MEBT studies for IsoDAR
Update

Roger Barlow

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This is not a very interesting talk

The IsoDAR cyclotron is challenging
The IsoDAR target is challenging

The MEBT is just a standard length of beamline connecting the two.

Aim of the current study is to show that it is buildable. A proper optimised design will come later, when the project gets funded.

Only (slight) interest is the need to keep losses low in a high-power beam which may be affected by space charge

Beam losses

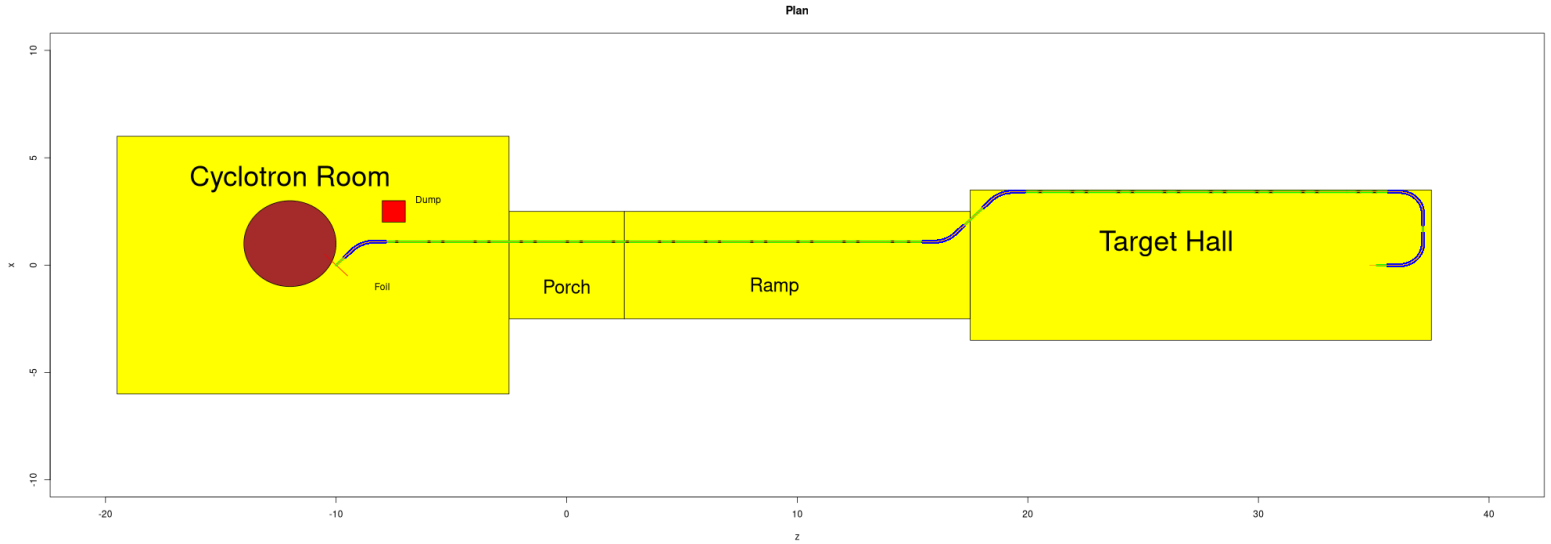
Take $\sigma = 6mm, \sigma' = 3mrad$ in both directions (more information needed: expect this to appear sooner or later. Probably later.)
Assume 5 cm radius (10 cm diameter) beampipe
Assume target limit of 1W/metre for beam losses
A 60 MeV, 10 mA beam is 600 kW, so should not lose more than 1 particle in 600,000 per metre
1 in 600,000 is around 5 sigma, for 2-D. So want rms spread below 1 cm.

