

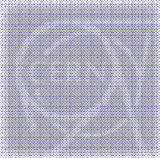
# The LHC Beam Dumping System

## The LHC Beam Dumping System

V.Kain, R. Suykerbuyk  
Input from: E. Carlier, B. Goddard

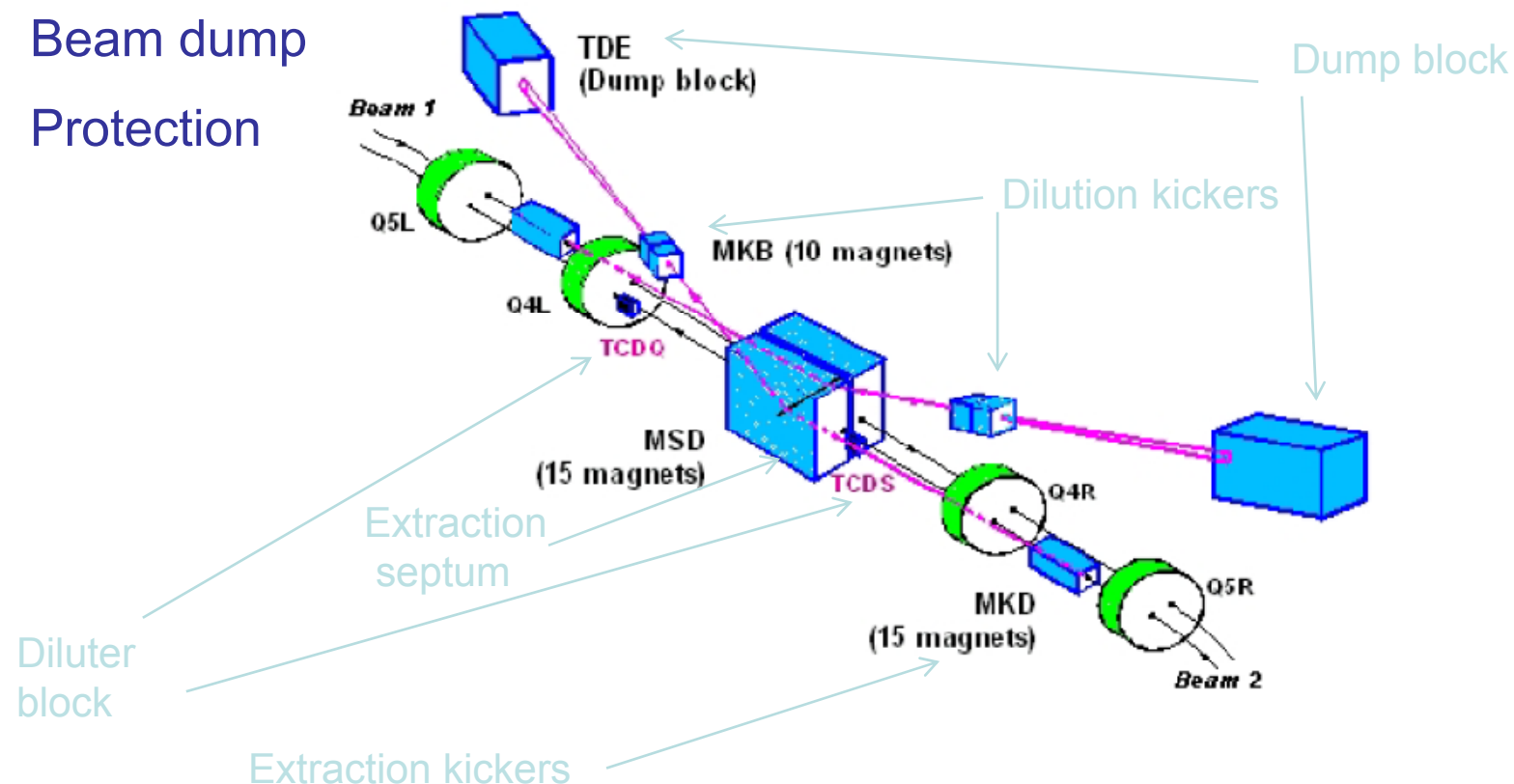
### Contents:

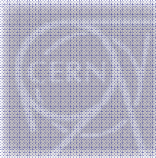
- LHC Extraction in LSS6 – LHC Beam Dumping System (LBDS)
  - Equipment, Interfaces, Software
- Testing – Reliability tests, Scenario tests
- Summary



# LHC Extraction in LSS6 – LHB Beam Dump System (LBDS)

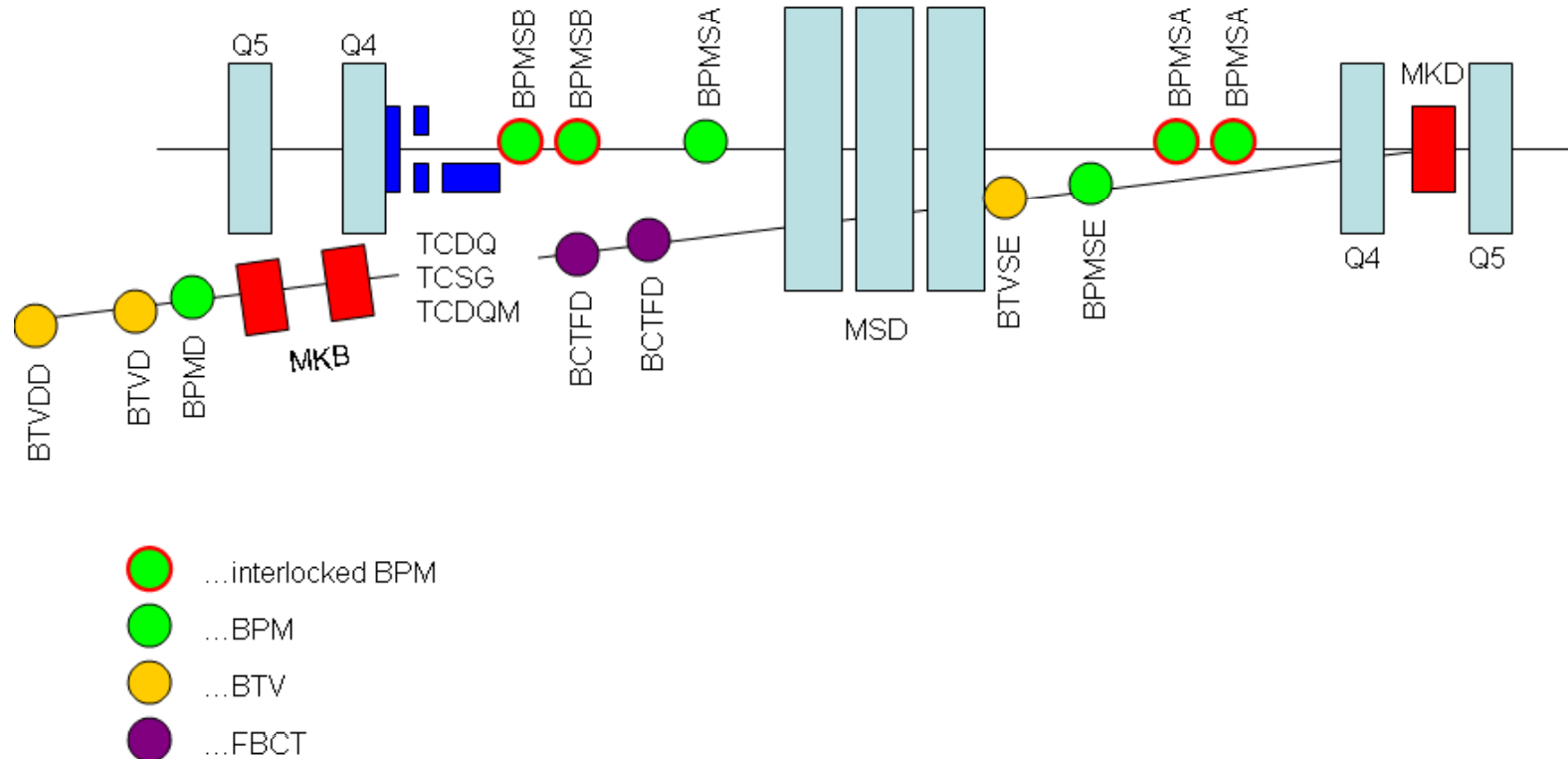
- Fast extraction (kicker and septa)
- Dilution
- Beam dump
- Protection

