Tagger Engineering Design

From GlueXWiki

- **Telephone meeting April 3, 2007** [*Elke's notes*]

  Sergey will be at Jefferson lab 30.04-07 - 01.05.07, we will have a meeting on April 30th with Franz coming to JLAB and Richard and Yang joining by video. Sergey will provide electronic versions of the drawing before this meeting to allow all people enough time to look to them and make remarks.

  In general the drawing follow the design from Jim Kellie and G. Yang. Special care should be taken to avoid stress on the vacuum chamber and o-rings. Franz will provide a list of hot topics on the design discussed in the past. Richard will provide Sergey where to find all the relevant information on the wiki. We will have a tagger-email list, which will have the list of people above pre-registered please tell your students or postdocs or .. to register so all the information is archived and all people are always informed.

- **Discussion and questions regarding the Serpukov tagger design drawings**
  - *Franz Klein*: The design effort should address the following areas of concern.
    1. Field and trajectory changes due to small misalignment of the magnets: this was answered in detail by Yang's simulation.
    2. Stress on vacuum chamber with 2 big magnets attached (relative motion of energized magnets and evacuated chamber).
    3. Sealing the large vacuum chamber at the contact with the magnets: large o-rings that show up in various drawings as two different shapes.
    4. I don't see how the largely reduced number of brackets around the pole stems can insure that the o-rings stay in place when heavy pole shoes are placed on top.
    5. I'd like to see an explanation of how the system (magnets+chamber) is put together.
    6. I want to see what FEA or other stress analysis has been done on the new design.
    7. There are comparatively detailed drawings about the stands but I cannot imagine that the stand for the vacuum chamber is sufficient to account for the large moments (vertical+horizontal(x-dir)).

-   - *Yang Guangliang*: About the drawings provided by the IHEP group, I found the following.
      1. In general, these drawings are based on our two identical magnet tagged design; the layout of the tagger has not been changed.
      2. Some of detailed things have been changed, they are:
         1. The number of brackets which are used to compress the O-ring and also to counteract the vacuum force has been reduced to half of the original number. The way to attaching this bracket to the pole shoes has been modified.
         2. The brackets used to support the coils have been redesigned.
         3. The vacuum chamber design has been modified slightly. A long metal strip was welded to those vacuum chamber edges which are around the pole stem, and are used to attach the O-ring compressing brackets to the vacuum chamber surface. At the same time, the pole shoe profiles have also been changed accordingly to accommodate the modified vacuum chamber.
         4. The O-ring groves were made on the vacuum chamber. Previously, we used a long strip of metal attached to the pole shoes lips to act as the O-ring groves.
         5. There is a detailed design about how to bolt the yoke and pole shoes together.
         6. There is a detailed design for the quadrupole magnet and stands.

7. The brackets used to support the vacuum chamber have been modified.
8. The thin window has been modified.
9. The hole through the return yoke of the second magnet which is used to accommodate the photon pipe is not in the correct position and direction.

3. There are several questions that I want to ask. They are:
   1. Have they done any stress analysis for the whole magnet to determine the location, size and the number of the bolts which are used to hold the magnet together? And what kind of method can be used to control the magnet deformation within limit when the magnet is operating at 1.5 T?
   2. Have they ever done any stress calculation for the vacuum chamber to determine how to support it?
   3. Have they done any stress analysis on the brackets to see if the brackets are strong enough? How many brackets are needed? From my point of view, I think the number of brackets used to compress O-ring is too small, and the number of brackets which are used to support the coil is too large.

- **Questions and comments raised during and after Sergei Denisov's design presentation (April 30)**
  - *Notes*:
    1. Dan and Franz discussed with Sergei inconsistencies in the drawings, specifications for the Hall-D tagger design, and all comments and questions raised in the morning.
    2. We discussed the specifications for the Hall-D tagger over several phone meetings and came up with a revised draft of specs [1] (http://argus.phys.uregina.ca/cgi-bin/private/DocDB/ShowDocument?docid=821)

- - *Elton, Smith*: Notes on Hall D Tagger Review 4/30/07 (and Franz' additions)
    1. General issues:
       1. For backup information it will be useful to have a brief description on the most recent experience at IHEP for designing and building magnets of similar size and scope as the tagger magnet.
       2. Engineering/Tim: define best interface for incorporating IHEP drawings into the JLab CAD system.
       3. Materials and machining tolerances should be specified on all drawings.
       4. Provide written documentation especially with motivations on changes in the Glasgow design, so that these can be used as input to deciding on the best solution for this magnet.
       5. Instrumentation for field measurement and vacuum test in Russia included in cost estimate, need update with assembly and test at Jlab!
    2. Specific comments and questions
       1. Size of yoke pieces was reduced to be more consistent with standard widths of Russian steel (25-26 cm) and also allow for machining at IHEP (also reduced weight of largest pieces by 2)
       2. O-ring: Glasgow design allows for adjustment of O-ring groove. IHEP design places requirements on precision during fabrication, but claims precision can be achieved in their shop.
       3. Franz: Drawings of O-ring grooves is sometimes square and sometimes round. These should be made consistent on drawings. The groove has to be rounded at pole edges (not simply rectangular).
       4. Yang: Gap will be reduced at 1.8T relative to the 1.5 T operation. Can the gap change be accomodated in the design? Sergei: Pole deformation specification is <200microns, which is

tolerated in the design, but calculations indicate that the gap gives <100 microns. Yang: The expected gap should be recalculated for the yoke with multiple pieces. He computed the deformation assuming a fewer steel pieces, but additional bolting will likely lead to larger changes in the gap.

