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**Magnets**

# Progress Report & Future Plans for the ATF2 FD Quads, FF&FD Sextupoles & FF Dipoles 21st March 2007


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# New Magnets Being Made/Acquired for the ATF2

- **Need 28 new FF and extraction line quads ("QEA").** 24 been made by IHEP, Beijing and measured at KEK. 6 of these were "stolen" by ATF-DR. 11 more (1 spare) to be made.
- **3 new dipoles B1,B2,B5** to be made: all one style.
- **5 new sextupoles** are needed: 3 in the FF: SD4, SF5 and SF6 and 2 in the "final doublet" (FD) (interleaved with final 2 quads): SF1 and SD0
- **2 new FD quads :** QF1 and QD0
- **6 new skew quads** : have 4 from old extraction line, need 2. No information in this talk-just learning they exist!

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# New Magnets Being Made for the ATF2: Philosophy & Constraints

- In general we are taking steps to minimize the cost of the new magnets and to produce them in timely way (original goal: all new magnets at KEK by end of October 2007- may slip to end Dec)
  - Using existing magnets
  - Using existing magnet movers
  - Modifying existing magnet designs
- Constraints on magnet sizes, apertures, coil ends, operating currents & voltages, from:
  - Fit in with existing movers
  - Beam height from floor of 1.2 m
  - Interface with 2 different styles of BPMs
  - Fit in with new power supply's current & voltage

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# Two old FFTB quads: 1.38Q17.72. are ready to be modified to become QD0 & QF1

- After several discussions decided to make bore aperture 50mm:
  - quad bore diameter= 40 + 2x 3.5 + 2x 2 = 50 mm  3.5mm=Cu beampipe thickness; 1mm= free space
  - S band BPM will attach to the quads using a custom adaptor
- Solid steel core
- Water cooled coils, 24 turns of 0.255" sq hollow Cu conductor; 2 water circuits per coil.
- Predicted currents and voltages:
  - QD0: 127.9 amps, 8.85 volts, $\Delta$T= 1.77 degrees C
  - QF1:  69.8 amps, 4.88 volts, $\Delta$T= 0.53 degrees C
- STATUS: Established that cannot EDM the poletips to my tolerances; very expensive to grind back the tips. So have decided to insert flat shims at the split planes.

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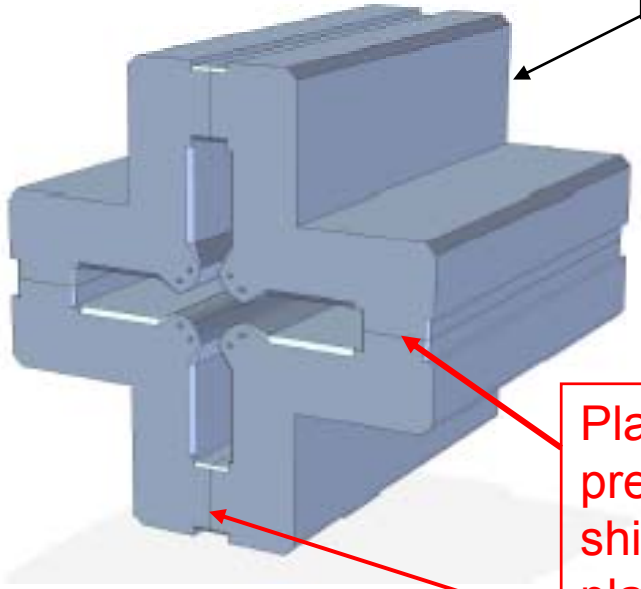
# Chosen method for enlarging the "QC3" quad's bore diameter

Dimensions of shims:

10.607mm thick
58.09mm wide
450.00mm long

Shim will be low carbon steel, ground to 0.0005" (0.0127mm) flatness.

Tolerances on width& length: +/-0.127mm



QC3's solid steel core, made from 4 equivalent pieces

Place a very flat and precise thickness shim in each split plane to "explode" the quad and enlarge the bore diameter.

Spencer reckons split planes were made to 0.02mm flatness & 0.02mm perpendicularity

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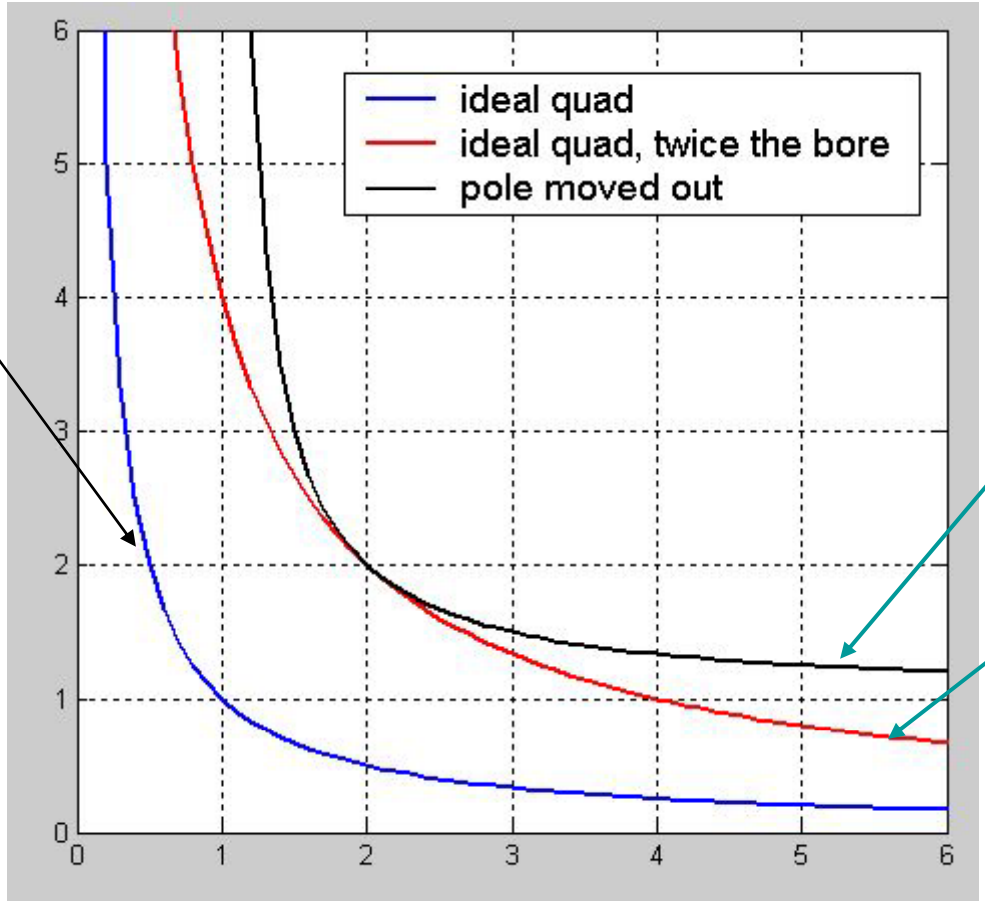
# What affect does shifting the hyperbolic poletip have on the multipole components?

