

# Japan – Fermilab Research Program

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Fermilab

31<sup>st</sup> Meeting of the Japan-US Committee  
for Cooperation in High Energy Physics  
May12-13, 2009



# Fermilab Current Programs and Future Plans

## Hadron Collider:

Tevatron  
CDF, DZero  
LHC  
Accelerator, CMS, ATLAS

## Lepton Collider:

ILC  
(CLIC)  
Muon Collider

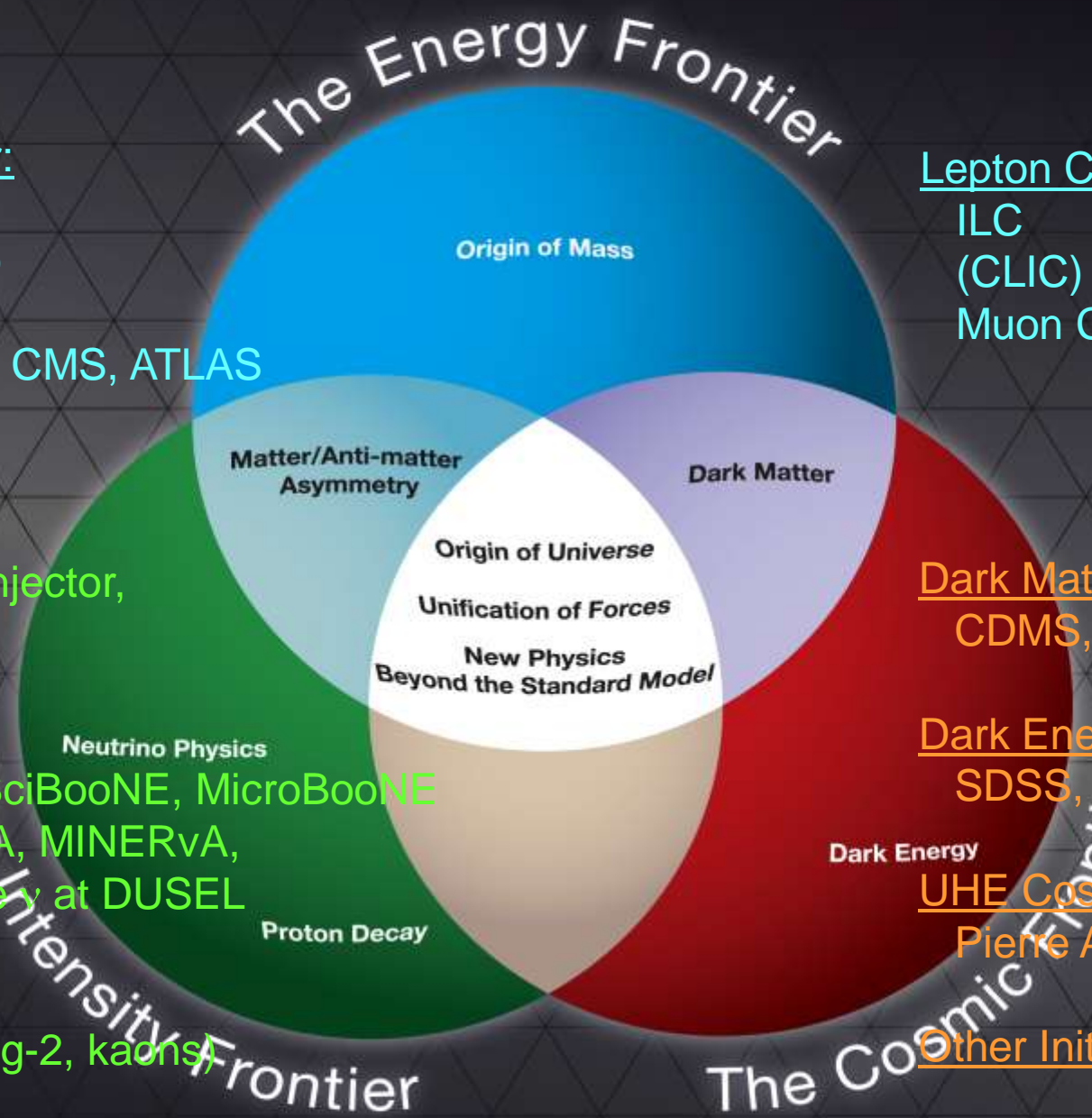
## Booster, Main Injector, Project X:

## Neutrinos

MiniBooNE, SciBooNE, MicroBooNE  
MINOS, NOvA, MINERvA,  
Long Baseline  $\nu$  at DUSEL

## Precision

mu2e, (muon g-2, kaons)



## Dark Matter:

CDMS, COUPP, LAr

## Dark Energy:

SDSS, DES, JDEM

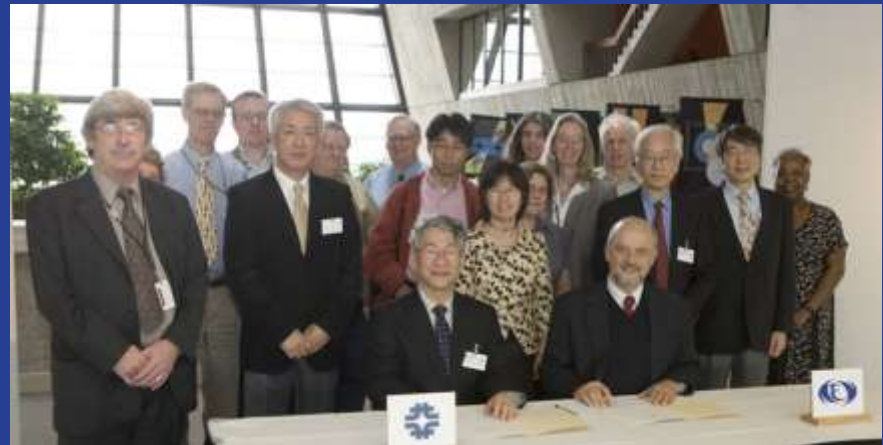
## UHE Cosmic Rays:

Pierre Auger

## Other Initiatives

# Towards Stronger KEK – Fermilab Collab.

- FNAL Directorate visited KEK / J-PARC
  - Nov. 2006
- KEK Directorate visited FNAL
  - April 2007
- Overarching FNAL-KEK MOU signed
  - April 2007



- Expected to have addenda/accords which detail individual activities

# KEK – Fermilab New Initiatives (Recent)

- Muon → Electron Conversion
  - MOU for collaboration on common issues – 2009
  - Joint COMET – mu2e workshop, Jan. 2009
- Neutrinos
  - Initiated International Neutrino Summer school by merging various specific neutrino schools
  - 1<sup>st</sup>: July 6-17, 2009 at Fermilab
  - 2<sup>nd</sup>: Summer 2010 at KEK
  - 3<sup>rd</sup>: Summer 2011 in Europe
  - .....
- Detector R&D
  - CERN-KEK-Fermilab Initiated forming “Facilitation Group” for world-wide communication and networking on “monolithic and vertically integrated pixel detector R&D” (within and beyond the particle physics community)
  - Announced it in TIPPO9 (March 2009, Japan)
  - Activities sponsored by CERN-KEK-Fermilab

