

Beam Dumping System and Abort Gap

LHC Beam Commissioning Workshop
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Session 4: Machine Protection Systems

Jan Uythoven TE/ABT
For the LBDS and Abort Gap Teams

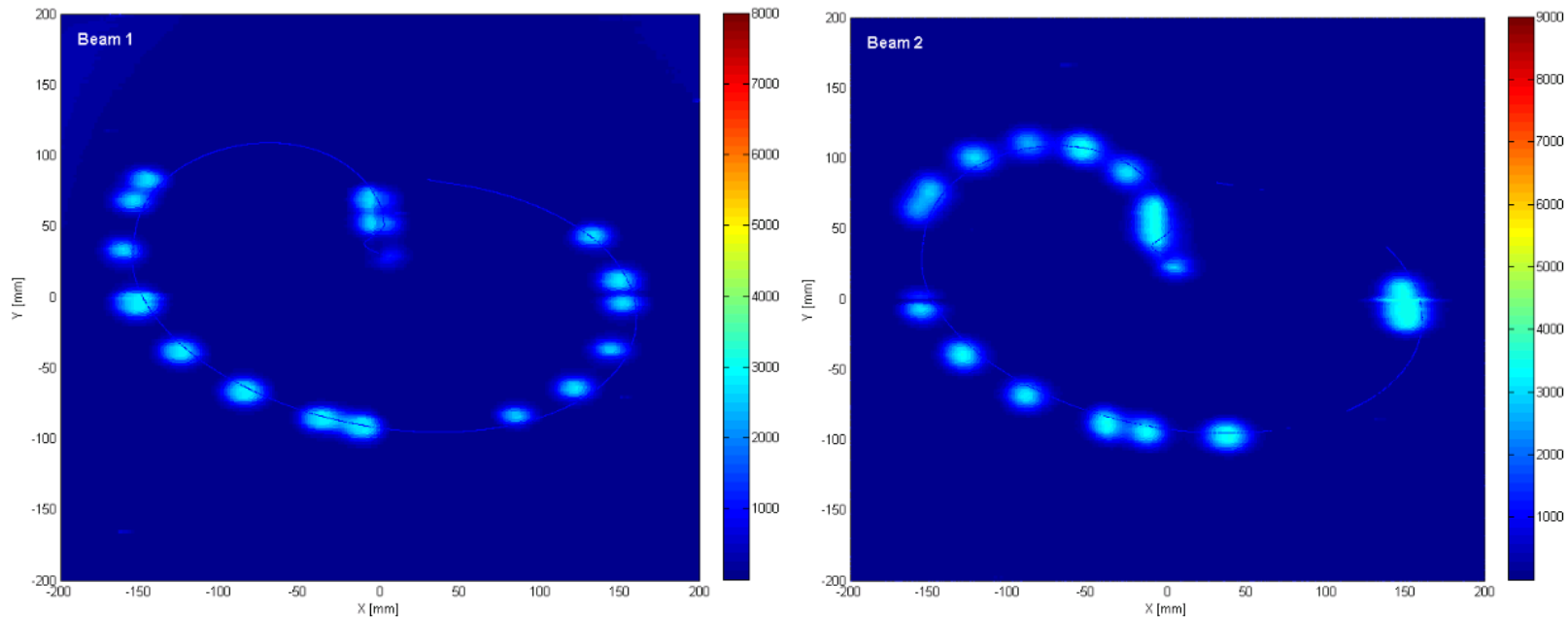
Outline

- Performance of the Beam Dumping System
 - Some Operational Statistics
- Beam Dumping System 'Failures' and Issues
 - Kicker systems
 - XPOC

Only 10 minutes from the Chairman

issues
intensities and higher energies?

Beams for physics dumped, at the right place! 450 GeV



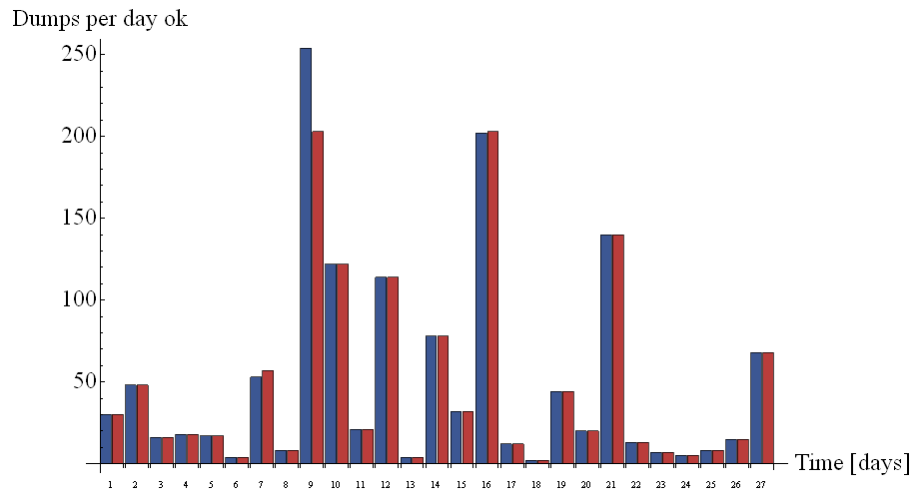
Beam dumps, 16 bunches + pilot, 14/12/09 around 21:00
BTVDD image = position on beam dump block TDE
Comparison with calculated positions from measured kicker
magnet waveforms.

