# Update on 2003 Forward Calorimeter Beam Test Analysis / Simulation

Submitted to the Lisbon Hadronic Calibration Workshop, June 2009

FCal Group

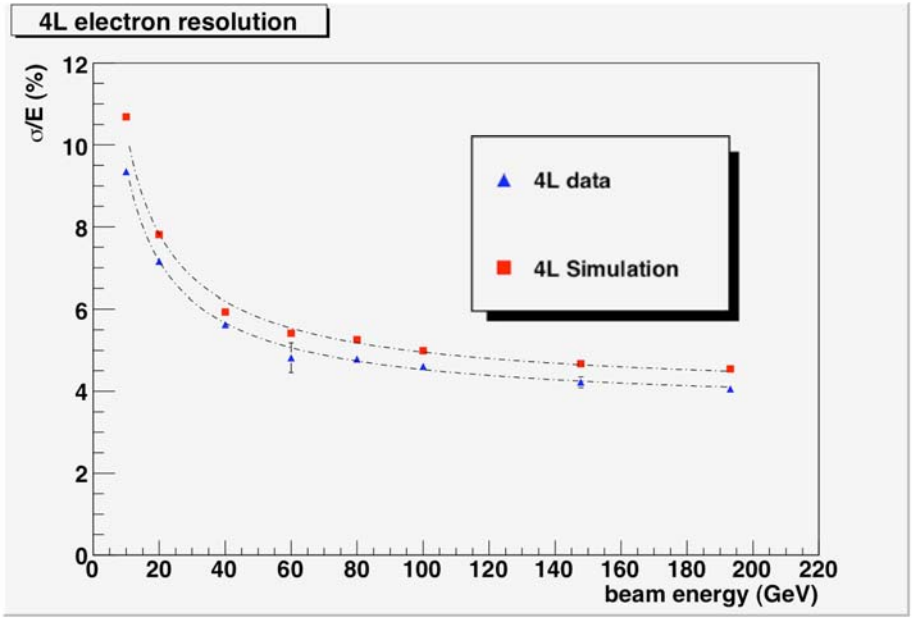
# Status of Testbeam Analysis

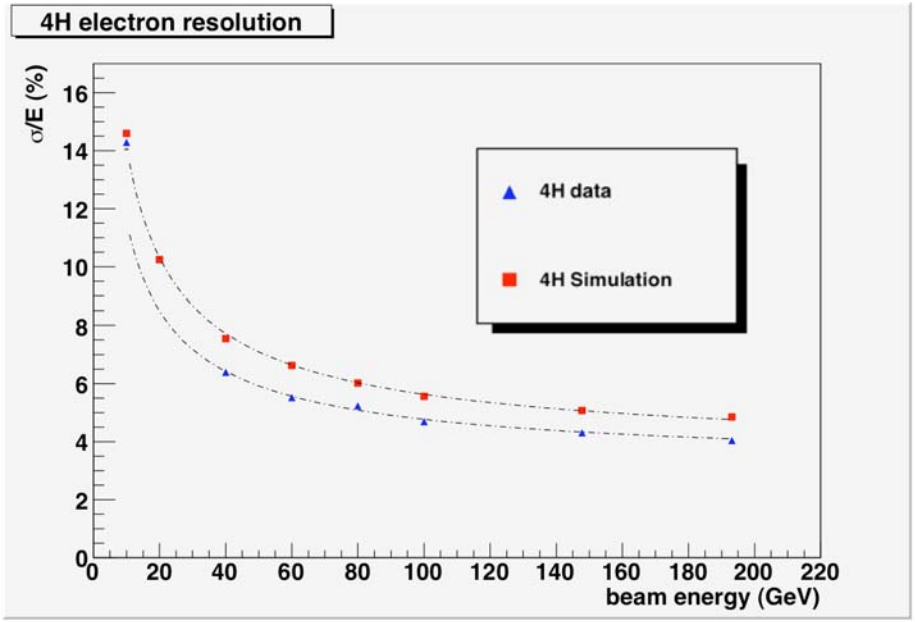
- Electrons and pions from 10-200 GeV in H6 beamline, summer 2003.
- Five beam impact points on detector face (see backup slides):
  - 1,2,3 are inner edge scan positions for leakage studies (L. Heelan).
  - 4H,4L are points at $\eta$~3.7 for full containment of shower energy.
    - at 4L position had minimal amount of material in front of the calorimeter
    - at 4H position had some upstream material in order to model ATLAS-like environment: (cryostat bulkhead, JM shielding).
  - 4L results for electrons and hadrons published in 2008 (note though that carrying EM-scale calibrations to ATLAS requires modelling of final ATLAS electronics since these we unavailable for the beam test in 2003).
  - Analysis of inner edge data in progress (L. Heelan, Carleton).
  - Analysis of 4H data in progress (P. Thompson, Toronto).
  - Hadronic calibration scenarios to be investigated.
  - Will not describe details of the analysis (~same as for published 4L results)
  - Purpose of these slides is to illustrate ongoing work on the comparison of the 4L/4H results with the G4 simulation.

