

Fluorescence Detector Calibration

Auger Collab. Meeting

Oct 24, 2001

1) What is the issue?

a) no "natural calibration"

b) need to know $\delta(\lambda) \longleftrightarrow$ ADC relation

2) Techniques:

a) "end-to-end" $\equiv$ illuminate telescope
w/ known (cross calibrated)
light source $\mid \lambda = 375 \text{ nm}$

b) "piece-by-piece":

- i) important cross check
- ii) full λ dependence

c) Rayleigh scattering $\equiv$ closest to "natural calibration" $\mid \lambda = 355 \text{ nm}$

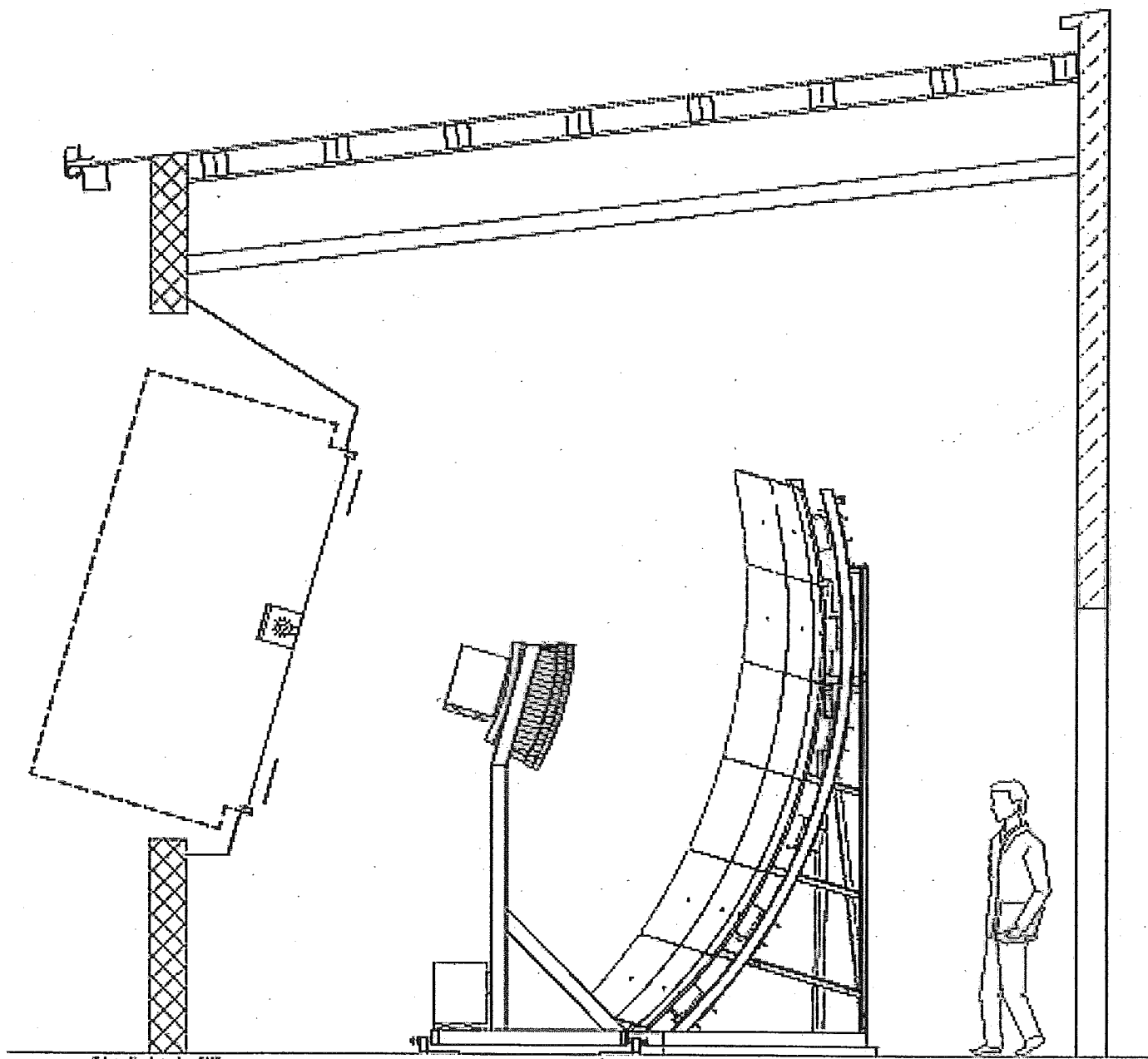
John Matthews / U.N.M.

Corrections to the (raw) data $\left[\begin{array}{c} \text{end-to-end} \\ \text{approach} \end{array} \right] :$

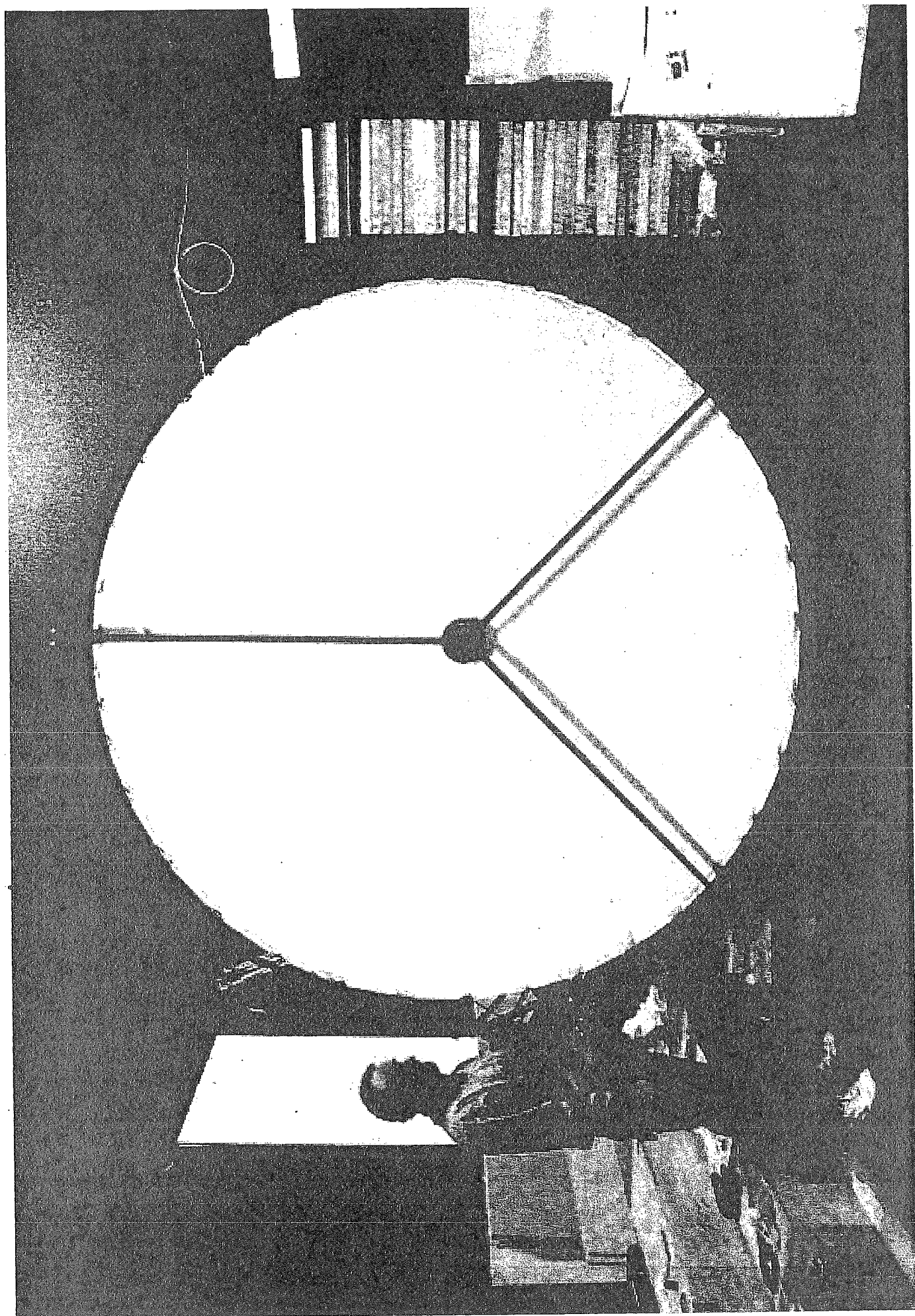
a) & b) combined:

