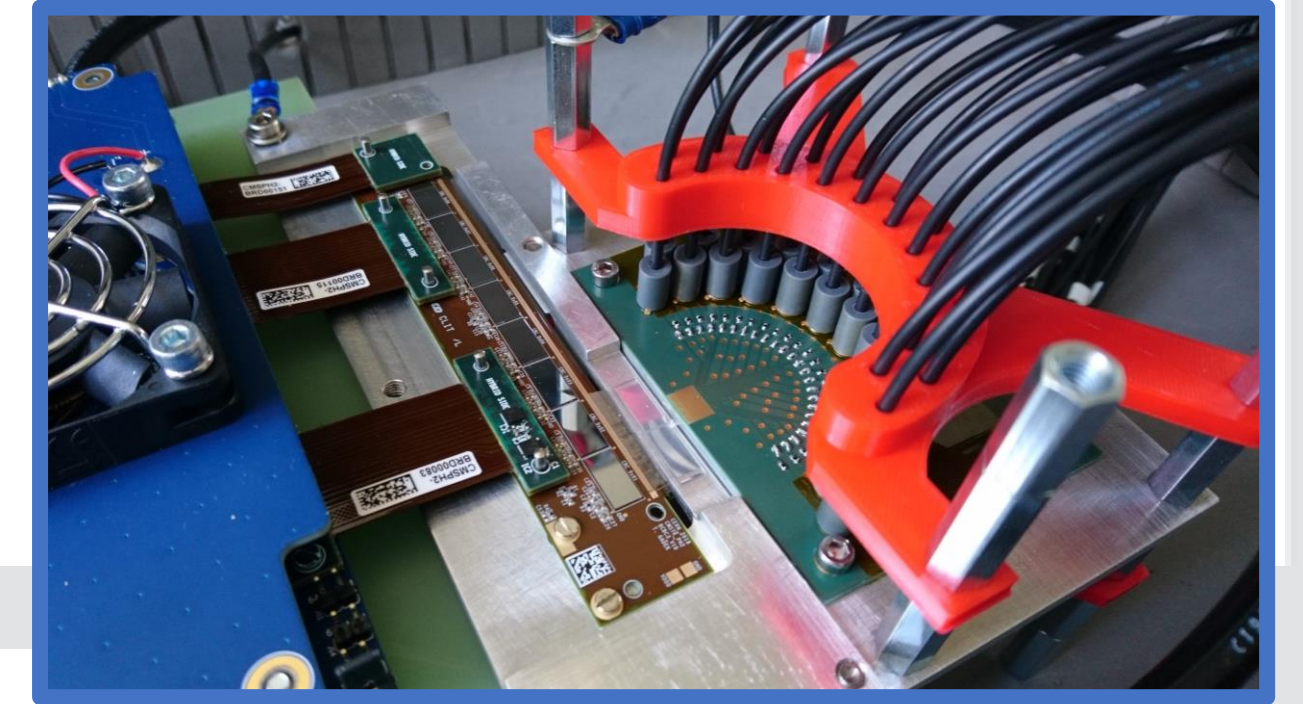


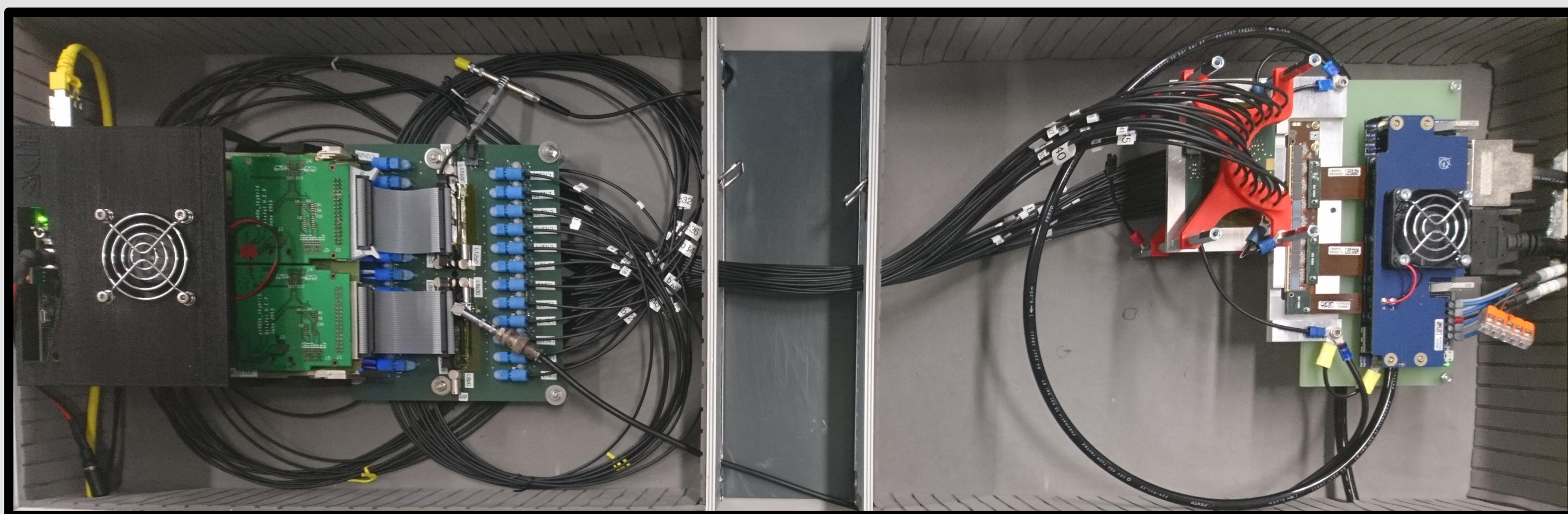
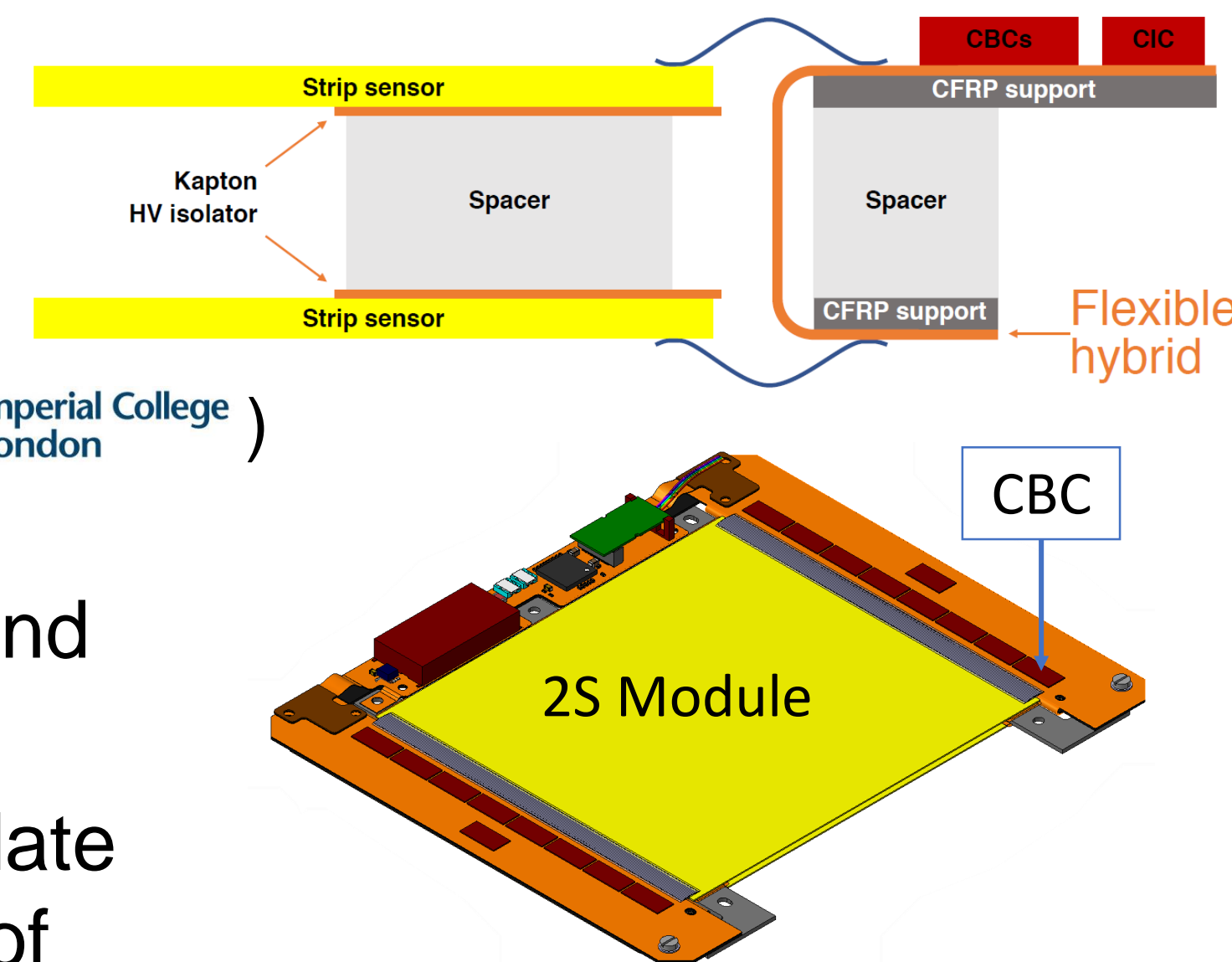
KARATE – A Setup for High Rate Tests of the CMS Outer Tracker 2S Module Readout Chain

