



# Workshop Logistics and Goals

Xin Qian  
BNL



# The First Wire-Cell Workshop @ 2015

## DUNE Wire-Cell Reconstruction Summit

 Dec 7, 2015, 8:00 AM → Dec 9, 2015, 5:00 PM US/Pacific

 Bldg 2 Room 100B (LBNL)

**Description** Discuss Wire Cell reconstruction method, its development and application to determine and evaluate requirements for DUNE LArTPC detectors and validating detector designs.

The summit will cover Wire Cell reconstruction method, how it works, current development status and near term plans. We will discuss how the design of the detector affects reconstruction through application of Wire Cell. We will develop analysis plans and future work needed to develop metrics and requirements for detector design.



Remote connection via Vidyo (click here to start)



Participants

<b>A</b> Abhinav Sarje	<b>A</b> Amir Farbin	<b>B</b> Brett Viren	<b>C</b> Chao Zhang	<b>C</b> Cheng-Ju Lin	<b>C</b> Craig Tull	<b>D</b> Daniel Dwyer
<b>E</b> Erica Snider	<b>H</b> Herbert Steiner	<b>H</b> Hin (Heno) Wong	<b>J</b> James Stewart	<b>K</b> Ka Tsang	<b>K</b> Kam-Biu Luk	
<b>M</b> Matthew Kramer	<b>M</b> Milind Diwan	<b>P</b> Paolo Calafiura	<b>S</b> Samuel Kohn	<b>S</b> Simon Patton	<b>T</b> Tingjun Yang	
<b>T</b> Tracy Usher	<b>X</b> Xin Qian	<b>Y</b> Yasuhiro Nakajima				

[DUNE Wire-Cell Reconstruction Summit \(7-December 9, 2015\) · Berkeley Lab Physics Division \(Indico\) \(lbl.gov\)](#)

# Wire-Cell @ 2015 (I)

## Double Deconvolution

$$M_i(t_0) = \int_t (R_0(t-t_0) \cdot S_i(t) + R_1(t-t_0) \cdot S_{i+1}(t) + \dots) dt$$

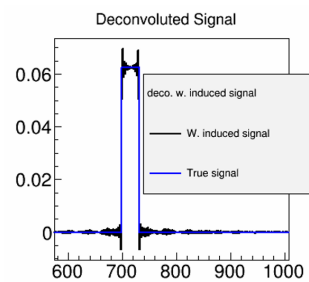
$$M_i(\omega) = R_0(\omega) \cdot S_i(\omega) + R_1(\omega) \cdot S_{i+1}(\omega) + \dots$$

- With induced signals, the signal is still linear sum of direct signal and induced signal

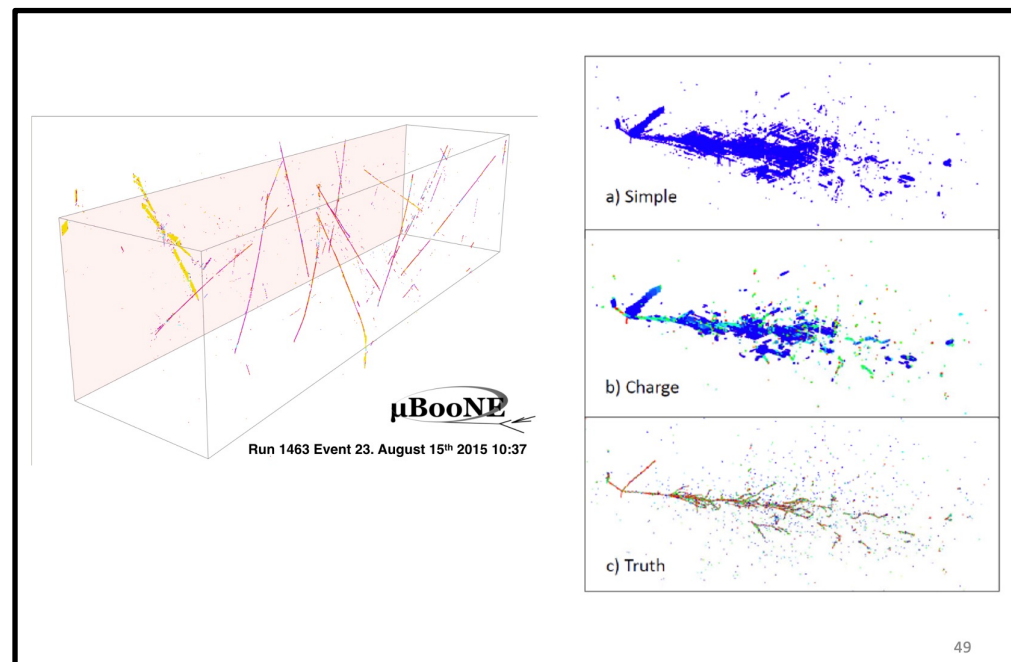
- $R_1$  represents the induced signal from  $i+1$ th wire signal to  $i$ th wire

