Transmittance Measurements of VUV Light as a Function of Water Vapor and Oxygen Concentrations

PHENIX Experiment, Brookhaven National Laboratory

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Purpose of Study:

Reference for the Hadron Blind Detector (HBD), which is going to be employed at the PHENIX experiment at the Relativistic Heavy Ion Collider (RHIC) facility, at Brookhaven National Laboratory.

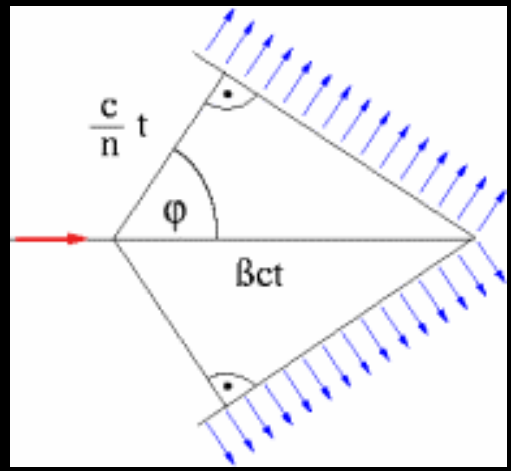
Reference: http://www.phenix.bnl.gov/

Introduction: Gas Cherenkov Detectors

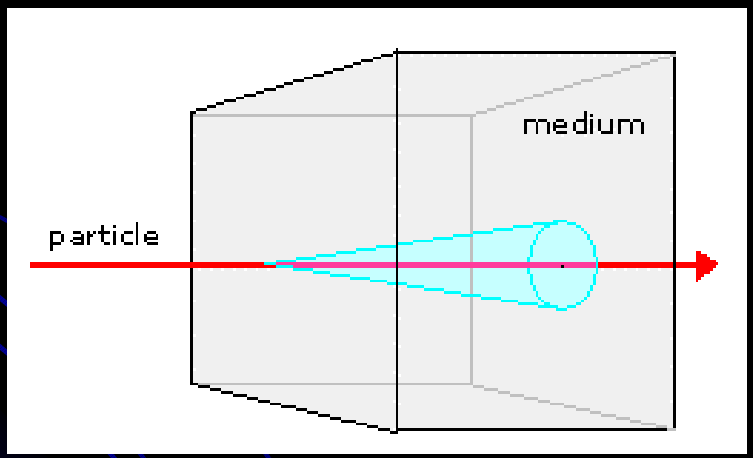
Detection of Cherenkov light

$v > c/n$ in medium (refraction index n)
$\beta = c/v$

$\cos\varphi = 1/n\beta$



Reference: http://encyclopedia.thefreedictionary.com/Cherenkov%20effect



HBD → Violet - Ultraviolet (VUV) light detection

Introduction: Gas Cherenkov Detectors:

VUV Transmittance factors:

- Gas Type (*radiator*, *transparent to desired λ*)
- Out-gassing (*vessel material*)
- Contaminant particles (N_2 , O_2 , H_2O *vapor*)

Study: Transmittance of VUV light as a function of H_2O vapor and O_2 concentrations

Reference for water and oxygen levels that can be tolerated within such a detector before any significant fraction of VUV light is lost

% Transmittance of VUV light in Ar gas

vs.

H_2O [ppm]

