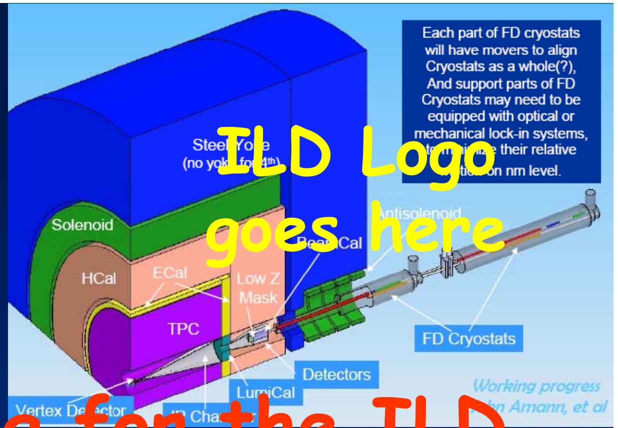
Worldwide Study of the Physics and Detectors for Future Linear $e^+ e^-$ Colliders



LCTPC "advanced-endcap" planning for the ILD LOI...

Summary of mtg #4 10.11.2008

Ron Settles MPI-Munich
LCTPC advanced-endcap studies for the LOI

Agenda for mtg #4 10.11.2008

Agenda:
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1. TPC-endcap issues (15')
Introduction by Ron Settles
2. LCTPC electronics issues (15')
by Luciano Musa
3. Cooling issues from CMS experience (15')
by Alain Herve
4. DAQ issues (15')
by Xavier Janssen

Summary of mtg #4 10.11.2008

Summary:
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1. TPC-endcap issues.
- We had three advanced-endcap meetings last year: 14 June, 26 July 2007 and 10 October 2007. The first two covered mainly the new electronics and the third included first thoughts by Luciano on the layout of and heat generated by the "advanced endcap" electronics.
- There are three main, highly-correlated and sometimes self-contradicting aspects: electronics (as many pads as possible), cooling (as little heat generated as possible) and mechanics (as thin as possible). In addition there are two main developments: standard TPC or pixel TPC.
- The density we choose will be governed by cooling (heat) and mechanics (X_0), as well as by the momentum resolution we want. How the problem was solved by Aleph was shown: 25% X_0 for 22000 pads and 1.3kW per side cooled using combined water and forced-air cooling.
- The heat generated will depend not only on the electronic density but also on how well the power-switching works. If it turns out we are generating too much heat or the endcap is too thick due to electonic density, we will have to reduce the number of pads and there are ideas as to how to do this while maintaining the momentum resolution, but the price you pay is higher occupancy.
=>=> However we don't want to consider this option yet, because we are still in the process of understanding the issues.

2. LCTPC electronics issues.

Luciano reviewed the Alice endcap: 285000 pads per side, an order of magnitude more that Aleph. Whereas Aleph only had the preamps on the endcap, Alice has the whole PASA/Altro chain which sums up to 11kw per side to be cooled. Copper cladding of all the electronics and water cooling solved the Alice heat problem, but Alice does not worry about thickness of the endcap so that such a solution for the LCTPC is not possible. The strategy for LCTPC is that power pulsing will work and reduce the heat to a managable level.

Luciano found that a density of 330000 pads per m^2 would be possible, based on preliminary layout of the PCB. He also showed first thoughts towards a power-pulsing circuit; if 1:100 power reduction can be achieved, that would leave 1.67 W/m^2 x 1/3 = 56 W/m^2 to cool for 1 million pads per endcap.

Finally he said that a cooling layer can be included in the PCB.

3. Cooling issues from CMS experience.

Alain reviewed the ideas used for CMS; these ideas are meant to open the discussion for the lctpc:

- Each sub-detector is basically adiabatic wrt others.
- The bulk of heat is removed locally by water as near as possible of where heat is created. Water is still the best liquid for that; there exist alternatives to water but they are expensive.
- The remaining part of heat is removed by natural convection in the surrounding inert atmosphere; vacuum vessel and massive detector components are used as cold sinks. This is compatible with an inert atmosphere inside the vacuum vessel as required for fire protection.
- Alain expressed concern that power-pulsing may cause problems for the mechnical stability of the detectors.

4. DAQ issues.

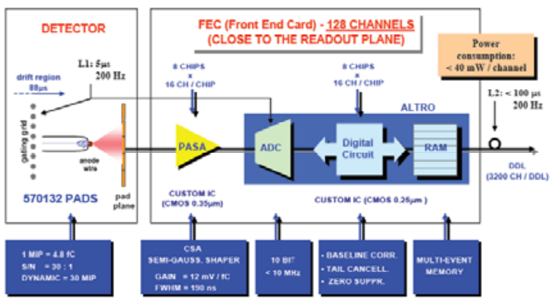
Xavier dispayed first thoughts.

- The advanced endplate electronics will be much more highly integrated than now and include more FEC and RCU functionalities. What is put on the endcap and what goes into the electronic hut must be decided.
- For the several options for the advanced-endplate electronics, a common data transfer protocol and DAQ should be defined.
- A "trigger" concept will be needed. E.g., the "trigger" should wake up the electronics before the bunch-train arrival and prepare for arrival of the data, and then put the electronics back to sleep after the bunch train has passed.
- Also data transfer needs redundancy and Xavier showed the architecture being planned by CALICE.

