Science & Integration Meeting

Agenda

- Detector & R&D
  - ›› NPRO stabilization results — Mason/Savage
  - ›› Interferometer acquisition modeling results — Sievers
  - ›› FMI wavefront sensing results — Mavalvala/Sigg
  - ›› PNI status & plans — Fritschel
  - ›› 40m recycling status — Logan/Spero
  - ›› Core Optics Status: REO coating performance analysis — Jungwirth
  - ›› FFT modeling (20 min) — Kells
  - ›› DAQ prototype plan for 40m — Bork/Barker

Coating Uniformity Tests

D. Jungwirth

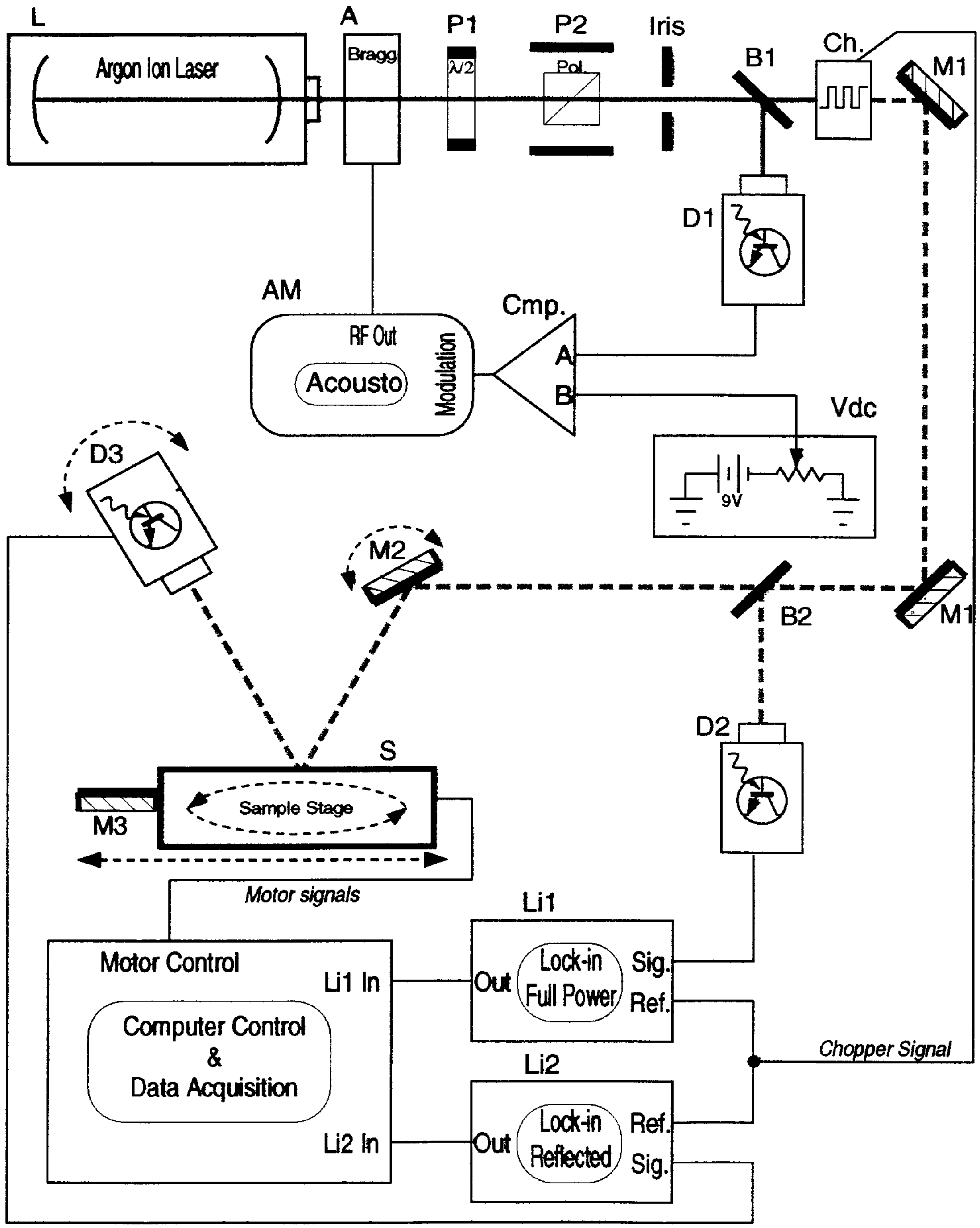
Problem

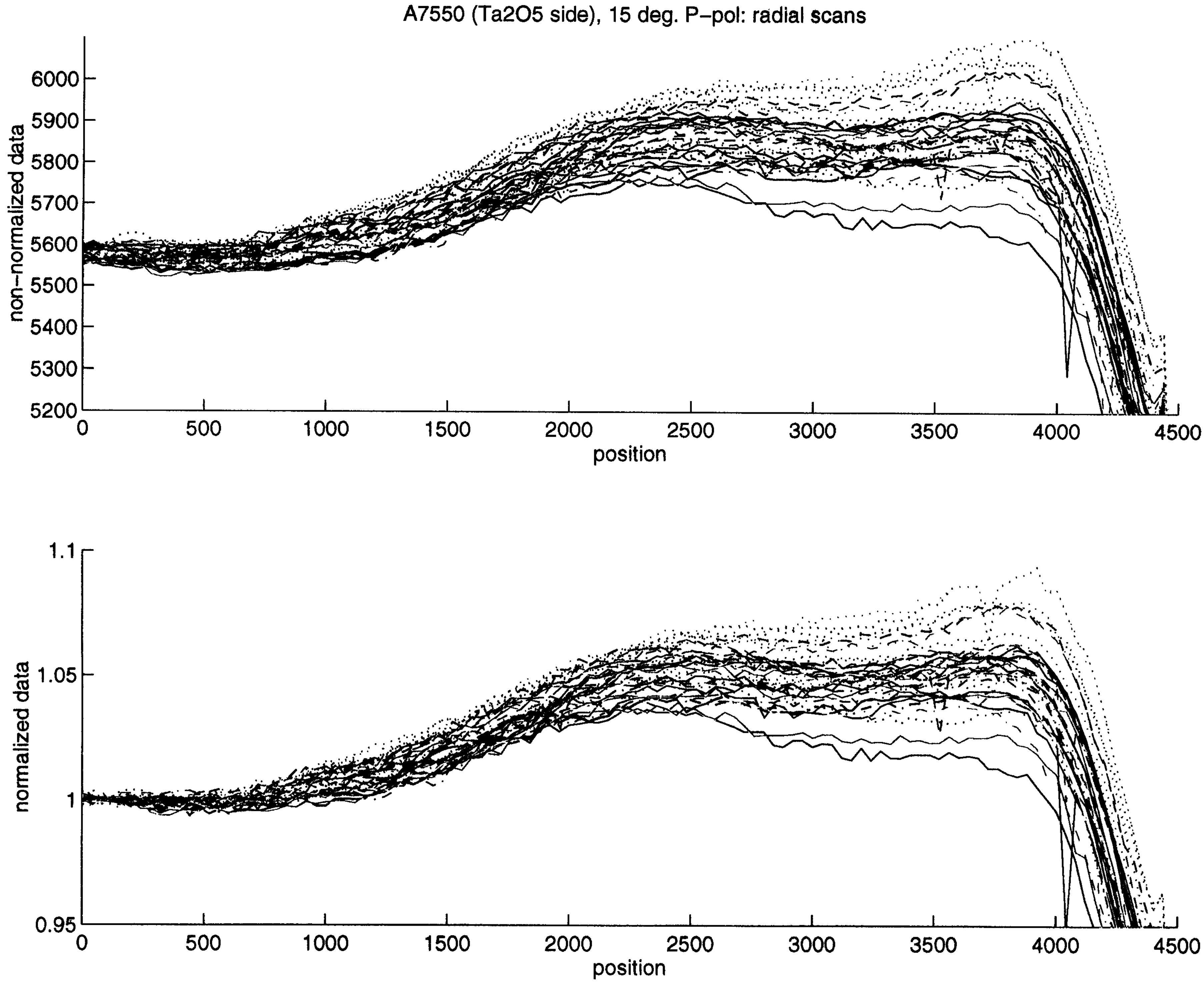
- REO does not know what their coating distribution is at the levels required for LIGO.
- REO's measuring techniques did not give the spatial resolution required for LIGO.
- REO's measuring techniques did not give the thickness accuracy that were required by LIGO