# Status of FCal 2003 Testbeam Simulation

- Simulation ported to Athena 14.5.0, geant4.9.1.patch03.atlas01
- QGSP-BERT, 30μm range cut, Birk's Law ON
- EM sampling fractions recalculated
- Noise is OFF in simulation (DB for simulation is incorrect by a factor of ~2 for most channels and we have had some difficulties overwriting this).
- ATLAS-H6-2003-02 geometry:
  - Polyethylene added upstream for 4H runs (see backup slides)
  - FCal2/3 absorber matrix density reset from 15.36 g/cm$^3$ to 14.39 g/cm$^3$
  - Tungsten rod material changed from WFeNi (slug material) to tungsten (changes density from 18.6 to 19.2 g/cm$^3$).
- Distributed beam spot simulated (but not yet with beam profile from data)

# Electron Energy Resolution




$a = 27.7\%$ $b = 3.6\%$ [ data ]

$a = 30.3\%$ $b = 3.9\%$ [ MC ]

$a = 35.6\%$ $b = 3.2\%$ [ data ]

$a = 43.2\%$ $b = 3.6\%$ [ MC ]

Data are noise subtracted. Simulation is with no noise. Fit values are for usual parametrization:

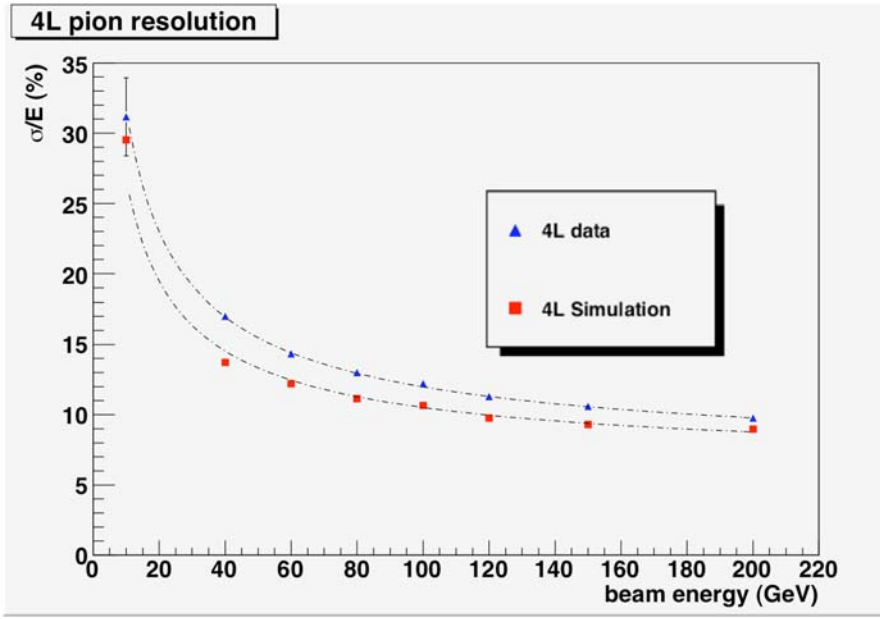
$$\frac{\sigma_E}{E} = \frac{a}{\sqrt{E}} \oplus b$$

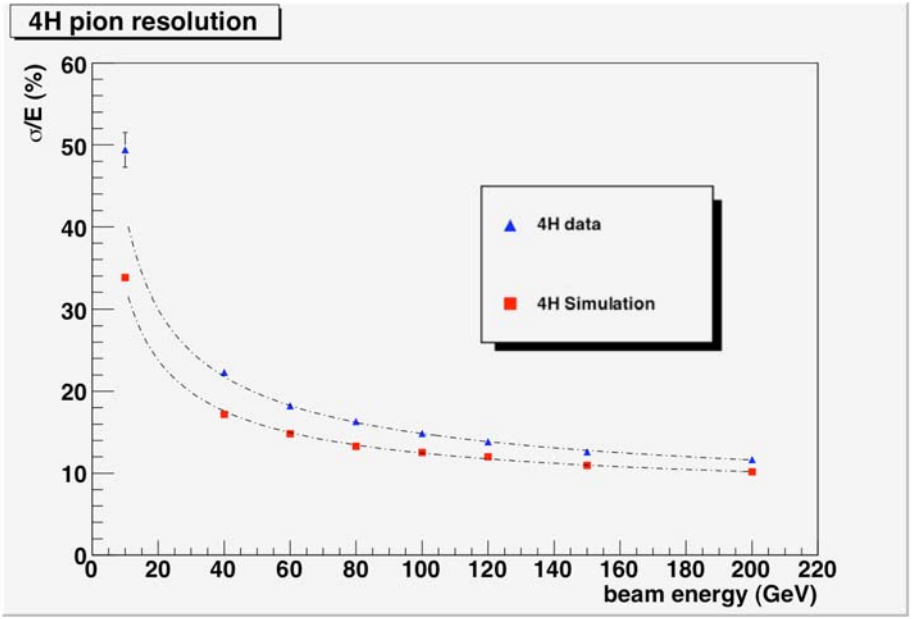
# Pion Energy Resolution

Energy reconstruction with 1 weight / module: $E_\pi = g_1 E_1^{EM} + g_2 E_2^{EM} + g_3 E_3^{EM}$

$E_i^{EM}$ = EM-scale energy reconstruction within 16cm of beam impact point (from tracking)

Weights derived from data by minimizing resolution for 200 GeV pions. Weights from data also used for reconstruction of Monte Carlo data.