In a real quad the hyperbola is truncated about here to make room for the coils.

So all real quads have some 12-pole component mixed in.




This section of the poletip is “missing” more material than it would if the pole had been machined back. This leads to higher 12-pole content in the shifted case.

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# Compare predictions of multipole content with tolerances from James Jones & S. Kuroda

| Magnet Name | Tolerance 6 pole/quad At r=1cm | Tolerance 12 pole/quad | POISSON Prediction 12pole/quad | Tolerance 20pole/quad | POISSON Prediction 20pole/quad |
|---|---|---|---|---|---|
| QF1 | $9.5\times10^{-5}$ | $2.46\times10^{-4}$ | $1.86\times10^{-3}$ | $1.19\times10^{-3}$ | $4.18\times10^{-6}$ |
| QD0 | $5.26\times10^{-5}$ | $3.08\times10^{-3}$ | $1.86\times10^{-3}$ | $5.98\times10^{-1}$ | $4.18\times10^{-6}$ |

ABOVE TABLE IS FOR A 50mm diameter bore with a shifted poletip that was originally designed for a 35mm diameter bore.

Tightest 12pole/quad tolerance is for QF1 and POISSON model predicts the 12-pole will be about 8 times larger.

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# Three ways to reduce the 12-pole component in an existing quadrupole

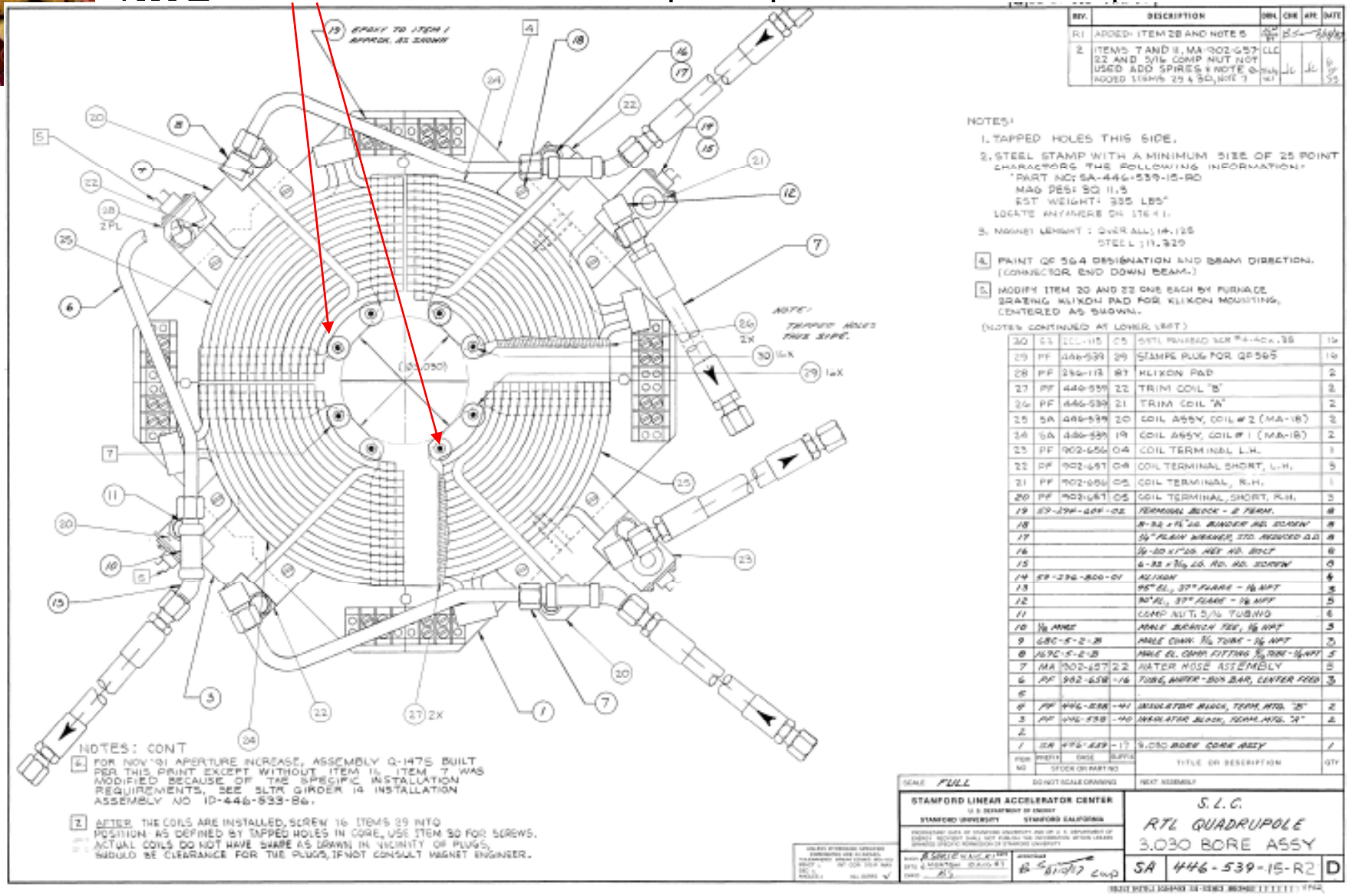
- If 12pole is too large we have at least 3 ways to reduce it (would prefer to only use one method):
- by chamfering poletip ends or
- by adding steel buttons on poletip end
  - Determine the button size and position by experiment :more on Spencer's experience with this below.
- Design a mirror plate with appropriate shape, sits close (< ~6cm) to one end of the quad ( has been done for a PEPII quad)



# Conclusion from “Halbach” perturbation calculations

- Sextupole component is very sensitive to a single poletip being at wrong radius  or the poletip being offset “azimuthally”
- Appears that errors of size 0.001” (=25 microns) are significant for producing unwanted sextupoles.
- Therefore have to be very careful with assembling cores.

