Summary of CAL/Muon session

ACFA/BILC07 plenary

2007/Feb/07

K. Kawagoe

Kobe University

We had one-day-long session

- My apologies: We had a total of 15 talks: impossible to cover all the talks in 20 minutes or less …

- 3 talks on RPC experience in China
  - CMS (FW Muon), BESSIII (Muon), STAR (MRPC for TOF)
- 1 talk on ILC detector geometry
  - Spherical Silicon Detector ?
- Calorimeter for PFA
  - 1 talk on SiW EM Calorimeter
  - 4 talks on Sci/W with MPPC
  - 2 talks on DHCAL (RPC, GEM)
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CMS bulletin April 2006

The Compact Muon Solenoid Experiment

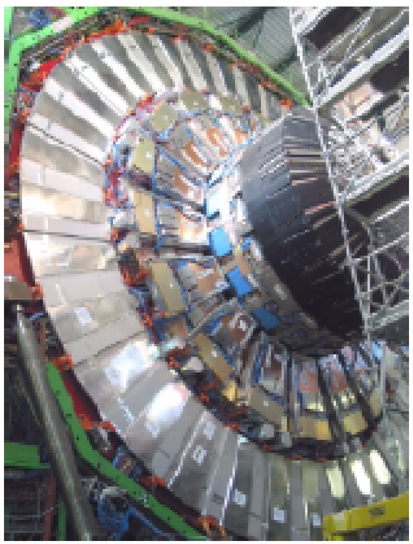
CMS Bulletin

CERN, CH-1211 GENEVA 23, Switzerland

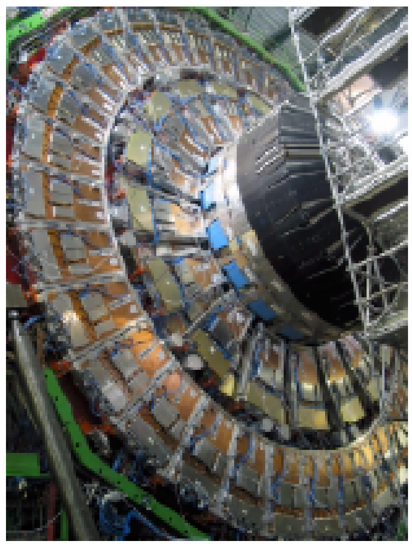
Bulletins are available on CMS internal information server: http://cmsdoc.cern.ch/cms.html

Number 06-01
13 March 2006

Moving Forward !



YE+1 yoke equipped with CSC/RPC packages (inner ring) and RE1/3 RPC's (outer ring).



The ME1/3 CSC's now cover the RPC outer ring and hence complete the first Muon station on YE+1.

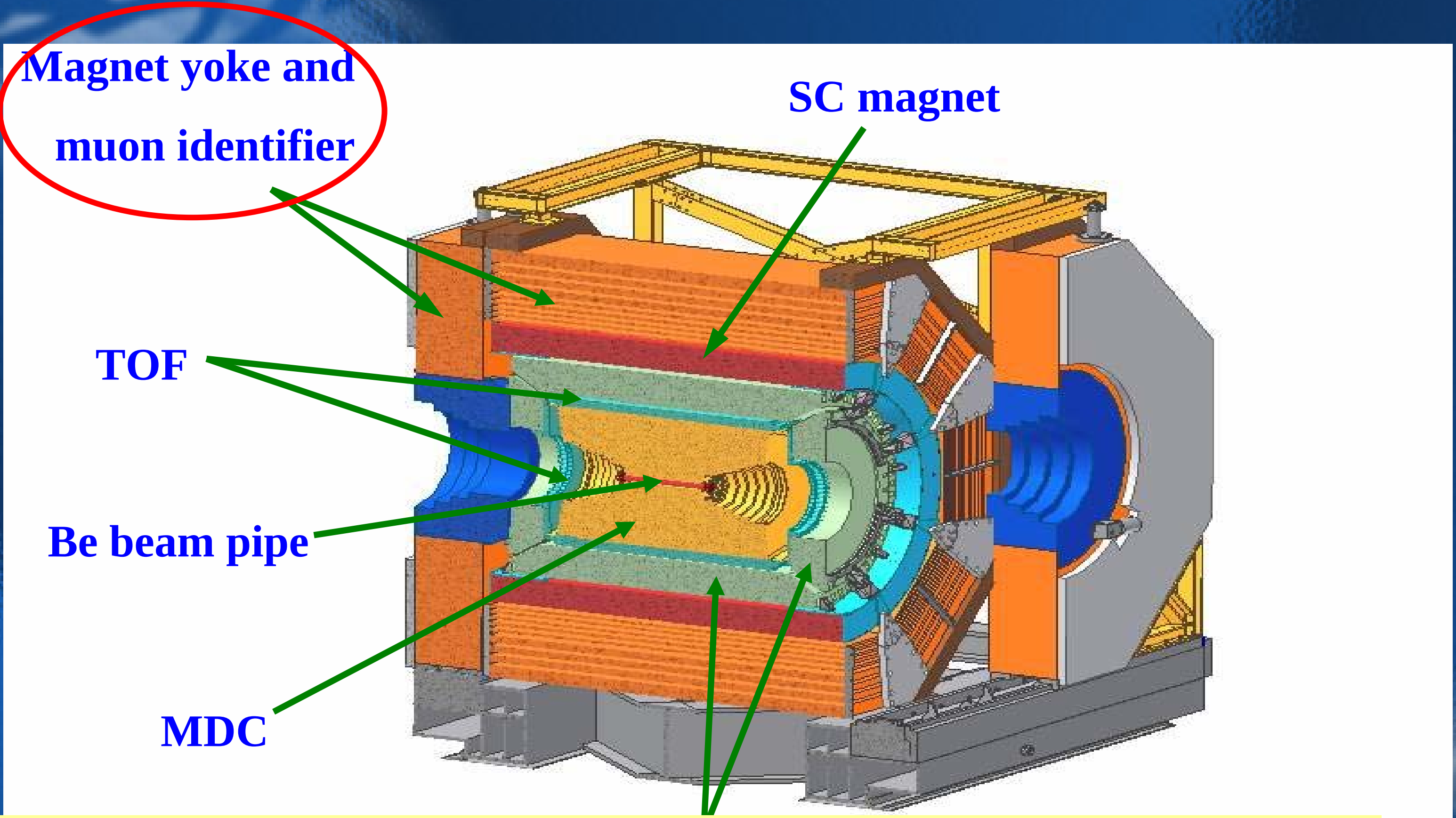
Feb. 2006, RE1/3 installed on CMS

Y. Ye

PKU-RPC will join the first run of LHC-CMS scheduled by the end of this year!!

The BESIII Detector

J. Zhan

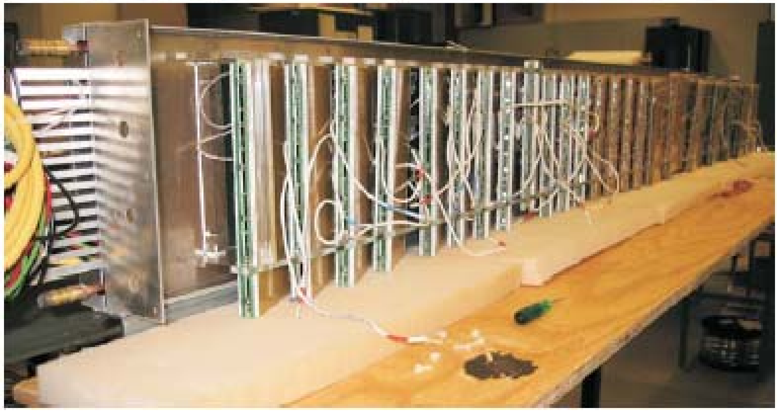


- The RPCs have higher efficiency, lower counting rate and dark current, and good long-term stability .
- The BESIII Muon detectors efficiency can reached to >98%, and the dark current is about <2 μ A/m^2, single counting rate is about $1000Hz/m^2$

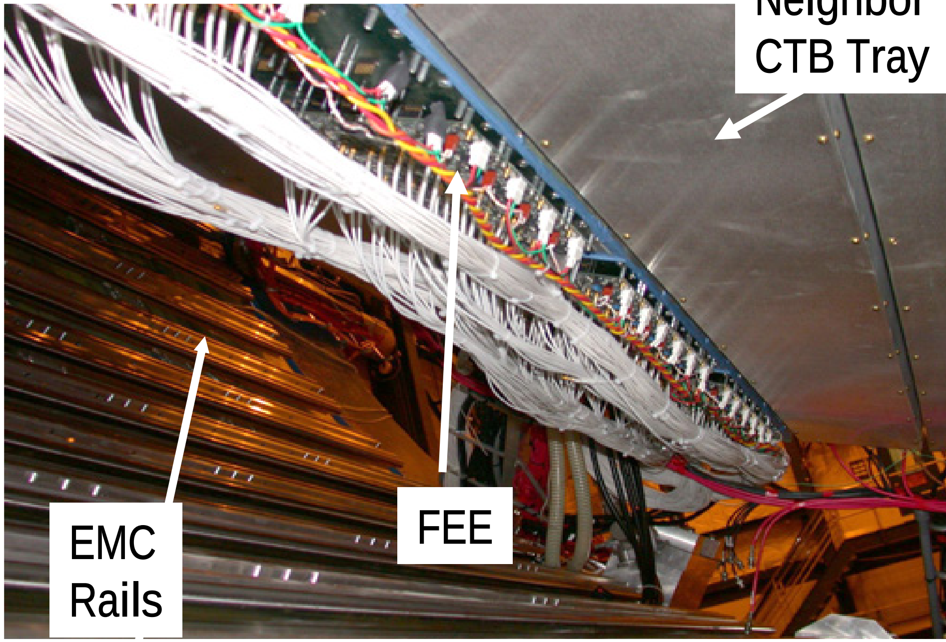
Prototype in TOFr Tray

(1 tray = 1/120 coverage of Barrel STAR)

Z. Zhao



28 MRPC, 24 from USTC



Completed Prototype 28 module MRPC TOF Tray installed in STAR Oct. ' 02 in place of existing central trigger barrel tray

To be used for PID at the STAR experiment at RHIC.
The prototype showed typical time resolution of ~80 ps.
Long MRPC is being developed now.

RPCs developed/produced in China

- are in operation in Asia, Europe, and US. They are great success.
- From conclusion of Y. Ye's talk
  - "Experiences with detector R&D, assembly and mass production have been accumulated and are valuable for future development and applications"
- RPC is a good candidate for MUD and DHCAL at ILC !

