IFIC summer school
2017

The DUNE experiment

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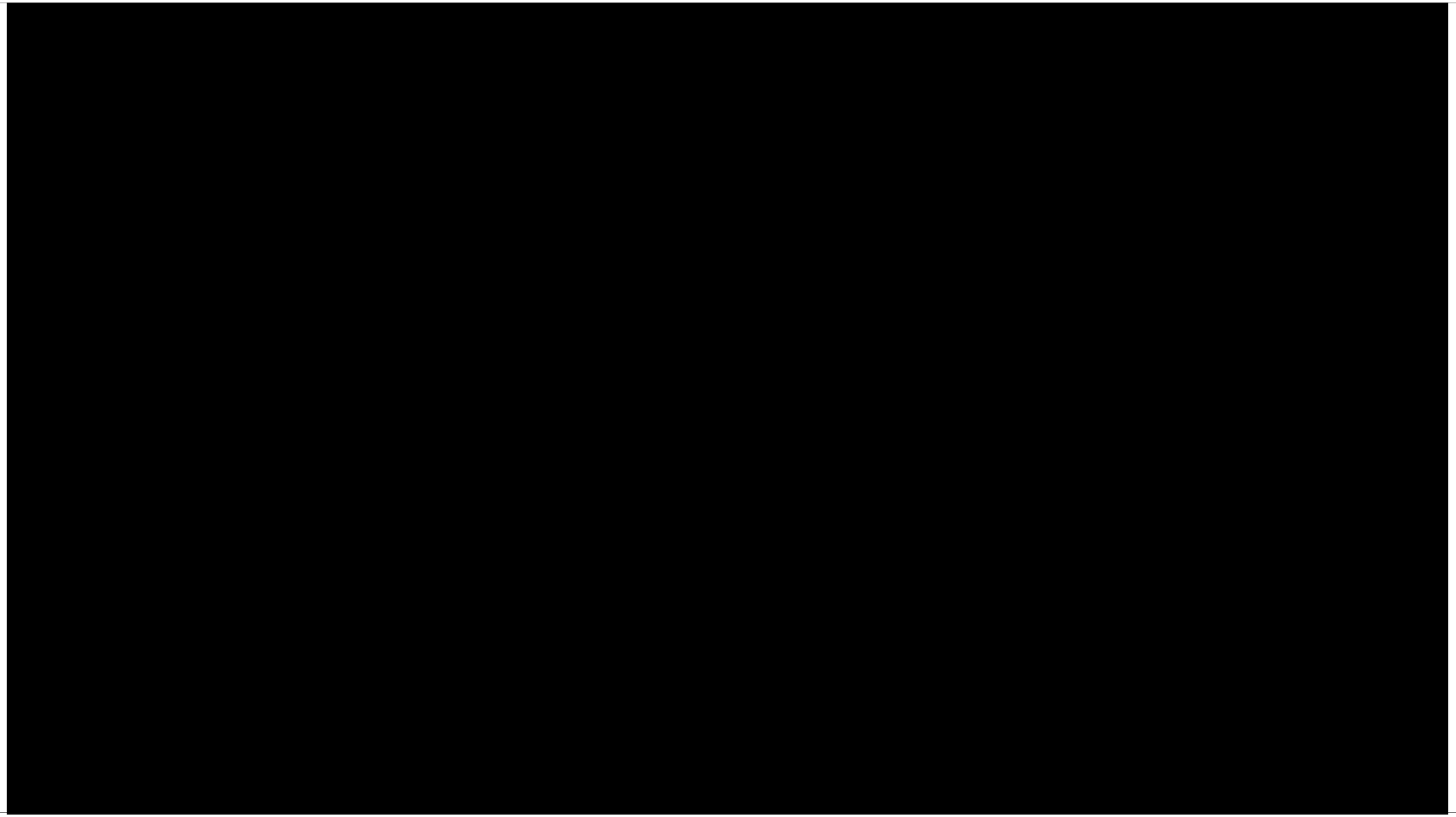
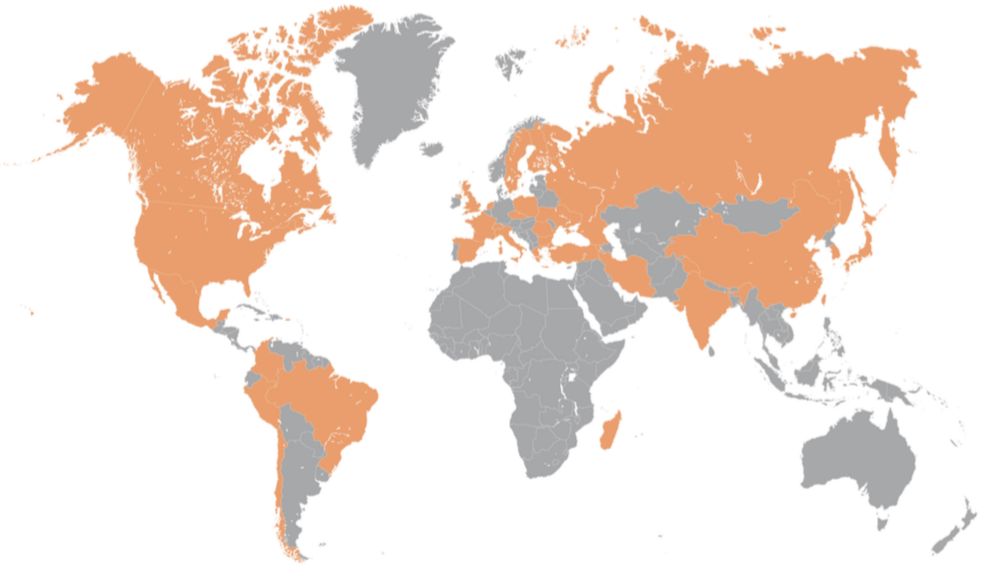
IFIC (UV- CSIC)
Valencia



The DUNE collaboration

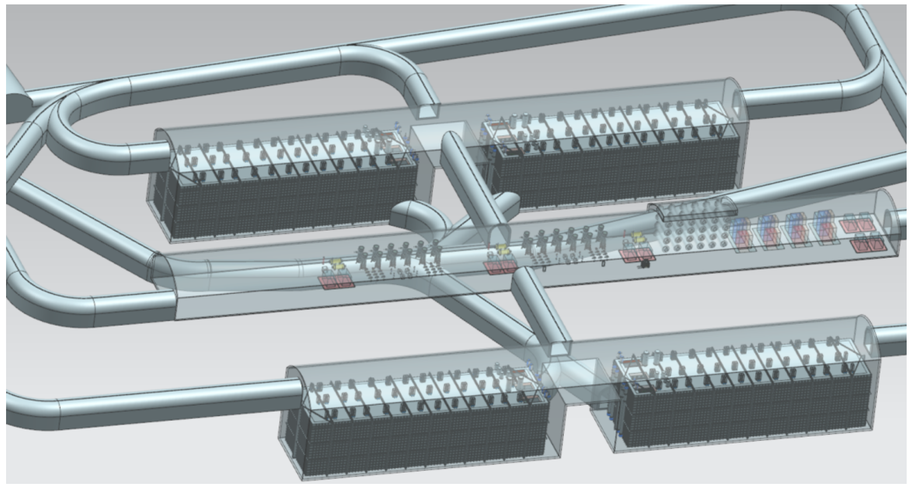
Global collaboration!

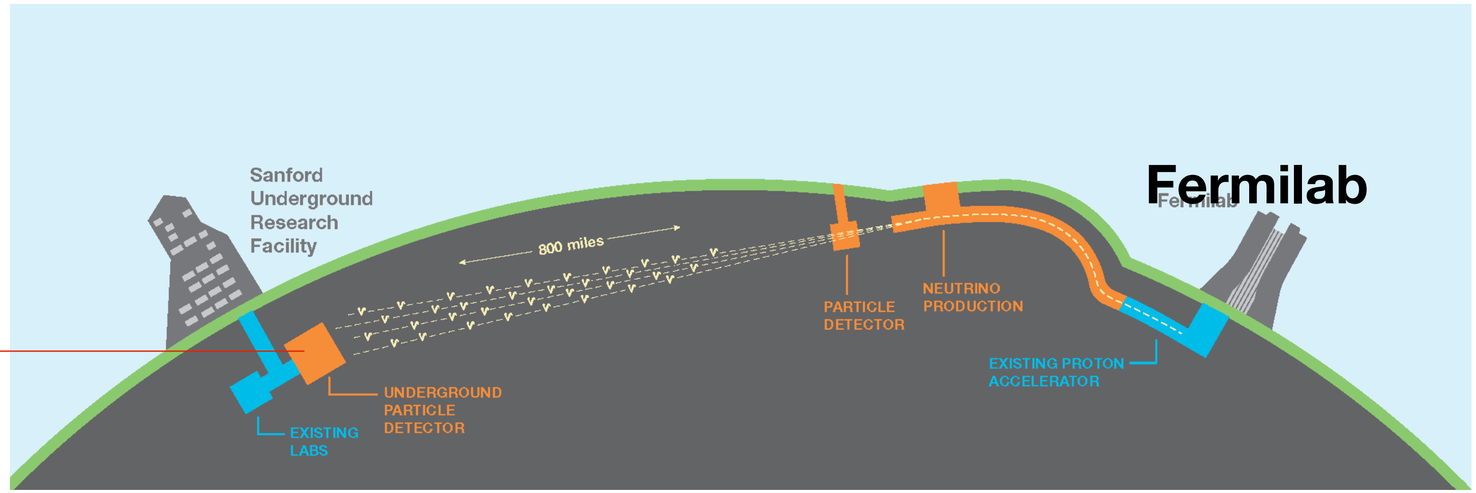
- 964 collaborators
- 164 institutions
- 30 countries

