Fermilab

Managed by Fermi Research Alliance, LLC for the U.S. Department of Energy Office of Science

Introduction to the Particle Physics Division

Jonathan Lewis

Fermilab Users' Meeting

16 June 2016

Organization

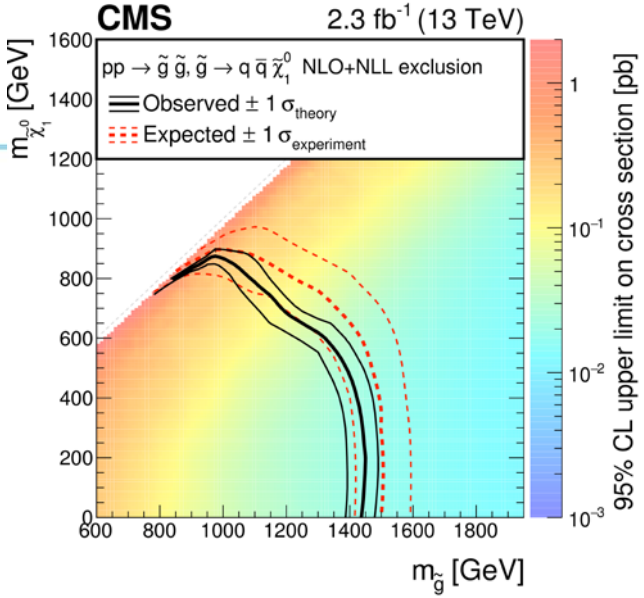
- Division Office
  - Head: Patricia McBride
  - Deputy: Bob Tschirhart

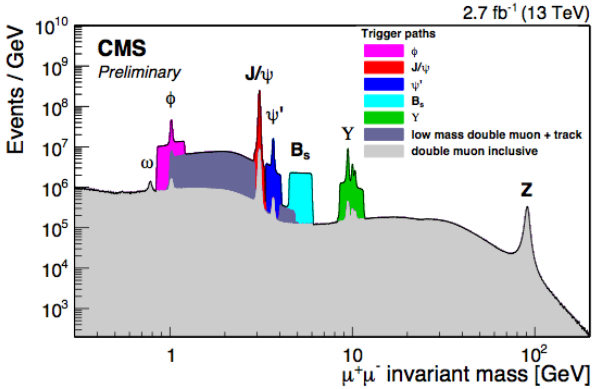
- Science Departments
  - CMS
  - Muon
  - Astrophysics
  - Theoretical Physics
  - Particle Physics Initiatives
- Technical Departments
  - Mechanical Engineering
  - Electrical Engineering
  - Alignment and Metrology
  - Detector Operations and Development

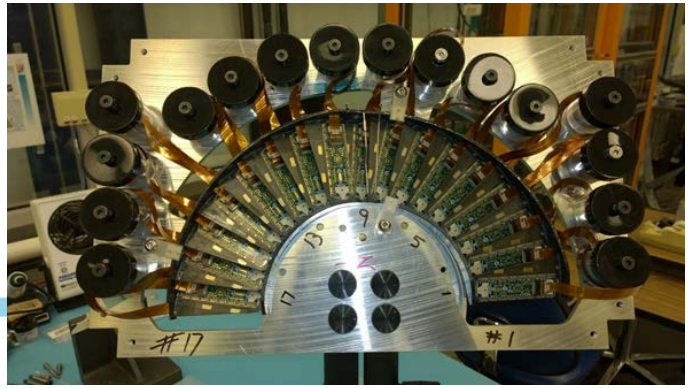
After an overview of the departments, the balance of the talk will be devoted to technical resources available to users

CMS

- Fermilab has the largest US group on CMS and second largest group overall
  - currently ~60 authors, including 15 postdocs
  - Total effort is >100 FTE
- PPD personnel are currently active in:
  - Analysis of Run 2 data (with SCD scientists):
    - Searches for SUSY, Dark Matter, other exotica
    - Higgs physics, SM measurements
  - Construction of Phase 1 detector upgrades: Hadron Calorimeter and Forward Pixels
  - R&D for HL-LHC detector upgrades: Hadron Calorimeter, Forward Pixels, Outer Tracker, Trigger
- Fermilab also hosts the LHC Physics Center and Remote Operations Center for users

