Status and Plans of ILD Full Simulation

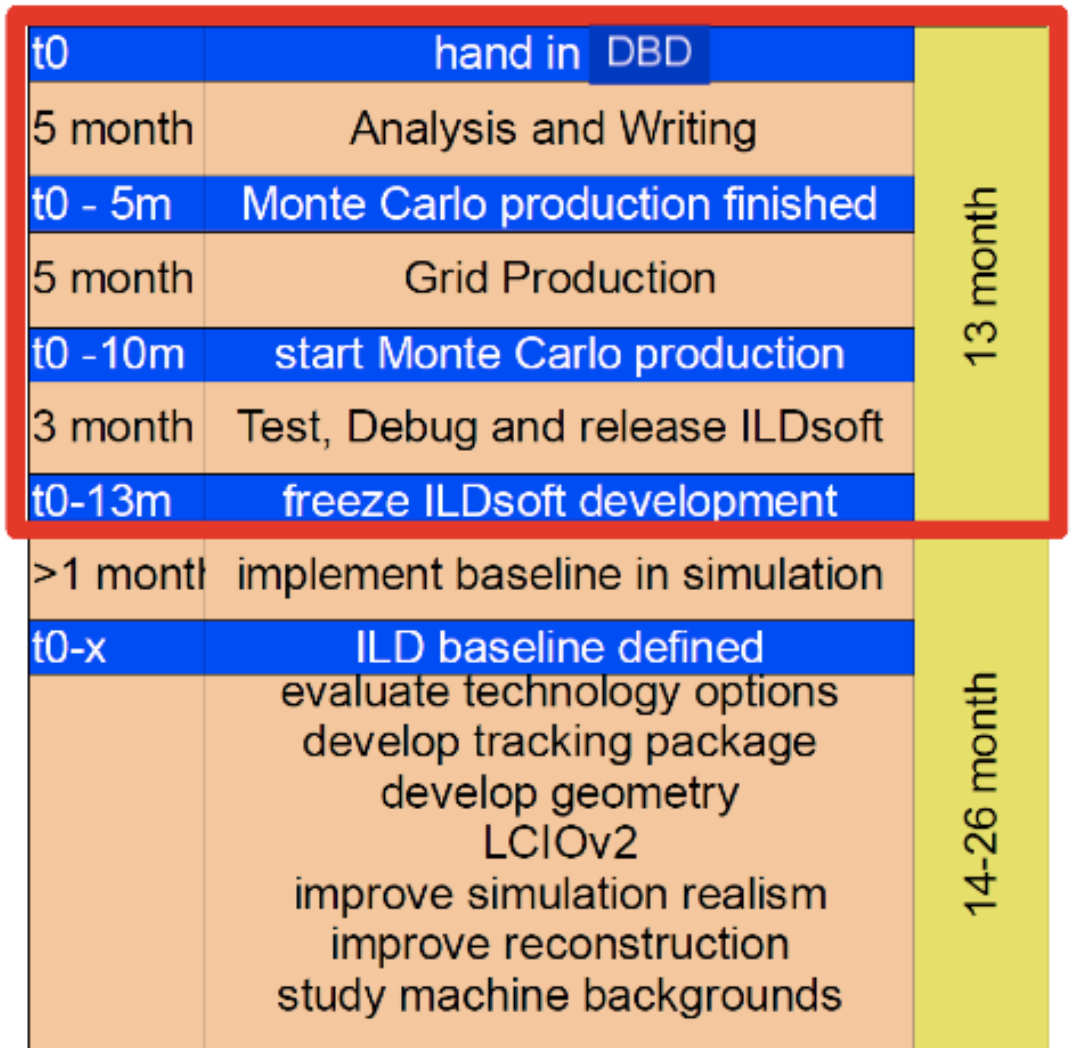
Steve Aplin
DESY

ILD Meeting
29th January 2010

Moving From the LOI to the DBD

- Improving the realism – faults and limitations.
- Bring different sub-detector technology options up to similar levels of detail.
- Move up to simulating at 1TeV.
- Improved treatment of Backgrounds.

Working Backwards



End of 2012

End of 2011

Mokka – Geant4 Full Simulation App.

- Currently uses Geant 4.9.2
- Used for both mass production physics studies and test beam experiments
- Now relatively mature – est.1999. Produced over 50 Million events for the LoI. Used for several test-beam campaigns.
- Following the LoI phase, it could probably do with a general health check before embarking on another mass production.

Current Production Models

- ILD_00 was used for LoI Physics studies.
- ILD_00fwp01 was used for post LoI background studies – IDAG questions and SB2009 studies.
  - the modifications made in ILD_00fwp01 only concerned treatment of background, namely in the treatment of micro curlers in the TPC, the beam pipe and a non uniform B-Field.

both models have obviously been frozen for some time …

Where to increase the realism

- Geometry and material description of the sub-detectors
- Digitisation – input to reconstruction
- Physics List.
  - For the LoI, all concepts agreed to use LCPhys created by Dennis Wright (SLAC)
    "The linear collider physics list I provided some time ago (LCPhys) is in fact no longer maintained. In its place I have been recommending the Geant4 reference physics list QGSP_BERT_HP."
  - Our proposal – useQGSP_BERT_HP as the default Physics list in Mokka
  - Clearly input from CALICE here is needed.

Next Step…

- Establish all sub-detector technology options in Mokka

- Irrespective of the configuration for mass production, experience shows that it is extremely beneficial to have all the different sub-detector technology options well described and up-to-date in Mokka.

Simulation Session – SW Workshop

Wednesday 27 January 2010 top

09:00->*09:10* Welcome (Convener: Paulo Mora de Freitas (*LLR*))

09:00	Charge to the workshop (10') (Slides)	Akiya Miyamoto (*KEK*)

09:10->*10:45* Status of ILD Simulation (Convener: Paulo Mora de Freitas (*LLR*))

09:10	Mokka - Overview and Plans (20') (Slides)	Paulo Mora de Freitas (*LLR*)
09:30	Silicon Tracking Simulation (20') (Slides)	Winfried Mitaroff (*Institut fuer Hochenergiephysik (HEPHY) - Oesterreichische Akade*) , Jordi Duarte Campderros (*IFCA - Instituto de Fisica de Cantabria-Consejo Sup. de Investig*)
09:50	TPC Simulation (15') (Slides)	Steve Aplin (*DESY*)
10:05	SiW Ecal Simulation (15') (Slides)	Gabriel Musat (*CNRS*)
10:20	VXD Simulation (15') (Slides)	Rita De Masi (*IPHC-Strasbourg*)
10:40	coffe break (20')	

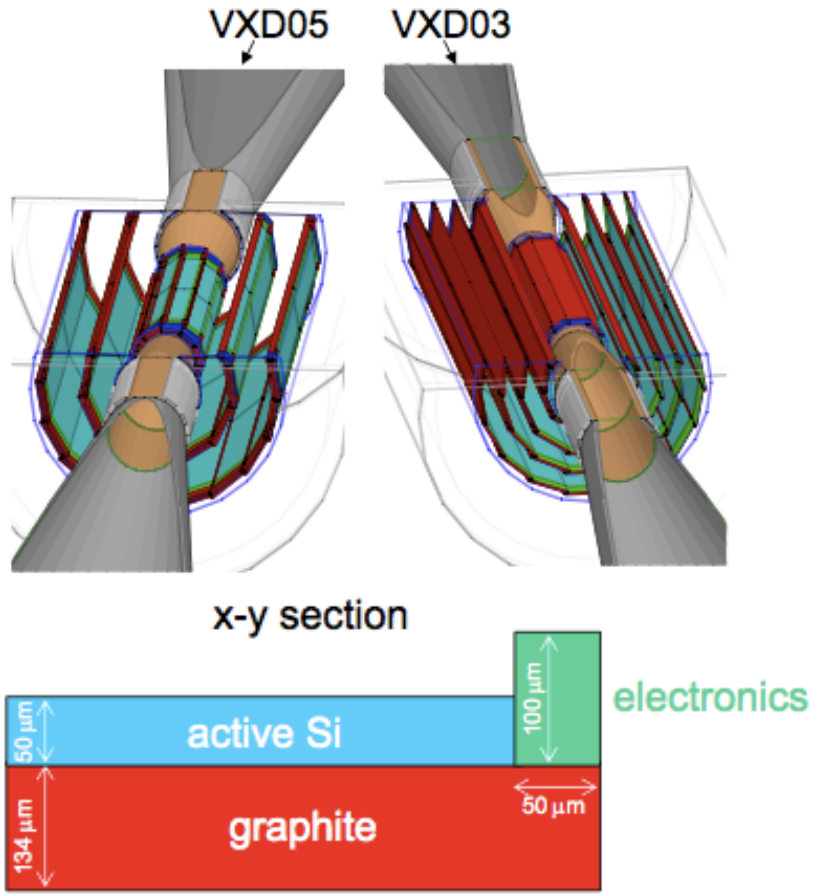
11:00->*13:00* Status of ILD Simulation ctd. (Convener: Steve Aplin (*DESY*))

11:00	SciEcal Simulation (15') (Slides)	Katsushige Kotera (*Shinshu University, Faculty of Science,*)
11:15	SciHcal Simulation (15') (Slides)	Angela Lucaci-Timoce (*FLC, CALICE, DESY*)
11:30	dHcal Simulation (15') (Slides)	Gerald Grenier (*IPN Lyon*) , Gabriel Musat (*CNRS*)
11:45	Lcal simulation (15') (Slides)	Bogdan Pawlik
12:00	Muon Simulation (15') (Slides)	Valeri Saveliev (*Moscow Physical Engineering Institute (MePhI)*)
12:15	Beampipe, Fwd, MDI Simulation (15') (Slides)	Henri Videau (*LLR-Ecole polytechnique*)
12:30	Simulation - discussion and summary (30')	Steve Aplin (*DESY*)
13:00	lunch (1h30')	

