



Instrumentation Performance in the Injector Complex in 2012 and Wishes for the Restart after LS1

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on behalf of the LHC Injector Teams
+ colleagues from connected machines

BI Day, Archamps, 06/12/2012

Outline

2012 Instrumentation Performance/Issues and wishes for the restart after LS1 of the

- LHC Proton Injector Chain

- Linac2 – PSB – PS – SPS

- ISOLDE + AD + EAST Area + NORTH Area

- LHC Ion Injector Chain

- Linac3 – LEIR – PS – SPS

- General Remarks

- Concluding Remarks

- **Not covered:** Linac4, CTF3/CLIC, HIE-ISOLDE, ELENA,...

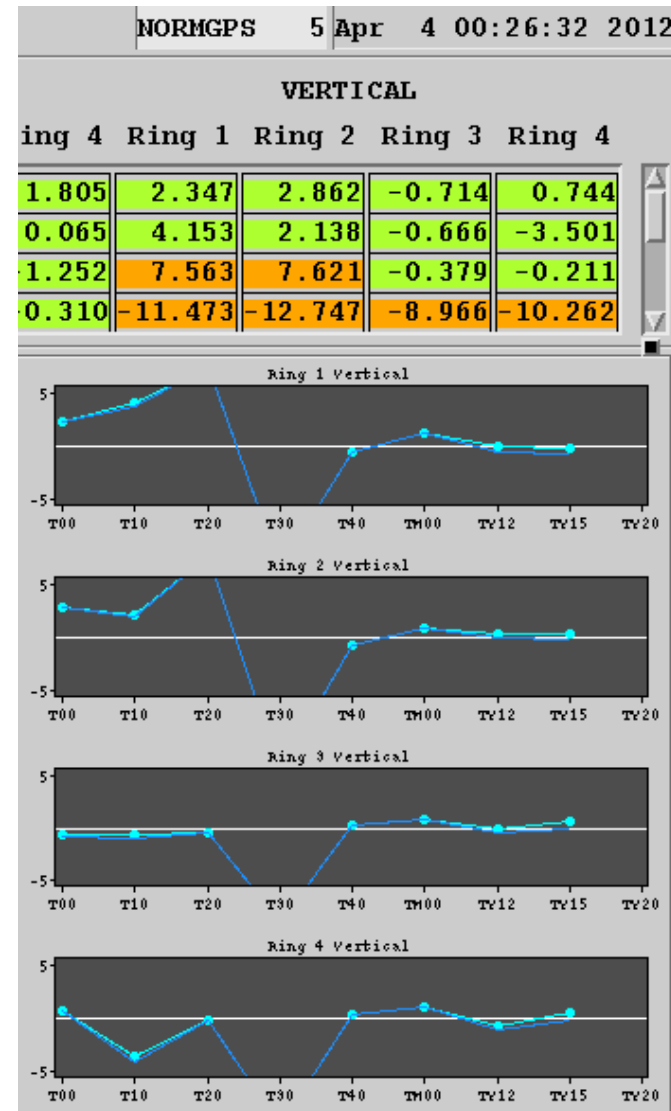
Linac2

- Main BI-related issue during 2012 operation:
 - Problems during startup in the measurement lines (LTE, LTL and LBE) with the **SEM-grid controls** (hard- and software very old).
- Managed to **reduce losses by 40% in the LT/LTB lines** by applying ‘steering’ with BLMs – would be nice to have the **new BLMs better integrated into the controls system!**
- New **Linac4-type pickup** installed in August (LTB.UMA20); OP curious to receive data... → presentation Michael Sordet
 - Plan to replace all LT/LTB/BI line PUs with this type during LS1.
- !! **After LS1**: Restart with **completely renovated pickup system** (hardware + electronics + software) and **new readout system based on TRIC cards for transformers** → thorough testing and system integration essential

PSB - Pickups

- Start of run: different PU issues hampering beam steering
 - **Vertical alignment** wrong for some of the newly installed PUs in BT recombination line + impedance mismatch with **amplifier**); other signal problems for PSB transfer line PUs still under study
 - Injection PUs: old system; droop for injection PUs recalibrated where possible → PU renovation during LS1
- New electronics for 3 **turn-by-turn ring PUs** installed
 - First data taken to prepare optics measurements
 - Full deployment not during LS1, but solution found to allow commissioning in parallel to standard operation
- **Bi-weekly meetings to follow up PU system issues** assured progress and stable running

Remark: YASP@PSB now one more client relying on correct PU information...



PSB – Continued...

