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# SBN Program Implementation

Peter Wilson

Fermilab PAC

15 January 2015

# Outline

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SBN Program Motivation – Carlo Rubbia

SBN Oscillation Sensitivity – David Schmitz

This talk:

- SBN Program Components
  - Far Detector: T600 Refurbishment
  - Middle Detector: MicroBooNE commissioning 2015
  - Near Detector: LAr1-ND
  - Cryogenics
  - Buildings
  - Possible BNB Improvements
- Program Schedule
- Program Funding
- Organization

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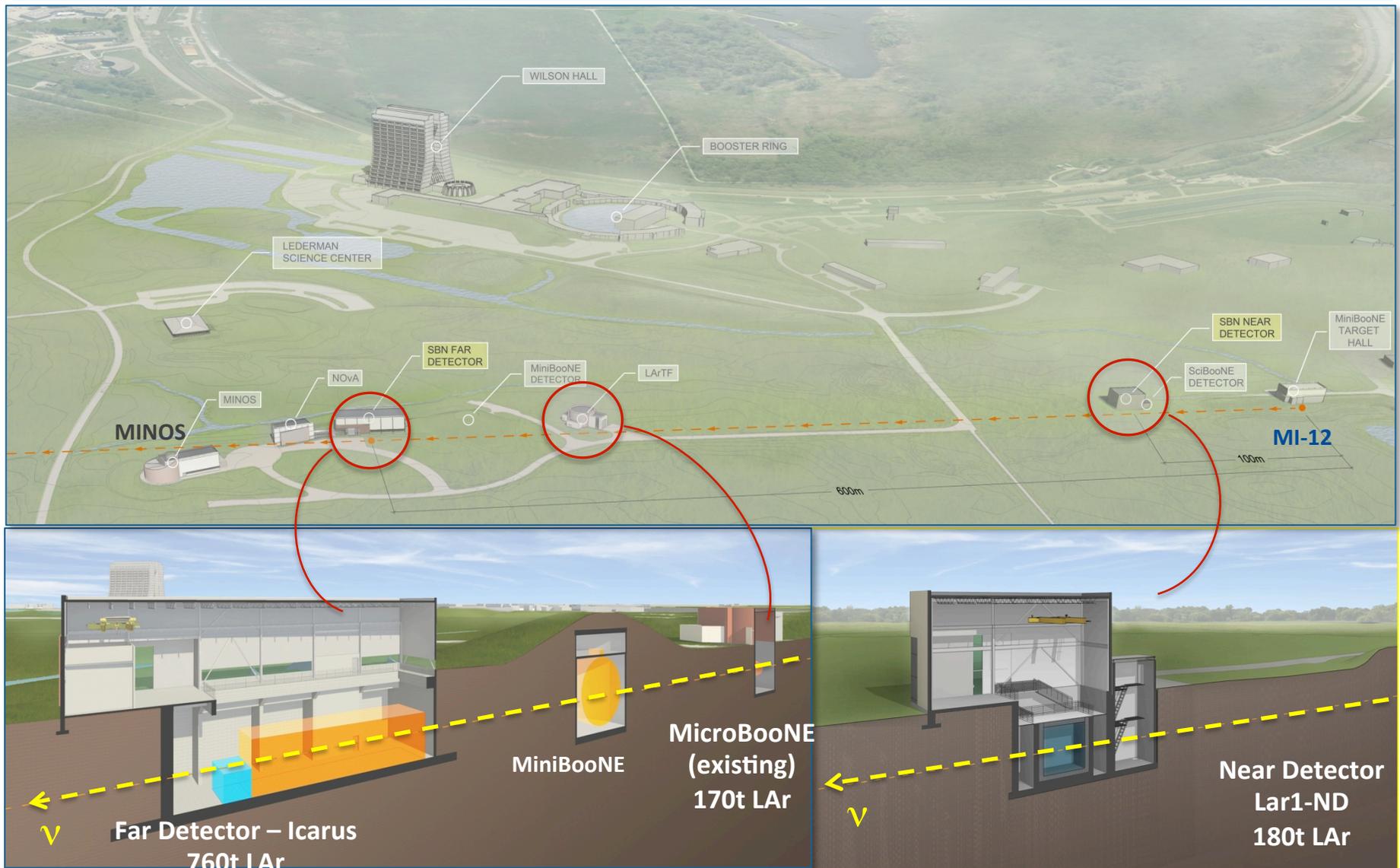
R. Acciarri<sup>10</sup>, C. Adams<sup>45</sup>, R. An<sup>13</sup>, A. Ankowski<sup>41</sup>, J. Asaadi<sup>40</sup>, L. Bagby<sup>10</sup>, B. Baller<sup>10</sup>, G. Barr<sup>30</sup>, M. Bass<sup>30</sup>, M. Bishai<sup>3</sup>, A. Blake<sup>4</sup>, T. Bolton<sup>21</sup>, C. Bromberg<sup>27</sup>, L. Bugel<sup>26</sup>, L. Camilleri<sup>9</sup>, D. Caratelli<sup>9</sup>, B. Carls<sup>10</sup>, F. Cavanna<sup>10</sup>, H. Chen<sup>3</sup>, E. Church<sup>10</sup>, G.H. Collin<sup>26</sup>, J.M. Conrad<sup>26</sup>, M. Convery<sup>39</sup>, S. Dytman<sup>34</sup>, B. Eberly<sup>39</sup>, A. Ereditato<sup>2</sup>, J. Esquivel<sup>40</sup>, B.T. Fleming<sup>45</sup>, W.M. Foreman<sup>7</sup>, V. Genty<sup>9</sup>, D. Göldi<sup>2</sup>, S. Gollapinni<sup>21</sup>, M. Graham<sup>39</sup>, E. Gramellini<sup>45</sup>, H. Greenlee<sup>10</sup>, R. Grosso<sup>8</sup>, R. Guenette<sup>30</sup>, A. Hackenburger<sup>45</sup>, O. Hen<sup>26</sup>, J. Hewes<sup>25</sup>, J. Ho<sup>7</sup>, G. Horton-Smith<sup>21</sup>, C. James<sup>10</sup>, C.M. Jen<sup>41</sup>, R.A. Johnson<sup>8</sup>, B.J.P. Jones<sup>26</sup>, J. Joshi<sup>3</sup>, H. Jostlein<sup>10</sup>, D. Kaleko<sup>9</sup>, L. Kalousis<sup>41</sup>, G. Karagiorgi<sup>25</sup>, W. Ketchum<sup>24</sup>, B. Kirby<sup>3</sup>, M. Kirby<sup>10</sup>, T. Kobilarcik<sup>10</sup>, I. Kreslo<sup>2</sup>, Y. Li<sup>3</sup>, B. Littlejohn<sup>13</sup>, D. Lissauer<sup>3</sup>, S. Lockwitz<sup>10</sup>, W.C. Louis<sup>24</sup>, M. Lu<sup>□thi</sup>, B. Lundberg<sup>10</sup>, A. Marchionni<sup>10</sup>, C. Mariani<sup>41</sup>, J. Marshall<sup>4</sup>, K. McDonald<sup>35</sup>, V. Meddage<sup>21</sup>, T. Miceli<sup>28</sup>, G.B. Mills<sup>24</sup>, J. Moon<sup>26</sup>, M. Mooney<sup>3</sup>, M.H. Moulai<sup>26</sup>, R. Murrells<sup>25</sup>, D. Naples<sup>34</sup>, P. Nienaber<sup>36</sup>, O. Palamara<sup>6,10</sup>, V. Paolone<sup>34</sup>, V. Papavassiliou<sup>28</sup>, S. Pate<sup>28</sup>, Z. Pavlovic<sup>10</sup>, S. Pordes<sup>10</sup>, G. Pulliam<sup>40</sup>, X. Qian<sup>3</sup>, J.L. Raaf<sup>10</sup>, V. Radeka<sup>3</sup>, R. Rameika<sup>10</sup>, B. Rebel<sup>10</sup>, L. Rochester<sup>39</sup>, C. Rudolf von Rohr<sup>2</sup>, B. Russell<sup>45</sup>, D.W. Schmitz<sup>7</sup>, A. Schukraft<sup>10</sup>, W. Seligman<sup>9</sup>, M. Shaevitz<sup>9</sup>, M. Soderberg<sup>40</sup>, J. Spitz<sup>26</sup>, J. St. John<sup>8</sup>, T. Strauss<sup>2</sup>, A.M. Szelc<sup>25,45</sup>, N. Tagg<sup>29</sup>, K. Terao<sup>9</sup>, M. Thomson<sup>4</sup>, C. Thorn<sup>3</sup>, M. Touns<sup>26</sup>, Y. Tsai<sup>39</sup>, T. Usher<sup>39</sup>, R. Van de Water<sup>24</sup>, M. Weber<sup>2</sup>, S. Wolbers<sup>10</sup>, T. Wongjirad<sup>26</sup>, K. Woodruff<sup>28</sup>, M. Xu<sup>13</sup>, T. Yang<sup>10</sup>, B. Yu<sup>3</sup>, G.P. Zeller<sup>10</sup>, J. Zennaro<sup>7</sup>, and C. Zhang<sup>3</sup>

