DBD HCAL section report and RPC DHCAL progress

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HCAL section outline (original)

- 4.3 Hadron Calorimeter
  - 4.3.1 HCAL requirements
  - 4.3.2 Description of the DHCAL concept
  - 4.3.3 Global HCAL mechanical design
  - 4.3.4 Baseline technology
    - RPC design
    - Readout
    - Active layer design
    - Services (Gas, HV, LV)
    - Results of prototype testing
      - RPC tests, DHCAL prototype and TCMT, test beam campaigns, results
  - 4.3.5 R&D towards technical feasibility and optimization
  - 4.3.6 physics performance specific to baseline
  - 4.3.7 Alternative technologies
    - GEM, Micromegas, Scintillators
- 4.4 Calorimeter Performance
  - 4.4.1 1TeV issues

HCAL section outline (current status)

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    - Results of prototype testing
      - RPC tests, DHCAL prototype and TCMT, test beam campaigns, (results)
  - 4.3.5 DHCAL prototype performance
    - Noise, muon calibration, positron response, pion response
  - 4.3.6 R&D towards technical feasibility and optimization
  - 4.3.7 physics performance specific to baseline
  - 4.3.8 Alternative technologies
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- 4.4 Calorimeter Performance
  - 4.4.1 1TeV issues

Things are more or less there

Have something, need update/discussion

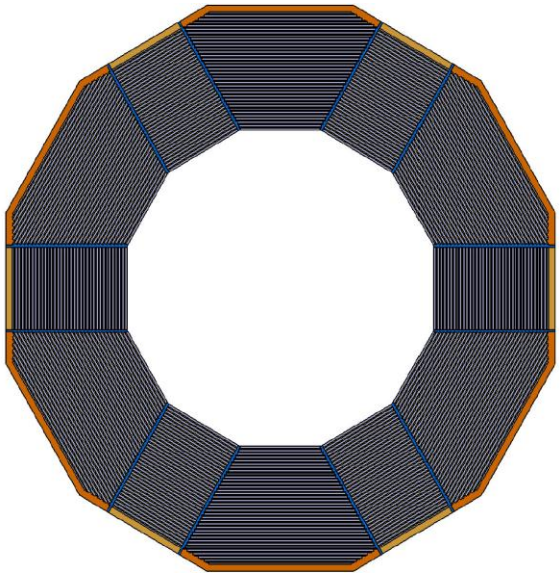
Nothing at the moment

Main issue

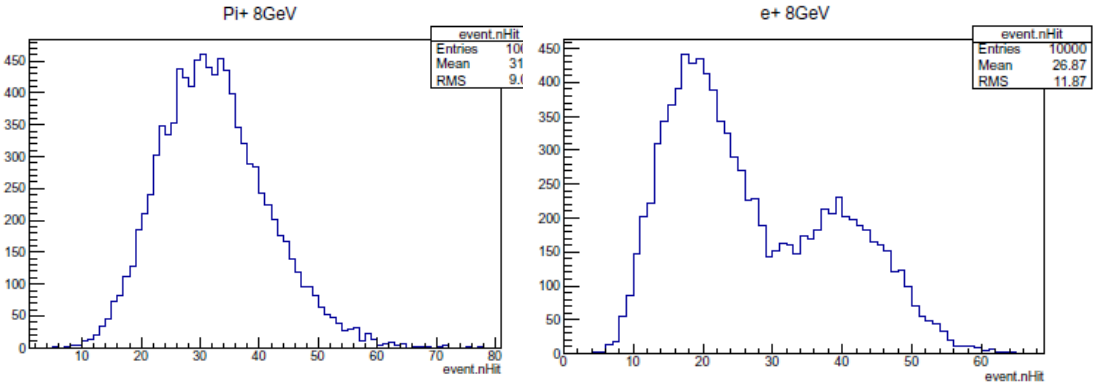
- DHCAL R&D made a lot of progress
  - Successfully built and tested a large prototype
  - Achieved proof of principle: DHCAL really works
  - Developed an embedded readout that works really well
- However, we didn't put in a lot of effort into designing a real detector:
  - We are confident that a real DHCAL system is within reach
  - But a lot design effort and R&D are needed to get there – don't have the resources to do it…
- For DBD: a lot of things can not be very detailed

