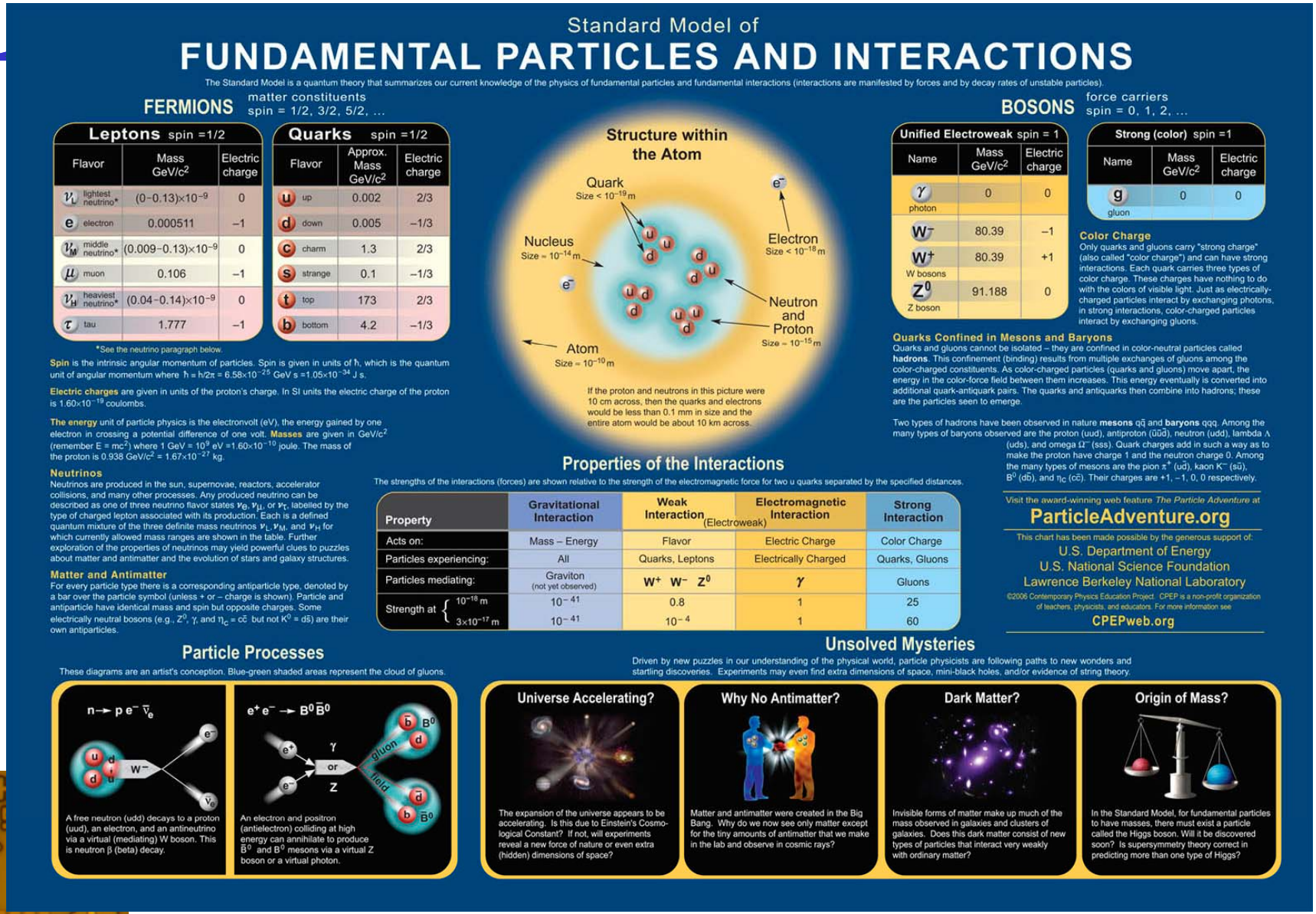
Year 2010
(party!) in the ID Lab

December, 2010

Why are we here??



Standard Model of

FUNDAMENTAL PARTICLES AND INTERACTIONS

The Standard Model is a quantum theory that summarizes our current knowledge of the physics of fundamental particles and fundamental interactions (interactions are manifested by forces and by decay rates of unstable particles).

FERMIONS matter constituents spin = 1/2, 3/2, 5/2, ...

Leptons spin =1/2

Flavor	Mass GeV/c²	Electric charge
ν_L lightest neutrino*	$(0–0.13)\times10^{-9}$	0
e electron	0.000511	–1
ν_M middle neutrino*	$(0.009–0.13)\times10^{-9}$	0
μ muon	0.106	–1
ν_H heaviest neutrino*	$(0.04–0.14)\times10^{-9}$	0
τ tau	1.777	–1

Quarks spin =1/2

Flavor	Approx. Mass GeV/c²	Electric charge
u up	0.002	2/3
d down	0.005	–1/3
c charm	1.3	2/3
s strange	0.1	–1/3
t top	173	2/3
b bottom	4.2	–1/3

*See the neutrino paragraph below.

Spin is the intrinsic angular momentum of particles. Spin is given in units of ħ, which is the quantum unit of angular momentum where $\hbar = h/2\pi = 6.58\times10^{-25}$ GeV s $=1.05\times10^{-34}$ J s.

Electric charges are given in units of the proton's charge. In SI units the electric charge of the proton is 1.60×10^{-19} coulombs.

The energy unit of particle physics is the electronvolt (eV), the energy gained by one electron in crossing a potential difference of one volt. **Masses** are given in GeV/c² (remember $E = mc^2$) where 1 GeV = 10^9 eV $=1.60\times10^{-10}$ joule. The mass of the proton is 0.938 GeV/c² = 1.67×10^{-27} kg.

Neutrinos
Neutrinos are produced in the sun, supernovae, reactors, accelerator collisions, and many other processes. Any produced neutrino can be described as one of three neutrino flavor states ν_e, ν_μ, or ν_τ, labelled by the type of charged lepton associated with its production. Each is a defined quantum mixture of the three definite mass neutrinos ν_L, ν_M, and ν_H for which currently allowed mass ranges are shown in the table. Further exploration of the properties of neutrinos may yield powerful clues to puzzles about matter and antimatter and the evolution of stars and galaxy structures.

Matter and Antimatter
For every particle type there is a corresponding antiparticle type, denoted by a bar over the particle symbol (unless + or – charge is shown). Particle and antiparticle have identical mass and spin but opposite charges. Some electrically neutral bosons (e.g., Z^0, γ, and $\eta_c = c\bar{c}$ but not $K^0 = d\bar{s}$) are their own antiparticles.

Structure within the Atom

If the proton and neutrons in this picture were 10 cm across, then the quarks and electrons would be less than 0.1 mm in size and the entire atom would be about 10 km across.

BOSONS force carriers spin = 0, 1, 2, ...

Unified Electroweak spin = 1

Name	Mass GeV/c²	Electric charge
γ photon	0	0
W^-	80.39	–1
W^+ W bosons	80.39	+1
Z^0 Z boson	91.188	0

Strong (color) spin =1

Name	Mass GeV/c²	Electric charge
g gluon	0	0

Color Charge
Only quarks and gluons carry "strong charge" (also called "color charge") and can have strong interactions. Each quark carries three types of color charge. These charges have nothing to do with the colors of visible light. Just as electrically-charged particles interact by exchanging photons, in strong interactions, color-charged particles interact by exchanging gluons.

Quarks Confined in Mesons and Baryons
Quarks and gluons cannot be isolated – they are confined in color-neutral particles called **hadrons**. This confinement (binding) results from multiple exchanges of gluons among the color-charged constituents. As color-charged particles (quarks and gluons) move apart, the energy in the color-force field between them increases. This energy eventually is converted into additional quark-antiquark pairs. The quarks and antiquarks then combine into hadrons; these are the particles seen to emerge.

Two types of hadrons have been observed in nature **mesons** $q\bar{q}$ and **baryons** qqq. Among the many types of baryons observed are the proton (uud), antiproton ($\bar{u}\bar{u}\bar{d}$), neutron (udd), lambda Λ (uds), and omega Ω^- (sss). Quark charges add in such a way as to make the proton have charge 1 and the neutron charge 0. Among the many types of mesons are the pion π^+ ($u\bar{d}$), kaon K^- ($s\bar{u}$), B^0 ($d\bar{b}$), and η_c ($c\bar{c}$). Their charges are +1, –1, 0, 0 respectively.

Properties of the Interactions

The strengths of the interactions (forces) are shown relative to the strength of the electromagnetic force for two u quarks separated by the specified distances.

Property	Gravitational Interaction	Weak Interaction (Electroweak)	Electromagnetic Interaction	Strong Interaction
Acts on:	Mass – Energy	Flavor	Electric Charge	Color Charge
Particles experiencing:	All	Quarks, Leptons	Electrically Charged	Quarks, Gluons
Particles mediating:	Graviton (not yet observed)	W^+ W^- Z^0	γ	Gluons
Strength at 10^{-18} m	10^{-41}	0.8	1	25
Strength at 3×10^{-17} m	10^{-41}	10^{-4}	1	60

Visit the award-winning web feature *The Particle Adventure* at
ParticleAdventure.org

This chart has been made possible by the generous support of:
U.S. Department of Energy
U.S. National Science Foundation
Lawrence Berkeley National Laboratory

Particle Processes

These diagrams are an artist's conception. Blue-green shaded areas represent the cloud of gluons.

