Measurement of the radiation hardness of the Philips dSiPMs

PANDA collaboration meeting

June 2013

Benno Kröck, *Avetik Hayrapetyan, Daniel Mühlheim, Erik Etzelmüller, Julian Rieke, Klaus Föhl, Michael Düren, Oliver Merle*

JLU Gießen

HIC for FAIR

Helmholtz International Center

Objectives

Measurement setup

Measurement results

Final discussion

Objectives ▷

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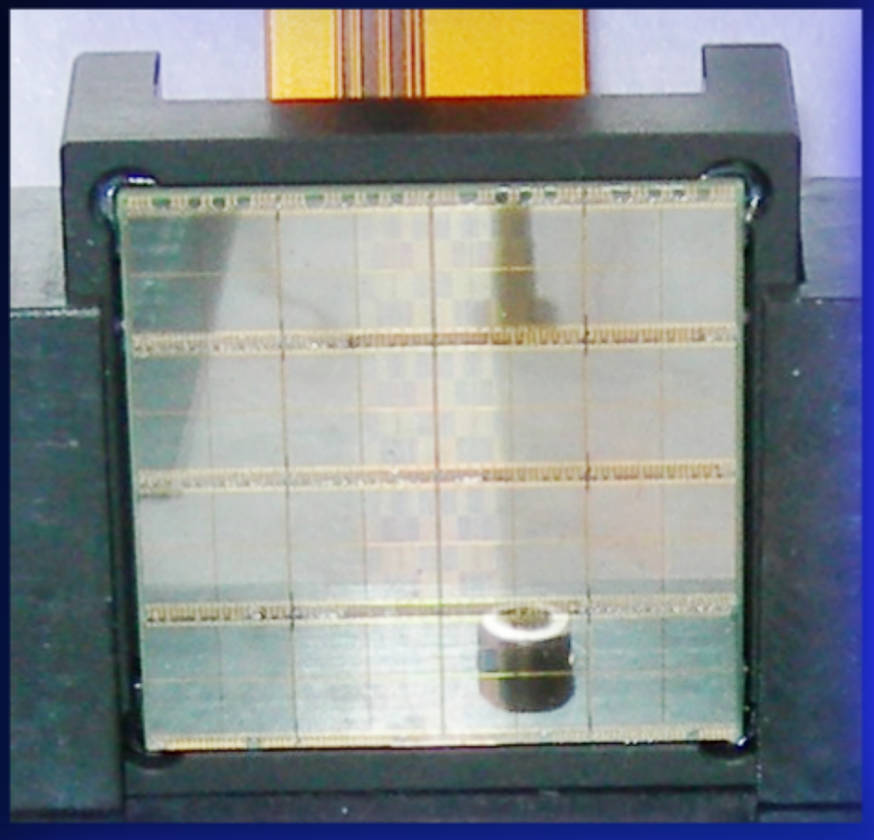
Schedule / radiant exposure



- TEK module, 25600 cells:
  exposition in steps until total destruction
- TEK module, 12800 cells:
  exposition in steps until total destruction
- two TEK modules, 12800 cells:
  lesser dose to study self healing

Bonn:

- protons
- 14 MeV

Disc DIRC:

- expected fluence for the sensors in 1 MeV neutron equivalent:
  $\approx 10^{12}$ per square centimeter
- fluence in 14 MeV proton equivalent is 3.7 times less

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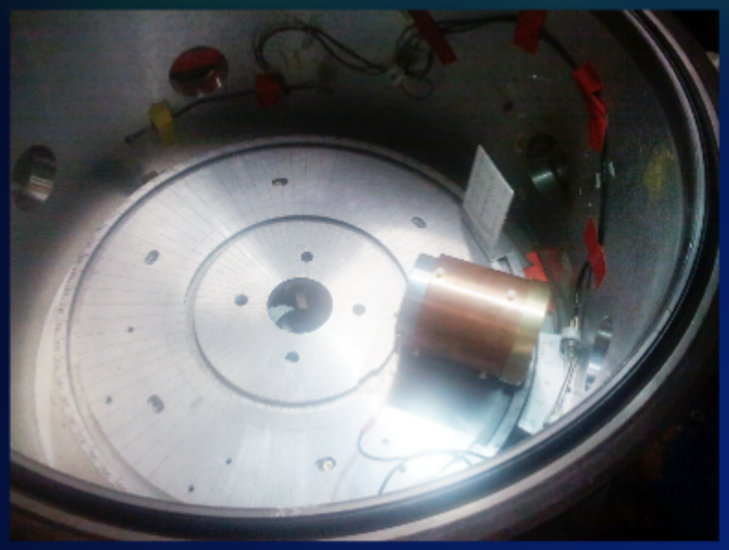
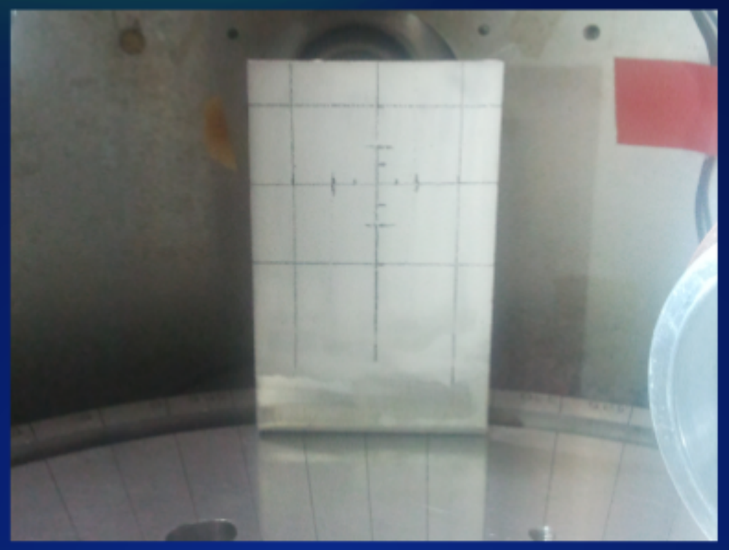
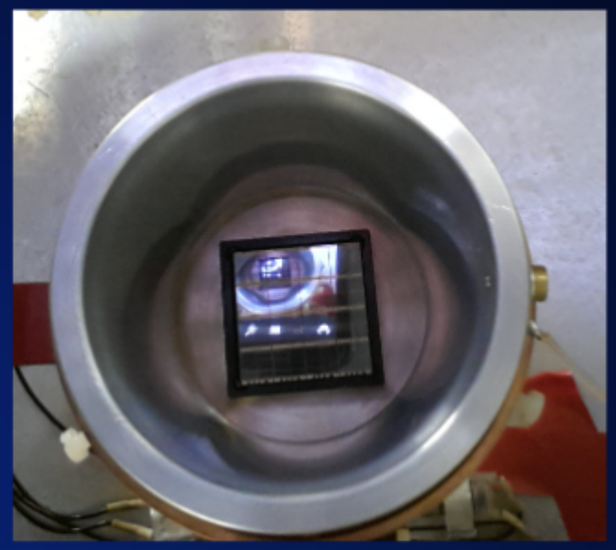
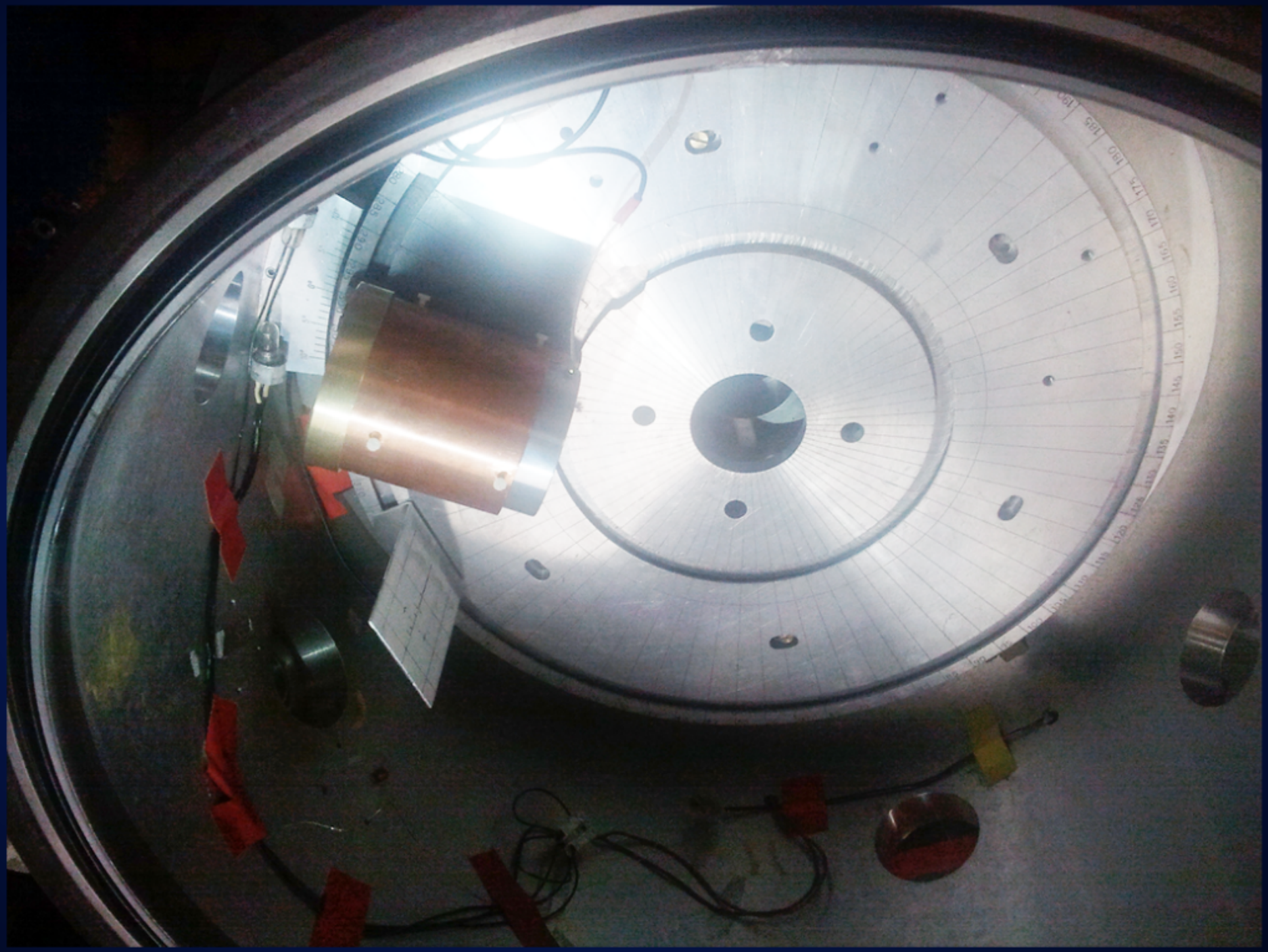
Scattering chamber

