

LEReC DOE Review

Nov 4 – 5, 2015

Highlights for Instrumentation

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Notes taken during review

- Sergei Negaitsev (JLAB) made no comments about our BPM development efforts; as I explained that we are **still exploring parallel paths of single electronics versus separate electronics** for electrons vs ions.
- John Lewellen (Los Alamos) shared with us a paper (see attached) describing a fail safe method of designing the **kicker upstream of the RF deflecting cavity** in response to comments from Sergie N. concerning "what happens if the kicker doesn't fire?"
- Homework for us was to expound on our **thoughts as to how to approach the design of the MPS system** for LEReC. Alexei, Wolfram and I worked after dinner to put together the attached presentation that I gave this morning (pulling from ERL & CeC presentations).
- Andrew Hutton (JLAB) and Michelle Shinn (ONP) recommended we consider a system implemented at JLAB to **test the beam aperture** by inducing a longitudinal oscillation on the beam of a fraction of a sigma and monitoring the position down stream with a lock-in amplifier monitoring the signal of a BPM button. This system, referred to as "the Locks" works so well for them (not sure on which machine) that they can leave it running during operation – although we will run it only from time to time as a diagnostic.
- Sergei described how they burned a hole in a bellows with only a few microamps of beam but over some period of time due to a bad orbit trajectory through a dipole that wasn't detected by any instrumentation. He asked us to consider how we could avoid this. After I described our **Nulling DCCT** beam loss protection scheme under development at the ERL, Andrew added that they had a system like this running at JLAB with a **1 microamp resolution!** John added that 1 microamp at our energy is about 2W and is probably OK depending on the area of deposition.
- Andrew mentioned that we need to install **magnetic field detectors in several places in the RHIC tunnel** to monitor the stray fields during a RHIC run. John added that they struggled with stray fields from improperly run magnet cables while commissioning a similar 2MeV gun at Los Alamos.

