

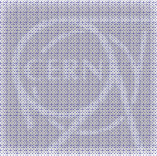
Extraction Studies with CNGS Beam

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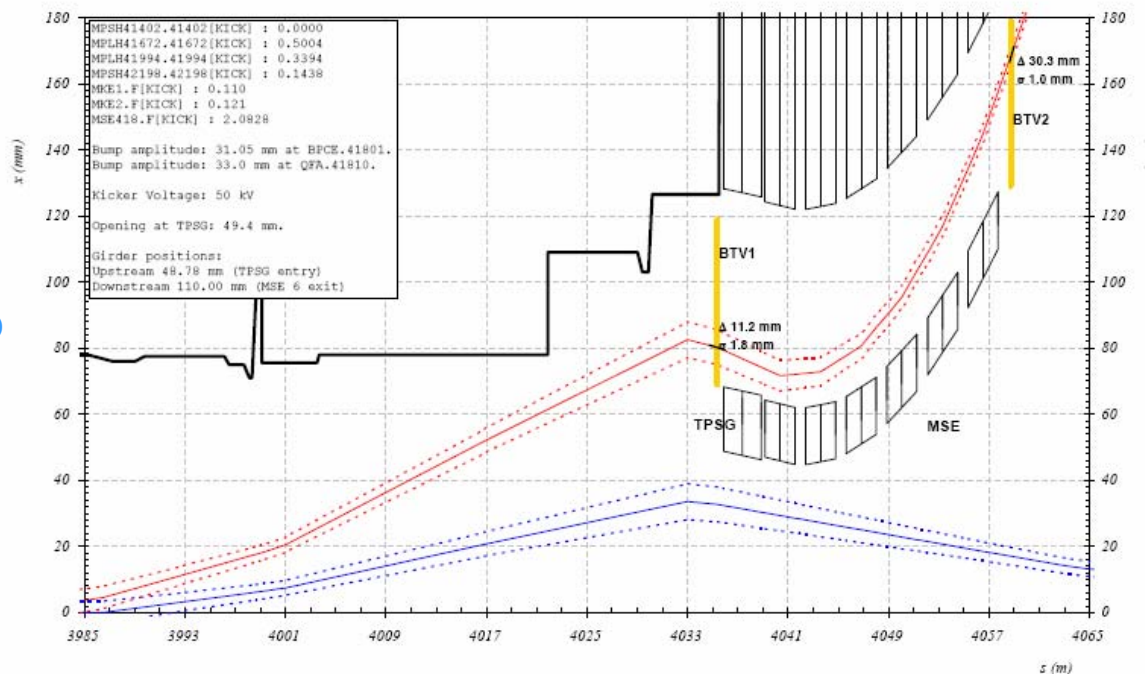
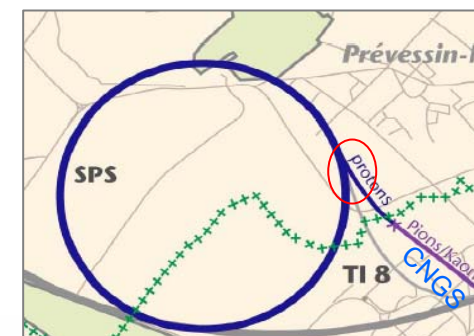


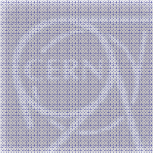
Introduction – Fast Extraction in LSS4

Extract 2 x 10.5 μ s long SPS batches, nominally $2.4e+13$ protons per batch at 400 GeV

EQUIPMENT:

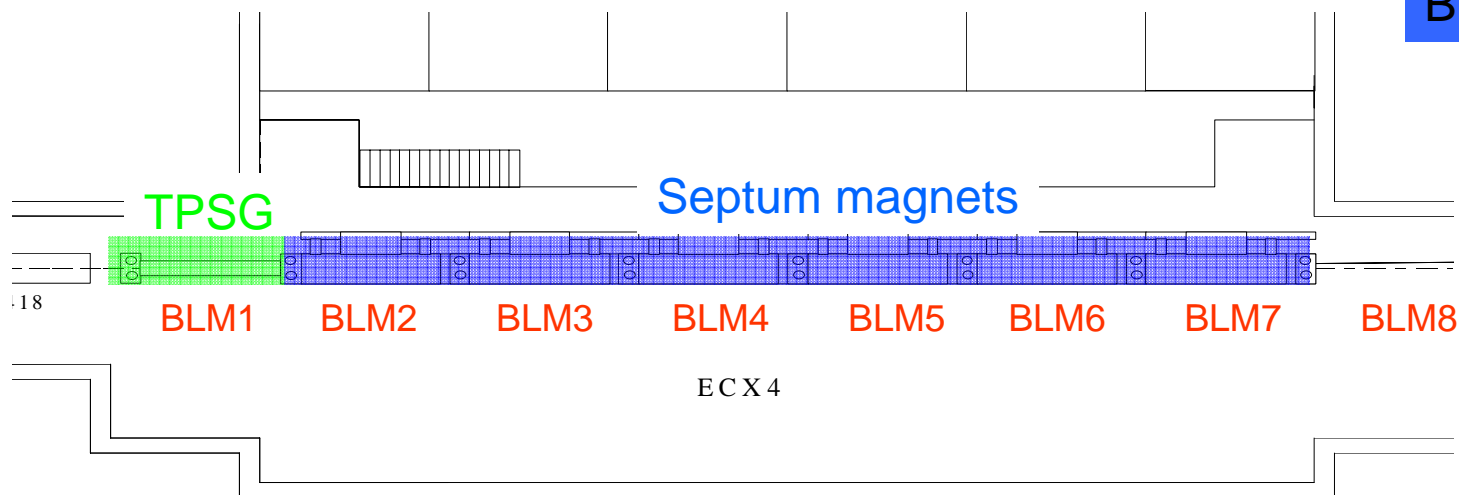
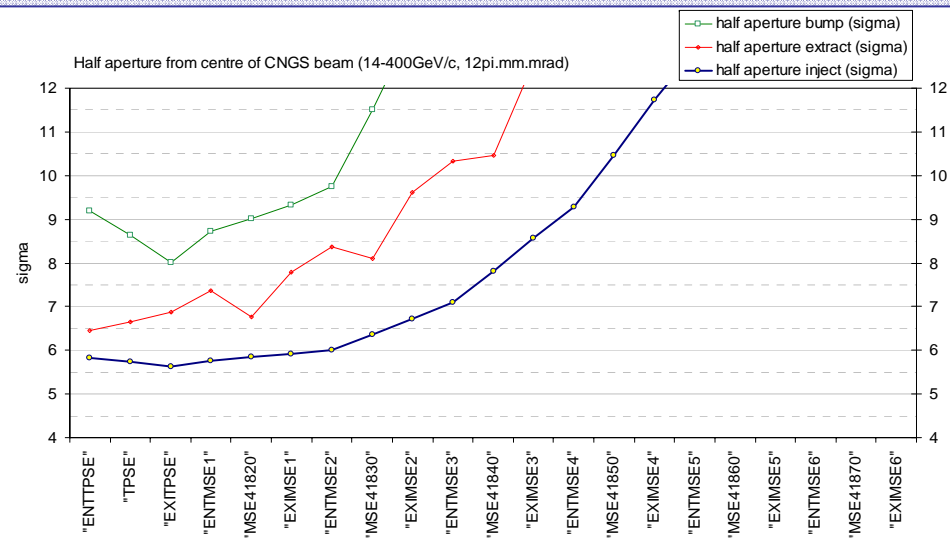
- 5 extraction kicker magnets (**MKE**):
 - rise time: 1 μ s, kick length: 11.3/12.1 μ s, voltage: 50 kV
- 6 septum magnets (**MSE**)
- **TPSG** – protection element for MSE
- 4 extraction bumper magnets:
 - 31.5 mm **extraction bump**
- **enlarged aperture** quadrupole magnets
- instrumentation