Alexander Dierlamm, Ulrich Husemann, Stefan Maier, Thomas Müller

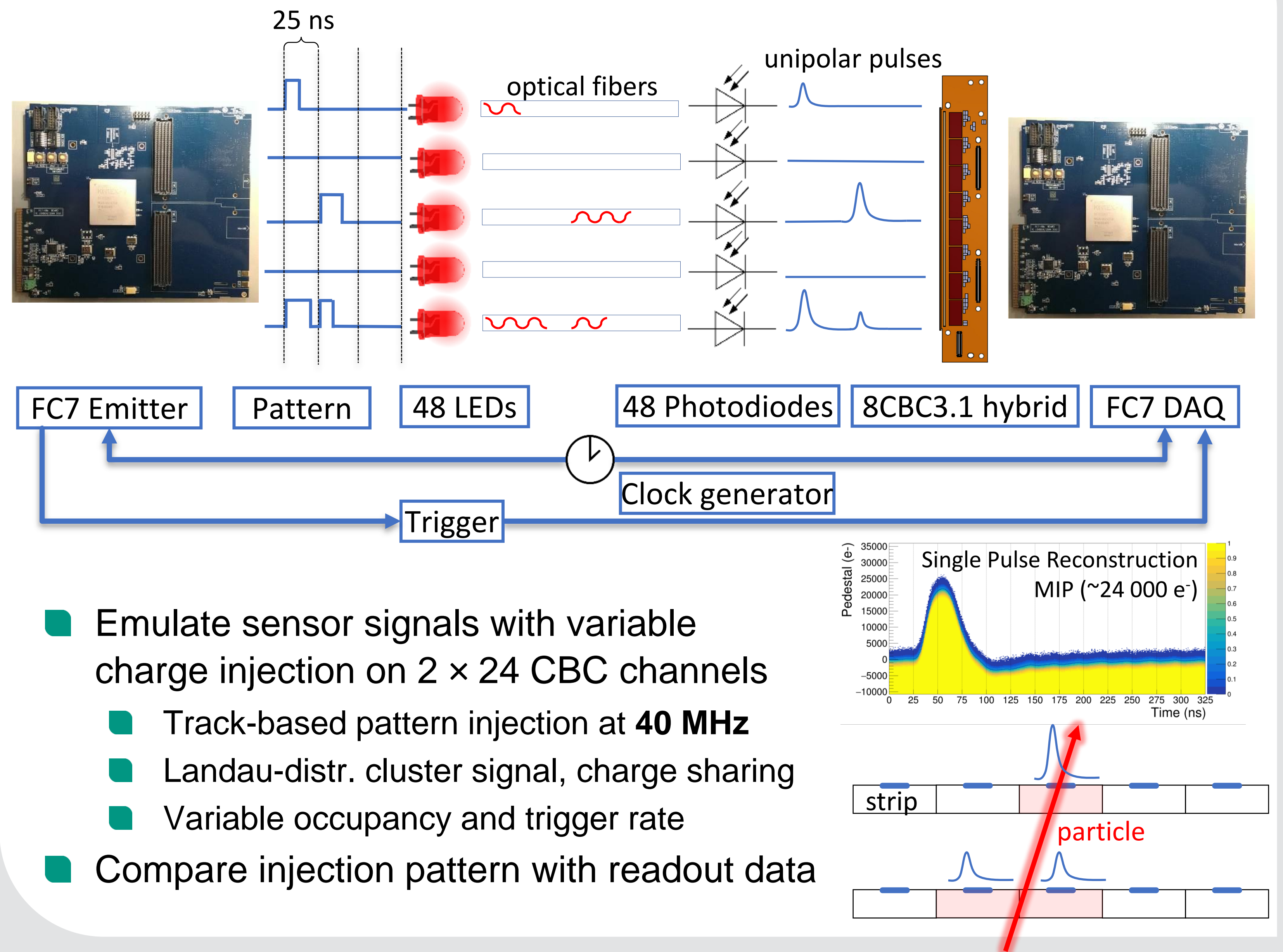


Phase-II Upgrade of the CMS Tracker

- New enhanced outer silicon tracker for HL-LHC
 - Double-sided p_T trigger modules
 - 2S module read out by 16 CMS Binary Chips (CBC)
- Usual tests below expected occupancy and trigger rates (750 kHz)
- Need for setup to validate high rate functionality of readout chain: **CBC (avail.)** → CIC → LpGBT → VTRx+