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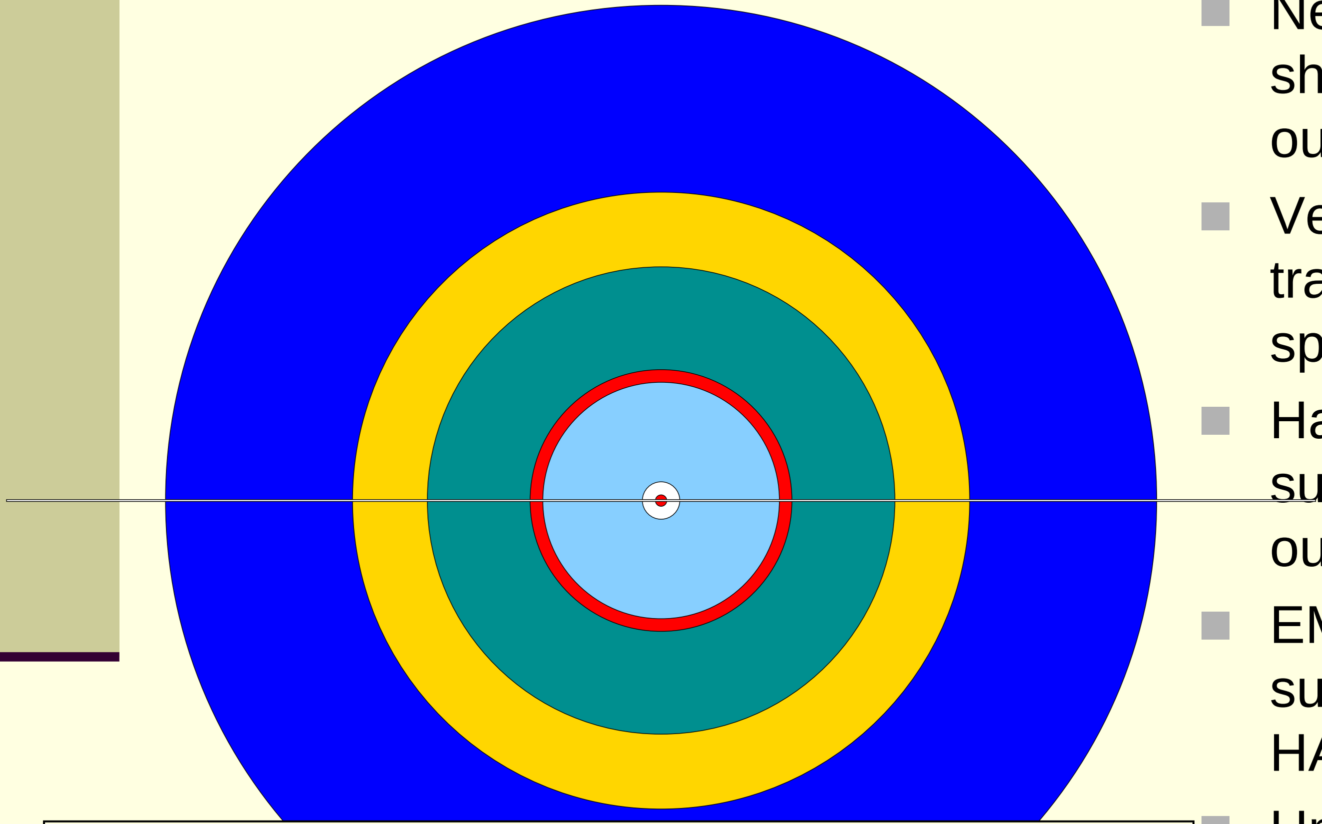
A. Para

Why not a Spherical Detector?

- Maximal symmetry of the detector
- Equal treatment of high and low angle regions, no corners and transition regions. Maintain good detector performance down to low angles.
- Best detector performance: detector surfaces ~orthogonal to the measured particles trajectories
- (Probably) the best use of the materials strength, the minimal need for the support structures
- Cost! Example:
    - A detector with radius R and length L=2R: area = $(4+2)\pi R^2$
    - A spherical detector with radius R: area = $4\pi R^2$
  - For the same detector radius a spherical detector is 1.5 times 'cheaper'
  - For the 'same cost' the spherical detector can be 1.2 times bigger
  - For detector with L>2R the cost savings are even bigger

A Spherical Detector?

A. Para

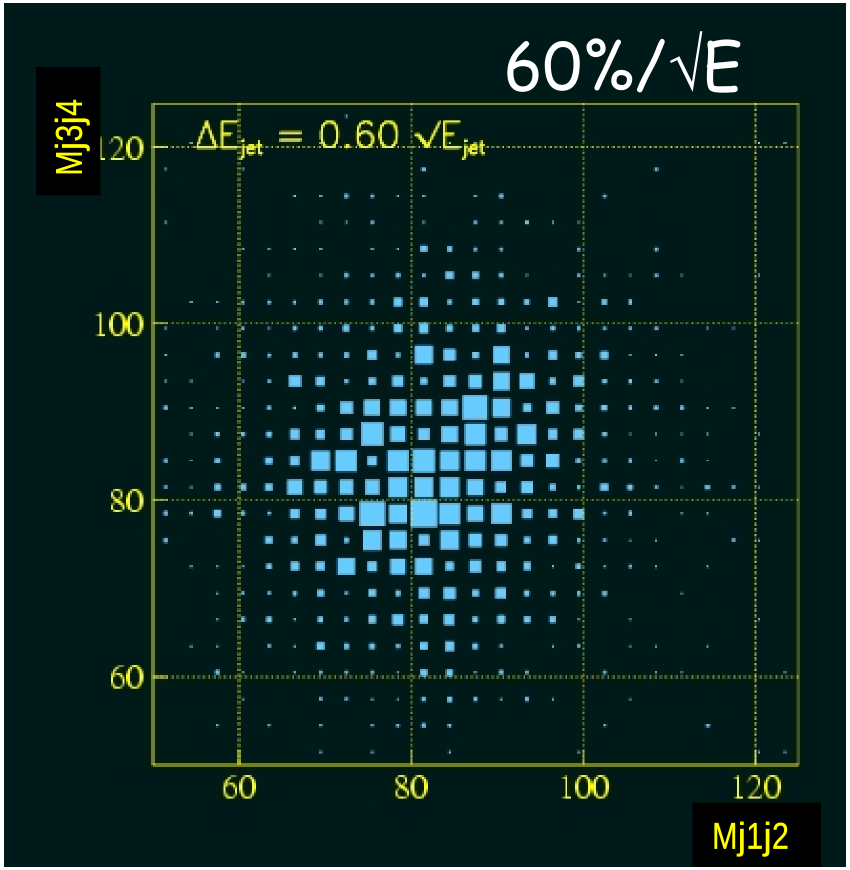


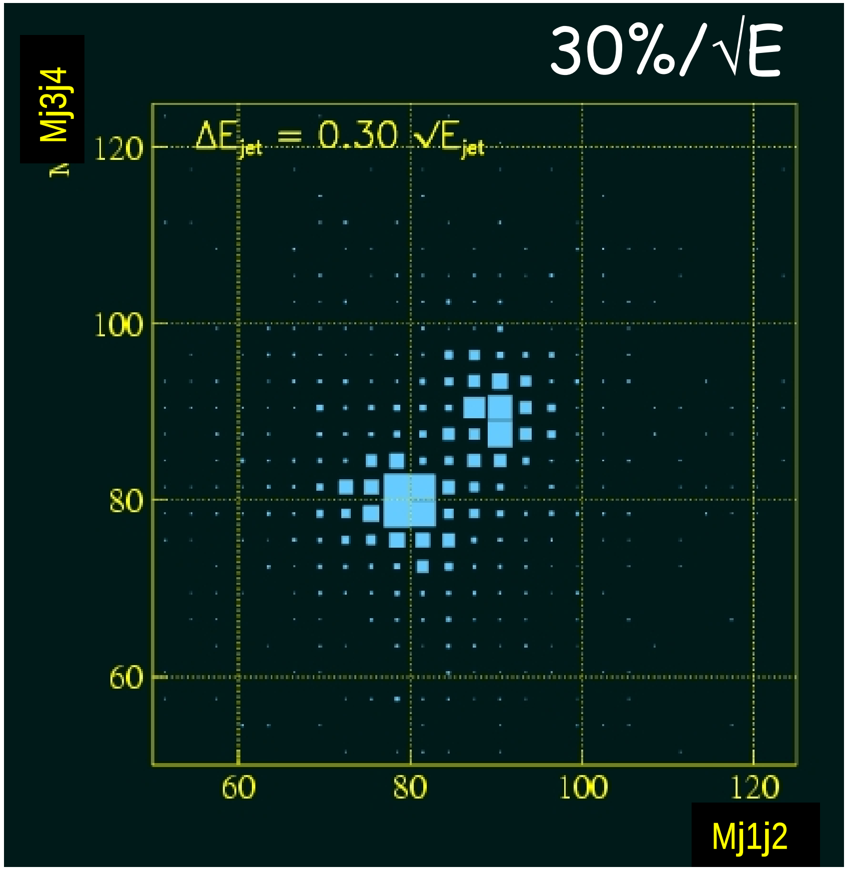
- Nested shells, inner shells supported form outer ones
- Vertex detector and tracker : spherical space frames
- Hadron calorimeter supported from an outer strong back shell
- EM Calorimeter supported from the HAD calorimeter
- Uniform calorimetry (identical 'towers')

Special care should be taken for magnetic field to obtain good momentum resolution in the small polar angle region.

What type of calorimeter to achieve jet energy resolution of 30%/√E?

Optimized for PFA ? Dual readout ? Any other method ?
Hardware R&D and simulation studies are both needed.





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The GLD Calorimeter

(joined CALICE last September)

- Sampling calorimeter with Pb/W - scintillator sandwich structure with WLSF readout
- Particle Flow Algorithm (PFA) needs particle separation in the calorimeter

⬇

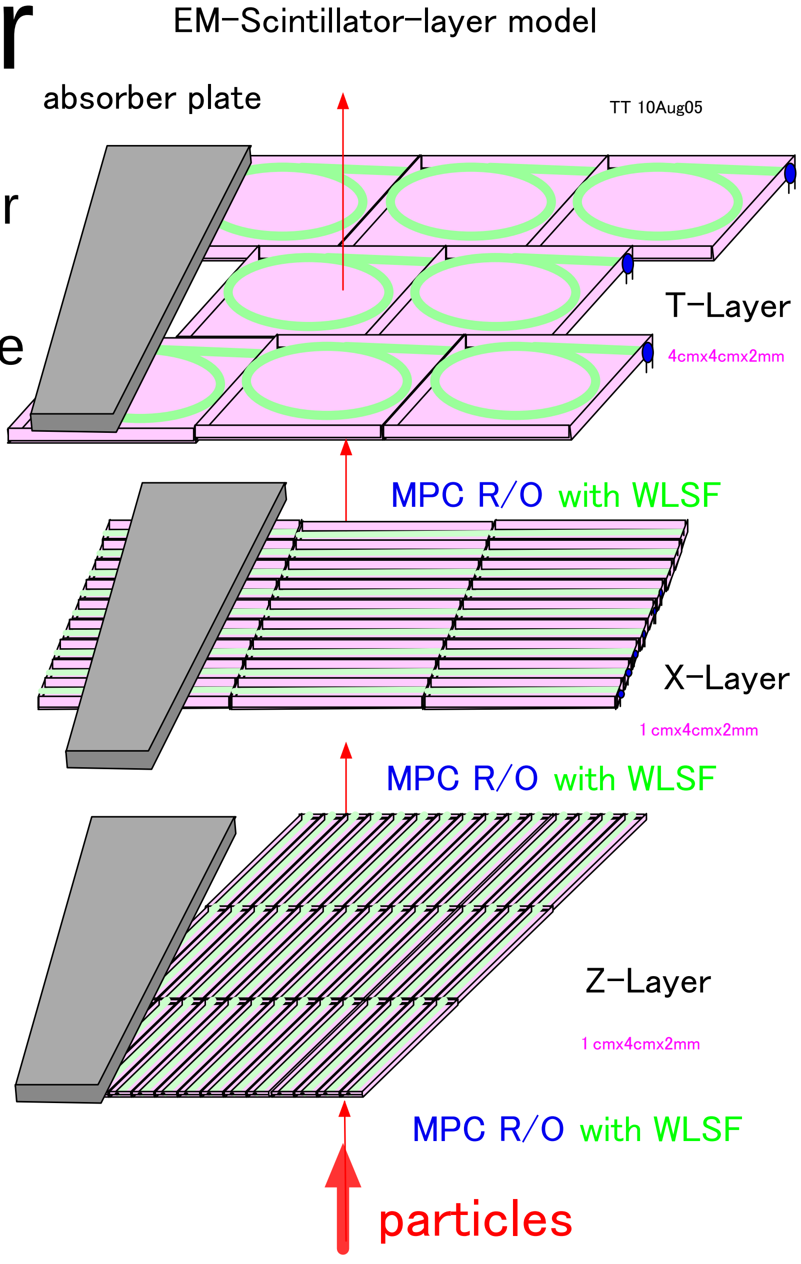
- Fine granularity with strip/tile scintillator

