Beam tests of the new scintillator HCAL modules at DESY

> results from DESY e^+ testbeam

- MIP calibration
- time measurement

> plans for CERN π testbeam

Katja Krüger (DESY)

LCWS2012 International Workshop on Future Linear Colliders
Arlington, Texas, 22-26 October 2012

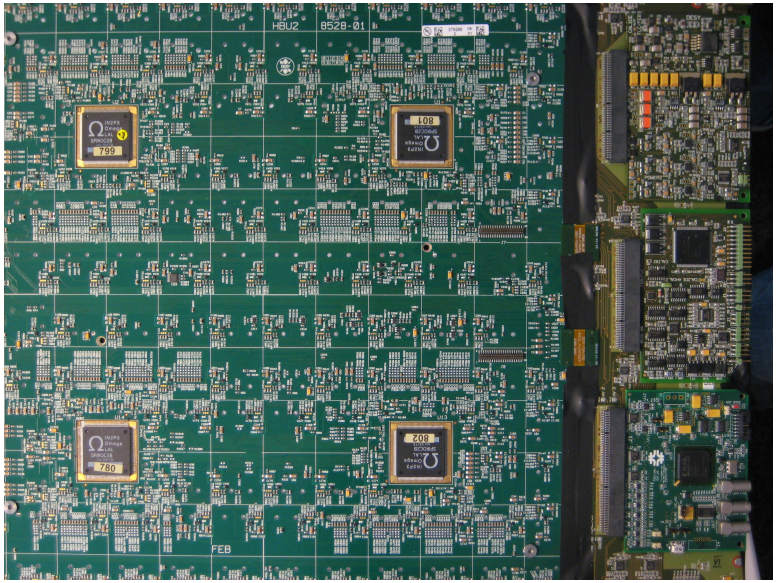
HELMHOLTZ ASSOCIATION

CALICE Calorimeter for ILC

Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

DESY

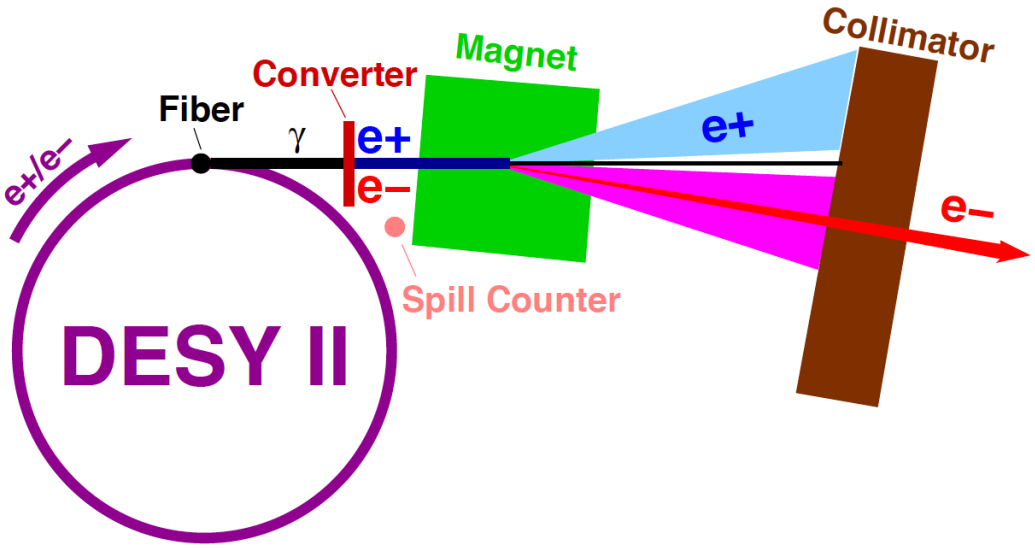
Scintillator HCAL



HCAL Base Units (HBUs)