A free neutron (udd) decays to a proton (uud), an electron, and an antineutrino via a virtual (mediating) W boson. This is neutron β (beta) decay.

An electron and positron (antielectron) colliding at high energy can annihilate to produce B^0 and $\bar{B}^0$ mesons via a virtual Z boson or a virtual photon.

Unsolved Mysteries

Driven by new puzzles in our understanding of the physical world, particle physicists are following paths to new wonders and startling discoveries. Experiments may even find extra dimensions of space, mini-black holes, and/or evidence of string theory.

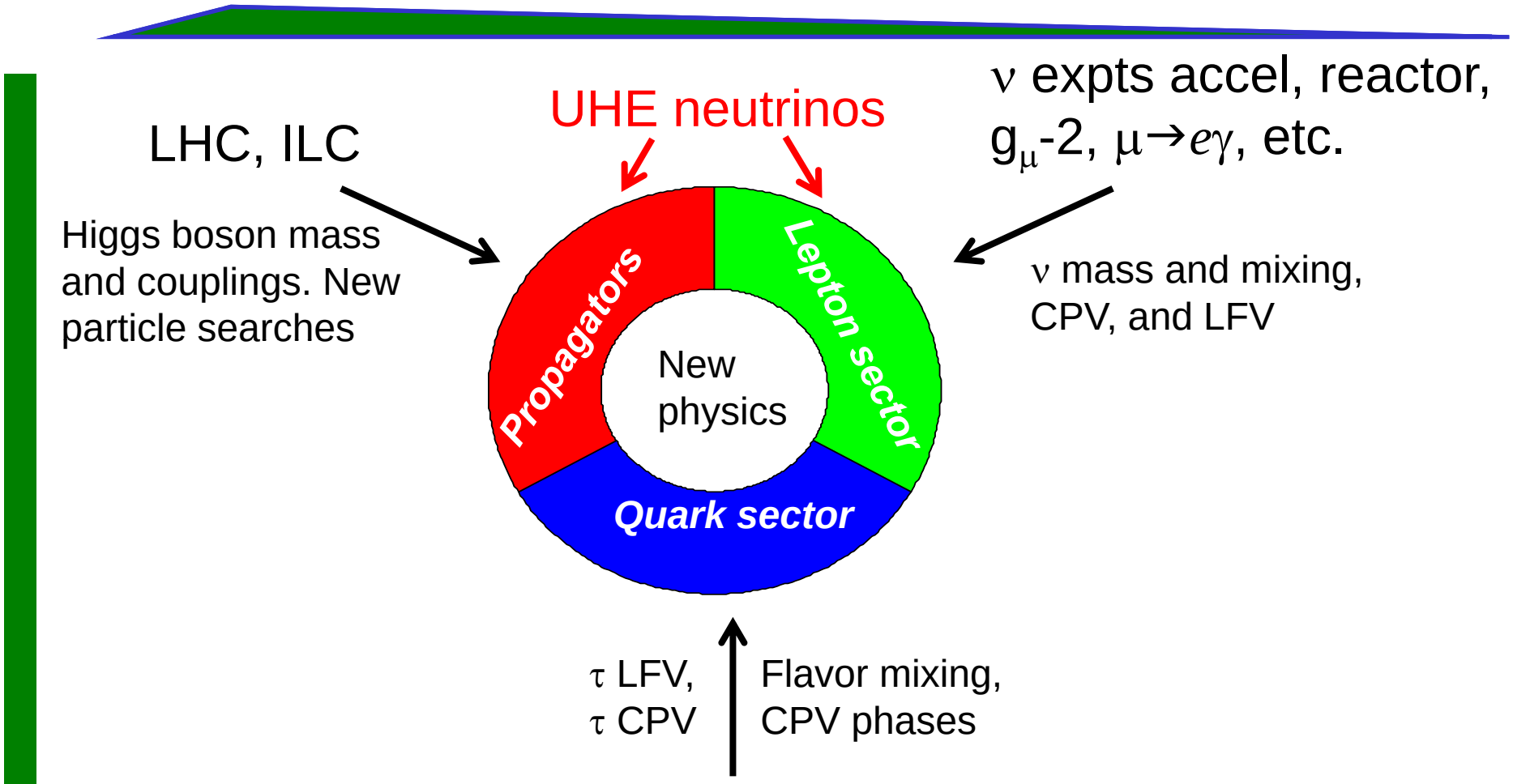
Universe Accelerating?
The expansion of the universe appears to be accelerating. Is this due to Einstein's Cosmological Constant? If not, will experiments reveal a new force of nature or even extra (hidden) dimensions of space?

Why No Antimatter?
Matter and antimatter were created in the Big Bang. Why do we now see only matter except for the tiny amounts of antimatter that we make in the lab and observe in cosmic rays?

Dark Matter?
Invisible forms of matter make up much of the mass observed in galaxies and clusters of galaxies. Does this dark matter consist of new types of particles that interact very weakly with ordinary matter?

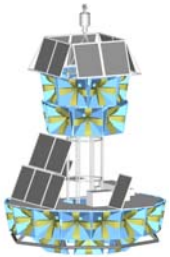
Origin of Mass?
In the Standard Model, for fundamental particles to have masses, there must exist a particle called the Higgs boson. Will it be discovered soon? Is supersymmetry theory correct in predicting more than one type of Higgs?

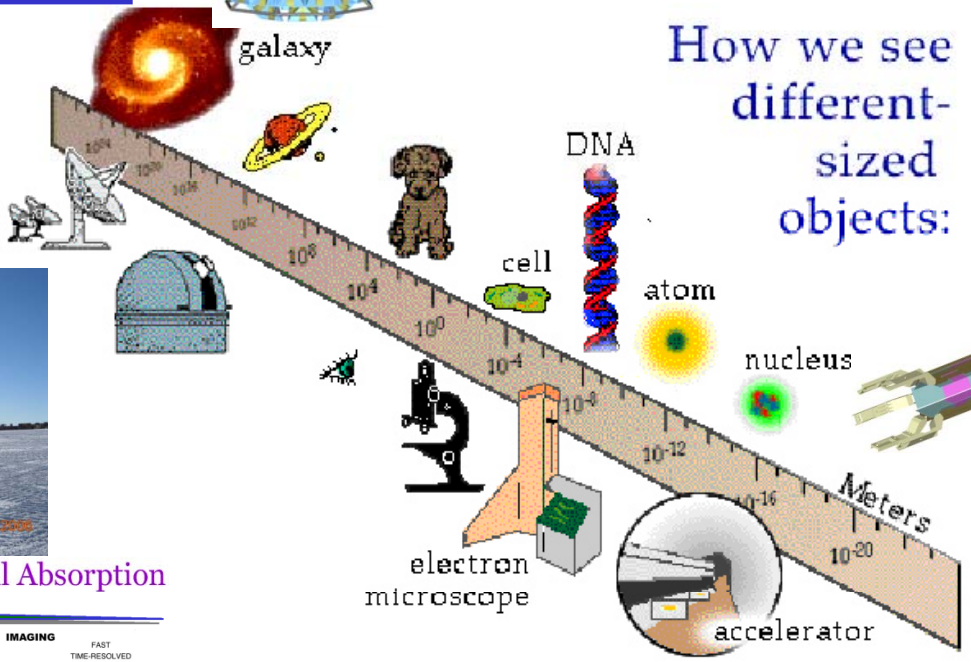
We need you! (for new measurements)



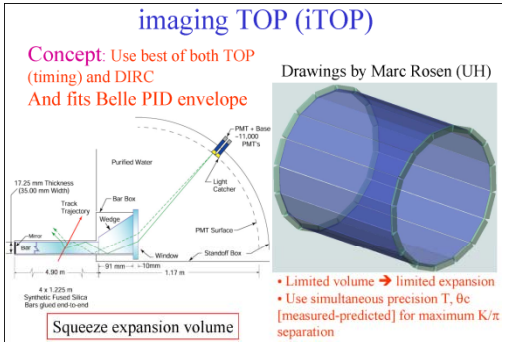
Big and Small

AMBER

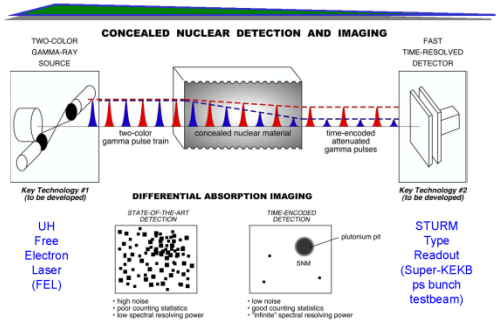




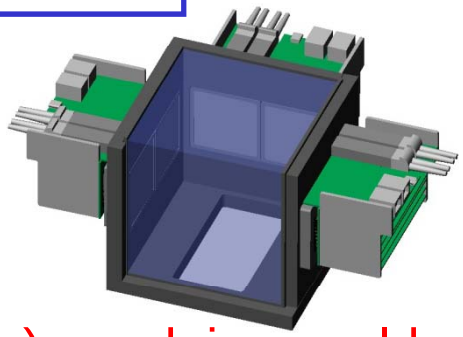
How we see different-sized objects:

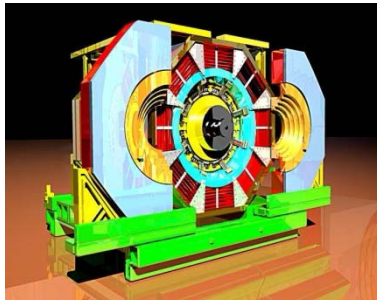


Time-Encoded Differential Absorption

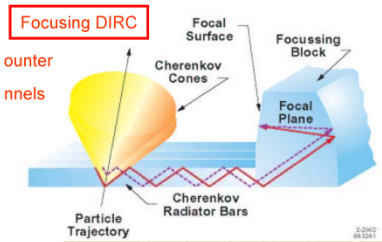


Neutrinos

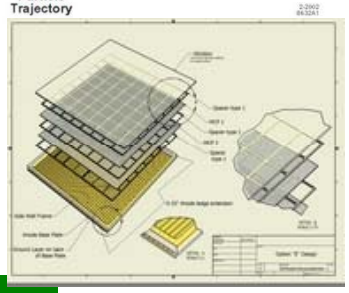




BESIII



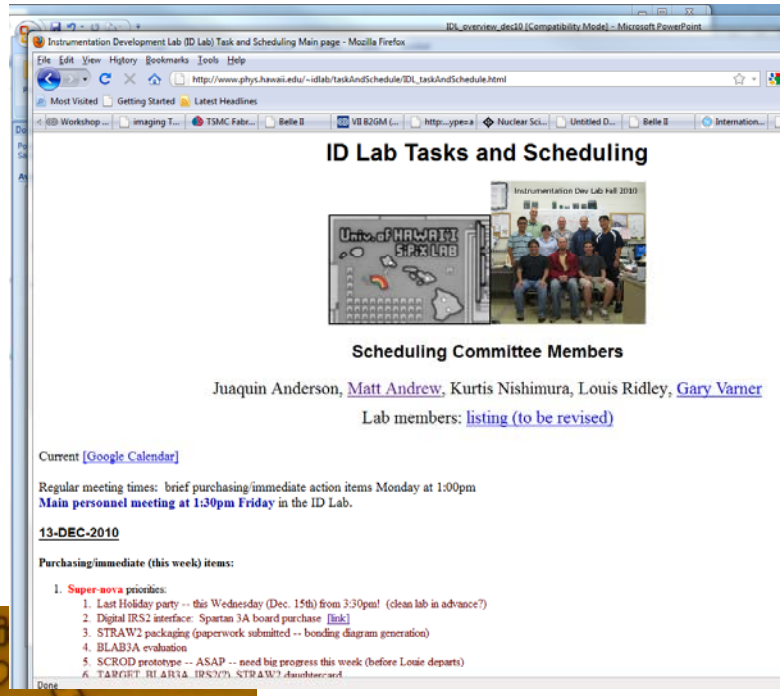
LAPPD→



We (you) are doing world-class research here

A very big year

- Hopeless to cover everything
- Just hit a few highlights
- For further detailed information, 2 new websites:



ID Lab Tasks and Scheduling

Scheduling Committee Members

Juaquin Anderson, Matt Andrew, Kurtis Nishimura, Louis Ridley, Gary Varner

Lab members: listing (to be revised)

Current [Google Calendar]

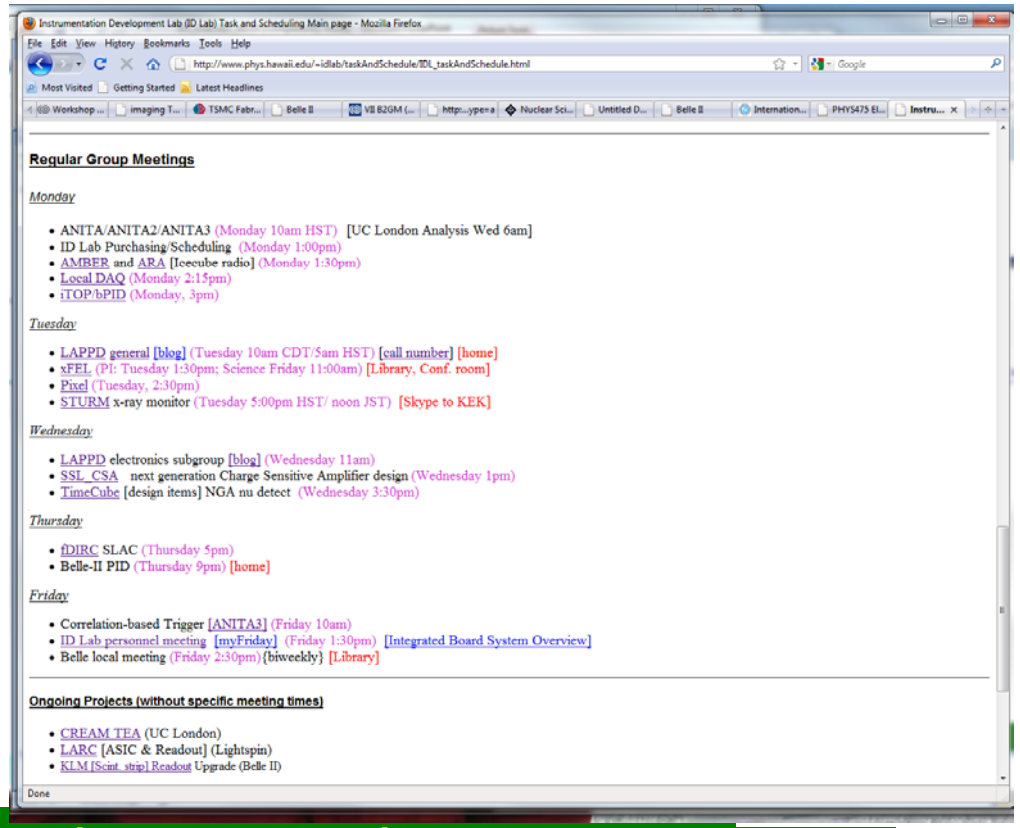
Regular meeting times: brief purchasing/immediate action items Monday at 1:00pm
Main personnel meeting at 1:30pm Friday in the ID Lab.

13-DEC-2010

Purchasing/immediate (this week) items:

1. Super-nova priorities:
   1. Last Holiday party -- this Wednesday (Dec. 15th) from 3:30pm! (clean lab in advance?)
   2. Digital IRS2 interface: Spartan 3A board purchase [link]
   3. STRAW2 packaging (paperwork submitted -- bonding diagram generation)
   4. BLAB3A evaluation
   5. SCROD prototype -- ASAP -- need big progress this week (before Louie departs)
   6. TARGET, BLAB3A, IRS2(?), STRAW2 daughtercard

Done



Regular Group Meetings

Monday

- ANITA/ANITA2/ANITA3 (Monday 10am HST) [UC London Analysis Wed 6am]
- ID Lab Purchasing/Scheduling (Monday 1:00pm)
- AMBER and ARA [Icecube radio] (Monday 1:30pm)
- Local DAQ (Monday 2:15pm)
- iTOP/bPID (Monday, 3pm)

Tuesday

- LAPPD general [blog] (Tuesday 10am CDT/5am HST) [call number] [home]
- xFEL (PI: Tuesday 1:30pm; Science Friday 11:00am) [Library, Conf. room]
- Pixel (Tuesday, 2:30pm)
- STURM x-ray monitor (Tuesday 5:00pm HST/ noon JST) [Skype to KEK]

Wednesday

- LAPPD electronics subgroup [blog] (Wednesday 11am)
- SSL_CSA next generation Charge Sensitive Amplifier design (Wednesday 1pm)
- TimeCube [design items] NGA nu detect (Wednesday 3:30pm)

Thursday

- fDIRC SLAC (Thursday 5pm)
- Belle-II PID (Thursday 9pm) [home]

Friday

- Correlation-based Trigger [ANITA3] (Friday 10am)
- ID Lab personnel meeting [myFriday] (Friday 1:30pm) [Integrated Board System Overview]
- Belle local meeting (Friday 2:30pm){biweekly} [Library]

Ongoing Projects (without specific meeting times)

- CREAM TEA (UC London)
- LARC [ASIC & Readout] (Lightspin)
- KLM [Scint. strip] Readout Upgrade (Belle II)

