(A/H) Higgs Factory, Possible CP Violation and 6D Cooling

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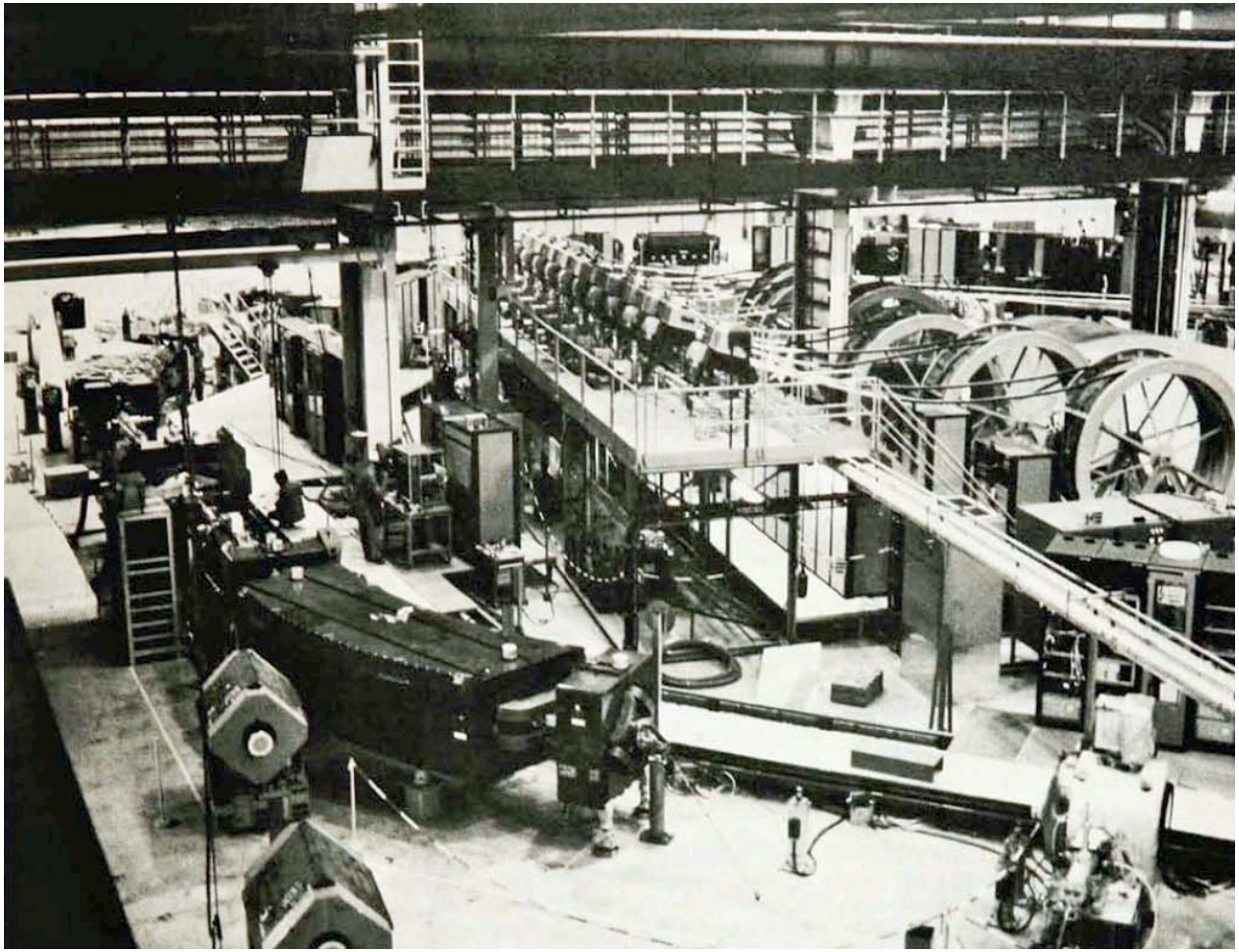
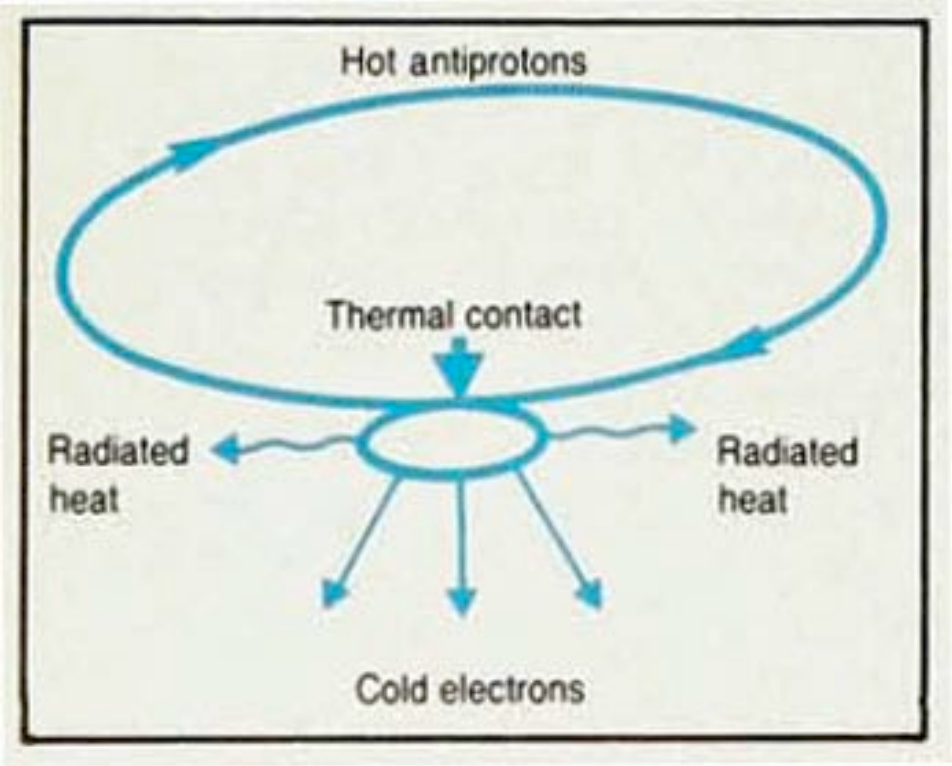
Abstract

