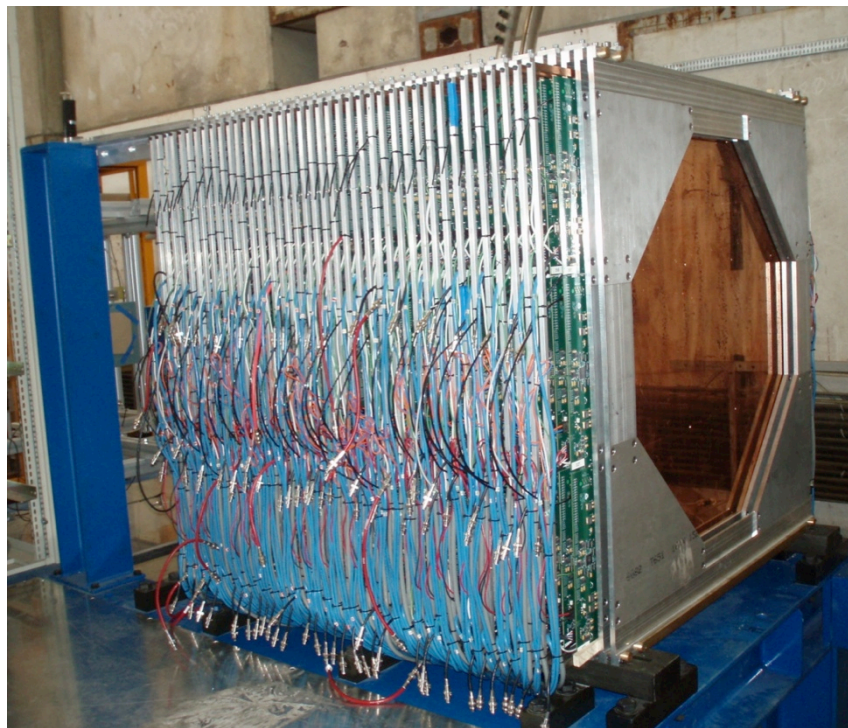


# Update on Ongoing Tungsten Digital HCAL Beam Tests

Erik van der Kraaij  
CERN LCD

- Test beam runs so far
  - PS T9: 2 weeks in May.
  - SPS H8: 2 weeks in June, 1 week in August.
  - Still to go: ~1 week in November.
- Before the PS run, Argonne team came over for installation.
  - Installed within 1 week, in zone next to T9.
  - Such that move of full detector to SPS could be done in 4 days.

Leak tested RPCs first after shipment: no problems.



Cassette insertion difficult

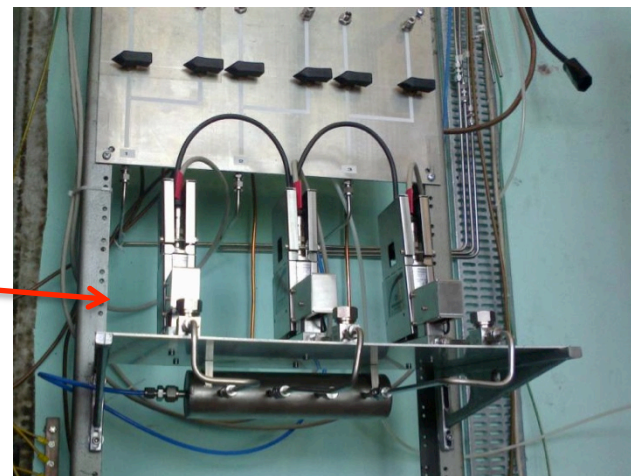
- Gap too small for electronic boards
- Had to move W-layer one by one, insert cassette, move next W-layer, etc.

Final gaps are 15 mm

- leaving ~2 mm between copper and tungsten layer

39 layers installed

- All cables are routed to basket underneath



Acquired and installed by CERN at PS:

- Three ATEX certified mass flow controllers.
- Controlled by PC a few meters further.
- Setup was moved (permanently) to SPS.

Need in total 10 individual 10A power circuit lines.

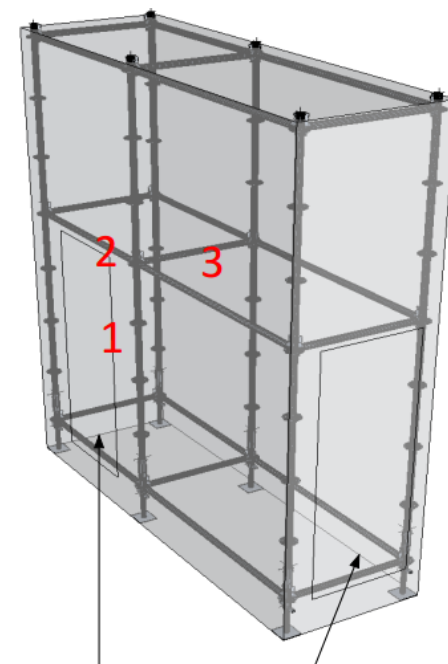
## DHCAL (39 layers)

- Produces about 3 kW

## Cooling:

- Air conditioner from CERN CV
  - 2x 4 kW units
  - 1x 7 kW unit
- Eight large fans.
- Tent built over DHCAL
  - Including barometer and thermometers to monitor all runs in PS & SPS

