Simulations of the Study 2 Cooling Channel with Realistic Absorber Windows

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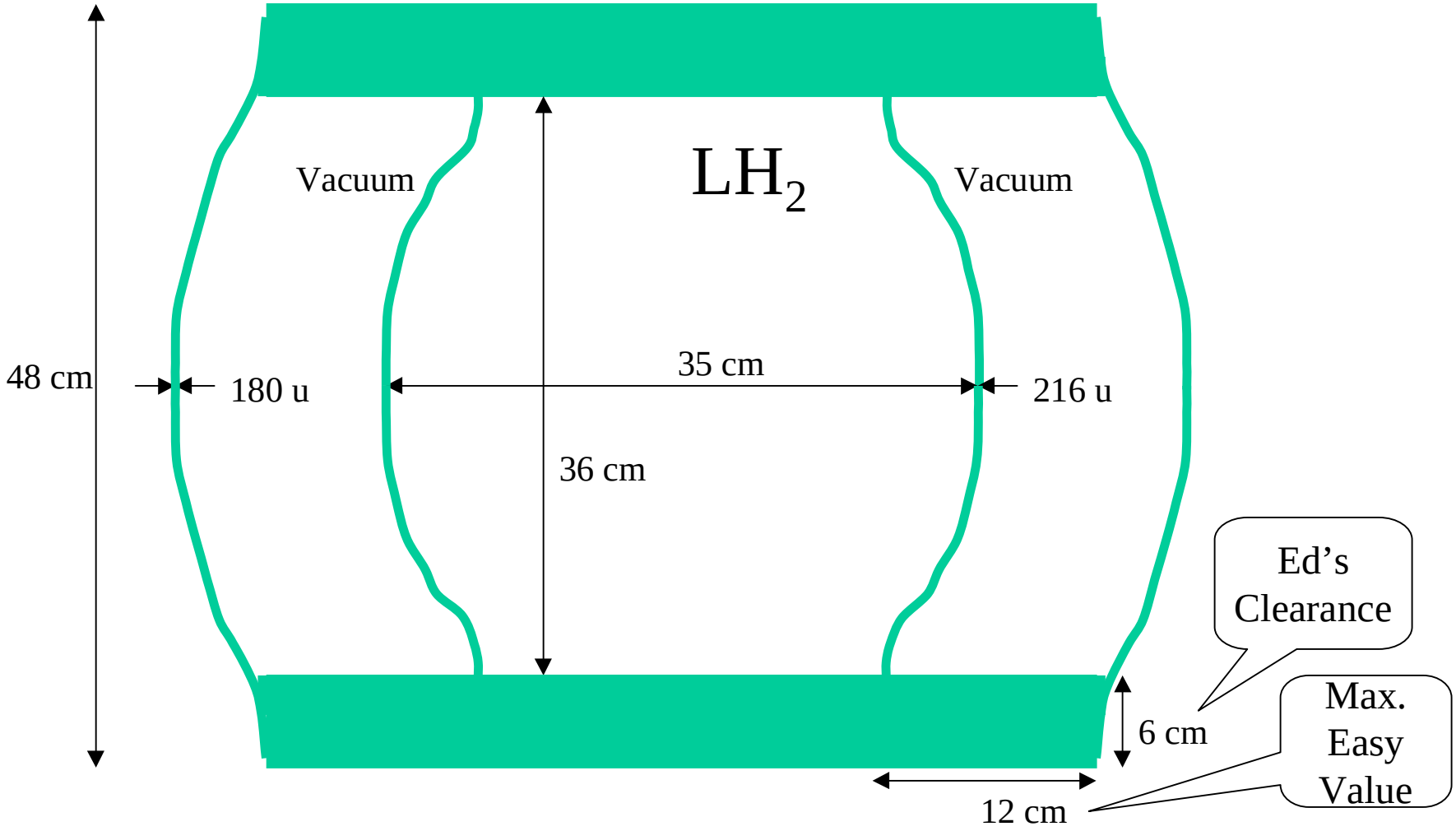
Geant4 Simulations

- This is a complete reimplementation of the Study 2 Cooling channel
  - Geant4 5.0
  - Fermilab Beam Tools 1.0
  - HistoScope 5.0
- All results use the 2631 events from EmittBunch5-207-Cooler.hst
- Revised Vacuum Window dimensions from my previous talk on Wednesday.

