Supersymmetric Higgs Factory and 6 D Cooling

UMiss March 11/12 2004

D Cline
UCLA

1. A General Strategy for the Muon Collider

2. What the LHC[CMS] could Discover — A, H Higgs and SP

3. A SUSY Higgs Factory

4. Ring Coolers with High Pressure Gas / Li Lens to Reach the Emittance Needed for Collider

History and Progress on Neutrino Factory
Muon Collider

1992 — Port Jeff Mtg — $\mu^+\mu^-$ look at again

92 1st Muon collider mtg Napa Valley
93 Small mtg at LANL
94 2nd $\mu\mu$ mt
95 3rd $\mu\mu$ mtg
⋮

} Define concept of <u>Higgs Factory</u>

~96-97 change emphases to Neutrino Factory

~ 2001 Snowmass ⇄ Linear Collider wins Collider Fight

Neutrino Factory Interest

⇓

~ 2003 DOE 20 year plan — Super Beam
~17 years but NO NEUTRINO FACTORY ON LIST

~ 2004 APS study [BNL/UCLA/ APS mtg BNL March 3-5 2004]
→

Catch 22 for Neutrino Factory – To observe $\not{CP}$ $\sin^2 2\theta_{13} > 0$

With a Super Beam (ie JPAK/SK T2K) one can go to $\sin^2 2\theta_{13} \sim 0.006$

– Reactors $\gtrsim 0.01$ possible?

If $\sin^2 2\theta_{13} > 0.01$ then Super Beams (ie BNL → Homestake/WIPP..) can search for $\not{CP}$

If $\sin^2 2\theta_{13} < 0.01$ then a Neutrino Factory is Needed

BUT $\sin^2 2\theta_{13}$ could be $\equiv 0$

Will any organization pay ~3B\$ to find out if $\sin^2 2\theta_{13} \neq 0$?

