MCTF progress & status

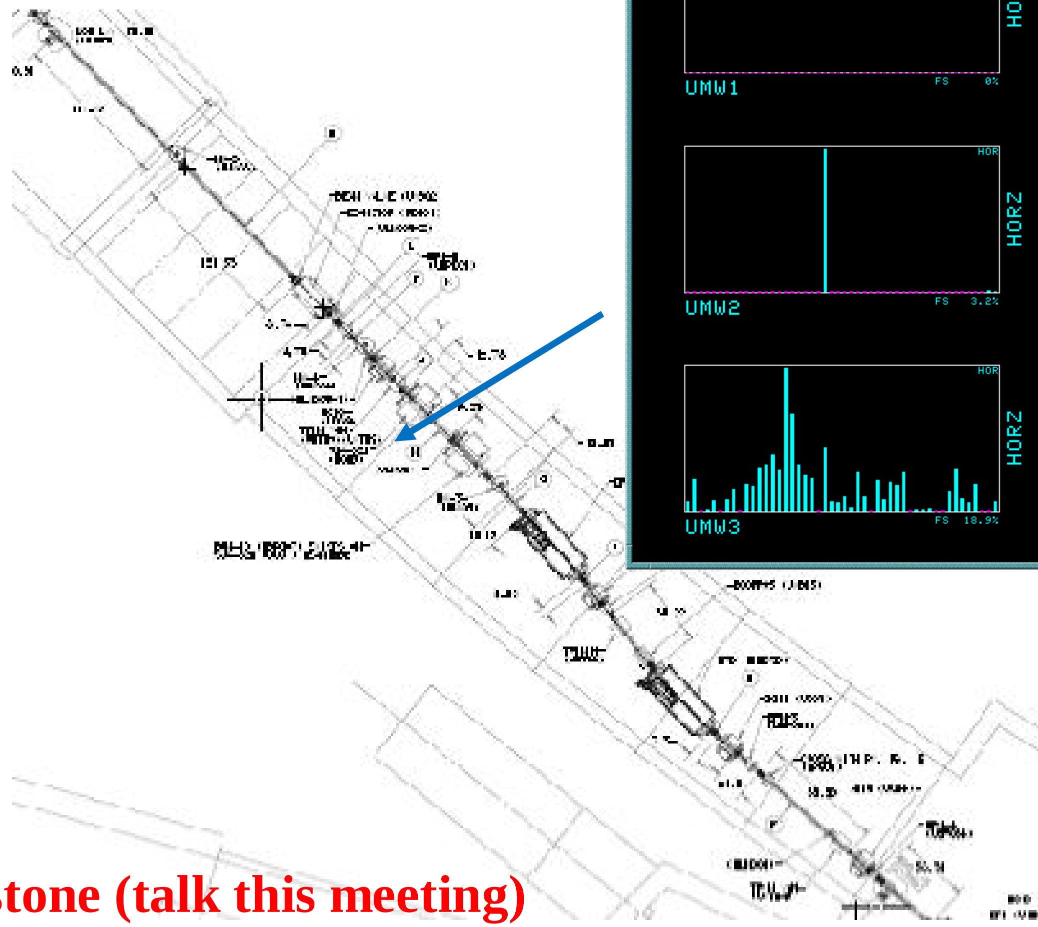
Andreas Jansson

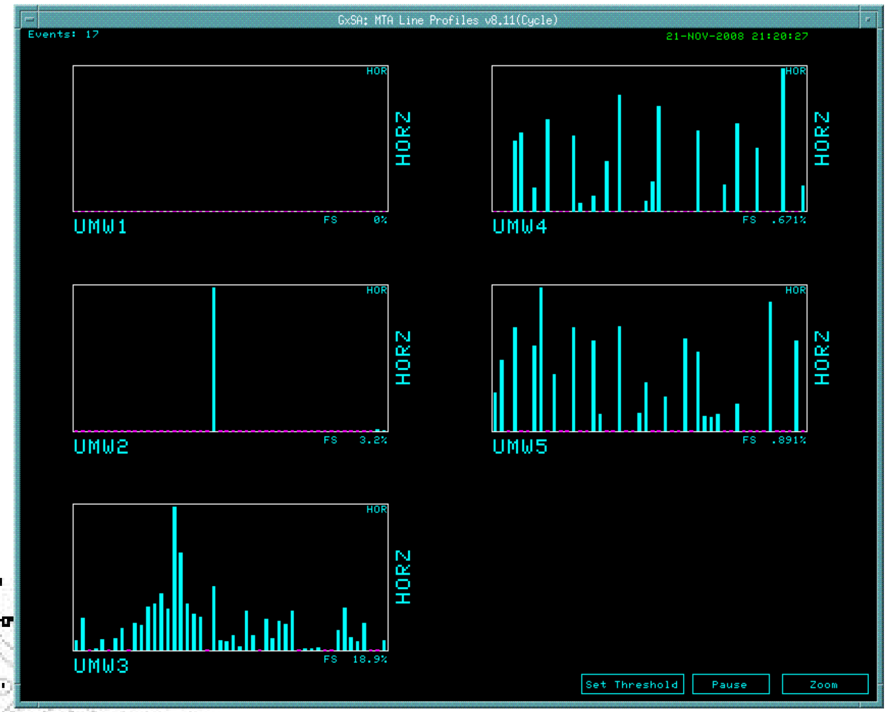
Introduction

- The directors charge to the MCTF is to investigate the long term prospects of a Muon Collider
- The main focus is on Muon Collider specific issues complementary to the NFMCC program
  - E.g. 6D cooling, Collider optics...
- During this year, a joint MCTF/NFMCC 5-year R&D plan was developed and submitted to DOE.

First beam in MTA line

Beam to first beam stop, visible on multiwire 3m upstream





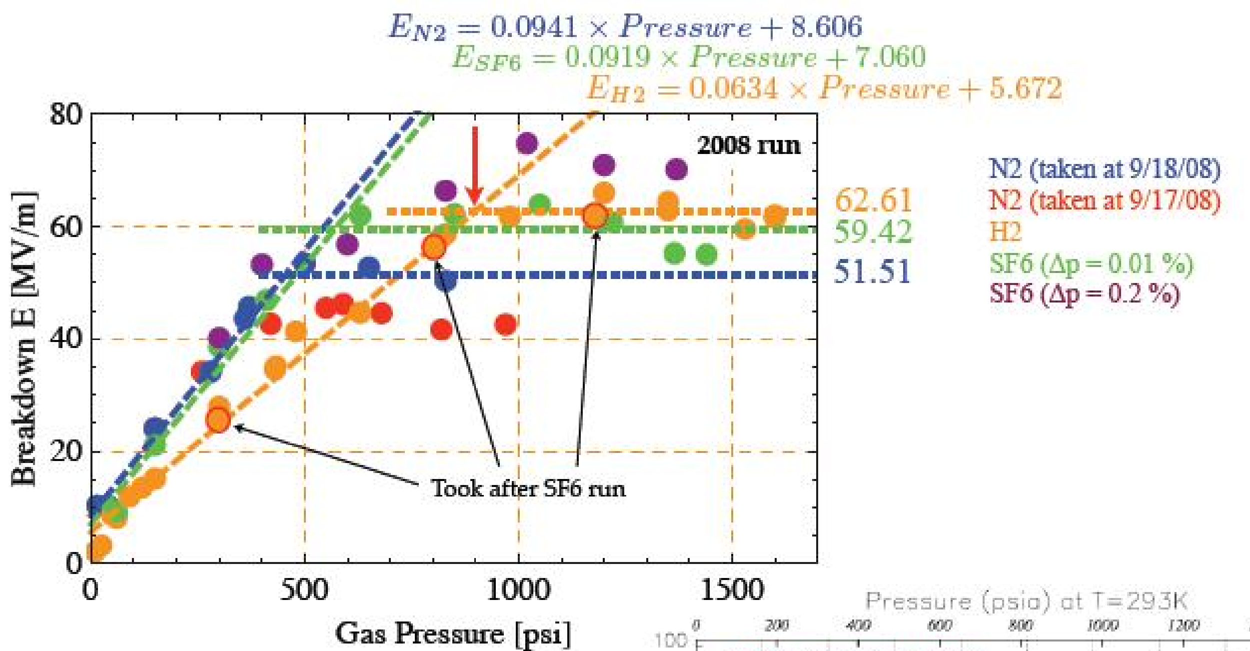
Johnstone (talk this meeting)