$$\underbrace{\delta(i)}_{\substack{375\text{nm} \\ \nearrow \\ \lambda \text{ of } \mu\text{V LED} \\ \text{in flat field} \\ \text{illumination} \\ \text{"drum"}}} = \frac{\sum \text{ADC}_i - \sum \text{"PED"}_i}{\underbrace{\epsilon_{\text{ADC}}(i, 375\text{nm})}_{\substack{\text{///} \\ \text{end-to-end} \\ \text{calibration} \\ \text{(ie } \delta_{375\text{nm}} \rightarrow \text{ADC)}^\dagger}}}} \quad i=1, \dots, 140$$

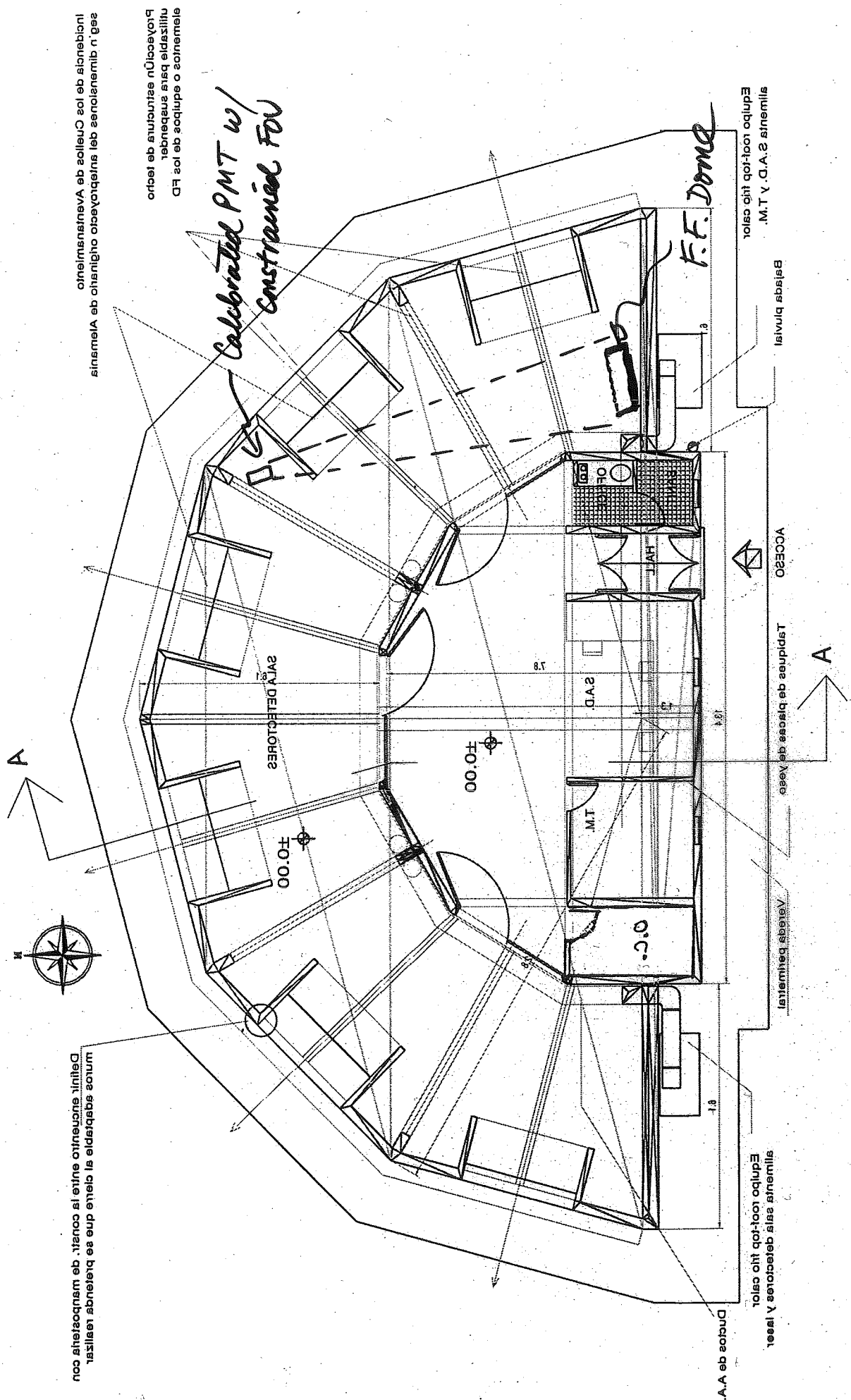
$$^\dagger \quad \underbrace{\epsilon_{\text{ADC}}(i, 375\text{nm})}_{\substack{\text{end to end} \\ \text{evaluation}}} \Leftrightarrow \underbrace{\epsilon(i, 375\text{nm}) * \text{ADC/PE}}_{\substack{\text{piece by piece} \\ \text{evaluation}}}_i$$



