Optics with M2D ON

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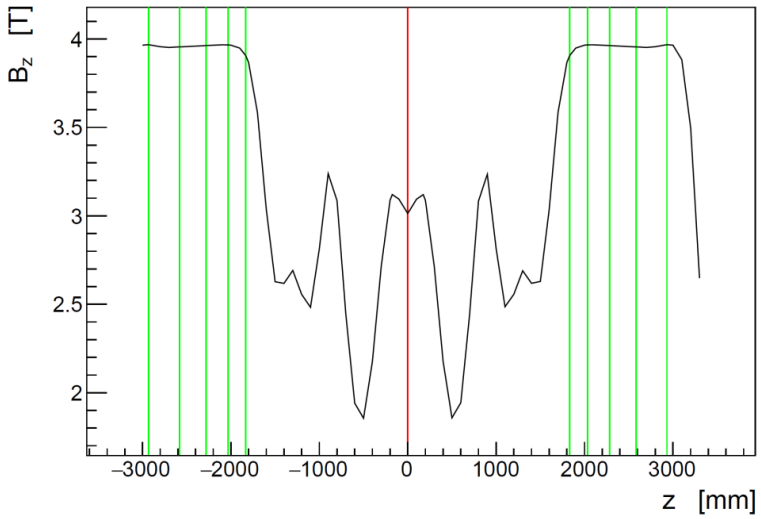
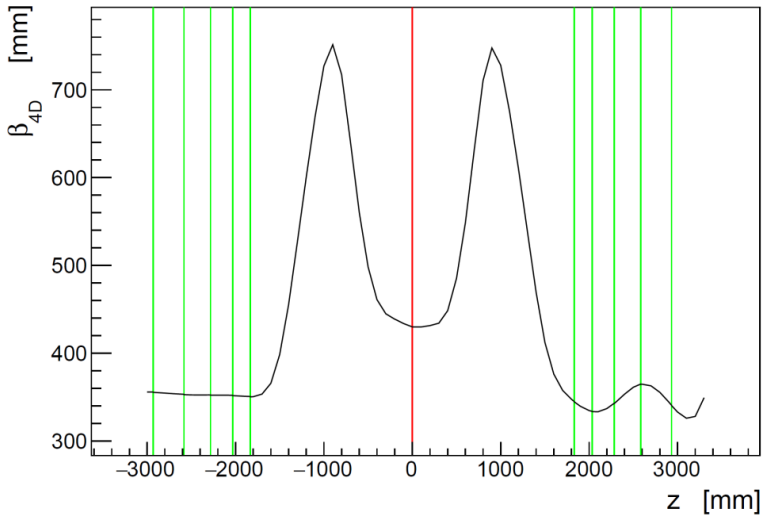
Design Optics in Cooling Channel





Bz and Beta in solenoid mode at 4T

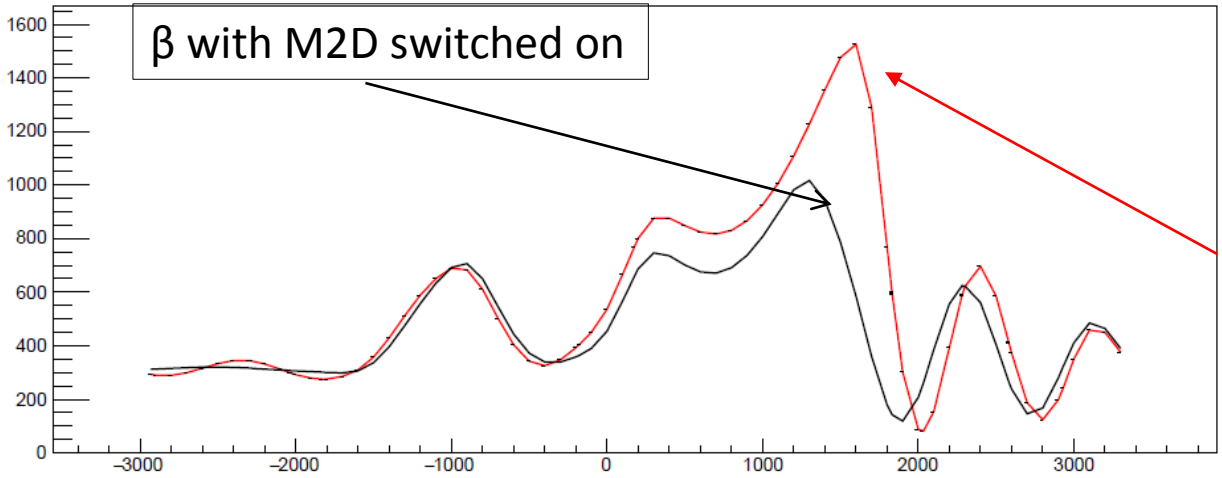
C. Hunt (IC) Thesis 2017

Beam incoming from beam line, optimised for transmission, passes through variable thickness high-Z diffuser to increase emittance above the equilibrium value in a controlled way at the entrance to the Channel.