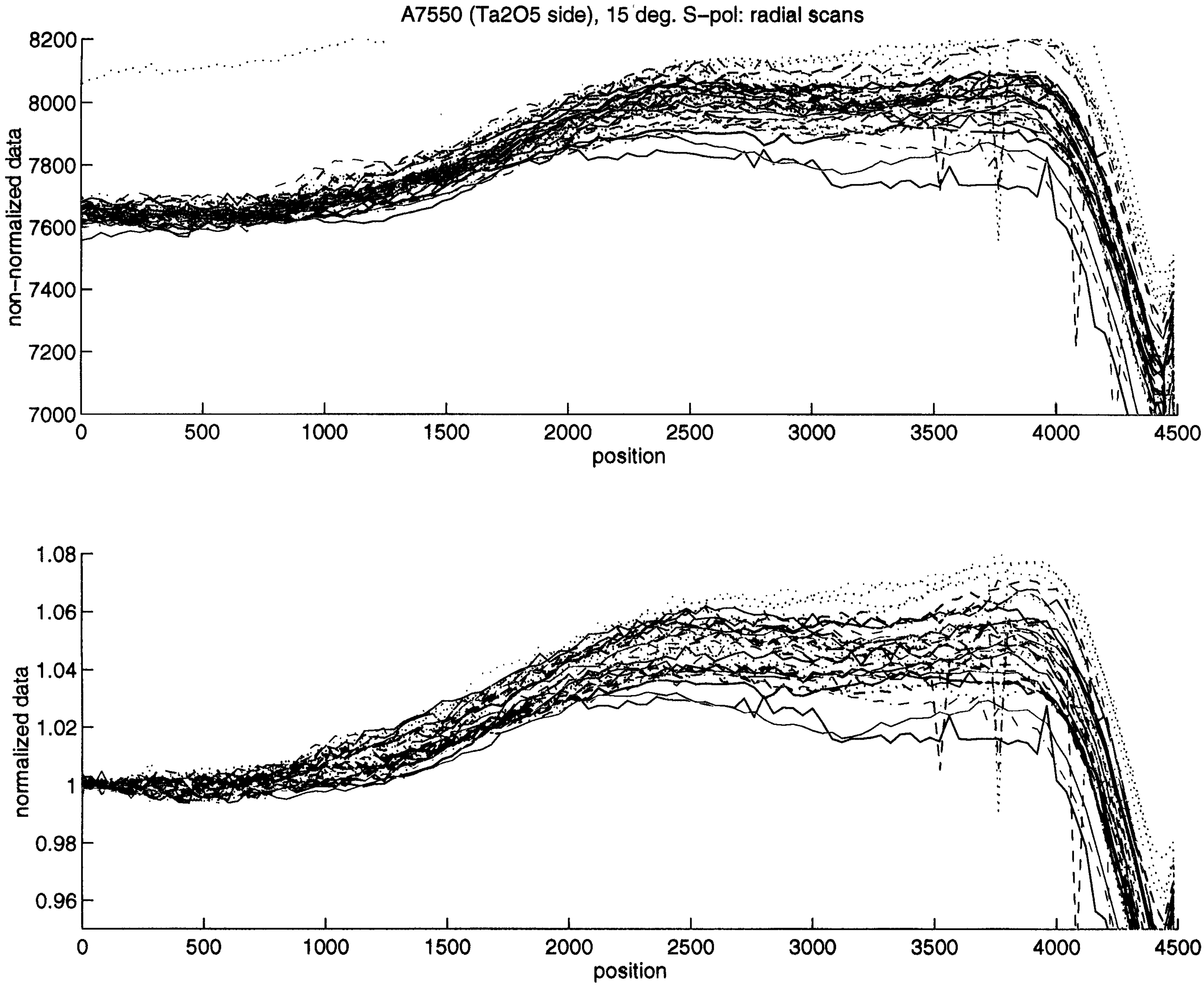
Approach

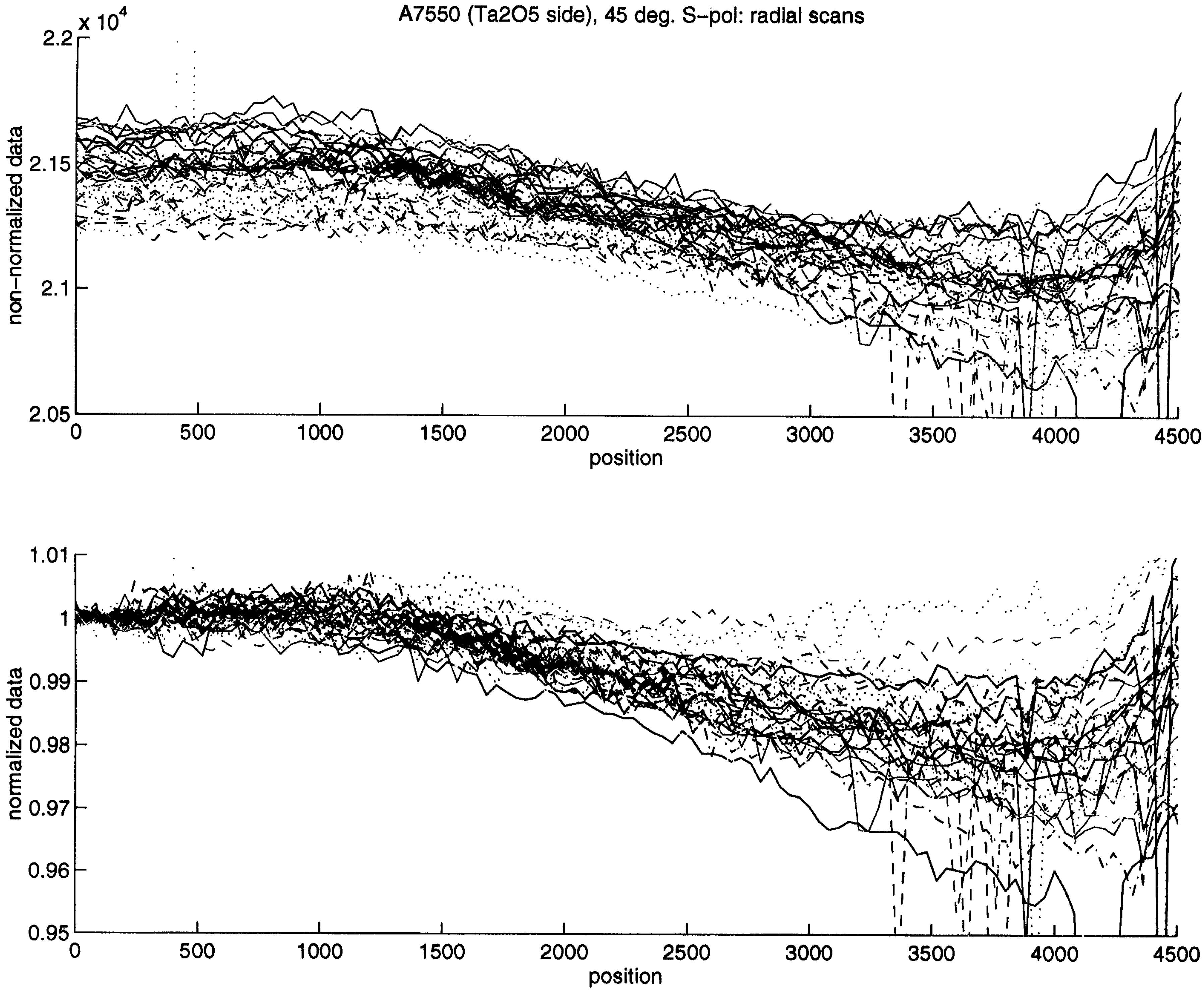
- A technique was developed to have full sized “AR” coatings made that are very sensitive to one material’s coating thickness and not sensitive to the other
- Measure reflectivity versus position for entire coated surface to get reflectivity map
