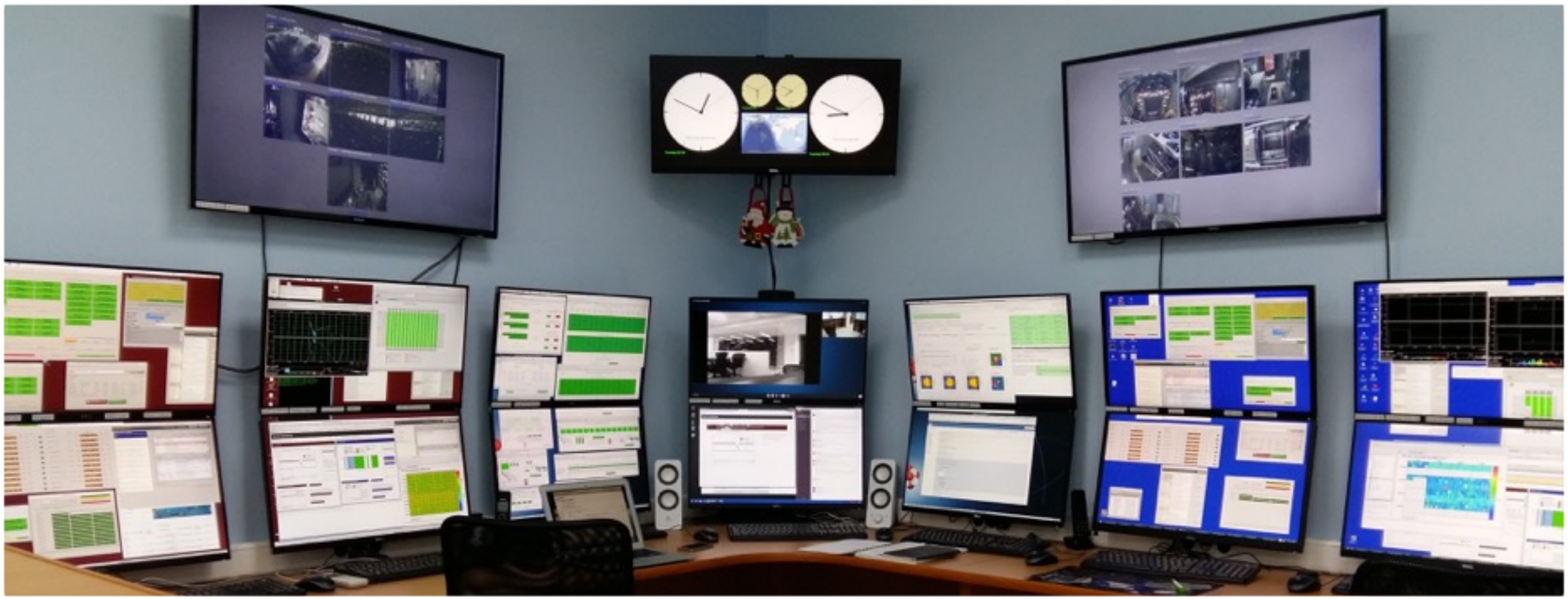


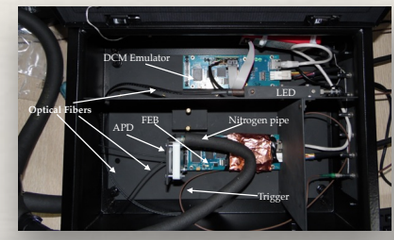
GRID-2016, Operation-Monitoring-Optimization Section, July 5, 2016

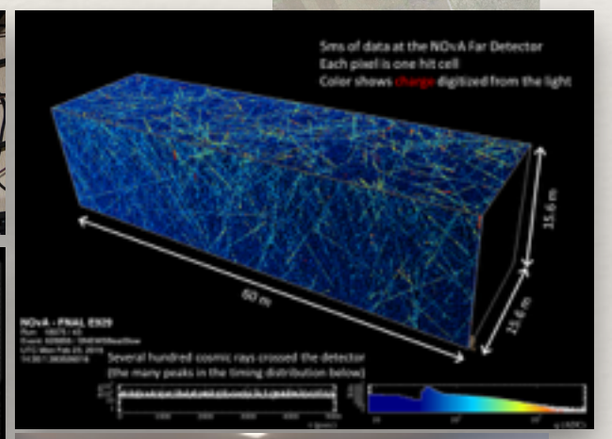
Remote Operation Center at Dubna for NOvA experiment

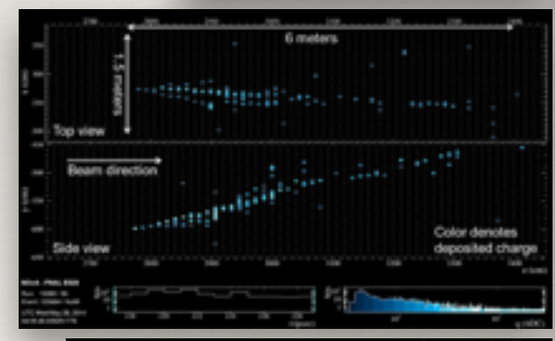
Nikolay Anfimov (DLNP)
Alexander Antoshkin (DLNP)
Nikita Balashov (LIT)
Christopher Kullenberg (DLNP)
Oleg Samoylov (DLNP)
Andrey Sheshukov (DLNP)

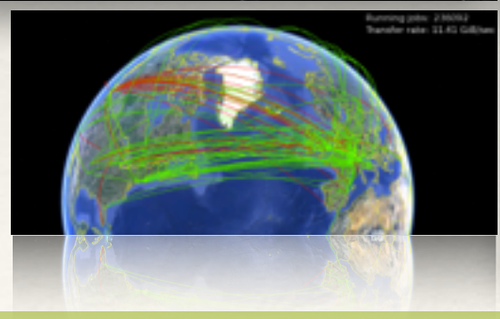
Outline

- **NOvA** experiment
- Remote Operation Centers **ROC** for the **Fermilab** experiments
- Remote control and operation at NOvA
- **ROC-Dubna**

