ATF2

Magnets

Design of Various ATF2 MAGNETS: STATUS REPORT to ATF2 Project Meeting, KEK, May 30th 2006

Cherrill Spencer, SLAC

Member of ATF2 Magnet Team

ATF2

Magnets

ATF2 Magnet Styles to Be Designed & Fabricated

- 14 final focus quads + 6 matching section quads + 8 extraction quads
  - All made from one design, called “QEA”, design completed last summer
  - 28 magnets + 1 spare been fabricated by IHEP, Beijing. Being measured at IHEP and KEK: Masuzawa will report on their measurements in this session
- 5 final focus sextupoles - in design, need your feedback on my design suggestion
- 3 final focus bends - in design, need your feedback on my design suggestion
- 2 final doublet quads – design has been chosen
- 2 final focus octupoles – need to get requirements!

FF sextupoles: requirements

- K2L values provided , bore aperture > 32mm, suggested effective length 0.2m
- K2L = (Gradient´ x L eff) / (B x rho)
  - (B x rho) of 1.3 GeV beam = 43.3633
  - Gradient´= (2 x B at poletip) / (bore radius) ^{2}
- Names of 5 sextupoles: SF6, SF5, SD4, SF1, SD0
- K2L values range from 0.84 to 14.34
- Look for existing sextupoles to use to save time and money. K2L values can be satisfied with variety of Leff & radii
- Have found 2 styles of existing SLC sextupoles. Designed & made by me in 1993 for the final focus optics upgrade of SLC.

ATF2

Magnets

Suggested design for SF6,SF5,SF1 & SD0

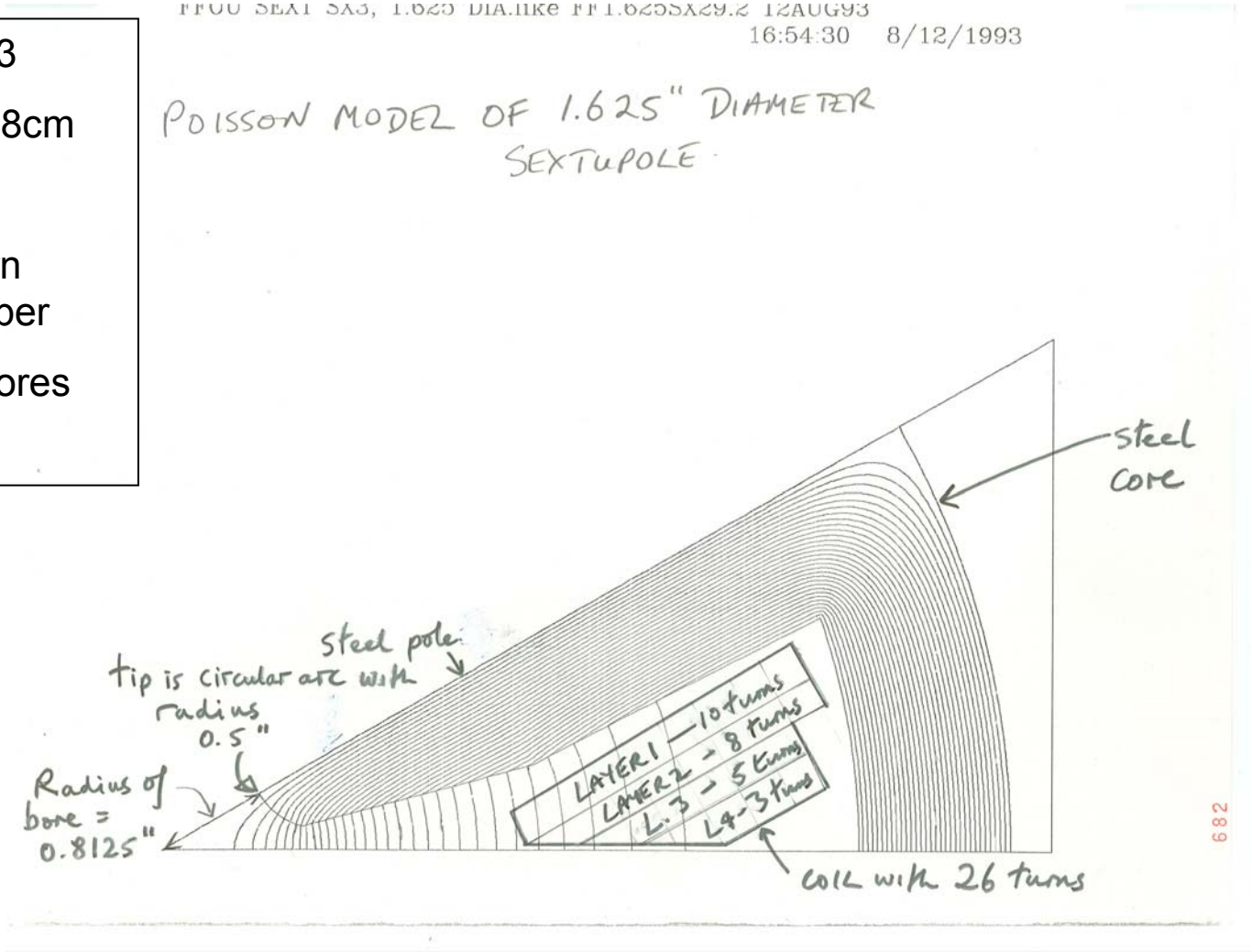
"SX3" : 1.625SX3.53

Bore radius = 2.0638cm

L eff = 0.1m

Water cooled 26 turn coils, 0.255"sq Copper

Solid C1008 steel cores



ATF2

Magnets

Suggested design for SD4 (strongest ATF2 FF sextupole)