Bellows Absorber Windows



(This is a hand-drawn figure roughly to scale, actual window data are from H2-Bellow-Window-concave-convex-coord-3.xls)

Summary at End of Cooling Channel

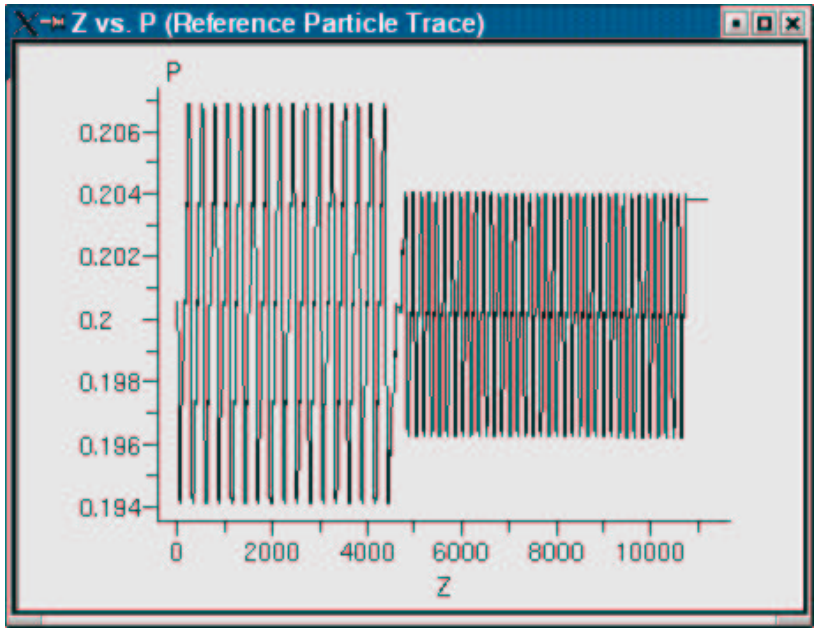
Windows	**E2D Trans. (mm mrad)**	**E2D Long. (cm mrad)**	**Mu/p into Acceleration***
Flat (Study 2)	2700	3000	0.171
Flat (no VacWin)	2554	2151	0.199
Bellows (no Vac Win)	2560	2049	0.195
Bellows (with VacWin)	2694	2024	0.187

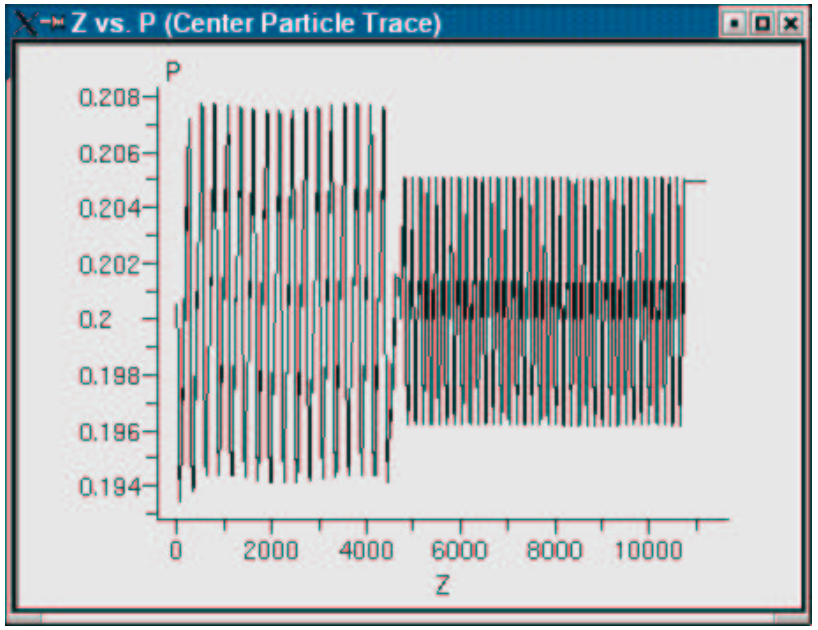
* Cuts: $140 < P < 260$ MeV/c, $|Dt| < 1.1$ ns,
$Acc_{long} = 15{,}000$ cm mrad, $Acc_{trans} = 15{,}000$ mm mrad

Tuning RF Cavities

- The approximation used to set the RF cavity timing is not good enough – synchrotron oscillations for the center particle of 5-10 MeV/c are common (that's a disaster).
- Individually tuning the first 2 cavities of each section permits tuning those oscillations down to ~0.2 MeV/c.
- My tunings differ from Study 2 by up to 20% in MV/m. The largest is only 5% above Study 2 values.
- HistoScope provides features that make it much more efficient to manually iterate tunes.
- A more accurate automatic tuning method is needed, as my manual tunes are clearly not optimal. I'm working on one.