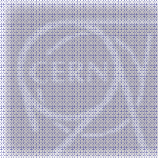




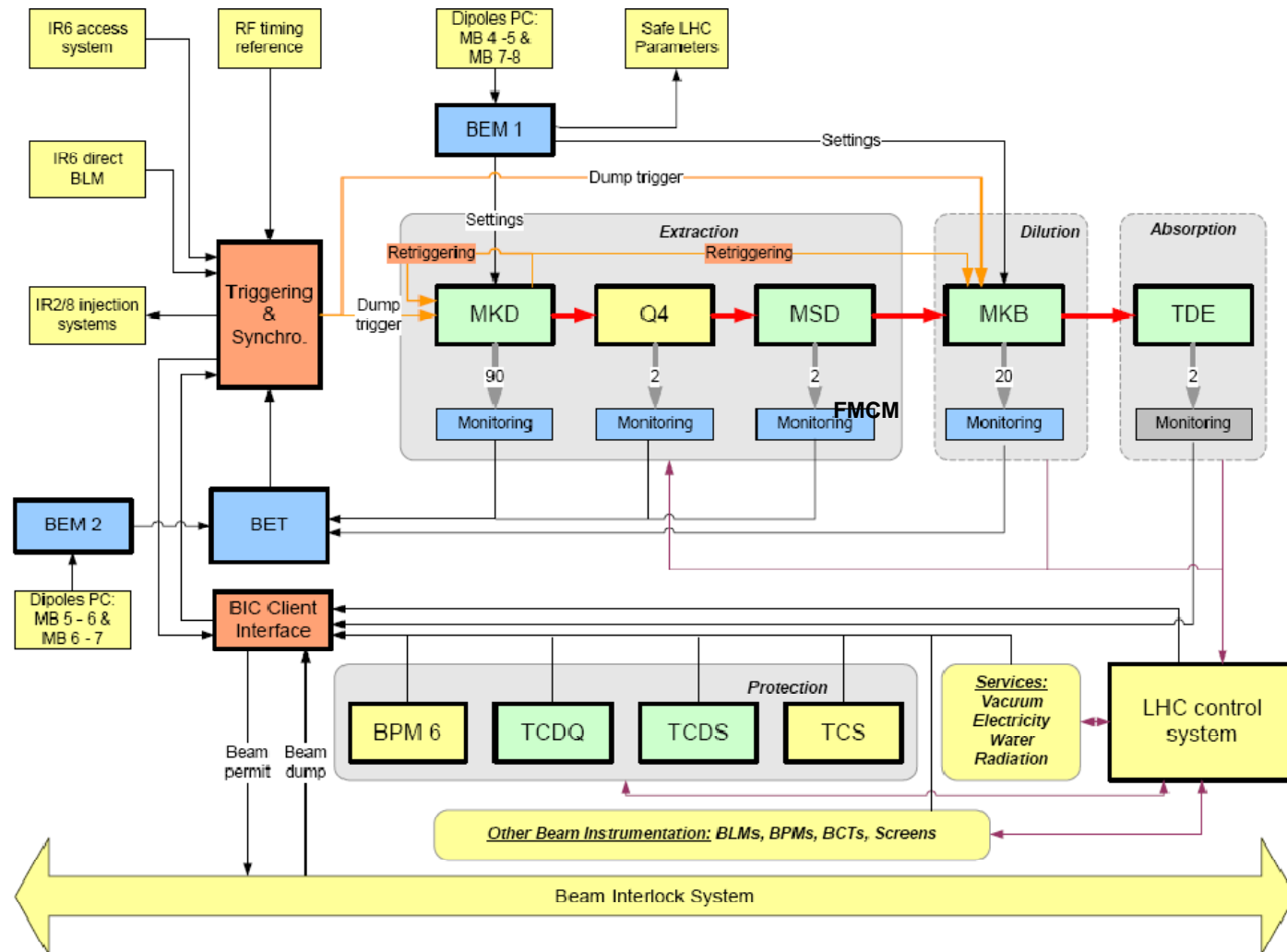
# LBDS Beam Instrumentation

- Additional beam instrumentation, shown for one beam
- BLMs missing...(32 per beam, 2 special ones on TCDQ)

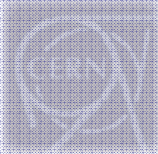




# LBDS Interfaces



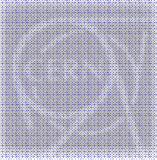
**Interfaces: triggering, synchronisation, energy tracking, arming, BIS, injection BIS**



# LBDS Software

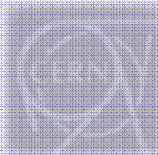
No mention of the internal LBDS controls software (slow control software, fast acquisition, synchronisation unit, ...).

- “LBDS Monitoring GUI” ← does not exist yet, no person assigned (maybe Eric)
  - like WinCC
  - shows alarms
  - IPOC results
  - shows status of different sub-systems
  - shows status of BETS
  - can be used to re-arm LBDS
- XPOC

