Magnetic Measurements and Fiducialization Of the Spear III Gradient-Dipcle Magnets

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Required Measurements

1) Fiducialization

   $\sigma_{X_{CTR}} < 100\ \mu m$

   $\sigma_{Y_{CTR}} < 100\ \mu m$

   roll $<$ 0.1 mrad

2) Excitation

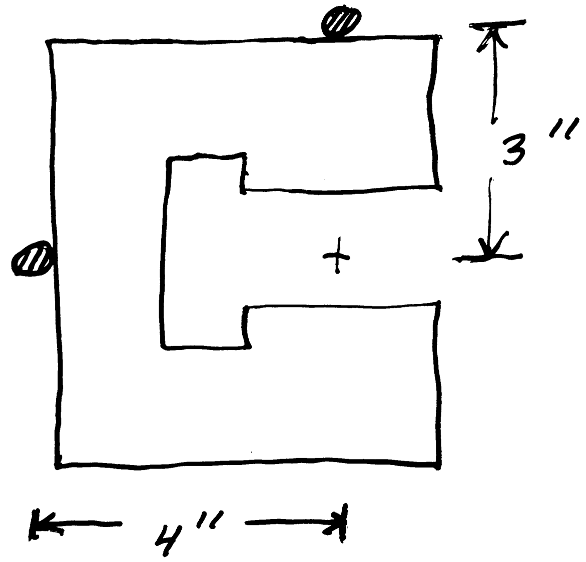
   BL vs I on the beam axis

   ↖ $\int B_y\, dz$

3) Field Quality

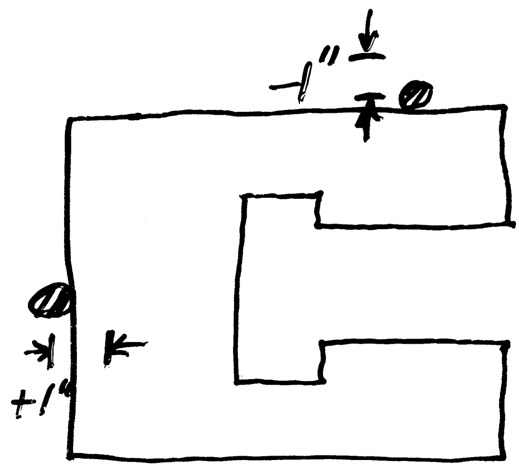
   bucking coil

Fiducialization



reference
measured in CMM

Magnet Under Test



X = 4" + 1"
= 5"

Y = 3" - 1" = 2"

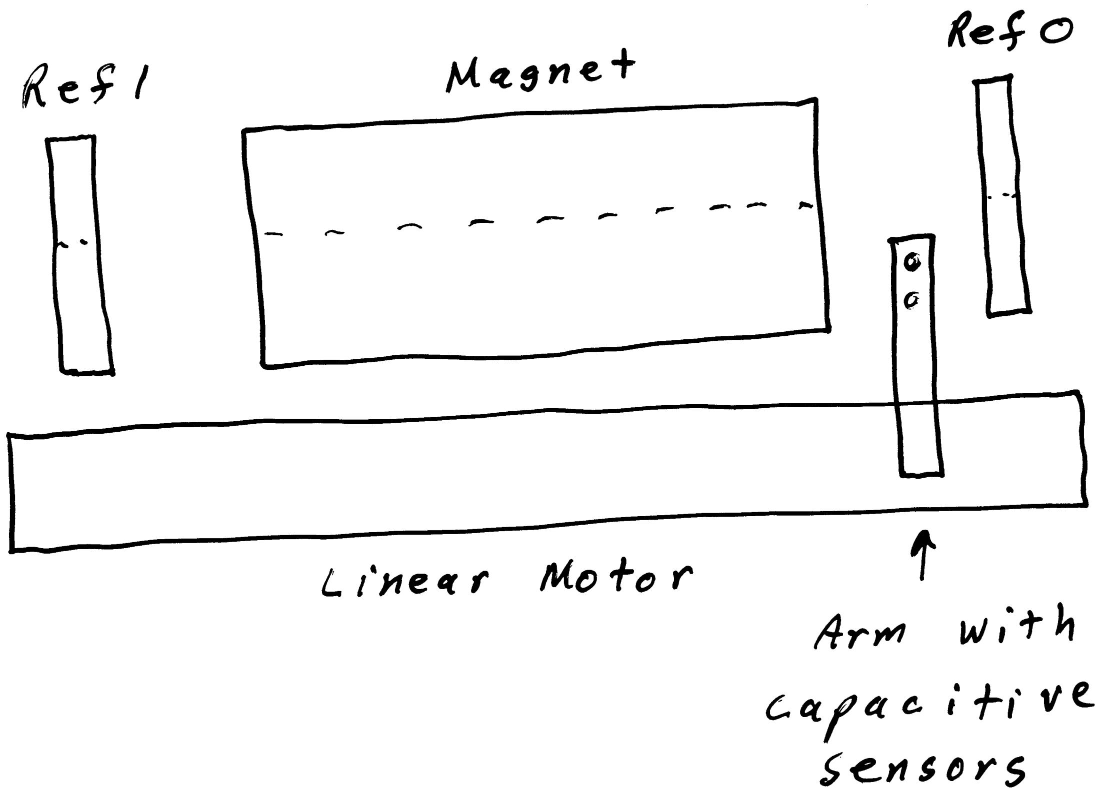
Line up pole surfaces

Measure difference in
tooling ball positions

Calculate the center in the
magnet under test using
the Known reference magnet
dimensions

Mechanical Fiducialization System

Same technique as PEP II.