$a = 98.0\%$ $b = 6.9\%$ [ data ]

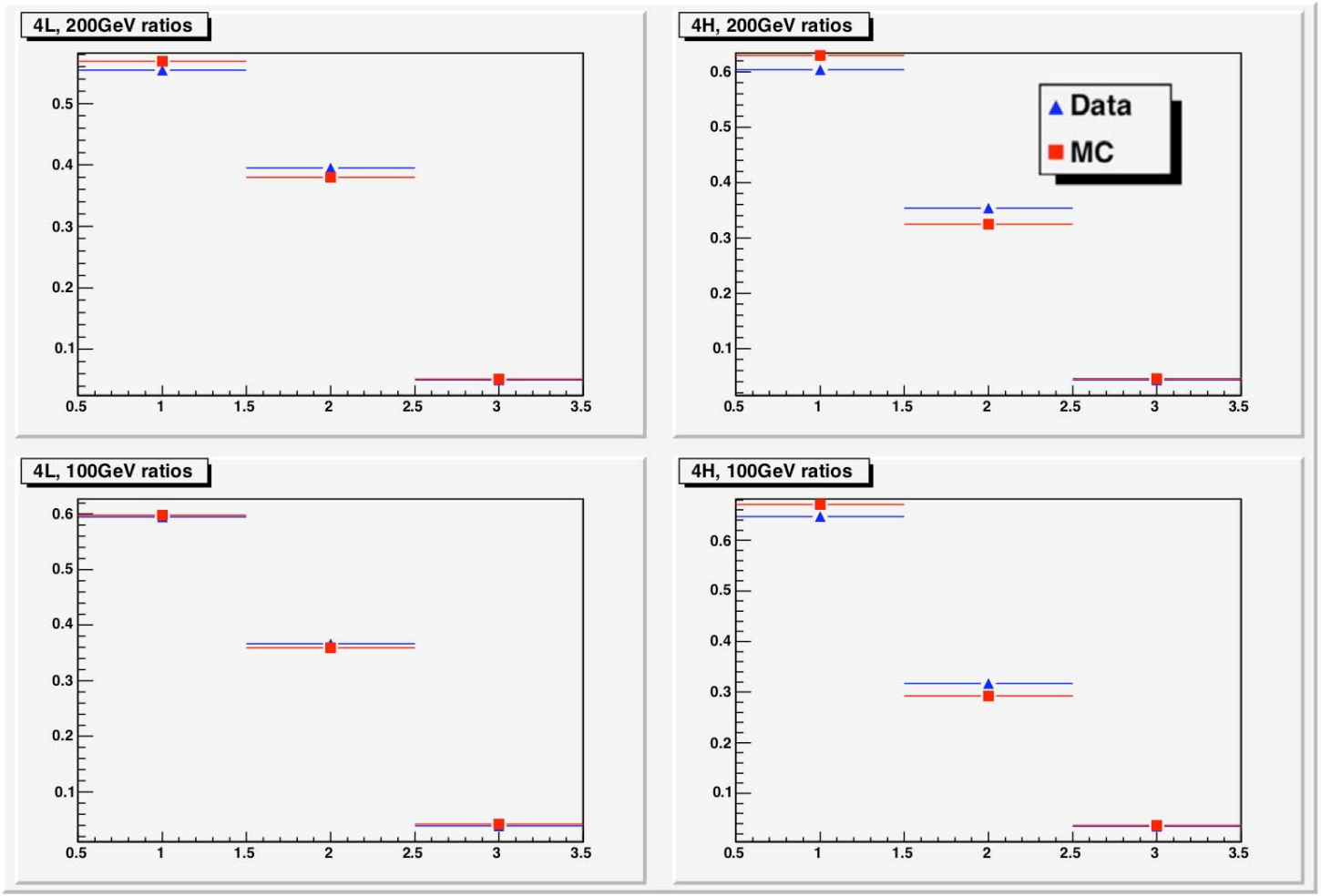
$a = 82.0\%$ $b = 6.6\%$ [ MC ]

$a = 130\%$ $b = 7.1\%$ [ data ]

$a = 101\%$ $b = 7.2\%$ [ MC ]

# Longitudinal Energy Deposition for Pions

Three longitudinal layers: FCal1,2,3.

