

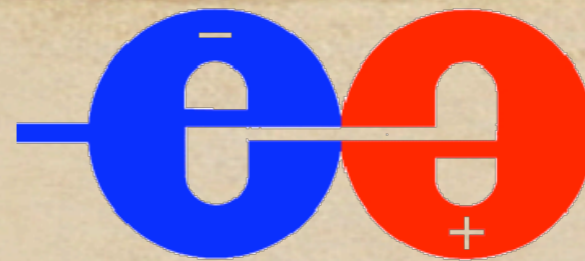
Worldwide Study of  
the Physics and Detectors

for Future Linear  
 $e^+e^-$  Colliders

# calorimetry and muons

Tohru Takeshita  
Shinshu Univ.

A Working Group summary talk should be a review of the current status of the topic. Please structure the talk with an overview of the topic, highlight **open issues** and **recent developments**, and report on expected future **near-term developments**.

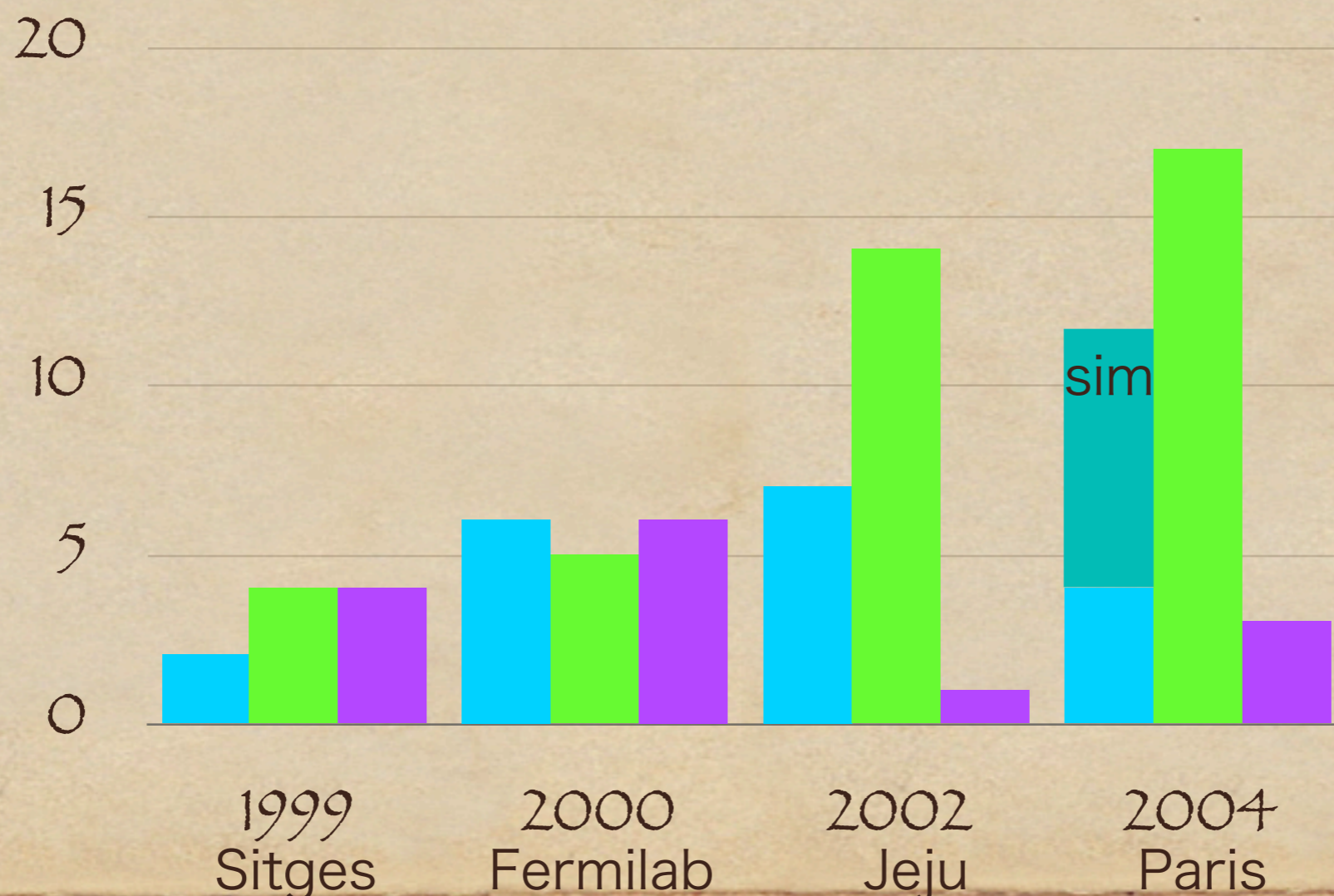


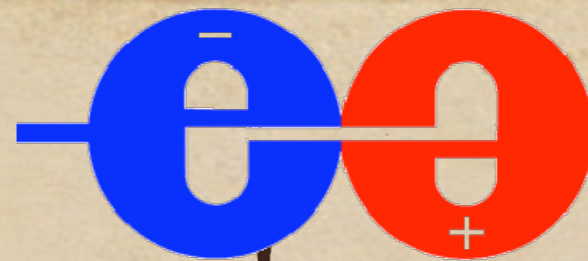
Worldwide Study of  
the Physics and Detectors

for Future Linear  
 $e^+e^-$  Colliders

# Number of talks in LCWS

cal-soft cal-hard muons





Worldwide Study of  
the Physics and Detectors

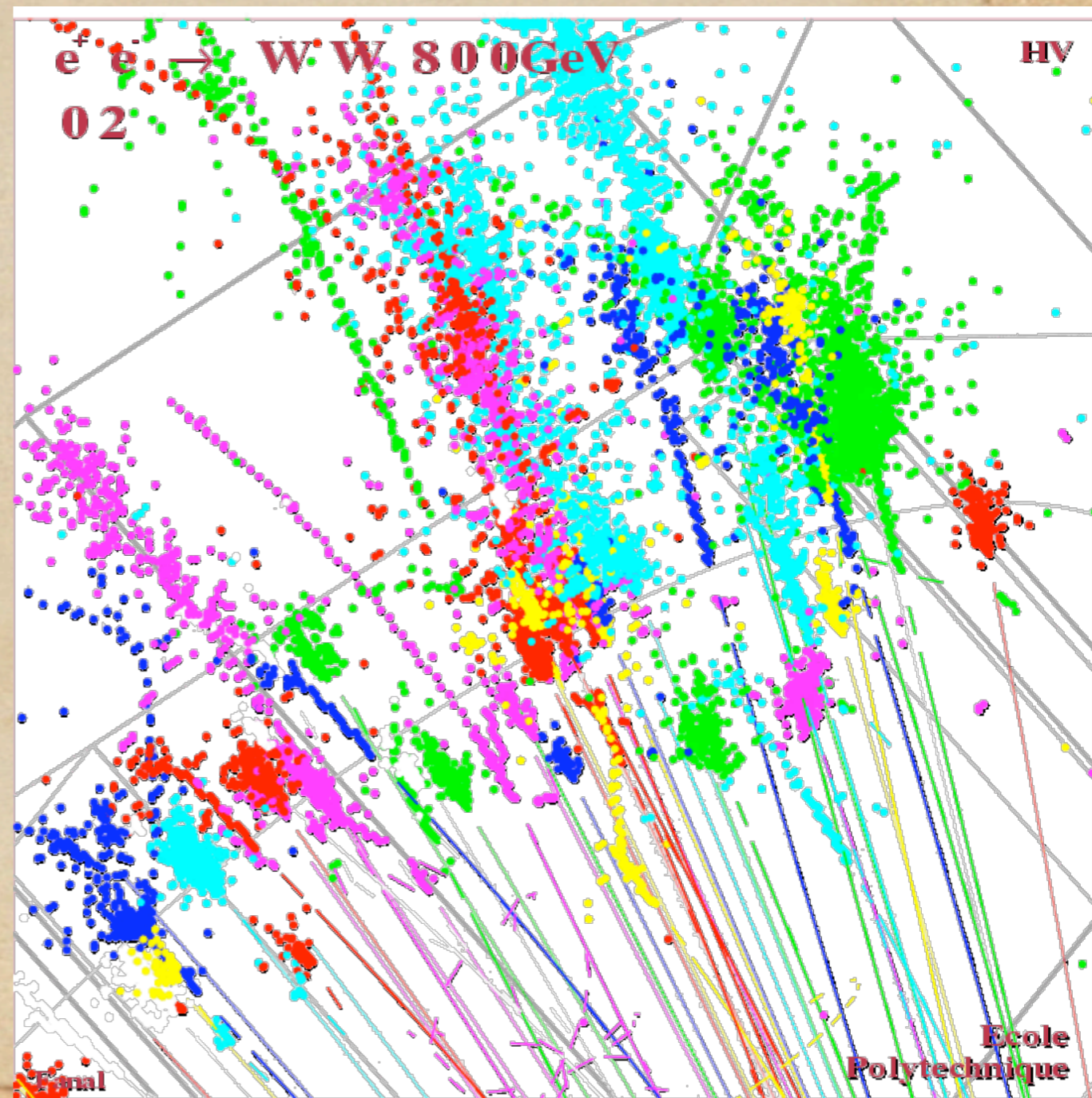
for Future Linear  
 $e^+e^-$  Colliders

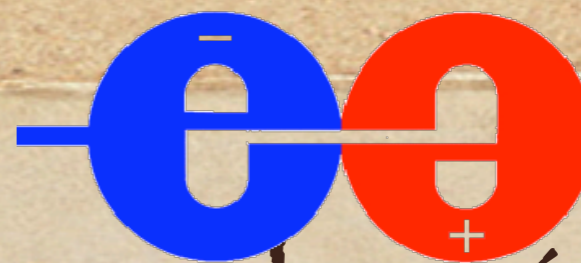
# Calorimeter and muons

hardware  
highlight

Particle Flow  
resolve jets

high segmentation / granularity  
detector both in lateral and  
longitudinal directions =3D





# calorimeter to resolve jet



identify particles in a jet

electron: track+EMCAL

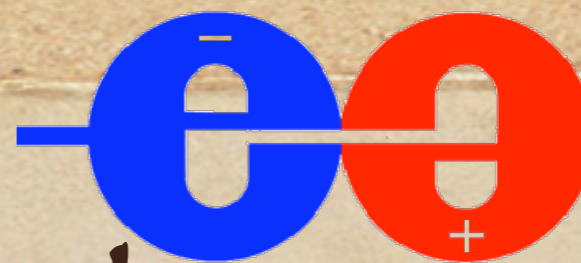
muon: track+EMCAL+HCAL+muon

measure energy of neutral

particles in a jet ~10-15%

neutral Kaon/neutron: HCAL

**combined work of all detector**



# calorimeter effort

needs

actual

separate clusters

large radius and depth

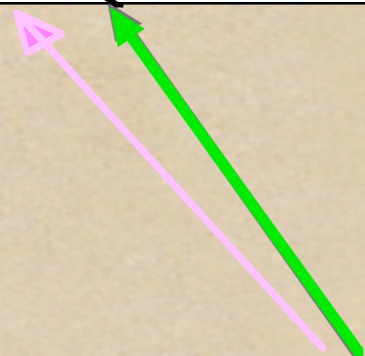
magnetic field

small Moliere radius

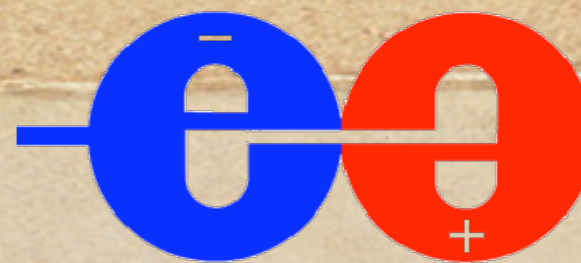
dense material

fine segmentation

cal



Particle Flow algorithm



# open issues

Tracker/VTX

calorimeter

momentum

cluster

$\vec{p}$   
 $p$

$E$

QCD

particle  $m$

missingE



jet

QCD

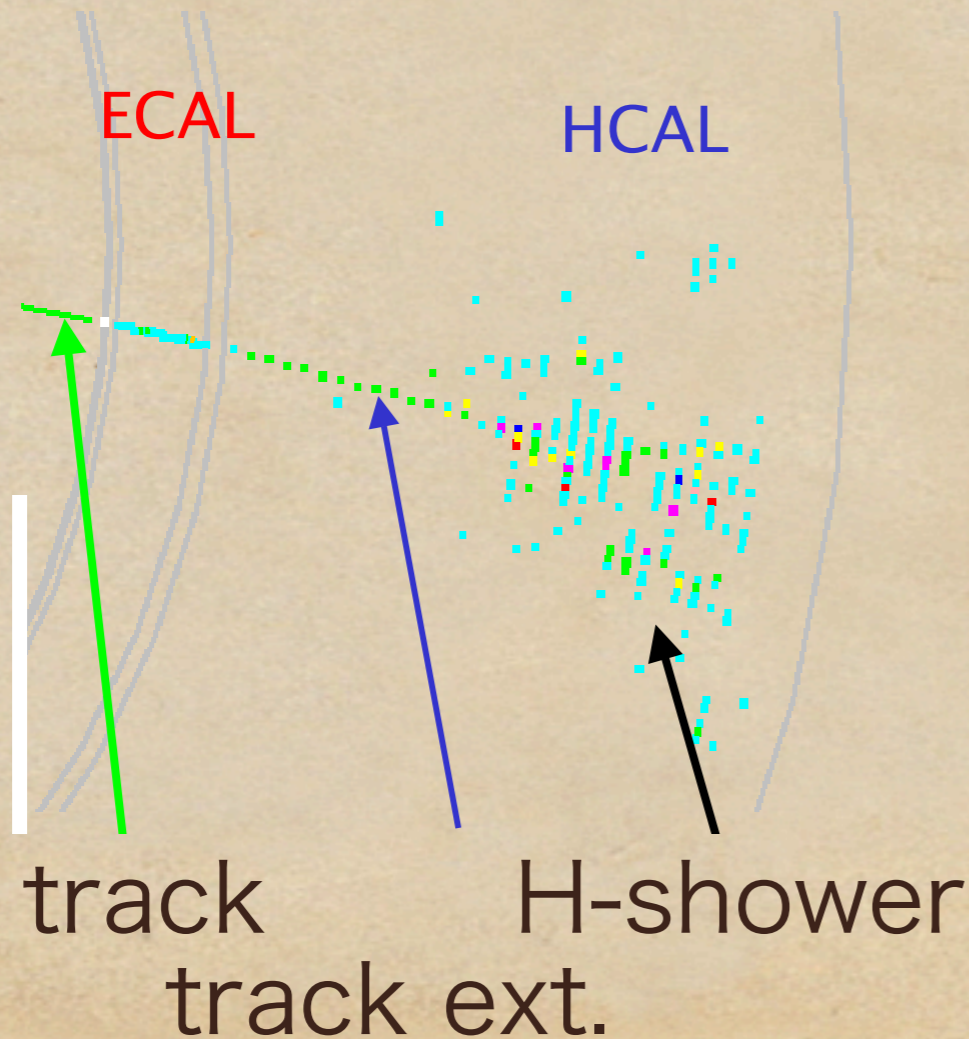


$q/l, g, W/Z$

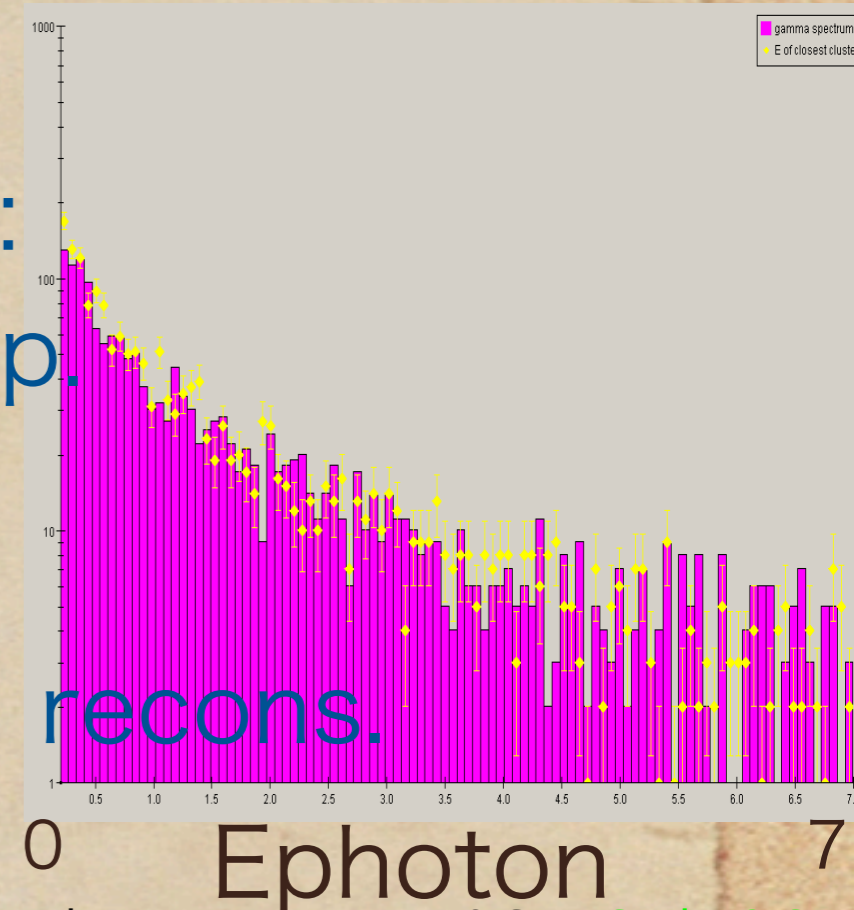
# Particle Flow Algorithms

in US recent developments

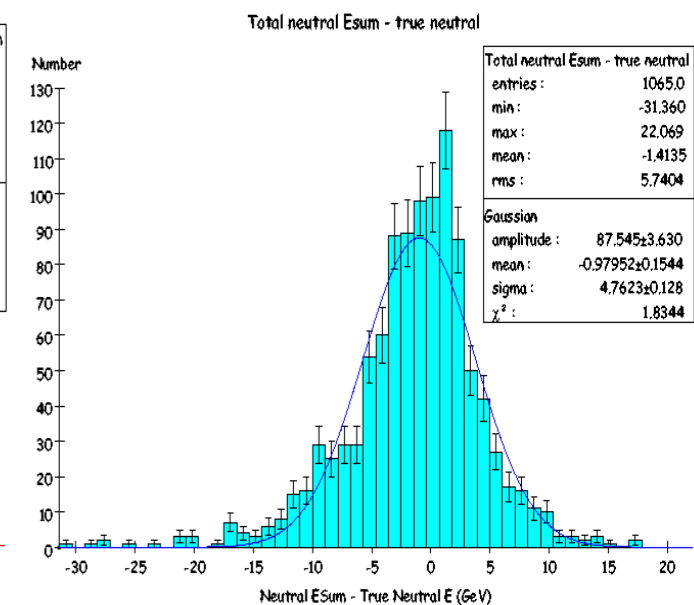
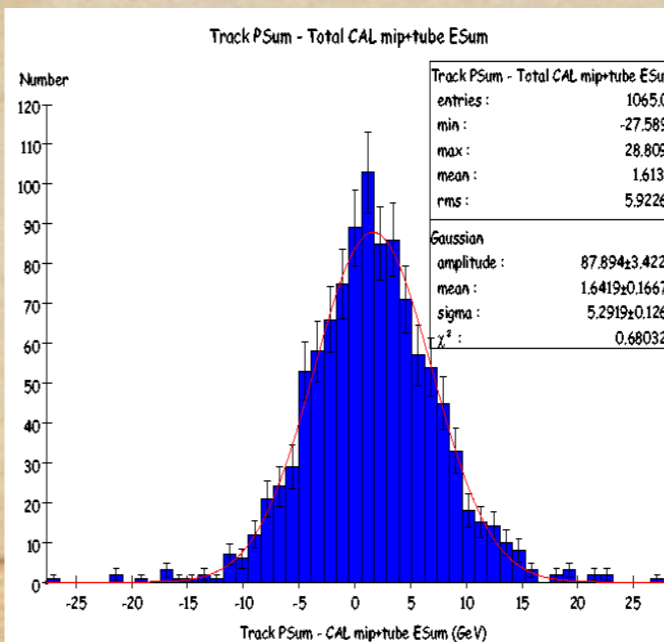
1. photon reconstruction inside jet:
2. H-shower recons. by track extrap.

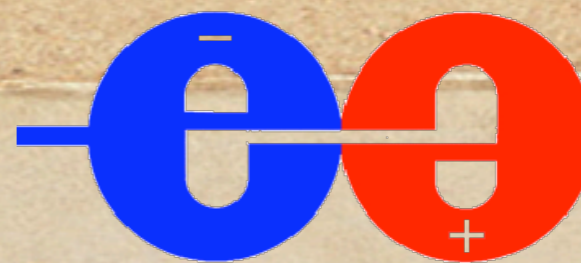


3. neutral H recons.