MTA Beamline

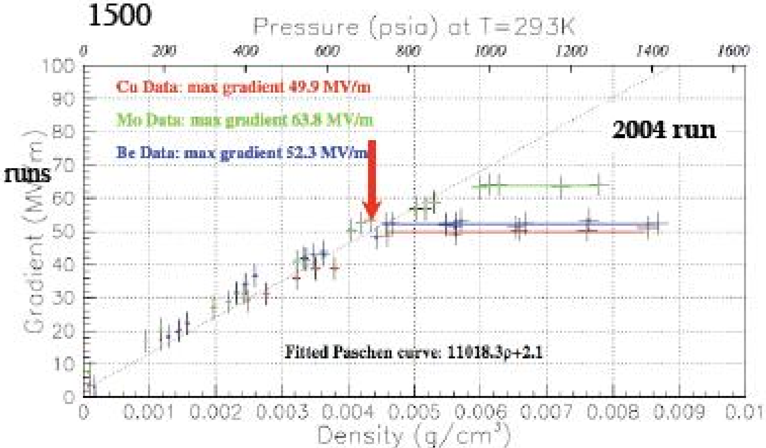
- Permission for first beam into hall contingent on
  - Shielding assessment approval by DOE
  - Replacing shielding in pit and hatch.
- Will be low rate (1/min) for first experiment

Johnstone (talk this meeting)

HPRF tests (w/o beam)

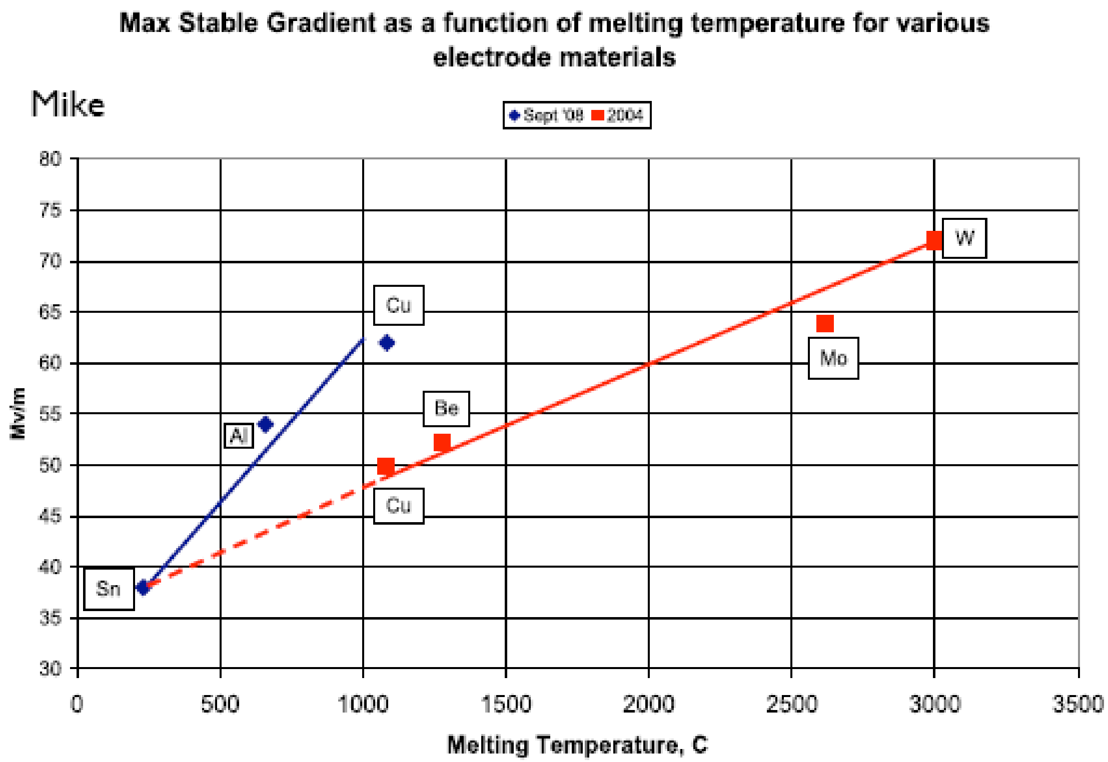


- Procedure: N2 run → H2 run → SF6 run
- Maximum field in 2008 run is ~20 % increased
- Good agreement of the Paschen slope between both ('08 & '04) runs
- Knee pressure (red arrow in upper plot) in 2008 run is 900 psi while that in past run (red arrow in lower plot) is 700 psi
- Increment of field in 2008 run can be real
- Plateau is different with different gas
- SF6 has big ambiguity



Yonehara et al (talk this meeting)

Dependence on surface material



- What changed for the copper electrode?
- Change in gas mixture and/or change in the copper surface

(Note that there is disagreement as to whether melting point the relevant parameter here)

Yonehara et al (talk this meeting)

4-coil HCC model magnet

Table 1: Solenoid Parameters

Parameter	Units	Value
Coil inner diameter	mm	426
Coil outer diameter	mm	455
NbTi superconducting cable	mm	12.34 x 1.46
Cable critical current at 7 T, 4.2 K	A	9660
Jc (non-Cu)	A/mm^2	1730
Copper to superconductor ratio		1.5:1
Strand diameter	mm	0.8
Helical orbit radius	mm	255
Number of turns per coil		10
Coil width	mm	20

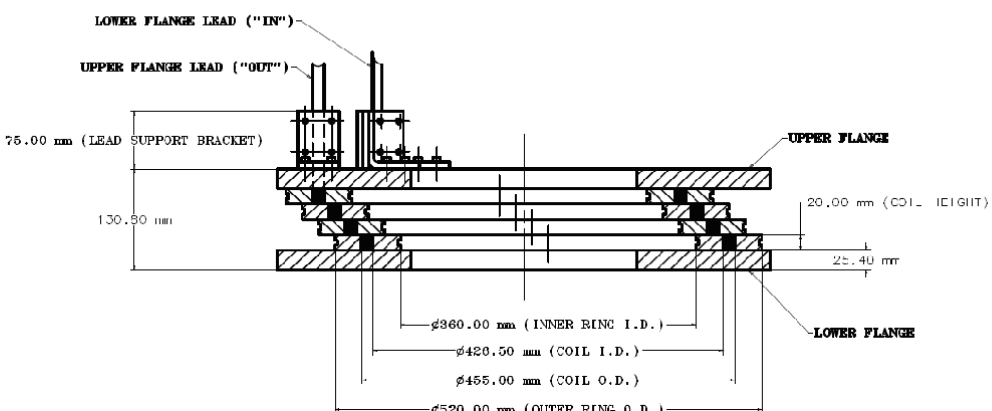
Main goal is to develop the mechanical concept which could be extrapolated to the long solenoids without changing the structure