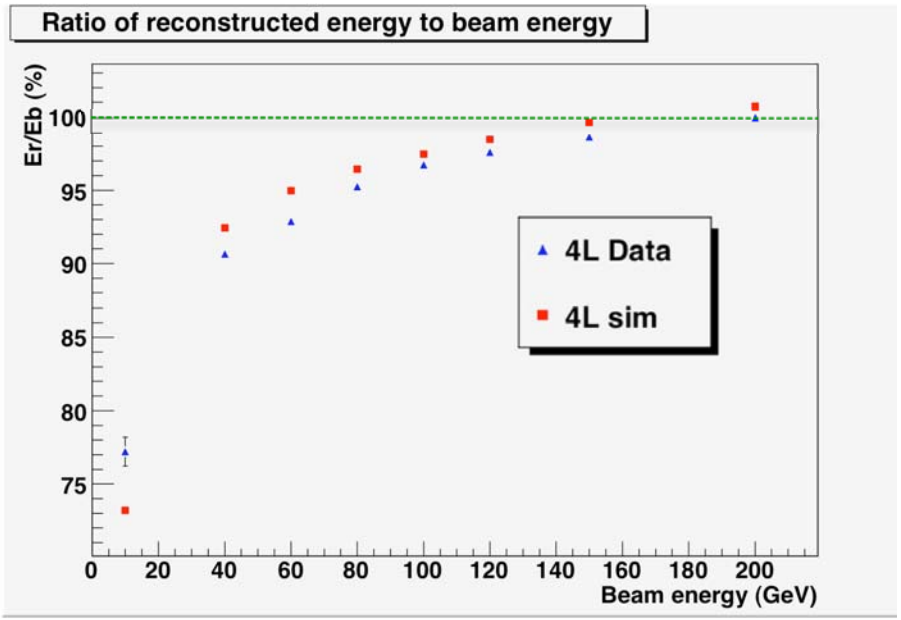


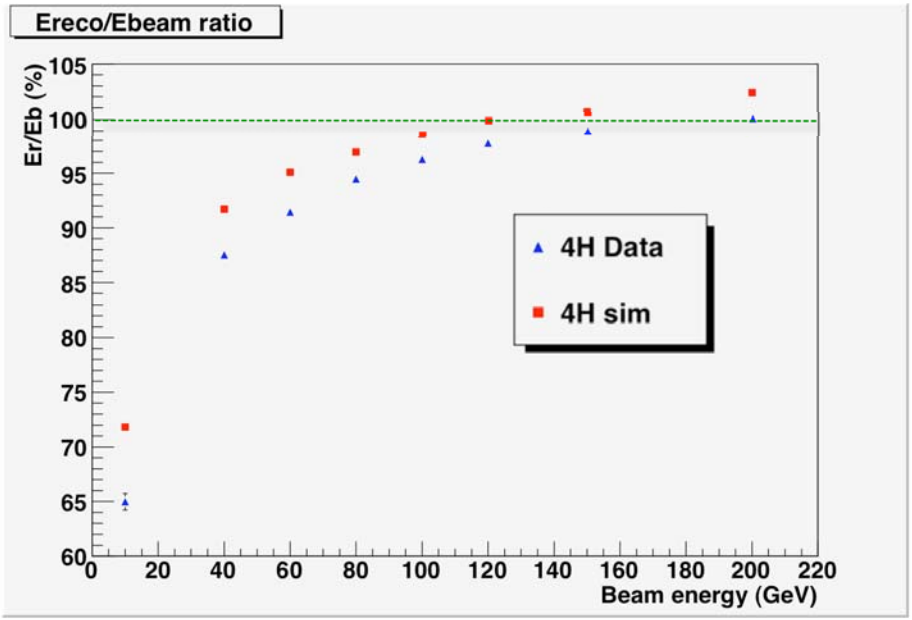

Relative energy deposits in OK agreement. However, overall Monte Carlo yields EM energy deposits that are larger than in data (see also slides from L.Heelan).

# Reconstructed Pion Energy

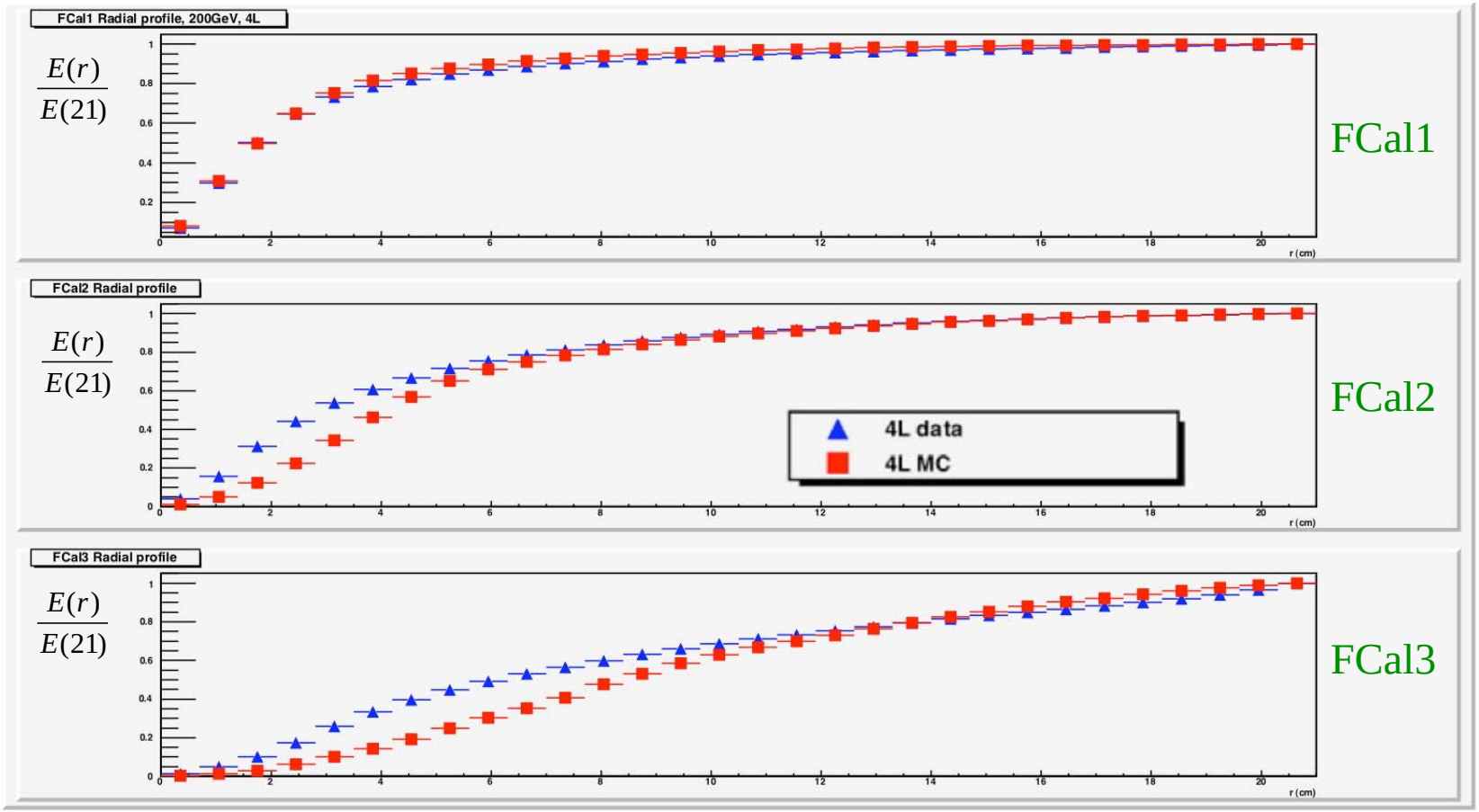
Weights derived from 200 GeV pion data, so for data $E_{reco}/E_{beam}$ = 100% at 200 GeV.

