Status Forward Endcap EMC

PANDA Collaboration Meeting 18/1, GSI, March 7, 2018

Thomas Held

Ruhr-Universität Bochum
Institut für Experimentalphysik I

FWEC EMC PRR II (APD Screening)

Forward Endcap EMC APD submodule review

Thursday, 7 December 2017 from **10:00** to **18:00** (Europe/Berlin)

Material: document | summary

Thursday, 7 December 2017

10:00 - 12:00 Review at GSI
Location: GSI

- 10:00 **Update on VPTT sub-module production** *15'* (GSI Auditorium side room, SB1)
  Speaker: Thomas Held (Ruhr-Universität Bochum(RUB))
  Material: Slides
- 10:30 **APDs: Requirements for Forward Endcap Usage** *15'* (GSI Auditorium side room, SB1)
  Speaker: Thomas Held (Ruhr-Universität Bochum(RUB))
  Material: Slides
- 10:45 **APD screening** *20'*
  Speaker: Christian Joachim Schmidt (GSI, Darmstadt)
  Material: Slides
- 11:30 **Visit of the APD screening facility (A. Wilms)** *30'*

12:00 - 13:00 Lunch Break (GSI)

14:30 - 18:00 Review at Giessen
Location: University of Giessen

- 14:30 **APD irradiation** *10'* (Seminar room 130)
  Speaker: Mr. Hans-Georg Zaunick (JLU Gießen)
  Material: Slides
- 15:00 **Visit of the irradiation facility** *30'*
- 15:30 **Fall back solutions** *15'* (seminar room 130)
  Speaker: Thomas Held (Ruhr-Universität Bochum(RUB))
  Material: Slides
- 15:45 **APD sub-module assembly** *20'*
  Speaker: Thomas Held (Ruhr-Universität Bochum(RUB))

PANDA Forward Endcap EMC

Production Readiness Review

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Internal Meeting Dec. 7, 2017

on the status of APD submodules

Anastasios Belias, Daniela Calvo, Herbert Löhner, Lars Schmitt, Tobias Stockmanns

January 24, 2018

FWEC EMC PRR II - Screening Requirements

Forward Endcap APD requirements: Summary

- Our test screening reveals the necessary scenario for high throughput
- A screening comprising only the necessary measurements must restrict to the following steps:
  - Lot-wise preselection to narrow the spread for matching
  - Dark current and DC light characteristic curves measurements on new APDs
  - Irradiation at Strahlenzentrum Giessen (about 30 Gy) w/o bias applied
  - Thermal annealing at 80 °C for 48 hours (common bias)
  - Dark current and DC light characteristic curves measurements on the annealed APDs
  - Matching

FWEC EMC PRR II - APD Submodule Production

Submodule production for the $\overline{\text{P}}$ANDA Forward Endcap EMC

$\overline{\text{P}}$ANDA EMC Note

INTERNAL DOCUMENT

Malte Albrecht, Thomas Held, Tobias Holtmann, Miriam Kümmel, Claudius Schnier, Cathrina Sowa

December 5, 2017

Institut für Experimentalphysik I
Ruhr-Universität Bochum

RUHR UNIVERSITÄT BOCHUM RUB

panda

3 Avalanche-Photodiode Units

3.1 Material and preparation

Before one begins to assemble a unit, it should be checked whether all the necessary material is available. A full list of the material for **one unit** is given below.

Make sure that you know the assignment of crystals to photo detectors and preamps of the submodule intended to build BEFORE beginning assembly!

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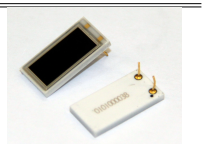
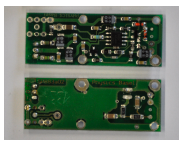
Make sure that you are always wearing ESD gloves, work on a grounded ESD mat and that you are connected to this mat by an ESD bracelet!

