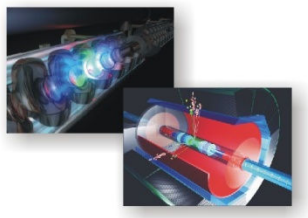
Dual Read out Calorimeter

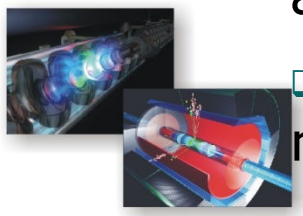
July 21th 2009

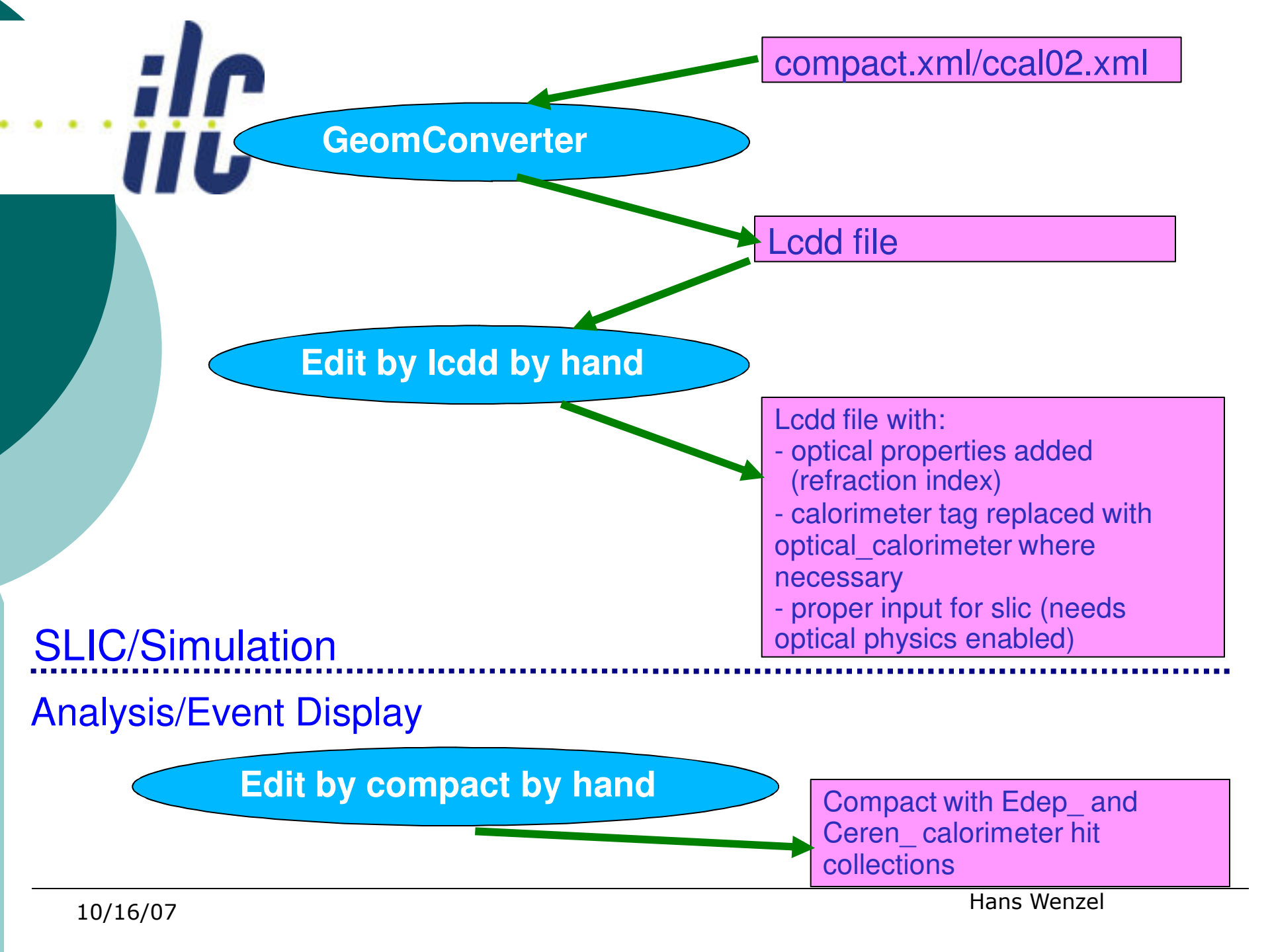
- Dual readout in lcsim.org. What has to be done to make it work?
- The ccal02 detector
- Conclusions



