

# Test Beam for ILC detectors

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# Darmstadt, DESY , CERN , FNAL Test beam , ...

- > Vertex detector
- > Tracker (TPC, Silicon tracker)

> Beam calorimeter

- > Calorimeter
- > Muons tagger
- > DAQ



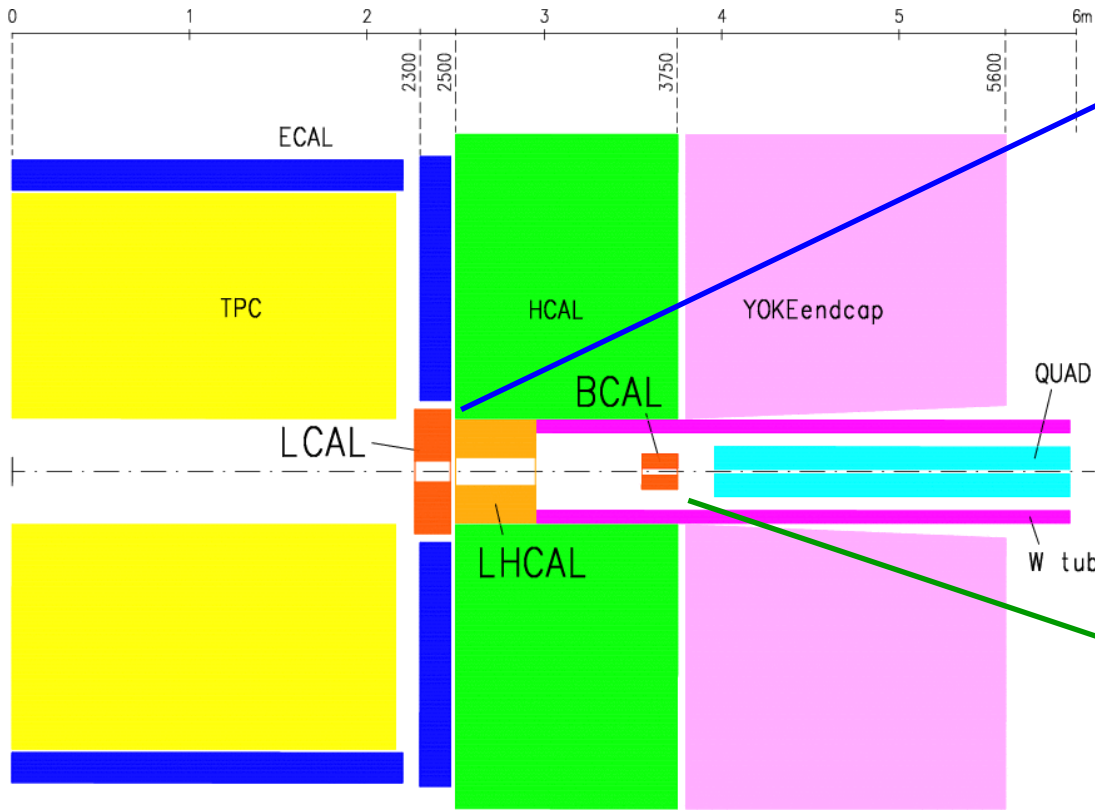
In EUDET  
program

I apologize, but within 30mn, I will not be able to cover in detail all the progress of all the projects.

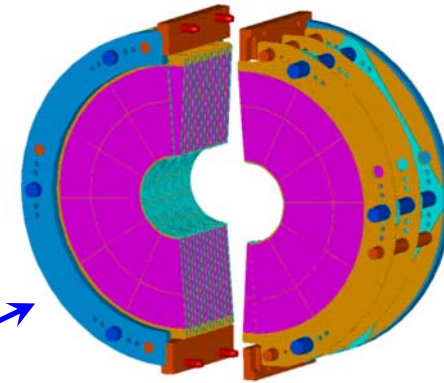
I will concentrate on FCAL and CALICE (end of TB period < 2 weeks)

# Beam calorimeter

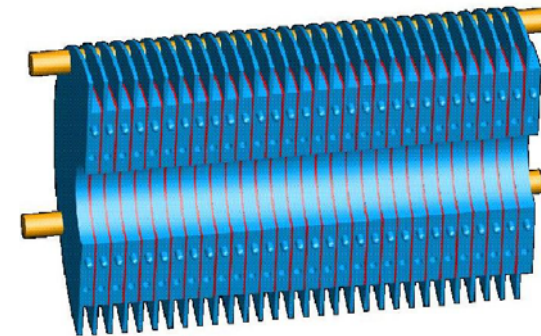
## Forward region of LDC (V2)



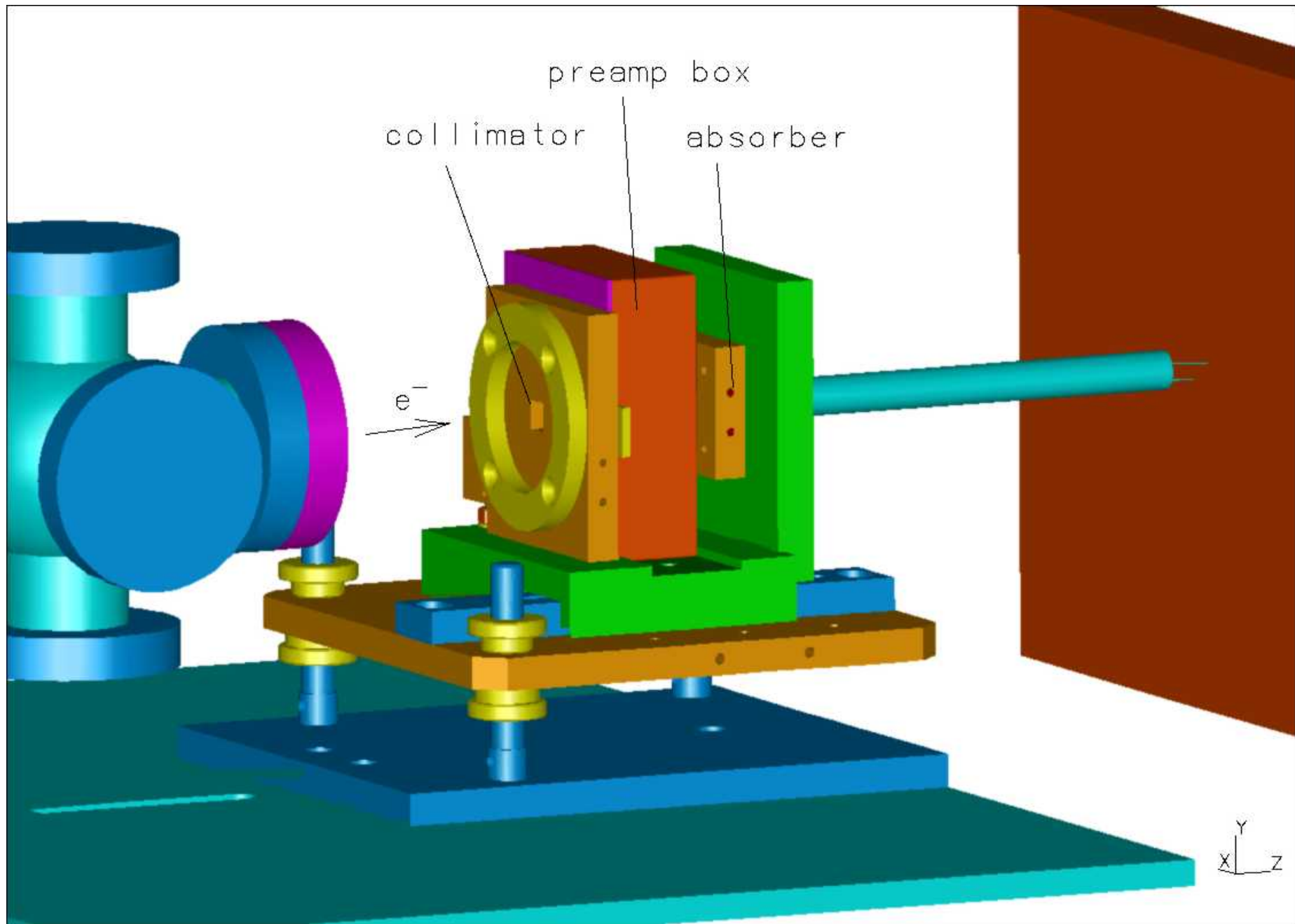
<b>LCAL</b>	$R_i = 60 \text{ mm}$	<b>LHCAL</b>	$R_i = 80 \text{ mm}$	<b>BCAL</b>	$R_i = 20 \text{ mm}$
	$R_o = 350 \text{ mm}$		$R_o = 290 \text{ mm}$		$R_o = 100 \text{ mm}$
	$z_1 = 2270 \text{ mm}$		$z_1 = 2500 \text{ mm}$		$z_1 = 3550 \text{ mm}$
	$z_2 = 2470 \text{ mm}$		$z_2 = 2950 \text{ mm}$		$z_2 = 3750 \text{ mm}$



**LumiCal**  
 30 layer Si:W  
 $26 < \theta < 155 \text{ mrad}$



**BeamCal**  
 30 layer CVD diamond:W  
 $5 < \theta < 28 \text{ mrad}$





### What FCAL coll. want to know

- the performance as a function of the absorbed electromagnetic dose for several sensor types
- the linearity and homogeneity of the response for prototype sensor planes to be used for BeamCal and LumiCal

### 2007 (DESY, JINR)

Study of the performance of pad sensors for the BeamCal as a function of absorbed electromagnetic dose up to MGy particles: electrons, 10 MeV (TU Darmstadt)  
Characteristics of different type of sensors (Diamond, silicon of different producers)

### 2008/2009 (DESY, JINR, Cracow, Tel Aviv)

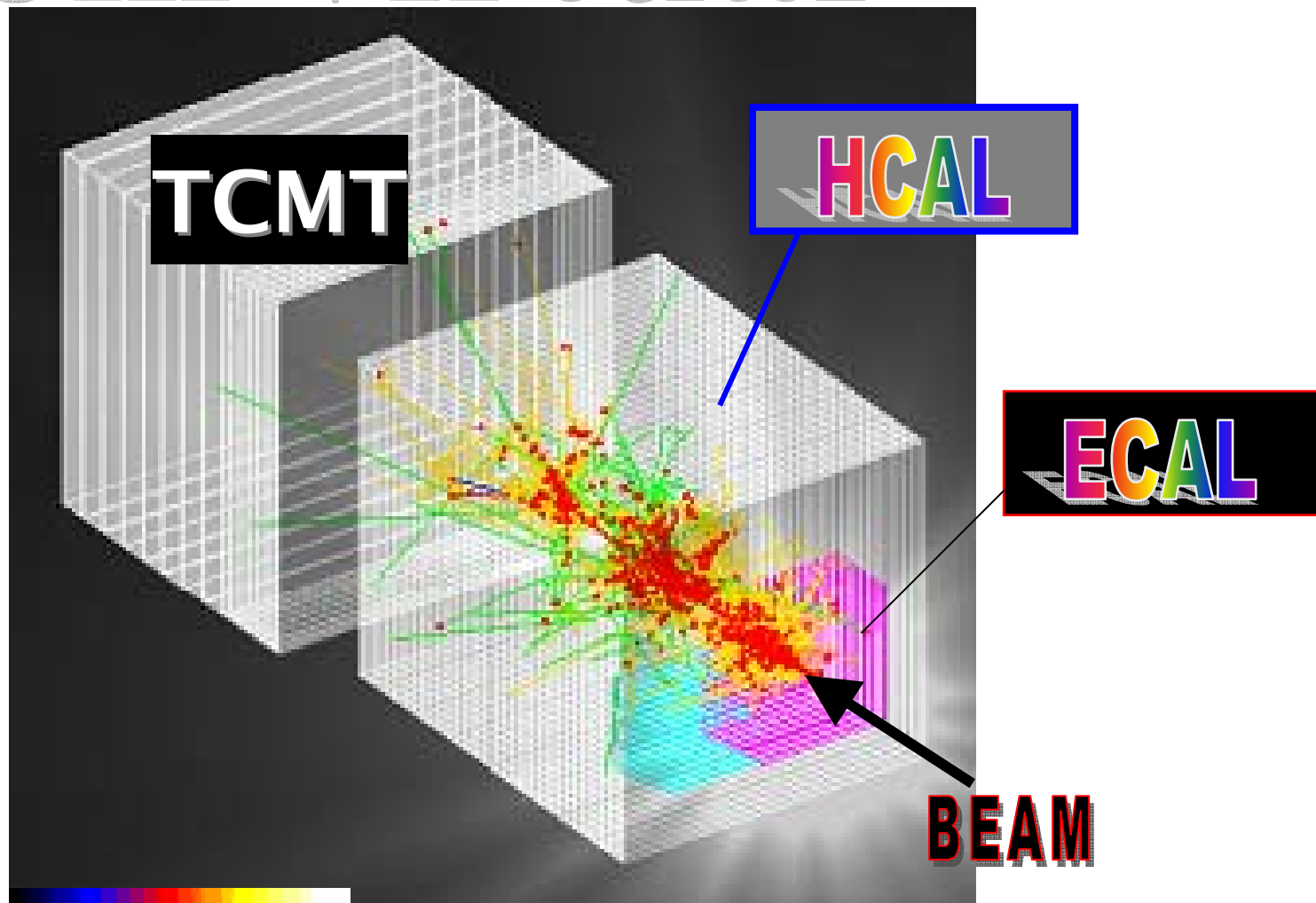
test of sensor planes for BeamCal and LumiCal to be done at DESY, electrons (within EUDET) and at the PS in CERN (linearity study using fast extraction) using unseparated beam, with a number of events is between a few 1000 (for fast extraction) up to  $10^4$  (MIPS)

Calorimeter

Muons tagger

DAQ

# From virtual



# to real

(scint.strip-SiPM)

TCMT

HCAL

(scint. Tiles-SiPM)

ECAL

(W-Si)



# CALICE plans

- A first generation prototypes, which allows to debug the concept and technologies **2001 - 2005**  
**in test beam for 2006-2008**
- A second step : a demonstrator , essentially the final detector in smaller size **2006 - 2009**  
**in test beam for 2009-2011**
- Ready for LOI, Proposal etc... at T0 ( **hope for 2010 !!**)

## First generation prototypes

- W-Si **ECAL** almost complete, in use at test beam
- W-Scintillator strip **ECAL** in construction,  
test beam@DESY , **Spring 2007**
- Tile **HCAL** using SiPM from Russia partially ready  
and in use at test beam
- Digital **HCAL** in plan ( waiting for funding !!!)