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# SBN Program Layout



# Far Detector: ICARUS-T600

- Successful operation at Gran Sasso in CNGS beam
  - Achieved electron lifetime  $>15\text{ms}$
  - Physics program including limits on sterile neutrinos
- ICARUS-WA104 collaboration: refurbish at CERN w/new cryostats and electronics, upgraded light detection
  - ✓ MOU between INFN and CERN approved
  - ✓ Move from Gran Sasso to CERN Dec 2014
  - ✓ Refurbishing started
- Schedule: TPC delivered to FNAL as soon as the building is available, currently foreseen as early 2017

Ready to  
leave LNGS

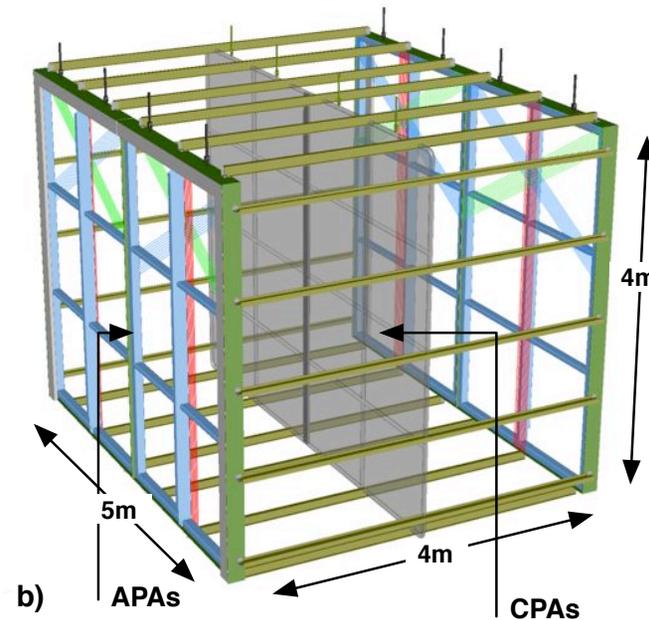
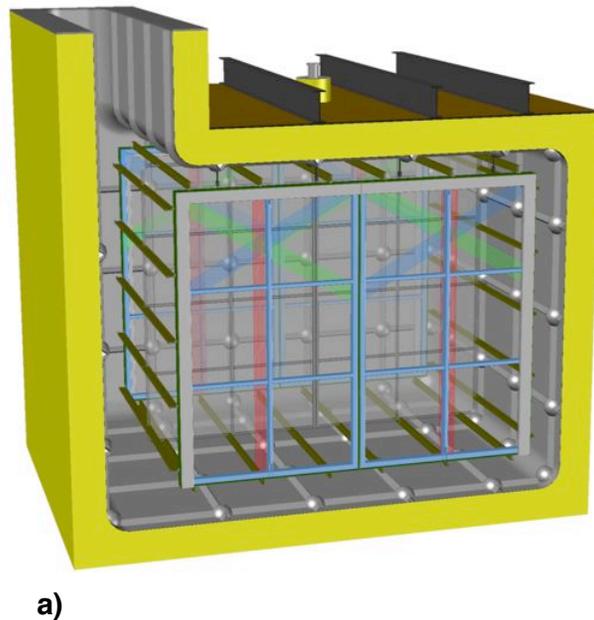


First T300 in  
Cleanroom at  
CERN



## Near Detector: LAr1-ND

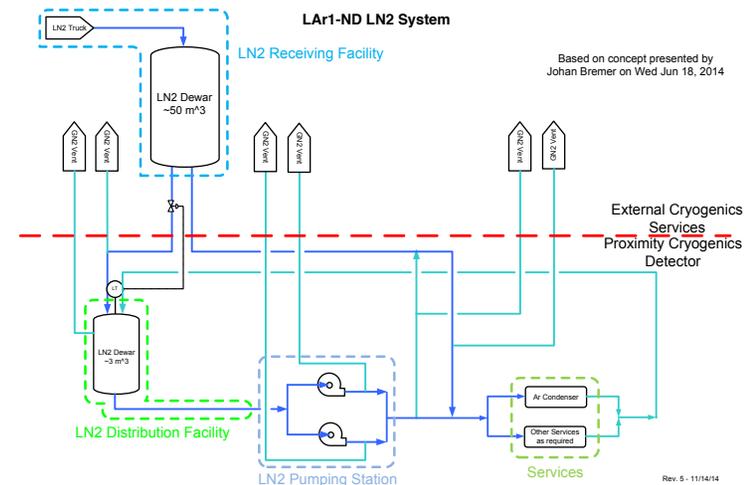
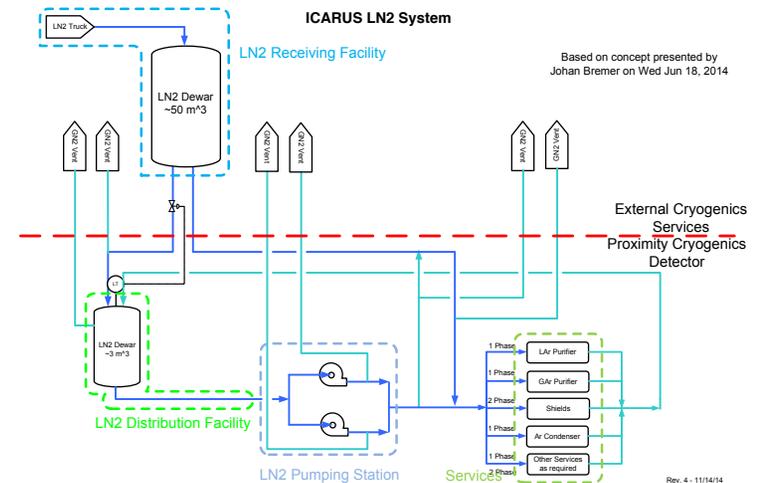
- Conceptual design included in proposal
- Preliminary designs started
  - TPC, cold electronics, laser calibration
  - Cryostat
- Technical design reviews in 2015
- Working on coordination with LBNF designs
  - eg cold electronics for CERN prototype compared to LAr1-ND
- Schedule: Final TPC assembled at FNAL early 2017



