

*What will we do for Beam
Preparation: Injection and
Beam Dump*

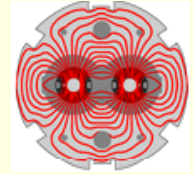
Jan Uythoven

Thanks to

M.Barnes, E.Carlier, L.Ducimetière, B.Goddard, R.Jones,
Y.Kadi, V.Kain, M.Meddahi, V.Mertens and many more



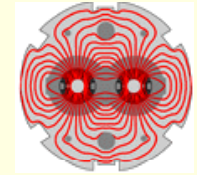
Injection and Beam Dump



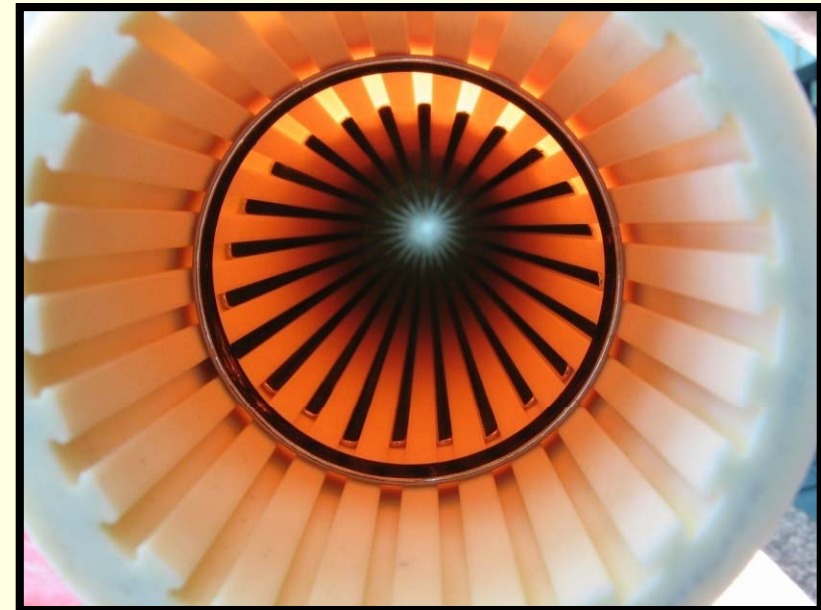
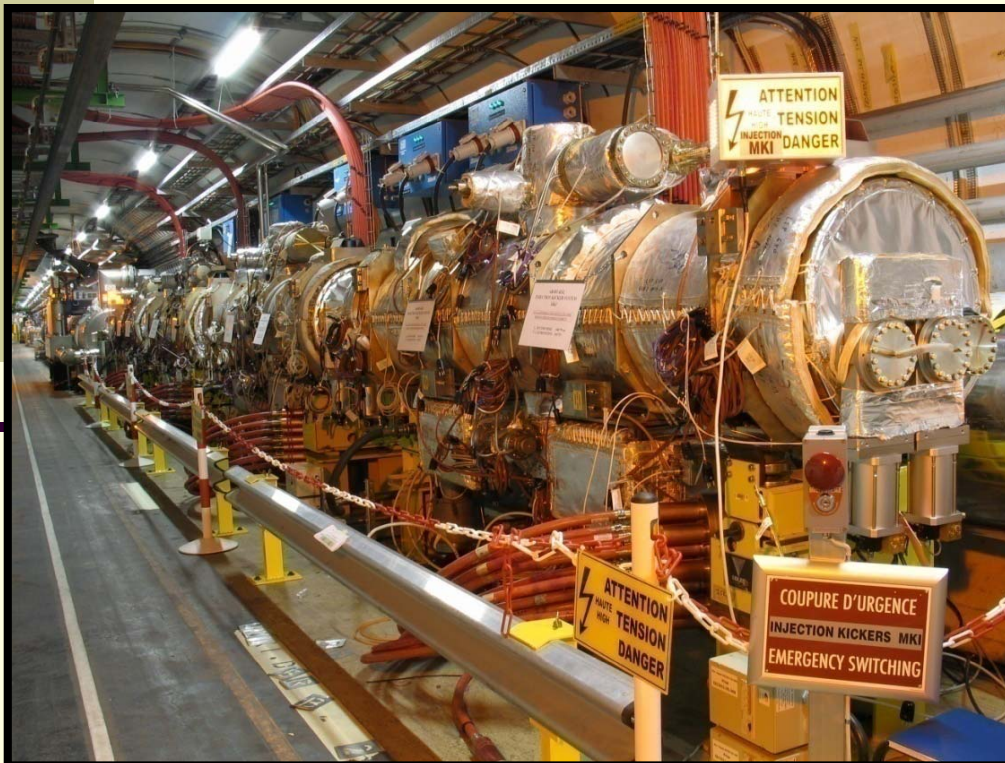
- Changes to the Injection and Beam Dumping Systems
 - Transfer Lines
 - Injection kickers MKI
 - Beam Dump kickers MKD & MKB
 - Their controls
- Requirements for commissioning before beam
 - Interfaces
 - Time



What is New: Injection System

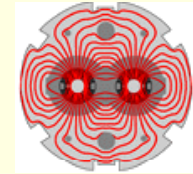


- Injection kickers MKI
 - Worked fine, but delicate equipment operating “near the edge”
 - Many - partly conflicting - design requirements (kick strength, rise time, flat-top ripple, aperture, beam impedance, vacuum, ...)