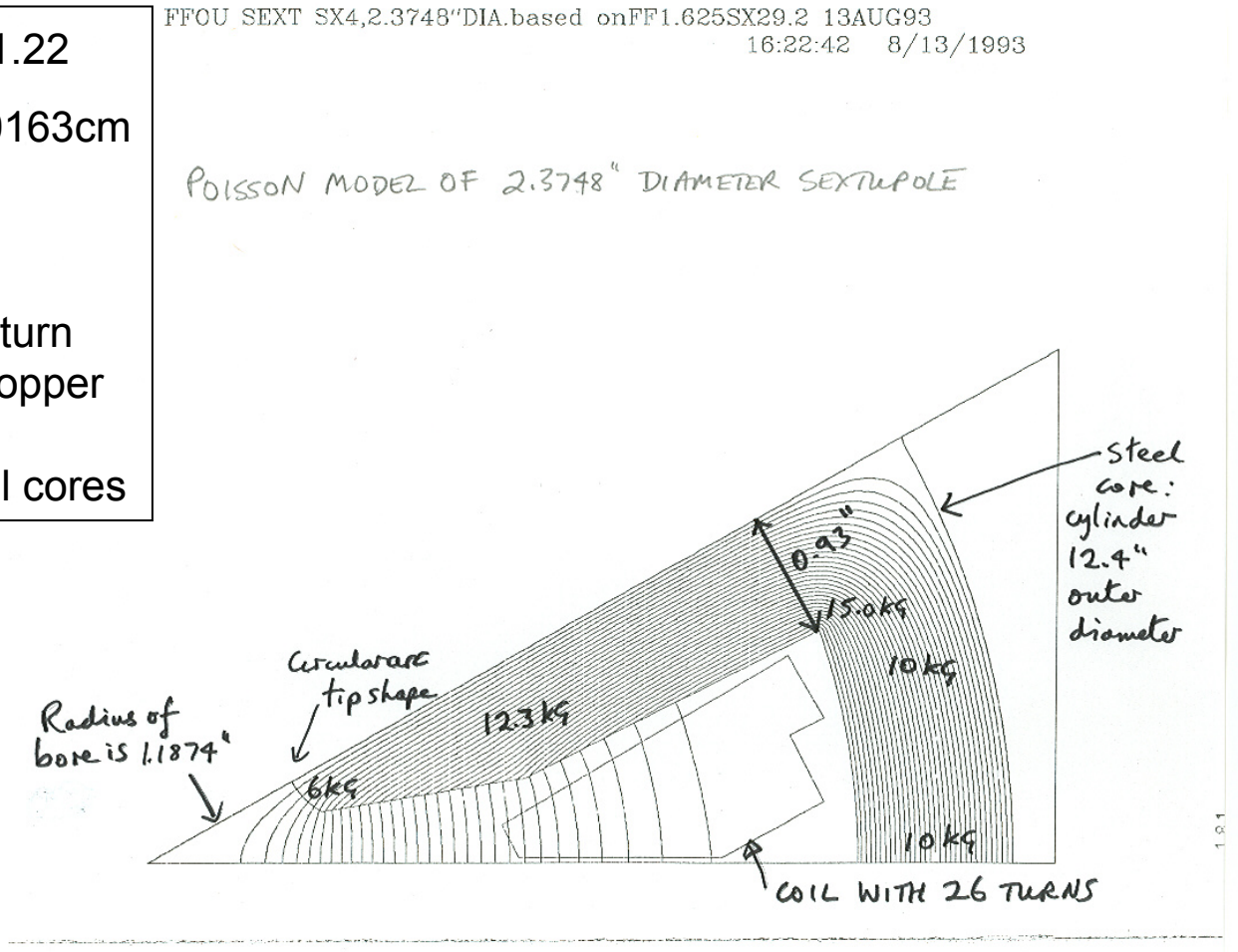
"SX4" 2.375SX11.22

Bore radius = 3.0163cm

Eff length = 0.3m

Water cooled 26 turn coils, 0.255"sq Copper

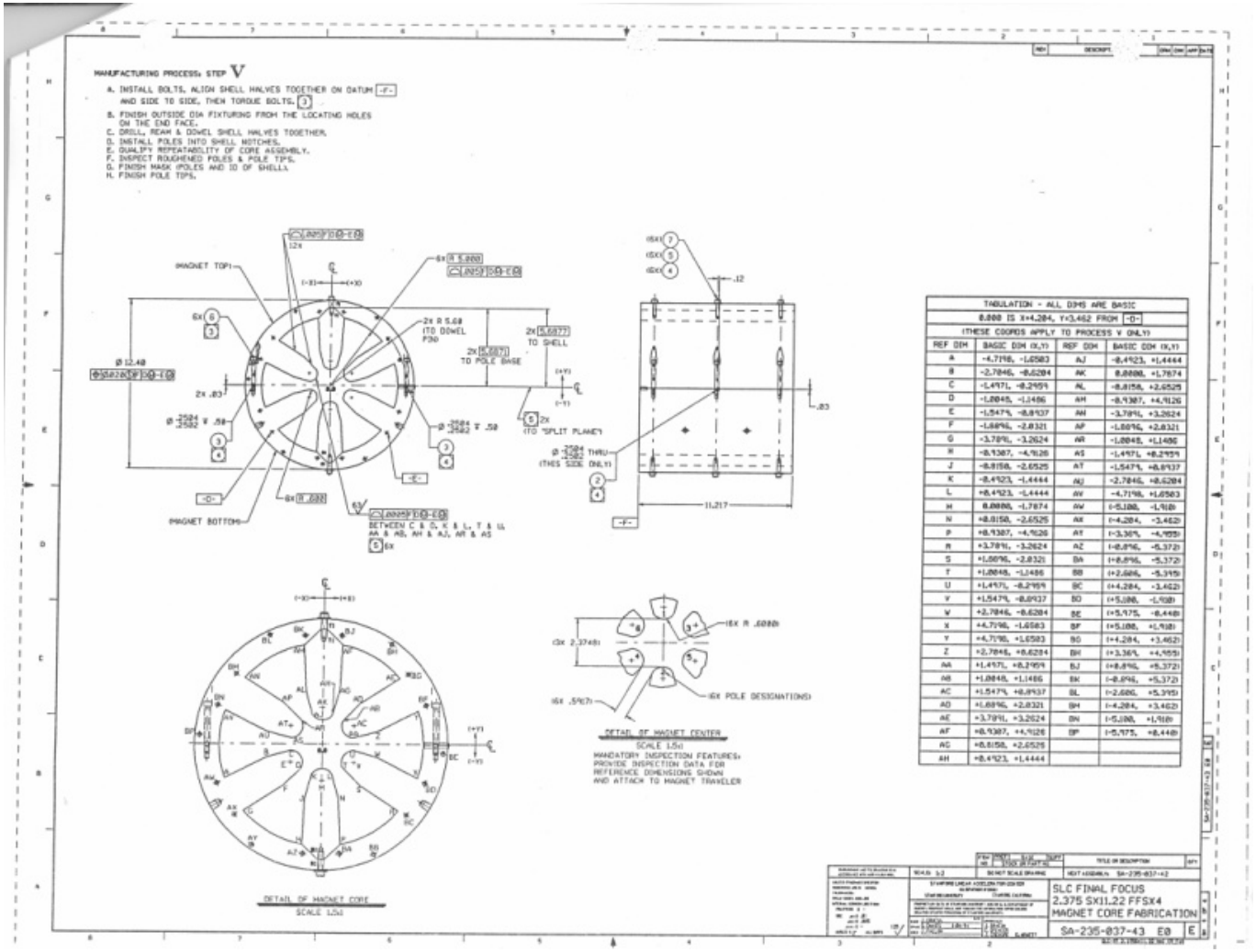
Solid C1008 steel cores



ATF2

Magnets

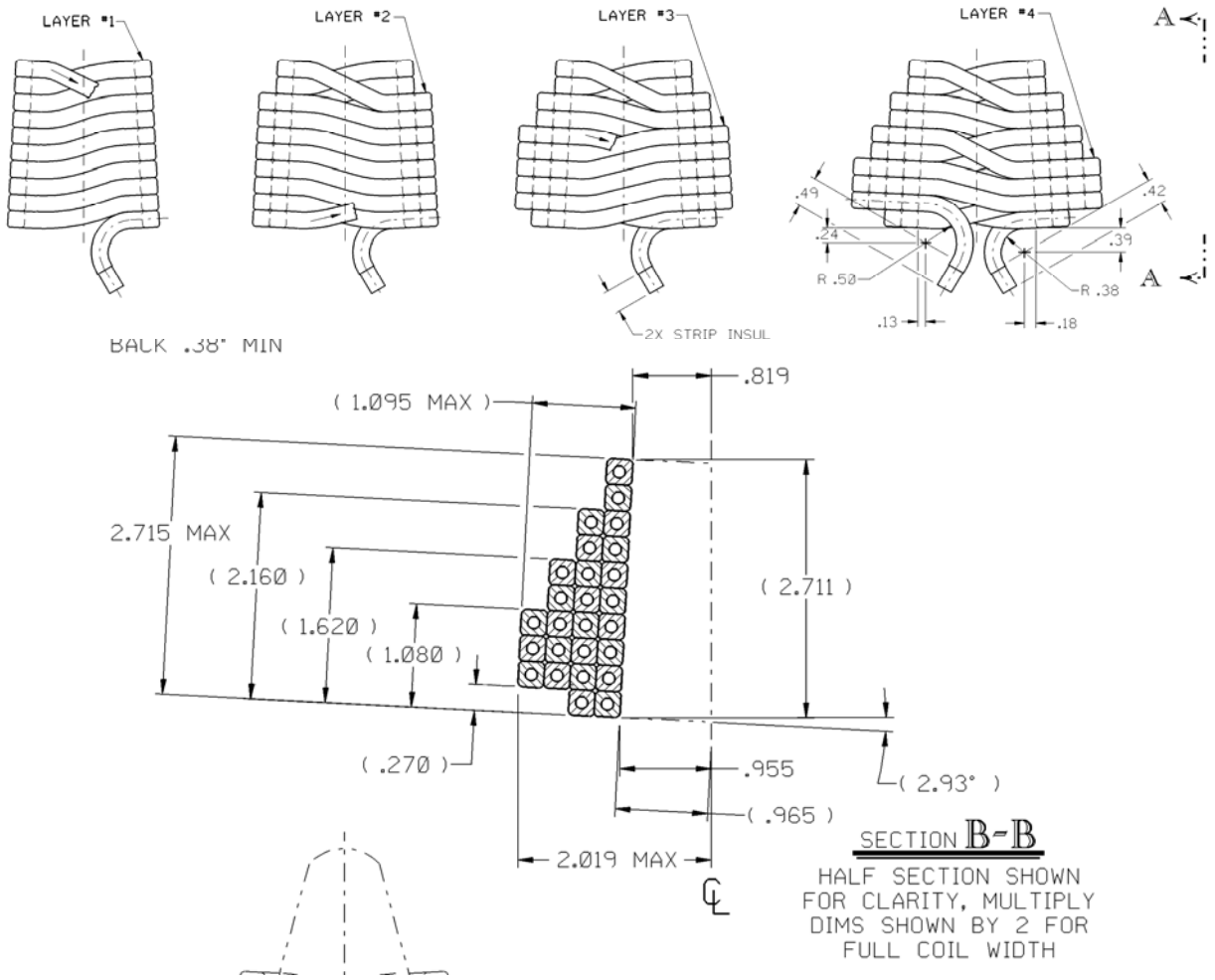
Solid steel sextupole core: tight tolerances on steel machining leading to low multipoles