At highest energies MC $E_{reco}/E_{beam}$ > 100% (EM scale energies too high in Monte Carlo)



# Pion Energy Deposition: Radial Profiles




$E(r)$ is the energy within a cylinder of radius *r*, centred on the beam impact point. 21cm is the limit before reaching the FCal edge (from the 4L or 4H positions).

In FCal2/3 showers wider in Monte Carlo than in data. These plots are for 200 GeV $\pi^-$ at 4L, but 4H results are similar, as are results for 100 GeV $\pi^-$.

Need to look at this as a function of effect of FCal matrix density?

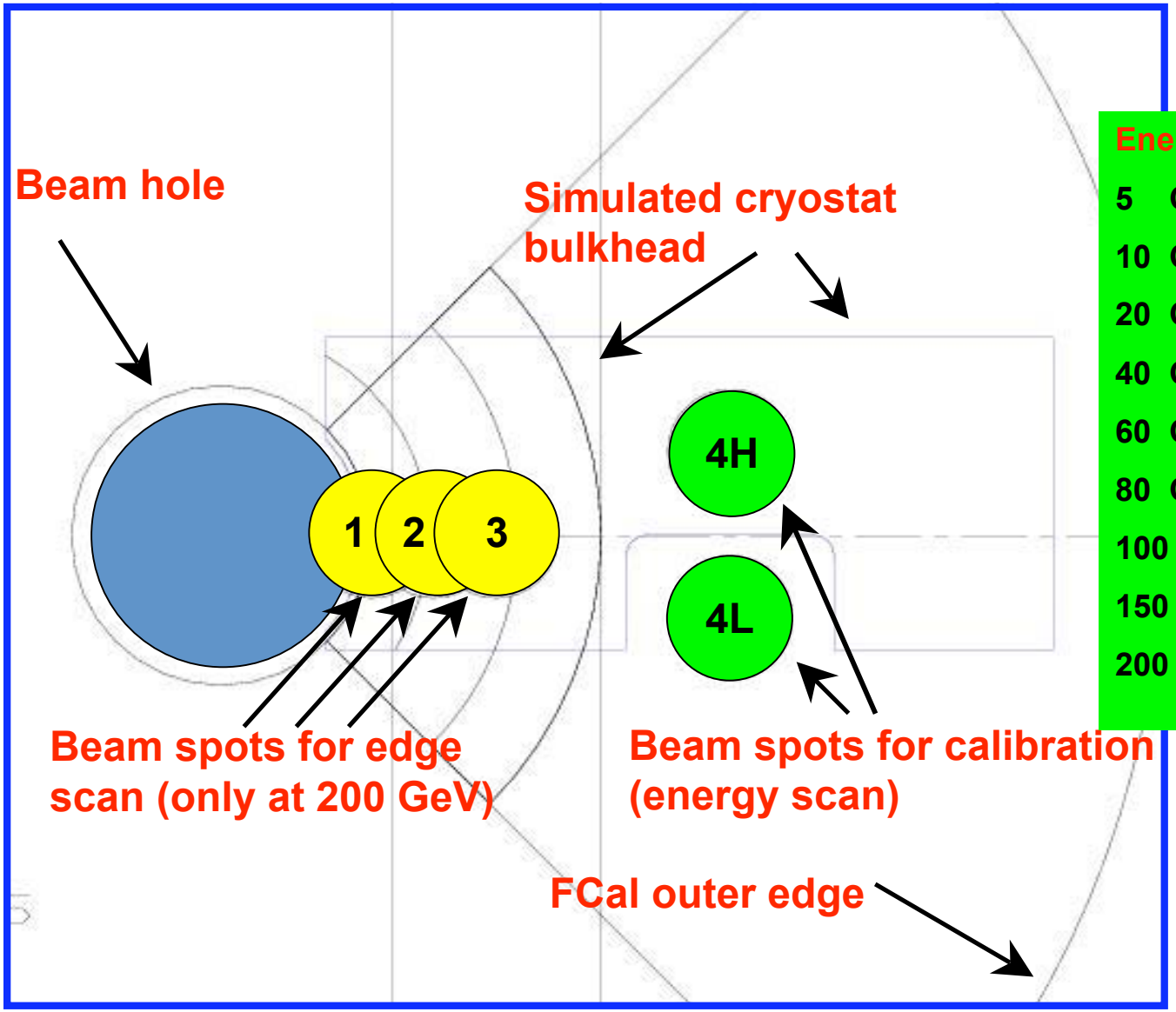
# FCal 2003 TB Data/MC Summary (4H/4L)