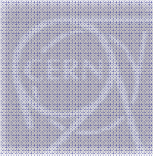




Constraints (1)

- Aperture for circulating bumped beam
 - design: 9.3σ
- Aperture for TPSG/MSE for extracted beam
 - design: 6.5σ
- Losses during extraction
 - below 0.1 % of nominal (radiation)



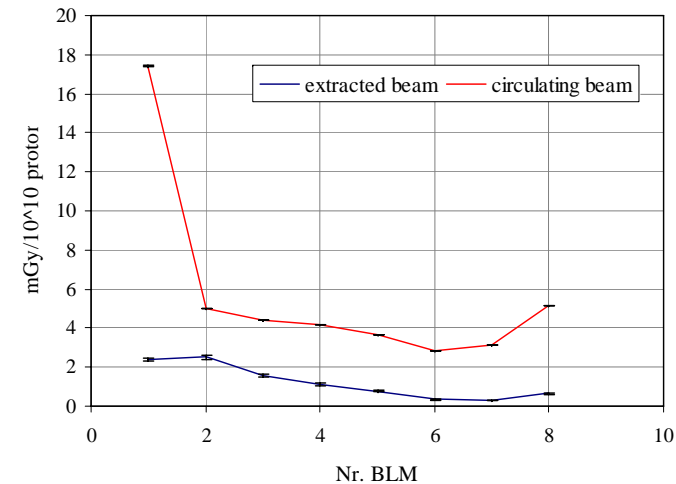


Calibration – Measurement Results during CNGS Commissioning (1)

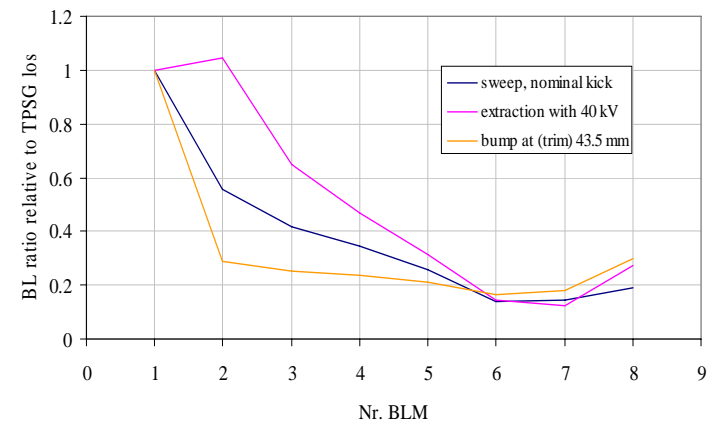
Measured Beam Loss Profiles on BLM1 – BLM8

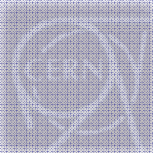
- Measurements with low intensity:
 - Intensities $\sim 3e+11 - 2e+12$
 - Beam loss per proton from **circulating beam 1)**
 - via increasing bump amplitude
 - Beam loss per proton from **extracted beam 2)**
 - via decreasing kicker voltage
- Outcome:
 - Beam loss on the inside of the TPSG leads to higher beam loss signals.
- Normal operation loss: most likely **swept beam**
 - Combination of 1) and 2)
 - Beam loss profile combination of 1) and 2)

