Hochratentests an der CMS Binary Chip-Auslesekette

Laboratory-based high rate tests on the CMS Binary Chip DAQ chain

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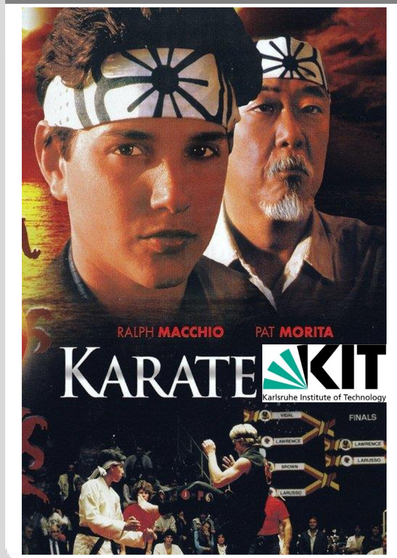
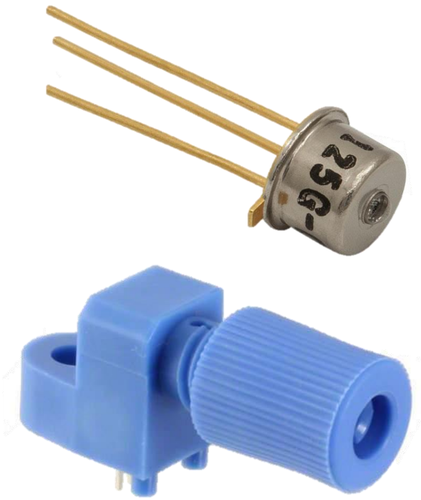
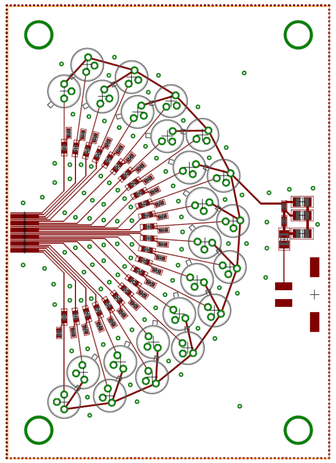
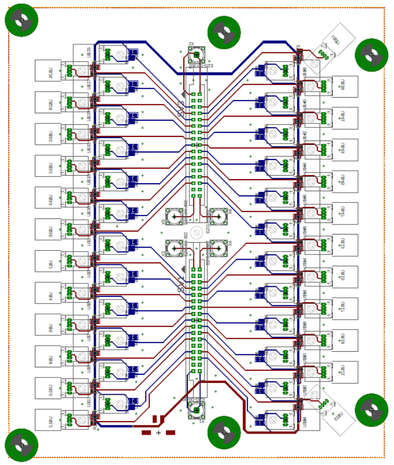
Felix Bögelspacher, Alexander Dierlamm, Ulrich Husemann, ●Stefan Maier, Thomas Müller, Pia Steck, Anita Weddigen

