Recent SHiP/Beam Dump Facility (BDF) MDs

9th MSWG meeting, 21st July 2017

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Thanks to the SPS-OP crew and J. Bernhard and L. Gatignon (EN-EA) for their support as well as NA62 and COMPASS

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- Summary of first results:
  - MD181: Deployment of SHiP/BDF cycle and extraction tests
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- Future plans

*For more details on the SPS Beam Dump Facility and SHiP see the Technical Proposal:
A Facility to Search for Hidden Particles (SHiP) at the CERN SPS, CERN-SPSC-2015-016
https://cds.cern.ch/record/2007512

Outline of MDs: MD181 SHiP/BDF cycle

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  - Extraction MDs must be dedicated as NA physics is blocked
  - Wednesday 7 June 08:00 – 18:00 (10 hours)
  - Wednesday 16 June 14:00 – 18:00 (4 hours)

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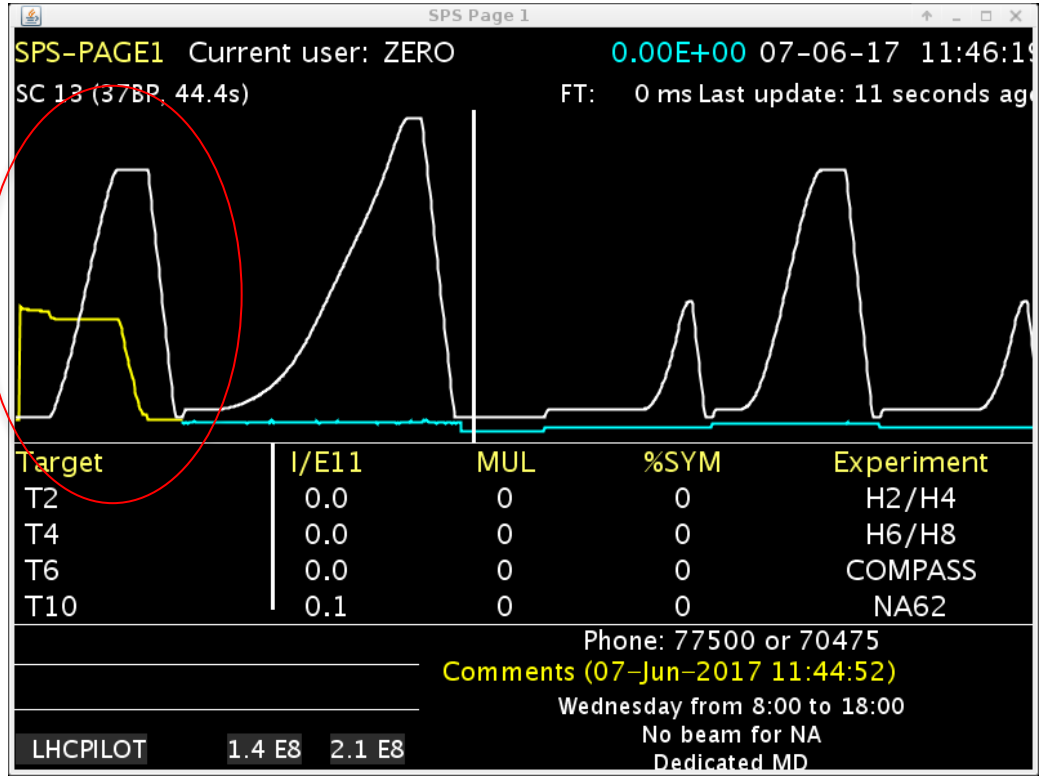
- Modified SFTPRO cycle with 400 GeV/c flat-top of 1.2 s, total cycle length of 7.2 s
- Spill length ≈ 1 second
- Momentum dominated 1/3-integer resonant extraction
- Chromaticity during extraction halved to -0.5 units to slow down the tune sweep and enable (almost) all beam to be extracted



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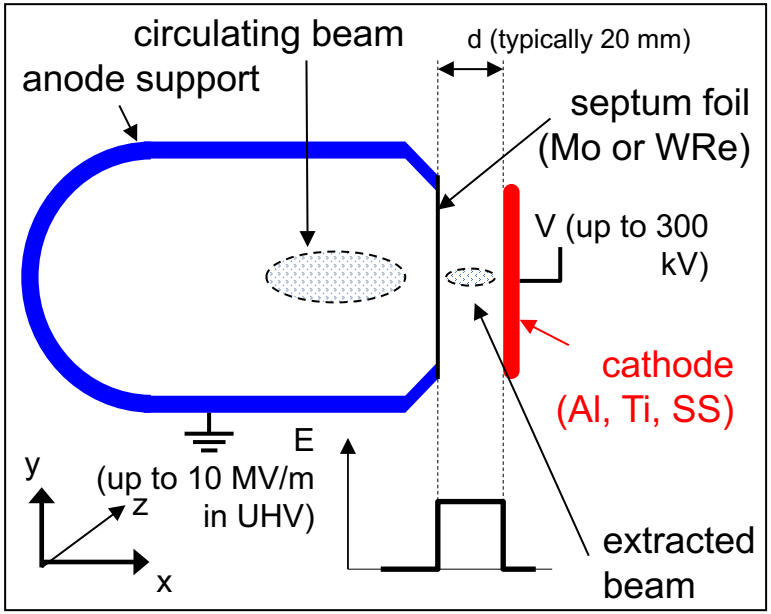
Schematic of electrostatic septum (ZS):



Outline of MDs: MD183 SHiP TT20 optics

- One dedicated MD slot allocated so far :
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  - Change TT20 optics to place beam entirely in dipole aperture of the first splitter (MSSB), **sending un-split beam to T6**

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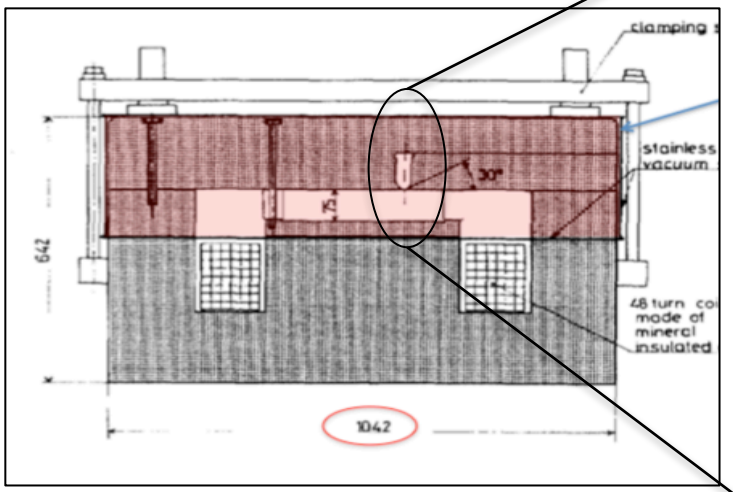
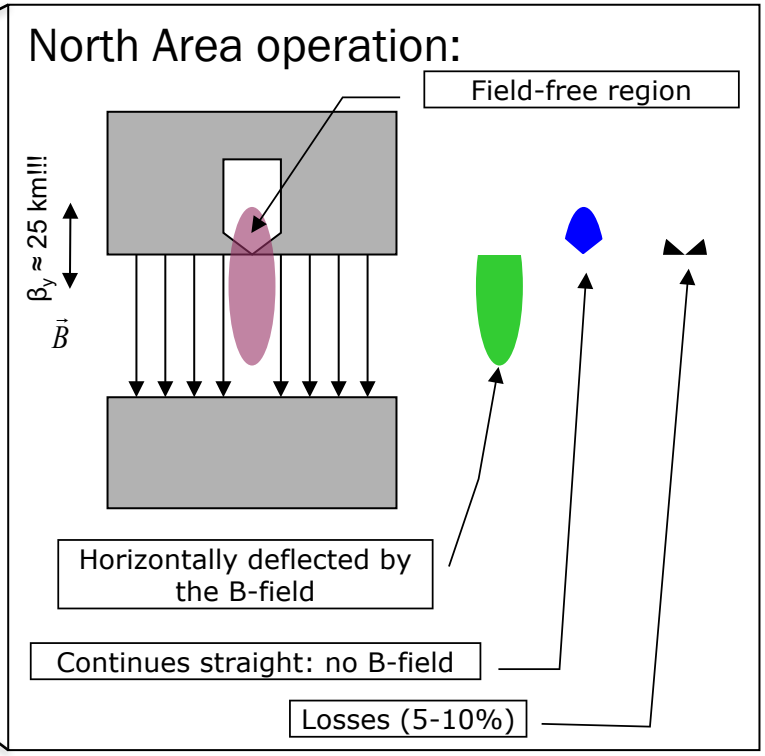