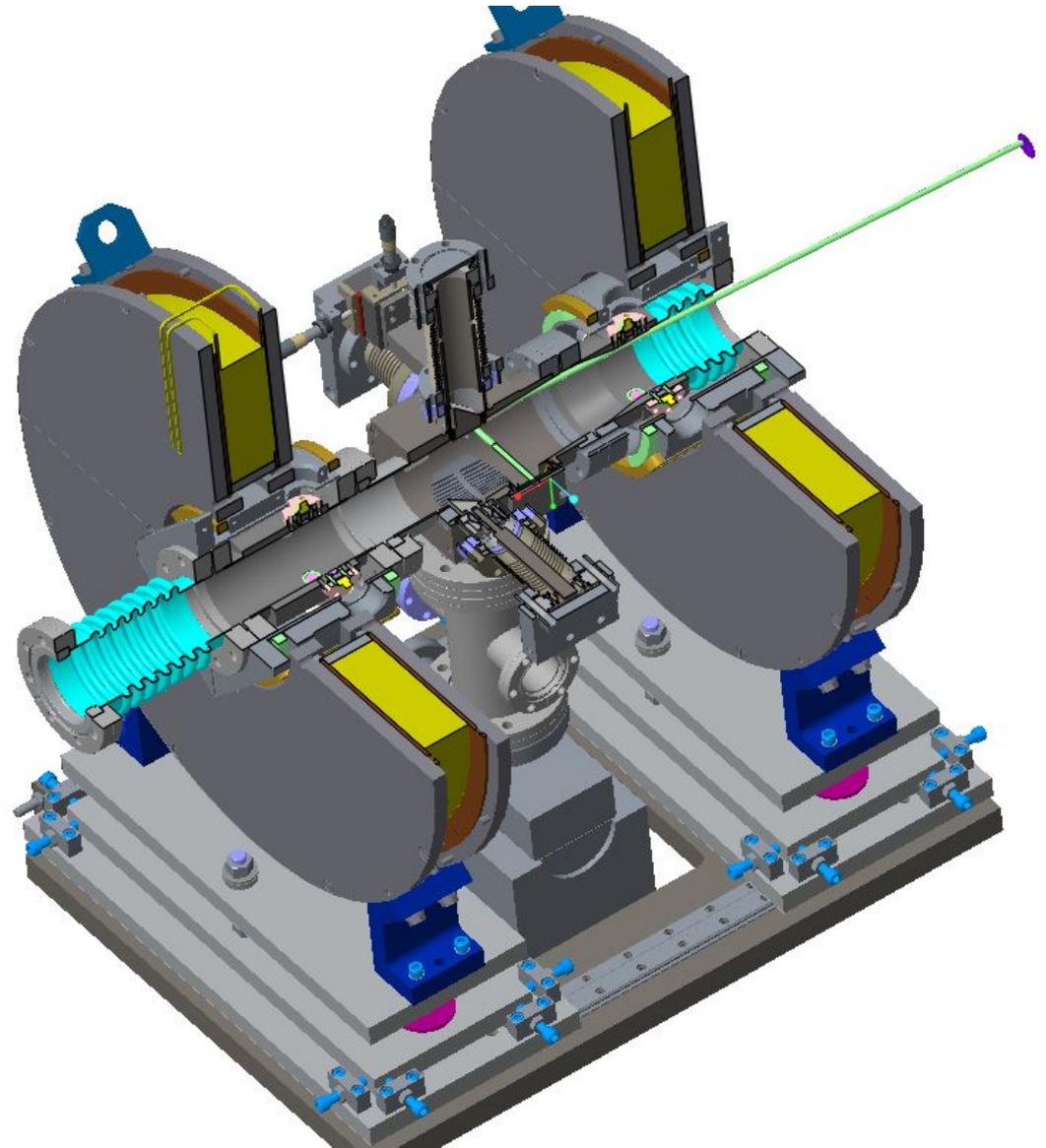
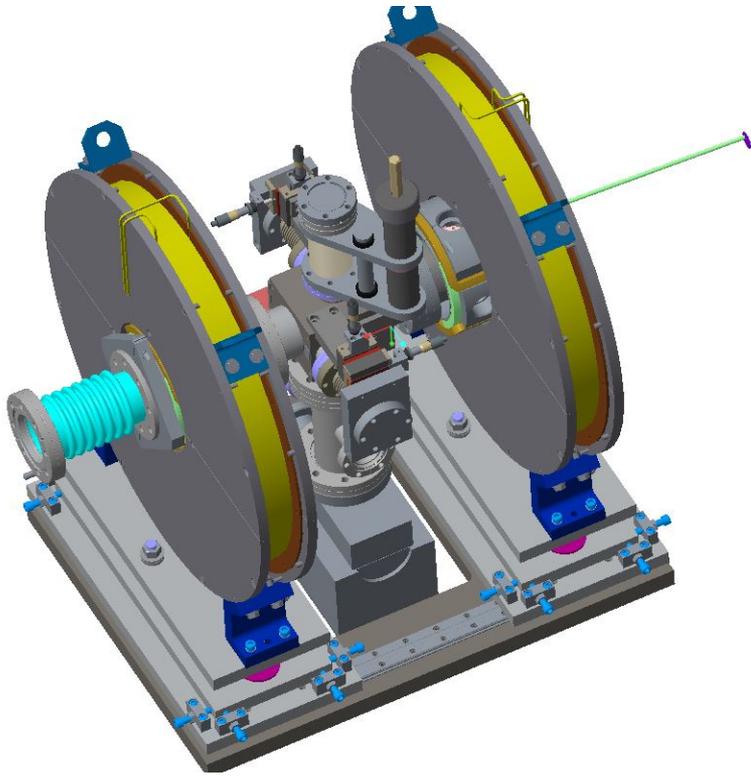
Notes taken during review

- Jorg's simulations of failure tolerance was discussed a lot and showed that the DC gun HVPS will be required to provide 1/1000 (0.1%) stability. While this seems feasible, it could be a challenge in our macro pulse mode. The committee recommended that we consider increasing the RF power to support **continuous 704MHz operation**. I explained after the meeting that we would still require a small gap on every turn to allow position measurement of the ion beam. This will certainly add transients that would have to be dealt with.
- I mentioned to **Sergei** that our group member in charge of **BPM** development reached out to him with eagerness to discuss this exciting project after learning that Sergei would be at the meeting. Sergei apologized for not being able to respond to Rob's email and agreed to talk with us in the upcoming weeks.
- A considerable amount of discussion was devoted to any **risk tied to the achievement of cooling**. There are many things but the committee's point was to identify them all and state a plan of how to mitigate each one but compensation, redesign, component replacement, system tuning, etc.
- The committee asked why there was no one to discuss the **laser system** and asked that we be ready to discuss details at the next review in 4 – 6 months, with a full cost and schedule estimate due in 3 weeks.
- The committee also asked that we make a presentation on **Machine Protection** and operations with feedback on measured parameters at the next review.
- Andrew **invited usto visit JLAB** (giving them about about a month to begin operating) to review their MPS schemes and the number of feedback systems they have running to optimize performance and mitigate failures. Alexei said we should make a trip there and bring key people to benefit from their experience. I imagine going with someone from LLRF and controls.