ATF2

Magnets

26 turn water cooled coils, can run up to 195 amps



ATF2

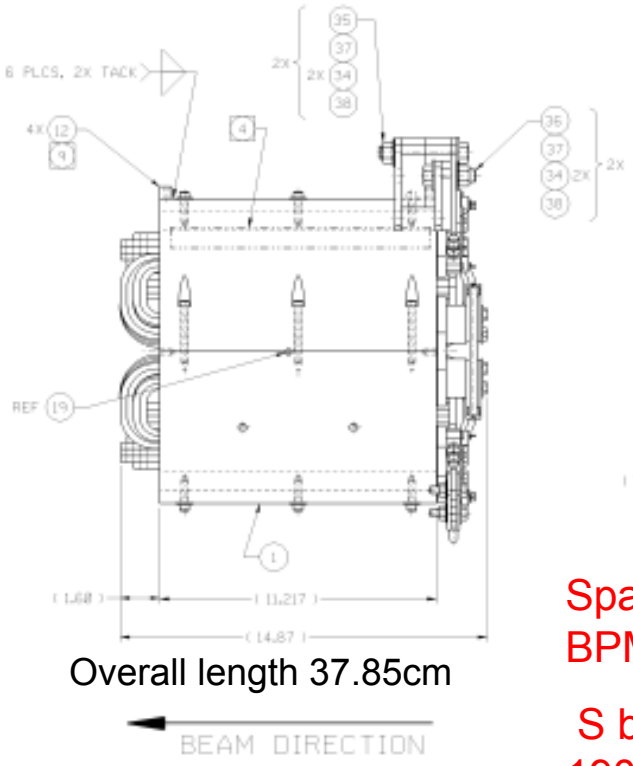
Magnets

Assembly drawing of “SX4” style.

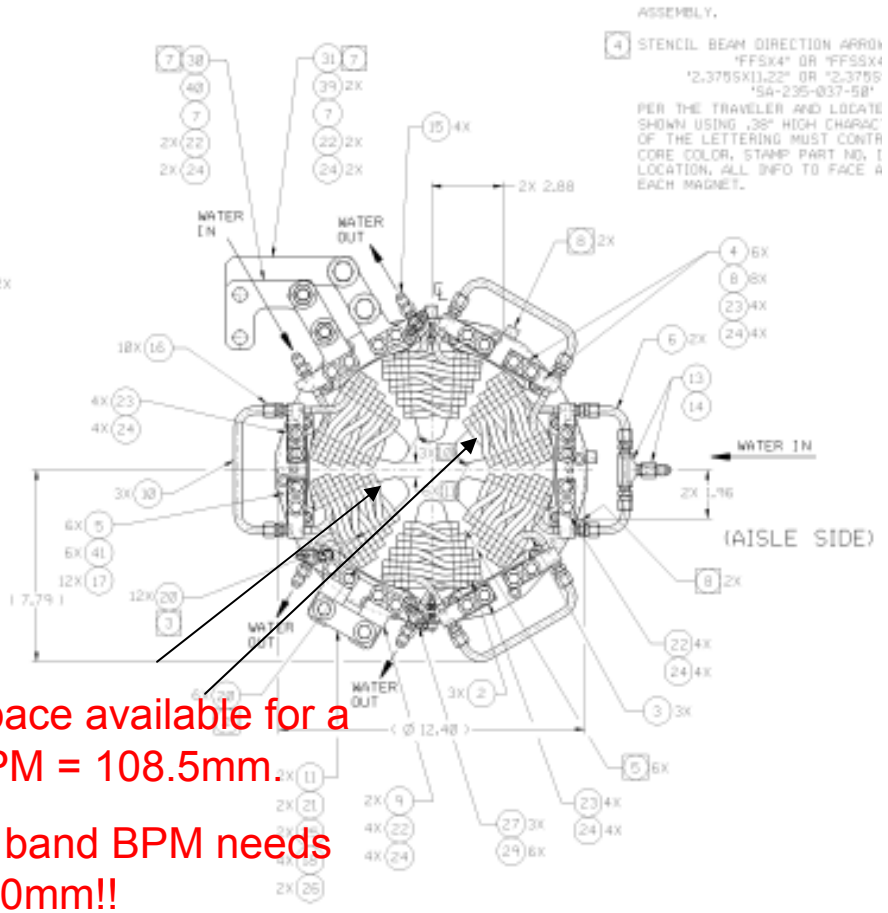
SX3 has similar profile, overall length is 18.26cm

Magnet Weights: SX3 ~ 56 kg

SX4 ~ 146 kg



Overall length 37.85cm



Space available for a BPM = 108.5mm.

S band BPM needs 190mm!!

