

ARICH new cooling system

Leonid Burmistrov

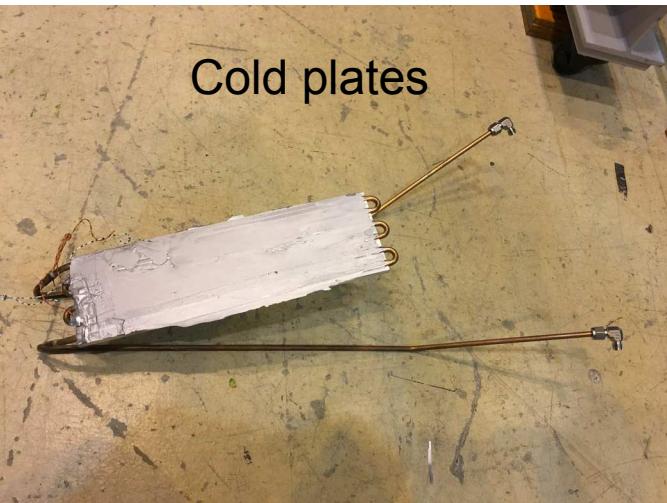


L. Burmistrov

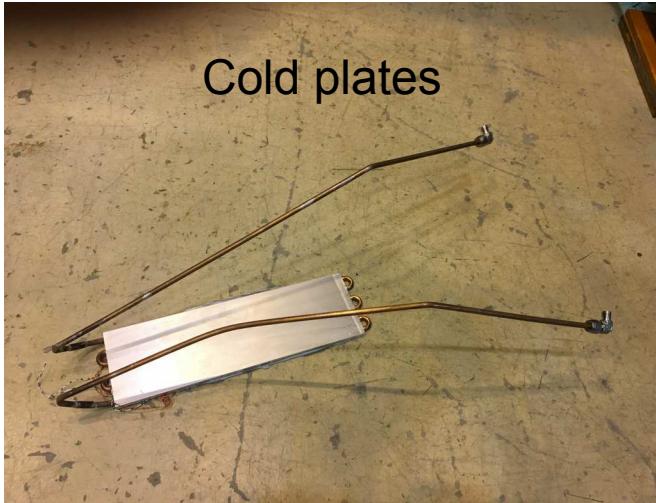


Removing of the old cooling system and mergers holder plates.

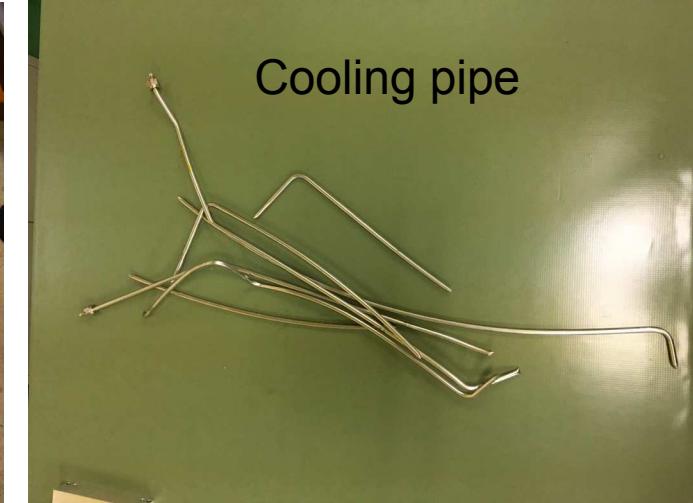
Cold plates



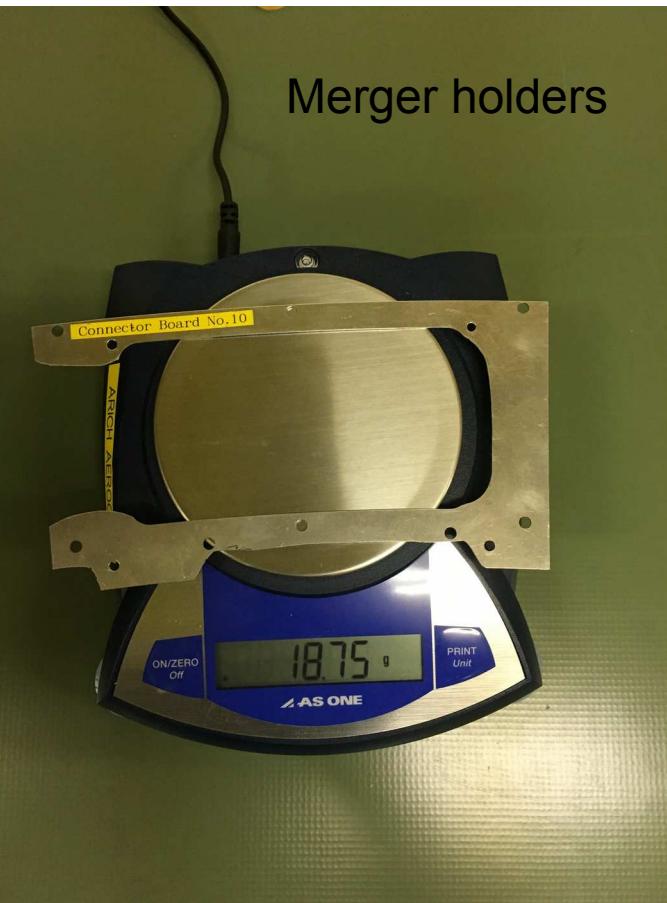
Cold plates



Cooling pipe

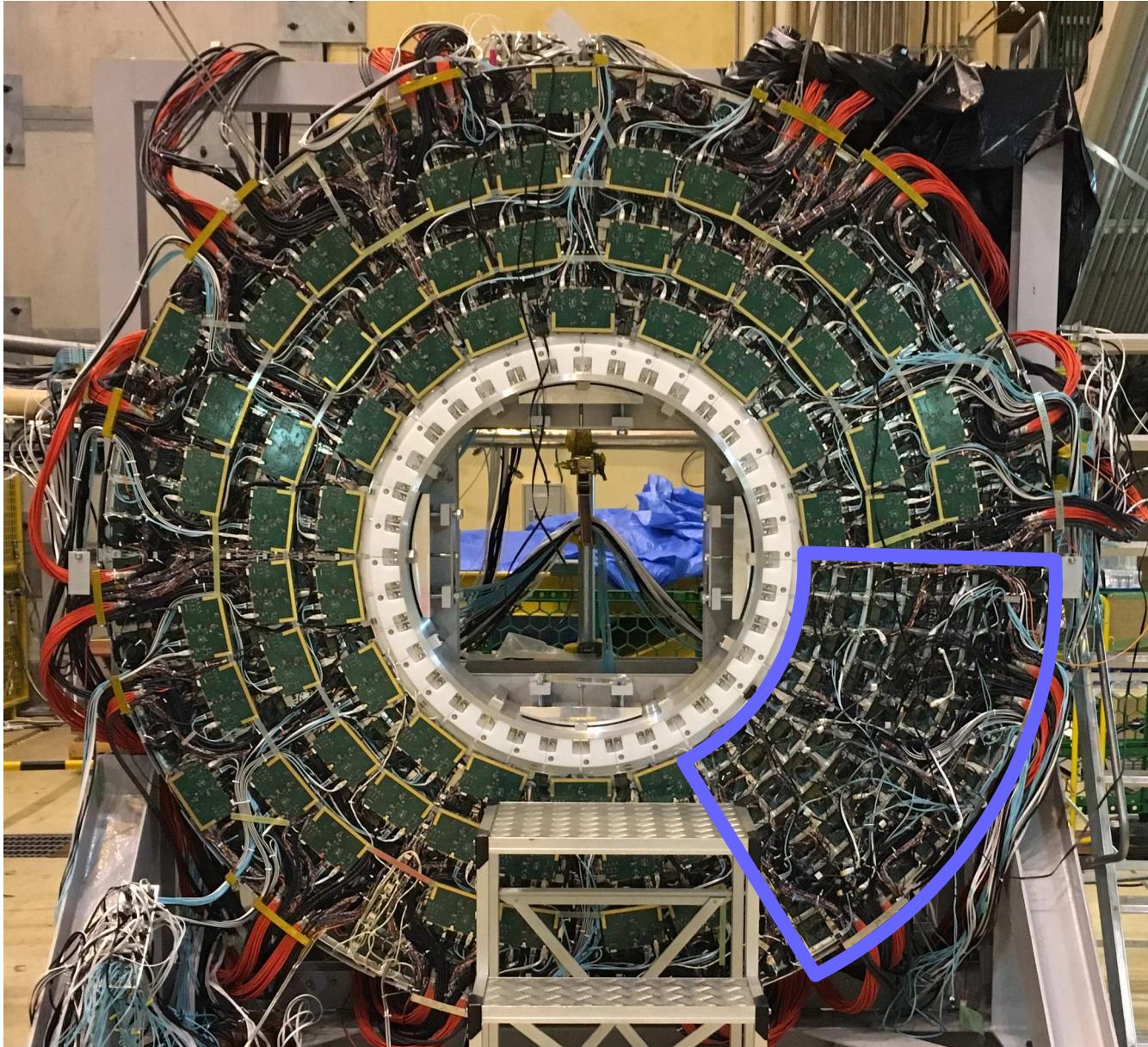


Merger holders



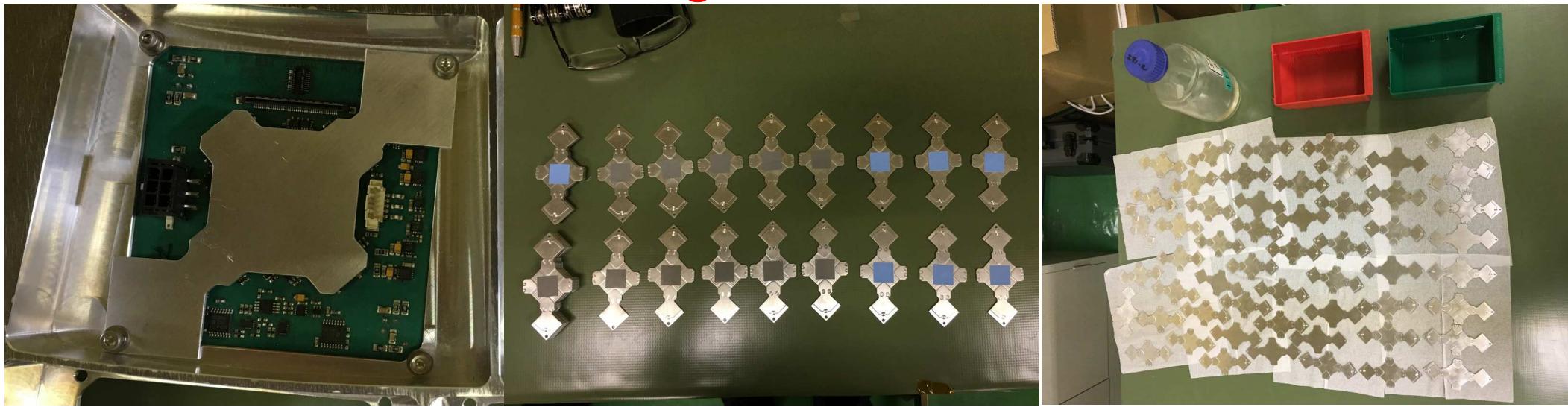
- Removing two/two cold plates
- Removing cooling pipe
- Removing merger holders
- Total weight of cooling pipes (stainless steel) :
3.543 kg
590.5 g per sector
- Total weight of merger holders (aluminum) :
1.35 kg
225 g per sector
- Total weight of cold plates (aluminum + copper) :
1.8 kg
0.9 kg per plate
- Screw are not taken into account.

New cooling system installation



- FPGA's of FEB's and mergers are the dominant source of dissipated heat.
- We started from sector 6.
- Dismount merger boards.
- Remove merger board holders.
- New cooling system consists from :
 - FEB – cooling contact plate
 - Merger – cooling bodies
 - Cooling pipes

FEB's cooling contacts with frame



- **First** the FEB's cooling contacts need to be installed.
- Their goal is to transfer heat from the FPGA to the aluminum frame.
- We want to test three main configurations :
 - No additional thermal contacts/pads
 - Additional thermal pads for tight contact with FPGA of type A (gray squares of $20 \times 20 \text{ mm}^2$)
 - Additional thermal pads for tight contact with FPGA of type B (blue squares of $20 \times 20 \text{ mm}^2$)
- The cooling contacts are made from aluminum by the cnc milling machine.
- Before the installation they have been cleaned with ethanol to remove the dust and residual grease.
- Total weight of FEB's cooling contacts (aluminum) :
3.154 kg
525.0 g per sector

Thermal pads for tight contact with FPGA

→ We test two types of thermal pads :

- Additional thermal pads for tight contact with FPGA of type A (gray squares of 20 x 20 mm²)
<https://eu.mouser.com/ProductDetail/739-A15972-02>
- Additional thermal pads for tight contact with FPGA of type B (blue squares of 20 x 20 mm²)
<https://eu.mouser.com/ProductDetail/951-GP30S30.010028NA>
- Both have same thermal conductivity : 3.0 W/(mK)

Type A - gray squares : Thermal Gap
Filler

Tflex™ HR600 Typical Properties

	Tflex™ HR600	Test Method
Construction	Filled silicone elastomer	NA
Color	Dark Grey	Visual
Thermal conductivity	3 W/mK	ASTM D5470
Hardness (Shore 00)	40 (at 3 second delay)	ASTM D2240
Density	2.5 g/cc	Helium Pycnometer
Thickness range	0.010" - .200" (0.25 - 5.0mm)	
Thickness tolerance	±10%	
UL flammability rating	94 V0	UL
Temperature range	-45°C to 200°C	NA
Volume resistivity	10 ^13 ohm-cm	ASTM D257
Outgassing TML	0.19%	ASTM E595
Outgassing CVCM	0.07%	ASTM E595
Coefficient Thermal Expansion (CTE)	217 ppm/C	IPC-TM-650 2.4.24

Type B – blue squares : Thermally Conductive, Reinforced, Soft “S-Class” Gap Filling Material

TYPICAL PROPERTIES OF GAP PAD 3000S30

PROPERTY	IMPERIAL VALUE	METRIC VALUE	TEST METHOD	
Color	Light Blue	Light Blue	Visual	
Reinforcement Carrier	Fiberglass	Fiberglass	—	
Thickness (inch) / (mm)	0.010 to 0.125	0.254 to 3.175	ASTM D374	
Inherent Surface Tack (1 side)	2	2	—	
Density (Bulk Rubber) (g/cc)	3.2	3.2	ASTM D792	
Heat Capacity (J/g-K)	1.0	1.0	ASTM EI269	
Hardness (Bulk Rubber) (Shore 00) (1)	30	30	ASTM D2240	
Young's Modulus (psi) / (kPa) (2)	26	180	ASTM D575	
Continuous Use Temp (°F) / (°C)	-76 to 392	-60 to 200	—	
ELECTRICAL				
Dielectric Breakdown Voltage (Vac)	>3000	>3000	ASTM D149	
Dielectric Constant (1000 Hz)	7.0	7.0	ASTM D150	
Volume Resistivity (Ohm-meter)	10 ⁹	10 ⁹	ASTM D257	
Flame Rating	V-O	V-O	UL 94	
THERMAL				
Thermal Conductivity (W/m-K)	3.0	3.0	ASTM D5470	
THERMAL PERFORMANCE vs. STRAIN				
	Deflection (% strain)	10	20	30
Thermal Impedance (°C-in ² /W)	0.040" (3)	0.66	0.60	0.54

1) Thirty second delay value Shore 00 hardness scale. 2) Young's Modulus, calculated using 0.01 in/min. step rate of strain with a sample size of 0.79 inch². 3) The ASTM D5470 test fixture was used. The recorded value includes interfacial thermal resistance. These values are provided for reference only. Actual application performance is directly related to the surface roughness, flatness and pressure applied.

Thermal conductivity

Experimental values of thermal conductivity

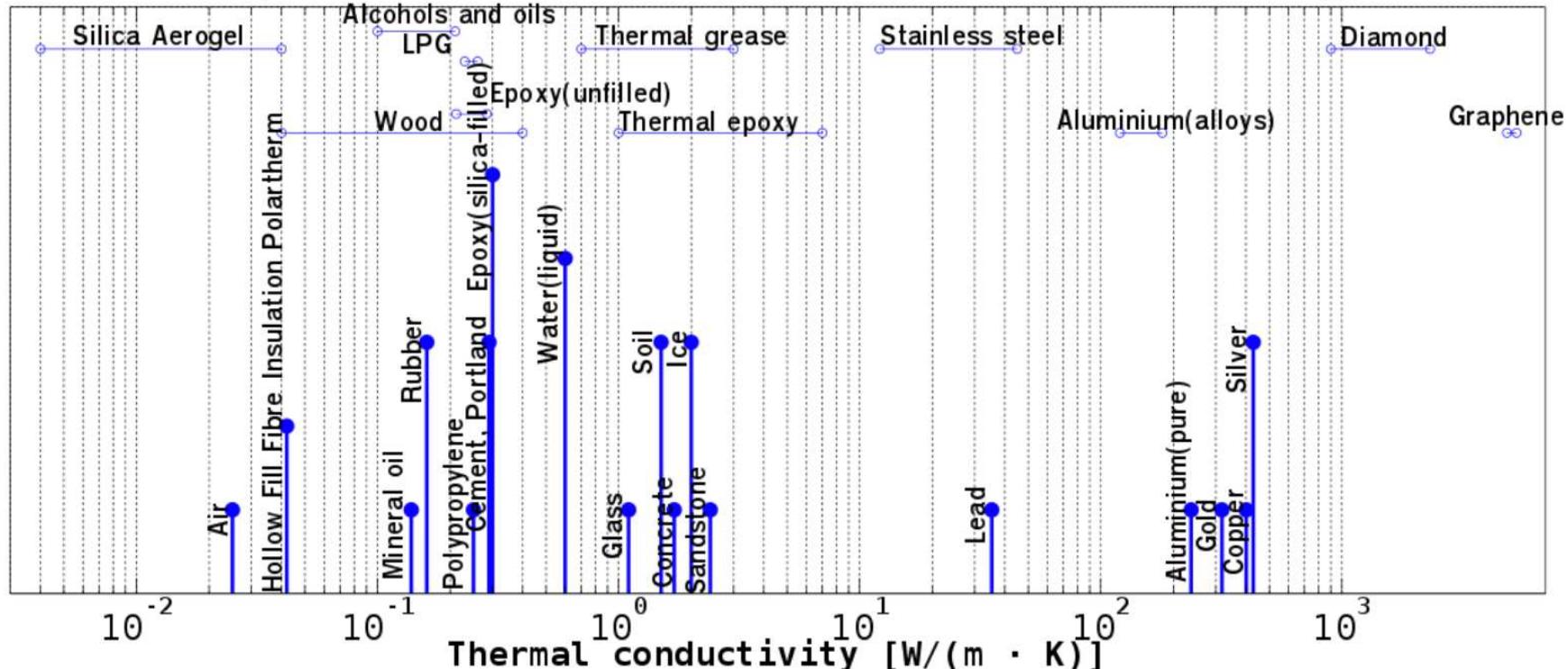


Table 7: Thermal conductivity.

Material	Thermal conductivity Wm ⁻¹ K ⁻¹
Copper	401
Aluminum	202-236
S Steel	15
Thermal pad A	3
Thermal pad B	3
Non conductive thermal grease	0.7 - 8
Air	0.022
Aerogel	0.017

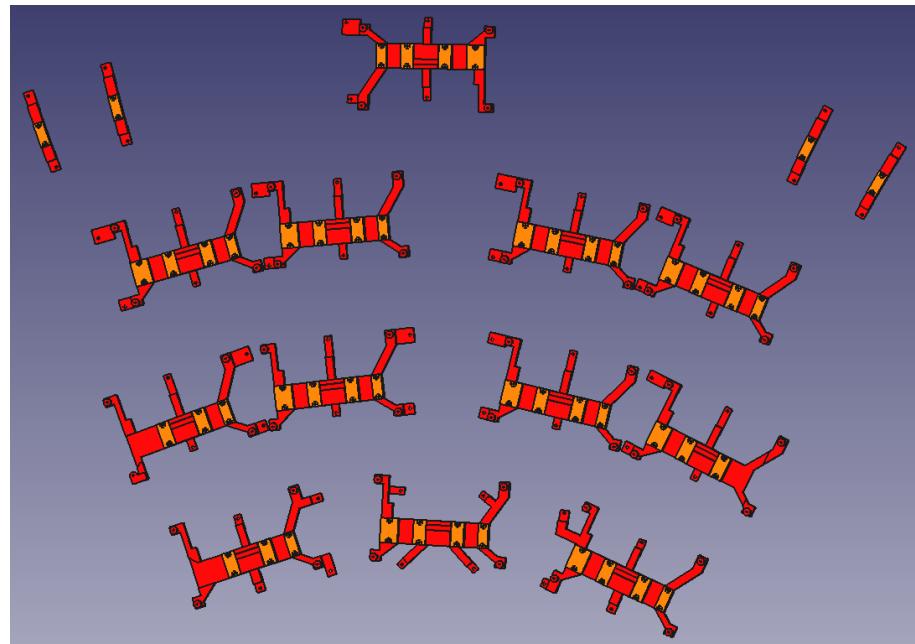
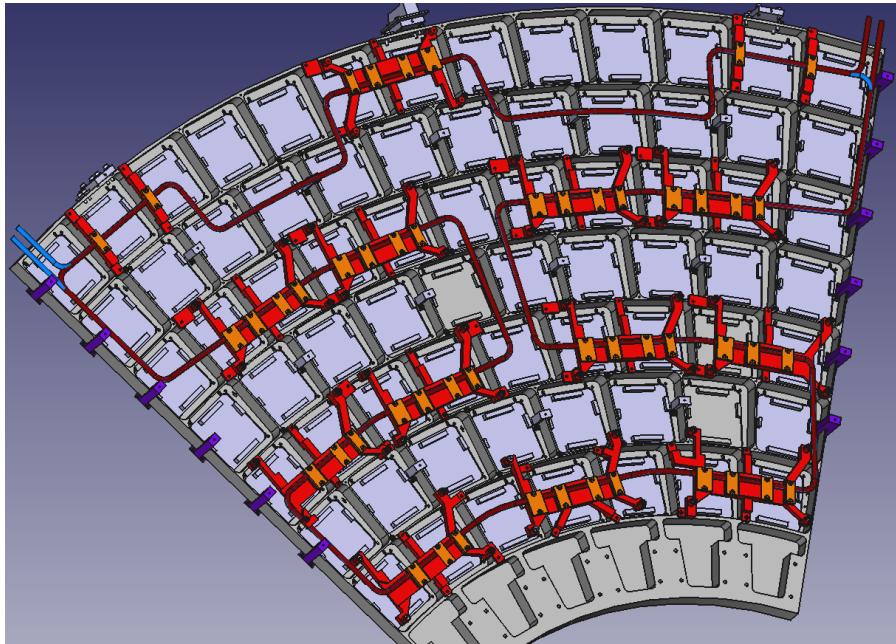
→ We decided to do not use any thermal grease because with time it will dry out to a dust.

→ There is a probability that thermal pads will lost their properties with time.



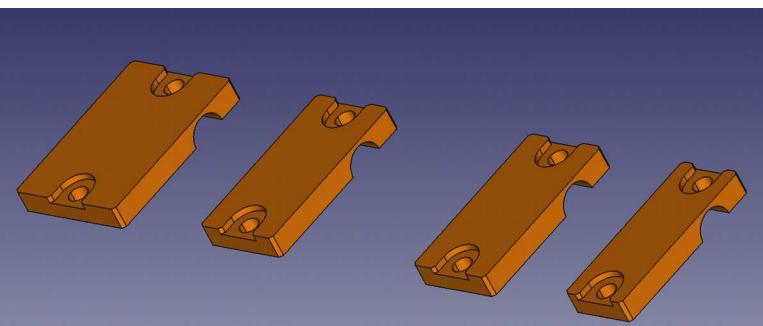
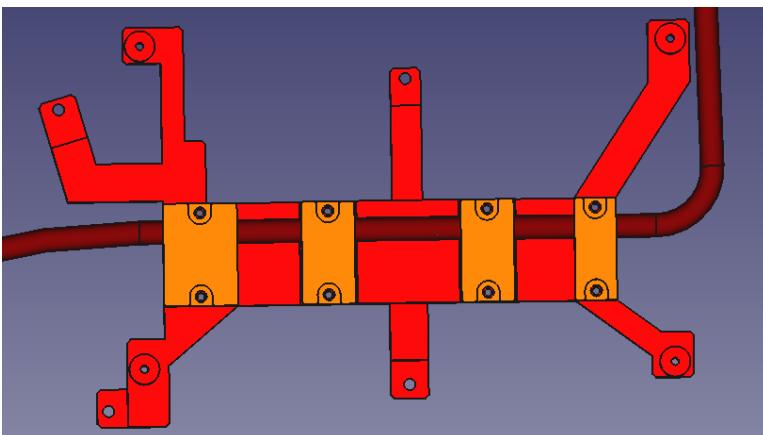
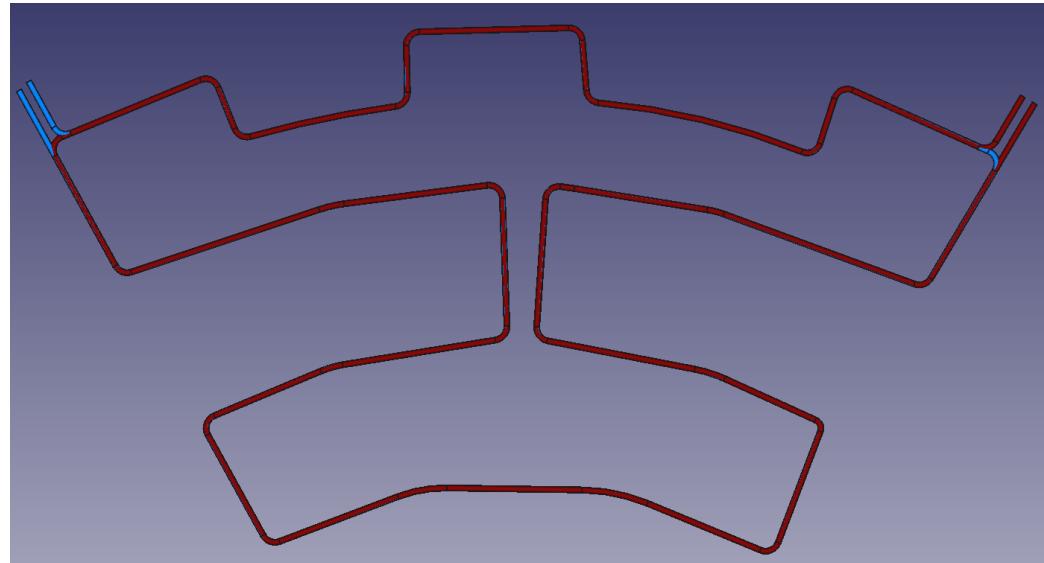
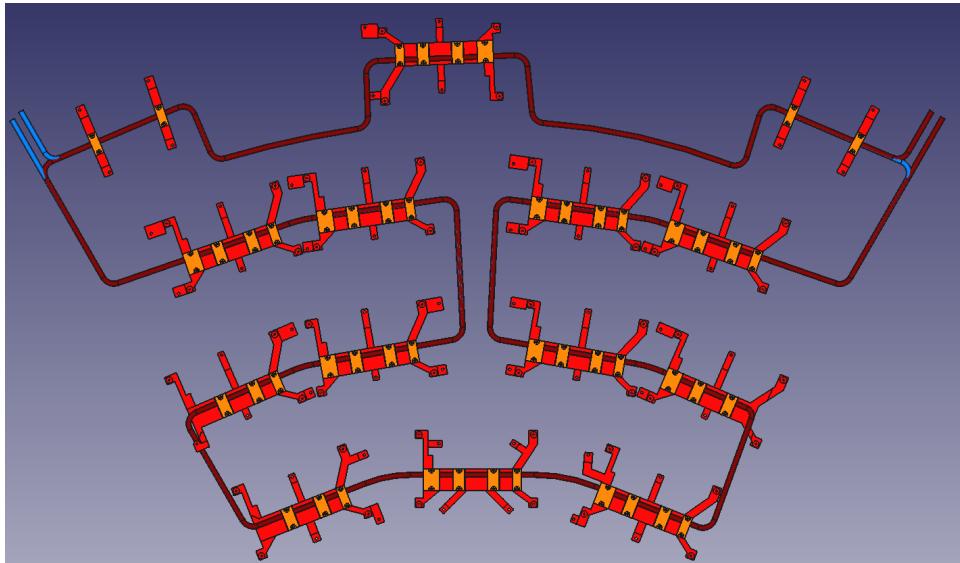
In case of similar performance - solution without thermal pads is preferable.

Mergers cooling bodies



- **Second** the merger cooling bodies need to be installed.
- Their goal is to recuperate heat from the FPGA and aluminum frame and evacuate it via aluminum cooing pipes.
- The cooling contacts done from aluminum by the cnc milling machine.
- Before the installation they have been cleaned with ethanol to remove the dust and residual grease.
- Total weight of merger cooling bodies :
6.681 kg
1.113 kg per sector

Cooling pipes and holders



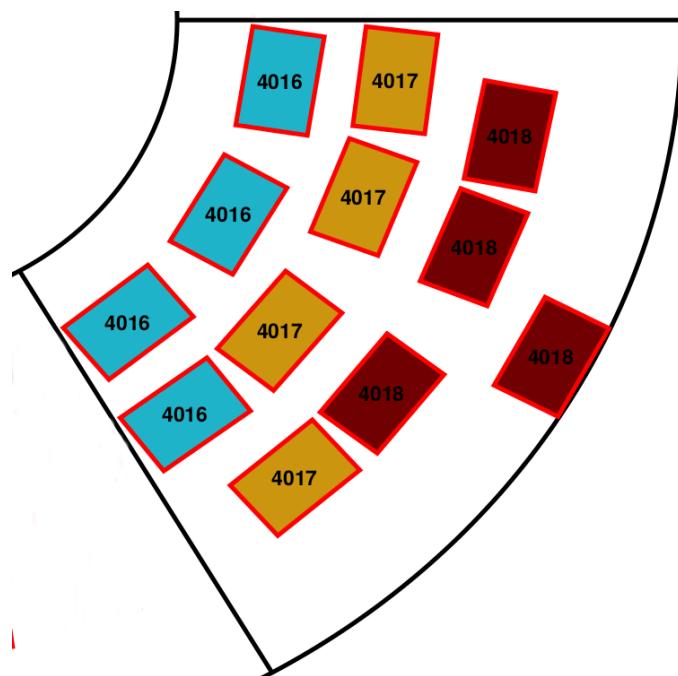
- **Third** the cooling pipes made from 6 mm (diameter) aluminum tube with initial length of 6 m.
- Close loop of circulated water will draw off the heat produced by the ARICH electronics.
- Pipe holder will be attach it to the merger cooling bodies and main frame.
- Total length of cooling pipes :
25.8 m
4.3 m per sector
- Total weight of cooling pipes :
1.059 kg
176.5 g per sector
- Total weight of pipe holders (aluminum) :
0.920 kg
153 g per sector

Old vs new cooling systems (weight comparison)

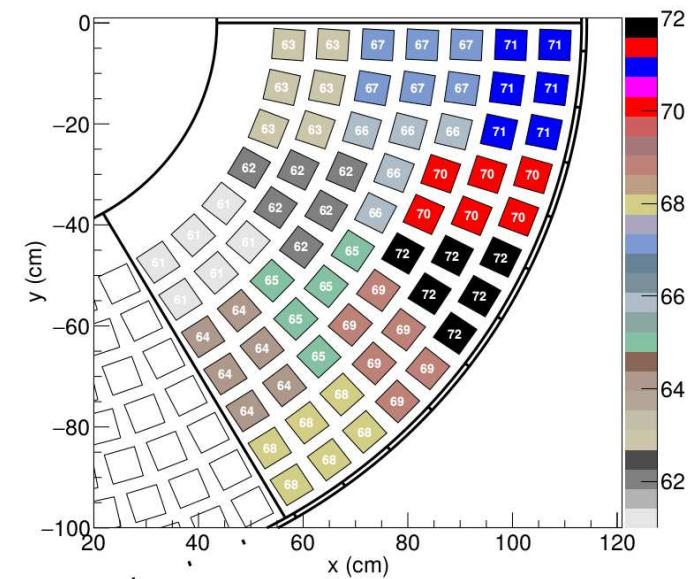
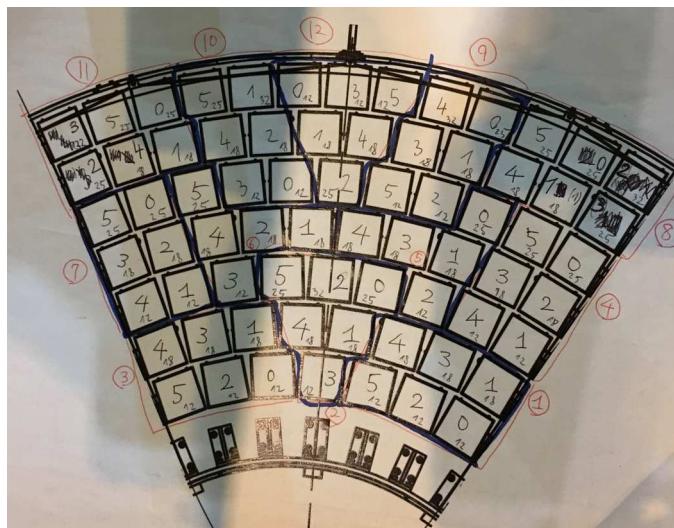
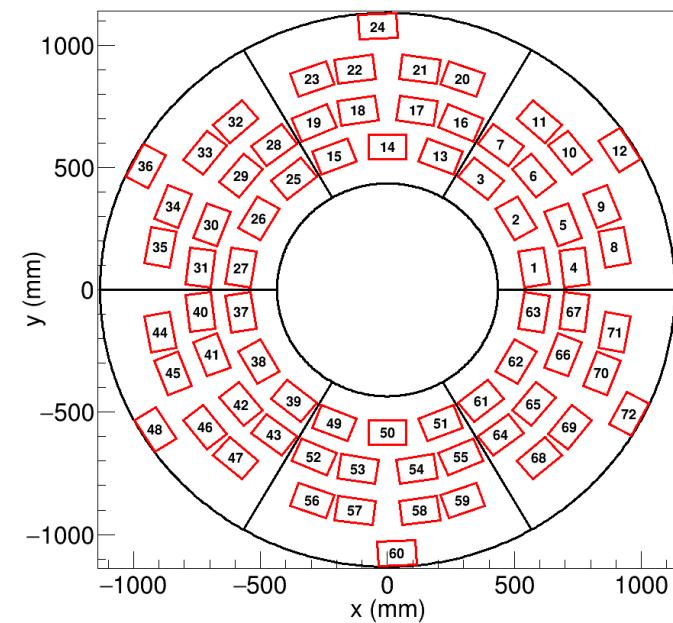
Old	New
Material : stainless steel Total weight of cooling pipes : 3.543 kg Weight per sector : 590.5 g	Material : aluminum Total weight of FEB's cooling contacts : 3.154 kg Weight per sector : 525 g
Material : aluminum Total weight of merger holders : 1.35 kg Weight per sector : 225 g	Material : aluminum Total weight of merger cooling bodies : 6.681 kg Weight per sector : 1.113 kg
Material : aluminum + copper Total weight of cold plates : 1.8 kg Weight per plane : 0.9 kg	Material : aluminum Total weight of cooling pipes : 1.059 kg Weight per sector : 176.5 g
Total weight : 6.7 kg	Material : aluminum Total weight of pipe holders : 0.920 kg Weight per sector : 153 g per
	Total weight : 11.8 kg

Copper board, merger and FEB mappings

Copper board ID



Mergers ID



Time line

Sep 21 : measurements of the FEB's temperature without cooling system for sec 6.

Sep 30 : MERGERs and FEB's temperature measurements with new cooling system (power-OFF) for sec. 6

Oct 1 : MERGERs and FEBs temperature measurements with new cooling system (power-ON) for sec. 6

Oct 18 : tests of the effect from gap fillers inserted between MERGERs and cooling bodies.

Nov 1 : Test of three bottom sectors: 6, 5, 4 with small chiller.

Nov 6, 7 : Test of all the system with two small chillers.

Note : During the night (~2.20) the cooling system switched-off by itself due to the power over consumption. Flux in sectors from the top – 1.9 L/min and 2.2 L/min from the bottom.

Nov 8 : Test of all the system with two small chillers with four Al-end-plates installed.

Note : Continue the test of all the system with two small chillers without four aluminum end plates two from the top two from the bottom.

Nov 9, 10, 11, 12 : system is off

Nov 13 : Test with main chiller (flow = 4.2 L/min, @ 20 °C) with all Al-end-plates installed.

Nov 14 : Test with main chiller (flow = 2.4 L/min, @ 20 °C) with all Al-end-plates installed and back cover.

Note : back cover has been installed to shield ARICH from the light (13.00).

Nov 15 : Test with main chiller (flow = 3.2 L/min, @ 20 °C) with all Al-end-plates installed and back cover.

Note : at 8:50 (Nov. 15) flow have changed to 3.2 L/min.

Nov 16 : Test with main chiller (flow = 4.2 L/min, @ 25 °C) with all Al-end-plates installed and back cover.

Note : at 9:40 (Nov. 16) the temperature of incoming circulation water becomes 25 °C.

Nov 17, 18, 19 : Test with main chiller (flow = 4.2 L/min, @ 20 °C) with all Al-end-plates installed and back cover.

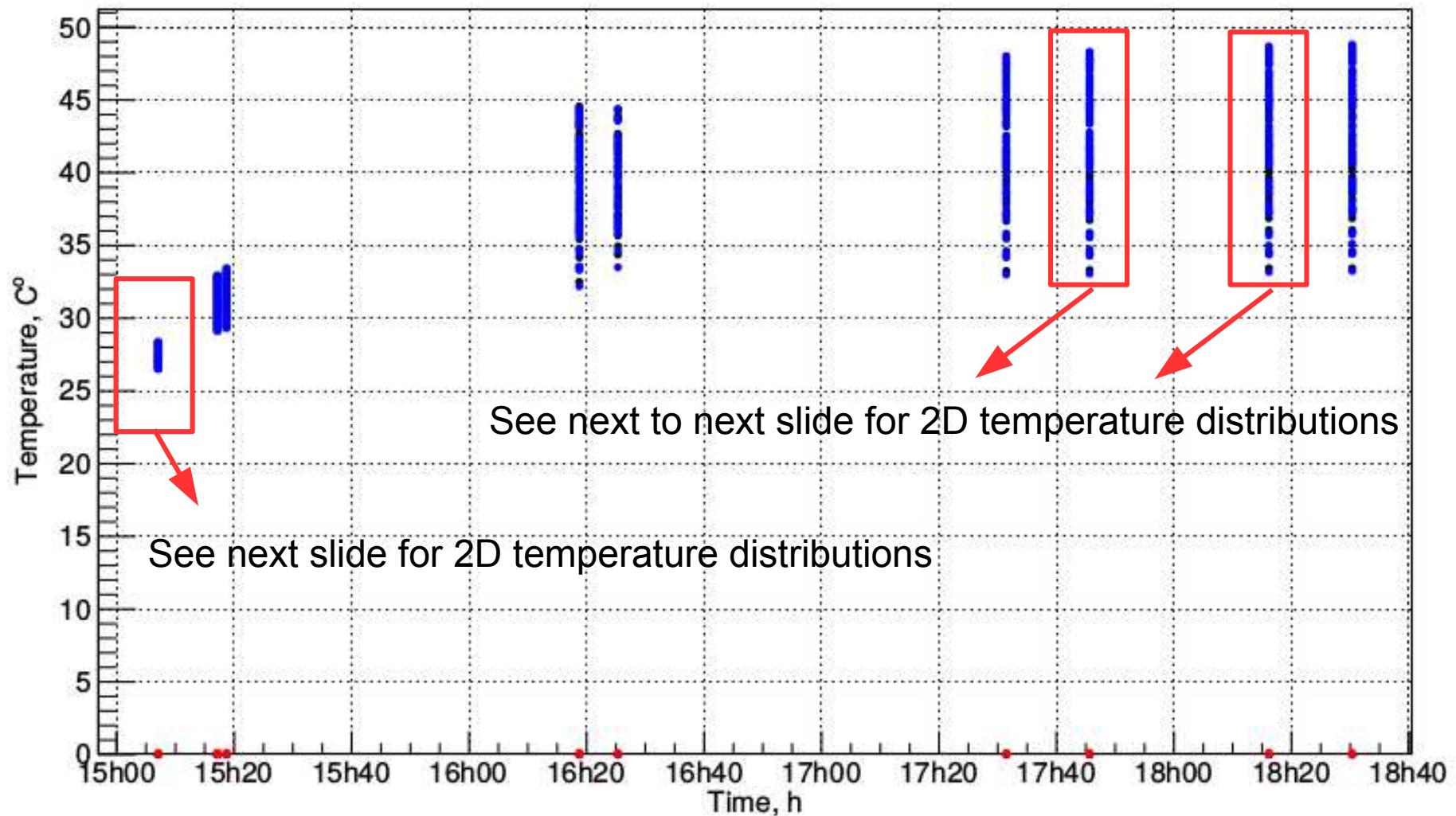
Time line

Nov 20 : Swapping the FEB data cables for sector : 1, 2, 3. All the Al-end plates are removed, no black cover.

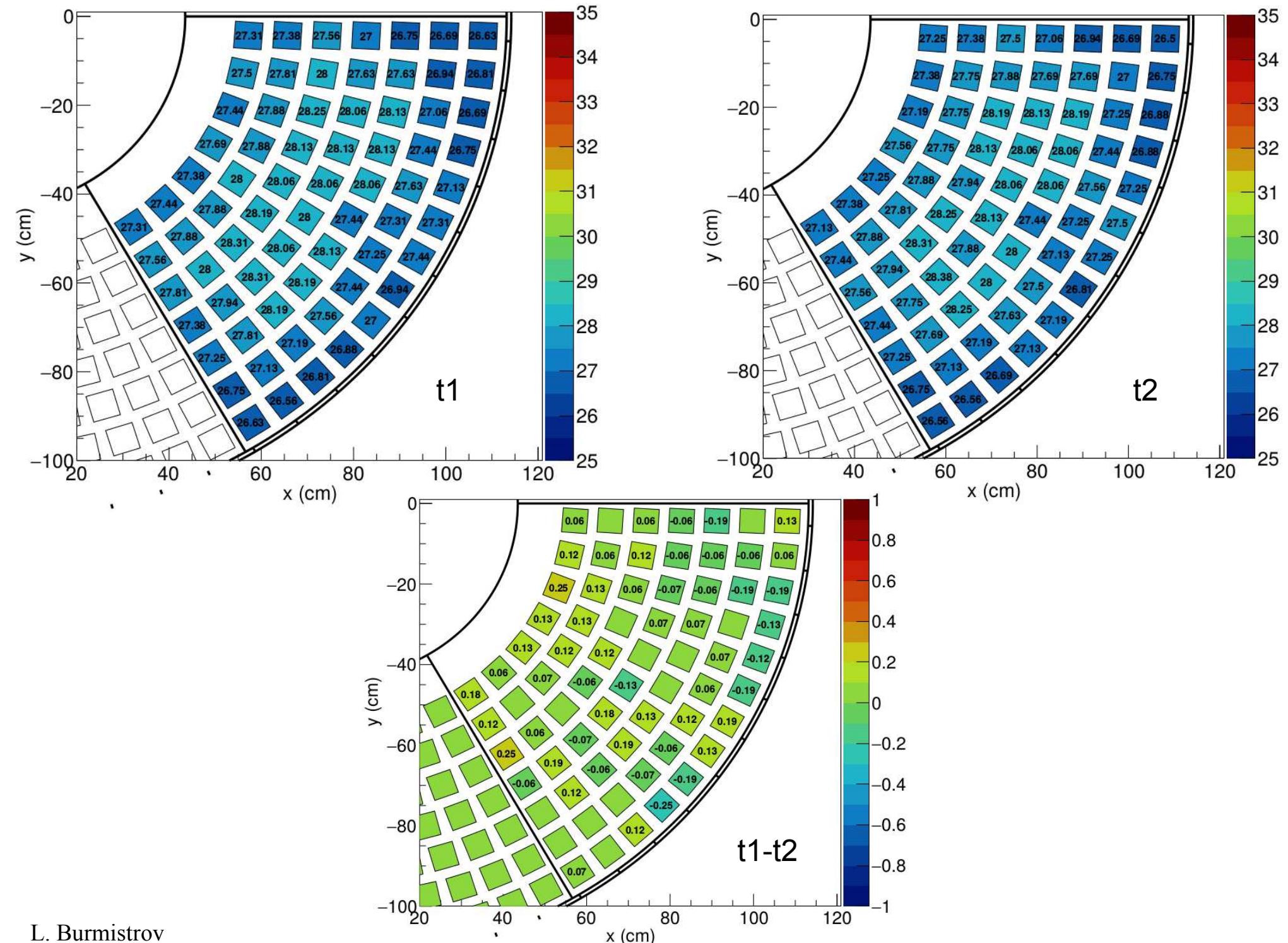
Nov 22 - 25 : All the Al-end plates are installed, with black cover.