Good RF Tune

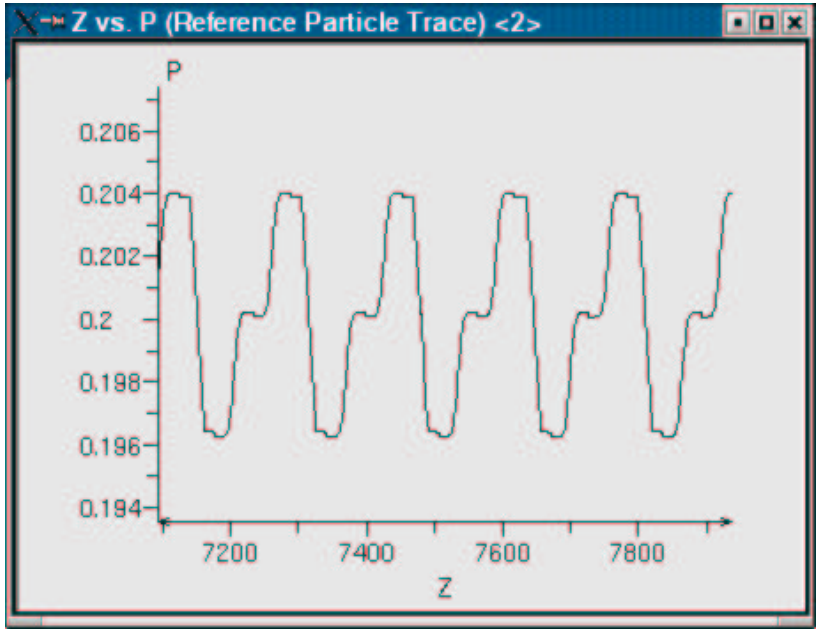


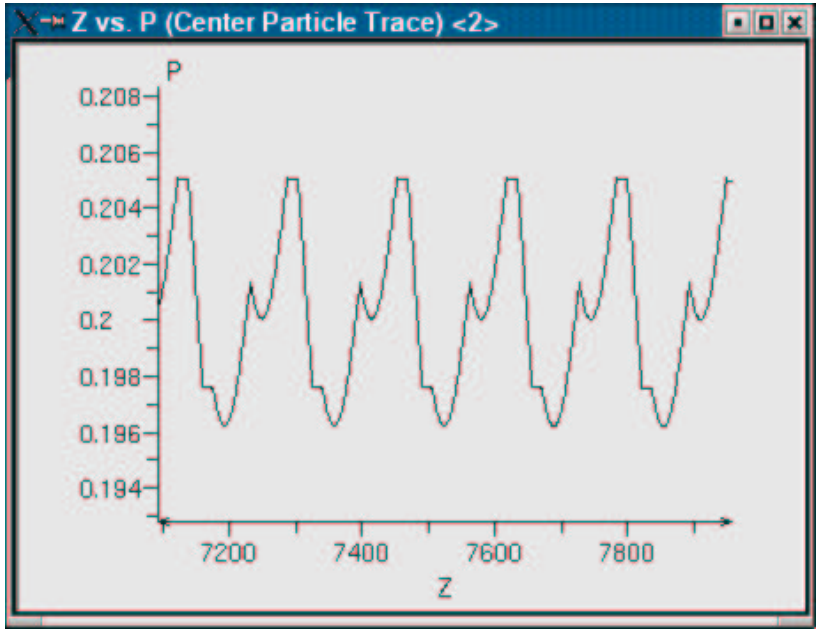


Momentum of the reference and center particles as they propagate down the cooling channel. Z is in cm, P is in GeV/c. The beam starts at the center of the first absorber and exits after the last RF cavity. The muon loses ~13 MeV/c in the 35-cm absorbers and ~8 MeV/c in the 21-cm absorbers. I am unable to eliminate the ~0.3 MeV/c synchrotron oscillation in the first section

Good RF Tune -- Not Really So Good

(These are just Z-expanded views of the previous graphs.