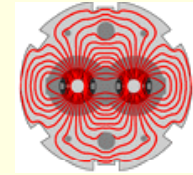
Injection Kickers MKI



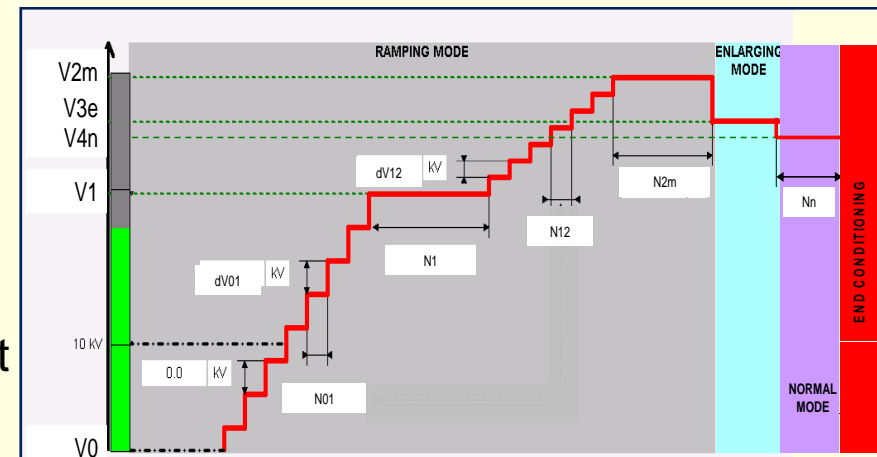
- **MKI magnet D in LSS2L now replaced against spare**
 - Had shown a breakdown, probably weakened by over-voltage during lab conditioning due to a calibration error
 - Assembly of second spare starts soon (to become ready in QIII/2009)
- Indications of MKI flashovers triggered by beam loss during aperture studies
 - Could become an issue when operational losses occur with higher beam intensity
 - “SoftStart” useful/mandatory (see next slide)
- Remote reset of vacuum interlock by expert (without tunnel access)
- Remote access to local scope improves diagnostics during operation
- Modification of MKI thyatron bias boards to reduce number of erratics
- BLMs definitively positioned between MKIs D/C and C/B to monitor beam losses
 - Presently only for diagnostics purposes; *need interlock level ?*
- Connection to injection BIC fully redundant
- Tri-axial cables for transfer line BCT → MKI synchronisation (OASIS)



MKI “SoftStart”



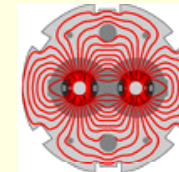
- Program to compensate for small drop in conditioning during extended periods without pulsing, before applying the full high voltage for injection
- Implies to anticipate 30 minute SoftStart period in injection preparation (can be done by sequencer, in parallel with other preparation activities)
- **New SoftStart** will have more configuration parameters
 - Faster ramp-up at lower voltages
 - Variation of pulse length
 - **All parameters under RBAC**
- Expect now standard duration of about 10 minutes
- Relies on RBAC, LSA, timing etc.
 - **Only to be used when machine is in ‘operational mode’ and data bases etc. are operational**



MKI GUI to be updated by OP



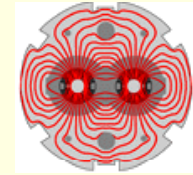
Collimators and Absorbers



- Injection absorbers **TDI** (leaky seals on motorisations)
 - LSS2L presently out, back beginning of March
 - LSS8R out when access to zone, back end of April
- Transfer line collimators **TCDI** (screws/springs, roller cages)
 - TCDI in TI 8 tunnel repaired before end March (SPS shutdown)
 - TI 8 TCDI in LHC tunnel: repair depends on LHC access to LSS8, before end of March
- **Will all need to be recommissioned and recalibrated**
 - Calibration is remote