Jet cones: 0.55; Neutral contribution to  $E_{\text{sum}}$ :  $\sim 4.8$  GeV; Goal:  $\sim 3$  GeV



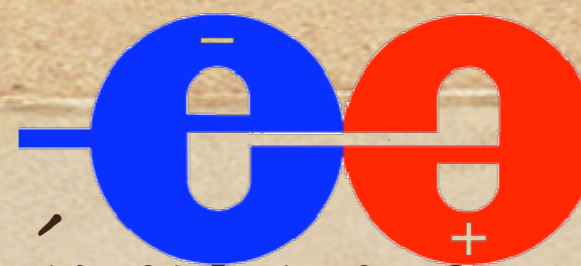


# Current CAL. activities

## E.M. CAL. R/D

type	granularity	collaboration
Si/W	0.5 ~ 1 cm	CALICE US-Si/W
Scinti.(+Si)	4 ~ 5 cm	LCCAL US-NICADD GLC-CAL

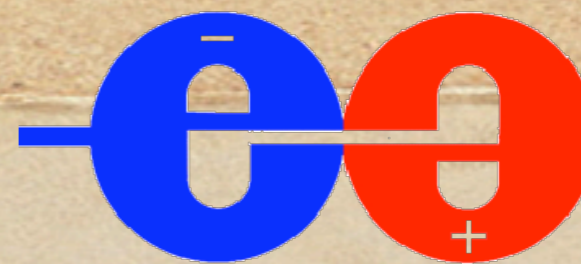




# Current CAL. activities

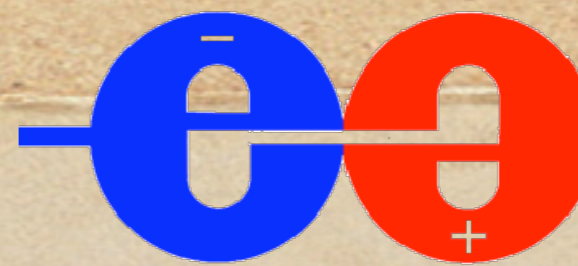
## H. CAL. R/D

R/O	granularity	active mat.	collaboration
Analog semi- digital	3-5cm	scinti.	CALICE-Tilecal NIU GLC-CAL
Digital	1-3cm	RPC GEM scinti.	CALICE-DHCAL GLC-CAL
dual	possible	scinti+ fiber	dream



# Current Muon activities

active mat.	granularity	collaboration
glass RPC	3cm	CaPiRe
scintillator strip w. WLSF	4cm(1cm <sup>†</sup> ) 3.5m	US-muon



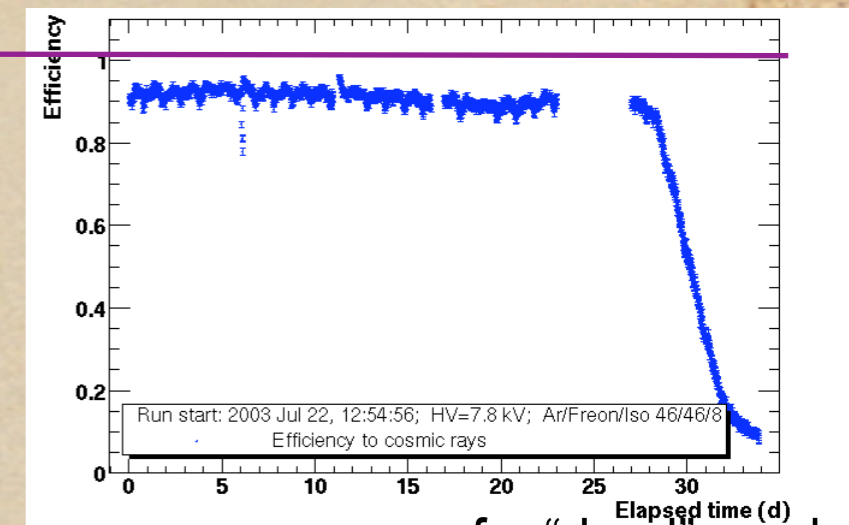
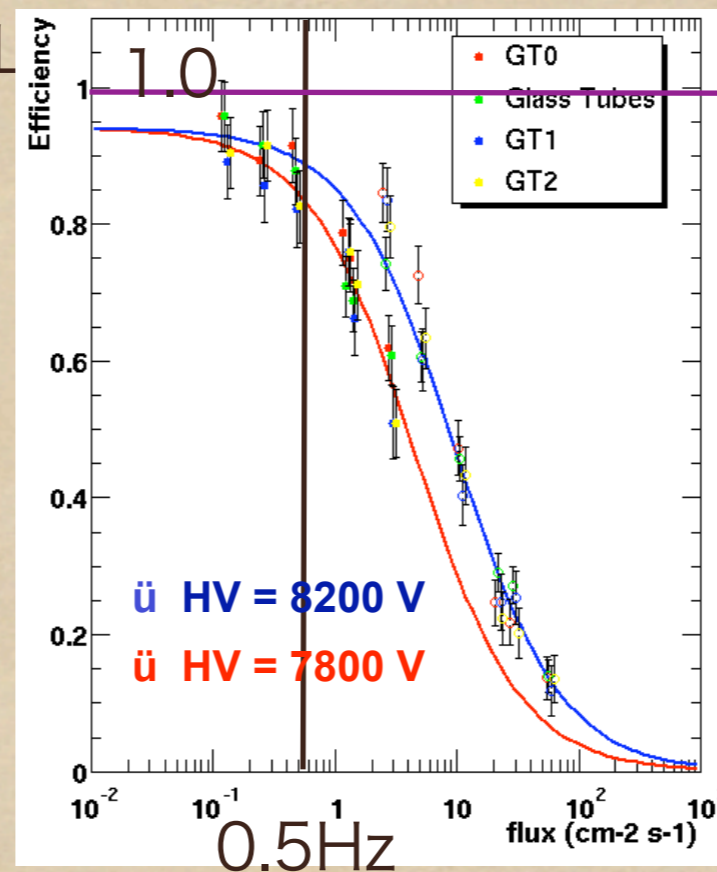
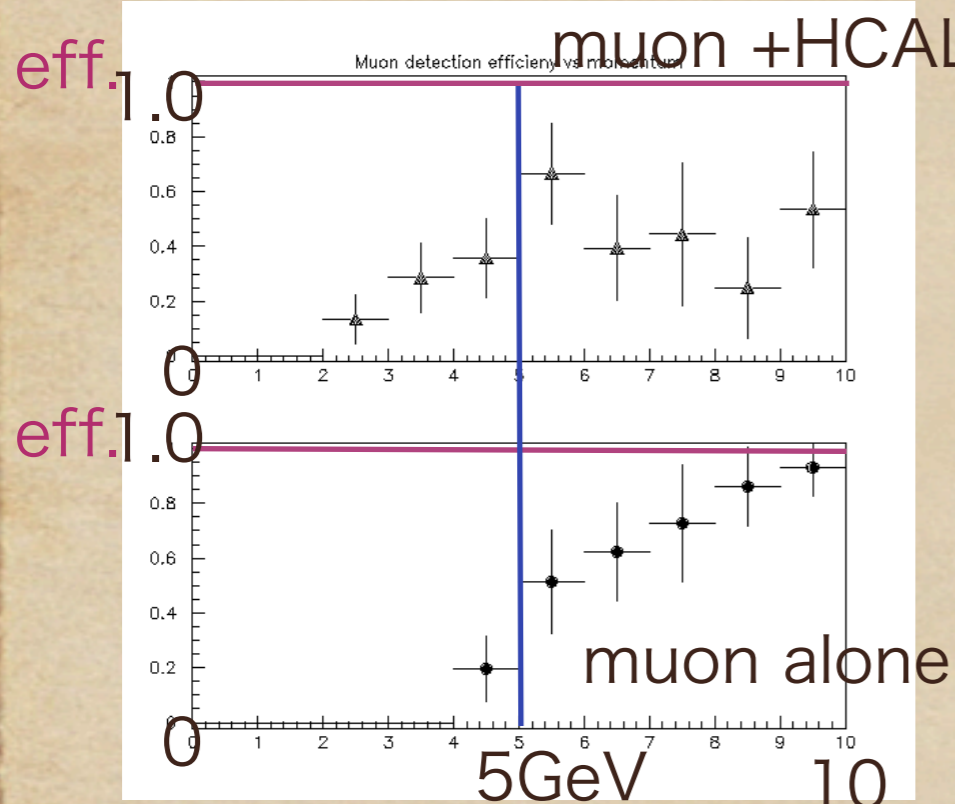
# Muon activities

**RPC** recent developments

1. muon ID soft.

2. rate test

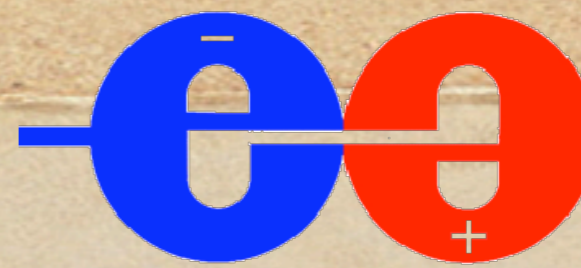
3. long term



temporary recovery of a "dead" chamber  
remove water < 100ppm

Marcello Piccolo

Tommaso-Tabarelli de Fatis



# Muon activities

RPC

near-term developments

muon ID soft.:

at low momentum, work with HCAL  
test with background muons

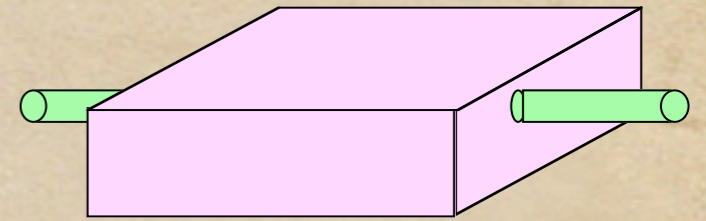
hardware :

rate dep. :extend the rate capability  
(avalanche mode and conductive glasses)

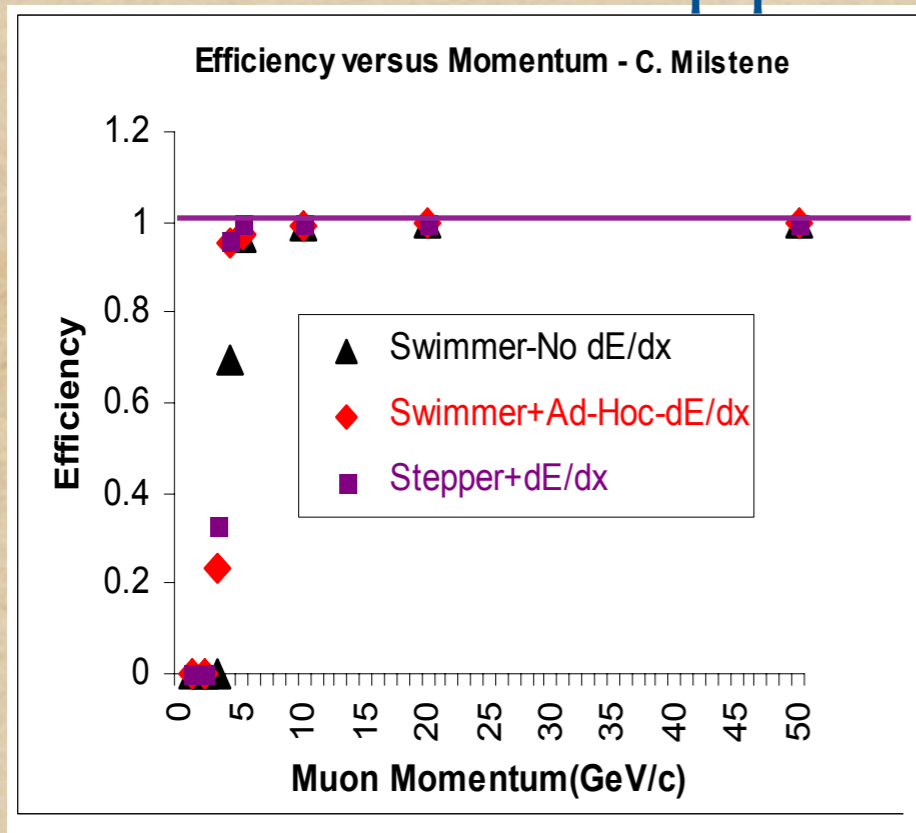
instability: Running with dry gas (chamber lifetime)

# Muon activities

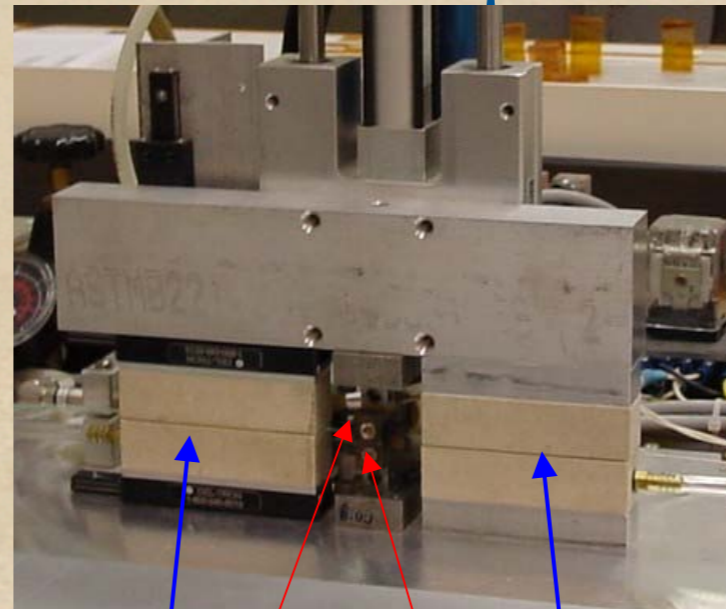
## scintillator recent developments



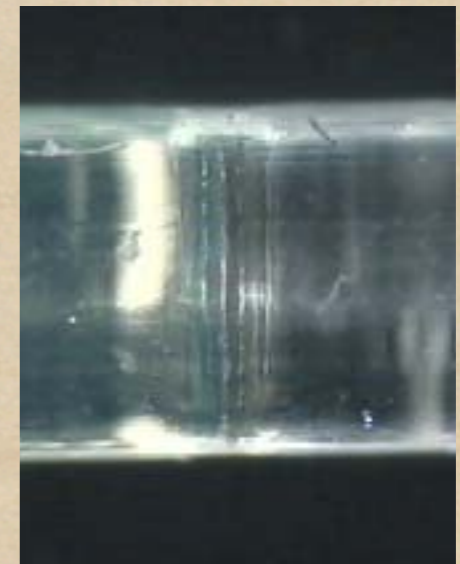
### 1. muon ID stepper



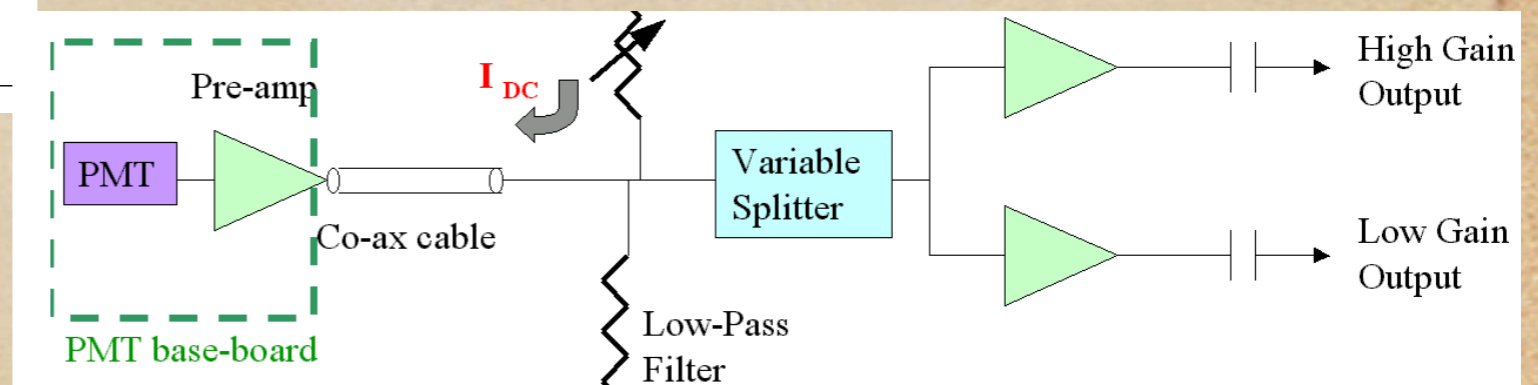
### 2. fiber splicer



Typical transmission of ~75 - 80%

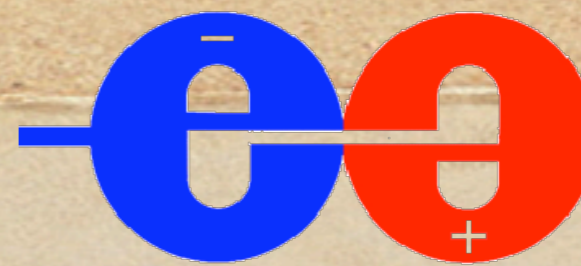


### 3. amp



punchthrough 1/80

Eugene Fisk



# Muon activities

scintillator near-term developments

simulation :

muon ID algorithms

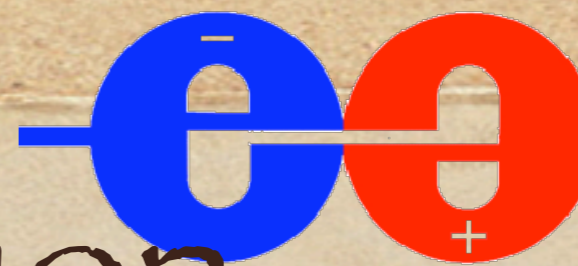
low p muons: tracking in HCAL

hardware :

1 m strip R&D, fiber splicing

MAPMT-calibration

FE electronics



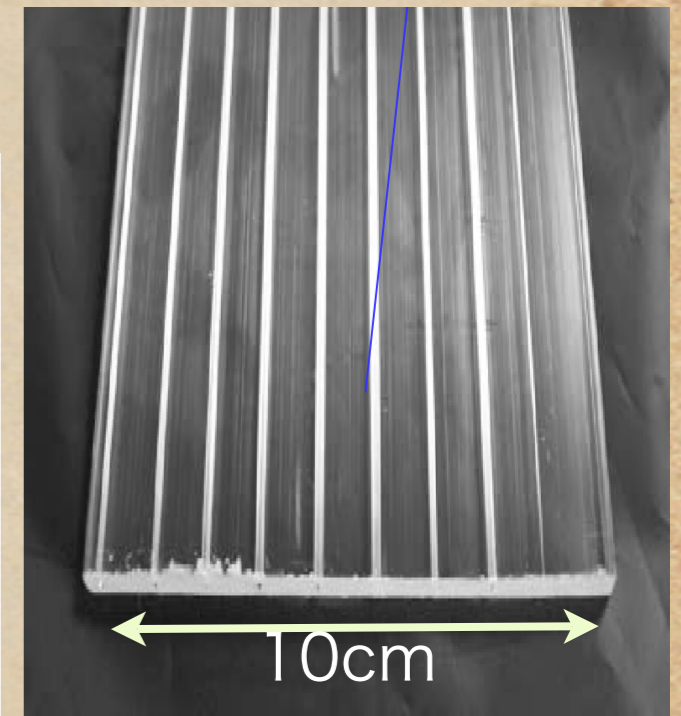
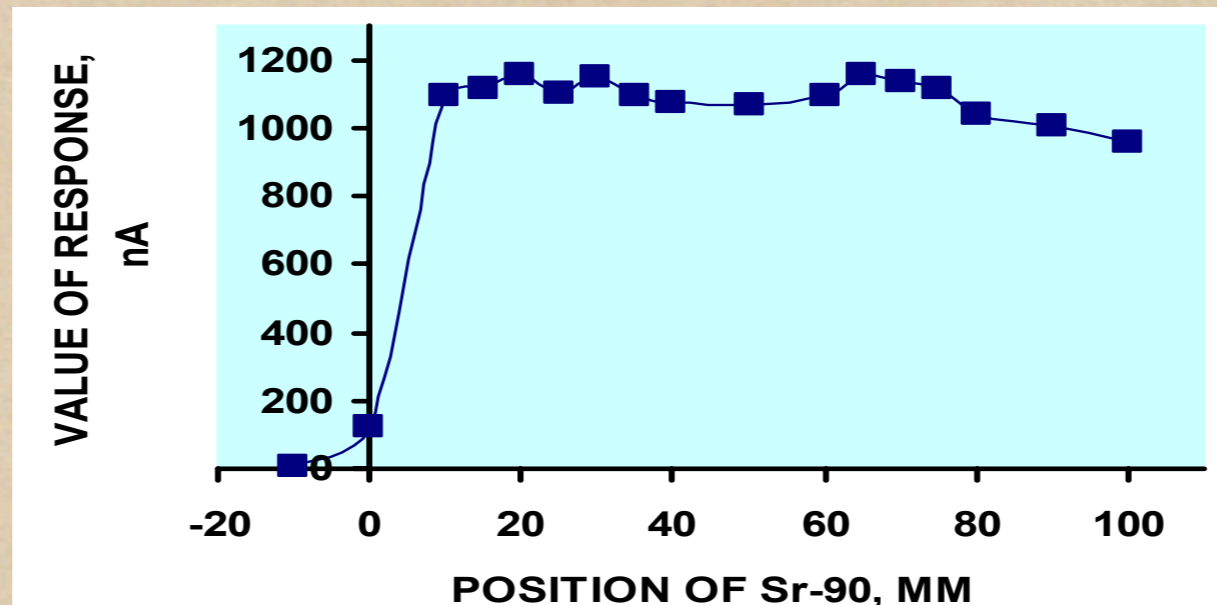
# Tail catcher or muon

