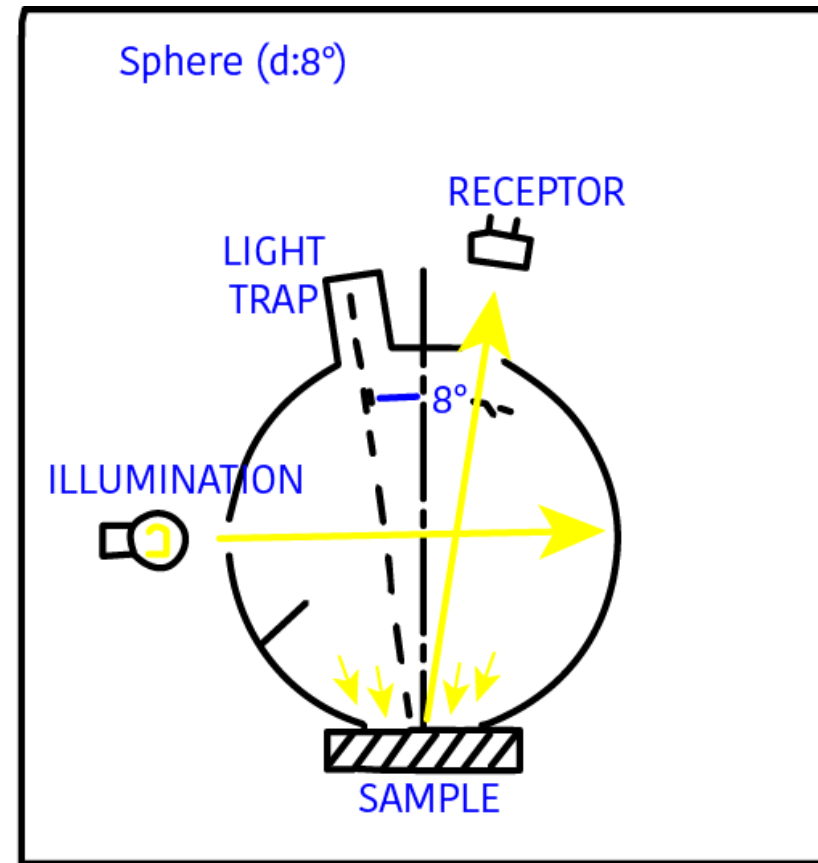
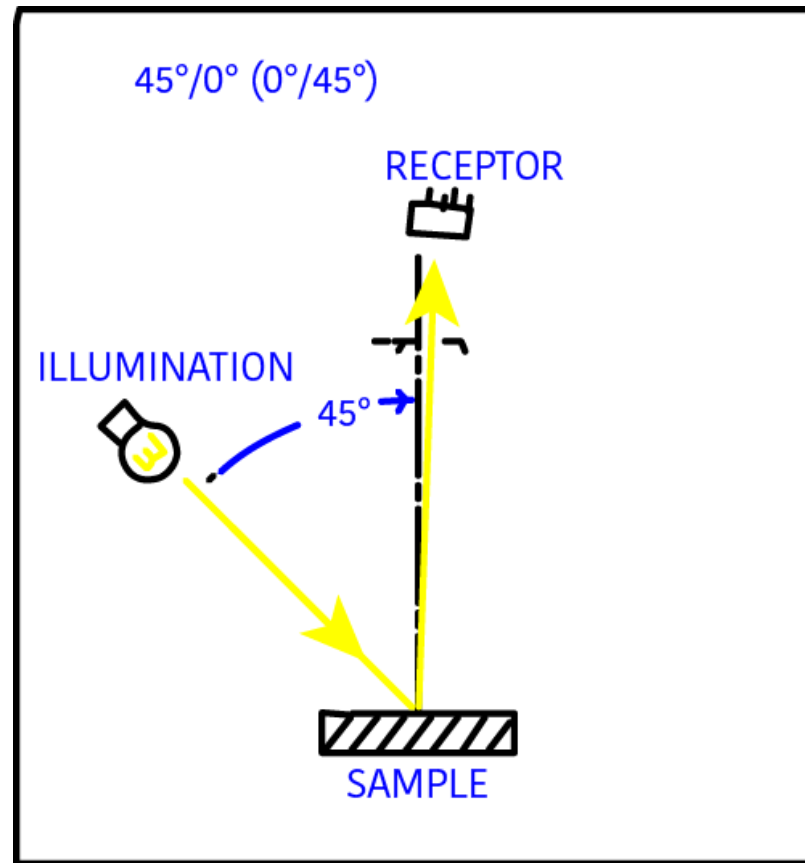


# An Evaluation of the Effect of Instrument Geometry on Color Management for Printed Textiles

- Bruce Leigh Myers, Ph.D.
- Rochester Institute of Technology
- School of Media Sciences

Houston, TX 2017

# Sphere vs 45°



# Nature of ICC Profiling

- Numerous Patches Measured to Create a Profile
  - *Typically, 100's to 1,000's*
- Automated Spectrophotometers Typically Utilized
  - *Relative vs. Absolute*
- No Known Automated Sphere Device Specifically for this Purpose

# Automated Patch Readings?



# Analyses

Quantitative Analysis	Qualitative Analysis
Numeric Gamut Volume	Visual Gamut Volume
Round-Trip Profile	Visual Gamut Shapes
Spot Readings	

# Variables

## Instruments

45°

Sphere:  
Specular Excluded

Sphere:  
Specular Included

## Substrates

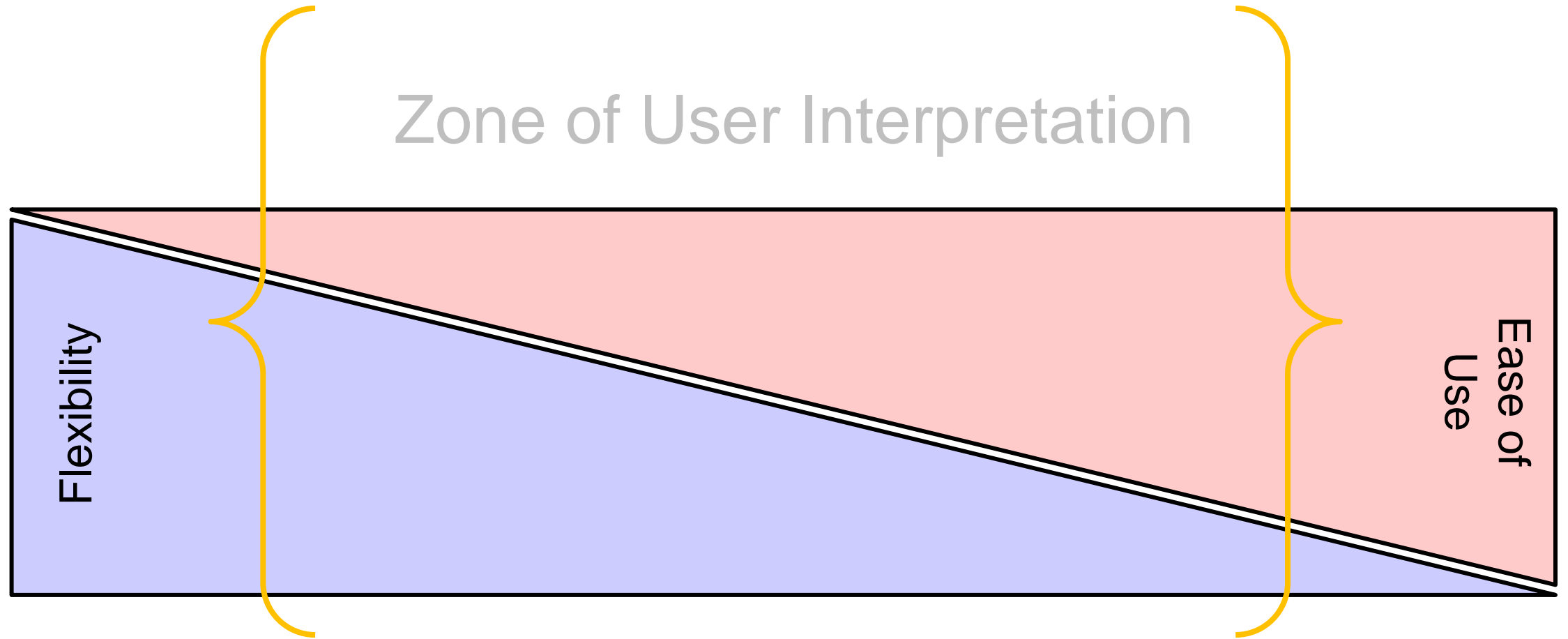
Ultra-Cotton (UC)  
High Texture / Low Gloss