1) Place magnet
2) Run arm
3) Move magnet
4) Run arm

Lines magnet gap up with reference gap.

height, pitch, X, yaw, roll

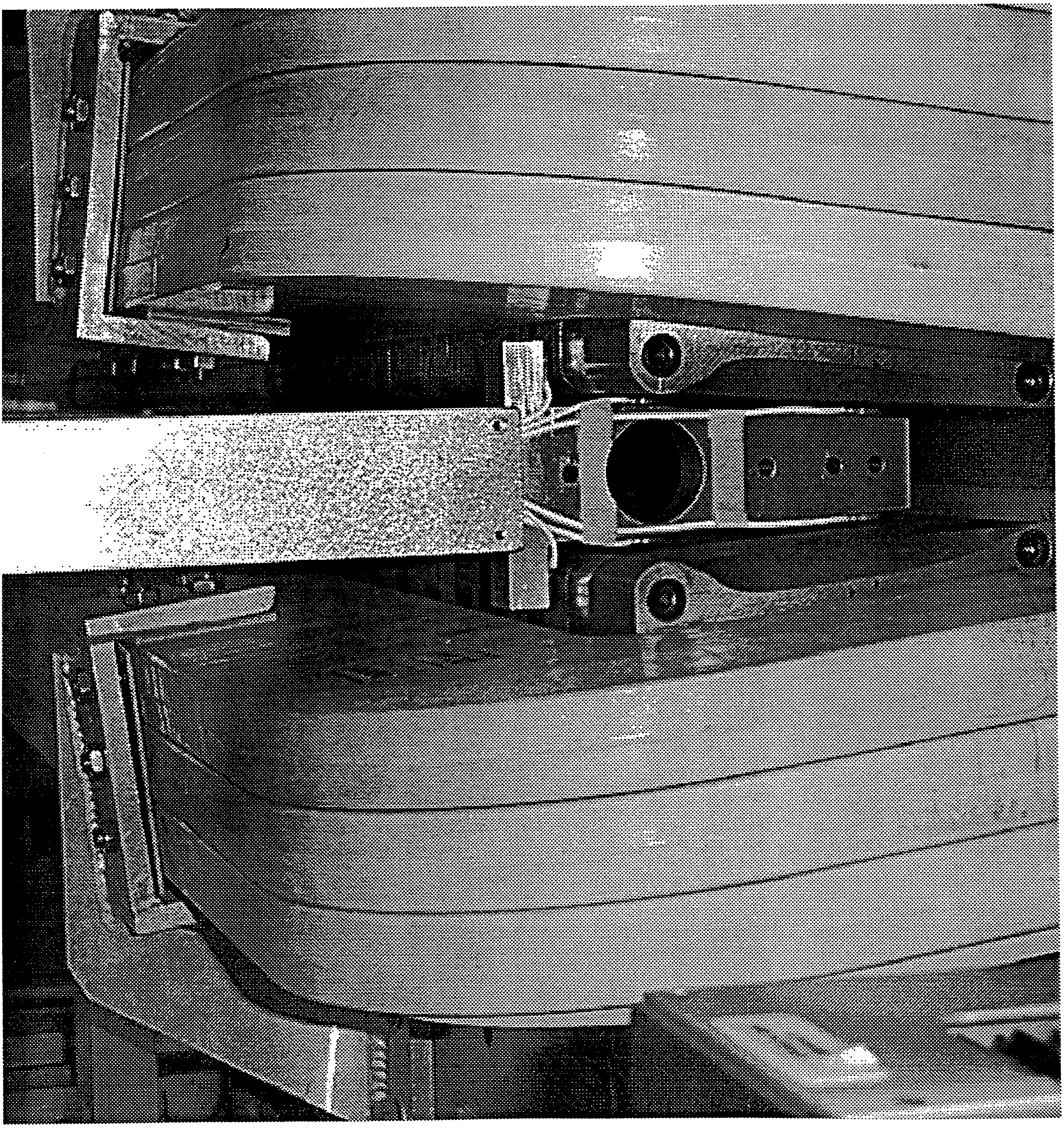
Corrections

Arm Tilt — Electronic Level

We measure the tilt of the arm relative to its value in the reference pole. The capacitive sensor measurements are adjusted accordingly.