scintillator

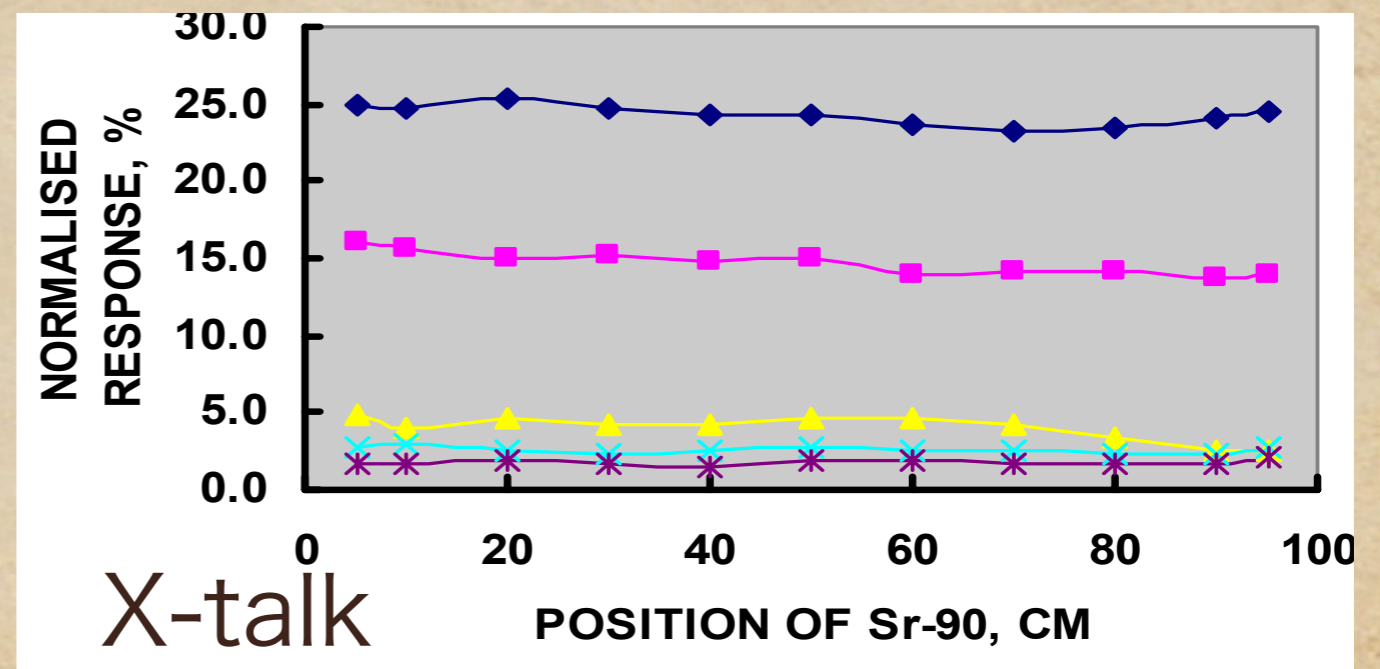
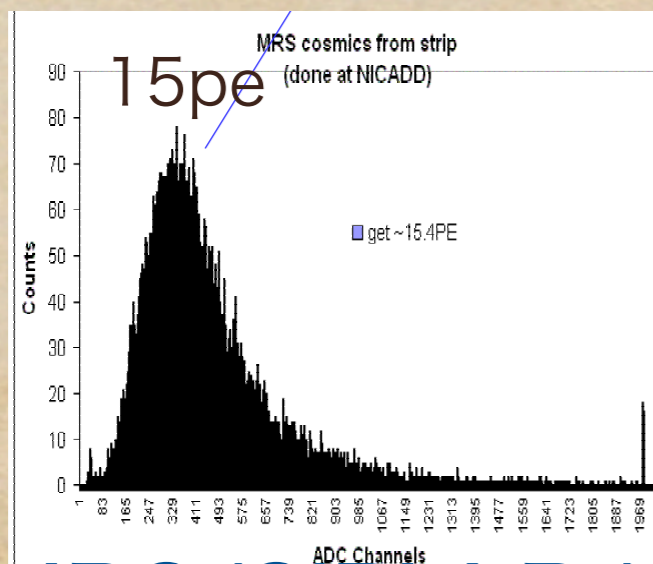
recent developments

extruded

1. uniformity



2. separation groove

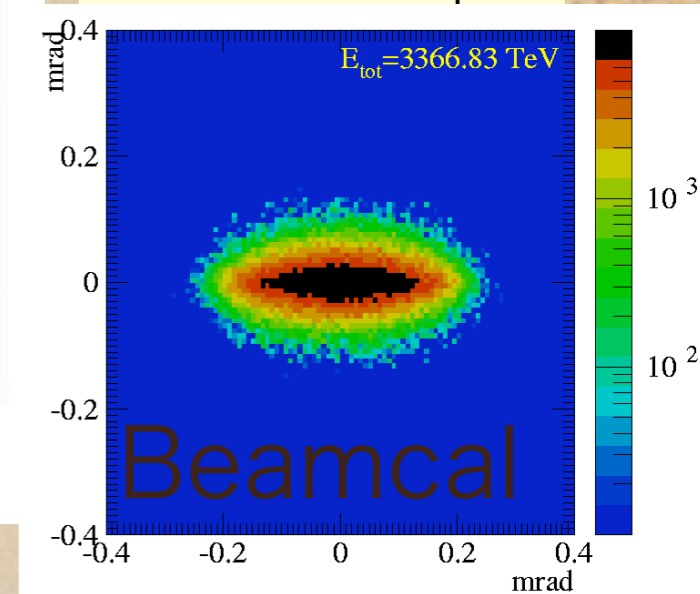
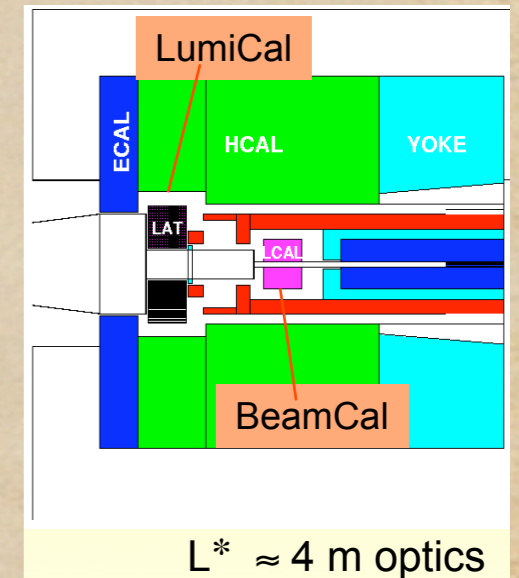
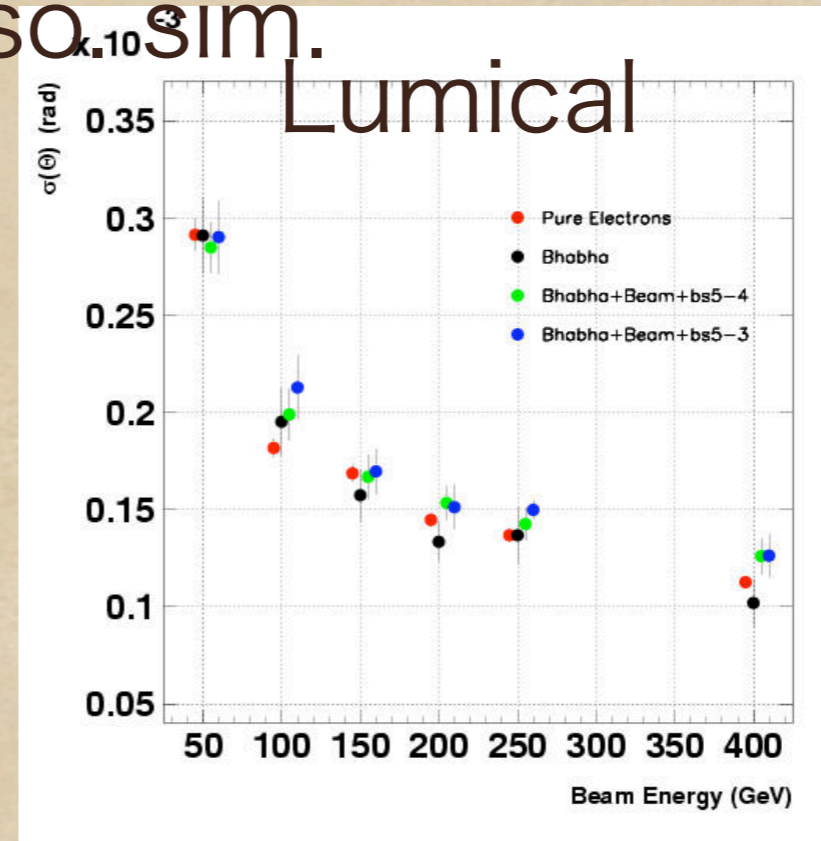
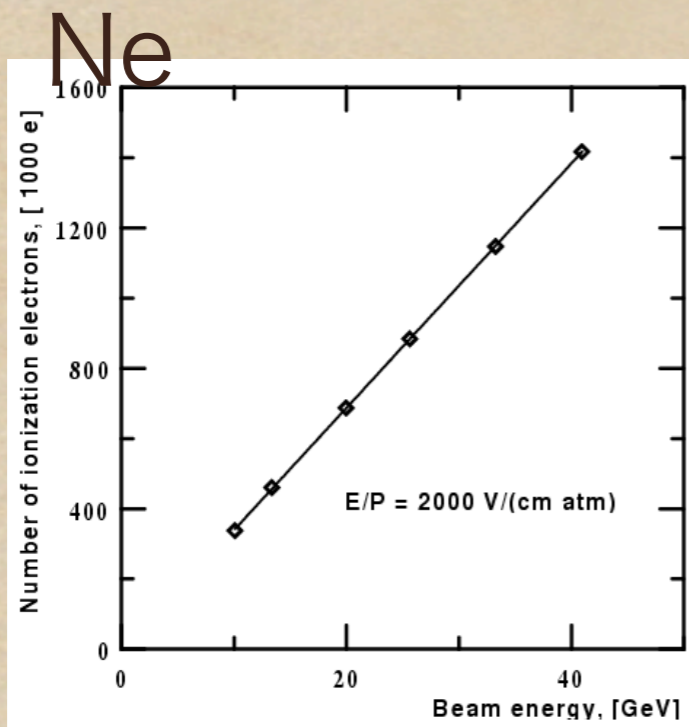


3. MRS/SiPM R/O

# Forward cal.

recent developments

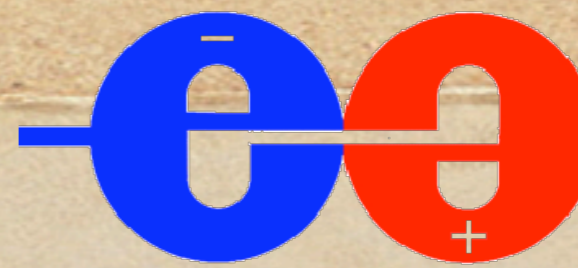
1. new design (Lumical & Beam cal)  
angle reso.  $\sim 10^{-3}$  sim.



2. gas ionization chamber

3. sensors test (Silicon/diamond/ccd)





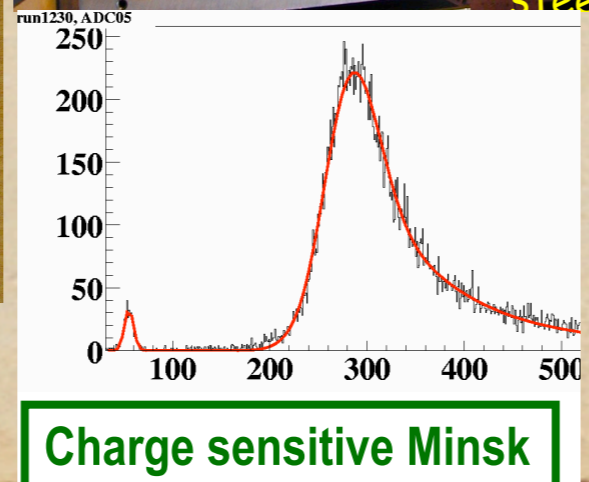
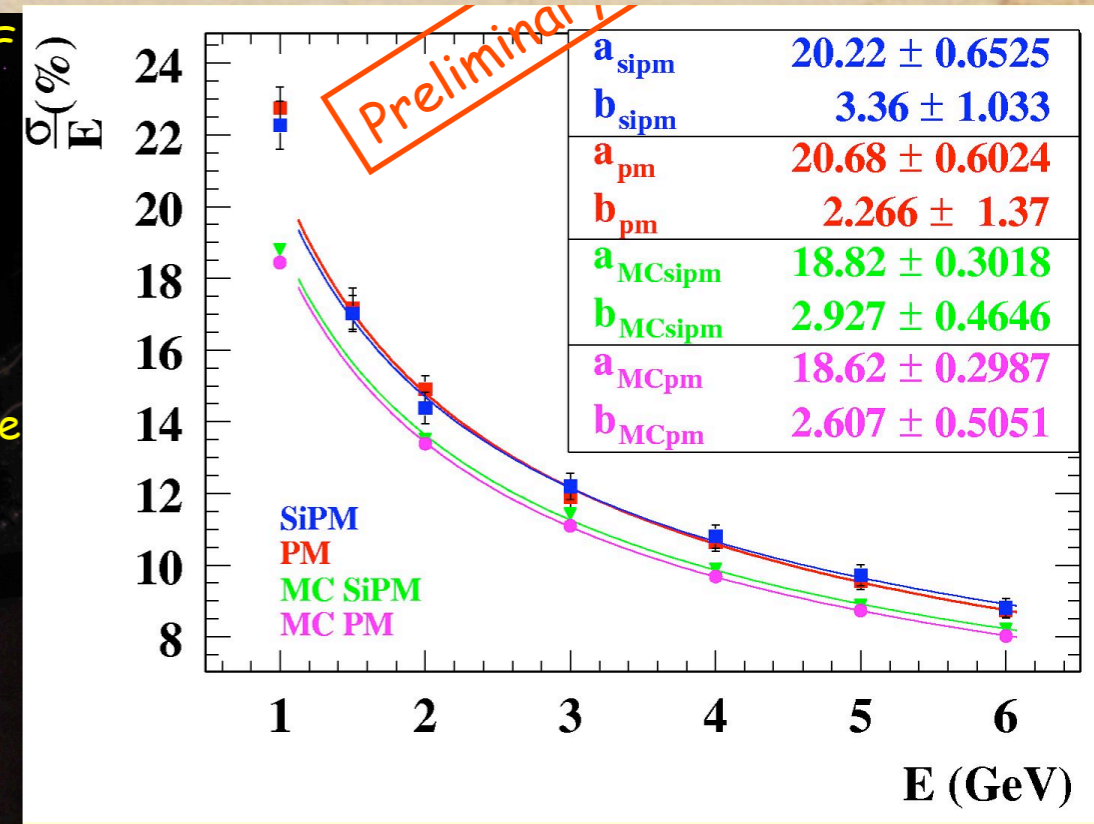
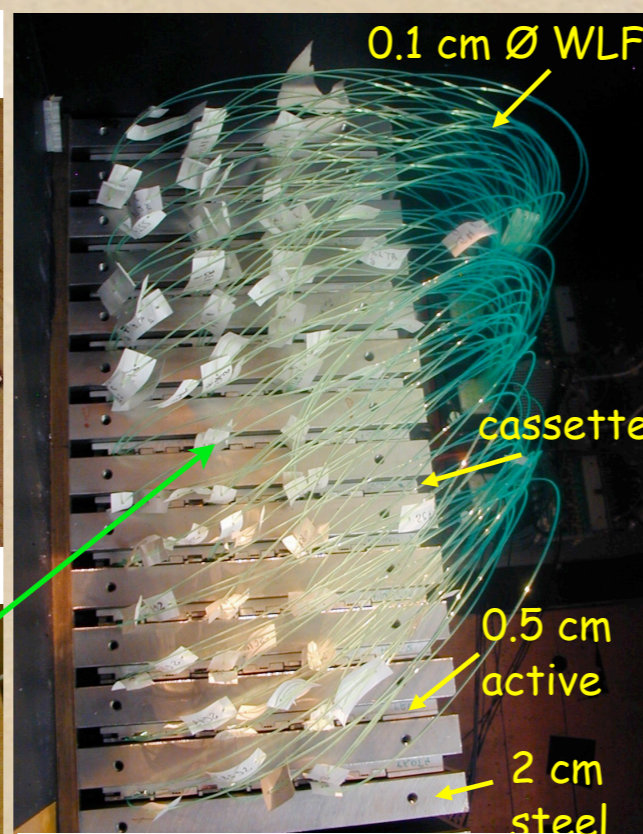
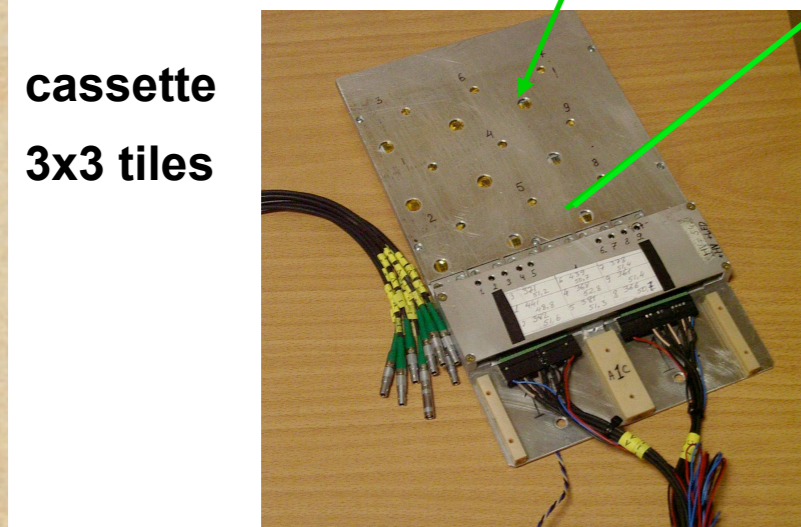
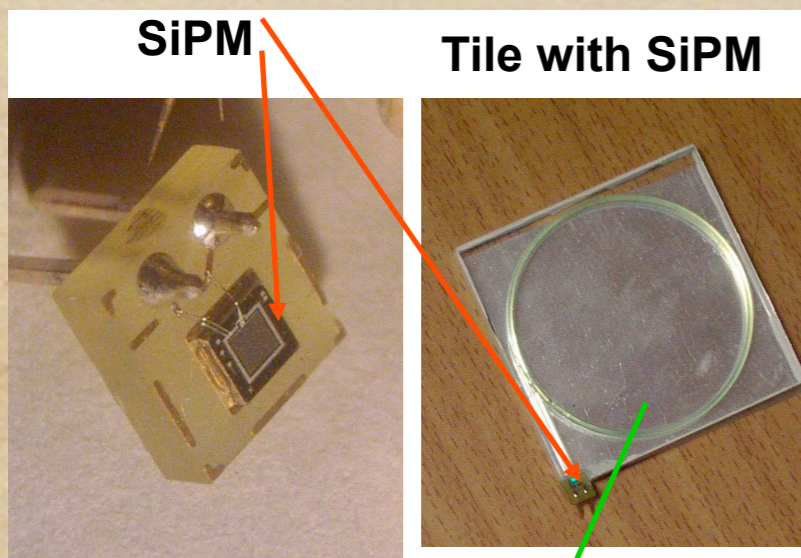
# H.CAL.

## Analog recent developments

1. tile w. SiPM prod.