# ATF2 Buttons added to an SLC quadrupole to reduce its 12 pole content



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# Effect of 8 buttons on one end of an SLC RTL quadrupole

- Bore diameter = 3.03” = 77 mm
- At r= 17.9mm
  - 12pole/quad without buttons = 0.148% = 1.48x 10(-3)
  - 12pole/quad with buttons = 0.017% = 1.7x10(-4)
  - BUT sometimes the octupole went UP with the buttons.
  - Effect of buttons on sextupole needs to be studied more- by Spencer- has data.

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# Future Tasks for modifying the two "QC3" quads, page 1/2

- Measure at least one of the 2 quads, as is, with our best rotating coil set-up: harmonics at various strengths. Move quad into set-up in room 111 next week.
  - Study sextupole content relative to mechanical dimensions
- Draw drawings of flat shims and how they will fit into the core. Hampered by lack of detailed QC3 drawings.
- Have 8 shims made at local grinding shop (they have low carbon steel plate in stock), drill mounting holes
- Disassemble quads, refurbish main coils, remove trim coils (will not use), clean up steel
- Reassemble core with new shims, drill new dowel holes

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# Future Tasks for modifying the two "QC3" quads, page 2/2

- Re-assemble core and coils; check critical dimensions
- Re-measure with same rotating coil set-up: integrated strength over 5 to 150 amps; harmonics at nominal operating currents.
- If necessary: decrease 12 pole component by one method or another. If sextupole is too high then make adjustments to symmetry of poletip dimensions.
- Calculate new core outer dimensions and consider how the T-1 plate and magnet mover layout needs to be modified to fit the wider quad.
- One smaller mover needs to be modified for the 2$^{nd}$ FD quad [there is only one larger mover-is in LAPP, Annecy]

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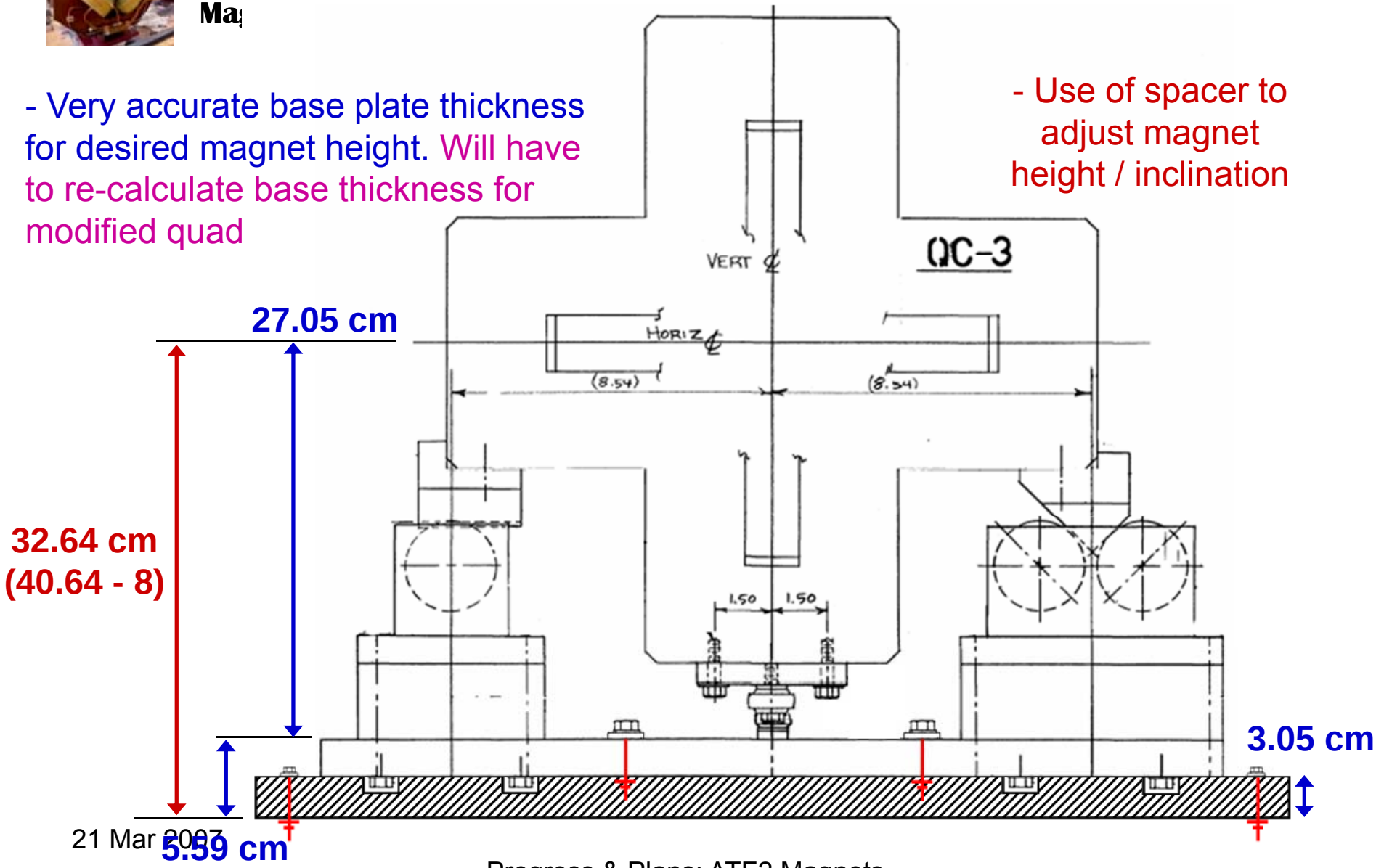
New design for wide mover support by N. Geffroy, LAPP.
With two possibilities for height adjustment

