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Current Status of:

- **Fw. Endcap frame**
- **EMC Readout**

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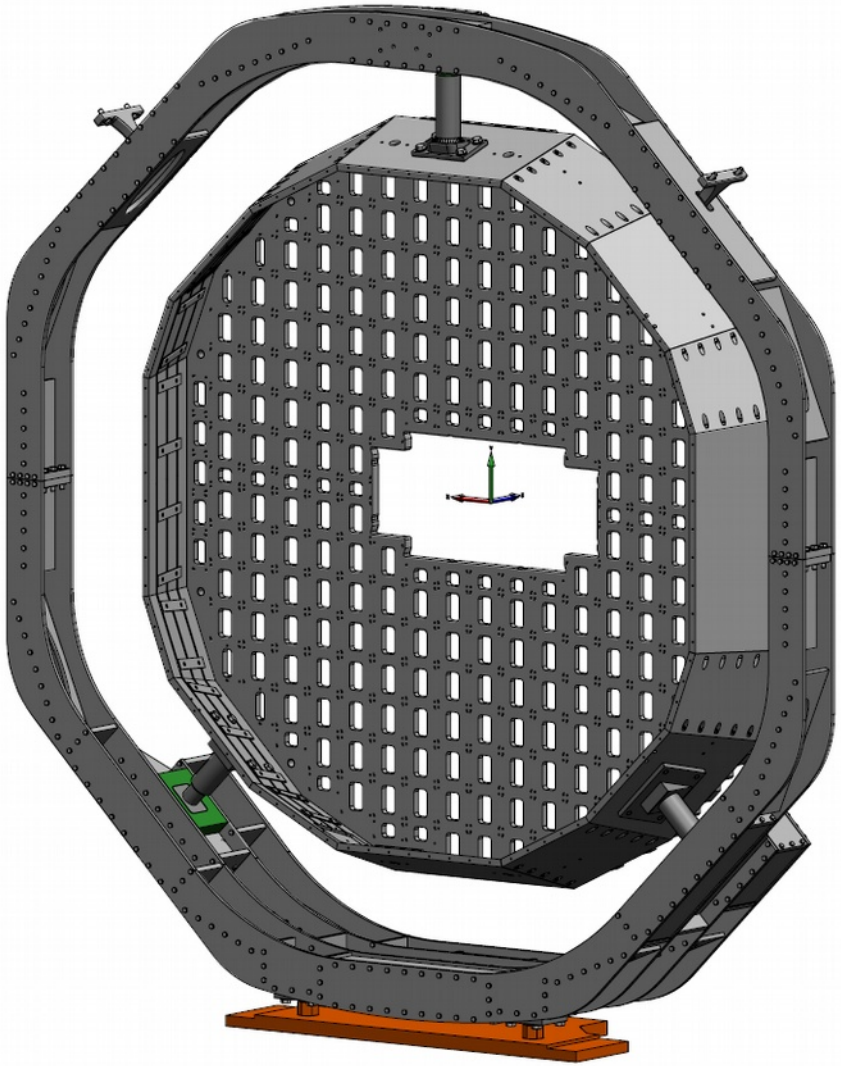
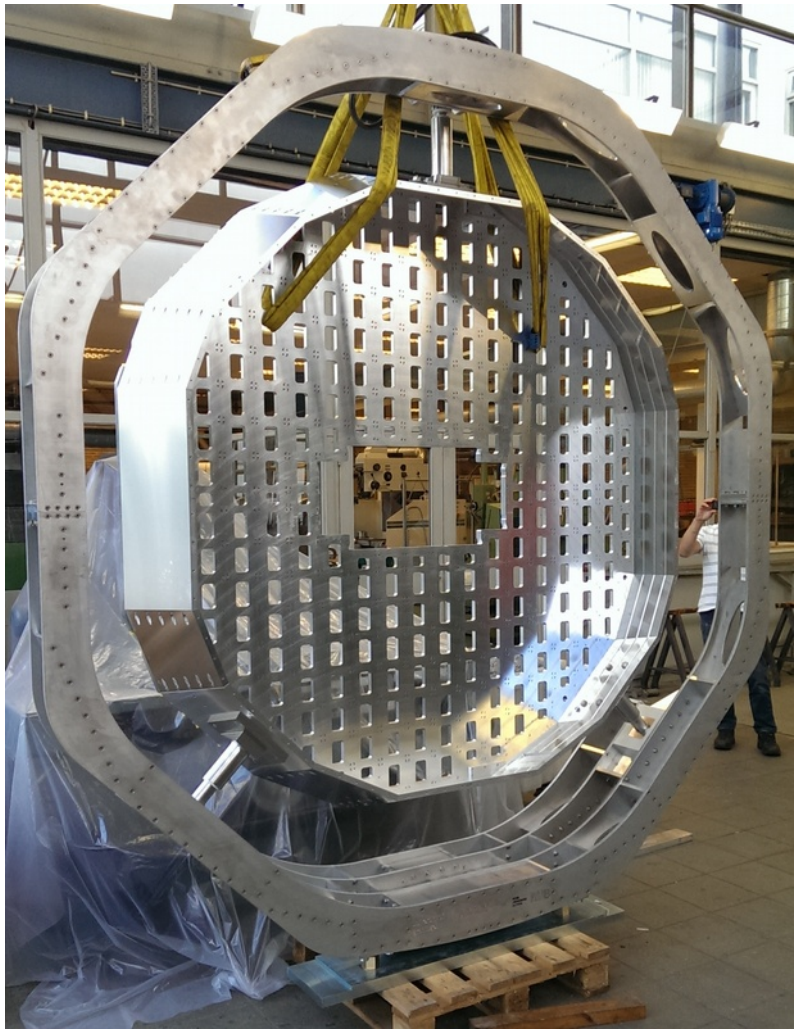
University of Groningen

Fw-Endcap Frame (Production)





Produced at KVI-CART:

- Design team: Michel Lindemulder, Henk Smit, Rick Veenstra
- Production team: Roelof Dussel, Sandra Eggens, Dirk Tilman, André de Vries

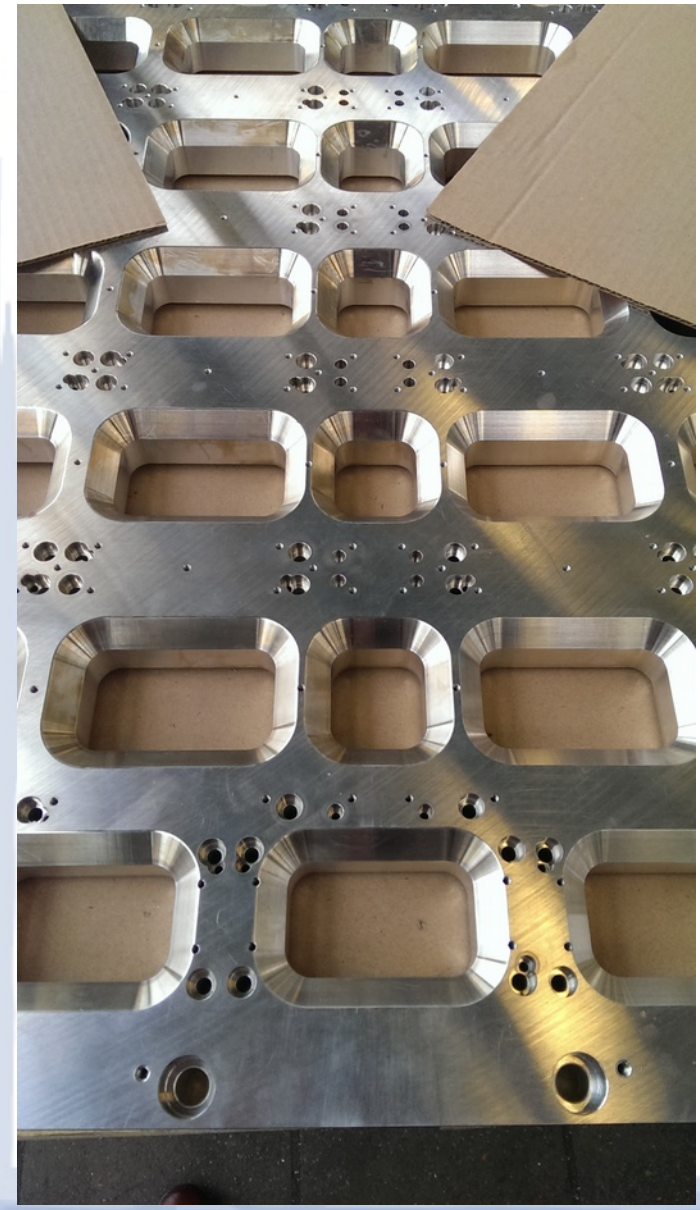
Mounting-plate Challenge

Production outsourced to external company. Inspection at KVI-CART:

- Visual inspection
- Check of NPT 1⁄2” threaded holes of cooling holes
- Check of other threaded holes
- Measurements of main dimensions
- Measurements of positions pockets and mounting holes interfaces
- Measurements dimensions pockets and mounting holes interfaces
- Leak test of cooling channels
- Measurements of test-settings drilling long holes

Production Faults

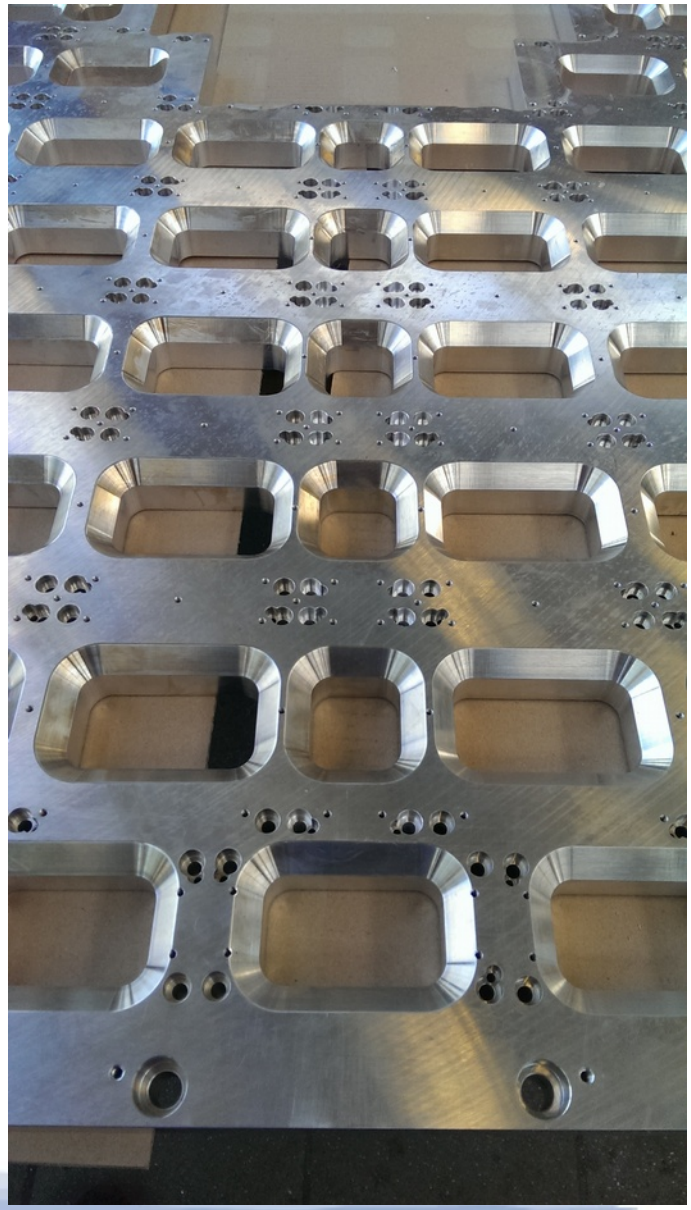
During visual inspection was found that some mounting holes are missing:



Mounting plate was sent to producer to fix the problem.

Plate with missing holes

Completed Plate



Positions of Pockets and Mounting-holes for Interfaces

To measure positions of holes dedicated pins were produced:

- Largest deviation **0.19 mm** (tolerance according to specifications **0.25 mm**)

Position of pockets:

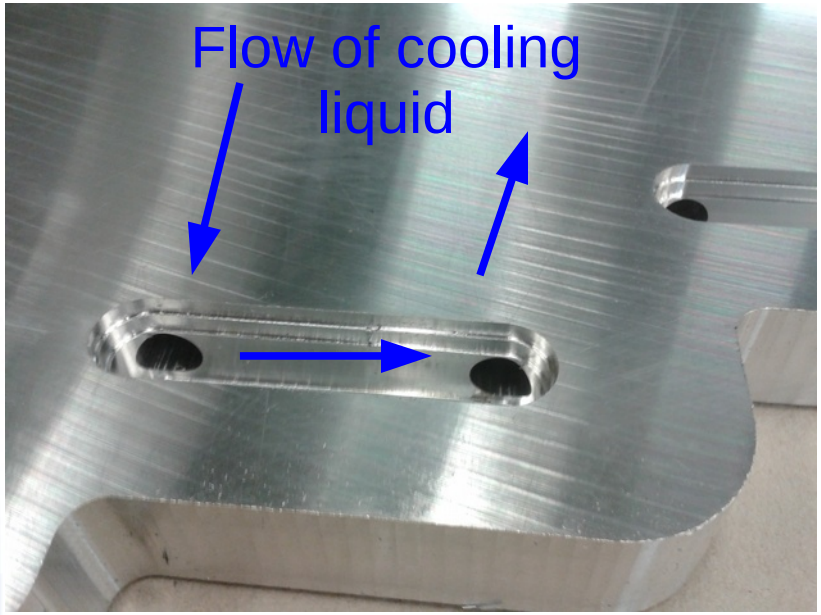
- Largest deviation **0.45 mm** (tolerance according to specifications **1 mm**)

Pitch mounting holes interfaces(mm)					
Position	Dimension	Measured	Deviation	Tolerance	Note
+X9 -Y1	44,5	44,41	-0,09	±0,25	
+X9 -Y1	44,5	44,43	-0,07	±0,25	
+X9 -Y1	98	97,98	-0,02	±0,25	
+X9 -Y1	98	98,02	0,02	±0,25	
+X8 -Y1	98	97,95	-0,05	±0,25	
+X8 -Y1	98	97,99	-0,01	±0,25	
+X8 -Y1	98	97,95	-0,05	±0,25	
+X8 -Y1	98	97,95	-0,05	±0,25	
+X7 -Y1	98	97,96	-0,04	±0,25	
+X7 -Y1	98	97,96	-0,04	±0,25	
+X7 -Y1	98	97,99	-0,01	±0,25	
+X7 -Y1	98	97,94	-0,06	±0,25	
+X6 -Y1	98	97,95	-0,05	±0,25	
+X6 -Y1	98	97,9	-0,1	±0,25	
+X6 -Y1	98	97,98	-0,02	±0,25	
+X6 -Y1	98	97,95	-0,05	±0,25	
+X5 -Y1	98	97,92	-0,08	±0,25	
+X5 -Y1	98	97,91	-0,09	±0,25	
+X5 -Y1	98	97,97	-0,03	±0,25	
+X5 -Y1	98	97,99	-0,01	±0,25	
+X4 -Y1	98	97,96	-0,04	±0,25	
+X4 -Y1	98	97,94	-0,06	±0,25	
+X4 -Y1	98	97,97	-0,03	±0,25	
+X4 -Y1	98	97,95	-0,05	±0,25	

About 100 measurements were done to check all dimensions (10-page document)

KVI Leak Test of Cooling Channels

U-turn pockets were closed by caps, welded and polished



All cooling channels were tested to be vacuum-tide
(requirement in specification: water tight):

Achievable pressure after pumping:

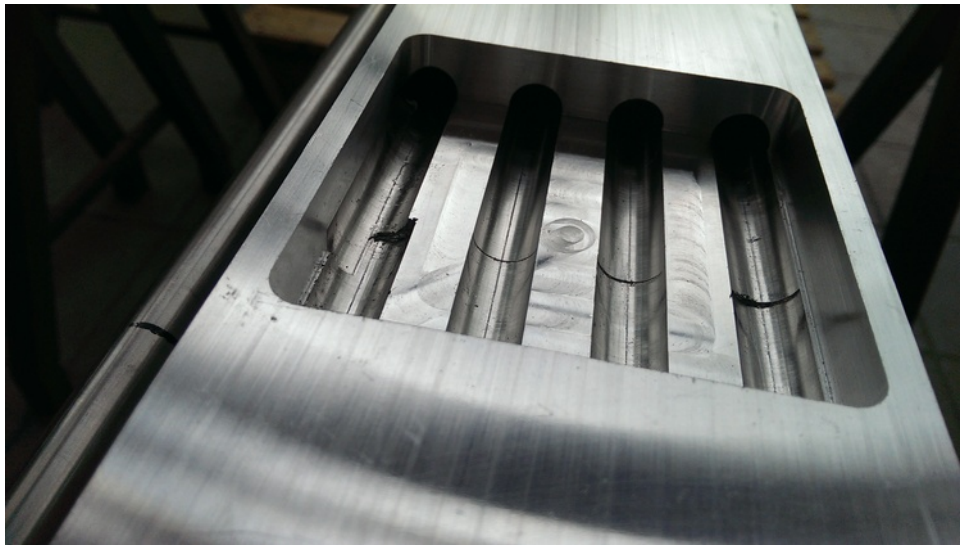
- Most of the channels: 10^{-9} – 10^{-8} mbar
- One channel with U-turn: 10^{-5} mbar

Conclusion: all channels are water tight

Long-holes Drilling

Deviation of the long holes were not measured for the mounting plate (too time-consuming)

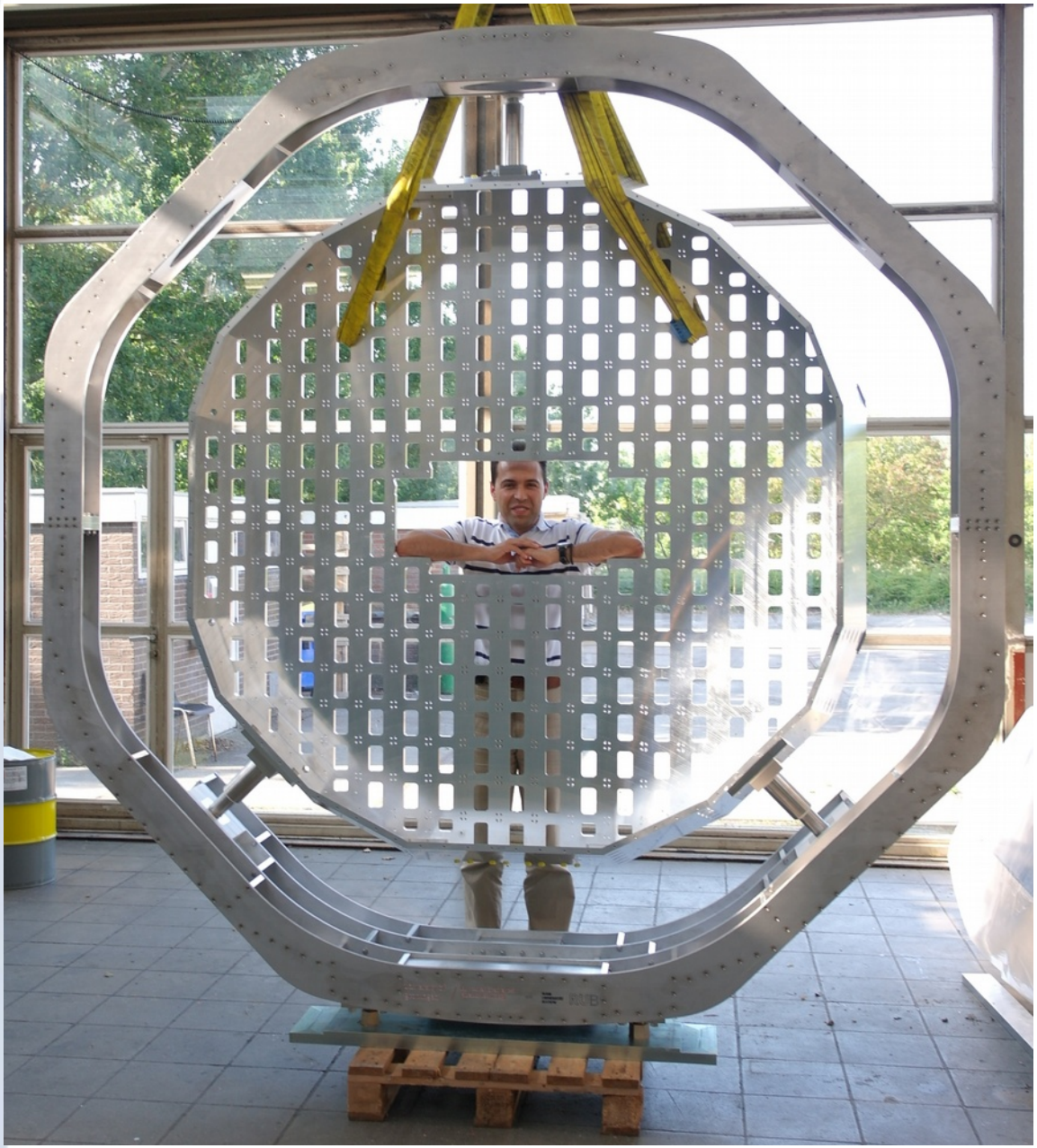
The test-drilling plate was opened in the middle (point of largest deviation):



Maximum measured deviation is 2.7 mm (closest drilling to the cooling channels is 4.25 mm):

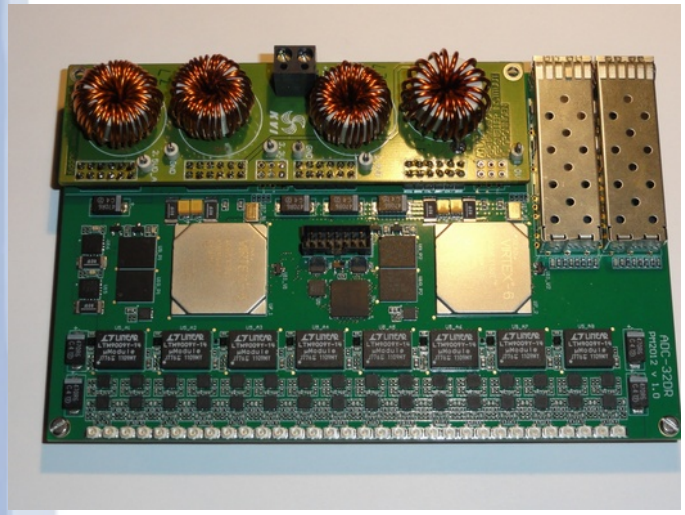
- For the test drilling the machine was not tuned
- For the drilling in the mounting plate the machine was tuned, therefore deviation should be smaller

Conclusion: drilling fulfils specifications



Frame is ready for further assembly of the endcap

EMC Readout

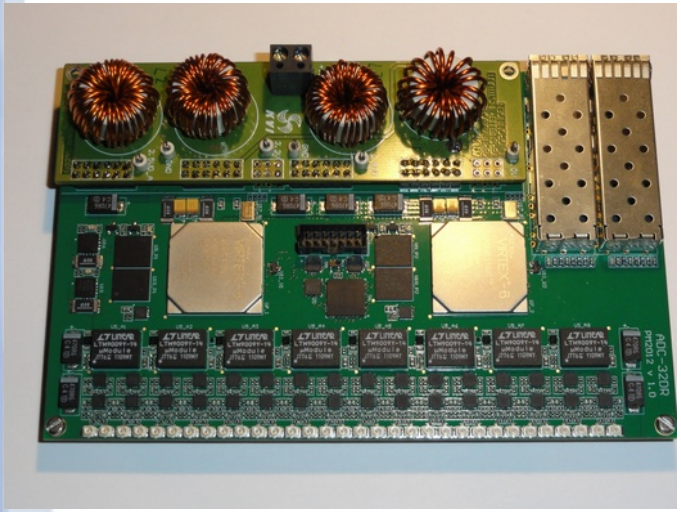


- **Tests of the digitiser performance at Bonn**
- **Status of the firmware**

Engineers working on the firmware:

Peter Schakel, Oscar Kuiken, Peter Lemmens

Performance-test at Bonn



Aim of the measurement:

- Collect waveforms to finalize pile-up recovery algorithm
- Tests of the on-line feature-extraction algorithm

