

# EMC Backward Endcap Status report

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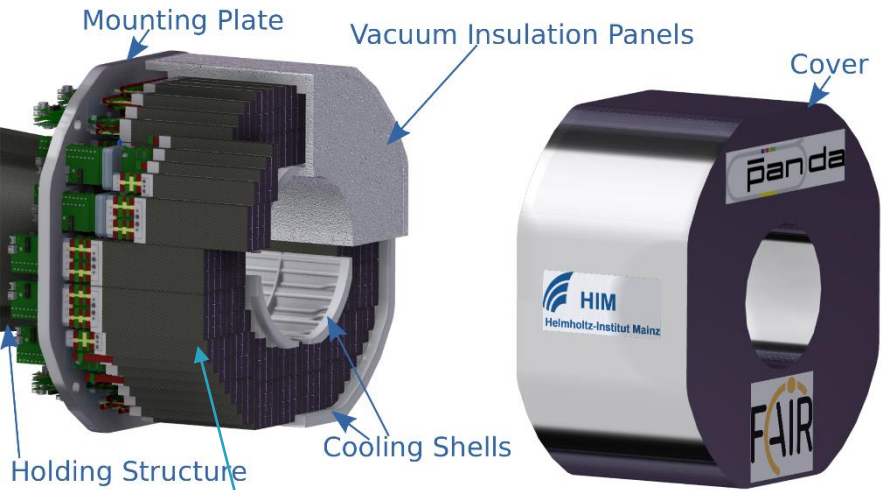
EMC Meeting Bochum, 6. 2. 2024



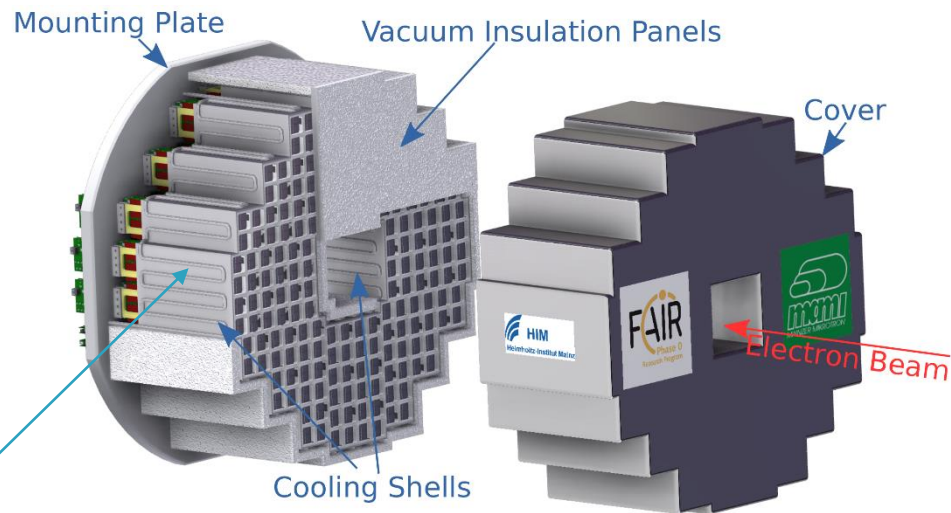
# Outline

- Submodule Production
- Submodule calibration status
- Slow control
- Mechanical status
- Summary

