Experiments protection from beam failures and experiments-machine signal exchange

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Workshop on Experimental Conditions and Beam Induced Detector Backgrounds, CERN 3-4 April 2008

OUTLINE

Beam failure scenarios

Signal exchange overview

Beam Interlock System (BIS)

General Machine Timing (GMT)

Data on the CERN Data Interchange Protocol (DIP)

To be done

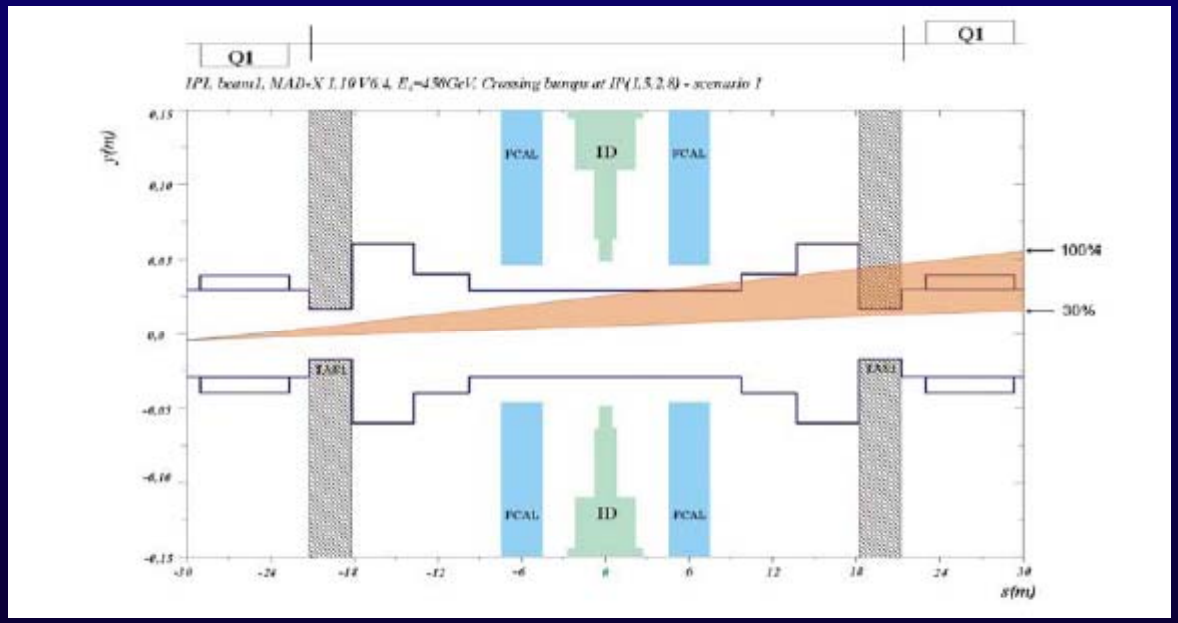
Conclusions

Discussion and implementation mainly via MPWG and LEADE WG

Identified beam failures scenarios directly involving the experiments (1)

Failures at injection and extraction

- **Wrong settings at injection**
  - Wrong settings LSS magnets: the beam may hit/scrape the TAS or directly impact on the experimental beam pipe
  - Protection: software interlock on magnet settings, probe beam flag, pilot beam procedure



MCBXV current higher than nominal (30-100 % maximum strength)

Identified beam failures scenarios directly involving the experiments (1)

Failures at injection and extraction

- **Wrong settings at injection**
  - Wrong settings LSS magnets: the beam may hit/scrape the TAS or directly impact on the experimental beam pipe
  - Protection: software interlock on magnet settings, probe beam flag, pilot beam procedure
- **Error failures at injection (mainly IR2 & IR8)**
  - Wrong settings transfer line magnets/injection septum, fast trip power supplies….
  - Protection: movable absorbers (TDI, TCLI), magnet current surveillance , fast current change monitors
- **Error at extraction (IR6)**
  - Loss of synchronisation with abort gap, over-populated abort gap, pre-firing one if the 15 kicker modules, failure energy tracking system
  - Protection: TCDQ, TCS, fixed TCDS, and TCDQM, TCT etc

Identified beam failures scenarios directly involving the experiments (2)

Failures during circulating beam

- **Magnets failures including operation mistakes**
  - Usually slow and detected first in the machine aperture restriction
  - Protection: collimators, BLM, fast current change monitors, experiments BCM
- **Uncontrolled closed bumps**
  - They can affect only experimental areas and therefore potentially dangerous for near beam detectors (VELO and Roman Pots)
  - Protection: collimators, BLM, fast current change monitors, experiments BCM