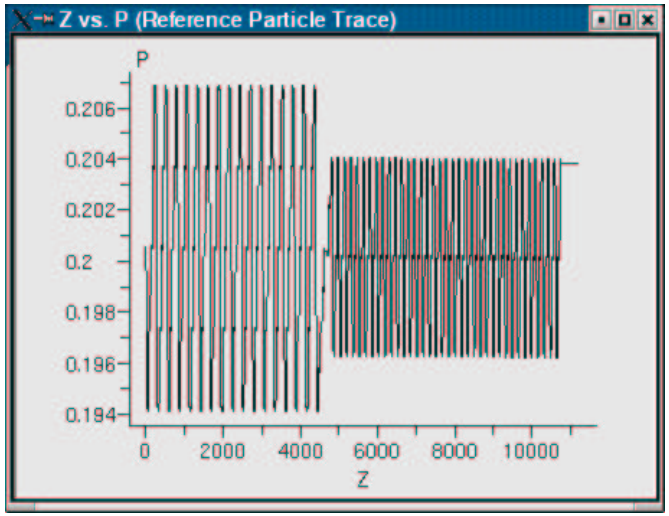


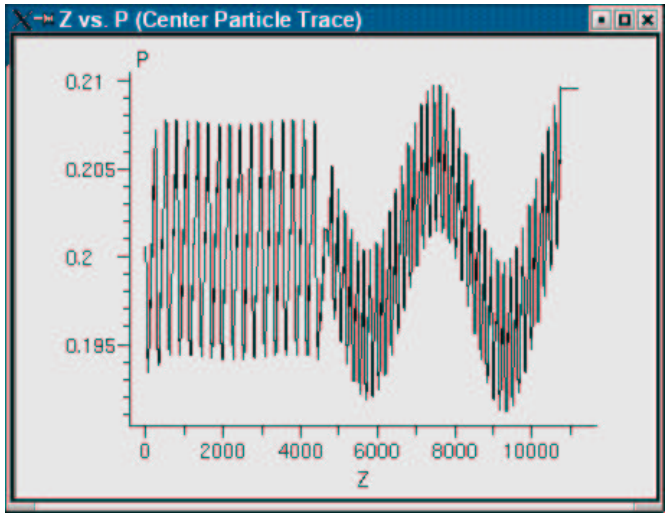


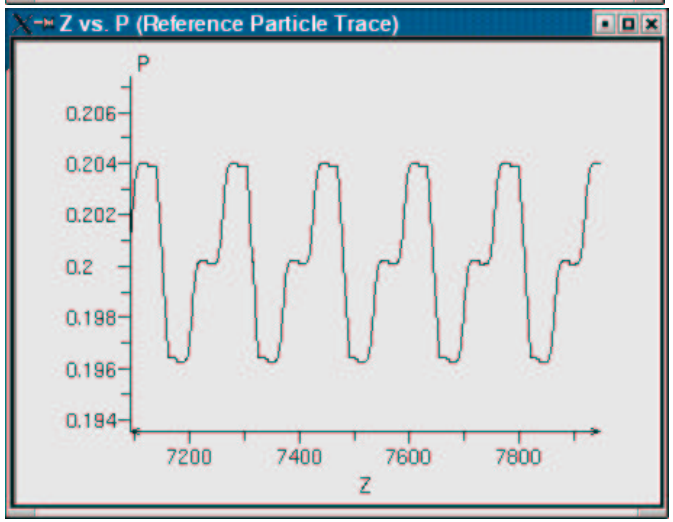
Note that the Center Particle LOSES momentum at the front of each cavity, then gains it back plus absorber loss.