Samba  
Less Texture / Higher Gloss

# Materials

Measuring Instruments:	X-Rite eXact (45°)	Konica Minolta CM700D (Sphere)	Legacy: X-Rite SP62 (Sphere)	Legacy: X-Rite 939 (0/45°)
Software:	X-Rite i1 Profiler (i1 Publish)	Legacy: X-Rite ColorPort	Legacy: X-Rite (Gretag Macbeth) ProfileMaker	Chromix ColorThink Pro
Hardware:	ColorScout A+ (x,y Table)	Vutek GS 3250 Inkjet Printer, UV Curable Ink		

# Flexibility and Ease of Use: Inverse Relationship





## Flexibility and Ease of Use: Inverse Relationship

### Flexible, but Hard to Use

- Customizable
- Onus of responsibility on user

### Closed, but Easy to Use

- Great – So Long as User is Lockstep with Engineer's Indented Purpose
  - *Includes Specific Application and Workflow*
- "Was not designed for that"

# It's a Good Thing that the Journey IS the Destination

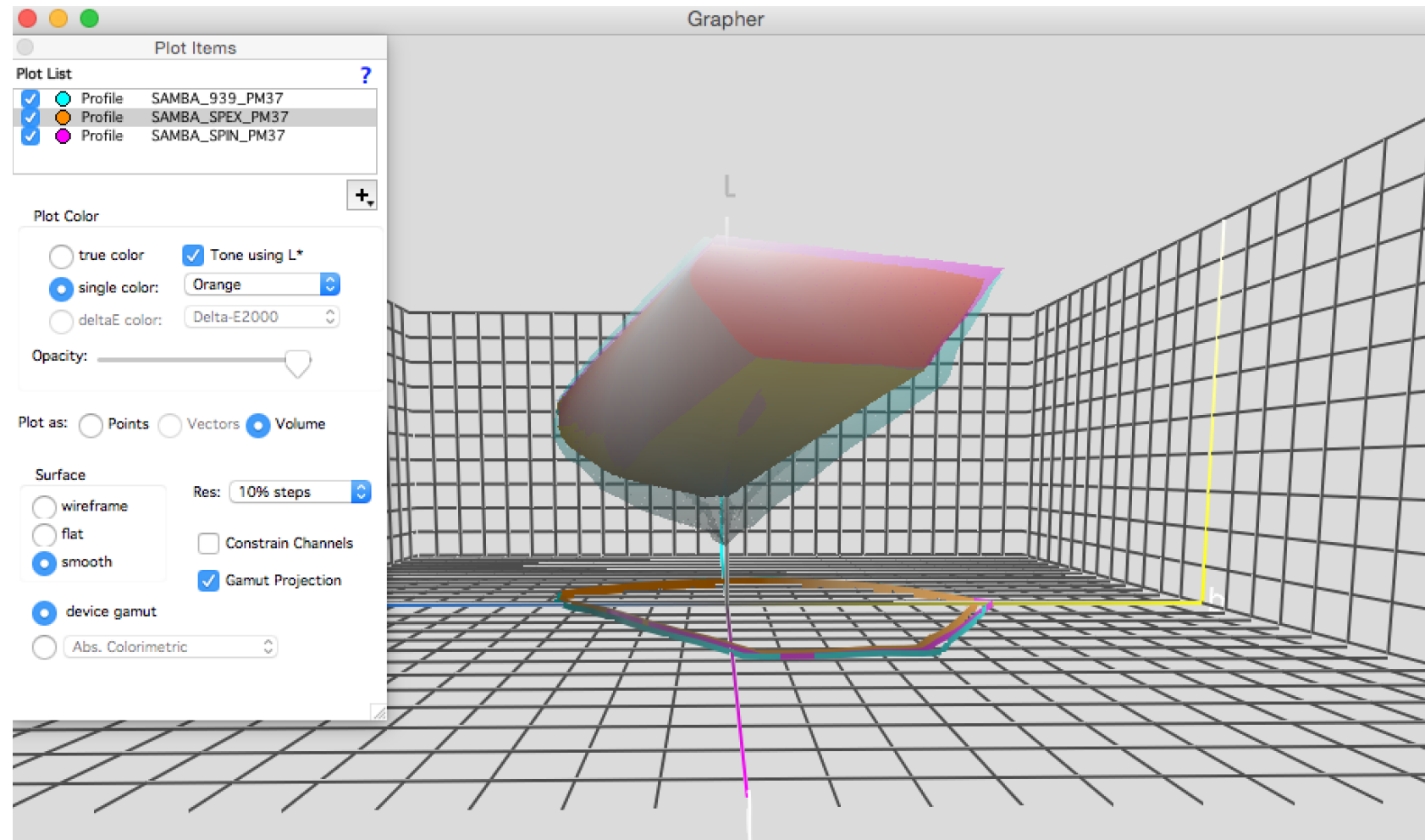
- Initial Spherical Readings Would Not Build Profile with i1 Profiler (i1 Publish) Software
- Forced to Turn to Legacy Solutions
  - *X-Rite ColorPort Direct Support for X-Rite SP64*
  - *X-Rite ColorPort Direct Support for ProfileMaker*
  - *Good Thing I Held on to that Motorola-Based iMAC*

# Quantitative: Numeric Gamut Volumes

SAMBA	
45°	250,155
Sphere Specular Excluded	195,429
Sphere Specular Included	210,523

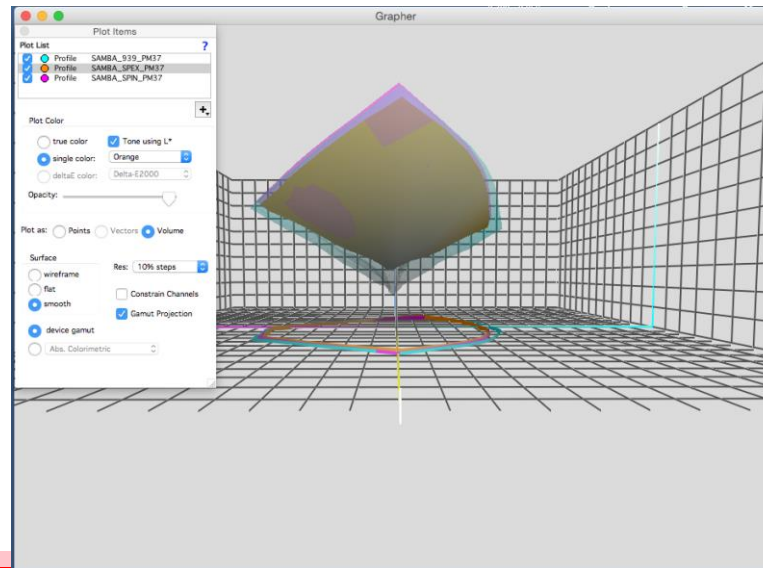
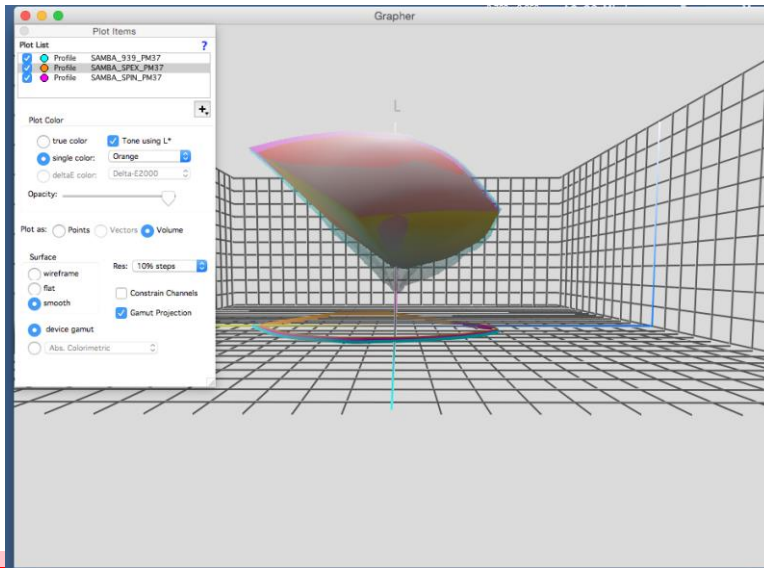
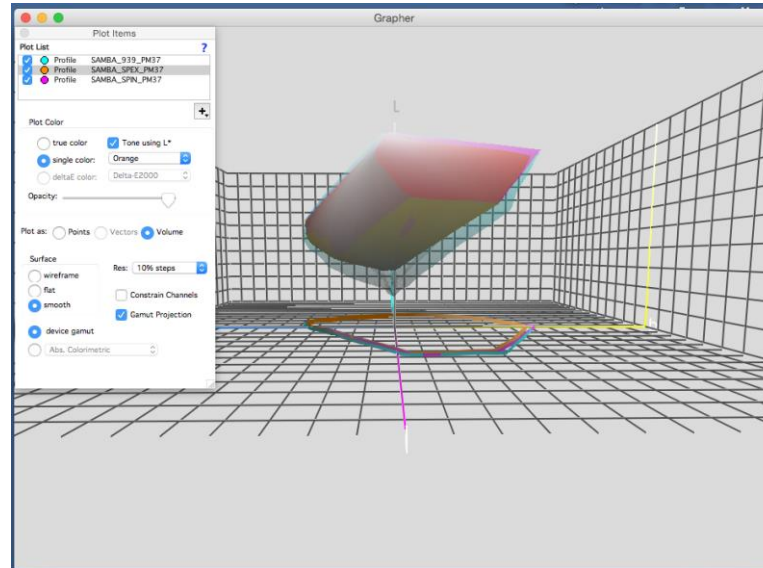
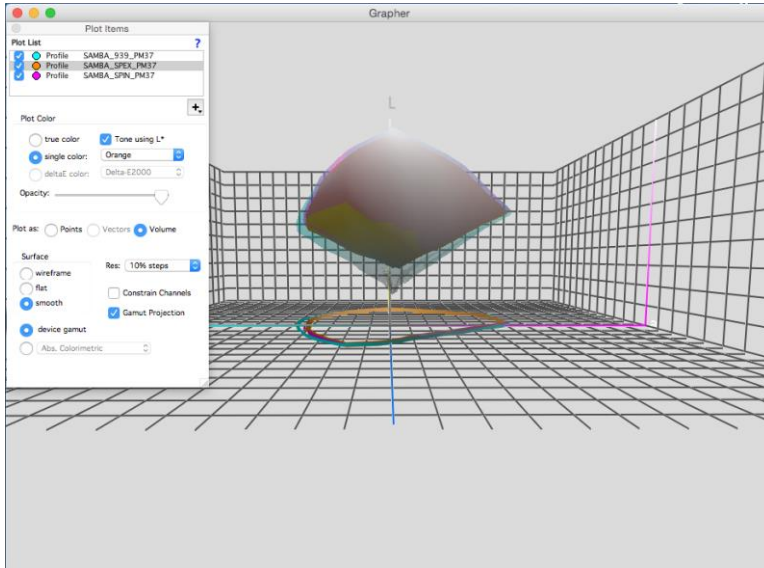
Ultra Cotton	
45°	253,231
Sphere Specular Excluded	236,232
Sphere Specular Included	224,914