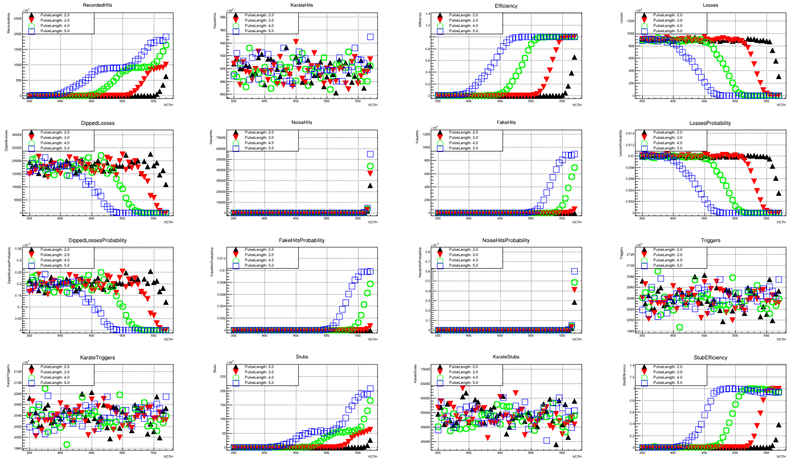
INSTITUTE OF EXPERIMENTAL PARTICLE PHYSICS, KARLSRUHE INSTITUTE OF TECHNOLOGY





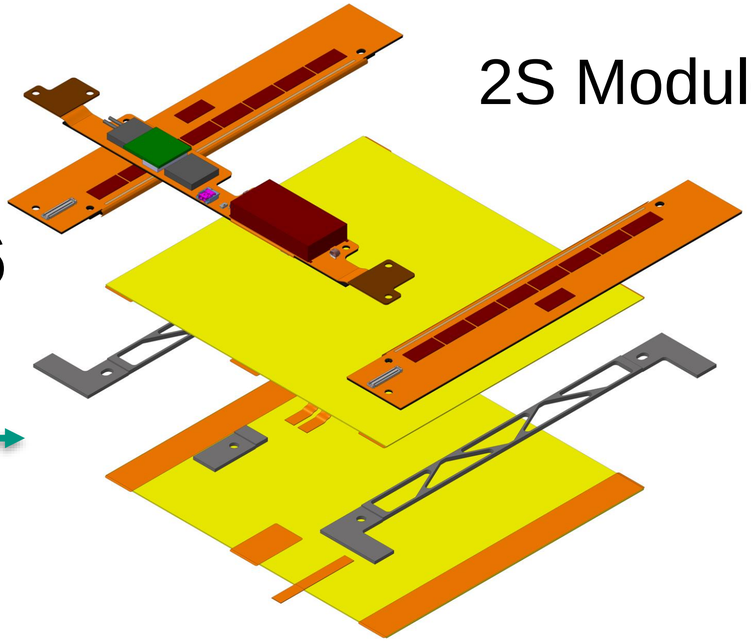


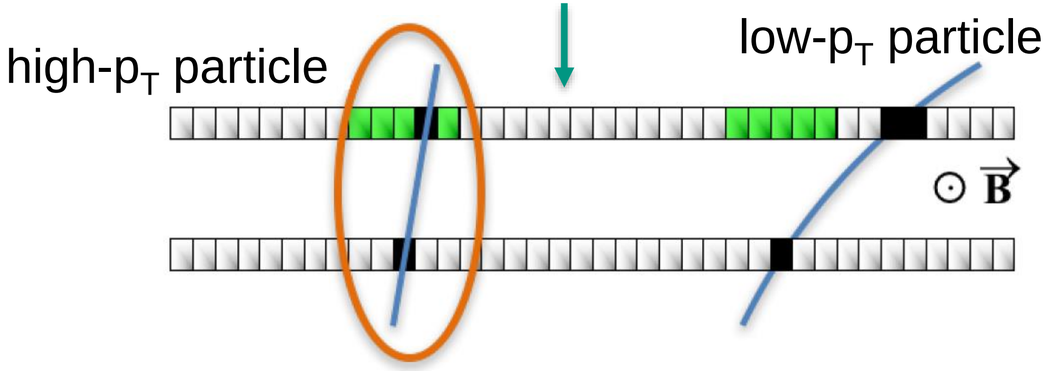


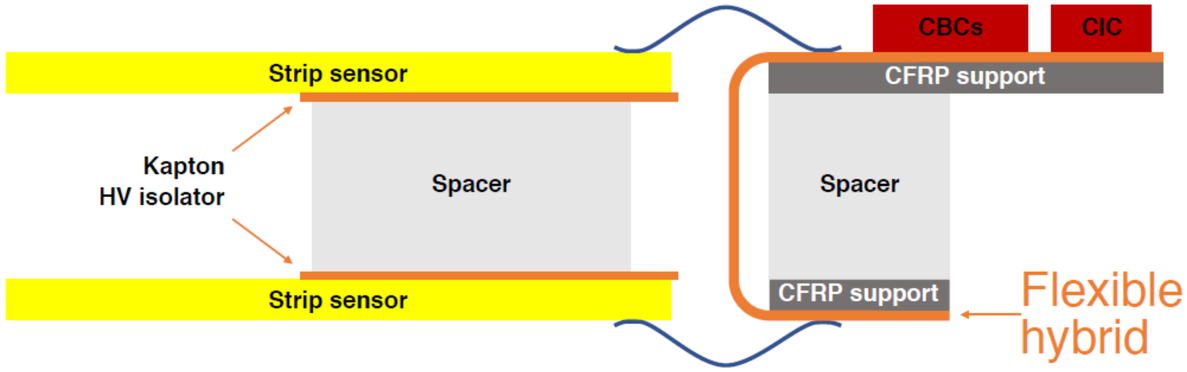


Introduction – Motivation

- For HL-LHC tracker of CMS is replaced by 2026
- Outer tracker built with **p_T-modules** to contribute to the level 1 trigger in CMS
  - ASICs (CBC) read out two stacked silicon sensors
  - On-module coincidence logic for **p_T discrimination**