COMMUNICATION CHANNELS EXPERIMENTS ⟷ MACHINE (1)

1. **Timing, Trigger and Control (TTC)** **->Trigger system**
   - **Transmits the LHC fast timing signals from the RF generators of the machine:**
     - 40.08 MHz bunch clock frequency
     - 11 kHz revolution frequency
   - **(It integrates the Level-1 trigger, fast signals, slow control and transmits this to the sub-detectors)**

2. **Machine Beam Synchronous Timing (BST)** **->Trigger system**

   Developed using TTC technology to provide the LHC beam instrumentation with:
   - **40.08 MHz bunch synchronous triggers and 11kHz LHC revolution frequency**
   - **Encoded message (can be updated on every LHC turn) mainly used by the LHC BI to trigger and correlate acquisitions. It also contains the current machine status and values of various beam parameters. The message is sent to the experiments and used to:**
     - Provide the TTC with the "Machine Status" information to define the type of clock delivered (rising, stable, not guaranteed)
     - Some experiments get the GPS absolute time, total intensities etc

3. **Beam Interlock System (BIS)** **-> Protection from beam failures**
   - **It collects and transmits in a safe way the injection inhibit signal and beam dump signal**

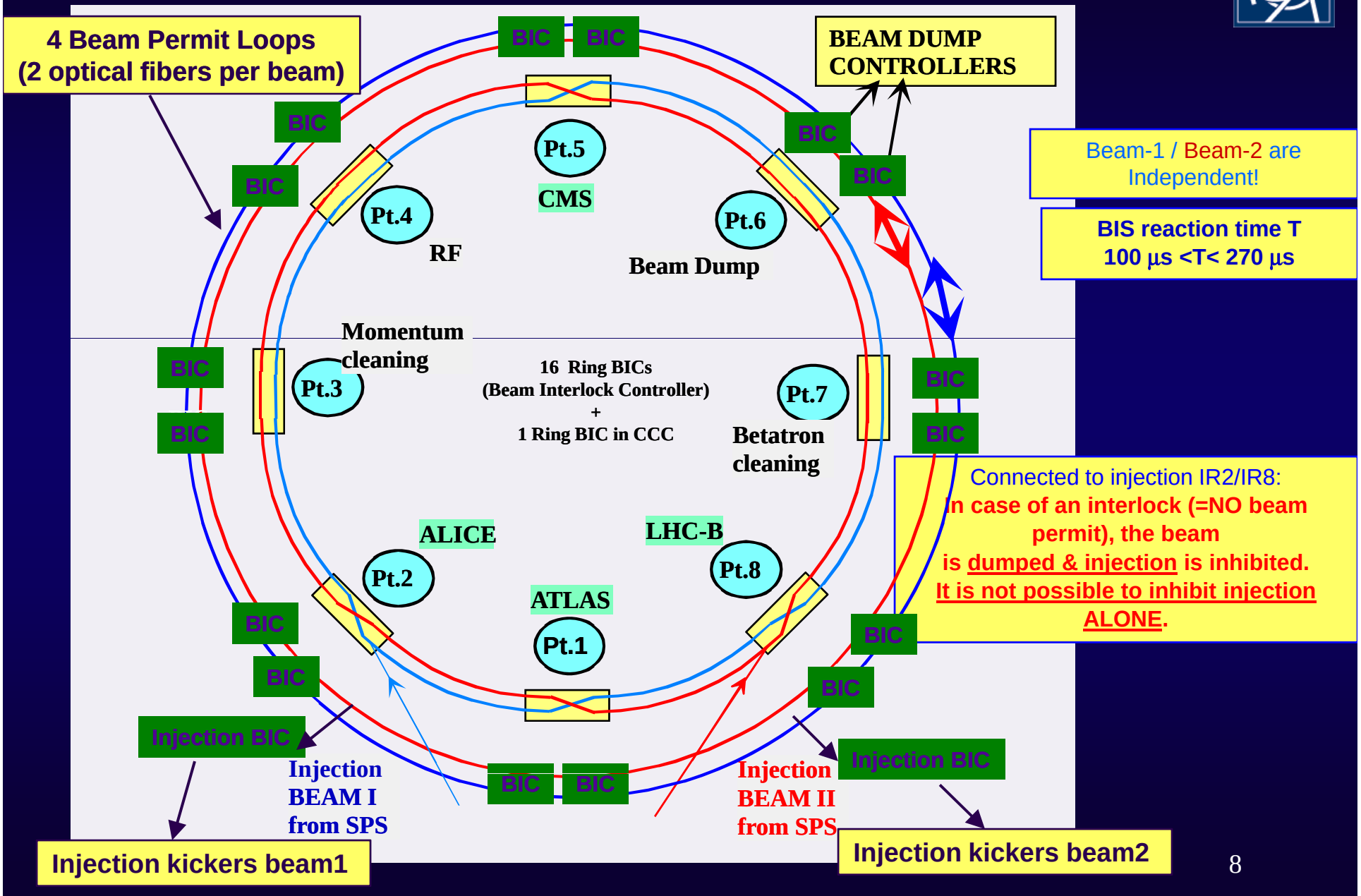
COMMUNICATION CHANNELS EXPERIMENTS ⟷ MACHINE (2)

