The DHCAL Vertical Slice Test and beyond

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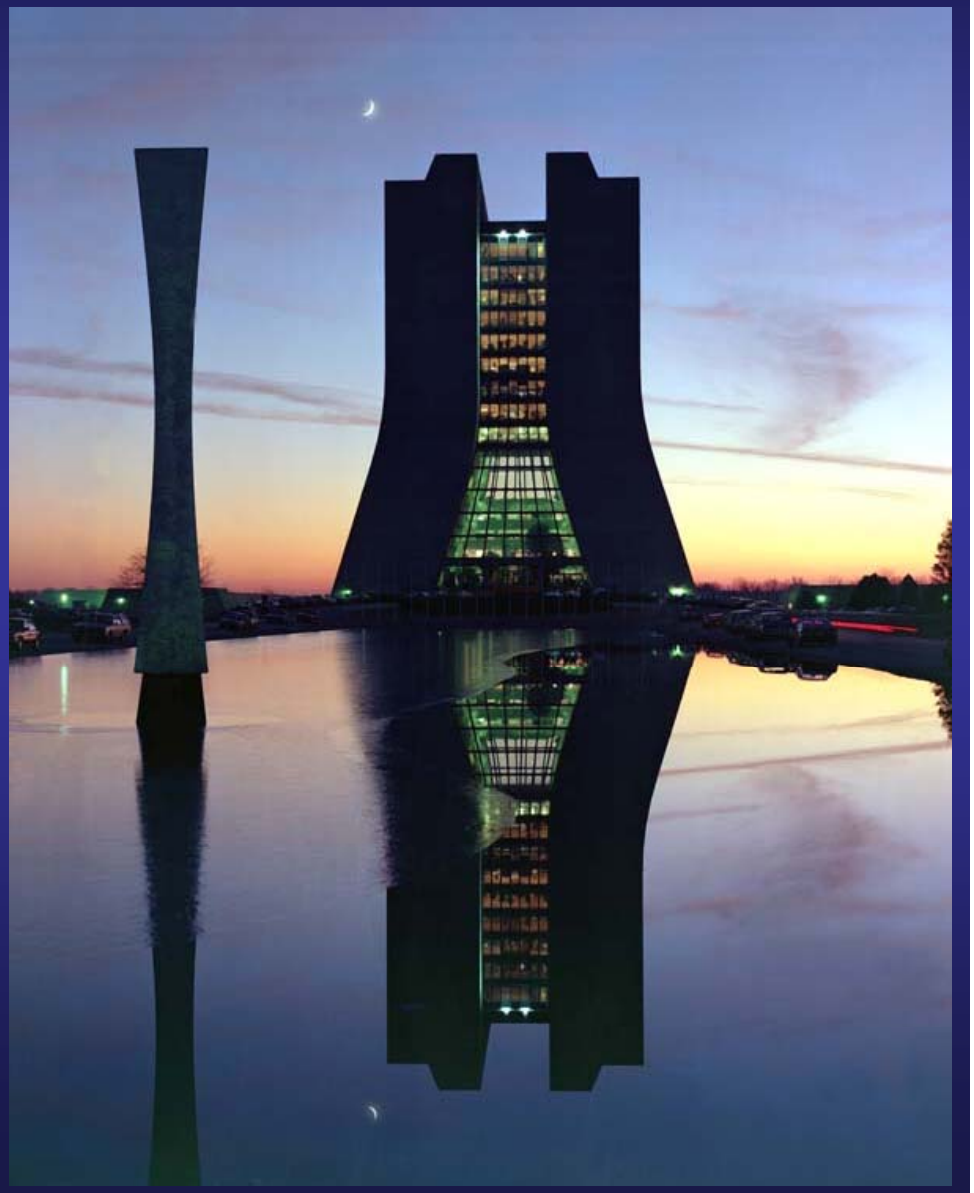
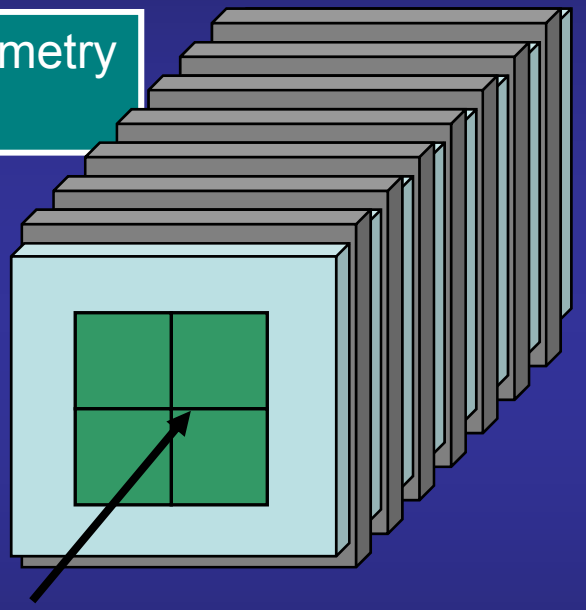


ALCPG Meeting
FNAL, October 22 – 26, 2007

Vertical Slice Test

Necessary step before beginning construction of prototype section
Where possible use identical hardware for what is needed for prototype section

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



Used some of the 104 front-end ASICs (DCAL)
from the 2nd prototype run

Equiped 9 chambers with 4 chips each

Chambers are 20 x 20 cm^2, rather than 30 x 100 cm^2
→ better exposure to showers in test beam
256 channels/chamber → **2300 channels total**

System designed such, that extension to 1 m^2 'natural' (but expensive)

Chambers interleaved with 20 mm steel-copper absorber plates
20 mm PVC plates with hole in middle (rate measurement)

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

CALICE Calorimeter for ILC

A short history

T970

MoU with FNAL – signed on July 16, 2007

Moved to FNAL – July 18th

Setup of experiment – July 19th (am)

Safety review – July 19th (pm)

Safety approval – July 20th (am)

First beam – July 20th (pm)

