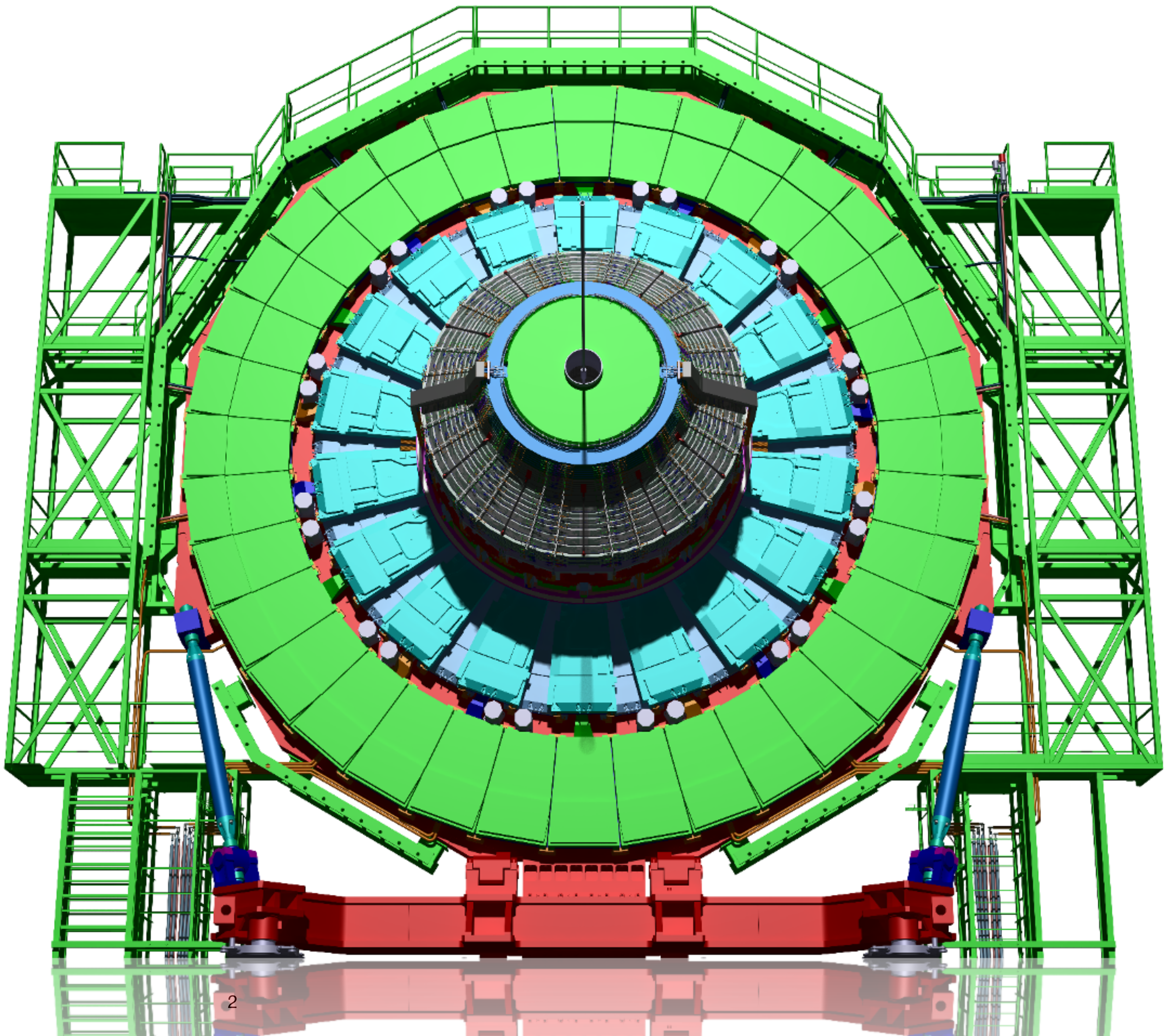
Characterisation of the Time of Arrival Sensor for the High-Granularity-endcap-Calorimeter

Alexander

Introduction to HGCal

a next-gen imaging Calorimeter

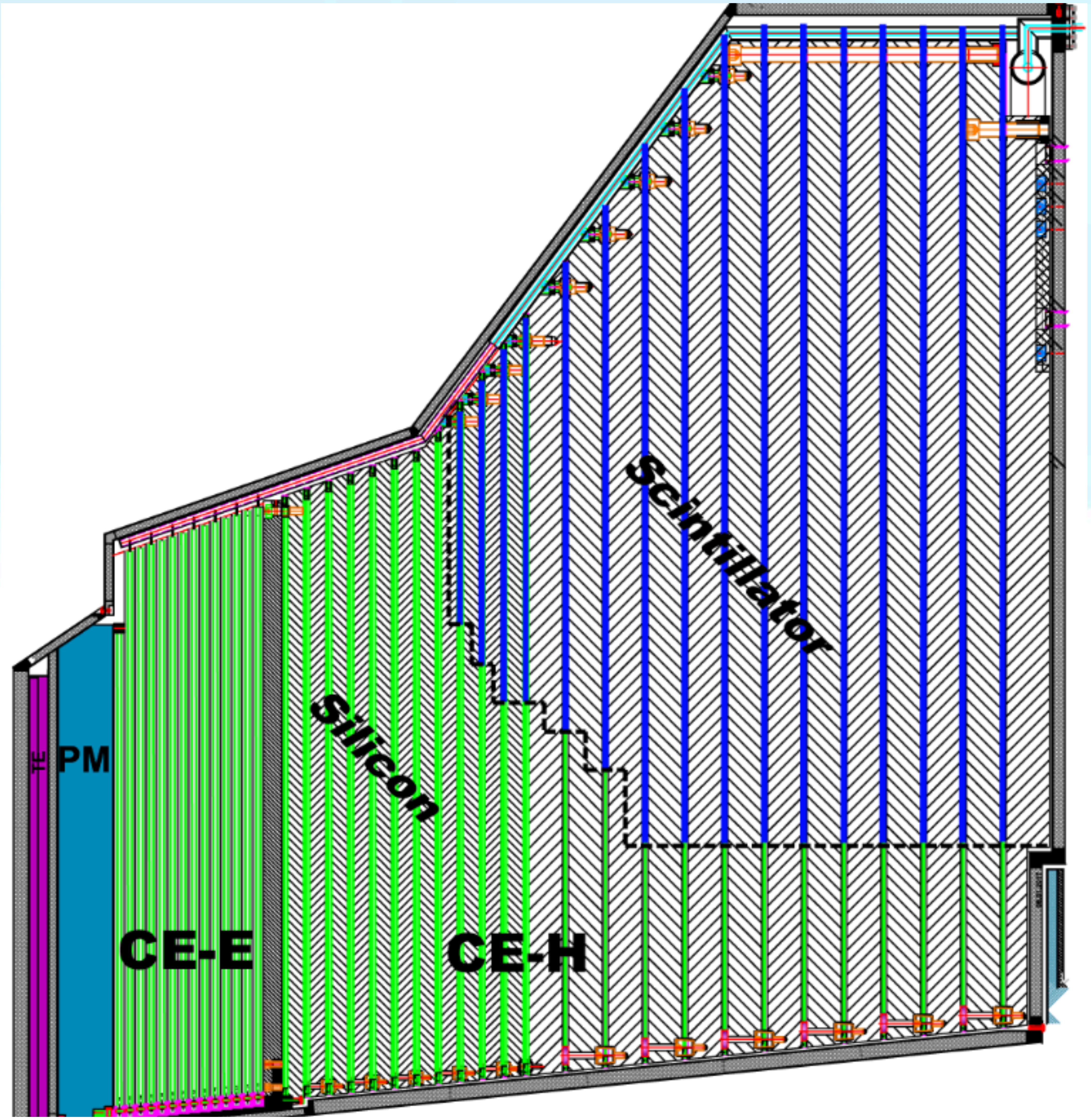


Why HGCAL

- HI-Lumi LHC upgrade will see an order of magnitude more pileup
- Current CMS endcaps are reaching their end of life
- High radiation environment in the endcaps requires radiation hard sensor material
  - Silicon Sensors for high radiation environment
  - Scintillators used in low occupancy areas
- very high pixel density and high resolution time of Arrival measurement allow for an ‘Image’ of the electromagnetic and Hadronic showers even at high fluences
- High granularity allows current level of physics performance at the interaction rates of the HL-LHC