# Common Systems: Cryogenics Infrastructure

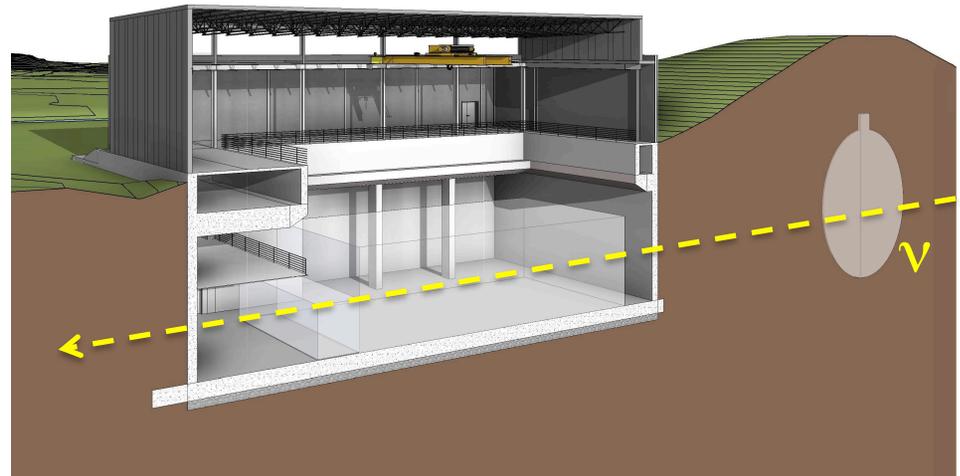
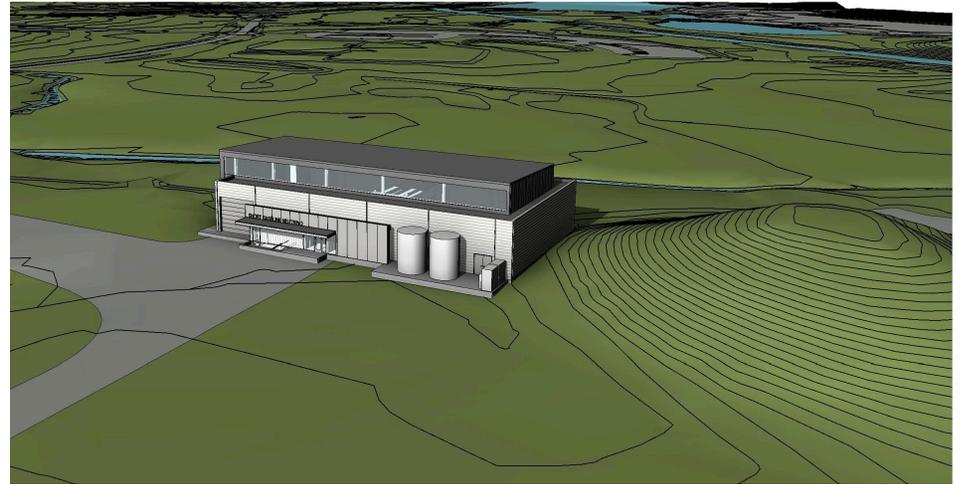
- Cryogenics teams for LAr detectors formed at CERN/INFN and Fermilab
  - Coordinated efforts on SBN and LBN
  - Fermilab cryogenics engineer based at CERN for calendar 2015
- Common designs wherever possible across multiple LAr-TPCs, e.g.
  - SBN: LN2 delivery (see right)
  - Cryostat design between LAr1-ND, WA104, LBNF CERN prototype
- LAr filtration design for LAr1-ND builds on experience from T600, LAPD/LBNE 35ton, MicroBooNE.
- Refurbishing for T600 cryogenics
- Cryogenics systems scheduled for delivery to Fermilab in early to mid-2017, installation in parallel with the detectors

