STATUS REPORT

V. Daniel ELVIRA 9/29/00
Fermilab

GEANT4 Simulation of a Helical Chanel (V. Balbekov's parameters)

- Simulation Code ← done by 9/17 (a few things under the rug)
- "Data" ← only 1000 events by 9/17
- Analysis ← in progress and Learn Beam Physics

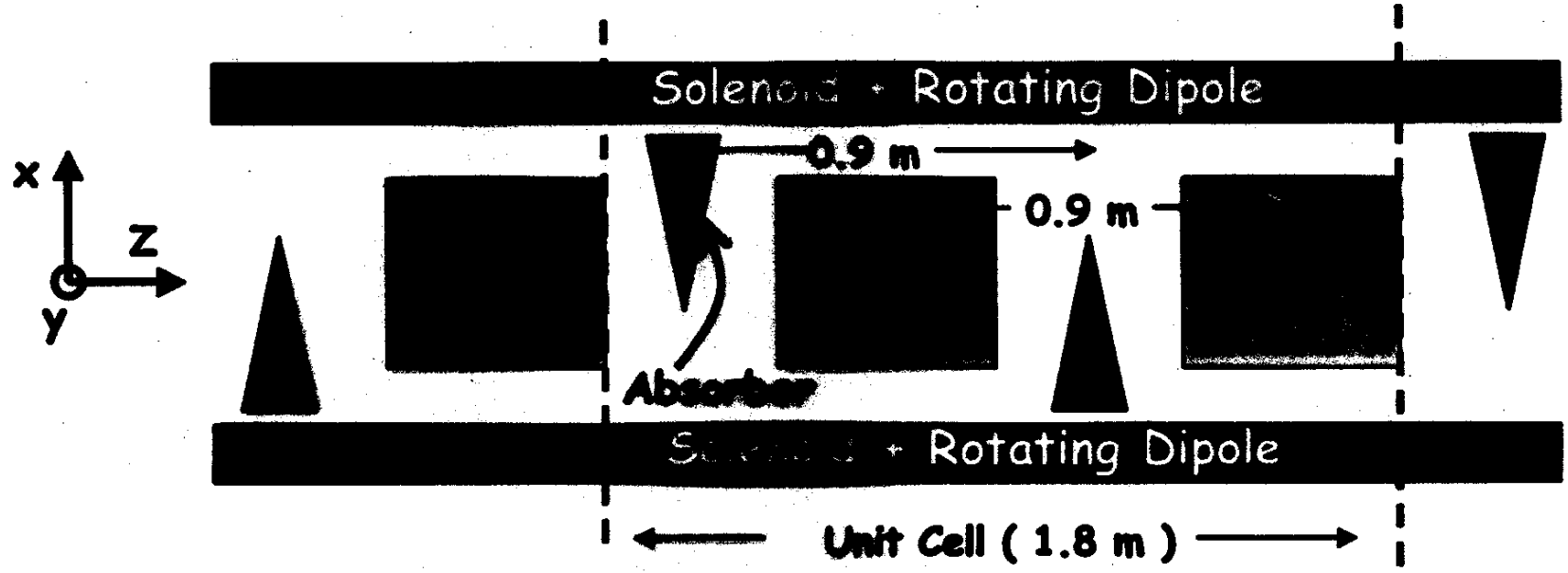
This couple of weeks....