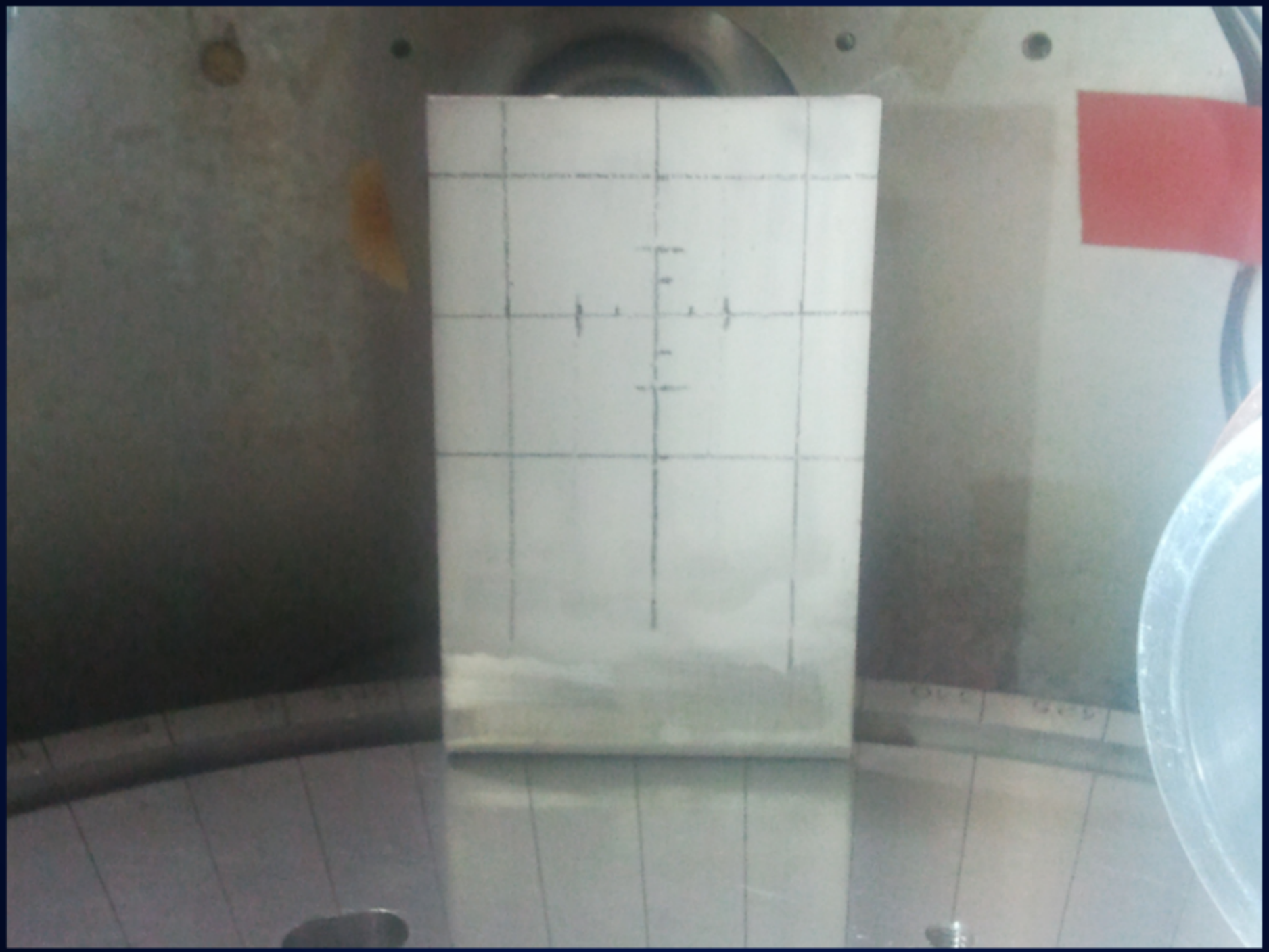


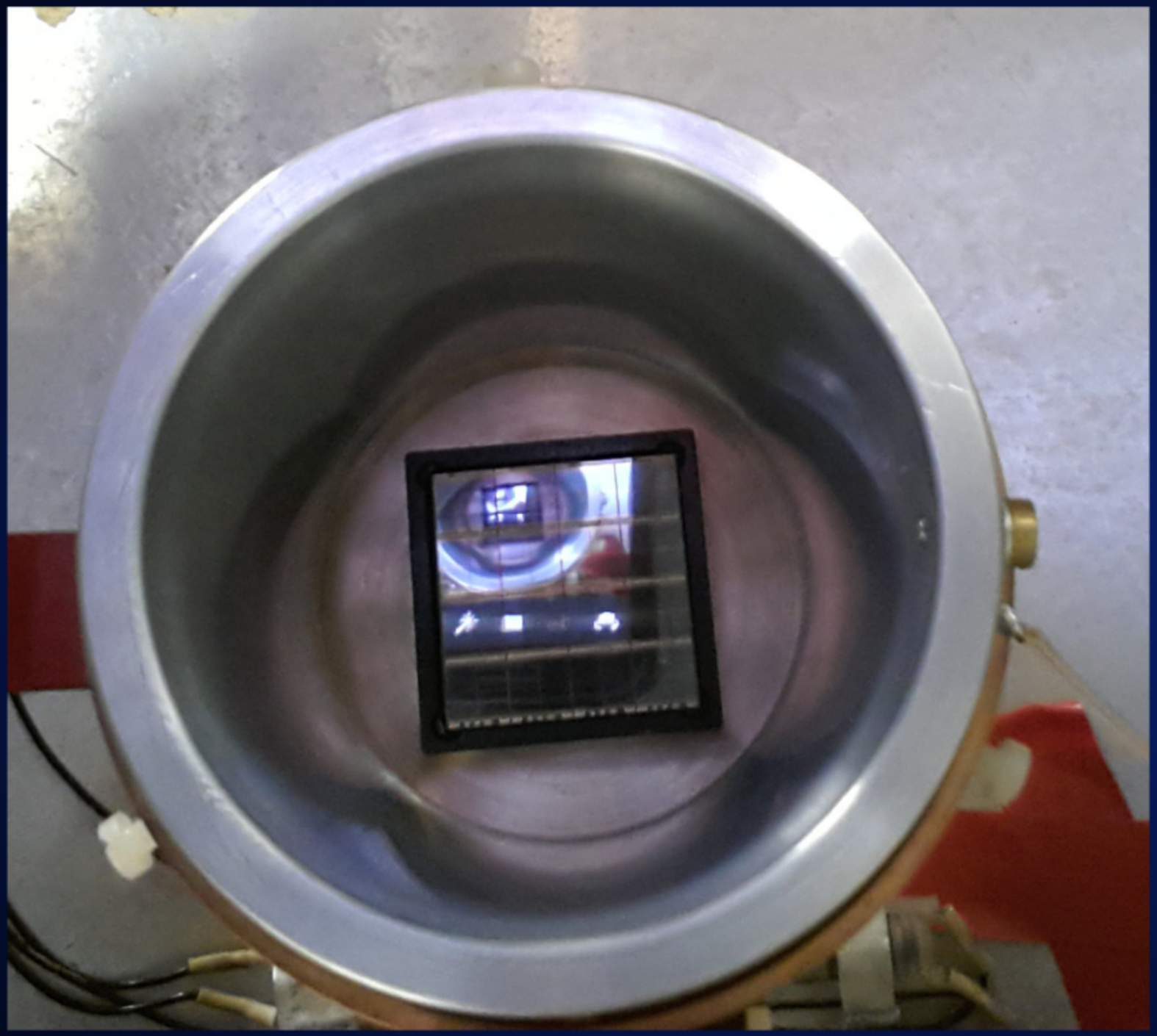




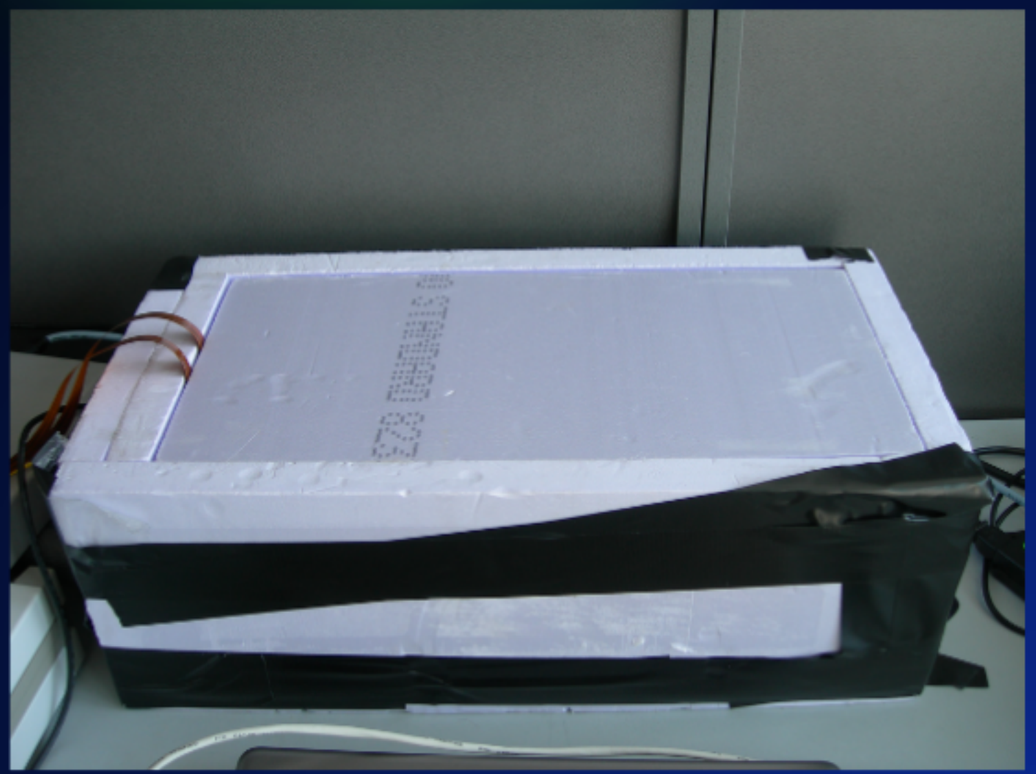
- vacuum: 10^{-5} millibar
- proton beam defocussed to illuminate quadratic area
- fluorescence monitor to check homogeneous illumination
- beam could be wobbled as well to irradiate sensor line by line, might illuminate more uniformly, but was not used here

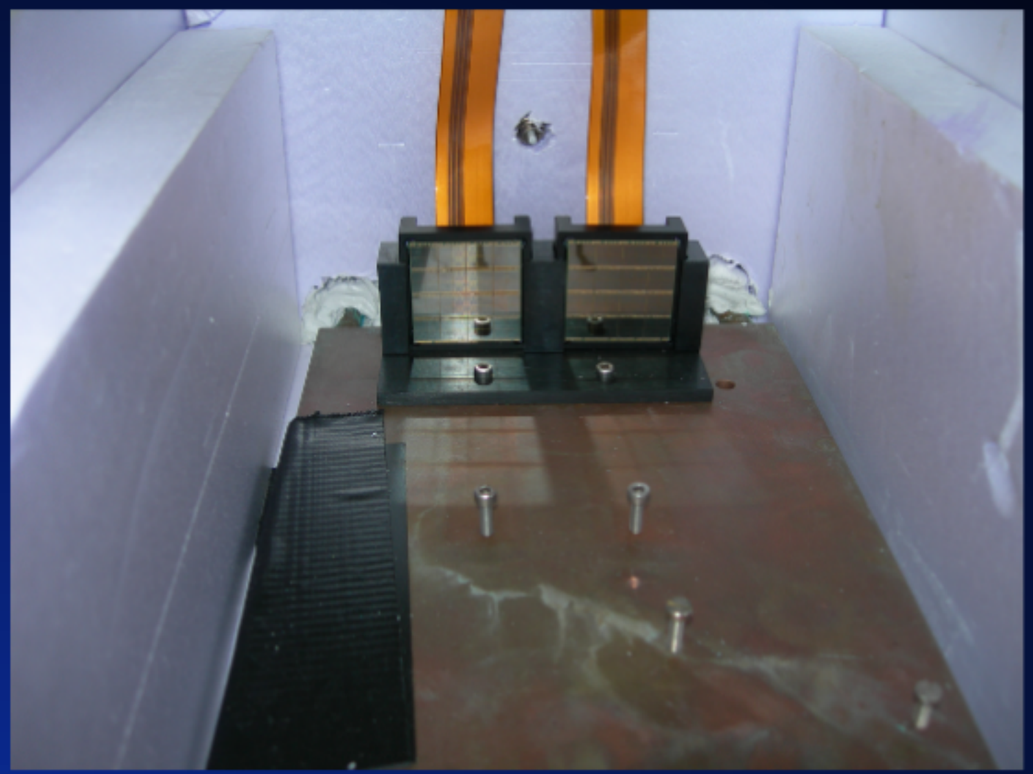




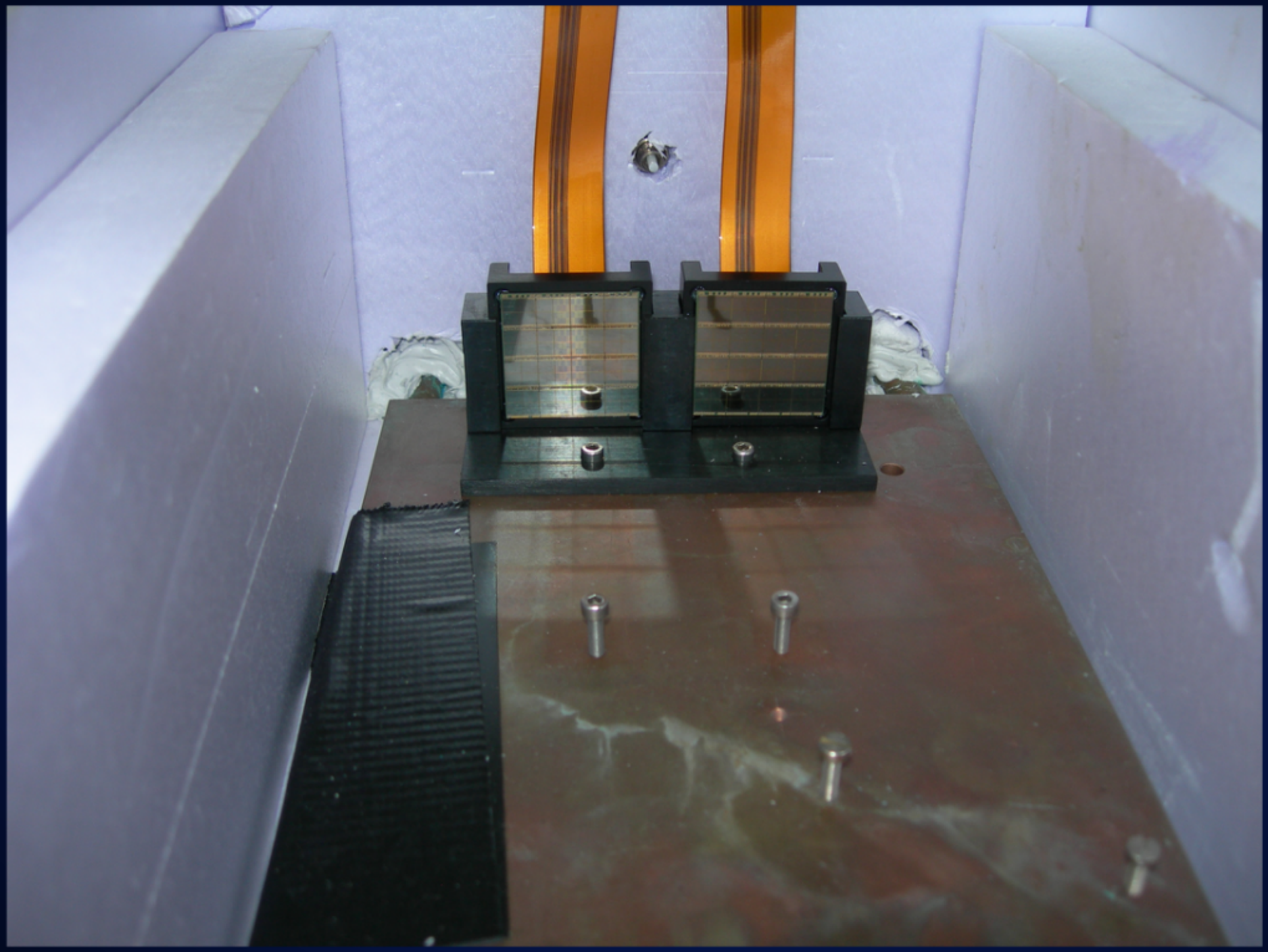


Cooling box





- irradiated sensor and identically constructed reference sensor mounted on copper plate which was soldered on a cooling coil
- cooling liquid tempereratures of -10°C and 20°C
- dark count rate measurements and measurements with pulsed laser (1 MHz, 400 nm)
- hole for laser glass fiber above the sensors, no direct light, but diffusely reflected from opposite inner surface of the box