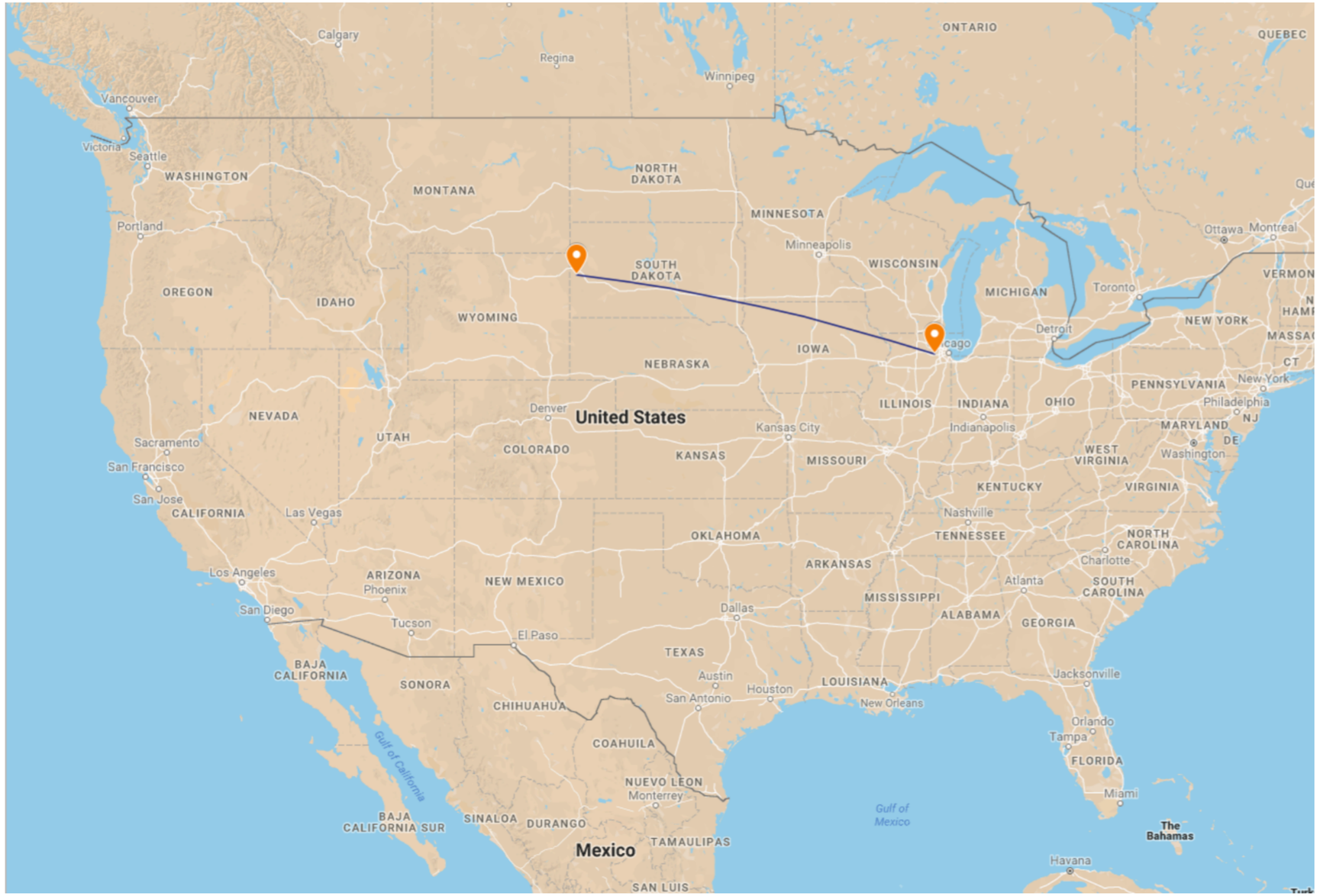


Deep **U**nderground **N**eutrino **E**xperiment

- Una técnica diferente, similar a la de NEXT, pero con Argón líquido en lugar de Xe gas
- 4 TPCs de 10.000 toneladas cada una
  - Similar en masa a Super-Kamiokande pero con una eficiencia de detección mucho mayor






Calgary
Regina
Winnipeg
ONTARIO
QUEBEC
Vancouver
Victoria
Seattle
WASHINGTON
NORTH DAKOTA
MONTANA
MINNESOTA
Portland
Minneapolis
Ottawa
Montreal
SOUTH DAKOTA
WISCONSIN
OREGON
IDAHO
MICHIGAN
Toronto
WYOMING
Detroit
NEW YORK
IOWA
NEBRASKA
PENNSYLVANIA
New York
Philadelphia
NEVADA
Denver
United States
ILLINOIS
INDIANA
OHIO
Kansas City
Indianapolis
MARYLAND
Sacramento
UTAH
COLORADO
KANSAS
MISSOURI
WEST VIRGINIA
Washington
San Francisco
KENTUCKY
VIRGINIA
San Jose
CALIFORNIA
Las Vegas
Nashville
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Charlotte
Atlanta
SOUTH CAROLINA
San Diego
Dallas
MISSISSIPPI
ALABAMA
Tucson
El Paso
GEORGIA
TEXAS
BAJA CALIFORNIA
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Jacksonville
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San Antonio
Houston
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CHIHUAHUA
Orlando
Tampa
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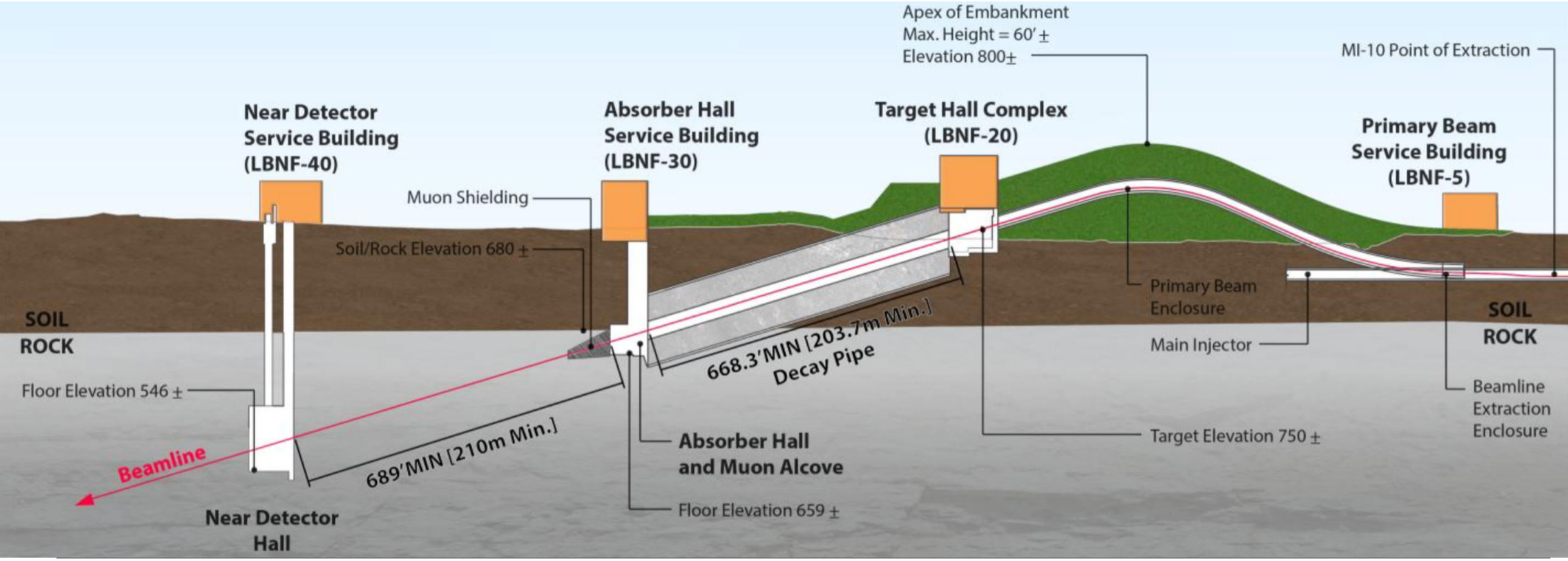
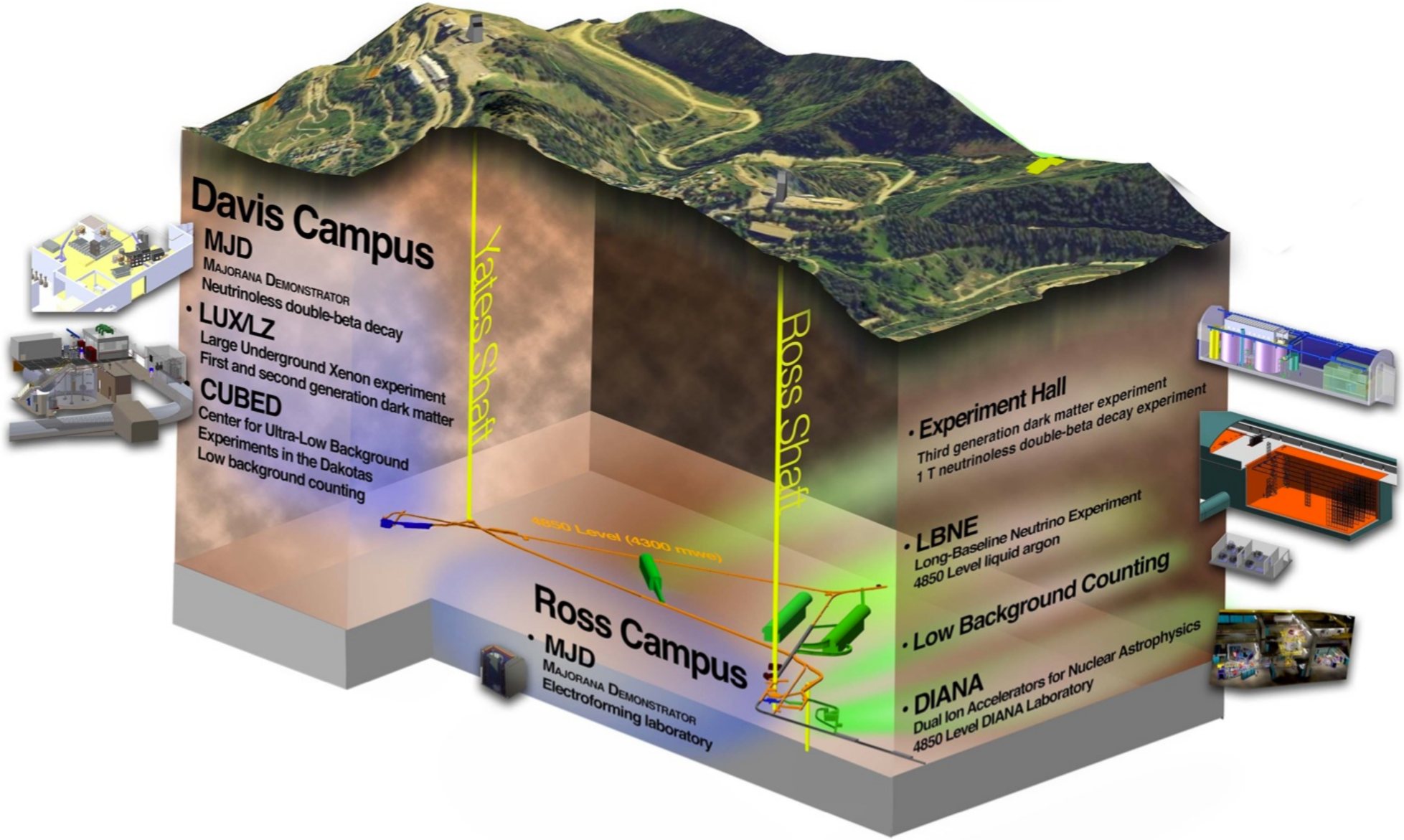
FLORIDA
NUEVO LEON
Monterrey
Miami
Gulf of California
Gulf of Mexico
BAJA CALIFORNIA SUR
SINALOA
DURANGO
The Bahamas
Mexico
TAMAULIPAS
Havana
SAN LUIS

