K_l *Flux Monitor MEMO*

The construction of a high precision K_l Flux Monitor would require a 1m long, 50 cm diameter solenoidal magnet with 1T magnetic field. We have contacted "Tesla magnet division" (www.tesla.co.uk) to investigate the possible options and obtain first costings. The company is well established and renowned for their manufacture of a range of MRI magnets which are reliable and designed to be operated without major supervision. They also manufacture resistive magnets.

This memo summarizes the outcome of this investigation.

1) Type of magnet. Four possible types of magnets were considered (one resistive and 3 superconductive):
   - **a.** **Resistive.** Will be very expensive and can hardly be manufactured due to such a large opening (50cm) at 1T field
   - b. **Zero-boiloff**. The coil would be submerged in a liquid helium bath, and any liquid boiling off (e.g. due to a heat leak into the cryostat) would be recondensed into liquid by a cryorefrigeration system (cold-head). This is typically how modern superconducting magnets are operated. They require service to the cold-head about every 2-3 years, and consume very little helium over their lifetime.
   - **c.** **Regular helium bath.** The coil would be submerged in a liquid helium bath, and any liquid boiling off due to heat leak into the cryostat would be lost to the outside. These magnet designs require a regular top-off of the liquid and hence have a higher operating cost due to the helium consumption. This method is typically only used for short runs in experiments where the magnet would be run for a few days and then turned off. **Not recommended for continuous operation**.
   - **d.** **Cryogen-free.** The magnet would contain **no liquid helium or other cooling medium**, but would instead be cooled by thermal conduction only, from a cryo-refrigerator. This type of system only requires power to operate, hence in the long term is cheaper to operate. Conversely they take longer to cool down during installation. If the experiment is continuously running this might be the most cost-optimal approach.

Since maintenance, long term reliability and operational costs are of our highest concerns option (d) was chosen as being most suitable for the project. As a downside it requires **5 days to cool it down** to operational temperature. The cooling time is tolerable considering the advance notice and reliability of beamtime scheduling at JLAB.

2) Two options of passive/active shielding were considered. Since we do not have a limitation in space/weight and do not plan to vary the magnetic field during the run, a **passive iron shielding** was selected. The installation of the shielding would require crane lifting. Such facilities are available in the hall.
3) Shimming. Since we do not plan to alternate the flux monitor to add or remove material from the magnet active area, we choose **passive shimming**.

The selected magnet design would have the following characteristics:

- Field: 1 T
- Room temperature bore: 500 mm
- Magnet length: 1000 mm
- Cryostat length 1200 mm
- Homogeneity: <1% over 540 mm
- Stray field (5 gauss): 3.6 m radial x 4.6m axial from magnet centre
- Current: 300 amps
- Fixed current leads
- Cooling: conduction cooled
- Cryocooler: Sumitomo RDK408D2
- Power supply and control electronics included.
- Cool-down time: 5 days from room temperature
- Overall weight: 1100 kg. The magnet will be shipped in one piece in assembly with the shielding and cryostat. It will be equipped with connectors for crane lifting and with skates to move around.
- The overall cost of the project was estimated to be 362.000 GBP, including electronics (essentially including everything but installation work).

As soon as the KLF proposal accepted or at least conditionally approved by the JLab advisory committee, the nuclear physics group of the University of Edinburgh (along with other UK collaborators) plans to apply for the UK grant to cover around 500kGBP of the direct equipment costs including the magnet and other major parts of the KLFlux Monitor and 250kGBP personnel costs (750kGBP combined).

Location

The Flux Monitor (FM) supposed to be located right after the Pair Spectrometer Magnet (PSM). The pair spectrometer magnet will be used as an effective shielding against K_l decay products from kaons decayed in tunnel on its way to the detector. Only kaons which decayed after the PSM will be accepted by the Flux Monitor. Two meter distance from the PSM to a front edge of the FM Magnet (1.8m till the cryostat) provide decent amount of decayed kaons to be monitored. On the figure below one can see possible position of the Flux Monitor Magnet in Hall-D.