XPOC Statistics Beam 1

Number of times dump triggered

XPOC = eXternal Post Operational Check

MKB (dilution) only 1 x false XPOC during Synch.-Asynch Dump



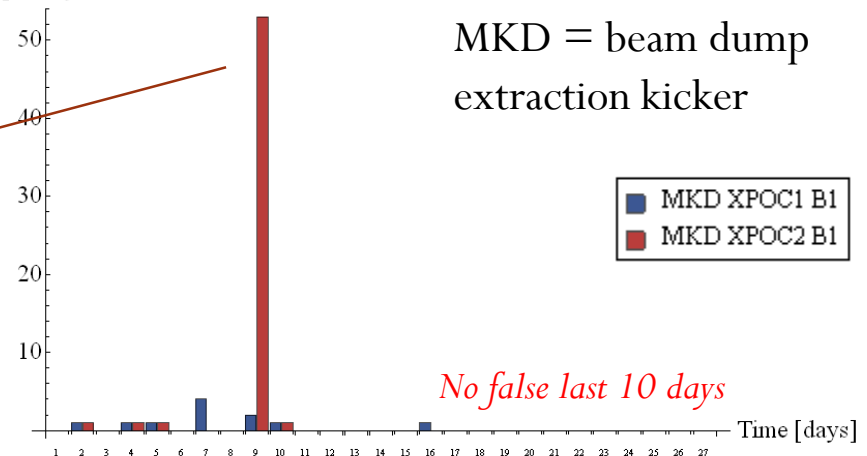
	OK	Not OK	Total
XPOC1	1355	11	1366
XPOC2	1309	57	1366

Energy	450 GeV	600 GeV	1200 GeV
# Dumps	1358	1	7

27 days from 20 Nov. to 16 Dec.

MKD Gen. K pulse length.
Limit enlarged. OK.
See later.

