Muon Collaboration

Cooling Channel status using Geant

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Fermilab

Muon Collaboration

Outline

- SFoFo Status: New Matching Section, window size/shape.
- Detailed Beam Optics:
  - Non-paraxial features.
  - Match quality and betatron resonances.
- Current vs anticipated performance.
- Required Correlations, I.L. + bunchers.
- New potential problem: “Field induced multipactoring” in cavity.

The Conclusion will be…

- SFoFo is very interesting…
  - Pushing the state of the art in simulation techniques.
  - Learning new beam physics…
- BUT, is it the right channel to propose for Feas. II ???
- The Single – Flip (or Double Flip) resolves many problems, and is therefore simpler to build!
- Please, let us honestly acknowledge that we still do not know yet which configuration is the best and we should at this point pursue both options with equal priorities.

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Geant4 Simulation Results

Geant4, mostly, not DPGeant, as it easier..

(IL + Buncher + Cooling Channel + multipactoring simulation are in.)

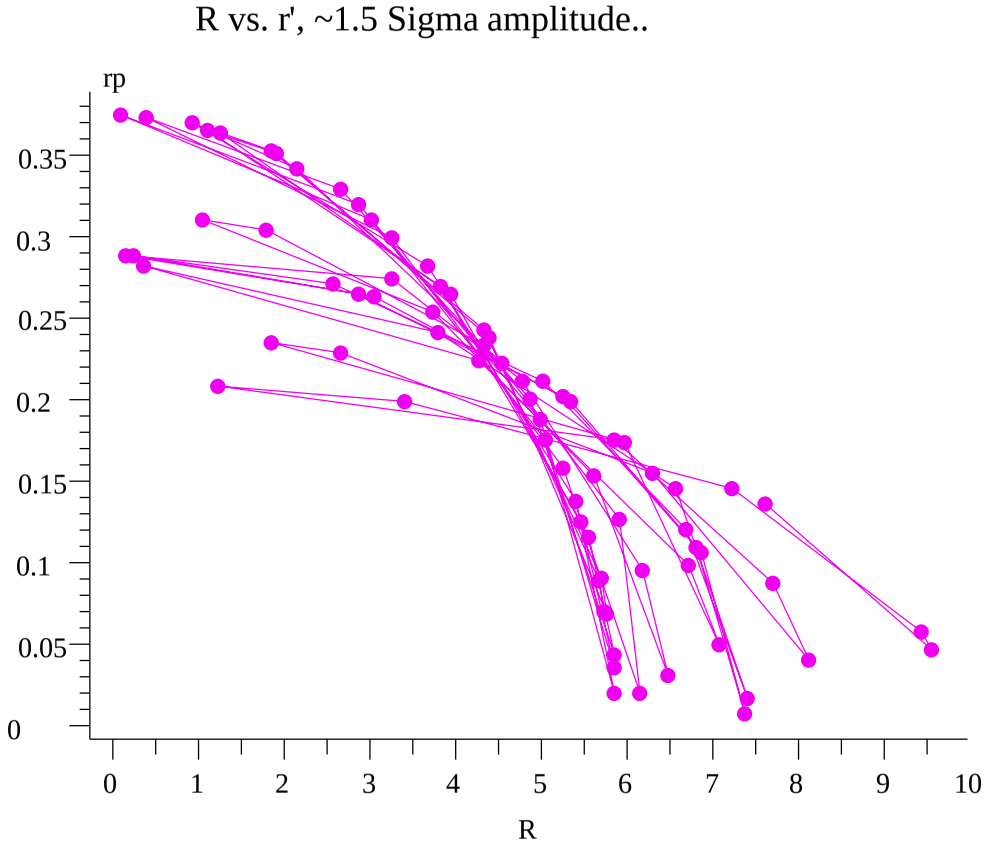
{ Benchmark DPGeant – Geant4 done.

But DPGeant still supported !

-> SFOFO, version 2, (Nov. 28) is in.