Component	Picture
- Hamamatsu	
- 2× Low-Noise Preamplifier (front + back shown)	
- 3D-printed nylon capsule - $2 \times 0.15\,\text{m}$ U.FL coaxial signal cable - $3 \times 0.15\,\text{m}$ High voltage cable (one red, one black, one blue) - $3 \times 0.15\,\text{m}$ Low voltage cables (one red, one black, one blue) - $3 \times 0.03\,\text{m}$ Low voltage cables (one red, one black, one blue) - 2× M2 nylon screws + nuts - wire pins for the APD-preamp connections - Aluminum pipe w/ attached GND strap	*see picture on next page!*

FWEC EMC PRR II - APD Submodule Production

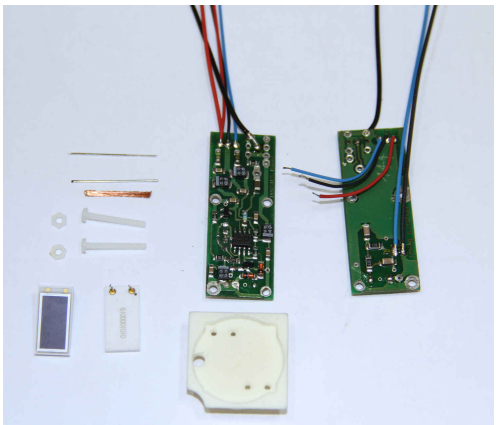


Figure 3.1: Components for the electronic assembly

3.2 Electronics assembly

Step-by-step instruction

For the electronics assembly you will need the components shown in picture **??**:

- Two screened, irradiated, annealed, re-screened and finally matched Hamamatsu Avalanche Photo Diodes (APDs).
- Two APD preamplifiers. Use two differently equipped preamplifiers to assemble one APD unit: One preamplifier is equipped with 15 cm long cables for the low voltage supply (one red, one blue, one black cable), as well as one 15 cm long red high voltage power cable. The second preamp is equipped with three short low voltage, as well as a blue and a black 15 cm long high voltage cables. Apart from these, both preamps must be equipped with a color-labeled AWG24 micro-coaxial signal cable.
- A 1.5 cm long copper ground strap
- Two wire pins for the connection between the preamplifiers and the APDs
- Two M2 nylon screws and nuts

First Step: Only one preamplifier is equipped with long LV cables that are fed out of the submodule and are connected to the patch-panel PCB on the forward endcap backplate. The second preamplifier will receive its LV supply from the respective other preamp, using short LV cables. Solder the three short LV cables to the correct pads of the preamp equipped with the long LV cables (see Fig.**??**) and pay special attention to the order of the cables! The short LV-patch cables should be placed **inbetween** the two preamplifiers, when they are joined to form a PCB sandwich with the OP-amplifier chip facing **outwards**.

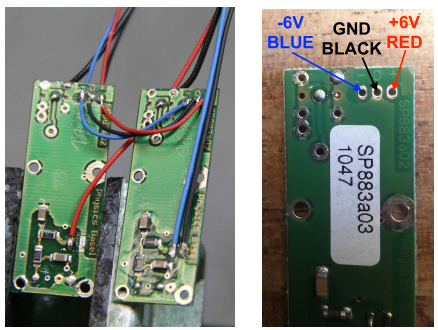


Figure 3.2: Connection of two APD preamplifiers. Double check the order of the colored LV cables!

Second Step: Now the two APDs have to be glued into a 3D-printed nylon capsule. For the forward endcap we decided to assign the two APDs of a unit to their position in the capsule using an easy naming scheme. The APDs will be called BLUE APD and RED APD depending on their position in the capsule. The APD situated **closer to the opening for the Light Pulser fibres in the detector (=cutout in one corner of the capsule)** is called the BLUE APD. This assignment is visualized in Fig.**??**. Glue the two APDs into the nylon capsule and **note the red/blue assignment using the database tool, which you can find here:** https://www.ep1.rub.de/endcapProductionDB/detector_assemble_form.php.

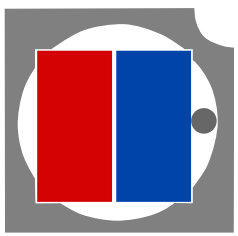
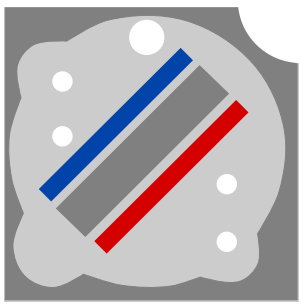


Figure 3.3: Position assignment of BLUE and RED labeled APDs in the capsule (capsule shown from front, looking at the sensitive surface of the APDs).