- $S_i$  and  $S_{i+1}$  are not directly related

$$\begin{pmatrix} M_1(\omega) \\ M_2(\omega) \\ \dots \\ M_{n-1}(\omega) \\ M_n(\omega) \end{pmatrix} = \begin{pmatrix} R_0(\omega) & R_1(\omega) & \dots & R_{n-1}(\omega) & R_n(\omega) \\ R_1(\omega) & R_0(\omega) & \dots & R_{n-2}(\omega) & R_{n-1}(\omega) \\ \dots & \dots & \dots & \dots & \dots \\ R_{n-1}(\omega) & R_{n-2}(\omega) & \dots & R_0(\omega) & R_1(\omega) \\ R_n(\omega) & R_{n-1}(\omega) & \dots & R_1(\omega) & R_0(\omega) \end{pmatrix} \begin{pmatrix} S_1(\omega) \\ S_2(\omega) \\ \dots \\ S_{n-1}(\omega) \\ S_n(\omega) \end{pmatrix}$$



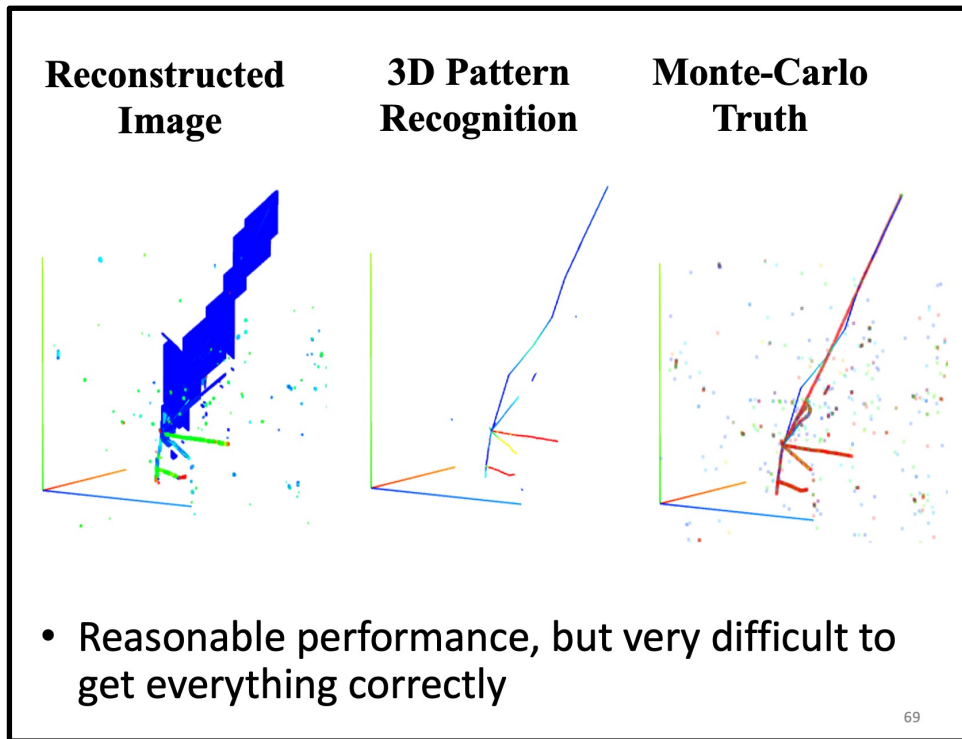
**The inversion of matrix R can again be done with deconvolution through 2-D FFT**



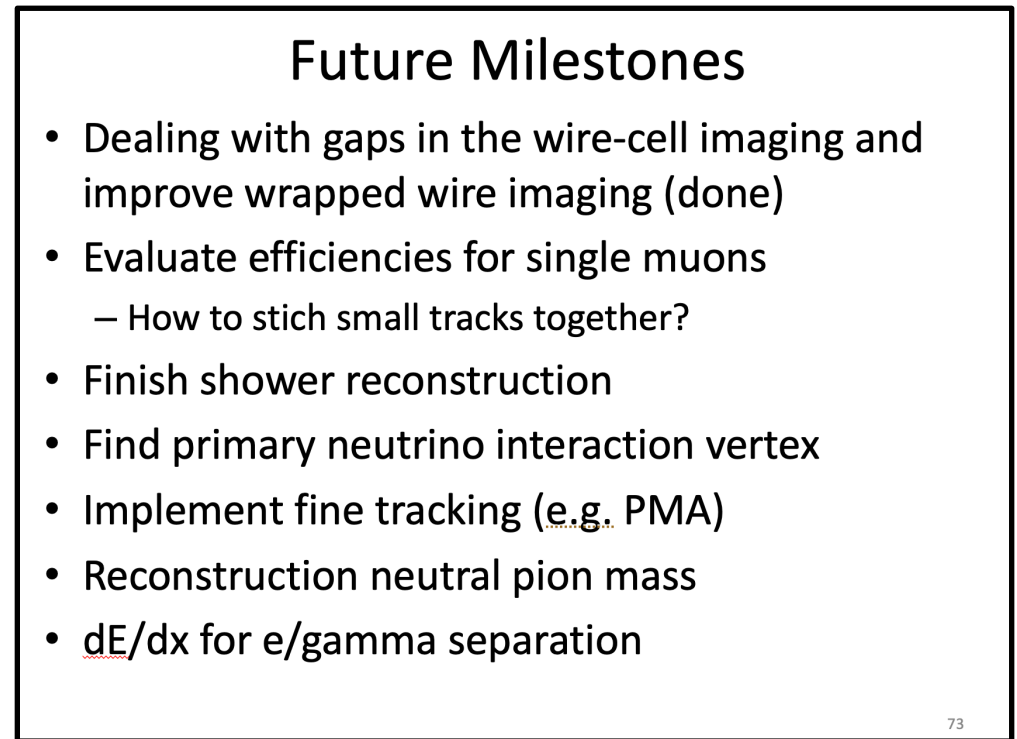
Just came up with the concept of the 2D deconvolution

The first successful 3D image from MicroBooNE, lots of gaps ...