## Design of cooling tent



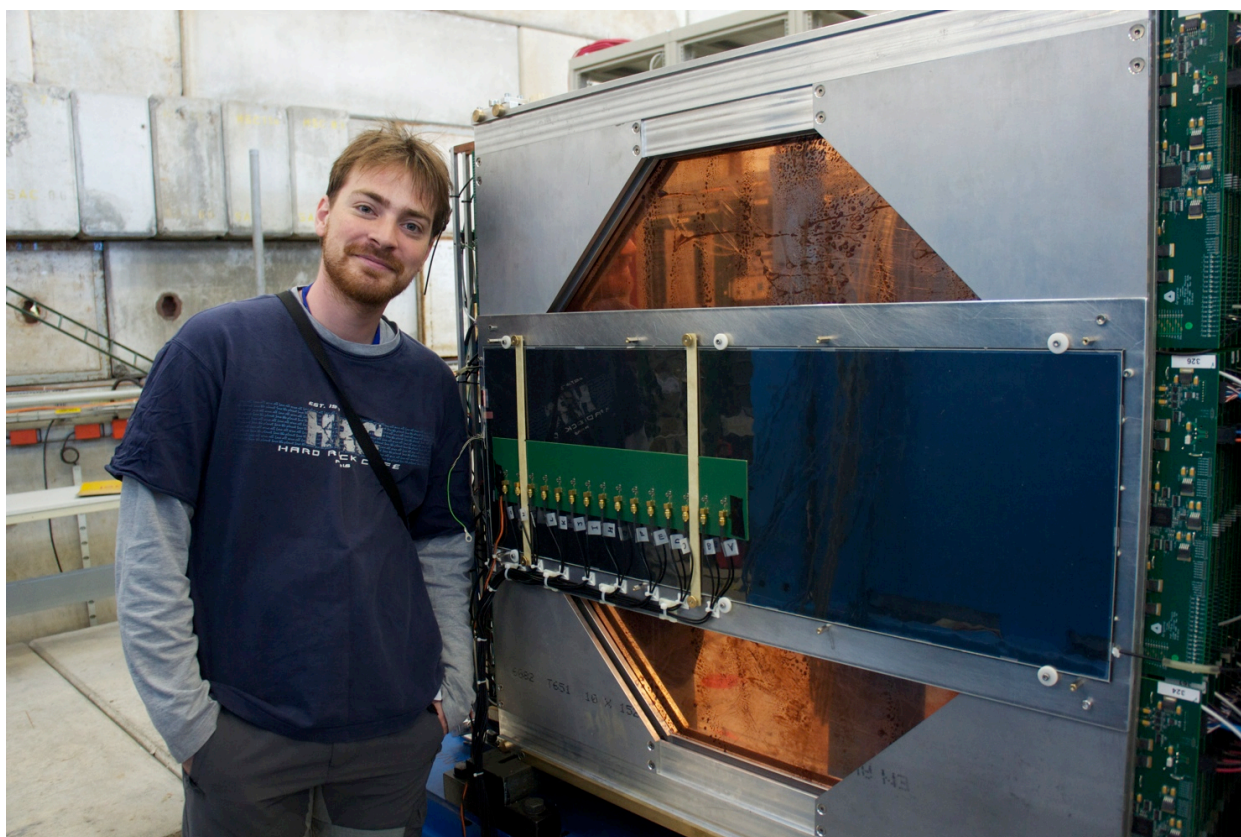
Door zip 2.00 x 0.80



# Additional detector: FastRPC

Developed with MPI: 1-D strip detector of 15 pads, each  $3 \times 3 \text{ cm}^2$ , with  $\sim 1 \text{ ns}$  readout accuracy, mounted on a spare glass RPC

→ study shower time development in tungsten, compare with AHCAL T3B.

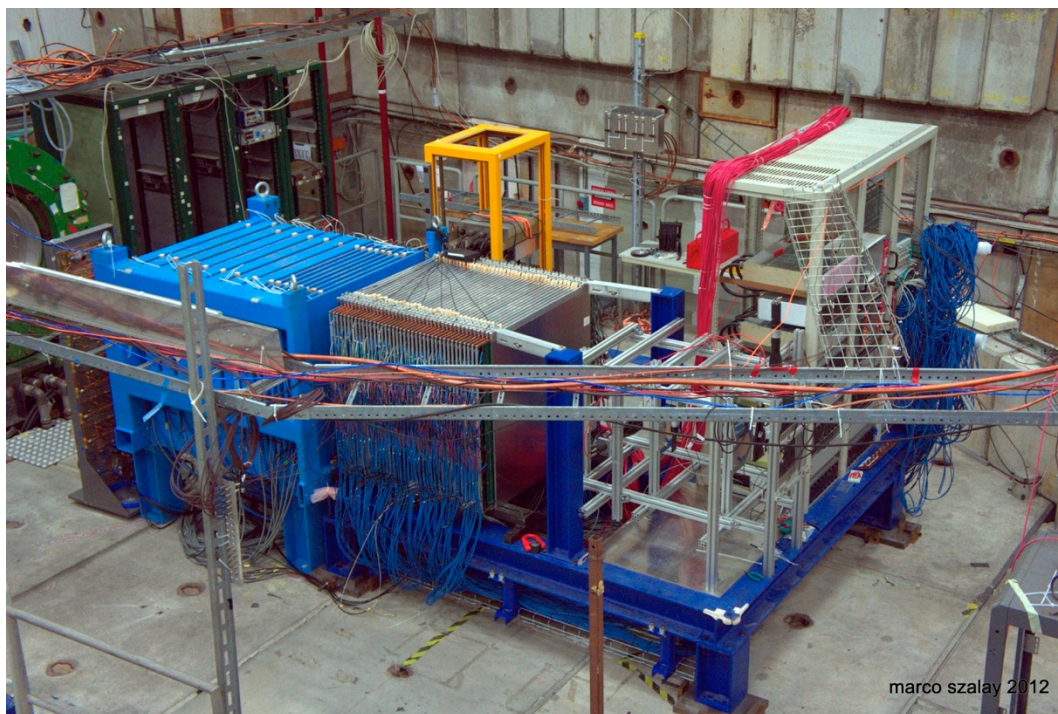




- Once into beam zone, many problems with the CAEN PCI-VME bridge.
  - Jim figured out: the link requires a strict connecting sequence
- Implemented dead time of 350 usec in NIM electronics, vetoing trigger and Cherenkov inputs to DHCAL.
- Lowered the default HV from 6.3 kV to 6.0 kV.
  - Due to different altitude (=pressure) at Geneva.