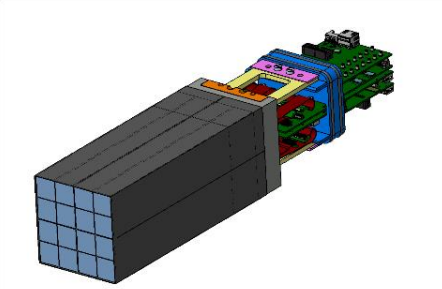
# PANDA Backward Endcap



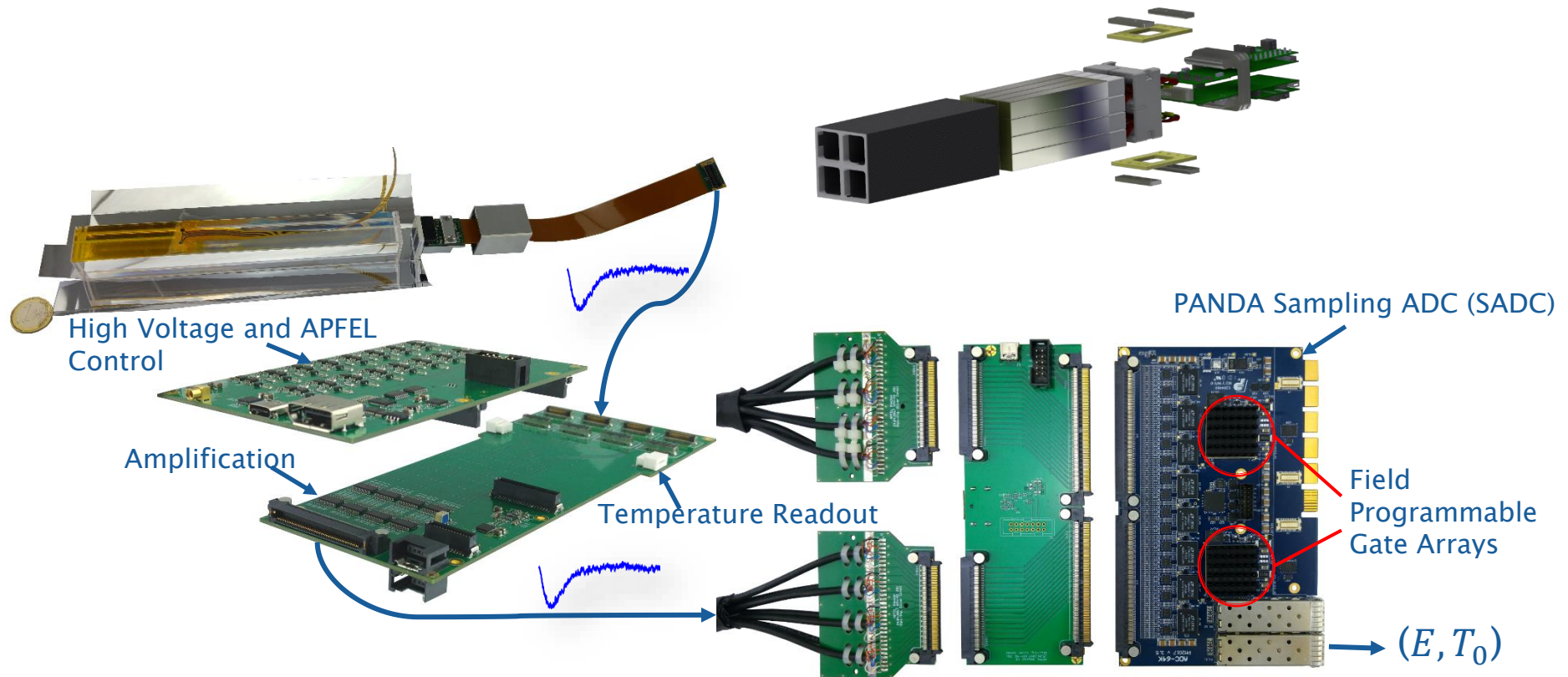
Panda Version



Phase-0 Version

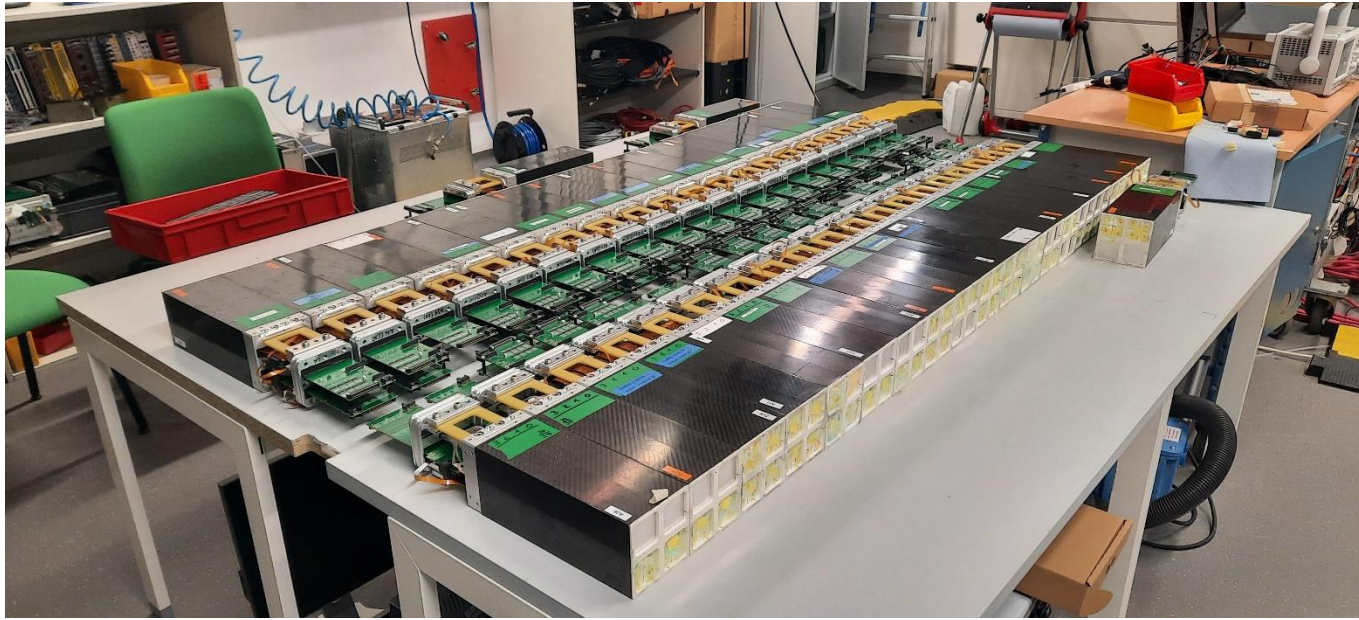


# PANDA Backward Endcap





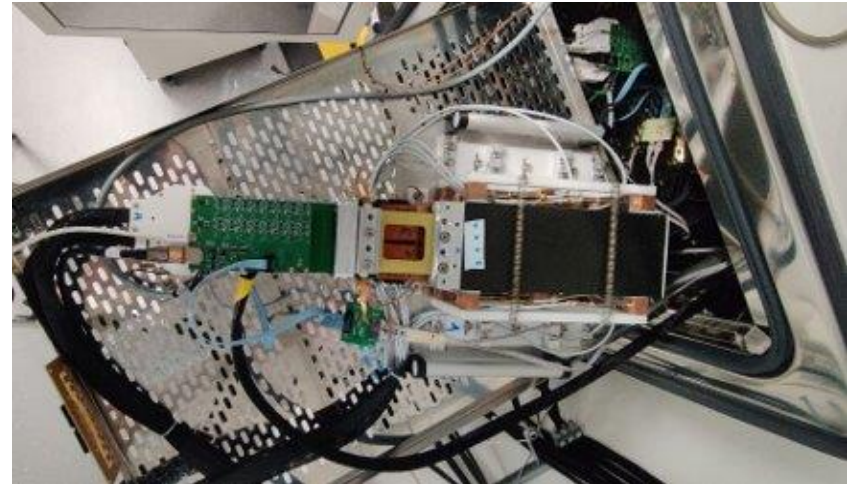
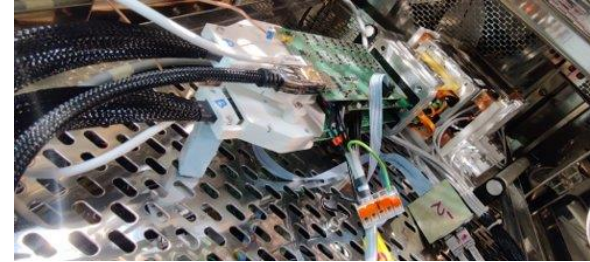
# Submodule Production



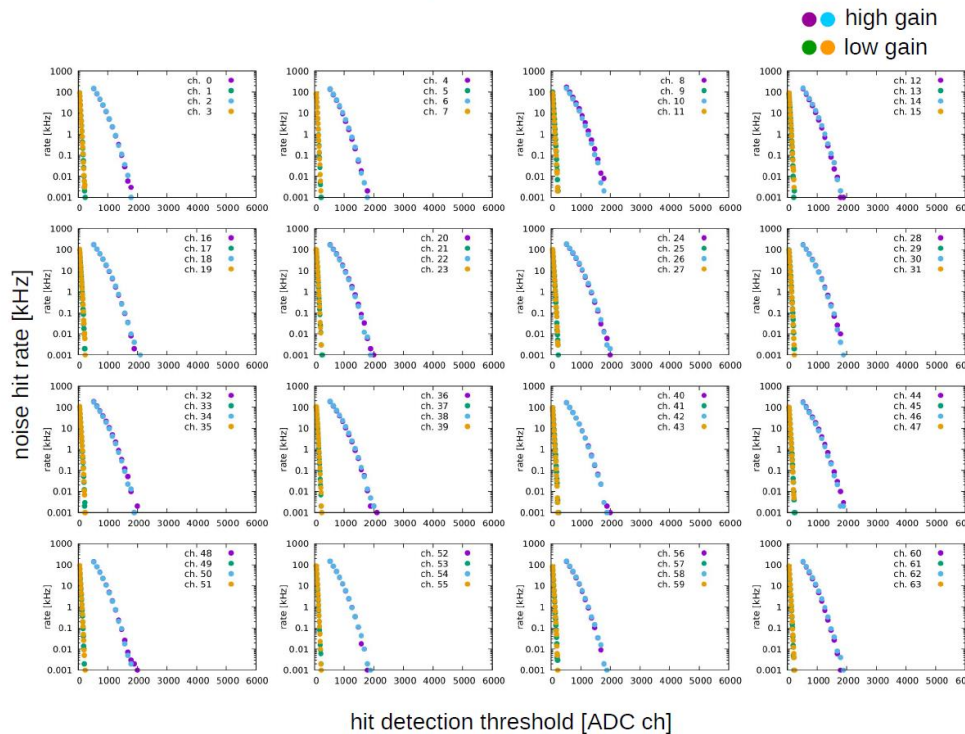
- Submodule production: **finished**
- Disassembled one prototype EMC to build final 2 half subunits
- 32/32 Full subunits
- 16/16 Half subunits

# Submodule Calibration

- Fully automated calibration in climate chamber of:
  - Temperature sensors
  - APD gain curve
  - Energy calibration with cosmics
- All submodules through calibration process
- Analysis of calibration data and calibration in progress



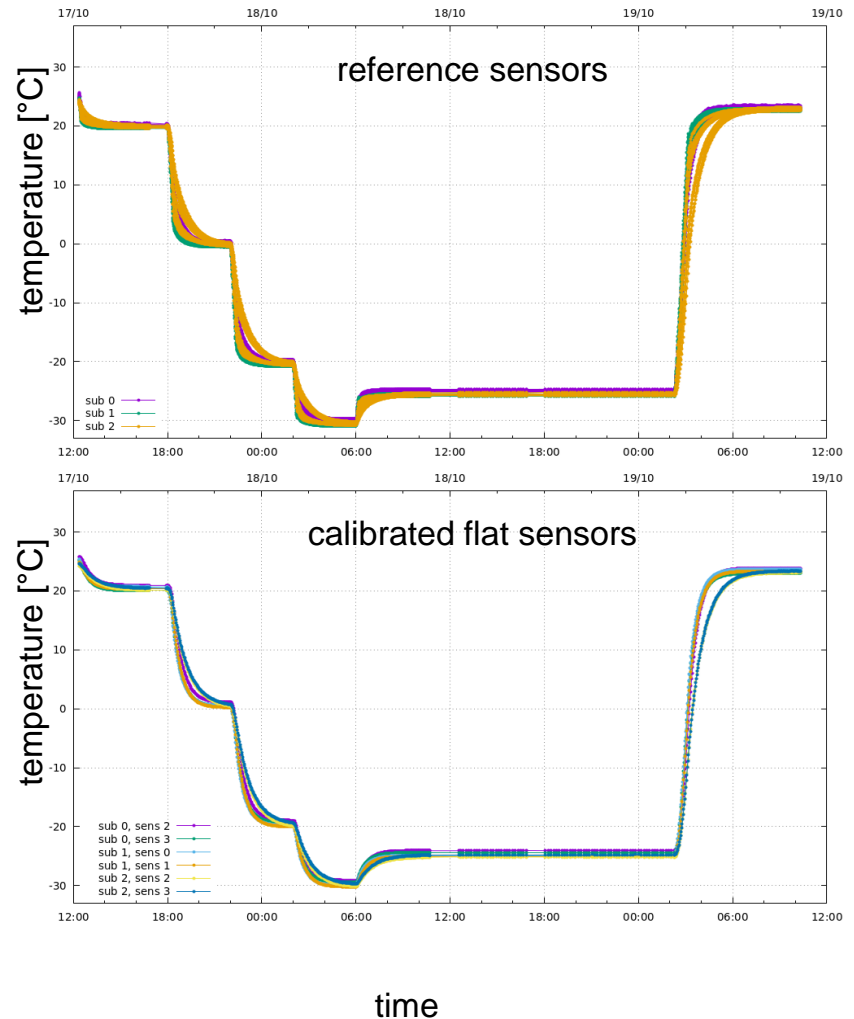
# Submodule Calibration: noise



- Noise characterisation by scanning the hit rate as a function of sadc threshold
- Identification of missing contact between APD and APFEL-ASIC
  - exclude channels from HV scan to not damage APFEL

