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:

- $e^-/\pi^-$ -> Noble Gas Čerenkov
- $\pi^+/K^+$ -> Heavy Gas Čerenkov
- $K^+/\pi^+$ -> Aerogel Čerenkov

The Heavy Gas Čerenkov will be the primary means for $\pi^+/K^+$ 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.
The heavy gas originally intended for this detector was $\text{C}_4\text{F}_{10}$.
- 3M stopped production of this gas some years ago, although it might still be available from a U.K. supplier (>$300/\text{kg})$.

$\text{C}_4\text{F}_8\text{O}$ 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.

  \textit{T. Skwarnicki, NIM A 553 (2005) 339-344.}


$\text{C}_4\text{F}_8$ was also investigated but found to be a less desirable substitute for $\text{C}_4\text{F}_{10}$. 
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 C₄F₈O (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 C₄F₁₀, 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 $\pi/K$ 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 $p_{\text{SHMS}} > 7.4$ GeV/c.
  - Intend to keep this system relatively simple, since our O$_2$, H$_2$O 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 $p_{\text{SHMS}}$ 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

- Delivery to JLab: Summer, 2012.
- Installation in Hall C: Winter, 2013.
Transmission of $\text{C}_4\text{F}_8\text{O}$

Transmission $\sim$100% in wavelengths surveyed