- Use computer codes to convert measured reflectivity measurement to single layer thickness map.
- Generate 16 layer and 40 layer HR coatings from these thickness maps and calculate “Phase” errors due to thickness variations.
- Introduce these “Phase” maps into the FFT code to predict LIGO response to coating induced errors.

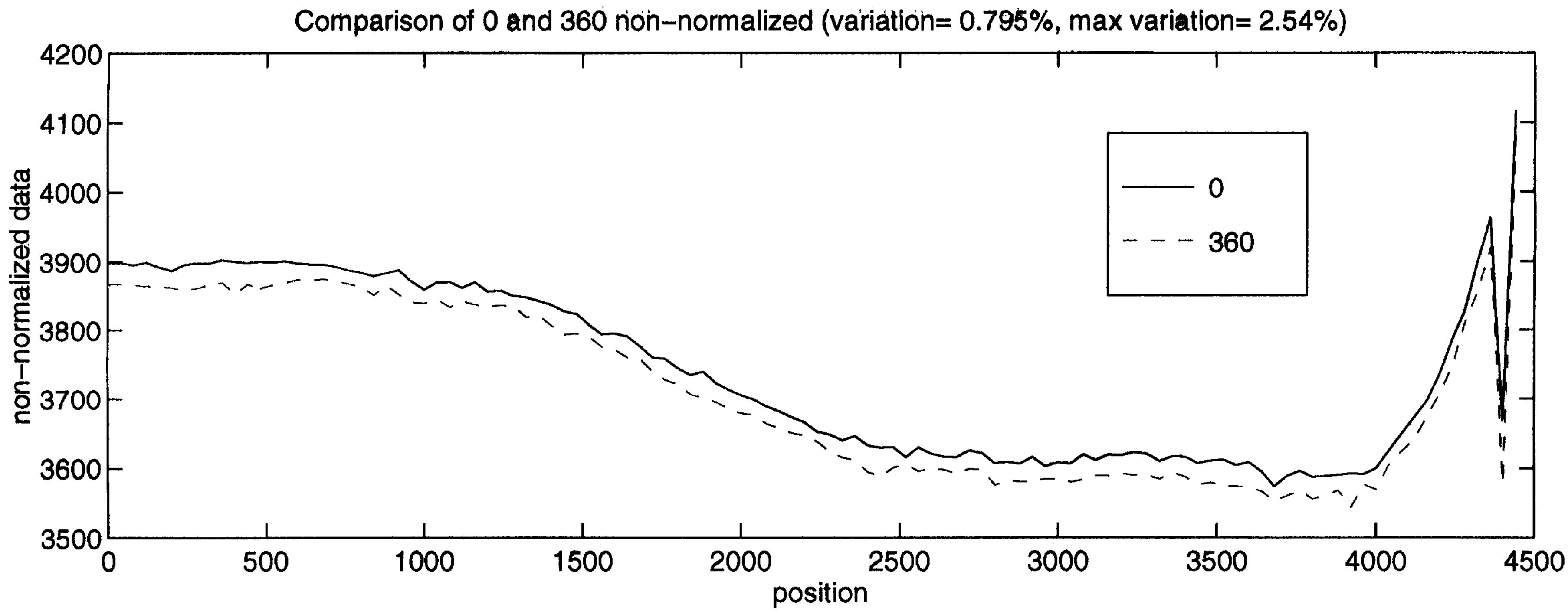
Schematic of AR Coatings Scanning Aparatus