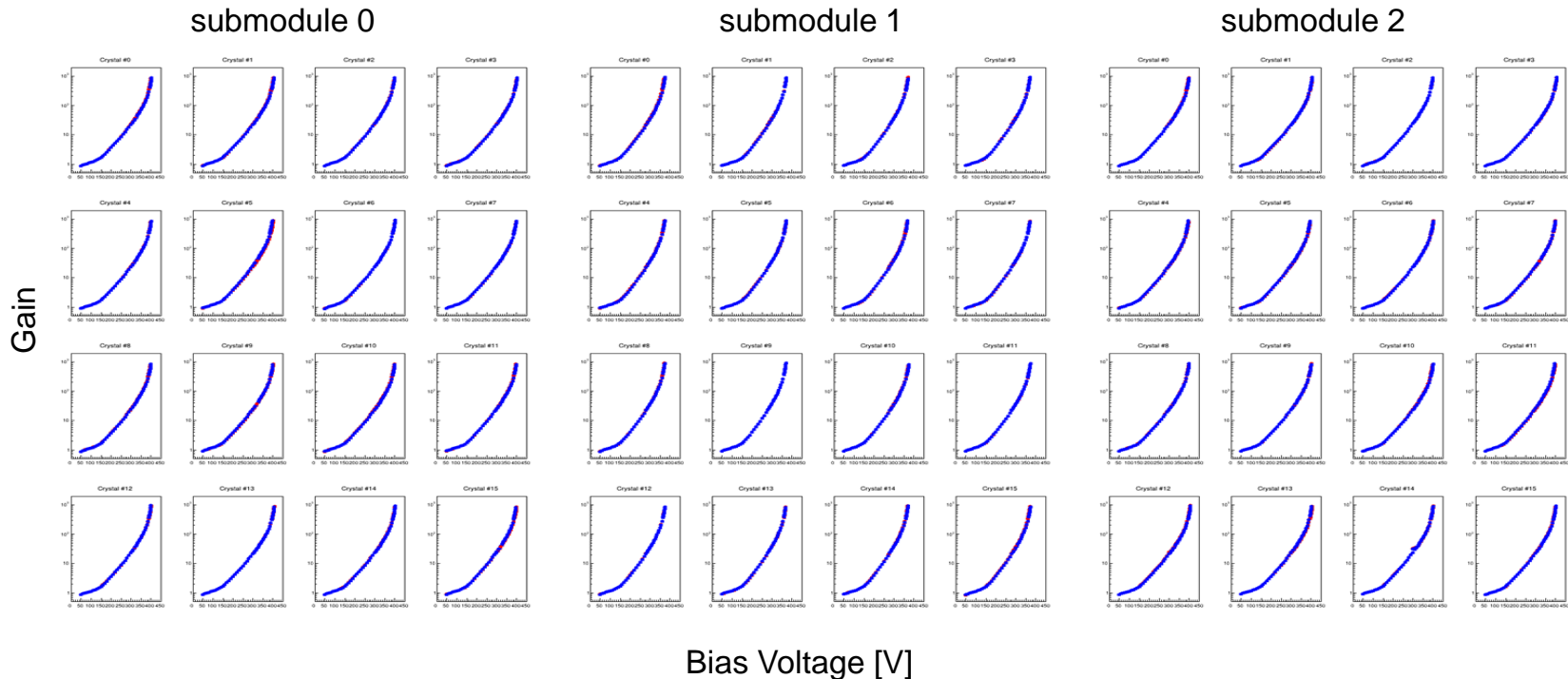
# Submodule Calibration: temperature

- 4 flat home-made pt100 per submodule to be calibrated
- 10 reference sensors around each submodule
- climate chamber set to 6 different temperatures: 20°C, 0°C, -20°C, -30°C, -25°C, 23°C
- reference values interpolated to the position of the flat sensors
- linear R(T) function calculated with two points (typically +20°C and -25°C)
- other data points used to check the accuracy
- typical accuracy: 0.1 to 0.2°C





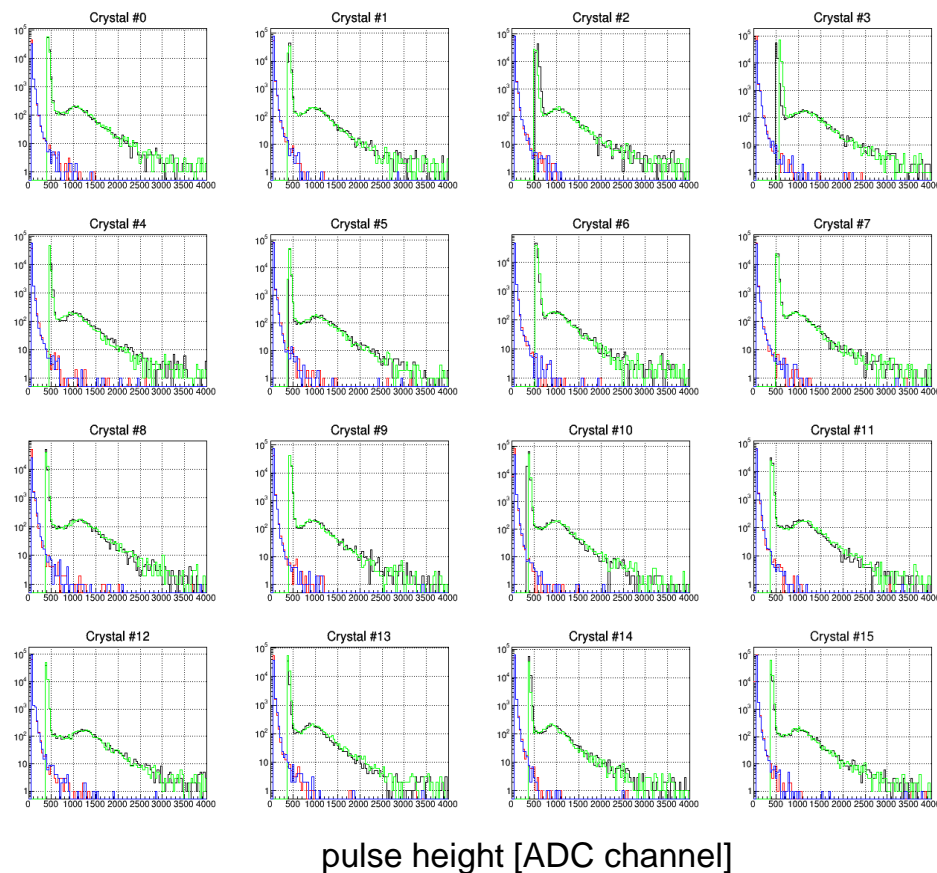
# Submodule Calibration: HV scans



- HV scans at +20°C and -25°C
- Measurement of gain/voltage characteristics of every APD with pulsed light
- Absolute gain determination to be fixed with cosmics data
- Results approximately compatible with Bochum characterization
- Example: scan data at -25°C, three submodules, one plot per crystal containing the curve of both APDs

