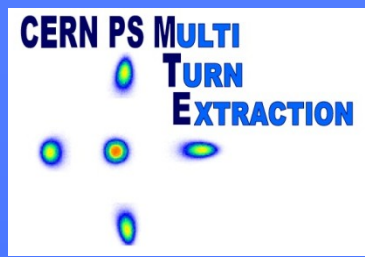


MTE roadmap – Beam physics aspects

S. Gilardoni, M. Giovannozzi

- **Introduction**
- **Latest data analysis**
- **Mitigation measures**
- **Current activities**
- **Situation of resources**
- **Future plans**

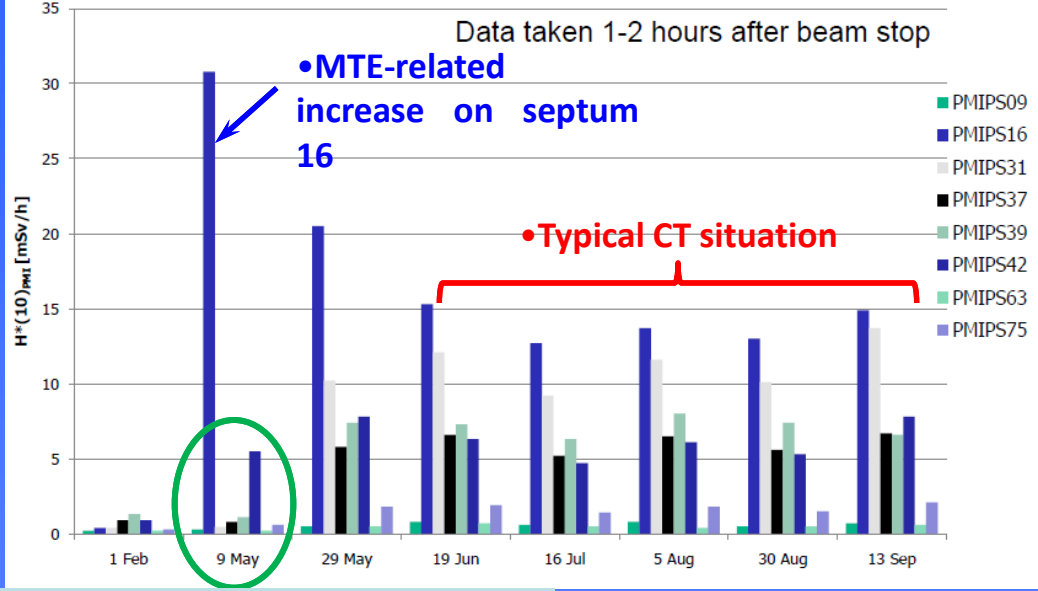
Acknowledgements: G. Arduini, H. Bartosik, A. Lachaize, M. Newman, Y. Papaphilippou and many colleagues in BI, CO, OP, RF, DGS-RP, and TE-ABT

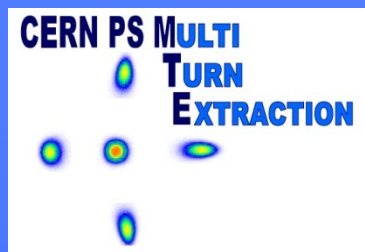


Introduction - I

- **MTE beam @ $2.2-2.3 \times 10^{13}$ (1 PS extraction) regularly delivered to the SPS for CNGS.**
- **Best trapping efficiencies up to 20% as required. PS Extraction efficiencies ~ 97-98% (typical CT extraction efficiencies ~ 93-94%)**
- **Beam for CNGS physics delivered exclusively with MTE up to about mid-May. Some mixed operation until beginning of June.**

PMI residual dose monitors shows significant reduction of PS ring irradiation w.r.t. CT.





Introduction - II

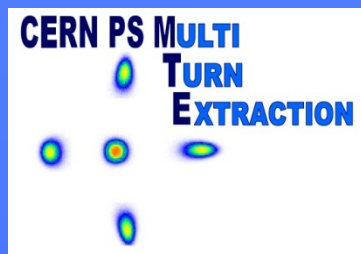
- SPS Transmission efficiency of MTE beam up to 94%, practically as a CT beam in the SPS at the start of the run (CT has been optimised since years...).
- With 2009 injection optics not matched for islands.

CNGS/MTE in May (old inj. optics)

CNGS/CT in September

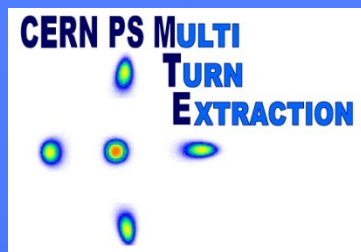
| CNGS Larger | | User: CNGS2 | | 01-May-2010 10:56:24 | |
|---------------------|-------|-----------------|-------|-------------------------|--|
| Former teletext 111 | | | | Last update: 1 secs ago | |
| TT2 | TT10 | %LOSS | INJ | %LOSS | |
| 2248 | 2167 | 3.6 | 2035 | 6.1 | |
| 2160 | 2082 | 3.6 | 1997 | 4.1 | |
| | I/E10 | %LOSS | %TRNS | TIME/ms | |
| INJECT | 3985 | 5.1 | 95 | 1210 | |
| END_FB | 3950 | 2.0 | 98 | 1260 | |
| 20 GeV/c | 3834 | 2.9 | 95 | 1470 | |
| 27 GeV/c | 3782 | 1.4 | 94 | 1530 | |
| 50 GeV/c | 3752 | 0.8 | 93 | 1740 | |
| 400 GeV/c | 3743 | 0.3 | 93 | 4200 | |
| SC: 28750 | | LOSS @ FB: 2.3% | | | |

| CNGS Larger | | User: CNGS1 | | 22-Sep-2010 16:27:38 | |
|---------------------|-------|-----------------|-------|--------------------------|--|
| Former teletext 111 | | | | Last update: 20 secs ago | |
| TT2 | TT10 | %LOSS | INJ | %LOSS | |
| 2235 | 2223 | 0.5 | 2160 | 2.8 | |
| 2253 | 2240 | 0.6 | 2171 | 3.1 | |
| | I/E10 | %LOSS | %TRNS | TIME/ms | |
| INJECT | 4311 | 2.9 | 97 | 1210 | |
| END_FB | 4302 | 0.7 | 99 | 1260 | |
| 20 GeV/c | 4252 | 1.2 | 98 | 1470 | |
| 27 GeV/c | 4209 | 1.0 | 97 | 1530 | |
| 50 GeV/c | 4203 | 0.1 | 97 | 1740 | |
| 400 GeV/c | 4193 | 0.2 | 97 | 4200 | |
| SC: 18294 | | LOSS @ FB: 0.9% | | | |



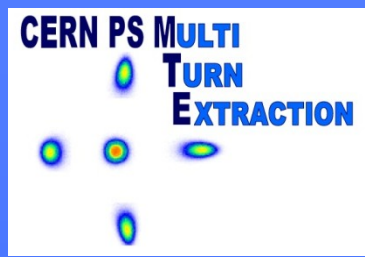
Introduction - III

- **The effects that blocked MTE operation in 2010**
 - **Activation of septum 16**
 - **Generated by longitudinal bunch structure**
 - **Impact on cool down time for intervention in septum area**
 - **Fluctuation of trapping efficiency in the PS**
 - **Long campaign of beam measurements to find source (not yet identified)**
 - **Huge amount of beam data analysed (already) and to be analysed. Some new results reported in next slides.**
 - **Injection trajectories fluctuations in SPS**



Latest analysis - I

- **Aim:** quantitative comparison of MTE vs. CT in PS and SPS and correlation studies.
- **Approach:**
 - **PS**
 - Evaluate extraction efficiency. This is obtained from the BCT for circulating and several BCTs in the TT2 transfer line.
 - Evaluate trapping efficiency, i.e., the amount of beam in each island normalised to the total intensity. This is obtained from a number of BCTs in TT2 capable of measuring intensity vs. time over the five extracted turns.
 - **SPS**
 - Evaluate transmission between different times in the cycle.



