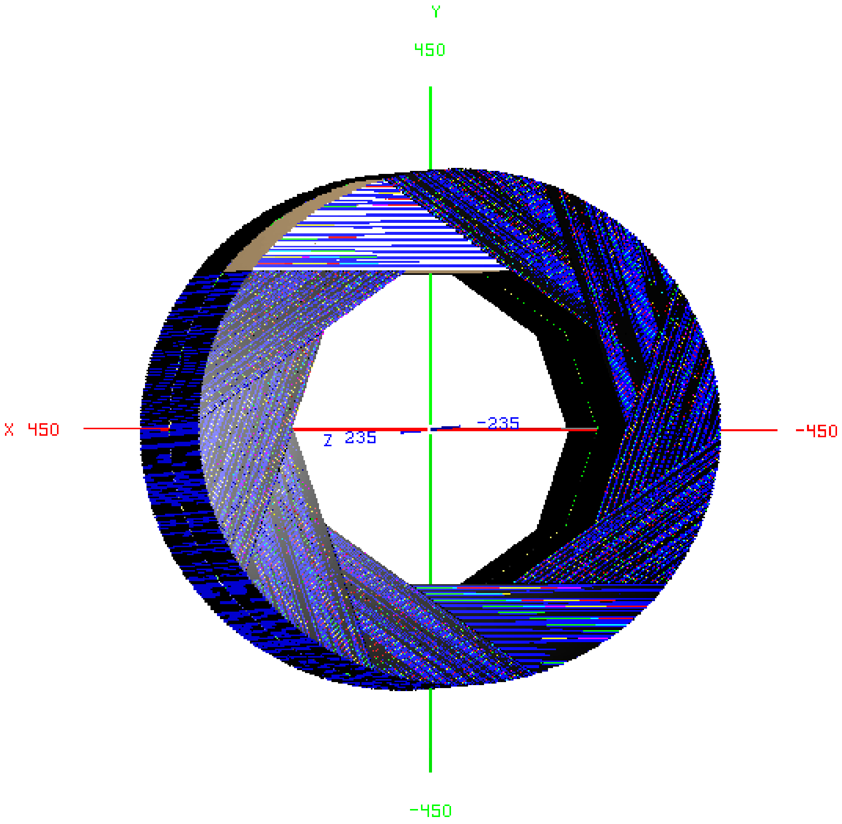
SDHCal Sofware Status and Optimization

SDHCal geometry in lcgeo
SDHCal digitizer (G.Grenier,A.Steen)
ArborPFA (R.Ete)
Roadmap to DD4hep
MC-samples@IPNL
Summary

Tibor Kurča
for IPNL-ILC group
Institut de Physique Nucléaire de Lyon

SDHCal in lcgeo

Videau geometry



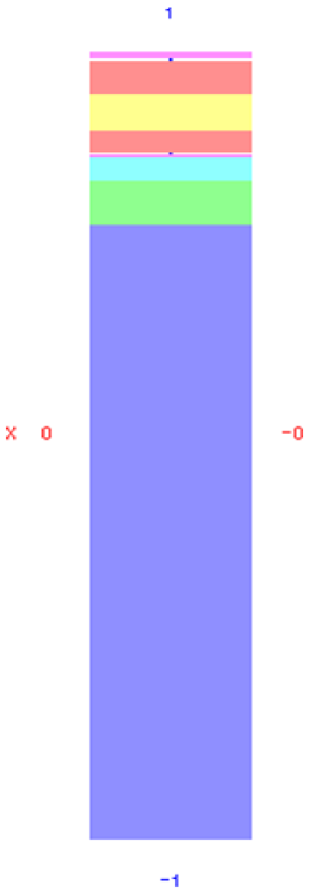
/lcgeo/trunk/ILD/compact/ILD_o2_v01/

ILD_o2_v01.xml
materials.xml
model_parameters_ILD_o2_v01.xml
Hcal_Barrel_SD_v01.xml

- **new materials :** RPCGAS2,
  FloatGlass
  mylar …
- **model parameters** (dimensions)
- **layer** (slices)