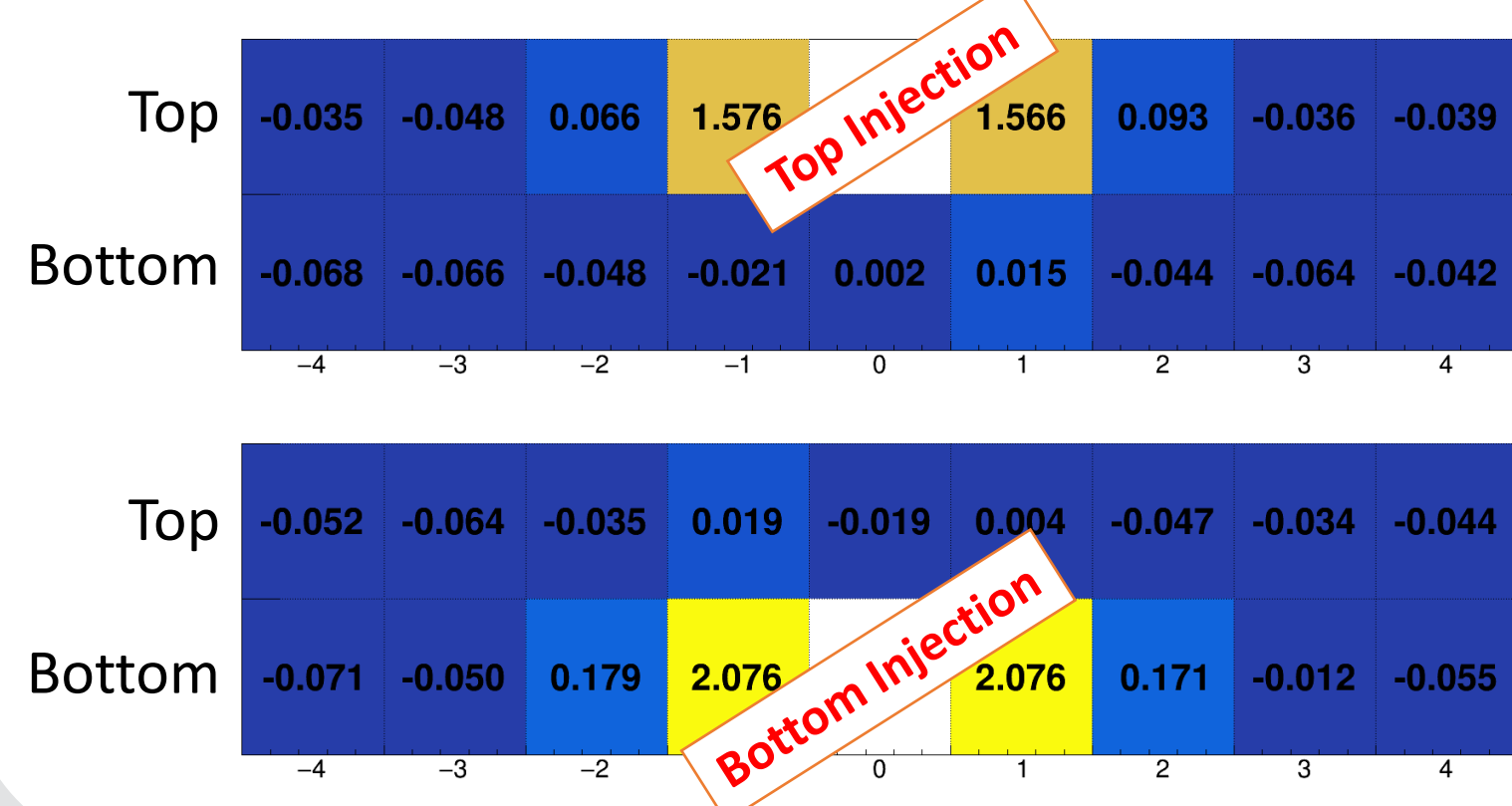
KARlsruhe high RATE Test: KARATE



- Emulate sensor signals with variable charge injection on 2×24 CBC channels
 - Track-based pattern injection at **40 MHz**
 - Landau-distr. cluster signal, charge sharing
 - Variable occupancy and trigger rate
- Compare injection pattern with readout data

XTalk Measurements

- Single channel pulse injection
 - Injection rate: **400 kHz**
- Observe neighbours
- Repeat with increasing pulse height for all channels