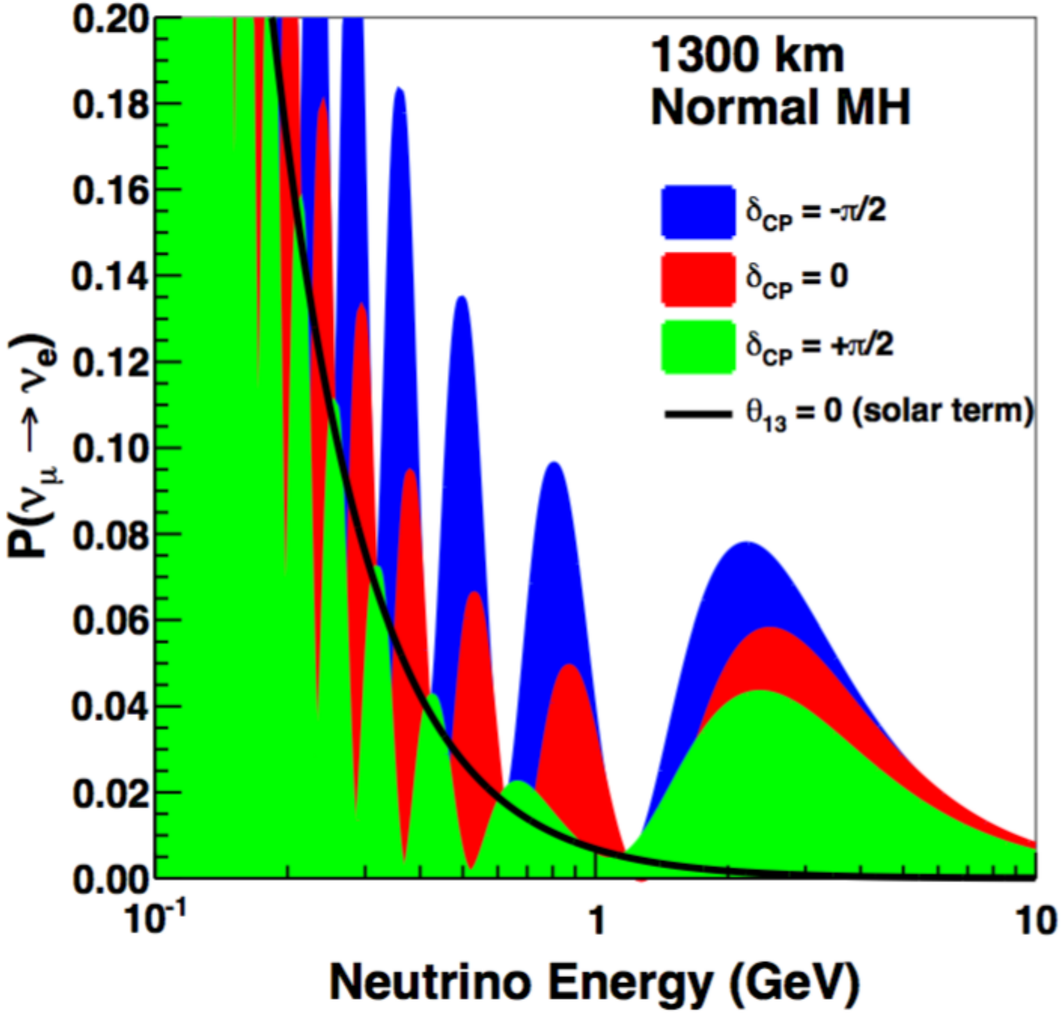
Instalaciones en Fermilab

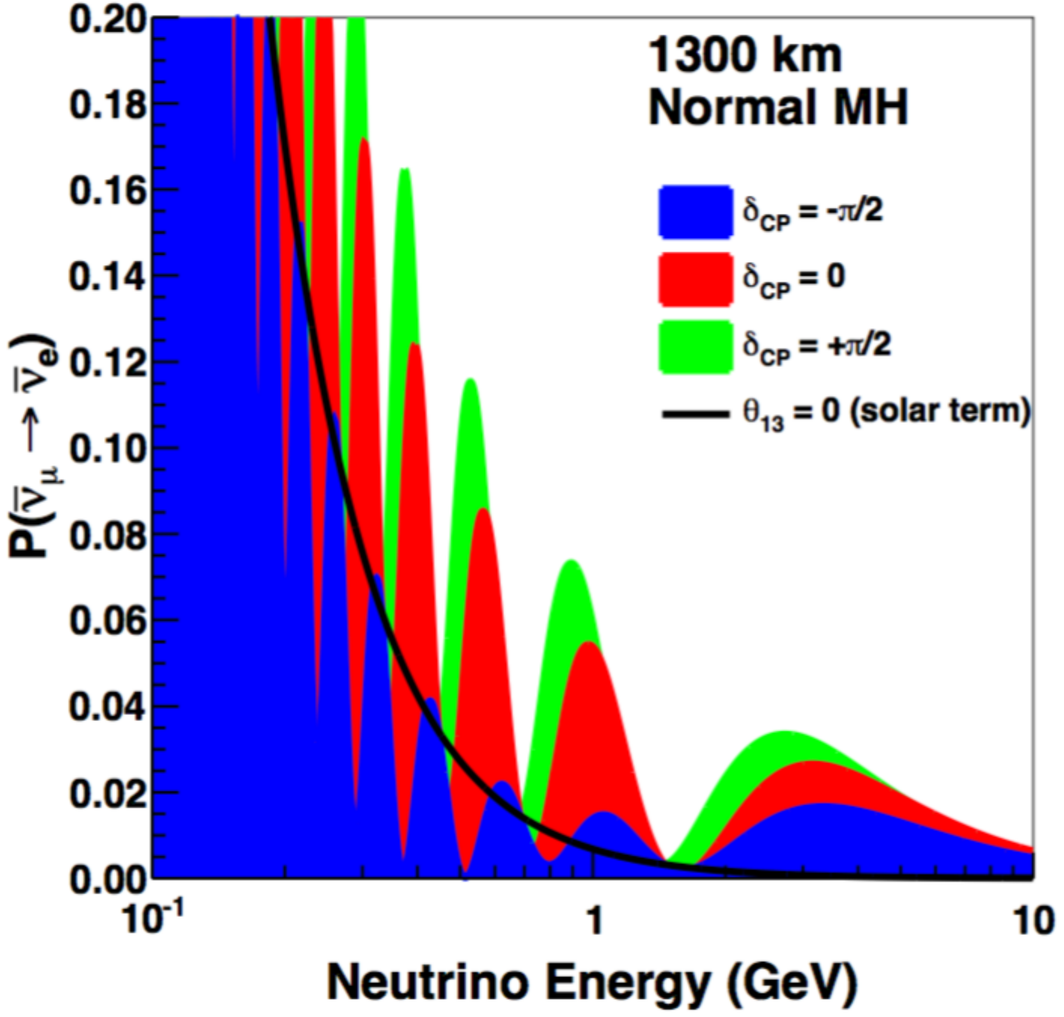


Instalaciones en SURF

Instalaciones en SURF




1300 km
Normal MH
$\delta_{CP} = -\pi/2$
$\delta_{CP} = 0$
$\delta_{CP} = +\pi/2$
$\theta_{13} = 0$ (solar term)
$P(\nu_\mu \rightarrow \nu_e)$
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
10^{-1}
1
10
Neutrino Energy (GeV)