# CALICE Detectors and contributions

## W-Si ECAL

**France** LAL-Orsay, LLR- Ecole Poly. , LPSC-Grenoble, LPC-Clermont  
**Czech Rep** IOP-ASCR **India** BARC-Mumbai **Korea** Kangnung NU. , Seoul NU., Ewha Univ., Sungkyunkwan U., Yonsei U. **Russia** Moscow SU  
**UK** Cambridge, Manchester, University CL, Royal Holloway UL

## W-Scint.strip ECAL

**Japan** KOBE Univ., SHINSHU Univ.

## Digital HCAL

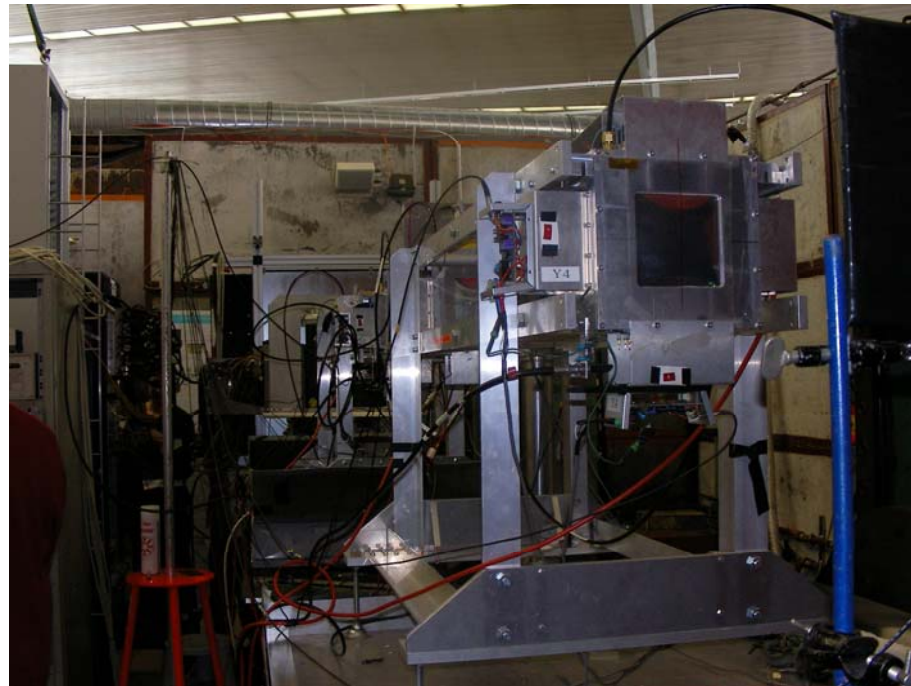
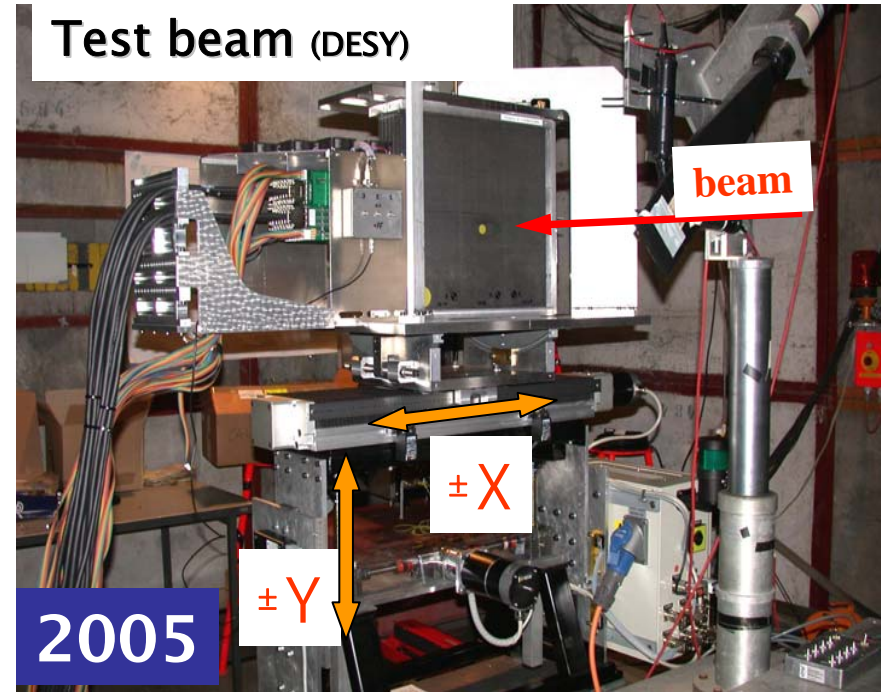
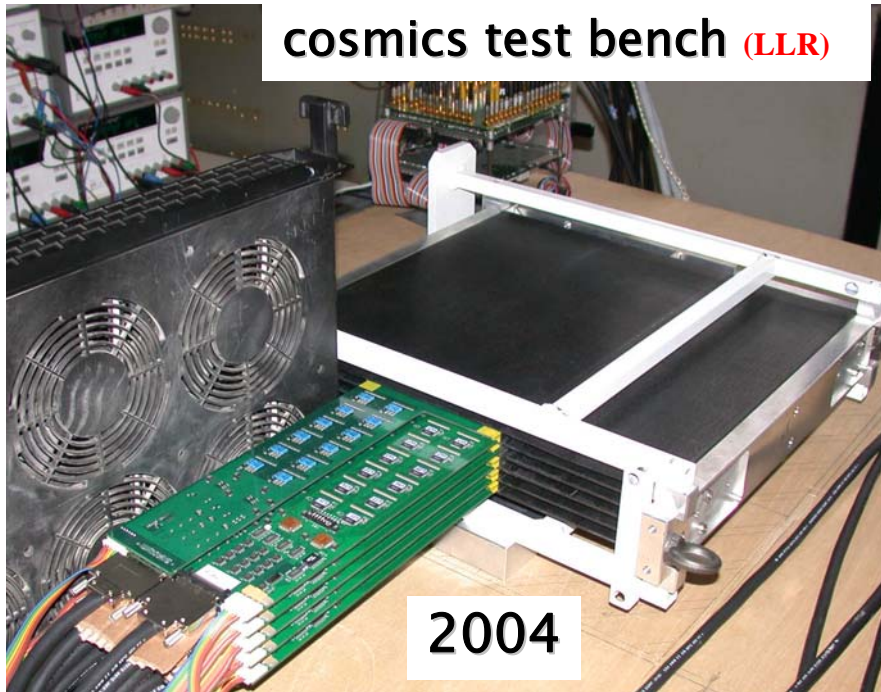
**France** LAPP-Annecy, IPNL-Lyon **Russia** IHEP-Protvino  
**USA** Argonne NL, Boston Univ., U of Chicago, Texas U @Arlington, Univ. Iowa St,  
*Close contact with Fermilab*

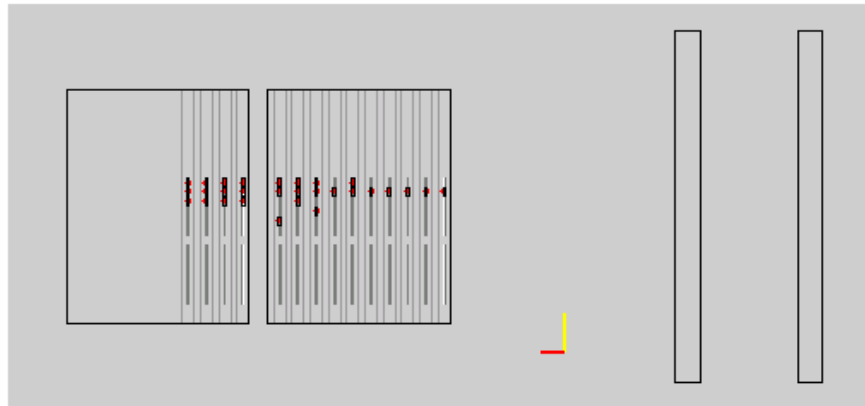
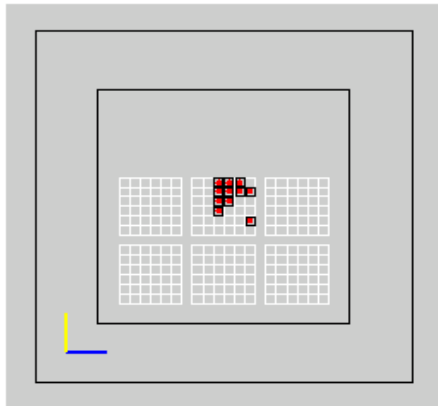
## Tile HCAL/TCMT

**Belarus** Minsk Univ. , **Canada** McGill Univ. , Univ. Of Regina  
**Czech Rep** Univ. Charles-Prague, **Germany** DESY , Univ. Hambourg  
**Russia** ITEP, IHEP-Protvino, LPI, MEPHI , **USA** North Illinois University

## DAQ

**UK** Birmingham, Imperial CL, University CL, Royal Holloway UL, Rutherford AL

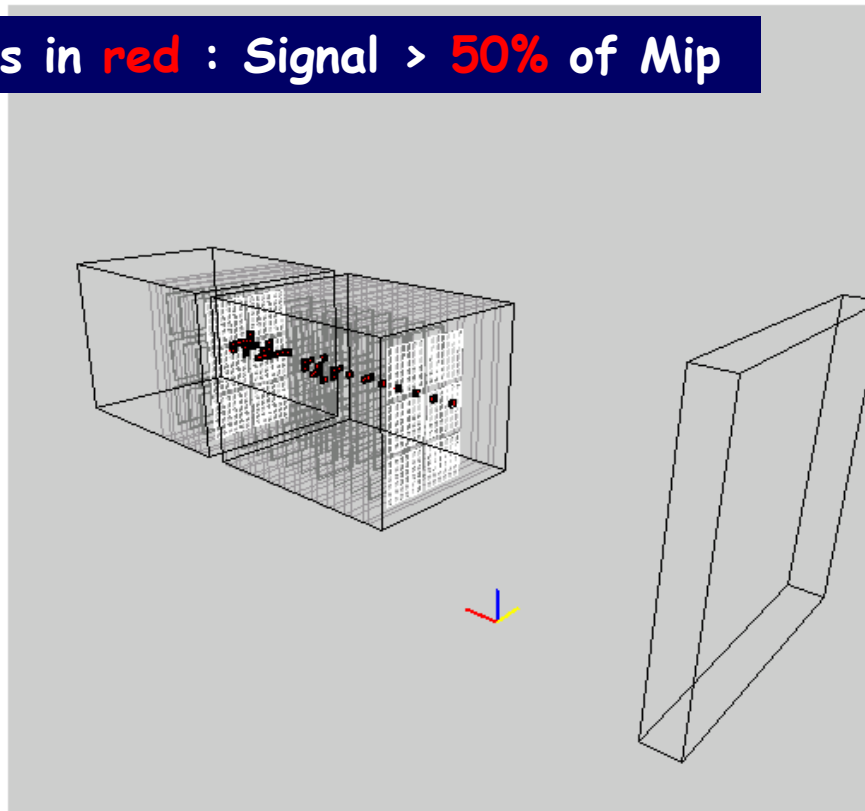
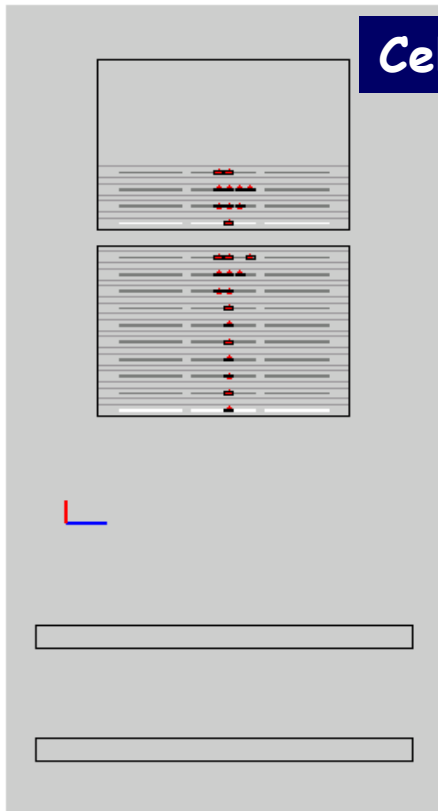




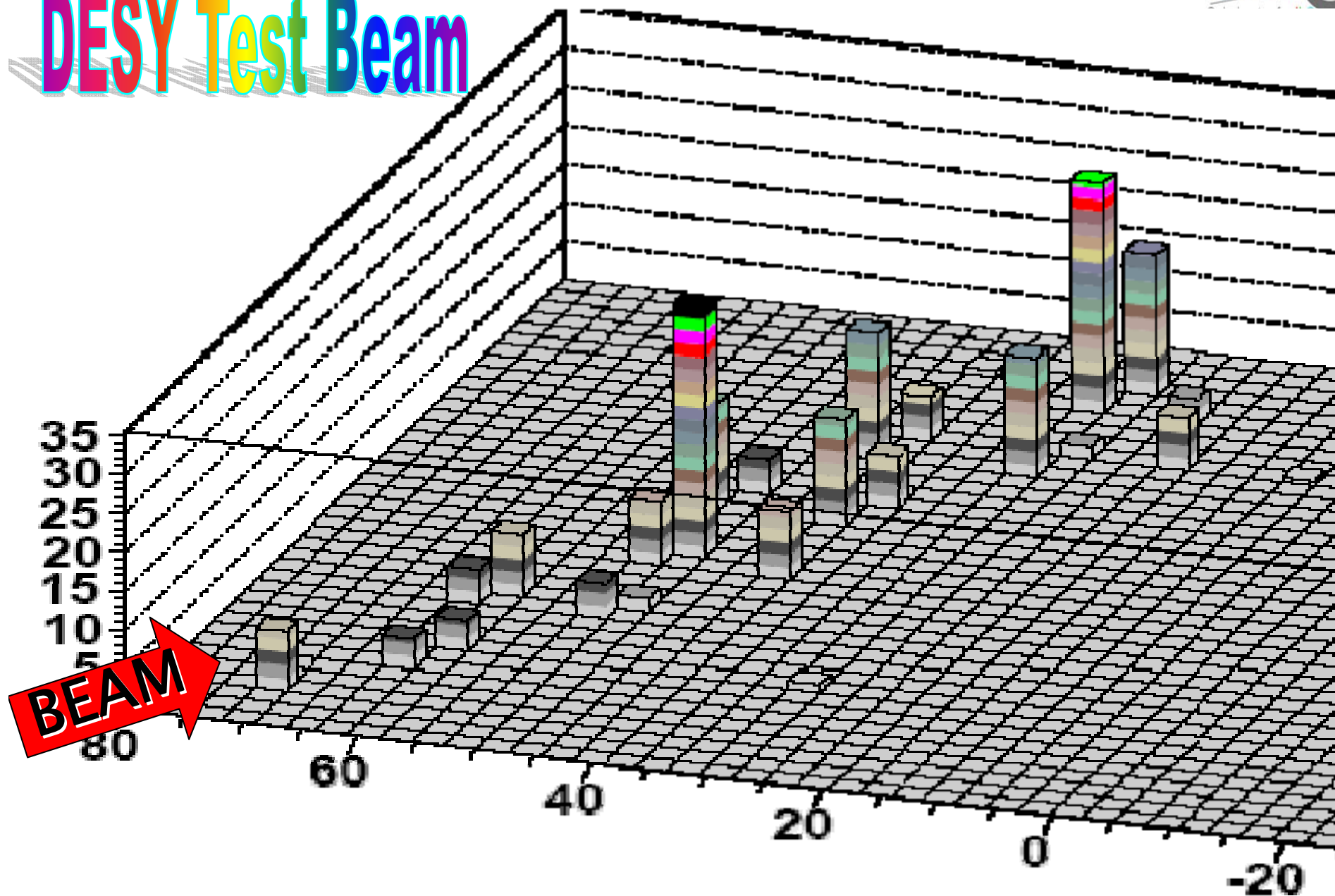
The first result !!