Latest analysis - II

Some comments:

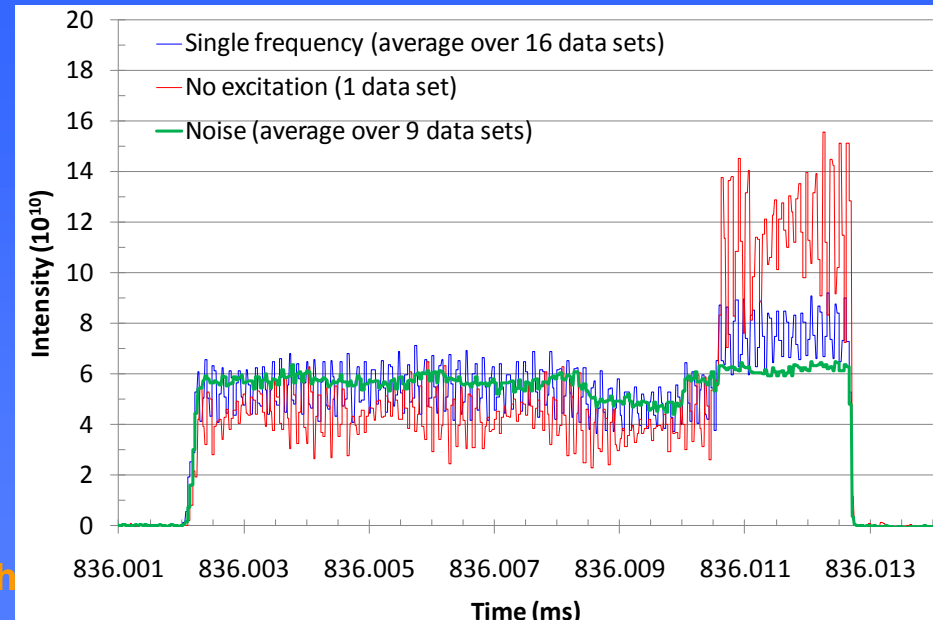
- The duty factor was suggested as figure-of-merit to understand the beam performance.
- An analytical estimate for the duty factor for an MTE-generated spill with trapping efficiency x is given by:

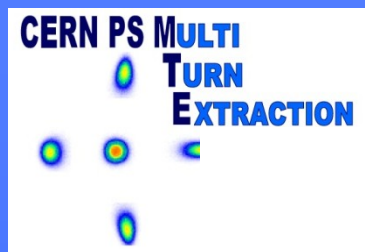
$$\frac{1}{5(1 - 8x + 20x^2)}$$

$$\frac{1}{T} \frac{\left(\int_0^T I(t) dt \right)^2}{\int_0^T I(t)^2 dt}$$

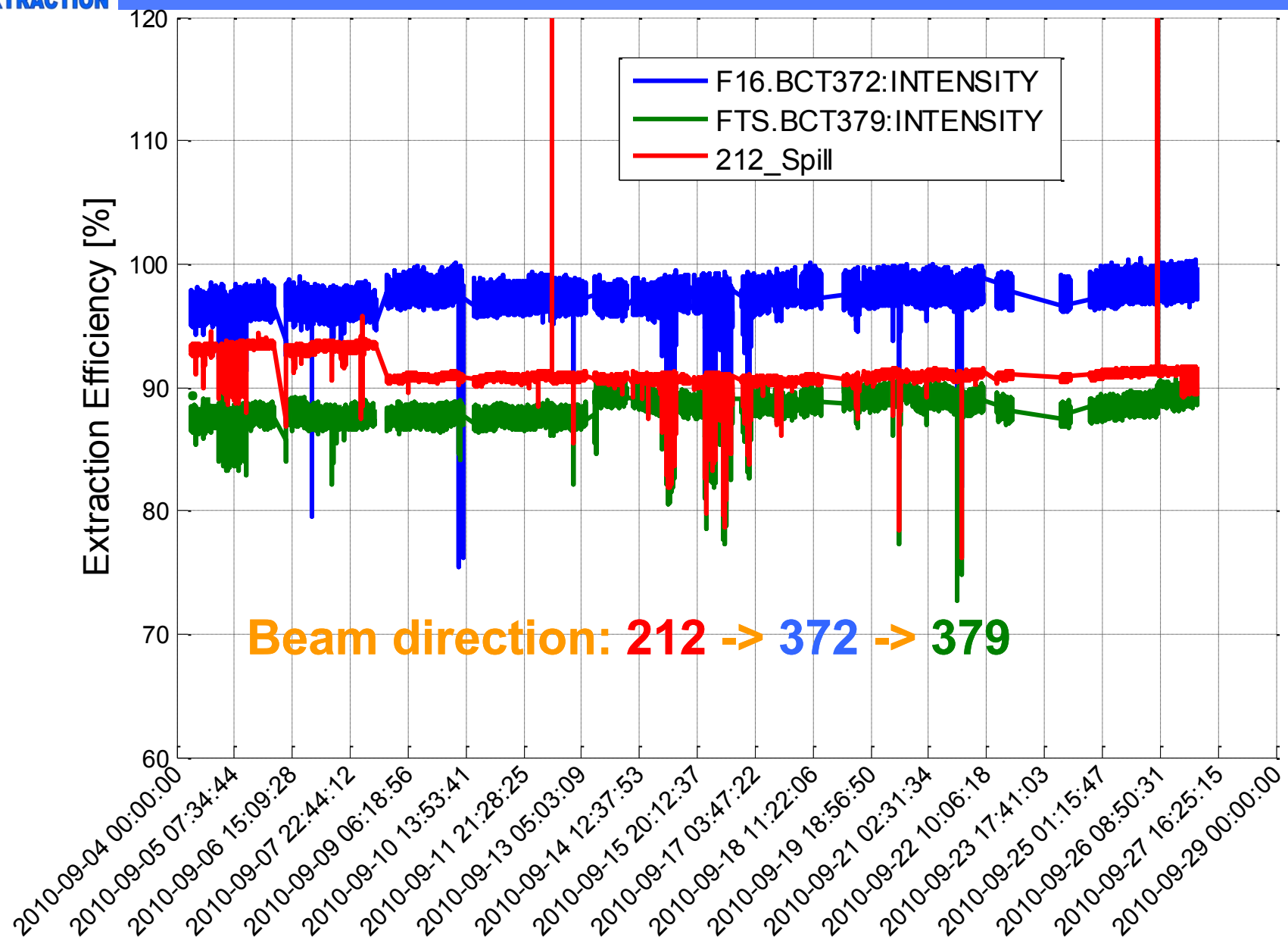
- Even if the CT beam is generated differently with respect to the MTE, a trapping efficiency was defined as well.