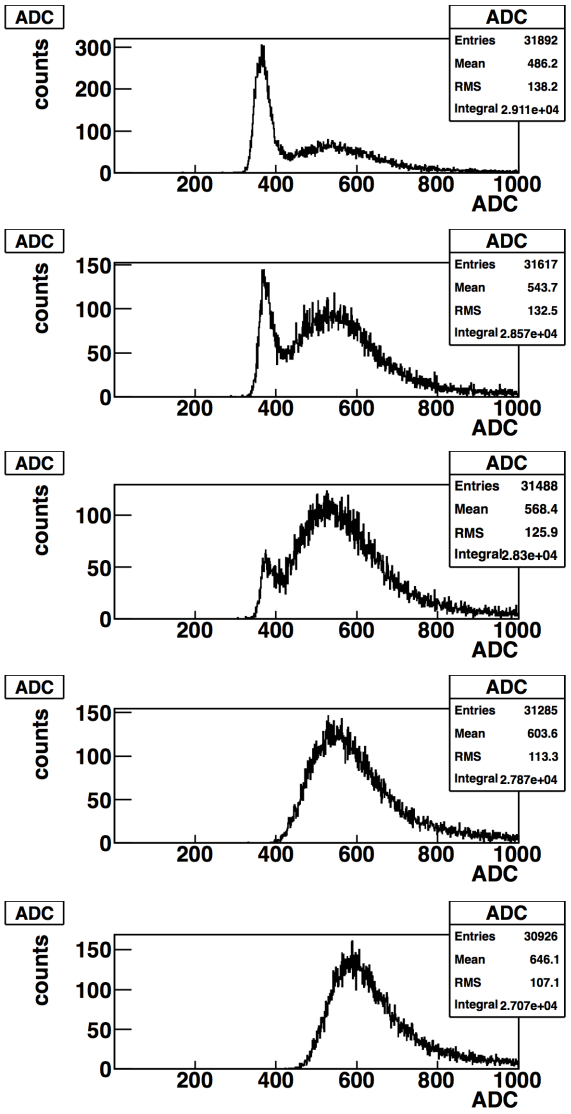
- 144 scintillator tiles
- 4 chips reading out 36 channels each
- two trigger modes:
  - external trigger
  - autotrigger: OR of 36 channels above threshold, possibility of trigger validation
- measurement of size (ADC) and time (TDC) of a signal
- 4 new HBUs: equipped with tiles, electronics for all channels adjusted in lab

DESY testbeam



- positron beam of 1-6 GeV, a few kHz rate at 2-3 GeV, nearly continuous
- goals
  - cross check gain equalization: positrons (or electrons) at these energies passing through a tile deposit nearly exactly the same energy as a Minimum Ionizing Particle (MIP)
  - test trigger verification
  - test external time reference

Calibration in DESY testbeam



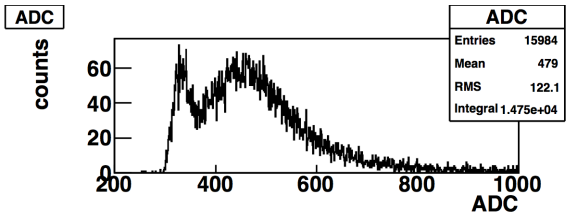
different thresholds

- verify channel gain equalization at an energy scale relevant for physics by measuring a MIP signal in all tiles
- setting trigger threshold for MIP measurement is a compromise between noise rate and minimizing influence on MIP signal

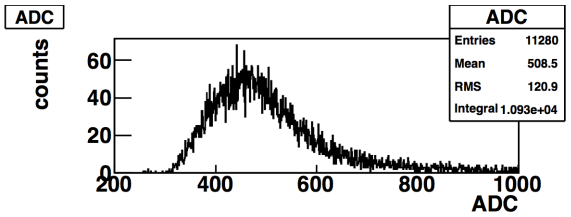
DESY Testbeam: Trigger Validation

- chips have buffer depth of 16 events
  - sufficient for ILC operation
  - limiting for testbeam operation
- trigger modes of Spiroc2b chip:
  - external trigger
  - autotrigger: OR of 36 channels
- trigger validation for autotrigger:
  - if no external reference signal is given (within a certain time window), the current buffer will be overwritten by the next event
  - ➔ use signal from trigger scintillator as external reference signal
  - ➔ large suppression of non-beam related background, essential for testbeam operation