ATF2

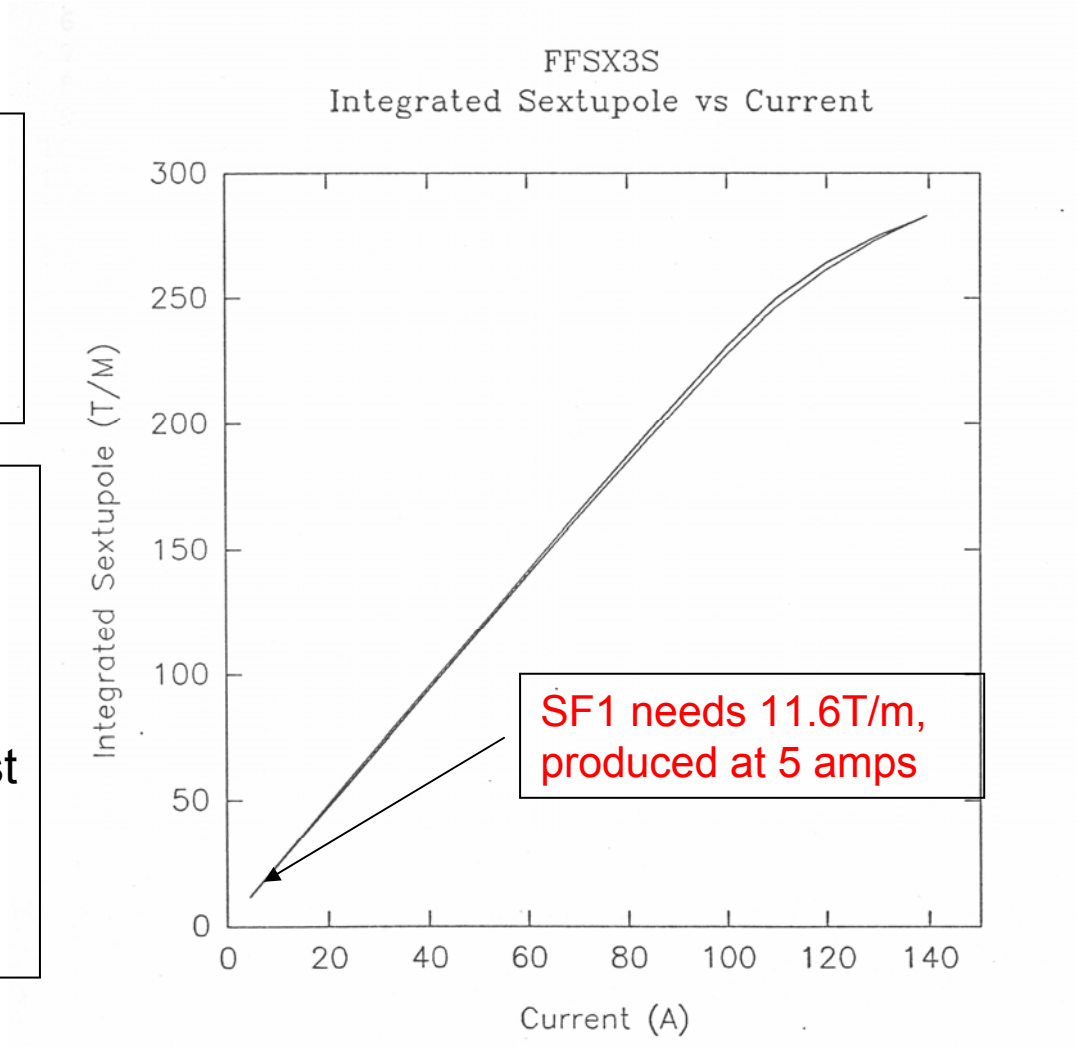
Magnets

Measured strength of SX3: used in a 55GeV SLC beam line.

Integrated gradients of the SX3 style can reach much higher than we need at ATF2

4 SX3 and 4SX4 magnets exist-sitting, unused in the SLC final focus.

I have made request to take 4 SX3 and 1 SX4 magnets-waiting on the reply



ATF2

Magnets

Implications of required strengths using existing SX3 and SX4 magnets

- Scaling down to ATF2 required strengths: the currents needed for 4 shorter sextupoles range from ~1.7 to 15.6 amps. Resistance of SX3 = 0.033 ohms, so voltages range from 0.056 to 0.5 volts. Do these I and V needs fit in with power supplies being considered?
- SX4 style used for SD4 : 30 amps & 2 volts.
- If these voltages are too small, we can change the coils for new design with fewer turns and smaller conductor (higher resistance/m). Even so, voltages still small: 0.4 to 1.2 v, and currents range from 3.4 to 31 amps.
- Need to decide if can use these old magnets or not.

ATF2

Magnets

Multipole tolerances for the sextupoles. Comparison with actual multipoles.

- Do the suggested old SLC sextupoles meet the multipole tolerances? Were all measured at SLAC in 1993 by rotating coil system
- What are the multipole tolerances? Table 3.7 in ATF2 proposal gives list, some ambiguity in units.
  - 18 pole is first allowed multipole, table 3.7, normal component at r=1cm: 18-pole/6-pole =0.306; 8-pole/6 pole= 0.0066
- SX3 data, measured at 1.535cm, scaled to 1 cm
  - highest octupole/sext= 0.002 at 1cm: OK
  - Highest 18-pole/sext = 0.0002 at 1cm : OK
- SX4 data, measured at 1.535cm scaled to 1cm
  - Highest octupole/sext = 0.0016 at 1cm : OK
  - Highest 18-pole/sext =0.00006 at 1cm : OK
- Conclusion: Multipole tolerances MET (need to check table 3.7)

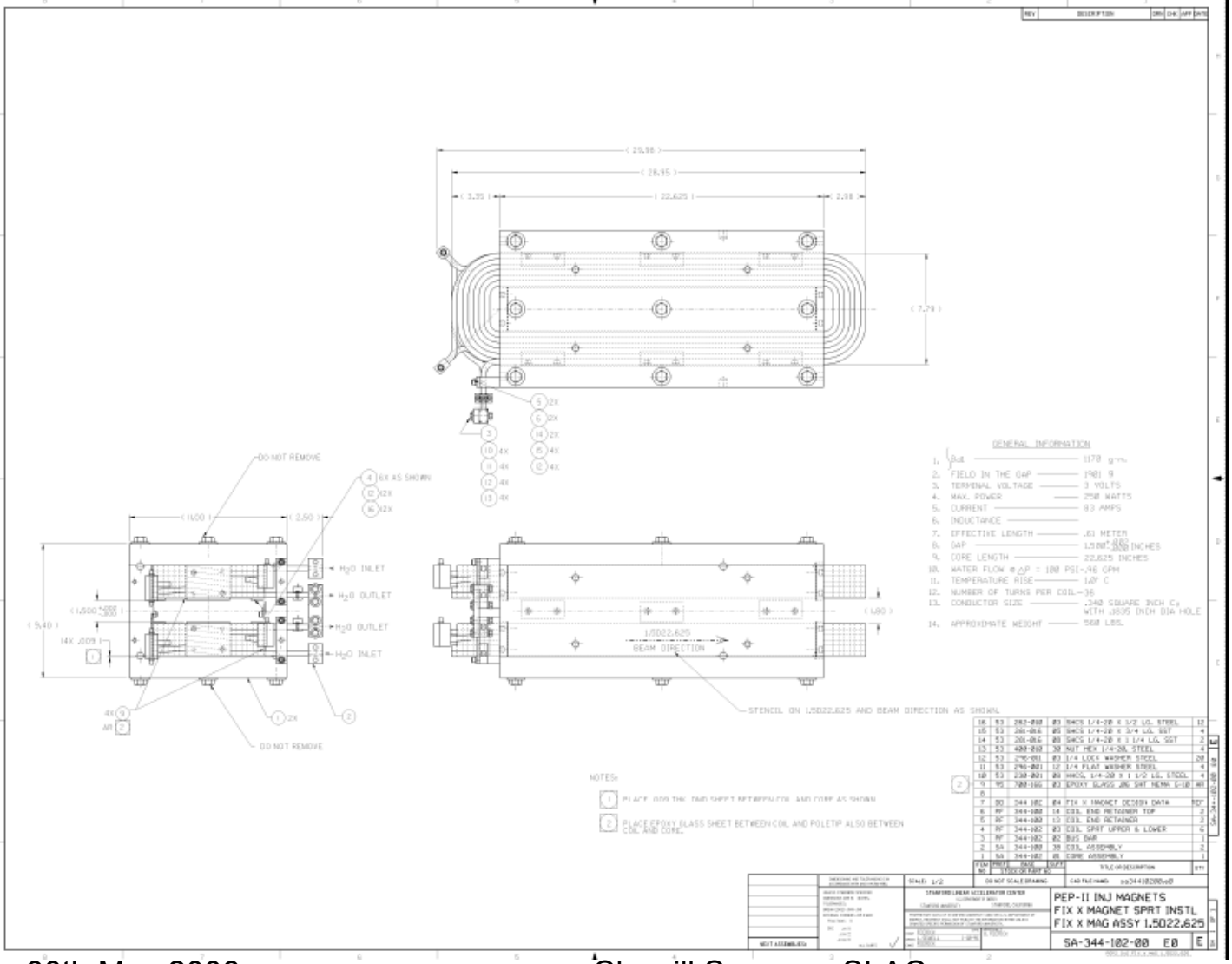
ATF2

Magnets

Requirements for the 3 FF bends

- B1,B2 and B5 (B3and B4 disappeared!)
- Integral B.dl with 1.3 GeV beam Sextupole/dipole at 1cm, 2% beam blow-up
  - B1 1.881 kG-m $<1.2 \times 10^{-3}$
  - B2 1.513 kG-m $<2.62 \times 10^{-4}$
  - B5 2.215 kG-m $<2.55 \times 10^{-4}$
- Suggested effective length = 0.8m
- Suggested full gap >=32 mm
- In order to save time and money I have searched for existing magnets (none) and existing design with full set of drawings: found a PEPII injector dipole

Suggestion for the FF bends: ”1.5D22.625”, use the PEPII drawings. Will have to build 3 dipoles.