- Resolution for electrons slightly poorer in Monte Carlo than in data.
- Resolution for pions too good in Monte Carlo.
  - Data weights used for MC pion energy reconstruction
  - Data/MC longitudinal profiles in imperfect but ~OK agreement
  - Radially, FCal2/3 showers wider in Monte Carlo than in data
- Continuing simulation studies (4L,4H positions):
  - inclusion of correct cell noise (run by run from data if necessary)
  - effect of different physics lists
  - effect of Birk's Law ON/OFF
  - shower profile variations with FCal2/3 absorber matrix density
- Investigation of hadronic weighting schemes using testbeam data / MC.
- Also some remaining data analysis issues (not discussed here).

# Additional Slides

(Testbeam Setup / Datasets)

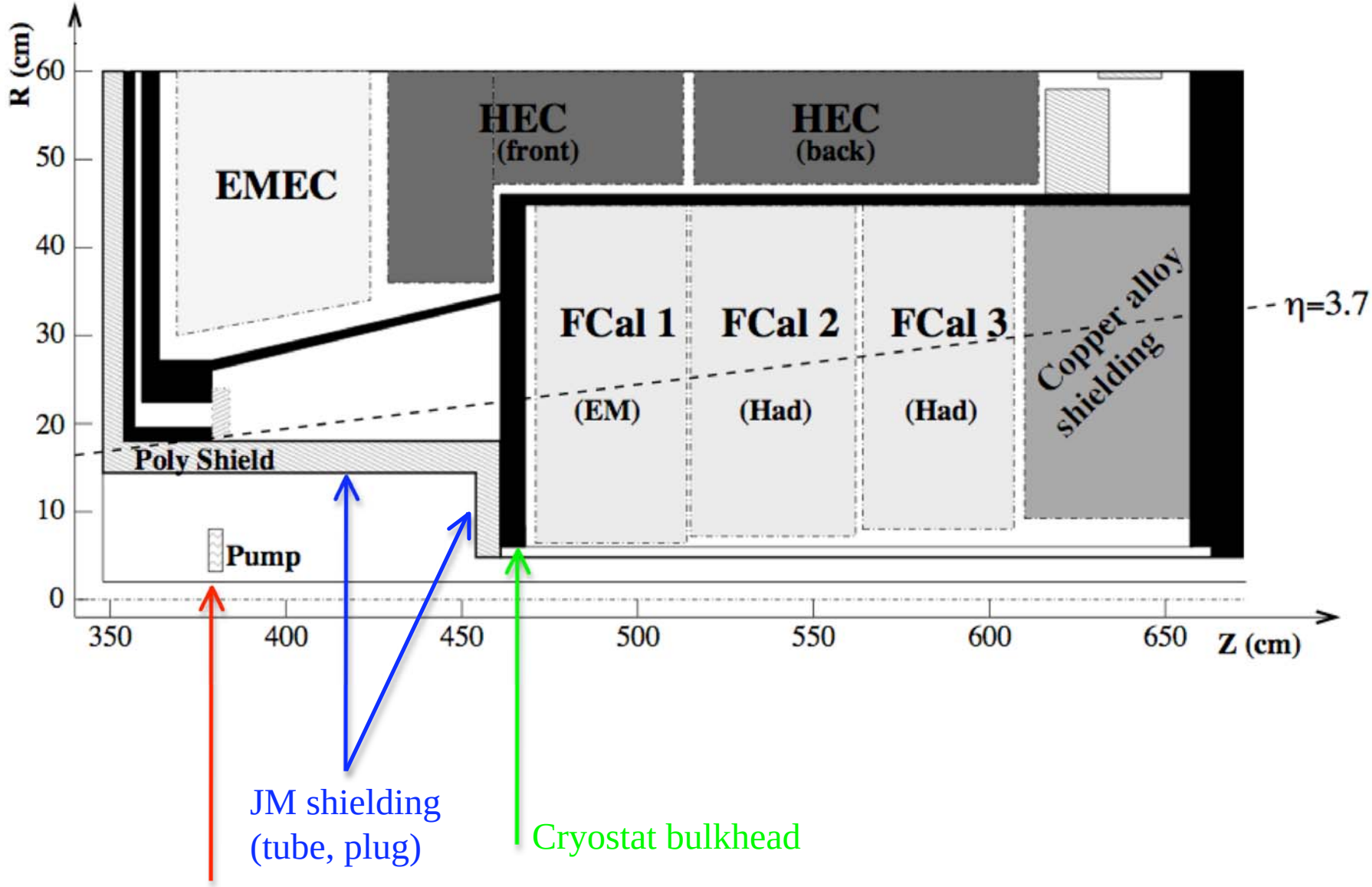
# Datasets for 2003 FCal Calibration Testbeam



