UK software work

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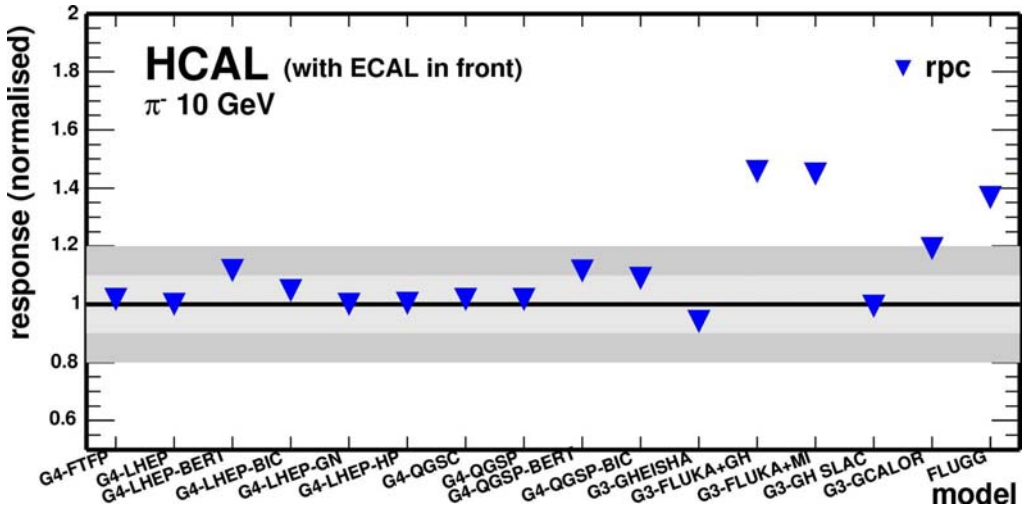
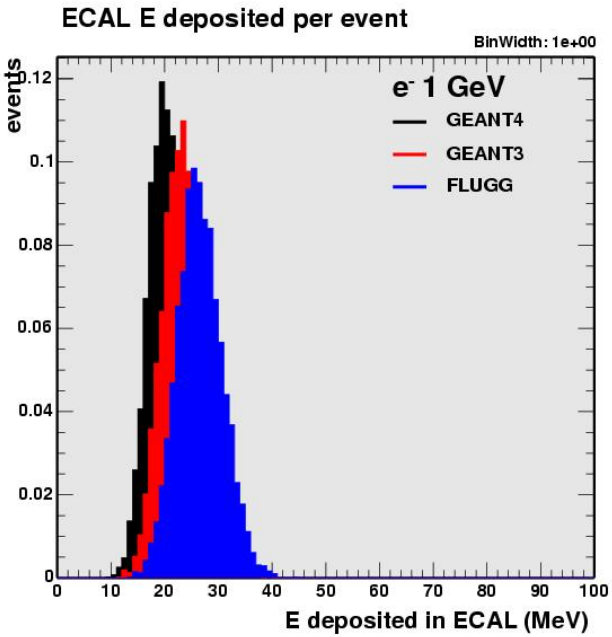
- Simulation
- Reconstruction
- Preparations for test beam

Simulation

- Comparisons between hadronic models in G3/G4 (see G.Mavromanolakis talk)
- Also now have some results from Fluka (using Flugg – N.Watson).
- Discrepancies between models for electron response, despite being OK(ish) for muons.





Electron simulation

- Unless we understand differences between electron shower, how can we interpret differences for hadrons?
- Geant4 results vary with version number. e.g. for 1 GeV electrons:

	Geant 4.5.2	Geant 4.6.0	Geant 4.6.1	Geant3	Flugg
N(Ecal)	28.6	29.1	28.2	32.3	35.1
E(Ecal) /MIPS	143.7	139.2	136.7	156.3	177.8

Electron simulation

- Made some investigations using Geant3/Geant4; turning off various combinations of physics processes.
- Reveals likely culprit is Multiple Scattering. Furthermore, multiple scattering code was rewritten in Geant 4.6 - the Geant 4.5.2 versions are still available as an alternative.
- Turn off Multiple Scattering completely:

	Geant 4.6.1	Geant3	Flugg
N(Ecal)	28.3	29.0	29.4
E(Ecal) /MIPs	196.7	195.9	205.3

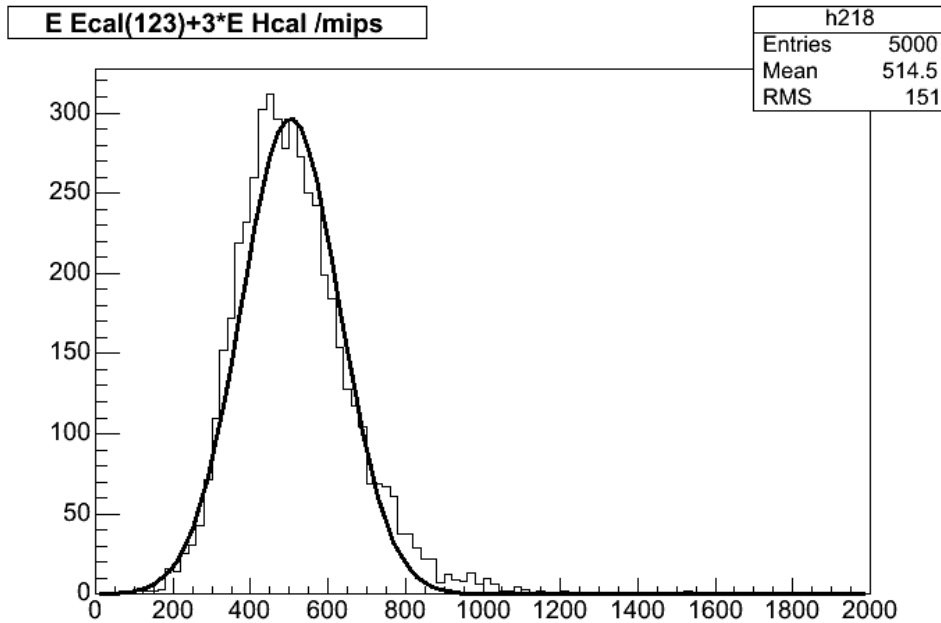
Of course the energy deposited changes completely, but now Geant4 and Geant3 agree well. Flugg much better, though still some discrepancy.
What is the mechanism? Seems that fine details of multiple scattering (choice of step length etc.) influence whether low energy electrons produced in tungsten sheets escape.
e.g. A 5 MeV e- produced in the centre of a 1.4 mm plate yields 0.15 MIPs in Geant4 and 0.55 MIPs according to Geant3 in the following Si layer.

Reconstruction

- In preparation for energy flow, need calorimeter clustering algorithm.
- Should function for different detector geometries/technologies.
- Work in Cambridge – see C.Ainsley's and G.Mavromanolakis' talks today. Also Mark Thomson.
- Combination with tracking still cumbersome. Use BRAHMS tracking code.
- During summer, Mark reached $\sigma(E)/E \sim 40\text{-}45\%/\sqrt{E}$. Some distance still to reach our $30\%/\sqrt{E}$ goal.
- Need energy reconstruction in ECAL/HCAL…

