



U.S. DEPARTMENT OF  
**ENERGY**



UNIVERSITY OF  
CALIFORNIA



Lawrence Berkeley National Laboratory



# VT RATING OF TDD

**Windows & Daylighting Group  
Building Technologies Department  
Lawrence Berkeley National Laboratory**

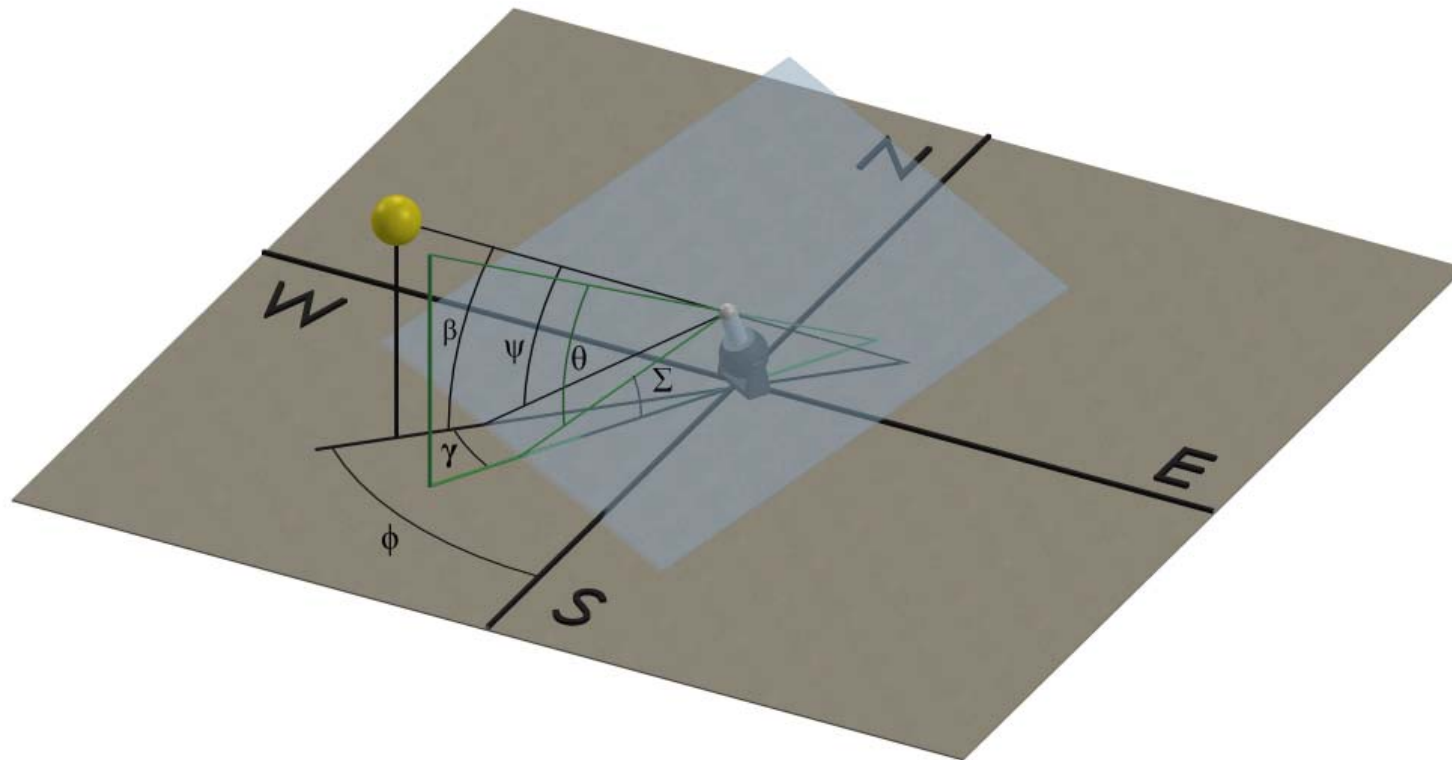
November 8, 2011

# MEASUREMENTS USING INTEGRATING SPHERE



Title of Presentation | Date

# ANGULAR DEFINITIONS



# VT CALCULATION

IRT:

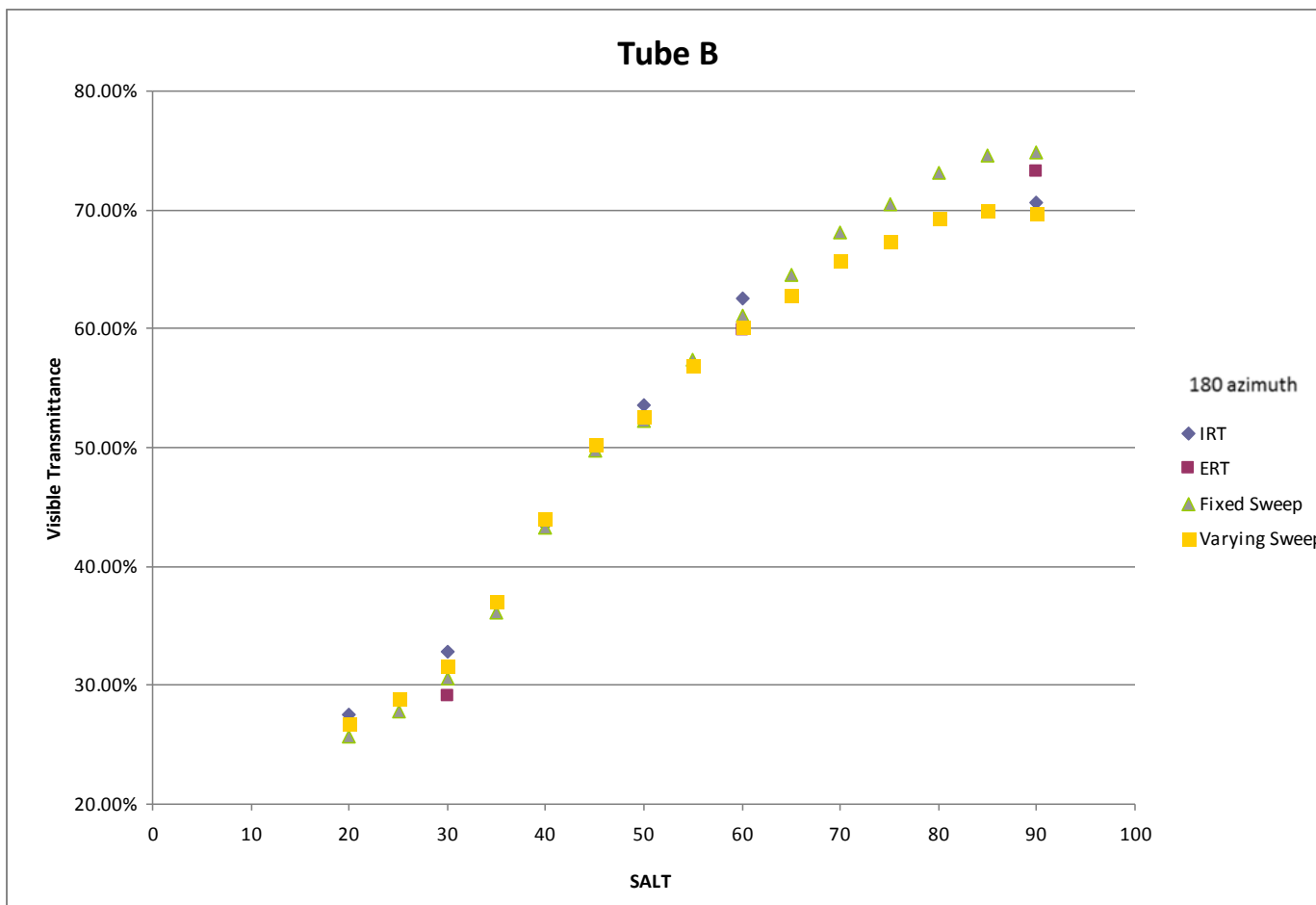
$$E_{Open, AreaCorr.} = E_{Open, Raw} \frac{A_{Spec. Aper.}}{A_{Sphere Aper.}}$$