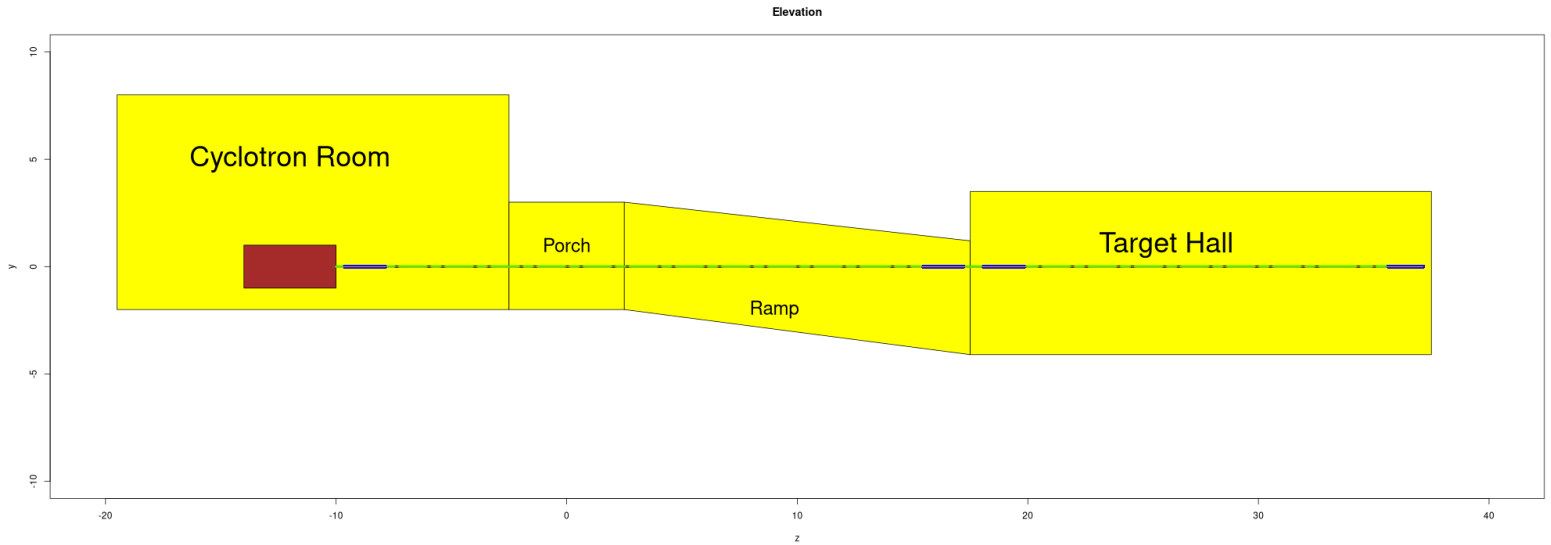
Tools:

- Focussing. But convergence becoms divergence
- Collimation. But angular spread means effect is not permanent

Estimate beam losses from particles lost in simulation - need 6,000,000 particles for good statistics.

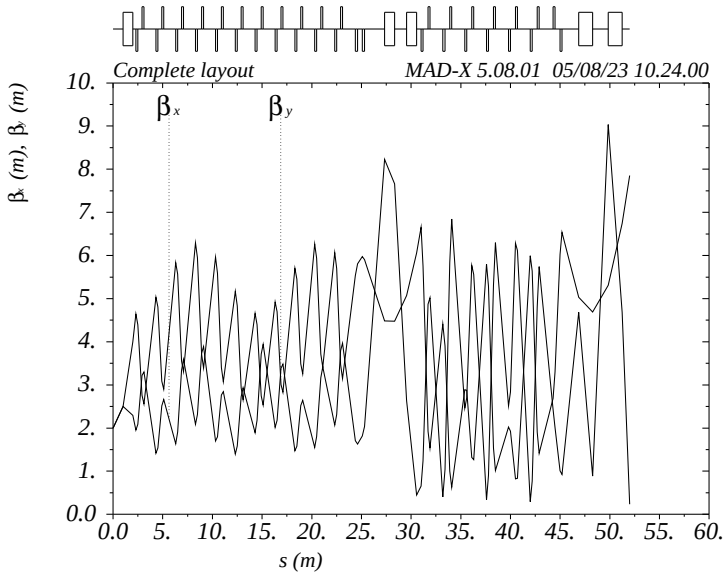
Overall layout





MADX simulation

shown previously



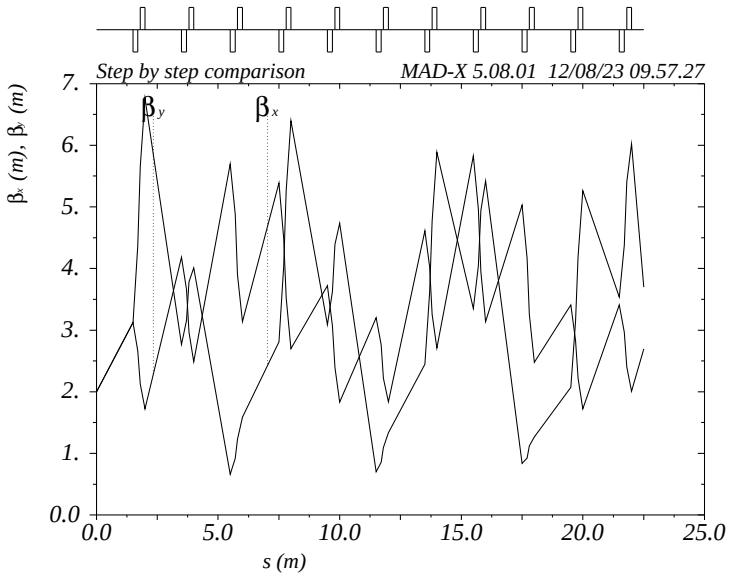
MADX "Matching" adjusts quadrupole strengths to fulfil constraints on β . (Want to keep it below about 6.0) Numbers and positions adjusted by hand...