L. Evans et al., The steel septum magnets for beam splitting at the CERN SPS, 6th International Conference on Magnet Technology, v.1, Bratislava, Slovakia, 29 Aug - 2 Sep 1977, pp.498-503



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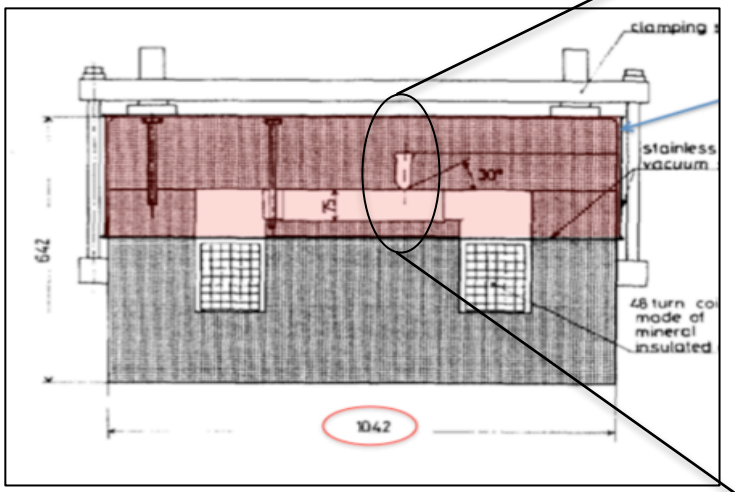

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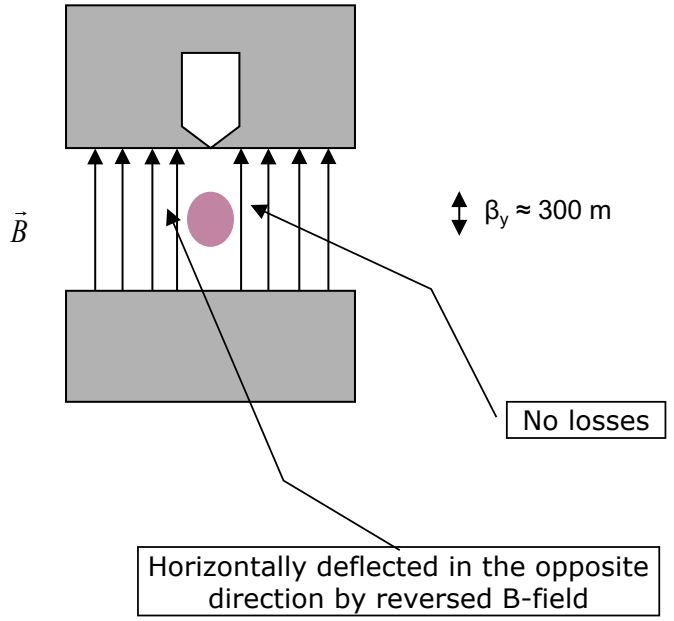
SHiP/BDF operation:



Outline of MDs: MD183 SHiP TT20 optics

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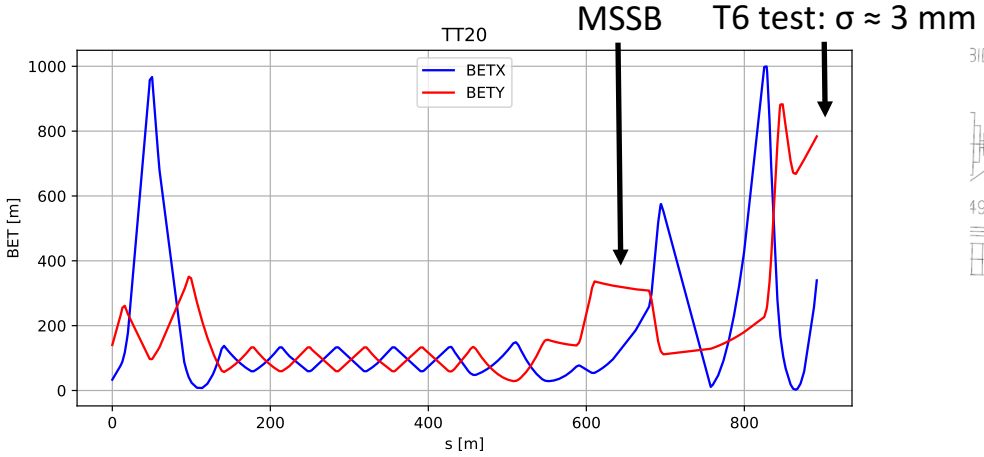
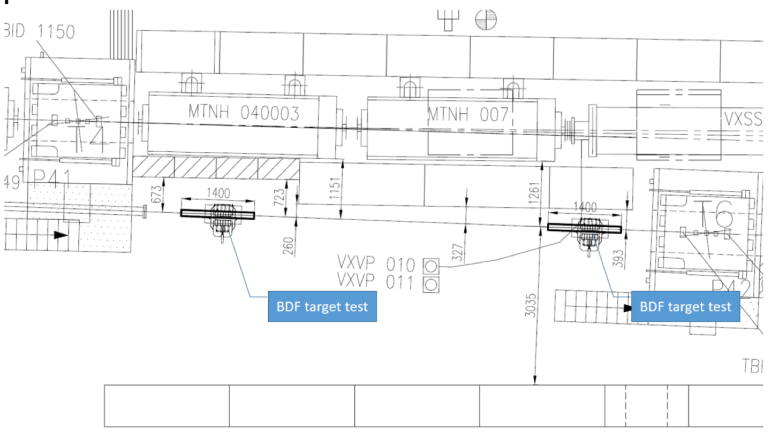
  - Wednesday 12 July 14:00 – 18:00 (4 hours) due to TAX issue on T2
  - Change TT20 optics to place beam entirely in dipole aperture of the first splitter (MSSB), **sending un-split beam to T6**
  - Tests in view of a BDF prototype target test in front of T6 in 2018:
    - Plenty of preparation work on-going in the *BDF target and target complex WG*
    - See for example WG meeting #6 on 26th June 2017:
      - *Status and perspectives of the BDF T6 target test*, O. Aberle, S. Girod et al.:
      - https://indico.cern.ch/event/642671/