# Under “Japan-US Project”

Tevatron:  
CDF

Neutrinos:  
SciBooNE for T2K

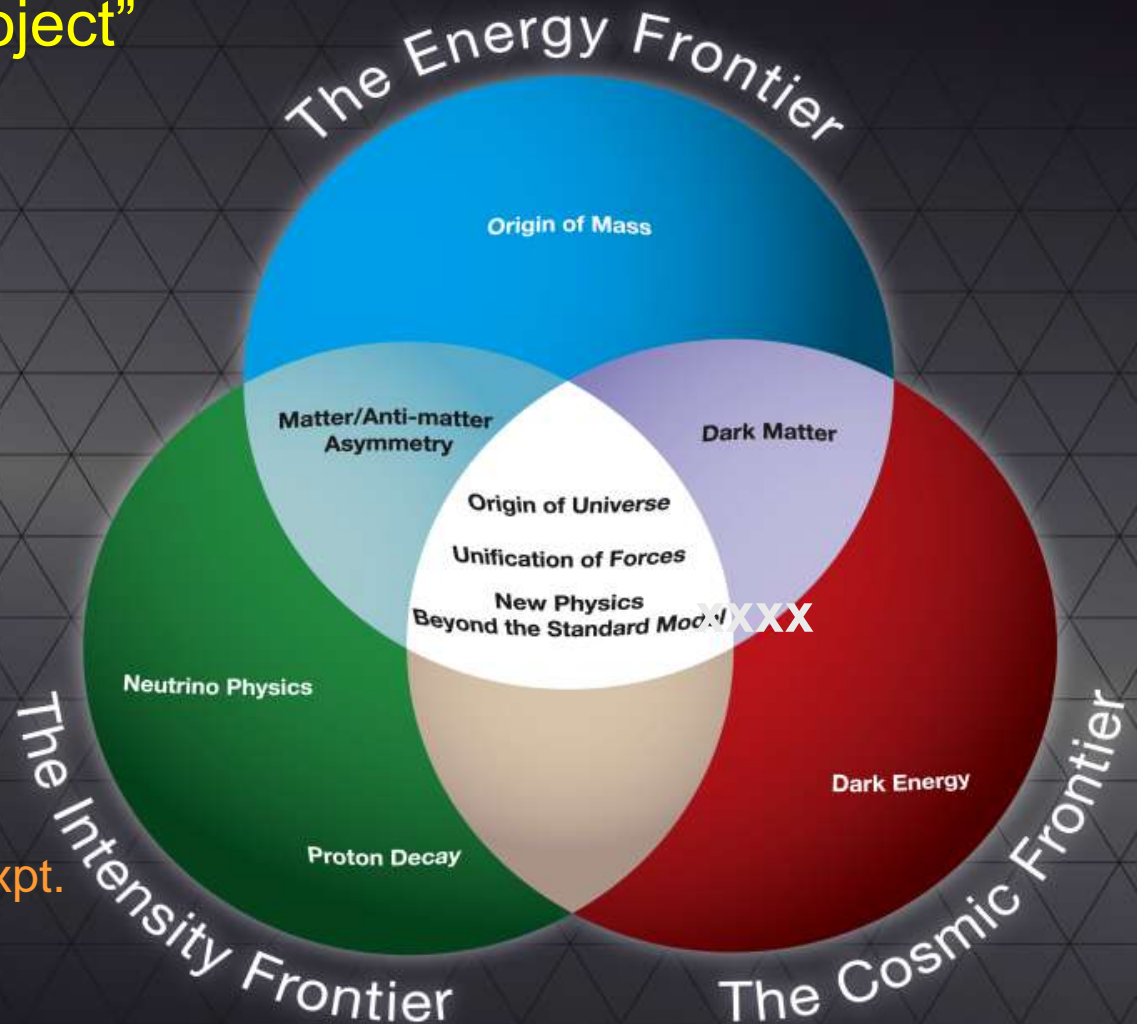
Muons:  
 $\mu$  to e Conversion

Kaons:  
KTeV det. for J-PARC expt.

Advancing Technologies:

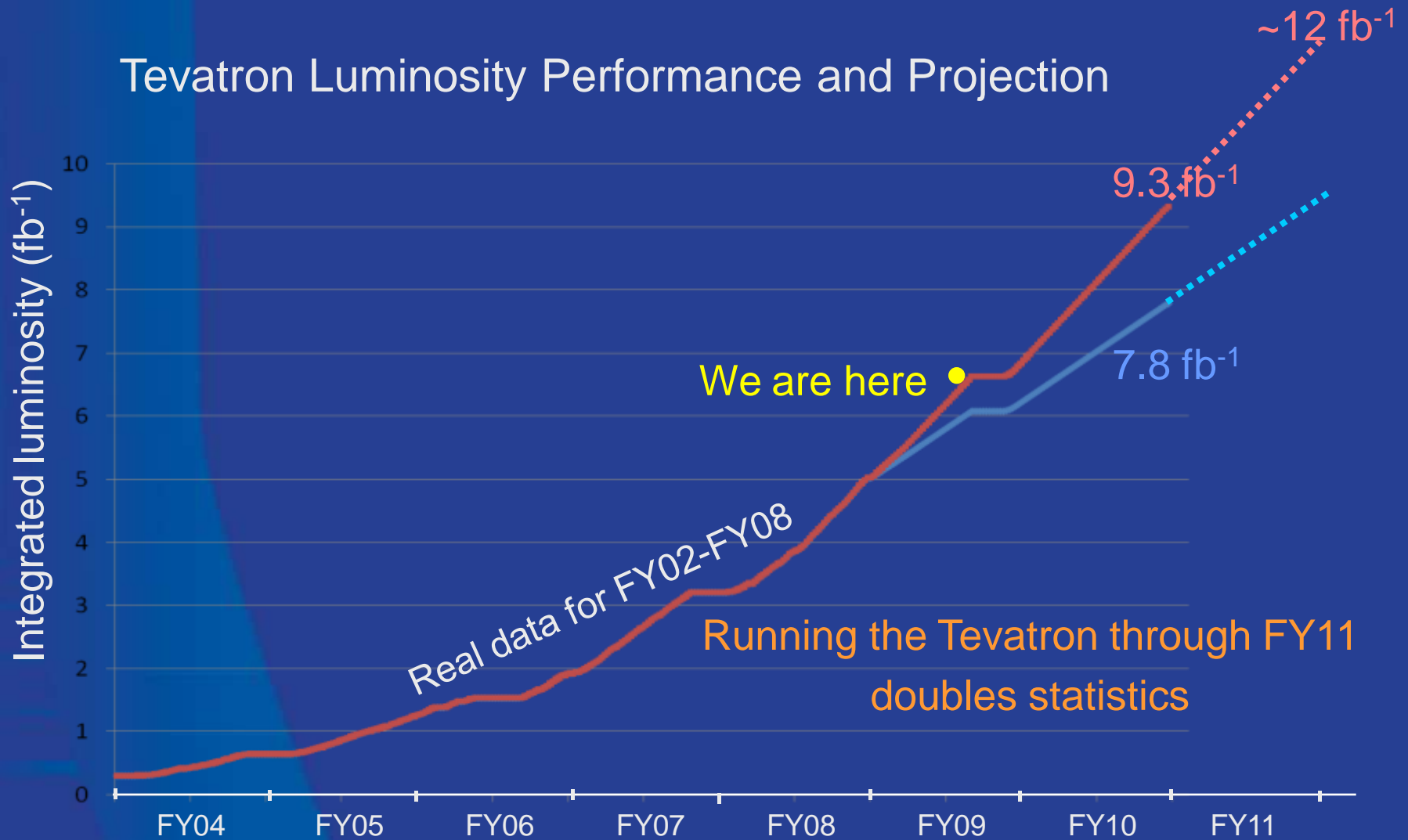
Detector R&D: Applicable to ILC, LHC, SuperB, Particle-Astro, ...