Measurements of the FEB's temperature without cooling system (21.09.2018)

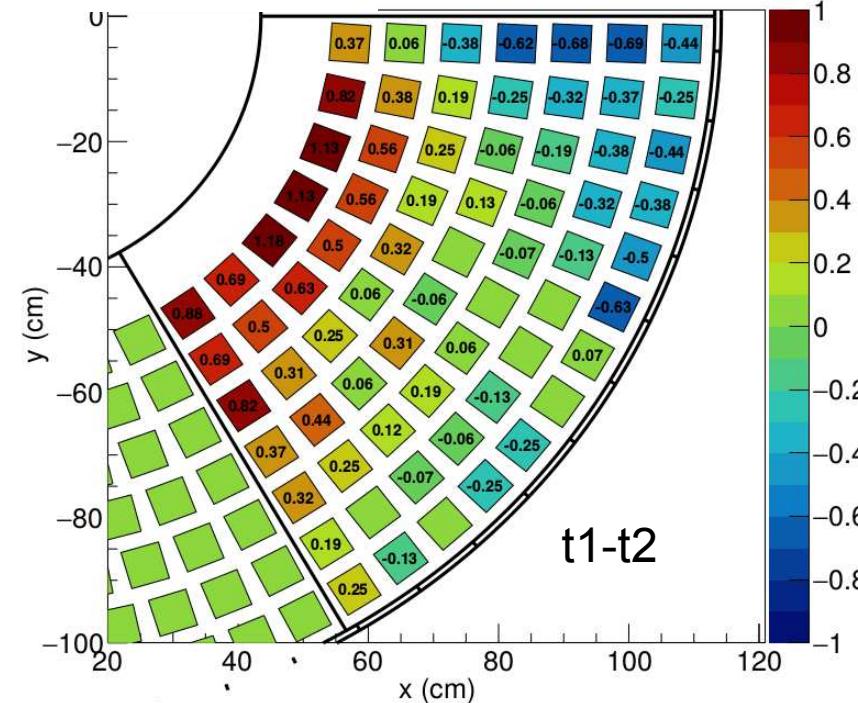
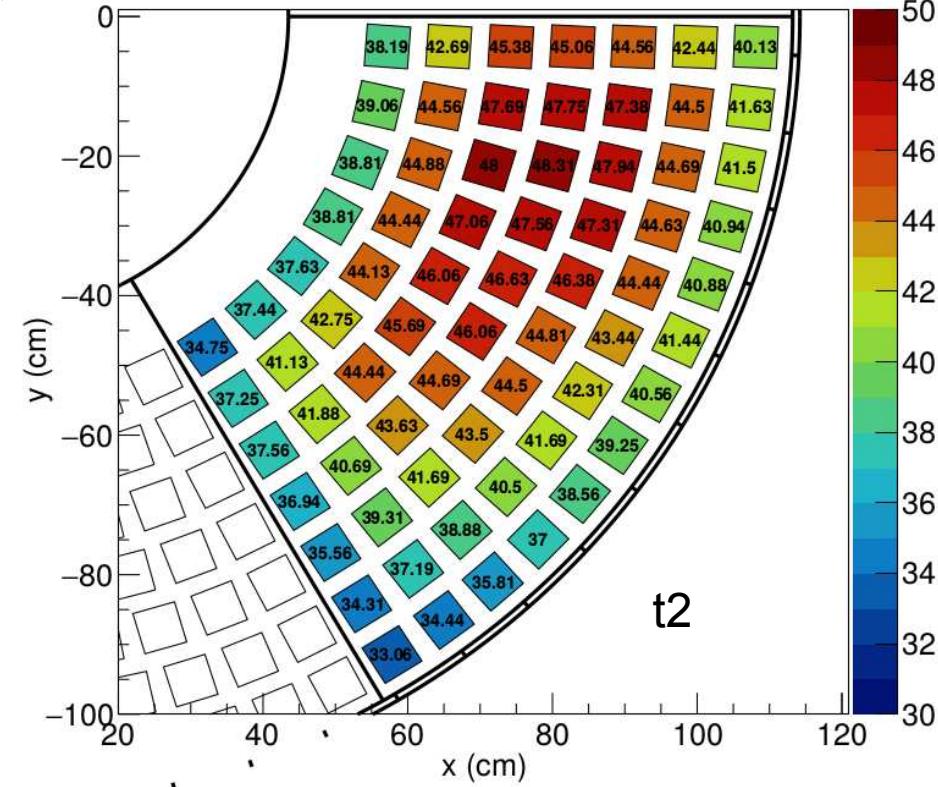
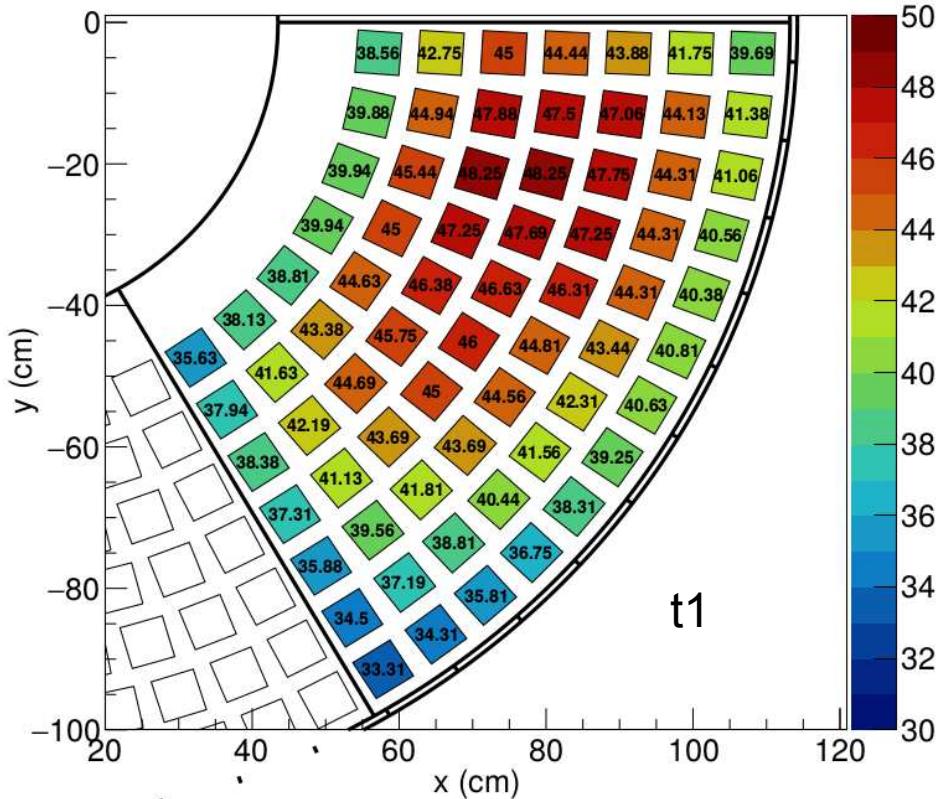
- Measurements done with low voltages on only for sector 6.
- Available data only for feb's. Latter measurements which includes data from mergers have been done.
- It take about two hours to reach equilibrium.



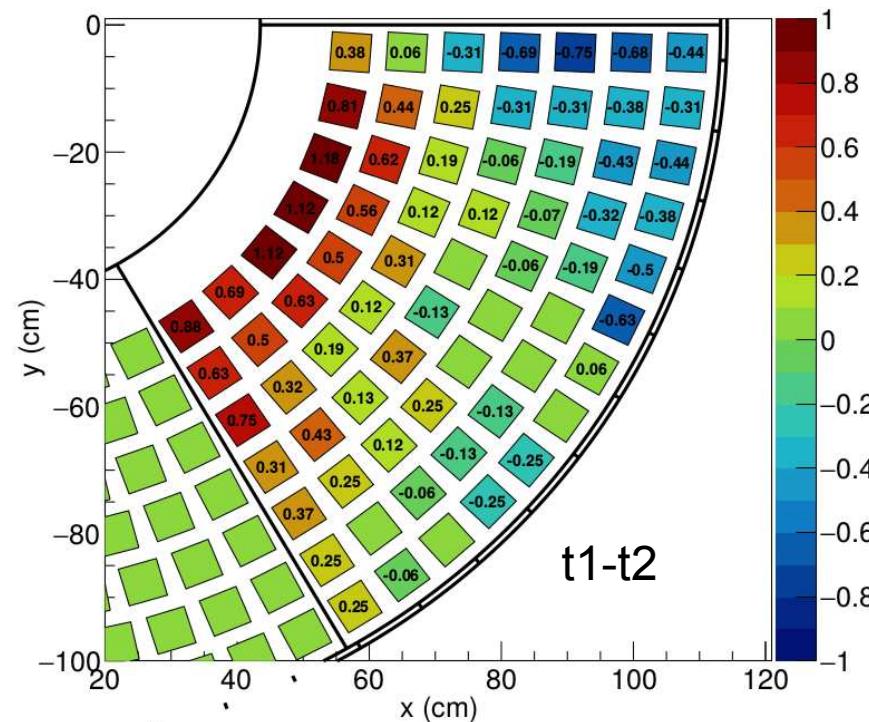
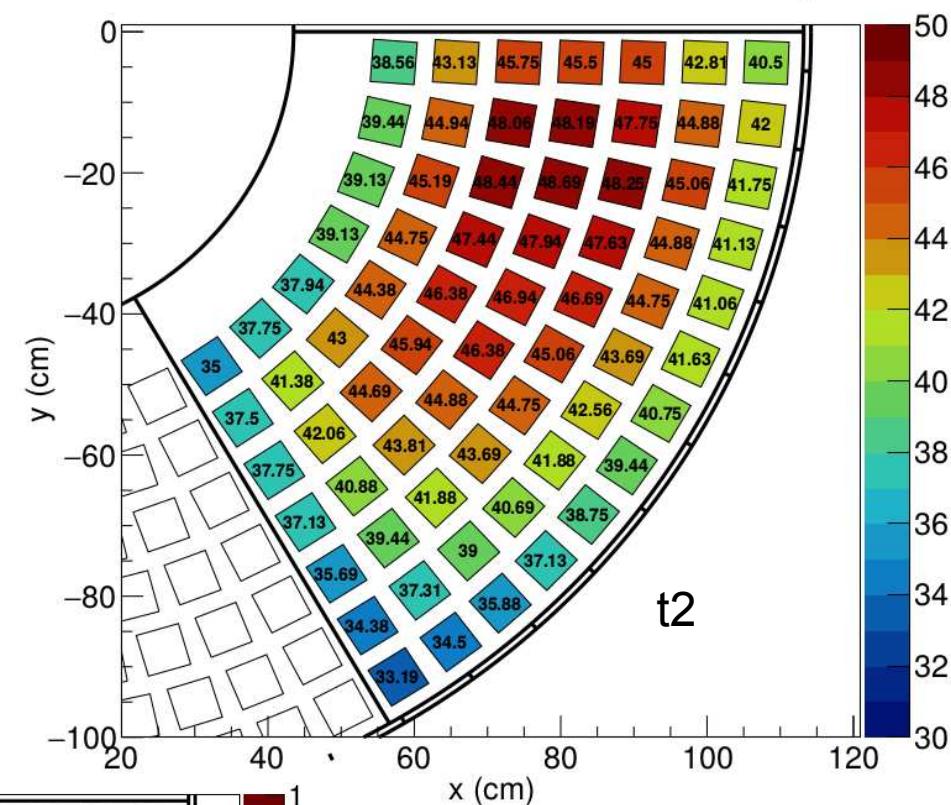
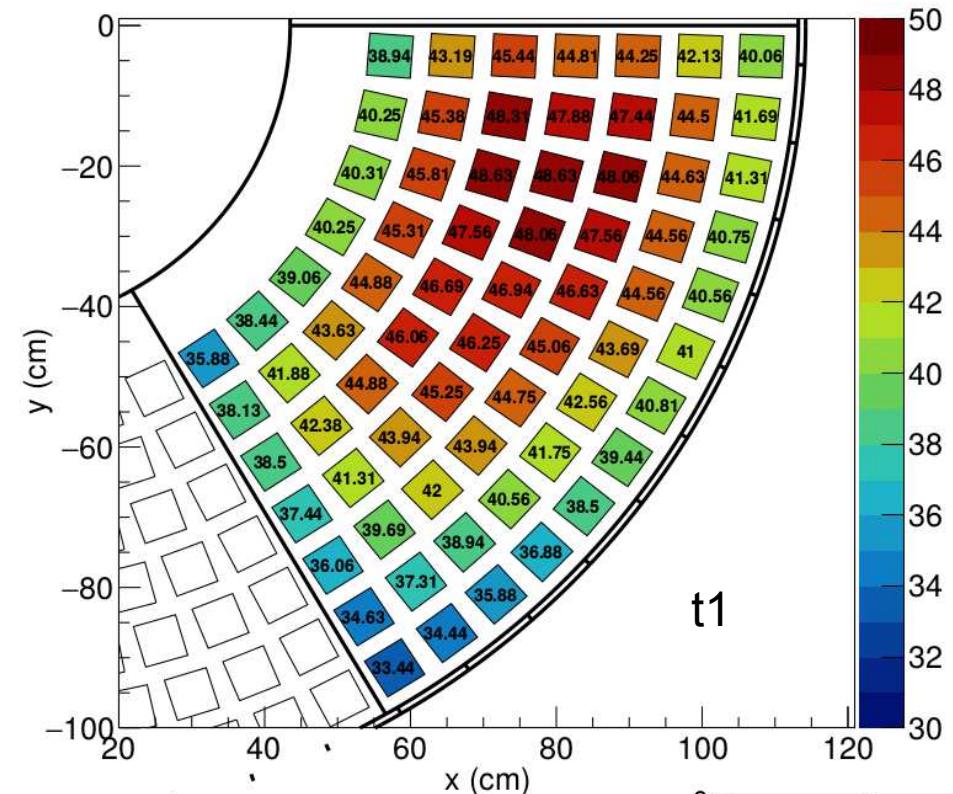
FEB's temperature without cooling system (21.09.2018) 15:6:7



FEB's temperature without cooling system (21.09.2018) - 17:45:38

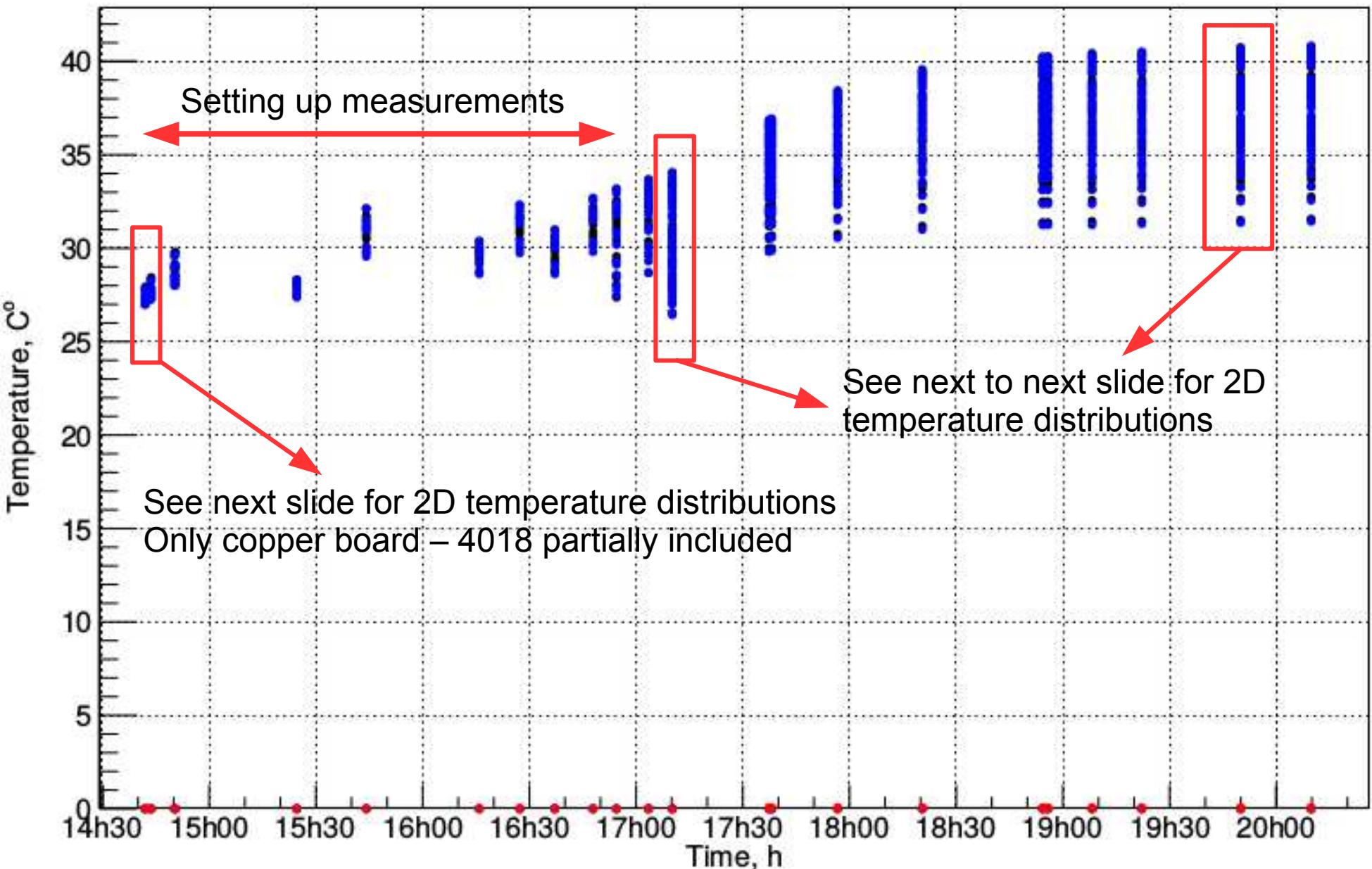


FEB's temperature without cooling system (21.09.2018) - reach equilibrium 18:16:10

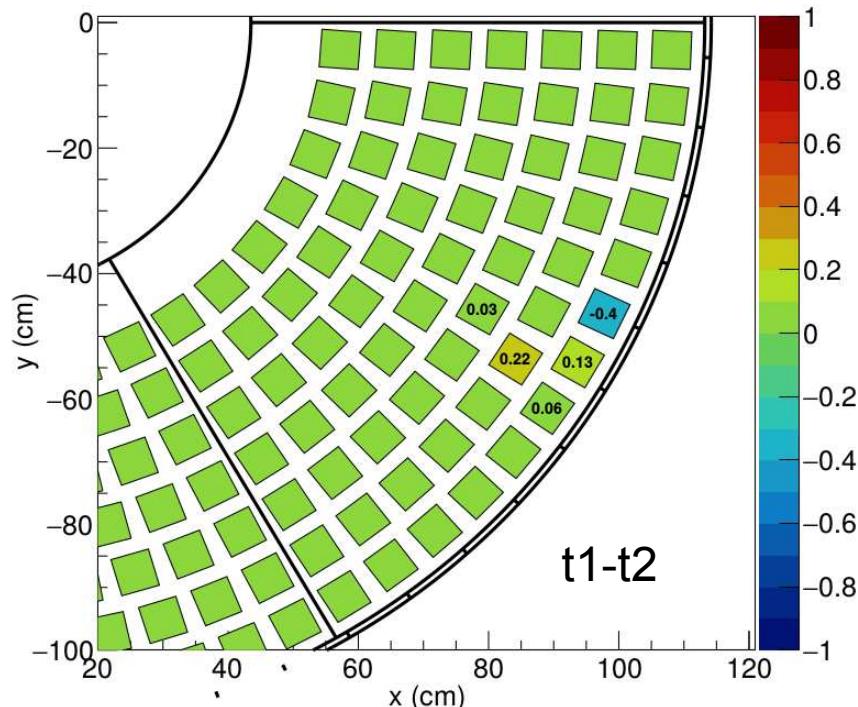
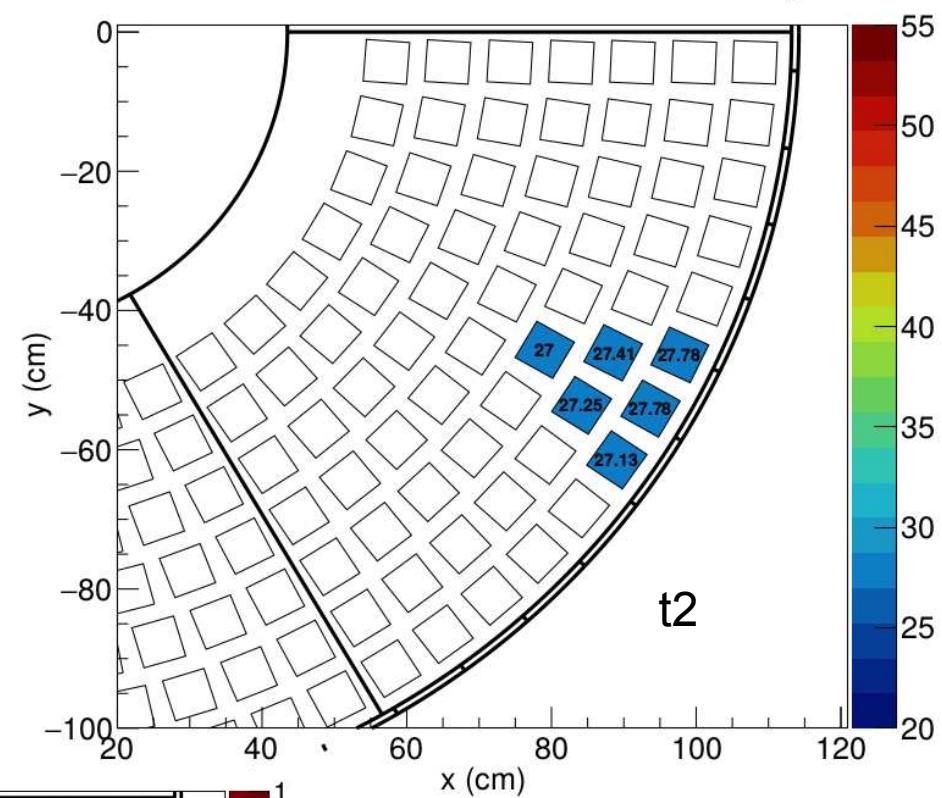
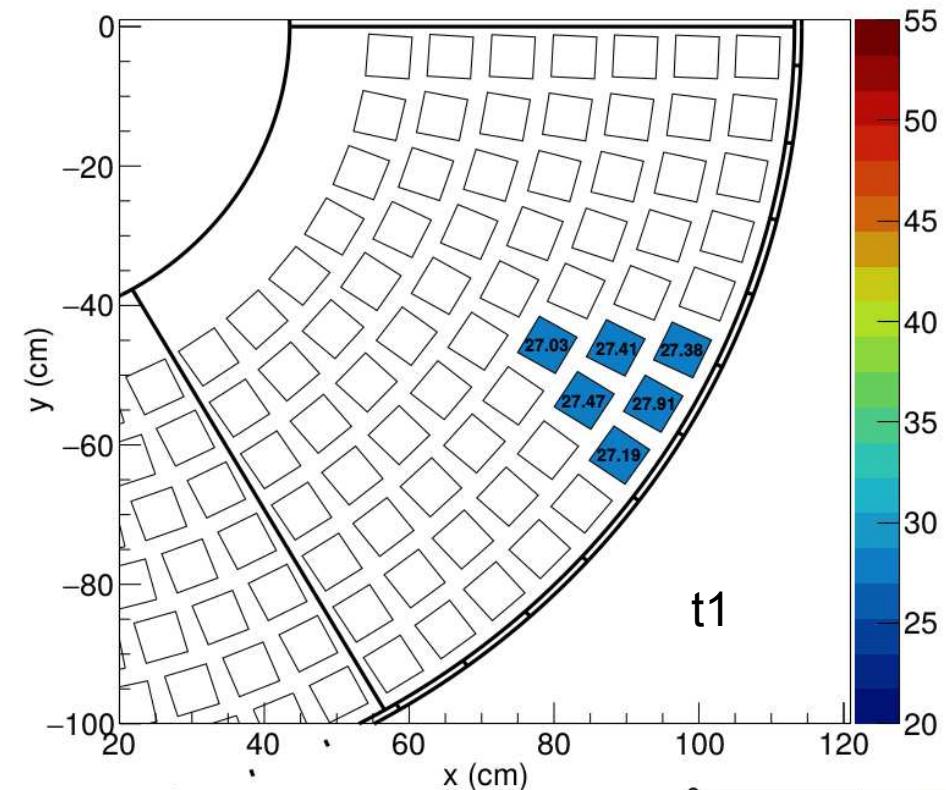


FEB's temperature without cooling system (30.09.2018)

- Copper board 4016 was not included
- Copper board 4017 partially included

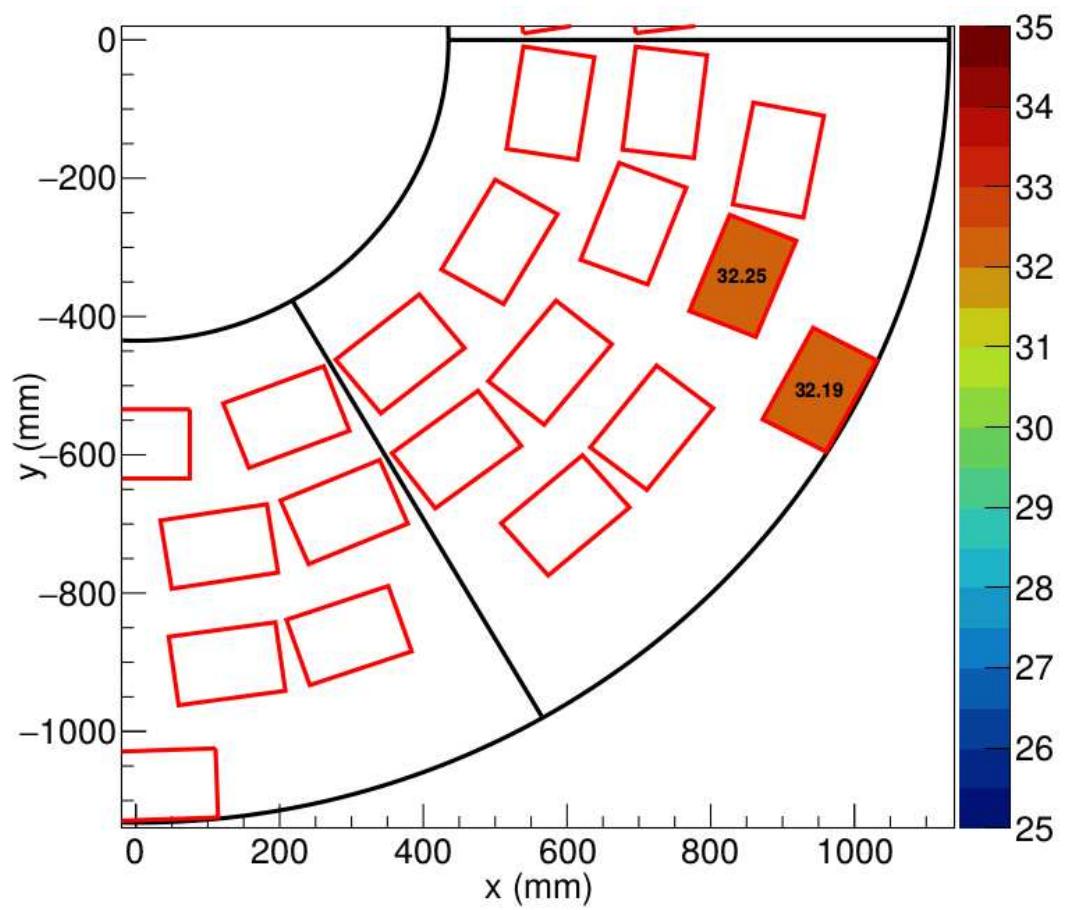
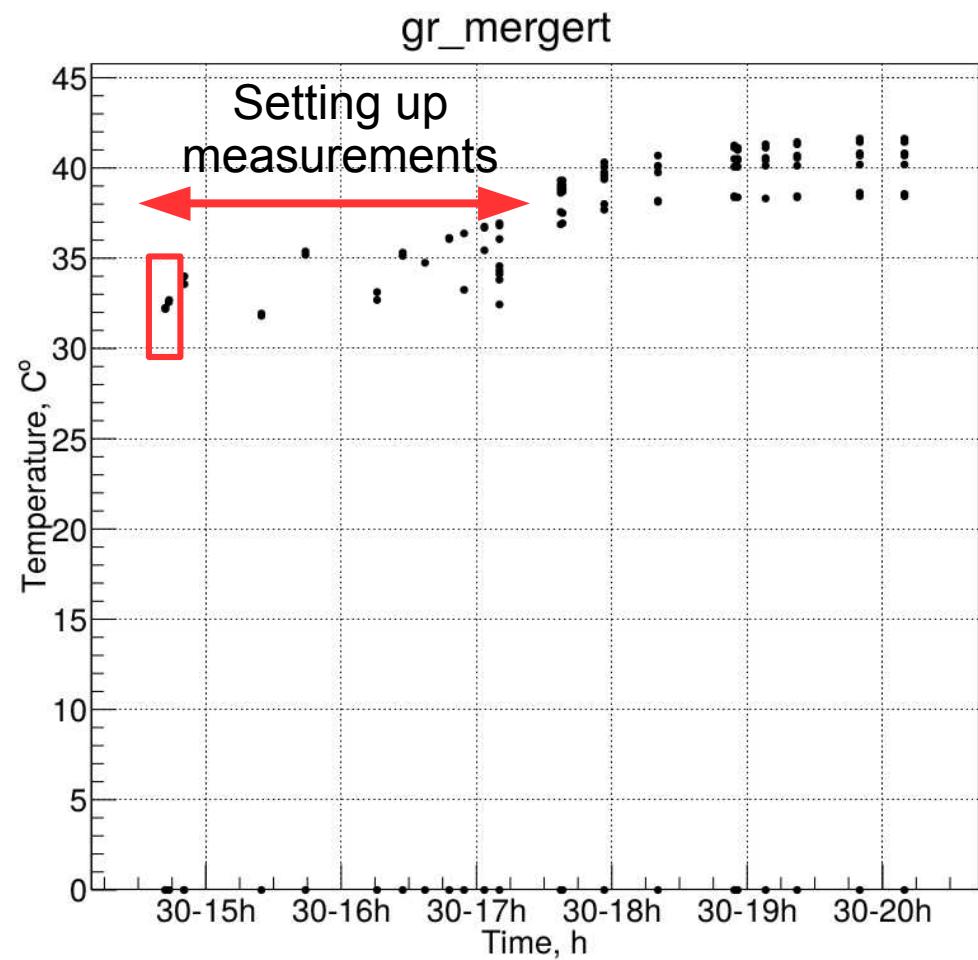


FEB's temperature without cooling system (30.09.2018) 14:41:56

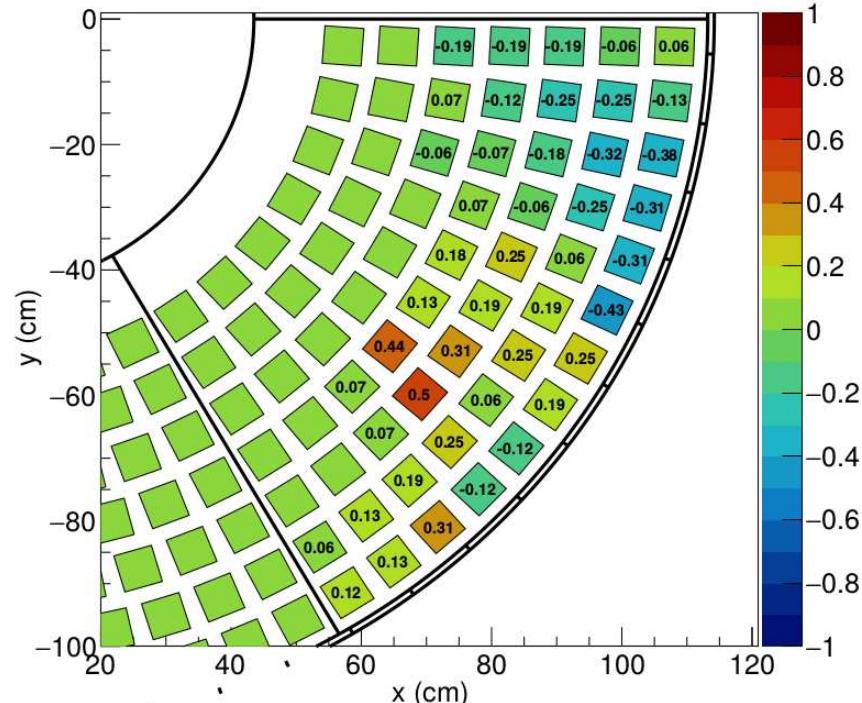
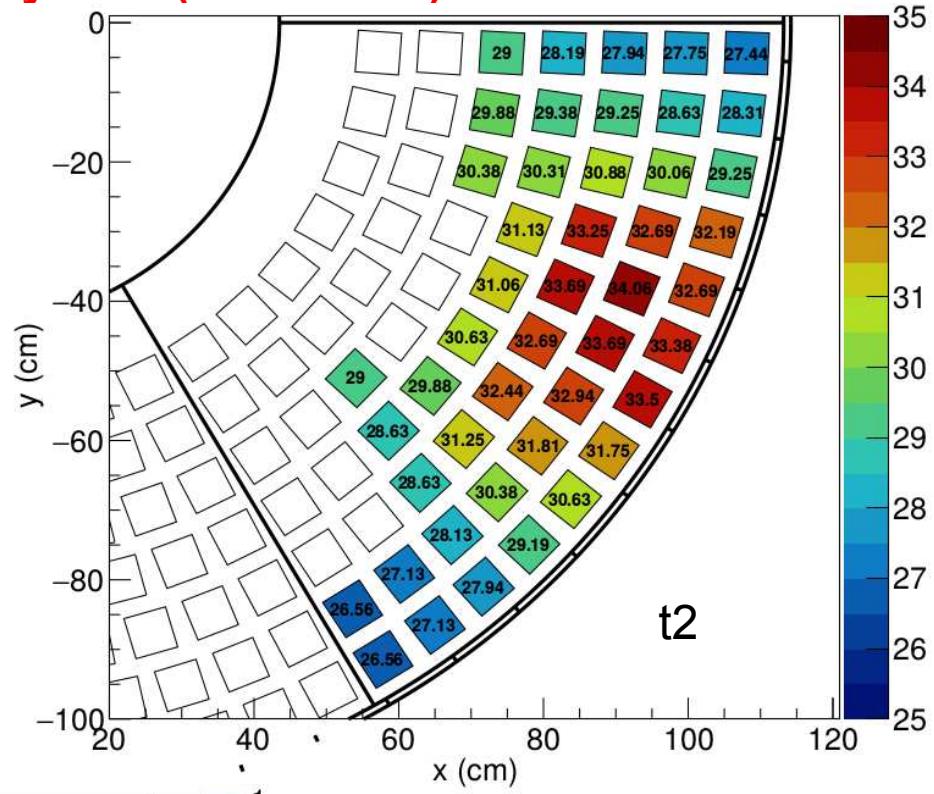
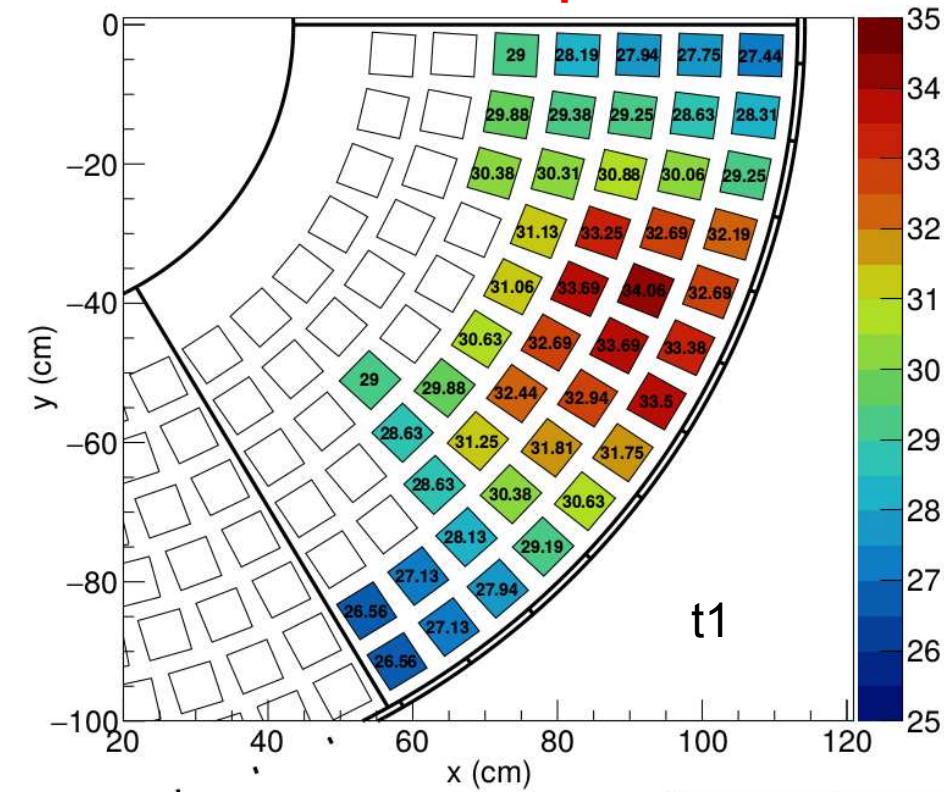


Mergers temperature without cooling system (30.09.2018)

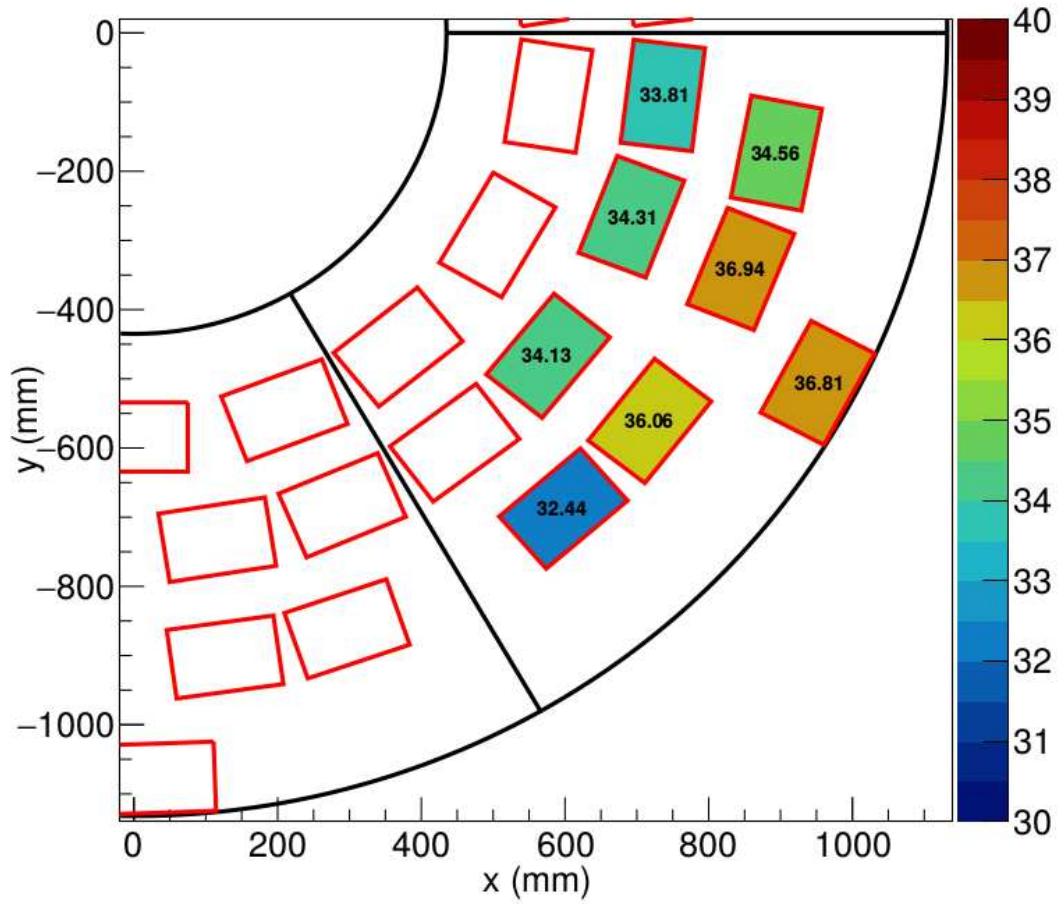
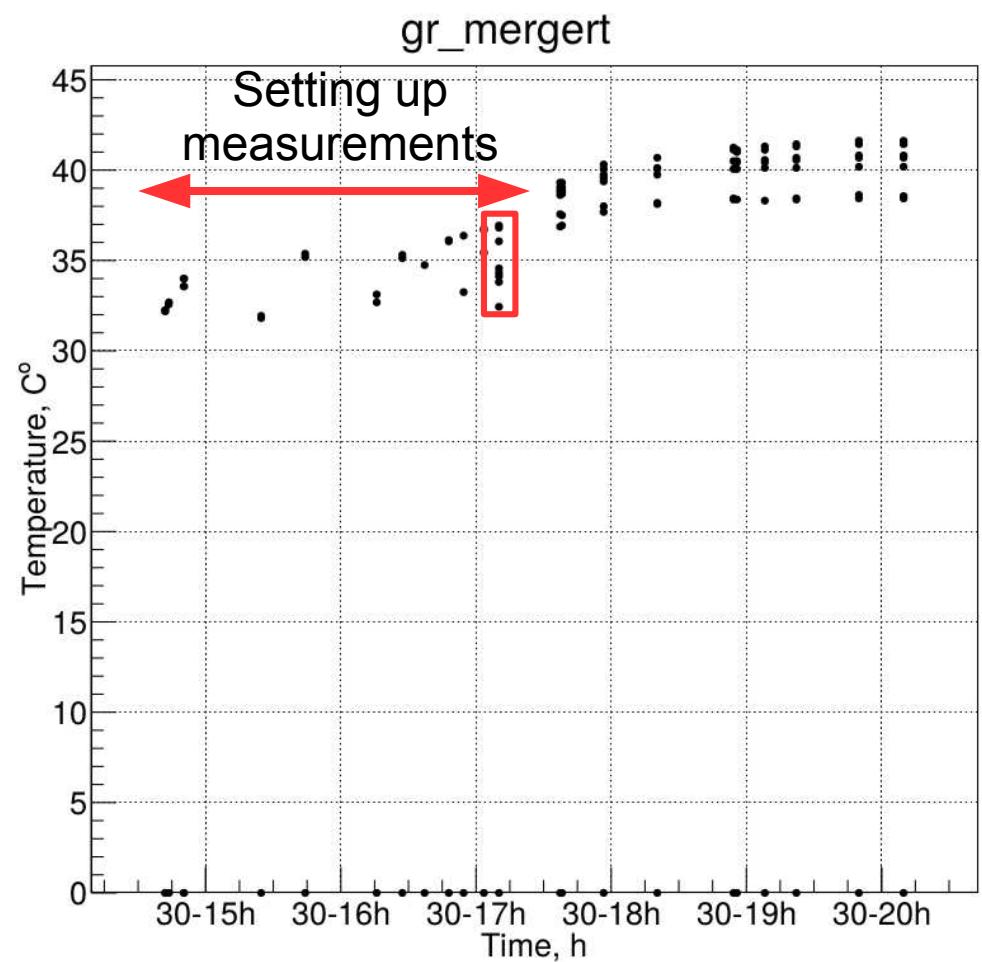
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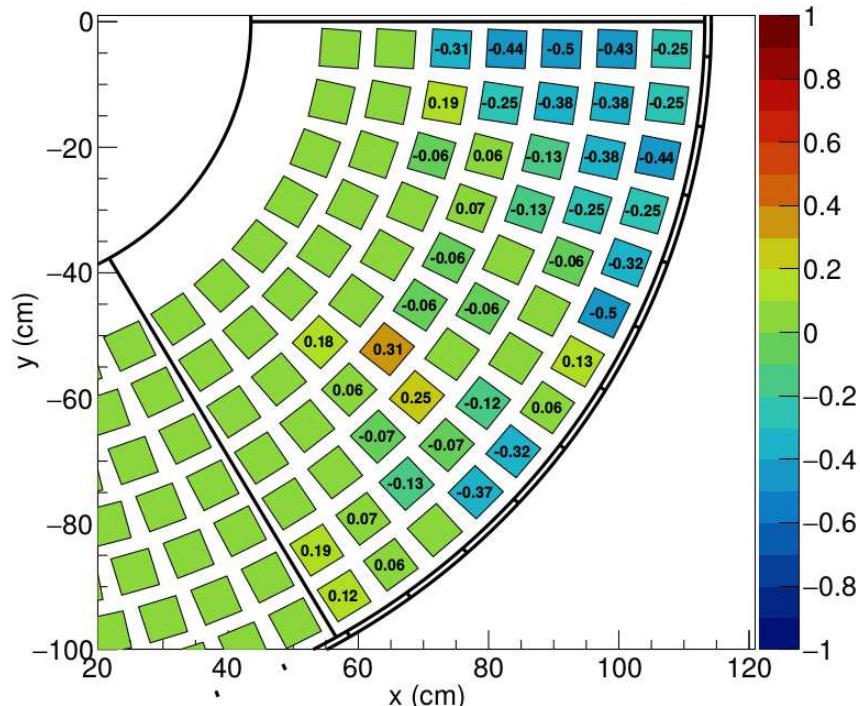
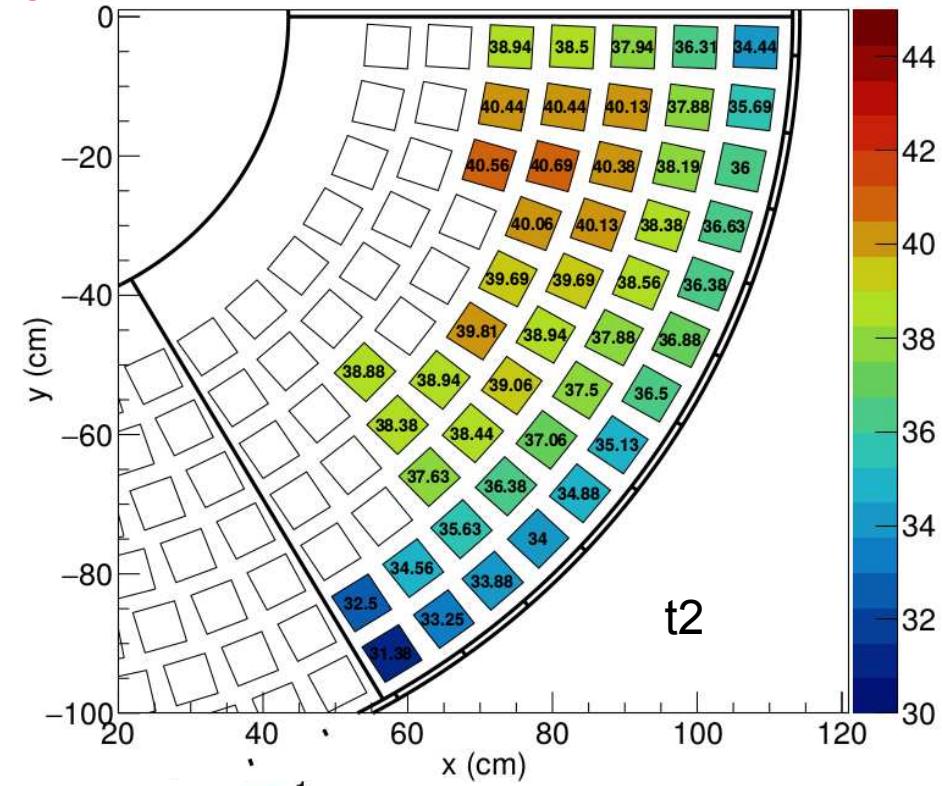
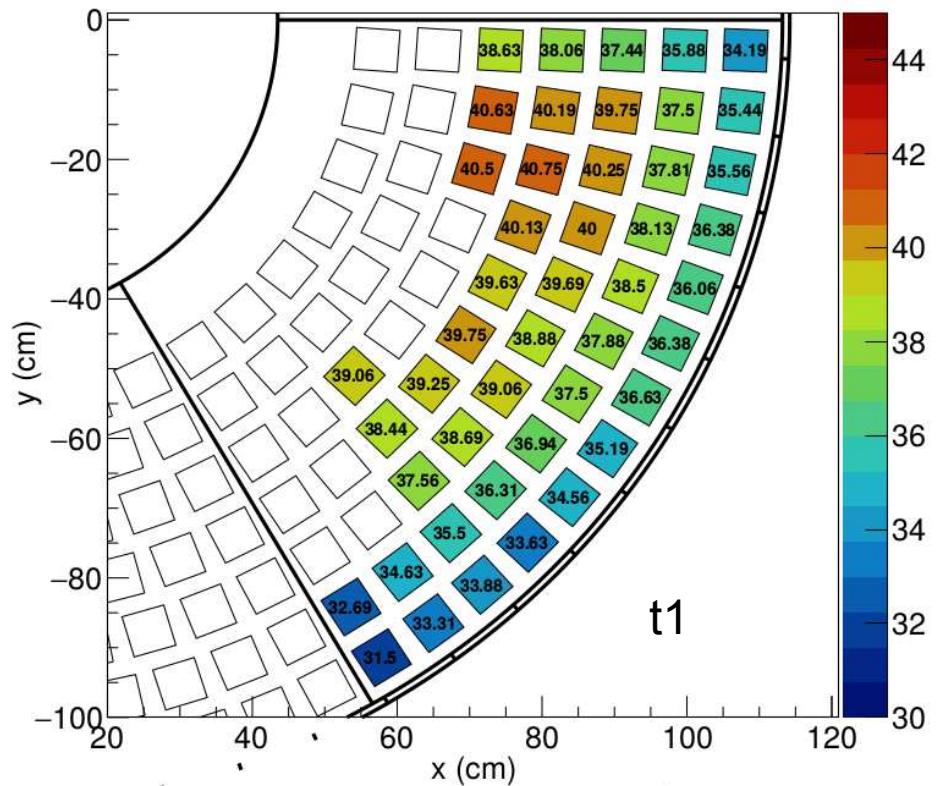
FEB's temperature without cooling system (30.09.2018) 17:10:11