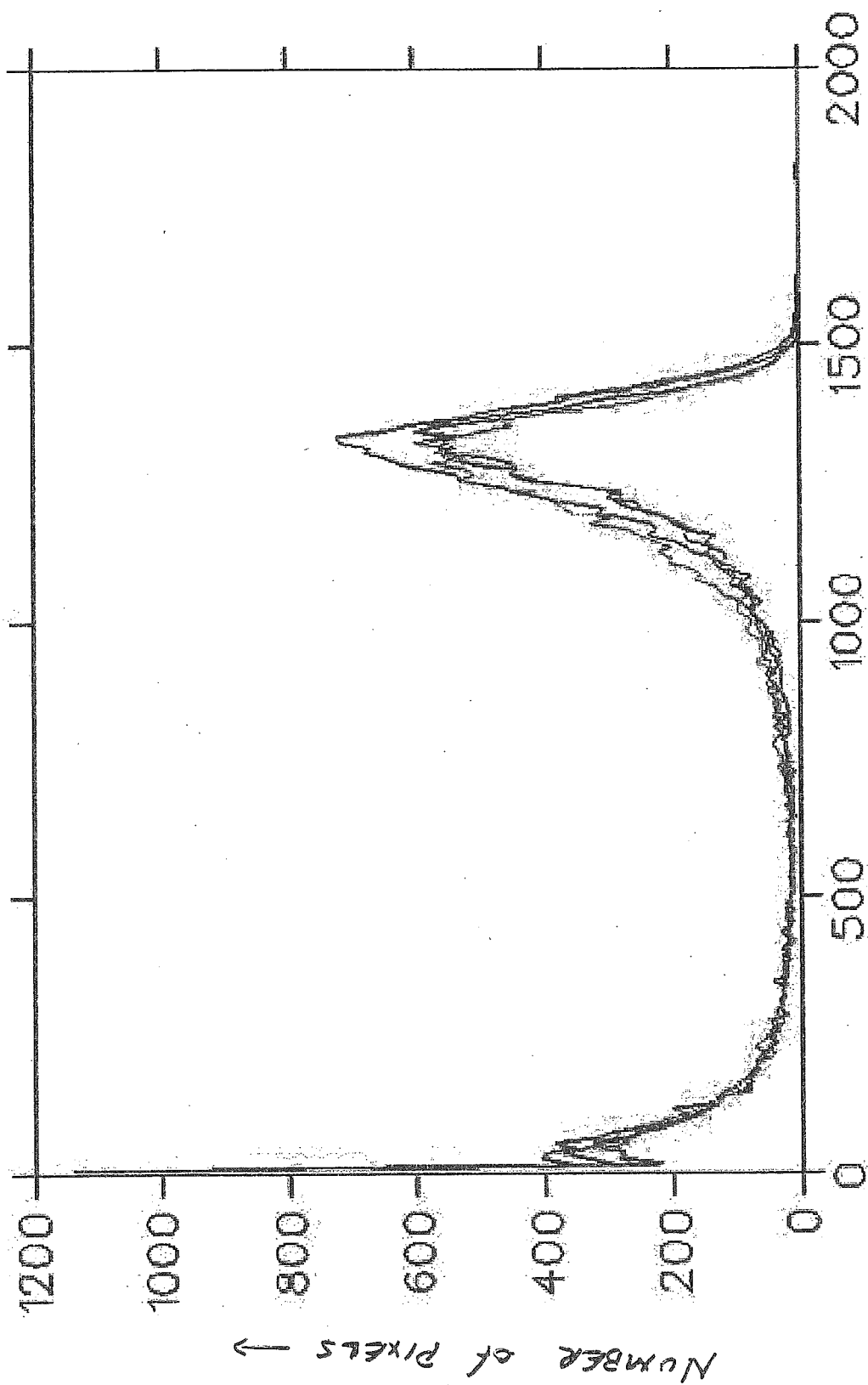
Сел. №. 149/01-100



Dome Calibration in Lo Leones F.D. Building



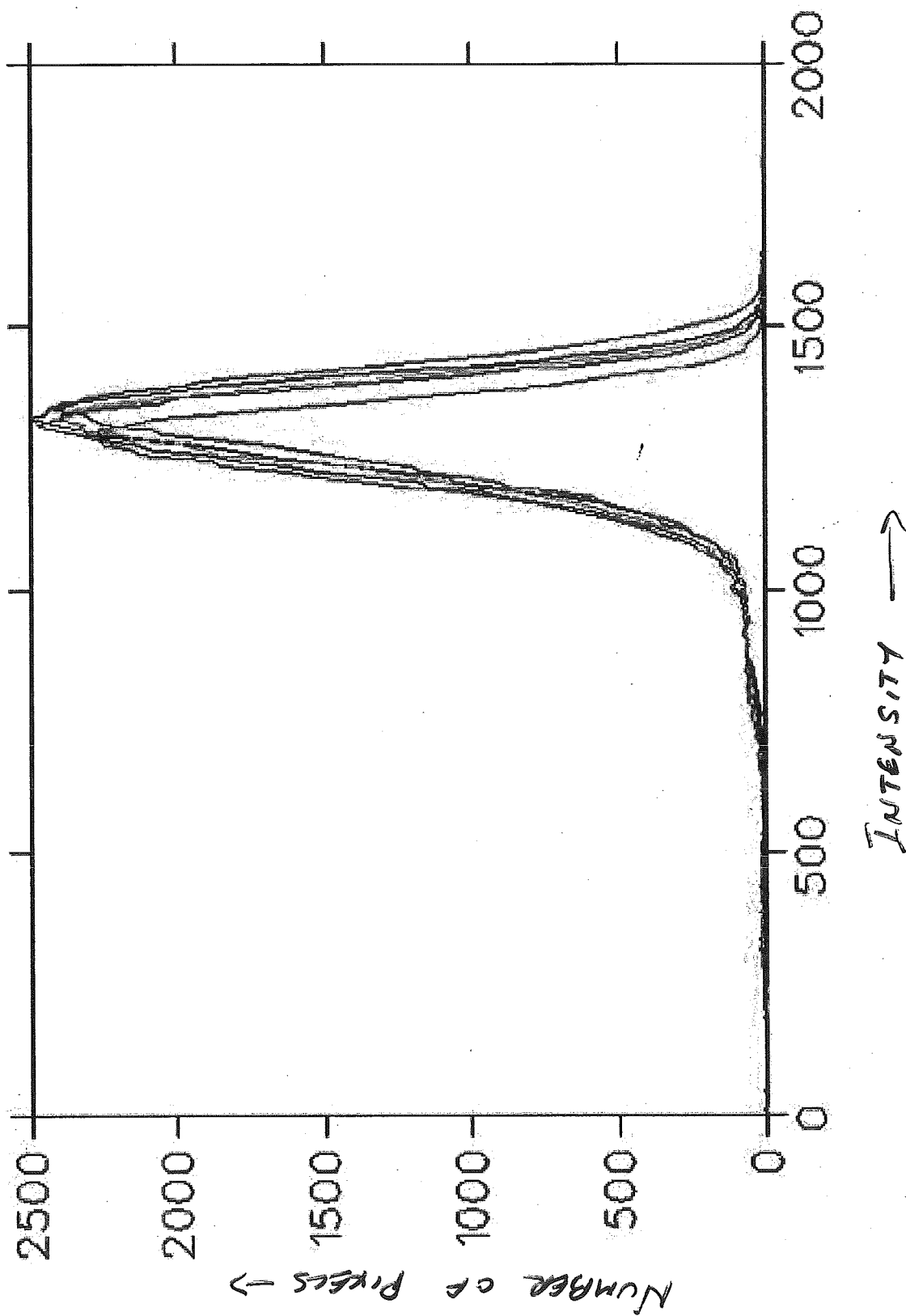