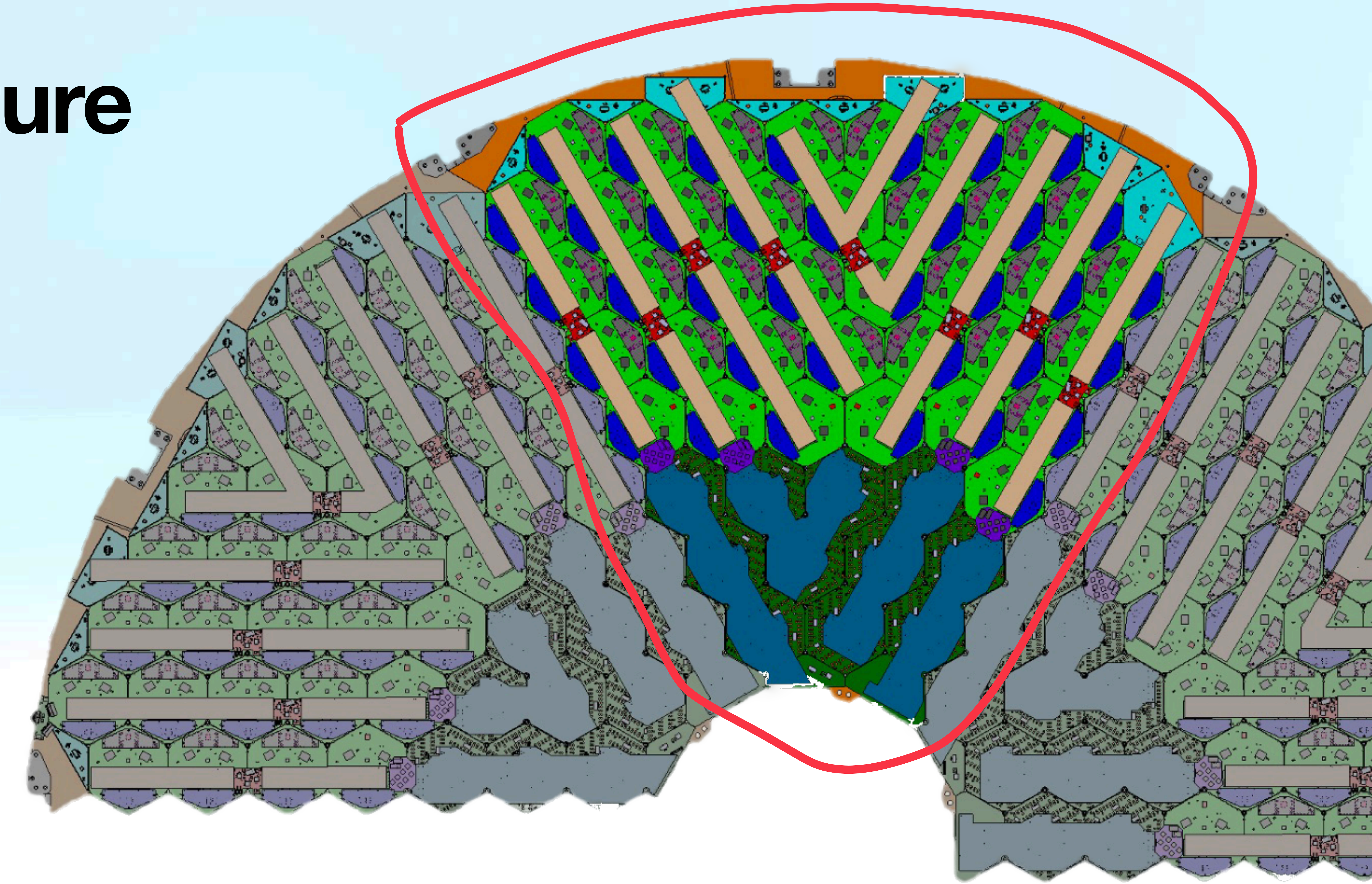
Detector-Architecture

- Sampling Calorimeter
  - Electromagnetic and Hadronic section
- 2 Sensor Types:
  - Silicon (Diode) (green)
  - Scintillator on SiPM (blue)
- 6M channels on ~620m^2 silicon
- 270K channels on ~ 370 m^2 of scintillator area
- High precision timing information for pileup mitigation
- **Imaging** Calorimeter



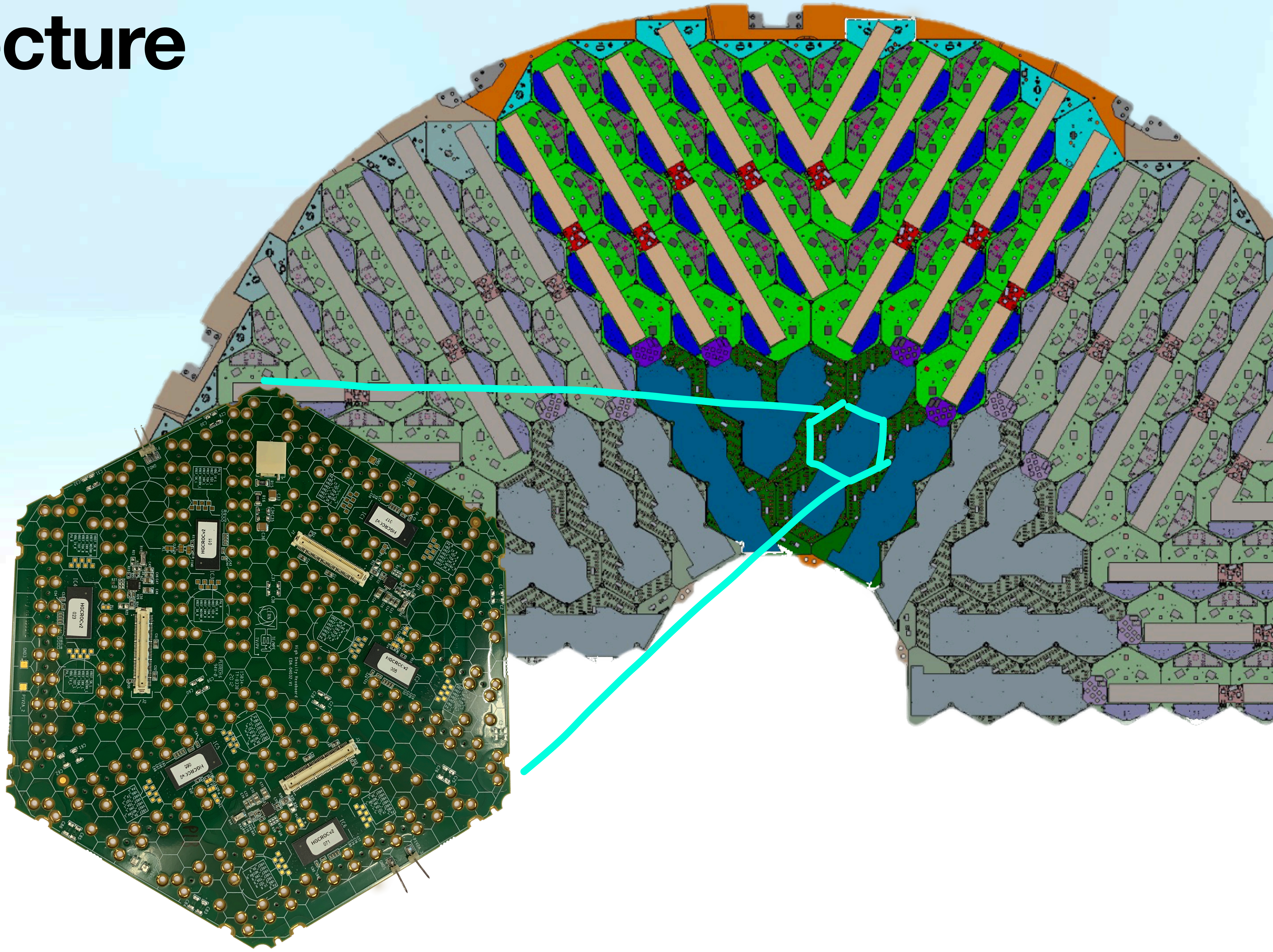
Detector Architecture

- Sampling-Detector built in layers
- Layers split into cassetts



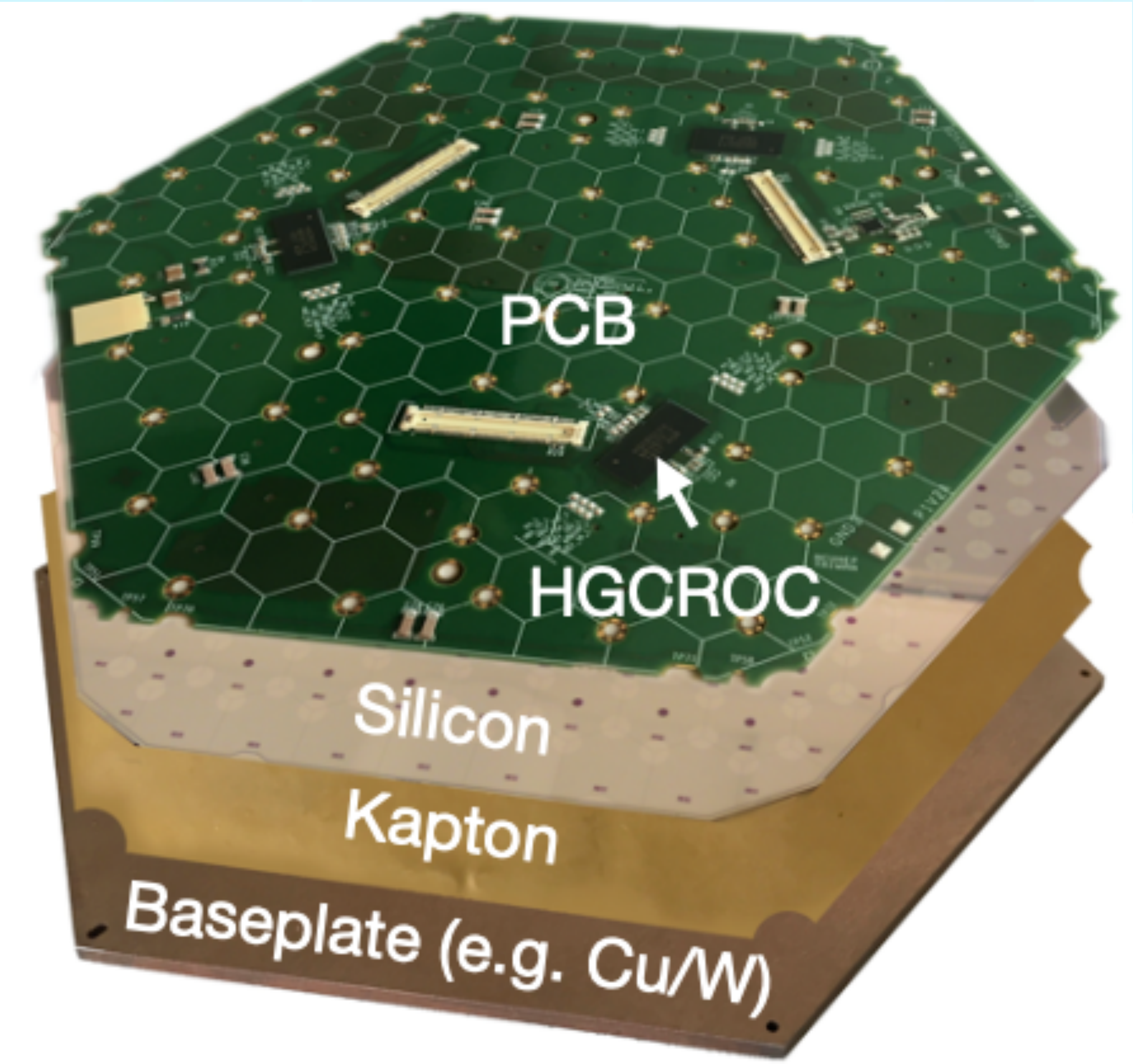
Detector Architecture

- Sampling-Detector built in layers
- Layers split into cassetts
- Cassette split into hexagonal modules
- modules carry 6/3 Read out Chips (ROCs)