2. minical

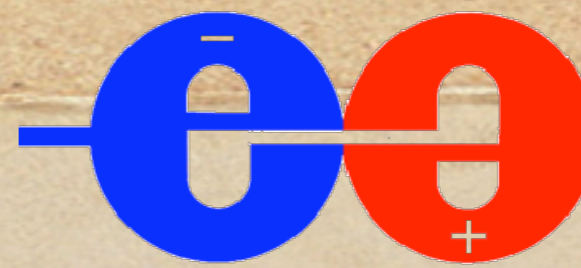
Erika Garutti



## 3. APD R/O

Jaroslav Cvach

Michael Danilov

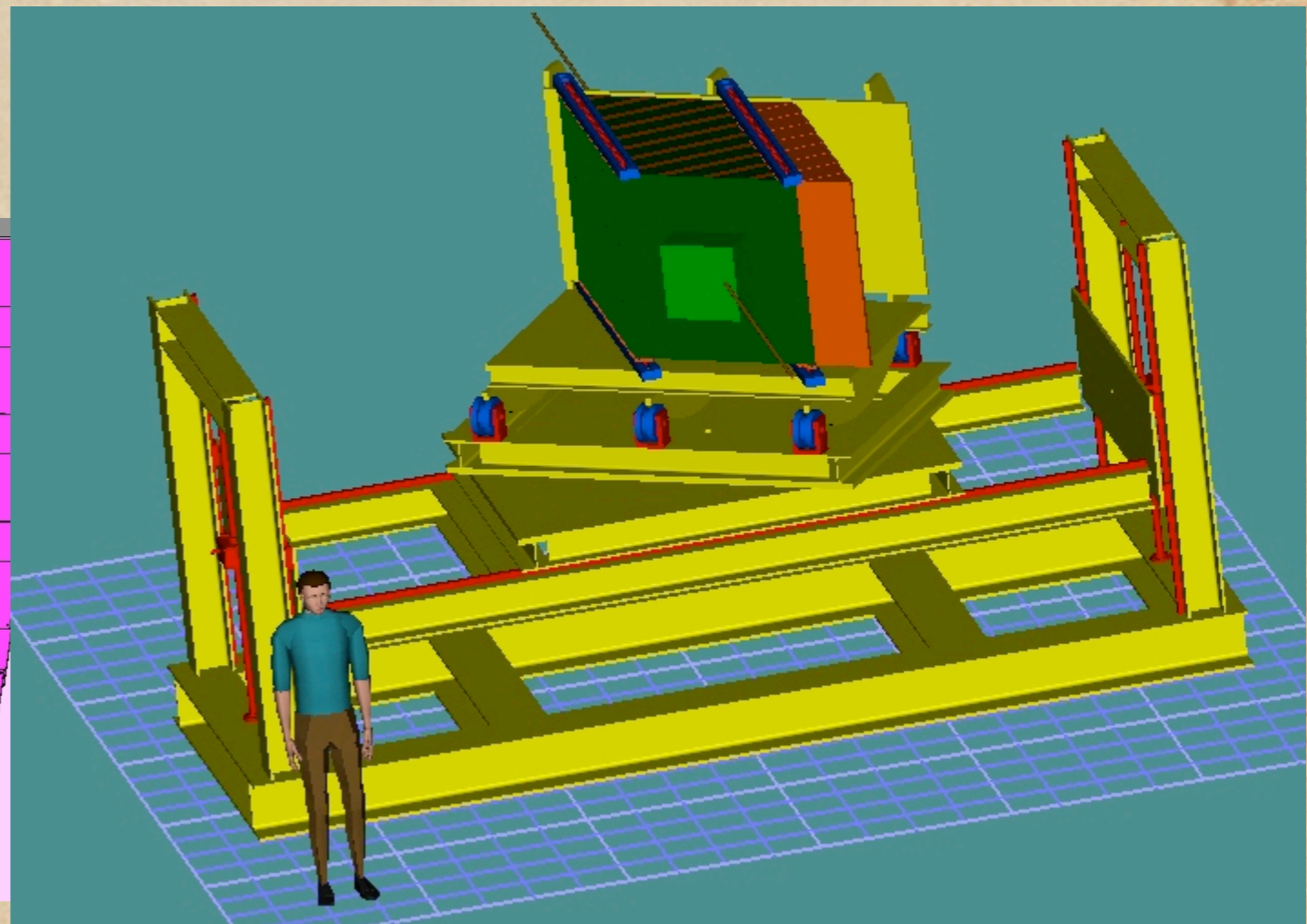
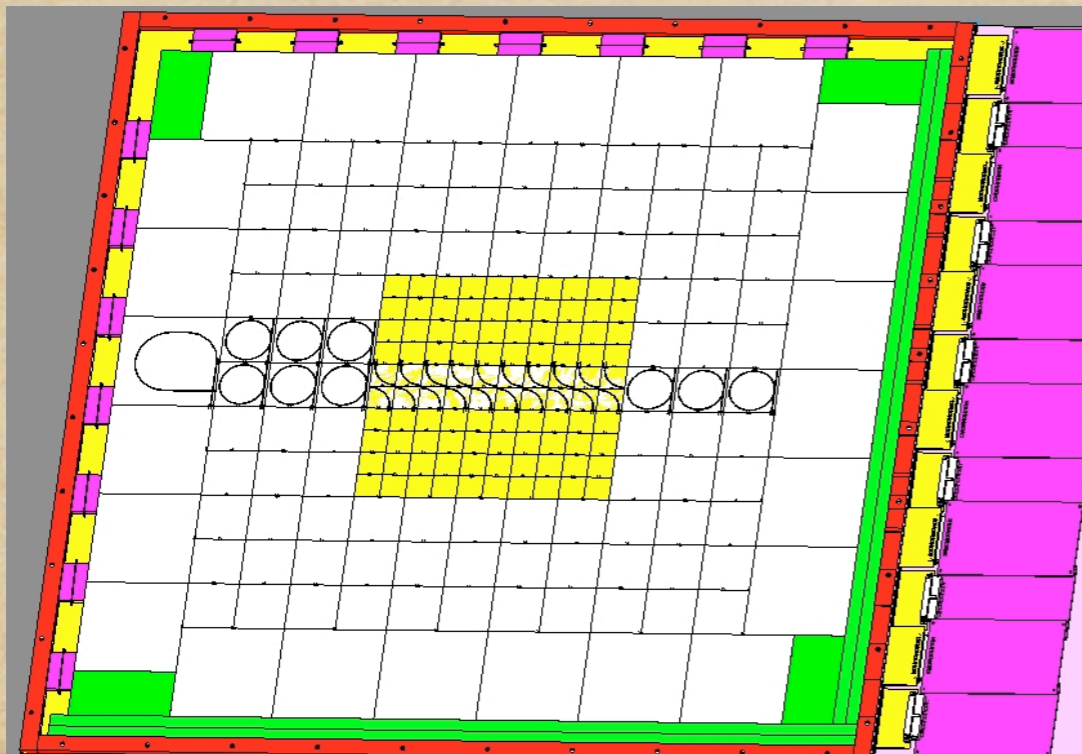


# H.CAL.

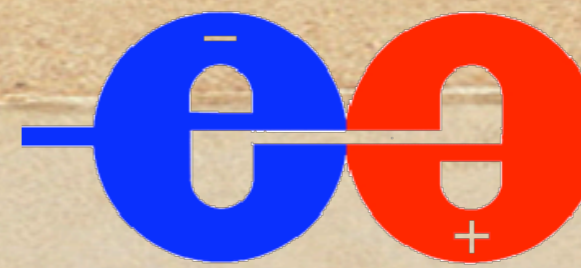
**Analog** near-term developments

1. physics prototype prod. test SiPM & Tiles
2. minical APD data anal.

1m



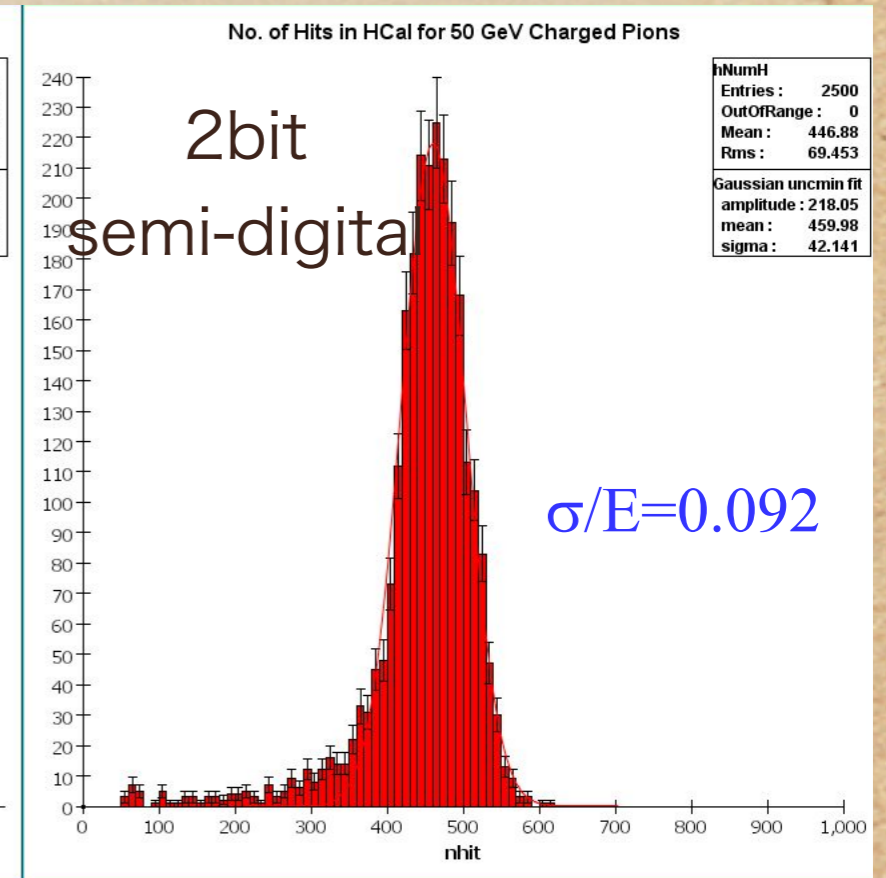
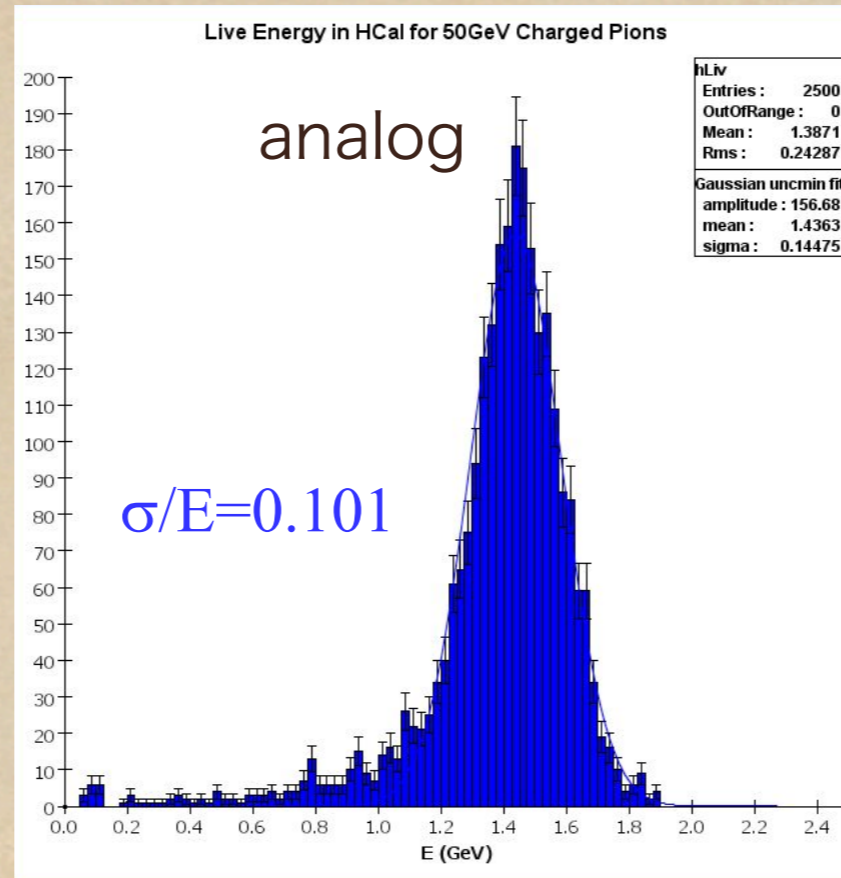
Michael Danilov



# H.CAL.

## Semi-Digital recent developments

### 1. simulation



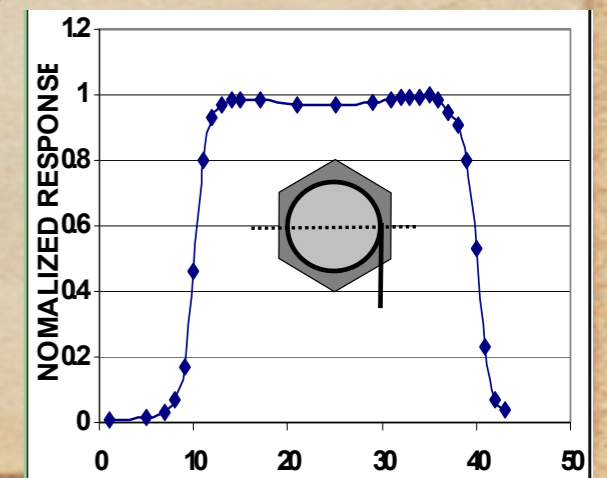
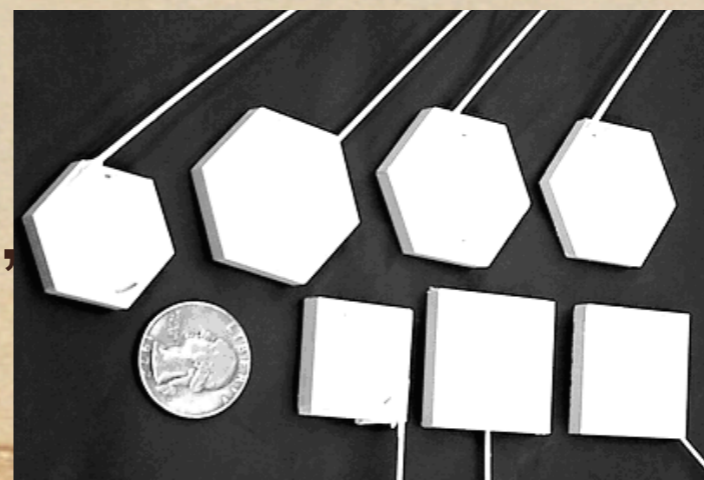
### 2. prototype test with SiPM and MRS

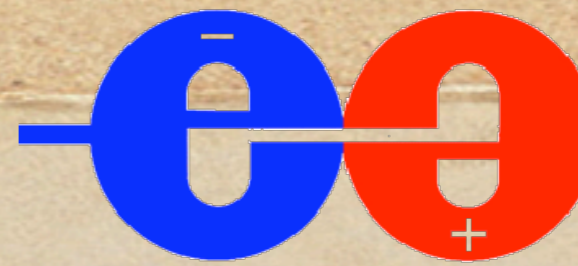
### 3. basic test

uniformity, wrapping ...

near-term developments

CALICE TB





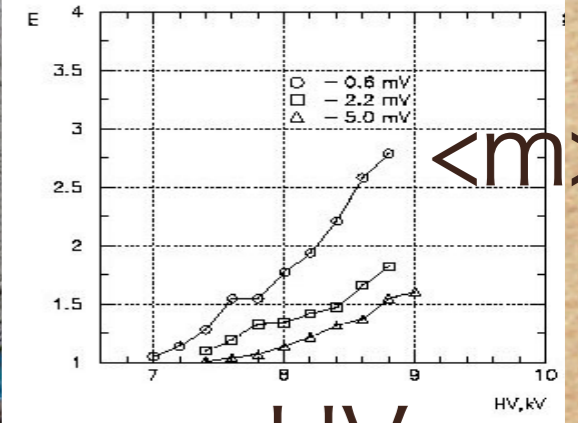
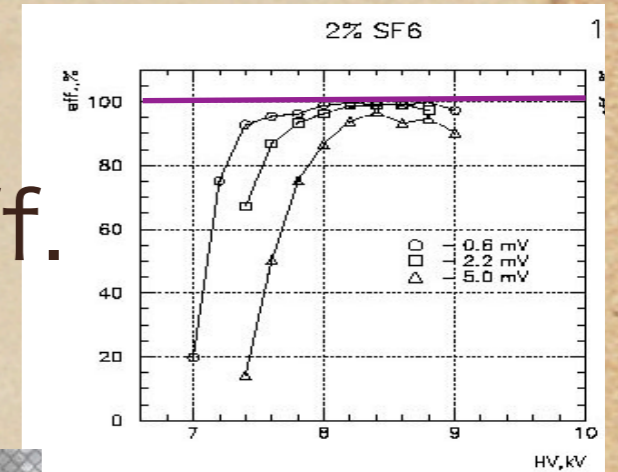
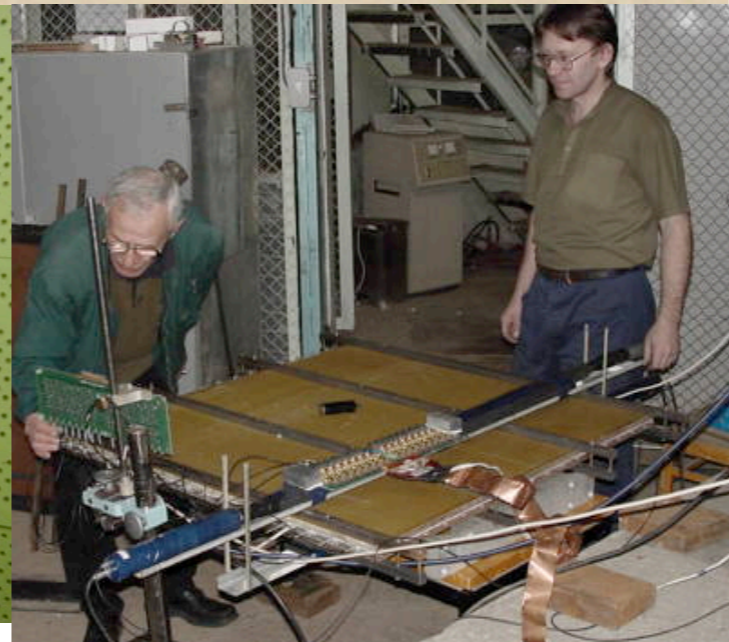
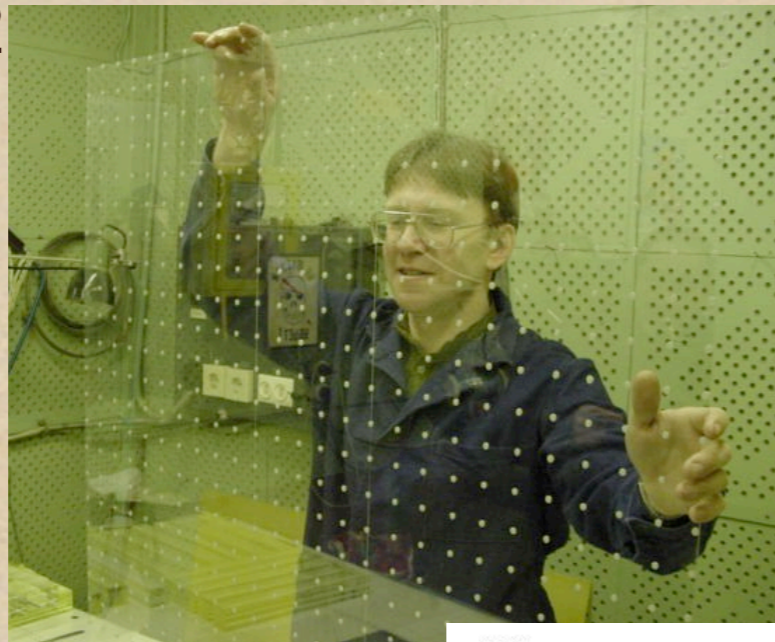
# H.CAL.

## Digital-RPC recent developments

eff.

1. operation mode: avalanche mode

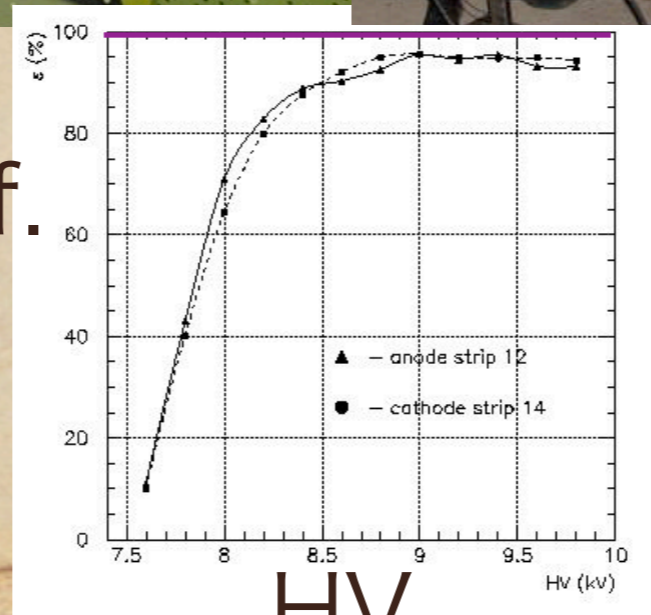
2. 1m<sup>2</sup>  
RPC



<m>

HV

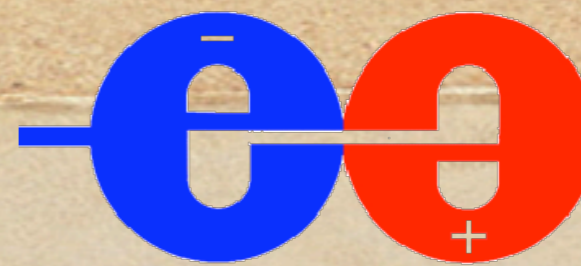
eff.