QUADRANTS : 15 deg drum angle



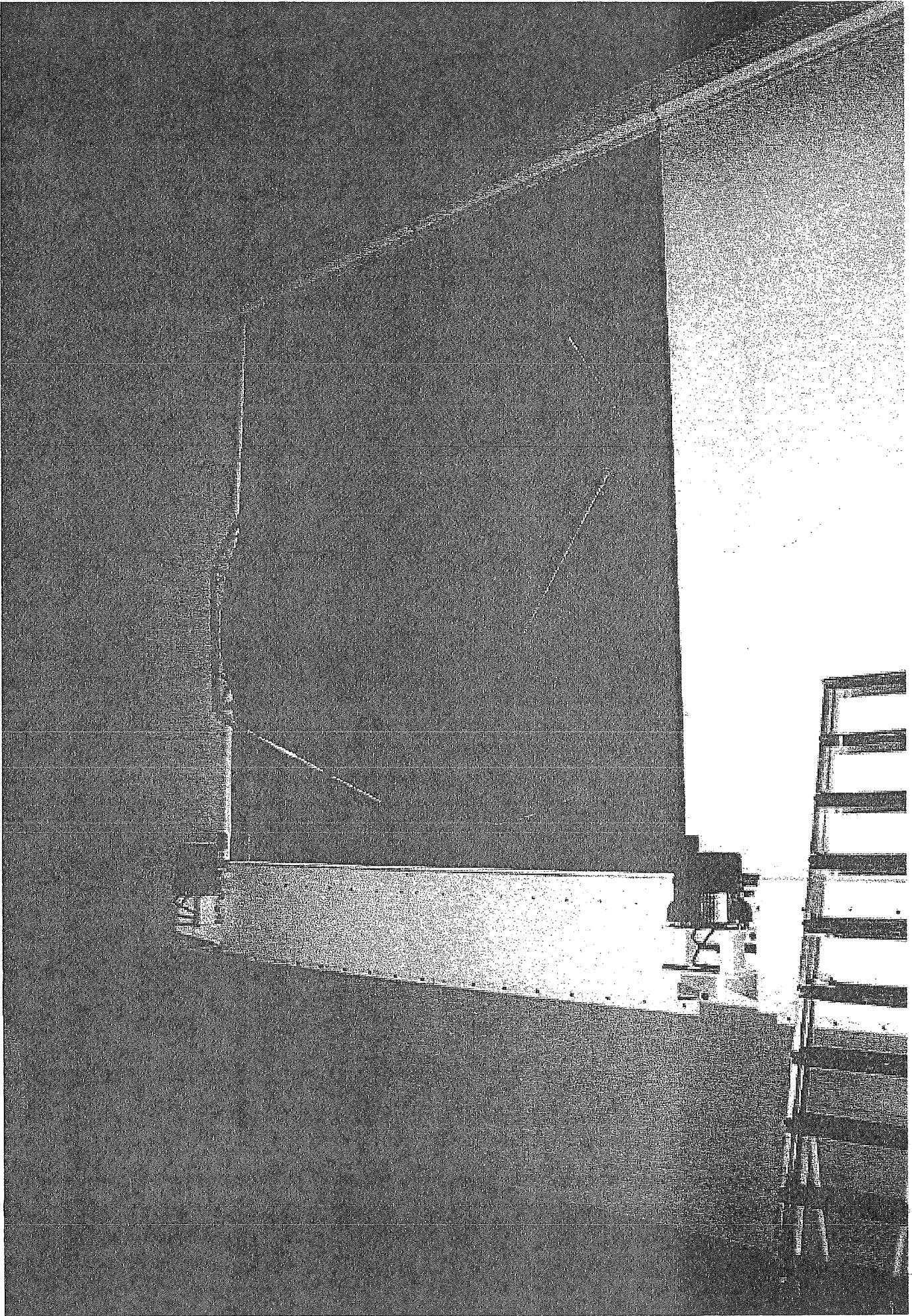
INTENSITY →

QUADS

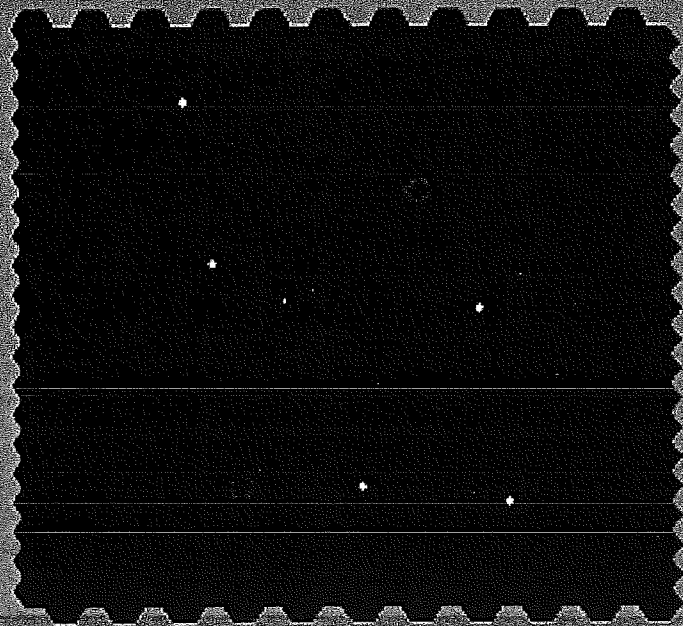
DRUM ANGLES : 0, 5, 10, 15, 20 deg.