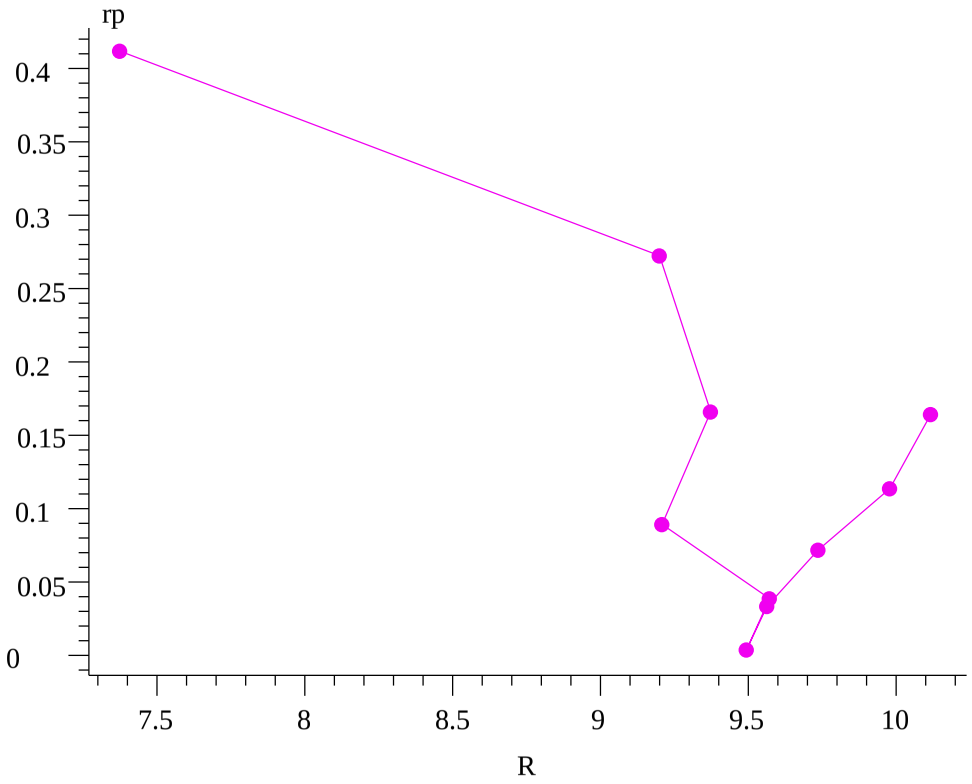
{No grids yet .. (few man-days to implement).}}

Non-Paraxial Features



At larger Radius…

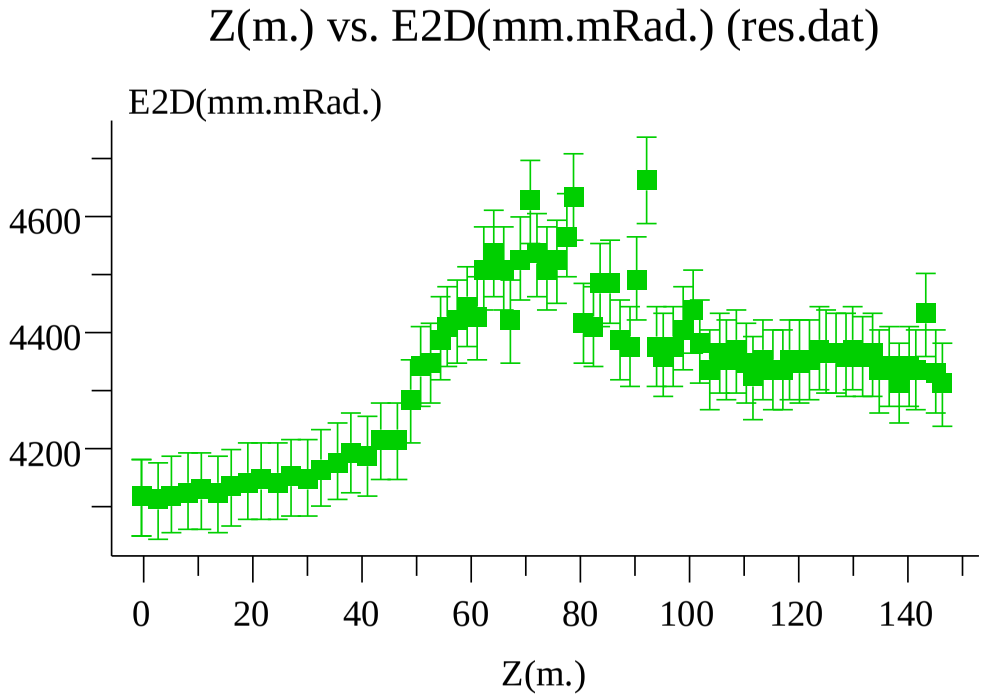
R vs r' , large ~ 3 sigma) amplitude...