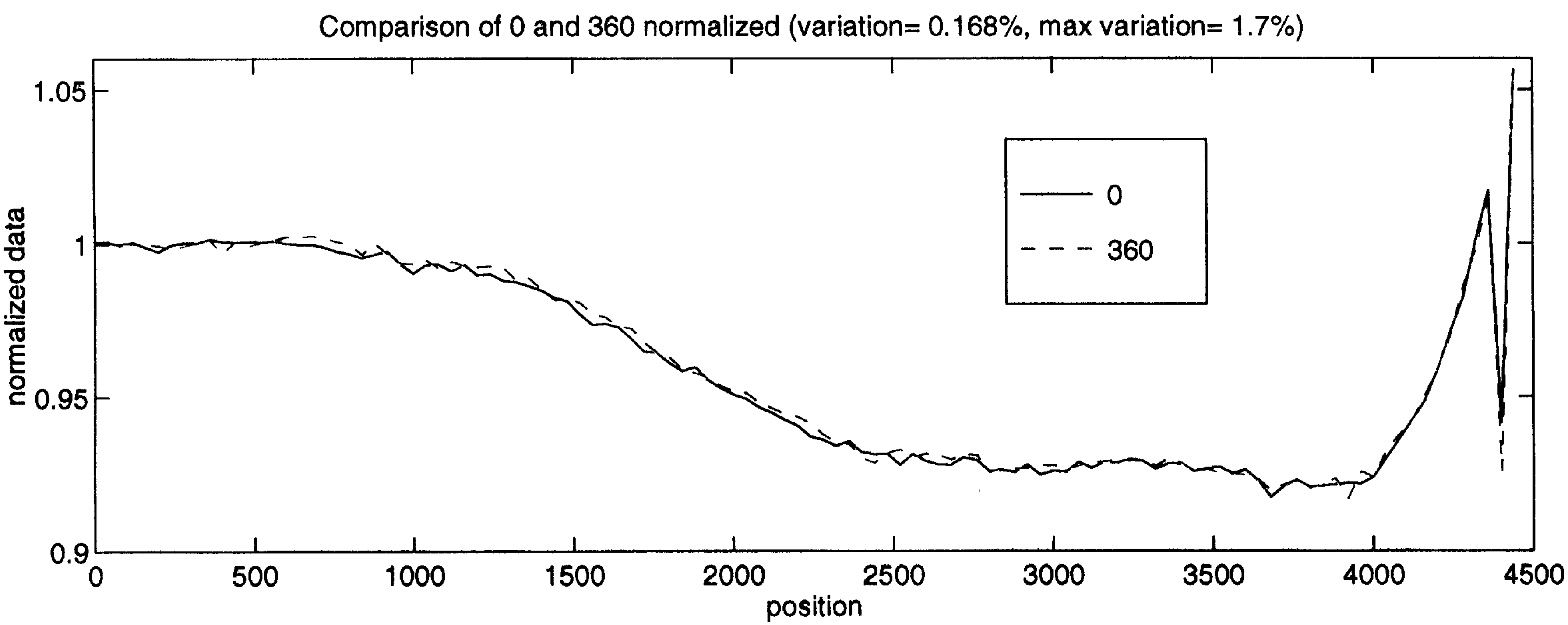



A7550 (Ta2O5 side), 15 deg. P-pol: radial scans
non-normalized data
6000
5900
5800
5700
5600
5500
5400
5300
5200
0
500
1000
1500
2000
2500
3000
3500
4000
4500
position
normalized data
1.1
1.05
1
0.95
0
500
1000
1500
2000
2500
3000
3500
4000
4500
position