Beam is very controlled (about 1 magnet/metre) to help keep losses down. May be relaxed in later designs.

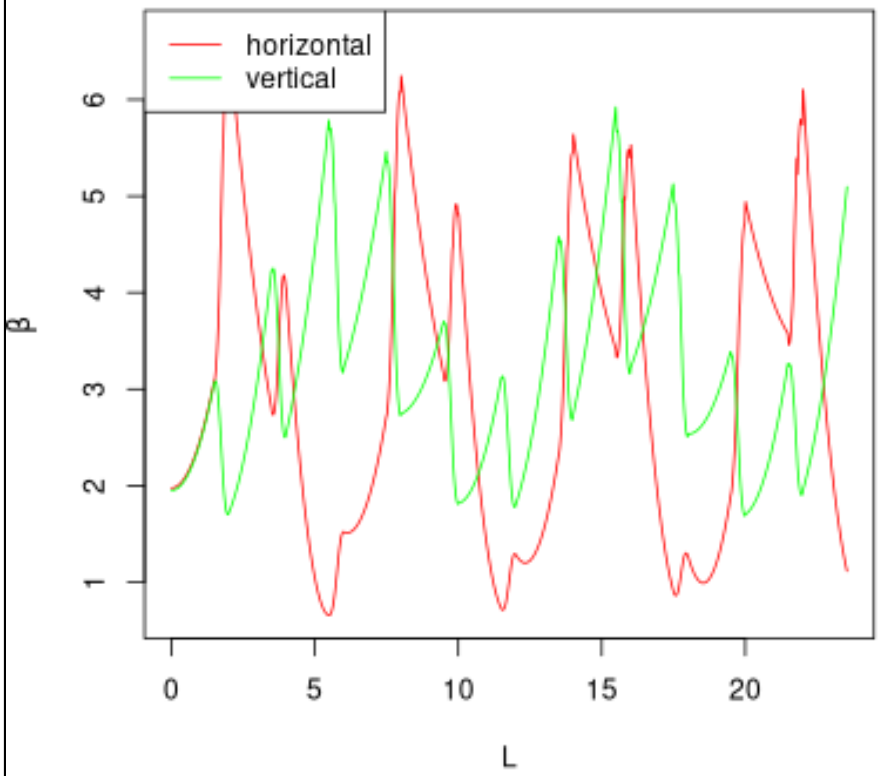
Conversion to OPAL

Begin with just the first set of quadrupoles (all cells identical)

MADX



OPAL (6000 particles)



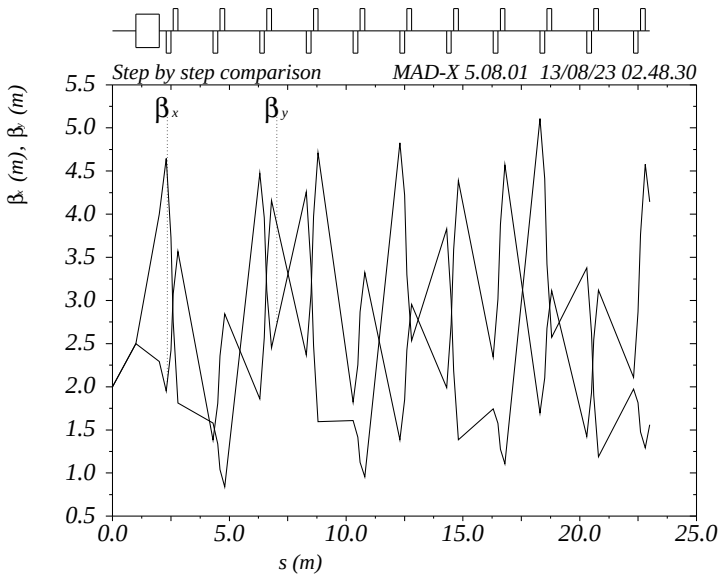
Getting these two to agree was a long journey!