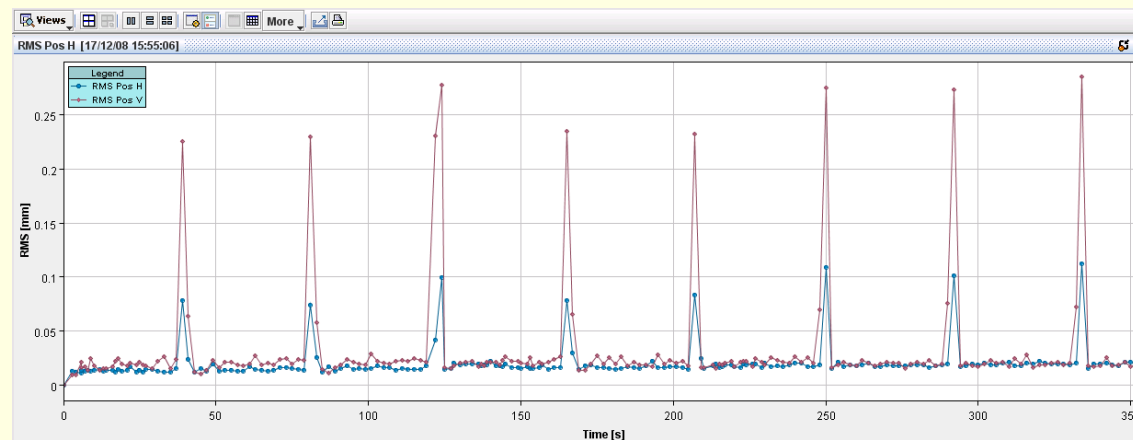


Transfer Lines



- **TI 8 BPMs** reading in both planes and 4 additional BPMs towards the end of the line.
 - Integrate in LSA, logging, YASP
 - TI 2 for 2010
- TI 2 and TI 8 full alignment campaign (for details see Malika's talk)
- All power converters on FESA
- Septum MSI stray field: run MSI in DC ?
 - To be tested during dry runs !
 - Need a smooth way of switching off MSI at end of injection

Beam
Position
rms H/V

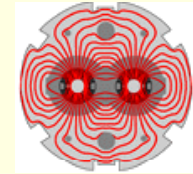


time

R. Steinhagen, J. Wenninger



Requirements Commissioning



V2, JU, 28/01/09	Feb				Mar				Apr				May				June				
	wk4	wk5	wk6	wk7	wk8	wk9	wk10	wk11	wk12	wk13	wk14	wk15	wk16	wk17	wk18	wk19	wk20	wk21	wk22	wk23	wk24
Injection Systems:																					
Replacement MKI installed	█																				
MKI LSS2 interlock testing etc							█	█													
MKI LSS8 interlock testing etc									█	█											
MKI LSS2 Automatic Cond											█	█	█								
MKI LSS8 Automatic Cond											█	█	█								
MKI LSS2 Soft Start tests														█							
MKI LSS8 Soft Start tests															█						
MKI LSS2 & LSS8: pre-pulse, timing, etc.																█					
Remote operation from CCC																	█	█	█	█	█
TL commissioning (MSI, collimators, BPMs)											█	█	█								
TL Beam Tests																			█	█	█
HV available, pulsing locally							█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
HV available, pulsing remote																	█	█	█	█	█

Commissioning for 2009:

• LHC Transfer Lines

- Hardware Commissioning during SPS cold checkout

Coordinate with LHC works !

- Test modified collimators and new BPMs. Test **MSI in DC** ?

- *Beam tests until downstream TED to be planned for May. Test high intensity?*

• LHC Injection System

- MKI control system commissioning starting in March. HV required.

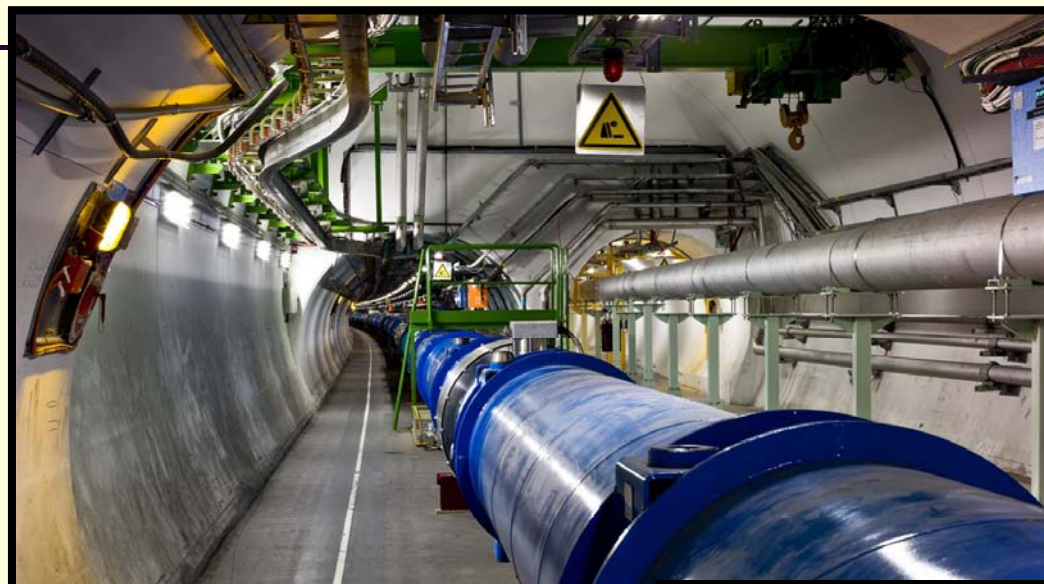
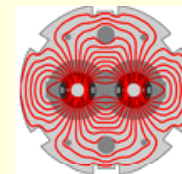
- HV conditioning end of March & April