VXD

R. De Masi

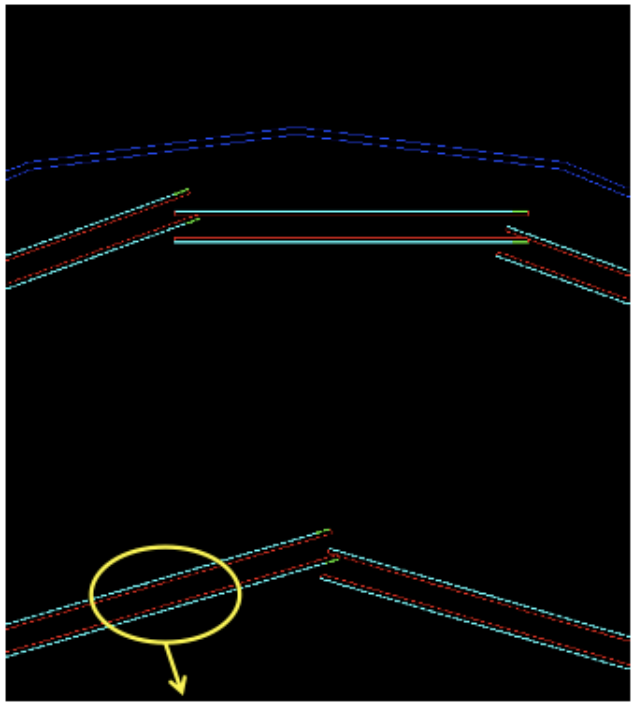
- Both geometric configurations are well described in Mokka for some time.
- Cryostat is present but at present the description of cables and services is not yet addressed.
- as well as the different geometric configurations there are also the different sensor technologies which need to be considered.



VXD

R. De Masi

- Both geometric configurations are well described in Mokka for some time.
- Cryostat is present but at present the description of cables and services is not yet addressed.
- as well as the different geometric configurations there are also the different sensor technologies which need to be considered.

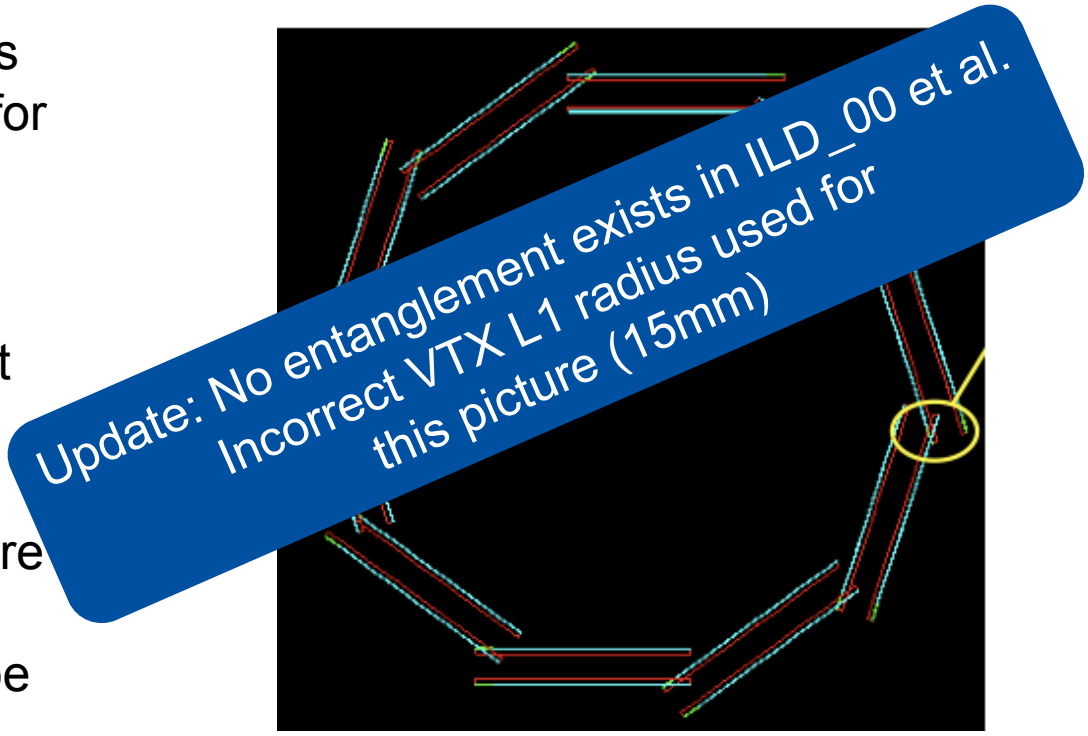


double layer implemented as double single layer
~ 2x0.11%X_0/layer instead of ~ 0.16%X_0/layer

VXD

R. De Masi

- Both geometric configurations are well described in Mokka for some time
- Cryostat is present but at present the description of cables and services is not yet addressed
- as well as the different geometric configurations there are also the different sensor technologies which need to be considered



possible entanglement of volumes in the inner layer of the double layer configuration

SIT + FTD + SET + ETD

W. Mitaroff

- Full Simulation Systems:
  - **Mokka** (*V. Saveliev*): not fully implemented ILD_00;
  - **ILCroot** (*A. Charpy*): full & detailed description.
- New Geometry System:
  - will replace present Mokka-GEAR database system;
  - commitment to the "full description" as in ILCroot.

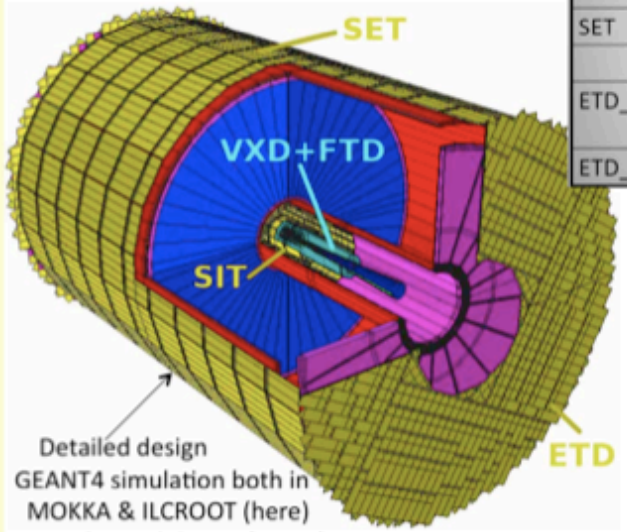
SIT + FTD + SET + ETD

W. Mitaroff

- Full Simulation Systems:
  - **Mokka** (*V. Saveliev*): not fully implemented ILD_00;
  - **ILCroot** (*A. Charpy*): full &
- New Geometry System:
  - will replace present Mokka-G
  - commitment to the "full descr

The Silicon Envelope in numbers
(current scheme)

ILD



Component	Layer #	# modules	# sensors/ module	# channels	Total surface m2
SIT1	1st layer	33	3	66.000	0.9
	2nd layer	99	1	198.000	0.9
SIT2	1st layer	90	3	180.000	2.7
	2nd layer	270	1	540.000	2.7
SET	1st layer	1260	5	2.520.000	55.2
	2nd layer	1260	5	2.520.000	55.2
ETD_F	X or U or V	82/quad =328/layer =984/ETD	2 or 3 or possibly 4	2.000.000	30
ETD_B	idem	idem	idem	idem	30

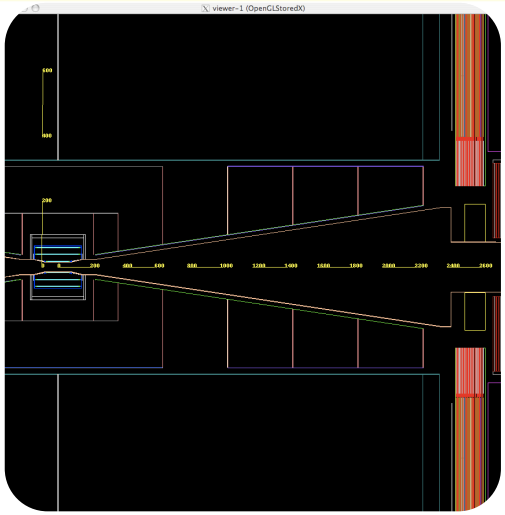
Total number of channels:
10^6 (SIT) + $5x10^6$ (SET) + $4x10^6$ (2 ETD)
= **10 $x10^6$ channels**
Total area:
7 (SIT)+110 (SET) +2x30(ETDs) = **180 m^2**
Total number of modules:
500 (SIT) + 2500 (SET) + 2000 (ETDs)=
5000 modules with unique size sensors

1/27/10 Si tracking in ILC concepts: integration 1

SIT + FTD + SET + ETD

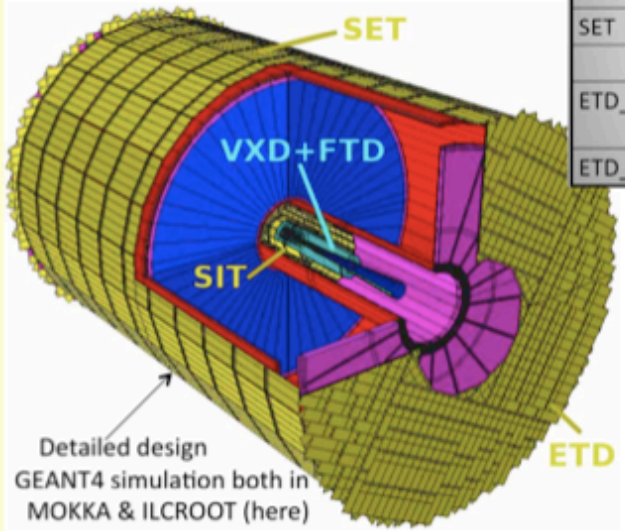
W. Mitaroff

- Full Simulation Systems:
  - **Mokka** (*V. Saveliev*): not fully implemented ILD_00;
  - **ILCroot** (*A. Charpy*): full &
- New Geometry System:
  - will replace present Mokka-G
  - commitment to the "full descr