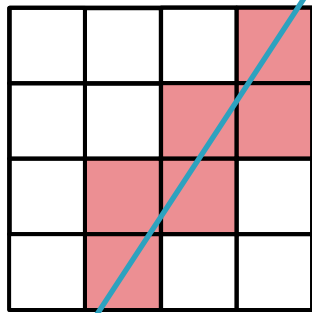
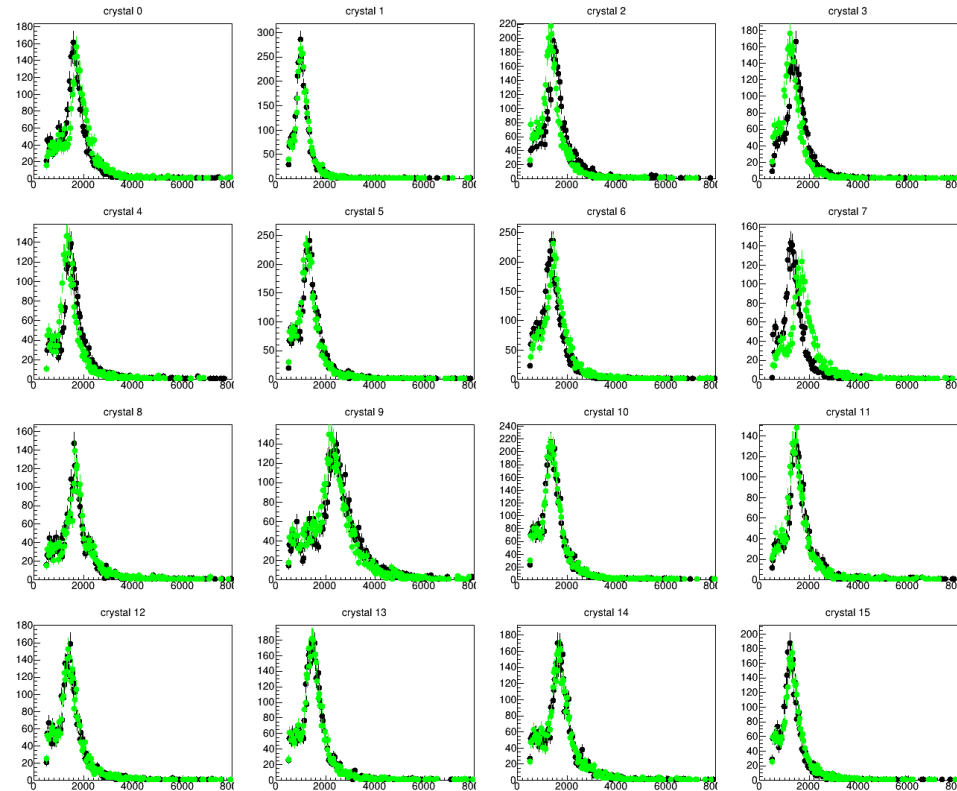
# Submodule Calibration

- Cosmics data at  $-25^{\circ}\text{C}$  with gain 200 and gain 400
- Absolute gain determination by using cosmic peak ( $\sim 25$  MeV)
- Here: raw data without event reconstruction
- Example:  $\sim 3$  hours run at gain 400  
(colours: blue+red=low gain, black+green=high gain)



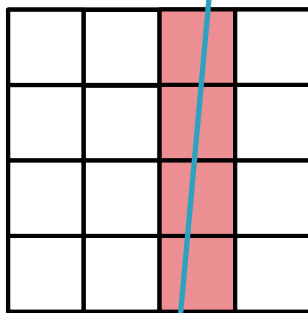
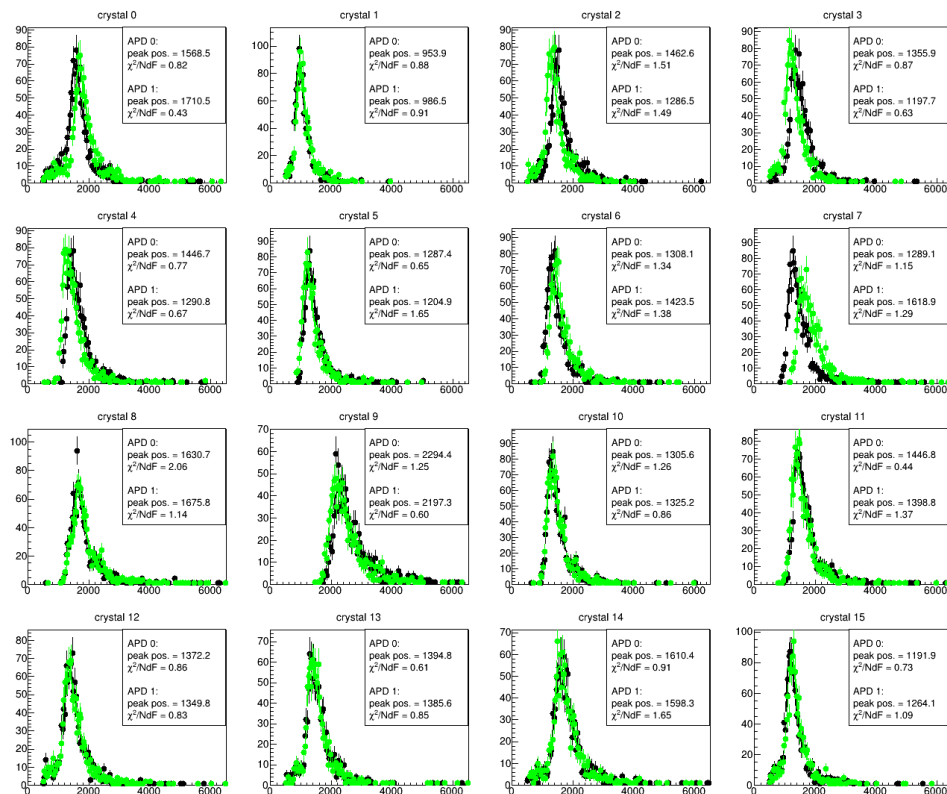
# Submodule Calibration

- Data at gain  $\sim 400$
- With event reconstruction
- At least one hit per row required
- Large reduction in noise by requiring e.g. signal in both APDs
- But: no clean landau distribution as expected, probably due to angled tracks



# Submodule Calibration

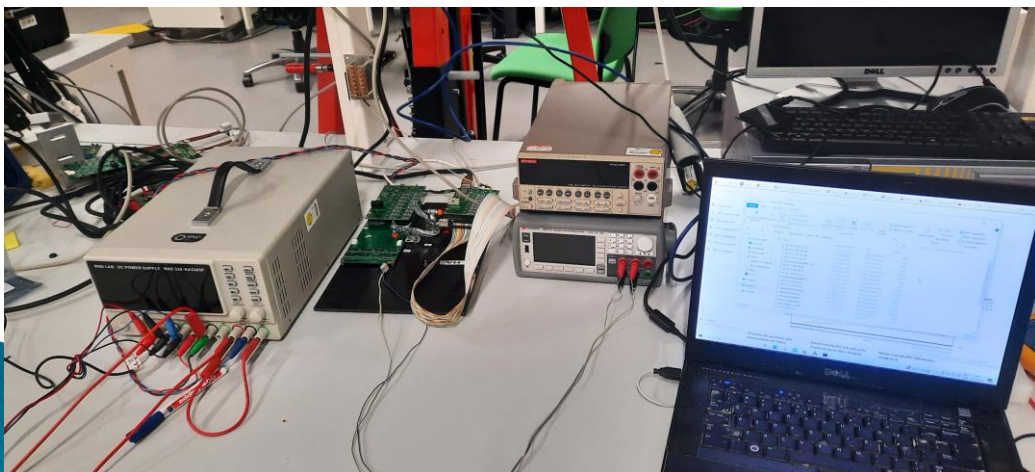
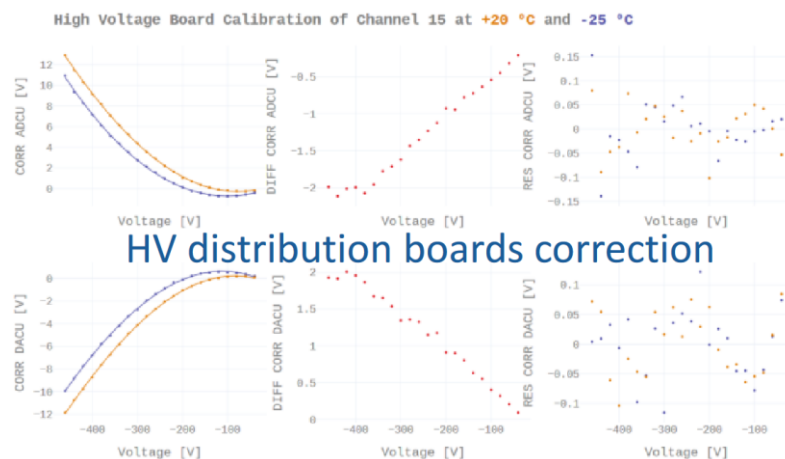
- Exactly 4 hits required in a column pattern
- Fit with landau distribution
- Calibration of energy/ADC channel with 25 MeV peak
- Absolute calibration of gain-bias curve of each APD
- Next steps:
  - Analyse and calibrate all submodules (gain 200 and 400)
  - Once full detector is setup, repeat cosmics measurement
  - Additional energy point by turning the detector 90° (~200 MeV)





