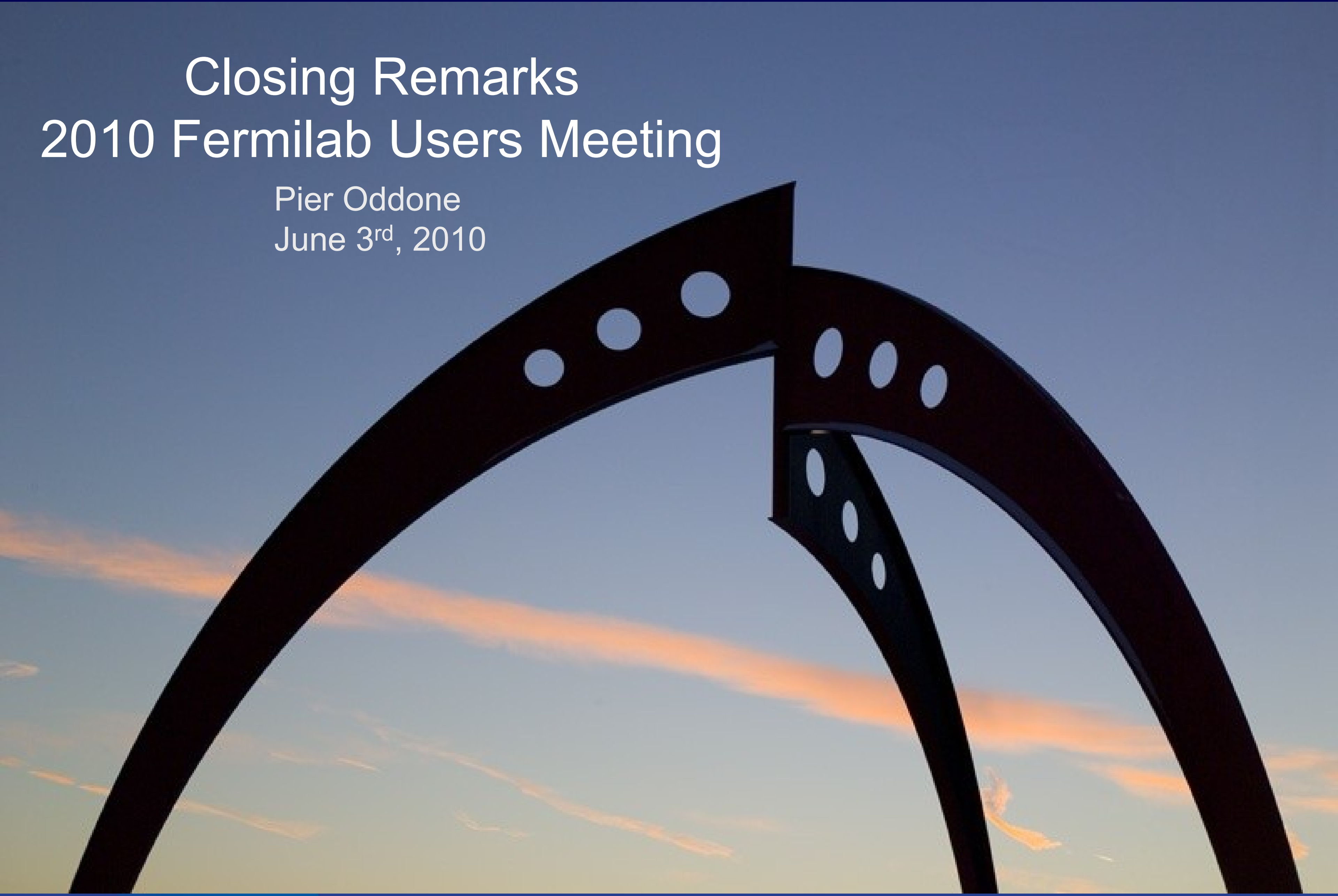
Closing Remarks
2010 Fermilab Users Meeting

Pier Oddone
June 3rd, 2010



U.S. DEPARTMENT OF ENERGY

Fermilab

We see a great program ahead

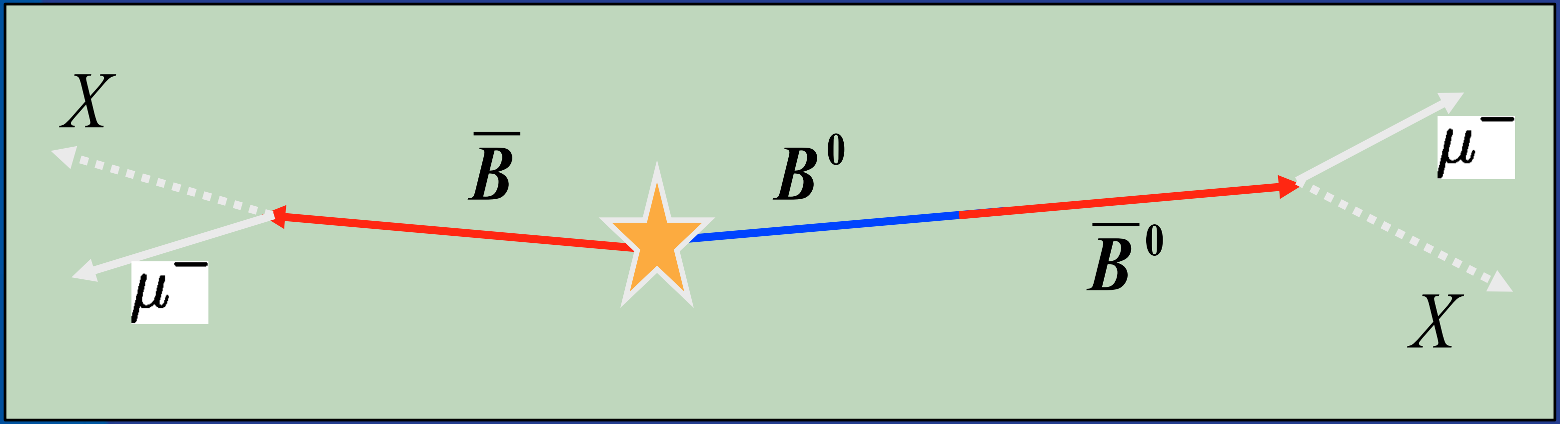
- Current opportunities: Tevatron, neutrinos, particle astrophysics, LHC
- In progress: the energy frontier at LHC, neutrinos and rare decay program at Fermilab, particle astrophysics
- Long term: intensity frontier with Project X with potential extensions to a neutrino factory and/or muon collider, possibly ILC

Fermilab in the world

- Three frontiers describe the national and international program in particle physics;
  - energy, intensity and cosmic frontiers
- In each Fermilab plays a unique and important role with:
  - Current operations and physics accomplishment
  - Ongoing construction of new projects
  - Long term vision and plans