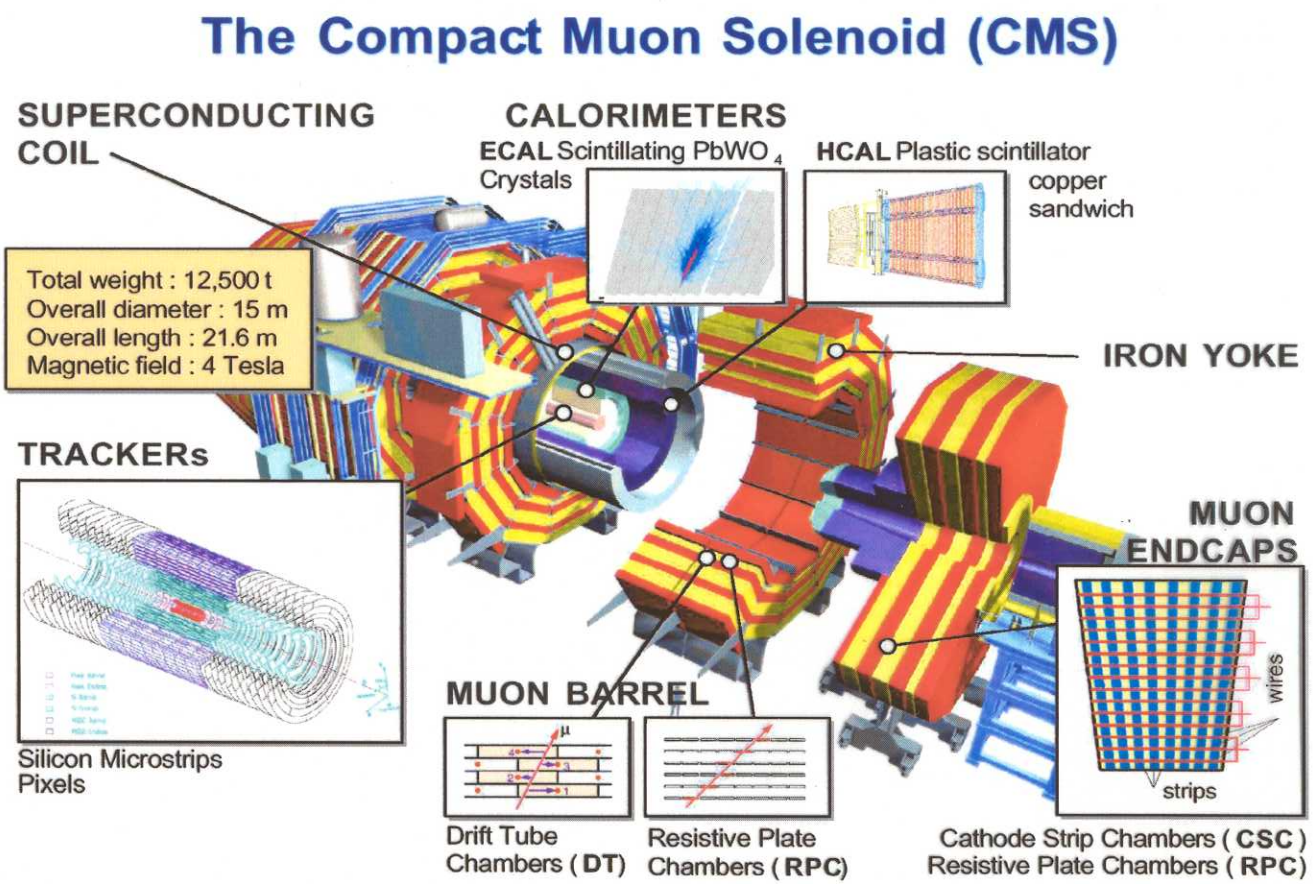
I talked to many theorists All said No

⇒ Conclusion – We must go back to Muon Collider [Bill Foster]

– But with Ring Coolers GD Cooling makes this more feasible

The CMS detector

Onion structure
- Tracker
- Calorimeters
- Muon system

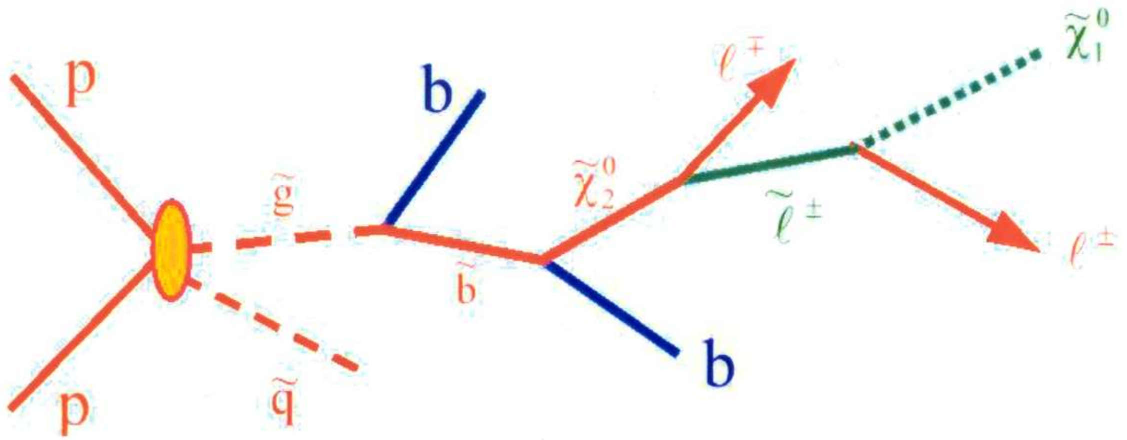


Precise
e, μ, γ, jets, E_T

Efficient
b tagging, τ detection

SUSY spectroscopy

Gluino, sbottom and squark reconstruction



reconstruction starts with $\chi_2^0 \to l^+ l^- \chi_1^0$

χ_2^0 2-body decay: Sharp edge in M(ll)

$$M_{\ell^+\ell^-}^{max} = \frac{\sqrt{(M_{\tilde{\chi}_2^0}^2 - M_{\tilde{\ell}}^2)(M_{\tilde{\ell}}^2 - M_{\tilde{\chi}_1^0}^2)}}{M_{\tilde{\ell}}}$$

$$\vec{p}_{\tilde{\chi}_2^0} = \left(1 + \frac{M_{\tilde{\chi}_1^0}}{M_{\ell^+\ell^-}}\right)\vec{p}_{\ell^+\ell^-}$$

assuming

$M(\chi_2^0) \sim 2M(\chi_1^0)$

SUSY spectroscopy

Example of sparticle reconstruction at “benchmark point B”