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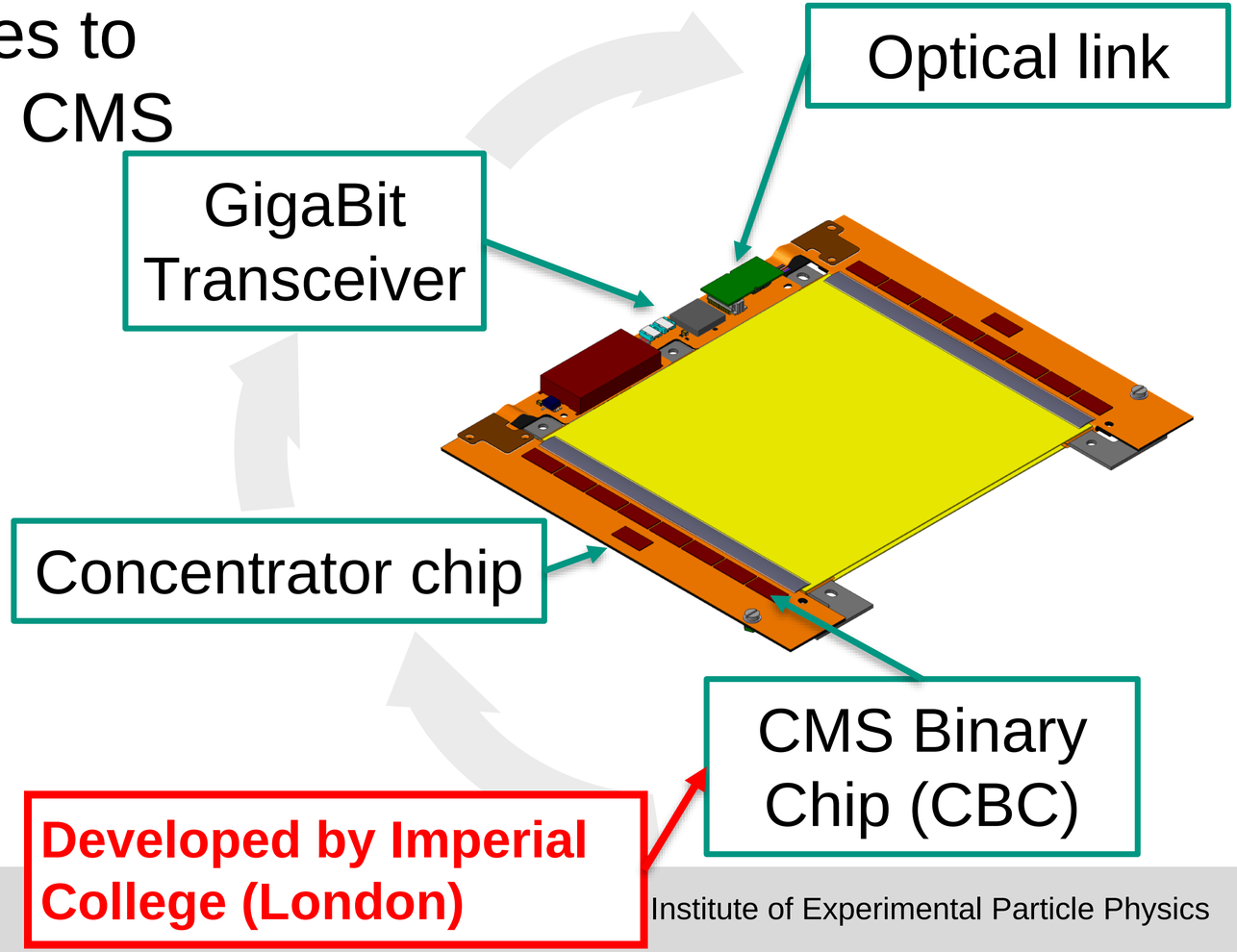
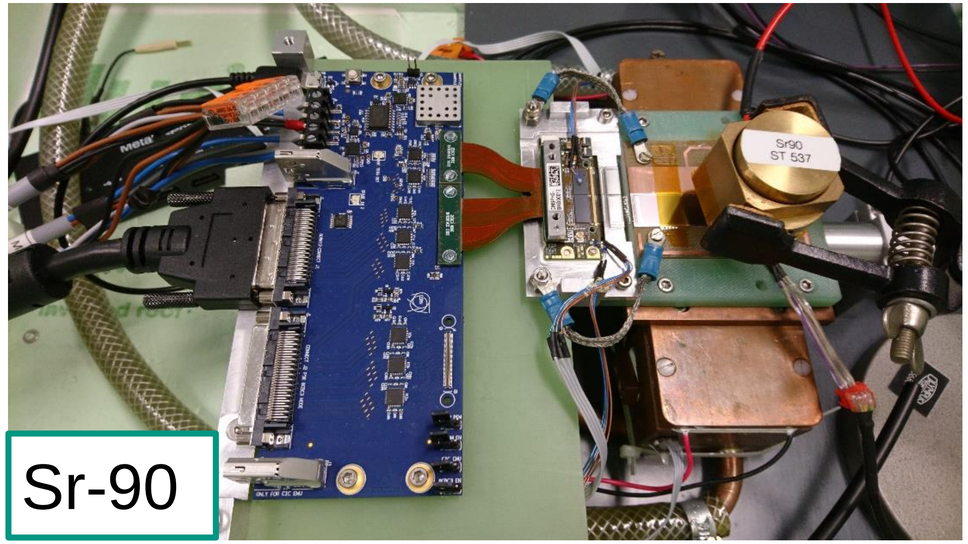
- New dedicated test setup to verify high-rate functionality of the **2S module readout chain**

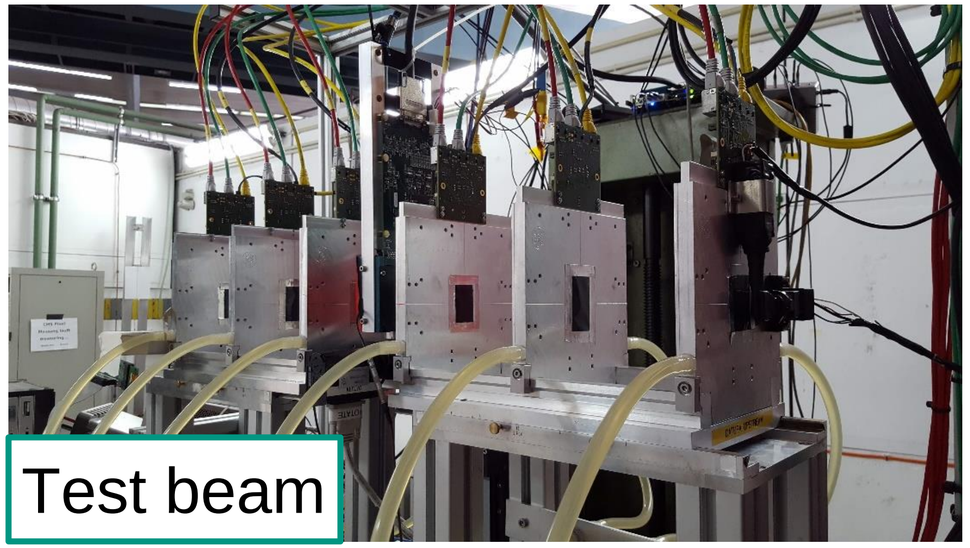


Standard Test Systems



Sr-90

- ~500 Hz trigger rate
- No particle tracking (Gaussian hit profile)