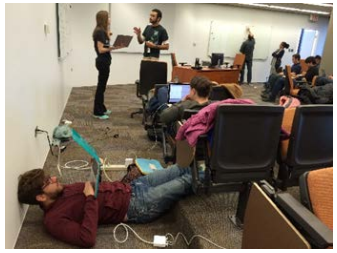






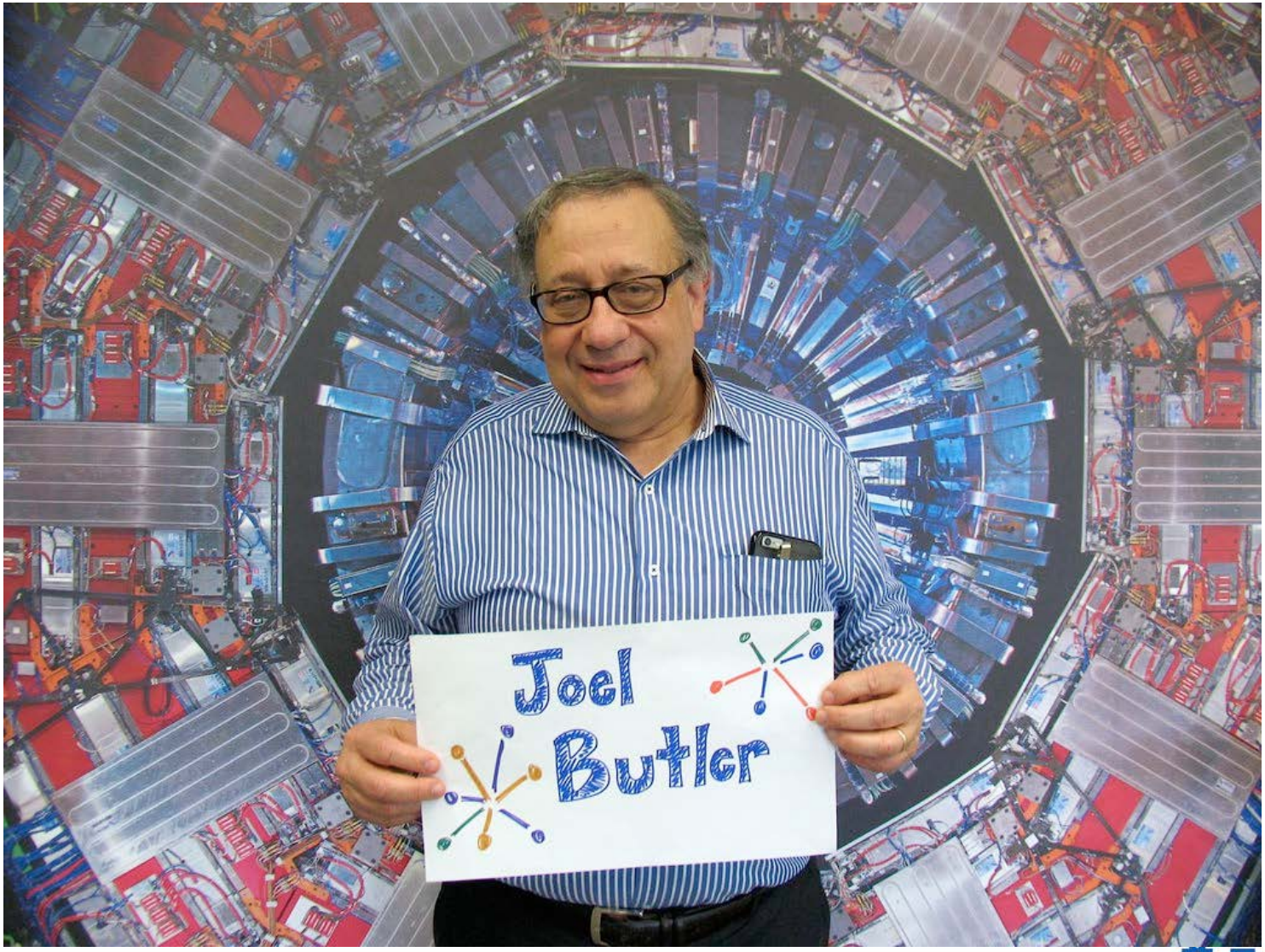
CMS: LHC Physics Center

- The LPC has been an outstanding center of excellence for US-CMS and for CMS – it has been championed by CMS
  - Make everybody more productive through its variety of programs and activities, e.g. trainings, workshops, seminars, etc.