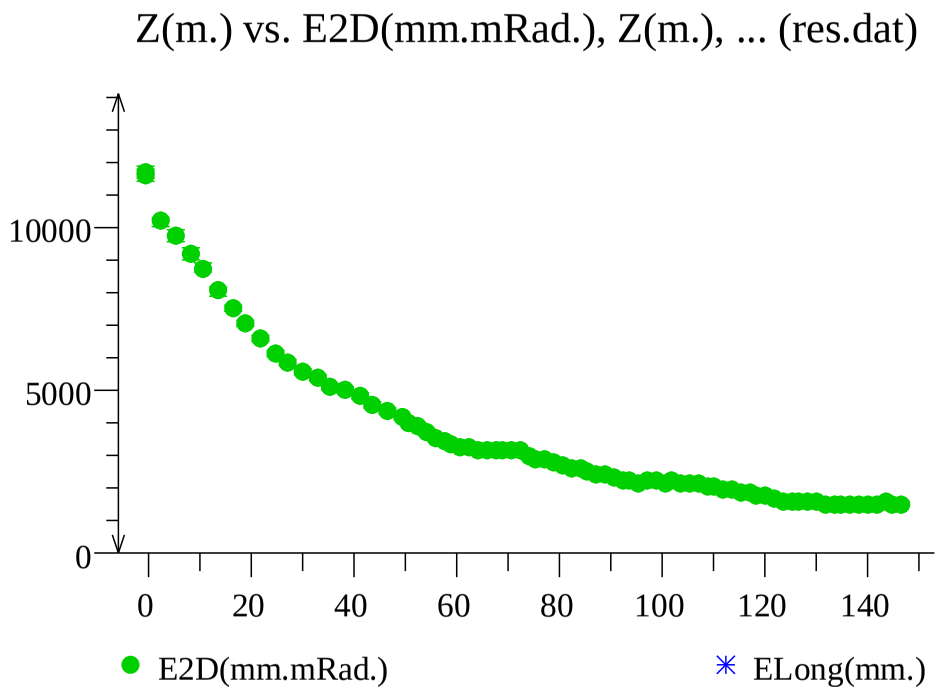
Tricky calculation…

- Particle wonders in very inhomogenous regions.
- Numerical accuracy of field maps at large radius matters.
- Moment calculation becomes unpredictive..
- These tracks were dead on nominal momentum !!!.

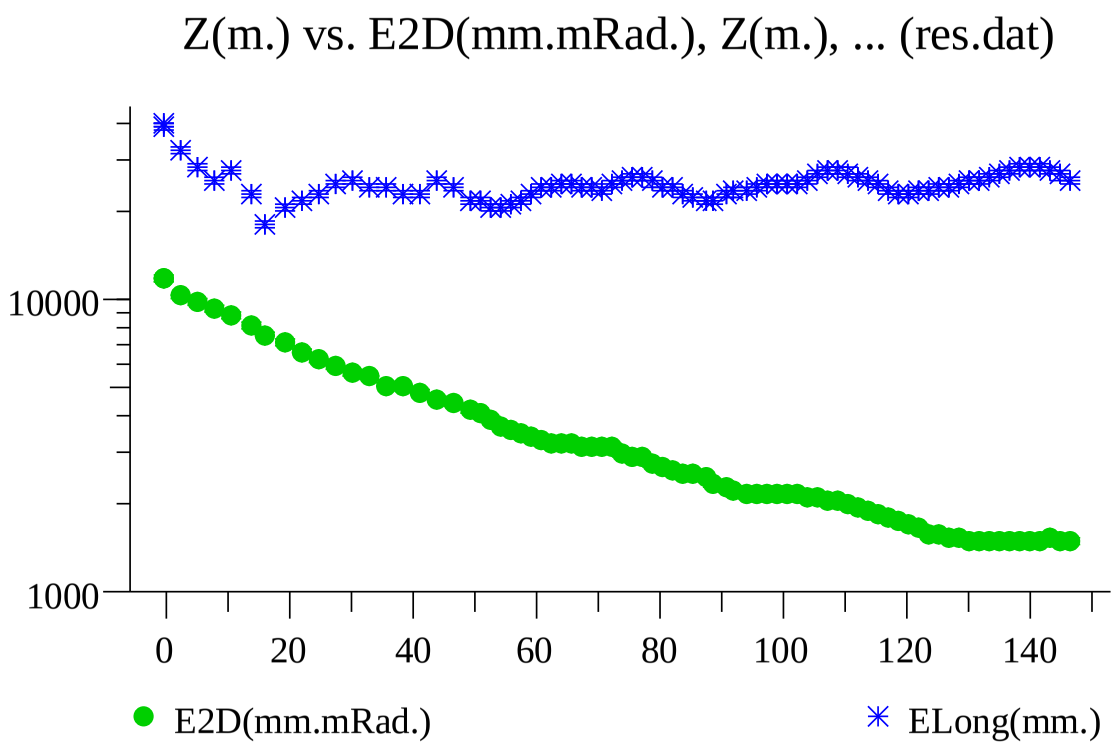
Emittance, Empty channel.