First events – July 21th (am)

Record Time

Shutdown – starting August 4th (pm)

Setup - configurations

Movable table

x – y motion (in 1(?)mm steps)
With remote control (from counting house)

RPC layer

(Default) Absorber

16 mm Steel + 4 mm Copper

Aborber for rate measurement

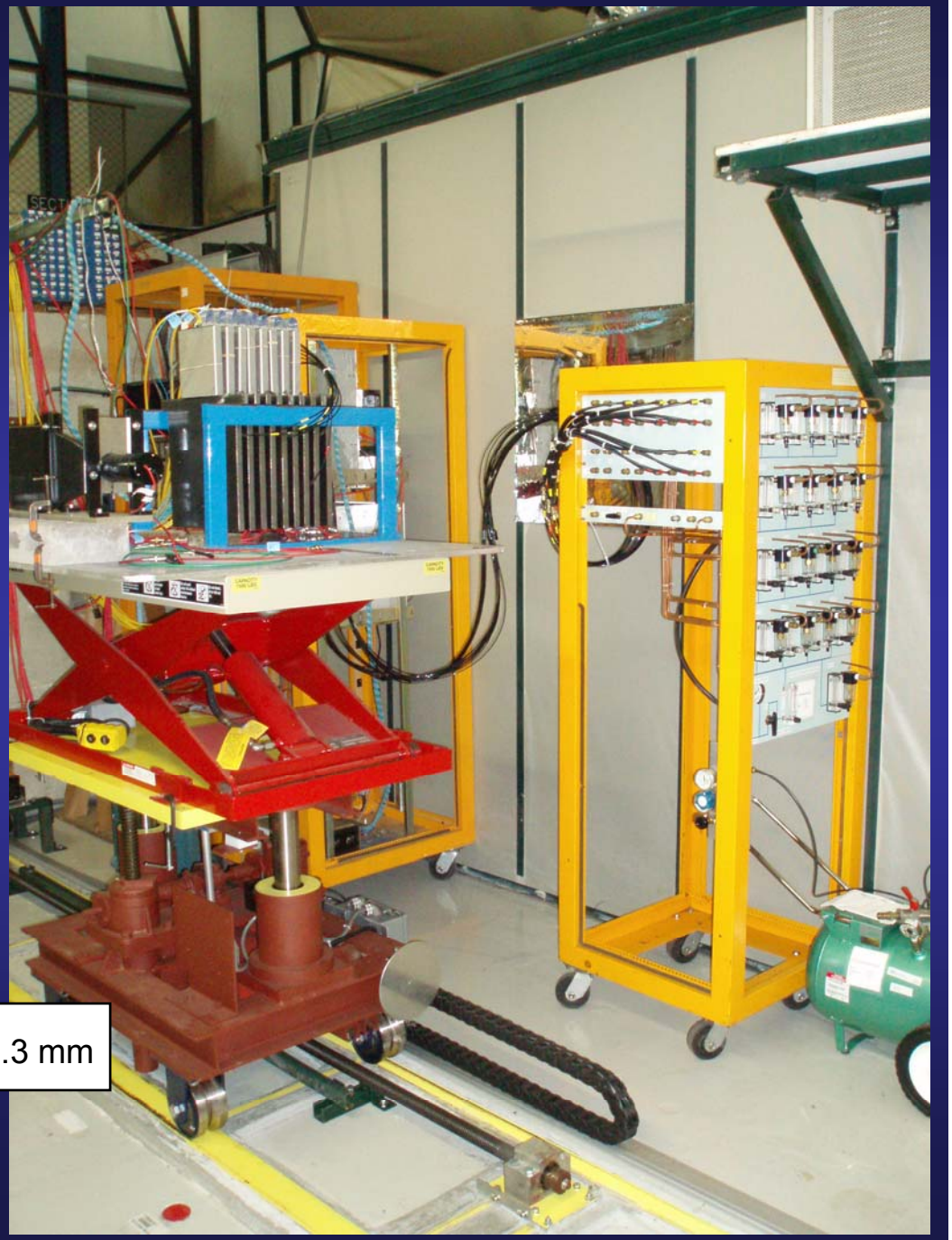
PVC with hole cut out

(Default) RPC with 2 glass plates
One (exotic) RPC with 1 glass plate only

Each layer 16 x 16 cm^2 (256 channels)

Thickness of individual layer:

Absorber	16+4 mm =	20.0 mm
RPC		3.7 mm
Pad- and FE board + ASICs		4.6 mm
Air		5.1 mm
Total		33.4 mm



Stack with 6 – 9 layers

Maximum number of channels → 2304

High Voltage

Using 1 Bertan unit for all default RPCs

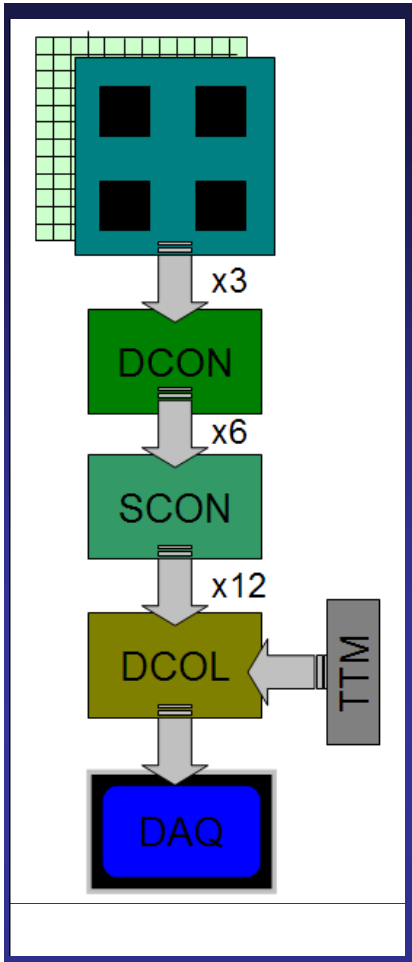
HV = 6.2 – 6.5 kV

Using separate Bertan unit for exotic RPC

HV = 5.9 – 6.1 kV

Gas system

Individual lines to each chamber
Premixed gas brought from ANL
Commercial premixed gas arrived at MTBF a week after the end of our test run!