Global HCAL mechanical design(●)

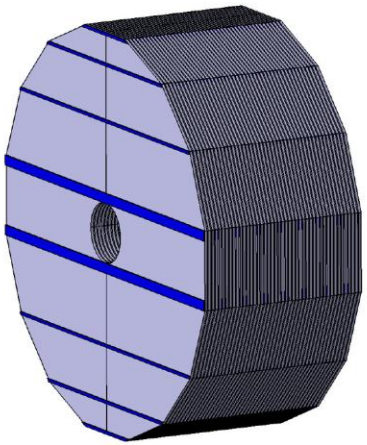
- Currently copied LoI
  - This design has very long (6M) barrel modules → is there any changes since LoI?
  - A similar design (Vic. Guarino, ANL) exist with shorter wedge shaped module
  - A new idea similar to ATLAS tile Cal (RPC plane vertical to beam) was studied with simulation (U. Oregon, ANL)
    - Studied response and position reconstruction
    - There are some issues
    - Certainly not ready for DBD



Barrel



Plots from: Chaowaroj Wanotayaroj, James Brau

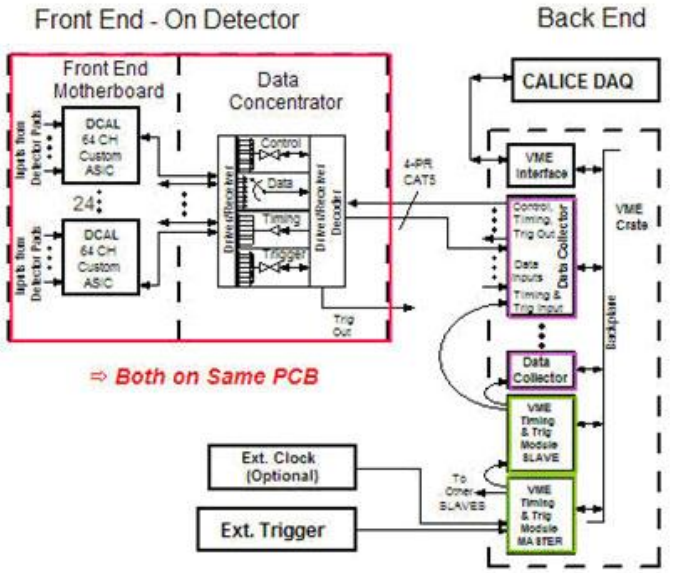


Endcap

- Do we need any update from LoI?

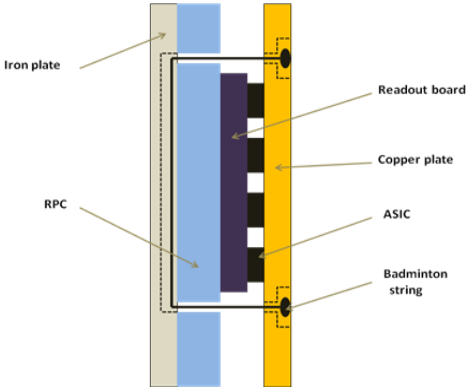
Baseline technology: readout (●)