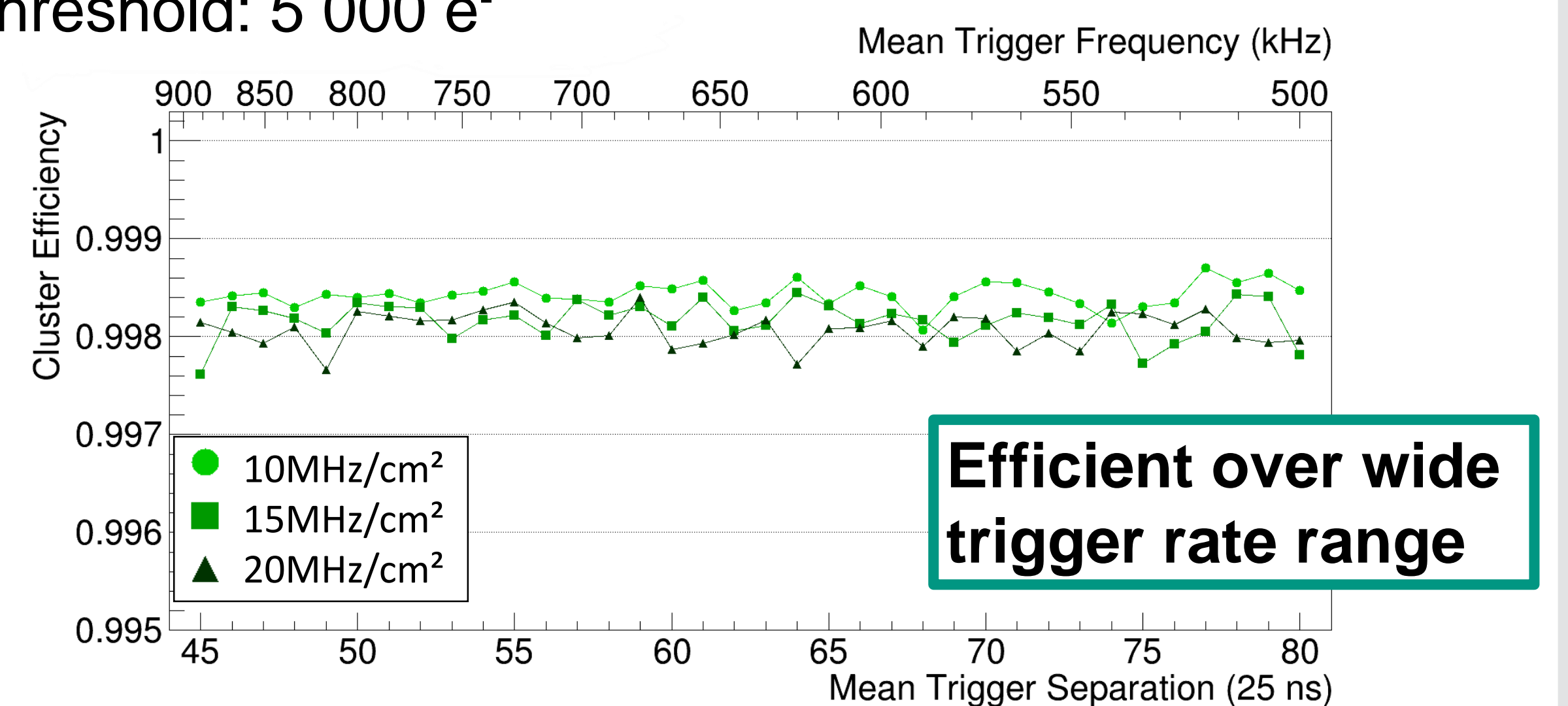


- Wiggle / Injection height
 - Top injection: 1.6 %
 - Bottom injection: 2.1 %