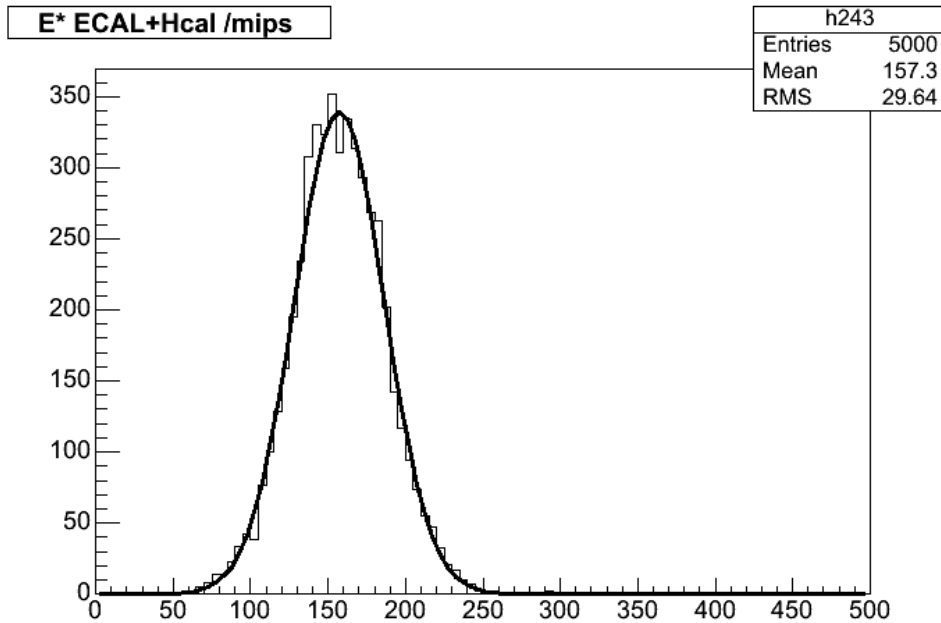
Energy reconstruction

- Studying Calice prototype (with scintillator tile HCAL; cell size 1 cm^2).
- Form E_{ECAL} by weighting three sections 1:2:3 to account for sampling density.
- Add E_{HCAL} with appropriate weight to optimise resolution; roughly $E_{ECAL}+3*E_{HCAL}$.
- Energy resolution about 29% for 5 GeV π.
- Non-Gaussian tail on high side.
- Cells with very high energy deposition tend to be caused by hadrons (mainly protons and nuclei).



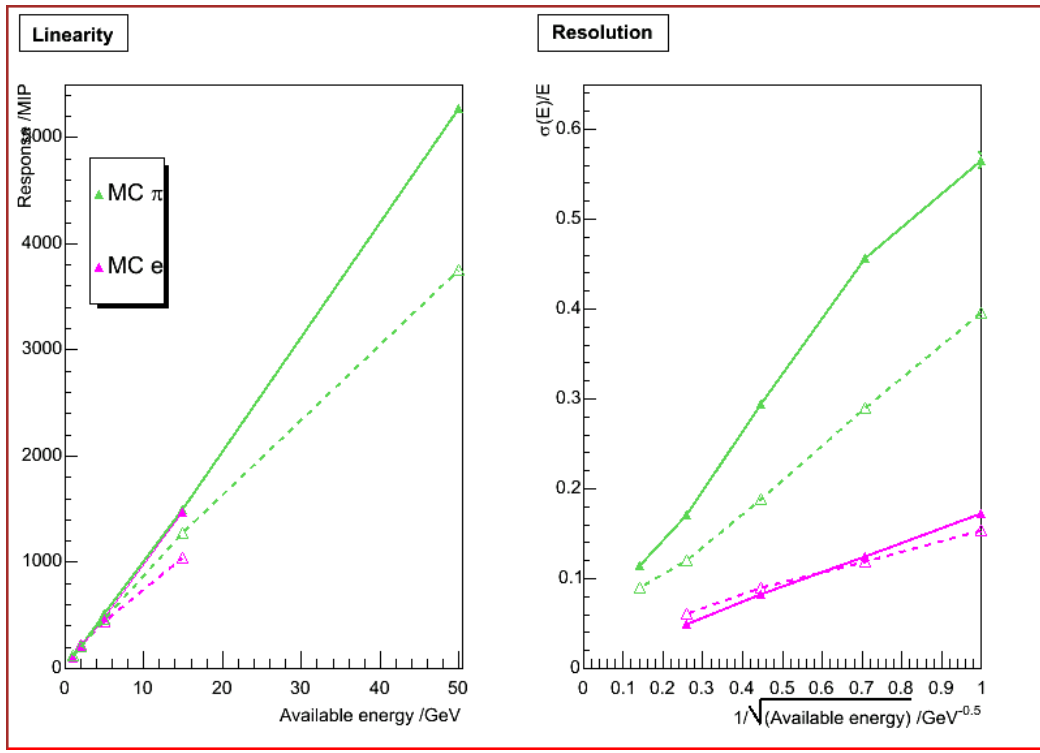
Energy reconstruction (contd.)

