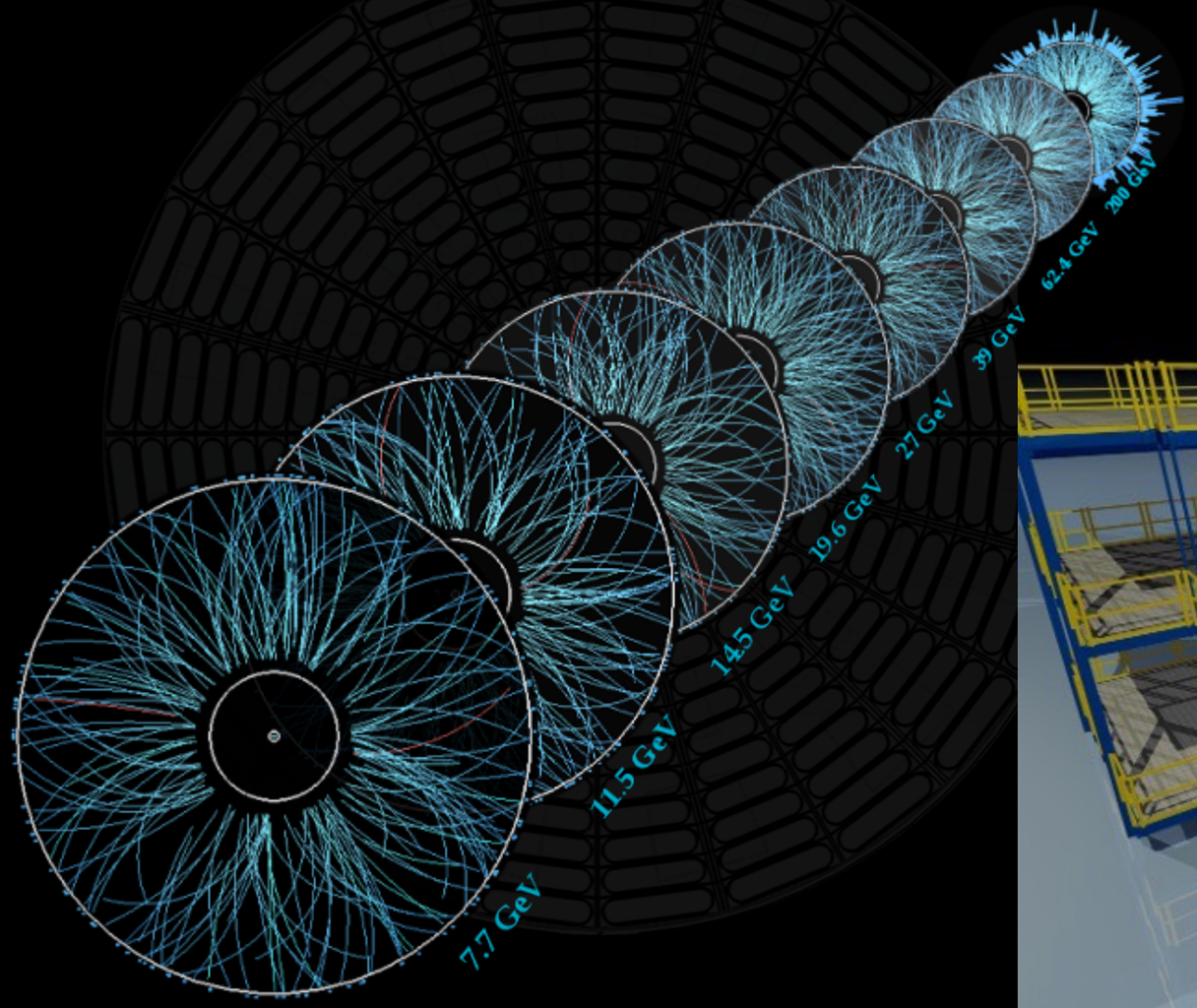
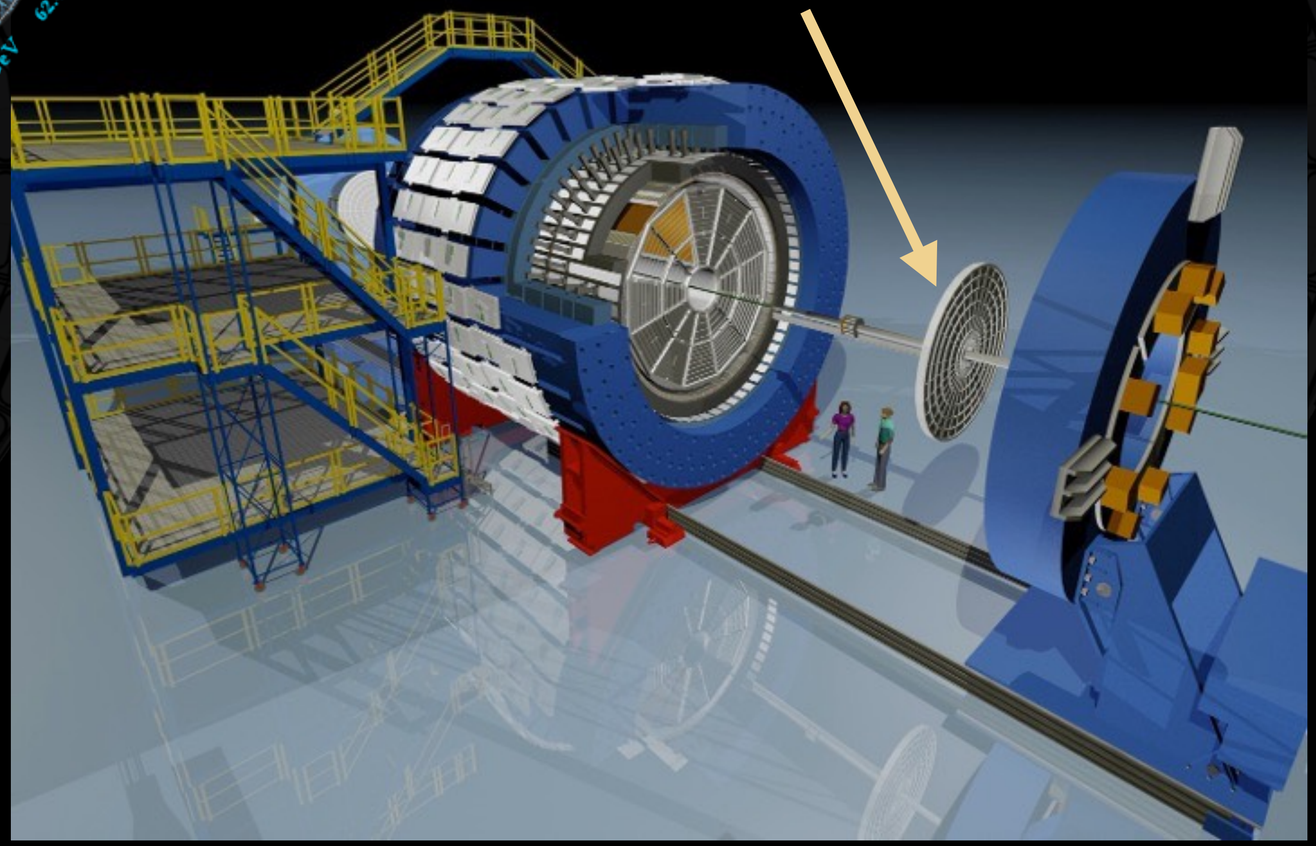
SiPM radiation damage

