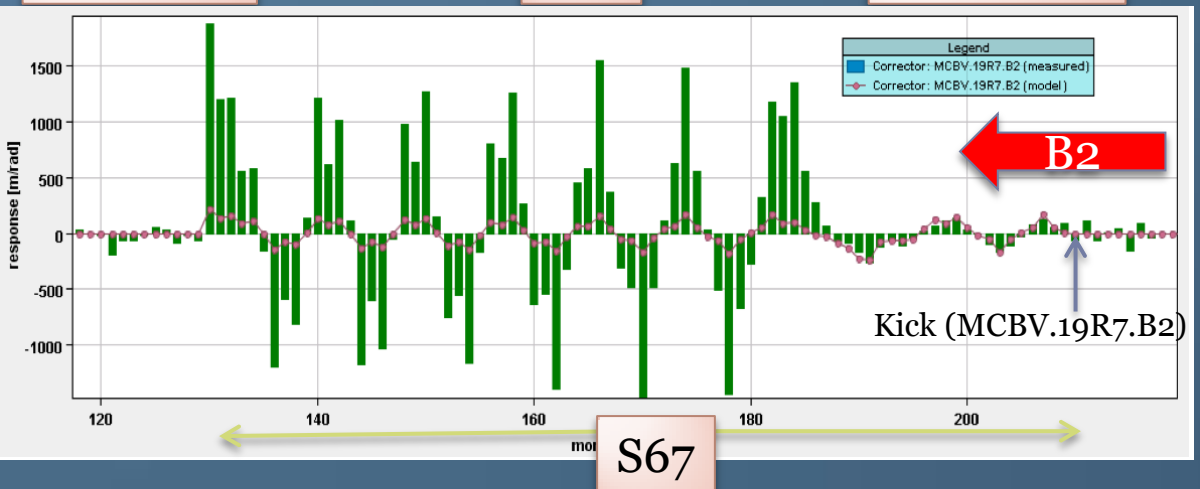
A bit of History

First BPM and COD polarities check



BPMs polarity errors spotted

Phase error S23: erroneous application of b2 harmonic compensator (Fig. top)