Accel. R&D: Applicable to ILC, Project X, SuperB, High Intensity Accelerators, ...



# CDF (F. Ukegawa's Talk)

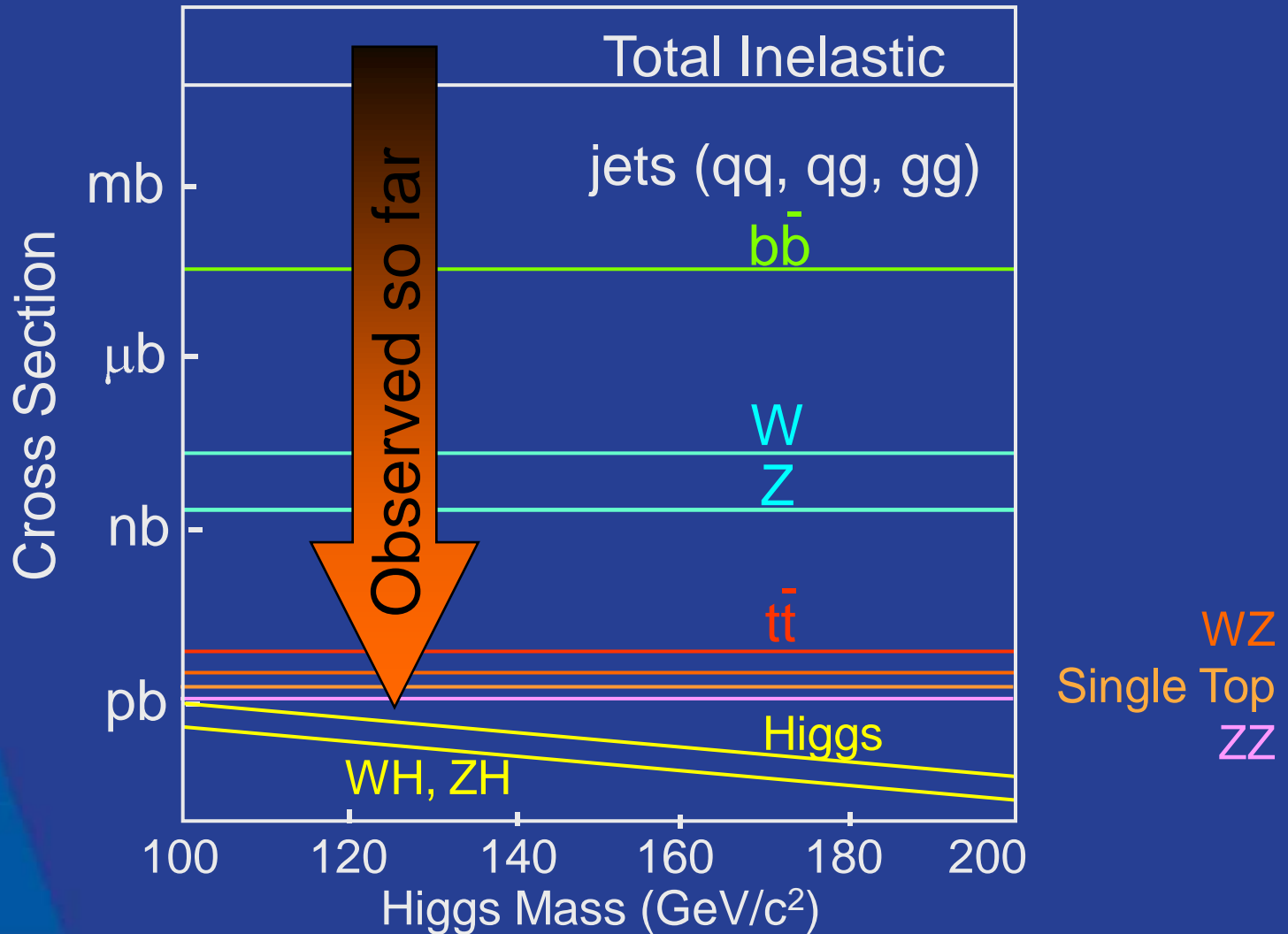
## Tevatron Luminosity Performance and Projection





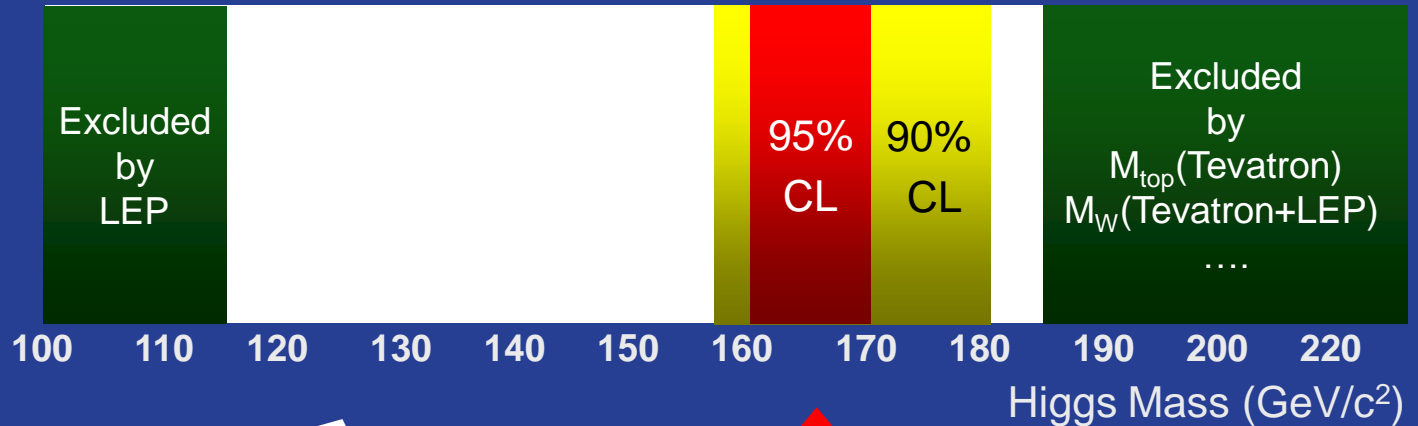
# Physics at the Tevatron

Last Year: ~100 Publications; ~60 Ph.D.s



# Tevatron Sensitivity on Standard Model Higgs

Favored Higgs Mass Region: 114 – 185 GeV at 95% CL



$H \rightarrow b\bar{b}$

$H \rightarrow W^+W^-$

Tevatron & LHC are complementary:

LHC:  $H \rightarrow \gamma\gamma, \tau\tau$

Tevatron:  $H \rightarrow b\bar{b}$

Excluded by Tevatron (3-4 fb<sup>-1</sup>)



# CDF Run-II Physics Analyses by Japanese Graduate Students

## Higgs, SUSY, new particles

Higgs searches      Osaka City: Wakisaka, Hamaguchi  
Tsukuba: Kobayashi, Ishizawa, Masubuchi, Nagai  
Waseda: Kusakabe

SUSY, Leptoquarks, Z'searches

Waseda: Ogawa, Ikado  
Tsukuba: Akimoto

## Top quark

Top mass      Waseda: Yorita, Ebina, Tuchiya  
Tsukuba: Sato, Kubo,

Production and decay, spin correlations, single top  
Tsukuba: Kimura, Nakamura  
Waseda: Naganoma

## B physics

*B<sub>s</sub>*, *B<sub>c</sub>* lifetimes      Tsukuba: Uozumi, Aoki  
*J/ψ* production      Okayama: Yamashita

## Electroweak

*W*+ $\gamma$  production      Okayama: Tanimoto  
Tsukuba: Nagano

## QCD

*W*+jet production      Tsukuba: Tsuno

Underlined: students who finished PhD's

New students are joining!!

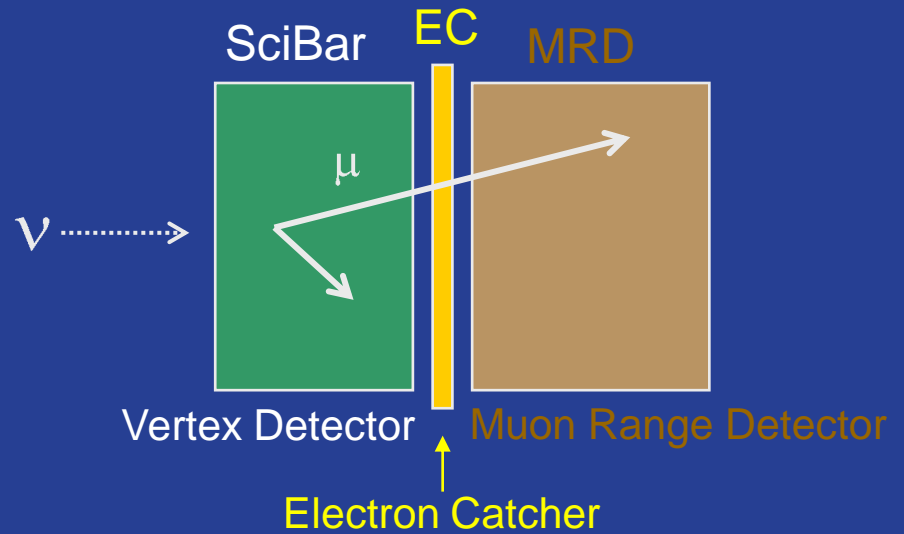
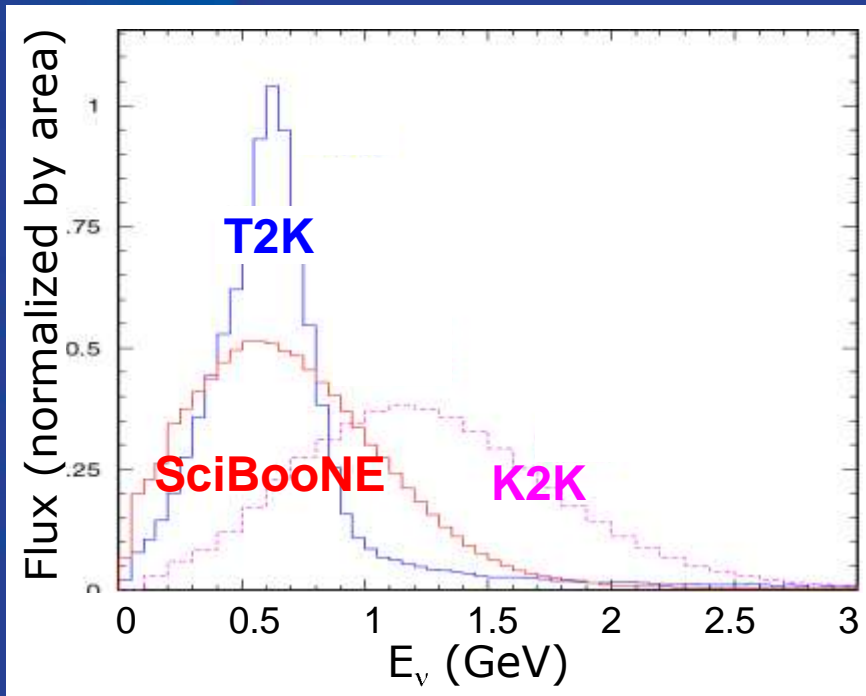
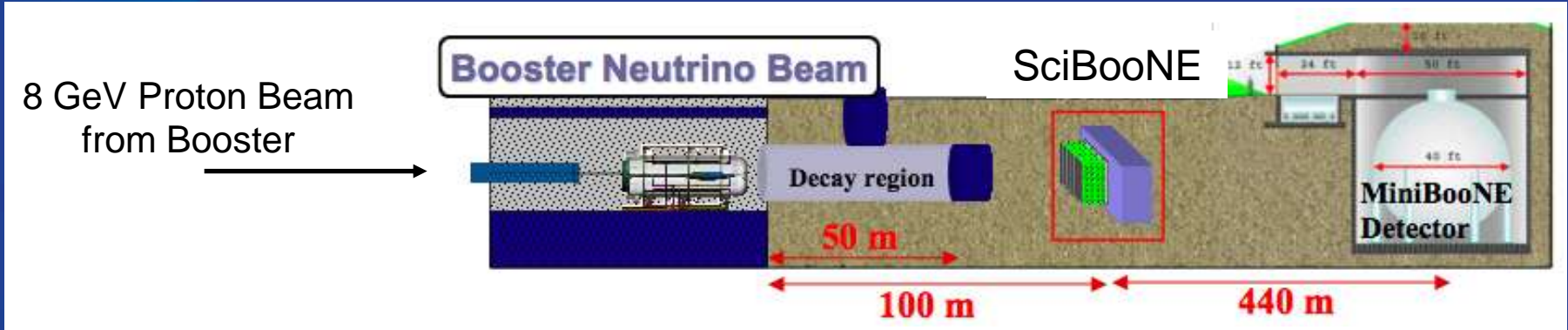
# CDF: Japanese Groups