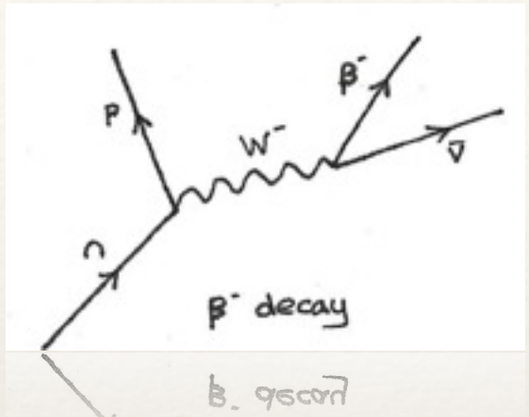



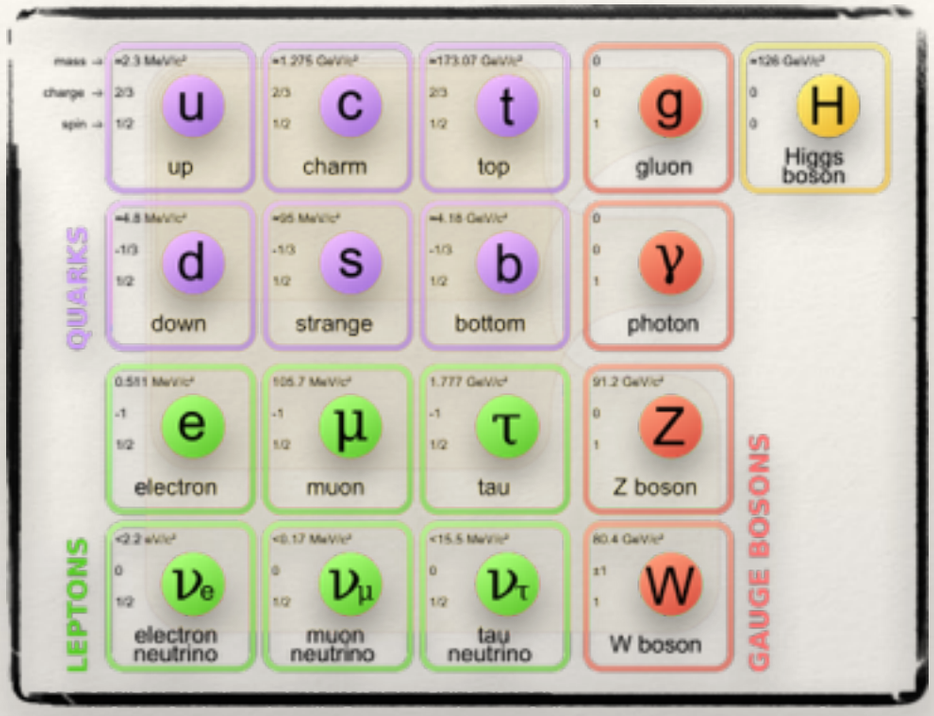




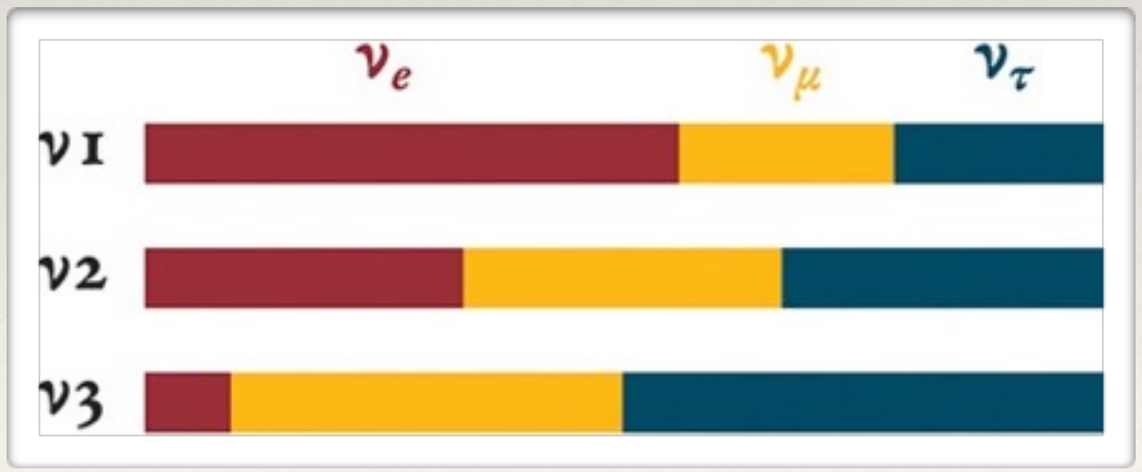



Simple HEP algebra for Neutrinos





- 2 x 2 = 4
- SU(3) x SU(2) x U(1) - is a Standard Model of Particles
- 3 physical “flavor” neutrino states are sum of 3 massive neutrinos, changing their composition through time / space — **Neutrinos Oscillate** !



Neutrinos oscillate

Oh, no problem

Unsolved problems around neutrino

- Strange feature of mixing matrix?
- Is CP violated like quark case?
- Are there only three types of neutrinos?
- Is the neutrino the origin of matter dominance?
- Order of mass (same as quarks?)
- Why are they so light compared to quarks or charged leptons? What is the origin of mass?
- Is the neutrino a Majorana particle?
- Absolute mass of the neutrino?
- Are there cosmic background neutrinos?

Experimental Approach

Neutrino oscillation

NOvA

Double-beta decay

«When the modern-era neutrino program launched in the mid-'90s with the MiniBooNE and MINOS experiments, I think it was safe to say that we really didn't know how far the program would go. Twenty years later, it is still going with a clear program mapped out for at least another 20 years. My how time flies!»

– Regina Rameika, head of the Neutrino Division, Fermilab

- **Neutrino Division** at **Fermilab**
- **Neutrino Platform** at **CERN**
- **Neutrino Program** at **JINR**

NOvA collaboration

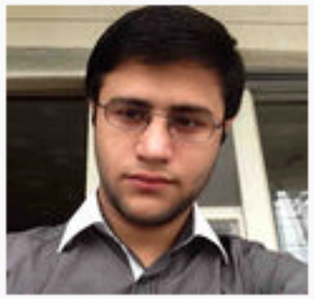
- *40 institutes*
- *7 countries*
- *over 200 collaborators*

Argonne National Laboratory • University of Athens • Banaras Hindu University • California Institute of Technology • Cochin University of Science and Technology • Institute of Physics of the Academy of Sciences of the Czech Republic • Charles University in Prague, Faculty of Mathematics and Physics, Institute of Particle and Nuclear Physics • University of Cincinnati • Colorado State University • Czech Technical University • University of Delhi • Joint Institute For Nuclear Research, Dubna • Fermi National Accelerator Laboratory • Universidade Federal de Goias • Indian Institute of Technology, Guwahati • Harvard University • Indian Institute of Technology, Hyderabad • University of Hyderabad • Indiana University • Iowa State Universite • University of Jammu • Lebedev Physical Institute • Michigan State University • University of Minnesota, Crookston • University of Minnesota, Duluth • University of Minnesota, Minneapolis • The Institute for Nuclear Research, Moscow • Panjab University • University of South Carolina, Columbia • South Dakota School of Mines and Technology • Southern Methodist University • Stanford University • University of Sussex • University of Tennessee, Knoxville • University of Texas, Austin - Tufts University • University of Virginia, Charlottesville • Wichita State University • Winona State University • The College of William and Mary

