SHMS Heavy Gas Čerenkov

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SHMS Detector Review
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Introduction

- At higher momenta, hadron species cannot be reliably distinguished by time of flight over the 2.2 m SHMS detector stack baseline.
- Good PID therefore requires a series of Čerenkov detectors, each with different index of refraction:
  - e^-/π^- $\Rightarrow$ Noble Gas Čerenkov (n-1 < 10^{-4})
  - π^+/K^+ $\Rightarrow$ Heavy Gas Čerenkov (n-1 ≤ 10^{-3})
  - K^+/p $\Rightarrow$ Aerogel Čerenkov (n-1 ≤ 0.03)
- The Heavy Gas Čerenkov will be the primary means for π^+/K^+ separation above 3.4 GeV/c.
  - A 1 m long cylinder with 1.6 m diameter, to be operated at up to 1 atm pressure.

Radiator Gas Update

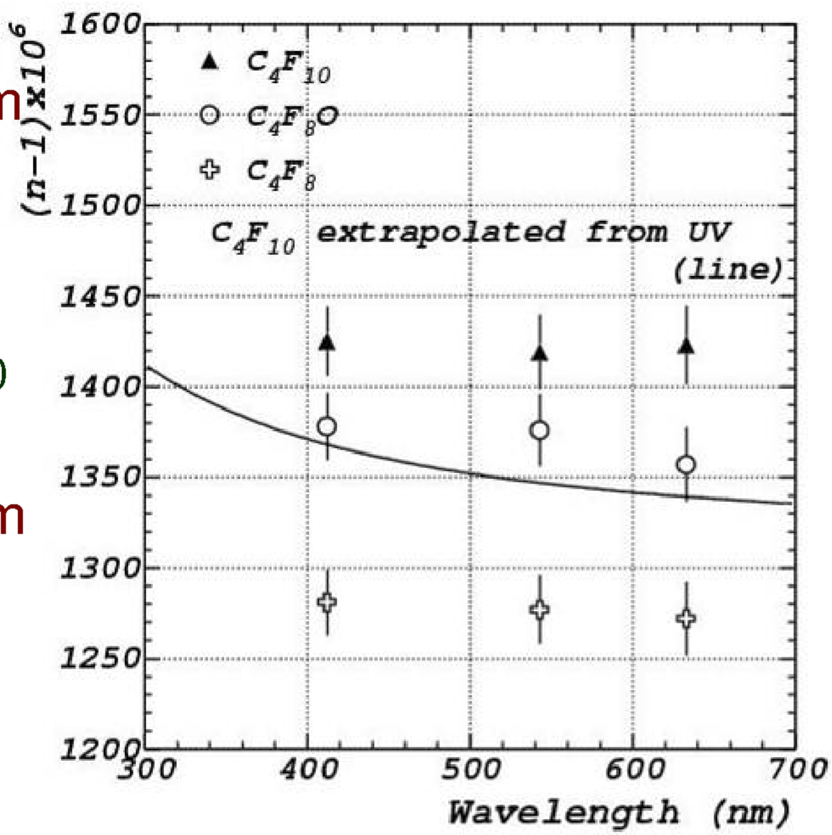
- The heavy gas originally intended for this detector was C_4F_{10}.
  - 3M stopped production of this gas some years ago, although it might still be available from a U.K. supplier (>$300/kg).
- C_4F_8O appears to be the optimal substitute.
  - Widely used in the semiconductor industry for plasma etching.
    - Easily available from many commercial suppliers.
  - Extensively studied by the BTeV collaboration for use in their RICH detector, including beam tests of their prototype.

    *T. Skwarnicki, NIM A **553** (2005) 339-344.*

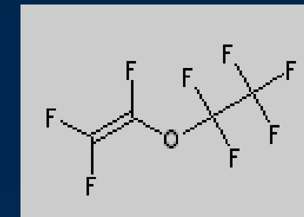
    *N. Artuso, et al., NIM A **558** (2006) 373-387.*
- C_4F_8 was also investigated but found to be a less desirable substitute for C_4F_{10}.

Refractive index measurements

- Michelson interferometer
  - Two identical vessels in beam paths
  - Three laser light sources
- First measurement of C_4F_{10} in visible range
  - Solid line is extrapolation from UV measurements
    - →Used in simulations
- C_4F_8O is best alternative
    - →Also, closest to simulations!