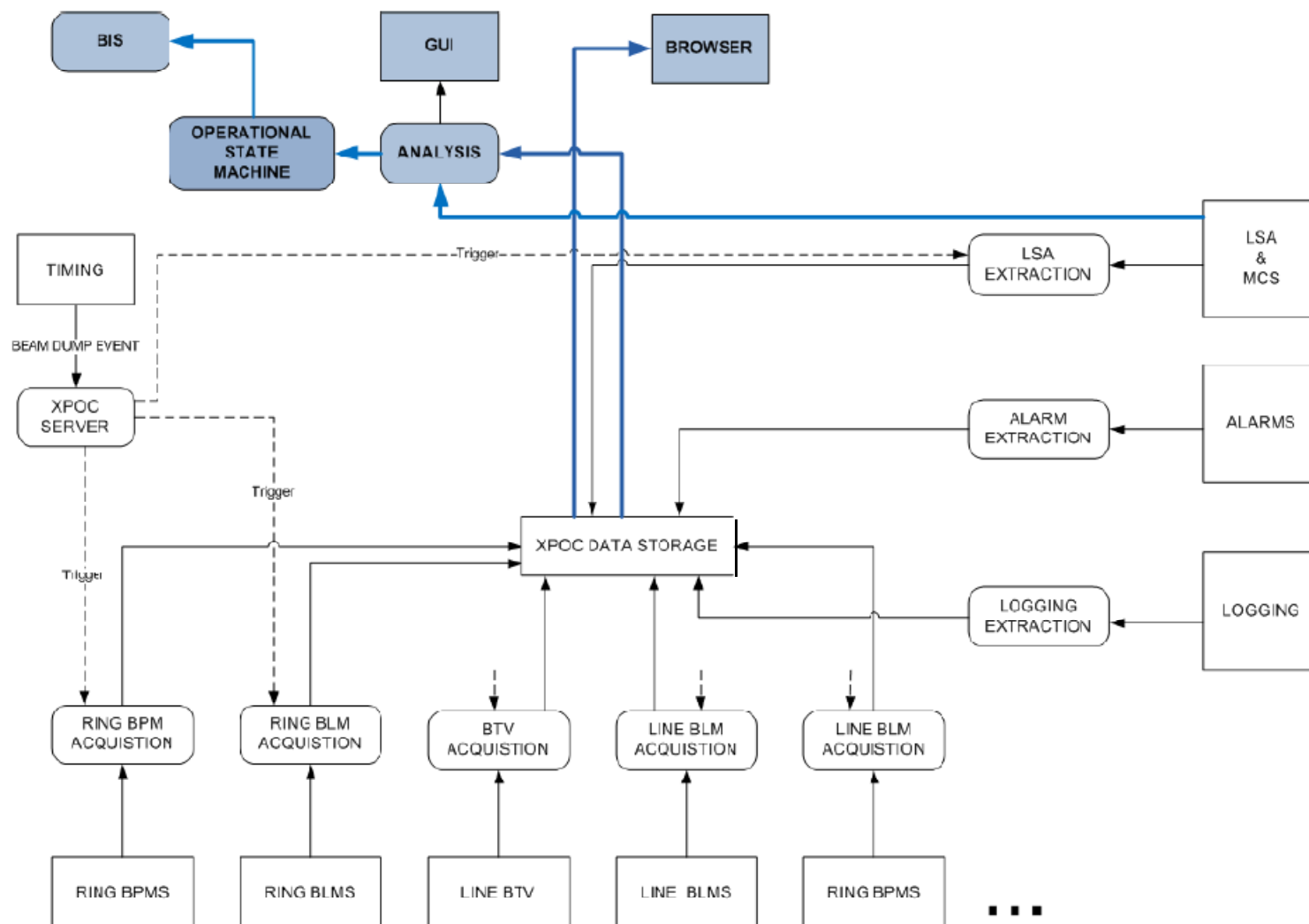


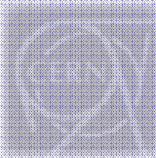
# LBDS software – XPOC (1)

- LSA software
- External Post Operational Check after EACH beam dump
  - LBDS safety critical
  - analysis of last beam dump to verify that worked correctly
  - IPOC (beam dump hardware) + BI + ...
  - even if postmortem event suppressed, XPOC carried out
    - XPOC analysis could cover enough even for “bad programmed dump” (no PM event)
- ‘Operational state’ of beam dump depends on XPOC result
  - analysis specified not to take longer than 5 s
- XPOC triggered on ‘beam dump’ event
  - XPOC on server. Data collection and analysis start automatically.
  - event generated by timing as soon as permit loop broken
  - during analysis beam permit removed [via SIS](#)
- SDDS file structure in event trees
  - results are written to file in event tree
- XPOC GUI: browser, model builder, view analysis results
- XPOC references [MCS settings](#)
  - List: LHC-TD-ES-0001



# LBDS software – XPOC (2)





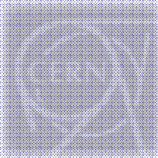
# LBDS software – XPOC (3)

System	Description	Data kB
MKD/MKB system	Measured MKD/MKB traces, IPOC summary, status	40000
MSD system	Measured currents/FMCM status	1
BETS	Measured/reference currents, voltages etc.	10
Abort gap monitor	Measured abort gap population	10
TCDs/Q/TCS	TCDQ up/down set/meas positions & status	10
BLMs	Losses before/during extraction (100 turns)	100
BPMs	Bunch positions before/during extraction (100 turns)	2000
BCTs	Circulating/extracted intensity (100 turns)	1000
BTV screens	BTV images, projections and status	4000
Total		47131

- XPOC Status

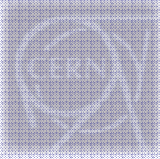
- analysis packages so far only for
  - BTVDD traces
  - MKD waveforms
  - MKB waveforms
- signals not written to event tree file structure yet
- no GUI with browser yet
- no references in LSA yet





