# Muon Collider Luminosity with Ribbon Beams

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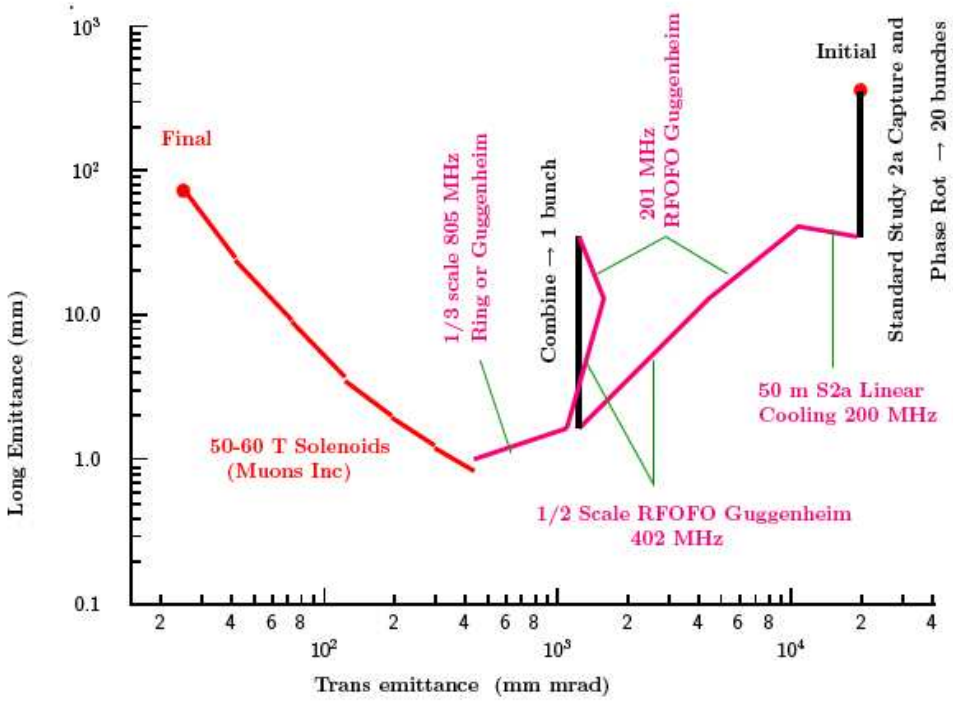
# 50T Solenoid Alternative

- **Five 50T plus one 60T Solenoids could provide the final cooling for a muon collider. See Steve Kahn *et al.*,** http://accelconf.web.cern.ch/AccelConf/e06/Pre-Press/WEPLS108.pdf

- **$\epsilon$(400, 400, .9) $\rightarrow$ $\epsilon$(25, 25, 80) Only 3$\times$ 6D cooling, but lots of inverse emittance exchange.** http://mice.iit.edu/mutac06/mutac06_palmer_bunchmergedcollider.pdf




- **50T YBCO solenoids $\rightarrow$ 18T $Nb_3Sn$/NbTi ring.**
- **$\epsilon$(400, 400, .9) $\rightarrow$ $\epsilon$(150, 150, .5) 12$\times$ 6D cooling.**

# $90^0$ RF Rotation

- $\epsilon$(150, 150, .5) $\rightarrow$ $\epsilon$(150, .5, 150)

- **Dispersion in RF Cavity**

**S. Berg, physics/0607278**

- **Crab Cavity**

**R. Palmer, Snowmass 88, page 613**

- **Series of Tilted RF Cavities.**

**Each tilted $10^0$ to push the beam to the right.**
**Alternately phased to give no net acceleration,**
**in the initial beam direction.**
**No torque on the bunch.**
**Bunch just makes a $90^0$ right turn.**

- $\mathcal{L} \propto \mathrm{n_{turns}}\ \mathrm{n_{bunches}}\ \ \mathrm{N^2_{\mu/bunch}}\ /\ \sigma^2_\perp$

$\mathcal{L}$ only depends on the beam area, NOT shape.

$\mathcal{L}$(150, .5, 150) = 8$\times$ $\mathcal{L}$(25, 25, 80)  but...

# Accelerating a Wide Beam

- **FFAGs accept 10000 mm mr,**
**so 150 mm mr is OK.**

- **Transverse Size** $= \sqrt{\epsilon\beta_\perp}$

**Tevatron** $\beta_\perp = 50$ **meters**

**Transverse Size = ???**

- **Width/Thickness = 300.**

**Width/Thickness = 30 at BaBar**

**Is 300 stable?**

# Tune Shift

- $\mathcal{L} \propto \mathrm{n_{turns}}\ \mathrm{n_{bunches}}\ \ \mathrm{N}^2_{\mu/\mathrm{bunch}}\ /\ \sigma^2_\perp$

  $= \mathrm{n_{turns}}\ \mathrm{n_{bunches}}\ \ \mathrm{N}^2_{\mu/\mathrm{bunch}}\ /\ (\epsilon_\perp \beta_\perp/\gamma)$

  $= \mathrm{n_{turns}}\ (\gamma\ \mathrm{n_{bunches}}\ \mathrm{N}_{\mu/\mathrm{bunch}})\ (\mathrm{N}_{\mu/\mathrm{bunch}}/\epsilon_\perp)\ (1/\beta_\perp)$

  $= \mathrm{n_{turns}}\ (\mathrm{P_{beam}})\ (\Delta\nu_{\mathrm{tune\,shift}})\ (1/\beta_\perp)$

- **S. Y. Lee, "Accelerator Physics," eq. 4.11.**

$\xi_{z\pm} = \mathbf{N}_\mp\ \mathbf{r}_0\ \beta^*_z\ /\ [\mathbf{2}\ \pi\gamma\sigma_z(\sigma_x + \sigma_z)]$

