Studies on slow extraction losses in LSS2

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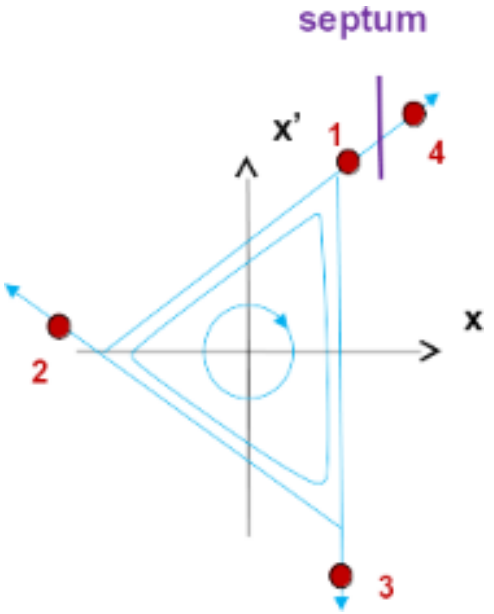
V. Kain, F.M. Velotti, C. Wiesner

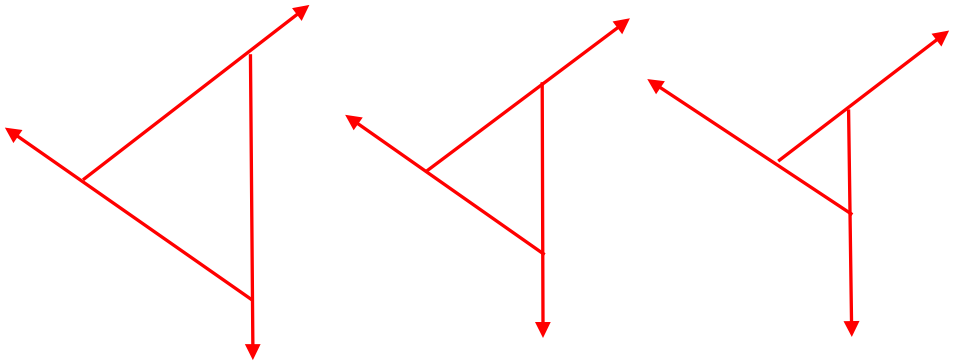
Outlook

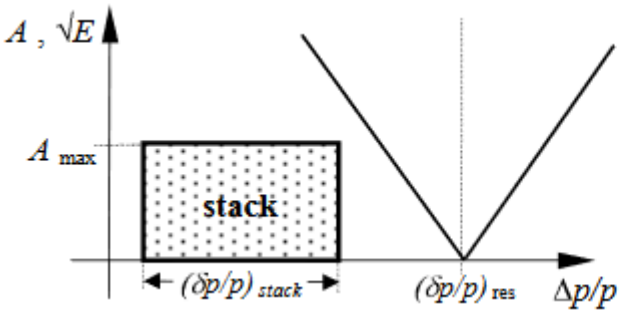
- Slow extraction
- Loss problem + solution
- Simulations and future MDs

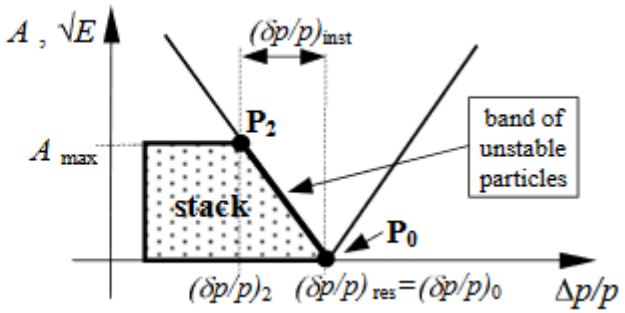
Slow extraction



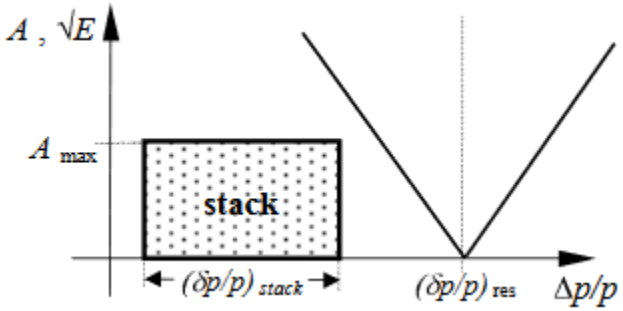
$|Q_1-Q_{res}| > |Q_2-Q_{res}| > |Q_3-Q_{res}|$