Sbottom

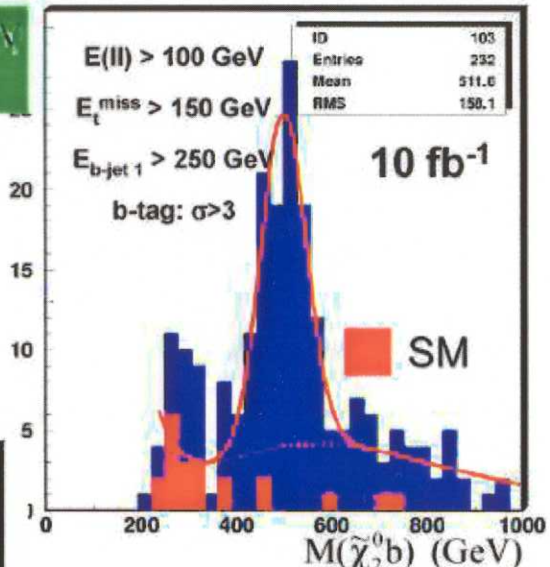
$M(\tilde{\chi}_2^0 b) = 499.4 \pm 6.6$ GeV

$\sigma = 47.6$

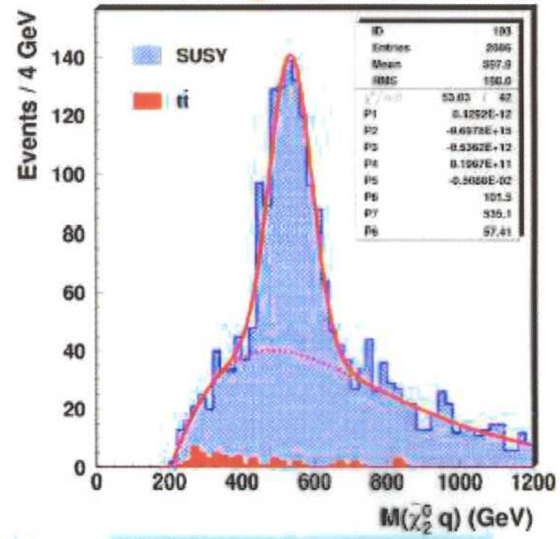
Generated masses:

$M(b_L)$=496 GeV

$M(b_R)$=524 GeV



Squark



$M(\tilde{\chi}_2^0 q) = 767 \pm 6$ GeV

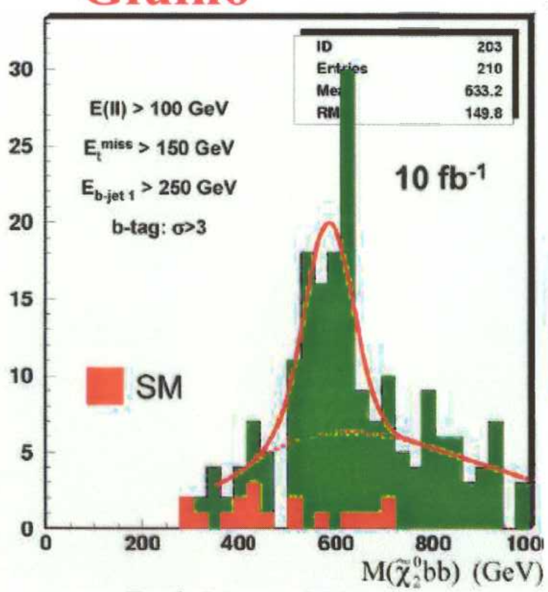
$\sigma = 80$ GeV

Generated squark masses:

$M(d_L)=M(s_L)$=778.0 GeV

$M(u_L)=M(c_L)$=773.9 GeV

Gluino



$M(\tilde{\chi}_2^0 bb) = 585.1 \pm 11.1$ GeV

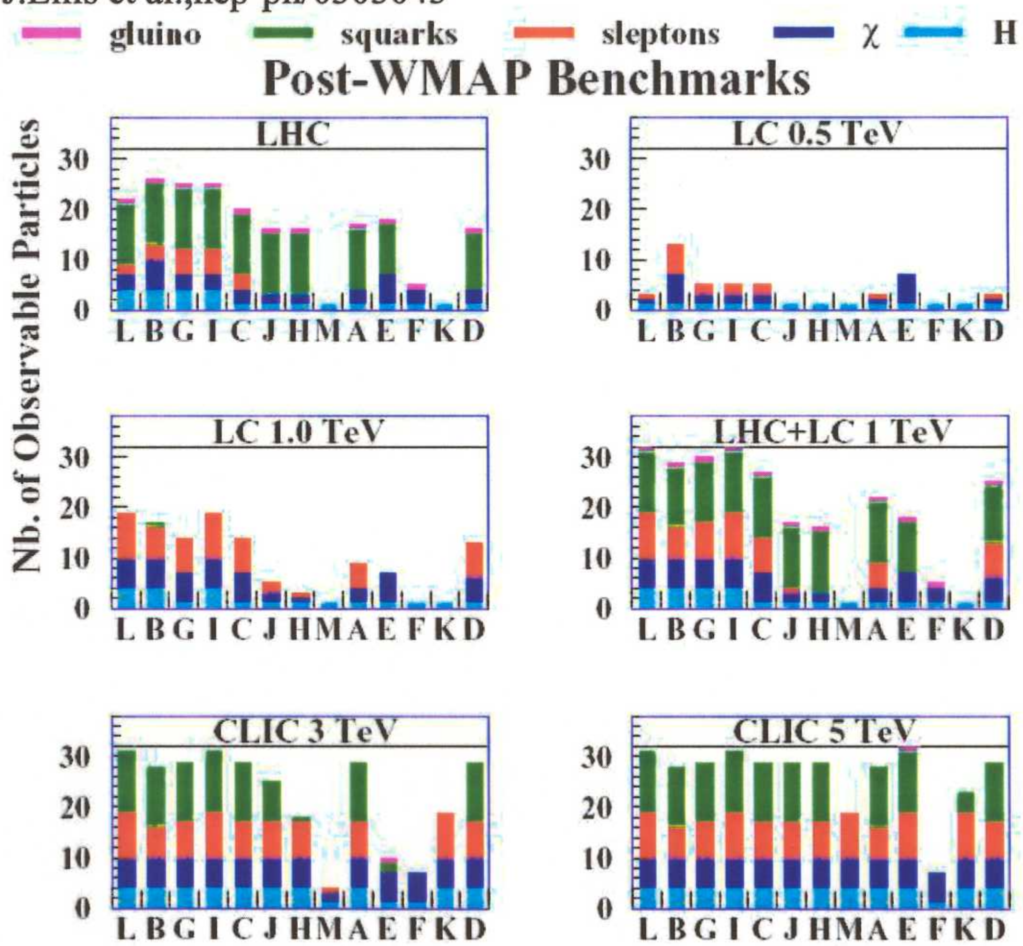
$\sigma = 50.1$

Generated $\tilde{g}$ mass

595.1 GeV

Future accelerators – expected number of detectable SUSY particles

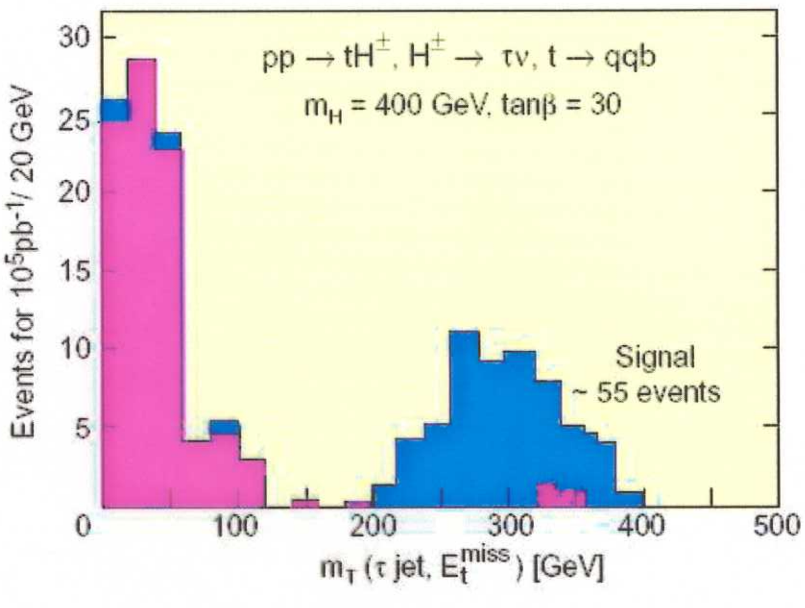
J.Ellis et al.,hep-ph/0303043

