# Welcome to Fermilab

# Welcome to the HL/HE LHC joint Meeting of the Higgs and EWSB, BSM, and Flavor working groups

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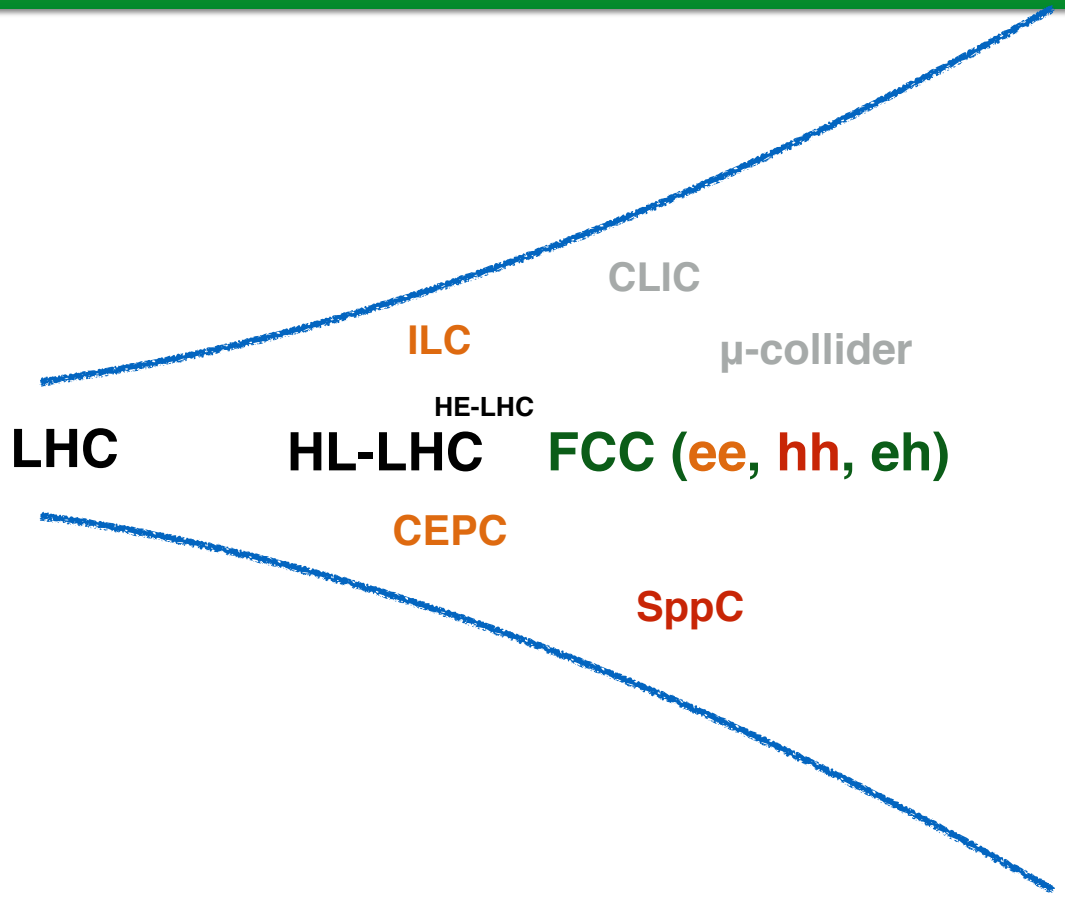
# Welcome to IARC:
# Fermilab Illinois Accelerator Center

**In your free time, please visit**

**the Theoretical Physics Department, 3rd floor in the Hi-rise**

# The Road Ahead




Markus Klute, 2016

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# The SM is Omnipresent

- The last seven particle colliders (three B factories, LEP, SLC,Tevatron, and LHC) have so far seen no conclusive evidence of Beyond the SM phenomena in the laboratory
- This is at least somewhat surprising for LHC, since strong arguments based on naturalness imply that the Higgs boson should be accompanied by BSM physics at a similar scale, ~ TeV
- The only BSM physics observed so far *in the lab* is neutrino mass (from neutrino flavor change)
- Some deviations in the flavor sector are intriguing, but not conclusive

Question:

**Physics motivation for the next generation of Energy and Intensity Frontier machines?**

Answer:

- **Higgs**
- **Neutrinos**
- **Dark matter**

} **BSM and Flavor**

# Higgs

Its existence implies the Higgs mechanism, a very sophisticated property of the quantum vacuum

It implies a phase transition in the early universe of unknown origin

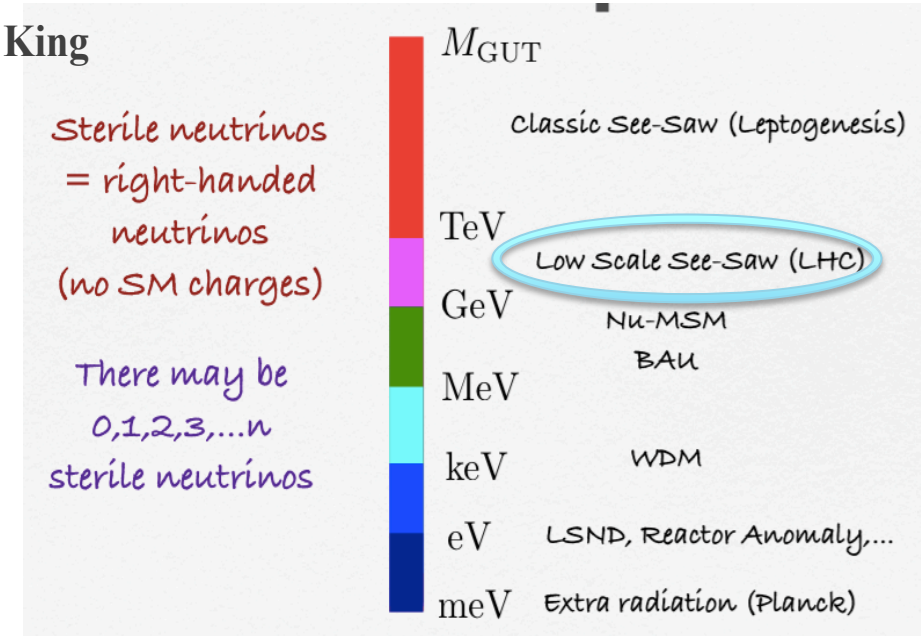
Obviously, it should be a top priority of HEP to detect, measure, and understand the detailed physics tied to the Higgs

- **Detect and measure with precision the various decay modes of the Higgs boson, including "invisible" decays.**
- **Detect the Higgs self-coupling; constrain directly the Higgs potential**
- **Detect evidence of Higgs compositeness ?**
- **Find heavier (or lighter?) additional Higgs bosons**

LHC and HL-LHC **can tell us a lot**,
but will **not** be definitive for any of these challenges

# Neutrinos

Neutrinos were discovered a long time ago, but are difficult to study




Our ignorance of the scales of new physics associated to neutrinos also poses challenges to Energy Frontier colliders

# Dark matter

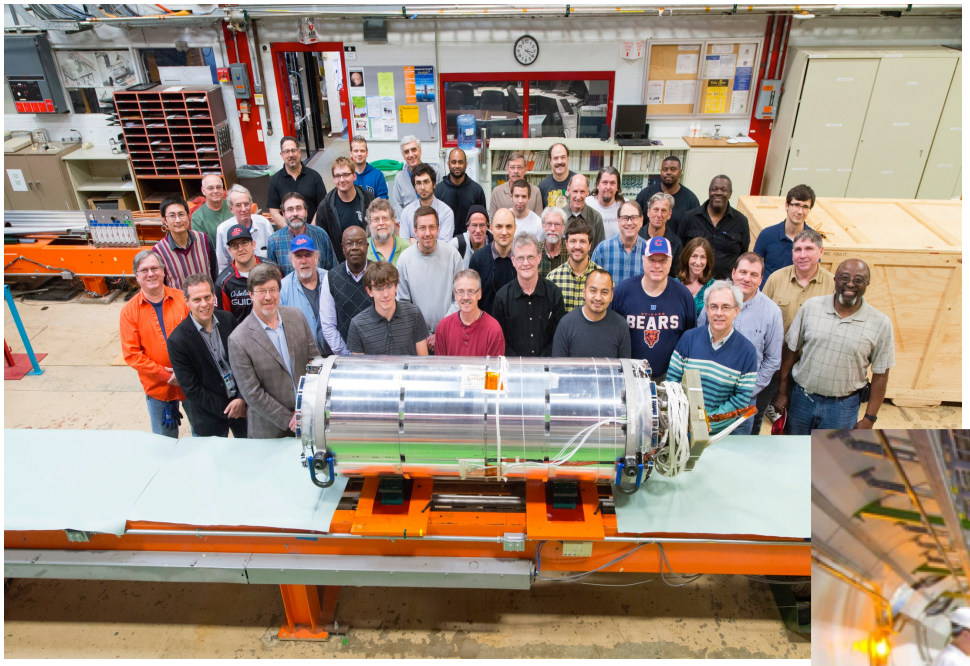
We only have evidence from gravitational interactions between dark matter and baryonic matter

