Letter of Interest @Snowmass

Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

# Common Coil Dipole for High Field Magnet Design and R&D


## Ramesh Gupta

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**Snowmass day, Jan 21 , 9-12:30**

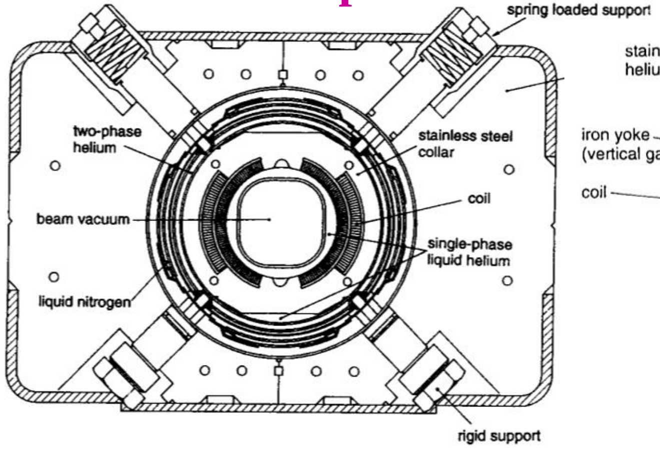
**More contributors are expected to join the whitepaper**

# Background

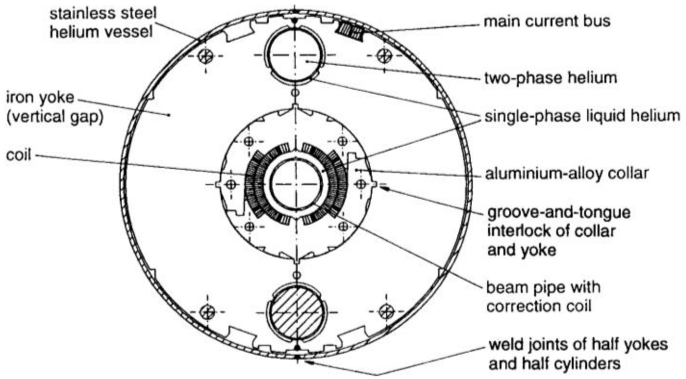
- Collider dipoles are one of the most technically challenging components and the cost driver of the next generation hadron colliders based on high field magnets.
- The goal of US Magnet Development Program (MDP), created after the last P5 (following the last snowmass), is to develop 20 T dipole. This is not an incremental change - LHC collider dipole: 8.33 T.
- This requires new conductors ($Nb_3Sn$ and HTS rather than NbTi), new technologies and new designs.
- Common coil design, invented at BNL, offers an alternate option for producing reliable, lower dipoles based on simple racetrack coils. The common coil geometry handles the large Lorentz forces, a key technical challenge in very high field magnets, in a fundamentally different way.
- Recent studies find that for 20 T, common coil design also uses less conductor than the conventional cosine theta design (contrary to the conventional wisdom).
- Magnet based on this design have been built at LBL, BNL, Fermilab, IHEP, etc. and was the design used in the US Very Large Hadron Collider (VLHC) proposal over 20 years ago.
- The design offers a unique modular, rapid-turn-around R&D program for carrying out systematic and innovative R&D, as demonstrated at BNL, essential for developing new designs and technologies.
- BNL is leading a multi-lab LOI at snowmass and plans to present a white paper on this design.

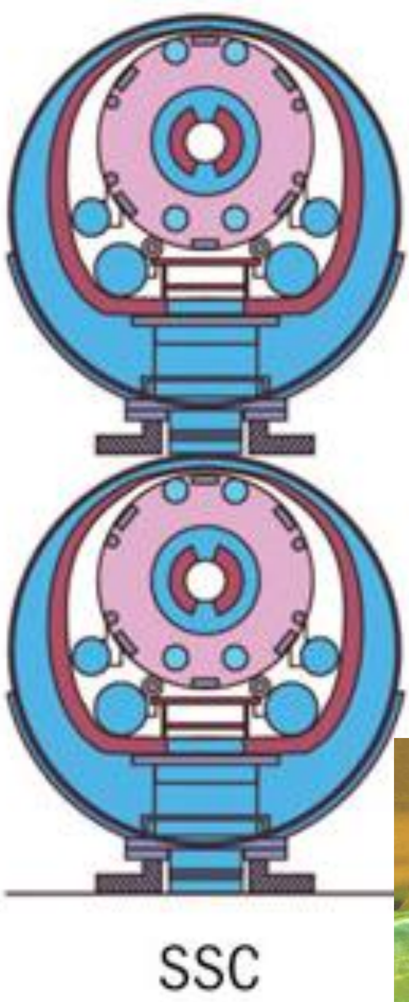
# Magnet Designs for <10 T Dipoles
# (all use NbTi conductor, and cosine θ design)