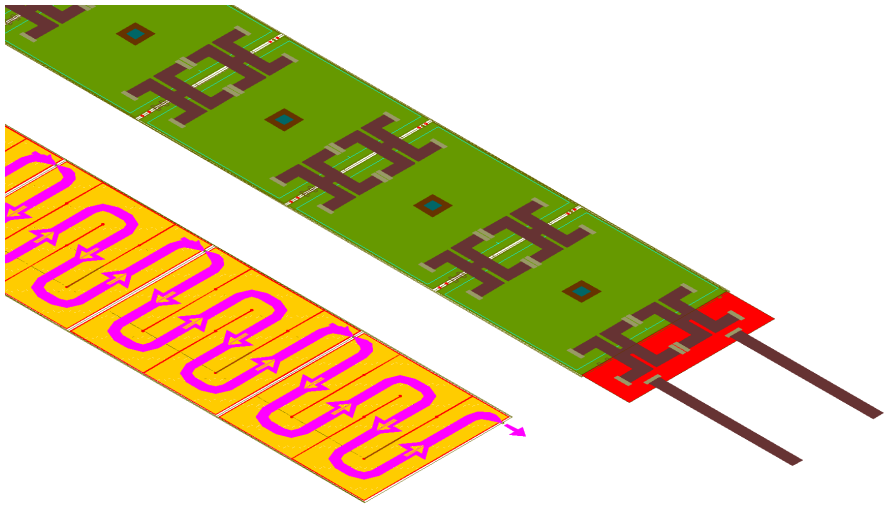
- Described the DHCAL prototype readout system
  - Built around DCAL chip
  - 2 stages of data concentration
  - Very successful for test beam and prototype tests
  - NOT for a real DHCAL system, but it is a good starting point
- Pointed out two possibilities for future R&D
  1. Continue development of the current DCAL system
     - Power reduction, better data transmission
     - Lower risk
  2. Adopting KPiX readout for DHCAL
     - Need to start from RPC tests, higher risk, less flexibility
     - More uniform readout across SiD subsystems
- Is this approach OK? Any suggestions?



Baseline technology: active layer design (●)

- Nothing is written down yet: discussion still on-going
- DHCAL prototype has a cassette structure that can be used as a starting point/reference
  - Layers inserted/taken out into/out of absorber structures multiple times
  - Survived multiple transportations without breaking any RPC
  - Proved possible for repairs
  - Thickness close to requirement, can be significantly reduced
  - DCON still sticks out, services need to be improved/re-arranged
- Marty's team has a new design based on 1-glass RPC and KPiX readout
  - Very inspiring design idea
  - 32x32cm^2 RPC + readout board as the building block
  - Total thickness within requirement – including tolerance!
  - However, some immediate worries: HV, gas distribution, cable/connector…
- Need guideline on how to proceed
  - Can we again list options, instead of making decisions?



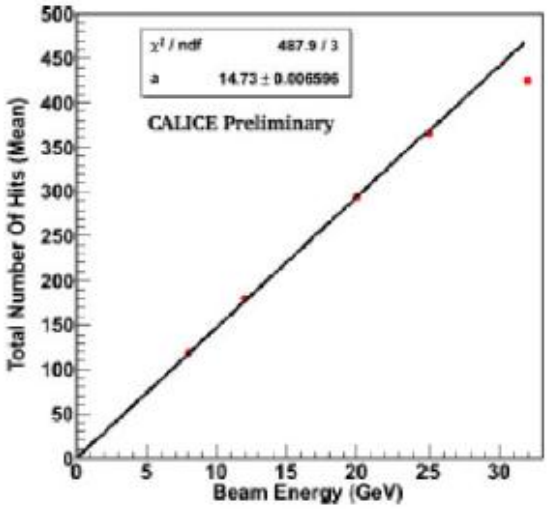


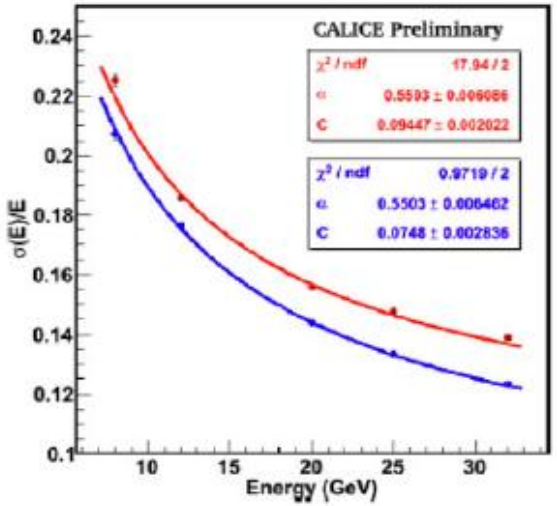
Baseline technology: services (gas, HV, LV) (●)

- The services is tightly coupled to layer design
  - It is almost not possible to have anything specific without making a lot of important design decisions
  - A lot of R&D is needed for gas and HV system
    - Gas recirculation
    - HV distribution and monitoring
- Do we still want to talk about services?
  - All I can imagine is to point out the necessary R&D's, but it is already included in the future R&D part…