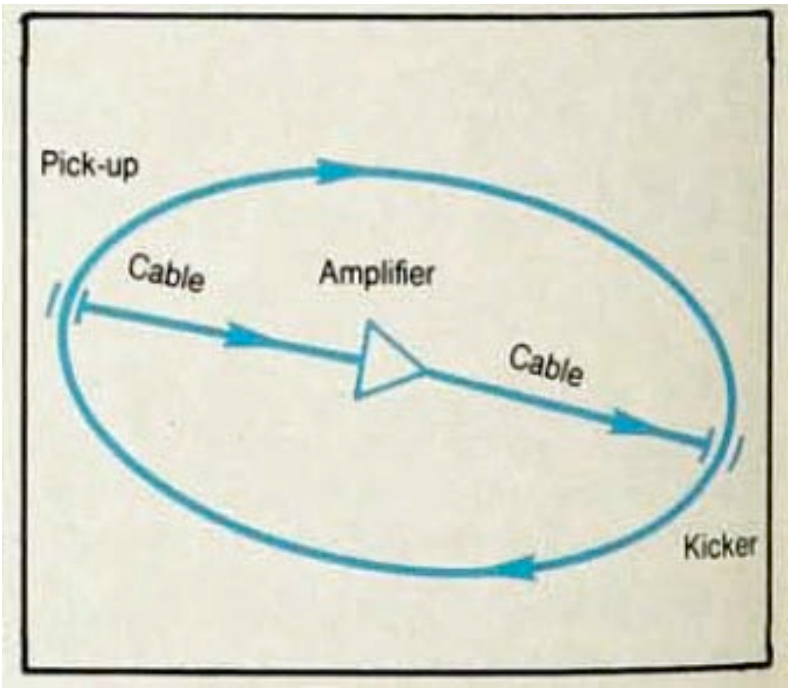
In the past the development of the proton-antiproton collider at CERN (and FNAL) relied on 6-D cooling of the beam. We briefly recount this and the following discovery of the W and Z bosons as an example of what we worked on. Currently, a possible discovery of similar magnitude could be made with a μ+μ- collider. Again as in the collider, 6D beam cooling is crucial. The current version of the *μ+μ-* collider was started in December 1991 at a UCLA workshop help in Napa, California. It was rapidly realized that such a machine is also a Higgs boson factory. Workshops in the 1990s confirmed this fact. In the case of the supersymmetric A and H Higgs bosons the interference of these two states might be one origin of CP Violation in Nature. CP Violation can lead to an excess of matter over antimatter in the current universe. Again, 6D beam cooling is needed! We indicate some of the possible methods for 6D cooling including the use of a 50T solenoid - a great technical leap forward.