- Including the TCMT, for commissioning purposes
  - Before tent installation:



Final data taken:

- With negative polarity:  $> 1\text{M}$  events at each point of 1, 2, ..., 10 GeV.
- With positive polarity:  $> 0.5\text{M}$  events at 4, 6, 8 and 10 GeV.

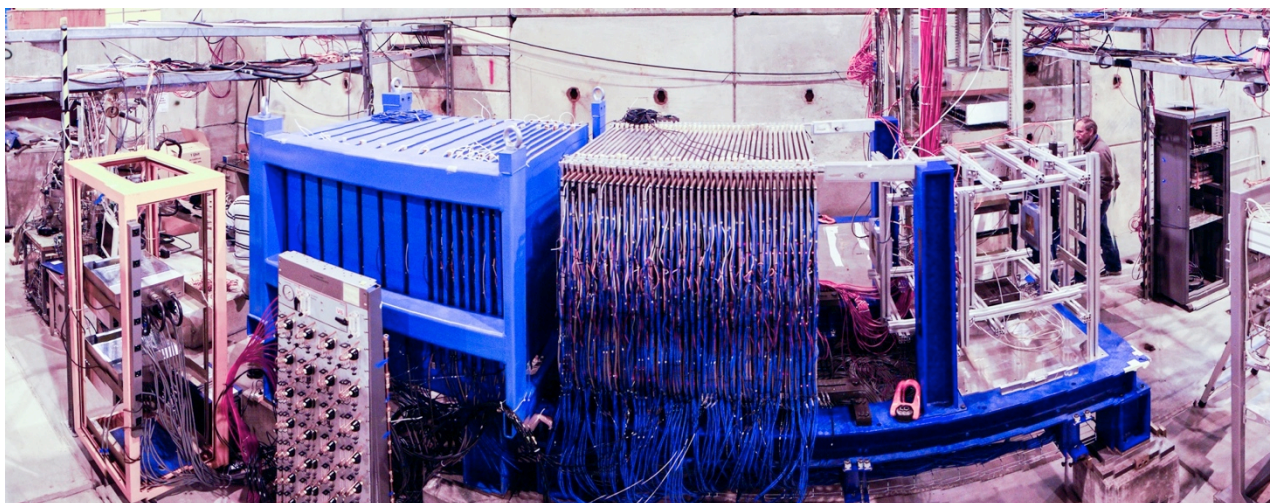


- By truck



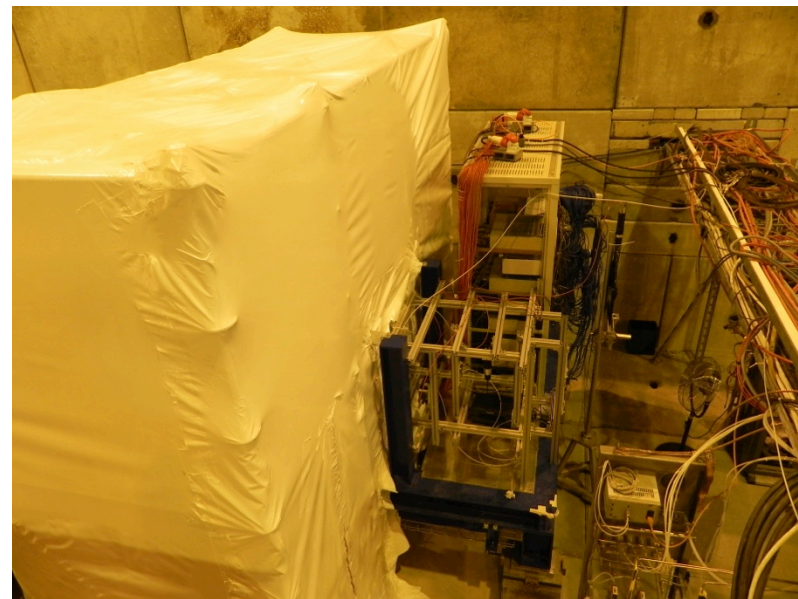
Before tent installation:

- Layer 45 taken apart so that middle and bottom RPC's could be reused in:
  - Layer 31: middle RPC leaked
  - Layer 34: middle RPC had no signals
- Layer 54 was moved to Layer 45 slot.
- Used spare RPCs for:
  - Layer 37: middle RPC had no signals
  - Layer 39: top RPC was very inefficient