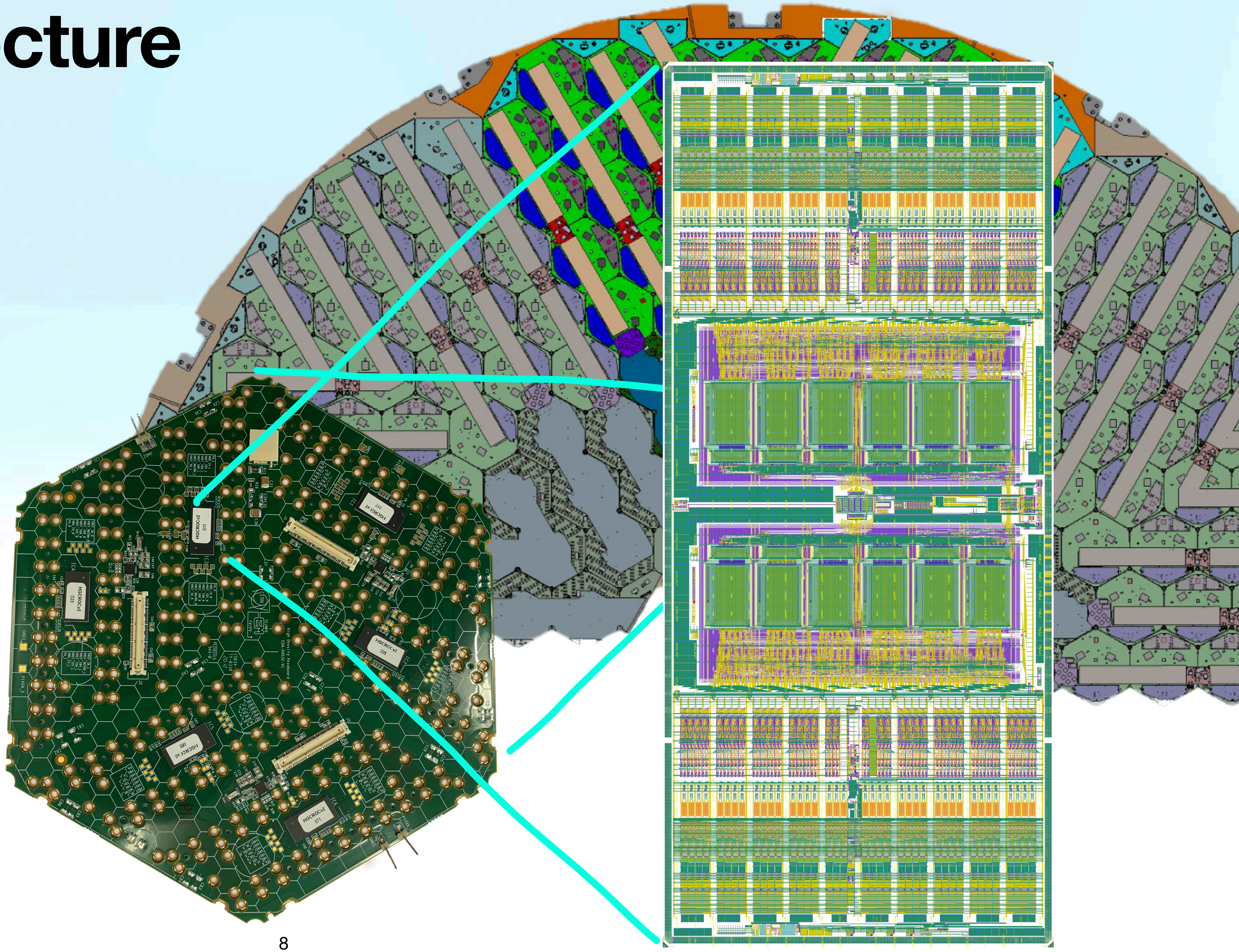
Detektor Architecture

- Module consists of Absorber Baseplate (Copper/Tungsten)
- Large 8’ silicon sensor with