- Very accurate base plate thickness for desired magnet height. Will have to re-calculate base thickness for modified quad

- Use of spacer to adjust magnet height / inclination



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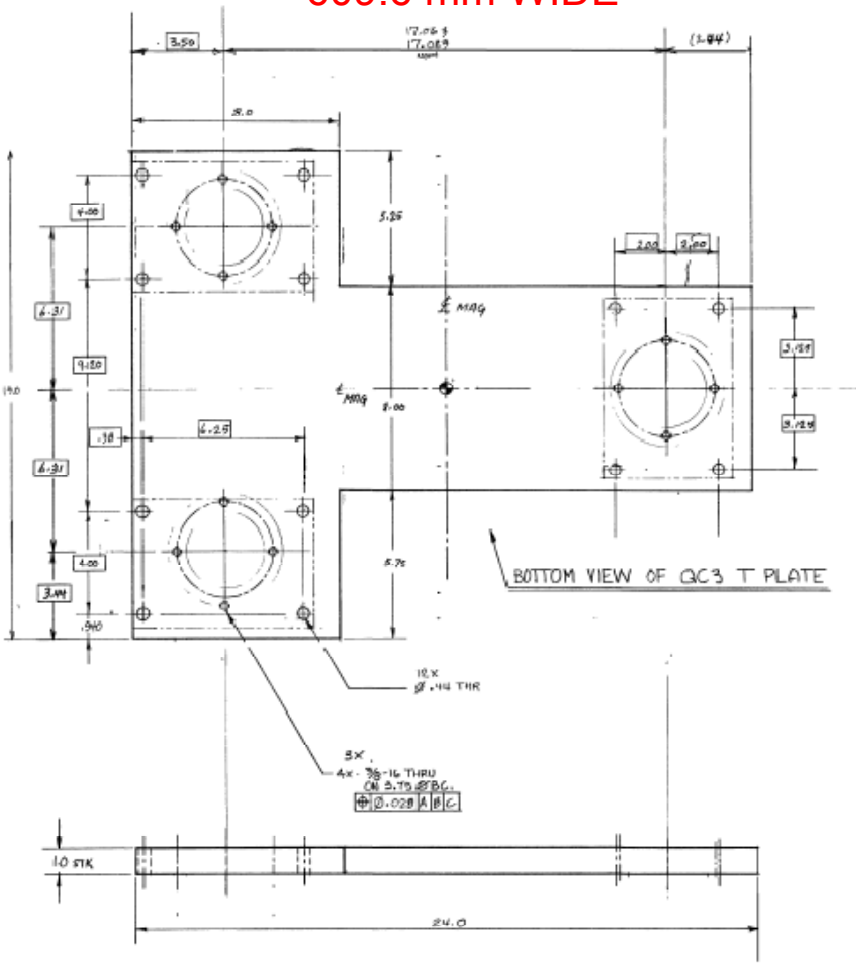
# T-1 plate for QC-3, sits under FFTB mover. We have only one QC-3 T-1 plate: for QF1

609.6 mm WIDE

482.6mm LONG




Maybe have to make 2 new T-1 plates, to accommodate the wider quads (after inserting the shims at the split planes)

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# Status of the 5 new ATF2 sextupoles

- **Five new sextupoles** are needed: 3 in the FF: SD4, SF5 and SF6 and 2 in the "final doublet" (interleaved with final 2 quads): SF1 and SD0.
- In continuing effort to save money I have been looking for existing sextupoles that we can use. Are constraints:
- **SF1 & SD0 constraints**:
  - will have (large) S-band BPMs attached to their core
  - their bore should match the QD0/QF1 bore (= 50 mm)
  - Cores can be somewhat longer than 90mm [am concerned about shortness of core relative to bore: fringe field effects]
  - their cores need to fit in with sitting on a plate on top of an FFTB mover & must put center of bore at 1.2m from floor
  - Current to be less than 50 amps, voltage less than 30 volts

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# Status of the 5 new ATF2 sextupoles, continued:

- **FF sextupoles' constraints:**
  - Bore to be at least as large as adjacent QEA quads: 32 mm diameter
  - Coil end shape to be compatible with a C-band BPM (or an adaptor will be used to clear the coil ends)
  - Core to be ~90mm long (OK with a 32 mm bore)
  - Current to be less than 50 amps, voltage less than 30 volts
  - If bottom of magnet is not flat then a special cradle will be designed and made. Extra spacer will make distance between core bottom and bore center be 295mm
  - Vertical distance between bottom of T plate (under a mover) and magnet bore center to be 541 mm.
  - If top of magnet is not flat then special fixture will be designed to hold the alignment reference plate.

