Calorimeter for ILC

Electronics for SiPM based calorimeter

by
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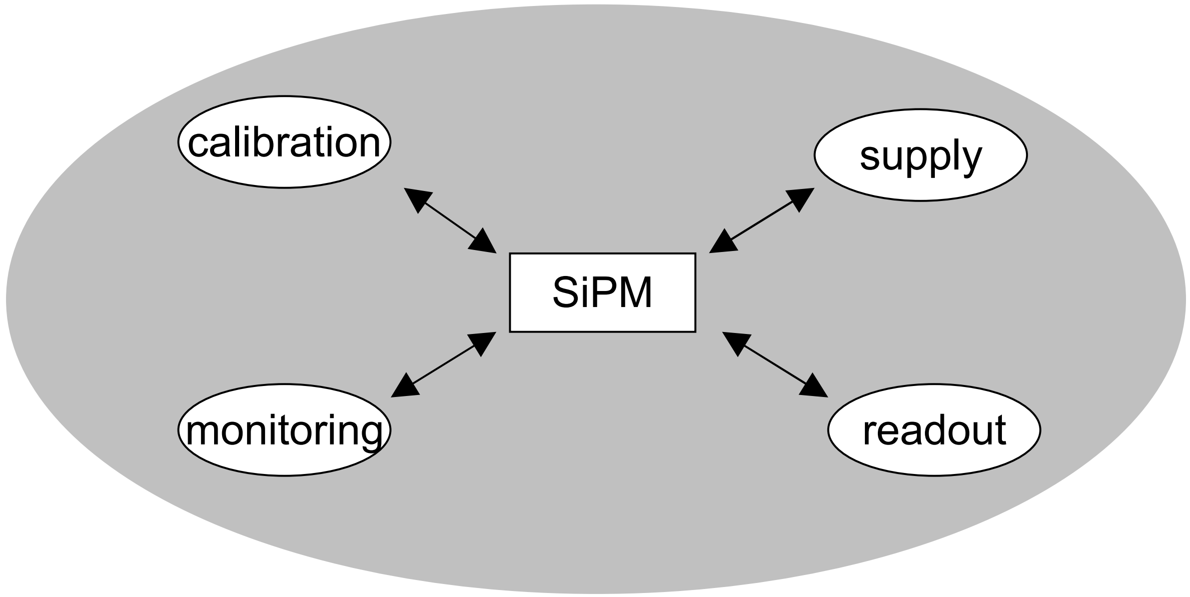
Introduction



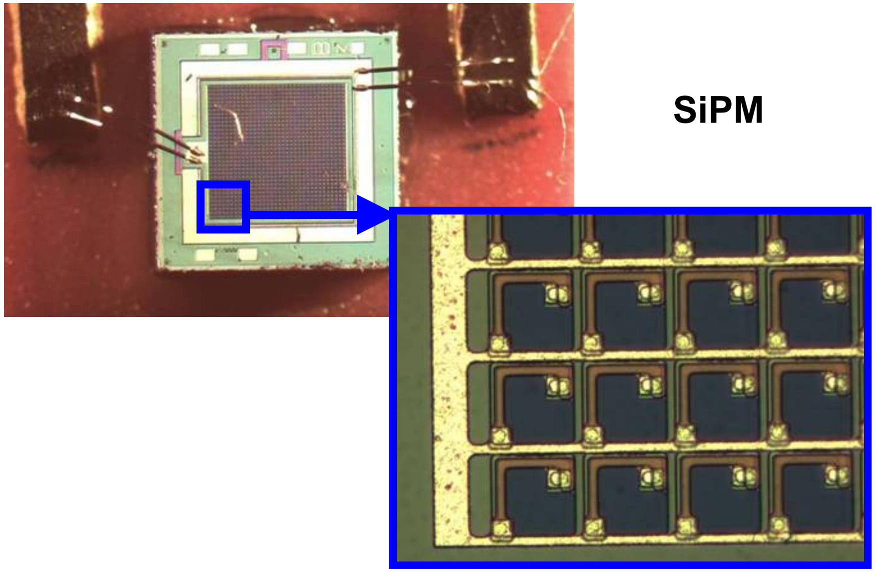
For scintillator calorimeters, the choice of SiPMs as readout device is attractive (size, cost, power consumption, magnetic field compatibilty).

The choice of SiPMs will influence the demands on

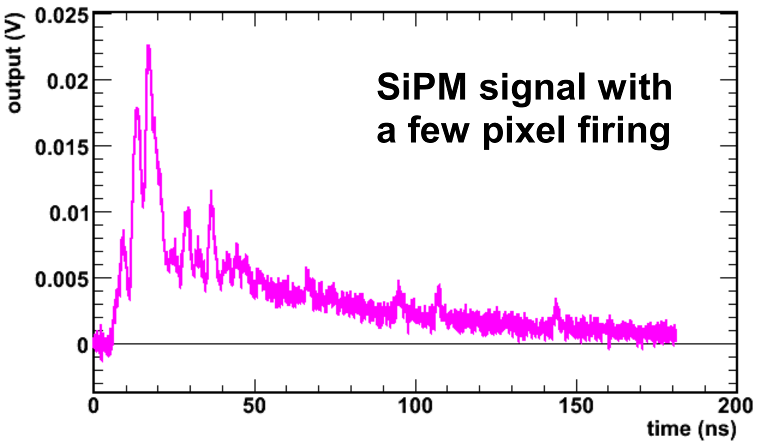
- supply & readout
- calibration & monitoring system

This talk will present some of the design choices, taken by the CALICE AHCAL group.