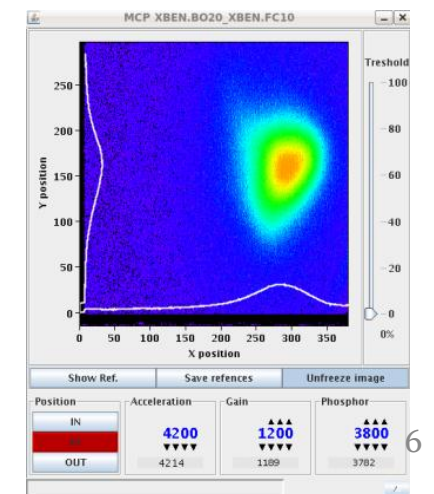
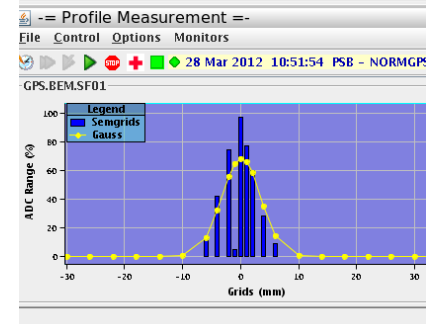
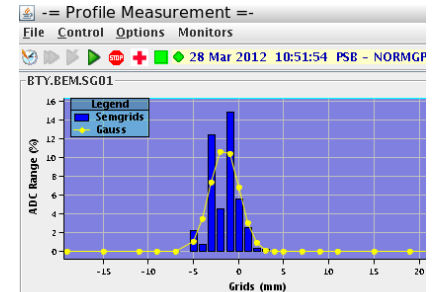
- Wire scanner emittance measurements: systematic studies continued throughout the year; quite satisfactory situation, but still some open issues to be solved (**calibration/mechanics, 20 m/s, parallel ring measurements...**)

!! **Wishlist for after LS1**

- !! Parallel ring measurements for wire scanners
- !! **Consolidation of SEM-grid electronics** implemented
- !! **Upgrade of tune kicker system**: remote control of tune kickers; ring-by-ring acquisition system synchronised with revolution frequency; chirp excitation with transverse damper; analog diagnostics; spare parts...
- !! New injection line PUs, new amplifiers for ejection line PUs + alignment correction, commissioning of turn-by-turn PUs (multiplexed per ring), commissioning of **new parallel LHC-type BLM system** with new electronics → **need support from BI for joint evaluation of new BI equipment**

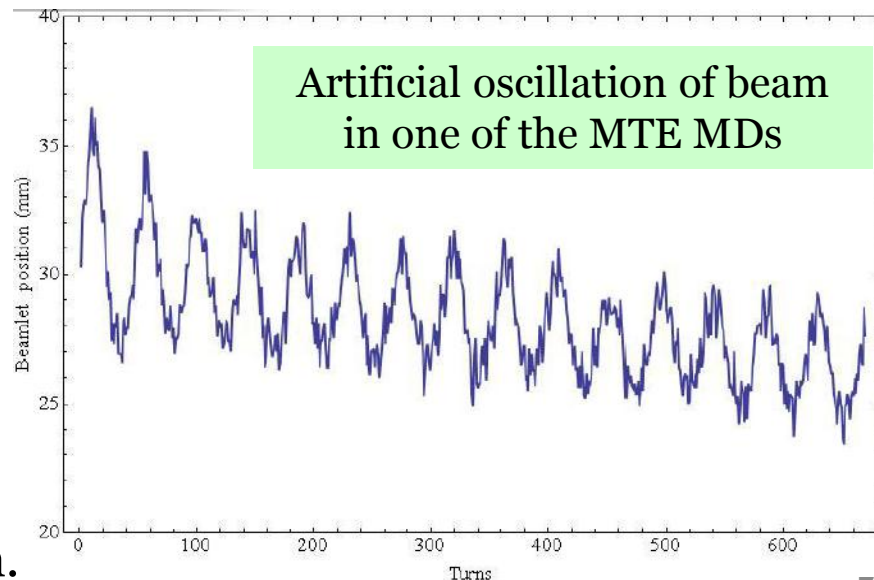
ISOLDE – Open Issues/Ongoing Development

- Maintenance of **GPS, HRS and target SEM-grid** (missing or noisy channels; review status)
- **Repair of Faraday Cups in HRS/GPS separators**
 - Due to mechanical issues several critical interventions on FC in the separator area during 2012
 - Missing cup in HRS.FC300
 - Need to procure ready-to-use spares and equipment to test them offline (fabricate special vacuum chambers)
- **MCP beam profiler in REX linac**
 - Started study on linearity and accuracy of MCP beam profilers (offline test bench)
 - Beam trigger synchronization implemented
 - Scale, image deformation and position calibration -> **ongoing work**