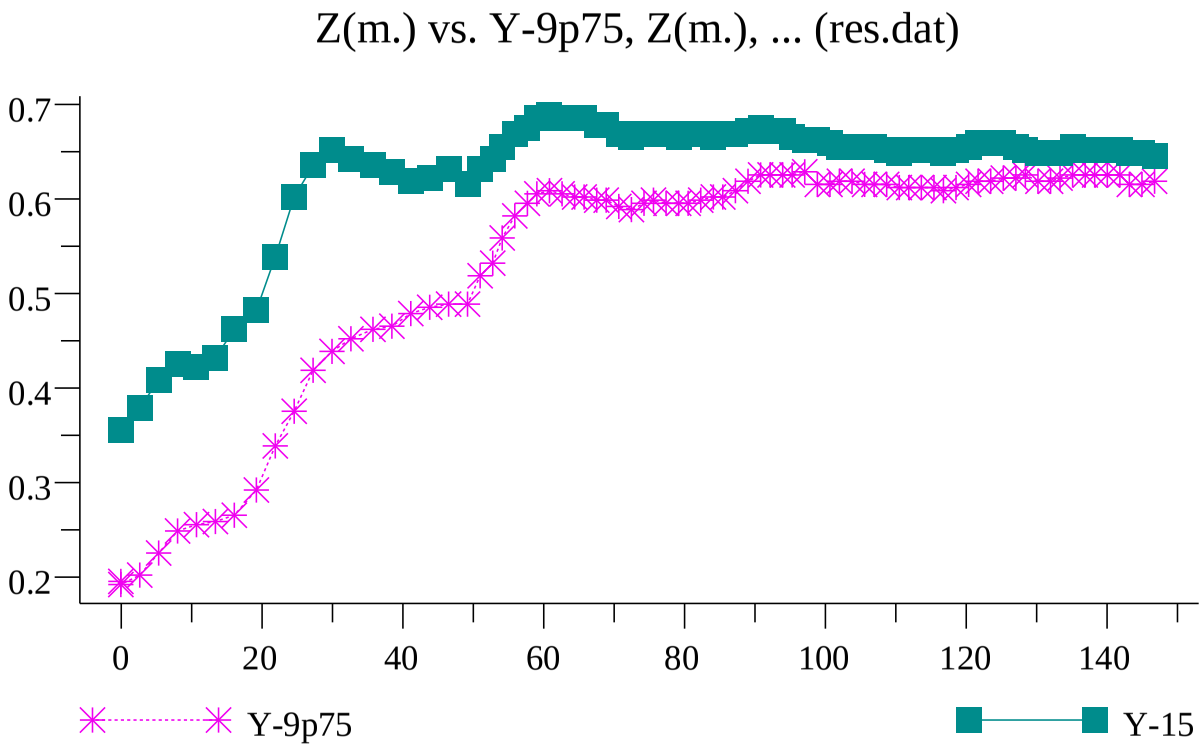
Emittance, 2D, No mult. Scatt..