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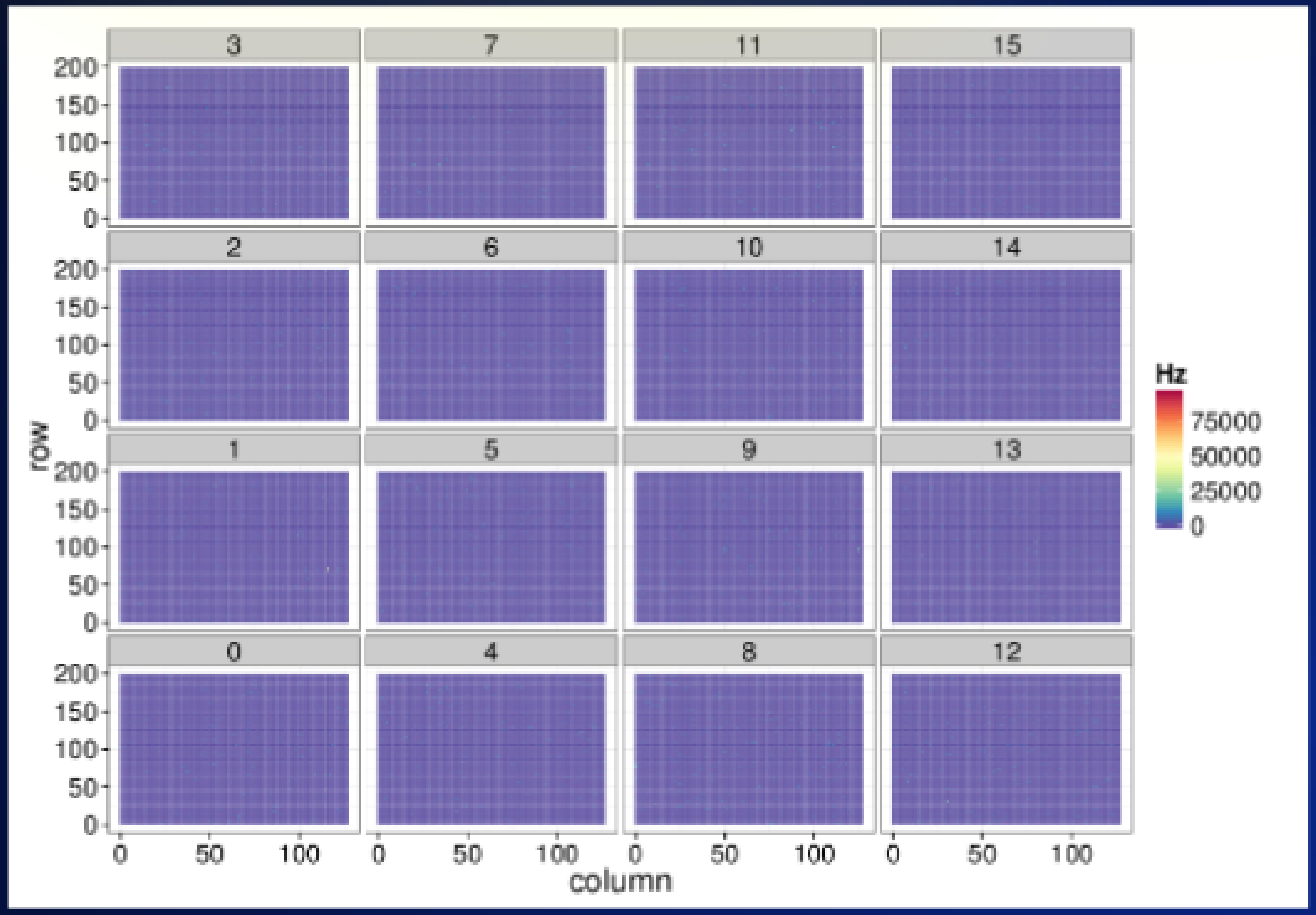
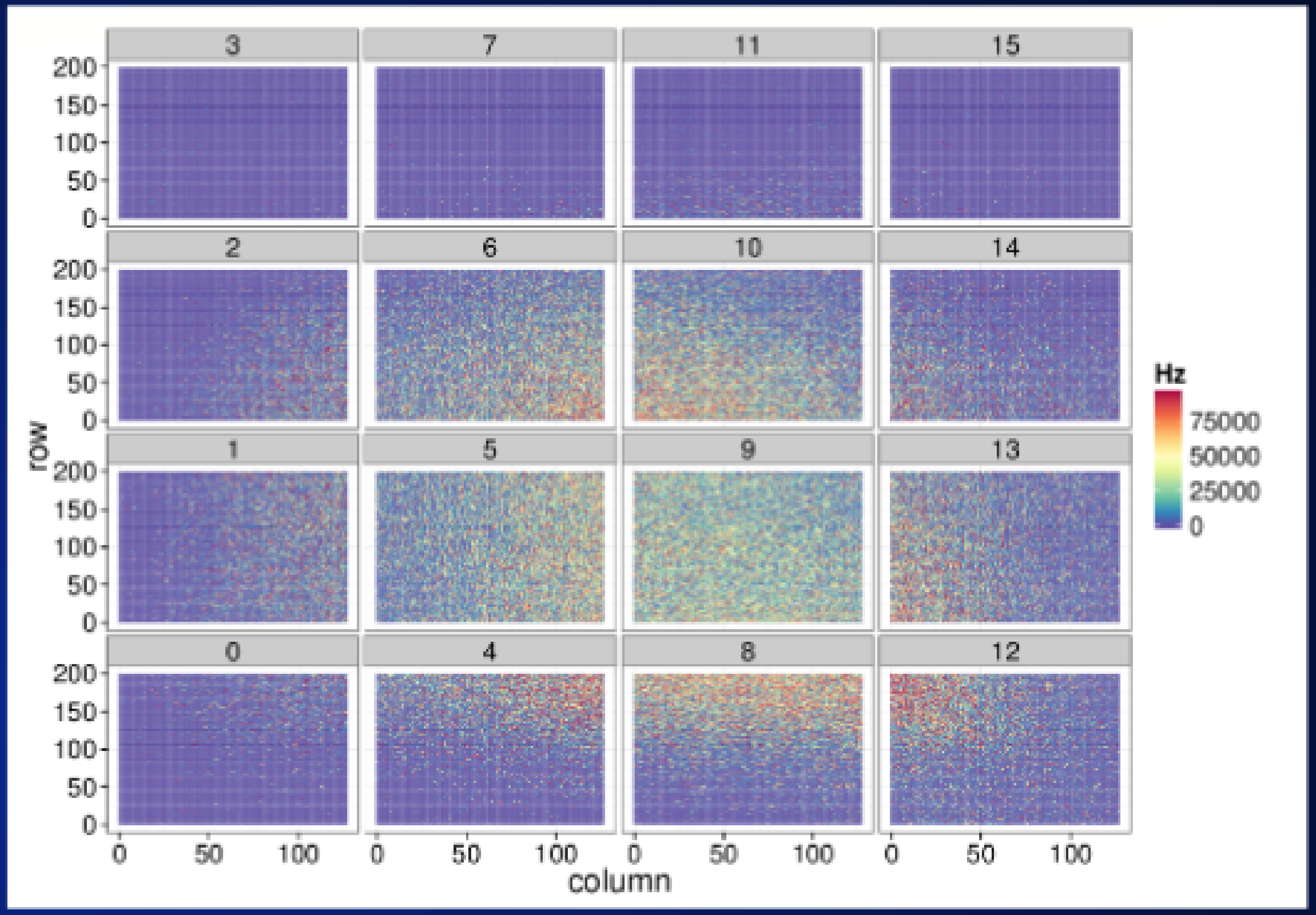
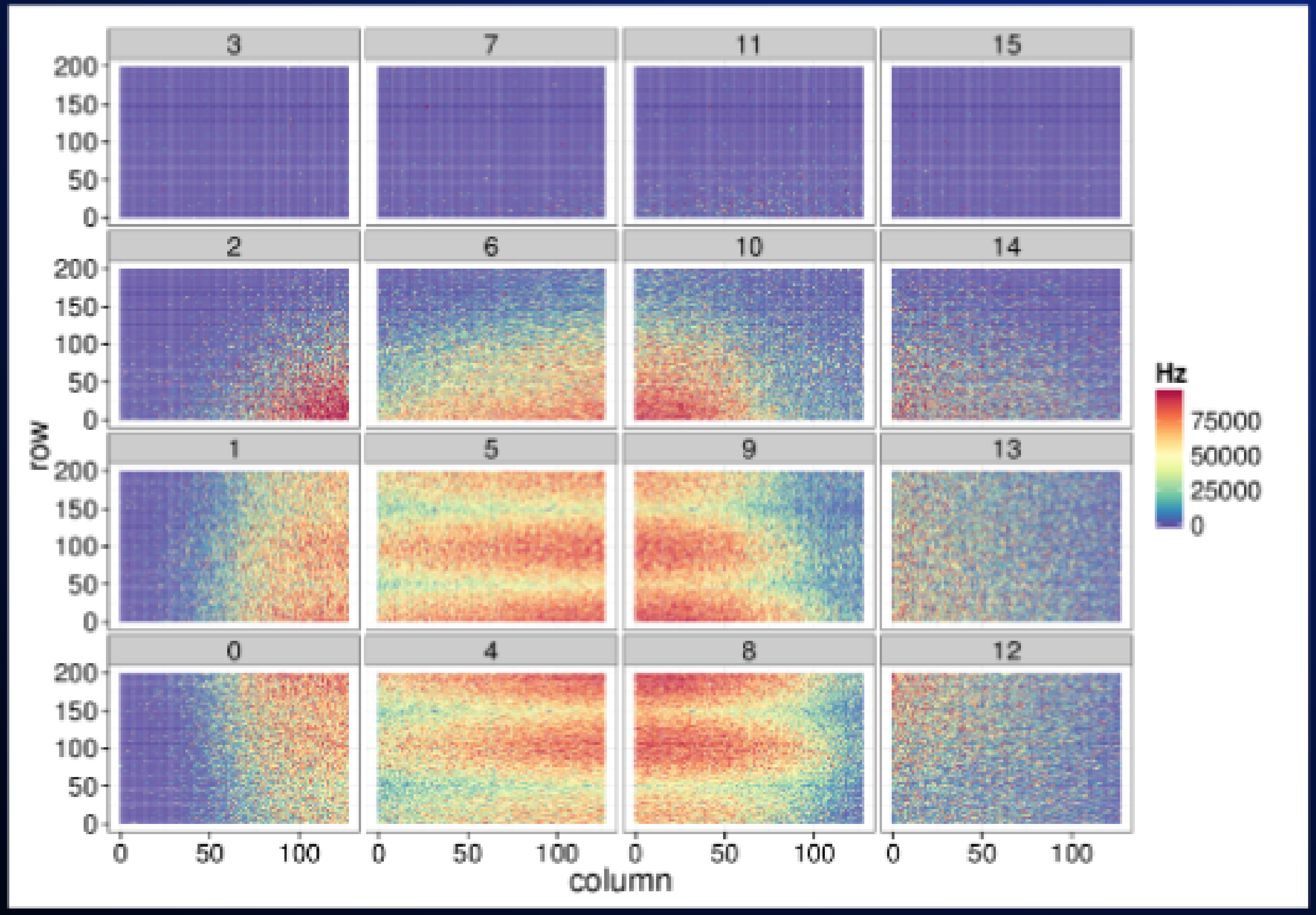
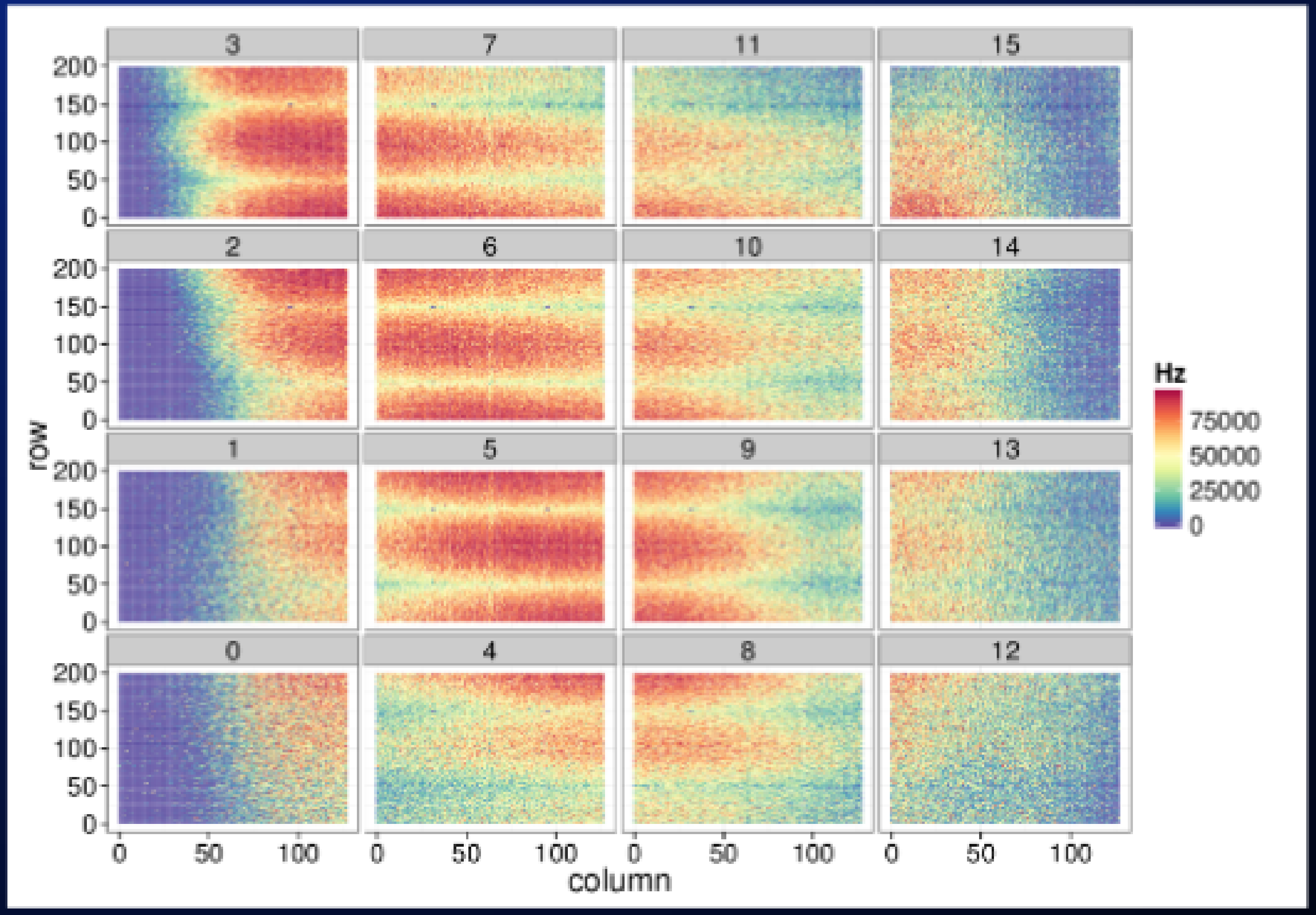
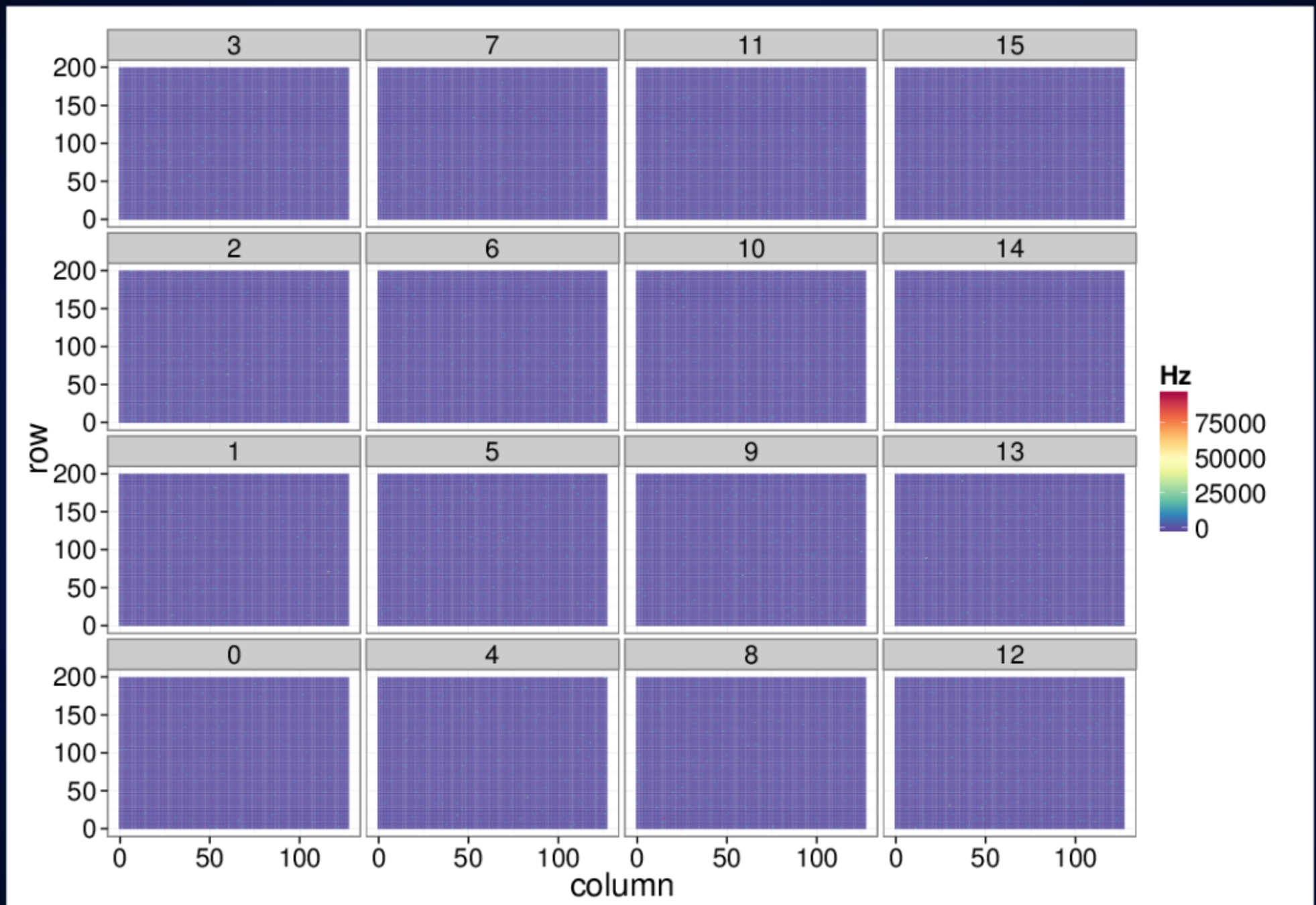
Dark count maps for the irradiated TEK modules