6D cooling in the ICE ring at CERN, 1978-1980



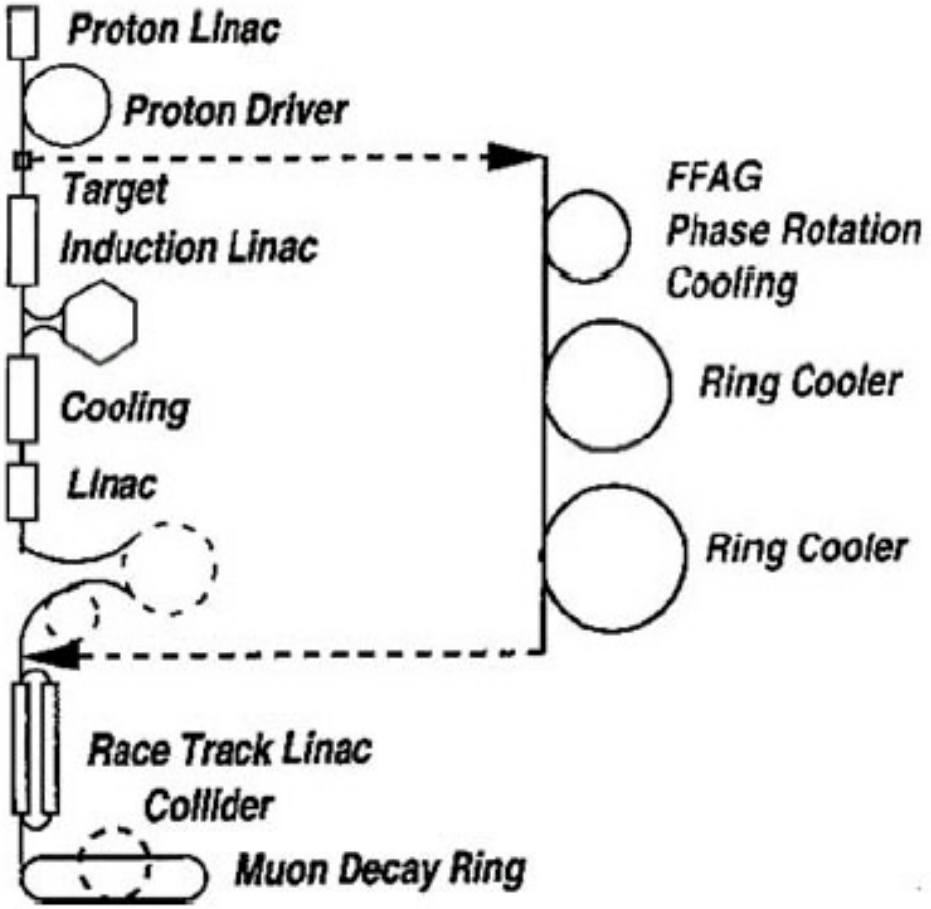
ICE 6D cooling experiment: methods of antiproton cooling - 6D cooling





The concept of a muon collider

Schematic concept for a muon collider



Formulas for 6D cooling of muons

$$\frac{d\varepsilon_\perp}{ds} = \frac{1}{\beta^2}\frac{dE_\mu}{ds}\frac{\varepsilon_\perp}{E_\mu} + \frac{\beta_\perp^*}{2\beta^2}\frac{(0.014)^2}{E_\mu M_\mu L_R}$$