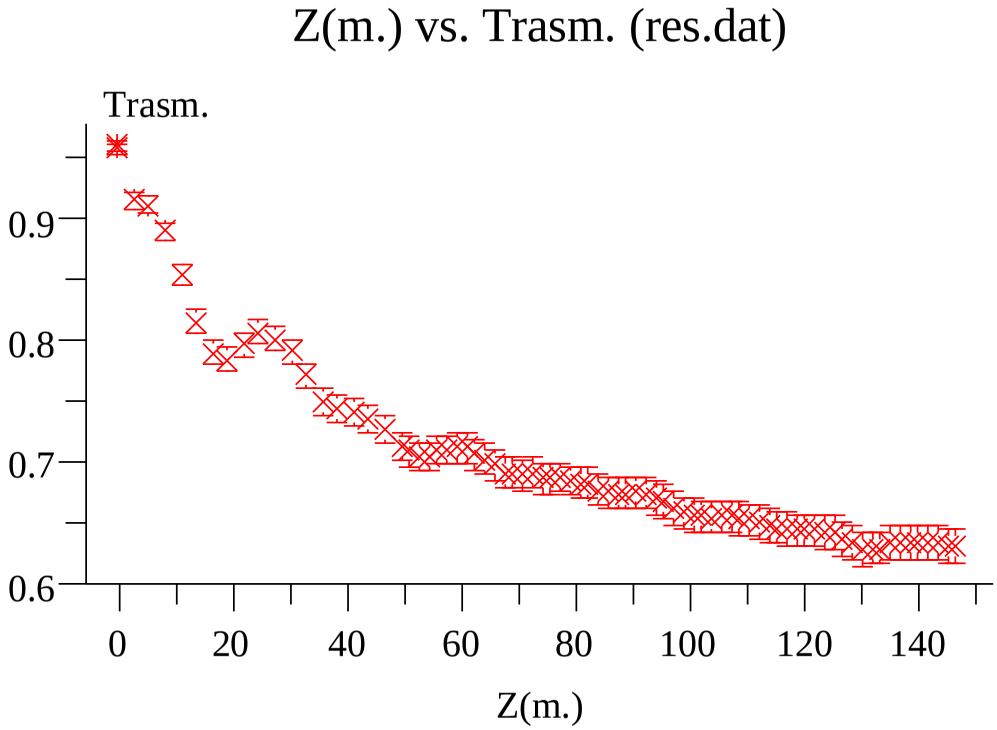
Emittance, 2D, (same sample)

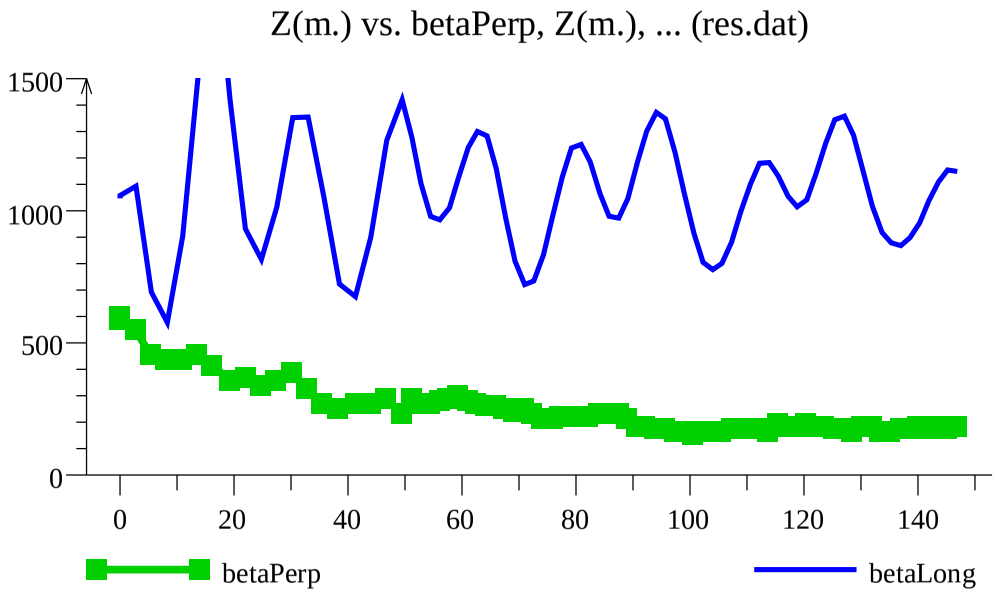


Yield in Acc. Accept.