- The LPC is steadily growing in its attractiveness within our CMS community
  - US - all 50 institutions take advantage of it
  - International - it hosts CMS colleagues from many countries in Latin America, Asia, and Europe
- It is referred to, and being praised and/or duplicated by others in HEP
  - US-ATLAS, Fermilab (NPC), DOE, theorists,…

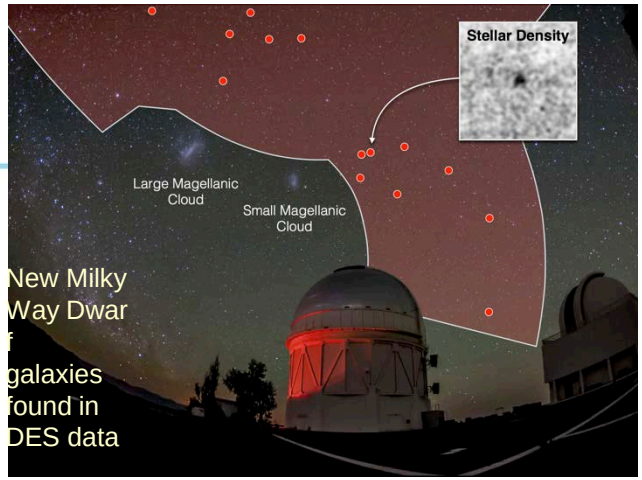
New CMS Spokesperson



Astrophysics

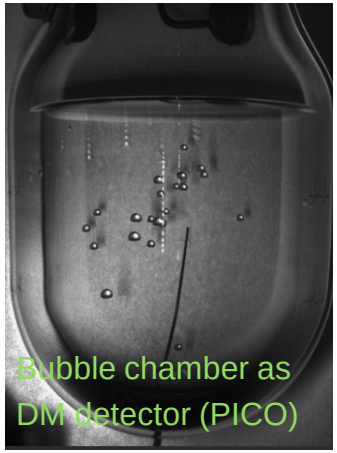
- Fermilab is leading the Dark Energy Survey and several Dark Matter projects and is contributing to future projects in Dark Energy, Dark Matter and CMB.
  - currently ~40 people, including 10 postdocs

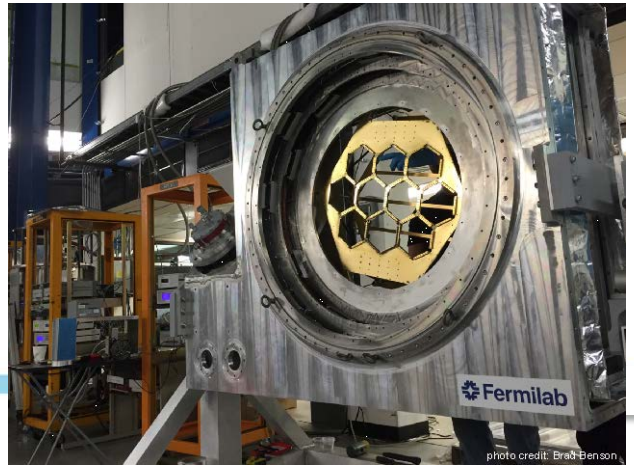
- PPD personnel are currently active in:
  - Publishing results:
    - DES >70 papers on early data, discovery of new dwarf galaxies, LIGO Gravitational wave follow-up, cosmology results
    - World leading Dark Matter limits for low mass and spin dependent WIMPS
    - SPT papers and cross-correlations with DES
    - Holometer exceeded design expectations
  - Construction of next generation projects:
    - Dark Matter: CDMS-Snolab, LZ, ADMX
    - Dark Energy: DESI, LSST
    - CMB : SPT-3g and S4 Planning
    - R&D for future DM and DE projects
  - Enabled by strong connections with theory group and by technical expertise in silicon detectors, precision assembly, testing and integration, cryogenic engineering, light detection, bubble chambers