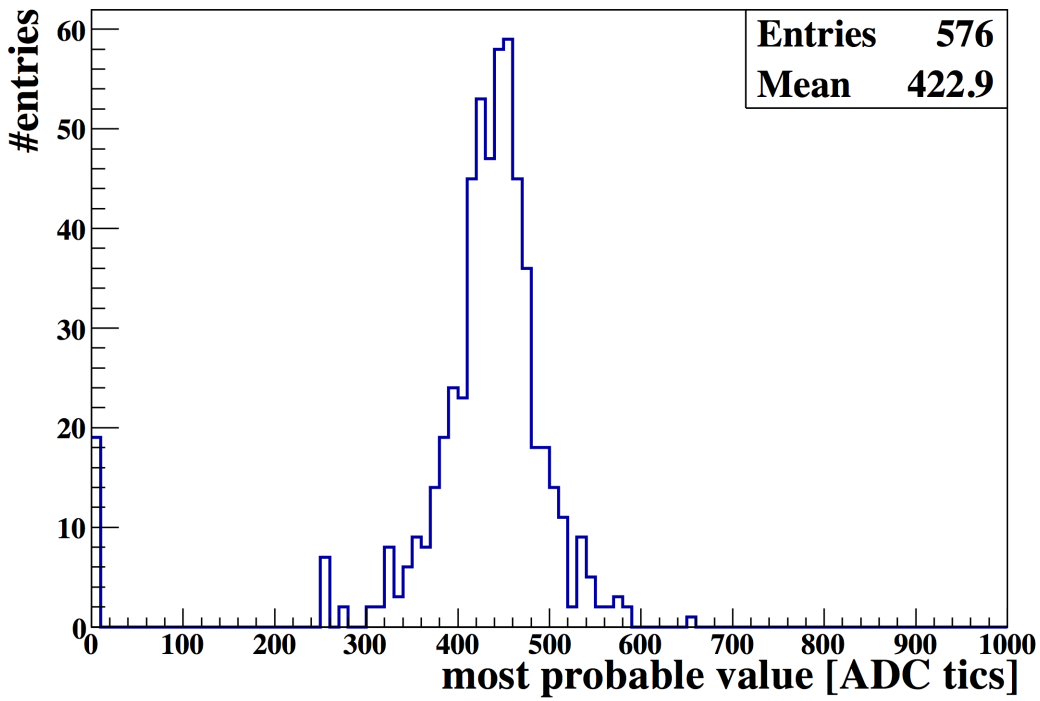
without validation



with validation



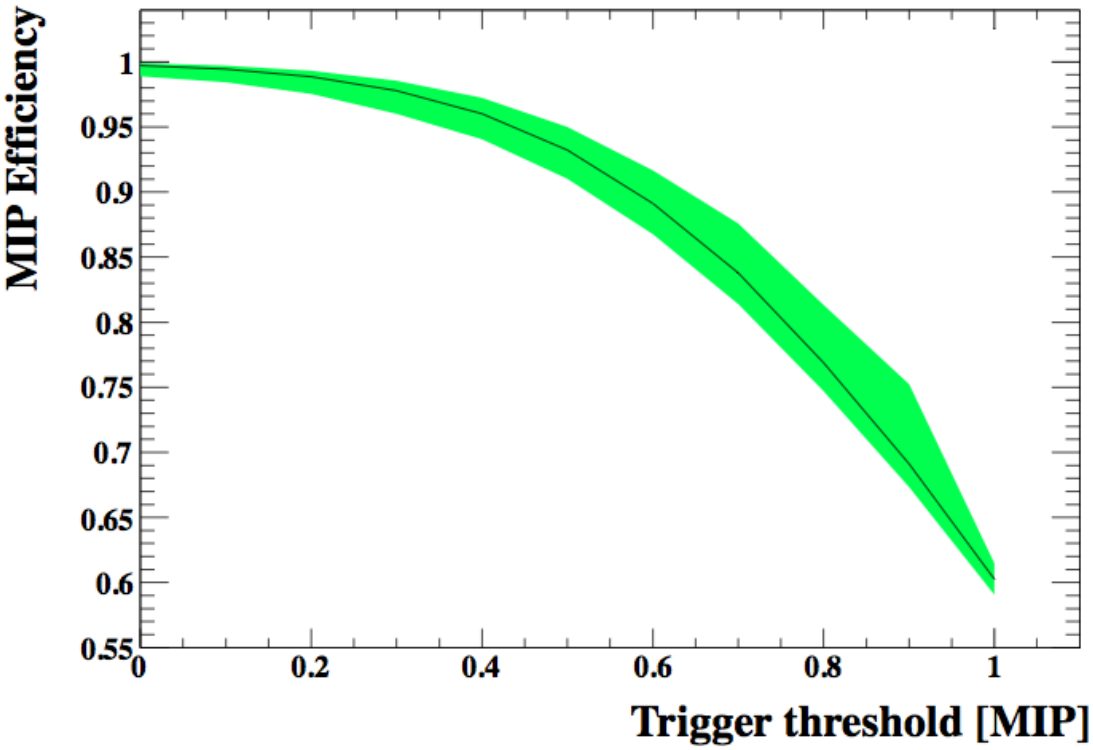
Distribution of MIP most probable values



- all MIP spectra are fitted with Landau ⊗ Gauss
- most probable value (before pedestal subtraction) consistent between channels