The Silicon Envelope in numbers
(current scheme)

ILD



Component	Layer #	# modules	# sensors/ module	# channels	Total surface m2
SIT1	1st layer	33	3	66.000	0.9
	2nd layer	99	1	198.000	0.9
SIT2	1st layer	90	3	180.000	2.7
	2nd layer	270	1	540.000	2.7
SET	1st layer	1260	5	2.520.000	55.2
	2nd layer	1260	5	2.520.000	55.2
ETD_F	X or U or V	82/quad =328/layer =984/ETD	2 or 3 or possibly 4	2.000.000	30
ETD_B	idem	idem	idem	idem	30

Detailed design
GEANT4 simulation both in MOKKA & ILCROOT (here)
& mechanical design (CATIA) in progress

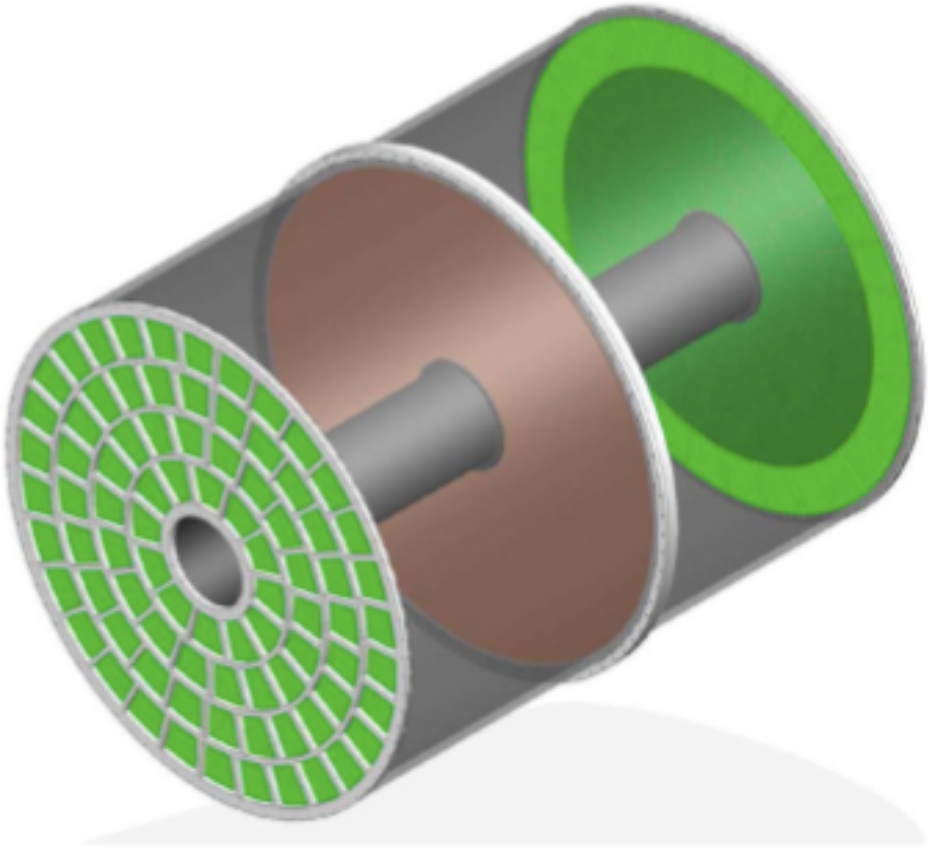
Total number of channels:
10^6 (SIT) + $5x10^6$ (SET) + $4x10^6$ (2 ETD)
= **10 x10^6 channels**
Total area:
7 (SIT)+110 (SET) +2x30(ETDs) = **180 m²**
Total number of modules:
500 (SIT) + 2500 (SET) + 2000 (ETDs)=
5000 modules with unique size sensors

1/27/10 Si tracking in ILC concepts: integration 1

TPC

SJA

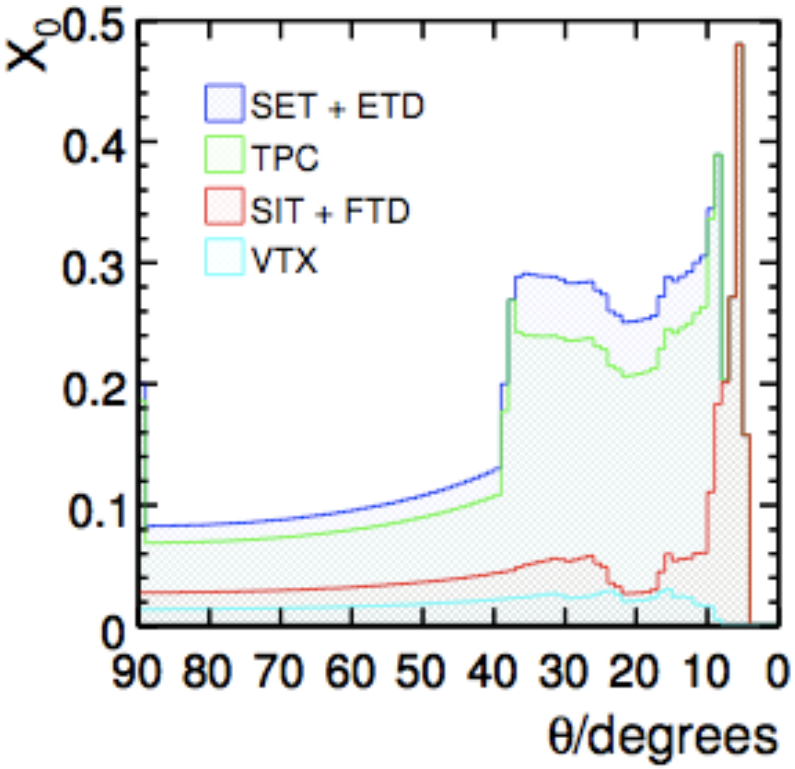
- Structure – Aluminium Frame
- Gas – Argon Mixture
- Cathode – Copper, Mylar
- End-Plate is currently described as sequential discs of appropriate material e.g. copper, air, G10
- Field cage is described as homogenous cylinders
- No services to or from the End-pate



TPC

SJA

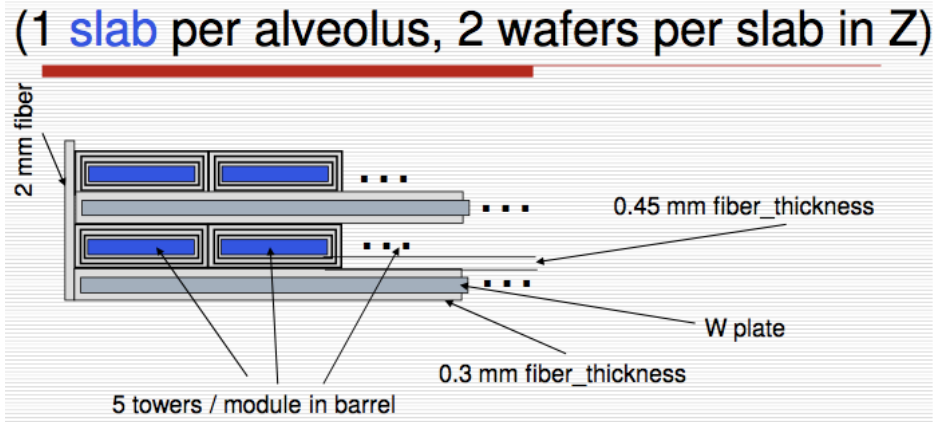
- Structure – Aluminium Frame
- Gas – Argon Mixture
- Cathode – Copper, Mylar
- End-Plate is currently described as sequential discs of appropriate material e.g. copper, air, G10
- Field cage is described as homogenous cylinders
- No services to or from the End-pate

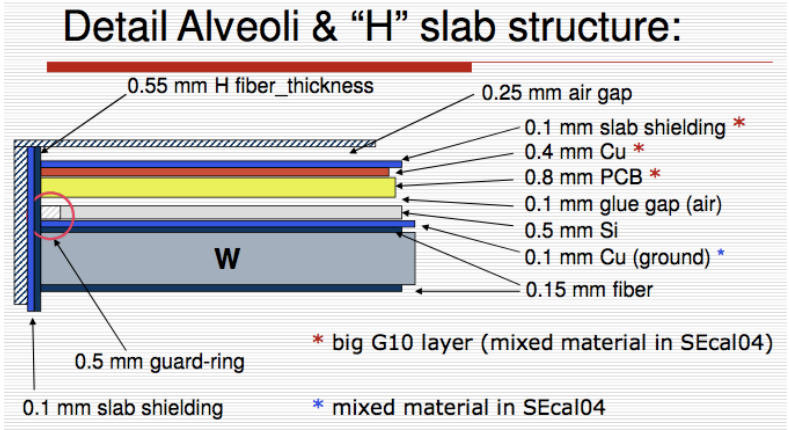


SiW ECAL

G. Musat

- Already quite a high level of detail for the LoI, still some questions concerning the description of the PCBs.
- Tungsten absorber can be replaced with Pb.
- Sensitive: Si (replaceable with polystyrene) uses virtual cells.
- Presently the description of the end-caps needs to be refined.
- Cooling and Services still to be addressed.