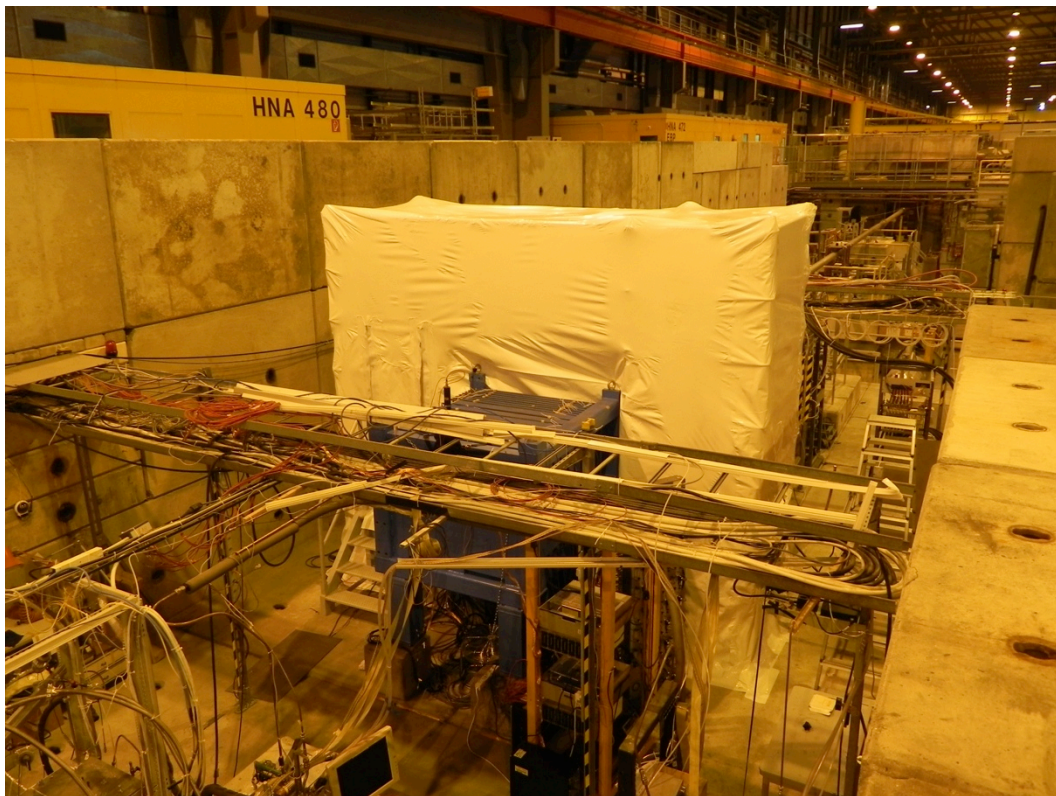




- Two-layered tent covering the DHICAL only, with two zip doors
  - Installed barometer and thermometers inside tent.



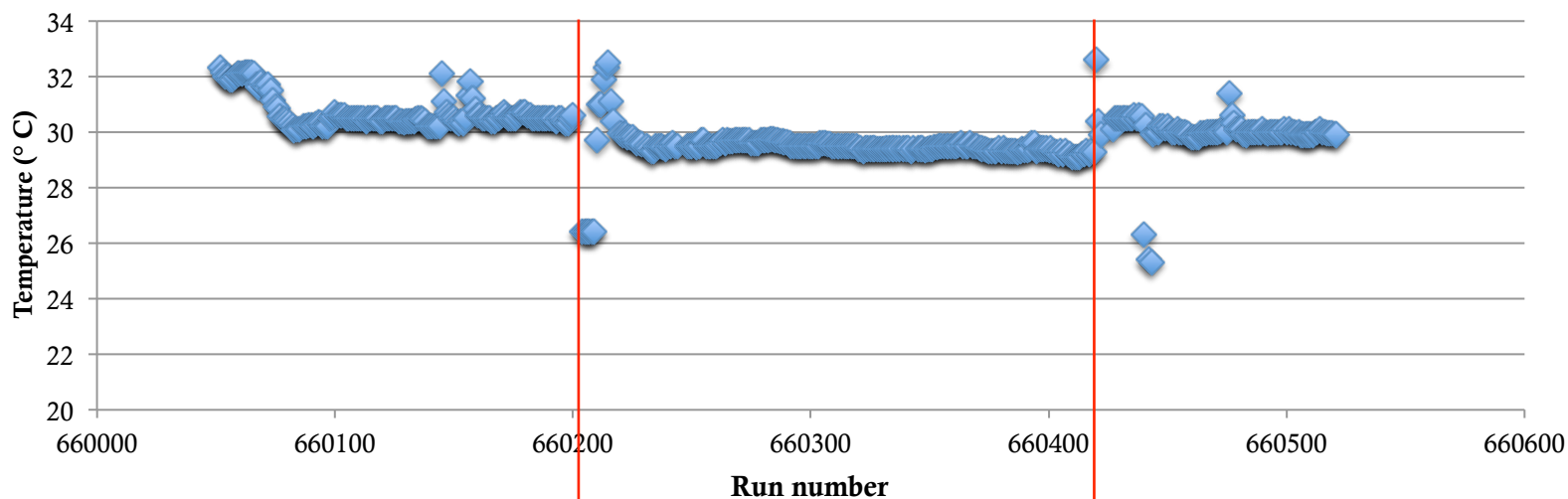
- ACs to cool air inside:
  - 2x 4 kW units
  - 1x 7 kW unit



# Temperature

Measured with Pt1000 sensor ~2 cm inside W-stack. We see:

- Fluctuations during installation
- Sudden drops: powercycle of LV
- Sudden rises: AC turned itself off
- Stable within  $\pm 0.5^\circ\text{C}$