FWEC EMC PRR II - APD Submodule Production

Third Step: After the APDs are assigned to their positions and glued into the capsule, the prepared assembly (see *First Step*) of two preamplifiers is mounted to the frame on the back side of the capsule using two M2 nylon screws. Remember, that also the preamplifiers have a **fixed unique position assignment**. One preamplifier is equipped with the blue HV cable, a blue-marked coaxial AWG24 signal cable and **only short LV cables**, which is called the BLUE PREAMPLIFIER and will be connected to the blue APD. Check, that the corresponding other preamp, called the RED PREAMPLIFIER has all red-marked cables.
This naming scheme is important to ensure and maintain the unique identification of all parts of the signal chain and must never be compromised!
The orientation of the two preamps is visualized in Fig.**??**, left. Note the serial number of each preamplifier in the database and if they are red or blue.
Make sure, that the **heads of both screws are located close to the capacitors mounted in one corner of the preamp** to avoid clashes which would occur when feeding the screw from the other side through the hole (see Fig.**??**, right). After the assembly is completed, cut the nylon screws right after the fitting bolt using an electronics cutter.



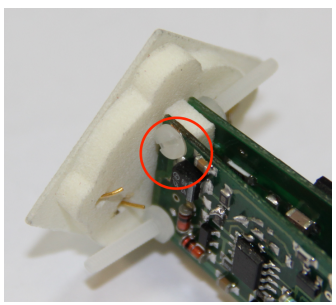
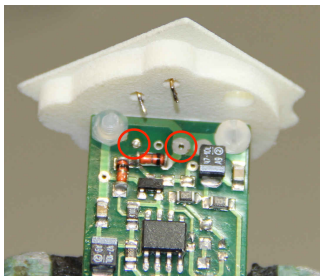


Figure 3.4: Mounting of the two electrically connected preamplifiers to a capsule

Fourth Step: The anode and cathode pins of both APDs have to be connected to the corresponding pads of the two preamps now. Use short bare wire pieces that are **thin enough** to fit into the holes in the preamp board marked in Fig.**??**, left. Gently bend the golden pins of the APDs towards the preamplifiers, solder the wire pieces to the preamp and then to the corresponding APD contact pin. The result must look as shown in Fig.**??**, right.



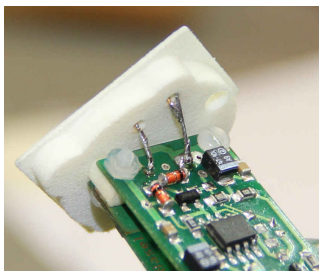


Figure 3.5: Left: . Right:

⇒ You have produced a Forward Endcap EMC APD unit. Now its time to perform the first functional test of the new unit. Perform the test in the same way as discussed for the test of the VPTT units in Section **??**. Remember to test both APDs-preamp units and record the results on the APD unit test sheet!

FWEC EMC PRR II - APD Submodule Production

Fifth Step: An aluminum tube with attached ground strap will now be used to cover the preamp-capsule assembly. Apply a thin layer of superglue to the edge of the aluminum tube **at the end, which is not equipped with the ground strap**. Move the aluminum tube over the preamplifiers towards the capsule. Turn the tube so, that the short copper ground strap attached to one of the two preamplifiers is close to the long ground strap attached to the tube as shown in Fig.**??**. Push the tube towards the capsule and check if the openin of the drill holw for the annealing LED ist as big as possible then maintain pressure until the superglue is cured.

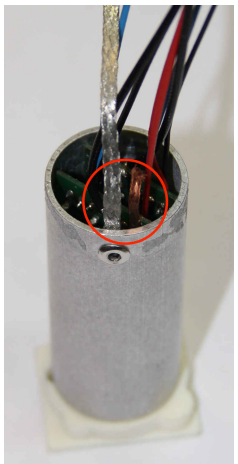


Figure 3.6: Watch out for orientation of aluminum tube. The short GND-strap soldered to the preamp must be joined with the one affixed to the aluminum pipe!

3.3 Elastosil casting

Step-by-step instruction

For the Elastosil casting you will need:

- 13.33 ml Elastosil RT601 A
- 1.67 ml Elastosil RT601 B
- A 15 ml syringe
- Small chunk of sealing compound

First Step: Fill the LED drilling with the sealing compound to prevent a leak of the pottant.