# Qualitative: Visual Gamut Volumes - SAMBA



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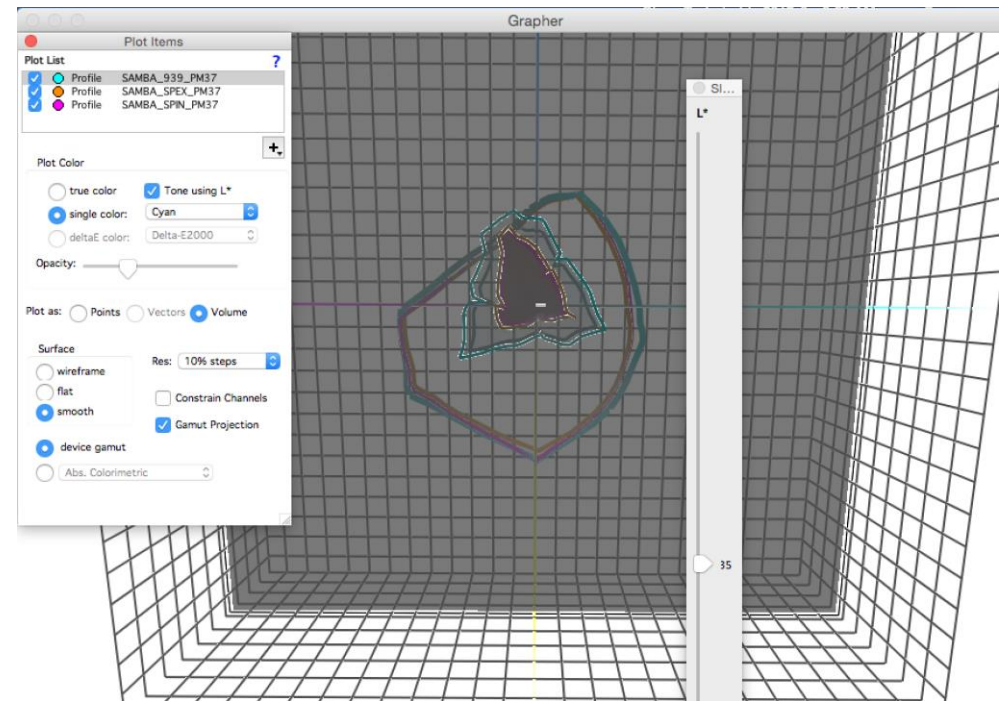
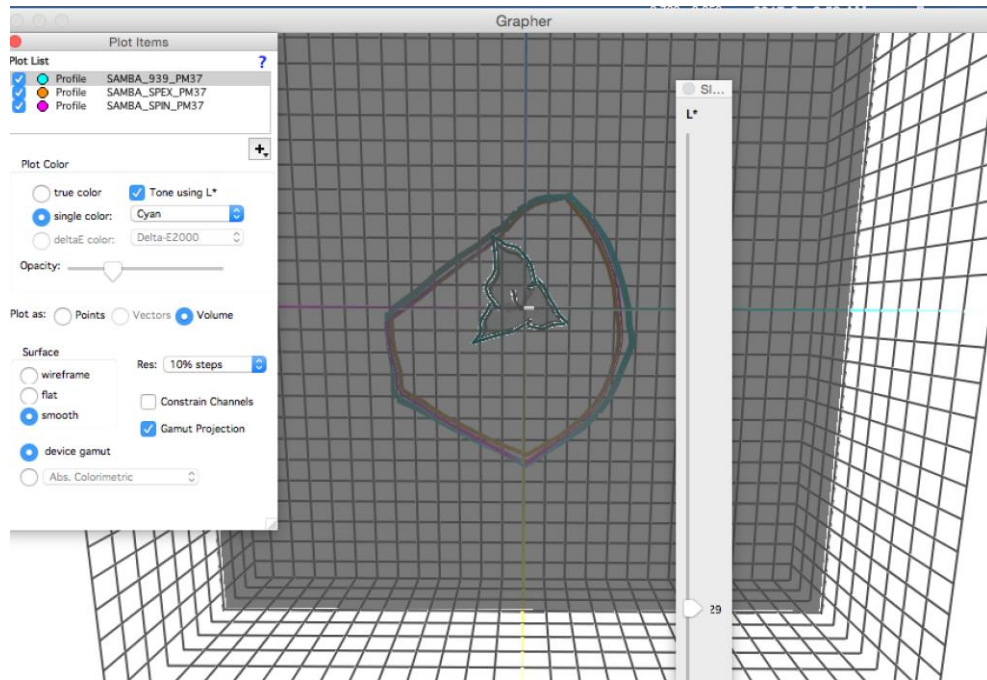
# Qualitative: Visual Gamut Volumes - SAMBA