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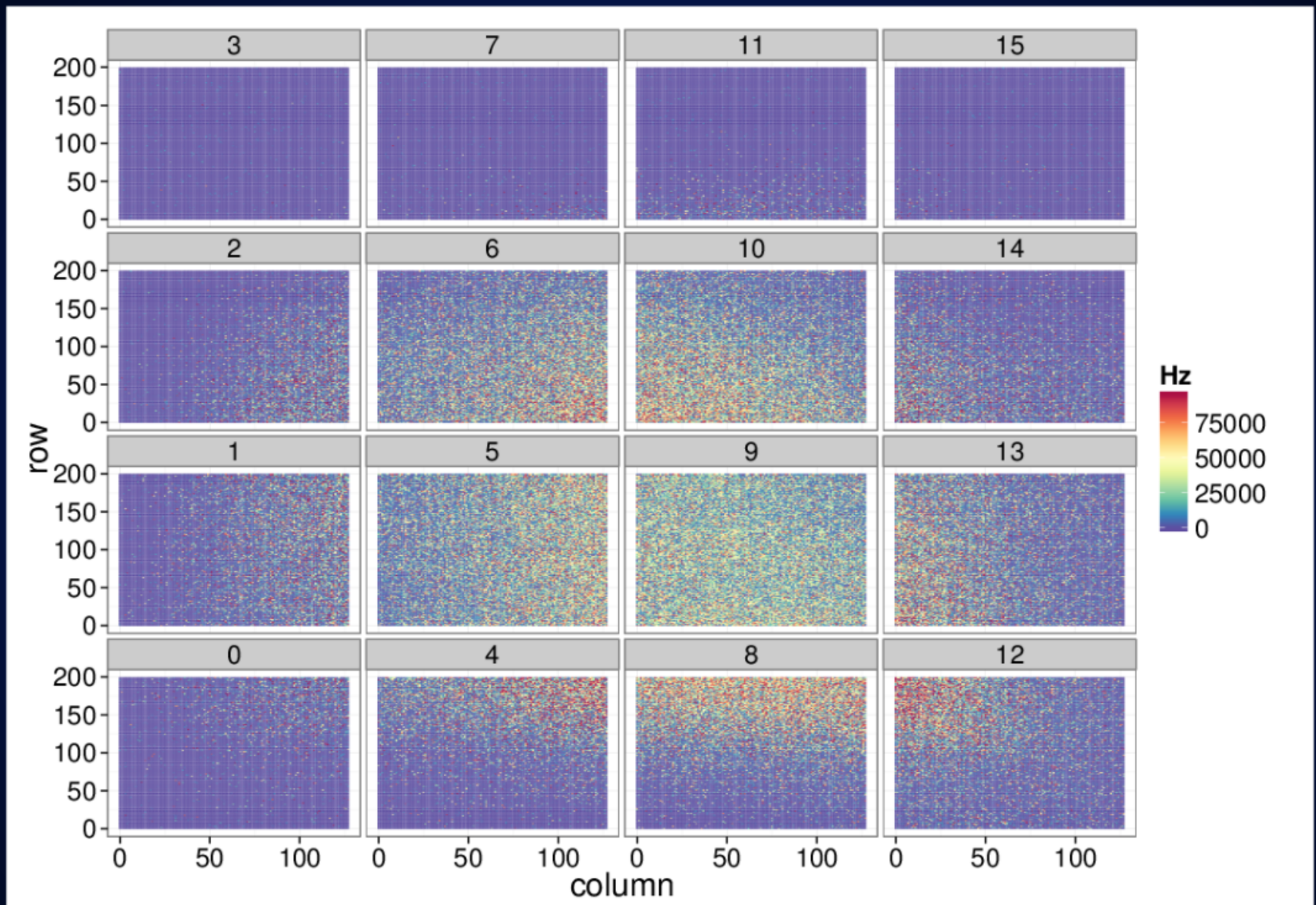
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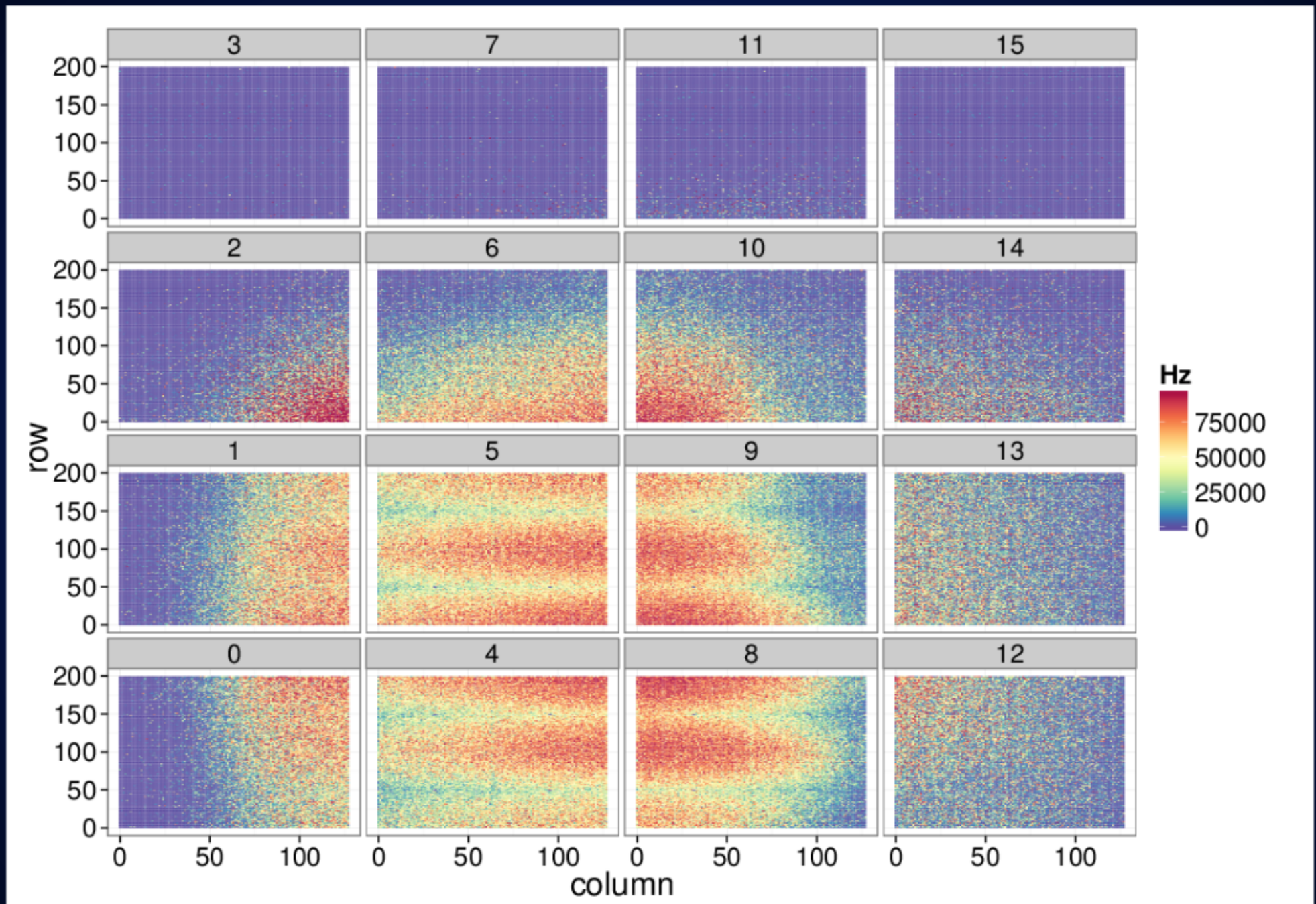
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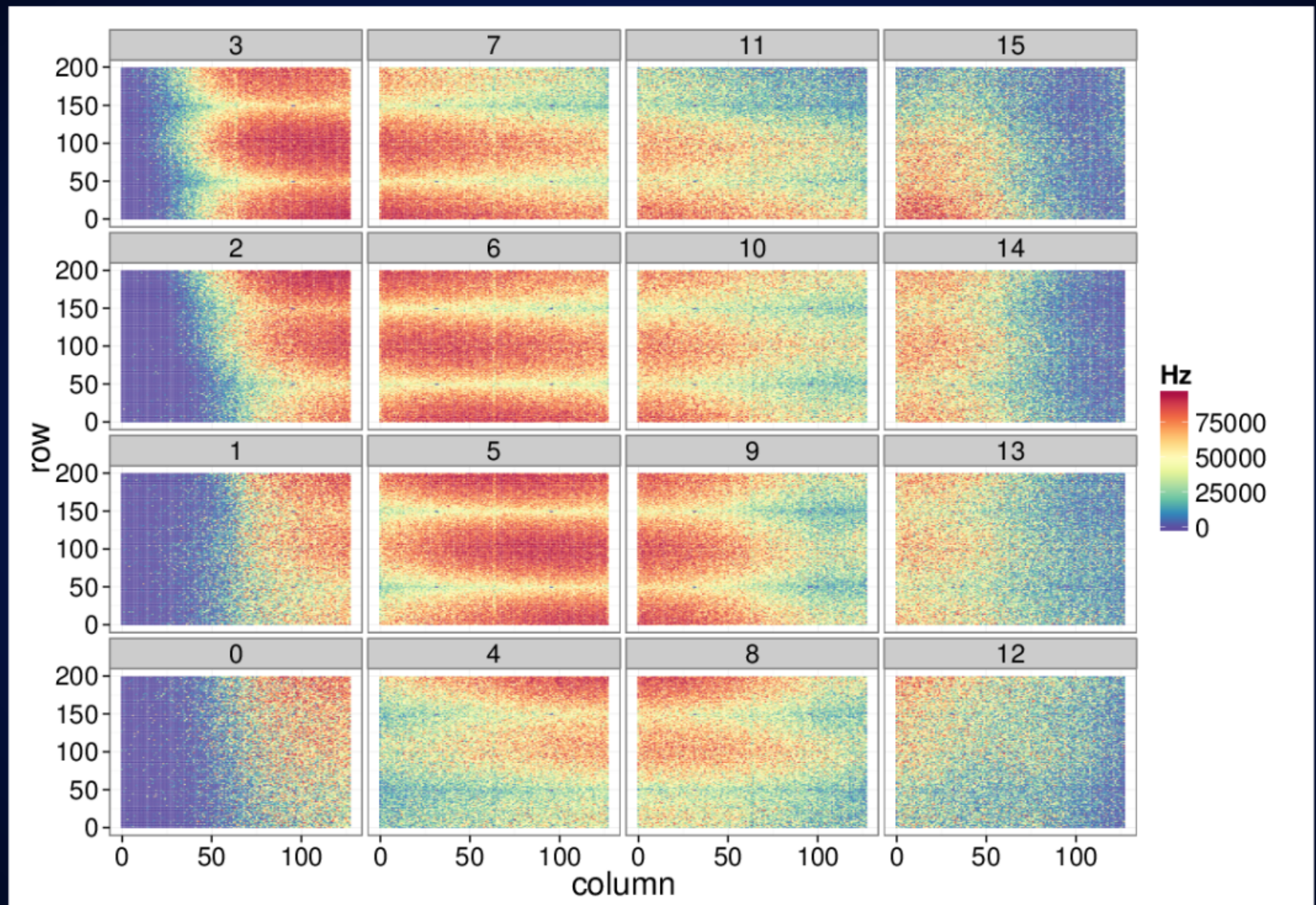