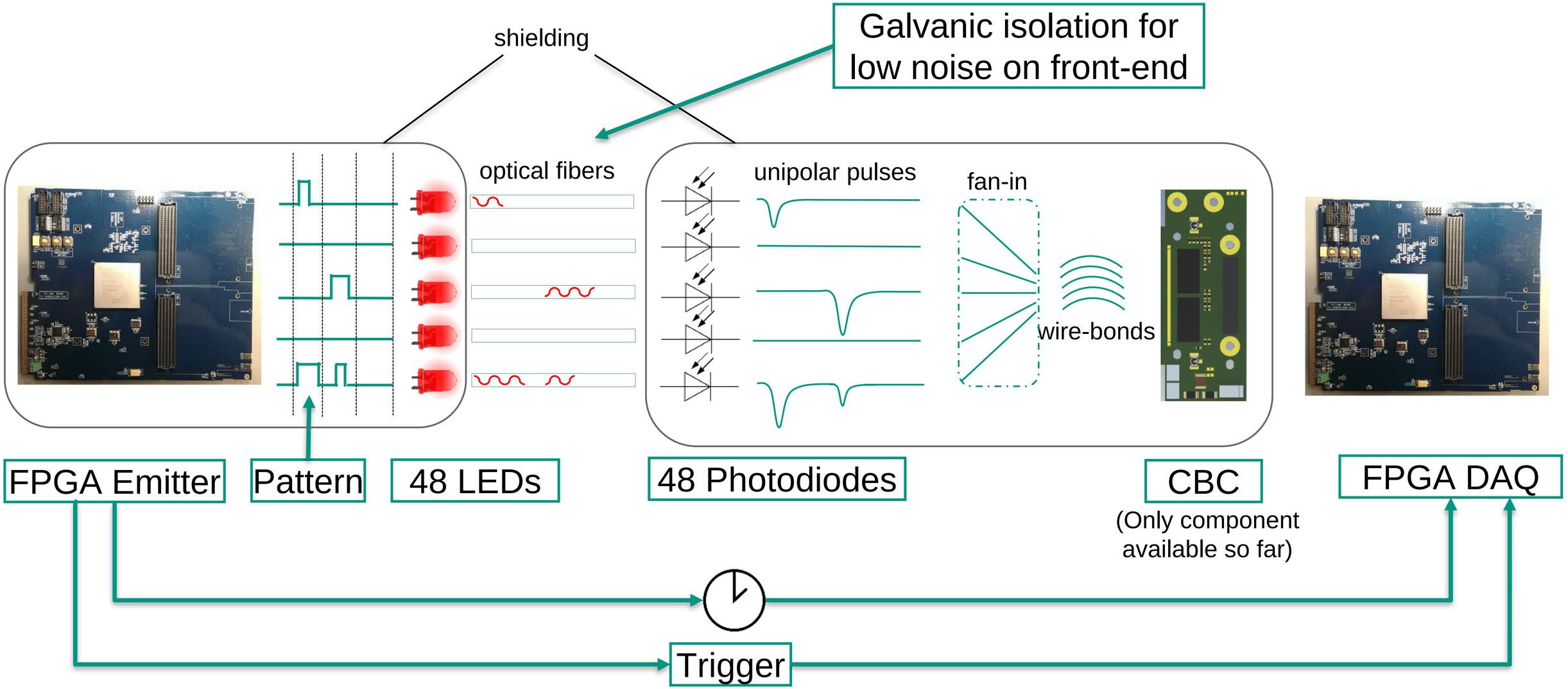
Test beam

- ~3 kHz trigger rate (DESY)
- Particle tracking

But: HL-LHC serves **~1%** hit occupancy at **40 MHz** and a trigger rate of **750 kHz**

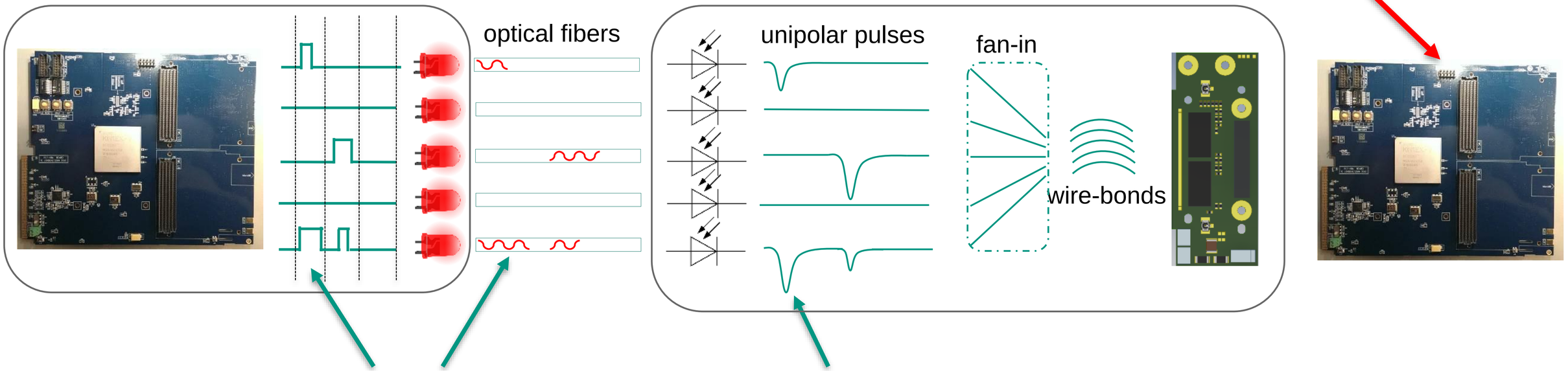
New dedicated test system to test readout chain on high hit and trigger rates