Steps to use Dual Read out/optical Calorimeter

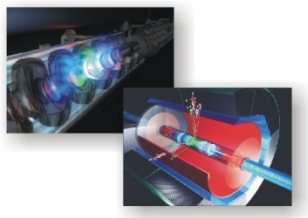
- Currently it's kind of a kludge and the integration into the the lcsim.org framework is not complete (entire my fault → concentrated on getting it working within SLIC).
- lcdd (input to slic) has optical_calorimeter tag and allows to add optical properties (e.g. refraction index as a function of photon energy).
- Compact description (input to Geomconverter/Analysis/Wired display) doesn't know anything about optical/dual read out calorimeters.
- This makes additional steps necessary as detailed in the next slide.




compact.xml/ccal02.xml
GeomConverter
Lcdd file
Edit by lcdd by hand
Lcdd file with:
- optical properties added (refraction index)
- calorimeter tag replaced with optical_calorimeter where necessary
- proper input for slic (needs optical physics enabled)
SLIC/Simulation
Analysis/Event Display
Edit by compact by hand
Compact with Edep_ and Ceren_ calorimeter hit collections

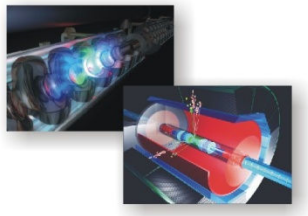
Finally for every new Detector:

- Fill in the the correct property values e.g. sampling fractions (for total absorption it's all 1.), values used by digisim....
- Steve will show results using the ccal02 detector.



The CCAL02 detector

- Based on SID02 geometry.
  - Fill the space currently occupied by ECAL/HCAL Barrel/ Endcap with Crystal calorimeter.
  - All other detectors (tracking etc.) as they are.
  - ECAL deep enough to contain most EM showers.



Material properties of Crystals and scintillating glass

Material	Density	Radiation length X0	IA length II
	[g/cm3]	[cm]	[cm]
BGO	7.13	1.12	21.88
PbWO4	8.3	0.9	18
SCG1-C	3.36	4.25	45.6

Geometry in compact.xml

```
<!-- Electromagnetic Calorimeter -->
<constant name="EMBarrel_inner_r" value="127.0*cm"/>
  <constant name="EMBarrel_outer_z" value="192.0*cm"/>
  <constant name="EMBarrelThickness" value="3.0*cm"/>

  <constant name="EMEndcap_inner_r" value="20.0*cm"/>
  <constant name="EMEndcap_inner_z" value="168.0*cm"/>
  <constant name="EMEndcap_outer_r" value="126.0*cm"/>
  <constant name="EMEndcapThickness" value="3.0*cm"/>


  <!-- Hadronic calorimeter -->
  <constant name="HADBarrel_inner_r" value="151.0*cm"/>
  <constant name="HADBarrel_outer_z" value="294.0*cm"/>
  <constant name="HADBarrelThickness" value="6.0*cm"/>

  <constant name="HADEndcap_inner_z" value="192.0*cm"/>
  <constant name="HADEndcap_inner_r" value="20.0*cm"/>
  <constant name="HADEndcap_outer_r" value="151.0*cm"/>
  <constant name="HADEndcapThickness" value="6.0*cm"/>
```

Compact description (cont.)

```
<!-- Electromagnetic calorimeter -->

<detector id="2" name="EMBarrel" type="CylindricalBarrelCalorimeter" readout="EcalBarrHits">
  <dimensions inner_r="EMBarrel_inner_r" outer_z="EMBarrel_outer_z"/>
  <layer repeat="8">
    <slice material="BGO" thickness="EMBarrelThickness" sensitive="yes" limits="EM_limit"/>
  </layer>
</detector>

<detector id="6" name="EMEndcap" reflect="true" type="CylindricalEndcapCalorimeter" readout="EcalEndcapHits">
  <dimensions inner_r="EMEndcap_inner_r" inner_z="EMEndcap_inner_z" outer_r="EMEndcap_outer_r"/>
  <layer repeat="8">
    <slice material="BGO" thickness="EMEndcapThickness" sensitive="yes" limits="EM_limit"/>
  </layer>
</detector>


<!-- Hadronic calorimeter -->

<detector id="3" name="HADBarrel" type="CylindricalBarrelCalorimeter" readout="HcalBarrHits">
  <dimensions inner_r="HADBarrel_inner_r" outer_z="HADBarrel_outer_z"/>
  <layer repeat="17">
    <slice material="BGO" thickness="HADBarrelThickness" sensitive="yes" limits="HCal_limit"/>
  </layer>
</detector>
<detector id="7" name="HADEndcap" reflect="true" type="CylindricalEndcapCalorimeter" readout="HcalEndcapHits">
  <dimensions inner_r="HADEndcap_inner_r" inner_z="HADEndcap_inner_z" outer_r="HADEndcap_outer_r"/>
  <layer repeat="17">
    <slice material="BGO" thickness="HADEndcapThickness" sensitive="yes" limits="HCal_limit"/>
  </layer>
</detector>
```