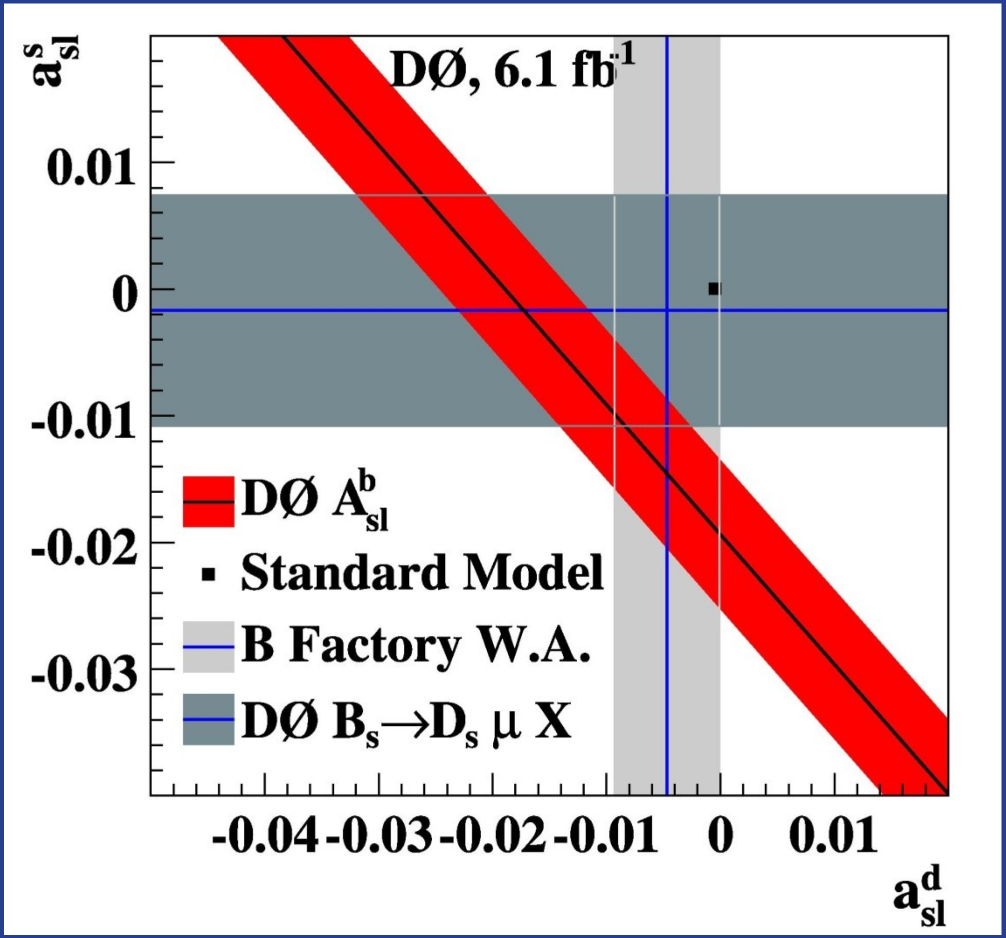
Energy Frontier: Tevatron

- Recent measurement of di-muon asymmetry in DZero



$$A_{sl}^{b} \equiv \frac{N_b^{++} - N_b^{--}}{N_b^{++} + N_b^{--}}$$

Energy Frontier: Tevatron

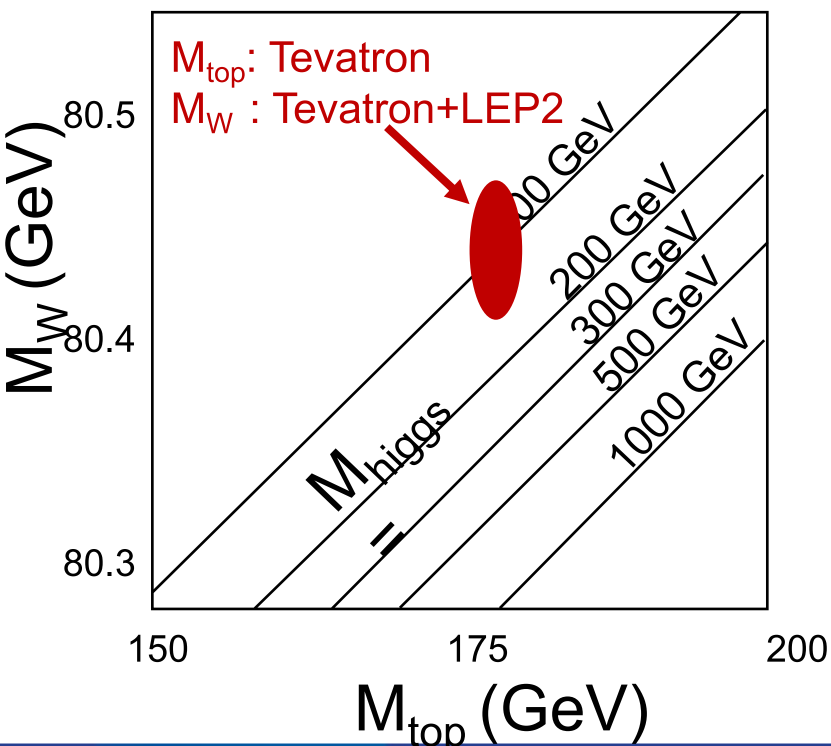


$$A_{sl}^{b} = 0.506\, a_{sl}^{d} + 0.494\, a_{sl}^{s}$$

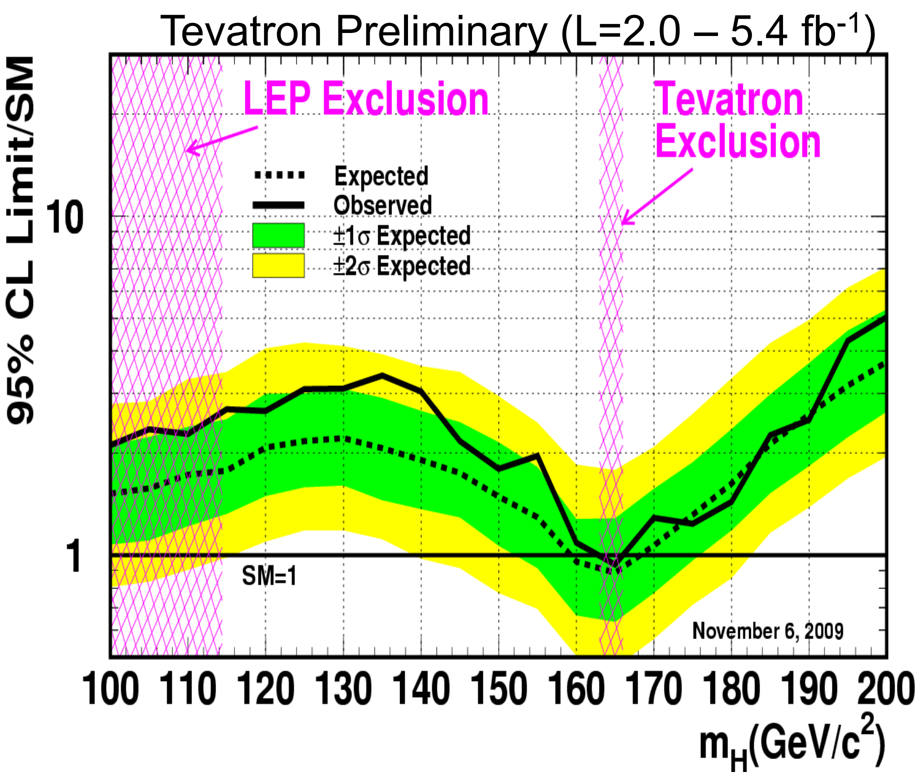
Energy Frontier: Tevatron

Electroweak fits

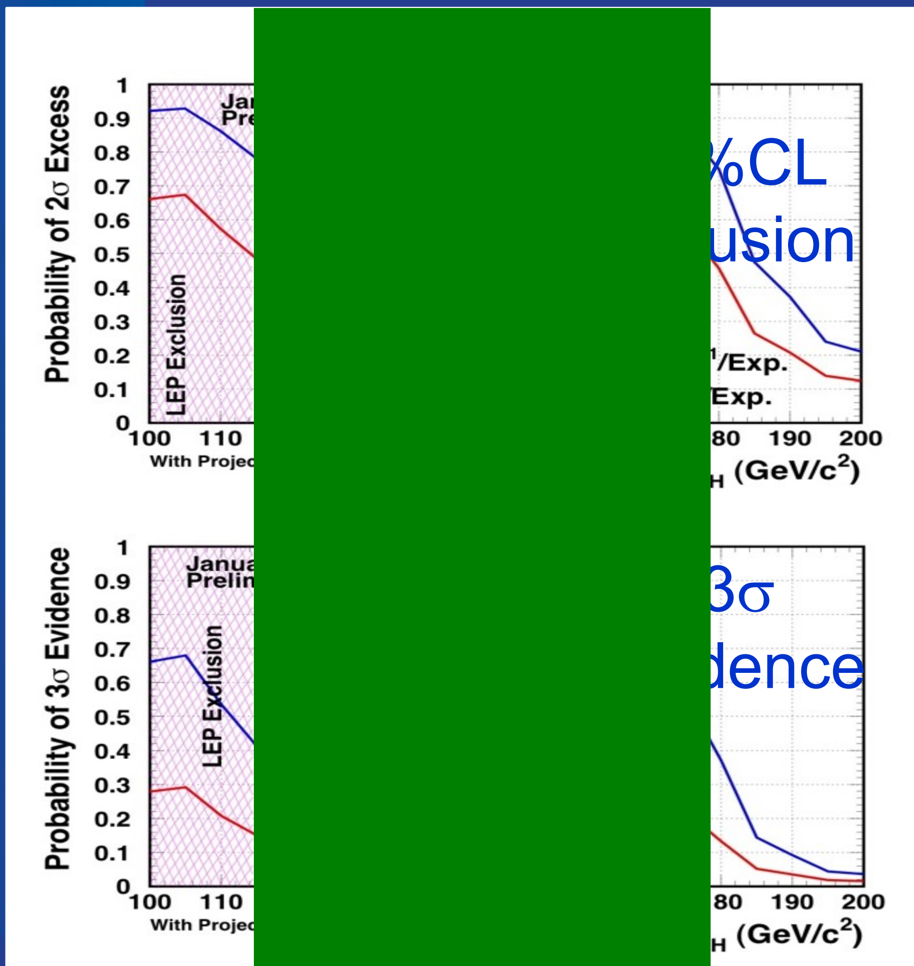
Predict Higgs Mass



Search for Higgs

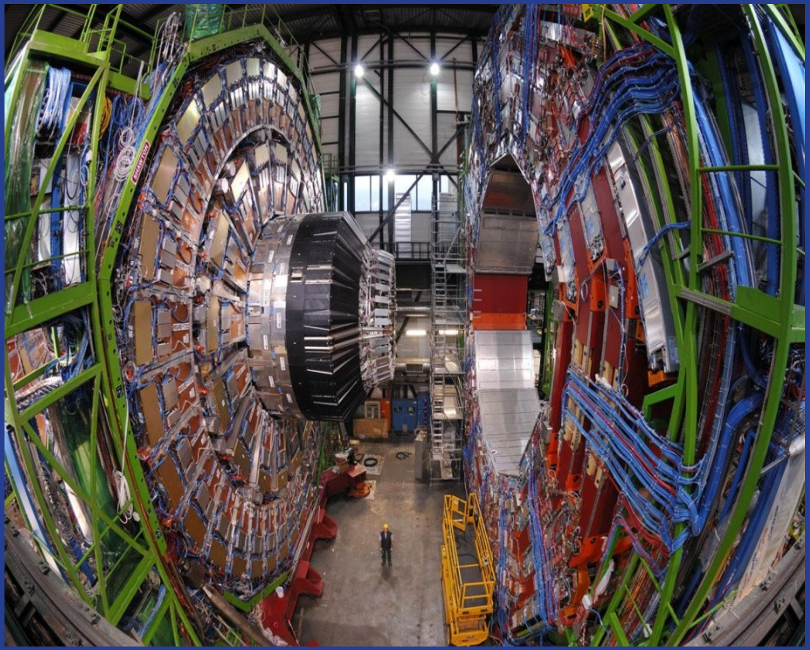


Is there more juice in the Tevatron?



- Tevatron graduates 60 PhD per year and produces about a 100 results per year
- Major results also in the intensity and cosmic frontiers
- Large fraction of the results (40%) at recent conferences come from Fermilab

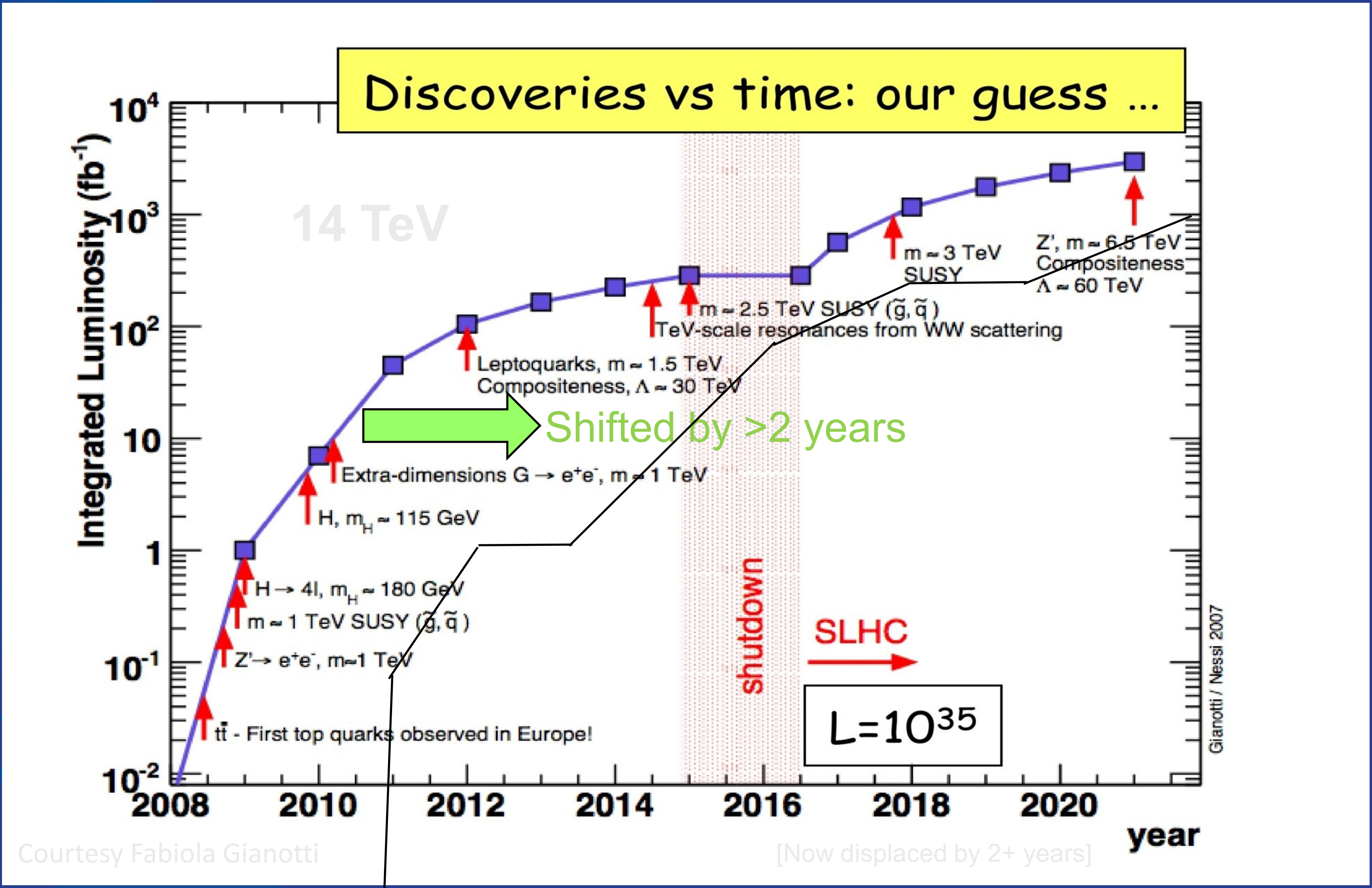
Energy frontier will move to the LHC



Fermilab is the lead US lab on the accelerator and the only US lab in CMS supporting over 50 universities