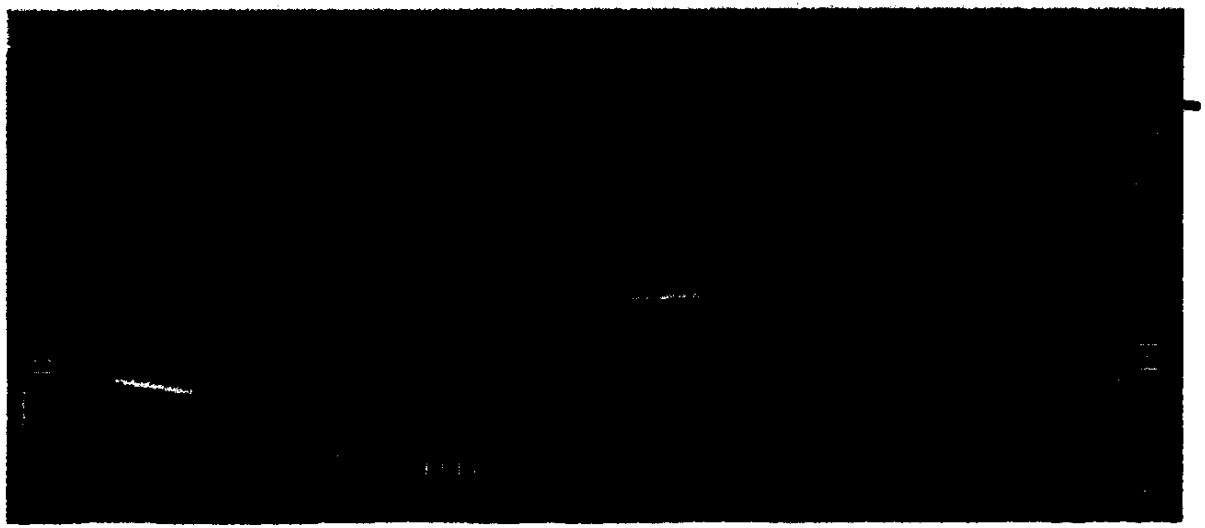
- bug in GEANT4 stepper: extrapolated Velocity > c (random crashes)
  [could produce only 50 events at a time]
- Problem in the geometry? (No!)
- Singular Emittance Matrix

FIRST BEAM PHYSICS EXPERIENCE!

Geometry of the Helical Channel*

* mostly based on V.Balbekov's design (Aug 7th 2000)





GEANT4 visualization (Open Inventor)

(the purple disks are idealized RF cavities)

40 cells long

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The Magnetic Field

Solenoid	Rotating Dipole
$B_z = f(r,z)$	$B_x = A\cos\left(\frac{2\pi}{\lambda}z\right)$
$B_r = g(r,z)$	
↑ Constructed from current distributions	$B_y = A\sin\left(\frac{2\pi}{\lambda}z\right)$
	$B_z = 0$

