BentSolenoid & Helical, with "realistic" fields Geant4: Status & Plan

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- Two Problems, an anticipated modest success, and expected difficulty:
  - "5D cooling" works : yield in a given r, r', Dp increase by almost a factor 1.5 with a realistic beam.
  - Construction of a realistic Helical wiggler by tilting and/or rotating current hoops (individual solenoids) is hard: I was not able to achieve Bs = 5 T., Bd = 0.3 T, Period of 1.8 m with a bore aperture of 75 cm, required to support the 205 MHz cavities.
- Plenty more work to do, hopefully not for an other millenium..

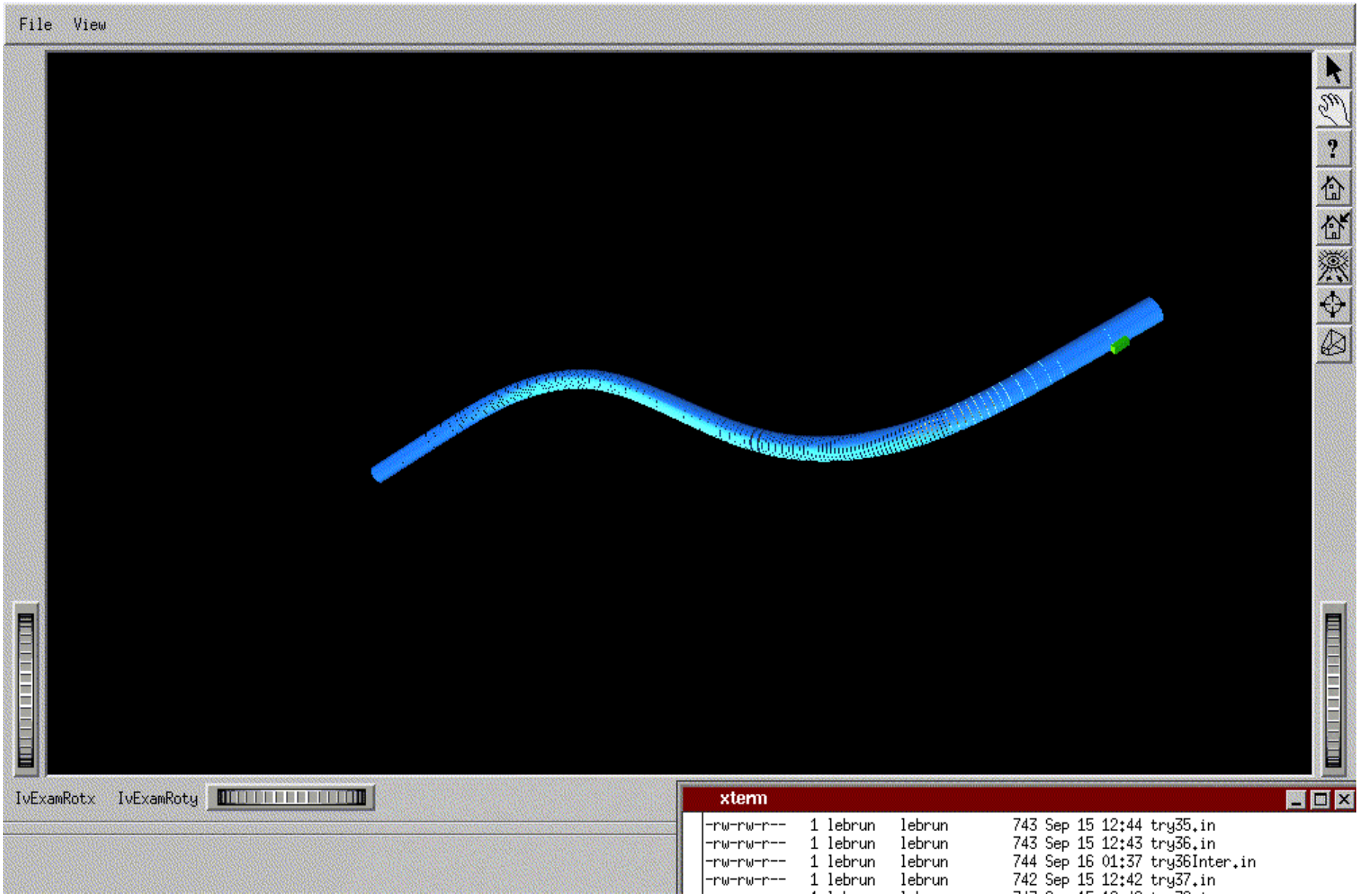
Plans & Discussion:status;

- Install the wedges.. .. Coding.. **Done**
- Real beam from a front-end.. minor coding.
  - From 800 MeV proton, 4T field capture Sol. **Done**
  - Your favorite one.. **not done : matching problem (1.25 T vs 4 T.)**
- Determine "isochronism" Delta tau vs bend.. (no coding..) **only semi-qualitative (one plot.)**
- Study the lattice defects.. (no coding..) **not done**
- Make an example of an Helical channel, compare with perfect dipole implementation of Daniel. **coded, no comparison yet**
- Allow for lattice building in the bend: shape B by tuning all coils individually.. (few lines of codes..) need definition of R-FoFo.. **not done in Geant4**
- Fix-up the visualization, if need be.. confirm the bug, no action yet.
- ;; //

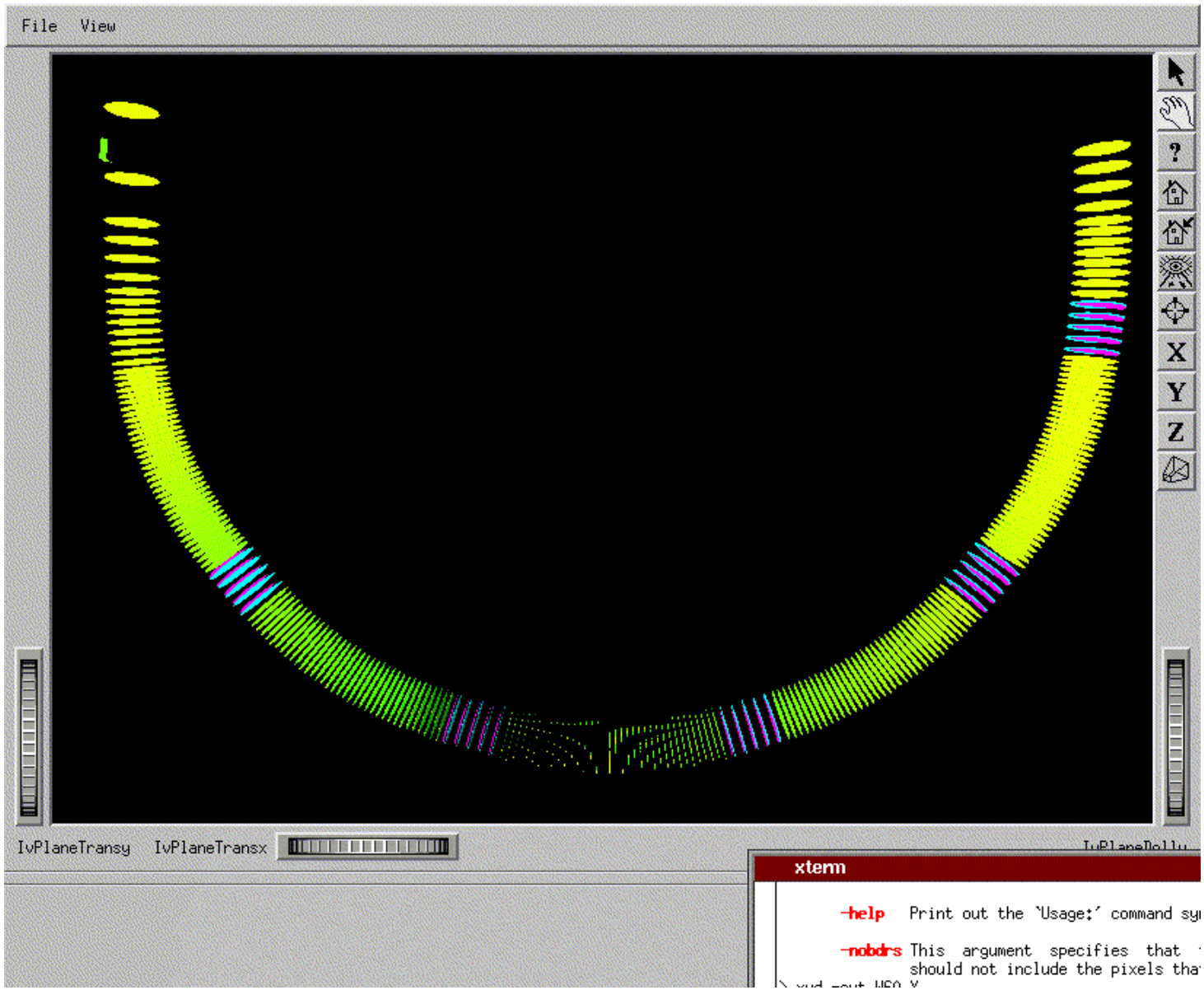
Suggestions received last week:

- "Increase dispersion: Bend more! Done!
- Extend the field map beyond beyond current sheet radius. Done
- Increase aperture, don't be shy! Done
- We know it's gona to work..why bother..
  - Well, if it works, let us be quantitative. I'll try!.
  - Prospect for Neutrino factory and feasibility II.
- Geant4: Some interest in running the code here at Brookhaven, but, please hide the C++ stuff.... Just give a "ICOOL Deck".
  - However, Daniel, Panagiotis and I have a lot of homework to do to achieve this goal..