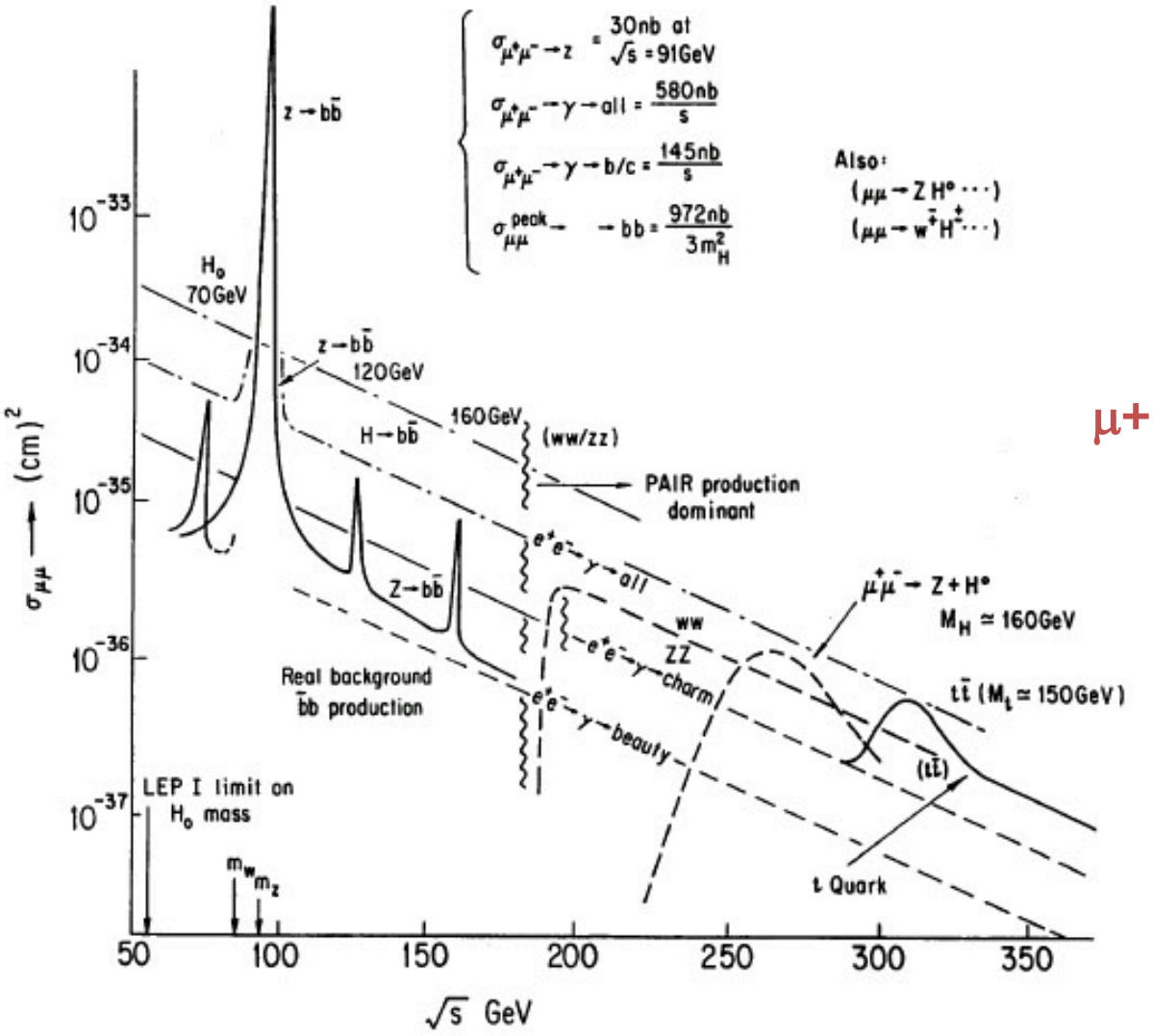
$$\frac{d(\Delta E_\mu)^2}{ds} = -2d[dE_\mu/ds]/dE_\mu\langle(\Delta E_\mu)^2\rangle.$$

TABLE 1. Arguments for a Higgs-Factory $\mu^+\mu^-$ Collider.[1,5]

1. The $m_\mu \backslash m_e$ ratio gives coupling 40,000 times greater to the Higgs particle. In the SUSY model, one Higgs $m_h < 120$ GeV!!
2. The low radiation of the beams makes precision energy scans possible.
3. The cost of a "custom" collider ring is a small fraction of the $\mu^\pm$ source.
4. Feasibility report to Snowmass established that $\mathcal{L} \sim 10^{33}$ cm^{-2} s^{-1} is feasible.