▪ Possible location of BDF target test

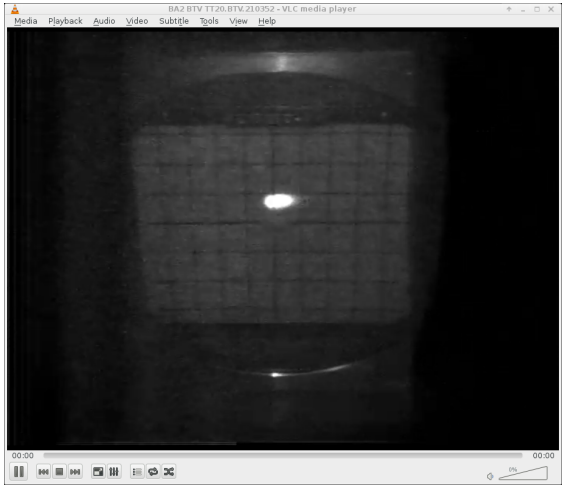


MD181: Deployment SHiP/BDF cycle and extraction tests

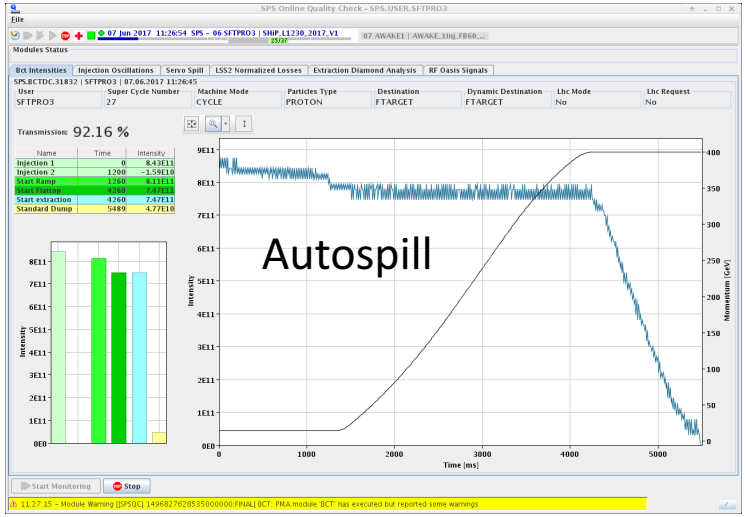
Summary of results

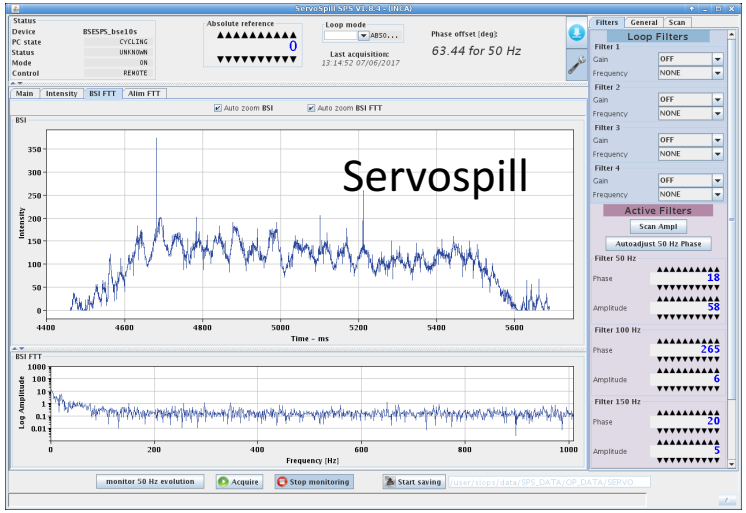
MD181 SHiP/BDF cycle: summary of results (1)

BTV upstream TT20 TED



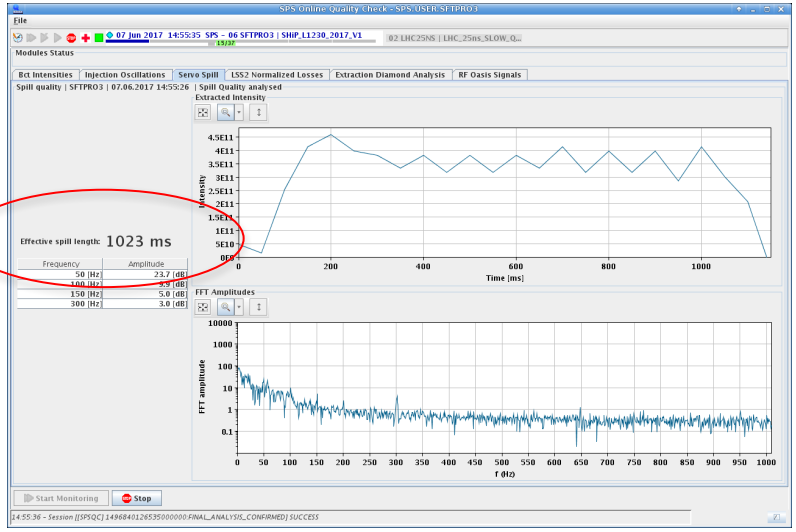
- Extraction set-up onto TT20 TED
  - 1E12 ppp, MTE core sent from PS (single turn: 2 μs)
  - RF gymnastics OFF
  - Chromaticity was halved to -0.5
  - Normalised loss profile at ZS similar to operational levels.
  - Losses vastly improved in 2017, understood as a tail (scattered from ZS wires) touching the cathodes.
  - Autospill and Servospill applications used to optimise extraction.

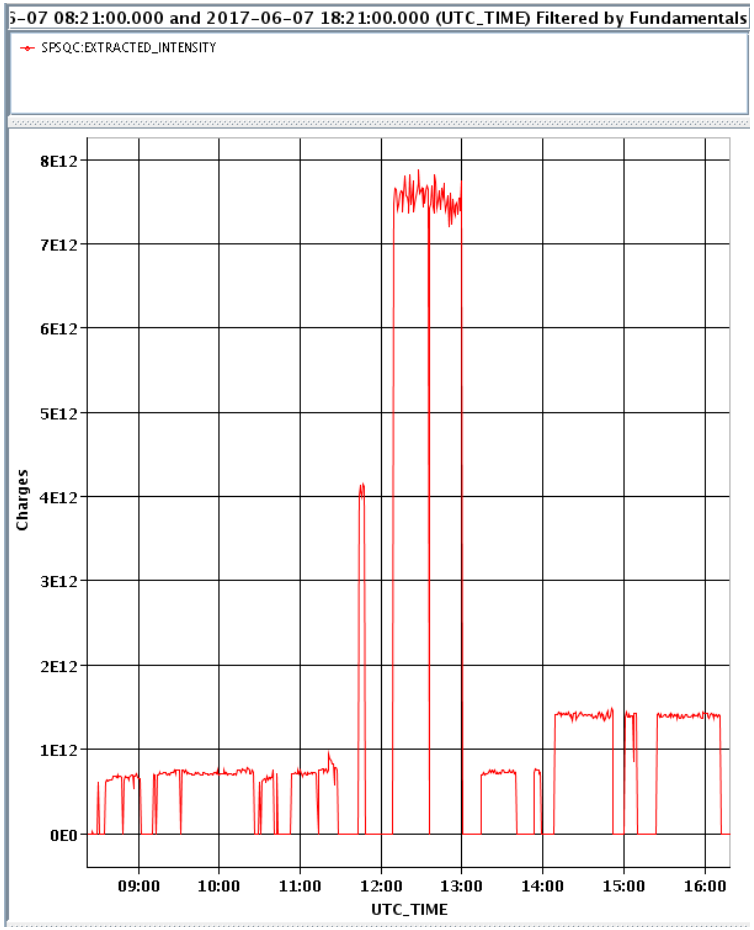




MD181 SHiP/BDF cycle: summary of results (2)

- Increased intensity to 4.25E12 before injecting 2 batches to extract 7.5E12 onto the TT20 TED.
- Spill control much easier with higher intensity due to BCT gain/noise issues:





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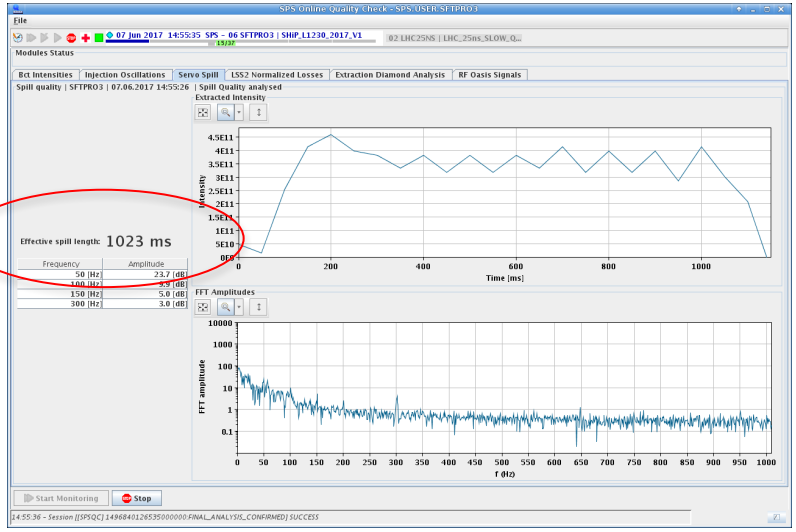
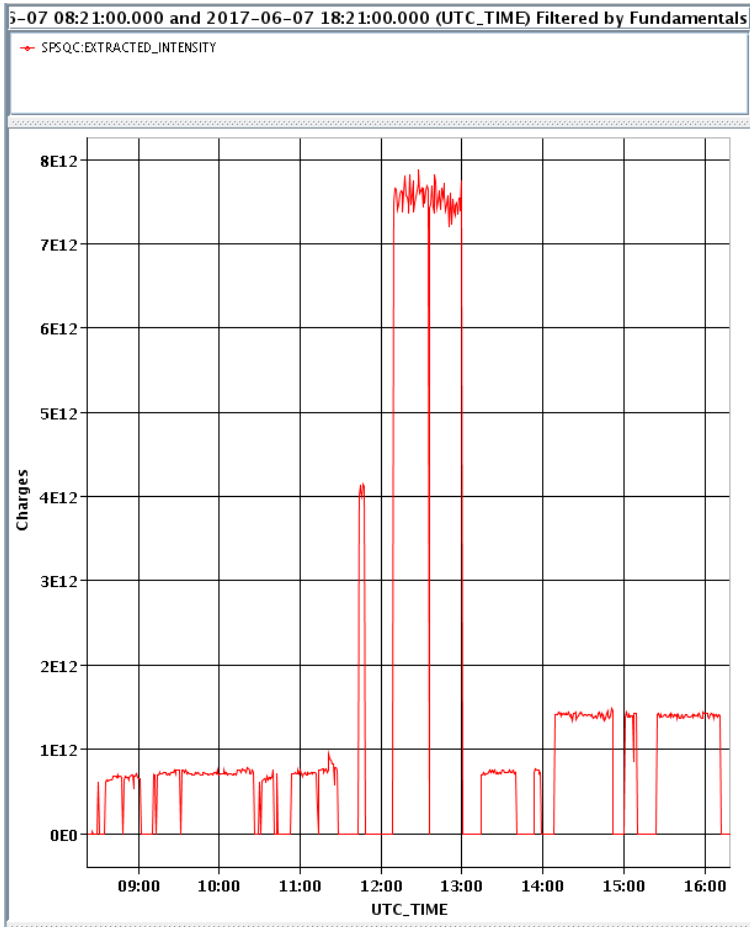
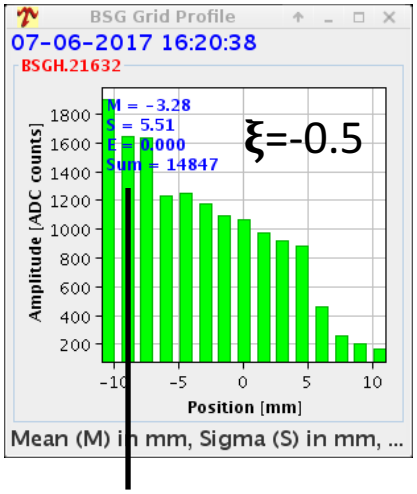