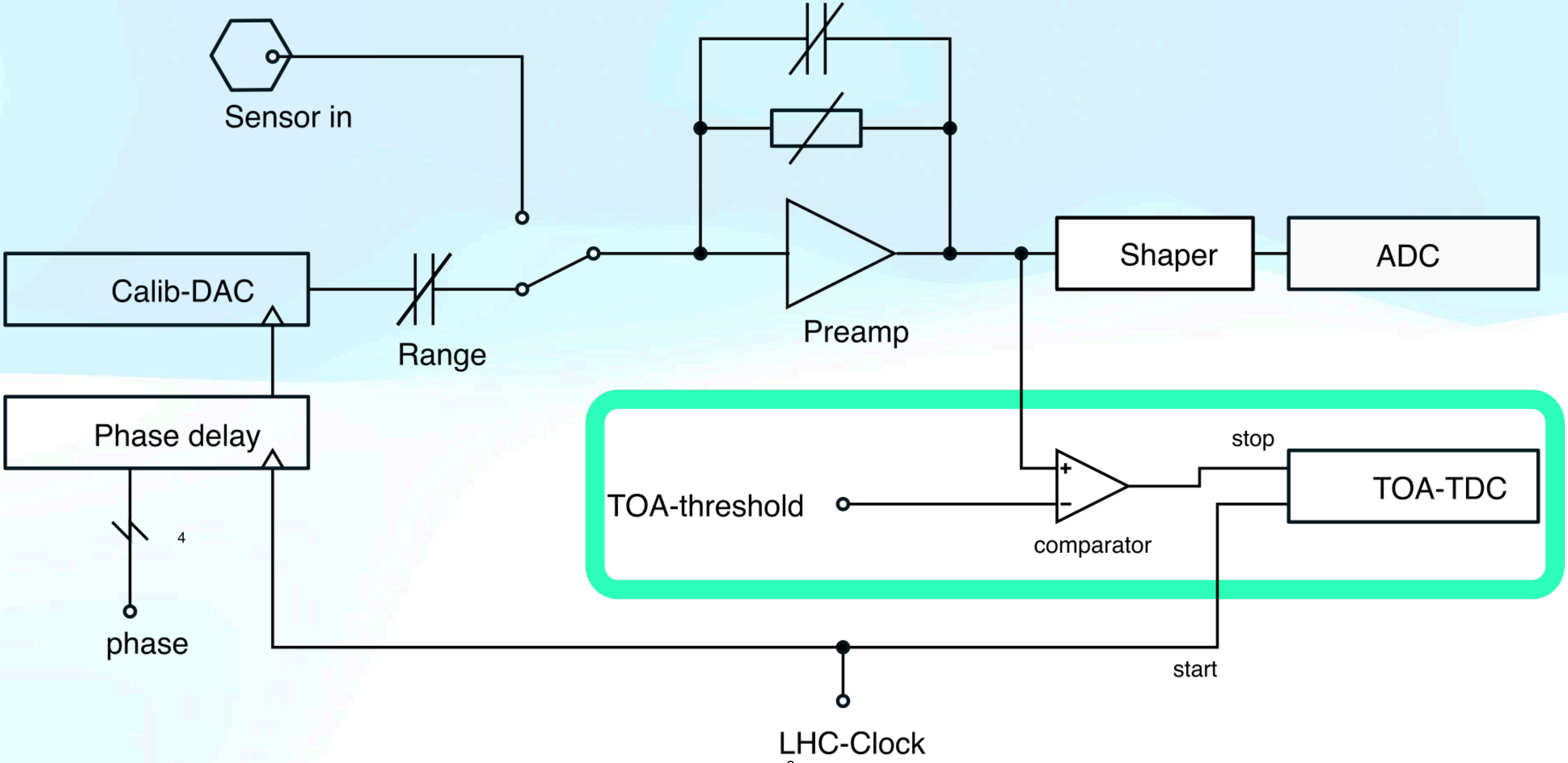


Detector Architecture

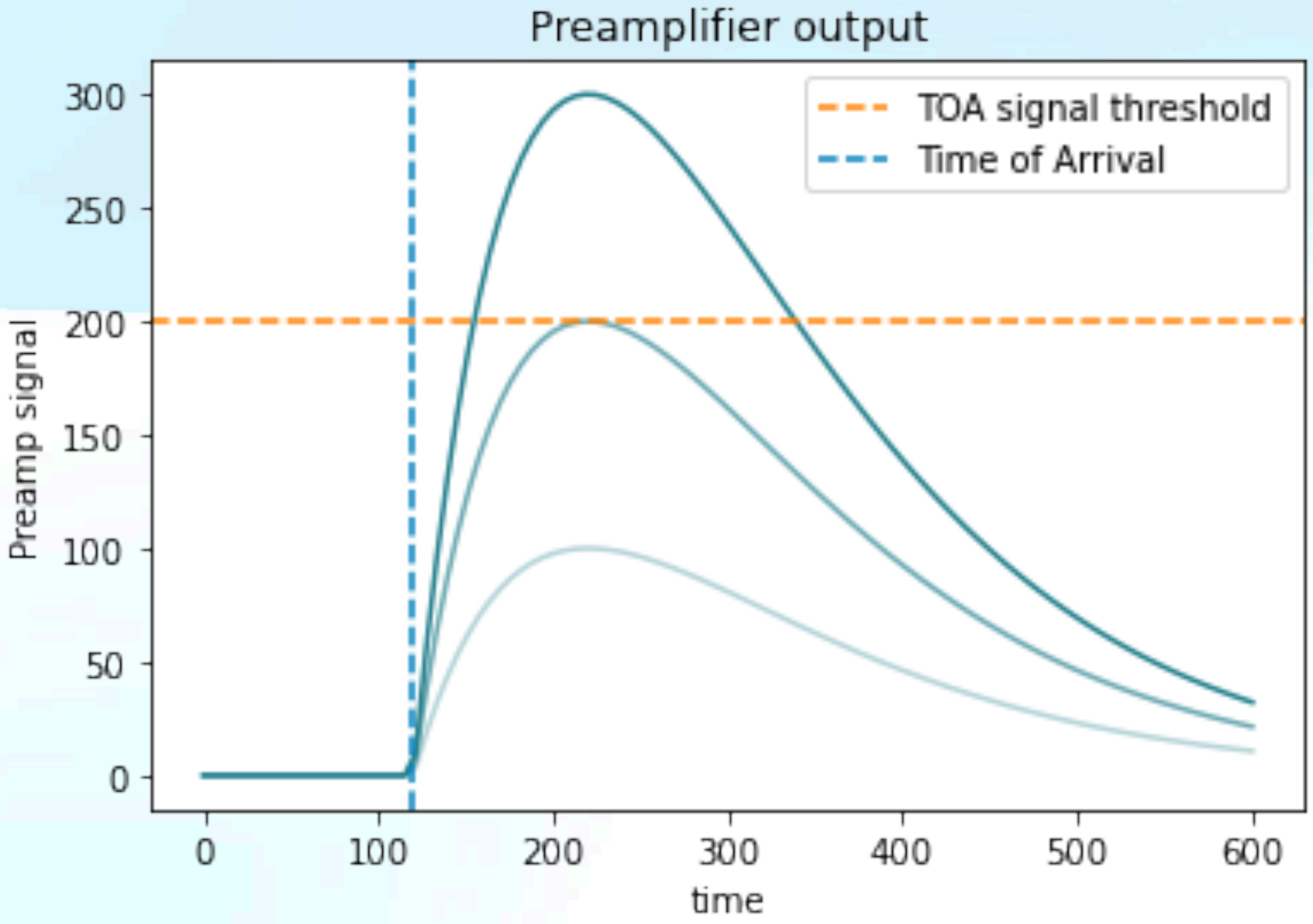
- Sampling-Detector built in layers
- Layers split into cassetts
- Cassette split into hexagonal modules
- modules carry 6/3 Read out Chips (ROCs)
- ROC carries channel wise analog front end and latency buffer