**S/N ~ 8**

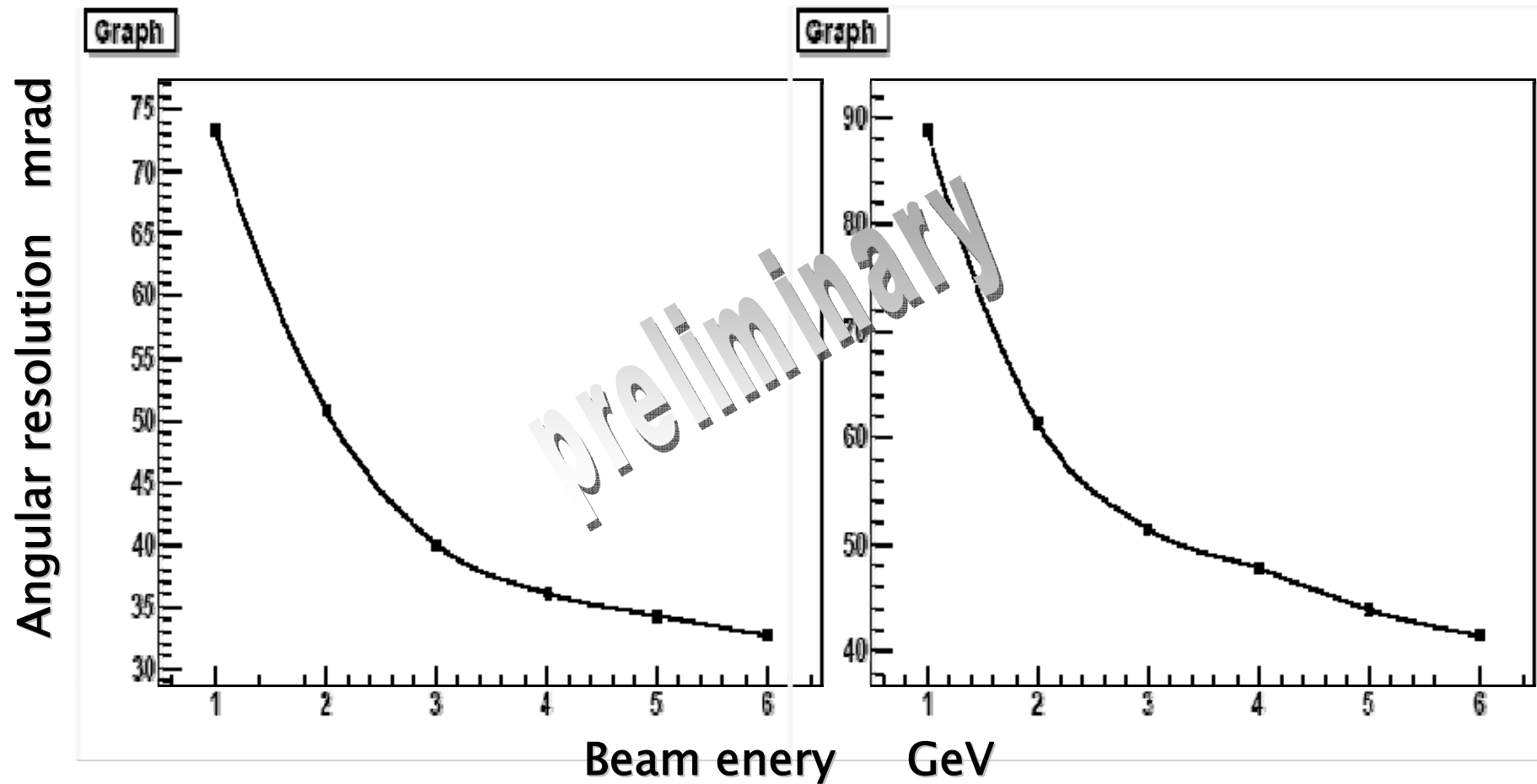
**Cells in red : Signal > 50% of Mip**

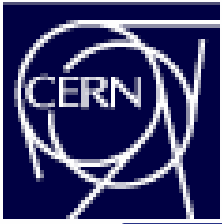


# DESY Test Beam



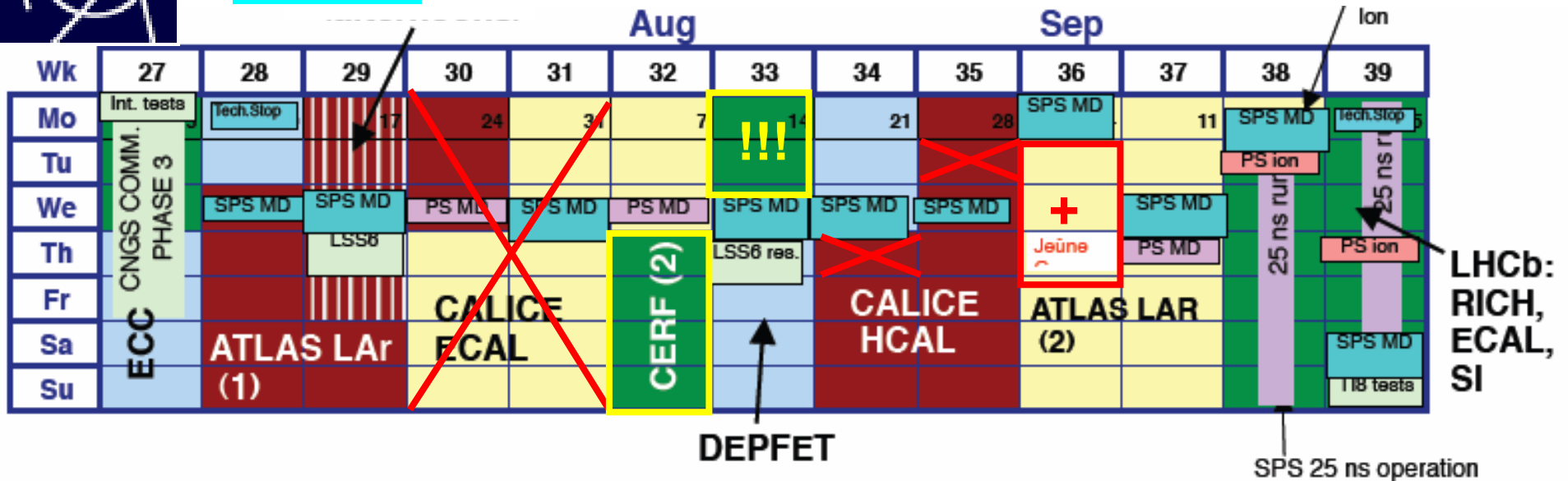
# Events at 20 degrees





2006

# CERN North Area test beam operation



## SPS Operation

Period 2 C 2006 - October 2 to October 18

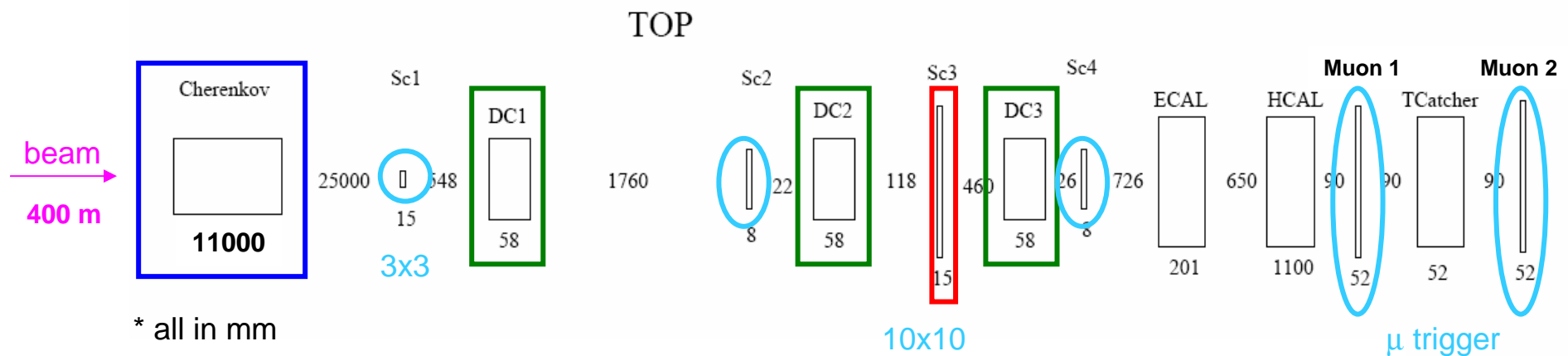
V2.2

Issue date: June 25, 2006  
Last modification: September 15, 2006

PS&SPS Users meeting (pink), week-ends & holidays (green), machine development times (yellow)

		Week-40							Week-41							Week-42						
		Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
		2-Oct	3-Oct	4-Oct	5-Oct	6-Oct	7-Oct	8-Oct	9-Oct	10-Oct	11-Oct	12-Oct	13-Oct	14-Oct	15-Oct	16-Oct	17-Oct	18-Oct	19-Oct	20-Oct	21-Oct	22-Oct
SPS		8:00-8:00 Long SPS MD							8:00-16:00 SPS MD							8:00 8:00-16:00 PS ION Long SPS+PS IONS						
North Area	T2	H2 A Malinin 172 H2A		CREAM					H2 M Ricci 172 H2A		PAMELA					H2 A Malinin 172 H2A		Chercam				
	T2	H4 P Bloch 164 H4B		CMS-ECAL							AMS											
	T4	H6 P Martinengo 146 H6A		ALICE-PMO					CALICE					CALICE								
	T4	H8 B DiGirolamo		ATLAS-LUMI					ATLAS-LUCID													

# The CERN setup

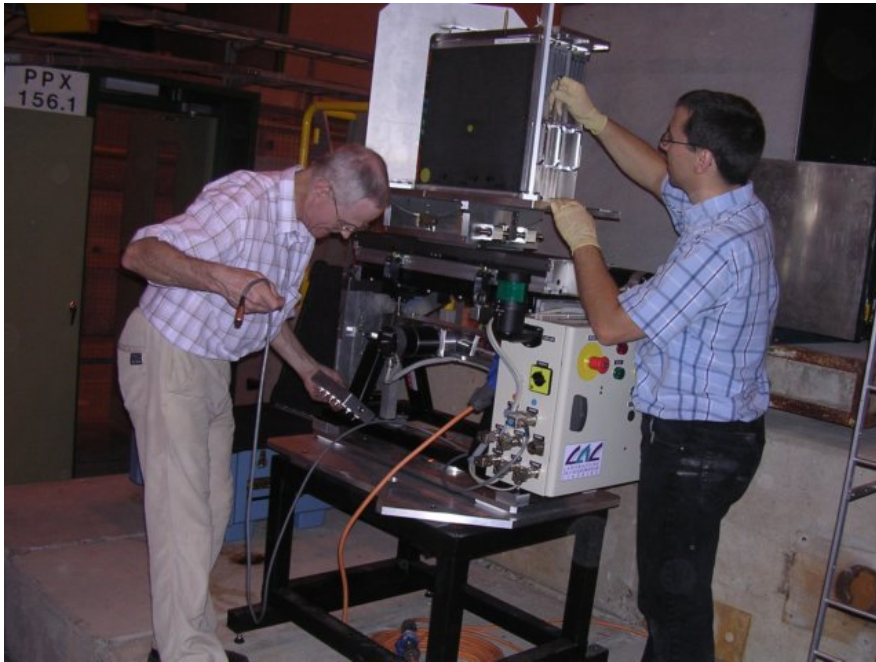


Beam instrumentation:

- 1) ~500 m beam line after Be trg = magnets, collimators, secondary trg, abs
- 2) Cherenkov detector for  $e/\pi$  separation < 40 GeV
- 3) 3 x/y pairs of MWPC with double readout, multi-hit capability
- 4) veto counter, r/o analog amplitude, to separate multi-particle events
- 5) trigger system

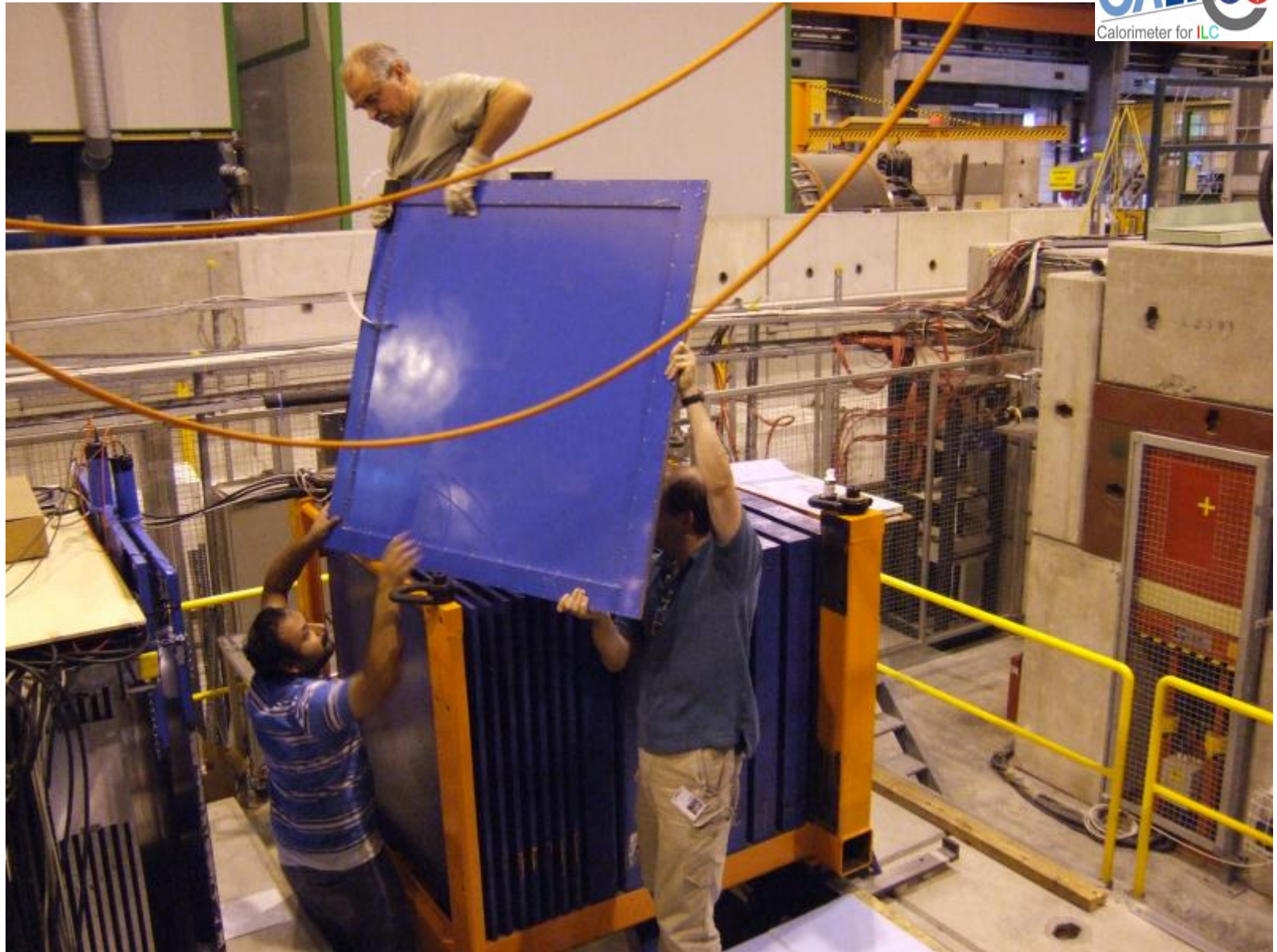
2) 3) 4) 5) are integrated in the **DAQ** and read out event by event