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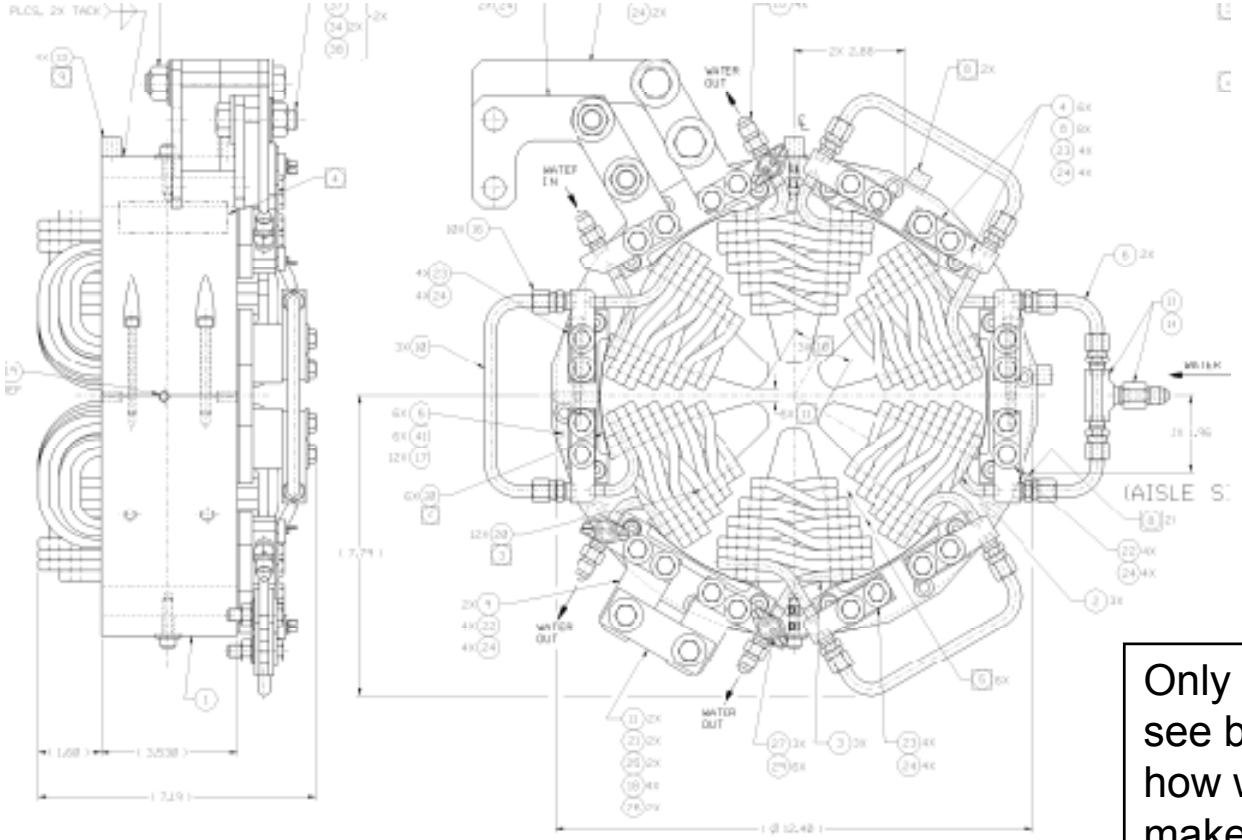
# Style of existing SLC FF sextupole, 4 of which acquired (with much effort) for the ATF2

Style name= 1.625SX3.53

Bore diameter= 41.28 mm

Core length =89.66mm

26 turns of 0.255” sq hollow Cu conductor per coil




Only 4 exist, see below for how we’ll make 5th sextupole

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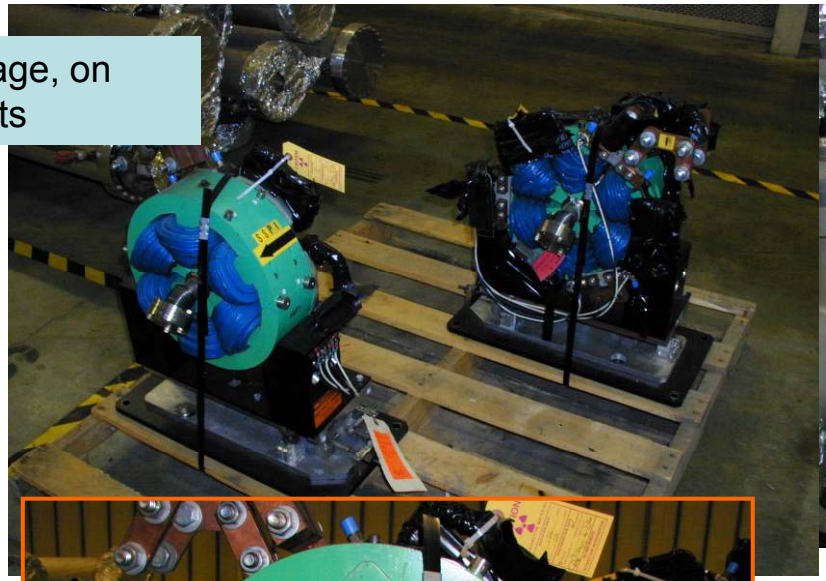
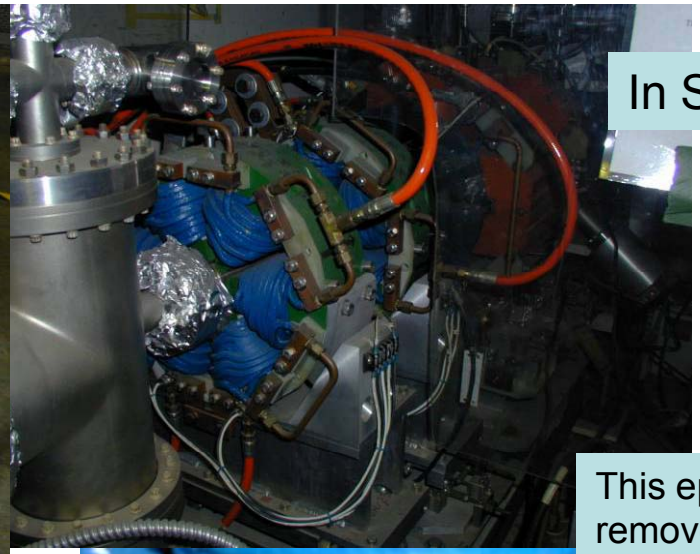
# Photos of the SLC "SX3" style sextupoles we will be using for ATF2 sextupoles

In storage, on supports



In SLC FF



This epoxy will be removed

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# Comments on ATF2 usage of the 1.625SX3.53 sextupoles

- The 3 magnets for the FF sextupoles do not need any modification.
- A special adaptor will be used to match the BPM to the sextupole's end
- One old sextupole will have to have its poletips machined (EDM'd?) back to make a 50mm diameter bore to be a FD sextupole.