Done

Linked from: www.phys.hawaii.edu/~idlab

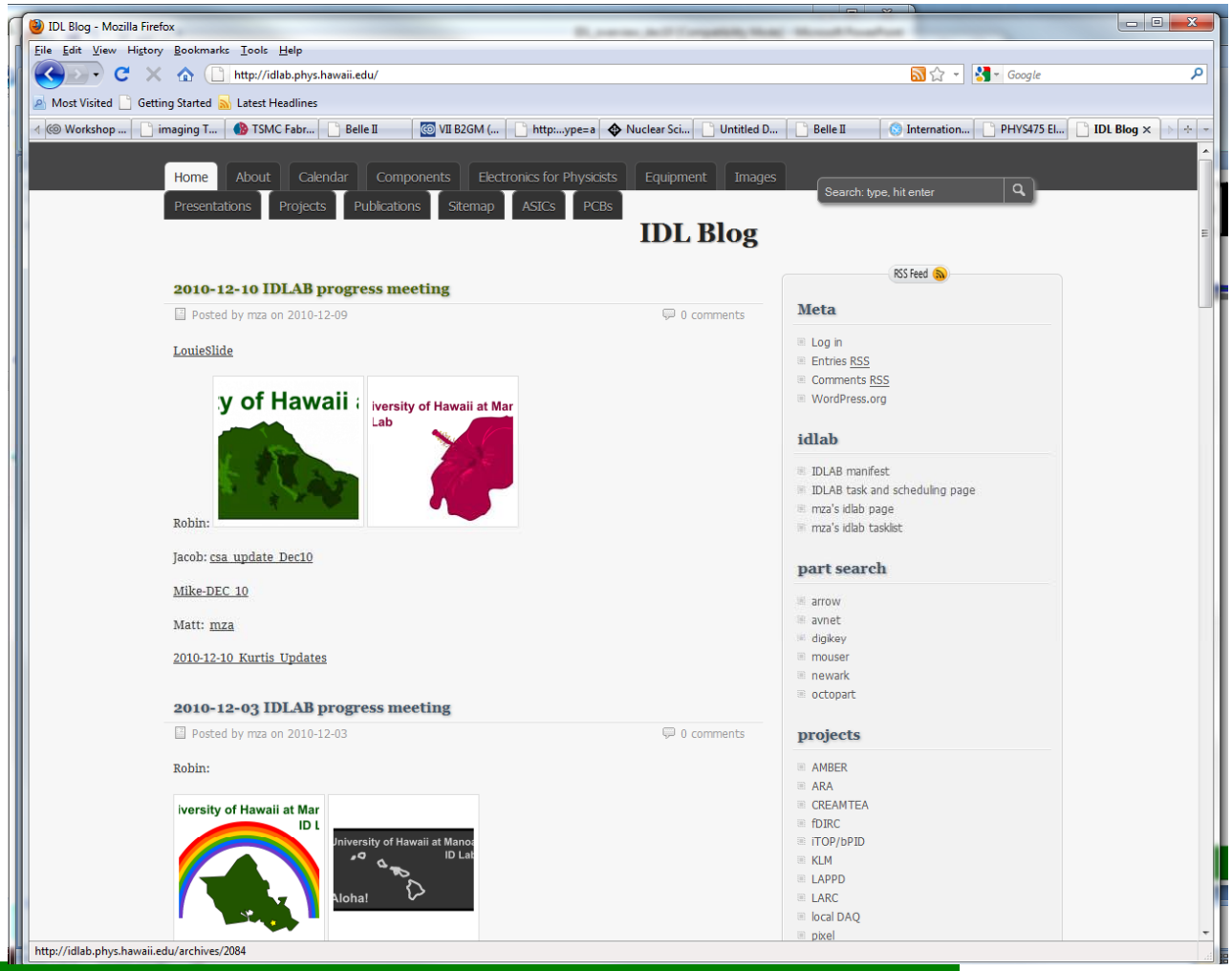
Trying to keep track…

- idlab.phys.hawaii.edu

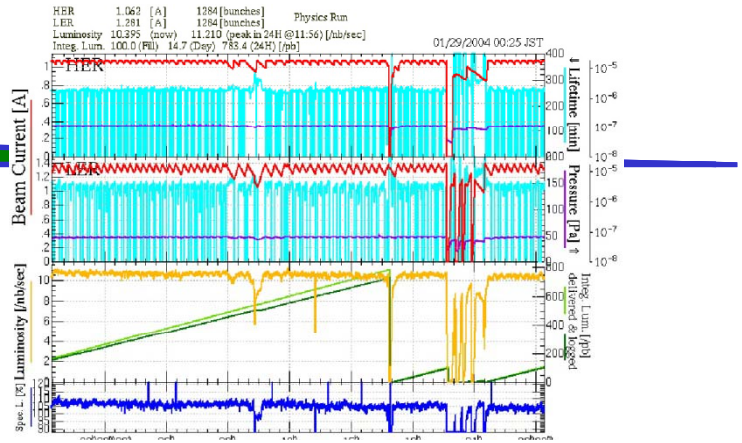
>50 active circuit board designs

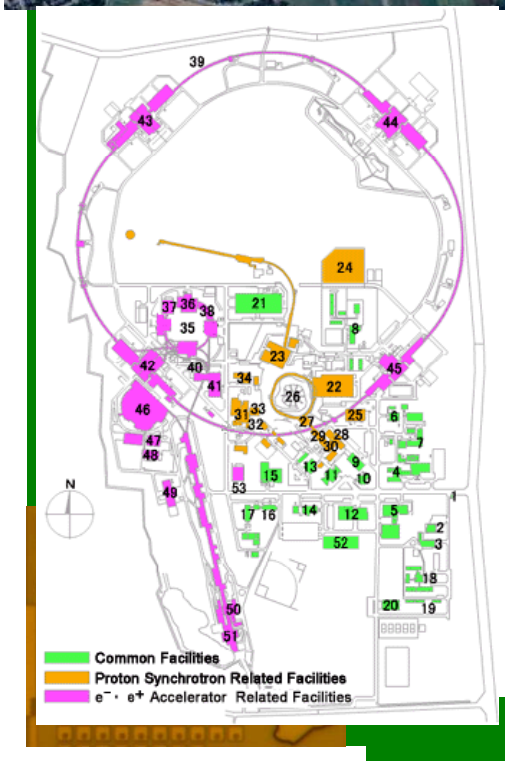
~10 active ASICs (chips)

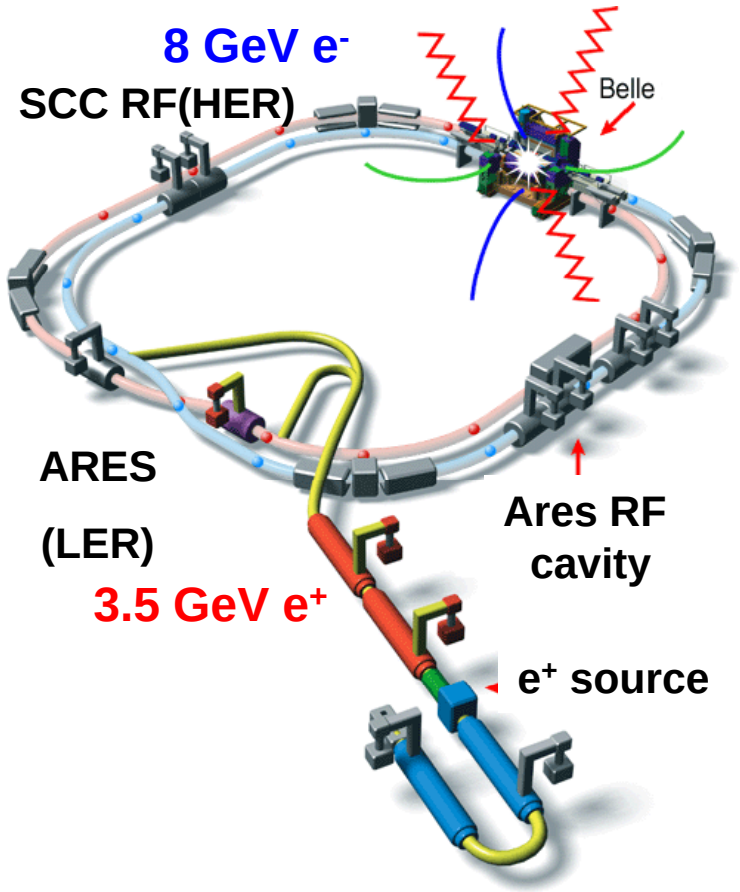
Huge number of design details, components, firmware, software