NOvA JINR group

Our NOvA team

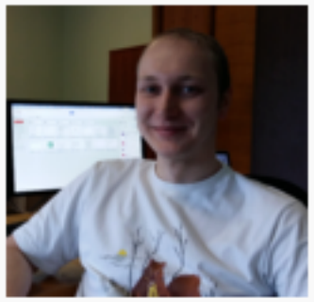
Members of our group:



Vladimir Allakhverdian (student)

Nikolay Anfimov (staff)

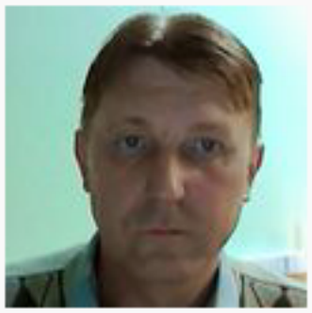
Alexander Antoshkin (PhD student)



Nikita Balashov (staff)

Alexandr Baranov (staff)

Anastasia Bolshakova (staff)

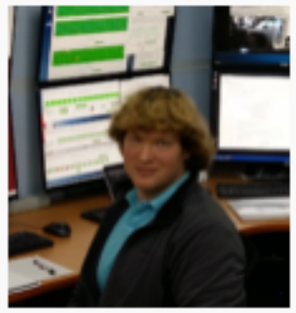


Andrey Dolbilov (staff)

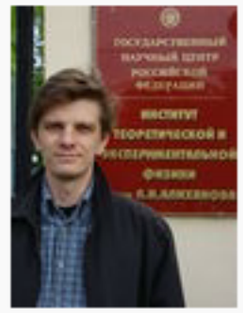
Igor Kakorin (staff)

Lyudmila Kolupaeva (student)

Zinoviy Krumstein (staff)



Chris Kullenberg (staff)



Konstantin Kuzmin (staff)

Vadim Naumov (staff)

Alexander Olshevskiy (staff, group leader)

Olga Petrova (PhD student)

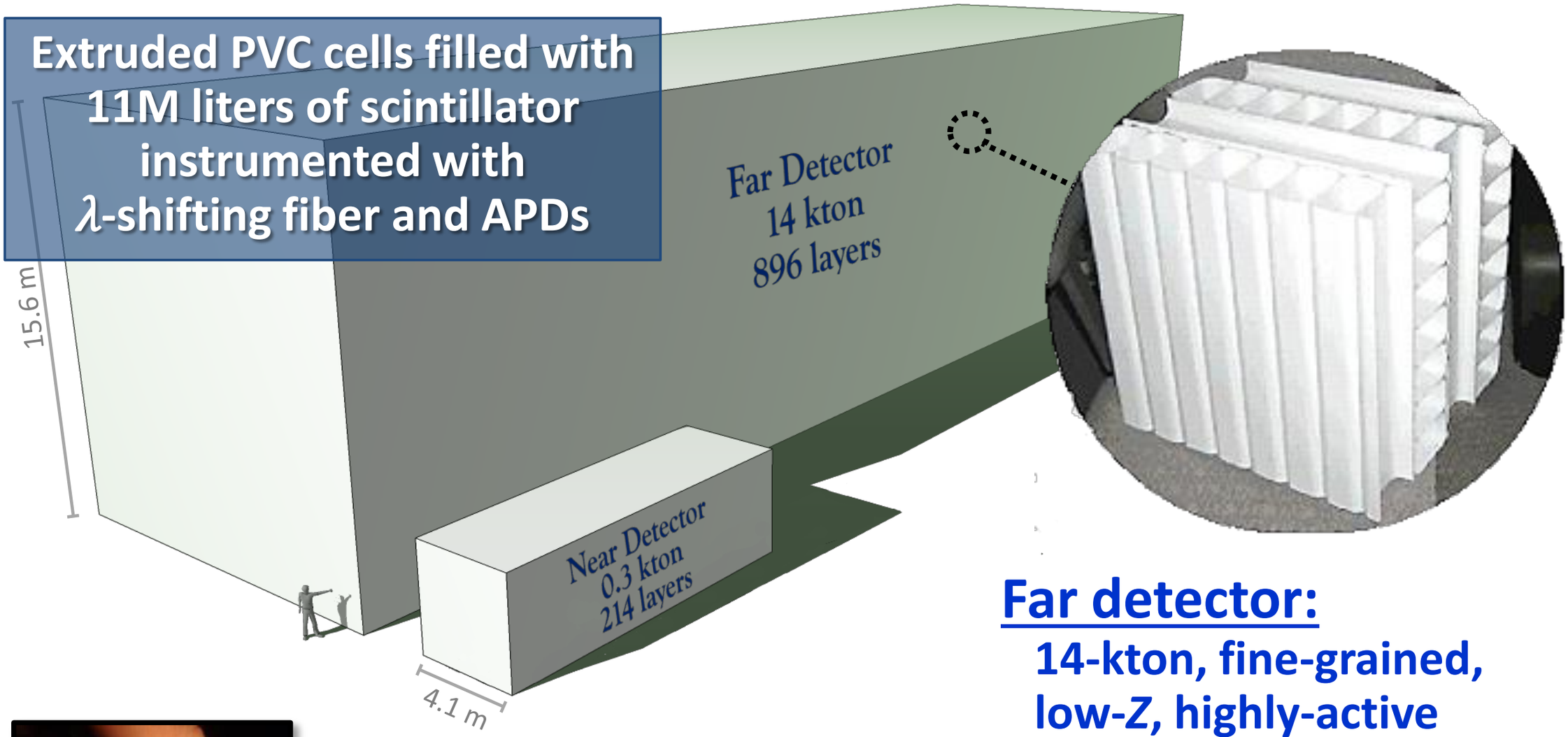
Oleg Samoylov (staff)

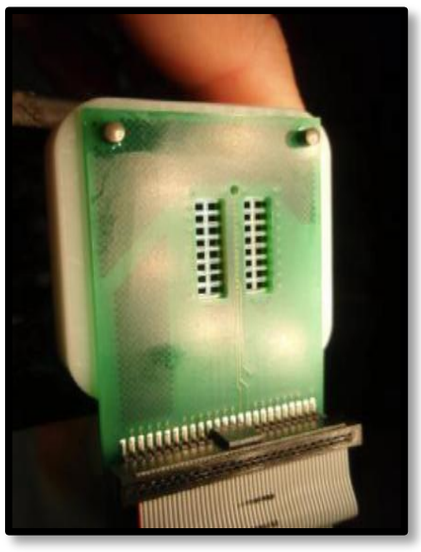
Albert Sotnikov (staff)

Andrey Sheshukov (staff)