SDHCal in lcgeo
layer structure

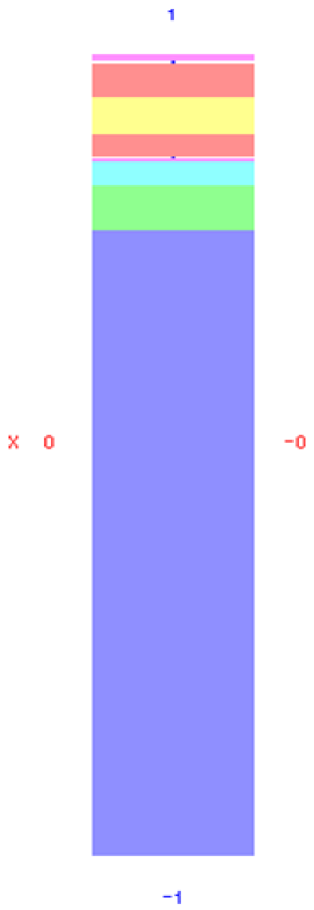
/lcgeo/trunk/ILD/compact/ILD_o2_v01/**Hcal_Barrel_SD_v01.xml - Rev 766**



detailed layer structure:

```
<layer repeat="Hcal_nlayers" vis="SeeThrough">
   <slice material = "Steel235"    thickness = "Hcal_radiator_thickness"          vis="BlueVis"  />
   <slice material = "g10"         thickness = "Hcal_g10_thickness"               vis="GreenVis" />
   <slice material = "PCB"         thickness = "Hcal_PCB_thickness"               vis="CyanVis" />
   <slice material = "mylar"       thickness  "Hcal_mylar_anode_thickness"        vis="MagentaVis" />
   <slice material = "graphite"    thickness ="Hcal_graphite_anode_thickness"     vis="Invisible" />
   <slice material = "FloatGlass"  thickness = "Hcal_glass_anode_thickness"       vis="RedVis" />
   <slice material = "RPCGAS2"     thickness = "Hcal_gas_gap"    sensitive ="yes"  vis="YellowVis" />
   <slice material = "FloatGlass"  thickness = "Hcal_glass_cathode_thickness"     vis="RedVis" />
   <slice material = "graphite"    thickness = "Hcal_graphite_cathode_thickness"  vis="Invisible" />
   <slice material = "mylar"       thickness = "Hcal_mylar_cathode_thickness"     vis="MagentaVis"/>
</layer>
```

SDHCal in lcgeo thickness parameters




```
<constant name="Hcal_cells_size" value="10*mm"/>
  <constant name="Hcal_chamber_thickness" value="6.0*mm"/>
  <constant name="Hcal_gas_gap" value="1.2*mm"/>
  <constant name="Hcal_pad_separation" value="0.408*mm"/>
  <constant name="Hcal_graphite_cathode_thickness" value="0.1*mm"/>
  <constant name="Hcal_graphite_anode_thickness" value="0.05*mm"/>
  <constant name="Hcal_glass_cathode_thickness" value="1.1*mm"/>
  <constant name="Hcal_glass_anode_thickness" value="0.7*mm"/>
  <constant name="Hcal_g10_thickness" value="1.4*mm"/>
  <constant name="Hcal_mylar_anode_thickness" value="0.05*mm"/>
  <constant name="Hcal_mylar_cathode_thickness" value="0.175*mm"/>
  <constant name="Hcal_mylar_thickness" value="0.2*mm"/>
  <constant name="Hcal_PCB_thickness" value="0.8*mm"/>
  <constant name="Hcal_radiator_thickness" value="20.0*mm"/>
```

for the geometry validation we need simulation …

SDHCal Digitizer Status

3 simulation programs

- Standalone GEANT4 application for prototype simulation (test beam studies)
- Mokka for previous ILD studies
- DD4hep for future ILD studies

2 digitizer versions

✓ private version for SDHCAL prototype simulation

✓ digitizer in the MarlinReco package (SimDigital)

 - svn version for Mokka based simulation

→ need a version for DD4hep based simulation.

Digitization logic

- **digitization:** the last step of detector electronics response simulation to the charged particles crossing the gas gap

- For each **SimCalorimeterHit**:
  - get list of steps positions in the "cell frame"
  - filter out some steps
  - for each kept step:
    - simulate the induced charge
    - dispatch the charge on the cell and neighbour cells
      - if a hit for this cell already exist, add the new charge
      - else create new hit and assign it the corresponding charge

  → hits are stored in a std::map[cellID0]=CalorimeterHit
- remove hit candidates below first threshold
- apply thresholds and store hits in the output collection

Digitizer for Mokka based simulation

- Simulates the "**hits multiplicity**" : the fact that one crossing particle (one entering Geant4 step in the gas) can fire more than one cell.

