FCAL Developments towards DBD and beyond

Labs involved:

Argonne, Vinca Inst, Belgrade, Bukharest IFIN, CERN, Univ. of Colorado, AGH-UST Cracow, Cracow INP, JINR Dubna, Royal Holloway, NCPHEP Minsk, Santa Cruz, Stanford University, SLAC, Tuhoku Univ., Tel Aviv Univ., DESY (Z.)

Wojciech Wierba

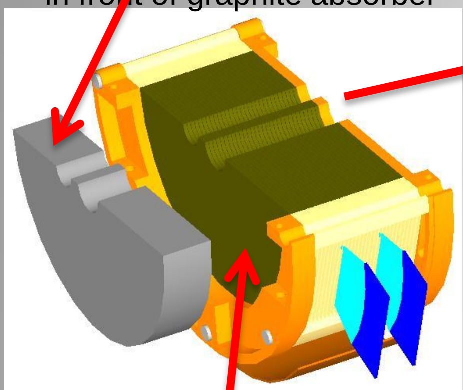
IFJ PAN

Cracow, Poland

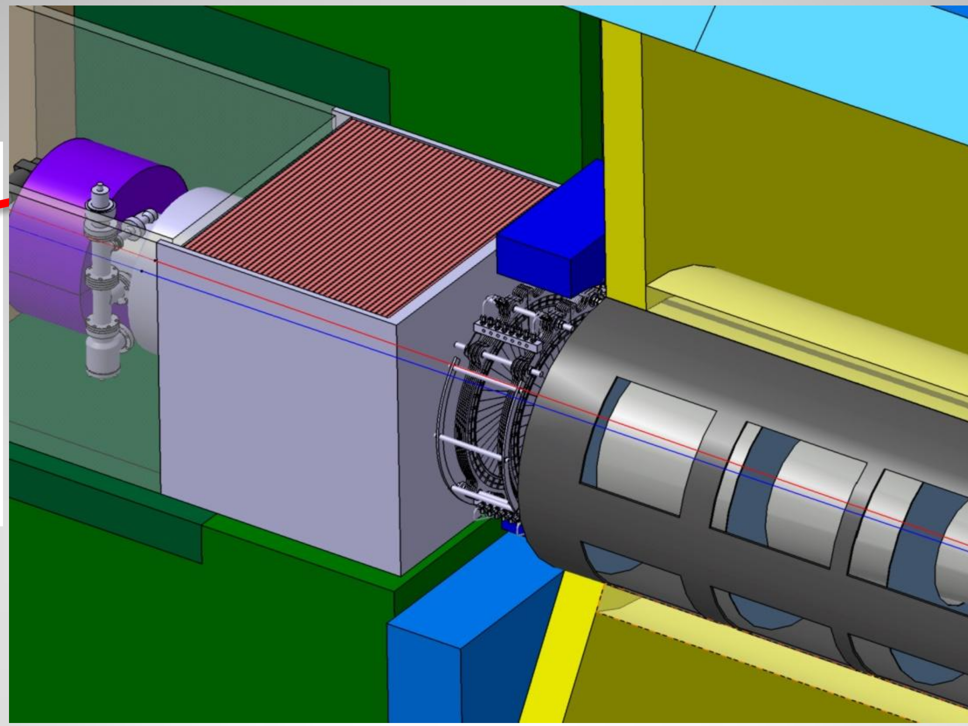
Very Forward Region – ILD Instrumentation

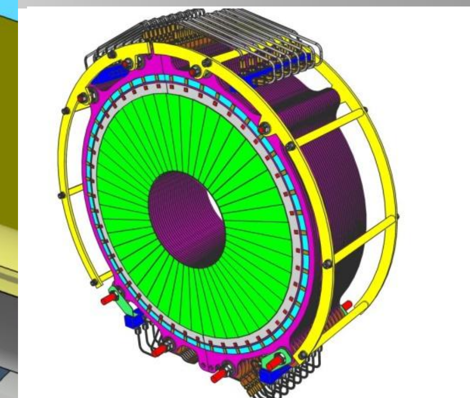
Pair Monitor

in front of graphite absorber



BeamCal





LumiCal

Main purposes:

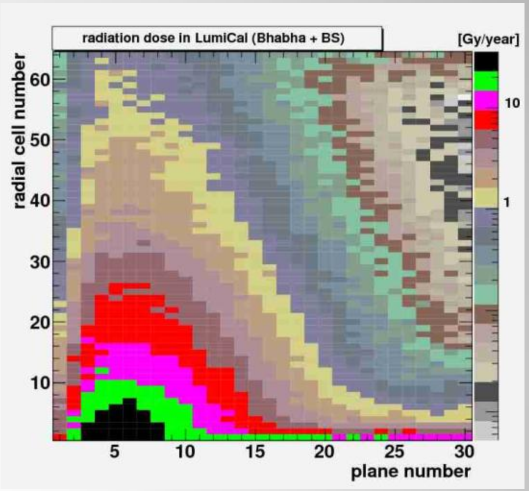
- precise luminosity measurement,
- hermeticity (electron detection at low polar angles),
- assisting beam tuning (fast feedback of BeamCal data to machine)

Challenges:

radiation hardness (BeamCal), high precision (LumiCal) and fast readout (both)

Design Studies for ILC 500 GeV

Design studies, background, systematic effects for 500 GeV advanced, published in Sept. 2010 in JINST.