KArlsruher high-**RA**te **TE**st Setup – **KARATE**



KArlsruher high-**RA**te **TE**st Setup – **KARATE**

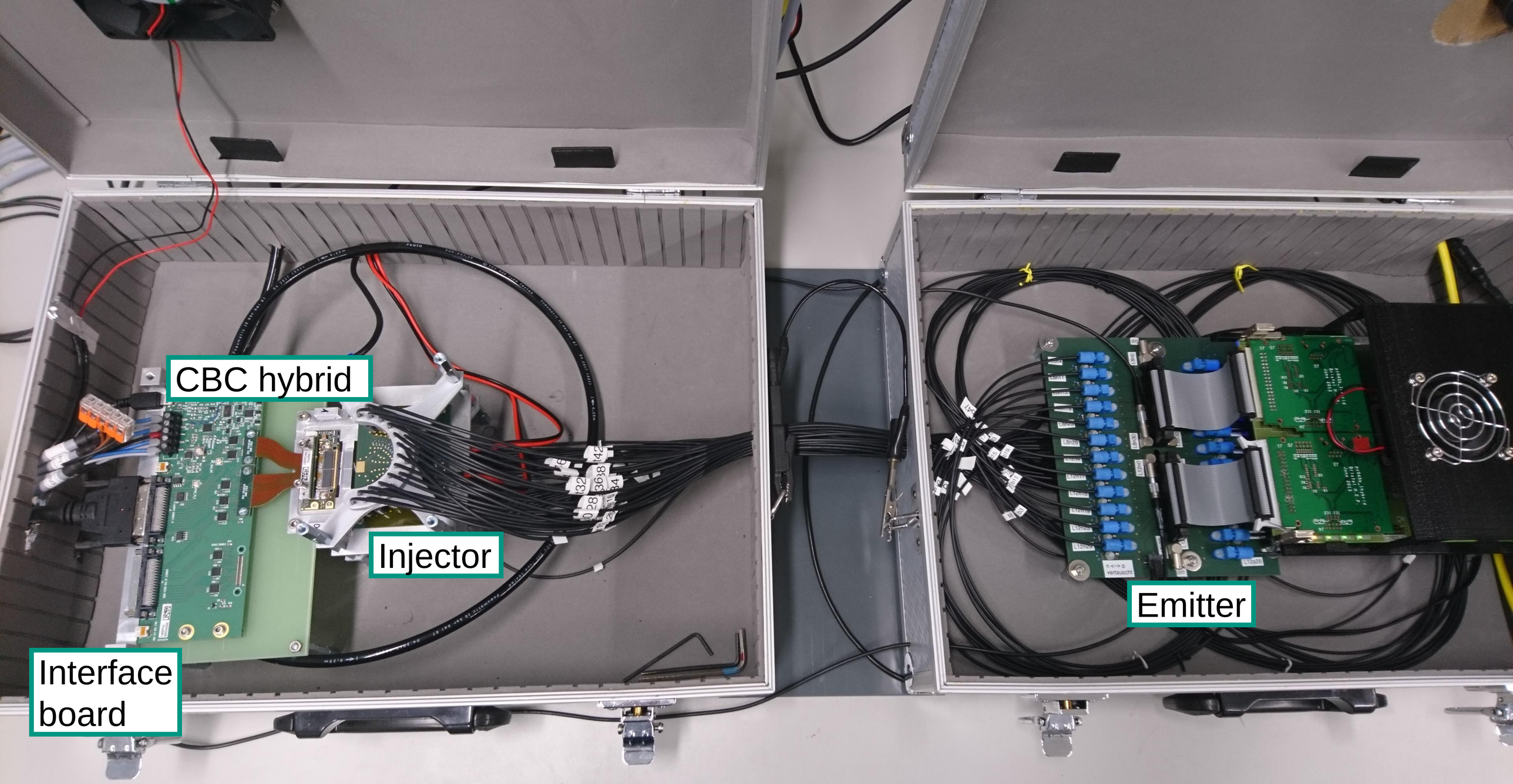
Developed by Imperial College (London) & CERN