To do that :

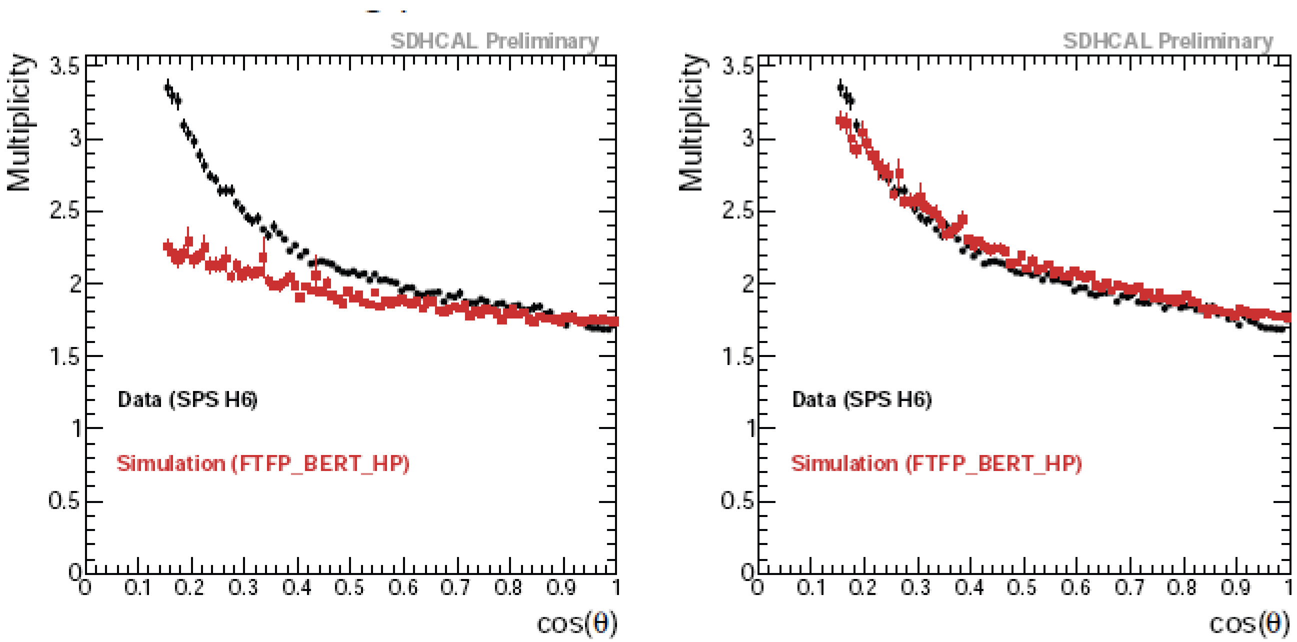
- need to know the position of the Geant4 steps (use SimCalorimeterHit collections with LCIO.CHBIT STEP=1)

- Mokka neighbour hits can be added - geometry dependent

→ digitizer is used to validate the Mokka geometry for SDHCal
(no angular corrections)

SDHCal Prototype Simulation & Data

- comparison between simulation and real test beam data available
- hit multiplicity of single crossing particle depends on the angle between the incoming particle direction and the RPC surface

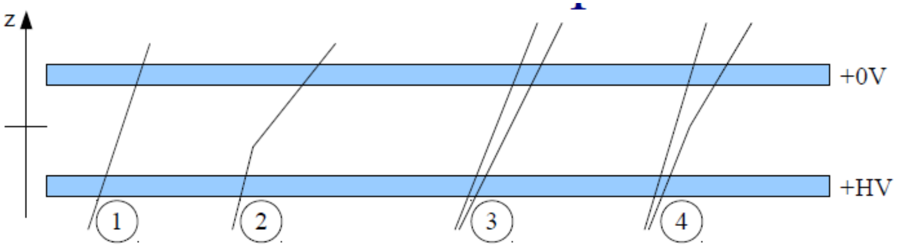


Multiplicity without (left) and with (right) GEANT4 step length (angle) correction

SDHcal prototype Simulation & Digitisation

- additional feature: hit multiplicity corrections based on the step length (angle)
  → SDHCal prototype simulation produces SimCalorimeterHit
  + LCGenericObject collection containing:
- 1 int for the cell-id of the corresponding SimCalorimeterHit
- 1 int for the Number of MC contribution of that SimCalorimeterHit
- 3 floats for the entrance point coordinate of the G4step
- 3 floats for the exit point coordinate of the G4step
- 1 float for the step total length

- each set of crossing steps → 1 entry in the collection
- set of crossing steps : one or more steps belonging to the G4 track(s) crossing the gas gap.