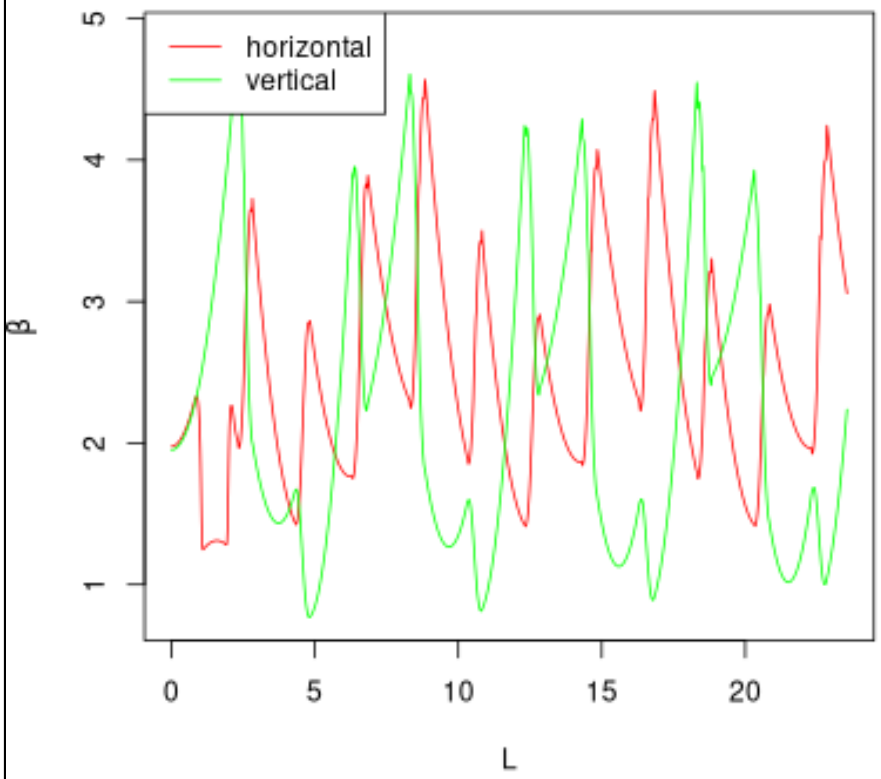
Add the first magnet

OPAL includes edge effects neglected by MAD

OPAL

MADX



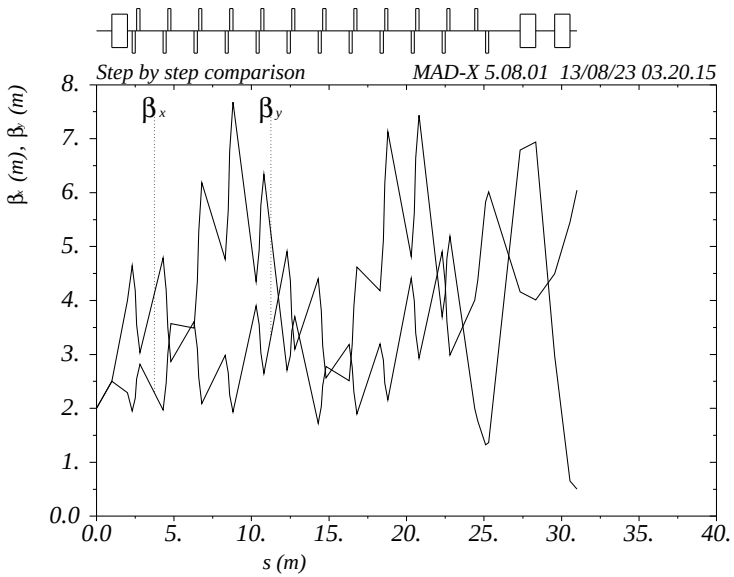


No longer identical - but close. β values still all good