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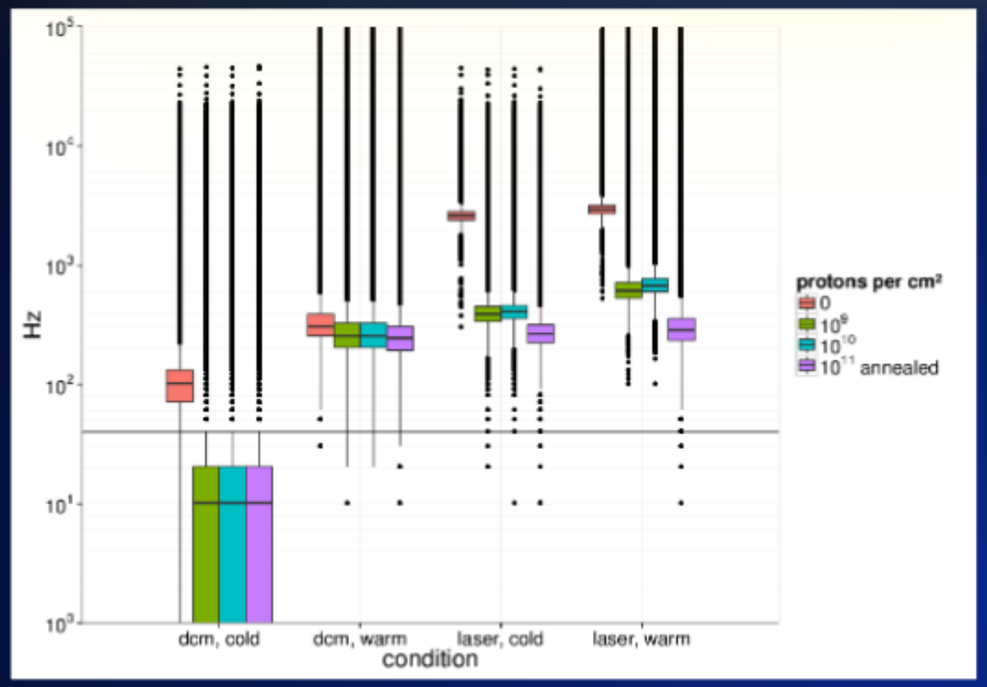
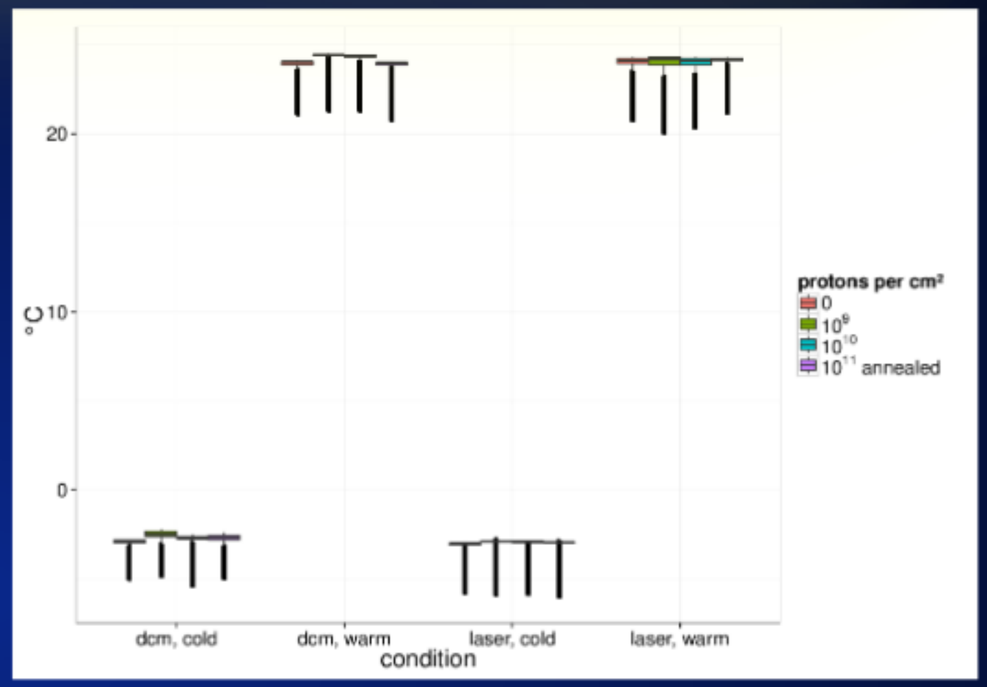
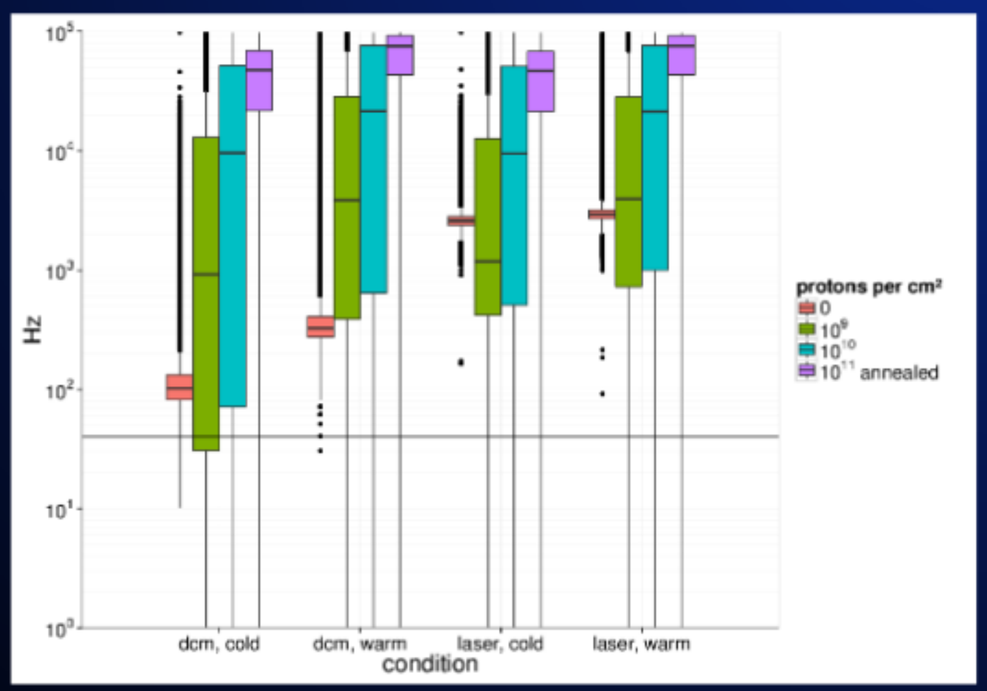
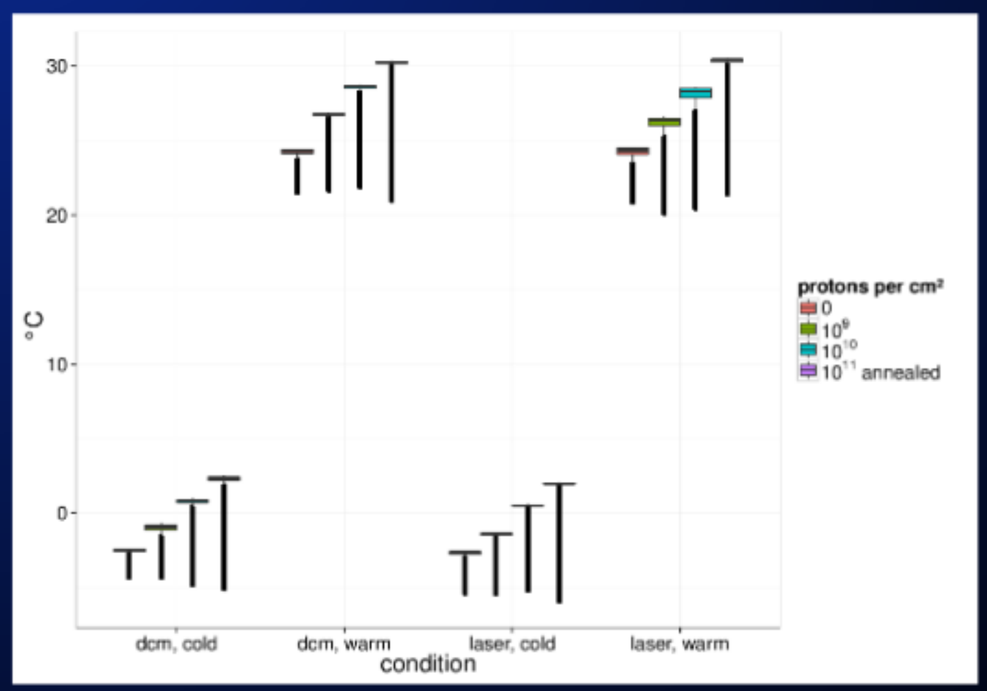
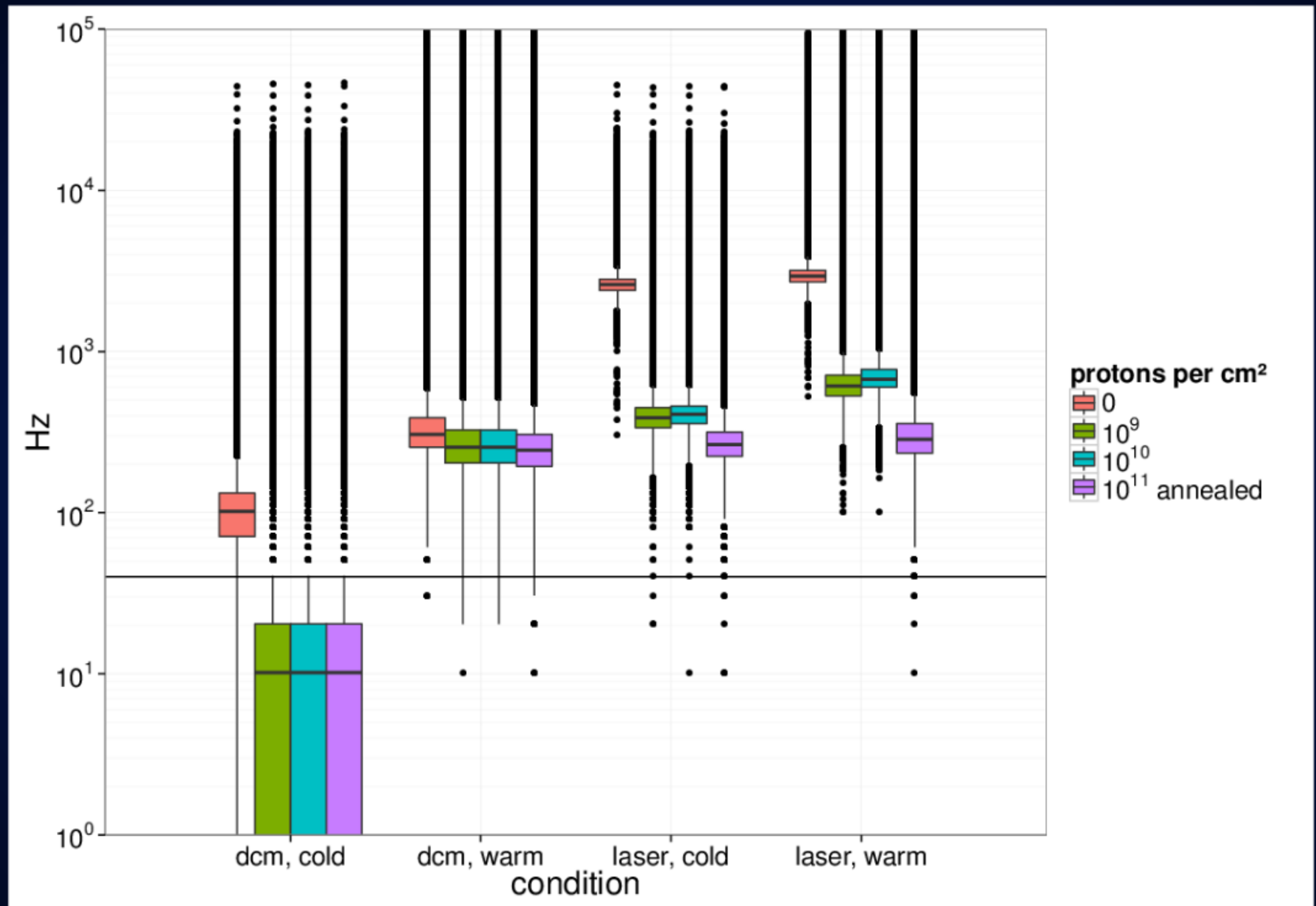
Rate and temperature distributions