## SBN LN2 Delivery Systems



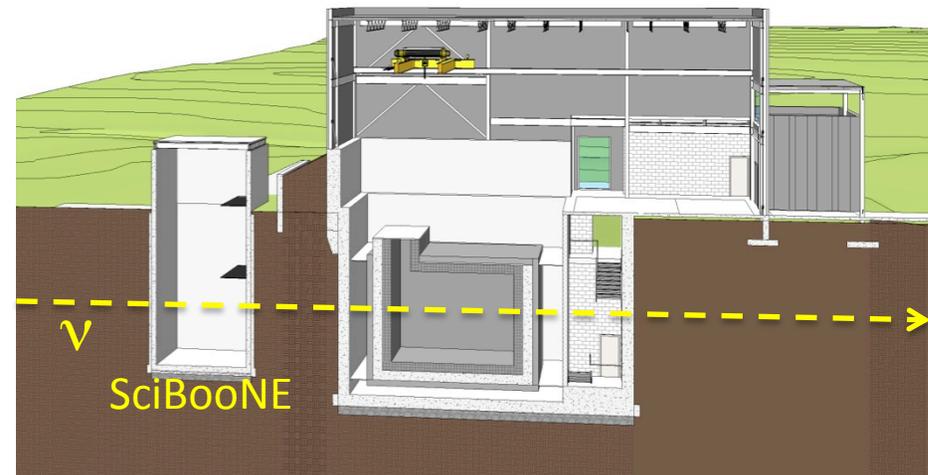
# Far Detector Building

- Designed with removable roof for installation of T600 cryostats
- Structure to support 3m concrete overburden covering detector inside the building
- Design status:
  - Final design started in November
  - Internal review at ~ 60% design completion next week
  - Complete by end of March
- Break ground in late spring 2015 and beneficial occupancy in fall 2016.



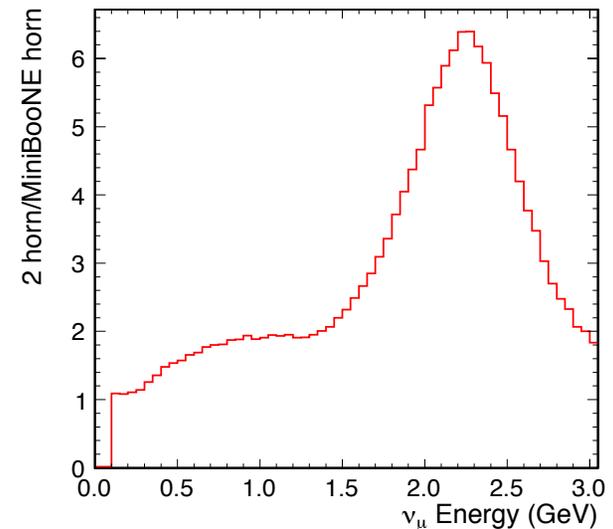
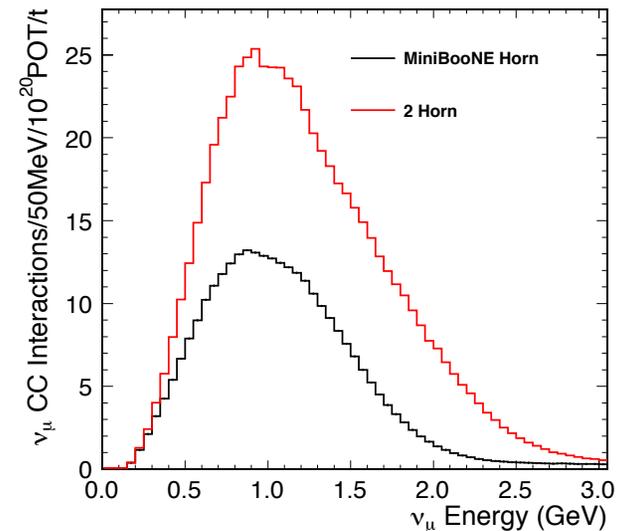
# Near Detector Building

- Structure to support 3m concrete overburden covering detector inside the building
- Design status:
  - Final design started in January
  - Complete in May 2015
- Break ground in late summer 2015 and beneficial occupancy in fall 2016.
- Exploring option of cryogenics in surface extension of near detector building
  - Preserves SciBooNE hall for a detector rather than infrastructure
  - Little or no impact on LAr1-ND cryogenics cost
  - Initial estimate of ~\$300k additional construction cost



