Fluka and Geant4

Using Fluka for CALICE

- Motivation
- Method
- Initial results
- Future

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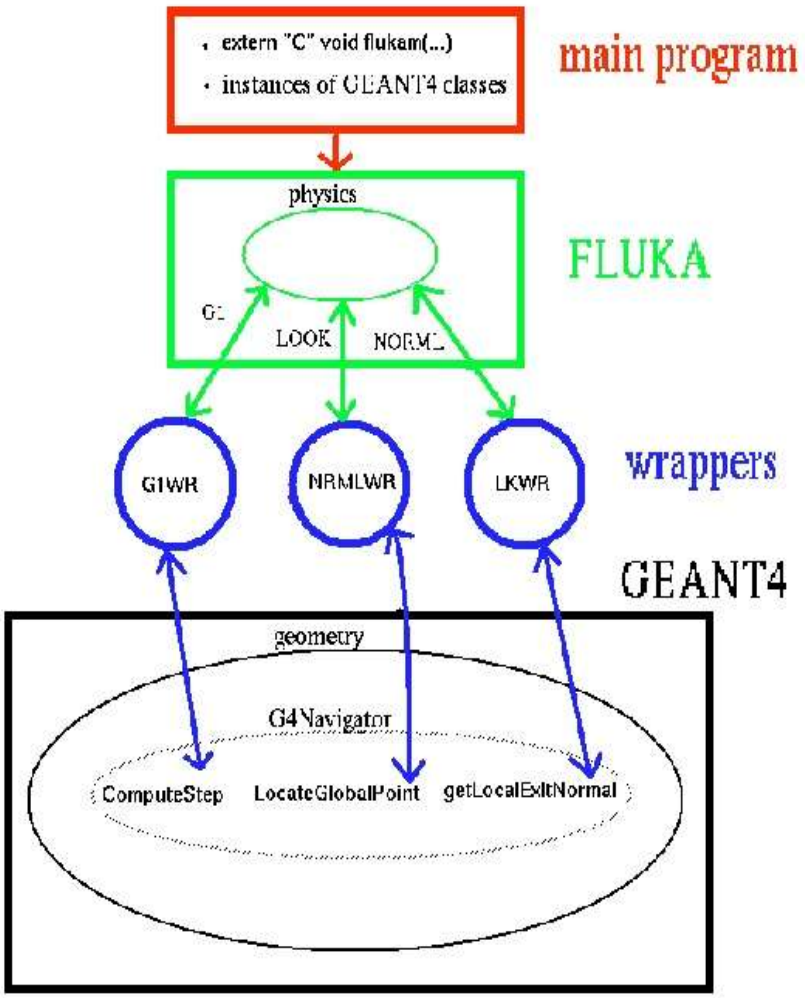
Motivation

- Systematic comparison of Mokka and Fluka physics modelling of CALICE test beam
- Particularly interesting for hadronic interactions
  - See G3/G4 studies (DRW, George Mavromanolakis)
- Wish to…
  - Test new Mokka detector models
  - Investigate full TDR type geometry
  - Avoid coding each geometry directly in Fluka
    - ⇒ error prone, may introduce non-physics differences
- Issues
  - Fluka geometry defined by data cards
  - Only limited geometrical structures supported
  - Repeated structures at 1 level only