# June 2006 , Installation at CERN H6 test beam area



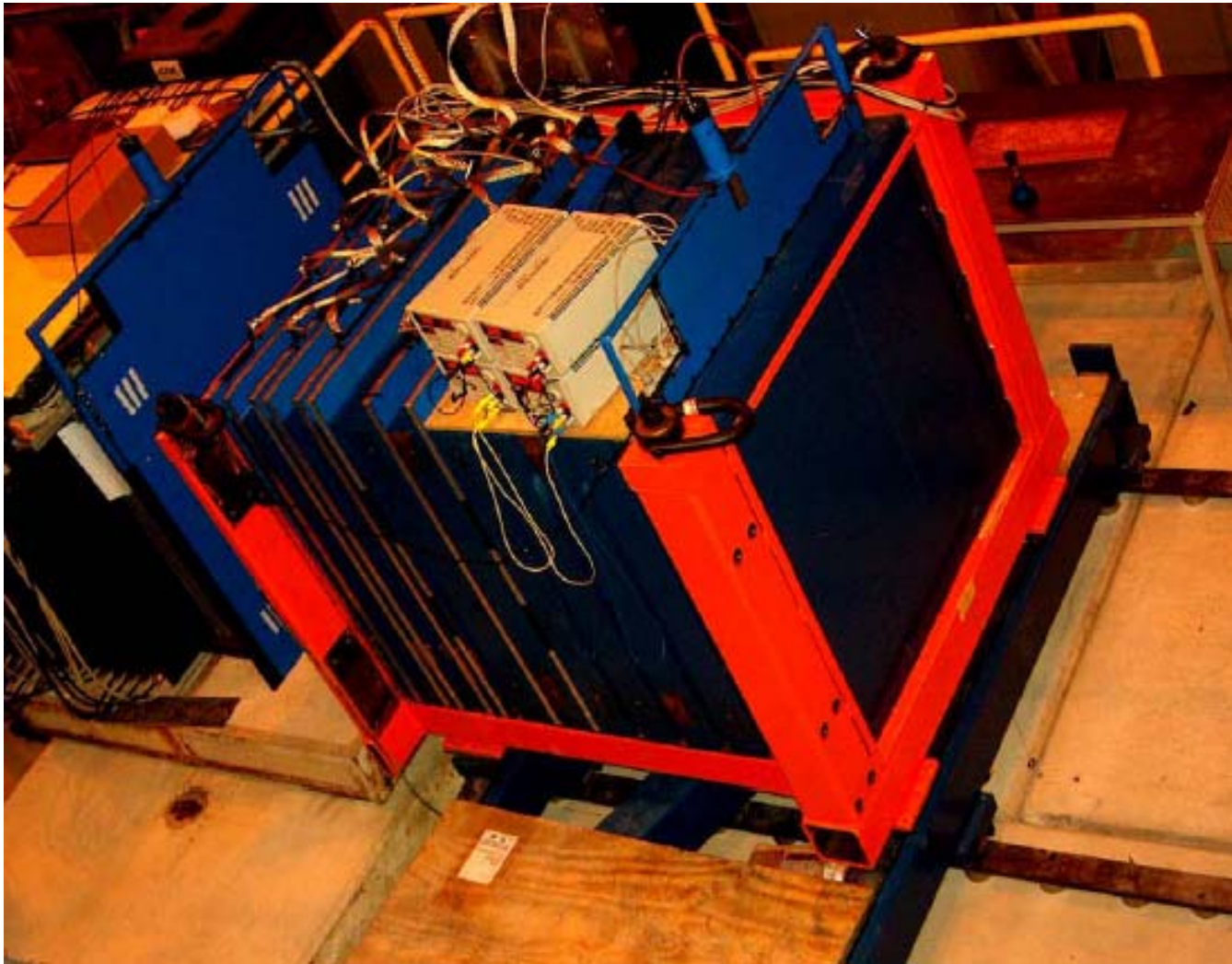


TCMT



Tail Catcher Muon Tagger

# TCMT



Fine (~ 2cm absorber)  
Coarse (~ 10cm Absorber)

About half (8) the layers  
were instrumented  
4 X and 4 Y  
20 chan/cassette

6 cassettes in fine sect.  
(Layers 1,2,4,5,7,8)  
2 cassettes in coarse sect.  
(layers 10,11)

# When going to real detector

Power supplies (for large number of pixels)

Slow Control (Defining the best GUI for 30M channels)

On-line monitoring (fast feedback for shift crew)

DAQ

(rate, efficiency, GUI, etc...) overall prototypes today is about > 10 000 channels

**Already more than LHCb, but in (18 cm)<sup>3</sup>**

Data access and Computing

(data storage, data access, reconstruction and software organisation, GRID )

Virtual Counting Room

Already in test and will be used for FNAL test beam period

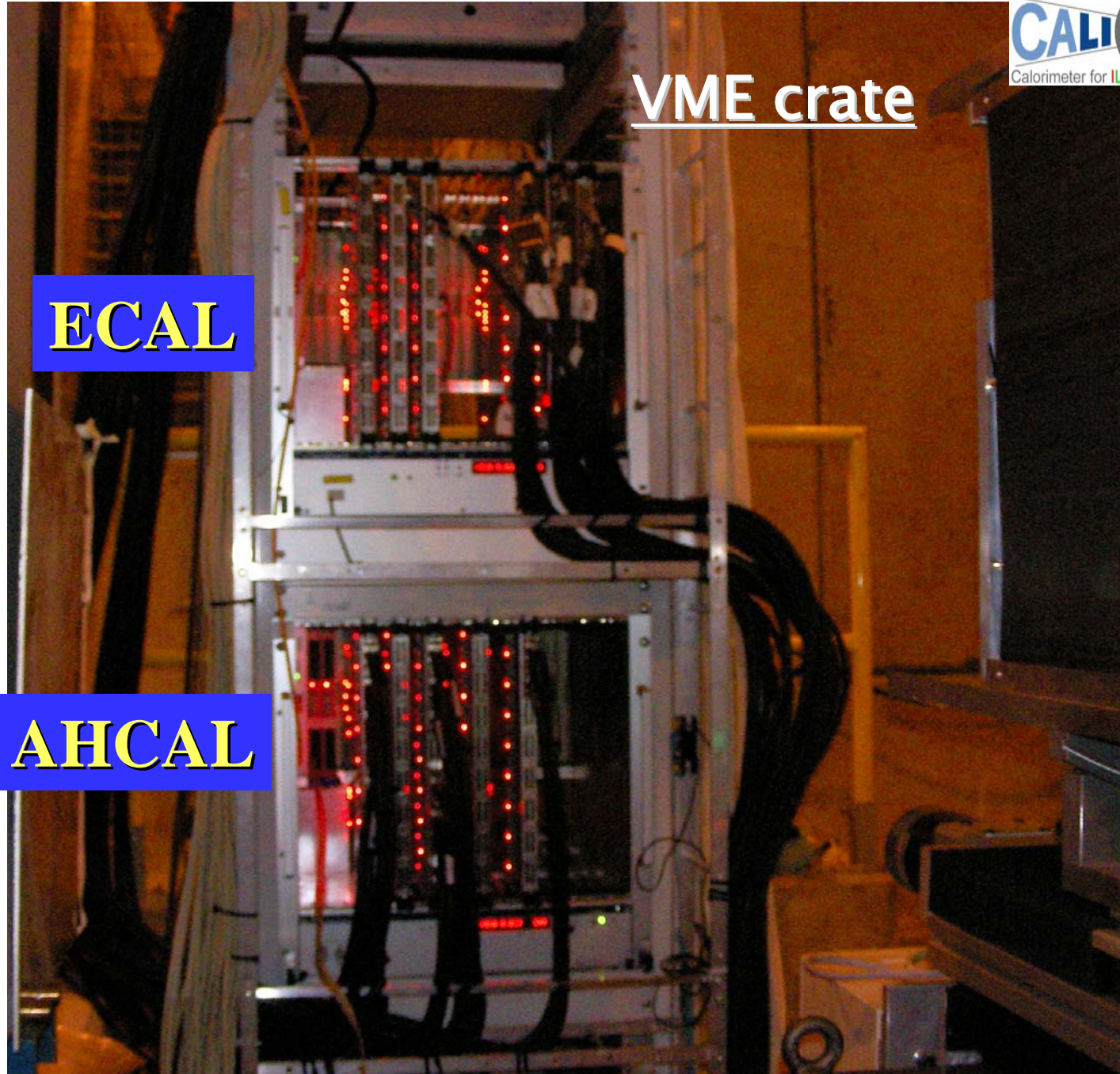
**Real experiments , VERY important step for debugging  
and to make the needed progress toward the final detector**

**DAQ**

VME crate

**ECAL**

**AHCAL**



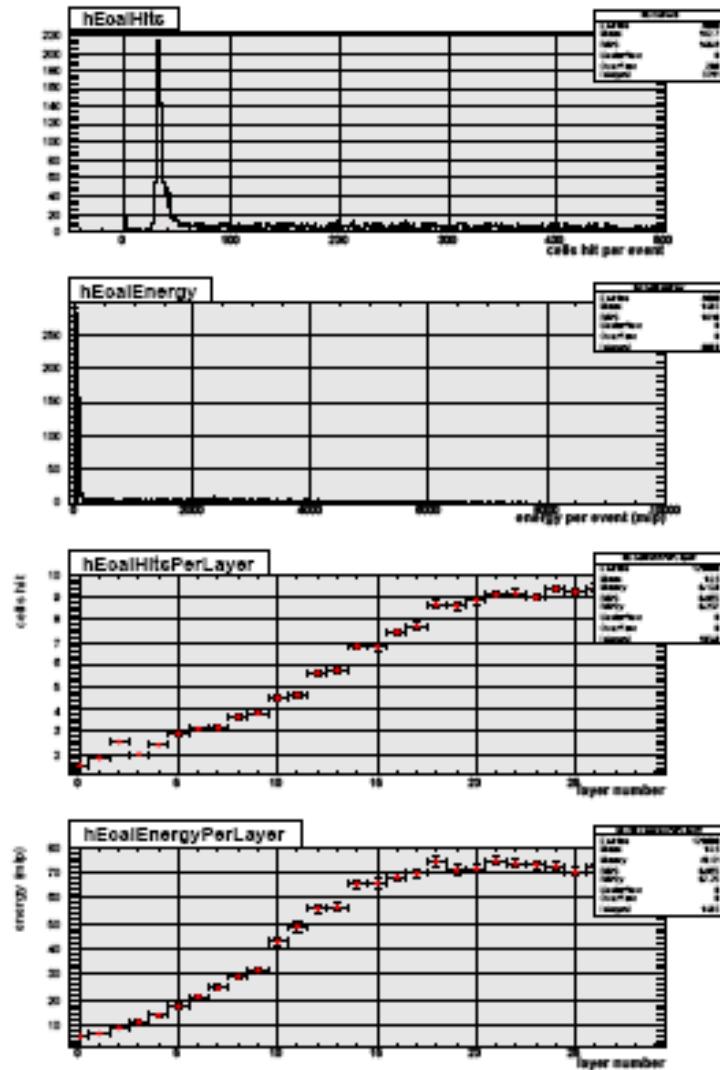
# DAQ

- 5 (ECAL) + 4 (AHCAL+TCMT+veto+PIN+trigger) CRC boards used
- Weakest hardware piece: NIM crate (twice replaced)
- All beam component successfully integrated (Ch, MWPC, veto, triggers)
- **Excellent performance** thereafter:
  - **120 Hz max average rate, ~500 Hz peak rate in spill**
- Stable operation, **continuous running w/o failures**
- Data taking inefficiency related to:
  - human mistakes in DAQ handling (selection of triggers, start up procedure)
  - missing communication to beam database
- Special develop. for TCMT achieved in time before operation required very complex firmware update (one CRC only)
  - gives  $O(10^{-5})$  bad readout in one CRC (no effect for ECAL&AHCAL)

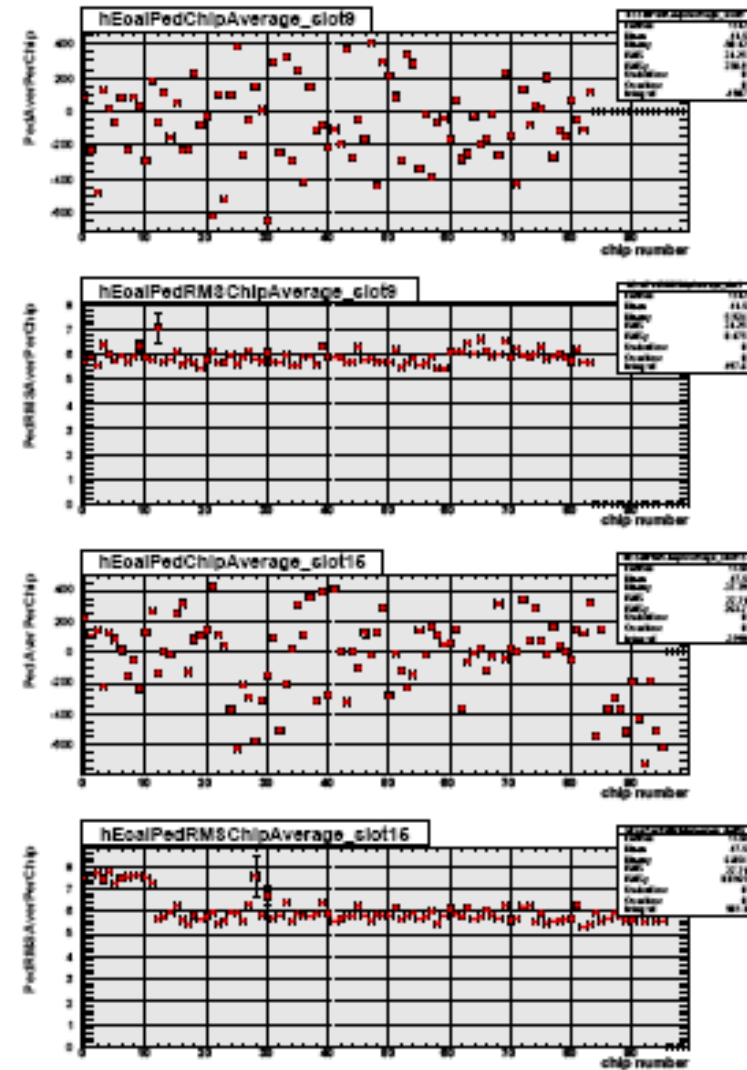
→ In general: **DAQ has fulfilled all expectations!!!**