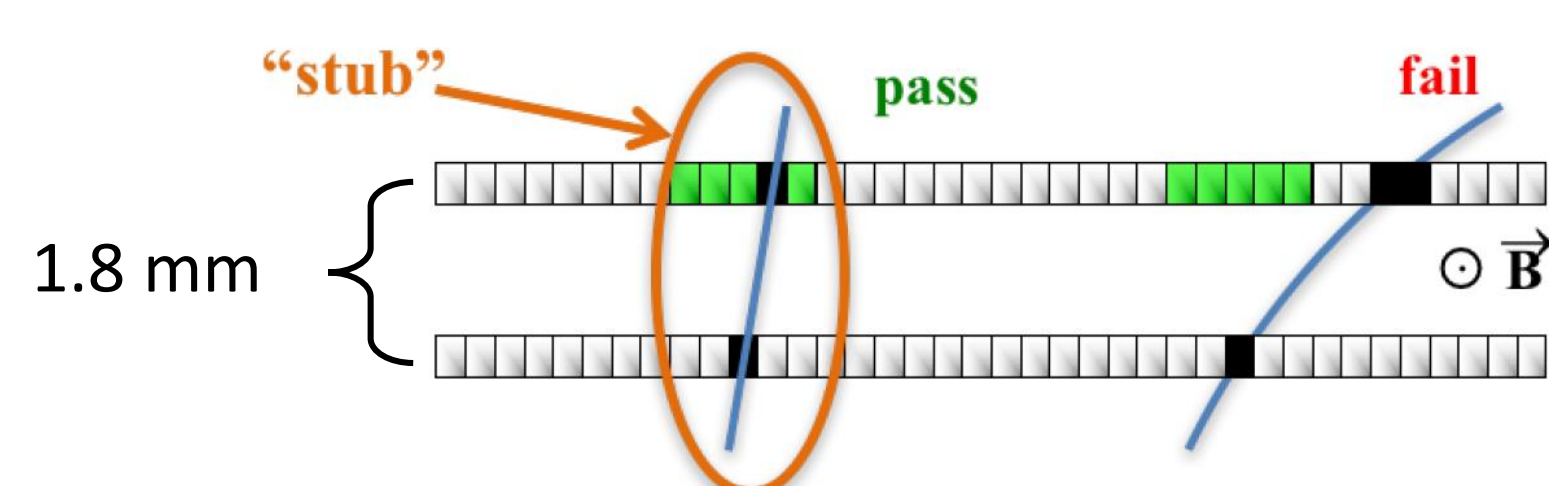
Bottom XTalk higher due to longer signal lines in hybrid fold over