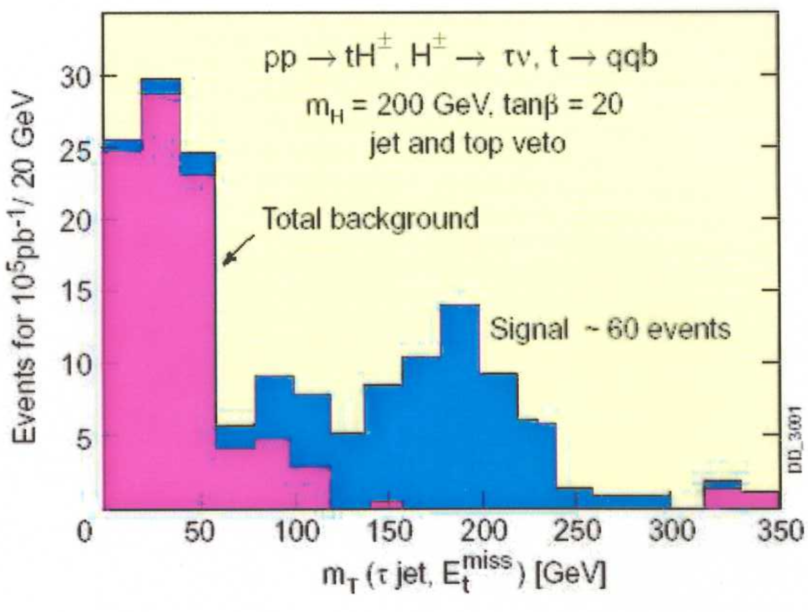


complementarity between electron and hadron colliders

The main LHC aim is to discover Higgs particles
-there is ambiguity between h and H_{SM} - but if a charged Higgs is found ⇒ SUSY is established

Charged Higgs observability in CMS





The Origin of CP̸ in K/B System could be the A/H Higgs Bosons !!