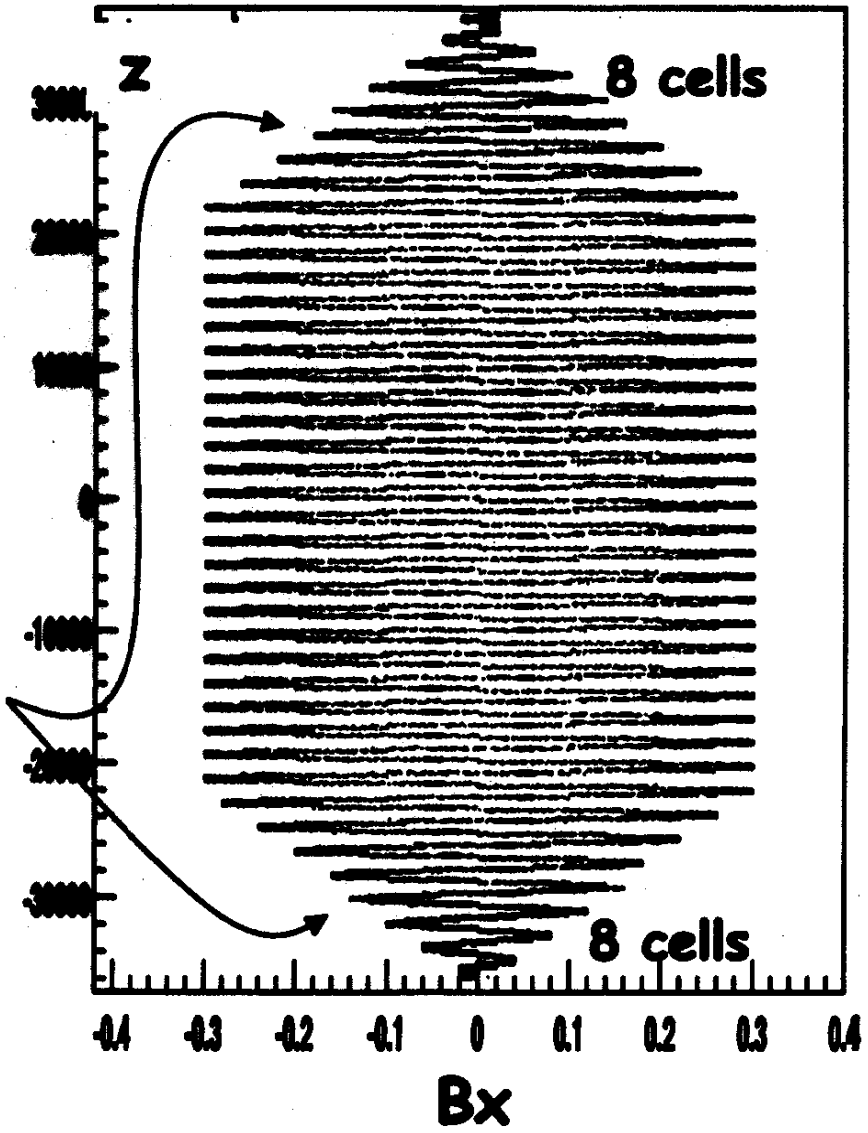
A = 0.3 Tesla adiabatic turn on/off

λ=1.8 m (dipole)

B_z^{max} = 5 Tesla (solenoid)

Parameters chosen for

Eref=260 MeV



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The Initial Beam

$\langle x_{Li} \rangle = 0 \quad \sigma_{xLi} = 3.25\,\text{cm}$

$\langle p_{xi} \rangle = 0 \quad \sigma_{pxi} = 48.7\,\text{MeV}$

Larmor centers

$\langle y_{Li} \rangle = 0 \quad \sigma_{yLi} = 3.25\,\text{cm}$

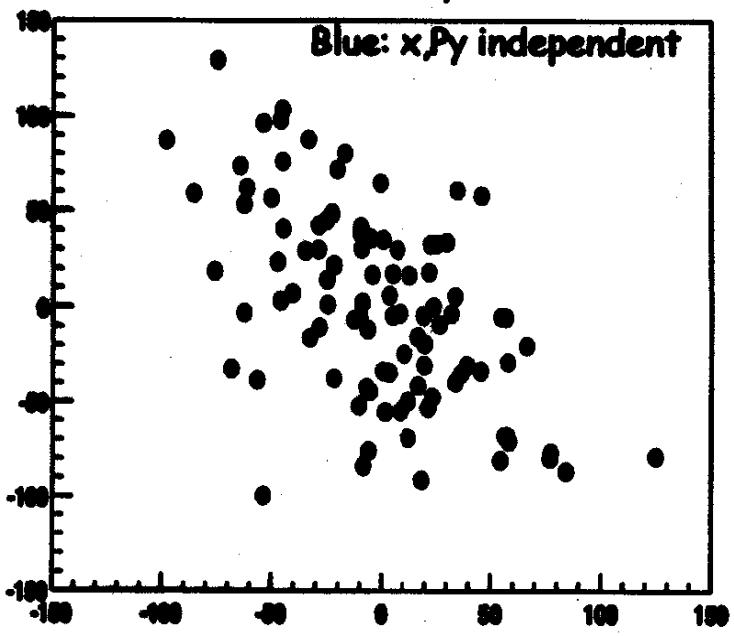
$\langle p_{yi} \rangle = 0 \quad \sigma_{pyi} = 48.7\,\text{MeV}$