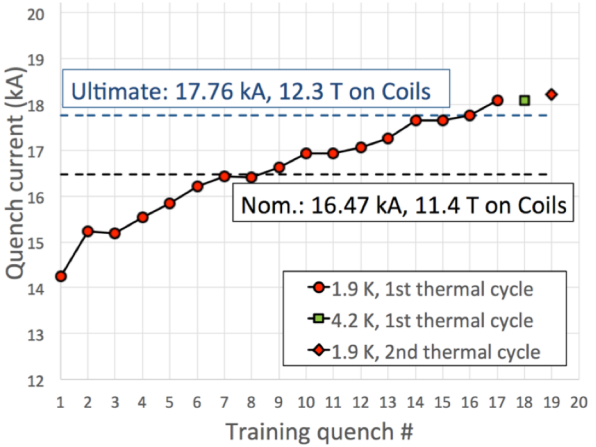
We do not know how many options for DM there are, or their origins, as well as their interactions via dark mediators (Higgs/photons, …)

Wide range of possible masses for both the DM & the dark mediators

Energy Frontier DM searches include missing energy searches and direct searches for dark mediators (lepton and hadron accelerators offer different possibilities)

# Fermilab is building high-field superconducting magnets for High-Luminosity LHC

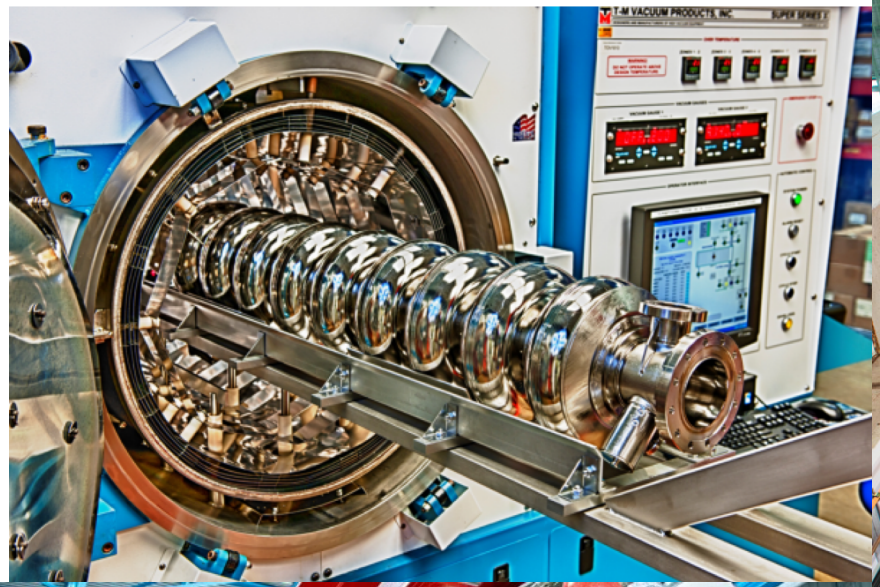






There are already Fermilab magnets in the LHC…

# Fermilab builds cutting edge accelerators



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# The BSM revolution: when? where? how?

- It is not enough to *discover* new physics - this we already have (dark matter, dark energy, inflation, baryogenesis, and neutrino masses)
- It is also not sufficient to build BSM frameworks – we have explored many
- **We need to find the key new ideas that will allow us to exploit the HL-LHC data to the greatest potential**.
- We probably need **new technologies propelled by novel ideas** to unlock the next revolution in particle physics

**The HE-LHC may allow us to explore unchartered territory and bring new knowledge about our universe**

**Enjoy the challenge!**

**Thanks for being at Fermilab**