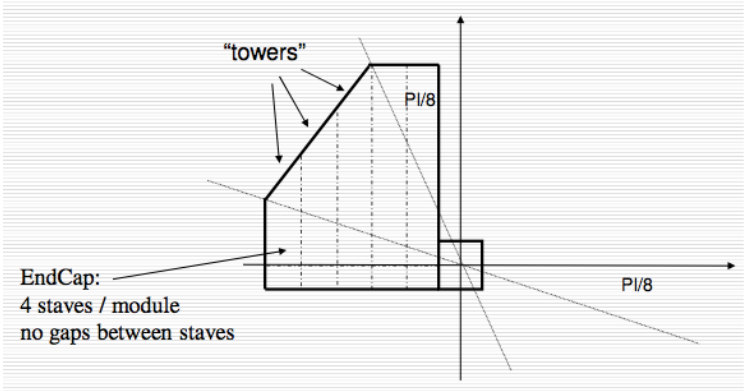


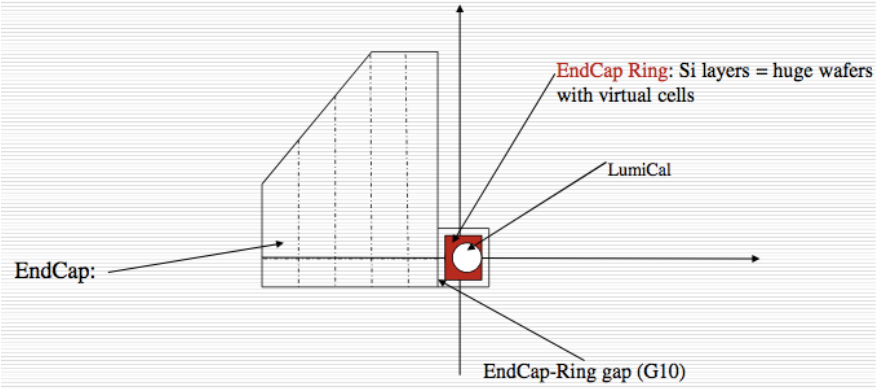


SiW ECAL

G. Musat

- Already quite a high level of detail for the LoI, still some questions concerning the description of the PCBs.
- Tungsten absorber can be replaced with Pb.
- Sensitive: Si (replaceable with polystyrene) uses virtual cells.
- Presently the description of the end-caps needs to be refined.
- Cooling and Services still to be addressed.

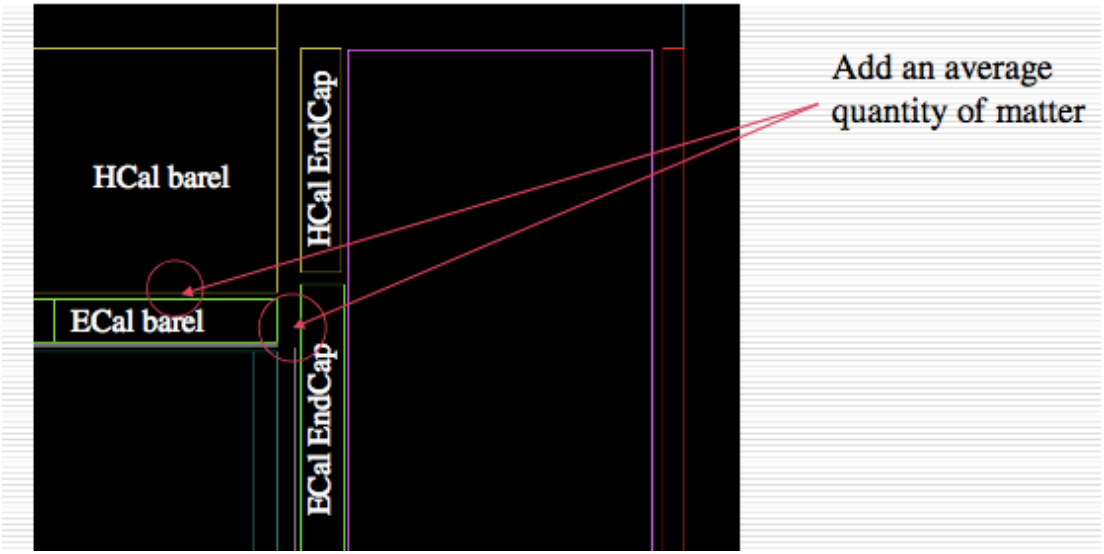




SiW ECAL

G. Musat

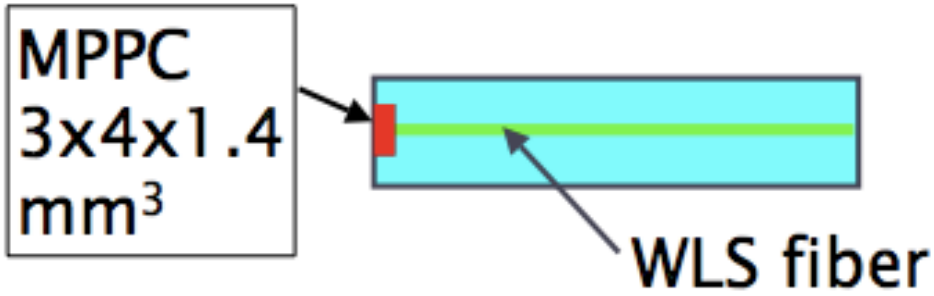
- Already quite a high level of detail for the LoI, still some questions concerning the description of the PCBs.
- Tungsten absorber can be replaced with Pb.
- Sensitive: Si (replaceable with polystyrene) uses virtual cells.
- Presently the description of the end-caps needs to be refined.
- Cooling and Services still to be addressed.

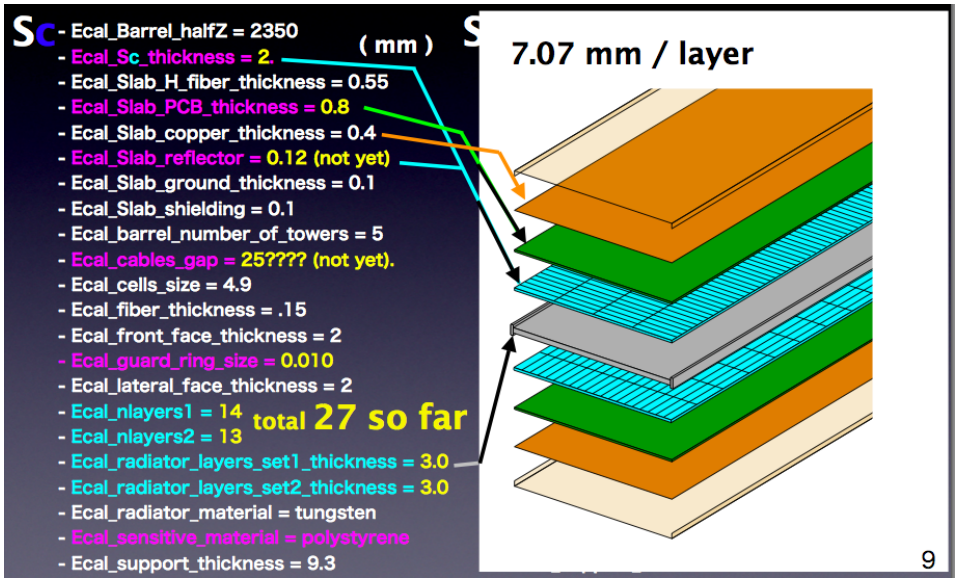


ScW ECAL

K. Kotera

- A detailed implementation in Mokka exists which takes into account, gaps etc.
- Currently square cells are used instead of strips.
- In the current default concerning the geometry of the Sc ECAL and Si ECAL, the ScECAL has larger sampling ratio than SiECAL.
- Also a there is the combined Silicon and Scintillator Ecal design, Paulo is working on Mokka driver.

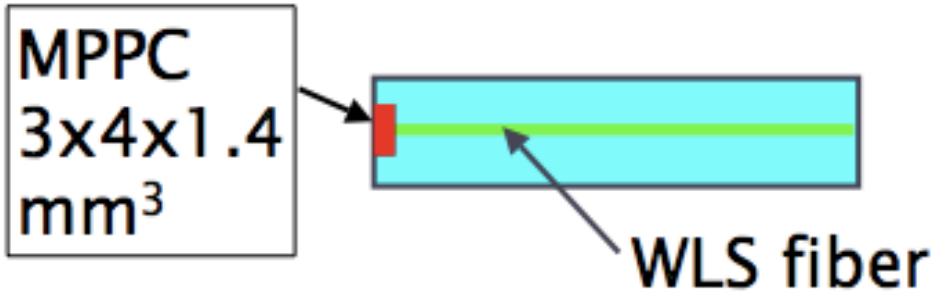


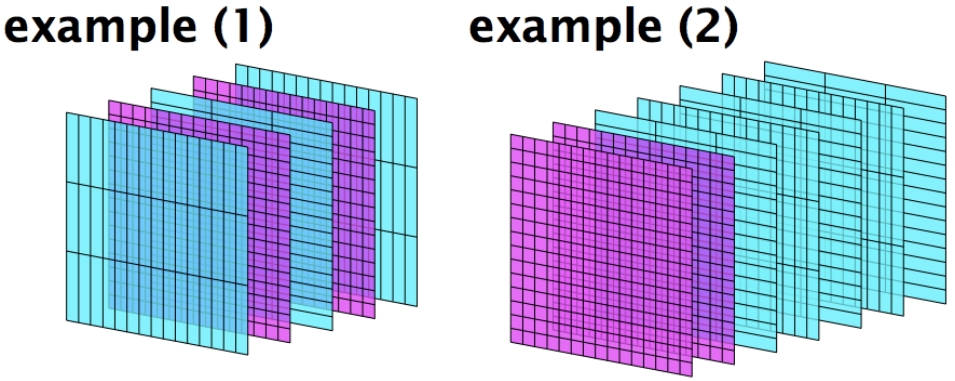


ScW ECAL

K. Kotera

- A detailed implementation in Mokka exists which takes into account, gaps etc.
- Currently square cells are used instead of strips.
- In the current default concerning the geometry of the Sc ECAL and Si ECAL, the ScECAL has larger sampling ratio than SiECAL.
- Also a there is the combined Silicon and Scintillator Ecal design, Paulo is working on Mokka driver.