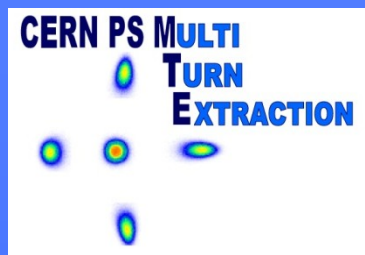
- Some plots will show the time evolution of key beam dynamics quantities, others the correlation between the beam dynamics quantities.





Latest analysis - III

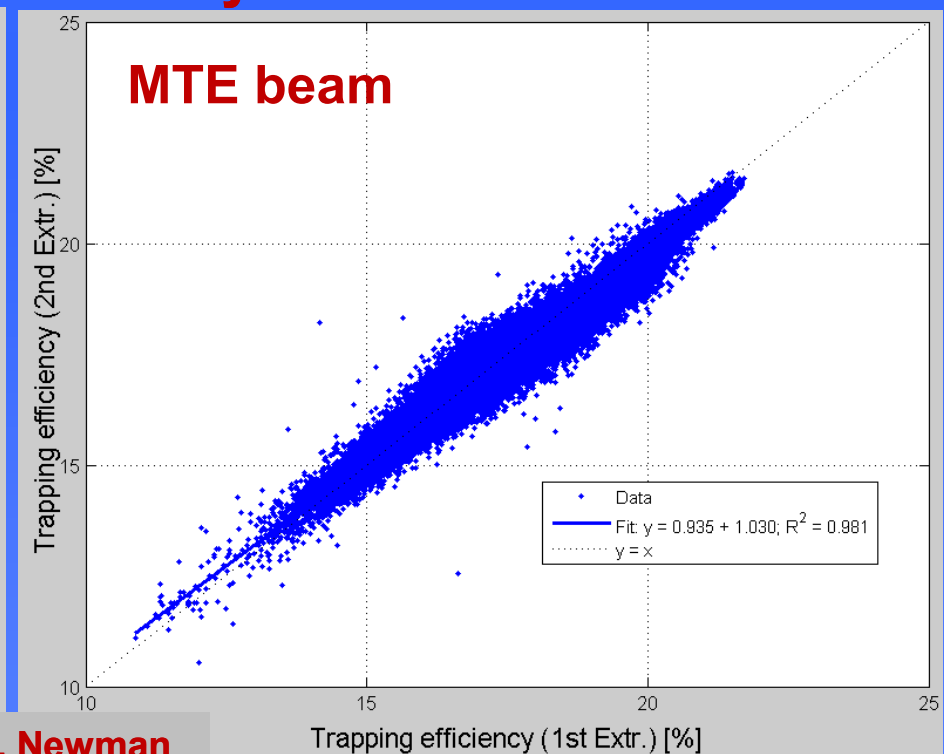
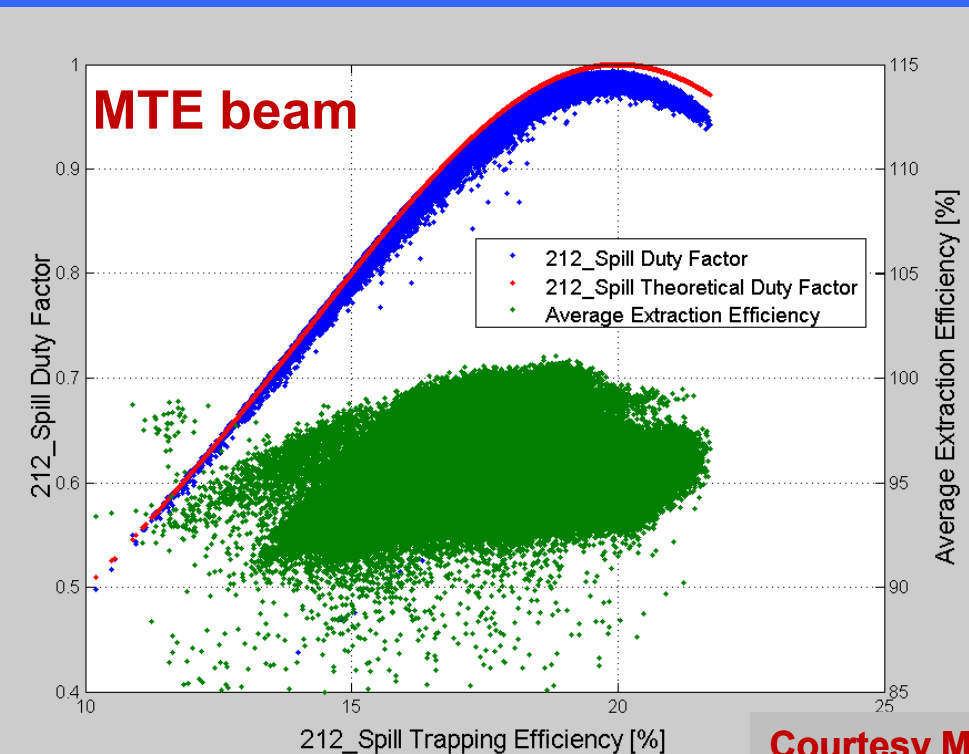




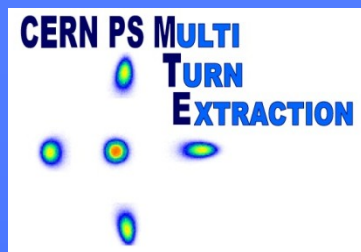
Latest analysis - IV

- No correlation between extraction and trapping.
- Analytical formula describes well the duty factor.

Perfect correlation between two consecutive extractions: time-scale of fluctuations is longer than one cycle.