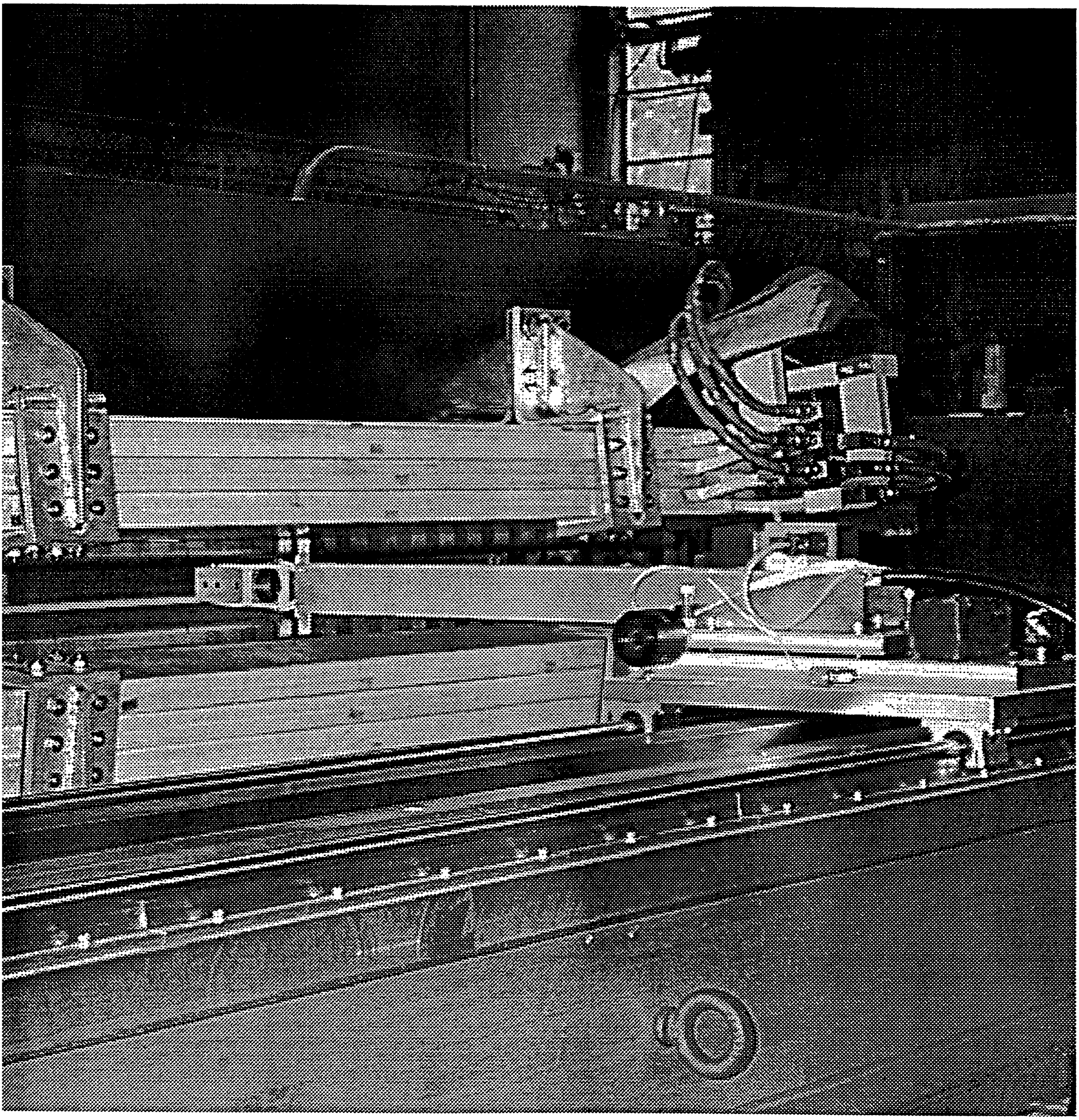
Rail Straightness — Map

We determine the straightness of the rail using a laser and detector. The capacitive sensor measurements are corrected for this effect also.