New Milky Way Dwar f galaxies found in DES data

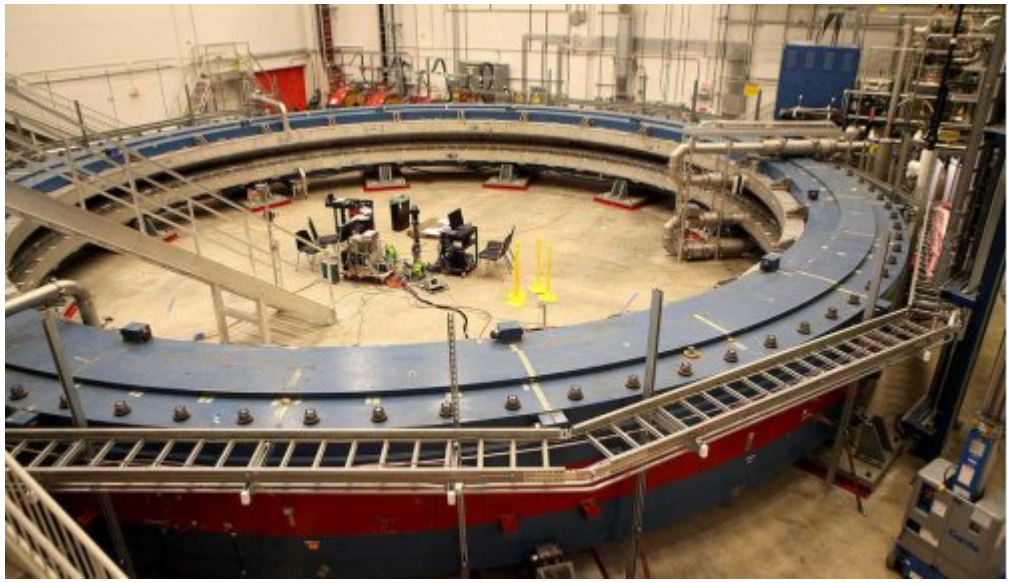
Dan Bauer w ith CDMS de tectors


Bubble chamber as DM detector (PICO)



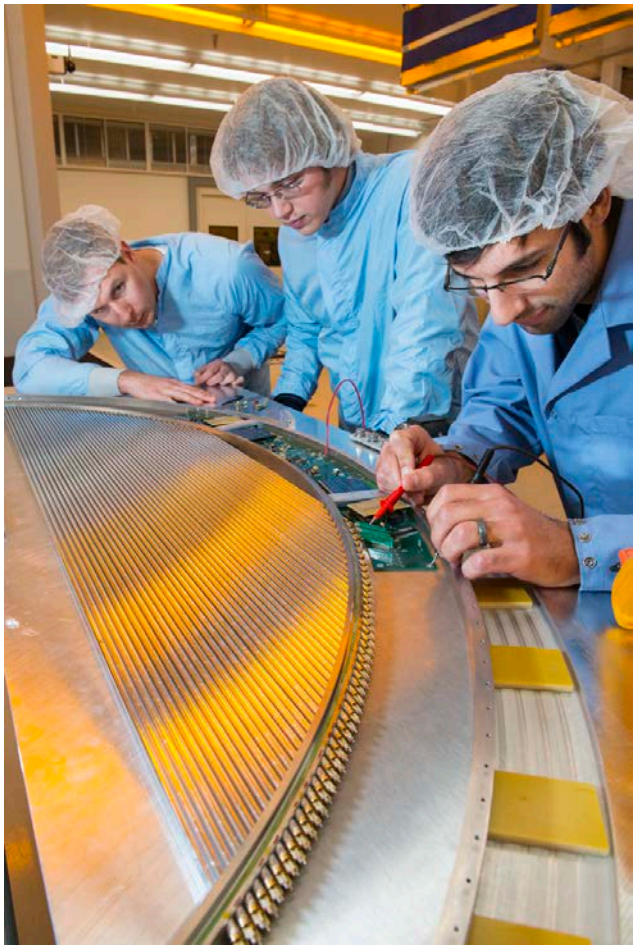
Muon

- Twenty scientists leading many aspects of Mu2e and g-2
- g-2 activities
  - Project and collaboration leadership
  - Leading the assembly, cool down, and shimming of the magnet to reach a uniformity of 15 ppm
  - Leading the computing and simulation team in preparation of mock data challenges
  - Making significant contributions to reconstruction and analysis software for the tracker
  - Making significant contributions to understanding the beam dynamics and their impact on the physics



Muon, cont.

- Mu2e activities
  - Project and collaboration leadership
  - Leading the development and prototyping of the straw tube tracker
  - Leading the computing and simulation team in utilizing over 30M cpu-h to generate >4e12 events to validate final design
  - Making significant contributions to reconstruction and analysis software for the calorimeter, tracker, and cosmic-veto sub-systems
  - Making significant contributions to understanding the effects of solenoid mis-alignments on the physics sensitivity of the experiment



