Holding fields magnets for polarized target

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The relaxation rate of spins due to field inhomogeneities is presented ([a] [b] [c]) by:

$$\frac{1}{T_1} = D\frac{|\vec{\nabla}B_x|^2 + |\vec{\nabla}B_y|^2}{B_0^2} \tag{1}$$

Here D, the diffusion constant for the polarized spins, is inversely proportional to the gas pressure. The mean magnetic field is assumed to lie along the z-axis and have a magnitude B_0.

In Hall A the Helmholtz coils for $^3\vec{\mathrm{He}}$ target used in the transversity experiment provide holding field with inhomogeneities

$$\left[|\vec{\nabla}B_x|^2 + |\vec{\nabla}B_z|^2\right]^{\frac{1}{2}} \sim 9\frac{\mathrm{mG}}{\mathrm{cm}}$$

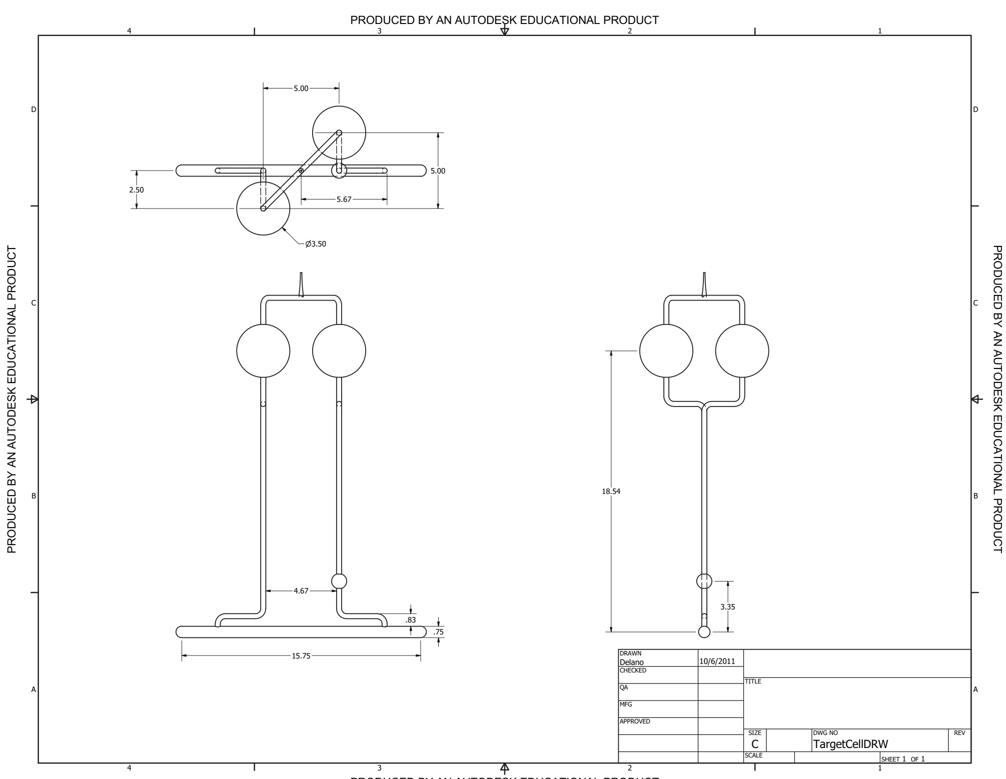
A recommended value should be $\leq 10\frac{\mathrm{mG}}{\mathrm{cm}}$.

[a] R.L.Gamblin and T.R.Carver Phys.Rev. v.138,946(1965)