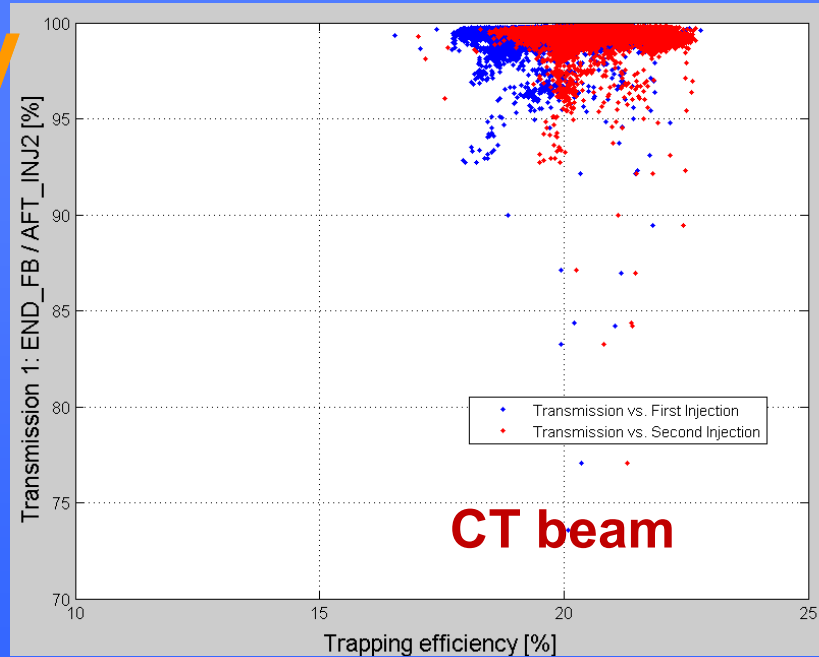


Courtesy M. Newman

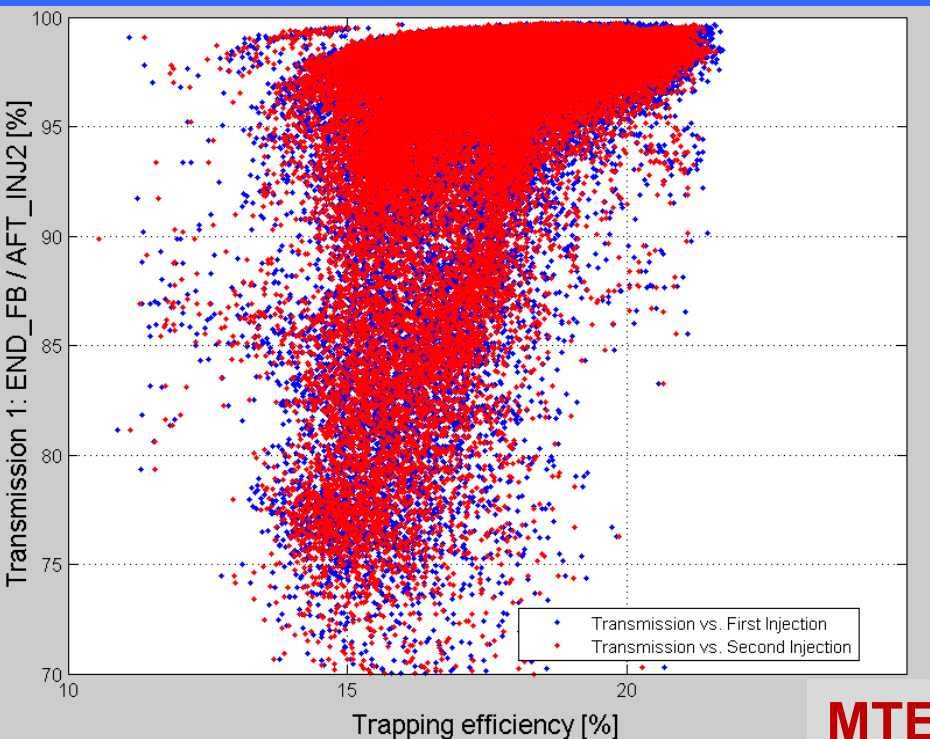


Latest analysis - V

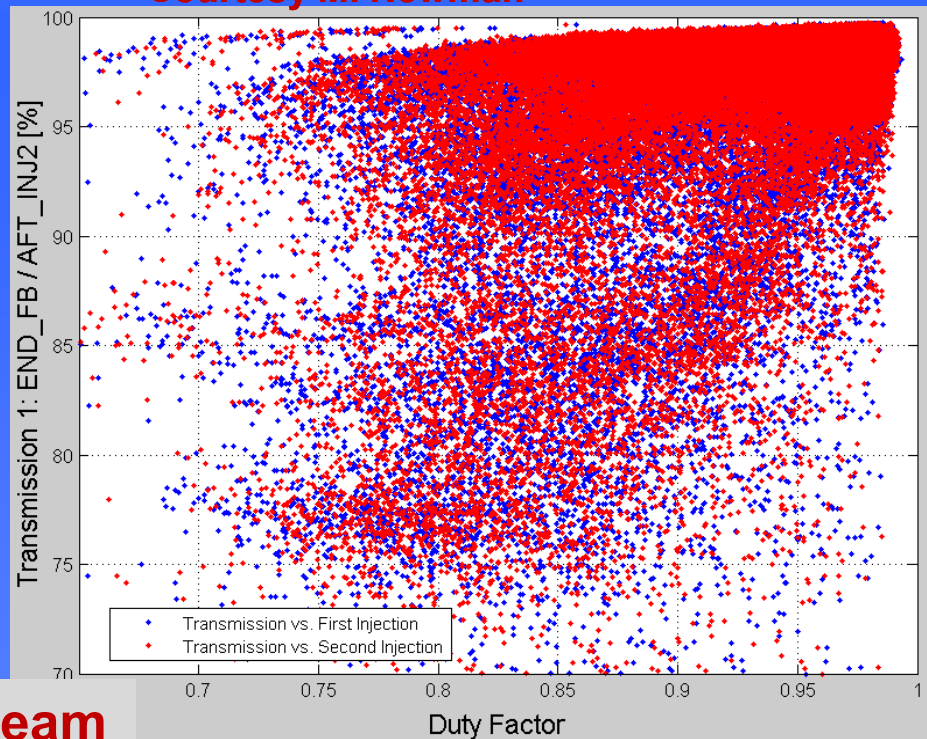
MTE: Bad MTE performance (huge fluctuations in transmission at injection flat bottom) is badly correlated with trapping (possibly correlated with trajectory fluctuations?)

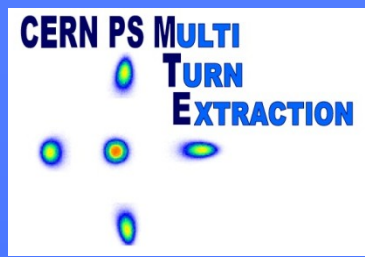


Courtesy M. Newman



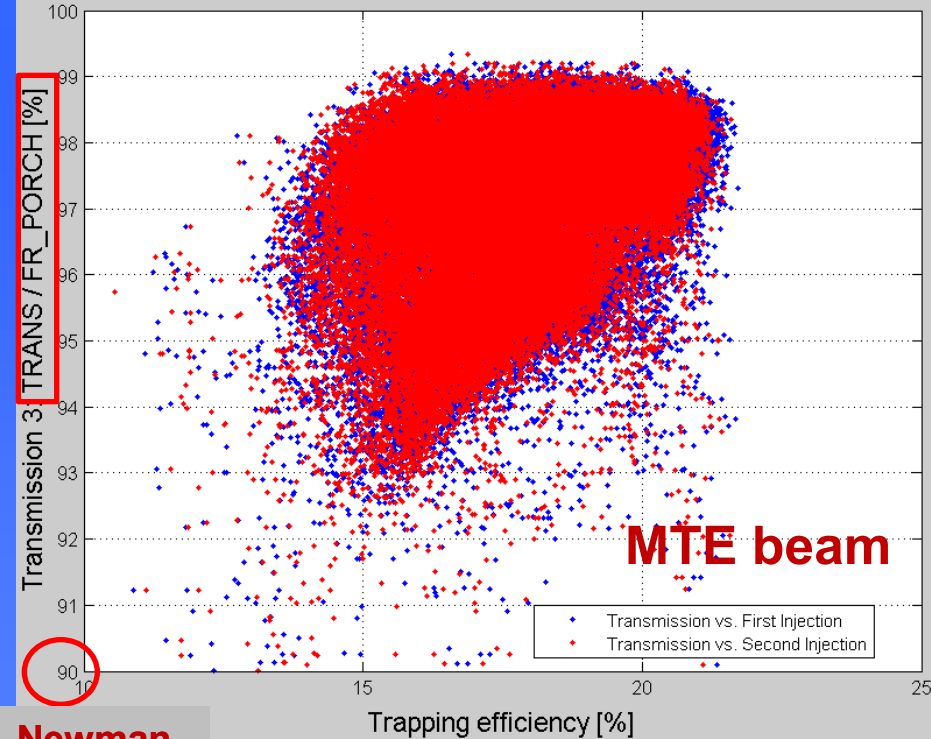
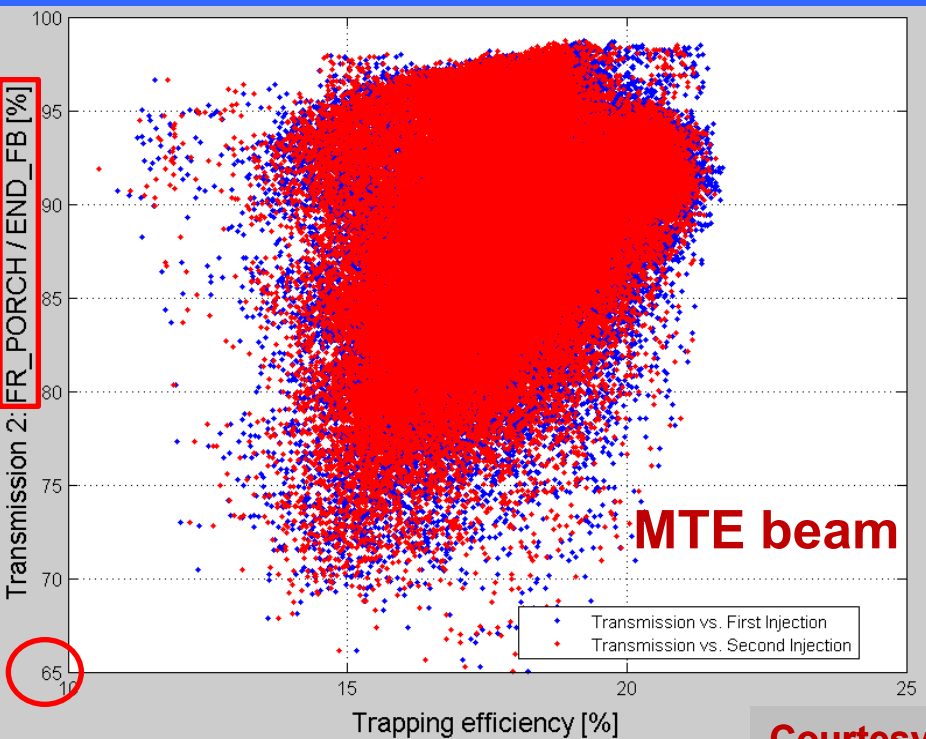
MTE beam