The previous thick bent channel:



The currently proposed Channel:



1 disk =
one Solenoid.
= Detector
(coils
invisible..)

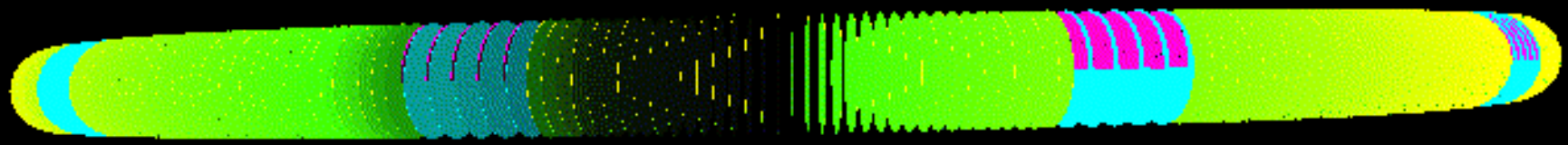
5 x 4 wedges
along the curb

optionally,
increasing in
thickness.

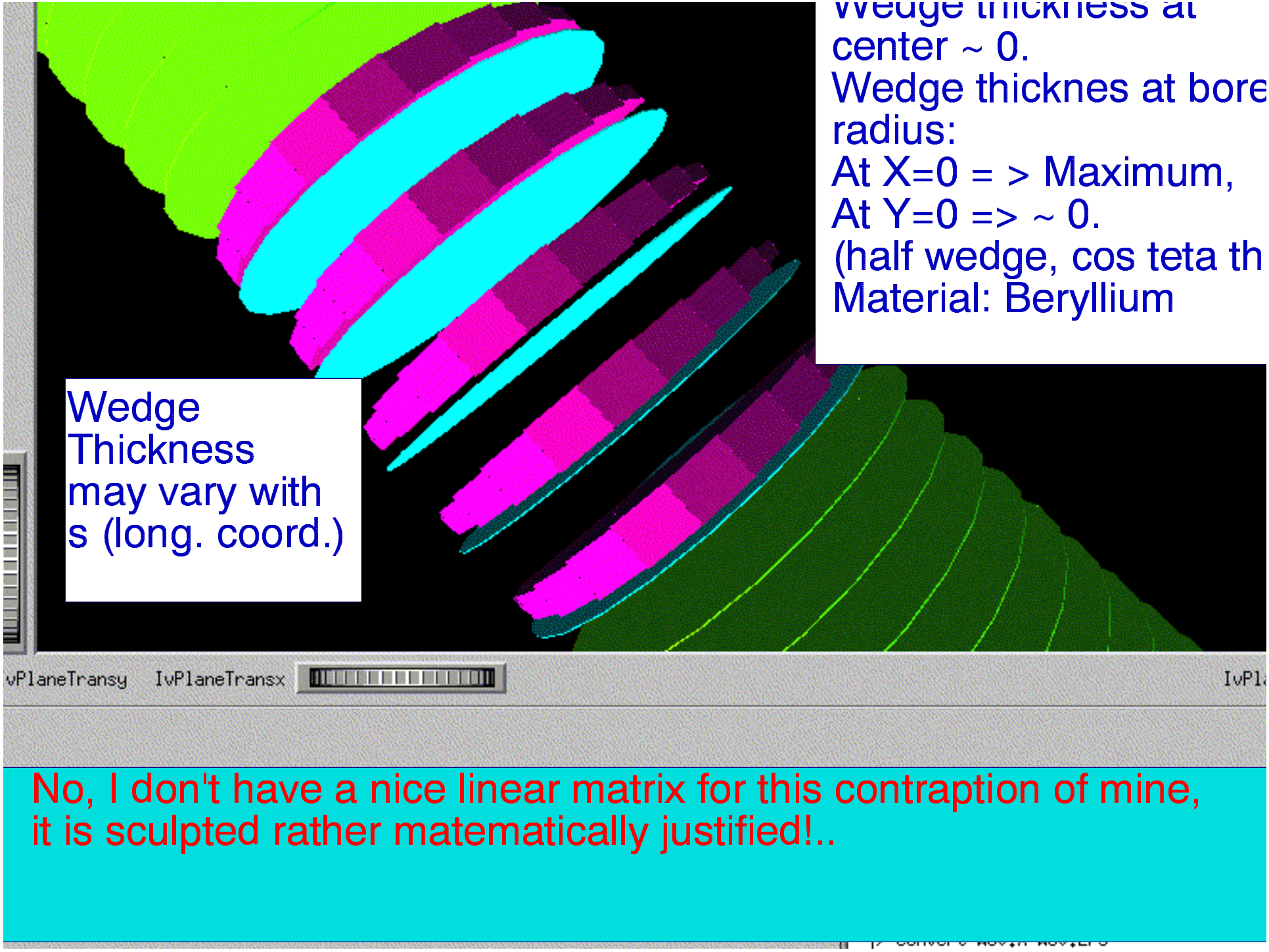
Details about this Bent Solenoid Configuration:

- Bore radius = rb = 80 cm., (from 40) shield 10 cm. thick, 5 current sheets placed at rb+i*2 cm,
- L = 2., 0.5, 0.25, 0.125 m + dl of 1.5 cm min. between coils.
- Adiabatic increase of bent angle, crude hyperbolic tangent: only at the beginning
- Maximum turn angle in the XZ plane per 12.5 cm hoop is 15 mRad. There are 180 such hoops per bent Sol.
- Y tilt angle = 0.7 X rotation (accidental coincidence, tune for 0.15 at 4 T.).

In the Y-Z plane : no longer in a plane,
the beam rises a bit on average:
Undercompensated Y tilt:
Linear + quadratic term in the foot print of the reference particle ..



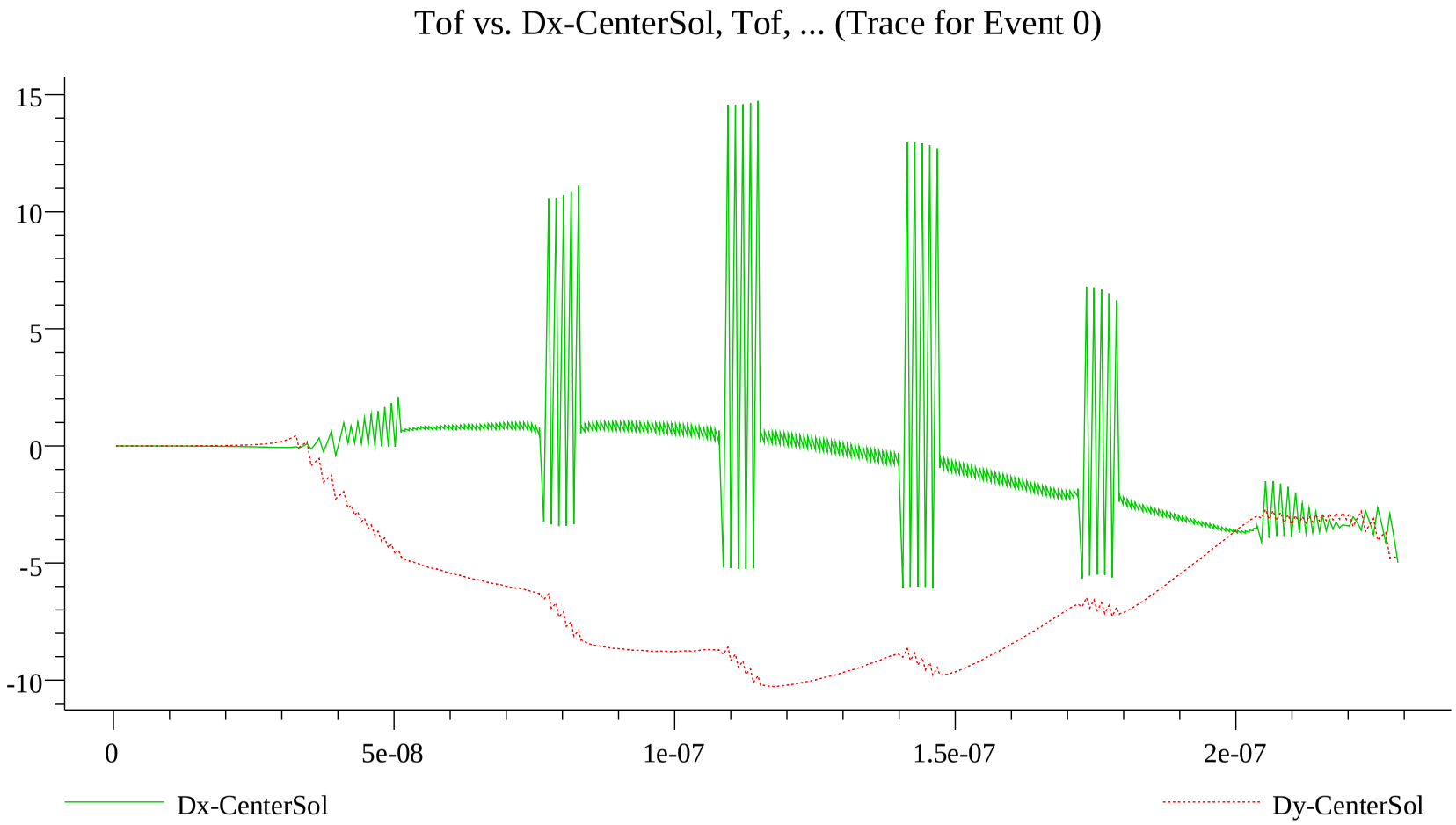
May be this could simplified a bit !