- Interface to other systems, operation from CCC in May. Dry runs required.

• No staged approach in Hardware Commissioning possible

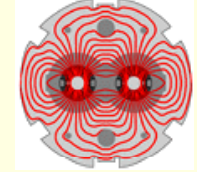


Beam Dumping System

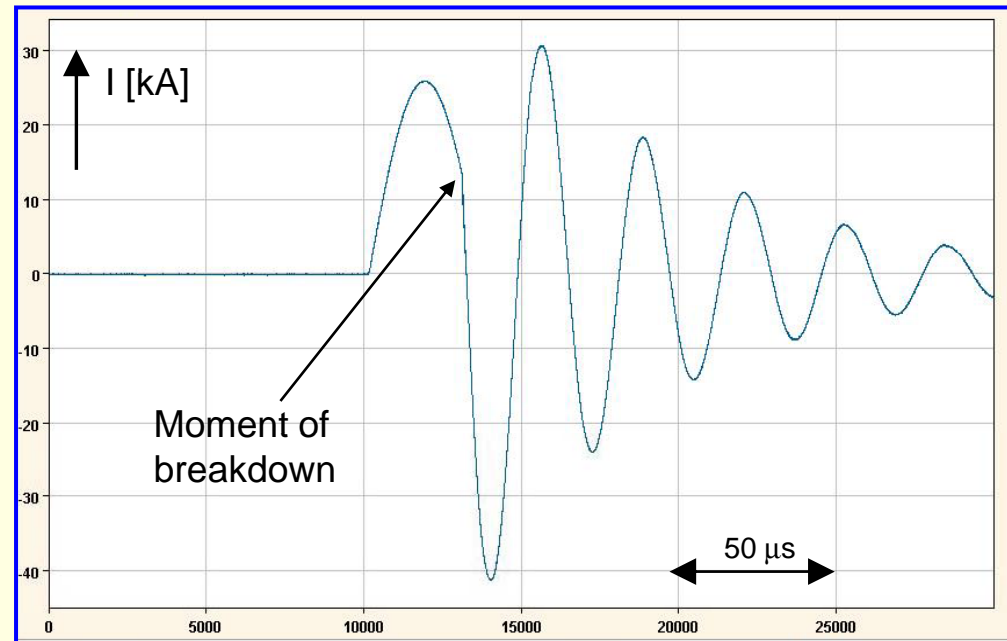




Dilution Kickers MKB



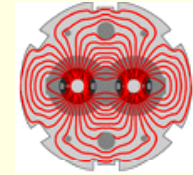
- **Additional dilution magnets MKB installed for 2009:**
 - MKBH inst. will become nominal: 4 magnets (in 2 tanks)
 - MKBV will have 4 magnets (in 2 tanks); nominal is 6 magnets
- **Flashovers** occurred in some of the installed magnets
- Weak insulator identified and replaced on all systems.
- Magnets with breakdown replaced (coil issue)
- Dangerous “common mode” failure
- Conductance will be reduced and will have additional turbo pumps installed