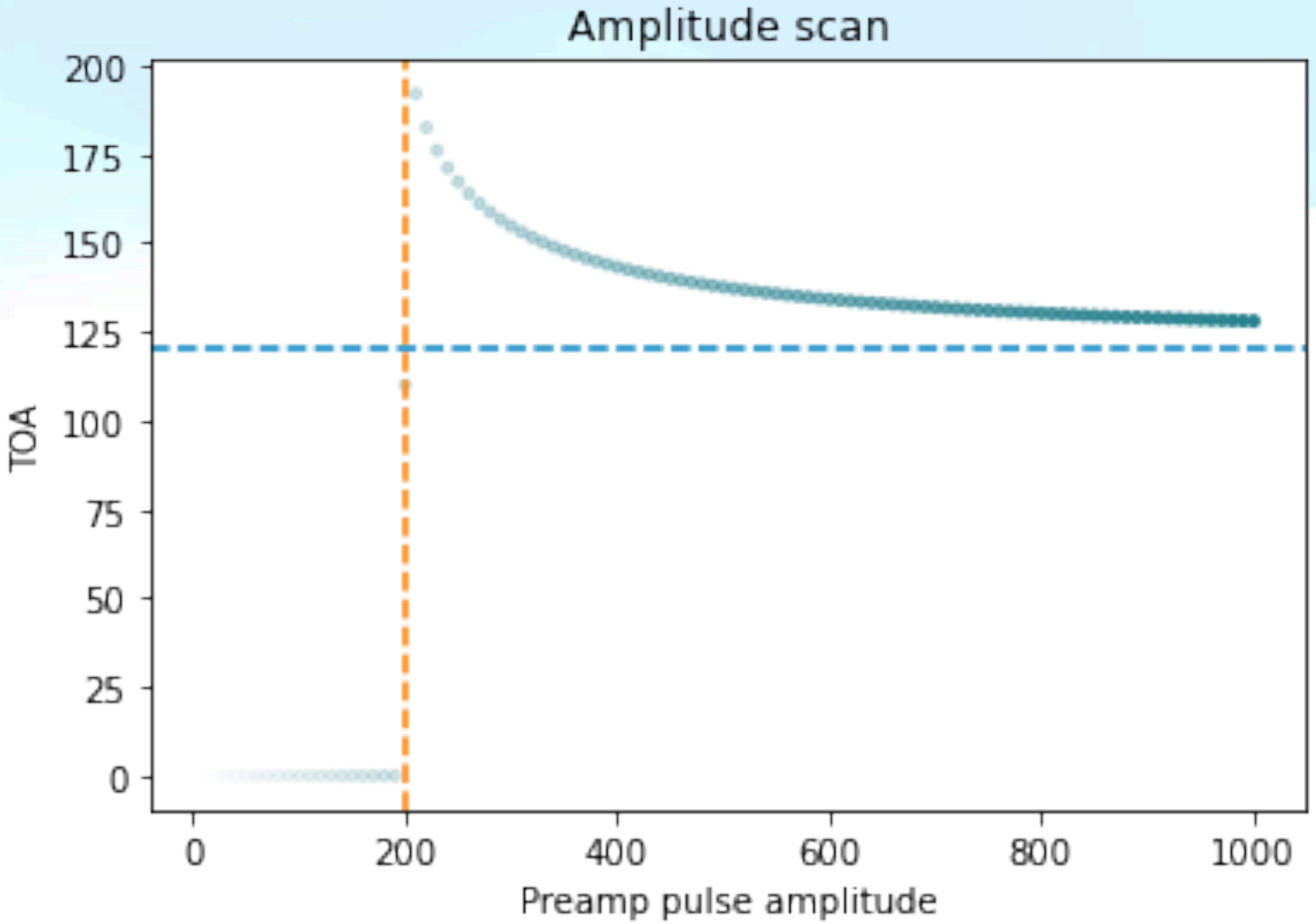


Time of Arrival Circuit characterisation



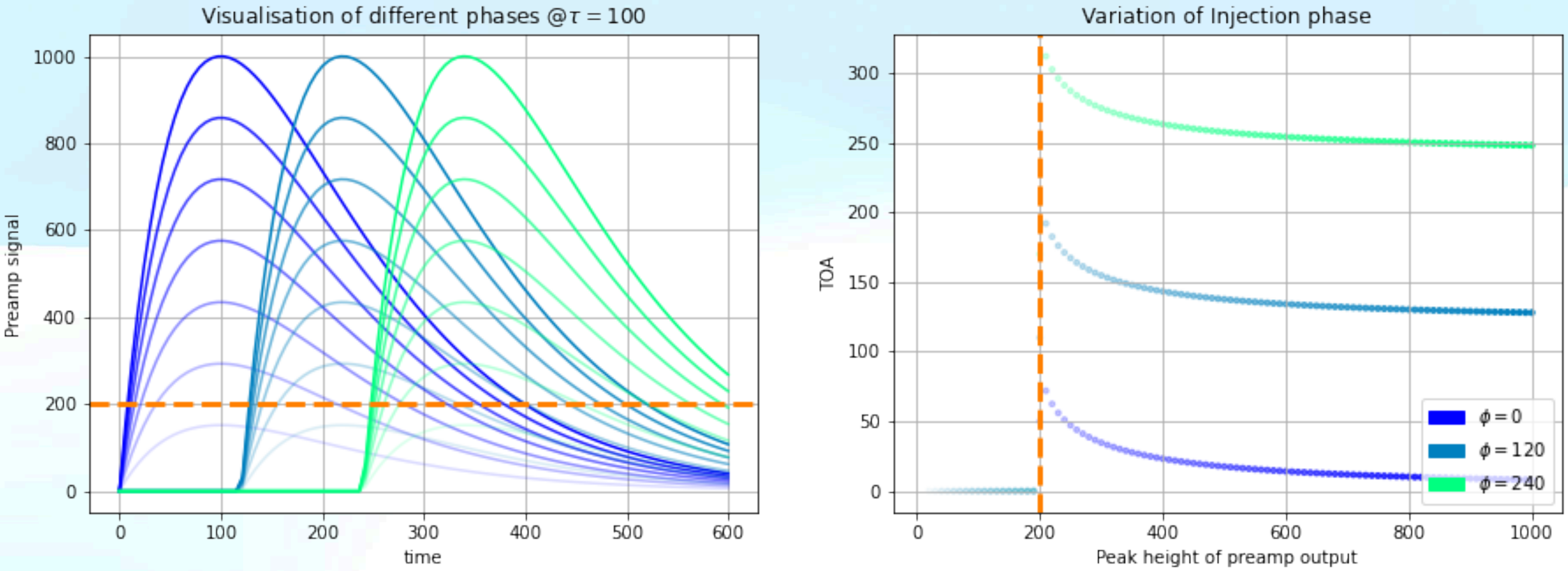
Simulation of TDC response





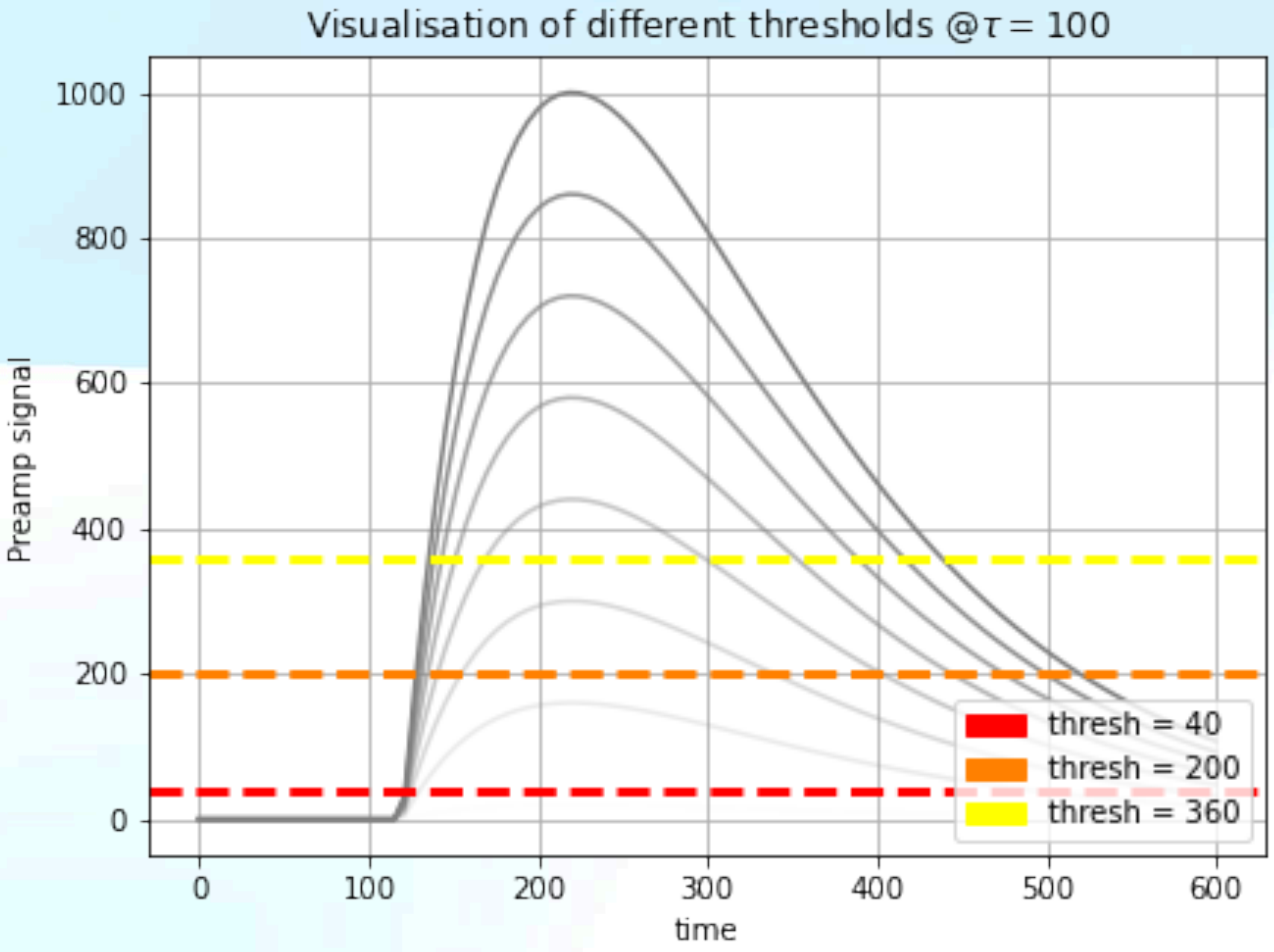
Simulation of TDC response

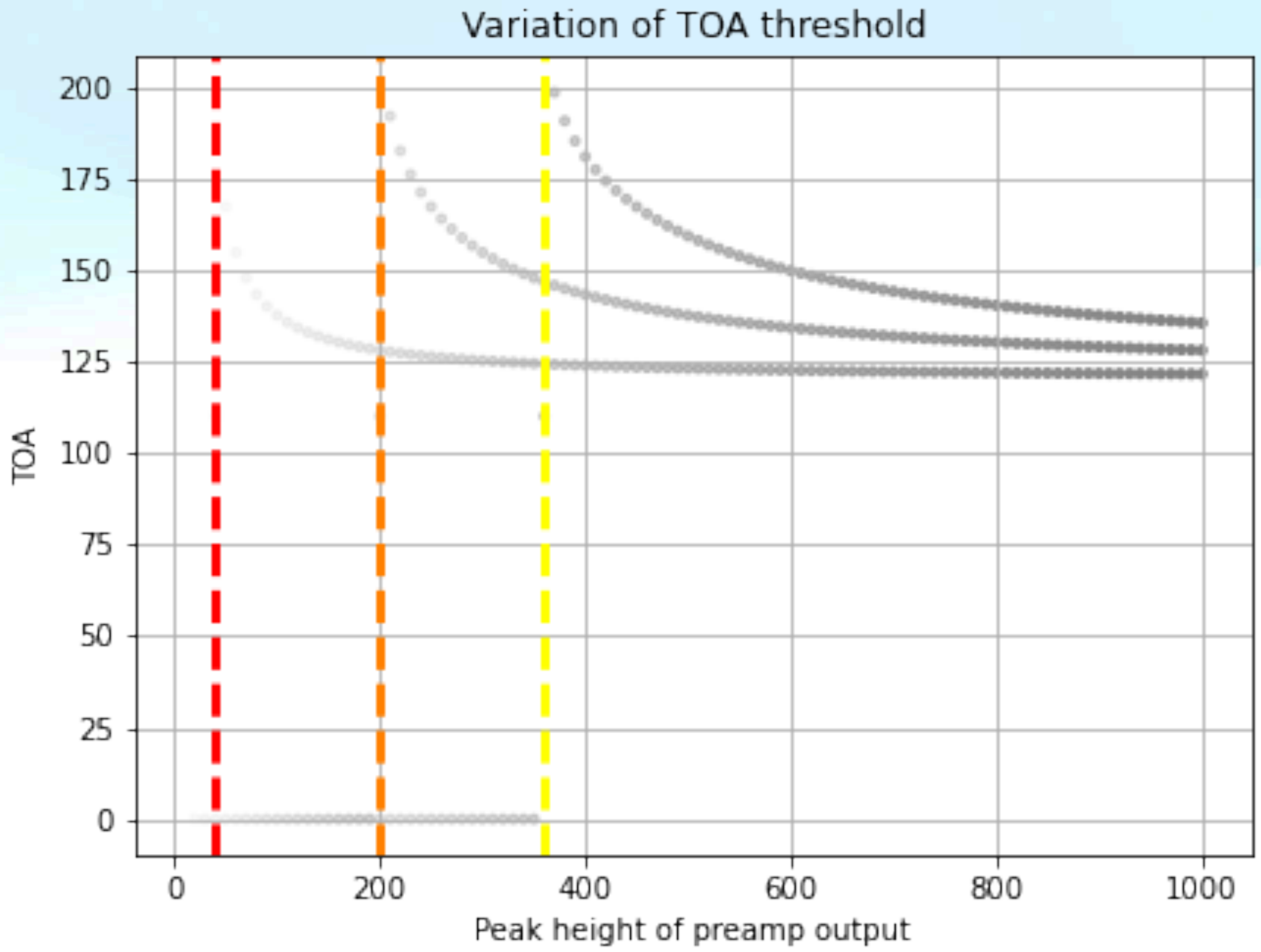
Change of arrival time