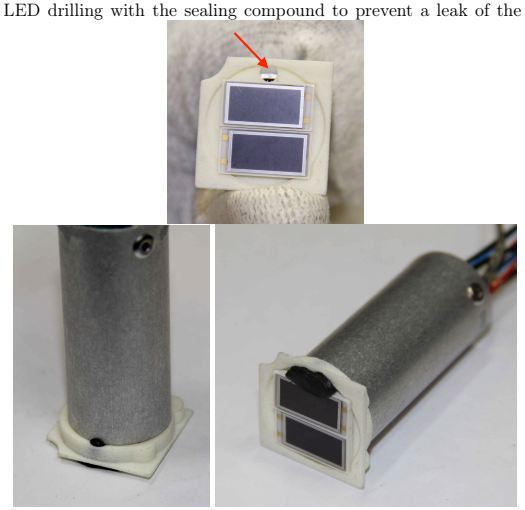


Figure 3.7: APD unit with LED drilling. Unfilled and filled with (black) sealing compound.

Second Step: Mix 13.33 ml Elastosil RT601 A with 1.67 ml Elastosil RT601 B. Use a syringe to fill the Elastosil into the space between preamplifier and aluminum pipe. The time needed to cure is about one day. Take care that the preamplifier is covered with Elastosil. Now it has to be tested again.

FWEC EMC PRR II - APD Submodule Production

3.4 Shielding and annealing LED

Step-by-step instruction

For the shielding and attachement of the annealing LED you need the following components shown in picture **??**::

- 7.5x2.5 cm self-adhesive aluminum tape (3M EMI Aluminum Foil Shielding Tape 1170)
- 1.5 cm self-sealing shrinking tube (black)
- 1x0.5 cm shrinking tube (yellow)
- Flex cable with annealing LED and attached cables

First Step: Wrap the self-adhesive aluminum tape around the top of the aluminum tube so that the whole top of the tube is covered by tape and 1.5 cm protrude above the rim. Then wrap the protruding aluminum tape together around the cables.

Figure 3.9: APD unit with aluminum foil shielding.

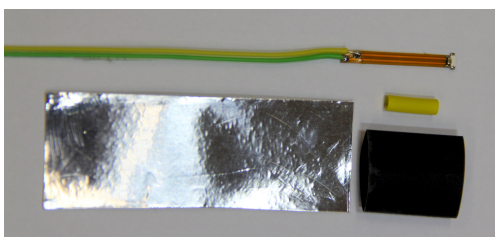


Figure 3.8: Components for the shielding and annealing LED

Second Step: Route the cable of the flex PCB through the drilled hole in the capsule from the front side of the capsule to the back until the LED is almost on the same level as the APD next to it. Cover the exposed contact of the Flex PCB with a piece of the small yellow shrinking tube. Set the APD unit with the APDs facing downward on the table top in order to achieve a good alignment of LED and APD. Affix the cables of the LED to the tube with some tape to avoid mis-alignement.

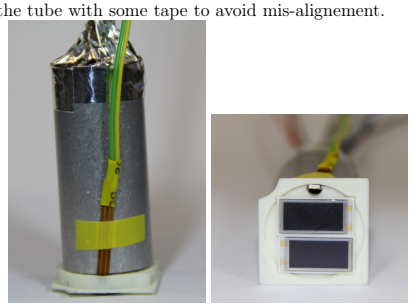


Figure 3.10: Positioning of the annealing LED. Cables fixated with a short strap of tape. Contacts are isolated using a piece of shrinking tube.

Third Step: Route all cables, the GND strap and the LED cable through the self-sealing, black shrinking tube and push it down as far as possible and take care that the cable of the LED lies flat on the alumium tube and shrink it. Then you can unfix the tape fixation of the cables for the LED.

Figure 3.11: Positioning of the self-adhesive shrinking tube.