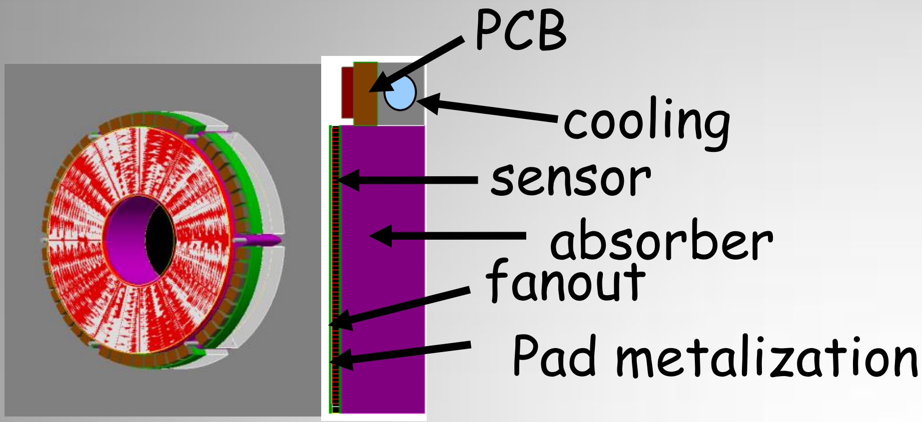
Preprint typeset in JINST style - HYPER VERSION

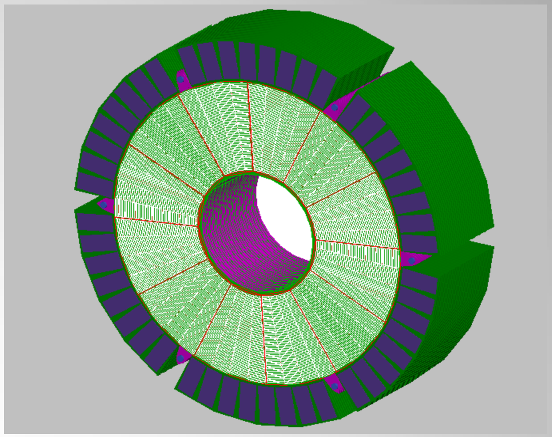
Forward Instrumentation for ILC Detectors

Halina Abramowicz[a], Angel Abusleme[b], Konstantin Afanaciev[c], Jonathan Aguilar[d], Prasoon Ambalathankandy[d], Philip Bambade[e], Matthias Bergholz[f,1], Ivanka Bozovic-Jelisavcic[g], Elena Castro[f], Georgy Chelkov[h], Cornelia Coca[i], Witold Daniluk[j], Angelo Dragone[k], Laurentiu Dumitru[i], Konrad Elsener[l], Igor Emeliantchik[c], Tomasz Fiutowski[d], Mikhail Gostki… Grzelak[j,3], Gunter Haller[k], Hans Henschel[f], Alexa… Kazutoshi Ito[m], Tatjana Jovin[g], Eryk Kielar[j], Jerzy… Szymon Kulis[d], Wolfgang Lange[f], Wolfgang Lohn… Moszczynski[j], Uriel Nauenberg[n], Olga Novgorodo… Orlandea[i], Gleb Oleinik[h], Krzysztof Oliwa[j], Alexar… Pandurovic[g], Bogdan Pawlik[j], Dominik Przyborow… Andre Sailer[l], Ringo Schmidt[f,1], Bruce Schumm[o], … Smiljanic[g], Krzysztof Swientek[d], Yosuke Takubo[m], … Wierba[j], Hitoshi Yamamoto[m], Leszek Zawiejski[j] a…

ABSTRACT: Two special calorimeters are foreseen for the instrumentation of the very forward region of the ILC detector, a luminometer designed to measure the rate of low angle Bhabha scattering events with a precision better than 10^{-3} and a low polar angle calorimeter, adjacent to the beam-pipe. The latter will be hit by a large amount of beamstrahlung remnants. The amount and shape of these depositions will allow a fast luminosity estimate and the determination of beam parameters. The sensors of this calorimeter must be radiation hard. Both devices will improve the hermeticity of the detector in the search for new particles. Finely segmented and very compact calorimeters will match the requirements. Due to the high occupancy fast front-end electronics is needed. The design of the calorimeters developed and optimised with Monte Carlo simulations is presented. Sensors and readout electronics ASICs have been designed and prototypes are available. Results on the performance of these major components are summarised.

MC Studies – LumiCal geometry





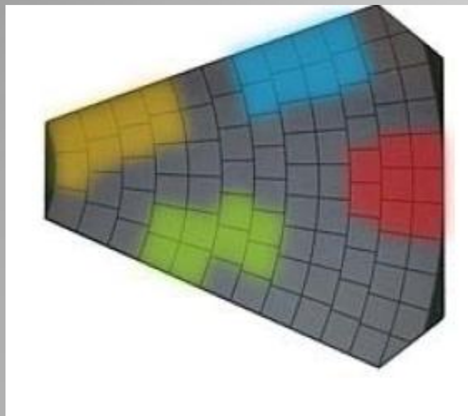
SLcal03 - LumiCalX01 (tag mokka-07-02 , Mokka model ILD_01pre00)
tile gaps, pad metalization, support structure, cooling, electronics

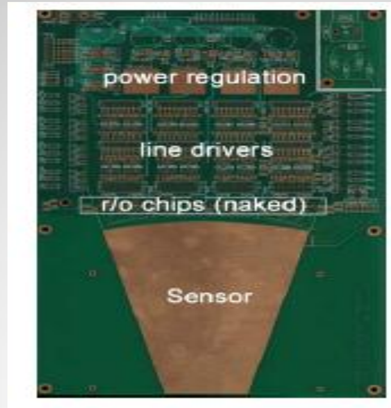
LumiCalV -LumiCalV00 (mokka tag > 07-04, models ILD_01pre01/pre01fw)
as above, instead real cells virtual one are implemented,
Recommended as it saves 30% CPU time