1300 km
Normal MH
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0.20
0.18
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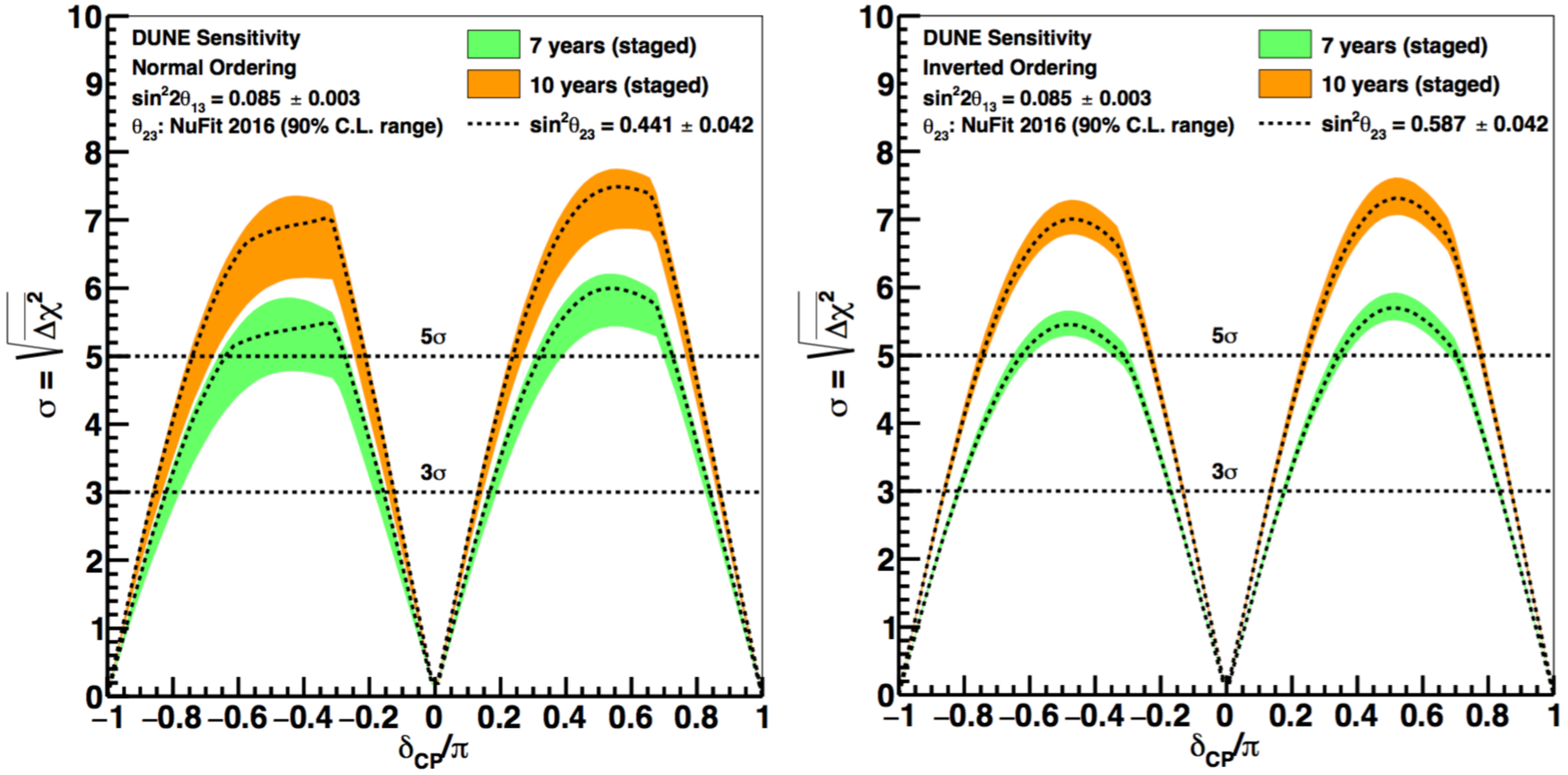
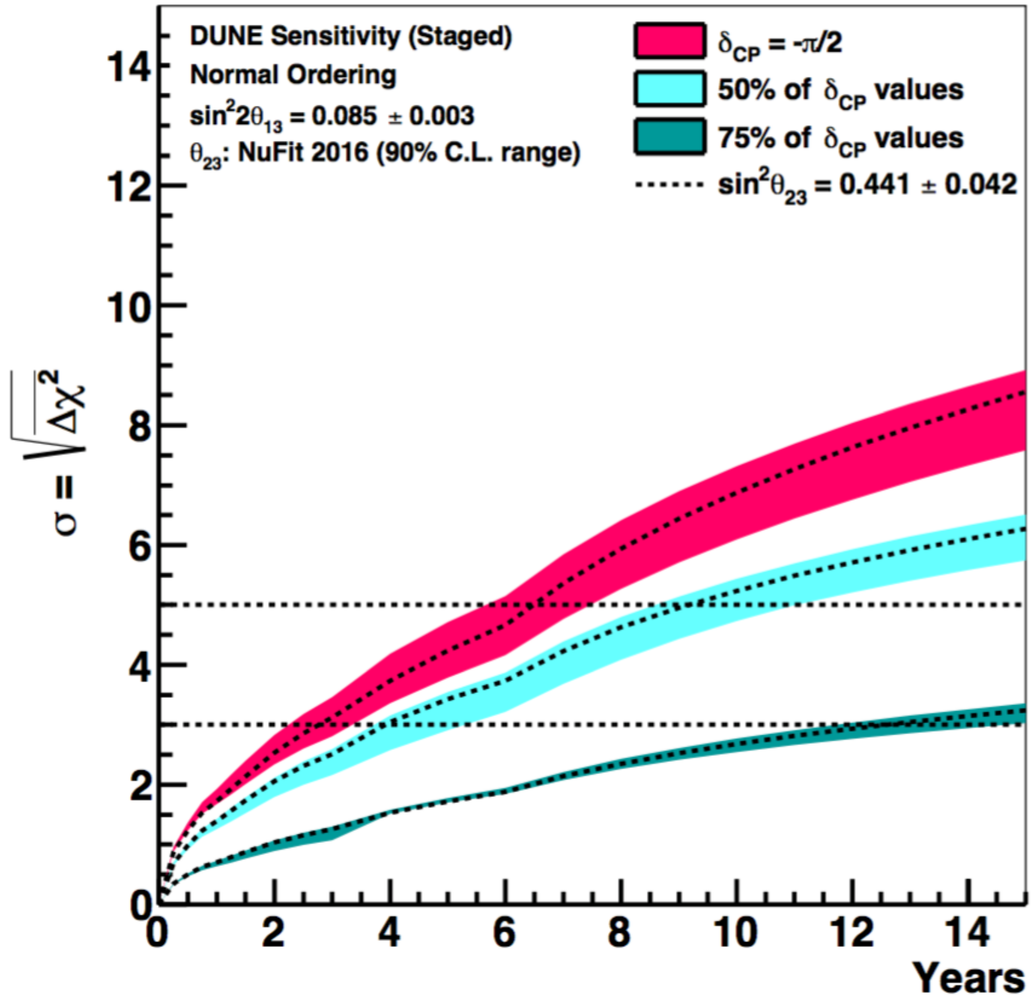
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
10^{-1}
1
10
Neutrino Energy (GeV)