# Wire-Cell @ 2015 (II)



Had some initial developments in the pattern recognition



Had a long wish list

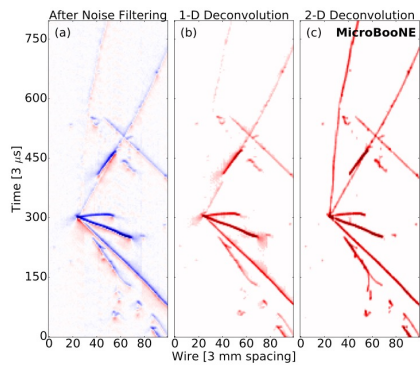
# Development of Wire-Cell in MicroBooNE (2015-2021)

noise filtering  
signal processing

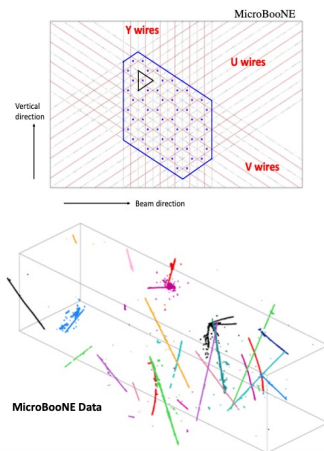
3D imaging  
clustering  
charge-light matching

3D trajectory &  $dQ/dx$  fitting  
cosmic muon tagger

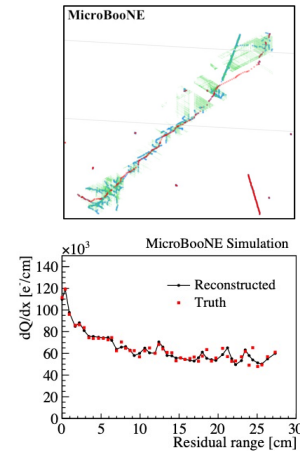
multi-track fitting  
3D vertexing  
particle identification



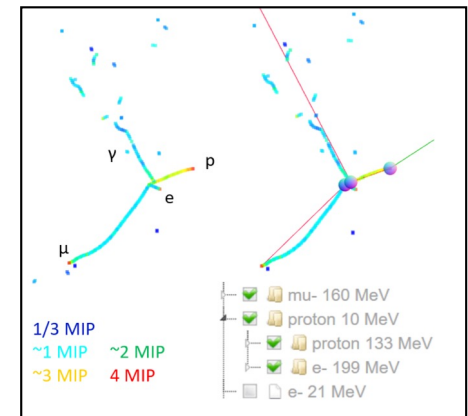
[JINST 12 P08003 \(2017\)](#)  
[JINST 13 P07006 \(2018\)](#)  
[JINST 13 P07007 \(2018\)](#)



[JINST 13 P05032 \(2018\)](#)  
[JINST 16 P06043 \(2021\)](#)



[Phys. Rev. Applied 15 064071 \(2021\)](#)  
[arXiv: 2012.07928 \(2020\)](#)

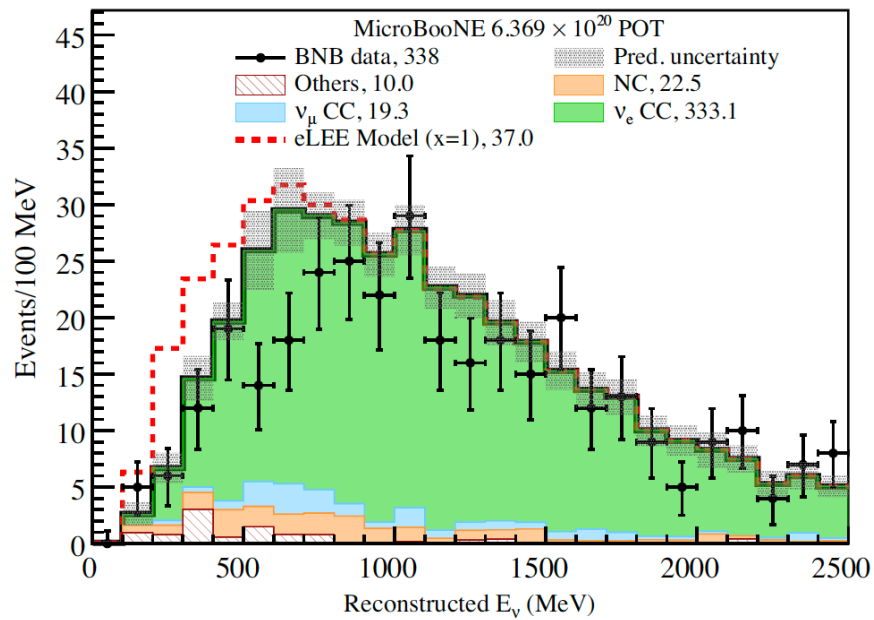


[JINST 17, P10037](#)