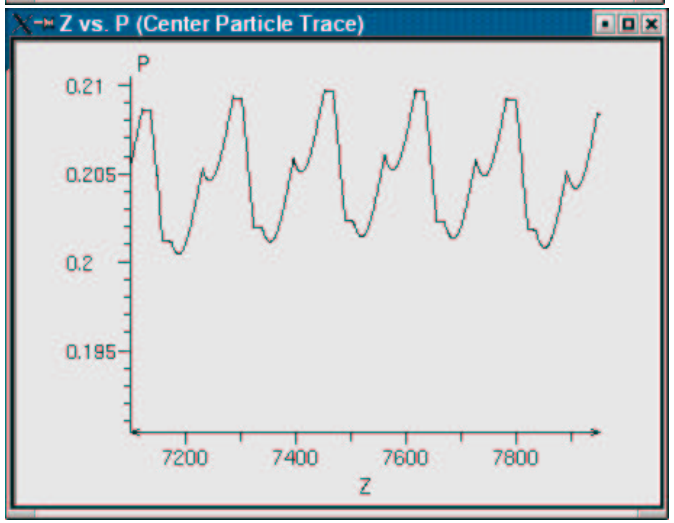
Poor RF Tune in Last Section

(Last section mistuned to induce 10 MeV/c synchrotron oscillation)