- Fairly constant efforts from the beginning of Run II through JFY2011
- JFY2008
  - On and Offline computing (GRID computing in Japan and disks at Fermilab)
  - flammable gas for COT and cryogenes
  - Common funds
- JFY2009
  - Expect similar types of expenditures

# SciBooNE



19 Institutions, 65 Physicists (19 Students)

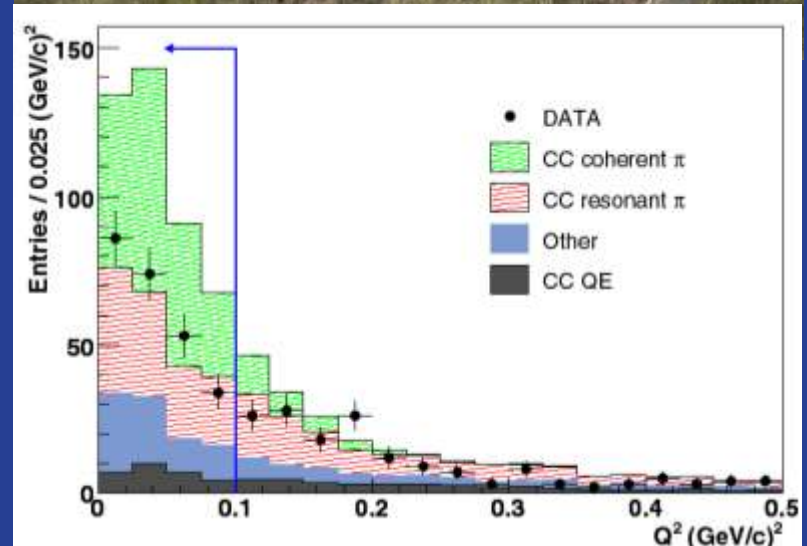


# SciBooNE

- Ground Breaking: **Sept. 2006**
- First beam: **June 2007**
- End of Run: **Aug. 2008**
  - $\nu$  mode and  $\bar{\nu}$  mode
  - Collected 25% more than requested

**JFY2008 Commitment: Complete**

- Detector disassembled and parts shipped to Japan: **Aug. 2008**
- First publication: **Dec. 31, 2008**
  - Phys. Rev. D78 112004 (2008)  
“Search for Charged Current Coherent Pion Production by Neutrinos”



# SciBooNE

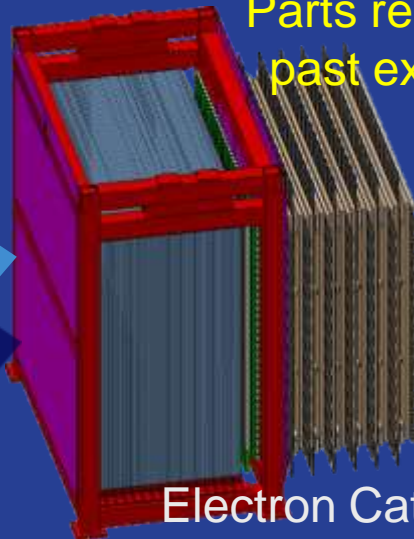
## Japanese Ph.D. Students

- ✦ Katsuki Hiraide [Kyoto] ( $\nu\mu$  CC  $1\pi^+$ )
- ✦ Yoshinori Kurimoto [Kyoto] ( $\nu\mu$  NC  $\pi^0$ )
- ✦ Yasuhiro Nakajima [Kyoto] ( $\nu\mu$  CC inclusive on carbon and iron)
- ✦ Hideyuki Takei [Tokyo Tech] ( $\nu\mu$  NC elastic)

## DOE-wide Pollution Prevention Star (P2 Star) Award

Scintillator Bar (SciBar)

Used in K2K  
experiment

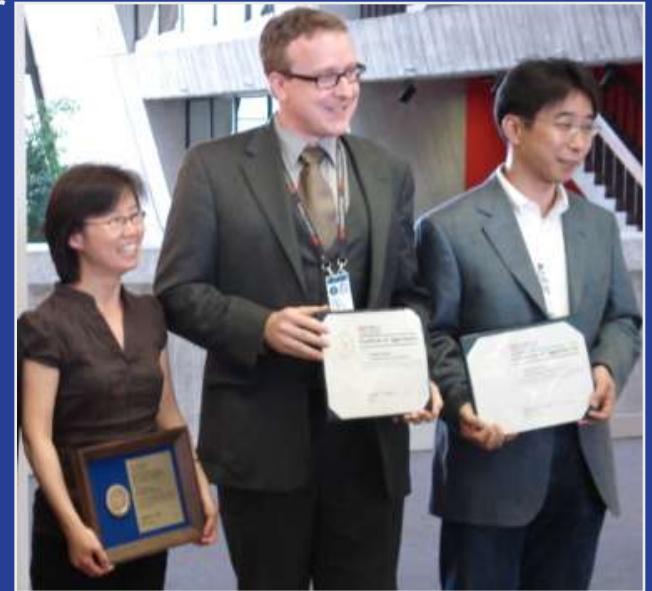


Muon Range Detector

Parts recycled from  
past experiments

Electron Catcher

Used in CHORUS, HARP and K2K





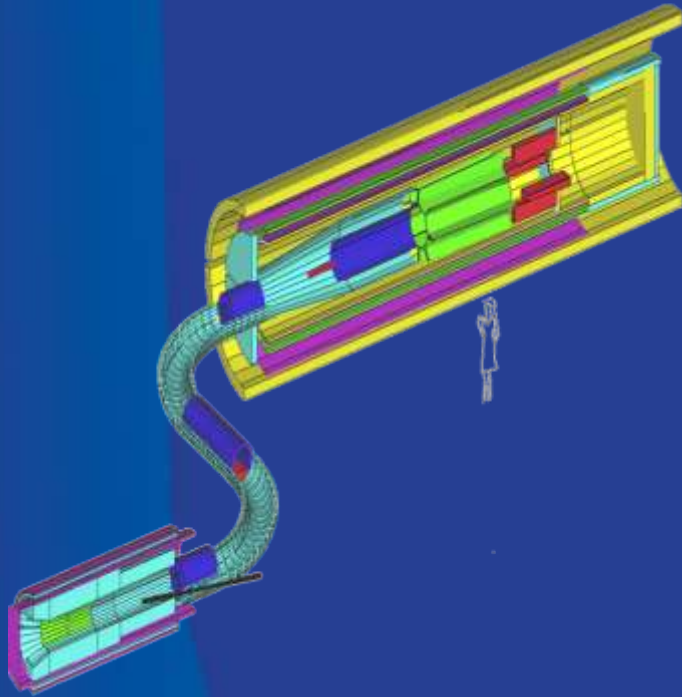
# $K_L \rightarrow \pi_0 \nu \nu$ at J-PARC