Dumps per day NOT ok

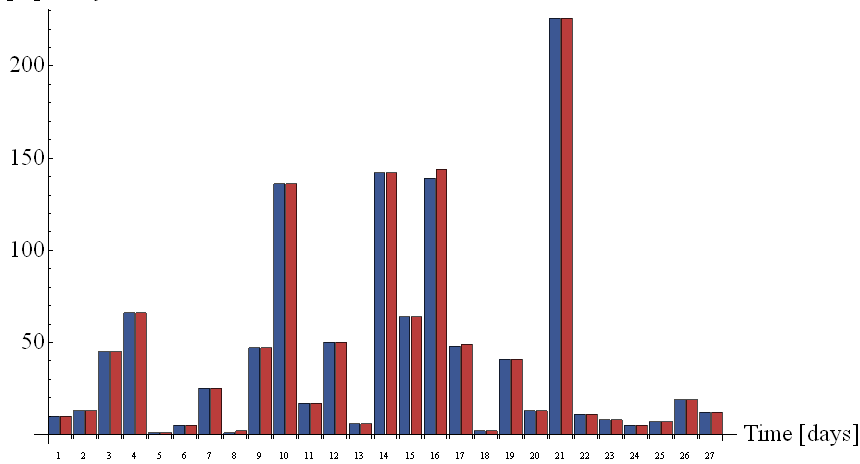


MKD = beam dump extraction kicker

No false last 10 days

XPOC Statistics Beam 2

Dumps per day ok



MKB no false XPOCs

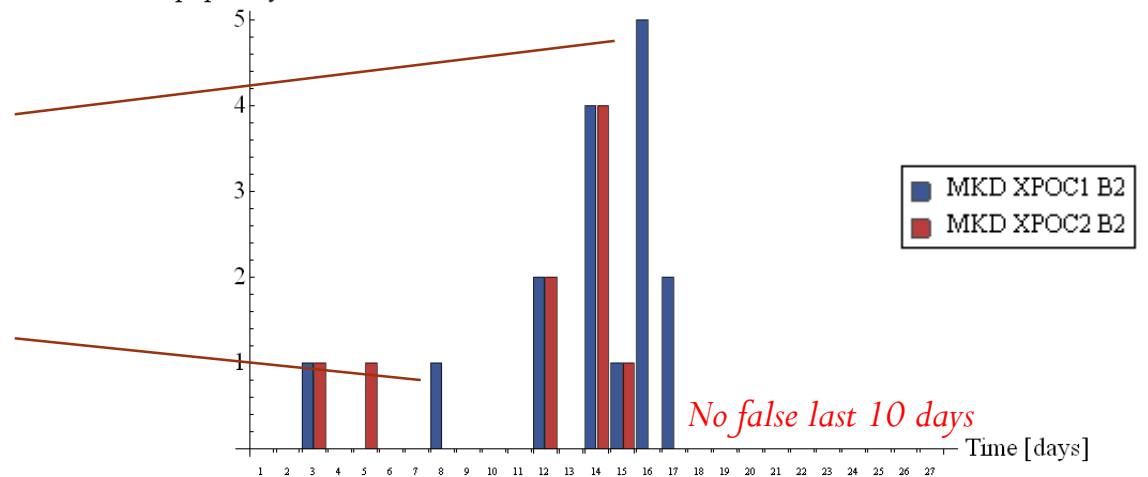
	OK	Not OK	Total	
XPOC1	1159	16	1175	
XPOC2	1166	9	1175	
Energy	450 GeV	600 GeV	800 GeV	1200 GeV
# Dumps	1159	1	1	7

27 days from 20 Nov. to 16 Dec.

Most errors due to 'Energy Error' in XPOC analysis. See later. Fixed.

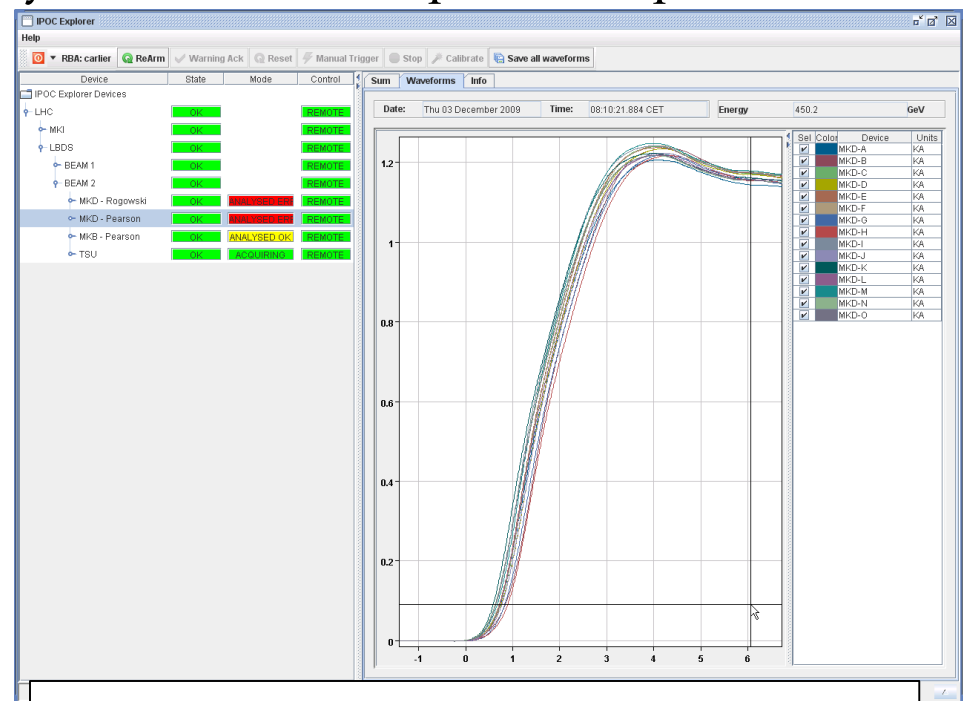
XPOC 1 errors due to noisy signal. See later. Fixed.

Dumps per day NOT ok



Beam Dumping System 'Failures'

- All dump 'failures' were caught by the XPOC and/or IPOC system
- There were no beam dump failures which were 'unacceptable'
 - Protected against asynchronous dumps with TCDQ
 - Would normally expect about 1 asynchronous dump per year
- However, 11 "Synchronous-Asynchronous" dumps due to problem with TSU
- Dump request received during the $1.5\mu\text{s}$ F_{rev} pulse duration
 - Dump request inhibited for the current turn
- Original inhibition mechanism lets a "glitch" going out
 - **Synchronous** trigger of the 15 kicker generators
 - **Asynchronous** trigger w.r.t. the circulating beam
- **TSU firmware upgraded and successfully tested**