Event Plane Detector @ STAR

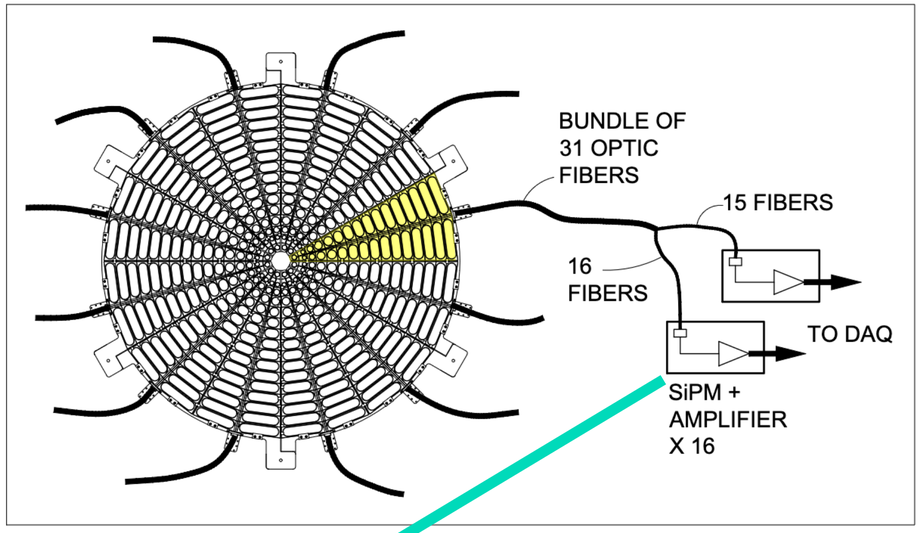
The Ohio State University Maria Stefaniak, June 25th 2025