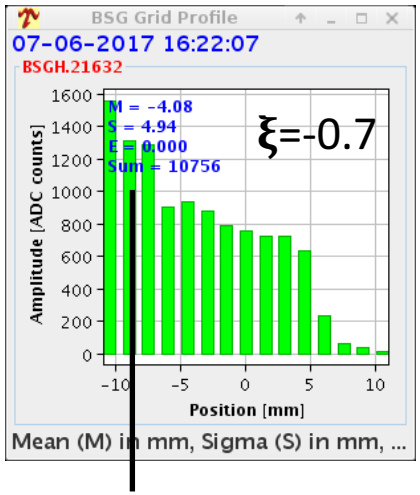
Waiting for FLUKA/ANSYS simulation studies of TT20 TED before increasing intensity again

MD181 SHiP/BDF cycle: summary of results (3)

- Scaled the chromaticity: tune of the reference momentum moved too, observed spill structure disrupted on Autospill:
  - radial position needed correction
- Little effect on losses and beam profile at ZS (H):



ZS wires



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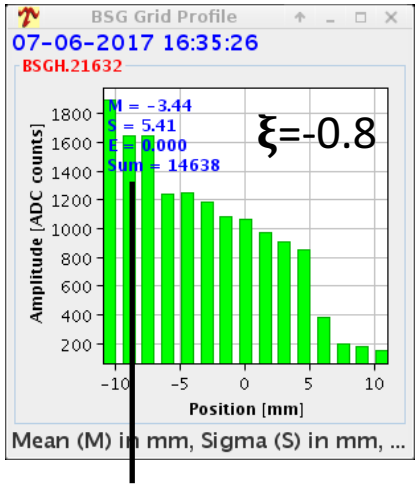
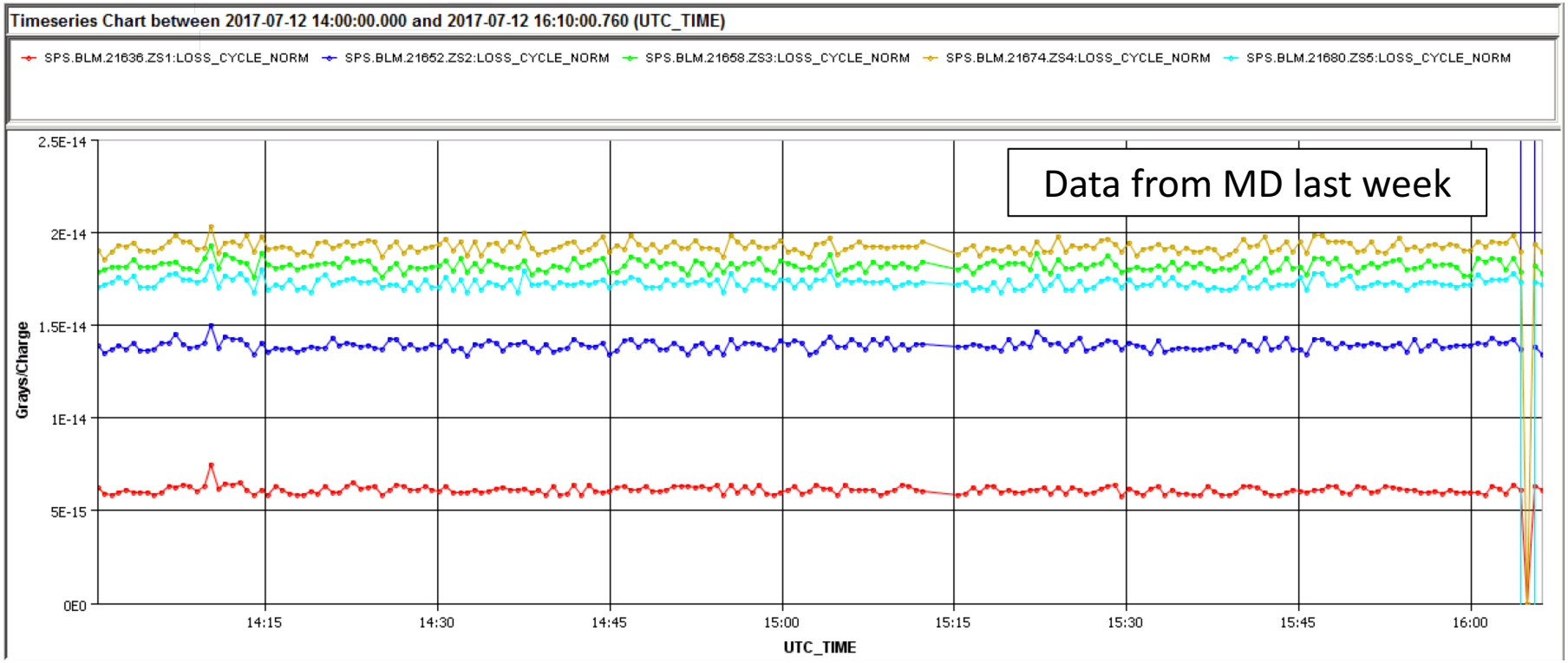


ZS wires

- SPS-OP steered the beam through TT20 and onto the targets for spill quality analysis by NA62 and COMPASS.

MD181 SHiP/BDF cycle: summary of results (4)

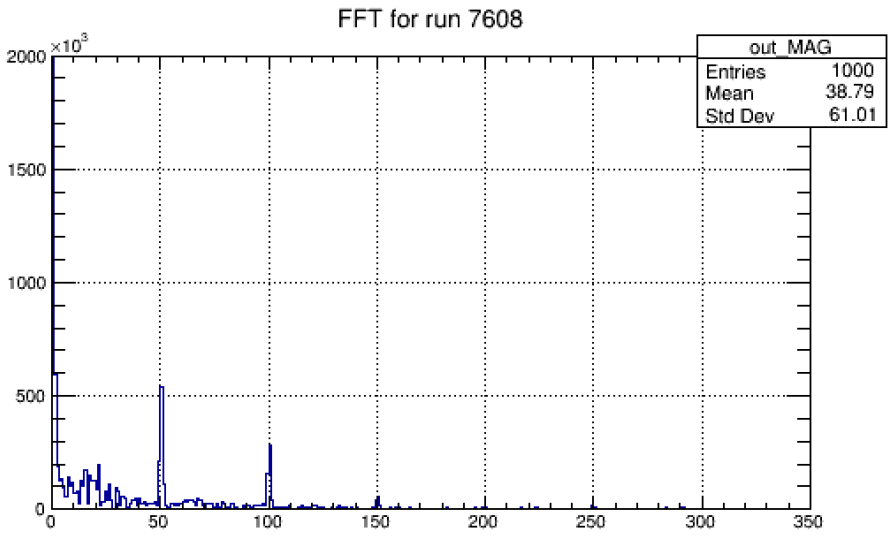
- Normalised loss profile [Gy/p$^+$] measured at ZS similar to the operational SFTPRO beam at 3E13 ppp:
  - Independent of chromaticity, rate of extraction and intensity…
  - To be seen if this remains the case as we increase intensity!