Houston, TX 2017

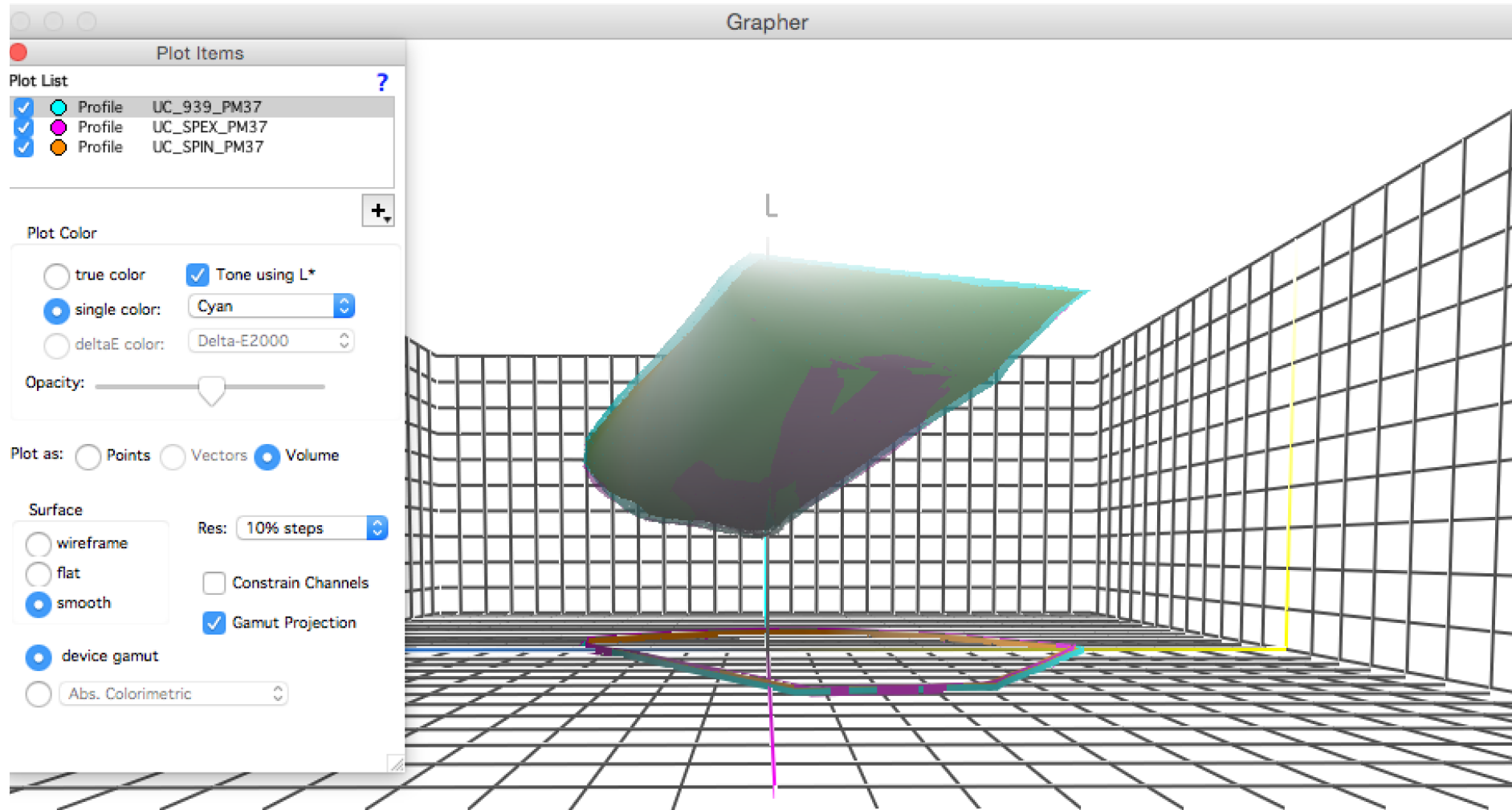
# Qualitative: Visual Gamut Volumes – SAMBA

## L\* Slice



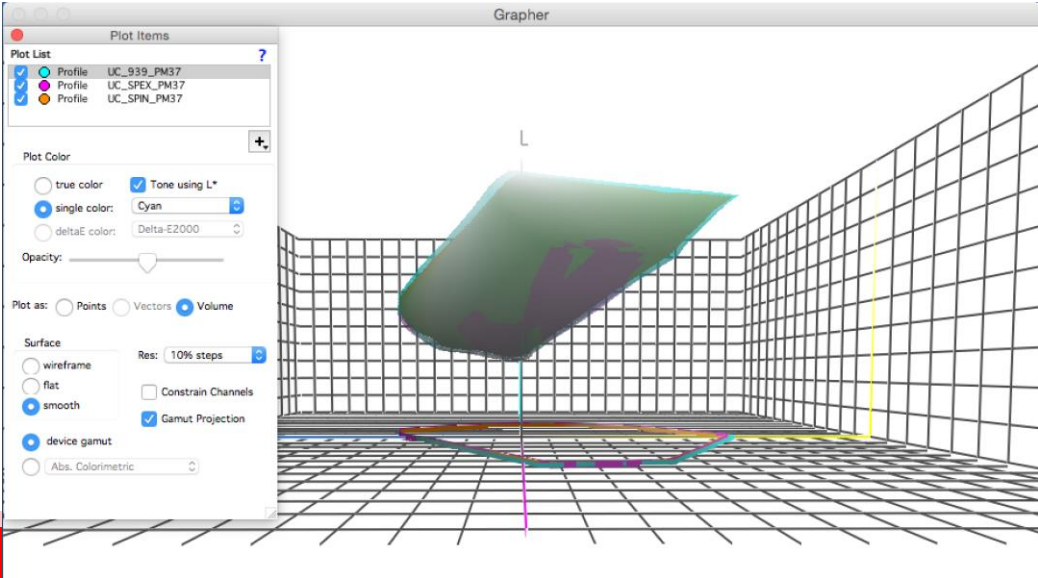
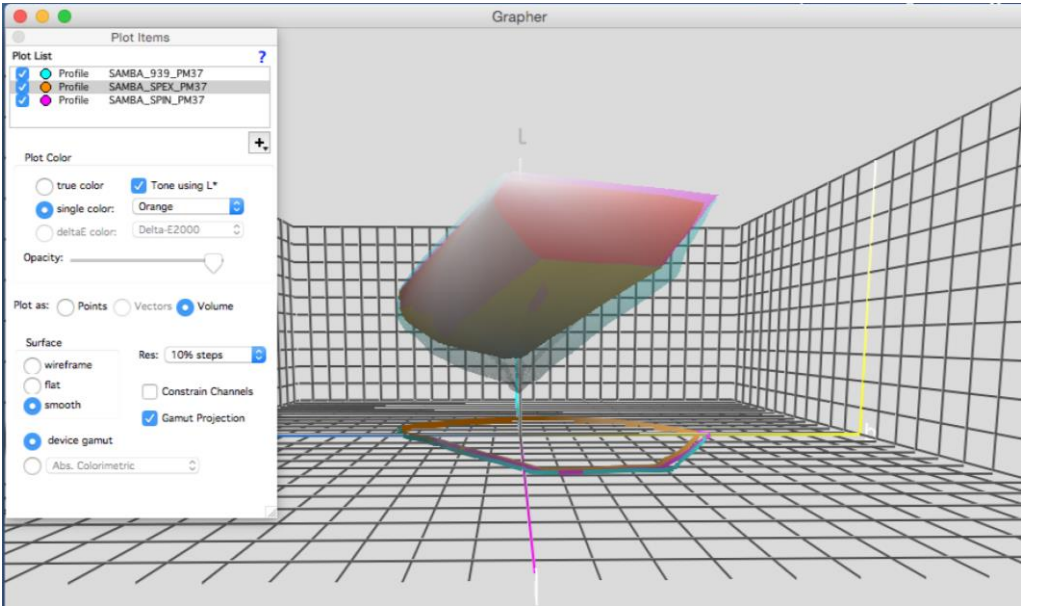
Houston, TX 2017

