ABT MD Requests

C. Bracco on Behalf of ABT/BTP

acknowledgements: OP, RF, Collimation, BI, Vacuum, Collective effect and FLUKA teams

Outline

- ABT MD requests :
  - Requests for 2015: what was done/not done
  - Documentation
  - New requests for 2016

LHC_MD267: Impedance and beam induced heating of TCDQ and TDI

2015

TDI heating during run 1 ➔ **consolidation measures** and **additional diagnostics. TCDQ** jaw from 6 to **9 m** (**CFC instead of C**). Investigations of **tune shifts** as a function of the **collimator gap** and **bunch length** and more accurate measurements of **transverse and longitudinal impedance** should be performed for both protection devices.

Merit: benchmark simulations and evaluate whether heating and impedance may affect future performance with high intensity beams.

Measurements:

- **Single bunch MD at injection**: (4 h at injections)
  - Move the **TDI and TCDQ jaws to several gaps** and monitor **tune shift** and **stable phase**. The **bunch length** can be changed at this occasion
  - Move the **TDI and TCDQ jaws to open and closed gaps** with **variable chromaticities** and **intensities** to check for **transverse instability thresholds**.
- **MD with the full beam at injection**: move the **TDI and TCDQ jaws to several gaps** and monitor **tune shift**, **stable phase**, **temperature and vacuum signals**. Change the **bunch length** and the **bunch profile**

Participants: ABT/BTP, B.Salvant, E.Metral, E.Shaposhnikova, V.Baglin, P.Baudrenghien

LHC_MD267: Impedance and beam induced heating of TCDQ and TDI

2015

TDI heating during run 1 ➔ **consolidation measures** and **additional diagnostics. TCDQ** jaw from 6 to **9 m** (**CFC instead of C**). Investigations of **tune shifts** as a function of the **collimator gap** and **bunch length** and more accurate measurements of **transverse and longitudinal impedance** should be performed for both protection devices.

Merit: benchmark simulations
affect future performance with

Measurements:

- **Single bunch MD at injection**:
  - Move the **TDI and TCDQ ja**
    The **bunch length** can be c
  - Move the **TDI and TCDQ ja**
    intensities to check for **tra**
- **MD with the full beam at injec**
  tune shift, stable phase, tempe
  bunch profile

Participants: ABT/BTP, B.Salvan

- Partially done (not MD time)!
- Single bunch measurements for TDI done mainly to investigate problems with heating and vacuum in point 8.
- These measurements (single bunch for TDI) must be repeated in 2016 during commissioning (4 hours at injection)
- Remaining measurements (full intensity, TDI and TCDQ) to be kept in MD requests list with MEDIUM priority (6 hours)

LHC_MD292: TCDQ-TCT retraction and losses during asynchronous beam dump

2015

The protection provided by the **TCDQ** in case of an asynchronous beam dump depends strongly on their **correct setup**. They have to **respect** the strict **hierarchy** of the full collimation system and **shield the tertiary collimators** in the experimental regions ➔ loss load at the TCTs as low as possible. **Asynchronous beam dump tests** have to be performed, with **different configurations**, to define the **retraction margin** between the **TCDQ** and the **TCTs**.

Merit: assess the minimum allowed retraction between TCTs and TCDQs and, as a consequence, on the β* reach.

Measurements:

- These measurements have to be done at **6.5 TeV and collision optics**. They consist in **reducing** the **relative retraction between the TCTs and the TCDQs** and perform an **asynchronous beam dump**. The load at the TCTs has to be evaluated for each setup. This experiment needs one dump at top energy per configuration. **Ideally parasitic measurements could be taken at the end of each test performed at 6.5 TeV** (going to collision optics) provided that the **residual beam intensity** is sufficient to get **~1e10 protons in the abort gap**.

Participants: ABT/BTP, R. Bruce, S. Redaelli

LHC_MD292: TCDQ-TCT retraction and losses during asynchronous beam dump

2015

The protection provided by the **TCDQ** in case of an asynchronous beam dump depends strongly on their **correct setup**. They have to **respect** the strict **hierarchy** of the full collimation system and **shield the tertiary collimators** in the experimental regions ➔ loss load at the TCTs as low as possible. **Asynchronous beam dump tests** have to be performed, with **different configurations**, to define the **retraction margin** between the **TCDQ** and the **TCTs**.

Merit: assess the minimum allowed retraction between TCTs and TCDQs and, as a consequence, on the β* reach.