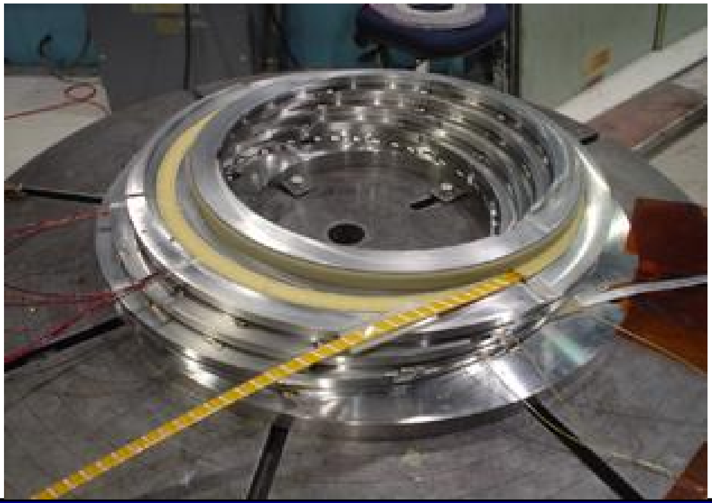
Each coil is wound from Rutherford type superconducting cable on a stainless steel bobbin

Outer stainless steel collar rings provide the coil support and intercept the radial Lorentz forces

The short model consists of four superconducting coils with support structures and end flanges

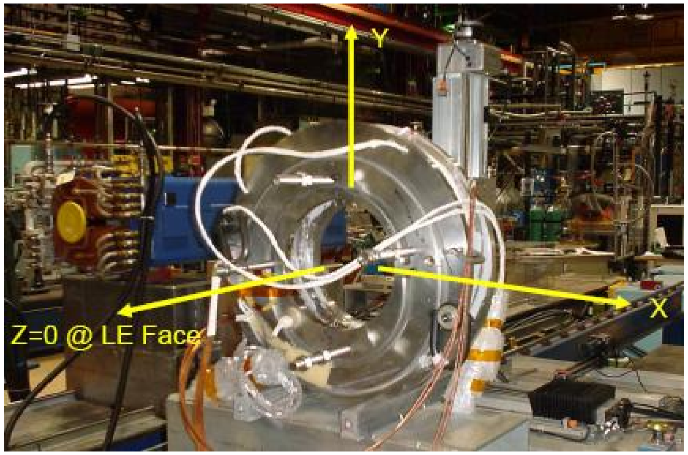
By operating at high current, 14 kA, it is intended to reach the fields, forces, and stresses of the long HS to verify the design concept and fabrication technology

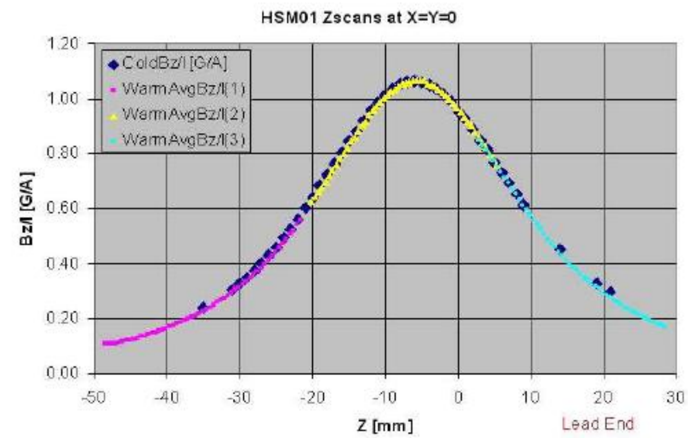


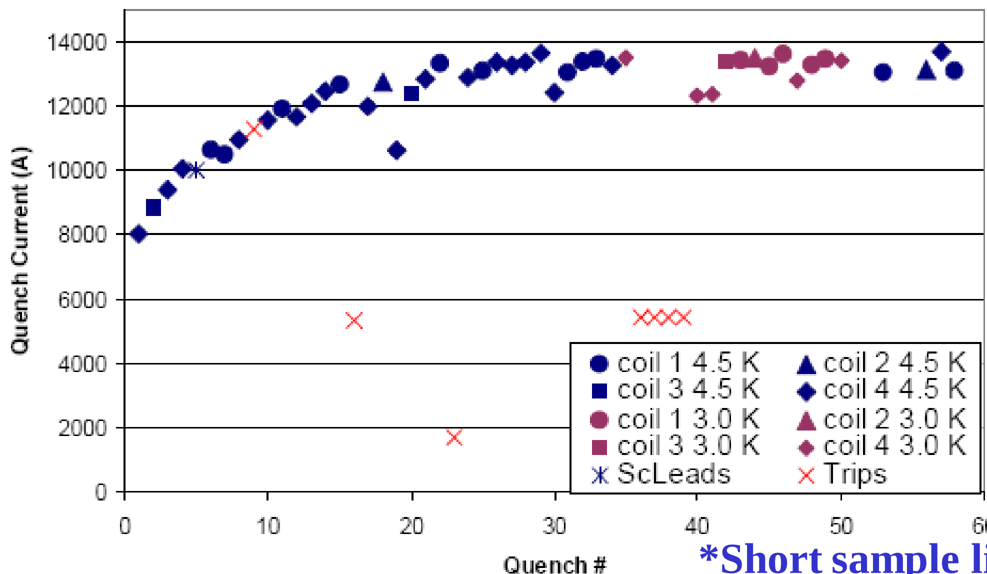


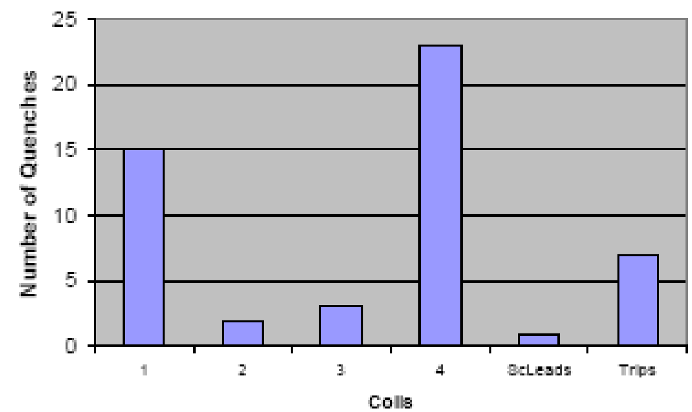
Kashikin et al (w. Muons Inc)