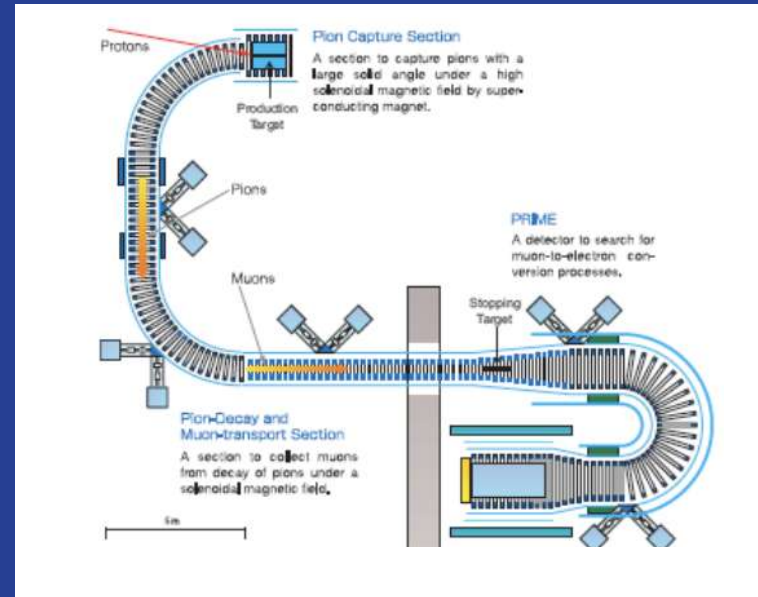
- JFY2007
  - Preparation for the shipment of the KTeV CsI crystals.
  - Dec. 2007: Beam tests at Fermilab for timing test (T976) – successful
- JFY2008
  - Fermilab completed the shipment of the KTeV CsI crystals and other electronics to Japan for J-PARC E-14.

**JFY2008 Commitment: Complete**
- JFY2009
  - Beam tests in Japan of CsI crystals and readout electronics

# Muon to Electron Conversion Experiments



Mu2e at Fermilab



COMET at J-PARC

R&D on common issues

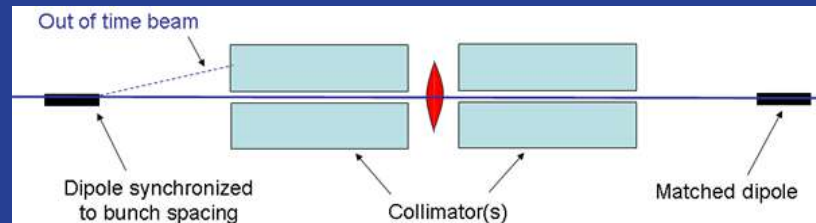
This collaborative effort would boost the realization of the experiment.



# Muon to Electron Conversion Experiments

## Extinction Dipole System

- A significant background is out-of-time beam. Extinction dipole system would only permit protons from the beam pulse to enter the beamline.



### JFY08:

- Osaka: Prototype PM fast gating circuit for extinction monitoring
- Fermilab: Purchased and tested ferrites for extinction dipole

**JFY2008 Commitment: Complete**

### JFY09:

- Osaka: Further gating circuit prototyping; exploring alternate monitor technologies (instead of PMT)
- Fermilab: Construction of partial mechanical model of extinction dipole and its energizing cable; prototyping Al-stabilized SC coils for solenoidal magnets.

# Pixel Sensors In SOI (Silicon on Insulator) Technology (Y. Arai's Talk)

Participated in 2 MPW runs: Dec.06, Jan. 08  
64x64 array of 26x26  $\mu\text{m}^2$  pixels (Mambo I)  
94x94 array of 47x47  $\mu\text{m}^2$  pixels (Mambo II)

## Goals:

Design of circuitry in the SOI process  
Understanding of the SOI process

## Accomplishments

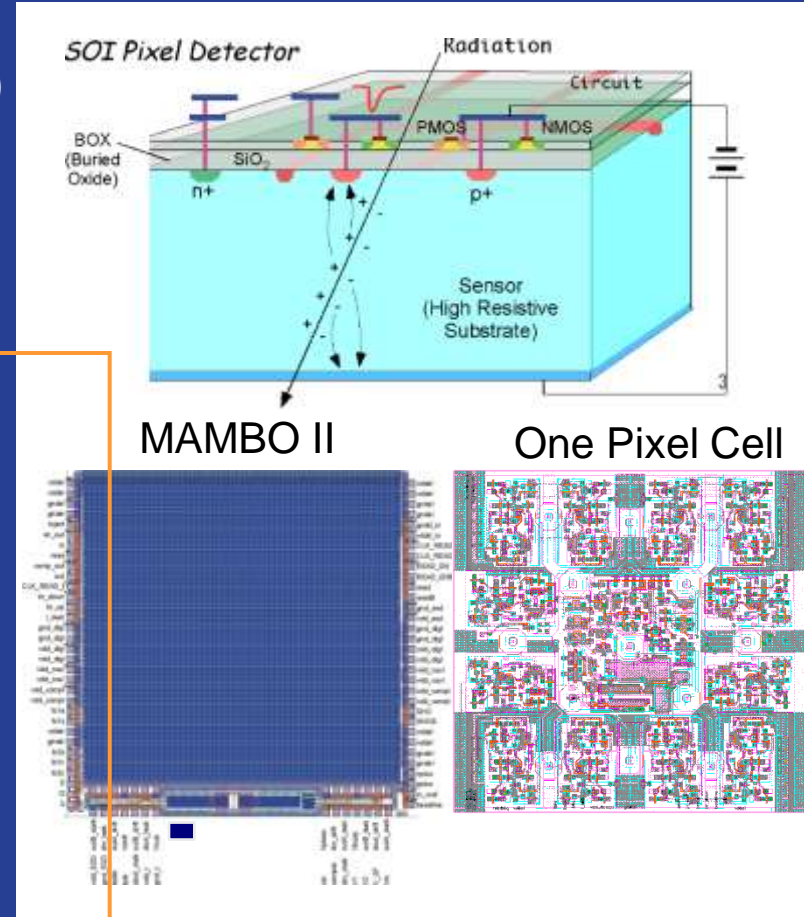
Achieved design of low-noise processing  
with event counting/pixel

## Lessons learned

Effects of fully depleted SOI  
Effect of detector grade substrate  
Coupling through thin BOX  
Tolerance to radiation