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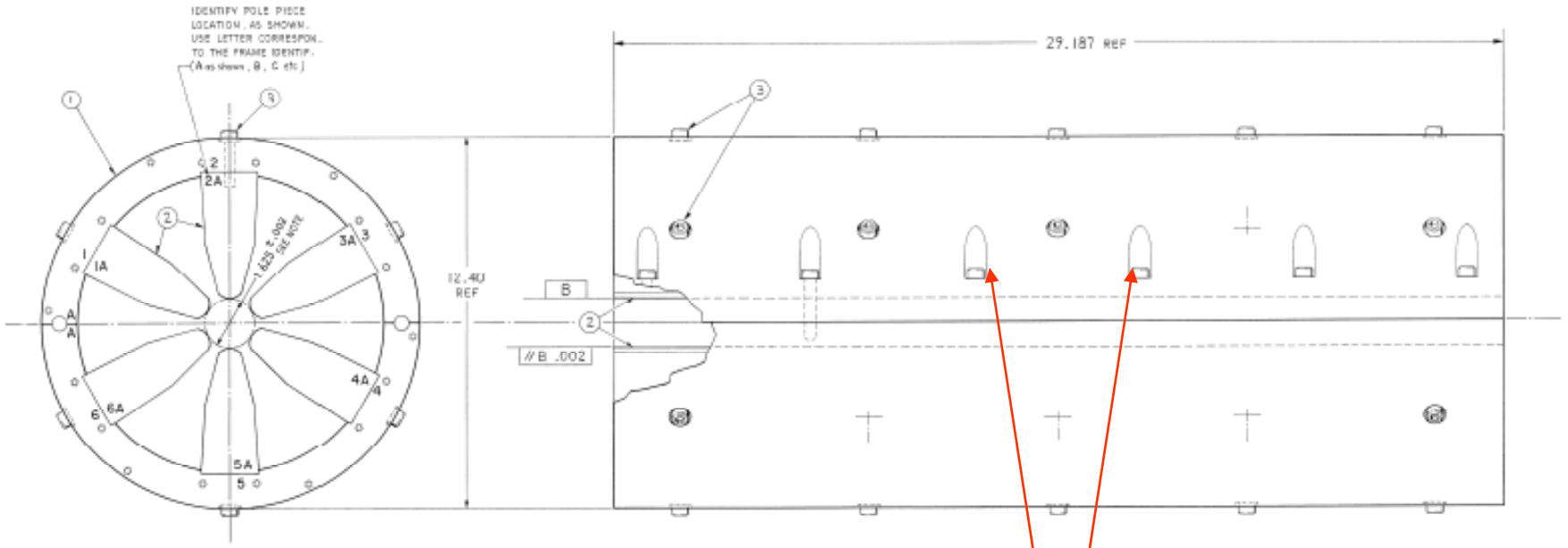
# Will use a 29.2” long old SLC sextupole to fabricate the 2nd FD sextupole




This much longer sextupole has same cross section profile as other 4 sextupoles, we will saw out a section of its core and mill the ends to make a 89.66 mm long core. The poletips will be machined back to 50mm diameter

4 11/16” between these bolts, will cut out this section

Set of 6 new coils will be made from existing drawings

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# Future tasks to prepare the ATF2 sextupoles: will take rest of 2007

- Remove 3 sextupoles from SLC (2 already out)
- Magnetically measure one of them to check its low current behavior and harmonic content
- Disassemble one of them and have its poletips machined to enlarge bore
- Design and fabricate special cradles for holding sextupoles – must be finely adjustable in roll
- Design and fabricate special fixtures for holding alignment reference base plate on top of magnet
- Fabricate new sextupole out of old long SLC sextupole
- Magnetically measure all 5 sextupoles after modifications and refurbishment

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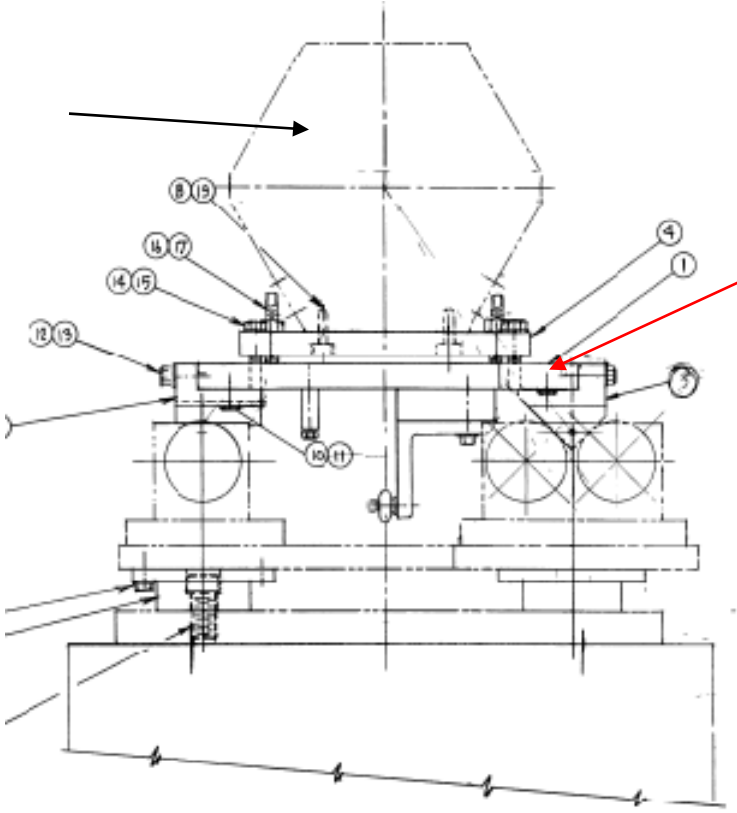
# Drawing showing how “not-quad” style sits on an FFTB mover