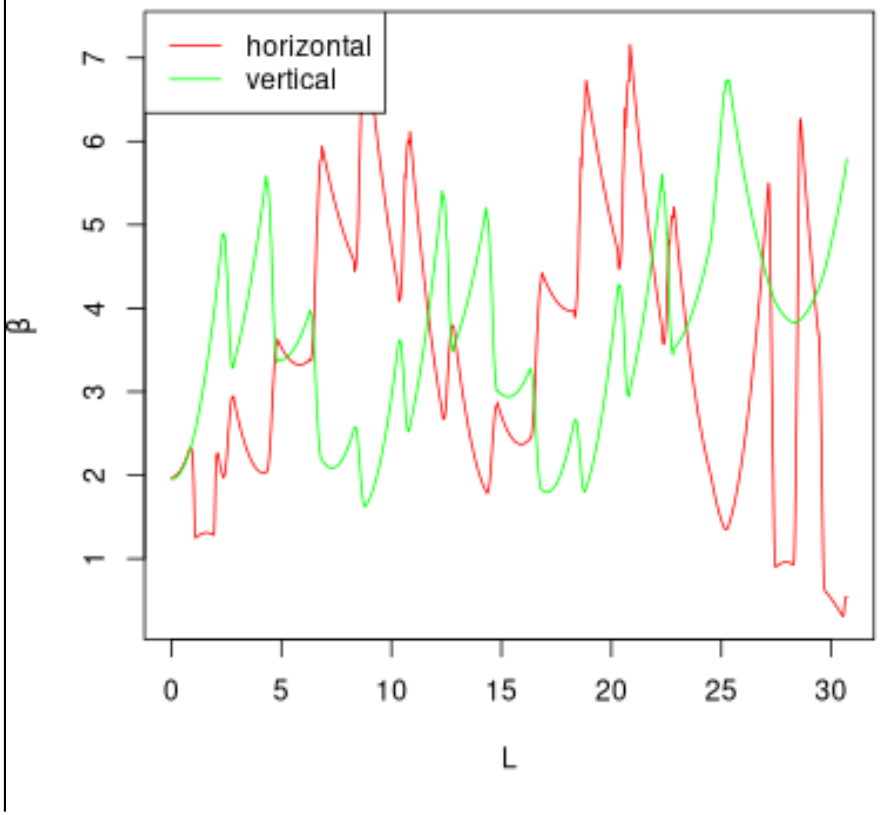
Add the wiggle

And one more, independent, quad pair. Flip comes from optimisation

MADX



OPAL

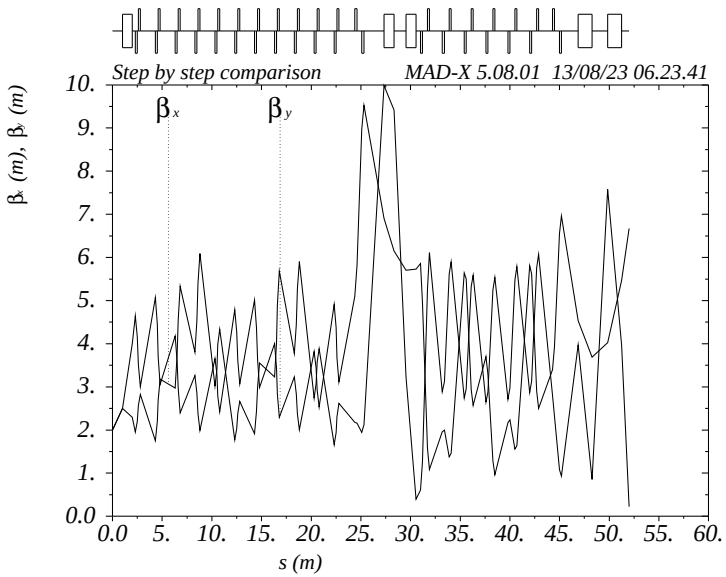


Still in reasonable agreement.