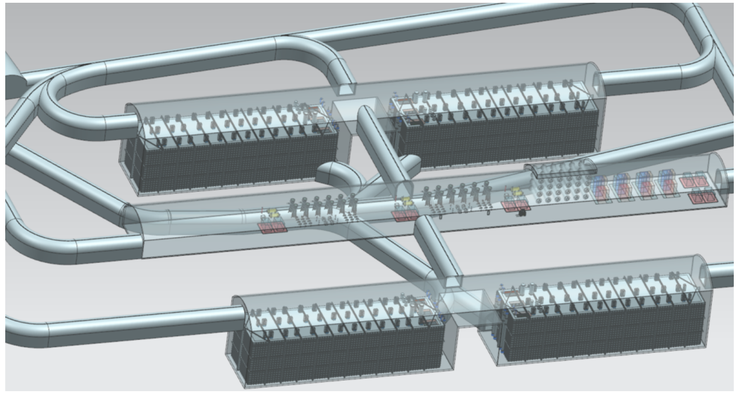
Sensitivity to CP violation

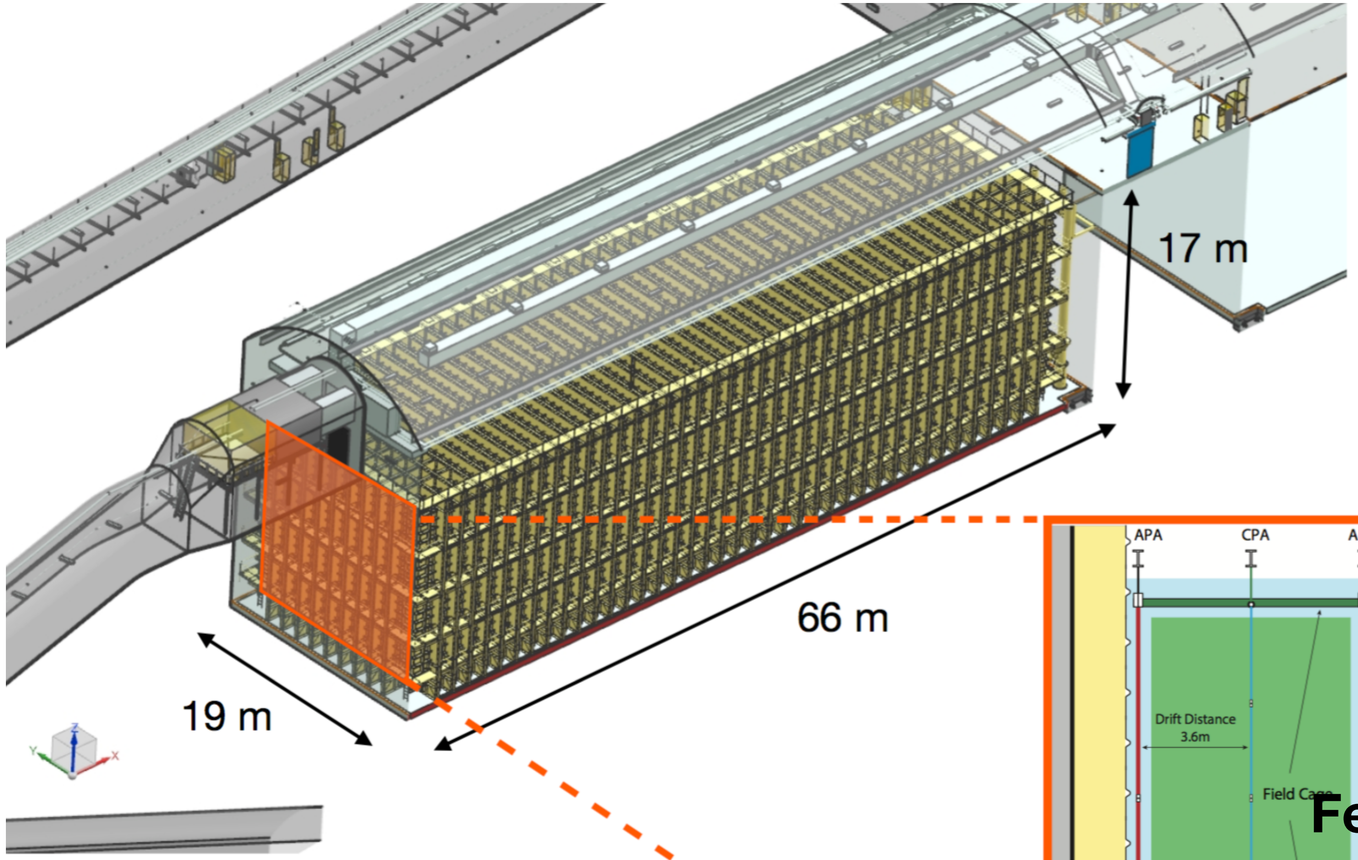


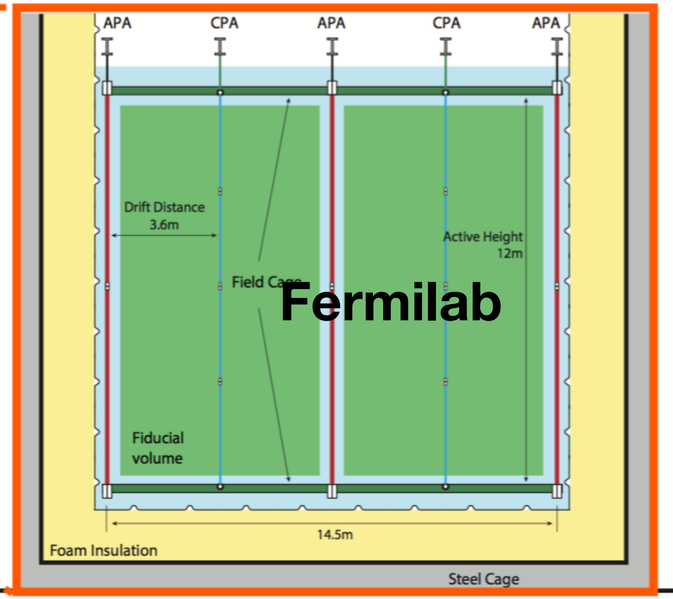
Width of bands represents range of sensitivities for the 90% CL region in θ_{23} values.
Sensitivity decreases with increasing θ_{23}.

CP Violation Sensitivity



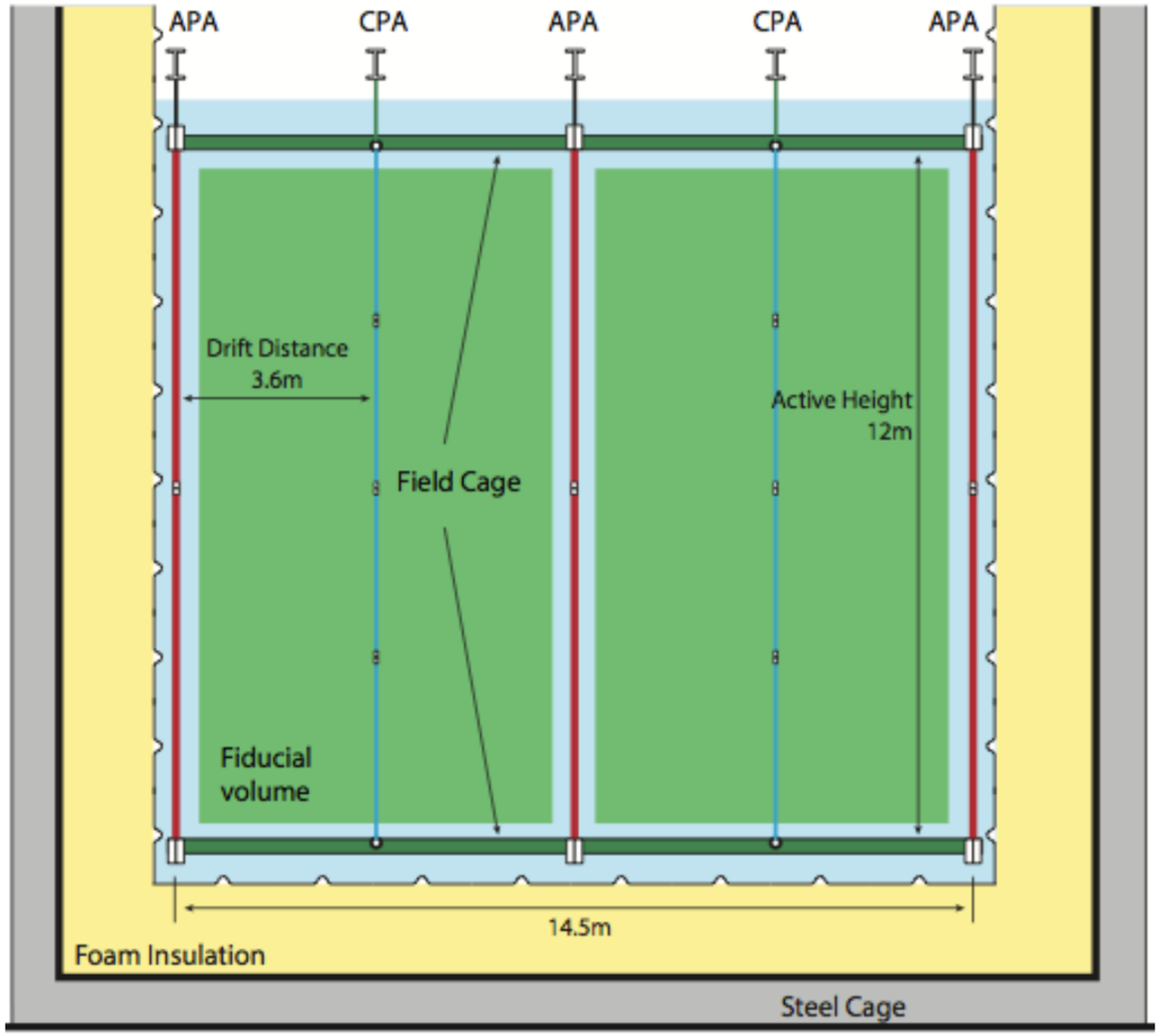


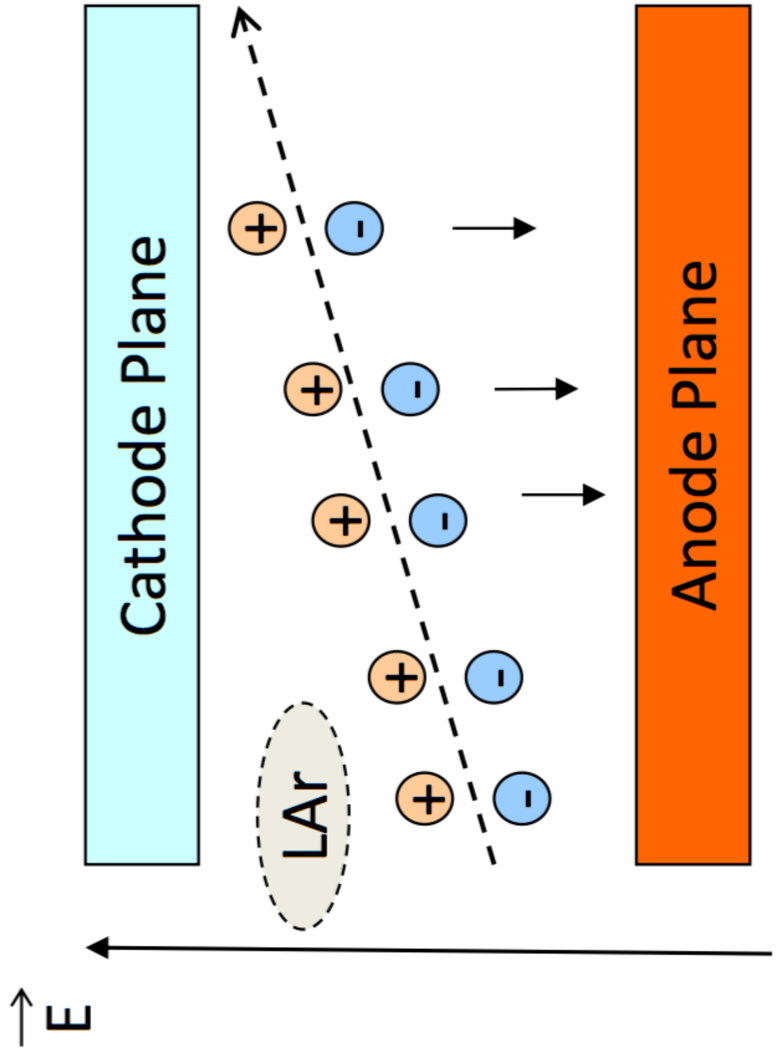

17 m
66 m
19 m


APA
CPA
APA
CPA
APA
Drift Distance
3.6m
Active Height
12m
Field Cage
Fiducial
volume
14.5m
Foam Insulation
Steel Cage