Beam loss per 10^{10} protons for extracted and circulating beam



Comparison of loss patterns

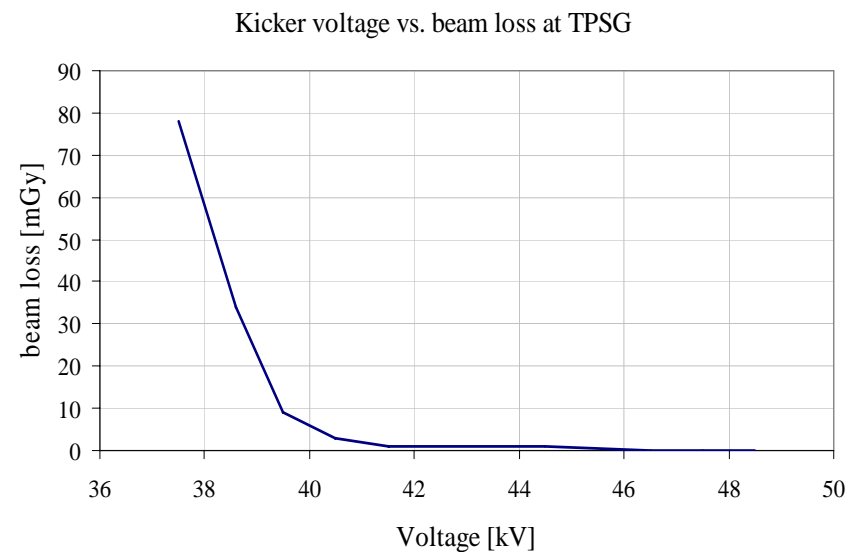
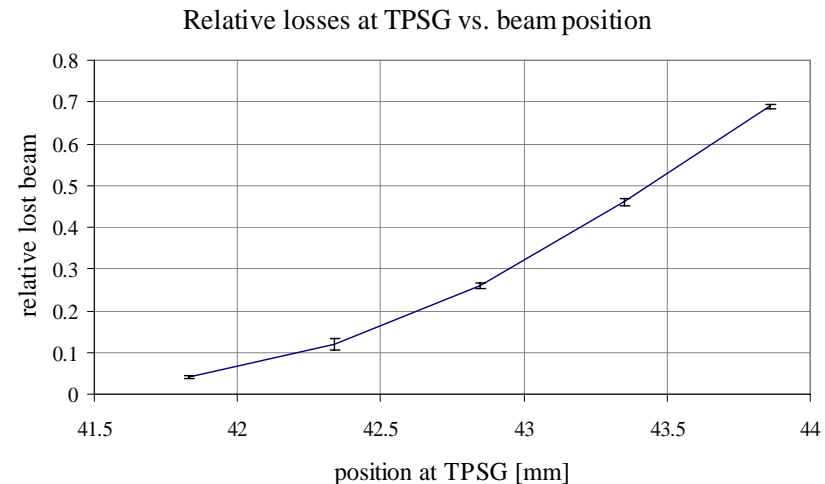


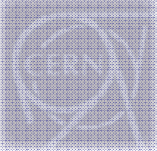


Calibration – Measurement Results during CNGS Commissioning (2)

Aperture Measurement

- Result for circulating beam (increasing bump):
 - TPSG edge ~13 mm from beam center
 - ~ 8.3 nominal sigma (design: 9.3 sigma)
- Result for extracted beam (decreasing kicker voltage):
 - TPSG edge ~ 10.6 mm from beam center
 - ~ 6.8 nominal sigma (design: 6.5 sigma)
- Apertures are OK





Calibration – Measurement Results during CNGS Commissioning (3)

Radiation in ECA4:

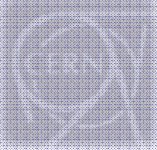
First comparison between simulation and measurements for a loss of 1.26×10^{11} protons @ 400 GeV/c on TPSG

	Latest calculation prediction	Measurement
Top of shielding	~ 1230 nSv	~ 700 nSv
Barracks	~ 30 nSv	~ 20 - 27 nSv
ECA4 floor (entrance TT40)	~ 30 nSv	~ 14 - 20 nSv

Possible explanations of difference between simulation and measurement:

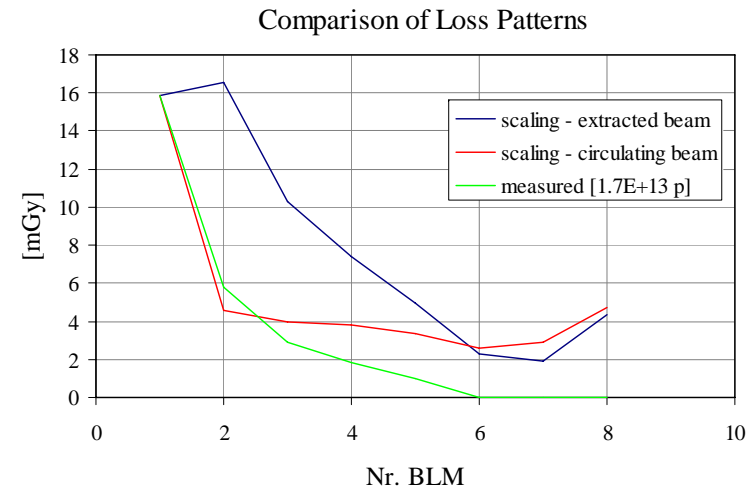
- real wall thickness 4.8m – 5m , simulated wall thickness: 4.8m (conservative approach)
- new wall (40 cm) at “ECA4 maze exit” not considered in calculation
- detectors are calibrated to AmBe source

H. Vincke

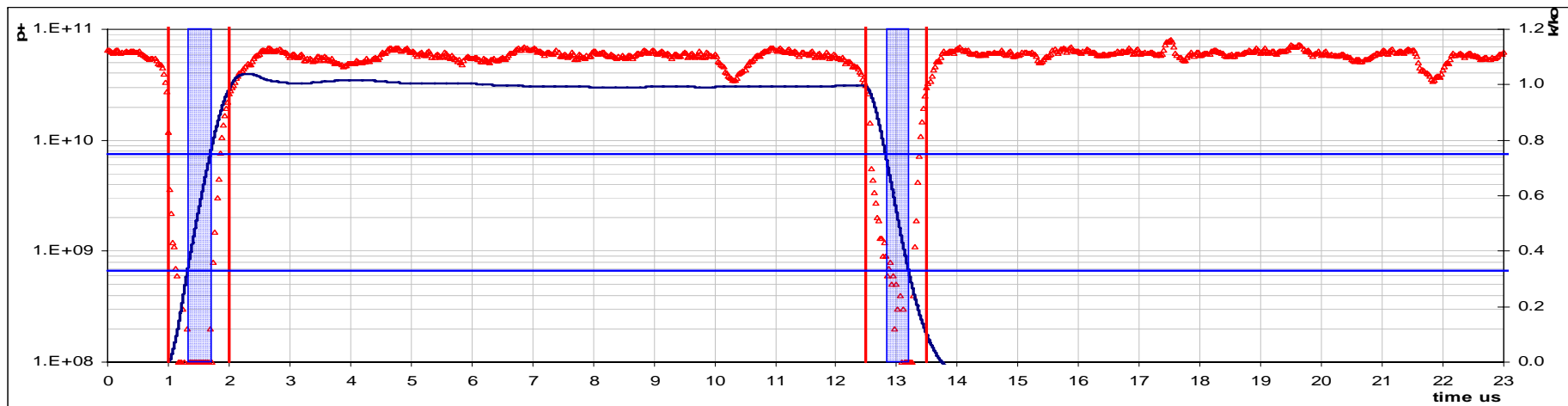


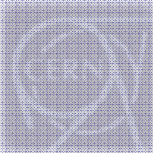
Normal Operation – Extraction Beam Losses (1)

- Nominal losses are between:
 - 0.05 % ...scaled with circulating beam loss pattern
 - 0.39 % ... scaled with extracted loss beam pattern
- Extraction related losses stem “only” from beam in gap
 - gap cleaned with first extraction (during fall and rise time of kicker)
 - no losses on second extraction



Beam loss on TPSG over 9 h operation (~1.7e+13 protons per extraction)