Wedge thickness at center ~ 0.
Wedge thicknes at bore radius:
At X=0 = > Maximum,
At Y=0 => ~ 0.
(half wedge, cos teta th
Material: Beryllium
Wedge Thickness may vary with s (long. coord.)
vPlaneTransy
IvPlaneTransx
IvPl
No, I don't have a nice linear matrix for this contraption of mine, it is sculpted rather matematically justified!..

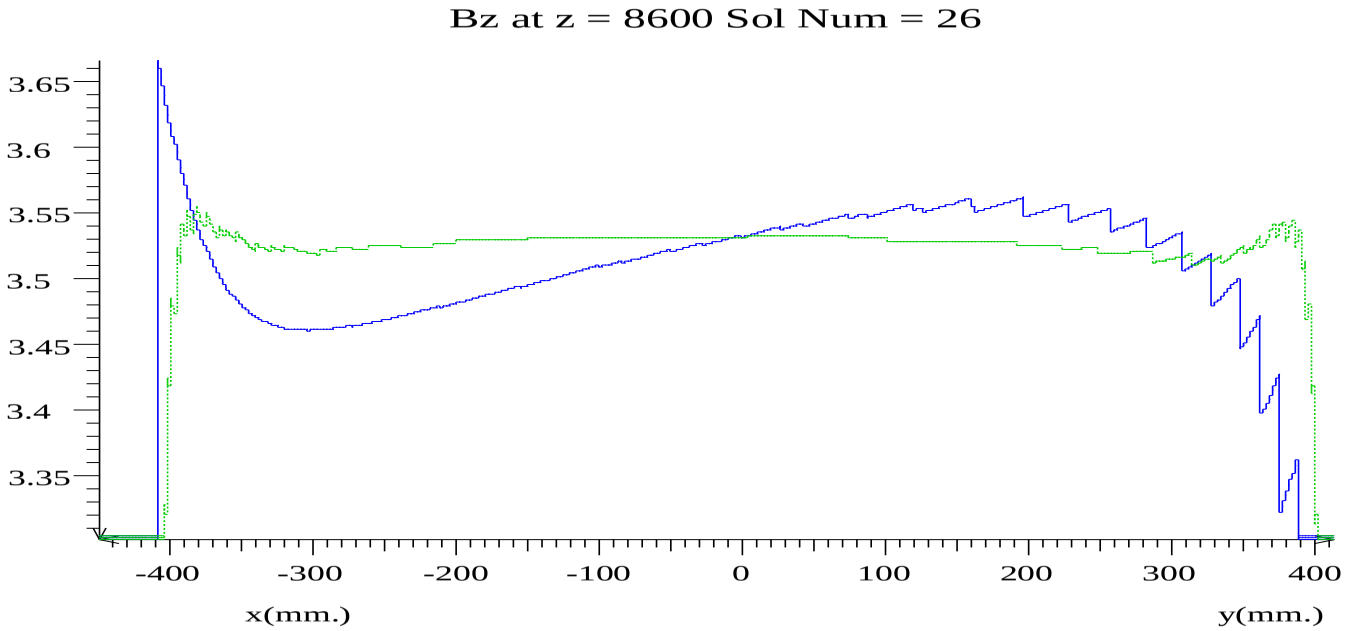
Motivation/justifications for such casual design procedure..

- Nominal momentum is ~150 MeV/c, or 85 MeV kinetic energy -> de/dx non-linear in this range -> linear wedge to match linear dispersion not optimum!
- Large amount of correlation in the input beam: Larmor center stronly correlated with Pt. (but Pt and Pz almost uncorrelated..)
- Pt ~ Pz !
- D' related to Pz more than Pt (Larmor motion very significant..)
- Give premium to low Pt, low Pz tracks..

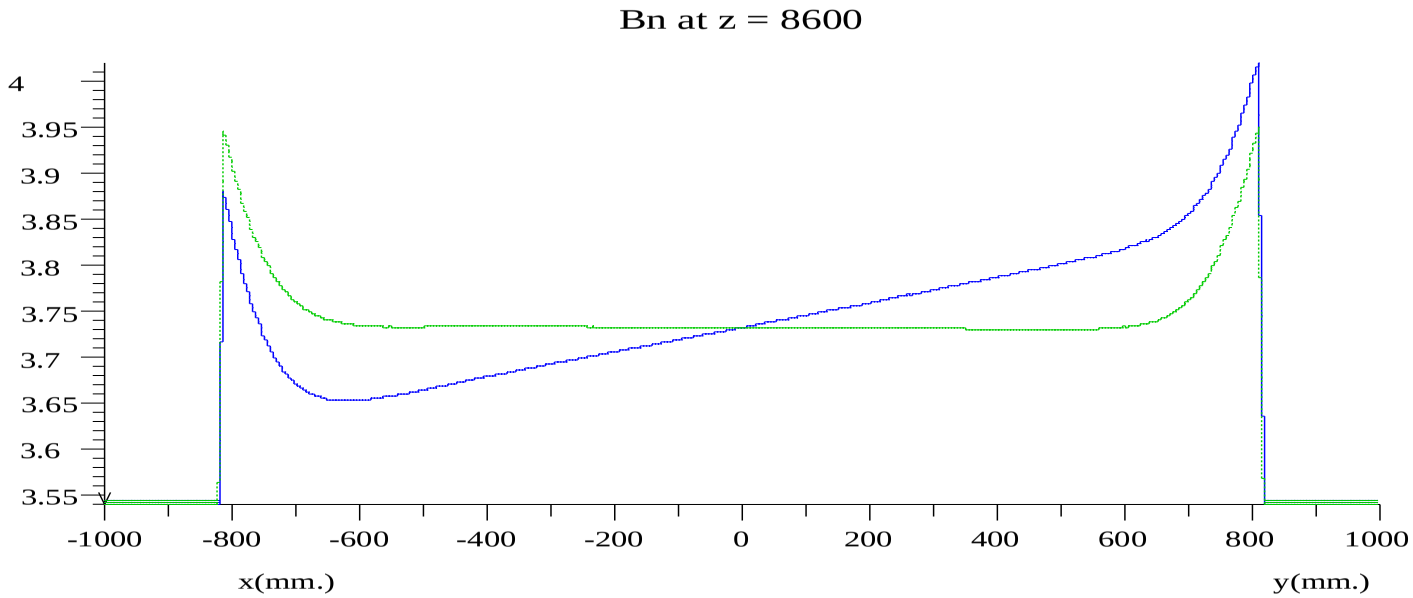
Reference trajectory.



Note :The magnetic field is now much smoother..