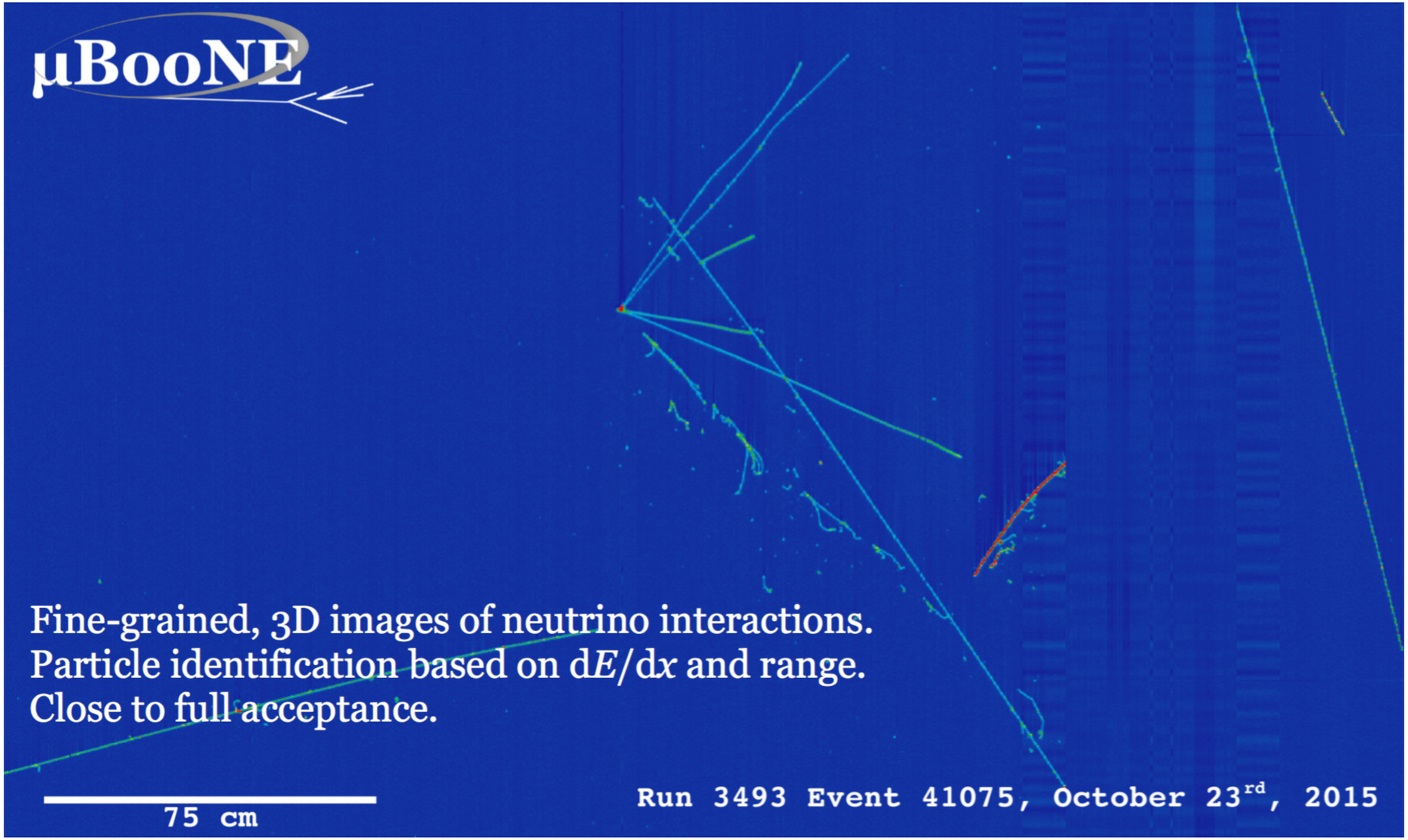
Fermilab

Time Projection Chamber (TPC)