$$VT = \frac{2E_{Specimen}}{E_{OpenBeforeAreaCorr} + E_{OpenAfterAreaCorr}}$$

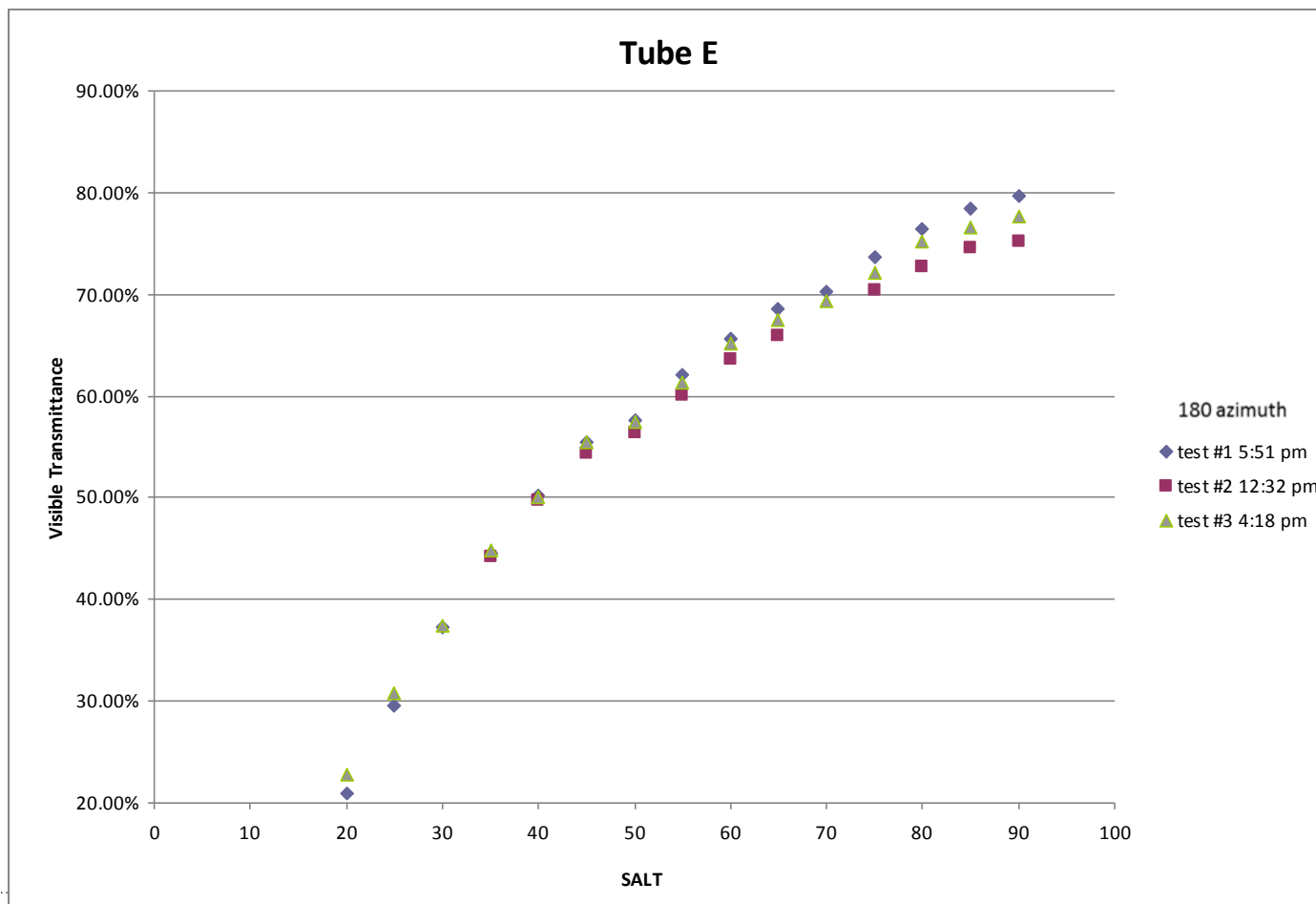
ERT:

$$VT = \frac{\left( \frac{E_{int, spec} \cdot A_{sphere}}{E_{ext, spec} \cdot A_{spec}} \right)}{\left( \frac{E_{int, open} \cdot A_{sphere}}{E_{ext, open} \cdot A_{port}} \right)}$$

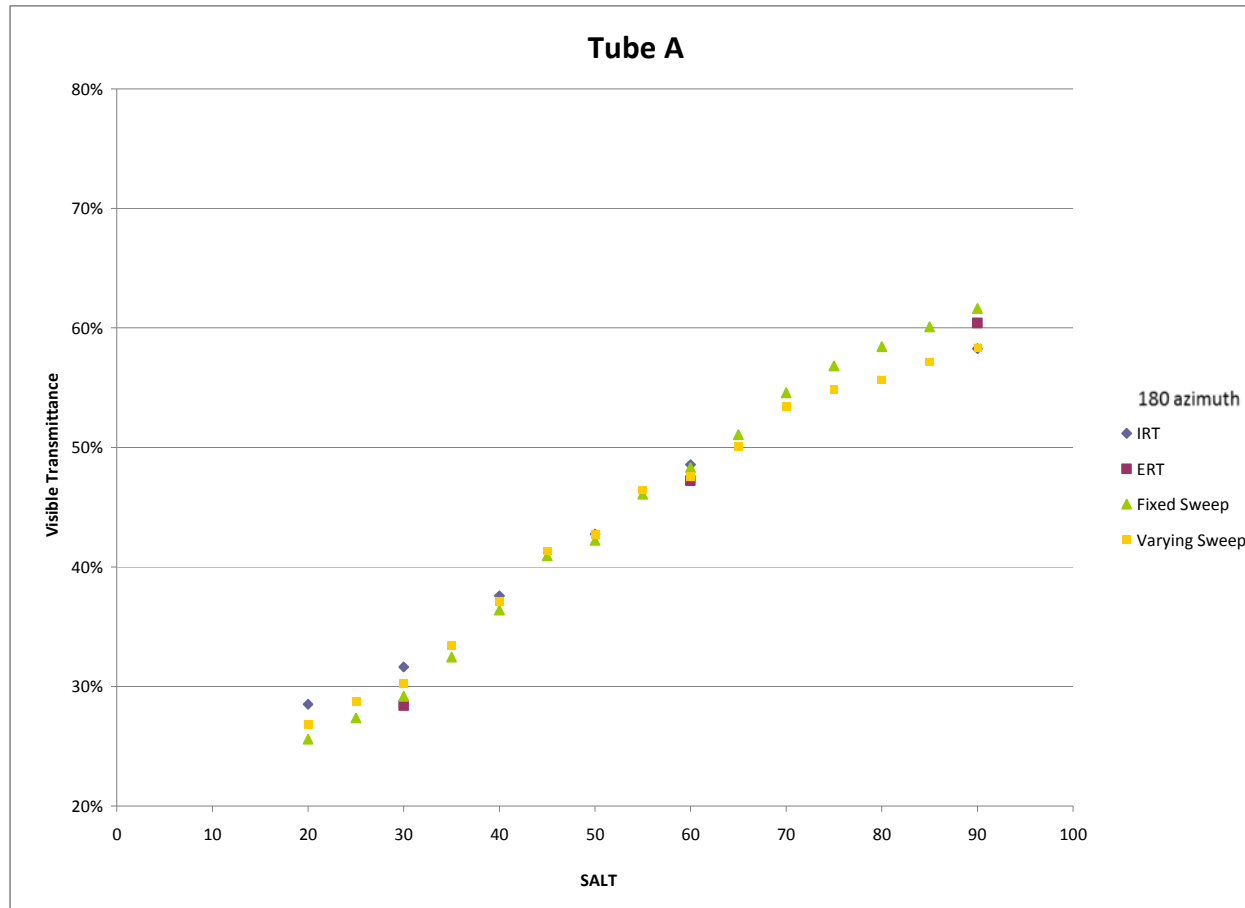
# COMPARISON OF DIFFERENT MEASUREMENT OPTIONS



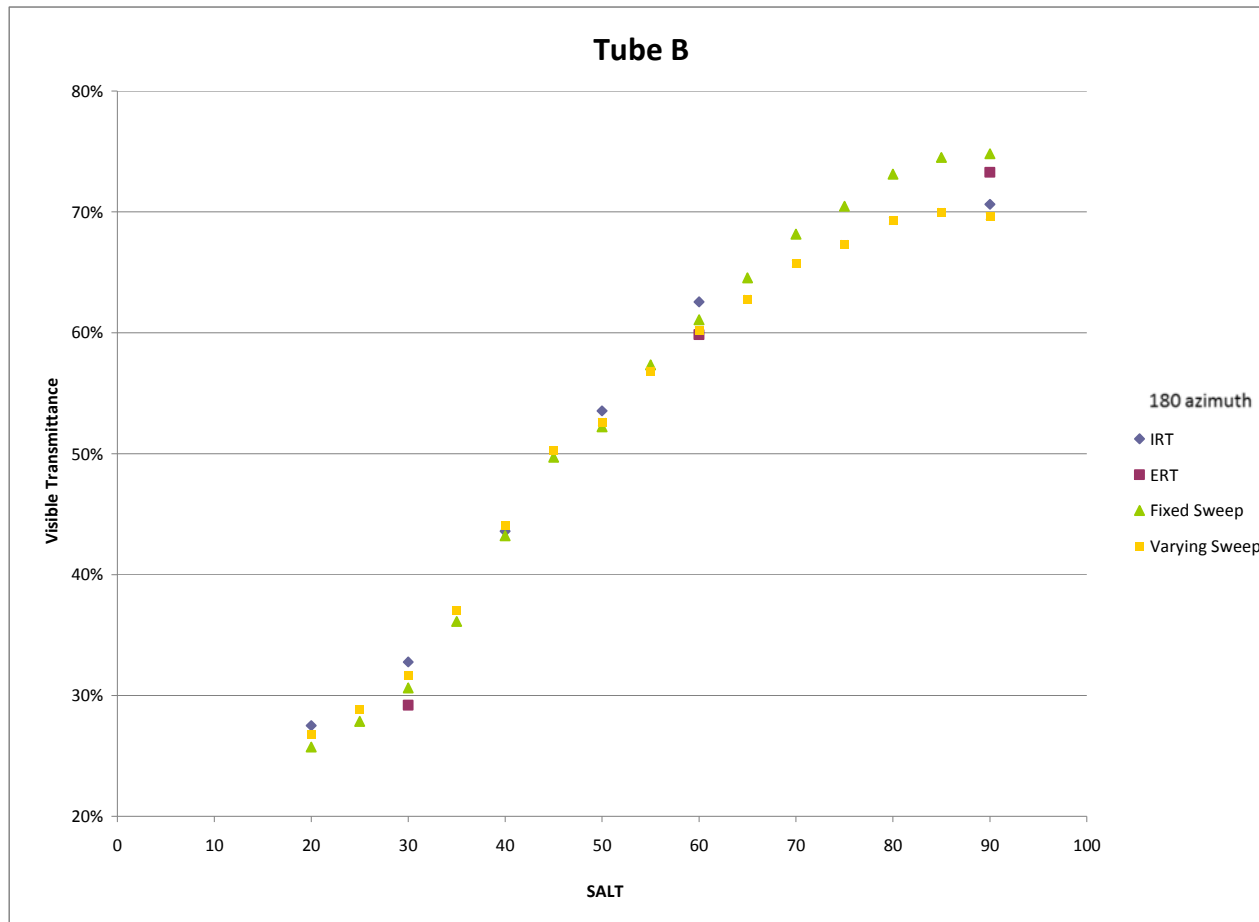
# MEASUREMENTS AT DIFFERENT TIMES OF DAY