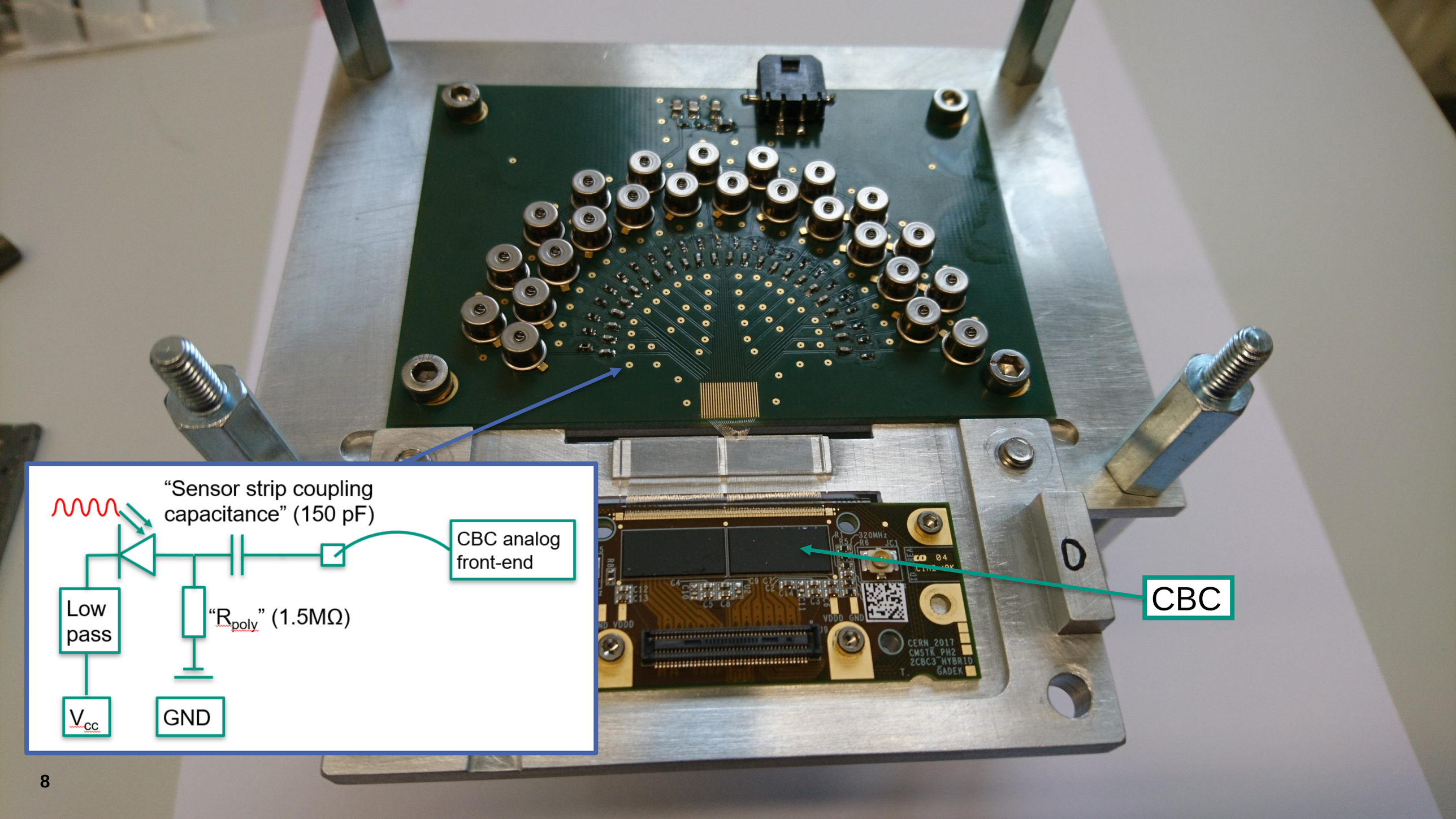


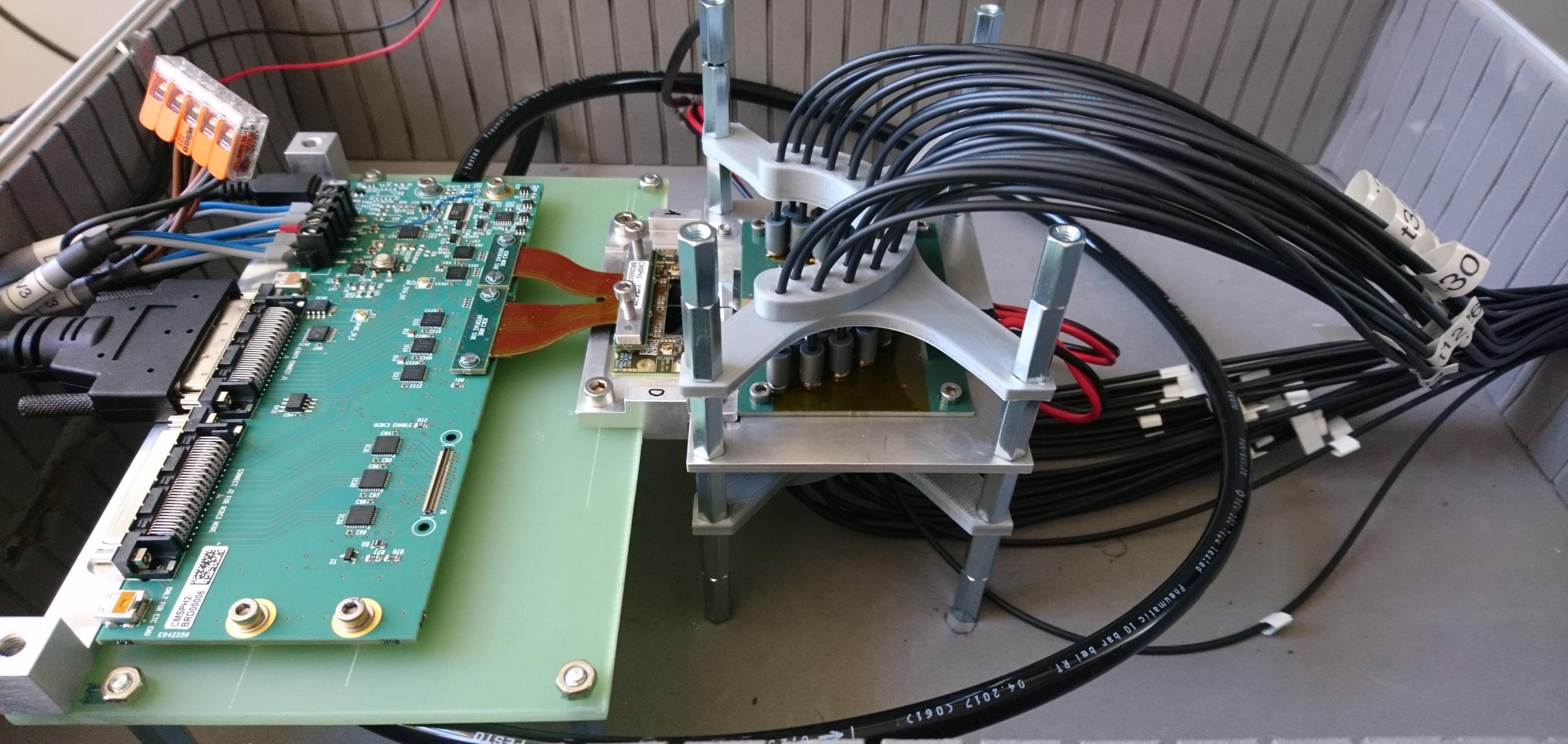
Pulse length on LED defines pulse height on chip front-end

(The longer the light shines, the more electrons are injected)

Direct comparison between injected hit patterns and readout!