# HV distribution boards

- HV distribution boards:
  - All boards produced (only 94/100...)
  - Small issue: 2 capacitors missing on boards  $\rightarrow$  Apfel communication not working properly
  - Boards currently in “repair”
- Calibration status:
  - Calibration of HV DAQ and ADC values done
  - Current calibration delayed due to aforementioned issue



# Slow control

- Epics integration:
  - Fully integrated:
    - Control of high voltage crate
    - Control of low voltage crate
    - Light pulser
    - Control of Apfel preamplifier
    - Control of high voltage boards

# Slow control

- Epics integration:
  - Fully integrated:
    - Control of high voltage crate
    - Control of low voltage crate
    - Light pulser
    - Control of Apfel preamplifier
    - Control of high voltage boards
    - Chiller

# Slow control

- Epics integration:
  - Fully integrated:
    - Chiller
- Integration of chiller control into web interface

**PRIMA Control Interface**

Start **Detector Control** Run Control Data Visualisation

Iseg High Voltage  
High Voltage  
Low Voltage  
APFEL  
LED Matrix  
Traces  
**Chiller**

**Chiller Control**

**EPICS connection status: ONLINE**

Temperature parameters:		Pressure parameters:		General parameters:	
Outflow Temperature:	23.43 °C	Outflow Pressure:	0.00 Bar	bath level:	3 [1/10]
set Temperature:	-27.00 °C <input type="text"/> °C <input type="button" value="send"/>	set Pressure:	0.00 Bar <input type="text"/> Bar <input type="button" value="send"/>	Pump power level:	1 [1/8] <input type="text"/> [1/8] <input type="button" value="send"/>
Temperature Ceiling:	30.00 °C <input type="text"/> °C <input type="button" value="send"/>				
Temperature Floor:	-30.00 °C <input type="text"/> °C <input type="button" value="send"/>				

**Before starting the chiller please make sure that following parameters are met:**

- > The amount of cooling substance is sufficient
- > The water hoses are connected, and the faucet for "vorlauf" is open
- > The cooling circuit hoses are connected and there can be no leakage

**Cooling operation:**



# Slow control

- Detector overview implemented for:
  - Traces (baselines)
  - HV control (work in progress)
- Example: traces app, tested with 1 Full subunit (external setup) and 3 half subunits (climate chamber)

The screenshot displays the PRIMA Control Interface, which is divided into several sections:

- Navigation:** Start, Detector Control (active), Run Control, Data Visualisation.
- System Status:** Isog High Voltage, High Voltage, Low Voltage, APFEL, LED Matrix, Traces.
- Plotting:** Includes a refresh rate of 1s, subunit selection, and options for channels, rates, scale max, dynamic scale, and log scale.
- Adjust Baselines:** Features target position (Freedom) with values 2000 and 500, and checkboxes for toggle adjust, auto-calib, and new method.
- Setup SADC:** Contains various parameters such as SADC channel, HG Threshold, LG Threshold, TUZ min/max, and TRL, along with buttons for program, load, pushmode, infomode, re-lev, scan, and cancel.
- Detector Overview:** A central grid of 40 numbered subunits (0-40) with a color scale from 0 to 200. A red box highlights subunit 3, which is further detailed in a smaller inset plot on the right.
- Controls:** Includes a 'crystals' status bar with four indicators (one green, three grey) and a 'reset watcher' button.

# Slow control

- Example: traces app, tested with 1 Full subunit (external setup) and 3 half subunits (climate chamber)
- 2D plotting for:
  - Rates

The screenshot displays the PRIMA Control Interface, which is divided into several sections:

- Navigation:** Start, Detector Control (active), Run Control, Data Visualisation.
- System Status:** Isog High Voltage, High Voltage, Low Voltage, APFEL, LED Matrix, Traces.
- Plotting Panel (highlighted with a red box):**
  - refresh(s): 1
  - sub #:
  - load, remove, reload buttons
  - Plotting controls: rates (dropdown), channels (dropdown), plot (checkbox), scale max (input), dynamic scale (checkbox), log scale (checkbox).
- Adjust Baselines:**
  - Target position: 2000, Freedom: 500
  - toggle adjust, auto-calib, new method (checkboxes)
  - Submodule, crystal Nr., adjust, cancel buttons
- Setup SADC:**
  - Submodule, SADC channel, program, HG Threshold, LG Threshold, TUZ min hg, TUZ max hg, TUZ min lg, TUZ max lg, TRL, Sync., SADC channel, Target rate, Iterations, Crude tuning (checkbox), scan, cancel buttons
- 2D Rate Plot:** A grid of 40 numbered cells (0-39) showing rate data. A color scale on the right ranges from 0 (blue) to 200 (red). A large number '3' is overlaid on the plot.
- Submodule Control:** submodule: 3, channel: 0-63, all, acknowledge, ignore, unignore, force, reset watcher, Alerts dropdown.
- Crystal Status:** crystals, chans, sub br, crystal br (checkboxes)

# Slow control

- Example: traces app, tested with 1 Full subunit (external setup) and 3 half subunits (climate chamber)
- 2D plotting for:
  - Rates
  - Baseline positions

The screenshot displays the PRIMA Control Interface, which is divided into several sections:

- Navigation:** Start, Detector Control (active), Run Control, Data Visualisation.
- System Status:** High Voltage, APFEL, LED Matrix, Traces.
- Plotting Panel:** Includes a refresh rate of 1s, subunit selection, and a red-bordered box containing controls for BL means, channels, plot, scale max, dynamic scale, and log scale.
- Adjust Baselines:** Features target position (Freedom), toggle adjust, auto-calib, and new method checkboxes.
- Setup SADC:** Contains fields for SADC channel, HG/LG Threshold, TUZ min/max, and TRL, along with buttons for scan, cancel, and re-init.
- 2D Plotting:** A central grid of 44 numbered subunits (0-44) with a color scale from 0 to 8207. A red box highlights a specific subunit (34) and its neighbors.
- Alerts Panel:** Includes submodule and channel selection, and buttons for acknowledge, ignore, unignore, force, reset watcher, and Alerts.

# Slow control

- Example: traces app, tested with 1 Full subunit (external setup) and 3 half subunits (climate chamber)
- 2D plotting for:
  - Rates
  - Baseline positions
  - Baseline standard deviation

The screenshot displays the PRIMA Control Interface, which is divided into several sections:

- Navigation:** Start, Detector Control (active), Run Control, Data Visualisation.
- System Status:** Isag High Voltage, High Voltage, Low Voltage, APFEL, LED Matrix, Traces.
- Plotting Panel (highlighted with a red box):**
  - refresh(s): 1
  - sub #: [input field]
  - Buttons: load, remove, reload
  - Plotting options: channels (dropdown), plot (checkbox), BL means (dropdown), scale max (input), dynamic scale (checkbox), log scale (checkbox).
- Adjust Baselines Panel:**
  - Target position: Freedom
  - Value: 2000 (input), 500 (input)
  - toggle adjust:  auto-calib:
  - new method:
  - Submodule: [input], crystal Nr.: [input]
  - Buttons: adjust, cancel
- Setup SADC Panel:**
  - Submodule: [input]
  - SADC channel: [input] program
  - HG Threshold: 4000 (+threshold)
  - LG Threshold: 400 (-threshold)
  - TUZ min hg: 20 (input) save
  - TUZ max hg: 200 (input) load
  - TUZ min lg: 20 (input) pushmode
  - TUZ max lg: 200 (input) lifemode
  - TRL: 727 (input) re-list
  - Sync.:
  - SADC channel: [input] scan
  - Target rate: 50 (input) cancel
  - Iterations: 20 (input)
  - Crude tuning:
- 2D Plotting Grid:** A grid of 44 numbered cells (0-44) with a color scale from 0 to 8207. A red dot is visible in cell 2.
- Legend:** crystals (radio buttons), chans (radio buttons), sub bit (radio button), crystal bit (radio button).
- Alerts Panel:** submodule: 3, channel: 0-03, all (dropdown), acknowledge, ignore, unignore, force: , reset watcher, Alerts (dropdown).