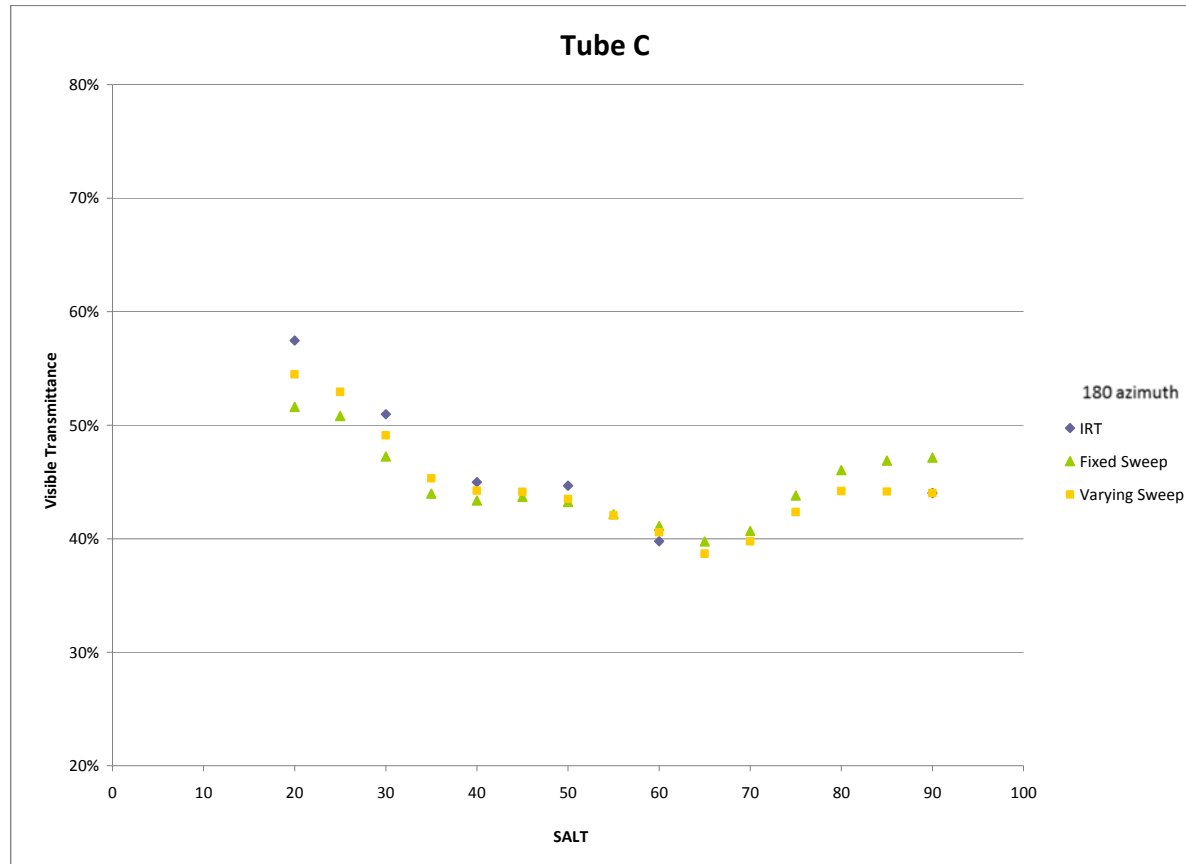
# TUBE A @ 180 Deg



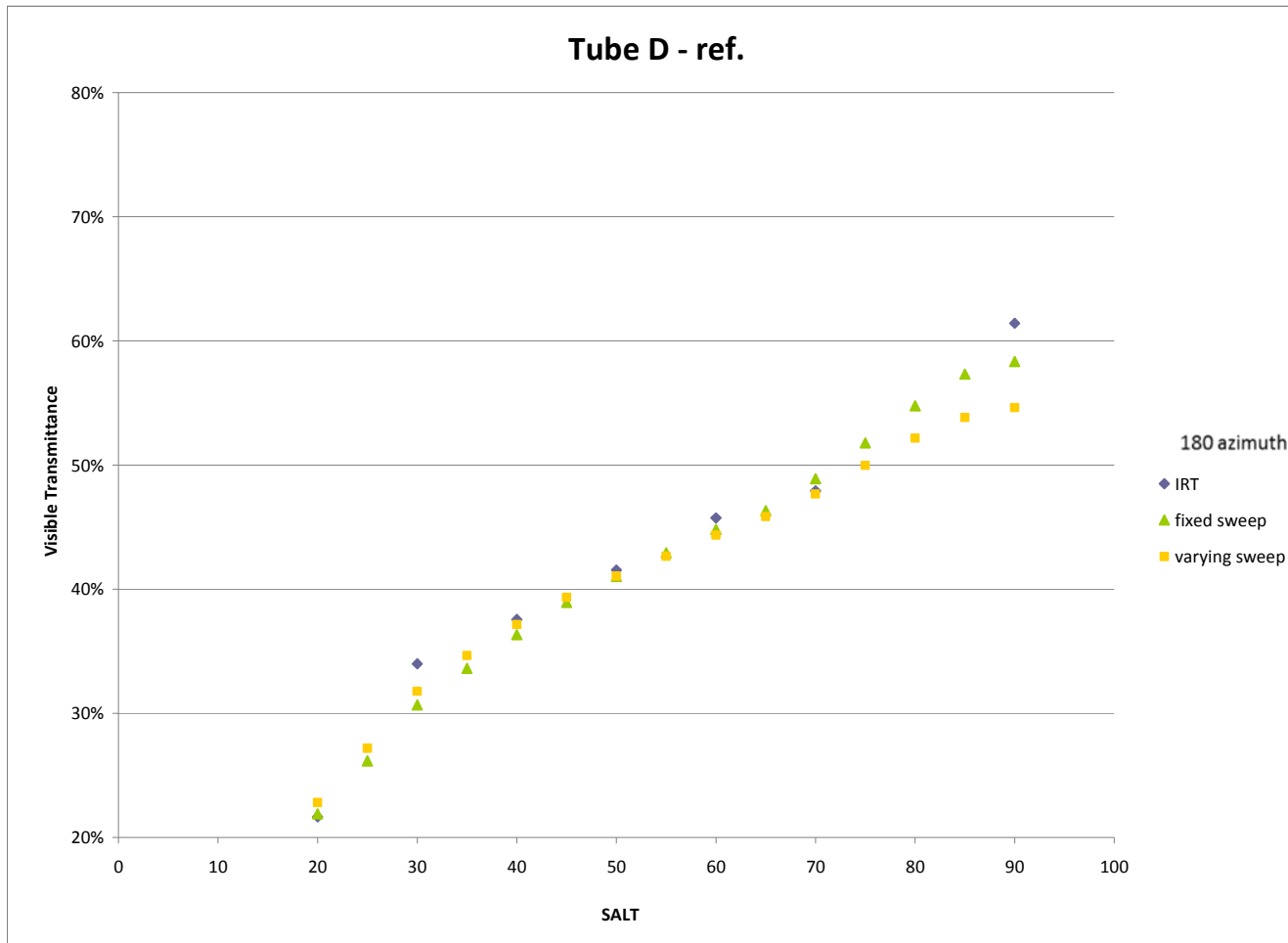
# TUBE B @ 180 Deg



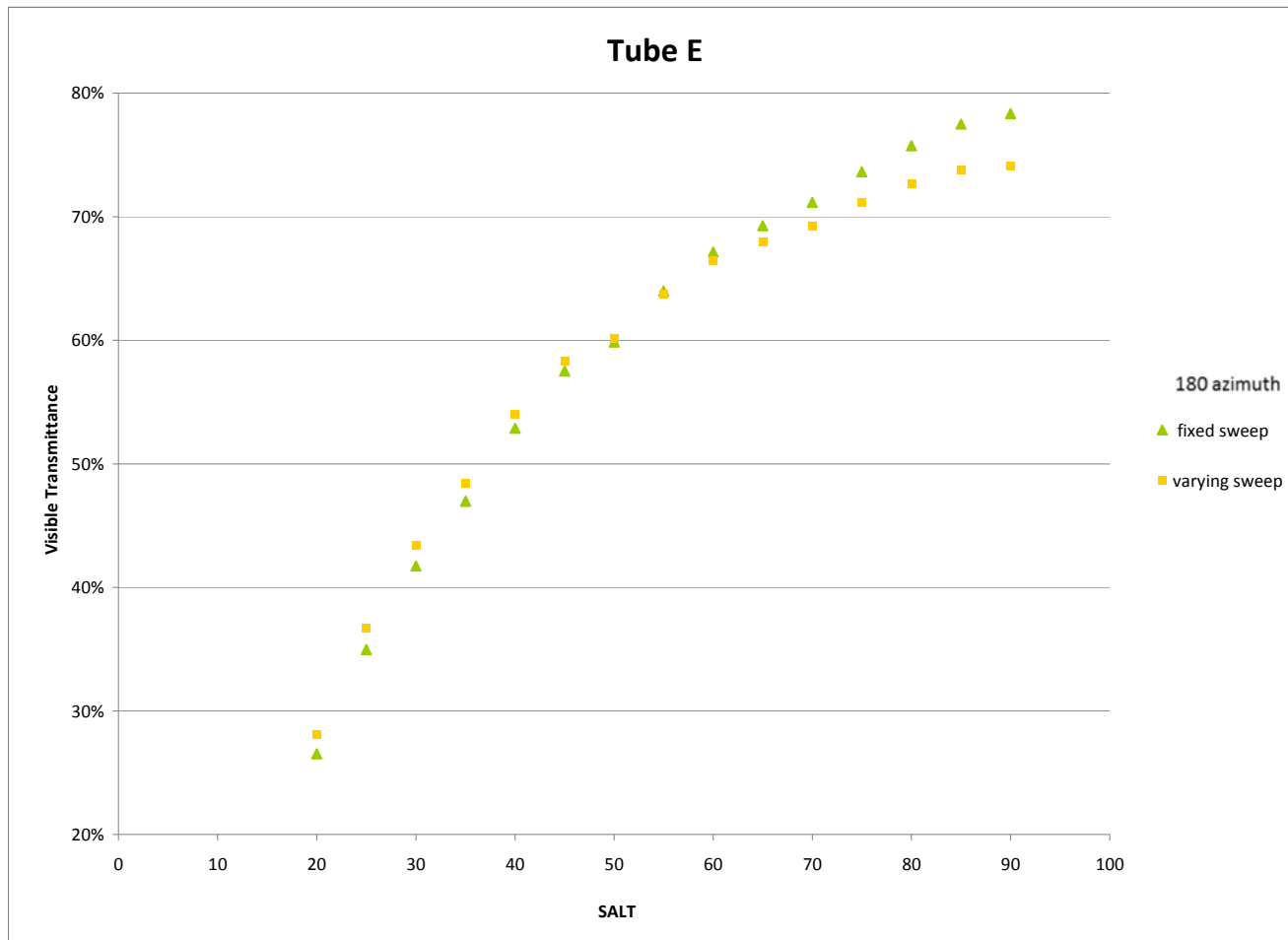
# TUBE C @ 180 Deg



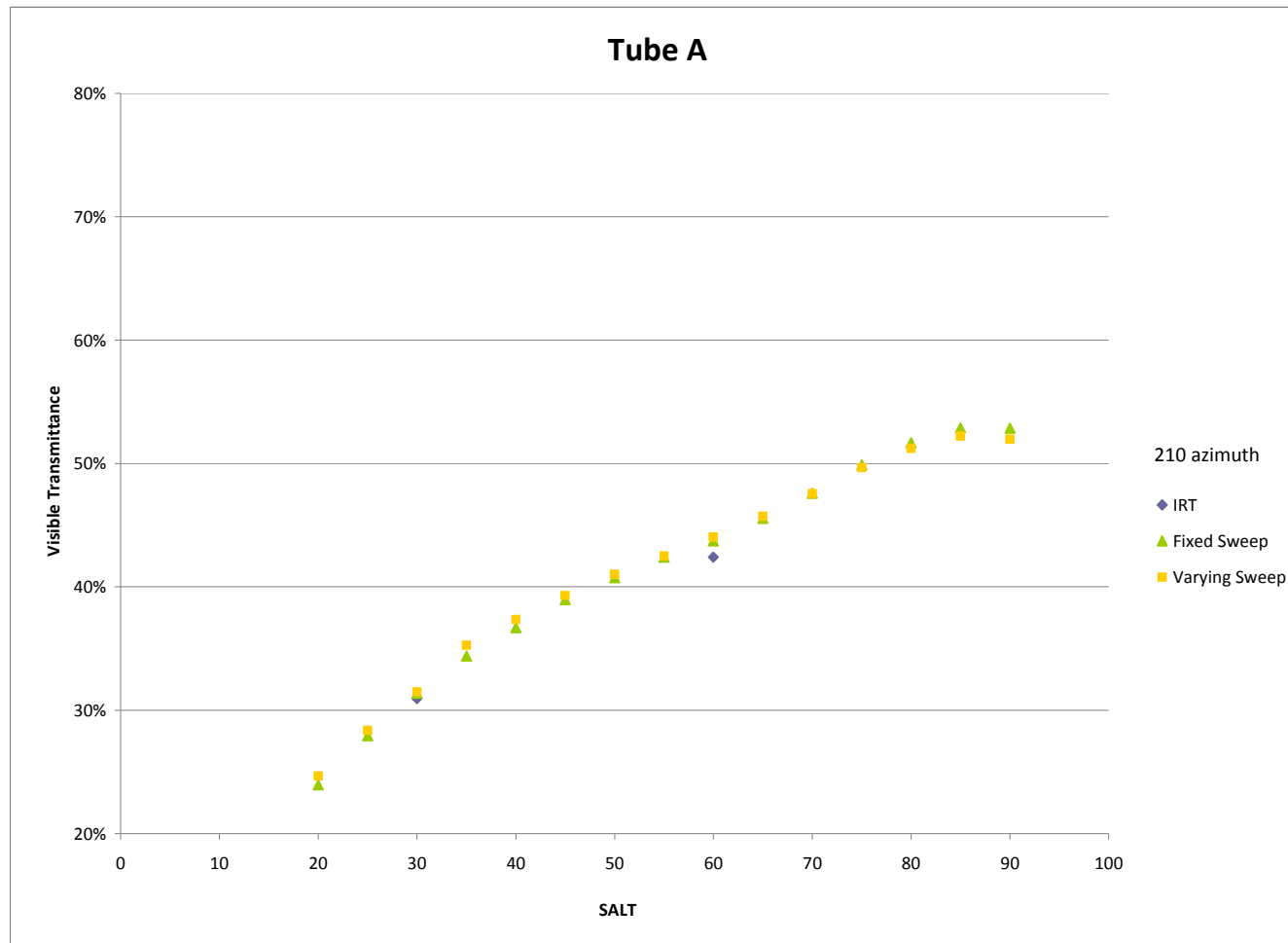
# TUBE D @ 180 Deg



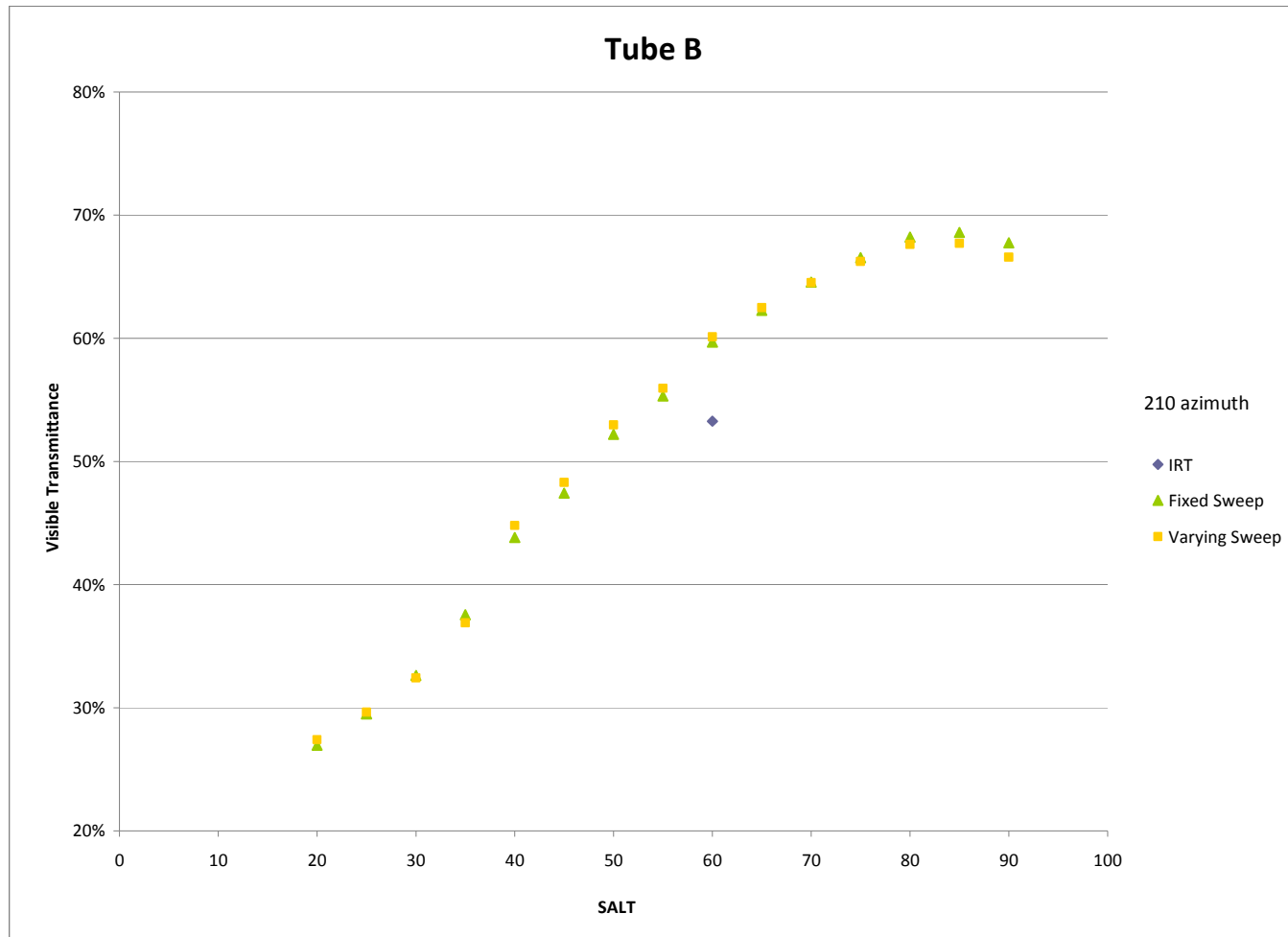
# TUBE E @ 180 Deg



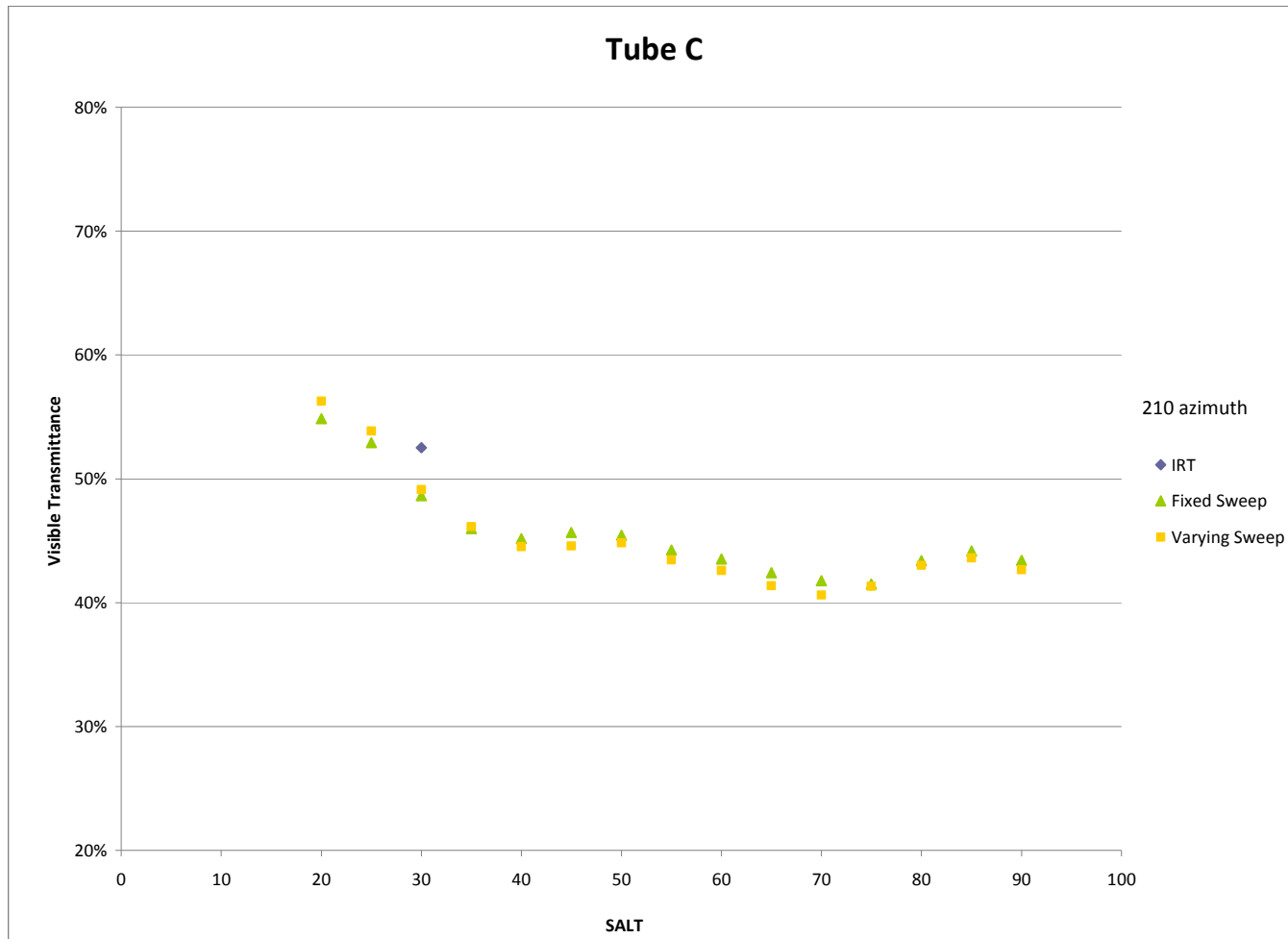
# TUBE A @ 210 Deg



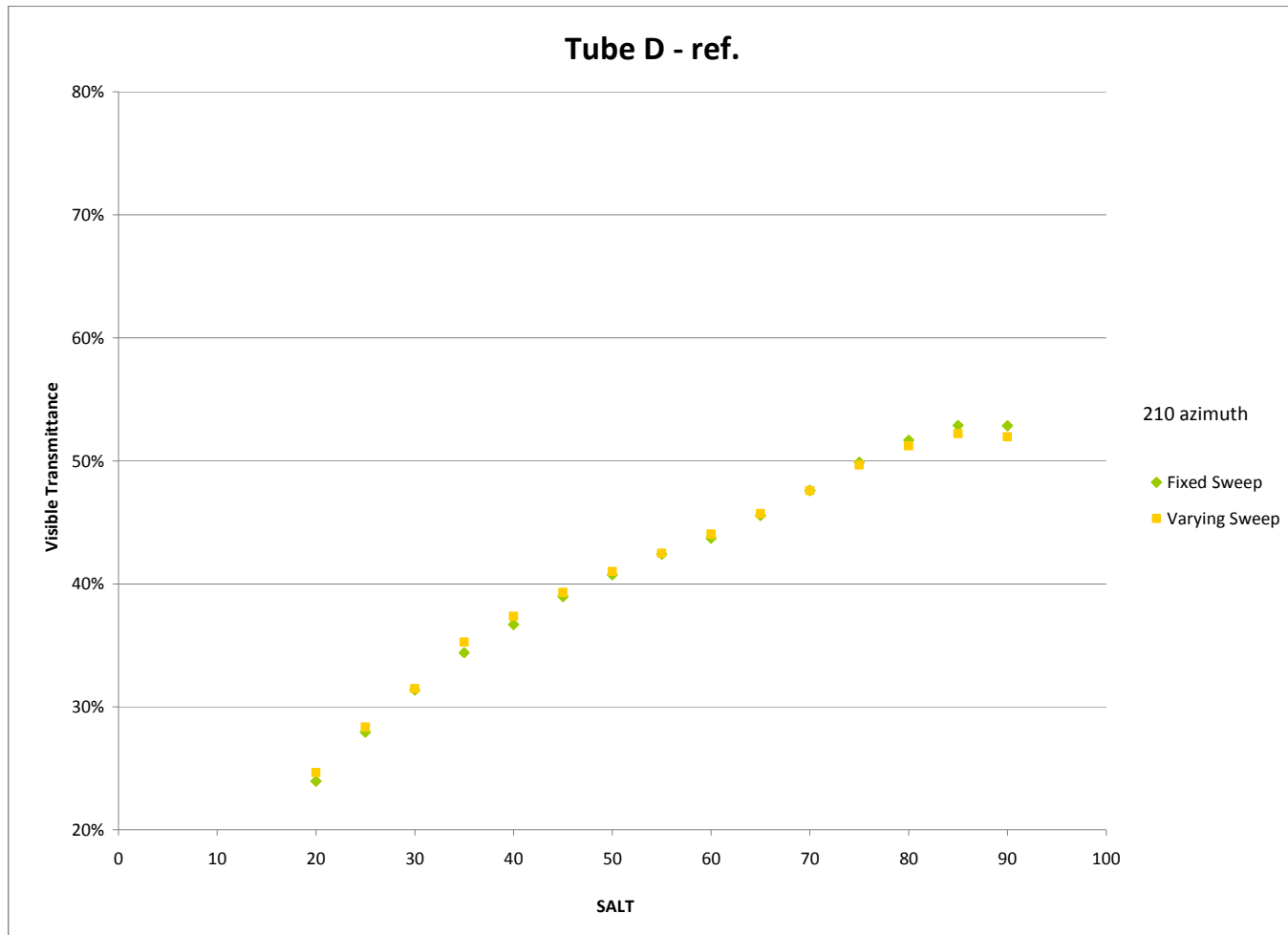