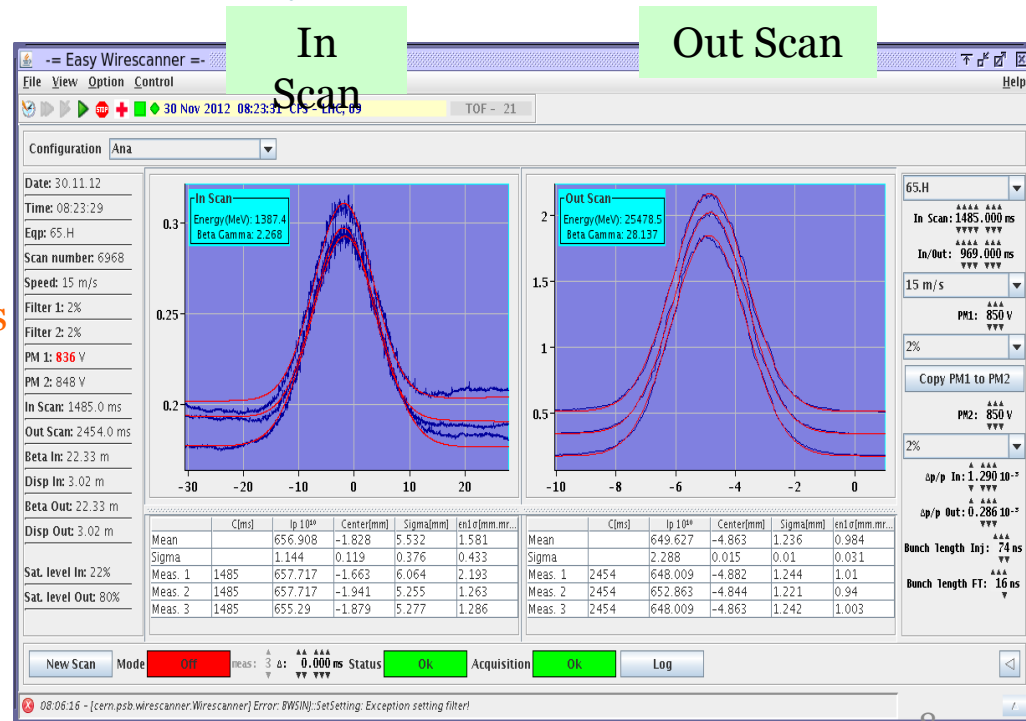
PS – Trajectory and Orbit Measurement

- Good and responsive support from BI.
- Improvements and new functionalities became available in 2012.
- Some issues were identified during (MTE) MD's where saturation of the **pre-amplifiers** was at the source of a presumed beam oscillation, but this was a measurement artifact.
- These kind of problems are often identified during MD's as machine and instrument performance is pushed.
- However, these issues are also issues for normal beam operation.