Mergers temperature without cooling system (30.09.2018) 17:10:11

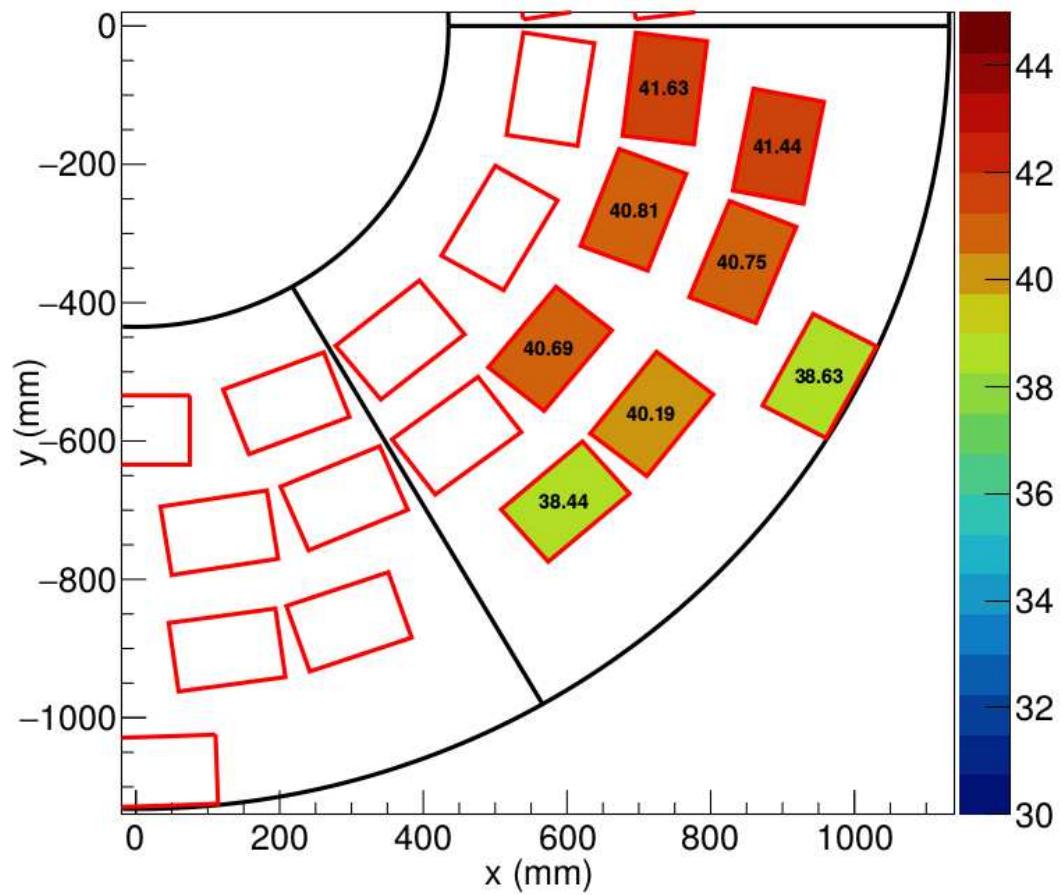
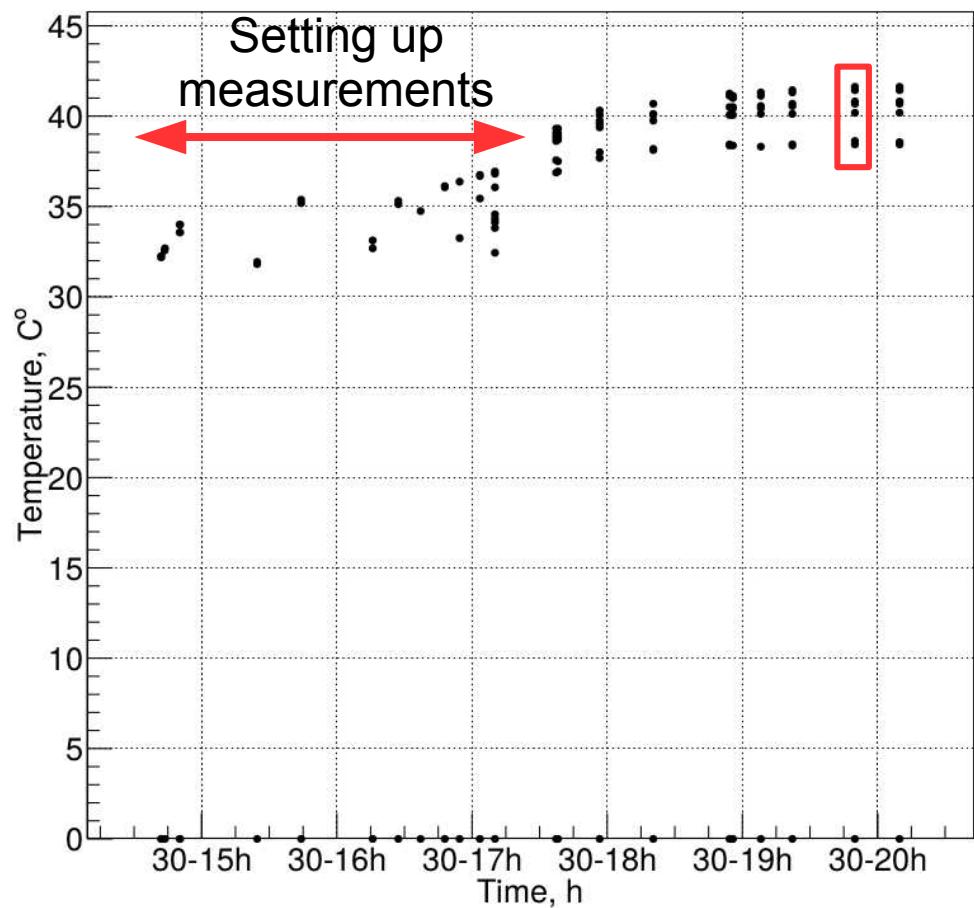


FEB's temperature without cooling system (30.09.2018) 19:49:57

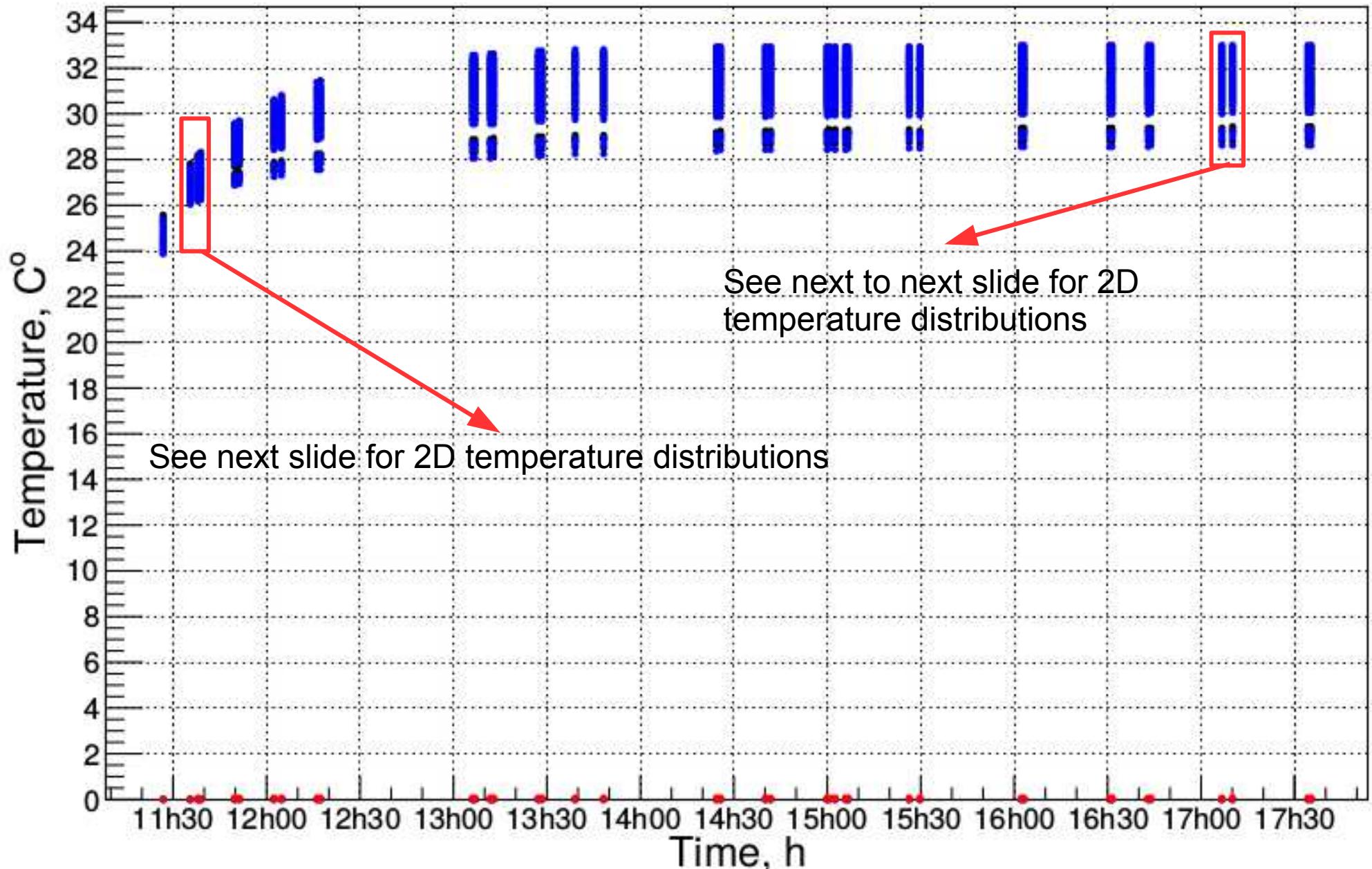


Mergers temperature without cooling system (30.09.2018) 19:49:57

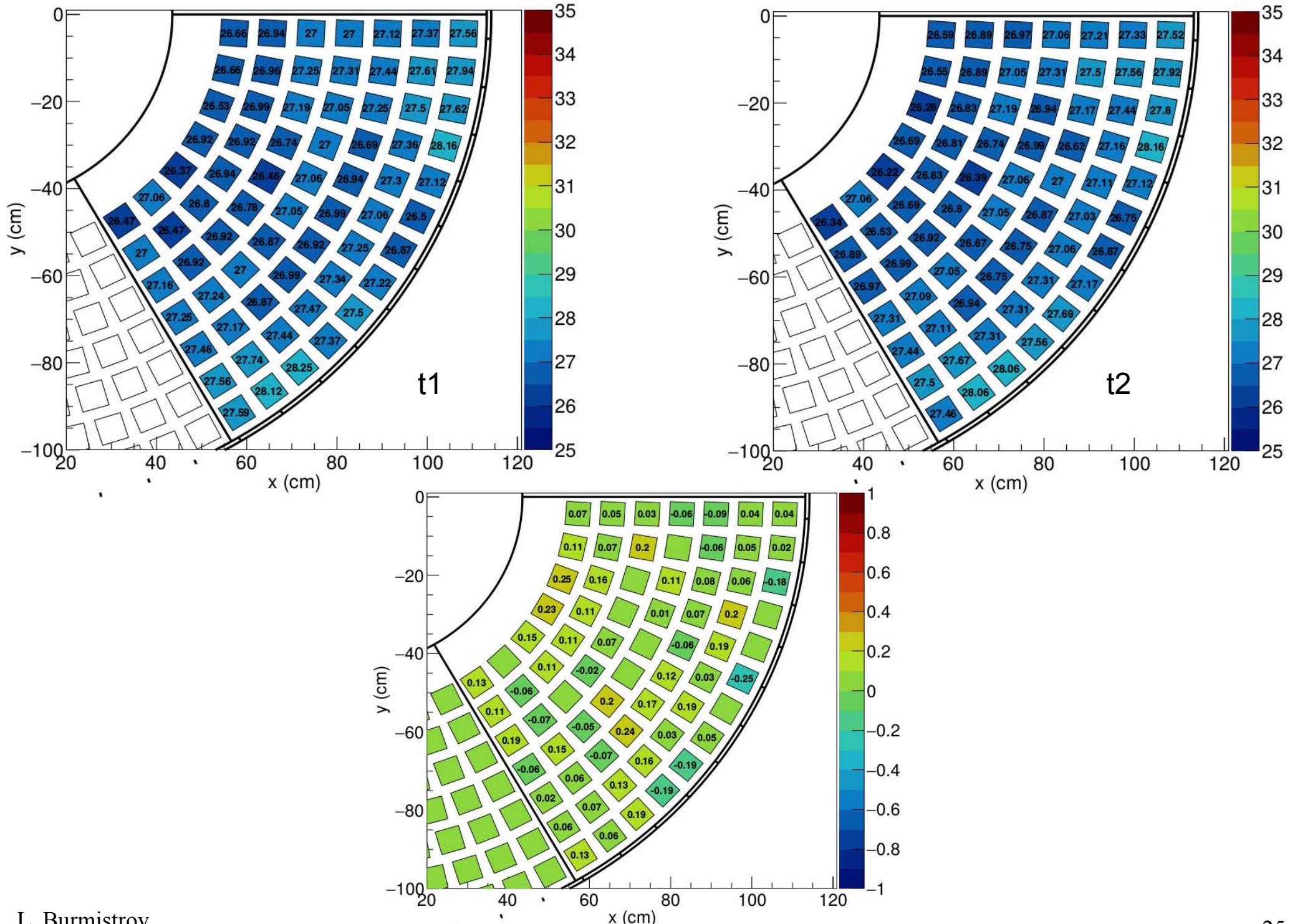
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FEB's temperature with cooling system (01.10.2018)

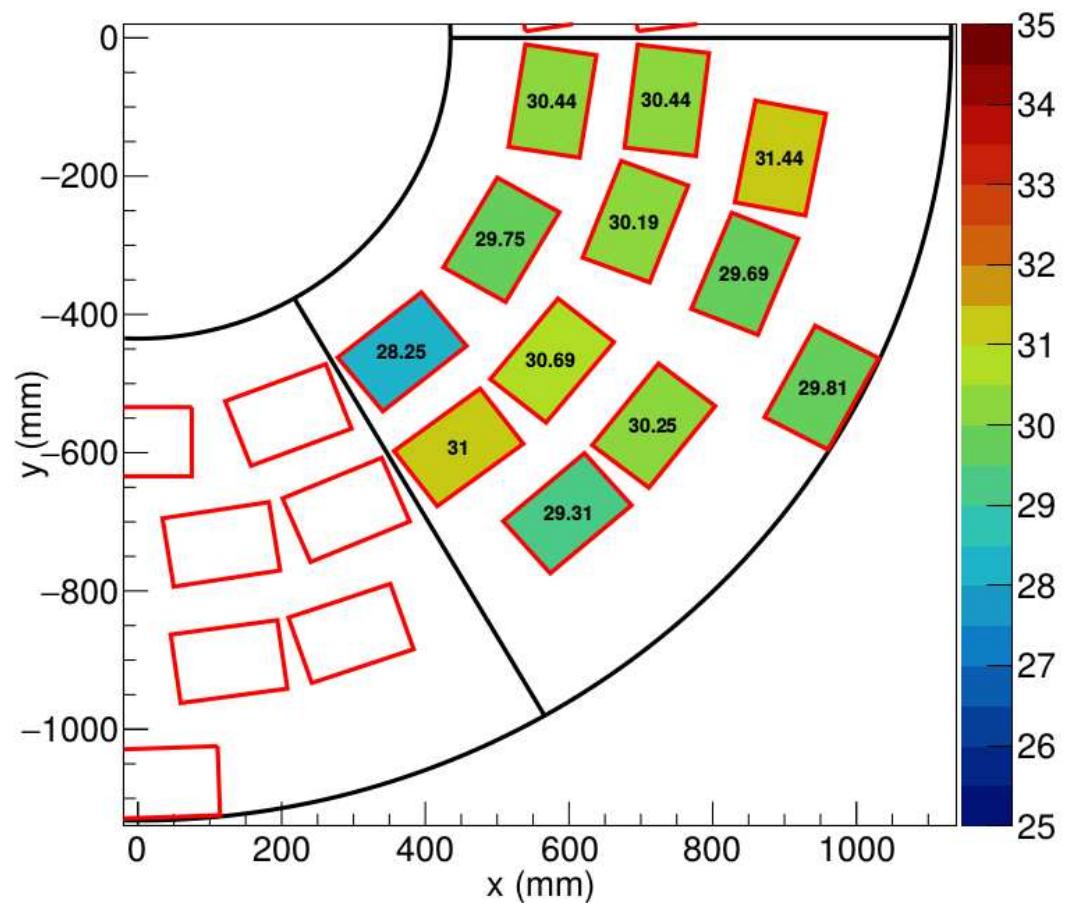
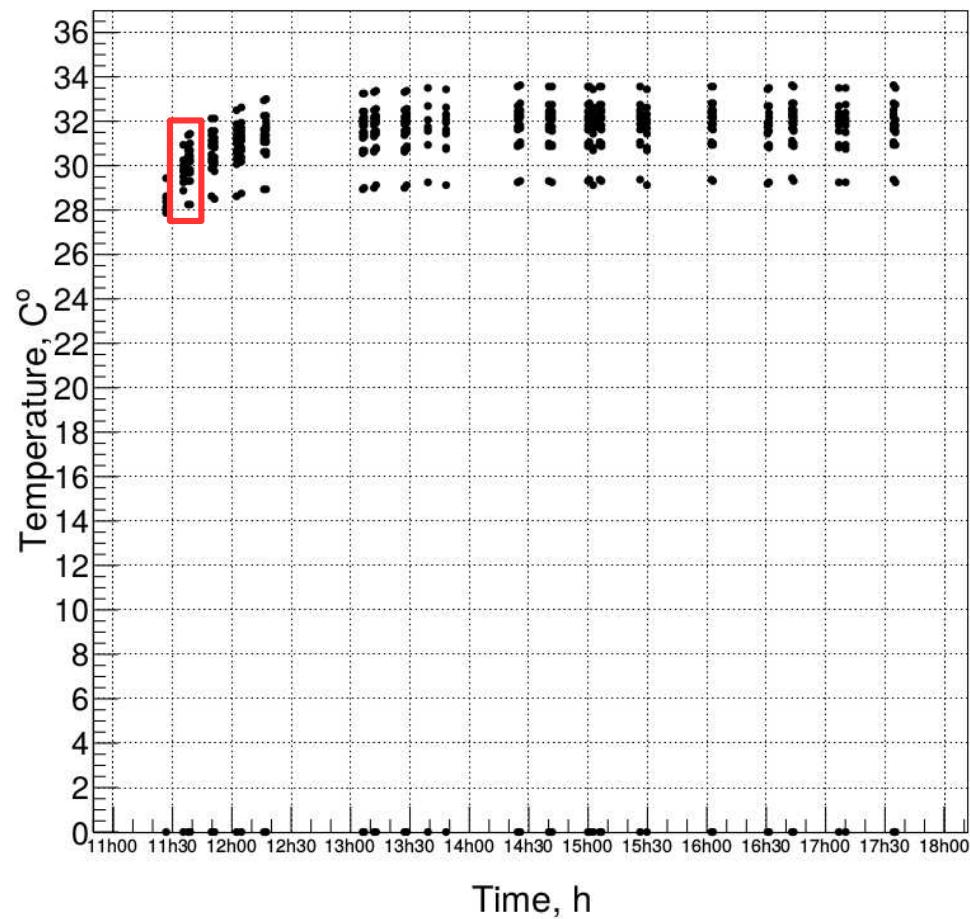


FEB's temperature with cooling system (01.10.2018) 11:37:56

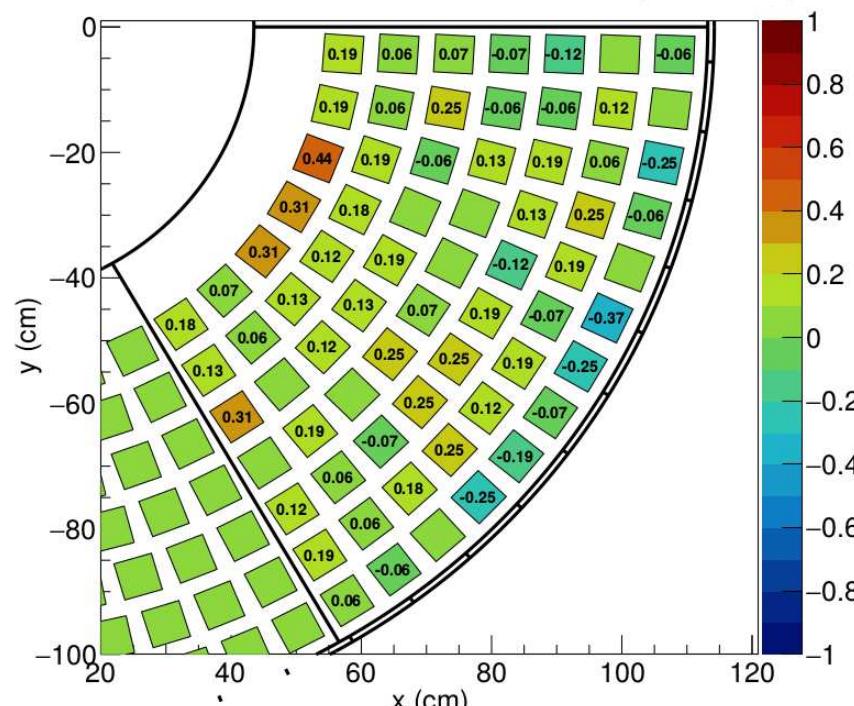
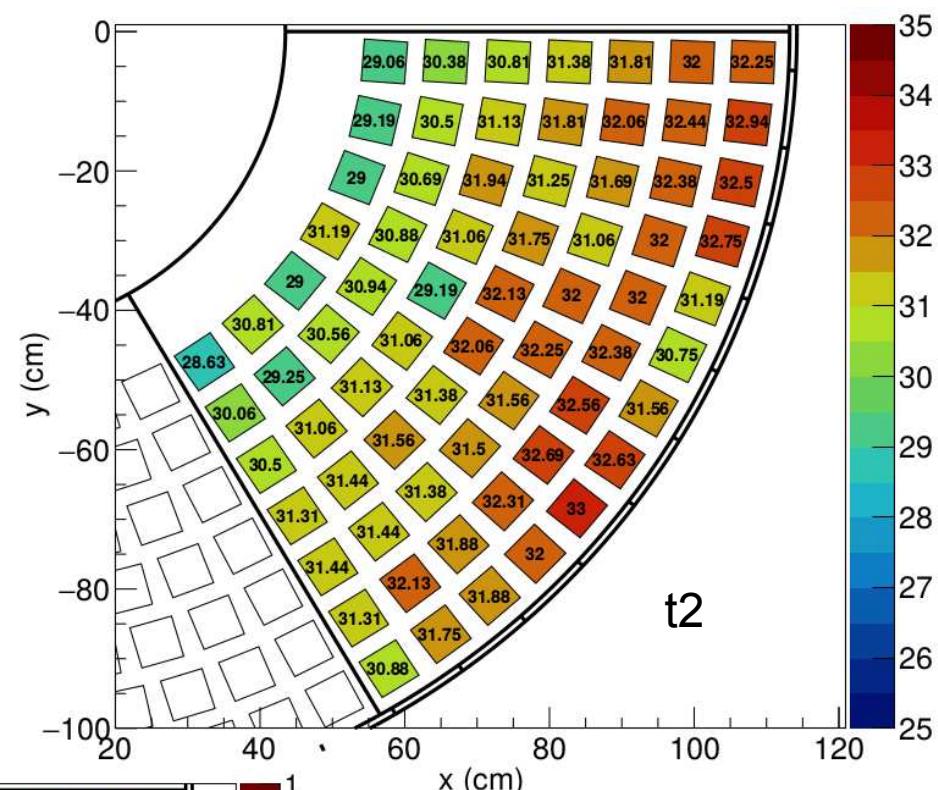
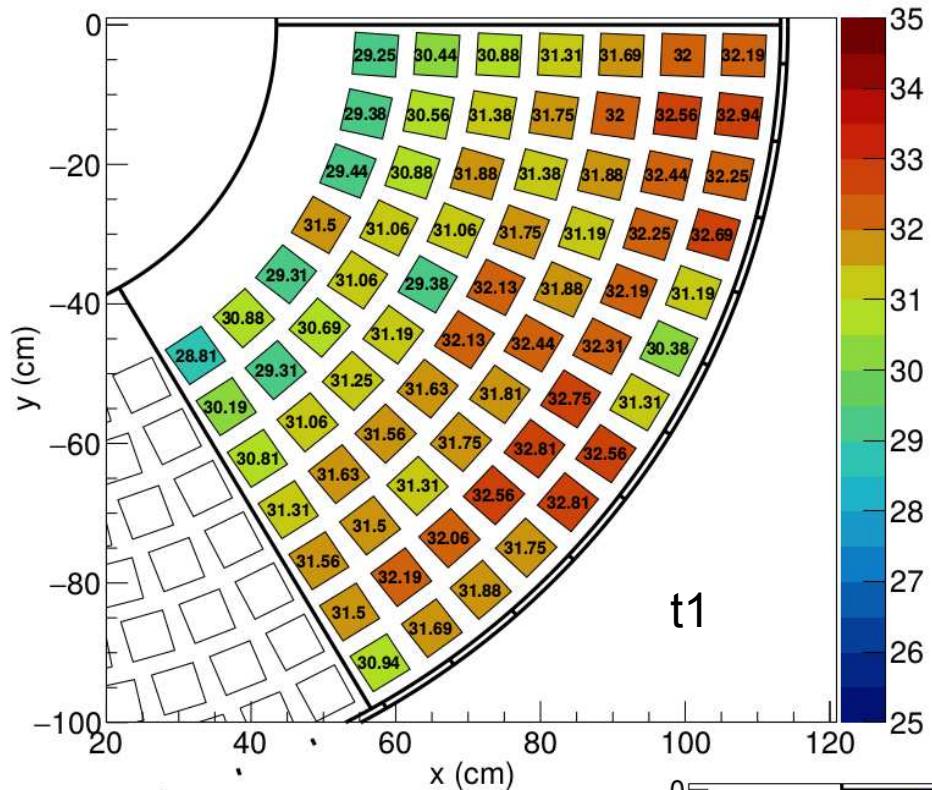


Mergers temperature with cooling system (01.10.2018) 11:37:56

gr_mergert

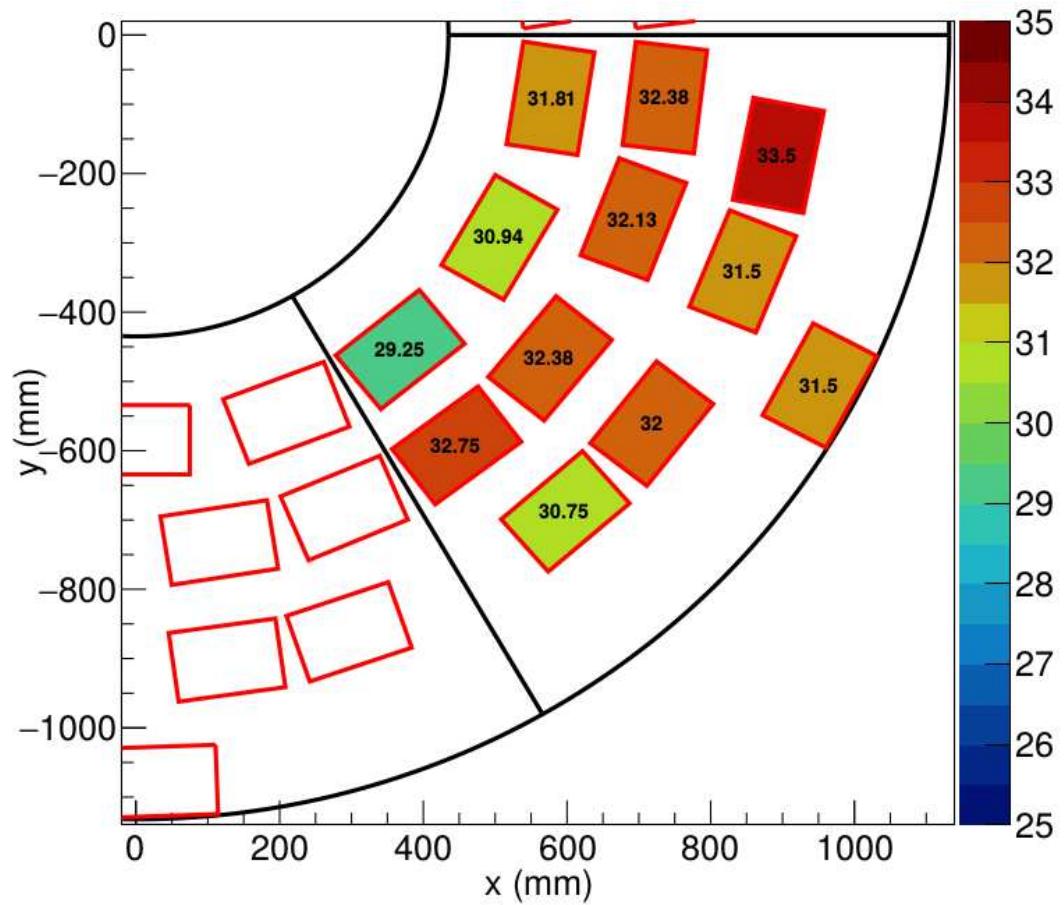
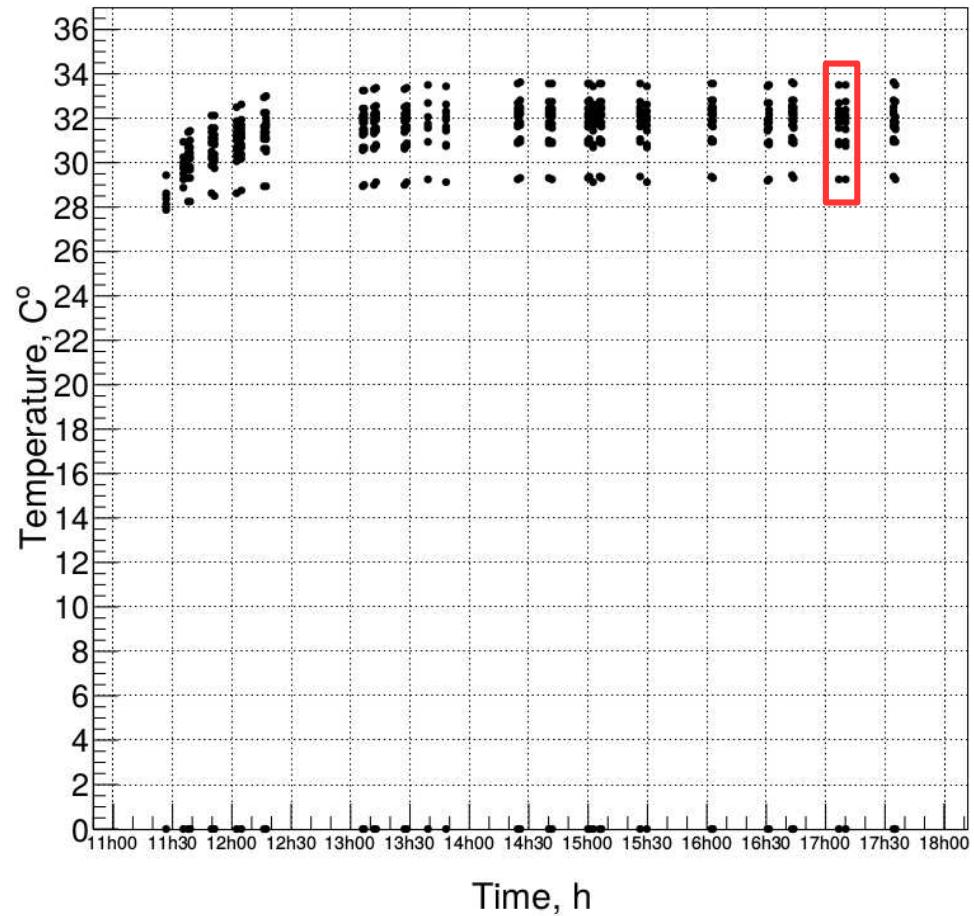


FEB's temperature with cooling system (01.10.2018) 17:10:6

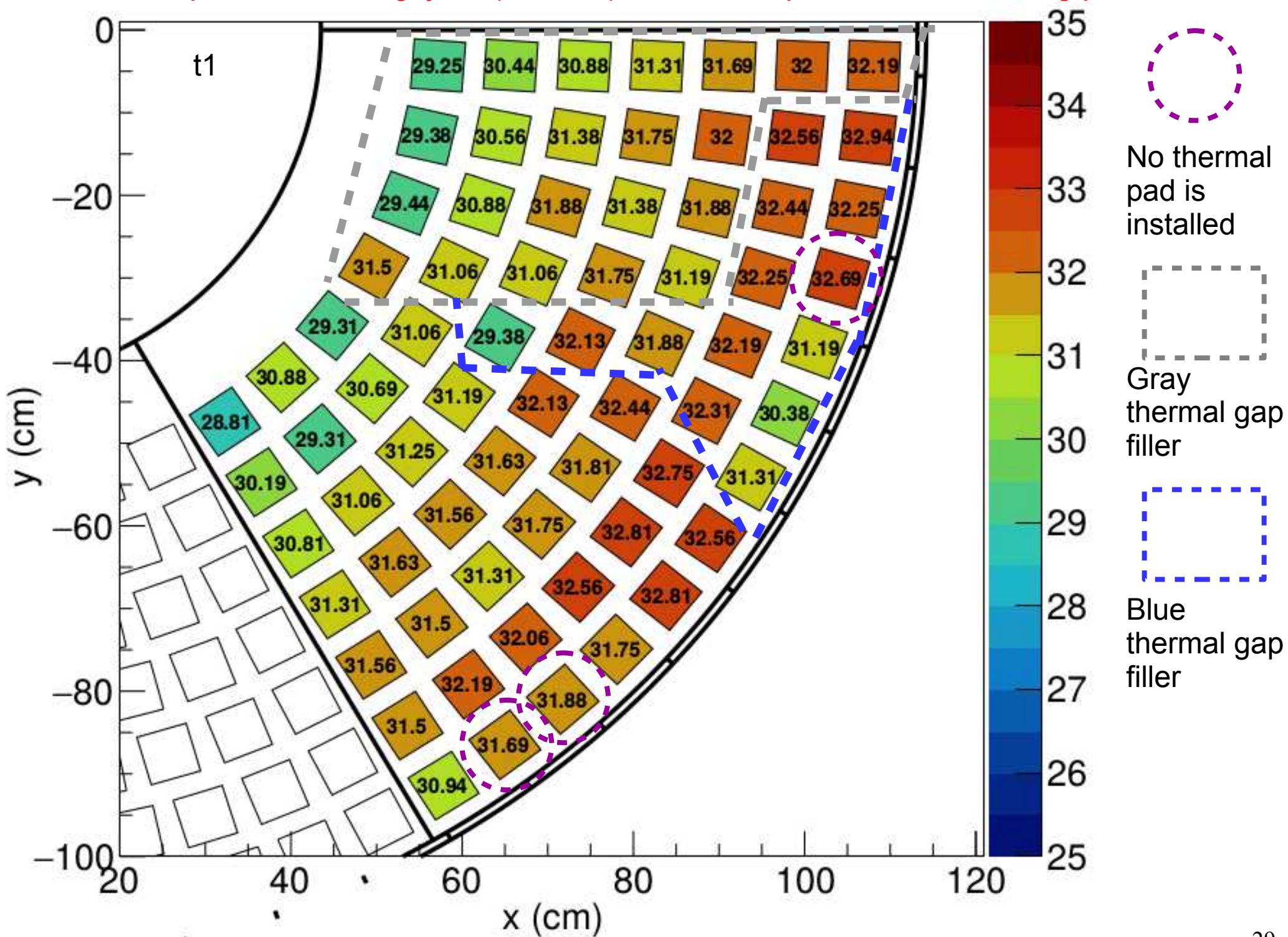


Mergers temperature with cooling system (01.10.2018) 17:10:6

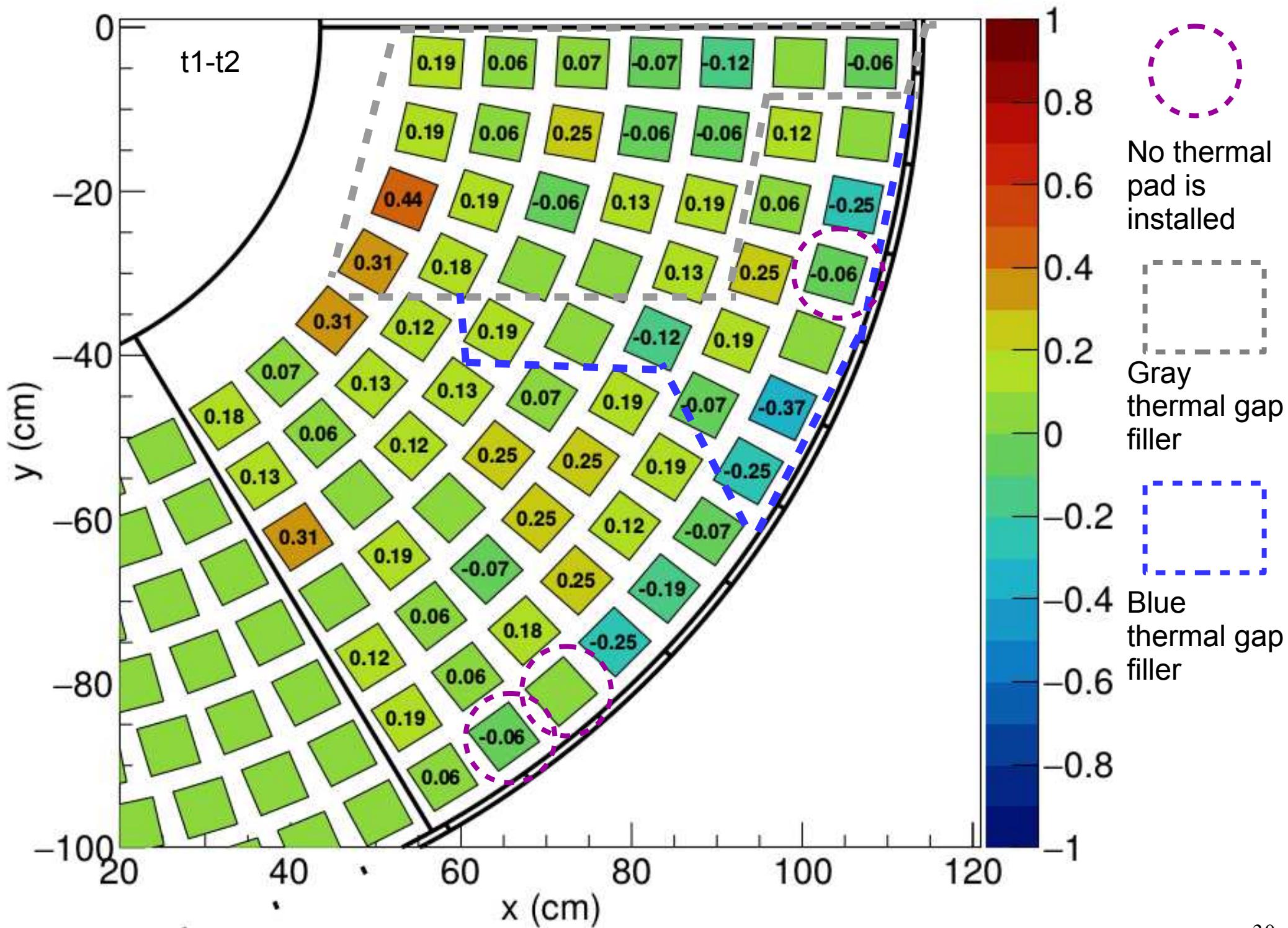
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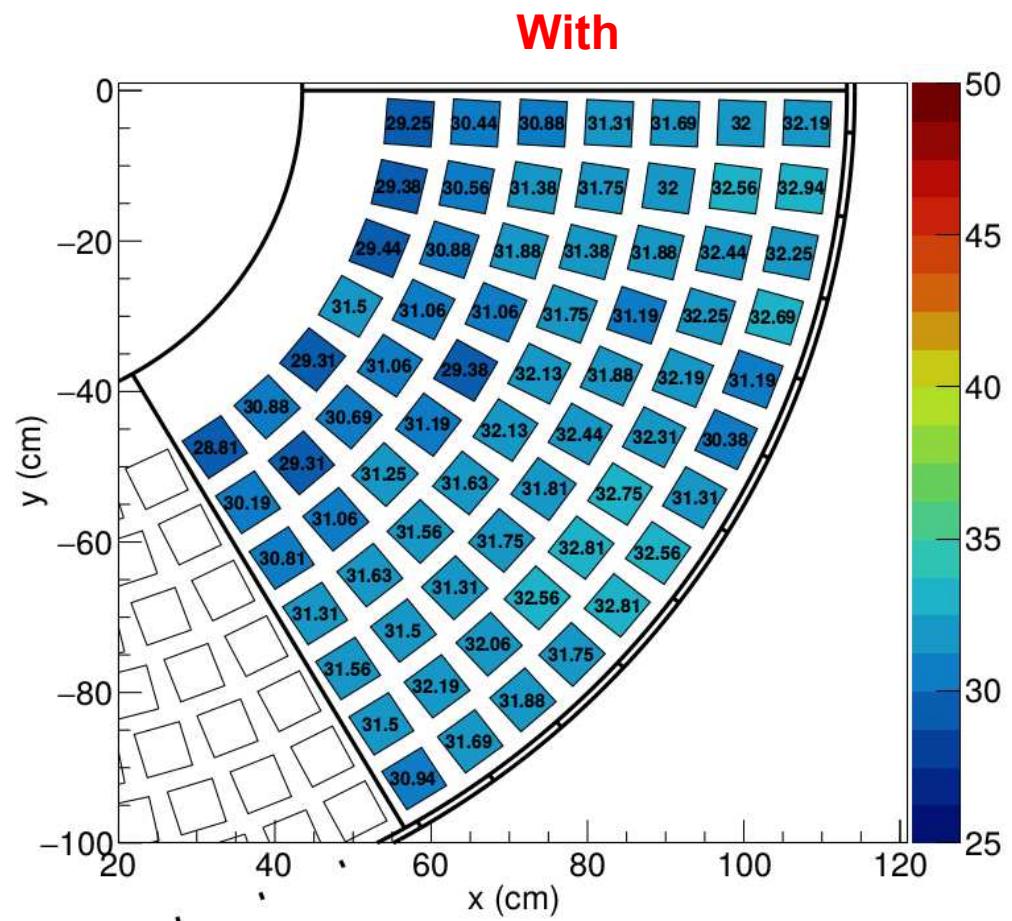
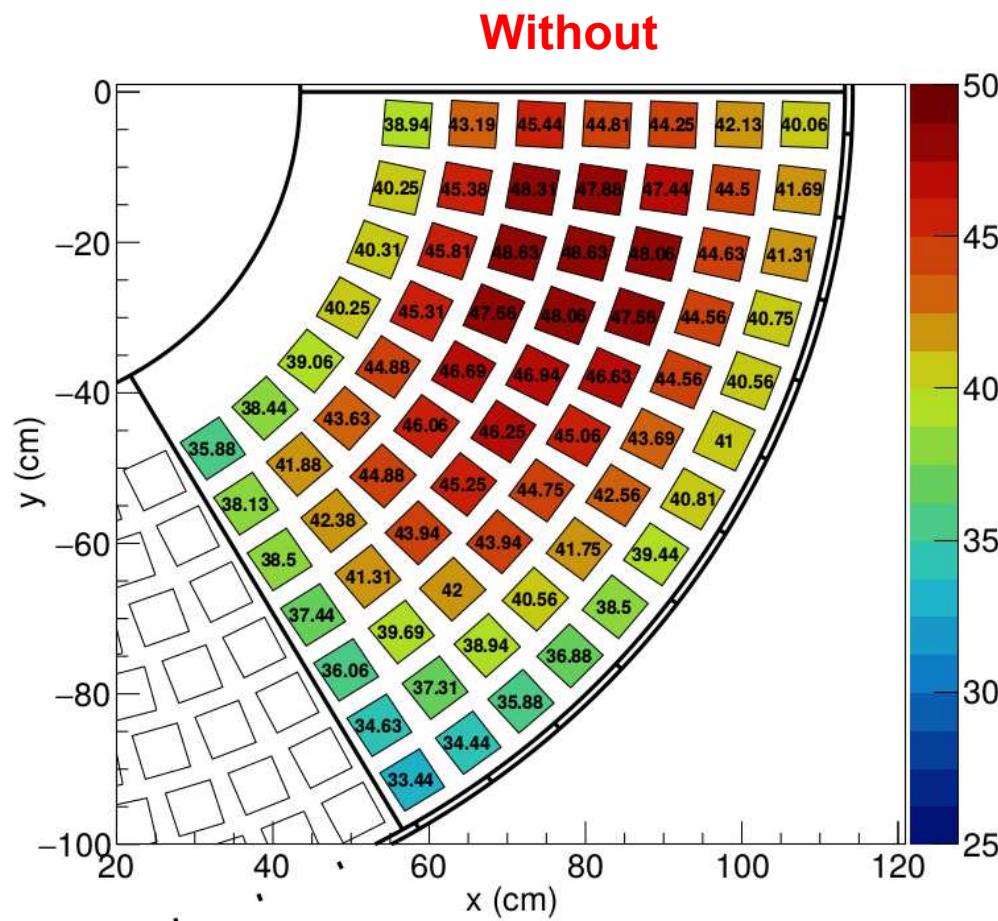
FEB's temperature with cooling system (01.10.2018) 17:10:6 thermal pads with/without thermal gap filler