- Optics of the channel assumes matched beam (α=0) in both upstream and downstream solenoids.
  - To maximise transmission.
  - To minimise emittance growth due to mismatch.
  - In practice this condition is met only approximately, but a matched beam sample can be selected with sufficient statistics.
- Small beta waist is created with the help of Matched Coils and AFC at absorber (centre).
  - Solenoid and flip modes are proposed and used for data taking.
- Optics can only be approximately symmetric due to energy loss and large momentum spread.

Beam Optics: Data Taking

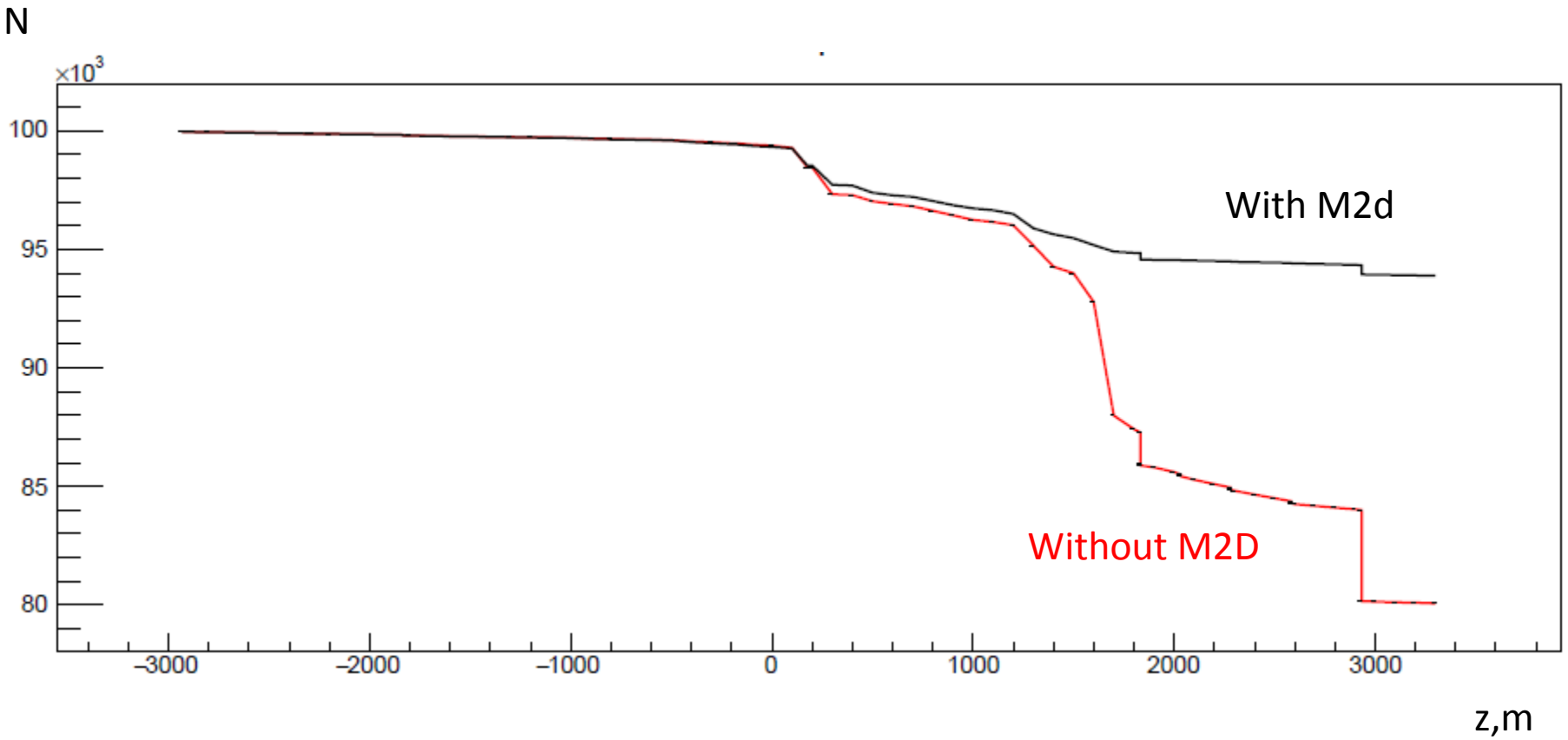
- Failure of QPS during training caused one of the Matching Coils in SSD to be inoperable.
- This caused beam mismatch and a decrease in transmission, which could be partially compensated.
  - Compensation required operation with reduced field in SSs (4T→3T)
  - As an effect the optics is non-symmetric
- In the downstream solenoid, the second match coil (M2D) was not operated as a precaution.
  - Operation with M2D on is foreseen in October.
- The flexibility of the lattice has allowed the optics to be tuned such that a cooling signal is expected.