NOνA detectors

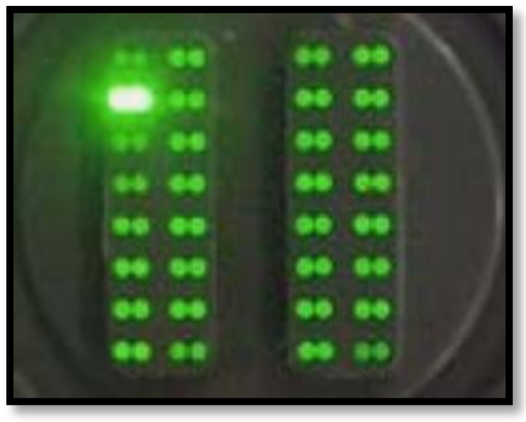
Extruded PVC cells filled with 11M liters of scintillator instrumented with λ-shifting fiber and APDs



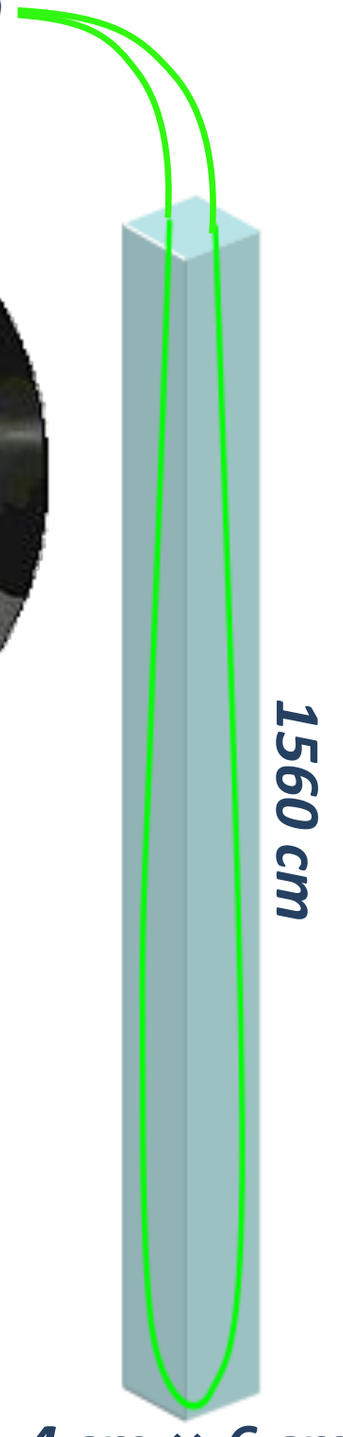


32-pixel APD

Fiber pairs from 32 cells



A NOνA cell



Far detector:

14-kton, fine-grained, low-*Z*, highly-active tracking calorimeter

→ ***344,000 channels***

Near detector:

0.3-kton version of the same

→ ***20,000 channels***

NOνA

A broad physics scope

Using $\nu_\mu \to \nu_e$, $\bar{\nu}_\mu \to \bar{\nu}_e$ ...

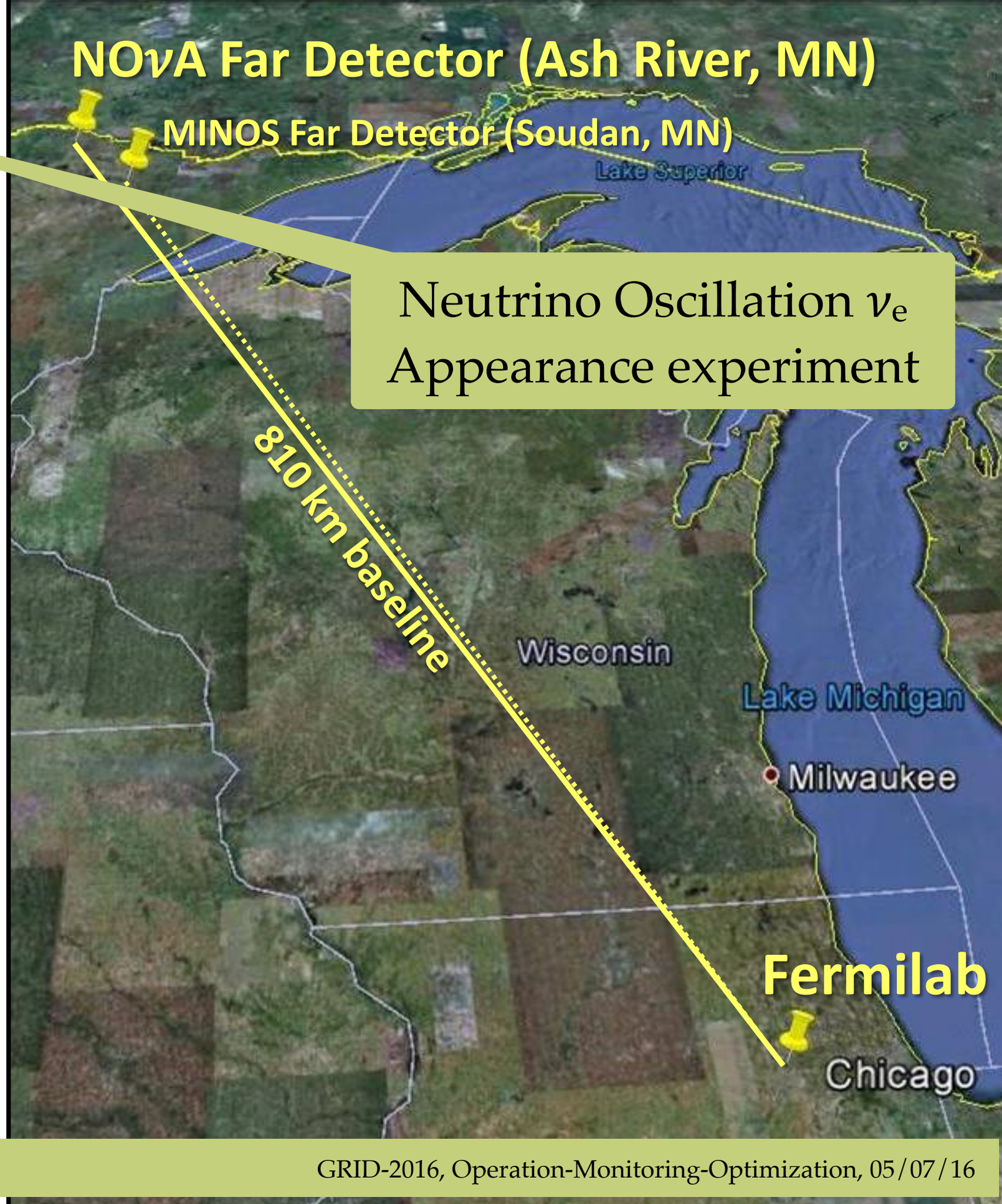
- Determine the **ν mass hierarchy**
- Determine the **θ_{23} octant**
- Constrain **δ_{CP}**

Using $\nu_\mu \to \nu_\mu$, $\bar{\nu}_\mu \to \bar{\nu}_\mu$ ...