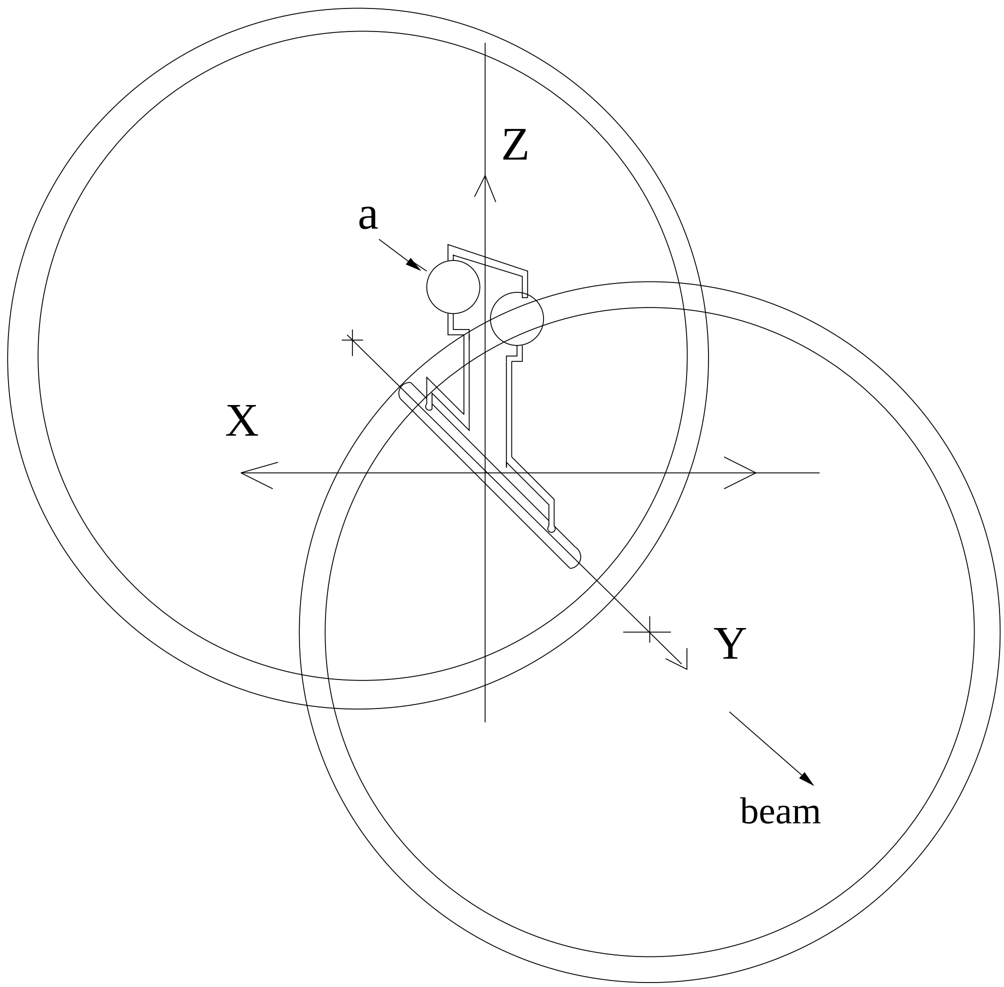
[b] L.D.Schearer and G.K.Walkers Phys.Rev. v.139,1398(1965)

[c] G.D.Cates, S.R.Schaefer, and W.Happer Phys.Rev. A37,2877(1988)

In **A1n** experiment $^{3}\vec{\mathrm{He}}$ target will have a new shape with two pumping chambers and longer transport tubes to get circulating gas through the target chamber. The length of the target chamber will be of 60 cm. The inhomogeneities of holding field within the target cell volume should be as low as possible.