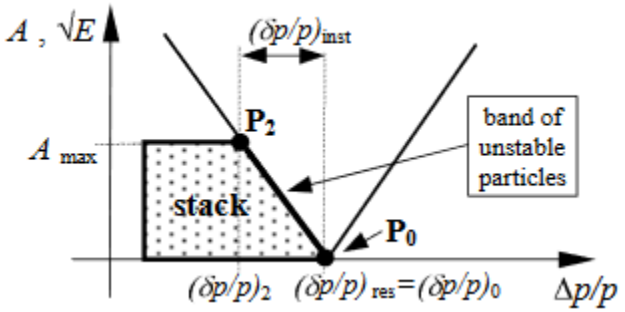


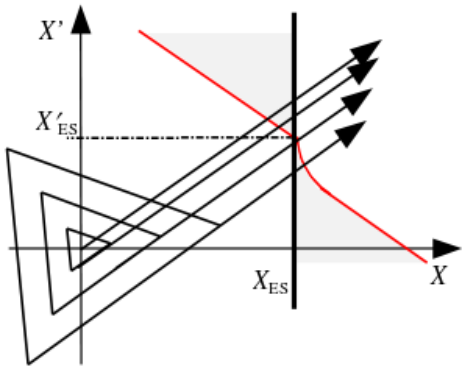


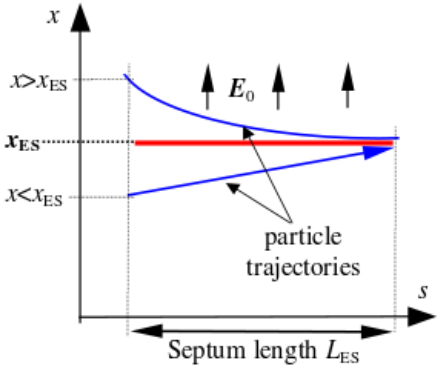


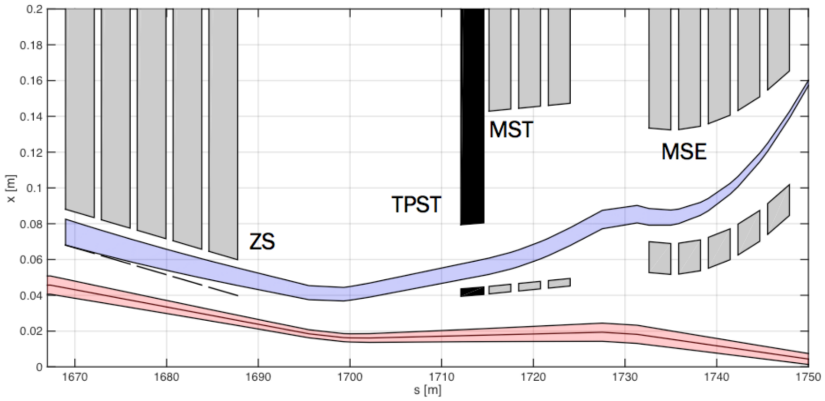
Slow extraction







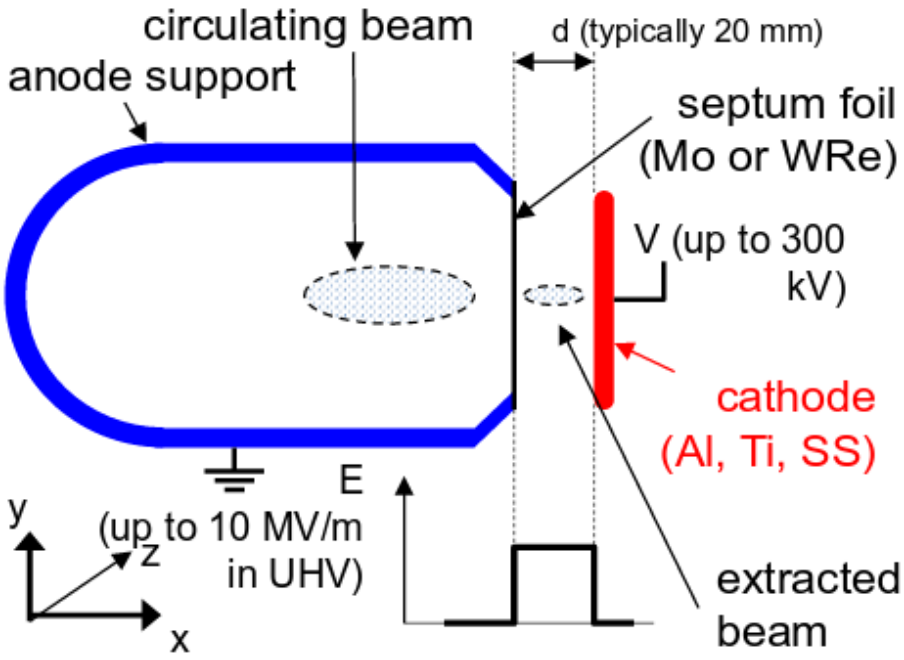




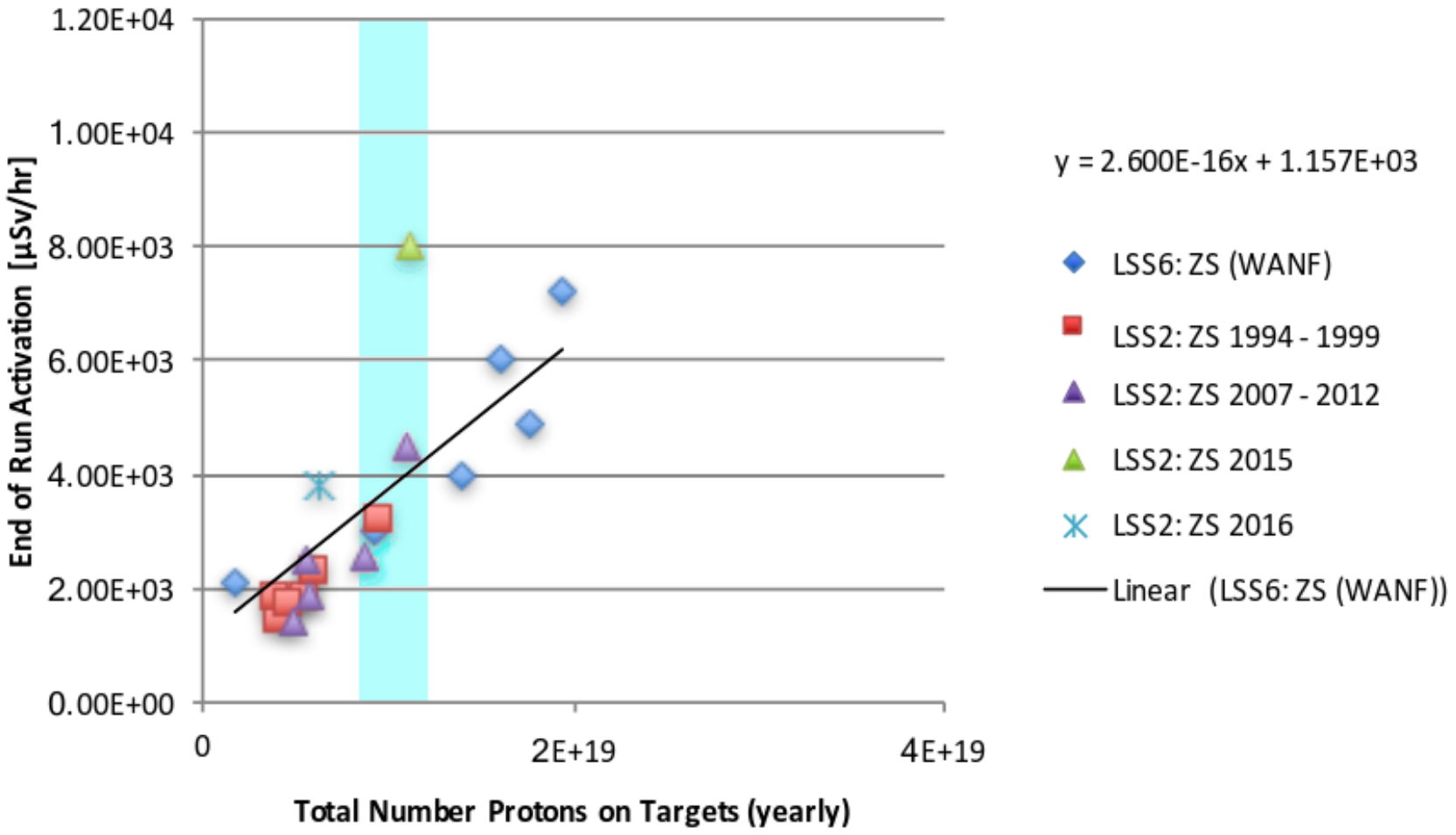
*Momentum extraction is nominal, but amplitude extraction was recently tested in MD

ZS alignment

- 5 tanks each 3.13 m long, wires of 60 or 100 µm
- Change position of each upstream/downstream end of the anodes and optimize on BLM signal



LSS2 activation – 30h



LS2 activation

2015:

- Highest extracted yearly flux in years
- End of year RP survey showed very hot ZS

⇒ Formation of SPS Losses and Activation WG, keep losses/activation in check, reduce for Beam Dump Facility operation

2016:

- Losses kept under control, several ZS re-alignments throughout the year
- ZS less activated at end of year
- … but TPST significantly more activated

SEXTANT 2 - Comparaison Novembre 2016 - Novembre 2015

Survey 30 heures de décroissance

Dose rate Novembre 2015

Dose rate Novembre 2016

TPST 21759
12.6mSv/h
19.9mSv/h

7.98mSv/h
3.83mSv/h
Poutre ZS 216

QFA 21810

MSE 218
1.02mSv/h
0.91mSv/h

23101

??? 214-215

Dose rate (uSv/h)

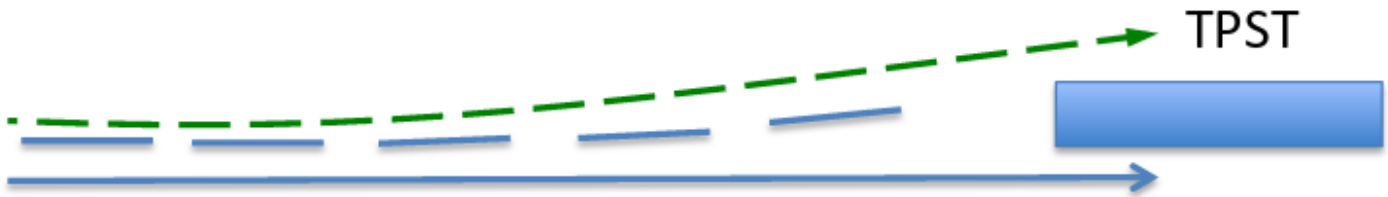
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
1.E-01
1.E-02

200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236

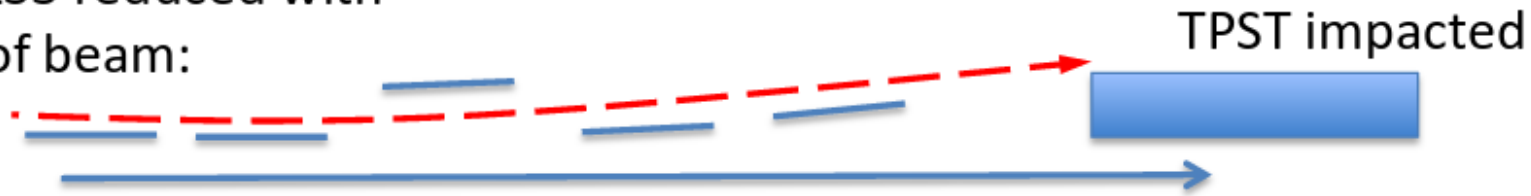
Position in Sextant

Courtesy N. Conan

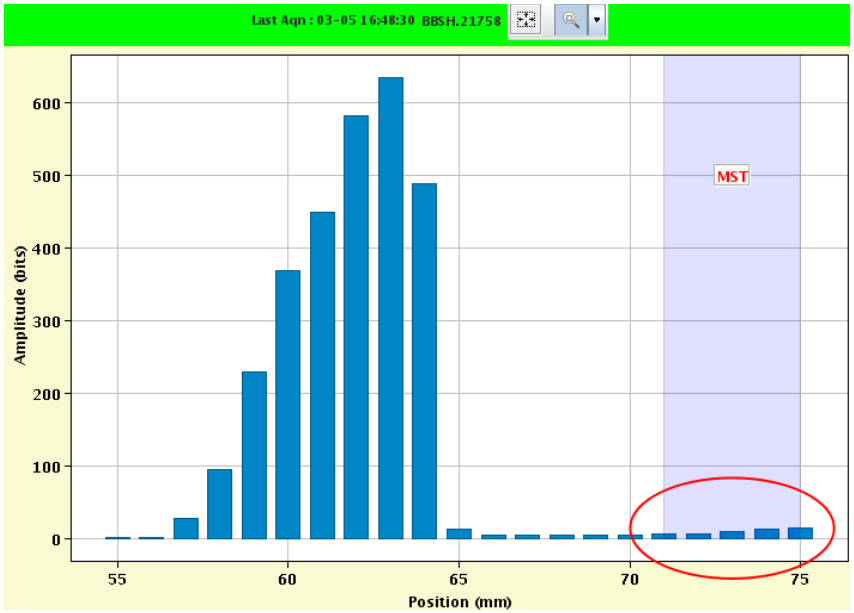
TPST losses



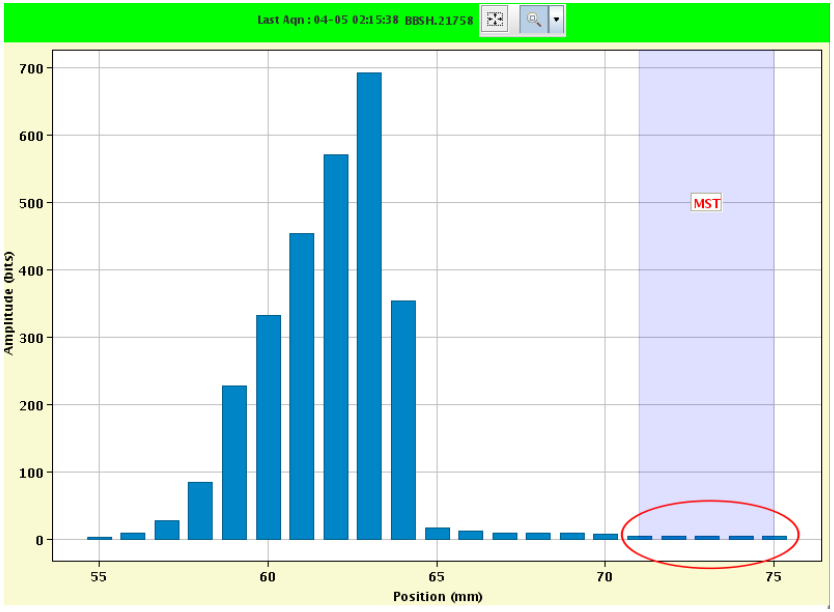
losses on e.g. ZS3 reduced with lower density of beam:



TPST losses



May 3rd, 16:48

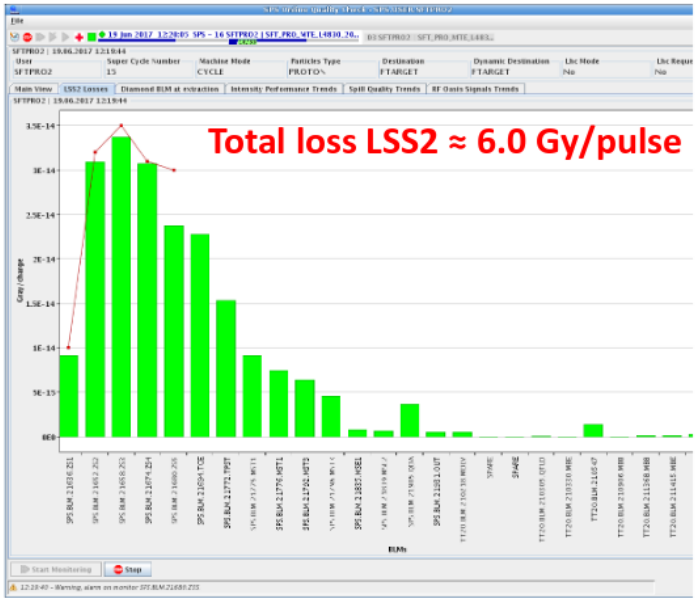


May 4th, 02:15

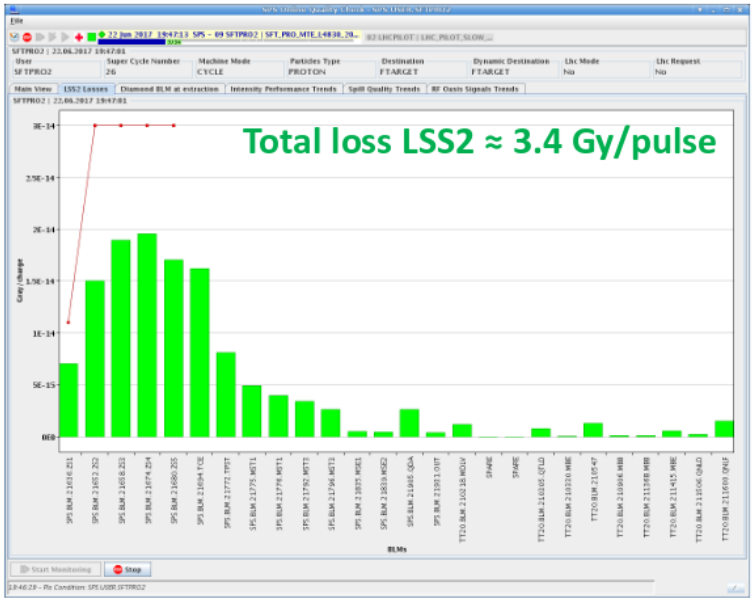
Normalized losses

- Figure of merit: losses per extracted proton [Gy/p+]
- Last few years worse than before LS1, particularly bad in the weekend of June 18th.

18th June 2017
Extracted p+ flux: 3E13 ppp



22th June 2017
Extracted p+ flux: 3E13 ppp

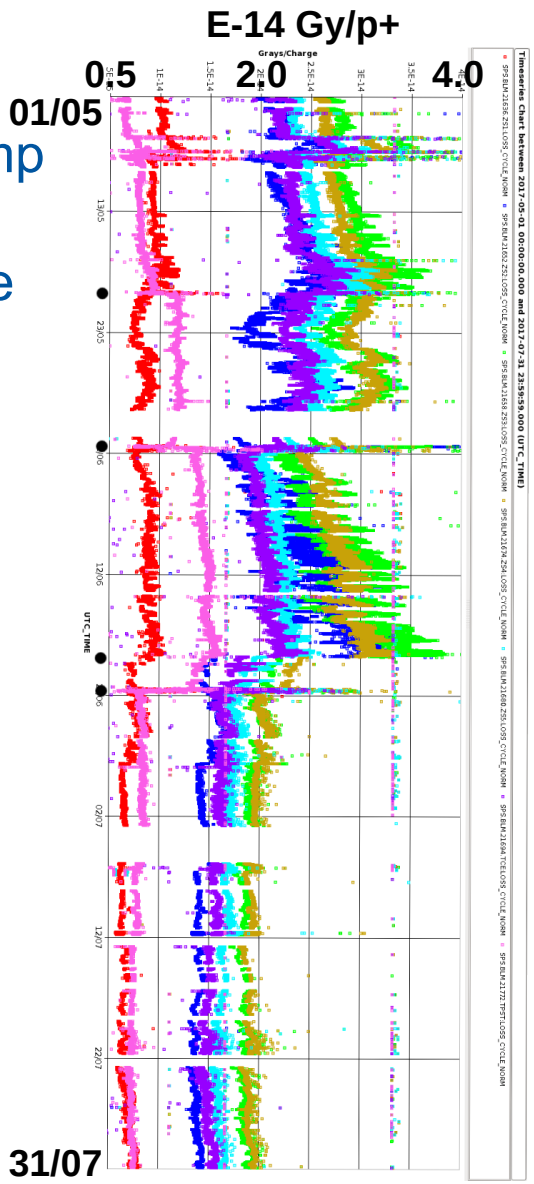


Normalized losses

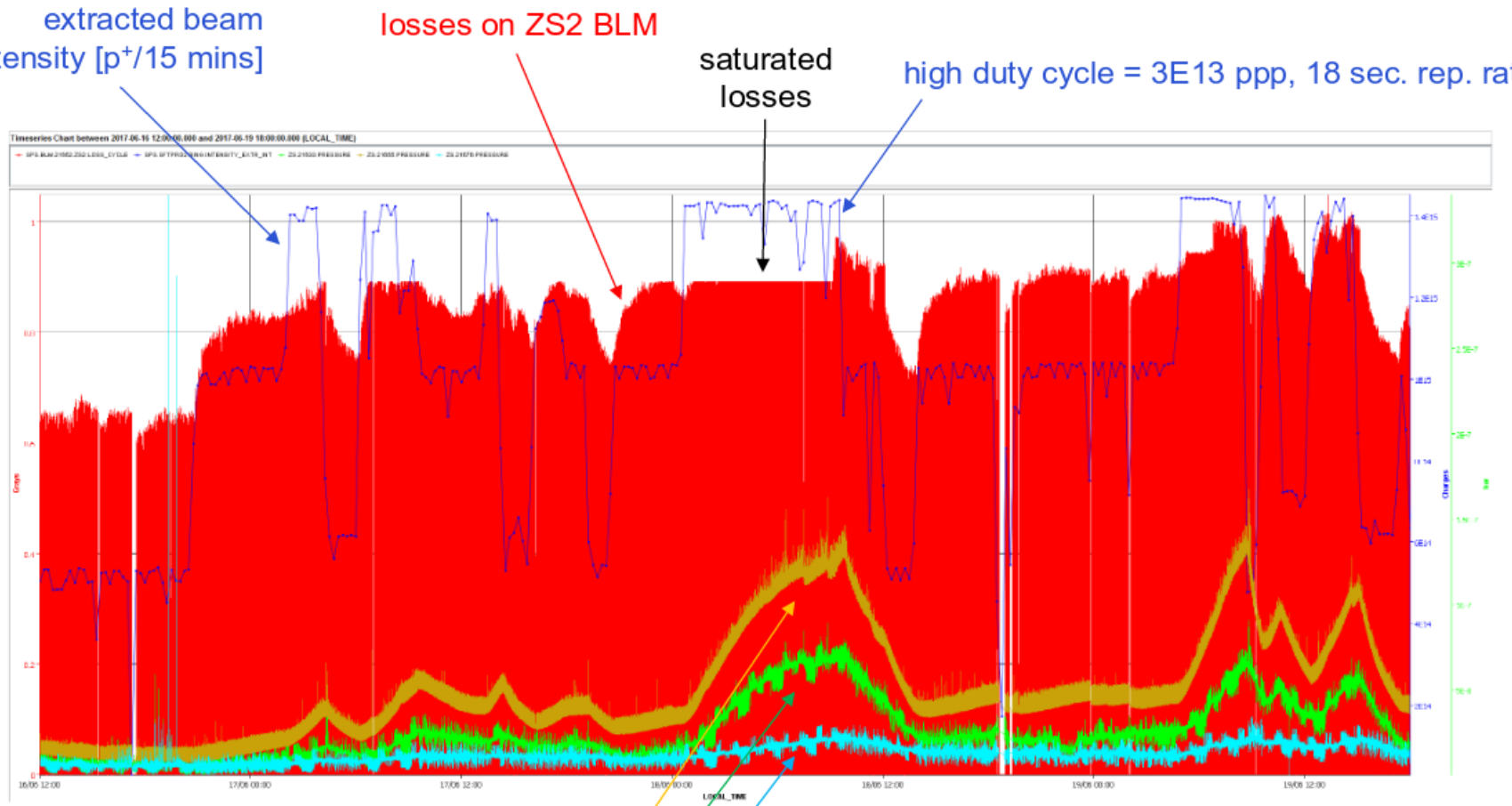
Early May: alignment, losses worsen with intensity ramp