SDHCal Simulation in DD4hep Roadmap

1. Convert Mokka-based digitizer to cope with DD4hep CellId encoding and geometry (GEAR → DD4hep)

2. Use the digitizer to validate the SDHCal geometry in DD4hep simulation

3. Update DD4hep simulation to produce the needed step information for the digitisation with step length correction
   → use either current LCGenericObject collection ??
   → or modified LCIO SimCalorimeterHit collection ??

4. Merge prototype digitizer with DD4hep-based digitizer

5. Update SDHCal prototype simulation code to use the merged digitizer too

ArborPFA - Status

Packages

Hosted on github : https://github.com/ArborPFA

Sub packages :

* PandoraSDK : PFA development toolkit
* PandoraMonitoring : PFA root TEve monitoring
* ArborContent : ArborPFA algorithms implementation
* MarlinArbor : ArborPFA Marlin interface
* SDHCALArborPFA : SDHCal specific implementation

Current status

* SDHCal : single particle and separation of overlaid particles

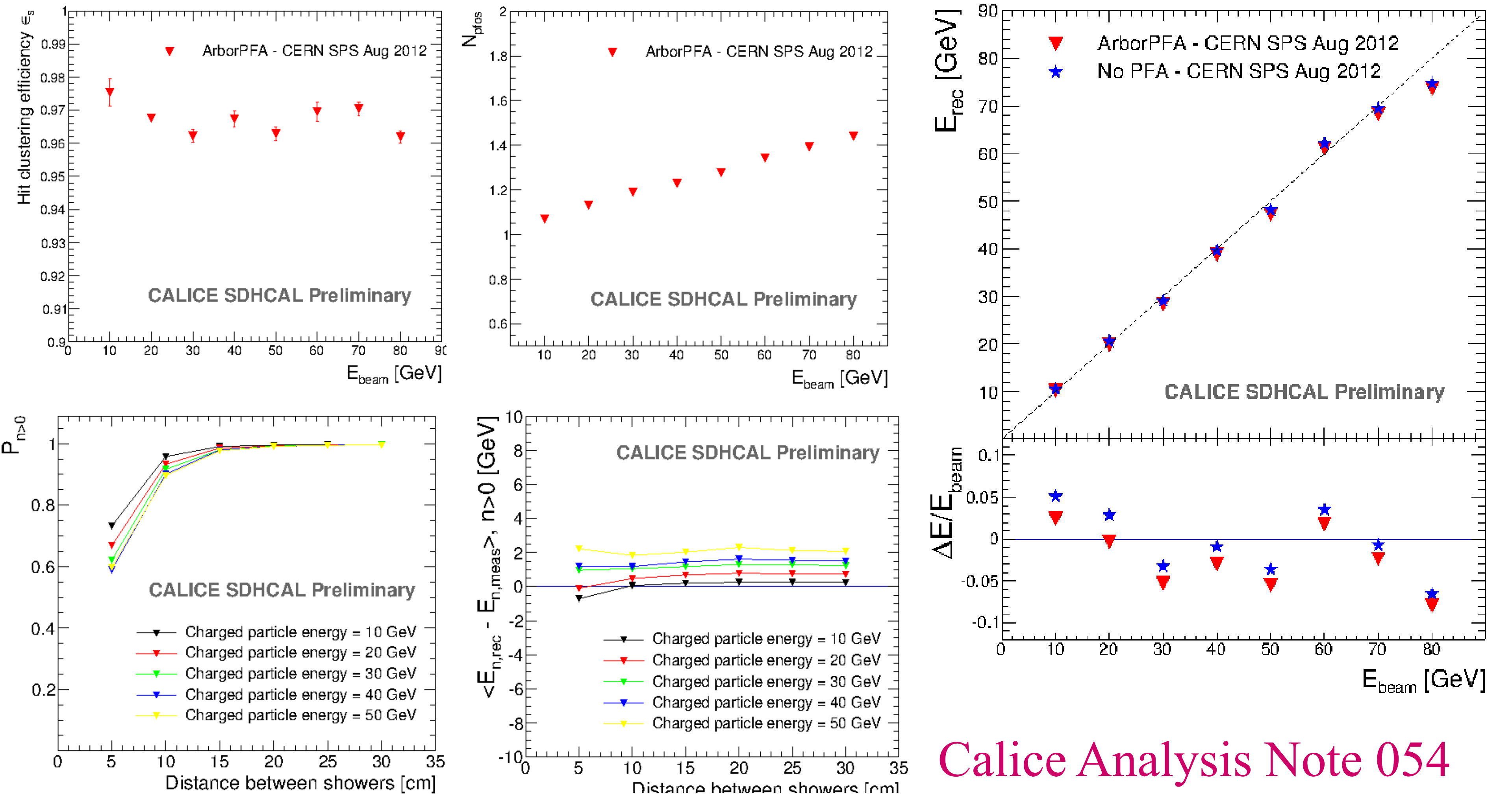
  Calice Analysis Note 054 approved. JINST publication on road …