# On-line monitoring

## ECAL Response



## ECAL Pedestals/Noise

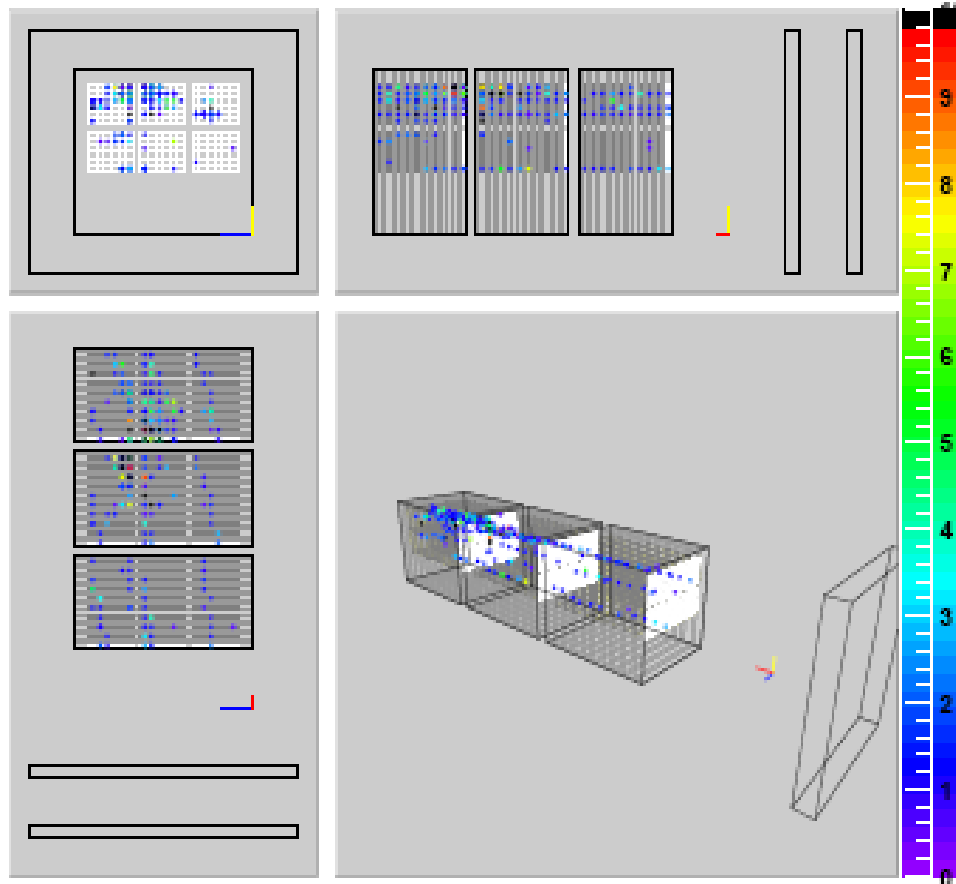


## ECAL Display

Run 300329:0 Event 1240

Time: 17:15:21:676:663 Mon Aug 28 2006

Hits: 252 Energy: 1123.32 mips

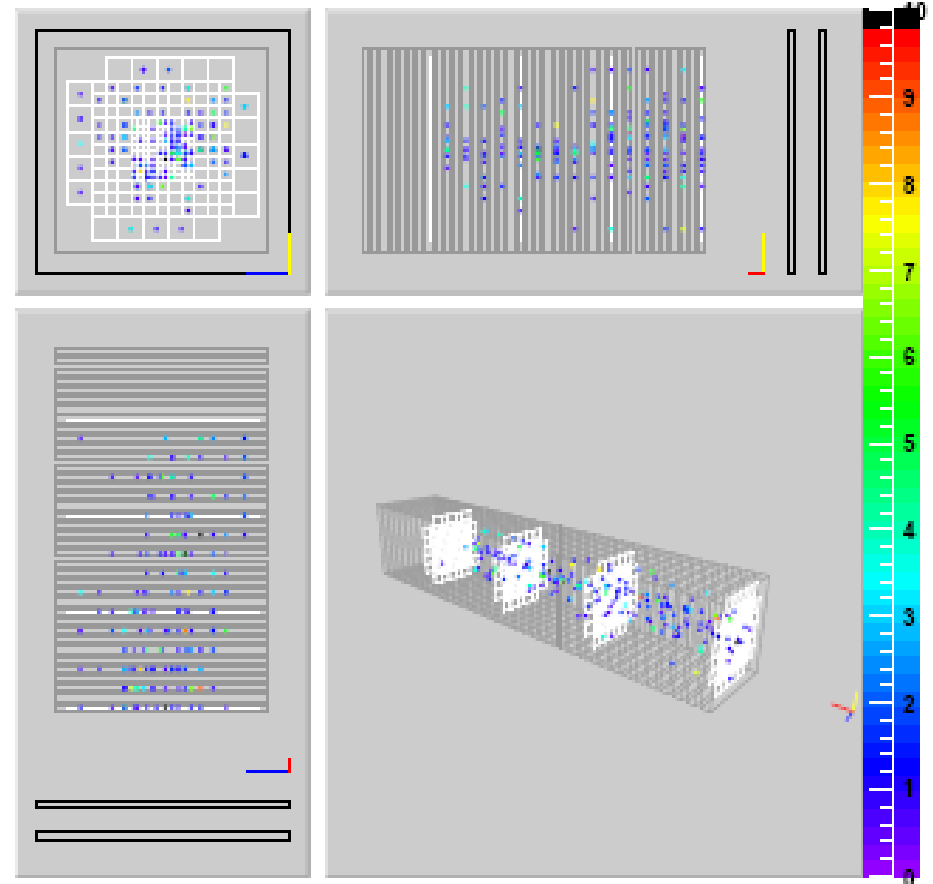


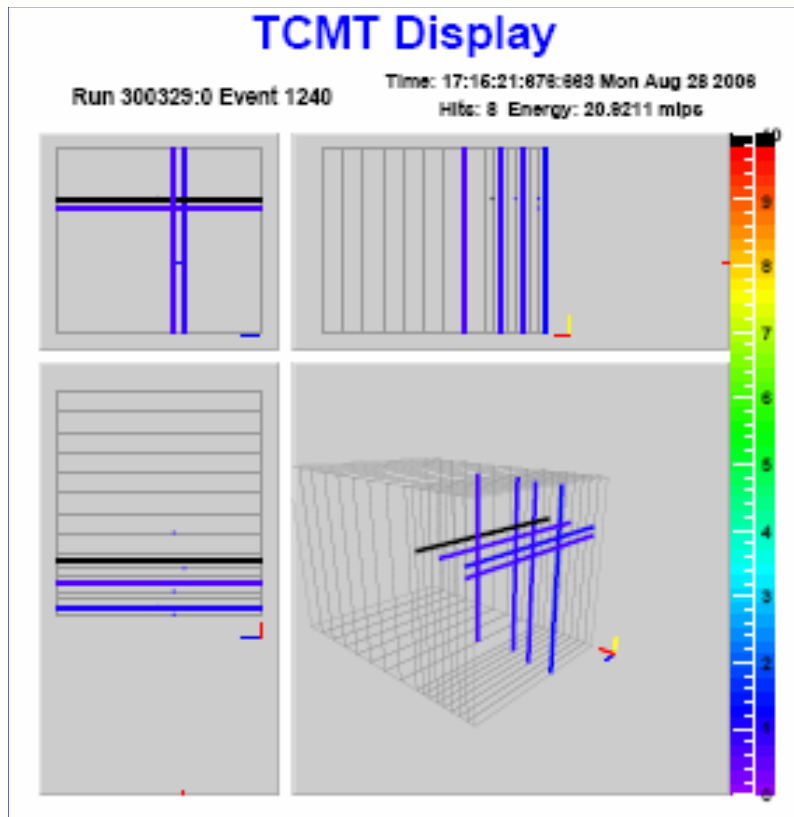
## HCAL Display

Run 300329:0 Event 1240

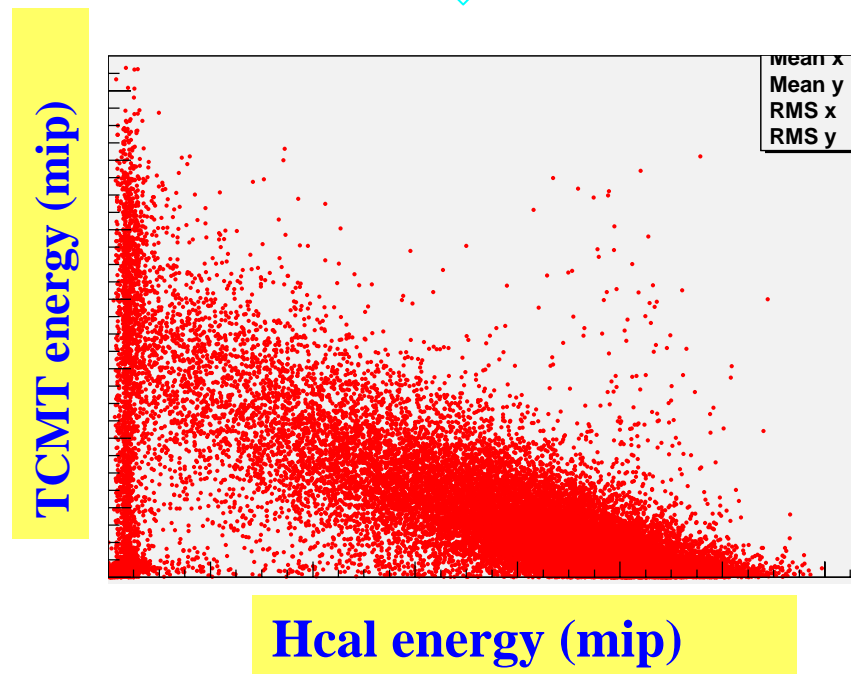
Time: 17:15:21:676:663 Mon Aug 28 2006

Hits: 197 Energy: 431.805 mips





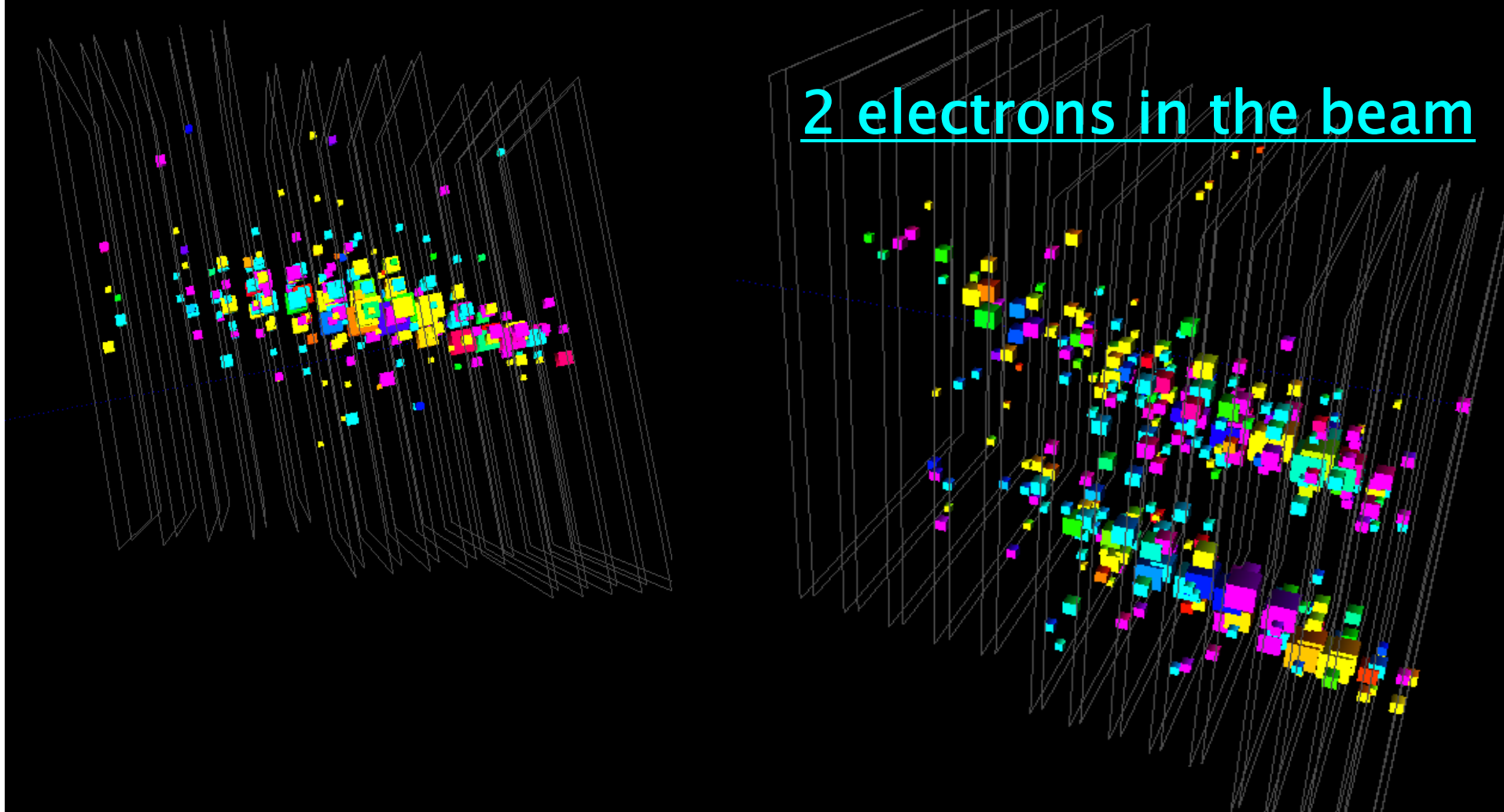
- After a very short time for commissioning
- After a very short time to integrate in DAQ
- After very crude calibration