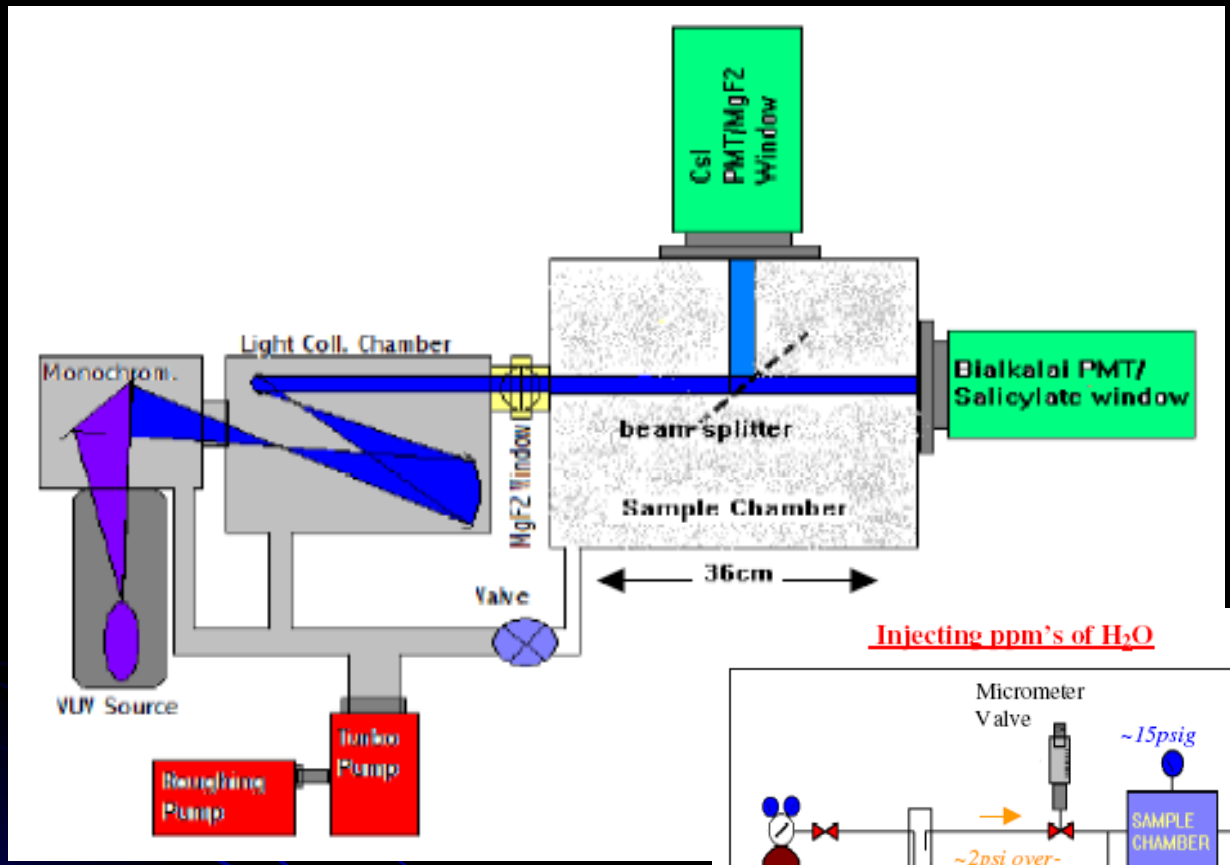
% Transmittance of VUV light in Ar gas

vs.

O_2 [ppm]

%T = (Flux out / Flux in)*100%

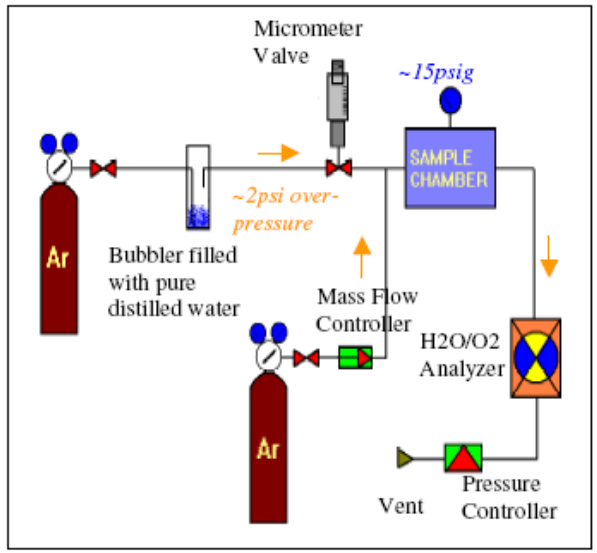
Method: Experimental Setup



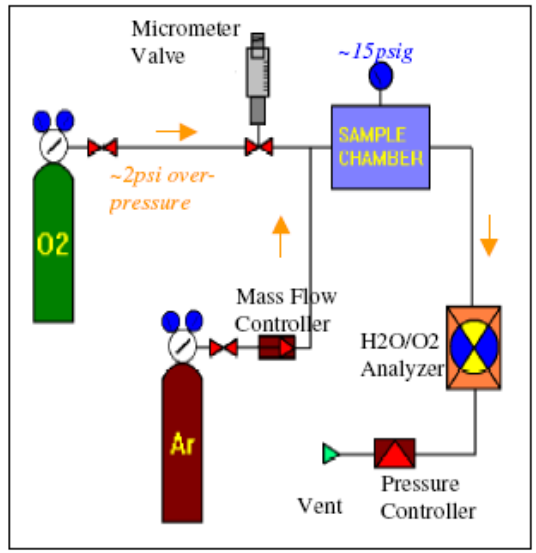
$$\%T = \frac{i_{sample}}{i_{vacuum}} 100\%$$