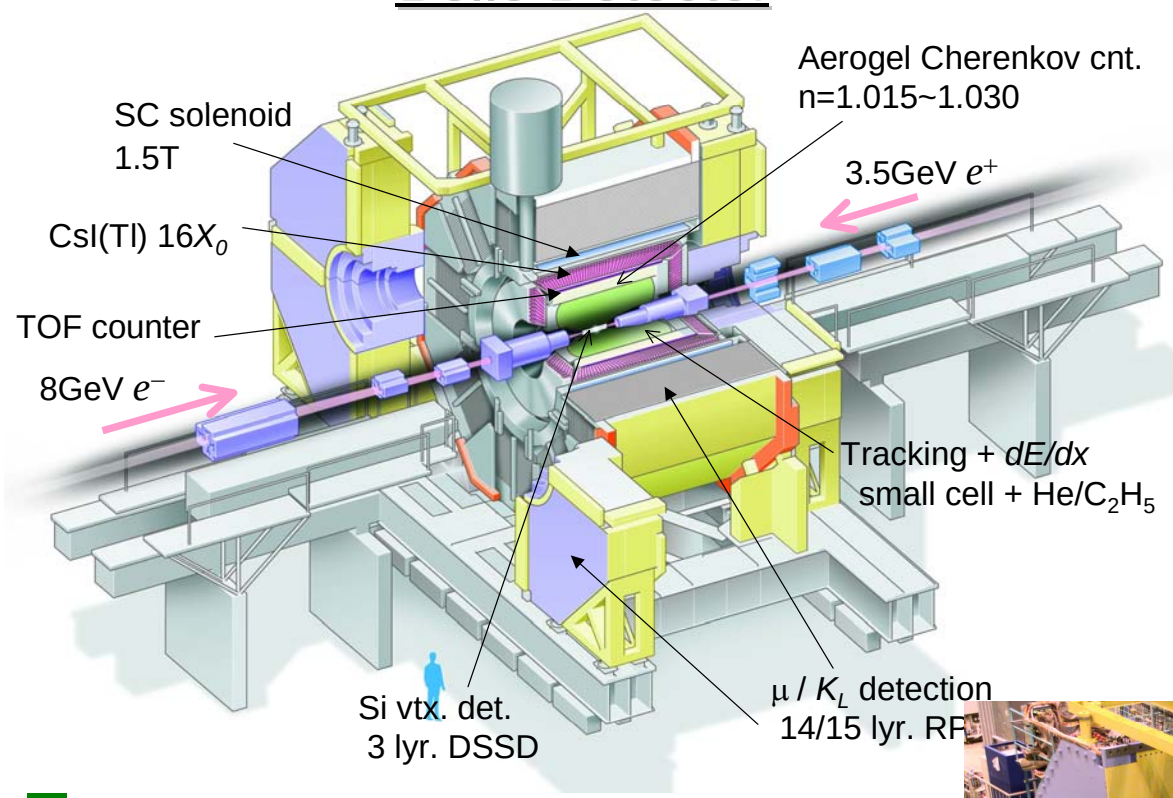
World's highest Luminosity collider

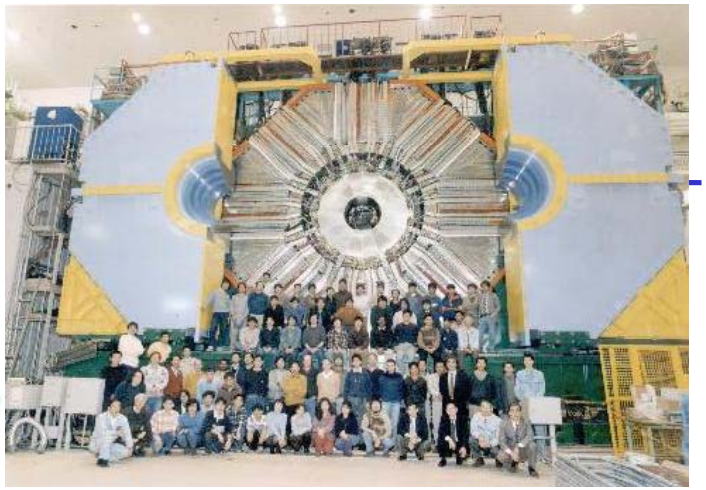






Belle Detector

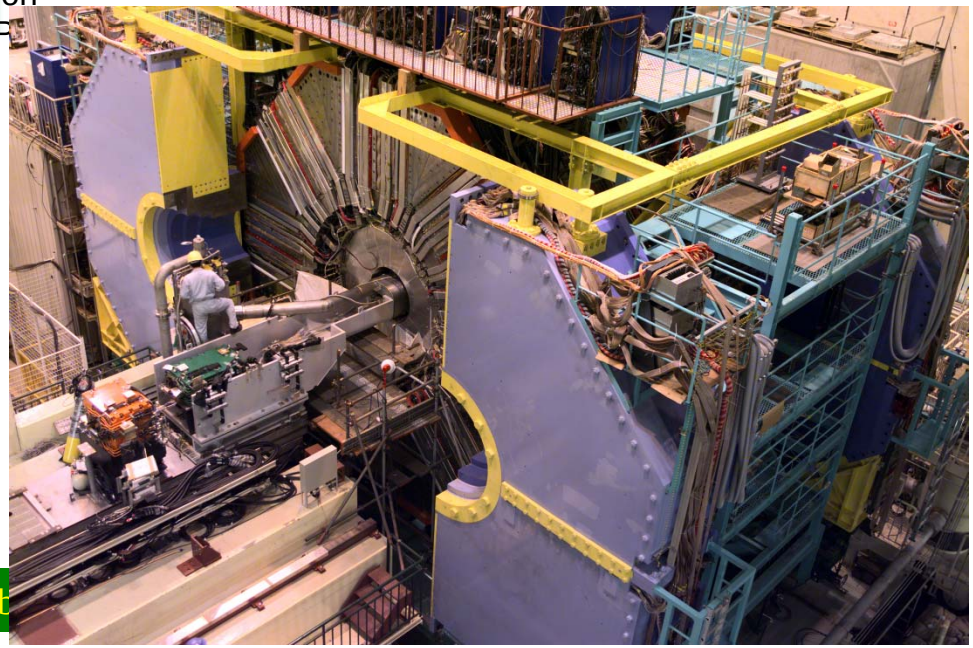




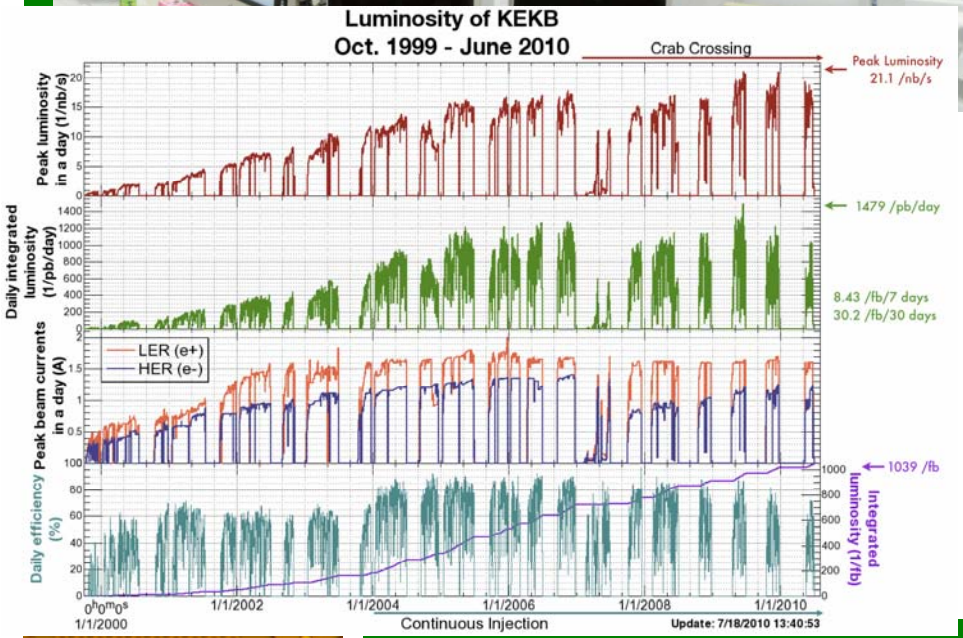
Year 2010 marked a huge milestone:
1000fb^-1 (1ab^-1)

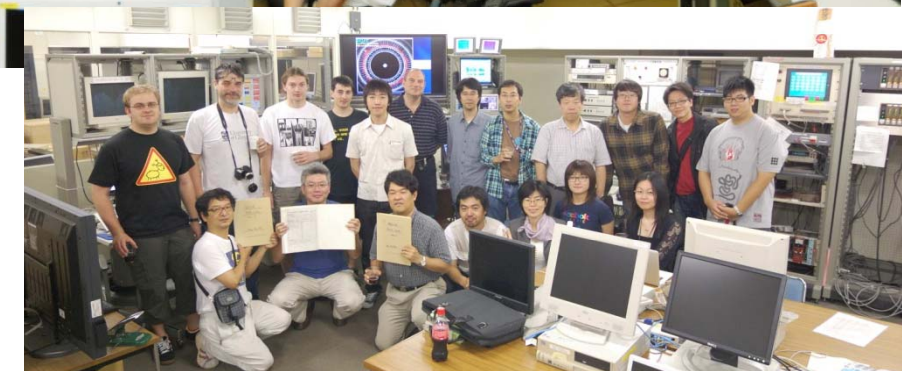
Upgrade project approved!

Side note: I first came to Hawaii (KEK) to work on building Belle in 1995



Final beam abort of KEKB on June 30, 2010 marked the start of SuperKEKB/BelleII



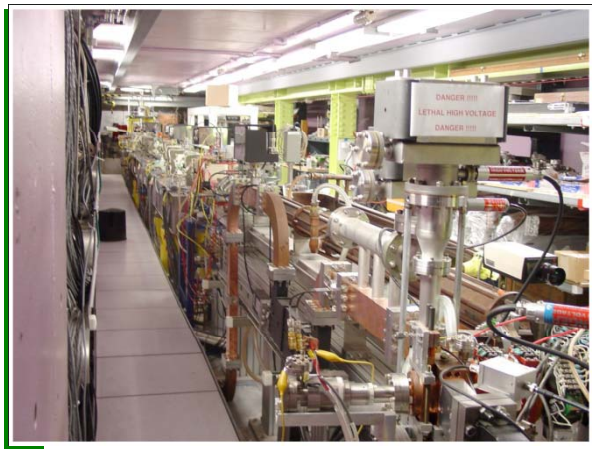


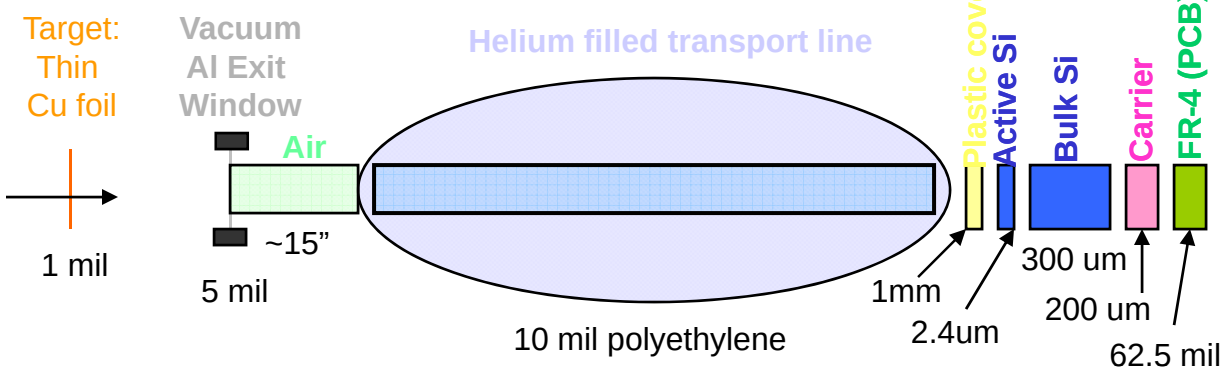
First physics run on June 2, 1999
Last physics run on June 30, 2010
$L_{peak} = 2.1 \times 10^{34}/cm^2/s$
$L > 1 ab^{-1}$

