Revisiting Iridium Optical Constants for the Chandra HRMA Effective Area
Participants in the Chandra Synchrotron Calibration Program

... include, but not necessarily limited to the following:
T. H. Burbine, G. Chartas, A.M. Clark, J.P. Cobuzzi, J.J. Fitch, R. Francoeur, B. Harris, R.H. Ingram, J.Z. Juda, E.M. Kellogg, A.G. Roy, D.A. Schwartz, E.S. Sullivan, J.B. Sweeney, and P. Zhao. Beamline scientists and technicians such as M. Sagurton (X8A), R. Alkire (X8C), S. Mrowka and Andreas Stonas (ALS 6.3.2) also contributed advice and assistance when needed.

The authors are grateful for discussions and encouragement provided by the late L.P. Van Speybroeck, whom we remember fondly.
Outline

• Introduction
• Modeling and parameters
• Review: Optical Constants 5-12 keV
• Overlayer modeling at M-edges
• 1000-2000 eV optical constants
• Low-energy results
• XPS measurements of the overlayer
Review and update of the Ir optical constants is timely.

- Currently we use 940-12000eV results from a single mirror.
- Mirror-to-mirror M-edge discrepancies were not resolved as of launch date.
  - Assumed n X CH$_2$ overlayer, unverified.
- 50-1000 eV low-energy data never reduced for use in Chandra calibration.
- Indications of Ir M-edge artifacts in Chandra source analyses.
Reviewing the coating configuration:

NOTE THREE LONGITUDINAL SECTIONS: A, B and C
OUTBOARD SAMPLES BECAME PRODUCTION WITNESS FLATS
Optical constants were determined from synchrotron reflectance measurements versus angle and versus energy.

- $R$ vs $\theta$ to determine $I_r$, $C_r$ layer depths, surface roughness/interdiffusion depths, and overlayer.
- $R$ vs $E$ to determine $I_r \, \delta(E)$, $\beta(E)$, with layer and roughness parameters frozen.
- Four beamlines used, with energy ranges broken down for optimized monochromaticity and intensity.
- At least one angle scan per energy range for alignment/parameters, except below 1000 eV.
We employ a four-layer model with an optional overlayer to derive $\delta, \beta$. 
5-12 keV optical constants: A1 mirrors are indistinguishable.
In the Ir M-edge region, an overlayer is necessary for fits, consistency.
M-edges require an overlayer in model due to masking of Ir absorption.
1000-2000 eV $\beta(E)$ is also more consistent with overlayer.
Low-energy data: As with M-edges, the detail obtained is significant.
Some significant differences appear from tabulated between N-edges.
C- and O-K leave signatures with our naïve overlayer composition.
In the featureless 600-1200 eV range, we obtain only slight variations from tabulated.
Here are our current best results (not yet implemented in the CalDB)
Our current results, with 1995 Henke/Gullikson for comparison.
XPS survey scan of 065 reveals several components in overlayer.
High-resolution C1s Spectra
High-resolution O1s Spectra

CHANDRA 065

CHANDRA 127

Binding Energy (eV)
High-resolution N1s Spectra

![Graph of CHANDRA 065 and CHANDRA 127 spectra]

- **CHANDRA 065**
- **CHANDRA 127**

Binding Energy (eV)
High-resolution Si2s Spectra

CHANDRA1367A2.spe

Binding Energy (eV)

Chandra Calibration Workshop 2004
High-resolution Ir4f Spectra

CHANDRA1367A2.spe

Ir4f5/2  Ir4f7/2

CHANDRA 065

CHANDRA 127

C/S

Binding Energy (eV)

Chandra Calibration Workshop 2004
Summary

• We have a nearly final set of Ir optical constants, which will soon be finalized and published. => Appl. Optics; Gullikson tables.
• Refinements must be folded into HRMA model to evaluate Ir M-edge artifacts in Chandra analyses. (See D Jerius, this workshop.)
• XPS confirms the overlayer, and may be evaluated further to help mitigate C, O, and N signatures in low-energy results.