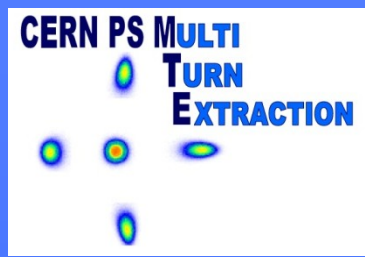


Latest analysis - VI

- Some correlation between transmission in SPS and trapping/duty factor from flat bottom up to front porch. Then rather uncorrelated for MTE.
- Global transmission in SPS rather correlated with trapping: mostly dominated by results at front porch.

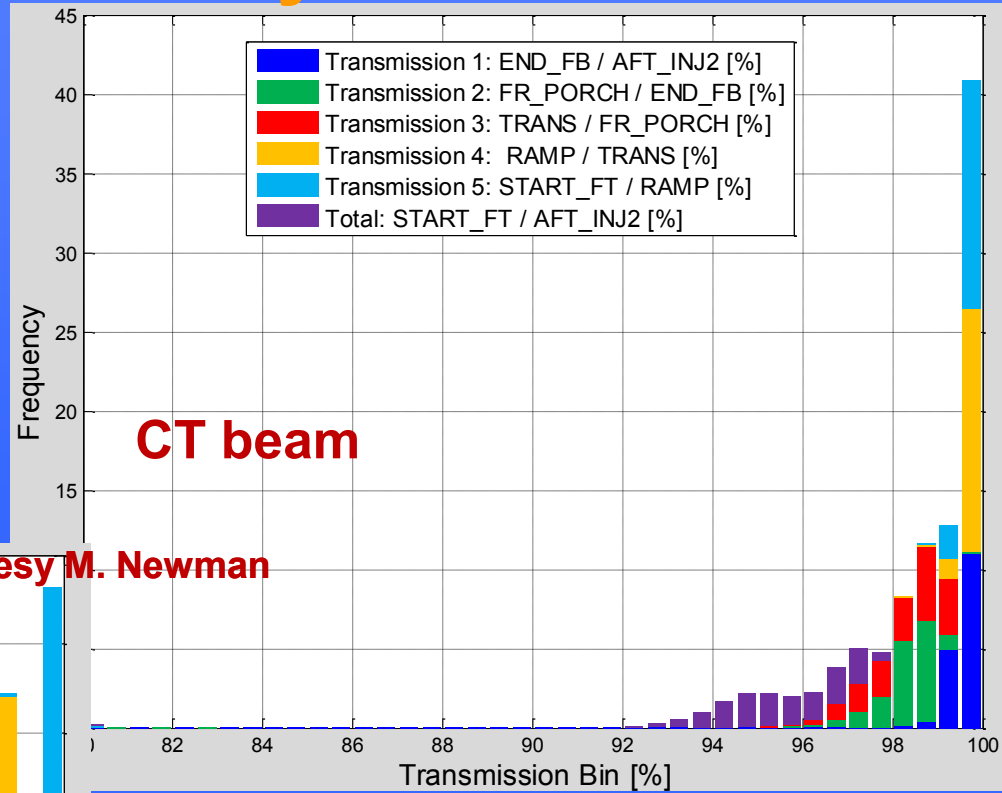


Courtesy M. Newman

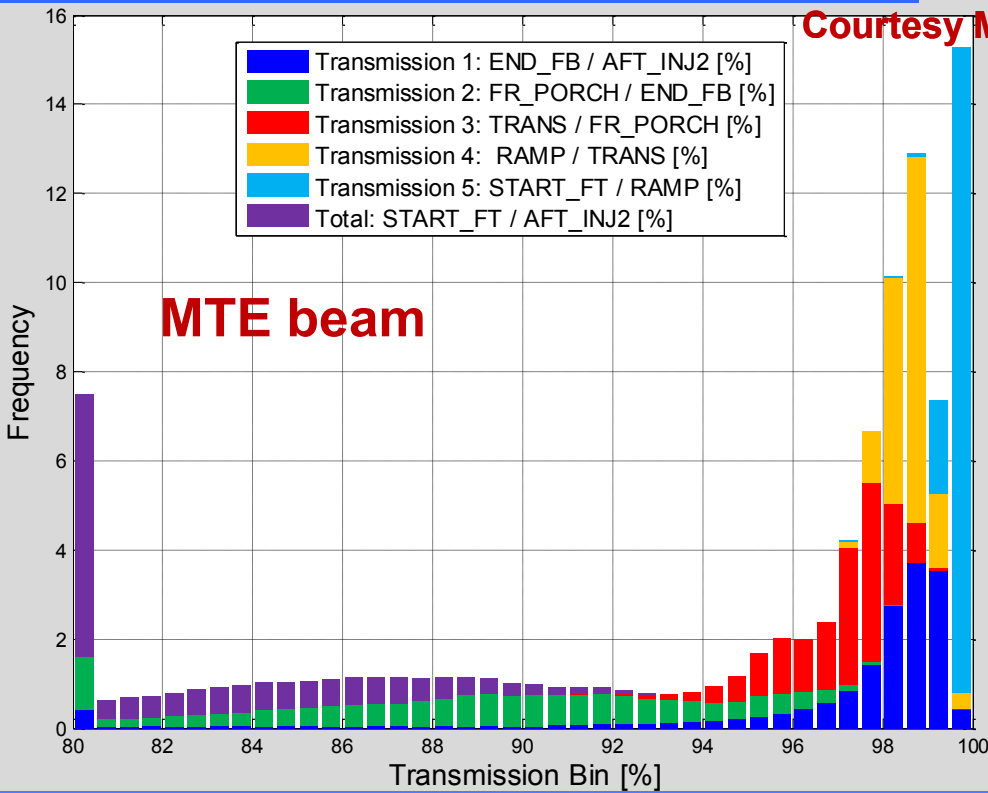


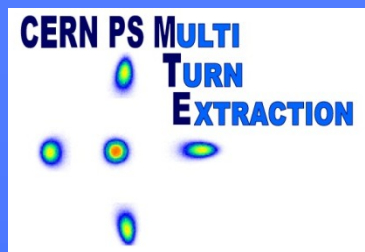
Latest analysis - VII

MTE: large spread in transmission up to front porch. Then spread comparable with CT.