HV

Vladimir Ammosov

# H.CAL.



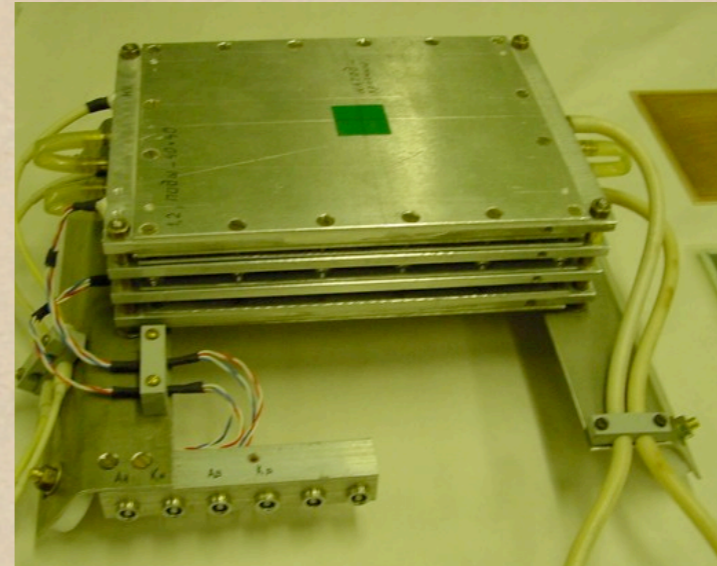
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## Digital-RPC

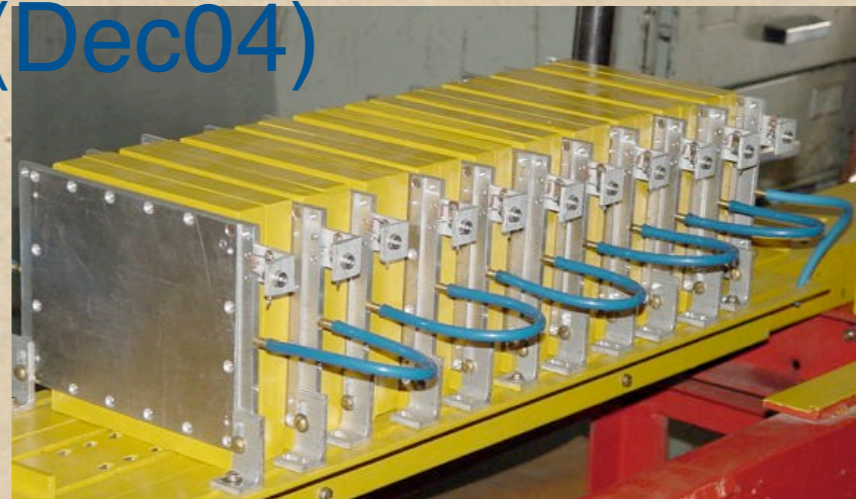
near term developments

1. 5T mag field test (June04)

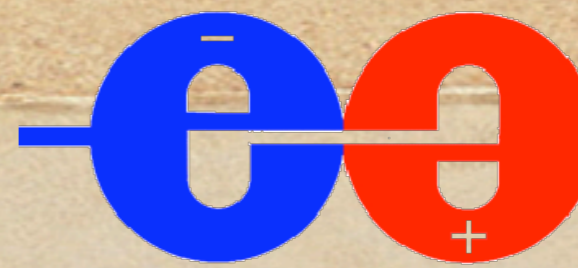


2. Mini DHCAL test in e-beam (Dec04)

3. production of 40 units  
of 1m<sup>2</sup> RP for 1m<sup>3</sup> DHCAL  
prototype (Apr05 )



4. beam tests of 1m<sup>3</sup> DHCAL prototype(Dec05)

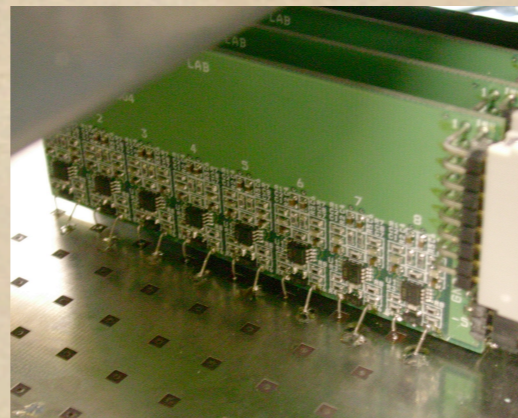


# H.CAL.

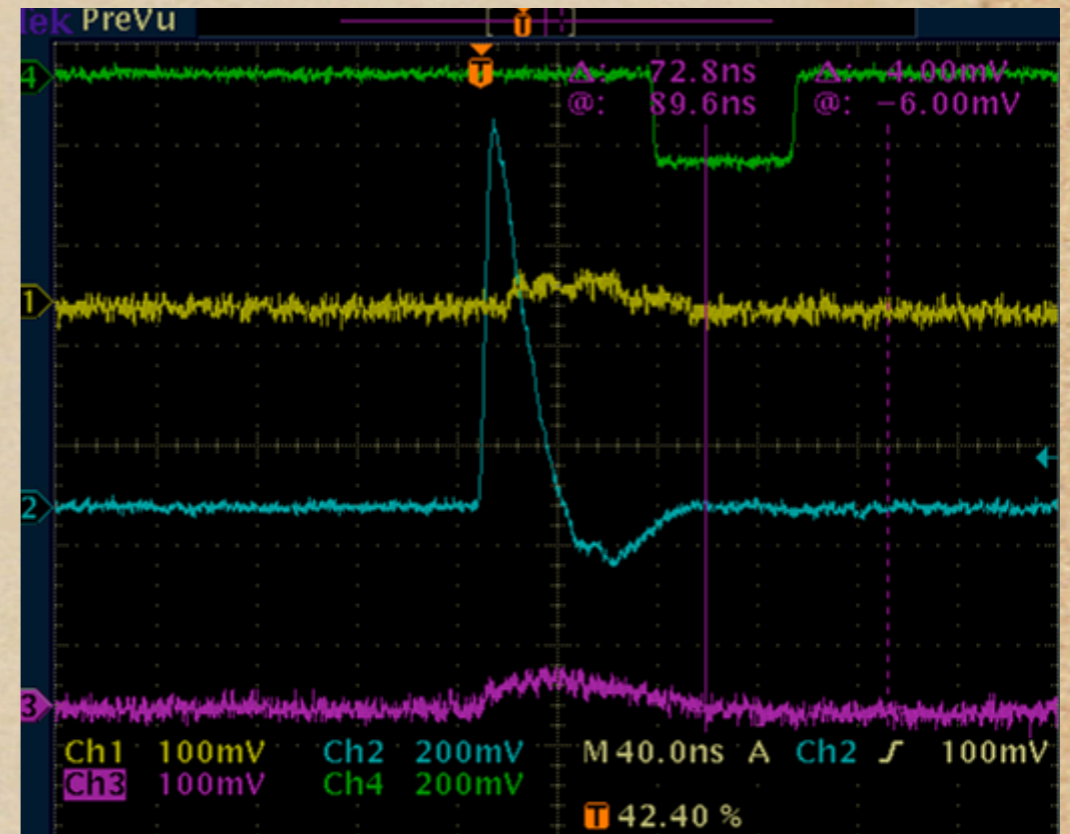
## Digital-RPC

recent developments

### 1. basic studies

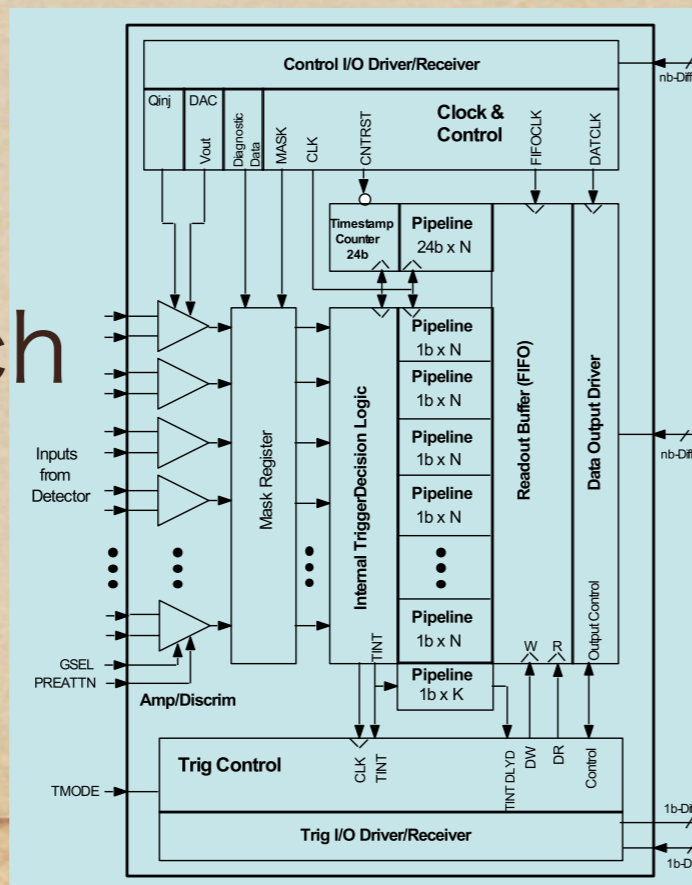


1x1 cm<sup>2</sup> pad



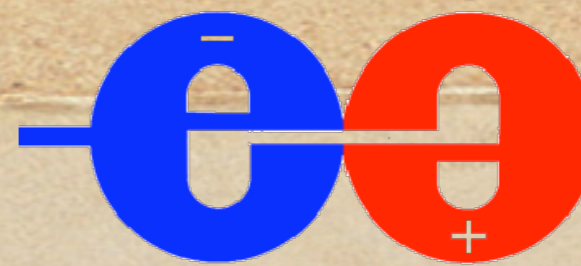
### 2. FE ASIC

64ch



### 3. back end VME

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e<sup>+</sup>e<sup>-</sup> Colliders

## Digital-RPC

## near term developments

1. graphite layer(silk screen)
2. RPC construction
3. Multi-channel VME readout

FY 2004: complete all R&D

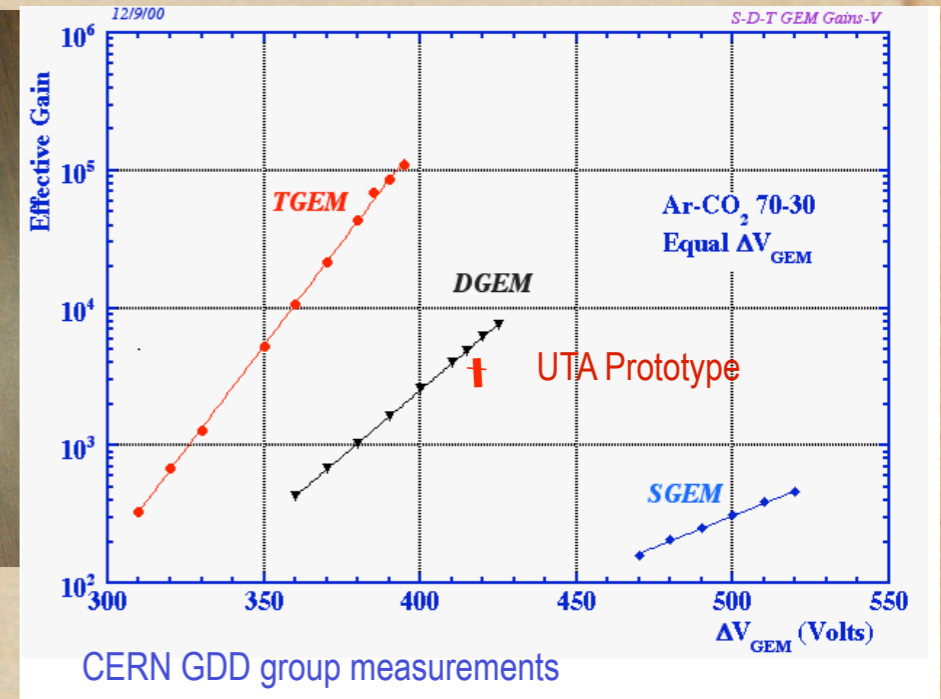
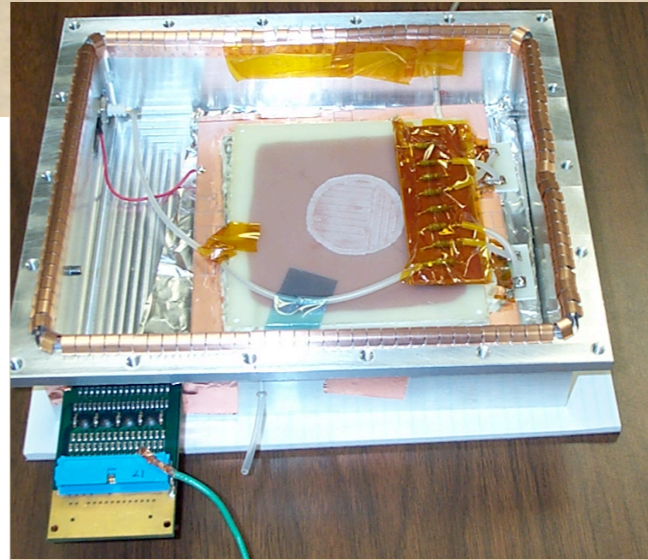
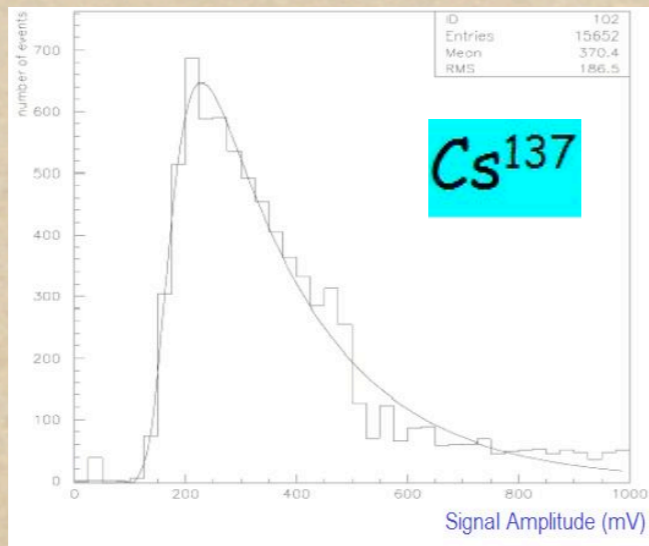
FY 2005: construct 1 m<sup>3</sup> prototype section

FY 2006: test in particle beams

# H.CAL.

## Digital-HCAL-GEM recent developments

### 1. prototype GEM



CERN GDD group measurements

2. investigating electronics
3. GEM module concept
4. sensitive layer

Andy White





# H.CAL.

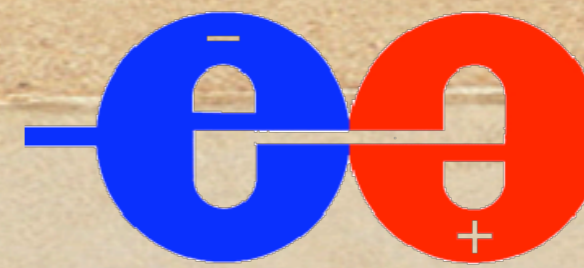
## Digital-HCAL-GEM near term developments

FY04 -> FY05

- Build and operate a complete working drawer and demonstrate track finding for cosmic rays.
- Develop readout scheme for test beam stack
- Engineering studies for calorimeter module and test beam stack

FY05 -> FY06

- Complete test beam stack design and readout scheme design
- As funding allows: acquire materials to construct 40-layer stack