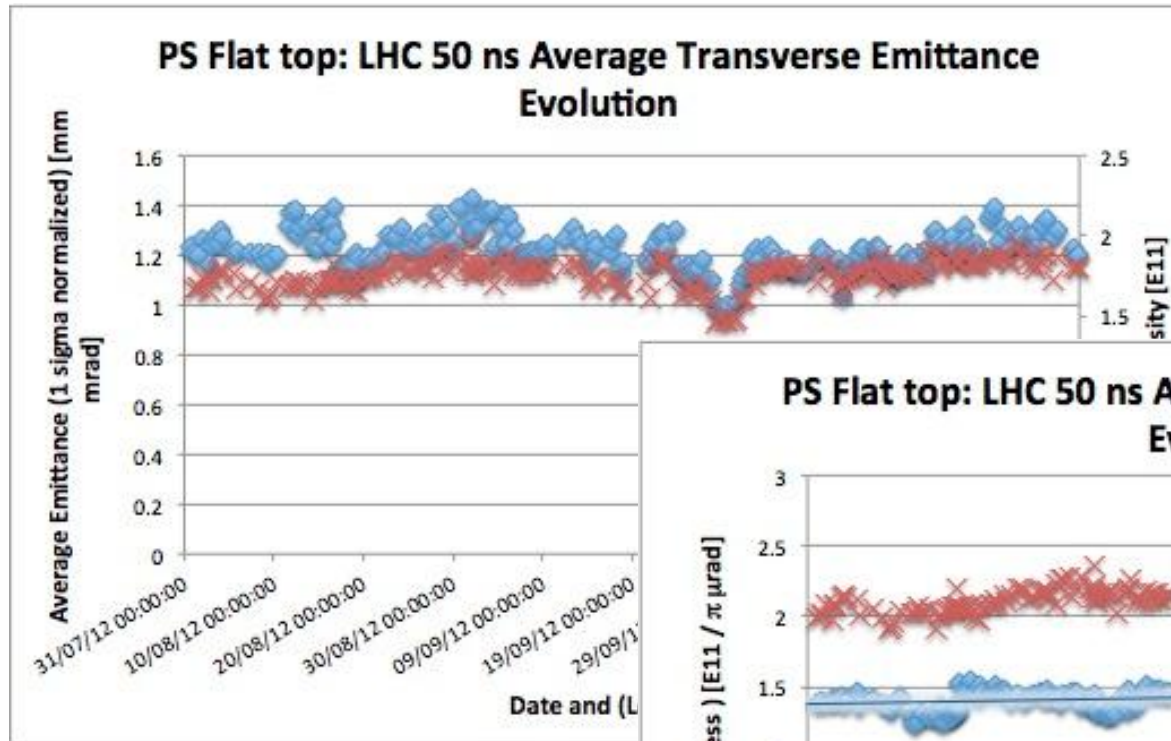


PS – Fast Wire Scanner measurements

- Substantial effort (BI, ABP, OP) went into understanding the settings management of the combination of the PM high voltage and the filter settings.
- Nevertheless transverse emittance measurements remain tricky, especially with the small emittance beams we have for the LHC.
- Since July IN and OUT scans are used on the same cycle to measure beam emittances.
- Different wire scanners continue giving different results on the same beam.
- One source of errors is also the optics definition (not trivial for the PS with the combined function magnets).
- Bunch-by-bunch measurement at fixed revolution frequency after LS1?