## Tevatron Dipole

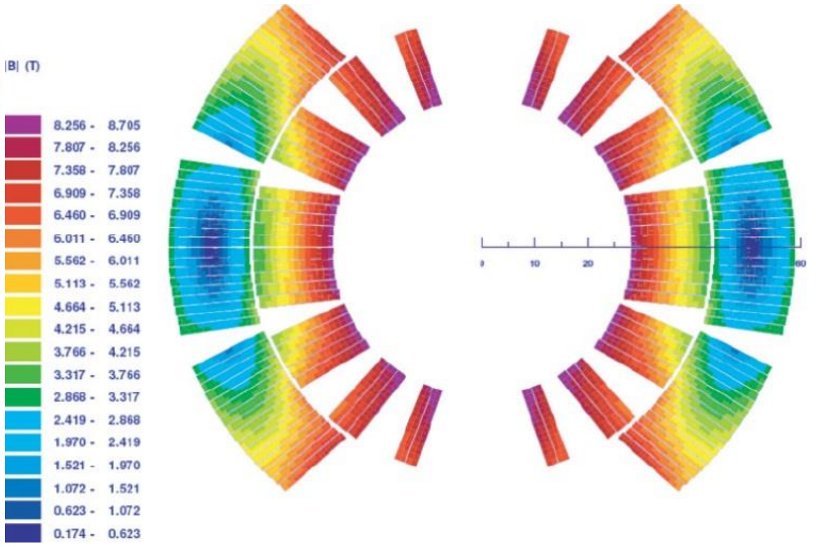



## HERA Dipole

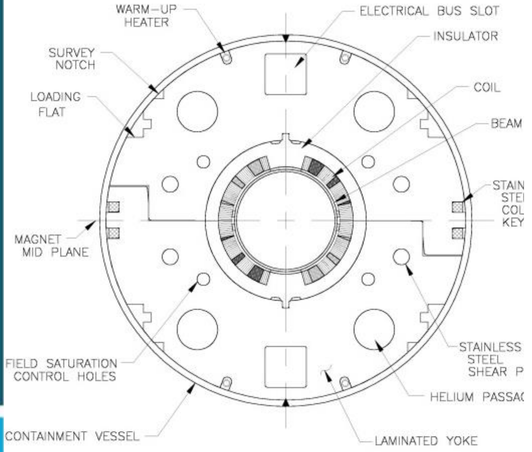


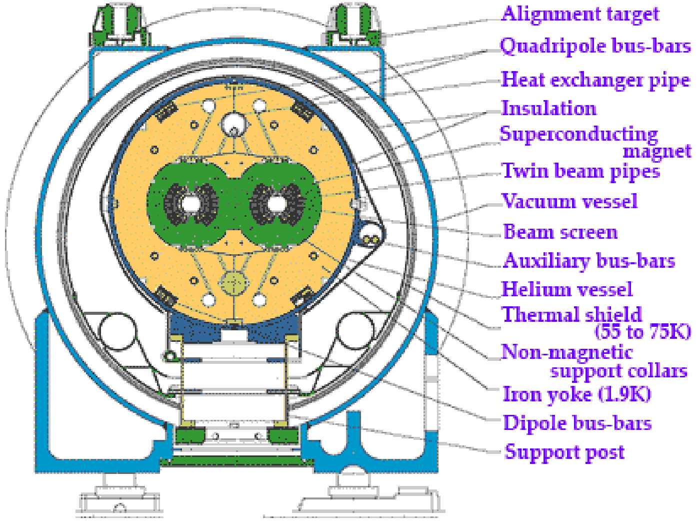

Cosine (θ) like current distribution



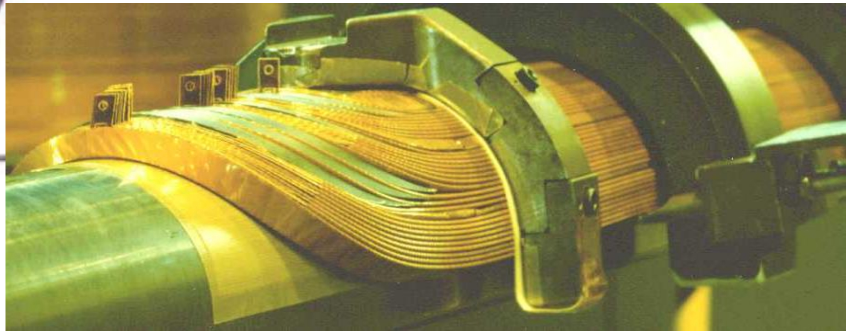

## RHIC Dipole




## LHC Dipole



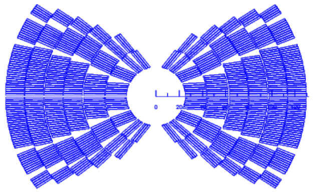

complex ends



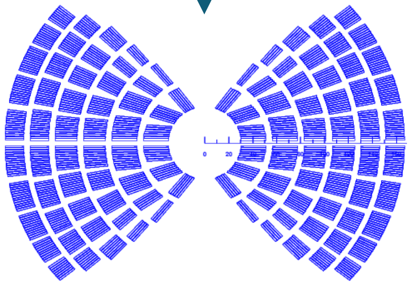