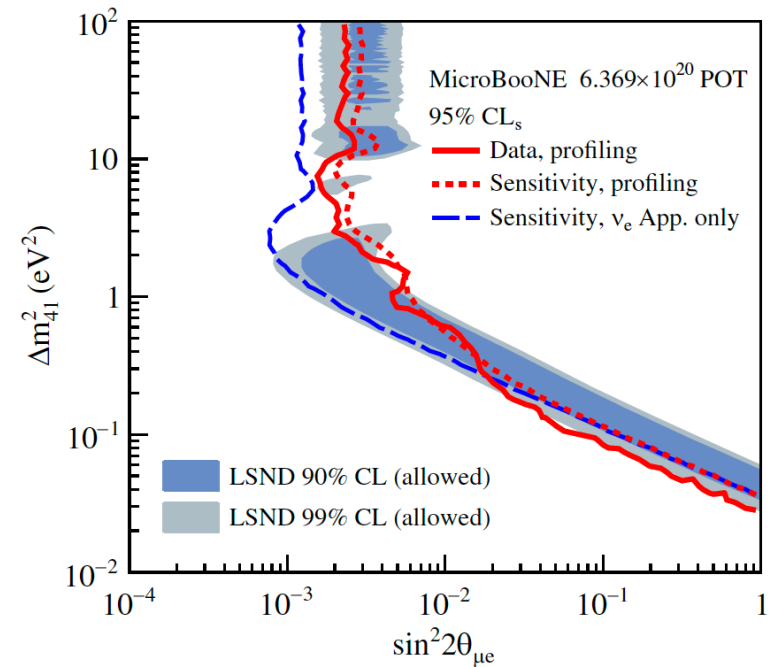
**Wire-Cell is a 3D tomographic event reconstruction for LArTPC. Started from the 3D event image reconstruction, it now covers a wide range of topics from TPC signal processing to 3D pattern recognition**



# Search for $\nu_e$ low energy excess and $\nu_s$



[Phys. Rev. Lett. 128, 241801](#)  
[Phys. Rev. D105, 112005](#)



[Phys. Rev. Lett. 130, 011801](#)

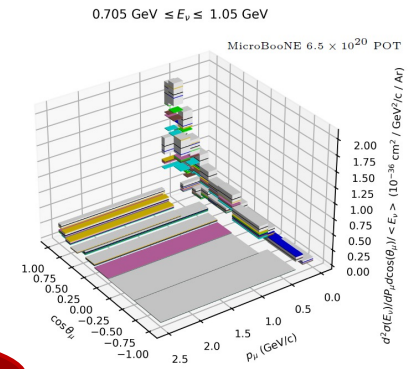
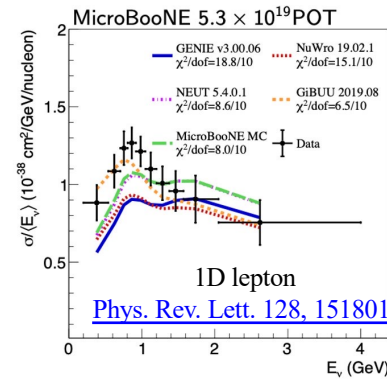
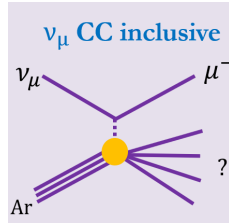




# $\nu - Ar$ Interaction Cross Sections

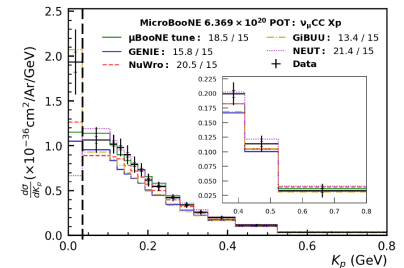
- Lots of progress were made on the measurement of cross sections in MicroBooNE leveraging the Wire-Cell event reconstruction paradigm

- Inclusive  $\nu_\mu CC$ :
  - 1D lepton
  - 3D lepton
  - 1D hadron
  - 3D lepton + hadron



Measurement	Channel	ndf	μBooNE tune	GENIE	NuWro	NEUT	GIBUU
$\frac{d^2\sigma}{dE_\nu d\cos\theta_\mu}$	0p	11	38.3	41.8	29.5	56.2	13.5
	Np	11	16.5	27.2	20.2	13.0	25.3
$\frac{d^2\sigma}{dE_\nu d\cos\theta_\mu}$	0p/Np	22	30.8	41.5	46.4	65.7	37.6
	Np	17	25.6	28.3	13.2	44.7	9.9
$\frac{d^2\sigma}{dE_\nu d\cos\theta_\mu}$	0p/Np	34	34.2	34.2	42.0	19.9	27.3
	Np	14	64.3	62.1	55.7	70.3	44.6
$\frac{d^2\sigma}{dE_\nu d\cos\theta_\mu}$	0p	3	37.5	45.1	28.8	91.4	9.2
	Np	6	12.7	24.3	20.6	20.7	26.3
$\frac{d^2\sigma}{dE_\nu d\cos\theta_\mu}$	0p/Np	9	63.3	66.2	52.1	133.5	59.0
	Np	5	32.8	39.5	29.9	71.7	0.8
$\sigma(E_\nu)$	0p	9	12.7	22.2	13.7	25.7	12.1
	0p/Np	14	43.3	56.8	40.4	85.1	14.3
$\frac{d^2\sigma}{dE_\nu d\cos\theta_\mu}$	0p	10	21.5	29.7	17.5	56.4	15.4
	Np	10	6.4	20.1	11.7	5.5	15.1
$\frac{d^2\sigma}{dE_\nu d\cos\theta_\mu}$	0p/Np	20	29.6	41.4	29.2	72.1	43.4
	Np	15	18.5	15.8	20.5	21.4	13.4
$\frac{d^2\sigma}{dE_\nu d\cos\theta_\mu}$	0p	14	15.4	13.8	13.4	15.8	10.6
	Np	20	16.0	22.4	9.9	28.4	48.0
Proton Multiplicity	Xp	4	7.1	19.8	9.9	22.2	10.5
	0p	55	129.8	140.9	109.7	180.3	102.8
$\frac{d^2\sigma}{dE_\nu d\cos\theta_\mu}$	Np	69	203.1	189.7	196.9	192.7	192.1
	0p/Np	124	287.5	266.4	263.7	298.8	249.8
$\frac{d^2\sigma}{dE_\nu d\cos\theta_\mu}$	Xp	69	129.6	140.4	169.3	104.7	161.5
	Np	96	144.2	138.8	120.3	204.4	274.1
$\frac{d^2\sigma}{dE_\nu d\cos\theta_\mu}$	Xp	249	274.2	336.9	309.4	330.6	313.9

