Fermilab

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# Nomura Research Institute Visit to Fermilab

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Fermilab
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# Nomura Research Institute Visitors and Outline of Agenda

**NRI visitors**: Yoshitaka Kuno, Professor, Osaka University
Susumu Kamada, Emeritus Professor (KEK)
Masashi Sato, Manager (NRI)

12:00– **Arrive at Fermilab, Introductions & Lunch**

1-1:20 – **Overview of Fermilab site** from WH15

1:20-2:00 – **Overview Presentations** – M. Sato & J. Lykken

2:00-3:15 – **Topics for research plans & projects in Fermilab**

3:15-3:30 - **Coffee Break**

3:30-4:00 – **Accelerator Overview Presentations**
S. Nagaitsev, H. Padamsee, & R. Kephart

4:00-5:15 – **Topics for particle accelerators - Fermilab & ILC**

5:15-5:45 – Summary and Discussions

5:45 – Limousine to Hotel

# Overview Presentations

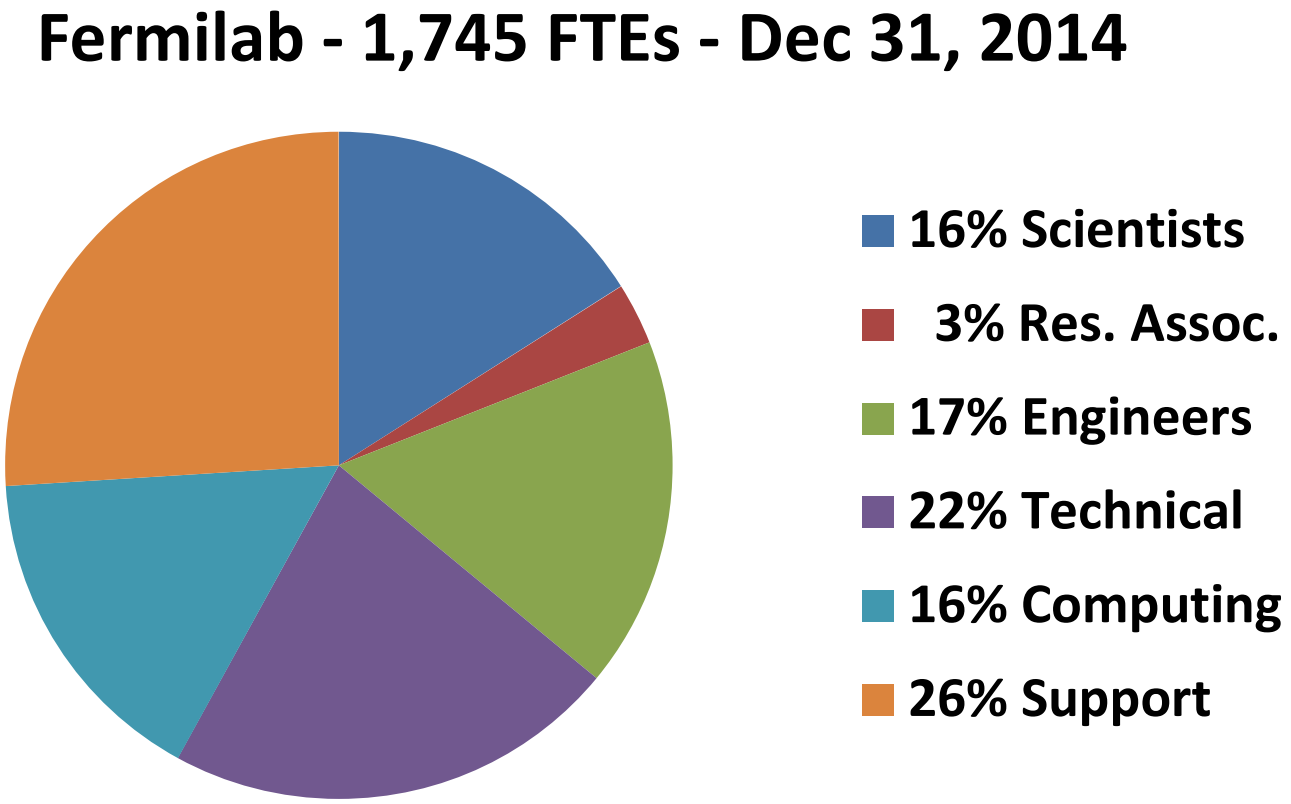
- Goals of the Visit
  – Masashi Sato – NRI – 10 minutes