FWEC EMC PRR II - Risk Management

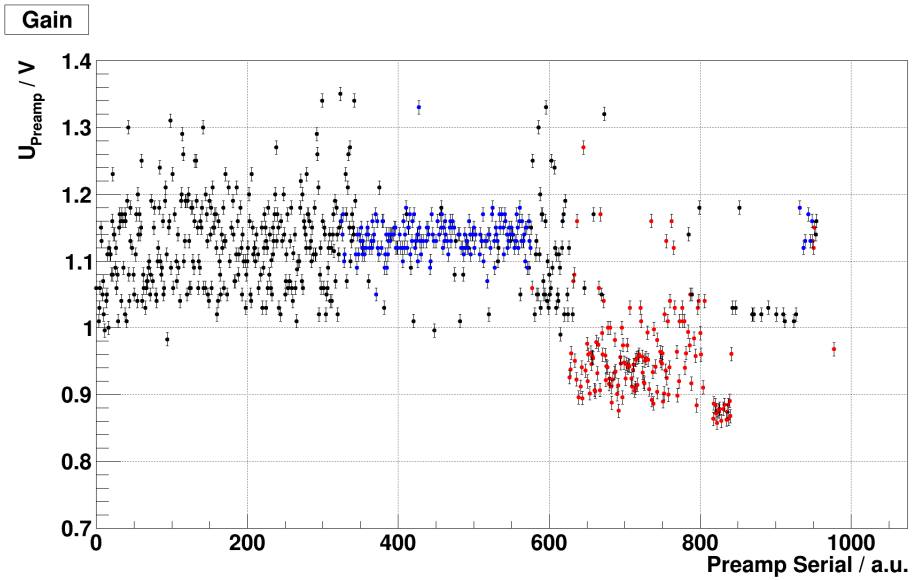
- APD throughput is critical
- Manpower at GSI is reduced
- APD screening at RUB, irradiation/annealing in Giessen
- Sequence sucessfully tested on 90 APDs
- High throughput screening:
  - Lot-wise preselection to narrow the spread for matching
  - Dark current and DC light characteristic curves measurements on new AP Ds
  - Irradiation at Strahlenzentrum Giessen (about 30 Gy) w/o bias applied, pins shorted by conductive foam
  - Thermal annealing at 80 °C for 48 hours (common 0 bias)
  - Dark current and DC light characteristic curves measurements on the an nealed APDs
  - Matching
- 250 APDs a week expected to be achievable (Bochum)

FWEC EMC PRR II - recommendations

I. Summary of recommended action items

Till when	What	By whom
Immediately	Scan of APD characteristics with 1V steps. Data points go into the database without fitting the data and are published to the whole EMC group.	
February	Optimize screening procedure to increase throughput of APDs. Try to automate the screening process as far as possible to reduce manpower needs.	
February	The operation of M=200 reduces significantly the safety margin between the operation voltage and the breakthrough voltage. A better motivation why this is needed is necessary. This operation condition should be reflected in the screening process.	
February	Investigate the long-term annealing behavior to properly determine the annealing time.	
One week after	Approval of new procedure.	
One week after	Implementation of new procedure; Update the list of reasonable and sensitive rejection criteria.	
February (Invested time should not exceed two weeks)	Investigation of "knee" by analyzing the existing data and a parallel irradiation of two times three grids, one with floating pins, one in conductive foam and one with bias voltage for M=100. Parallel measurement afterwards of the grids in Bochum and PSL with an exchange of the samples and crosscheck of results.	
February	Bring the Bochum screening side up and running. Measure already tested good and bad samples from PSL to verify the comparability of the results.	
Regularly	Regularly exchange samples between PSL and Bochum to cross-check the screening process.	
Regularly	Regular meetings of all involved groups are needed to improve the collaboration and the information flow.	

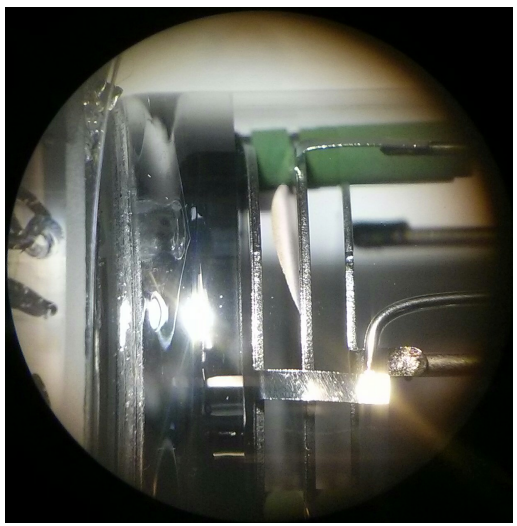
VPTT Submodule Production

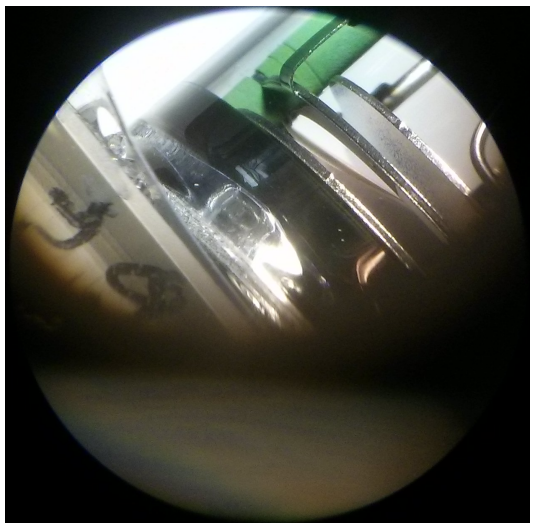


- Determination of individual preamp gains of photo-detector-preamp units already glued to crystals with LP finished (2nd try with reflective foil removed)
- One submodule resulting from corresponding new crystal-tube-preamp matching in production (containing directly/indirectly measured preamps 1:1)