# BNB Improvements

- Increased  $\nu$  statistics would further secure the program sensitivity
  - More protons on target
  - Higher  $\nu$  production efficiency
- BNB  $\nu$  energy distribution optimized of MiniBooNE Cherenkov detector
  - LAr-TPCs can tolerate high energy tail
- Reconfiguration to a two horn system could provide factor of two more  $\nu$ /p.o.t.
- Modest reconfiguration of proton beamline provides space for 2<sup>nd</sup> horn
- Cost will be in new horn(s), power supply(ies) and collimator
- Detailed cost and schedule estimate needed



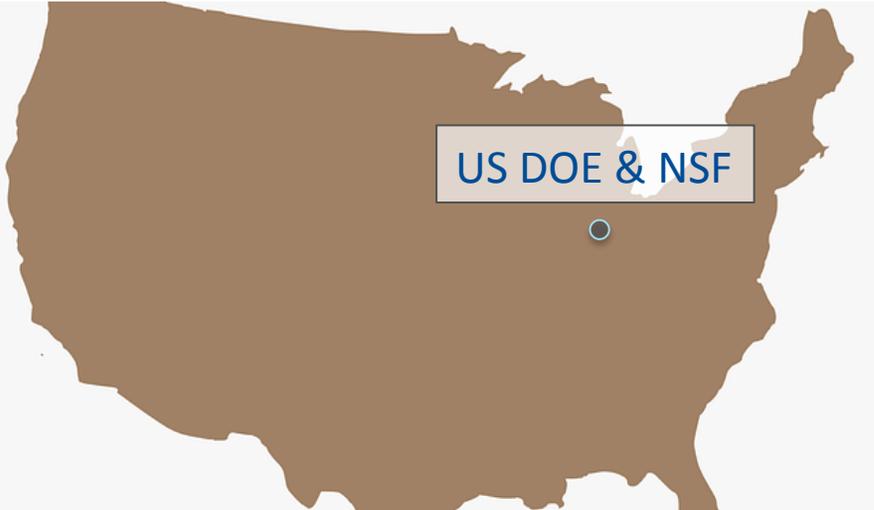
# Milestones for Near and Far Detector Delivery

- Schedule assumes approval by PAC at this meeting ✓
- After the PAC will look for every opportunity to advance this schedule ✓  
Today
- Detailed schedule based on bottoms up estimate under development ✓
  - Starting with near detector and new cryostat/ cryogenics work
  - Needed for review proposed for spring 2015
- Readiness reviews prior to production and installation