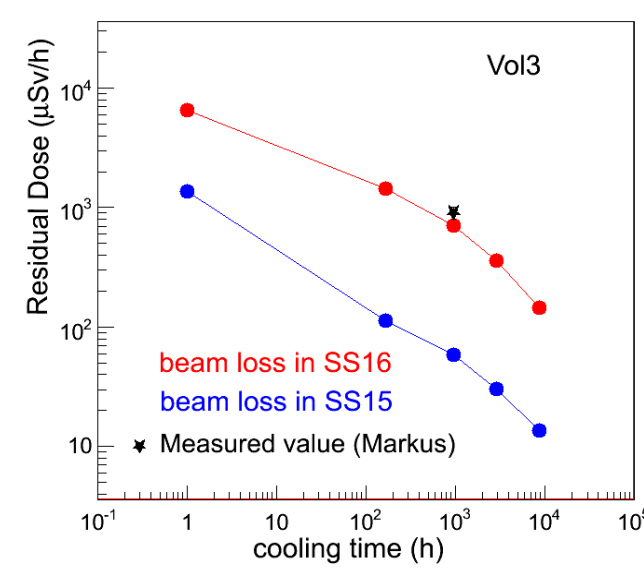
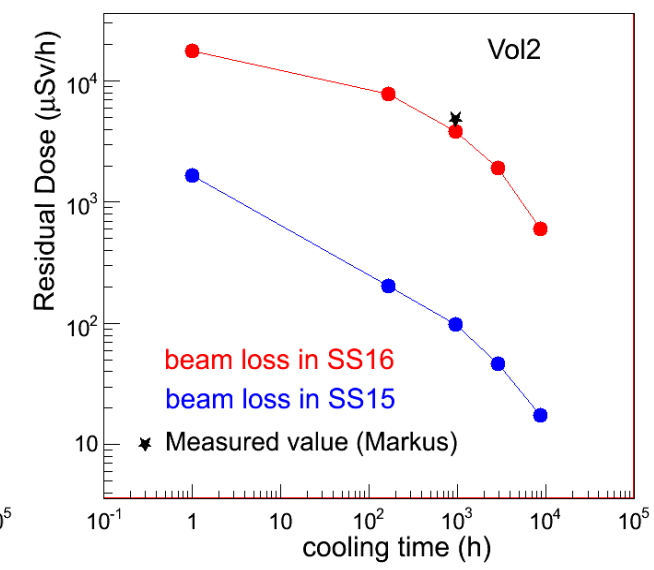
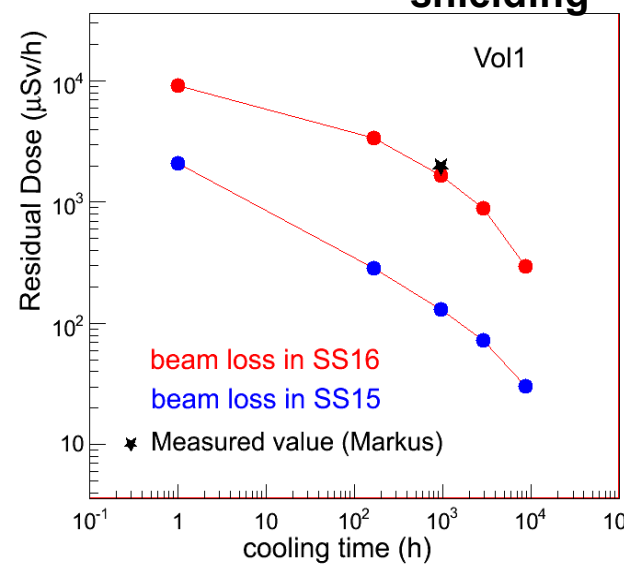
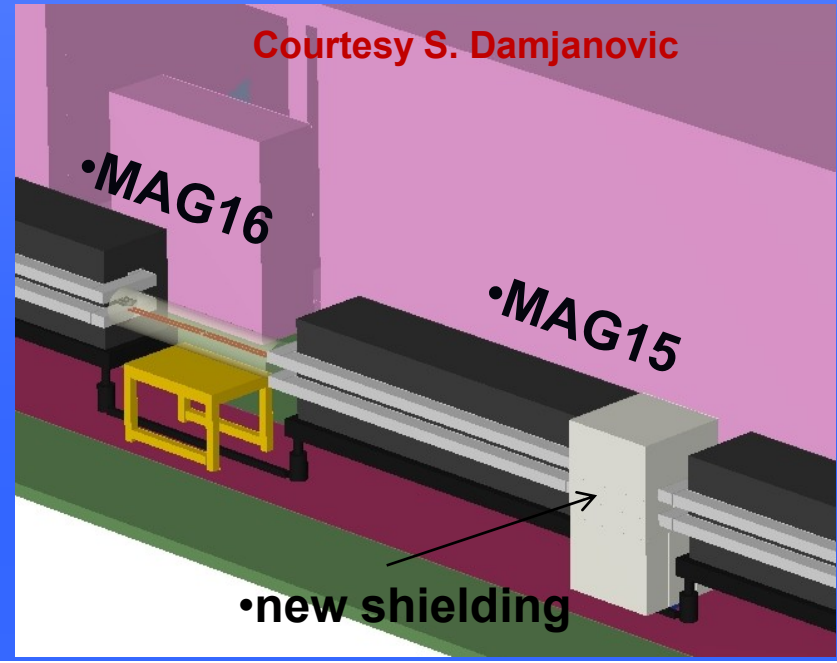
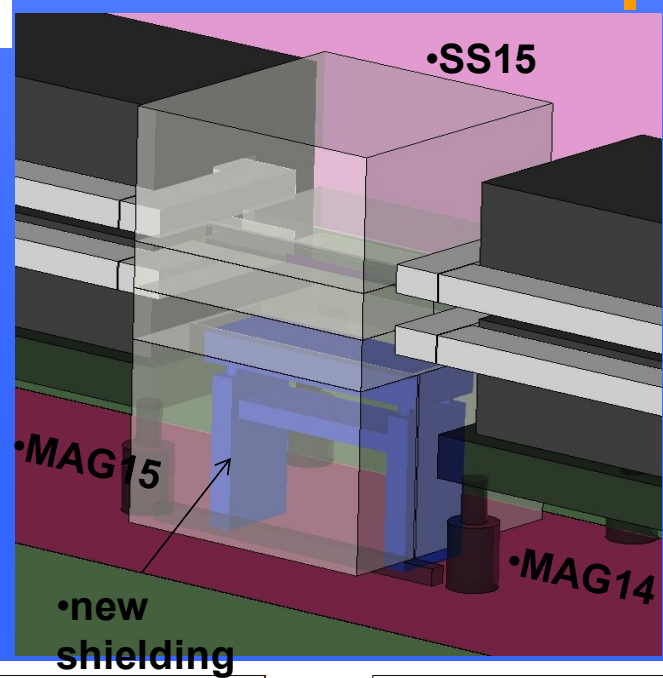