5. Supports for vacuum chamber: Two versions are kept for discussion, the one proposed by Glasgow and a new less expensive support by IHEP. Cost estimate uses the Glasgow support. Franz: in discussion with Sergei he agreed that we should go with the Glasgow support (less dependent on changes in hall flooring).
6. On the slides showing the tagger assembly, add notes to indicate what pieces are added as slides are updated.
7. Design for photon beampipe seems to include a window. This must be eliminated or revised. Dan: critical is the transition between vacuum chamber to beampipe. We rely on little or no background in the broad band tagger that counts single rates. This area needs to be feed back into the simulation to insure that backgrounds are tolerable.
8. Photon beam pipe must be directly attached to the vacuum chamber (no window!).
9. Check specification of power supply. Cost is $30k compared to $70k? estimate from Danfysik.
10. We need finite element analysis of deformation of both the vacuum box as well as pole gap.
11. GlueX needs to decide on how to specify the field uniformity. IHEP assumes 150 um flatness in machining pieces.
12. Mapping effort: Dan: There should be a mapping effort and needs to be reflected in plans to assemble and commission the magnet. The critical area is the transition point between magnets. (Is this included in the cost estimate?)
13. Sergei: B-field calculations were performed and showed that the changes in the field due to additional yoke pieces (and bolts) was below the 10^-4 level.
14. Tim: Does IHEP have a 3-D model of the magnet? (It appears from the presentation) Can the 3-D model be given to JLab for incorporation into the I-deas design?
15. Calculations not updated from last year? Do B-field calculations include additional bolts and gap variations?

3. Action Items:
   1. Check location of photon beam pipe though magnets
   2. Check number of vacuum box brackets as well as tension on each one of them.
   3. Give backup information to cost estimate
      1. specifications of power supply (compare to Danfysik)
      2. specifications for materials used (especially yoke iron). Compare Russian #10 steel to American standards. (Cost ~1$/kg)
      3. specification of machining tolerances for large pieces in magnet.
      4. prices per kg of the materials used (steel, Cu, etc)

- - *Yang Guangliang*: About the tagger magnet drawings provided by the IHEP group, I have the following questions.
    1. what kind of steels are proposed to be used for the magnet yoke and magnet pole. The quality of the steel will affect the magnet performance very much. If we use low quality steel to build the magnet, it will not be easy to meet the field uniformity requirement of the tagger (see document Hall_D_Tagger_specs).
    2. Since the IHEP group decide to split each yoke into two layers, and also from their presentation, we find that the gap between these layers has significant effect on the magnetic field uniformity, so I

want to know the precision of the machining they proposed, and also want to know if it is adequate to guarantee the field uniformity.

3. I'd like to see a detailed finite element analysis for the vacuum chamber. The drawing provided by IHEP reduced the number of the brackets used for compressing the O-ring and also counteract the vacuum forces, and they also move the external support for the vacuum chamber from the centre of the vacuum chamber to positions near the thin window, these will increase the forces applied to each rod used for compressing the O-ring and supporting the vacuum chamber. The vacuum forces applied to the magnet are on the level of tens of tonnes, and also the forces needed to compress O-ring are very huge. So great cares should be paid to the O-ring compressing and vacuum chamber supporting brackets. A finite element analysis on this part is definitely needed.
4. On the other hand, the forces applied to the brackets used to support the coils are relatively small. So possibly we don't need so many brackets for supporting coils. The weight of the each coil is around half tonne.
5. The O-ring should be designed carefully, because the total length of the O-ring will be around 7 meters and once the magnet has bee assembled there is no access to the O-ring. So the O-ring should be defined very well. We don't want to have vacuum problem every year.
6. Because the magnetic forces applied to a pair of the pole shoes is around 200 tonnes when the magnet is operating at 1.5 T, the pole gap reduction caused by these forces will be on the level of 100 to 300 microns, this will cause problem for the magnetic field distribution. Is there any calculation or finite element analysis for this gap reduction for the layered magnet design?
7. for the strong back support, in my original design, I just showed an idea about how it should look like. I didn't do any stress analysis for it. My question for this strongback support is, is it strong enough to support the whole tagger system? Again we need a stress analysis for that.
8. For the power supply, bearing mind we have two identical magnets, so we need two power supply for each dipole magnet, or we need one big power supply for the two magnets and an additional balancing power supply to balance the filed. We also need an individual power supply for the quadrople.
9. The most important thing is the field uniformity. We need a specification about how to get required field uniformity.
10. we need the materials specification for the vacuum camber and all the brackets. If stainless steel type 304 will be used to build the vacuum chamber, how to ensure that the machining will not alter the propertied of the steel too much. More clearly, machining and welding will affect the type 304 stainless steel magnetic properties. (type 304 stainless steel is the cheapest one.)