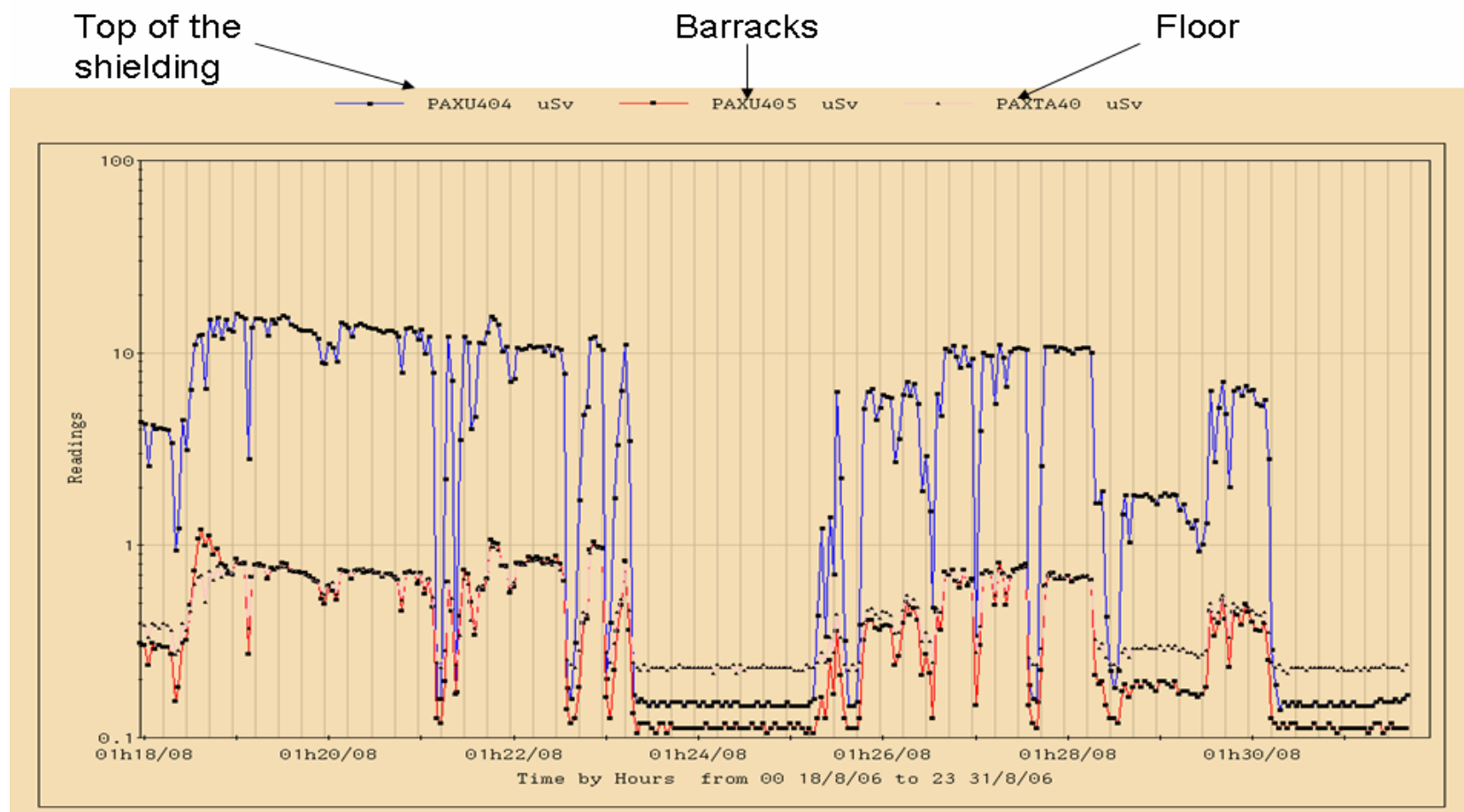




Normal Operation – Extraction Beam Losses (2)

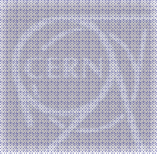
Radiation in ECA4:

Detector readings during CNGS Opera run



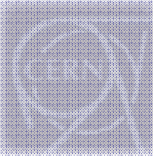
The monitors show maximum radiation values of 1 $\mu\text{Sv/h}$ in accessible regions.