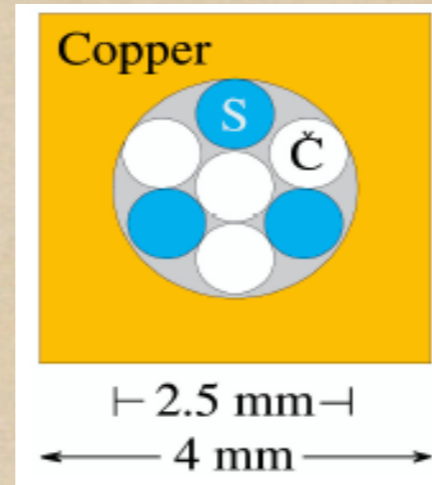


# H.CAL.

## Dual R/O

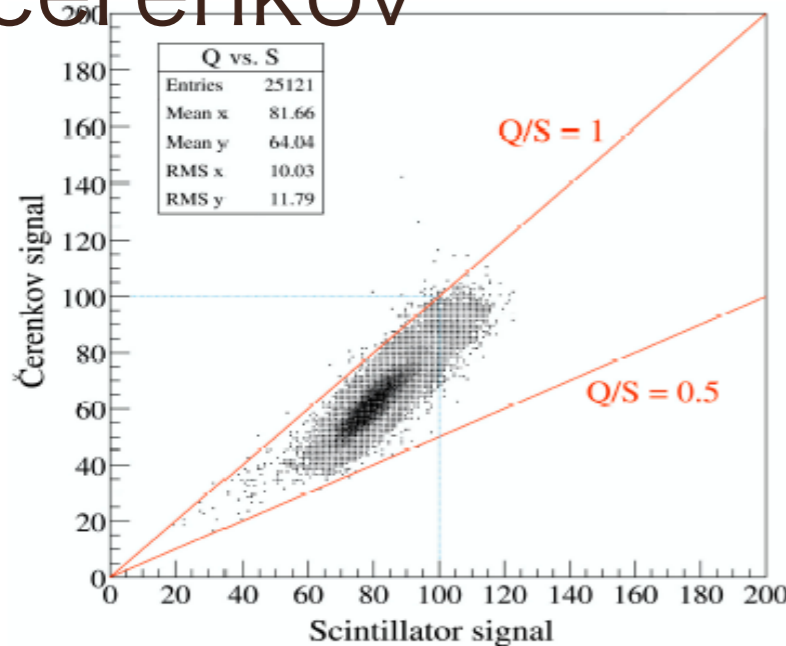
## recent developments

### 1. detector

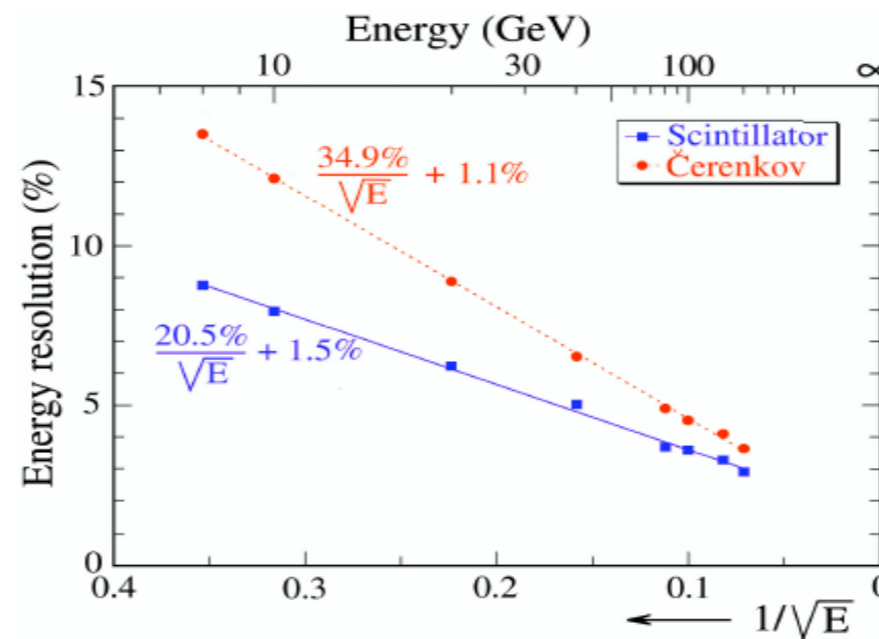


### 2. results

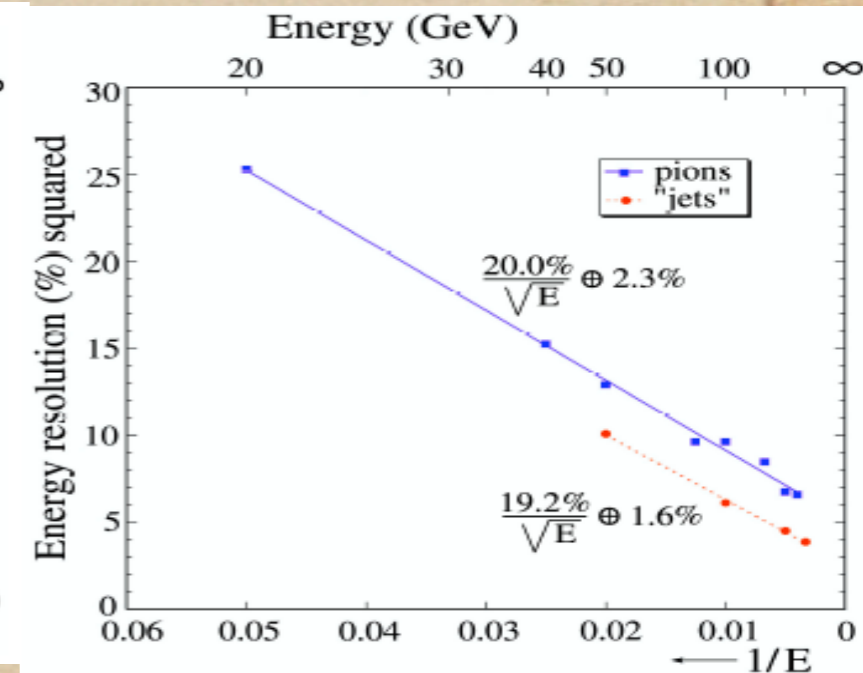
#### cerenkov



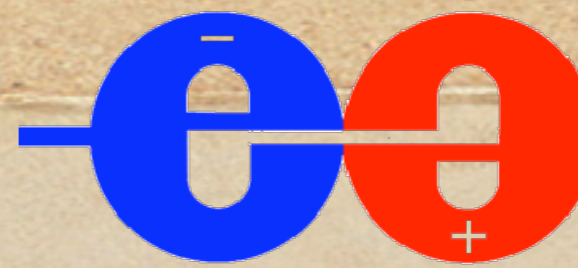
scintillator



electrons



pions

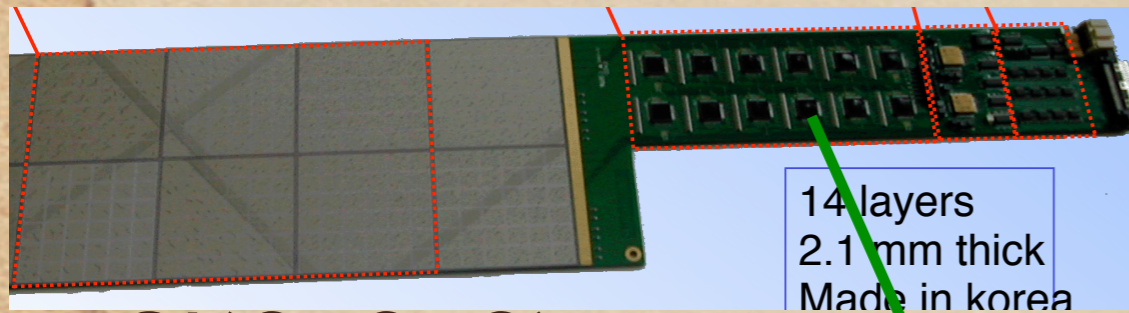


# E.M.C.A.L.

## Si/W-CALICE

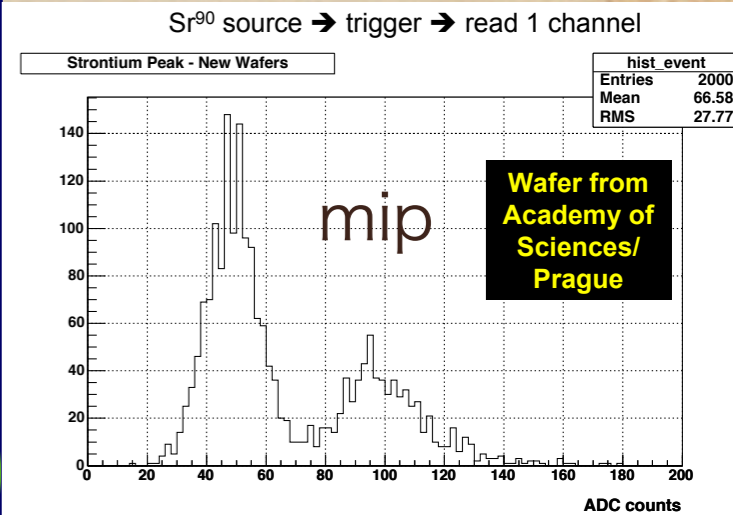
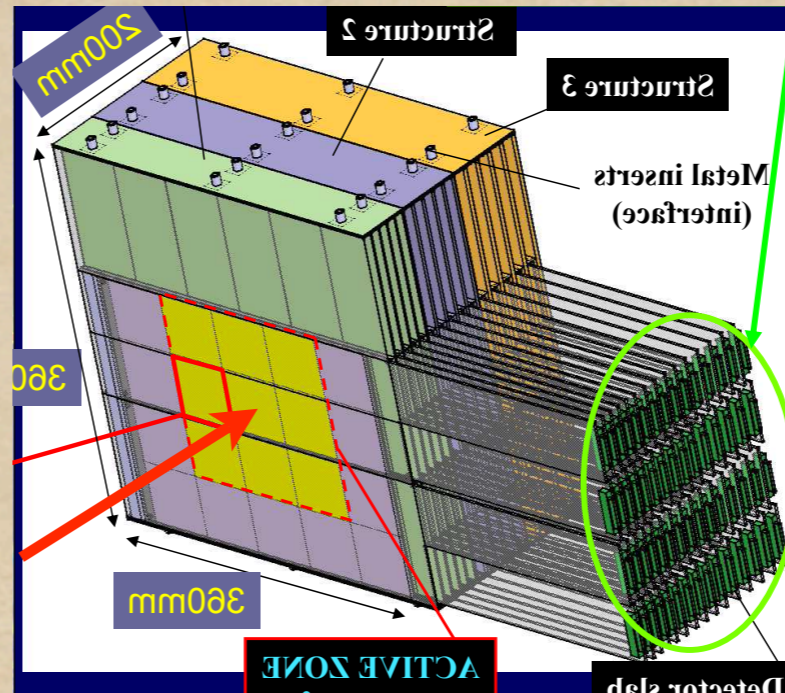
## recent developments

### 1. prototype EMCAL

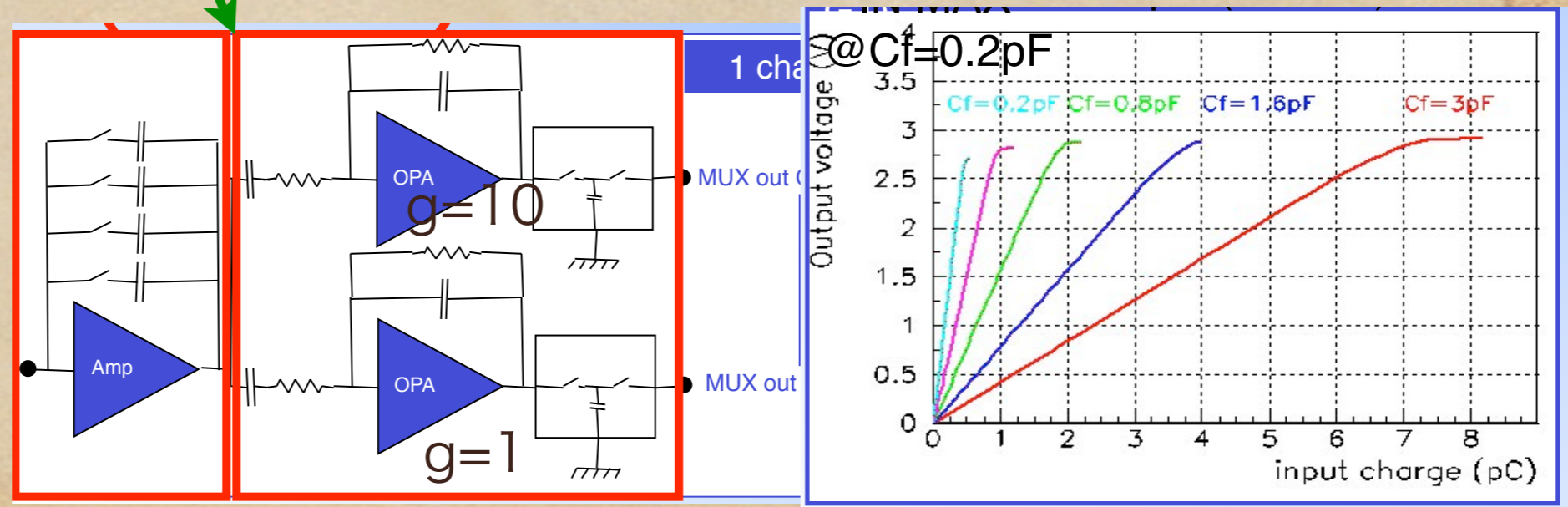


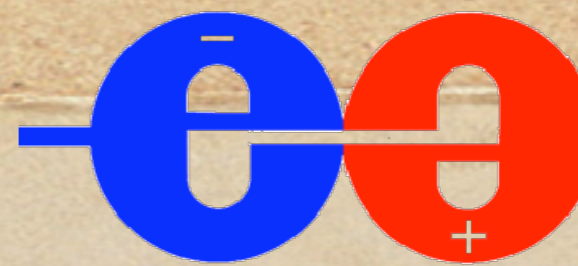
14 layers  
2.1 mm thick  
Made in Korea

Si(6x6x6)



### 2. electronics for prototype





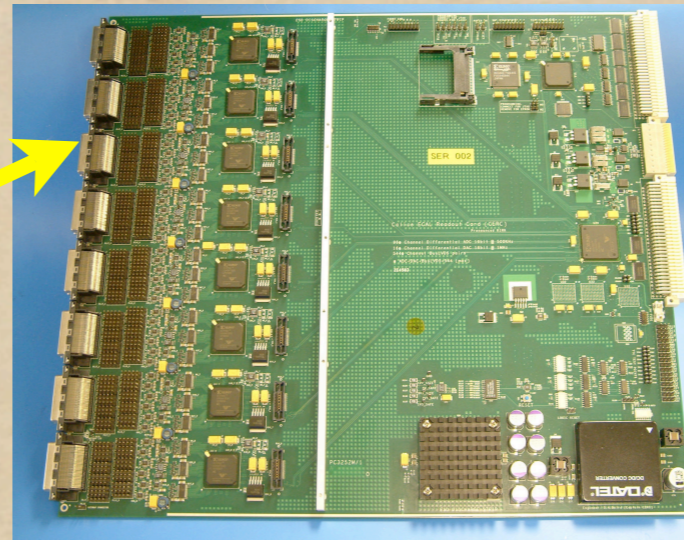
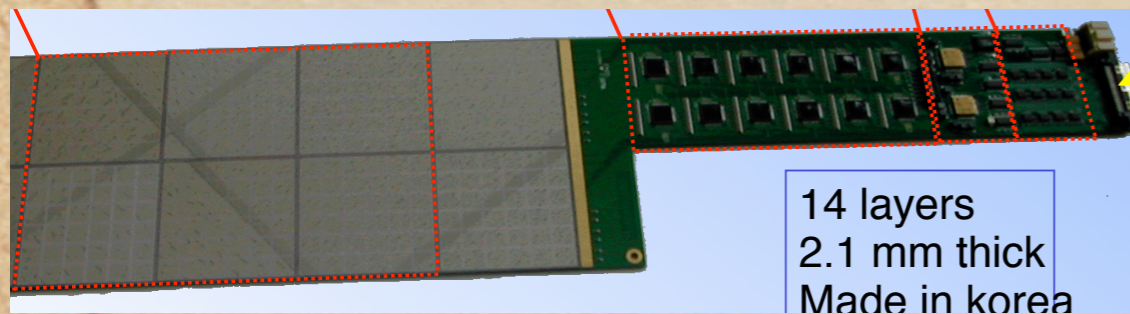
# E.M.CAL.

## Si/W-CALICE

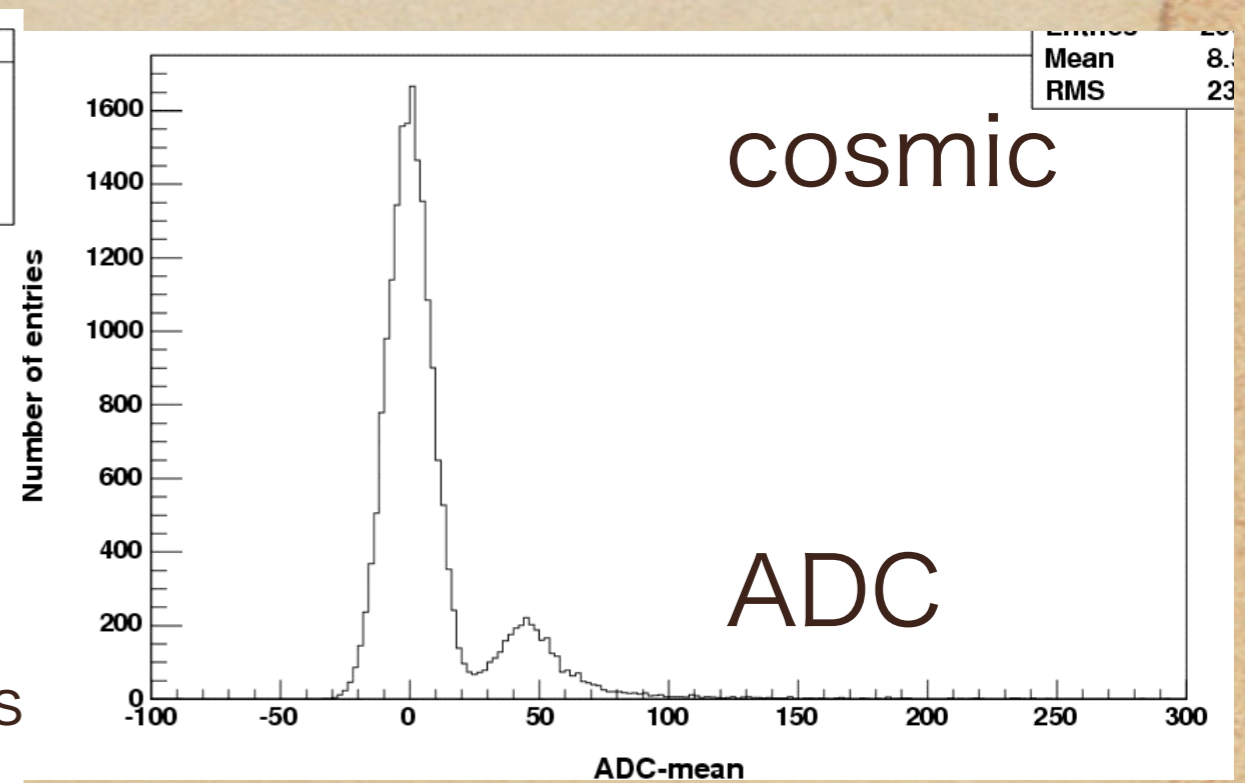
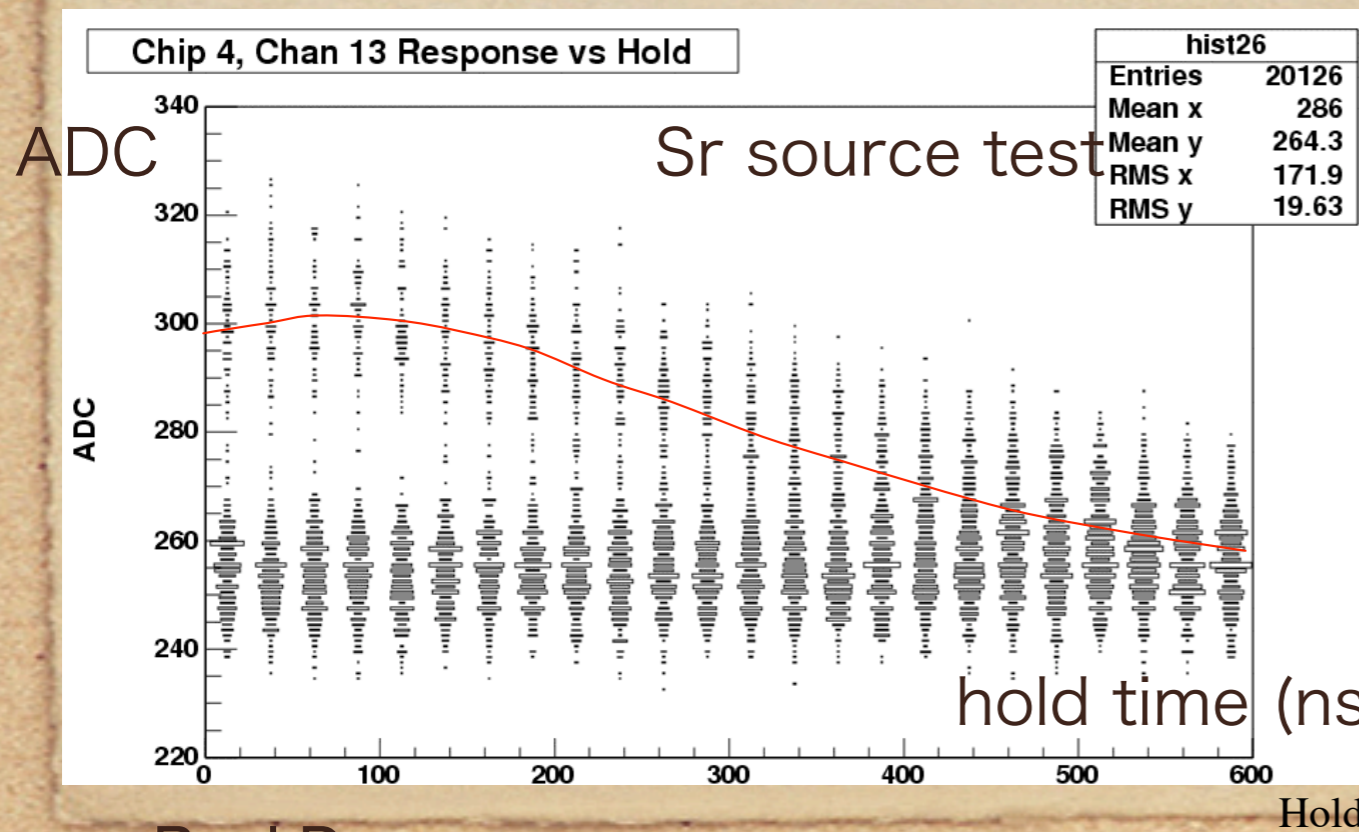
recent developments

VME

### 3. Readout prototype



digitise &  
memory



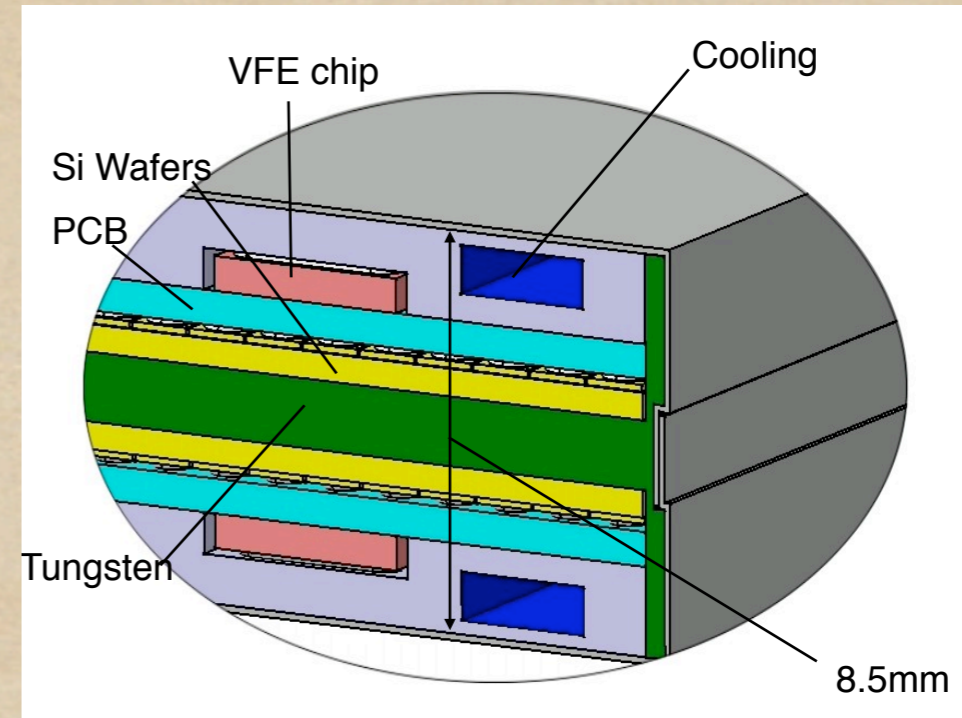
# E.M.CAL.

## Si/W-CALICE

near term developments

1. technology prototype

cooling( low power), ADC



2. VFE to analog-HCAL R/O

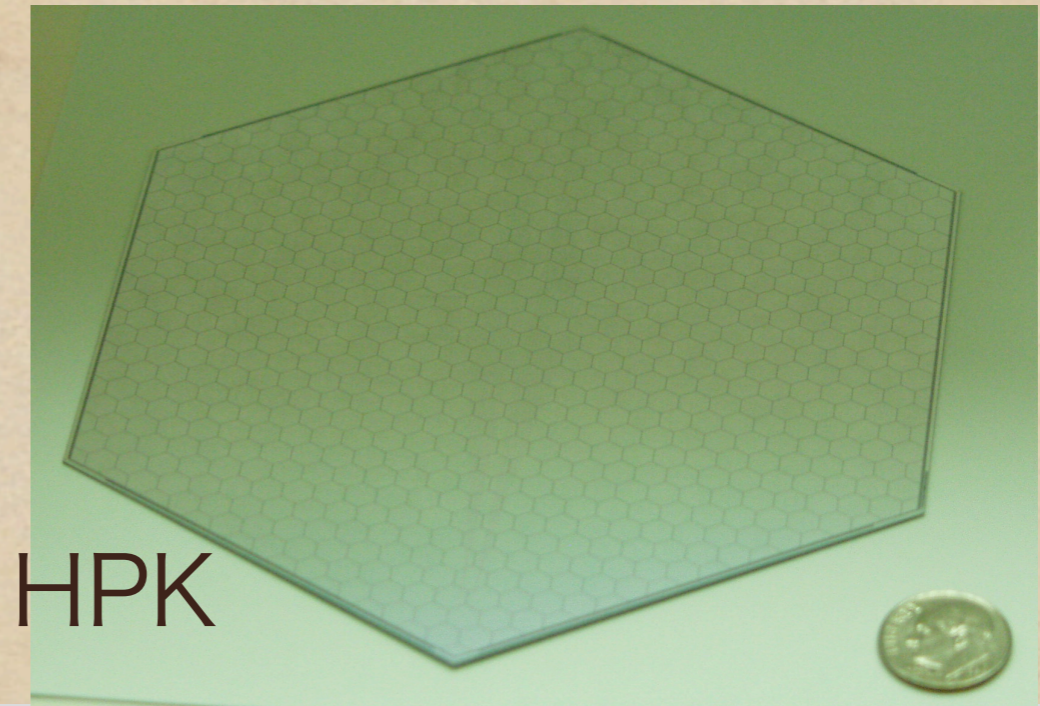
# E.M.CAL.