Lepton + hadron  
[arXiv:2402.19216](#)





# Upcoming Physics Results

## New Physics Search

- Search for a sterile neutrino combining the BNB + NuMI flux
- Search for low-energy photon excess in the  $N\Delta$  radiative decay
- Search for low-energy excess in inclusive photon channel
- Search for low-energy excess in  $e^+e^-$  channel (dark neutrino)

## Cross Section Measurements

- Neutral-current  $\pi^0$  cross sections
- Simultaneous  $\nu_e CC$ ,  $\nu_\mu CC$ ,  $NC\pi^0$  cross section measurements
- Combined cross section measurements with both BNB and NuMI beams
- Extraction of effective Axial mass from CCQE process
- Transverse Kinematics Imbalance in  $CC\pi^0p$





# The Second Wire-Cell Reconstruction Summit

Hosted by Brookhaven National Laboratory  
The workshop will held as a hybrid event on April 10–12, 2024

[Home](#) [Registration](#) [Agenda](#) [Logistics](#) [Join Remotely](#) [Contact Us](#)

## Motivation

Wire-Cell is a reconstruction paradigm for the event reconstruction of large liquid argon time projection chamber detectors (LArTPCs). The goal of this wire-cell summit is to advertise the reconstruction paradigm in current/future LArTPC experiments, to establish better connection and interface with LArSoft and LArTPC AI/ML communities, and to enlarge the user base.

The topics that will be discussed include:

- Exchange ideas on the pattern recognitions and AI/ML algorithms
- Prompt signal processing
- Discuss specific needs from various experiments (DUNE-FD, ProtoDUNE, DUNE-ND, SBN)
- Data interfaces between Wire-Cell and other software system

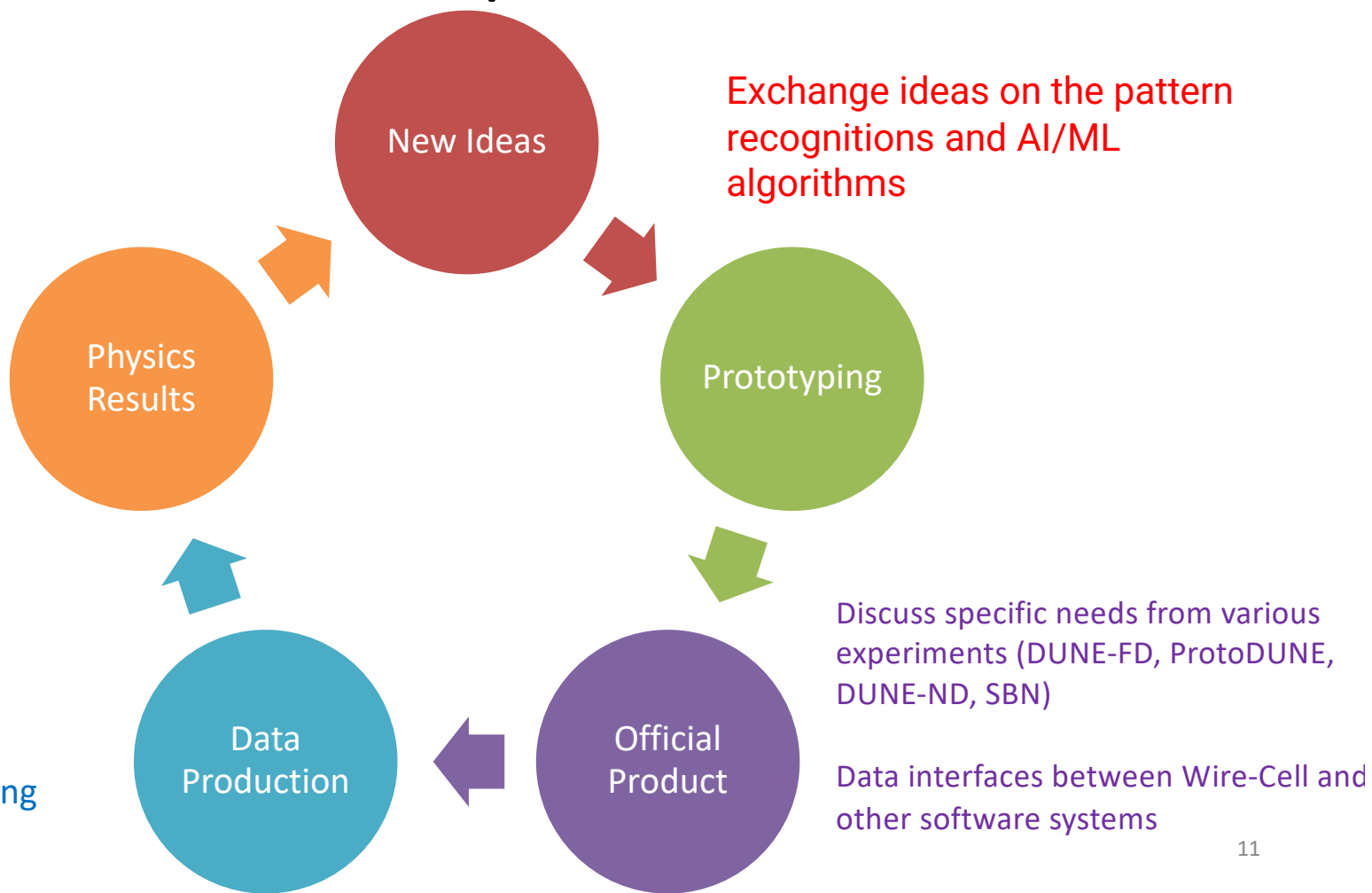
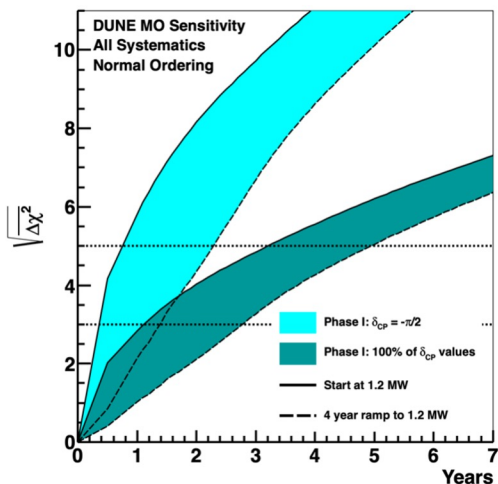
## Important Dates