# Design Options for 20 T  Dipole
## (from comparative studies performed under MDP)

Cosϑ without and “with stress management”

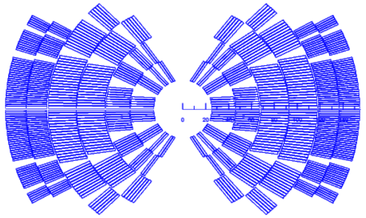
(a)



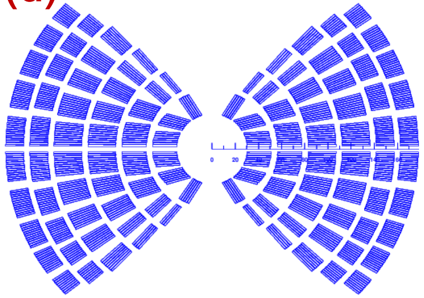
(b)



(c)

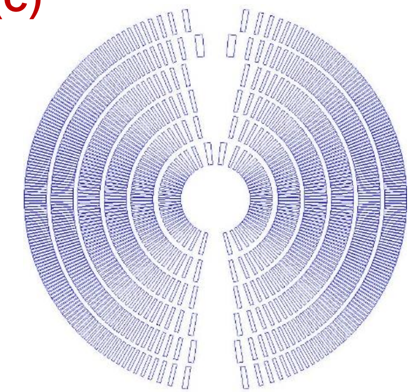


(d)



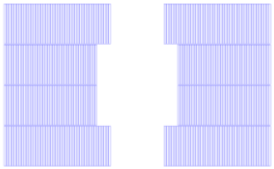
Canted Cosine Theta

(e)

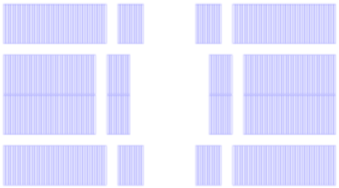


Block coil designs

(f)



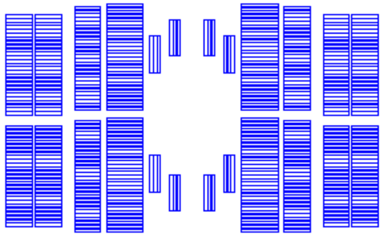
(g)