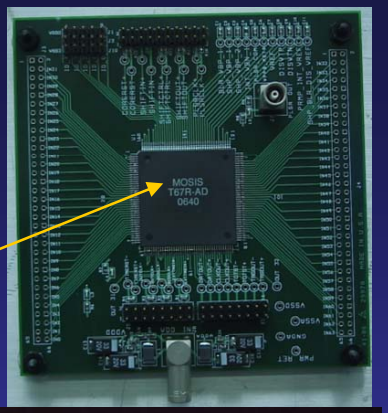


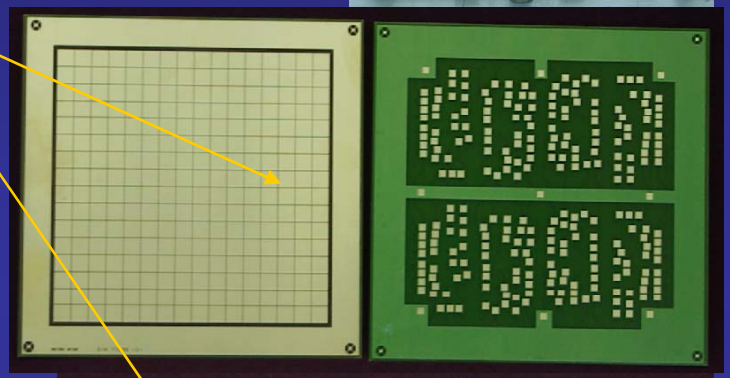
Electronic Readout System

Attempt to be as similar as possible to what's needed for the PS

Components

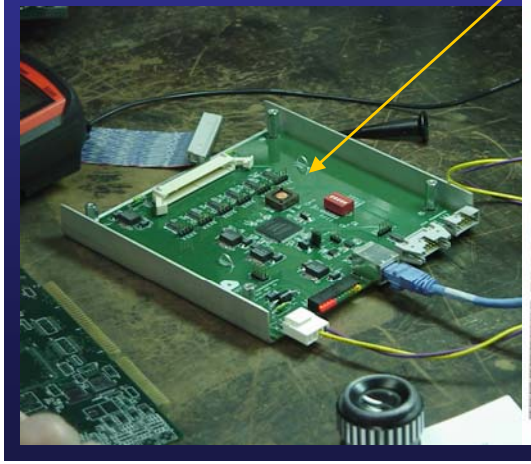
DCAL ASIC	ANL/FNAL
Pad-boards	ANL
Front-end boards	ANL
Data concentrators	ANL
Data collectors	Boston
Timing and trigger module	FNAL

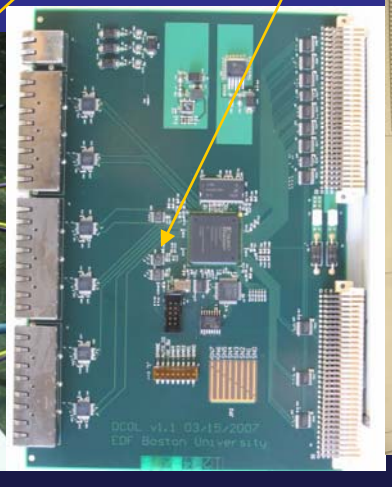


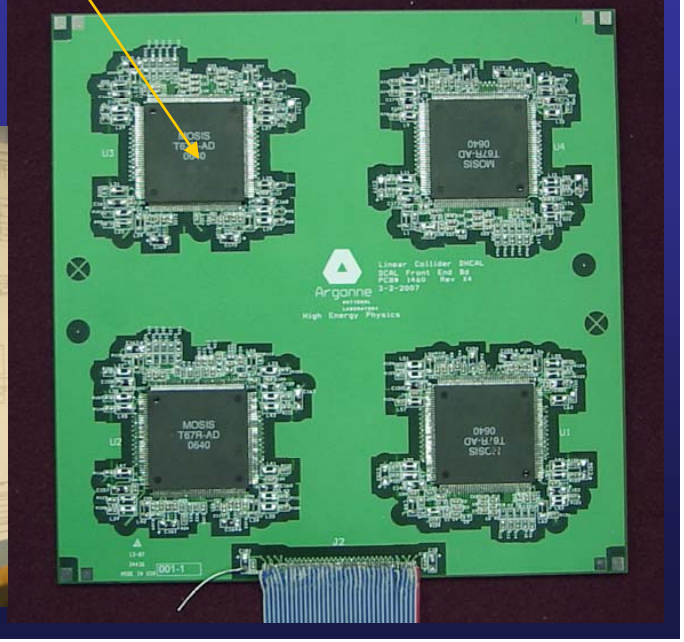


Prototyping and commissioning

Used 2nd round of DCAL prototypes
All other components: 1st prototypes
→ all worked very well







Trigger counters

Two 19 x 19 cm^2 scintillator panels
Initially used three 1 x 1 cm^2 finger counters
(imaging calorimeter makes these redundant)

Additional Fe Absorber

For muon runs at 2 GeV/c stacked additional Fe blocks in front of RPCs

~ 50 cm deep corresponding to 3 λ_I
→ 97% of π interact
→ ΔE_μ ~ 600 MeV

Running conditions

Beam between 6:00 – 18:00 daily
1 spill every minute with 4 sec flat top
Interruptions due to Tevatron shots/machine problems (rare…)

Rate adjusted to RPC recovery time

MTBF

Very positive experience

Machine people very cooperative!