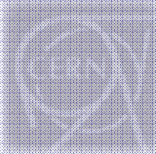
# LBDS - Controls Requirements (1)

- “No” LSA settings – LBDS core is hardcoded
    - But:
      - Q4 currents, discussion: critical settings
      - MSD currents, discussion: critical settings
      - TCDQ functions
  - Only command: ARM (before first injection)
- 
- Logging
    - to be defined
    - e.g. BETS logged with 1 Hz, during pulse higher frequency
  - Fixdisplays
    - to be defined
    - BTVD, BLMs in extraction region, BPMSE **update each dump** ...N2 pressure at TDE **continuous update**,...
  - MCS
    - XPOC references
    - BETS look-up tables: MKD/MKB strengths vs. energy, Q4/MSD current vs. energy, DCCTs vs. energy, ...
    - Q4, MSD current?
  - Alarms
    - to be defined for operations. Alarms on FESA level defined → WINCC
  - OASIS
    - idea for the time being: 1+15 MKD kicker waveform, revolution frequency, circulating beam signal
    - Maybe not required: IPOC FESA class prepares everything digitally
  - TCDQ: collimator control



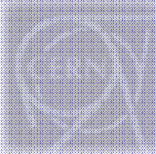
# LBDS - Controls Requirements (2)

- Applications for BI:
  - BTVs: application of Fabio
  - BPMs: BPMD in a separate FESA class
    - BPMD probably only for XPOC
  - Interlocked BPMs?
    - Probably YASP, critical settings, like CNGS
    - (fast position interlock for later on)
  - BLMs: normal ones in dump line?
    - Special ones on TCDQ?
  - FBCTs: application of Markus



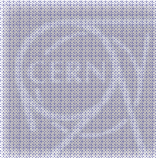
# LBDS - Controls Requirements- Sequencer

- Has to arm the LBDS (+ BIS)
  - via LBDS FESA device
- Has to manage the OPERATIONAL STATES of the LBDS.
  - depend on XPOC results, access in LSS6
    - e.g. LBDS available for operation without beam/ pilot at 450 GeV
- Provokes programmed dumps
  - depending on operational scenario:
    - unlink/link permit loops via BIC FESA class
    - prepare timing tables with events to:
      - dump beam
      - post mortem suppression/re-enable
        - » For inject & dump, circulate & dump, injection intermediate, single beam MD
- Set # turns on turn counter value at inject & dump LBDS hardware



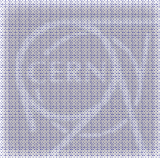
# Other stuff

- Access procedures?
  - Padlock dump caverns during run?
    - During shutdown needs to be accessed for maintenance of BTVDD electronics, radiation monitors, water pump
- FMCM on MSD
  - Supervision application ready



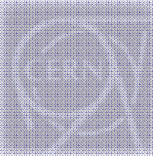
# Testing... (1)

- As LBDS is safety critical a RELIABILITY TEST is planned
- Two phases:
  - ‘stand-alone’ reliability test
    - 10 weeks during hardware commissioning
  - ‘fully-connected’ reliability test
    - 450 GeV ‘fully-connected’: 2 weeks, during machine check-out
    - 7 TeV ‘fully-connected’: 4 weeks, during machine check-out
- Documentation will be in MTF
- A lot of open issues...parallelism? Availability of closed BIS loop,...
- As soon as possible from CCC – running already in local
  - would need:
    - timing: XPOC triggering
    - sequencer – arming, timing