Reference:
http://www.phenix.bnl.gov/phenix/WWW/publish/azmoun/Trans_O2_H2O.pdf

Injecting ppm's of H_2O



Injecting ppm's of O_2



Theory: Theoretical Transmittance

$$I(x) = I_o\, e^{-\mu x}$$
$$I(x=L) = I_o e^{-\sigma NL}$$
$$I(x=L) = I_o e^{-\sigma pNL}$$

I(x) : flux after the beam has traversed a distance x trough the absorber

I_o *: initial flux*

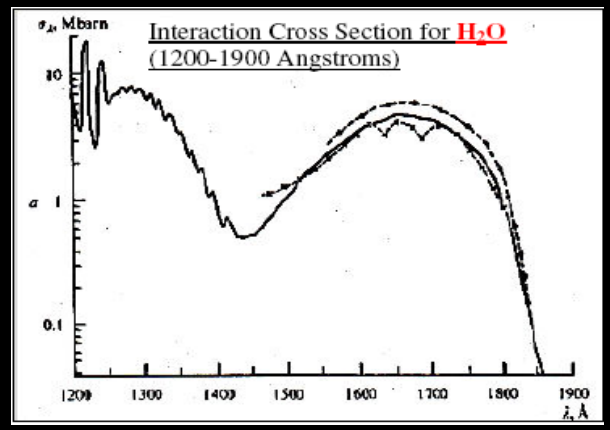
μ *: attenuation coefficient*

N : particle density (particles per cubic cm)