Modified compact.xml to be used for Wired and reconstruction/analysis

```
<!-- Electromagnetic calorimeter -->

 <detector id="2" name="EMBarrel" type="CylindricalBarrelCalorimeter" readout="Edep_EcalBarrHits">
    <dimensions inner_r="EMBarrel_inner_r" outer_z="EMBarrel_outer_z"/>
   <layer repeat="8">
      <slice material="BGO" thickness="EMBarrelThickness" sensitive="yes" limits="EM_limit"/>
   </layer>
 </detector>
 <detector id="22" name="EMChBarrel" type="CylindricalBarrelCalorimeter" readout="Ceren_EcalBarrHits">
    <dimensions inner_r="EMBarrel_inner_r" outer_z="EMBarrel_outer_z"/>
   <layer repeat="8">
      <slice material="BGO" thickness="EMBarrelThickness" sensitive="yes" limits="EM_limit"/>
    </layer>
 </detector>
 <detector id="6" name="EMEndcap" reflect="true" type="CylindricalEndcapCalorimeter" readout="Edep_EcalEndcapHits">
    <dimensions inner_r="EMEndcap_inner_r" inner_z="EMEndcap_inner_z" outer_r="EMEndcap_outer_r"/>
    <layer repeat="8">
      <slice material="BGO" thickness="EMEndcapThickness" sensitive="yes" limits="EM_limit"/>
    </layer>
  </detector>
 <detector id="26" name="EMChEndcap" reflect="true" type="CylindricalEndcapCalorimeter" readout="Ceren_EcalEndcapHits">
    <dimensions inner_r="EMEndcap_inner_r" inner_z="EMEndcap_inner_z" outer_r="EMEndcap_outer_r"/>
    <layer repeat="8">
      <slice material="BGO" thickness="EMEndcapThickness" sensitive="yes" limits="EM_limit"/>
    </layer>
  </detector>
```

The ccal02 detector

				BGO		$PbWO_4$	
Name	Layers	Thickness/Layer	Segmentation	X_0	λ_I	X0	II
		[cm]	[cm x cm]				
ECAL Barrel	8	3	3 x 3	21.4	1.1	27	1.3
HCAL Barrel	17	6	6 x 6		4.7		5.7
Total Barrel	25				5.8		7
ECAL Endcap	8	3	3 x 3		1.1		1.3
HCAL Endcap	17	6	6 x 6		4.7		5.7
Total Endcap	25				5.8		7

- Segmentation should be sufficient to do Particle Flow
- No material for readout, support structure etc.
- ccal02 currently in CVS here at FNAL will put it in CVS once finalized
- See Steve's presentation.

Activities

Three summer students:

Earle Wilson: detailed studies of Cerenkov,optical physics, especially timing for fp420, PID for with the dual readout calorimeter.

Eric Shinn: detailed studies of single calorimeter crystal concentrating how to separate scintillation from Cerenkov photons.

- Nayeli Azucena Rodríguez Briones: Mass resolution, effects of magnetic field etc

- Other activities:
  - Cosmic ray test-stand to study crystals and separation of Cerenkov and scintillation (demonstrated for scintillating glass)
  - Weekly meetings: http://ilcagenda.linearcollider.org/categoryDisplay.py?categId=151

Conclusion

- Things are working and are in usable shape.
- But would be nice if compact?Geomconverter allows for:
  - Using optical_calorimeter tag
  - Attach more than one Hit Collection to detector (like geant 4)
  - Attach Hit collections to slices e.g silicon layers between Crystals to provide precision position measurement.