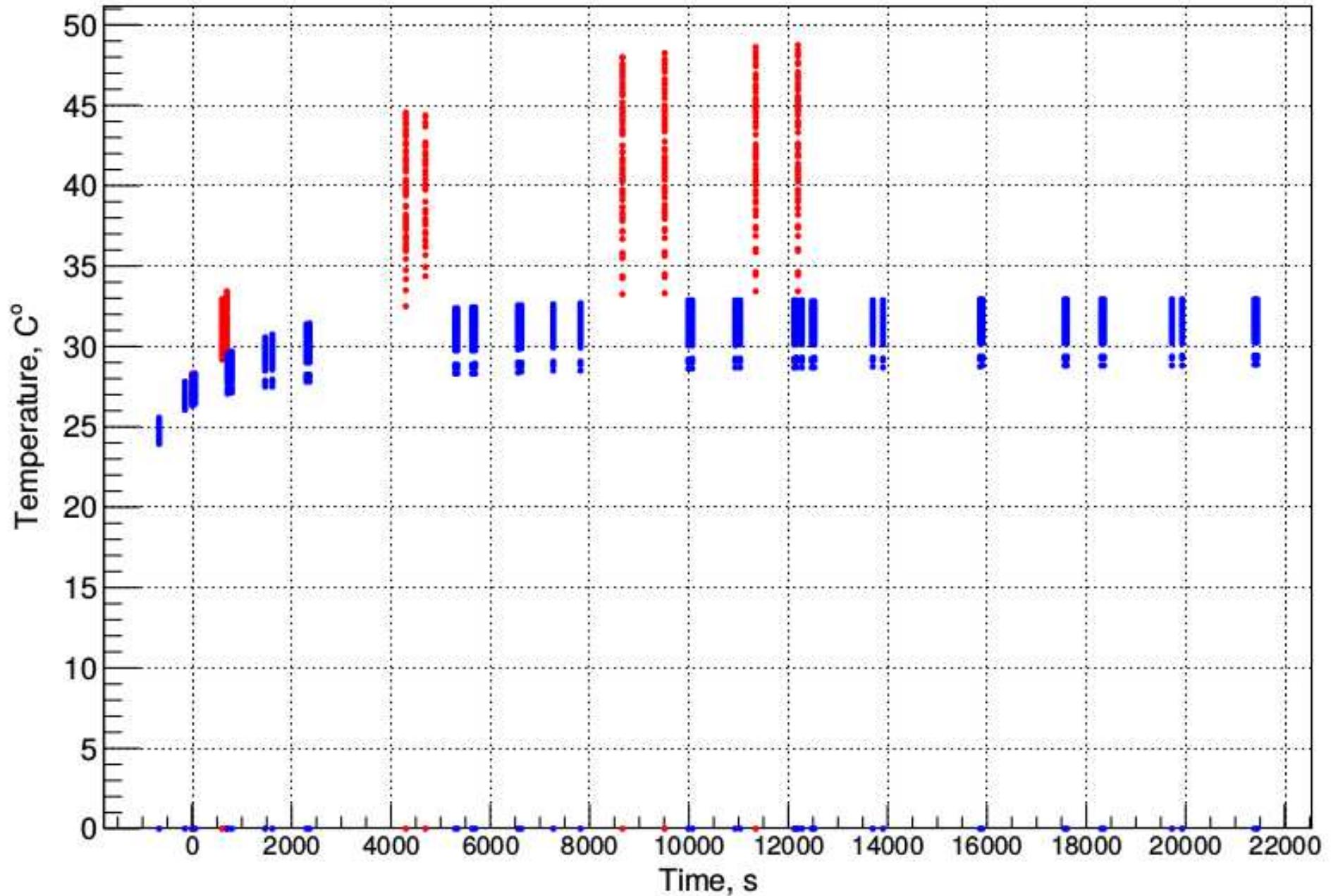
FEB's temperature with cooling system (01.10.2018) 17:10:6 thermal pads with/without thermal gap filler



Comparison of the FEB's temperatures with/without cooling system (01)

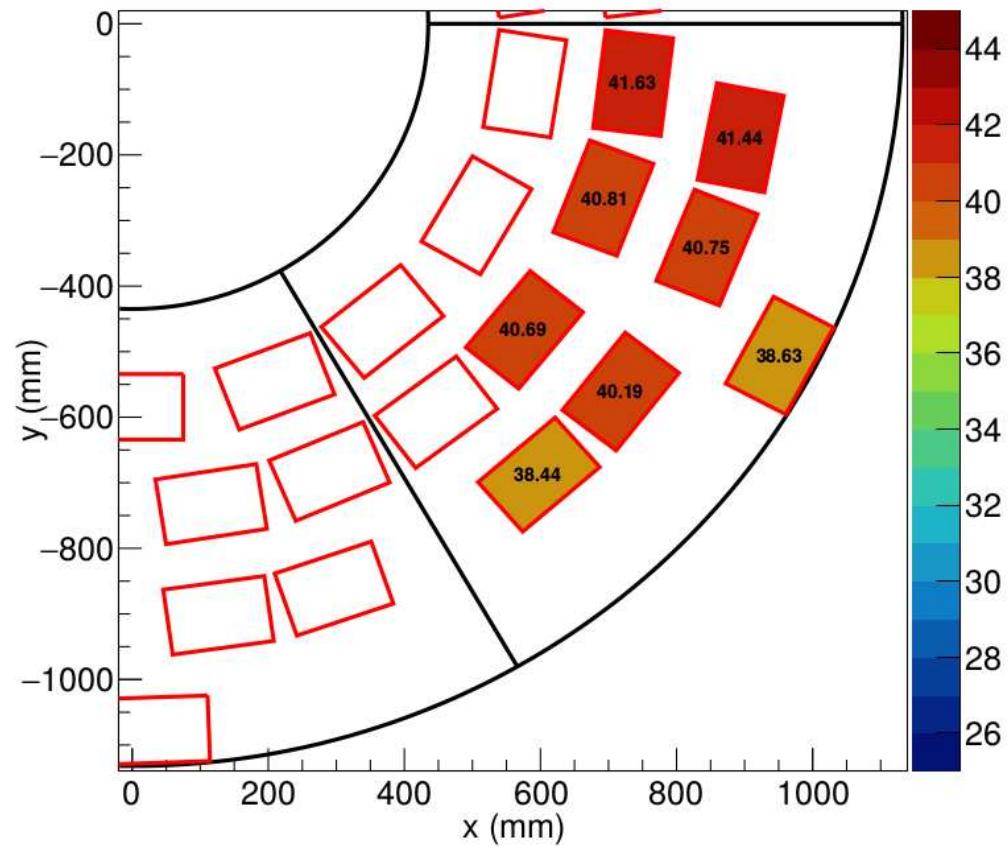


Comparison of the FEB's temperatures with/without cooling system (02)

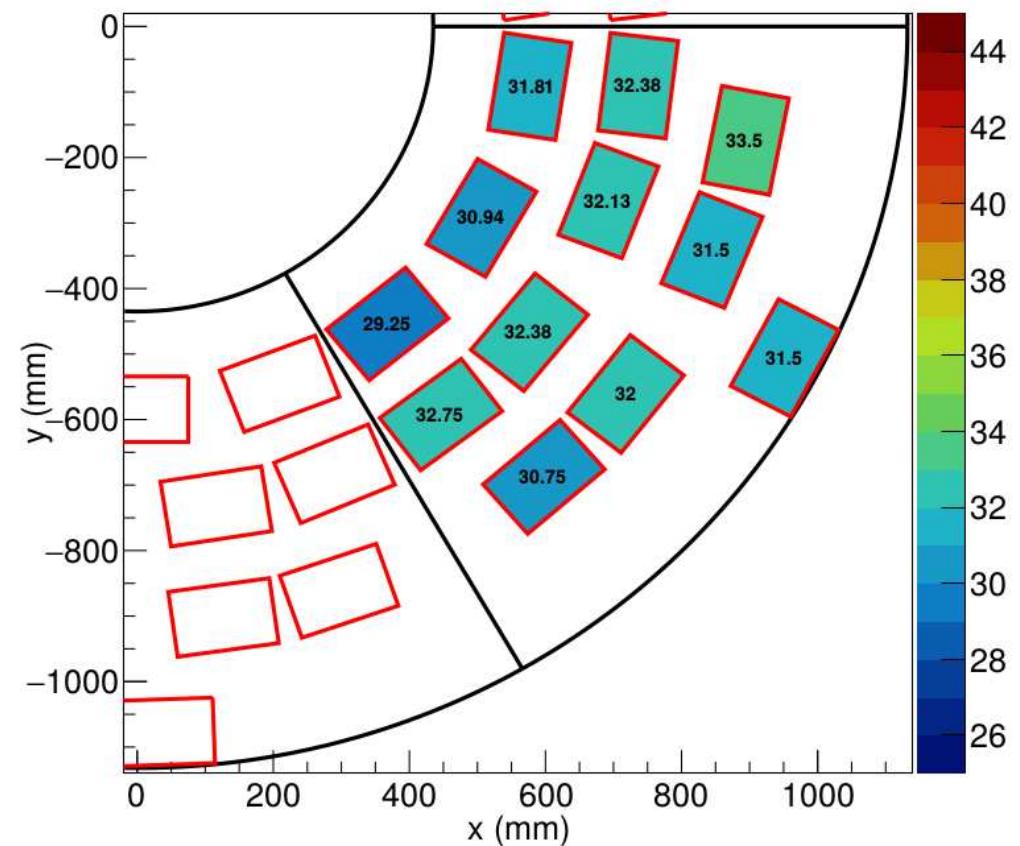


Comparison of the mergers temperatures with/without cooling system (01)

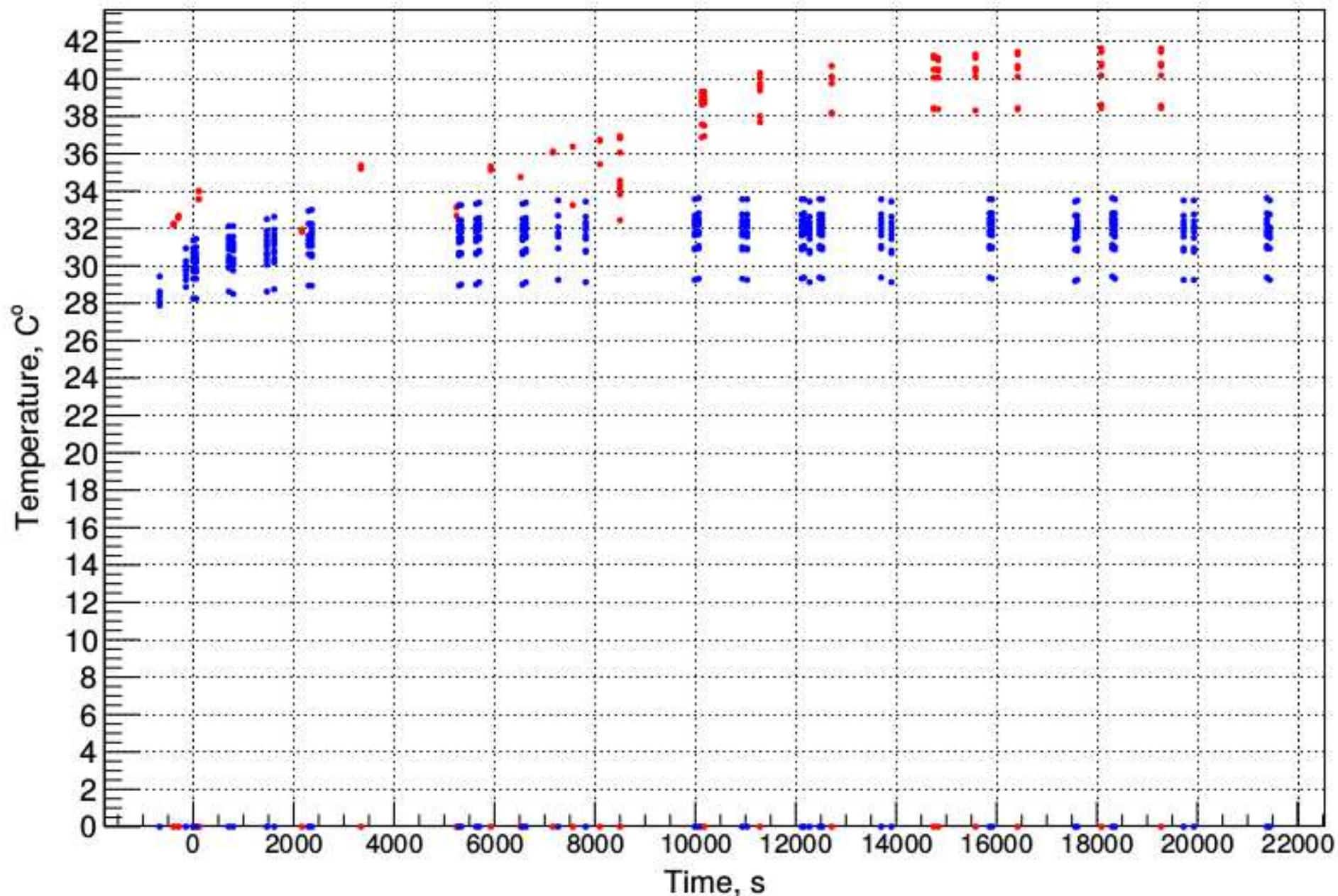
Without



With



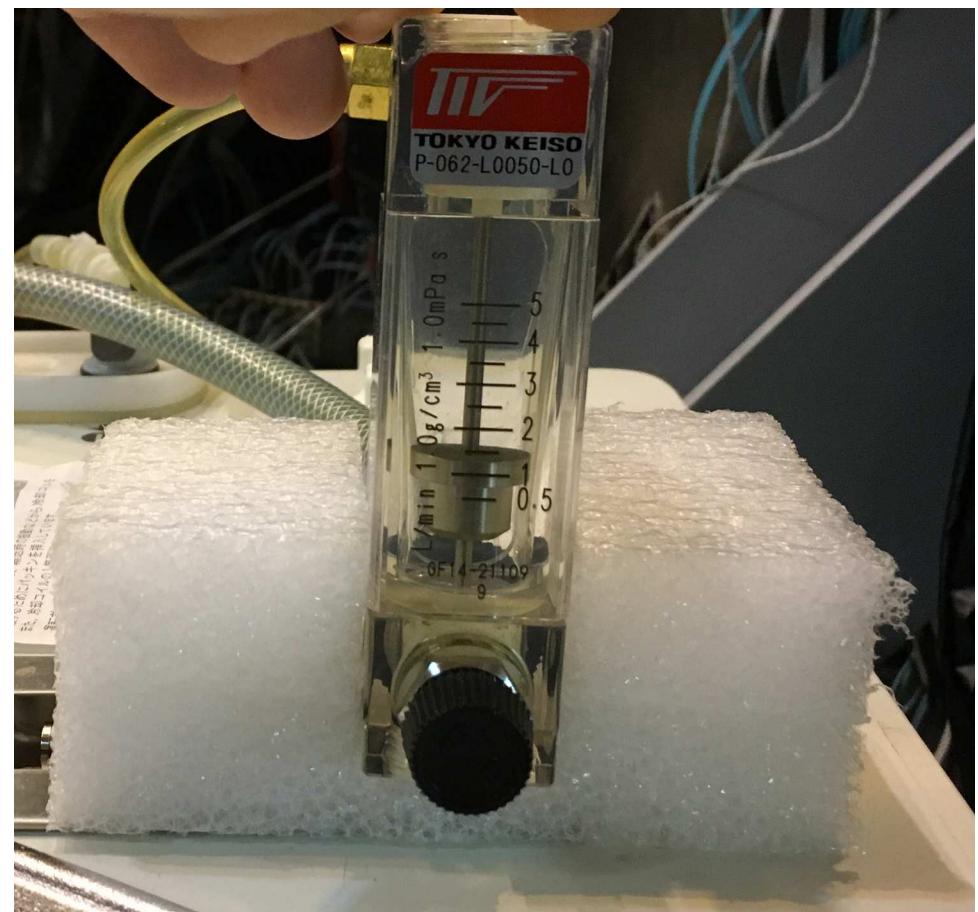
Comparison of the mergers temperatures with/without cooling system (02)



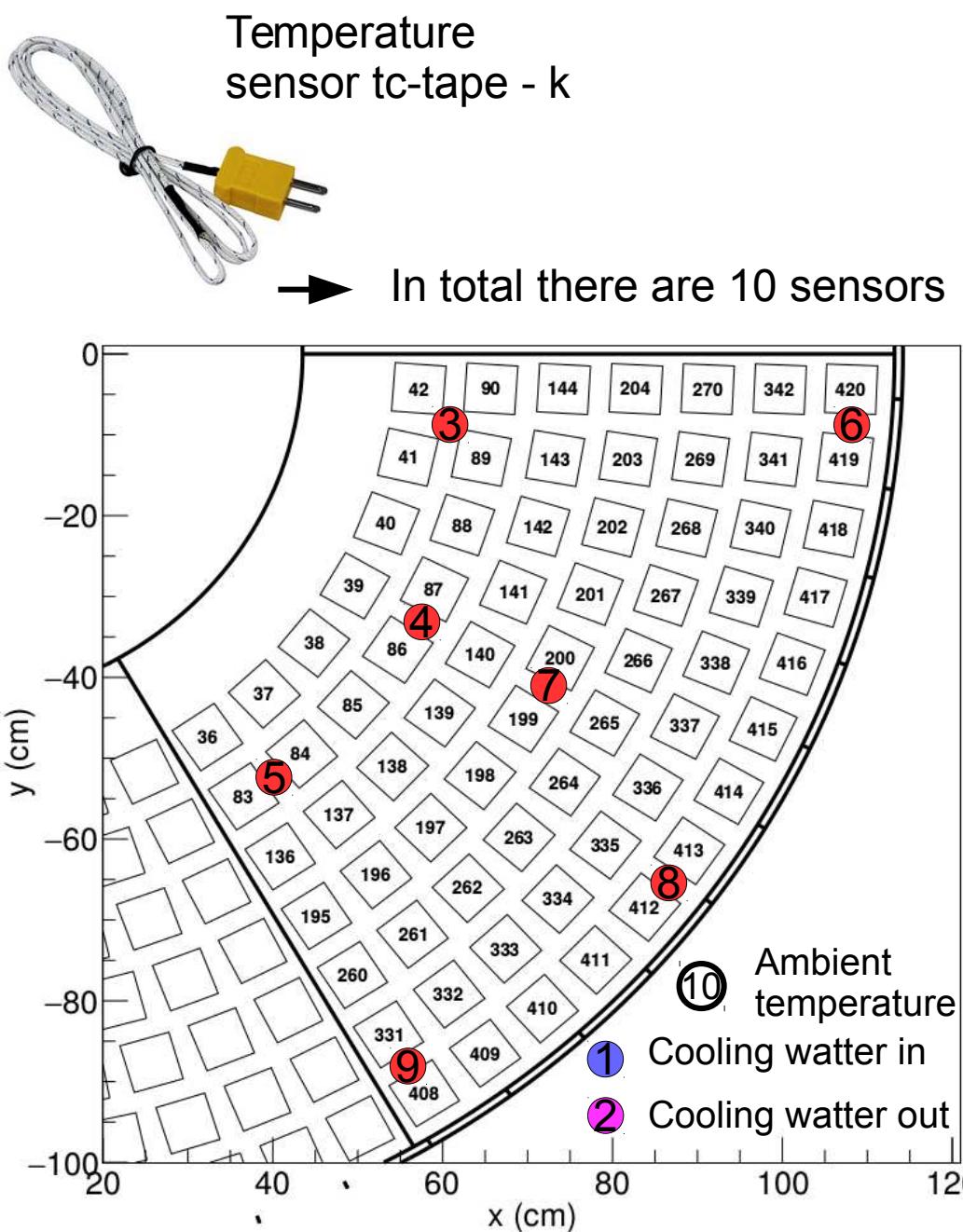
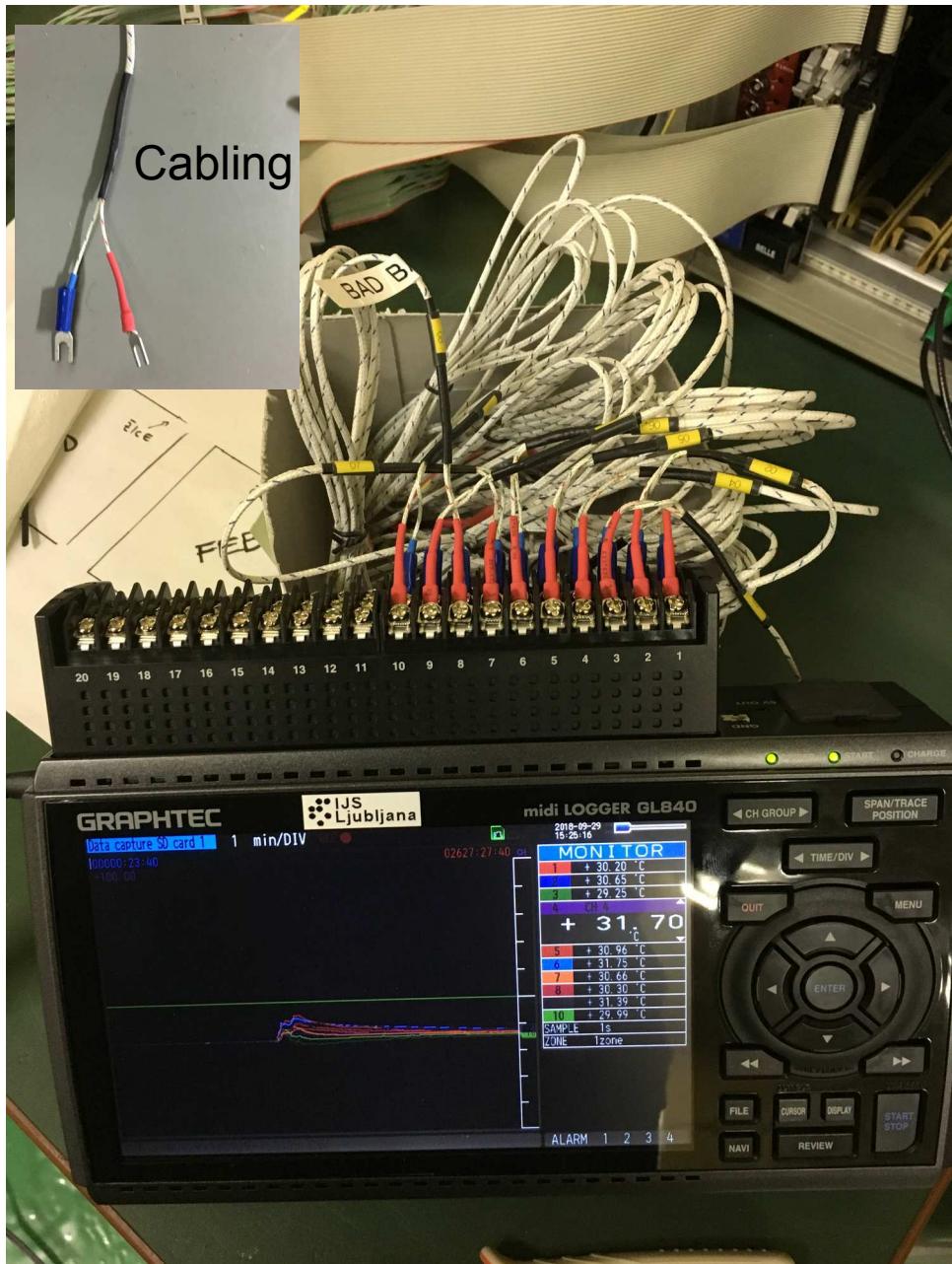
Cooling system for the tests



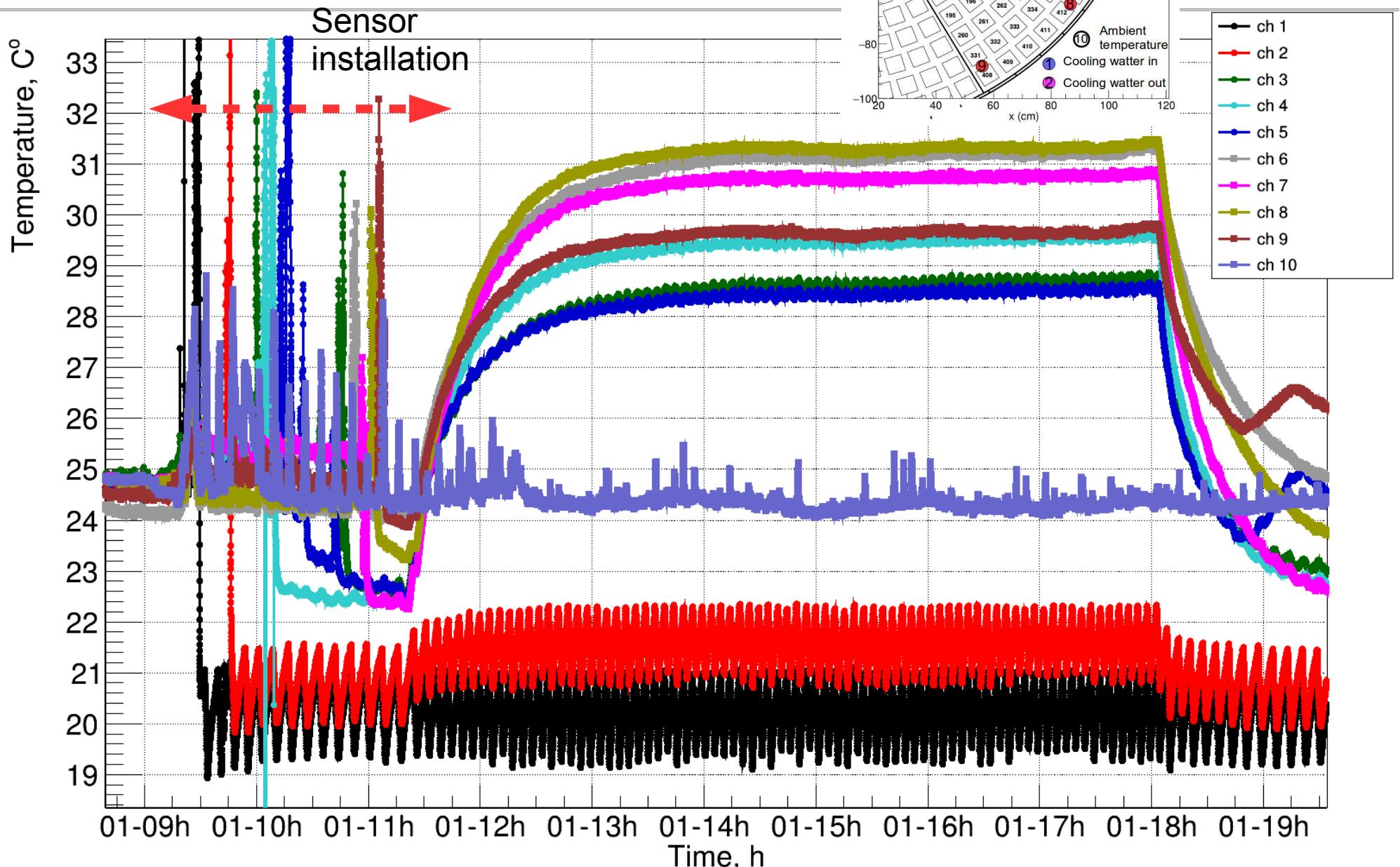
- Full sector wired back
- Temperature sensors attached to the structure
- Water cooling flow $\approx 1.2 \text{ l/min}$ and temperature $\approx 20^\circ\text{C}$



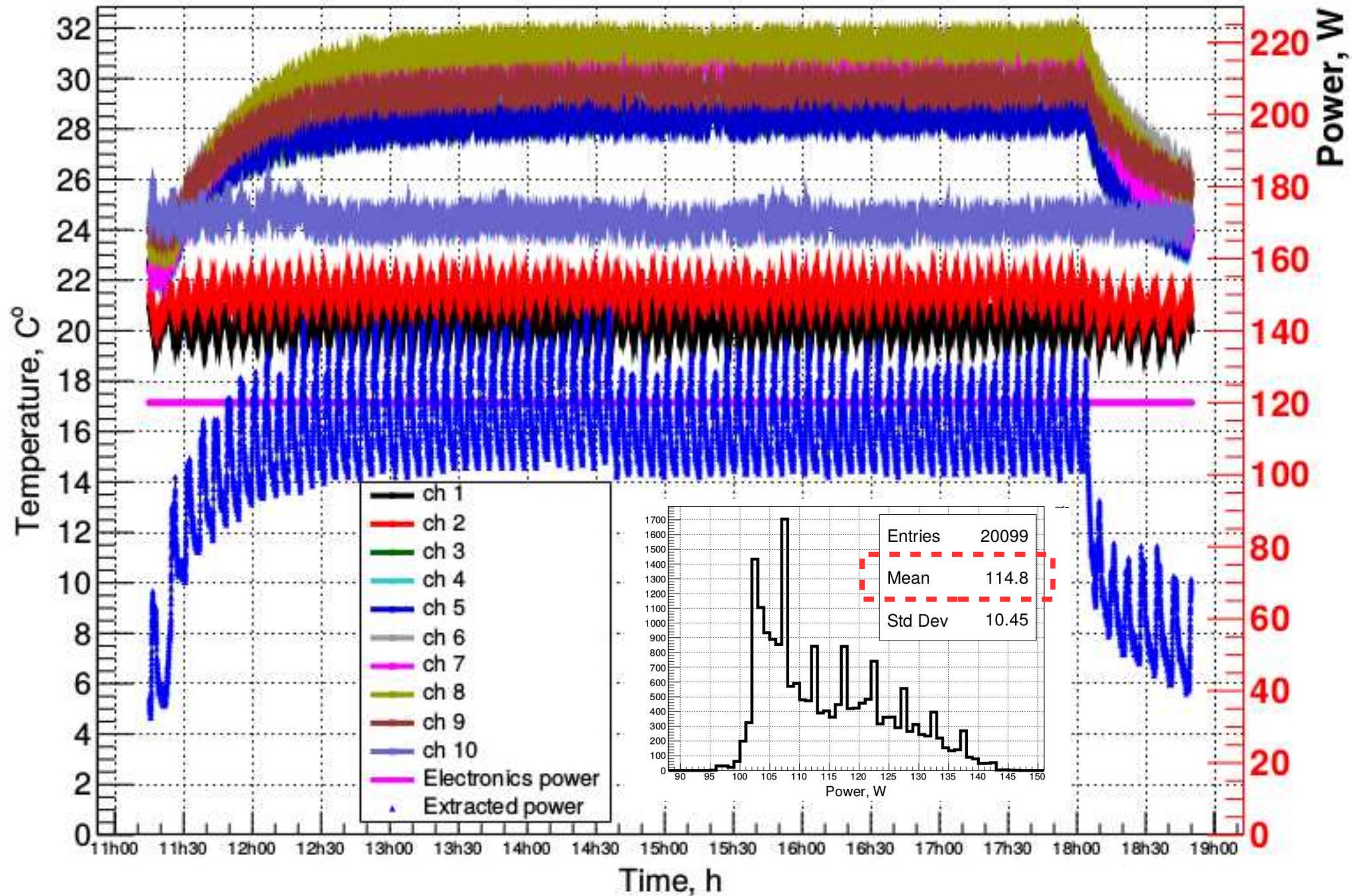
Temperature logger – additional measurements of the ARICH mechanical structure temperature and extracted power calculation power calculation.



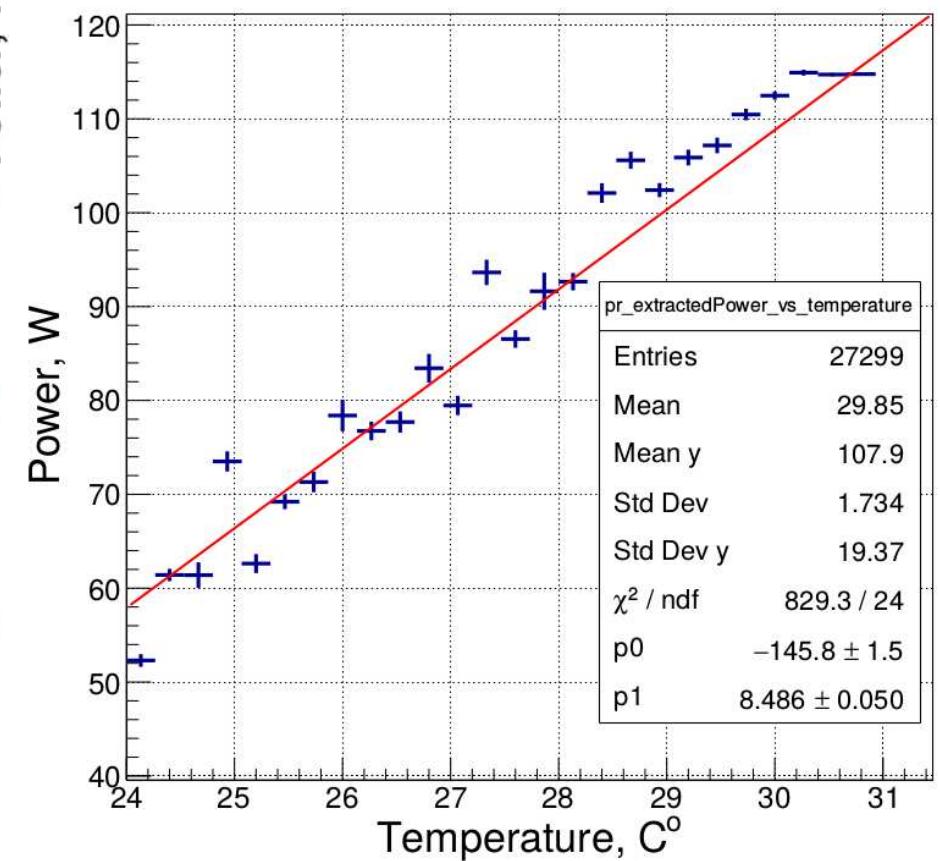
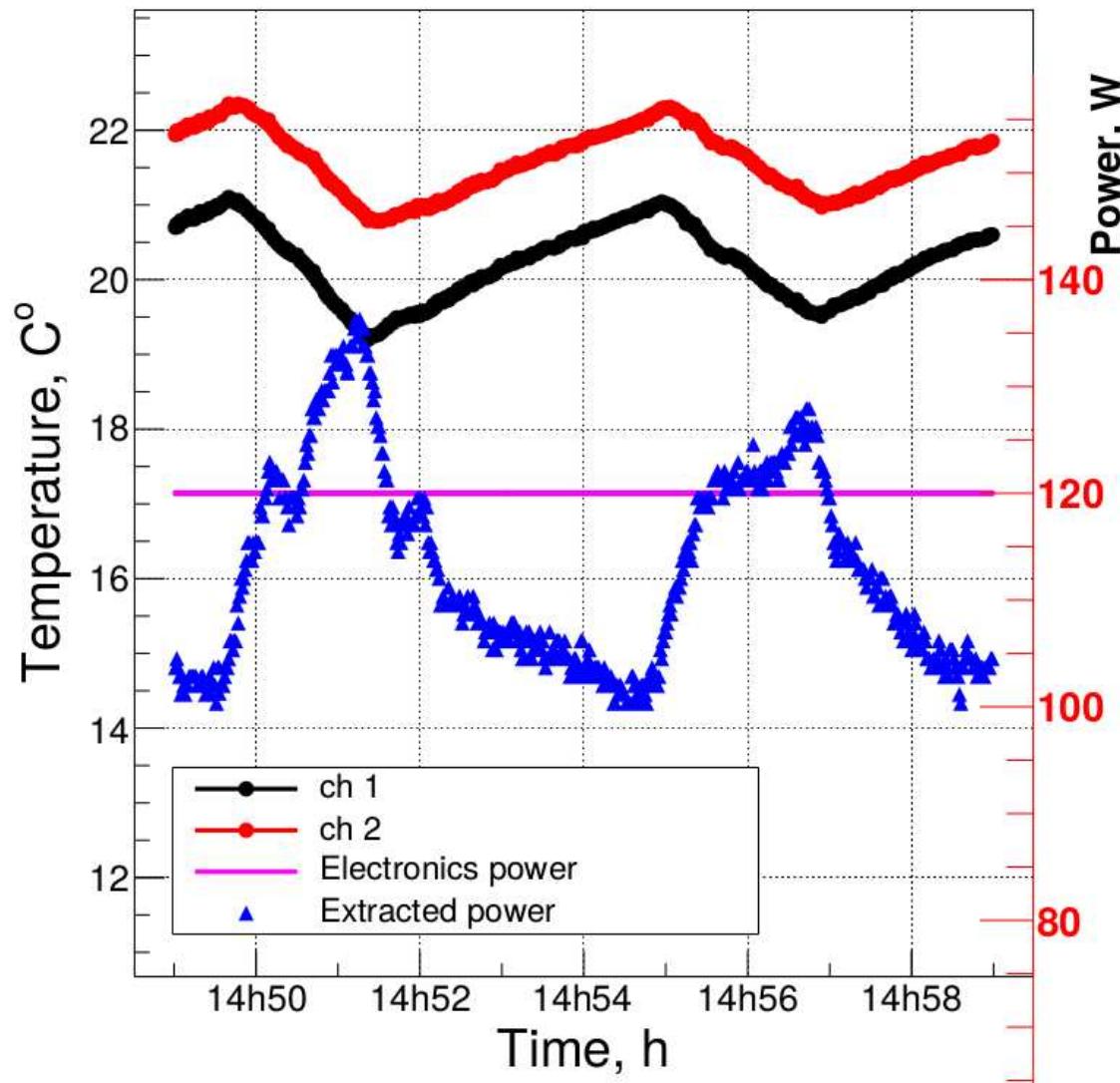
ARICH mechanical structure temperature



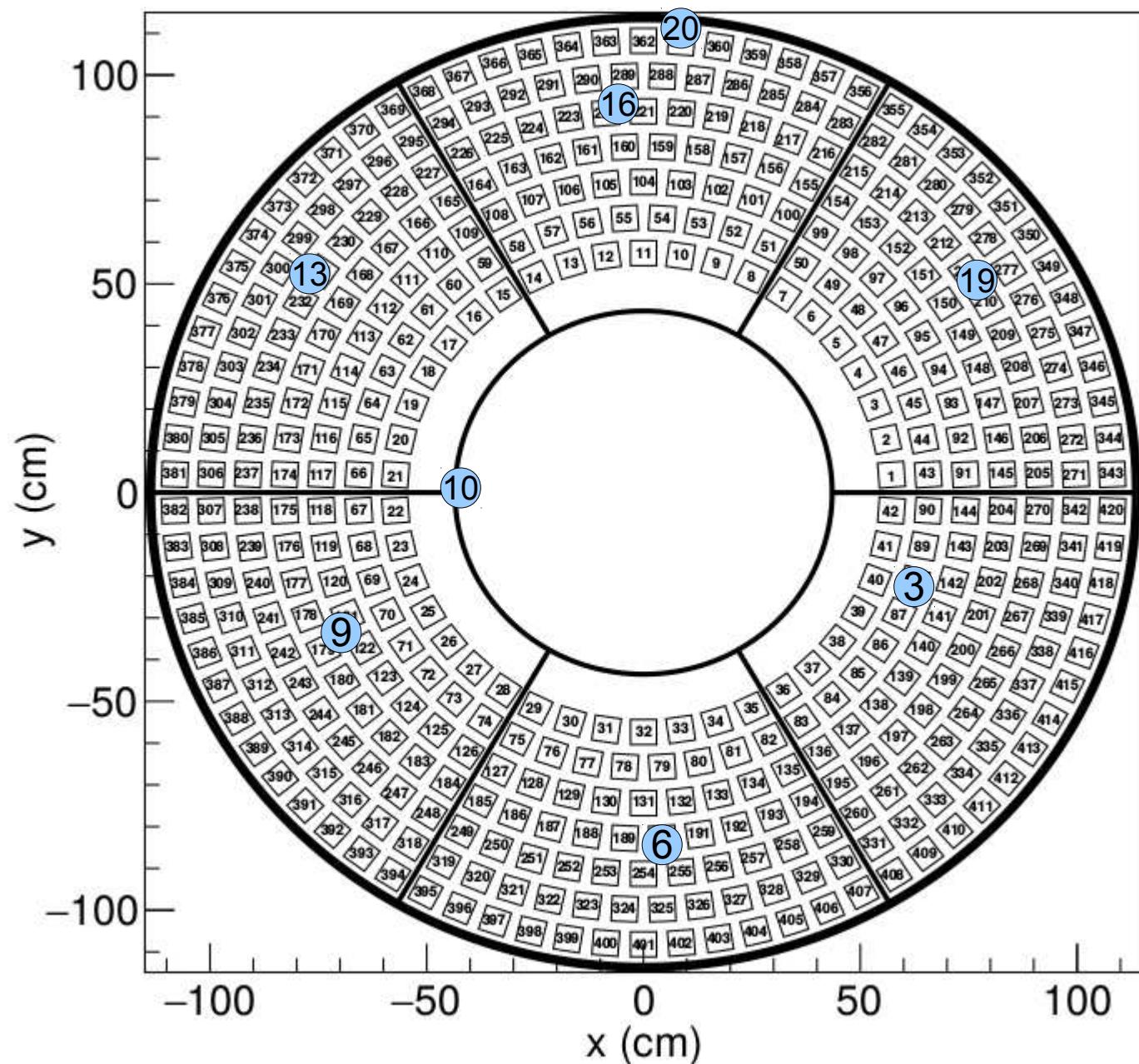
Electronics vs extracted power



Extracted power



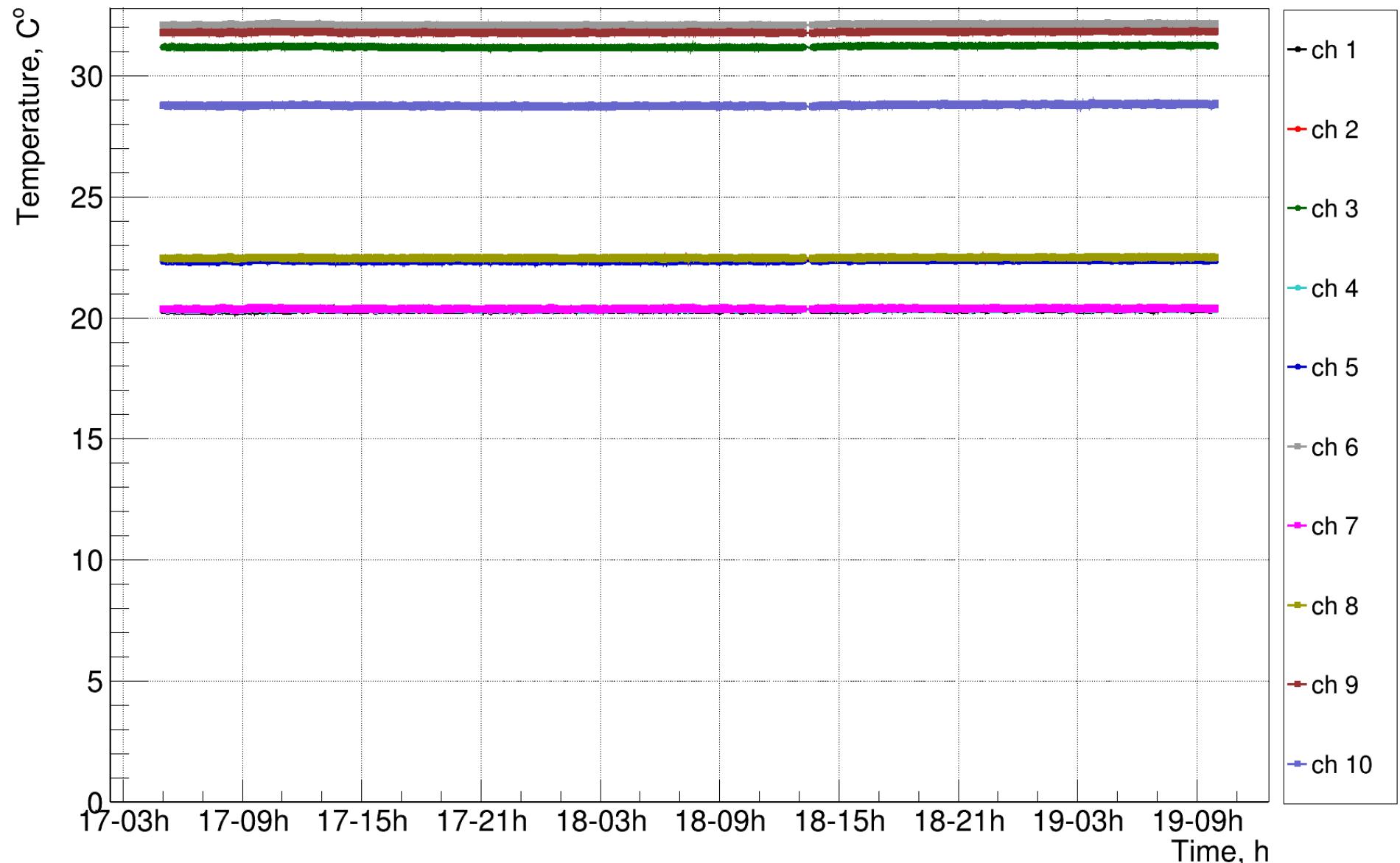
Structure and in/out pipes temperatures – channel map.