# TUBE B @ 210 Deg



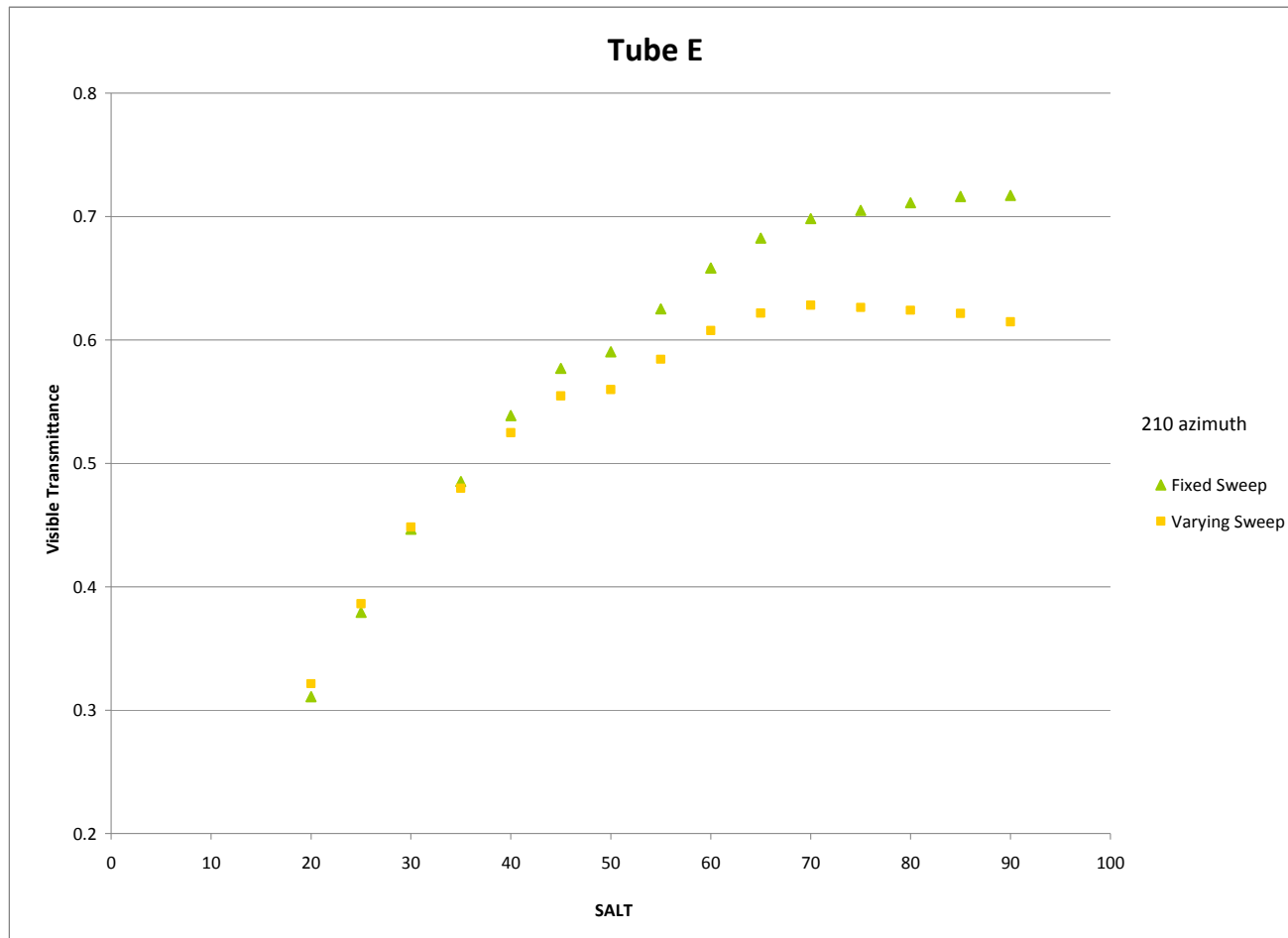
# TUBE C @ 210 Deg



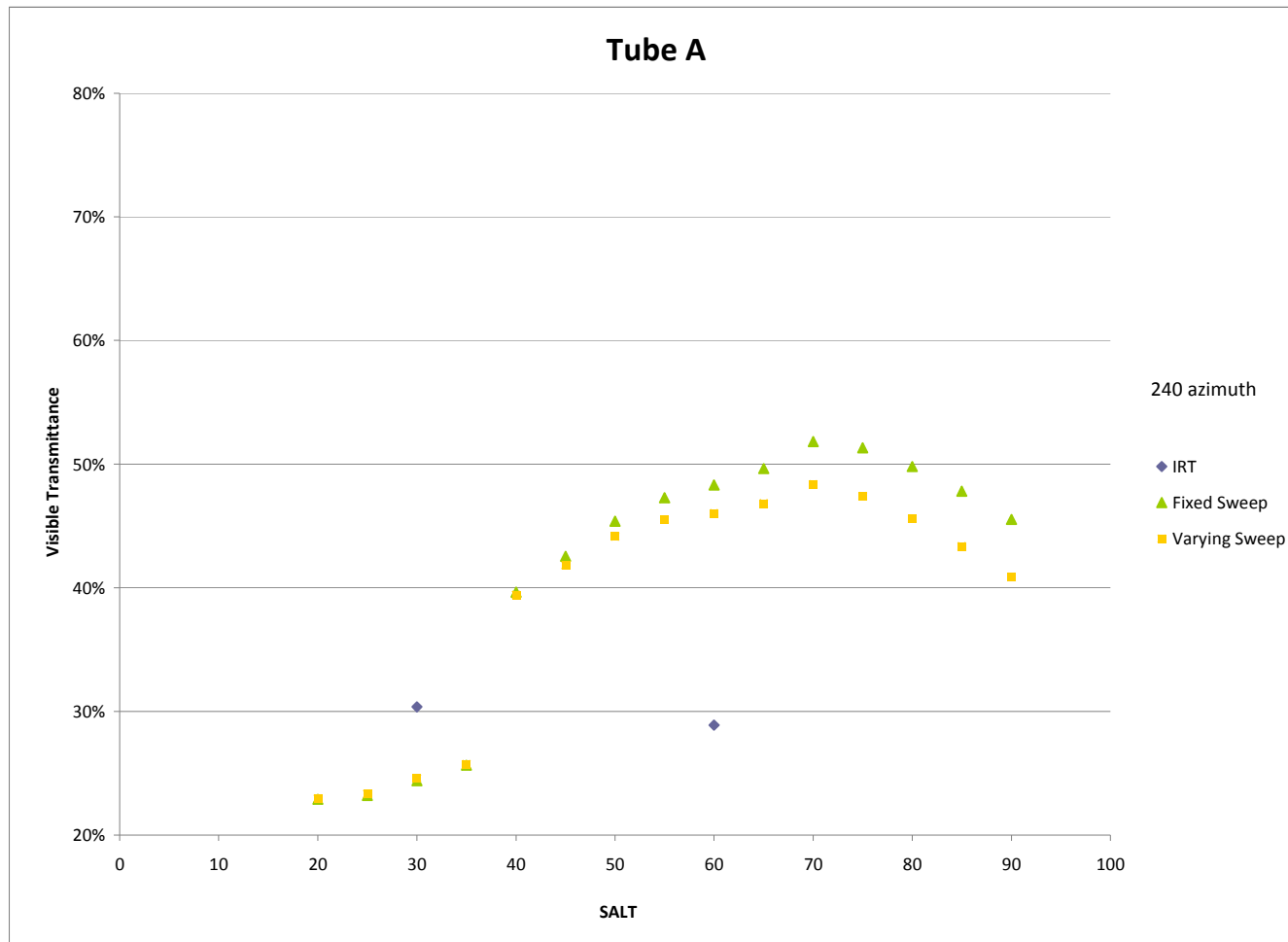
# TUBE D @ 210 Deg



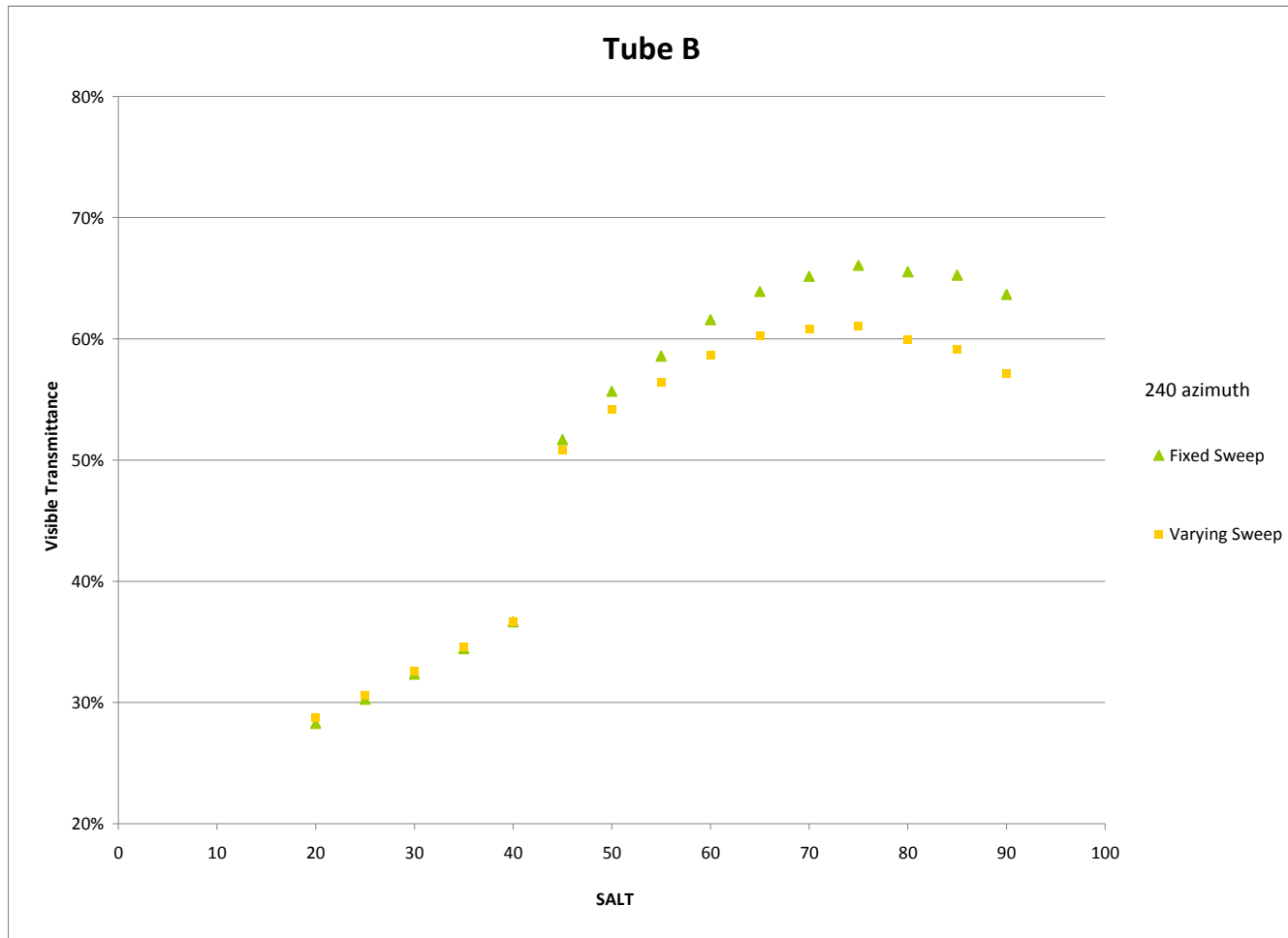
# TUBE E @ 210 Deg



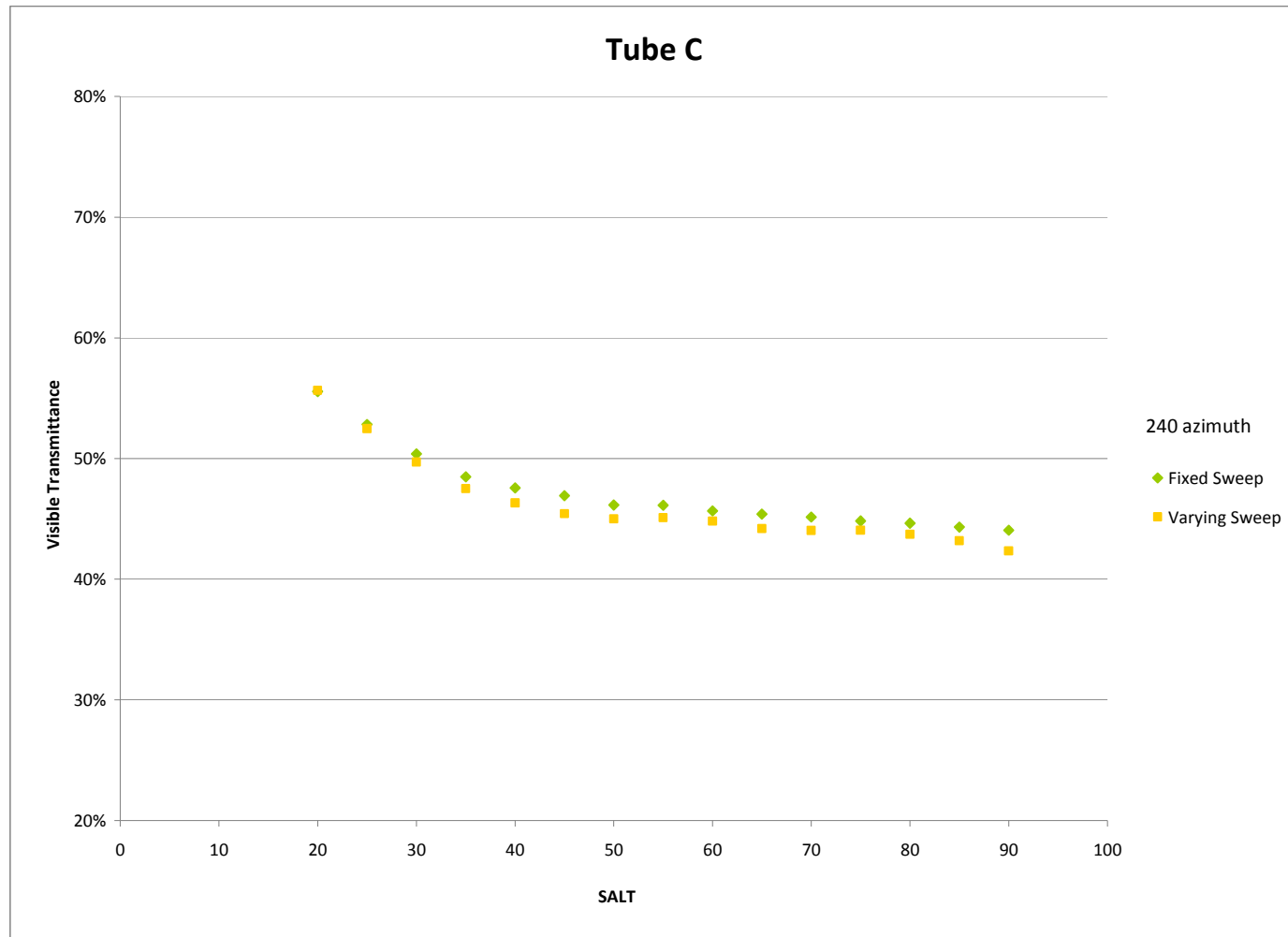
# TUBE A @ 240 Deg



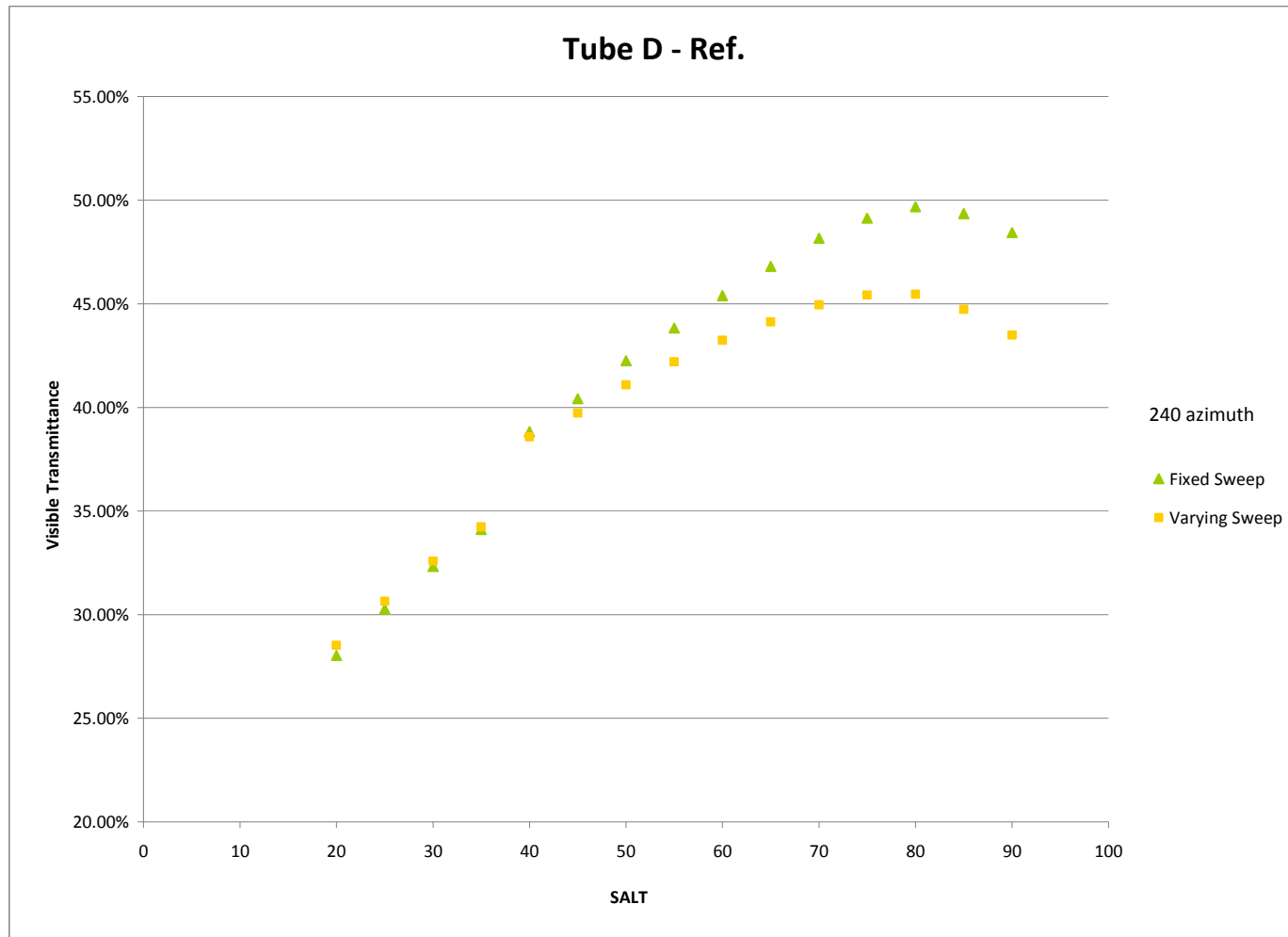
# TUBE B @ 240 Deg



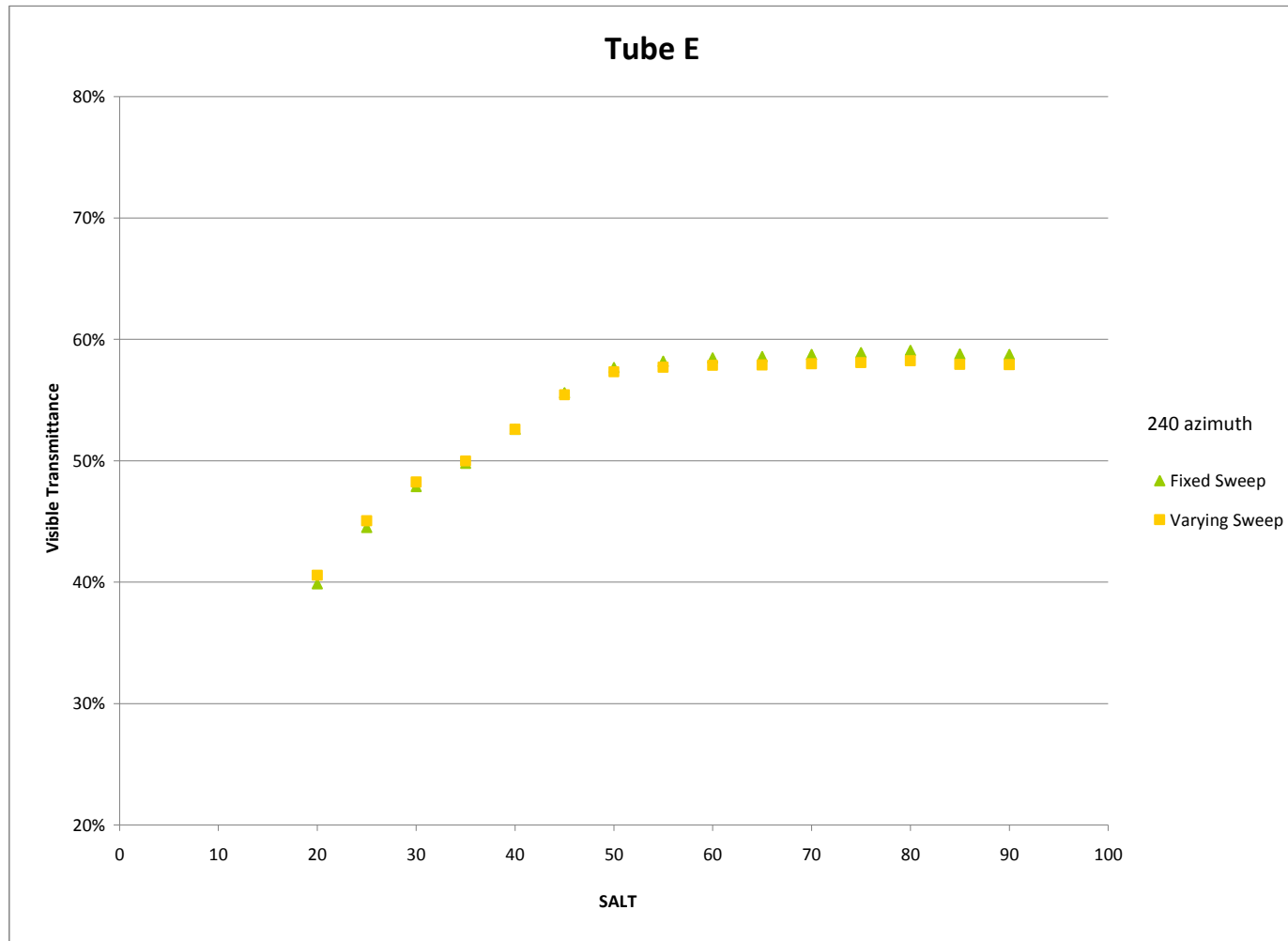