⬇

- Huge number of readout channels
  - ~10M (ECAL) + 4M (HCAL) !
  - 10K for muon detector
- Used inside 3 Tesla solenoid

  ➔use MPPC as photon sensor (multi-pixel avalanche photodiode being developed by HPK)

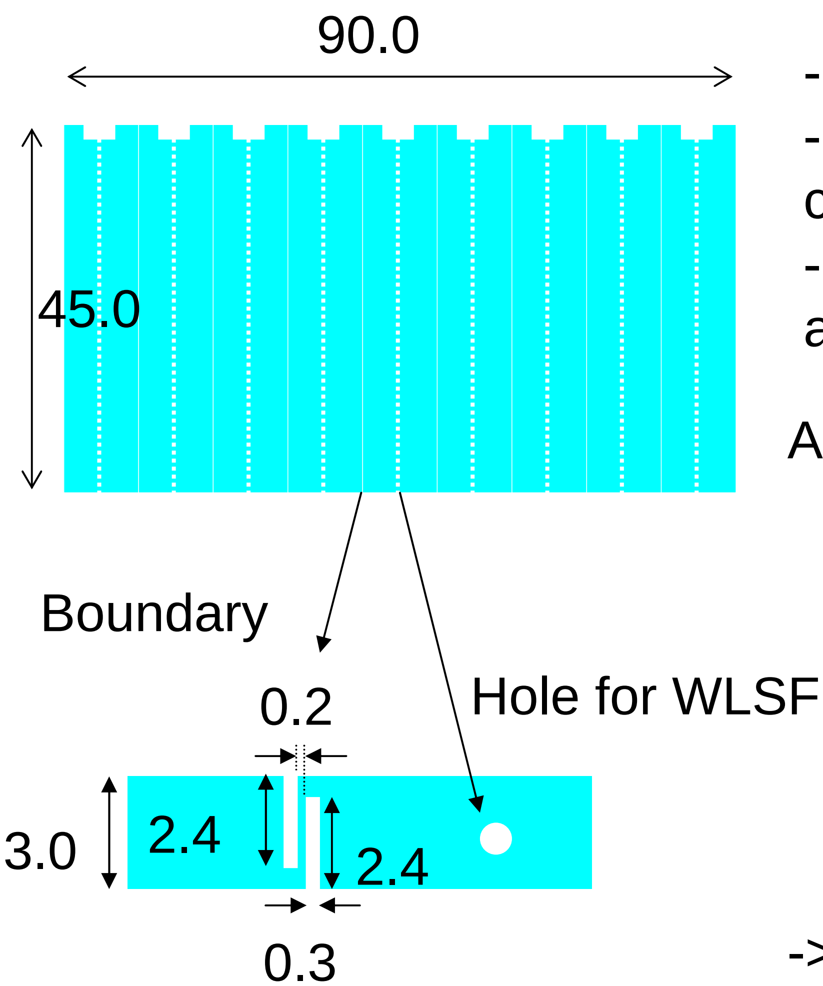
- ECAL beamtest at DESY in preparation



Structure of a mega strip plate

S. Itoh

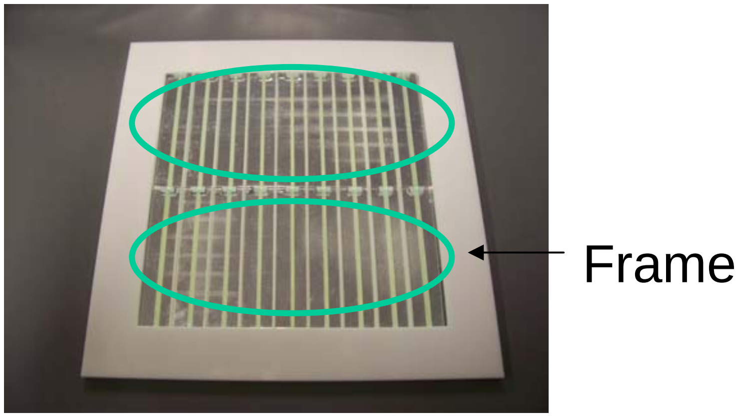
One of the good solutions for fine segmentation



Unit. in mm

- 9 strip structure on a mega plate
- Boundary grooves : mechanically connected but optically separated
- Insert reflector films into the grooves to avoid light crosstalk

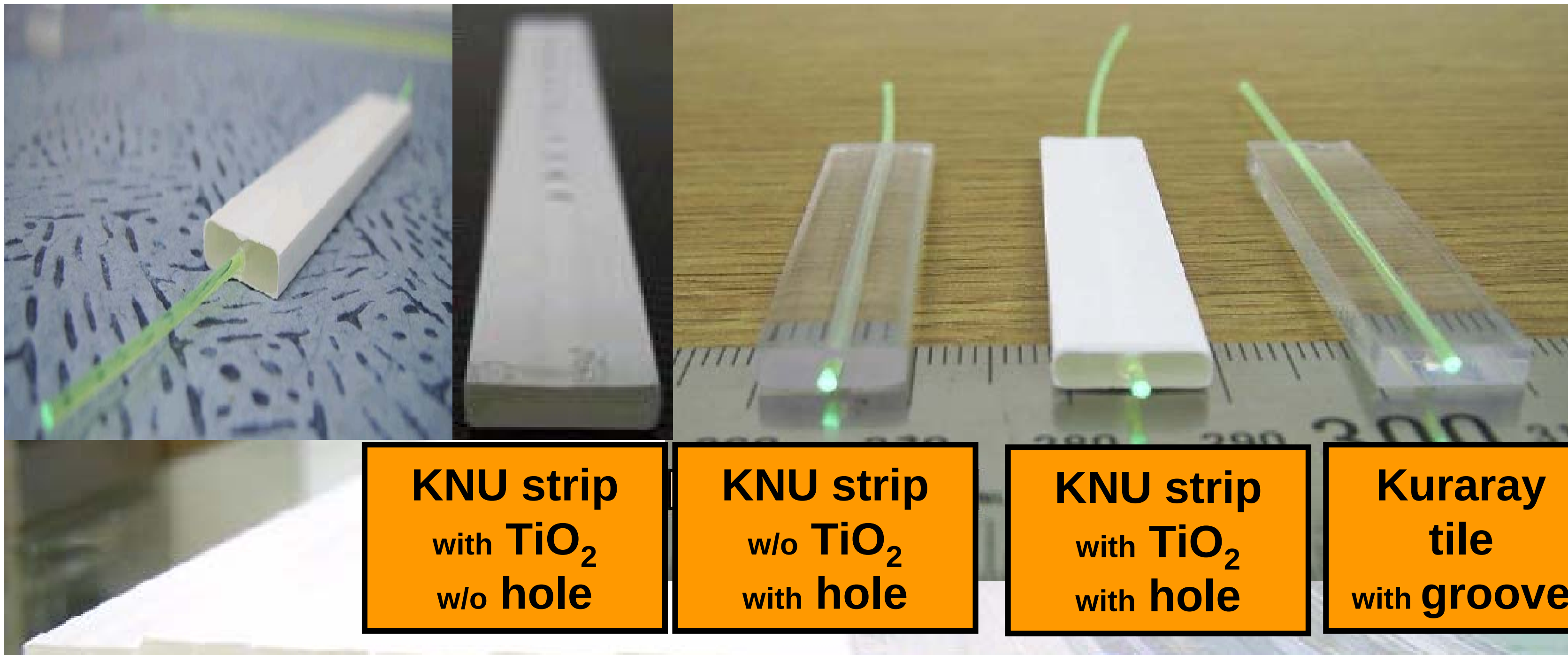
A layer consists of two mega plates



-> Easy for assembly and alignment (compared with array of simple strips)

S. Chang

Produced fine scintillator strips

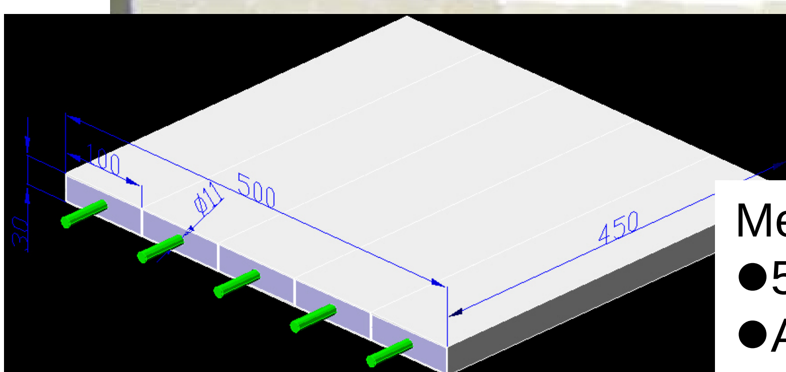


KNU strip with TiO_2 w/o hole

KNU strip w/o TiO_2 with hole

KNU strip with TiO_2 with hole

Kuraray tile with groove

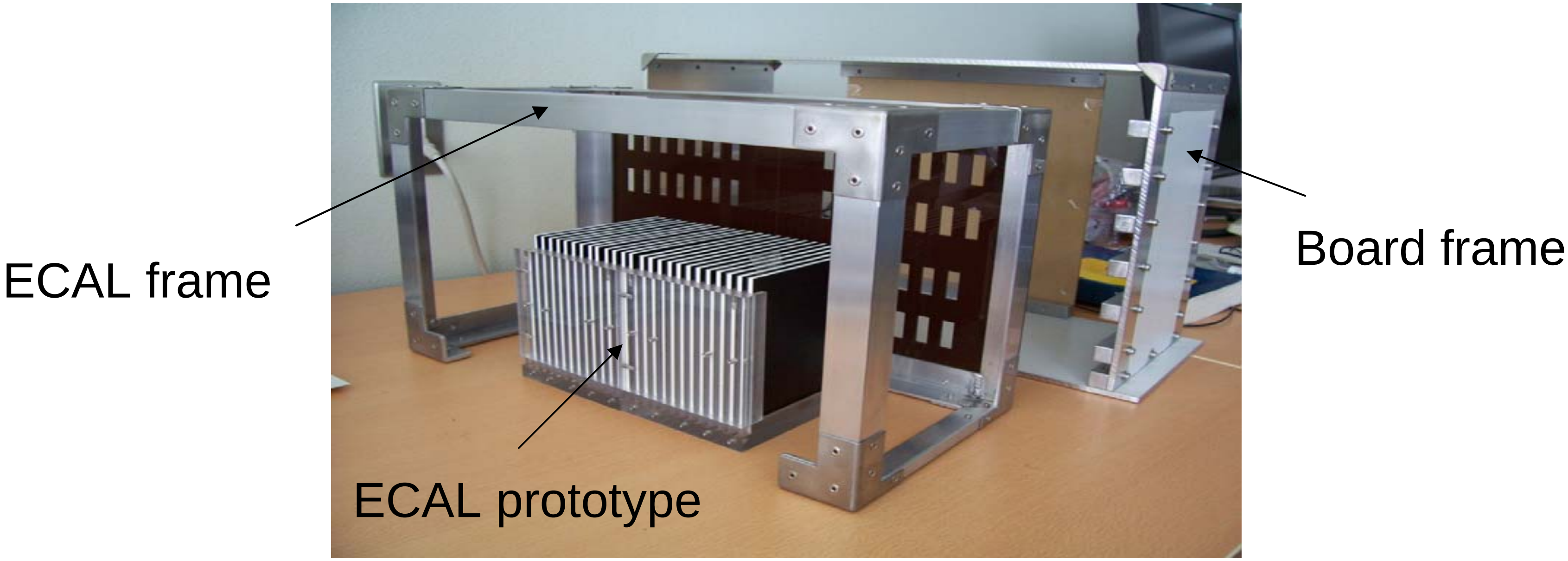


Megastrip being developed:

- 5 strips together
- All with TiO2 as reflector
- Each cell optically isolated

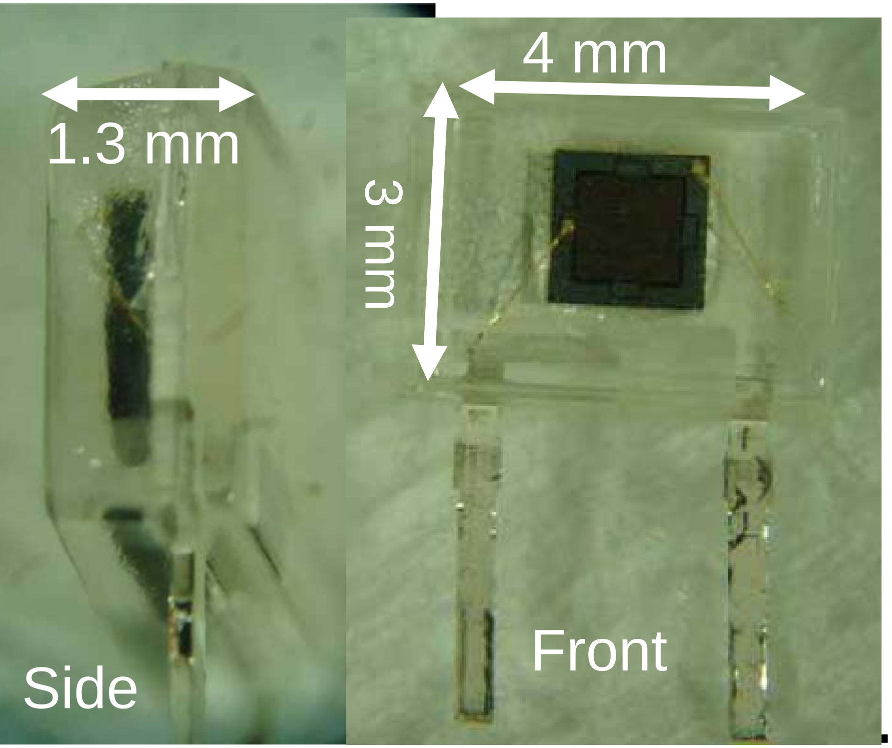
S. Itoh

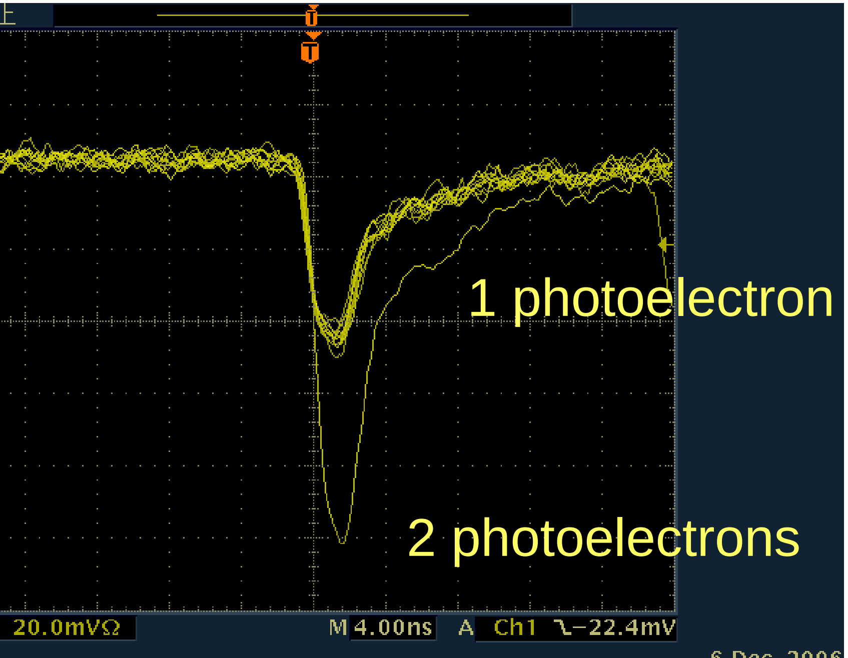
Status

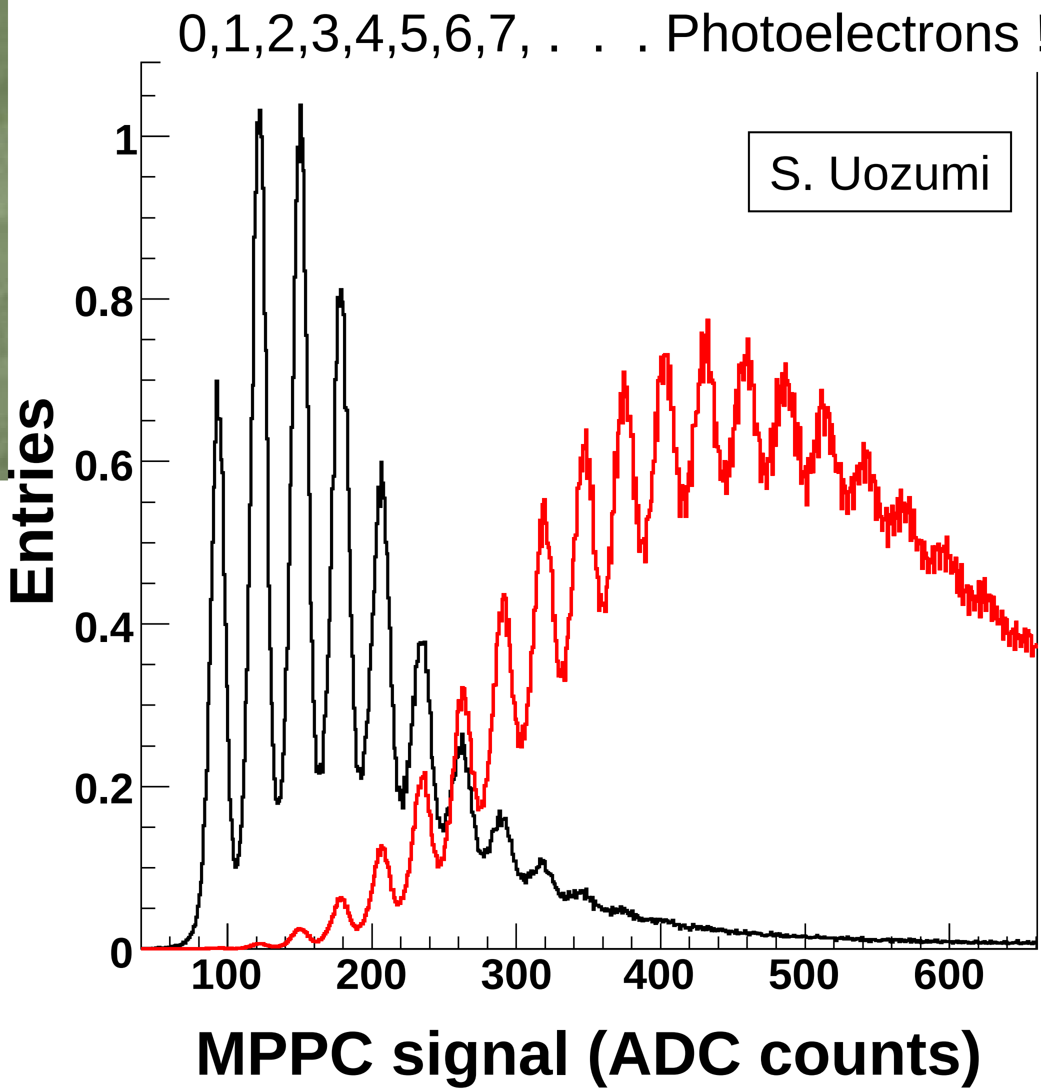


- Construction has been almost finished
- We will set MPPCs in the Mega strip and check the signal by β source after ACFA
- 15 FEB : Shipping to DESY