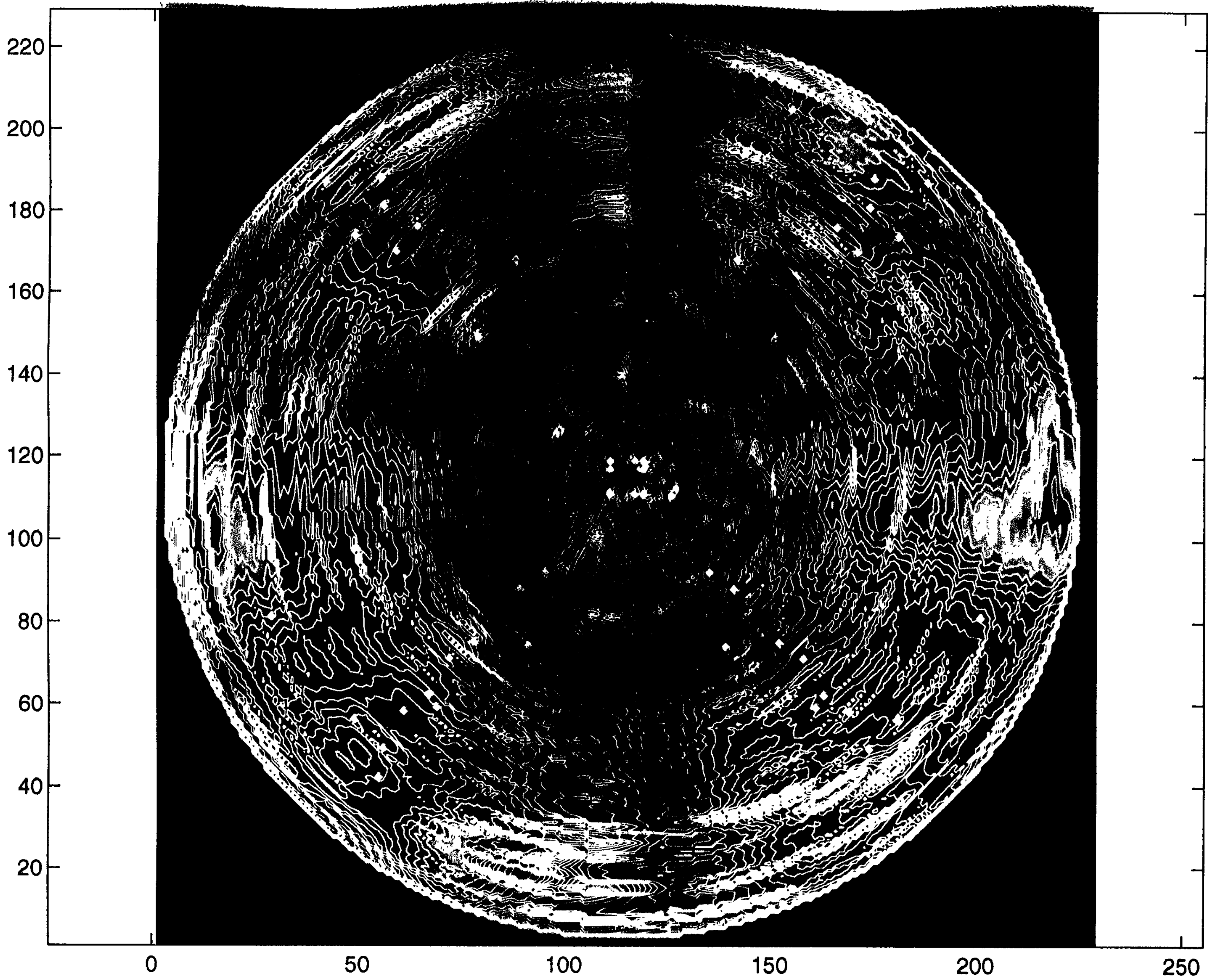

A7550 (Ta2O5 side), 15 deg. S−pol: radial scans
non−normalized data
8200
8000
7800
7600
7400
7200
7000
0
500
1000
1500
2000
2500
3000
3500
4000
4500
position
normalized data
1.08
1.06
1.04
1.02
1
0.98
0.96
0
500
1000
1500
2000
2500
3000
3500
4000
4500
position