Eff. L = 0.61m
instead of 0.8m

Gap is
38.1mm
instead of
32mm

Overall length
= 73.5cm

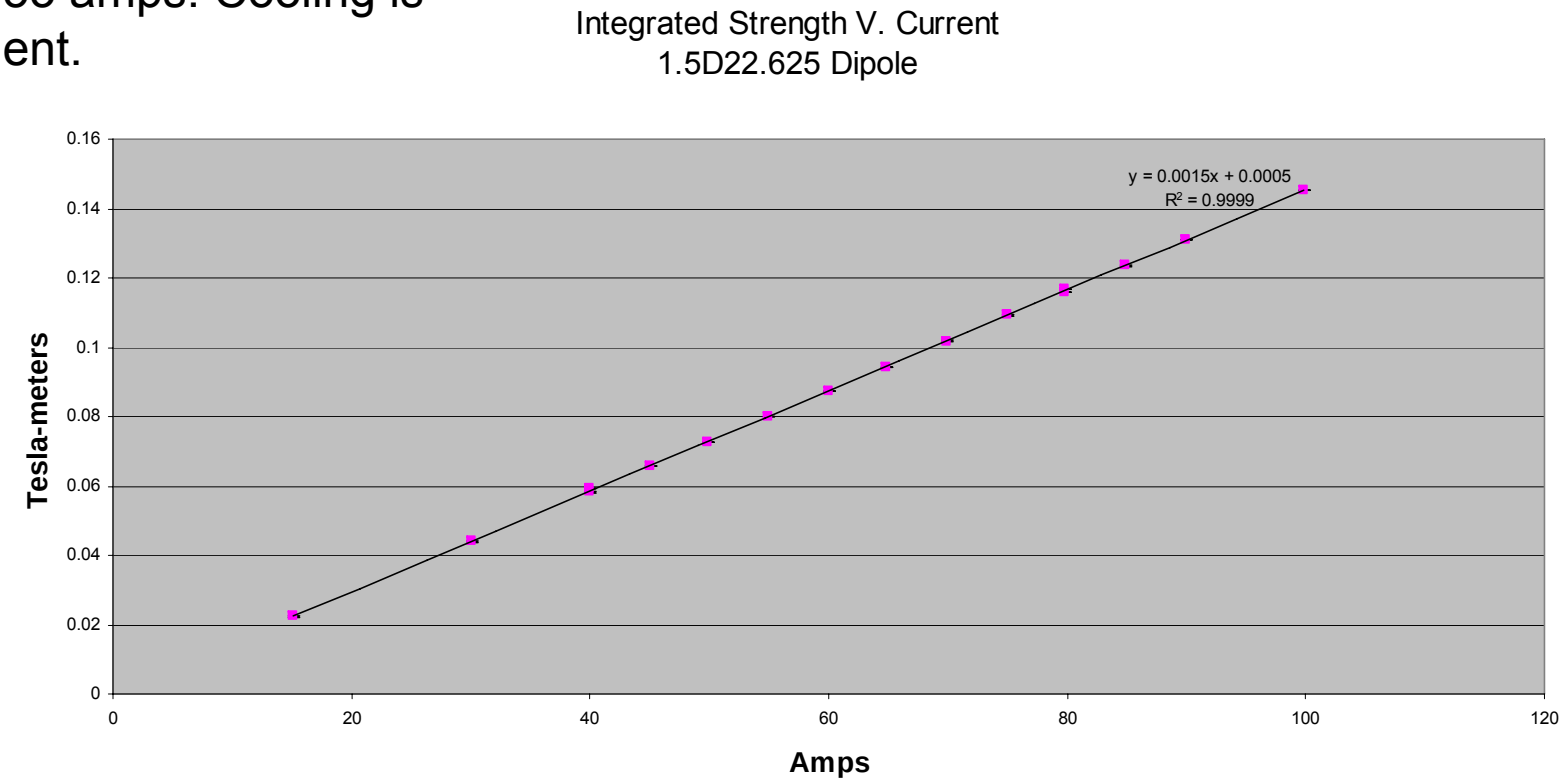
Integrated strength range is acceptable

ATF2

Magnets

Measured integrated strength: up to 100 amps, but can be run at higher currents

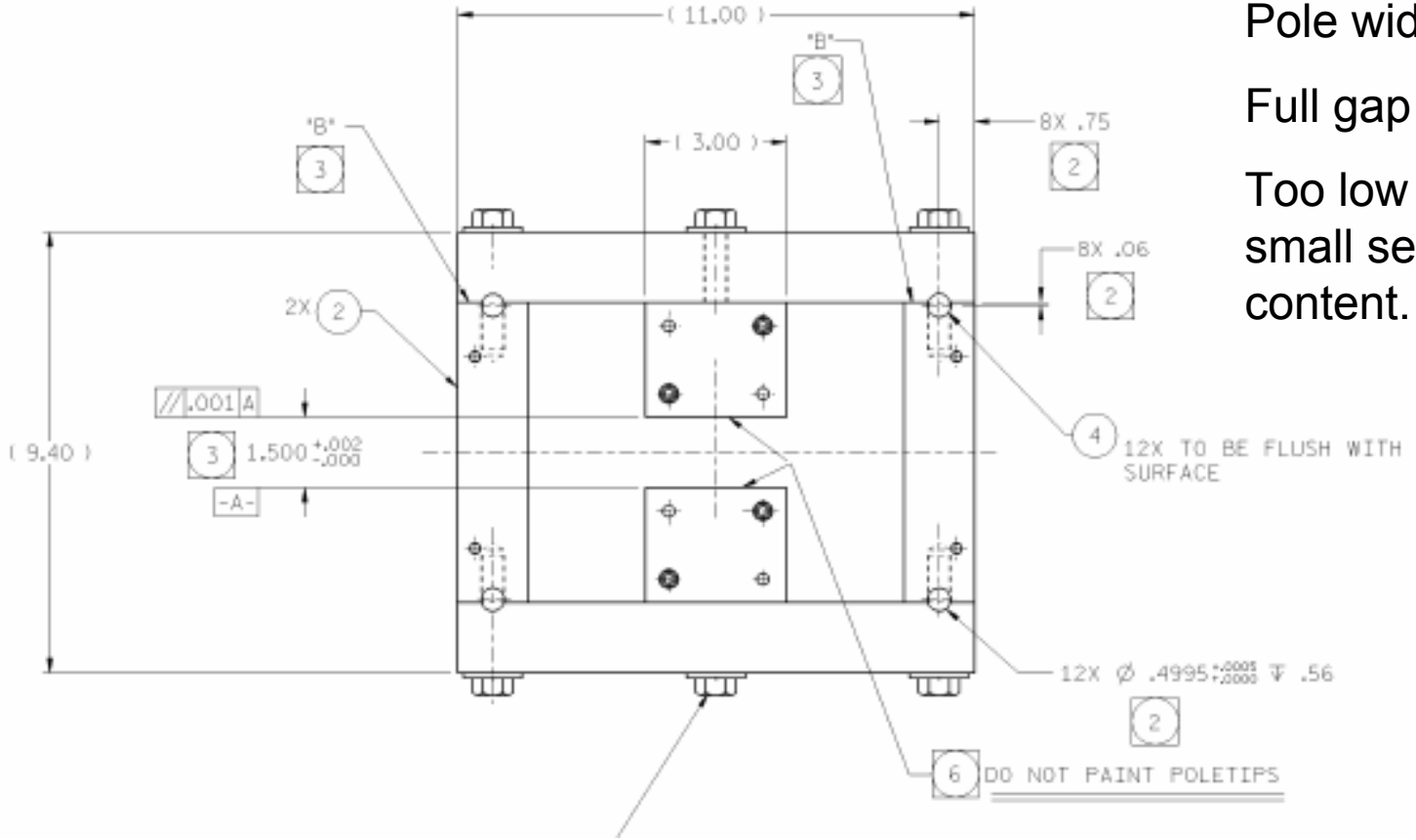
Range of currents needed: 104-153 amps. Cooling is sufficient.