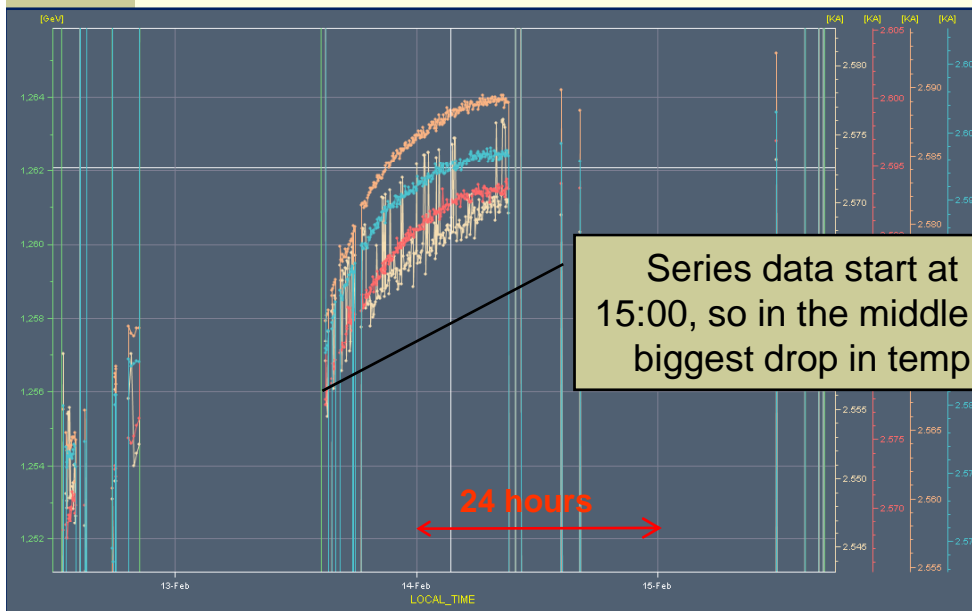
Measured MKB wave form



Extraction Kickers MKD Cooling



- The temperature of the MKD generator has been found to significantly affect the MKD kick strength



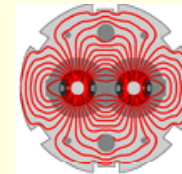
Measure kick currents at 1 TeV
Tunnel temperature down by 4 degrees, kick gone up by about 0.7 – 0.8 %,
Kick response appears to lag behind temperature change, which seems logical.



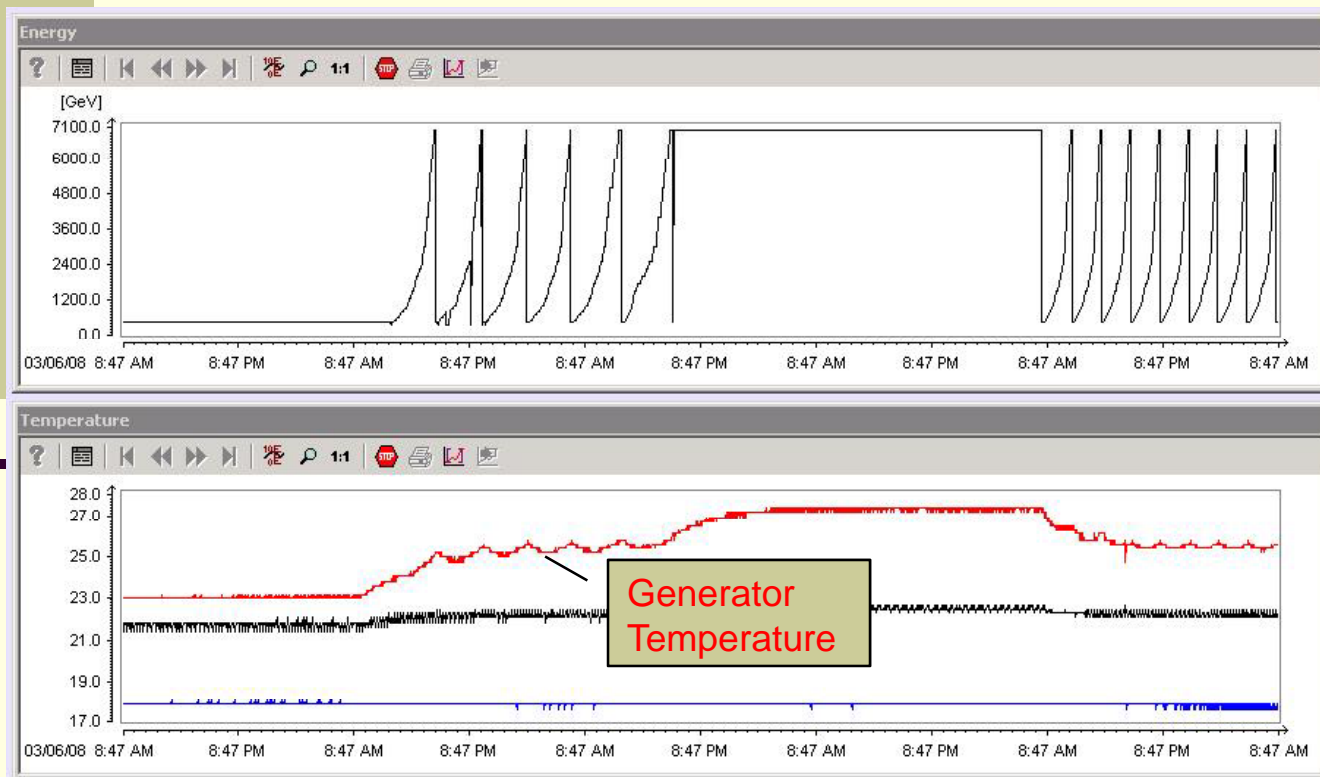
Yellow curve is tunnel temp.
dt = 4 degrees
Starting 13:00, biggest drop reached at 20:30
stable 24 hours later