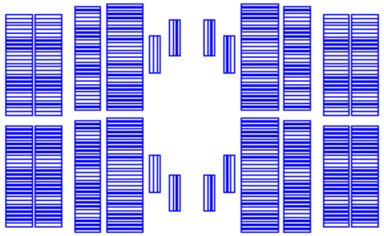
single aperture dipoles

Common coil design

(h)

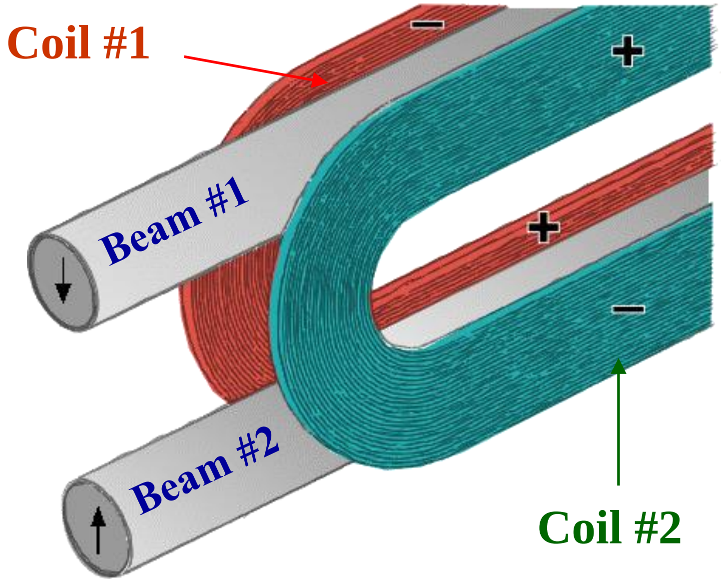


dual aperture dipole

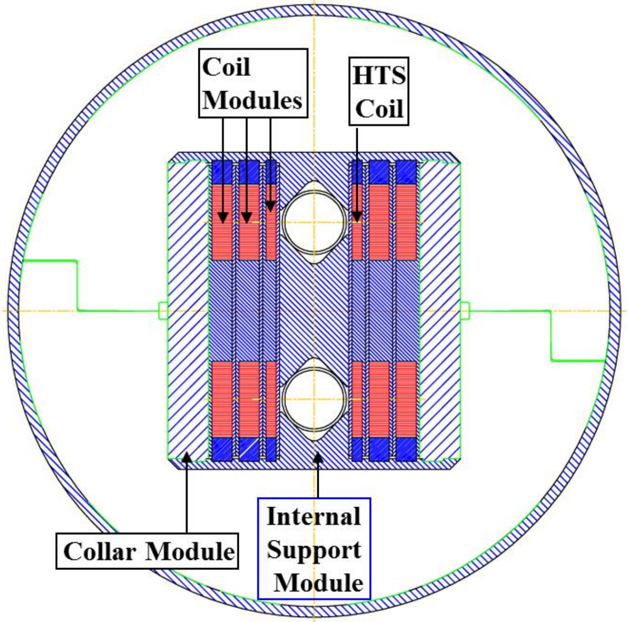


# Common Coil 2-in-1 Dipole Design

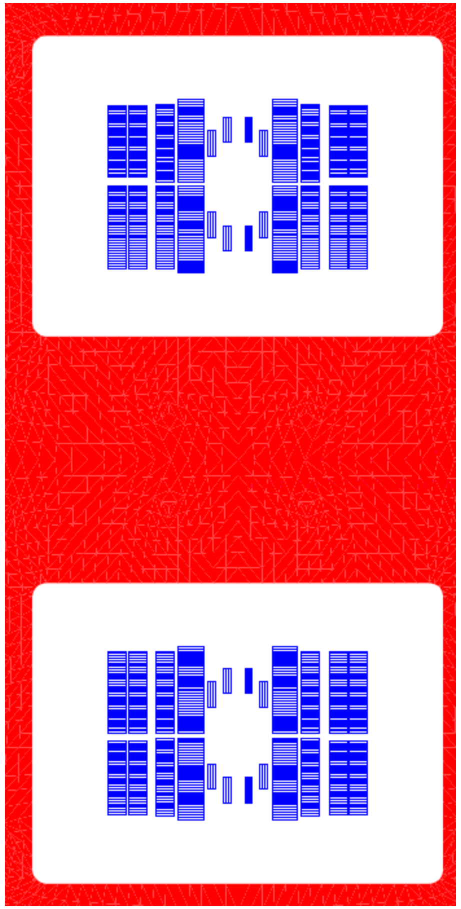
Main Coils of the *Common Coil Design*




Modular Design for R&D Magnets



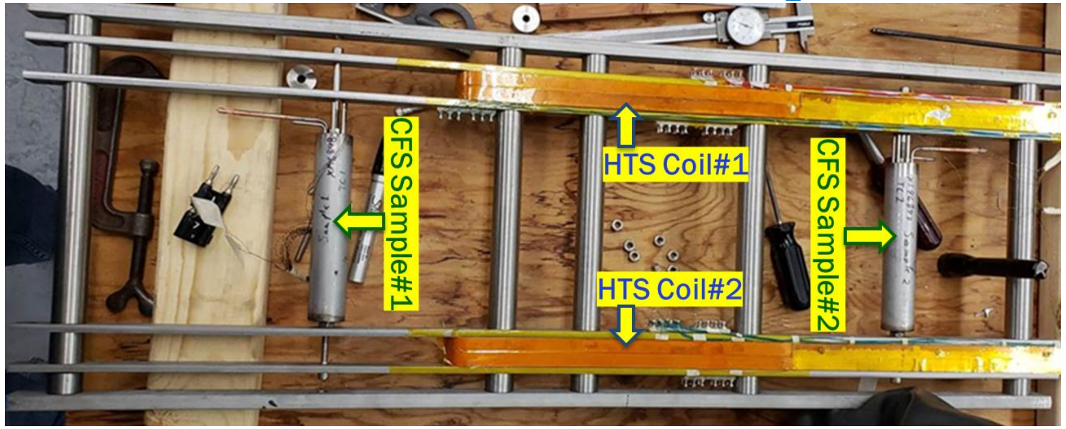

Field Quality Design for Accelerator Magnets

