Homework Answers

1. Do we have any information on rack space layout? Karl.

Currently there are two efforts on this front:

1) John Barley is collecting a spreadsheet of all components that need to be rack mounted, accounting for the BPM and instrumentation needs, the magnet power supplies, and the vacuum hardware.

- Roughly 20-25 additional racks are needed for the FFAG loop.

2) Due to potential shielding need for a roof over the FFAG loop, we have planned to install the racks on the top of the roof shielding, spread evenly around the loop.

- This would minimize cable runs and cable tray density.
- If a roof is not required, the racks would be positioned in the center of the loop.
- This scheme (roof mounting), used successfully at NSLS II, saves valuable floor space.

2. Review the most credible beam loss incident w.r.t. location and time structure.
Adam (& Val).

We only recently determined what has perhaps been our largest source of machine trip in past high current injector operation.

- Some kind of ion or charged dust particle is accelerated by the gun, hitting the cathode, and causing a vacuum spike, radiation spike, and (brief) current increase, tripping the gun power supply.

Often, before the power supply sends the trip signal to the fast laser shutdown, the gun continues to operate at a lower voltage.

- This has caused the ICM cavity to experience a sudden change in beam loading, which when the LLRF feedback tries to compensate, has caused the ICM to trip on a cavity coupler arc.
- Due to the sudden change in gun voltage, arrival phase at the ICM, and eventually the energy gain in the ICM, the beam is most likely to be lost in the dispersion of the merger, if not well before

(continued)

Homework Answers

2. (Continued) Adam (& Val).

So until the fast laser shutdown can shut off the laser, the injector beam will be lost somewhere in the gun/ICM/merger.

Recently, shutoff time has been on the order of 1 microsecond, though before we discovered a delay in the signal, it had taken as long as 500 microseconds to shut off, without catastrophic effect.

Assuming something similar happens in CBETA, the injector beam will still be lost in the gun/ICM/merger area, but the previously stored beam in the ring will be lost differently.

- The loss of energy recovery in the MLC will cause the beams exiting the MLC to have incorrect energy.
- The most likely scenario is that the change in energy causes the beam to be lost very quickly in the areas of largest dispersion—the spreaders.
- There is ~100 ns of beam stored in the rings, so the beam is effectively “shut off” on that time scale.

3. What space is reserved in the splitter section for diagnostic boxes? Dave.

The question needs clarification but here are my best answers assuming different meanings for 'diagnostic boxes'.

- Instrumentation ports will be placed such that the actuation is vertical. For example, a view screen will be stored in a position just above the beam line and actuated downwards into the beam path when needed.
- For all the energy level beam lines (S1-S4), there is approximately 200mm after the first dipoles and before the last dipoles to place instrumentation ports. The typical YAG-Ce view screen module is only 136mm flange-to-flange leaving adequate spacing for installation.
- Controllers for pumps, BMPs, and instrumentation will be placed above the Splitters on top of a mezzanine planned for shielding and/or power supply racks.

4. Magnet sorting? Stephen B.

Magnet sorting - either of individual permanent magnet blocks or constructed magnets - is not needed in the baseline case.

- The proof-of-principle magnets were of adequate quality without it: shim wires were strong enough to correct the multipoles in all 12 cases (9 measured, 3 simulated).
- Pre-measurement of individual blocks is also not needed provided the overall distribution from the manufacturer is suitable (see answer to Q5 below).

Magnet sorting may be used as a fallback in case we get an unexpectedly wide distribution of magnetisation vectors and want to cancel between blocks in the two longitudinal layers of the Halbach construction.

Homework Answers

5. Magnet rejection criteria. Stephen B.

Assembled magnets are rejected on the basis of poor multipoles after wire shimming, using multipole tolerances derived from tracking.

The figure of merit M = sum_n (multipole_n/tolerance_n)^2 will be observed and if this exceeds the value for the recommended maximum set of multipoles, the magnet will be rejected.

Individual permanent magnet blocks are typically not rejected unless there is evidence during measurement of constructed magnets that one of the blocks is grossly out of range.

Acceptance of manufacturers depends on the RMS of the magnetisation distribution of delivered magnets.

This may be controlled by a combination of asking for ranges on what the factory can do (e.g. maximum angle error) and also observing the true distribution of samples of delivered magnets.

But it is not a simple range tolerance and should not be specified as such to avoid overly-tight tolerances and inflated costs.

Homework Answers

6. Spare part policy – customized magnets? Joe T (& George M).

No operational spares, but we will have in stock most of the critical components from which spares could be built. Halbach magnet construction is simple.

Will be buying 5% (or more) extra blocks for sorting, more would affect budget. Also we are going to buy better quality material so there shouldn't be a lot of rejects or sloppy handling of the blocks.

The aluminum frames should not be easily damaged. The correctors are very tough. We have a lot of similar magnets here and they don't fail.

We have to work on the lattice to reduce or eliminate special Halbach magnets.

Homework Answers

7. Is 3-D printing a viable technical option for production parts? George M, Yulin.

George M:

We've proven it to be a perfectly acceptable production technology.

- The wire holders on the bore of the Halbach magnets are a good example.
- It should also be noted that parts like this are trivial to replace, if need be, by anyone with a printer.
- We might use one of the many "printing houses" available to us because of the volume of parts involved instead of printing them ourselves.

Yulin:

Simple answer: not for vacuum components.

Longer answers: We propose to make the 'switchyard' chambers in the splitter out of two halves that are then welded together.

- It is unlikely to 3D print aluminum alloy material that is ultra-high vacuum compatible and weldable.