MPPC: Excellent photon counting capability





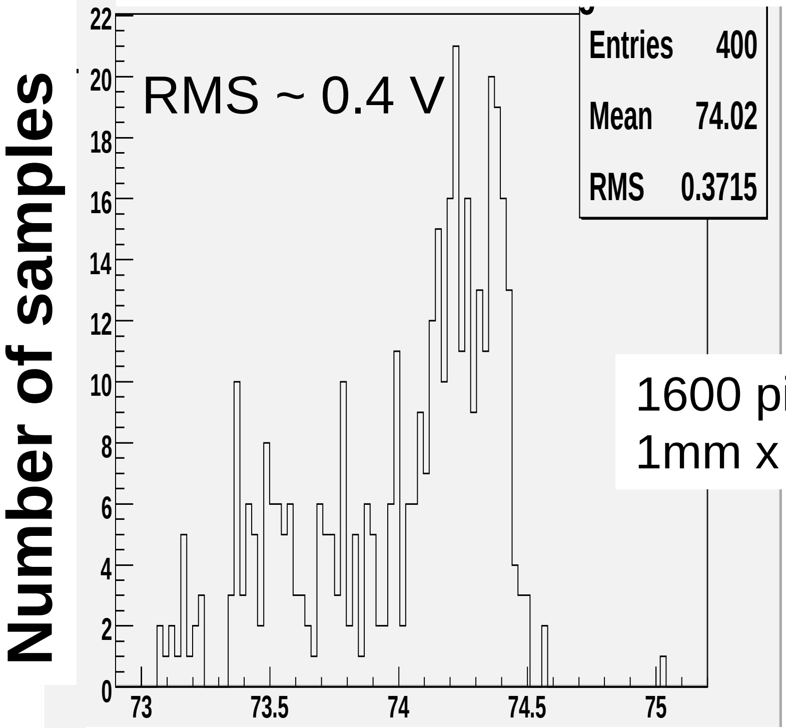


$$Gain = C \times (V_{bias} - V_0)\ /e$$

Variation of C and V_0 over 400 MPPCs

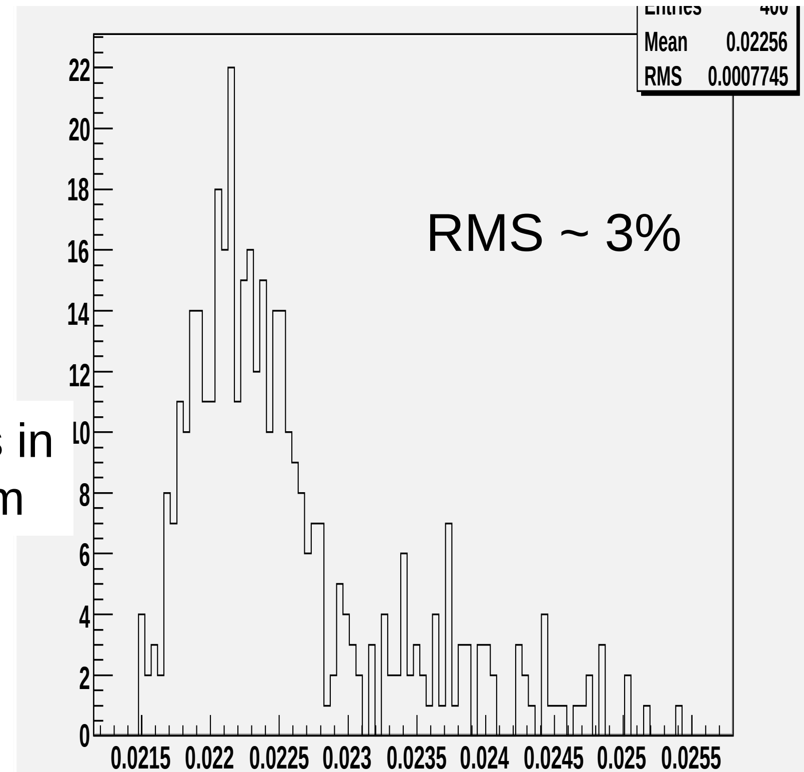
S. Uozumi

Measured at 15ºC



Breakdown voltage

1600 pixels in
1mm x 1mm

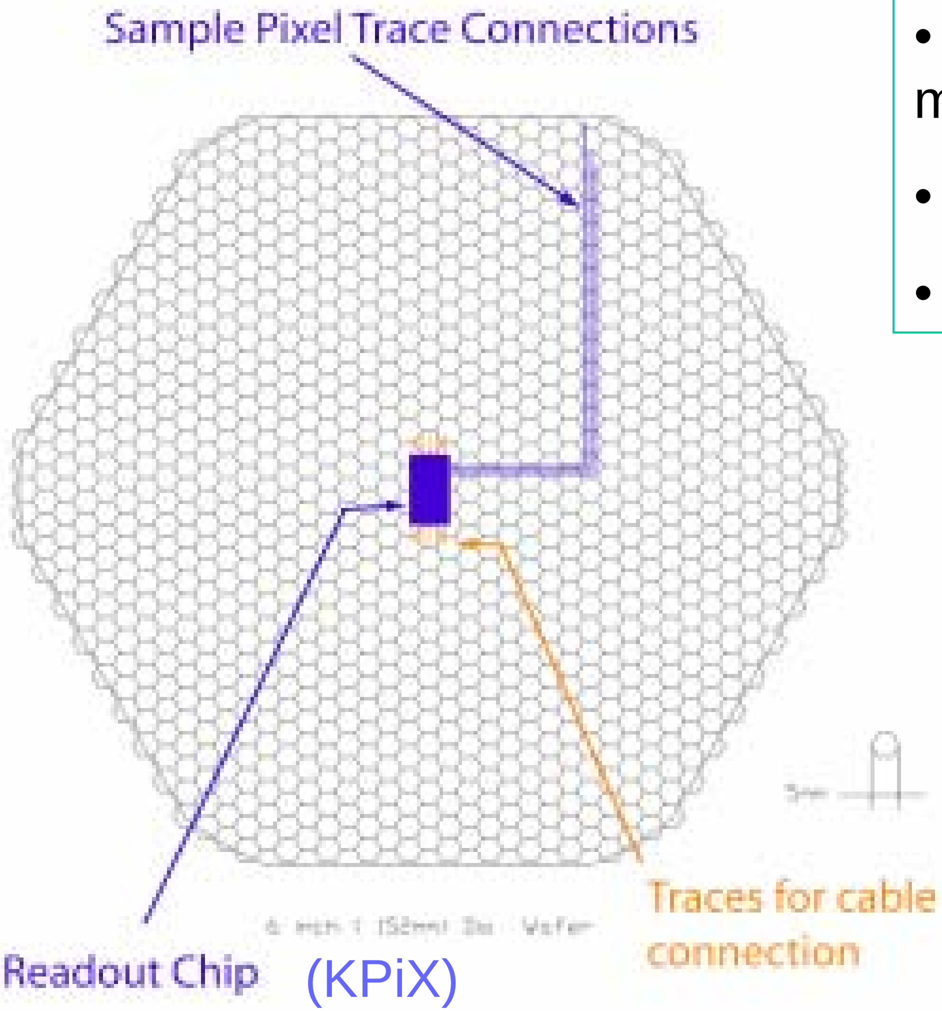


Pixel capacity

- 400 MPPCs have been delivered for a coming ECAL beamtest, and we have measured all of them.
- Observed variation of breakdown voltage is small enough and acceptable.
- A new mass-test system is being developed by H. Otono.

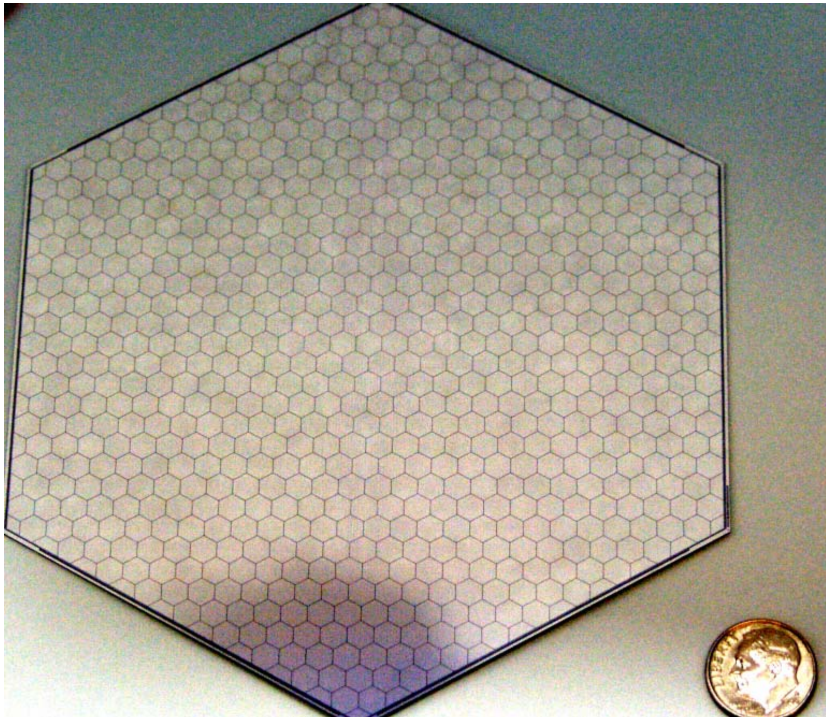
Silicon detector layout and segmentation

N. Graf for US SiW ECAL



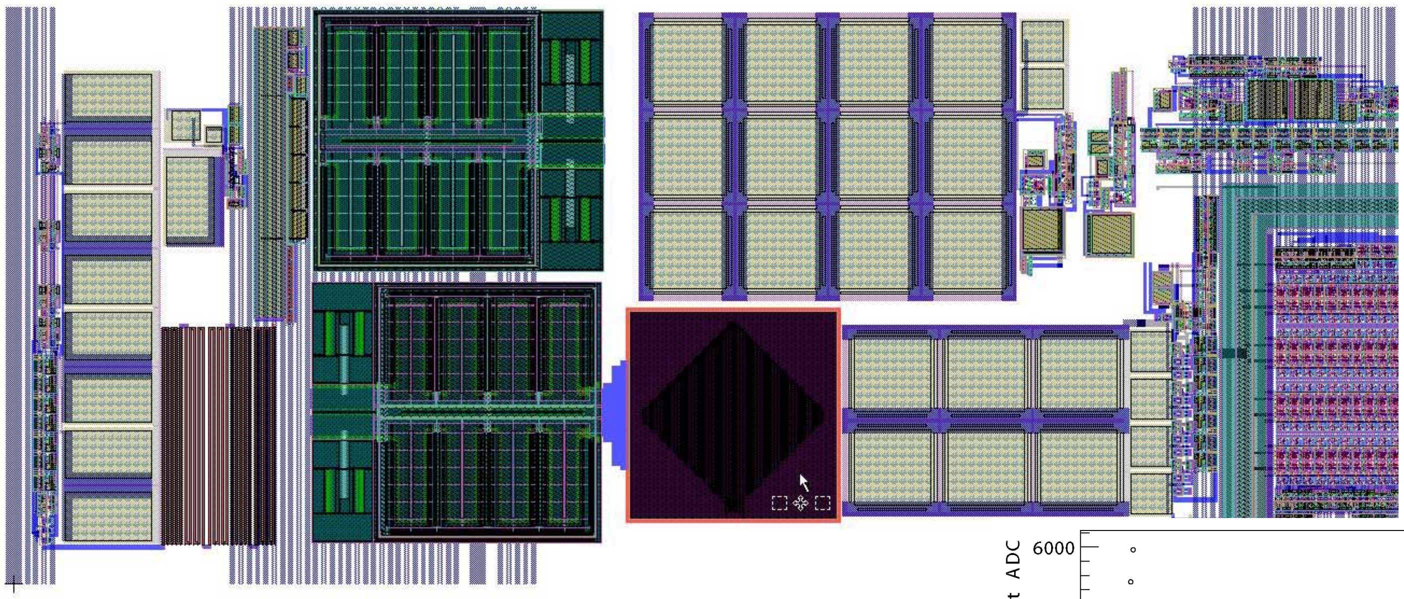
- Silicon is easily segmented
- KPiX readout chip is designed for 12 mm^2 pixels (1024 pixels for 6 inch wafer)
- Cost nearly independent of seg.
- Limit on seg. from chip power ($\approx$2 mm^2)

Fully functional prototype (Hamamatsu)



KPiX Cell 1 of 1024

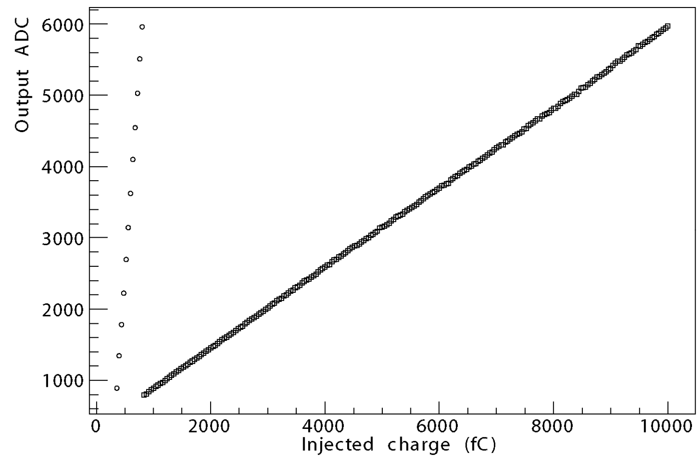
N. Graf



64-channel prototypes:

- v1 delivered March 2006
- v4 delivered Jan 16, 2007

It's a complicated beast – may need a v5 before going to the full 1024-channel chip ?



Dynamic range from 1 MIP to 500 GeV electron

R&D Milestones

N. Graf

I. Connect (bump bond) prototype KPiX to prototype detector with associated readout cables, etc

- Would benefit from test beam (SLAC?) - 2007
- A “technical” test

II. Fabricate a full-depth ECal module with detectors and KPiX-1024 readout * – functionally ≈equivalent to the real detector

- Determine EM response in test beam – 2008
- Ideally a clean 1-30 GeV electron beam (SLAC?)