# Qualitative: Visual Gamut Volumes – Ultra Cotton



Houston, TX 2017

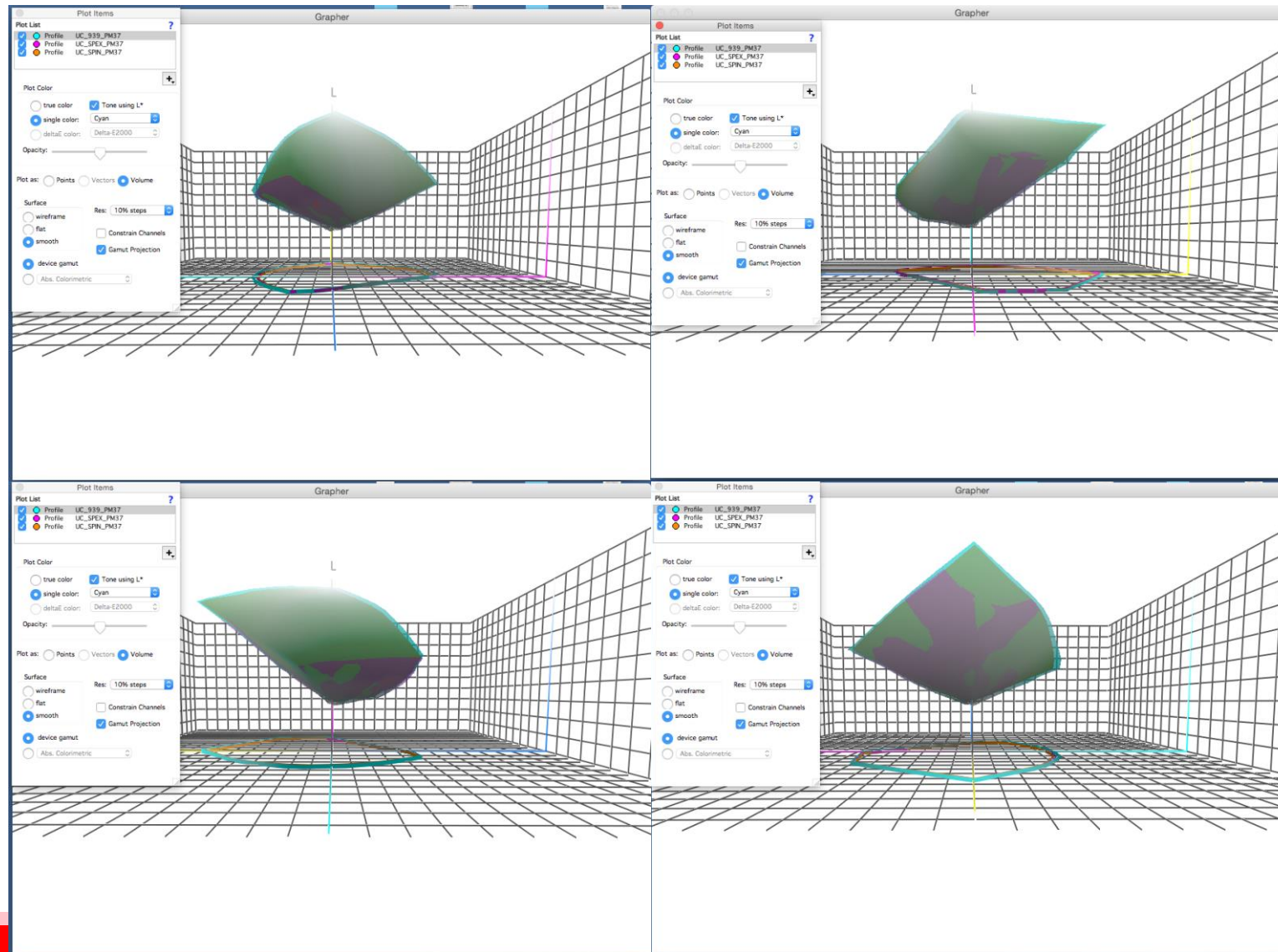
# Qualitative: Visual Gamut Volumes – SAMBA vs. Ultra Cotton



Houston, TX 2017



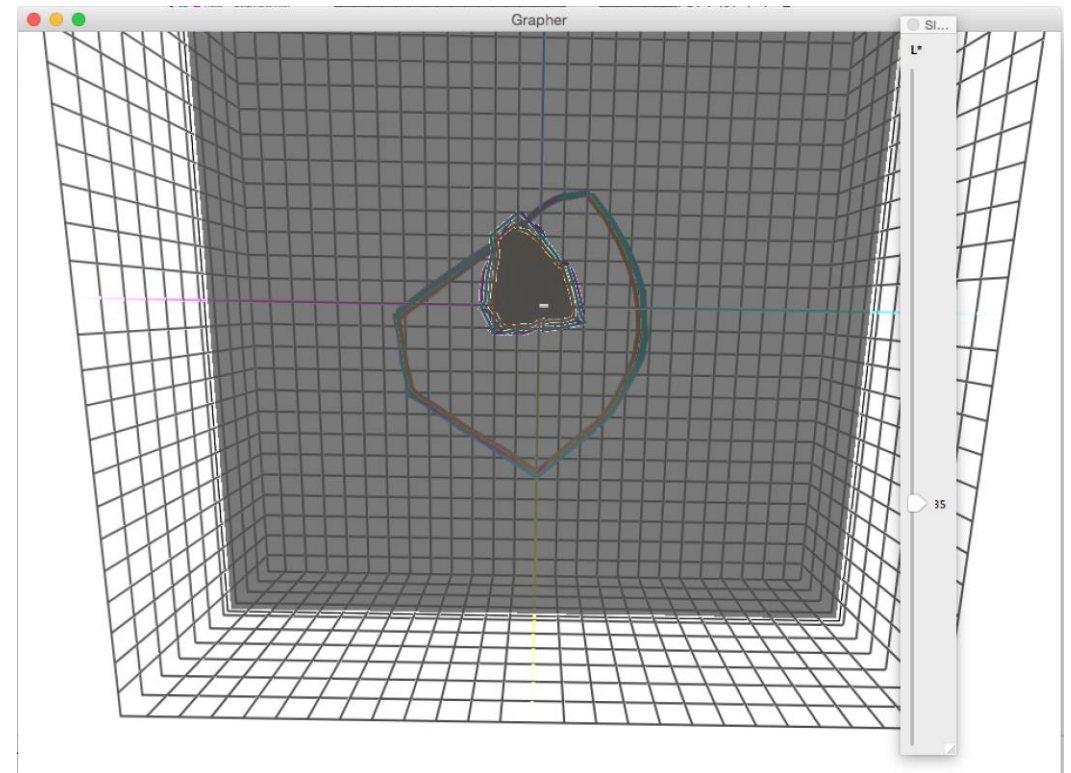
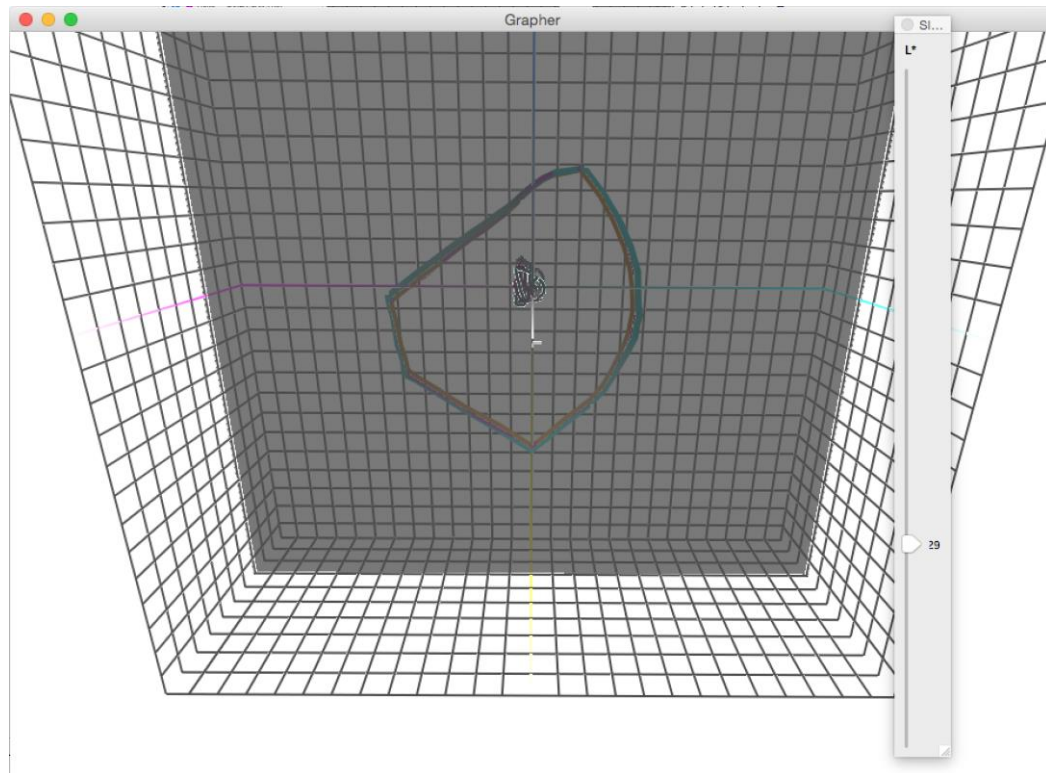
# Qualitative: Visual Gamut Volumes – Ultra Cotton