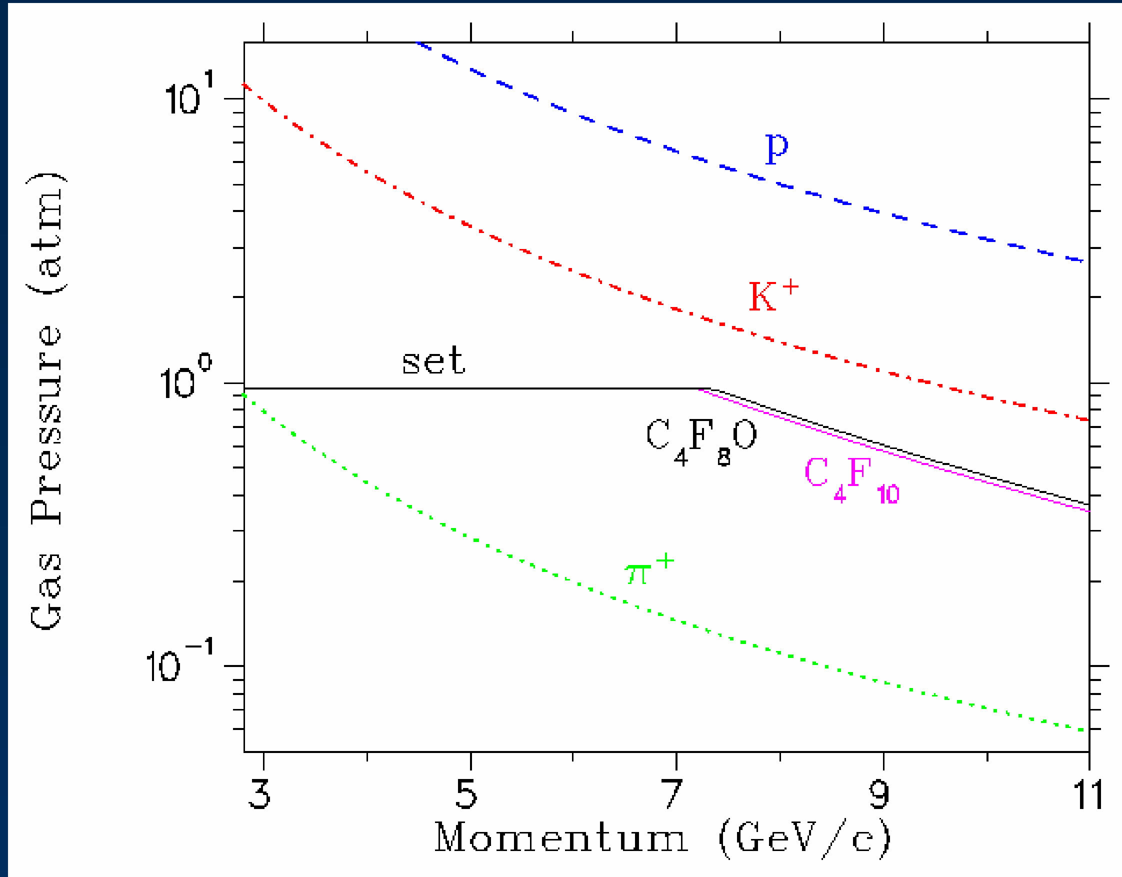


Properties of C_4F_8O (OctaFluoroTetraHydroFuran)



- Gas phase is about 10 times heavier than air (9.19 g/L at 21°C).
- Boiling point: -5°C.
- Vapor pressure: 1.7 atm @ 21°C.
- Stable, non-toxic, non-explosive, non-reactive (except with alkali halide metals).
  - BTeV performed 10 year equivalent exposure tests with a variety of materials (plastics, mirror material, epoxies, composites, water).