- **General Machine Time (GMT)** **-> Protection from beam failures**
  It distributes in a very reliable way the safe beam parameters and flags needed for the interlock system

- **CERN Data Interchange Protocol (DIP)**
  - System which allows relatively small amounts of soft real-time data to be exchanged between very loosely coupled heterogeneous systems

-> General communication channel, handshaking signals and level-2 protection from beam failures

Architecture of the BEAM INTERLOCK SYSTEM



THE EXPERIMENTS INJECTION INHIBIT

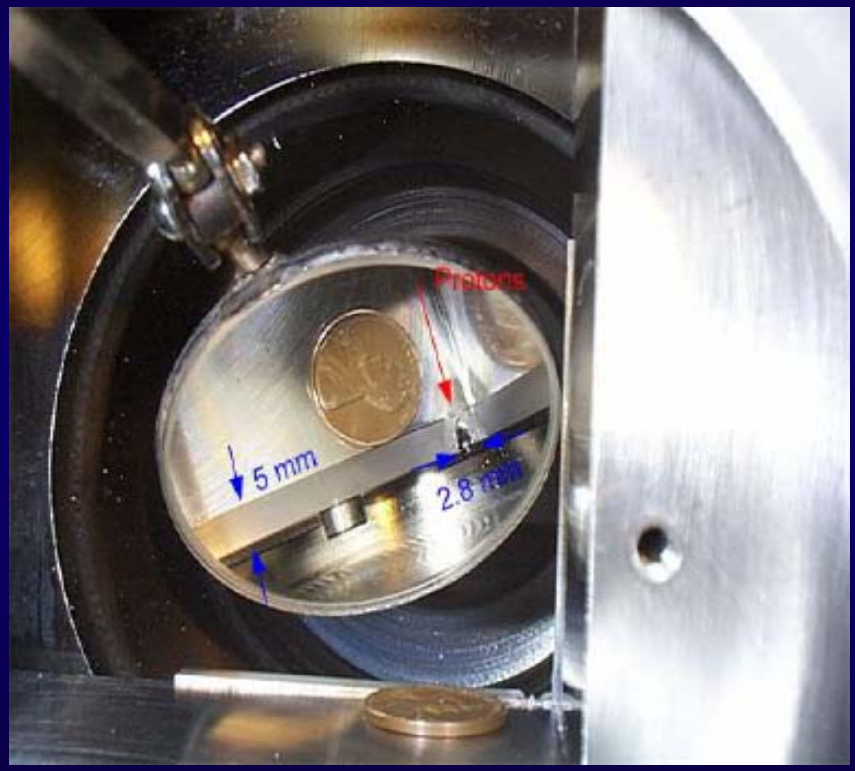
- Experiments have asked the possibility to inhibit injection without dumping the beam. In fact, the injection inhibit is based on the state of the detectors and does not depend on data from radiation monitors (apart from the requirement that the radiation monitors are operational).

- New HW has been developed for the Extraction Systems and it is available since middle of 2007. The new HW allows for a direct link via optical fibers to the Injection BICs in SR2 and SR8.

- The new HW will be used by the experiments to inhibit injection without dumping the beam (with the exception of LHCf which will make use of the Software Interlock).