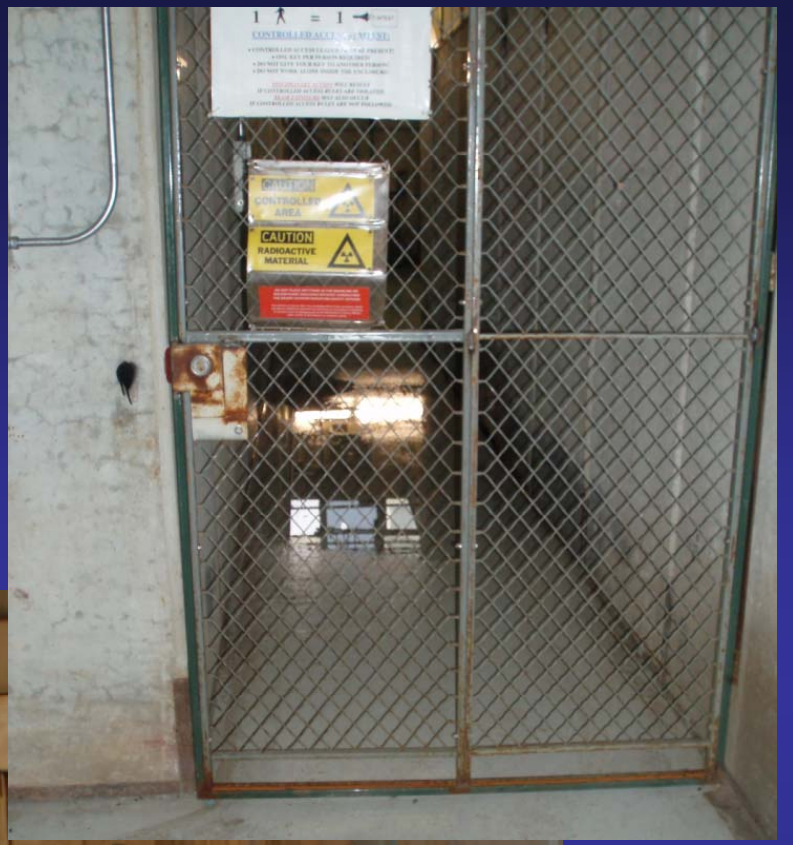
Beams reliable and only short interruptions

Roof still leaking, but fixed in the meantime

New laser alignment system (very useful)

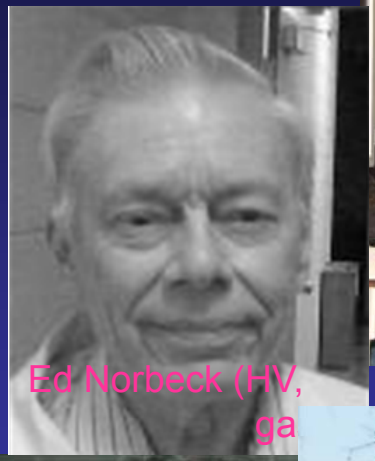
Nicely labeled cable panels in test area and counting house

User area greatly improved

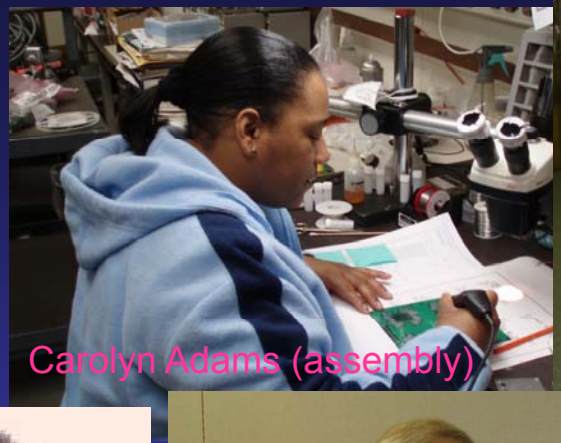


Pictures from the past…

(Some) people


Ed Norbeck (HV, ga


Tim Cundiff (Pad-, FE-baords)


Carolyn Adams (assembly)


Dave Underwood (trigger, data taking)

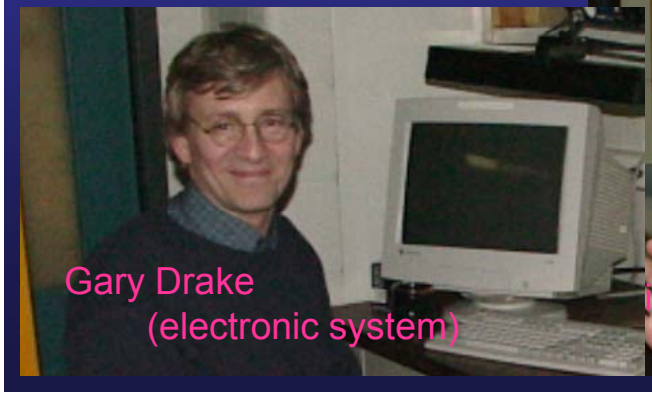

Shouxiang Wu (DCOL)


José Repond (coordination, offiline)


Georg Mavromanolakis (event display)


Bill Haberichter (DCOL)


Eric Hazen (DCOL)


Gary Drake (electronic system)


Xia (RPC, data taking, offline)


Andrew Kreps (slow control)


Ed May (DAQ, data taking)