All observations communicated to collaborators

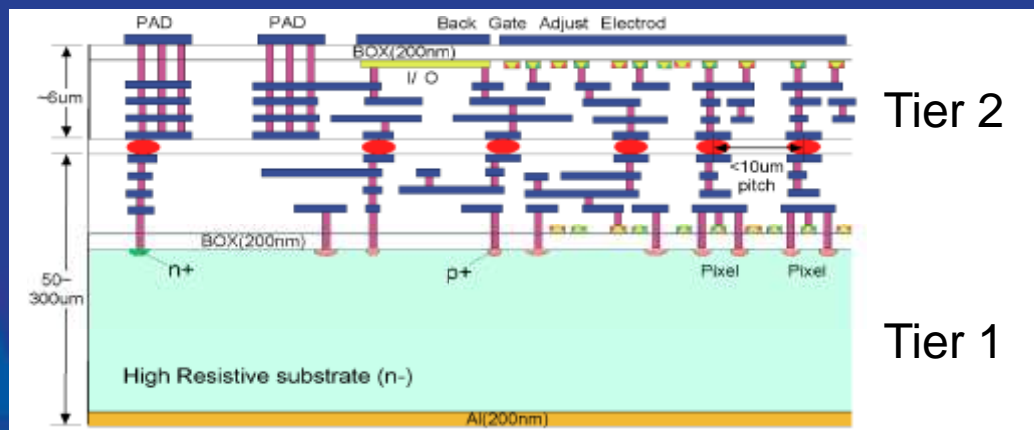
**JFY2008 Commitment: Complete**



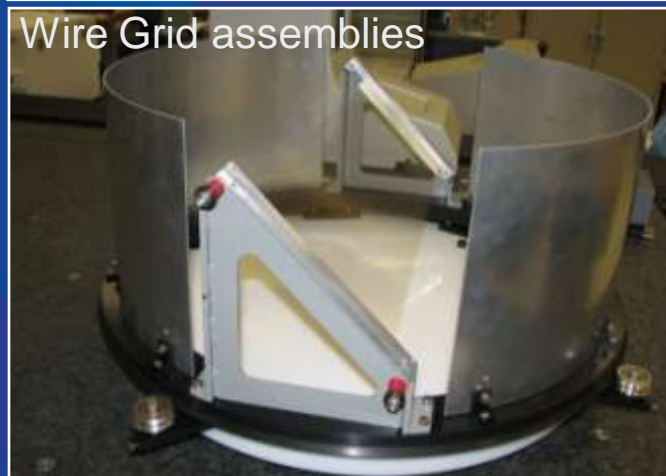
# Pixel Sensors In SOI (Silicon on Insulator) Technology

- JFY2009 New Initiatives

- Refine the SOI process for further improvements in pixel arrays
- Current idea to add 3D technology to OKI SOI process
  - Would complement 3D work at Fermilab.
  - Vertical integration of face to face bonding by Zycube
- Participating in fourth MPW run for summer 2009
  - Translate the existing design to the two-tier design
  - Tier 1 contains detector diodes substrate biases and metal screens
  - Tier 2 contains MAMBO II circuitry



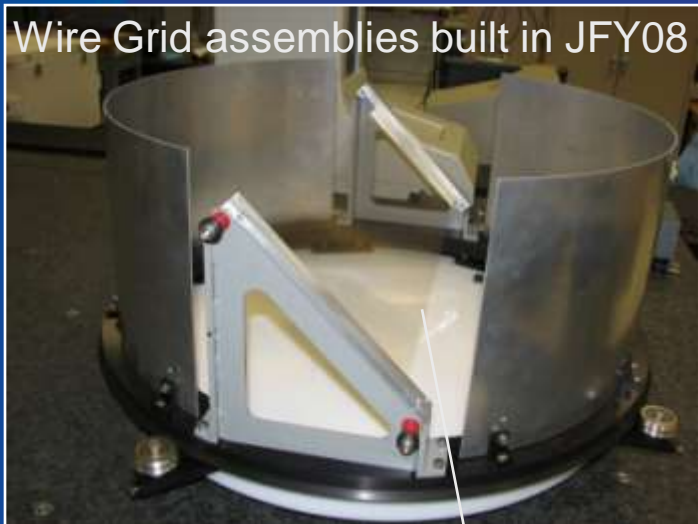
# Detector R&D for Particle-Astro (JFY2008)



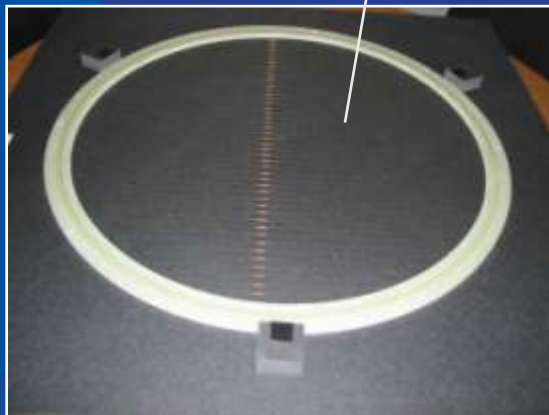
- 20 Kelvin Black Body Microwave Source For Full-System Characterization of Microwave Detectors
  - Funding paid for a commercial 5W@20K Cryocooler, and vacuum components.
- Rotating Wire Grid for modulating microwave polarization
  - Funding paid for mechanical components.

JFY2008 Commitment: Complete

# Detector R&D for Particle-Astro (JFY2009)

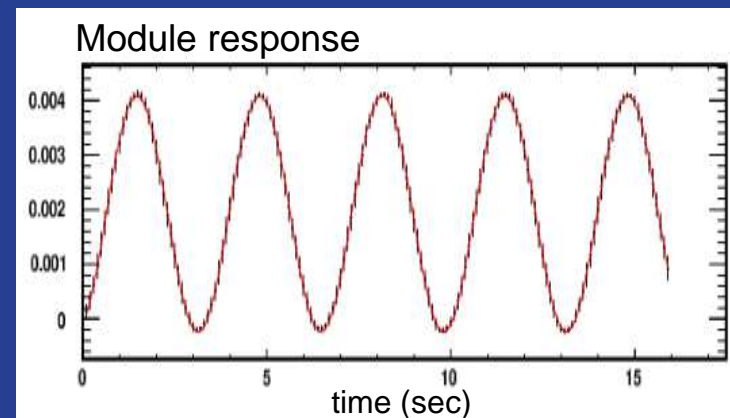


Accurate wire placement and large aperture achieved via traditional HEP chamber winding machines



- Further Development of Rotating Wire Grids for modulating microwave polarization
- Application to detectors with frequency exceeding 100 GHz

Typical Response from a 90 GHz Module as Grid is being rotated



# Advanced Accelerator Technology (S. Yamaguchi's Talk)

- RF gun and RF gun coupler
  - Complete
  - Will be delivered to KEK by June 2009
- Cavity tuning machine
  - Not yet complete
  - Work will extend into JFY2009