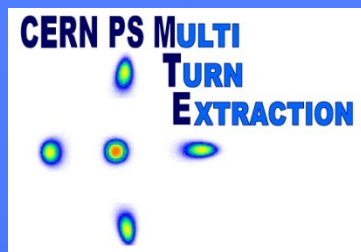
Courtesy M. Newman





Mitigation measures: activation of septum 16 - I





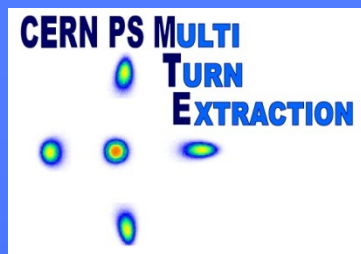
Mitigation measures: activation of septum 16 - II

❶ Dummy septum

- ❶ In principle, it provides a reduction acceptable for RP.
- ❶ Improvement of the radiation released outside the tunnel due to the corridor in front of the tunnel
- ❶ Linac3 radiation field to be revised
- ❶ Relocation of DHZ15 and gamma-jump quadrupole to be studied.
- ❶ It can be installed only during LS1.

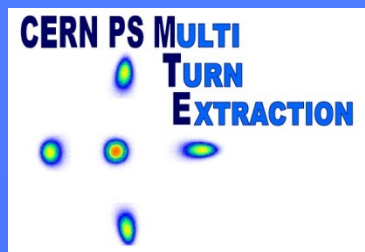
❷ New extraction scheme using SEH31

- ❶ Re-use the electrostatic septum and the BFAs.
- ❶ Principle: paper study in progress.
- ❶ Hardware: HV cable connection improved to allow quick polarity change (about 1 hour tunnel intervention, only).
- ❶ The CT elements remain untouched: always possible to use the CT during the new extraction tests.



Current status of new extraction tests

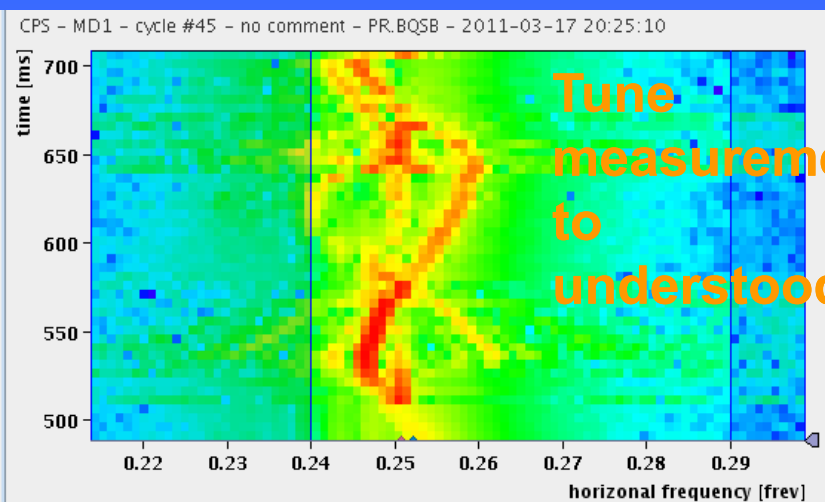
- ❑ First tests non-conclusive: losses indicates the beam jumps beyond the septum jumped.
- ❑ The kick of the septum is not visible on the trajectory downstream of the septum
- ❑ Kick imparted by KFA21+BFA21 is larger than 10 mm as required, but the beam is even larger
- ❑ Tests to be repeated soon with a smaller beam and after verification of trajectory measurements.
- ❑ **Issues:**
 - ❑ RF tree to be re-built after first week of test. Corrupted by a non-clear reason
 - ❑ Doubt about the measured orbit



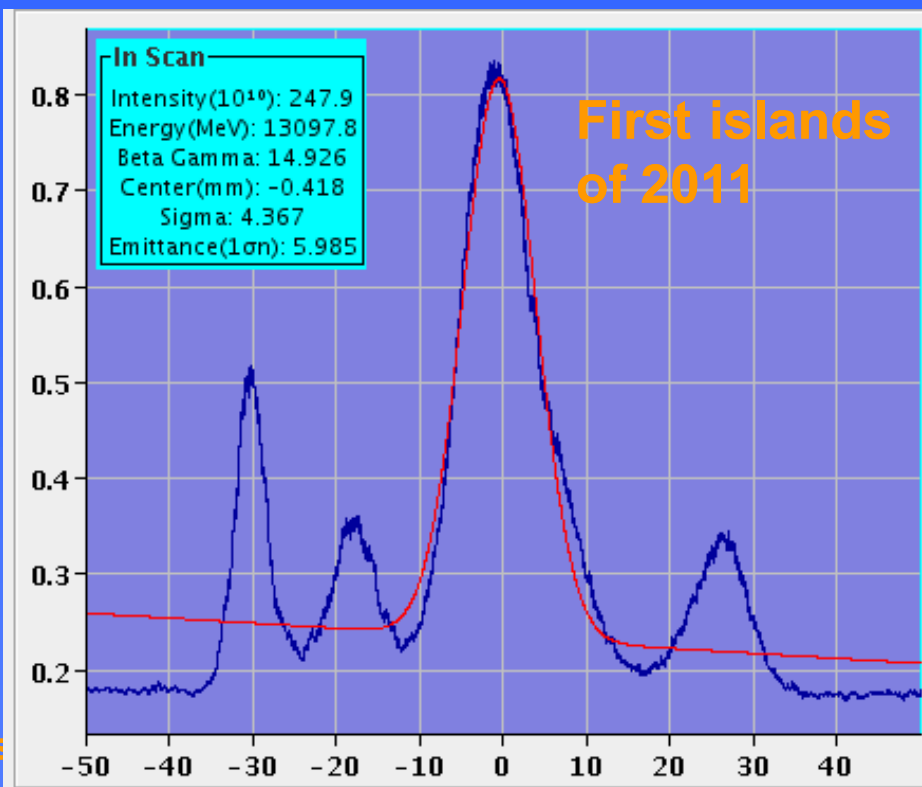
Fluctuations - I

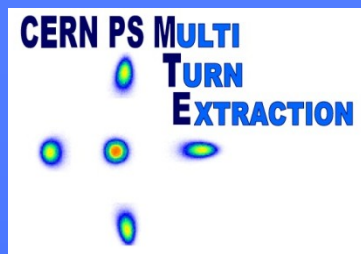
Some key tests to perform

- Correlation with B-field fluctuations. This tests was already performed in 2010 and gave no correlation. However, during winter technical stop it turned out that the ADC used for the measurement had a Firmware issue!
- Perform trapping tests with POPS to compare performance with last year.