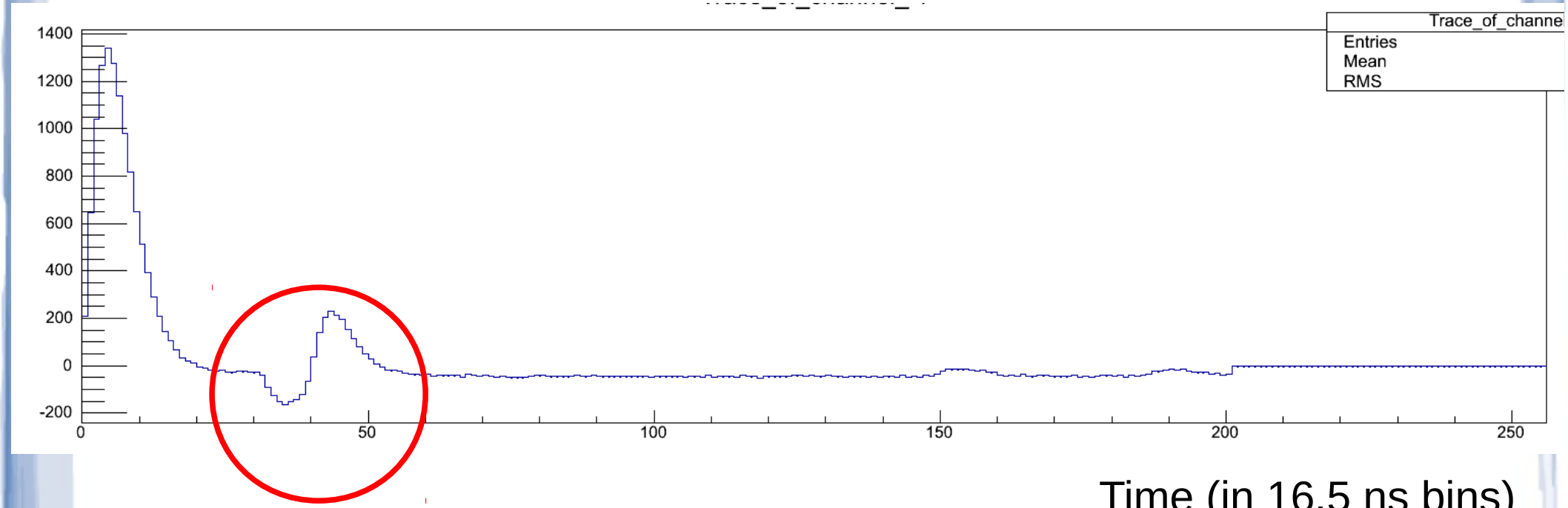
Beam:

- Electrons of ~1.2 GeV (rate up to 500 kHz)
- Photons + light pulser (rate up to 500 kHz)

Limitations of the test:

- Limited band-width DC-PC (losses of data)
- No Super-burst building (some hits from one cluster might be lost)

Waveforms Inspection



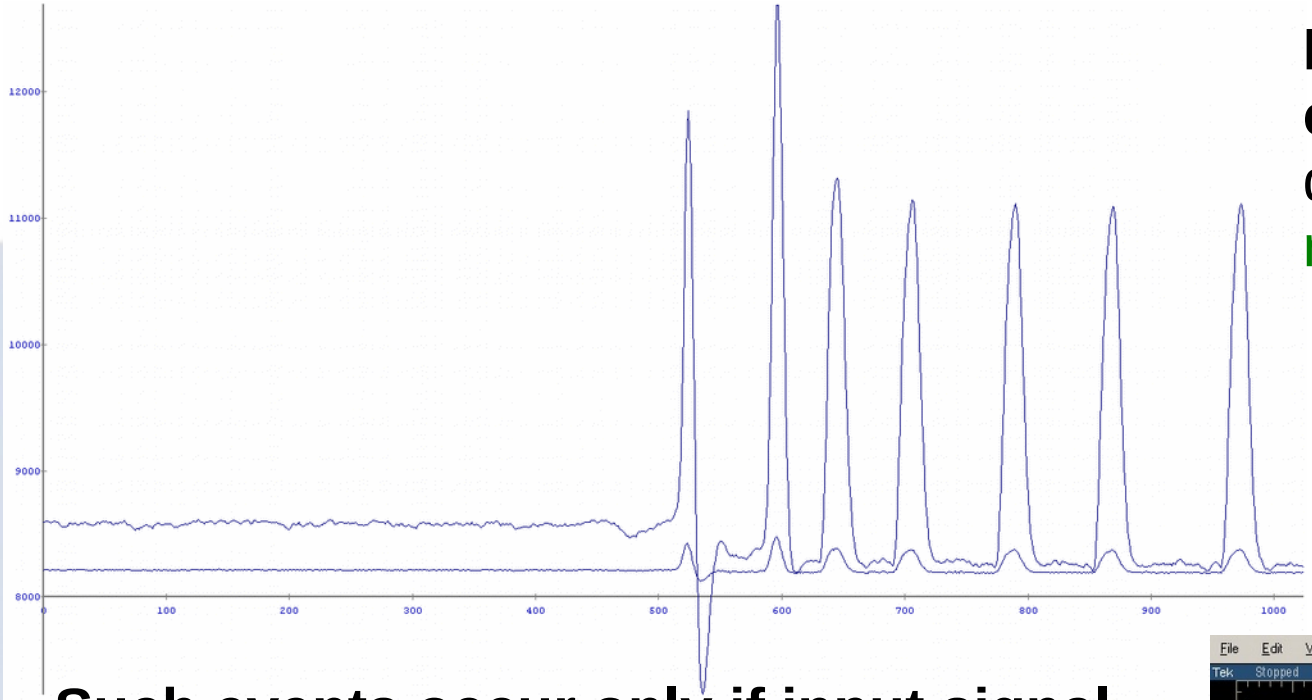
Time (in 16.5 ns bins)

Negative pulses observed!

- Fault of the feature-extraction (base-line follower)?
- Fault of input stages?
- Fault of the preamplifier?

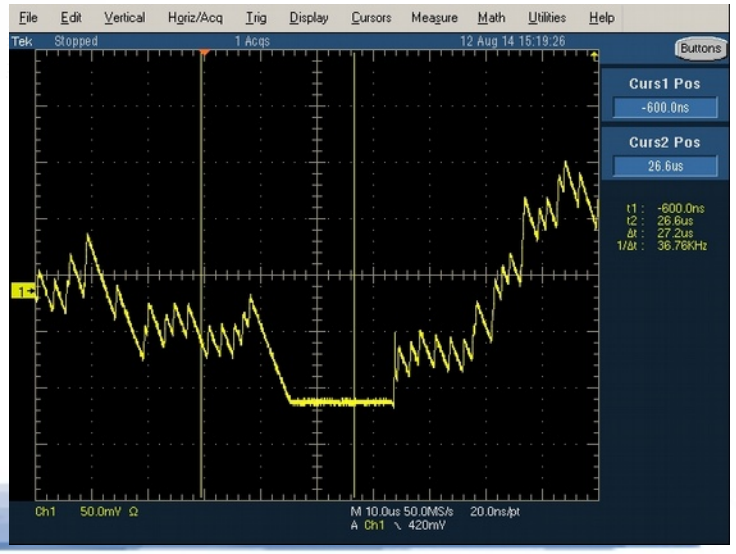
Tests with Pulse-Generator

The effect was reproduced with the ORTEC random pulse-generator:



Picture captured with chip-scope (data coming directly from ADC chip, no feature-extraction)

Such events occur only if input signal clips to the rail (preamplifier overloaded)



Conclusion:

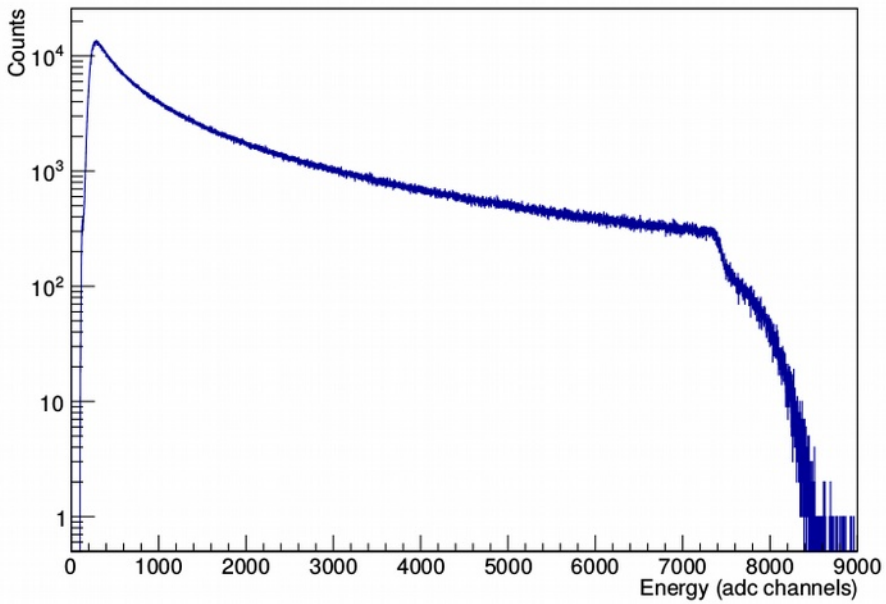
- **At Bonn the rate/beam-energy were too high**
- **Feature-extraction works properly**