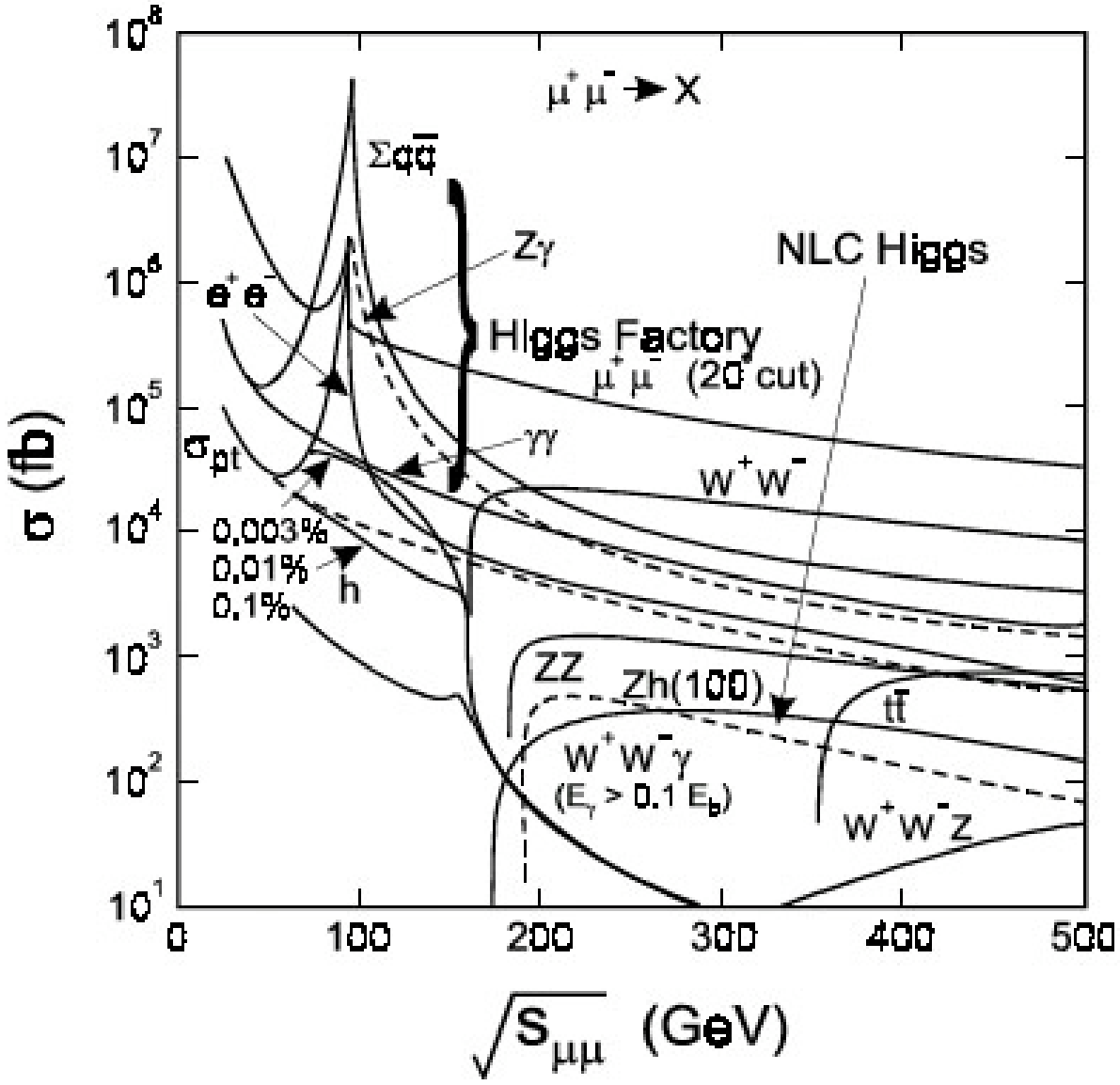
A Higgs factory and CP violation at a muon collider A/H Higgs boson