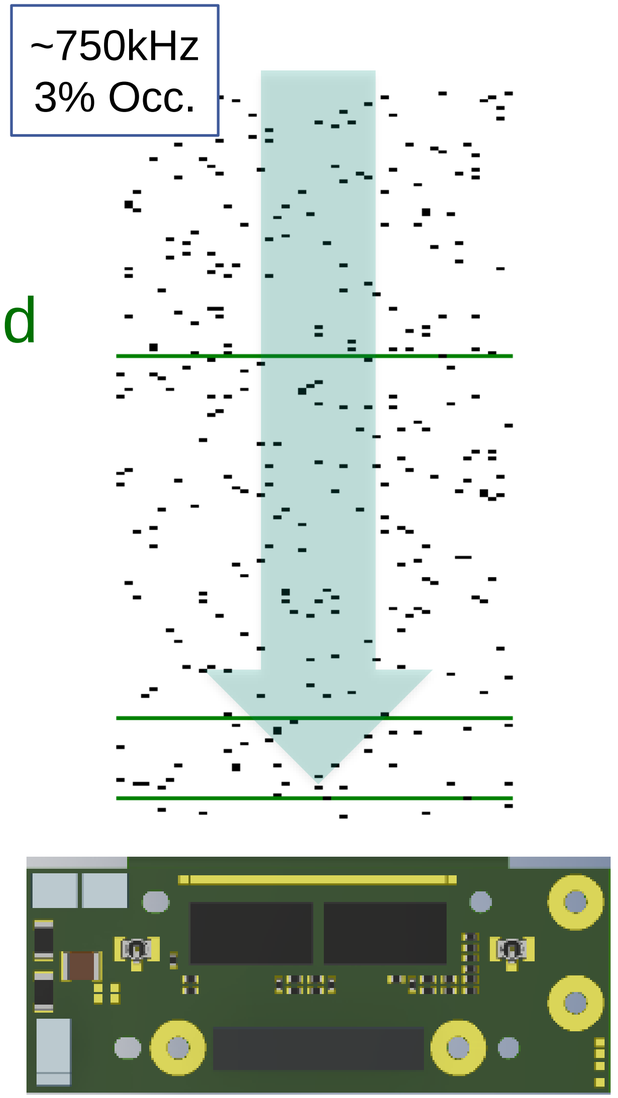

CBC hybrid
Injector
Interface board
Emitter


“Sensor strip coupling capacitance” (150 pF)
CBC analog front-end
Low pass
“R_{poly}” (1.5MΩ)
V_{cc}
GND
CBC


CMSPH2-
BRD00006
E942256
SCDC3 ENABLE
pneumatic 10 bar bei RT
04.2017 (061)
FESTO

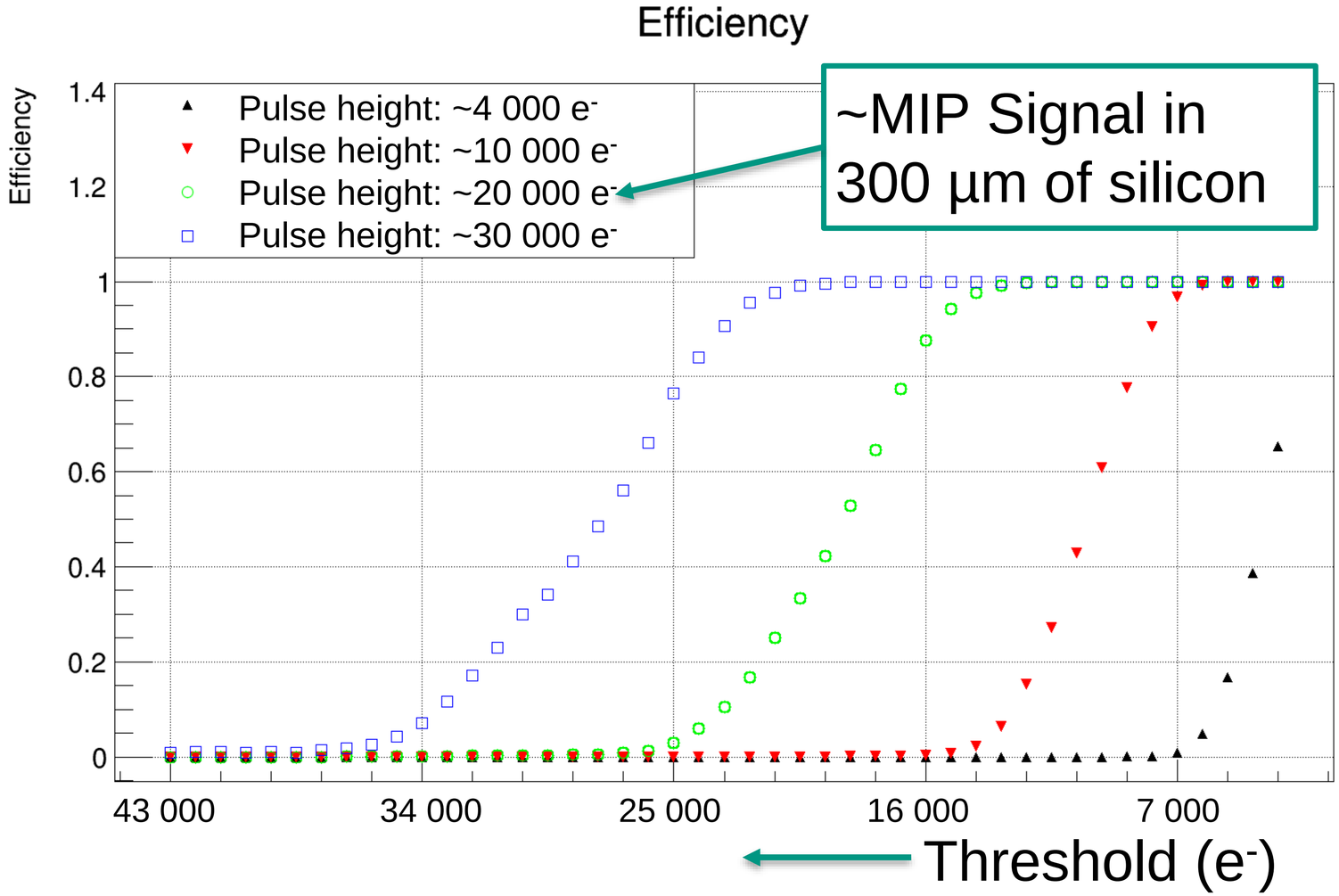
High-Rate Measurement Procedure

- Generate list of pattern with parameters
  - Injection occupancy
  - Trigger frequency
  - Pulse heights
  - Readout threshold
  - …
- Write list on emitter FPGA and inject into ASIC front-end
- **Compare readout event by event, channel by channel**



