Forward region in future electron-positron colliders

Two specialized calorimeters foreseen:
- LumiCal - precise luminosity measurement;
- BeamCal - fast luminosity estimate and beam parameters control.

Both calorimeters improve the hermeticity of the main detector at very small polar angles.

\begin{center}
\begin{tabular}{|c|c|c|}
\hline
LumiCal & CLICdet & ILD forward region \\
\hline geometrical acceptance [mrad] & 31-77 & 36-110 \\
fiducial acceptance [mrad] & 41-87 & 44-60 \\
\hline z (from IP) [mm] & 2480 & 2509 \\
\hline number of layers (W+Si) & 30 & 40 \\
\hline BeamCal & CLICdet & Thin LumiCal module \\
\hline geometrical acceptance [mrad] & 5-40 & 10-40 \\
\hline z (from IP) [mm] & 3200 & 3181 \\
\hline number of layers (W+sensor) & 30 & 40 \\
\hline
\end{tabular}
\end{center}

Test beam campaigns

- Several test-beam campaigns, 2014-2020
- Started with 4 fully equipped LumiCal planes with APV25 readout
- Last campaign (2020) - 15 LumiCal planes, new FLAME readout tested.

Goals:
- Tests and demonstration of multi-plane operation of the forward detector prototype;
- Study of the electromagnetic shower in a precise and well known structure and compare with MC simulations;
- Measurement of Molière radius;
- Study of e-/\gamma

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\begin{center}
\begin{tabular}{|c|c|c|}
\hline
Parameters & FLAME & APV25 \\
\hline number of mixed-mode channels (FE & 10bit ADC) & 32 & 32 \\
- Sampling rate of up to 50MHz. & - & - \\
- Ultra low power (< 2mW/ch). & - & - \\
- Fast serializer & driver (up to 8 Gbps). & - & - \\
- 4 FLAME controlled by single FPGA. & - & - \\
\hline
\end{tabular}
\end{center}

Conclusions and future steps

- Major components developed by FCAL Collaboration can be operated as a system in future LC experiments.
- The FCAL collaboration continues the detector R&D and forward region design optimisation.
- Thin LumiCal module with submillimeter thickness was developed and produced. Its geometry meets requirements of LumiCal conceptual design.
- Dedicated FLAME readout ASIC together with FPGA back-end were developed and tested in the beam for the first time.
- Results from the test of the compact calorimeter prototype are promising.
- Analysis of data and MC from the full compact calorimeter prototype test-beam is ongoing.
- Technologies developed in FCAL are applied in other experiments, e.g.CMS, XFEL and considered for LUXE at DESY.