January 24, 2023	General registration opens
March 13, 2024	Additional <b>non-U.S. citizens</b> registration deadline for all participants who do not have an active appointment with Brookhaven Lab. You will be directed to the appropriate form once you have completed the event registration.
April 12, 2024	General registration closes

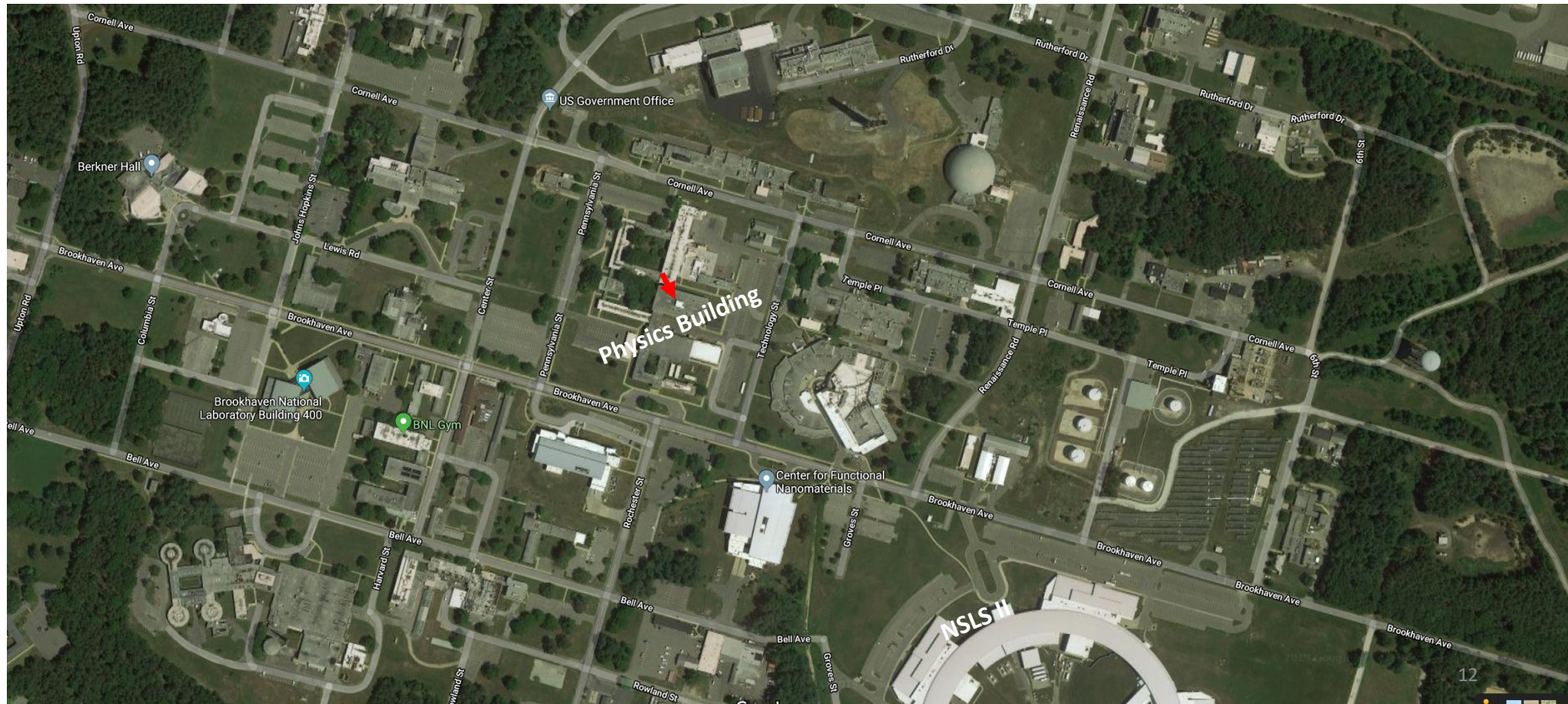
# Workshop Agenda

- This morning:
  - General introduction of Wire-Cell
- This afternoon:
  - Prompt signal processing
- Thursday morning:
  - Data Interface, better integration with other software packages
- Thursday afternoon:
  - Experimental needs
    - MairoBooNE, SBND, ICARUS
    - ProtoDUNE HD, VD, DUNE FD1/2
    - DUNE ND 2x2, ND
- Friday:
  - AI/ML & exchange ideas on reconstruction techniques

# Workshop Goals



# BNL Site Map



## A few words about Safety

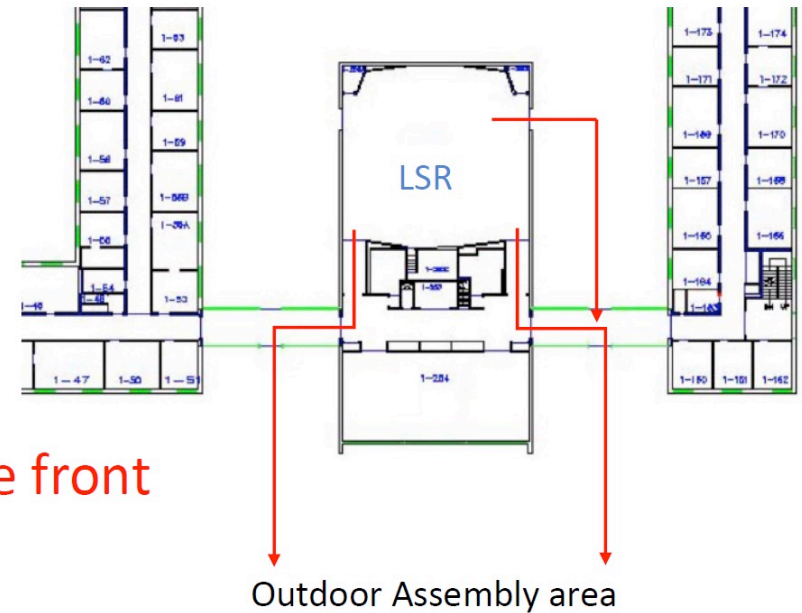
- Alarms
  - **Intermittent Site Siren:** Evacuation Area
  - **Building Bell Alarm:** Report to the Building Evacuation Area
  - **Steady Site Siren:** Report to the Emergency Assembly Area
- Construction work at the main gate. Please exercise caution

# Large Seminar Room - Safety



510  
Main  
Entrance

LSR has three exits:  
two in the rear and  
one emergency exit in the front



Outdoor  
assembly  
area

large  
seminar  
room