# TUBE C @ 240 Deg



# TUBE D @ 240 Deg



# TUBE E @ 240 Deg



# VT CALCULATIONS

- ZT Averaged VT

Yearly efficiency =

$$(VT_{20} * ZT_{20}) + (VT_{30} * ZT_{30}) + (VT_{40} * ZT_{40}) + (VT_{50} * ZT_{50}) + (VT_{60} * ZT_{60}) + (VT_{70} * ZT_{70})$$

OPTION #1 7 angles (sunrise to sunset)			OPTION #2 6 angles (10° to 10°)			OPTION #3 6 angles (15° to 15°)			OPTION #4 3 angles (15° to 15°)		
ZT	SALT range	angle used	ZT	SALT range	angle used	ZT	SALT range	angle used	ZT		
0.247											
0.176	10° - 25°	20°	0.307	15° - 25°	20°	0.234	15° - 35°	25°	0.486		
0.1895	25° - 35°	30°	0.2275	25° - 35°	30°	0.252					
0.1365	35° - 45°	40°	0.164	35° - 45°	40°	0.182	35° - 55°	45°	0.329		
0.111	45° - 55°	50°	0.133	45° - 55°	50°	0.147					
0.086	55° - 65°	60°	0.103	55° - 65°	60°	0.114	> 55°	65°	0.186		
