Radiation Hardness Study on Fused Silica

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on behalf of the
PANDA Cherenkov Group

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Details on PANDA DIRC detectors

- K. Föh, 'The DIRC projects of the PANDA experiment at FAIR'
- P. Schönmeier, 'The Endcap DIRC of the PANDA experiment'
- C. Schwarz, 'The Barrel DIRC of the PANDA experiment'
Irradiation at KVI

- Proton beam (150MeV)
  - Average stopping power in SiO$_2$ (SRIM) 4.7MeV/(g/cm$^2$)

- Beam size determination
  - LANEX scintillating screen + CCD
  - FWHM ~4mm

- Ionisation chamber
  - Beam current between 0.5 and 100nA
  - Max dose of 10Mrad in app 6 min
Samples

- 3 fused silica samples
  - Corning 7980
  - Schott Lithosil Q0
  - Heraeus Suprasil 1
- Estimated dose ~ 100krad
  - Planned dose 10krad, 100krad, 1Mrad and 10Mrad
  - Delivered dose sys 20% higher
Transmission Measurement

- Cary 300 double beam Spectrophotometer
  - Wavelength between 200 and 800nm
  - Beam spot 2x8mm
  - Precision better than $10^{-3}$
  - Wavelength accuracy better than 0.2nm

- Each sample measured before irradiation at 4 spots

Measurements performed by E. Bennet & E. Cowie
Finding Radiation Spots

- Measurements 4 weeks after irradiation
  - Samples stored in light-tight box
- Two scans across sample
  - 2mm steps (determined by beam spot size)
- 10 krad spot not visible due to beam halo
- Remaining spots clearly visible
- Use to adapt sample positioning in spectrophotometer
Sensitivity

- Normalised difference
  \[ \Delta I = \frac{I_{\text{ref}} - I_{\text{sample}}}{I_{\text{ref}}} \]

- Compensate for Fresnel loss

- Error sources and contributions
  - Sample positioning \(~ 0.1\%\)
  - Sample inhomogeneity \(< 0.3\%\)

- Sensitivity better than 1%
Example Analysis of LiF

- Only 1 and 10 Mrad spot visible
- Transmission measurement reveals two lower dose spots
Fused Silica – Corning 7980

- Sample size 80x80x20mm³
  - Irradiation spots separated by 40mm
- First and last measurement in a scan influenced by edge effects
- No irradiation spots detected
Fused Silica – Schott Lithosil

- Sample size 50x50x15mm³
  - Irradiation spots separated by 25mm
- This sample exhibits most homogeneous result of all fused silica samples
- Small deviations around 200nm probably due to cleaning
Fused Silica – Heraeus Suprasil 1

- BaBar reported significant transmission loss between 200–300nm for Suprasil Standard (NIM A515(2003) 680)
- Different sample geometry
  - BaBar: 20cm
  - This work: 2cm
    - Expect 5% deviation at 200nm
- No significant damage observed for Suprasil 1
Surface Study

- Zygo GPI XP/D interferometer
  - He-Ne laser at 632.8nm
  - $\lambda/300$ (2$\sigma$) resolution
- Check for surface dilatation
  - observed for silicate crown glasses under proton irradiation (> 1Mrad)

➔ No significant surface change observed
   ➢ Corning 7980 sample shown
Conclusions

- 3 fused silica types irradiated with 150MeV proton beam
  - 3 established dose levels: 100krad, 1Mrad and 10Mrad
  - Irradiation spots clearly visible in crown glass and LiF
- Transmission behaviour between 200 and 800nm monitored
  - No significant radiation damage observed in any fused silica sample
  - Sensitivity better than 1.0%
- No surface dilatation observed
- Further activities
  - Neutron damage