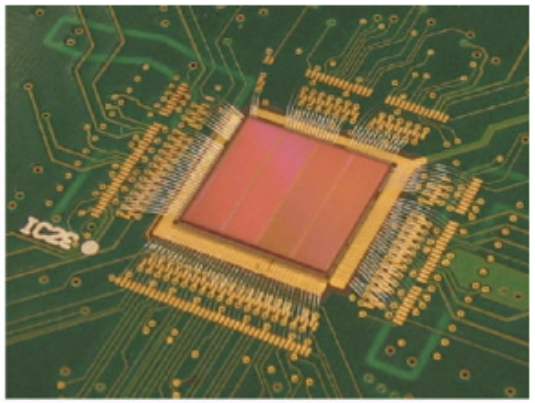


Combined Silicon and Scintillator Ecal

Digital ECAL – Maps

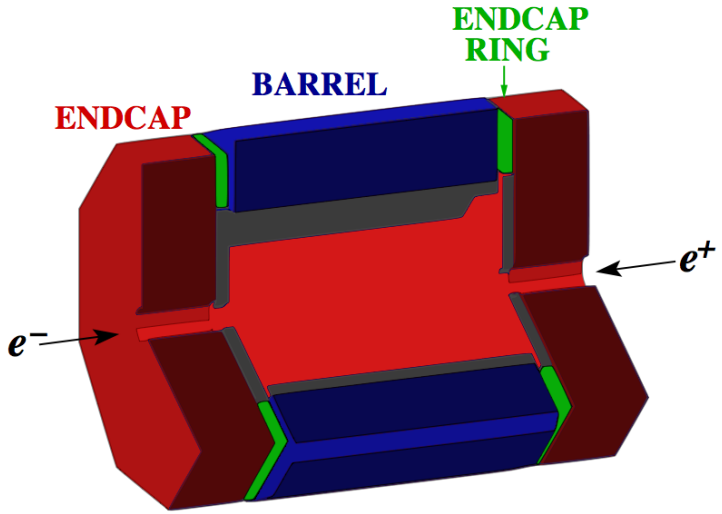
N. Watson

- Benefit from following as closely as possible the SiW design “swap in alternative”.
- Mokka driver exists, just needs to be tagged in Mokka.

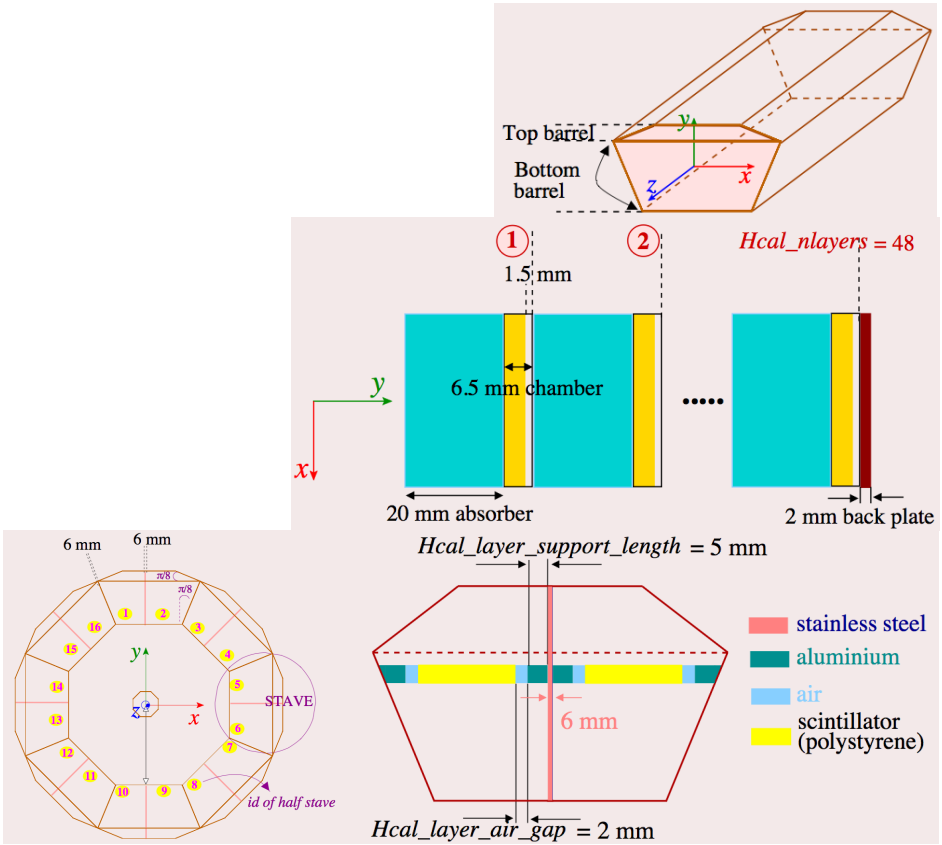


Scintilator HCAL

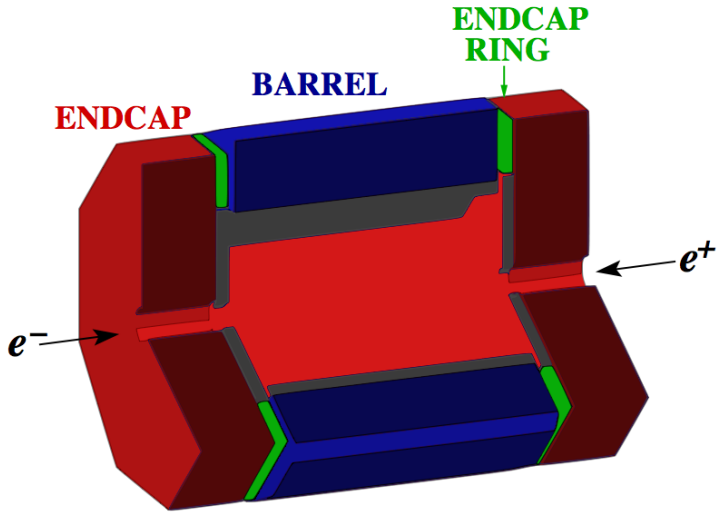
A. Lucacci



Detailed Model implemented in Mokka for the LoI.
Barrel: Circular structure divided into 8 **staves.**
For mechanical reasons, each stave divided into 2.



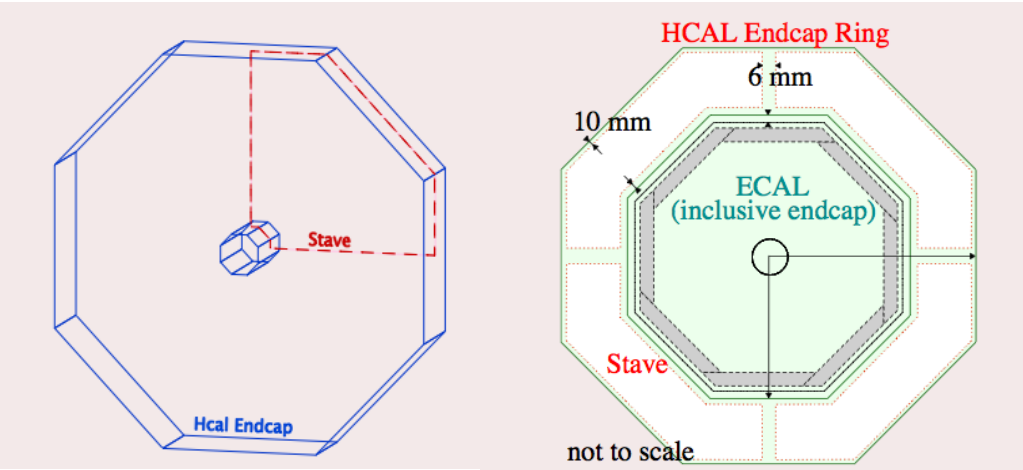
Scintilator HCAL



A. Lucacci-Timoce

End-cap Rings: No specific engineering design yet.
Use the same simple geometry as for the end-caps.
Number of layers constrained by thickness and outer radius of the ECAL end-caps (ILD 00: 5 layers)

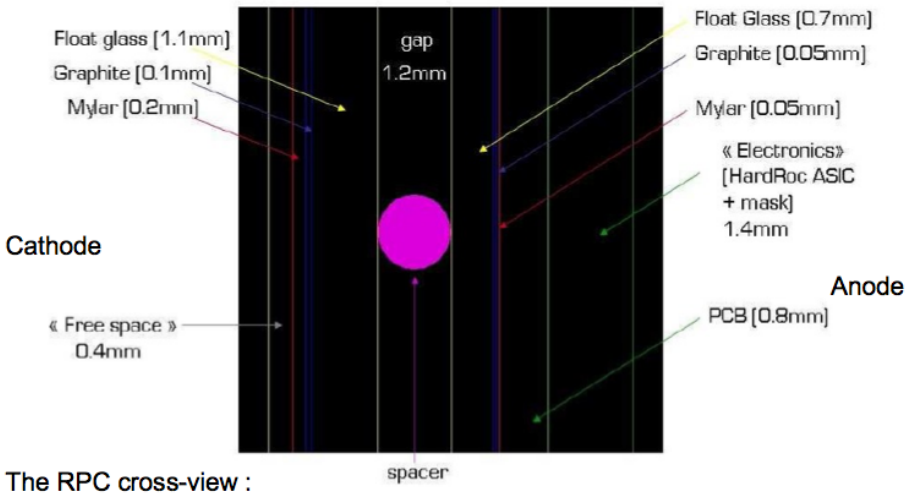
End-Cap: No specific engineering design yet.
Simple geometry: octagonal shape, with an octagonal hole for the beam pipe.
Same sampling structure as for the barrel; 3 cm cells;