III. Test with an HCal module in hadron test beam (FNAL?) – 2008-?

- Test/calibrate the hadron shower simulations; measure response

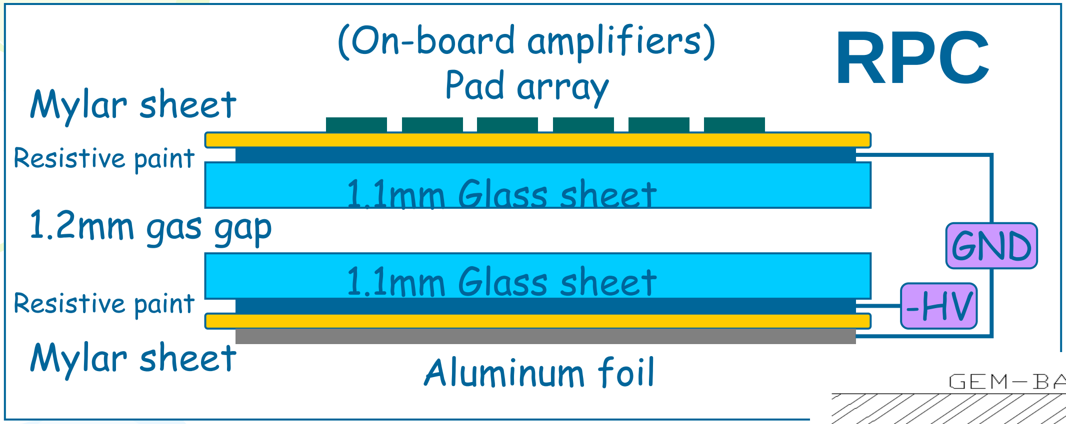
IV. Pre-assembly tests of actual ECal modules in beam – >2010

* *pending funding*

DHCAL

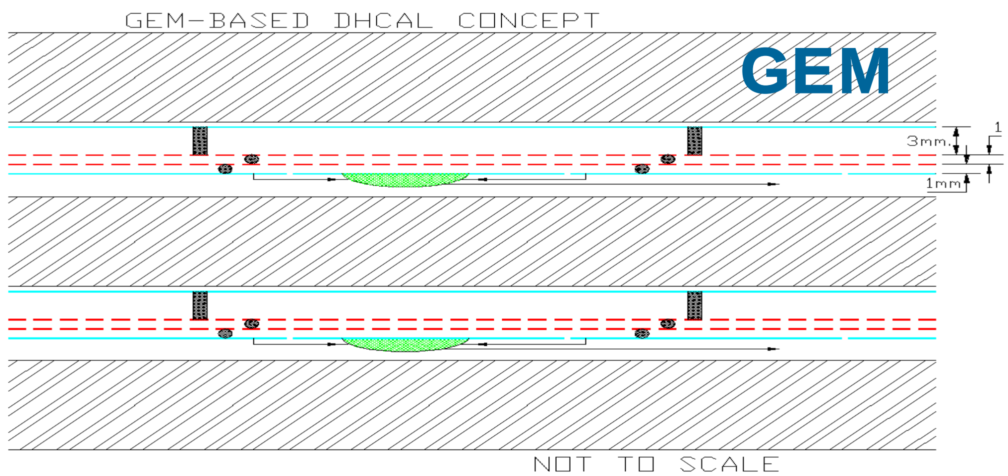
Active Medium Candidates

L. Xia
@IDTB07

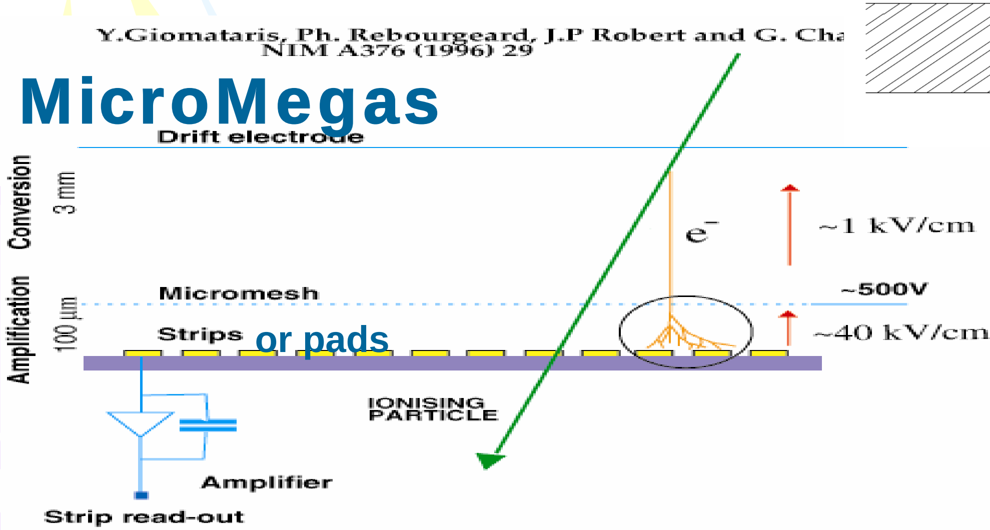


European Group:
IHEP (Protvino) + collaborators

US Group:
Argonne + collaborators

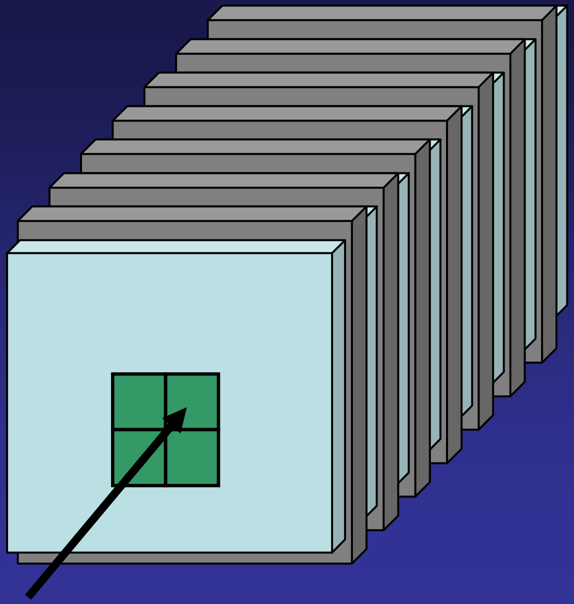


UTA + collaborators



LAPP (Annecy) + collaborators

Vertical Slice Test



Uses the 40 DCAL ASICs from the 2nd prototype run

Equip ~8 chambers with 4 DCAL chips each

256 channels/chamber
~2000 channels total

Chambers interleaved with 20 mm copper - steel absorber plates

Electronic readout system (almost) identical to the one of the prototype section

Tests in MTBF beam planned for Spring 2007

→ Measure efficiency, pad multiplicity, rate capability of individual chambers
→ Measure hadronic showers and compare to simulation

Validate RPC approach to finely segmented calorimetry
Validate concept of electronic readout

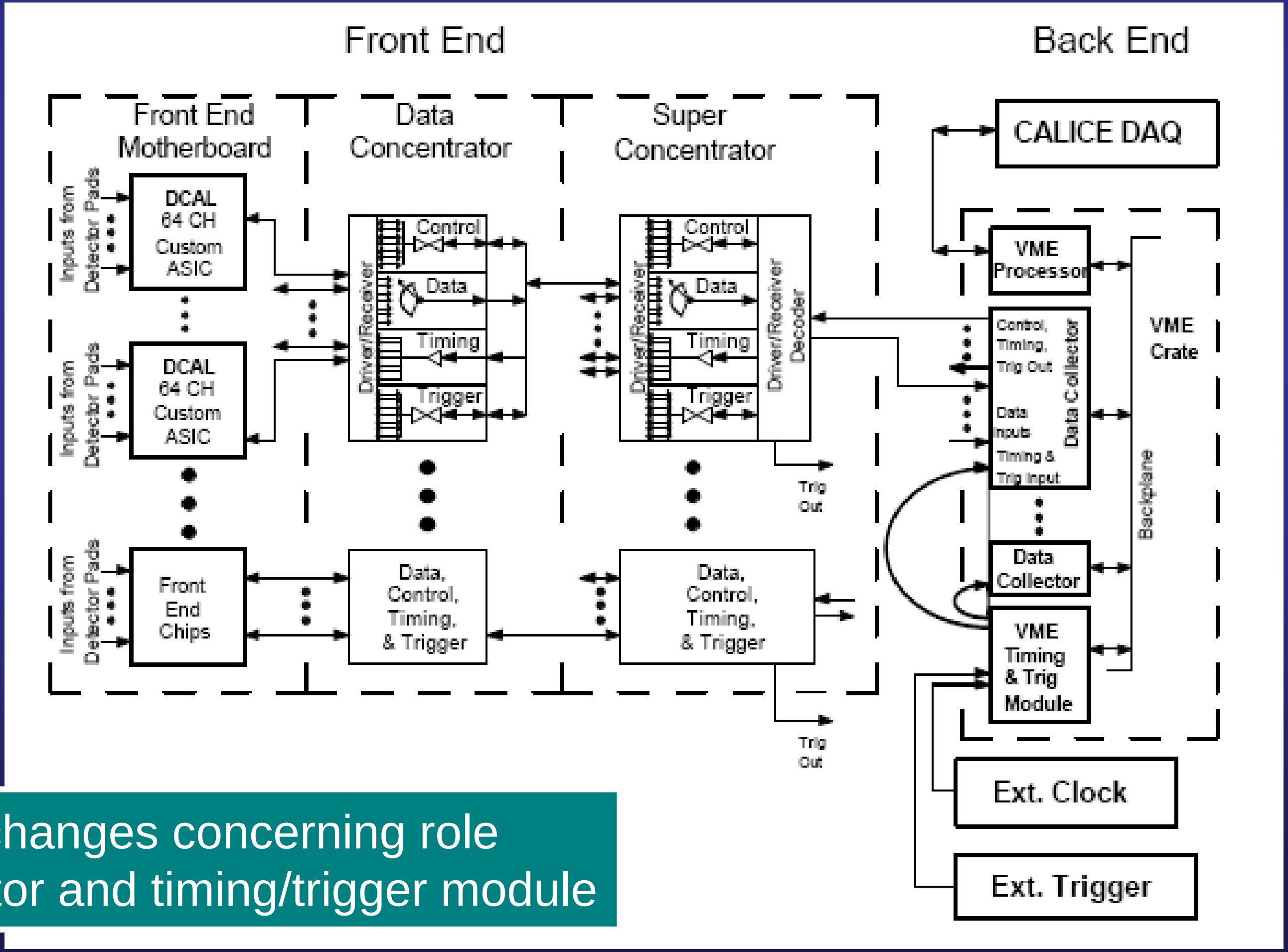
Electronic Readout System for Prototype Section

Suitable for both RPCs and GEMs

40 layers à 1 m^2 → 400,000 readout channels

More than all of DØ in Run I; ATLAS tilecal HCAL is 10,000 channels; ATLAS ECAL 200,000

- I Front-end ASIC
- II Pad and FE-board
- III Data concentrator
- IV Super Concentrator
- V VME data collection
- VI Trigger and timing system



Some recent changes concerning role of data collector and timing/trigger module

Costs and Funding

A) Slice test is funded by LCDRD06, LDRD06 and ANL-HEP, and Fermilab

B) Prototype section not yet funded, but…

Stack	Item	Cost	Contingency	Total
RPC stack	**M&S**	607,200	194,600	801,800
	Labor	243,075	99,625	342,700
	Total	**850,275**	**294,225**	**1,144,500**
GEM stack*	**M&S**	400,000	165,000	565,000
	Labor	280,460	40,700	321,160
* Reusing most of the RPC electronics	**Total**	**680,460**	**205,700**	**886,160**
Both stacks	**M&S**	1007,200	359,600	1366,800
	Labor	523,535	140,325	663,860
	Total	**1,530,735**	**499,925**	**2,030,660**

Proposal for supplemental funds for $500k/year over two years submitted to DOE
Help from ANL (LDRD), ANL-HEP, FNAL expected…

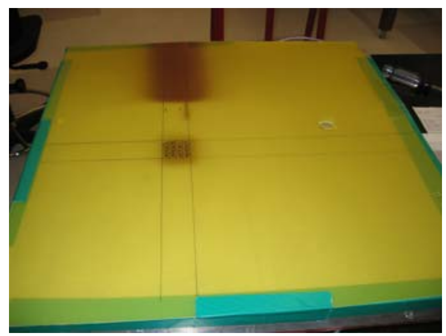
30cm x 30cm GEM Chamber Development

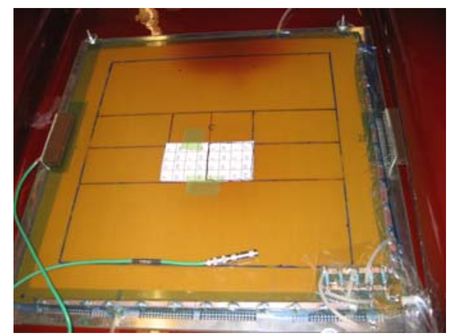
- Foils HV tested and certified
- Jigs made to mount foils, stack chamber.
- Initial multilayer 30cmx30cm anode board made to work w/ Fermilab QPA02-based preamp cards
- Verify aspects of chamber operation:
  - Stability
  - pulse characteristics (cf. 10cm x 10cm chamber using CERN foils)
- Exposed to 10MeV electron beams at Korea/KAERI beam tests in May

UTA GEM Chamber in KAERI Electron Beam

- e^- beam: 10^{10} particles in 30ps pulse ~every 43μs
- Scans 4cmx60cm area every 2 seconds

4-pad area (2cm x 2cm) exposed to scanning beam for ~2000 sec.