PS – May  
"hot" weather

SPS – June  
"rainy" weather

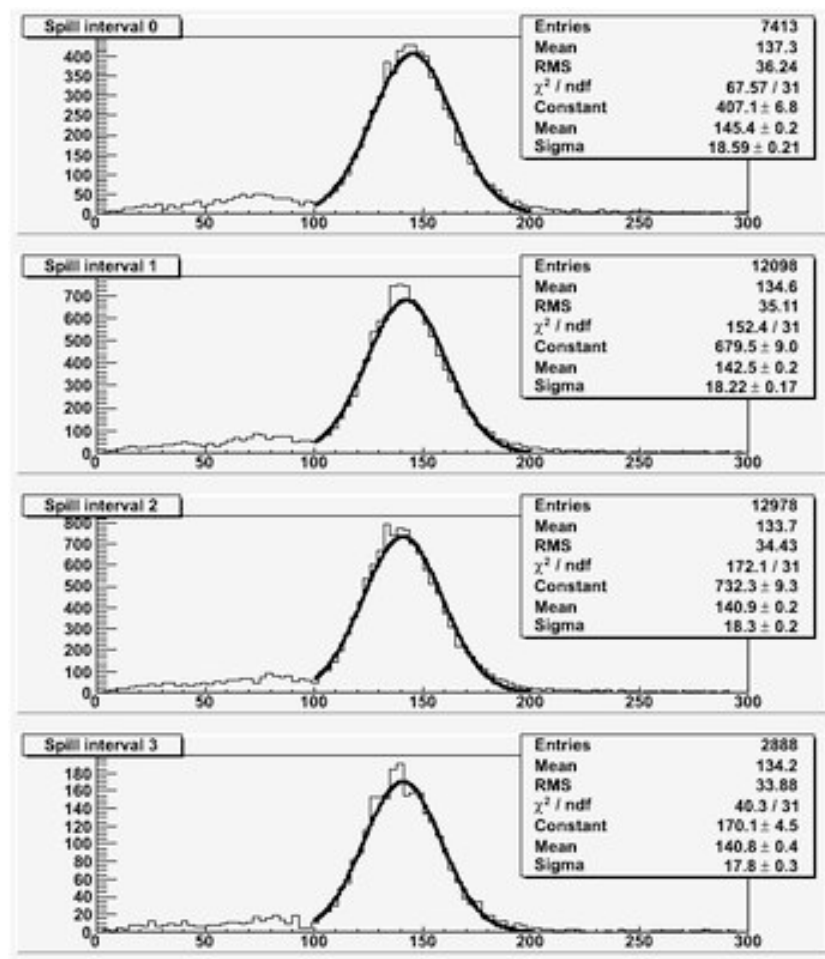
SPS – July  
"hot" weather



Run 660285 ; E = -30 GeV ; ev/spill = 250

To check whether spill rate is acceptable, Jim created a tool to look at #hits/ev in 4 different intervals during a spill →

- Operate with no more than 4-5% decrease in efficiency during spill.



- Observed lower efficiencies over several layers.
  - Educated guess: due to HV connectivity to resistive paint
- Lost RPC 27-middle
- Took again muon samples for new calibration.

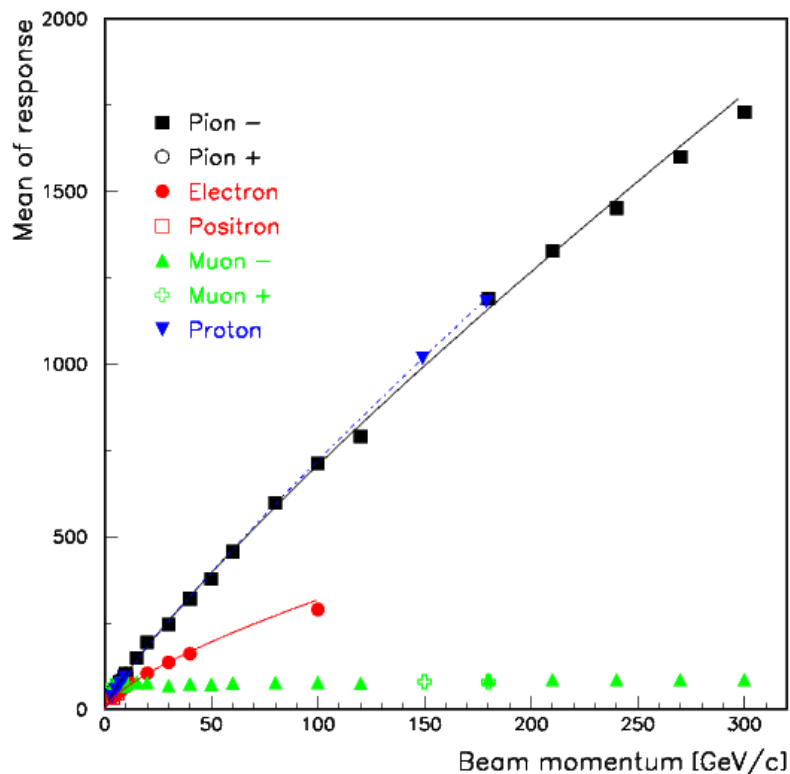
# Data taken @ SPS H8

Better timing structure of beam and better duty cycle at CERN

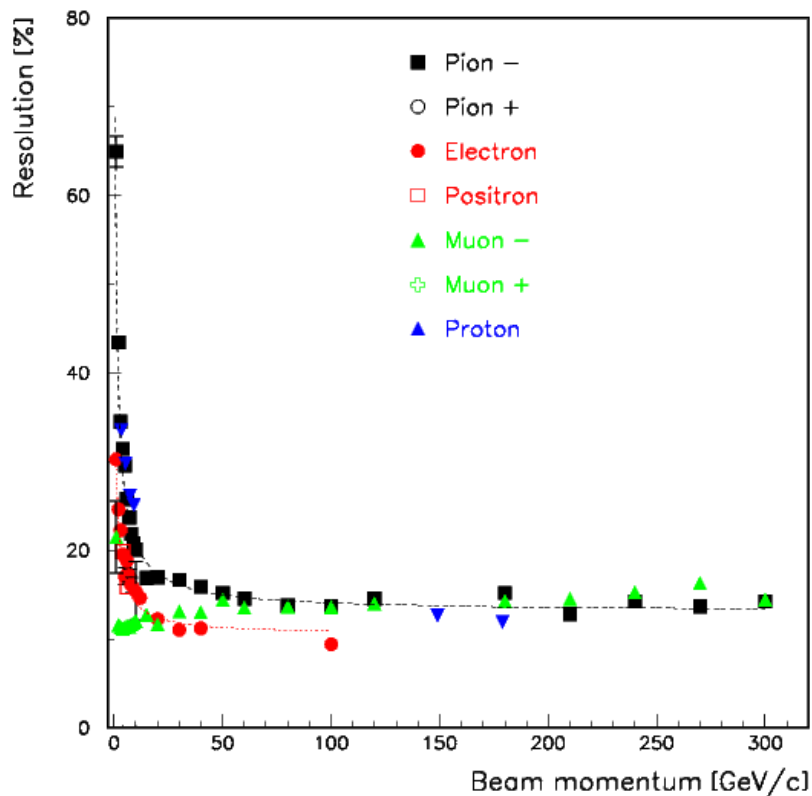
- Already more data than several months data taking at Fermilab
- Dedicated electron samples at 12, 20, 30, 40 and 100 GeV (- pol.)
- Mixed samples, 200k – 500k each, at 15 points with  $15 < E < 300$  GeV.
  - Pion content varies from 20% to 100%. (- pol.)
- One night of high rate for fastRPC, with DHCAL HV off. (+ pol.)
  - 1.6M at 180 GeV.
  - 2.0M at 80 GeV.
- Muon runs: with 30x30 cm<sup>2</sup> trigger, took 500k events in 9 different locations covering the detector surface.