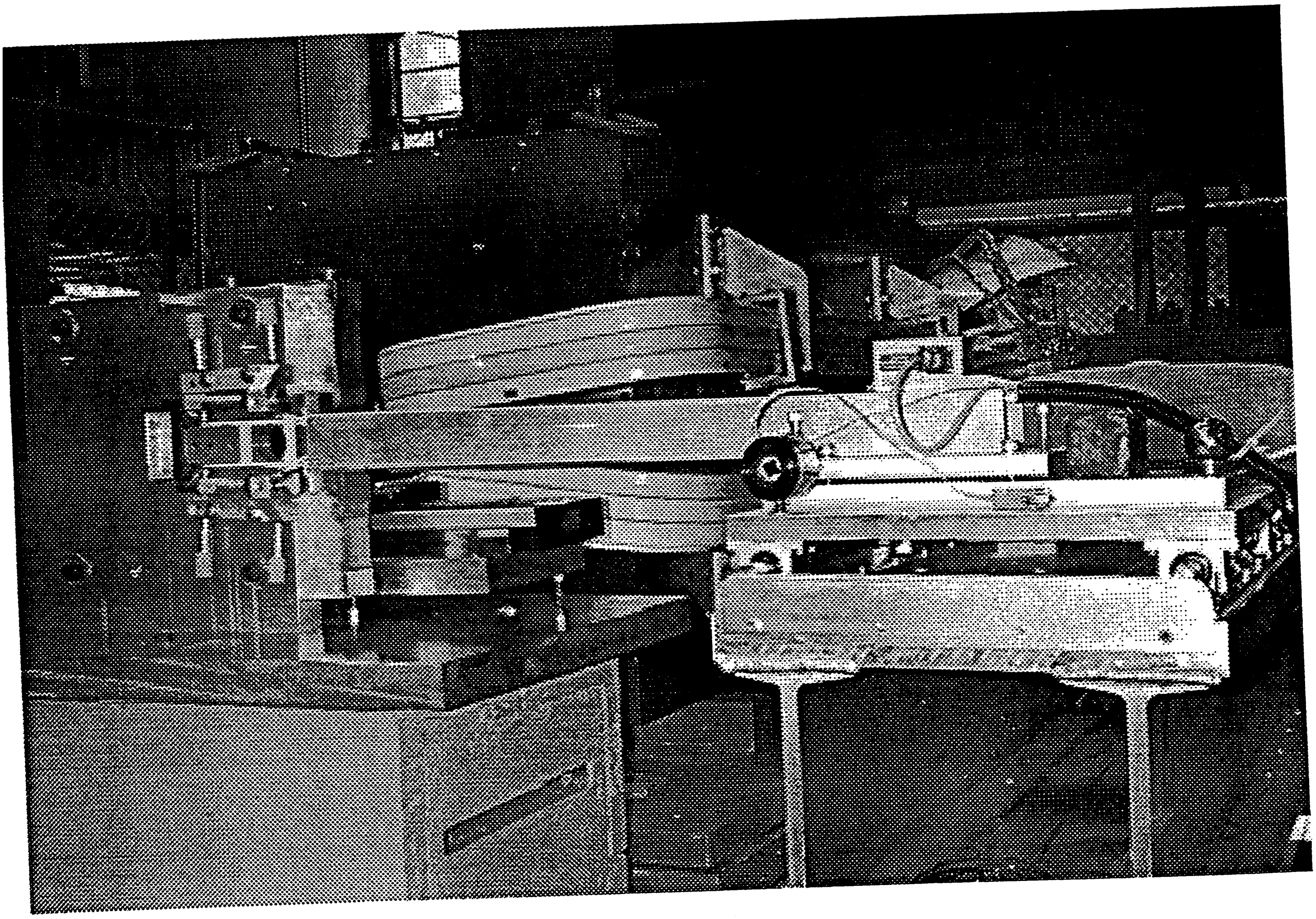


Arm with capacitive sensors in magnet

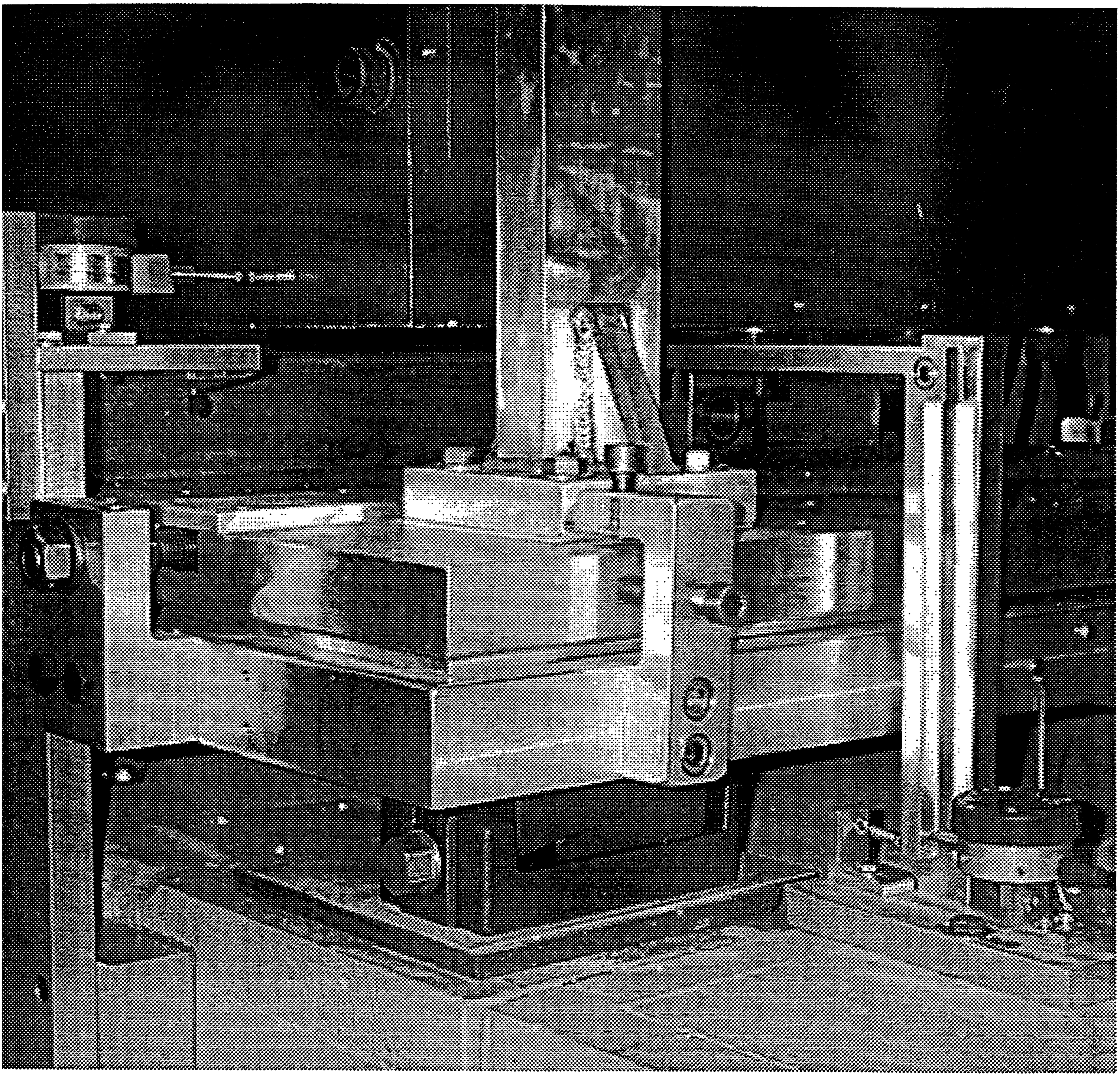
Reference poles



Rails, linear motor, level, laser position detector



capacitive sensor calibration
second reference pole used
as a check.



Move magnet, monitor position

Required Motions To Bring The Magnet Into Alignment

Top View

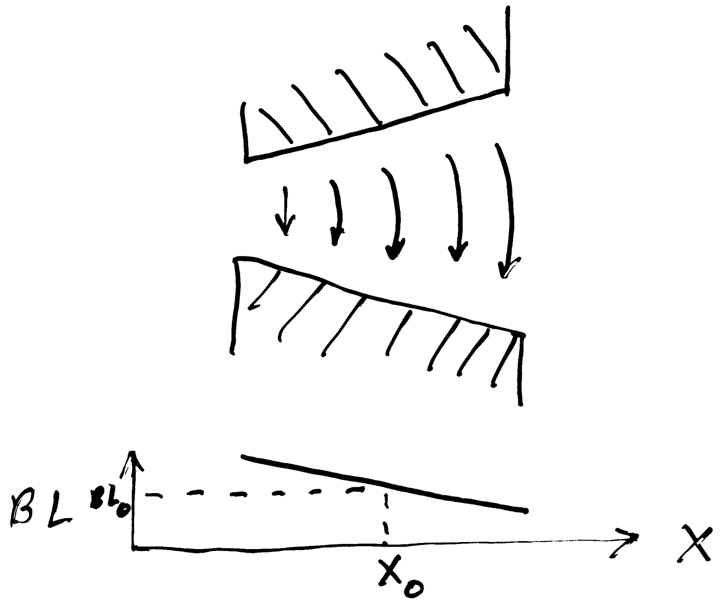
```
          -----------------------
          |                O  --|
          |               y2  | |x2      x2 =      0.3 mils
          |                   --|
          |                     |
          |                     |
          |                     |
          |                     |
 +z       |                     |        y2 =    -10.6 mils
  ^       |y3                   |
  |->     |O                    |        y3 =     -0.9 mils
     +x   |                     |
          |                     |        y1 =     -0.4 mils
          |                     |
          |                     |
          |                     |
          |                     |
          |                   --|
          |               y1  | |x1      x1 =      0.4 mils
          |                O  --|
          -----------------------

      Gap Side              Back Side
```