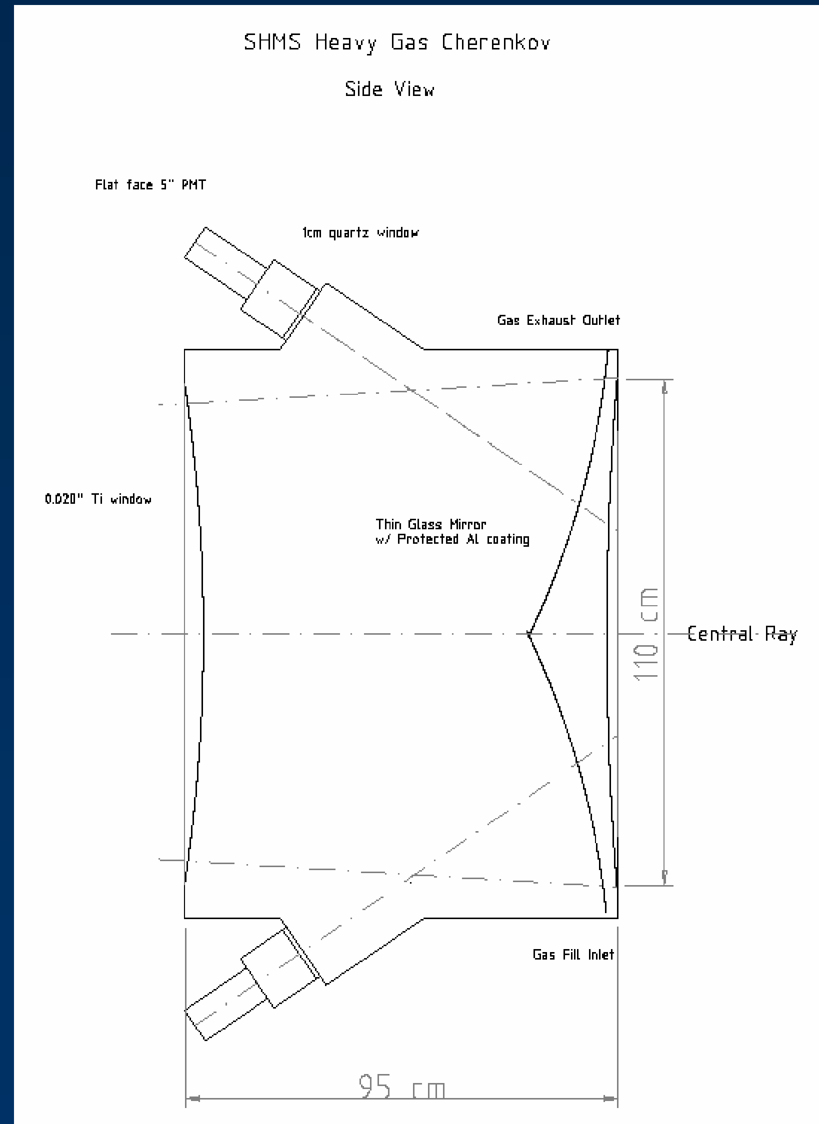
    "No measurable changes seen."
- Can pick-up and transport oils.
  - need to avoid contact with organic materials.
- Unlike C_4F_{10}, it does not destroy ozone.
- Rated as having high global warming potential due to its long atmospheric lifetime if released.
- About $100/kg.