Homework Answers

8. Describe how the factor of 2 in the KPP is achieved. Georg H.

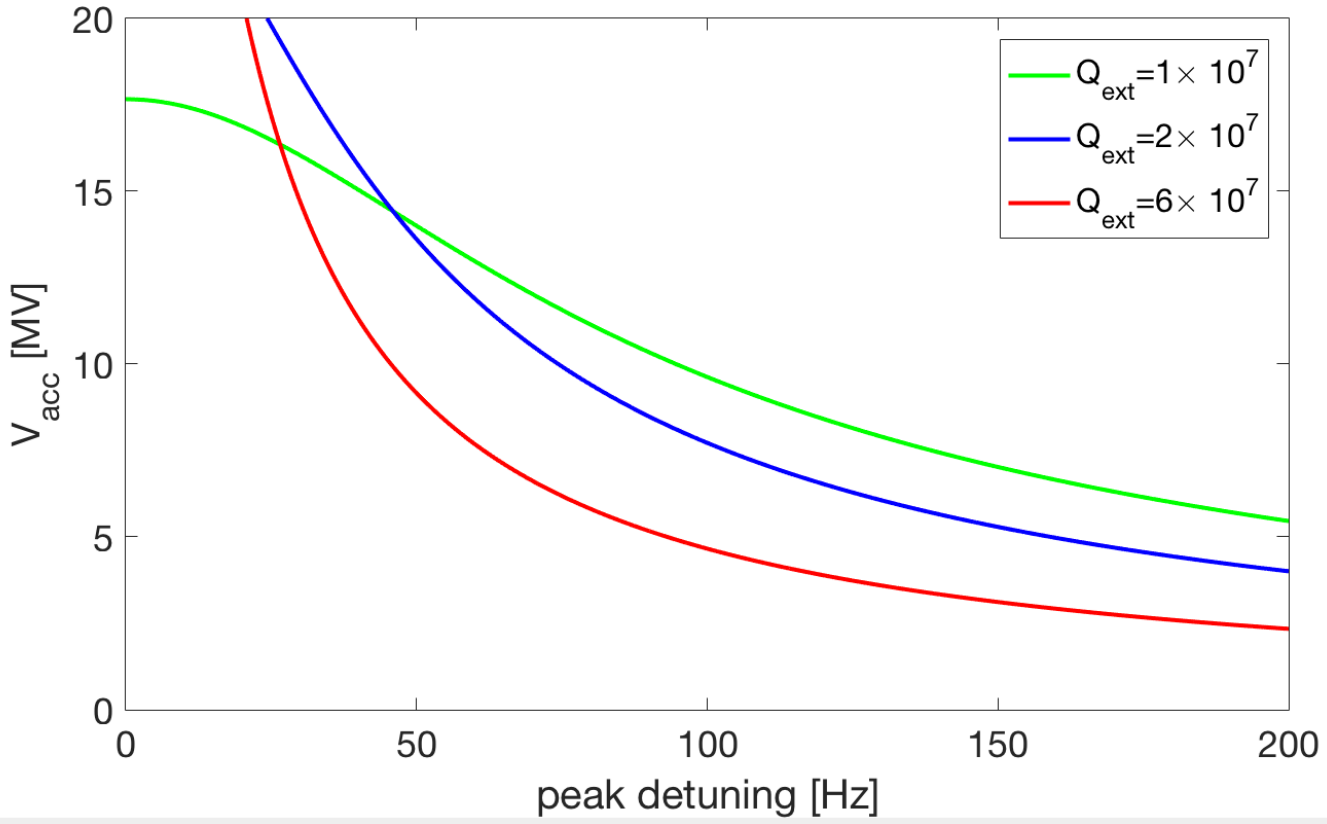
- The design limit for the MLC is 77MeV, it's KPP and UPP for CBETA is only 36MeV energy gain. We have tested it's RF performance and it reaches these UPPs.
- Cavity #4 underperformed in tests by 12%, leading to an energy gain limit of 76MeV.
- Cavity #4 and #6 fell short of the design Q0 by about 30%. With the specified cooling, limiting the energy gain to 73MeV.
- With the measured microphonic, which is largest for cavity #3, and with installing 5kW per coupler, we can only achieve 50MeV in CW operation.
- If microphonic does not improve (and we are working on improvements), our energy range for the FAT test is nominally 42MeV to 56MeV. But we can inject into the FFAG below the bottom energy and we can accelerate in the ICM to more than specified, leading to an energy range of about **40MeV to 62MeV**.

- This impacts the energy range of the FAT test but not the KPPs of CBETA. We will establish the **full factor of 2 (42MeV to 84MeV)** energy acceptance in the FFAG once the second spreader/recombiner is available.

9. What is the strategy to run the MLC if the microphonics cannot be reduced (cavity #3)? Fumio.

1) lower Q_ext with 3-stub tuner. The graph shows the max accelerating voltage for one cavity vs. peak detuning, assuming 10kW RF power.

2) reduce voltage and run other cavities with smaller detuning at slightly higher voltage.



Homework Answers

10. Formal sign-off in the procurement process? Ritchie, Thomas.

The CBETA Oversight Board, as stated in the Project Management Plan, approves the construction start of each WBS L2 subsystem after reviewing the cost items of the subsystem.

After this approval the Project Director will sign-off on all procurements above $50k in the approved subsystems.

Between $5k and $50k the PM or the DPM will approve.

Procurements in excess of $500k also require the approval of the BNL Deputy Director for Science and advanced notification of NYSERDA.

Homework Answers

11. When will we see an integrated layout for the splitter? Dave.

On Friday Feb 10 the splitter SX will have all the available instrumentation, vacuum pumps and BPM models located with the existing magnet conceptual models.

In lieu of any finalized equipment, a block model that is the approximate size will represent in the layout.