DHCAL performance

- 4.3.5 DHCAL prototype performance
  - This is an added subsection, intended to replace 4.3.7
  - Have test beam data in hand, but only preliminary results
  - Not ready to validate simulation or access baseline design performance
  - Thought it might be a good idea just to talk about prototype performance and point out its similarity to baseline
- 4.3.7 physics performance specific to baseline
  - Suggest to remove this subsection





Alternative technologies

- GEM
  - Andy already wrote this part
- Micromegas
- Scintillator
  - I forgot to ask for updates from these two efforts (mostly due to a misunderstanding)
  - Currently have LoI entries in hand
  - Will ask for updates after this workshop

Calorimeter Performance, 1TeV issue

- I have nothing for this section (not sure if I should)
- Seems to me that the content should come from PFA studies…

Summary of DHCAL section

- A good fraction of the text is in place
- Suggest to remove a few items
- Need guideline for a few subsections/items
  - Mechanical design
  - Readout
  - Layer design
  - Services
  - Baseline/prototype performance

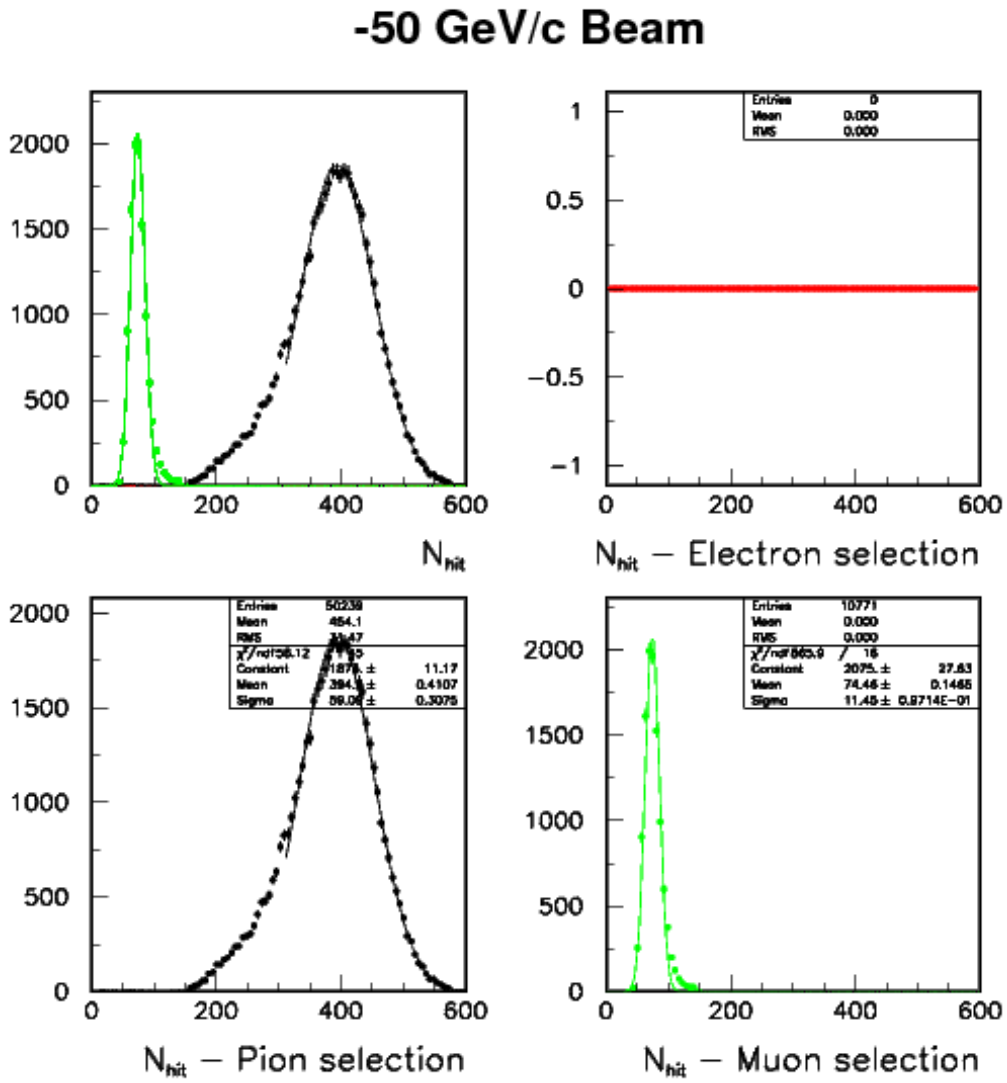
RPC DHCAL R&D update

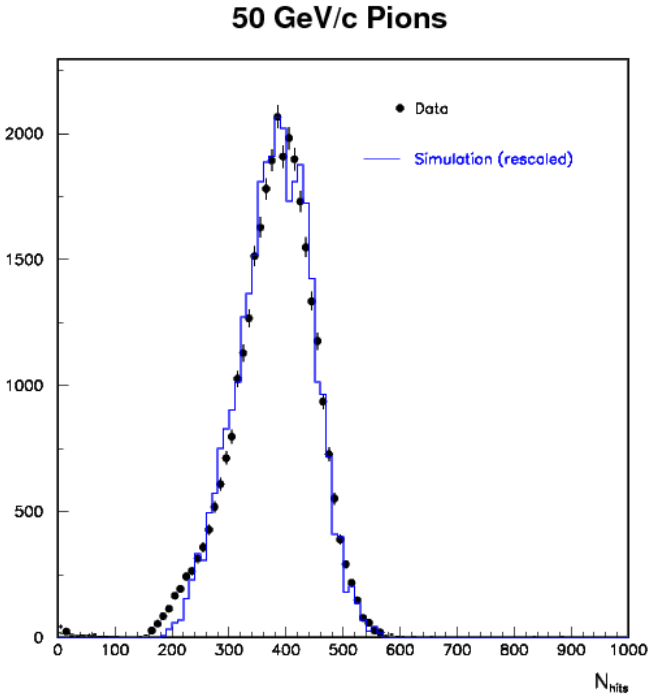