POSITION INTERLOCK FOR EXPERIMENTAL MOVABLE DEVICES

- It concerns detectors moving in the beam vacuum (i.e. VELO and Roman Pots)
- Movable Devices are potentially very dangerous both for machine and experiments
- Dedicated channel for these detectors in the BIC to interlock their movement
- In general, the movable devices are allowed to leave the garage position only during ‘stable and unstable beam mode”



Damage to tungsten collimator at TEVATRON due to uncontrolled movement of RP

HANDSHAKING SIGNALS

PREPARE → FILLING → RAMP

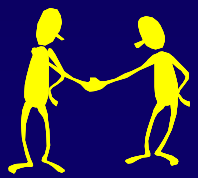
Normal flow

'Degraded' beam conditions

INJECTION IMMINENT from CCC
READY-FOR-BEAM from Exp.

ADJUST

UNSTABLE-BEAMS



ADJUST-REQUEST from CCC
READY-FOR-ADJUST from Exp.

STABLE-BEAMS

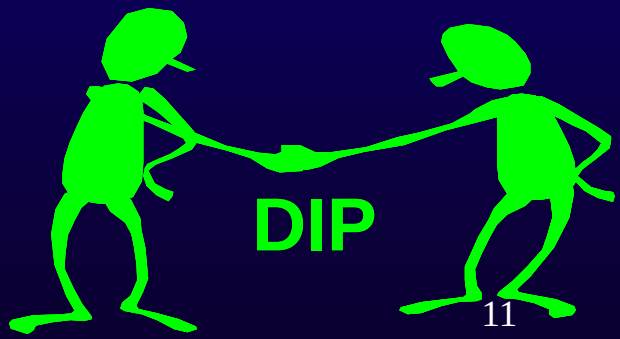
NO TIME for HANDSHAKING
(info from DIP and GMT)

BEAM-DUMP-REQUEST from CCC
READY-FOR-BEAM-DUMP from Exp.

BEAM-DUMP

RECOVER

IN ANY CASE
DO NOT FORGET



GMT network

It distributes:

- **The UTC time of the day**
- **The LHC telegram**
  - It's a message sent out each second. It is a snap shot of the LHC machine state. It includes the Safe Machine Parameters (SMP) .
- **The machine events**
  - An event is sent punctually when something happens that affects the machine state. Example: post-mortem triggers
  - SMP Flags are also sent as event

GMT Telegram & events distribution to the experiments

- **The following machine events are supplied as HW signals:**
  - Post-mortem
  - SMP Flags necessary for the interlocks (Safe Beam, Stable Beam and “Movable device allowed in”)

- **Part of the telegram information relevant to the experiments (Beam Modes, Machine Modes, SMP) are distributed via DIP**