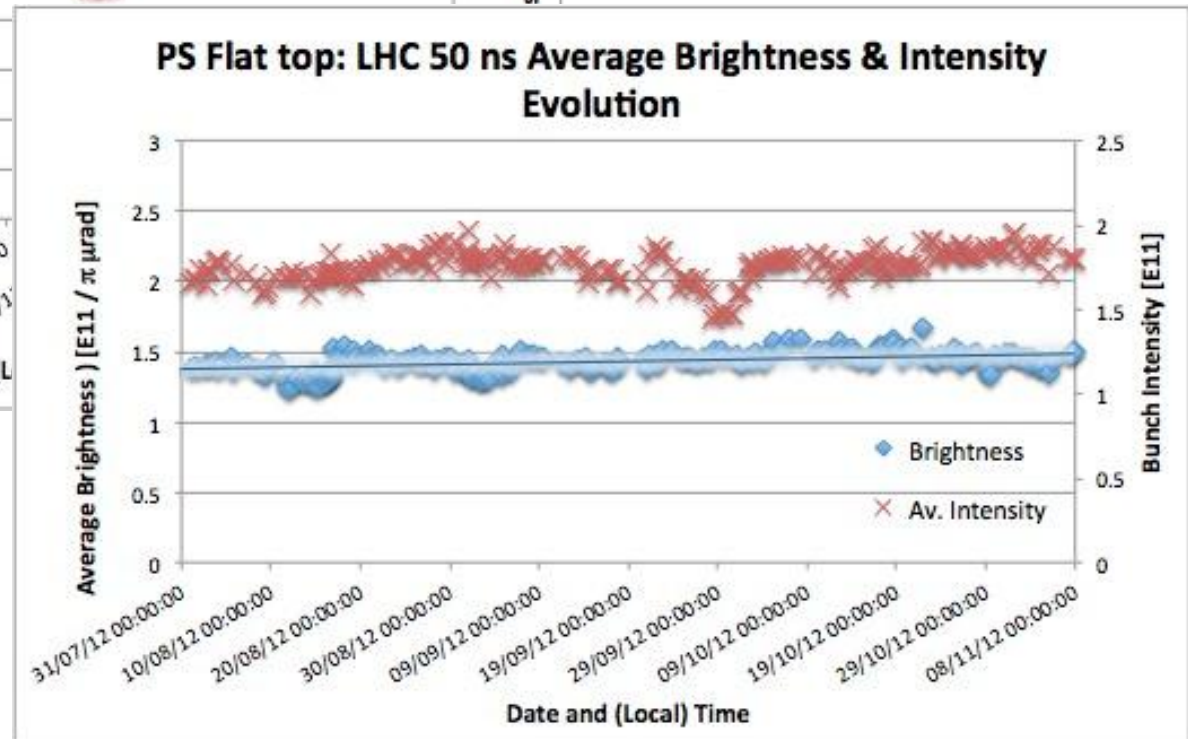


PS – Use of Wire Scanner Measurements



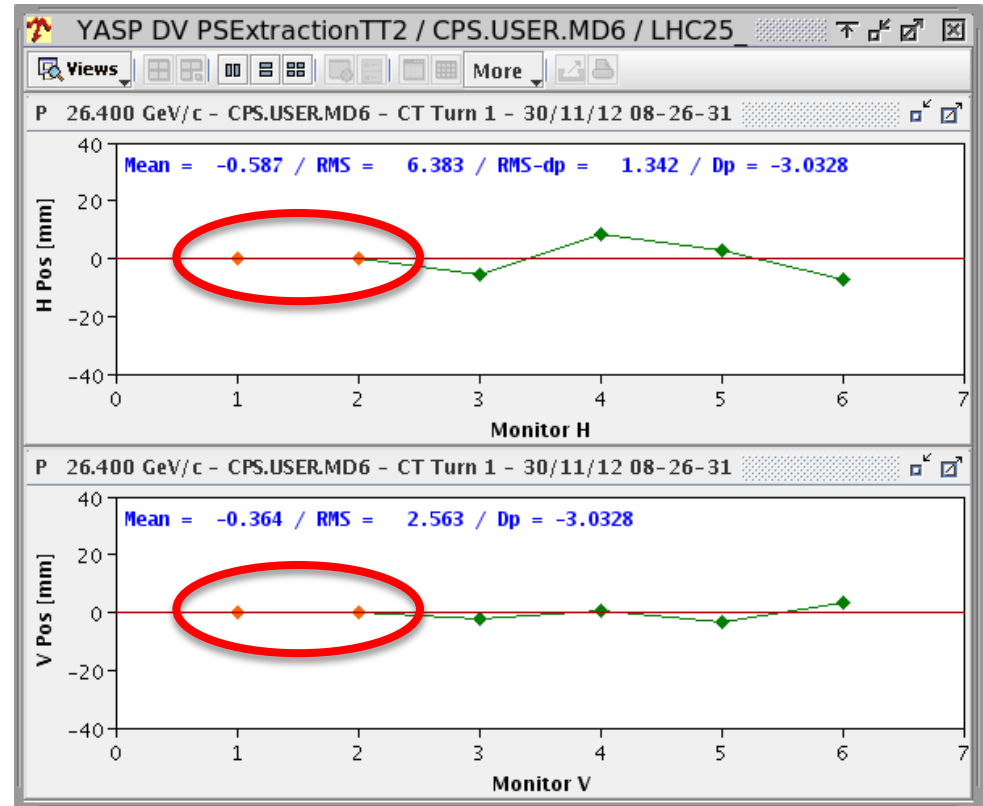
- From end July systematic measurements and logging, once every shift in PSB and PS.

- Each result per plane is an average of 3 measurements.
- Many scans, **no bellow problems.**