L : total length through which the VUV beam travels

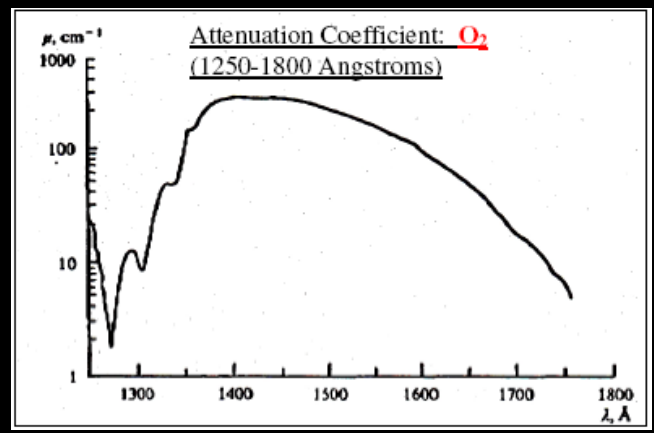
σ *: interaction cross section*

Interaction cross section, [Mbarn] Vs wavelength [Angstroms] for H2O



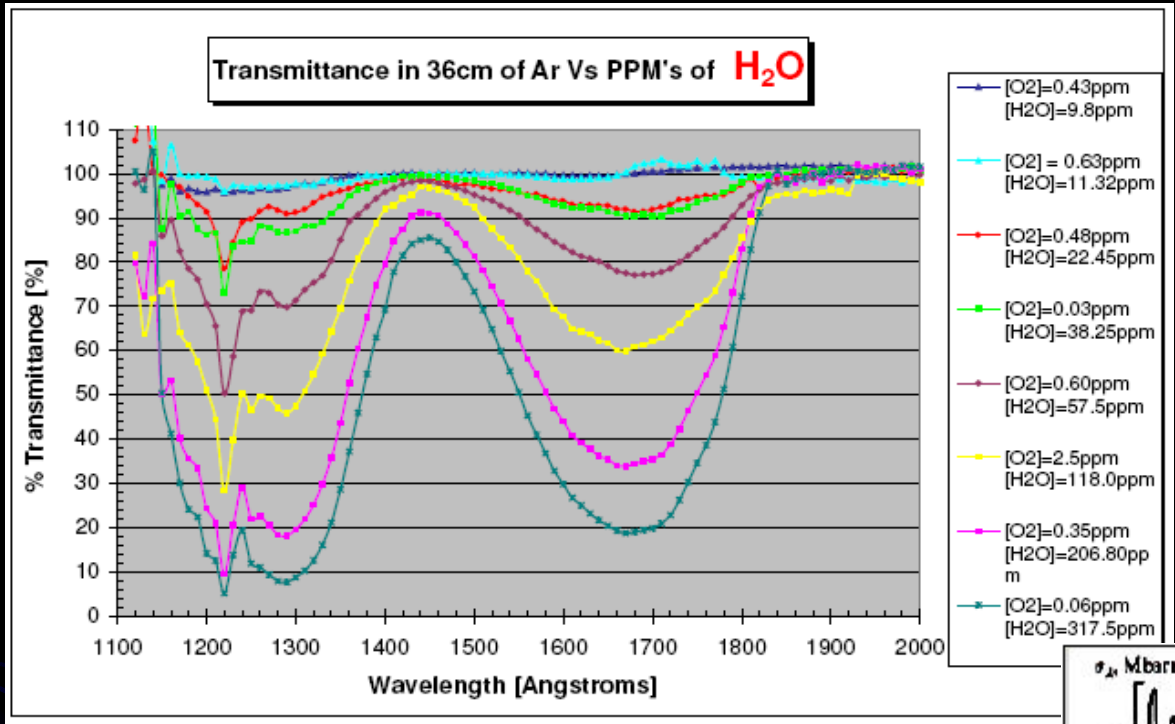
Reference: A.N. Zaidel' and E.Ya. Shreider, Vacuum Ultraviolet Spectroscopy. Ann Arbor-Humphrey Publishers; Ann Arbor, London 1970

Attenuation coefficient, μ [cm-1] Vs wavelength [Angstroms] for O2

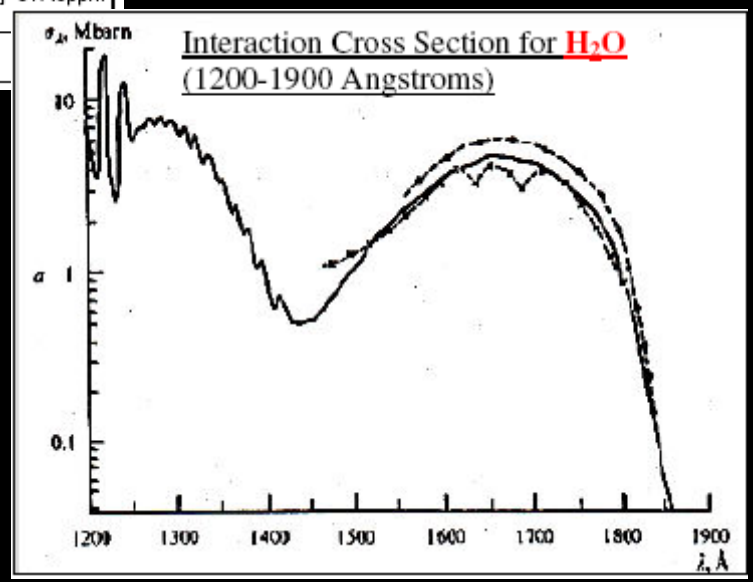


Reference: A.N. Zaidel' and E.Ya. Shreider, Vacuum Ultraviolet Spectroscopy. Ann Arbor-Humphrey Publishers; Ann Arbor, London 1970