4-coil model magnet tests









***Short sample limit estimate 16K**

Kashikin et al

Future HCC models

NbTi 4-coil model 2 plans

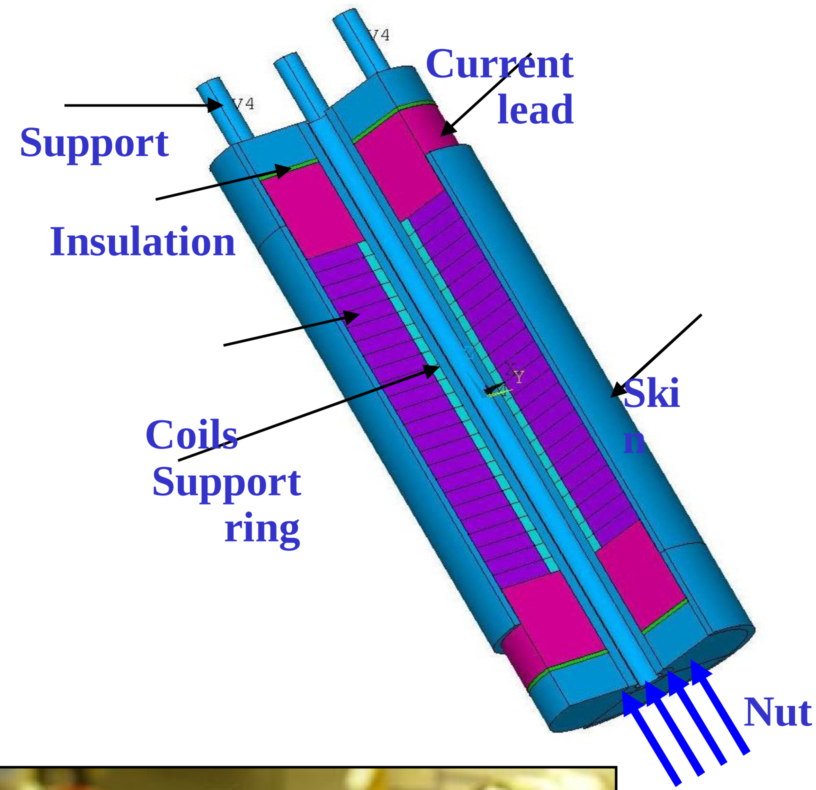
• The base line of magnetic and mechanical design is the same as for Model 1
• The design should accommodate NbTi and Nb3Sn cable technology
• Need to improve mechanical structure and insulation:
  - Place G10 spacers between turns to compensate for cable keystone
  - Use the same ground insulation as in Model 1
  - Correct the leads outlet areas to avoid shorts and carefully secure the leads in space outside the solenoid

Nb_3Sn 4-coil model 3 plans
• Same base line magnetic and mechanical design as for Model 2
• Use the Nb_3Sn ~ 15mm x 28 strands 1 mm diameter cable
• Insulation and reaction details need to be worked out

Kashikin et al

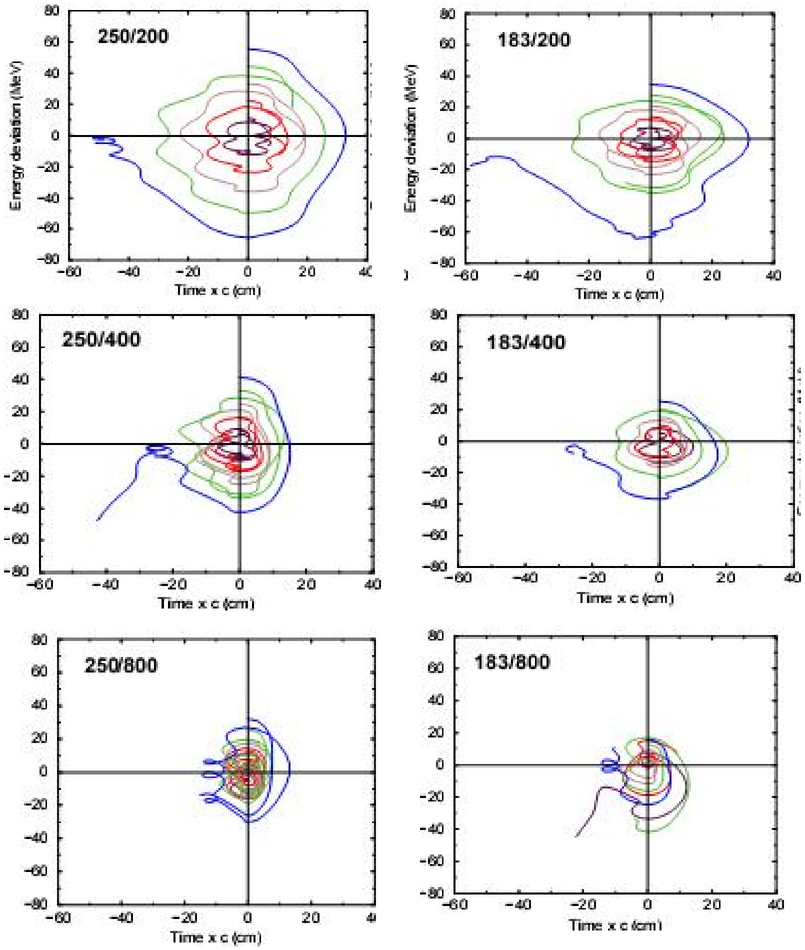
HTS

- Single and double layer HTS coils designed and tested
- Modular HTS test facility designed and being procured
  - Test many coils inside 16T solenoid
- BSCO-2212 cable and wire work will be done within National Collaboration



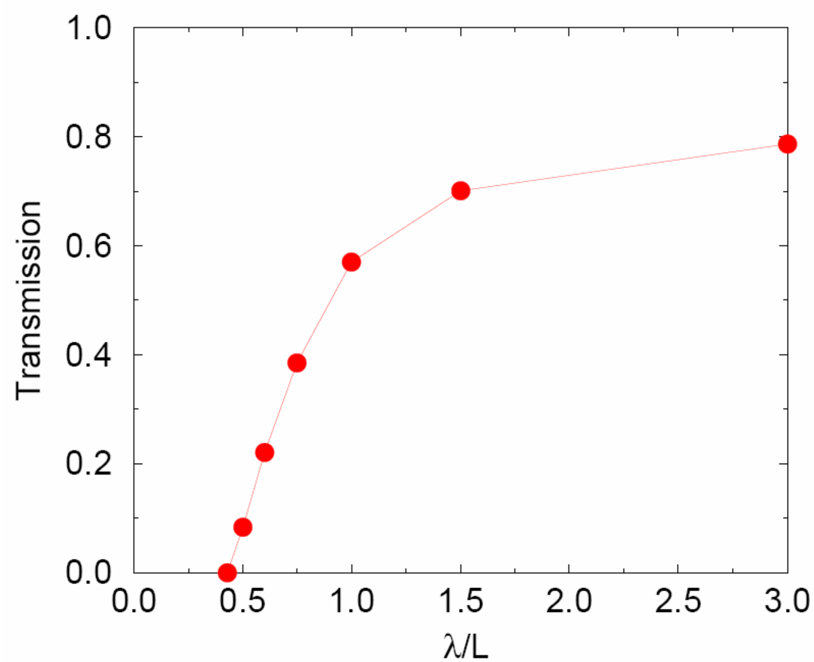
Barzi (talk this meeting)

Optimal HCC Frequency



Perturbation of longitudinal motion by betatron oscillations decreases the channel acceptance

Particles loss vs relative wavelength (simulation at 250 MeV/c, 30 MV/m, 15 MeV/m, L = 1 m).