MKD Temperature Changes



- Temperature changes due to UA temperature variation
- Temperature changes due to being at 'stand-by' at high beam energies

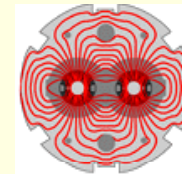


$$\Delta T = 2 \text{ }^{\circ}\text{C} + 2 \text{ }^{\circ}\text{C} = 4 \text{ }^{\circ}\text{C}$$

by running at 7 TeV



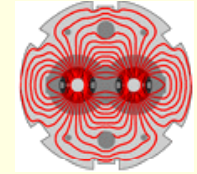
MKD Cooling



- **Peltier temperature regulation units** installed on each of the 30 MKD generators
 - Together with temperature isolation and ventilation
 - Humidity sensor & interlock
- Set regulation of tunnel temperature = 23 degrees
 - Interlock +/- 1 degree
 - Synchronous Beam Dump if temperature gets out of regulation window
 - Restart only possible when correct conditions are back
- **Some weeks of operational experience required before first beam**



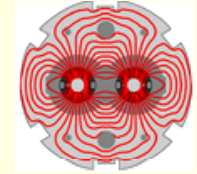
Other Changes to the LBDS



- Internal Post Operational Checks (IPOC):
 - Second MKD current measurement by Rogowski system: will be used for IPOC with realistic limits
- Installation of a fast detection system of mains / UPS instabilities at the level of the TSU
 - Directly connected to the re-trigger lines
 - React after $t > 75$ ms (adjustable) with **asynchronous** beam dump
 - On top of existing detection system at a higher level which triggers a **synchronous** dump ($t > 60$ ms)
 - One week of testing needed

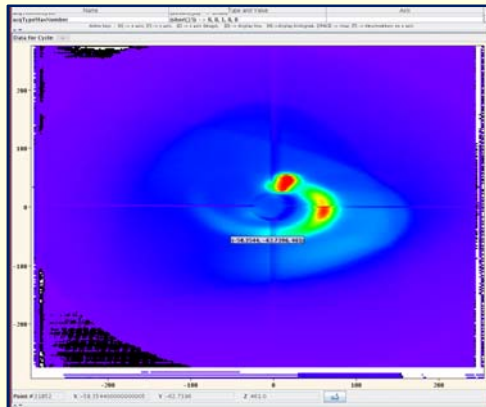


XPOC



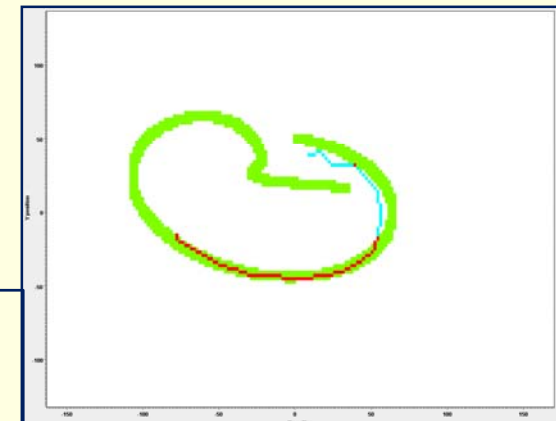
- External Operational Check (XPOC)
 - MKD and MKB kicker waveform check was already fully operational last year: ok
 - **New for 2009: BI related checks**
 - Beam losses from BLM
 - Current measurement in TD line FBCT (get working!)
 - BTVDD image
 - Beam position
 - Abort Gap monitor

Depends on filling pattern !