Houston, TX 2017

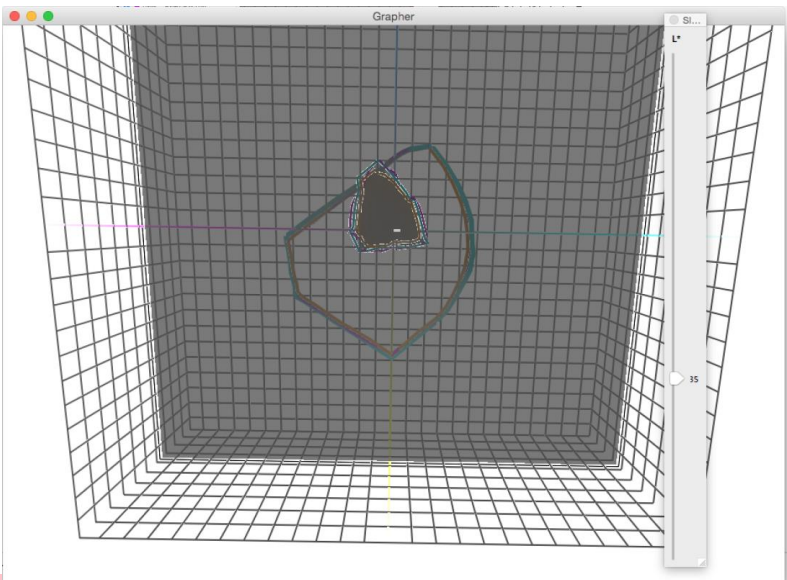
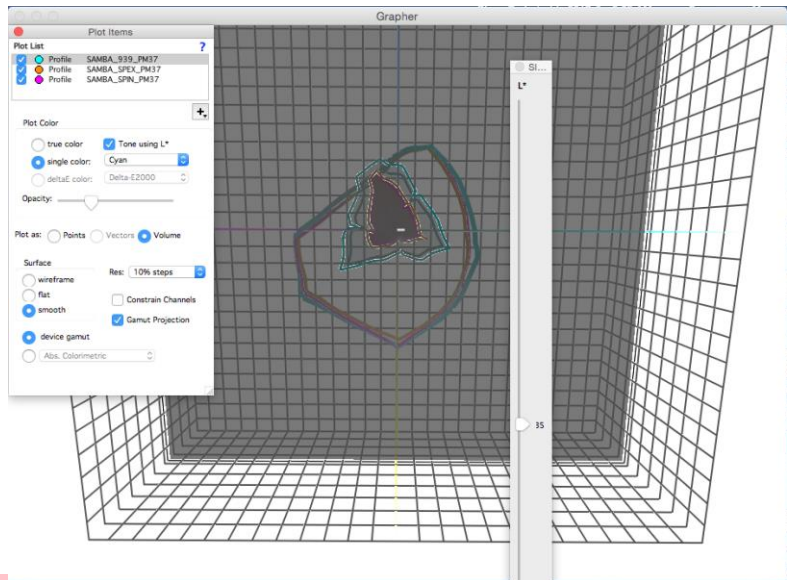
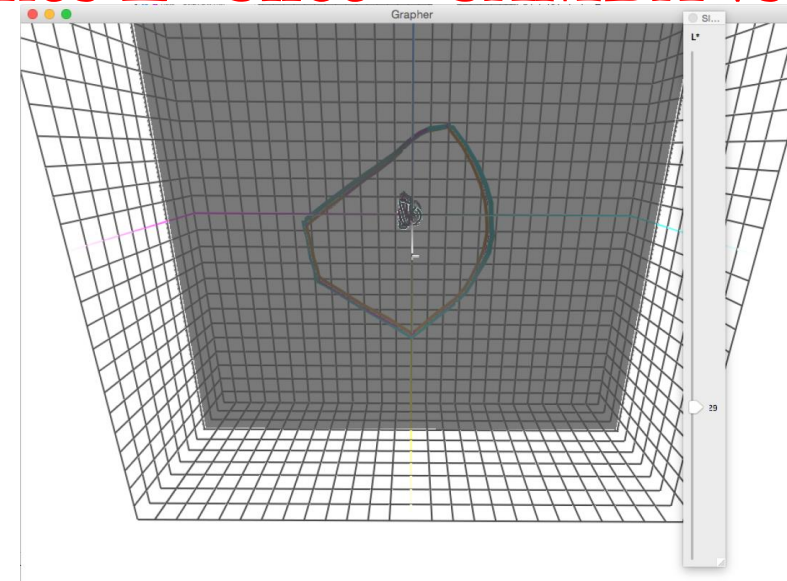
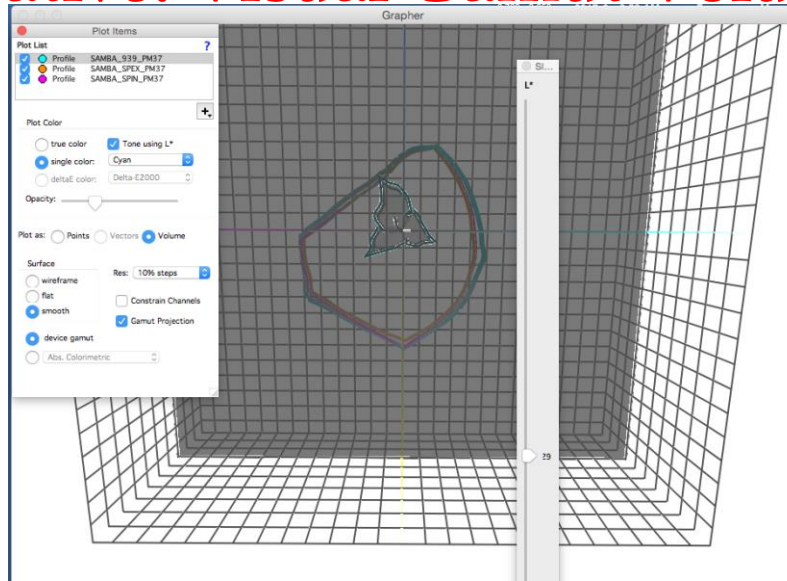
# Qualitative: Visual Gamut Volumes – Ultra Cotton

## L\* Slice



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# Qualitative: Visual Gamut Volumes L\* Slice – SAMBA vs. Ultra Cotton



Houston, TX 2017

# Directionality Spot Readings: Eight Readings at 45° Increments

	SAMBA SUBSTRATE		
$\bar{x}$	0/45°	SPEX	SPIN
L*	93.18	92.63	92.76
a*	1.94	1.49	1.38
b*	-5.71	-3.66	-3.62
C*	6.03	3.95	3.88
h°	288.76	292.18	290.93
Range			
DL*	0.64	0.3	0.28
Da*	0.07	0.12	0.15
Db*	0.37	0.22	0.2
DC*	0.36	0.19	0.19
DH*	0.07	0.12	0.12
S			
DL*	0.22	0.1	0.1
Da*	0.02	0.04	0.05
Db*	0.13	0.07	0.06
DC*	0.12	0.06	0.06
DH*	0.02	0.04	0.04

	Ultra Cotton Substrate		
$\bar{x}$	0/45°	SPEX	SPIN
L*	93.51	92.94	93.05
a*	1.98	1.46	1.35
b*	-5.59	-3.12	-3.09
C*	5.93	3.45	3.37
h°	289.44	294.99	293.66
Range			
DL*	0.39	0.2	0.19
Da*	0.07	0.08	0.11
Db*	0.31	0.1	0.12
DC*	0.3	0.1	0.14
DH*	0.05	0.04	0.05
S			
DL*	0.13	0.08	0.07
Da*	0.02	0.03	0.04
Db*	0.1	0.04	0.04
DC*	0.1	0.04	0.05
DH*	0.02	0.02	0.01

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# Directionality Spot Readings: Rich Black (100, 85, 85, 0)

SAMBA SUBSTRATE			
$\bar{x}$	0/45°	SPEX	SPIN
L*	24.76	32.51	33.96
a*	-4.35	-1.33	-1.13
b*	0.8	0.31	0.23
C*	4.43	1.37	1.16
h°	169.61	166.88	168.52
Range			
DL*	1.61	0.13	0.21
Da*	1.13	0.19	0.16
Db*	0.25	0.11	0.09
DC*	1.08	0.17	0.14
DH*	0.25	0.07	0.06
S			
DL*	0.55	0.05	0.07
Da*	0.39	0.06	0.5
Db*	0.09	0.04	0.04
DC*	0.38	0.5	0.04
DH*	0.08	0.03	0.02

ULTRA COTTON SUBSTRATE			
$\bar{x}$	0/45°	SPEX	SPIN
L*	31.58	32.61	33.38
a*	-2.8	-1.9	-1.86
b*	1.09	0.56	0.48
C*	3.01	1.98	1.92
h°	158.8	163.61	165.64
Range			
DL*	2.17	0.21	0.27
Da*	0.62	0.25	0.18
Db*	0.7	0.14	0.14
DC*	0.74	0.22	0.15
DH*	0.29	0.1	0.09
S			
DL*	0.86	0.08	0.1
Da*	0.23	0.09	0.07
Db*	0.19	0.06	0.05
DC*	0.26	0.07	0.06
DH*	0.1	0.03	0.03

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# Directionality Spot Readings: 4x100 (100, 100, 100, 100)