+x is to the right in the figure
+y is up
+z is to the top of the figure

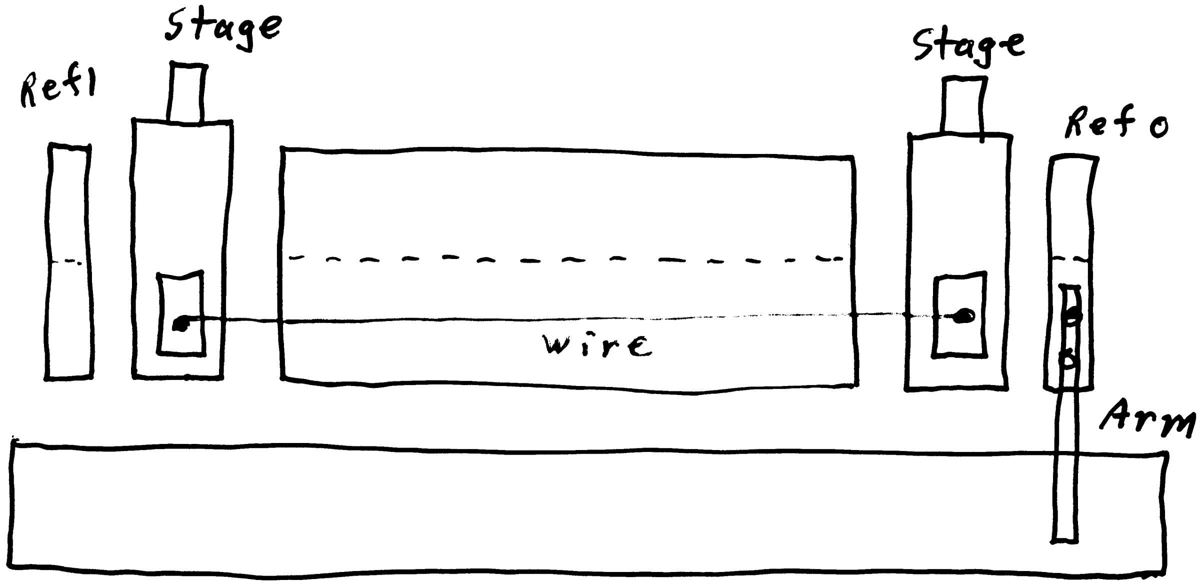
Sample printout telling the operator how to move the magnet to bring it into alignment with the reference poles and rail system.

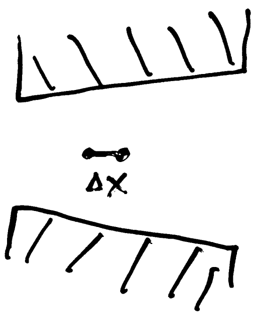
Magnetic Fiducialization



Want X_0 where BL has a certain value BL_0

Stretched Wire System





$$v = \frac{d\Phi}{dt}$$

$$\Delta\Phi = \int v\, dt$$

$$\Delta\Phi = BL \cdot \Delta X$$

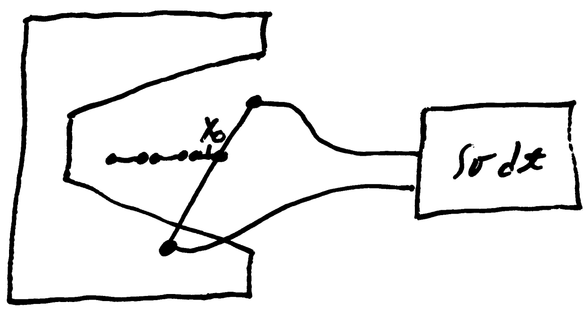
$$BL = \frac{\int v\, dt}{\Delta X}$$

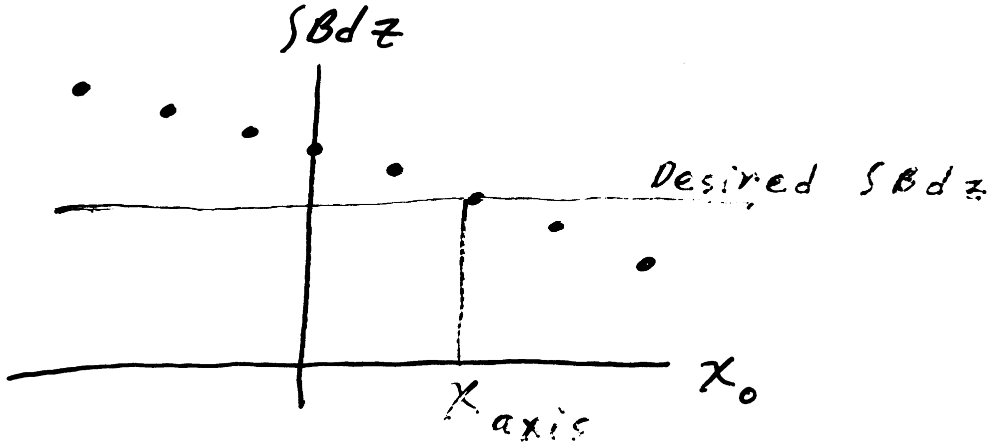
Measure across gap.