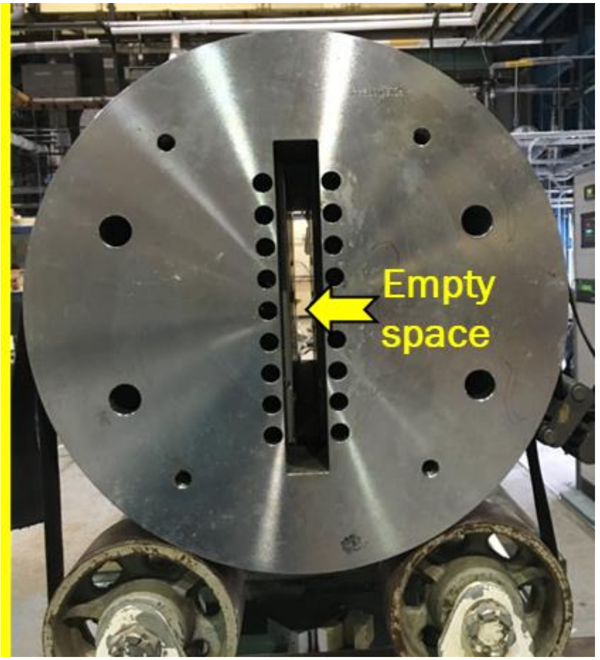


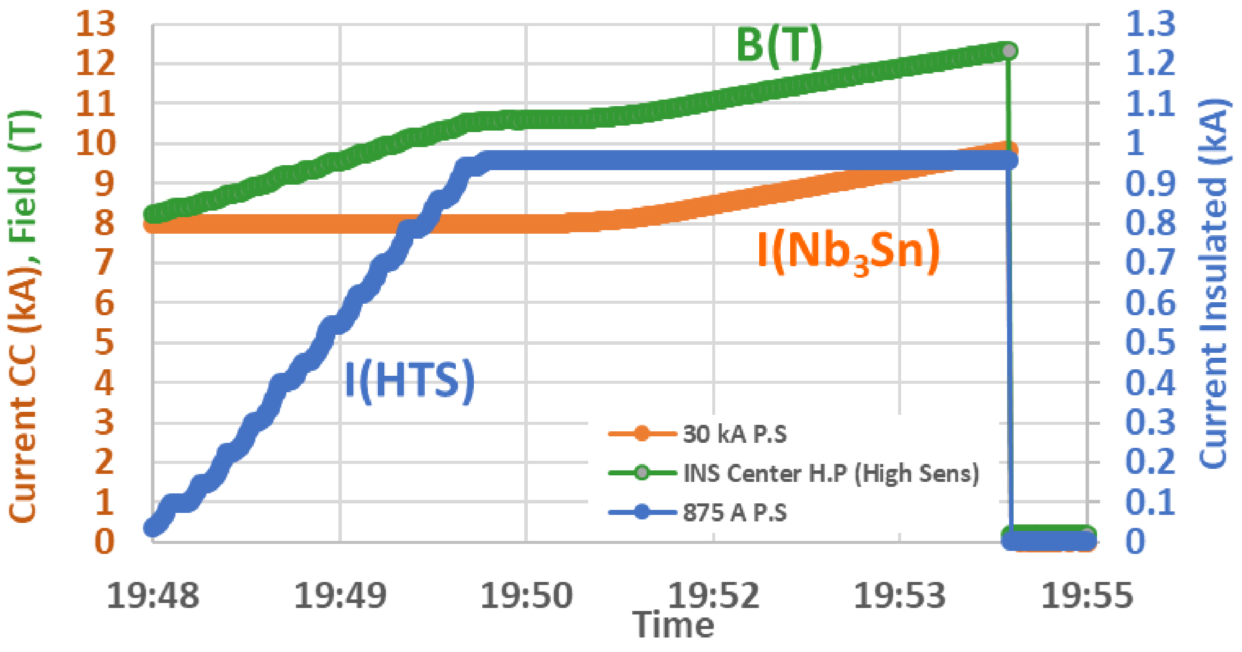
- **Simple, large bend radii, conductor friendly design**
  - ➢ **General philosophy: work to the strength of conductor, allow various technology options**
- **Same coils for two apertures : 2-in-1 design for both iron and coils**
- **Modular design for R&D magnets; Efficient use of different conductors (HTS and LTS)**