- Test beam
  - Finished test beam at Fermilab with Fe absorber
  - Started new test beam effort at CERN with Tungsten absorber
- Data analysis
  - Fermilab data is not quite done yet
    - Calibration is more complicated than thought – but getting there
    - Noise analysis, shower analysis, simulation effort all made good progress
    - Drafts for instrumentation paper exist and being circulated within group
  - More data flowing in with CERN test beam
    - Working with CERN team on new data

Very successful CERN test beam

- Wonderful test beam experience
  - Many thanks to CERN LCD team! (Lucie, Eric, Wolfgang, Jan, and many others …)
- RPC/readout/cassette survived inter-continental shipping
- CERN built a cooling tent around DHCAL – very stable temperature
- Had 2 weeks at PS → 1 – 10 GeV
- Had 3 weeks at SPS, 1 more week coming up in Nov. → up to 300 GeV
- Already had more data than several months data taking at Fermilab
  - Much better timing structure of the beam at CERN
  - Also better duty cycle at CERN

First look at Tungsten data





Simulation

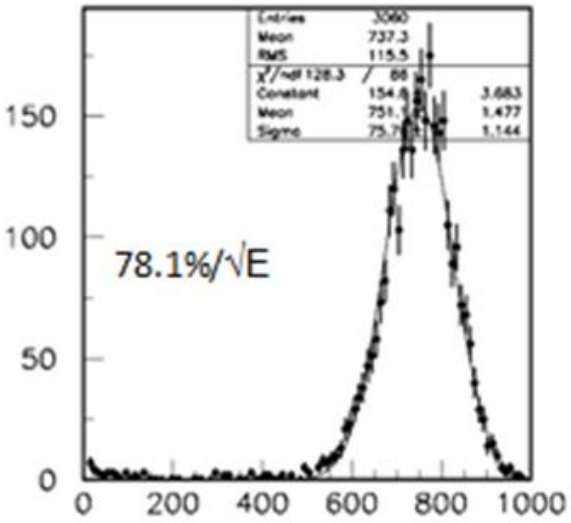
Operating conditions of Fermilab
At CERN quite different (6.3 ⟶ 6.0 kV)
Response (in x) rescaled to match data