ATF2

Magnets

Does this design meet multipole tolerances? Look at measurements.



Pole width = 3”

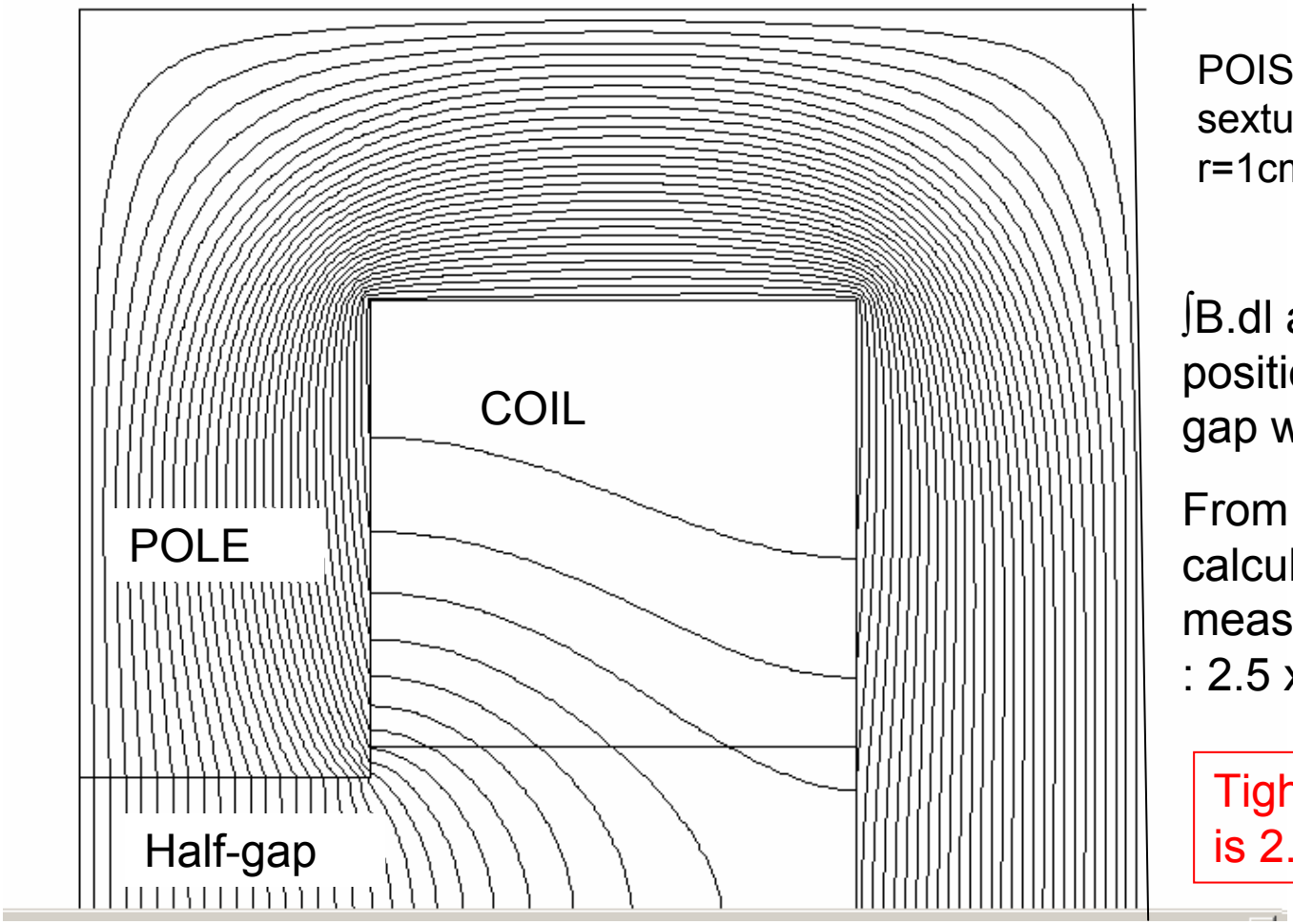
Full gap = 1.5”

Too low ratio for small sextupole content.

ATF2

Magnets

2-D POISSON model of this dipole. Top right-hand corner modeled



POISSON predicts sextupole/dipole at r=1cm : 1.52 x 10^{-3}

$\int B.dl$ at many X positions across the gap were measured.