DIP: Machine to Experiments

https://twiki.cern.ch/twiki/bin/view/Leade/WebHome

Machine to experiments

<td bgcolor="#ffffff" valign="top" style="vertical-align:top;"> 1 Hz

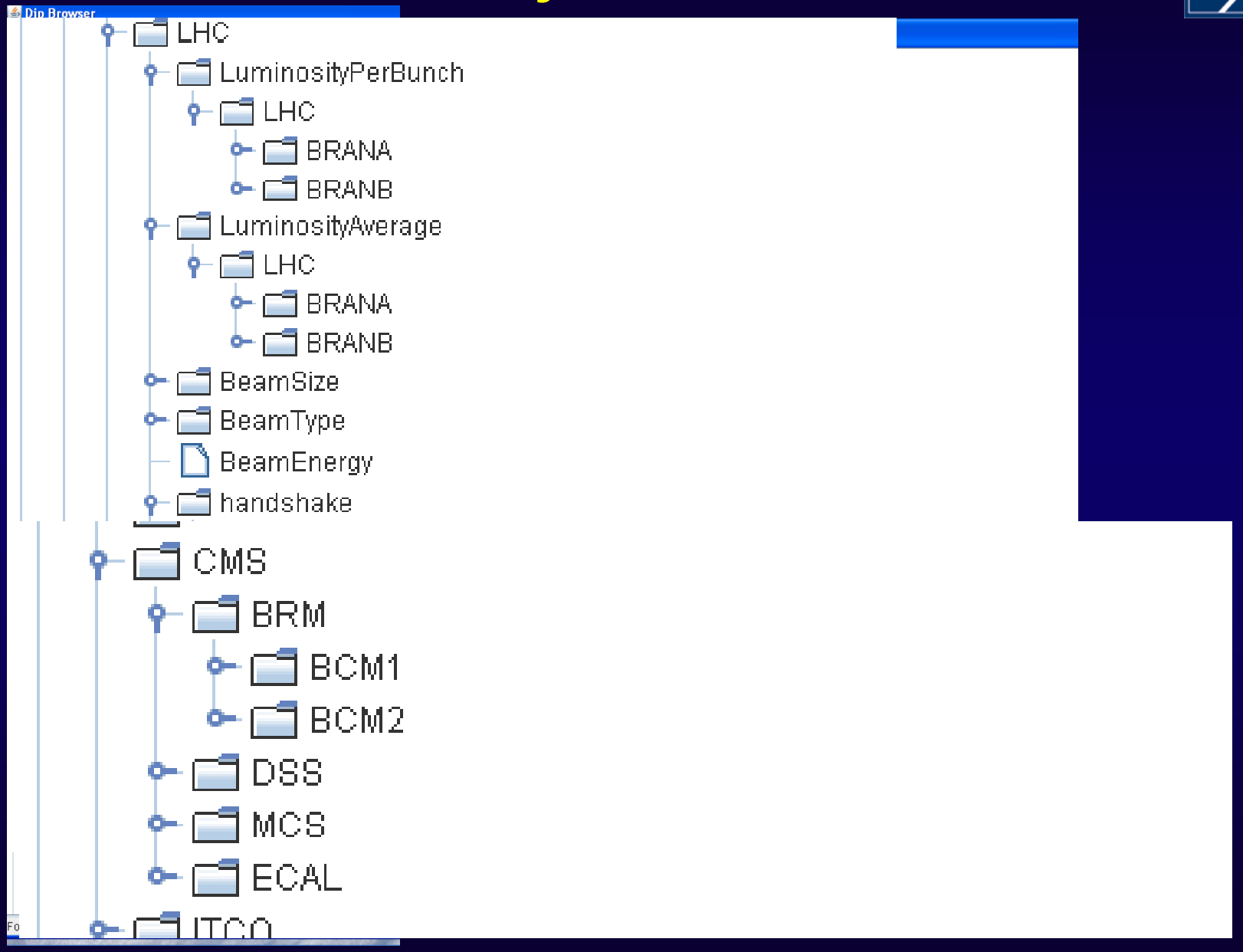
Measurement	DIP item name/source data description	Publication contact	Data contact	Volume Bytes	Frequency	Estimated availability
Total beam intensity	dip/acc/LHC/BeamIntensity/Total/* (Ring1 and 2) http://bdidev1.cern.ch/bdisoft/development/BDI-Domains/bdeyelids/bdeyelids.php?currentSelection=GI&currentDomain=LHC&currentInstrument=BCTDCLHC	K. Kostro	AB/BI, M.Ludwig	small	<1 KB	simulation available on request
Individual bunch intensities	dip/acc/LHC/BeamIntensity/PerBunch/* (Ring1 and 2) http://bdidev1.cern.ch/bdisoft/development/BDI-Domains/bdeyelids/bdeyelids.php?currentSelection=GI&currentDomain=LHC&currentInstrument=BCTFRLHC	K. Kostro	AB/BI, M.Ludwig	~50 KB	1 Hz	Dec 2007
Average 2D beam size	dip/acc/LHC/BeamSize/* (Ring1 and 2) http://bdidev1.cern.ch/bdisoft/development/BDI-Domains/bdeyelids/bdeyelids.php?currentSelection=GI&currentDomain=LHC&currentInstrument=BSRTSLHC	K. Kostro	AB/BI, A.Guerrero	1 KB	1 Hz	Dec. 2007
Average bunch length	dip/acc/LHC/Class/Property/Device	K. Kostro	AB/RF A.Butterworth	8	1 min	after 2008
Luminosity cdte mean	dip/acc/LHC/LuminosityAverage/* http://bdidev1.cern.ch/bdisoft/development/BDI-Domains/bdeyelids/bdeyelids.php?currentSelection=GI¤tInstrument=BRASCLHC¤tDomain=LHC	K. Kostro	AB/BI, S.Bart Pedersen	16	1 sec	published
Luminosity cdte b-by-b	dip/acc/LHC/LuminosityPerBunch/* http://bdidev1.cern.ch/bdisoft/development/BDI-Domains/bdeyelids/bdeyelids.php?currentSelection=GI¤tInstrument=BRASCLHC¤tDomain=LHC	K. Kostro	AB/BI, S.Bart Pedersen	28 512	10 sec	published
Luminosity Gas mean	dip/acc/LHC/LuminosityAverage/* http://bdidev1.cern.ch/bdisoft/development/BDI-Domains/bdeyelids/bdeyelids.php?currentSelection=GI&currentDomain=LHC&currentInstrument=BRASGLHC	K. Kostro	AB/BI, S.Bart Pedersen	16	1 sec	published
Luminosity Gas b-by-b	dip/acc/LHC/LuminosityPerBunch/* http://bdidev1.cern.ch/bdisoft/development/BDI-Domains/bdeyelids/bdeyelids.php?currentSelection=GI&currentDomain=LHC&currentInstrument=BRASGLHC	K. Kostro	AB/BI, S.Bart Pedersen	28 512	10 sec	published
Average Beam Loss	dip/acc/LHC/BLM/Avg50	K. Kostro	BLM concentrator, M.Lamont	16	10 sec	Dec. 2007
HOR & VER Positions	dip/acc/LHC/BPM/Q1	K. Kostro	BPM concentrator, M. Lamont	128	1 sec	Dec. 2007
HOR & VER Positions	dip/acc/LHC/BMP/Totem	K. Kostro	BPM concentrator, M. Lamont	64	1 sec	Dec. 2007
HOR & VER Positions	dip/acc/LHC/BPM/Atlas	K. Kostro	BPM concentrator, M. Lamont	16	1 sec	Dec. 2007
Total longitudinal distribution	dip/acc/LHC/LongitunalDistribution	K. Kostro	AB/BI	285.120	1 min	after 2008
Machine Mode	dip/acc/LHC/MachineMode accelerator modes encoding defined by LHC operation http://wwwpsco.cern.ch/private/timing/timing/Seq/tgmLines.html?mode=OPER&net=LHC&mch=LHC	K. Kostro	AB/CO, I. Kozsar	1 int	on change	published
Beam Mode	dip/acc/LHC/BeamMode beam modes encoding defined by LHC operation http://wwwpsco.cern.ch/private/timing/timing/Seq/tgmLines.html?mode=OPER&net=LHC&mch=LHC	K. Kostro	AB/CO, I. Kozsar	1 int	on change	published
Beam type	dip/acc/LHC/BeamType/* (Ring1 and 2) beam type encoding defined by LHC operation http://wwwpsco.cern.ch/private/timing/timing/Seq/tgmLines.html?mode=OPER&net=LHC&mch=LHC	K. Kostro	AB/CO, I. Kozsar	1 int	on change	published
Beam energy	dip/acc/LHC/BeamEnergy multiply by 120 to get MeV value	K. Kostro	AB/CO, I. Kozsar	1 int	on change up to 10Hz	published
Safe beam flags	dip/acc/LHC/LTIM/SafeBeam/* (Ring1 and 2) flags encoding defined by LHC operation http://wwwpsco.cern.ch/private/timing/timing/Seq/tgmLines.html?mode=OPER&net=LHC&mch=LHC	K. Kostro	AB/CO, I. Kozsar	1 int, bitmap	on change	published