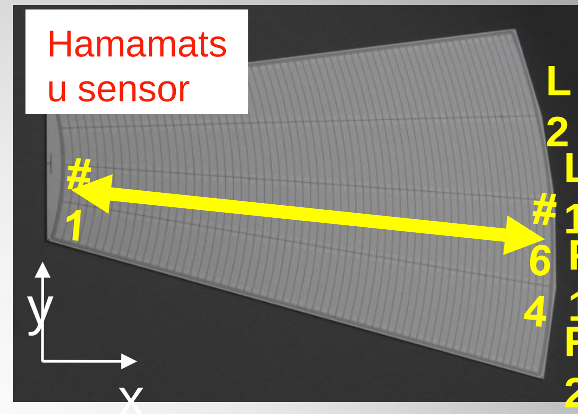
-Both drivers are tested , stable and no changes foreseen
-Bugs : not known
-Ready for massive production

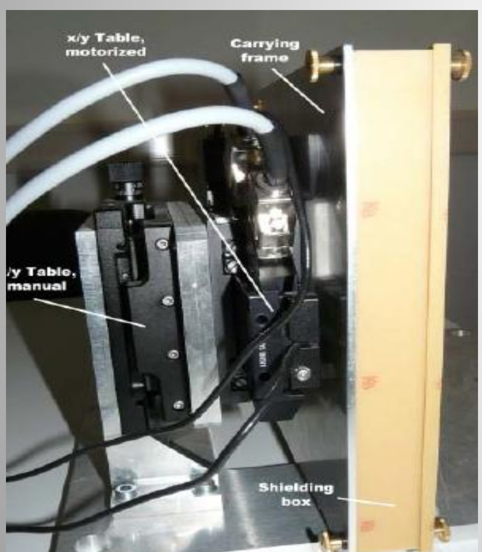
BeamCal also implemented in Mokka/Marlin

Successful beam tests August 2010







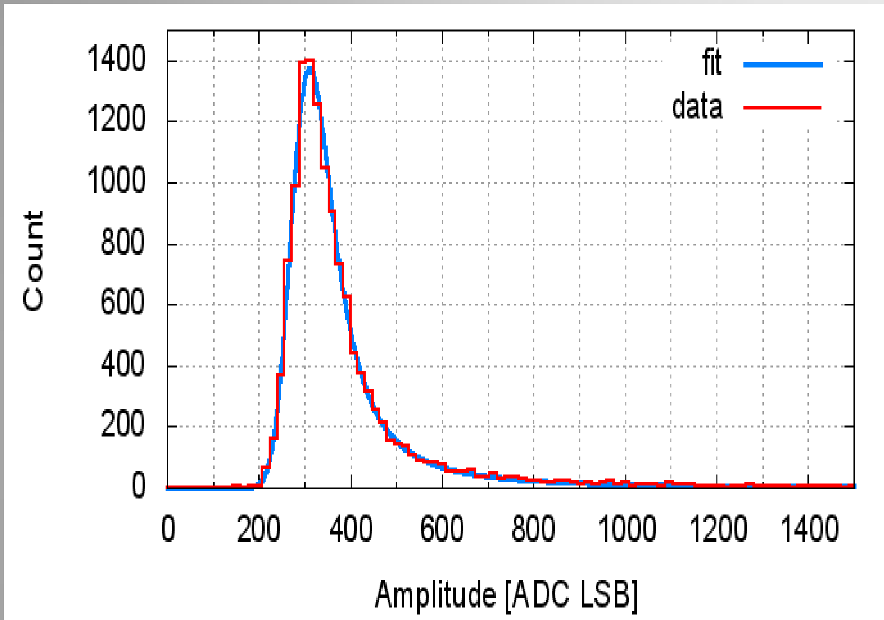


Results presented by Olga Novgorodova

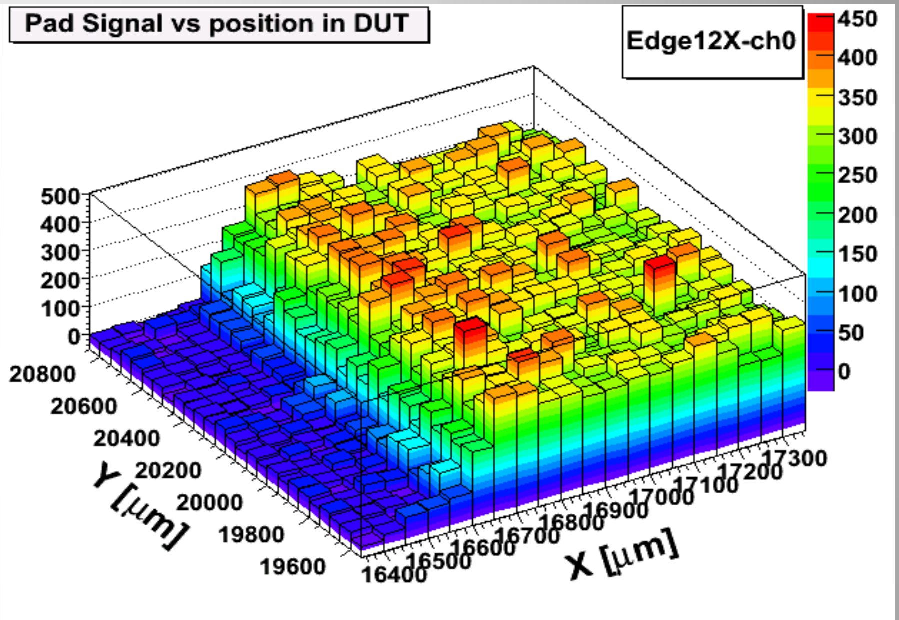
Beam T-22 at DESY, 4 GeV electrons, sensors equipped with FE ASICs from UST Cracow