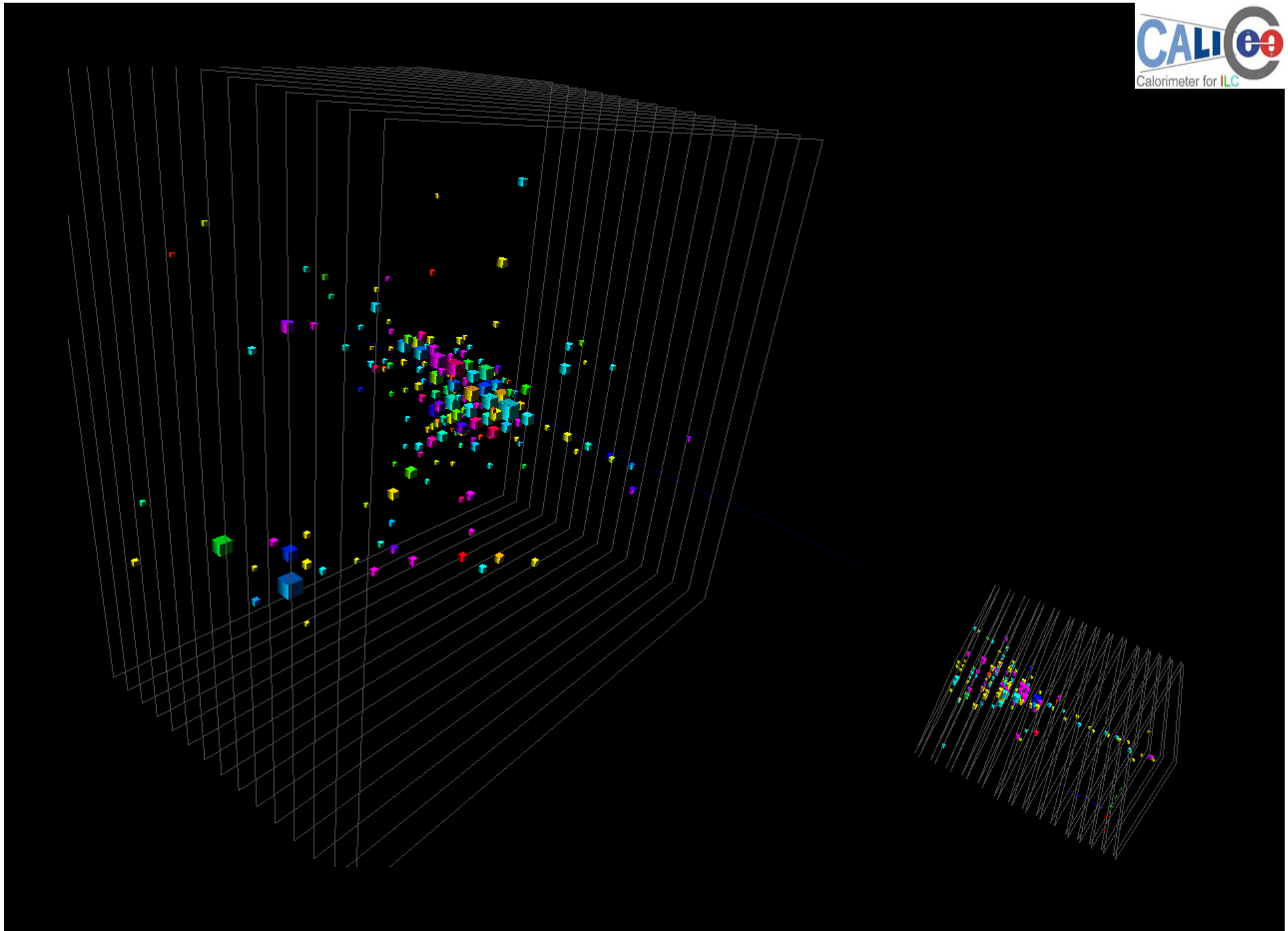


Great success for our  
CALICE-US colleagues

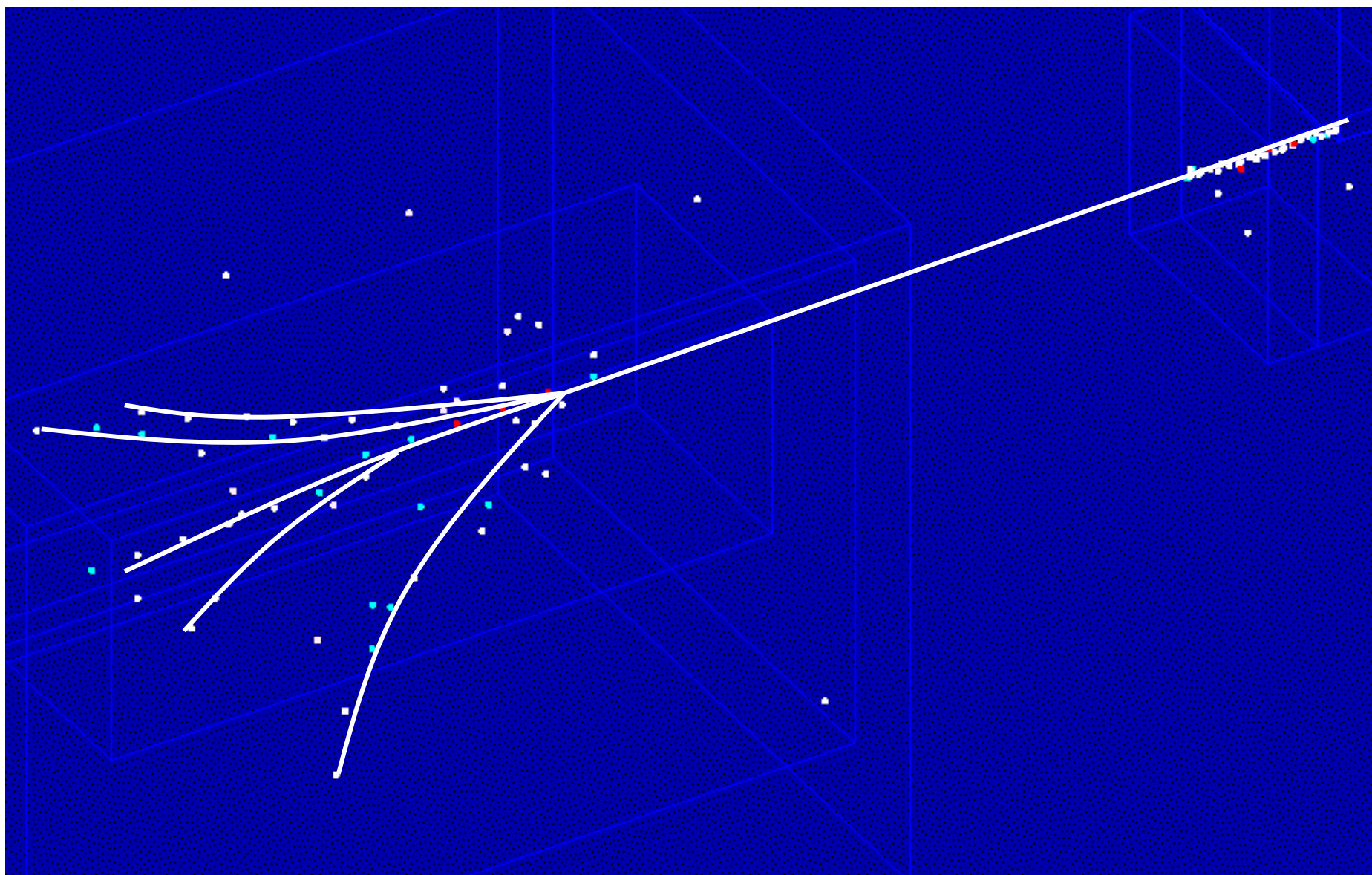


## 2 electrons in the beam

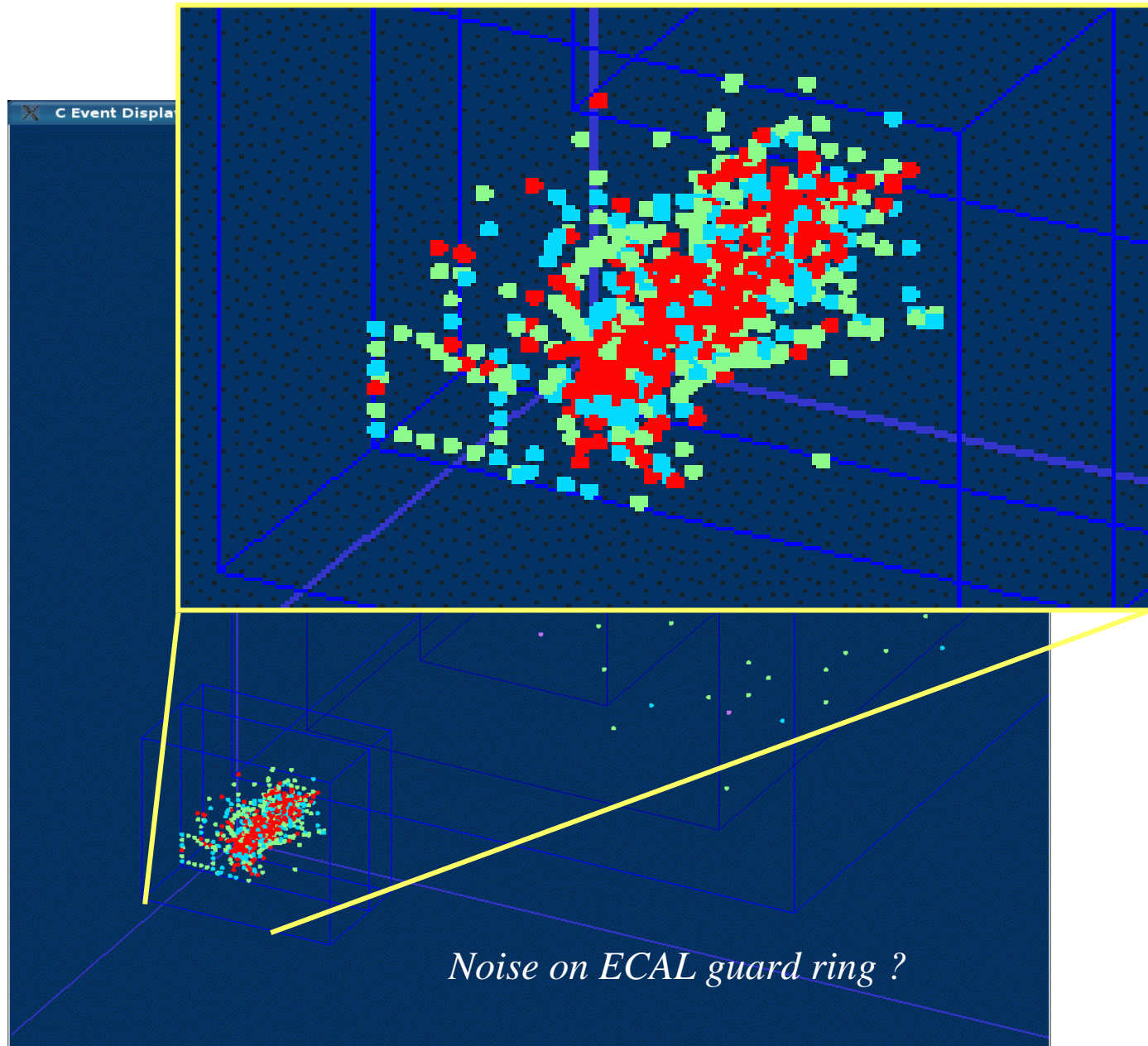


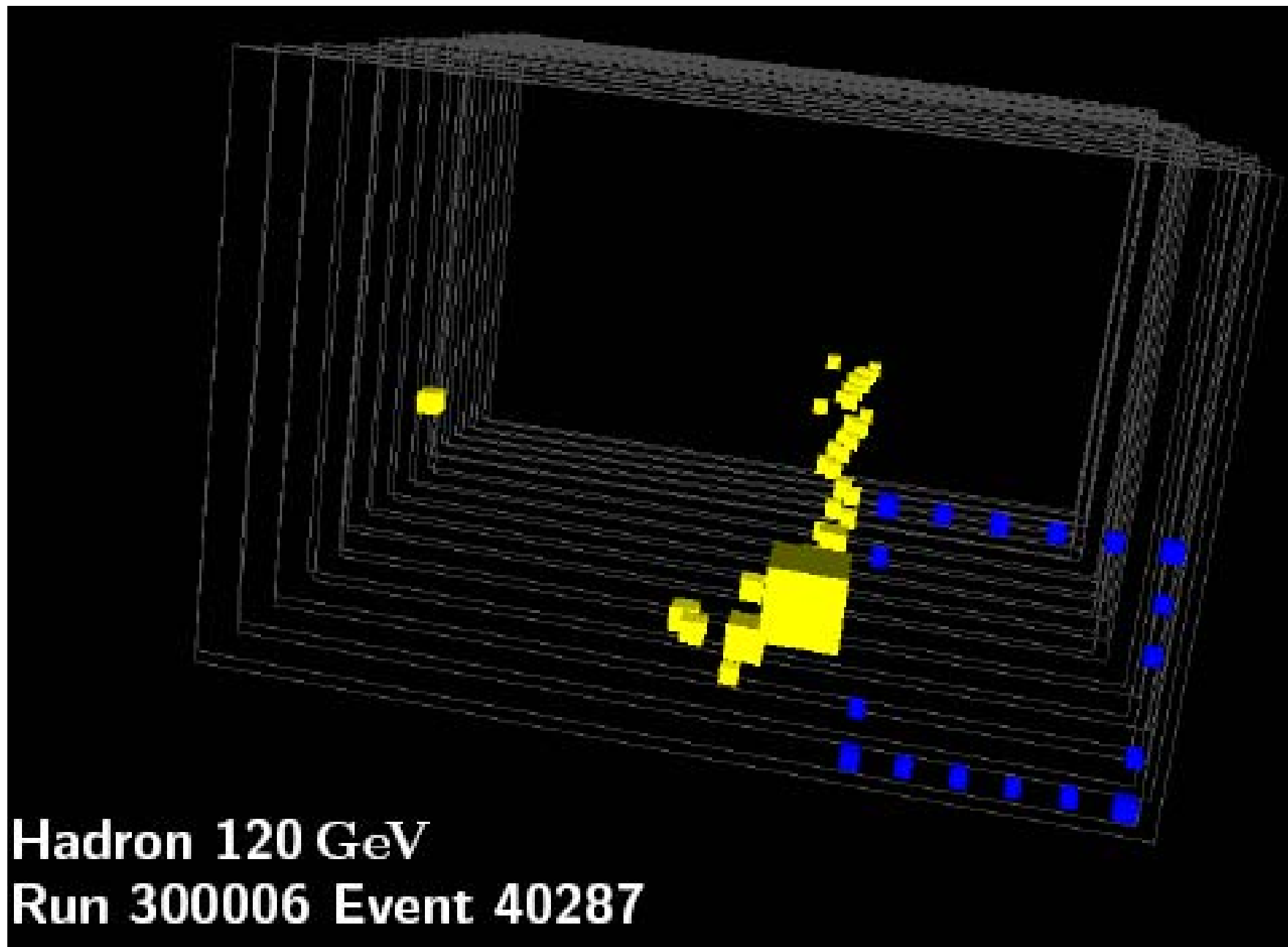


# PFA on hadronic shower in TEST BEAM



# Example of technology debugging





**Hadron 120 GeV**  
**Run 300006 Event 40287**

# A first summary of CERN data taking

(Before last period in October)

## Some numbers:

- Total data taking time is about 25 days
- people on shift ~ 56
- beam duty cycle (during running time) ~ 60%
- detector up time > 90% (including ECAL + AHCAL + TCMC + DAQ)

## Some comments:

- + very nice experience of cooperation within the collaboration
- + we are capable to deal with the expected and the unexpected
- + the detector is robust and reliable
- +/- the tools we have available online are good but need improvements
- difficult organization with other users / machine
- slow learning curve on beam quality