May 20th: realign, had to increase TPST loss to be able to lower the ZS loss
June 2nd: realign, increase the TPST even more, to lower ZS, still neither was 'good'

June 18th: losses get really bad at high duty cycle
(Not related to magnetic cycle!)



ZS2 problems: weekend of 17-18 June 2017



*High spark activity also detected on ZS tank 2

Normalized losses

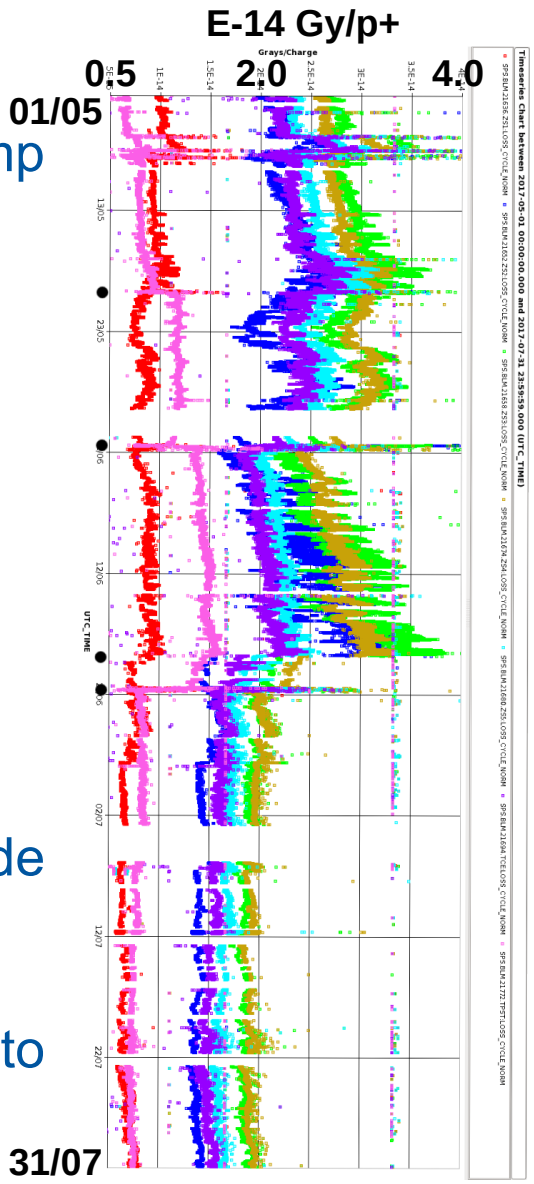
Early May: alignment, losses worsen with intensity ramp

May 20th: realign, try to keep TPST low, but sacrifice a bit to lower the ZS
June 2nd: realign, sacrifice more on the TPST, to lower ZS, still not good

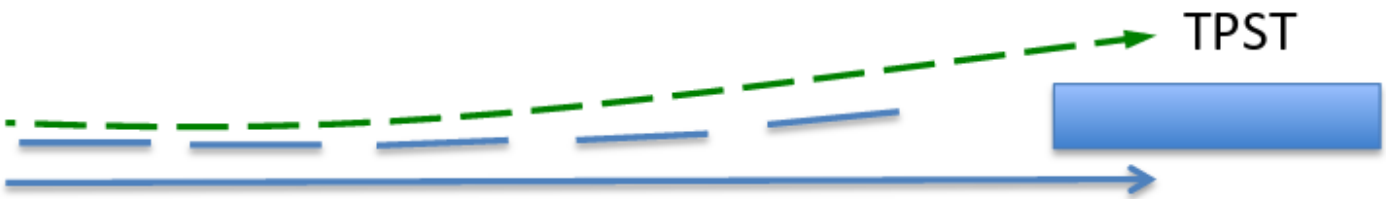
June 18th: losses get really bad at high duty cycle
June 19th: **retract ZS2 cathode by 2mm**
June 22nd: realign, TPST loss back down

Following weeks: Some quick MDs changing anode gaps and voltage → further improvement

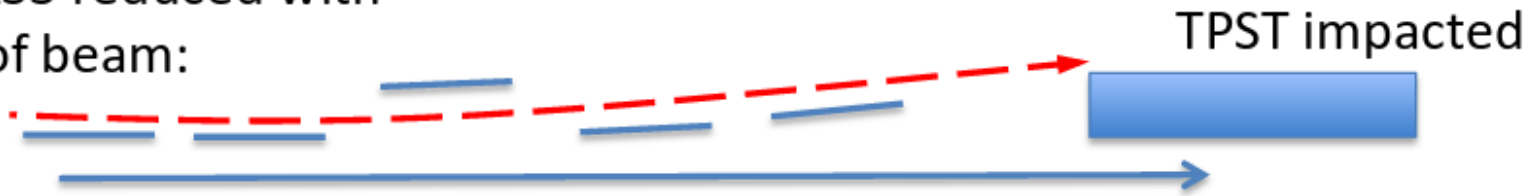
Now: nominal voltage, changed gap sizes, back to expected normalized losses and stable!



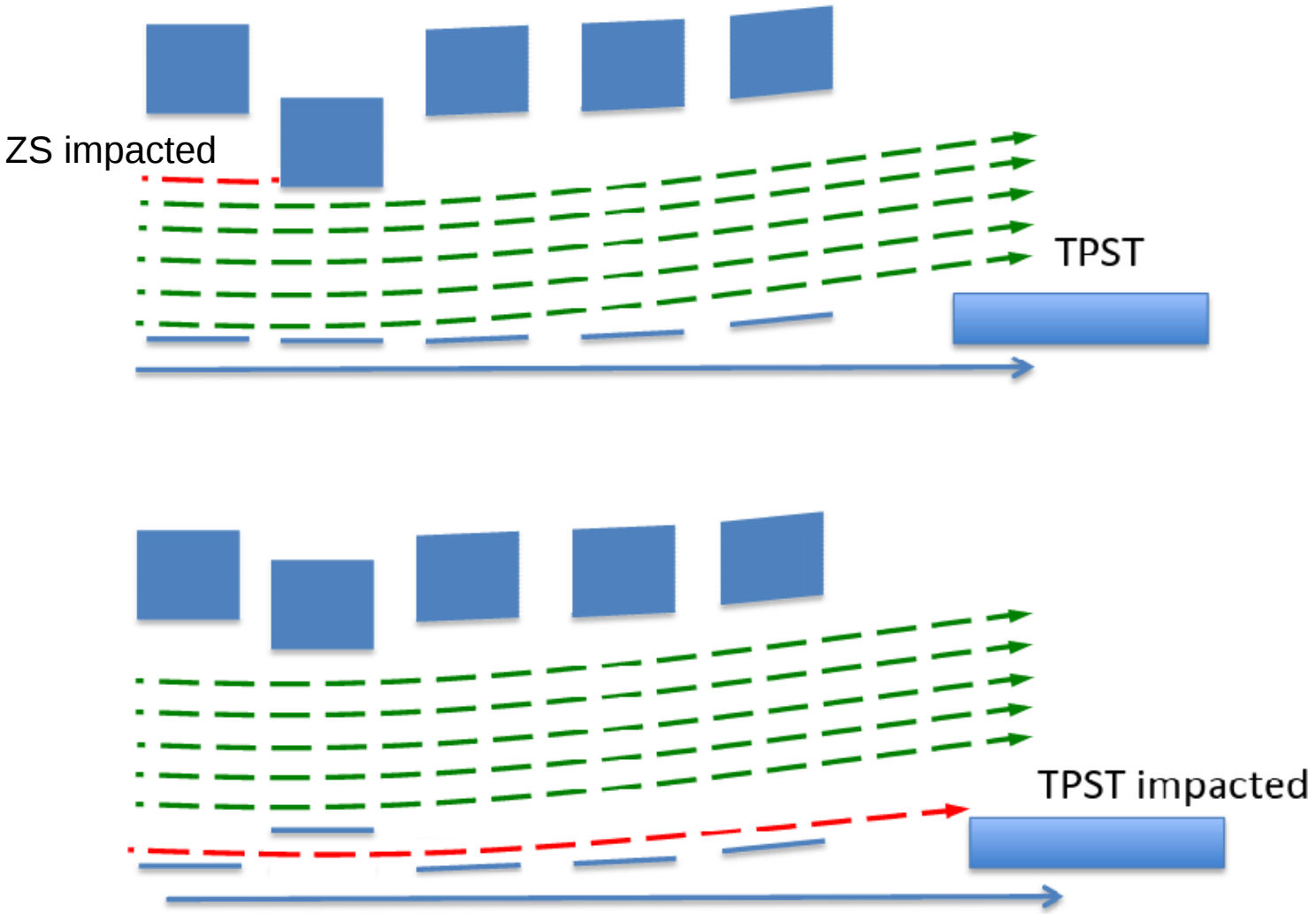
TPST losses



losses on e.g. ZS3 reduced with lower density of beam:

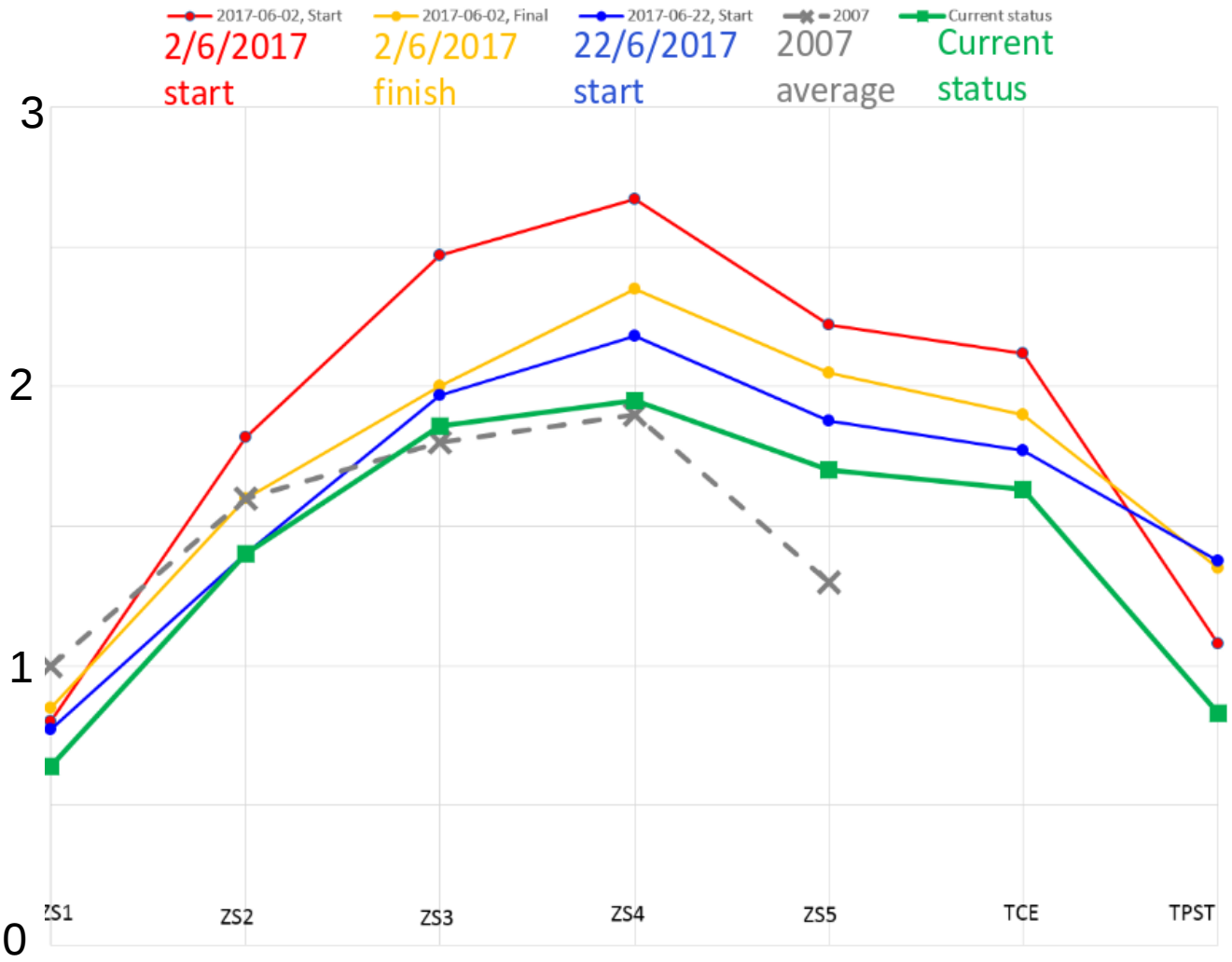


TPST losses



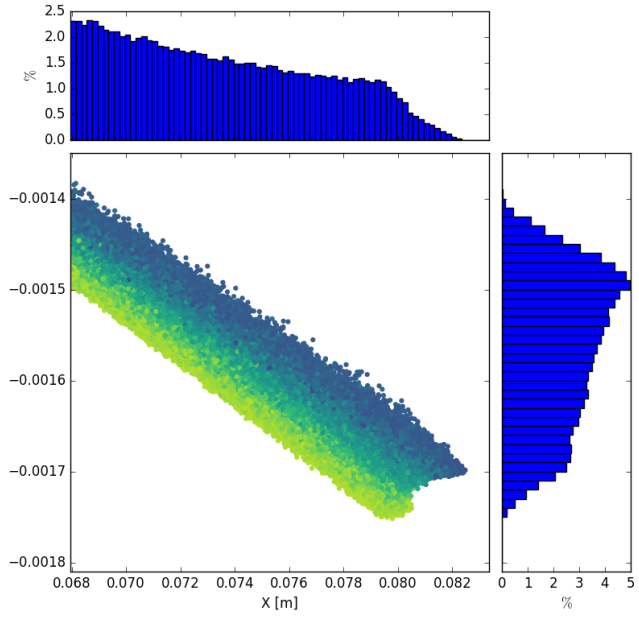
ZS losses

E-14 Gy/p+



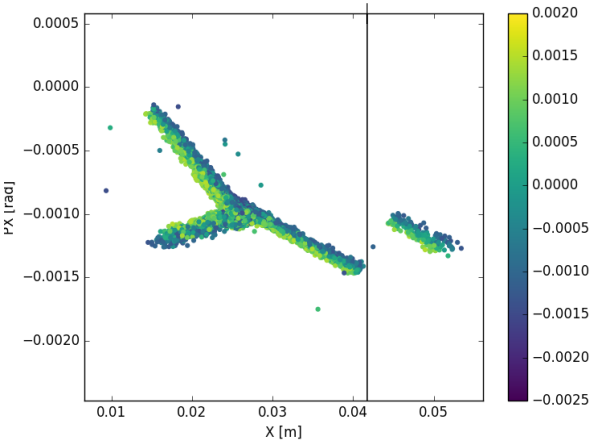
Simulations

- Slow extraction over many turns with changing optics in MAD-X thin track with pycollimate (scattering routine by F.M. Velotti, SPS OP)



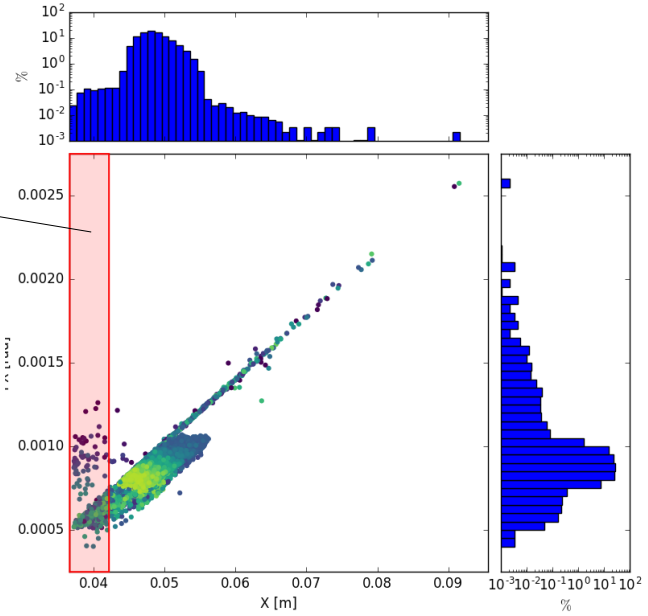
ZS entrance extraction aperture (no scattering)