SAMBA SUBSTRATE			
$\bar{x}$	0/45°	SPEX	SPIN
L*	14.93	28.35	30.89
a*	0.89	1.38	1.38
b*	-0.06	0.23	0.23
C*	0.89	1.4	1.4
h	356.13	9.52	9.65
Range			
DL*	1.43	0.58	0.38
Da*	0.35	0.17	0.15
Db*	0.23	0.13	0.09
DC*	0.35	0.16	0.15
DH*	0.13	0.09	0.04
S			
DL*	0.43	0.19	0.15
Da*	0.11	0.06	0.05
Db*	0.07	0.04	0.03
DC*	0.11	0.05	0.05
DH*	0.04	0.03	0.01

ULTRA COTTON SUBSTRATE			
$\bar{x}$	0/45°	SPEX	SPIN
L*	27.82	29.75	30.65
a*	1.17	1.33	1.29
b*	0	0.09	0.01
C*	1.17	1.34	1.29
h	359.87	3.68	0.32
Range			
DL*	1.92	0.38	0.49
Da*	0.3	0.1	0.08
Db*	0.51	0.07	0.08
DC*	0.3	0.09	0.08
DH*	0.26	0.04	0.05
S			
DL*	0.67	0.12	0.18
Da*	0.09	0.03	0.03
Db*	0.2	0.03	0.02
DC*	0.09	0.03	0.03
DH*	0.09	0.01	0.02

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# Directionality Spot Readings: Black (0, 0, 0, 100)

	SAMBA SUBSTRATE				ULTRA COTTON SUBSTRATE		
$\bar{x}$	0/45°	SPEX	SPIN	$\bar{x}$	0/45°	SPEX	SPIN
L*	34.36	35.57	36.14	L*	33.03	33.04	33.62
a*	0.49	0.43	0.43	a*	0.7	0.62	0.61
b*	-0.33	0.05	0	b*	0.63	0.9	0.8
C*	0.59	0.43	0.43	C*	0.94	1.09	1.01
h	325.74	7.17	0.38	h	42.25	55.14	52.6
Range				Range			
DL*	0.67	0.16	0.04	DL*	0.37	0.17	0.18
Da*	0.06	0.05	0.06	Da*	0.08	0.04	0.07
Db*	0.22	0.07	0.07	Db*	0.17	0.04	0.06
DC*	0.1	0.05	0.06	DC*	0.11	0.04	0.08
DH*	0.13	0.03	0.03	DH*	0.09	0.02	0.03
S				S			
DL*	0.2	0.06	0.02	DL*	0.13	0.07	0.06
Da*	0.02	0.02	0.02	Da*	0.02	0.01	0.03
Db*	0.08	0.02	0.02	Db*	0.06	0.01	0.02
DC*	0.04	0.02	0.02	DC*	0.03	0.01	0.03
DH*	0.04	0.01	0.01	DH*	0.03	0.01	0.01

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# Simulate Round-Trip Error

- Forward Transform (A to B)
  - *Device Color Space to Profile Connection Space*
- Inverse Transform (B to A)
  - *Profile Connection Space to Device Color Space*



# Simulate Round-Trip Error

- CGATS TR016 Graphic Technology Printing Tolerance and Conformity Assessment
- T8.7/4 - 2005 Graphic technology - Input data for characterization of 4-color process printing  
(1,617 Patches)

# Simulate Round-Trip Error

Color Worksheet

Workflow 1

Profiles: Abs Colorimetric

Images: <untitled image>

Colors: IT8.7-4 CMYK.txt

#	Name	C	M	Y	K	L	a	b	C	M	Y	K	L	a	b	ΔE00
1552	2K40	0.0	100.0	100.0	70.0	31.88	9.09	6.27	50.5	89.4	67.9	24.9	34.78	7.88	4.42	2.89
1080	Z30	100.0	100.0	40.0	100.0	26.90	2.55	-1.08	84.1	84.1	65.9	53.8	29.55	1.02	-0.64	2.89
272	G20	100.0	40.0	0.0	60.0	30.05	-0.04	-12.84	91.9	76.6	38.5	13.5	33.09	0.46	-10.65	2.89
1611	2M15	10.0	100.0	20.0	20.0	41.94	35.14	1.39	26.7	93.9	33.7	0.0	44.19	30.51	0.23	2.88
372	I36	0.0	100.0	20.0	20.0	45.09	41.55	6.03	18.7	91.0	33.4	0.0	47.11	36.37	4.02	2.87
1410	2H24	70.0	100.0	10.0	20.0	32.35	12.09	-16.55	71.5	91.9	25.4	3.8	34.92	9.95	-16.84	2.86
1494	2J24	100.0	100.0	20.0	20.0	30.53	5.63	-14.75	81.4	86.1	32.8	8.1	33.56	4.22	-13.48	2.86
1052	ZZ	100.0	100.0	20.0	60.0	29.13	3.86	-5.87	82.6	87.4	47.1	27.6	31.23	2.11	-4.57	2.83
574	N28	40.0	0.0	100.0	60.0	38.10	-10.05	12.27	61.6	48.4	81.9	11.7	40.70	-8.70	10.00	2.83
1608	2M12	70.0	100.0	40.0	40.0	30.17	5.48	-3.44	72.5	89.1	51.1	29.4	31.72	3.35	-2.38	2.82
858	U18	70.0	0.0	100.0	60.0	34.44	-10.90	6.75	73.2	51.0	75.3	16.3	37.18	-9.39	5.06	2.82
1231	2D13	100.0	100.0	0.0	100.0	28.18	3.04	-1.43	81.4	84.1	62.6	49.0	29.88	1.14	-1.10	2.82
1306	2F4	100.0	0.0	40.0	60.0	32.73	-9.50	-3.96	89.5	56.3	55.2	18.2	35.27	-7.55	-4.25	2.82
1170	2B36	40.0	100.0	0.0	100.0	28.79	3.27	0.31	76.5	83.1	66.1	49.5	30.06	1.28	-0.23	2.82
1142	2B8	40.0	70.0	0.0	80.0	29.88	4.07	-2.26	75.3	85.5	56.2	35.7	31.22	1.97	-1.86	2.82
690	Q18	40.0	100.0	70.0	80.0	29.28	3.07	1.89	72.5	81.1	67.7	43.3	30.86	1.39	0.39	2.82
1005	X39	40.0	0.0	100.0	40.0	44.92	-15.88	20.17	55.0	37.5	82.6	3.9	46.87	-13.77	16.52	2.81
436	K16	40.0	100.0	20.0	40.0	32.65	14.09	-5.52	56.6	97.3	39.4	12.4	35.28	11.77	-4.86	2.80
800	T2	0.0	100.0	100.0	80.0	30.71	5.65	4.37	59.4	84.8	66.9	30.7	33.25	4.64	2.40	2.78
426	K6	0.0	100.0	70.0	20.0	44.42	38.07	22.27	19.8	91.7	73.0	0.0	46.02	32.42	21.00	2.76
573	N27	100.0	40.0	20.0	40.0	33.38	-4.83	-15.29	87.9	64.6	36.8	7.0	36.31	-3.77	-13.70	2.76
614	G35	20.0	100.0	20.0	20.0	32.83	10.33	-13.03	70.5	92.5	51.2	7.5	34.43	3.14	-12.63	2.76
287	G35	20.0	20.0	100.0	40.0	44.87	-3.12	22.04	42.2	46.1	84.6	6.6	47.07	-3.27	18.75	2.76
1180	2C4	20.0	100.0	0.0	60.0	32.14	13.33	-2.35	53.9	96.9	44.5	18.2	34.69	11.07	-1.95	2.76
1416	2H30	0.0	0.0	40.0	0.0	92.77	-5.73	45.00	2.4	2.4	41.5	0.0	88.78	-5.43	41.43	2.76
645	P15	0.0	0.0	40.0	0.0	92.77	-5.73	45.00	2.4	2.4	41.5	0.0	88.78	-5.43	41.43	2.76
524	M20	7.0	0.0	7.0	0.0	89.81	-9.50	-1.51	7.2	2.2	8.0	0.0	87.95	-6.91	-1.27	2.75
1401	2H15	100.0	20.0	100.0	60.0	31.39	-7.59	1.77	83.0	55.4	66.9	27.0	33.99	-6.45	0.14	2.73
1192	2C16	15.0	0.0	0.0	0.0	84.71	-13.43	-19.45	16.7	3.5	3.2	0.0	81.17	-11.93	-17.50	2.70
1295	2.00E+35	100.0	100.0	10.0	20.0	42.18	36.18	-2.14	26.2	93.5	27.1	0.0	44.23	32.05	-3.71	2.70
1321	2F19	40.0	100.0	100.0	80.0	29.28	2.28	2.18	74.0	78.8	69.2	44.1	30.77	0.84	0.51	2.70
675	Q3	20.0	40.0	100.0	40.0	41.70	3.37	18.34	41.5	56.6	83.4	10.0	43.81	2.25	15.51	2.70
256	G4	20.0	100.0	70.0	60.0	32.27	9.38	5.57	50.7	89.7	65.9	24.1	34.87	8.14	3.79	2.69
127	D1	100.0	40.0	100.0	20.0	35.00	-14.15	4.79	78.9	47.9	73.0	12.9	37.67	-12.38	3.68	2.69
751	R37	100.0	0.0	0.0	60.0	33.27	-5.48	-13.50	88.4	64.2	39.1	8.7	36.06	-4.27	-12.09	2.69
1220	2D2	100.0	70.0	0.0	60.0	28.85	3.42	-10.34	86.4	86.2	39.1	16.9	31.89	2.63	-8.94	2.68
1435	2I7	100.0	10.0	100.0	20.0	39.87	-27.05	9.77	20.2	13.3	80.1	2.6	40.13	23.76	8.07	2.67
1325	2F23	70.0	100.0	20.0	40.0	30.01	7.71	-8.59	73.4	94.8	38.4	16.1	32.52	5.95	-7.79	2.67
519	M15	100.0	40.0	40.0	40.0	32.62	-7.75	-7.19	92.4	61.1	47.8	16.4	34.95	-5.90	-6.86	2.67
893	V11	0.0	20.0	100.0	60.0	40.72	2.69	16.94	43.0	56.6	84.3	12.6	42.67	1.46	14.30	2.67
1319	2F17	10.0	100.0	100.0	0.0	48.55	44.27	30.58	12.2	83.9	72.5	0.4	49.69	37.89	26.01	2.67