$\langle ct \rangle = 0 \quad \sigma_{ct} = 10\,\text{cm}$

$\langle E \rangle = 260\,\text{MeV} \quad \sigma_E = 25\,\text{MeV}$

Red: x,Py correlated

Blue: x,Py independent



$$x = x_L - \frac{P_y}{B_z^{max}}$$

$$y = y_L + \frac{P_x}{B_z^{max}}$$

x-y correlations simulate the beam entering the solenoid

6D Emittance

Of blue and red are the same

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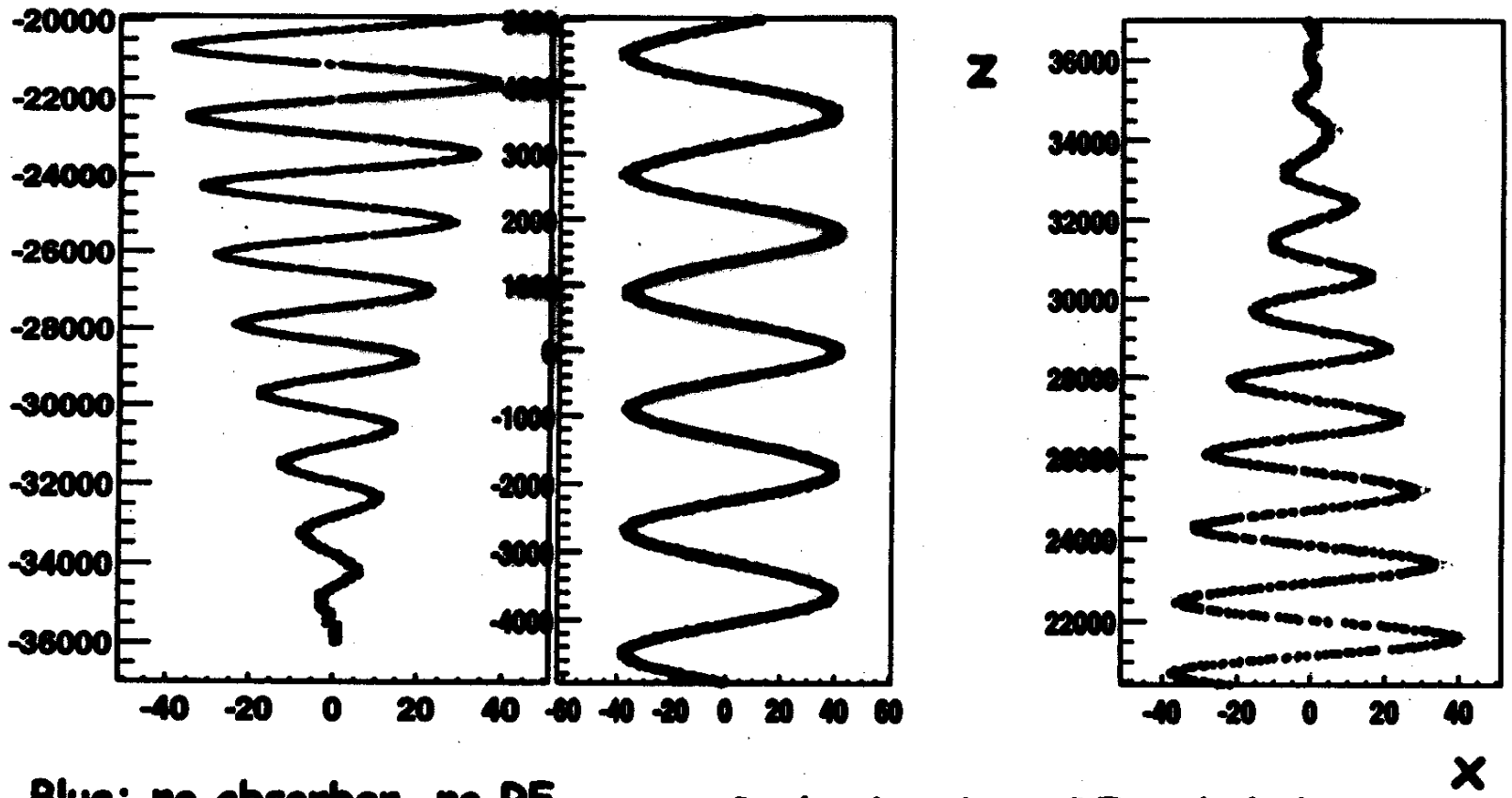
Tuning the System for the Ideal Particle