Excerpt from committee results

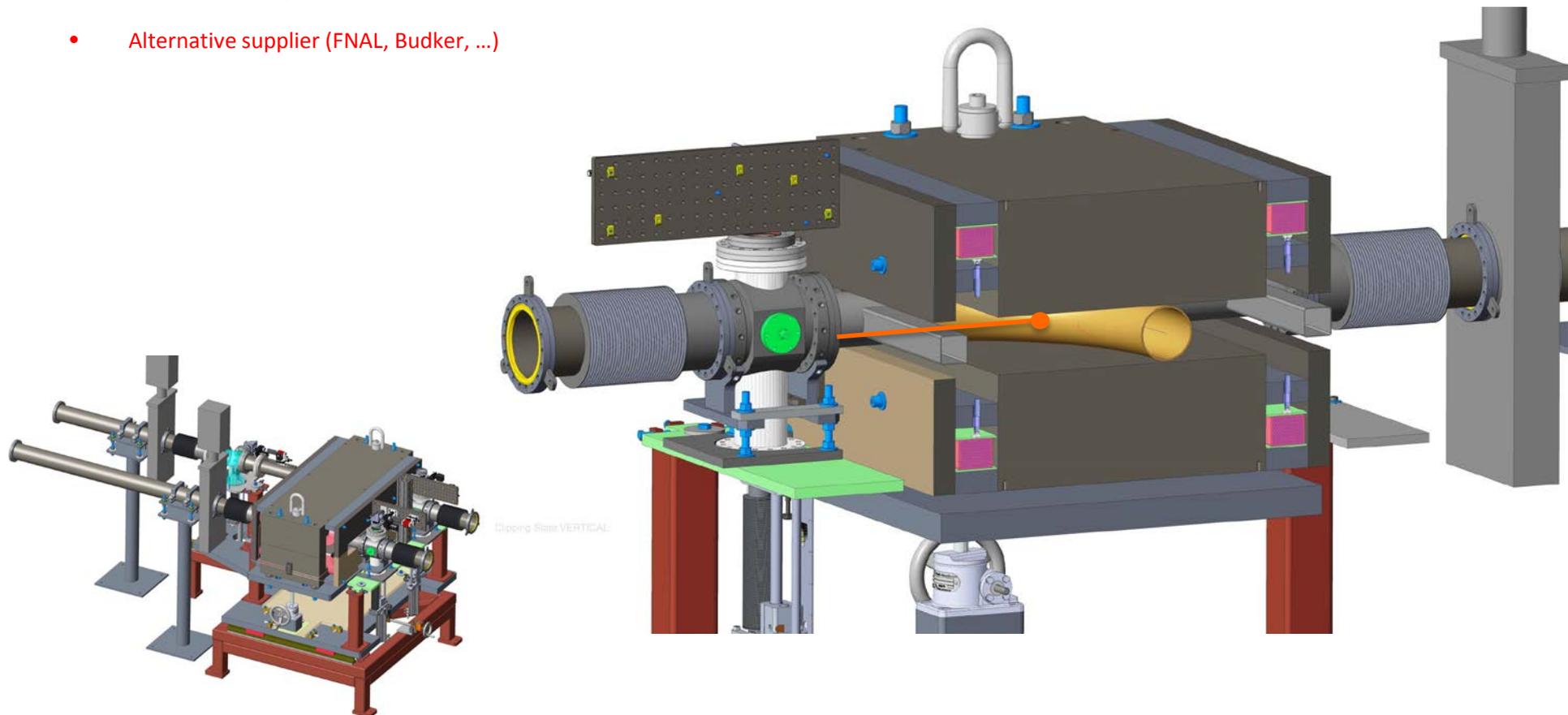
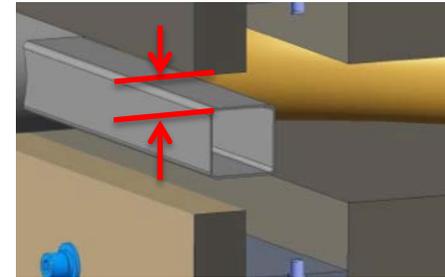
- **Diagnostics systems** designs are progressing well. The capabilities presented are well-matched to the commissioning measurement requirements. **Operational tuning and stabilization diagnostics should be added.**
- The LEReC project relies very heavily upon diagnostics, instrumentation and components designed for, and sourced from, the energy recovery linac (**ERL**) **test ring**; however, the ERL will not exercise these components at average currents comparable to LEReC. **Additional opportunities for testing at higher currents should be explored.**
- The decision regarding **BPM electronics** – one set or two – is not currently time-critical, but could become so without **a well-defined decision down-select date.**
- **Generate a schedule, list of long-lead procurements, performance specifications, and commissioning plan for the diagnostics beamline and submit to NP by February 4, 2016.**
- **Present the design of the Deflective Cavity Diagnostics system.** Pay attention to the deflecting RF cavity and associated diagnostics as these will be essential tools for tuning the longitudinal phase space.
- **Present result from installing several magnetic sensors in the RHIC tunnel** (at the LEReC location) to measure the remnant magnetic fields at the location and observing their time dependence during the upcoming RHIC run.

