Light from Carbon targets

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Motivation

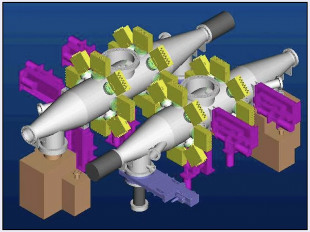
Direct measurement of temperature of carbon targets

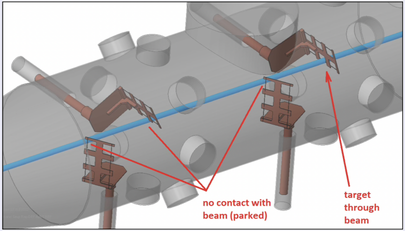
- Current Situation
  - At present, the temperatures of carbon fibers in the polarimeter targets at RHIC's IP12 cannot be measured directly.
  - The targets survive proton bombardment, indicating that the carbon sublimation temperature ($T_{\mathrm{sub}} = 3915$ K) is not reached.
  - This observation aligns with energy loss calculations by Peter Thieberger (BNL), assuming appropriate beam sizes. Thieberger's code is available on SharePoint.
- Importance of Carbon Beam Polarimeters
  - Essential for RHIC and will be for EIC, enabling fast beam polarization measurements.
  - Targets measure polarization components (p_x, p_y) of $\vec{P} = (p_x, p_y, p_z)$.
  - It is critical to verify the applicability of carbon fibers for polarimetry with increased proton beam currents.
  - Temperature estimates suggest similar target temperatures at IP4 in the HSR (EIC) as at RHIC, due to favorable beam optics despite increased RF heating.
- Direct temperature measurement of carbon targets remains crucial goal
  - Black-body radiation theory [1] offers a method to determine temperature by analyzing the emitted light spectrum.

IP12 CNI chambers setup

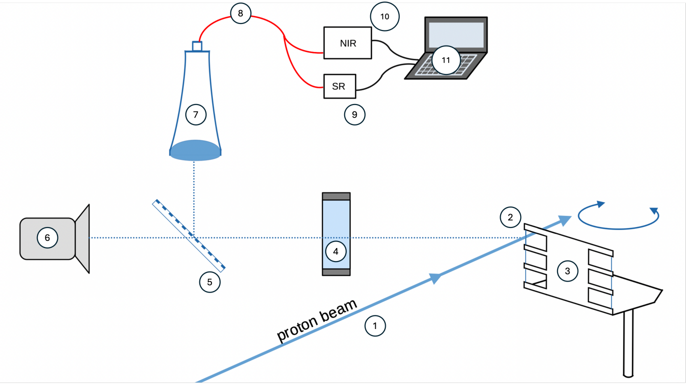
- Two double-target chambers in IP12
- Recoil detectors at different azimuths
- Side flanges pointing towards the interactions
- Target holder forks for vertical and horizontal targets
- Holder first does a translation from its parking position, and then rotates to sweep a fiber target through the beam

CNI chamber





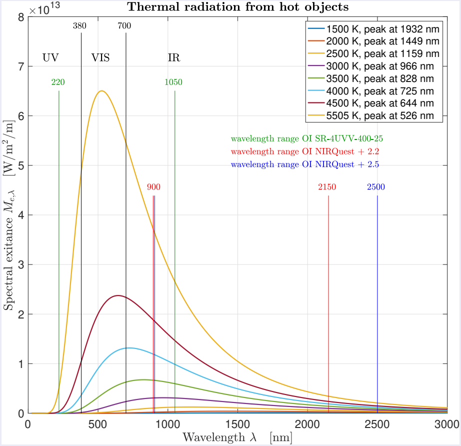
Experimental setup



1. proton beam
2. fiber target
3. target holder
4. fused-silica viewport
5. semi-transparent polka-dot mirror
6. optical camera
7. collimator lens
8. fiber splitter (VIS and IR)
9. spectrometer VIS (SR)
10. spectrometer IR (NIR)
11. spectral analysis ($\lambda = 200 - 2200\,\text{nm}$)