- Generator synchronisation OK
- Kick delay w.r.t. beam abort gap FAULTY

Other Beam Dump System Hardware Problems

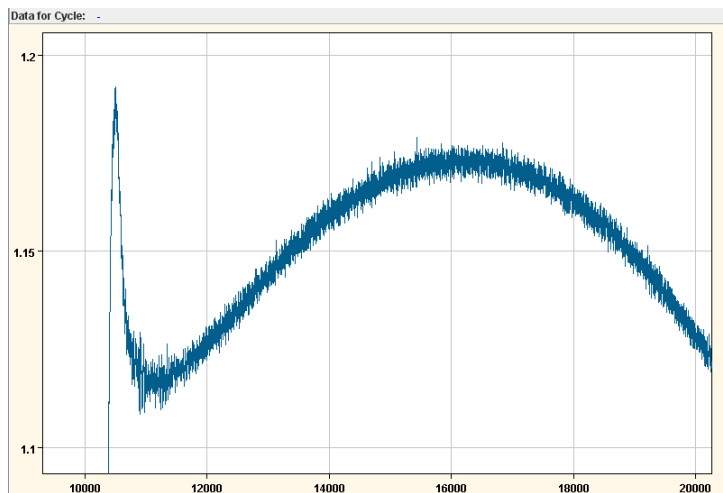
- 2 x fuse on MKB power trigger converter broken
 - Needed access to change – no safety issue
 - Reduced the power consumption of converter in this Techn.Stop
- BPM signal used for synchronisation: 2 μ s off-set
 - Being checked...
- Resistors used for re-triggering in case of MKD switch conduction not via stack: 15/60 broken
 - Masked in the generator interlock
 - Still one per generator active, but no redundancy left
 - **For this reason we should not operate present system above 5 TeV and high beam intensities**
 - Switch erratics issue above 5 TeV,
 - More important after installation of generator cooling = dry air
 - **Replacement resistors available in some wks, need about 2 wks for swap**
- Reliability of Pelletier cooling of MKD generators
 - Some failures of cooling, but still ok because little heating at low energies
 - Gives interlock when outside ± 1 °C temperature range

False XPOC / IPOC results

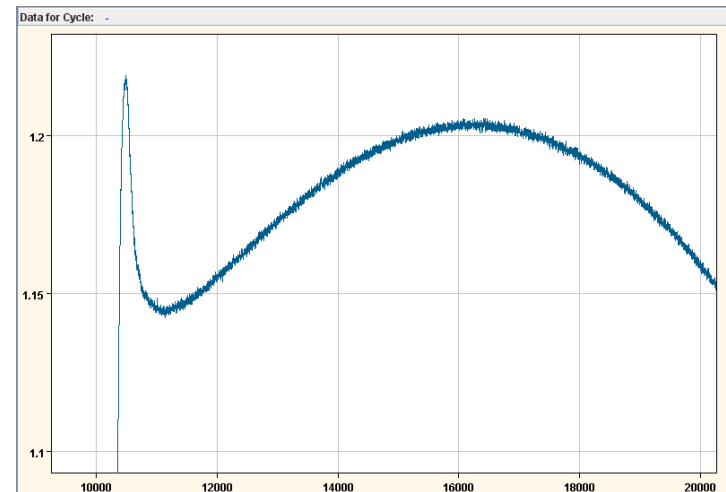
.... Signaling a REAL hardware Problem I

- Synchronisation errors due to TSU problem
 - Real problem – solved
- MKD XPOC1
 - Analysis based on Rogowski current measurement which is known to be more noisy than the Pearson signal used for XPOC2
 - Occasional bad XPOC1
 - OK after doubling the acceptance window