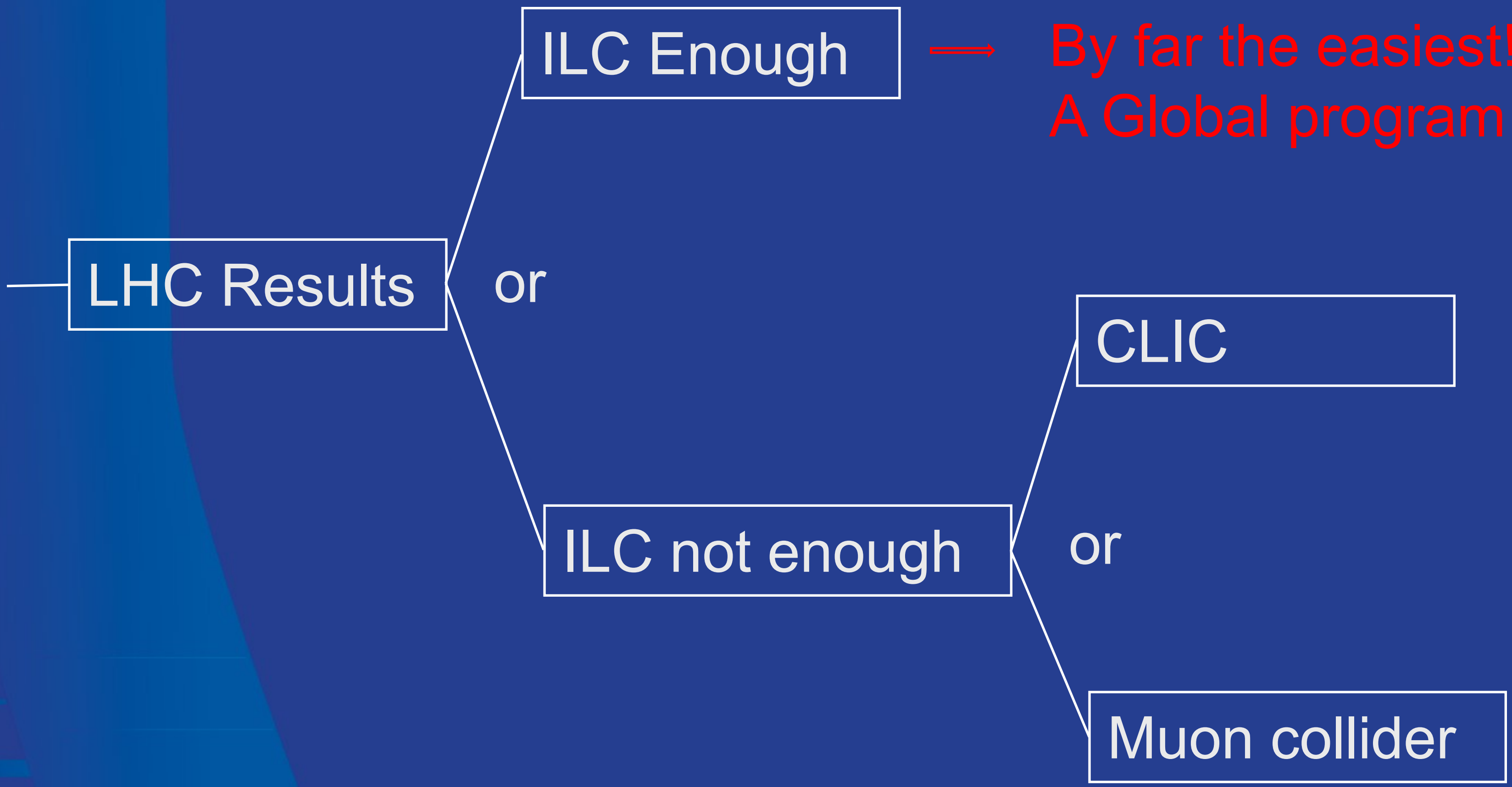
Play

LHC physics reach (3 years ago)

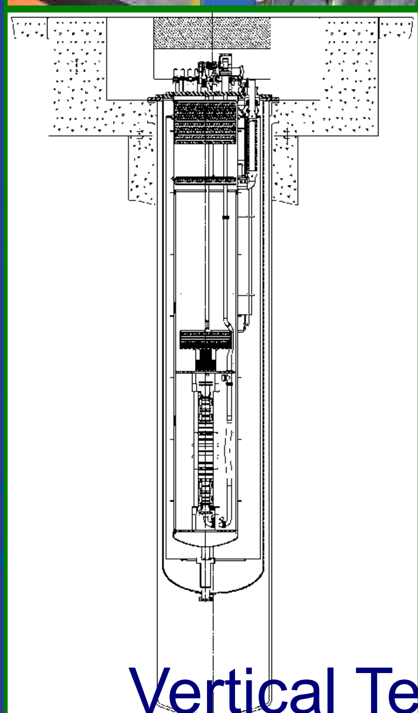


Fermilab

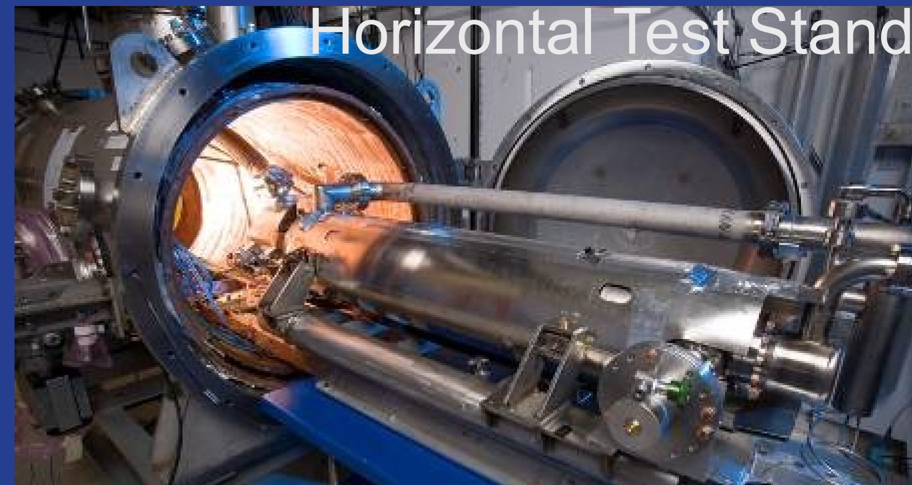
Biggest decision of the decade !



ILC/Project X/XFEL technology

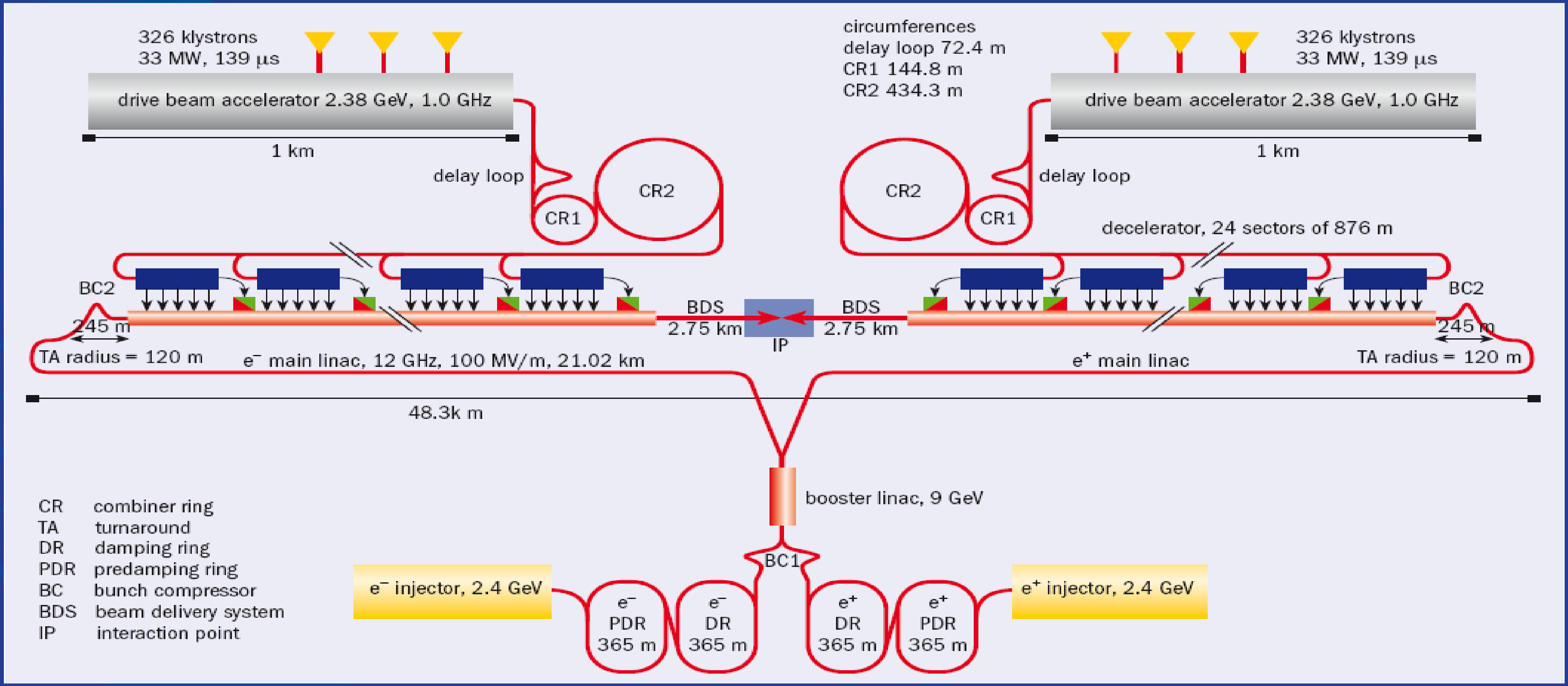


Vertical Test Stand



If we need higher energies…..

- If the energy of the ILC is too small (0.5 TeV or a little higher) we will need another approach: CLIC or muon collider