- Introduction to Fermilab
  – Joseph Lykken, Fermilab, Deputy Director – 30 minutes

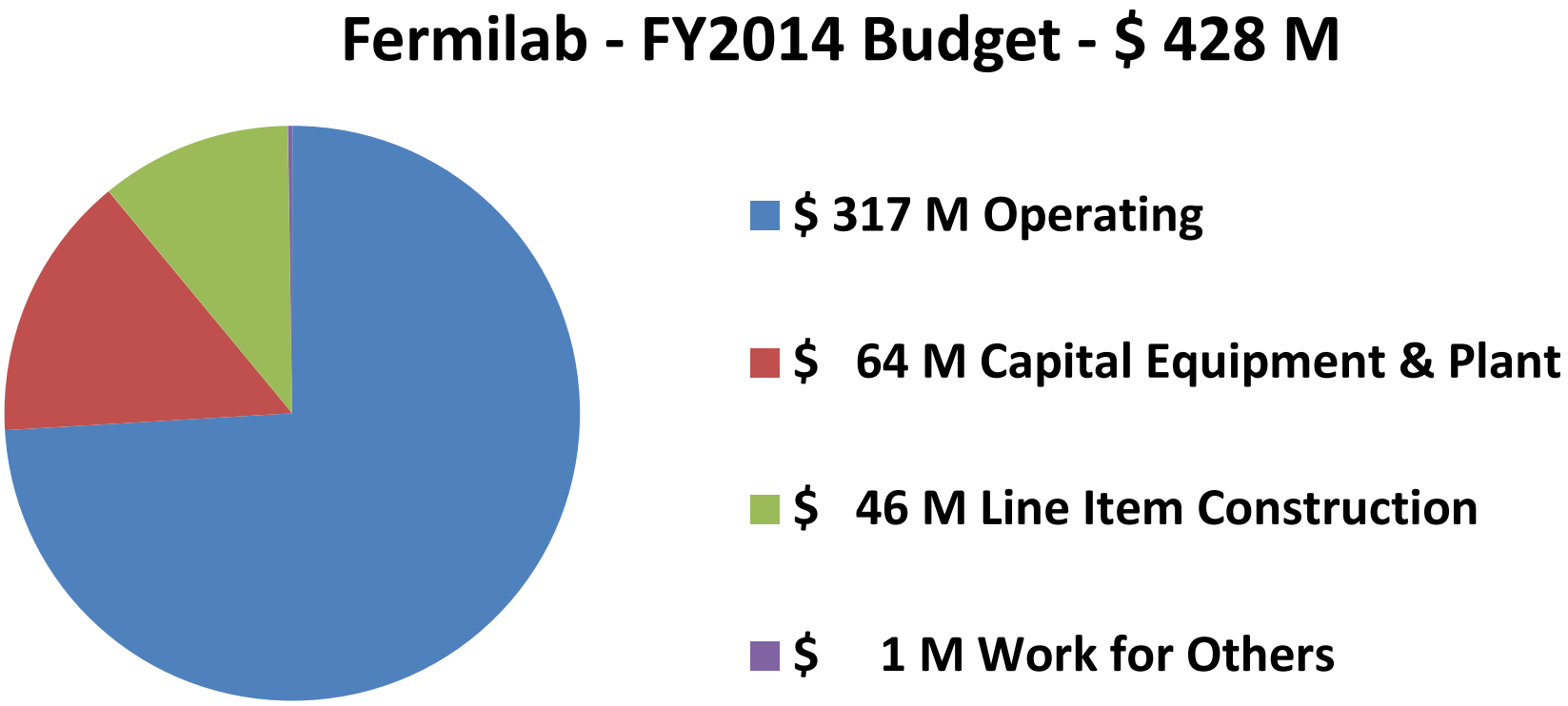
# 1. Topics for research plans and projects in Fermilab (1 hour 15 min)

1) Personnel and budgetary makeup of the institute

a) Number of personnel by job category, and total number (latest)



# b) Item-by-item budget amount and total amount (latest)



2) Overview and goals for the research plans and projects currently underway, and personnel and budget allocation status for the project

a) Overview and targets for the research plans and projects currently underway

b) Status of personnel and budget allocation for the research plans and projects currently underway