Problems

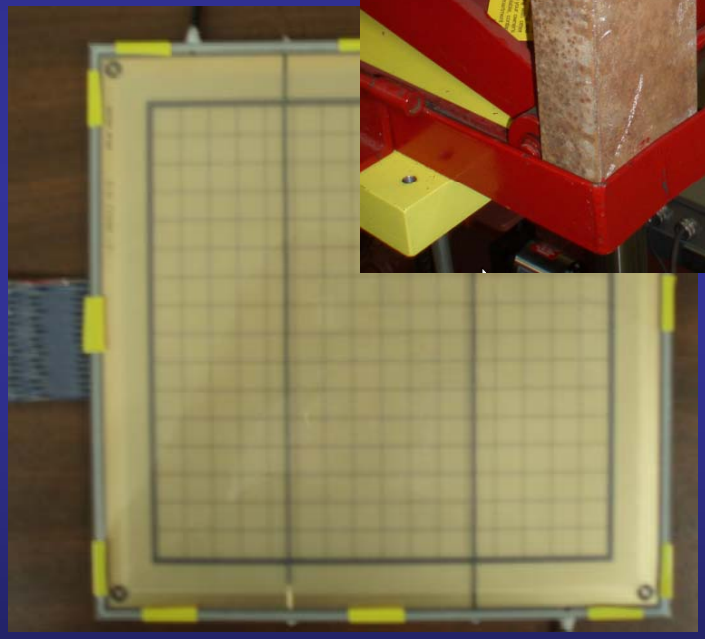
Scanning table

Sagging
→ solution

No show stoppers

Humidity

Rain into the bulding (roof being repaired)
Very humid conditions
→ changes in the surface resistivity
→ a few HV break downs

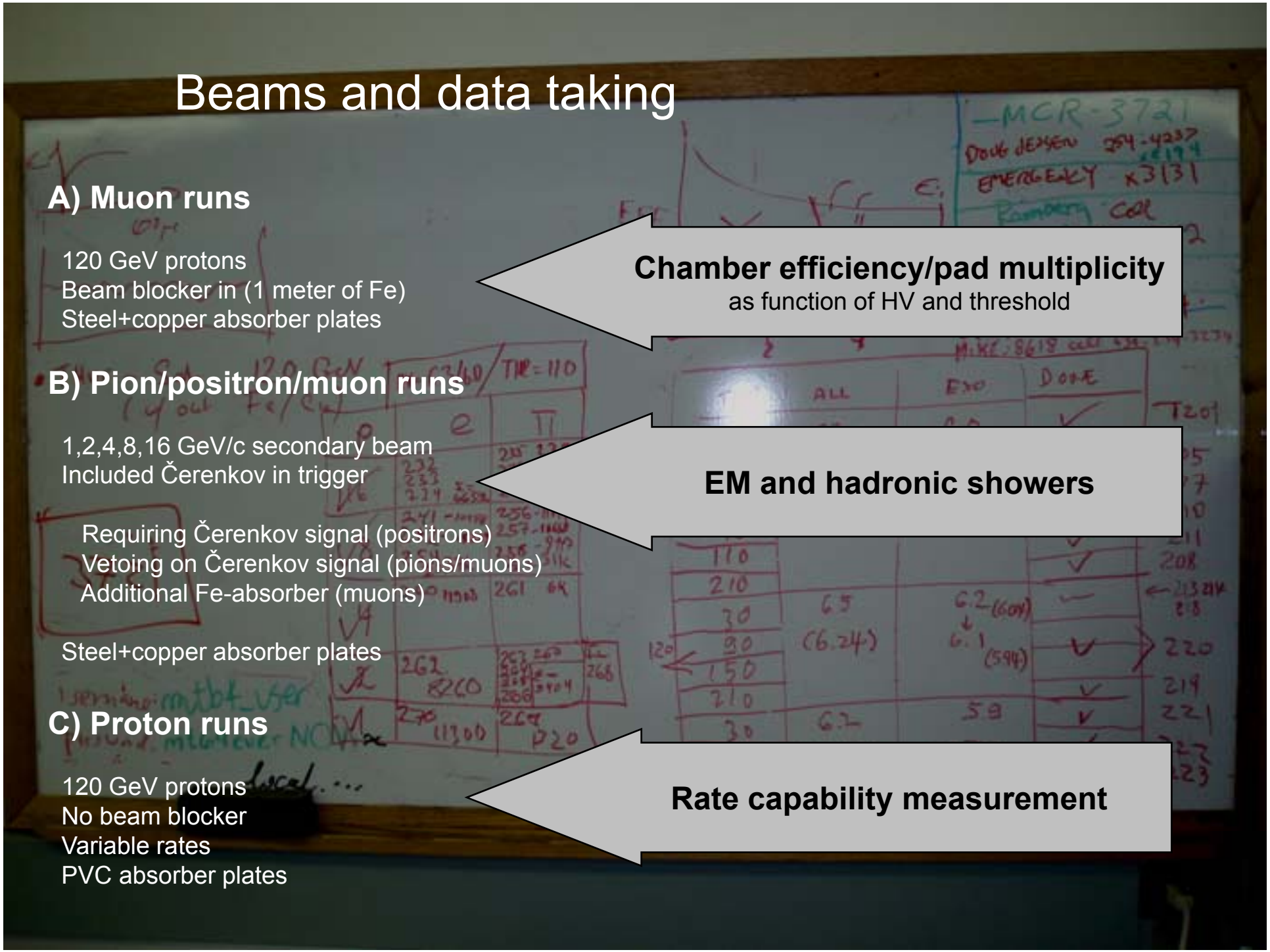


Noise

Resetting slow control constants
→ running slow control every 30 seconds
→ new grounding scheme

Due to rush to beam tests, only minimal diagnostics tool available at the time

Beams and data taking



A) Muon runs

120 GeV protons
Beam blocker in (1 meter of Fe)
Steel+copper absorber plates

Chamber efficiency/pad multiplicity
as function of HV and threshold

B) Pion/positron/muon runs

1,2,4,8,16 GeV/c secondary beam
Included Čerenkov in trigger

Requiring Čerenkov signal (positrons)
Vetoing on Čerenkov signal (pions/muons)
Additional Fe-absorber (muons)