Leave wire where BL has desired value.

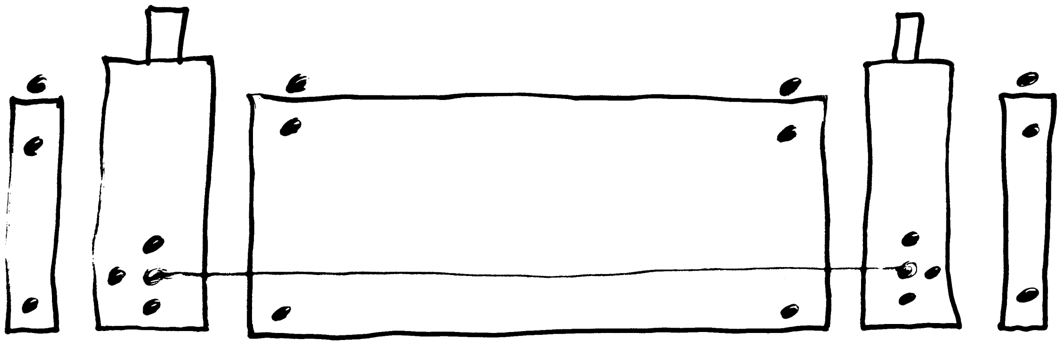
Magnetic Axis

Find the x position which gives a specified $\int B\,dz$ at a specified current.





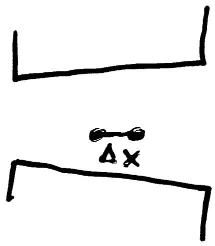
Combine The Mechanical And Magnetic Measurements



• Tooling Ball

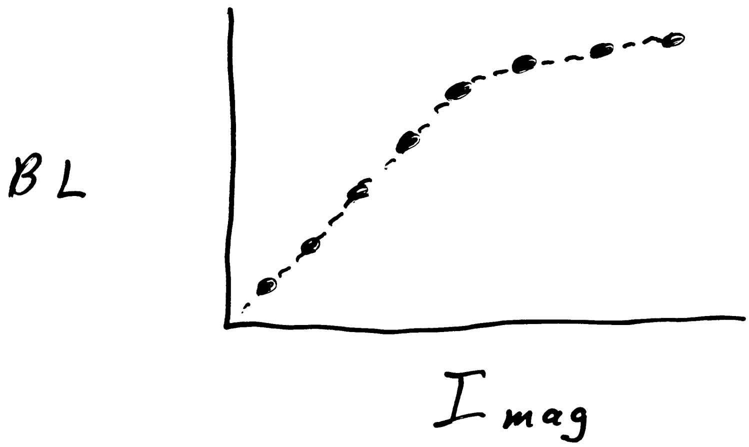
1) The magnet is lined up with the reference poles. sets height, pitch, X_{mech}, yaw, roll
2) The wire is positioned at the magnetic center X_{mag}.
3) A laser tracker locates the tooling balls on the magnet relative to the reference poles and the wire.