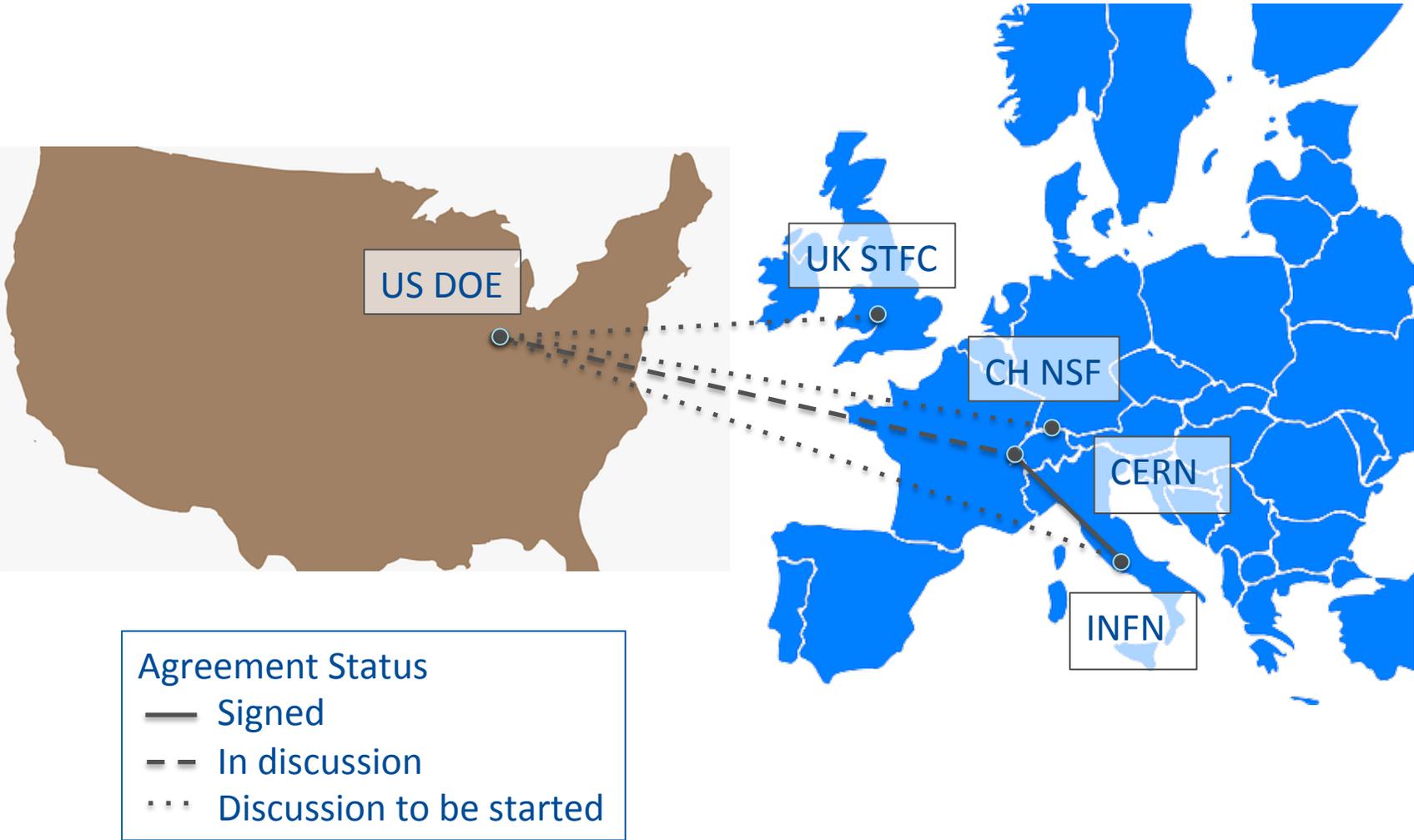
Milestone	Date
Far Detector building: final CE requirements and start final design	Nov 2014
Far Detector: T600 at CERN and refurbishing starts	Dec 2014
Submit SBN proposal to PAC	Dec 2014
Near Detector: Start preliminary design of TPC and installation	Dec 2014
PAC Review of SBN Proposal	Jan 2015
Near Detector cryostat: Start preliminary design	Jan 2015
Cryogenic plants: Start preliminary design	Jan 2015
Draft MOUs: e.g. Fermilab-INFN, Fermilab-CERN, Fermilab-CH-NSF	Feb 2015
Near Detector building: final CE requirements and start final design	Feb 2015
Independent Review of Near Detector, ND Cryostat and ND Cryogenics (CD-1/2 like)	May 2015
Independent Review of Far Detector refurbishing, cryogenics and installation planning	May 2015
Far Detector building: ground breaking	May 2015
Near Detector building: ground breaking	Aug 2015
Independent review of near detector production readiness	Nov 2015
Independent review of far detector production readiness	Nov 2015
Near Detector building: beneficial Occupancy	Sept 2016
Independent review of installation readiness for near and far detectors	Oct 2016
Far Detector building: beneficial Occupancy	Nov 2016
Near Detector cryostat: start installation	Nov 2016
Far Detector cryostat: start installation	Dec 2016
Far Detector: ICARUS-T600 ready at CERN for transport	Dec 2016
Near and Far Detector Buildings Complete	Jan 2017
Far Detector: start T600 installation	Mar 2017
Near Detector: Start LAr1-ND installation	April 2017
Far Detector: T600 Installed	May 2017
Near Detector: LAr1-ND Installed	July 2017
Far Detector: Cryogenic plant complete	Aug 2017
Near Detector: Cryogenic plant complete	Oct 2017
Start detectors cooling and commissioning	Nov 2017
Start data taking with beam	Apr 2018