- In case of a fire alarm, grab your things and go to the “Outdoor assembly area” just outside the building from the LSR
- When you hear a continuous siren, stay in the LSR, it’s the “Indoor assembly area”
- BNL Safety announcements will be made via the wall speakers

# Wireless Network Access

- Option 1: **Corus** (BNL visitor wireless network)
  - Need to register as a guest user

**Log In With Your BNL AD Credentials**  
(do not include @bnl.gov)

**BNL WiFi Login**

Username:

Password:

Personal Device:  Click if this device is not owned by BNL

**Visiting BNL and need a guest account?**  
[Click Here](#)

If you need assistance, then contact the ITD Help Desk, (631) 344-5522.

**Access the BNL Wireless Network**  
Complete the form (below) to access the BNL visitor wireless system.

**Self-Registration**

\* Your Name:   
Please enter your full name.

\* Phone:  (201) 555-0123  
Phone to receive SMS Messages

\* Confirm:  I accept the [terms of use](#)

\* required field

**Already have an account? [Sign In](#)**

If you need assistance, then contact the ITD Help Desk, (631) 344-5522

Then you should be able to get a message with your temporary username & password.

- Option 2: **eduroam** (education roaming)
  - Allows students, researchers and staff from participating institutions to obtain Internet connectivity across campus and when visiting other participating institutions by simply opening their laptop.