ZS wire



ZS exit

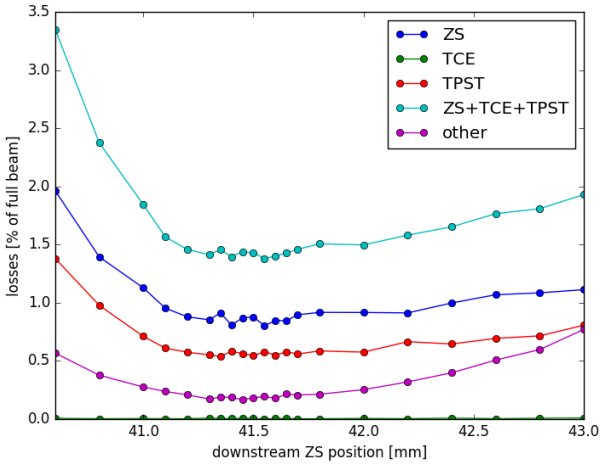
TPST blade

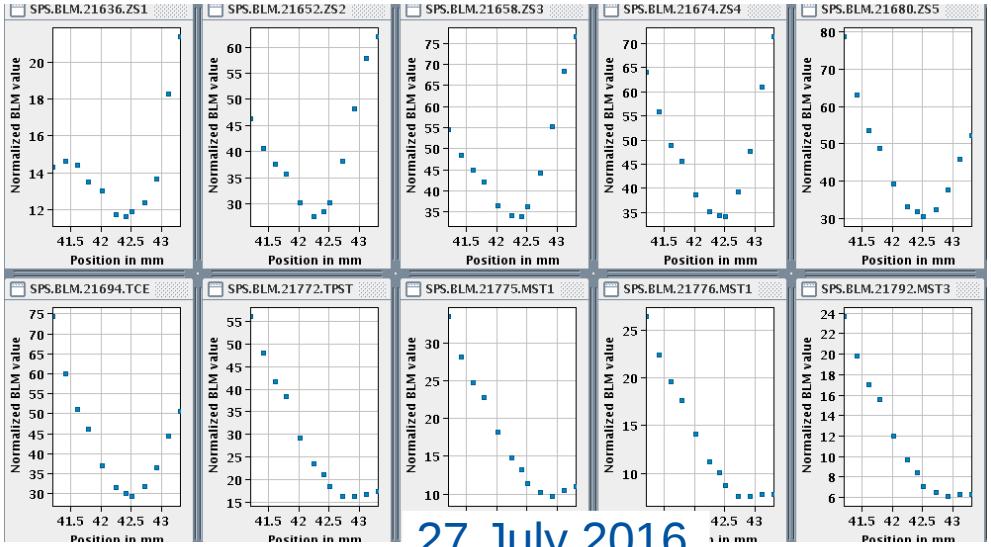


TPST extraction aperture

Simulations – Girder scan

- Upstream position fixed, scan downstream position to optimize girder angle
- Assume perfect alignment of the anodes: model 1 long septum blade with 200 µm effective width and correct total density
- Primary loss + scattering, but no showers/BLMs
- Collaborating with EN-STI and RP to create FLUKA model of LSS2

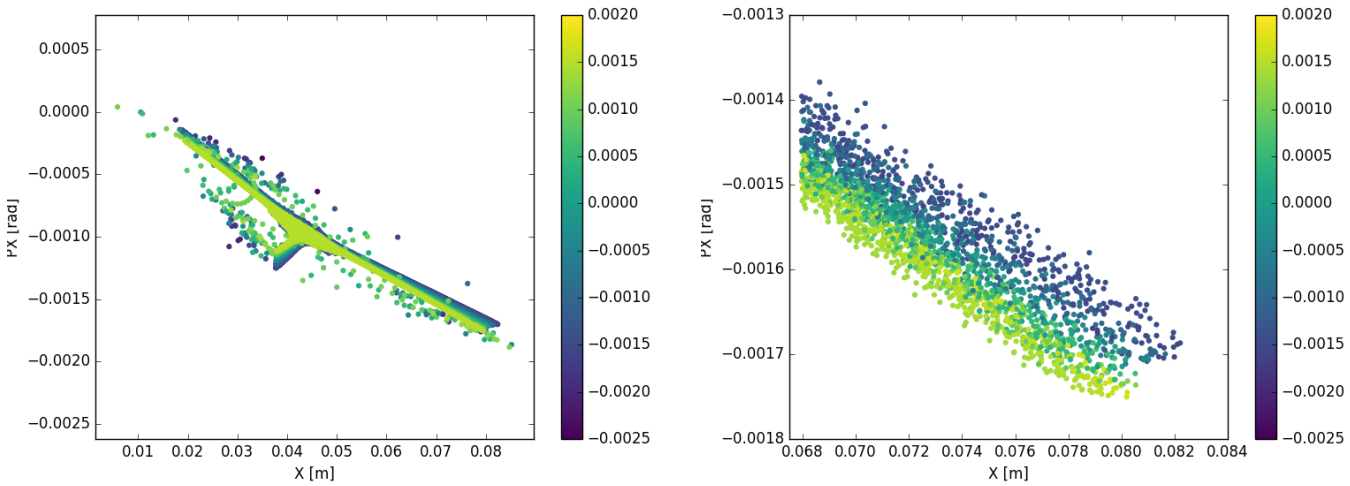




27 July 2016

Future MDs – Dynamic bump

- Slowly changing x and x' bumps to counteract movement of the beam throughout the spill (dispersion, changing optics)
- Document for MPP approval of first tests of the bumps is being prepared



Nominal

Future MDs – Dynamic bump

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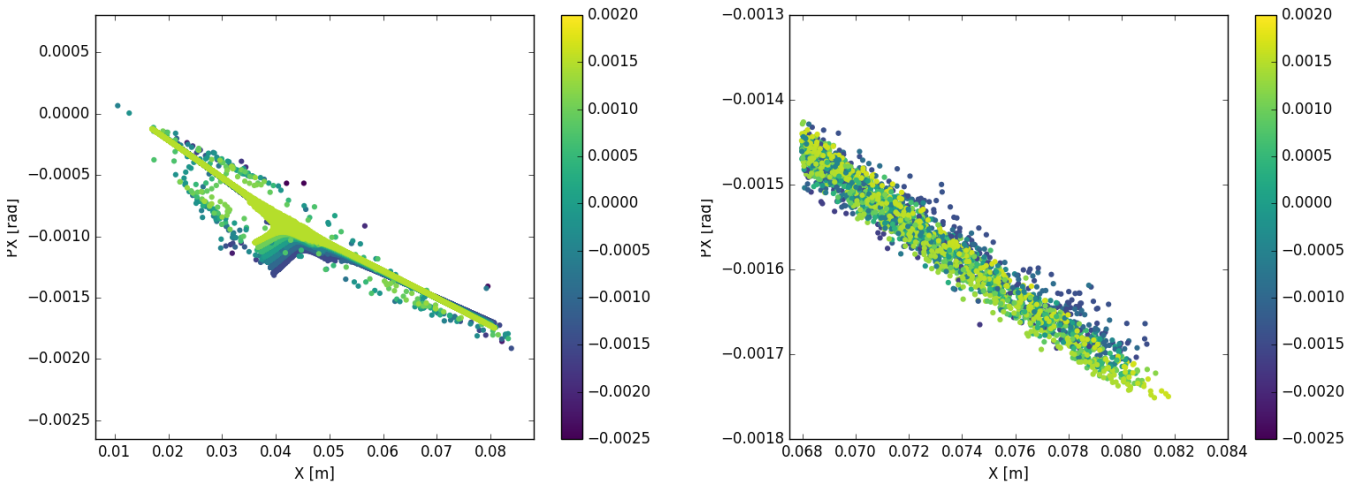
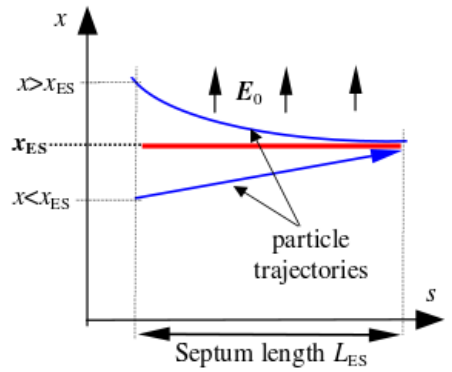
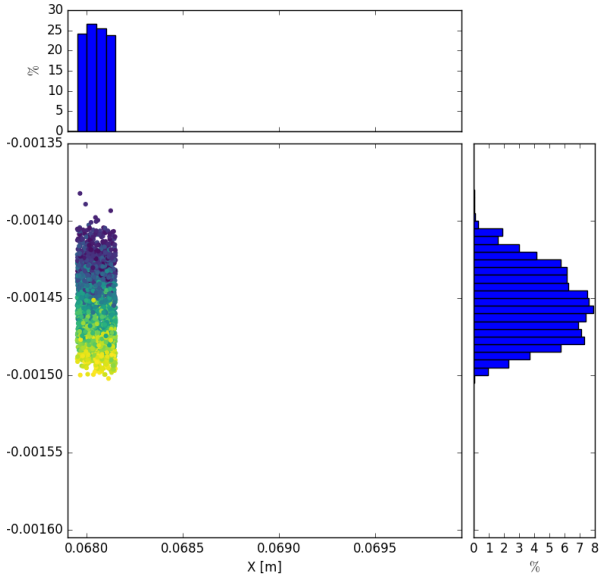