# Response and resolution

PS and SPS Measurements



PS and SPS Measurements



	$\beta$	$\alpha$	c
Fit 1		$73.1 \pm 0.1$	
Fit 2		$51.21 \pm 0.18$	$13.06 \pm 0.04$
e fit		$29.73 \pm 0.18$	$10.47 \pm 0.08$



# Conclusion

- RPC/readout/cassette survived shipping and flight.
- Installation successful, move to SPS went smooth.
- Cooling by tent+ACs better than hoped.
- Efficiency drop due to HV connectivity.
- With november run, should finish full program (up to 300 GeV).
  - Operate with lower HV, in high gain mode, to test higher rates.
- Will add:
  - AHCAL-2 prototype
  - High rate capable glass RPC prototype
- Return shipment to ANL is being prepared.

# Backup

# Transport to CERN

Two transports: 6 crates with electronics and cables  
2 crates with RPCs and DAQ

## TRANSPORT DEVICE

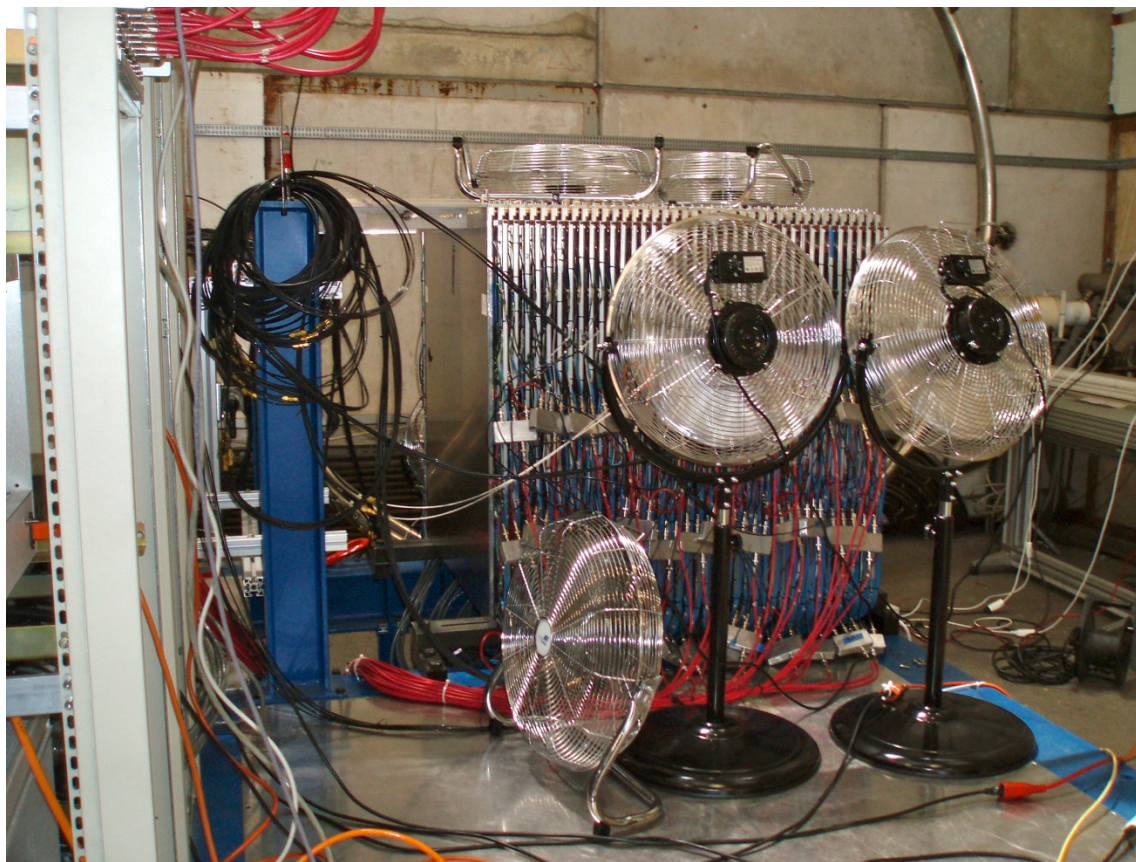


All RPCs have been leak tested

- 6 RPCs leaking slightly more than before shipment  
→ Installed at the back of the tailcatcher.

Acquired 8 fans.

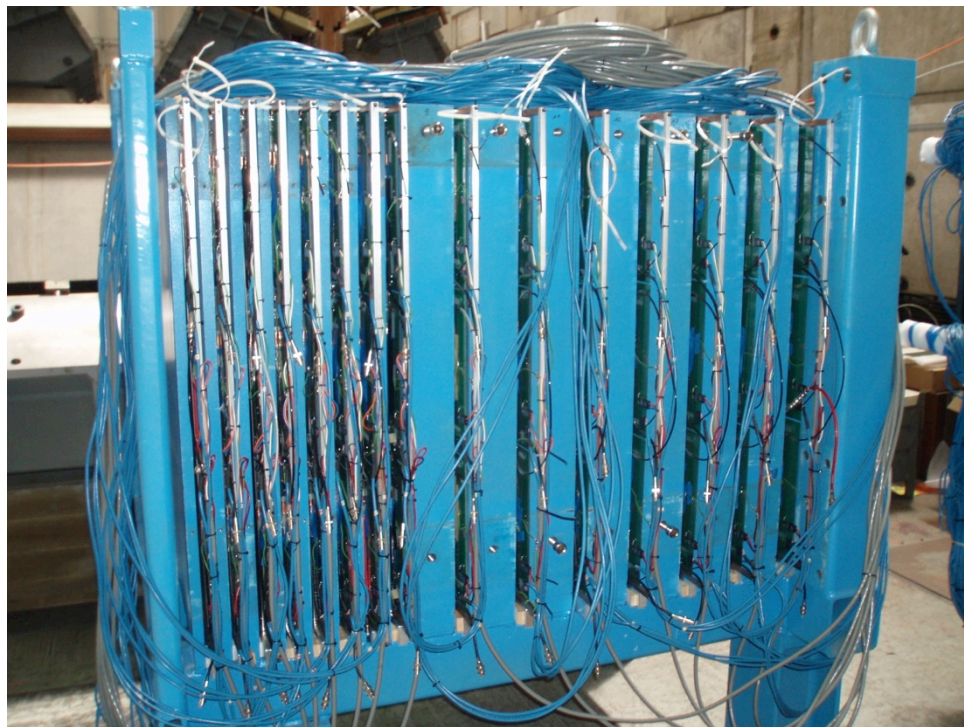
During installation:







- 15 layers installed
  - Of which one layer cannibalized at the SPS for repairs





# Power supply

With 220V, need:

- 7 times 6A for LV supply → each needs an individual circuit
- 3 extra circuits of ~10 A for other electronics, cooling, etc.

At PS T9:

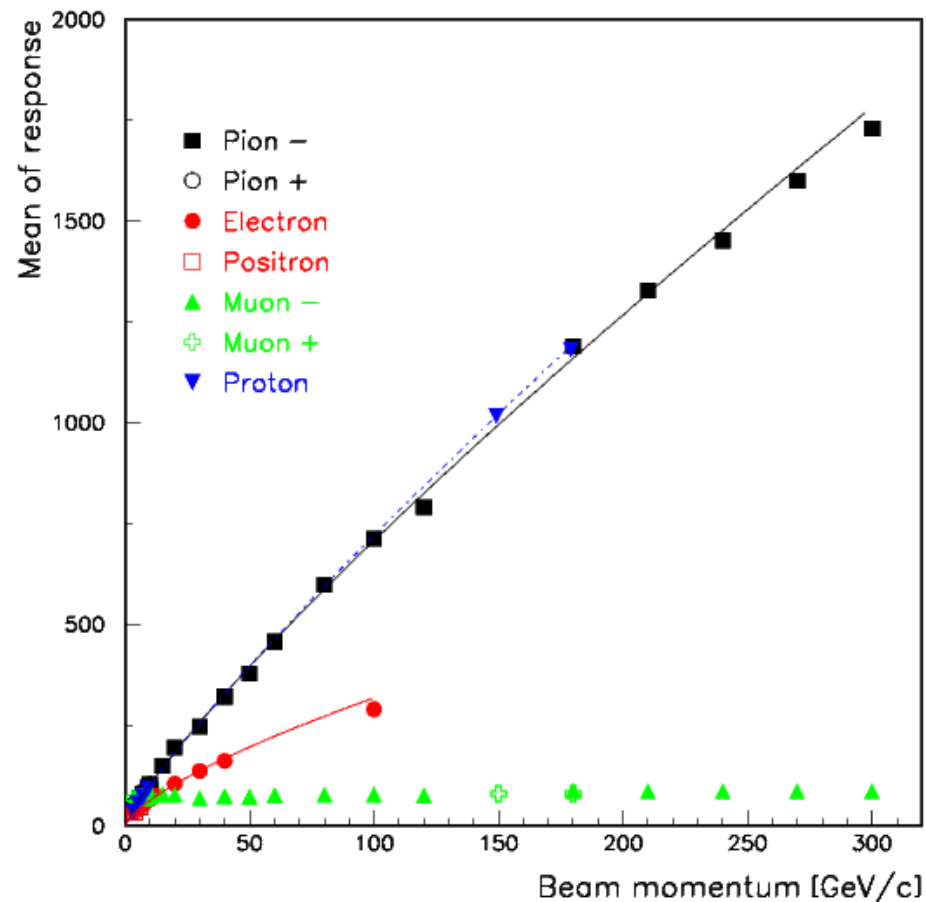
- Enough 10A or 16A circuits in the zone; all distributed by one 380V, 3-phased 32A circuit.

At SPS H8:

- Not enough circuits yet. Will need 30m cable for 380V; converters to 220V will be installed in H8 zone.