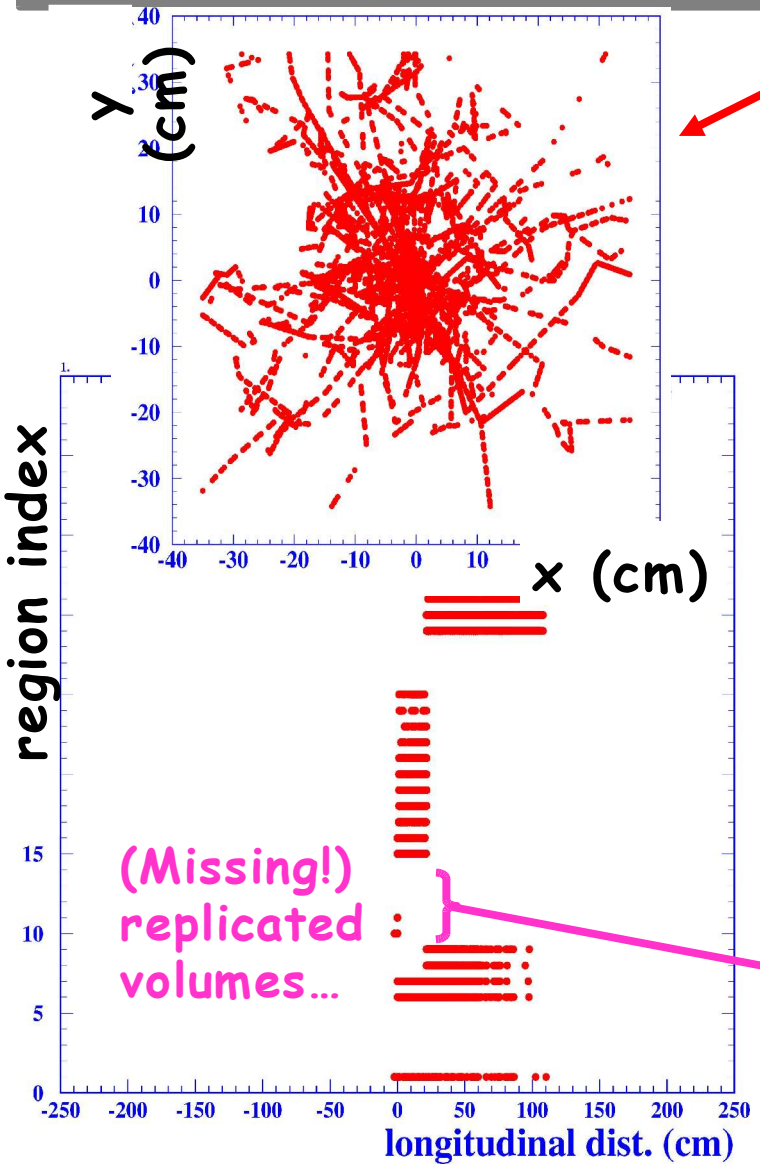
"Flugg" Package (P.Sala et al)



[From ATL-SOFT-98-039]

- Geometry & physics decoupled in G4 and Fluka
- Wrappers for f77/C++
- Fluka authors' comparisons of G4 with Flugg (FLUka+G4 Geometry)
  - Simple detectors, identical results
  - Complex T36 calorimeter: 81 layers Pb (10mm)-scint.(2.5mm) Consistent results
- My first test
  - Use T36 calorimeter as above