Theory

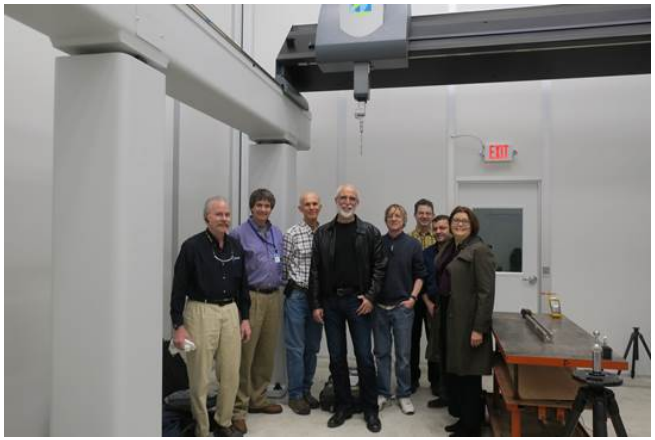
- World-leading theoretical particle physics & theoretical astrophysics research in key areas directly related to the U.S. and worldwide experimental programs:
  - Collider phenomenology, Higgs physics, flavor physics, BSM mode building, neutrino physics, perturbative and lattice QCD,
  - Dark matter, baryogenesis, dark energy, inflation, CMB, cosmic neutrinos, large scale structure.
- Frequent interaction and collaboration between the HEP and cosmic groups
- Synergies with Fermilab programs on LHC, Cosmic, Muons, Neutrinos, computational science
  - Train next generation of theorists in data-rich environment; contribute to educating junior experimentalists.
  - Provide a national resource for university physicists.
  - Foster an intellectually vibrant atmosphere at the lab
- FNAL theorists happy to talk to you (see backup slides for directory)

Engineering

- Electrical
  - Department Head: Terri Shaw
  - Front-end, DAQ, grounding/shielding, power distribution
  - ASIC development facility
- Mechanical
  - Department Head: Russ Rucinski
  - Cryo
  - Design of structures, fixtures, etc.
- Alignment and Metrology
  - Department Head: Horst Friedsam
  - Surveying, etc.

Detector Operations and Development Department

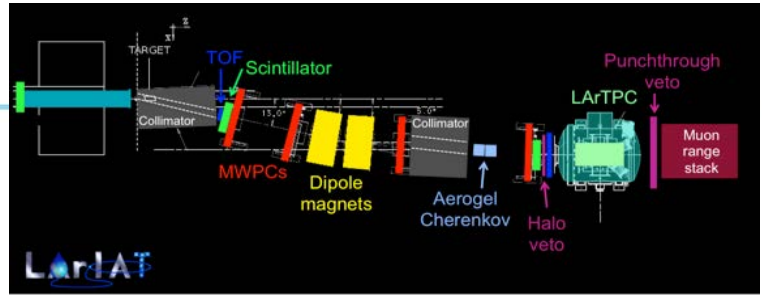
- Facilities
  - Test Beam
  - Silicon Detector
  - Precision Metrology
  - Rapid Prototyping and Special Materials
  - Scintillator Detector Development
  - Thin-Film
  - Noble Liquid Detector Development Facility
- Technical groups
  - Detector manufacturing and assembly
  - Experiment operations
  - Facility operations
- Assembly and lab space
- Head: Rick Ford



Facilities

- Fermilab has many technical capabilities that have been optimized for the development and construction of detectors for HEP
- Our facilities are available to qualified researchers in the HEP community
  - The work may be your own initiative
  - You may work in collaboration with an approved lab effort
    - In this case there may be financial support for the technical work
- Staff of the facilities support full life cycle of experiments
  - R&D
  - Construction
  - Operations
  - Decommissioning

Fermilab Test Beam Facility (FTBF)



- Two beam lines
  - MTest
    - 1 GeV to 120 GeV beams
      - Depends on species
    - Multiple stations
    - Typical installations 1-4 weeks
  - MCenter
    - 200 MeV to 80 GeV
    - Long term installation
    - LArIAT was first customer
  - 4 sec spill every 60 seconds
  - Tunable rate (100 Hz – 100,000 Hz)
- No charges for users
- Infrastructure
  - Facility beamline instrumentation, silicon pixel telescope
  - Gas, HV, signal, networking capabilities

More info at ftbf.fnal.gov
Manager: Mandy Rominsky

Noble Liquid Detector Development Facility

- Argon and Xenon detectors for neutrino and dark matter detection
  - Housed at PAB
  - Strong partnership with Neutrino Division
- Several cryostats for testing detector structures, materials, light or charge collection techniques, HV distribution, etc.
- Staff support for cyro system construction and operation

Scintillator Detector Development Facility

- Manager: Anna Pla-Dalmau
- Hosts extruder for large-scale production of detector scintillator pieces
  - Prototyping runs come first
  - Developing a die requires time and money
- Equipped for for preparation of scintillator paddles
  - Cutting, polishing, etc.