- Precision measurements of **$\sin^2 2\theta_{23}$** and **Δm^2_{32}**.
  (*Exclude $\theta_{23}=\pi/4$?*)
- **Over-constrain** the atmos. sector (*four oscillation channels*)

Also ...

- Neutrino cross sections at the NOνA Near Detector
- Sterile neutrinos
- Supernova neutrinos
- Other exotica

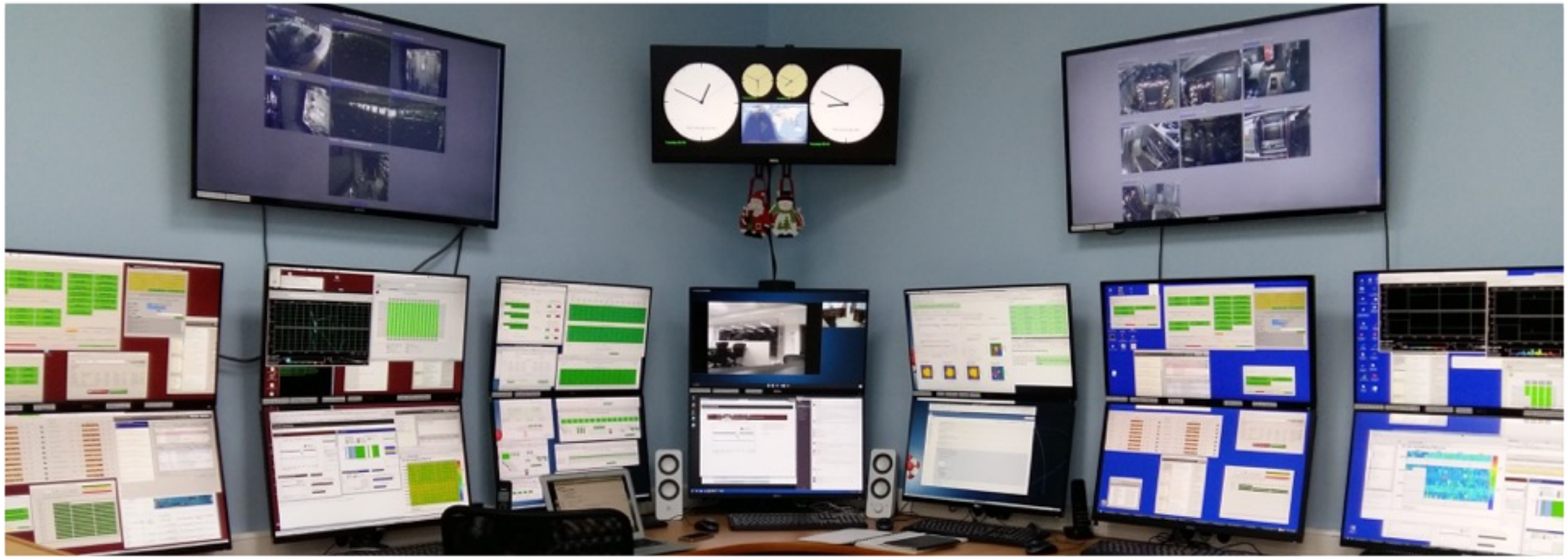


Remote Control

- The study of **Neutrino Oscillations** requires a **long baseline** for Neutrino Source and (Far) Detectors
- While collecting online **Data it can be safely recorded into local storage**
- A more **efficient monitoring** system may be to use a single **Remote Operation Center** for both location simultaneously

Remote Control

- **This idea** came to Fermilab after starting the **LHC Era**
- All of the **NuMI experiments** are developing Remote Operation Centers (**ROCs**)
- Main Remote Operation Center **ROC-West (US,1)** placed in FNAL (Wilson Hall)
- Currently **12 ROCs** are operating for NOvA:
  Minnesota US (2), Wichita US (3), Harvard US (4), Indiana US (5),
  Tufts US (6), Dubna Russia (7), Wiliam & Mary US (8),
  Sussex UK (9), Goias Brazil (10), Colorado US (11),
  South Carolina US (12)



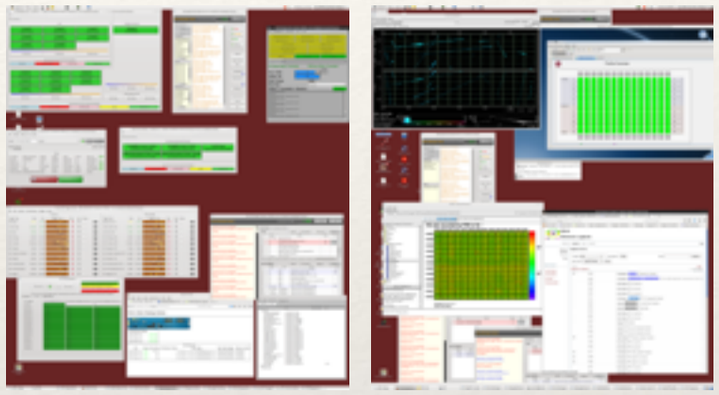
Internet connection

- **We control and operate NOvA** detectors from over **14000 km away**, a little bit less than halfway around the Earth

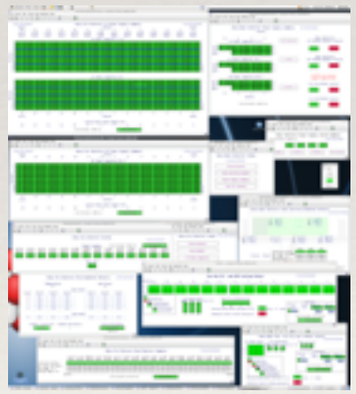
How ROCs work

- 5 active Scientific Linux based VNC-sessions are connected directly to Near/Far Detectors' Nodes at FNAL and through GateWays to another World
- 1 Linux Node for Web-monitoring of the systems (Beam, ND/FD Cameras, Data transfer control, Ganglia, Nearline)
- 1 Windows Node for Communication (NOvA electronic loogbook, latest version of Expert contact and Bulletin board, Polycom via Vidyo, Slack-chat, Skype)
- Developed infrastructure to ensure 8 hours continues work (stable internet, international land-line, kitchen, this is also public JINR area)