## Si/W-US-SiD

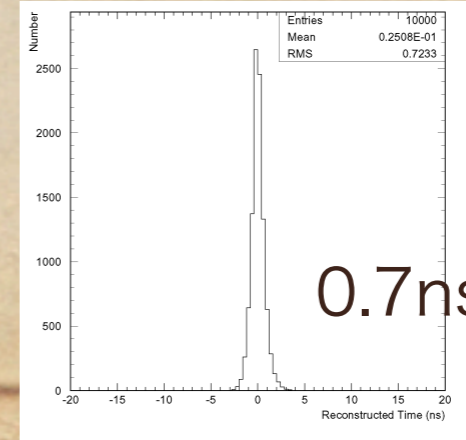
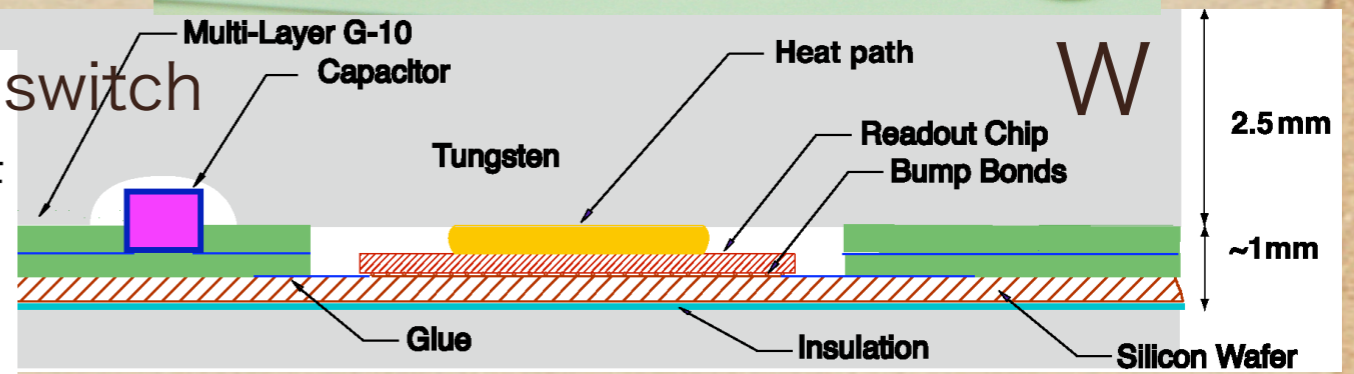
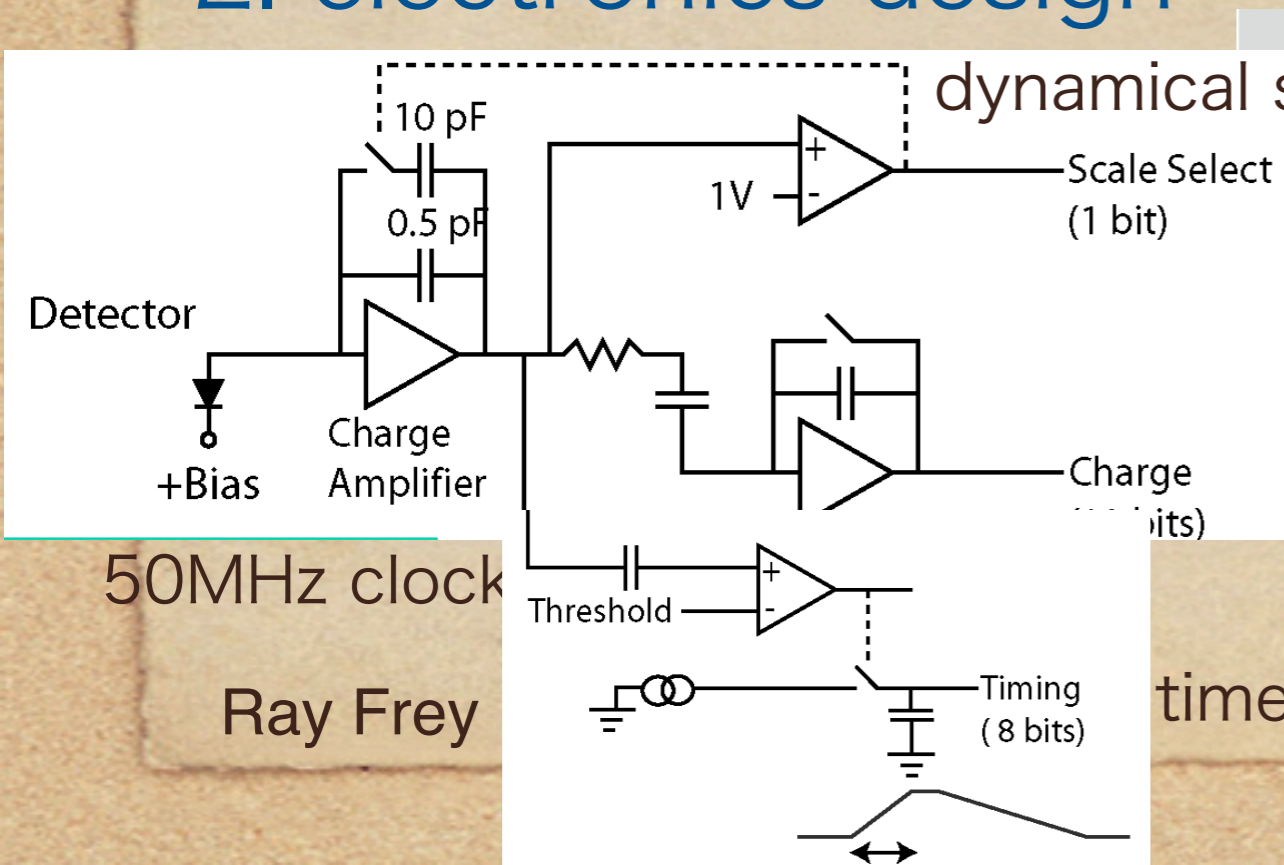
recent developments

### 1. components

W



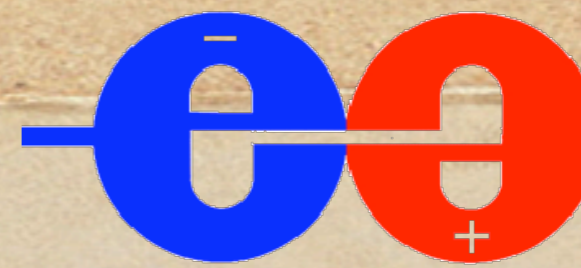
### 2. electronics design



50ns  
30sample

0.7ns

time expansion



# E.M.CAL.

Si/W-US-SiD

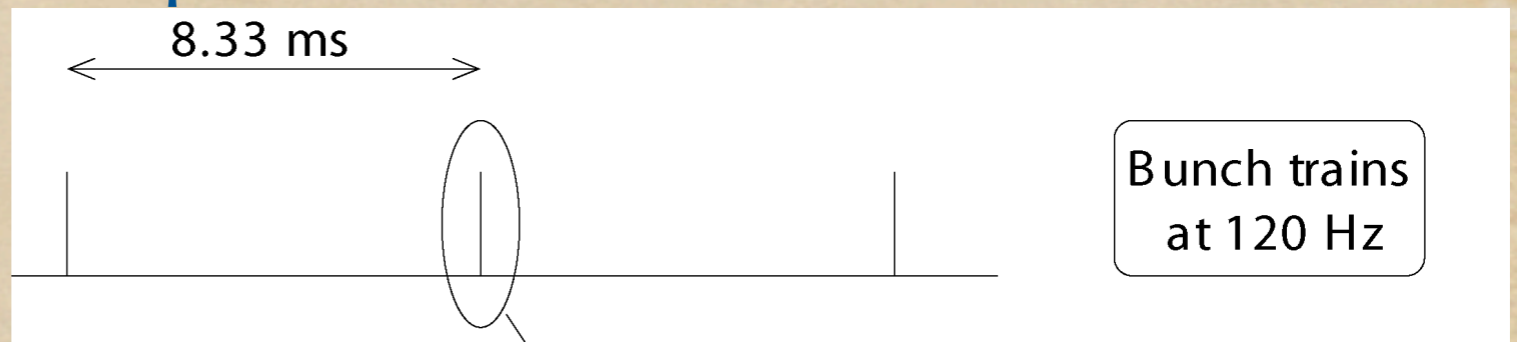
near term developments

## 1. timing resolution

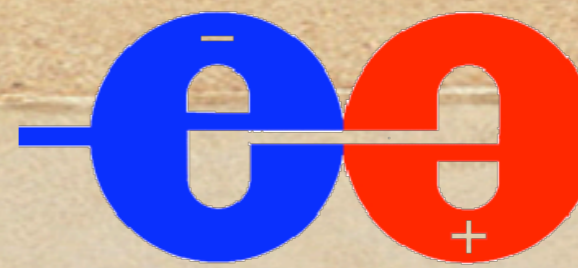
Needs testing with real electronics and detectors  
verification in test beam

## 2. low power consumption

Use power cycling  
34mW/wafer(10<sup>3</sup>ch)



## 3. Fabricate initial RO chip and test

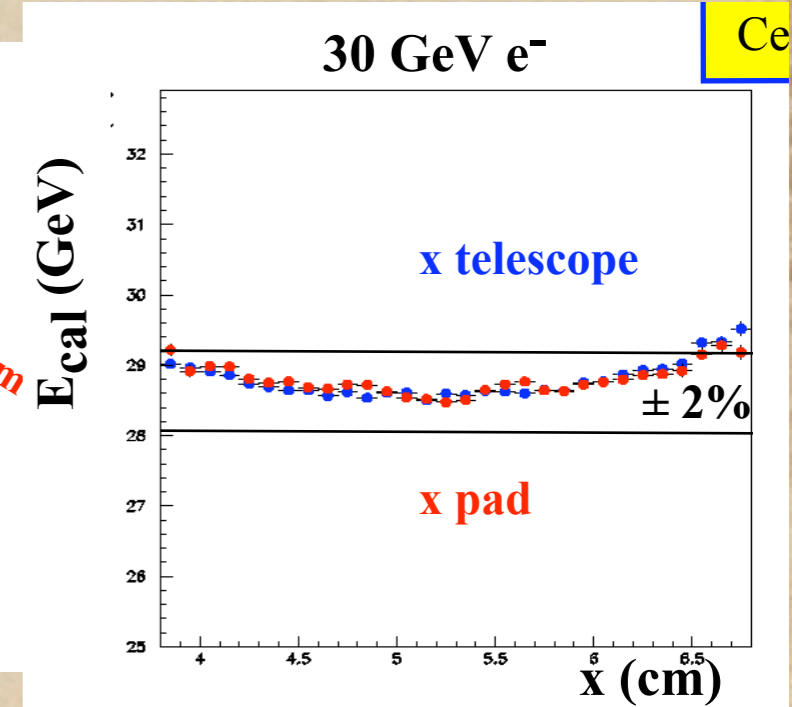
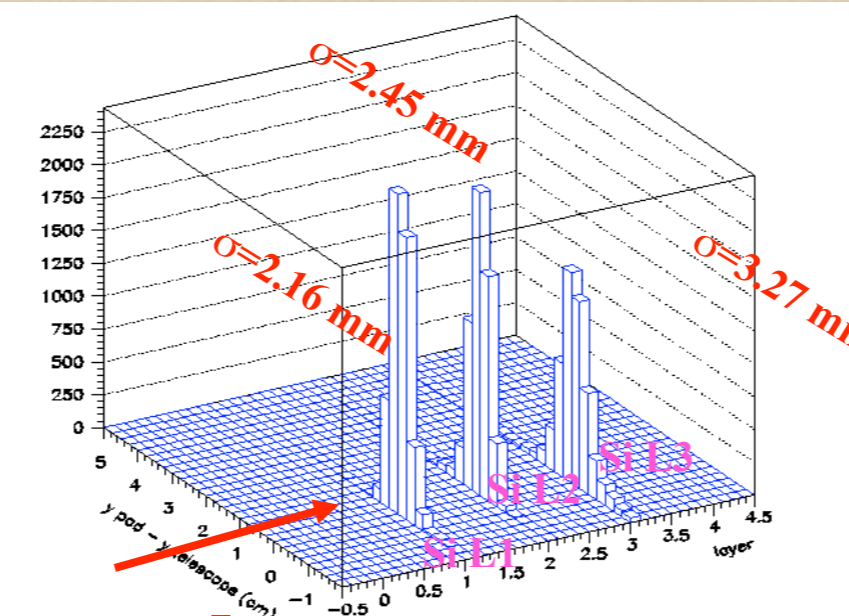
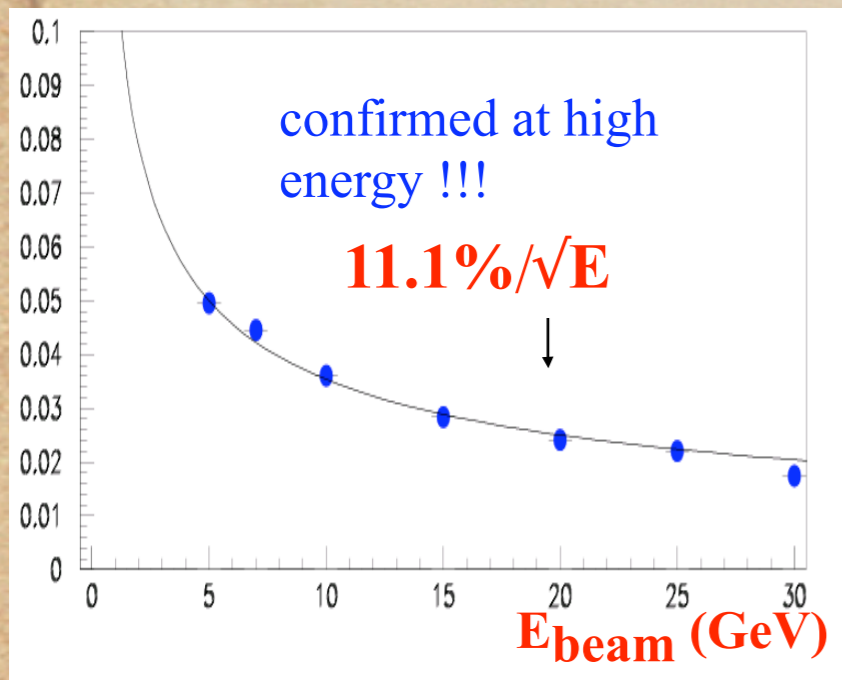
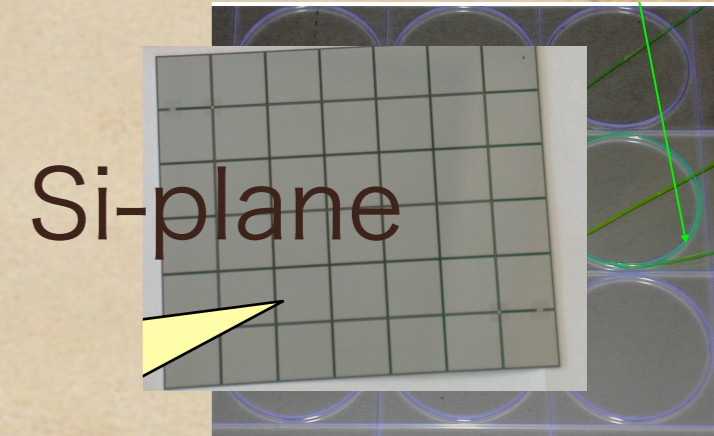
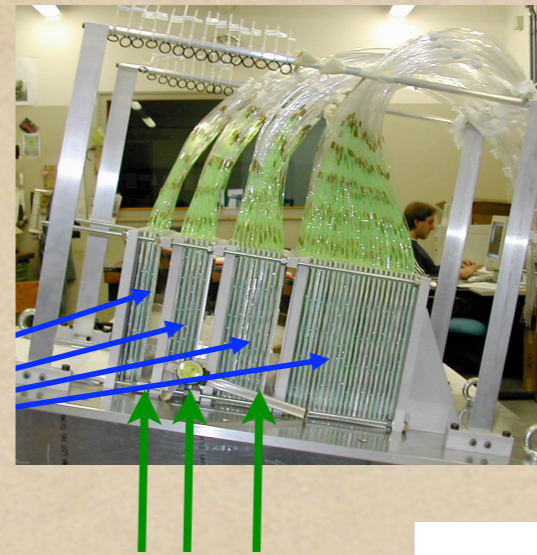


# E.M.CAL.

## Scintillator/Si-LCCAL

## recent developments

- 1. det. constructed and tested
- 3 Si-planes



near term developments

simulation



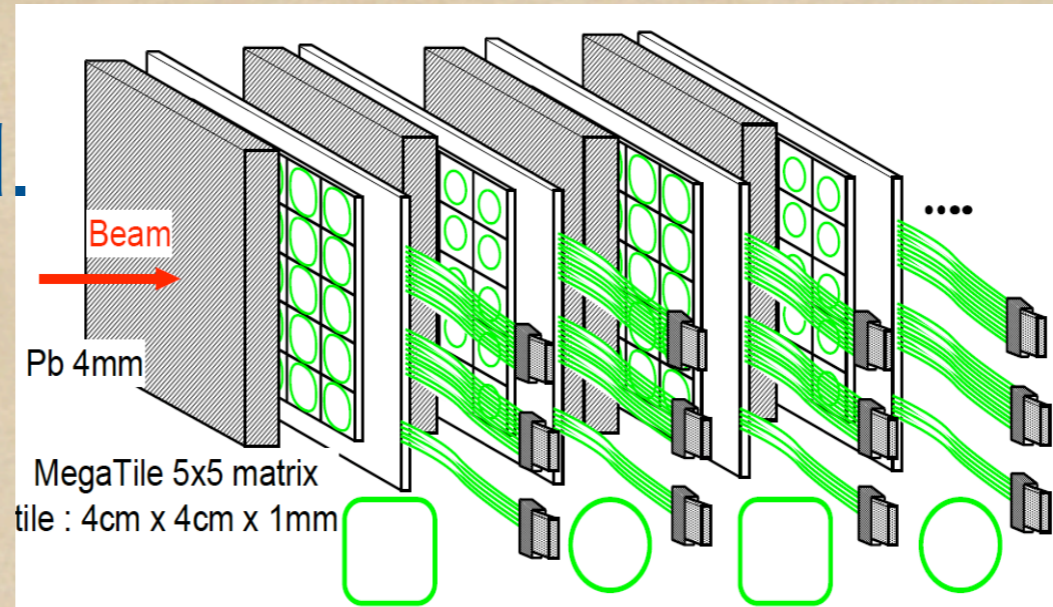
# E.M.CAL.

## Scintillator-GLC

## recent developments

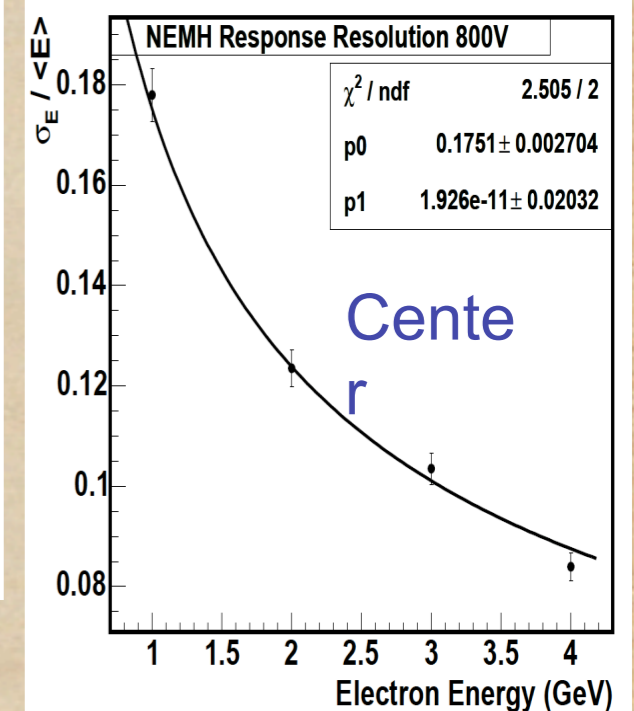
1.mega-tile cal.