A7550 (Ta2O5 side), 45 deg. S-pol: radial scans
x 10^4
2.2
2.15
2.1
2.05
non-normalized data
0
500
1000
1500
2000
2500
3000
3500
4000
4500
position
1.01
1
0.99
0.98
0.97
0.96
0.95
normalized data
0
500
1000
1500
2000
2500
3000
3500
4000
4500
position


Comparison of 0 and 360 non-normalized (variation= 0.795%, max variation= 2.54%)
non-normalized data
position
0
360
4200
4100
4000
3900
3800
3700
3600
3500
0
500
1000
1500
2000
2500
3000
3500
4000
4500


Comparison of 0 and 360 normalized (variation= 0.168%, max variation= 1.7%)
normalized data
position
0
360
1.05
1
0.95
0.9
0
500
1000
1500
2000
2500
3000
3500
4000
4500

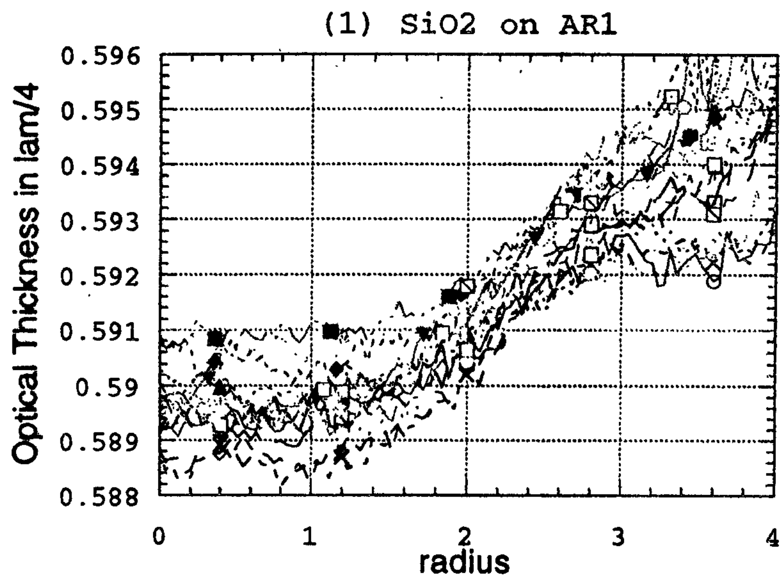
Interpolated, normalized contour map of substrate A7550 (Ta2O5 sensitive side): at 60 degrees, S-polarization.