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Extraction related Machine Protection (1)

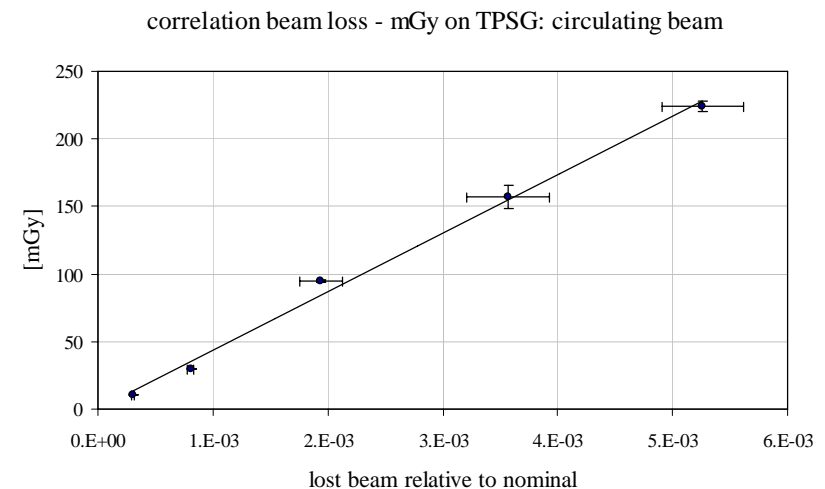
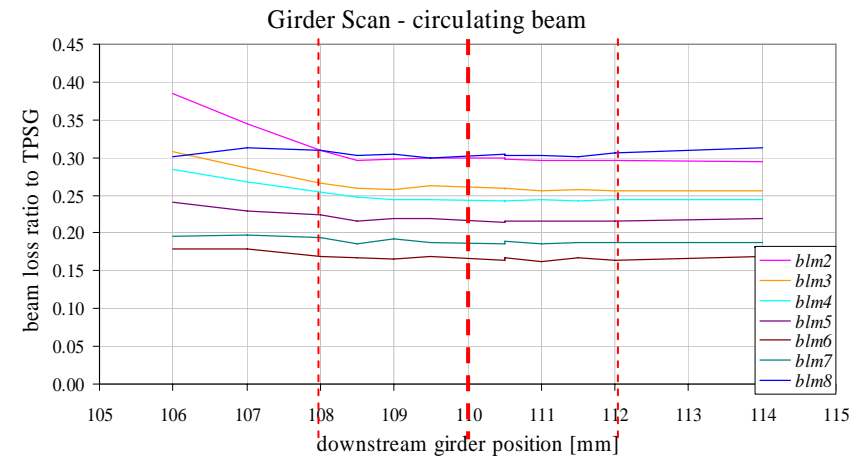
- Nominal intensity for CNGS extraction ~ **factor 10 above damage limit** of equipment.
- Machine protection system in place to protect extraction and transfer line equipment.
- In this talk only extraction machine protection covered.
- Passive protection + active protection
 - Passive: TPSG – absorber in front of septum magnets.
 - Active: interlocking system (monitoring of critical parameters).
 - If threshold is exceeded, extraction is not permitted.

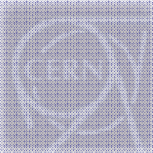


Extraction related Machine Protection (2)

Extraction equipment interlocking

- Girder position interlock (± 2 mm)
 - Protection of MSE with TPSG
 - 110 mm nominal position
- MKE voltage interlock (± 2 kV)
 - 1 kV change corresponds to ~ 1 mm change at TPSG
- Bumped beam position (BPCE) interlock
 - ± 1 mm
- Beam loss monitors in LSS4 threshold interlock:
 - Thresholds on BLM1-BLM8 to respect loss limit 0.1% of nominal
 - 38, 18, 18, 18, 18, 18, 18, 18 mGy
- Fast Magnet Current Change Monitor (FMCM) for the MSE:
 - Threshold on current change of $< 0.2\%$