*As the systems are redundant,
this is acceptable*



Raw SDDS data XPOC1



Raw SDDS data XPOC2

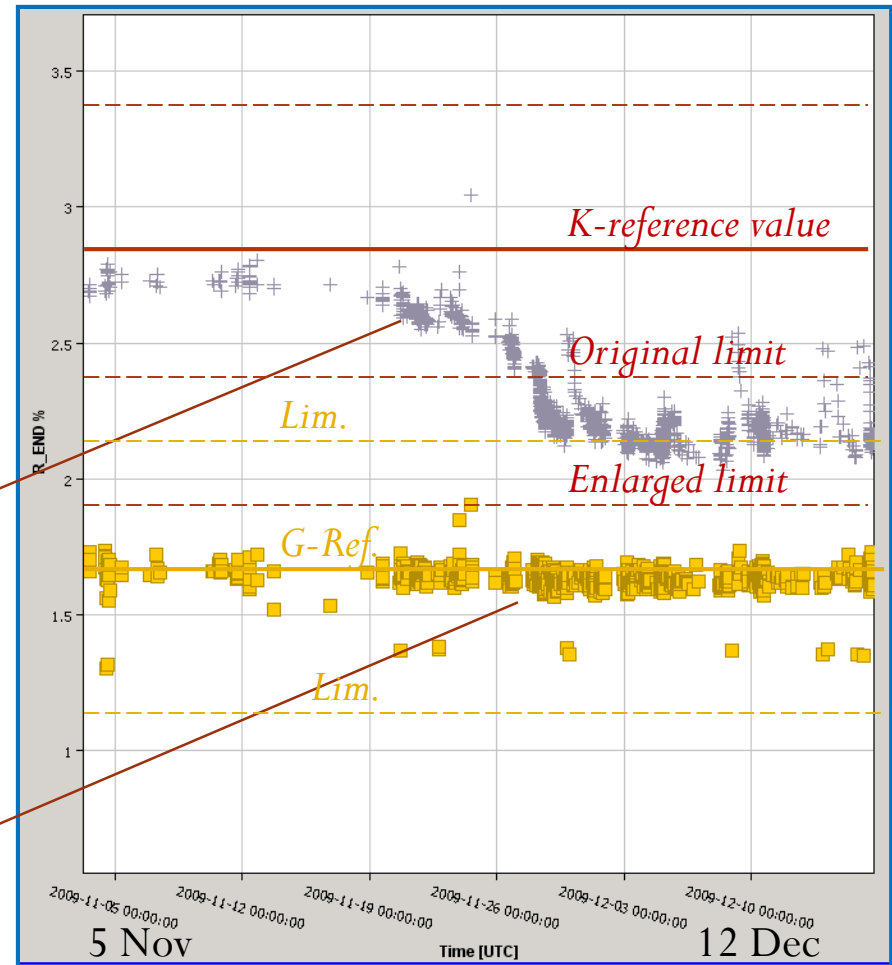
False XPOC / IPOC results

.... Signaling a REAL hardware Problem II

- MKD Beam Generator K
 - Varying pulse length
 - ‘sign of something changing’
 - Under investigation in this Technical Stop

MKD B1 Generator K,
Pulse length drops during operational period
but ‘jumps back’ when dumps at 1.2 TeV

MKD B1 Generator G,
for comparison



False XPOC / IPOC results

.... Signaling an XPOC / IPOC Problem

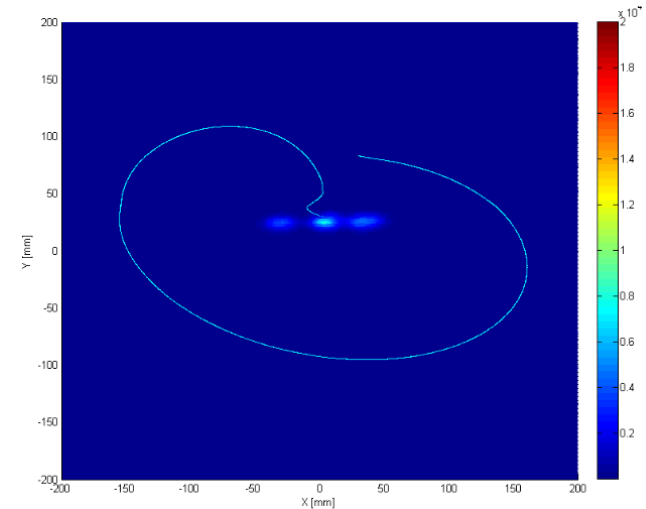
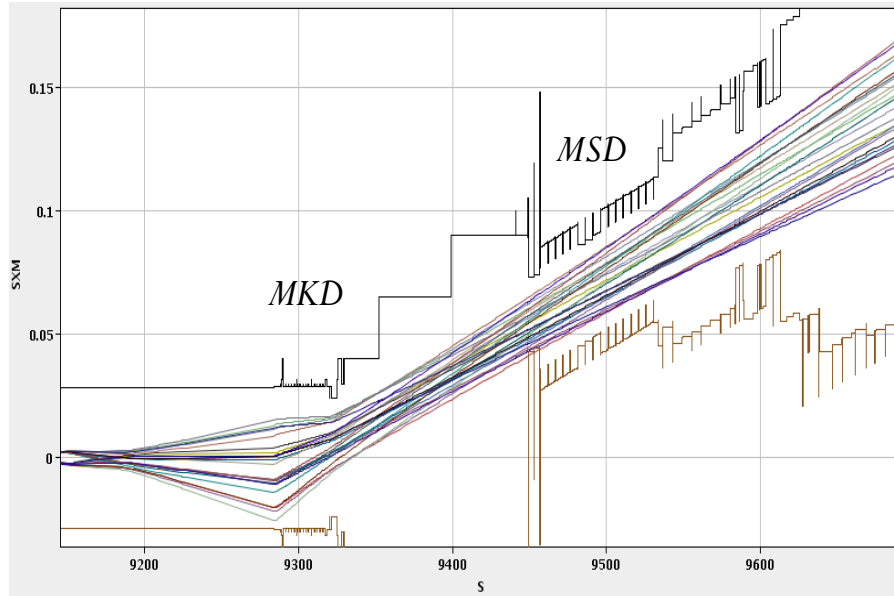
- XPOC sequencer task picking up different time stamps from MKD and MKB IPOC
 - Solved during operation by applying the correct tolerance
- XPOC MKD analysis failed because of different energies
 - Solved during operation by applying the correct tolerance
- IPOC MKD analysis failed, giving some analysis points 'dangling in the air'
 - Solved during in Technical Stop by small change in algorithm (same problem as for MKI IPOC used for IQC)

These false XPOCs were annoying for both the operators and the experts, however I'm convinced that we have to maintain the Expert Reset for XPOC, as the LBDS is too safety critical.