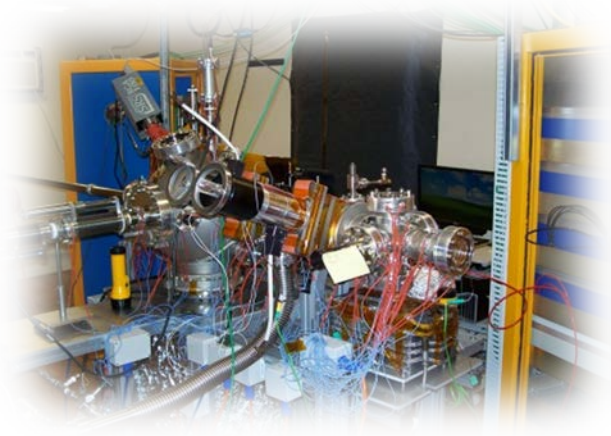
Scintillator Detector Development

- Chemical and analytical labs are maintained for R&D on scintillator materials
  - Extensive work on NOvA liquid scintillator

- Large stock of “pre-owned” scintillator paddles/bars and phototubes
  - Contact: Anatoly Ronzhin
- Legacy wire chamber winding facility with unique detector fabrication capabilities also maintained

Thin Film Facility

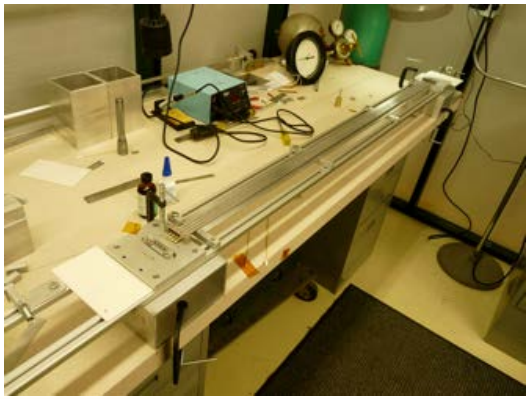
- Provides for application of evaporated and sputtered thin coatings on detector components
- Also specializes in optical fiber and plastic connector polishing and plastic fiber splicing
- Special furnace that provides heat treatment of metals in a vacuum



- Manager: Eileen Hahn

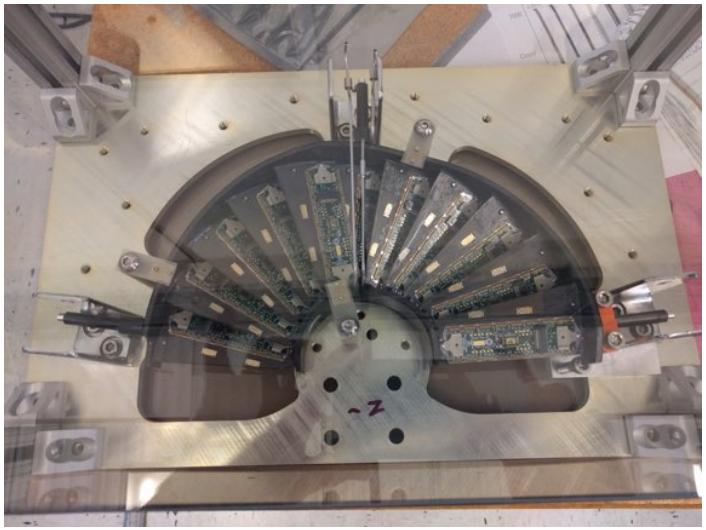
Rapid Prototyping & Special Materials Facility

- Focuses on fabrication and assembly of complex detector elements
- Low-Z carbon fiber production facility
- Houses large, specialized machines adapted for fabrication of detector elements using special materials
- Large clean rooms for detector assembly
- Manager: Dave Butler



Rapid Prototyping & Special Materials

- Examples of prior work
  - Research & Development
    - COUPP Bubble Chamber Assembly
  - Project Work
    - Mu2e Straw Tracker
    - CMS Phase 1 Pixel Detector Frames
    - CMS Phase 1 Endcap Muon Panels
  - Work for Others
    - JLAB SVT Modules
    - NIU Proton CT Fabrication



Silicon Detector Facility

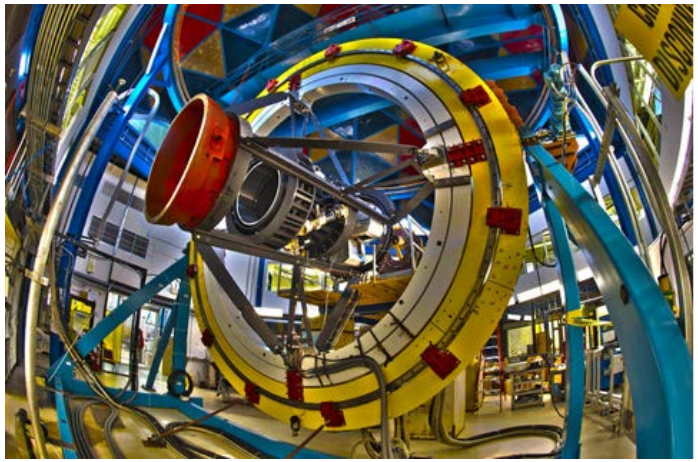
- Long history at the forefront of detector R&D including the development of silicon tracking detectors for CDF, D0, and CMS as well as the development of the DES camera and SPT-3G detectors
- Facility infrastructure includes equipment for the production of silicon devices (e.g. clean rooms, high-precision measuring devices, and wire-bonding machines) as well as that required for the testing and QA performed on these devices
- Facilities are continually being upgraded to support development and production of the next-generation versions of these devices
- Leader: Gino Bolla