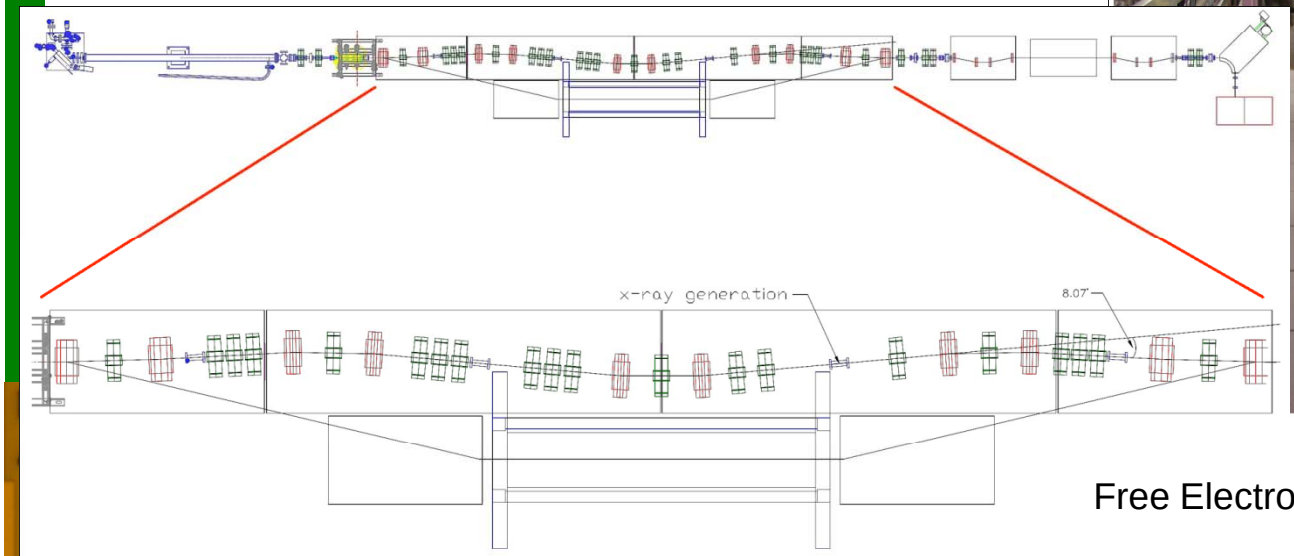
Bremsstrahlung x-rays: UH FEL (1ps!!)

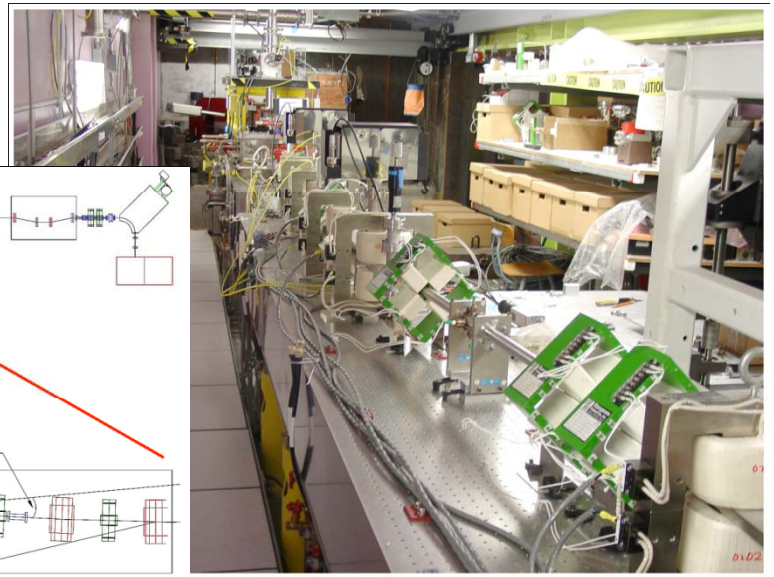
First x-rays: September 2010

50MeV max. (40MeV typ.)