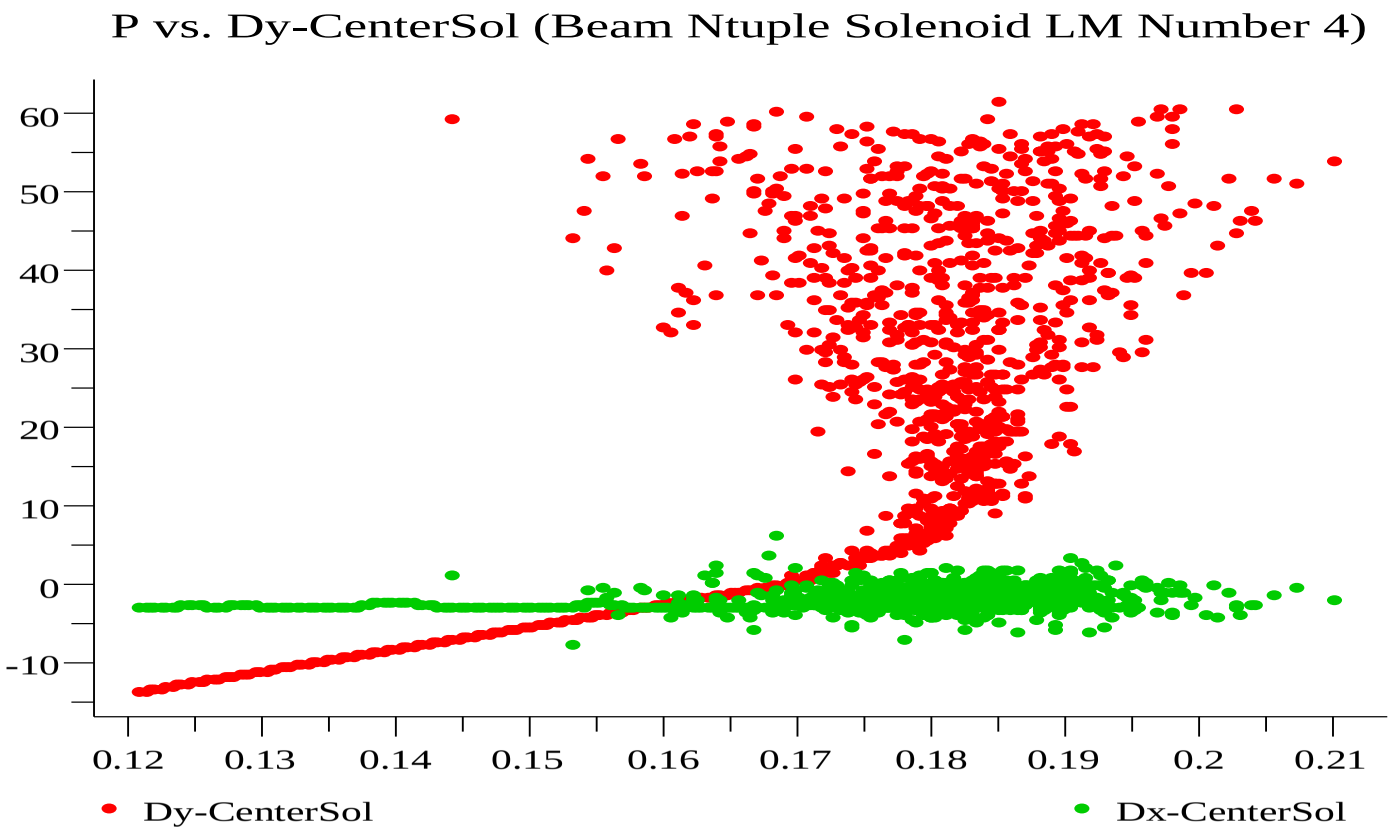


Old (40 cm. bore, small ma



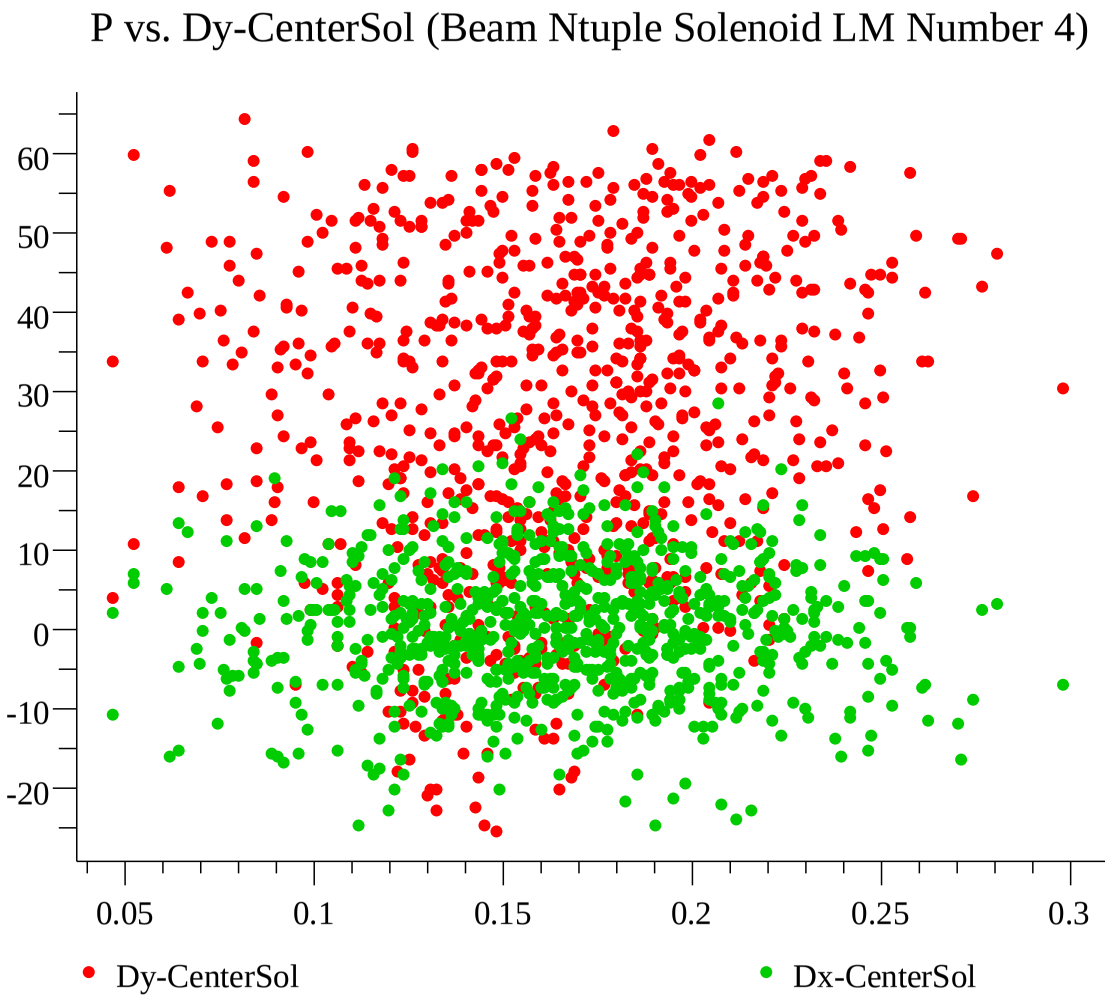
New! (80 cm. bore, large map)

Dispersion Plot, Wedge Corrected, $\varepsilon_{perp} = 0$.



D = <P> Δy/ΔP = 170 * 14.1/48 ~ 50 cm.

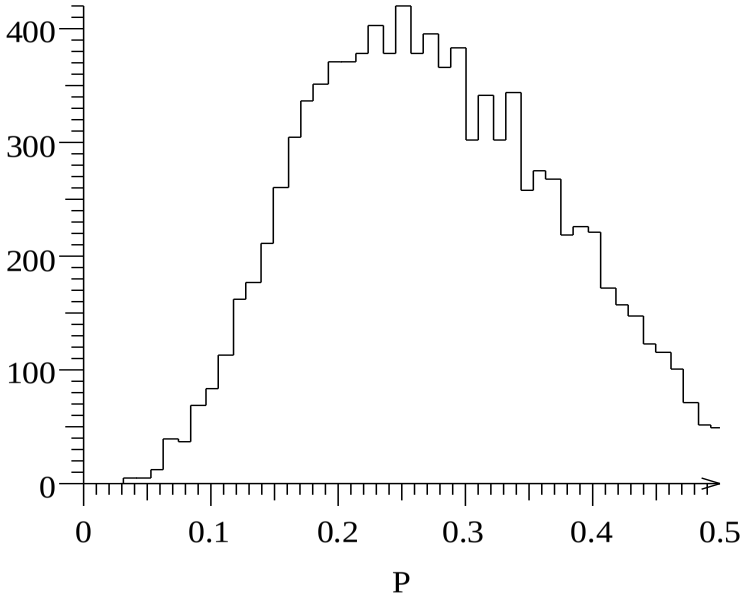
Dispersion Plot, Wedge Corrected, ε_{perp} ~ 10 cm x 20 MeV/c