Simulation of TDC response

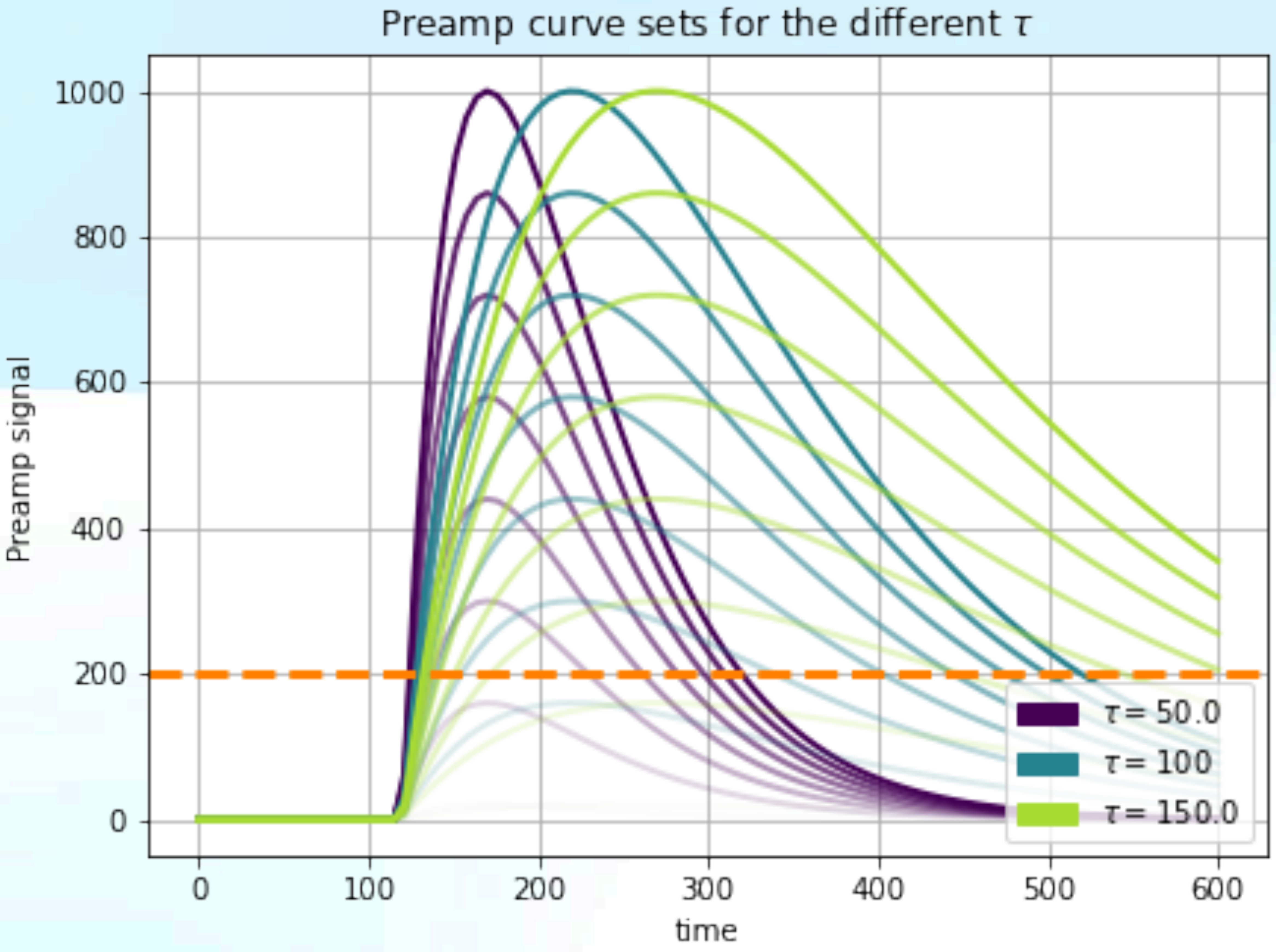
Change of the ToA threshold

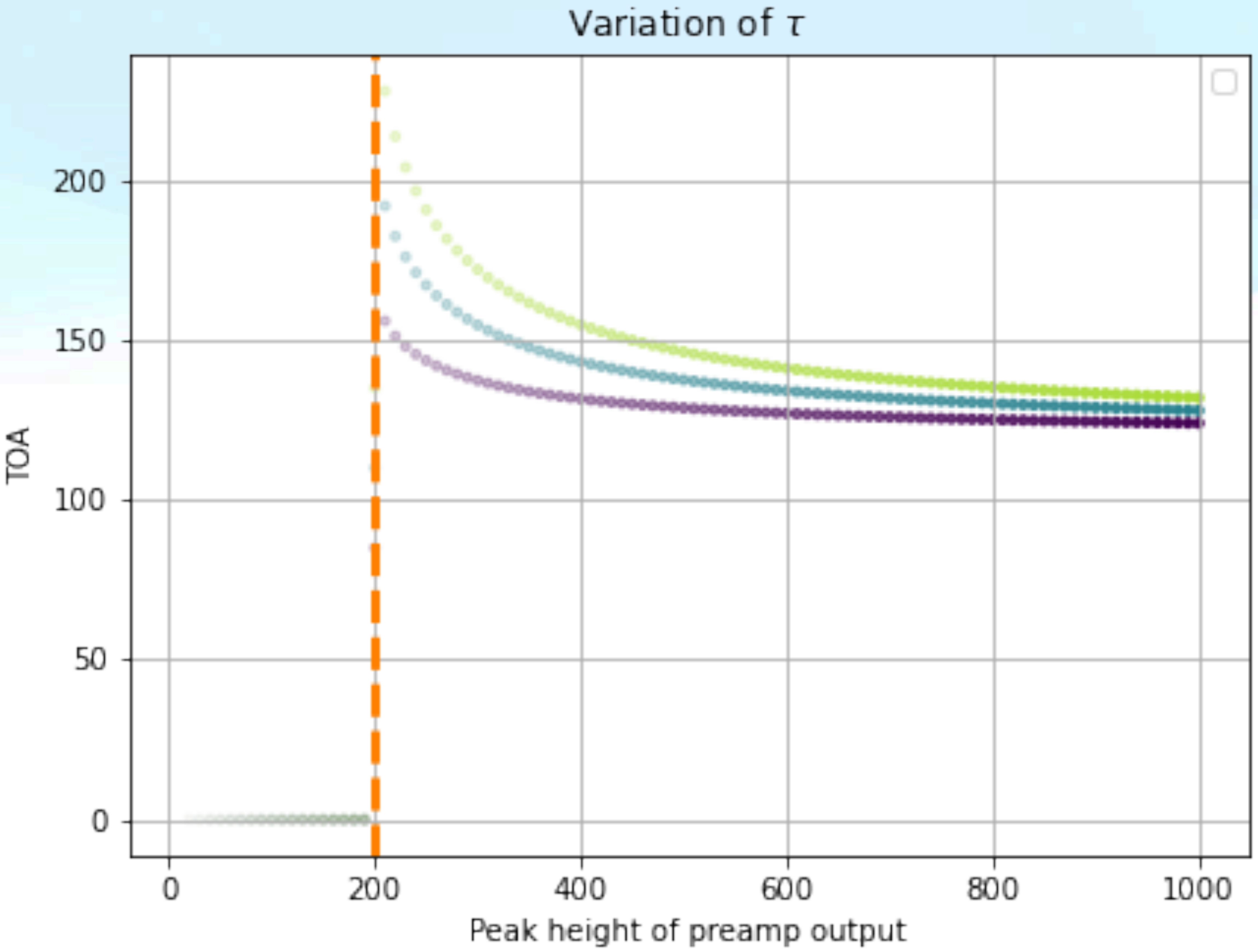




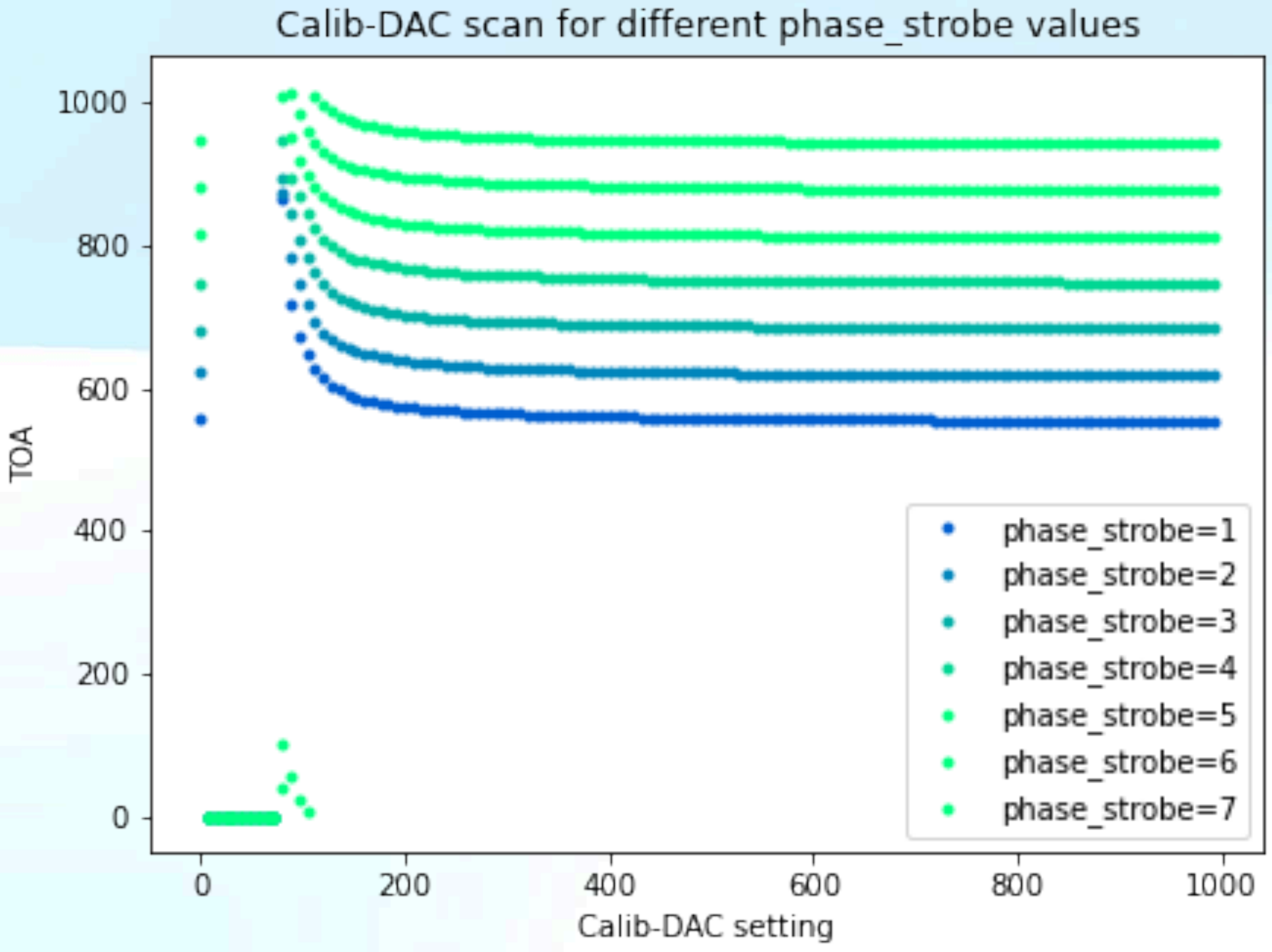
Simulation of TDC response

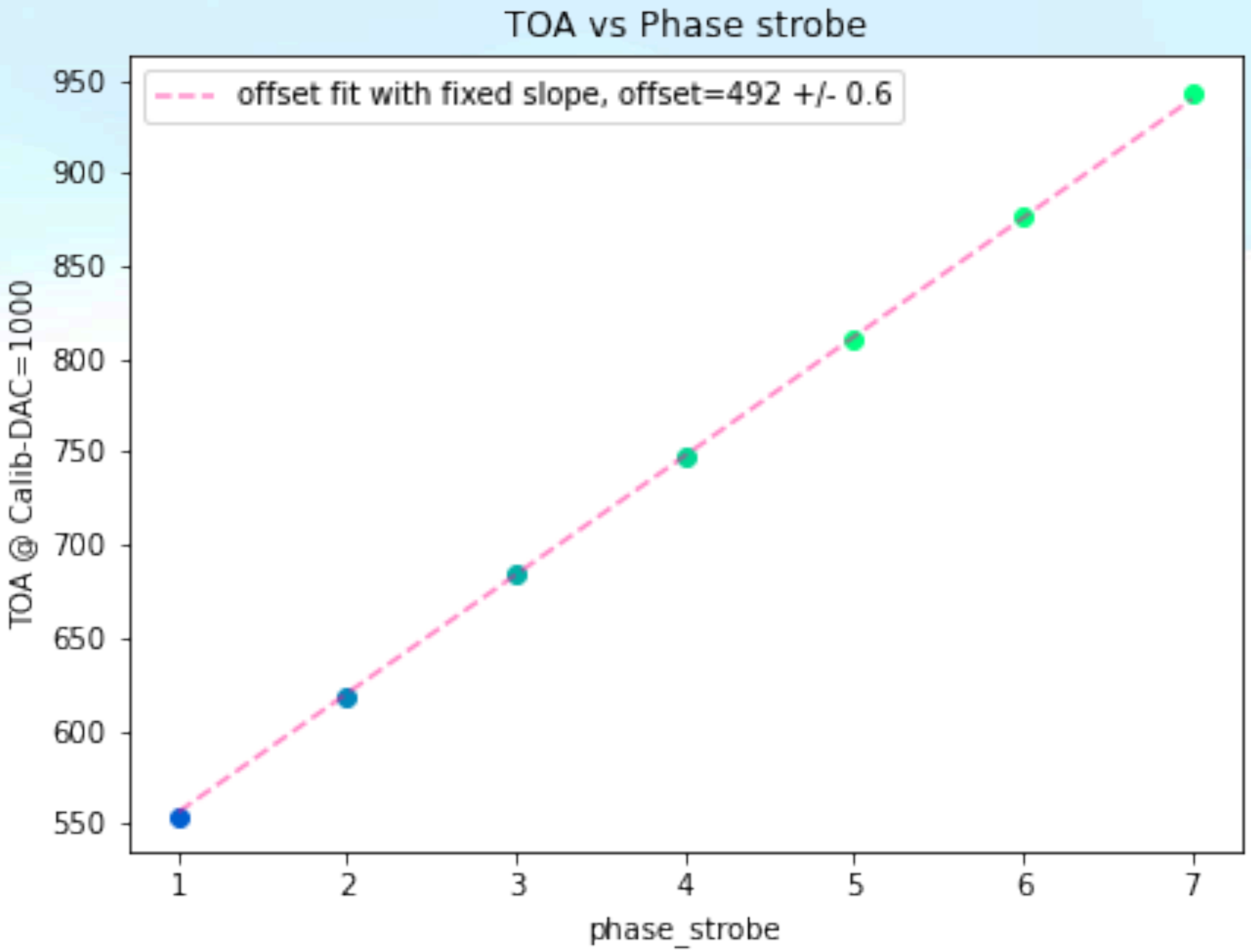
Change of the Preamplifier pulse shape