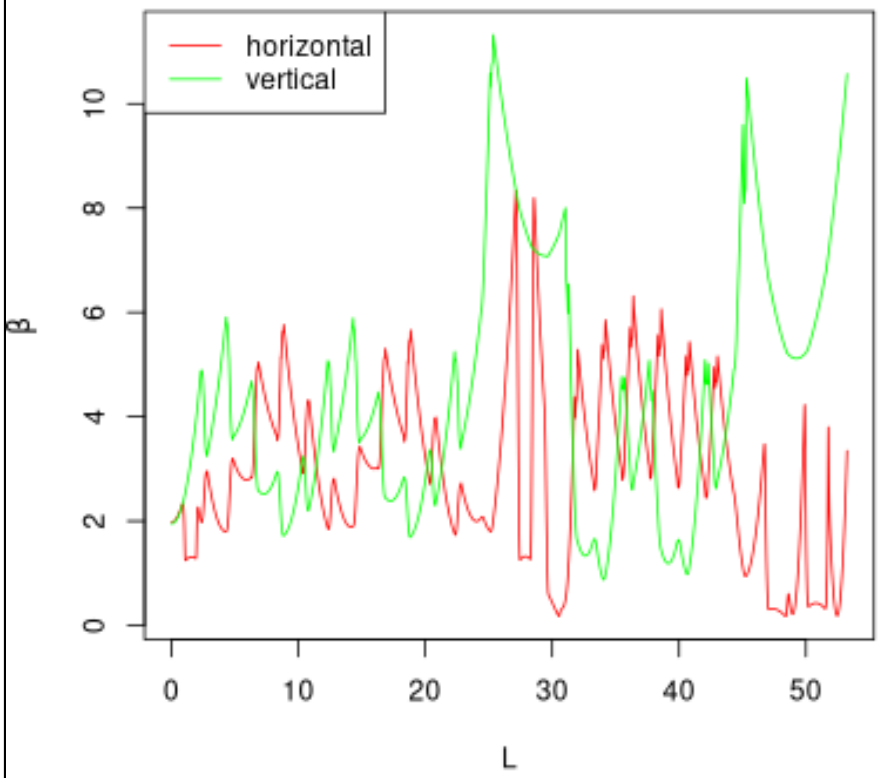
Complete beamline

More quads and the final two 90° magnets

MADX



OPAL



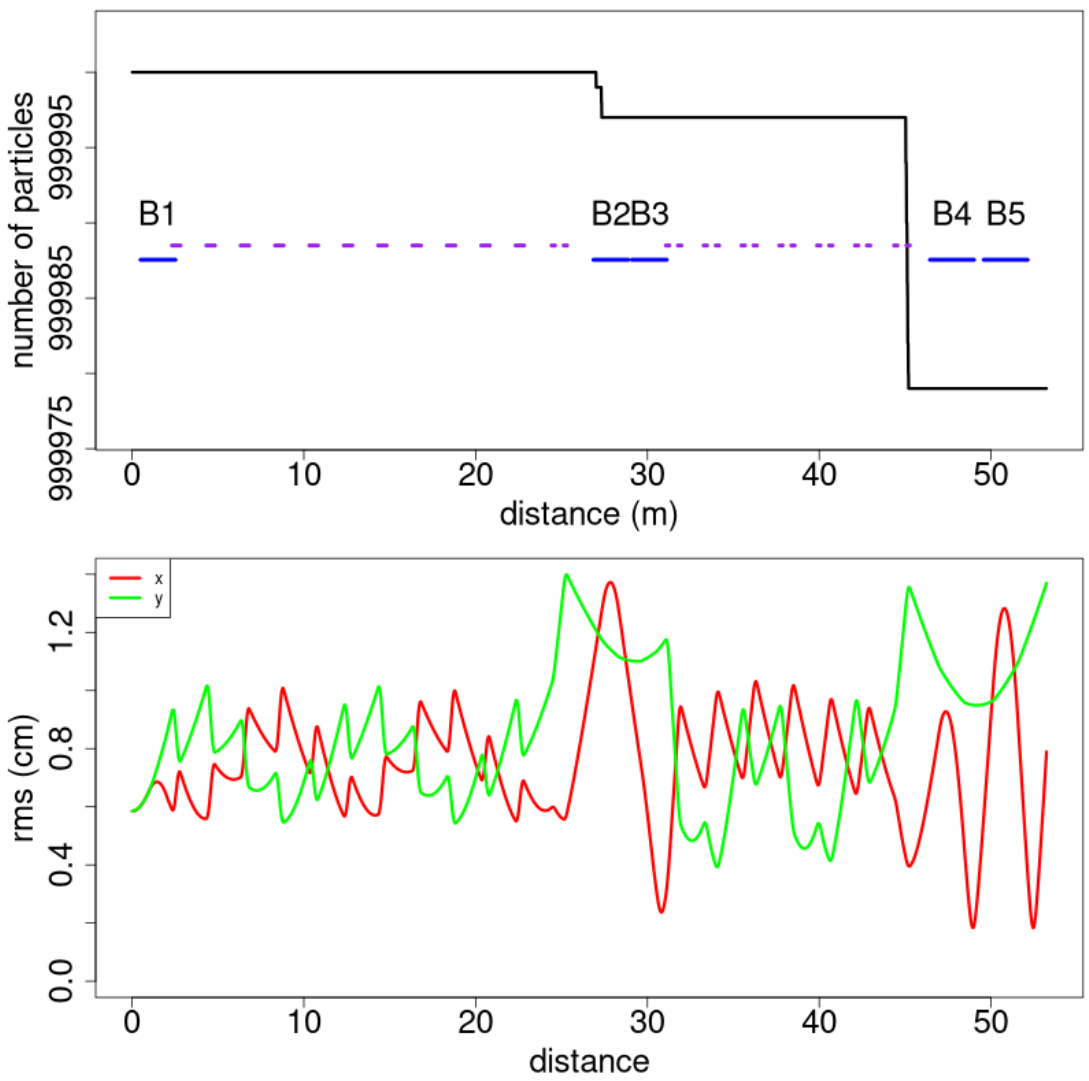
Optimised with MADX but still looks viable with OPAL