18%@1 GeV



Pb4:Sci1mm

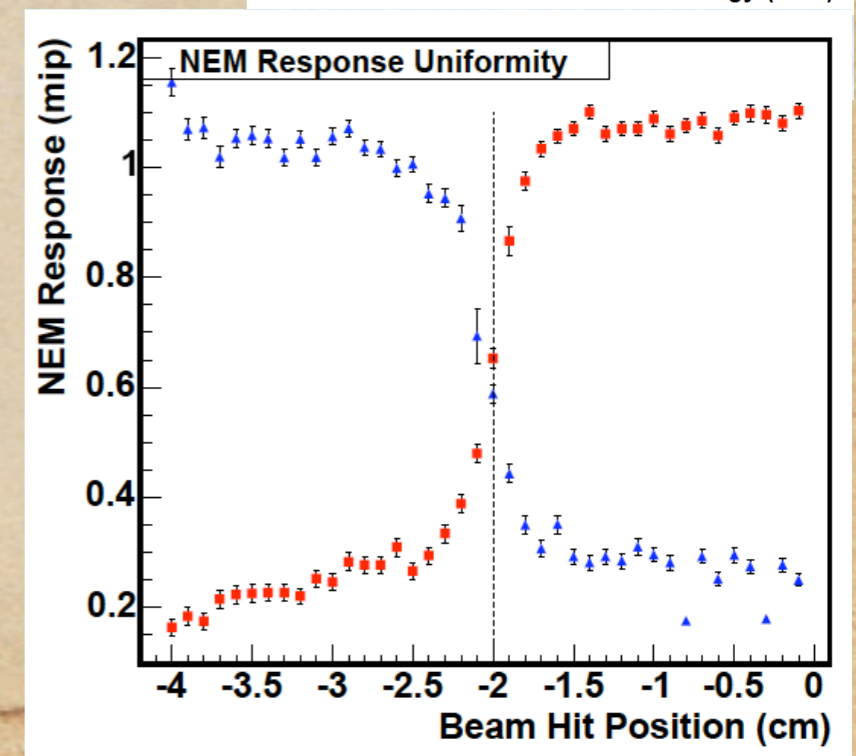
Pb2:Sci1mm



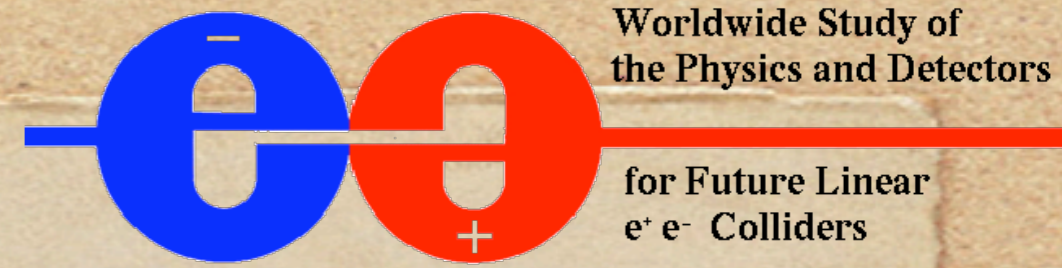
2.JINR-tile cal.

12%@1 GeV

less thick



# E.M.CAL.



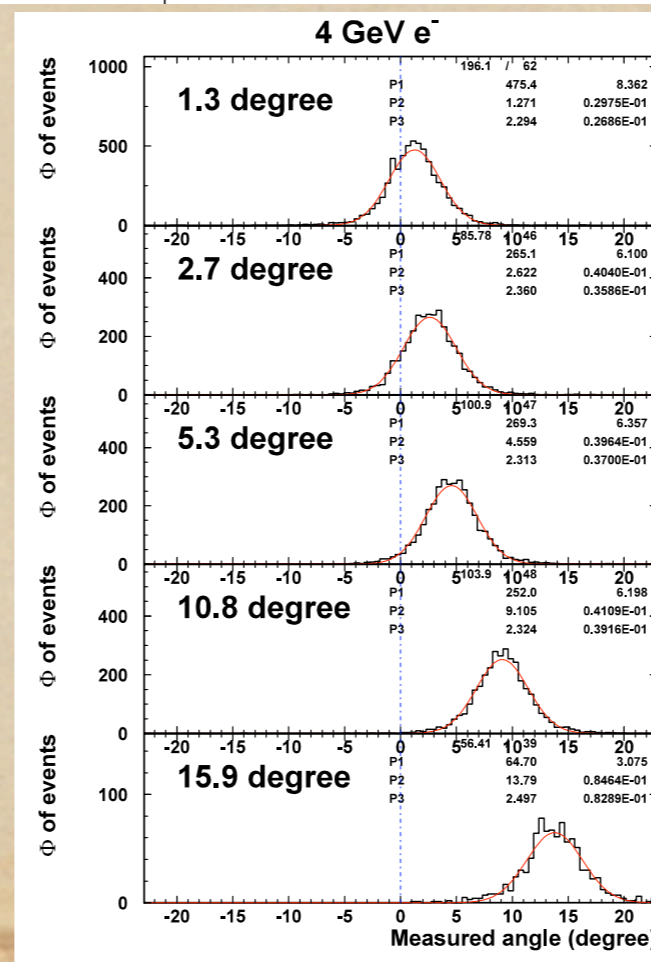
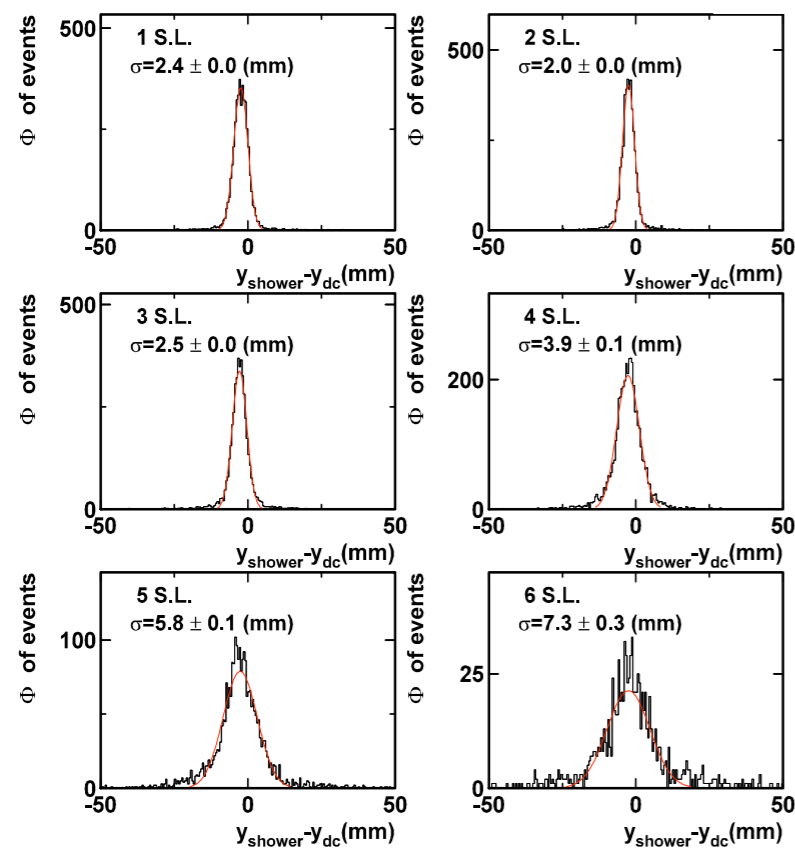
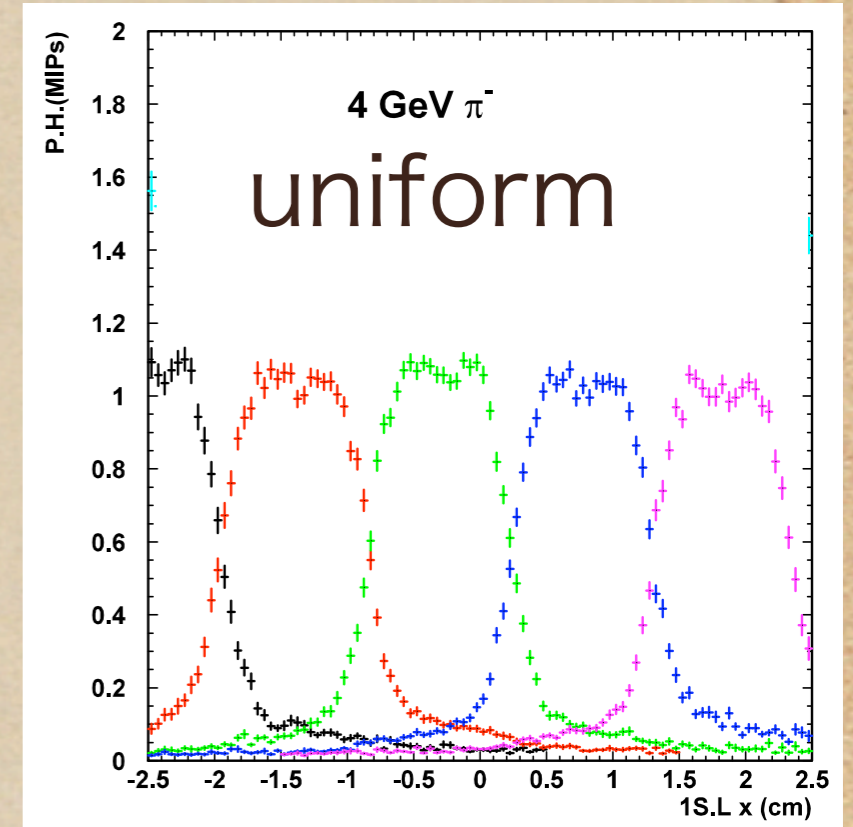
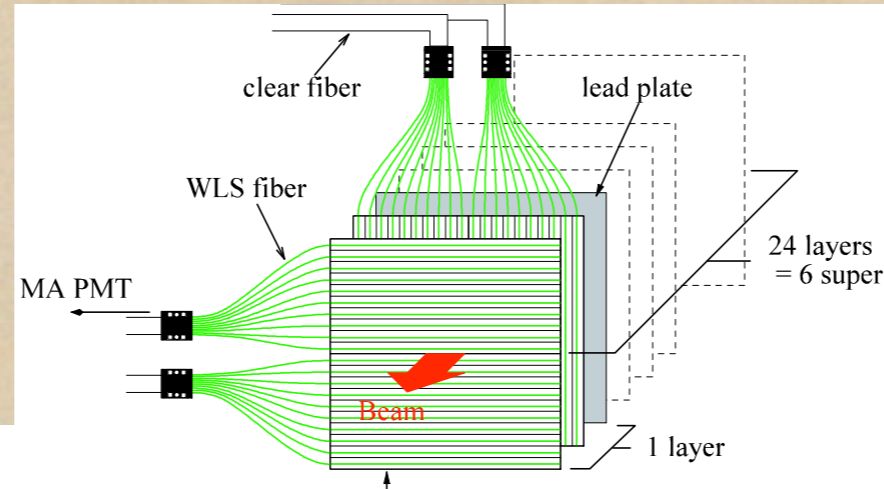
## Scintillator-GLC

## recent developments

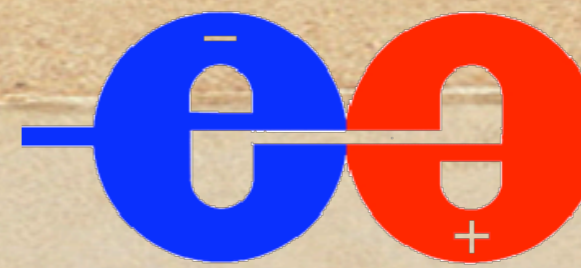
1.strip cal.

13%@1GeV

pos. reso.



angle reso.

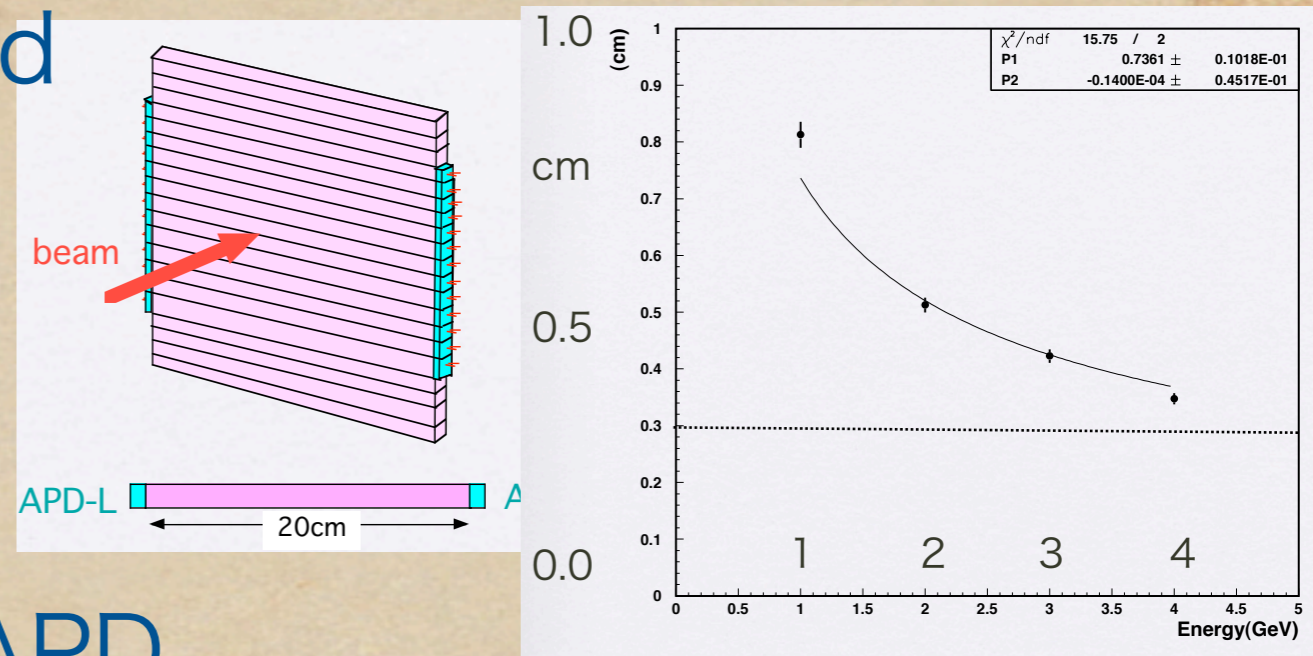


# E.M.CAL.

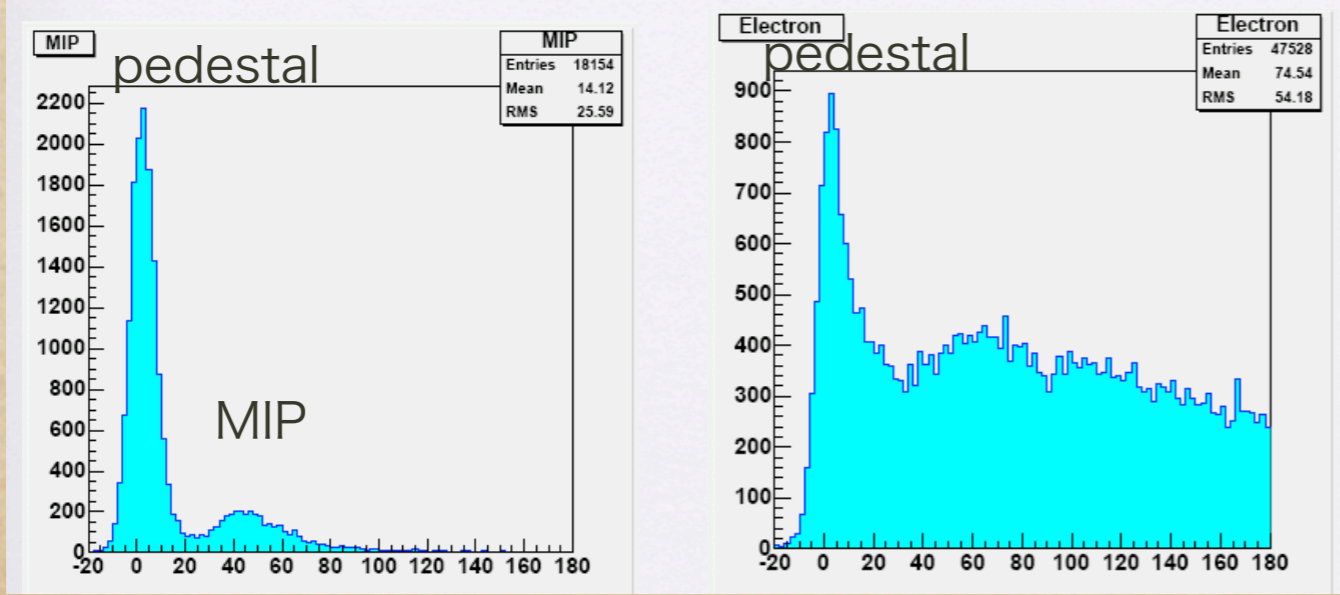
## Scintillator-GLC

## recent developments

1.strip shower max. w. apd

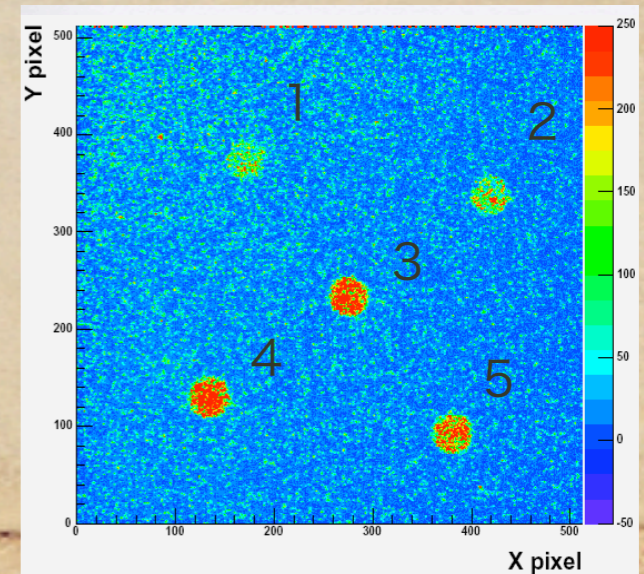


2.strip shower max. w. HAPD  
pions electrons



3.strip shower max. w.

EBCCD-camera



# E.M.CAL.

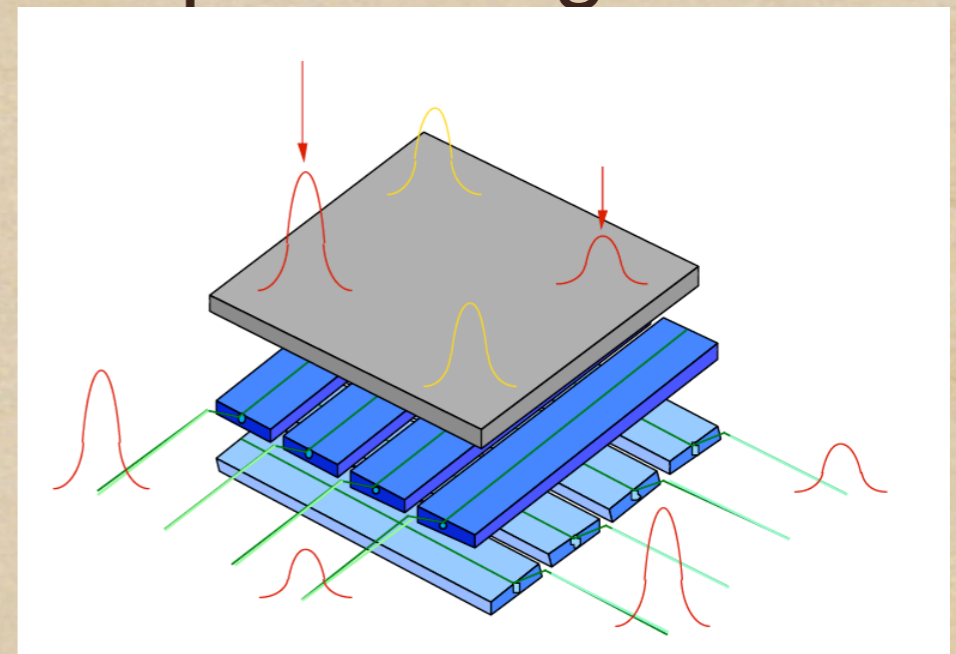
## Scintillator-GLC

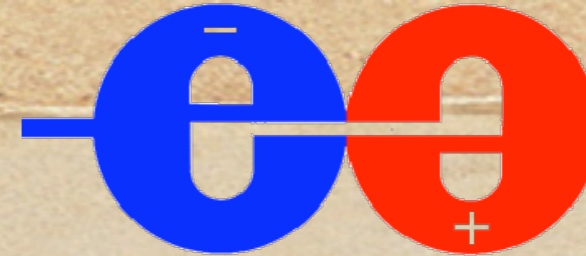
## near time developments

1.detail analysis including particle ID performance  
for tile cal.

2.need more study two-particle separation/ghost  
rejection

3.more efforts on HAPD  
and SiPM R/O





# Summary

**Hard studies are going on  
motivated by PFA**

**Muons: simulation studies are going on**

**HCAL: construction of digital HCAL  
and beam test are on schedule**

**EMCAL: Si/W EMCAL will be tested**

**hope to identify source of jets**