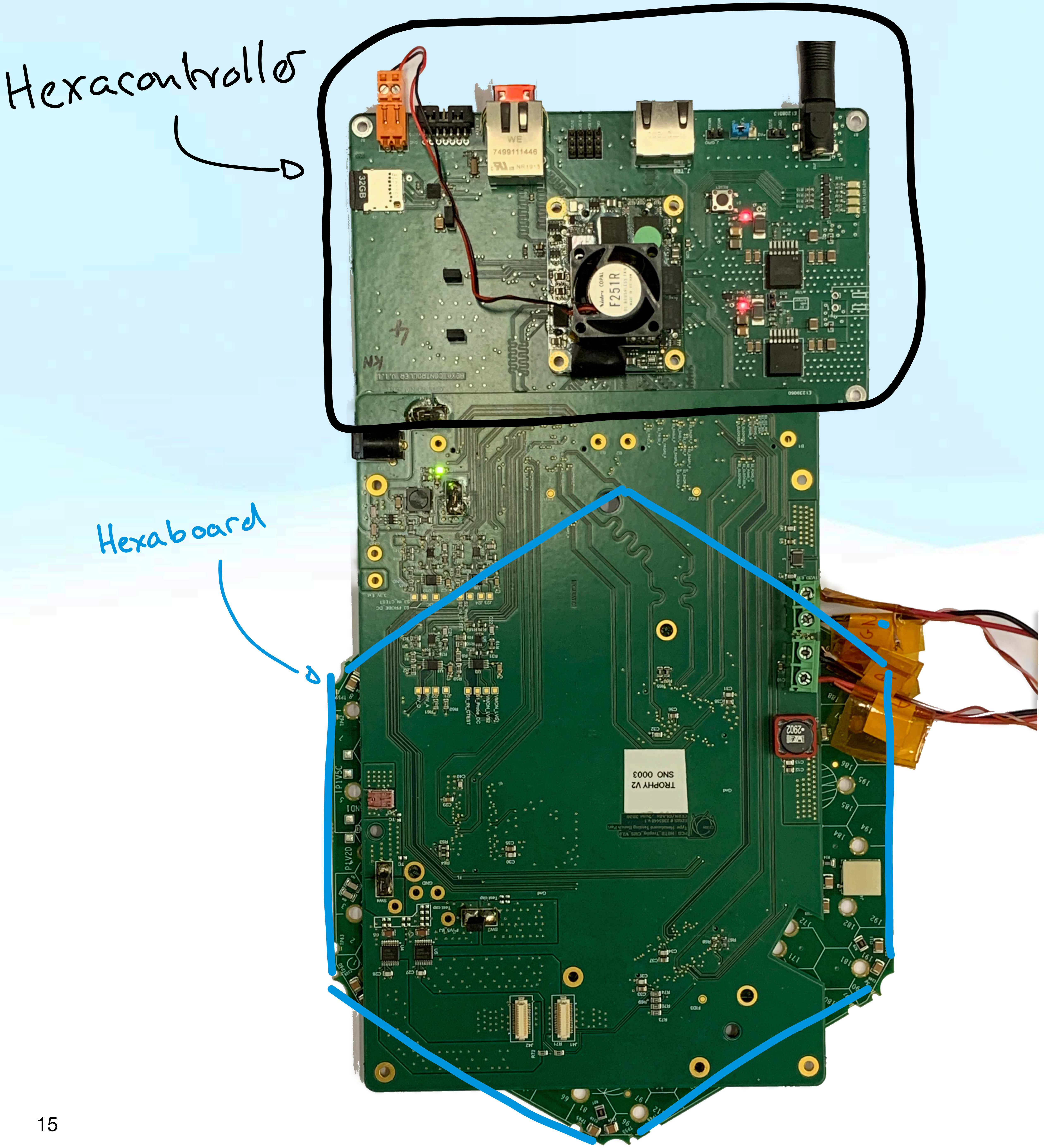
Lab Measurements





System Tests

- Hexacontroller used to gather Data from the modules during Beamtest/Lab tests
- Based on ZYNQ-SoM with custom firmware to interface with the ROCs
- Software interfaces with the firmware to configure ROCs and collect data