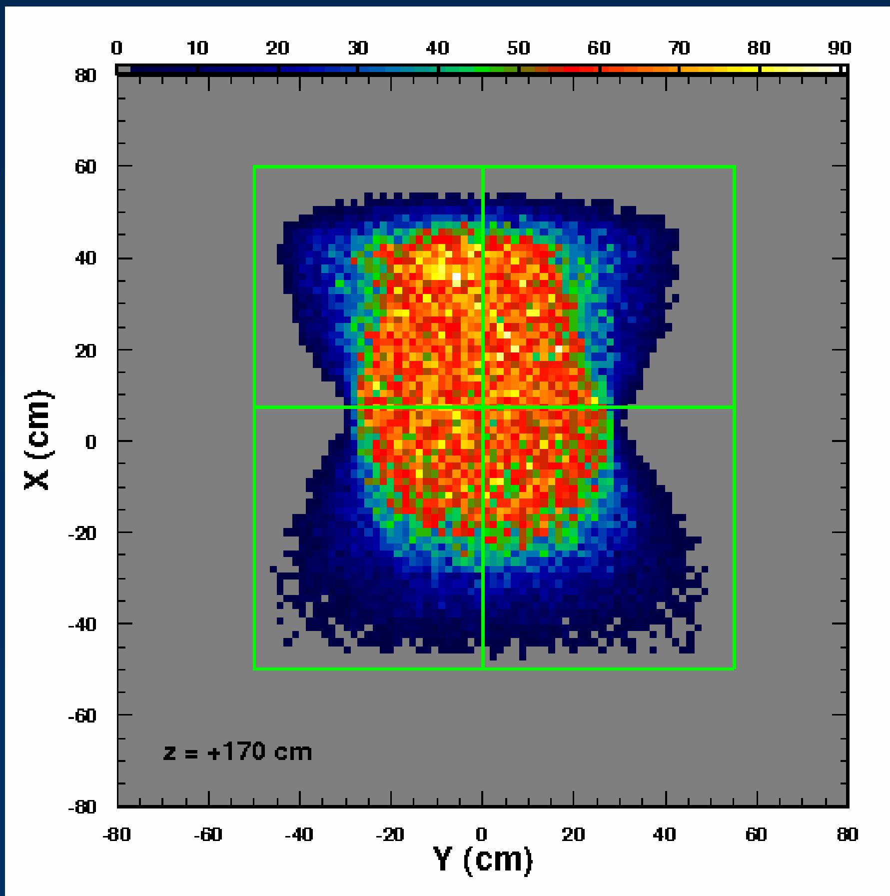
- Maintain sub-atmosphere (0.95 atm) pressure below 7.3 GeV/c.
- Above 7.3 GeV/c, the gas pressure must be reduced to maintain good π/K separation.
- The gap between the `set' and `K' curves takes into account the SHMS momentum bite and a possible 0.1 atm error in the setting of the gas pressure regulator.

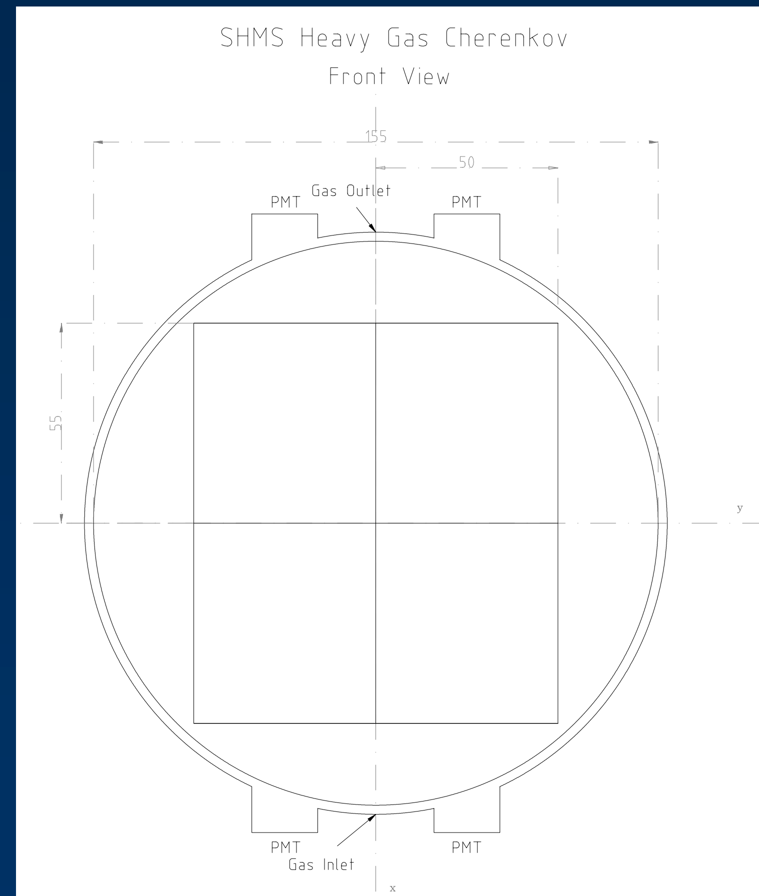
Schematic Design

- Non-magnetic stainless steel pressure vessel.
  - 1.6m diameter cylinder.
- Titanium entrance and exit windows.
  - `One-way' windows since enclosure to be always sub-atmospheric pressure.
- Four high quality thin glass spherical mirrors (50cmx55cm)
  - Structurally reinforced outside beam envelope.
- A gas recirculation and purification system is needed since the gas pressure will be changed frequently for p_{SHMS}>7.4 GeV/c.
  - Intend to keep this system relatively simple, since our O_2, H_20 contamination tolerances are modest (0.1%).