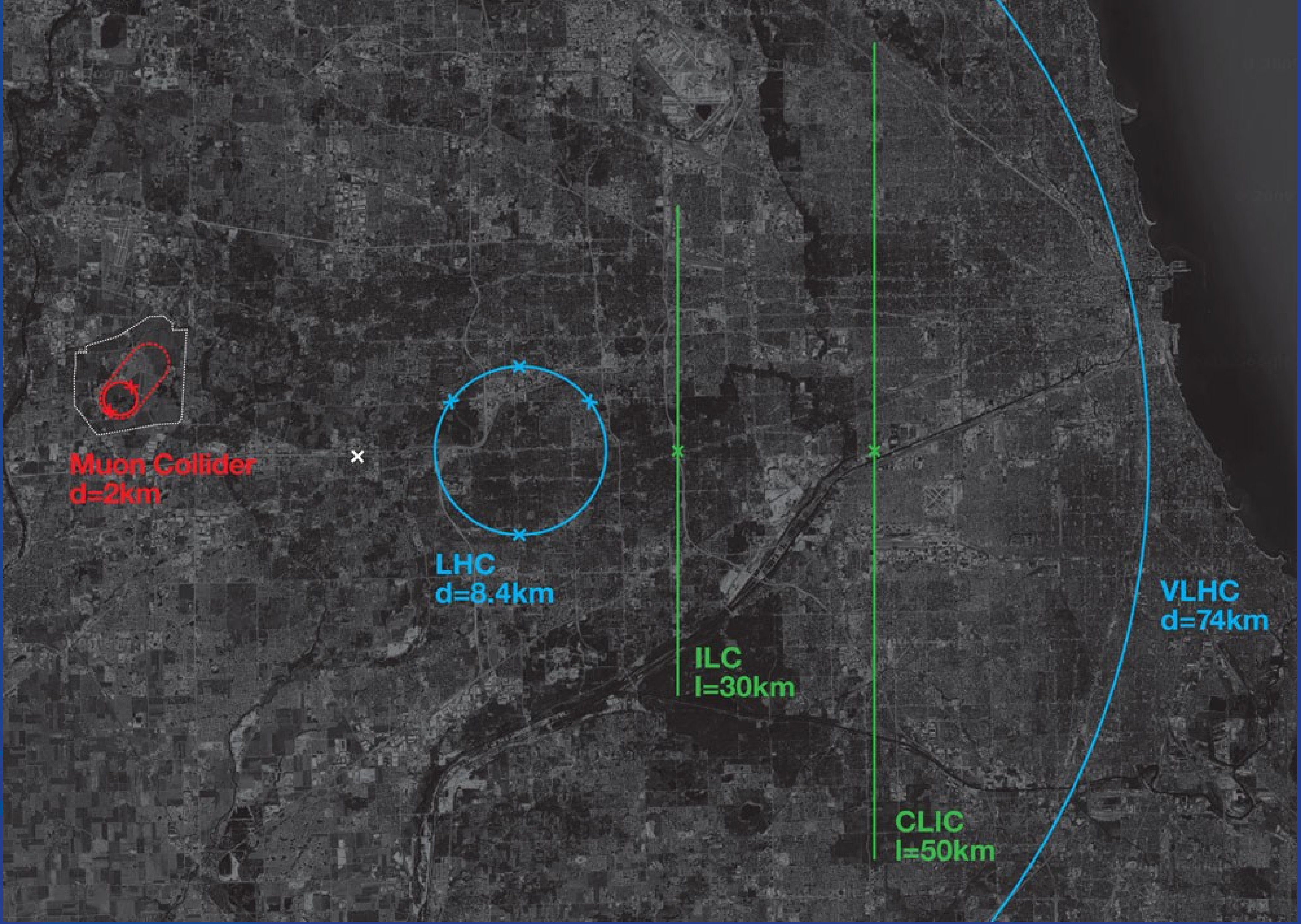


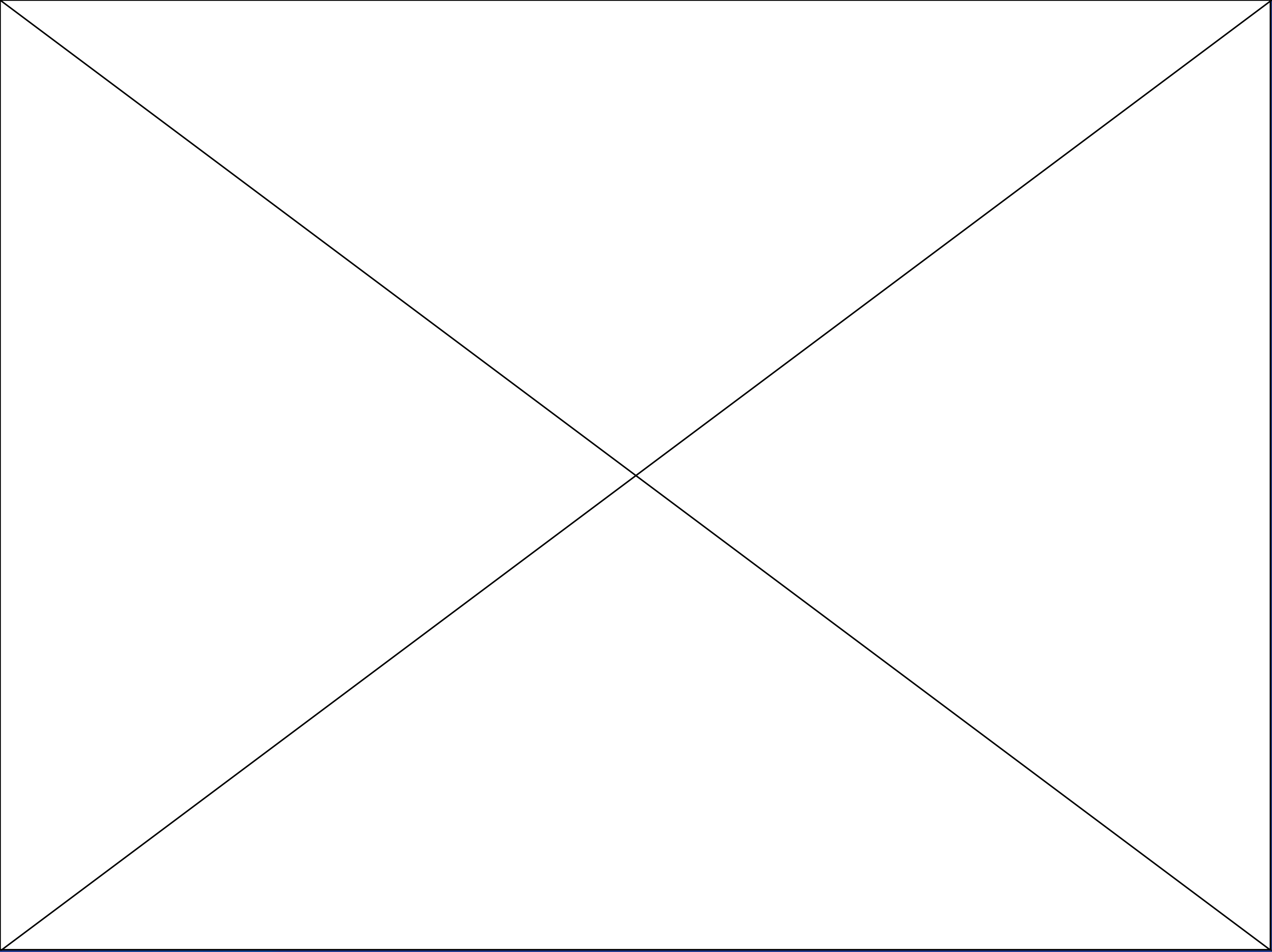
Muon Collider approach

- If the energy of the ILC is too small (0.5 TeV or a little higher) we will need another approach: CLIC or muon collider
- Collider based on a secondary beam: we have experience basing colliders on antiprotons. For muons we must do it in 20 msec.
- The biggest advantages are: narrow energy spread (no beamstrahlung) and small physical footprint (no synchrotron radiation
- DOE OHEP has asked Fermilab to organized the national R&D program

Comparison of Particle Colliders

To reach higher and higher collision energies, scientists have built and proposed larger and larger machines.



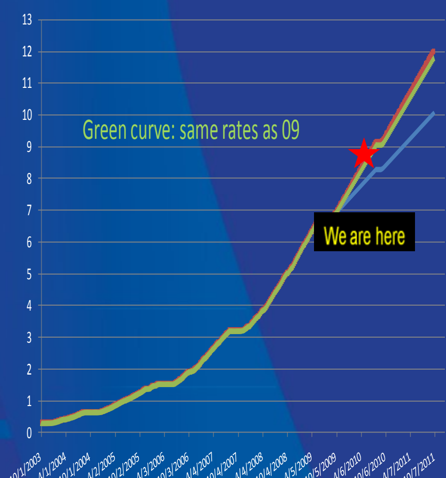


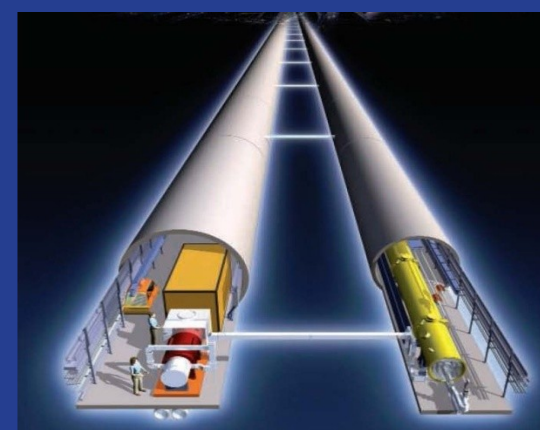
Energy frontier summary

Energy

Now – 2013	2013 – 2016	2016 – 2019	2019 – 2022
Tevatron LHC	LHC LHC upgrades	LHC ILC??	LHC ILC, CLIC or Muon Collider

Now 2013 2016 2019 2022

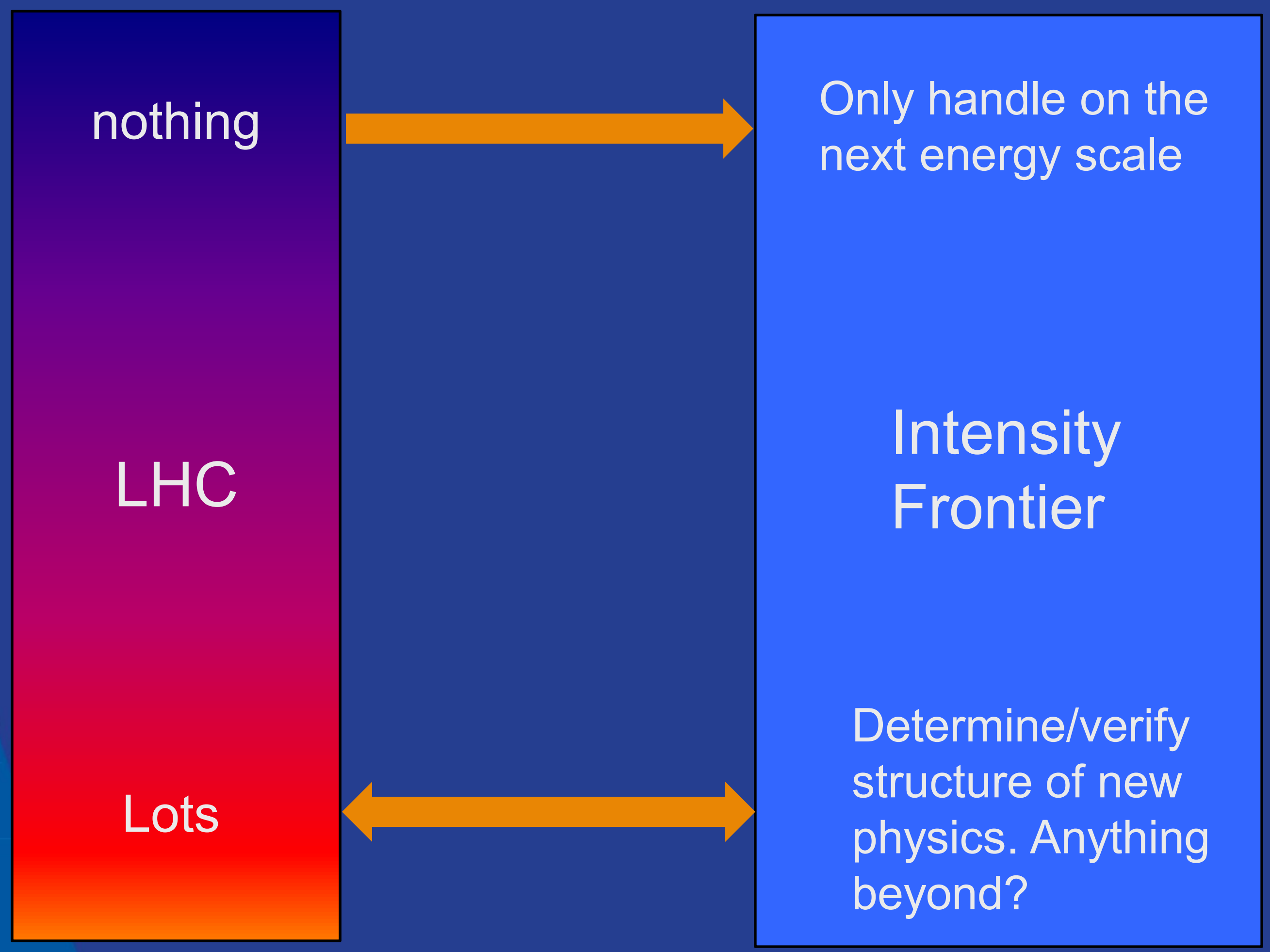




Intensity frontier: current

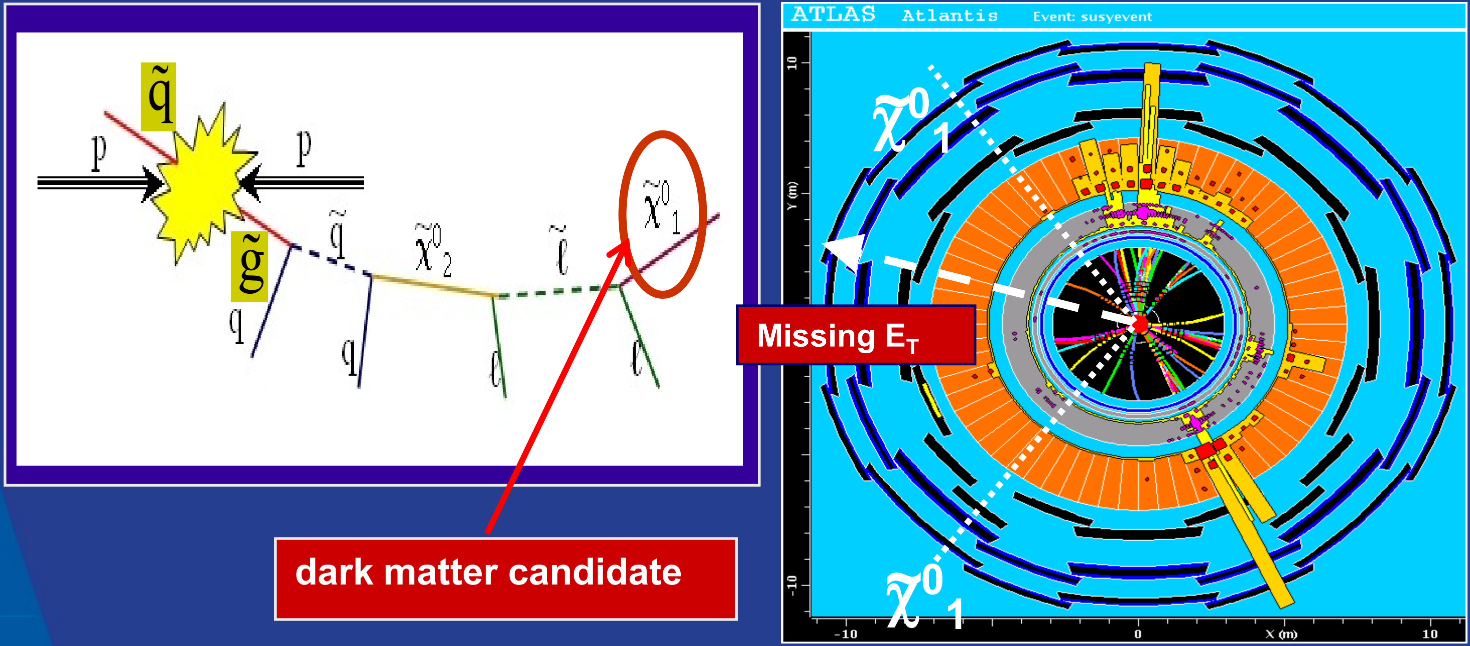
- Minos best result on electron appearance
- Minos result in middle of June on mixing parameters for anti-neutrinos
- MiniBooNE anomalous low energy neutrino cross sections
- MiniBooNE anti-neutrino results in the middle of June
- Most extensive data set of neutrino interactions in liquid argon TPC with MicroBooNE
- MINERvA study of cross sections