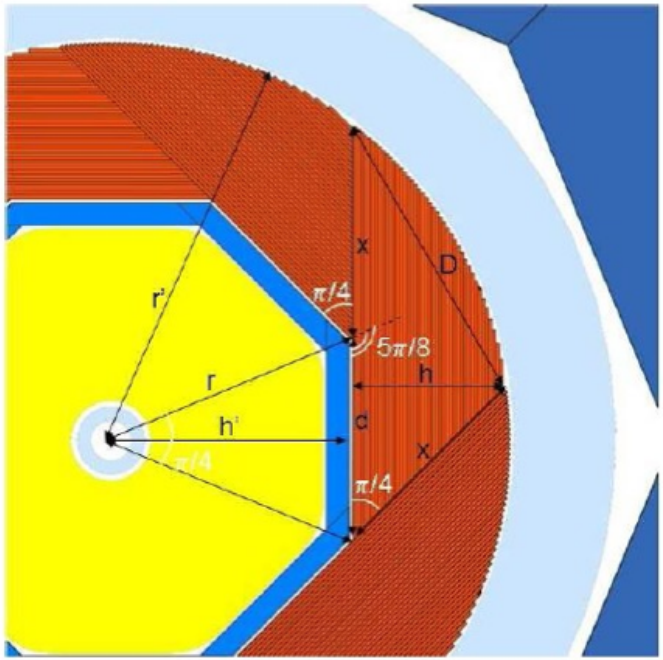
DHCAL

G. Grenier

- ILD_00Dhcal (i.e. ILD_00 with DHCAL)
- ILD_00fw_Dhcal (i.e. ILD_00fw with DHCAL)
- The geometry is parametrised by 3 quantities :
  - Number of layers
  - Outer radius (r')
  - Distance between center and first plate (h')



The RPC cross-view :

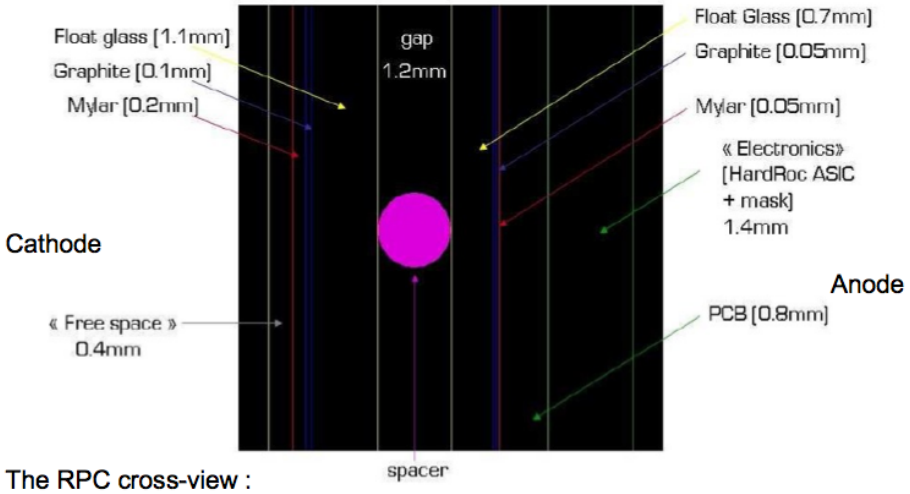


For the End-Caps and EndCap-Rings, there is a mixed material used for the Mylar, the Graphite, the electronics, the PCB and the "free space".

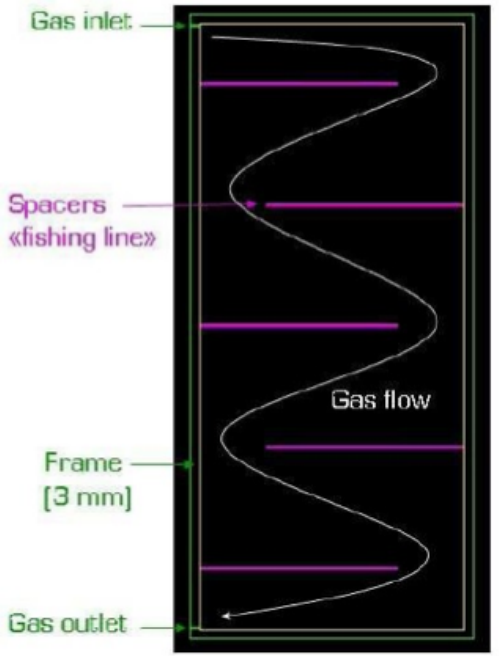
DHCAL

G. Grenier

- ILD_00Dhcal (i.e. ILD_00 with DHCAL)
- ILD_00fw_Dhcal (i.e. ILD_00fw with DHCAL)
- The geometry is parametrised by 3 quantities :
  - Number of layers
  - Outer radius (r')
  - Distance between center and first plate (h')



The RPC cross-view :

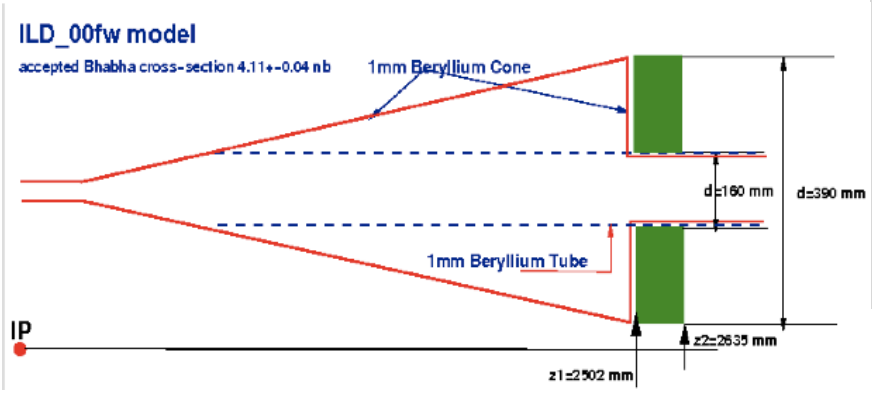


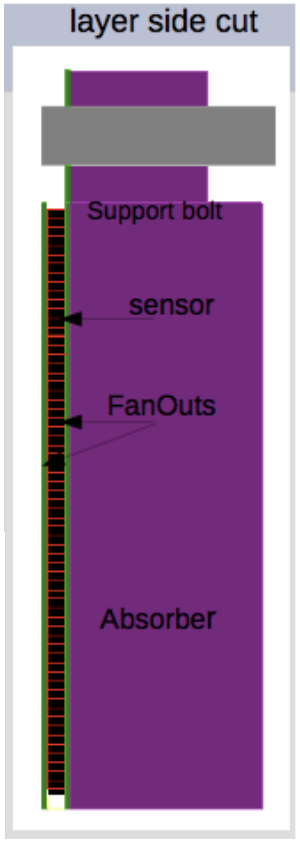
In the current design, the spacer are no longer nylon "fishing lines" but ceramic balls. (One ball every 10 cm).
Currently 2 material for the balls : ZrO2 and Si3N4

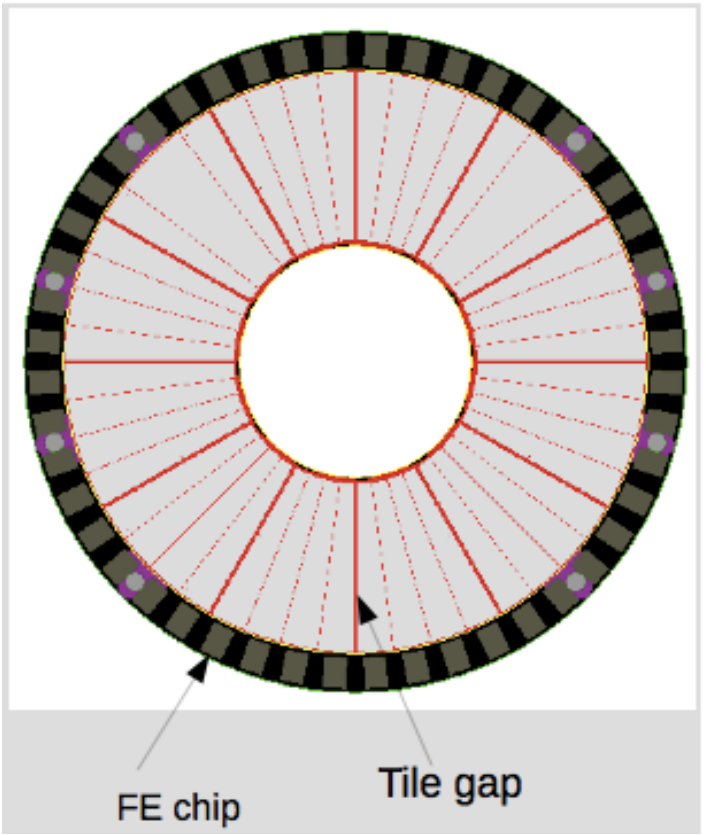
LCAL

B. Pawlik

- New drivers SLcal03/ LumiCalX01 features
  - mechanical support structure
  - FE electronics
  - dead spaces between tiles
  - FE to sensor interconnection boards (PCB)
  - Electronics is treated as a homogenous mixture of copper mylar etc
- No cooling or cables