From this data can calculate the measured sext/dipole : 2.5 x 10^{-3} at 1cm

Tightest sext/dipole is 2.55 x 10^{-4}

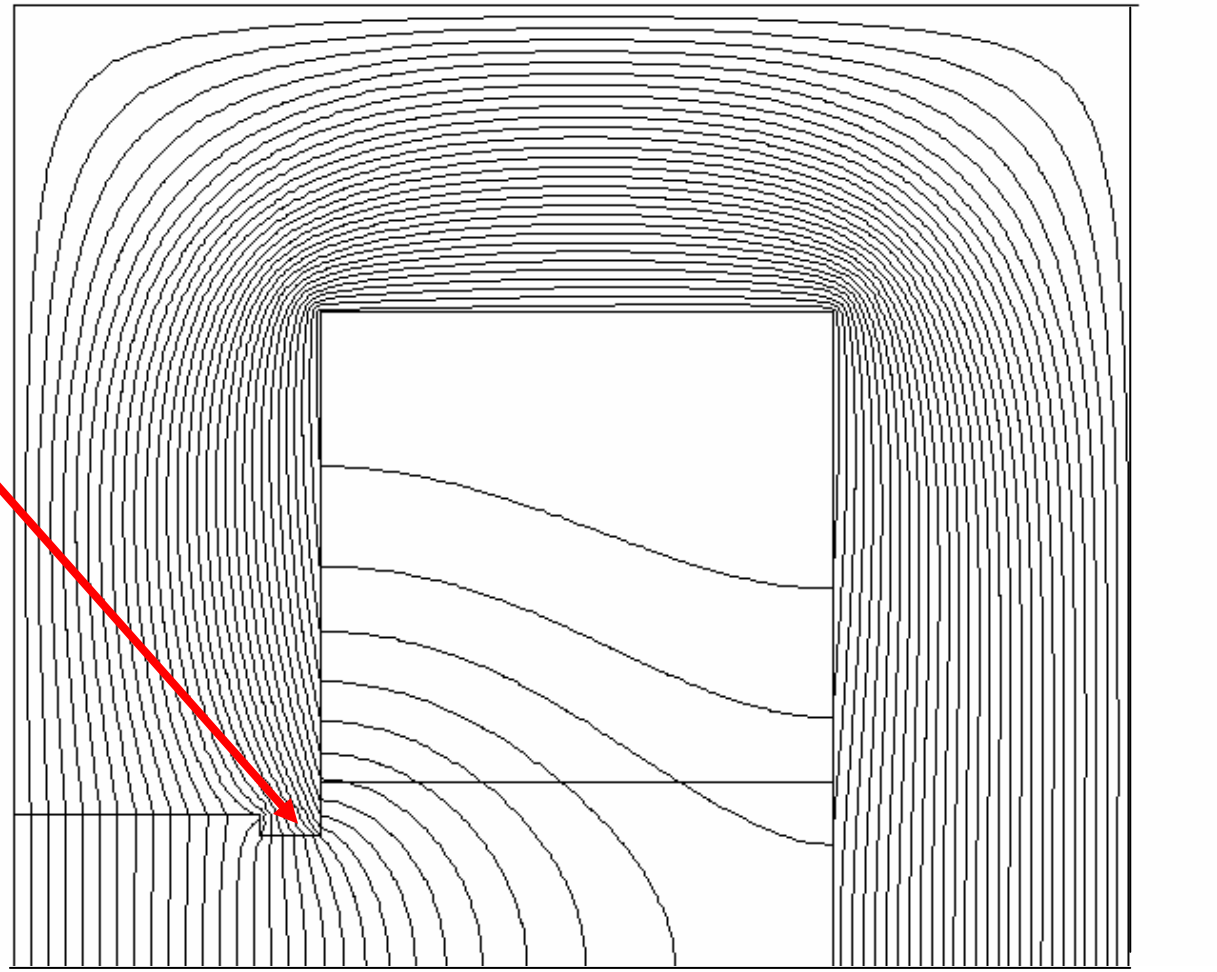
ATF2

Magnets

Sextupole is ~ 10 times too large: try modifying ends of poletip to reduce it

Add a small shim at end of poletip and see effect on sextupole content: tried 3 different shapes (on Saturday last) and not yet found one that reduces sextupole.

I think the poletip is just not wide enough to reach the 2.5 x10 $^{-4}$ level, there is no shape that will help



ATF2

Magnets

How to proceed with the design of the 3 FF bends?

- I will try some other pole end shapes- but I am doubtful I can find a shape that reduces the sextupole in such a narrow poletip (compared to gap).
- So, will have to make a new design from scratch– will choose the coil parameters so the power requirements fit in with high-availability power supply concept.

ATF2

Magnets

At February 2006 ATF2 project meeting my design suggestion for Final Doublet Quads was accepted

- QF1 and QD0 requirements:
- Definition of K1 :

  Gradient = K1 x Brho / Effective length

  At 1.3 GeV, Brho = 4.3363 Tesla-meter

Latest requirements are:

- QF1 K1 = 0.737
- QD0 K1= -1.351
- Using the “QC3” style FFTB quad [1.38Q17.72]
- Aperture: 35.06mm diameter ; Eff L= 0.4675m;
- Gradients: QF1: 6.834 T/m; QD0 :12.533 T/m

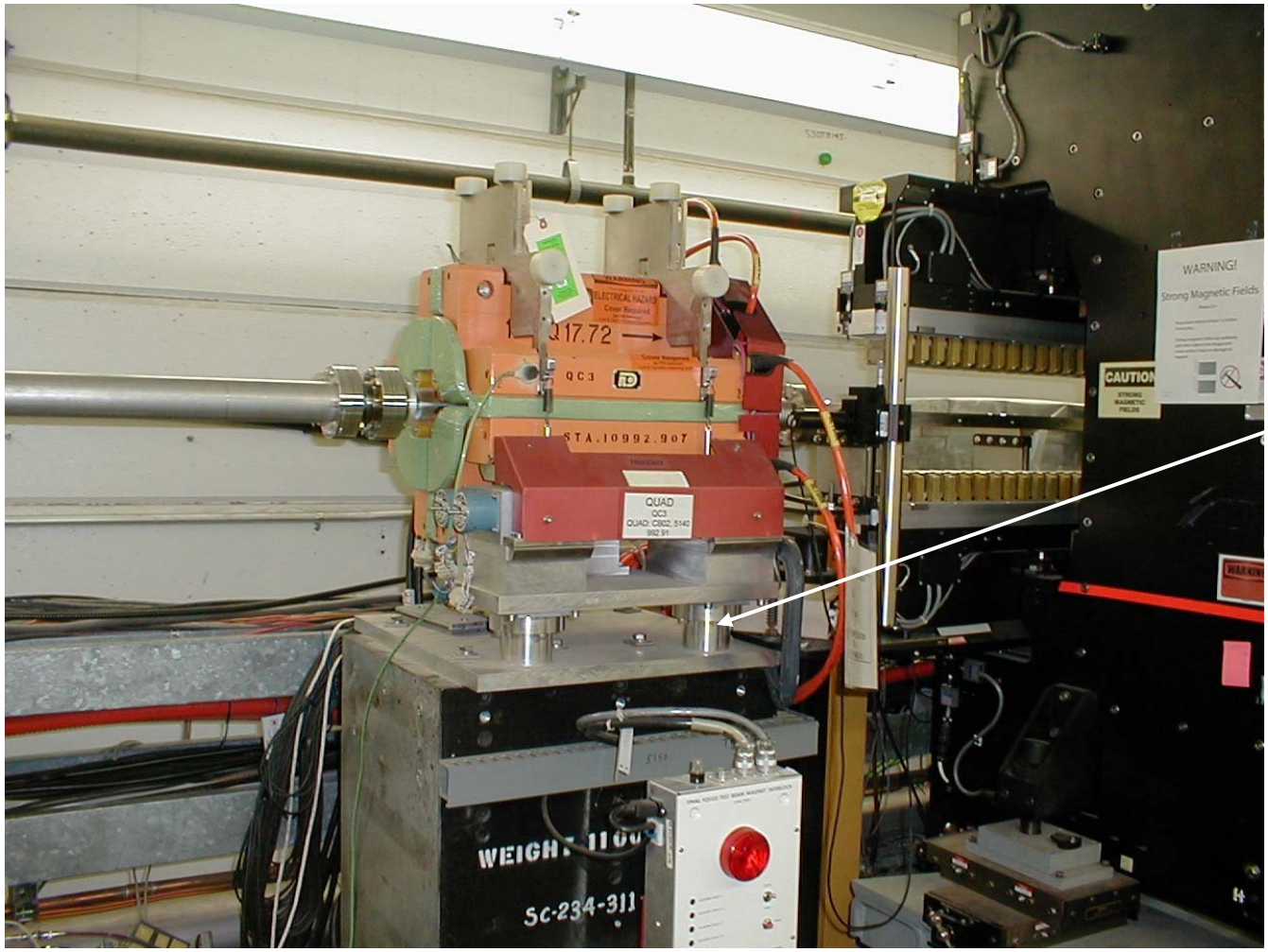
ATF2

Magnets

Two old FFTB quad: 1.38Q17.72. being removed this week from FFTB

- FFTB “QC3” style = 1.38Q17.72. Made in Protvino, Russia, 1991
- Bore = 1.38” = 35.06mm; Core length = 17.72” = 45.009 cm
- Effective length= 46.762 cm
- Water cooled coils, 0.255” sq hollow Cu conductor; Solid steel core
- Maximum current capability: ~320 amps
- Needed for nominal specs: between 70 and 132 amps

FFTB "QC3" in SLAC FFTB beamline Sitting on a SLAC magnet mover



This support can be re-designed to be ~8cm less tall, so magnet center at desired height.

ATF2

Magnets

Field quality of the 1.38Q17.72: is it good enough to be an ATF2 final doublet?

- All FFTB quads designed and made in Russia in 1991
- Magnetic measurements made in Protvino, Russia and SLAC
- Sextupole multipole has the tightest tolerance.
- Latest information from Kuroda-san:

  (Normal) Sextupole/quadrupole <~ 5 x 10^{-4} at radius =10 mm

Sextupole only measured in Russia. I have (in my old folders) data at 250 amps : 2.1 x 10^{-4} at r= 10mm

12 pole measured in Russia and at SLAC.