Phase of RF cavities adjusted to provide a sync phase of 30° at arrival of ideal particle (dE/dx fluctuations and multiple scattering turned off)



Blue: no absorber, no RF

Red: absorber, RF included

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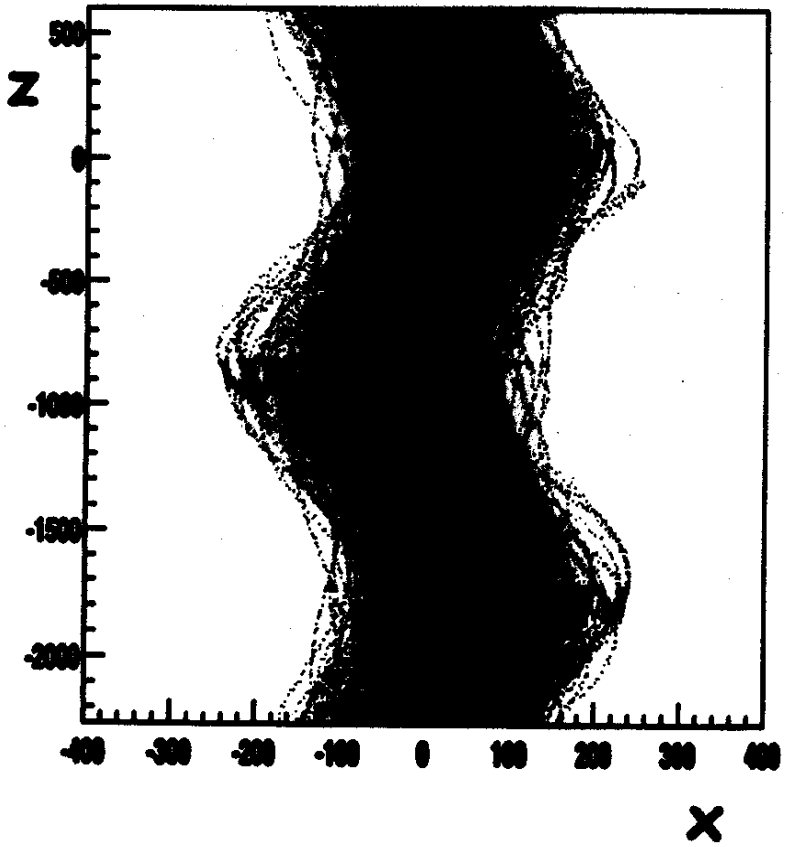
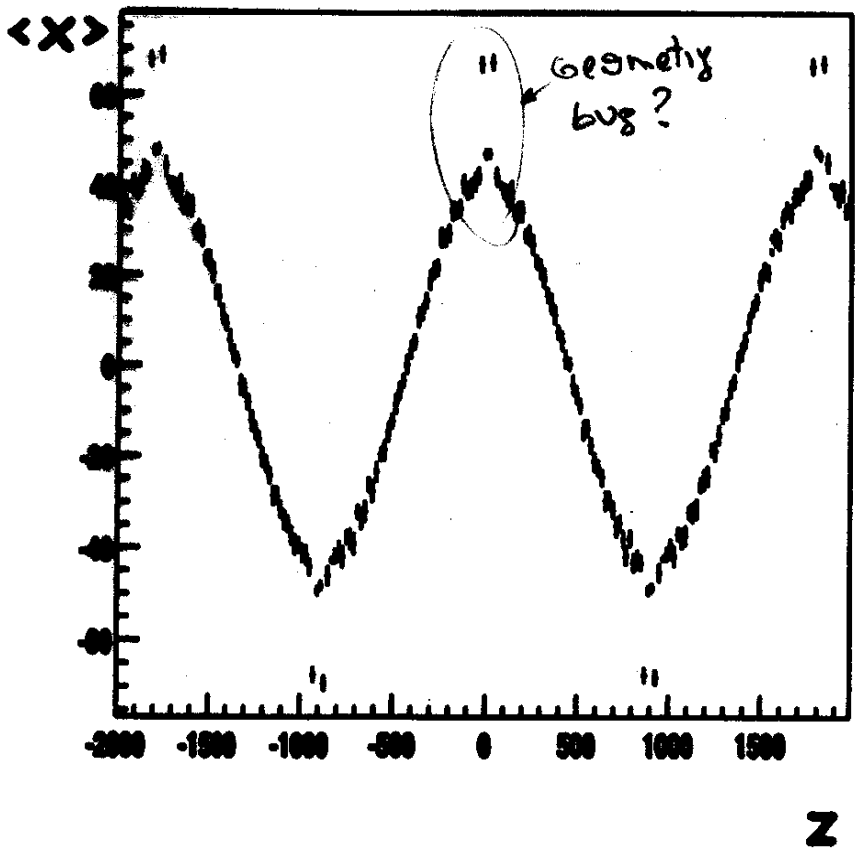
X vs Z for the Beam