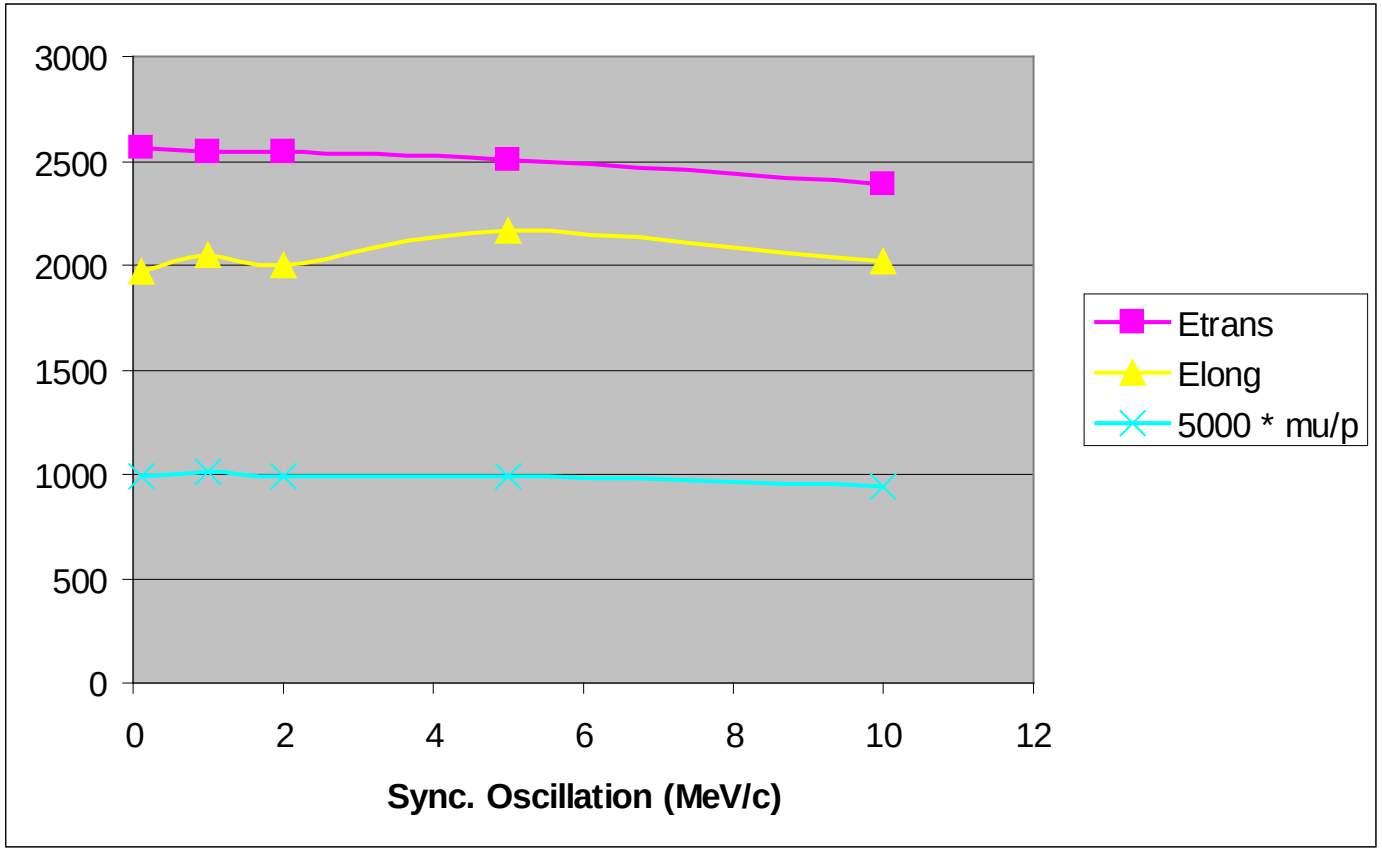








Emittance and Yield vs Synchrotron Oscillation Amplitude



Conclusions

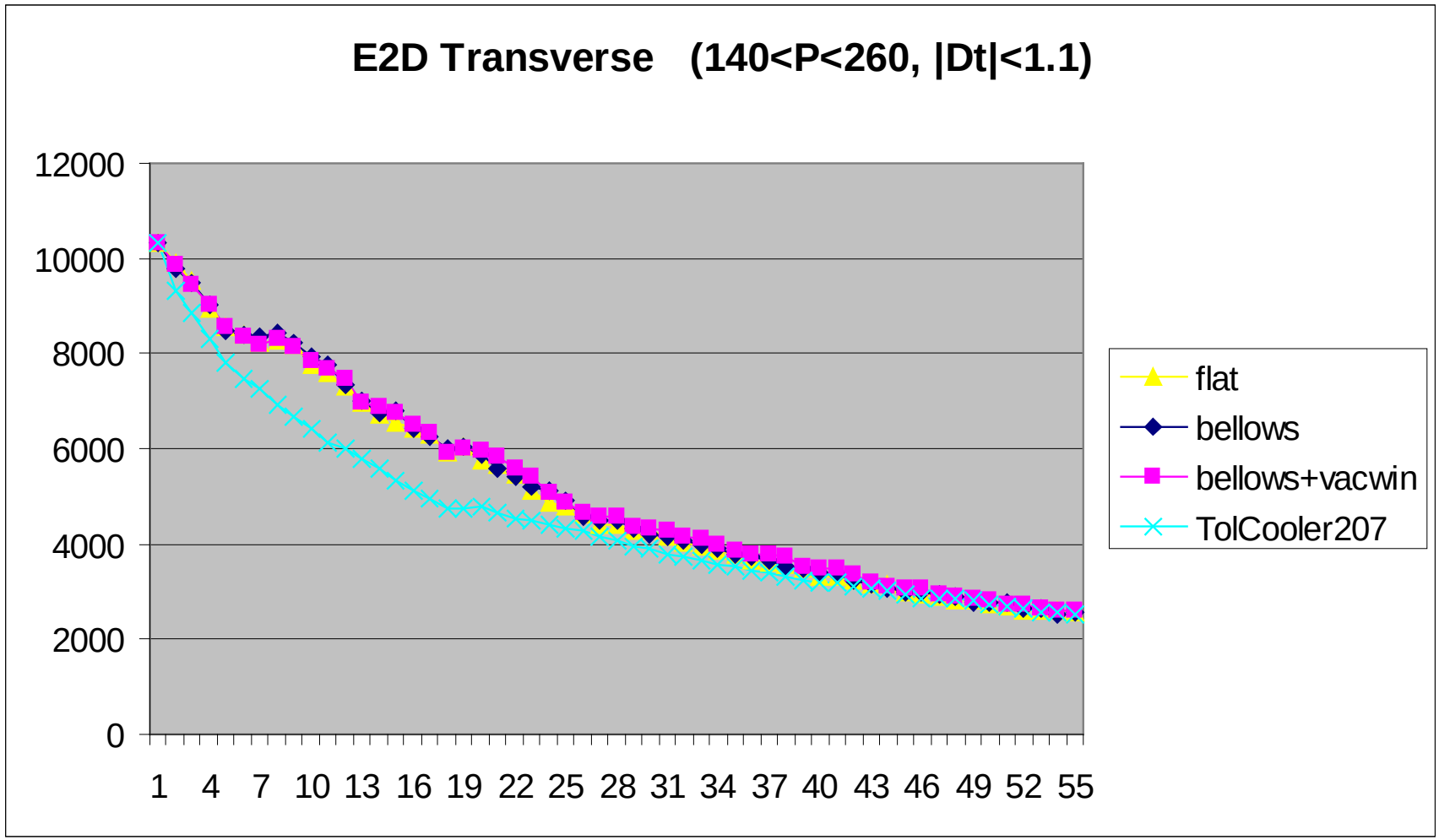
- RF Tuning is more subtle than I thought. There are still puzzles – why are emittance and yield virtually independent of the synchrotron oscillation of the center particle?
- The bellows windows used in these simulations should achieve cooling performance comparable to that in Study 2.