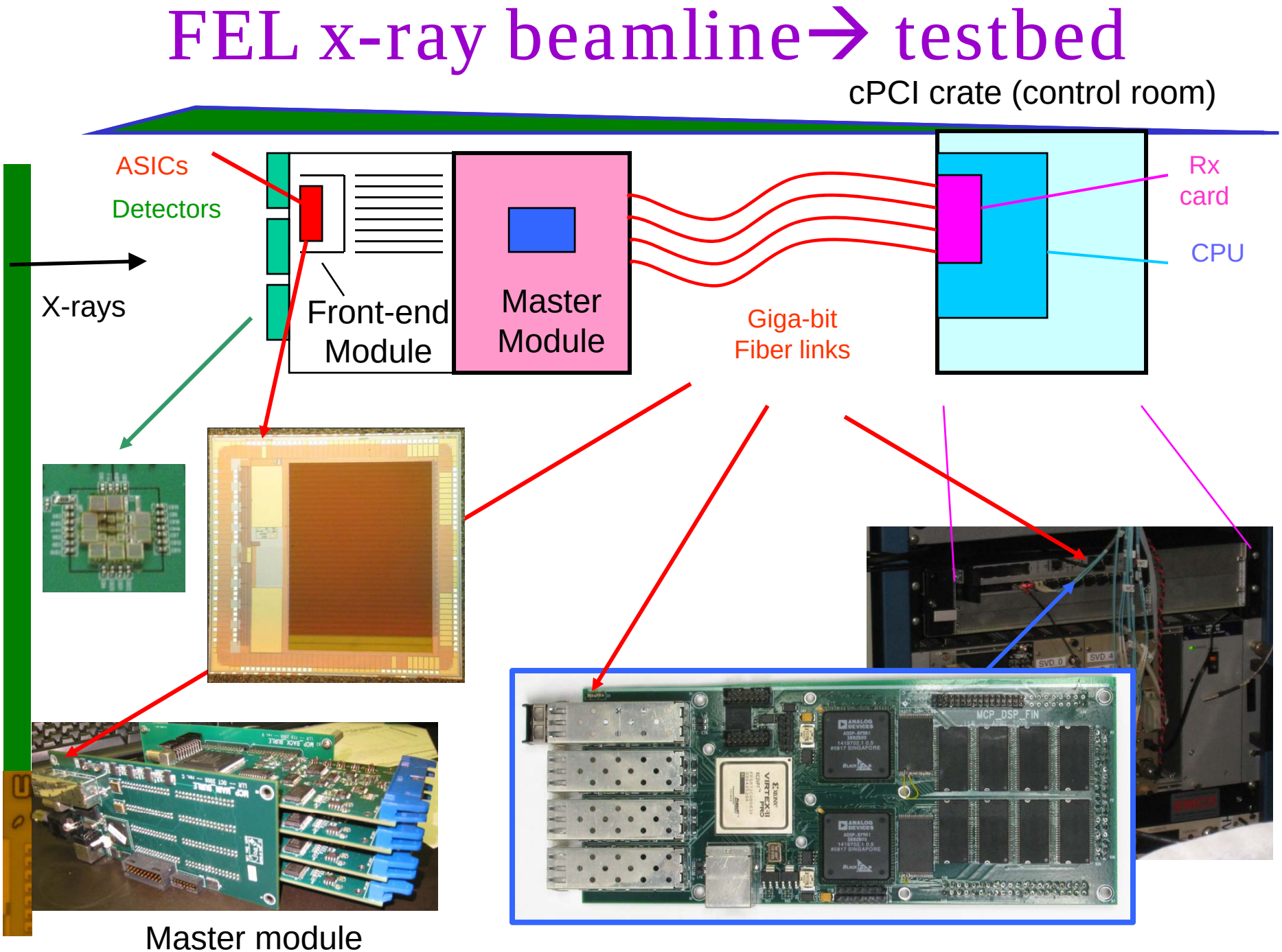






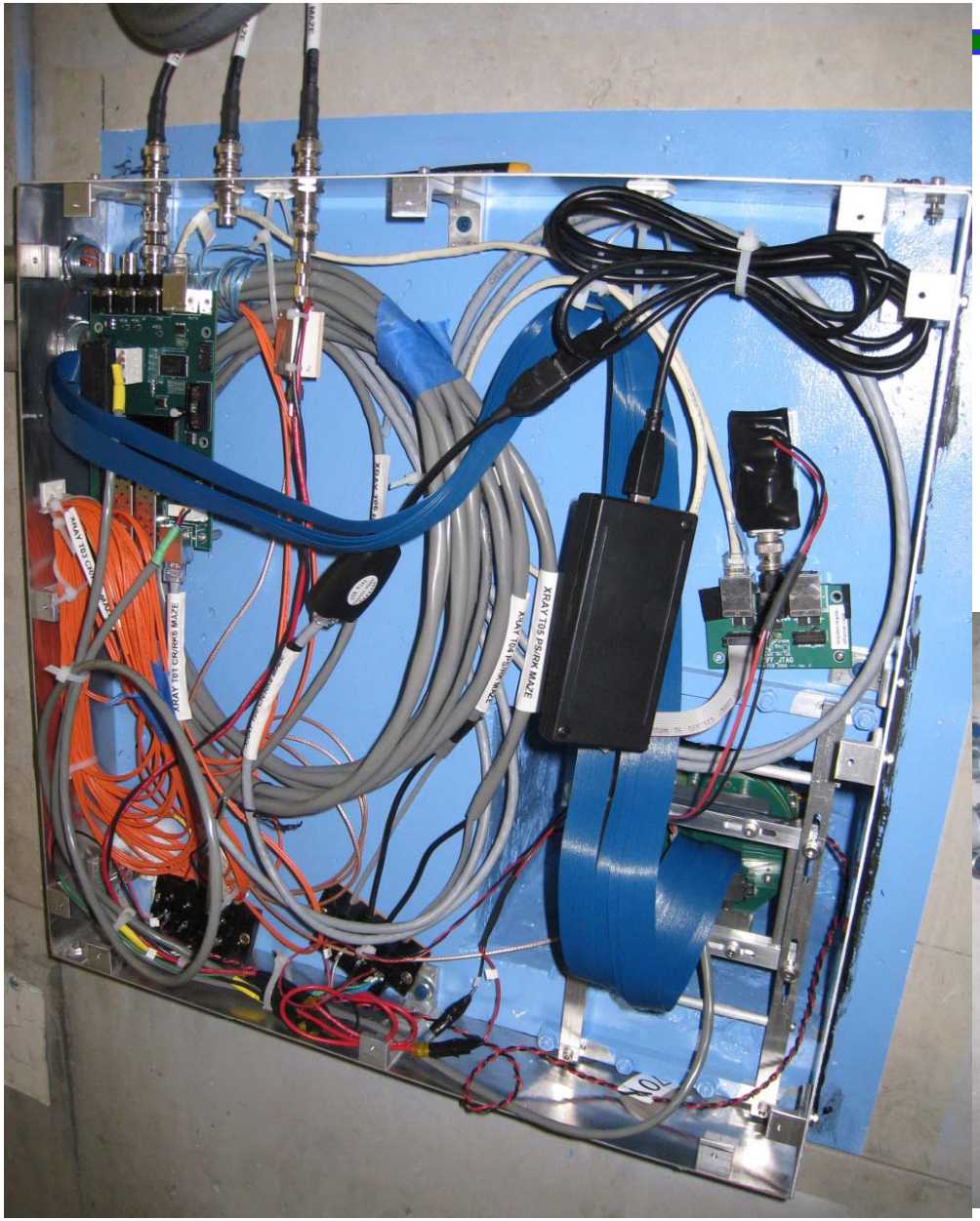
Free Electron Laser → in old machine shop

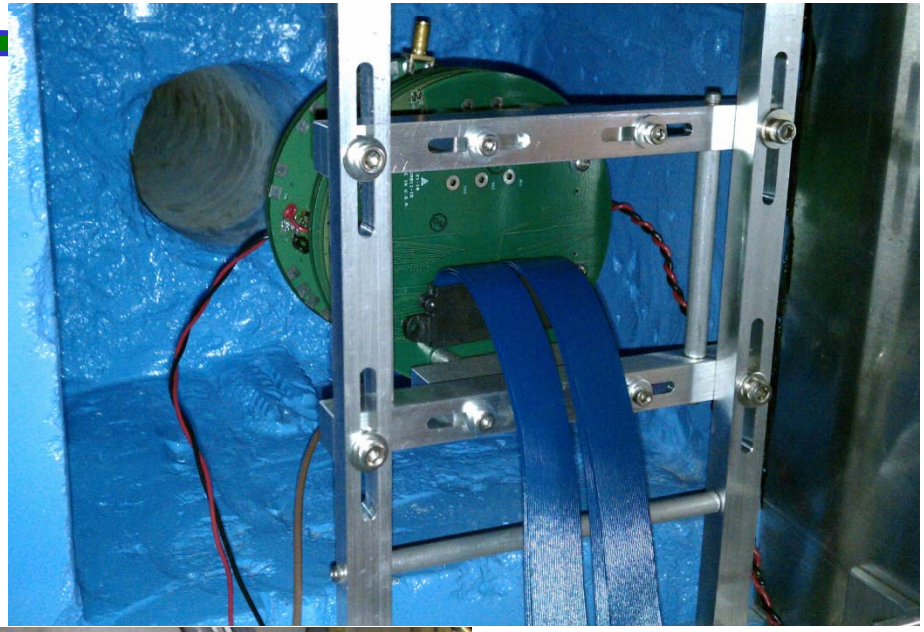
FEL x-ray beamline→ testbed



Master module

Experimental test Hutch



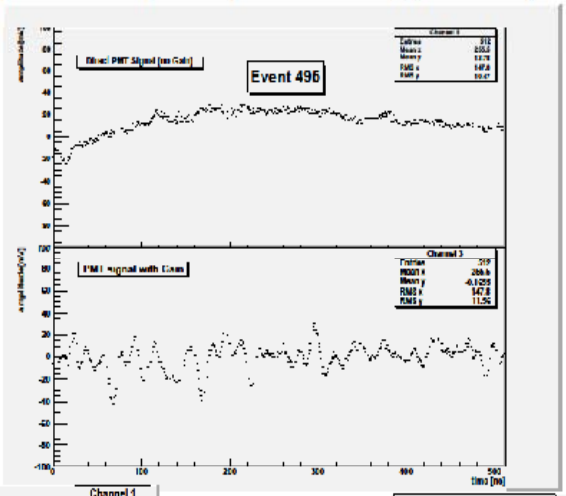


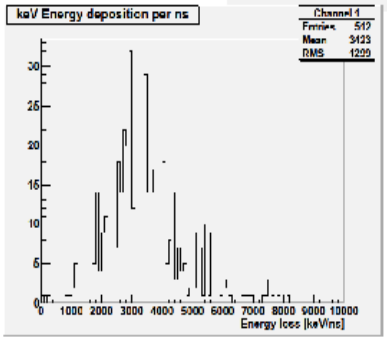
Services, fixed infrastructure

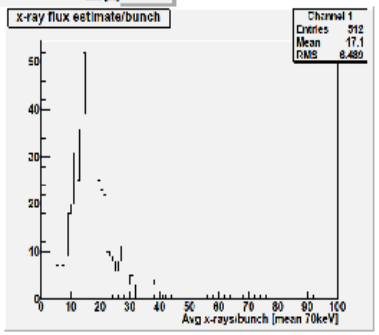
First Measured x-rays!

Flux/spectrum roughly what expected

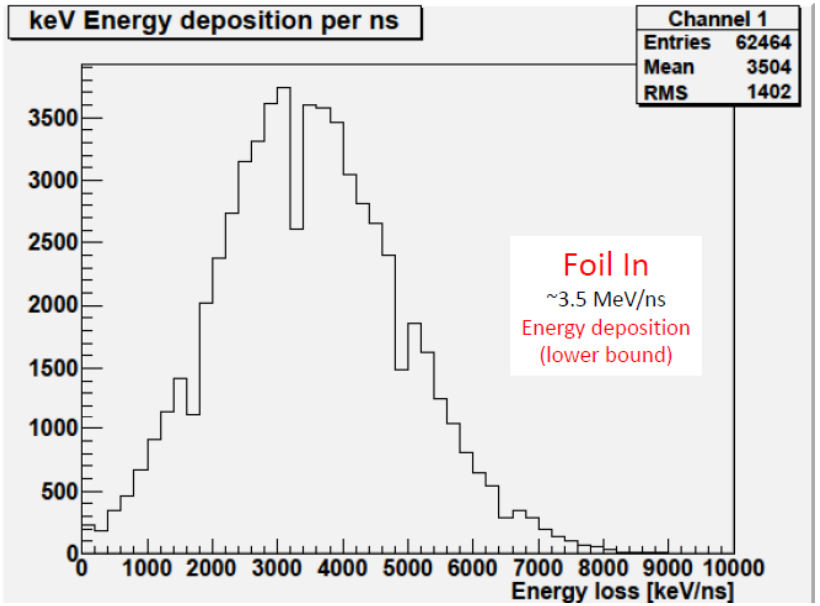
Typical spill (foil target in)







Full data set (Evts 377-500)