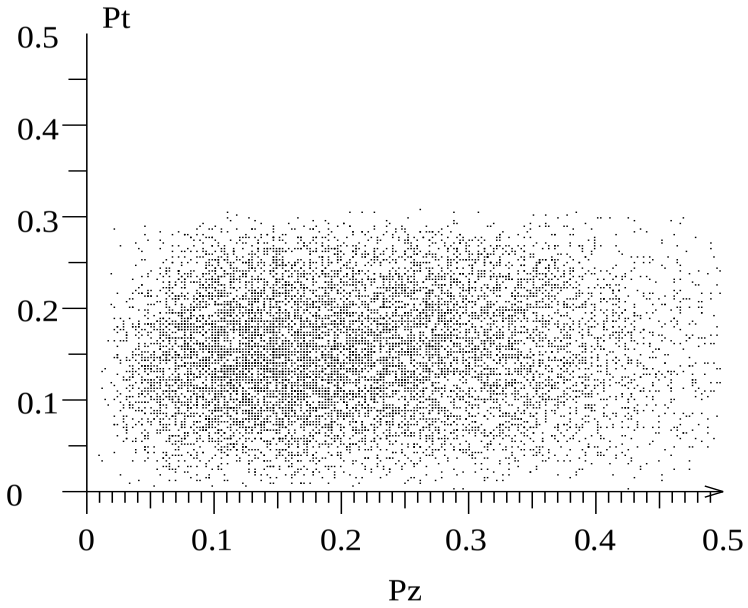


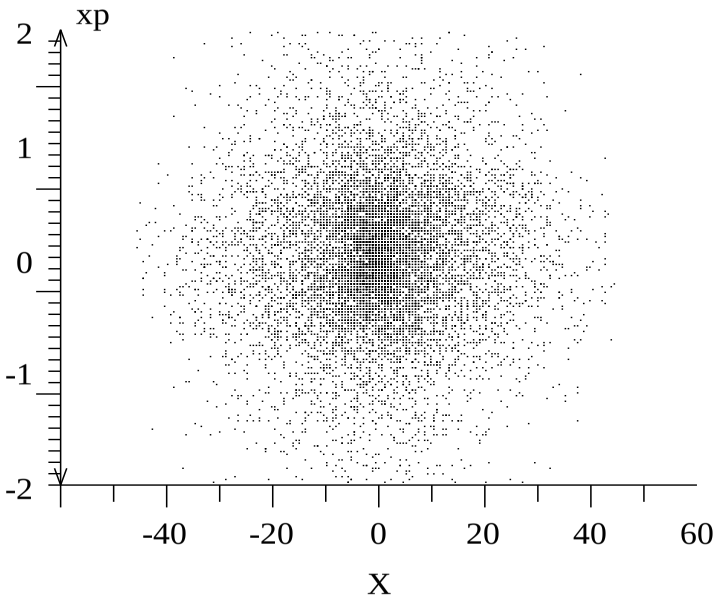
Let us try it on a realistic beam

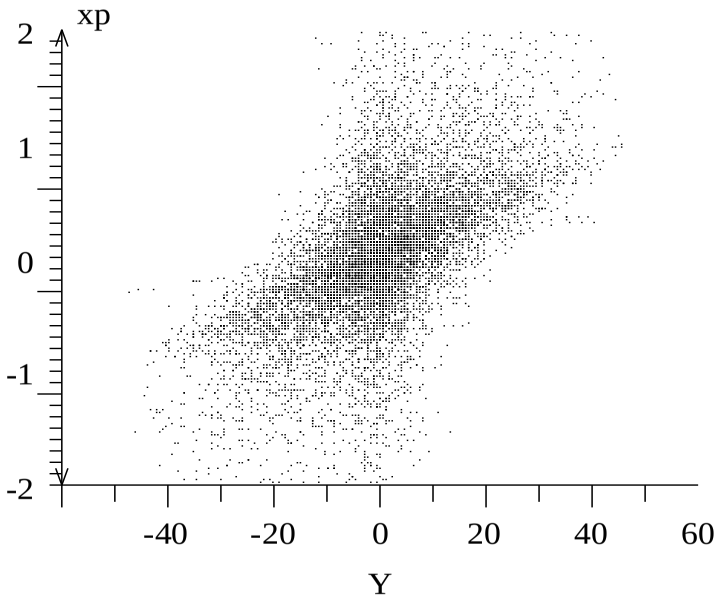
- Beam :
  - Obtained by a 800 MeV proton hitting a Carbon-Lithium target (Liquid Lithium for eventual cooling), in 4 T. capture solenoid (the optimum is not 20 T. : cold pions are re-capture).
  - Cross-section and kinematics from data
  - No beam tilt!
  - 4 T. all the way => flat b function.
  - ==> strong correlation between Larmor radius and Pt, Larlor centers at ~ 0.
  - But relatively small D P !
  - May be this scheme will work even better with the feasibility II beam!.
- Wedge: 65 cm at R=70cm.. (all of them).