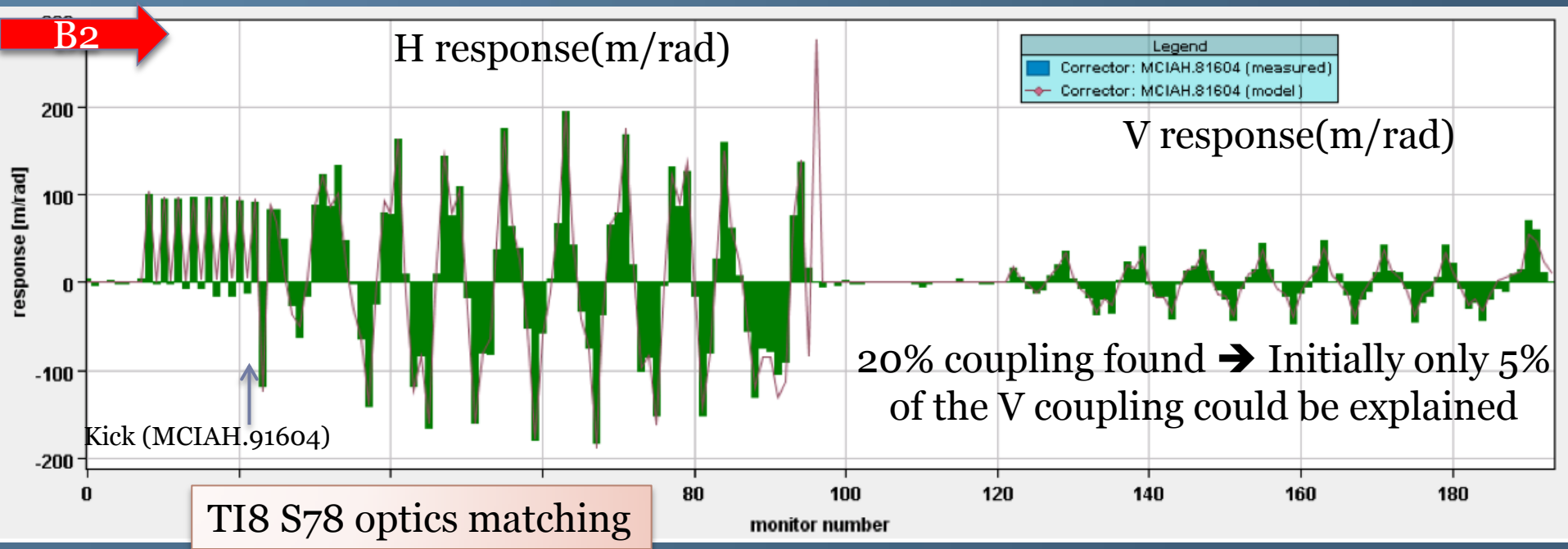


Wrong amplitude S67:
Inversion of polarity of Q6.L7 (Fig. bottom)

— Theoretical response
█ BPM measurement

A bit of History

First BPM and COD polarities check

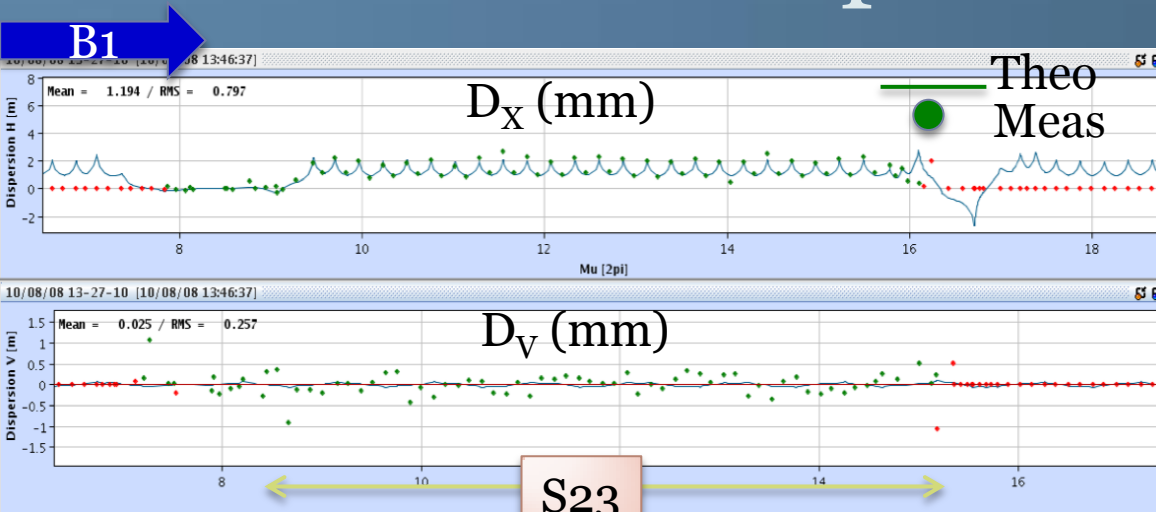


Kick response measurements can spot cross-plane coupling

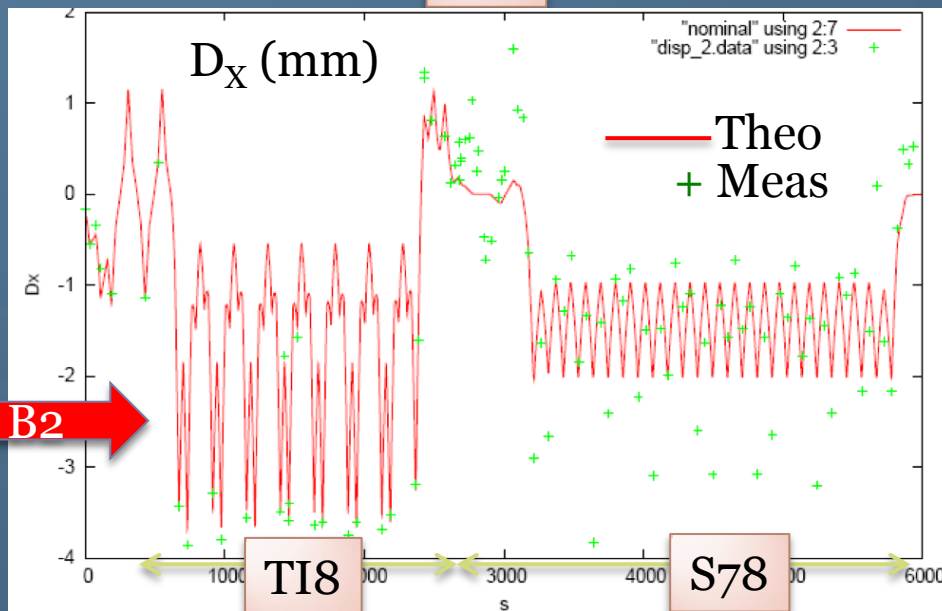
— Theoretical response
█ BPM measurement