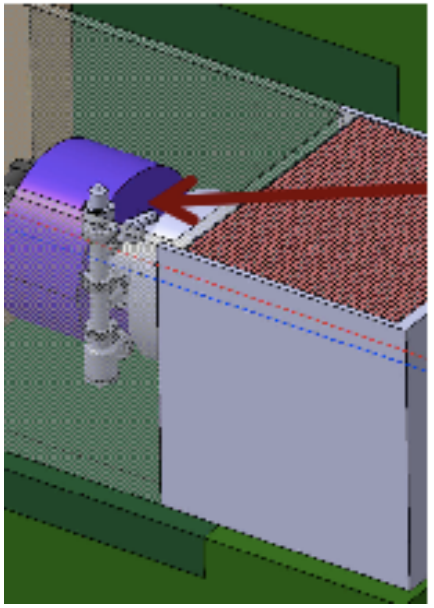


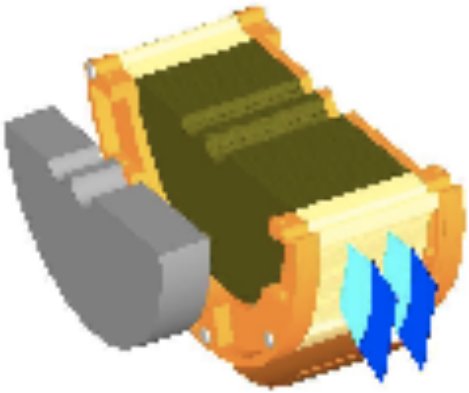


BCAL

B. Pawlik

- A version of the BCAL and pair monitor which was implemented in the standalone Geant4 application BeCaS was brought into the ILD_00 models
- The model is quite detailed and describes the segmentation and electronics material.
- An update of the detector model will be implemented by FCAL

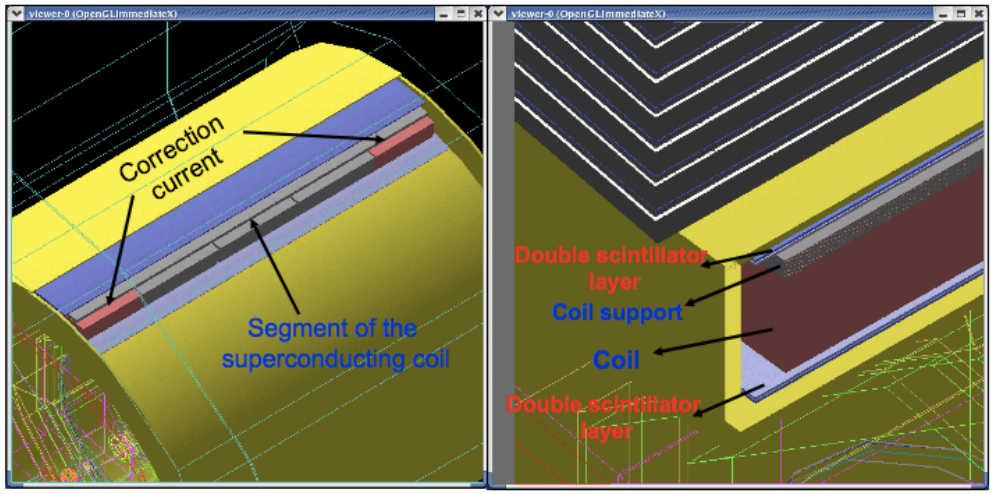


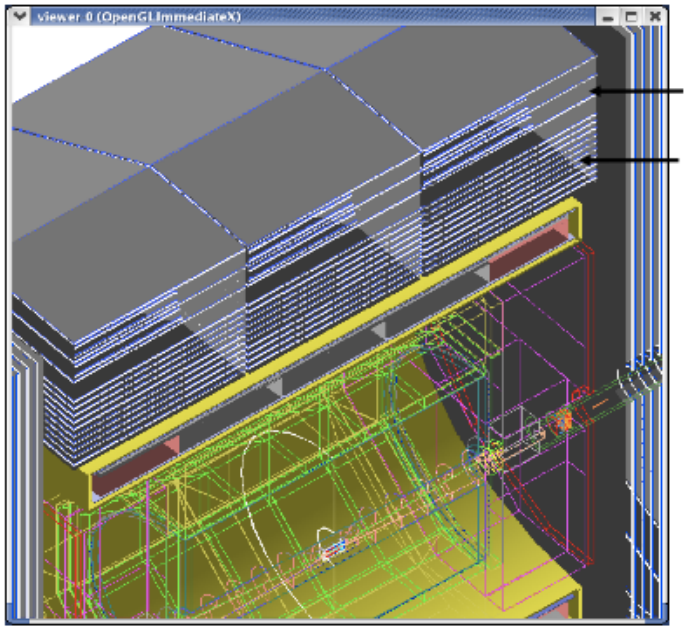


Muon System, Coil and Yoke

V. Saveliev

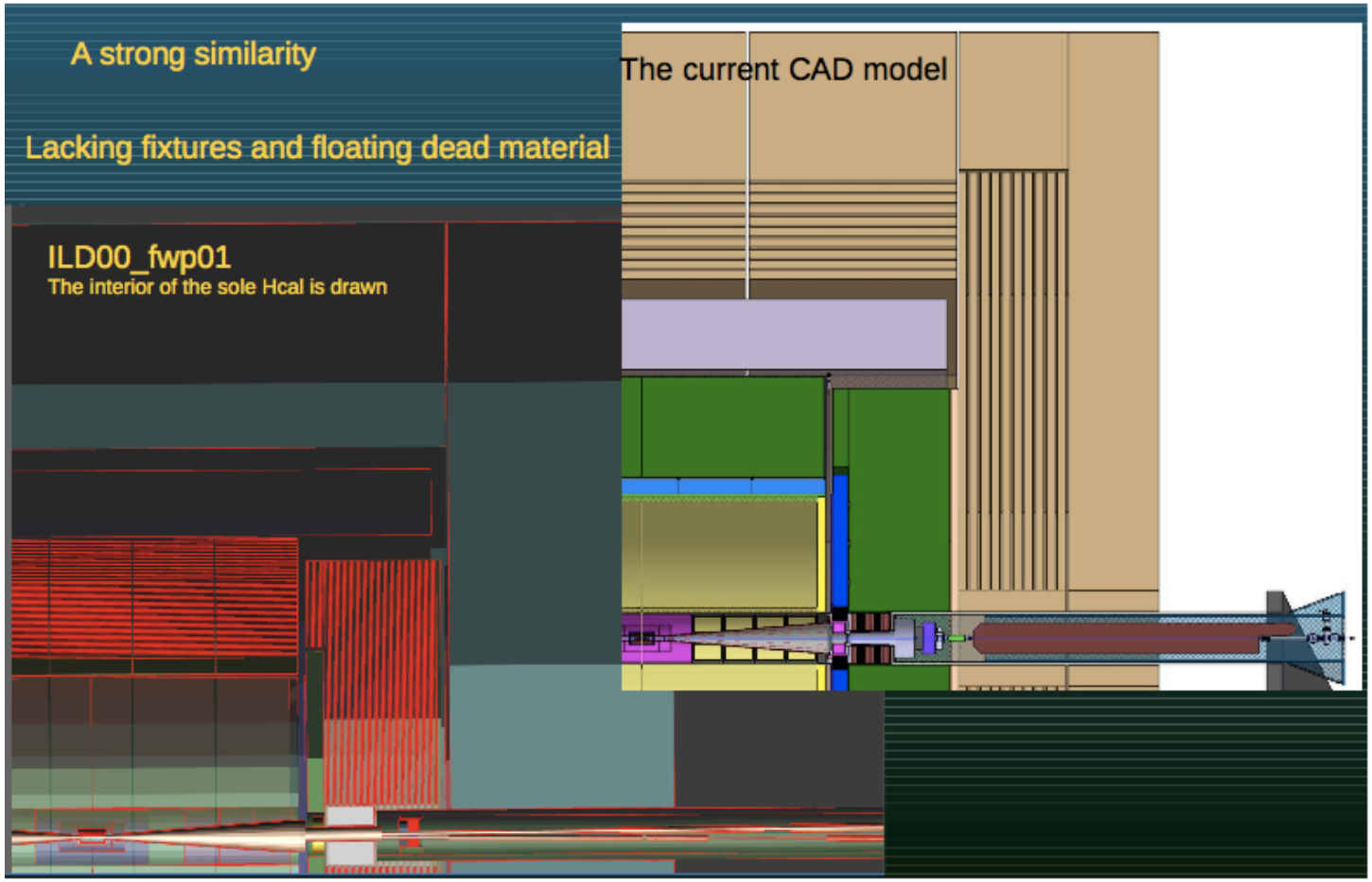
- Updated version of the Muon System written in Mokka, needs integrating with the central code
- Includes a more detailed description of the solenoid and yoke, including instrumentation within the solenoid.





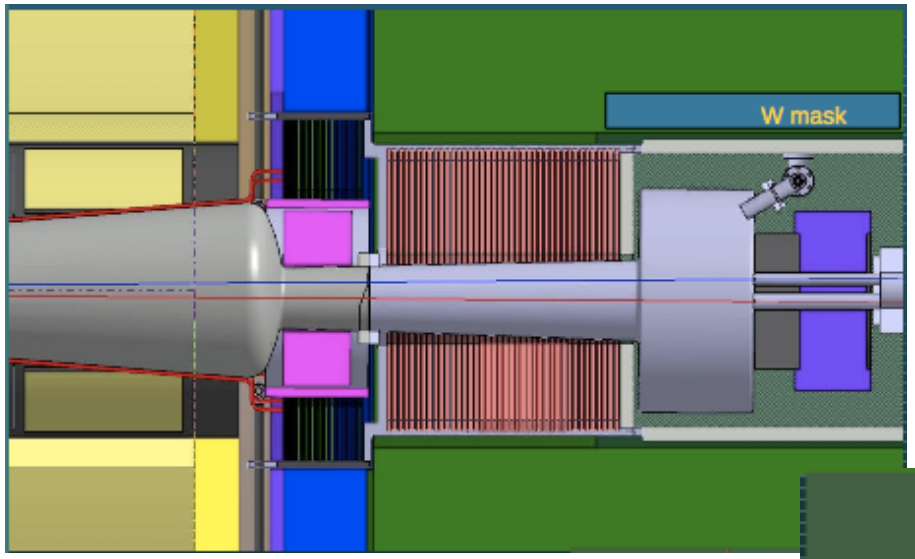
MDI – Fwd region, Mask, etc.