Theta



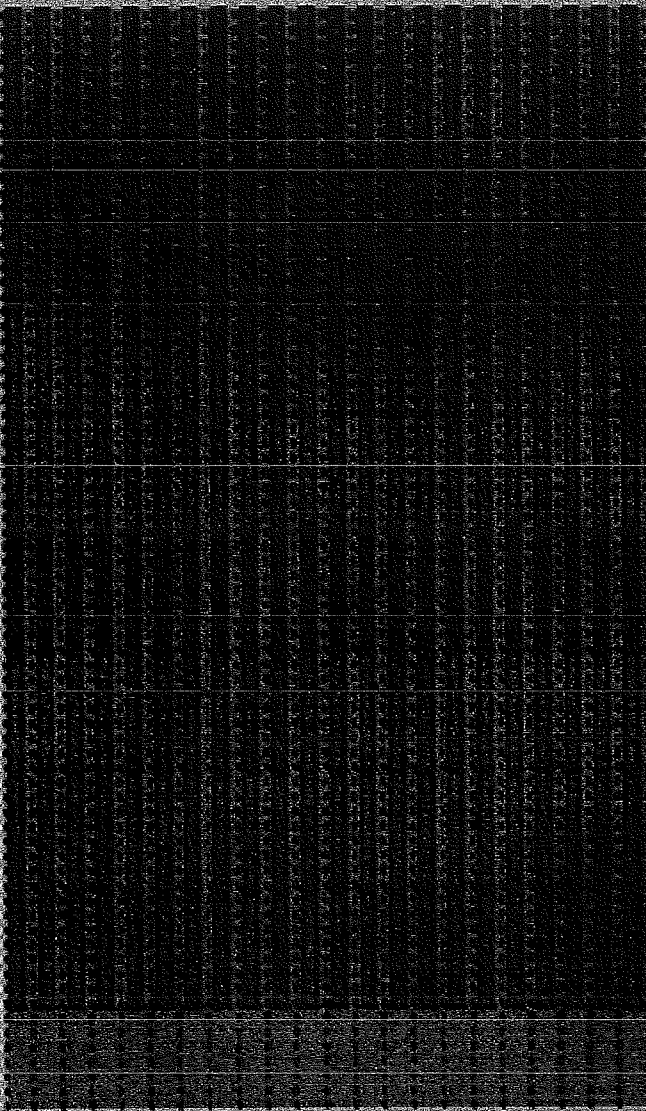
SLI Motor view



SLI Time Altitude View

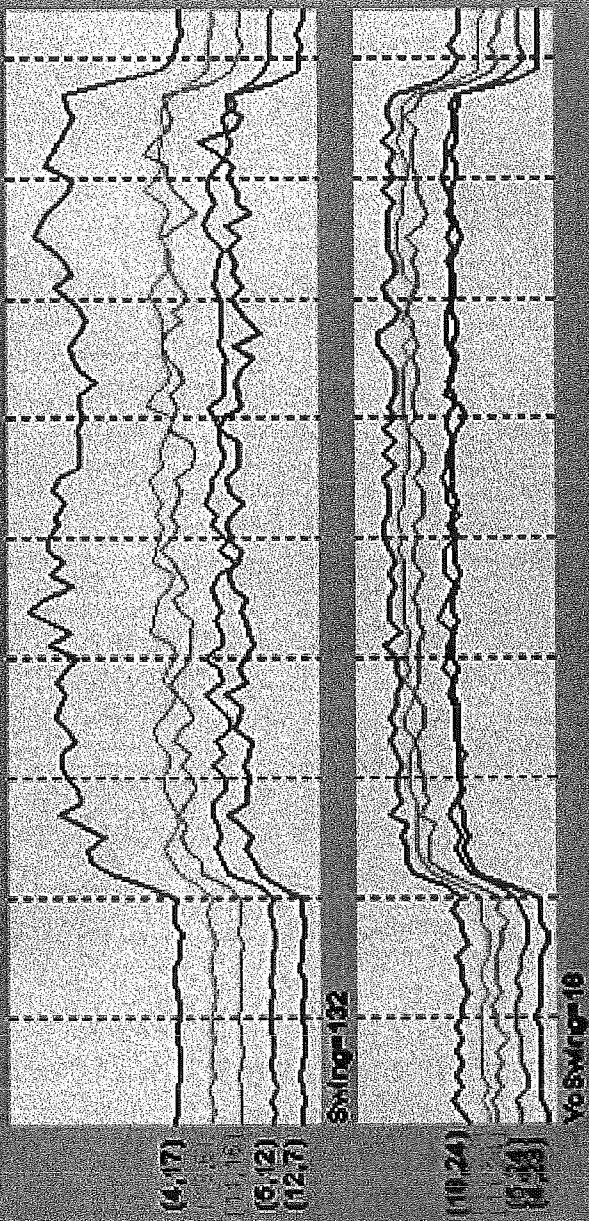
View Window Event Next

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22



StartInd=45 SlotInd=49 EndInd=64
EventWin NP=275905m19m23r274m15910m In 8m85.10m Pgt=0x.13

ADC data



1. The present system

*Calibrate camera at 1 wavelength, 1 measurement, end-to-end

*Reference standard is NIST-calibrated Si photodiode

*Calibration is transferred

a) from Si to PMT

Uses scanning monochromator:

deuterium light source

beam splitter

Si on one beam

PMT on other beam w/ 10^{**3} attenuation (ND filter)

data acquisition

ADC integration box (BB IV102 chip)

calibrated channel for Si detector

(PMT DAQ channel arbitrary)

b) from PMT to Flat-field-illuminator (drum)

PMT views drum surface from distance

limits ang-of-inc effects on PMT

PMT DAQ is same channel of integration box as

used for PMT calibration

*Drum

Illuminates entire aperture: 2.5 m diameter

Provides uniform distribution (theta, intensity)

Intensity measured with CCD camera

Materials:

Reflective sides and back are Tyvek

same as early tank laminate w/o clear metallocene

Transmitting front surface is teflon

good diffusive characteristics

Drum light source

UV LED: 375 nm: Nichia; 1 mW; ± 12 nm

Teflon diffuser: 2.5 cm sphere

LED centered in front face, reflects off back

Monitor Si detector mounted on teflon diffuser

*Procedure

Mount drum in aperture

Pulse drum source

Fill aperture with known flux of photons

All PMTs in camera go above threshold

Compare camera ADC outputs to drum flux gives calibration

*Use this one-w.l. absolute calibration

to normalize calculated full curve

Full curve comes from combining curves measured

individually at various collaborator's laboratories for:

window

corrector plate

mirror

mercedes cones

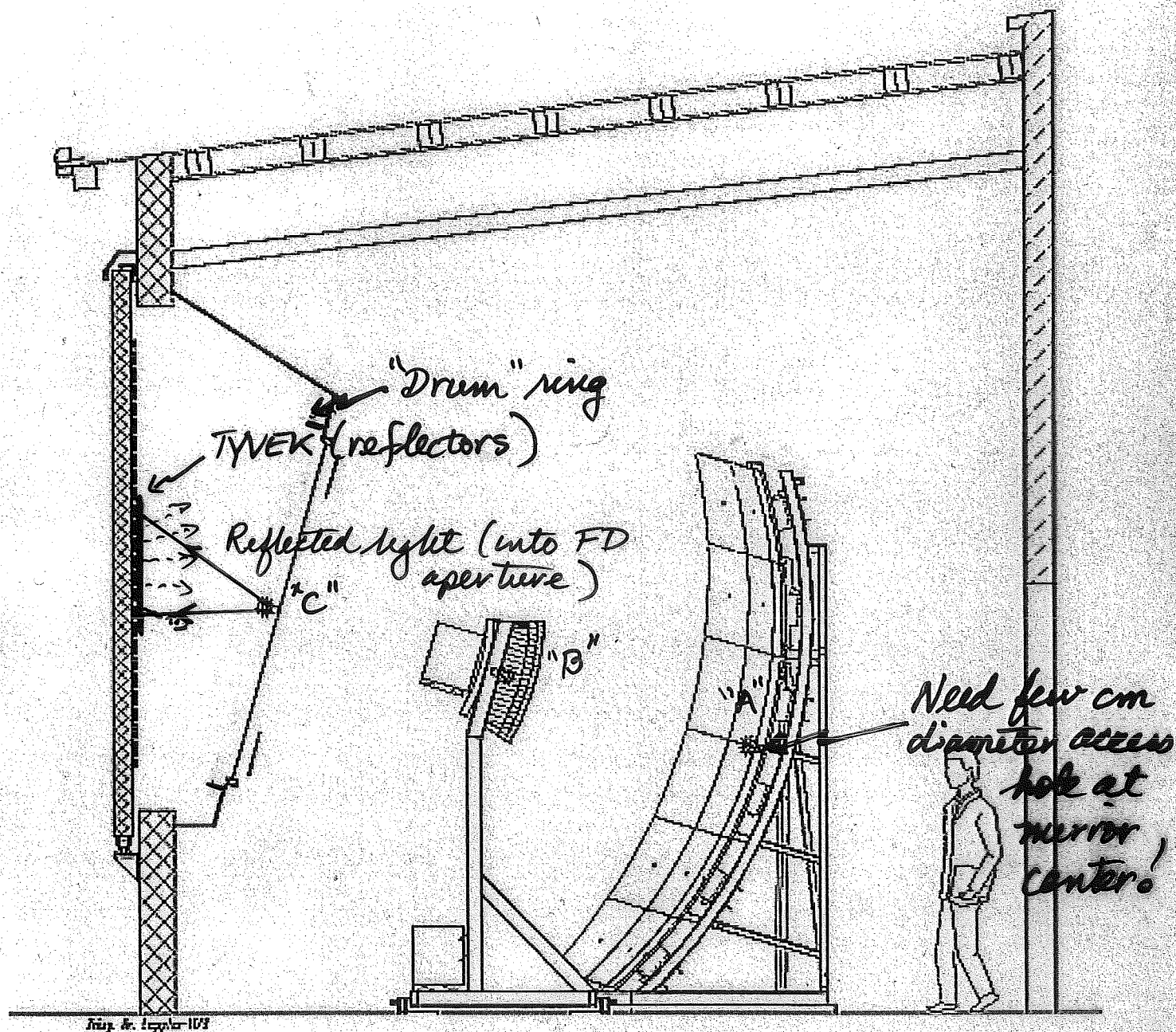
PMT QE

PMT gain

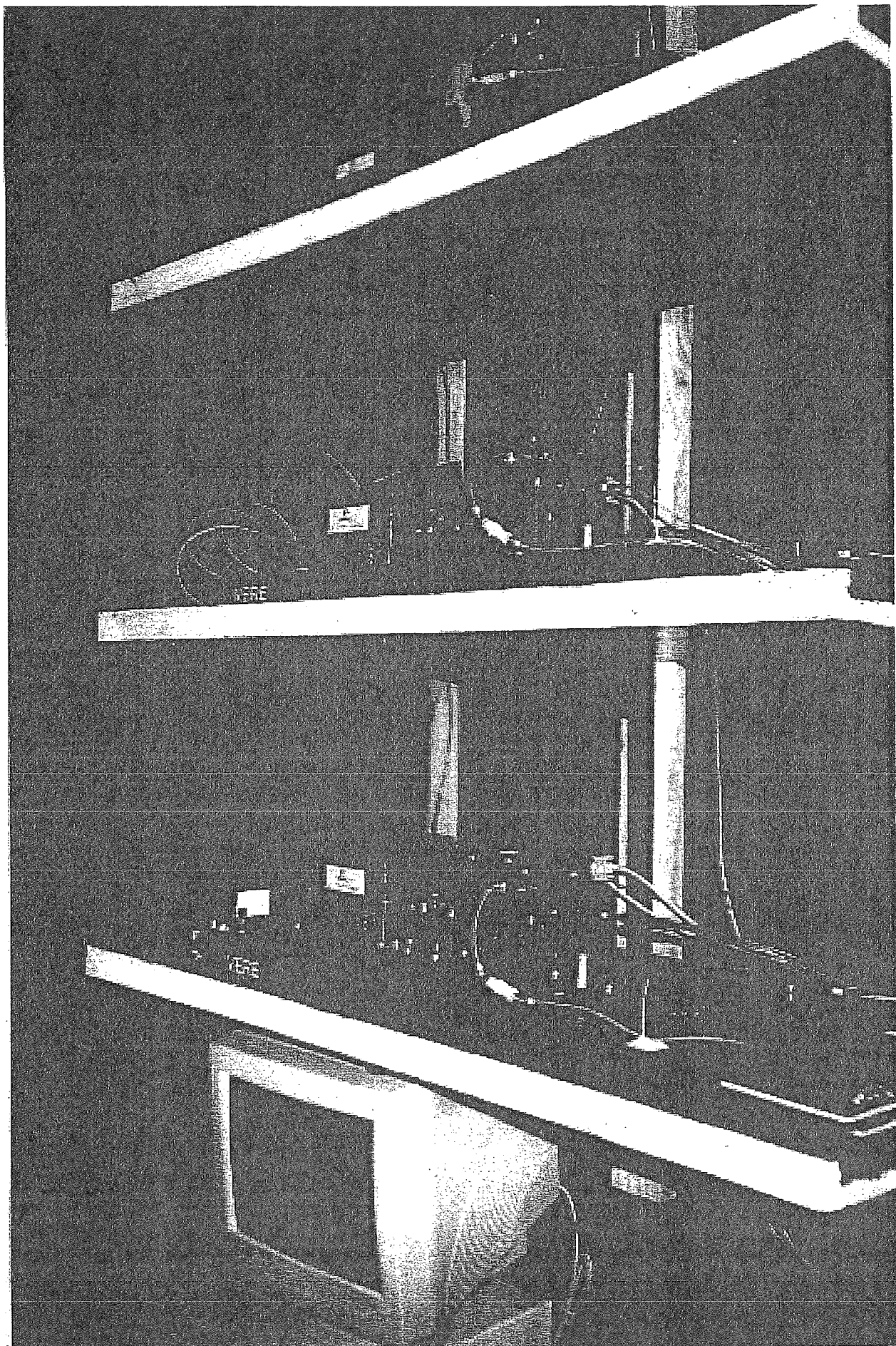
ADC conversion

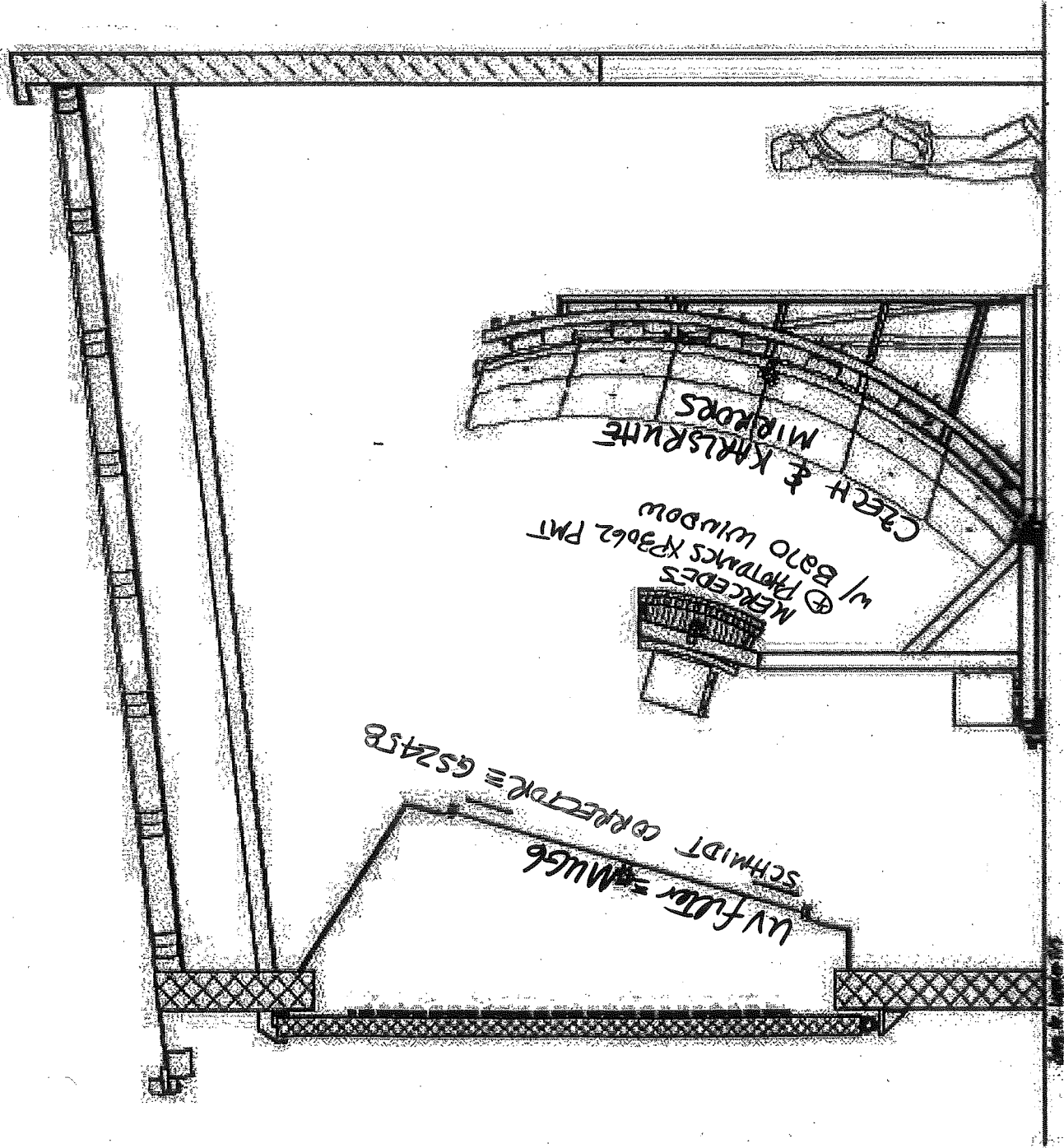
ether, etc.