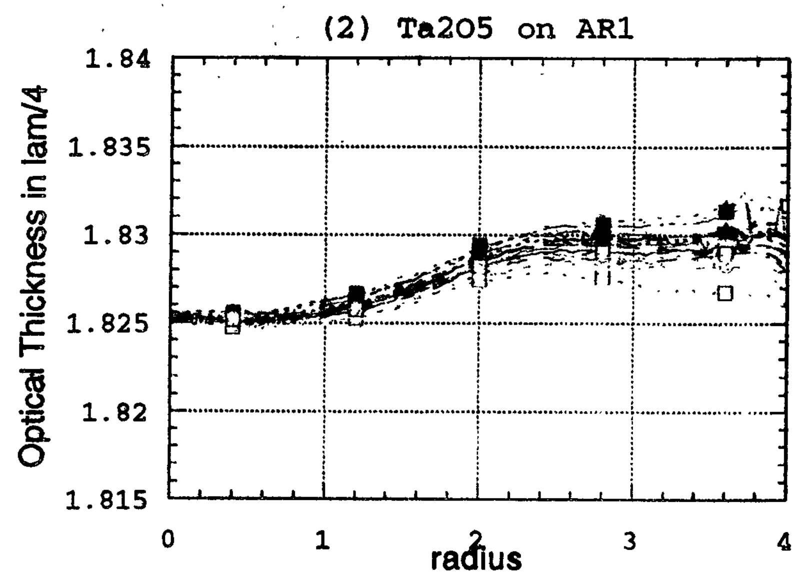


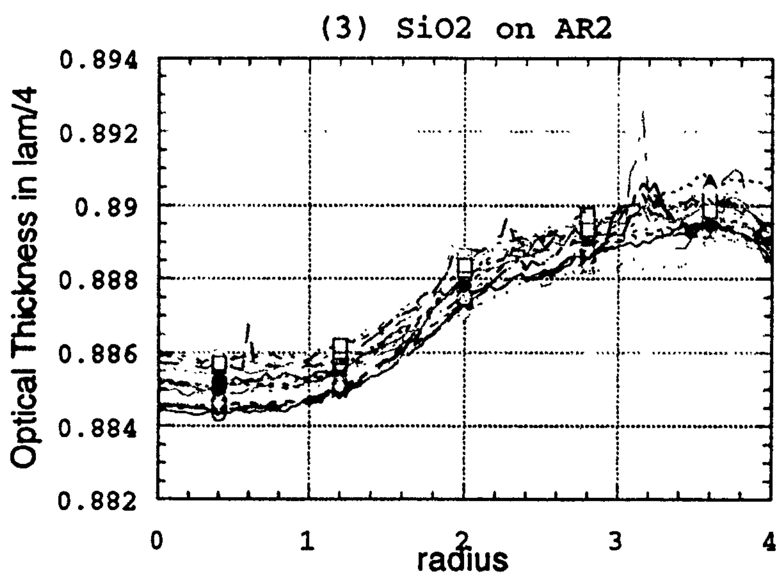
Data Analysis

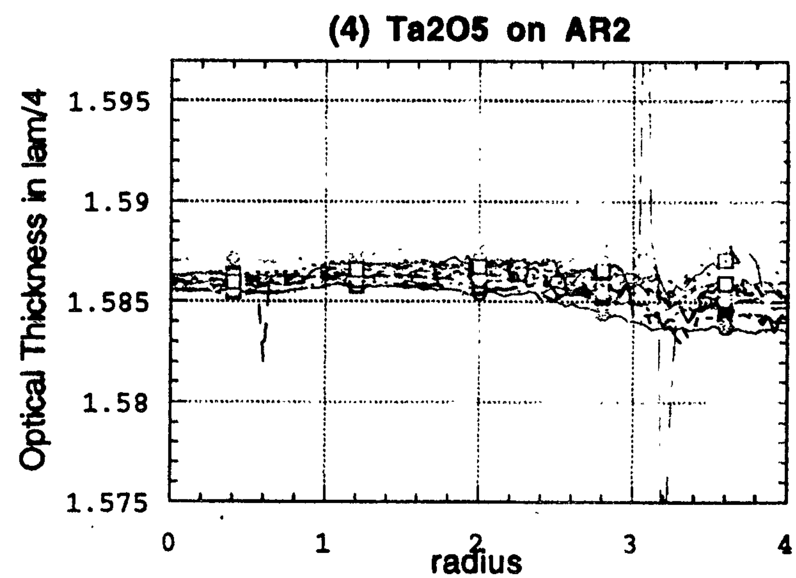
Analyzed data two way

- Simple minded approach
  - Same coating distribution for SiO_2 and Ta_2O_5
  - Normalized data
  - Calculate Reflectivity vs. Thickness slope at design point
  - Use these slopes to estimate thickness variations
- Multi-variable analysis (done by Hiro Yamamoto)
  - Uses as variables
    - input angle
    - polarization
    - calibration uncertainty
    - noise calculations
    - 6 measurements


(1) SiO2 on AR1
Optical Thickness in lam/4
0.596
0.595
0.594
0.593
0.592
0.591
0.59
0.589
0.588
0
1
2
3
4
radius


(2) Ta2O5 on AR1
Optical Thickness in lam/4
1.84
1.835
1.83
1.825
1.82
1.815
0
1
2
3
4
radius


(3) SiO2 on AR2
Optical Thickness in lam/4
0.894
0.892
0.89
0.888
0.886
0.884
0.882
0
1
2
3
4
radius


(4) Ta2O5 on AR2
Optical Thickness in lam/4
1.595
1.59
1.585
1.58
1.575
0
1
2
3
4
radius

Thickness

Thickness.ps

- Thickness of SiO2 and Ta2O5 in AR1 and AR2 as a function of radius in inch
- 19 lines for difference angles at 0, 20, 40, ..., 320, 360
- Vertical scale is chosen so that the scale is the same, i.e., a variation from bottom of the graph to the top is 1.4% for all figures.
- Curvature is smaller
  - Ta2O5 in AR1 : 0.27% thicker at 4 inch that r=0
  - SiO2 in AR2 : 0.57 % thicker at 4 inch than r=0
  - old coating : 2 % thinner at 4 inch than r=0 for both layers

Curvature (coefficient of Z20 term) of each layer

	SiO2	Ta2O5
old coating	-2.8×10^{-3}	-7.4×10^{-3}
new coating	1.7×10^{-3}	1.1×10^{-3}

- Ta2O5 shows less angular variation than SiO2 (see next)