General Requirements for SiPM Readout Electronics



SiPM



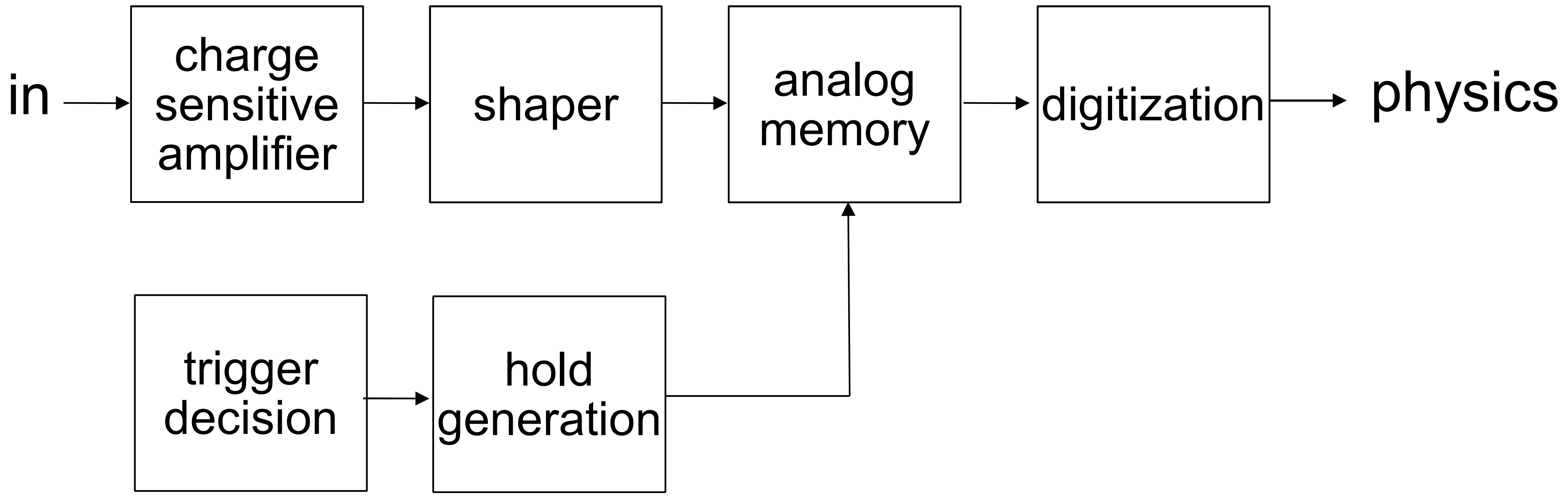
features of SiPM (electronics point of view)

- signal is sum of charge sources
- each SiPM needs individual bias voltage
- thermal noise
- O(1000) pixels