A bit of History

First dispersion measurement



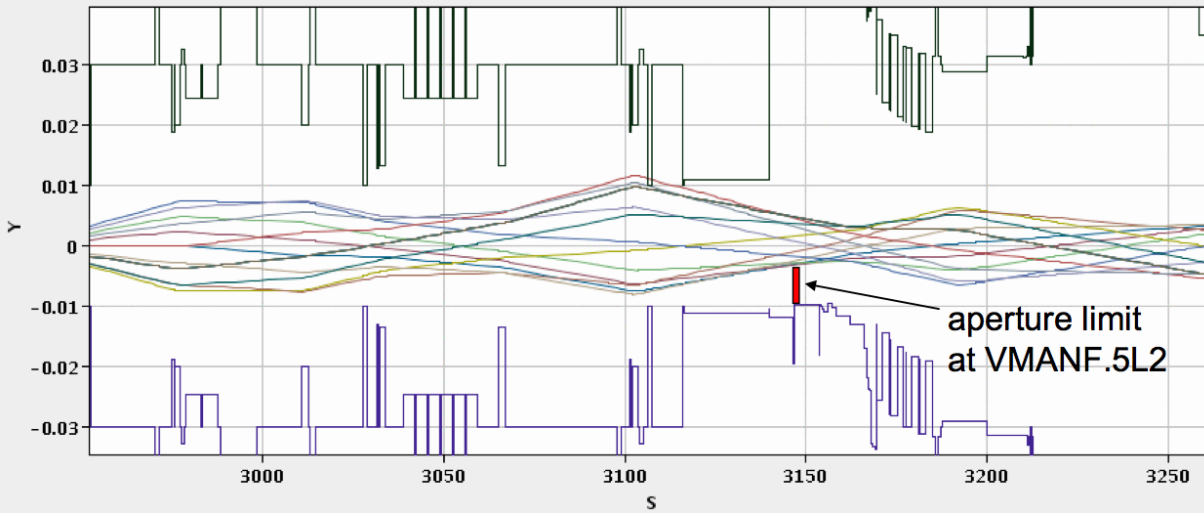
Dispersion measurement revealed optics problem in IR3
Right → some of the trim quads powered with the wrong polarity,



and a strong mismatch between TI8 and S78 → a real puzzle and took some time to understand

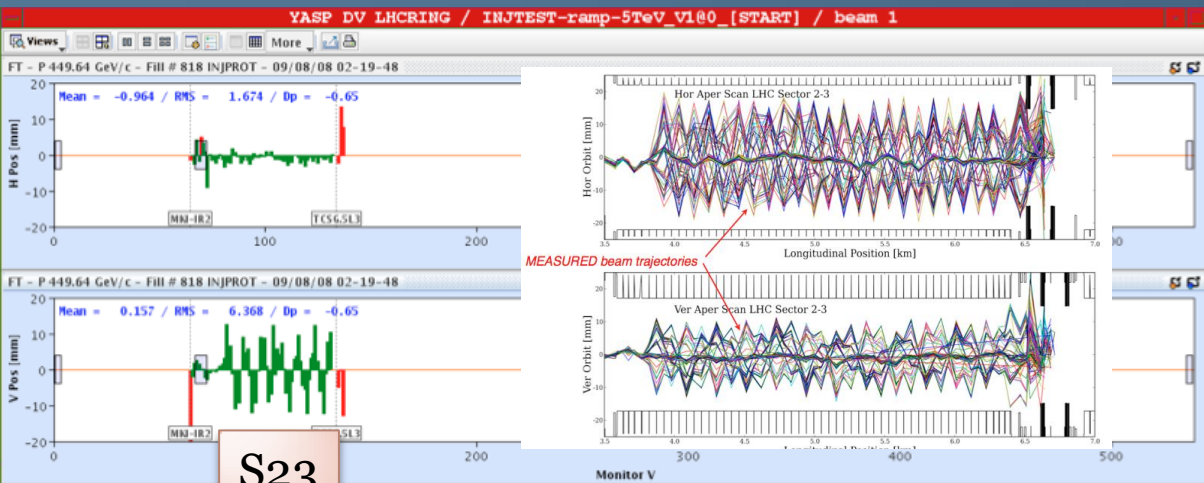
A bit of History

First aperture



First aperture scan (first quench with beam, 1 pilot ~ $4 \cdot 10^9$ p) → two COD/plane 90° phase advance; BLM determine the loss location