Input Pion Beam

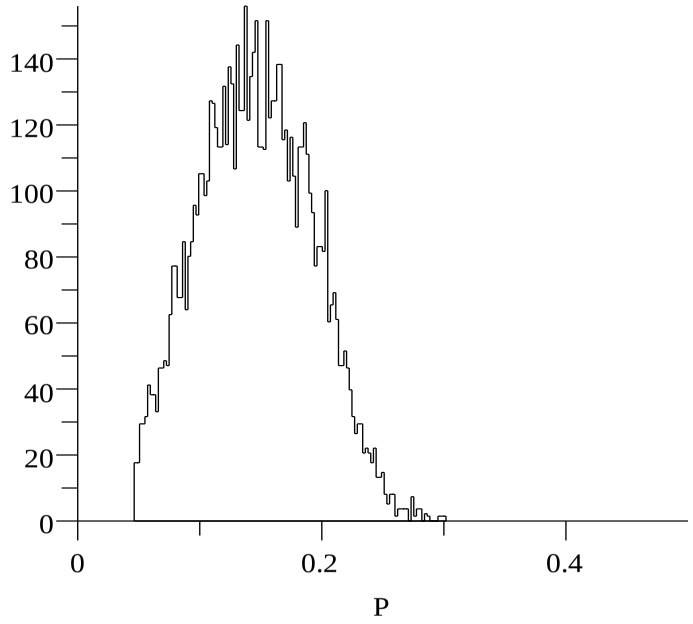


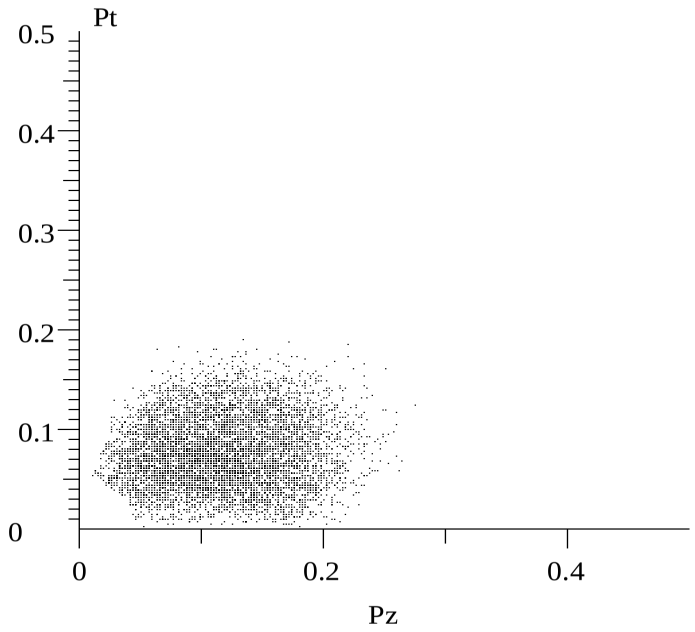


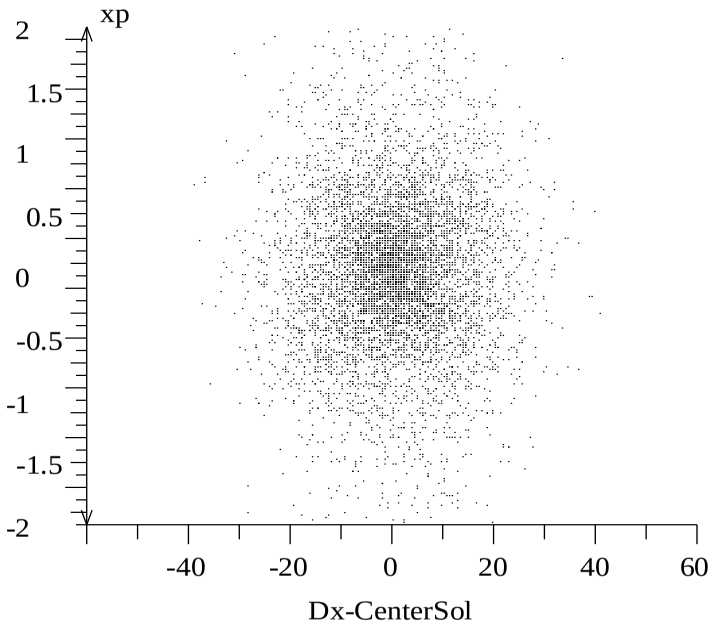


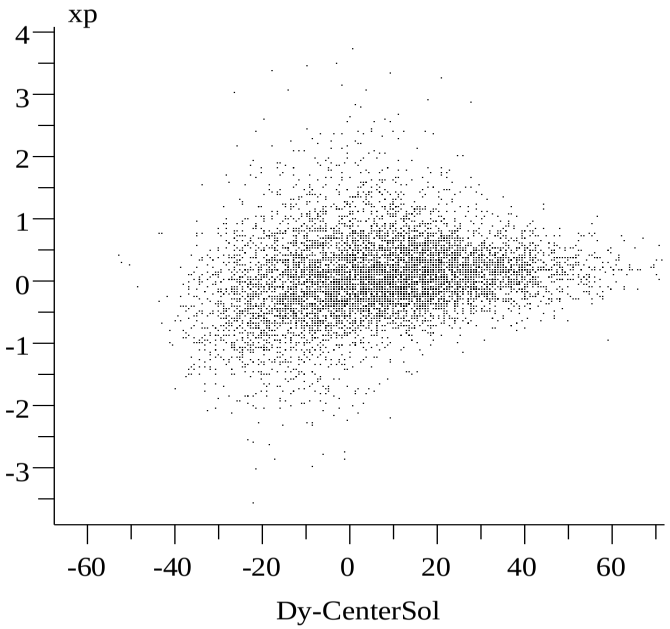


End Mini-Cooling





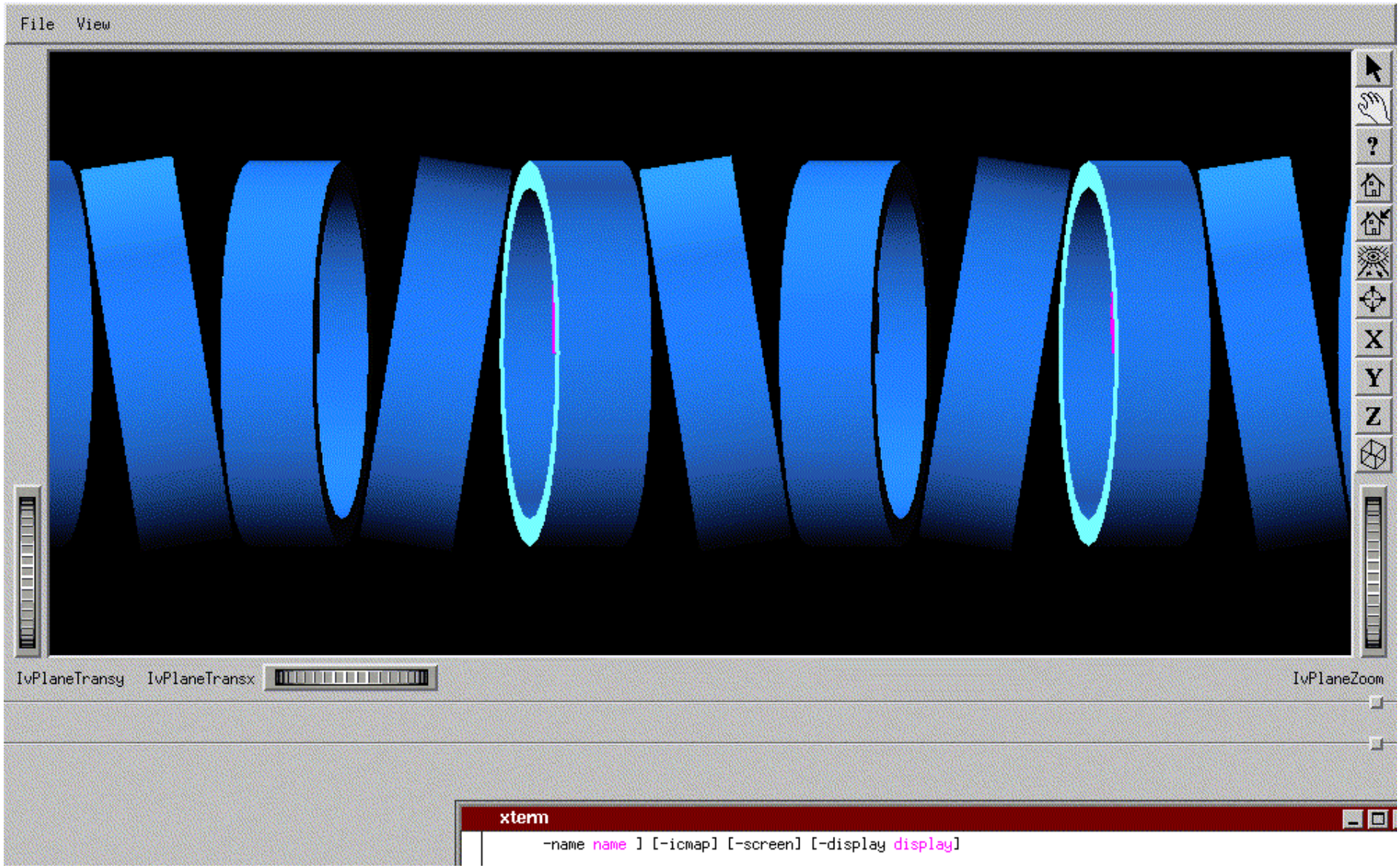




Preliminary Result:

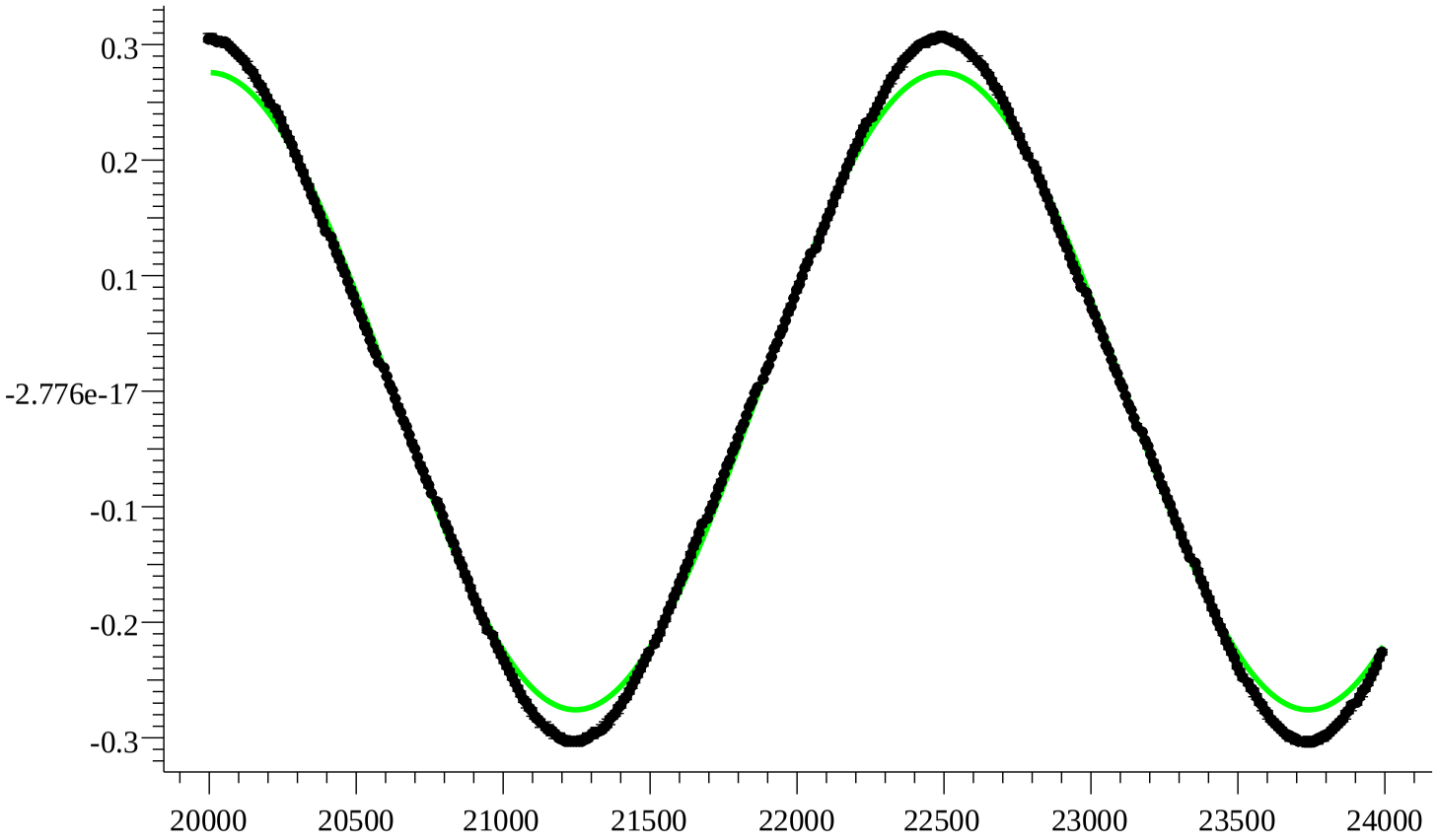
- UnOptimized wedge thickness and s distribution..
- Transmission : 66 %
- Within a P +- DP = 150 +- 75 MeV., r< 20 cm, rp < 1.5 ==> 30 % transmission. Merit factor (yield coming out/coming in = 1.5 (30/20 % transmission)
- Got rid of all high energy componenent (good).
- Note : gain or loss due to muon decay included.

