**Version 2**

**EIC Crab Cavity R&D:**

Crab cavities are needed for both eRHIC and JLEIC for both protons (hadrons) and electrons. Crab cavities give eRHIC an increase in luminosity about a factor 33. For JLEIC the luminosity increase is about a factor of 10 (need to check?).

The required number of crab cavities and required voltages are still evolving as the interaction region designs have changed somewhat over the past year. eRHIC needs about 10 to 15 crab cavities per side of the IR for hadrons and about 2 to 3 per side for electrons. JLEIC needs about 6 to 8 cavities per side for the hadron beam and about 2 per side for electrons.

The crab cavity development at BNL has been mainly focused on LARP for the high luminosity LHC project but which should be highly applicable to eRHIC. Attention has been placed on the crab cavity test in the SPS at CERN but those tests will likely come late to BNL’s self-imposed linac-ring / ring-ring downselect timeframe. However, as both options require crab cavities, such a downselect would be equivalent to a crab cavity frequency downselect. Design work for eRHIC crab first harmonic cavities has started. The required crab cavity locations in the eRHIC accelerator lattice seem quite mature. Work on the third harmonic crab cavities has not yet started, but are expected to be the same as the crab cavities required for the electron beam.

For the JLEIC collider design, there are presently two locations in the rings where crab cavities could be located leading to two sets of crab specifications. Both vertical and horizontal crab cavities are used to correct for detector solenoid rotation effects. The JLEIC crab specifications will likely solidify in the coming year. There is presently dispersion at the location of the crab cavities in JLEIC. The committee was concerned about potential beam dynamic issues that may arise from dispersion which should be studied.

Crab cavity work at ODU on design and fabrication has been excellent. ODU is investigating several cavity shapes, cell apertures, and the number of cells per cryomodules for JLEIC.

More extensive simulations of hadron beams with strong crab cavities, long bunches, and beam-beam collisions need to be done which will lead to improved specifications. These simulations should include phase jitter tolerances, voltage variations, beam rotations due to the detector solenoid, transverse beam offsets in the cavities, dispersion, IR upstream-downstream cancelation, and third harmonic cavities.

Crab cavity tests with hadron and/or high current electron beams will be important for a CD1 decision for an EIC. This is a sizable effort so care must be taken to do the right and most productive test. This experiment could be done at several accelerators including the future potential bunch cooler ring test facility at JLAB, at RHIC at BNL, or CBETA at Cornell, as well as the upcoming possibilities to contribute to the crab cavity tests at the SPS at CERN.

Risks:

As crabbing is required to reach ultimate luminosity goals, there is the risk that the cavities so not achieve the required performance, including peak voltage and degradation with time. In particular, the presence of the crabbing cavities on the dynamics of the high-current electron and ion beams (for example instabilities, beam loading, and multipole components) need to be explored. Various degradation effects should also be investigated.

Recommendations:

R1: Continue crab cavity design, simulation, prototype development efforts.

R2: Foster collaborative design efforts between the JLab and BNL design teams;

R3: More tightly integrate crab cavity activities into the broader design effort, specifically ring dynamics studies and detailed IR design.

R4: Demonstrate crab cavity operation in a hadron ring