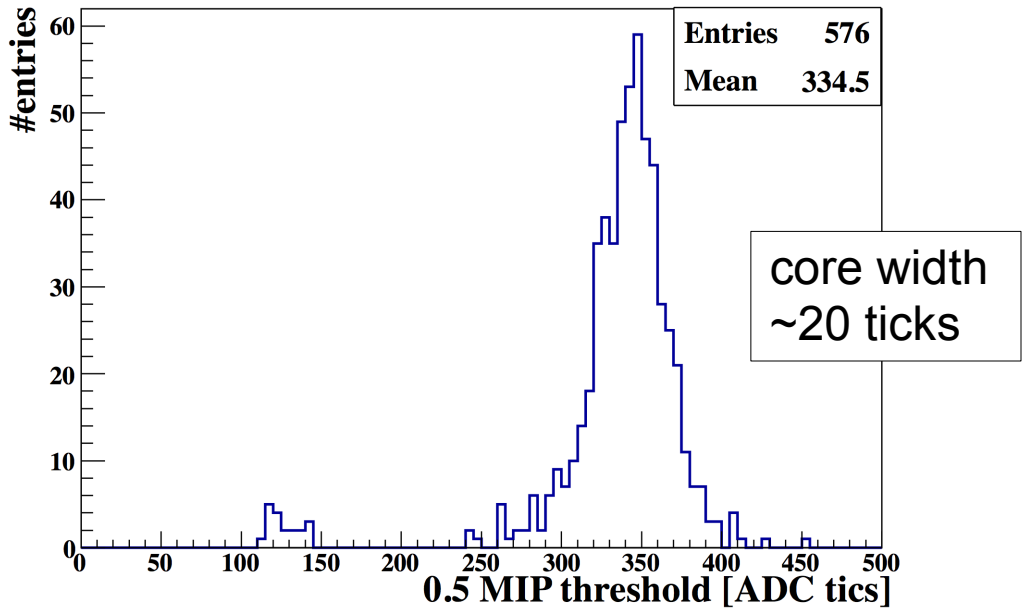
Efficiency

- determine trigger efficiency for a MIP as function of threshold from shape of MIP signals
- for thresholds below 0.5 MIP efficiencies of ~95% or better are reached
- aim to run with threshold below 0.5 MIP



Threshold setting

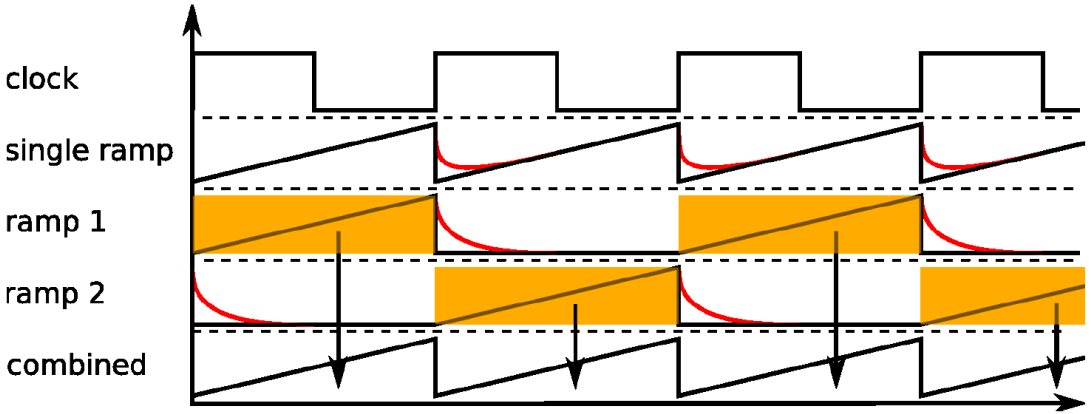
- 1 global trigger threshold per chip, necessary conditions:
  - uniform gain (gain equalization with single pixel spectra and preamplifier capacitances → talk by O. Hartbrich)
  - uniform light yield (adjusted SiPM voltages)
- verify that position of 0.5 MIP is similar for all channels

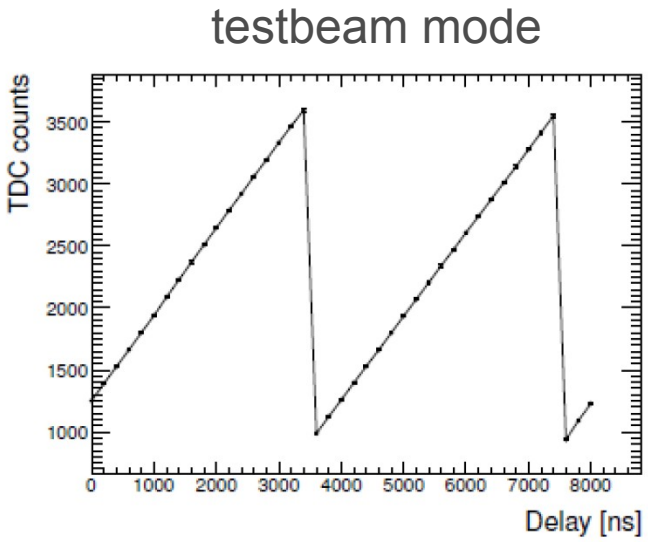


- fulfilled for all four HBUs

Time measurement

- measure time in auto-trigger mode relative to bunch clock
- time measurement is implemented with TDC ramps (low power consumption)
- dual TDC ramp in switched by a multiplexer to reduce dead time due to ramp reset