Muon collider Higgs boson factory: h^0 Higgs boson m_{h0} ~ 120 GeV

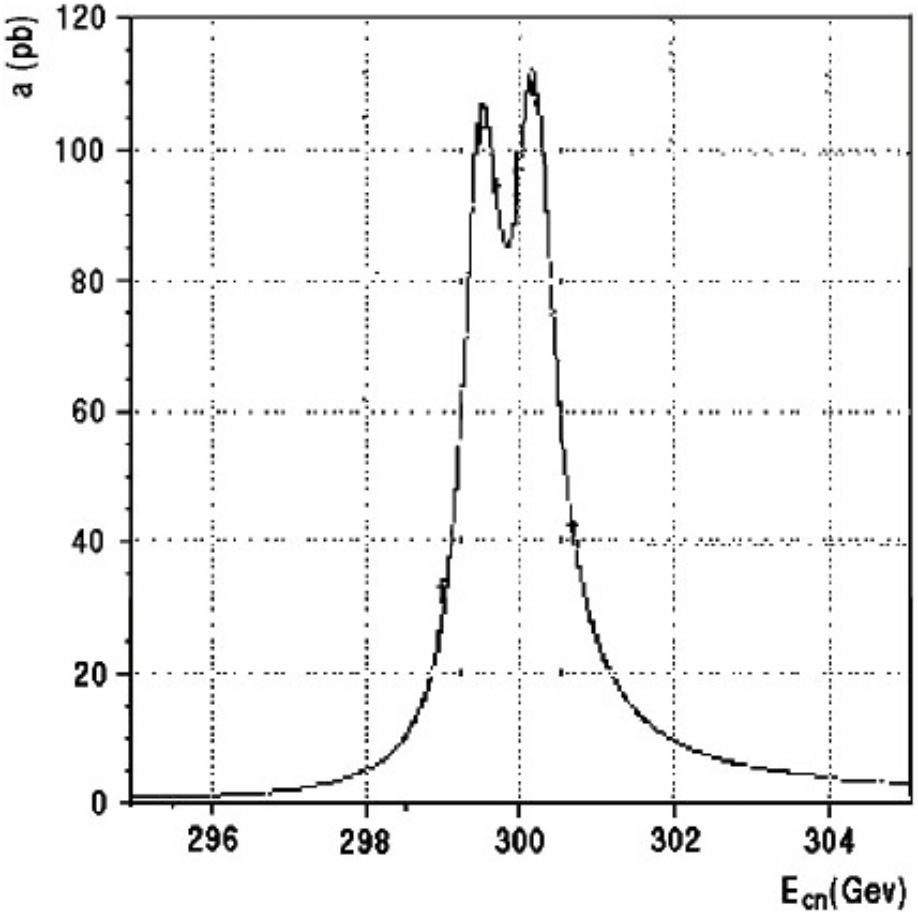


μ+μ- Higgs boson factory

Comparison of μ+μ- and e+e- production



A/H Higgs bosons (I)