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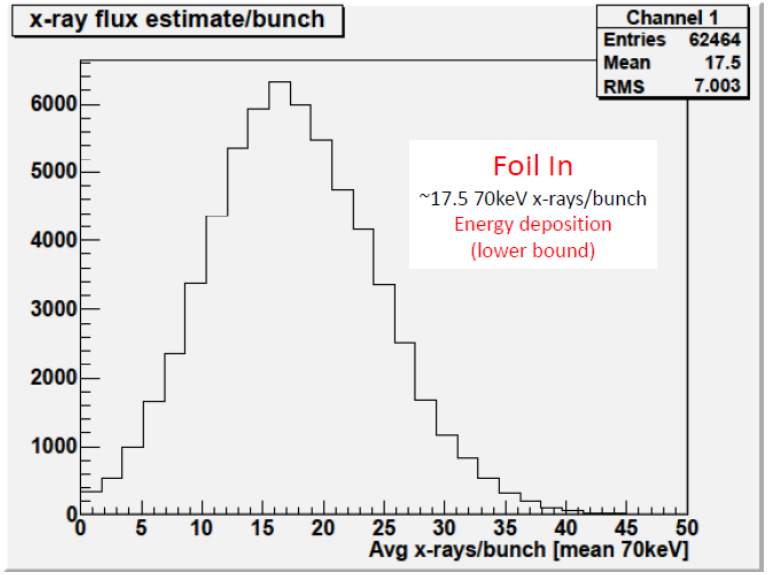
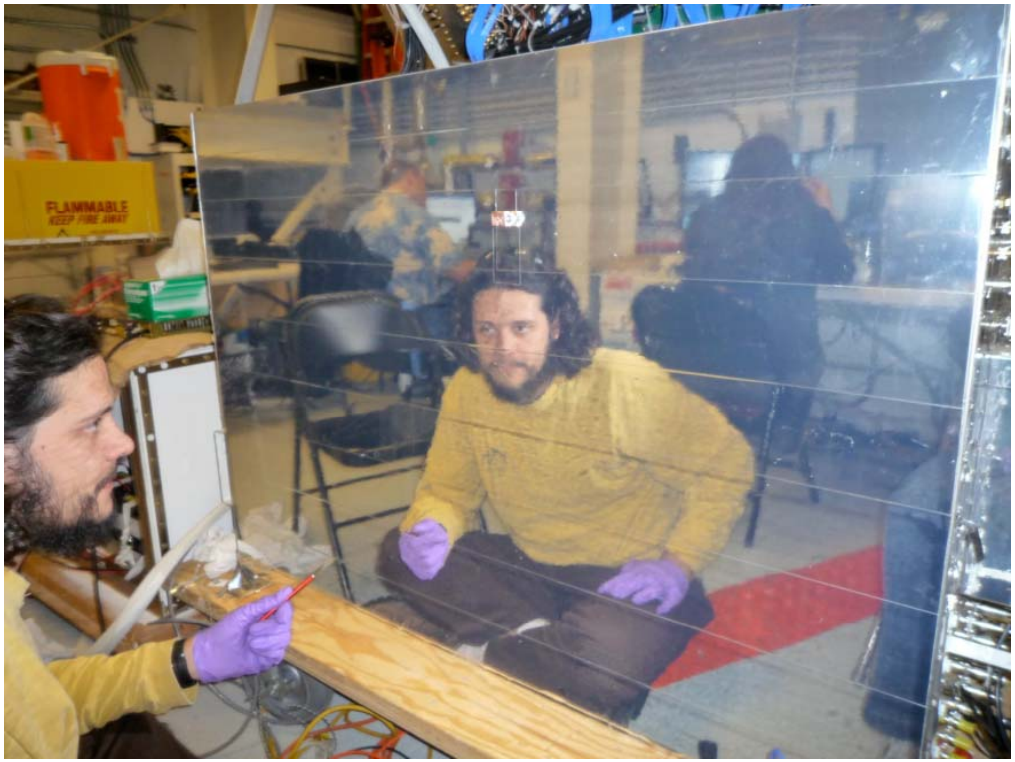


Of course, people come to learn … to leave… (or not)

Dr. Kurtis Nishimura

Larry Ruckman (Masters')
Now with Creare Inc.

Associate Professor Gary Varner



Dr. Himansu Sahoo

Andrew Wong (Masters)

Jim Kennedy (6 years) → Matt Andrew

Dr. Andres Romero-Wolf
Jet Propulsion Laboratory

Looking ahead…

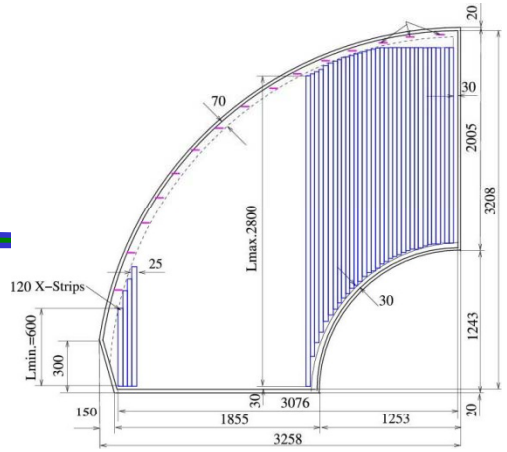
- PhD's in the pipeline
  - Jamal → finishing up light Higgs search
  - Mike → penultimate SOI CAP
  - Jikun (Jacob) → start new project (CSA ASIC)

- Likely visitors
  - Jussi Malin (Finland) → project to be determined
  - IHEP (Beijing) engineer → waveform sampling ASICs
  - French (Paris) visitor → next generation ps-Timing ASICs
  - Roberto Mussa → AMBER and iTOP developments(?)

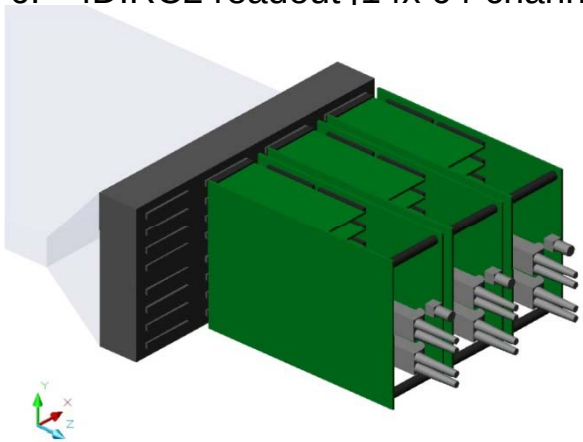
Personnel additions...

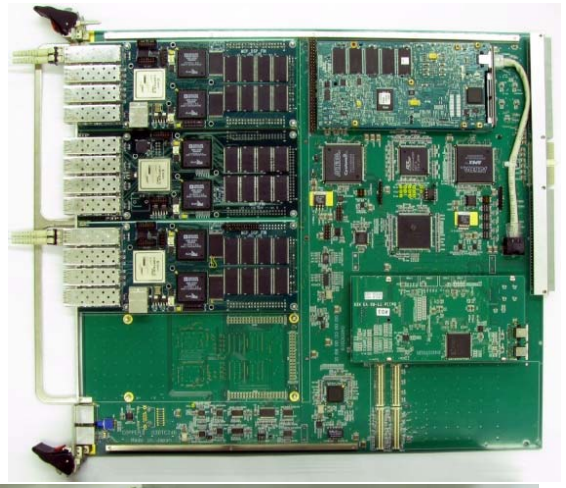
- In January, 2x more engineers:
  - Lili Zhang
    - DSP programming
    - iTOP cosmic/beamtest (summer?)
  - Joshua Sopher
    - Firmware muscle
    - IceCube firmware
    - Just returned from Pylos (Greece)
    - Initially 2 month stay
- With Juaquin, Serge, and Andrew, an impressive team
- Anticipate seeing new post-docs around (if will do hardware): Igal, Jared, new Belle postdoc...

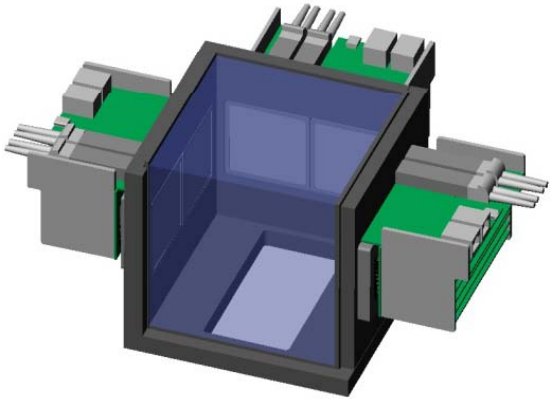
They will be needed...



1. Endcap KLM 150 channel system (full quadrant test of muon system) →
2. iTOP rework --> boards and board test plan
   [512 channel system = 4x 128ch]
3. ATF2 (Fermionics-based) DAQ [128 channels]
4. xFEL Fermionics readout [128 channels]
5. mini-Time Cube [12x 64-channel tube readout minimum?]
6. fDIRC2 readout [14x 64-channel tubes]







Univ. of HAWAI'I SiPix LAB

What is the Future?

- Belle II – iTOP by 2014, pixel upgrade thereafter
- Disruptive technology: LAPPD (<2 years left to deliver)
- ANITA 3rd Flight approved → active R&D (ASICs, trigger…)
- Deploy AMBER station this next year → large array?
- New initiatives: ARA Test bed installed now, year 2 & 3
- Great opportunities – life cycle of a university
  - Jr./Sr. research projects
  - Directed study/NASA Space Grant/REU/PUF (Japan/Antarctica/Paris)
  - Publications (NIM/IEEE/JINST …)
  - Board/firmware/chip design (PHYS476)
  - Many designs in queue; TARGET2, BLAB3B, CAP11, BSR…
    - Design, layout, simulation and test opportunities