DIP: Experiments to Machine

Measurement	Units	Production Volume (Bytes)	Production Interval (sec)	Data Rate (Bytes/sec)
Total luminosity	$cm^{-2}s^{-1}$	4	1	4
Average rates	Hz	12	1	12
Luminosity per bunch	$cm^{-2}s^{-1}$	14256	60	238
Rates for individual bunches	Hz	42768	60	713
Position and size of luminous region (average over all bunches)	cm	24	600	0.04

EDMS 701510 & 772011

What is already available on DIP?



What else ?

- **Actual value of the SPS Probe Beam flag (default value 10^{10} p, maximum value 10^{11} p). Experiments requested to provide it as SMP flag, however acceptable via DIP for start-up**

- **Background levels: the experiments will send 2 complementary signals (ex. Large/Small angle, Charged/Neutral flux, Beam1/Beam2, etc..) and normalised as following:**
  - < 0 No information available
  - <1 Good conditions
  - > 5 Very bad conditions: danger detector trips or very low quality data

  Information independent of data taking (available before stable conditions declared). Rate ~ 1 Hz. It is mainly coming from detectors located around the beam pipes (BCM, minimum bias scintillators, etc…)

- **Collimator settings, beam lifetime, filling scheme..?**
- **(WEB?) status page of the experiments?**
- **…….**

Commissioning without beam

- **BIC <-> CIBU system will be commissioned between end of April and end of June. Commissioning procedures and dates will be sent to the BISU.**

- **Dry runs to commission the mainly hand-shake signals will be scheduled starting from middle of April. Contact person to be nominated by the experiments (machine contact person: Mike Lamont).**

Thanks for your attention