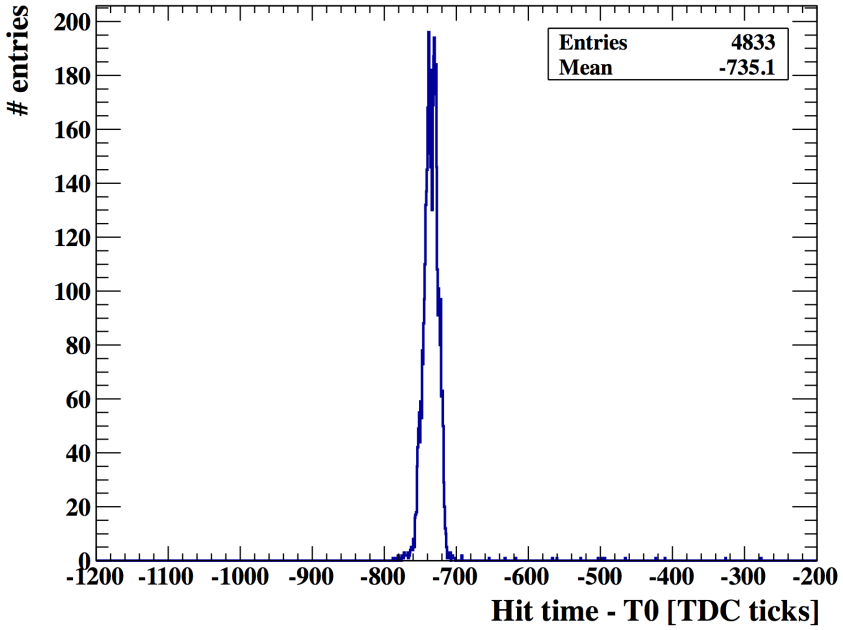




External time reference

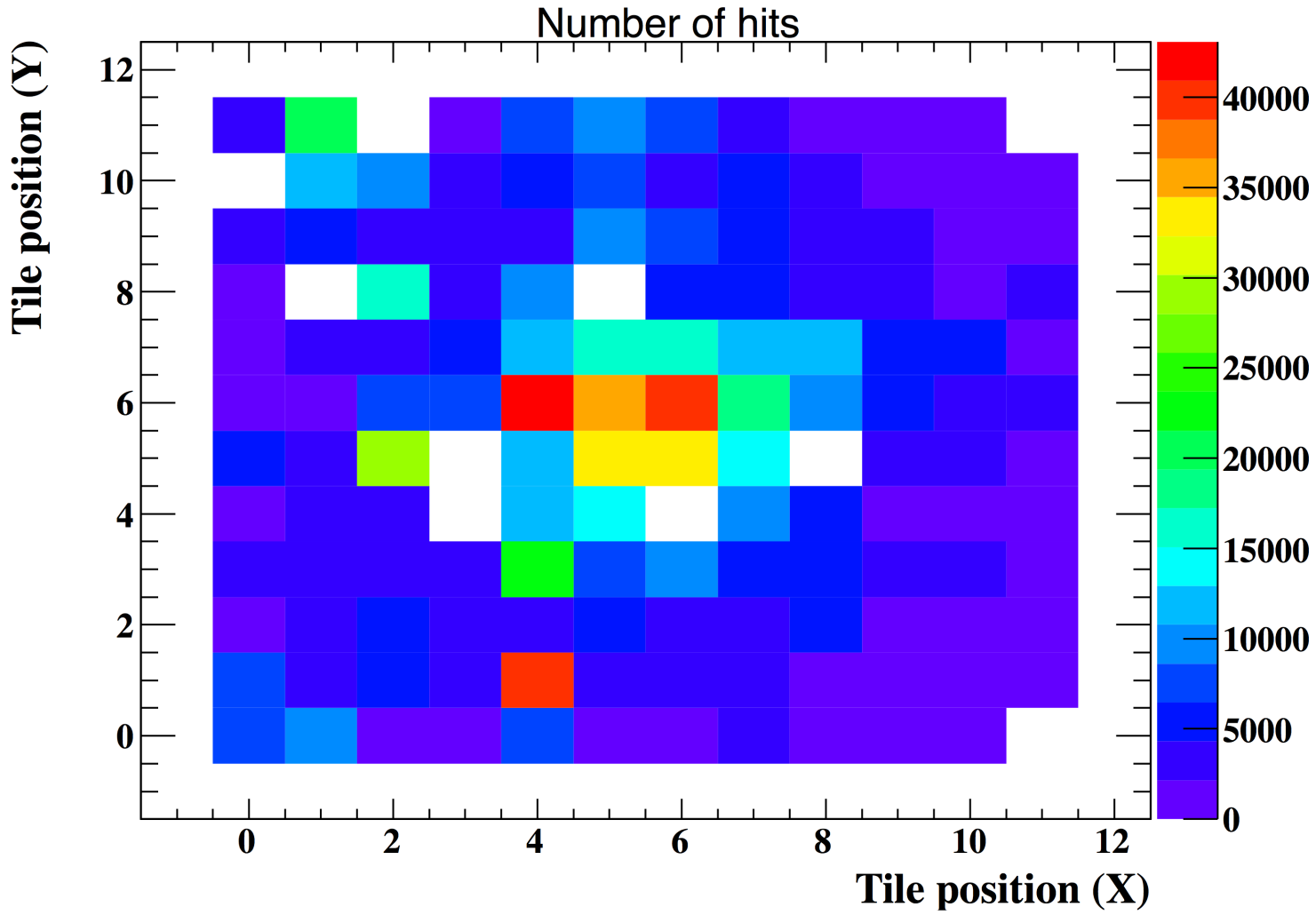
- for testbeam running, the internal clock is not correlated to the beam
- no direct input of external time reference foreseen in electronics