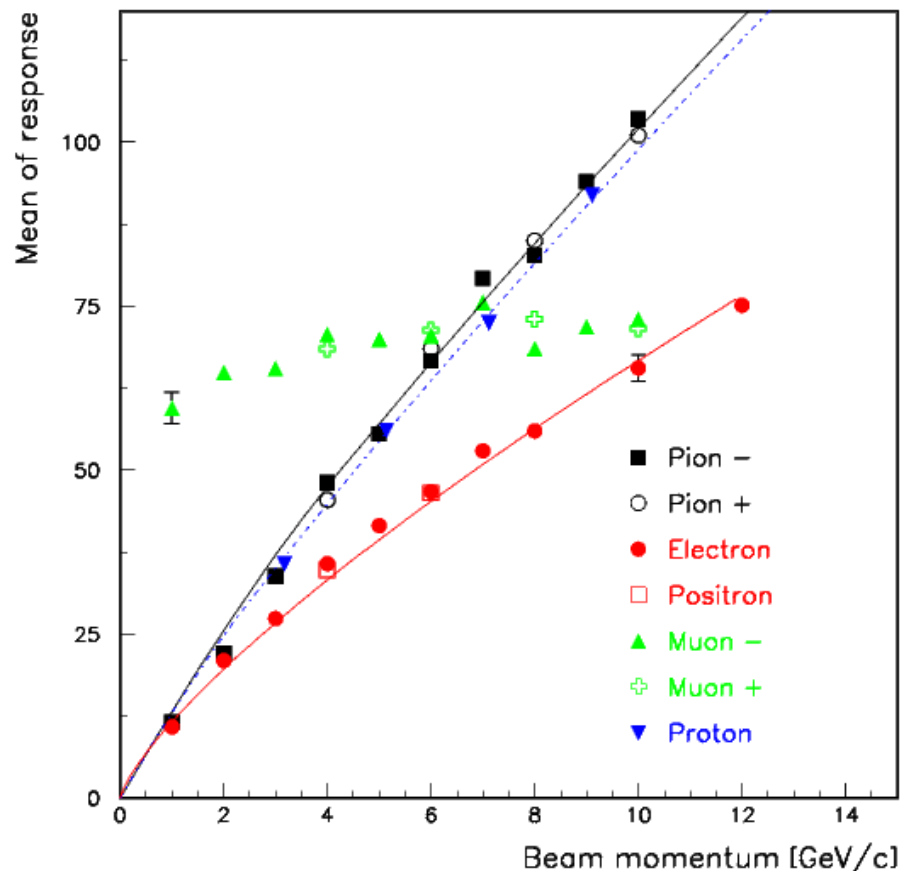
# Response from 1 – 300 GeV

PS and SPS Measurements



Fits to  $\alpha E^\beta$

PS and SPS Measurements

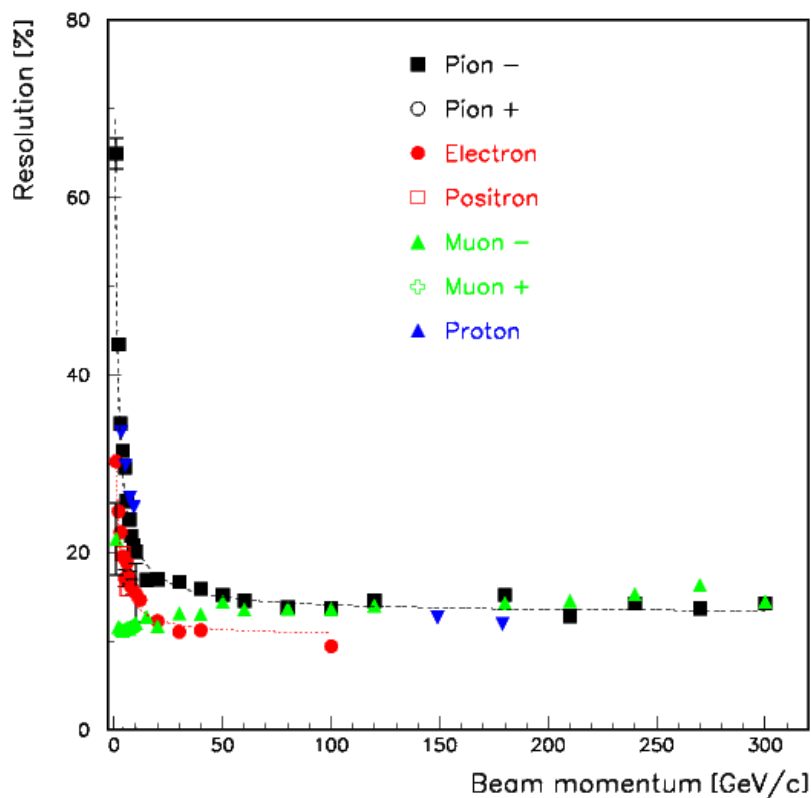


Data not-calibrated yet

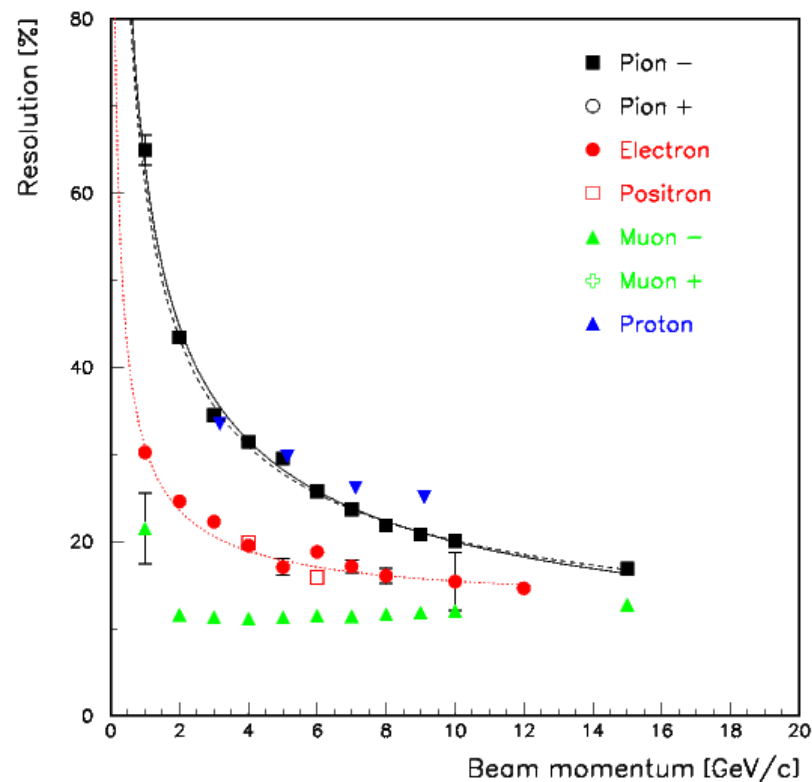


# Resolution from 1 – 300 GeV

PS and SPS Measurements



PS and SPS Measurements



	$\beta$	$\alpha$	c
Fit 1		$73.1 \pm 0.1$	
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e fit		$29.73 \pm 0.18$	$10.47 \pm 0.08$

	$\beta$	$\alpha$	c
Fit 1		$63.2 \pm 0.1$	
Fit 2		$60.7 \pm 0.3$	$6.0 \pm 0.3$
e fit		$28.2 \pm 0.2$	$12.6 \pm 0.2$