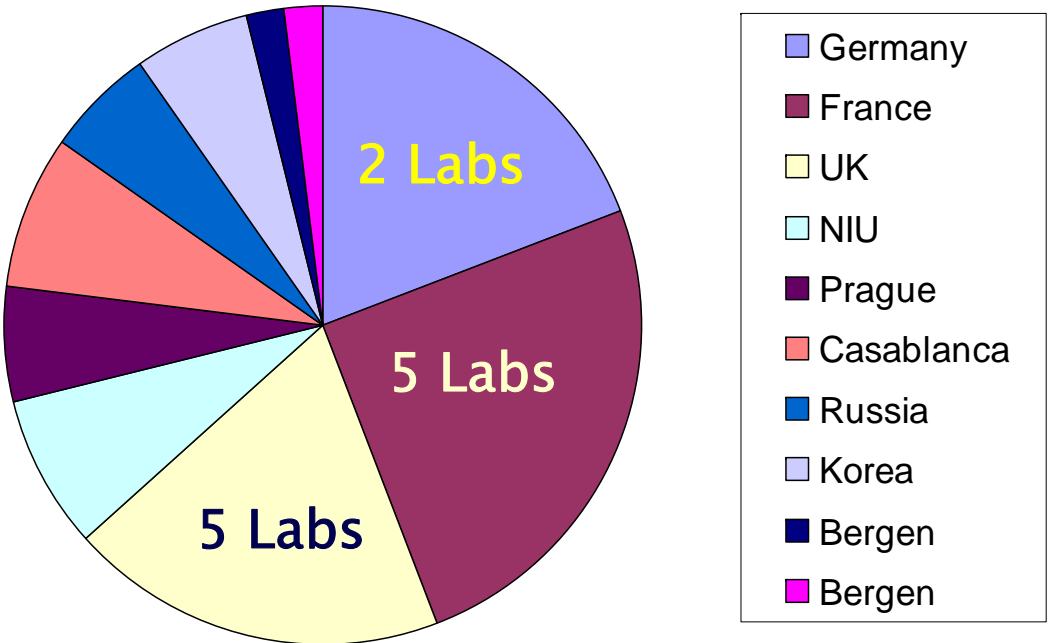
international linear collider



**56 people in shift** \* !!! from 9 countries and as much of engineers on board for the more specific technical aspect

Not yet officially but in close discussion

Statistics CERN TB (people in shift)



**ADDITIONAL TB@FNAL**  
 DHCAL "slices test"  
 8 layers of small size, carried out by CALICE US- DHCAL

no entry for Indian and Japanese crews  
 Joining CALICE too late for the TB period

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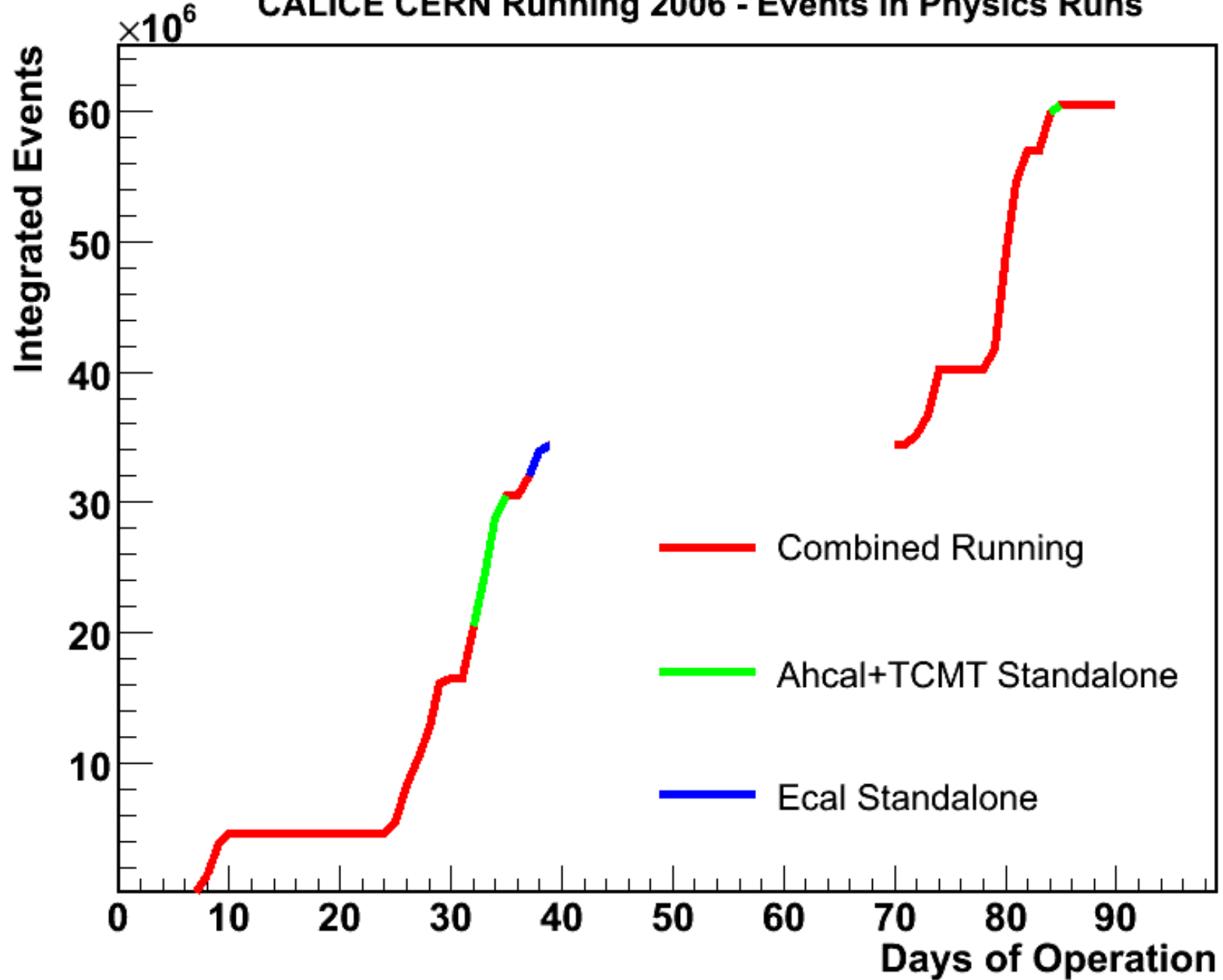
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“At CERN, the accelerator crew, the experimental area team and me were all very impressed by the excellent prepared, professionally organised and efficiently carried out beam-test from you and your collaborators.” C.Rembser (CERN)



# CALICE CERN Running 2006 - Events in Physics Runs



# In real world ,we also need computing...

Hosted by DESY: [Data access and processing on the grid \(VO CALICE\)](#)

Page for registration is <https://grid-voms.desy.de:8443/voms/calice>

Virtual Organization Membership Service

The calice VO Administration » Users » List of users

There are 28 users in /calice :

<a href="#">/C=UK/O=eScience/OU=Birmingham/L=ParticlePhysics/CN=nigel watson</a>	<a href="#">edit</a>	<a href="#">remove</a>
<a href="#">/C=UK/O=eScience/OU=Cambridge/L=UCS/CN=david ward</a>	<a href="#">edit</a>	<a href="#">remove</a>
<a href="#">/O=GermanGrid/OU=DESY/CN=Roman Poeschl</a>	<a href="#">edit</a>	<a href="#">remove</a>
<a href="#">/C=UK/O=eScience/OU=Imperial/L=Physics/CN=anne-marie magnan</a>	<a href="#">edit</a>	<a href="#">remove</a>
<a href="#">/DC=org/DC=doegrids/OU=People/CN=Guilherme Lima 269451</a>	<a href="#">edit</a>	<a href="#">remove</a>
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<a href="#">/O=GRID-FR/C=FR/O=CNRS/OU=LLR/CN=Goetz Gaycken</a>	<a href="#">edit</a>	<a href="#">remove</a>
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<a href="#">/O=GRID-FR/C=FR/O=CNRS/OU=LPSC/CN=Laurent Morin</a>	<a href="#">edit</a>	<a href="#">remove</a>
<a href="#">/O=Grid/O=NorduGrid/OU=ift.uib.no/CN=Trygve Buanes</a>	<a href="#">edit</a>	<a href="#">remove</a>
<a href="#">/O=GRID-FR/C=FR/O=CNRS/OU=LAL/CN=Henqne Li</a>	<a href="#">edit</a>	<a href="#">remove</a>
<a href="#">/O=GRID-FR/C=FR/O=CNRS/OU=LAL/CN=Manqi Ruan</a>	<a href="#">edit</a>	<a href="#">remove</a>

26 Members  
... and  
counting

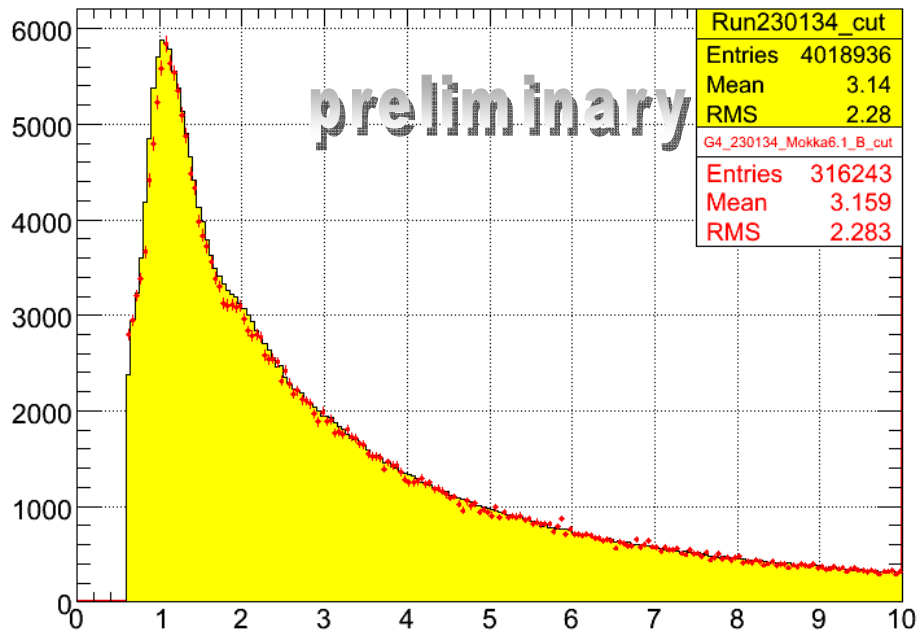
VO Manager: R.Poeschl/LAL, Deputy: A. Gellrich/DESY

# DATA ANALYSIS

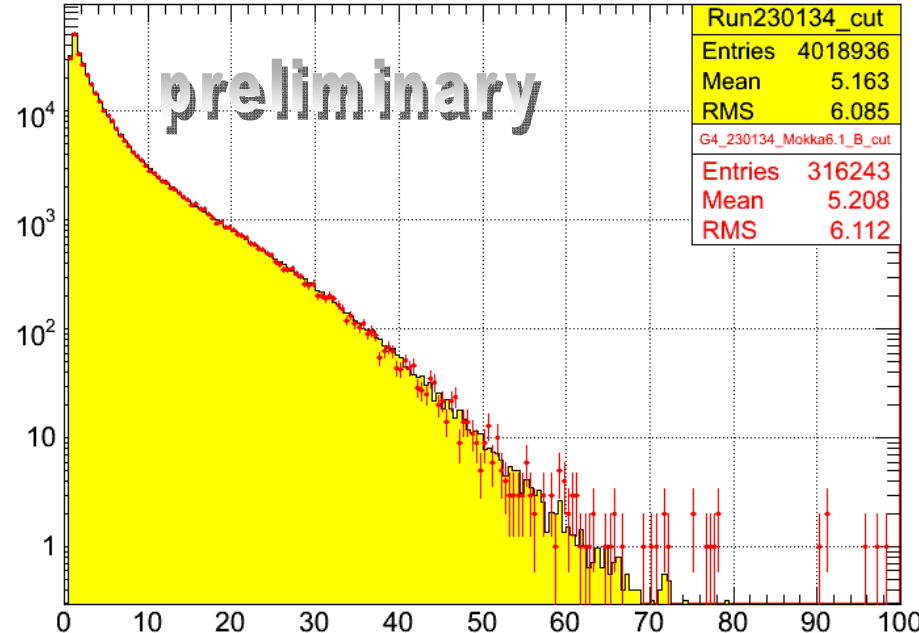
Start comparison data/MC

3 GeV electrons – hit energies

E Ecal hits /mips



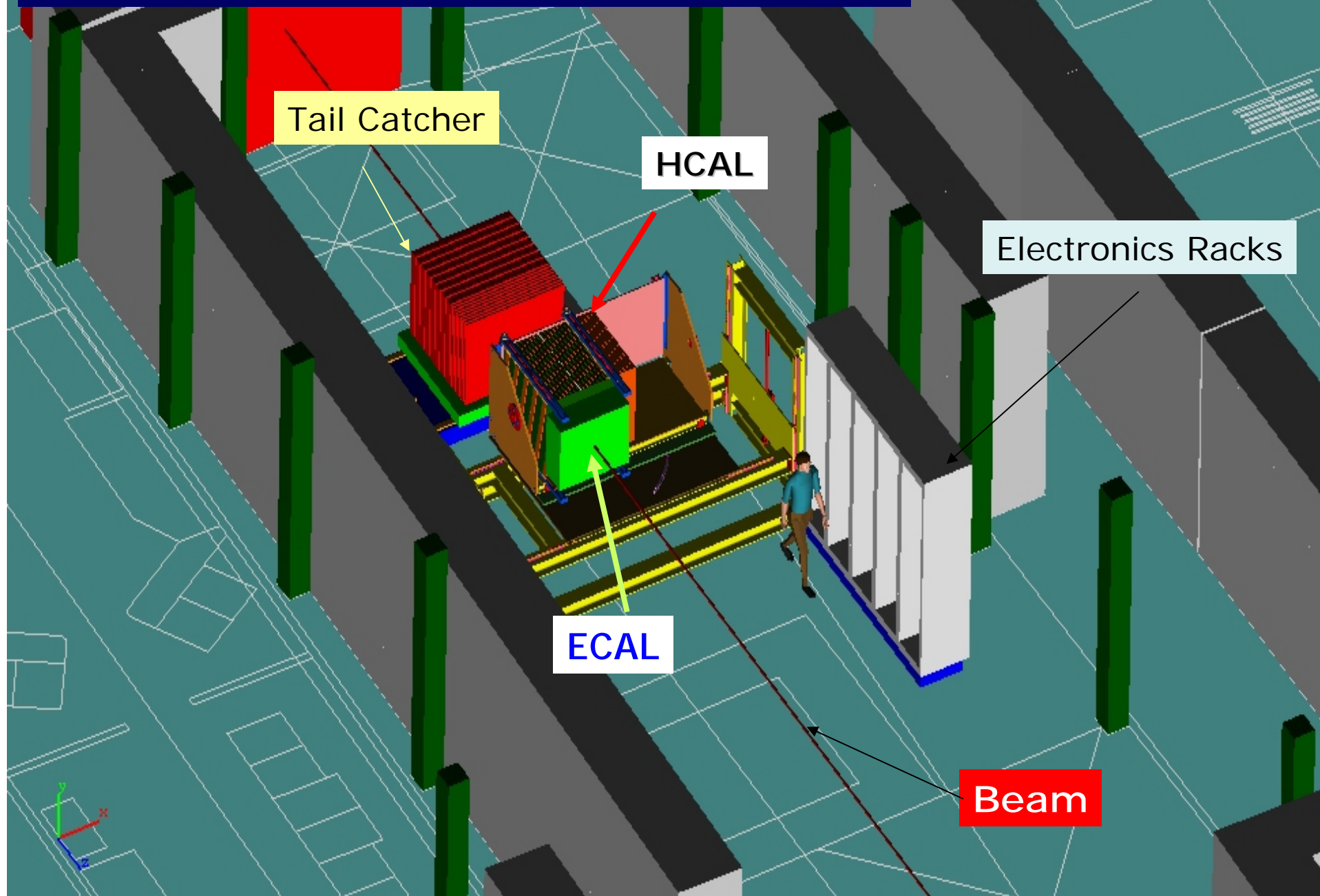
E Ecal hits /mips



# Next steps

- 2007 - 2008 test beam period
  - DESY ECAL scintillator strips in TB in February–March 2007
  - CERN will ask for additional TB in May–September 2007
  - FNAL– MTBF will ask for installation at Fermilab, September–October 2007  
(low energy beam)
- 2009 - EUDET : Construction of ½ ECAL module ,  
an important part of a Digital HCAL module (or 1 m<sup>3</sup>)  
an important part of an Tile HCAL module

# Possible setup at FNAL MTBF



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- 2009 - EUDET : Construction of ½ ECAL module ,
  - an important part of a Digital HCAL module (or 1 m<sup>3</sup>)
  - an important part of an Tile HCAL module



Next steps

## EUDET Detector R&D towards the International Linear Collider

### Mission

EUDET is a project supported by the European Union in the Sixth Framework Programme structuring the European Research Area. The project comprises 31 European partner institutes from 12 different countries working in the field of High Energy Physics. In addition, 20 associated institutes will contribute to and exploit the EUDET research infrastructures which aim to support the detector R&D in Europe for next large particle collider project, the ILC.