Results: Transmittance in H2O vapor



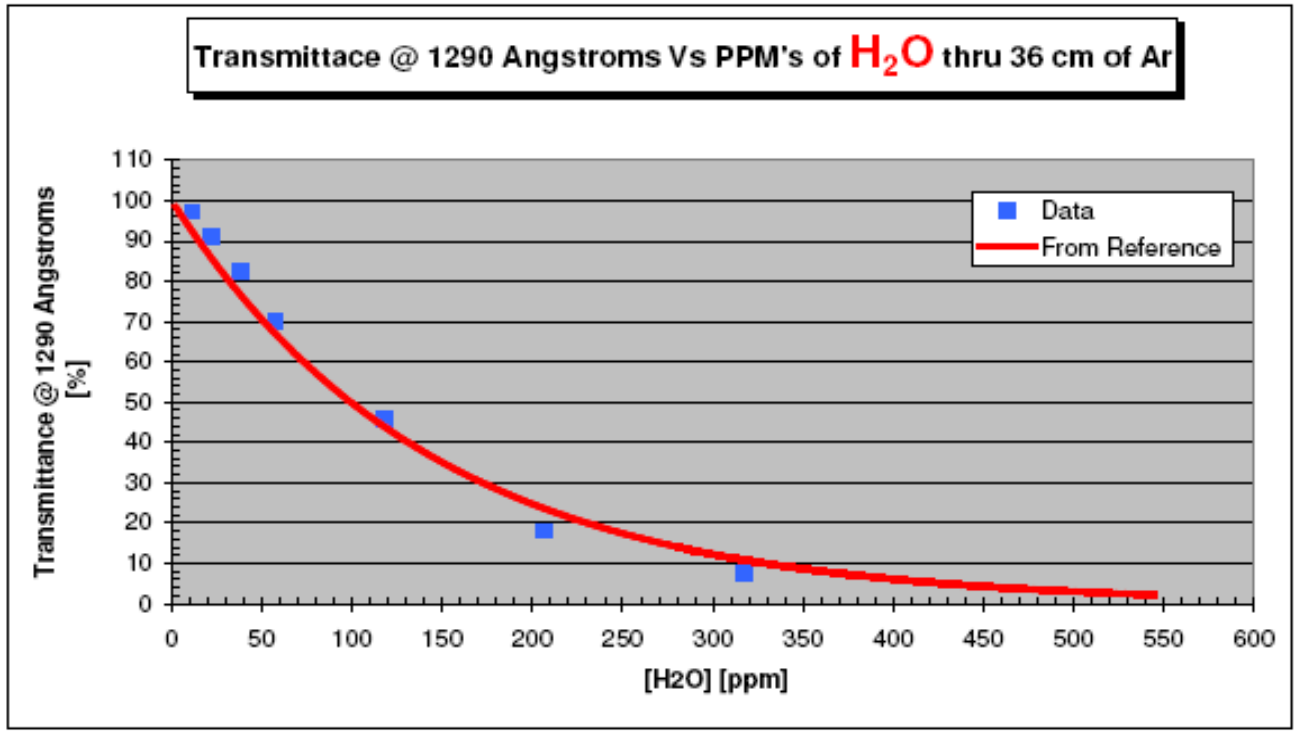
Plot 1: Transmittance spectra as a function of H2O levels



