Vlhc with a full energy injector

Introduction

Pros and cons

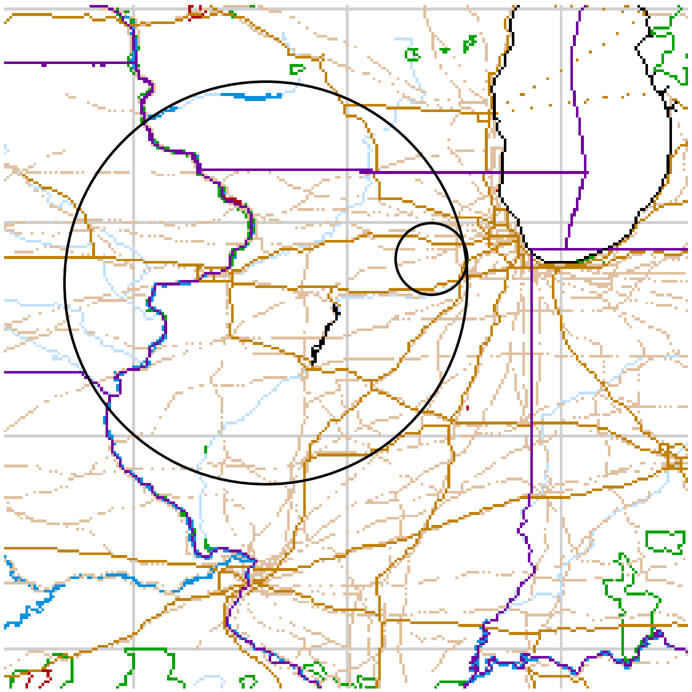
Magnets

Conclusion

Introduction

- Consider a high field (12T) collider with a higher injection energy than in the Snowmass parameter set (3 TeV)
- Injector in the same tunnel: E_{inj} = 50 (B_{inj}/12) TeV: e.g., use SSC dipoles in the injector->25 TeV injection
- The extreme case: 50 TeV (full energy) injector in its own tunnel; B_{inj}= 2 T