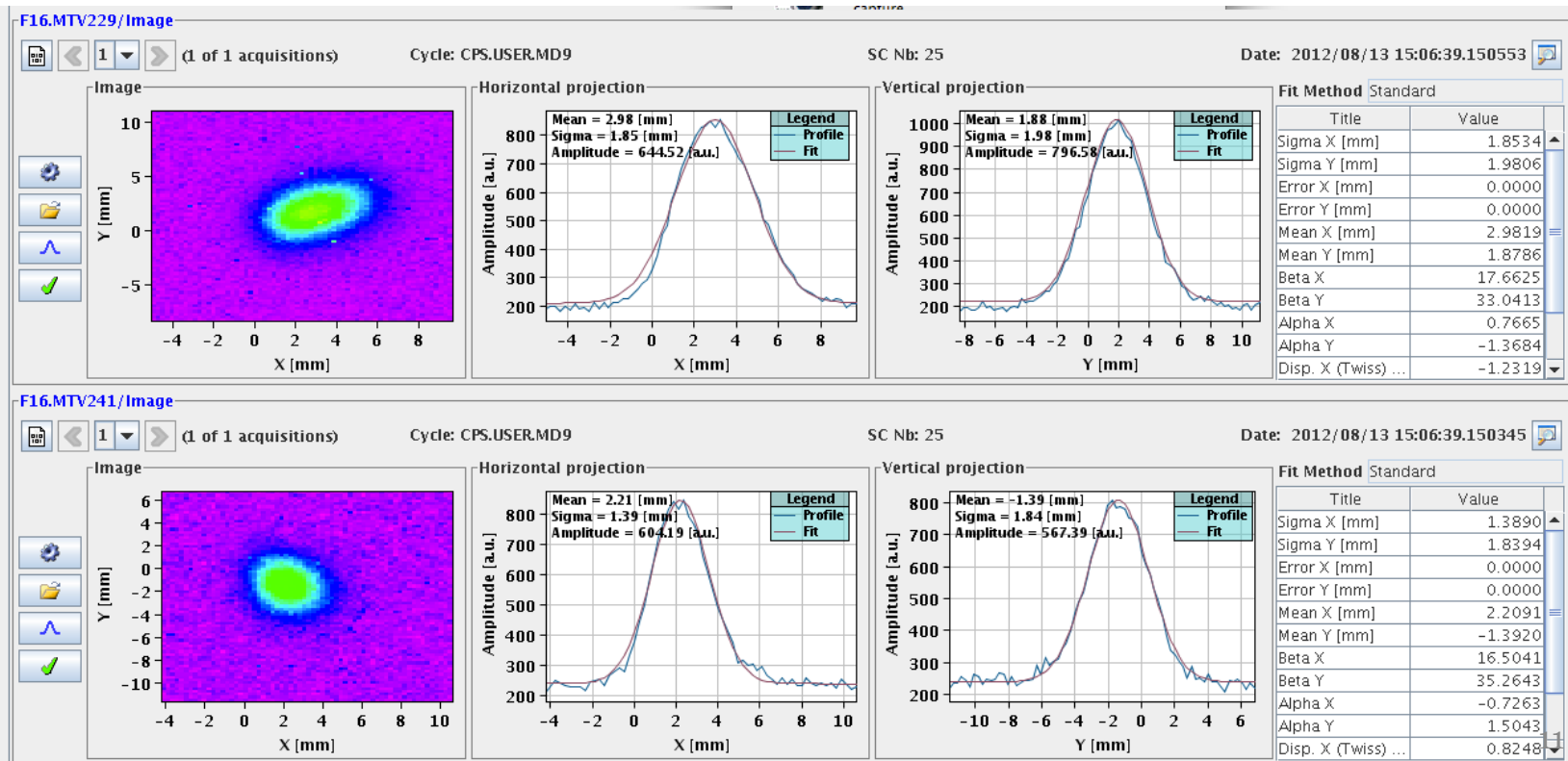
PS – TT2 Trajectory Measurement & Steering (YASP)

- TT2 strip line couplers used for TT2 beam steering instead of SEM-grids.
- Very good improvement, extending trajectory measurement and steering capabilities.
- However, often some are not available and intervention in TT2 is required.
 - Can this be improved ? (Rad-hard electronics or shielded electronics?)



PS – TT₂ OTRs

- The 4 OTR screens have been made working and will be used to measure and log transverse emittances in the future. Commissioning to be continued with BI (**calibration of emittance measurement!**).

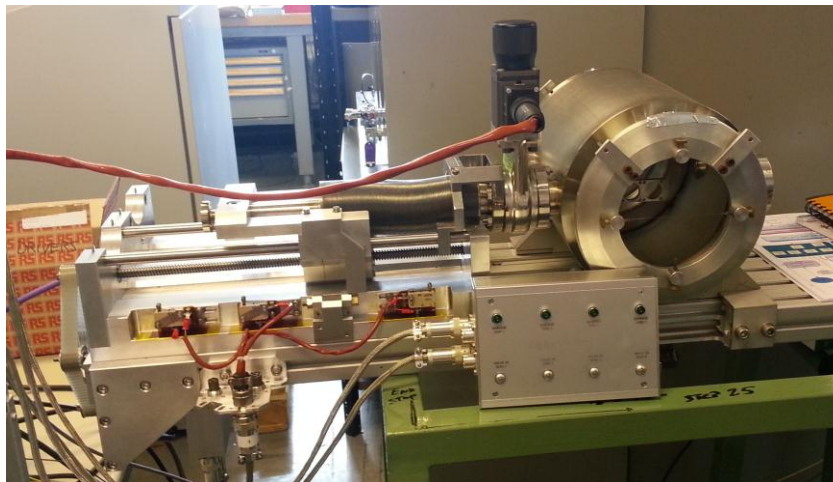


PS – Various

- 1000-turn transformer
 - Unfortunately not operational due to firmware issue.
 - Very important tool to measure and control injection losses (during injection bump decent; see also last year's request during BI Day).
 - Will this be operational after LS1?
- Transverse damper PUs: improve reliability.
- New PU in TT2 after extraction septum for LS1 restart.
- Renovation of East Area primary beam line instrumentation
 - Fast BCT revived, enabling cross-calibration of secondary emission chambers, using fast extracted beam.
- Logging:
 - In 2012 we started logging more acquisitions from BI equipment.
 - After LS1 this will be further extended.