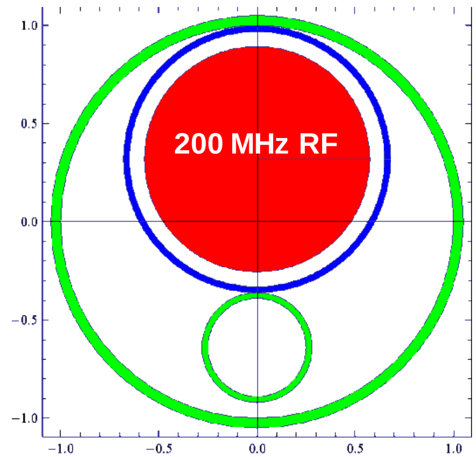


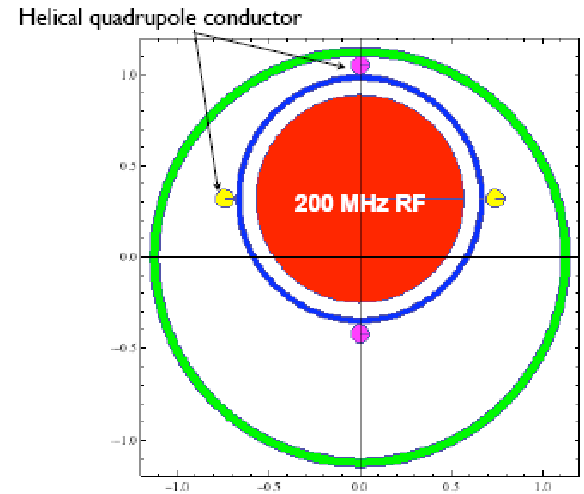
Equilibrium emittance proportional to L!

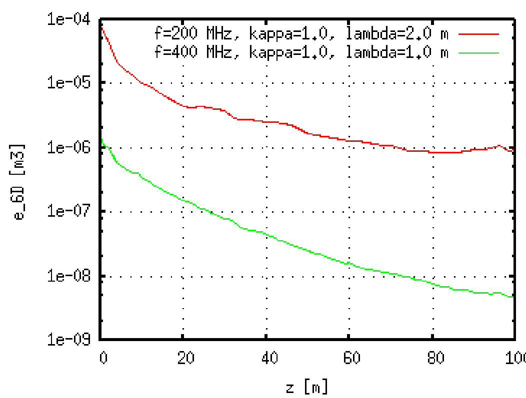
Balbekov

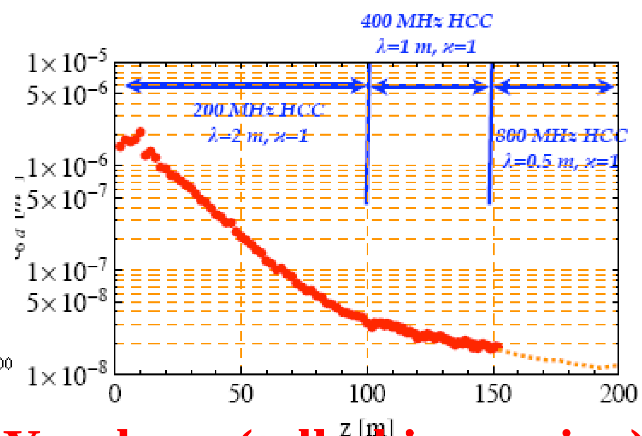
How to make space for RF

- Possible to increase available aperture by adding correction coils to the helical solenoid.
- Correction scheme will depend on required aperture for a given helix wavelength, and may be very challenging (impossible?) for short helix/high frenqency.





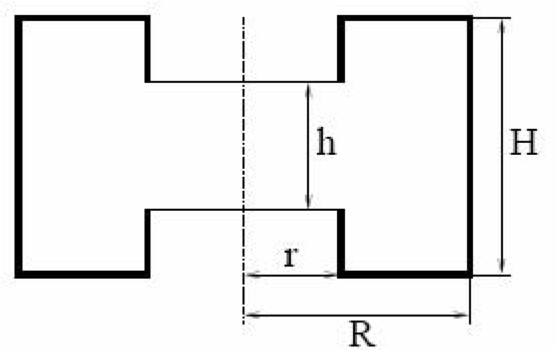




Yonehara (talk this meeting)

Can we make cavities smaller

Toroidal cavity

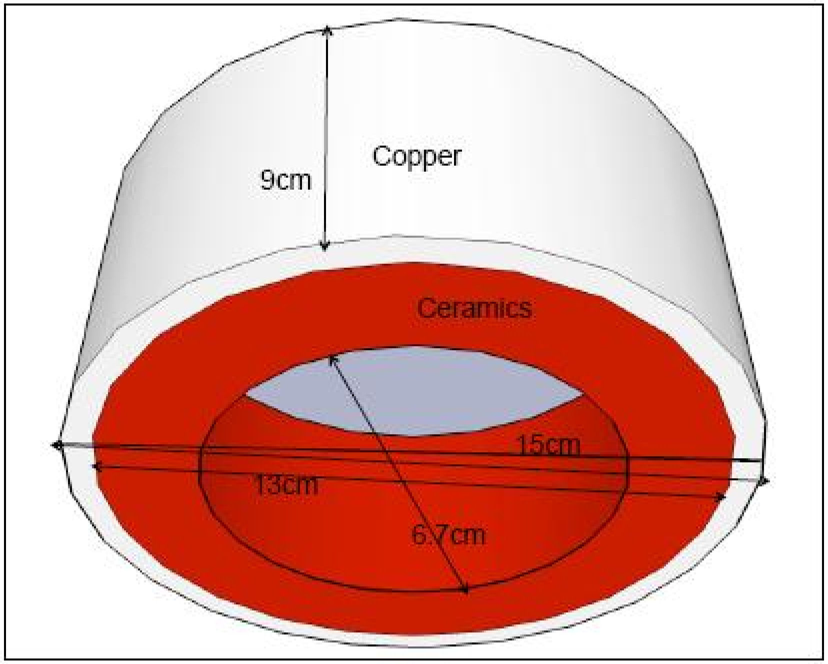


$$\lambda \simeq 16\, r \sqrt{\frac{H}{h}\, \ln \frac{R}{r}}$$

(HCC can work with lower average gradient and lower gas pressure)