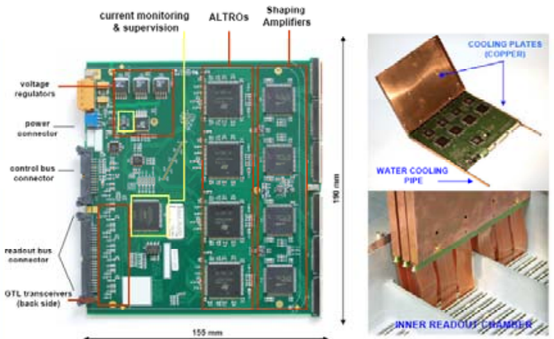
Here are slides from that meeting for quick reference

Alice TPC FEE - MWPC Readout

Front End Electronics Architecture



ALICE TPC Front End Card: Layout, Cooling and Mounting



Installation of ALICE Front End Electronics (Feb-May '06)

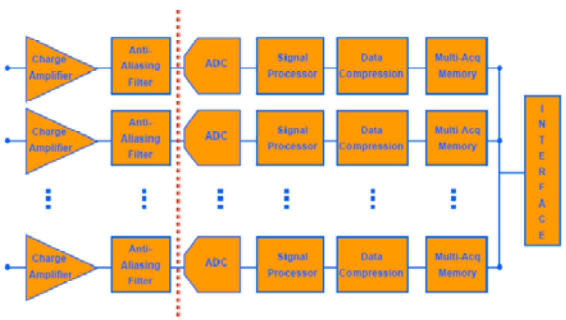
Charge readout chip for MPGD

A general purpose charge readout chip for MPGDs

- number of channels: 32 or 64
- programmable charge amplifier
  - sensitive to a charge in the range: ~10^2 - ~10^6 electrons
  - Peaking time: 20ns – 100ns
- high-speed high-resolution A/D converter
  - sampling rate: 40MHz
- programmable digital filter for noise reduction and signal interpolation;
- a signal processor for the extraction and compression of the signal information (charge and time of occurrence).
- Two readout modes: external trigger or self-triggered
- Trigger can have any position wrt the acquisition window
- Standby mode

Charge Readout Chip Block Diagram

32 / 64 Channel



Considerations on readout plane

IC Area (die size)

N.B. 3.3 M !!

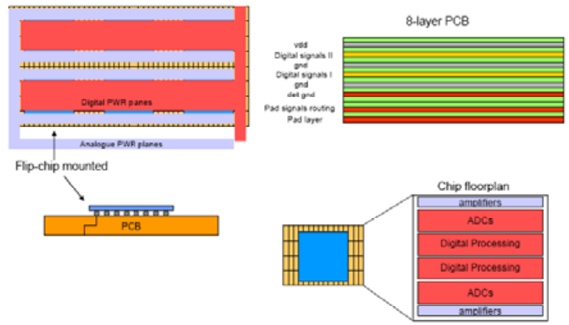
- 1-2 mm² /channel
  - Shaping amplifier 0.2 mm²
  - ADC 0.7 mm² (prototype ➡ room for improvement)
  - Digital processor 0.6 mm² (estimate)
- in the following we consider the case of 1.5mm² / channel
- 64 ch / chip ➡ ~ 100 mm²

Area of the chip on the PCB: 14 x 14 mm² / chip ⇨ ~ 3 mm² / pad

PCB dimensions < 40 x 40 cm² ⇨ ~53000 pads, ~800 FE chips / board

Considerations on readout plane

PCB topology and layer stack-up



Considerations on readout plane

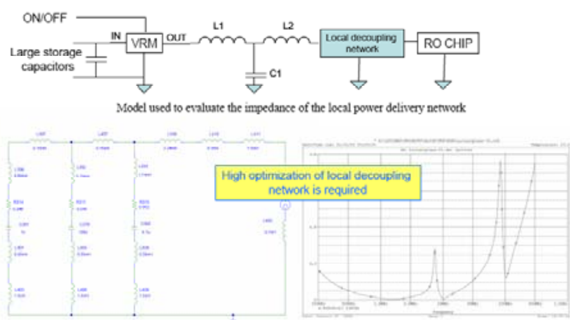
Power consumption

- amplifier 8 mW / channel
- ADC 30 mW / channel
- Digital Proc 4 mW / channel
- Power regulation and links 10 mW / channel
- duty cycle: 1%
- average power / channel ~ 0.5 mW / channel
- average power / m² 167 W

N.B. ÷ by 3 !!

Considerations on readout plane

Readout Board power delivery network



Model used to evaluate the impedance of the local power delivery network

Impedance (W) versus frequency for the local power delivery network connected to the RO chip through a power plane with zero inductance.

CMS

Cooling Consideration from CMS Experience

A. Hervé / ETHZ

ILD-endcap studies,10 November 2008

Introduction

- I have prepared this list at the request of Ron Settles.
- The general concept of ILD seems close enough from the CMS one, that some of the experience can be used directly.
- This is particularly true for fire protection and cooling (for example).