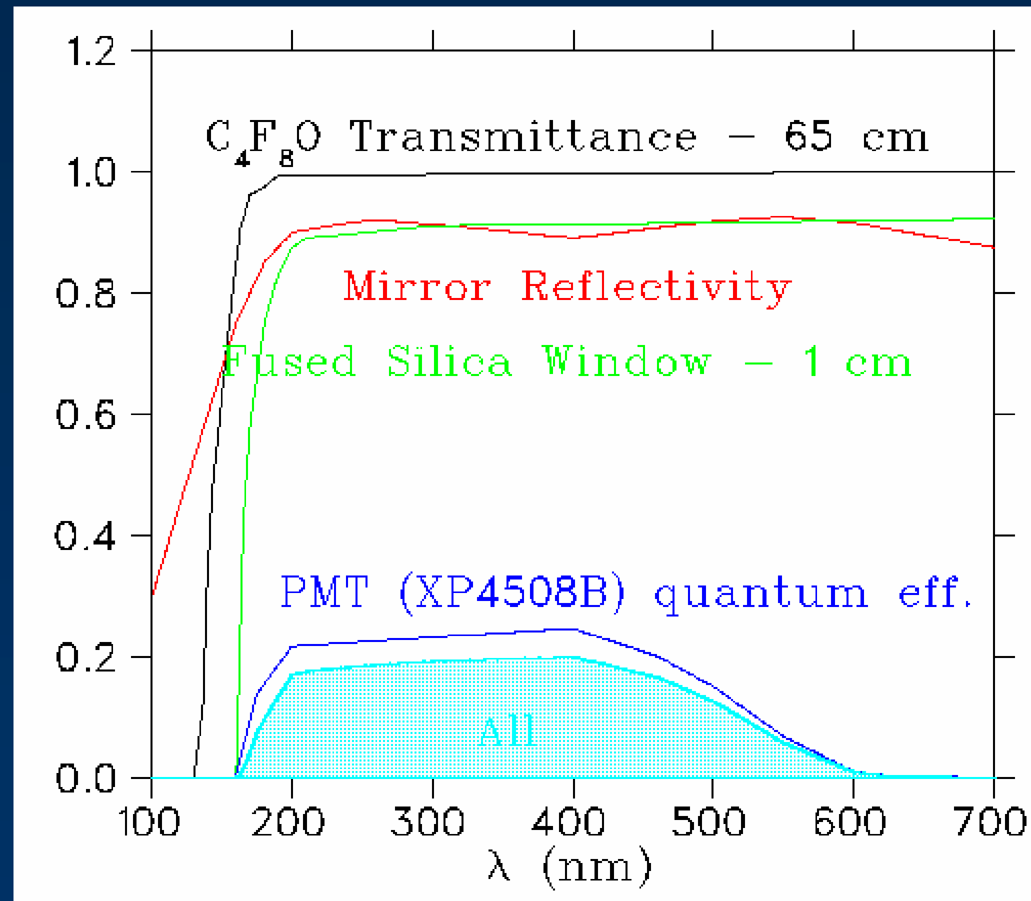
SHMS Focal Plane View



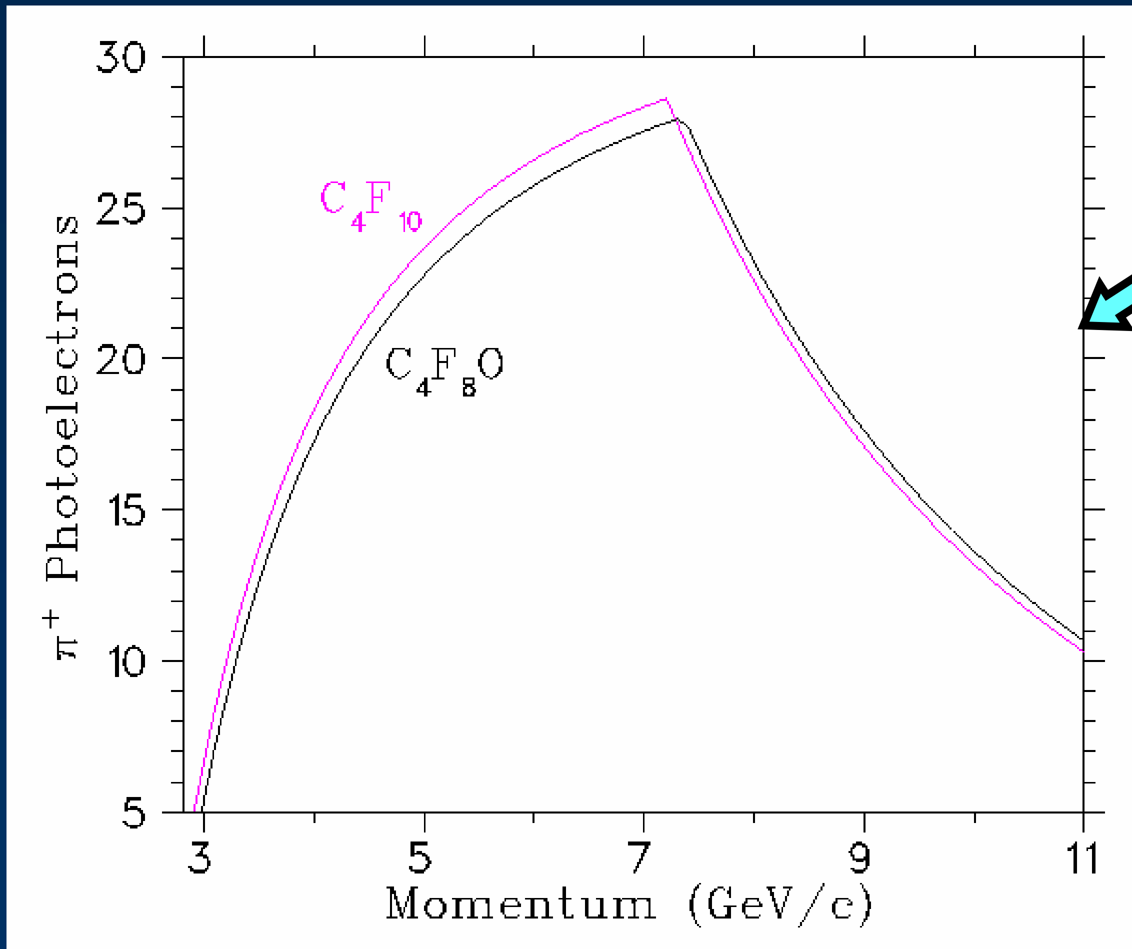


Primary Design Components

- Protected mirror coatings.
  - Reference Al coating from Lambda/Ten Optics.
  - >90% reflectivity down to 200 nm.
- PMTs view enclosure through 1cm UV-grade window.
  - Allows for better isolation of the pressurized cavity.
- Photonis flat-face 5” PMTs mounted flush to window.
  - Bases to incorporate voltage boost between photocathode and first dynode to provide optimum focusing of photoelectrons.



Projected Performance



Projected #p.e. assuming 0.6m effective radiator path length and possible optical misalignment.

Useful (7 p.e.) lower momentum limit estimated to be 3.4 GeV/c.

Integration

- Will deliver:
  - Pressure tested Čerenkov enclosure.
  - Mounted and aligned mirrors.
  - PMTs with custom bases.
- Will need to co-ordinate with JLab staff:
  - Location of mounting and alignment fixtures.
  - Design, location and fabrication of gas recovery and purification system.
- Expecting JLab to provide:
  - Readout electronics, HV channels, cables.
  - Mounting and alignment on SHMS detector frame.
  - User interface for remote pressure change when p_{SHMS} changes.
- Coordination with U.Virginia (Noble Gas Čerenkov):
  - Design, and procurement, where appropriate.