- Try non-linear weighting of cells.
- Sum E_i^k instead.
- k=1 corresponds to normal procedure. k=0 is digital calorimeter.
- k=0.5 seems somewhere near optimal.
- Form E'ECAL+1.1*E'HCAL:
- Energy resolution about 19%.
- Much nicer Gaussian shape.



Energy reconstruction (contd.)

- Check other energies:
- Quite a dramatic improvement in hadron energy resolution; achieving around 40%/√E. Not much effect on electron resolution (up to 15 GeV).
- But, linearity of energy response is much less good, especially for electrons. This may be a bad thing. Could calibrate it for single particles, but could mess up jets with overlapping energy deposits.
- e/π ratio is further from unity.
- Worth further study? For example compare with RPC DHCAL, look at dependence on cell sizes etc. More careful optimization of parameters.
- Have made similar study in Minos (4 cm scintillator strips), and confirmed similar results using test beam data. Actually using it for hadronic event reconstruction.



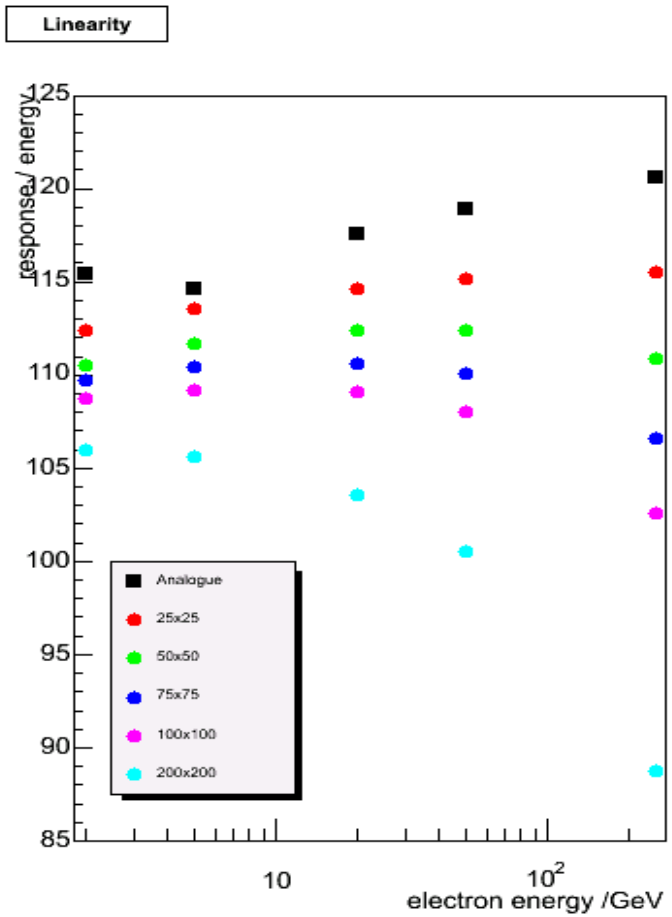
MAPS simulation

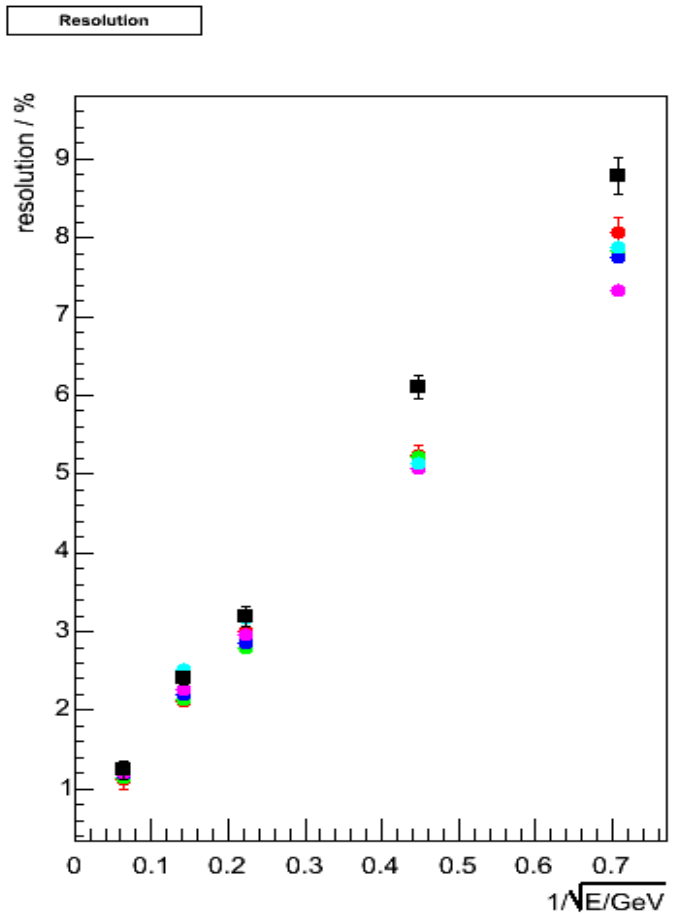
- Method - run Mokka 3.2 with modified local database. Change Si thickness from 500 to 5 microns; keeping all else the same.
- D09 Geometry (40 layers).
- Store energy deposits in 25x25 micron cells for subsequent analysis; they can then be merged into larger cells as required.
- Apply threshold of 0.3 MIP (=450 eV).
- Look at <N> and r.m.s./<N> for electrons at various energies and cell sizes.
- Compare with analogue mode, i.e. 500 micron Si
- In both cases, weight layers 31-40 by a factor 3.

MAPS simulation

	5 GeV e- <n>	rms/<n>	50 GeV e- <n>	rms/<n>
25x25μm	568±1	5.22±0.13%	5758 ±5	1.97±0.07%
50x50μm	559±1	5.21±0.13%	5620 ±5	2.12±0.07%