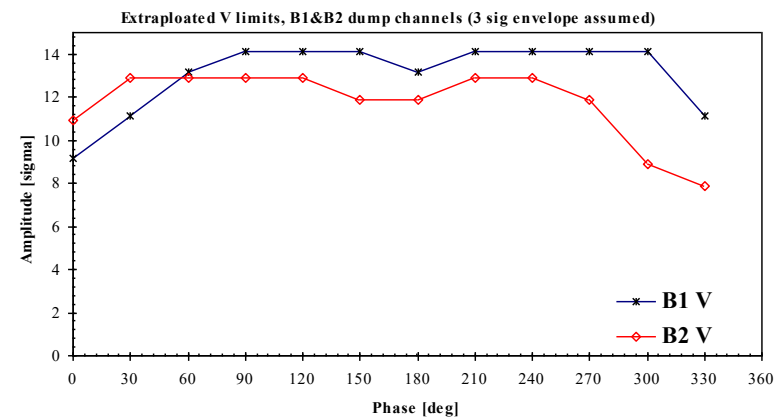
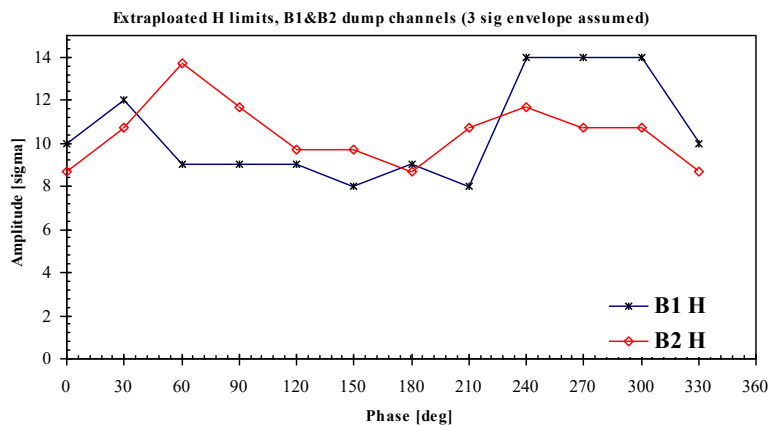


Beam Dump Channel Aperture

Aperture limits measured with all phases in H and V plane for B1 and B2 → as expected

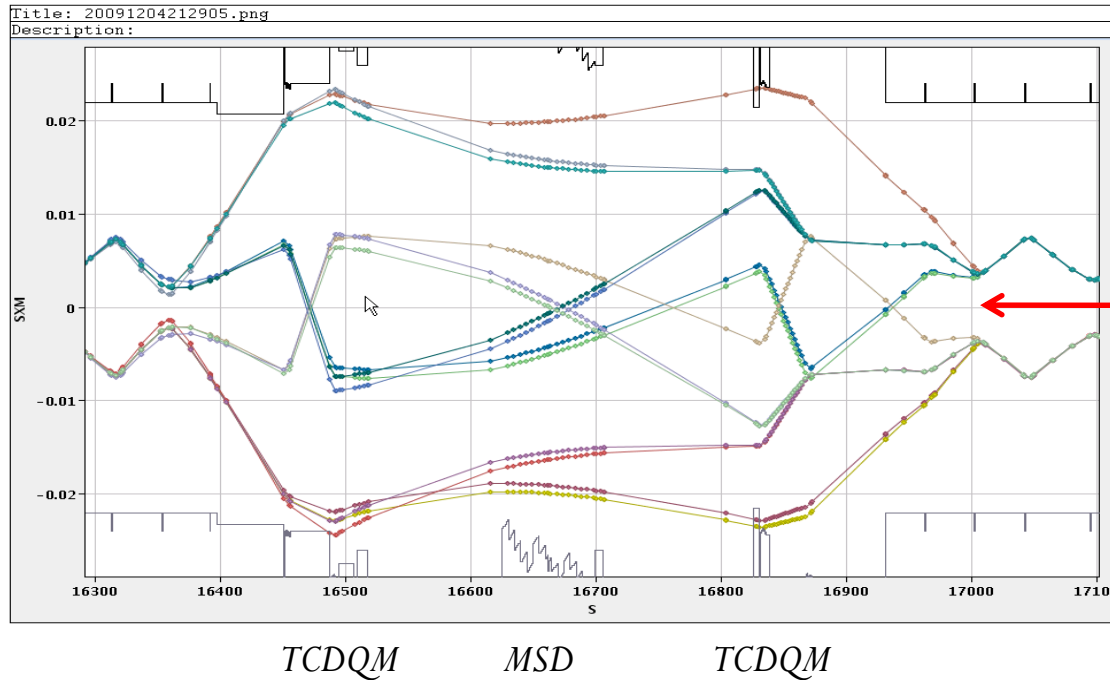


Can dump without losses with ± 1.67 MKD for B1, +1.333 and -1.67 MKD for B2. Spec: + 0, -1 MKD.