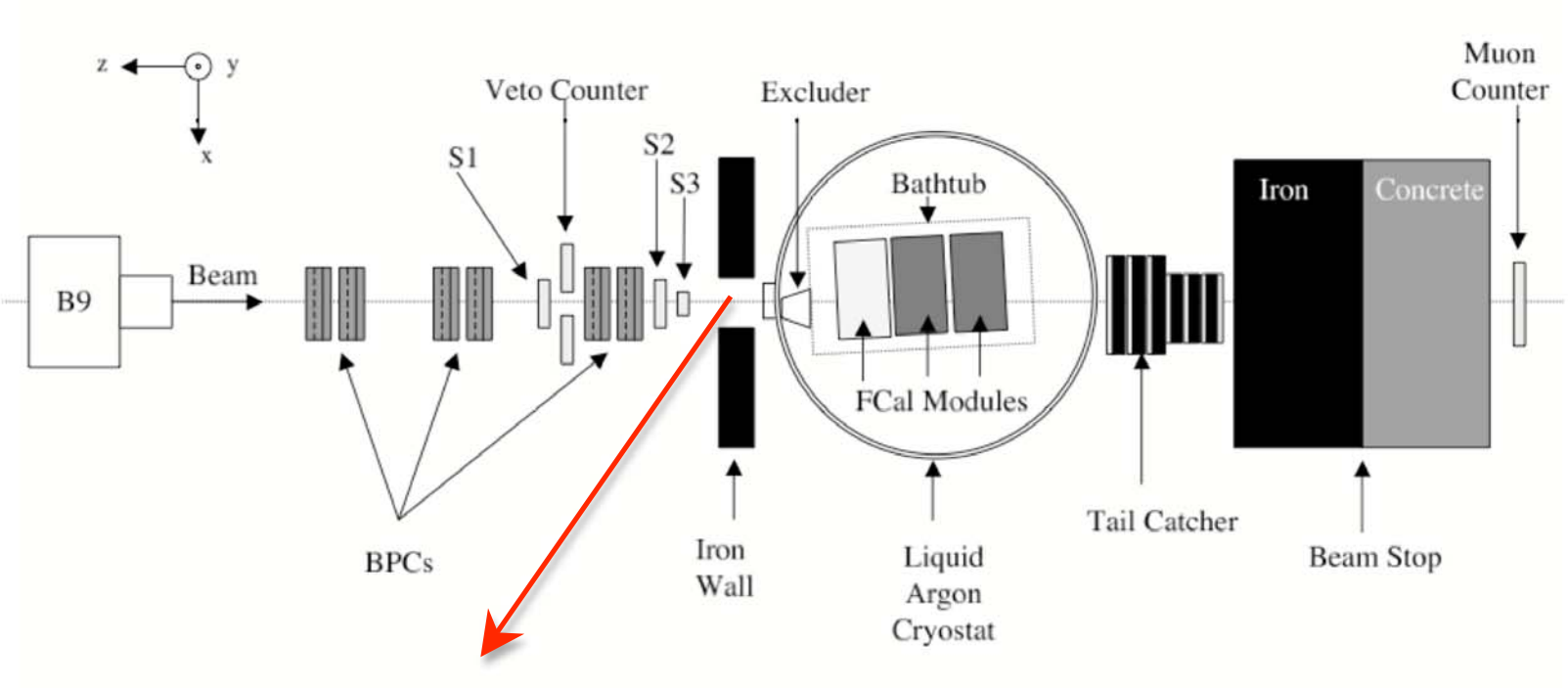

| Energy Scan Data Points | | |
|---|---|---|
| 5 | GeV | electrons |
| 10 | GeV | electrons, pions |
| 20 | GeV | electrons, pions |
| 40 | GeV | electrons, pions |
| 60 | GeV | electrons, pions |
| 80 | GeV | electrons, pions |
| 100 | GeV | electrons, pions |
| 150 | GeV | electrons, pions |
| 200 | GeV | electrons, pions, μ |