Interaction cross section, [Mbarn] Vs wavelength [Angstroms] for H2O

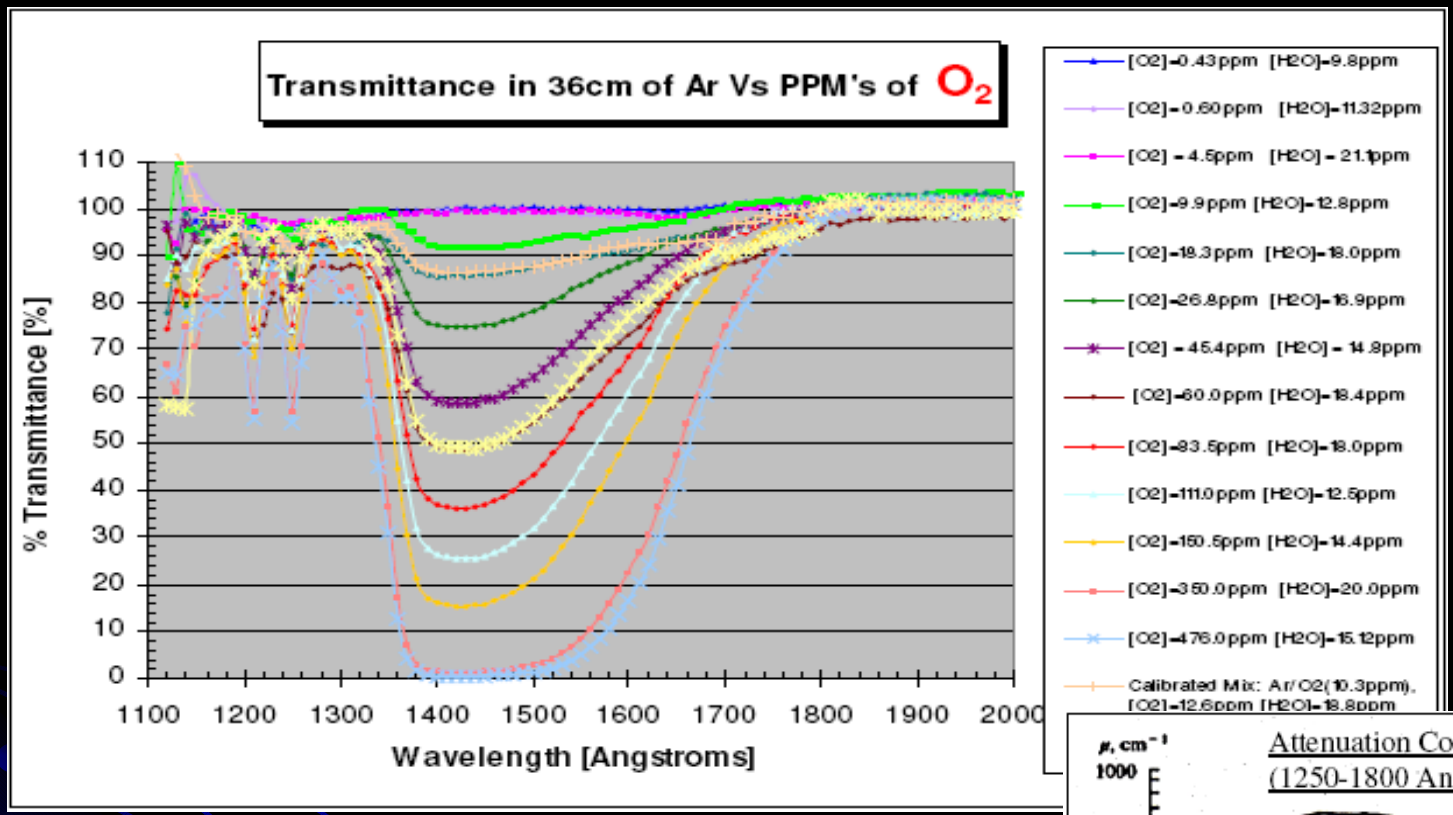
Reference: A.N. Zaidel' and E.Ya. Shreider, Vacuum Ultraviolet Spectroscopy. Ann Arbor-Humphrey Publishers; Ann Arbor, London 1970

Results: Transmittance in H2O vapor

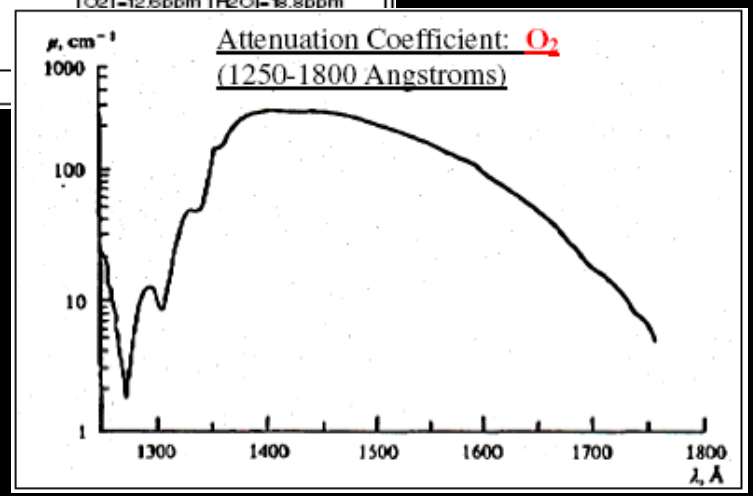


Plot 2: Transmittance data @1290 Angstroms Vs H2O levels, compared to the expected transmittance--calculated from the interaction cross section @1290s Angstrom, extracted from the theoretical data for attenuation coefficient.