- **Expect lower cost : Number of coils half, simpler geometry/manufacturing, high reliability, etc.**

# Unique Raid-turn-around R&D with the Common Coil Dipole

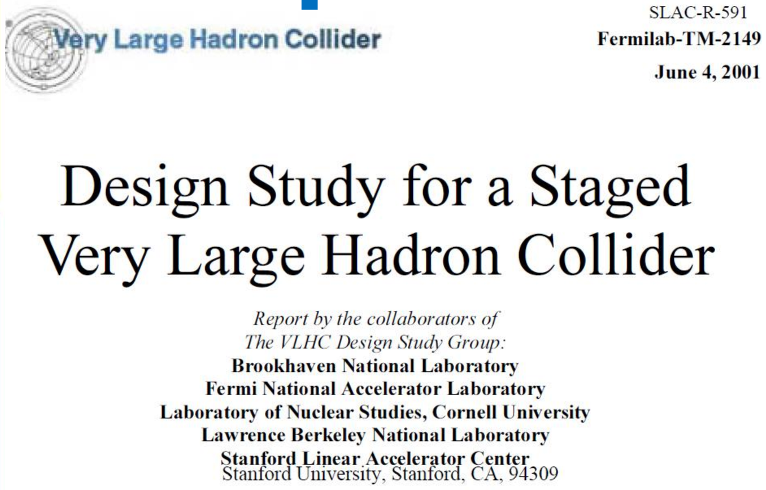
- Created a record ~12.3 T HTS/LTS hybrid dipole field
- In past, such demo required a major R&D program
- Insert coils become an integral part of the magnet
- Approach can be taken in the next generation R&D