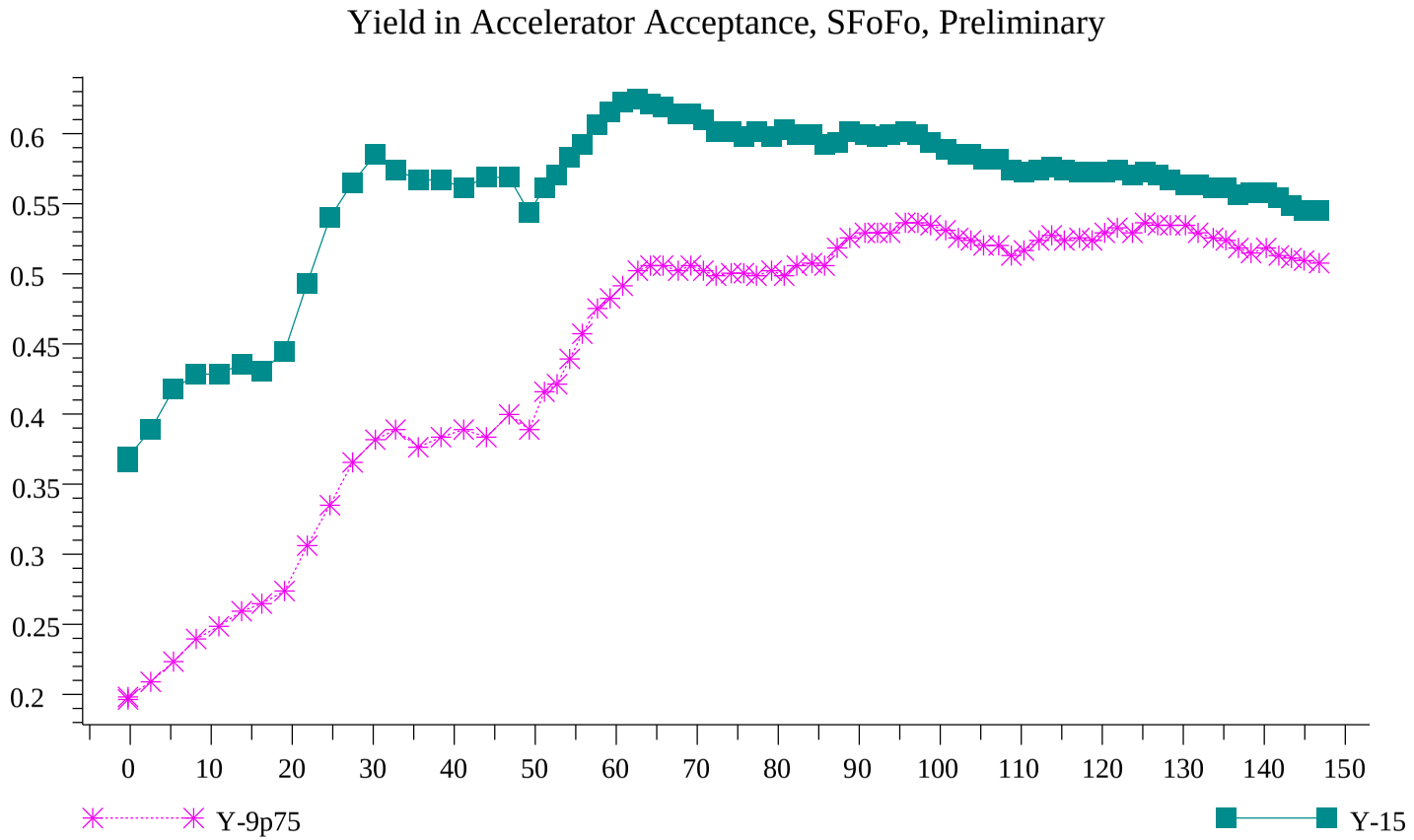


Transmission.