Solenoid Tracker at RHIC

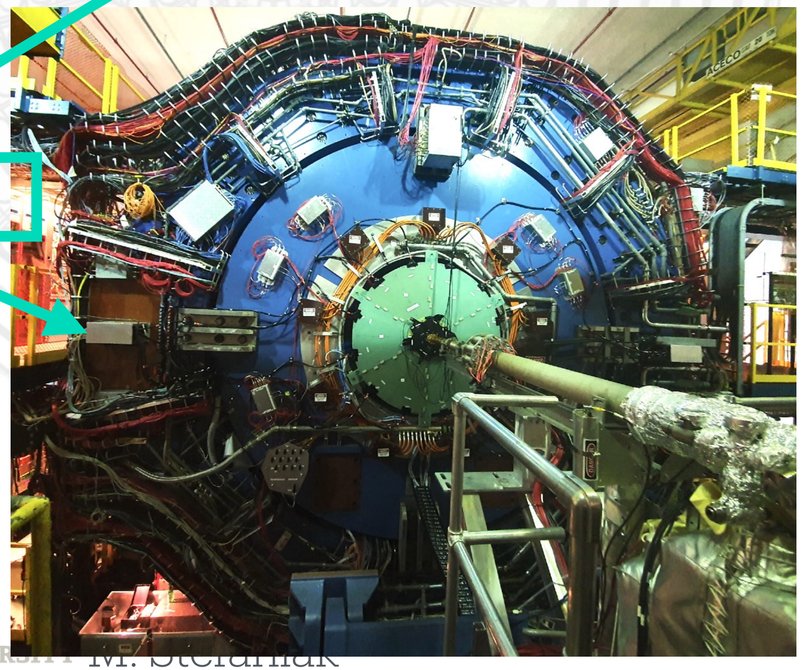




EPD design



SiPMs in FEE box

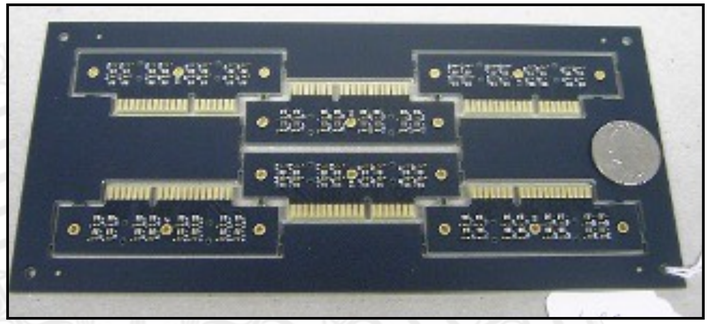


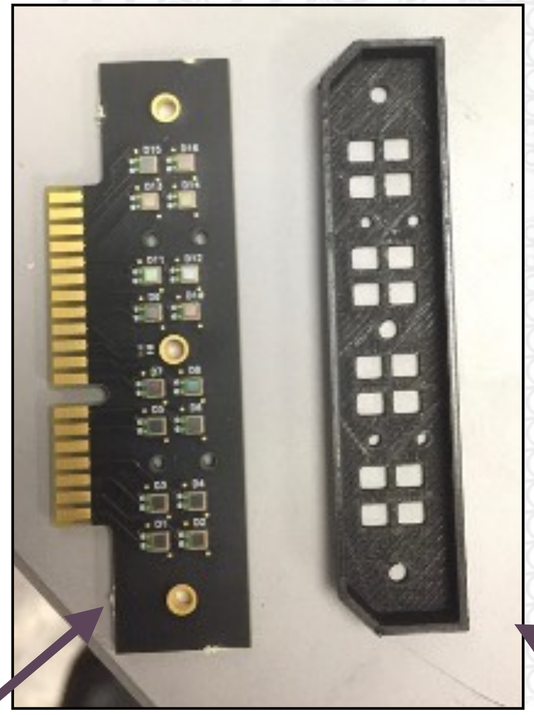
Links with more details:
Construction proposal
M. Lisa, et all: The STAR Event Plane Detector

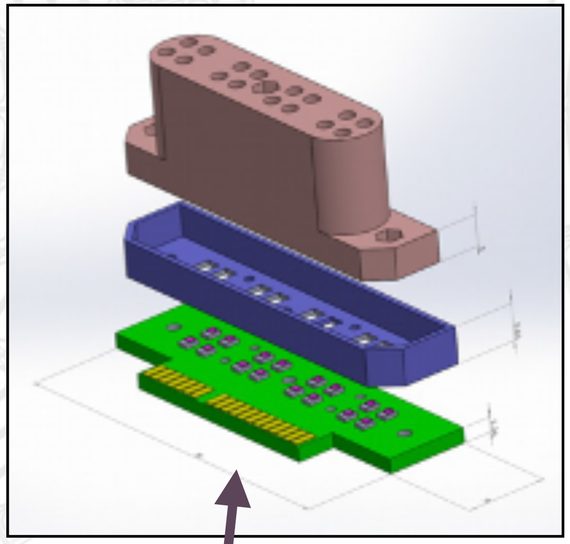
- 2 wheels, each composed of 12 super sectors
- Each supersector: 31 optically-isolated tiles:
  - 1.2-cm-thick scintillator (Eljen EJ-200)
  - 3 turns of WLS fiber (Kuraray Y-11, 1mmD)
  - R_{in}=4.5 cm, R_{out}=90 cm, z_{mount}=375 cm
- Each of 12x31x2 =744 channels
  - Optical signal transported **5.5m** on clear fiber (Kurary 1.15 mmD BJ round)
  - **Coupled to SiPM (Hammatsu S13360-1325PE)**
    - **25 μp pixels →1600+ illuminated pixels**
  - Read out by STAR FEE/QTs
- Custom-built connector components