Light-pulser measurement

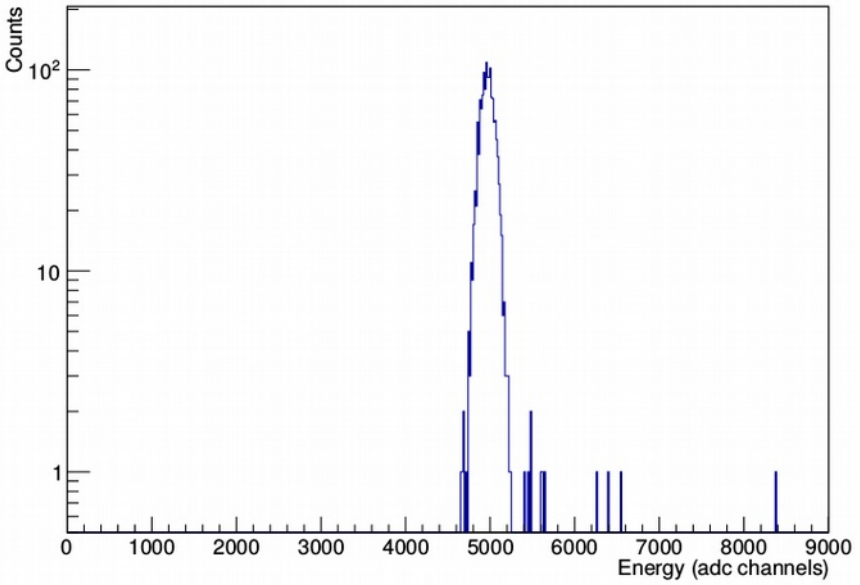
Measurement was performed with one crystal (VPTT):

- Light pulser with fixed energy (rate ~30 Hz)
- Light-pulser trigger was fed to one channel of digitizer (selection of the LP events)
- Photon beam as background (rate up to 500 kHz)

Energy spectrum of all hits (photons + LP)