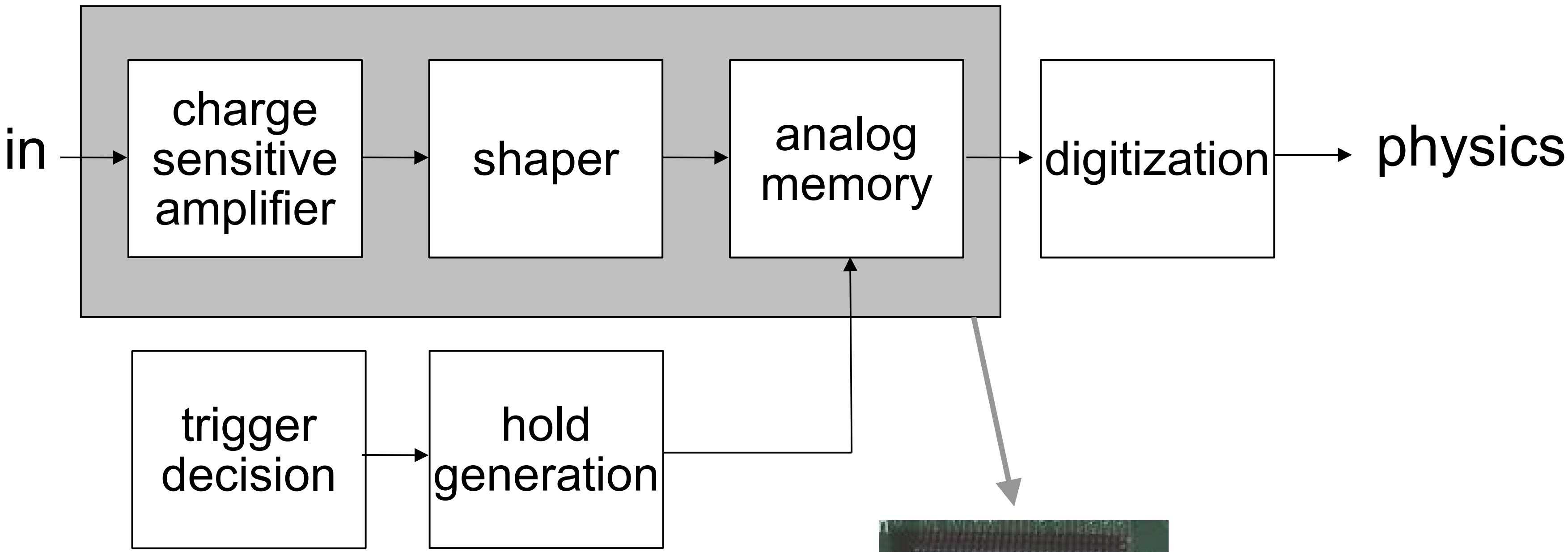
requirements for electronics

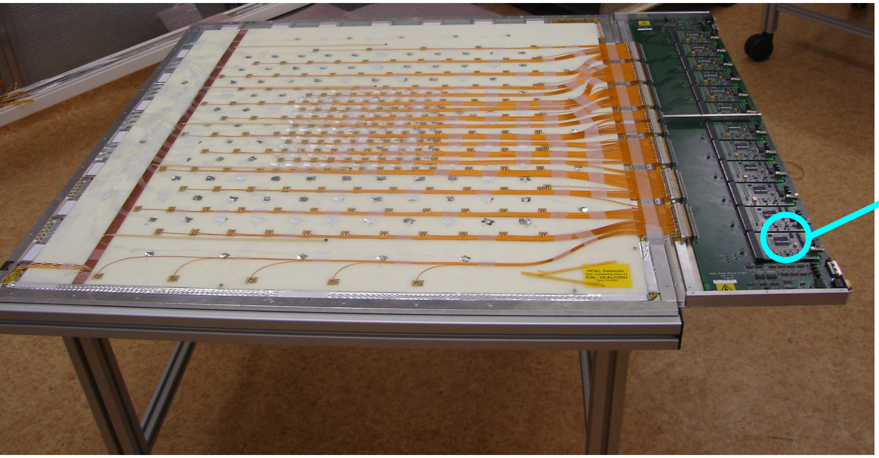
- charge measurement
- channel by channel bias regulation
- short integration time to reject thermal noise
- high resolution to resolve charge quantization
- high dynamic range to cover 1 pixel to full saturation