Sec 6	
In	1
Out	2
Sec 5	
In	4
Out	5
Sec 4	
In	7
Out	8
Sec 3	
In	12
Out	11
Sec 2	
In	14
Out	15
Sec 1	
In	18
Out	17

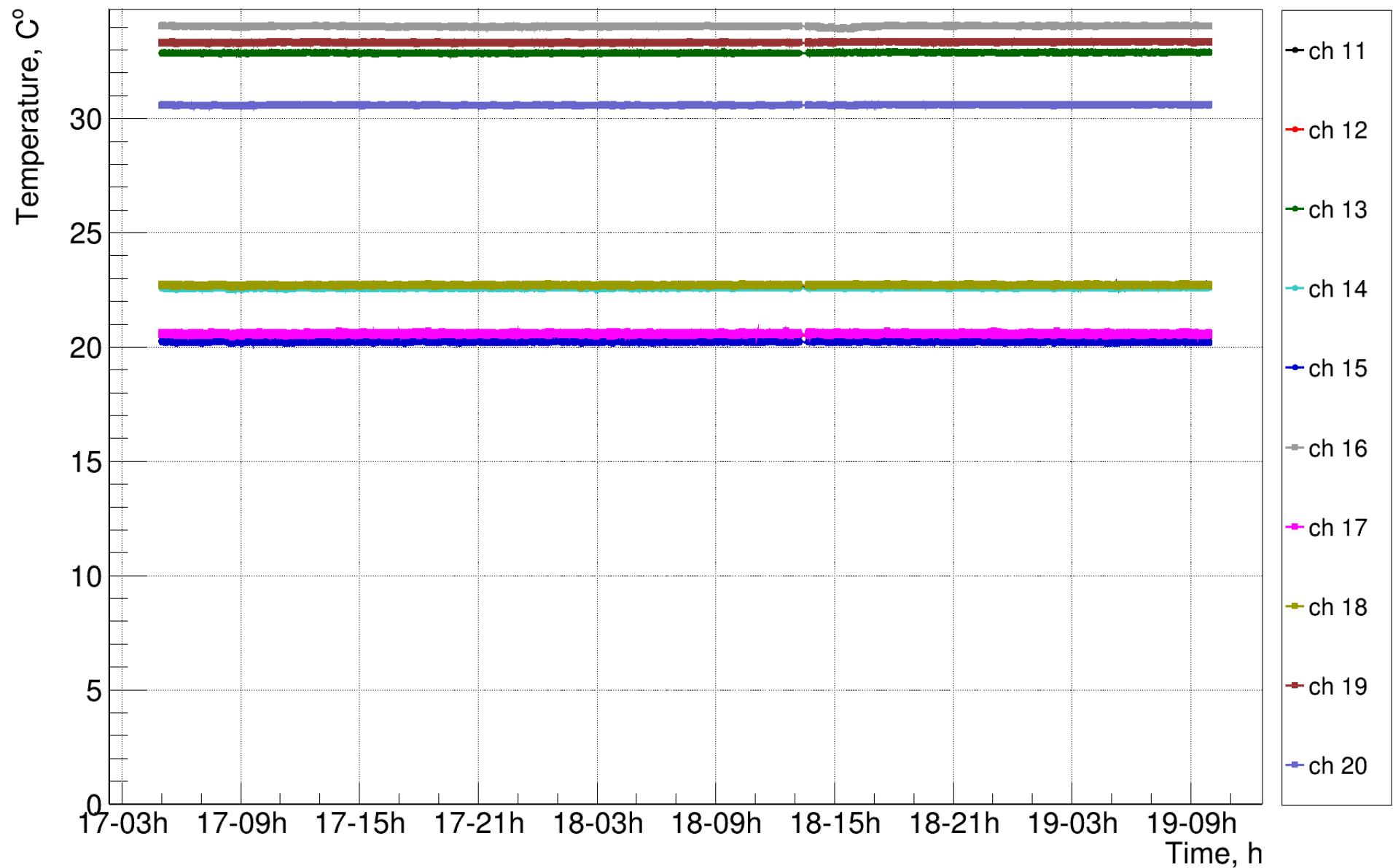
Sectors 6, 5, 4 – structure and in/out pipes temperatures

Nov 17, 18, 19 : Test with main chiller (flow = 4.2 L/min, @ 20 °C) with all Al-end-plates installed and back cover.



Sectors 3, 2, 1 – structure and in/out pipes temperatures

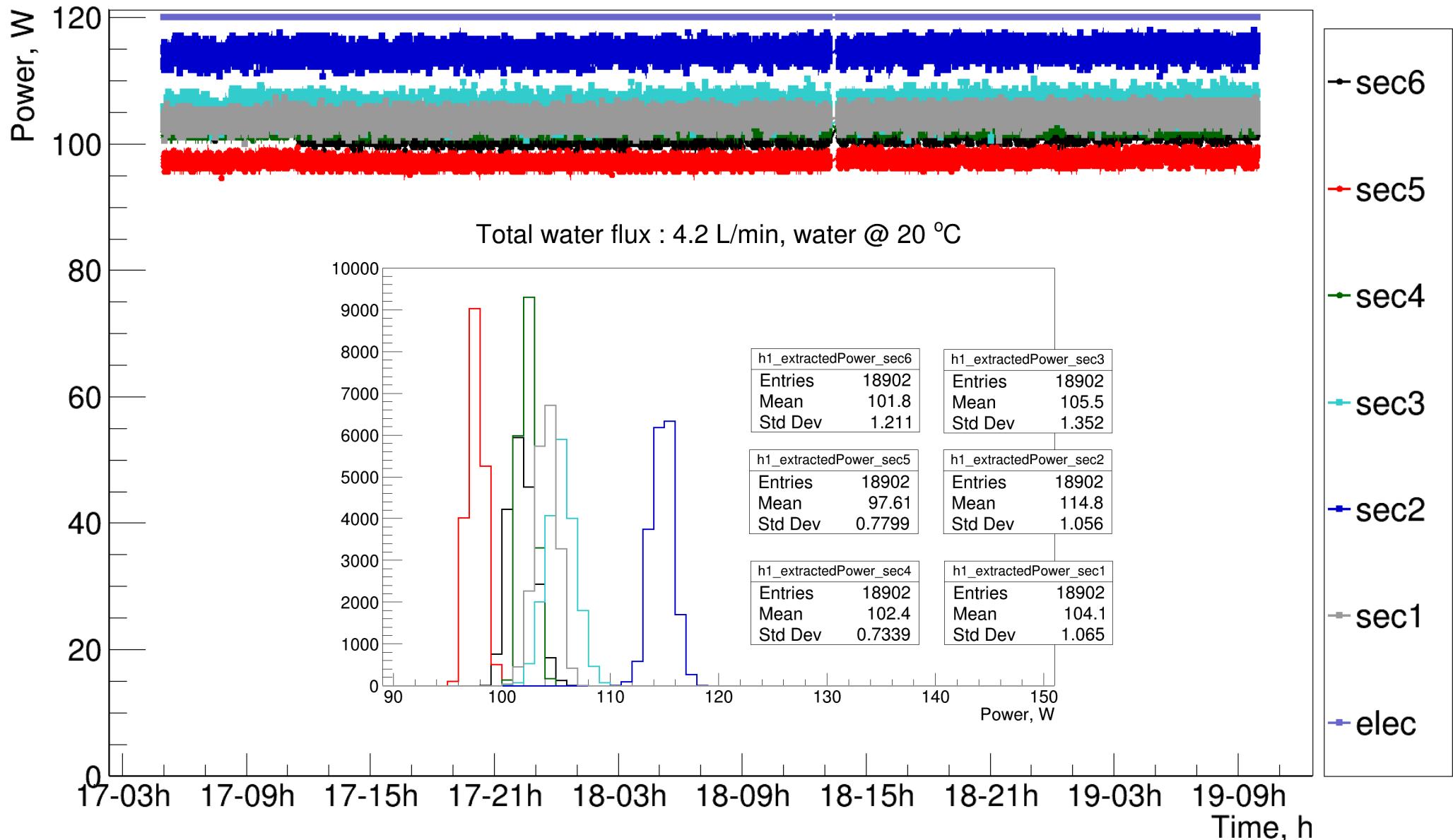
Nov 17, 18, 19 : Test with main chiller (flow = 4.2 L/min, @ 20 °C) with all Al-end-plates installed and back cover.



Extracted power

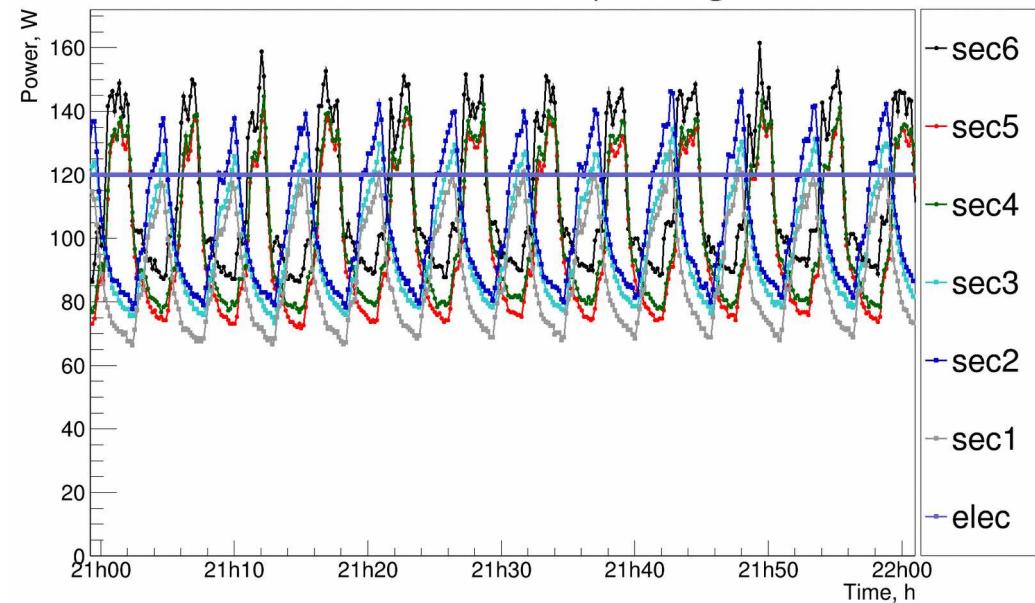
Nov 17, 18, 19 : Test with main chiller (flow = 4.2 L/min, @ 20 °C) with all Al-end-plates installed and back cover.

Total water flux : 4.2 L/min, water @ 20 °C

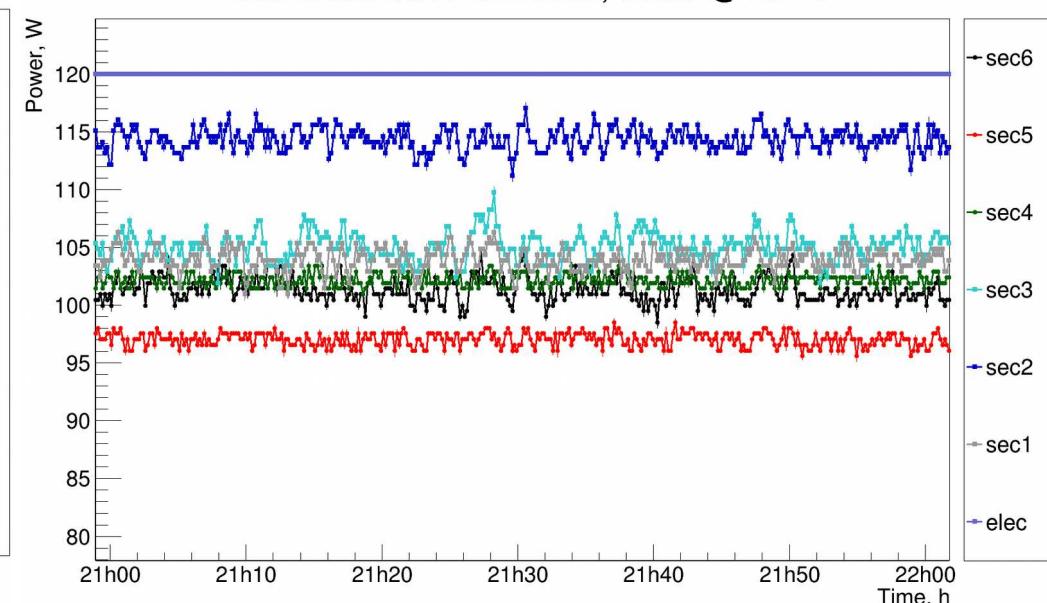


Extracted power – main chiller vs two small chillers

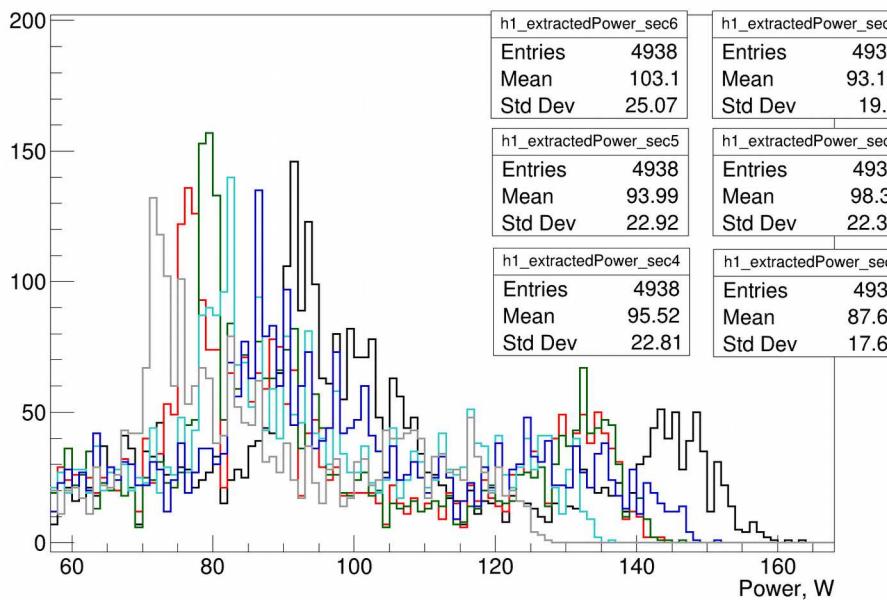
Total water flux : 4.1 L/min, water @ 20 °C



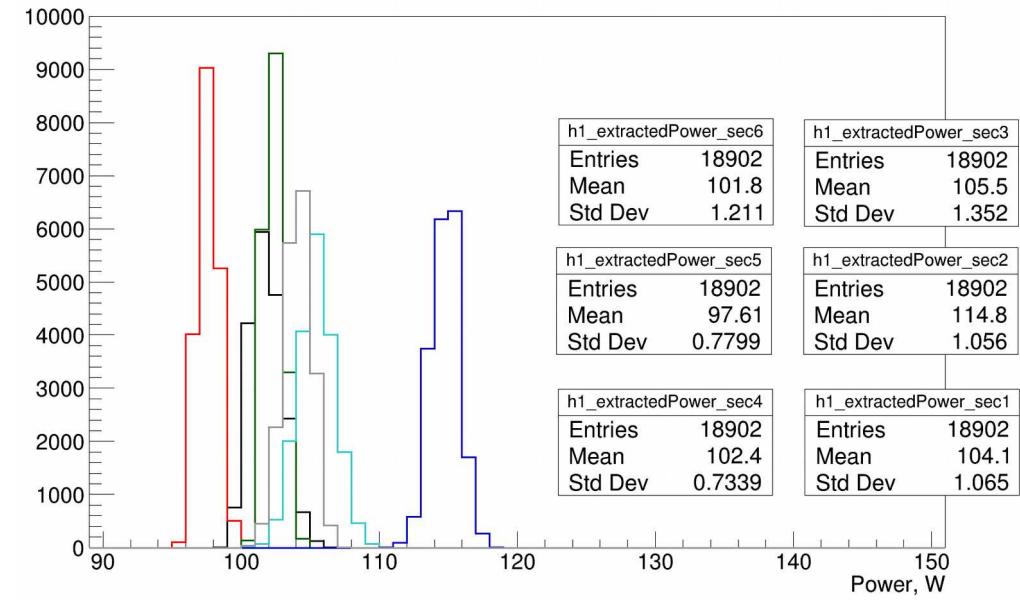
Total water flux : 4.2 L/min, water @ 20 °C



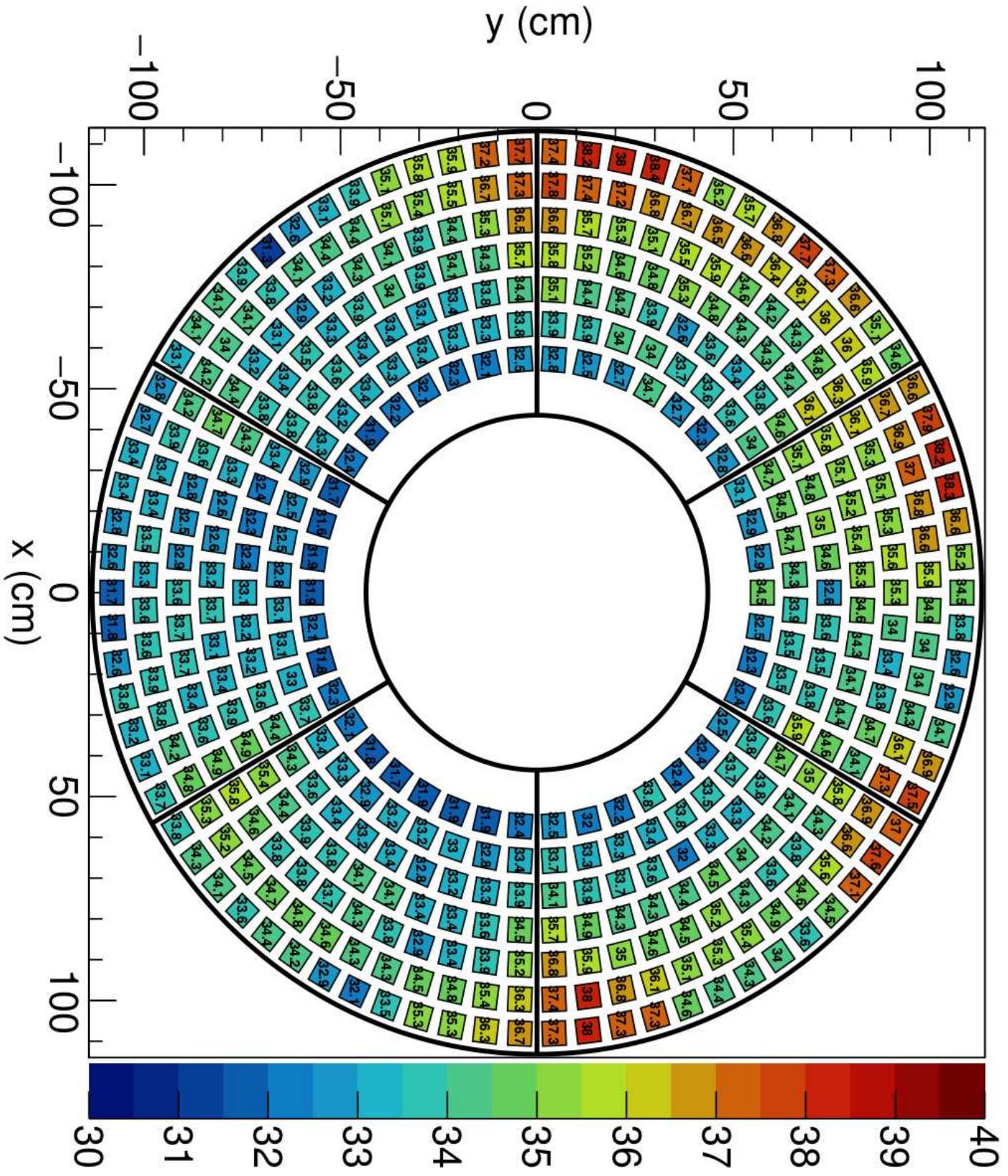
Total water flux : 4.1 L/min, water @ 20 °C



Total water flux : 4.2 L/min, water @ 20 °C



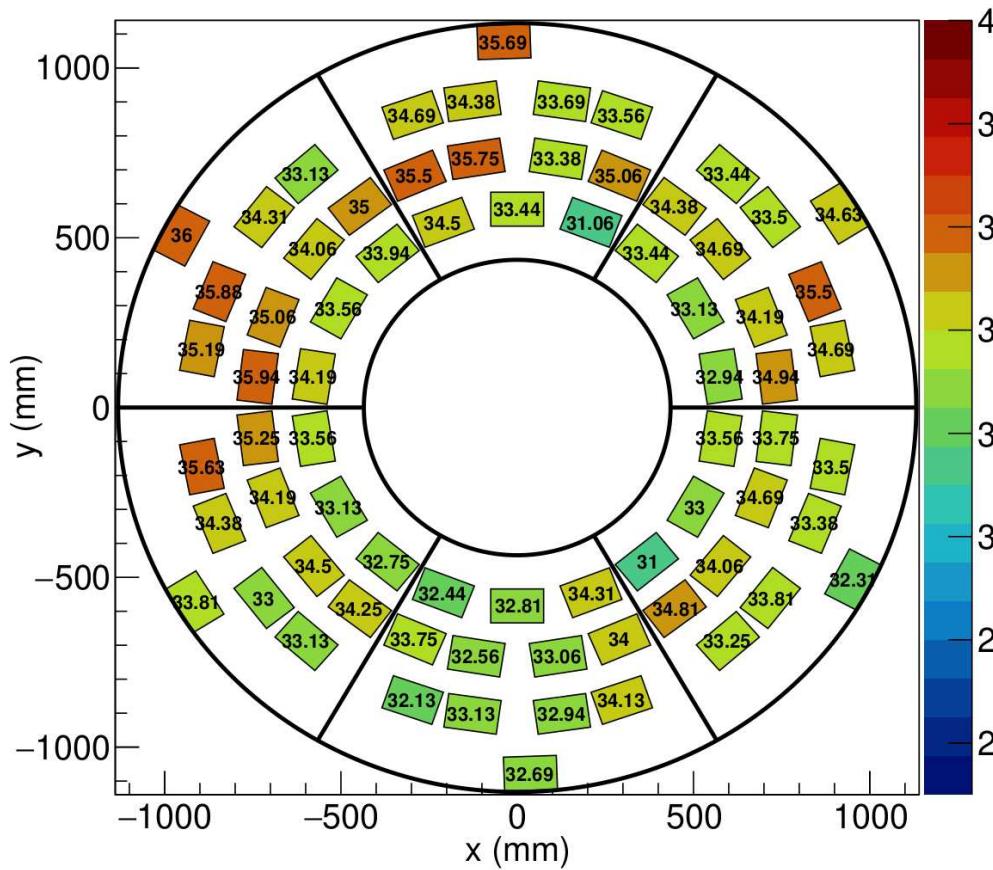
feb_t1 2018.11.18 3:35:16



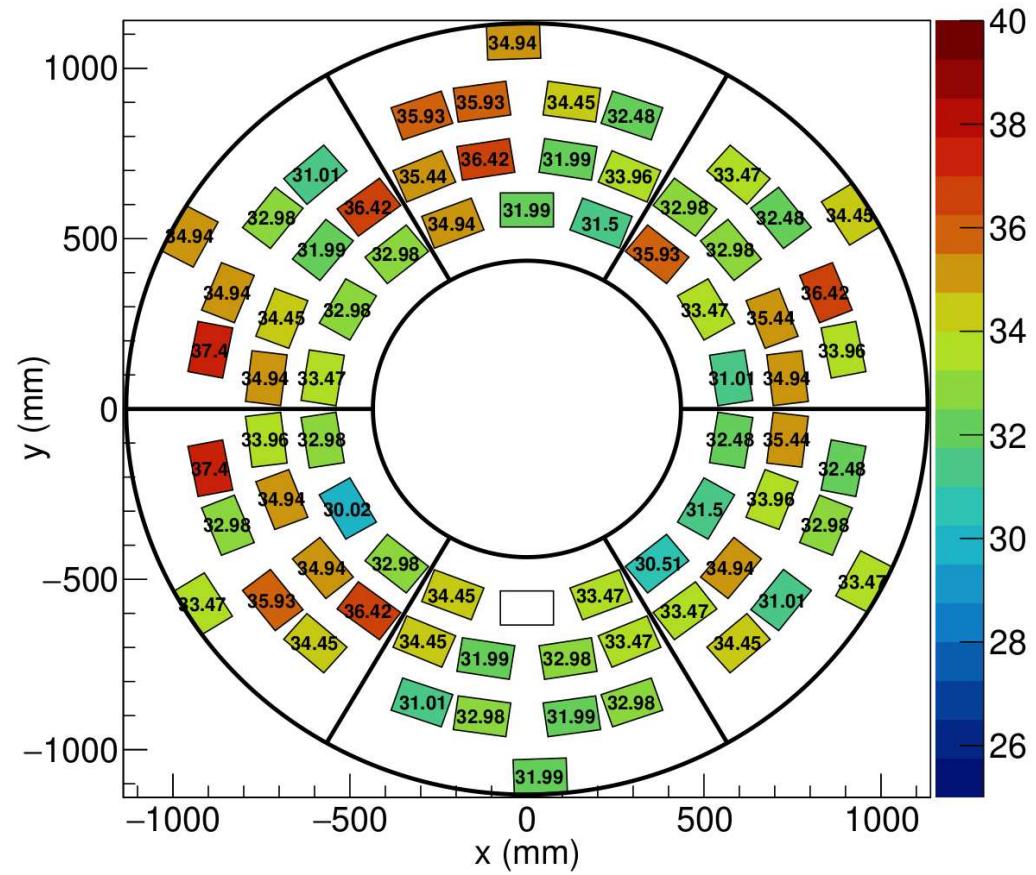
**FEBs temperature
(sensor 1 – from the cooling body side)**

MERGERs temperature

merger_t_board 2018.11.18 3:35:16

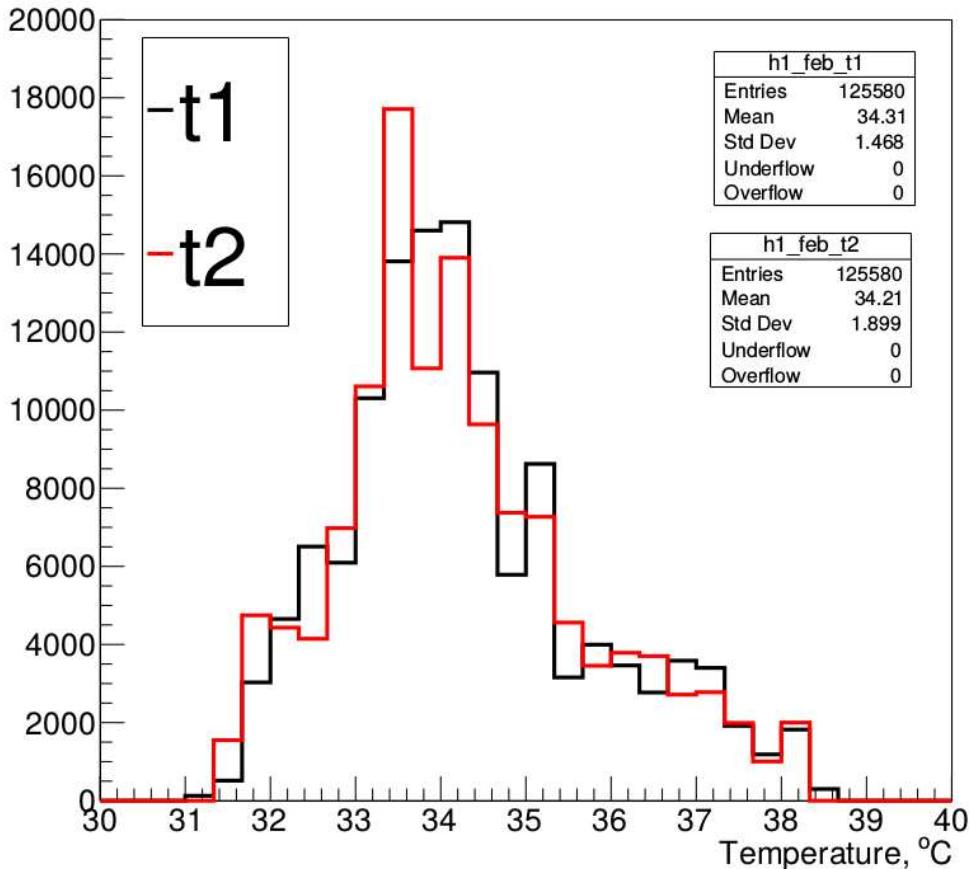


merger_t_fpga 2018.11.18 3:35:16

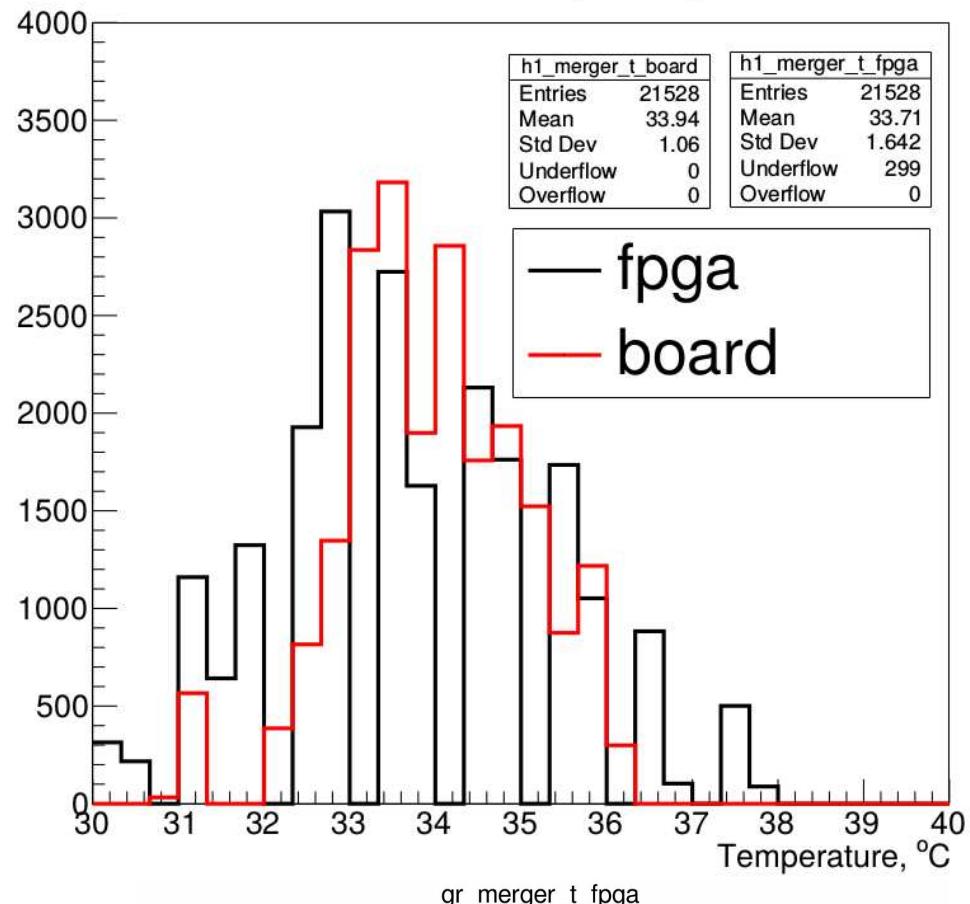


Average MERGERs and FEBs temperatures

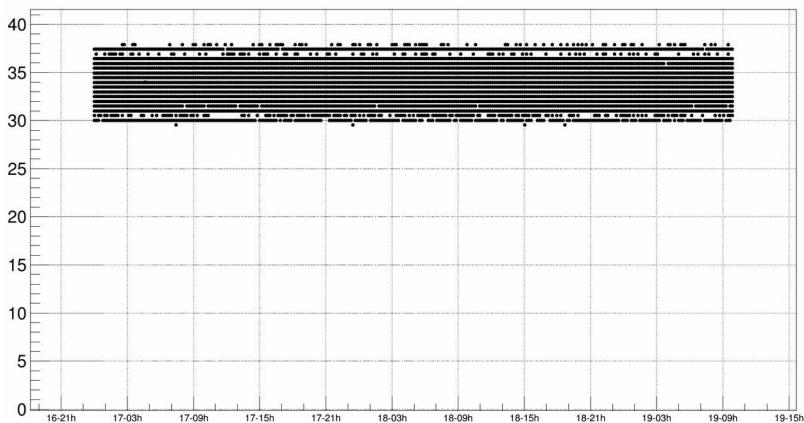
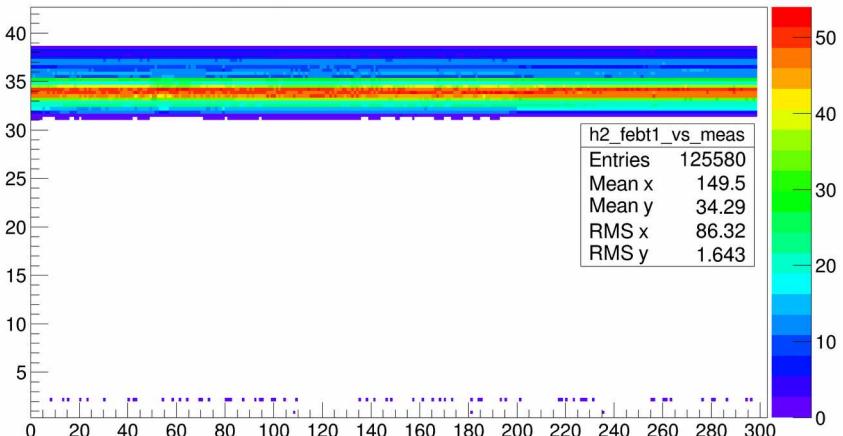
Total water flux : 4.2 L/min, water @ 20 °C



Total water flux : 4.2 L/min, water @ 20 °C



febt1 vs meas



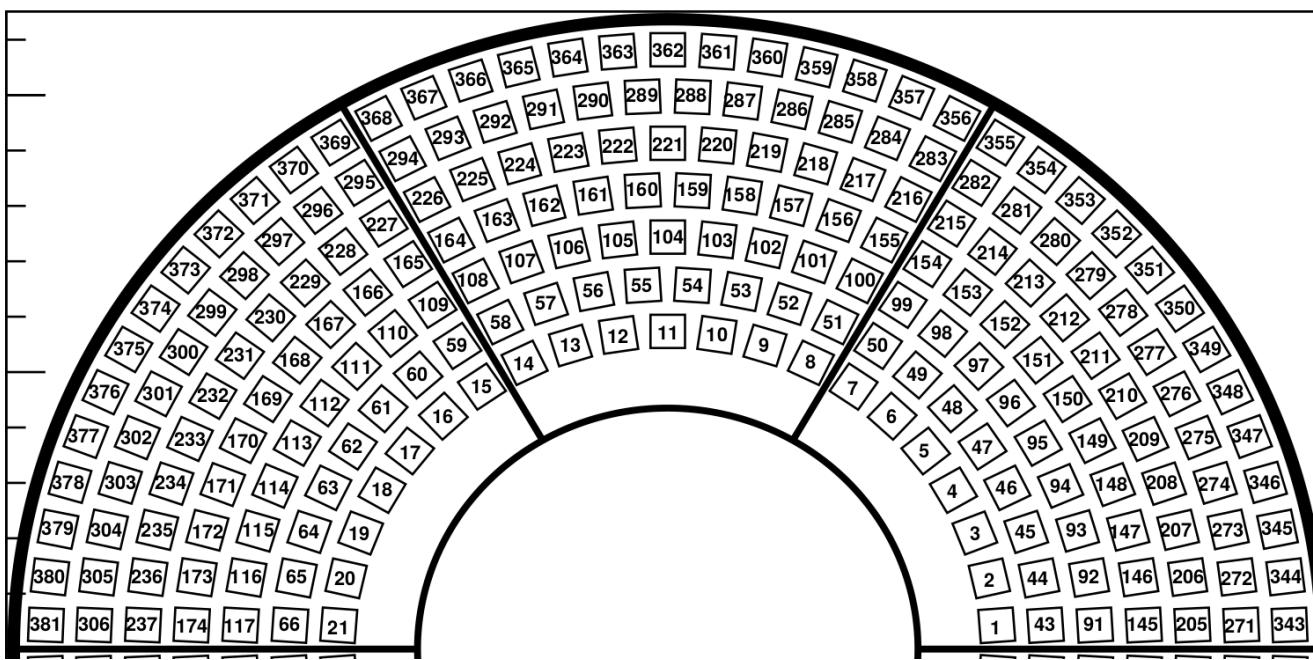
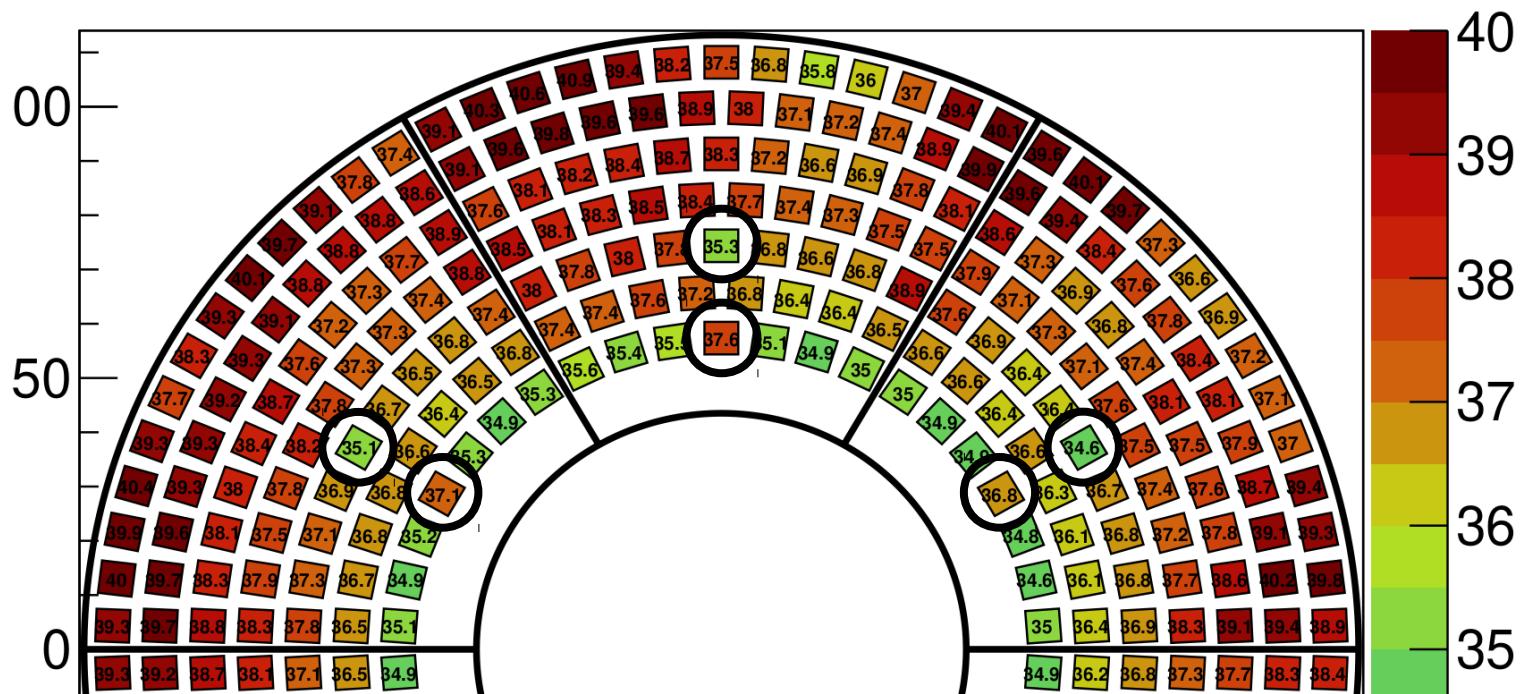
Conclusion