Balbekov

Ceramic loaded cavity

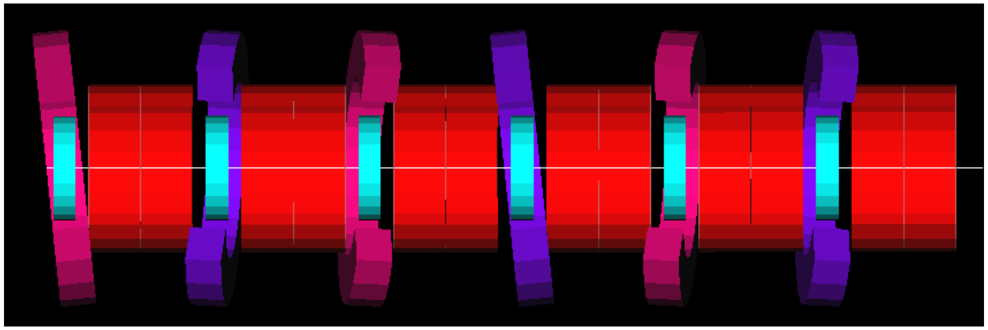


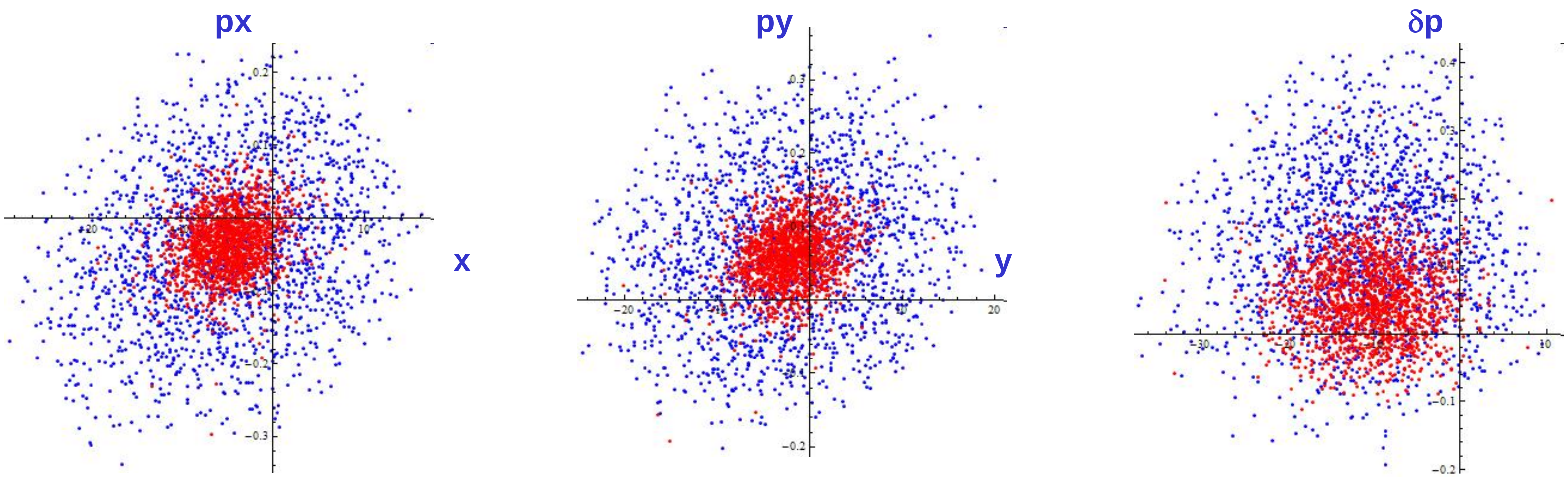
Popovic (talk this meeting)

(Also an idea for helical travelling wave structure from L. Thorndahl/Muons Inc)

FOFO Snake

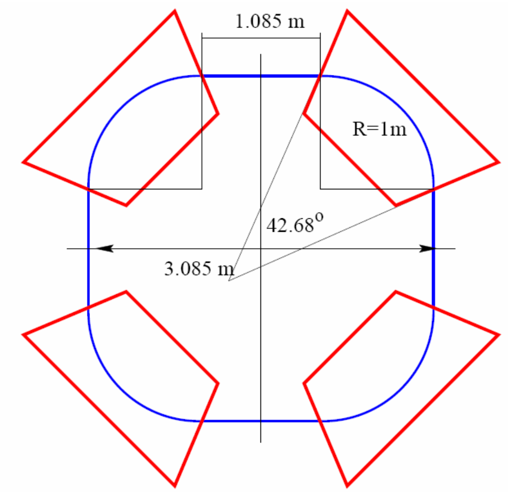
- Moved from planar snakes to helical snakes with some encouraging results.
- Need further study.

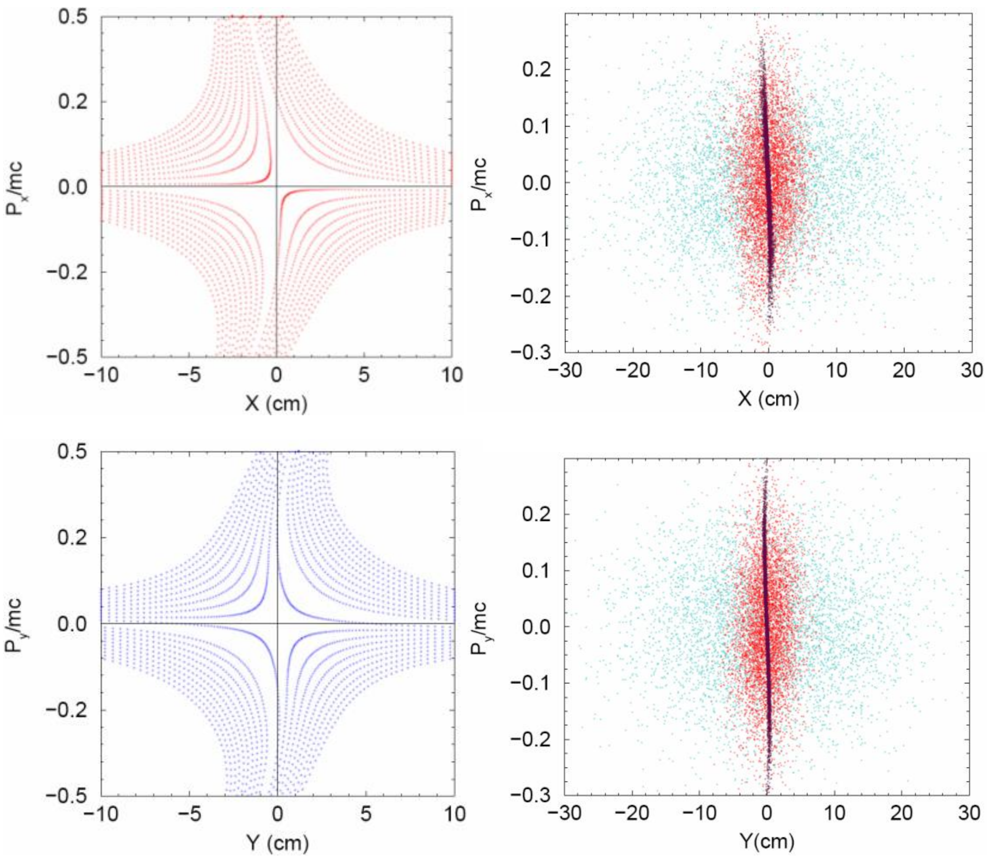




Alexahin (talk this meeting)

Weak Focusing PIC ring





- Weak focussing ring have large momentum acceptance and less problems with aberrations.