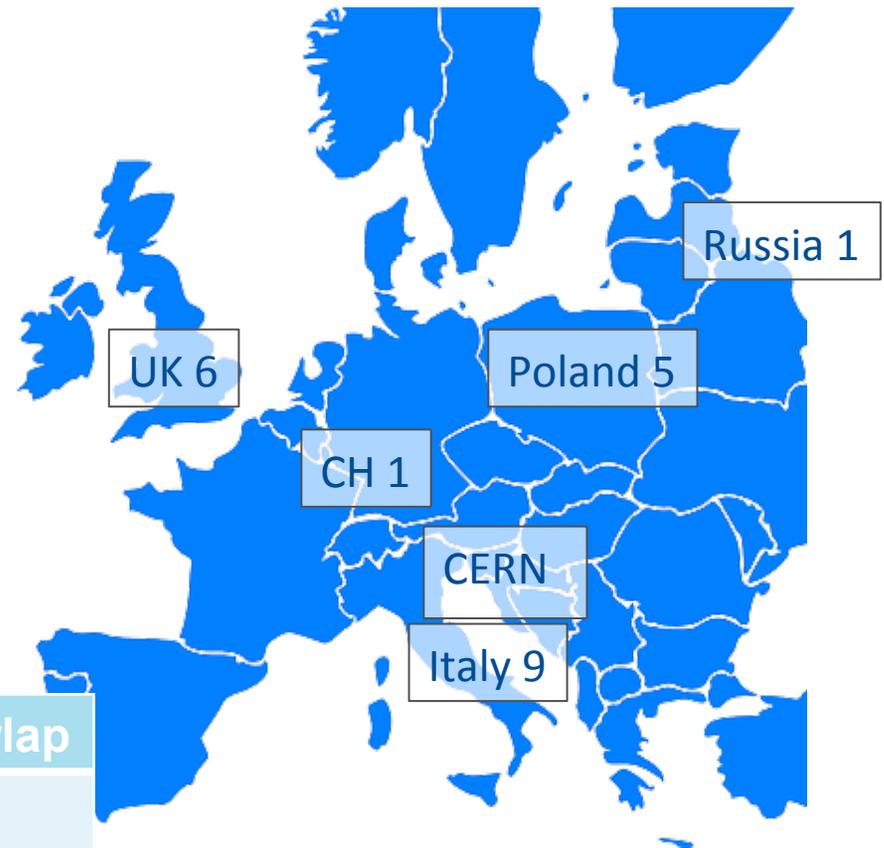
# Main Funding Sources



# Main International Agreements



# SBN Institutions and Authors



Collaboration	Authors	Overlap
ICARUS-WA104	57	} 6 } 59
LAr1-ND	108	
MicroBooNE	118	
<b>All SBN (excl overlaps)</b>	<b>218</b>	

# FTEs for Delivery of Detectors

- Total effort of about 75 FTE per year covering T600, LAr1-ND and infrastructure
  - Includes scientific and technical labor
- Effort not included:
  - Work on: MicroBooNE, BNB, and civil construction
  - Contracted labor

ICARUS-WA104 T600 group	Manpower (FTE)
Gran Sasso Science Institute (GSSI)	1
INFN, Sezione di Catania	2.5
INFN, Sezione di Milano	1.5
INFN, Sezione di Milano Bicocca	0.5
INFN, Laboratori Nazionali del Gran Sasso (LNGS)	1
INFN, Sezione di Napoli	0.5
INFN, Sezione di Padova	7
INFN, Sezione di Pavia	6
CERN Neutrino group and services	9
<b>Total</b>	<b>30</b>

LAr1-ND Group	Average FTE/yr
Univ. of Bern	4
Univ. of Chicago	2
Columbia Univ.	2.3
Indiana Univ.	1
MIT	2
Syracuse Univ.	1.5
Yale Univ.	1.5
Cambridge, Lancaster, Liverpool, Manchester, Sheffield, UCL	5.9
ANL	1.5
BNL	7
FNAL	12.5
LANL	2.7
<b>LAr1-ND Total</b>	<b>43.9</b>

General FNAL SBN Effort	5.5
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# SBN Organization

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- SBN task force was charged by Fermilab, CERN, and INFN with delivery of the SBN proposal to the PAC.
  - The SBN proposal is the product of a close collaboration between members of all three experimental collaborations
  - Mission will (hopefully) be completed at this meeting
- Moving forward need to execute two distinct aspects of the program leading up to beam operations:
  1. Completion of the three detectors: MicroBooNE commissioning, ICARUS refurbishing and LAr1-ND construction. Requires:
    - Completion of international agreements
    - Establish international oversight and review
  2. Preparations for the physics analysis program including Monte Carlos, reconstruction software etc

# Conclusions

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- The SBN program can make a definitive statement on the LSND and MiniBooNE anomalies with the potential for a ground breaking discovery in neutrino physics.
- The SBN program brings together three LAr-TPC detectors developed by leading teams of scientists and engineers from Europe and the US:
  - ICARUS** - the only large-scale LAr-TPC in the world exposed to a neutrino beam
  - MicroBooNE** - the largest LAr-TPC built in the US, starting operations in 2015.
  - LAr1-ND** - providing a new opportunity for development on the path to LBNF
- The combination of these three detectors and associated collaborations represents a tremendous scientific and R&D opportunity toward the future LBN program.

# Conclusions

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We have outlined today an exciting opportunity for Fermilab and the international neutrino community. We request the following actions:

1. Approval of the three detector SBN program to move forward quickly to next steps.
2. Approval of T600 as far detector.
3. Approval of LAr1-ND (T1053) as near detector to move to a technical design to be reviewed in 2015.
4. Approval to complete final design of the near and far detector buildings and start construction of the far detector building in spring 2015 and near detector building in summer 2015.
5. Provide resources to develop a cost and schedule for BNB reconfiguration into a two horn system in collaboration with CERN. Study to be completed before Summer PAC.

# T600 Entering CERN Cleanroom



# Institution List

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- <sup>8</sup>University of Cincinnati, Cincinnati, OH
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LAr1-ND	108	
MicroBooNE	118	
<b>SBN Total (excl overlaps)</b>	<b>218</b>	

Country	Institutions
International (CERN)	1
Italy	9
Poland	5
Russia	1
Switzerland	1
UK	6
USA	22
<b>SBN Total</b>	<b>45</b>