- Test with main chiller (flow = 4.2 L/min, @ 20 °C) has been done.
- Average extracted power per sector measured to be 100 W (@ 120 generated).
- The structure temperature does not exceed 35 °C.
- Average FEBs temperature measured to be 34 °C and does not exceed 39 °C
- Average MERGERs temperature measured to be 34 °C and does not exceed 39 °C

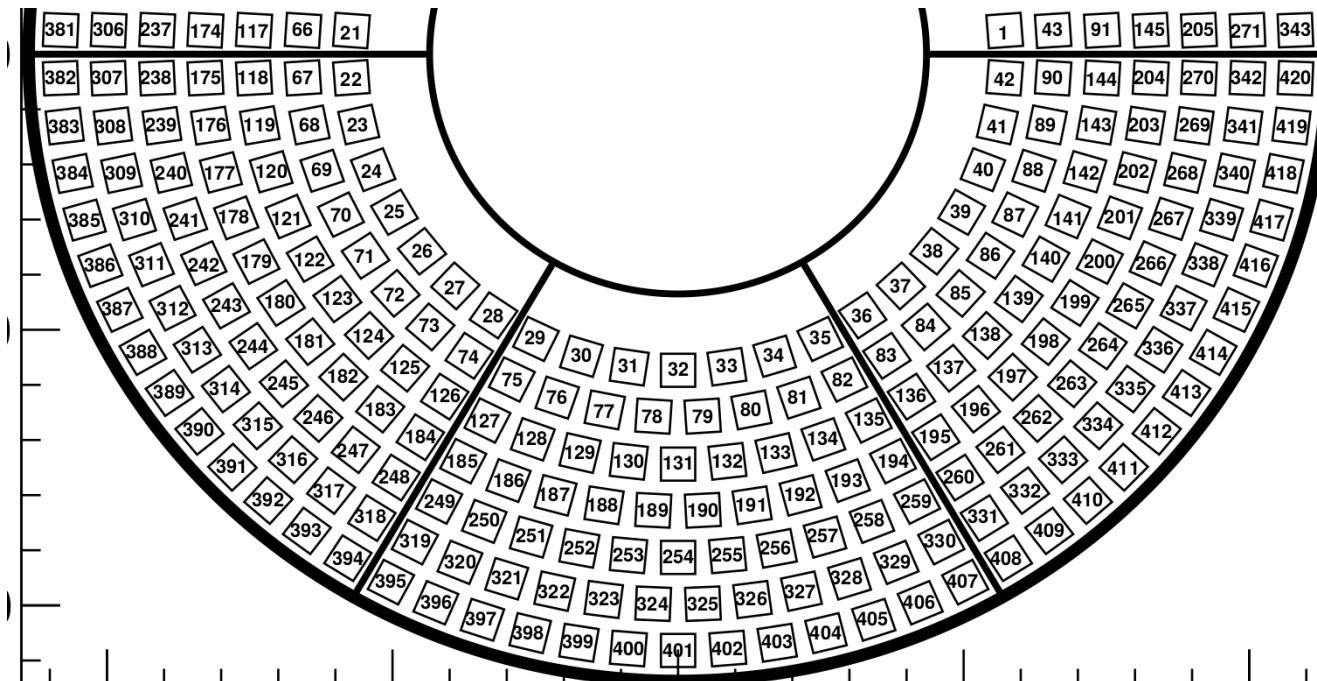
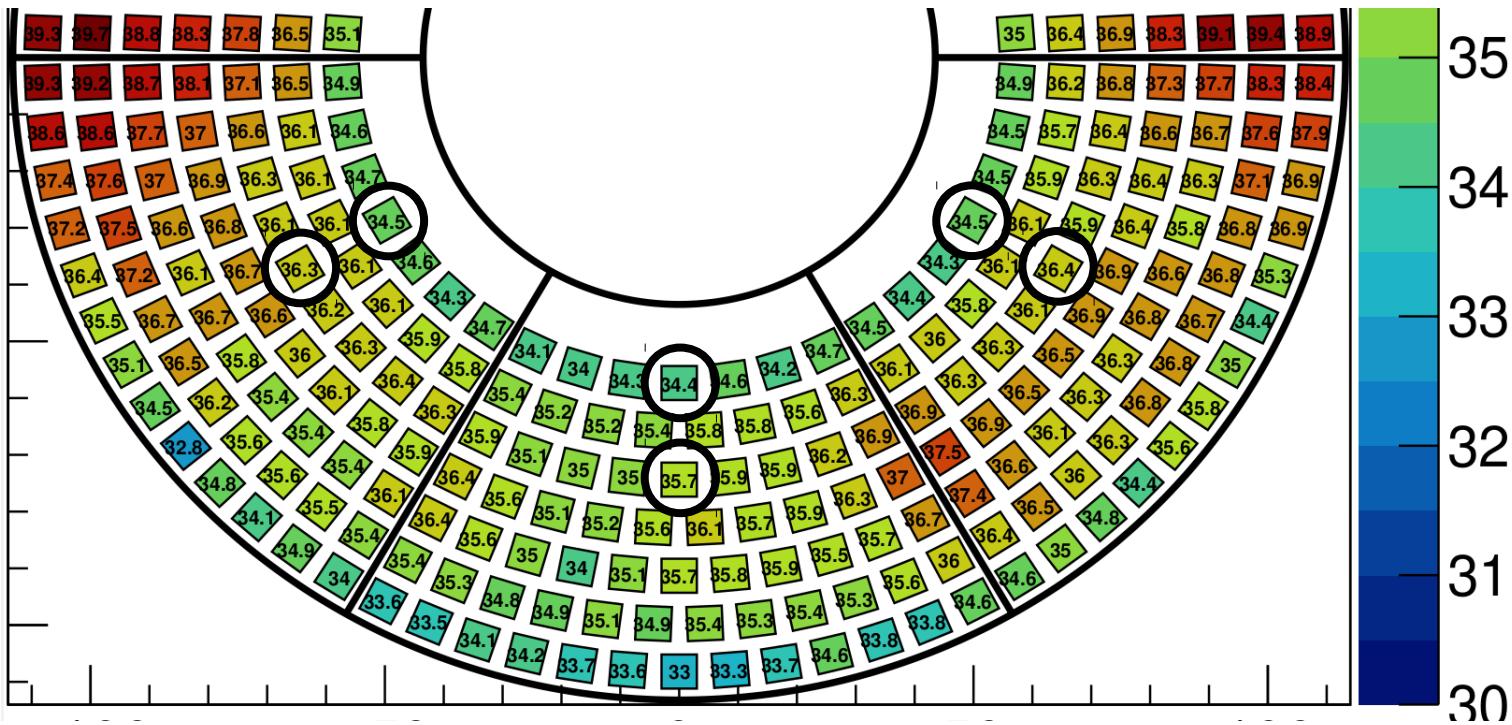
BIS

Strange behavior of FEB's temperatures (4 → 95) (11 → 104) (18 → 113)

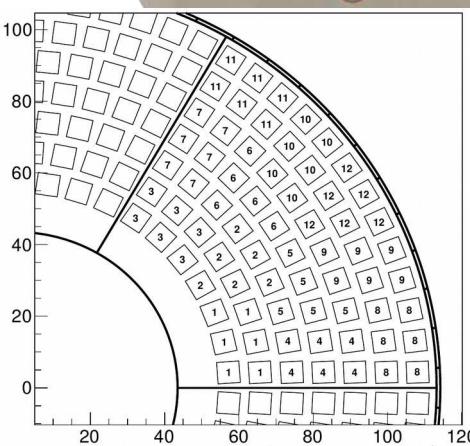
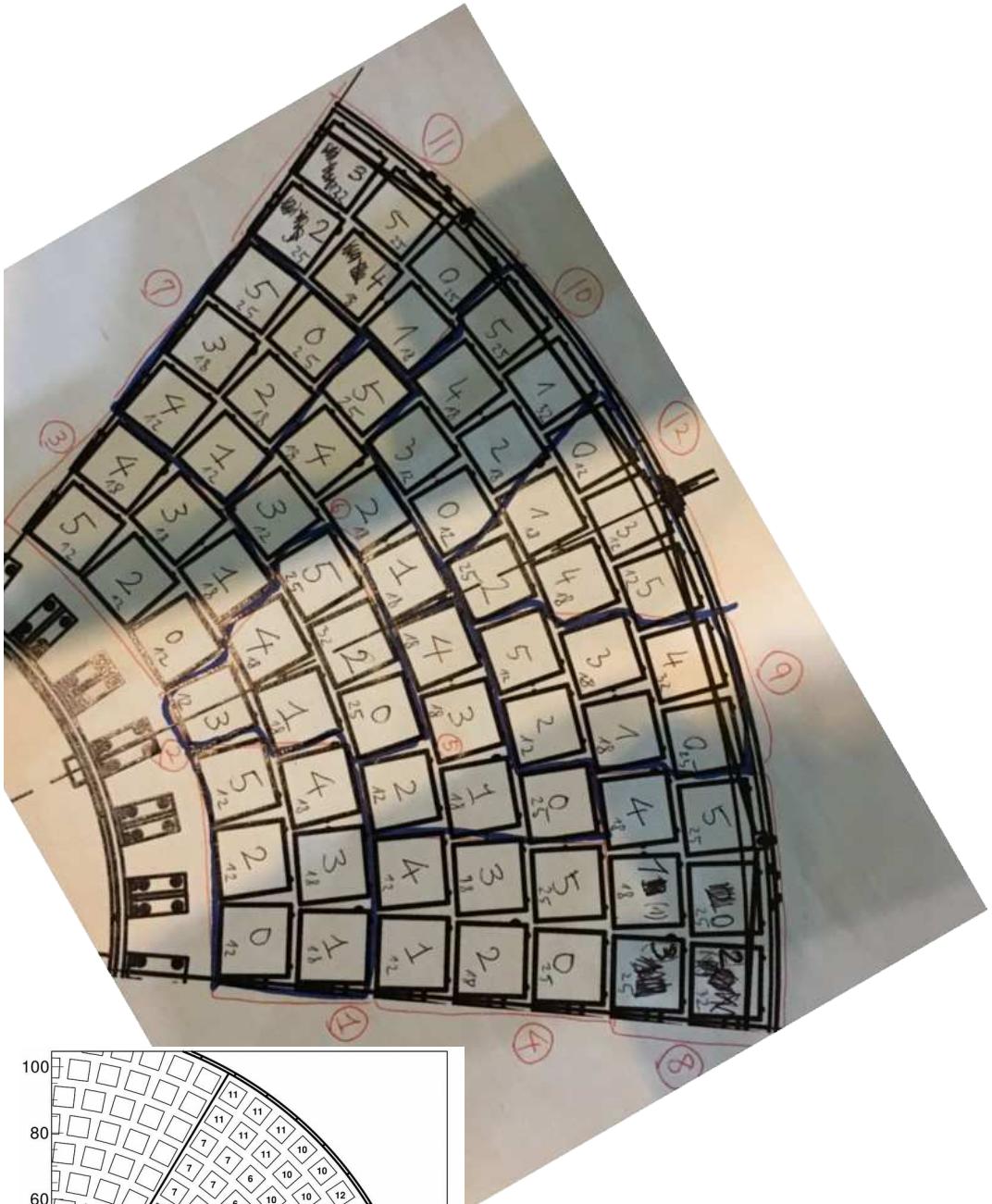
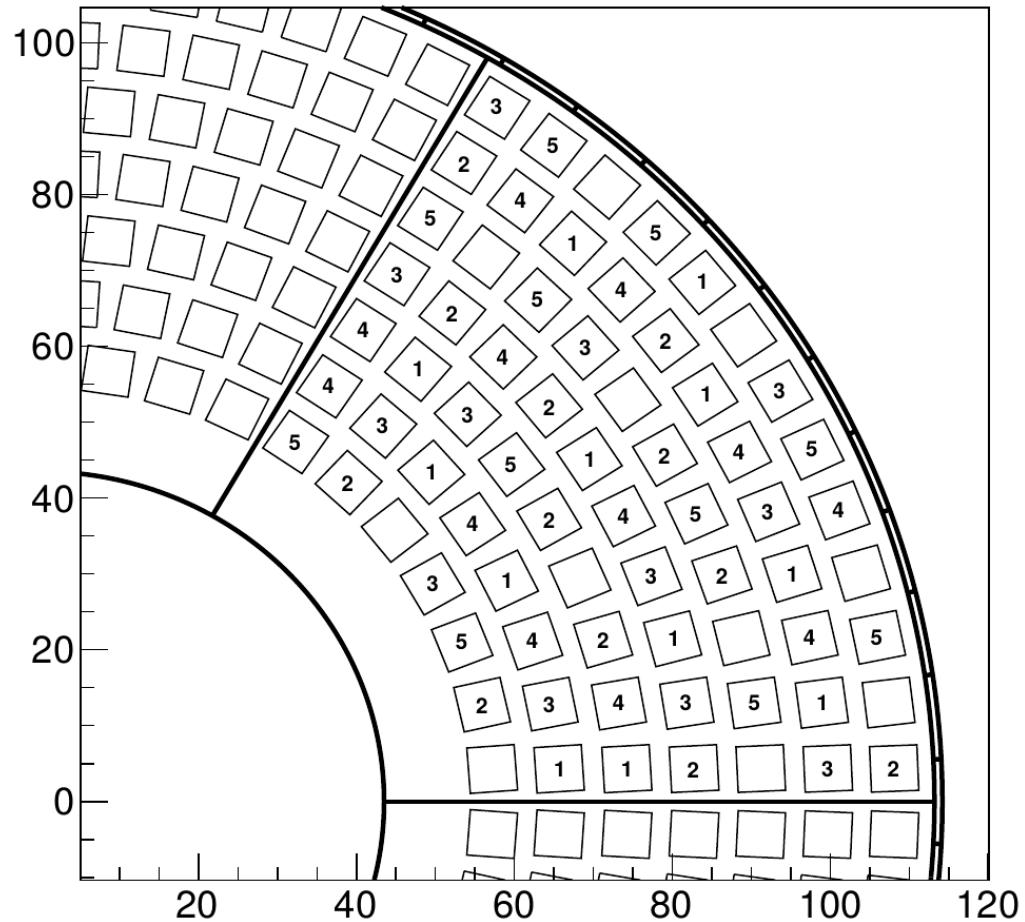
feb_t1 2018.11.16 15:25:35



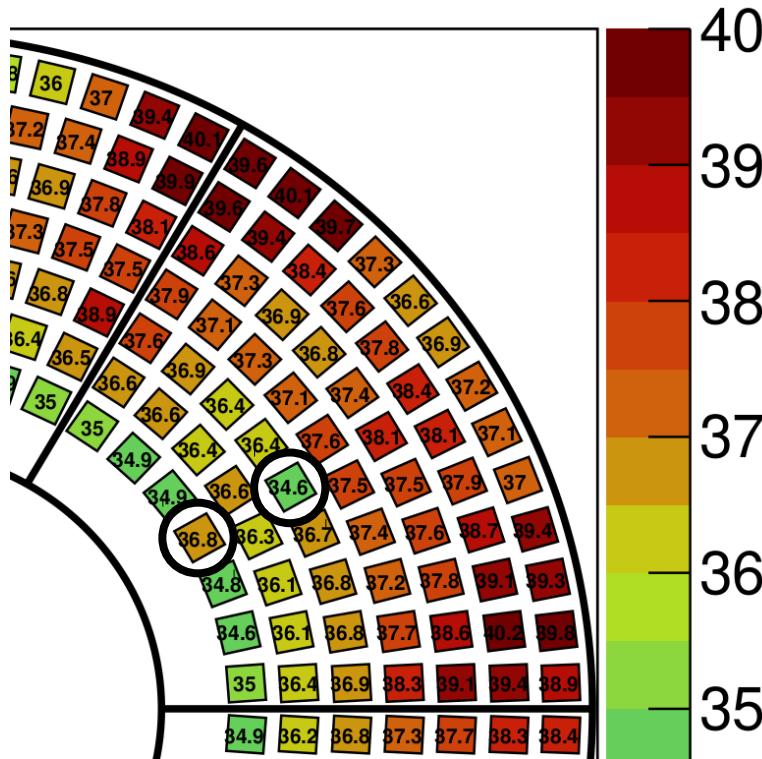
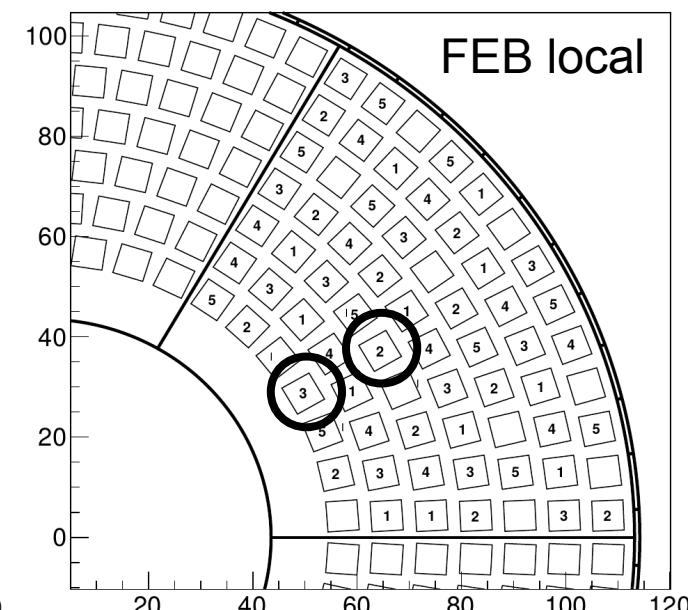
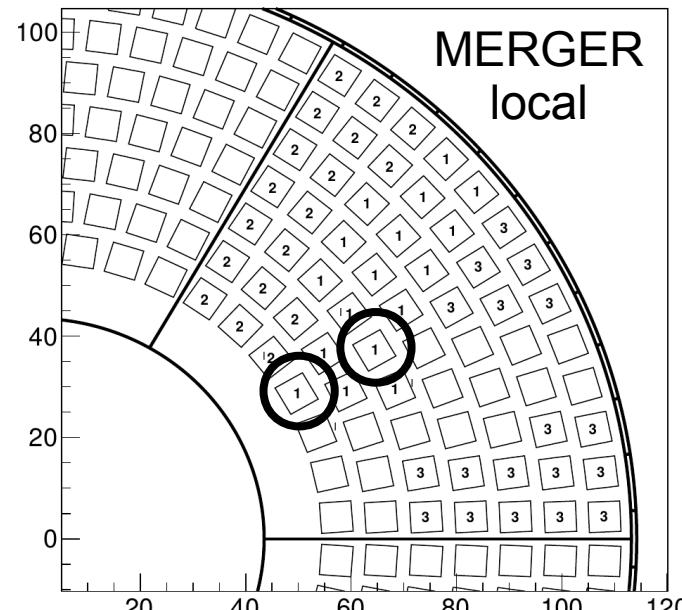
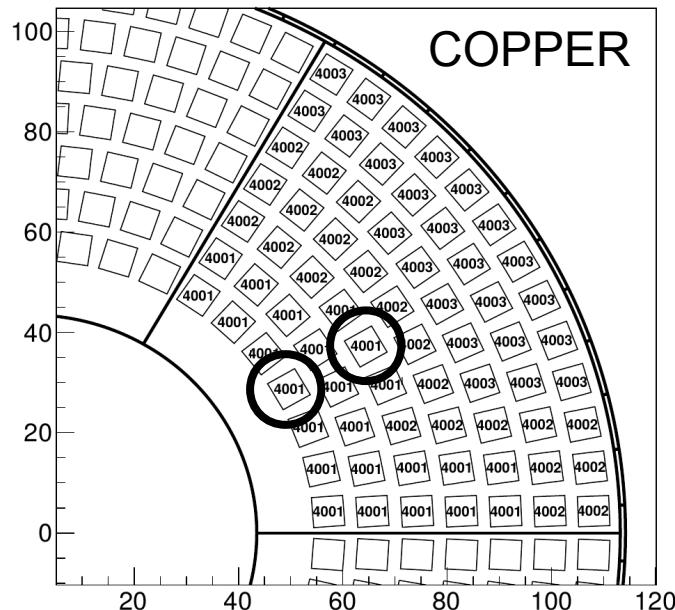
This strange behavior of FEB's temperatures is not observed for bottom part of ARICH



FEB's local maps

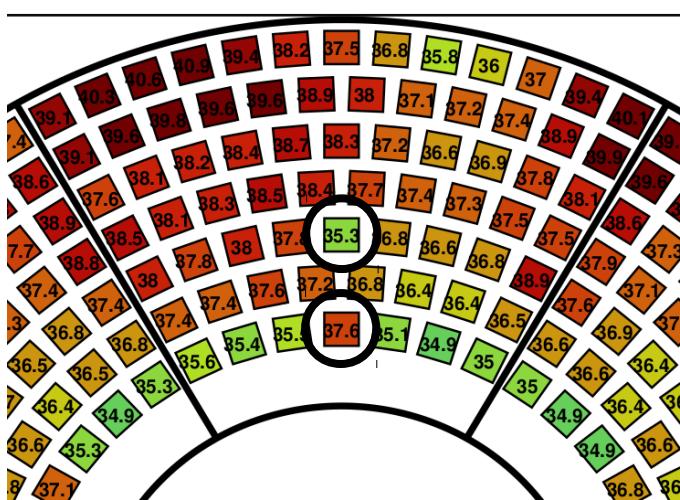
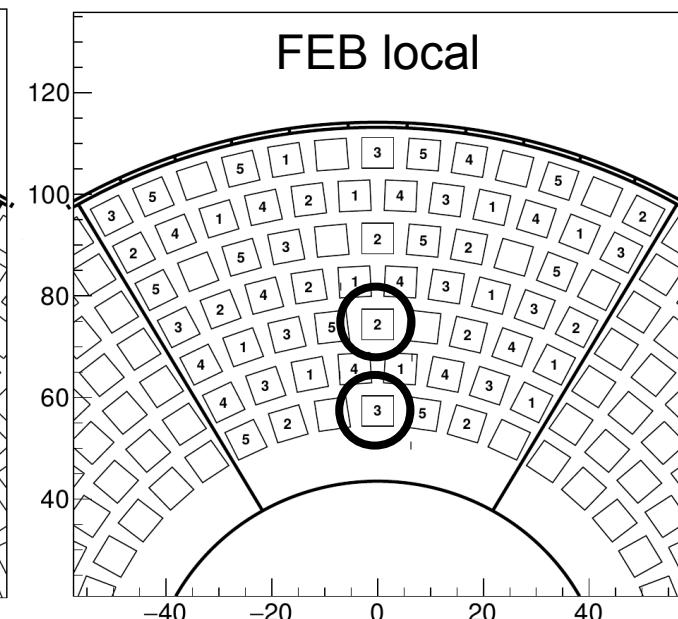
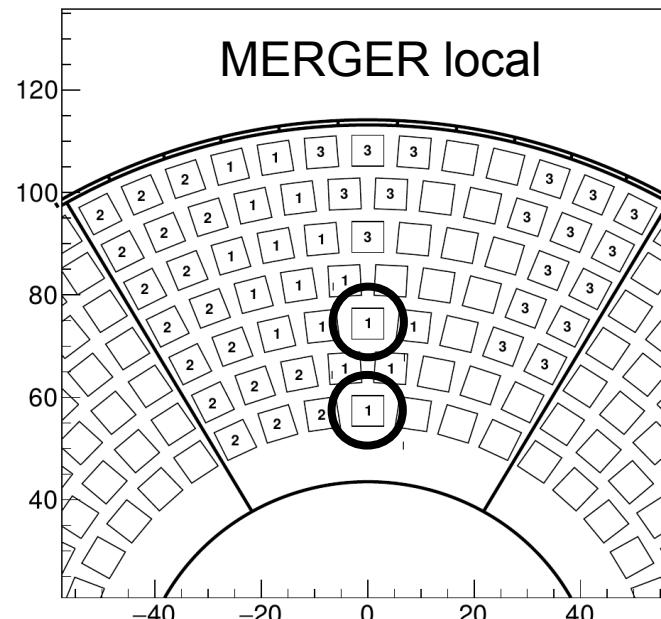
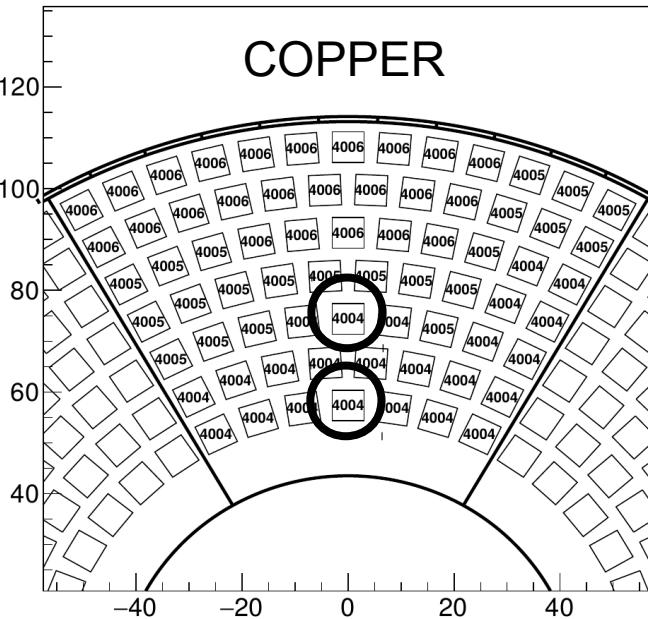


Raw data for sector 1



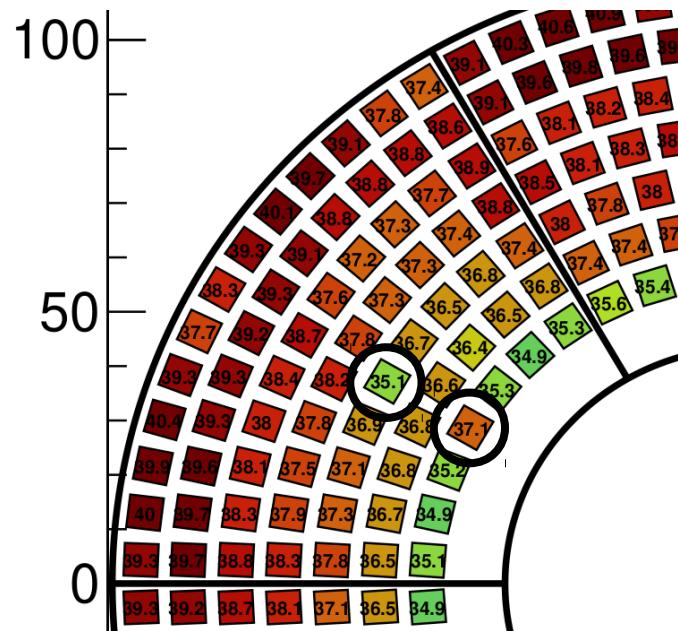
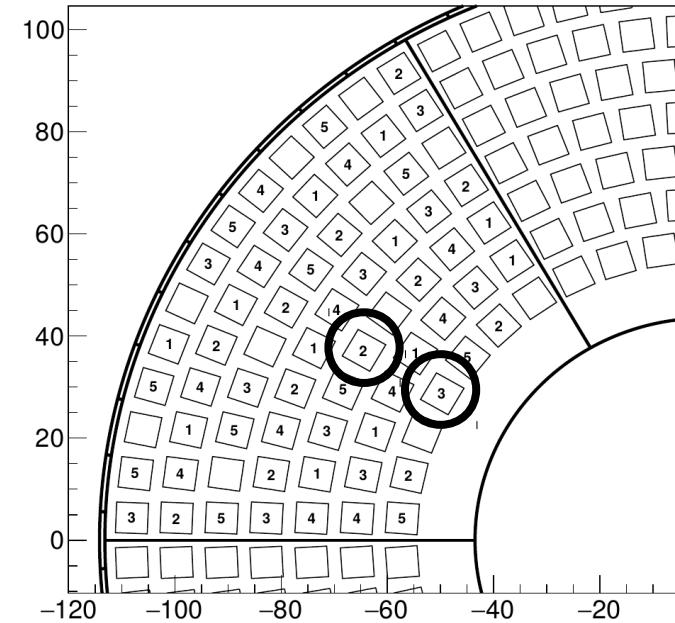
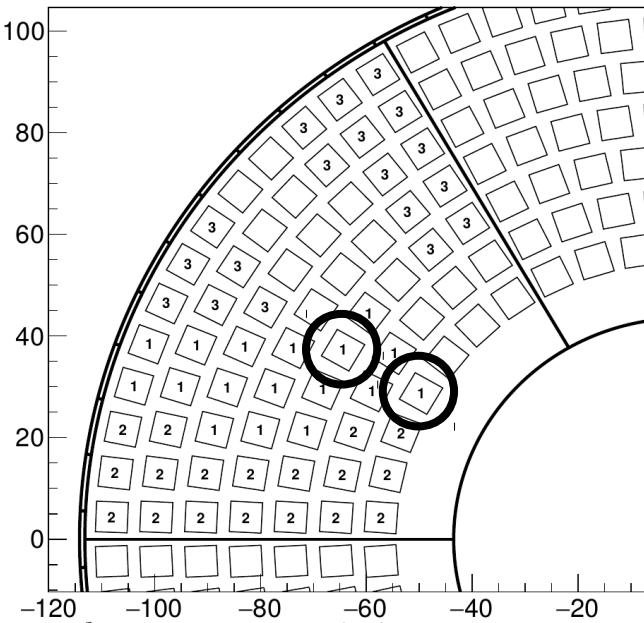
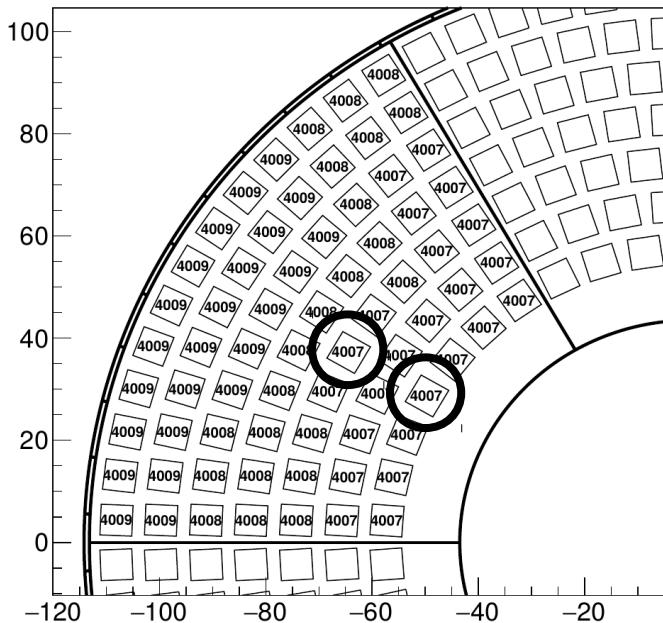
arich[1].feb[0].t1 : 36.687500
 arich[1].feb[0].t2 : 36.500000
 arich[1].feb[1].t1 : 36.312500
 arich[1].feb[1].t2 : 36.187500
arich[1].feb[2].t1 : 34.562500
 arich[1].feb[2].t2 : 34.500000
arich[1].feb[3].t1 : 36.812500
 arich[1].feb[3].t2 : 36.625000
 arich[1].feb[4].t1 : 36.625000
 arich[1].feb[4].t2 : 36.562500
 arich[1].feb[5].t1 : 36.375000
 arich[1].feb[5].t2 : 36.437500

Raw data for sector 2



arich[1].feb[0].t1 : 36.812500
arich[1].feb[0].t2 : 36.687500
arich[1].feb[1].t1 : 36.812500
arich[1].feb[1].t2 : 36.375000
arich[1].feb[2].t1 : 35.250000
arich[1].feb[2].t2 : 35.187500
arich[1].feb[3].t1 : 37.625000
arich[1].feb[3].t2 : 37.562500
arich[1].feb[4].t1 : 37.187500
arich[1].feb[4].t2 : 37.062500
arich[1].feb[5].t1 : 37.750000
arich[1].feb[5].t2 : 37.625000

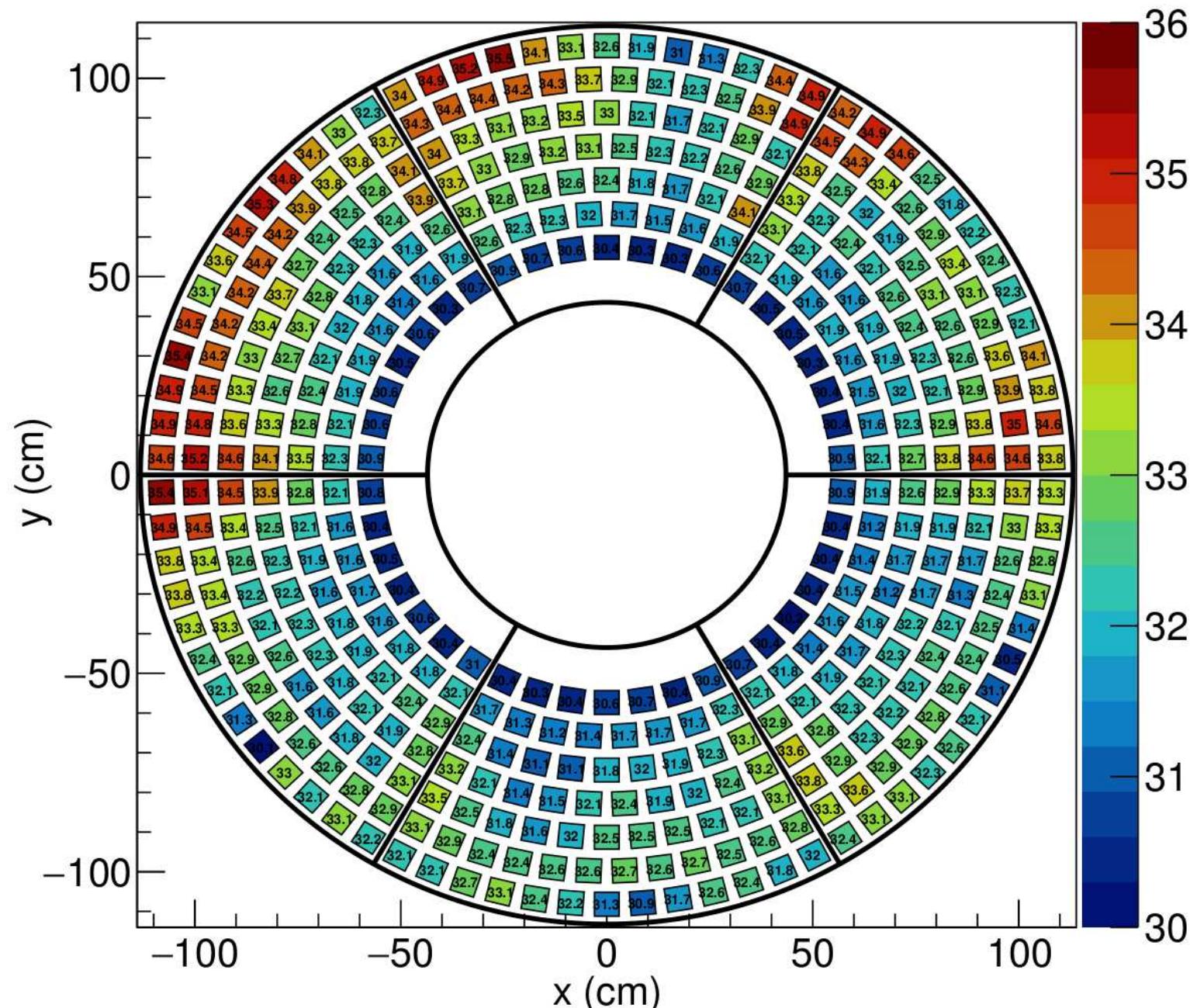
Raw data for sector 3



arich[1].feb[0].t1 : 36.687500
arich[1].feb[0].t2 : 36.562500
arich[1].feb[1].t1 : 36.562500
arich[1].feb[1].t2 : 36.500000
arich[1].feb[2].t1 : 35.125000
arich[1].feb[2].t2 : 34.812500
arich[1].feb[3].t1 : 37.062500
arich[1].feb[3].t2 : 36.750000
arich[1].feb[4].t1 : 36.812500
arich[1].feb[4].t2 : 36.750000
arich[1].feb[5].t1 : 36.937500
arich[1].feb[5].t2 : 36.875000

Swapping the FEB ↔ MERGER data cables for sector : 1, 2, 3.

feb_t1 2018.11.21 0:44:12



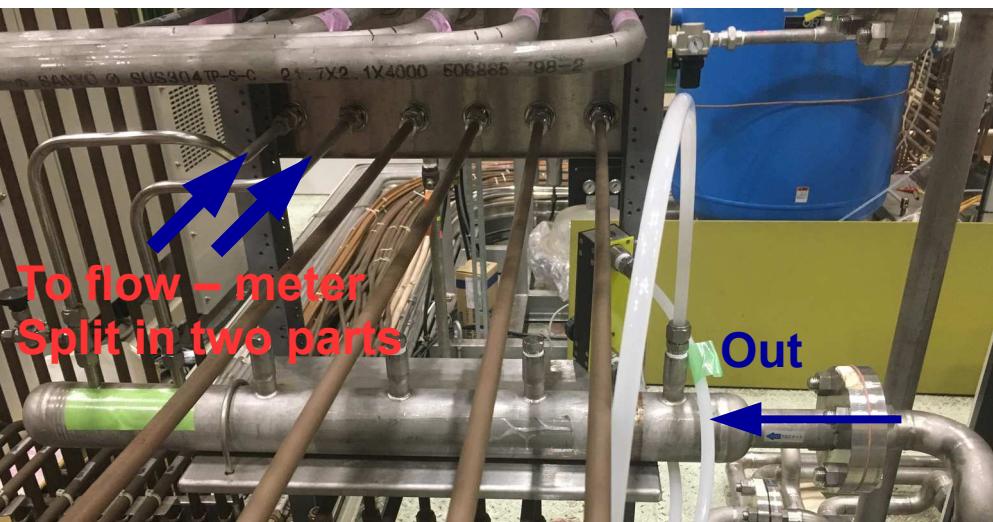
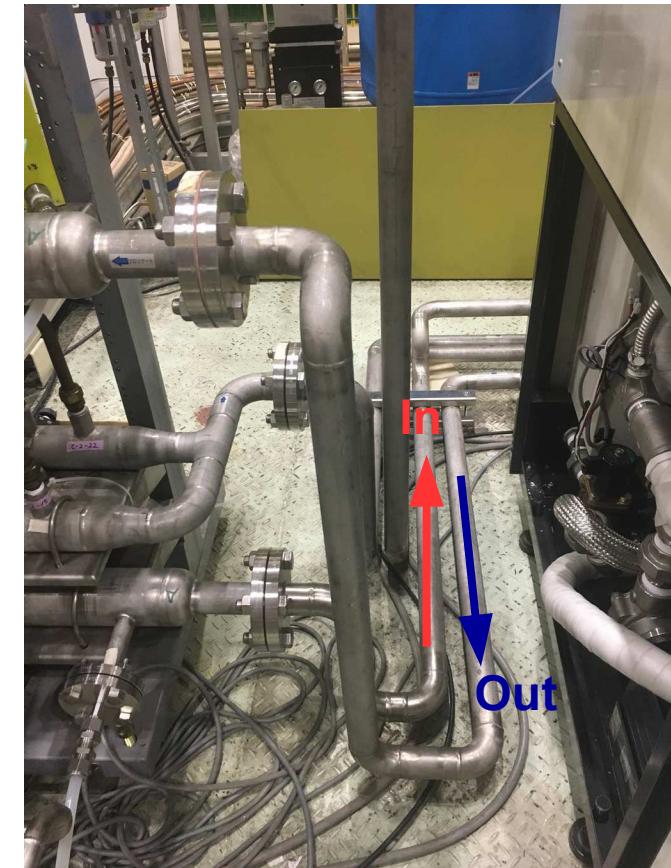
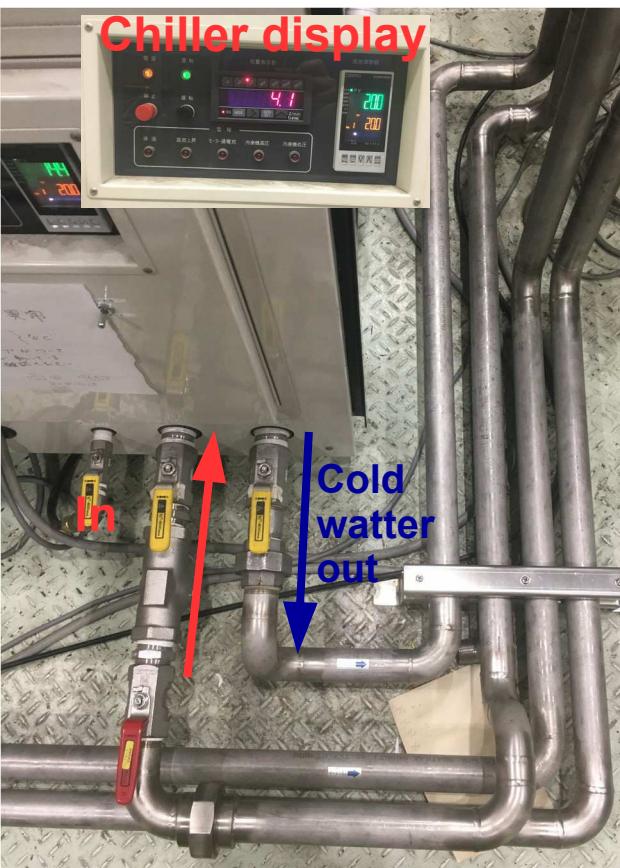
BIS+

Photos of input/output pipes of the ARICH main chiller

Flow - meters



Chiller display

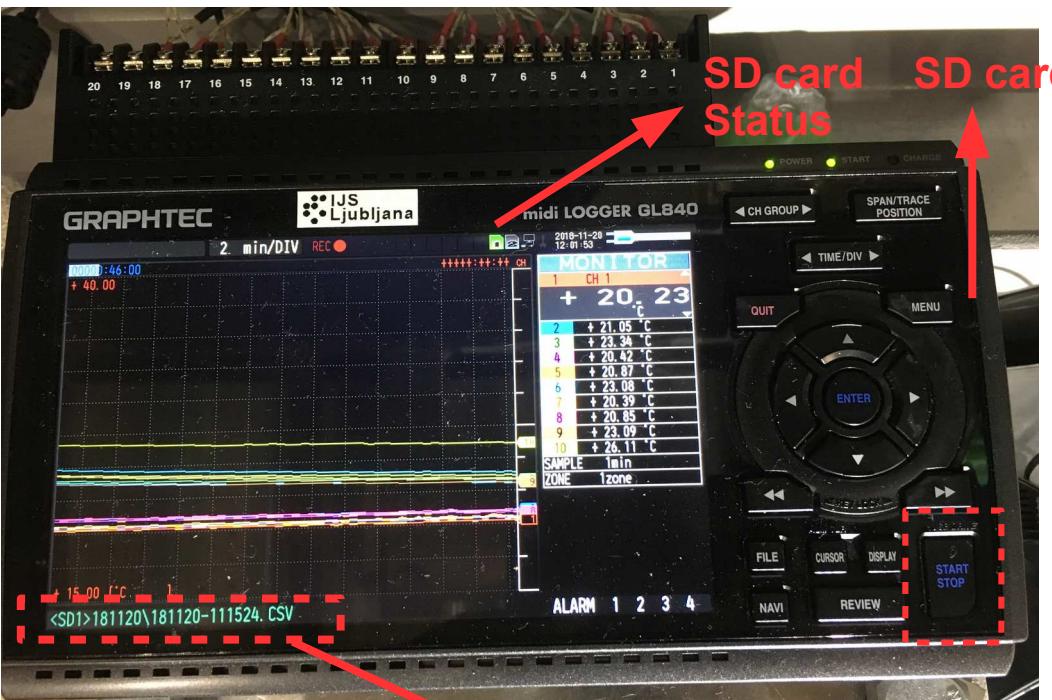
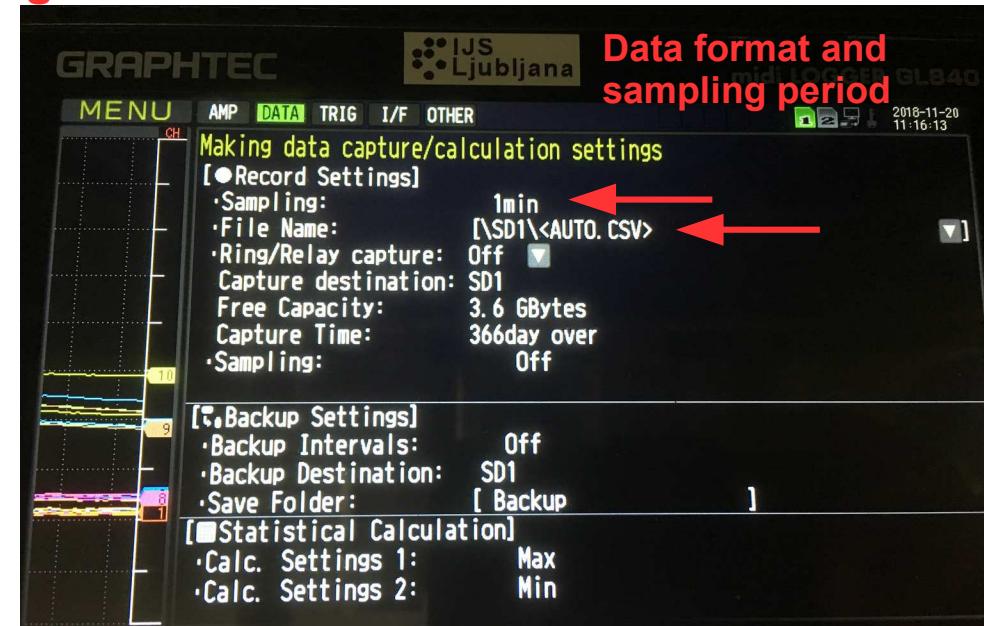
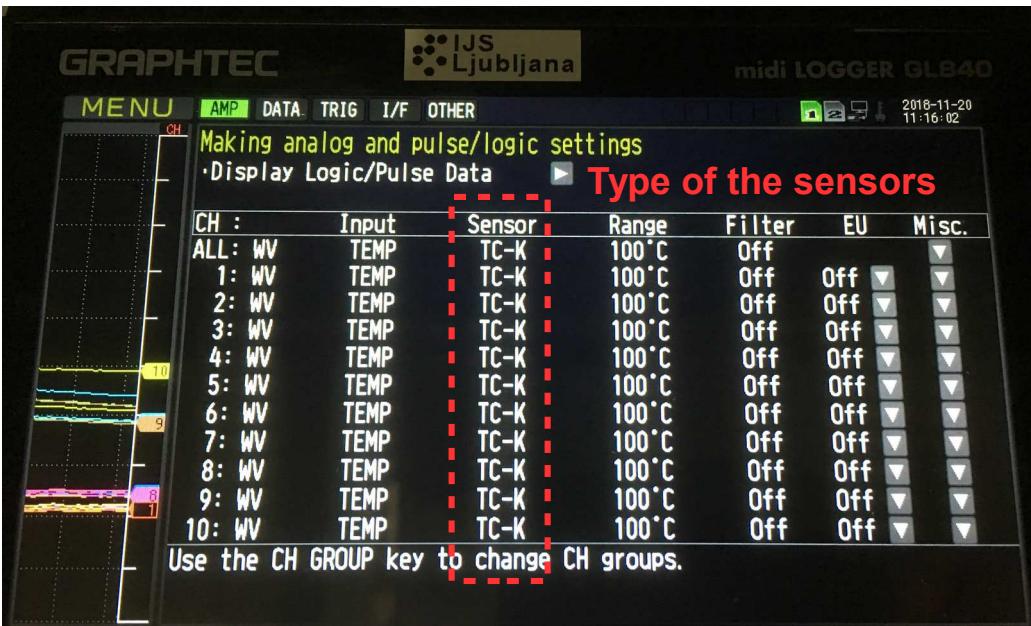


Out / In towards ARICH



BIS++

Fast manual for the data taking with midi LOGGER GL840.