A Basic Readout Concept



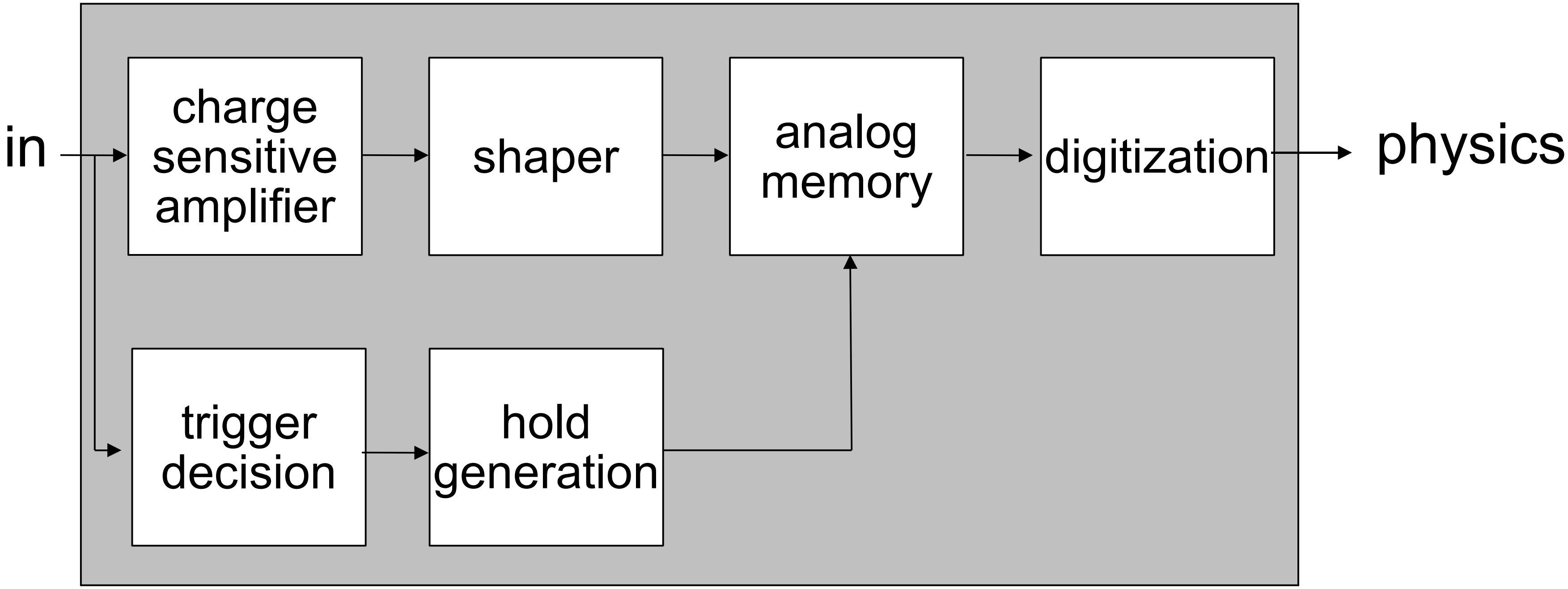
First Generation ASIC ILC_SiPM





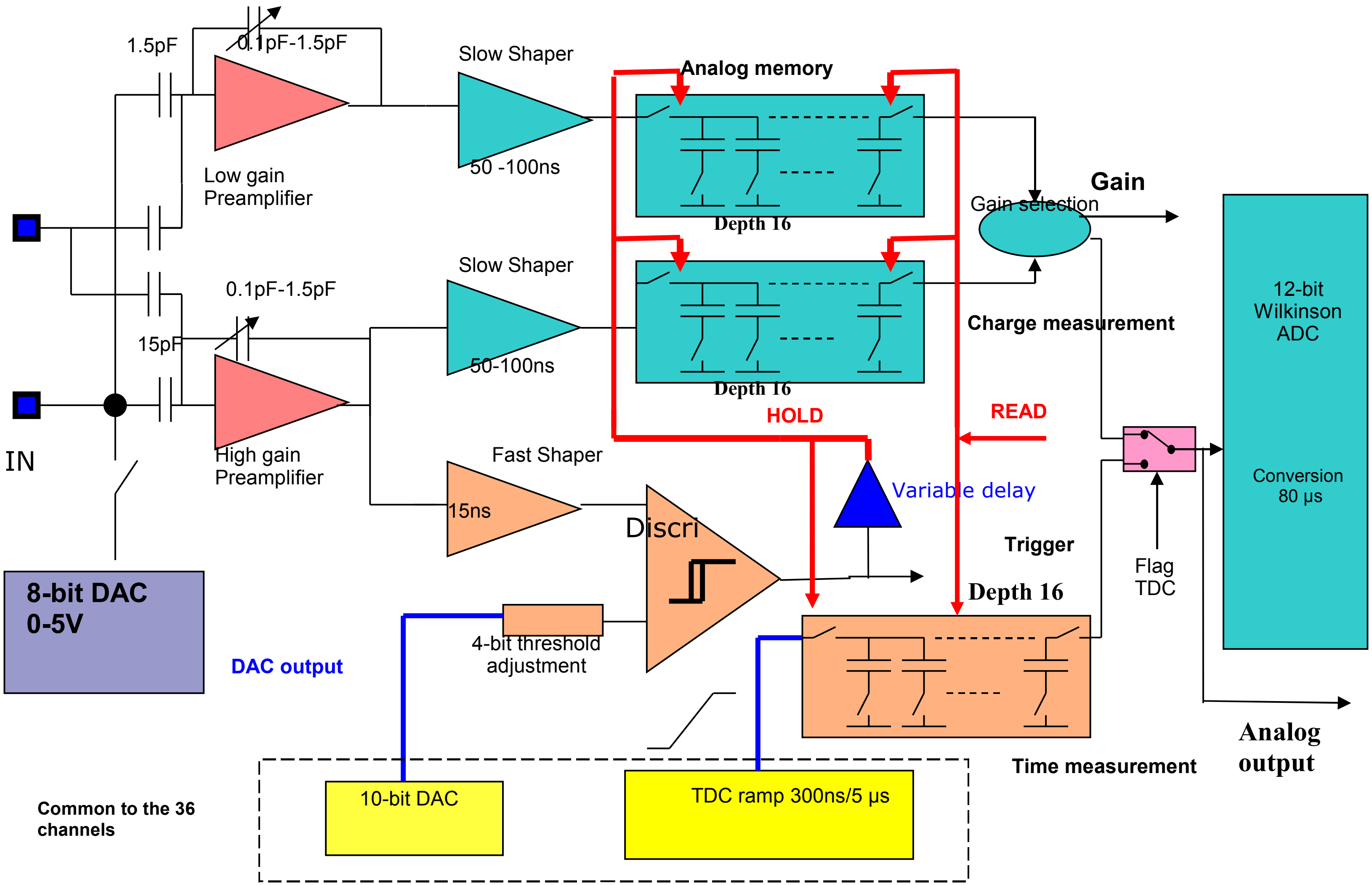
- **successfully used in 1m³ prototype**
- **feasibility of the amplifier design proofed**

Next Generation ASIC SPIROC

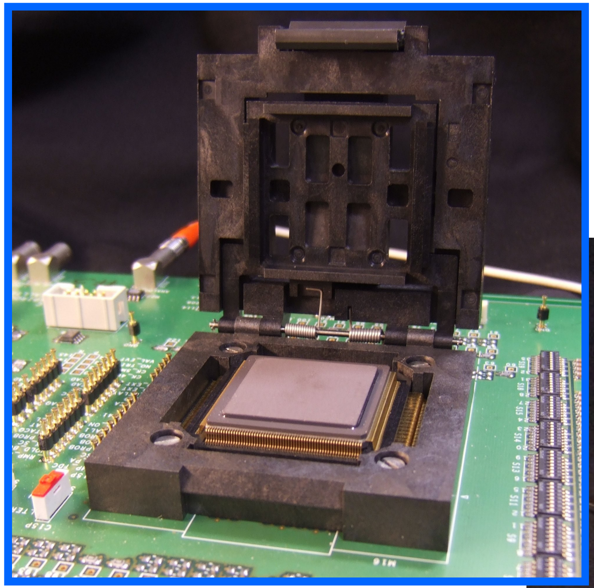


- go near a real detector integration density and miniaturization
- proof low power (pulsing) design
- use self triggering and hardware zero suppression
- time measurement & multi event storage

SPIROC
(SiPM Integrated Read Out Chip):