Very promising beam tests results

LumiCal Signal spectrum



BeamCal Sensor response

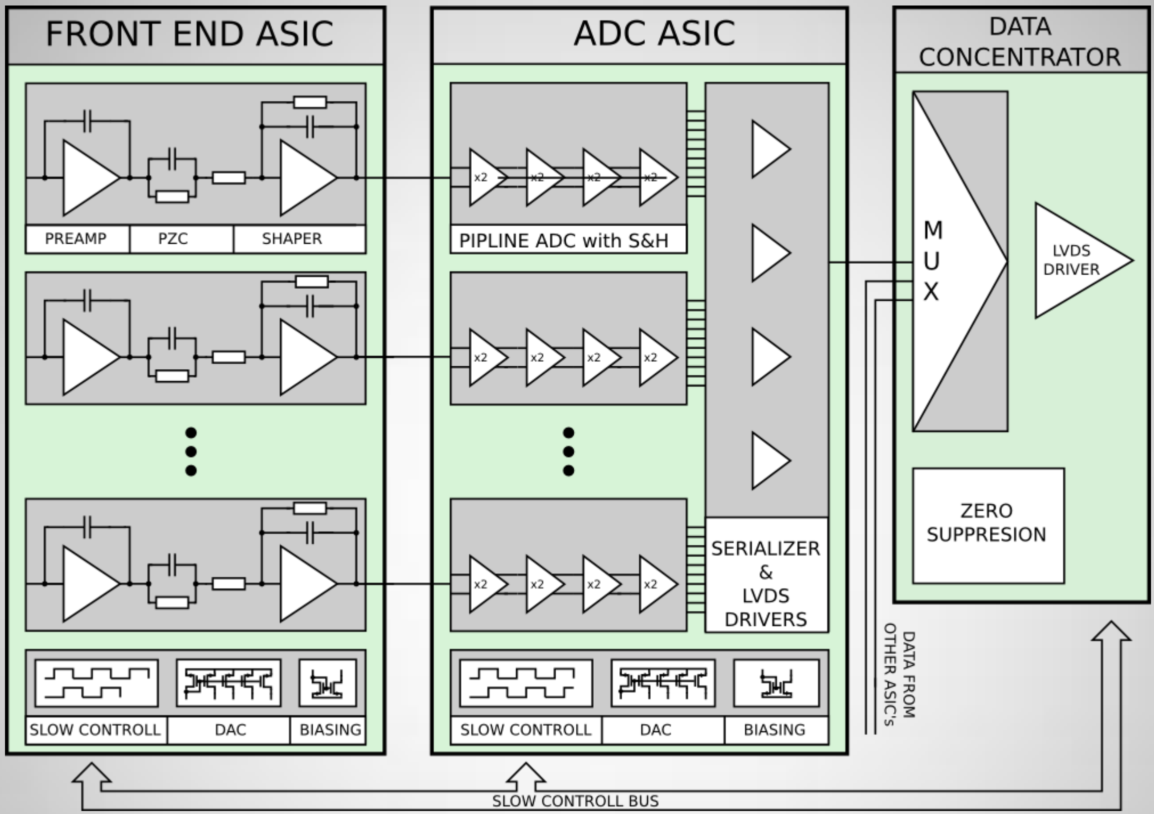


S/N ~ 20

Cross talk: ~ %

In addition: study of stability, edge effects

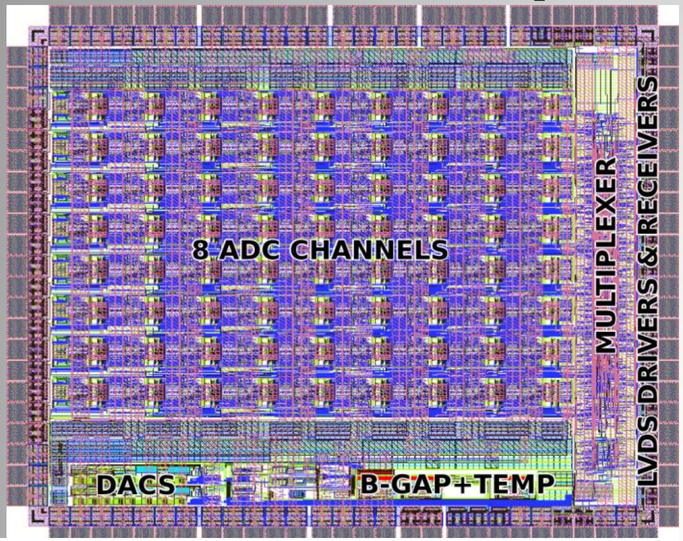
LumiCal electronic readout chain

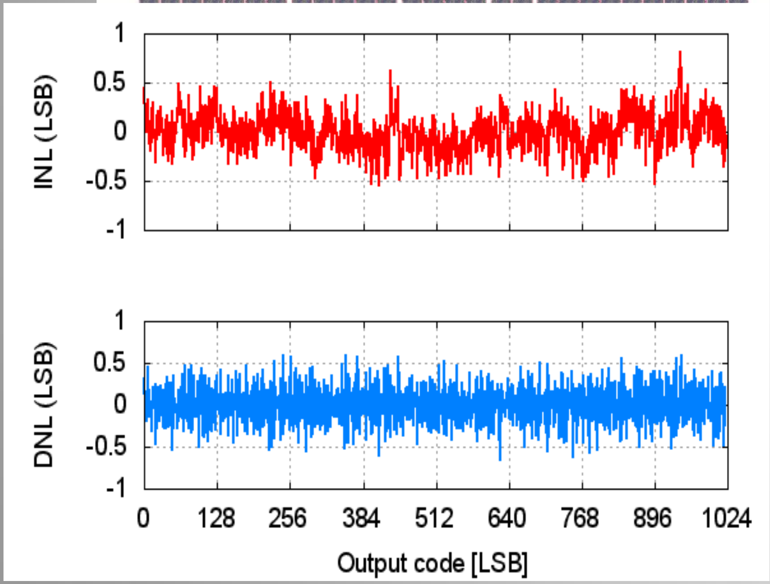


First prototypes of each multichannel ASIC/FPGA circuit already available. The complete multichannel readout chain will be used during testbeam in July 2011