Steel+copper absorber plates

EM and hadronic showers

C) Proton runs

120 GeV protons
No beam blocker
Variable rates
PVC absorber plates

Rate capability measurement

Data Quality Monitoring

A) Online event display and monitoring

Extremely useful for quick turn around
Made shorter test runs redundant

B) Offline event display

Useful to understand beam
detect noisy layers

Available <30 seconds after EOR
Binary → ASCII (x,y,z,t) ntuple

C) Offline data analysis

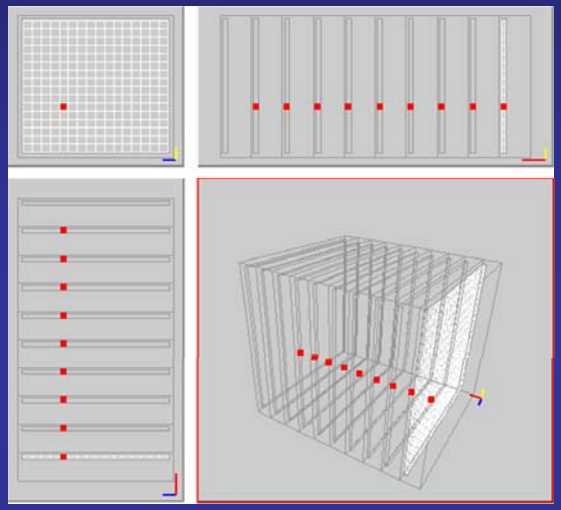
Useful to detect hardware problems
obtain quick preliminary results
decide on further runs

Plots available <60 seconds after EOR

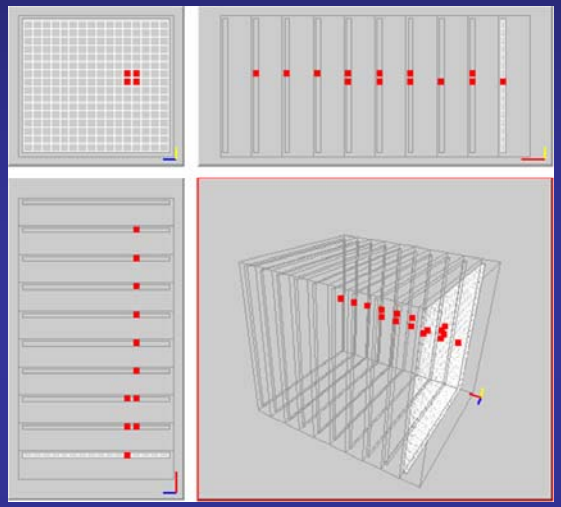
A few events… μ Calibration Runs

120 GeV protons with 1 m Fe beam block
no μ momentum selection

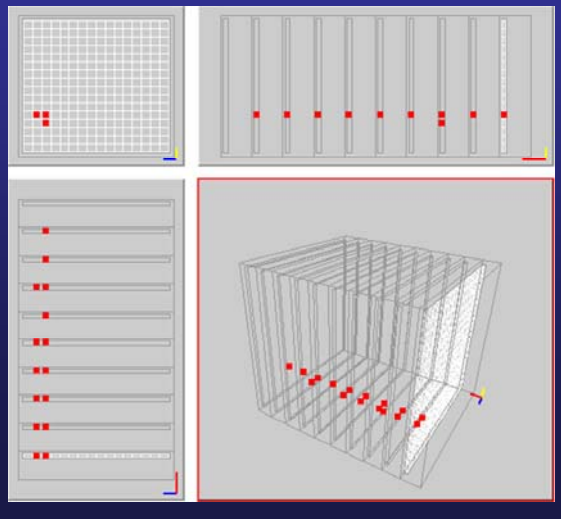
One of many perfect μ event



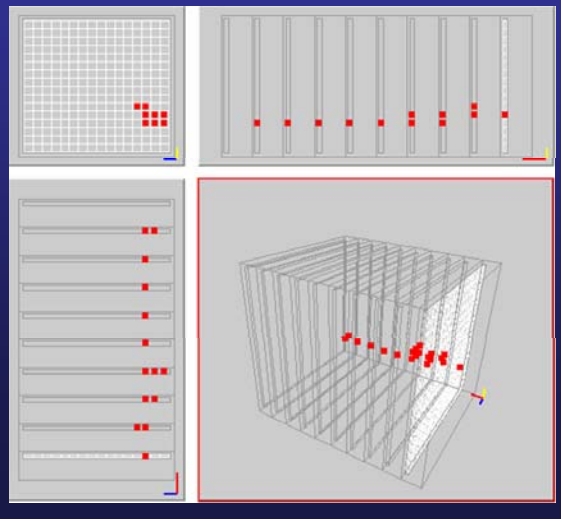
μ at an angle or multiple scattering



μ event with double hits in x



μ event with δ ray or π punch through

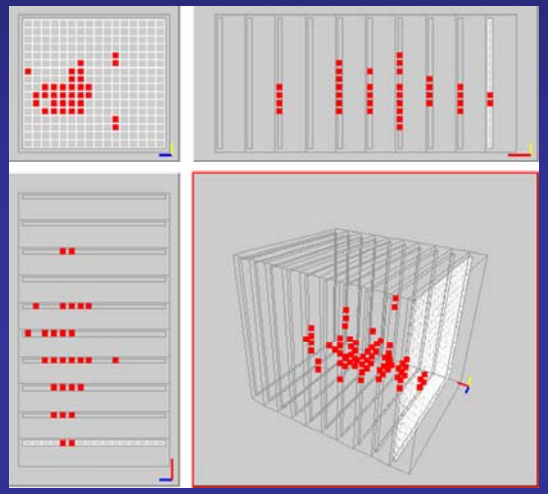


A few events…e^+ Run

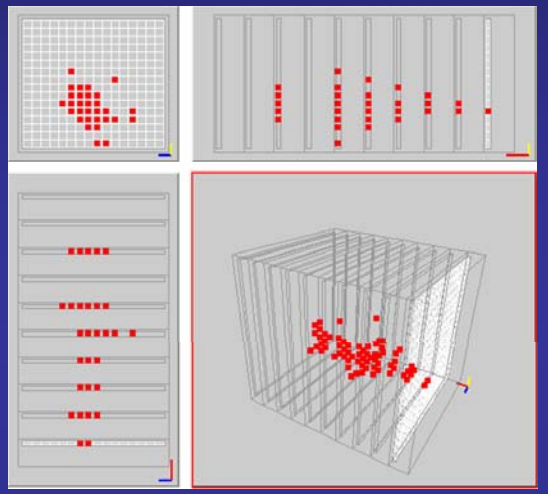
1 - 16 GeV secondary beam
Čerenkov signal required