β without both downstream Matched Coils

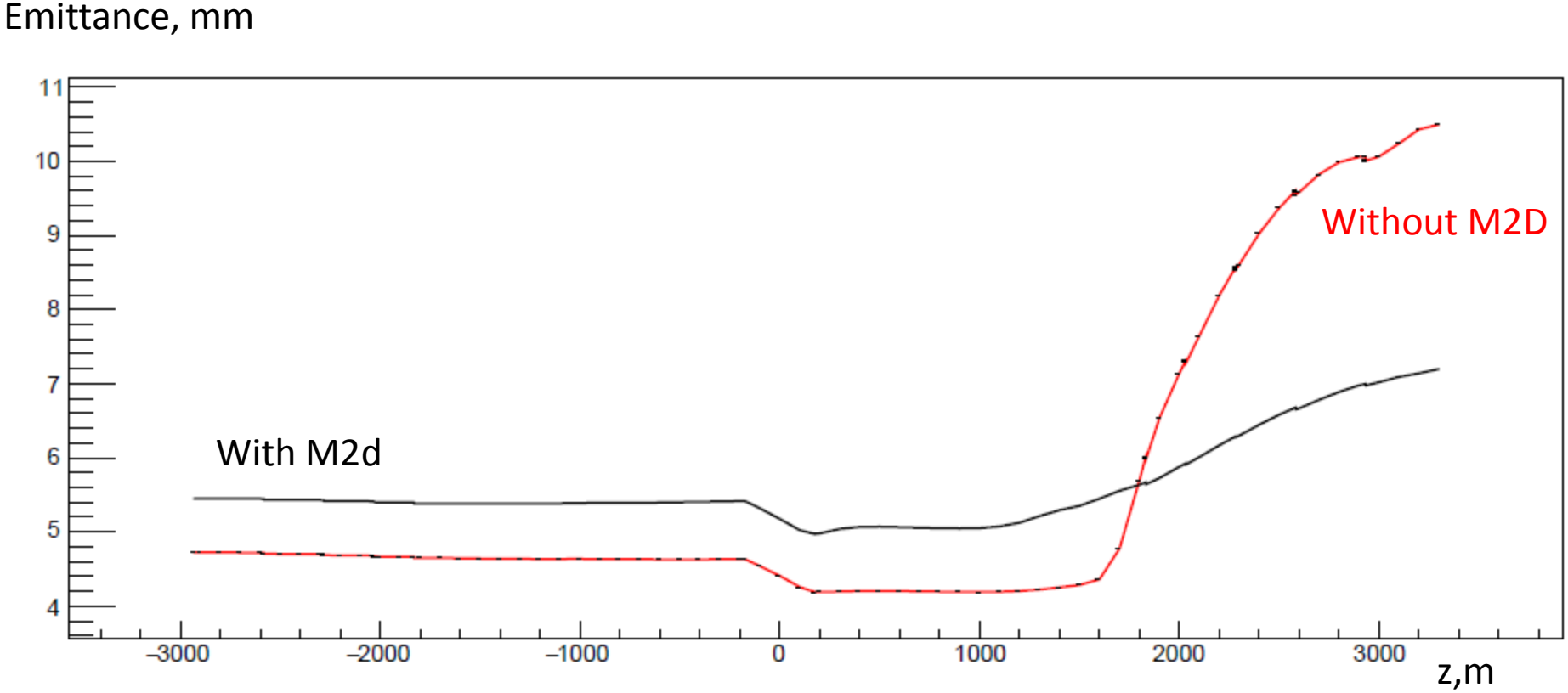
Beta function in flip mode

Transmission with and w/o M2D



Beam: 140MeV/c, 6mm,

Emittance with and w/o M2D

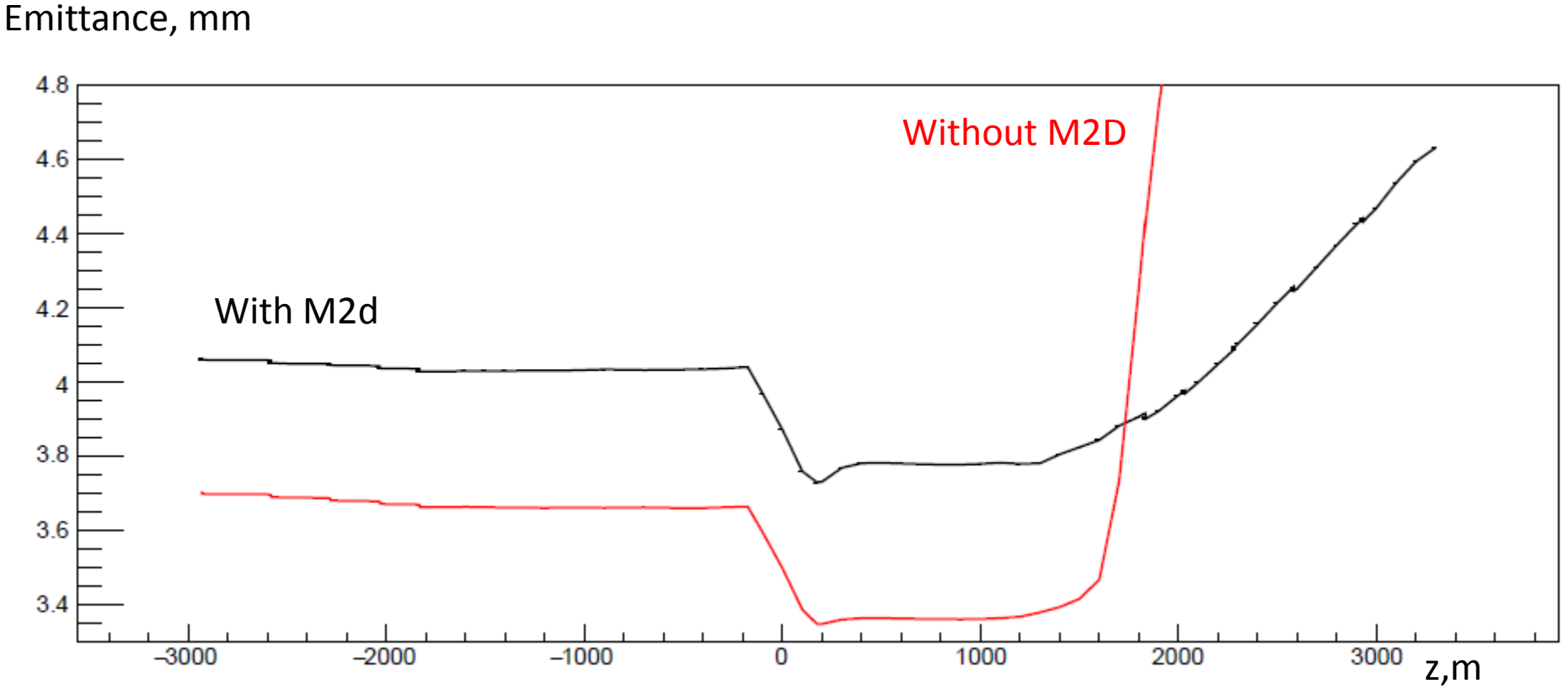


Beam: 140 MeV/c, 6mm, 4.8% dp/p

How to reduce emittance growth?

- Reduce 4D emittance
  - Cooling effect will be affected
- Reduce momentum spread
  - Statistics will be smaller

Emittance with and w/o M2D



Beam: 140 MeV/c, 4.2mm, 1.5% dp/p

Example new setting with M2D on FLIP

- Beamline:
  - pionic at 140 MeV/c
- Cooling channel:

Currents in A

Setting	E2u	Cu	E1u	M2u	M1u	FCu	FCd	M1d	M2d	E1d	Cd	E2d
Sol_140_with M2d	205.7	205.7	205.7	168.25	191.0	129.24	-129.24	0.0	-195.72	-205.7	-205.7	-205.7

- Stored energy in SSD ~1.9 MJ
- SSU/FC force 13t

Search for solenoid mode seetings

- Constraints
  - Acceptable forces
  - 205.7A in E-C-E (both SSs)
  - Good transmission
  - As good cooling as possible
- Method
  - Choose the lattice based on lattice parameters
  - Test the performance using MAUS MC (Imperial framework developed by C. Hunt and J-B. Lagrange)

  Or
  - Scan parameters space using MAUS MC
- We tested many lattices and downselected

Downselected lattices
Solenoid mode

Black Lattice

Currents in A

Setting	E2u	Cu	E1u	M2u	M1u	FCu	FCd	M1d	M2d	E1d	Cd	E2d
Sol_140_with M2d	205.7	205.7	205.7	177.52	193.97	65.73	+65.73	0.0	+192.81	+205.7	+205.7	+205.7