Trigger Rate Scans

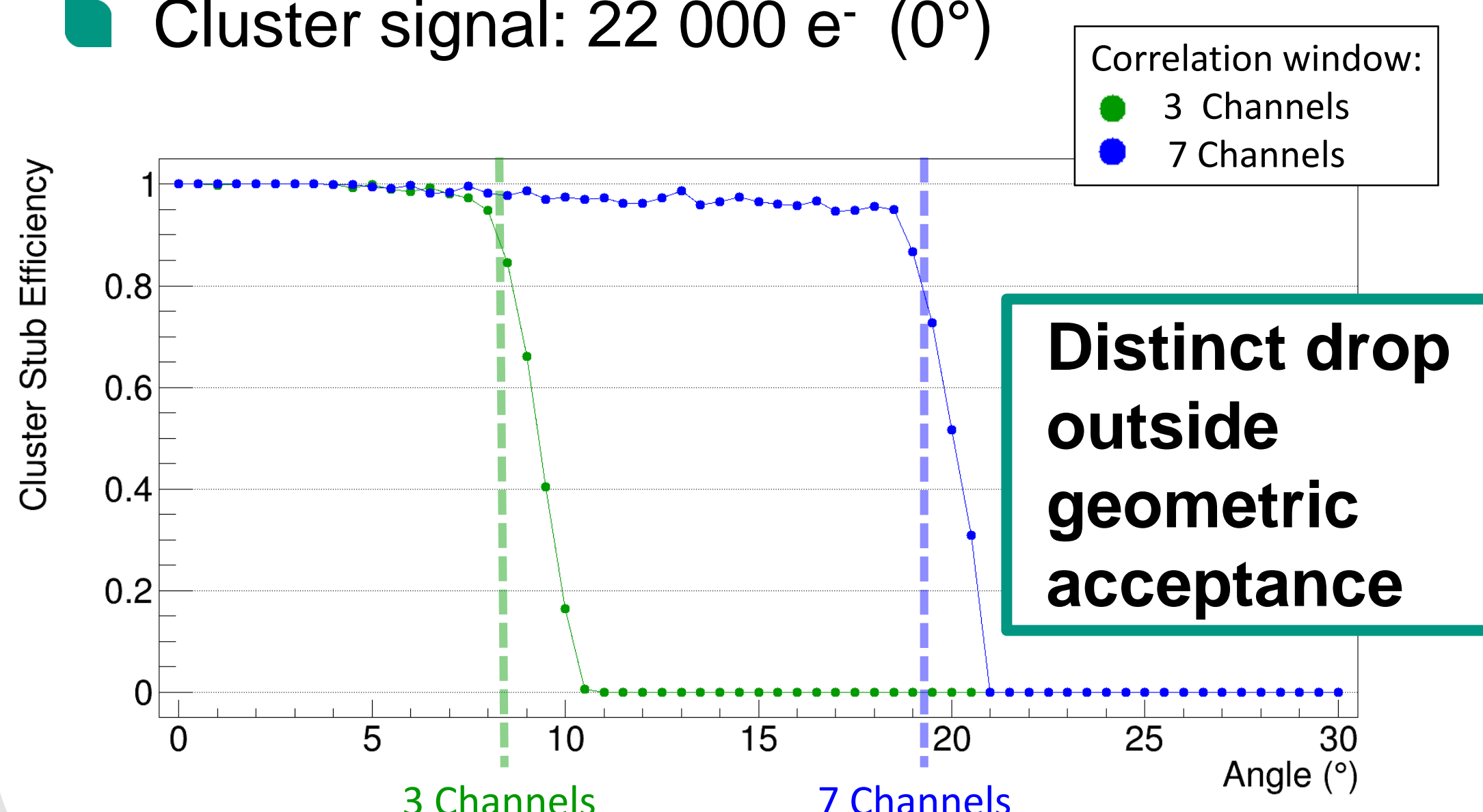
- Vary av. trigger rate (Poisson-distr.)
- Vary av. track density: **10 – 20 MHz/cm²**
- Reduced cluster signal: 17 000 e⁻ → 2.5×10^{14} n_{eq}/cm²
- Threshold: 5 000 e⁻



Track Inclination and Stubs



- Trigger rate: **750 kHz**
- Threshold: 5 000 e⁻
- Cluster signal: 22 000 e⁻ (0°)



Threshold Scans

- Vary cluster signal to emulate sensor irradiation
 - 22 000 – 17 000 e⁻ ($0 - 2.5 \times 10^{14}$ n_{eq}/cm²)
- Poisson-distributed trigger
 - Pile-up 140: **500 kHz**
 - Pile-up 200: **750 kHz**
- Track-based hit patterns
 - Perpendicular track orientation
 - Track density: **10 – 15 MHz/cm²**

Consistent with ⁹⁰Sr lab measurement

Pile-up independent