DAQ-system Architecture

Making System Configuration Consistent

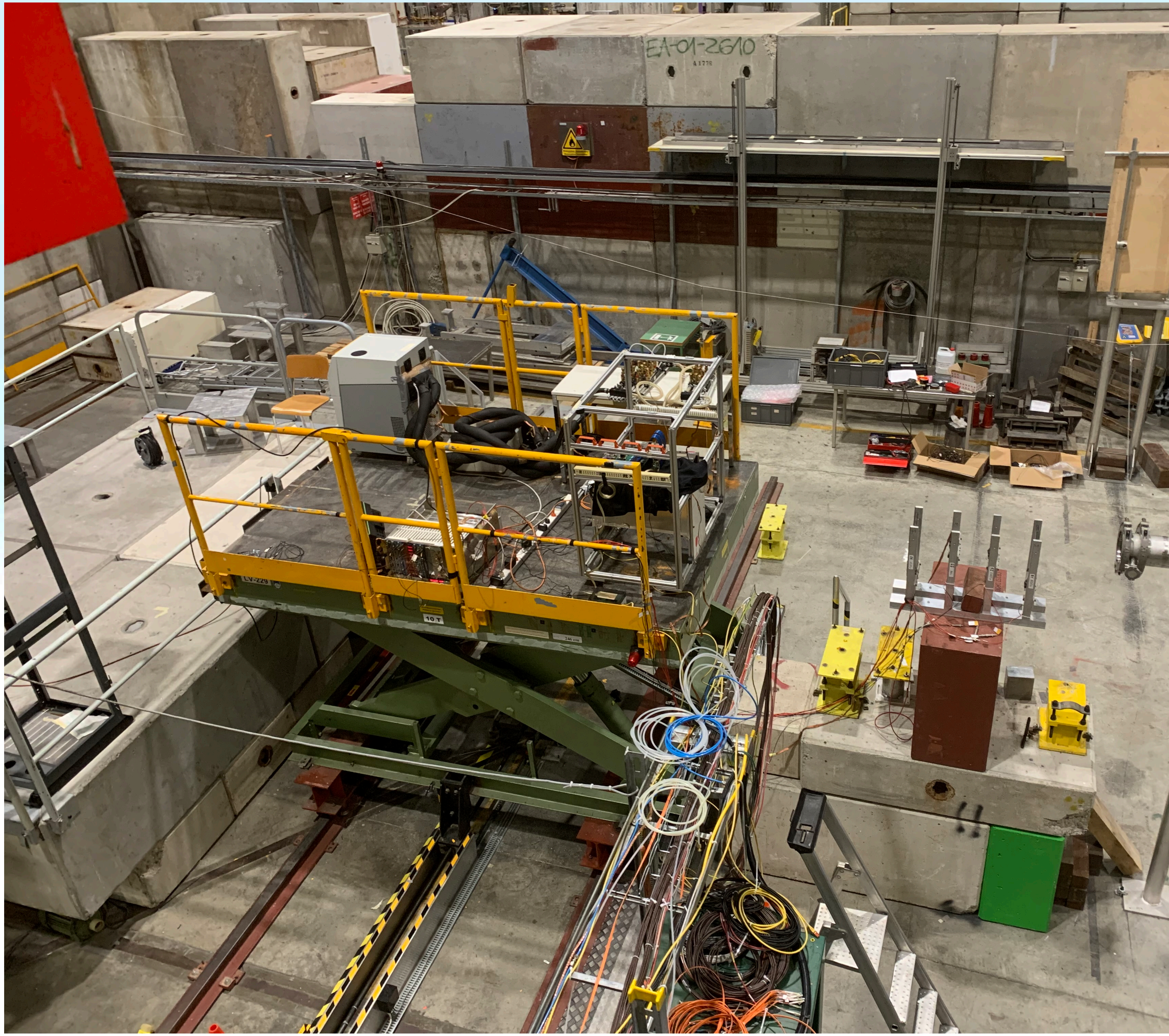
- Configuration was done using custom scripts for every procedure that was to be run
- Debugging was time consuming and often required expert knowledge
- Configuration integrity could not be guaranteed by system alone
- **The Datenraffinerie was designed to provide a consistent user interface for quick and easy definition of measurement and analysis procedures**

Datenraffinerie Goal

- Samples the desired region of the system phase space, using a regular grid with user-adjustable granularity.
- Produces a Single output file (pandas DataFrame compatible) containing data and user specifiable configuration parameters. Can split single file into multiple files to make reading easier.
- Make testing more consistent

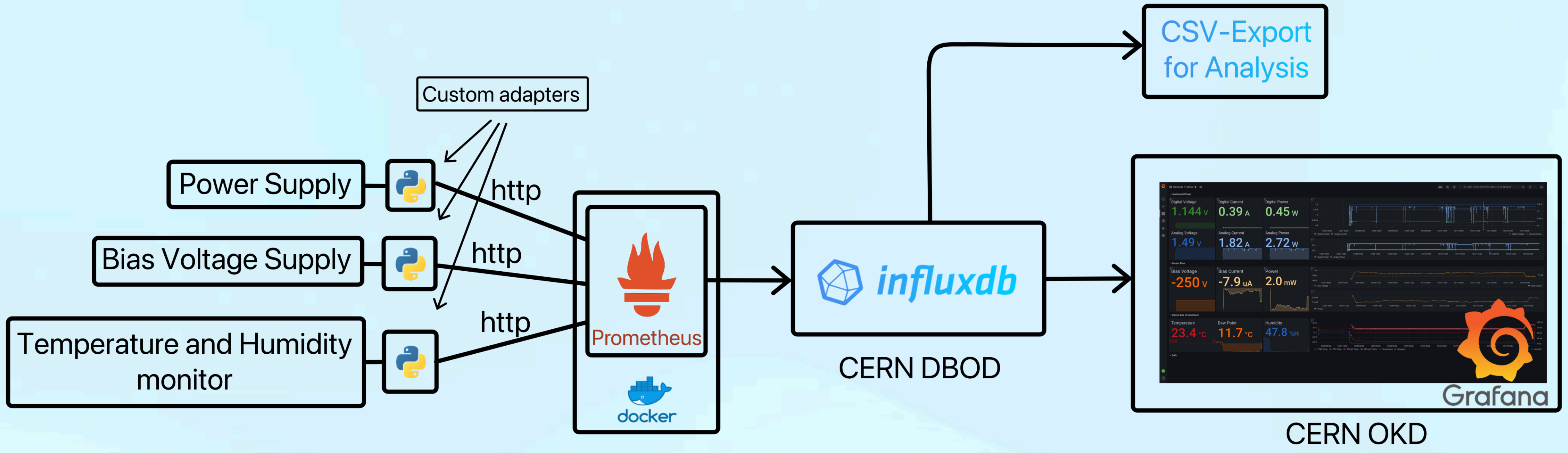
The Beam Test

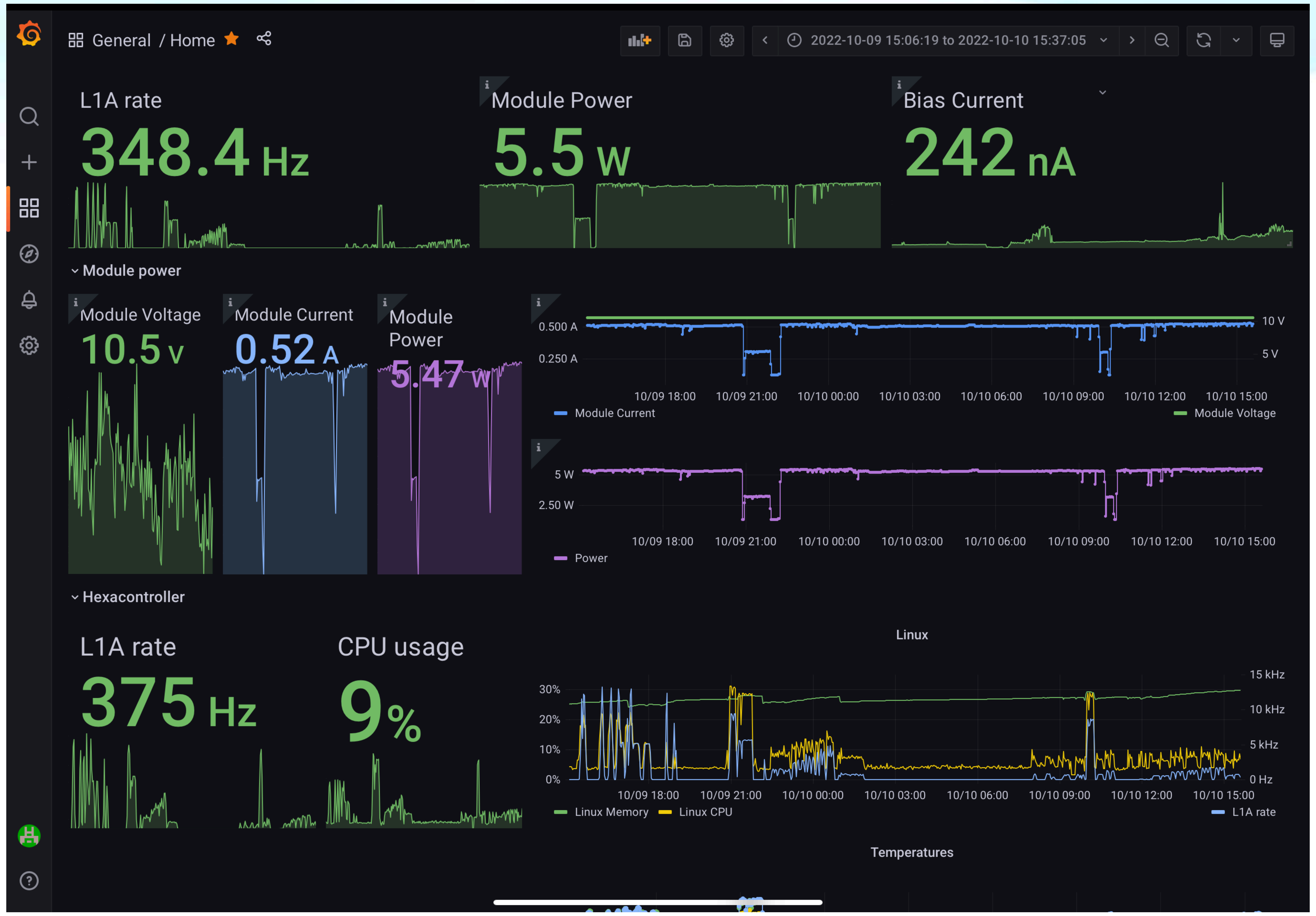
- Acquired large amount of ToA data
- Used the Datenraffinerie to build calibration procedure for the ToA
- Tested Datenraffinerie but found bug in the configuration of the ROCs not seen previously (investigating)
- Possibility for another beam test in early November



On-line Monitoring

- Used an InfluxDB/Grafana stack to visualise environmental Information
- Integrated Trigger rate measurement during latest beam test
- Used monitoring to cross check data taking (was able to verify bug in the Datenraffinerie using this)





Next Steps

- Analyse the ToA data to ultimately extract ToA resolution
- Improve understanding of the ToA using the acquired Data
- Possibly prepare for upcoming beam test in November
  - Find bug in the Datenraffinerie and fix it -> use the Datenraffinerie to take data
  - Improve flow for Shifters during operation
  - Improve data quality monitoring for the ToA