# Slow control

- Example: traces app, tested with 1 Full subunit (external setup) and 3 half subunits (climate chamber)
- Alert system:
  - Watcher which checks whether parameters are within limits

The screenshot displays the PRIMA Control Interface, which is divided into several sections:

- Navigation:** Start, Detector Control (active), Run Control, Data Visualisation.
- Left Panel:** Includes status indicators for High Voltage, APFEL, LED Matrix, and Traces.
- Detector Control Section:**
  - Refresh rate: 1 s
  - Subunit selection: sub # 35, with load, remove, and reload buttons.
  - Plotting:** Options for BL means, channels, plot, scale max, dynamic scale, and log scale.
  - Adjust Baselines:** Target position (2000) and Freedom (500) fields, with toggle adjust, auto-calib, and new method checkboxes.
  - Setup SADC:** Fields for SADC channel, HG Threshold, LG Threshold, TUZ min/hg/max, and TRL, with various control buttons.
- Detector Layout:** A grid of 44 numbered detector positions (0-44) arranged in a ring-like pattern. A color scale on the right ranges from 0 to 8209.
- Plot:** A large grid plot showing a single detector (3) with a value of 3. A red box highlights the plot area.
- Alert System:** A section for "baselines alert: channel 48" with submodule and channel dropdowns, and buttons for acknowledge, ignore, unignore, and force.

# Slow control

- Example: traces app, tested with 1 Full subunit (external setup) and 3 half subunits (climate chamber)
- Alert system:
  - Watcher which checks whether parameters are within limits
  - If not, acoustic and visual alerts

The screenshot displays the PRIMA Control Interface, which is divided into several sections:

- Navigation:** Start, Detector Control (active), Run Control, Data Visualisation.
- System Status:** Isog High Voltage, High Voltage, Low Voltage, APFEL, LED Matrix, Traces.
- Detector Control:** Includes a refresh rate of 1s, subunit selection (35), and buttons for load, remove, and reload.
- Plotting:** Features a grid of 44 numbered detector channels (0-44) arranged in a circular pattern. A color scale on the right ranges from 0 to 8209. A large number '3' is overlaid on the grid, indicating the selected subunit.
- Adjust Baselines:** Includes target position (2000), toggle adjust (checked), auto-calib (checked), and new method (checked).
- Setup SADC:** Includes submodule selection, SADC channel, HG Threshold (4000), LG Threshold (400), TUZ min/max (20), and TRL (717).
- Alert System:** A red-bordered box highlights the alert system, which includes a 'baselines alert: channel 48' message, a 'submodule channel' dropdown (set to 3), and buttons for acknowledge, ignore, unignore, and force.

# Slow control

- Example: traces app, tested with 1 Full subunit (external setup) and 3 half subunits (climate chamber)
- Alert system:
  - Watcher which checks whether parameters are within limits
  - If not, acoustic and visual alerts
  - Controls which allow to acknowledge/ignore alerts in certain channels

The screenshot displays the PRIMA Control Interface, which is divided into several functional areas:

- Navigation:** A top bar with tabs for 'Start', 'Detector Control' (active), 'Run Control', and 'Data Visualisation'.
- Left Panel:** A sidebar with sections for 'Isag High Voltage', 'High Voltage', 'Low Voltage', 'APFEL', 'LED Matrix', and 'Traces'.
- Detector Control Panel:** A central control area with a green header '#'. It includes a 'refresh(s)' input (set to 1), a 'sub #' dropdown (set to 35), and buttons for 'load', 'remove', and 'reload'. Below this is a 'Plotting' section with options for 'BL means', 'channels', and 'plot', along with 'scale max', 'dynamic scale', and 'log scale' settings. The 'Adjust Baselines' section features 'Target position' and 'Freedom' inputs, and checkboxes for 'toggle adjust', 'auto-calib', and 'new method'. The 'Setup SADC' section contains various parameters like 'SADC channel', 'HG Threshold', 'LG Threshold', 'TUZ min lg', 'TUZ max lg', 'TRL', and 'Sync.', each with a corresponding input field and control buttons.
- Plotting Area:** A large grid representing the detector layout, with cells numbered 0 through 44. A color scale on the right ranges from 0 (blue) to 8209 (red). A red box highlights a specific cell containing the number '3'.
- Alert Management Window:** A red-bordered window titled 'baselines alert: channel 48'. It shows 'submodule' as '3' and 'channel' as '0-03'. It includes buttons for 'acknowledge', 'ignore', 'unignore', and 'force', along with a 'reset watcher' button and a dropdown menu for 'Alerts: Baseline Alert'.

# Slow control

- Example: traces app, tested with 1 Full subunit (external setup) and 3 half subunits (climate chamber)
- Control of multiple subunits:
  - Controlling baseline position

The screenshot displays the PRIMA Control Interface, which is divided into several sections:

- Navigation:** Start, Detector Control (active), Run Control, Data Visualisation.
- System Status:** Isog High Voltage, High Voltage, Low Voltage, APFEL, LED Matrix, Traces.
- Detector Control:** Includes a refresh rate of 1s, subunit selection (sub # 35), and buttons for load, remove, and reload.
- Plotting:** Features a 'plot' button, 'BL means' dropdown, 'scale max' input, 'dynamic scale' toggle (checked), and 'log scale' toggle.
- Adjust Baselines (highlighted in red):** Contains fields for 'Target position' (2000) and 'Freedom' (500), with 'toggle adjust' and 'new method' checked. It also includes 'auto-calib' and 'cancel' buttons.
- Setup SADC:** Includes fields for 'Submodule', 'SADC channel', 'HG Threshold', 'LG Threshold', 'TUZ min lg', 'TUZ max lg', 'TRL', and 'Sync.'.
- Detector Layout:** A central diagram showing a grid of detector channels numbered 0 to 44. A color scale on the right ranges from 0 to 8209.
- Channel 48 Plot:** A zoomed-in view of channel 48, showing a large '3' in the center and a small red square in the bottom-left corner. Below the plot are controls for 'baselines alert: channel 48', 'submodule', 'channel', and 'Alerts: Baseline Alert'.

# Slow control

- Example: traces app, tested with 1 Full subunit (external setup) and 3 half subunits (climate chamber)
- Control of multiple subunits:
  - Controlling baseline position
  - Programming SADCs

The screenshot displays the PRIMA Control Interface with the following components:

- Navigation:** Start, Detector Control (active), Run Control, Data Visualisation.
- System Status:** Isog High Voltage, High Voltage, Low Voltage, APFEL, LED Matrix, Traces.
- Plotting:** refresh(s) [1], sub # [35], load, remove, reload. Includes options for channels, plot, BL means, scale max, dynamic scale, and log scale.
- Adjust Baselines:** Target position (2000), Freedom (500), toggle adjust, auto-calib, new method.
- Setup SADC (highlighted in red):** Submodule, SADC channel, HG Threshold (4000), LG Threshold (400), TUZ min hg (20), TUZ max hg (200), TUZ min lg (20), TUZ max lg (200), TRL (727), Sync. (red indicator).
- Plot:** A grid of subunit positions numbered 0-44. A color scale on the right ranges from 0 to 8209. A subunit '3' is highlighted in a red box.
- Alerts:** baselines alert: channel 48, submodule 3, channel 0-03, all, acknowledge, ignore, unignore, force, reset watcher, Alerts: Baseline Alert.

# Slow control

- Example: traces app, tested with 1 Full subunit (external setup) and 3 half subunits (climate chamber)
- Control of multiple subunits:
  - Controlling baseline position
  - Programming SADCs
  - Automatic threshold adjustment to reach defined noise rate

The screenshot displays the PRIMA Control Interface, which is divided into several sections:

- Navigation:** Start, Detector Control (active), Run Control, Data Visualisation.
- System Status:** Isog High Voltage, High Voltage, Low Voltage, APFEL, LED Matrix, Traces.
- Plotting:** Includes a 'refresh(s)' field set to 1, a 'sub #' field set to 35, and a 'plot' button. There are also checkboxes for 'dynamic scale' (checked) and 'log scale'.
- Adjust Baselines:** Features 'Target position' (Freedom) and 'Freedom' (2000) fields. It includes checkboxes for 'toggle adjust' (checked), 'auto-calib' (checked), and 'new method' (checked).
- Setup SADC:** Contains fields for 'Submodule', 'SADC channel', 'HG Threshold', 'LG Threshold', 'TUZ min lg', 'TUZ max lg', 'TUZ min lg', 'TUZ max lg', 'TRL', and 'Sync.'. A red box highlights the 'SADC channel', 'Target rate' (50), and 'Crude tuning' (checked) fields.
- Detector Layout:** A central diagram shows a grid of detector channels numbered 0 to 44. A color scale on the right ranges from 0 (blue) to 8209 (red). A red box highlights a specific channel in the layout.
- Alerts:** A section on the right shows 'baselines alert: channel 48' and 'Alerts: Baseline Alert'.