  → good single particle efficiency, reconstructed energy

  → powerfull hadr. showers separation down to 5 cm

* ILD reconstruction : in development
* **Re-clustering recently added. Looks promising ...**

ArborPFA – SDHCal results



Calice Analysis Note 054

MC-samples simulated @IPNL

- **Detector model Mokka ILD_o2_v05**
- **ILCDirac production at IPNL**
- **Data stored at SE IN2P3-SRM**

250 GeV

4f-zz-h I106573, I106574 ~1.6 M evts
4f-zz-sl I106575, I106576 ~ 1.7 M
4f-ww-h I106551, I106552 ~ 1.2 M
4f-ww-sl I106577, I106578 ~ 2.1 M

qqh_zz I108063, I108064 ~ 40 k
qqh I106485, I106486 ~ 122k+268 k

500 GeV

4f_ww_h I250006 ~3.8 M
4f_ww_h I250008 ~ 17 k
4f_ zz_h I250002 ~ 340 k
4f_zz_h I250004 ~ 136 k

1000 GeV

4f-zz-h I200061, I200062 ~416 k
4f-ww-h I200006, I200008 ~ 3.4 M

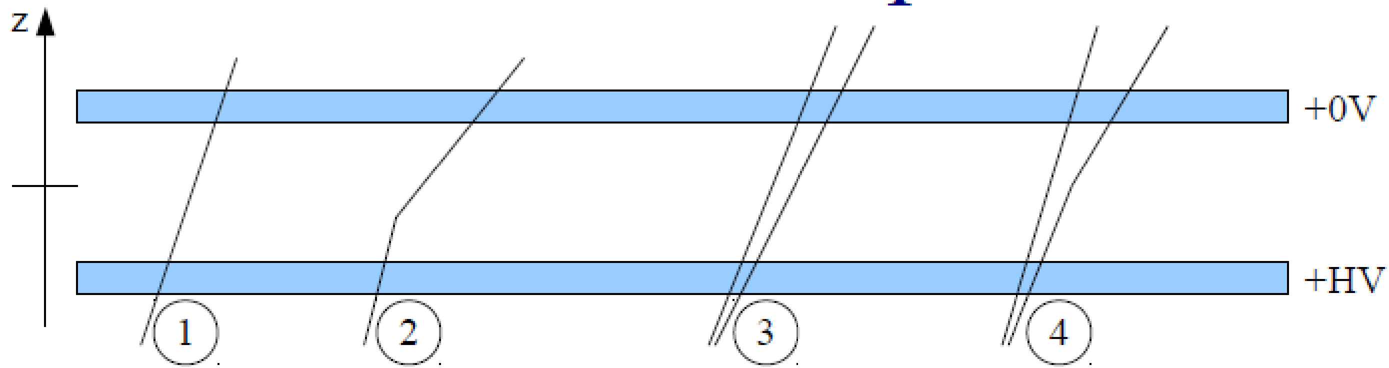
W,Z → jet reconstruction studies (A.Steen thesis)

Summary

- SDHCal Videau geometry with proper materials in lcgeo
  - do we need more details ?
- Digitizer for DD4hep on road → geometry validation
- ArborPFA for SDHCal in good shape → work continues
- bunch of MC-samples privately simulated at IPNL
  → in the future want to ask for official production

- Backup slides

Filter out steps



- Step position from Mokka is the middle of the GEANT4 step
  - 1 : one particle and one step at z=0 (in “cell frame”)
  - 2 : one particle and two steps at z≠0
  - 3 : two particles and two steps at z=0
  - 4 : two particles and 3 steps.

Simulate induced charge

- Each step produced a random induced charge according to a Polya distribution.
  - Charge measured analogically on a small GRPC cathode
- Processor parameters :
  - "PolyaAverageCharge"
    - Parameter 'a'
  - "PolyaWidthParameter"
    - Parameter 'b'
  - Parameters might need tuning depending on GAS mixture used.