A and H Higgs bosons have opposite CP states

The interference between A and H can cause CP violation

A/H Higgs boson factory to observe CP violation

H/A Higgs mixing in CP-noninvariant supersymmetric theories

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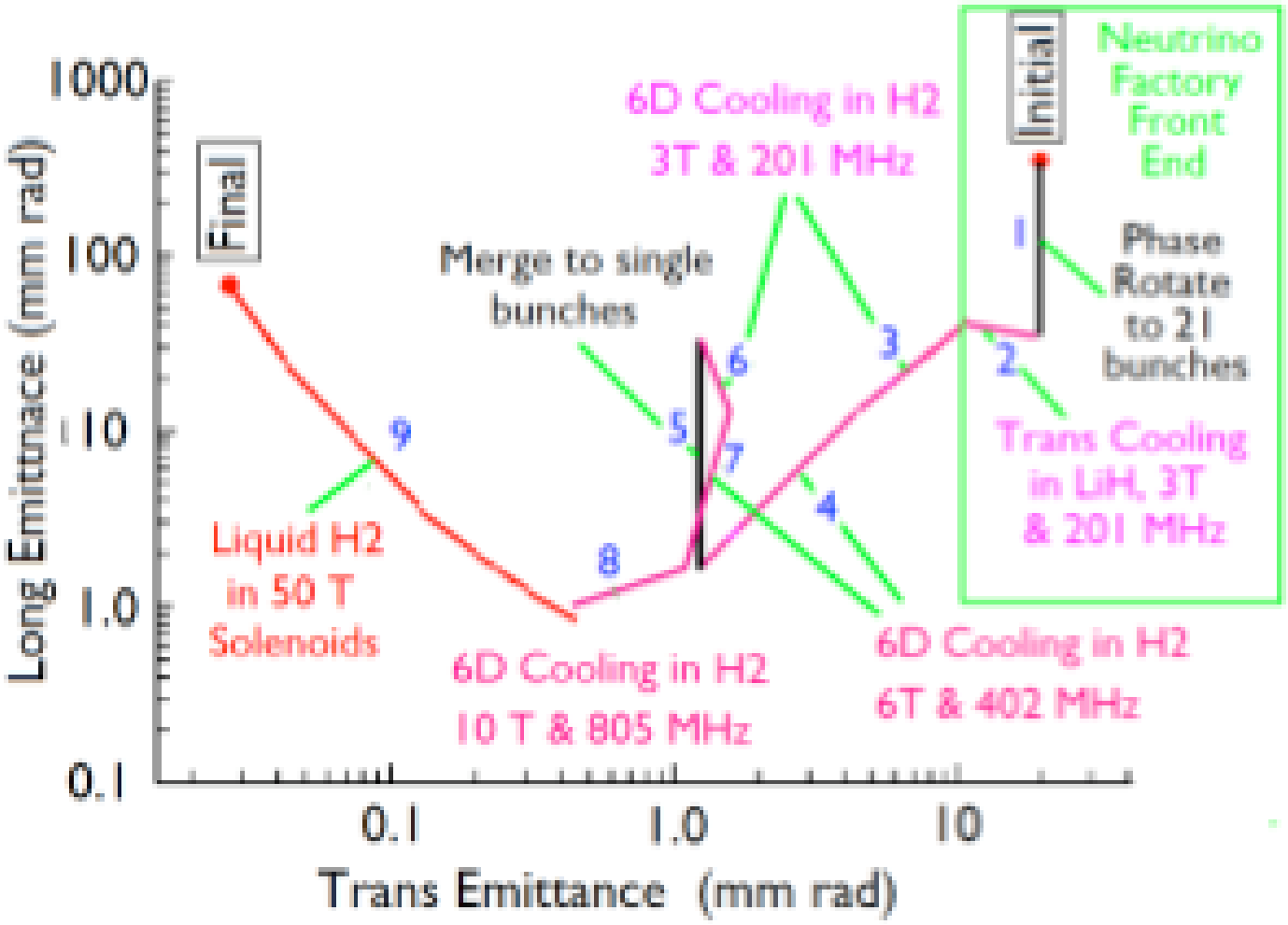
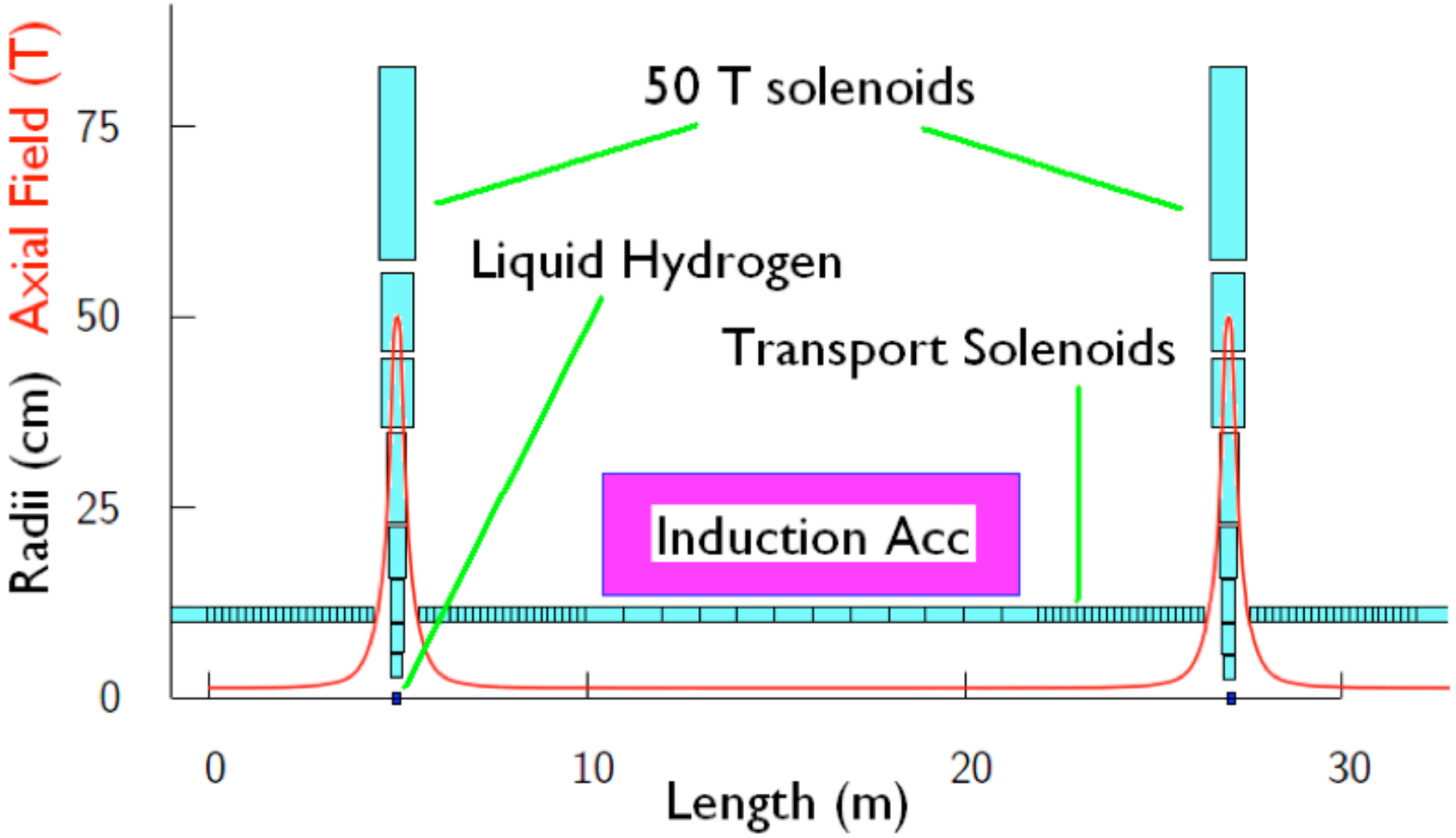
Abstract. For large masses, the two heavy neutral Higgs bosons are nearly degenerate in many 2-Higgs doublet models, and particularly in supersymmetric models. In such a scenario the mixing between the states can be very large if the theory is CP-noninvariant. We analyze the formalism describing this configuration, and we point to some interesting experimental consequences.

6D Cooling for muon colliders



Emittance required for muon collider



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Summary

In the recent history of elementary particle physics the cooling of a beam to 6D (momentum and angle) has been very important for the discovery of the w/z bosons at CERN and the top quark at FNAL. With the advent of the muon collider concept, 6D cooling will become crucial again. To develop important discoveries such as the properties of the h^0 Higgs bosons (the origin of mass) and CP violation(the possible origin of large amounts of matter in the universe compared to antimatter) could be studied. The Higgs factory would produce the largest number in the world. The muon collider Higgs factories could be a major breakthrough. We have shown one form of 6D muon cooling that uses a 50 Tesla magnet (the largest field so far) being studied by the company Particle Beam Lasers Inc. and Brookhaven National Labs.