- no information about absolute time of a hit
- use capability of time measurement of the channels, replace 1 tile signal by signal of trigger scintillator
- time difference between channel with MIP signal and channel with reference T0 shows sharp peak:
  - width ~10 ticks, 1 tick ~ 1.5 ns (no corrections applied)
  - offset due to electronics

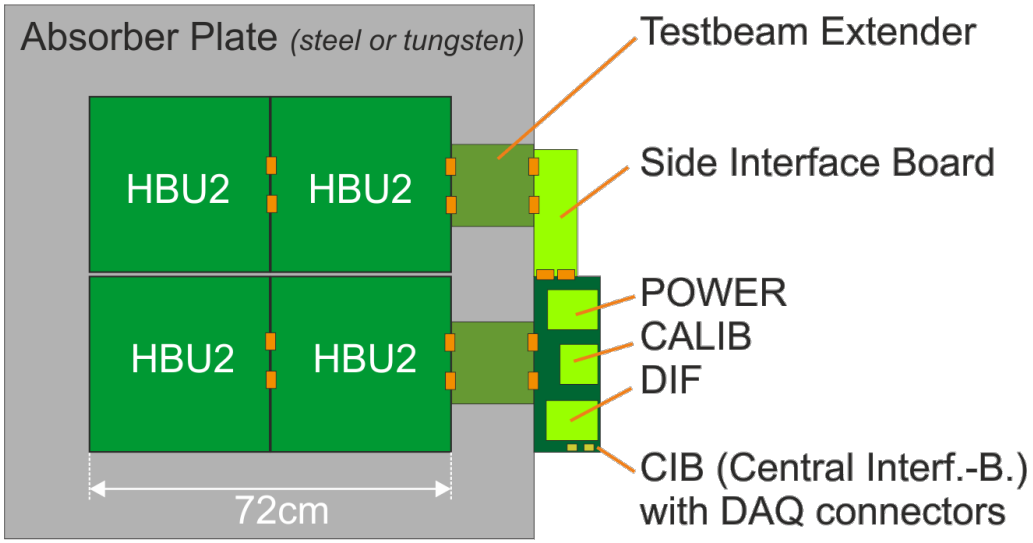


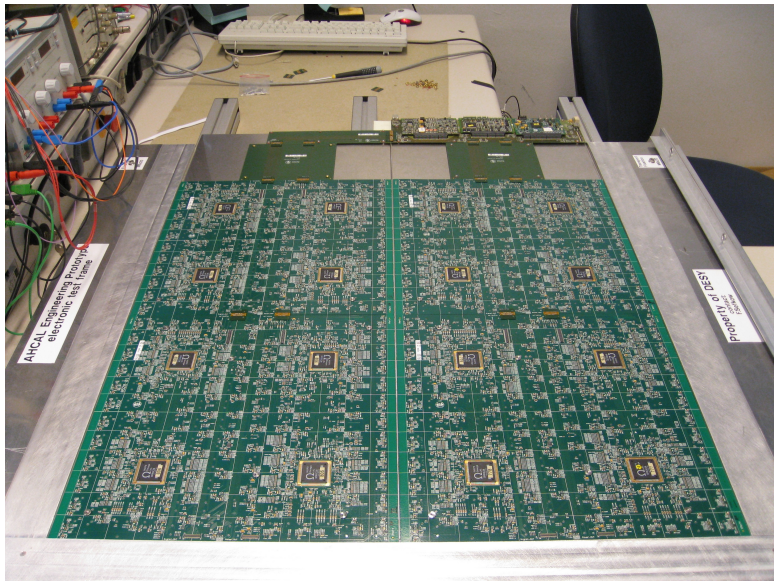
Electromagnetic shower

- tested operation with signals in all 4 chips with electromagnetic shower



Preparation for CERN testbeam