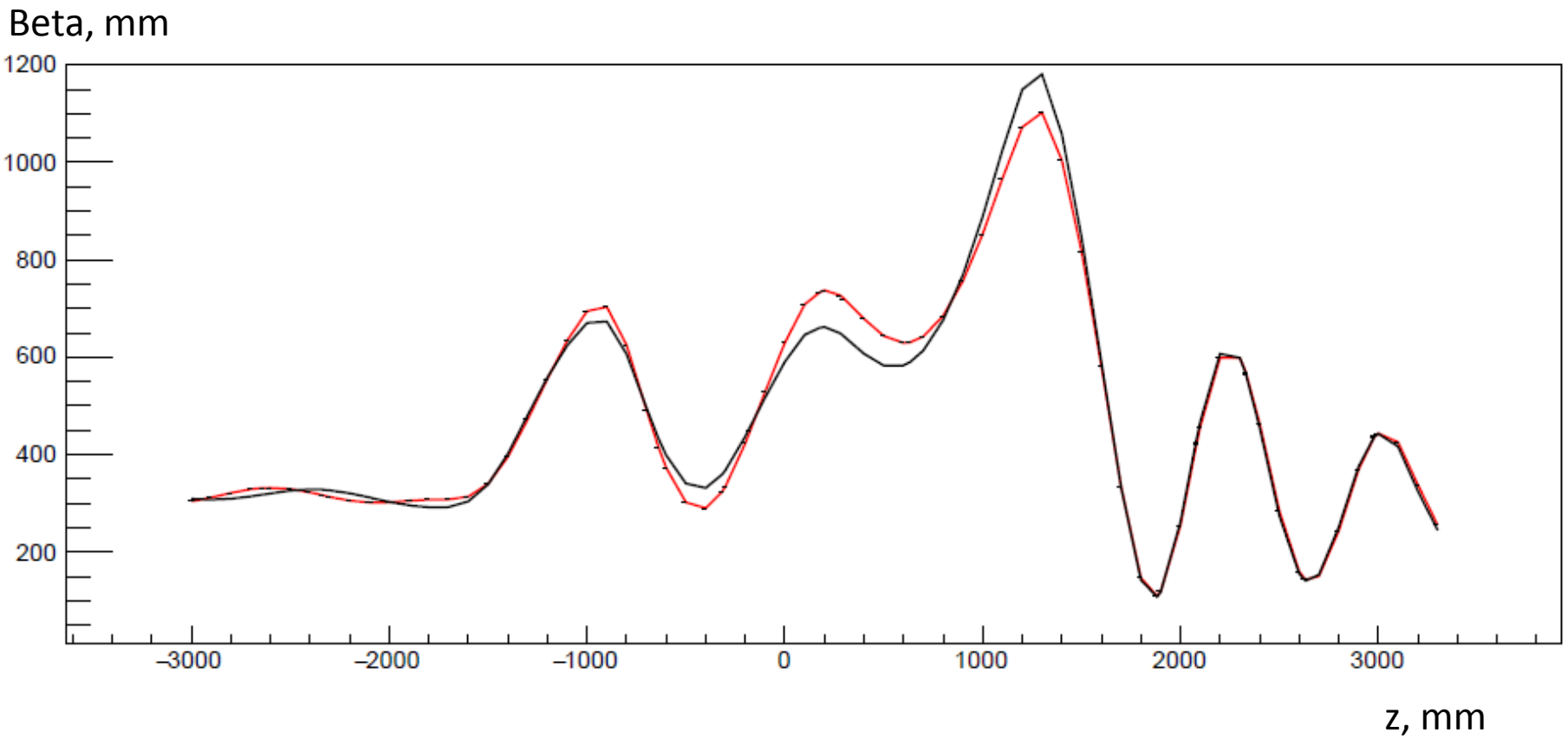
Red Lattice

Currents in A

Setting	E2u	Cu	E1u	M2u	M1u	FCu	FCd	M1d	M2d	E1d	Cd	E2d
Sol_140_with M2d	205.7	205.7	205.7	154.2	209.54	65.53	+65.53	0.0	+190.86	+205.7	+205.7	+205.7