- Define the sensor type (**TC-K**) for our temperature sensors
 - Define sampling period (use **1 min**)
 - Choose **CSV format**. The conversion program use only this format.
 - Press **START/STOP** button to start or stop recording the data.
 - The data is stored in SD – card
 - Check that the data is saved into the file.
- The data is saved into the file.

BIS++

Automatic temperatures monitors (crontab)

<https://burmist@stash.desy.de/scm/~burmist/temperaturefebmergerslowcontrol.git>

hvala@ariterm1

```
#  
# Fri Nov 23 12:38:31 JST 2018  
# Autor: Leonid Burmistrov  
#  
# Crontab file to monitor ARICH FEBs and MERGERs temperature  
#  
# Useful crontab commands :  
# To see the setup file for crontab  
# > crontab -l  
#  
# To define setup file for crontab  
# > crontab crontab.file  
#  
# To stop crontab  
# crontab -r  
#
```

- Each 10 minutes we read the FEB and Merger temperatures.
- Two times a day (11:55, 23:55) the data converted to histograms and send by email
- Two times a day (15:58, 23:58) the time synchronization is verified and send by email

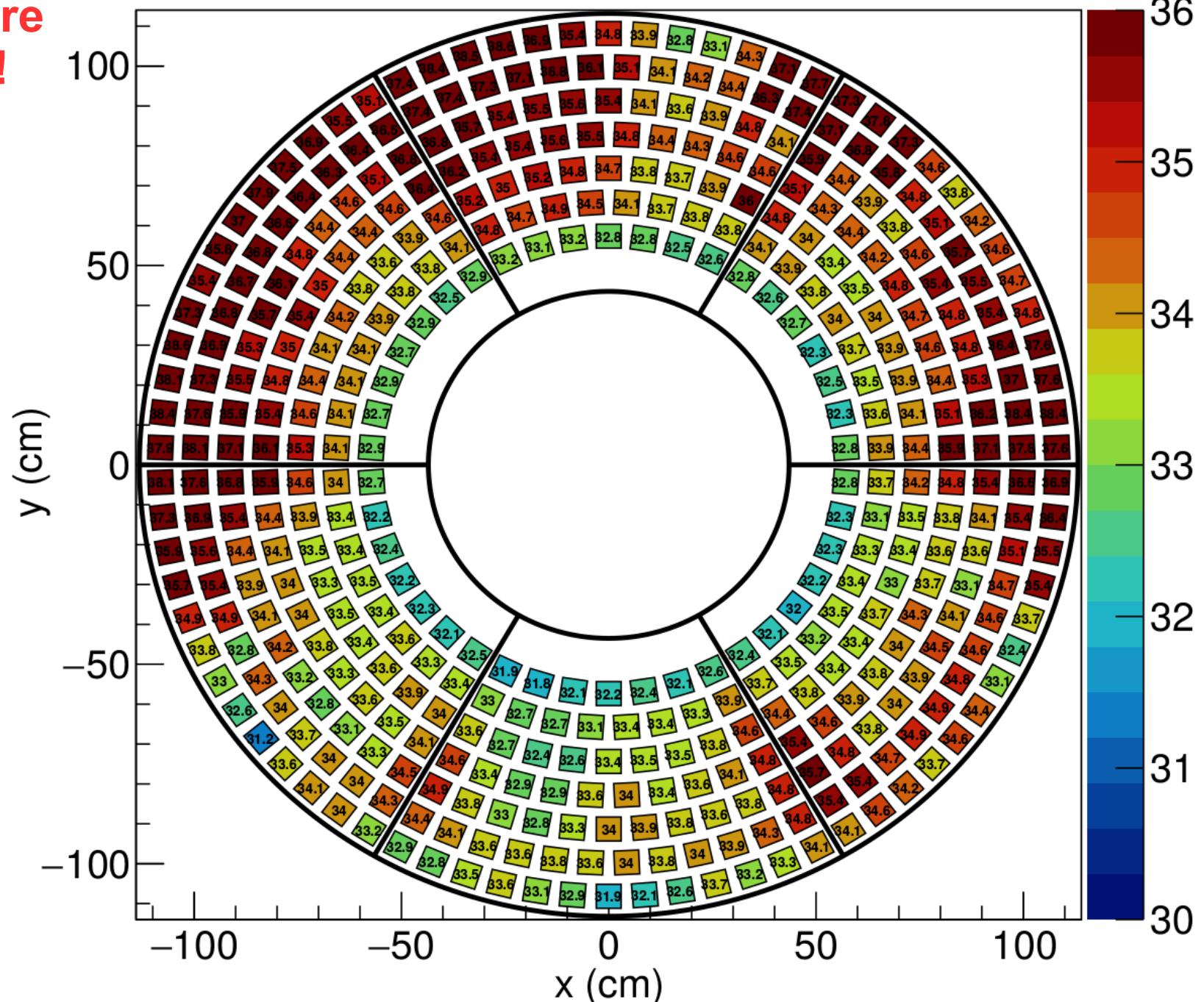
```
#Temperature measurements each 10 minutes (1 min 11 min .... )  
1,11,21,31,41,51 * * * * /home/hvala/nishida6/temp_auto_crontab.sh -d
```

```
#Conversion of the temperatures to pdf and root two times a day at (11:55 and 23:55)  
55 11,23 * * * /home/hvala/nishida6/data/moveFilesToDailyFolders.bash -d ;  
/home/hvala/temperaturefebmergerslowcontrol/convertFebTemp_main_crontab.screen.bash -d ;
```

```
/home/hvala/temperaturefebmergerslowcontrol/convertFebTemp_main_crontab.screen.bash -d ;  
58 15,23 * * * /home/hvala/ntpools/ntpLoopstatsOne.bash -email
```

Automatic
temperatures
monitors are
working!!!

feb_t1 2018.11.26 7:51:1



BIS+++

Time synchronization (ntp)

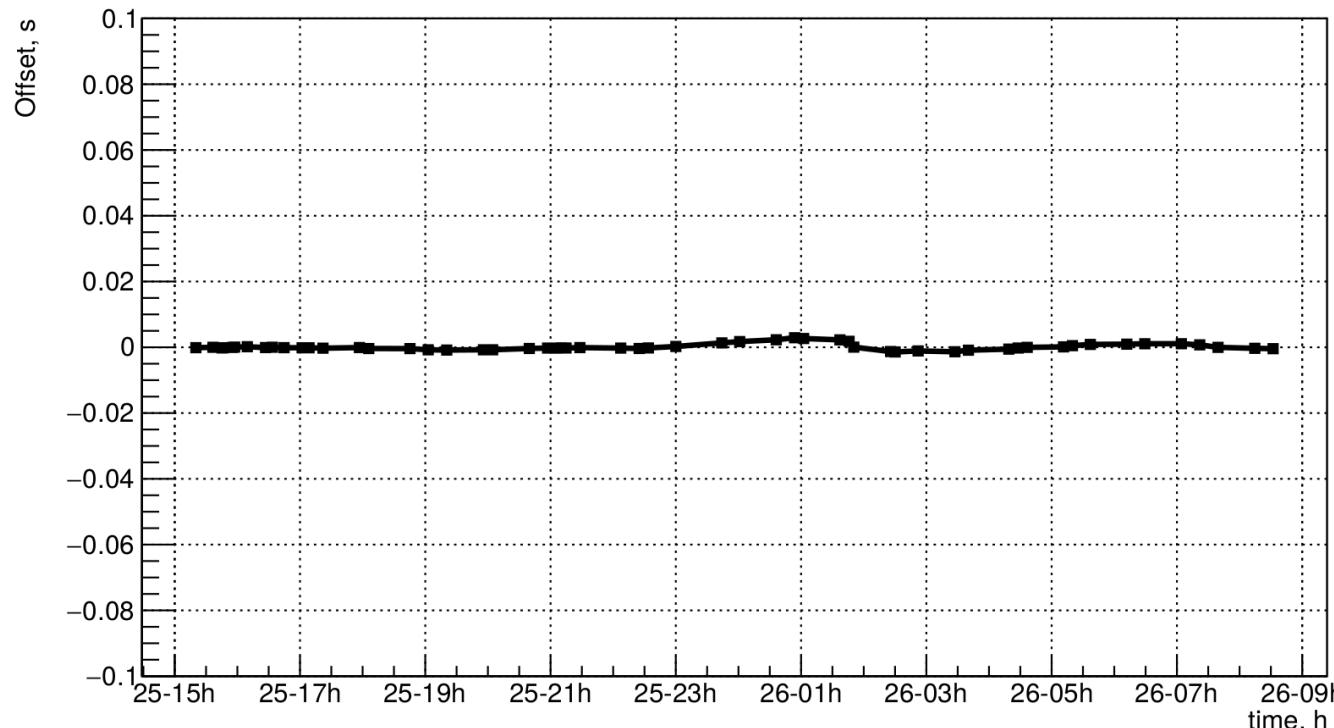
<https://burmist@stash.desy.de/scm/~burmist/ntptools.git>

```
[hvala@ariterm1 ntptools]$ date  
Sun Nov 25 15:08:22 JST 2018  
[hvala@ariterm1 ntptools]$ _
```



- ariterm1 time was desynchronized (~ 2 min)
- ntpd have been installed (/etc/ntp.conf → configuration file)
- time have been updated with ntpdate : sudo ntpdate 172.22.16.4
- NTP server seen from bdaq network : 172.22.16.4
- The time now synchronized better than 0.005 s

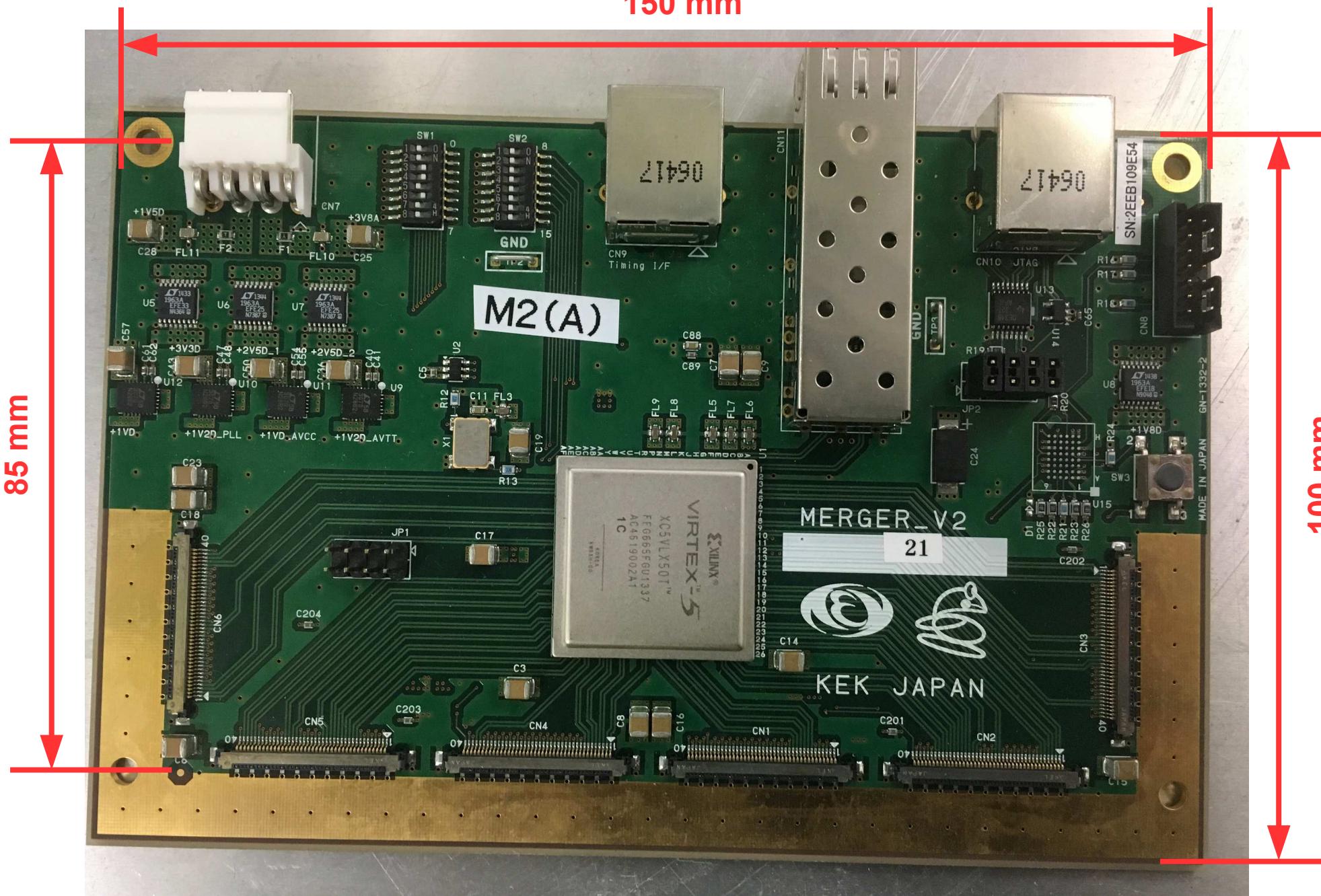
ariterm1 loopstats.20181125



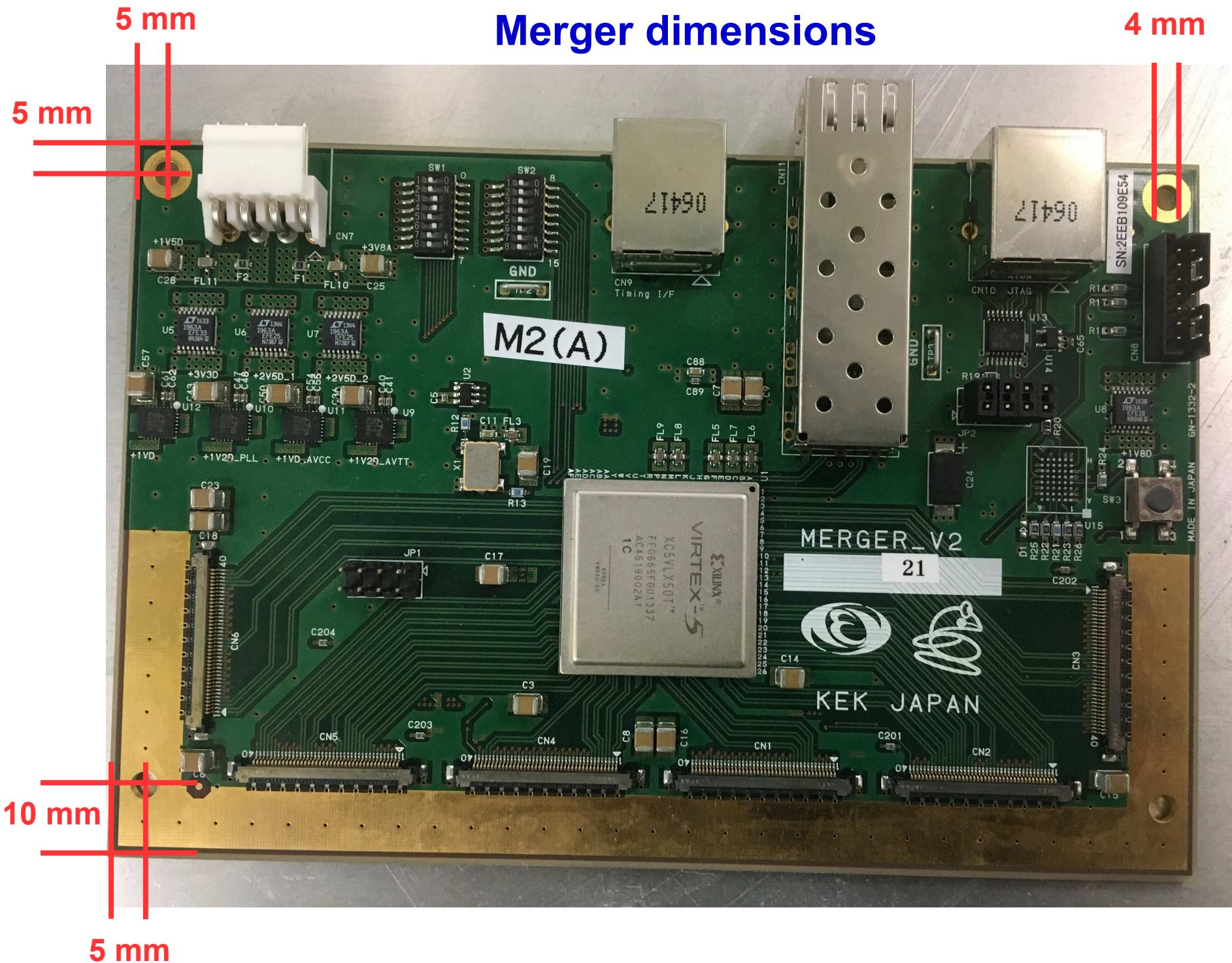
BIS+++++

Merger dimensions

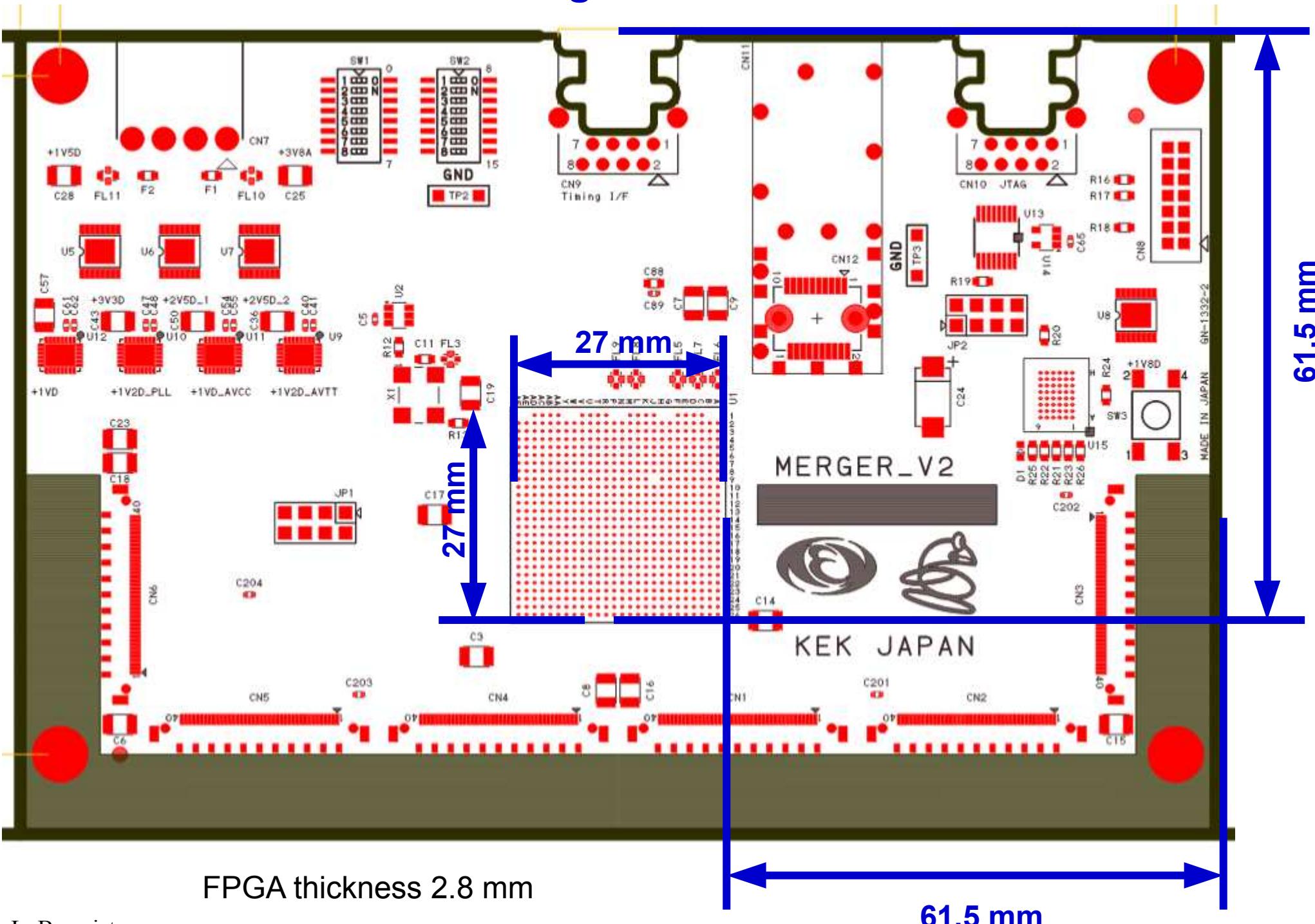
150 mm



Merger dimensions



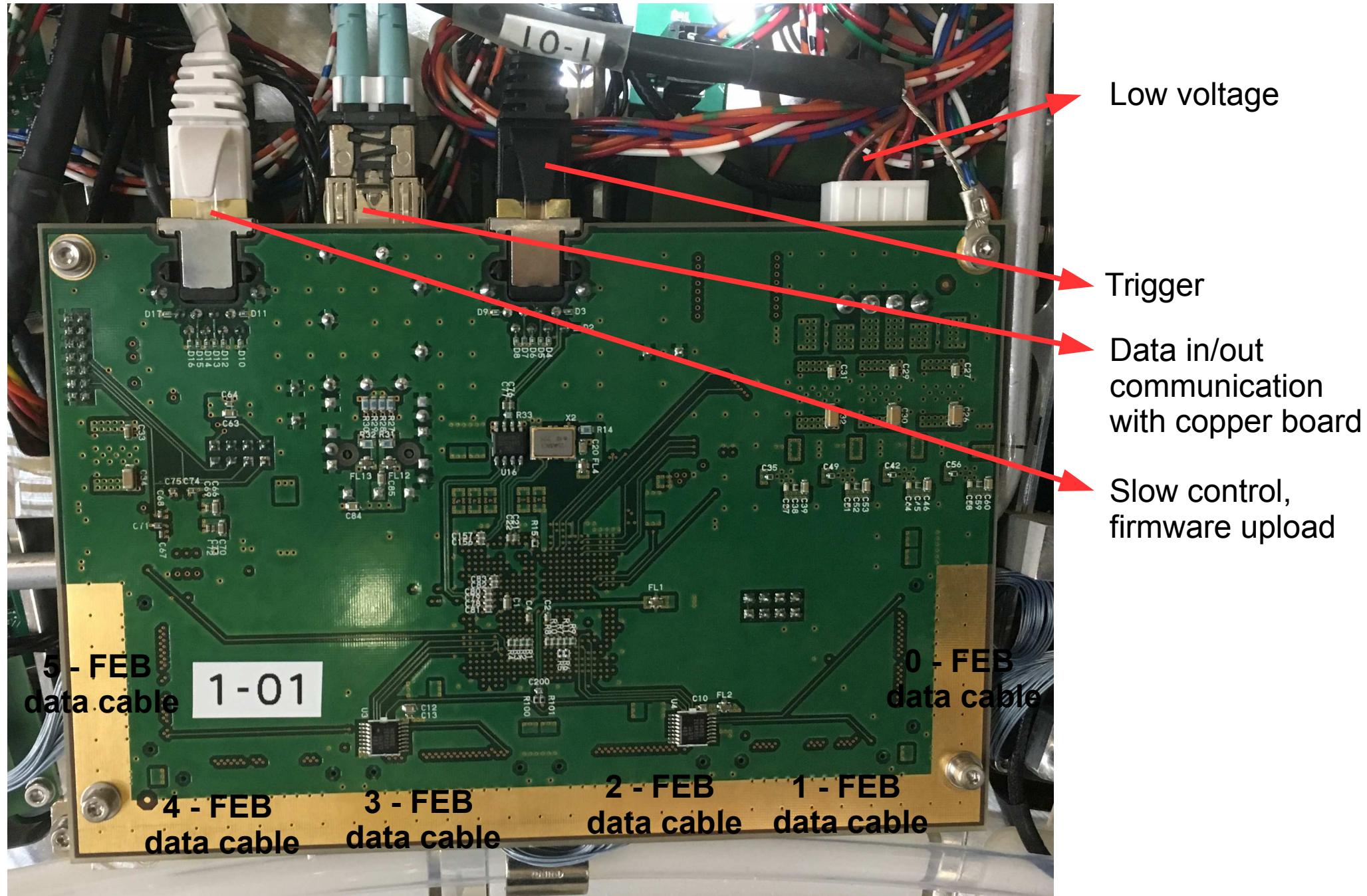
Merger dimensions



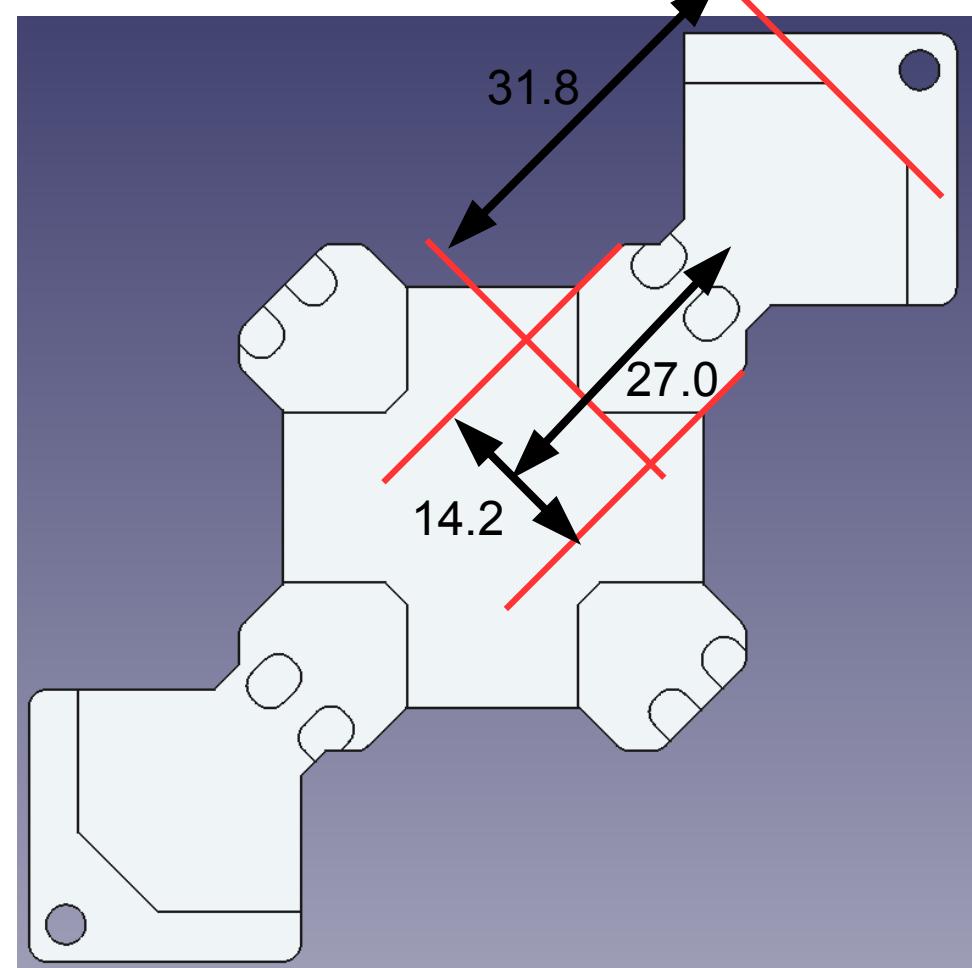
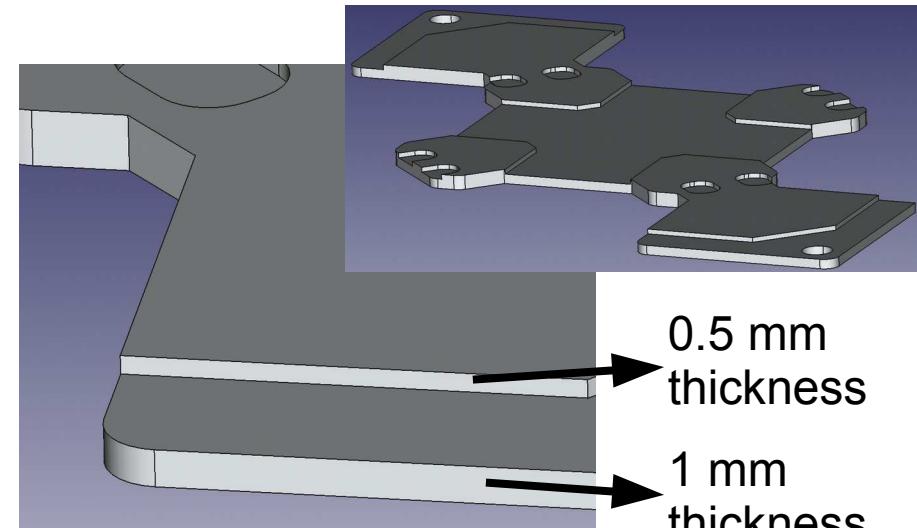
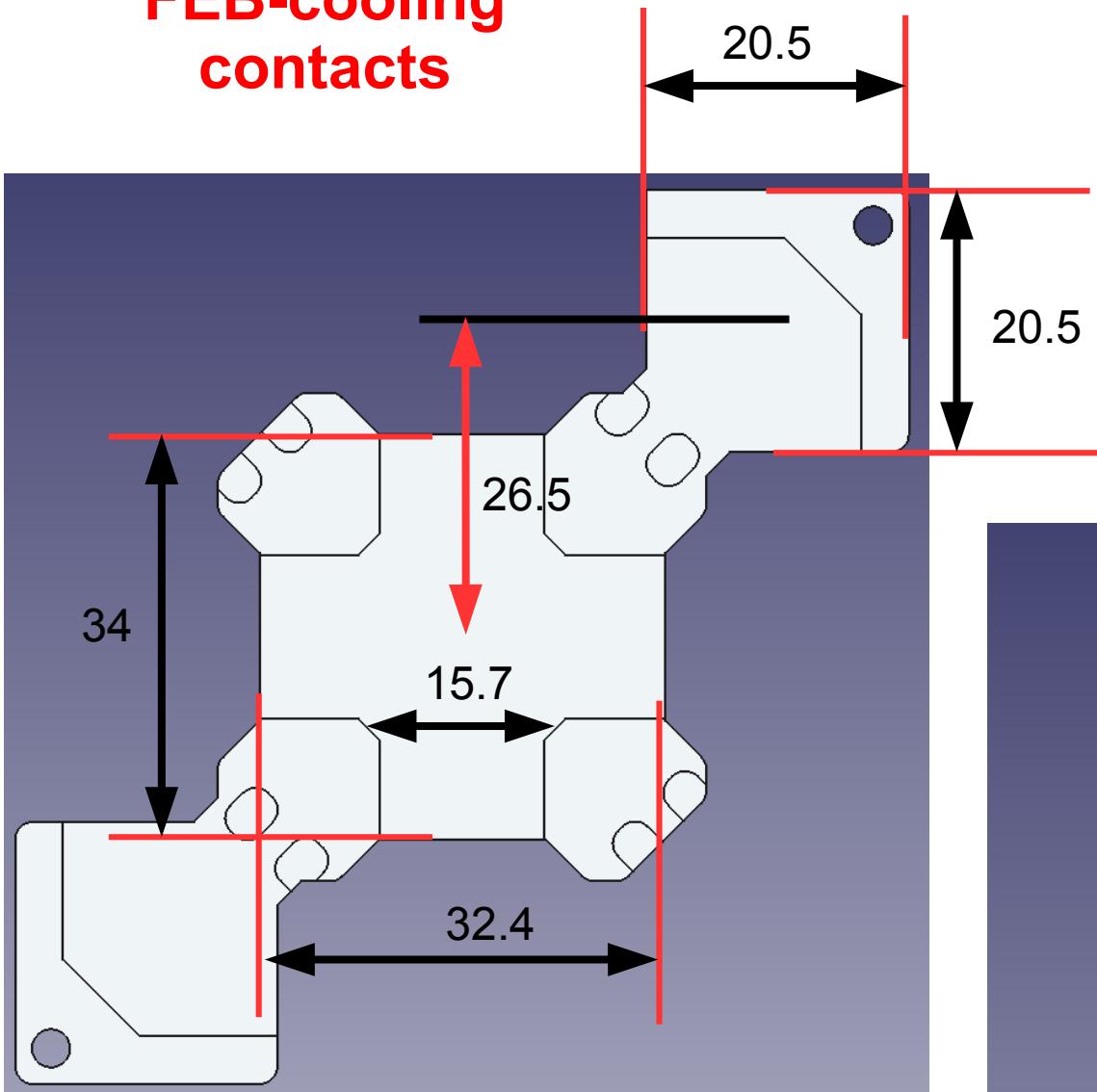
FPGA thickness 2.8 mm

61.5 mm

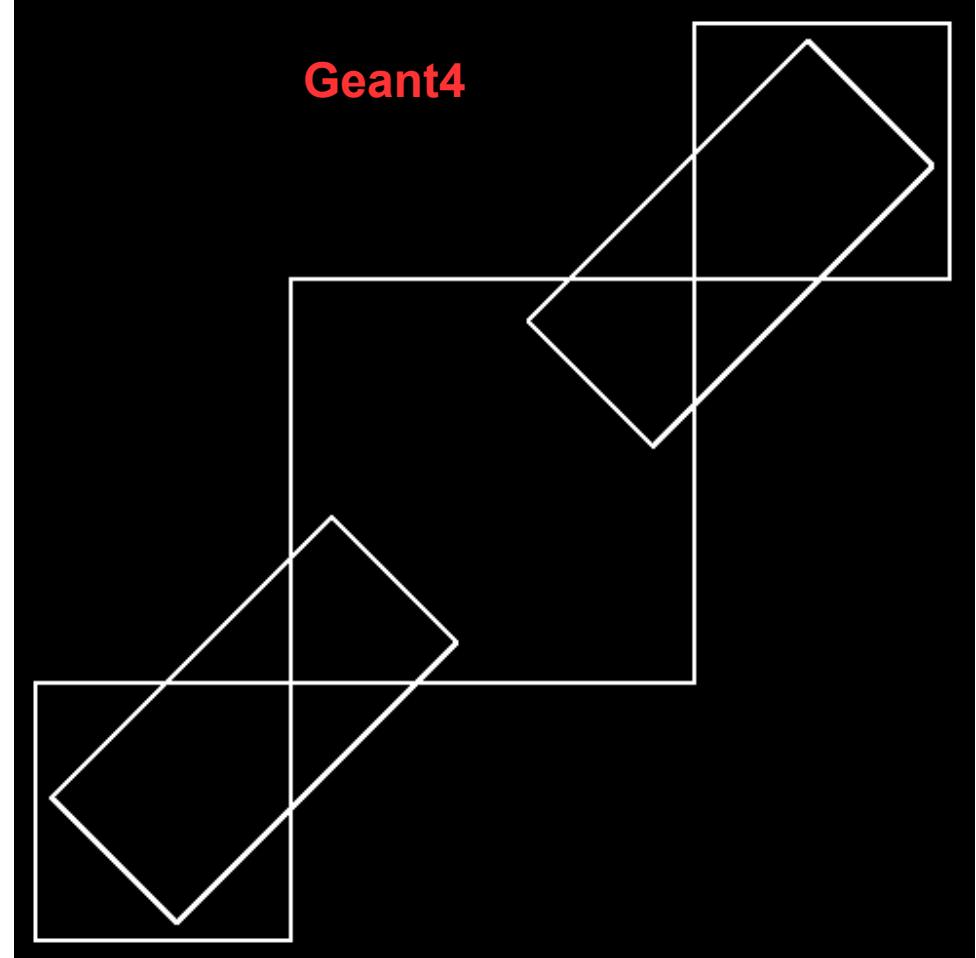
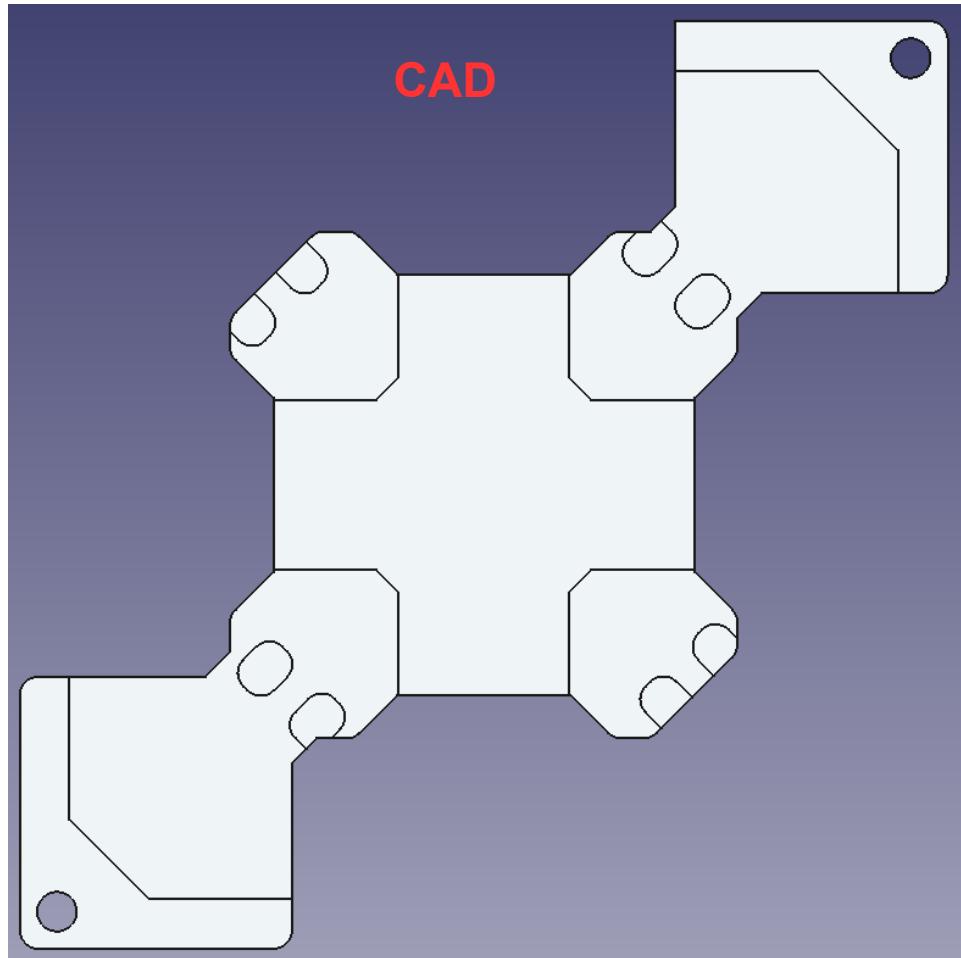
Merger inputs/outputs



FEB-cooling contacts



FEB-cooling contacts CAD vs simplified Geant4 model (geomID = 6)



- Relatively simple to implement with G4Box class.
- Merger cooling bodies are more complex to build with use of standard geometry classes.