Flugg Issues

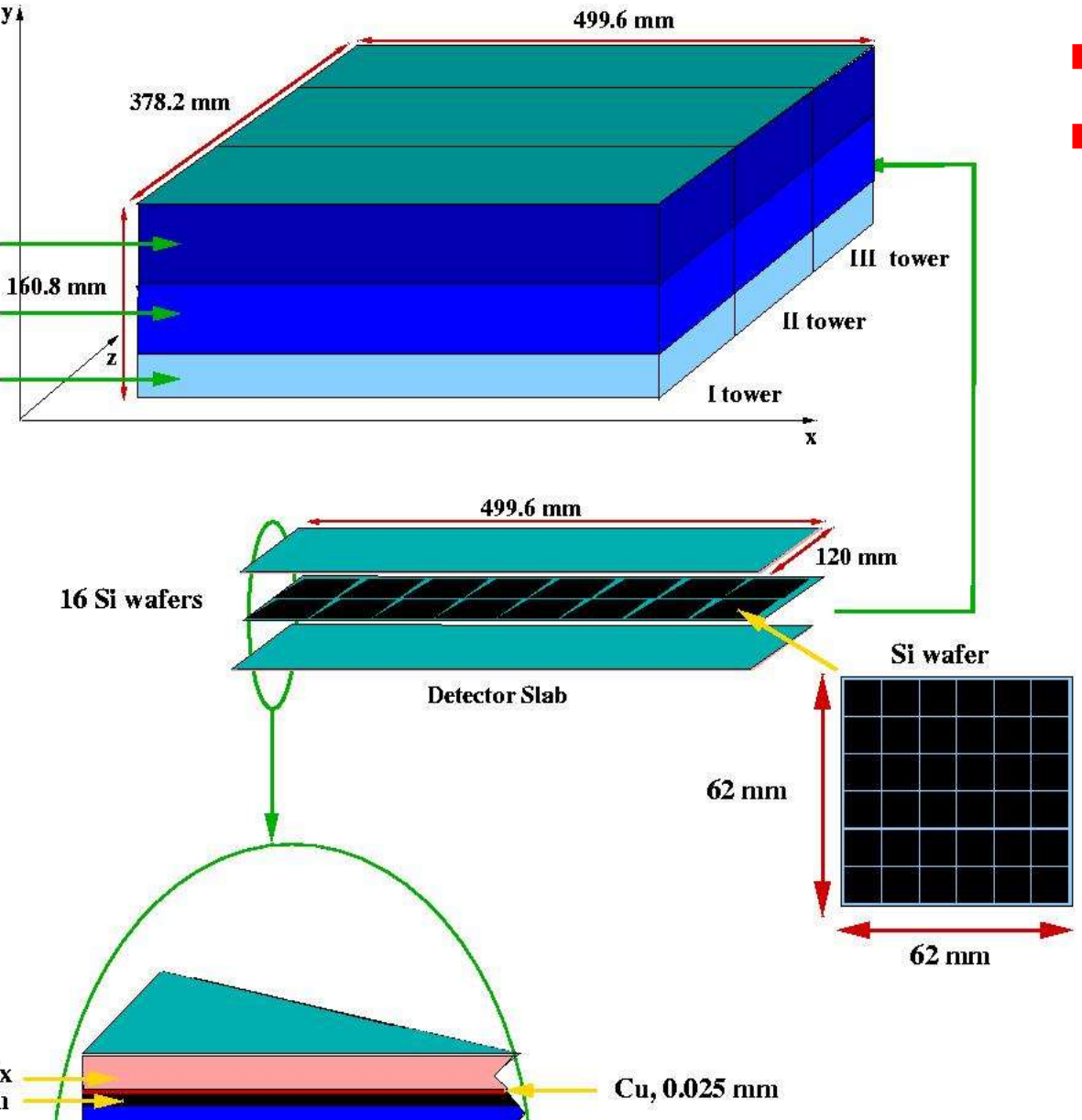


- Transverse response of T36 calo. to 10 GeV π^- in flugg
- User control available:
  - at every tracking step, via rudimentary drawing routine (slow)
  - at every energy deposition event

Note

- For G4 replicated or parametrised volumes (correspond to Fluka "lattice volumes")
  - Region index is degenerate
  - Boundary crossings sometimes not detected

Volume Ambiguity



- fluka 'sees' 3x32 Si volumes
- id for wafers degenerate
  - in z (x3 towers)
  - in y within a stack of 5 detector slabs (10 Si layers)

Current Status

- Mokka running within flugg/Fluka framework
  - Using Mokka-01-05 + Geant4.5.0.p01 + clhep1.8.0 + gcc3.2
  - Flugg05 (Jan. 2003)
  - Fluka 2002.4 (May 2003)
- Procedure: start from Mokka release and delete:
  - all classes except for detector construction, detector parametrisation, magnetic field construction
  - corresponding #include, variable, class definitions in .cc/.hh
  - anything related to G4RunManager, DetectorMessenger
  - code where SensitiveDetector is set
  - interactive code, visualisation, etc.
- Validation
  - Minimal debugging tools in flugg, e.g. P55 prototype geometry
  - Library/compiler consistency (fluka object-only code)

Flugg Operation

Two pass operation

- One-time initialisation
  - Read G4 geometry/material definitions
  - Generate fluka input cards
    - ⇒ Material/compound definitions
    - ⇒ Material to volume assignments
- Subsequent runs with a given geometry model
  - Use generated Fluka cards
  - Tracking within G4 geometry
  - Physics processes from Fluka