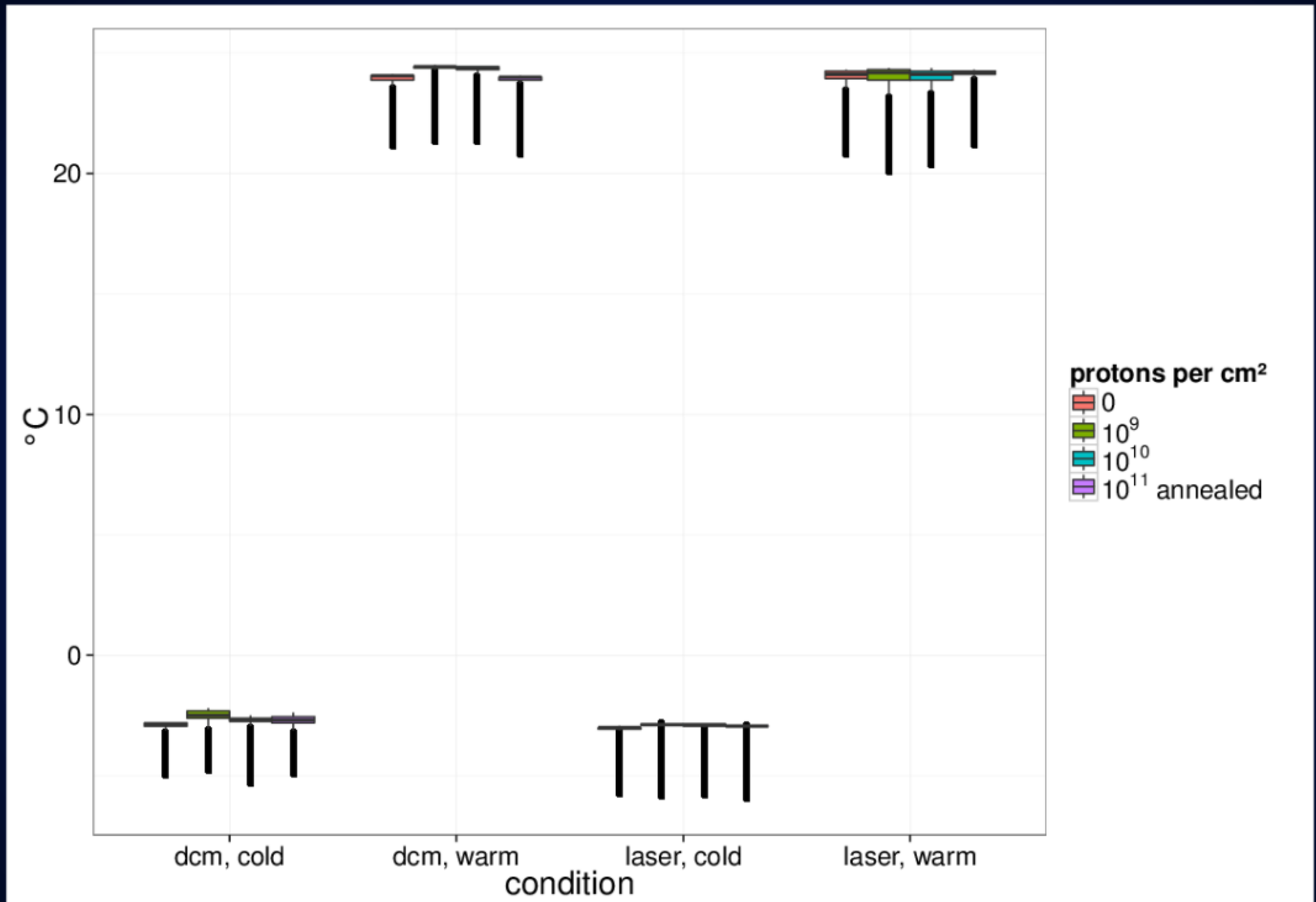









10^5
10^4
10^3
10^2
10^1
10^0
Hz
dcm, cold
dcm, warm
laser, cold
laser, warm
condition
protons per cm²
0
10^9
10^{10}
10^{11} annealed


20
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dcm, cold
dcm, warm
laser, cold
laser, warm
condition
protons per cm²
0
10^9
10^10
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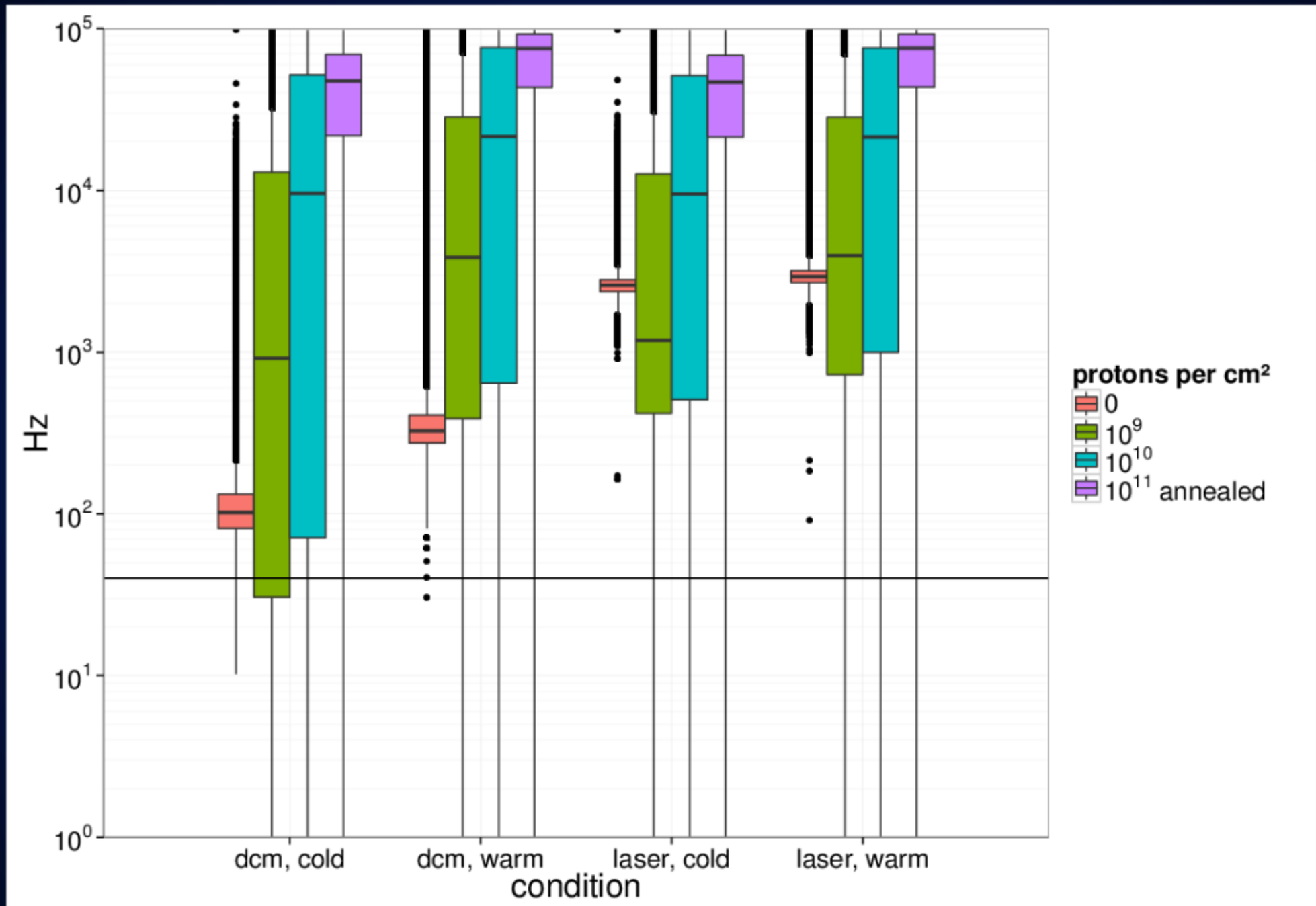
10^5
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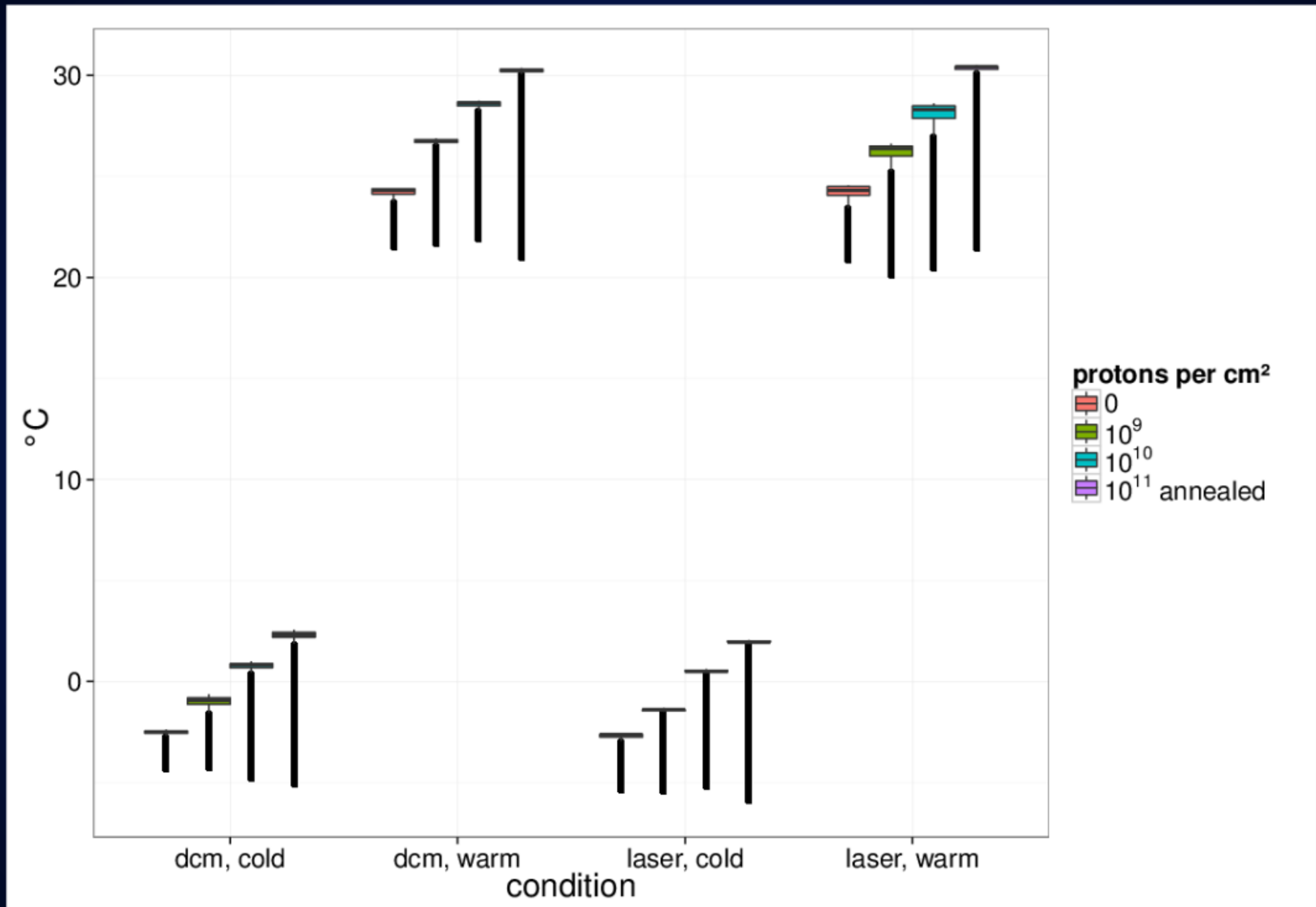
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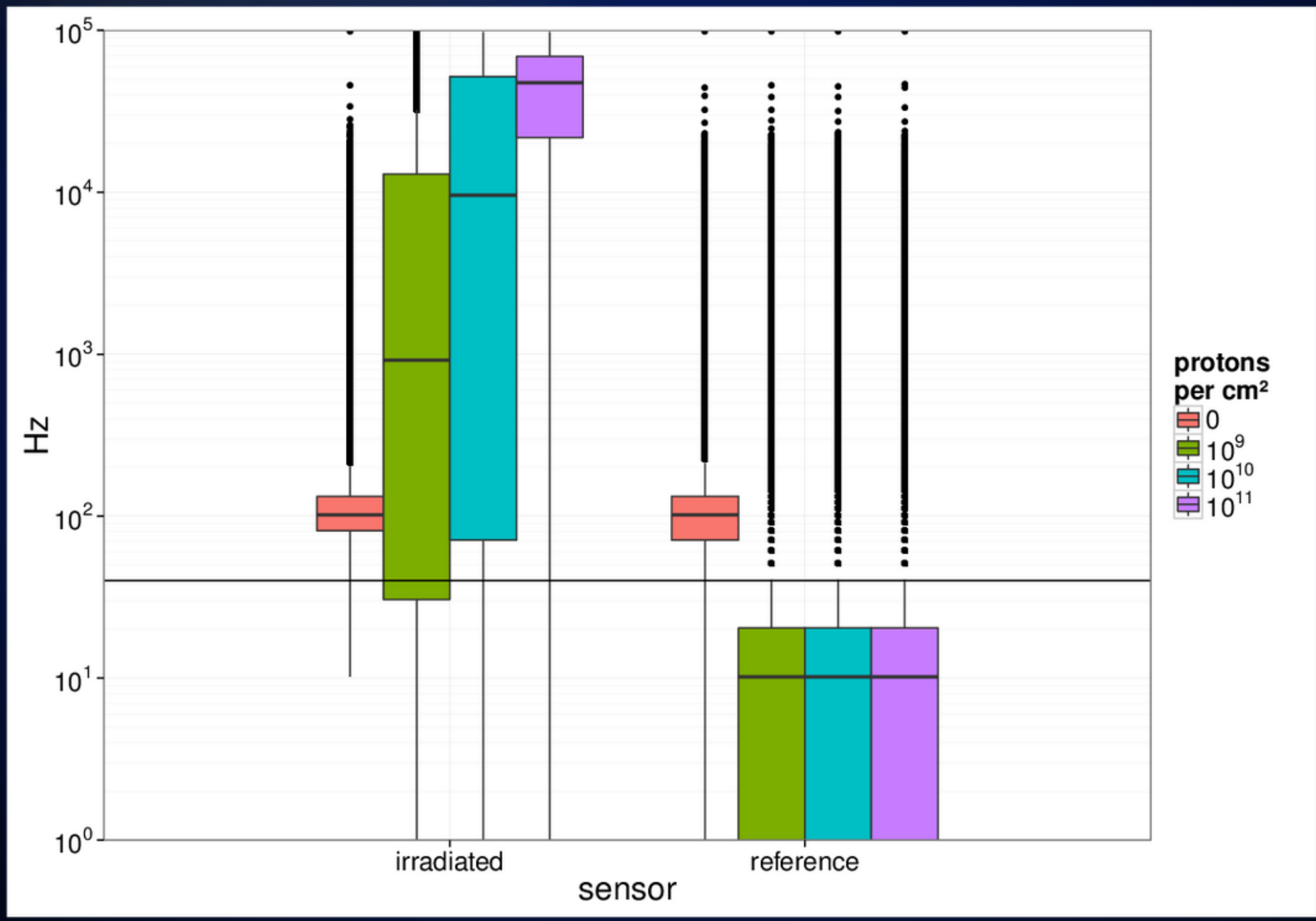
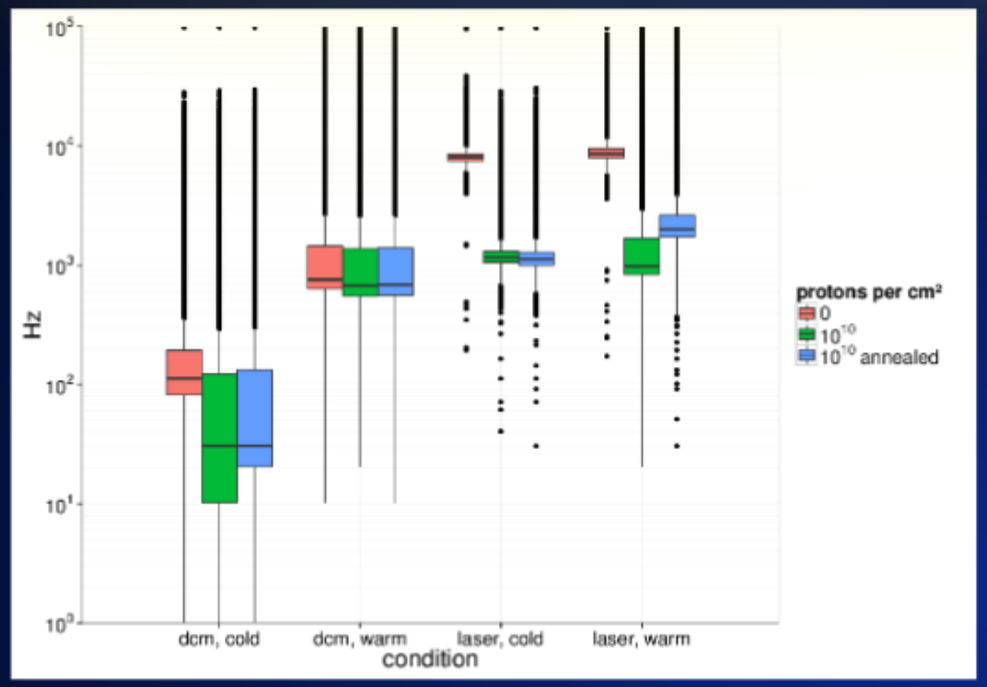
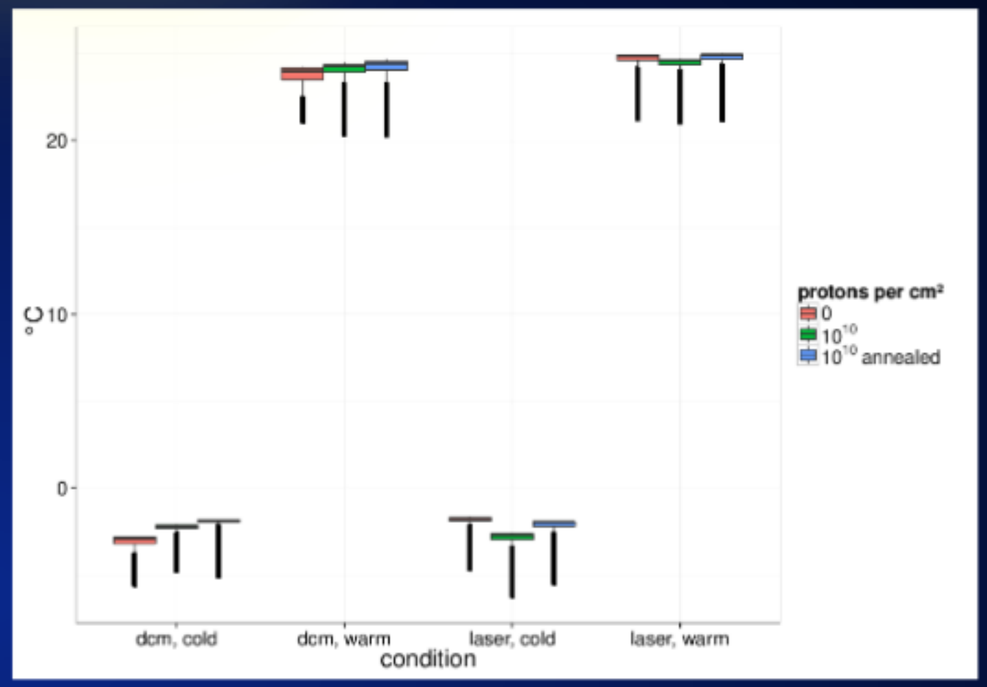
°C
dcm, cold
dcm, warm
laser, cold
laser, warm
condition
protons per cm²
0
10^9
10^10
10^11 annealed