ADC ASIC prototype

8 Channel ASIC ADC chips tested connected to the FE ASICs





- 8 channel pipeline ADC:
- Scalable power(~1mW/MHz) and sampling frequency(up to ~25MHz)
- Digital multiplexer/serializer:
  - Serial mode (<250MHz): one data link per all channels (max fsmp ~ 3 MSps)
  - Parallel mode (~250MHz): one data link per channel (max fsmp ~ 25MSps)
  - Test mode (single channel readout)
- High speed LVDS I/O (~1GHz)
- Low power DACs references/bias
- Precise BandGap reference source and Temperature sensor

Few results:

ENOB ~9.7

INL < 0.8 LSB

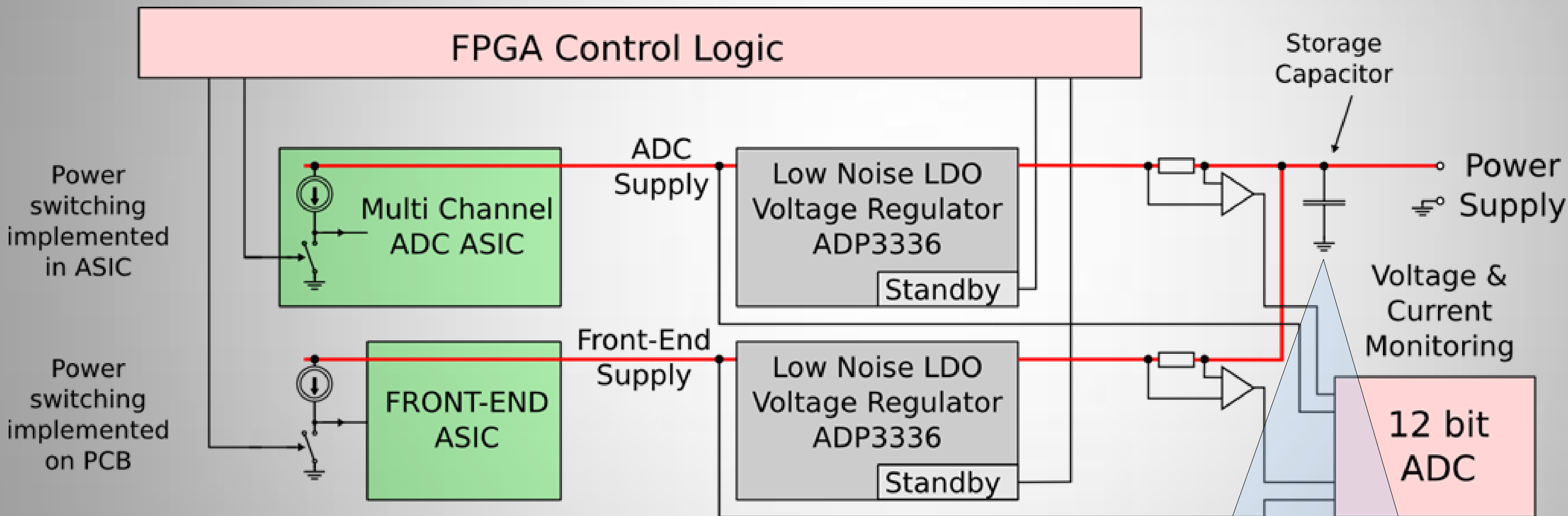
DNL < 0.6 LSB

Power Pulsing

- Worst case peak power/current estimation for ILC: 200 000 * 15mW/chan ~ 2.8kW/850A
  - done for present AMS0.35um front-end(<9mW) and ADC&serialization(~6mW), without power pulsing
- With power pulsing (already implemented in ADC) with duty cycle 1% gives: 28W/8.5A
- Moving to smaller size technology (in view of CLIC specs., radiation hardness) we expect a huge drop of power consumption

Power Pulsing

We are just developing a prototype detector system with 32 channels (comprising 4 pairs of FE+ADC chips and FPGA based data concentrator) allowing also the studies of power pulsing.