All the physics processes except multiple scattering are modeled (1000 particles)





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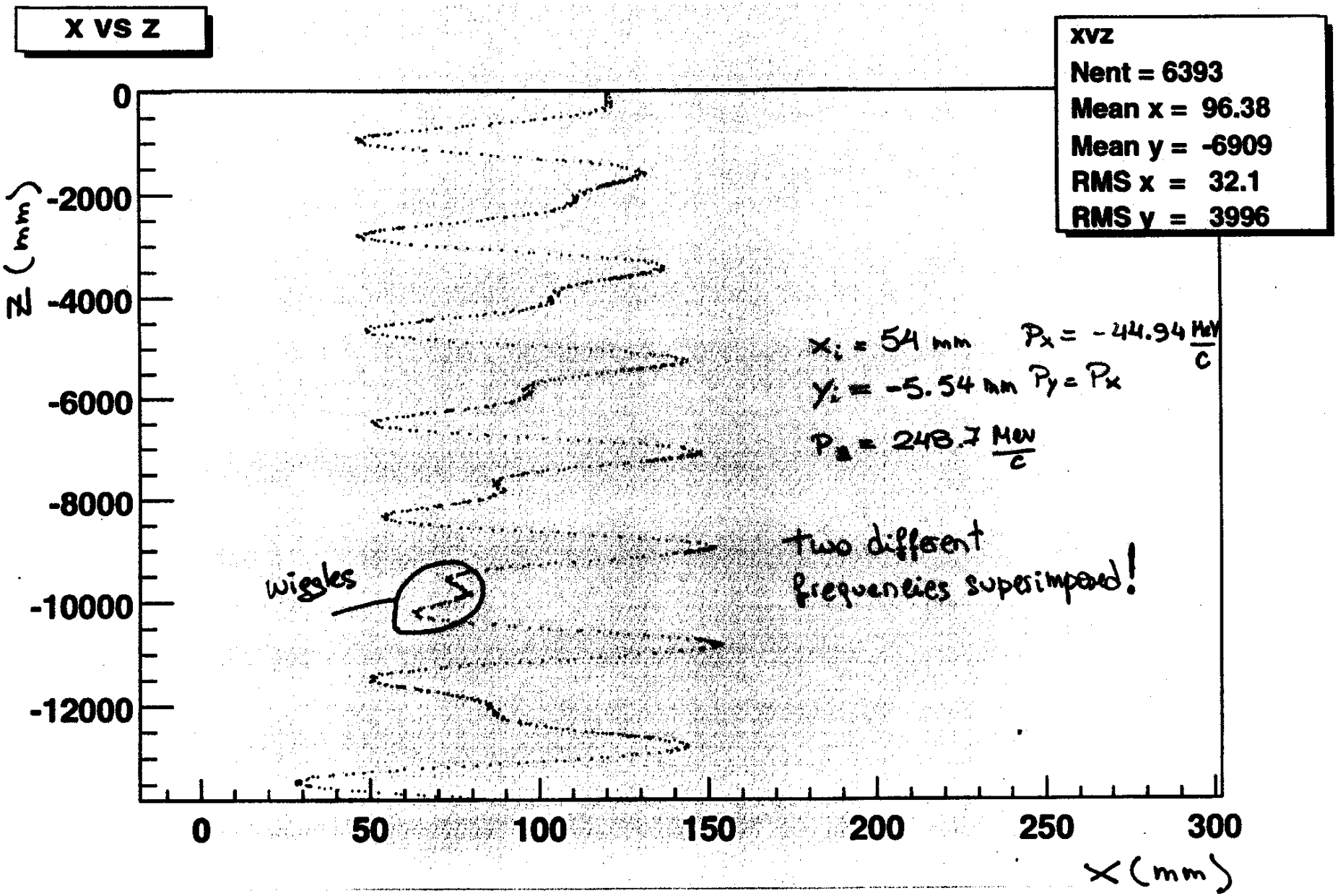
Most of the tracks are nice and smoth.
Some, however .....