## Zoom Connection:

- The Zoom chat window will be visible on the monitor for the room to see
  - People can also use the Zoom chat to ask questions
- Any voices from the audience in the room will be picked up by the room mics and transmitted over Zoom. The room may not hear you but Zoom will
- Zoom subtitles: they can be displayed on the lectern monitor



# Lunch Choices (Onsite)

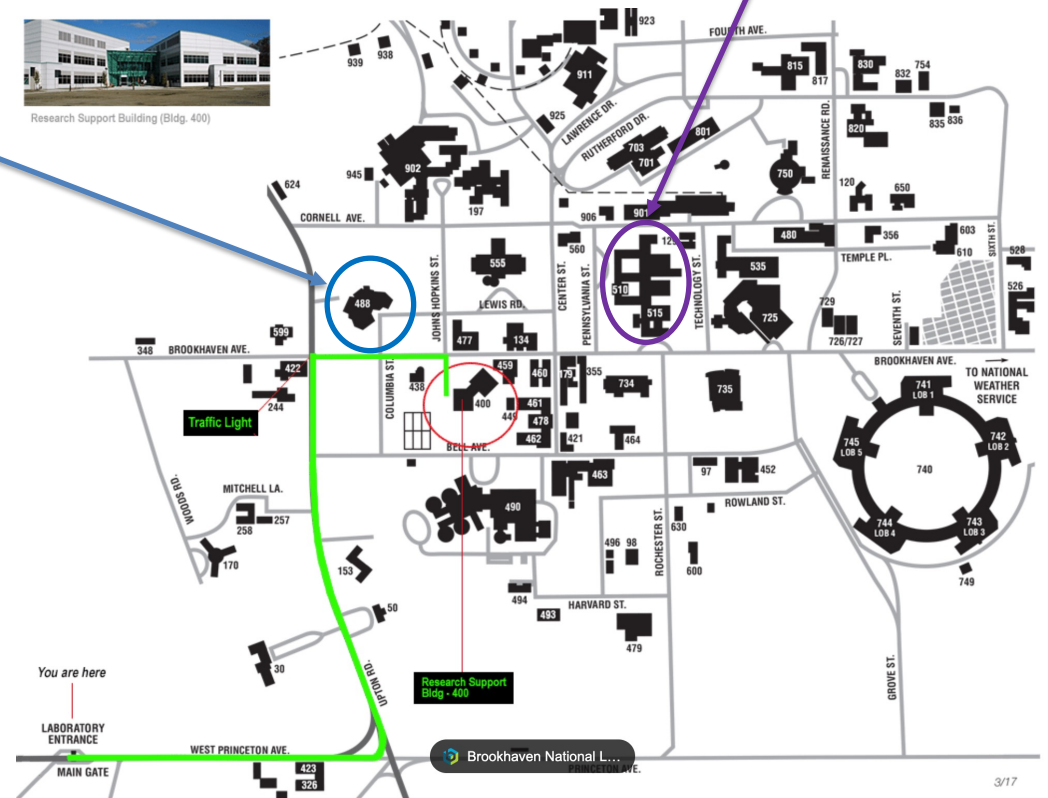
We are here, building 510

- Berkner Hall (488)
  - Sandwiches, salads ...



Research Support Building (Bldg. 400)

- Building 400
  - Vending machines



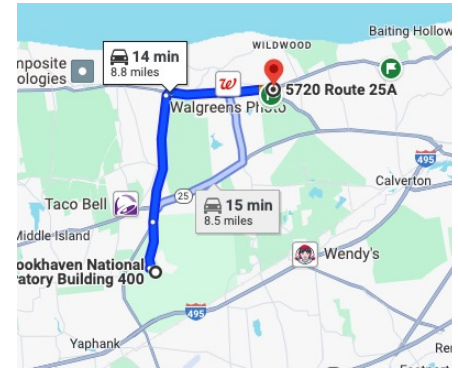
# Nearby Restaurants for lunch

(always go out the Main gate – Google maps sometimes takes you to the North gate which is only open 4:30-5:30pm)

- Alfredo's Pizza: 1679 Middle Country Rd, Ridge, NY 11961 (3 mi)
- Go Burger: 1699 Middle Country Rd, Ridge, NY 11961 (3 mi)
- McDonald: 1175 Middle Country Rd King Kullen Plaza, Middle Island, NY, 11953 (5 mi)
- Subway: 1187 Middle Country Rd King Kullen Plaza, Middle Island, NY (5 mi)
- Good Wok (Chinese): 1209 Middle Country Rd, Middle Island, NY 11953 (5 mi)
- Okeno Sushi: 451 Glen Dr, Shirley, NY 11967-1100 (4 mi)
- Applebees, 855 Montauk Hwy, Shirley, NY 11967 (7 mi)
- Boston Market, 803 Montauk Hwy, Shirley, NY (7 mi)
- Mama Lisa Restaurant (Italian), 1226 Montauk Hwy, Shirley, NY (8 mi)
- Mediterranean Kitchen, 1171 Montauk Hwy, Shirley, NY (7 mi)

# Group Dinner Information

- Date & Time: **Thursday, Apr 11, 6:30 PM**
- Restaurant: **Desmond's** at East Wind
- Location: 5720 Rte. 25A, Wading River, NY 11933
- Entrée options (choose one at the restaurant)
  - Stuffed French Breast of Chicken
  - Cod with Dill
  - NY Strip Steak
  - Special menu: vegetarian and other options
- Total cost (w/ tax & tips): \$50 (+\$5 for steak)
- Payment: pre-paid to Wenqiang Gu  
[wgu@bnl.gov](mailto:wgu@bnl.gov) (cash or e-transfer)



Cash bar available!



# Acknowledgement

- BNL:



**Brookhaven**  
National Laboratory

- BSA: [BNL | Brookhaven Science Associates](#)