VPTT Submodule Production

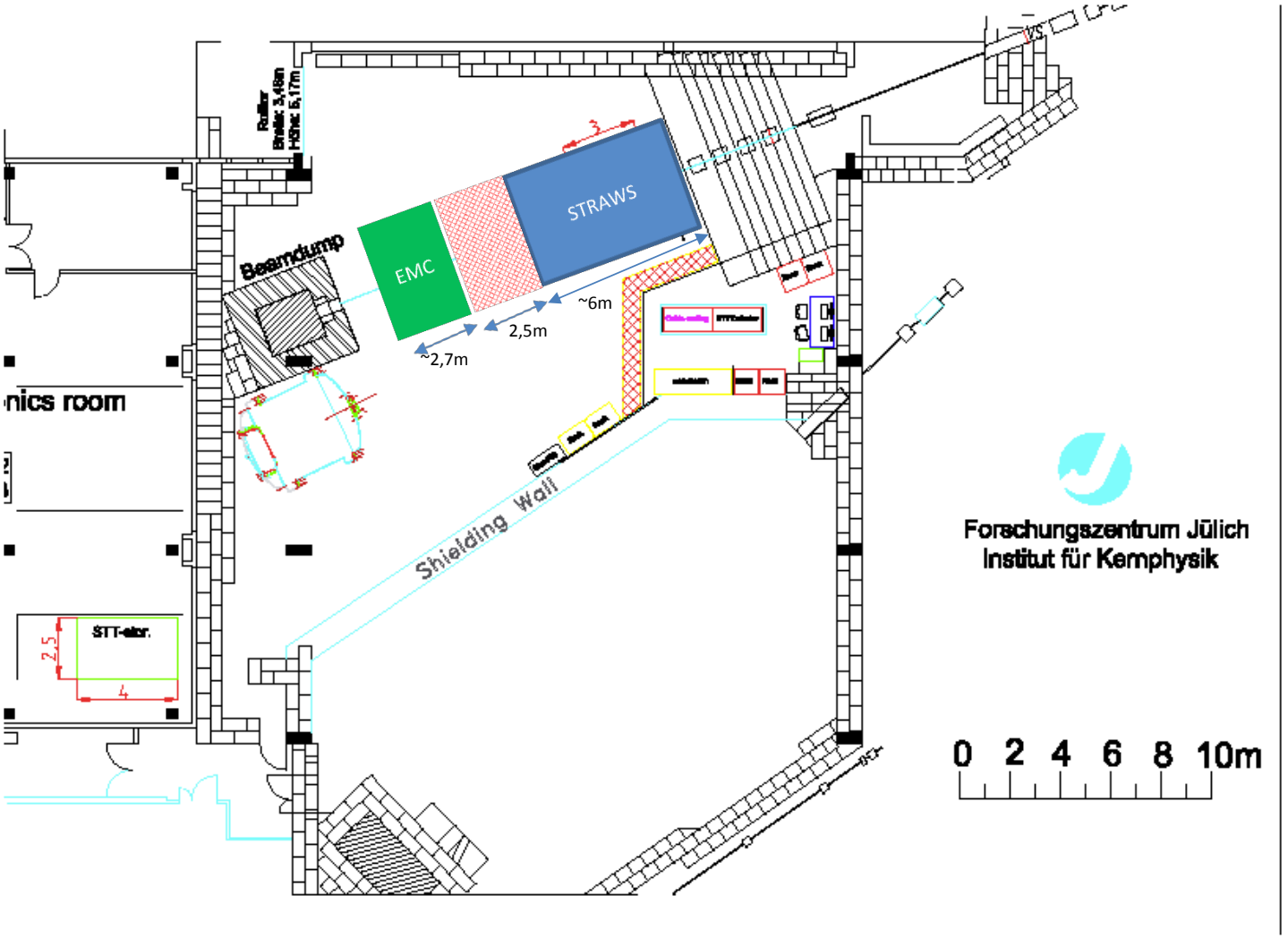
- During 2nd light pulser screening of crystal-detector-preamp units one unit showed low gain and high voltage divider current
- After cause could be tracked down to the tube we finally removed tube wrapping and graphit coating to look inside
- Mesh anode suspension broken, touching 1st dynode
- Hamamatsu claims this to result from an “impact of mechanical force (vibration, acceleration)”