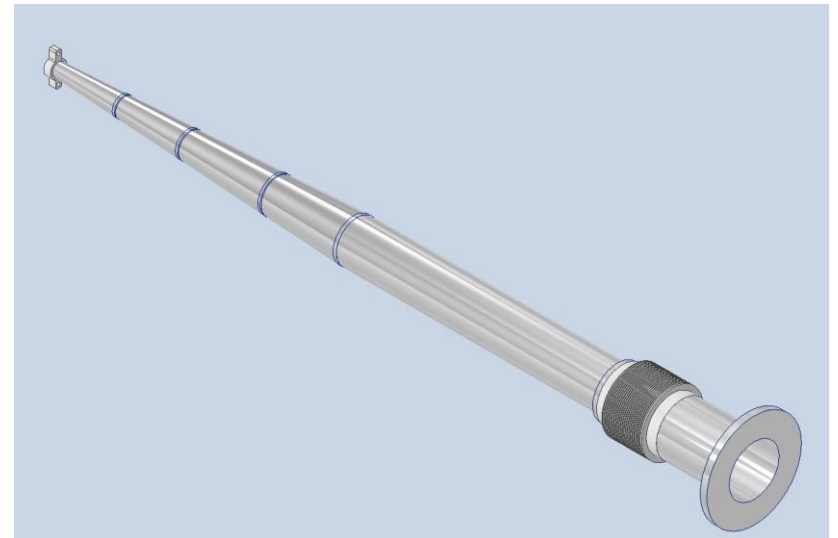
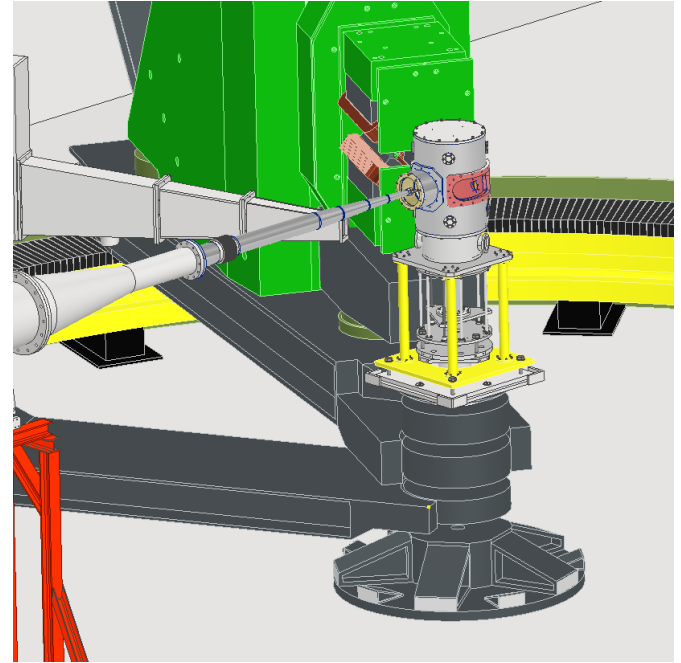


# SADC firmware and DAQ status

- Dedicated talk by Olliver Noll (7.2. 9:40)

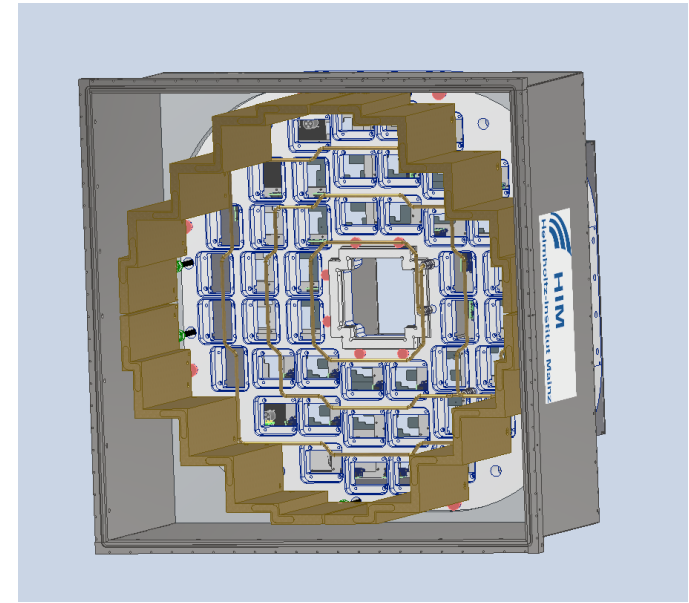
# Mechanical status

- Exit beampipe for Phase-0 experiment in production in workshop



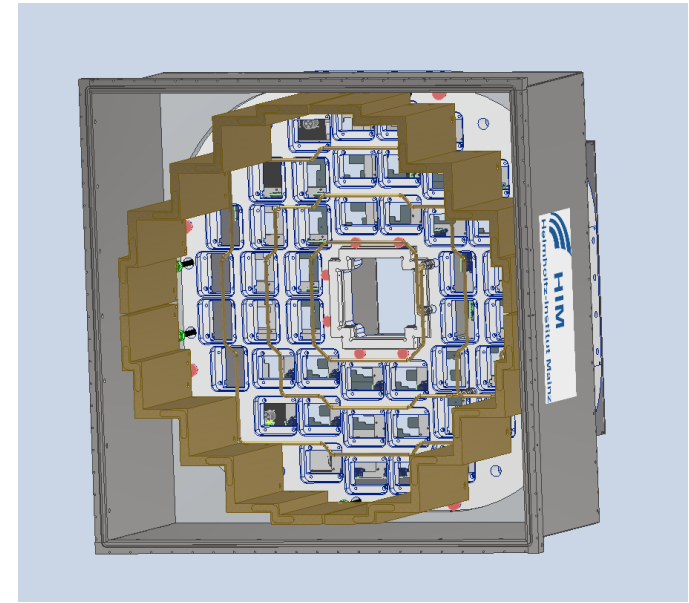
# Mechanical status

- Exit beampipe for Phase-0 experiment in production in workshop
- Cooling system for Phase-0 setup:
  - Test setup with manifolds and chiller built in our hall



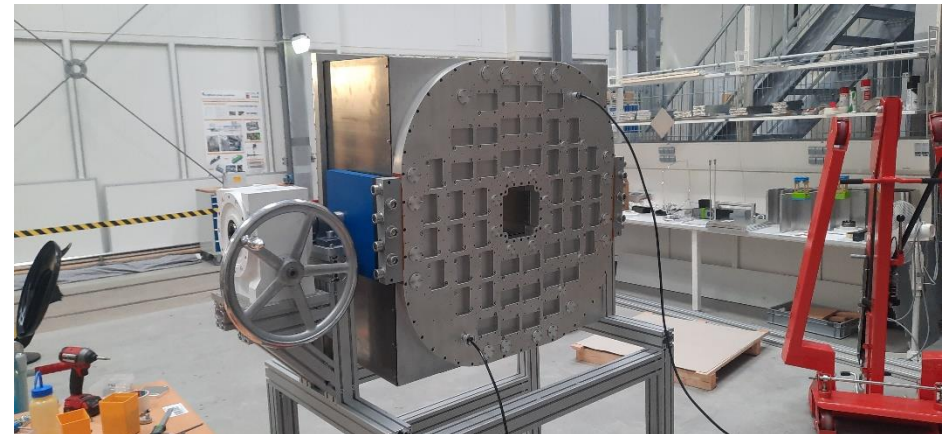
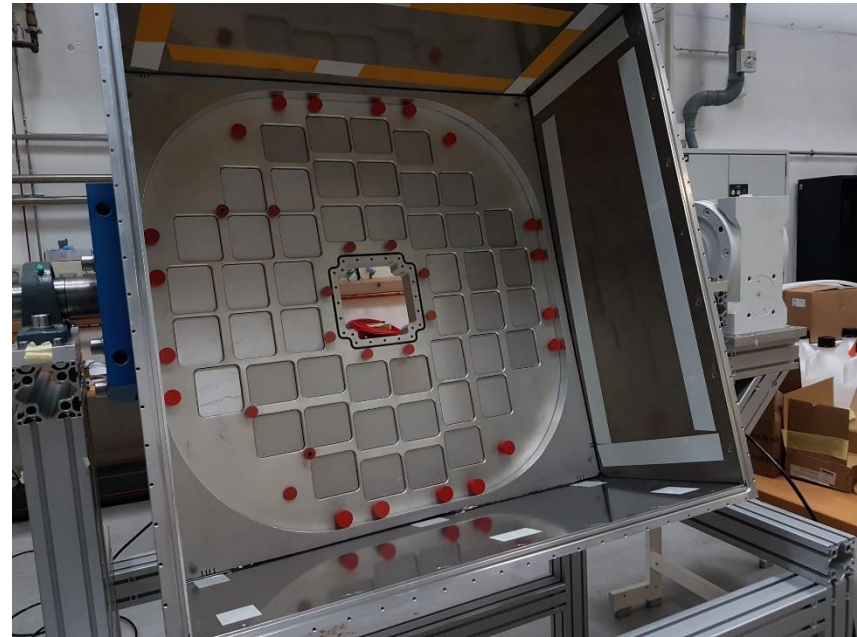
# Mechanical status