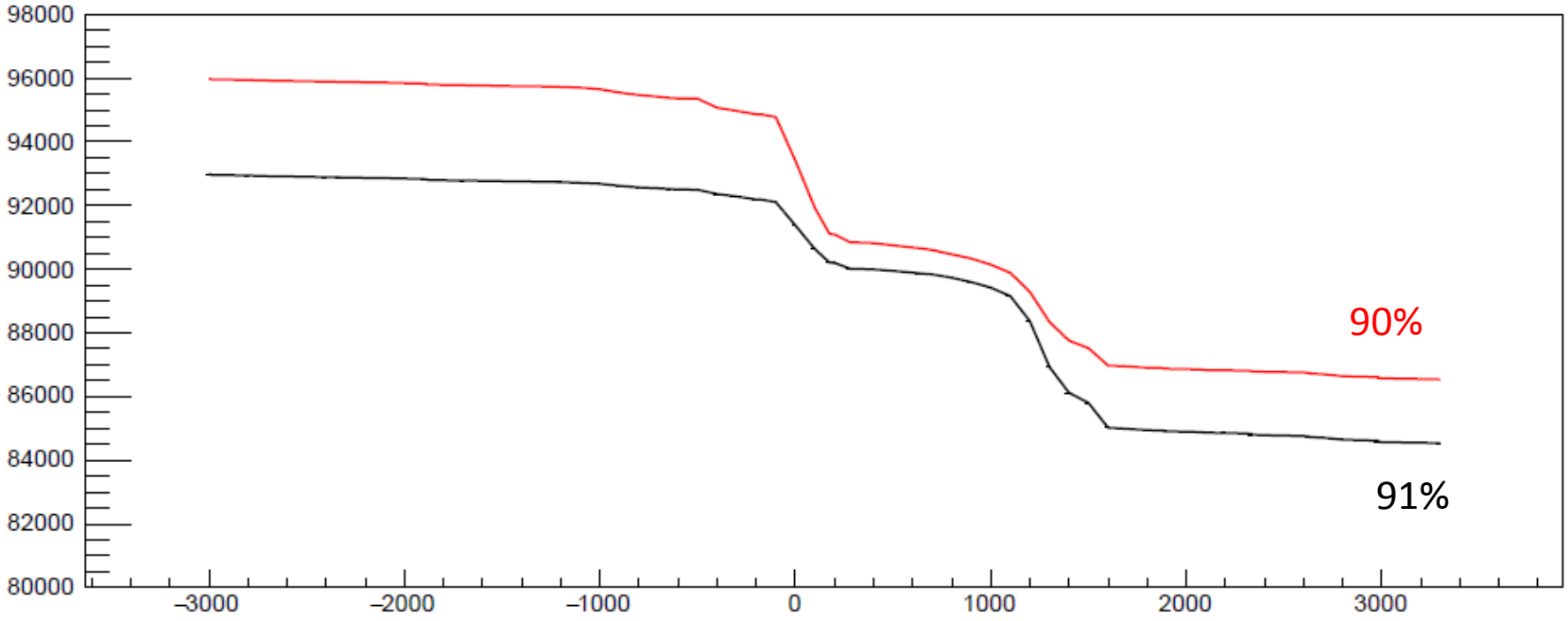
- SSU/FC force 13.7t for red

Optics, 140 MeV/c



Transmission, 6mm beam

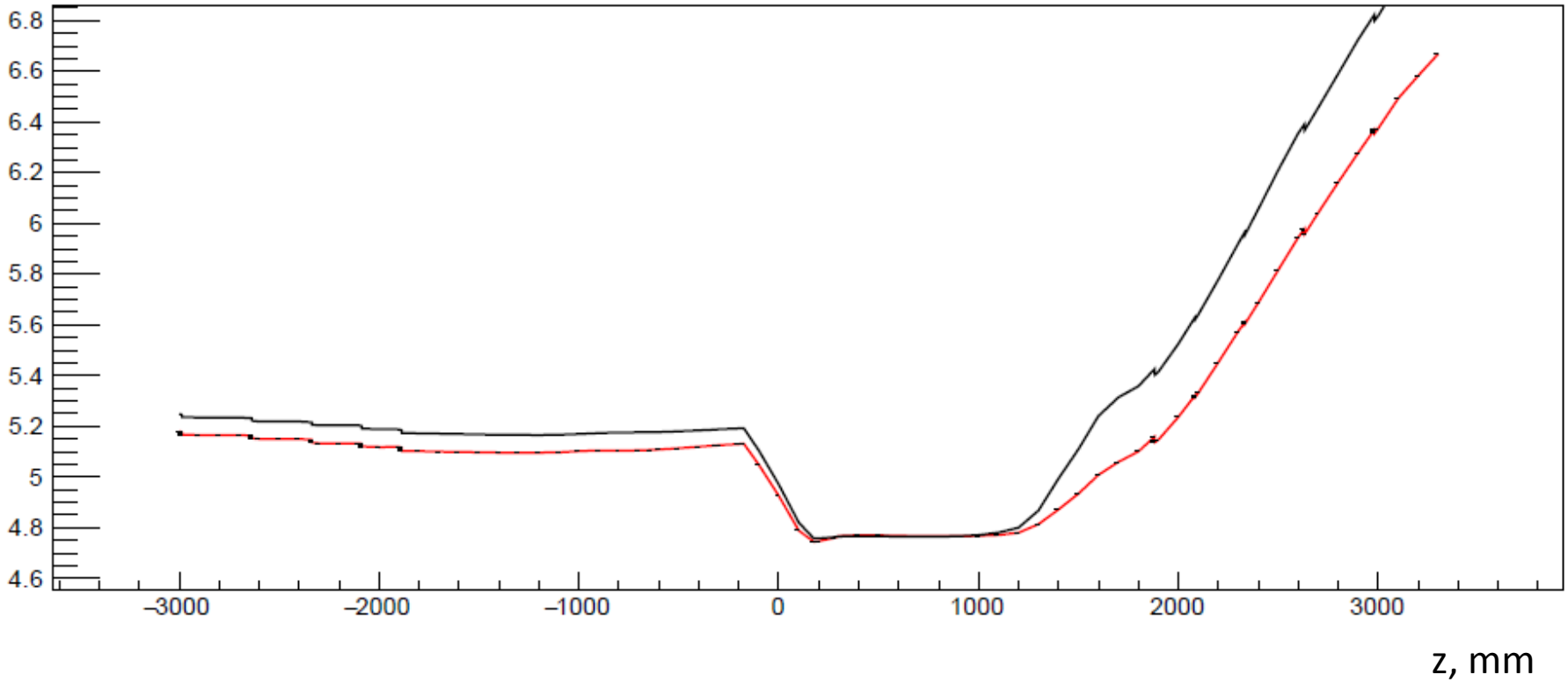
N of particles



z, mm

Emittance evolution, 6mm beam