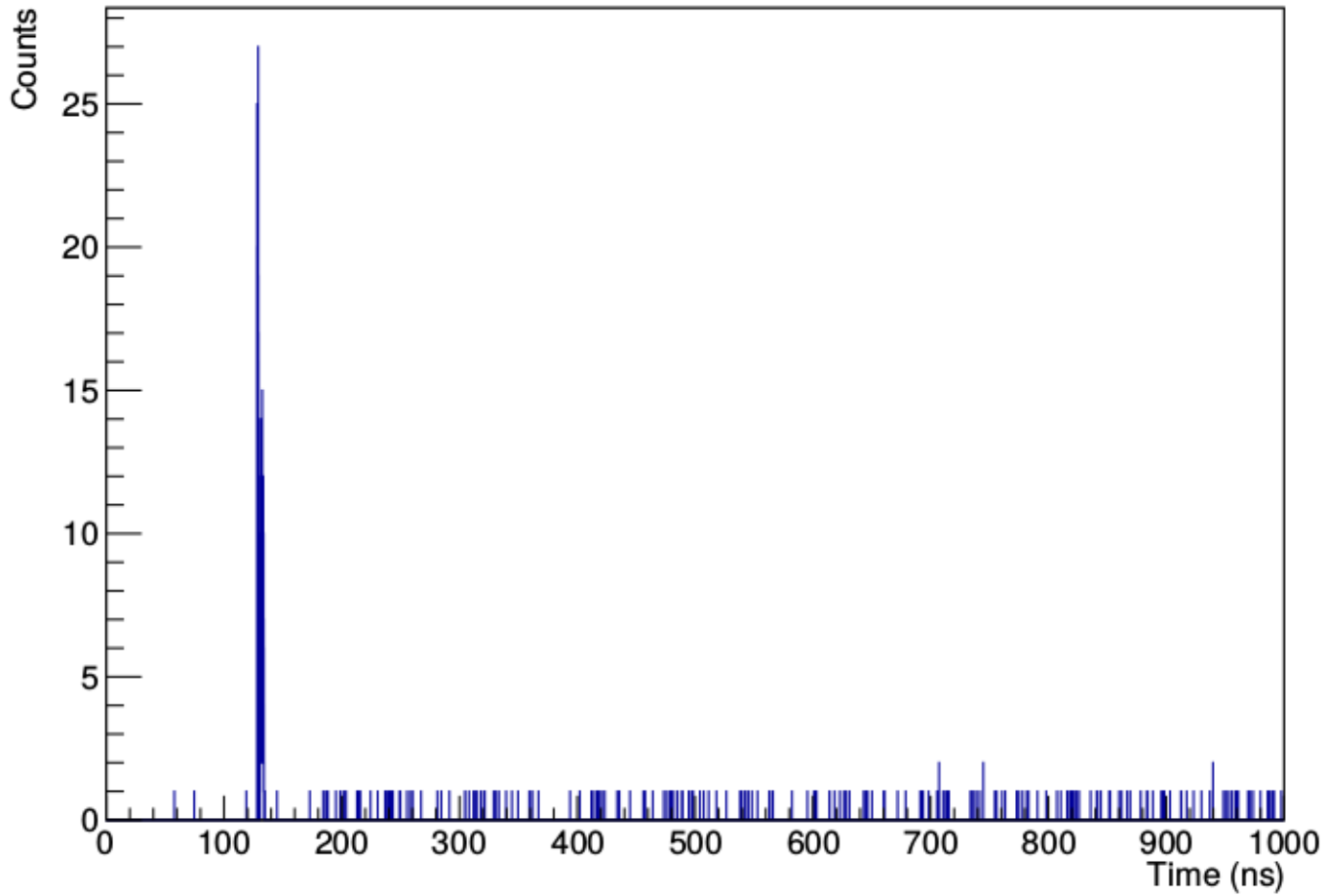


Energy spectrum of hits tagged as LP



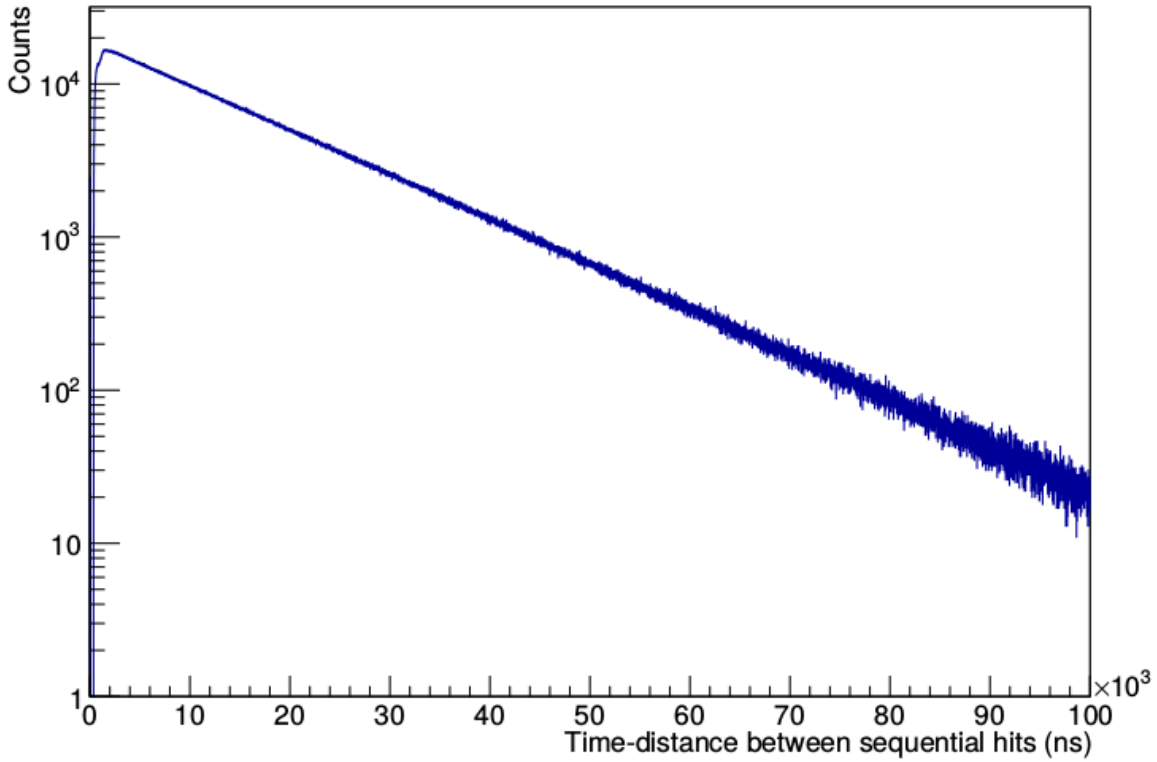
Event Selection

Time-difference spectrum for tagger (trigger) hits and the and the photon/LP hits



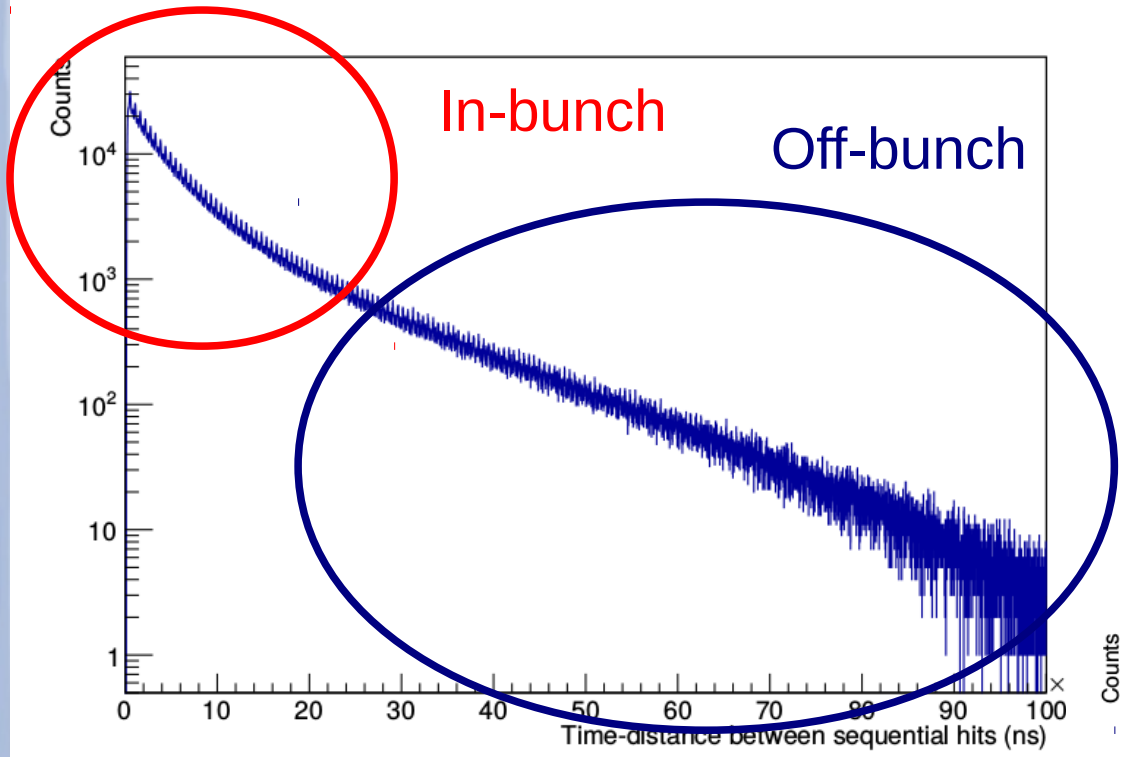
Hit-Rate Determination

Time-distance between sequential hits is supposed to have an exponential distribution (Poisson process): **slope ↔ hit rate**

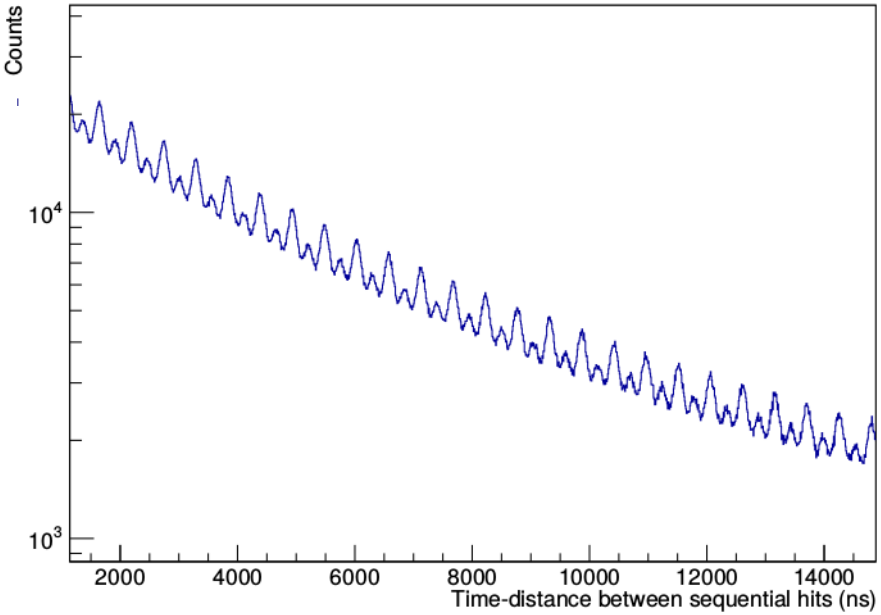


Measurement with ORTEC random pulse-generator

Hit-Rate @ Bonn



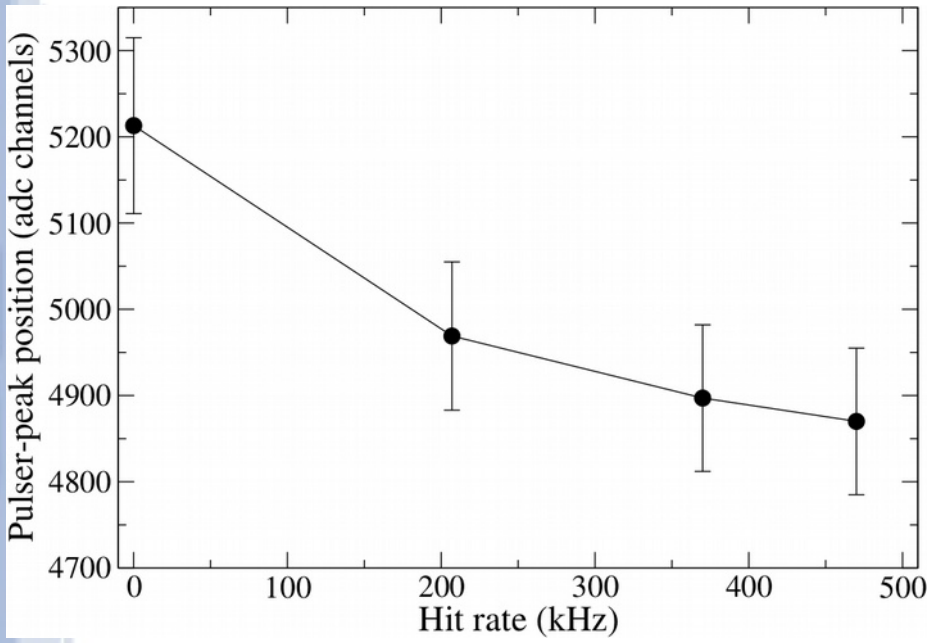
Zoom of the distribution:
RF structure of accelerator?