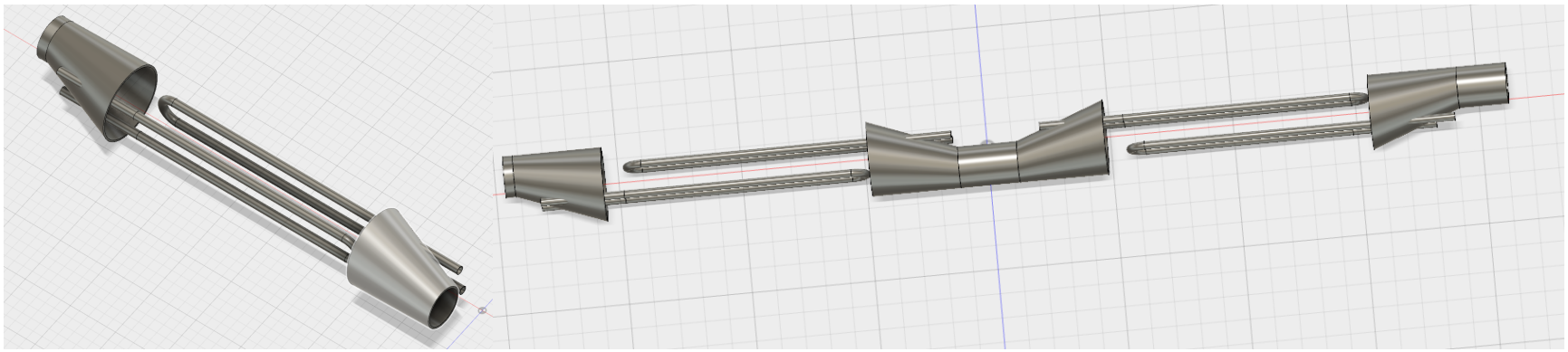
Jülich Preassembly Pedestal

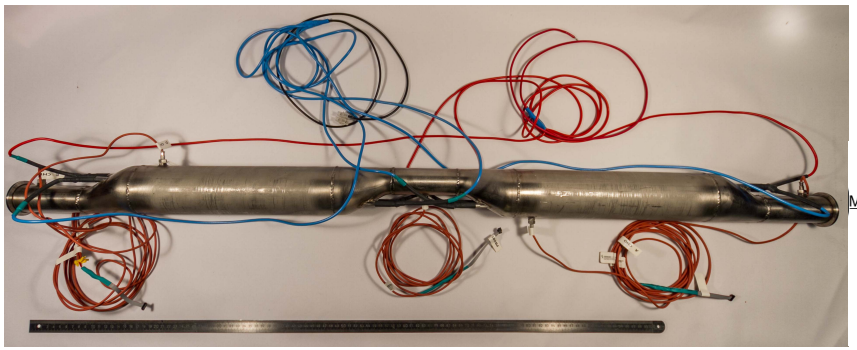
Jülich Preassembly Pedestal

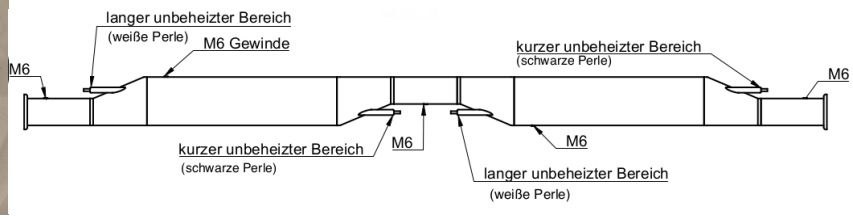


FWEC Temperature Regulation

- 4 heater elements per unit, 400 W each
- 900 mm overall length, 76 mm diameter max.