Bottleneck in injection region found, confirmed by radiation survey and fixed (Fig. top)

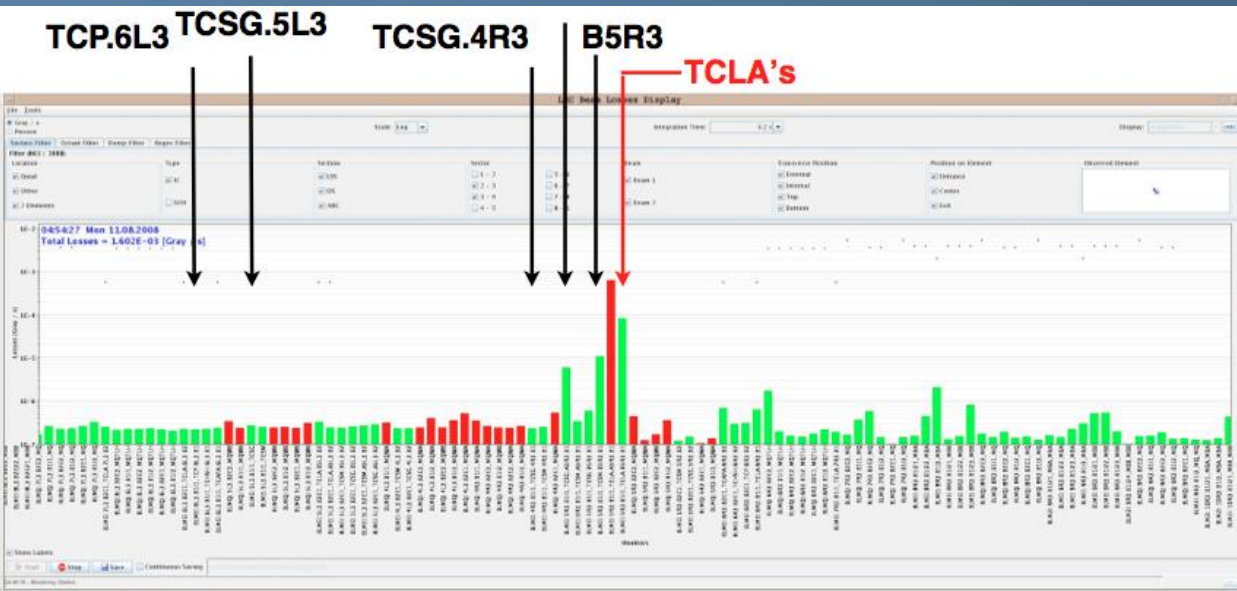


H ARC Aperture 18-20 mm. V limitation at Q8/Q7-L3 of about 10 mm (Fig. bottom)

Coupling errors detection

A bit of History

BLM commissioning



BLM response at
collimators

	Time	TRANSFER LINE TEST: TI2 & TI8	Δt (h)
	11		1
Friday	12	Patrol and closure of LHC S12-S23, S81-S78, LHCb and ALICE. Last interlock checks/tests. TT40/TT60 extraction (TEDs in)	3
	15	Beam down to TI2 TED, establish rough trajectory (threading/steering). BI commissioning with beam. TI2 interlock commissioning with beam. SPS-TI2 energy matching and acceptance. SPS mastership.	8
	23	LHC mastership commissioning. B1 MSI & MKI pulsing. BI commissioning (cont.). Timing of B1 and MKI pulse.	5
Saturday	4	LBDS-MKI B1 synchronization. Inject and dump commissioning.	5
	9	Beam down to TI8 TED, establish rough trajectory (threading/steering). BI commissioning with beam. TI8 interlock commissioning with beam. SPS-TI8 energy matching and acceptance. SPS mastership.	8
	17	B2 MSI & MKI pulsing. BI commissioning (cont.). Timing of B2 and MKI pulse.	5
	22	LBDS-MKI B2 synchronization. Inject and dump commissioning.	5
Sunday	3	BPMs and orbit corrector polarity and gain checks TI2, rough linear optics & dispersion TI2.	4
	7	BPMs and orbit corrector polarity and gain checks TI8, rough linear optics & dispersion TI8. LHCb TED shots in parallel. If interleave injection then both lines together.	4
	11	MKE waveform scan LLS4/LLS6.	4
	15	TL trajectory stability TI2 - beam on TED. More TL BI passive commissioning.	3
	18	TL trajectory stability TI8 - beam on TED. More TL BI passive commissioning. LHCb TED shots in parallel.	3
Monday	21	Set TCDI, automatic application TI2/TI8.	3
	0	Rough LSS4 extraction region aperture scan.	3
	3	Rough LSS6 extraction region aperture scan. LHCb TED shots in parallel.	3
	6	End of TI2/TI8 test. RP survey	2