Layer 6 dead
→ input to DCOL broken
→ limited diagnostics at time of data collection

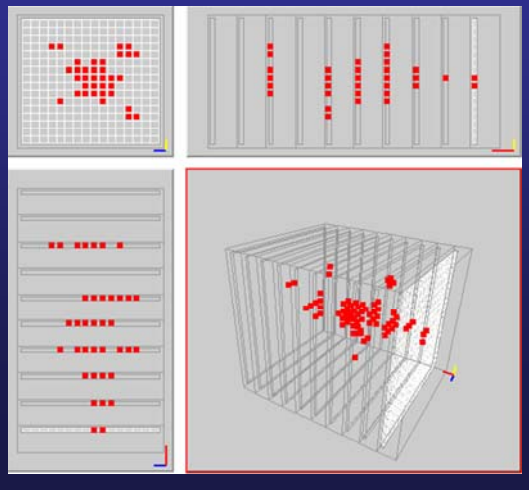
8 GeV e^+ event



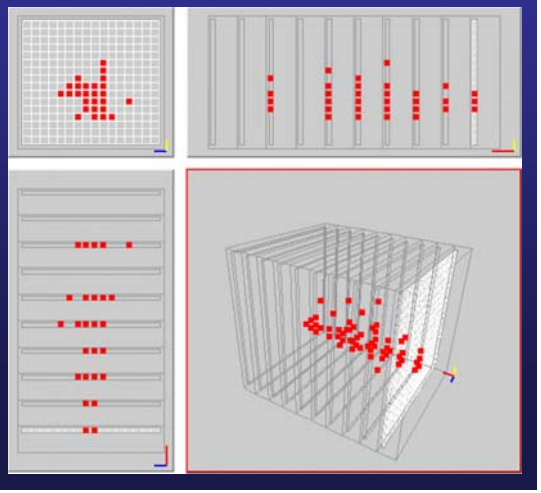
8 GeV e^+ event



8 GeV e^+ event with satellites



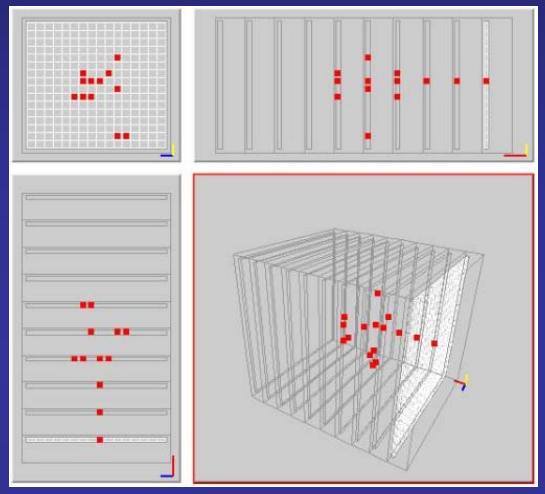
8 GeV e^+ event



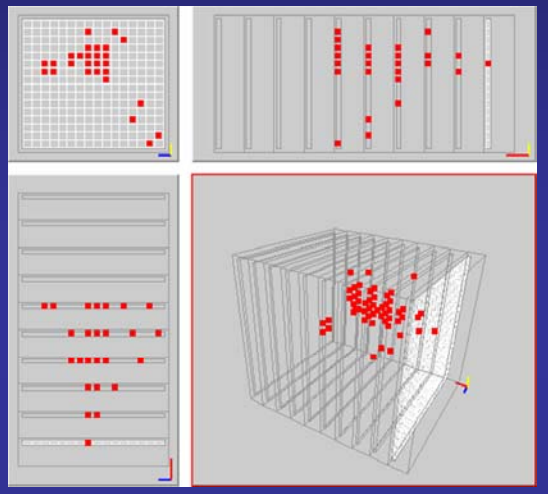
A few events…π^+ Run

1 – 16 GeV secondary beam
Veto on Čerenkov signal

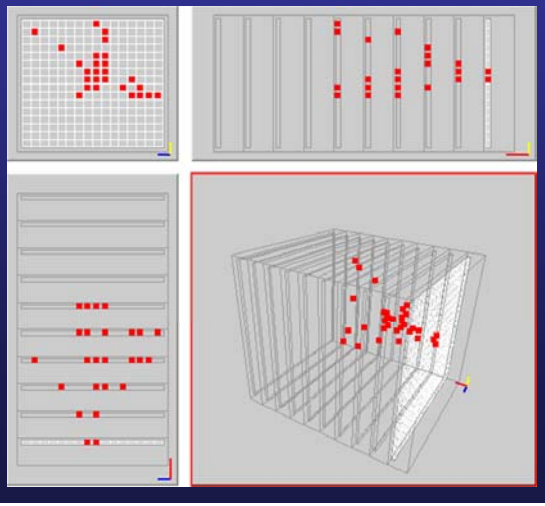
8 GeV π^+ event (typical)



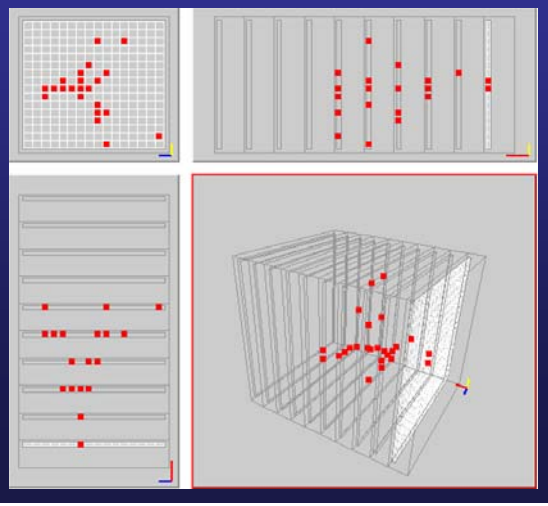
8 GeV π^+ event (early shower)