2 FarDet VNCs



Power Supply VNC

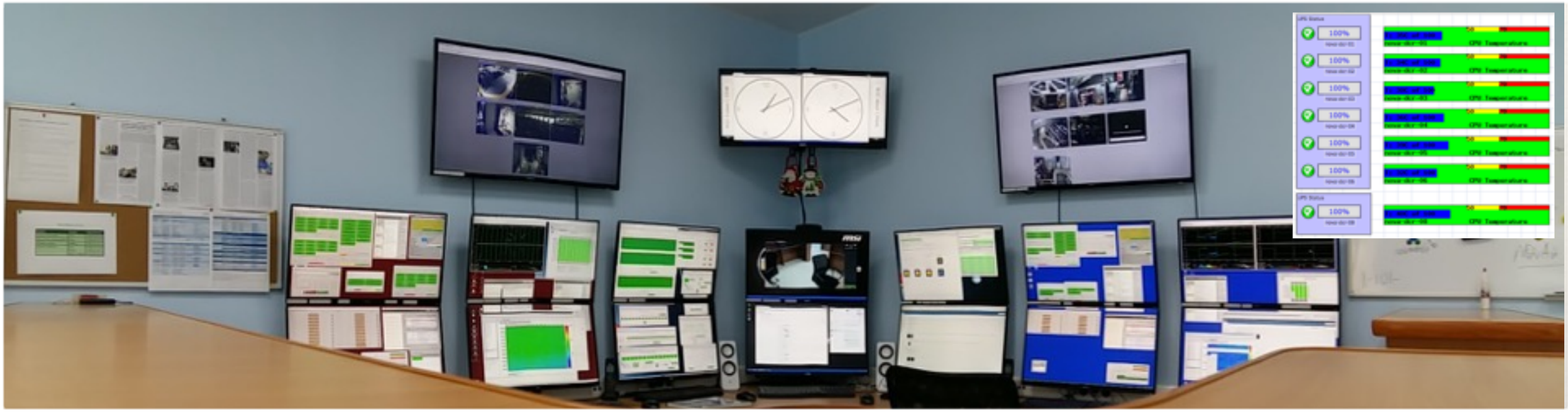


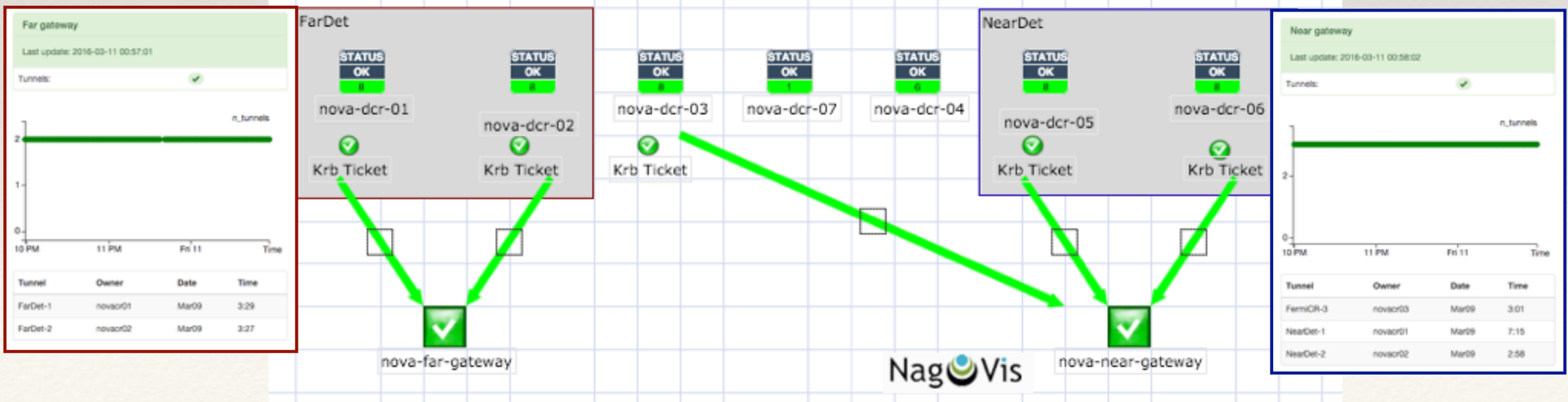
Retina Display
2560x1440

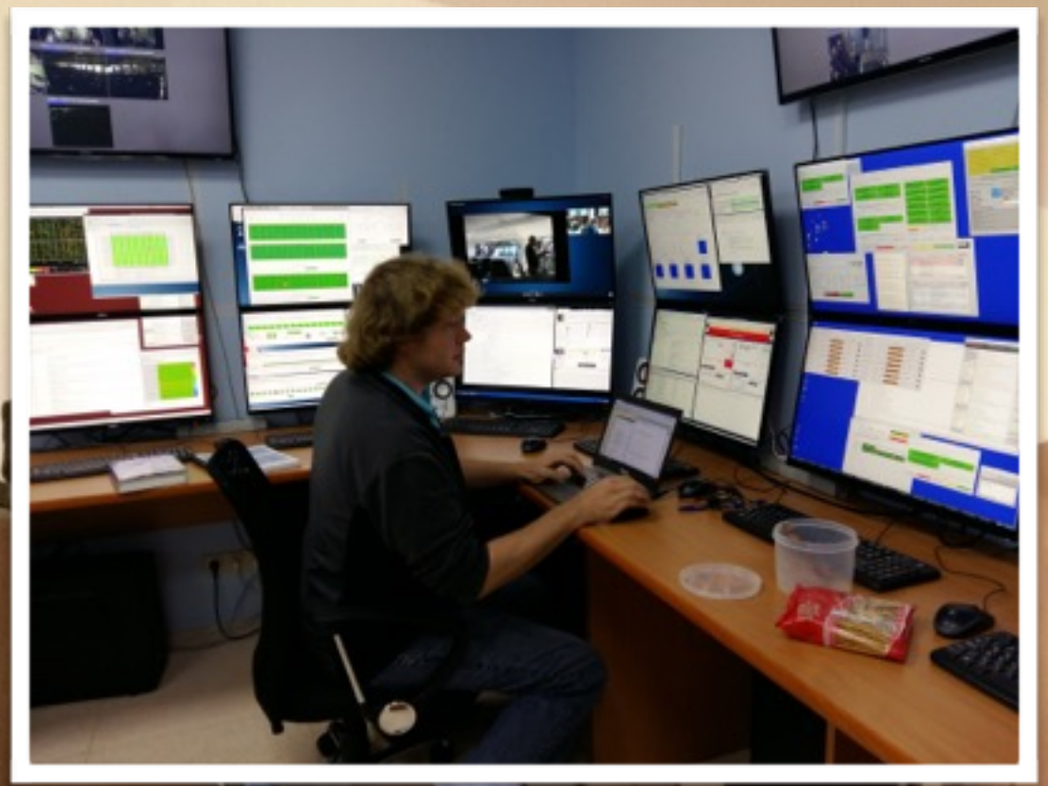
Total resolution
2560x2880

Full HD
1920x1080

How ROCs work







ROCs are working 24 / 7 days a week

How ROCs work

3 Run Coordinators - NOvA Operation Guards

ROC-West