Scale



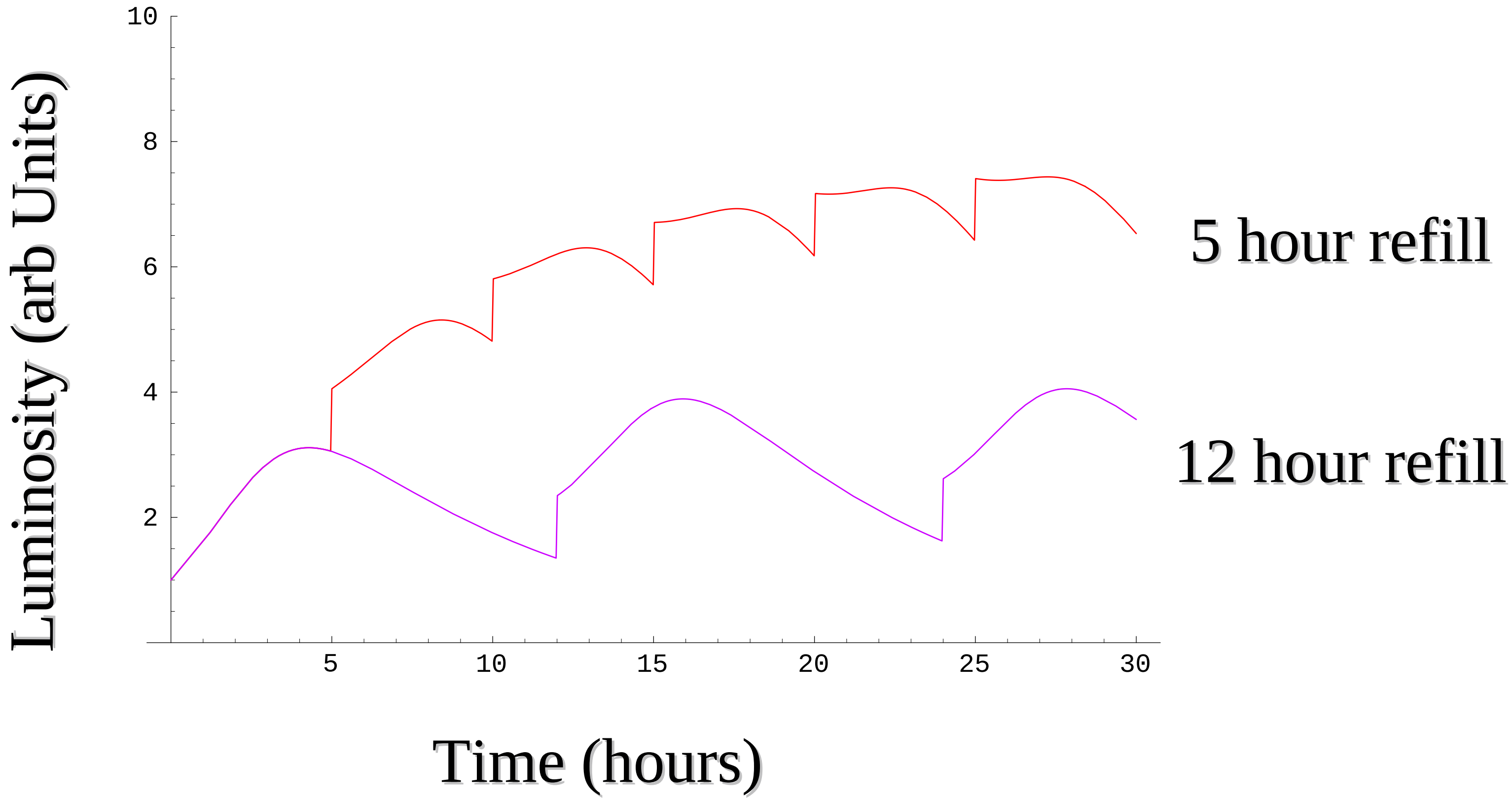
Pros

- Smaller high-field magnet aperture is possible=>lower total currents=>smaller total forces
- High-field magnets are dc; minimal persistent current fields, no ac loss problems; field can be optimized at a single operating point
- Simpler rf and beam abort systems
- More rapid filling, and perhaps “topping off”, is possible, giving more integrated luminosity

Cons

- Two tunnels (100 km, 600 km circumference) are required
- The 50 TeV injector will require thousands of magnets (but they will be simple, single aperture, superferric devices); injector performance is not crucial because of radiation damping in the collider
- More complex (50 TeV) injection system required
- 50 TeV injector could be used for fixed target physics while not filling the collider

Topping off



Luminosity (arb Units)
10
8
6
4
2
5
10
15
20
25
30
Time (hours)
5 hour refill
12 hour refill

Magnets

Aperture budget

Lattice model: 300 m long, 90° cells.

Beam properties: $\varepsilon_n = 1\mu m; \ \sigma_\delta = 5x10^{-5}$

Maximum rms. beam size: 210 μm

Quadrupole alignment: 200 μm rms.

Relative dipole errors: $3x10^{-4}$ rms.