LHCb & ALICE TED shots

S78-s67-LBDS test schedule

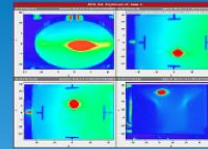
	Time	SECTOR TEST 2: T18, S78-S67, LBDS B2	Δt(h)
Friday	12	Patrol and closure of LHC and experiments. Magnets pre-cycle. Last interlock checks/tests. T60 extraction (TEDs in)	3
	15	Beam down to T18 TED, establish trajectory. LHC mastership. MSI & MKI pulsing. LHCb TED shots in parallel.	2
	17	T18 TED out, MKI off/on, beam to DI. Thread last part of T18 and MSI. Set DI, CLI. More LBI commissioning	2
	19	TDI out, beam to R7 right. First BL commissioning (BLM, BPM, BTV). Threading	3
	22	Beam to R6 LBDS B2 with orbit correctors (TCDO & TCSG in beam and interlocked). Steering. Beam dump line BL commissioning. Synchronization. Rough check of extraction channel aperture.	3
Saturday	1	Beam to R6 LBDS B2 with inject and dump (TCDO & TCSG in beam and interlocked). Steering. More check BL. Synchronization. Rough check of extraction channel. MKD knob test. MKB	6
	7	BPMs and orbit corrector polarity checks T18 & S78-S67, linear optics & dispersion T18 & S78-S67	9
	16	Screen matching T18 injection	2
	18	TDI in, physical aperture measurements in T18 and the injection region. LHCb BCM+BLM calibration in parallel	8
Sunday	2	MKI waveform scan	2
	4	TL trajectory stability T18 beam on TED. More LBI commissioning. LHCb TED shots in parallel	3
	7	Rough SS6 extraction region aperture scan. LHCb TED shots in parallel	1
	8	BLM latency check	1
	9	BLM response (collimator splashes)	2
	11	Aperture R8 and S78S67 Could be combined	9
	20	Magnet polarity (RCO.A78B2, Q5L8, skew quads, sample of MQT, MQTL)	4
Monday	0	Set TCDI, automatic application T18 (if not done in ST1)	3
	3	Pre-cycle effects	3
	6	End of T18/S78S67/LBDS B2 test. RP survey	2

Very very Preliminary

ST2 program = f(outcome of TL & ST1)

LHCb TED shots = 2+3+1 hours

TOT: 66 h → 8.25 shift



LHC SECTOR TESTS 2014-2015

[Home](#)[SCHEDULE](#)[MACHINE CONFIGURATION](#)[BEAM MEASUREMENTS](#)[MEETINGS AND DOCUMENTS](#)

LHC Sector Tests 2014-2015

1. SCHEDULE
2. PROGRAM FOR TI₂, TI₈ AND SECTOR TEST S₂₃
3. PROGRAM FOR SECTOR TEST S₇₈-S₆₇
4. PROGRAM FOR TRANSFER LINE TEST TI₂ & TI₈
5. MACHINE CONFIGURATION

Conclusion

- Sector tests are **essential precursor** and a **high profile milestone** in preparation for full beam commissioning
- Two sector tests are proposed for 2015:
 - **ST1: 7-8 Feb 2015 → ti₂/ti₈ re-commissioning & s₂₃**
 - **ST2: 21-22 Feb 2015 → ti₈ re-commissioning & s₇₈-s₆₇-lbds b₂**
 - **TL: 22-23 Nov 2014 → ti₂&ti₈ commissioning**