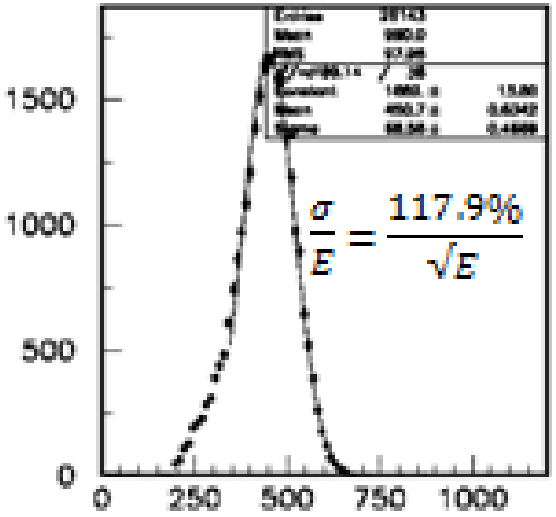
Asymmetric tail present as well

EM response is significantly depressed → very non-compensating
→ good test for software compensation

First look at Tungsten data

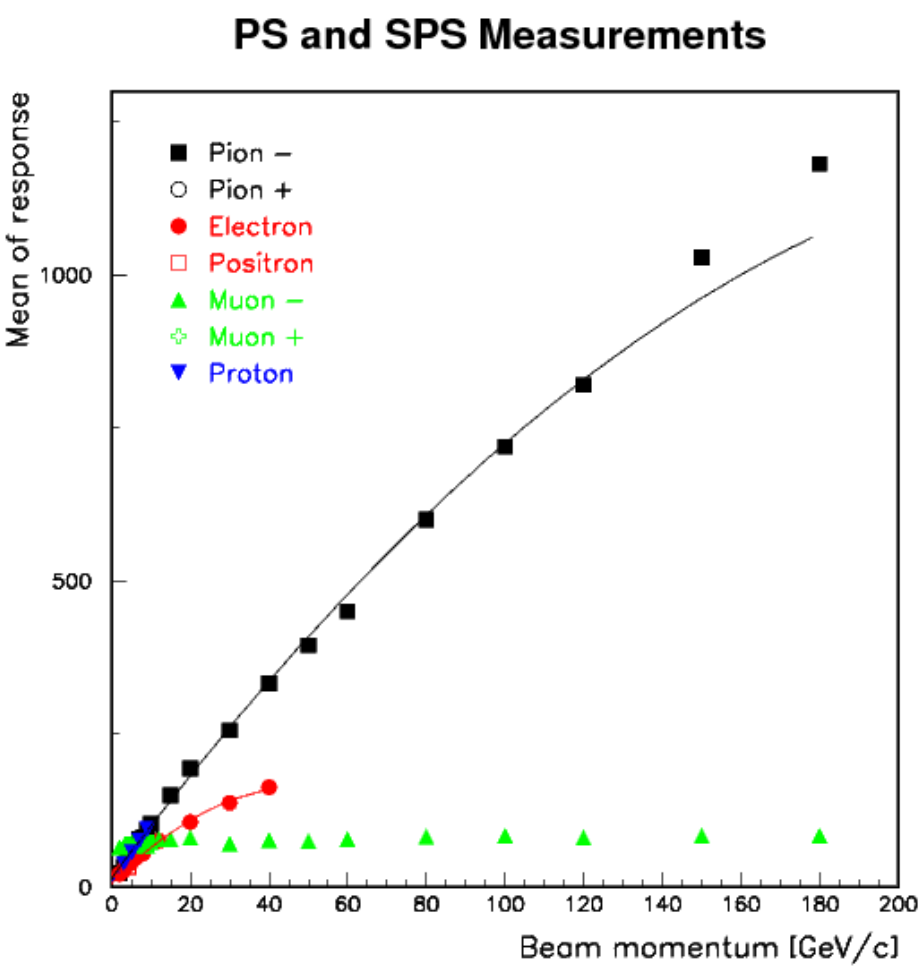
Energy	Steel absorber	W absorber
40	69%	97%
50	76%	106%
60	78%	118%