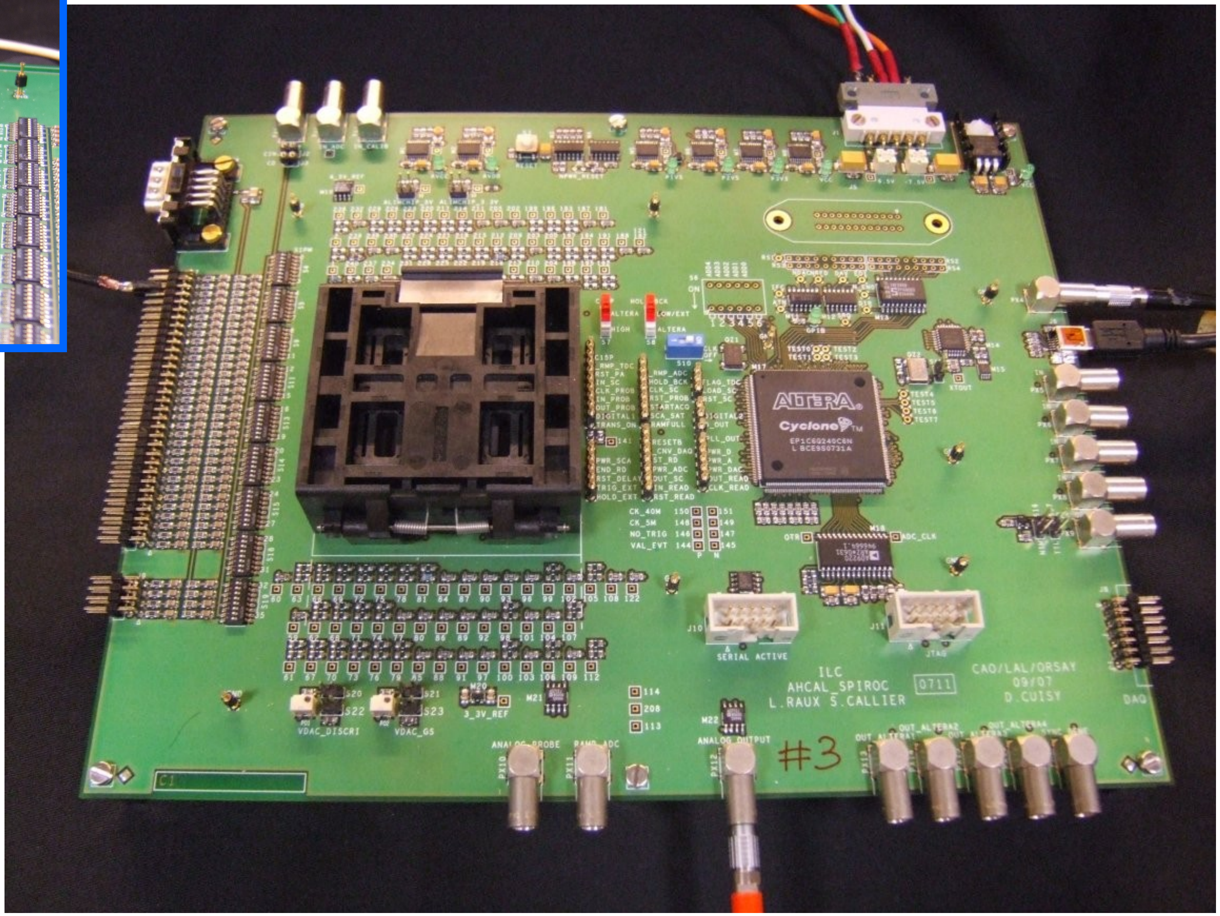


First SPIROC Prototype



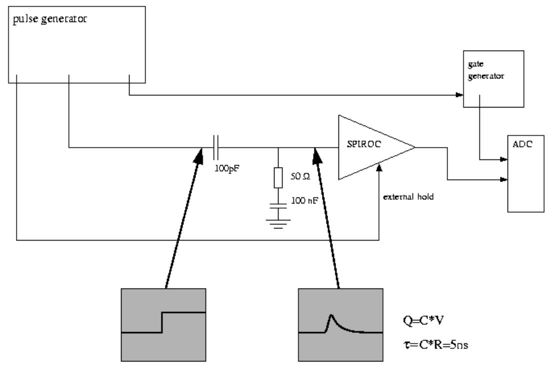
dedicated test-board designed by LAL group

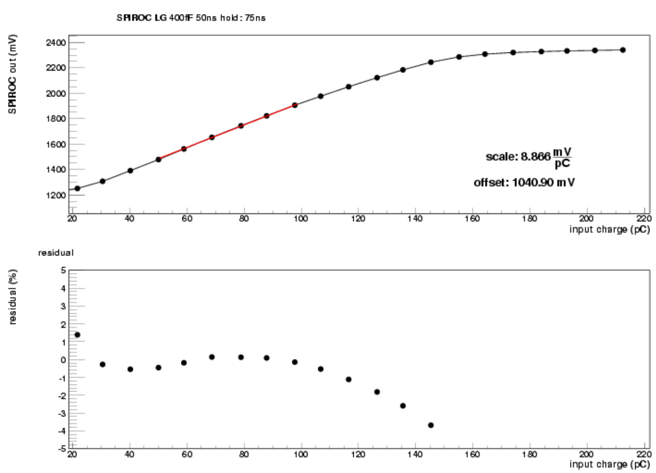
first chip prototypes currently tested at DESY & LAL