MD181 SHiP/BDF cycle: summary of results (5i)

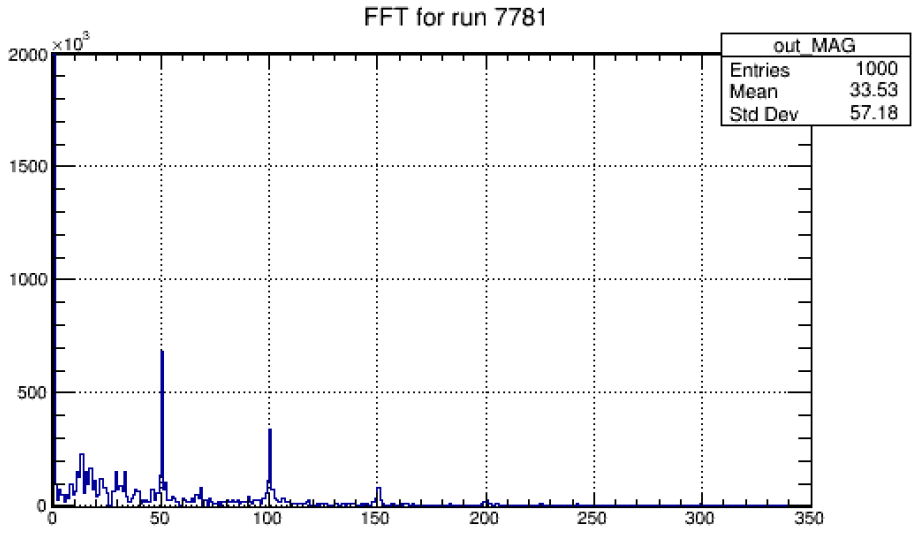
- **Low frequency** harmonic content of the spill:
  - Data courtesy of Dario Soldi, Karim Massri and NA62 collaboration
  - Very little difference between the two extractions…

Extraction on
1.2 second flat-top



Frequency [Hz]

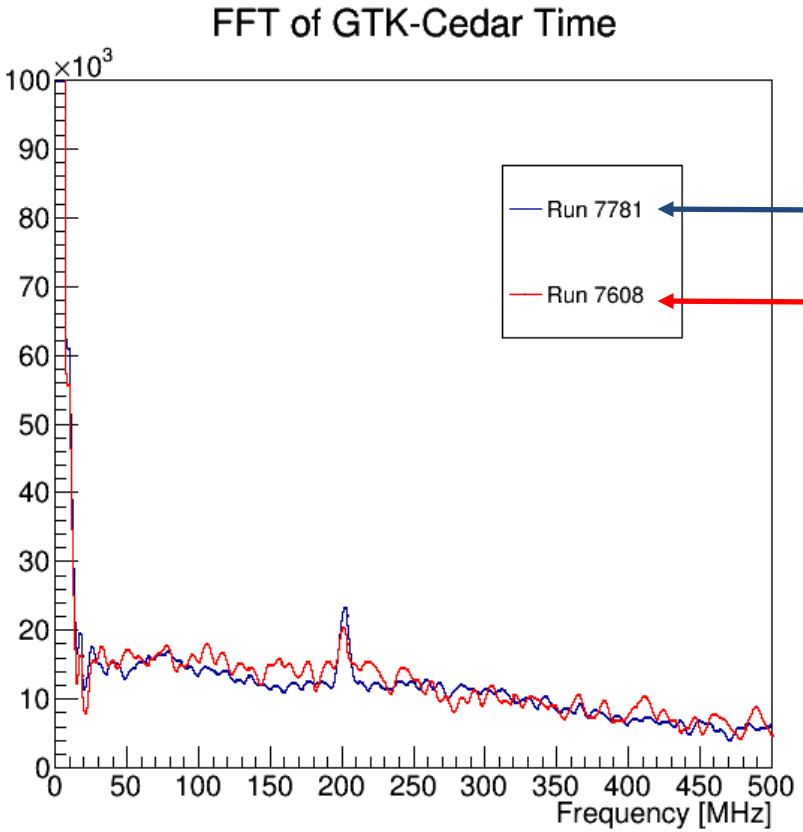
Extraction on
4.8 second flat-top



Frequency [Hz]

MD181 SHiP/BDF cycle: summary of results (5ii)

- **High frequency** harmonic content of the spill:
  - Data courtesy of Dario Soldi, Karim Massri and NA62 collaboration
  - 200 MHz component looks smaller in the shorter spill?



Extraction on
4.8 second flat-top

Extraction on
1.2 second flat-top

FFT carried out on entire spill: will request as a function of time during spill

MD181: Deployment of SHiP/BDF optics for TT20

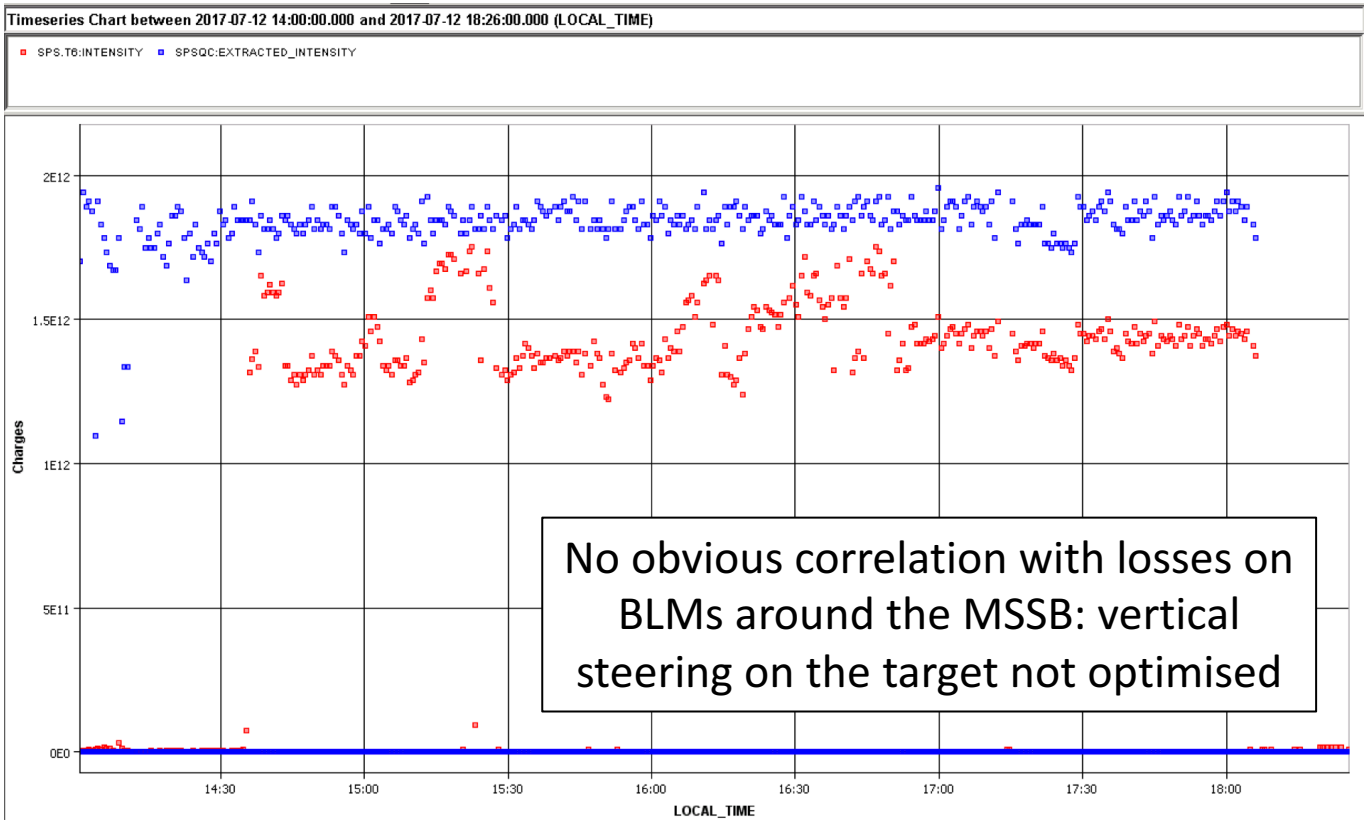
Summary of results

MD183 SHiP/BDF TT20 optics: summary of results (1)

- A big effort from SPS-OP to steer the beam in TT20, through the MSSB dipole aperture to T6.