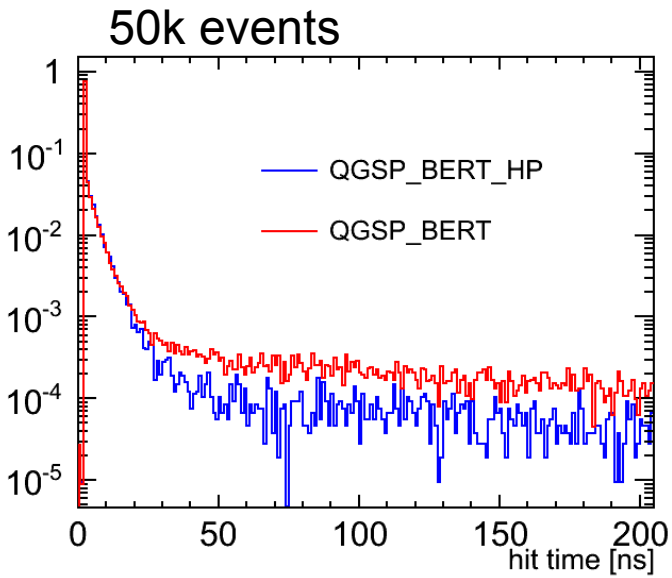


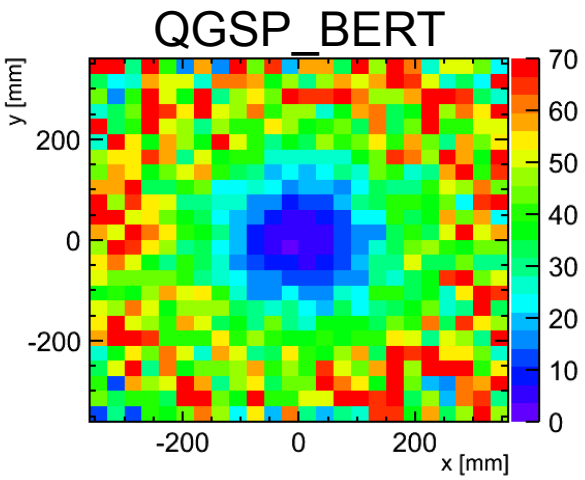


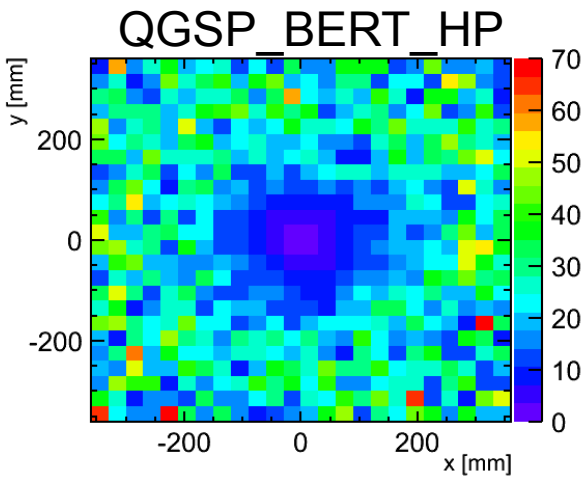
- will operate 1 layer with 4 HBUs in 50-180 GeV π beam
- assembly done at DESY
- first operation tests successful

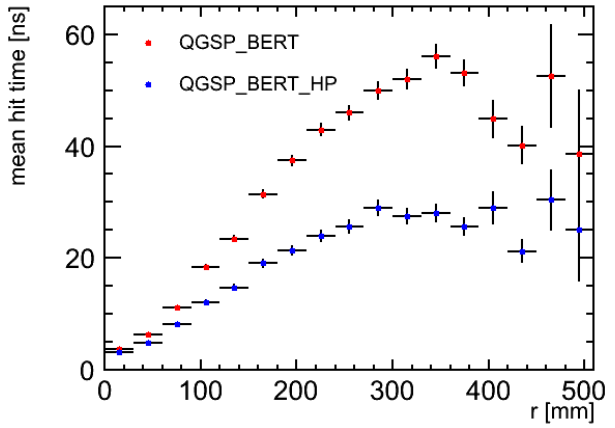
Goals for Testbeam at CERN

- System test of prototype with 4 HBUs
- Study time structure of hadron showers
  - differences in the time development of showers between tGeant4 physics lists
  - HP contains better modeling of low energy neutrons
  - differences especially in the shower tail