Excitation Function



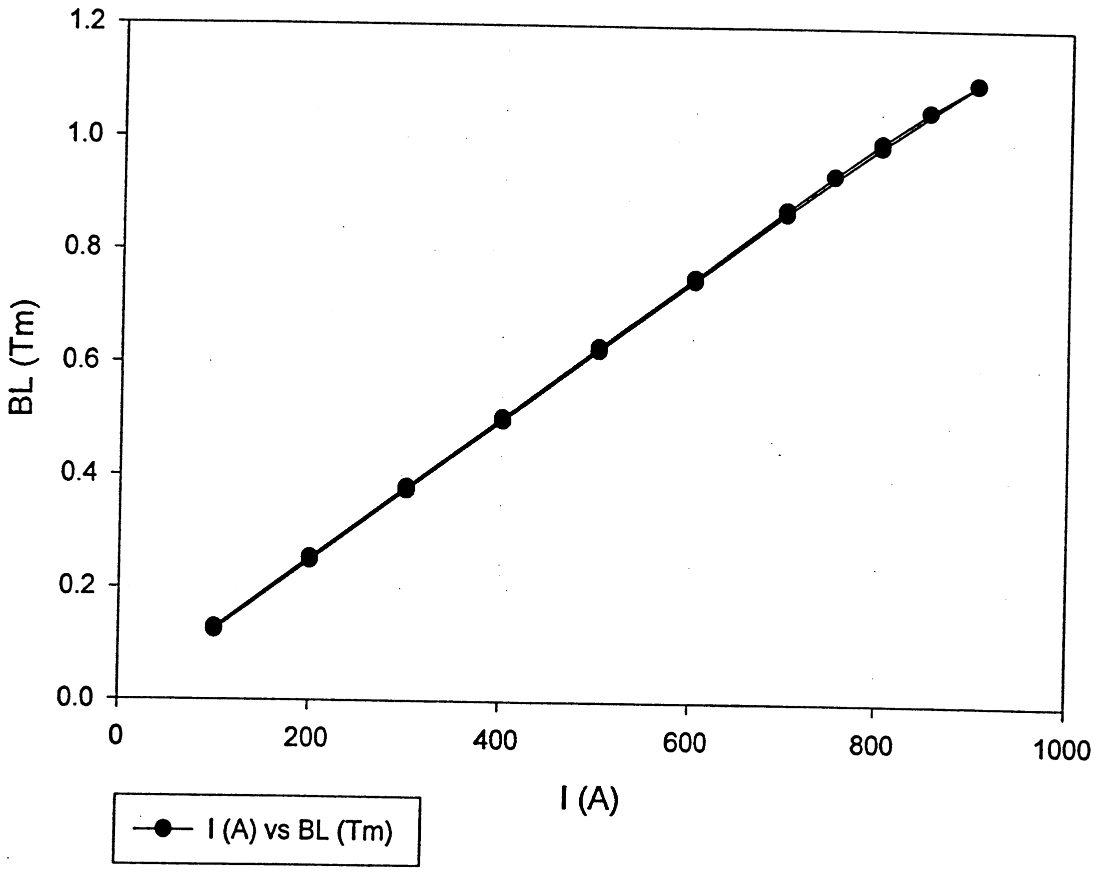
$$BL = \frac{\int v\,dt}{\Delta x}$$

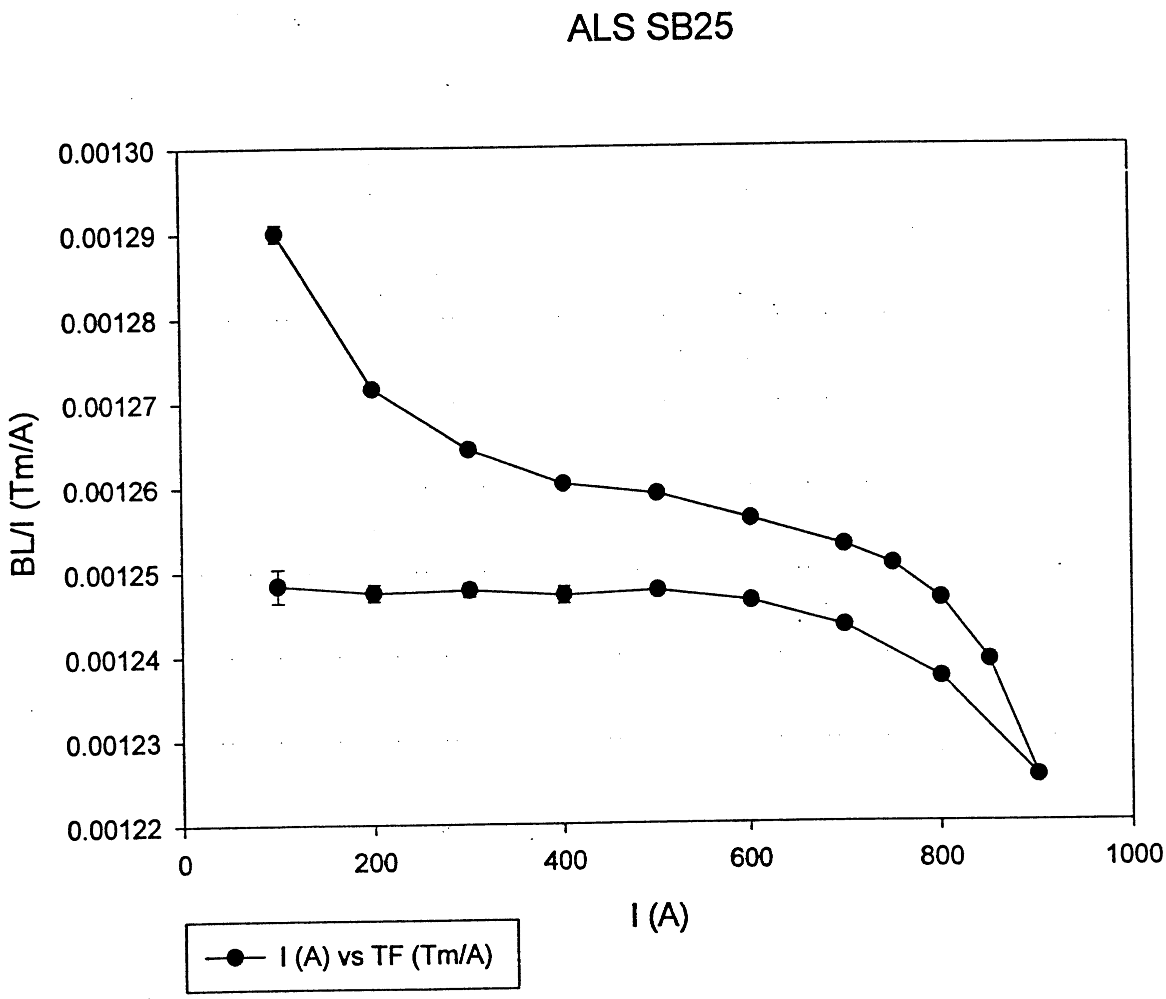
The wire is moved about the magnetic center.



Find BL as a function of Imag. Use this to set the magnet current.