This has been prepared for discussion only.

Alain Hervé, CLIC08 Workshop, 16 October 2008 2

I - CMS principles that seems useful to be retained

- Active cooling of front-end electronics is *a must* especially in confined areas like Vacuum Tank.
- Temperature stabilization is needed as temperature dependence of sub-detectors is often neglected or known quite late, light detectors, RPCs, ….
- It is good practice that each sub-detector can be considered as an adiabatic, or isothermal enclosure wrt. its neighbors, that is each one is responsible for removing its own thermal flux.
- Air (or gas) cooling is very inefficient, it can be used *at best* to remove residual heat.

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II - CMS principles that seems useful to be retained

- The inside of the vacuum tank is inaccessible, although its contains the heart of the experiment in terms of investment in time and cost. It *must* be protected against fire by maintaining an inert atmosphere (enriched in nitrogen) to quench any source of fire ignition.
- Thus, inside VT, gas cooling can only be natural convection. Cold sources must be provided by stabilizing in tempearture the Vacuum Tank itself or the HCAL absorber (for example).
- Liquid cooling is thus mandatory to extract the heat as near as possible from where it is created.
- Water as cooling fluid still seems to be the best choice.

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ILD Considerations

- The cycling of power is a tremendous help for keeping the heat inventory as low as possible.
- This has also the advantage of limiting the section of cables and pipes reaching the inner detectors.
- However, I am worried by the consequence of cycling the accompanying Lorentz force at the same 5Hz frequency.
- This could be completely destructive for light detectors like Vertex, Tracker.
- This could also render the alignment and stability of sub-detectors very difficult to achieve.

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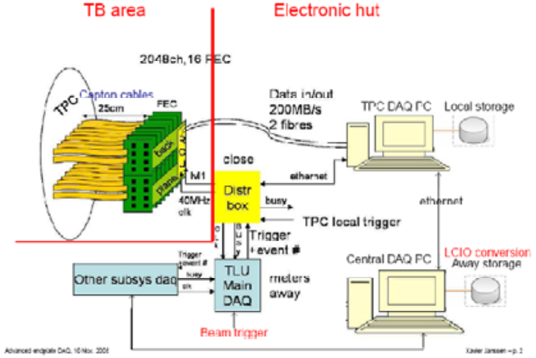
Xavier Janssen - Université Libre de Bruxelles

LP-TPC DAQ for Advanced Endplate

LCTPC Advanced Endplate Meeting, CERN, 10th Nov. 2008

Advanced endplate DAQ, 10 Nov. 2008 — Xavier Janssen – p. 1

ALTRO r/o: LC-TPC DAQ for Test Beams



Advanced endplate DAQ, 10 Nov. 2008 — Xavier Janssen – p. 2

Detector Interface

Detector Interface in ALICE r/o (and test beams):

- Detector side: Up to 32 FECs connected to RCU
- Data transfert: via optical link (+ trigger fiber)
- DAQ side: Computer farm with D-RORC receiver PCI-X card

... and for the Advanced Endplate:

- Advanced Endplate integrates FEC functionalities
- RCU functionality should fit with (on ?) the Endplate size
- Data transfert should integrate redundancy (see later)
- "Trigger" concept should be defined (see later)
- DAQ side: should be defined

⟹ Need to do all of above in line with CDAQ of future experiment.

Advanced endplate DAQ, 10 Nov. 2008 — Xavier Janssen – p. 3

Data transfer issue

Several possible technologies for the Advanced endplate:

- Gaseous detecor + ADC electronic: ALTRO or AFTER
- Gaseous detecor + TDC electronic: Rostock University
- Si detector: Timepix, Medipix, ...
- Other (yet unknown ?) possibilities

⟹ Need for a common data transfer protocol from the different frontend electronic to a common base DAQ electronic.

"Trigger" and data synchronisation tasks:

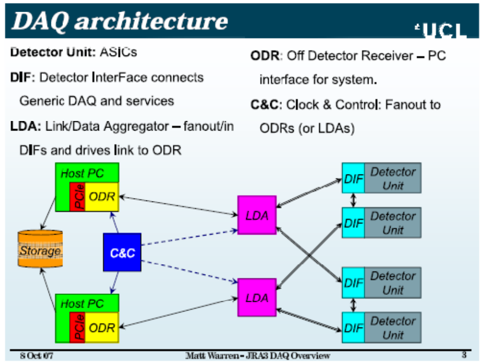
- Wake-up electronic before bunch train arrival
- Trigger data acquisition synchroneous to bunch train.
- Flag data with bunch train number / some kind of ID.
- Put electronic in sleep mode after bunch train.

⟹ All this is part of a common data transfer protocol probably.

Advanced endplate DAQ, 10 Nov. 2008 — Xavier Janssen – p. 4

Redundancy issue: *CALICE example*

CALICE is building a DAQ architecture with redundant data path:



The final TPC DAQ should also include a redundacy of data path to avoid the impact of intermediate electronic failure

Advanced endplate DAQ, 10 Nov. 2008 — Xavier Janssen – p. 5