Silicon Detector Facility Infrastructure

Clean Rooms

Wire Bonding Machines

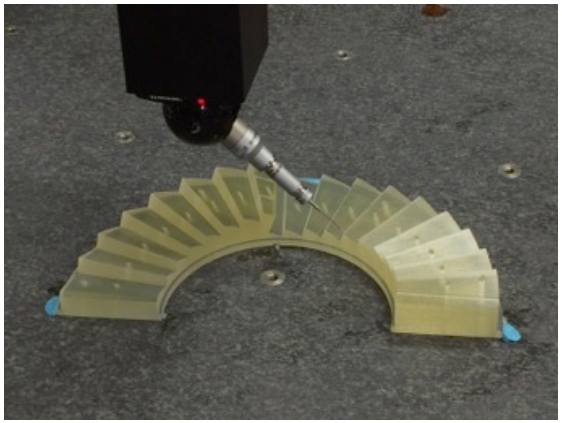
Cryogenic Test Stand



Large Area Assembly Spaces

Precision Metrology Facility

- Closely associated with Silicon Detector Facility
- Provides infrastructure needed for performing high-precision measurements associated with assembly of small-scale detector elements
  - Coordinate measuring machines (CMMs)
  - New gantry CMM for 2m scale devices
- Manager: Mike Roman

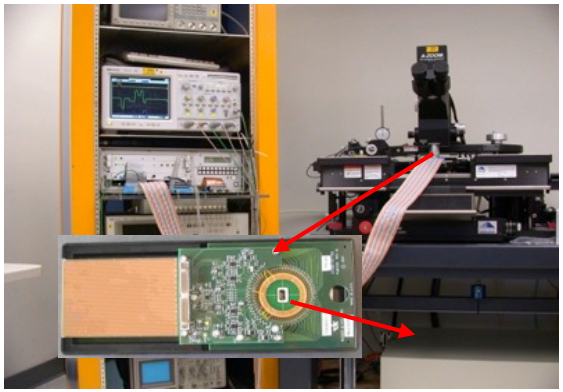


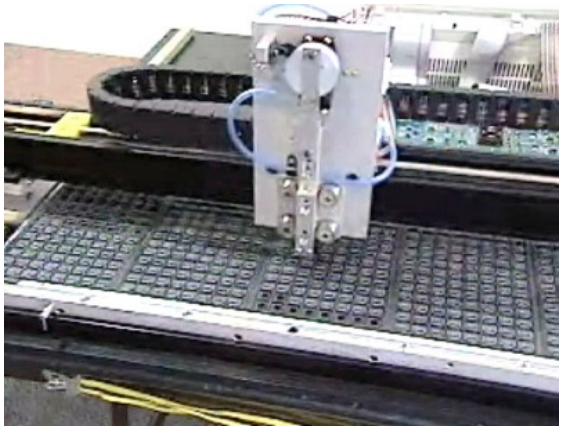
ASIC Development Facility

- Contributes to leading-edge technologies for the design of custom integrated circuits and sensors
- Special attention to designs that are radiation tolerant and that can operate in low temperature environments
  - Currently working on COLDATA chip for DUNE
- Unique contributions to the development of vertically integrated (3D) chip designs, with a focus towards sophisticated on-detector processing of pixel data and large volume data processing for triggering
- Leader: Gregory Deptuch (EED)

ASIC Development Facility Infrastructure

- Fabrication
  - Wire Bonding
  - Robotic Tester
  - Wafer Probing
- Testing
  - Printed Circuit Board Design
  - Field Programmable Gate Array (FPGA) Design
  - Cold Vacuum Chamber
  - Sensor Characterization
  - Mobile ASIC Test Setup





