Radiation hardness tests of Silicon Strip Detectors
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Facility for Antiproton and Ion Research (FAIR)
- under construction at GSI, Darmstadt
- provides high intensity beams from protons to uranium ions for several associated experiments
- 29 GeV proton and 11 AGeV Au beams

Silicon Strip Detectors
- reverse biased silicon detectors
  - 1024 strips per side
  - 58 µm pitch, ~200 µm thickness
  - strips on p-side inclined at an angle of 7.5°
  - several formfactors depending on position within the STS: 5 × 6, 6 × 6 cm, 6 × 4 cm and 6 × 2 cm

Compressed Baryonic Matter (CBM)
- probing the nuclear equation of state in the baryon-rich region
- investigation of dense nuclear matter through heavy ion collisions
- high beam intensity, fixed target ⇒ high collision rate, large statistics

Compressed Baryonic Matter (CBM)
- 8 layers of double-sided silicon strip detectors
- particle momentum measurement inside 1 T dipole magnet
- triggerless continuous readout of ~1300 sensors

Silicon Tracking System (STS)
- triggerless continuous readout of ~1300 sensors
- 1300 sensors
- 8 layers of double-sided silicon strip detectors
- high beam intensity, fixed target ⇒ high collision rate, large statistics

Radiation Damage
- interaction rates of 10^7 Hz cause high doses of ionizing and non-ionizing radiation (10^4 n/cm^2 over several years, depending on on running conditions, need to be replaced after that)
- lattice defects cause additional doping ⇒ change in electrical properties ⇒ detector failure
- common irradiation methods very short (few minutes)
- cross-check of simulations and measurements needed with long-term irradiation and live monitoring

Neutron generation
- Roemer Van-de-Graaf accelerator provides primary deuteron beam
- deuterium gas target installed into beamline (see Fig. 1)
- generated neutrons emerge uncollimated, but with boost in beam direction
- detector mounted close to the gas target to maximize solid angle coverage

Challenges and gas target design
Issues of previous designs
- low deuteron energies (~2.5 MeV) ⇒ thin entrance window with low Z required
- high gas density necessary to maximize collision probability
- high target gas pressure (~4 bar) causes large stresses on entrance window
- beam energy deposition heats up and weakens entrance window ⇒ reduced lifetime

Improvements
- 1 µm thin window from Si or SN
- cooling by liquid nitrogen (via copper rod)
- beamline vacuum provides thermal insulation
- small gas target length improves solid angle coverage of detector
- increased gas density without increasing pressure, increased window lifetime due to lower temperature and pressure

Readout system
- stainless steel housing, electromagnetic shielding
- Peltier cooling to -5°C (STS specification)
- light-tight setup for PMT
- fixed connection between Alibava daughter board and detector, necessary for bonding wires

Detector housing and readout
- parallel readout of up to 256 channels via 2 beetle chips
- software for testing, calibration and readout

Irradiation setup
- parallel readout of up to 256 channels via 2 beetle chips
- software for testing, calibration and readout
- daughter board directly connected to sensor (see Fig. 6)
- ^90Sr source to generate detector pulses
- trigger signal provided by plastic scintillator + PMT, reduces noise issues

Current status
- gas target operational
- liquid nitrogen dewar provides ~1 week cooling time
- additional insulation necessary to account for beam heating
- housing and holding structures in construction
- readout software tested via built-in simulation functions, final setup to be tested
- slow control and live monitoring in development

References