ROC-UMN | ROC-WSU | ROC-HU

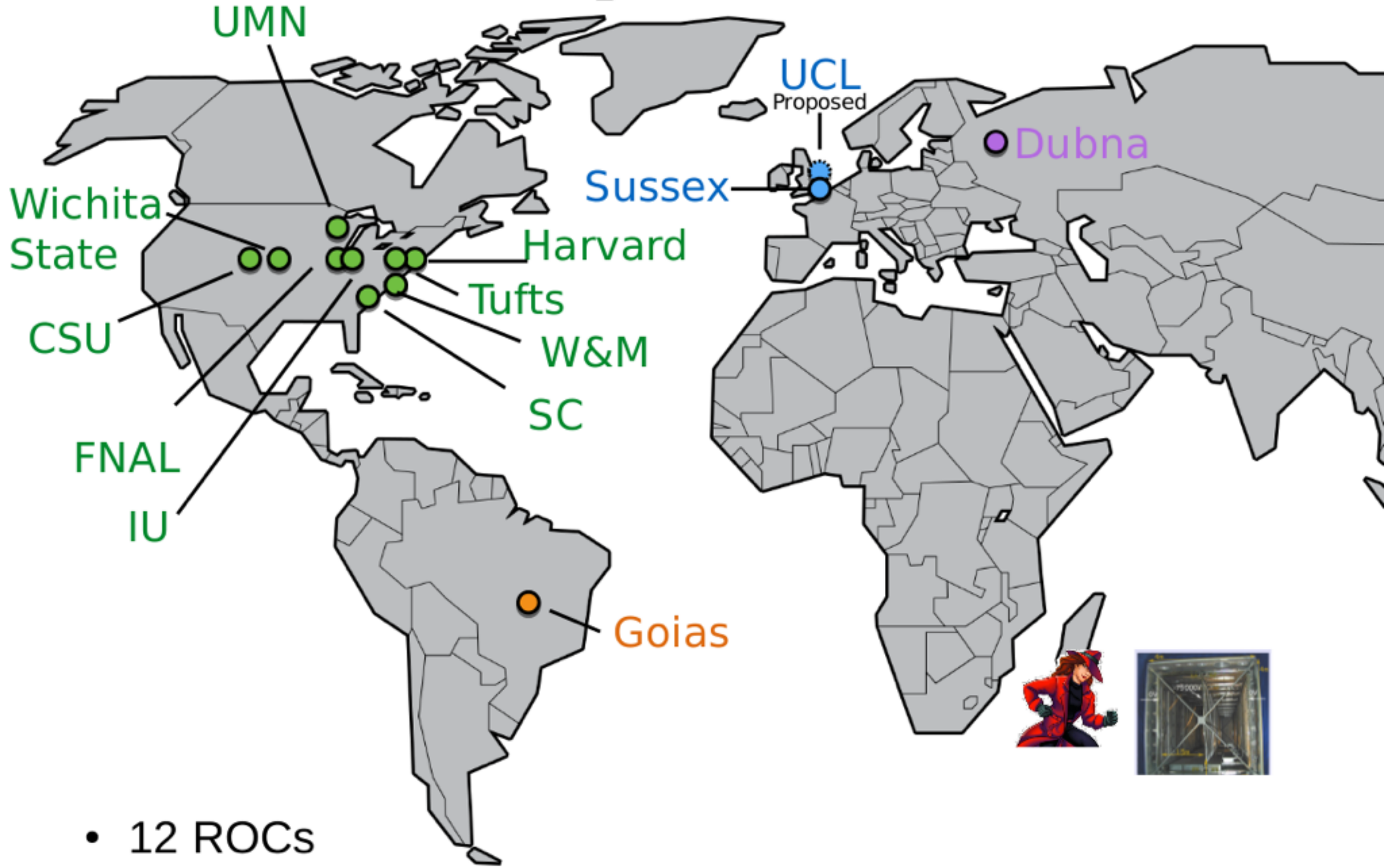
ROC-UIB | ROC-TUF | ROC-Dubna | ROC-W&M

ROC-Sussex | ROC-Goias | ROC-CSU | ROC-SC

Emergency contacts | DAQ experts | DCS experts

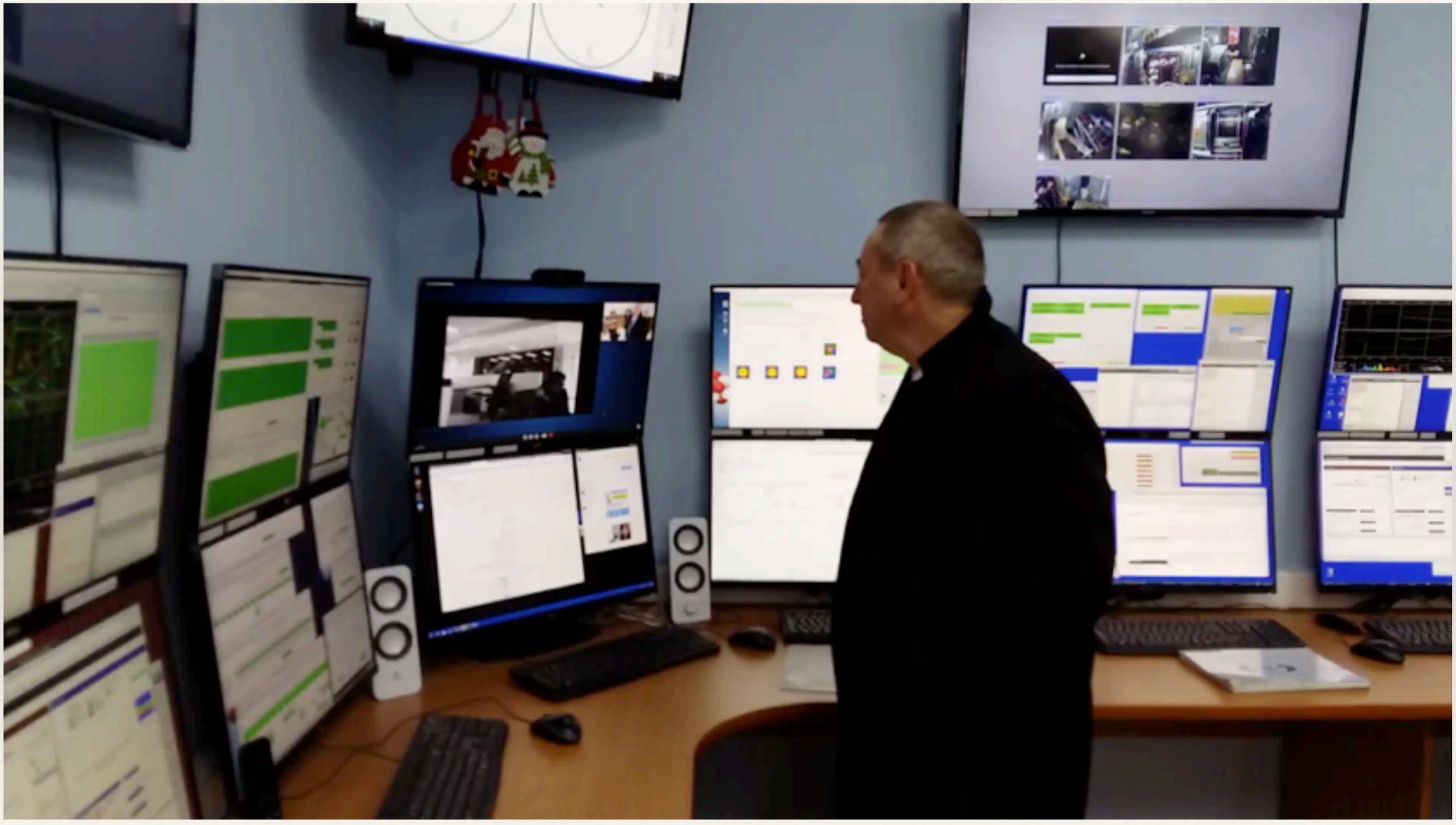
- The system allows for experts and shifters to work together monitoring beam, electronics, file transfers **to take NOvA DATA**