***> Need these curves (w/uncertainties) from each institution

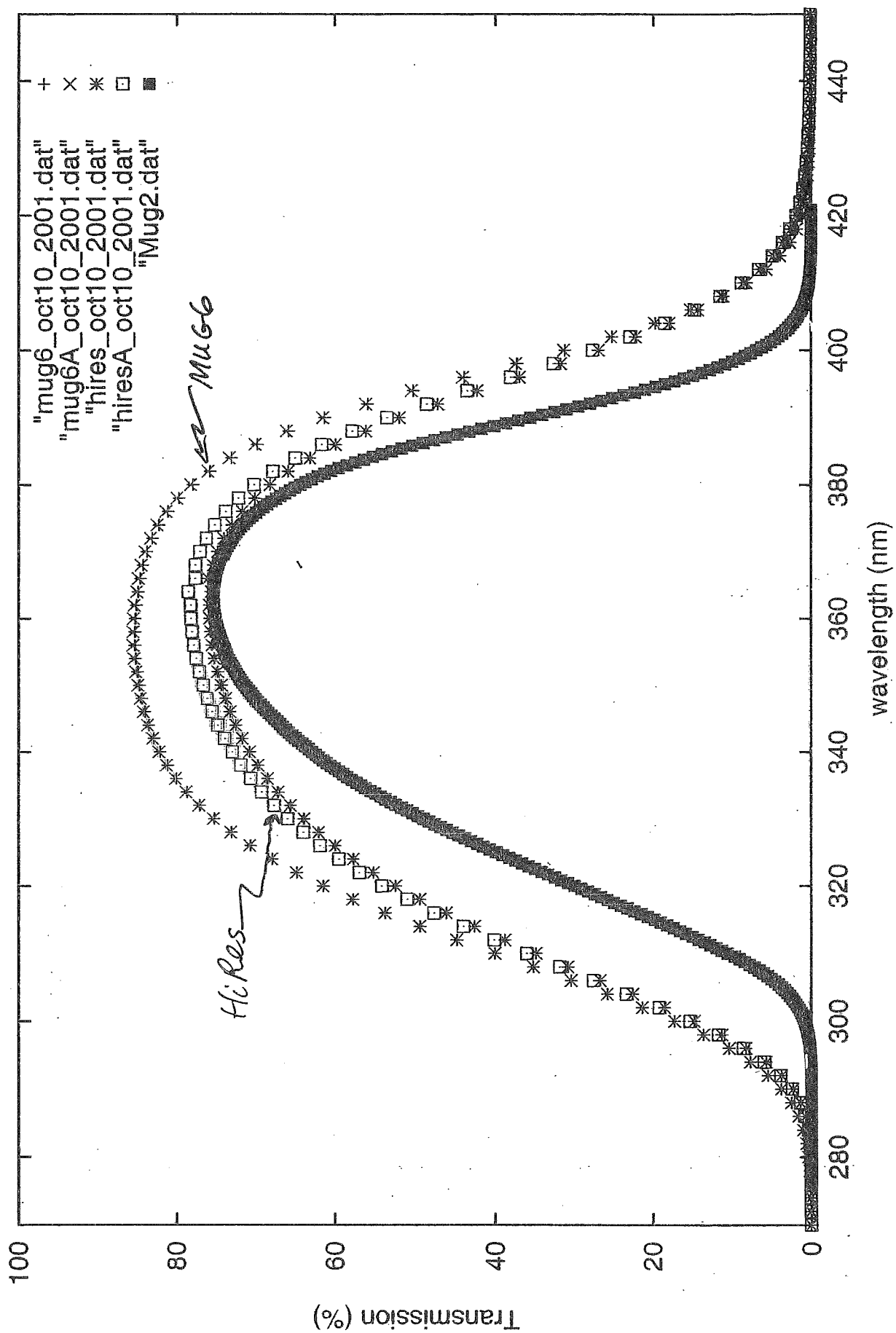


TYVEK reflectors on Polish Shutters

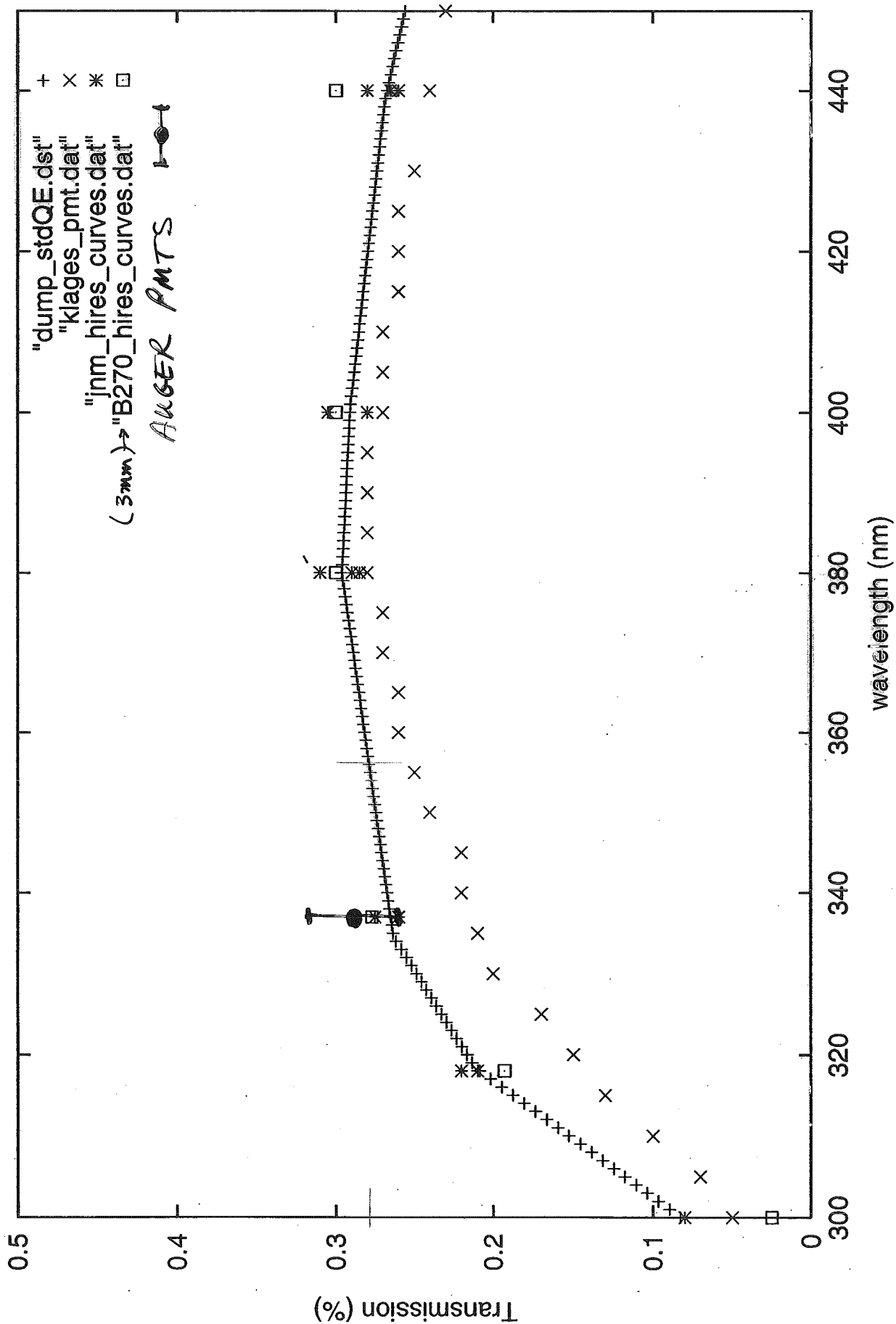




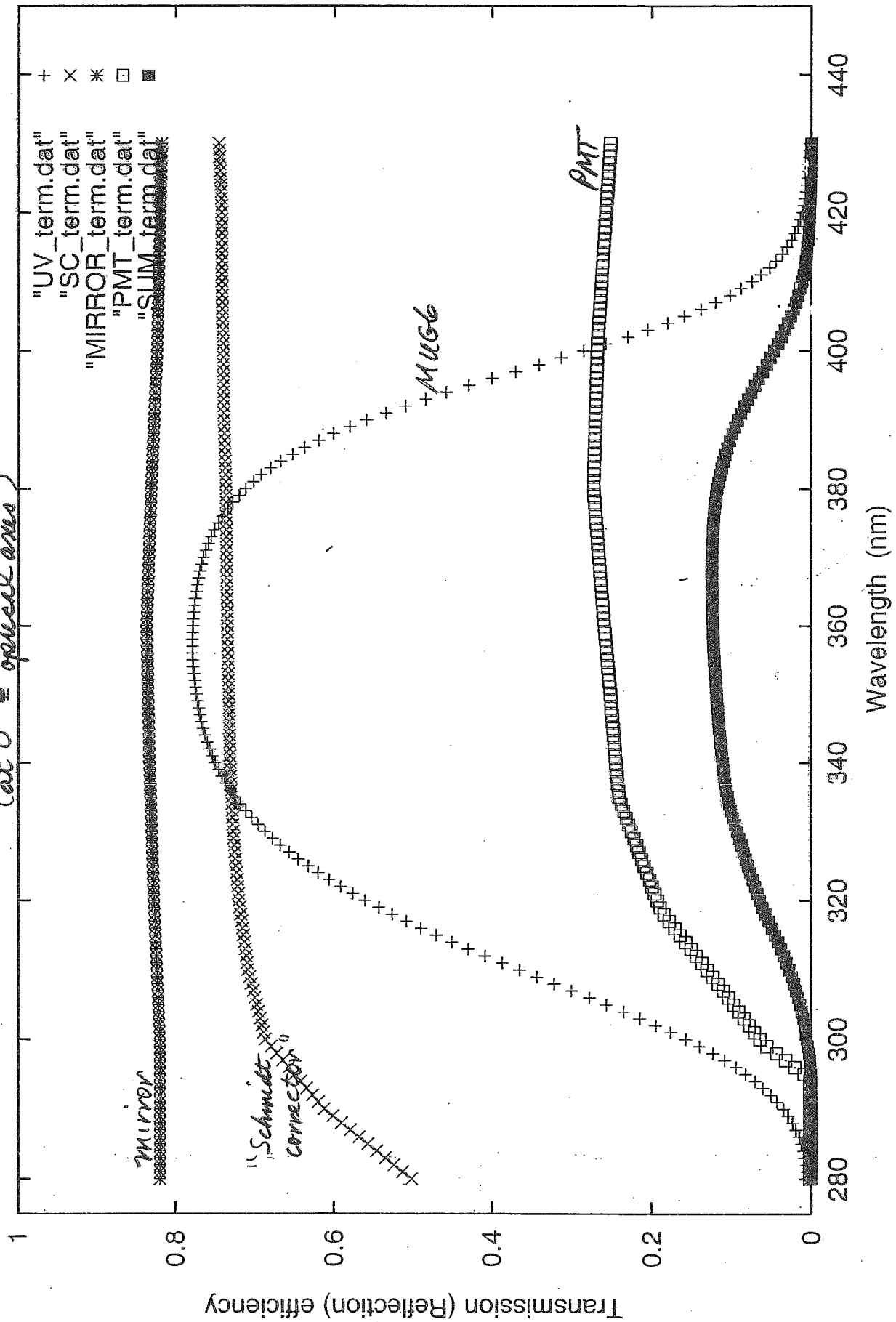