MD183 SHiP/BDF TT20 optics: summary of results (2)

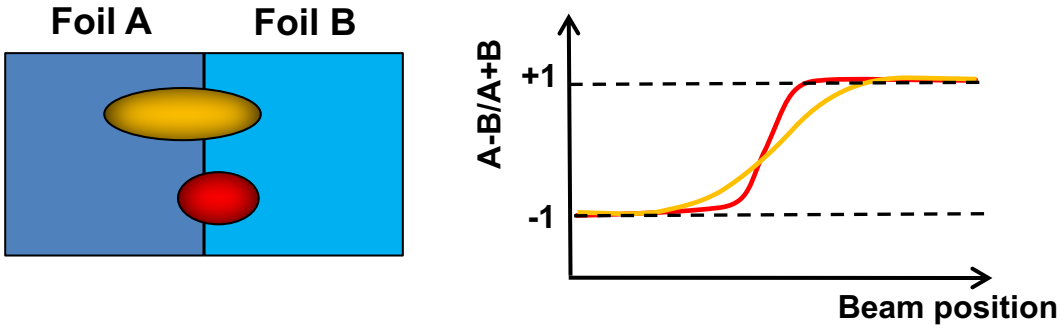
- Transmission from SPS ($BCT_{start\ FT} - BCT_{dump}$) to BSI on T6:



- To be followed-up:
  - BLM coverage (loss profile and locations), BSI calibration, etc…

MD183 SHiP/BDF TT20 optics: beam instrumentation

- The North Area beam instrumentation makes setting-up the transfer lines a challenge:
  - DC beam necessitates interceptive diagnostics
  - Split SEM foils are the cheap option but have limitations:

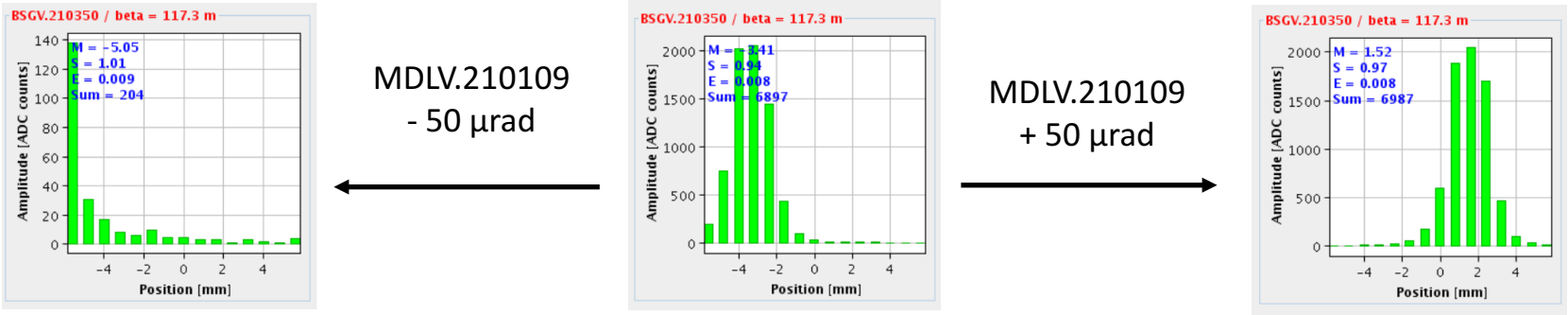


Quoting J. Wenninger in his NA training lectures, 2007:

→Steering is delicate in TT20… more than in LHC ??

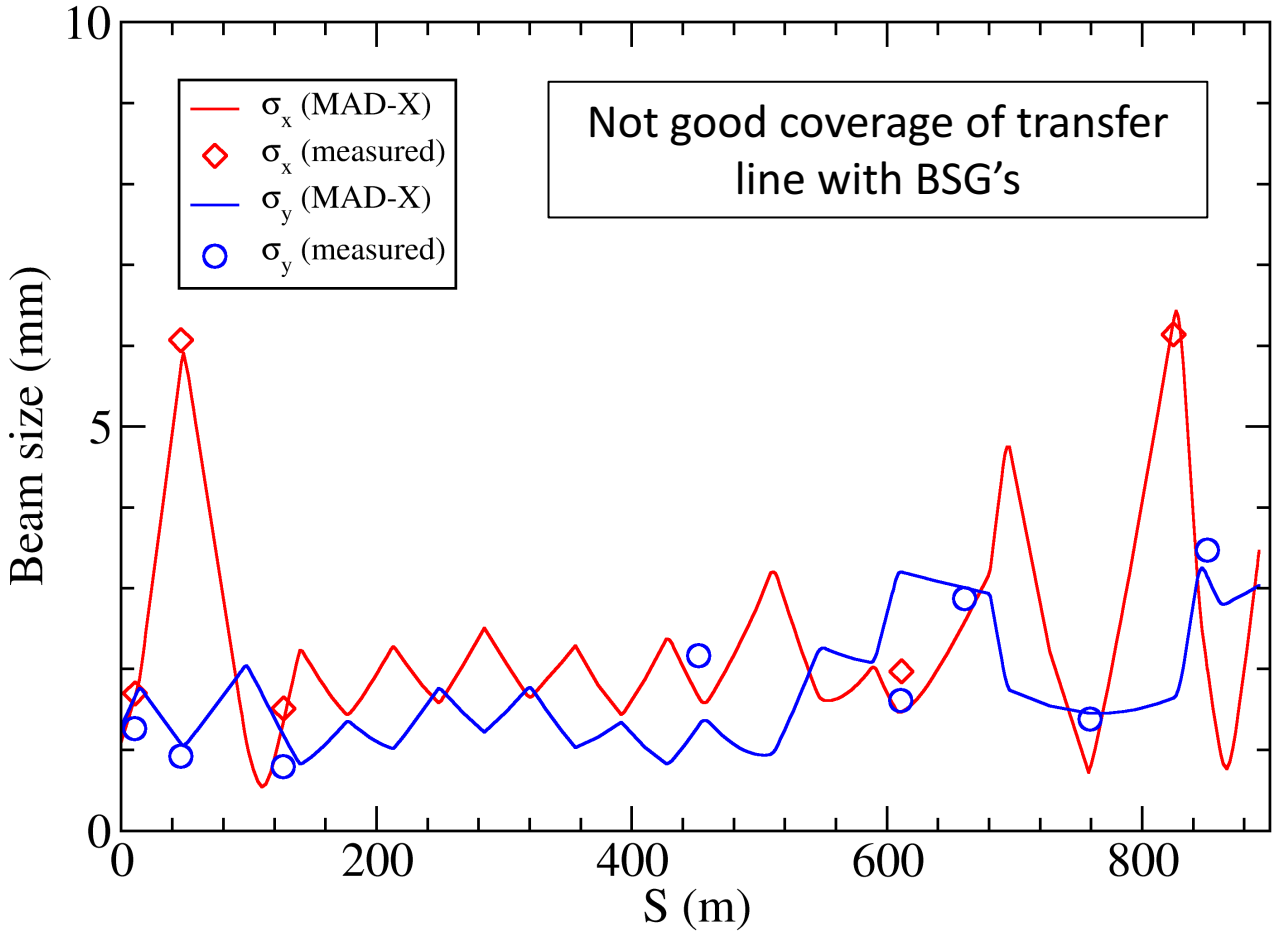
…well, YES!

  - SEM grids are the more expensive option (multiple channels, cabling, etc.) but also have limitations:



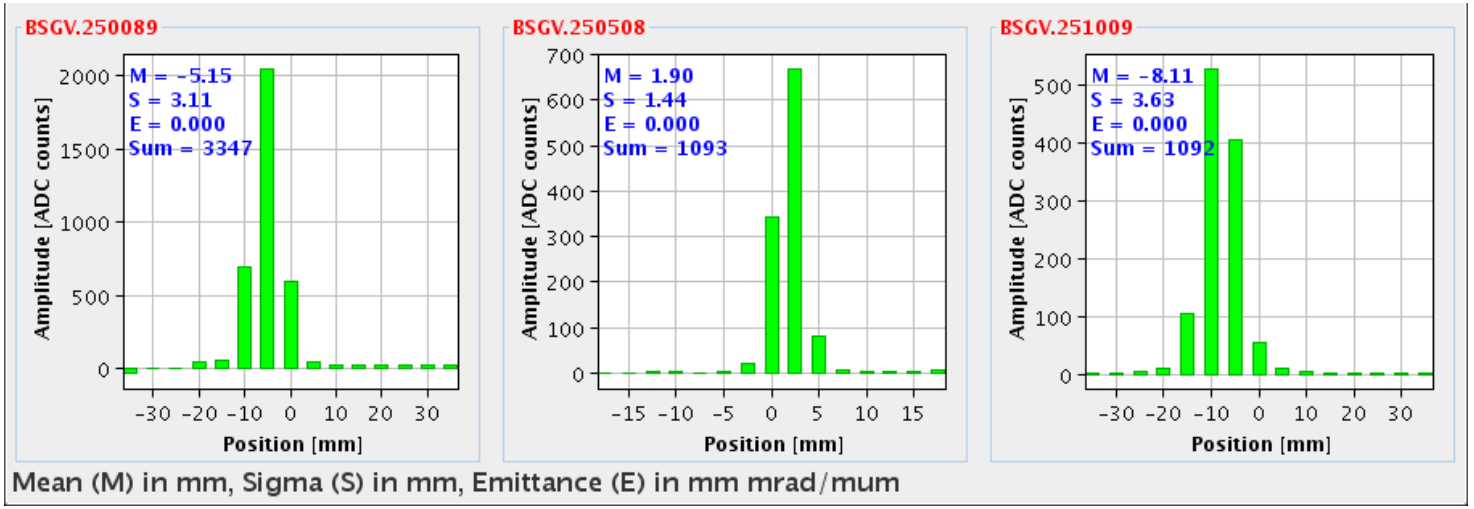
MD183 SHiP/BDF TT20 optics: summary of results (3)