C Works





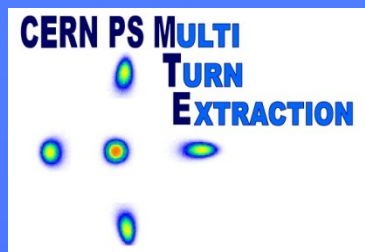
Fluctuations - II

● Capture

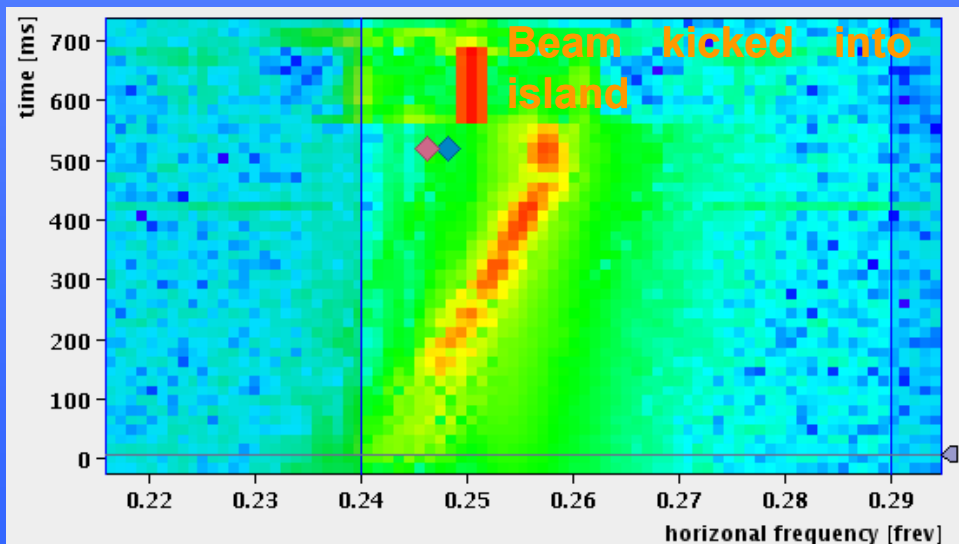
- Capture set-up on 2 BP cycle
- Capture efficiency at 12-13 % without non-linear coupling correction

● Issues:

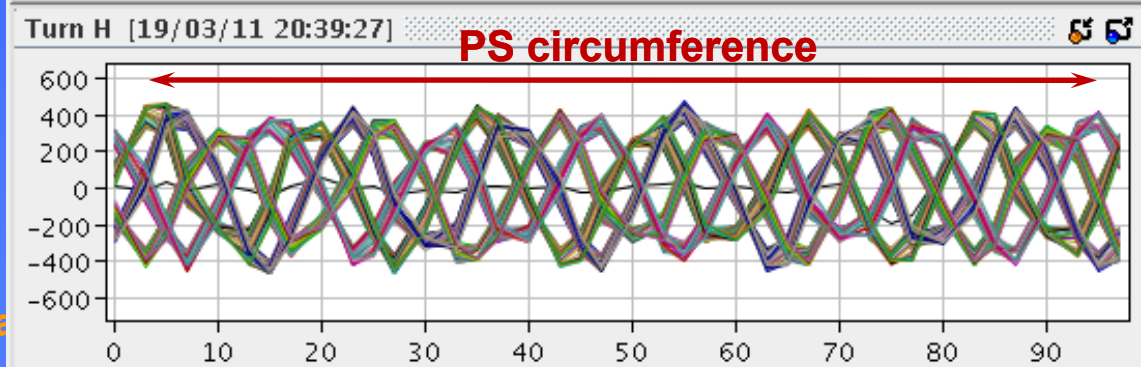
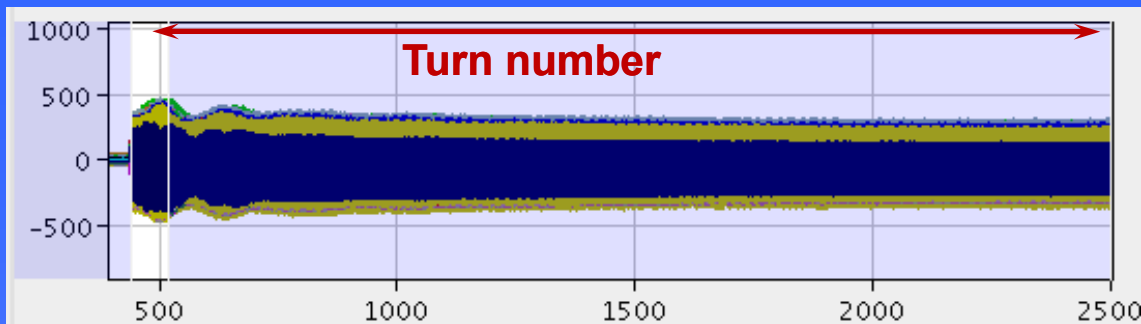
- Setting-up delayed by difficulty in setting up a completely new cycle in INCA.
- Tune measurement not fully available due to noise (affects all the beams).
- Not clear if the noise seen on the tune affects the capture.

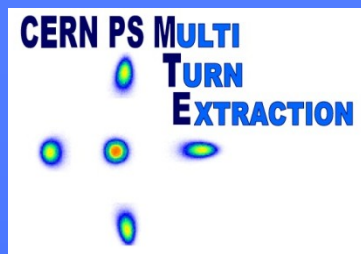


Trajectory fluctuations



- Analysis of data taken last year in progress.
- Study with beam the closure of the slow and fast bumps (for the islands) started.





Situation of resources

● Beam dynamics studies:

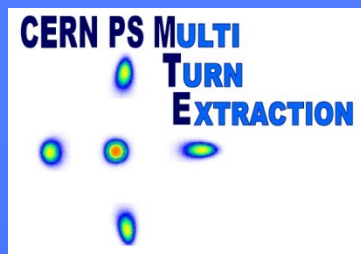
- extremely small group of people (recently new people joined the team). Barely sufficient for this year, probably insufficient by the end of the year.

● PS activities:

- we rely heavily on OP for setting up (this year for the new extraction studies) and systematic data taking.
- Instrumentation and controls: we normally stress the systems and act as guinea pig. We need support beyond what is needed for standard operation.

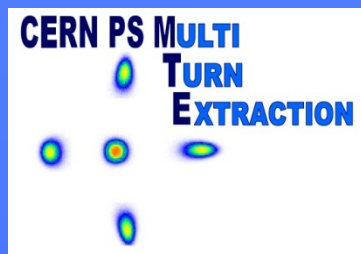
● SPS activities:

- we depend critically on OP for pushing the setting up and the studies at the SPS (main conclusions of the MTE Workshop in September 2010)



Schedule: studies in 2011

- **Initially mainly focus on the PS to**
 - Pursue studies for new extraction scheme
 - Tests closure of slow bump and stability of extraction conditions.
 - Additional tests on trapping (correlation with energy fluctuations, POPS, etc.)
 - We should aim at drawing conclusions on new extraction/dummy septum by June/July this year.
- **Then resume SPS injection to study**
 - Injection (trajectory, optics)
 - Overall performance



Future: some scenarios

● The new scheme with SEH31 works

- We could aim at putting in operation MTE (after the list of additional studies to be performed).
- Would the dummy septum still be needed?
- Analysis of how to proceed with CT elements to be recuperated for MTE (SEH31, BFAs).
- Answer to the previous two points would provide input for the activities for LS1.

● The new scheme with SEH31 does not work

- We could aim at delivering at most a couple of cycles to SPS with MTE before LS1.
- Activities during LS1 would be linked to installation of dummy septum, always keeping CT alive for the start-up after LS1.