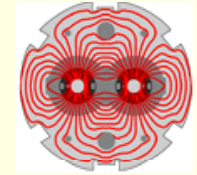
Extraction of debunched beam

XPOC comparison with theory





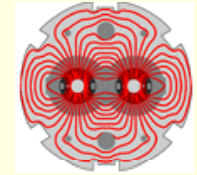
TCDQ Energy Interlock



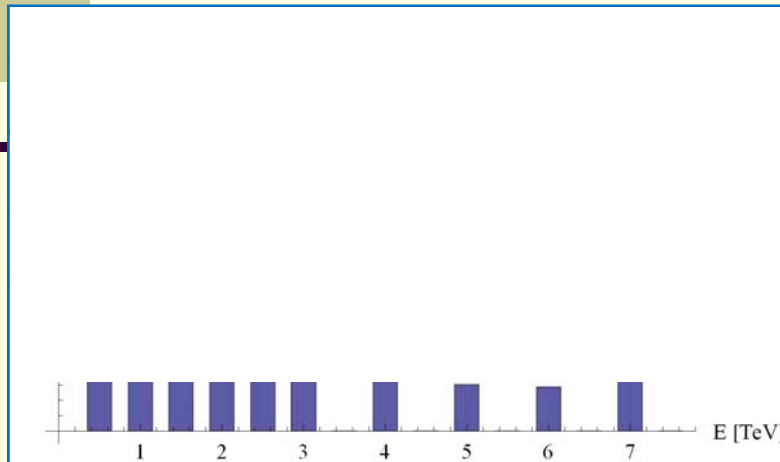
- TCDQ position is a function of energy, and gets triggered by a timing event (like collimators)
- Sensitive to errors related to timing system
- For 2009 there will be an **'independent' check** on the TCDQ position, taking the **beam energy** as input parameter
- Dump the beam if the TCDQ is at the wrong position as expected relative to the beam energy



Running from the CCC



- Reliability Run, as done in 2008, produced sufficient data for 'equipment statistics'
- However, 2009 will need at least **four weeks of effective running** to obtain failure statistics after system modifications
 - MKD cooling, new MKBs
- Well organised **dry runs** for testing interface to other equipment
 - For LBDS try to start in June, in parallel with last phases of hardware commissioning



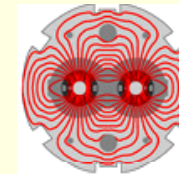
Jan Uythoven, TE/ABT

	Beam 1	Beam 2
# Pulses	23'534	15'469
Time considered	10.5 months	9.1 months
Continuous running ($p < 13$ h)	2.7 months	1.7 months

Data from 8/11/07 to 19/09/08



LBDS Commissioning



1 Equipment 'controls' commissioning

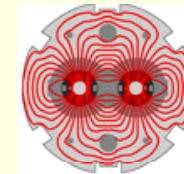
- MKD cooling – full re-testing of generators since fully “de-cabled” to install cooling
- New MKB generators
- HV required for testing at controls level

2 Local operation under HV

- Energy reference locally generated
- Check operation up to 7 TeV
- Generate calibration tables used for generation of settings / checking of the settings
- Generation of IPOC and XPOC limits for MKD and MKB



LBDS Remote Operation (I)



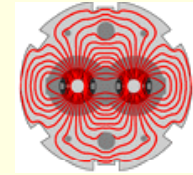
3a Remote operation from the CCC

- Energy reference can be
 - **BETSsim**: simulation program for generation of energy reference
 - **Main Bends**; nominally 4 adjacent sectors, during transition period can split signal from one or more octants
- Energy value distributed by the timing system as part of the **Safe Machine Parameters**
 - Used by other systems: BLMs, Collimators etc.
 - Only available from the moment BETSsim back in operation

Coordination required !!



LBDS Remote Operation (II)

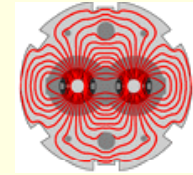


3b Remote operation from the CCC

- **Dry runs**
- Interface to many systems:
 - BIC, closing the loop: **new arming sequence**
 - **Will need to mask many systems (incl. access) to be able to close the loop**
 - **Foresee to alternate 'masked' and 'unmasked' BIC periods of 1 – 2 weeks**
 - Access system (mask on the access system level)
 - Timing & RF -> synchronisation
 - Q4, MSD
 - XPOC, LSA, MCS, RBAC
 - Abort Gap Monitoring
 - Injection System