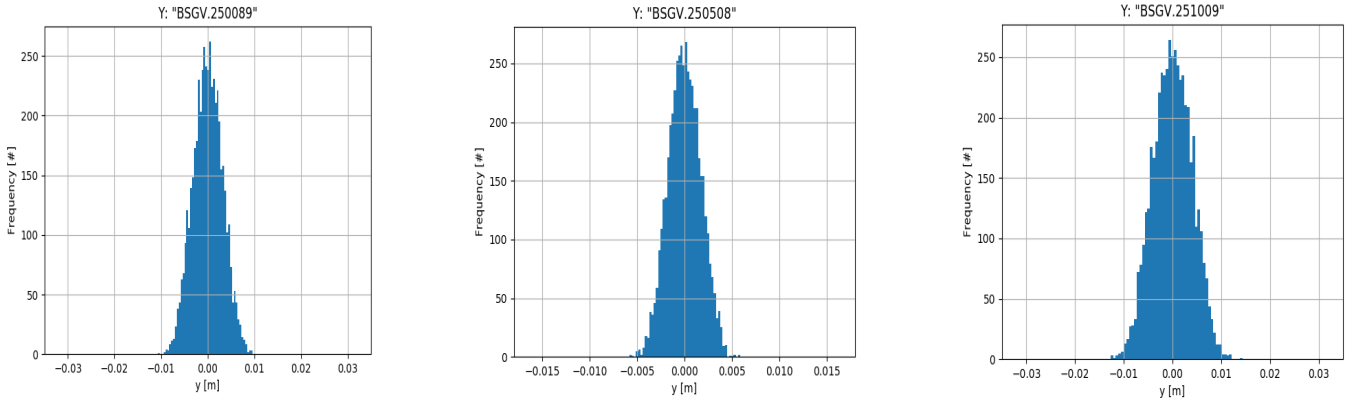
- Beam size measured and computed along the line at BSG's:



MD183 SHiP/BDF TT20 optics: summary of results (4)

- **Vertical beam size** measured and computed at BSGV's by tracking in TT20-T6 using the simulated particle distribution at extraction from SPS:





MD183 SHiP/BDF TT20 optics: summary of results (5)

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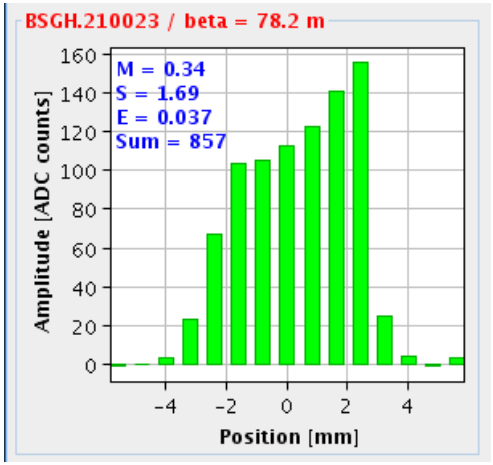
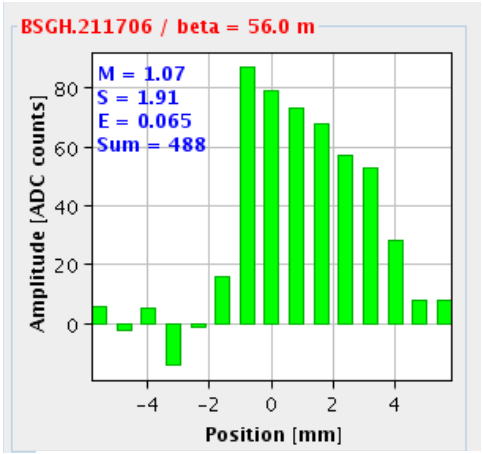
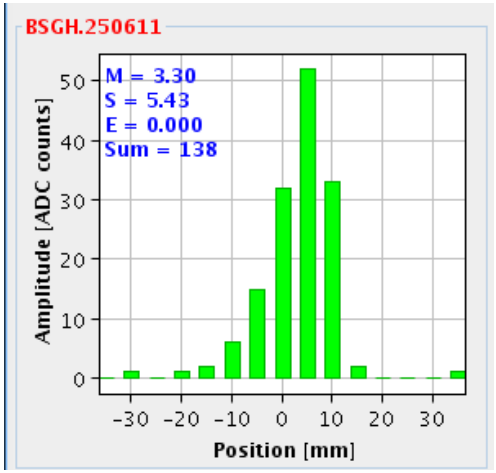
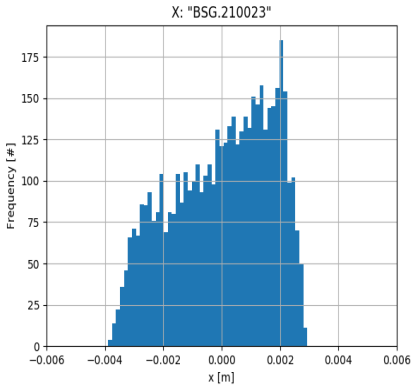
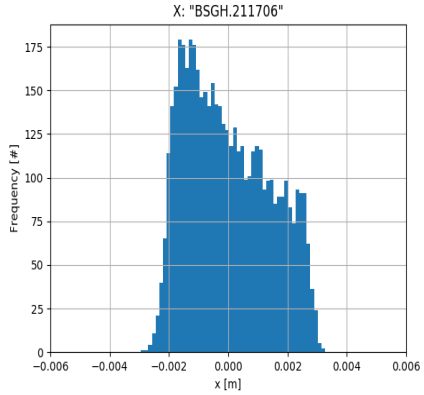
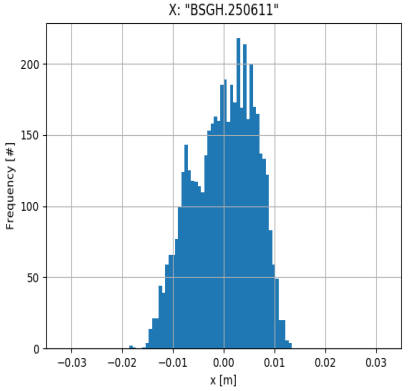