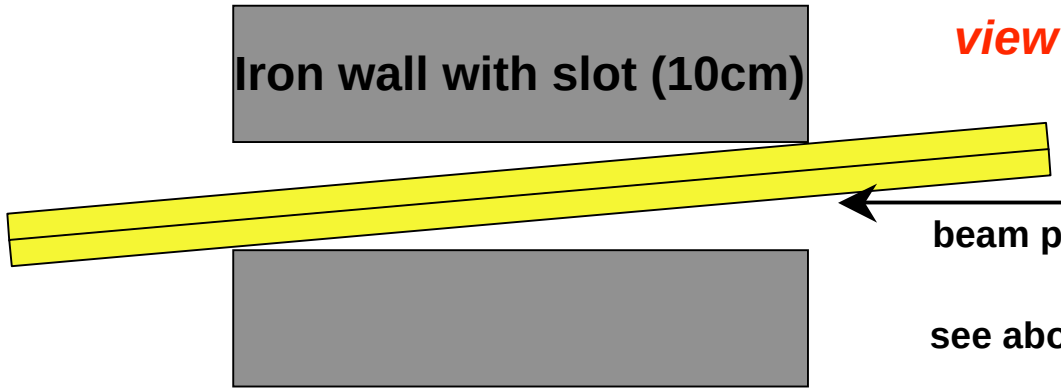
Wide (5cm) beamspot used to average over impact point on face of calorimeter

# FCal Environment in ATLAS



# Mockups of Upstream Material in 2003 FCal TB



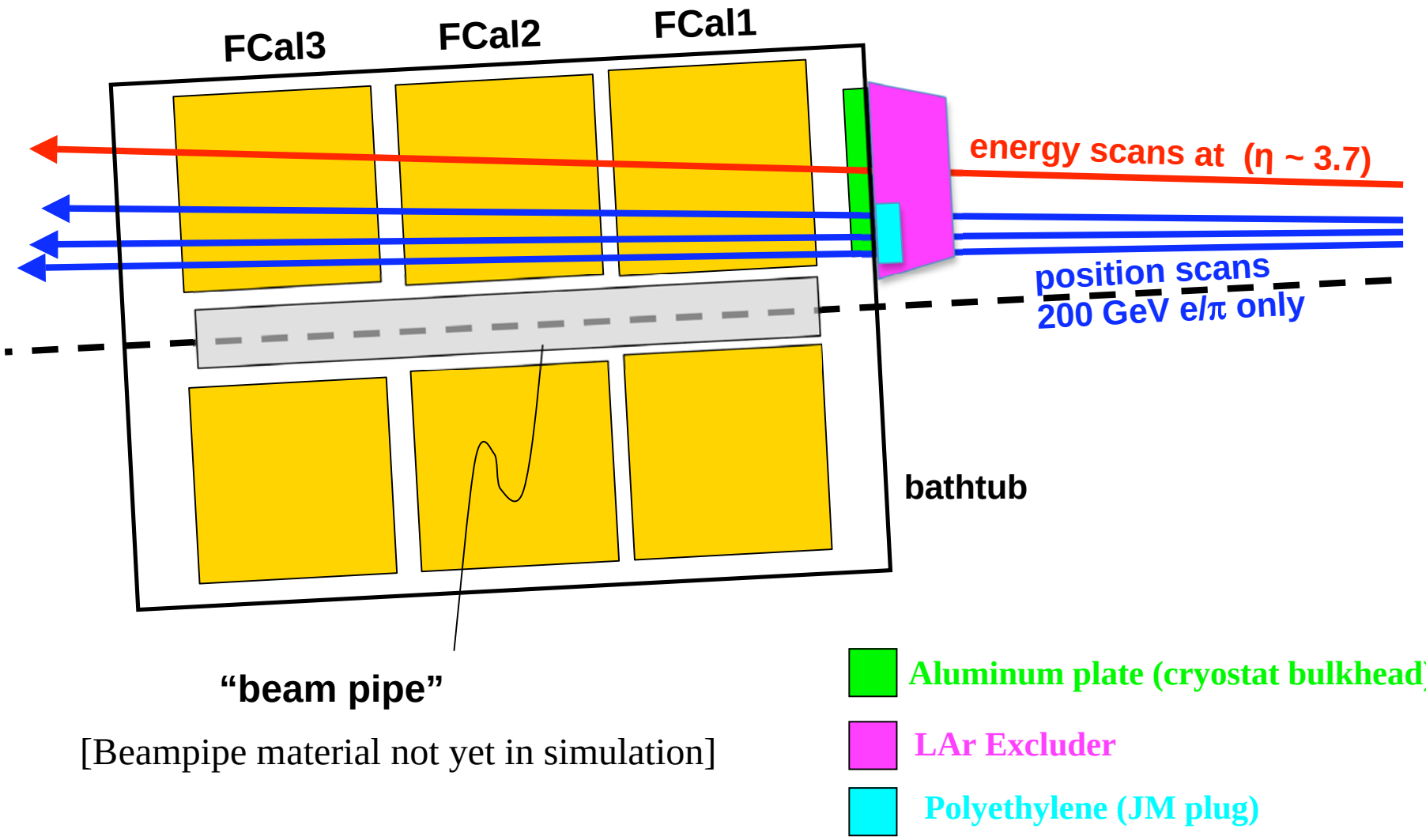

***view from above***

**beam particles (5cm diameter beam spot):**

**see about 40 cm of polyethylene (JM tube)**

**angle in atlas is somewhat shallower**

# Mockups of Upstream Material in 2003 FCal TB




[Beampipe material not yet in simulation]