- Exit beampipe for Phase-0 experiment in production in workshop
- Cooling system for Phase-0 setup:
  - Test setup with manifolds and chiller built in our hall
  - Find leakage problems, perform measurements for bachelor thesis (Jonas Geisbüsch)



# Mechanical status

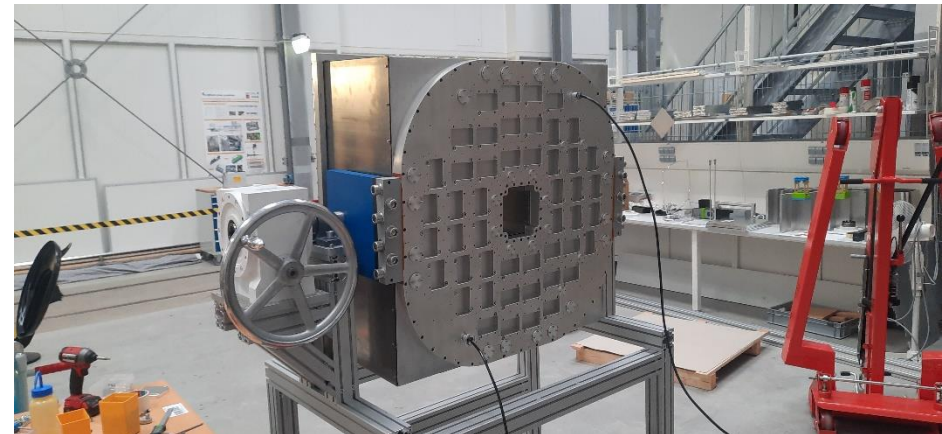
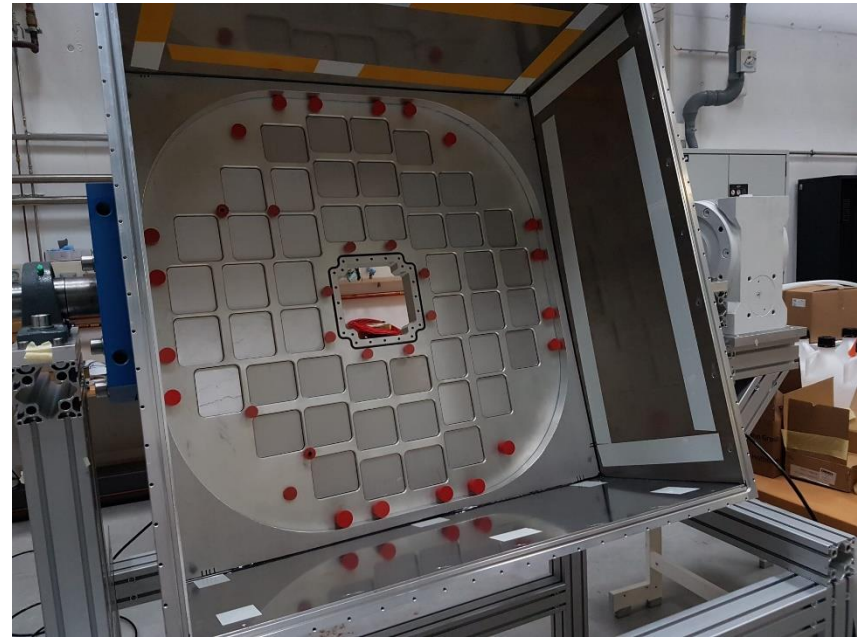
- Exit beampipe for Phase-0 experiment in production in workshop
- Cooling system for Phase-0 setup:
  - Test setup with manifolds and chiller built in our hall
  - Find leakage problems, perform measurements for bachelor thesis (Jonas Geisbüsch)
- Tests of airtightness of detector ongoing:
  - Baseplate openings sealed
  - Coverbox glued
  - Detector flooded with nitrogen with defined flowrate
  - Check flow at outflow





# Mechanical status

- Exit beampipe for Phase-0 experiment in production in workshop
- Cooling system for Phase-0 setup:
  - Test setup with manifolds and chiller built in our hall
  - Find leakage problems, perform measurements for bachelor thesis (Jonas Geisbüsch)
- Tests of airtightness of detector ongoing:
  - Baseplate openings sealed
  - Coverbox glued
  - Detector flooded with nitrogen with defined flowrate
  - Check flow at outflow
- Replacement of nitrogen system with dried air, procurement in process





# Summary

## ▶ Submodule production:

- Finished ✓

## ▶ Calibration of submodules:

- Measurements finished ✓
- Analysis in progress

## ▶ HV boards:

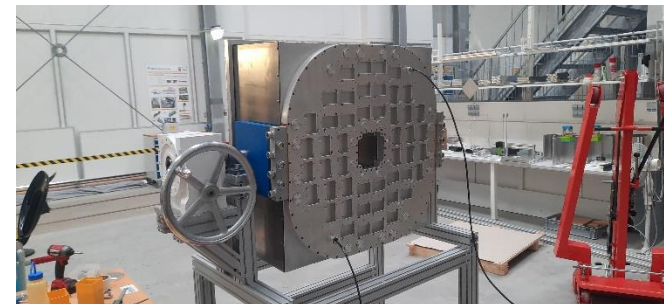
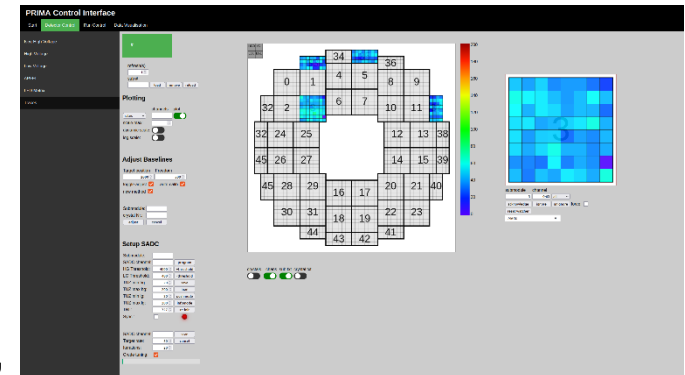
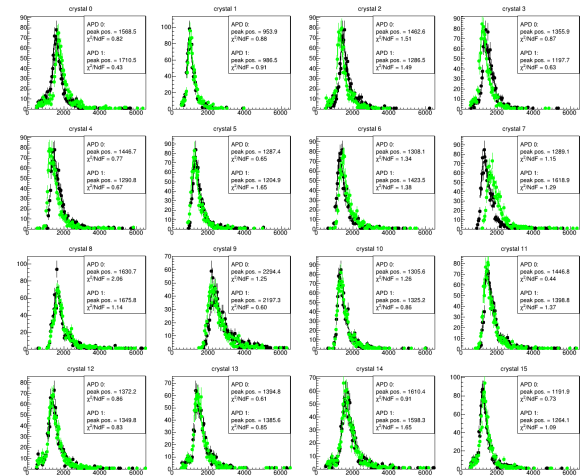
- All boards produced, HV calibration done
- Boards currently in repair due to minor issue

## ▶ Slow control:

- Epics and web interface integration of chiller control finished
- Detector overview implemented in web interface, including 2D plots, alert system and multi submodule detector controls

## ▶ Mechanical status:

- Exit beampipe in production
- Cooling and airtightness tests of the Phase-0 setup in progress



**Thank You!**