Measurements:

- These measurements have to be done at **6.5 TeV and collision optics**. They consist in **reducing** the **relative retraction between the TCTs and the TCDQs** and perform an **asynchronous beam dump**. The load at the TCTs has to be evaluated for each setup. This experiment needs one
  measurements could be tal
  to collision optics) provided
  ~1e10 protons in the abort

Done! MD note:CERN-ACC-NOTE-2016-0017

- Additional tests to be done at 40 cm β* during commissioning (nominal and worst settings scenarios)

Participants: ABT/BTP, R. Bruc

LHC_MD287: Injection and emittance preservation of high brightness beam

2015

High brightness beams will be produced in the **LHC injector chain**. Investigation on the **emittance preservation** when **transferring** the **high brightness beams** from the SPS and injecting them into the LHC have to be performed.

Merit: provide fundamental information on emittance preservation for the LIU and HL-LHC era.

Measurements:

- Inject 12 nominal bunches for safe beam presence.
- Measure bunch by bunch emittance of high brightness beams in the SPS (ideally at 450 GeV, otherwise at 26 GeV).
- inject in the LHC one or more BCMS batches. Measure bunch by bunch emittance at flat-bottom in the LHC (measure evolution for 20-30 minutes).
- Repeat the test
- **Time: 2 hours.**

Participants: ABT/BTP, V. Kain, M. Kuhn

Not Done! To be kept in MD request list with MEDIUM priority (2 hours).

LHC_MD273: Beam angle measurements with a short collimator

2015

A completely **new design** of the **TDI** is considered for the HL-LHC (three ~1.4 m long modules). The TDI has to be carefully aligned with respect to the beam and the other modules. A well established **angular alignment procedure** exists only for long collimators (TDI and TCDQ) while a new technique has to be defined for **short jaws**.
Merit: test the new technique and assess the achievable accuracy

Measurements:

- Use the TCLIA which is 1 m long and sits in the crossing and separation bump region (like TDI). Define a **reference beam edge** with the **vertical TCP**. Apply a **2 mrad angle** to one **TCLIA jaw** and move it in **steps (20-50 um)** towards the beam until **first losses** appear. The TCLIA is then retracted and the beam blown up (with MKQ) until losses reappear at the TCP. A **-2 mrad angle** is applied to the same TCLIA jaw which is moved again in steps into the beam until first losses are recorded. The same procedure is followed for the other jaw. **The difference in the position of the upstream and downstream corners when touching the beam should allow to calculate the beam angle** (crosscheck with MADX, **beam axis and divergence**).

Participants: ABT/BTP, A. Lechner

Not Done! Keep it in the list as LOW priority MD (2 hours).

LHC_MD274: Injection mismatch and matching monitors

2015

The LHC matching monitors and other screens in the lines and injection region can be used to determine betatron matching. From the LHC sector tests we know that the dispersion, especially of TI 8, is not perfectly matched. Part of the MD will therefore be used to carefully re-measure the dispersion matching into the LHC.

Merit: determine the accuracy of the injection betatron and dispersion matching and provide input for re-matching

Measurements:

- **Fat pilot bunch** in **inject and dump 300 turns mode**. Mis-match the beam in the line on purpose and measure effect in the LHC with matching monitors.

Participants: ABT/BTP, F. Roncarolo S. Burger, E. Bravin, V. Kain

Not Done! To be kept in MD request list (4 hours LOW priority)

LHC_MD283: Tune scan in the SPS and transfer line trajectory

2015

Long term **trajectory drifts**, mainly due to **SPS orbit drifts**, were observed in both TI2 and TI8. Studies were performed to investigate the **effect of tune variations on the SPS orbit** and understand which is the **source of** the expected **working point drift**. A first MD will be done in the SPS to evaluate the possible expected tune variations, then the **effect on the TLs trajectories** has to be evaluated.

Merit: quantify the trajectory drifts expected in the TLs due to different SPS tunes.

Measurements:

- Pilot or INDIV LHC beam will be **extracted** from the **SPS** (from both LSS4 and LSS6) while **varying** the machine **working point**, according to the outcome of the first MD performed in the SPS. Sets of **TL trajectories** will be **recorded** for each individual **tune** settings, carefully checking all the other **machine parameters**.

Participants: ABT/BTP, V. Kain

SPS MD done! These measurements and simulation studies showed that the tune shift influence on TL stability is negligible ➔ LHC MD not needed!

LHC_MD290: Q4 IP6 Quench level

2015

A **quench test** can be performed **injecting a bunch at 450 GeV and dumping it directly on the TCSP.4R6** collimator in IR6. At the same time, the individually-powered quadrupole magnet **MQY.4R6**, which is in the shadow of the collimator, can be **powered at varying current levels** to simulate operation at different energies.