Access to Resources

- Engineers and Technicians
  - Available for consultations and questions
  - Significant work requires a funding source
    - Experiment operations or project budget, outside funding
- Space or equipment for R&D work
  - By agreement with host department (usually DDOD)
- Proposal process: Technical Scope of Work (TSW)
  - Outlines work to be performed and laboratory resources required
    - Effectively a mini-MOU
  - Identifies safety concerns
  - Updated as work progresses and needs change
  - Contacts:
    - Test beam: Mandy Rominsky
    - R&D: Erik Ramberg and Raymond Lewis
- Safety review for operations: Operational Readiness Clearance (ORC)

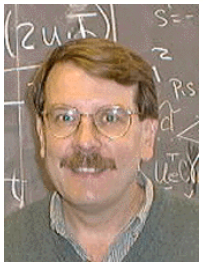
Conclusion

- PPD Scientists taking leading roles in CMS, Muon, and Cosmic programs
  - Technical work in areas with synergy with lab capabilities
  - Scientific research focused on core topics
  - Committed to supporting users
- PPD maintains a collection of world-class facilities for detector R&D
  - The unique capabilities of these facilities are available to the entire HEP community
  - We are eager to assist users in achieving their R&D goals
    - Questions or concerns: jdl@fnal.gov
  - Our facilities are evolving
    - Please let us know your needs so we can meet them

BACKUP

FNAL theorists are happy to talk to you

Neutrinos:



Stephen Parke
Neutrino Physics Center Coordinator

Pilar Coloma
New Associate Scientist

Andreas Kronfeld
Steering Group on Neutrino-Nucleus Interactions

Also:
Bogdan Dobrescu
Scott Dodelson
Roni Harnik
Chris Hill
Boris Kayser
Chris Quigg

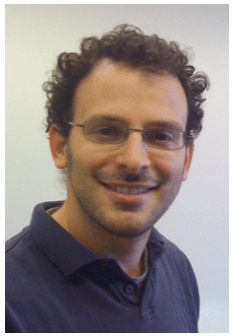
LHC:

John Campbell

Marcela Carena
Particle Physics Department Head

Bogdan Dobrescu
LPC

Paddy Fox



Roni Harnik
LPC

Walter Giele

Chris Hill

Pilar Coloma
New Associate Scientist hire: 07/01/2016
Neutrino Expert

FNAL theorists are happy to talk to you

Cosmic:

Scott Dodelson

Josh Frieman
DES Director

Nick Gnedin

Dan Hooper

Albert Stebbins
Astrophysics
Department Head

Also:
Marcela Carena
Roni Harnik
Paddy Fox

Muons:

Ruth Van de Water

Estia Eichten

Chris Quigg

Also:
Roni Harnik
Andreas Kronfeld

Plus several postdoctoral Fellows and Fermilab Distinguished Scholars

Computational:

Writing a TSW

- Use a graded approach
  - Shorter document for brief activities and/or limited resources
  - Longer for more involved activities
    - Example: ANNIE built at D0 Assembly Building
- Template and instructions online
  - http://ppd.fnal.gov/tsw_template.html
- Two parts
  - List of researchers and their activities
  - List of needed resources
    - Space, equipment, labor from technical groups
  - These are generally distinct
- Assistance available from
  - Division Safety Officers : Eric McHugh and Raymond Lewis
  - R&D Liason: Erik Ramberg

Completing the TSW

- Review by relevant parties
  - Safety officer to ensure that proper safeguards are in place
    - Help identify hazards
    - Requirements for training, personal protective equipment, etc.
    - Plan for ORC (see next slide)
  - Division management
    - Ensure that resources are available and can be provided to the effort as described
  - R&D Liasons
    - Verify that goals are achievable and resources are well-matched
- Refinement
  - For more complex efforts, may need to iterate on document prior to approval
- Never really complete
  - As requirements and conditions change, TSW may require update

Operational Readiness Clearance (ORC)

- A review is required before equipment can be operated unattended
- Division Safety Officers (DSOs) and facility managers will help you with this process
- TSW provides a list of hazards that may need review
  - Others may become apparent only after design or assembly
    - Example: general electrical safety
- Subject-matter experts will review design and construction
  - May require modification to apparatus
  - While parts are under review, may operate others with pORC (partial ORC)
- Division approval required

Paying for work

- If you are collaborating on a Fermilab R&D effort or construction project, you may be able to get Fermilab to pay for work
- You can pay with outside funds for work done by Fermilab staff by setting up a Strategic Partnership Project (SPP)
  - Formerly known as a Work for Others agreement
  - Defines scope of work and cost
  - Not difficult to establish
- Small jobs, answers to quick questions can be handled without a charge-back account
- Never any charge for use of floor or bench space, use of equipment, training, test beam