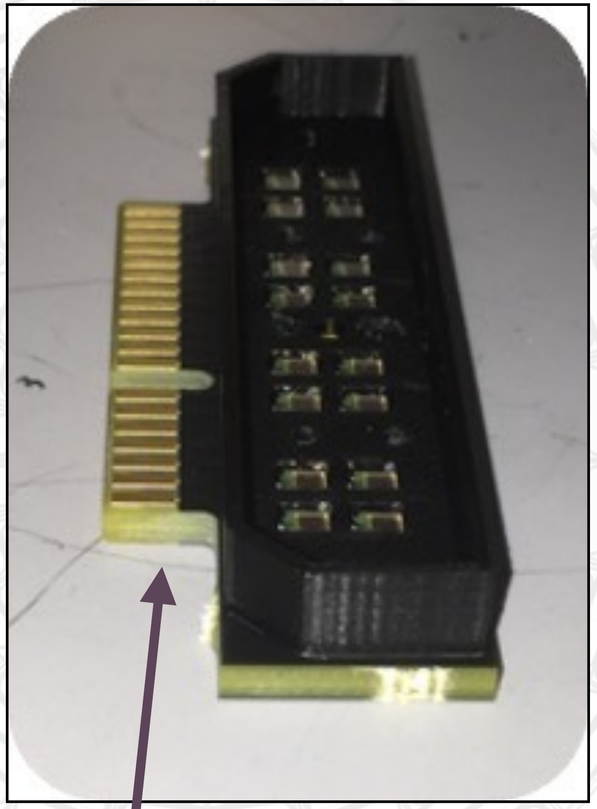
EPD SiPM

EPD SiPM PCBs
(Sierra Circuits, Calif.)









Edge connector plugs into EPD FEE card

EPD SiPM card: 16x 25 µm SiPMs
(Assembly CEM, Long Island)

EPD FSC spacer block (3D printed)