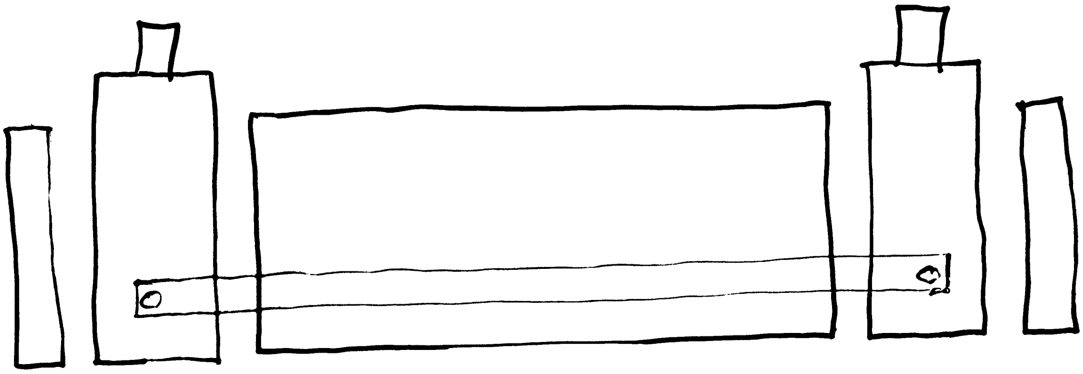
ALS SB25





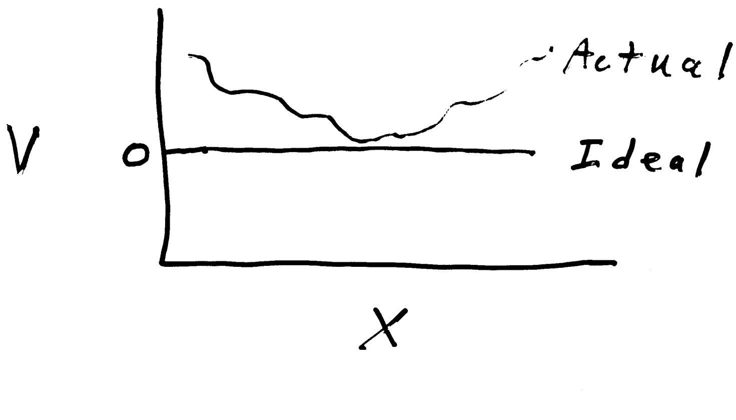
ALS SB25
BL/I (Tm/A)
0.00130
0.00129
0.00128
0.00127
0.00126
0.00125
0.00124
0.00123
0.00122
0
200
400
600
800
1000
I (A)
I (A) vs TF (Tm/A)

Field Quality



Bucking Coil

The bucking coil is insensitive to the dipole and quadrupole fields, but gives an output voltage for higher multipole fields.

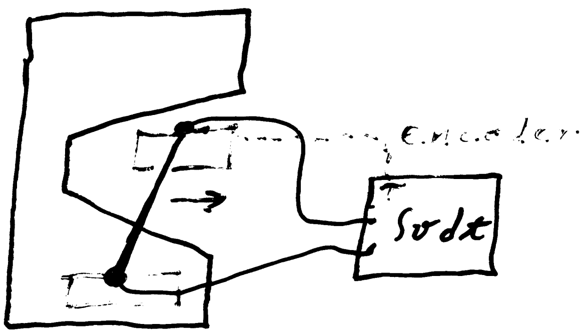


Field Quality

We use the existing stages to move a coil package on the magnet midplane.

The coil package consists of a wire and two flat coils.

Single Wire

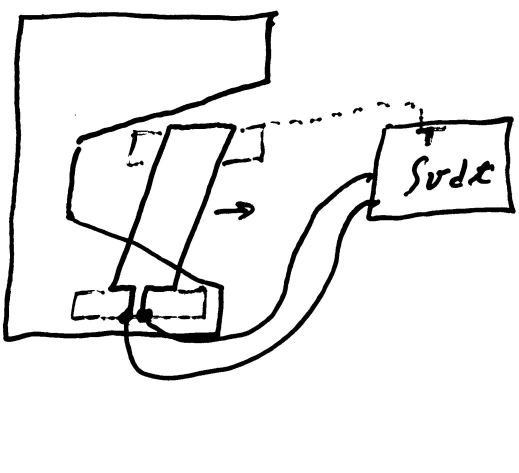


gives $n = 1, 2, 3, \ldots$

use for $n = 1$

dipole

Single Coil



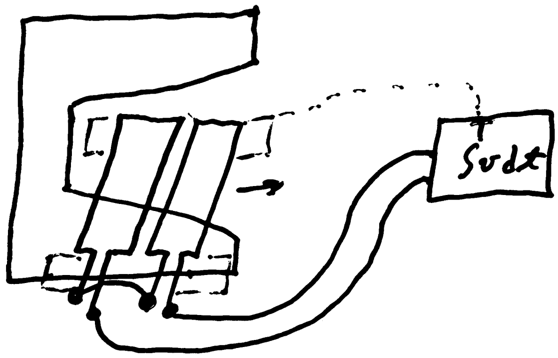
bucks $n = 1$

gives $n = 2, 3, \ldots$

use for $n = 2$

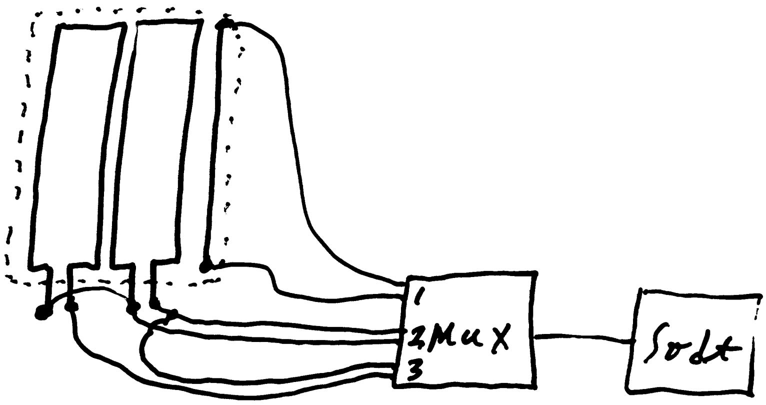
quadrupole

Double Coil



bucks $n=1, 2$
gives $n= 3,4,\ldots$
use for $n= 3,4,\ldots$

Coil Package



Summary

We set the height, roll, pitch, and yaw of the magnet by aligning its pole faces to a reference pole using capacitive sensors.

We set the X position so the magnet has a specified $\int B\,dz$ at a specified current using a stretched wire system to measure $\int B\,dz$ vs X.

A laser tracker locates the magnet relative to the reference pole and the wire.

We measure the excitation function of the magnet using a stretched wire system which gives $\int B\,dz$ vs I.

We determine the field quality by sweeping a single wire, a single coil, and a double coil across the midplane of the magnet.

The measurements are a little over half complete.