Interplay: LHC ⟷ Intensity Frontier



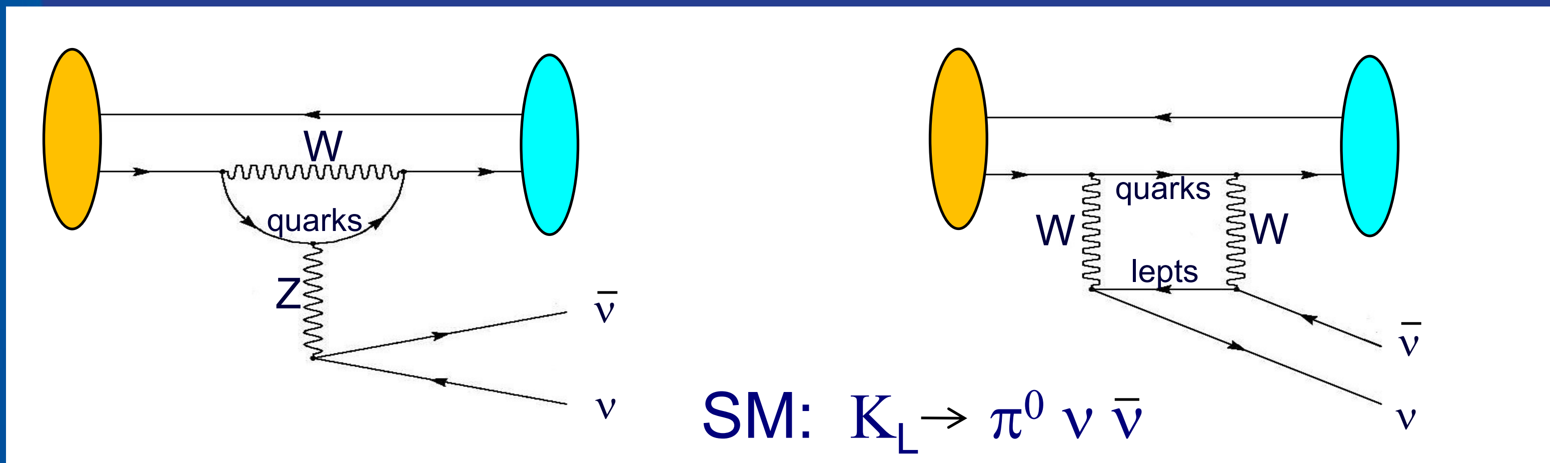
More interplay LHC/Intensity frontier

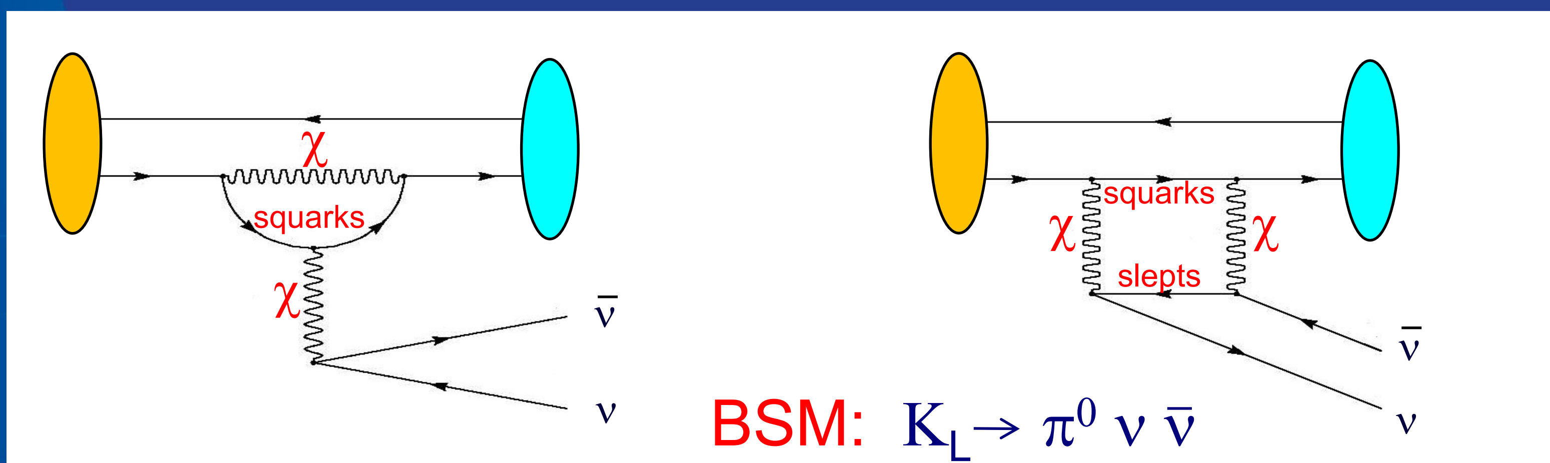
- ATLAS/CMS discovers strongly coupled SUSY



- A host of new particles: fit roughly some masses, make assumption on couplings

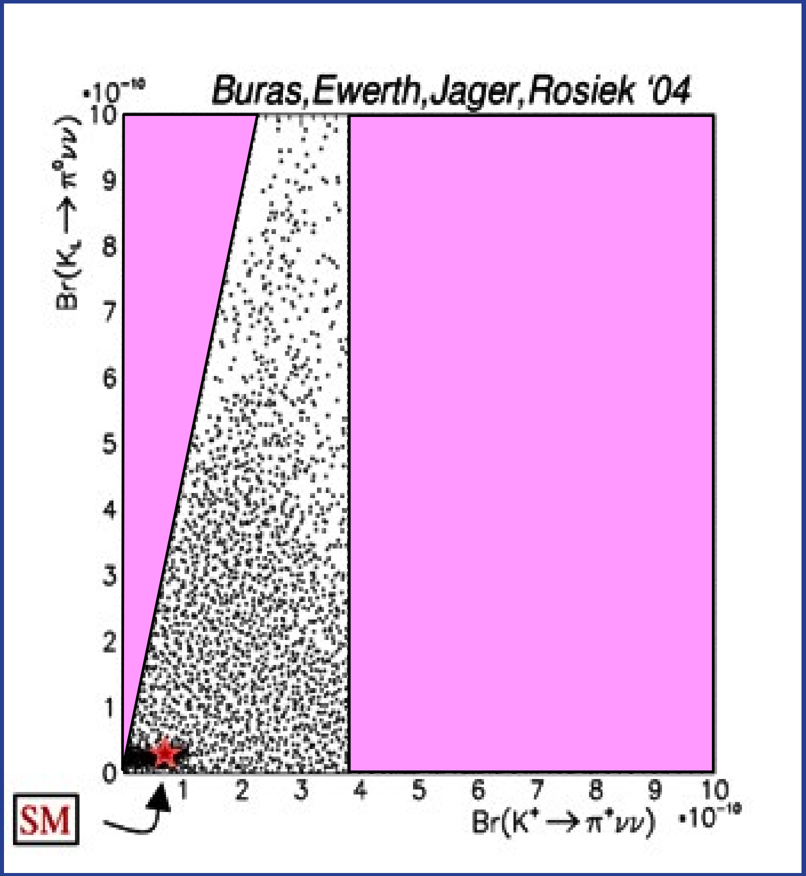
Large effects in kaon decay rates





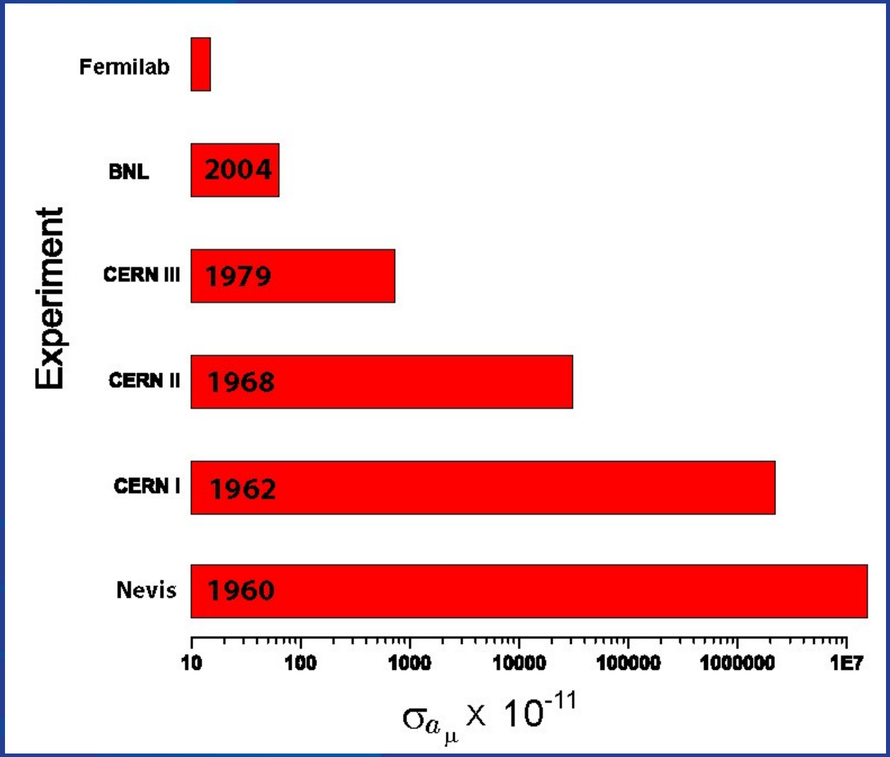
For particular classes of SUSY

Decay	Branching Ratio ($\times 10^{10}$)	
	Theory (SM)	Experiment
$K^+ \to \pi^+ \nu\bar{\nu}(\gamma)$	0.85 ± 0.07[1]	$1.73^{+1.15}_{-1.05}$[2]
$K_L^0 \to \pi^0 \nu\bar{\nu}$	0.28 ± 0.04[3]	< 670 (90% CL)[4]

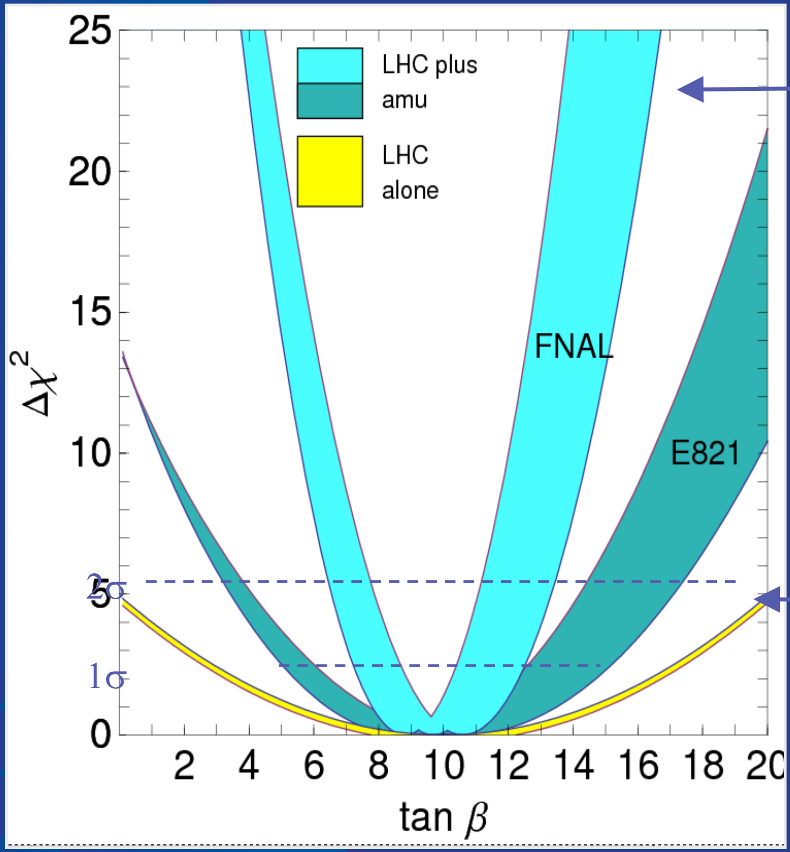


- Large effect on rare K decay modes highly suppressed with SM particles
- Much higher SM backgrounds in B and C decays
- (See also Neubert at BF2010)