Dynamic bump

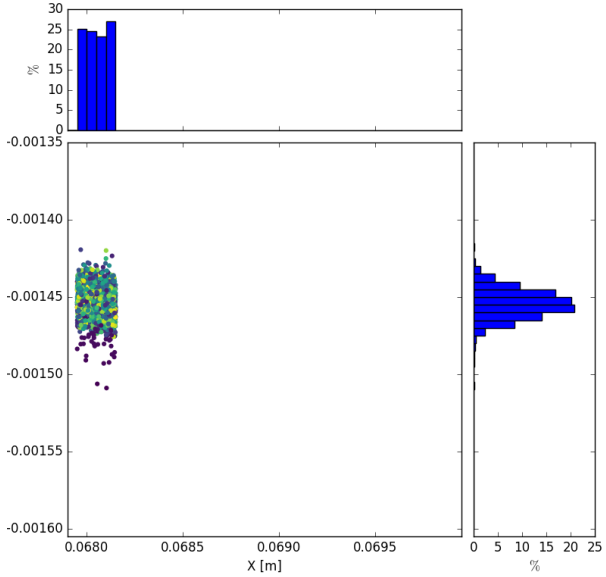
Future MDs – Dynamic bump

- Angular spread influences losses, so correct change in angle during the spill





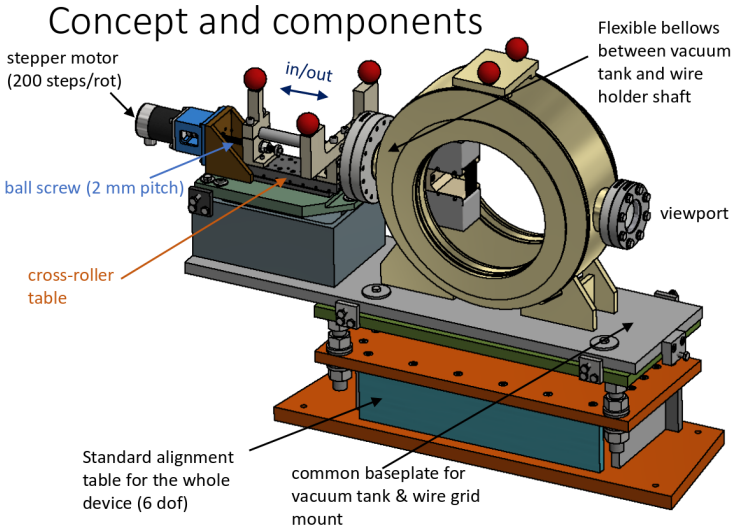
σ = 22.1 μrad

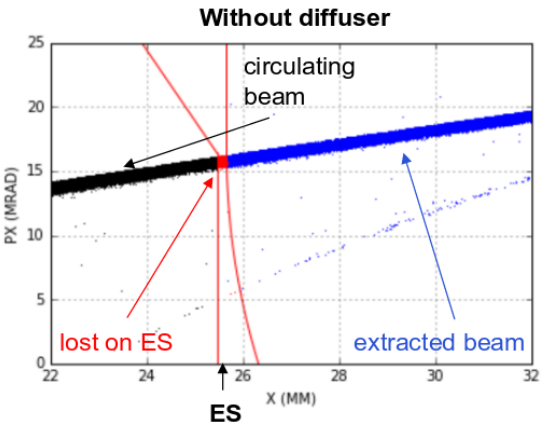


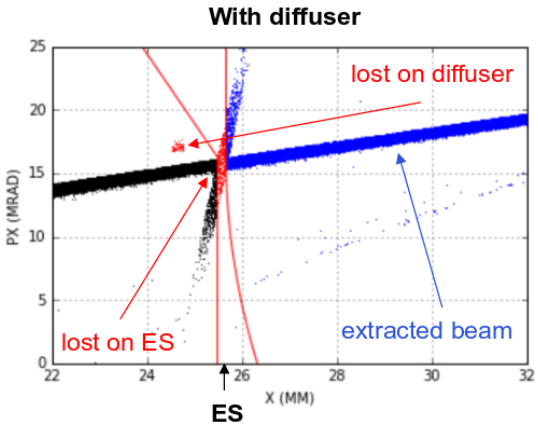
σ = 9.4 μrad

Future MDs - Diffuser

- Short wire array upstream of the ZS to 'cut' (scatter) the beam, alignment procedure like ZS
- Construction starting soon at Wigner institute
- Aiming for installation in YETS, MDs in 2018







Courtesy D. Barna

Future MDs - Diffuser

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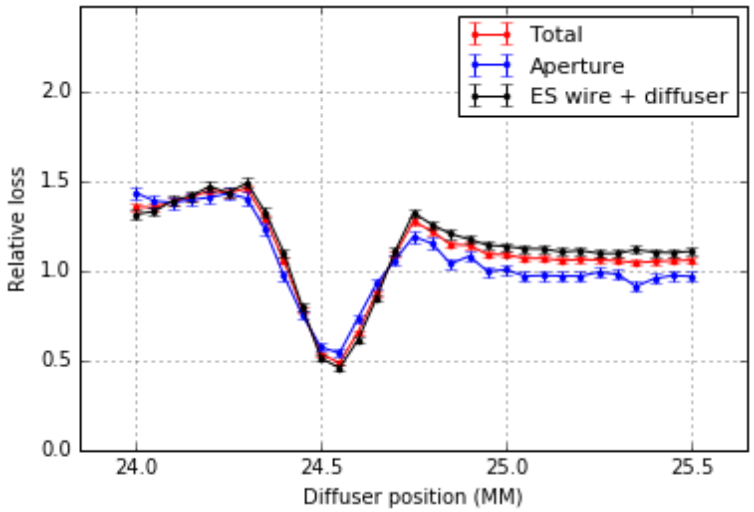
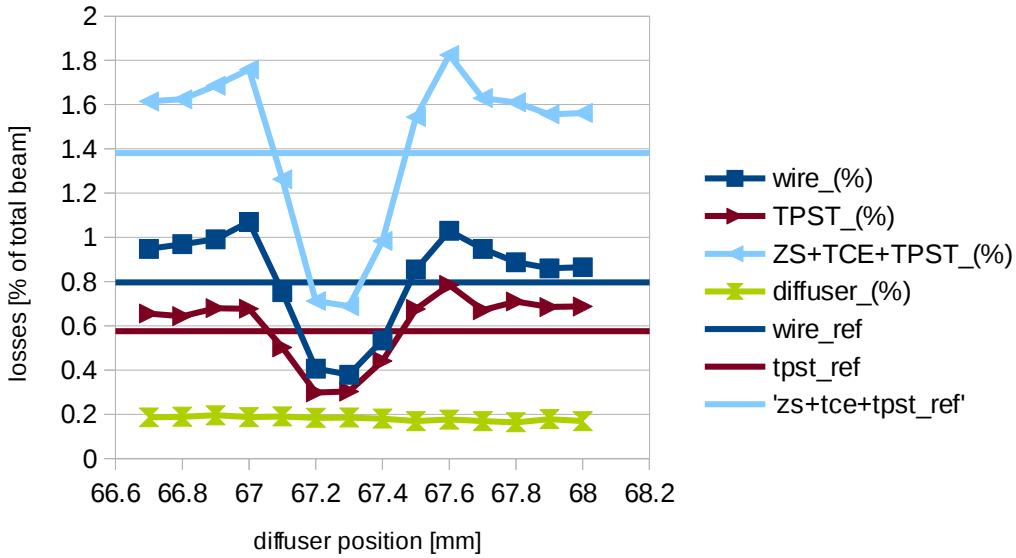




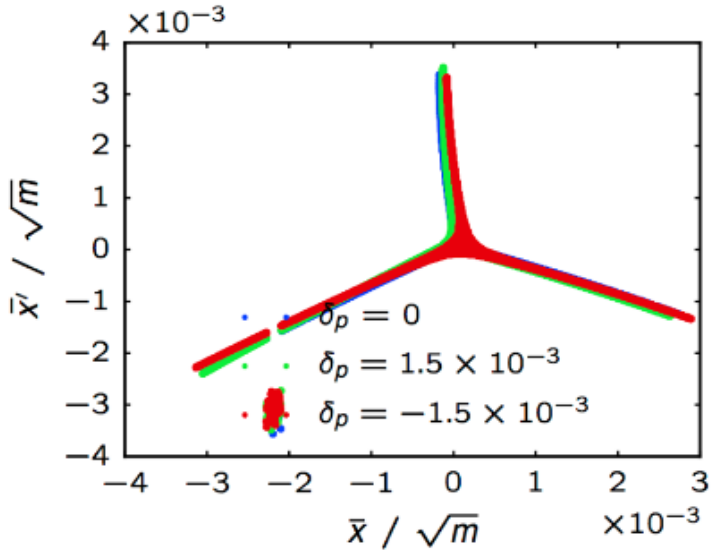
Preliminary results, changes to code in progress

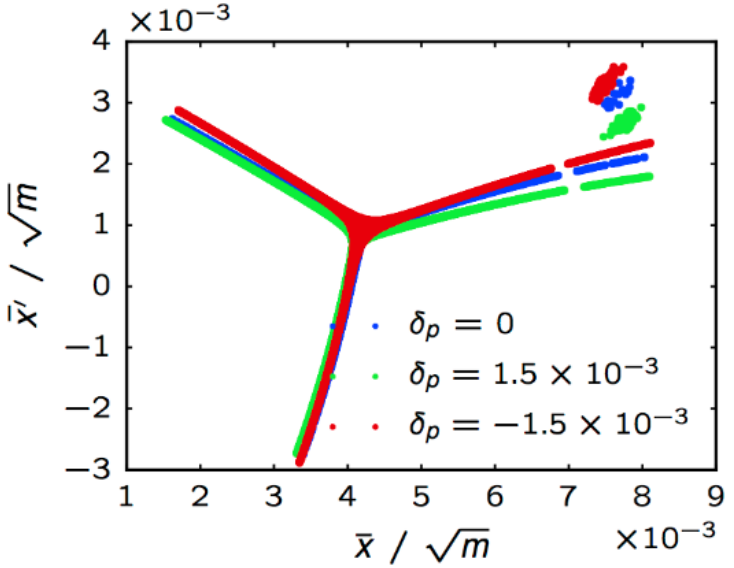
Conclusion

- LSS2 losses finally back to what they used to be
- Losses need to be much lower for Beam Dump Facility (~ x4)
- MDs will test future loss mitigation proposals, but also benefit current operation
  - Dynamic bump
  - Diffuser
  - Crystal 'shadowing'
  - Collimating scattered particles
  - Multipoles
  - ...