Results: Transmittance in O2



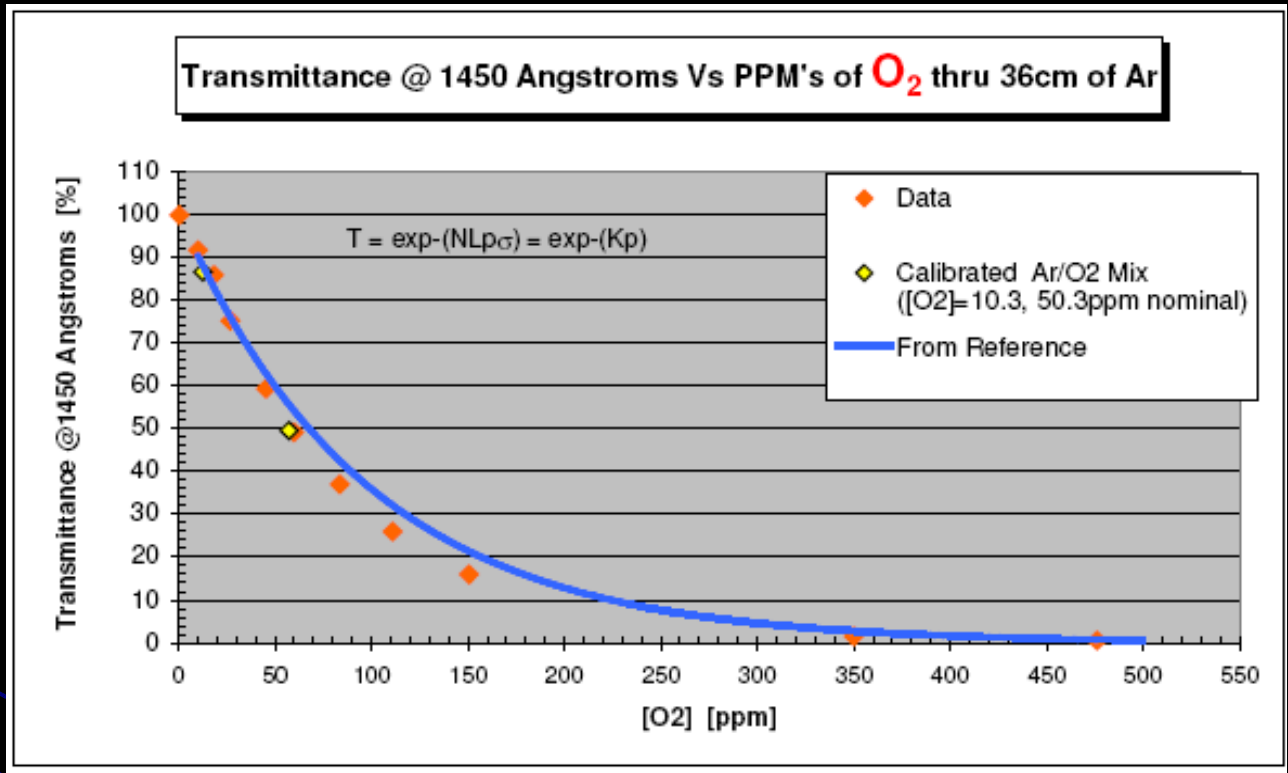
Plot 3 Transmittance spectra as a function of O2 levels



Attenuation coefficient, μ [cm-1] Vs wavelength [Angstroms] for O2

Reference: A.N. Zaidel' and E.Ya. Shreider, Vacuum Ultraviolet Spectroscopy. Ann Arbor-Humphrey Publishers; Ann Arbor, London 1970

Results: Transmittance in O2



Plot 4: Transmittance data @1450 Angstroms Vs O2 levels, compared to the expected transmittance--calculated from the attenuation coefficient @1450 Angstroms, extracted from the theoretical data for attenuation coefficient.

Conclusions

- In **agreement** to previous experimental data
- Provided **reference for tolerable contaminant levels** for **efficient operation of the HBD detector**
- Determined the **necessity for good sealing**

References

- A. N. Zaidel and E. Ya. Shreider. *Vacuum Ultraviolet Spectroscopy.* Ann Arbor Humphrey Publishers; Ann Arbor, London; 1970.

- B. Azmoun, G. Karagiorgi and C. Woody. *Transmittance as a function of water and oxygen levels in the VUV regime*. September, 2004.
  http://www.phenix.bnl.gov/phenix/WWW/publish/azmoun/Trans_O2_H2O.pdf

- http://www.phenix.bnl.gov

- http://www2.slac.stanford.edu/vvc/detectors/cerenkov.html