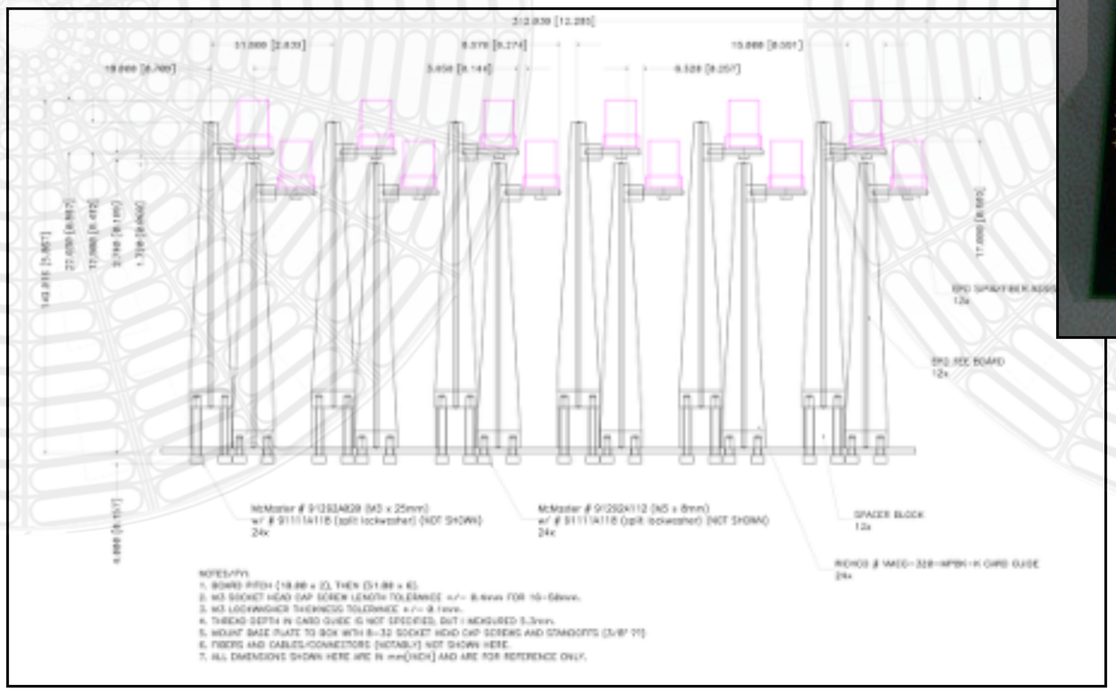
EPD SiPM - FEE Electronics

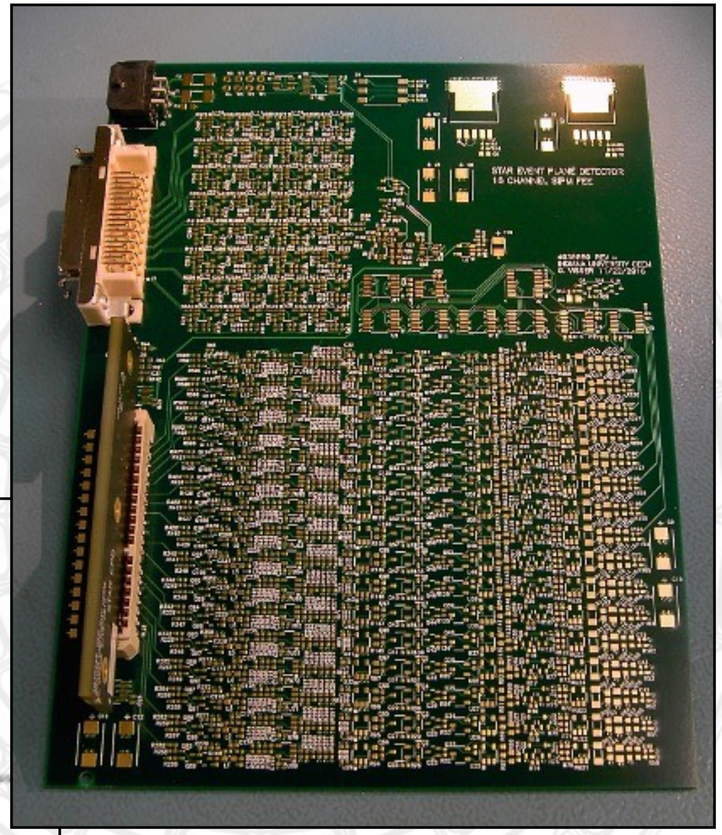
PCB order from Teknet in the end of 2016

VERY compact (considering fiber bend):

4 FEE boxes → handling 6 supersectors

(12 FEEs, 186 channels)





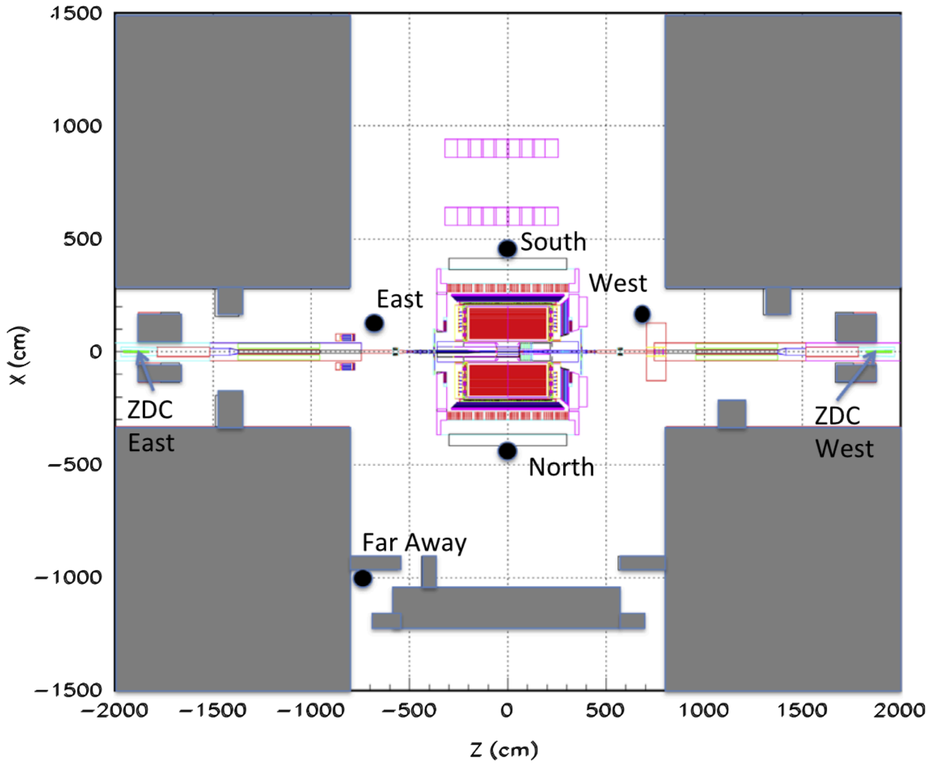
Radiation Damage of SiPM - predictions

Construction proposal :