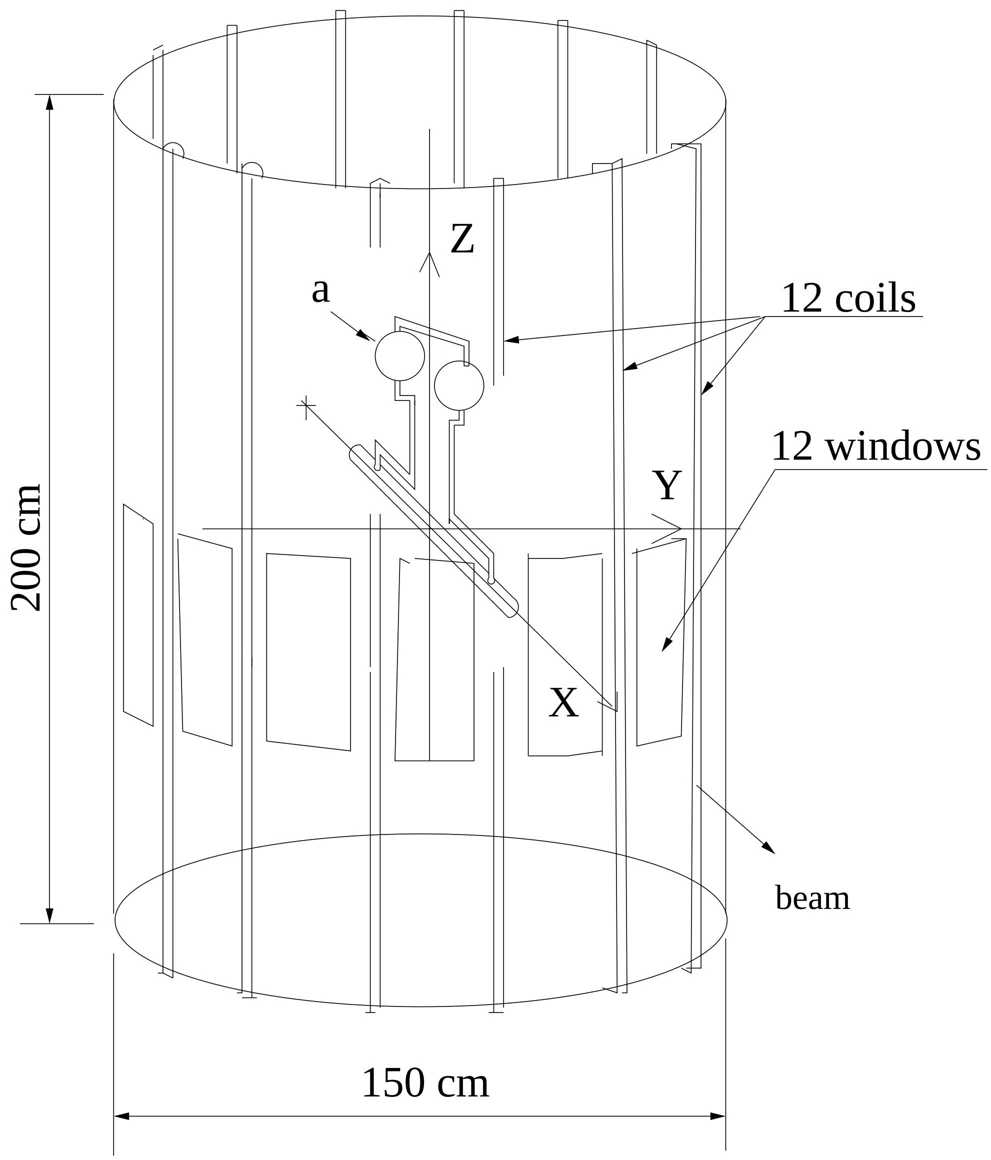
The simulation of magnetic field for the new cell in the existing Helmholtz coils was done with iron clamp placed in the front of BigBite magnet.

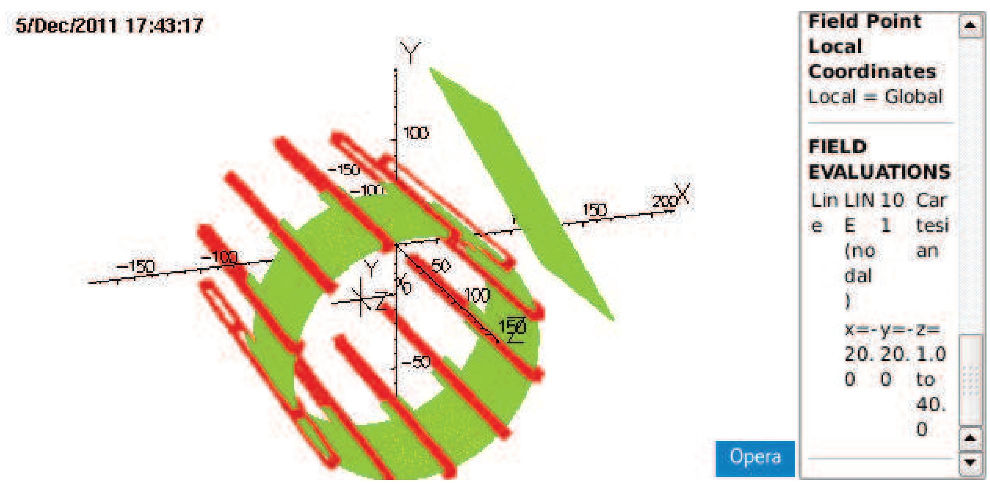


The inhomogeneities in volumes of pumping chambers (pointed by arrow **a**) is:

$$\left[|\vec{\nabla} B_x|^2 + |\vec{\nabla} B_z|^2\right]^{\frac{1}{2}} \sim 250\frac{\mathrm{mG}}{\mathrm{cm}}$$

Moreover the direction of field inside pumping chamber is different from direction in the target chamber by angle $\sim 5^o$.
Helmholtz coils diameter should be increased about 1.5 - 2 times but the limited room around target does not allow do it.
Here we are considering a barrel type of magnet with 12 separated coils. The soft iron walls (1 cm) will serve as a shield against outside magnetic fields and provide uniform field inside.

