Summary of LHC-CC08

Design Fabrication and Processing Group

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KEK Crab Accomplishment

First of a Kind World Achievement

- Successfully demonstrated operation of two crab cavities
- 509 MHz, V > 1.44 MV kick,
  - high beam current to observe crabbing (beam deflection),
  - head-on collision,
  - increase of vertical tune shift,
  - increase of specific luminosity per bunch for low bunch current.

Cavity Performance

- Vertical, horizontal and beam tests all exceeded design values for crab kick 1.4 MV
  - Epk = 21 MV/m and Hpk = 64 mT
- Beam currents of 1.7 and 1.3 A (detuned)
- HOM power absorbed = 10 kW
- Trip rate fell from 3 per day to 1 per day over 4 months of operation and learning.
- Some troubles with coaxial coupler cooling and the tuner still need work.
- The kick has fallen to 1.1 MV due to these troubles.
- Several challenges encountered and addressed with the coaxial coupler and tuners, the most troublesome parts.

Max Luminosity..(Stay Tuned)

- At higher bunch currents, the specific luminosity falls faster than simulations for head-on
- Possibly due to many effects which are under investigation.

Summary of Discussion for LHC Crab Options

- One crab cavity in one ring for global crabbing.
  - emphasizes the development and testing of the cavity and cryomodule in LHC environment
  - without significant immediate benefits to luminosity
  - minimal information about beam-beam interactions.
- Two crab cavities in the global crabbing mode, one per beam
  - information on the beam-beam interactions in head-on collisions
  - possibly 10 -15% gain in luminosity, if all goes well.
  - the increased luminosity would make it more attractive for LHC to support the installation.
  - the small increase in luminosity however may be difficult to measure.

Crab Options (con’t 1)

- Four crab cavities in the global mode to benefit two interaction regions.
  - With many developmental aspects that need to be addressed this option is more risky,
  - more expensive and would need more time to implement.
  - The potential benefit to two interaction regions would probably generate more support for installation.
- Four crab cavities in the local position.
  - Possibly 10 -15% gain in luminosity if all goes well.
  - More risky and expensive, as above
  - Have to address the tighter space availability near the IPs.
  - The geometry of polarization can be used to accommodate the 800 MHz cavity.

Crab Options (con’t 2)

- General Remarks
  - A common crab cavity design that works for both local and global positions would be best to minimize repetition of the development and prototype effort.
  - Practical considerations such as the availability of refrigeration may influence the choice of local or global positions.

Cavity : Frequency and Aperture

- The highest frequency compatible with aperture and rf curvature considerations is 800 MHz.
- A lower frequency than 800 MHz
  - would face space challenges, esp. for the local crabbing option,
  - And need more crab voltage for a given crossing angle.
- The smallest aperture (depending on upgrade IP design) is 8 cm diameter beam pipe.
  - It would be wiser to design for a larger aperture.
- The need to extract HOMs will lead to larger apertures anyway

Cavity Design Options
One-cell

- Crab kick needed
  - At 800 MHz a crab voltage of 2 MV would deliver the needed crossing angle (1 mrad) for the proper location and lattice (choice of beta at the crab position).
- *Single cell* (default option)
- Same surface fields as the KEK crab cavity
  - f = 509 MHz, Epk = 21 MV/m, Hpk = 60 mT, kick = 1.44 MV
- Scale the cavity to 800 MHz and raise the surface fields X 2
  - kick voltage of 1.8 MV
  - Epk = 40 MV/m, Hpk = 120 mT
  - Consistent with the maximum push in technology recommended (Kneisel)
- The cell design can be further optimized to lower surface fields (10%).
- The operating temperature has to be 2 K due to the higher frequency.
- Paths to refrigeration need to be developed.

Two-cell

- Same surface fields as for KEK
  - or higher crab kick.
- Strong HOM damping should still be possible with 2-cells through 2 beam tubes.
- Lower surface fields are better for reduced trip rate.
  - LHC is very sensitive to trip rate because fill time is very long.

Additional Development Work Needed

- *LOM coupler*
- Source of many troubles both during development and operation.
- A waveguide coupler is an alternative for the coaxial LOM coupler.
- A choke filter is still needed for the crab mode.
- Significant development work is needed for the change.

Exotic Structures

- A number of exotic shape ideas are brewing.
- Rod type structure has very small aperture.
- Magnetic field of TM010 mode needs careful study for beam loading and instability.
- Pursue this option in parallel
  - with baseline TM110 crab cavity
  - Based on KEK success.