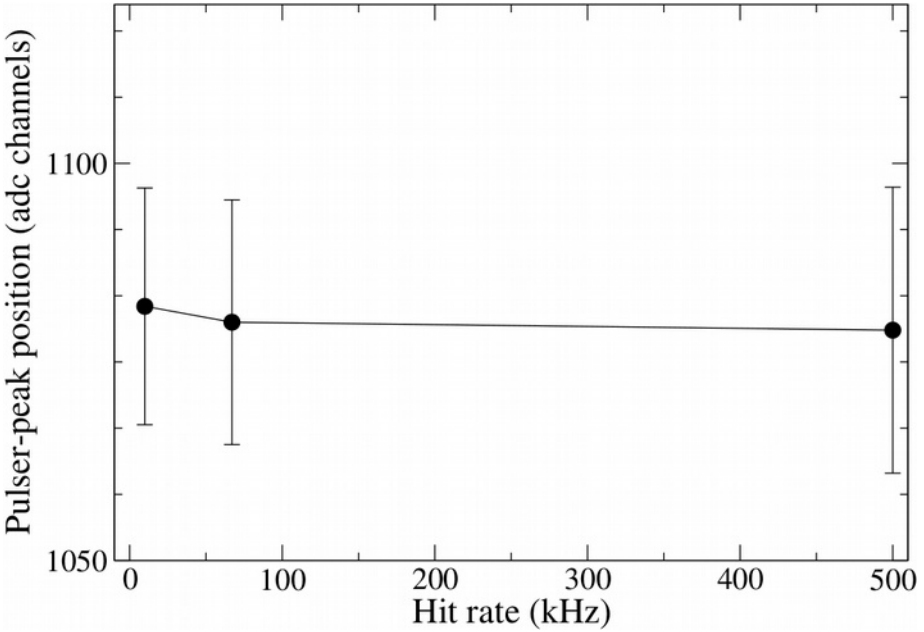
For all further measurements I took the steepest slope as the hit-rate

Dependence of VPTT gain on hit rate

Position and width (sigma) of LP peak



Peak position measured for the ORTEC random pulse-generator



Conclusion: VPTT demonstrates significant rate dependence

Status of the Readout Chain

- **SODANET frequency is set to 160 MHz (ADC operate at nominal 80 MHz)**
- **Data concentrator:**
  - Running on TRB3 board and WASA VME board (Virtex 6)
  - Receiving Waveforms and Hit-data over fiber from FEE
  - **Energy calibration for each ADC channel (low and high gain separately)**
  - **Superburst building**
  - Put each Waveform in one Panda data-packet (debugging mode)
  - Send Panda data-packets over fiber to UDP translator
  - **Slow Control with SODANET**
  - **Combine hits from two digitizers corresponding to the same crystal**
  - Additional features:
    - On-line histogram
    - Data monitoring: hits and waveforms
    - Error detection and counting
- Digitizer: Rewriting some parts of the code in order to improve modularity (towards triple modular redundancy)

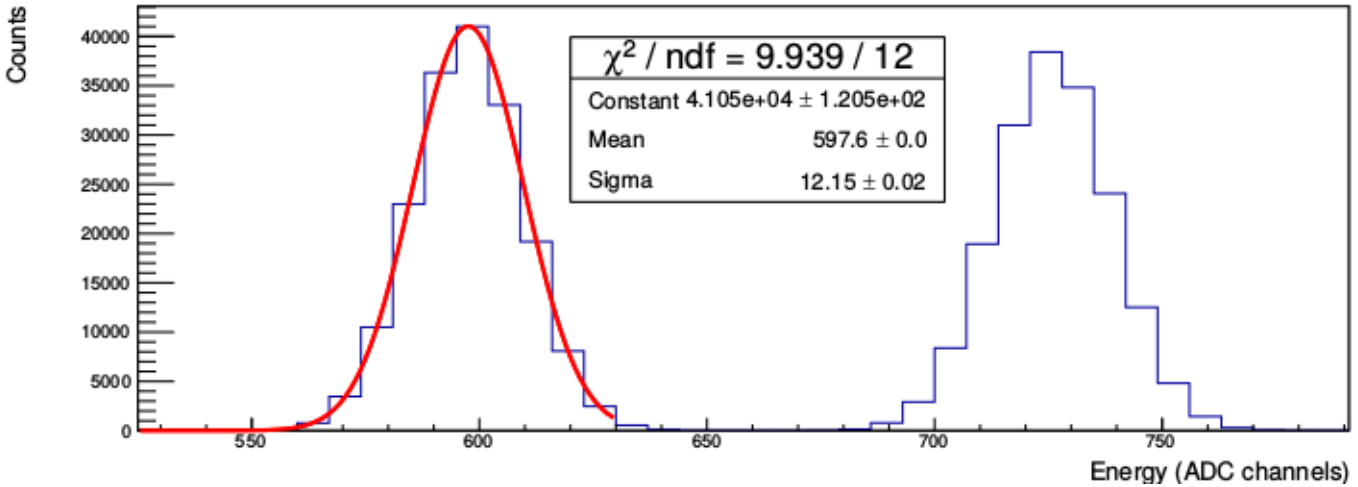
Test of hits-Combining

Hits measured by two LAAPDs mounted on one crystal have to be combined in the data concentrator:

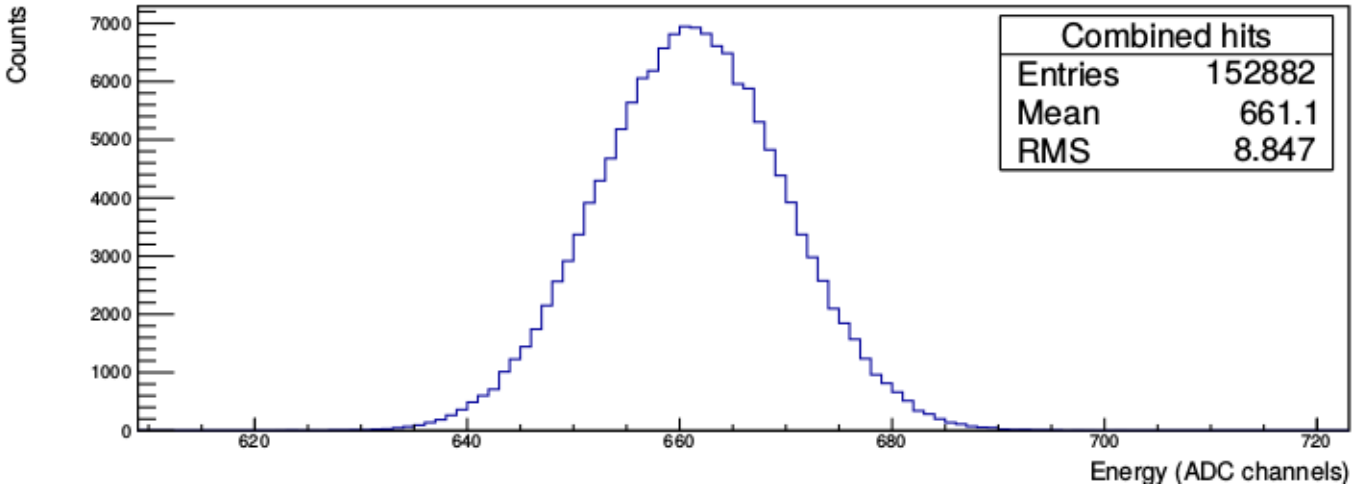
- Combining works for high and low gains (prior energy calibration is necessary)
- Hits with too large energy difference are not combined but marked with dedicated status bit (nuclear counter effect)
- Energy and time information for combined hit is averaged (gain of 1.4)

Improvement of Energy Resolution

Not combined hits (sigma for both channels ~12)



Combined hits (sigma ~9)



Same effect observed for the time-difference distributions

Summary

- Frame for the forward-endcap EMC is produced according to specifications
- Beam-test at Bonn demonstrated expected performance of the digitizer at realistic conditions
- Collected waveform data will be used to finalise on-line pile-up recovery algorithm
- Functionality of the EMC data concentrator is completed
- Firmware of the EMC digitizer is being redesigned to incorporate modular redundancy and on-line pile-up recovery