EAST Area

- Install BLMs in primary beam lines
 - OP request, but will only happen after LS1.
- BTV adaptation to new marguerites
 - Present marguerites old and fragile, where **EITHER** target heads **OR** screen can be used
 - New layout (for after LS1) offers combined **target AND screen** position



AD – 2012 Highlights

- Intensity measurement during the AD cycle with DSP-based Schottky analysis → the workhorse of AD diagnostics; constantly in use and extremely useful/important. No faults over the year – please keep it up!
- All MWPCs in the ejection lines are now replaced with GEM-detectors including new electronics & controls interface: In regular use for all of 2012 → better profile measurements; helped in optics validation and machine improvements; also very reliable!
- BTV cameras replaced with CCD-type: now possible to observe the faint and large pbar beams in the injection line downstream of the target.

AD – Post LS1 Wishes

- Renewal of orbit and ionisation profile monitor systems in LS1; **orbit measurements during ramps highly desirable!**
- BBQ-tune system: **in the pipeline; measurements during ramps highly desirable!**
- **Complete AD controls renovation** in LS1 (front-end renewal, FESA, MTG, InCA, HW renewal) → **keep posted...!**

SPS (1)

- Cameras
 - Some cameras in TT10 and TT20 have 'blind spot' in the centre after years of intensive use.
 - Ring cameras in LSS2 and LSS6 are only used in case of really big trouble. They have not been used during last years and have an old (or non existing) control. After LS1 we will face a difficult start up, where these cameras might be needed, so they have to be put in an operational state.
- SEM (position and profile monitors in TT10 and TT20)
 - TT10 SEM-grid spacing too coarse for small beams (LHC beams)
 - SEM-grids in splitter region of TT20 have bad channels.
 - Motors on mini-scan of T2 (NA) not working.

SPS (2)

- **BPMs in transfer lines**
 - Failing BPMs in regions with high losses and radiation: end of TT10, close to CNGS target, close to HiRadMat experiments. **Could a more radiation hard version be developed?**
- **MOPOS**
 - **Some bad PUs in LSS1, LSS2** need interventions in the tunnel.
 - Still an issue with **acquisition on very long cycles (>21 s)**.
- **BCT**
 - **New BCT in LSS5 for Fixed Target intensity interlock** (primary Pb-beam) expected to be **operational after LS1**.

SPS (3)

- Spill measurement in TT20
 - A **high bandwidth** (10 MHz or higher) **intensity acquisition in TT20** in order to check the de-bunching. In the past a PM was used (only for ions). **A new system, robust enough to cope with protons, is required.**
- BLMs
 - An renewal and extension of the system is being developed in the framework of LIU, but this is planned on a longer timescale.

Installation of new wire scanner prototype during LS1!

SPS (4)

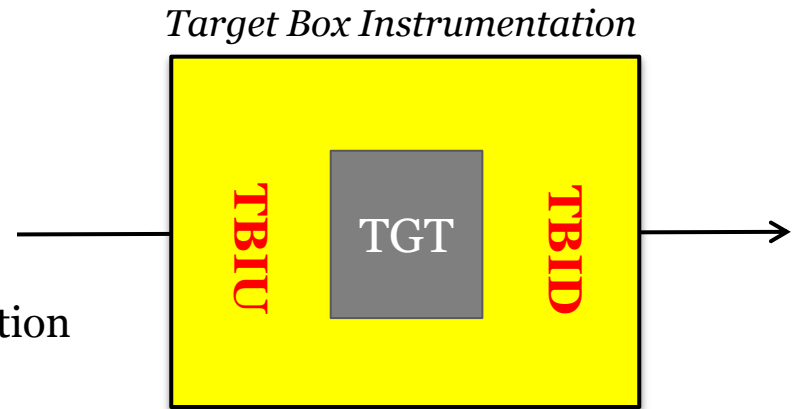
- WS and Emittance measurements

- Extensive use of wire scanners throughout the year on LHC beams (high intensity, high energy and high brightness).
- Multiple scans gave very good results, but increased the number of scans dramatically.
- High energy, high intensity beams increase the frequency of broken wires – the **nominal LHC 25ns and 50ns beam at flat top is BEYOND the wire breakage limit as calculated by BI!**

- 4 WS (2 per plane) should be operational for LHC beams. At least one WS per plane should be able to measure bunch-by-bunch.
- Define range of valid settings for HV/filter settings.
- Investigate a more robust design for WS with easier and faster repair interventions.
- A robust synchrotron light monitor for emittance measurements at high energy should be (re-)installed as soon as possible.
- Ionisation gas monitor should be operational after LS1 to follow emittance evolution during the cycle.