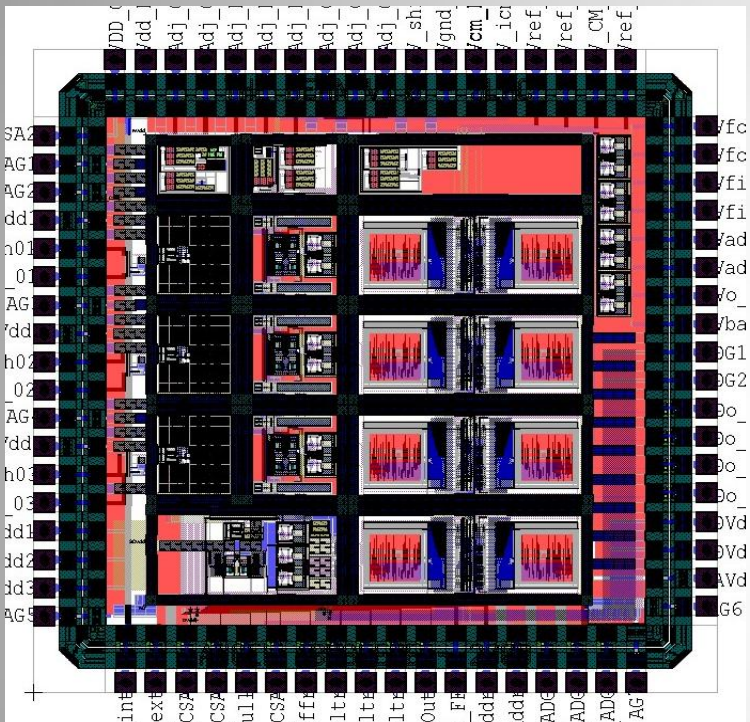


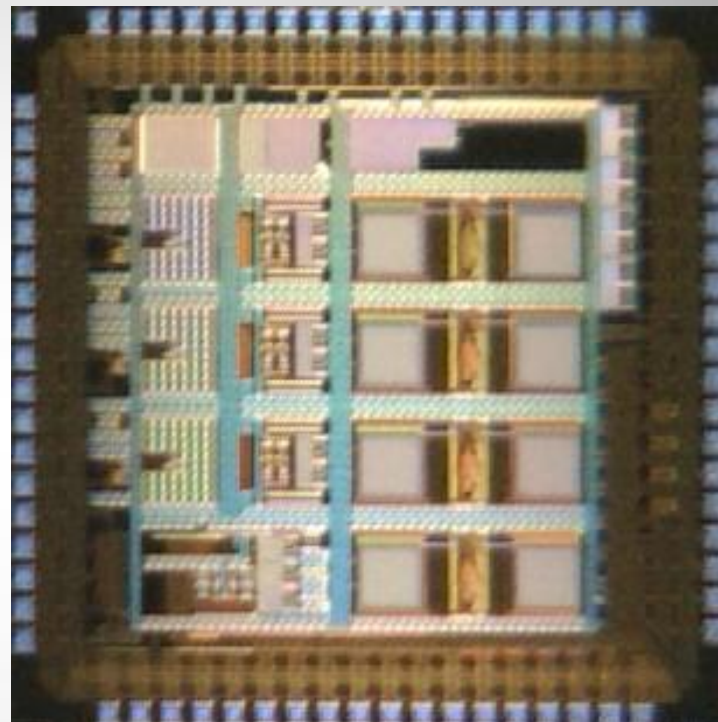
Commercial voltage regulator (ADP3336)

needs about 1ms to switch on

BeamCal FE ASICs (KPiX)

Designed especially for BeamCal (fast feedback function)





- TSMC 0.18um, 1.8V
- 72 pads, 2.4mm x 2.4mm (incl. pads)
- 3 charge amplifiers, 4 x 10-bit, fully diff. SAR ADCs, 1 SC adder, 3 SC filters

Status presented by Angel Abusleme

New developments

Developments just started:

- Development of data concentrator (FPGA or ASIC)
- Development of new multichannel, low power radiation hard front-end and ADC ASICs (130nm technology) (AGH-UST Cracow)

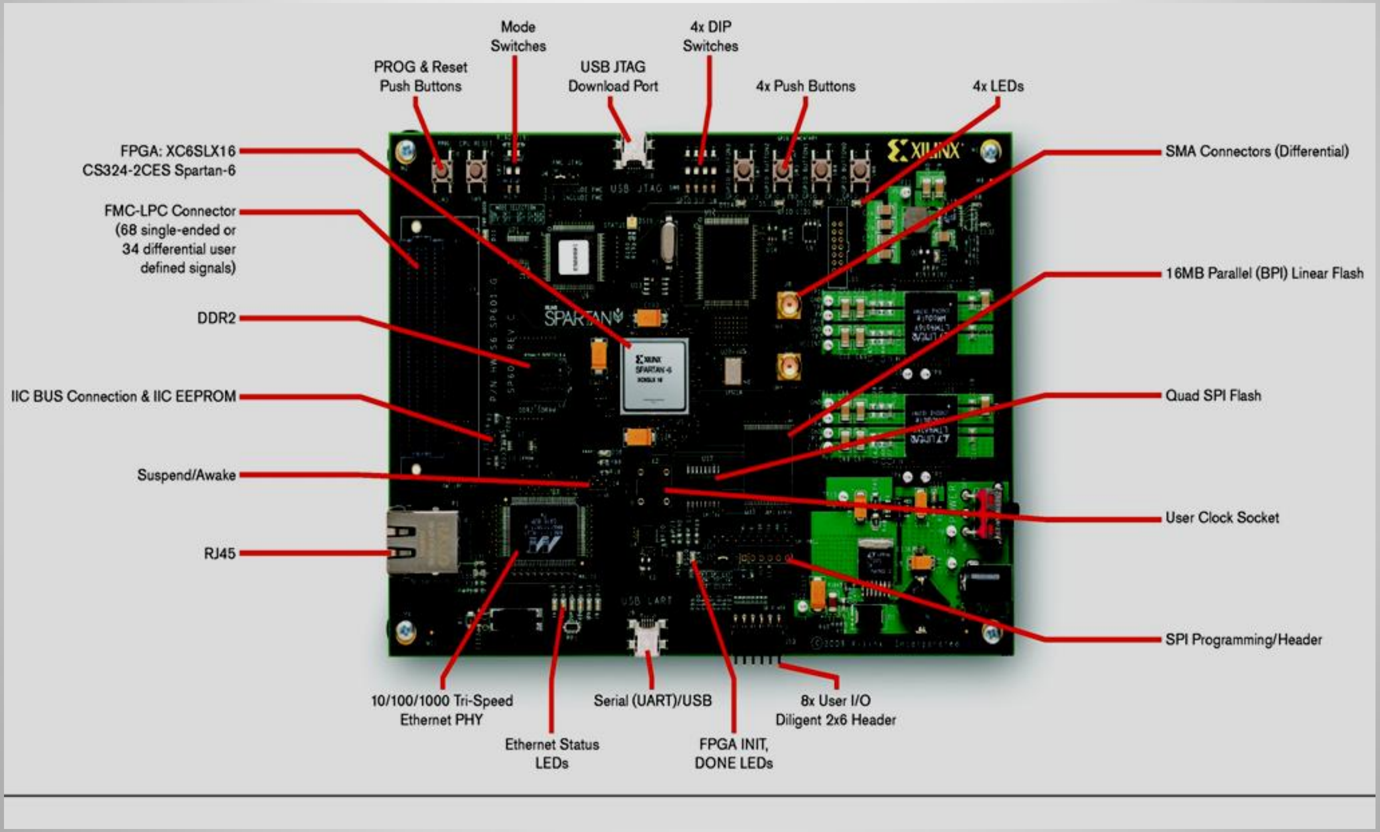
Developments in progress:

- DIF link to ILD detector DAQ
- Pair Monitor
- Transparent position sensors for LumiCal precision alignment

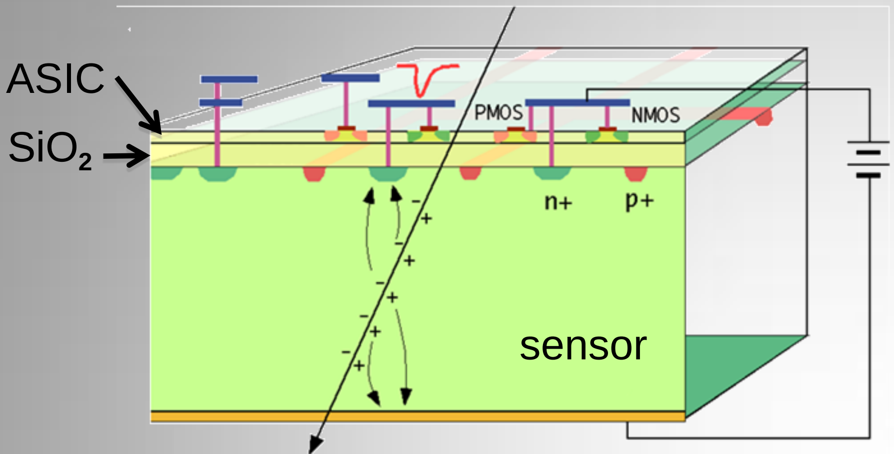
DIF – detector interface to ILD DAQ

Design of FCAL DIF under work (LumiCal version)

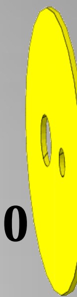
For next test beam the DIF functionality is implemented by a commercial FPGA –SPARTAN6 (XILINX SP601) board



Pair Monitor



- Pixel size: 400 x 400 μm^2
- Radius: 10 cm
- Total number of pixels: **~200,000**

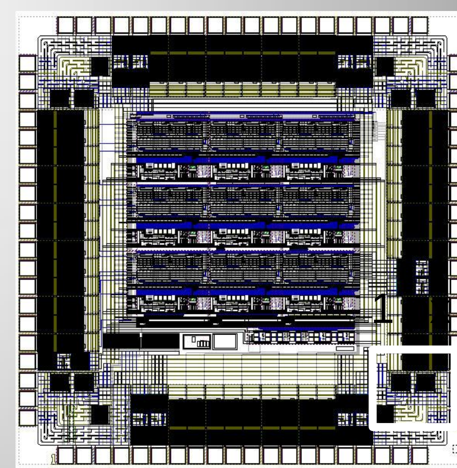


Monolithic construction allows the elimination of the bump-bonding process.

- First step:
  design of a readout prototype ASIC for 3x3 pixels: digital readout (preamp, discriminator, counter)

- manufactured chip (CMOS 0.2 mm, SOI technology)
- performance measurements done

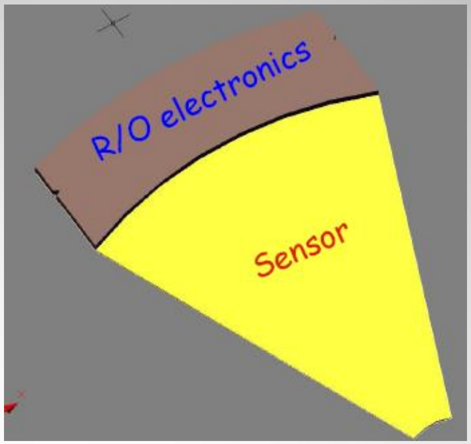
Publication accepted !

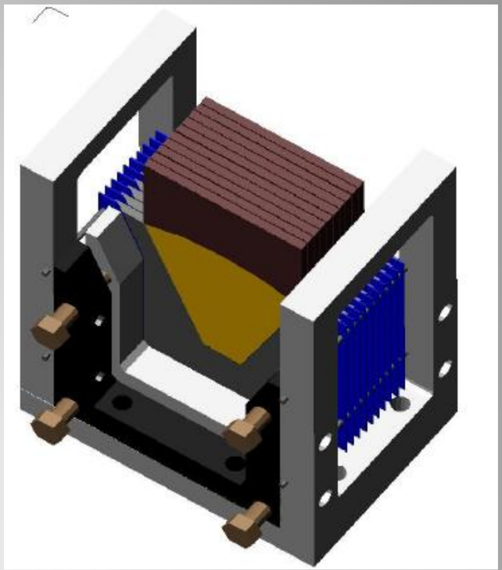


Calorimeter prototype – AIDA (EU supported)

Preparation of a prototype Calorimeter:

- Flexible, high precision tungsten structure,
- Fast FE Readout
- Innovative connectivity scheme
- Position control devices
- Fully assembled sensor planes, covering ≥ 30^0
- Power pulsing





Infrastructure common with others:

- Data acquisition
- Tracking in front of the calorimeter

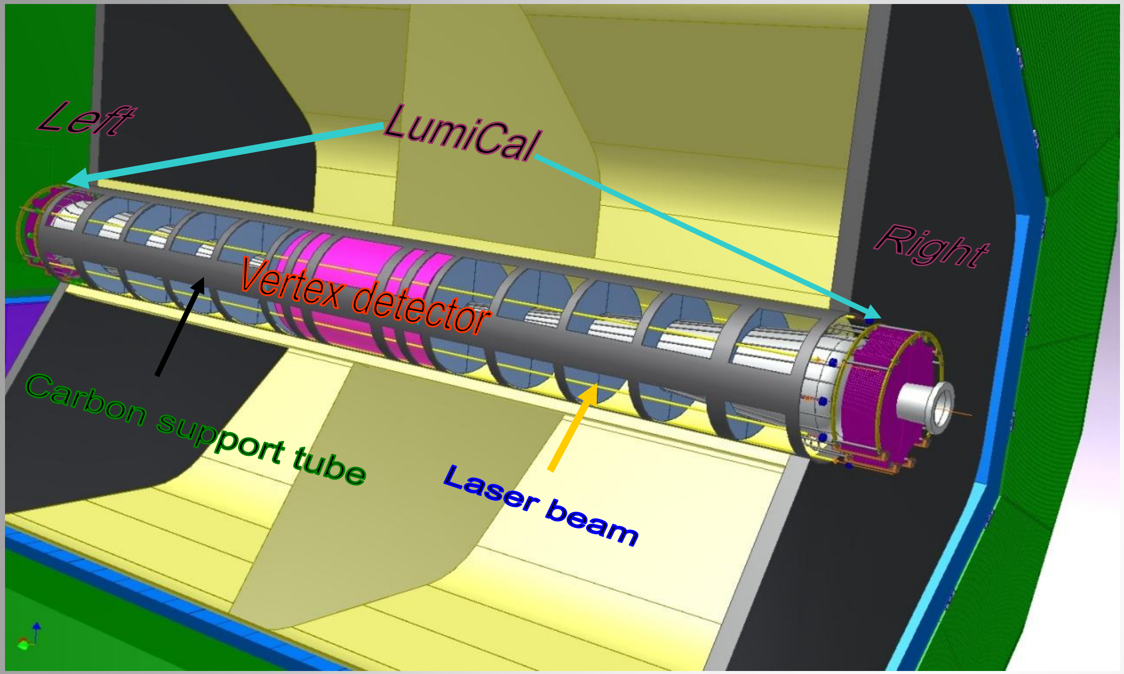
Time schedule:

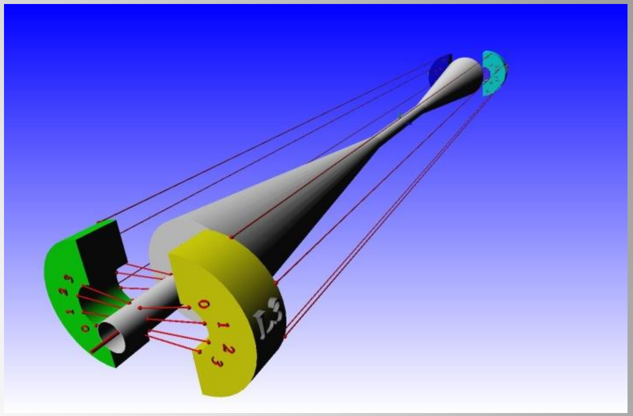
- Flexible tungsten structure: design 2012, manufacturing 2013, ready 2014
- Multichannel readout ASICs: design start 2011, 1st prototype production, 2012, 2nd 2013
- Complete prototype of sensor plane 2012
- DAQ: 1st DIF prototype 2011, prototype of complete DAQ 2012, ready 2013
- Design fixed beginning 2013
- Production 2014

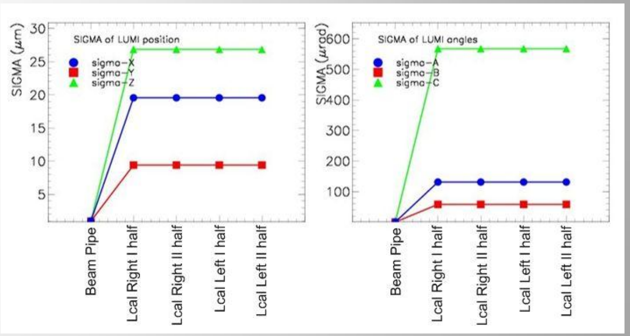
Participating Institutes:

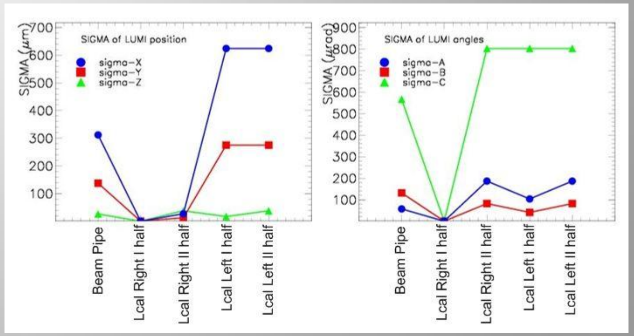
AGH-UST (Cracow), CERN, DESY (Zeuthen), IFJPAN (Cracow), TAU (Tel Aviv)

Integration in ILD









Simple Freq. Scannin Interfer. Simmulation

- 6 laser beams between two LumiCal's
- 8 laser beams from each LumiCal to the beam pipe
- Scenarios: beam pipe as reference, no reference

Next step – add transparent x, y position detectors

See my talk: „Status of LumiCal Mechanical Structure and Alignment", ILD MDI meeting

Milestones Ahead

- ILC detector Detailed Baseline Design Report 2012

  - refining design considerations (MC studies)

  - completing the measurements with fully assembled sensor plane prototypes
  - complex tests of FE ASIC, ADC ASIC, DataConcentrator FPGA, DIF
  - beam tests with fully assembled plane prototypes
  - performance studies with a few planes
  - impact of power pulsing

Summary

- FCAL started test-beam measurements to test assembled prototype sensor planes, Results so far satisfactory
- The readout will be completed in a few steps, beam-tests planned July 2011
- Long term goal is a calorimeter prototype, ready in 2014, including

  - power pulsing

  - DIF to standard DAQ

  - position monitoring