A new (g-2) to error of $0.14*10^{-11}$

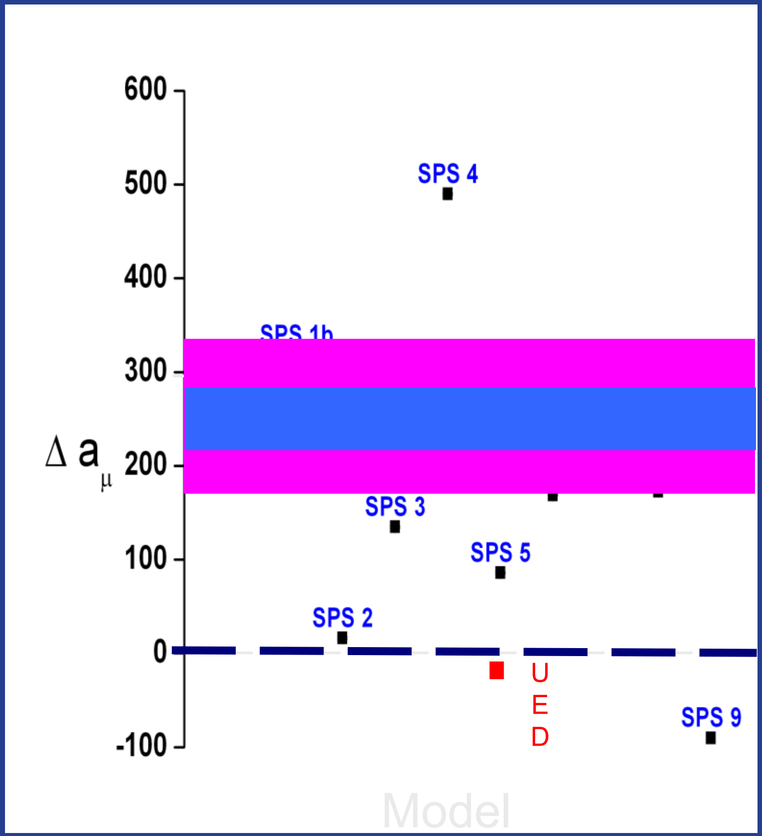


A new (g-2) to $0.14*10^{-11}$

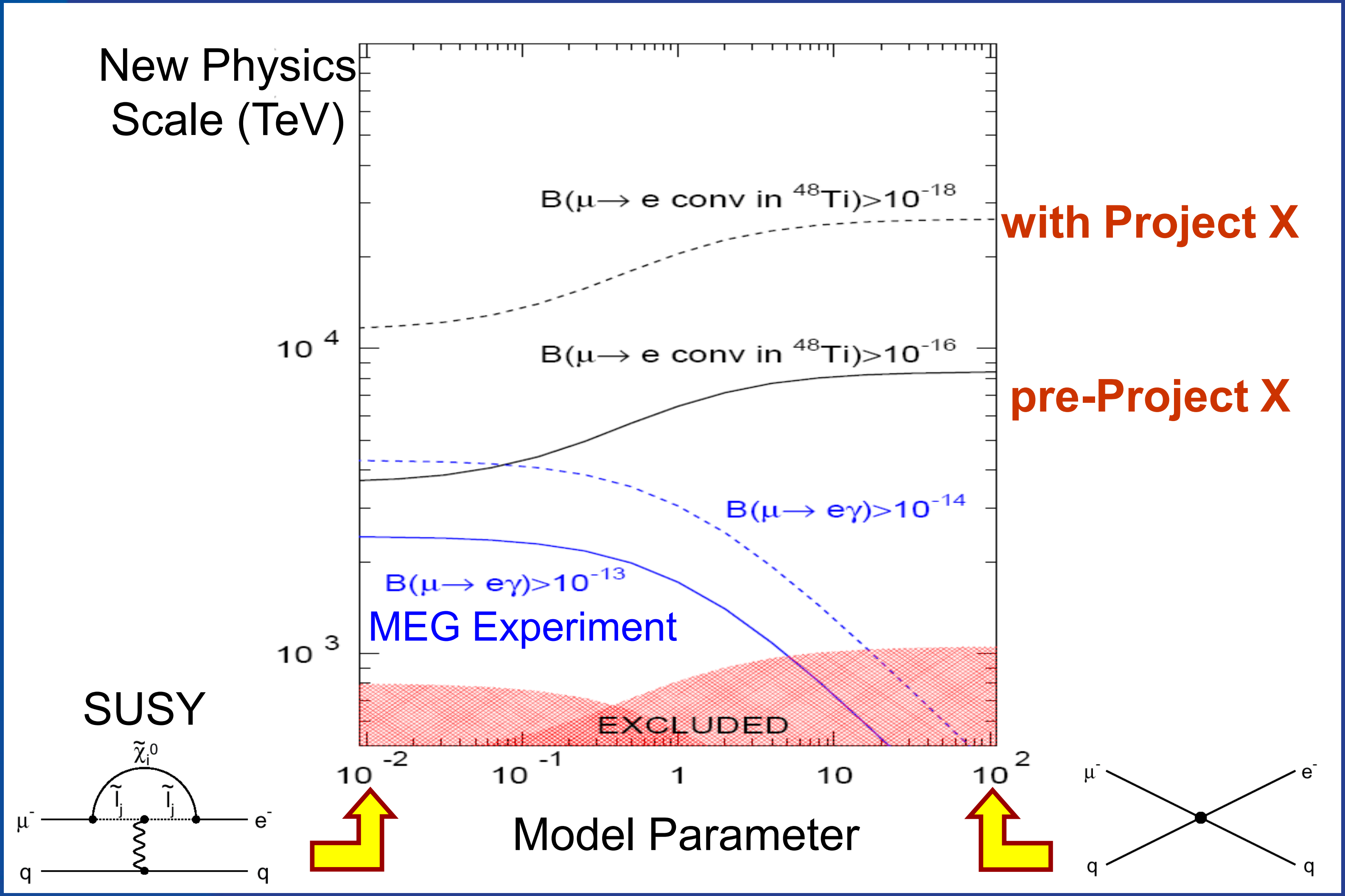


New g-2

LHC



Mu2e can probe 10^3 – 10^4 TeV



Intensity is key for neutrinos

- Only weak interactions: very small cross sections >> hard to study
- Need large flux of particles and massive detectors
- Complementary to LHC: measure neutrino parameters (new symmetries?), neutrino masses, matter-antimatter symmetry violation and surprises.
- This route like the energy path depends of what we find in the current generation of experiments

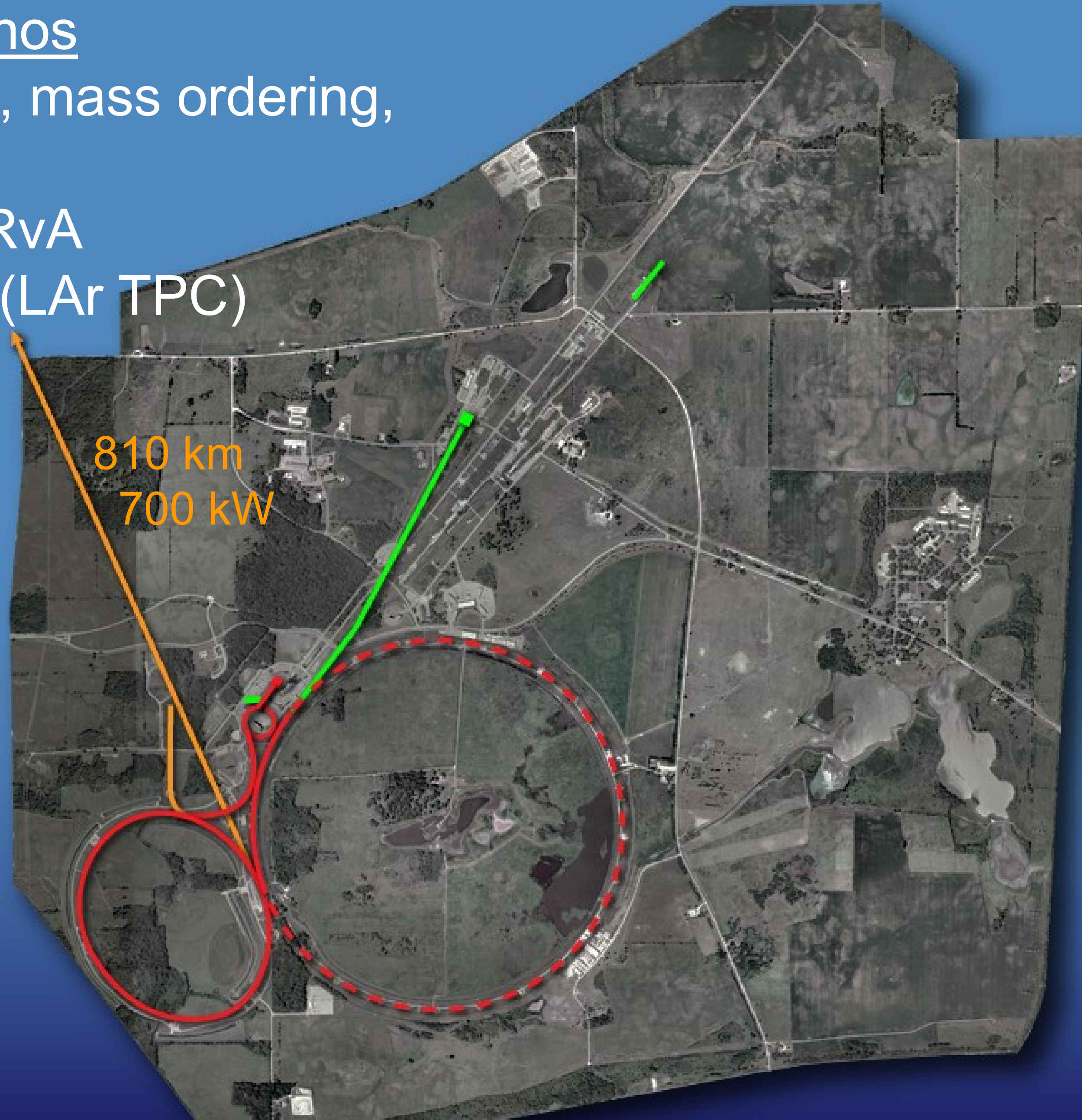
Neutrinos

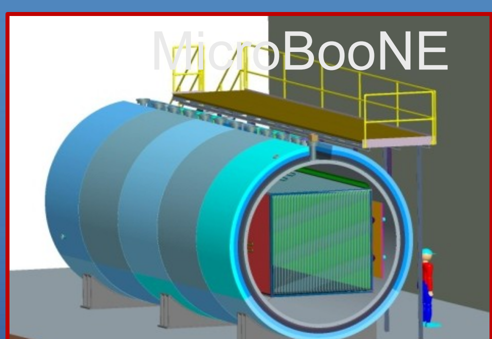
NOvA (off-axis): θ_{13}, mass ordering,

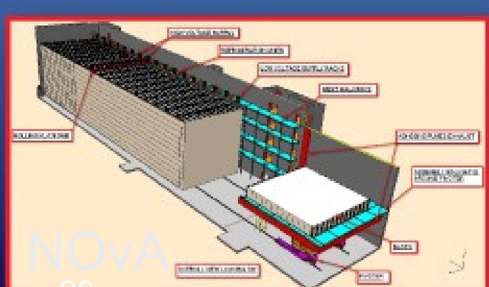
….