Not perfect, but will do as a straw-man design.

Beam losses

Assume 10 cm diameter beam pipe
rms deviations match β values
No particles lost (out of 6000 - not very stringent)

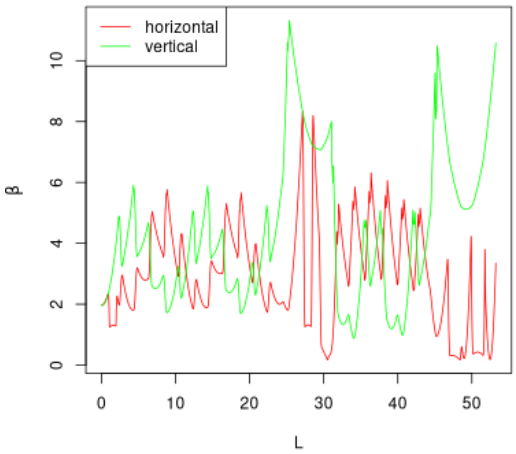
Repeat with 1,000,000 particles (takes about 20 hours, using 8 cores)
21 particles lost
Looks very nice...



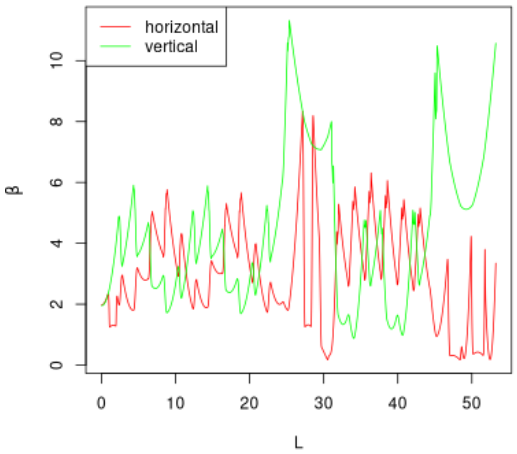
Space charge

No apparent effects at our beam current

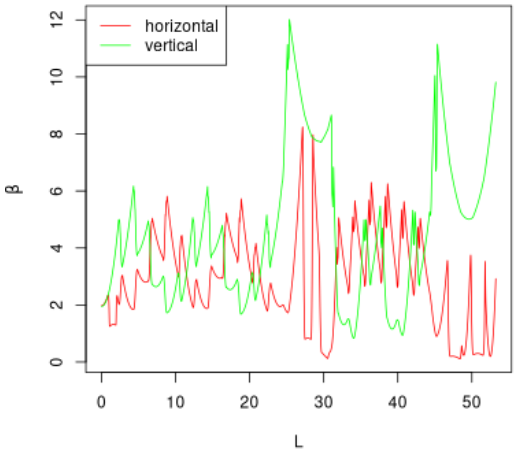
Off



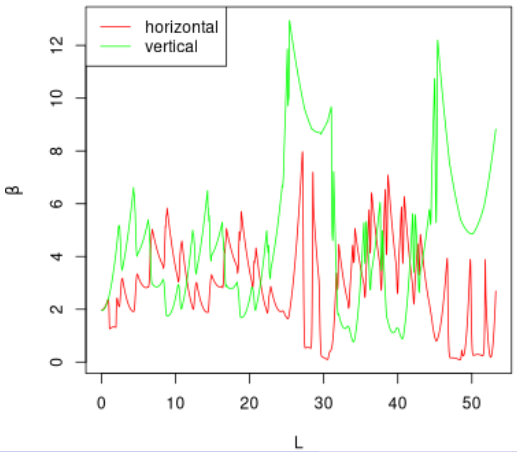
On, 10 mA



On, 25 mA



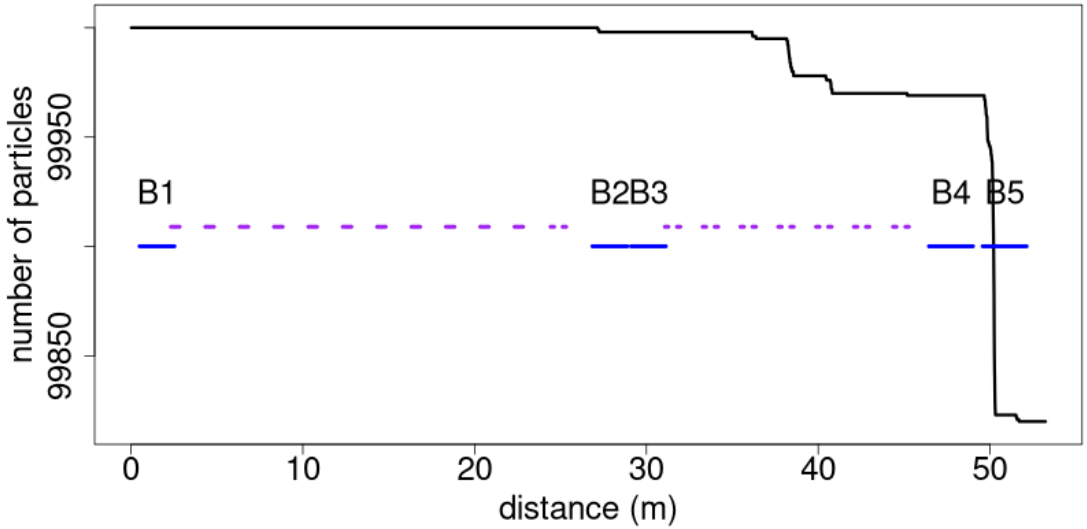
On, 50 mA

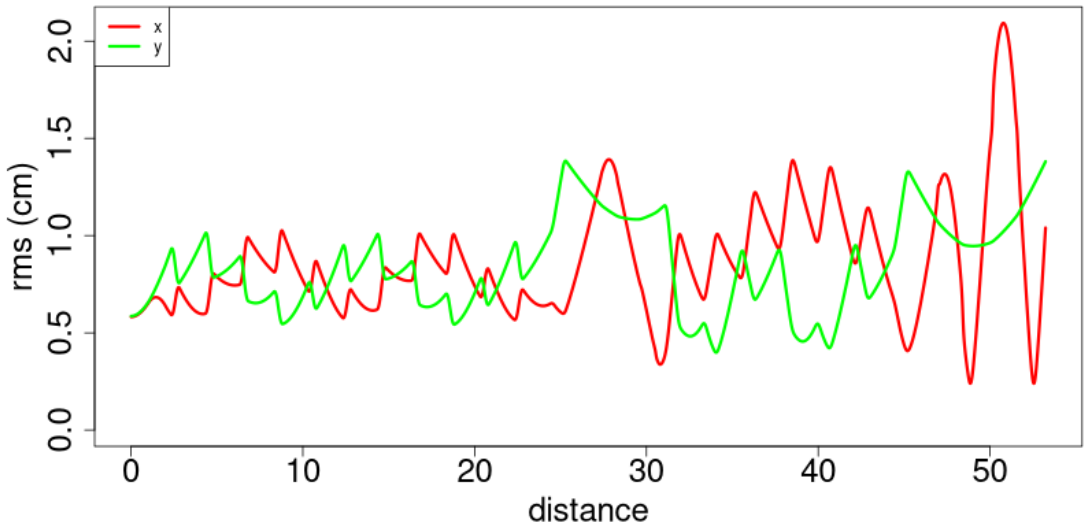


Energy spread

Quoted as 0.17 MeV

Run with 100,000 particles (about 2 hours)





Significant losses.
200/100000

Linked to larger horizontal spread at large L

This is a (fixable) problem.

Conclusions

1. The MEBT is straightforward, as expected. Low ($< 1W/m$) losses are achievable.
2. Can use MAD to optimise and OPAL to verify
3. Need another round of optimisation to reduce large β values upstream of both magnet pairs
4. Must also reduce horizontal spread in later part of beamline, possibly increasing vertical spread, to accomodate σ_E. Could increase beampipe size in final few metres.
5. Should also look at lattice designs using fewer quadrupoles.
6. Beam on target will be a Gaussian ellipse with dimensions around 1 cm.
7. Final MEBT design will need definitive description of beam emerging from cyclotron and stripping foil

All very boring (in a good way).