N. RMS emittance, mm

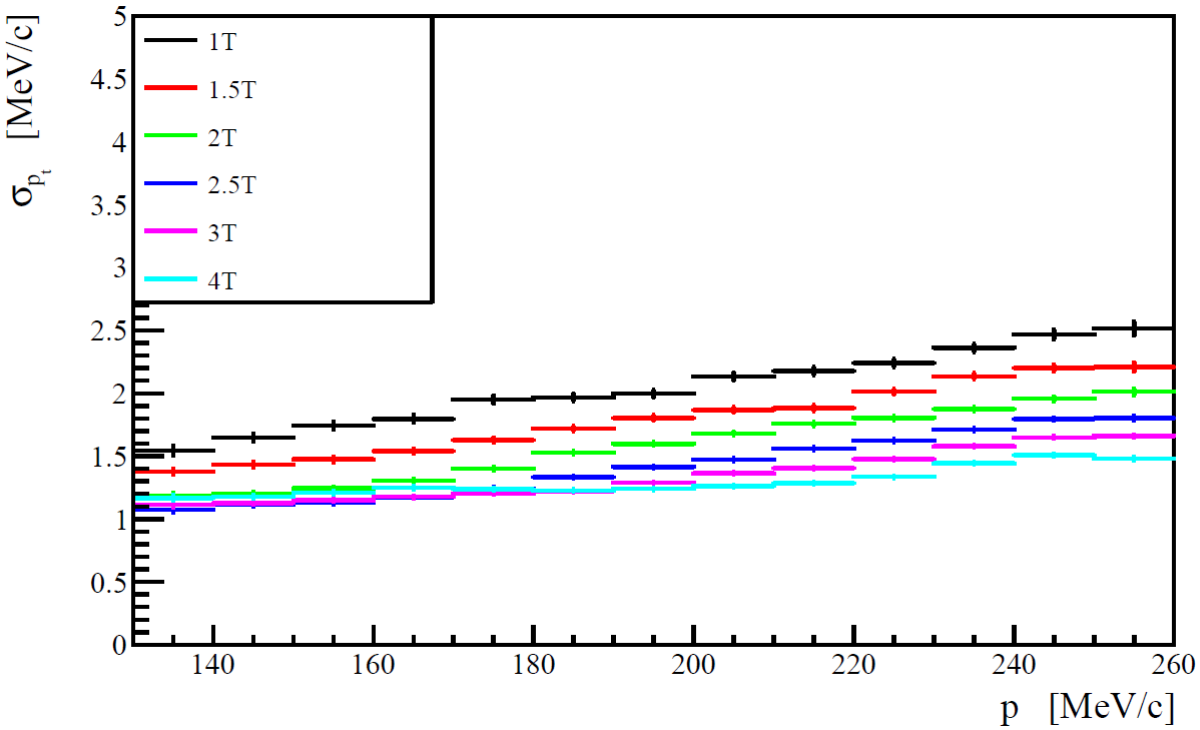


Black seems to have stronger emittance growth

- due to larger beta downstream the absorber?

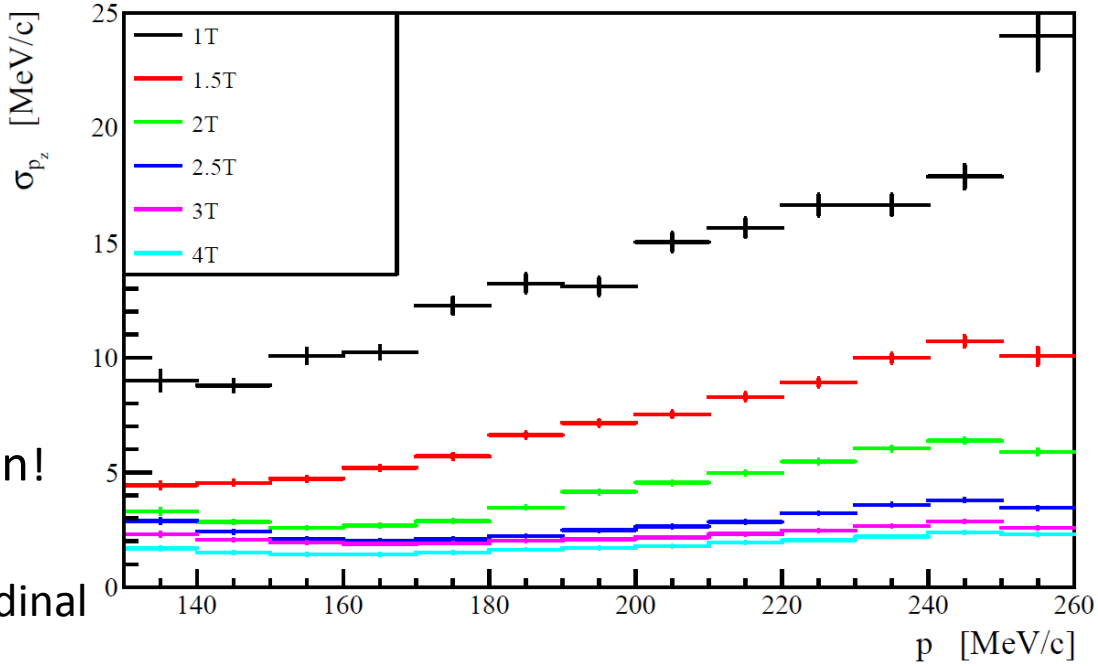
Which to choose?