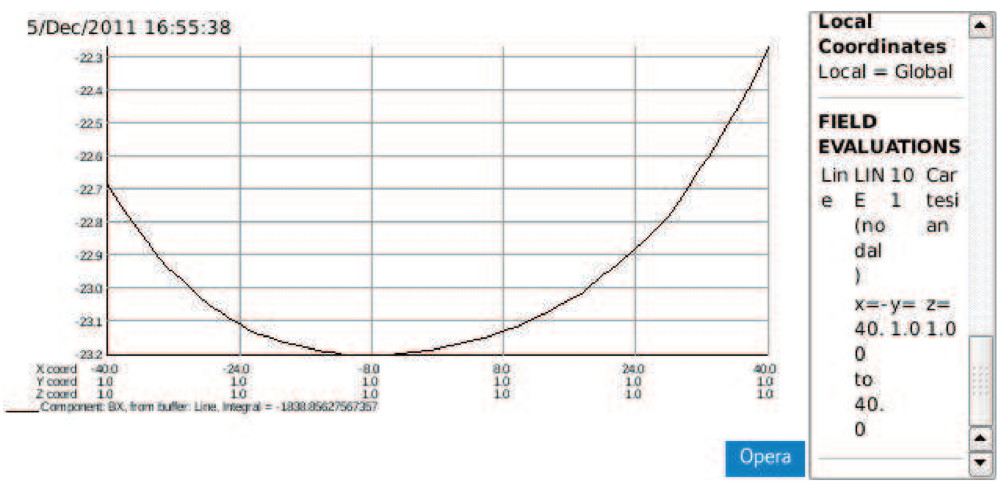

Z
a
12 coils
12 windows
Y
200 cm
X
beam
150 cm

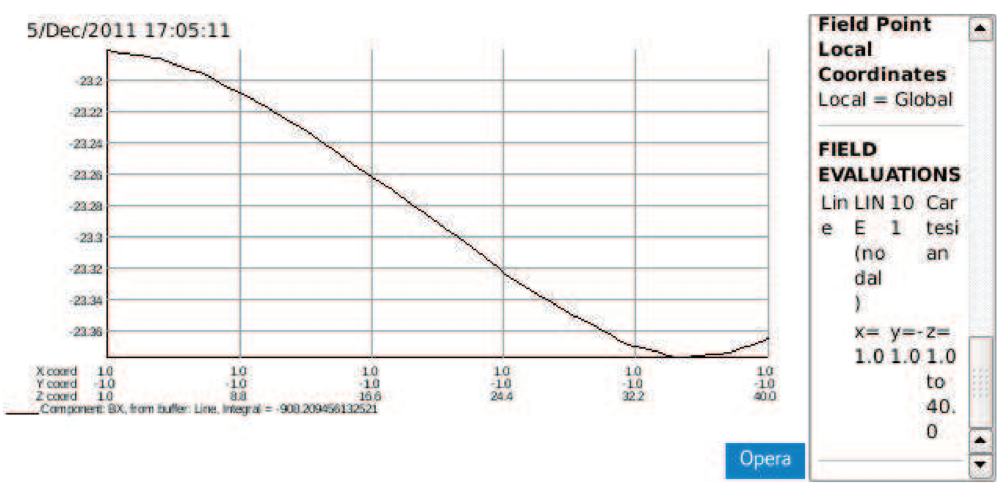

5/Dec/2011 17:43:17
Y
X
Z
100
150
200
−150
−100
50
−50
Field Point
Local
Coordinates
Local = Global
FIELD
EVALUATIONS
Opera

Current in coil is determined as a function:

$$I(\theta) = I_0 sin(\theta)$$

Where θ is angle of coil position relatively desirable direction of the holding field. In this geometry we have only 3 magnitudes of current. If holding field is assumed to lie along x-axis we have:





The barrel type magnet provides holding field for new target cell with inhomogeneities:

$$\left[|\vec{\nabla}B_y|^2 + |\vec{\nabla}B_z|^2\right]^{\frac{1}{2}} \sim 20\frac{\mathrm{mG}}{\mathrm{cm}}$$

The angle between directions field in the target and pumping chamber is $\sim 0.7^o$.

The first consideration show that barrel type magnet is very promising. To decrease gradient we plan optimize sizes of the barrel magnet.