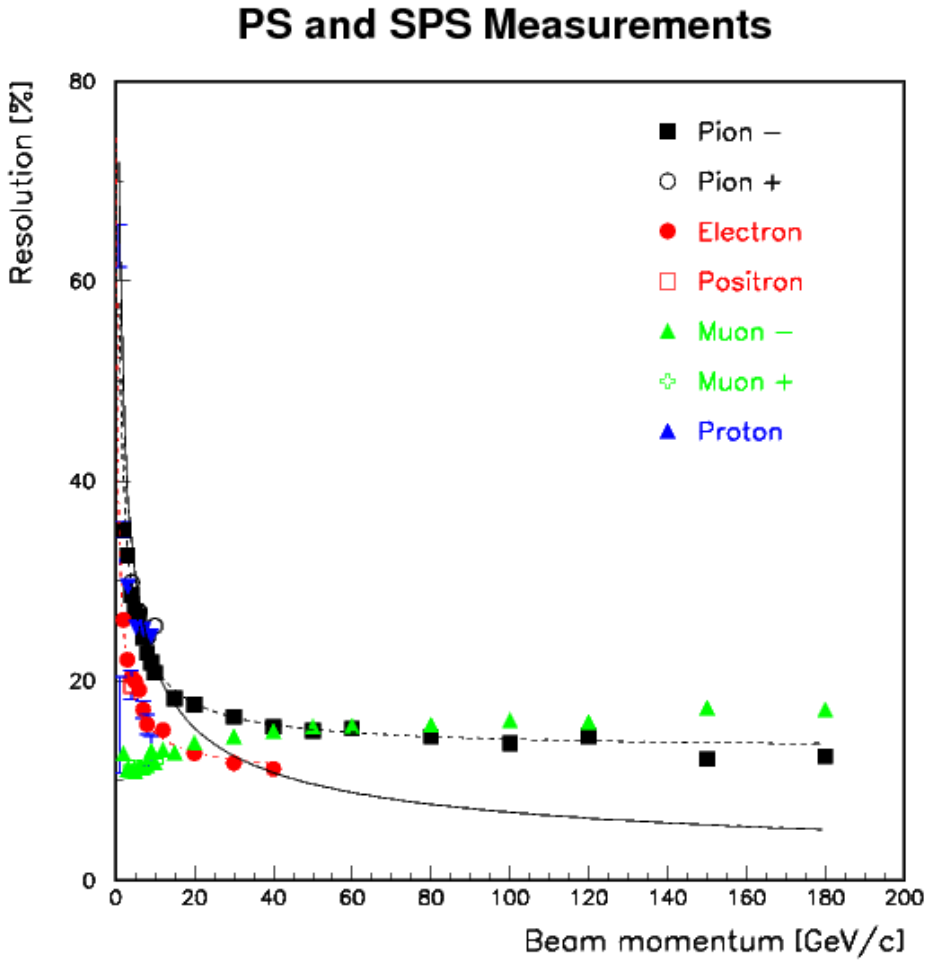




DHCAL has significantly less number of hits in Tungsten than in Fe
If go with Tungsten absorber, one should consider smaller pad size for DHCAL

DHCAL response – first look only





Lessons/issues learned (random order)

- RPC gap size needs better control during production
- HV insulation is not trivial
  - Especially when HV is all the way to the edge of RPC and absorber plate is right next to it
  - Used to hold prototype production for several weeks
- HV lead needs improvement
  - Currently using copper tape – but the adhesive seem to interact with resistive paint and make it losing conductivity
  - This is THE major problem we had at test beam
- Gas leakage can cause a lot of headache
  - Mainly due to crack on the glue trace, can be repaired
- Noisy regions in some RPCs
  - Glass cleaning issue during production

- Most of these issues are understood and can be avoided in construction phase

Summary

- W-DHCAL test beam is the major task this year
  - 2 weeks @ PS, 3 weeks @ SPS are done, one more week at SPS in November.
  - The test beam running is very successful, a lot of new data
- Data analysis is on-going
  - All analysis topics are making good progress
  - Calibration is still a main issue
- We learned a lot from the large scale prototype tests
  - Valuable experience for detector design/construction