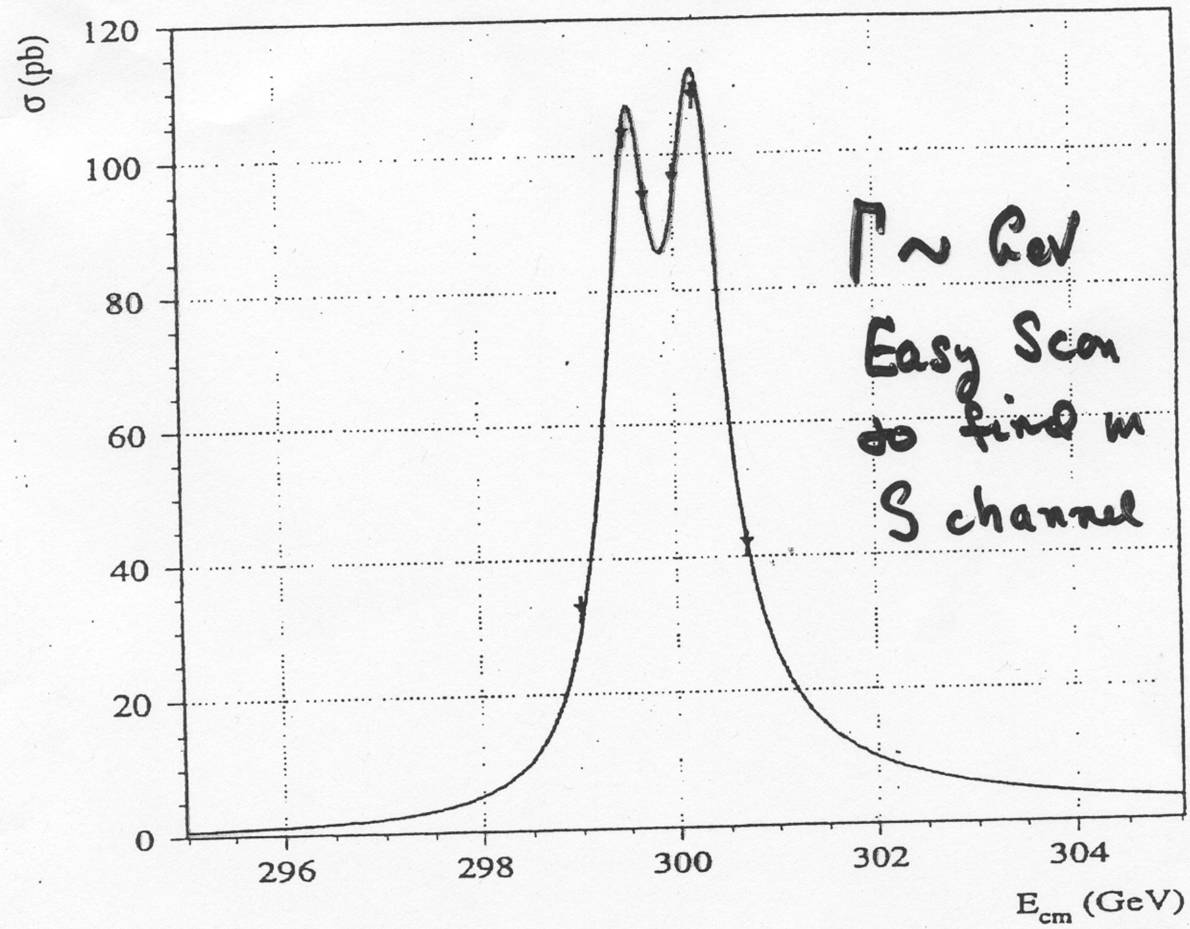


Figure 3. H and A particles with small mass difference.

A & H Particle Masses
are expected to be nearly
mass degenerate but have
different CP states

A + H → CP̸

⟨ A, H To close to same mass to
Resolve at LHC ⇒ $\mu^+\mu^- \to A, H$
Search for CP̸ [like B Factory] ⟩

A, H Higgs Factory Parameters

Table 1

CoM energy (TeV)	**0.4**
P energy (GeV)	16
P/bunch	2.5×10^{13}
Bunches/fill	4
Rep. Rate (Hz)	15
$1/\tau_\mu$	240
P power (MW)	4
μ/bunch	2×10^{12}
μ power (MW)	4
Wall power (MW)	120
Collider circum. (m)	1000
$\langle B \rangle$ (T)	4.7
$\delta p/p$ (%)	0.14
6-D $\varepsilon_{6,N}$ $(\pi m)^3$	1.7×10^{-10}
Rms ε_n (π mm-mrad)	50
β^* (cm)	2.6
σ_z (cm)	2.6
σ_r spot (μm)	26
σ_θIP (mrad)	1.0
Tune shift	0.044
$n_{turns}^{effective}$	700
Luminosity ($cm^{-2}s^{-1}$)	10^{33}
Higgs/year	

SBIR PROPOSAL TO DOE

Ring Coolers with High Pressure Gas + Ring Coolers with Li Lens Instants should give $\varepsilon_{x,y,z}$ small enough for SUSY Higgs Factory