Cathode Imaging



Permanent Magnetic Field Sensor

- Aprx. 1" clearance to insert a magnetic probe.
- ~\$22K budget quote, awaiting tests of R&D device
- Details from NMR manufacturer (Caylar)
 - NMR sensor is not very radiation sensitive & can come with a copper shield to further protect it from radiation.
 - An option for the electronics rack to be located ~200m away
 - quoted delivery time of 2
 - Can supply fire rated cable for 200m run
- Alternative supplier (FNAL, Budker, ...)



Notes from this meeting

- A new proposed design of the kicker upstream of the RF Deflecting cavity – Longitudinal Phase Space Monitor – was discussed and needs to be reviewed for its level of stability. See attached paper on the subject.
- A novel system to vibrate the beam transversely was discussed to test the beam aperture periodically. This should only require the addition of a function generator and a pair of bipolar supplies, such as the Kepco BOP, connected to a Horizontal & Vertical trim coils. A lock-in amplifier may need to be used to analyze a downstream BPM signal to improve S/N ratio. This was used at JLAB with good results, according to Andrew Hutton & Michelle Shinn.
- JLAB also indicated that they employ a Nulling Differential DCCT system with 1uA resolution, according to Andrew Hutton. We hope to learn from their experience.
- A magnetic field survey will need to be conducted in the tunnel to the miligauss level at places along the LEReC beam line with all magnets off and during the run at injection currents. This will have to be presented in ~4mo. at the next DOE project review.
- The LEReC team will seriously consider, per the DOE review committee's recommendations, operation at 704MHz CW instead of pulse trains. This would increase the average beam power roughly by a factor of 2. This does not affect instrumentation and does not alleviate the need for the commissioning beam line.
- It was suggested to give up making on-line BPM measurements of the ion beam in the cooling section during operation so that the electron beam would not have to be interrupted. Once the ion beam is aligned using cooling section BPM signals, its position can be monitored from the BPMs outside the cooling section. - PLEASE CONSIDER ANY RAMIFICATIONS OF THIS...
- The electron beam position will still be measured every turn in the RHIC abort gap.
- We are sending a team of 5 to visit JLAB's FEL, by invitation of Andrew Hutton, to review their machine protection system and LLRF/instrumentation based diagnostics systems for operational tuning and stabilization. The DOE review committee recommend we add these systems to LEReC.
- The DOE review committee also suggested we find other was to test our ERL instrumentation being transferred to LEReC at high power before ERL is ready. It was unclear in today's meeting how much these instruments would benefit from such an effort.
- As we are still considering in parallel single vs dual BPM electronics for electron & ion measurements in the cooling section, the committee recommended that we identify a firm date by which this decision will need to be made so as not to impact the project schedule.
- We plan to focus our LEReC instrumentation efforts on the design and cost estimation of the commissioning beam line to make the DOE mandated deadline of Feb. 4.
- The need for cathode imaging in the gun was discussed. The current design does not support this. A method was proposed during a post meeting discussion with Igor to image the cathode through the laser injection port using a 45 degree mirror with a hole for the laser to pass through. We need to verify that the resulting field of view of the cathode area is large enough to allow a view of the cathode at the limits of the laser steering mirror.
- A conversation with Caylar (NMR probe manufacturer) today showed encouraging results. We expect more information next week with a meeting via Skype to discuss specs and details.