JFY2008 Commitment: Extend into JFY2009



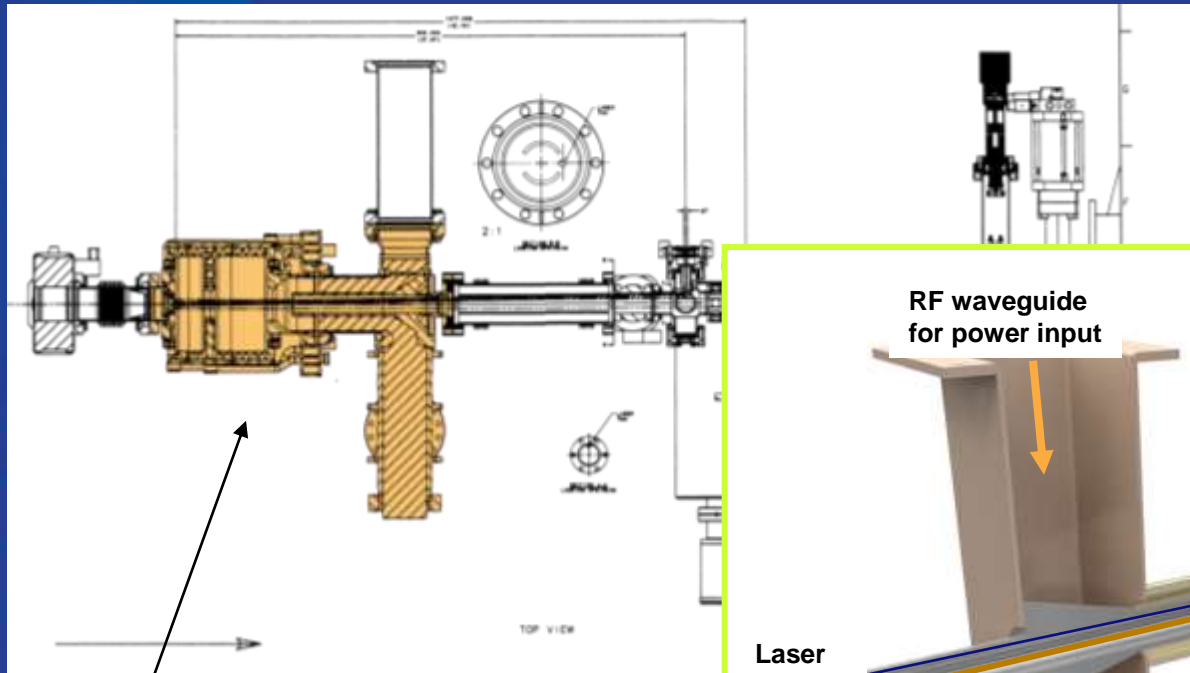
# RF Gun Cavity and Input Coupler

## JFY08 Accomplishments:

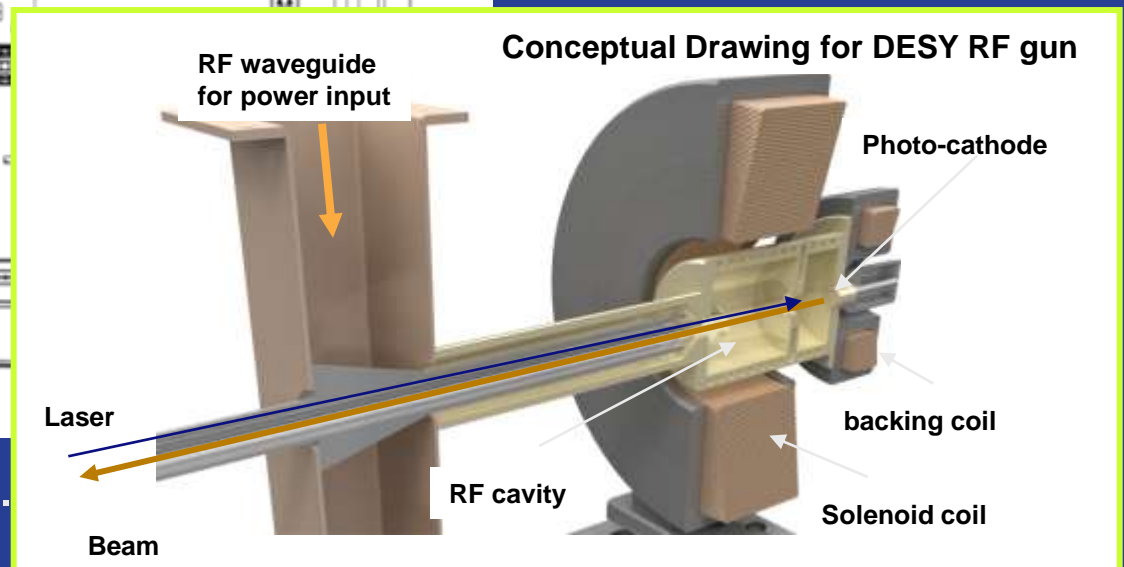
FNAL – Design modification for DESY RF-gun complete.  
FNAL to provide RF-gun cavity and input coupler to KEK.  
KEK to provide ATF RF gun technology.



Existing FNAL RF gun; FNAL replace this cavity to modified DESY design.



Provide RF-gun cavity to KEK.





# Automatic Cavity Tuning Machines



Only machine of its kind in operation at DESY

4 new 9-cell cavity automatic tuning machines, based on an operating DESY machine, are being fabricated as part of a FNAL-DESY-KEK collaboration.

Mechanical design and fabrication started in JFY07. Two complete mechanical assemblies, one for the KEK machine and one for the Fermilab machine, are scheduled to be shipped to Fermilab by end of August 2008



4 motorized cavity tuning devices fabricated during JFY07 (photo shows the one at Fermilab delivered on February 2008)

Fermilab will design, fabricate, and install the control system for all machines during JFY08. Commissioning of the first machine scheduled for February 2008.

The KEK machine will be commissioned at Fermilab and then shipped to KEK

# Development of Beam Control for Advanced Accelerators (ATF)

- Fermilab
  - Design and development of items for ATF BPM readout system upgrade
- JFY2008
  - Procurement of electronics parts and components for beam tests at ATF

**JFY2008 Commitment: Complete**
- JFY2009
  - Complete ATF BPM readout upgrade

# Beam Control Development for Advanced Accelerators JFY2008 Accomplishments

- Design / development for ATF BPM read-out system
  - Analog downconverter with integrated calibration system
  - 8-ch 125 MS/s VME digital receiver
  - Hardware and software for CAN-bus control
  - BPM EPICS interface and driver software
- Procurement of electronics parts and components
  - For approximately 70 (of 96) downconverters for the ATF DR BPMs
- Pre-series production of 10 downconverters
  - Successful tests and operation in the lab. environment
  - Beam tests during April 17 – 25 at the ATF damping ring.
  - After verification: series production of downconverters.



# R&D for the Next Generation High Luminosity Colliders (JFY2009)

- R&D for issues relevant to any high intensity accelerators
- Fermilab T-972
  - US-Japan collaboration study at Fermilab for shielding and radiation from 120 GeV protons on targets
  - Useful for Monte Carlo codes MARS and PHITS for accelerator, shielding, and experiment design
  - Measurements were made in JFY2008 and will continue in JFY2009.

Fermilab looks forward to  
continuous fruitful collaboration / cooperation.