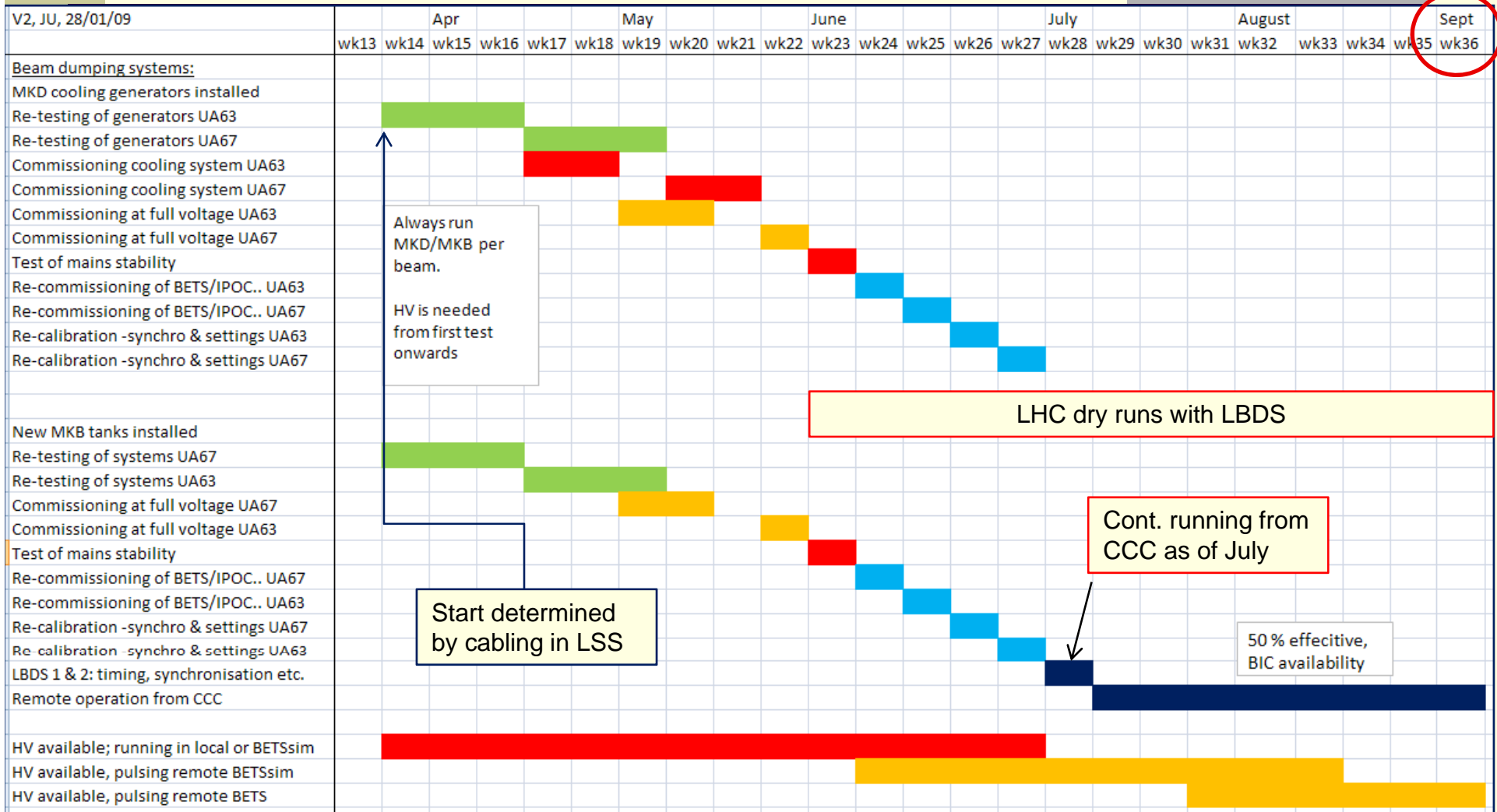
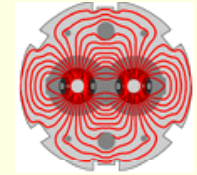
Constraints for Commissioning



- For all commissioning work High Voltage is required
- Start (only) week 14 when **cabling campaign** is finished
- Always run complete beam dumping system
 - MKD 63 ↔ MKB 67, MKD 67 ↔ MKB 63
- Timing and synchronisation as of week 28:
 - **BIC, RF, Timing, Access, LSA, RBAC, XPOC, Sequencer**
 - Estimate **at least 4 weeks of effective LBDS running from CCC** required to get everything running smoothly including reliability of new / modified systems
 - **8 calendar weeks** if 50 % effective period with BIC masked
- Main Bends as energy reference **as much as possible** before first beam
 - Only one switch-over from BETSsim to Main Bends
 - Need 'Main Bends' time to make checks on BETS
 - Can be staged 1...4 octants
- No system commissioning in stages: needs to be fully operational and checked before first beam

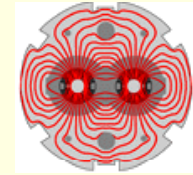


MKD / MKB Re-Commissioning





Conclusions



- **Injection System:**
 - TI 8 BPMs upgraded, TI 2 and TI 8 realigned
 - TL Beam commissioning up to downstream TEDs end May: **close 3 LHC sectors / test**
 - One injection kicker MKI replaced; additional BLMs; new SoftStart
 - Commissioning does not seem to be time-critical, no major surprises expected
- **Beam Dumping System:**
 - Doubled the number of dilution kickers MKB
 - Added cooling (& interlocks !) to all 30 MKD generators
 - Commissioning time-critical due to late start and a lot of work
 - Interface to many other systems known to be important and time consuming to test:
 - BIC availability
 - Transmission of Energy via SMP, used by others
 - Will need at least **8 calendar weeks running from CCC**, assuming 50 % availability
 - With present planning start from CCC in July (wk 28), finish **September** (wk 36)
- **Dry runs** required for both the injection and the beam dumping system
- **No staged 'non-beam' commissioning possible**
- **Thorough commissioning of the fully connected system mandatory for Machine Protection**
 - Energy tracking & triggering