EMITTANCE CALCULATION

$$\xi = \begin{pmatrix} \langle \delta x^2 \rangle & \langle \delta x \delta p_x \rangle & \langle \delta x \delta p \rangle & \langle \delta x \delta p_y \rangle & \langle \delta x \delta ct \rangle & \langle \delta x \delta E \rangle \\ \cdots & \langle \delta p_x^2 \rangle & \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \langle \delta y^2 \rangle & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \langle \delta p_y^2 \rangle & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots & \langle \delta (ct)^2 \rangle & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots & \langle \delta E^2 \rangle \end{pmatrix}$$

$$\varepsilon_{ij} = \varepsilon_{ji} \quad \wedge \quad \boxed{\varepsilon_{6N} = \frac{\sqrt{\det \xi}}{m_\mu^3}} \ \text{(III)}$$

$$\delta x = x - x_0 \Rightarrow \langle \delta x^2 \rangle = \langle x^2 \rangle - x_0^2 \equiv \sigma_x^2$$

$$\delta x \delta p_x = (x - x_0)(p_x - p_{x0}) \Rightarrow \langle \delta x \delta p \rangle = (\langle x p_x \rangle - x_0 p_0)$$

(I) • if $\langle \delta A \cdot \delta B \rangle = 0 \Rightarrow \varepsilon_{6N} = (\sigma_x \sigma_{p_x} \sigma_y \sigma_{p_y} \sigma_{ct} \sigma_E)/m_\mu^3$
(with $A \neq B$)

(II) • if $\left.\begin{array}{l} \langle \delta a \delta p_a \rangle \neq 0 \\ \langle \delta a \delta p_b \rangle = 0 \\ (a \neq b) \end{array}\right\} \Rightarrow \varepsilon_{6N} = \varepsilon_{xN} \times \varepsilon_{yN} \times \varepsilon_{CTN}$

$$\varepsilon_{iN} = \sqrt{\left[(\langle x^2 \rangle - x_0^2)(\langle p_x^2 \rangle - p_0^2) - (\langle p_x \rangle - p_0 x_0)^2 \right]} / m_\mu$$

(III) • if $\langle \delta a \delta b \rangle = 0$ $(\forall a \wedge b) \Rightarrow$ Equation III

INITIAL BEAM

$\varepsilon_{6N}^{(I)} = 10.7\ \text{cm}^3$ (inside solenoid before dipole $\langle \delta x \delta p_y \rangle \neq 0$)

$\varepsilon_{6N}^{(II)} = 5.37\ \text{cm}^3$ (before solenoid or dipole $\langle \delta x \delta p_y \rangle = 0$)

$\varepsilon_{6N}^{II} \gtrsim 5.37\ \text{cm}^3$

$\varepsilon_{6N}^{III} \longrightarrow$ SINGULAR MATRIX

FUTURE

Provided I solve the probably trivial $\mathcal{E}_{GW}$ issue .....

(A) Emittance Exchange

- Generate more events & study channel performance as it is.
- Add multiple scattering & " " "
- Introduce realistic cavities and dipole fromCurrents
- Push parameters to the limit
- Turn the channel into a ring ?

(B) Feasibility study II

- Simulate s.r.d.k.f.h FOFO ?
- whatever looks promising for F.S. II.

MEETING: PANAGIOTIS, PAUL, DANIEL

Decide who will do what and for when