G10 boards in the exposed area discolorized. But no damage to the GEM foils

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4th concept (J. Hauptman, C. Gatto)

Mostly orthogonal to other three concepts

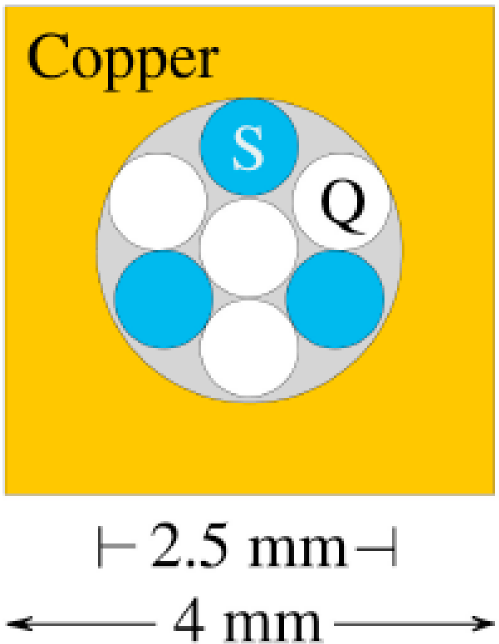
Basic design principle: only four basic, powerful systems, each as simple as possible. Obviate any need for tail-catchers, pre-showers detectors, end-cap chambers, or silicon blankets to augment performance of main detector.

- Pixel Vertex (PX) 20-micron pixels (like Fermilab/SiD thin pixel)
- TPC (like GLD or LDC) "gaseous club sandwich" (Paul Colas)
- Triple-readout fiber calorimeter: scintillation/Cerenkov/neutron (new)
- Muon dual-solenoid iron-free geometry (new), cluster counting (new)

Measure *all* partons with high precision

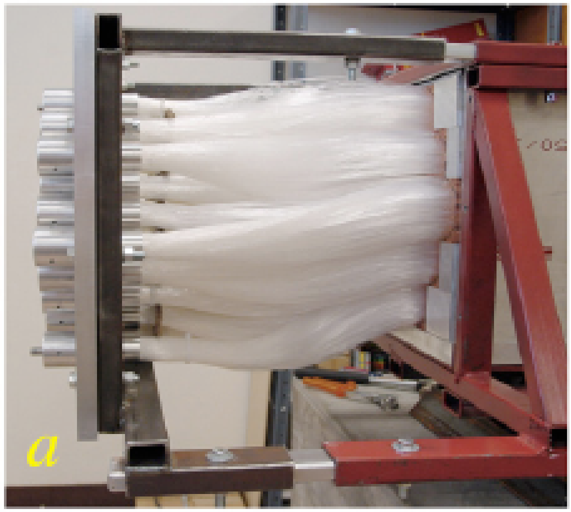
$$e, \mu, \tau \to e/\mu/\pi; \quad uds \to j; \quad c, b\ (\lambda_{decay}); \quad t \to Wb;$$
$$W \to jj \text{ and } Z \to jj, \mu\mu, ee \text{ (mass)}; \ \nu \text{ (subtraction)}$$

Calorimeter is new: a "dual readout" fiber calorimeter to measure EM fraction fluctuations, first developed by R. Wigmans

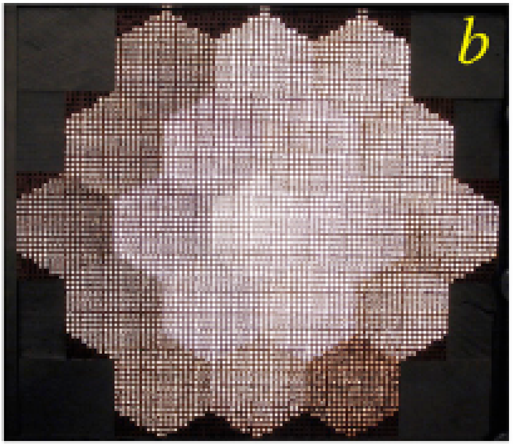


Unit cell

Back end of 2-meter deep module



Physical channel structure



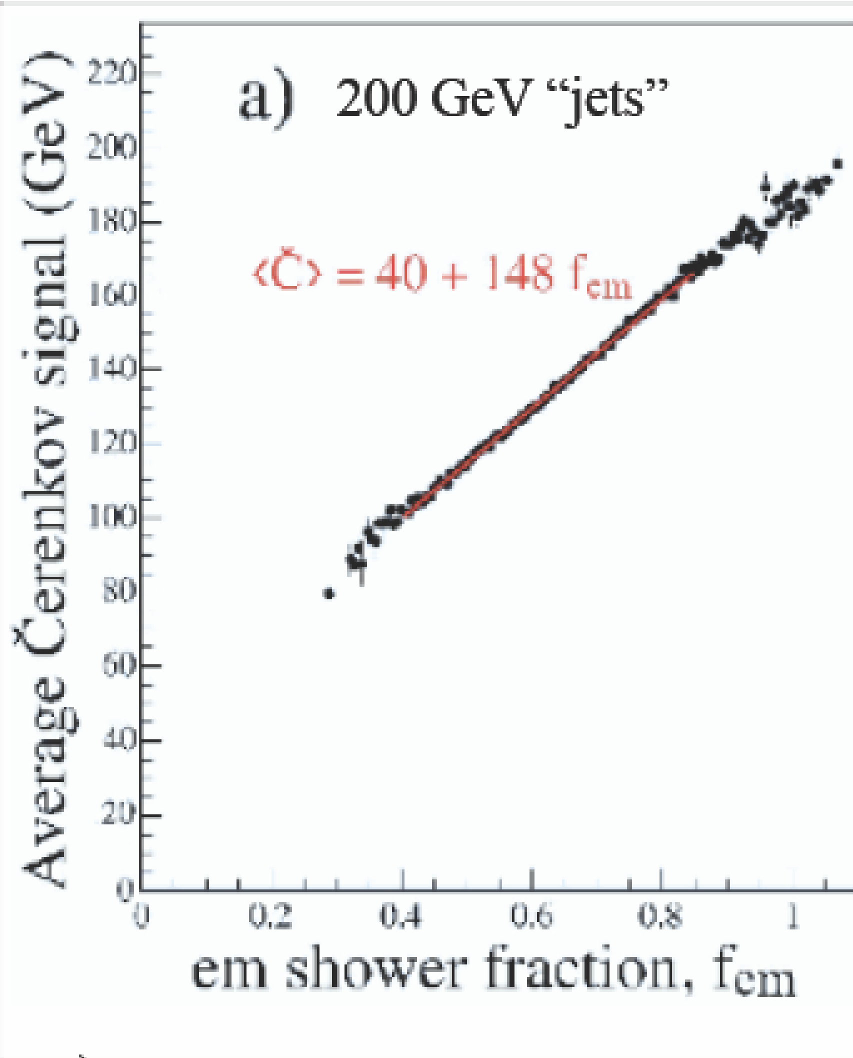
http://www.phys.ttu.edu/dream

Dual-Readout: Measure every shower twice - in scintillation light and in Cerenkov light. Calibrated with 40 GeV electrons into the center of each tower.

$$(e/h)_C = \eta_C \approx 5$$
$$(e/h)_S = \eta_S \approx 1.4$$

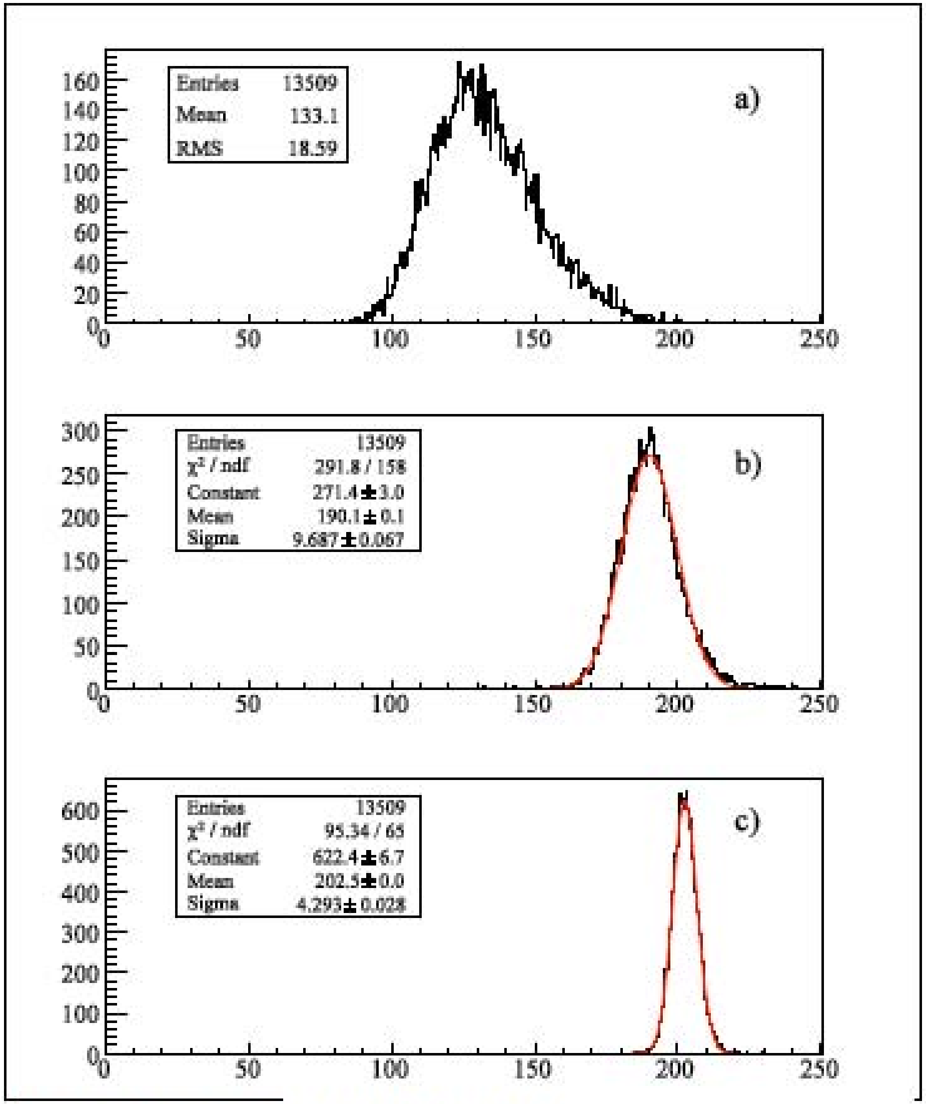
$$C = [f_{em} + (1 - f_{em})/\eta_C]E$$
$$S = [f_{em} + (1 - f_{em})/\eta_S]E$$

$$\rightarrow C/E = 1/\eta_C + f_{em}(1 - 1/\eta_C)$$



Data NIM A537 (2005) 537.