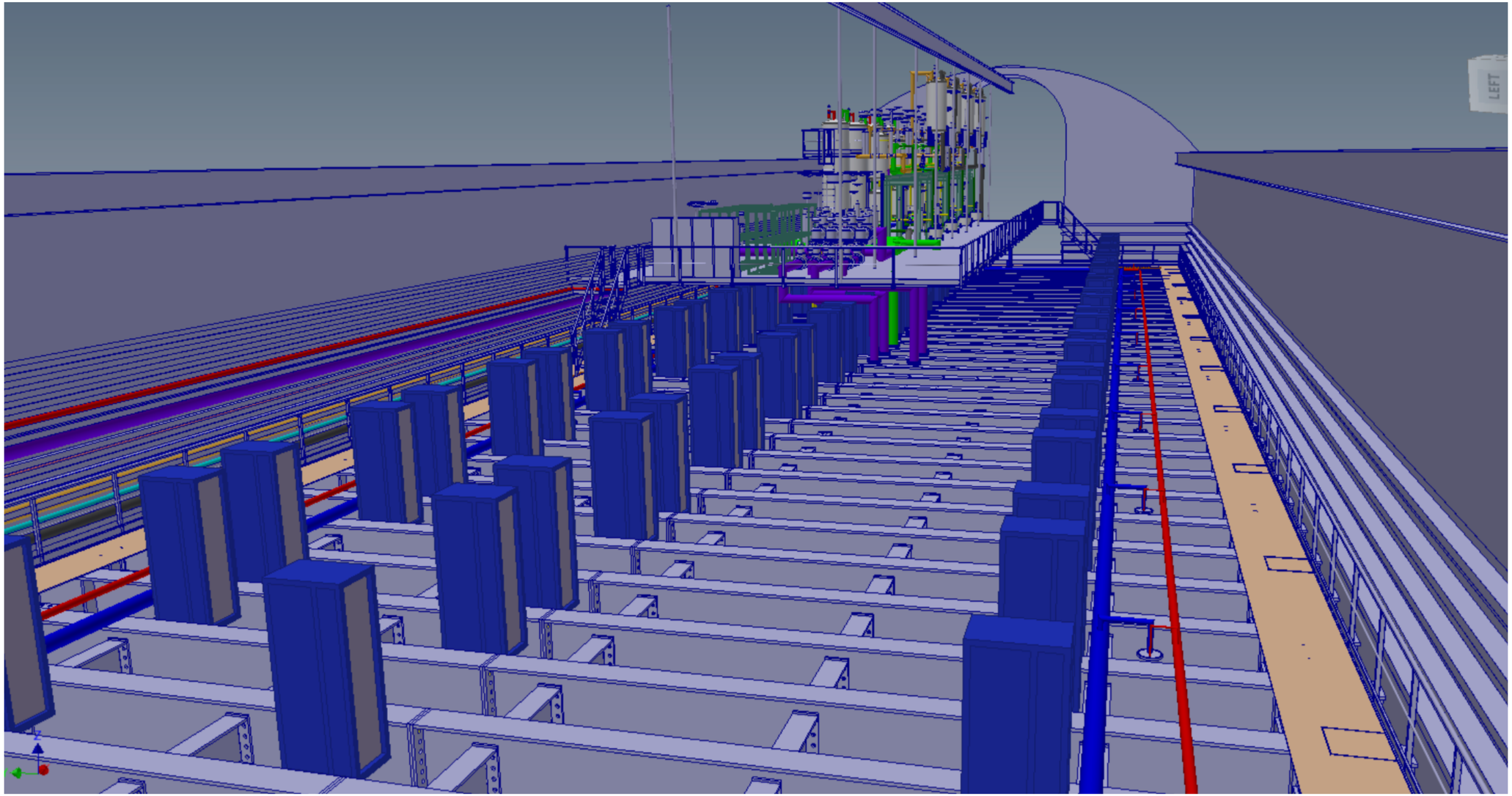
Liquid Argon events

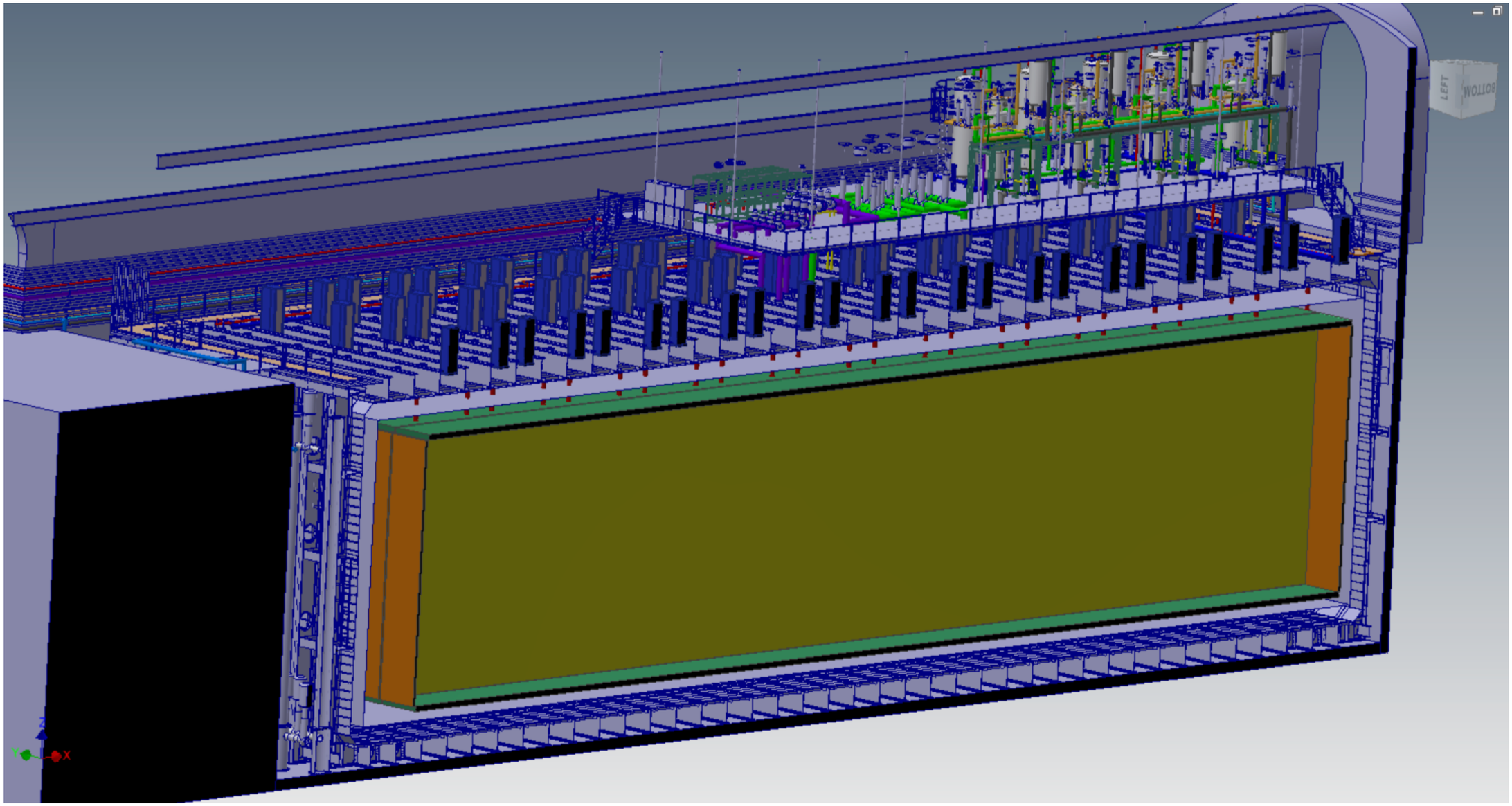


Argón Líquido

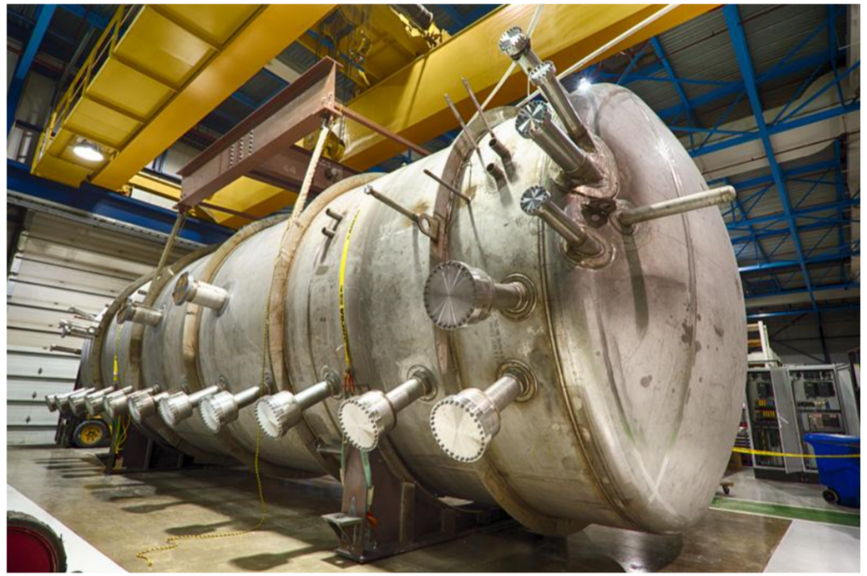
- Es un gas noble y por tanto tiene electro-negatividad 0, de forma que no absorbe los electrones producidos por el paso de una partícula
- Abundante (1% de la atmosfera) y relativamente barato (1-2 euros/litro
- Es bastante denso 1.4 g/cm^3 de forma que asegura un numero de interacciones de neutrinos razonablemente alto
- El argón se hace líquido a 88 K

DUNE cryogenics system

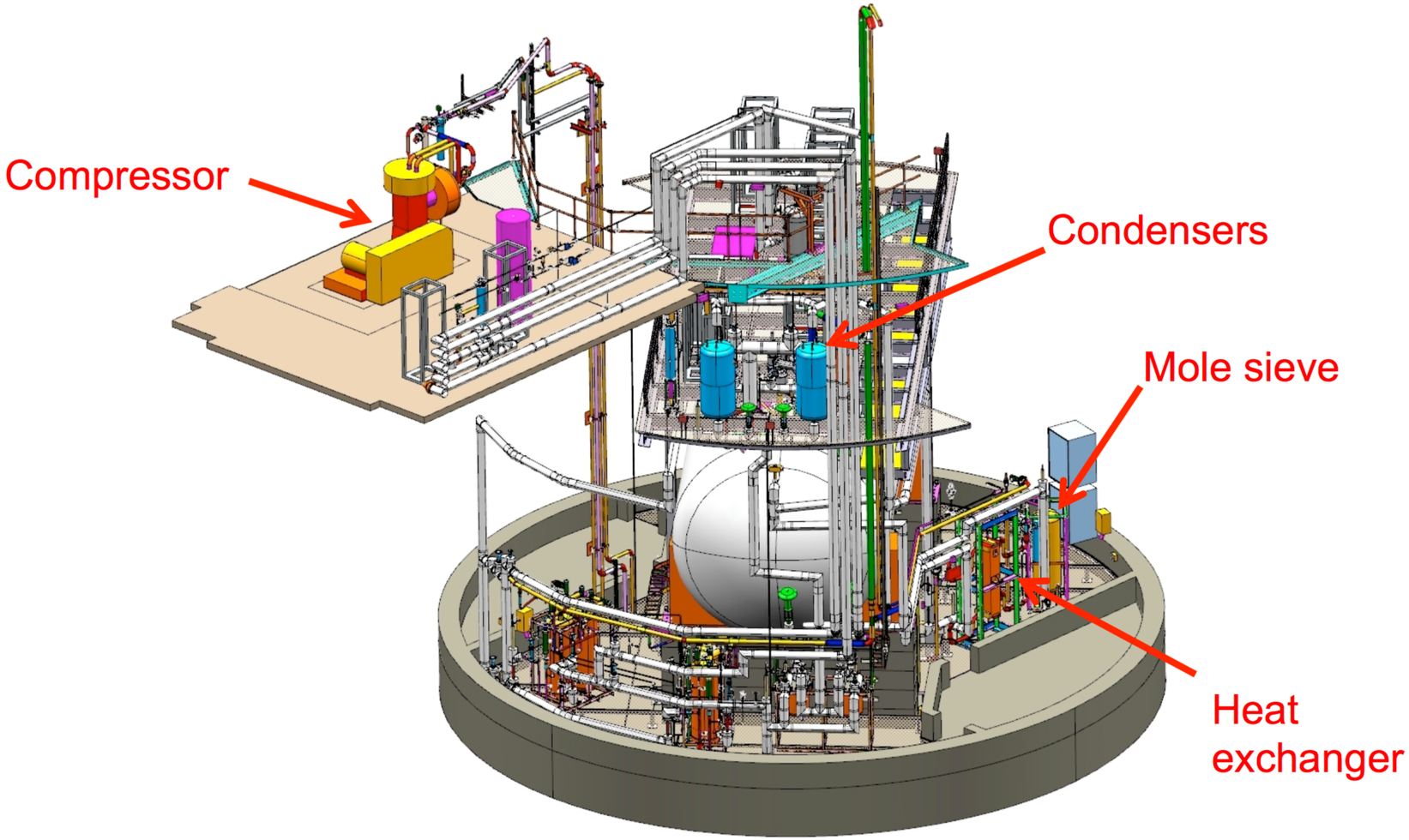



LEFT
BOTTOM

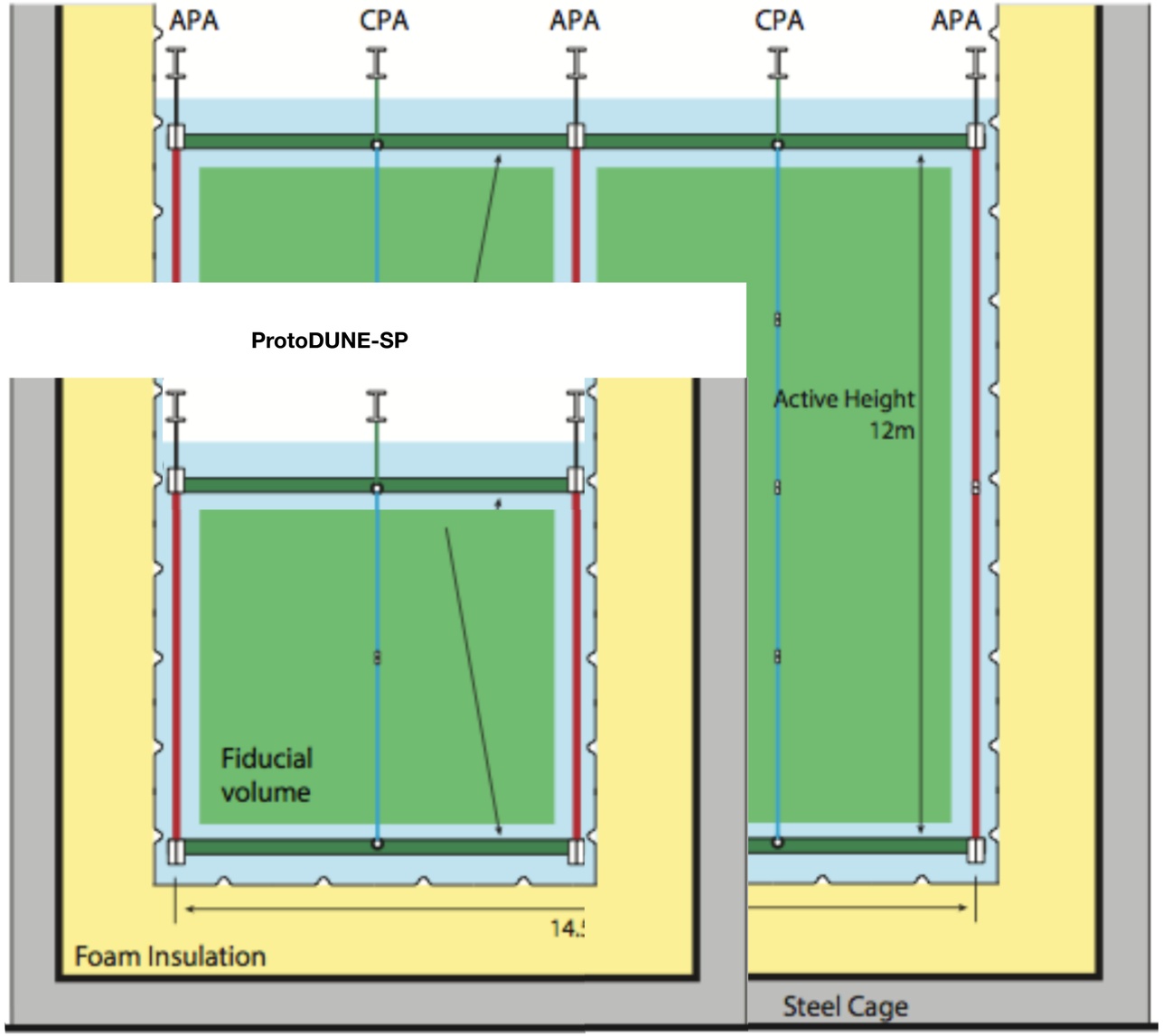
MicroBooNE cryogenics system



- MicroBooNE cryostat has a 150” diameter and is 40 ft long and 6/17” thick
- Will be insulated with spray on Polyurethane (16”) for a heat leak of ~11 W/m^2
- Will hold 170 t of LAr, fiducial volume of 60 t