Point 6 – Circulating Beam Aperture

Circulating beam aperture in H and V for B1 and B2 checked carefully at TCDs, TCDQM, MSDC and MKD, with bumps through the region → beam lost where expected

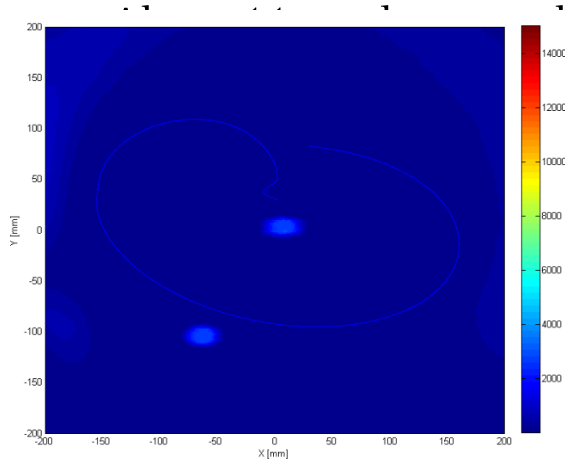
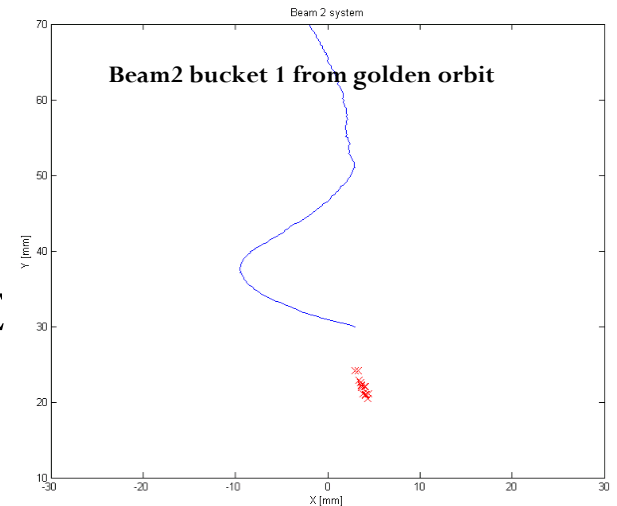


“Official aperture model”

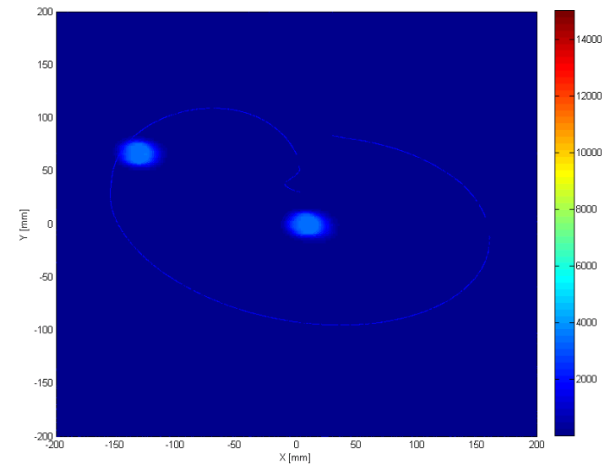
IR6 H Beam2, circulating

Dump at 1.2 TeV

- Vertical dump position low at 1.2 TeV for both beams
 - After orbit correction to golden orbit
 - Maybe 7-8 mm vertical error at the TDE for both beams
 - Can be an MSD calibration issue?