Balbekov

RLA RF power estimate

HE2008, 1.5 TeV

N	Muon losses,%	RF power, MW	Total cryogenic losses, MW	Losses in HOM couplers, MW	Total power, MW	Number of klystrons (10 MW)	Number of cavities	Average klystron power, kW
10	6.4	20	4.8	1.5	24.8	180	2920	59
20	9.3	16	3.8	2	19.8	122	1460	70
30	11.1	14	3.5	2.2	17.5	92	973	81

LE2008, 1.5 TeV

N	Muon losses,%	RF power, MW	Total cryogenic losses, MW	Losses in HOM couplers, MW	Total power, MW	Number of klystrons (10 MW)	Number of cavities	Average klystron power
10	6.4	68	13.9	1.8	81.9	90	2920	402*
20	9.3	48.6	8.7	2.5	57.3	61	1460	424*
30	11.1	42	7.4	2.8	49.4	46	973	486*

***Available 10 MW klystrons have an average power of 150 kW.**

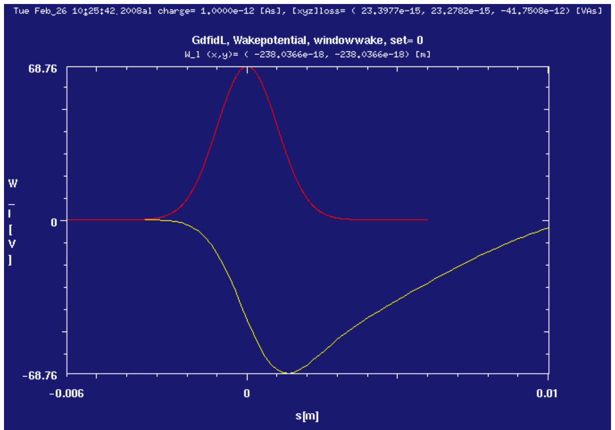
Yakovlev/Solyak

Wakefields in SC cavities

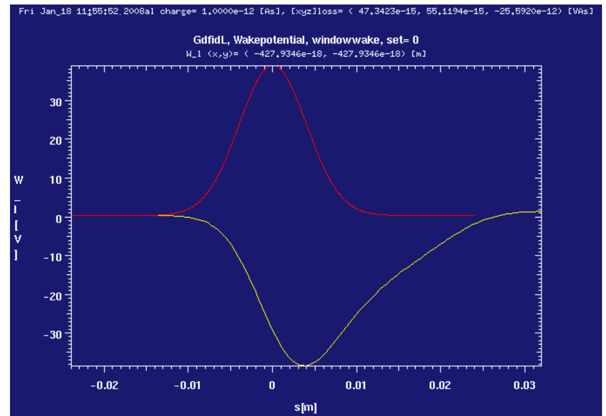
Short range longitudinal wake per unit length:

$W_{max} \sim q/(\lambda\sigma)$ for a "long" bunch ($\lambda\sigma > a^2$, a - aperture).

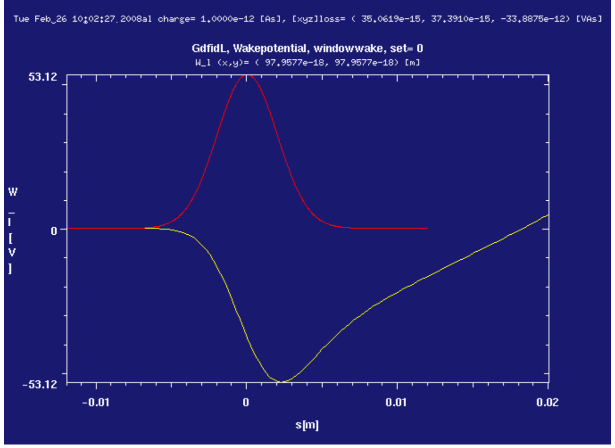
For N=2e12, f=1.3 GHz (ILC-like structure) and σ=8 mm W_{max}= 6.2 MV/m!



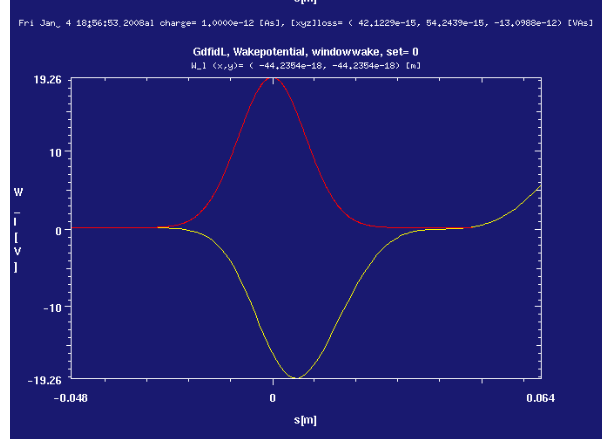
σ=1 mm



σ=4 mm



σ=2 mm

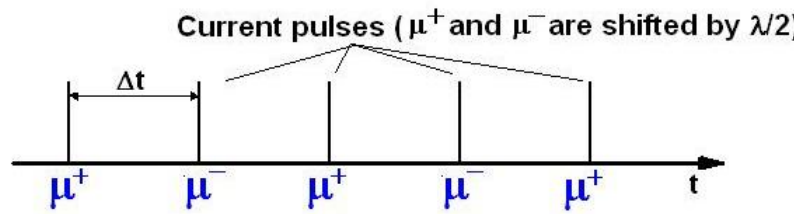


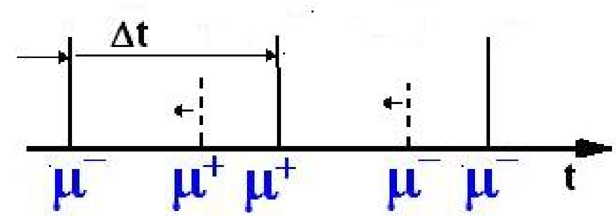
σ=8 mm

Yakovlev/Solyak

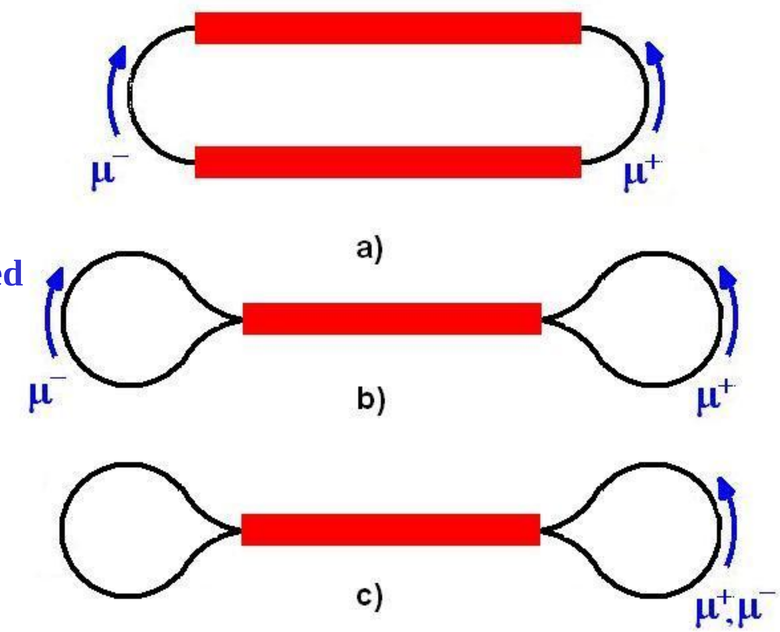
Bunch timing

Preferred by RF

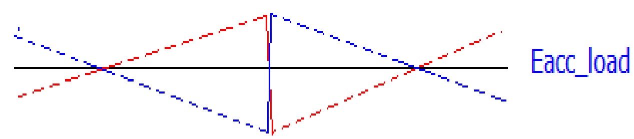




Preferred machine design



(Separate arcs for μ^+ and μ^-)



Acceleration gradient along linac,

Red -one direction,

Blue-opposite direction

Yakovlev/Solyak

Collider Ring Optics

- "Dipole first": bending magnets are introduced to create dispersion in the IR (not at IP) and accommodate sextupoles close to the IR quadrupoles (local chromaticity correction)
- Oide-like optics: Non-interleaved sextupole correction scheme requiring "ad hoc" optics and using a large number of sextupoles to control higher order chromaticity.