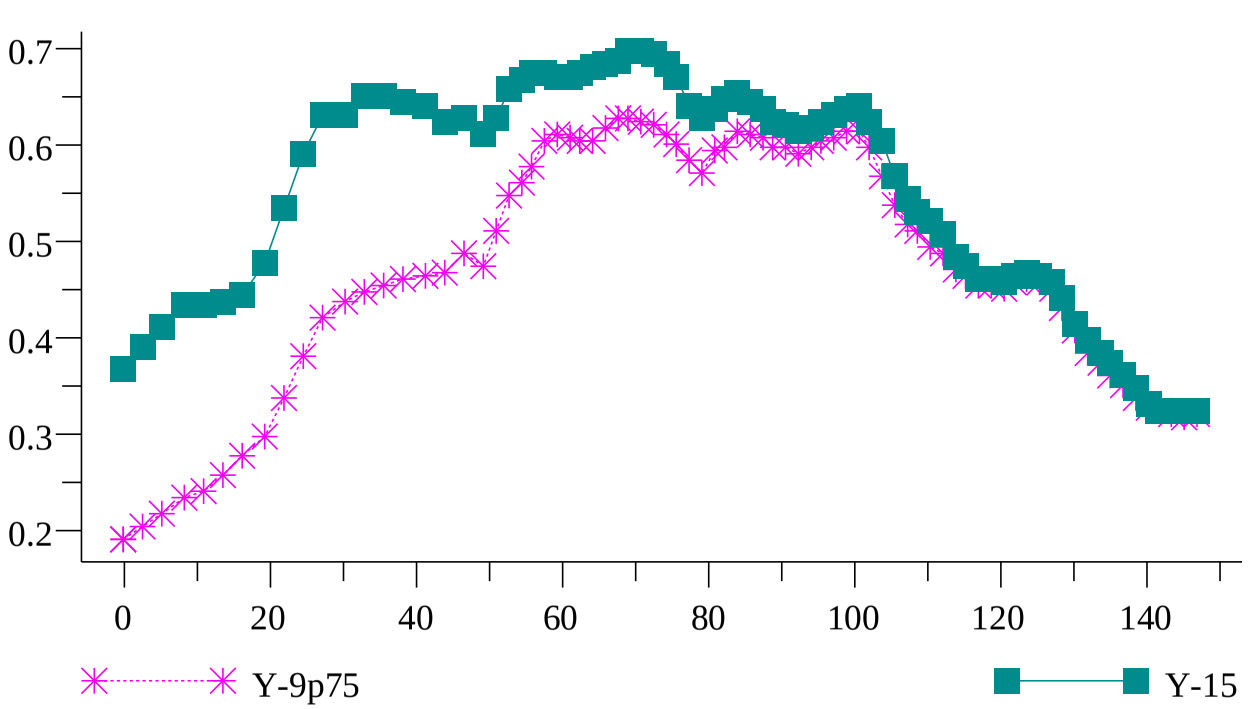



Z(m.) vs. betaPerp, Z(m.), ... (res.dat)
1500
1000
500
0
0
20
40
60
80
100
120
140
betaPerp
betaLong

With Multiple Scattering..



Slightly mistuned r.f. (No multiple scattering).



Ongoig foil/aperture optimization..

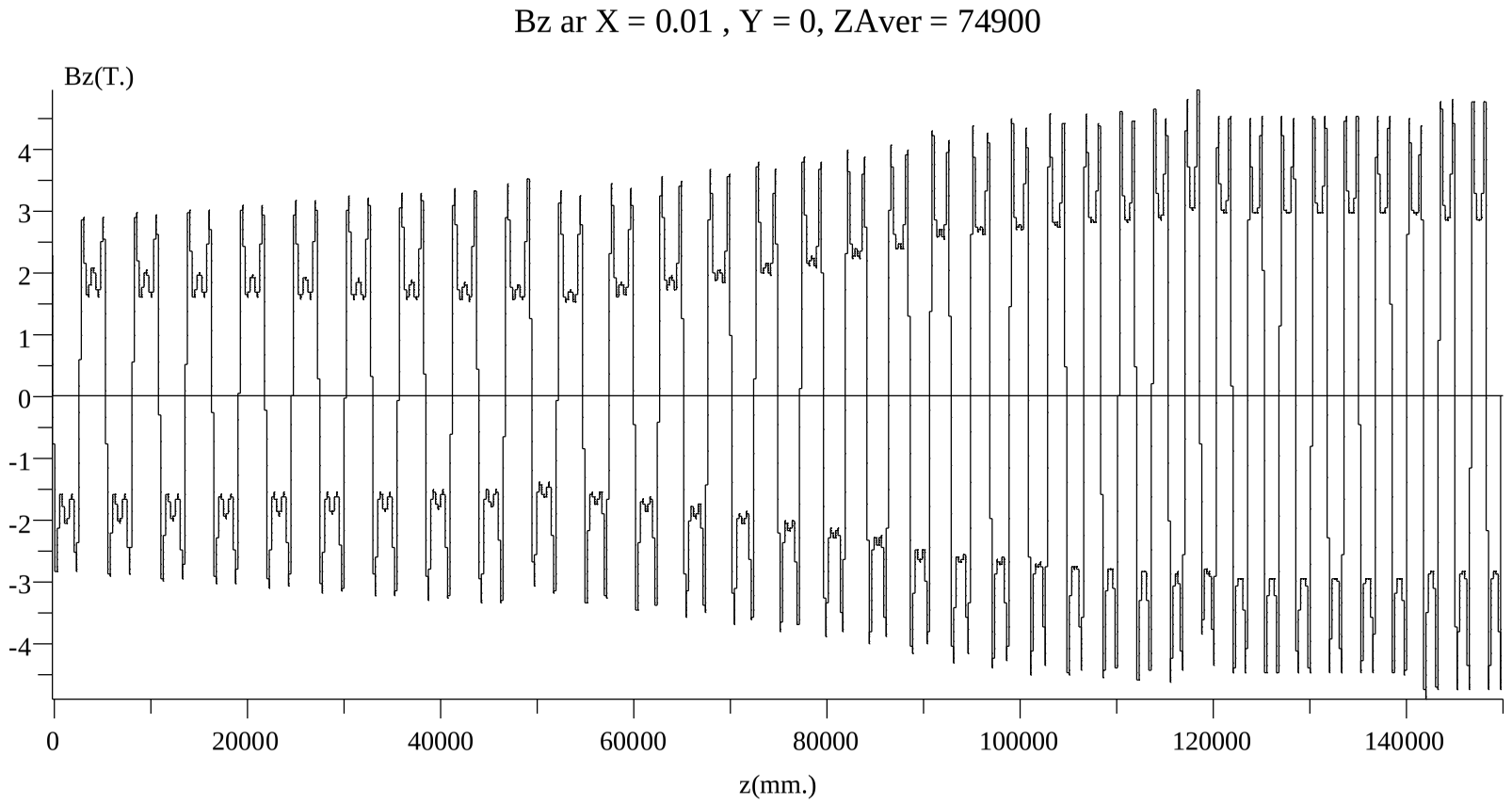
- Need to slightly change the average energy/gain per cell, energy loss in the window starts to count!.
- So I don’t the exact numbers corresponding to Bob’s, Nov 28, ..