Remote Operation Centers



- 12 ROCs
  - 2 commissioned since last collaboration meeting

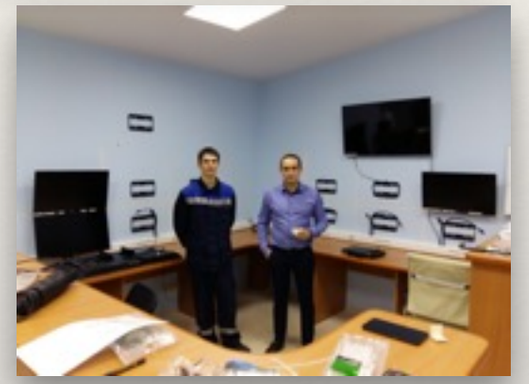
How ROCs work

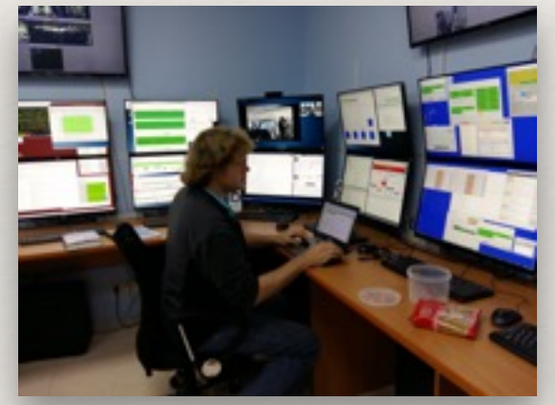


- In this video the director of Fermilab is waking a NOvA shifter at Fermilab from Dubna

Tasks done at JINR

- First ROC-(UMN) outside of FNAL started Nov-2014
- Started to discuss the idea ROC-Dubna, Nov-2014
- Checked connection from JINR to FNAL, Dec-2014
- Estimated costs of the ROC-Dubna, then buying the equipment, March-July-2015





- Installing the Hardware, July-2015
- Setting up the Software, August-2015
- Completed FNAL certification, Sept-2015
- We have been taking Shift-credits since Oct-2015

- Our Russian colleagues (INR, Moscow and FIAN) took their shifts in ROC-Dubna (April and June 2016)
- Stay tuned our local System!

ROC-Dubna crew

- Oleg Samoylov, ROC-manager, Software expert
- Nikolay Anfimov, Hardware expert
- Chris Kullenberg, Super-Shifter
- Alexander Antoshkin, Hardware
- Andrey Sheshukov, Software
- Nikita Balashov, Software and IT-support
- Andrey Dolbilov, Internet and IT emergency

Dubna Shifters

	A	B	C	D	E	F
1	**Name**	**Last shift / shadow**	**Expiration**	**Validity**		**Points**
2	Kullenberg, Christopher	9/22/2015	3/22/2016	take shadow		19
3	Samoylov, Oleg	9/28/2015	3/28/2016	take shadow		10
4	Anfimov, Nikolay	9/29/2015	3/29/2016	take shadow		7
5	Gornushkin, Yuri	4/24/2014	10/24/2014			6.5
6	Petrova, Olga	11/5/2015	5/5/2016	take shadow		4
7	Antoshkin, Alexander	10/22/2015	4/22/2016	take shadow		4
8	Sotnikov, Albert	4/21/2014	10/21/2014			3
9	Sheshukov, Andrey	1/31/2016	7/31/2016	ok		3
10	Kolupaeva, Lyudmila	6/29/2016	12/29/2016	ok		2
11	Shandrov, Igor	2/11/2016	8/11/2016	ok		2
12	Bolshakova, Anastasia	2/11/2016	8/11/2016	ok		1
13	Balashov, Nikita	1/1/2010	7/1/2010	take shadow	3 shifts	0

Advantages to having ROC at Dubna

- ROC-Dubna allows taking Shifts and save traveling budget and time scheduling / shifting / jet lag
- ROC-Dubna is an Operation and Communication Center of the NOvA experiment / 14000 km away
- Our Russian colleagues (INR, Moscow and FIAN) start taking their shifts in ROC-Dubna (April and June 2016)

Dear Colleagues,

On behalf of the NOvA collaboration I would like to express our deep appreciation of the NOvA group working at JINR. The group joined NOvA in 2013 and since then has made a number of important contributions to the experiment including a unique and detailed study of the performance of our front end electronics, in addition to efforts on computing, data acquisition, triggers, computing and data analysis.

We are especially appreciative of the Remote Operations Center (ROC) at Dubna which, while it is 14,000 km distance from Fermilab allows close collaboration of the Dubna scientists and enables smooth operation of the detector and, given the large time difference between Dubna and Fermilab, relieves some of the burden of around-the-clock shift staffing in the U.S.

ROC-Dubna is one of eight NOvA Remote Operation Centers and was the first located outside the U.S. The center could serve as a valuable model for participation in other experiments based at Fermilab including Mu2e, Muon g-2, and DUNE.

The remote operations center is a great aid to collaboration, but it cannot replace in-person collaboration made possible by regular visits of Dubna scientists to FNAL and other U.S. institutions which host our collaboration meeting such as the up-coming meeting in Dallas, Texas. NOvA has recently posted its first publications and we expect several very productive years ahead.

Sincerely,

Mark Messier
Co-spokesman
NOvA Collaboration
Fermilab E929