Backup Slides

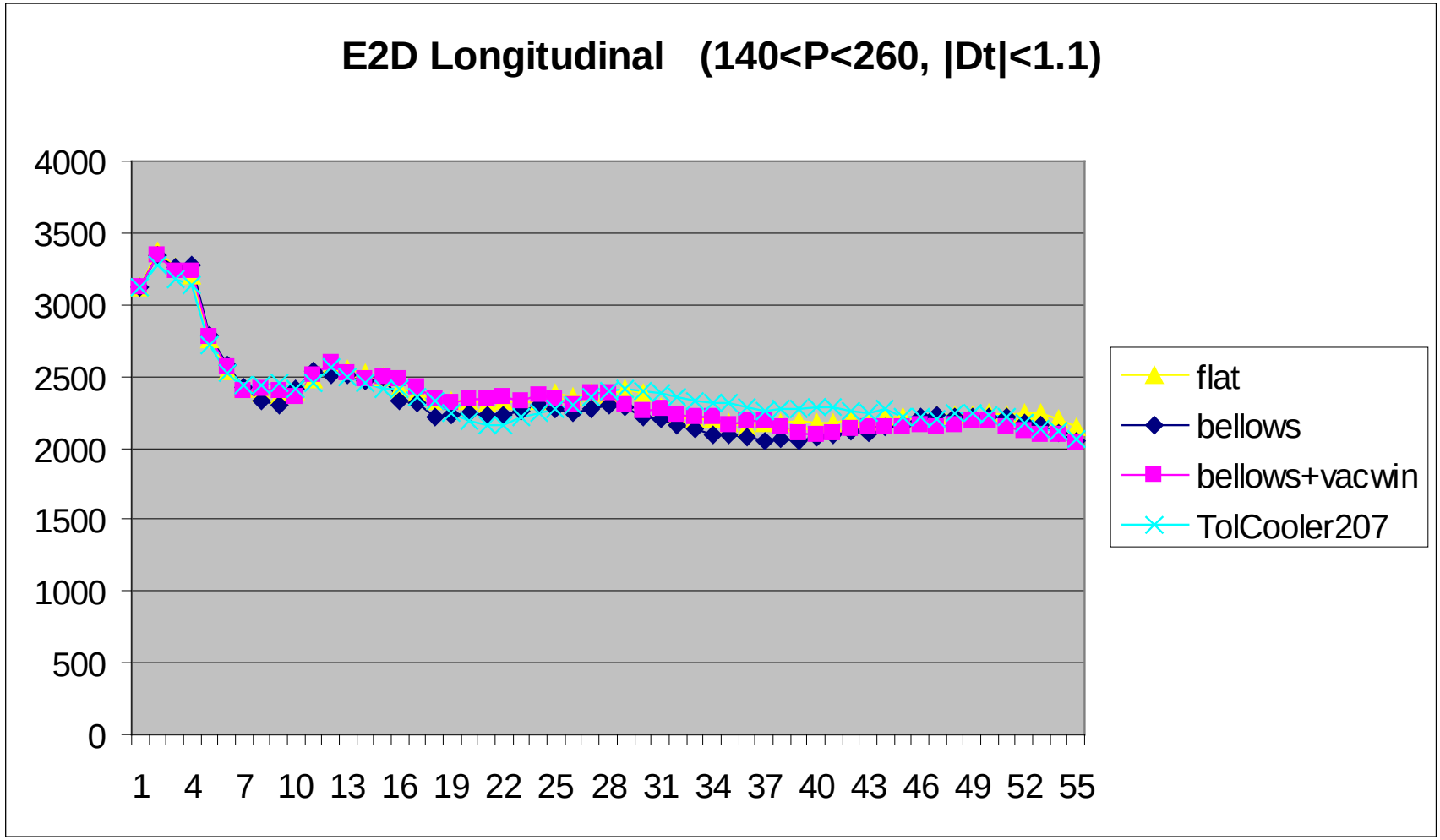
Beam Characteristics at End of Cooling Channel