Tolerance for 12 pole 2.5 x 10^{-4}.

At 189 amps 12pole/quad <~ 4 x 10^{-4} at radius =10 mm

So – field quality looks to be close and will re-measure at SLAC in next few months- try to get the normal and skew components.

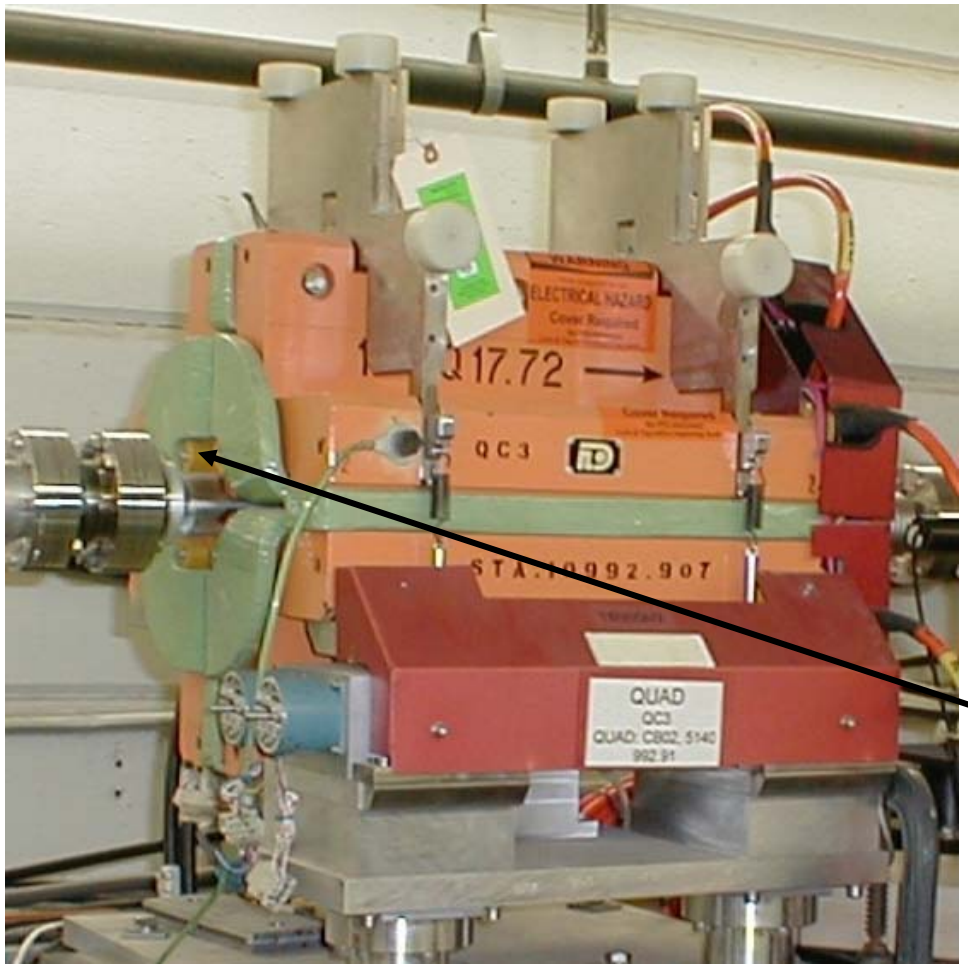
ATF2

Magnets

What about possible vibrations from water flowing in coils?

- With a delta water pressure of 80 psi (same as other ATF2 quads) the water velocity would be 6.2 ft/sec
- When this quad measured for its vibration in 2000 its water velocity was 8.9 ft/sec and the vibration measured was ~<2nm
- See LCC-0036 Technical Note by R.J.Fenn et al

Information about physical size of 1.38Q17.72 quadrupole



Overall length (including terminals at on end) = 51 cm

Weight of magnet = 400 Kg

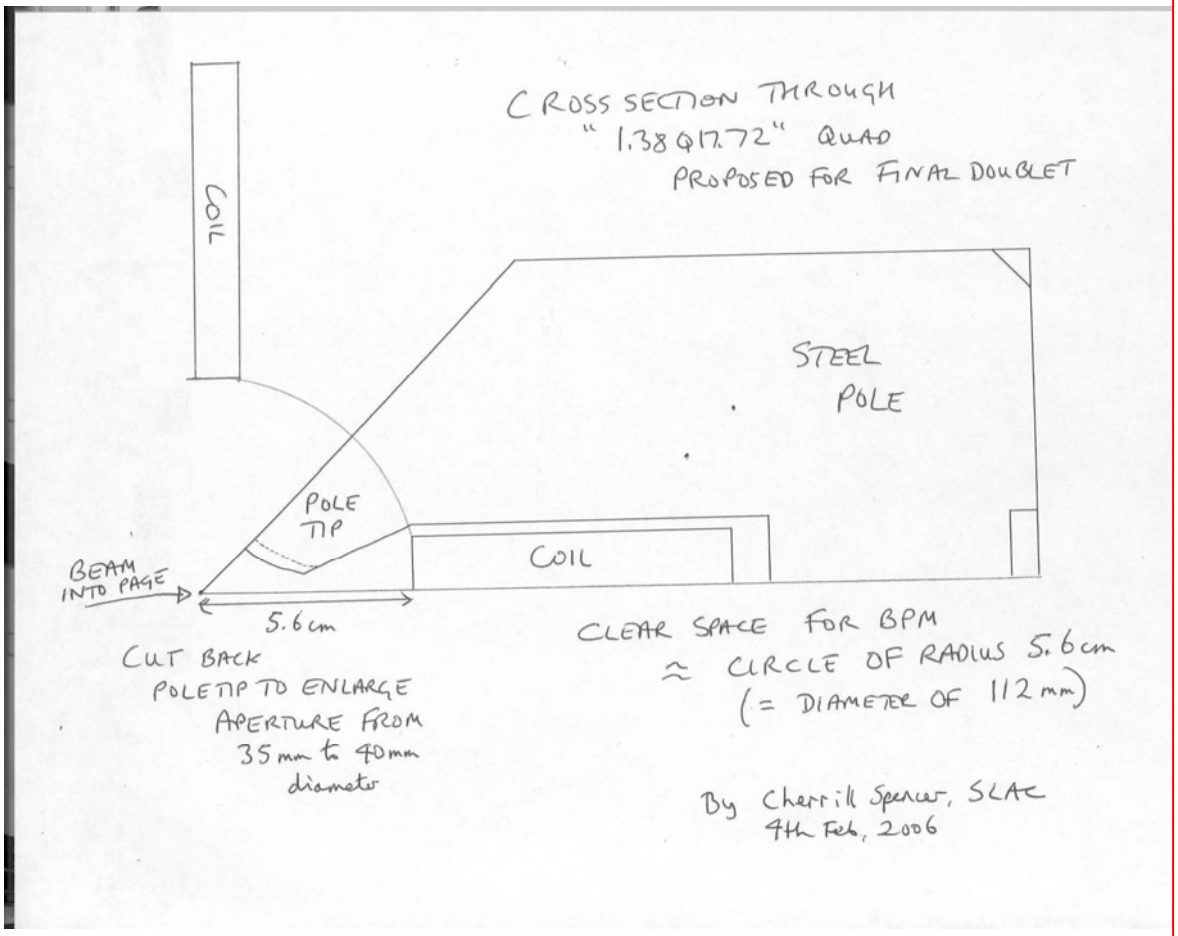
Also note– has a set of 4 trim coils; one around each back leg

Look at coil ends- space for BPM?

ATF2

Magnets

Space available for a BPM in the 1.38Q17.72 quad



In Feb 2006 understood needed ~110mm clear space for some BPM- could satisfy.

Today I learn a different BPM is being considered which is 190mm – much too large a space to leave without coils. I think would affect field quality to place coils so far away from aperture.