- see earlier presentation by Joe Lykken

3) Accomplishments anticipated for the research plans and projects currently underway

a) Academic accomplishments (in particle and nuclear physics aspects)

b) Technological accomplishments (in technological development aspects, including accelerators)

- see earlier presentation by Joe Lykken

4) Overview of the future plans and projects being prepared or studied for implementation, and the state of progress of the review process

- see presentations by

Joe Lykken, Sergei Nagaitsev & Hasan Padamsee

# 5) Views or information on relationship to the ILC project

Views or information regarding the relationship between the current/future plans and projects in Fermilab and ILC project

Bob Kephart - US industries, Shekhar Mishra - US/India for PIP-II Padamsee, Solyak, Mike Harrison (LCC & BNL)

- Developed US Industrial Capability for producing SC Cavities
- Operating the only 8 cavity cryomodule with the ILC specified average gradient of **31.5** MV/m
- Will soon operate ILC cryomodule with beam at ASTA
- R&D on Q-slope for ILC Cavities for higher gradient & efficiency

– Fabricate & Test ILC-like cavities & cryomodules for LCLS-II

- R&D for ILC detector design and optimization – Dmitri Denisov.

# 15 minute Break….

# 2: Topics for particle accelerators in Fermilab and ILC (1 hour 15 min)

**Accelerator Overview Presentations** (10 minutes each):

Vision for Fermilab's Accelerator Program – Sergei Nagaitsev

Vision for Fermilab's Technology Program – Hasan Padamsee

Illinois Accelerator Research Center (IARC) – Bob Kephart

# Technology spin-off from particle accelerators in Fermilab and ILC

1) Fields of technology and products that have been newly developed or introduced for the construction of large-scale accelerators in Fermilab

   - Hasan Padamsee and Bob Kephart

2) Number of businesses and business categories that have signed supplier agreements during the process of the construction of large-scale accelerators, and the contract amount of such agreements in Fermilab

Economic Impact and Fermilab Procurements

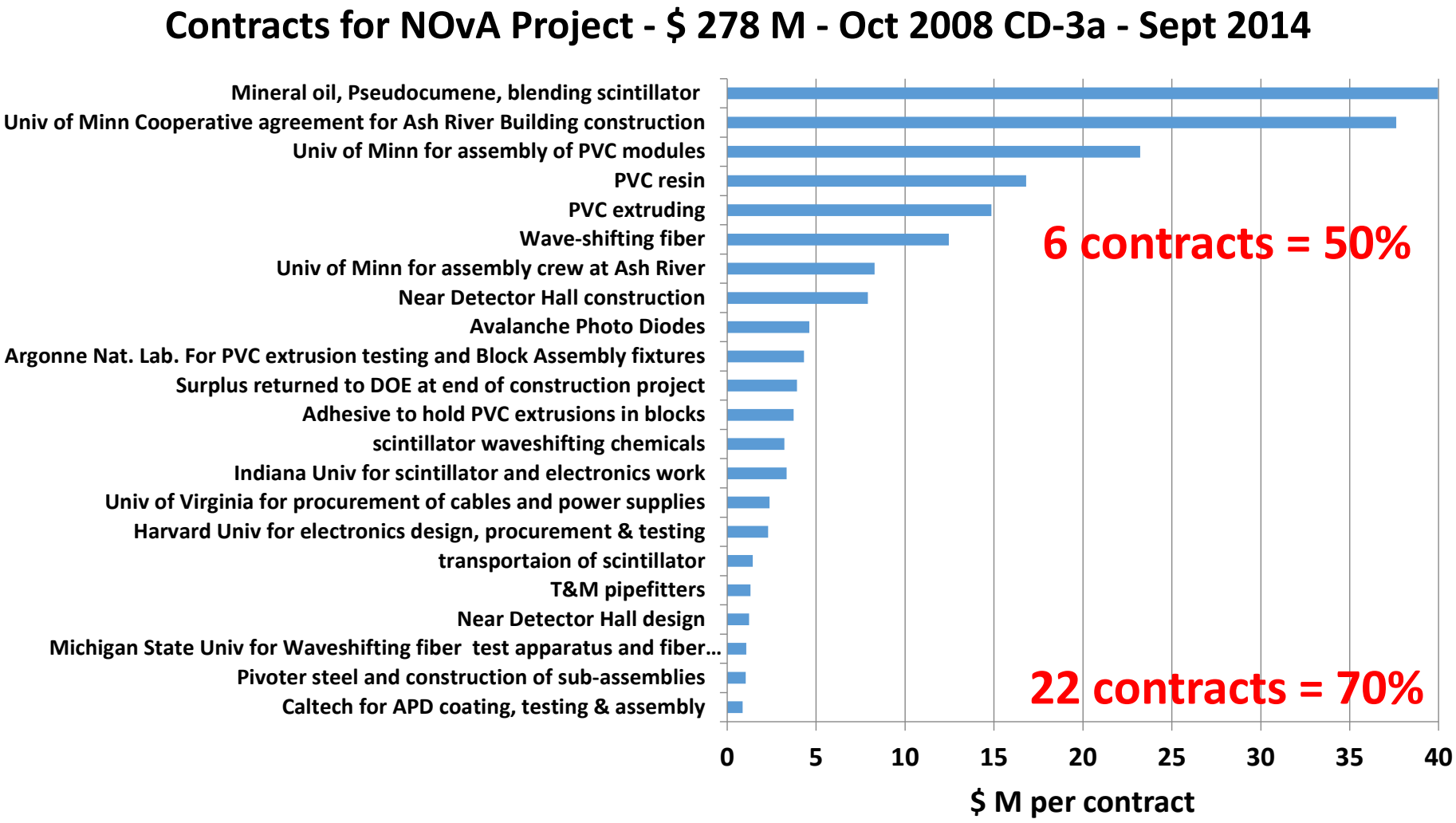
The Economic Impact of FNAL - U of C commissioned study