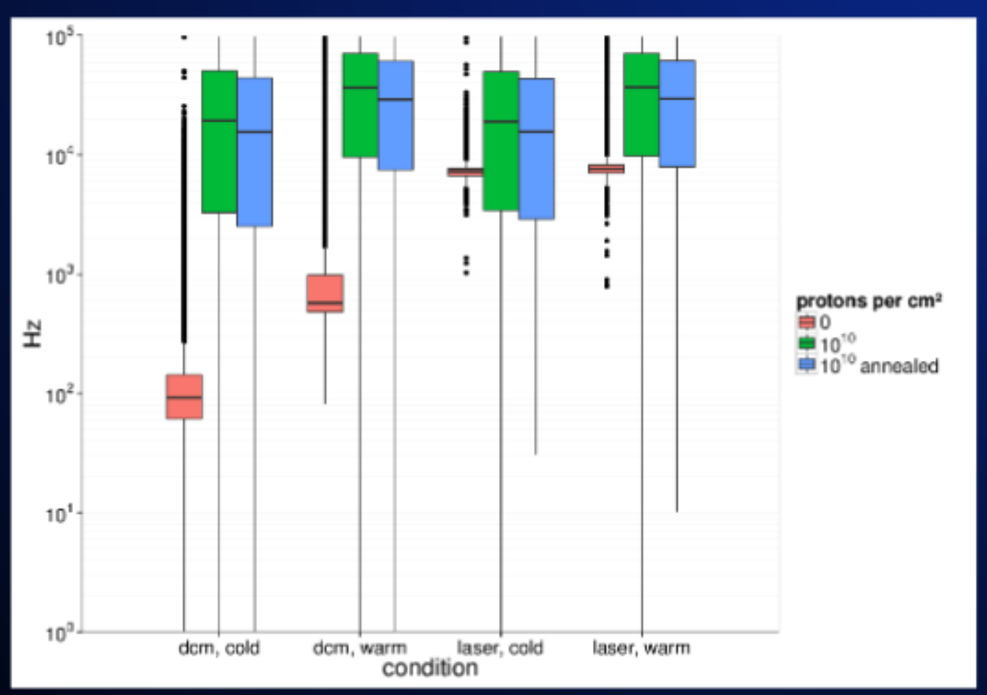
Comparison of the dark count measurements