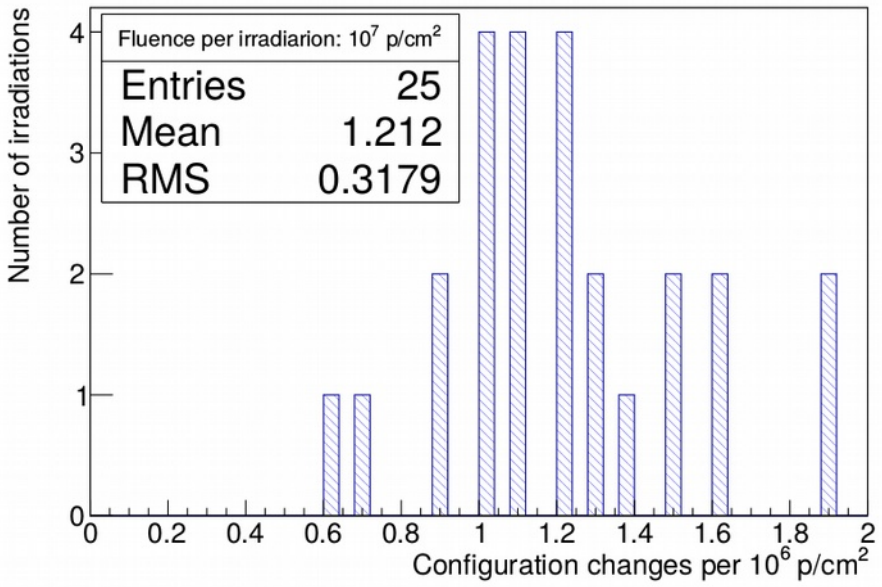
Radiation Hardness of FPGAs

Irradiation of Virtex-5 and Kintex-7 FPGAs:

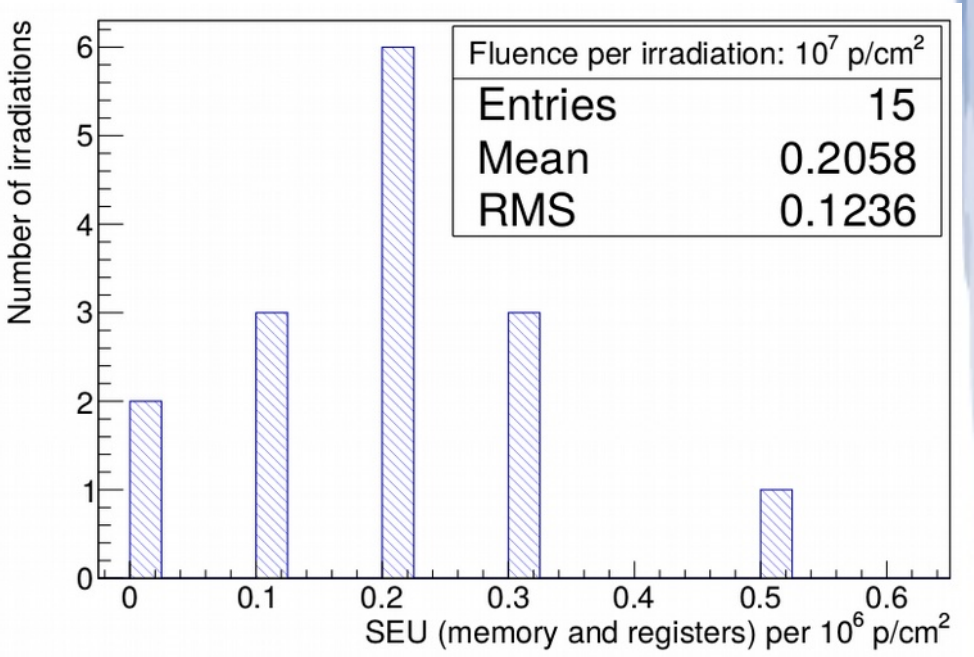
- Irradiations were performed with proton beams (~150 MeV)
- FPGAs were configured to constantly compare content of registers and memory blocks (SEU check)
- At the end of irradiation cycle number of configuration errors were measured, FPGA was reconfigured

Irradiation of Virtex-5

Configuration changer per 10^6 p/cm^2



SEU per 10^6 p/cm^2

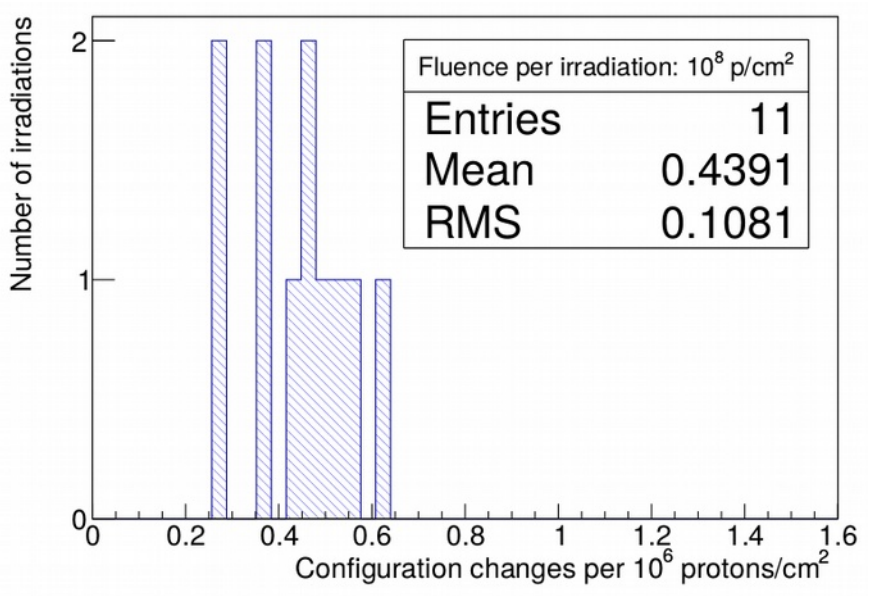


Used resources:

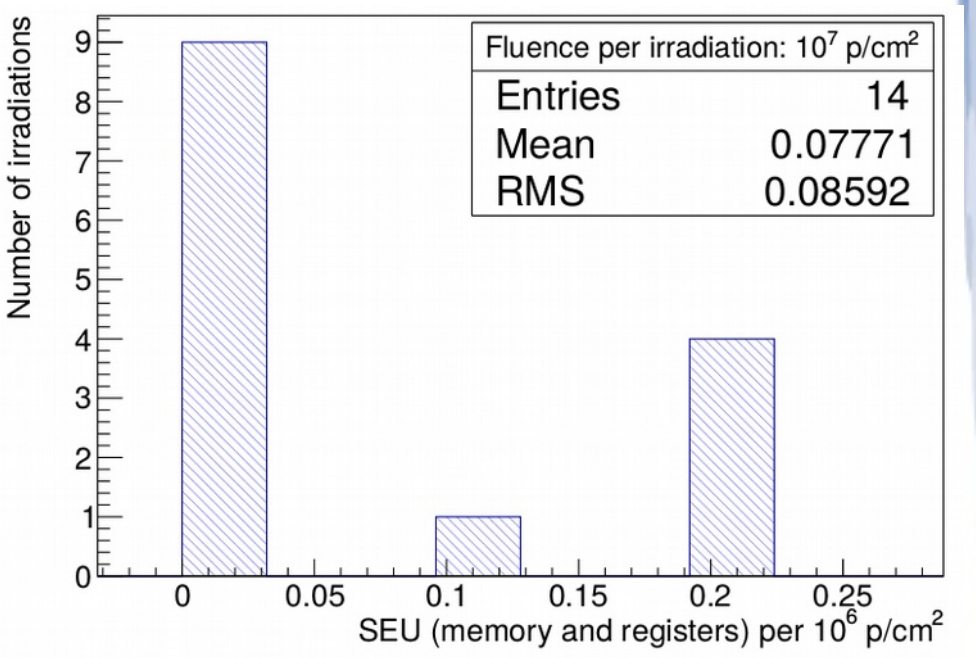
- 28800 registers, **64% used**;
- 2160kb ram, **55% used**

Irradiation of Kintex-7

Configuration changer per 10^6 p/cm^2



SEU per 10^6 p/cm^2



Used resources:

- 407600 registers, **54% used**;
- 16020kb ram, **86% used**

Averaged number of configuration changes: 0.46(13) pre 10^6 p/cm^2

Summary
(FPGA irradiation)

- Kintex-7 is less prone for the configuration changes (factor 3) even without taking into account that is has much more resources (factor 10)

- During the measurements it was never observed SEU without a single configuration change →
  SEU is much less probable then the configuration change

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Thank you for your attention!