Likely Failure Scenarios: Extraction Kicker Failures

- Failure scenarios

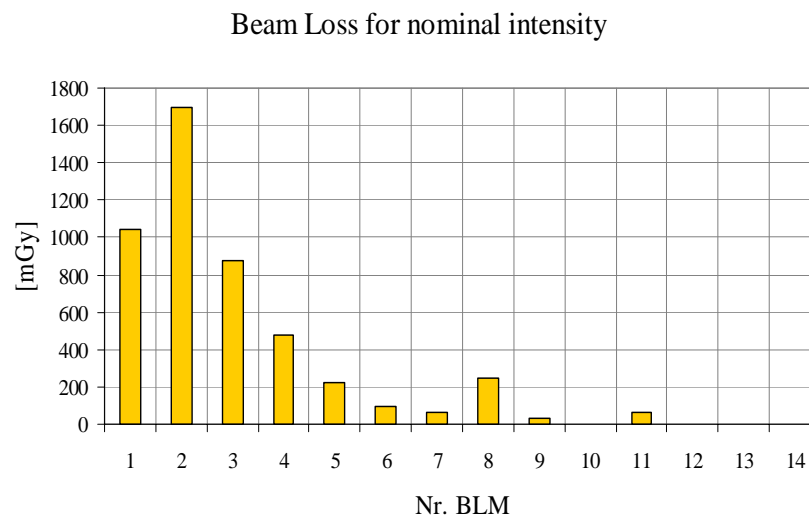
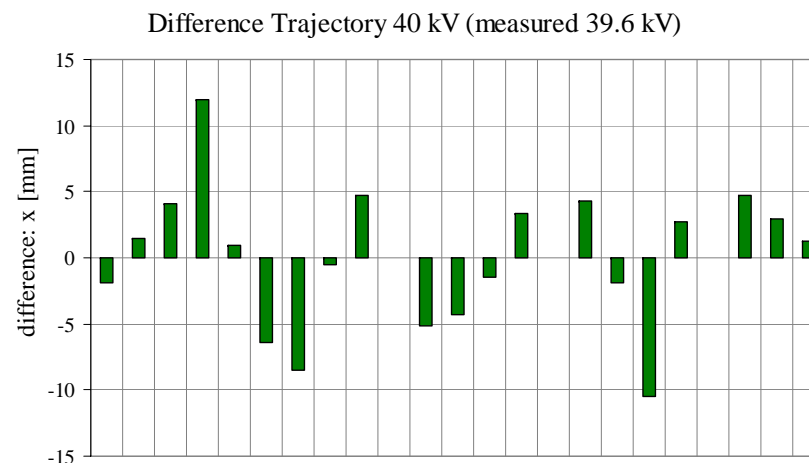
- MKE erratic (main switch)
- MKE missing
- **MKE erratic (clipper switches)**
- Sweep (timing error)

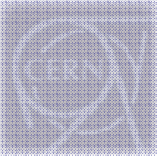
- Experiment: MKE 80 % kick, low intensity

- corresponds to one kicker out of 5 missing

- Outcome:

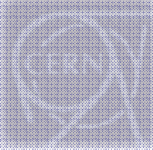
- big oscillations down the line (peak > 10 mm); target out of tolerance
- no beam loss in TT41 during test
 - might be due to gain of monitors with low intensity
 - → for nominal intensity, losses in TT41 are <30 mGy.
- TPSG/MSE high losses, but MSE protected





Summary

- The extraction is set up “cleanly” in the transverse plane
- “All” losses stem from beam in gap
 - Losses are acceptable concerning radiation in ECA4.
- Machine protection systems are in place to protect extraction equipment and line.
 - What about the target during kicker failures (2 mm excursions)?
- Outstanding issues:
 - Confirm “gap-losses” hypothesis (extract only second batch?)
 - Monitoring of gap population
 - Kicker gap cleaning to remove losses during extraction: with transverse damper?
 - ...



MKE kicker system in LSS4

Status July 20, 2006

- End of June: main switches M2, M5 erratic problems;
 - Situation improved with grounding and conditioning.
- Up to July 15th: clipper switches erratic problems + contact erosion + divider resistors;
 - Aluminum contact changed – all installed switches;
 - Divider resistor (top) changed – all clipper switches;
 - Divider resistor (bottom) changed – C1 and C2.
- On July 15th: 1 spark in magnet #2.
- Statistic since July 15th
 - 36 hours (WE) + 12 hours (night);
 - No clipper erratic;
 - 2x M2 interlock (problem with setting tables).

L. Ducimetiere