e.g. a sextupole



Put extra plates to lift up magnet as it does not fit between the shafts

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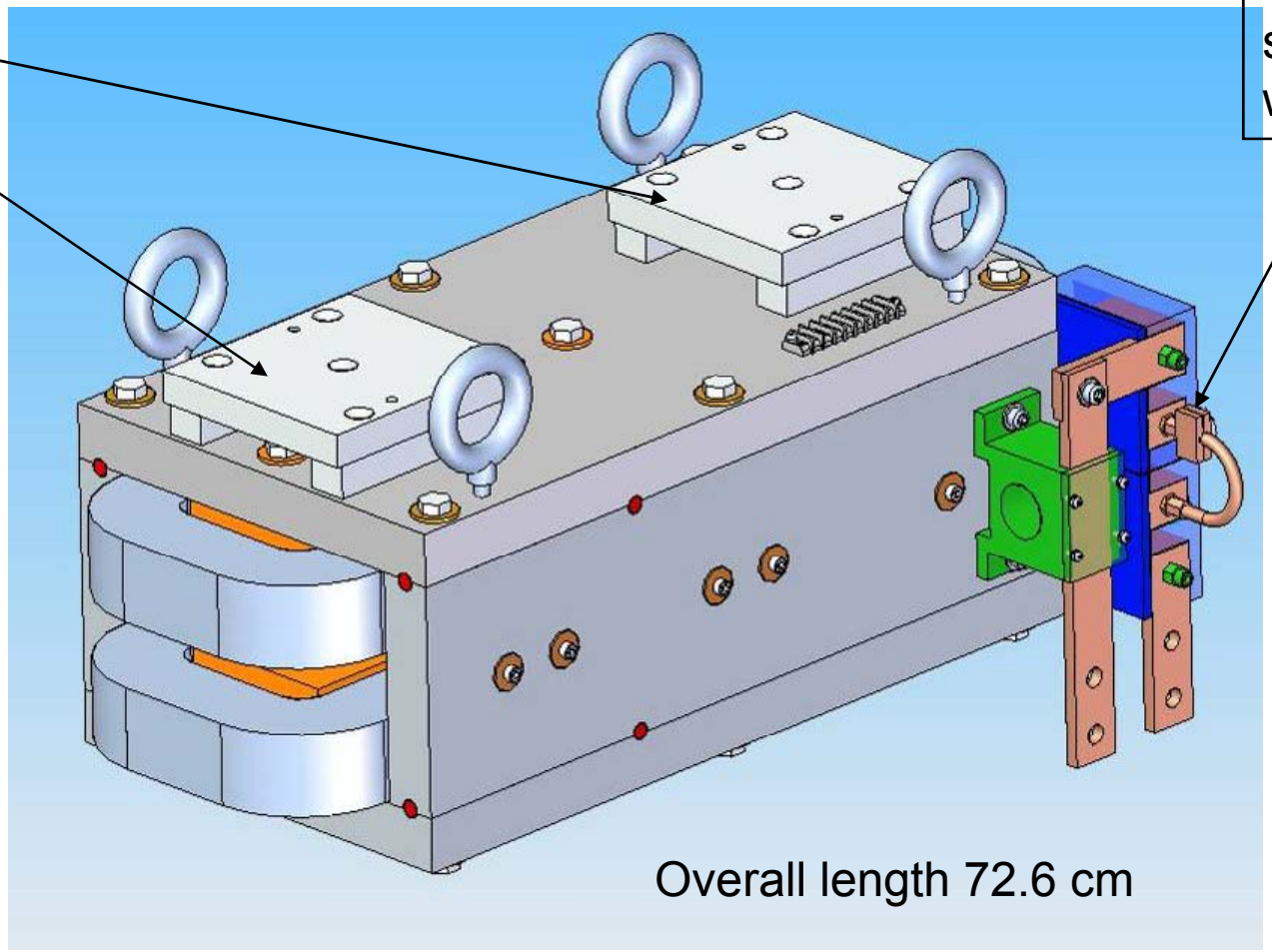
# Design of ATF2 dipole: 3D figure

Bases for alignment tools

Thermal switch; one water circuit




Magnet can be split for installation in the beam line & precisely re-assembled

Power terminals oriented to receive power cables from floor

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# Status of ATF2 B1,B2, B5 dipoles

- Since last project meeting (Dec 2006)
  - Manufacturing specifications for coils, core & magnet assembly written
  - 3 potential USA magnet vendors identified
  - Statement of work written; pre-purchase order paperwork done
  - Request for bids went out on 2nd January 2007. 3 bids received on 19th January 2007
  - Lowest bid was higher than our budgeted amount. Holder of the purse strings said had to wait 'til Oct!.

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# Future Tasks for getting dipoles fabricated

- Have made some informal enquiries to non-USA magnet vendors and believe the dipoles can be made for less money than the January bids. Purse strings have been loosened.
- Adding some non-USA magnet vendors to our SLAC Purchasing database so Request for Bid (RFB) can be sent to them– should be complete by end of week.
- Will send out a new RFB to at least 5 magnet vendors, including IHEP, Beijing, PRC and JINR, Dubna, Russia
- Will place order with lowest bid that fits with our budget
- Expect fabrication will take about 10 weeks
- Dipoles will be sent to SLAC for detailed measurements?
  (KEK does not have a stretched wire measuring set-up. We need to decide how and where to measure these new dipoles to minimize transportation time and costs)