8 GeV π^+ event (early shower)



8 GeV π^+ event (early shower)

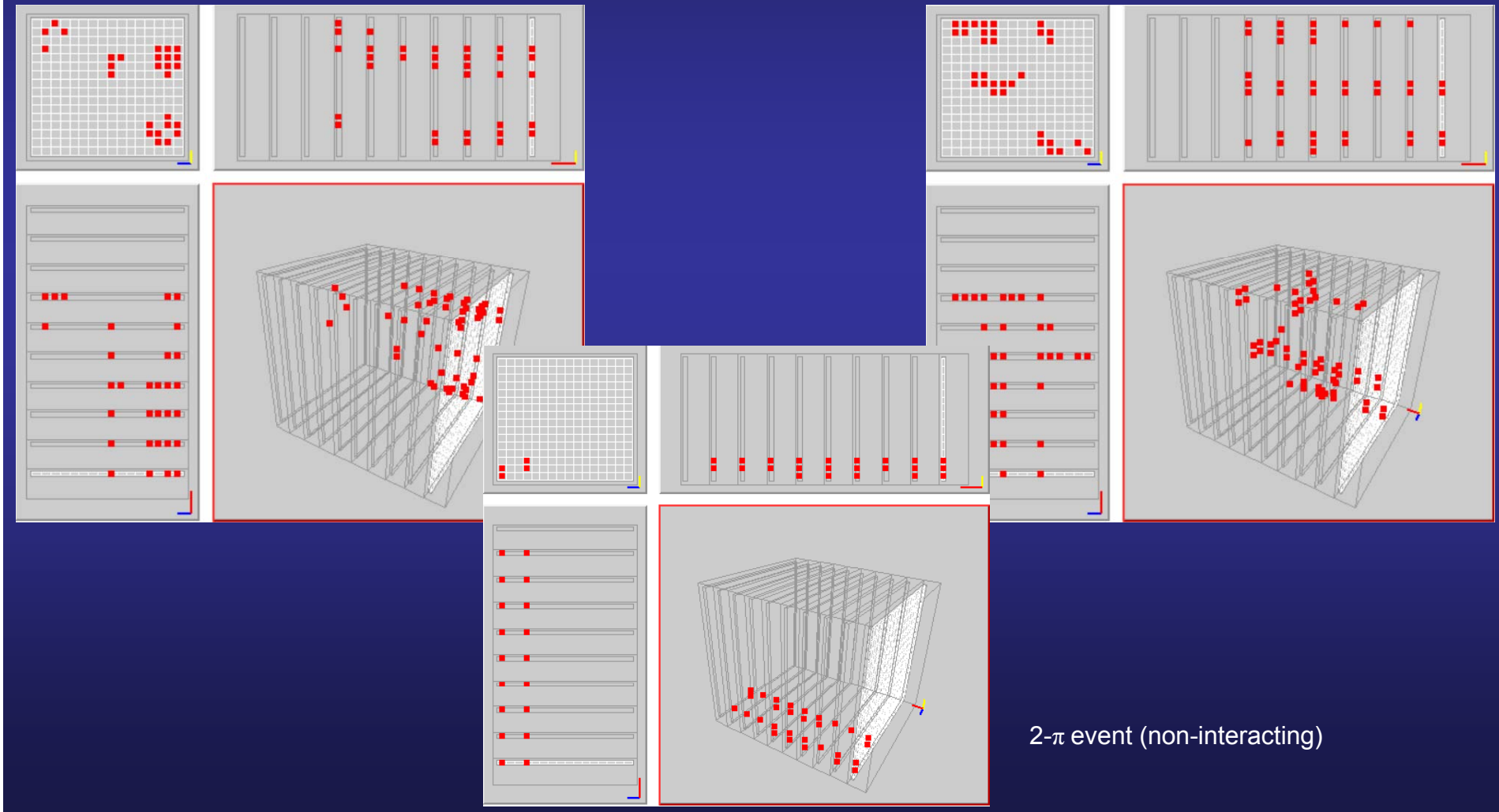


A few events…Multiple particles

120 GeV protons with/without beam block

2-π event (upstream shower?)

3-π event (upstream shower?)



2-π event (non-interacting)

Conclusion

The Vertical Slice Test was a big success

The RPCs
Electronic readout system
Data acquistion
Beam
} worked very well

Expect 4 – 5 papers

We validated the DHCAL concept and our technical approach

→ **We are ready for the next step**

To be completed in 2007?

i.e. prototype

Larger RPCs
Cheaper Pad- and Front-end boards
Final data (and super) concentrators

Identical to what's needed for the PS

Physics prototype

Gas and HV system ~ complete
DCAL ASIC design finalized (no more prototyping needed)
DCOL only needs assembly (10 units needed)
TTM done

Test beam experience is invaluable

Much more difficult environment than lab
We were faced with many problems we did not necessarily anticipate

Noise
Humidity
Grounding
Failures

→ **We are still learning about the system**

(a 1% problem might be fatal when extrapolating by x200)

→ **Our experience is feeding back into the final design for the PP**

Physics prototype

Necessary step before technical prototype (ILC wedge)
Can't solve all problems at once

Leave out: power pulsing, thickness optimization, maximum multiplexing,
integrated gas and HV/LV supplies, wedge shaped geometry,
reliablity, redundency (!!!!)…

Trying to do everything at once leads to

Slow progress, no intermediate experience with detectors, many iterations, high cost…

Tour on Thursday afternoon

Please, visit MTBF (transportation will be provided)

- You'll see a completely water tight roof
- The first functioning digital calorimeter prototype
- Posters of various test beam activities in the past 12 months…