**For the same transverse area, wide ribbon beams give twice the vertical tune shift of round beams.**

- **So, decrease $\mathbf{N}_{\mu/\mathrm{bunch}}$ and increase the number of bunches.**

**$\mathcal{L}$(150, .5, 150) = 0.5$\times$ $\mathcal{L}$(25, 25, 80)**

**for the same beam power.**

# Increasing Luminosity by 8

- **8 70 million Palmer Buck BaBar class Detectors**

**LEP had 4 detectors. PEP had 5 detectors.**

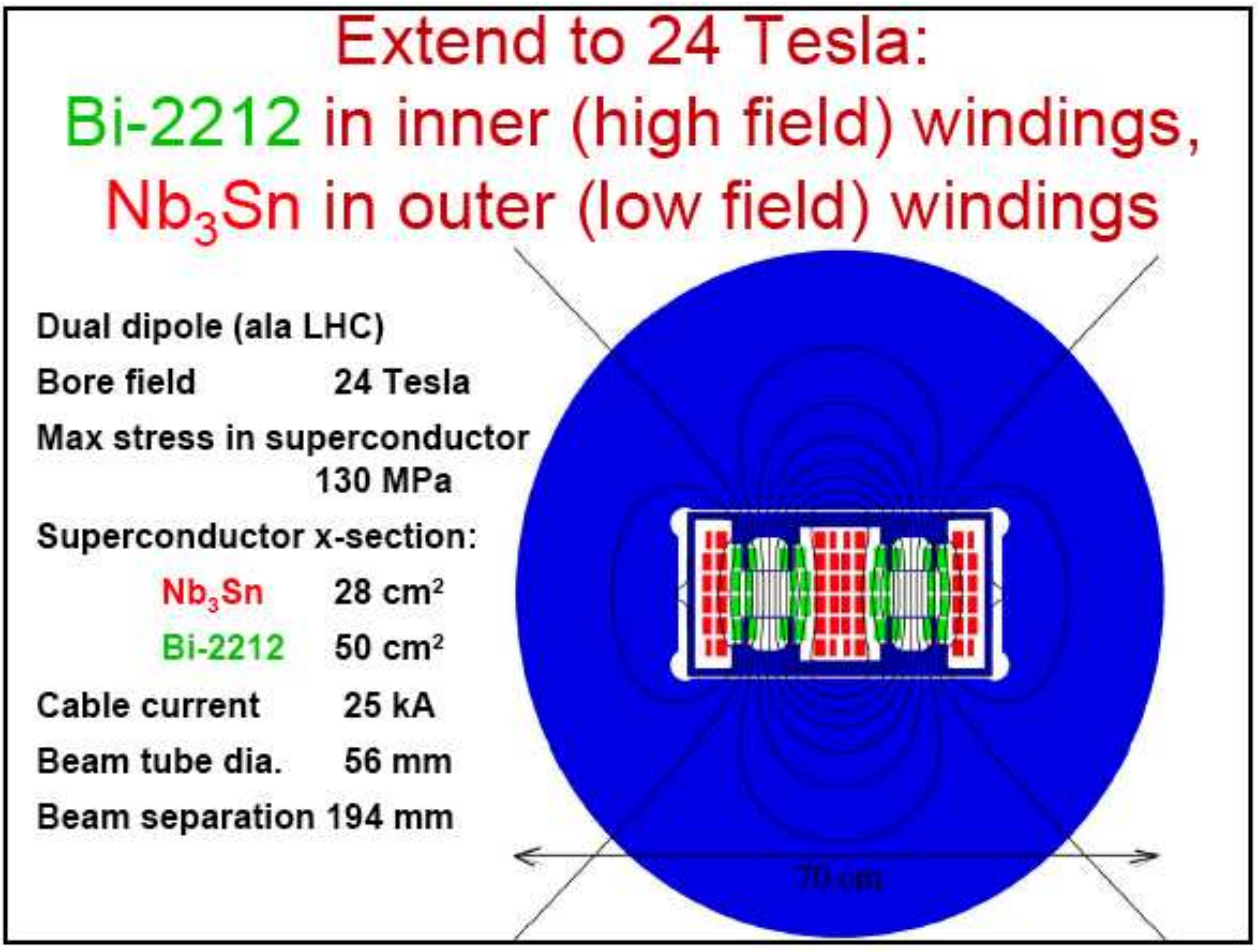
- **CCD inner tracking like SLD.**

**Read out CCDs between beam shots.**
**$BL^2$ tracking resolution with low B and large L.**
**Calorimeters outside beam halo at large r ??**
**MINOS style calorimeters.**
**No W $\rightarrow$ JJ, Z $\rightarrow$ JJ separation!**
**Try to minimize channel count, except CCDs.**
**Can CCDs be radiation hard enough ?**

- **1×1 Bunches allows 2 Detectors**
  **2×2 Bunches allows 4 Detectors**
  **3×3 Bunches allows 6 Detectors**
  **4×4 Bunches allows 8 Detectors**

# Increasing Luminosity by 2

- **24T LHC Tripler Proposal (Texas A&M)**




- **20T Muon Collider open midplane ring option?**

# Summary

- **Can a bunch be RF rotated $90^0$?**
- **Are very wide ribbons OK?**
- **Vertical tune shift (ribbon/round) = 2.**
- **But ribbons may still allow muon colliders to operate, if 50T solenoids prove difficult.**
- **More detectors and a higher field collider ring, more than buy back the factor of 2 ribbon loss, WITHOUT increasing offsite neutrino radiation.**
- **YBCO/BSCCO superconductors are important in all scenarios.**