Funding

- Cost estimate:

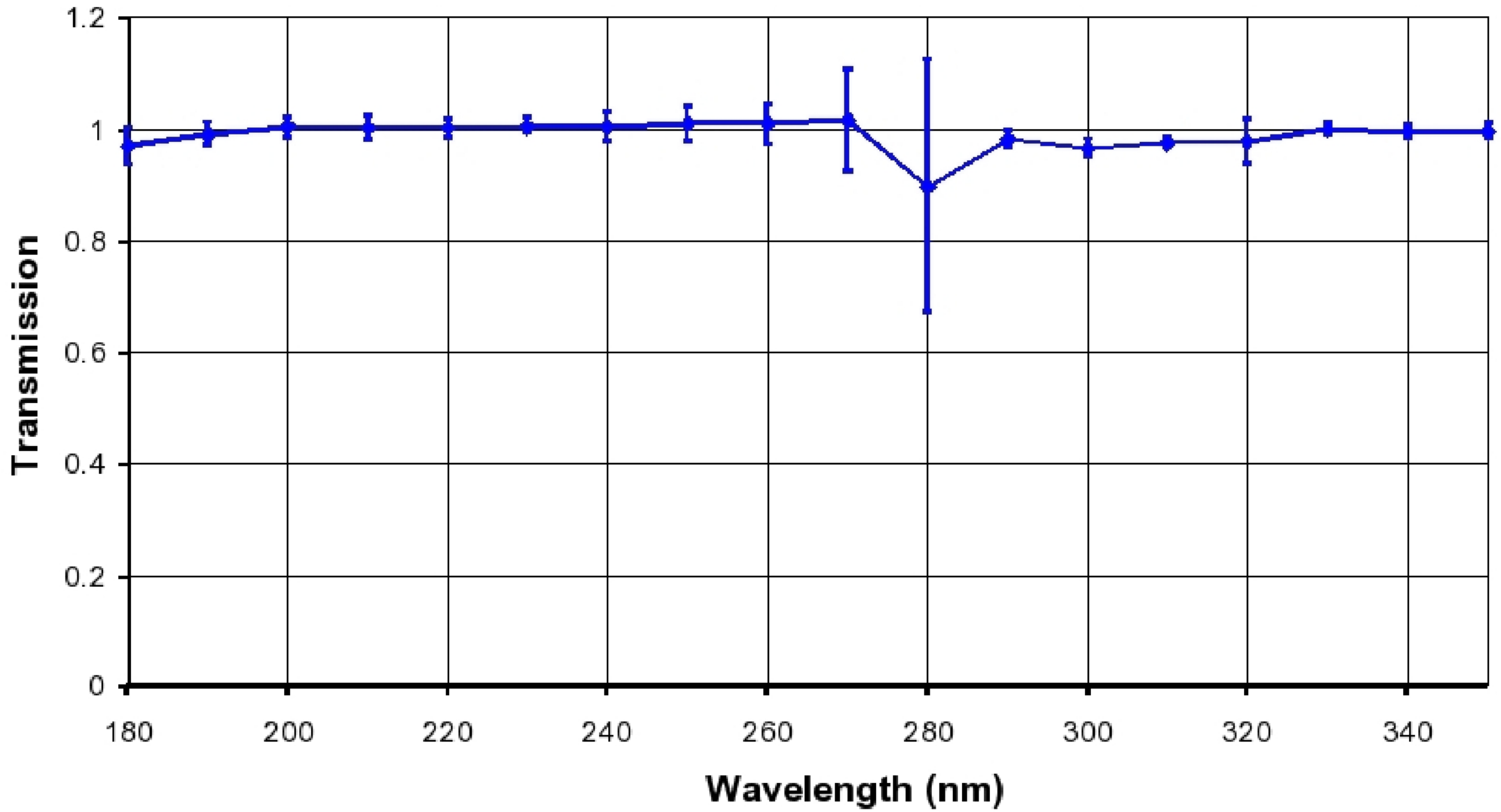
  $142k (FY07), Contingency $33k (23%).

- I intend to submit a Research Tools and Instrumentation (RTI) request to NSERC in Fall, 2008.
  - Timing of request is dictated by necessity of CD-3 granting prior to Canadian funding deliberations in early 2009.
  - NSERC grants are announced April 1 each year.
- If the NSERC grant request is successful, it will count as a foreign contribution to the Hall C upgrade and help relieve pressure on the 12 GeV cost book.

Timeline

- Finalize Design: 2009.
- Construction: 2009-2011.
- Delivery to JLab: Summer, 2012.
- Installation in Hall C: Winter, 2013.
- Commissioning: Winter, 2014.

Transmission of C_4F_8O



- Transmission ~100% in wavelengths surveyed