0.054	>65°	70°	0.065	> 65°	70°	0.072					
1			0.9995			1.001			1.001		

# CALCULATED VT VALUES

	Tube A	Tube B	Tube C	Tube D - ref	Tube E
#1, Yearly efficiency (sunrise) - 7 angles - 180 azi	0.27	0.31	0.35	0.26	0.37
#2, Yearly efficiency (10 deg) - 6 angles - 180 azi	0.35	0.40	0.48	0.33	0.47
#3, Yearly efficiency (15 deg) - 6 angles - 180 azi	0.36	0.41	0.46	0.34	0.49
#4, Yearly efficiency (15 deg) - 3 angles - 180 azi	0.36	0.41	0.46	0.34	0.50
#3, Yearly efficiency (15 deg) - 6 angles - 210 azi	0.32	0.40	0.47	0.34	0.49
#4, Yearly efficiency (15 deg) - 3 angles - 210 azi	0.32	0.40	0.47	0.34	0.49
#3, Yearly efficiency (15 deg) - 6 angles - 240 azi	0.29	0.39	0.46	0.34	0.49
#4, Yearly efficiency (15 deg) - 3 angles - 240 azi	0.29	0.38	0.47	0.34	0.48
Ave #3	0.32	0.40	0.46	0.34	0.49
Ave #4	0.32	0.40	0.47	0.34	0.49