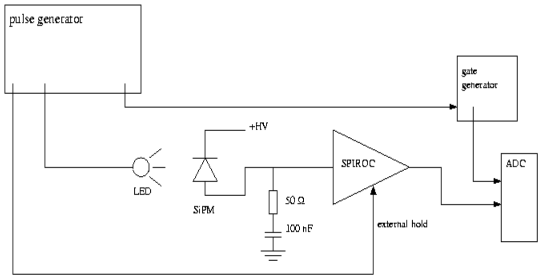
Current Measurements @ DESY

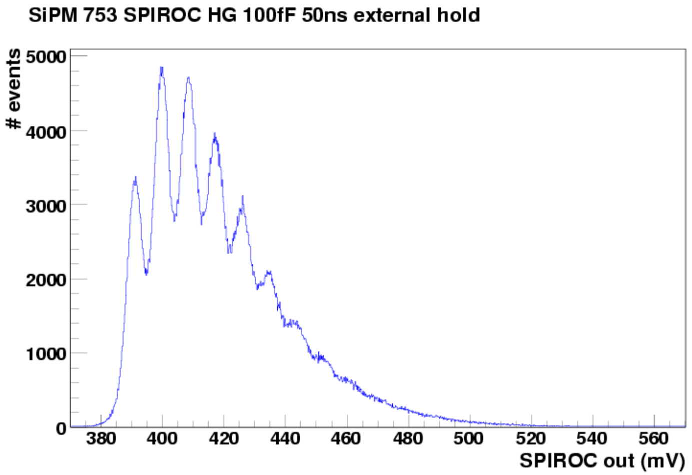
gain & linearity measurement using charge injection





resolution of spe spectrum for pixel gain calibration using LED illuminated SiPM





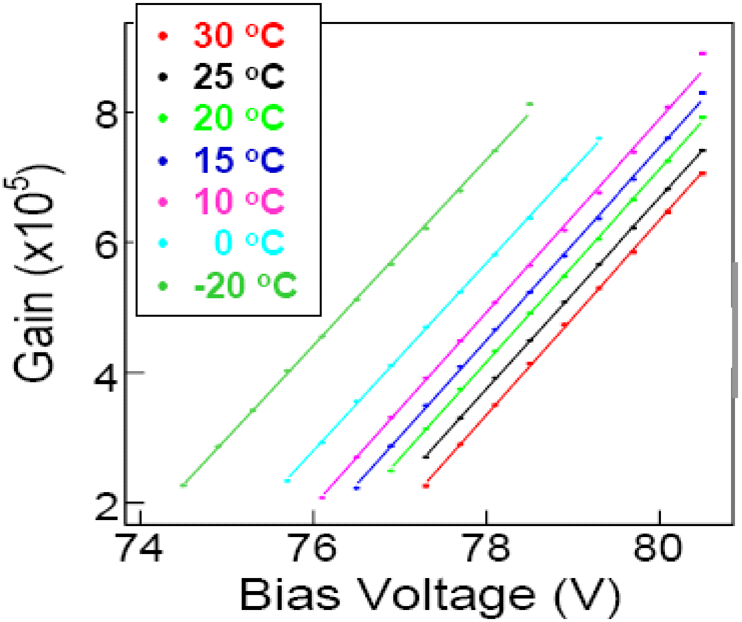
SiPM Induced Calibration and Monitoring Requirements

SiPM properties depend on

- voltage
  - **dG/dV:** 2.6%/100mV
  - **dQ/dV:** 5.6%/100mV
- temperature
  - **dQ/dT:** -4.0%/K
  - **dG/dT**: -1.7%/K

deduced requirements

- SiPM gain monitoring
- SiPM response monitoring
- temperature monitoring



Gain = C (V_{bias}-V_0) / e
C : Pixel capacity
V_0 : Breakdown voltage

LED Calibration System

requirements from measurement

to monitor the SiPM gain
- short light pulse
- low intensity (few pixel firing)
- high statistics