First pass, G4 → Fluka conversion

```
Connecting to the database models00

Building sub_detector P66WNominal, geometry db P66WNominal, driver proto01:
Ecal prototype driver  with W  ideal thickness (reference)
Connecting to the database P66WNominal
proto01: proto size is (499.600000,160.800000,3
proto01: placing prototype at (0.000000,236.000
Sub_detector P66WNominal DONE!


Building sub_detector SinglehcalFeRPC1, geometry
Single module Hcal Fe & RPC as prototype
Connecting to the database SinglehcalFeRPC1
The sensitive model in Hcal chambers is RPC1
Iron is the radiator material being placed.
Sub_detector SinglehcalFeRPC1 DONE!

tRadlen() = 89867.3 mm
Styropor->GetRadlen() = 17518.3 mm
C->GetRadlen() = 188.496 mm
CGAGeometryManager starting the detector constru
Asking for the model ProtoEcalHcalRPC:

Building Proto release 01
total_W_layers = 30
MixDensite = 2.15747 g/cm3
Mix->GetRadlen()= 75.0202 mm
Proto done.
```

generates fluka input deck

```
Building Hcal...
Detector construction done.
          * G4PhysicalVolumeStore (0x401b5288) has 2424 volume
          * Storing information...
                    + Tungsten: dens. = 19.3g/cm3, nElem = 1
                      Stored as TUNGSTEN
                    + TungstenModified: dens. = 11g/cm3, nEl
                      Stored as TUNGST02
                    + Copper: dens. = 8.96g/cm3, nElem = 1
                      Stored as COPPER
                    + Silicium: dens. = 2.33g/cm3, nElem = 1
                      Stored as SILICIUM
                    + SiVXD: dens. = 8.72g/cm3, nElem = 1
                      Stored as SIVXD
                    + Iron: dens. = 7.87g/cm3, nElem = 1
                      Stored as IRON
                    + Aluminum: dens. = 2.7g/cm3, nElem = 1
                    + TetraFluoroEthane: dens. = 0.00455g/cm
                      Stored as TETRAFLU
                      Stored as RPCGAS1
                      Stored as GRAPHITE
                    + Mix: dens. = 2.15747g/cm3, nElem = 9
                      Stored as MIX
        --------------- … ----------------
          * Printing FLUKA materials...
          * Printing FLUKA compounds...
          * G4PhysicalVolumeStore (0x401b5288) has 2424 volume
          * Printing ASSIGNMAT...
          * Printing Magnetic Field...
            No field found...
 *** Entering UsrIni.f!! ***
 *** Entering HistIn.f!! ***
```

Operation

G4 volume index

```
*...+....1....+....2....+....
3
*
1          WorldPhysical

8          DeadWBlock

2          SensWafferPhys

3          DeadWBlock

4          DeadWBlock

5          DeadWBlock

6          DeadWBlock

7          DeadWBlock

9          DeadWBlock

10         SlabWBlock

11         SlabWBlock

           & etc

2417       EndCapChamberPhy
2418       EndCapChamberPhys
2419       EndCapChamberPhys
2420       EndCapChamberPhys
2421       EndCapChamberPhys
```

material definitions

```
*...+....1....+....2....+....3....+....4....+....5
*
MATERIAL         74.0   183.840 1.930e+01        3.0
TUNGSTEN
MATERIAL         74.0   183.840 1.100e+01        4.0
TUNGST02
LOW-MAT           4.0
TUNGSTEN
MATERIAL         29.0    63.546 8.960e+00        5.0
COPPER
MATERIAL         14.0    28.090 2.330e+00        6.0
SILICIUM
MATERIAL         14.0    28.090 8.720e+00        7.0
SIVXD
MATERIAL         26.0    55.850 7.870e+00        8.0
IRON
MATERIAL         13.0    26.980 2.700e+00        9.0
ALUMINUM
MATERIAL          4.0     9.012 1.848e+00       10.0
BERYLLIU
MATERIAL         18.0    39.950 1.780e-03       11.0
ARGON
MATERIAL                         1.290e-03       12.0                    AIR
MATERIAL          7.0    14.010 9.990e-01       13.0
NITROGEN
MATERIAL          8.0    16.000 9.990e-01       14.0
OXIGEN
MATERIAL                         1.000e-05       15.0
BEAM_
MATERIAL                         2.200e+00       16.0
QUARTZ
MATERIAL         14.0    28.090 9.990e-01       17.0
```