MINERvA

MicroBooNE (LAr TPC)







P Oddone, Fermilab Users Meeting, June 3, 2010

Neutrinos

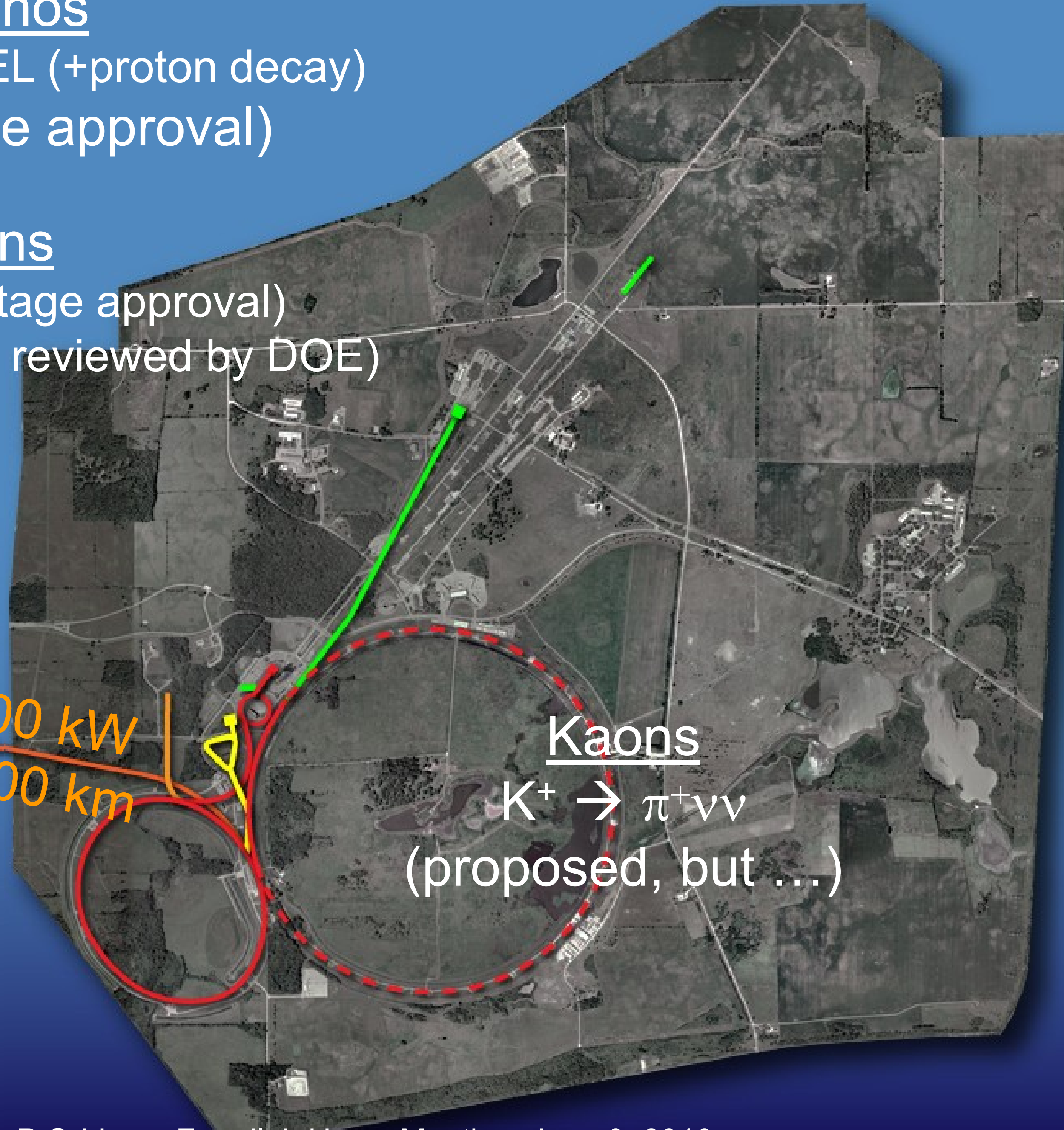
LBNE: FNAL→DUSEL (+proton decay)

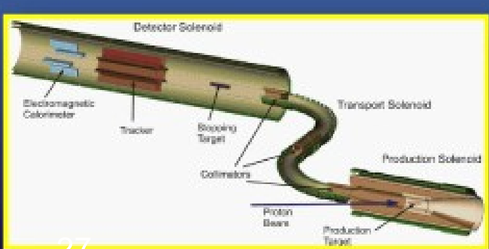
(DOE 1st stage approval)

Muons

Mu2e (DOE 1st stage approval)

Muon g-2/EDM (to be reviewed by DOE)

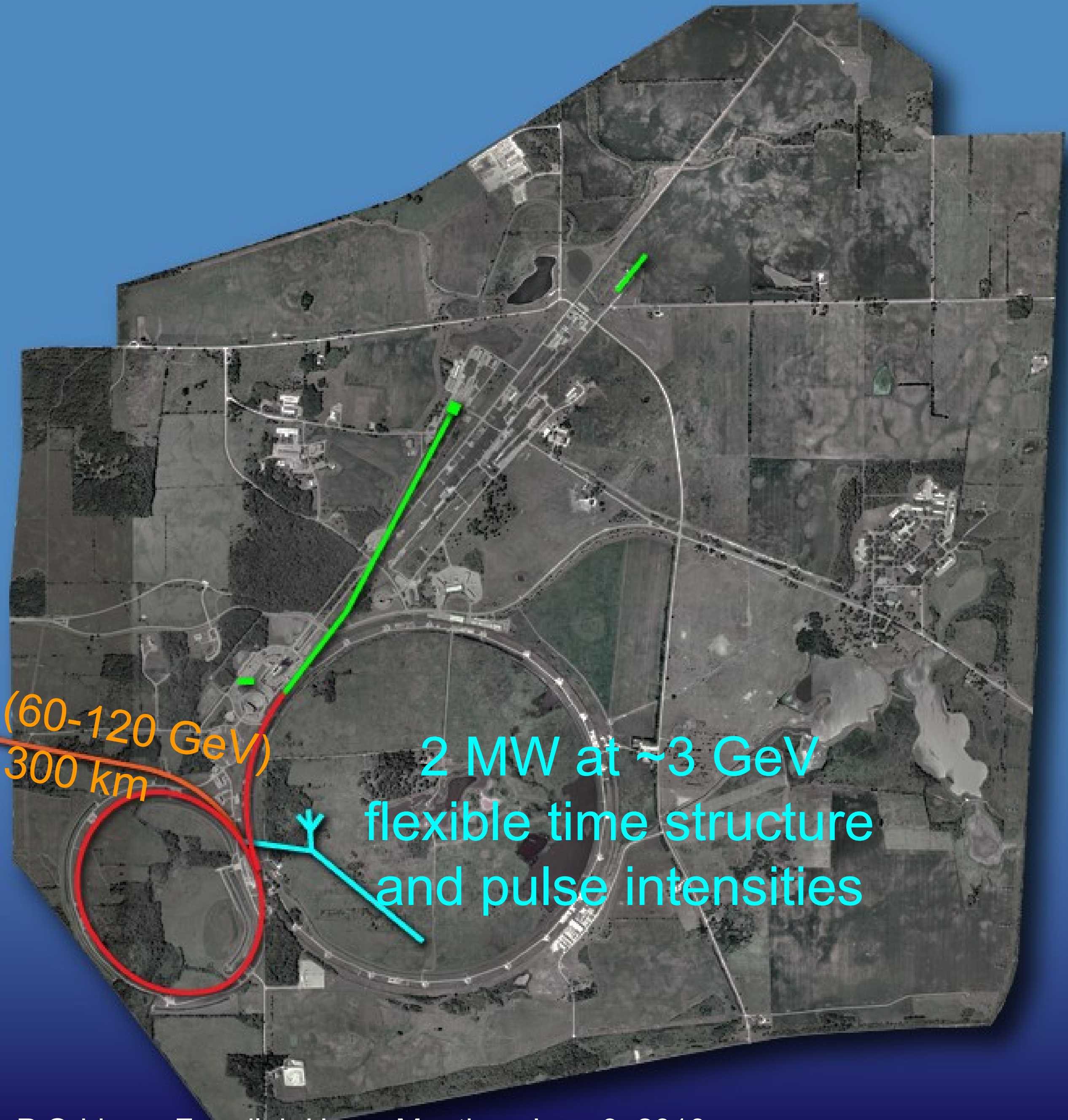


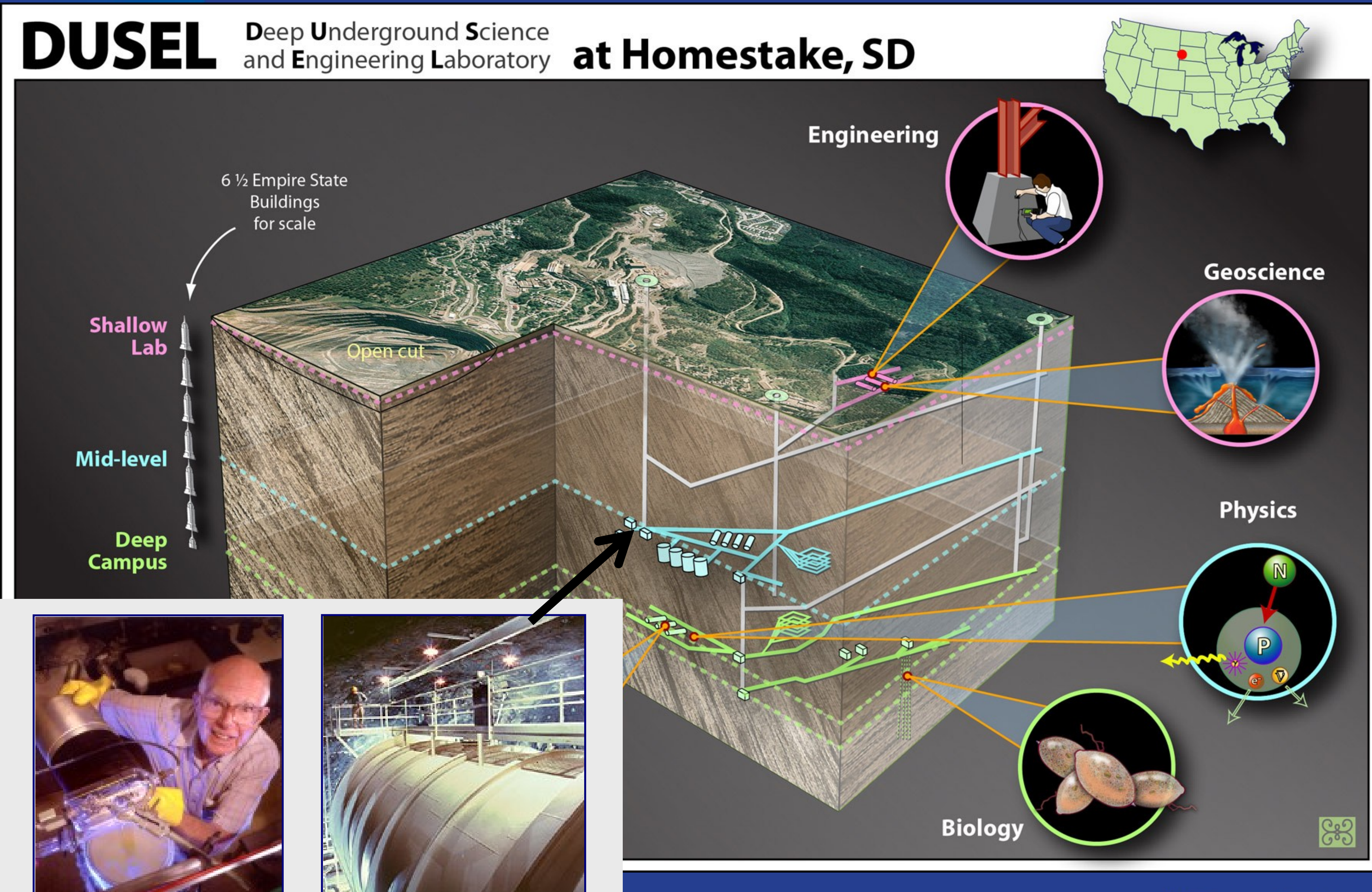


<u>Project X</u>

Neutrinos
Muons
Kaons
Nuclei

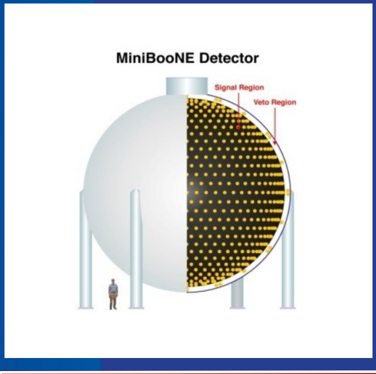
"simultaneously"