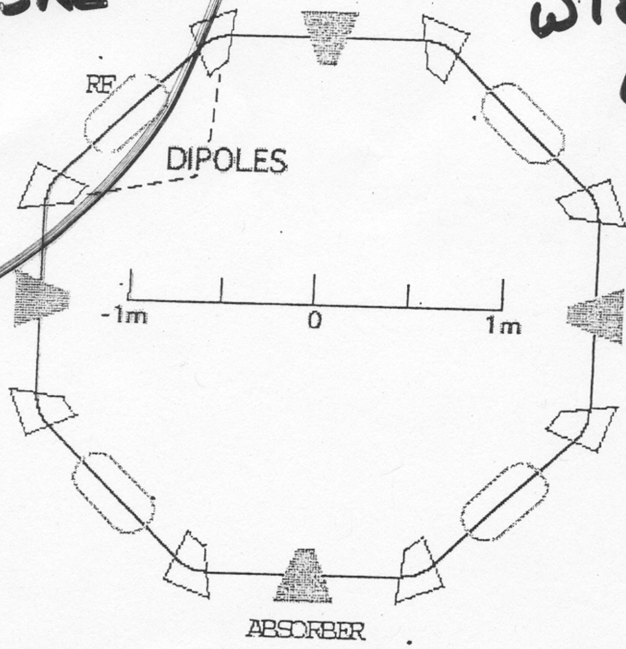


Figure 1. A dipole-only 4-cell ring lattice. The required focusing is accomplished by adjusting the dipole entrance and exit pole-face angles.

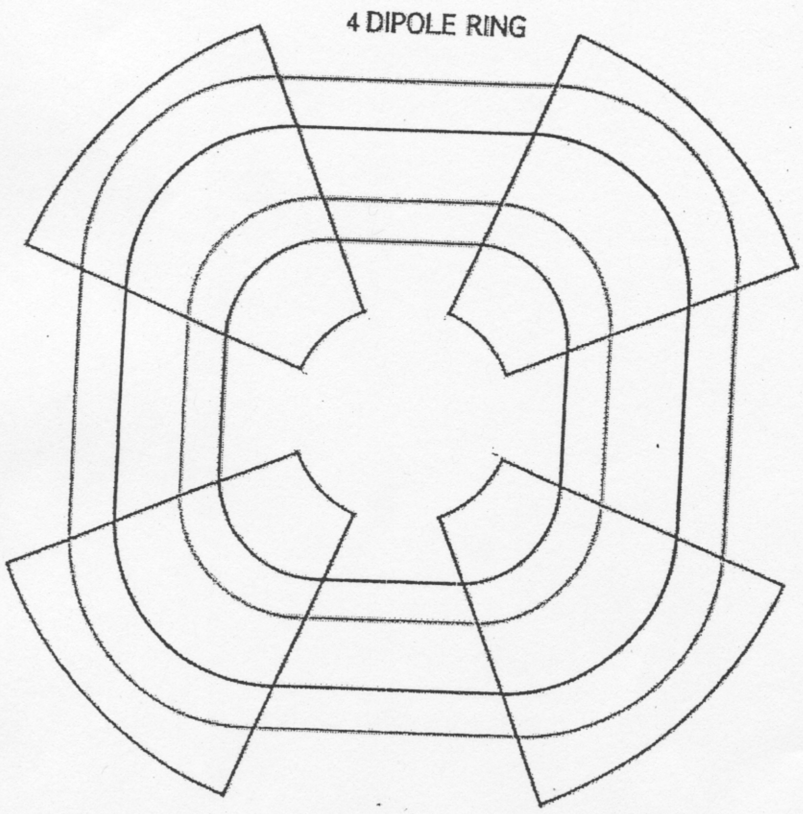


Fig. 2 Magnets and closed orbits of different energies in a 4-sector gas-filled ring

Summary

1) Neutrino Factories face a "Catch 22" if $\sin^2 2\theta_{13}$ is large, Super Beams can do the physics; if small $\theta_{13} \to 0$

2) The Argument for a muon collider could be strong if the LHC observes the A/H Higgs Bosons - a Higgs Factory could probe these states in the S channel and observe CP̸ — this could determine the fundamental cause of CP̸ in K/B systems

3) A SUSY Higgs Factory is easier than the h^0 Higgs Factory if adequate 6D cooling can be obtained.

4) Ring Coolers with (a) High Pressure Gas (b) Li lens inserts could provide the needed 6D cooling

5) A TEST RING COOLER PROTOTYPE COULD BE CRUCIAL!