# A case study:

The last major accelerator constructed at Fermilab was the Main Injector during the mid-1990s, so the requested contracting information was not available. NOvA was the last major Fermilab construction project. It was mainly detector and experimental facilities, but included ~ 15% for accelerator upgrades.

The 6 largest NOvA contracts represent 50% of the total cost. The top 22 contracts represent 70%. The remaining 30% was for Fermilab costs including small contracts for components and Fermilab labor for assembly, testing, installation, integration, project management.

# Example of Contracts on a recent Fermilab Project



# Technology Transfer or Spin-off to Industry

3) Any actual cases of technology transfer (spin-off) to an industry from the construction of large-scale accelerators in Fermilab. If such cases exist, name the businesses and products, and identify the sizes of the newly created markets.

- Tevatron SC wire and magnet technology into MRI magnets
- Fermilab produced proton therapy accelerator for Loma Linda MedicalCenter in California
- Fermilab produced RFQ accelerator for PET isotope production for a hospital in Louisiana
- CERN's Development of World-Wide Web for High Energy Physics
- Development of two U.S. companies for SRF Cavities
- **Pure** niobium ingot production for use in SRF cavities has developed into a world-wide industry in China, Brazil, Japan, and the US
- Fermilab acts as the customer, working with existing supplier companies, collaborating and facilitating their capabilities to produce products required by the accelerator community

4) Fields of technology and products those are (likely) to be newly developed and introduced for the construction of ILC

    - Bob Kephart, Hasan Padamsee, Mike Harrison

5) Fields of industries and products expected to be transferred the newly developed technology from the construction of ILC

    - Bob Kephart, Hasan Padamsee, Mike Harrison

# Use activities of particle accelerators in Fermilab

1) Demand for accelerators (actual usage in the last five years, purchase status over the last five years, future prospects, required accelerator performance and capabilities)

From Particle Physics: Benefits to Society: Besides direct Research

> 30,000 particle accelerators are in operation around the world today

Medical Accelerators have treated > 30 Million patients around the world

Particle Detectors for Medical Imaging, e.g. γ-ray detectors for PET

Market for Medical and Industrial Accelerators is > $ 3.5 B per year

The $ 2 Trillion/year Electronics Industry invests

$ 1.5 B/year for accelerators for ion-implantation

Products that are processed, treated, or inspected by particle beams have a collective annual value of > $ 500 B

2) Research activities using accelerators
over the past 10 years and the results

- see Bob Kephart's earlier presentation

# 3) Changes in research activities attributable to the introduction of accelerators over the past 10 years.

Peter's personal list of some "***game changers***" over the last 10-15 years;
a ***very*** incomplete list, just as a starting point for discussion:

SRF Cavities for $e^+e^-$ storage rings & light sources (many) - Hasan's booklet

SASE – Self-Amplified Simulated Emission Free Electron Lasers (FEL)
high brightness and short time resolution hard UV & soft-X-rays
first at FLASH at DESY - SRF,
then Linear Coherent Light Source (LCLS) at SLAC – NC RF

SNS – Spallation Neutron Source at ORNL – SC proton linac
you visited earlier ATLAS SC proton linac at Argonne National Lab

Electron Cooling of Antiproton Beams – Fermilab – Sergei Nagaitsev
increased Luminosity for pbar-p colliders

Slip-Stacking of proton beams – Fermilab – Proton Improvement Plan (PIP)
increases proton beam power for Neutrino Experiments
250 KW (prior) => 350 KW (now) => 700 KW (~ 1 year from now)

# game-changers (continued)

In progress or near-term plans:

LCLS-II at SLAC – higher energy, higher brightness X-rays – using SCRF electron linac

Facility for Rare Isotope Beams (FRIB) – Michigan State U – using SCRF proton linac

PIP-II at Fermilab – SRF proton linac to replace 40 year old Normal Conductor (copper cavities) linac to increase proton beam power for Neutrino Experiments to 1.2 MW

4) Issues in the use of accelerators over the past 10 year (cost, capabilities, etc.)

- see Bob Kephart's earlier presentation

5) Research or industrial fields in which the demand for the use of accelerators is anticipated to increase, and fields in which the use of accelerators is likely to prove beneficial

- Bob Kephart & Hasan Padamsee

# Summary and Discussions

***Thank you!***

Fermilab notes from NRI visit

# Reference URLs

Annual Laboratory Planning Fermilab 2014
extracted from the full DOE/Office of Science Report
**this report was issued just after the P5 Recommendations,**
**so it was not fully aligned with the P5 Recommendations**
https://www-ilcdcb.fnal.gov/NRI/SC_Consolidated_Laboratory_Plans_Fermilab_2014.pdf

Particle Physics Project Prioritization Panel (P5) Report - May 2014
http://science.energy.gov/~/media/hep/hepap/pdf/May%202014/FINAL_P5_Report_053014.pdf

Accelerators for America's Future – Accelerator R&D Stewardship Report – 2012:
http://science.energy.gov/~/media/hep/pdf/accelerator-rd-stewardship/Report.pdf
website: http://www.acceleratorsamerica.org/
`website: http://science.energy.gov/hep/research/accelerator-rd-stewardship/

Accelerators and Beams – Tools of Discovery and Innovation American Physical Society – 2013
http://www.aps.org/units/dpb/upload/accel_beams_2013.pdf

Report of the Fermilab ILC Citizens' Task Force
http://www.fnal.gov/pub/neighbors/docs/FermilabILCCitizensTaskForceFinalReport.pdf

The Economic Impact of Fermi National Accelerator LaboratoryAnderson Economic Group, LLC – 2011 – commissioned by the Univ. of Chicago
http://ovprnl.uchicago.edu/sites/ovprnl2014.uchicago.edu/files/Fermilab_Economic_Impact_Full_Study.pdf

Economic Impacts:
https://www-ilcdcb.fnal.gov/NRI/Fermilab-economic-impact.pdf

Fermilab Procurements:
http://www.fnal.gov/pub/presspass/factsheets/pdfs/FermilabProcurements_FY2014.pdf

RF Superconductivity 2010 – Science, Technology, and Applications - H. Padamsee – Cornell University
https://www-ilcdcb.fnal.gov/NRI/RF_Superconductivity_2010.pdf

Fermilab single sheet factsheets and brochures (select tab):
http://www.fnal.gov/pub/presspass/factsheets/

Superconducting Particle Accelerator Forum of America
http://spafoa.org/

Tools, Techniques, & Technology Connections of Particle Physics
http://science.energy.gov/~/media/hep/pdf/files/Banner%20PDFs/TTT-connections-May14.pdf

Brookhaven National Lab Economic Impact Report, Oct. 2011
http://www-ilcdcb.fnal.gov/NRI/BNLEconImpactReport11_05.pdf

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