Second topic: Helical channel with tilted Coils



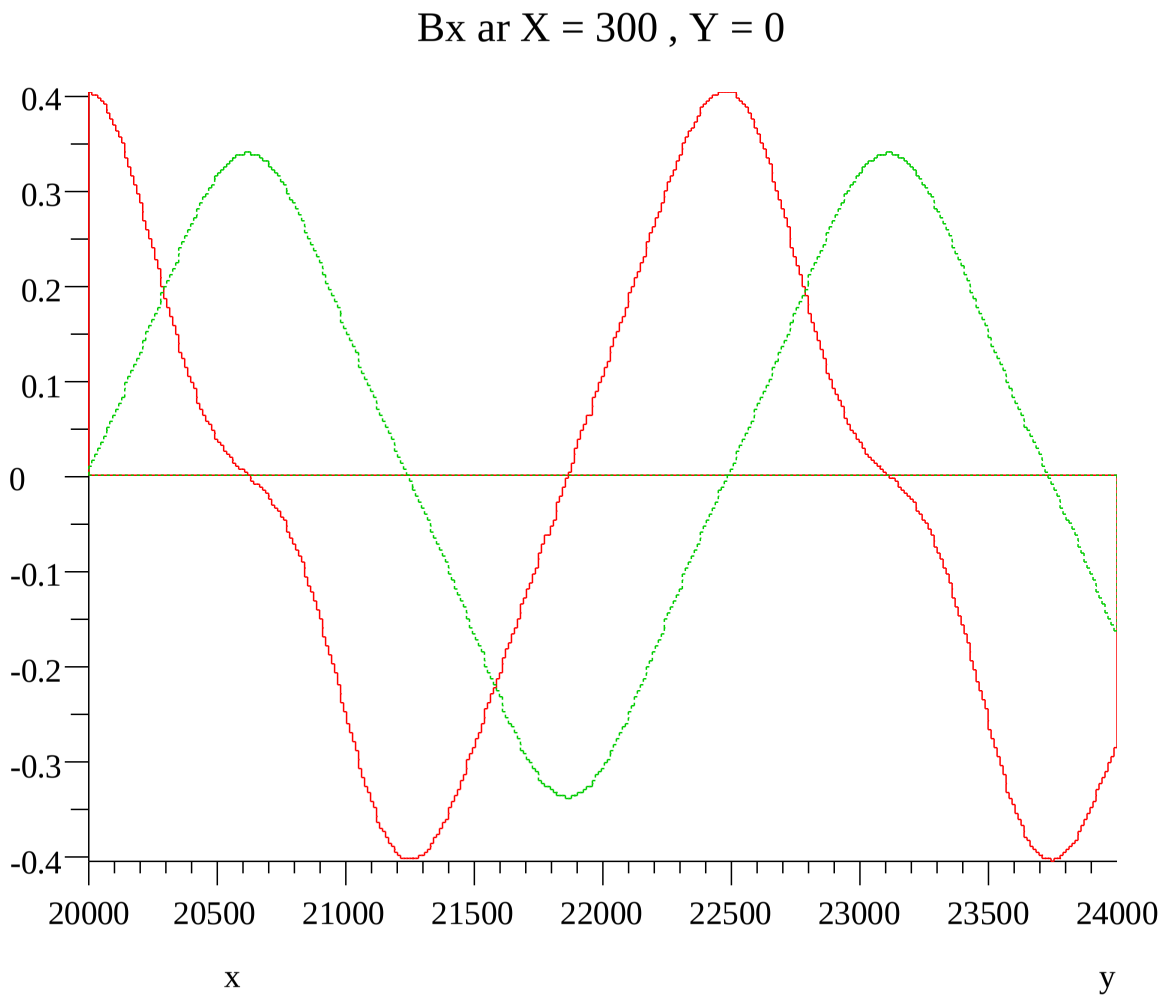
Field on axis:

field12X.dat

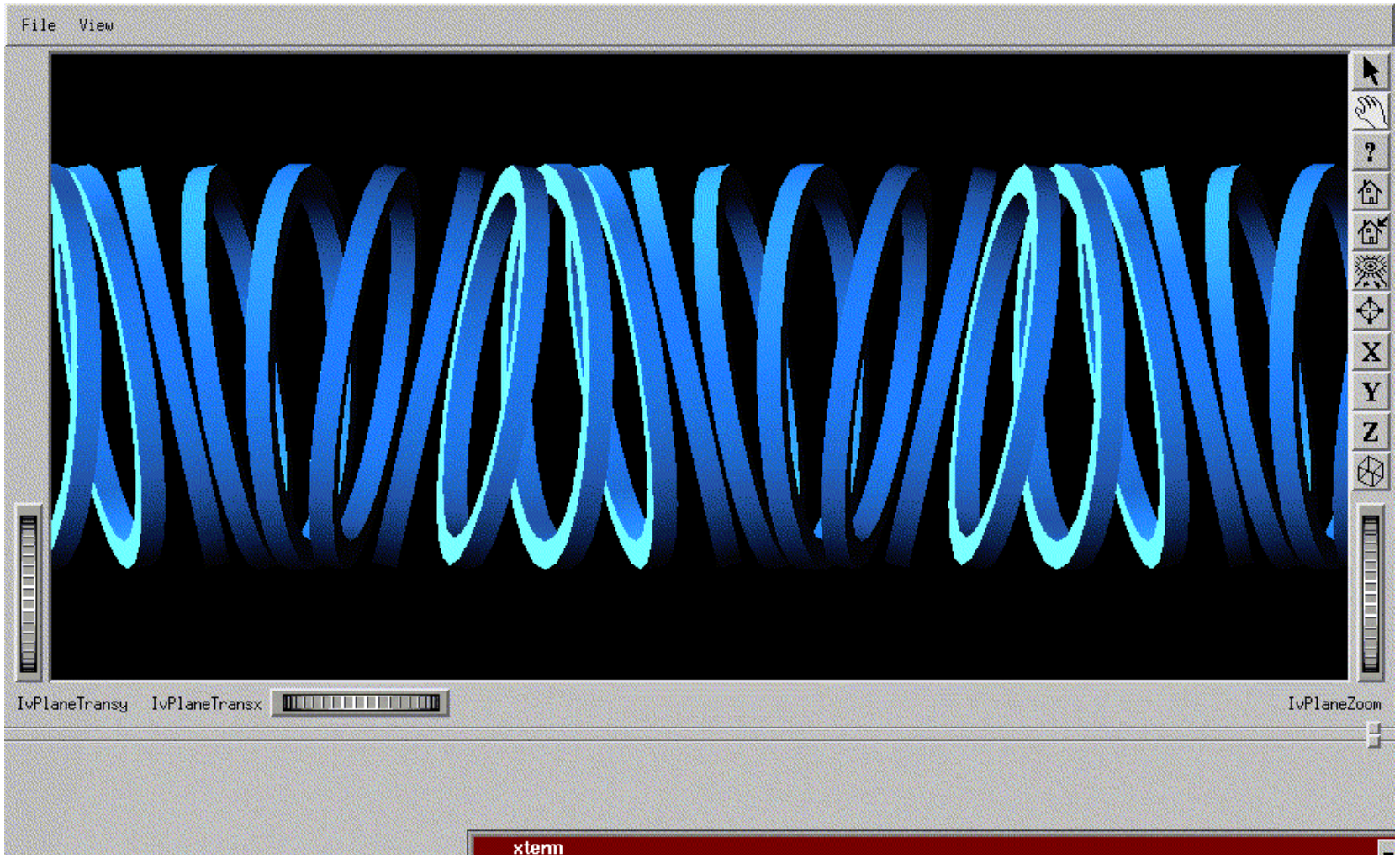


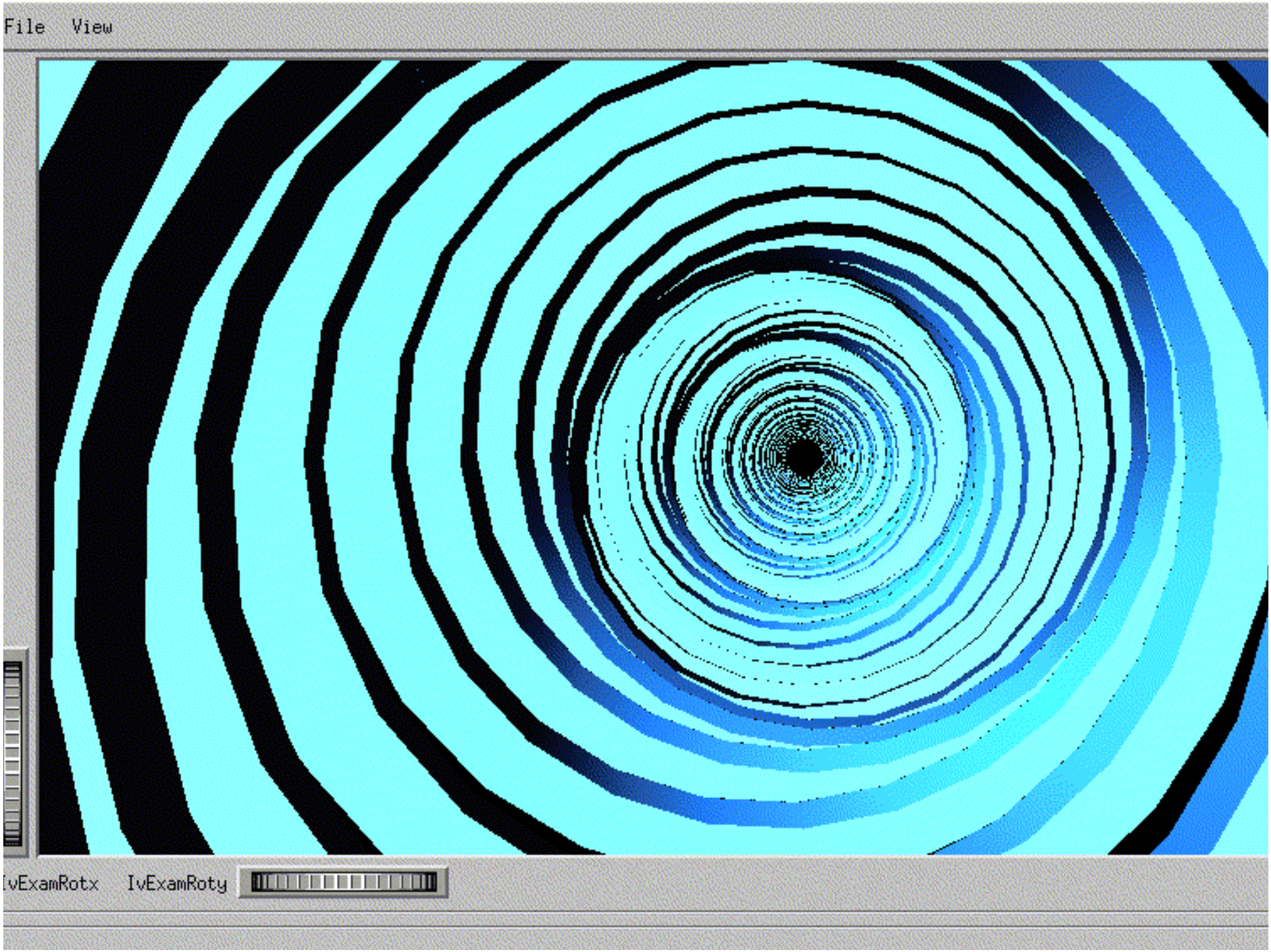
Amplitude Too small (~2), period wrong by ~15 to 20 %.

And at 30 cm..

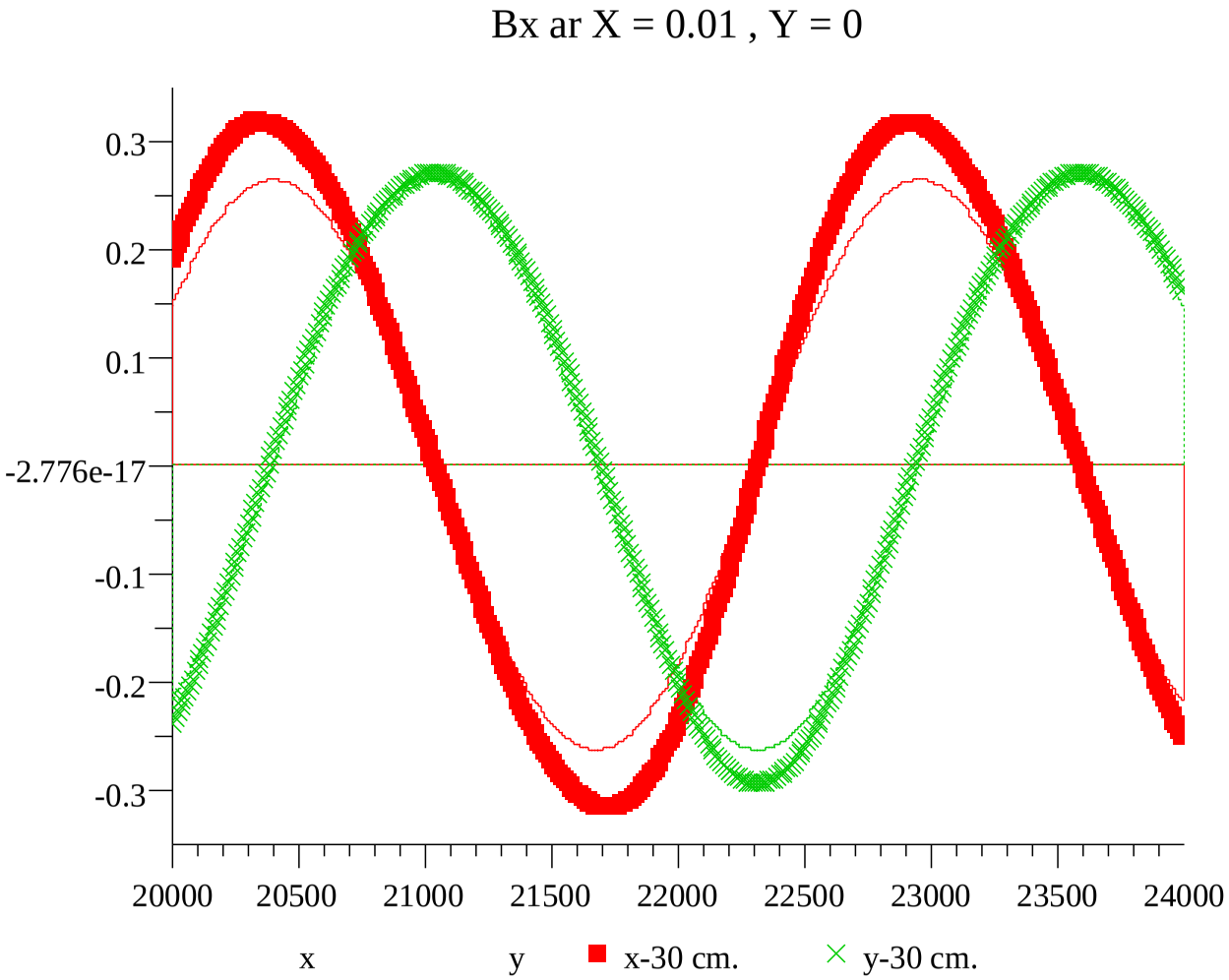

Bx ar X = 300 , Y = 0
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
20000
20500
21000
21500
22000
22500
23000
23500
24000
x
y

Smoothing the helical motion, raising the angle..




File View
IvExamRotx IvExamRoty

Field, transverse..



Result:

- Field magnitude can be achieved, but not the period (still ~ 5 % to 10 % too high !)
- At a cost : raising the current in the sheet by a factor two with respect to the straight solenoid ==> packing factor very poor ! .
- Assume the coil blocks are only 10 cm. thick!
- hoop stress uncalculated..
- ==> better talk to your favorite magnet engineer to see if feasible at all!
- ==> try with a genuine helical winding
  - move Juan G. code to G4, make a 3D grid..