B1

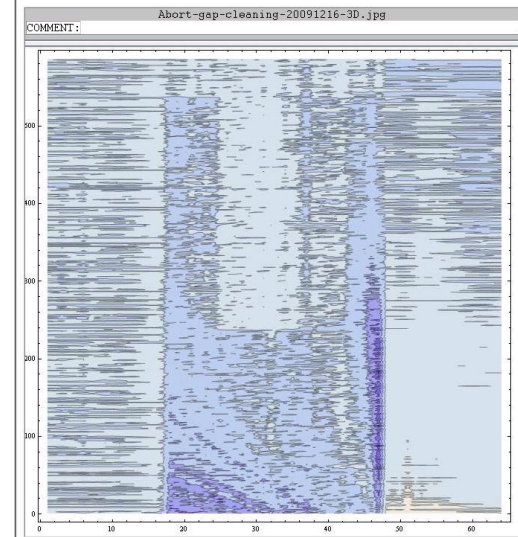
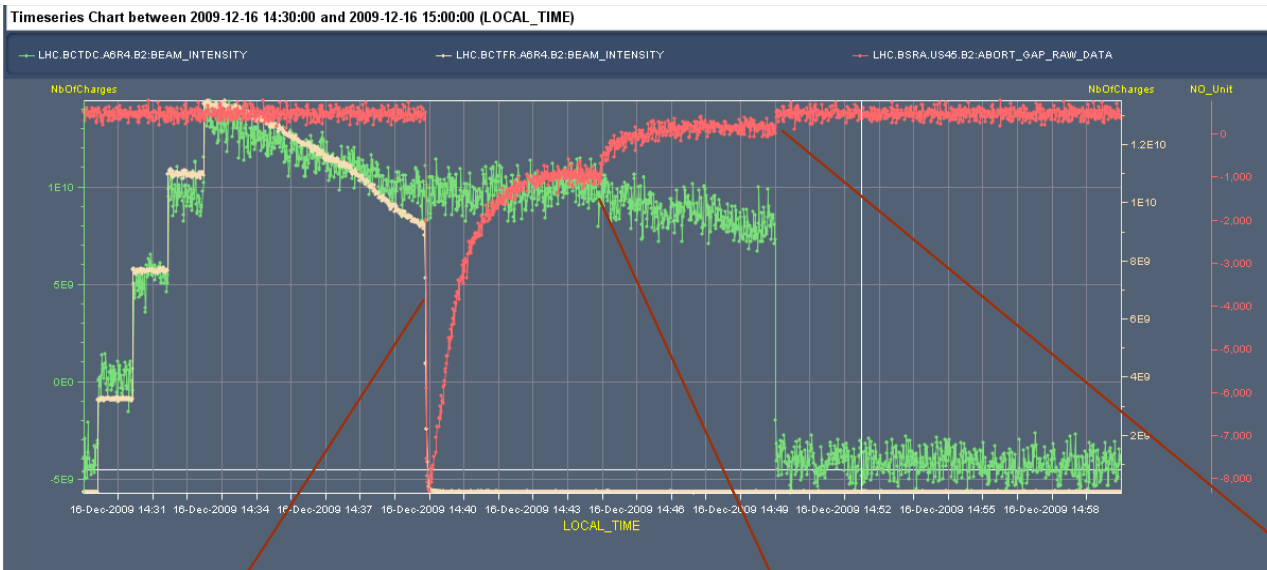


B2

Abort Gap Cleaning Tests

First functionality tests performed on December 15-16, 2009
Used vertical dampers on beam 2

BSRA data show gap partially cleaned



RF-Off:

BCTFR signal to 0
BCTDC signal flat
BSRA signal pops up
and reduces when
beam disperses

Cleaning on:

BCTDC signal shows losses =
cleaning
BSRA signal decreases from previous
equilibrium to new equilibrium

Beam Dumped:

BCTDC to 0
BSRA to 0

Losses at BLMs at TCDQ / TCDS, at moment of dump,
are reduced to about 10 – 12 % relative to no cleaning!

Conclusions on Abort Gap Cleaning

- Undulator and synchrotron light monitor successfully commissioned for beam 2
 - Beam 1 remains to be commissioned
- Abort Gap Cleaning “works” already during first tests!
 - But needs to be further optimised to clean over the full 3 μs while limiting the losses outside the abort gap
 - About 10 % of the beam was left in the gap
- Concerning Machine Protection we will need to commission the **Abort Gap Monitoring Interlock**
 - Interlock values to be found and tested with beam

Conclusions / Are we Ready for Higher Intensities and Higher Energies?

- The beam dumping systems worked very well and the XPOC and IPOC systems caught all failures
 - Only real failures were the Synchronous-Asynchronous dumps: solved after TSU firmware upgrade
 - Opening up of XPOC1 window and one MKD generator which drifted
 - Other XPOC/IPOC 'false' were software issues, sorted out during the 2009 run
- Many tests with beam outstanding
 - Dump at intermediate energies, already some energies 'missing' up to 1.2 TeV
 - Follow commissioning procedures for increasing energy and intensity: edms 896392
- Sort out vertical dumped beam position on TDE (MSD calibration?)
- Should not pulse with unsafe beam above 5 TeV without redundancy on resistors for erratic trigger protection (new ones ordered)
- Further BI-XPOC modules to be commissioned
- With the present 'habits' and possibilities to skip sequencer tasks, the SIS latching is mandatory
 - At some point the SIS interlock of the XPOC will have to become unmaskable
- We will need to converge to a more standard way of running sequences and clear instructions which tasks are mandatory to be run before each injection or each fill and under which conditions tasks can be skipped: **PROCEDURES – Master Sequence**
- BSRA – Abort Gap Monitoring Interlock to be commissioned and tested with beam
 - Abort Gap cleaning also needs further commissioning, but should not be a machine safety issue

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