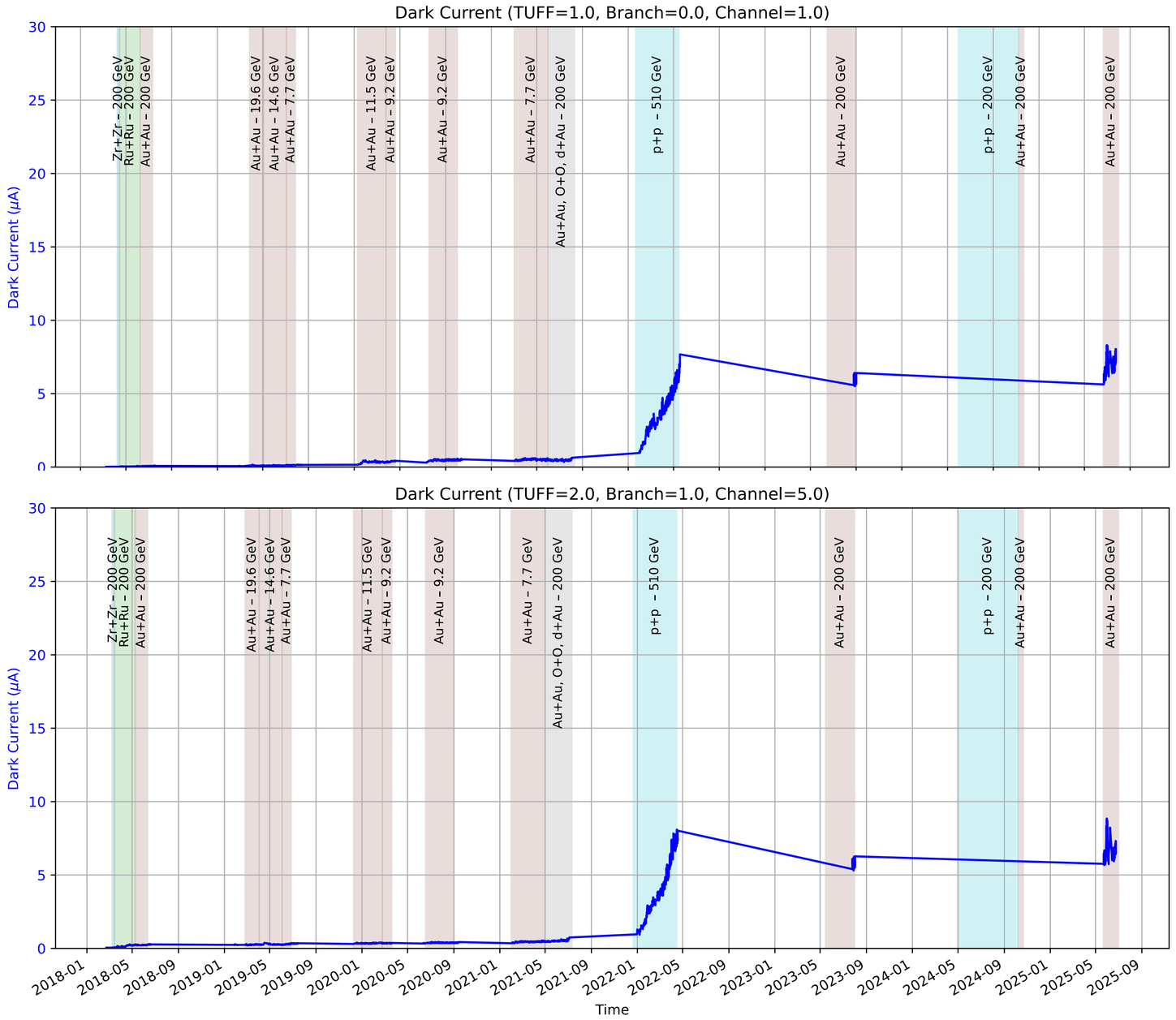
4.1.2 Radiation Damage of SiPMs

It was necessary to ensure that radiation damage does not affect our measurements within the two years of BESII running, as well as for any additional runs that utilize the EPD. It is estimated that the amount of radiation during BESII in collider mode is on the order of $3x10^{11}/cm^2$. The additional background radiation is still unknown. Based on neutron flux measurements in the STAR cave during the high luminosity p+p 510 GeV run [46], we can make an estimation for the expected radiation dose. The integrated number of neutrons for one run (100 days) with $E_{kin} \geq 100$ keV close to the beampipe at a distance of 6.75 m is on the order of $10^{10}/cm^2$. This can be compared to detailed radiation hardness measurements of several SiPMs for the JLab hall B calorimeter, which have been recently performed [47]. Preliminary estimates indicate that we should be aware of possible radiation damage effects during the BES II run. We are investigating this issue in more detail by analyzing the prototype installed in RHIC in run 16. A more comprehensive study will be done during our Run 17 commissioning run, however at the moment we see no evidence of radiation damage in the SiPM signals.

[46] Y. Fisyak, O. Tsai,et all: Thermal neutron flux...
[47] Y. Qiang et all: Radiation Hardness (JLab) ...