H. Videu

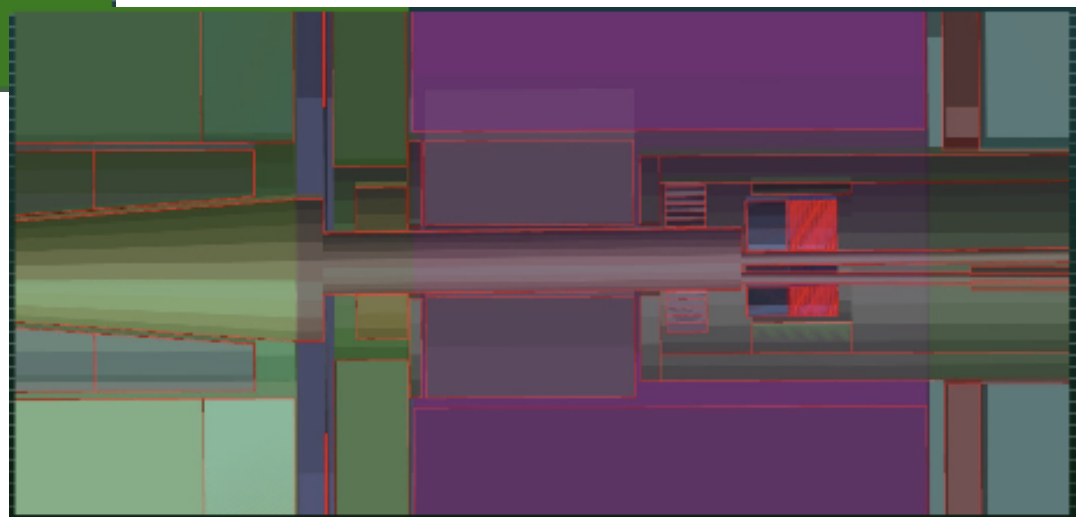


MDI – Fwd region, Mask, etc.

H. Videu



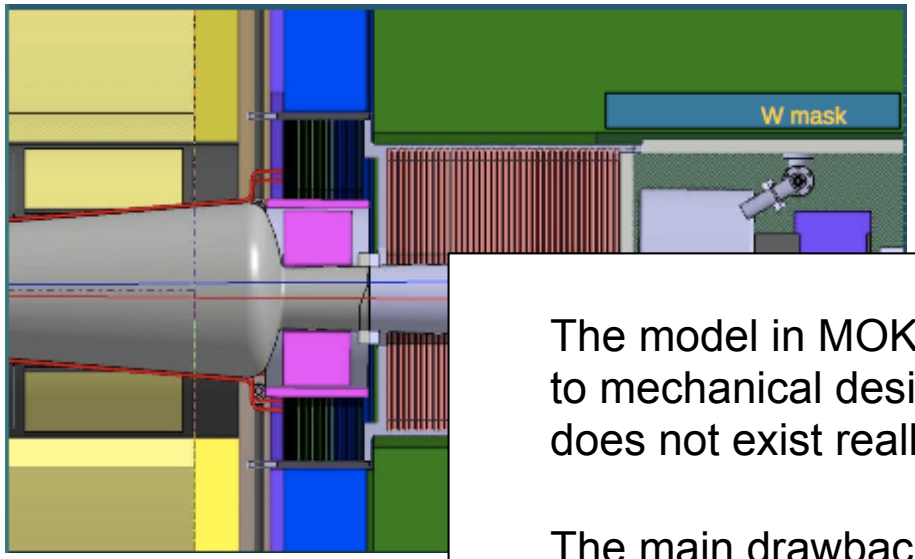
Almost all the features are there.
Beam tube: the thickness is different the cupola is absent, the services around are missing.
Lcal, placement slightly different ECAL ring special handling.



LHCAL fixtures
W mask
Support tube square
Beam tube conical
Pump
BCAL shielding absent in CAD

MDI – Fwd region, Mask, etc.

H. Videu



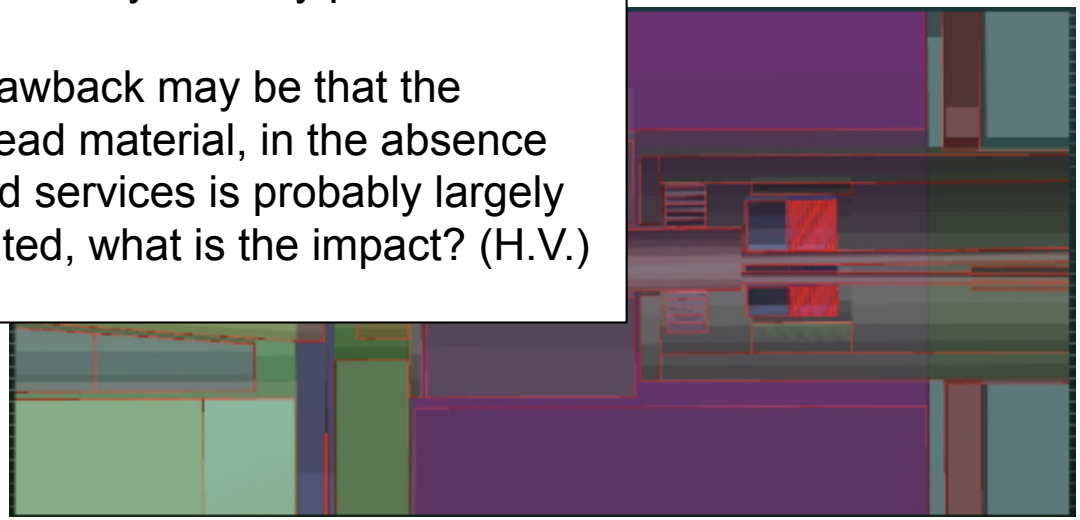
Almost all the features are there
Beam tube: the thickness is different the cupola is absent, the services around are

ntly different ECAL

The model in MOKKA is pretty close to mechanical design, but this design does not exist really in many places.

The main drawback may be that the amount of dead material, in the absence of cables and services is probably largely underestimated, what is the impact? (H.V.)

LHCAL fixtures
W mask
Support tube square
Beam tube conical
Pump
BCAL shielding absent in CAD



Contact People for Mokka Drivers

Description	Technology	Contact Person
VXD	Double Layer	Takubo Yosuke
	Single Layer	Rita De Masi
FTD	Strips and Pixels	Jordi Duarte
SIT	Strips	V.Saveliev, A. Charpy
ETD	Strips	V.Saveliev, A. Charpy
SET	Strips	V.Saveliev, A. Charpy
TPC	GEM/MicroMegas/Digital	Steve Aplin
ECal	SiW	Paulo Mora de Freitas, Gabrie Musat
	ScW	Katsushige Kotera
	Maps	Nigel Watson
HCal	ScFe Analog	Angela Lucacci
	ScFe Digital	Gerald Grenier
Muon		N.D'Ascenzo, V.Saveliev
BeamCal		Olga Novgorodova
LumiCal	SiW	Bogdan Pawlik
LHCal		?
Beam-pipe masks		Paulo Mora de Freitas
B-Field		?

Common Issues – Space & Services

- Having this list of contact people well established will also help in terms of the common effort necessary to deal with the interplay between some of the sub-detectors, as well as addressing the regions where services need to be routed in and out of the detector.

- There is also the issue of scaling …

Moving towards Mass Productions

- Based on experience from the LoI, we think that it is important that we have at least first software implementations of the different sub-detector options defined in Mokka later in 2010.
- This would put ILD in a good position to refine the detector descriptions, debug, and then finalise them in 2011 ready for the mass production phase.
- Time needs to be allocated for the development of the reconstruction algorithms, especially where the treatment of background is concerned, and as much as possible we want to avoid having to do this in a hurry, to deal with some greater level of detail, introduced on the eve of starting the mass production.

Digitisation

- Another key issue concerning the input to the reconstruction which directly effects the level of realism is of course digitisation.

- SimHit Philosophy

  – Simulate Now $\longrightarrow$ Digitise Later

  – This provides flexibility for the level of realism and in the past different technology options have been able to use the same simulation files. Although with an increasing level of realism this may change …

Digitisation

- With the results from the larger prototypes within the R+D groups, there is an increasing level of understanding in the generation of detector signals, and hence an improvement in their simulation.
- Given that running dedicated detailed digitisation is prohibitively slow regarding mass production we need to ensure that the understanding gained, is effectively fed back into the production via appropriate parameterisations for detector hits.
- My feeling is that this is not such a major concern for the calorimeters, but for the tracker it is essential.

Digitisation

- For the TPC a parameterisation is used to transform Sim Hits into track measurements, but this does not involve the production of pads charges and the subsequent hit building.

	$\sigma_{r-\phi}/\mu\mathrm{m}$	$\sigma_z/\mu\mathrm{m}$		$\sigma_{r-\phi}/\mu\mathrm{m}$	$\sigma_z/\mu\mathrm{m}$
VTX	2.8	2.8	FTD	5.8	5.8
SIT/SET	7.0	50.0	ETD	7.0	7.0
TPC	$\sigma^2_{r\phi} = 50^2 + 900^2 \sin^2\phi + \left((25^2/22) \times (4/B)^2 \sin\theta\right) z\,\mu\mathrm{m}^2$ $\sigma^2_z = 40^2 + 8^2 \times z\,\mu\mathrm{m}^2$				

- Where there is significant need for improvement, is in the treatment of strip detectors in the Silicon Tracking system. Currently Sim Hits in these detectors are treated simply as 3D space-points, which clearly degrades the level of realism significantly concerning the strip detectors detectors.

Summary

- How realistic is realistic?
- Very happy to see the list of contact people coming together well. Need to finalise it and find coverage for the outstanding areas.
- We should not forget to address the less glamorous regions of the ILD detector and its environment, e.g. services, magnets, collimators … as they do have an impact on studies.
- Timeline and milestones, clearly depend on what studies need to be done when?