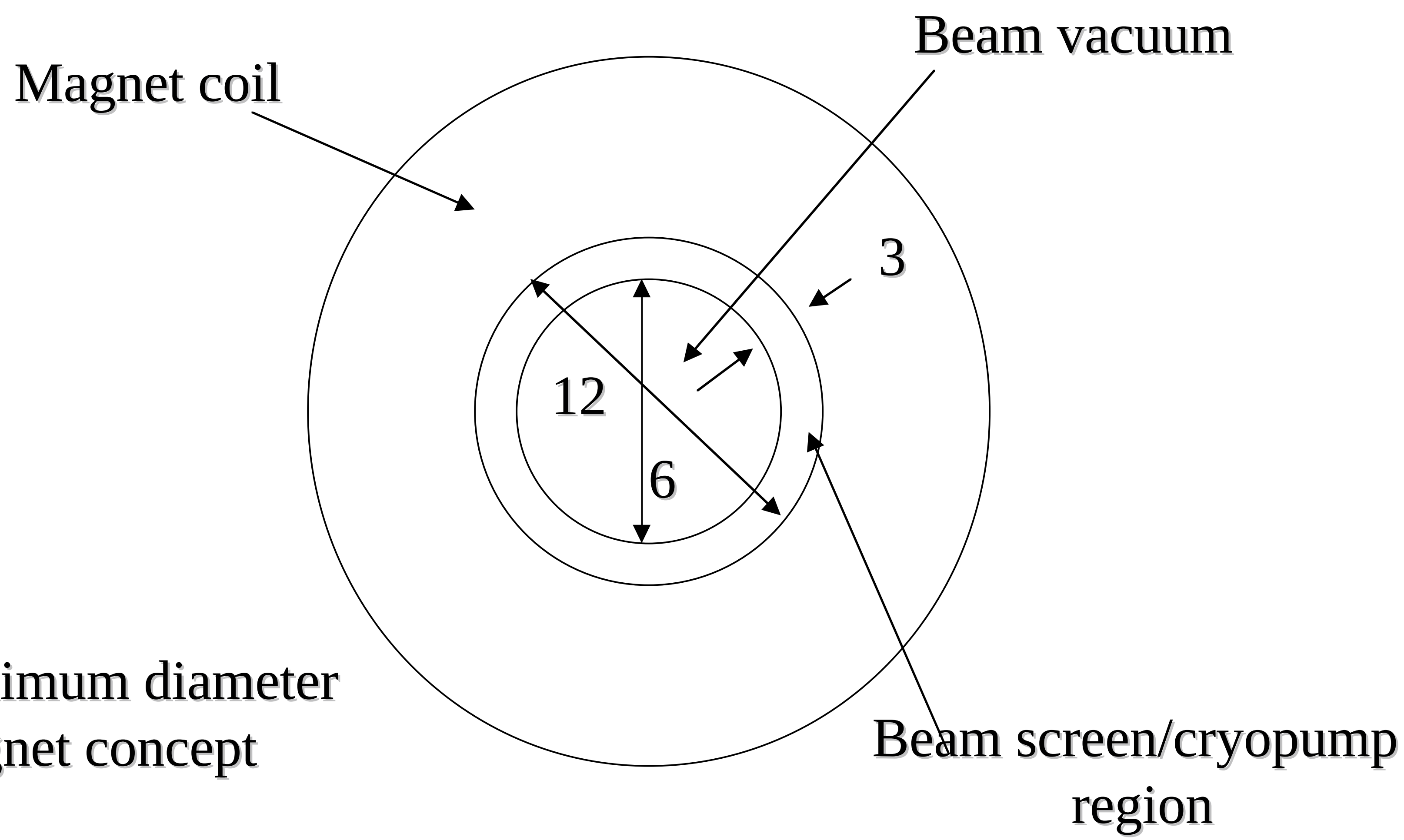
Dipole roll: 0.25 mrad rms.

Closed orbit error (after correction, scaled from SSC CDR work): 190 μm

Total required radial aperture: 400 μm x 5 = 2 mm, +1mm for injection errors => **3 mm**

Magnets

Units: mm



Minimum diameter magnet concept

Magnets

What diameter coil is required to get a 3 mm radial dynamic aperture?

SSC CDR tracking studies: 40 mm diameter coil=>12 mm radial dynamic aperture

If aperture scales with square of coil diameter, a 20 mm coil diameter is required for a 3 mm radial dynamic aperture.

So, the coil diameter should be between 12 and 20 mm. A smaller diameter than 20 mm may be possible because the dynamic aperture may be greater in the absence of persistent current multipoles.

Magnets

Possible questions for this workshop:

What are the advantages and disadvantages associated with small diameter, dc high field magnets ?
What are the expectations regarding achievable field quality in such magnets?
If there is a cost advantage over larger aperture, ac devices, is it possible to quantify it?
What is the cost of single-aperture 2T superferric injector magnets?

Conclusion

- A 50 TeV vlhc with a full-energy injector would require small-aperture, dc, high-field magnets; such magnets might have significant advantages over larger aperture, ac magnets required in the conventional approach
- The machine would have additional advantages in system simplicity, and possibly better integrated luminosity performance
- For this approach to make sense, the cost advantage in magnet (and other) systems in the collider would have to be larger than the cost of the 50 TeV injector, including its large tunnel.