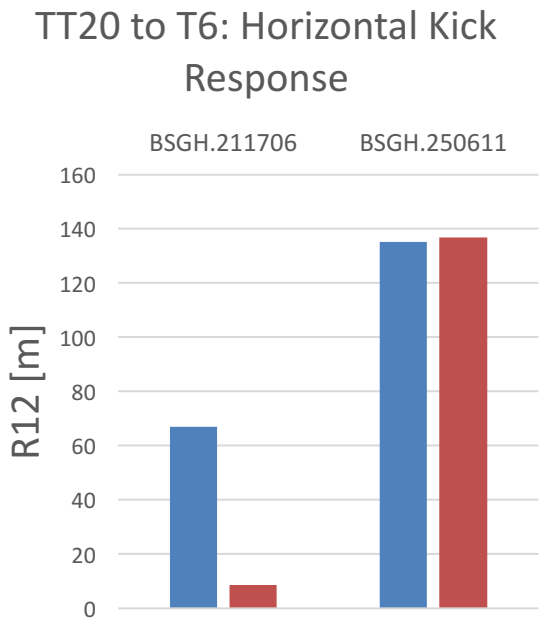


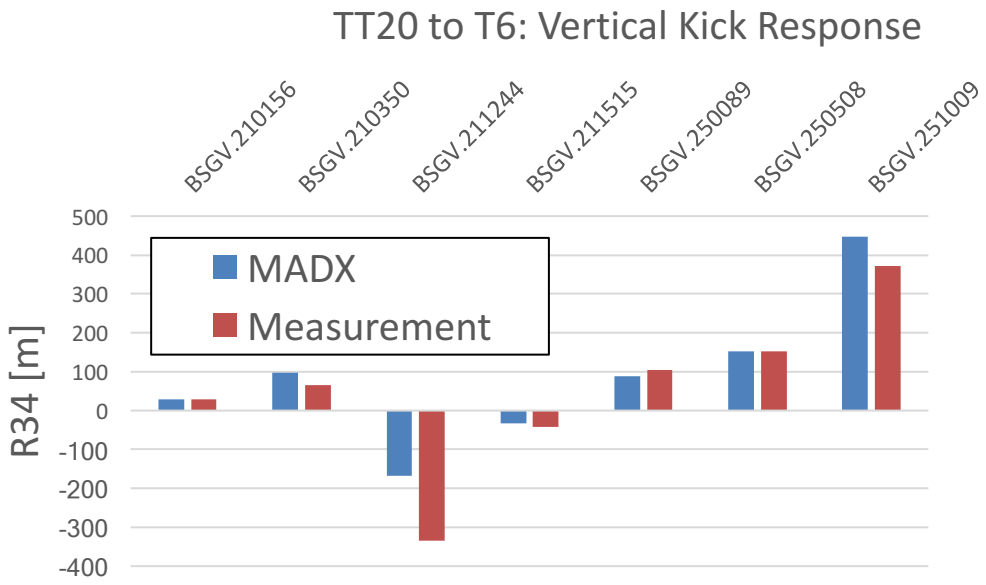




MD183 SHiP/BDF TT20 optics: summary of results (6)

- First optics measurements attempted via a kick response using the first two correctors in TT20 (MDLH.201212, MDLV210109):
  - Rapid test due to limited time: ±50 µrad (can't steer too far: fall off BSG's)
  - Limited number of suitable grids in H, more in V: trusting the software output for M (mean), further checks needed.
  - Split foils (BSP's) did not provide useful data so used available grids due to saturation effects (100% beam L or R, U or D)



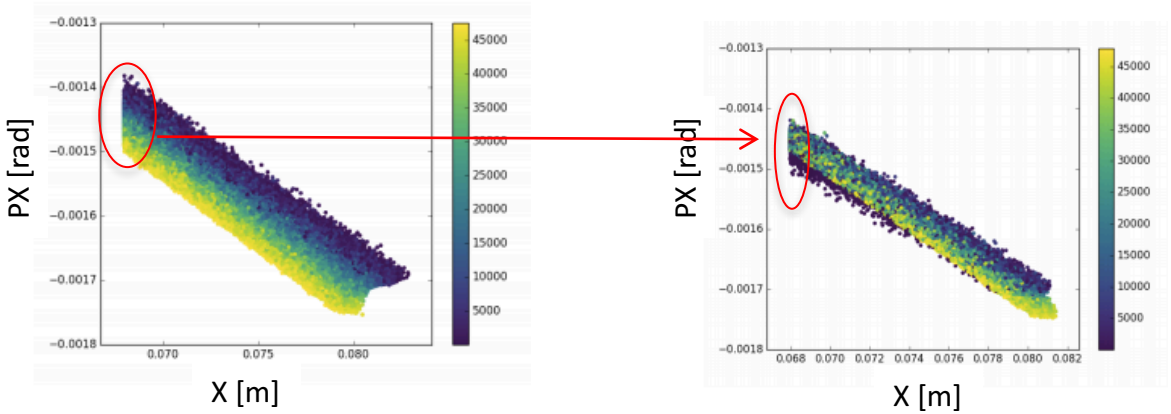


Follow-up:

- Optics measurements need completing, including dispersion
- TT20 TED intensity limit being studied by EN-STI:
  - Beam spot size at TED provided to EN-STI: measurements checked with simulation
  - M. Calviani advised against extracting more than 2E12 ppp onto the TED until these simulations have been completed
  - Linked to decision on beam parameters for T6 SHiP target tests:
    - 1.2 or 4.8 second extraction flat-top?
  - T6 limit should also be assessed
- Where is the beam lost in TT20 and T6?
  - Probably near the target but needs further investigation
  - BLM coverage: 5 new BLM's to be installed in TT20, more on T6?
- BI requirements for TT20 are being followed-up in the SPS Loss and Activation Working Group:
  - MD's highlighted the non-PPM nature of the amplification/gains of electronics of TT20 BI: how can we work more efficiently?
  - Wishlist created, these MDs will guide writing of Function Specification

Future plans for SE MD's (1)

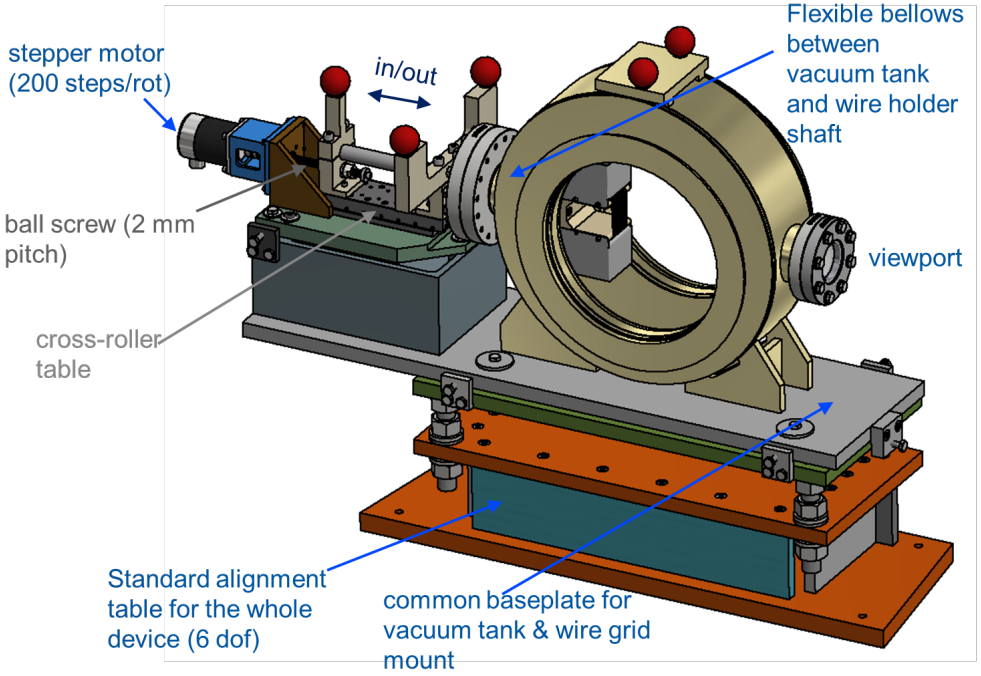
- Dynamic extraction bump test reduction of normalised losses:
  - Overlap seperatrices on ZS to reduce angular spread impacting it:
  - MD procedure being drawn up, to be submitted to rMPP

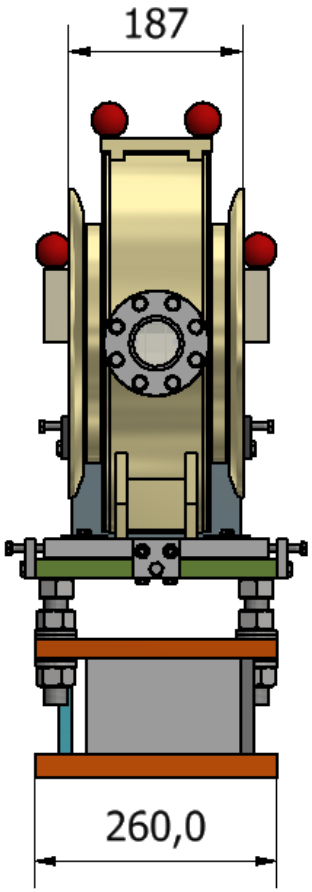


- Parallel MDs (without extraction):
  - Work with BE-RF to investigate how the longitudinal distribution can be better tailored
  - Measure non-linear chromaticity
  - Assess movement during spill due to feed-down: de-bunched beam, using BGI and BRST thanks to G. Trad, J. Storey… first data acquired yesterday.
- Reliability run/statistics:
  - It would be interesting to run in parallel with physics for an extended time period (parallel MD?) within rate limit of experiments

Future plans for SE MD's (2)

- Crystal-assisted extraction to TT20 in COAST with UA9 were carried out in 2016, further tests planned for 2017.
- Passive and active diffuser tests planned for 2018:
  - Function specification EDMS 1780182. ECR is coming…
  - Design & drawings being completed. Very compact device!
  - Being built by Wigner (HU) collaboration for end 2017





Thank you for your attention!