Illuminant: D50 2° 5,001K

# Simulate Round-Trip Error

- T8.7/4 - 2005 Graphic technology - Input data for characterization of 4-color process printing (1617 Patches)
- When Round-Tripped  $\Delta E_{00}$  are Sorted Largest to Smallest, 81<sup>st</sup> Largest Value Represents 95<sup>th</sup> Percentile

# Round-Trip Error Results

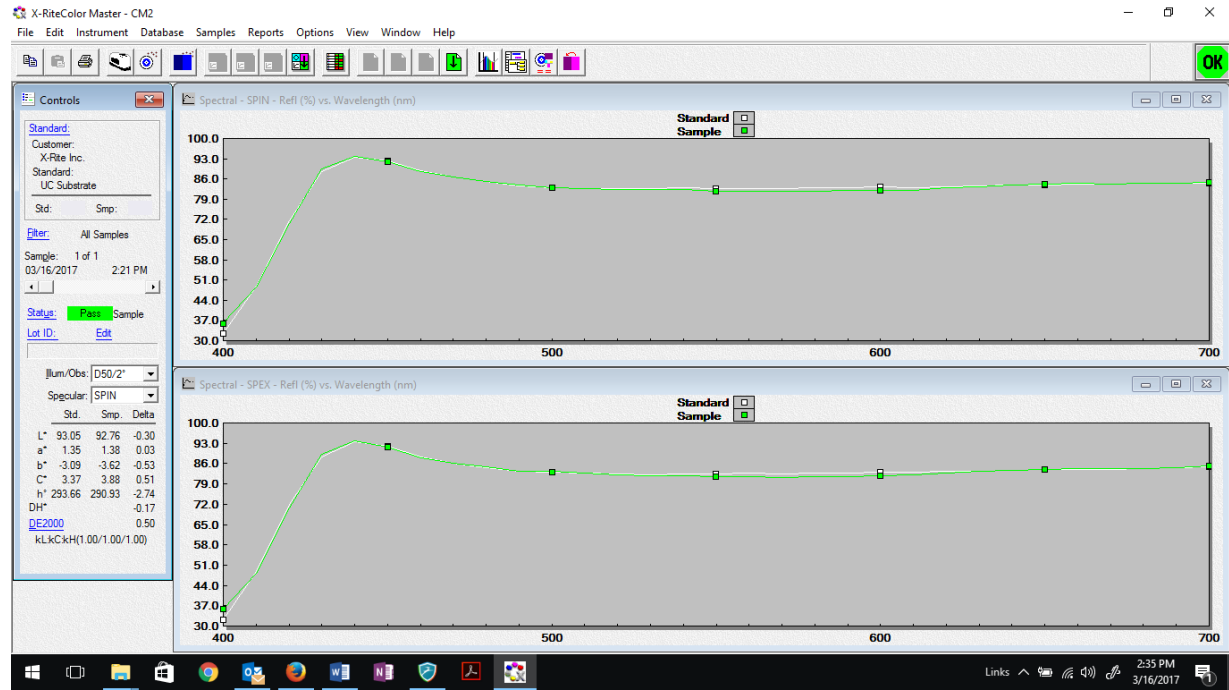
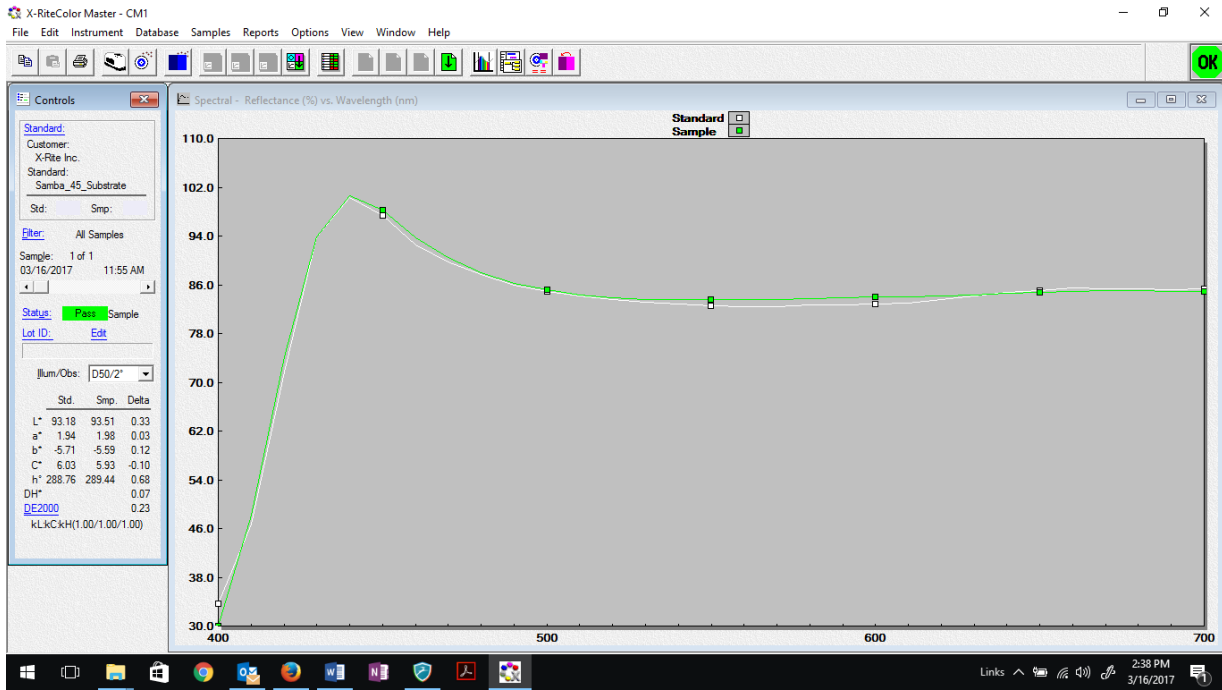
	<b>SAMBA 95<sup>th</sup> Percentile <math>\Delta E_{00}</math></b>	<b>Ultra Cotton 95<sup>th</sup> Percentile <math>\Delta E_{00}</math></b>
0/45°	5.31	2.76
Sphere Specular Excluded	2.64	2.69
Sphere Specular Included	2.61	2.71

# Conclusions/Implications

- Surface Qualities (e.g.: Gloss, "Sheen") Critical
- Directionality of Instrument Introduces Variance

# Future Research

- Profiles Built at Differing Directionality (Instrument Orientation), Average
- Separate Texture from Other Surface Qualities
- Ink Limiting
- Other Profiling Solutions
- Control for OBAs



# Future Research –

## Other Profiling Software Options, e.g.:

- Argyll Color Management
  - <http://www.argyllcms.com>
- basIC COLOR
  - <http://www.basiccolor.de/>
- FujiFilm ColorPath
  - [http://www.fujifilmusa.com/products/graphic\\_arts\\_printing/workflow-solutions/colorpath/](http://www.fujifilmusa.com/products/graphic_arts_printing/workflow-solutions/colorpath/)



# Thank you