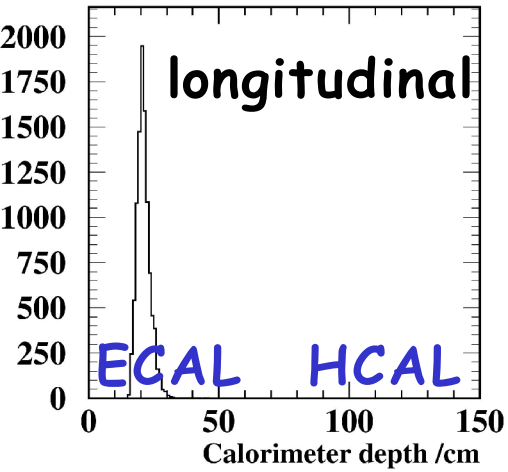
material to region assignments

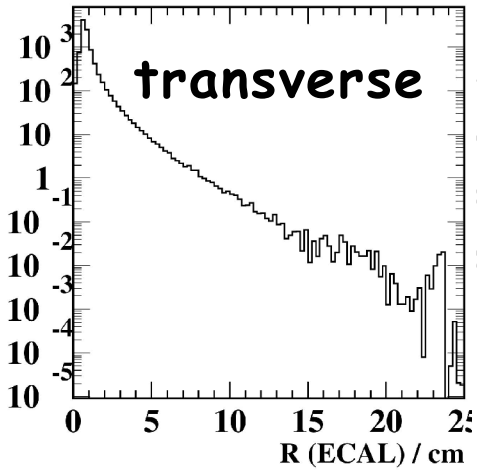
```
ASSIGNMAT        12.0
1.0
ASSIGNMAT         6.0
2.0
ASSIGNMAT         3.0
3.0
ASSIGNMAT         3.0
4.0

& etc

ASSIGNMAT        21.0
2423.0
ASSIGNMAT        21.0
2424.0
ASSIGNMAT         1.0
2425.0
```