to monitor SiPM response
- stable light intensity
- 1-10 MIP intensity

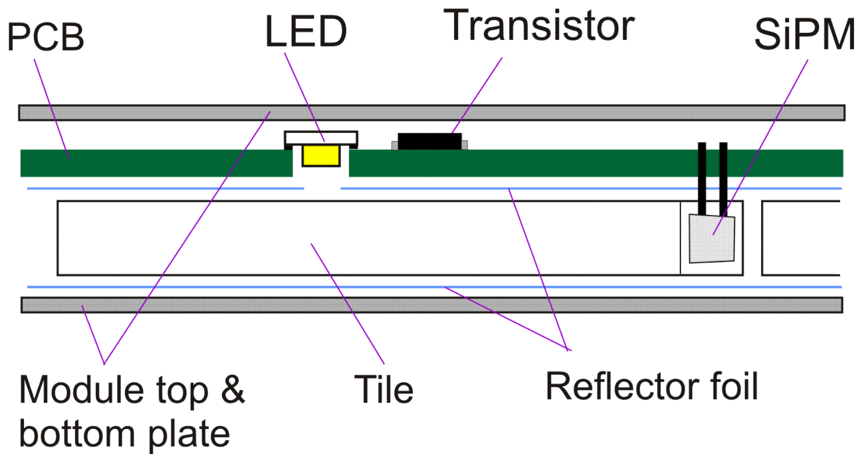
requirements from integration

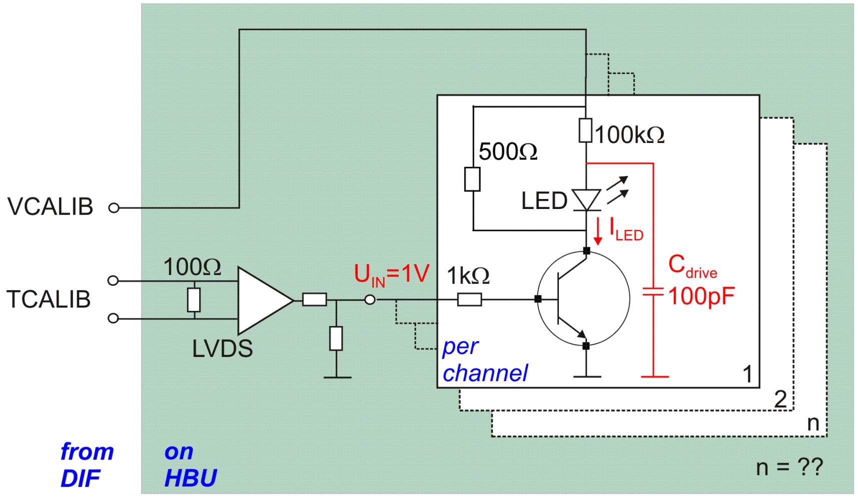
driving circuitry
- low power (heat)
- low pick up (despite fast signal)

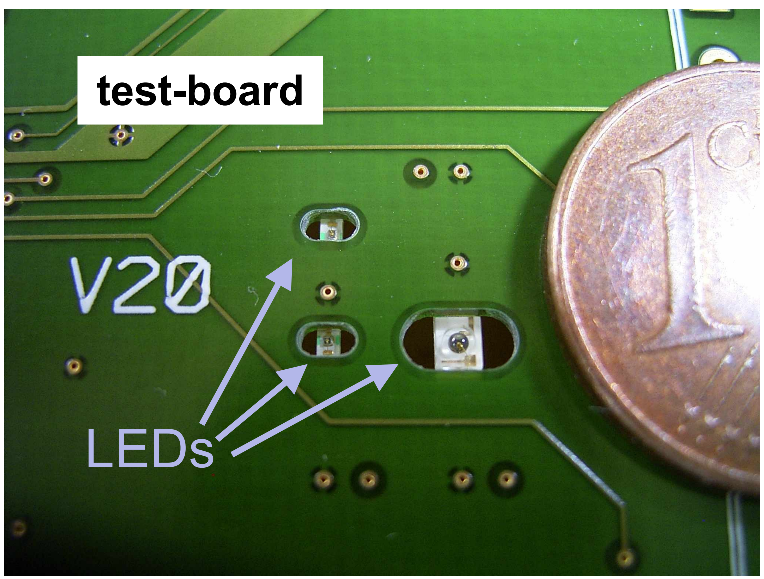
distribution
- homogenous
- space saving

Current 1m³ prototype uses extended LED system developed by the Prague group. This system is able to measure full SiPM saturation curve which is not foreseen for the final detector.
Current research follows two approaches:
- optical light distribution (Prague)
- electrical distribution (DESY, see next slide)

In Layer LED Calibration System



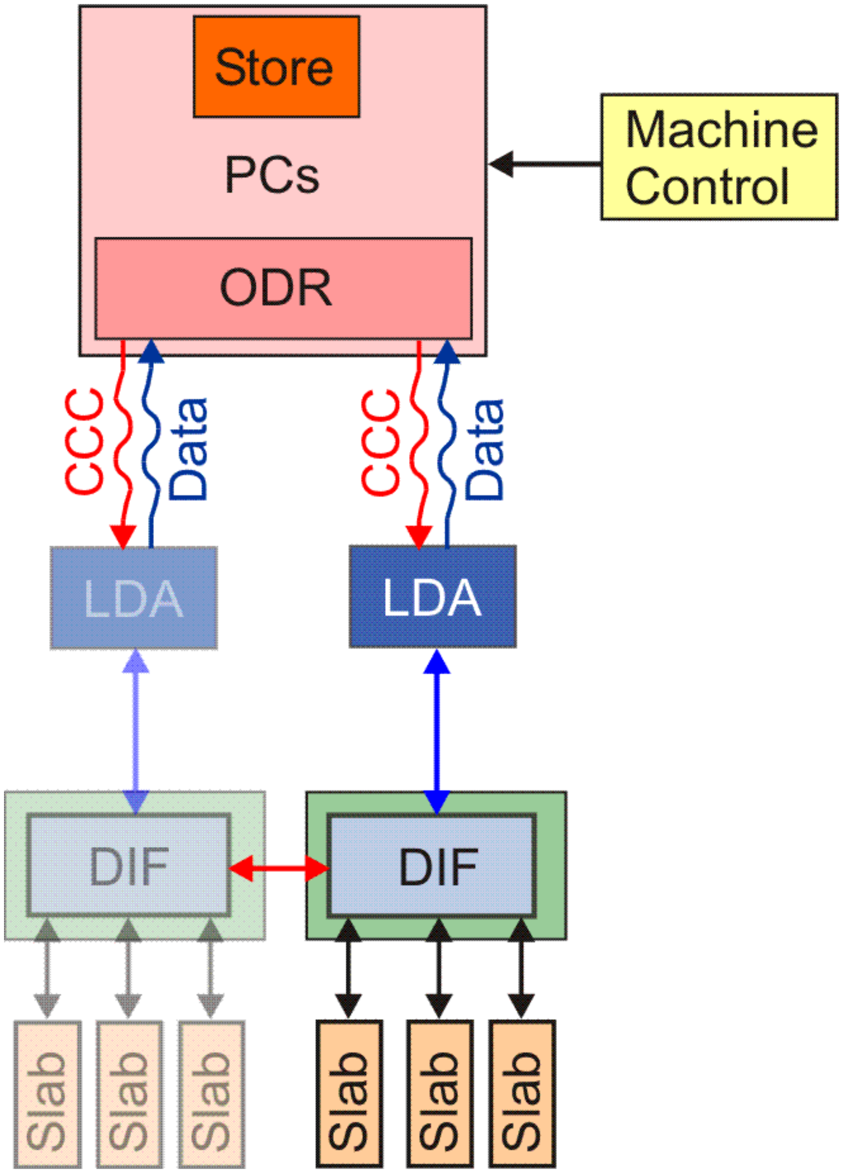




prototype results

- confirmed
  - short light pulses
  - range from few pixel to few MIP
  - SPE spectrum taken
  - suited for machine production
- work ongoing on
  - channel to channel uniformity