75x75μm	552±1	5.06±0.13%	5505 ±5	2.11±0.07%
100x100μm	546±1	5.07±0.13%	5400 ±5	2.27±0.07%
200x200μm	528±1	5.14±0.13%	5026 ±5	2.47±0.07%
1x1cm analogue	1091±2	6.10±0.13%	11292 ±14	2.41±0.09%

MAPS study


Linearity
response/ energy
125
120
115
110
105
100
95
90
85
10
10^2
electron energy /GeV
Analogue
25x25
50x50
75x75
100x100
200x200


Resolution
resolution / %
9
8
7
6
5
4
3
2
1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
1/√E/GeV

MAPS study

- Samples from 2 to 250 GeV give some indication of linearity of response. Digital mode no worse than analogue.
- Ideally aim for 50x50 micron cells?
- Energy resolution actually slightly better for digital mode, especially at low energies.
- Should look at effect on pattern recognition.
- Variation of <n> with cell size gives some measure of multiple hits.

Preparations for test beam

1. Conversion of calorimeter data to LCIO format.
2. Store beam-related (and environmental) data in LCIO.
3. Apply calibration to data (may be part of item 1.)
4. For MC - simulation of "digitization" (e.g. noise). Do this after Mokka (assuming info is adequate). Base on Catherine Fry's work?
5. Analysis of MWPC/Čerenkov beam data; particle id etc; may use as filter before subsequent analysis.
6. Clustering code (CGA/GM etc)
7. Histogramming + analysis
8. Event display.

Reconstruction + analysis

- First “reconstruction framework” exists: MARLIN

  Modular Analysis and Reconstruction for the LiNear Collider
- see talk by J. Samson in this meeting
- simple, open framework
  - dynamically configured through steering file
  - defines a standard structure for a module
  - LCIO based
- It’s a starting point, lots still needs to be done

From ECFA04 summary

existing modules:

HCAL prototype ganging module

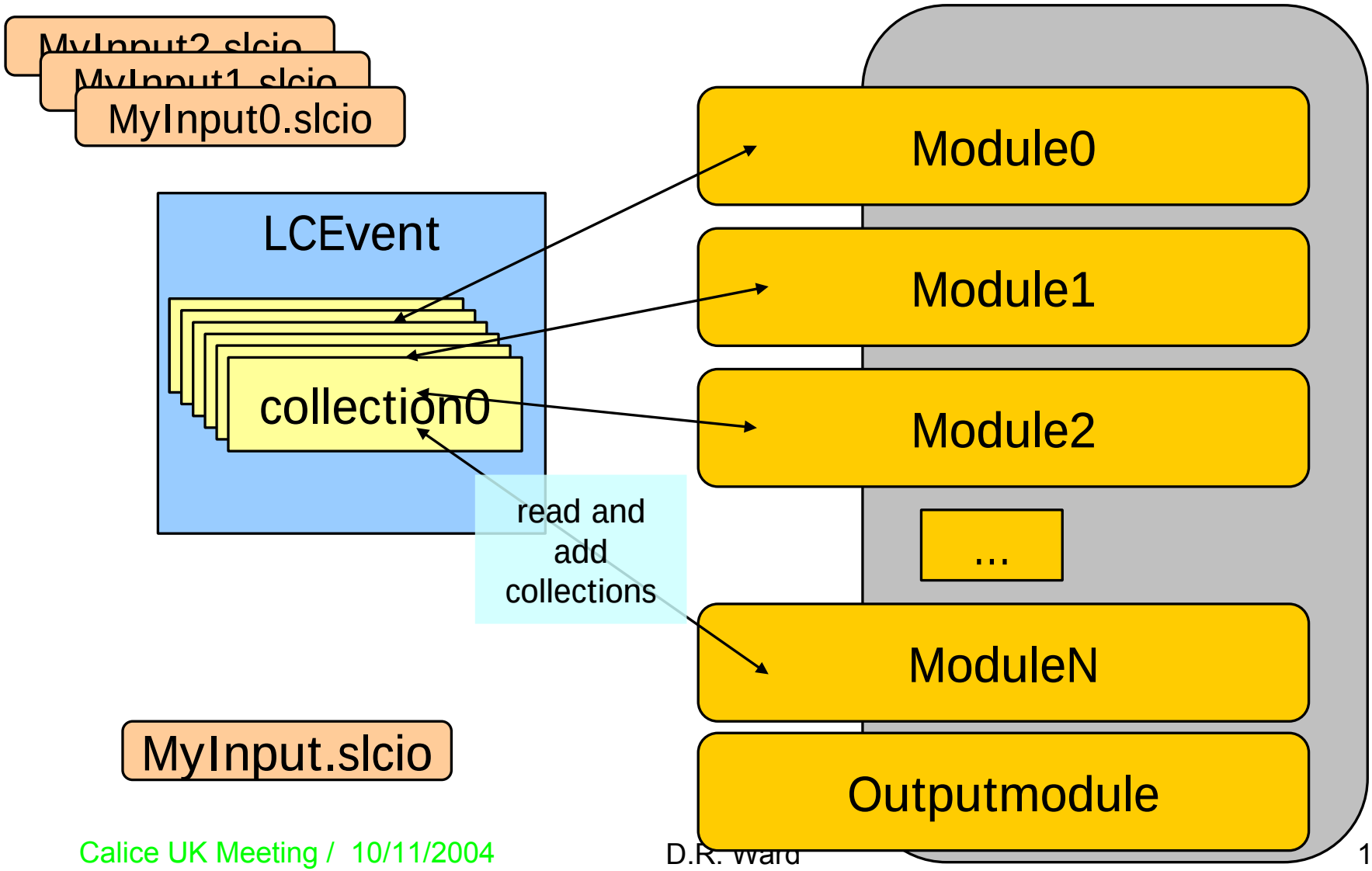
Jet Finder, Lepton Finder, ZVTOP module

soon: wrapped reconstruction software (tracking, ...)

Cluster finding

Need to make all this work together; make it usable.