Merit: acquire further understanding in fast-loss events and quench levels

Measurements:

- The **TCSP in IR6** has to be **closed in order to fully intercept the beam**, the TCDQ has to be opened to parking position. Inject **pilot bunches** (inject and dump 1 turn mode) of **increasing intensity** (up to 6e10 protons) and **monitor** the **QPS signal** (a digital oscilloscope has to be installed in parallel with the QPS during a TS). and the **losses** at the BLMs downstream of the TCSP. **Increase the current** in the **MQY** in steps of 200-500A until the maximum allowed current or until the magnet quenches.

Participants: ABT/BTP, B. Auchmann, M. Bednare

Done! MD note is being prepared and will be ready within end of January.

LHC_MD905: Injection losses reduction and TCDI dBLMs set-up with beam

2015

MD 905 showed that the longitudinal losses at injection are well understood and loss mitigation techniques, like cleaning with the MKQ in the SPS or MKI f.t. length increase, improve the situation. This has to be further investigated. Together with TCDI dBLMs (will be installed mid 2016) the losses along SPS extraction, beam transfer and LHC injection will be studied.

Merit:

- **Calibrate dBLMs signals to number of lost particles.**
- **Optimize loss mitigations techniques and make them operational.**
- **Set-up TCDI dBLMs with beam.**
- **Establish new MKI waveform measurement with de-bunched LHC beam.**

Measurements:

- 450 GeV, injection settings, up to 288b per injection.
- Pilots on TDI and TCDI for dBLM calibration.
- Injections with different MKQ parameters. MKQ kick optimization (in the SPS).
- MKI f.t. length changes (within limits).
- Inject 4 nom. bunches, switch RF off, let the bunches de-bunch, fire MKI for waveform measurements.
- **Time required: 8h. High Priority!**

Participants: ABT/BTP, M. Barnes, V. Kain, O. Stein

LHC_MD905: Injection losses reduction and TCDI dBLMs set-up with beam

2015

MD 905 showed that the longitudinal losses at injection are well understood and loss mitigation techniques, like cleaning with the MKQ in the SPS or MKI f.t. length increase, improve the situation. This has to be further investigated. Together with TCDI dBLMs (will be installed mid 2016) the losses along SPS extraction, beam transfer and LHC injection will be studied.

Merit:

- **Calibrate dBLMs signals to nu**
- **Optimize loss mitigations tech**
- **Set-up TCDI dBLMs with bean**
- **Establish new MKI waveform**

Measurements:

- 450 GeV, injection settings, up
- Pilots on TDI and TCDI for dBL
- Injections with different MKQ
- MKI f.t. length changes (within
- Inject 4 nom. bunches, switch
- **Time required: 8h. High Priori**

Participants: ABT/BTP, M. Barnes,

Partially done!

- MD note is being prepared and will be ready within end of January.
- To be repeated since:
  - Low statistics (4 h instead of requested 8 h)
  - Injection intensity limitations (TDI)
  - New HW (TCDI) and improved diagnostics now available!
- New MD request done MD_1077 (8 hours, HIGH priority)

LHC_MD288: Injection of "high performance reach" 80b 25 ns beam

2015

The option of producing **batches of 80 bunches** in the PS is explored in view of a future **"high performance reach"** for the LHC.

Merit: investigate if a clean transport up to the LHC in terms of emittance blow up, injection losses, ghost bunches and/or uncaptured beam can be achieved.

Measurements:

- Set up the extraction of the 80 bunches from the SPS (define optimum delay wrt the MKE waveform). Measure **emittance** in the **SPS** and in the **LHC**. Check with IQC **injection losses**, **injection oscillations**, etc… check **e- cloud effects**

Participants: ABT/BTP, “e- cloud” team

Partially done (not MD time)! Could be combined with MKI MD for injection of several batches of 80 bunches

MD: MKI pulse length and ripple definition

New!!

Motivation:

- Special batch schemes for ecloud mitigation require a longer pulse length of the MKI by about 10% - this might be achievable by the HW, exact value to be determined
- Electrical pulse length of the PFN and of the field differ – exact value to be measured to be sure the maximum field pulse length can be fully exploited
- Measure if design report specification of +/- 0.5 % is the limit or if injection oscillations at a higher offset from the nominal value are acceptable, and consequently the rise and fall time and thus the interbatch spacing be reduced

Merit:

Asses possibility of using exotic beams (several 8b+4e and 80 bunches, equivalent to 288). Rise and fall time plus intra-batch spacing reduction ➔ higher accumulated intensity

Beam/interlock conditions

- Pilot bunches, 450 GeV, I&D
- Close the TDI
- Insert screen at the TDI, new cameras available which should give more precise measurements
- No changes to MKI and TDI BETS
- **Time: 8 hours. HIGH priority!**

Participants: ABT/BTP, M. Barnes.