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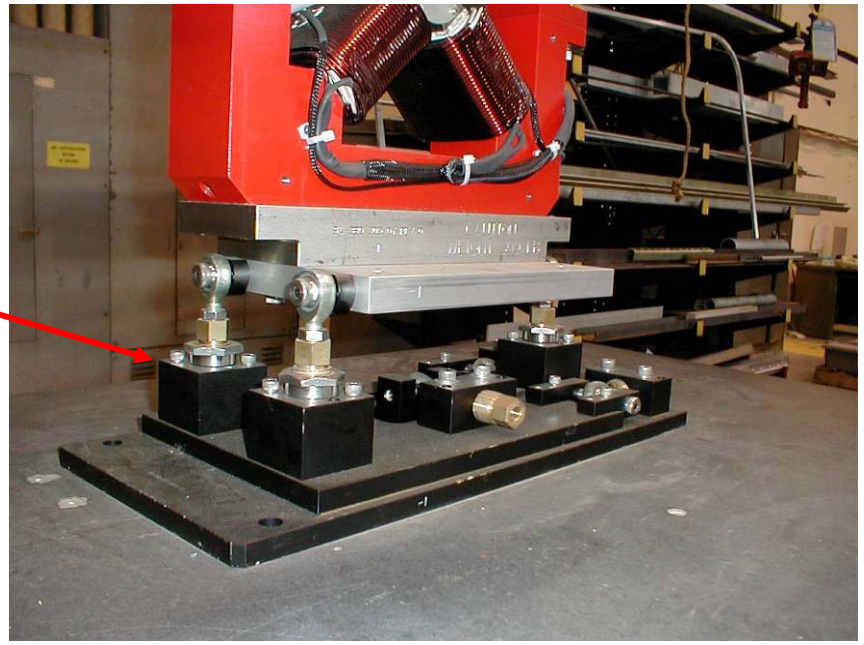
# Future tasks for getting adjustable dipole supports designed & fabricated

- Each dipole needs an adjustable support under it. Must fit in with the concrete base that KEK is providing and put the dipole gap at 1200mm above floor
- The style of support shown in the photo to right has been suggested. This “T1” style, made for LCLS, fits, without change, with our dipoles.
- Need to do some vibration testing (LCLS was supposed to do- will check)
- Need to budget funds for design & fab of 3 supports



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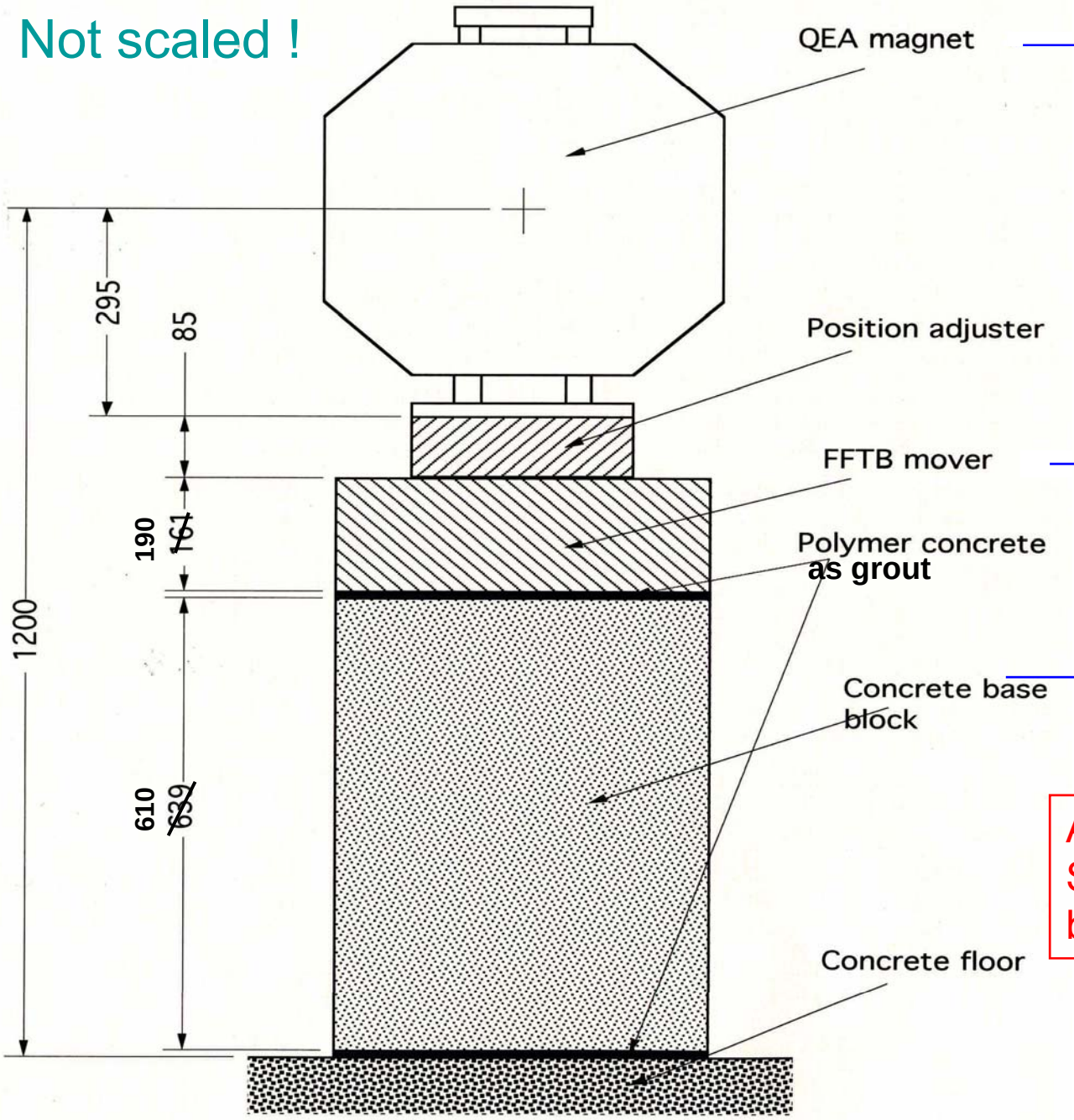
# Outstanding Issues

- Last year concluded that the 4 “FD” magnets and their movers would fit on the CLIC table and the “QC3” mover assembly would have to be modified so that the center of the magnets’ bores would sit at 1.2 m off floor. CLIC table is 0.874m tall (same, special feet :on or off).
- Now we are considering modifying the use of the CLIC table or maybe buying a different support structure. I am proceeding making the FD quads and sextupoles with the sizes that were determined for fitting them on the CLIC table, so any new support must accommodate these sizes.

Not scaled !




24 were made last year
More have been ordered

27 have been ordered

24 out of 29 arrived
at KEK (others at LAPP)

24 have been ordered.
TWO styles. Dipoles will
sit on concrete too.

ATF2 MAGNET
SUPPORT SYSTEM,
by Sugahara (KEK)