# Preparation of Whitepaper for Snowmass

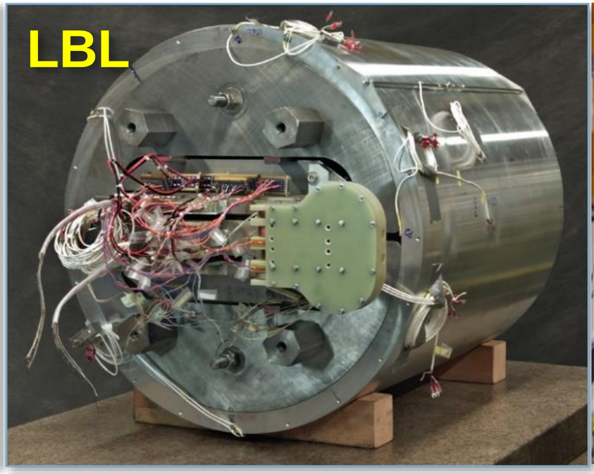


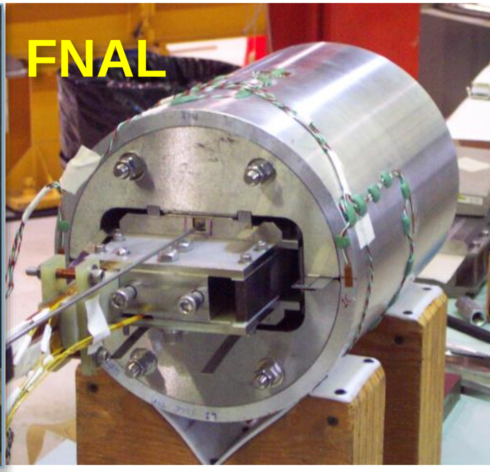
Very Large Hadron Collider

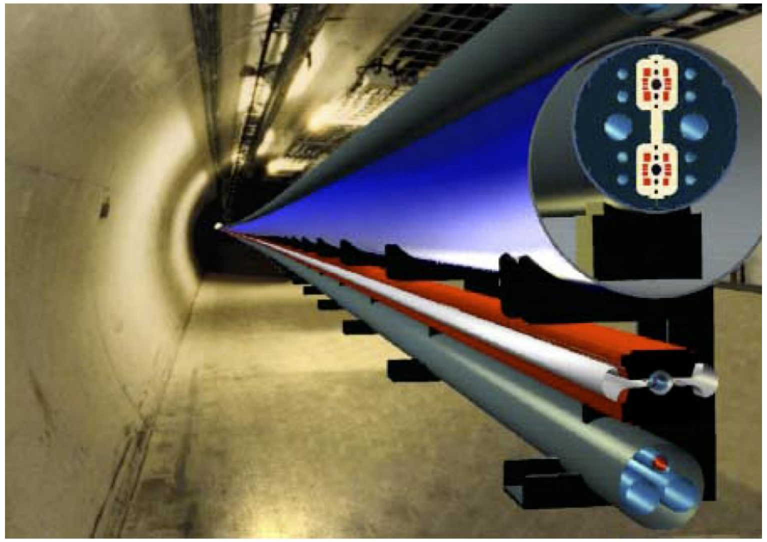
SLAC-R-591
Fermilab-TM-2149
June 4, 2001

Design Study for a Staged
Very Large Hadron Collider

*Report by the collaborators of*
*The VLHC Design Study Group:*
**Brookhaven National Laboratory**
**Fermi National Accelerator Laboratory**
**Laboratory of Nuclear Studies, Cornell University**
**Lawrence Berkeley National Laboratory**
**Stanford Linear Accelerator Center**
Stanford University, Stanford, CA, 94309

- Assemble a team of interested people from all over the world who have previously worked on the common coil design and/or are interested in it
- Further develop the design and the R&D program
- Perform a broader comparative study on cost and other benefits, such as technological options, etc.
- If the common coil design works out to be as strong as it appears to be, then snowmass is a good platform to help incorporate it in a future HEP program

**A potential major contribution of BNL to HEP**

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