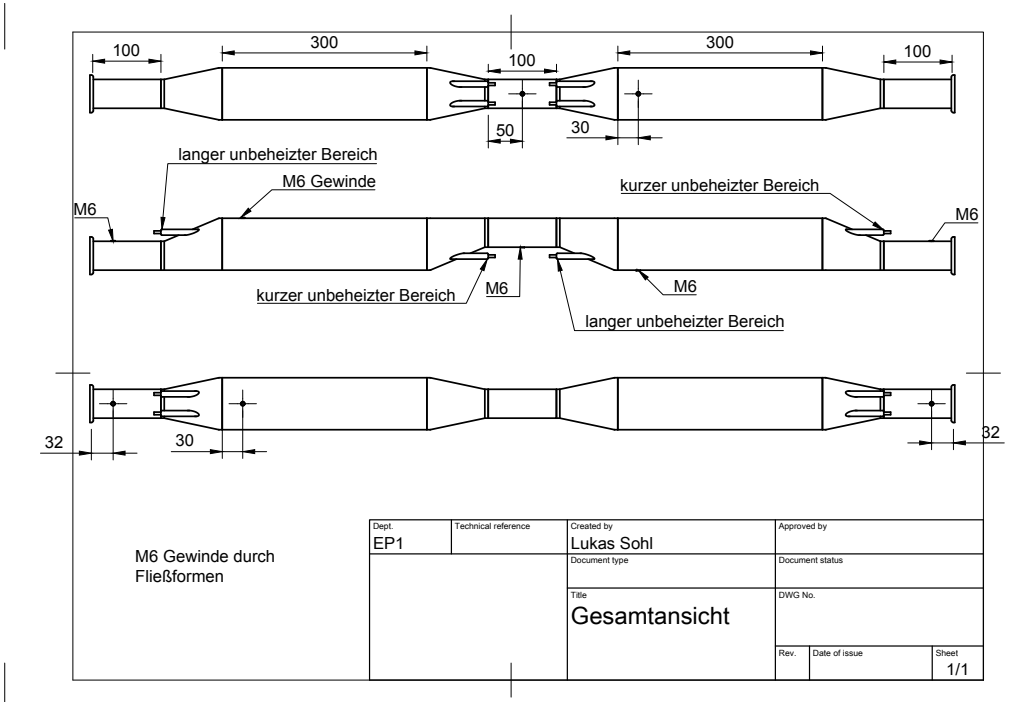


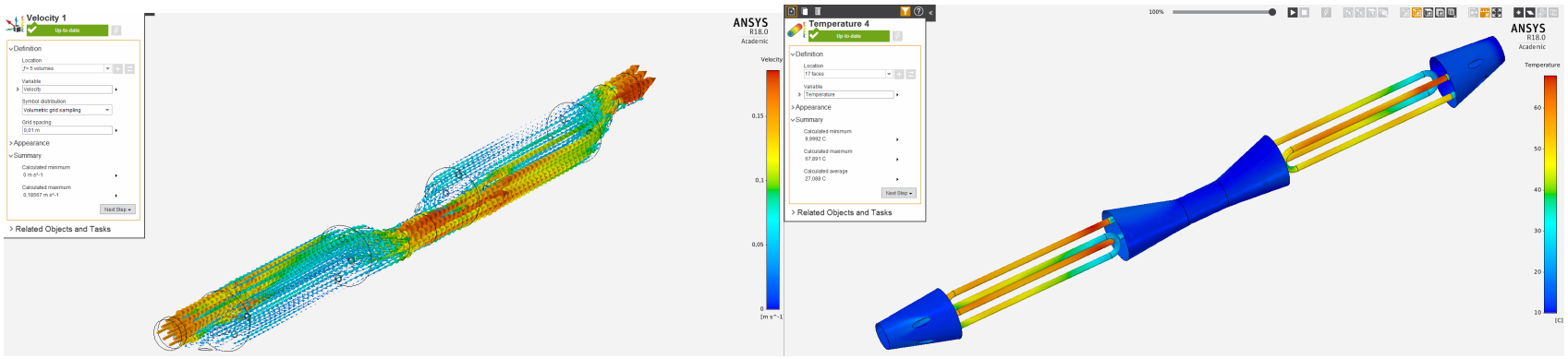




- Currently under test in Bochum

FWEC Temperature Regulation





Summary

- APD screening related FWEC PRR in December
  - $\Rightarrow$ Working on recommendations list
    Getting screening facility running in BO
- VPTT submodule production: 'Half and half' submodule under construction
- One broken VPTT, needs to be removed from crystal
- Jülich preassembly pedestal delivered, going to be installed in mounting position
- Heater units for temperature regulation constructed and currently tested