NORTH Area – Wishes for LS1 Interventions

- **TBIU/TBID need consolidation**
 - Suffered from wrong positions in 2012
 - **Consolidation foreseen in LS1**
 - To be coordinated with target renovation
- **Calibration factor** for XION and experimental scalars
 - Factor for COMPASS changes between muon and hadron beams
 - Should be remotely **controllable** (CO+BI)
- Replace wire chambers installed in secondary beam lines by **GEMs**





The LHC Ion Chain

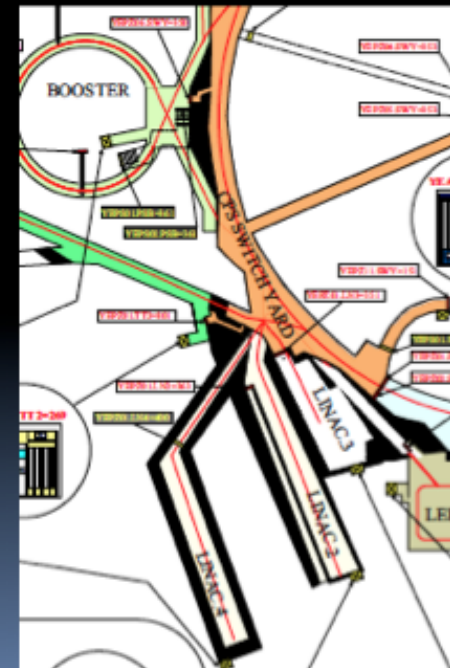
Linac3

- ✓ ITL.MSGo2: Lifetime issue solved by installing shielding for parked SEM grid
 - Long-standing issue: **Noisy** beam trace of transformers **TRA25** and **TRA41** – is there a solution in view?
- !! Wished for after LS1** (or at earliest possibility):
- !! Emittance device (pepper pot) in LEBT
 - !! Dedicated Linac3 emittance and energy/energy spread measurement devices at the end of Linac3 – very difficult to use LBE/LBS!



LINAC3

- The energy measurement of the ions is only possible in the LBS and it is due to the coupling with PSB a quite tricky procedure, critical for setting up of the de-buncher cavity
- No emittance measurement in the linac and after the linac
- The beam sent to LEIR cannot properly be quantified
- Without additional diagnostics the setup of new ion beams becomes a trial-and-error exercise



LEIR

- BI has been very responsive throughout the run! 😊
- Some problems during 2012 with
 - Tune measurement: New operating system; some cards (unintentionally...) cannibalised

!! Wishlist for after LS1:

- !! SEM-grid measurements at injection (sensitivity)
- !! Make Schottky measurements operational from CCC
- !! Make ionisation beam profile monitor measurements operational from CCC
- !! Revive scraper controls



PS (Ions)

- Tune PU to be installed during LS1.

A Few General Remarks

- Cross-calibration of BCTs along the injector chain – where are we??
- Satisfactory cross-calibration of emittance measurements along the injector chain and the LHC – point still open...
- Functional BI Specification Reviews
 - Define wish-list for future machine operation, including LIU
 - Reviews held so far: Beam intensity, beam position
 - How to go from a ‘wish-list’ to ‘can be provided’ and ‘as measured’?
- Introduction of ‘BI issues’ in elogbook
 - Very useful - allows fast dispatching of issues and good follow-up for BI and OP
- ACCOR renovations need to go ahead during LS1...

Conclusions and Outlook

- Good progress and many improvements of beam instrumentation over last years
- Steady push for increased **beam quality** at reduced beam losses translates often to new requests for improvements of our beam instrumentation
- Echo throughout the machines: **BI very responsive!**
- We would like ***to thank all the BI colleagues, also those that work more behind the scenes***, for their support and ensuring that beam instrumentation is available and operational.
- **The BI equipment are the eyes of the operations teams!**

Special thanks for having provided information to:

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