Crystal assisted slow extraction

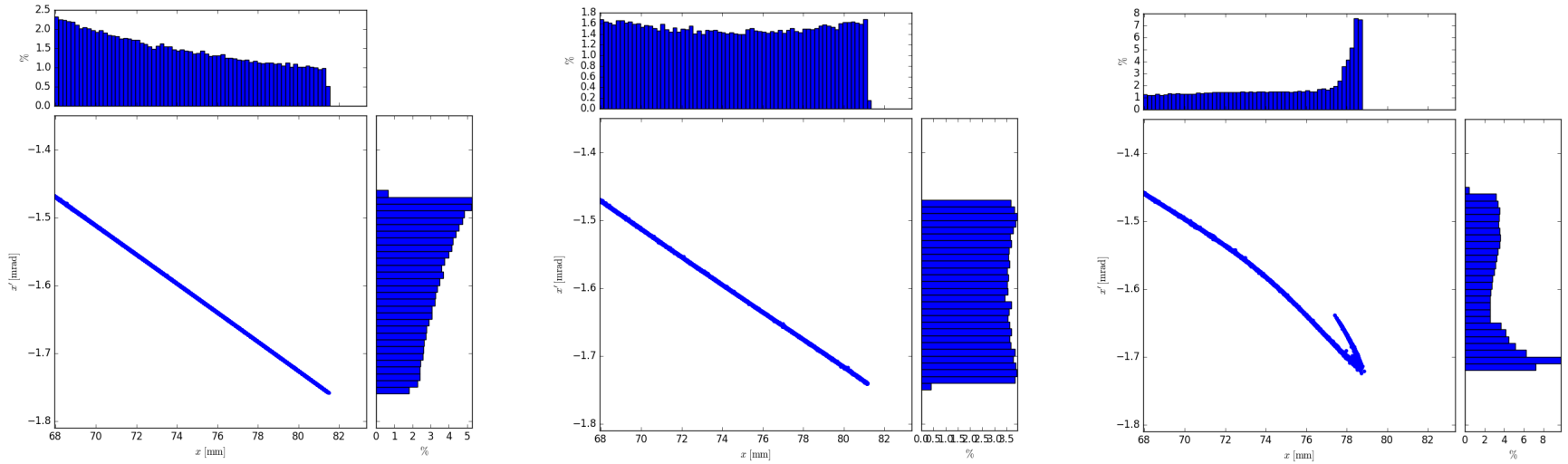
- Crystal channels particles that would end up hitting the septum, so that they reach the extraction channel: “shadowing”.





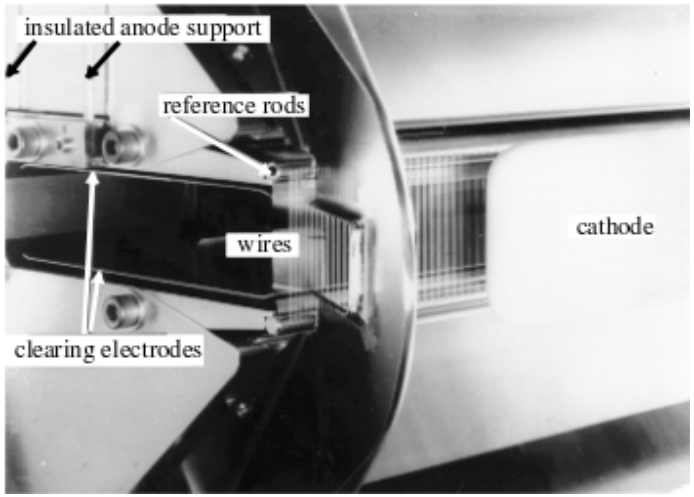
Phase-space folding

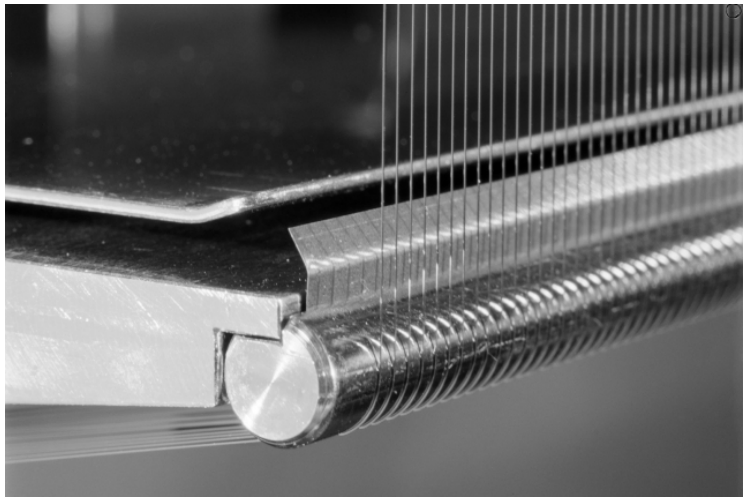
- Use multipoles to change beam density
- Decapoles in SPS (IPAC'17)



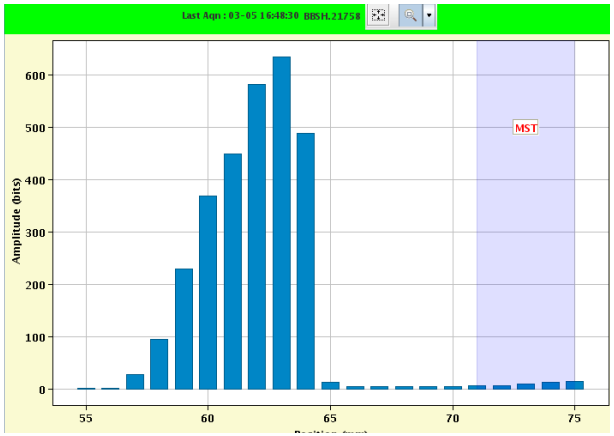
- Machine Development studies with octupoles?

ZS tanks and wires





TPST losses



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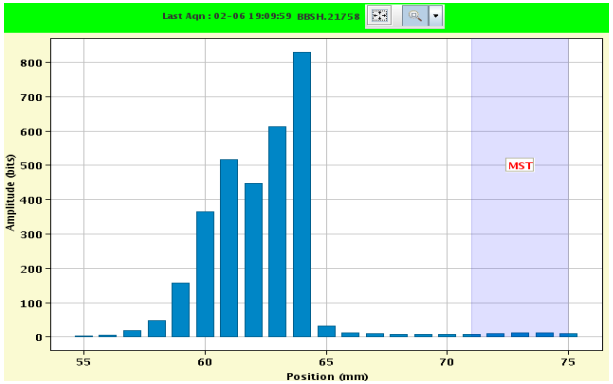
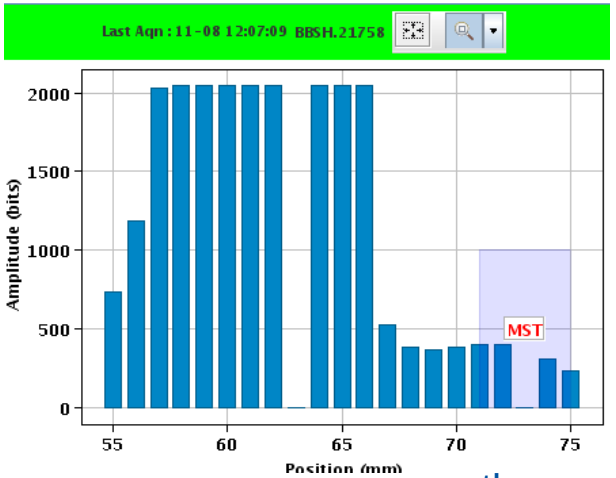
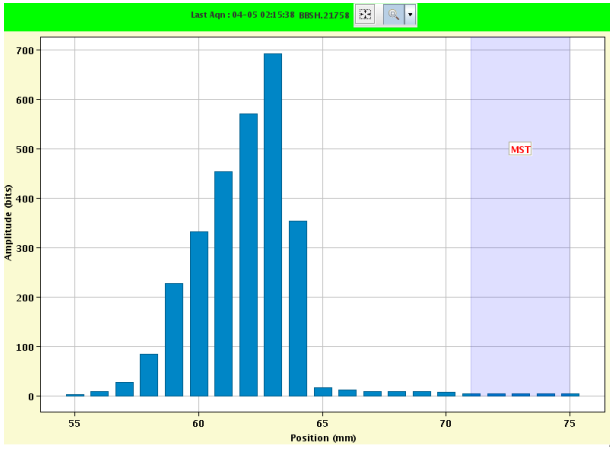


June 2nd



August 11th



May 4th, 02:15