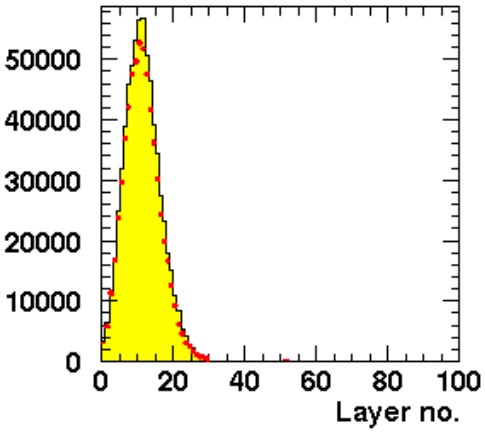
Fluka with G3/G4

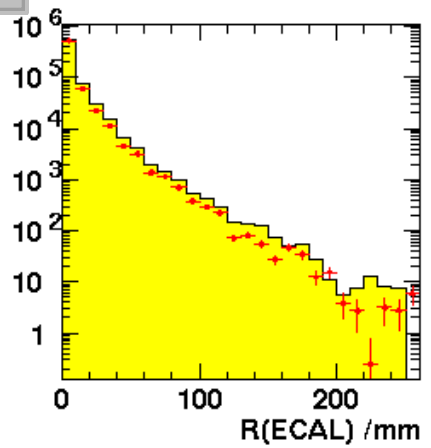
ProtoEcalHcalRPC, 5 GeV e⁻

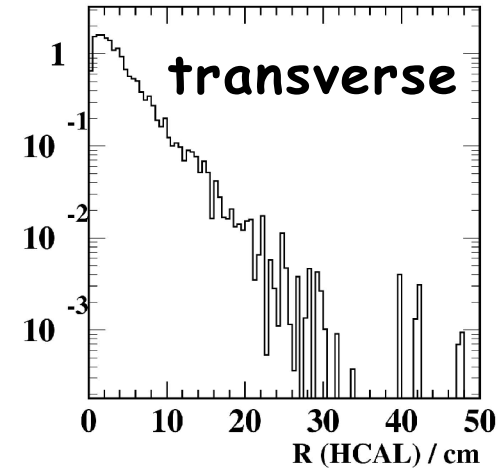
5 GeV e⁻



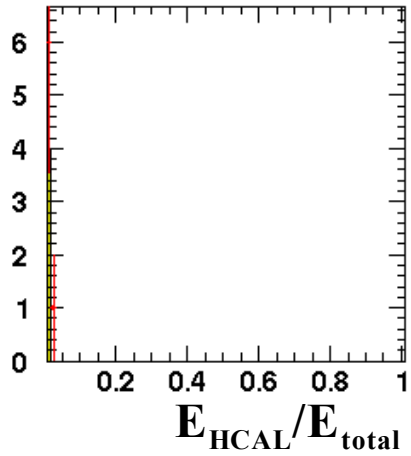


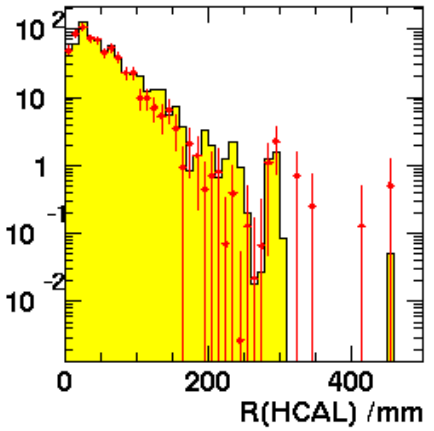






In these plots, fluka has energy deposited in all material, not just active layers



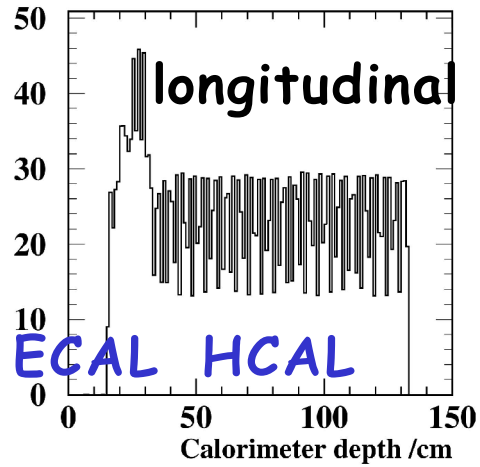


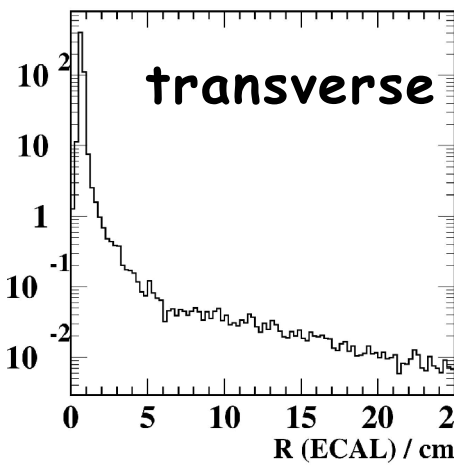
[G3/G4 plots from DRW]