Black body radiation

Ideally, one would measure:



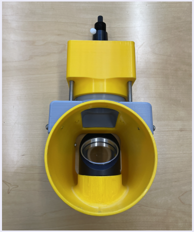
But: wavelength-dependent attenuation in

- fused-silica viewport
- polka dot mirror
- collimator lens
- 100 m glass fibers from IP12 to spectrometers

Lab test measurement using IR light source

Experimental setup

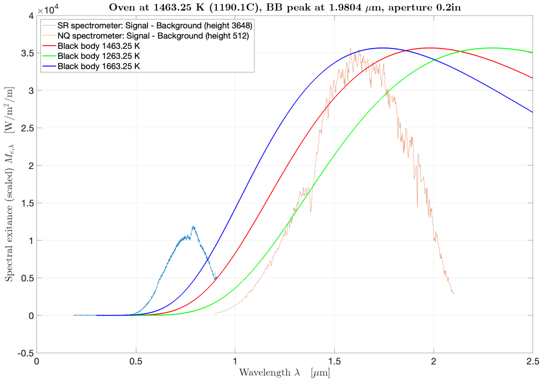

Viewport holder




Lab test measurement using IR light source

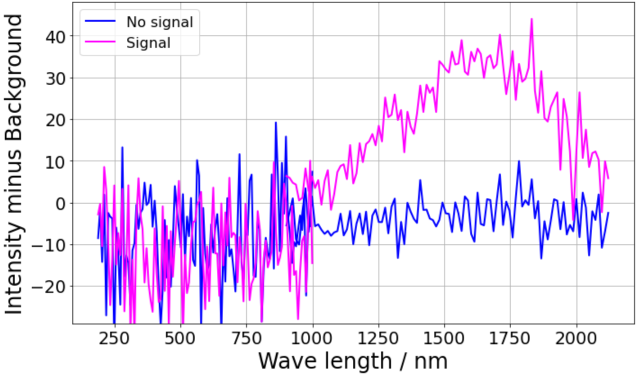
Black body radiation using oven at 1463 K

- SR spectrometer: 200 to 900 nm
- NIR spectrometer: 900 to 2100 nm
- Light path includes fiber splitter and 100 m glass fibers
- Measured spectrum compared to blackbody radiation spectra at 1463 K, 1263 K, and 1663 K



Test measurements using C targets at IP4

- In 2024, equipment/components arrived late, thus optimal alignment of light collection system at IP4 was not possible.
- The data were continuesly taken, integration time of spectrometers is 1 s.
- We observe a clear signal, however, the light intensity is low because we don't aim at the brightest spot on the target
- For the same reason, the temperature we observe is only around 1400 K, about half of what we would expect

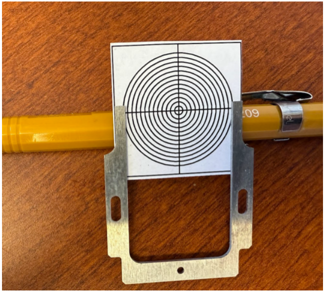


Summary

- **The understanding of heating of carbon polarimetry fiber targets by high energy proton beam is crucial for EIC**
- Light collection system was installed and operated during run 24
- A small but clear signal was detected from the Y1 target.
- Due to misalignment we are missing target center
- As CNI chamber was already sealed off/pumped down when all components were available, light collection system could not be properly aligned

Summary

- **Improve alignment before ring closes, repeat measurement in run 25**
  - For the alignment a visual crosshair target at the beam-target intersection position will be used
  - New improved viewport holders were designed and printed
- Will use four targets in blue, two horizontal ones and two vertical ones
- Need 100 GeV protons in blue with max. number of bunches stored
- APEX proposal was made. APEX dedicated time is only required in case no proton beam available in run 25. With 100 GeV stored protons, we can run parasitically.



References

[1] M. Planck, *The Theory of Heat Radiation* (P. Blakiston's Son & Co., 1914).