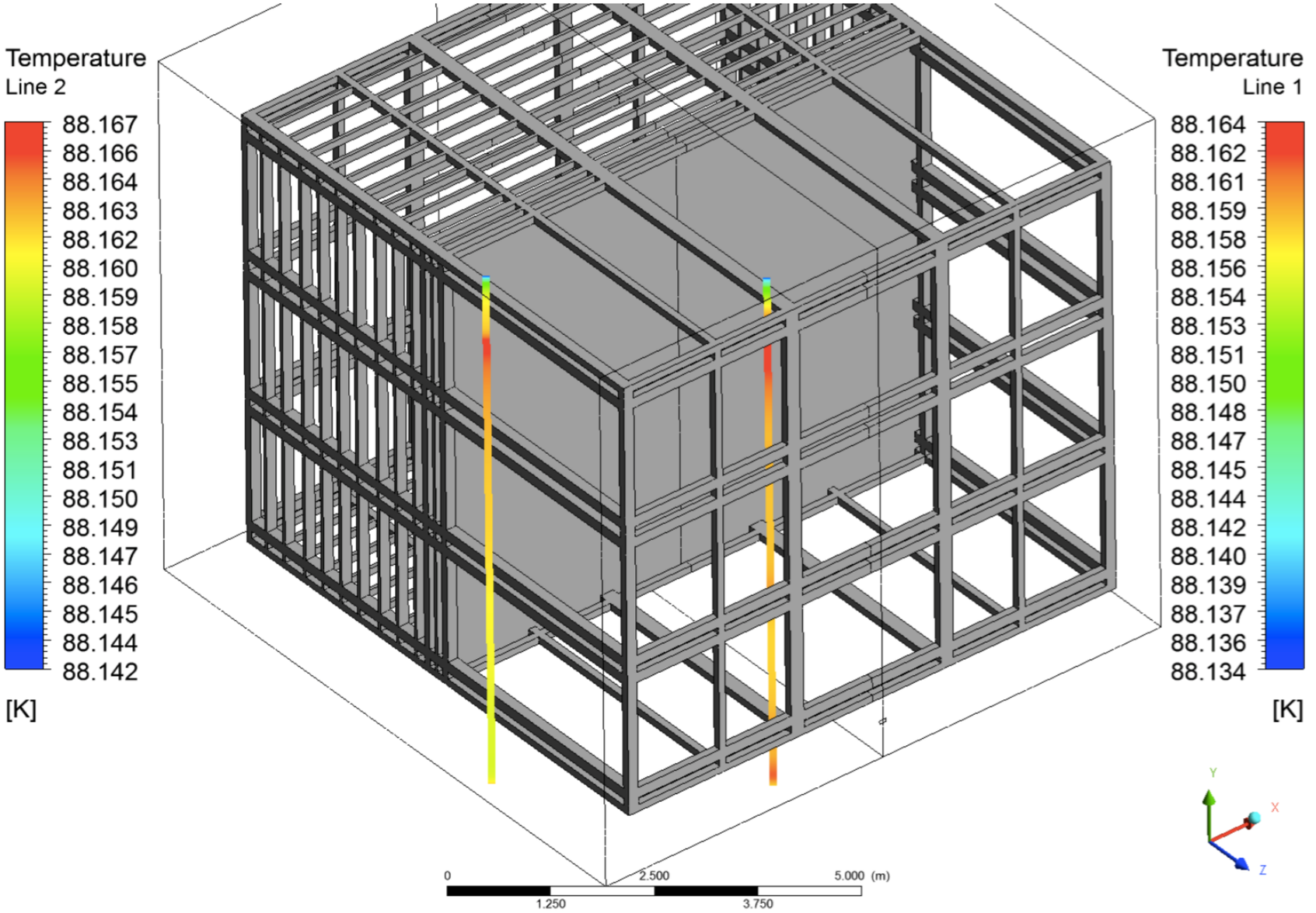
ProtoDUNE en el CERN



El sistema críogénico

- El criostato de ProtoDUNE-SP es el mas grande jamás construido: 855x790x790 cm3.
- Es crucial entender la temperatura del argón líquido en todo el criostato, pues esta no solo afecta la física (diferente velocidad de deriva de los electrones) si no también el correcto funcionamiento del sistema criogénico, incluyendo la homogeneidad y pureza del argón líquido

$\Delta T_{vertical}$ ~0.02 k



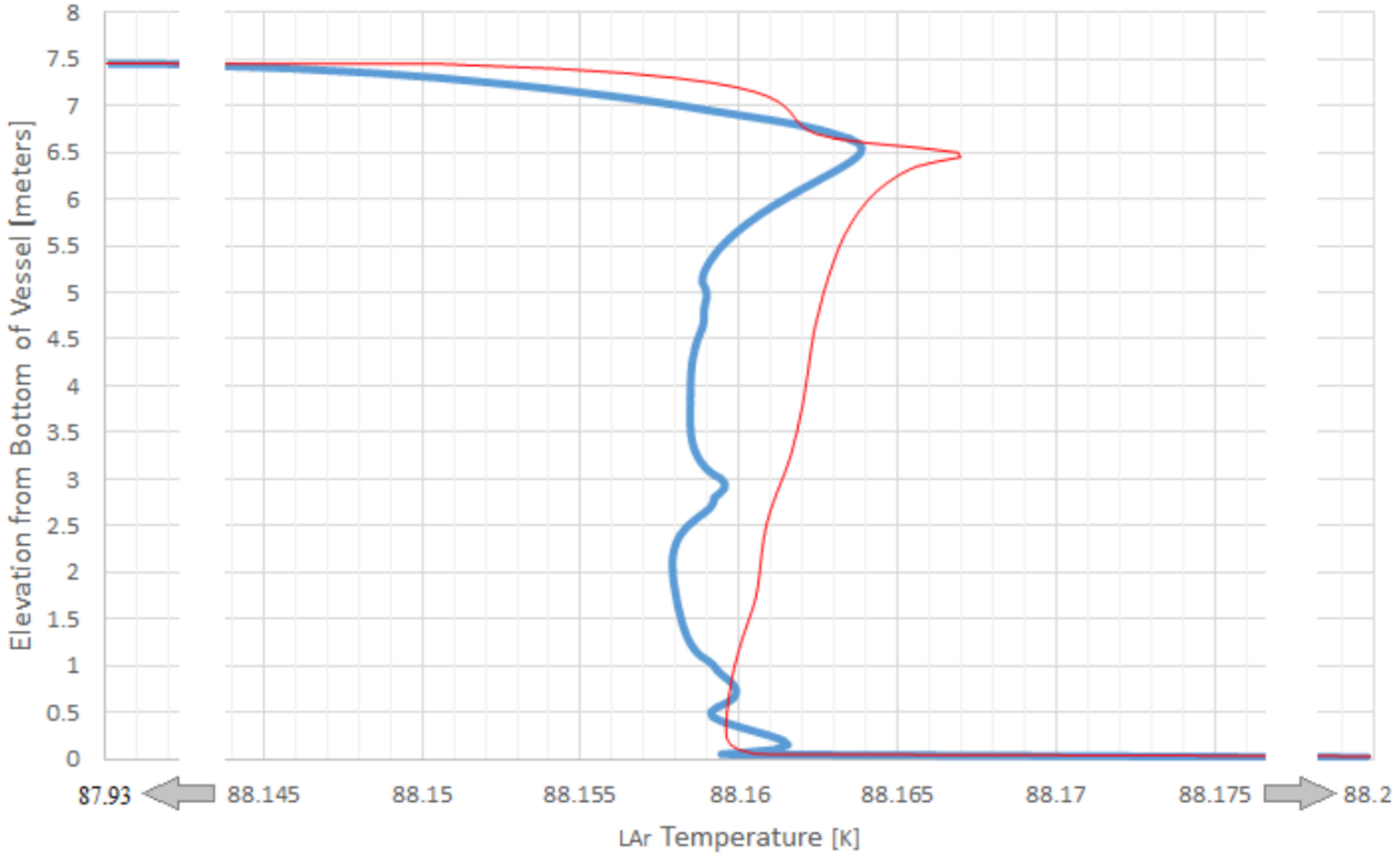
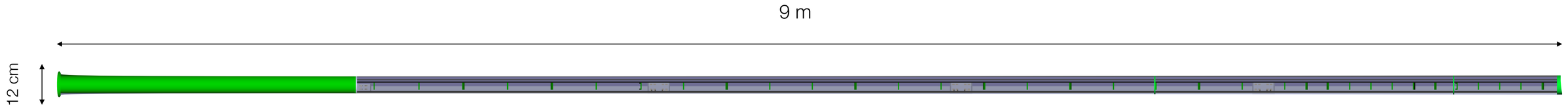


Figure 2. Liquid argon temperature as a function of height for two different locations in the cryostat


9 m
12 cm