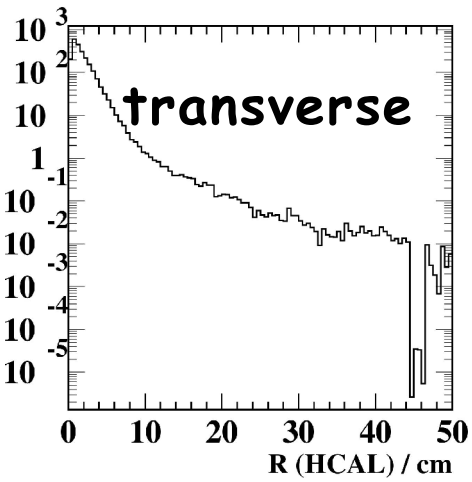
Fluka with G3/G4

ProtoEcalHcalRPC, 5 GeV μ^-

5 GeV μ^-







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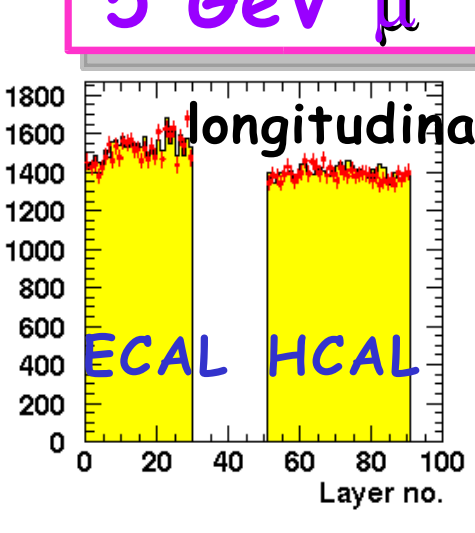
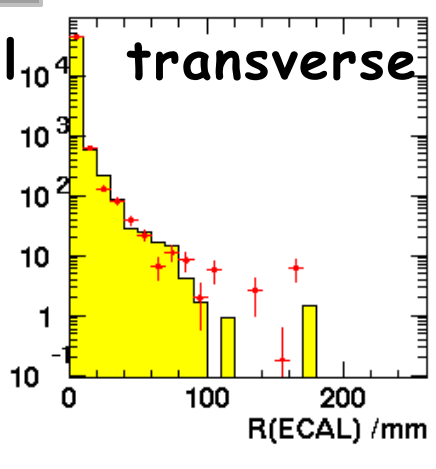
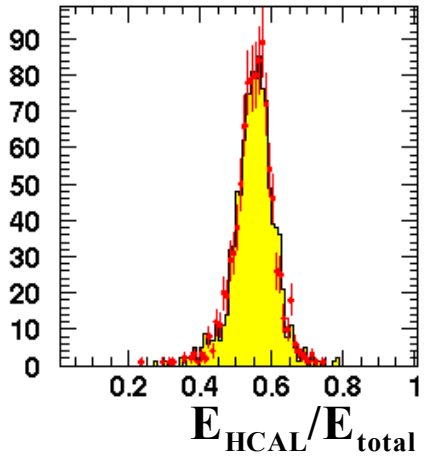
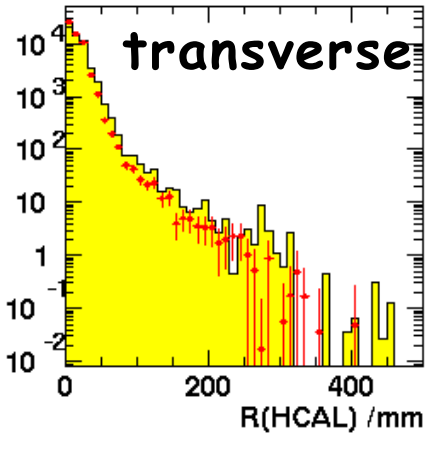




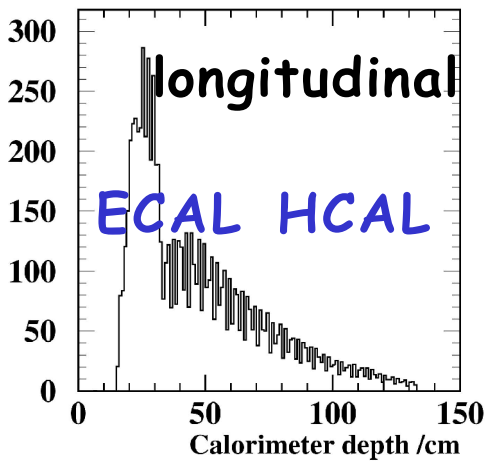


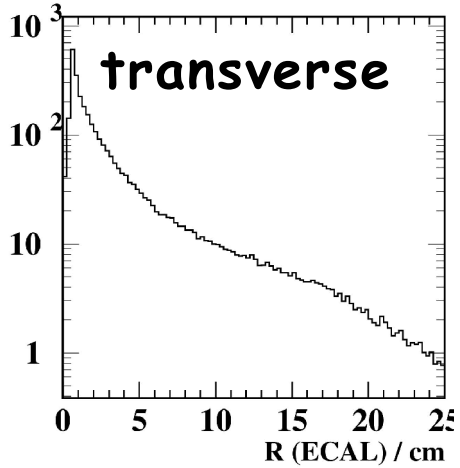


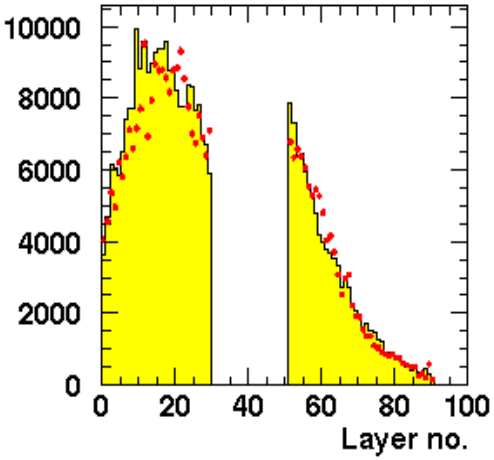
[G3/G4 plots from DRW]