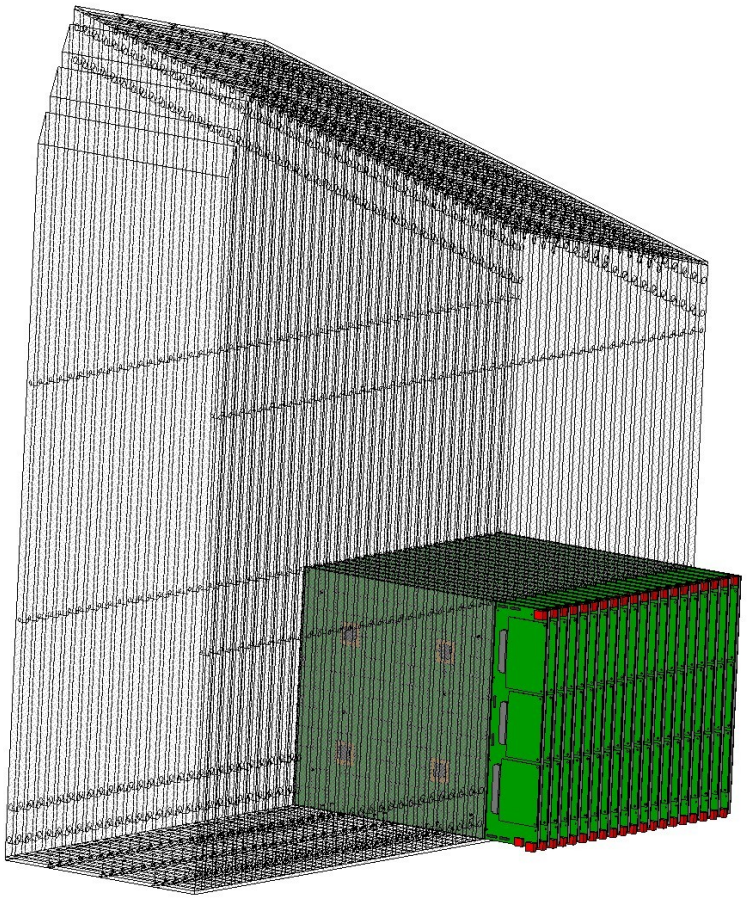






Summary & Outlook

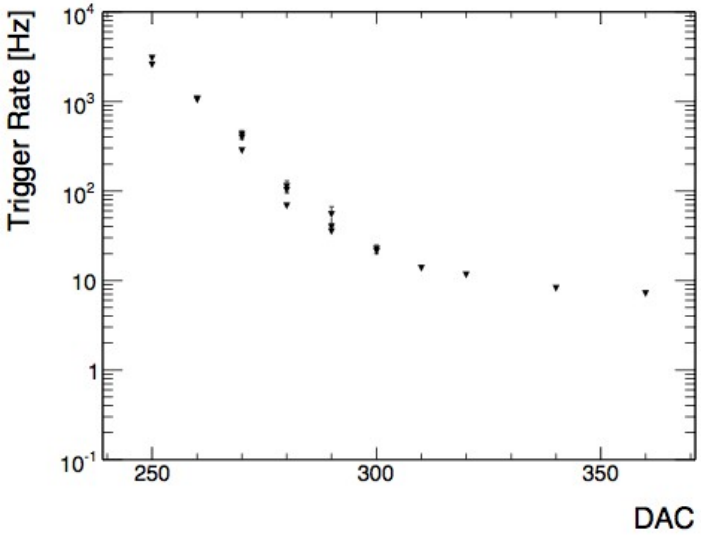
- tests & calibrations of single HBUs done in DESY positron beam:
  - MIP measurements
  - time reference
  - electromagnetic shower
- first tests with 4 HBUs
- plans for CERN hadron beam:
  - demonstrate operation of engineering prototype layer
  - measure time structure of hadron showers
  - simulation studies started
- next steps
  - slab with 6 HBUs
  - small elm. stack
  - large $1m^3$ prototype



Backup

Noise Rate

- determine noise rate with threshold at 0.5 MIP:
  - dependence of rate on trigger threshold (in DAC) already measured in Lab



  - need MIP measurements to determine threshold we will use