### EUDET comprises of the following Scientific Activities:

- \* JRA1 Test Beam Infrastructure
- \* JRA2 Infrastructure for Tracking Detectors
- \* JRA3 Infrastructure for Calorimeters
- \* NA1 Management of I3
- \* NA2 Detector R&D Network
- \* TA1 Access to DESY Test Beam Facility
- \* TA2 Access to R&D Infrastructure

Example next slide

# SILC @ DESY



Test set-up 1: Two CMS modules  
First one read out by 4VA1  
Second one read out by  
VA1&180nmUMC

Test set-up 2: One GLAST module  
Read out by VA1&180nmUMC

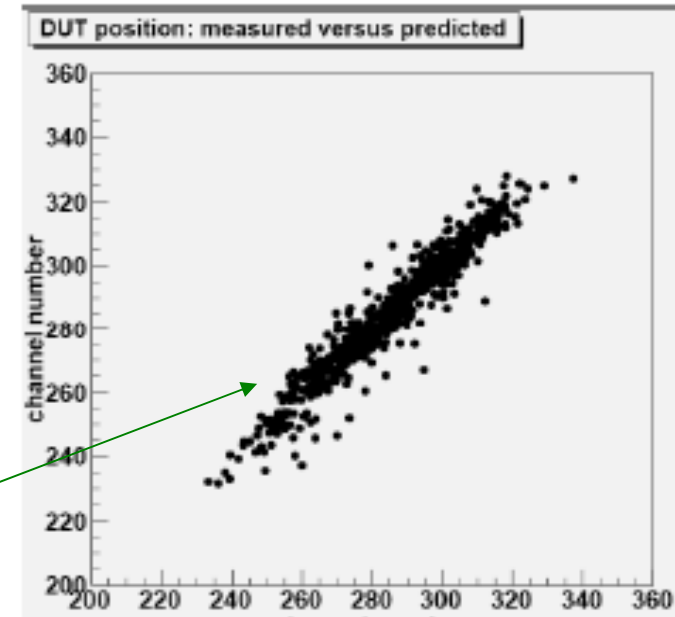


Position correlation between  
silicon detector beam telescope

## Test Beam at DESY

16 peoples from 6 institutes

HIP-Helsinki, IEKP-Karlsruhe  
OSU-Russia, LPNHE-Paris,  
CU Prague, IFCA-Santander





# Next steps in calorimetry

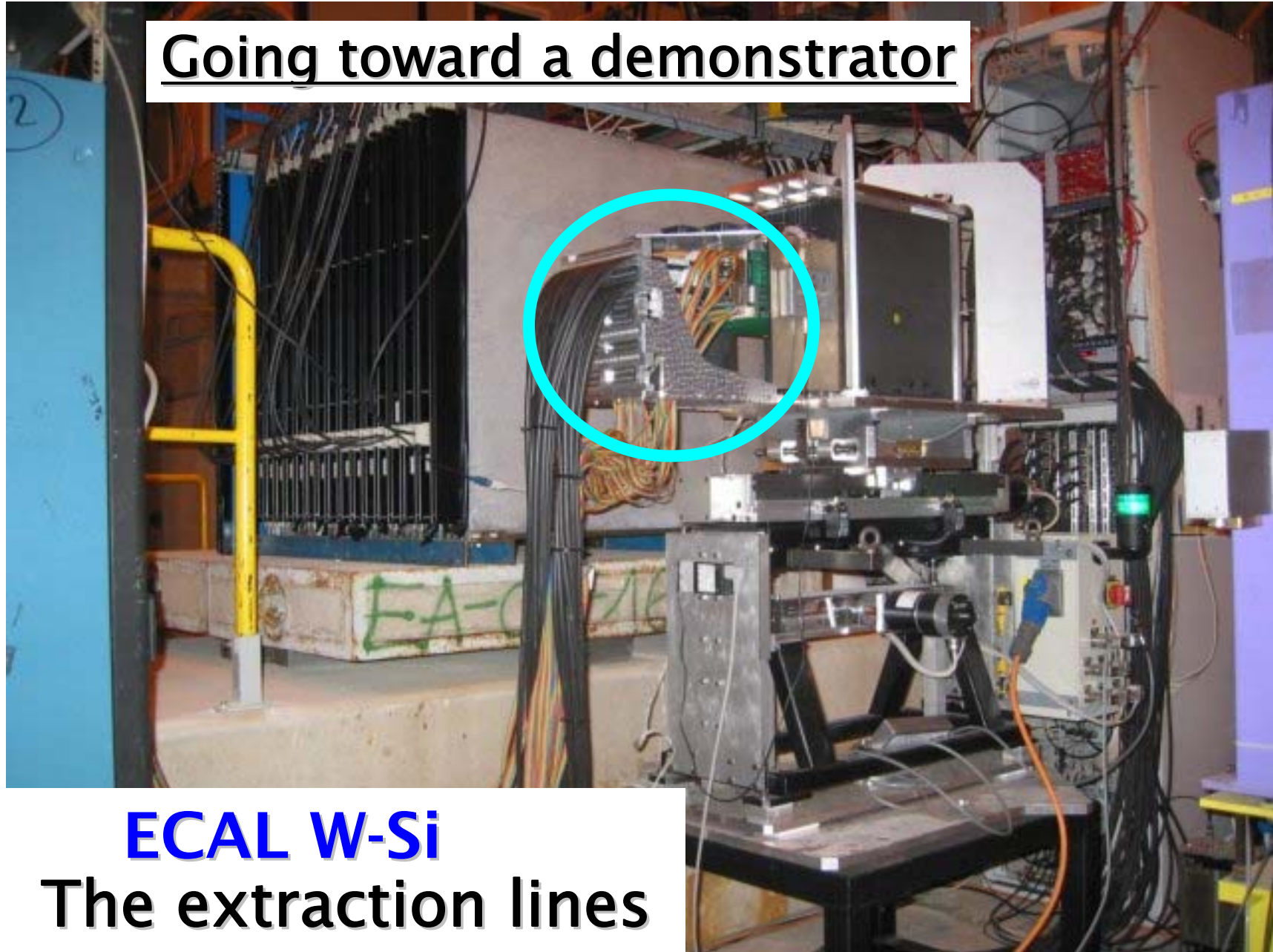
- 2007 – 2008 test beam period
  - DESY ECAL scintillator strips in TB in February–March 2007
  - CERN will ask for additional TB in May–September 2007
  - FNAL– MTBF will ask for installation at Fermilab, September–October 2007
- 2009 – EUDET : Construction of  $\frac{1}{2}$  ECAL module ,  
an important part of a Digital HCAL module (or 1 m<sup>3</sup>)  
an important part of an Tile HCAL module



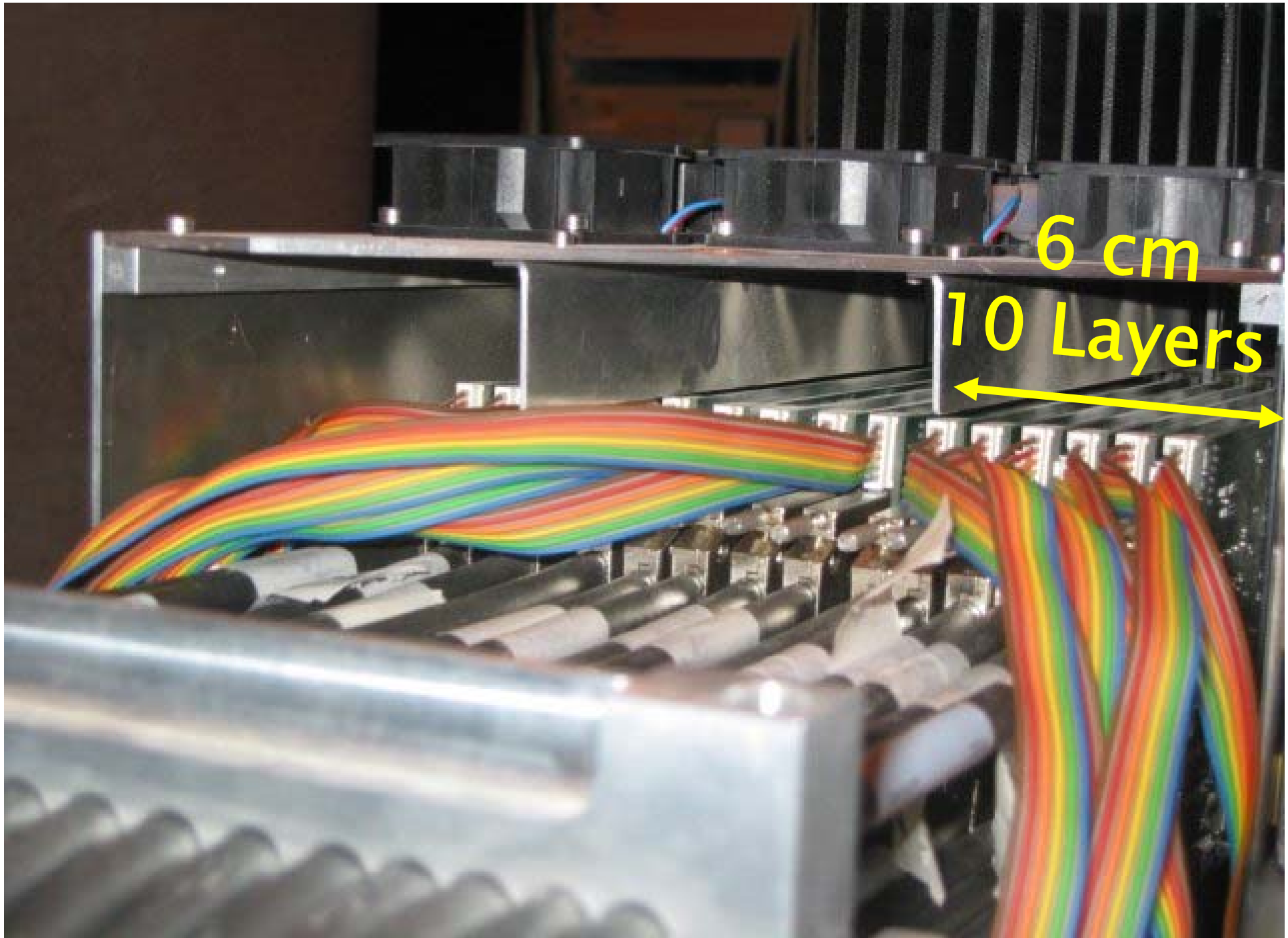
## Second step : the demonstrator

- Solve problems found in the first prototype
- Design and built a new ECAL and AHCAL device as close as possible to the final detector
- **Design and built a Digital HCAL demonstrator**

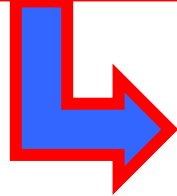
Going toward a demonstrator



**ECAL W-Si**  
**The extraction lines**



Most of the detector concepts propose to have the VFE inside !!  
Never tested at the maximum of the shower and for HE electrons

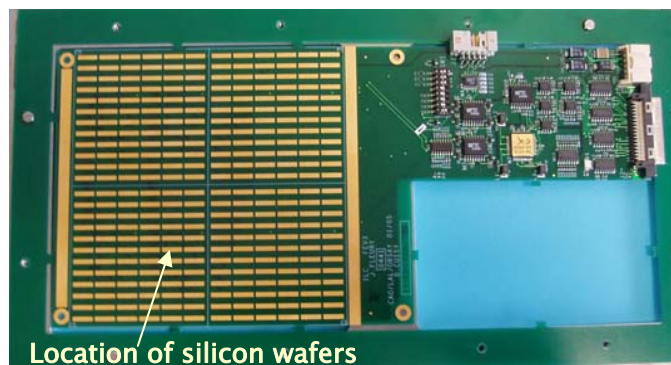


**CERN test beam 100 GeV electrons**  
Shoot on the VFE chip at the maximum of the shower

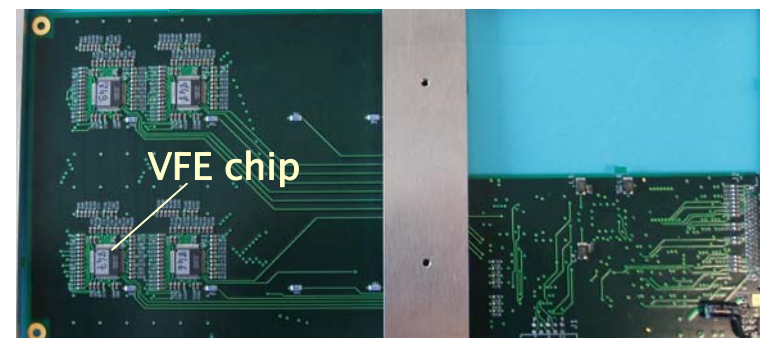
Test of the behaviour of the VFE chip in high energy em shower

New PCB with chip inside the detector

Front side



back side



These data are under analysis

## Summary and conclusion

- > FCAL in TB with crucial test of silicon/diamond sensors radiotolerance
- > CALICE data take 60M interactions !! (about 20 Tbytes)
- > Reconstruction of the data on the grid CALICE-VO
- > Simulate the test beam and distribute it on the grid
- > ...
- > [Problem of VISA for our Russian colleagues](#)

TEST beam (i.e. in CALICE) are mandatory to test and debug all the concepts developed for ILC detector in the

- > The hardware technology (mechanics, electronics, DAQ, etc..)
- > The software (VCR, Simul. and Rec. on the grid)

### Personal comment

A project like the ILC is the one from a community (Accelerator, Detector & Physics). The test beam period is a very good way to strengthen the detector community and to feel that [we are a community](#)