Implementation of the more complex geometries from CAD

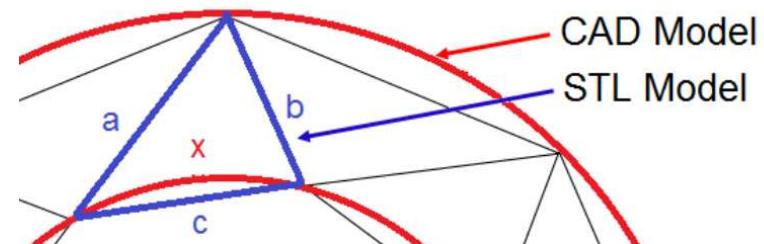
CAD (STEP file)



Free CAD
<http://www.assimp.org/>

Conversion from CAD to Mesh
format – STL for example

```
@article{poole2012acad,  
  title = {{A CAD Interface for GEANT4}},  
  author = {Poole, C. M. and Cornelius, I. and Trapp, J. V. and Langton, C. M.},  
  journal={Australasian Physical & Engineering Science in Medicine},  
  year = 2012,  
  month = September,  
  doi = {10.1007/s13246-012-0159-8},  
  url = {http://www.springerlink.com/content/u563877422284578}  
}
```



The open Assimp Importer Lib
<http://www.assimp.org/>

Library to read standard mesh
formats

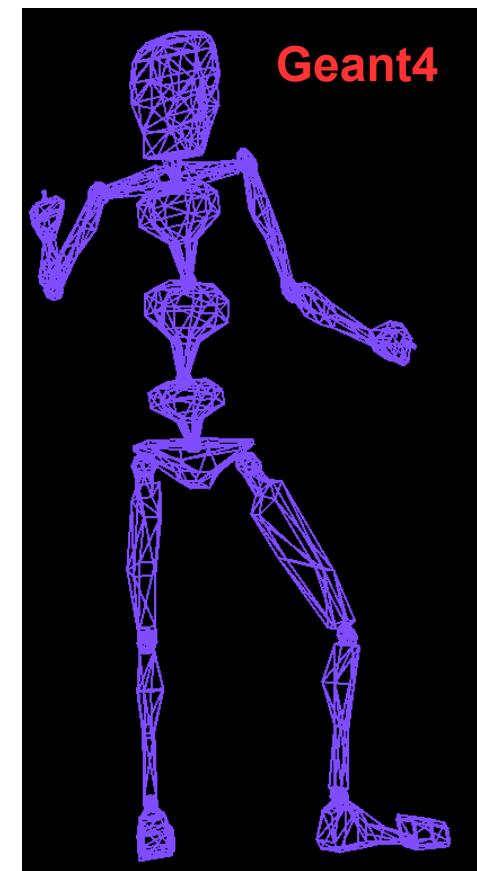
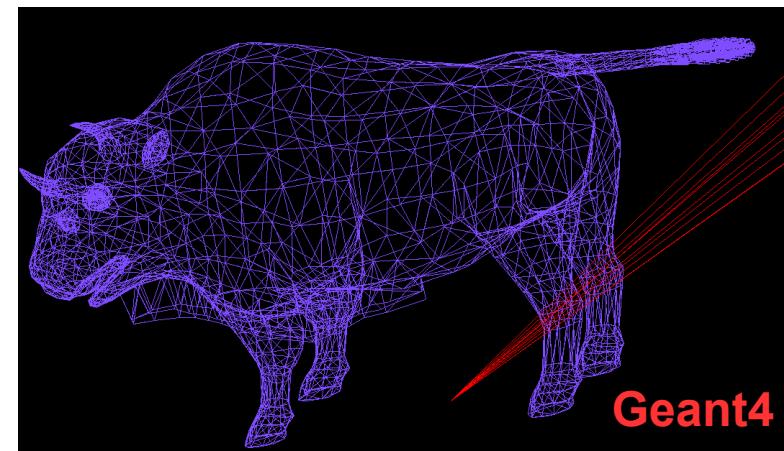
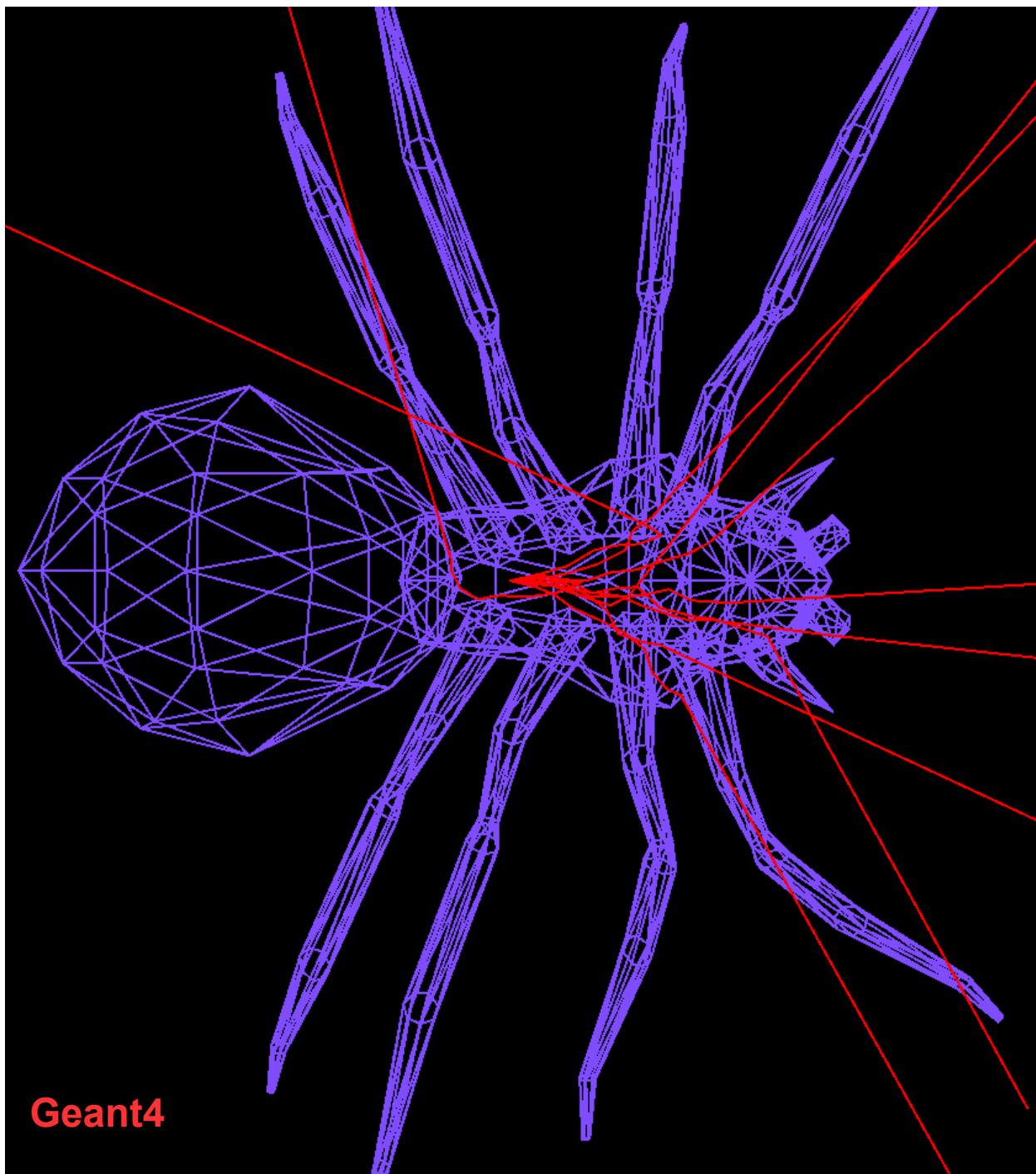
```
@article{poole2012fast,  
  title={Fast Tessellated Solid Navigation in GEANT4},  
  author={Poole, C. and Cornelius, I. and Trapp, J. and Langton, C.M.},  
  journal={IEEE Transactions on Nuclear Science},  
  volume={99},  
  pages={1--7},  
  year={2012},  
  publisher={Institute of Electrical and Electronics Engineers}  
}
```

Standalone Geant4
Simulation with CADMesh*
library

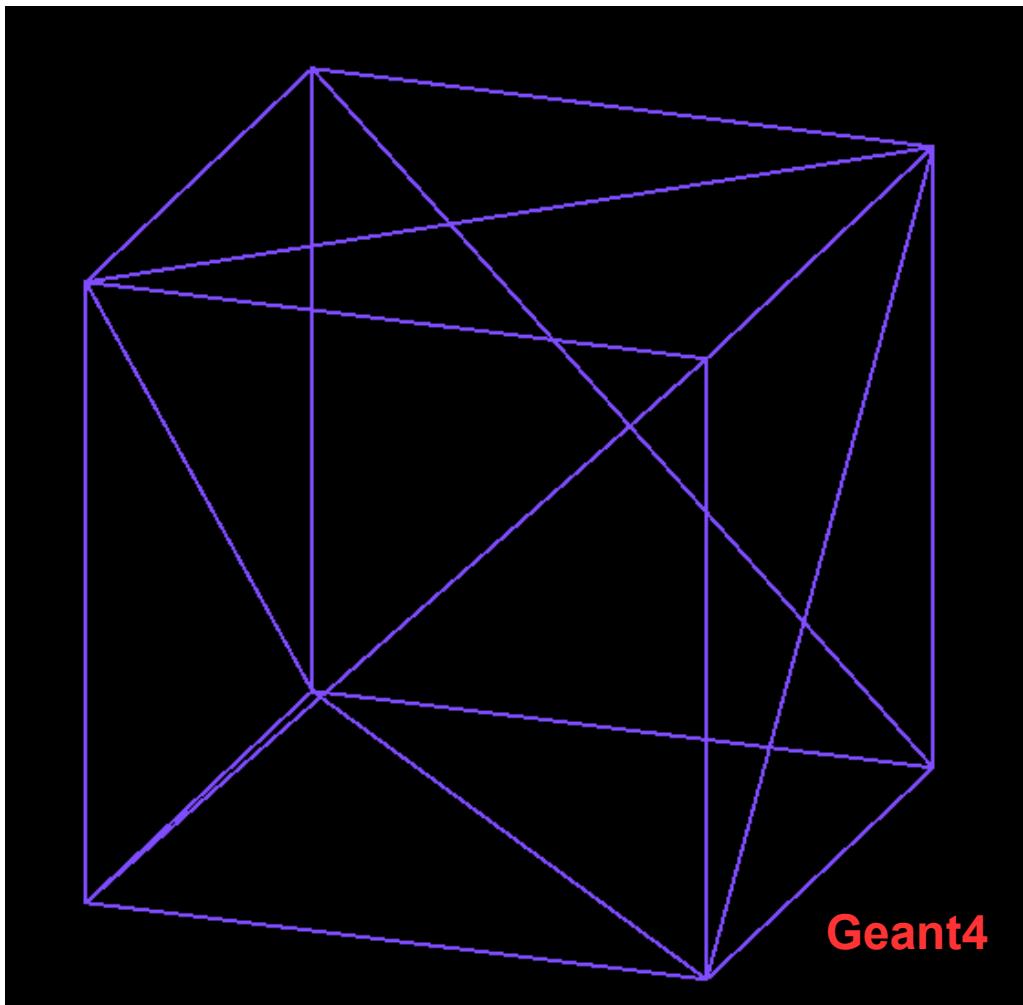
Simulation to check geometry,
make compression in one axis
and generate output xml data file

* <https://github.com/christopherpoole/CADMash>

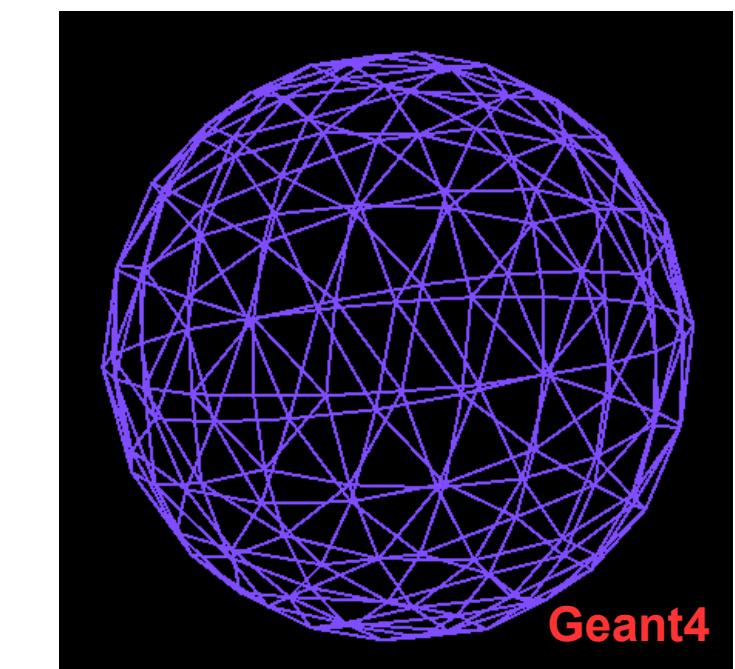
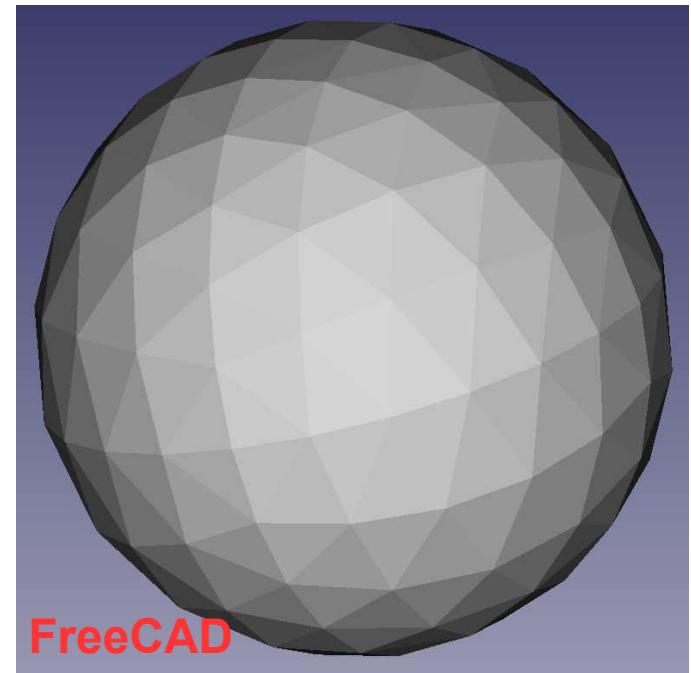
The method work fine



Number of faces for different objects

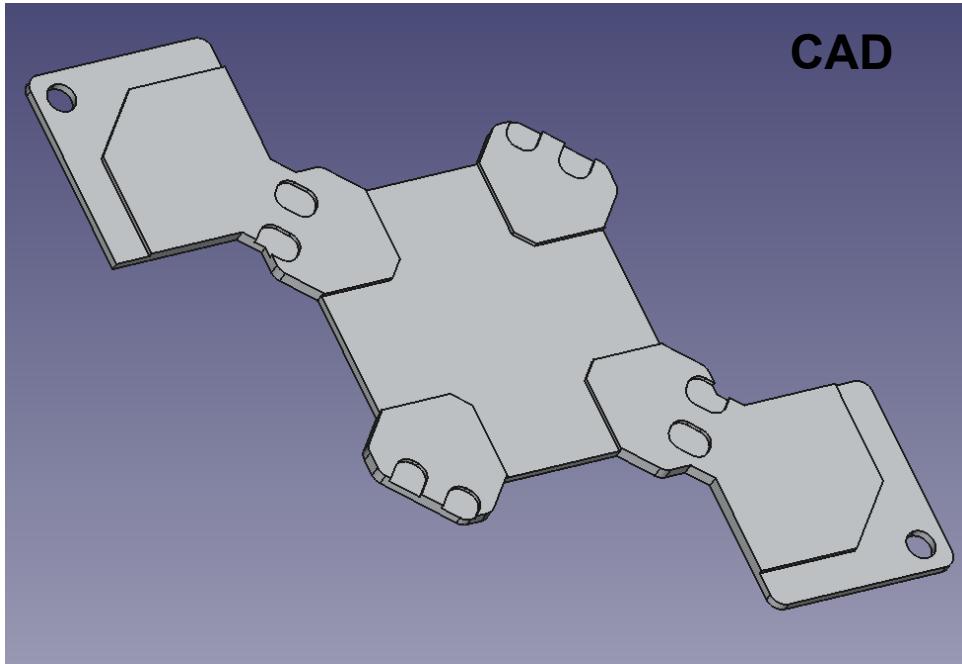


m->mNumFaces : 12



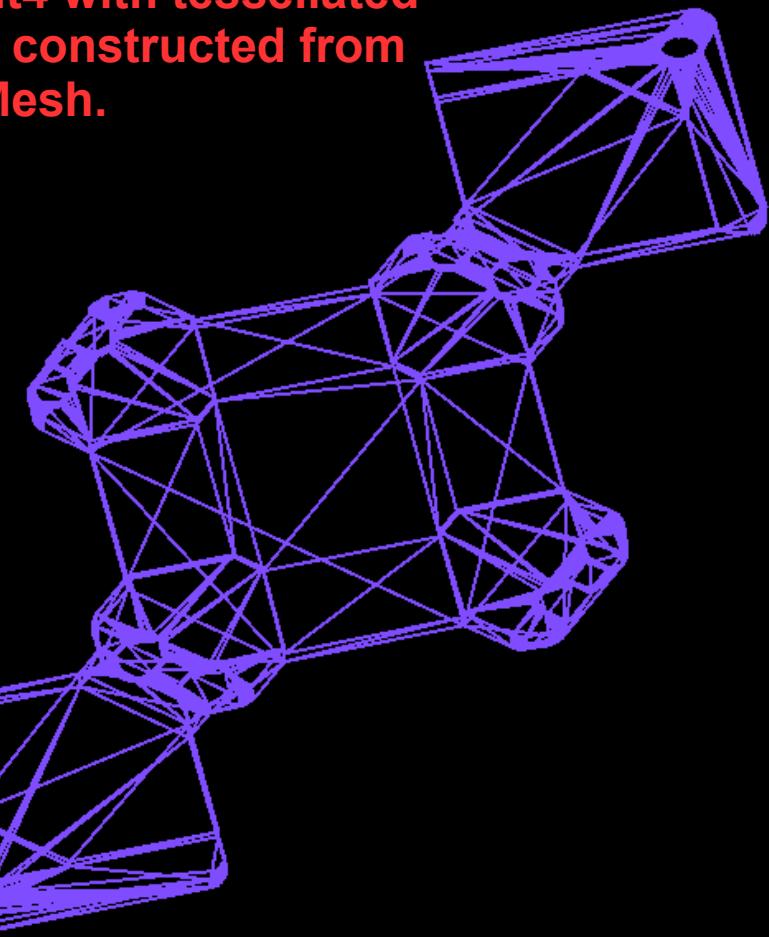
m->mNumFaces : 285

Comparison of tessellated solid implementation and simplified implementation into the Geant4

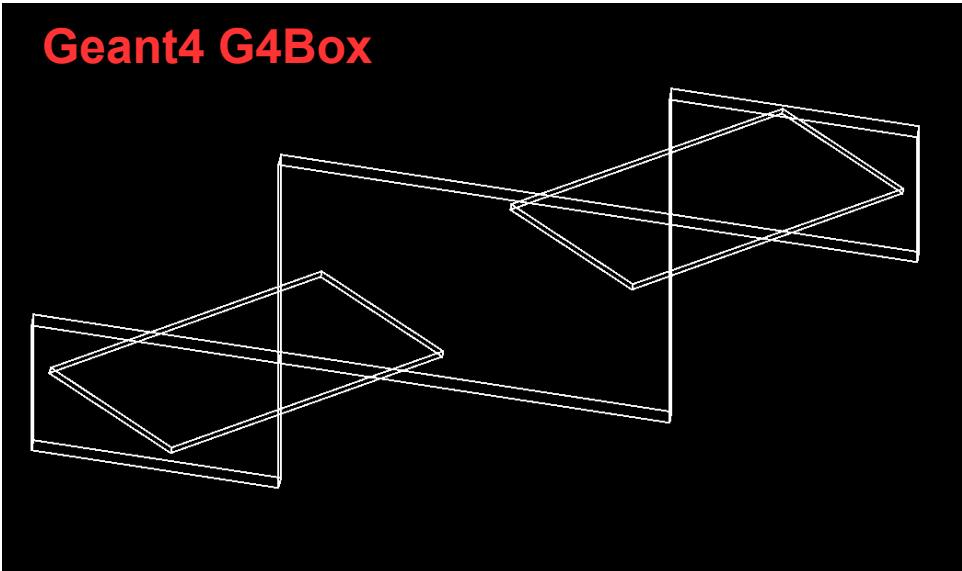


CAD

Geant4 with tessellated solid constructed from the Mesh.



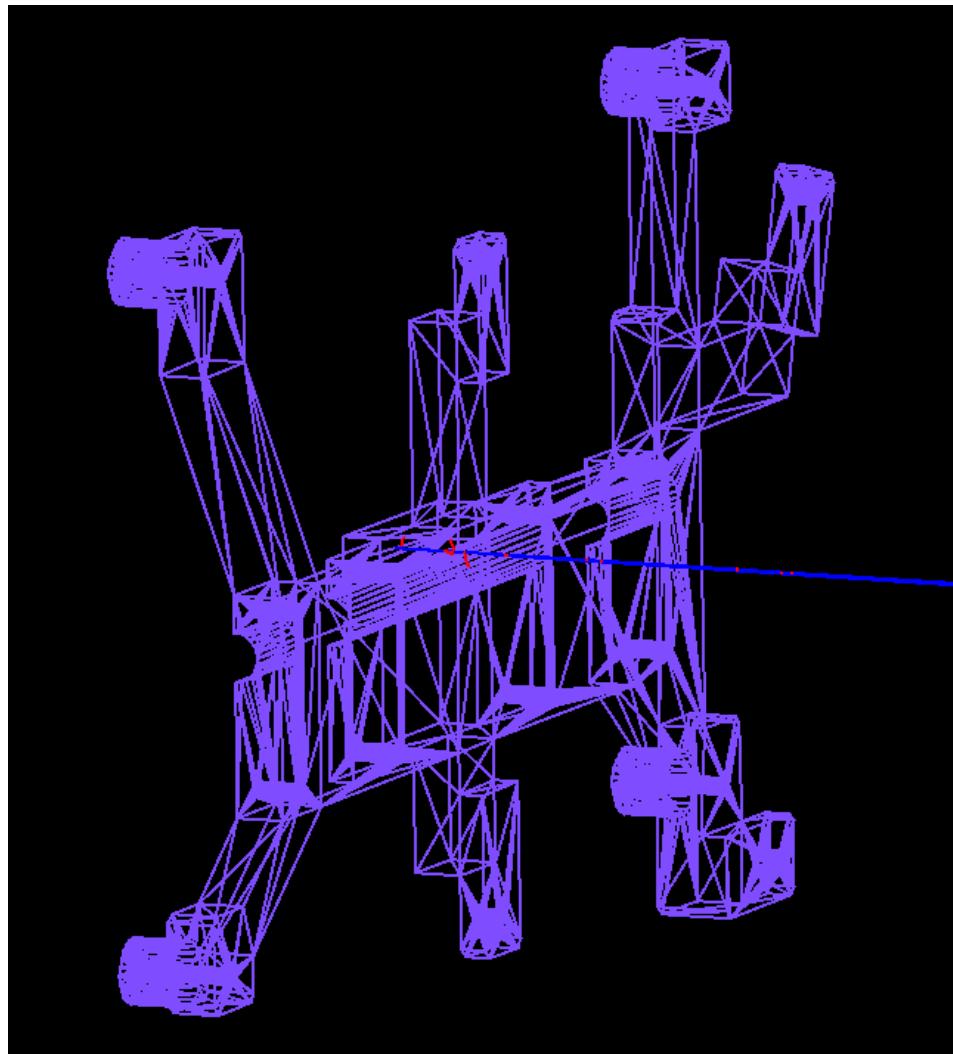
Geant4 G4Box



The drawback - is the big amount faces (planes) to construct G4TessellatedSolid.

We will use this method only for the mergers cooling bodies.

Implementation of the merger cooling bodies (stand alone)



Implementation into BASF2 – first trial

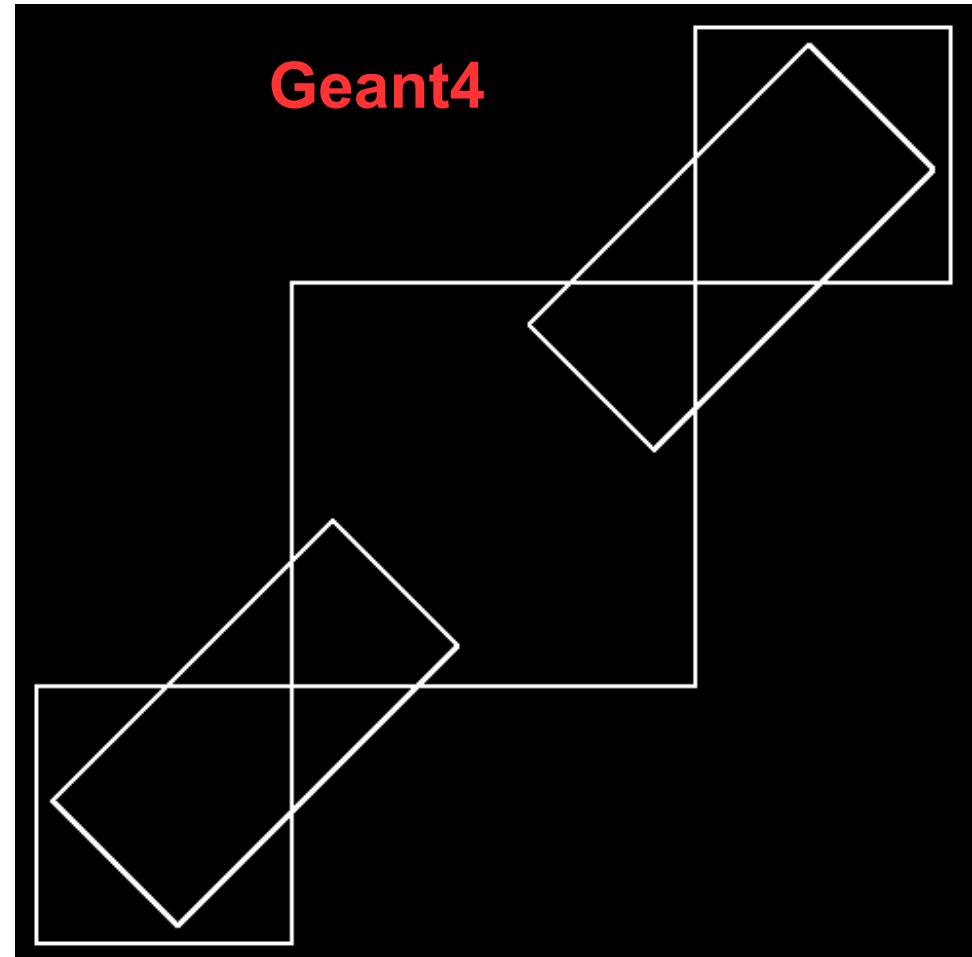
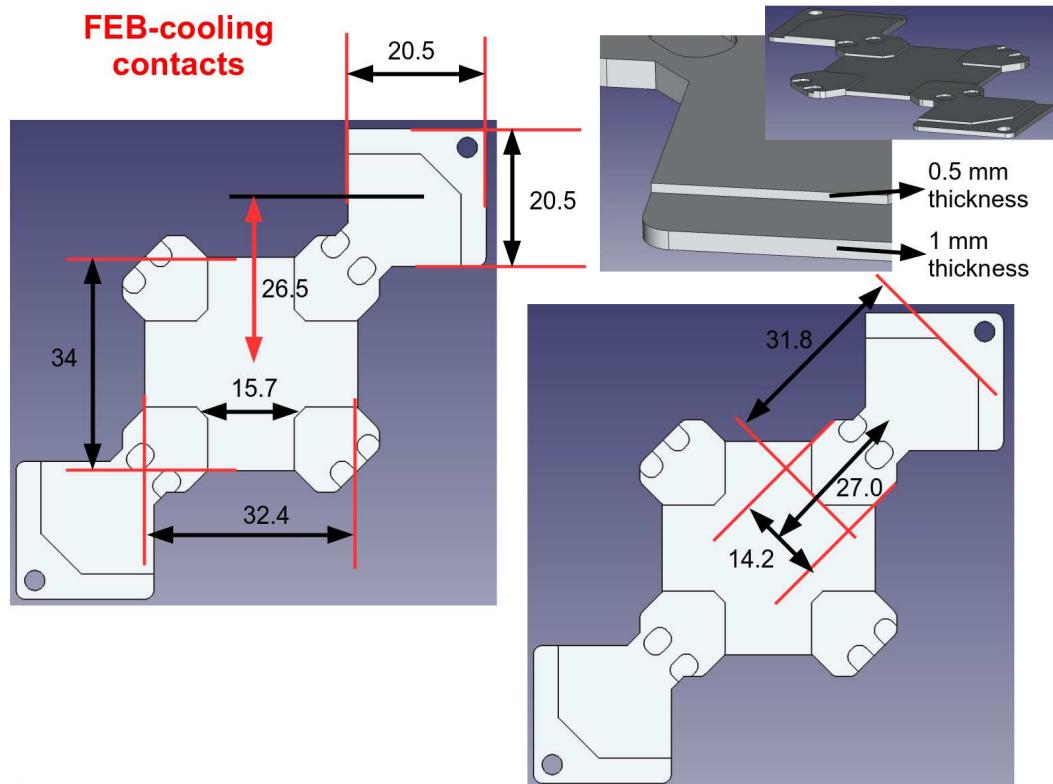


Very first version

Conclusions

- Implementation of the new cooling system for BASF2 is in process.
- Magnetic field effect study is in the process
- Mirror alignment is in process.

Implementation of the FEB-cooling contacts.



- Total weight of FEB's cooling contacts : **3.2 kg**
- Relatively simple to implement with G4Box class.
- **OK.**

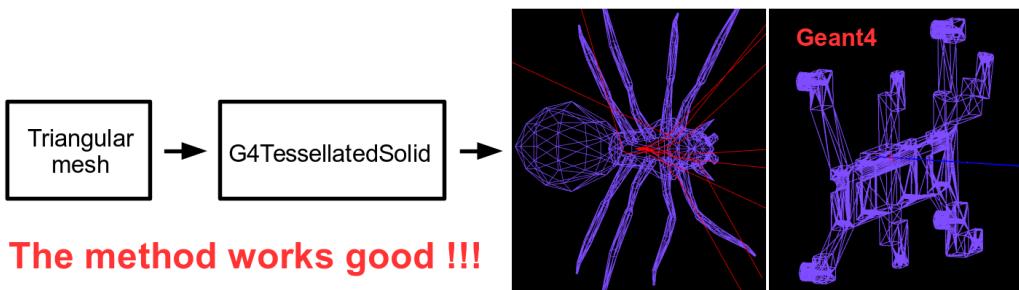
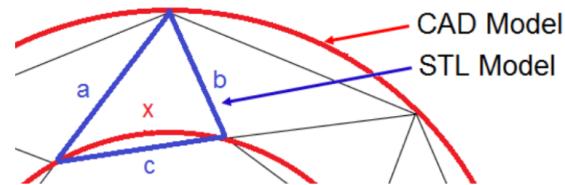
Implementation of the MERGER - cooling contacts.

→ Merger cooling bodies are more complex to build with use of standard geometry classes.

Implementation of more complex geometries from CAD



Example of the triangular mesh



The method works good !!!



→ Speed and memory tests

→ We generate 10000 events with BASF2 using ARICH stand alone geometry (ARICHStandAlone.py)

	With tessellated volume	Without tessellated volume
Execution time, sec	1104.10	1235.24
Proportional memory : max, MB	512.64	511.23
Proportional memory : avg, MB	500.00 +/- 19	499.00 +/- 19

Tessellated volume can not be visualized with BASF2 event display

- BASF2 event display use ROOT geometry description TGeo objects.
- There is no equivalent of G4TessellatedSolid in Root TGeo.

- Conversion to root is done with VGM (external module)

The virtual geometry model

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- Even if VGM will support G4TessellatedSolid in Geant4GM (the Geant4 implementation of VGM), it would not be able to convert it to Root ...
- Proposed solution :

- **setVisibility(*volume_logical, false);** - sets visualization option to false.
- During conversion with VGM – check visualization flag.

- The developer and librarian of the VGM - Ivana Hrivnacova.

=====

e-mail: Ivana.Hrivnacova@cern.ch
address: Institut de Physique Nucléaire, 91406 Orsay, France
phone: +33 169156594

=====

- I am in contact with Ivana – she agree to provide help.

Implementation of the MERGER - cooling contacts.

- Merger cooling bodies are more complex to build with use of standard geometry classes.
- Has been implemented with use of G4TessellatedSolid.
- Speed and memory tests → **OK**
- We generate 10000 events with BASF2 using ARICH stand alone geometry (ARICHStandAlone.py)

	With tessellated volume	Without tessellated volume
Execution time, sec	1104.10	1235.24
Proportional memory : max, MB	512.64	511.23
Proportional memory : avg, MB	500.00 +/- 19	499.00 +/- 19

- BASF2 event display use ROOT geometry description TGeo objects. The conversion from Geant4 geometry to TGeo objects done with VGM package. But G4TessellatedSolid does not have equivalent in TGeo.
- Very first proposed solution **does not work** :
 - `setVisibility(*volume_logical, false);` - sets visualization option to false.
 - During conversion with VGM – check visualization flag. Does not work : because it convert all world volume which contains the all sub-detectors.
- The developer and librarian of the VGM - Ivana Hrivnacova. She help me to find needed solution.

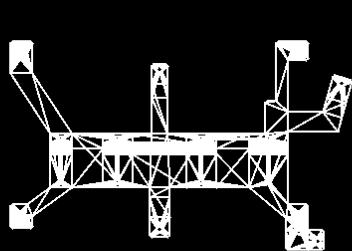
=====

e-mail: Ivana.Hrivnacova@cern.ch
address: Institut de Physique Nucléaire, 91406 Orsay, France
phone: +33 169156594

=====
- **RootGM::Factory::SetIgnore(1);**

Stand alone test

HepRep visualization

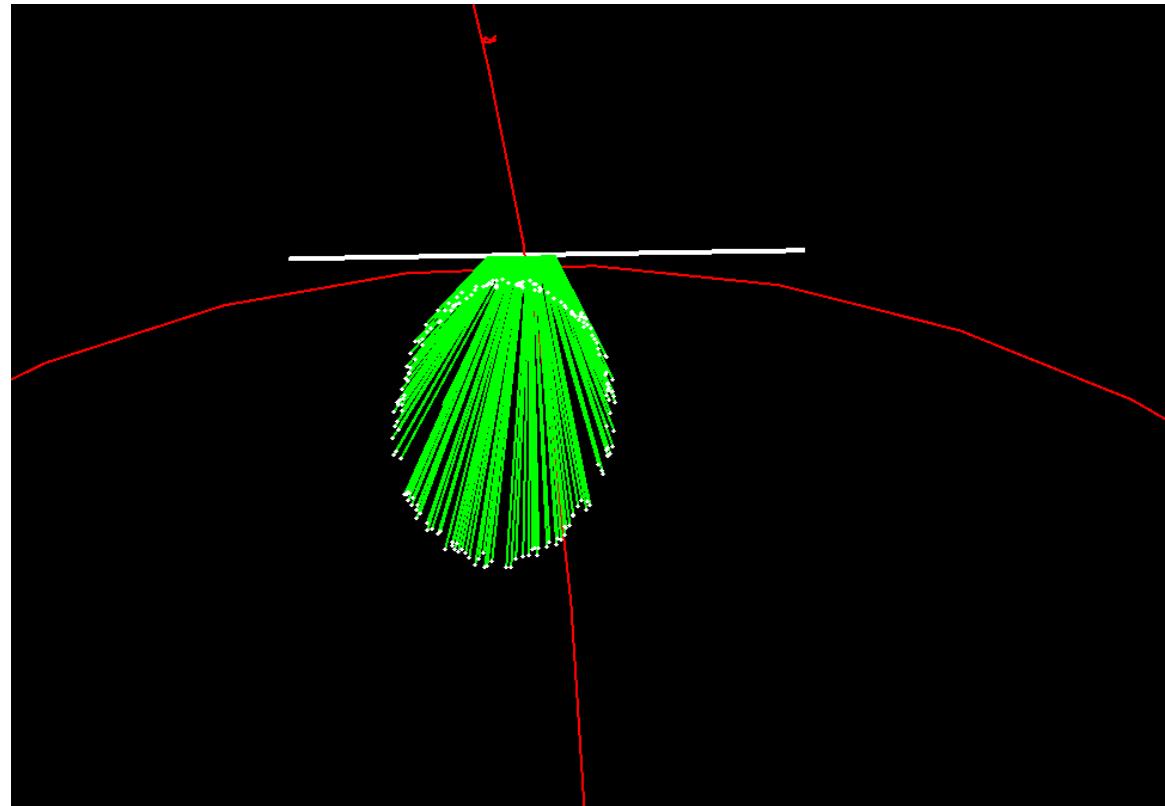
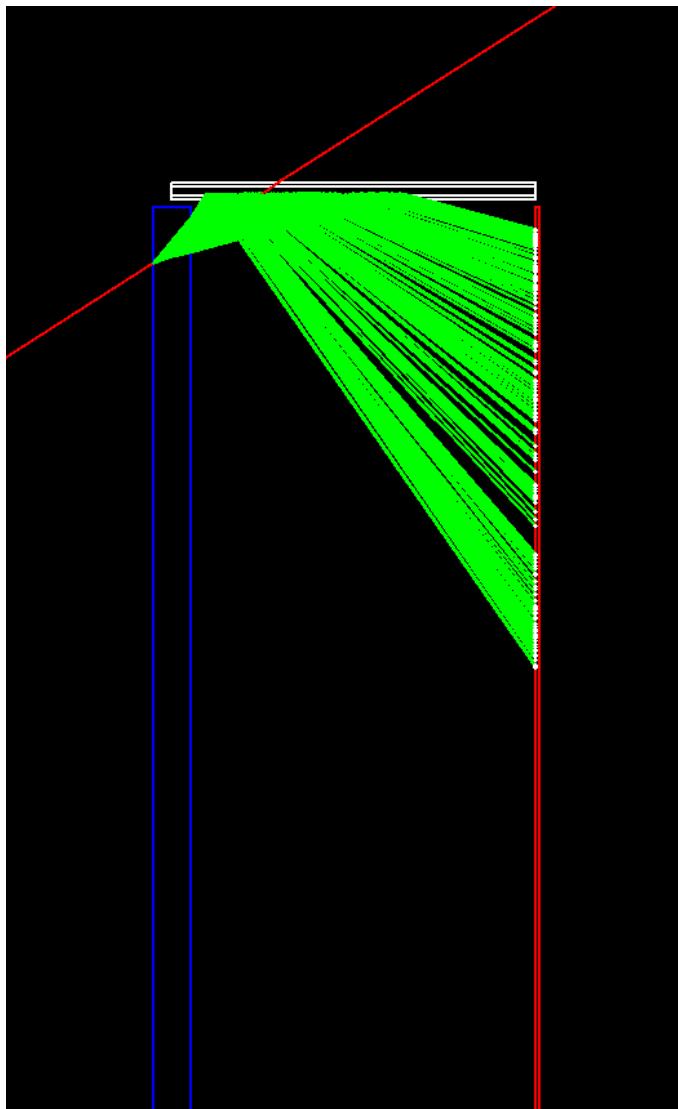


ROOT TGeo visualization



Not supported volume
represented by small box

Stand alone Geant4 simulation of the ARICH detector for first study of the mirror alignment.



Particle type : mu-
Momentum : 3 GeV/c
Theta : 33 deg
Phi : 82 deg

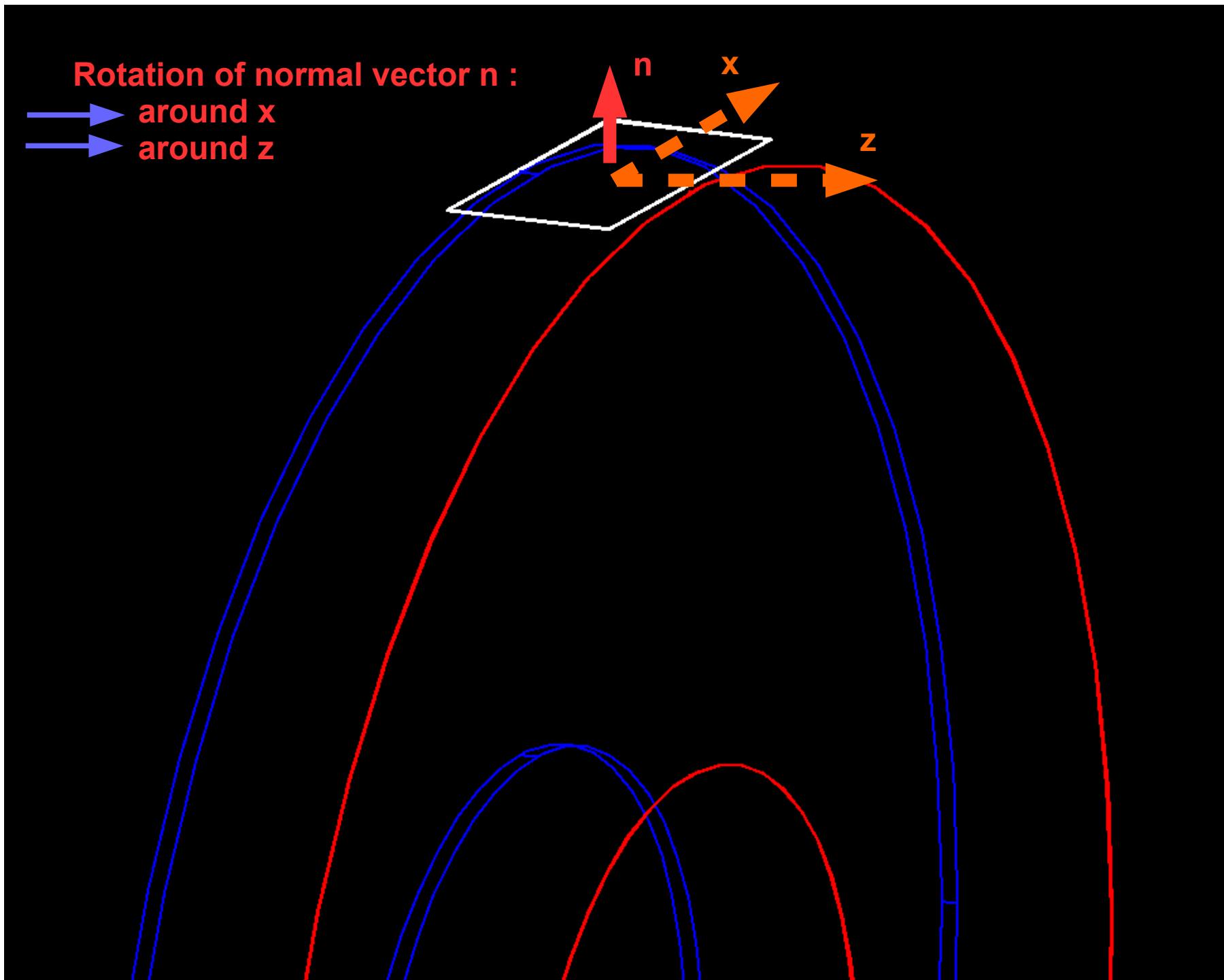
Local coordinates definition → origin : middle of the mirror

y : parallel to normal vector

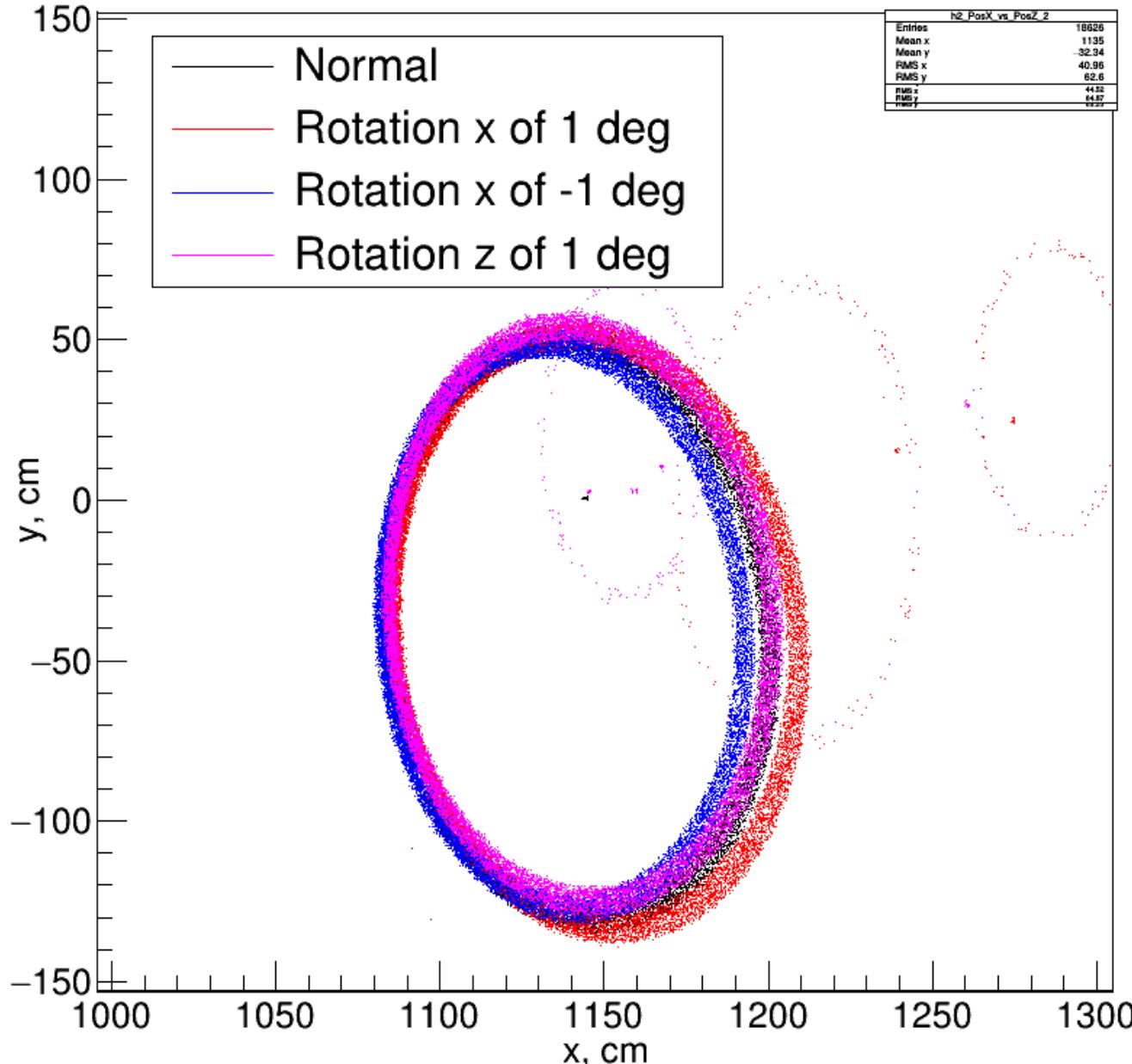
z : parallel to direction of the beam

x : defined from y and z (right handed coordinate system)

Rotation definition



Very preliminary results and conclusions :



One degree rotation of normal vector **around x – axis** (of local coordinates) **can be measured**

One degree rotation of normal vector **around z – axis** (of local coordinates) **can not be measured
(dependence is weak)**