Dark Current @ SiPM



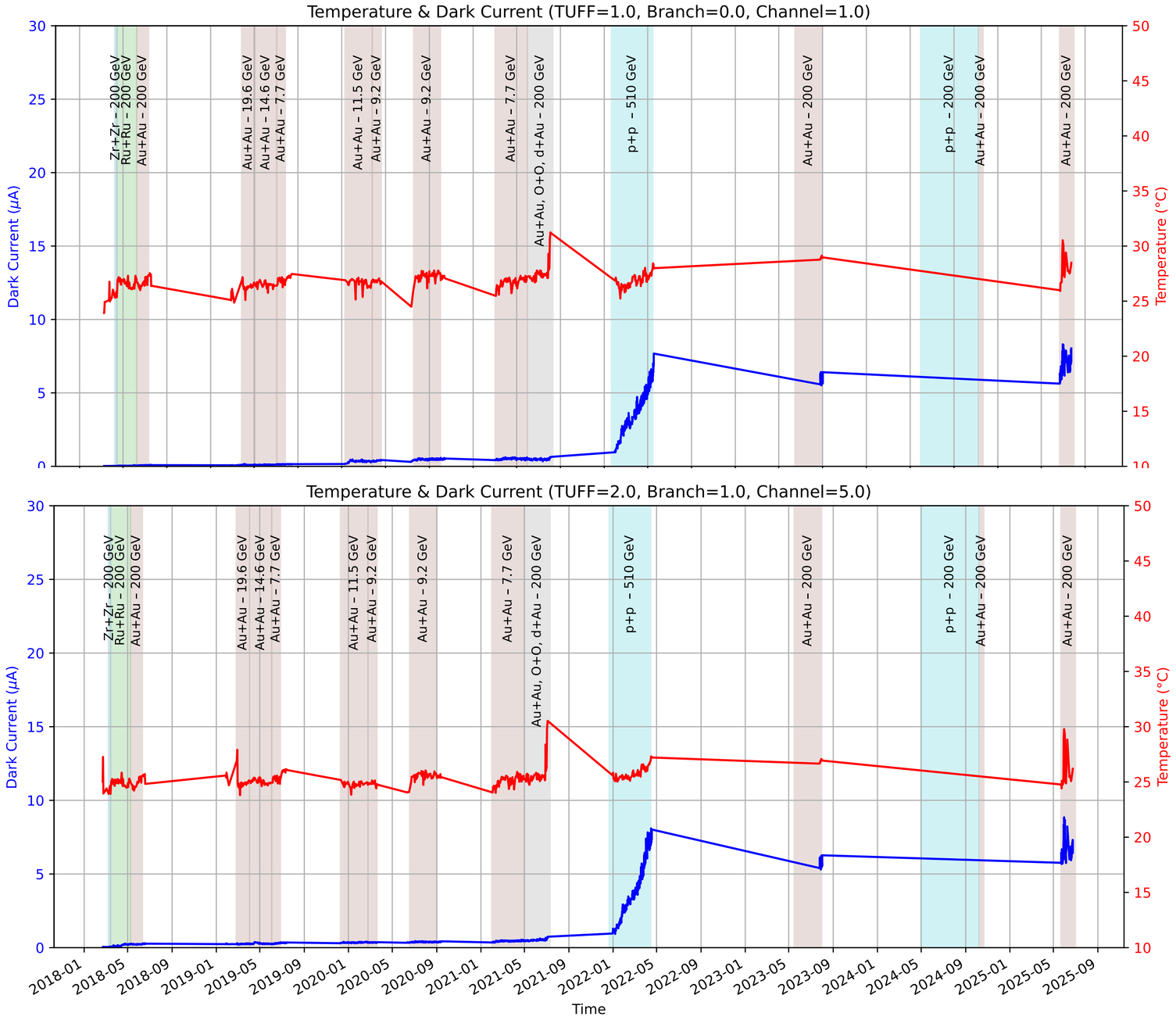
Two selected SiPMs (not connected to tile)
From different E/W and S/N sides of FEE boxes

V_{gain}: 59.5V - 60.5V

p+p run at 510 GeV critical for the radiation damage.

All the plots

Dark Current @ SiPM



Two selected SiPMs (not connected to tile)
From different E/W and S/N sides of FEE boxes

V_{gain}: 59.5V - 60.5V

p+p run at 510 GeV critical for the radiation damage.

Temperature increases

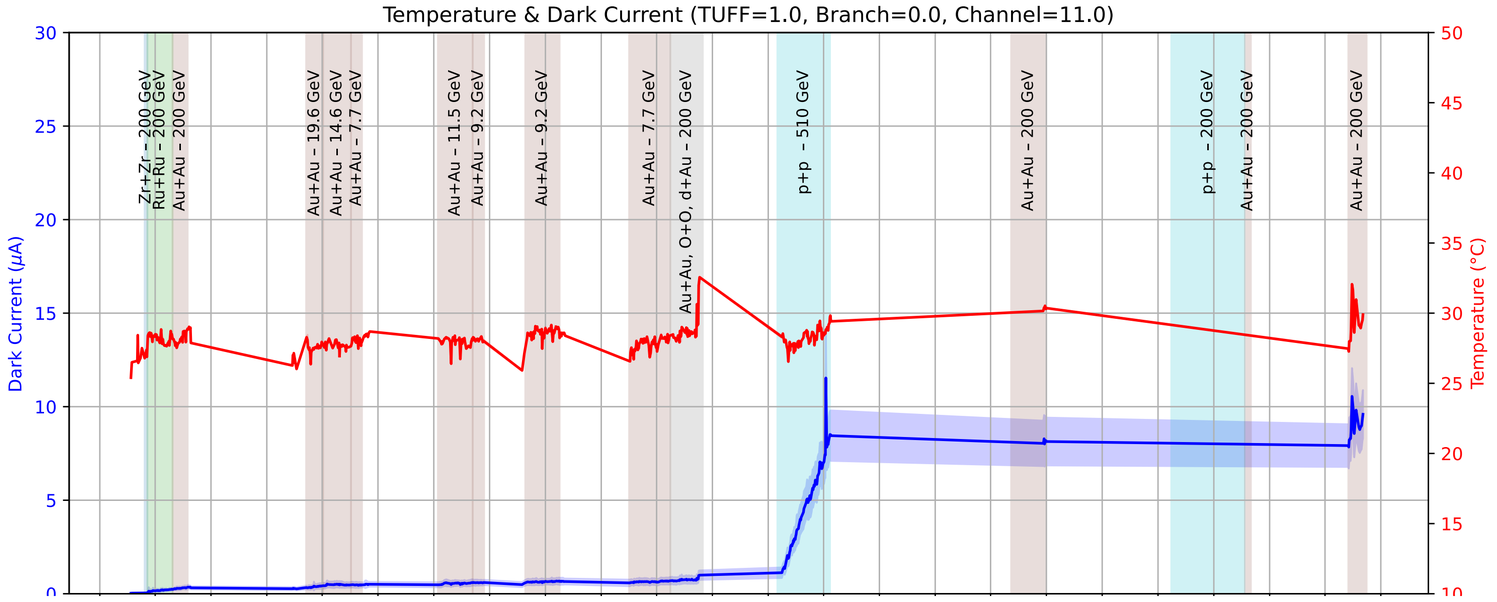
More information about the pp run:

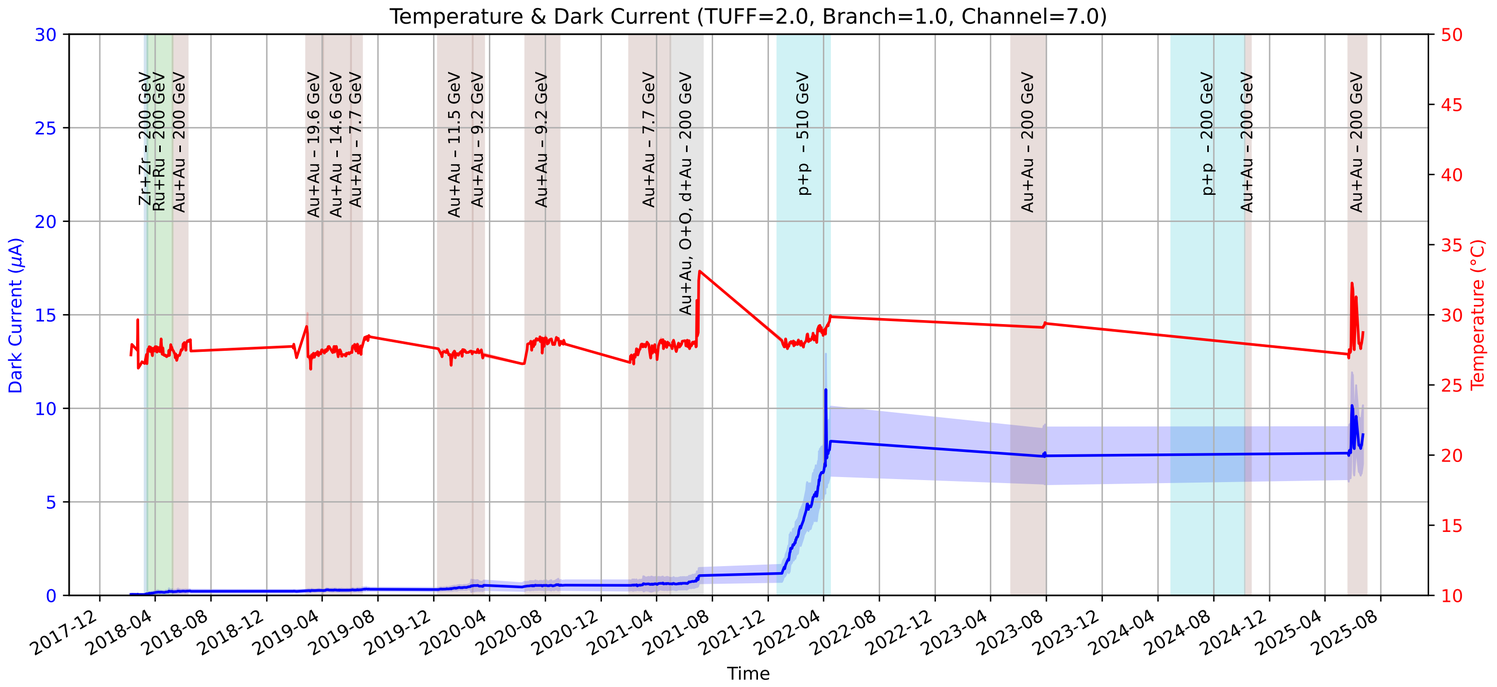
V. Schoefer, E. Aschenauer et all: RHIC polarized proton operation in run 22

All the plots

Dark Current @ SiPM

Mean for each board; error = 1 σ





Two selected Channels
From different E/W and S/N sides of FEE boxes

V_{gain}: 59.5V - 60.5V

p+p run at 510 GeV critical for the radiation damage.

Temperature increases

More information about the pp run:

V. Schoefer, E. Aschenauer et all: RHIC polarized proton operation in run 22

All the plots

Summary

- p+p run at 510 GeV critical for the radiation damage: Increase of Dark Current from 0.2 μA even up to 8 μA !