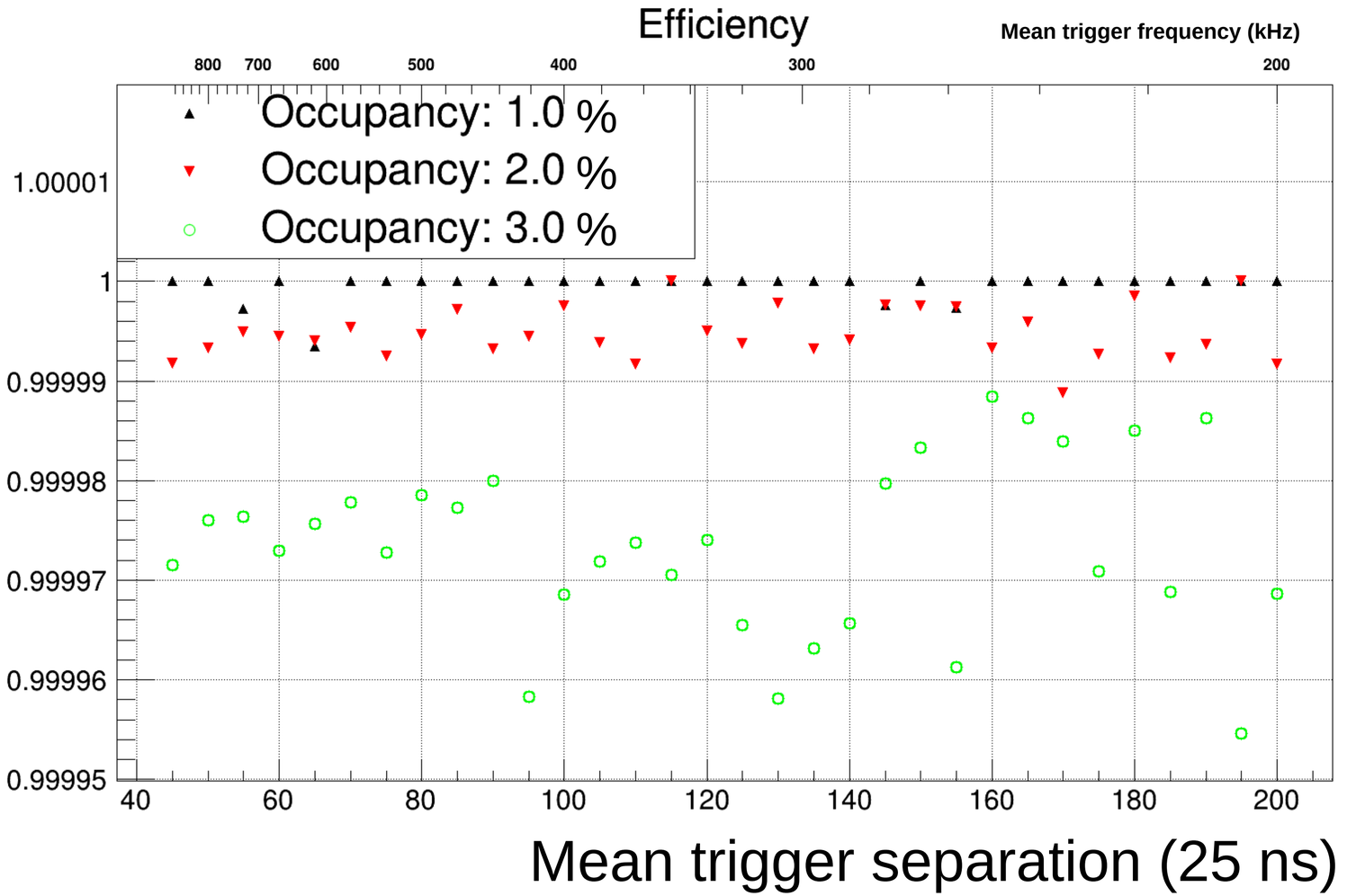
Efficiency (Pulse Length, V_{CTH})

- Inject pattern sequences with varying pulse heights and scan over threshold
- Mean trigger frequency: ~ 750 kHz
- Occupancy: 1%
- As expected, with higher pulses the efficiency plateau increases

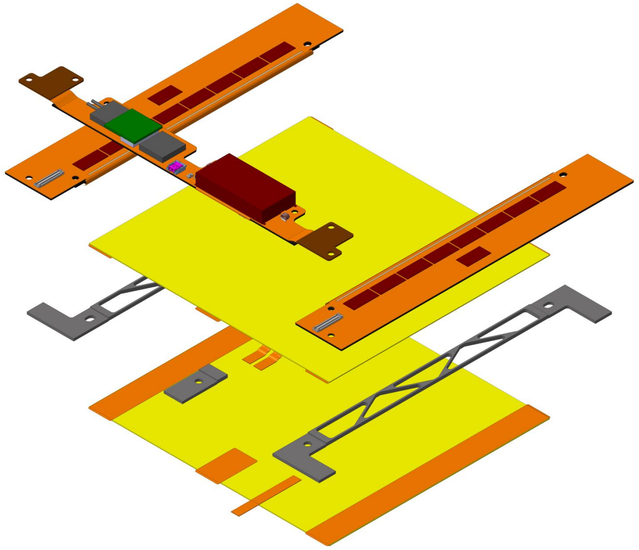


Efficiency (Occ. , Mean Trigger Frequency)

- Inject pattern sequences with varying mean trigger separations and occupancies
- Constant threshold
- ~ 20 000 e^- / hit
- CBC well efficient for reasonable trigger rates



Summary



- New CMS Outer Tracker for HL-LHC uses p_T modules with readout ASICs simultaneously connected to two stacked silicon sensors
- New setup **KARATE** to verify high rate functionality of the 2S module readout chain
  - Charge injection at 25 ns on 48 front-end channels
  - Variable pulse heights, occupancy and trigger rates
- First measurements verify CBC efficiency at high trigger rates
- Successive tests on extended readout chain as soon as components available