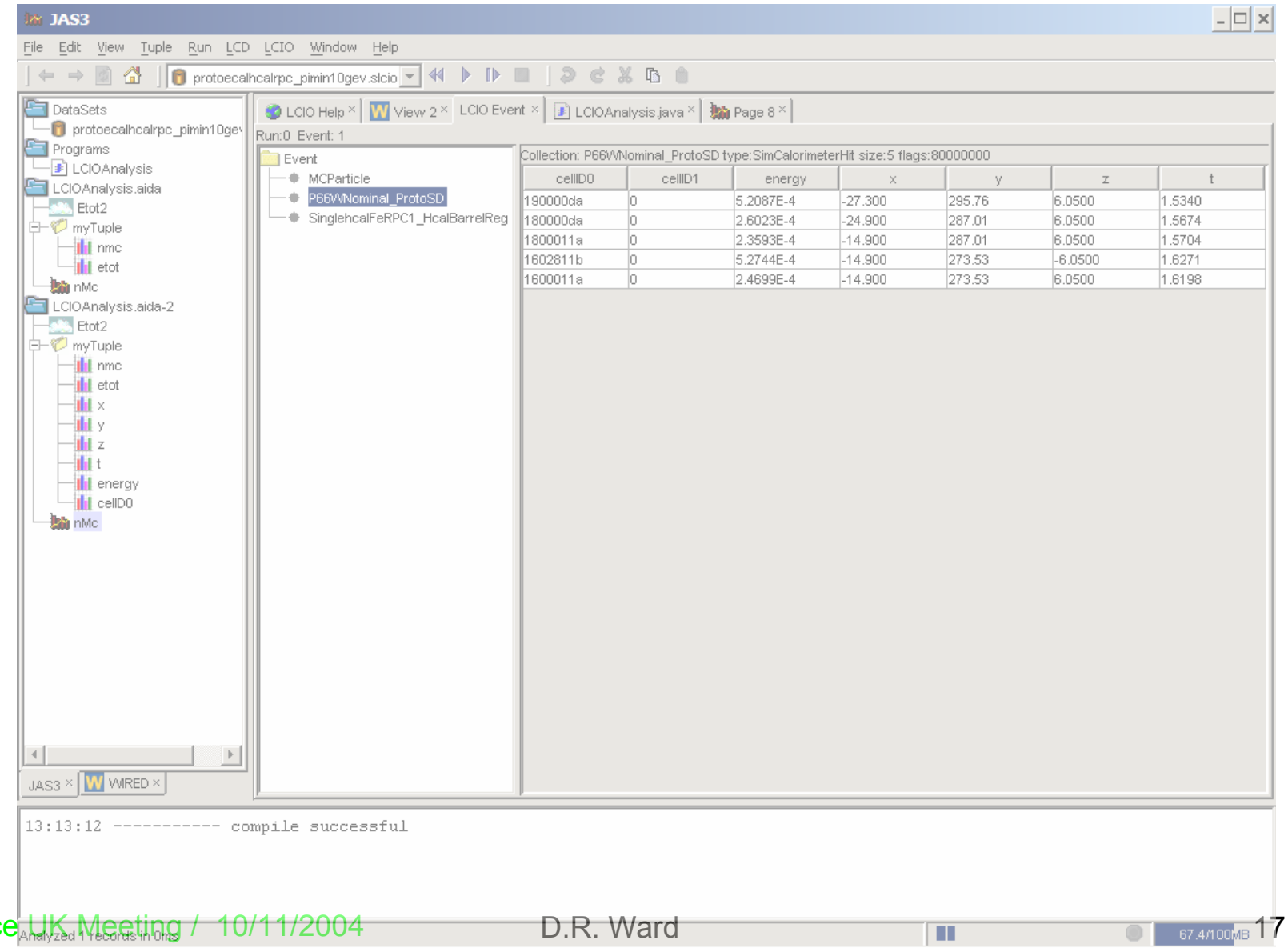
MARLIN – modules and LCIO



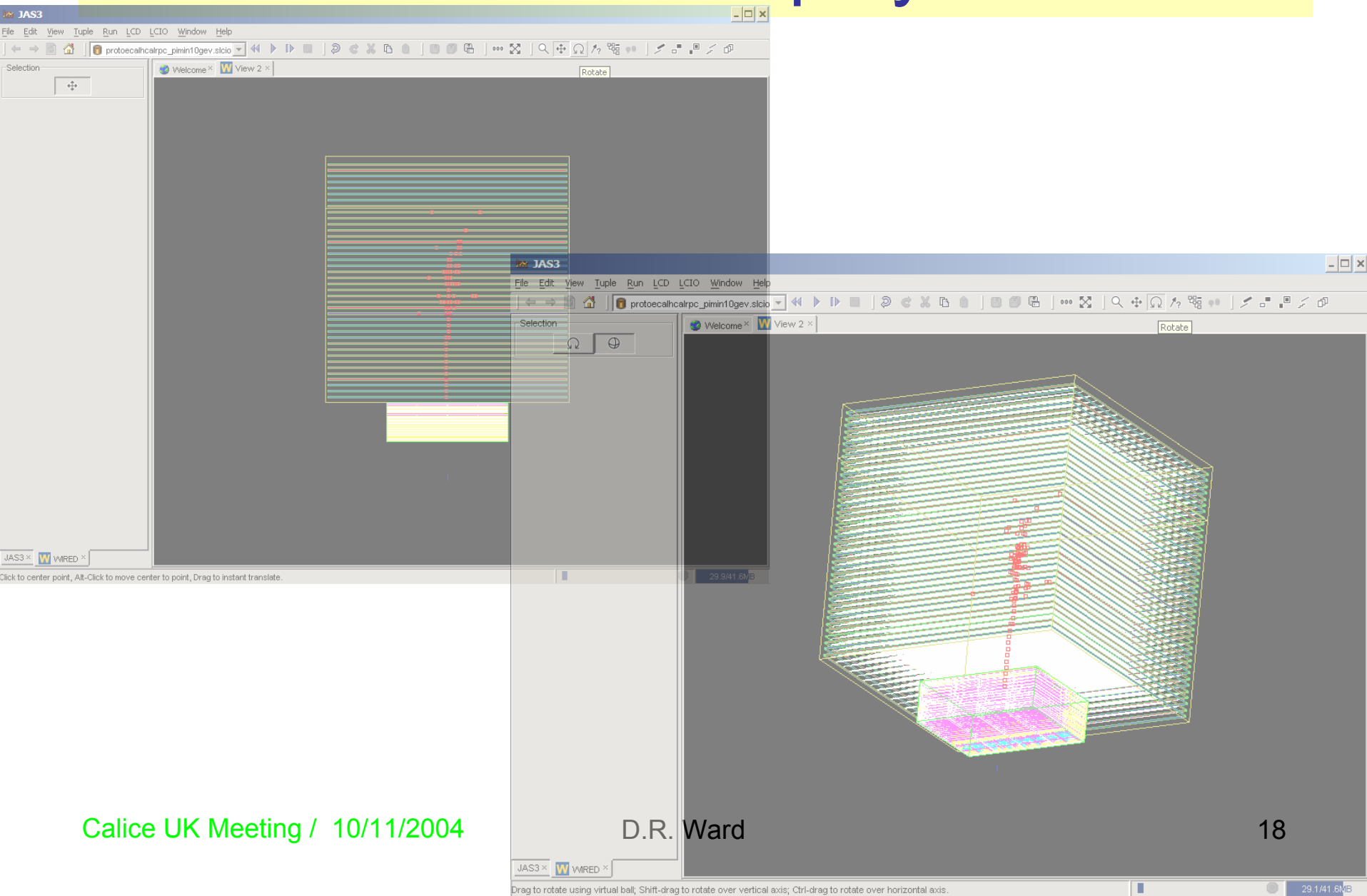
First tests with JAS3/Wired4 (NKW)

- Initial tests using JAS3 and Wired4 (plugin only now)
- Feedback on experience posted on Freehep forum for Wired4/JAS3
  - http://forum.freehep.org/
- Quite positive, easy to get started
- Some small corrections/features required, in next release (soon…)
- Could be useful as event display/debugging tool for DESY test beam
- Easy to install, functional
  - Integrates LCIO browser with simple wire-frame event display, geometry generated directly by Mokka (Heprep2)
  - Reads raw LCIO files via plugin (internally converts to Heprep format)
  - Can run AIDA compliant analysis (e.g Java), should consider as one option for early running

LCIO event browser



Event Display



Event analysis in JAS?