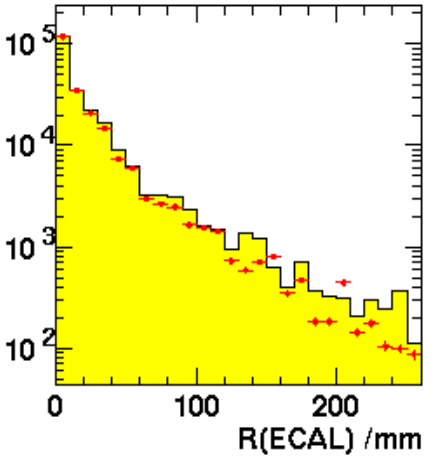
Fluka with G3/G4

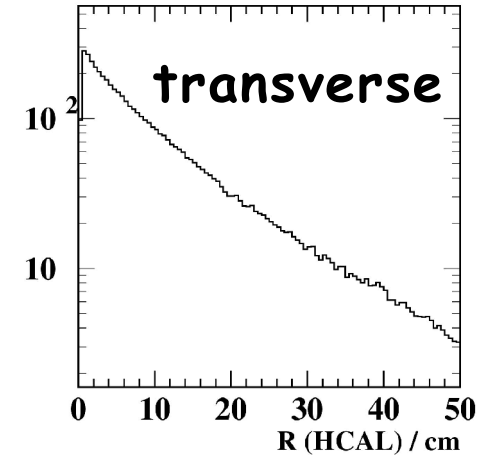
5 GeV π^-











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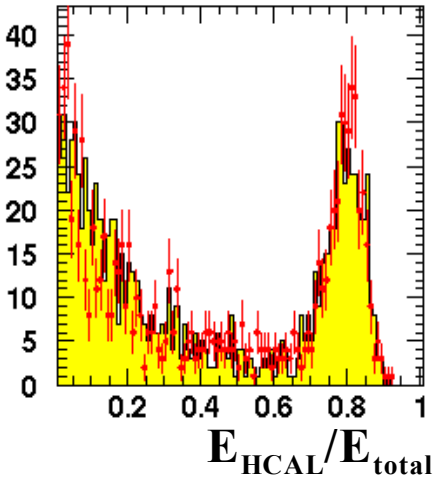

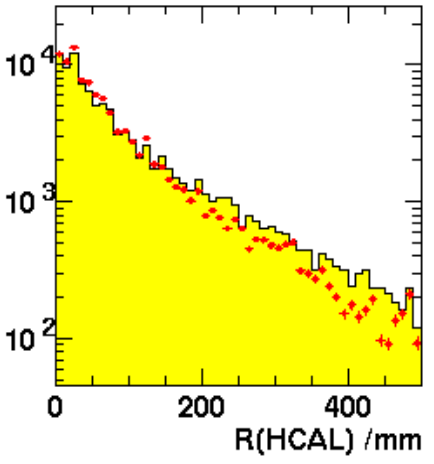

[G3/G4 plots from DRW]

Ongoing Work

- Restrict study to energy deposited in active layers
- Improve reliability for larger samples
  - ~understood technical issue
- Review energy thresholds/step size in Fluka
  - default min. K.E. > 100 keV
  - neutrons, 19.6 MeV
  - energy e/γ > 500 keV (??)
  - low energy neutron cross-sections
- Compare systematically with G3/G4 results,
  - Same initial conditions
  - Thresholds, mip normalisation, etc.
  - Adopt same output format as DRW/GM

Summary

Identified "easy" way of comparing G4/Fluka

- Alternative to deprecated G-Fluka
- Preferable to "standalone" Fluka as more efficient for variations in geometry

Integration with Mokka geometry classes

- Need to feed changes back to Mokka developers

Will be useful input when devising test beam programme/strategy