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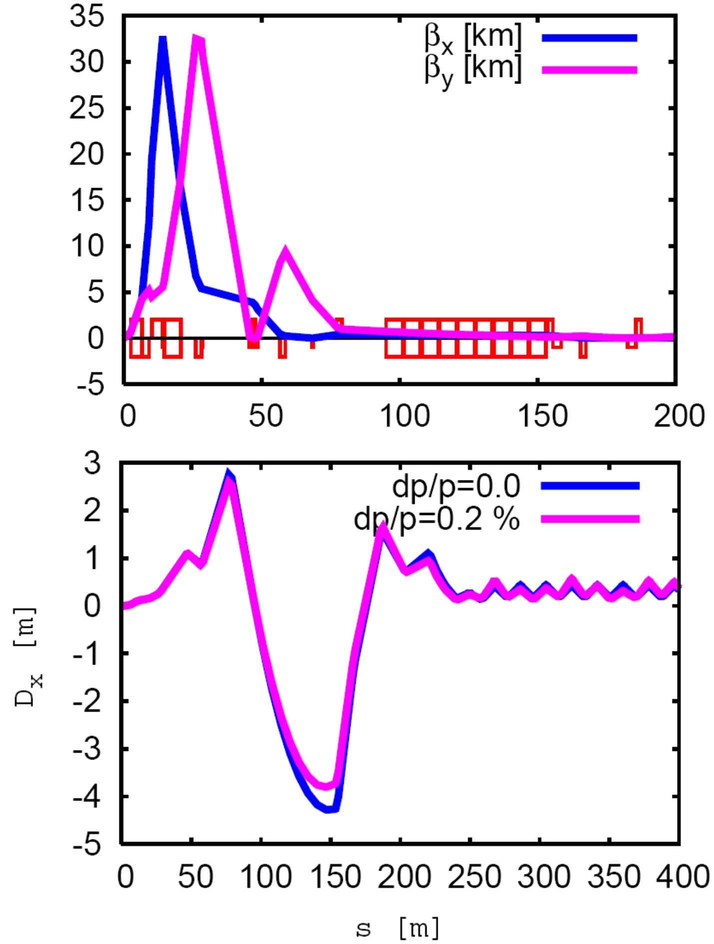


Gianfelice/Alexahin (talk this meeting)

The MCTF Scenario

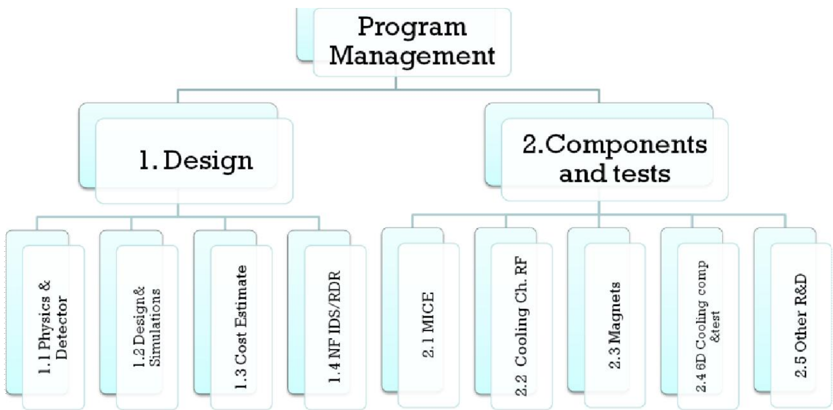
	Low Emit.	High Emit.	MCTF07	MCTF08
$\sqrt{s}$ (TeV)		1.5		
Av. Luminosity ($10^{34}/cm^2/s$) *	2.7	1	1.33-2	
Av. Bending field (T)	10	6	6	
Mean radius (m)	361.4	500	500	$\Rightarrow$ 495
No. of IPs	4	2	2	
Proton Driver Rep Rate (Hz)	65	13	40-60	
Beam-beam parameter/IP	0.052	0.087	0.1	
β* (cm)	0.5	1	1	
Bunch length (cm)	0.5	1	1	
No. bunches / beam	10	1	1	
No. muons/bunch (10^{11})	1	20	11.3	
Norm. Trans. Emit. (μm)	2.1	25	12.3	
Energy spread (%)	1	0.1	0.2	
Norm. long. Emit. (m)	0.35	0.07	0.14	
Total RF voltage (GV) at 800MHz	$407\times10^3\alpha_c$	0.21**	0.84**	$\Rightarrow$ 0.3†
Muon survival $N\mu/N\mu0$	0.31	0.07	0.2	?
μ+ in collision / proton	0.047	0.01	0.03	?
8 GeV proton beam power	3.62***	3.2	1.9-2.8	?

***) Luminosity calculated taking account of the hour-glass factor but ignoring the dynamic beta effect.**
****) Momentum compaction in the present ring design $\alpha_c=1.5\times10^{-4}$. Note that it would be better to assume f=1.3GHz to keep the RF voltage at a reasonable level (0.52GV for MCTF07 set)**
*****) Assumes μ /p ratio of 0.15 after capture and precooling, and only decay losses afterwards. Positive and negative muons are assumed to be produced independently (from different protons).**
†) The latest ring design has $\alpha_c=5.5\times10^{-5}$. Voltage for HE option is now 75MV

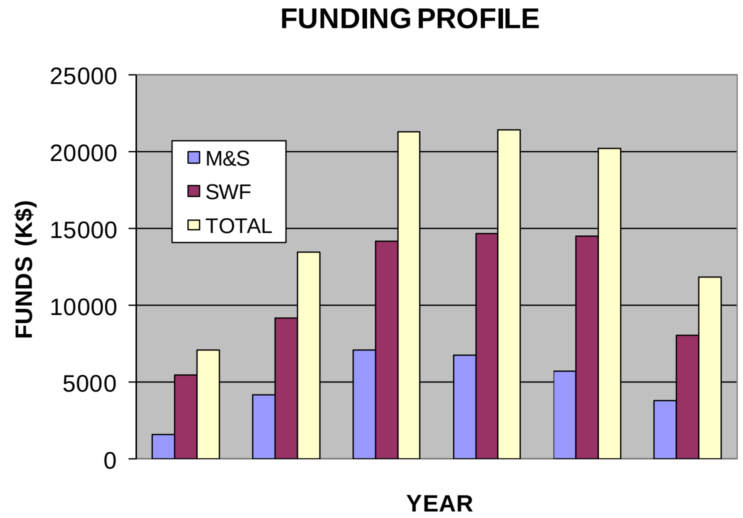
Alexahin

The 5-year plan

Organisation



Budget request



Manpower needs

	Now	Year 1	Year 2	Year 3	Year 4	Year 5
BNL	6.5	7	8	10	10	10
FNAL	20.8	23	28	30	33	33
LBNL	2.5	6	8	9	11	13
Other	7	13	35	32	32	32
TOTAL	35.6	49	79	81	86	88

Geer et al (talk this meeting)

Summary

- Progress in many areas, despite very difficult year in terms of budget.
  - More details in talks during this meeting.
- Focused most of M&S budget on completing MTA beam line.
  - Expect beam into hall in a couple of months
- Major undertaking to propose 5-year plan in order to increase funding in coming years.
  - We are ready to ramp up effort.
  - Hopefully, “change is coming” (perhaps in the form of a large stimulus package).