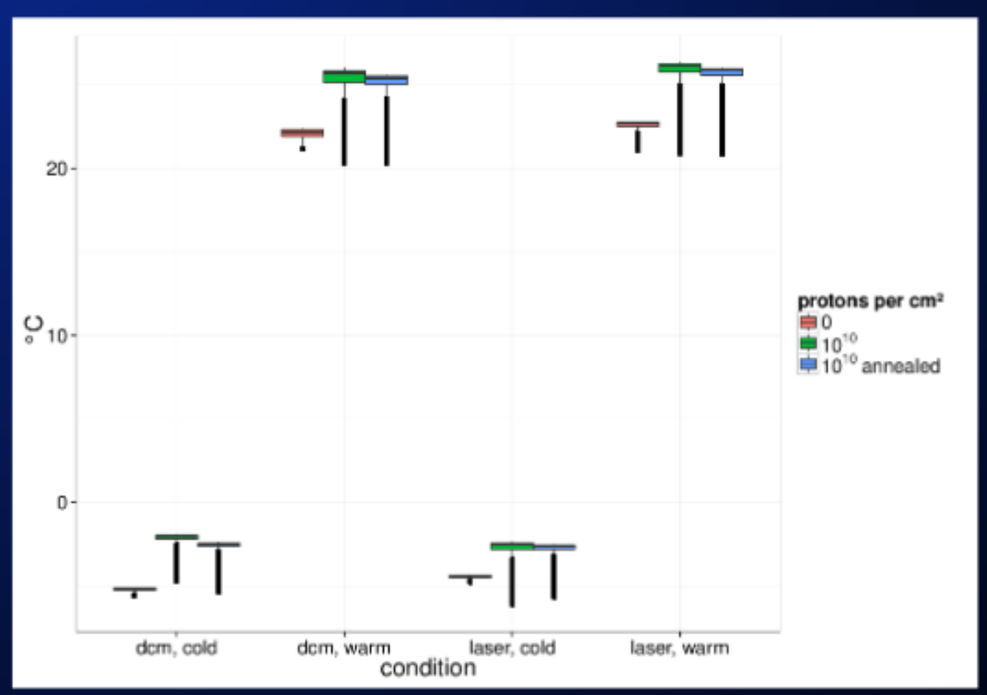


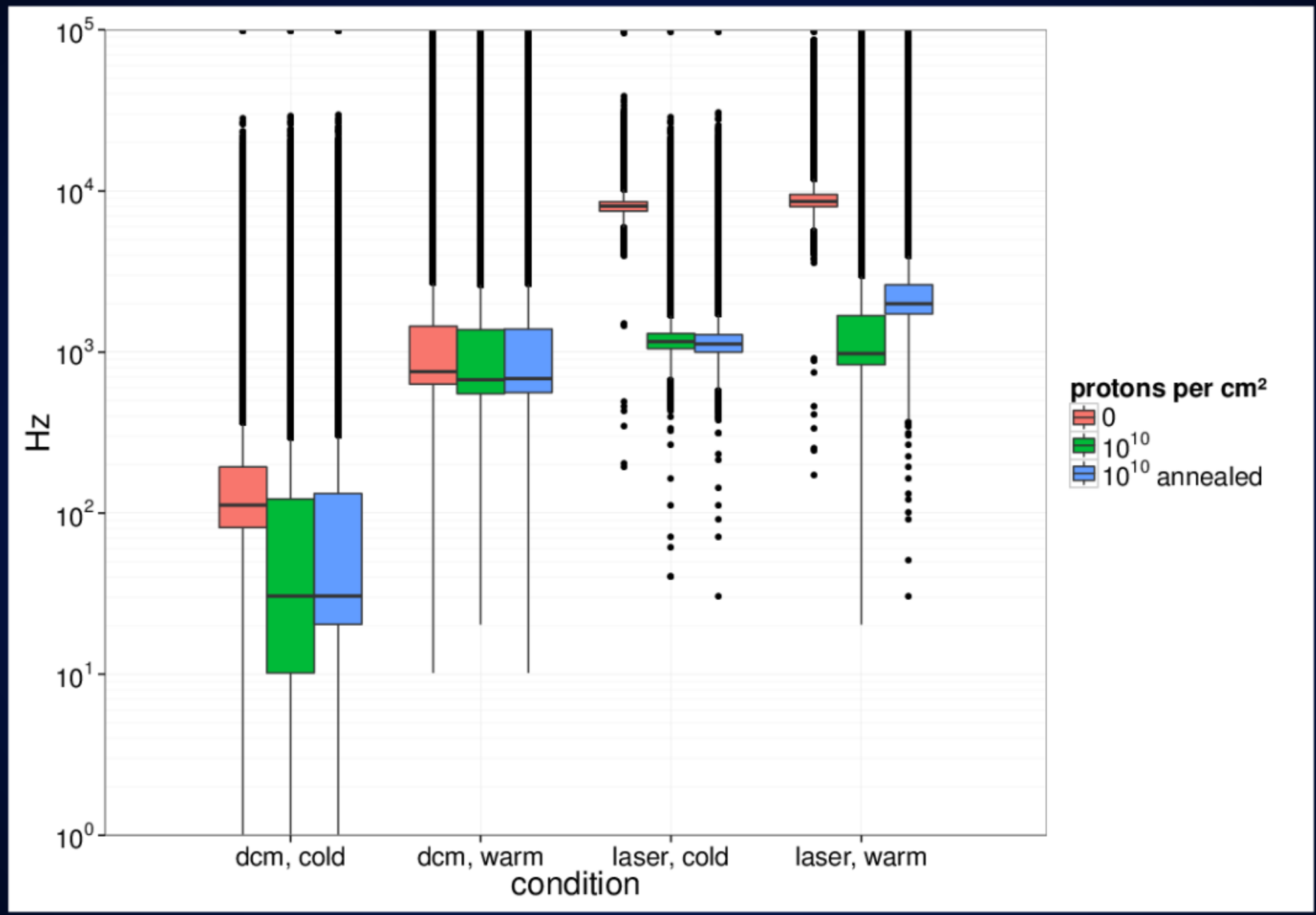
Annealing effect studies







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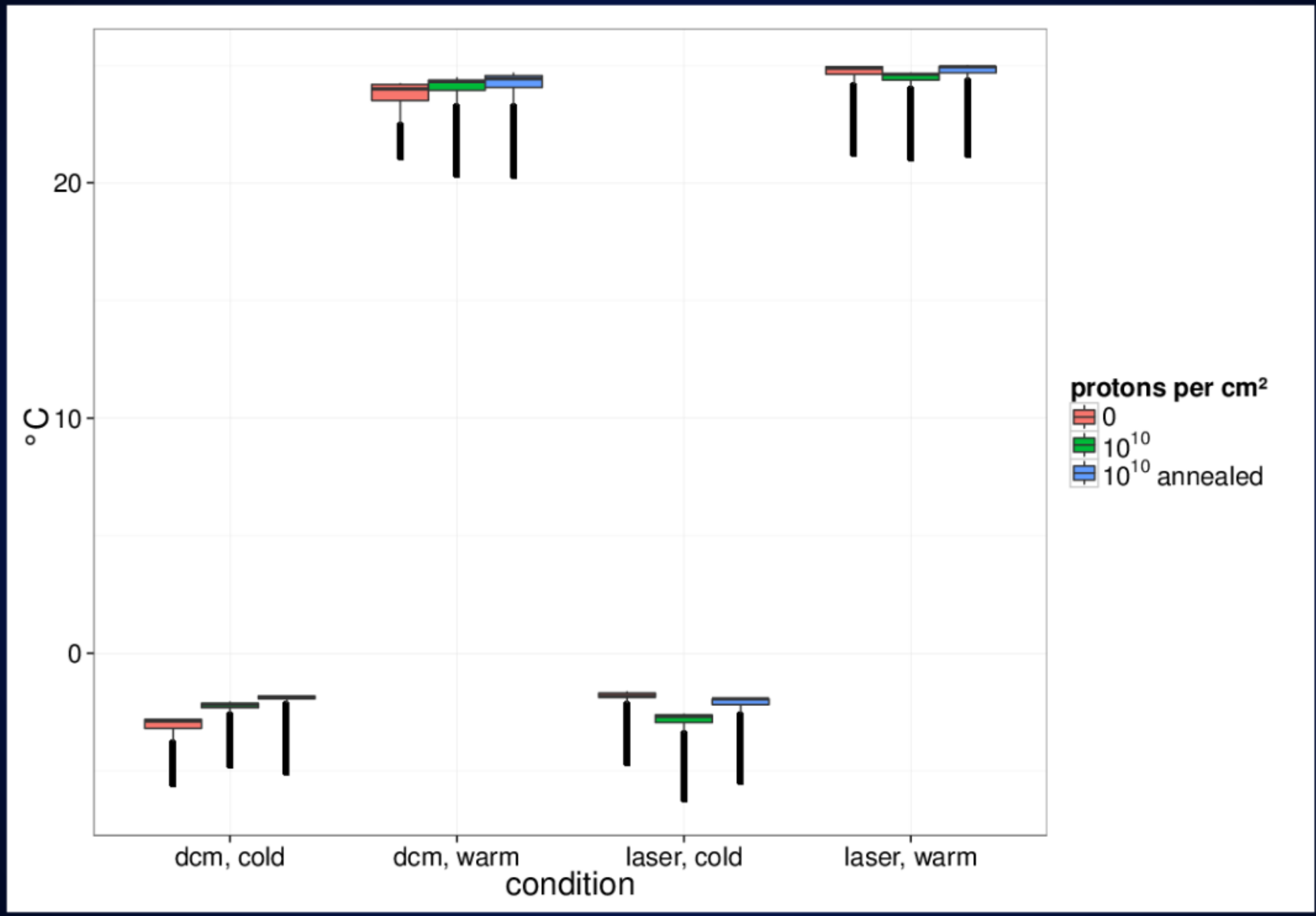
10^{10} annealed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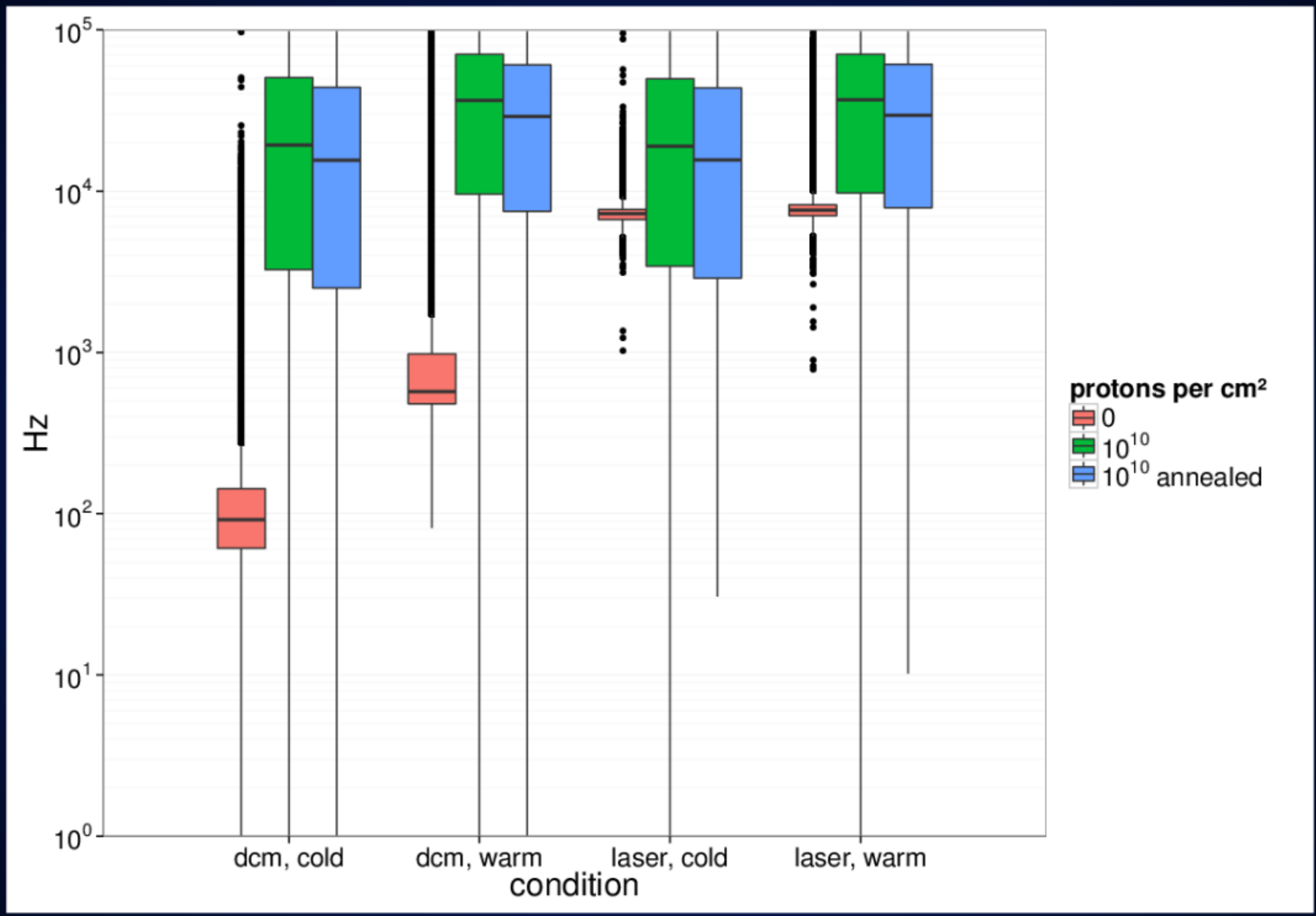
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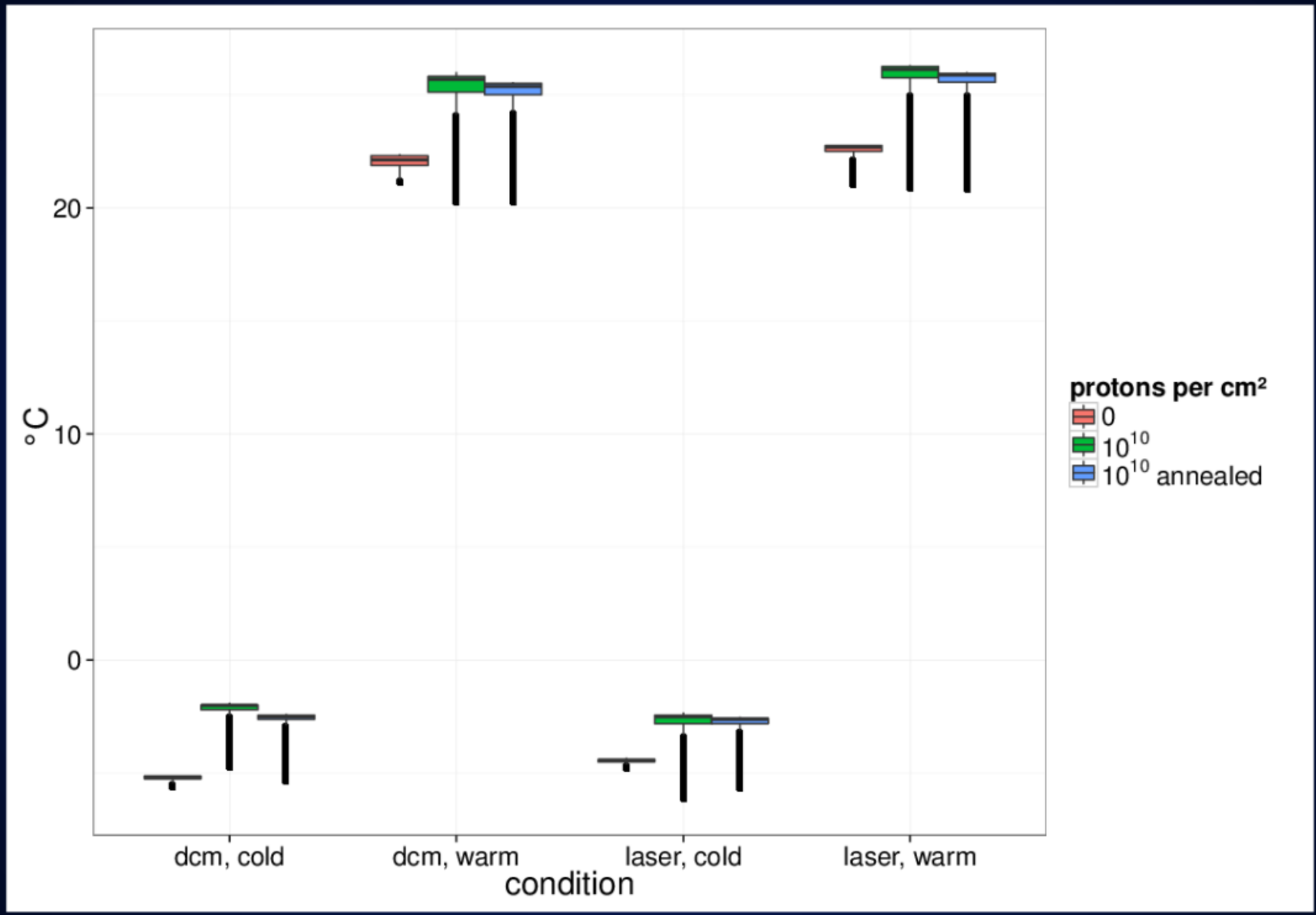
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Interpretation of the radiation damage

Damage from defects in lattice or oxide charging?

▷ TEK module in stove at 80°C right now

Damage in SiPM cells or in electronics?

▷ Observed patterns ⇒ damage in electronics?

▷ Used transistors → ring transistors with guard ring

- requires more space
- fill factor decreases
- PDE becomes worse

▷ Philips has already prototypes with radiation hard components.

Conclusion

- Dark count rate of TEK modules increases significantly after irradiation with protons.
- Cause of the damage is still analyzed.
- Currently available TEK modules are probably not suitable for PANDA.

Thanks to

- Dr. P.D.Eversheim (HISK Bonn)
- Operators from HISKP Bonn
- Thomas Frach (Philips)
- Ralf Schulze (Philips)