However…

Performance still limited by beam optics, not multiple scattering!…

- Matching section need more work.
- Note: it has a new coil. The last cell of the (1,3) part has either a different absorber or a different Linac, as it won't fit.
- A better match will invariably make more mechanical adjustments.
- Leading towards the fully tapered channel..

Smoothly decreasing beta.



Fully tapered Lattice..

- Not a lattice !
- Every cell is different, although it only double the number of cavity lengths/Linacs.
- Still too complicate.
- Not yet optimum: min beta does not decreases as fast as it should (~6% per cell optimum), got only 1%..

Other studies...

- The buncher does correlate the beam, but it picks the “matched” part of the 6D phase space. (for all calculation, Atr = 700 MeV was used.).
- The match going into the (1,1) lattice need more work, 20 % emittance increase.. Not good enough !..
- The matching out of the (2,3) section will very hard: the bucket is already full, tucked in between two resonance: can not accelerate! -> must do a transverse match first. This will invariably dilute the bucket..
- And….

Other studies...

- The induction *could* correlate the beam, but imperfectly: At a fixed momentum, small bunch length (with respect to 200MHz), the drift followed by an I.L. can accelerate the high transverse Pt particles, if the right value of Bz is set. However, it won't correlate with the transverse position. So this correlation works only for the first section of the single flip..

Multi-Pactoring

- In absence of static magnetic field, this occurs only, if any, at a transient voltage, for a well engineered cavity.
- However, for a non-trivial, large static field, there are many paths a low energy electron will follow. If this path has the right length (matching the 1/beta of the cavity), back-and forth resonating condition are set.
- In addition, the field is at some location at large angle(45 deg.) with the cavity axis, allowing for transient, but large cyclotron motion.
- Interesting simulation to be done!….

Multi-pactoring in Geant4...

- Geant4 has a new “low e.m. simulation package” , close to X-ray range (9 KeV is the energy cut for electron in Beryllium).
- There are software caveats, though..
- So.. Let 1 MeV loose in the cavity (we got plenty of those..)
- If B = 0, o.k., 30 % more electron created, few MeV each.. Cute e^+ e^- annihilation peak, nice spectrum.
- If B nominal, event 1289 ran out of virtual memory..
- To be pursed!..

Single Flip…

- The basic advantage: Allows us to decouple the r.f. design from the magnetic field!.
- R.f. less demanding !.. Uniform beta function allows for thicker foils.
- Correlation are easier to bring about.

Other studies...

- The buncher