- Red seems to have better emittance evolution, while both have pretty similar transmission
  - But where is cooling?



Transverse

Reconstruction studies at various fields for different beam momenta, C. Hunt.



- Can we use downstream E-C-E current as an additional degree of freedom in optics studies?
- This may affect the reconstruction!
- May be ~2T is sufficient?

Longitudinal

Downselected lattices
Solenoid mode with lower SSD field

Black Lattice 2T

Currents in A

Setting	E2u	Cu	E1u	M2u	M1u	FCu	FCd	M1d	M2d	E1d	Cd	E2d
Sol_140_with M2d	205.7	205.7	205.7	175.55	174.36	55.88	+55.88	0.0	+205.81	+137.13	+137.13	+137.13

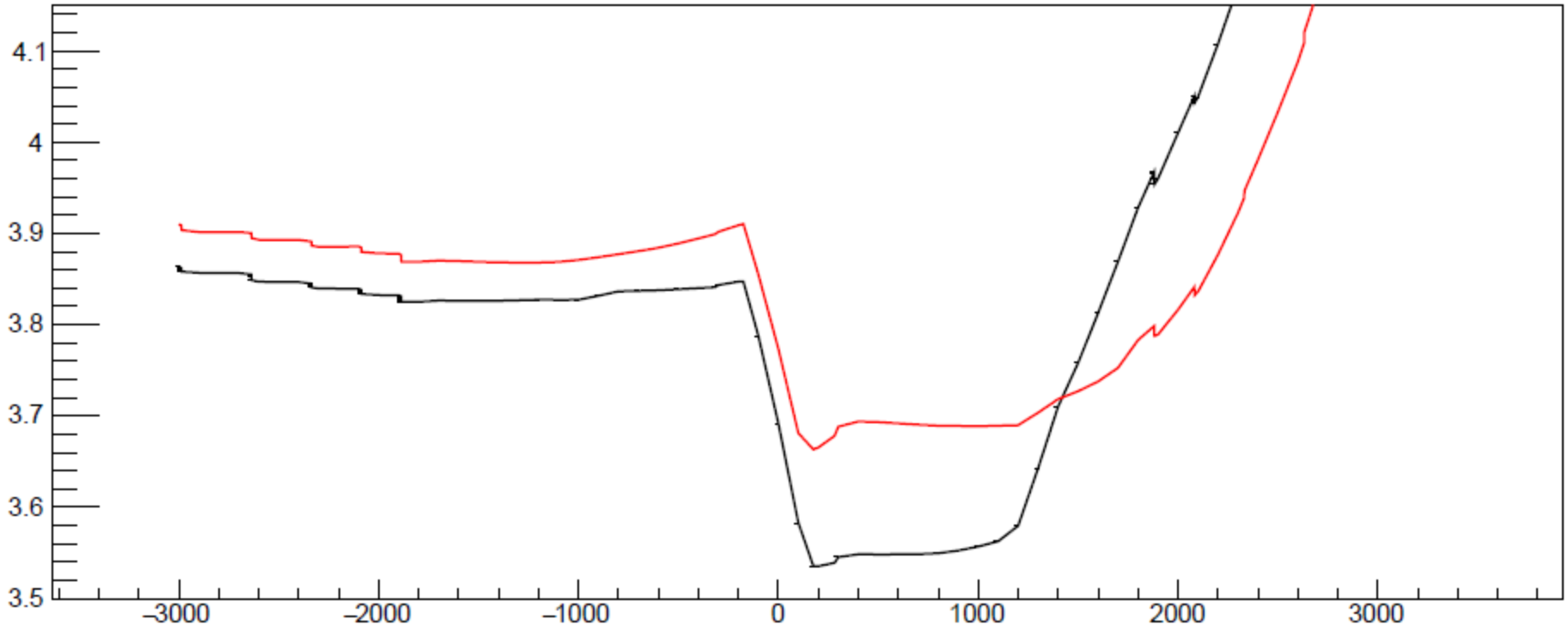
Red Lattice 2.1T

Currents in A

Setting	E2u	Cu	E1u	M2u	M1u	FCu	FCd	M1d	M2d	E1d	Cd	E2d
Sol_140_with M2d	205.7	205.7	205.7	154.2	209.54	65.53	+65.53	0.0	+190.86	+144.0	+144.0	+144.0

- SSU/FC force 13.7t for red

Emittance evolution, low SSD B, 4.2mm beam, 140 MeV/c



Red lattice has ~2% cooling effect, while black does not have (in IC MC MAUS framework)

Summary

- Red lattices seems to perform a bit better using IC analysis toolkit.
  - We have a different results in MC (comparing with C. Rogers), which causes the decision making more challenging.
- Still both black and red are very close in many aspects, which is quite promising.
- Proposal:
  - Run 140 MeV/c with high and reduced field in solenoid mode
  - Run the best cooling performance and one 200 MeV/c setting in the flip mode.
  - Can we have more settings (next Run?)