DREAM data 200 GeV π^-: Energy response



Data NIM A537 (2005) 537.

Scintillating fibers only

Scintillation + Cerenkov

$f_{EM} \propto (C/E_{shower} - 1/\eta_C)$

(4% leakage fluctuations)

Scintillation + Cerenkov

$f_{EM} \propto (C/E_{beam} - 1/\eta_C)$

(suppresses leakage)

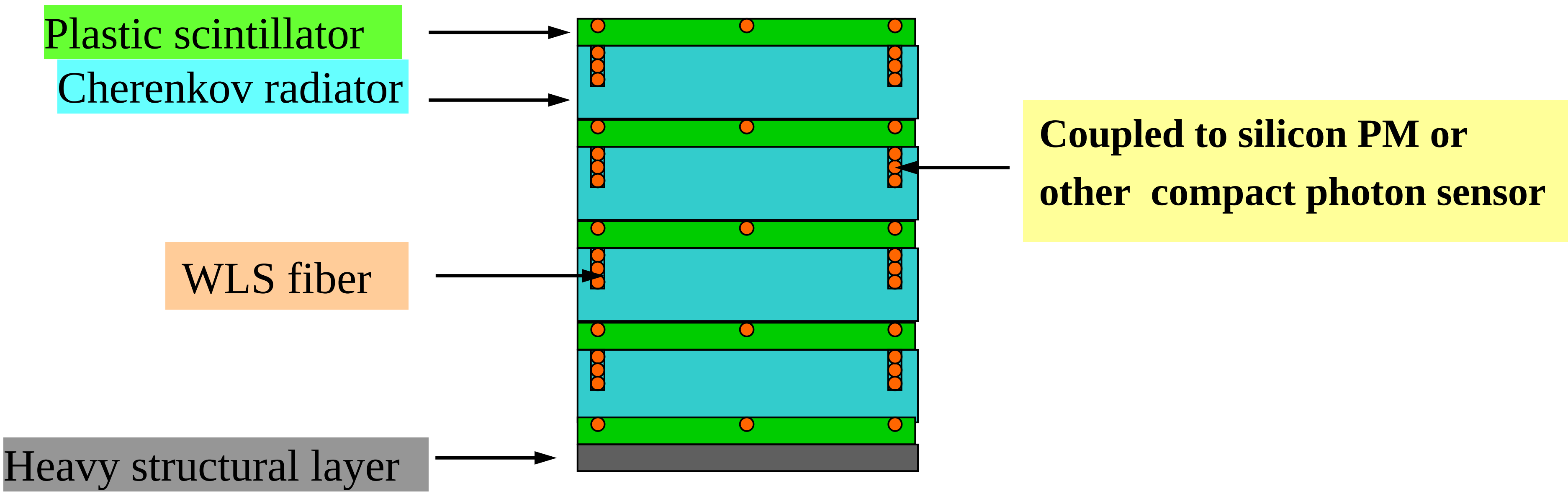
Basic Detector Configuration (1)

T. Zhao

- **Thin plastic scintillator plates**

- **Thicker heavy lead glass plates as Cherenkov radiator**
  "Low cost hot pressed glass plates!"

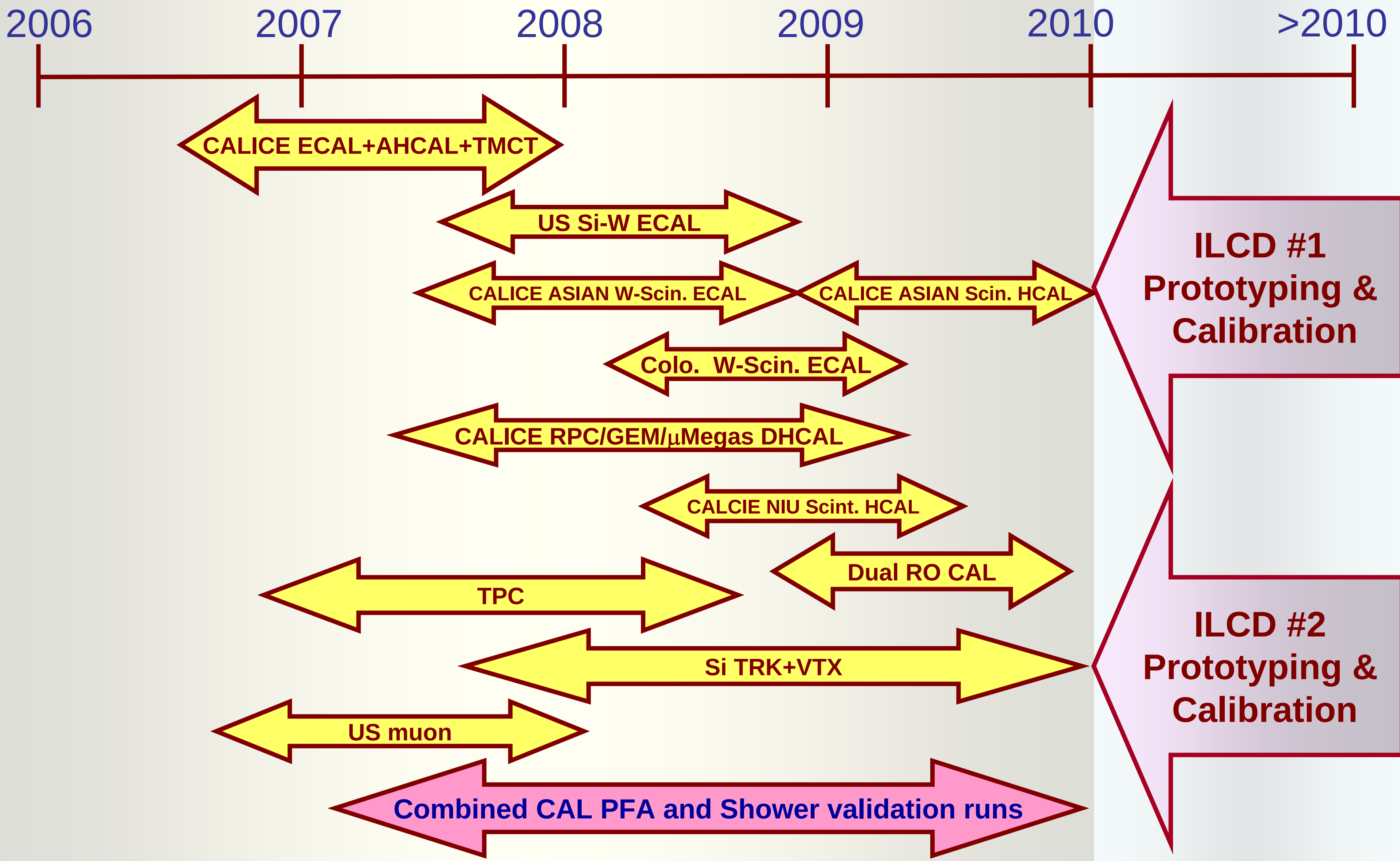
- **Analog readout (WLS fiber and imbedded silicon PMT)**



- **Use large plates to reduce the readout channel**

Timeline of Beam Tests

J. Yu @IDTB07



Phase I: Detector R&D, PFA development, Tech. Choices

Phase II: Global ILC Det. Proto. & calibration

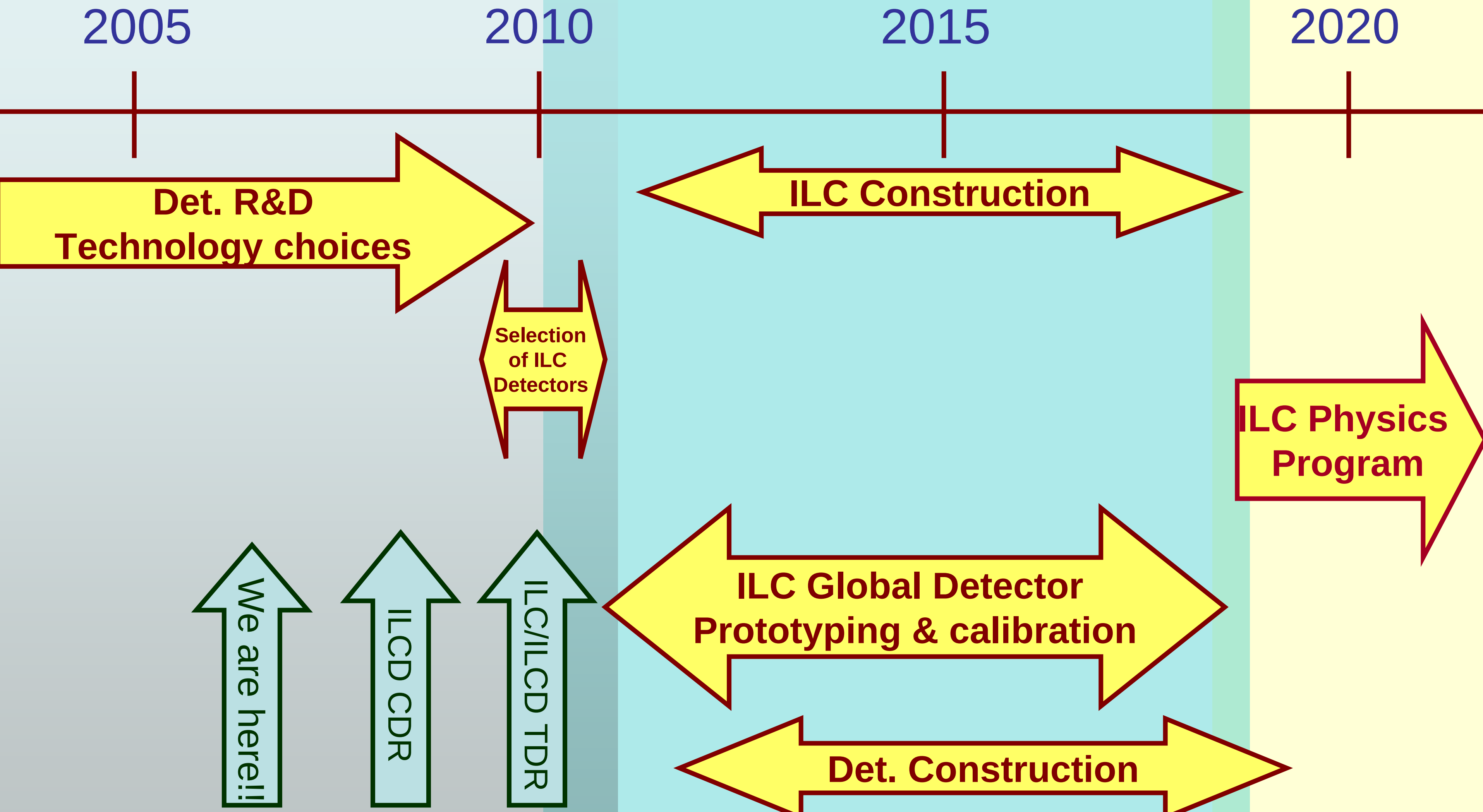
Summary

- We have a variety of on-going R&D studies on CAL/MUD, essential to develop the detectors to reach the unprecedented performance goals
- Mon-power is limited: horizontal collaborations are highly welcomed.
- New ideas are still arising: wish to have more.

Backup slidess

LC Detector Time Line

J.Yu @IDTB07



Detector R&D, ILC Detector Concept Development

ILC Detector prototype testing, Construction & Calibration

ILC Physics

"Dual Solenoid"

New magnetic field, new ``wall of coils'', iron-free:
many benefits to muon detection and MDI,
Alexander Mikhailichenko design