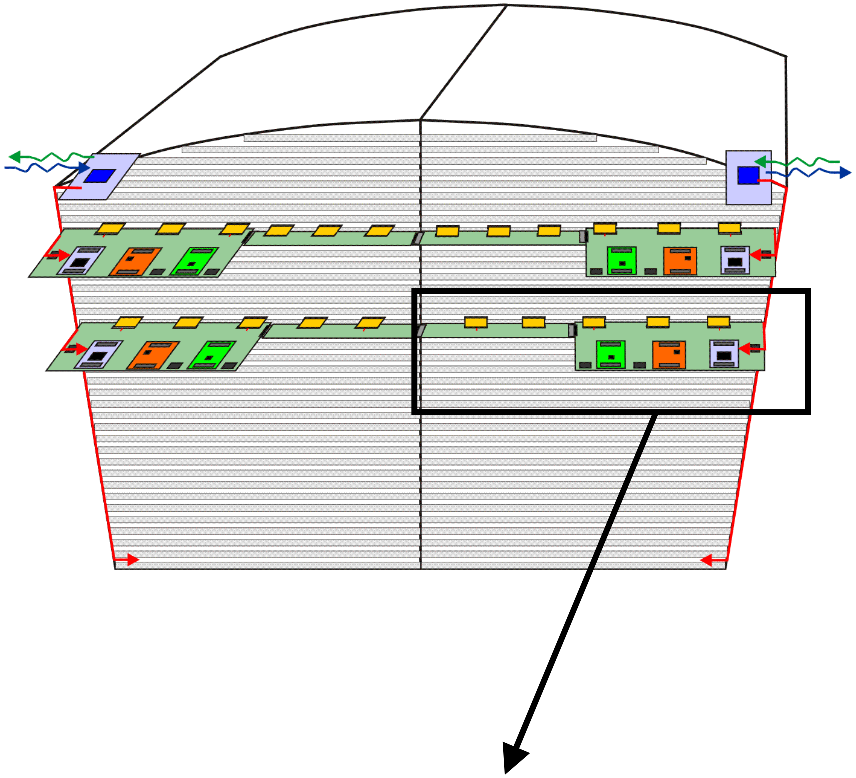
Data Readout



Combined readout concept for the calorimeter system

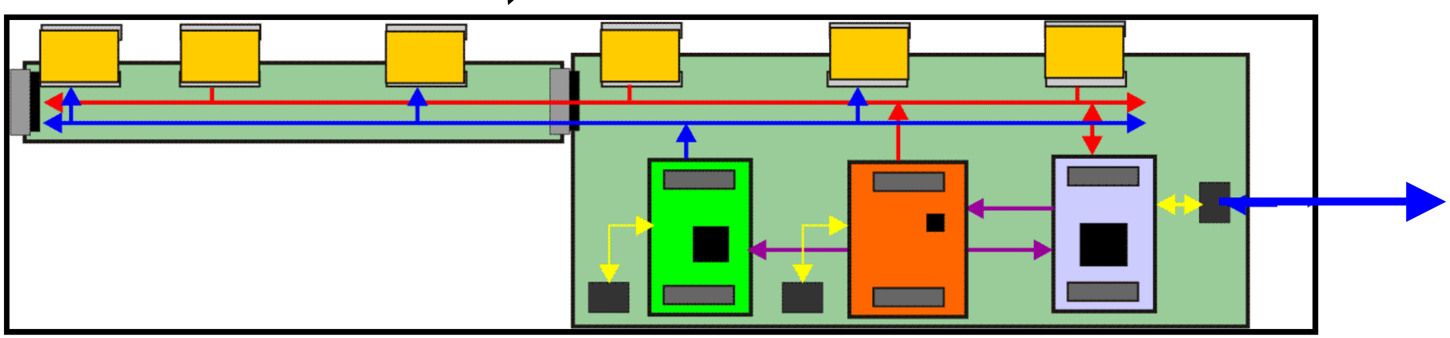
- prefer standardized components
- minimal duplication
  - DIF is gate between detector specific readout and common DAQ backend
  - DIF has common part for all detectors
  - power & calibration systems are slaves to the DIF
- fault safe
  - simple
  - redundant

AHCAL DIF (Detector InterFace)



The requirements on
- data readout
- ASIC control
  - SiPM voltage
  - thresholds (zero surpression)
  - power pulsing
- calibration & monitoring
  - temperature readout
  - LED amplitude steering & trigger
- redundancy

will give design constrains on the DIF



POWER CALIB DIF

Calorimeter for ILC

Summary

- first generation ASIC for SiPM was successfully used during the last years
- next generation ASIC will introduce important features for real detector design
- dedicated calibration systems for SiPM are developed in parallel
- all electronics are integrated into a common calorimeter DAQ system