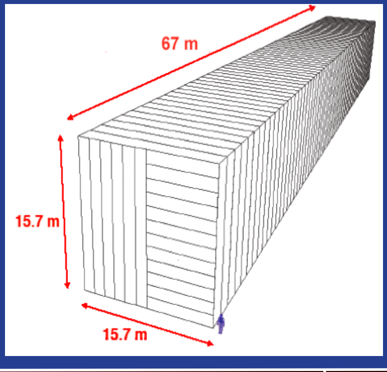


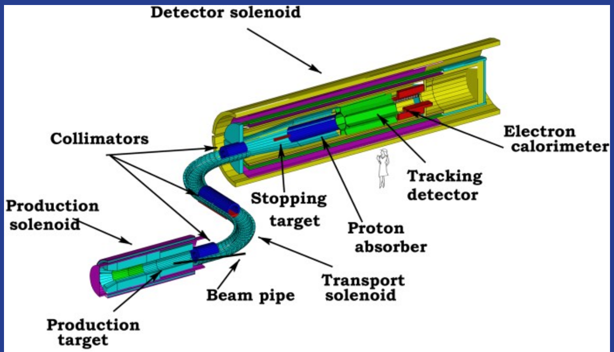


Ray Davis's Experiment

Intensity Frontier Summary



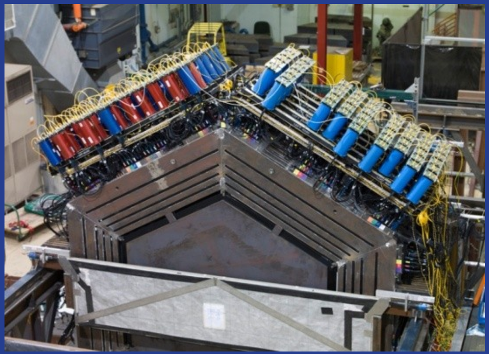


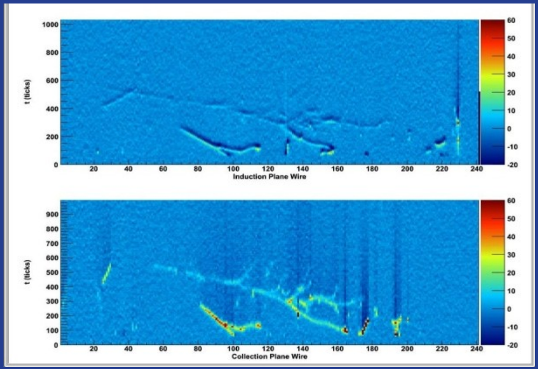


Intensity

Now – 2013	2013 – 2016	2016 – 2019	2019 – 2022
Minos MiniBooNE MINERvA	NOvA MicroBooNE MINERvA g-2 ?	LBNE Mu2e	Project X+LBNE Mu2e ν Factory ??

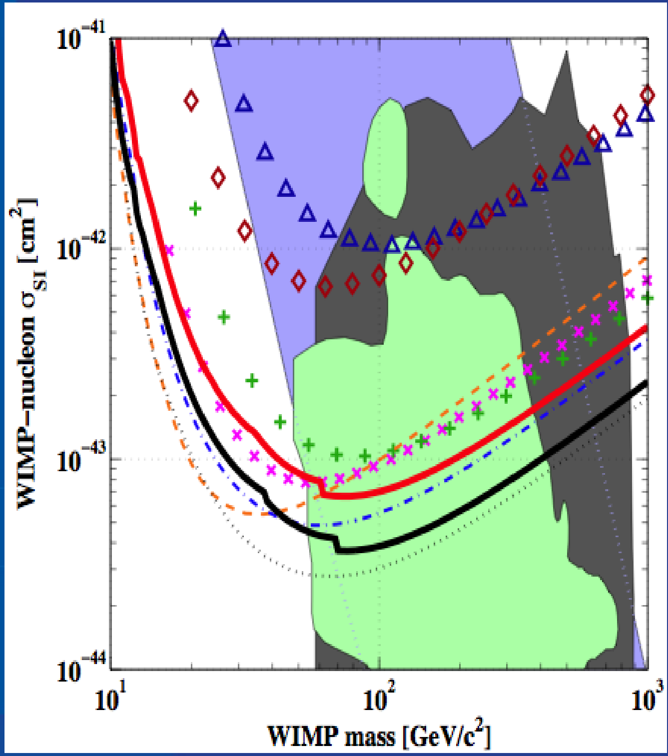
Now 2013 2016 2019 2022

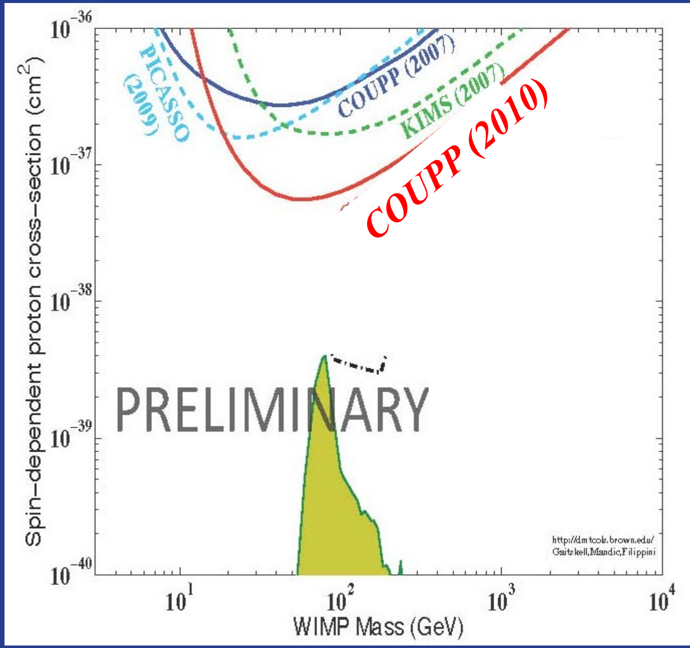




Cosmic Frontier: current results

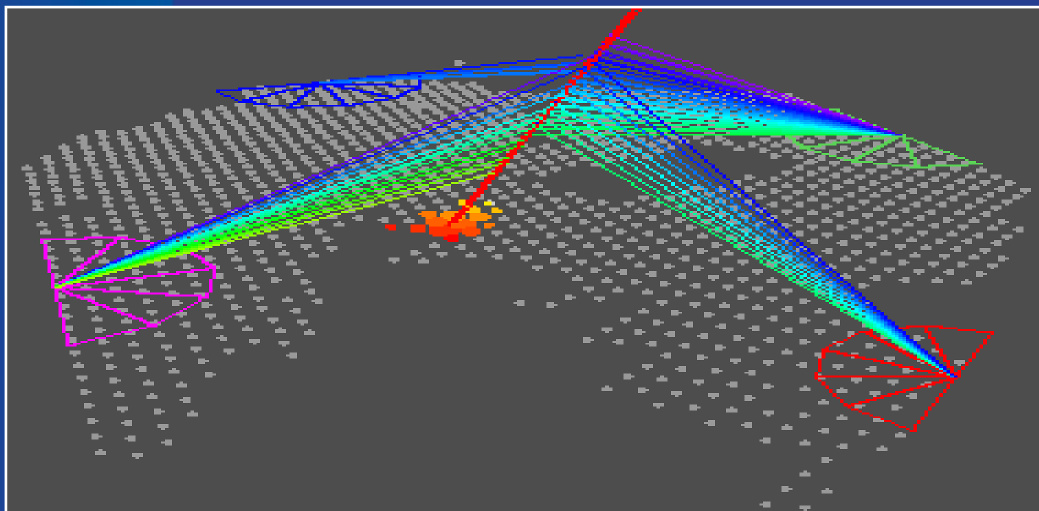
CDMS

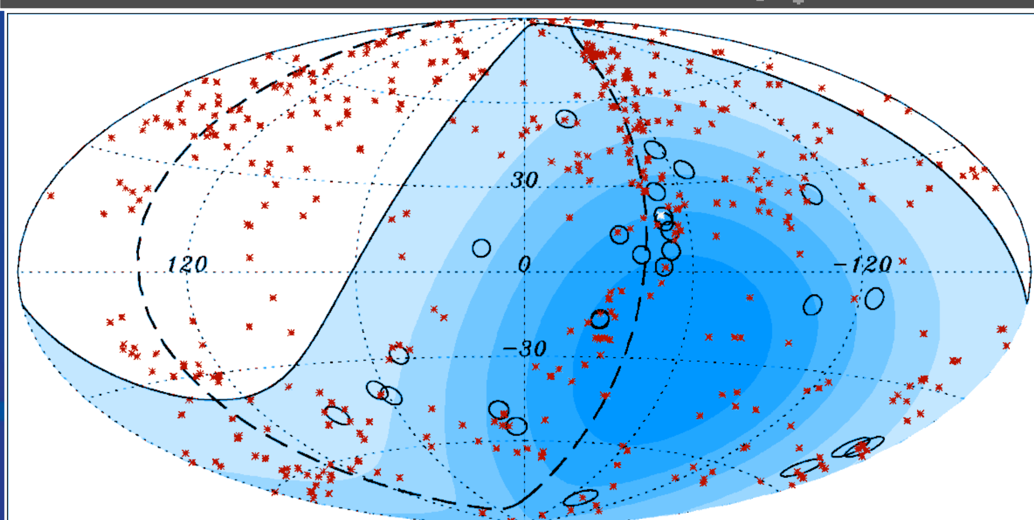




COUPP

Present results: UHE Cosmic Rays





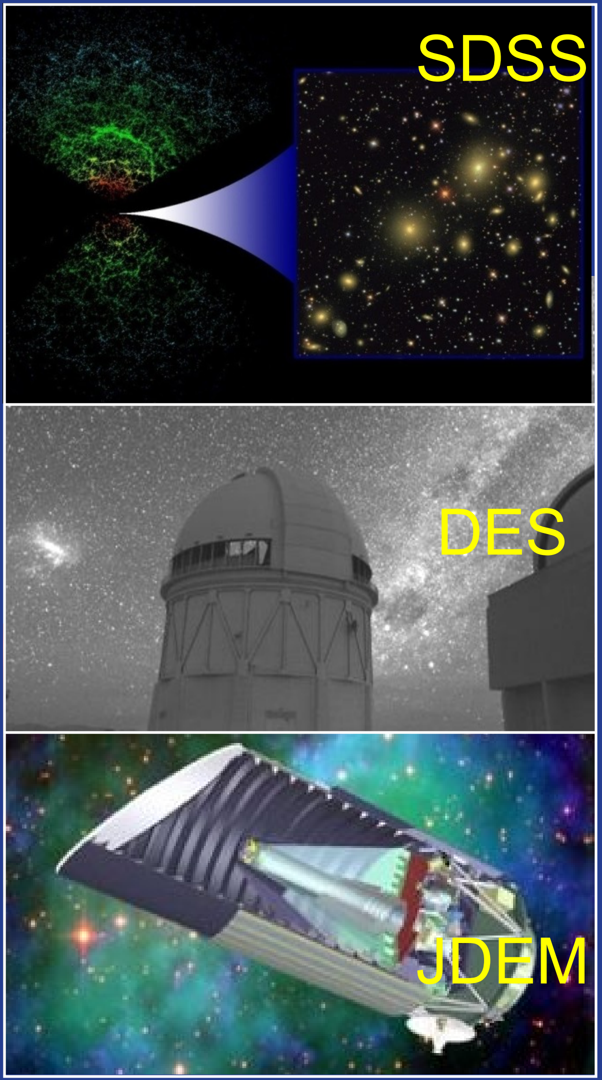
Auger Observatory studies ultra-high energy cosmic rays.

o – Cosmic rays with E > 57,000,000 TeV

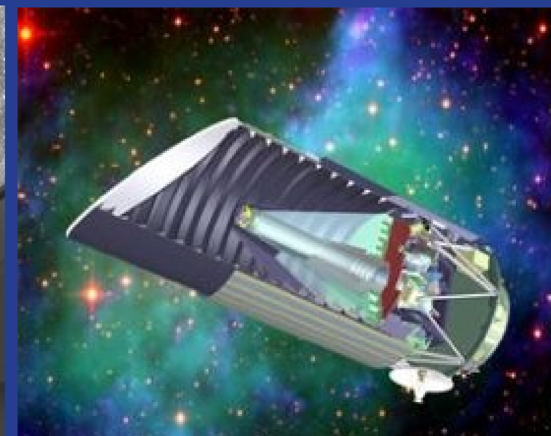
Correlation

x – Active Galactic Nuclei

1. SDSS (Sloan Digital Sky Survey)
   - 2.5 meter telescope in New Mexico
   - Ranks as the facility with the highest impact in astronomy for the 3rd year in a row.
   - Power spectrum of galaxies constrain dark energy density parameter.
2. DES (Dark Energy Survey)
   - 4 meter telescope in Chile
   - DES Camera under construction
   - Operation: 2011 – 2016
3. JDEM (Joint Dark Energy Mission)
   - Space telescope
   - Fermilab Goal: Science Operation Center



Cosmic Frontier Summary



	Now – 2013	2013 – 2016	2016 – 2019	2019 – 2022
Cosmic	P Auger DM Searches SDSS	P Auger North? DM: scalable? DES	JDEM DM searches Holometer?	JDEM

Thanks to all of you who have made this meeting a success!