Channel	**σ_x (cm)**	**$\sigma_{x'}$ (mrad)**	**σ_p (MeV/c)**	**σ_t (ns)**	**<p> (MeV/c)**
Study 2 Report	1.6	94	28	0.51	207
TolCooler207	1.5	79	20	0.41	210
Flat (no VacWin)	1.5	85	20	0.43	215
Bellows (no VacWin)	1.5	89	20	0.41	215
Bellows + VacWin	1.6	91	19	0.41	215

(TolCooler207 is an old run)



(TolCooler207 is an old run)



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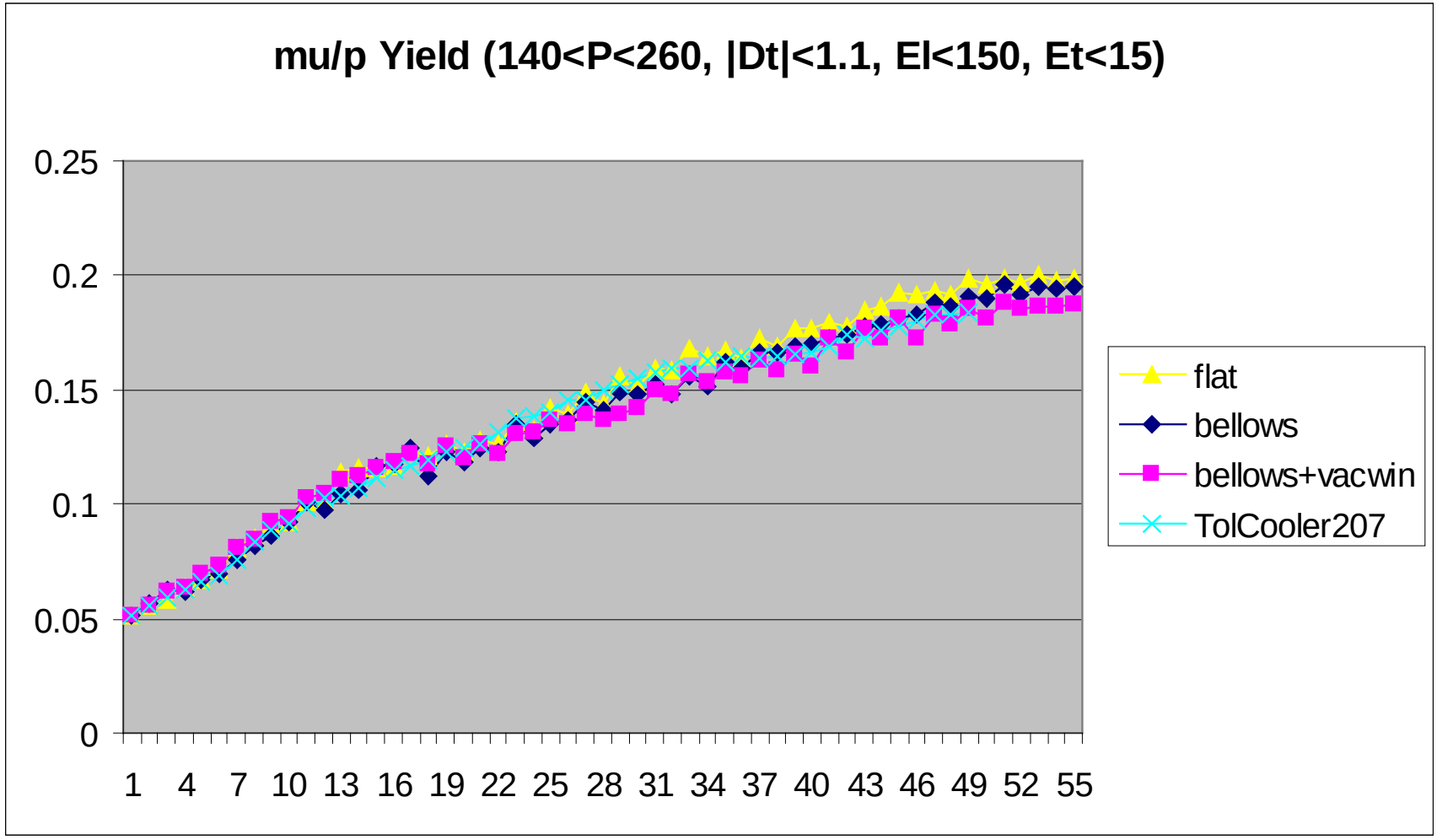

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