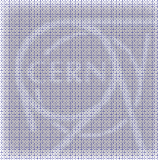
# Testing...(2)

	stand-alone	fully-connected 450 GeV	fully-connected 7 TeV
<u>'debugging phase'</u>	pulse every ~ 5 minutes, dump at different energies  2 weeks	Connection to other systems. Triggering via timing or BIS. Test of arming via control system (inhibit of MKI, 500 ms BIS blind,...) Dump at 450 GeV Define operational state in sequencer, verify  1 week	Triggering programmed or BIS. Pulse every ~ 5 minutes. Energy tracking Dumps at different energies  2 weeks  Define operational state in sequencer, verify
<u>'collecting statistics'</u>	pulse every ~ 1 h: ramp to 7 TeV, dump at 7 TeV  6 weeks	Pulse every ~ 1 h, 450 GeV settings  1 week	Pulse every ~ 1 h. Cycle the machine. Dump at different energies.  2 weeks.
<u>'fault injection'</u>	Retriggering (how?), missing MKD, RF synchronisation lost, IPOC and XPOC need to detect the failures  2 weeks	-	-
when	during hardware commissioning	during check-out	during check-out



# Reliability Testing (1)

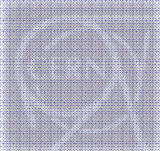
- ‘Stand-alone’ (10 weeks) – during hardware commissioning
  - NEEDS LOGGING CONFIGURED
  - NEEDS XPOC (to some extent)
  - (NEED IPOC)
  - Fake DCCT signals from MBs, Q4 and MSD to BEM/BETS from local FGCs
    - is there
  - No connection to access system
  - Fake RF signal from local FGC (for RF revolution frequency signal)
    - is there
  - BIS needed: if loop not closed yet, close locally
  - The arrival of the signals from DCCTs, access system,... have to be tested independently of the stand-alone reliability test during the hardware commissioning, also:
    - » FMCM on MSD
    - » MSD software interlocked? BETS tracking....
    - » TCDQ functions
  - IPOC fully tested after this phase



# Reliability Testing (2)

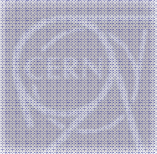
- ‘Fully-connected’ – during check-out
  - 450 GeV (2 weeks)
    - allows beam operation at 450 GeV, pilot
    - Connection to LHC access system: the LHC needs to be CLOSED!!
    - TCDQ direct link BLMs
    - SLP distribution to be tested
    - Links to MKIs to be tested
    - Real DCCTs from MBs, MSD, Q4.
    - RF
    - BIS. Loop closed
    - Operational: MKD, MKB, MSD, Q4, BIS, TDE, Vac, TCDQ, TCS, BI, DCCTs, RF ref. freq. signal
    - LHC cycling
  - 7 TeV (4 weeks)
    - allows beam operation up to 7 TeV, pilot
- XPOC will only be fully commissioned after first experience with beam





# Scenario Testing

- **We should foresee “scenario tests”**
- **Emergency beam dump: permit loops are linked, PM not suppressed**
  - USER\_PERMIT change
  - Both permit loops broken
  - LBDS triggers both dumps
  - CTG detects open loop, sends beam dump event (XPOC) and PM event
  - XPOC
  - PM buffers frozen by PM event
  - PM data pushed to server
- **Programmed dump at end of fill: permit loops linked, PM not suppressed**
  - Timing table executed containing events dump beam 1 and dump beam 2
  - Removes CTG user permit
  - ...
- **Dump only one beam at end of fill, need to suppress PM event for this beam**
- **Inject & dump:**
  - Injection warning, suppress beam 1 PM (with correct delay), dump beam 1 in timing table
  - Inject and dump hardware: set with the correct delay turns
  - Suppress the PM event for one beam, unlink permit loops
  - Inject and dump hardware counts number of turns and then removes user permit
  - ..
  - After dump re-arm BIS and LBDS
- ...



# Summary

- LBDS equipment – installation – hardware commissioning:
  - Work in progress
- Settings into LSA, XPOC, applications:
  - Most of it defined, people assigned
  - “LBDS Monitoring GUI” not assigned yet
- Testing...
  - Big issue – parallelism,...
  - Need to discuss also “partial testing” for “Sector test” , etc.
  - Very much work in progress