MUG6/HIRES filter transmission VS wavelength



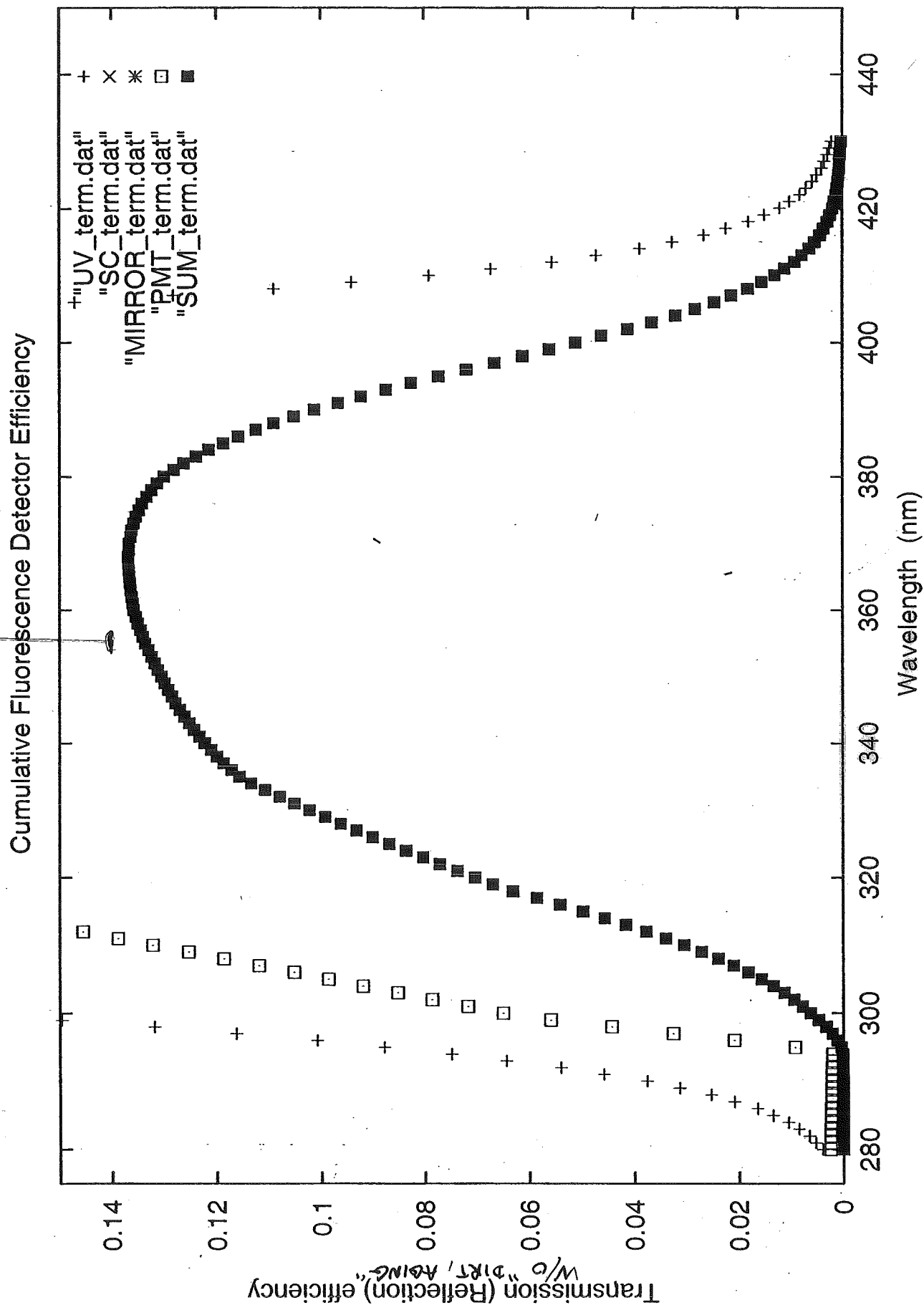
HiRes PMT effic VS wavelength



Cumulative Fluorescence Detector Efficiency (at 0° = optical axis)

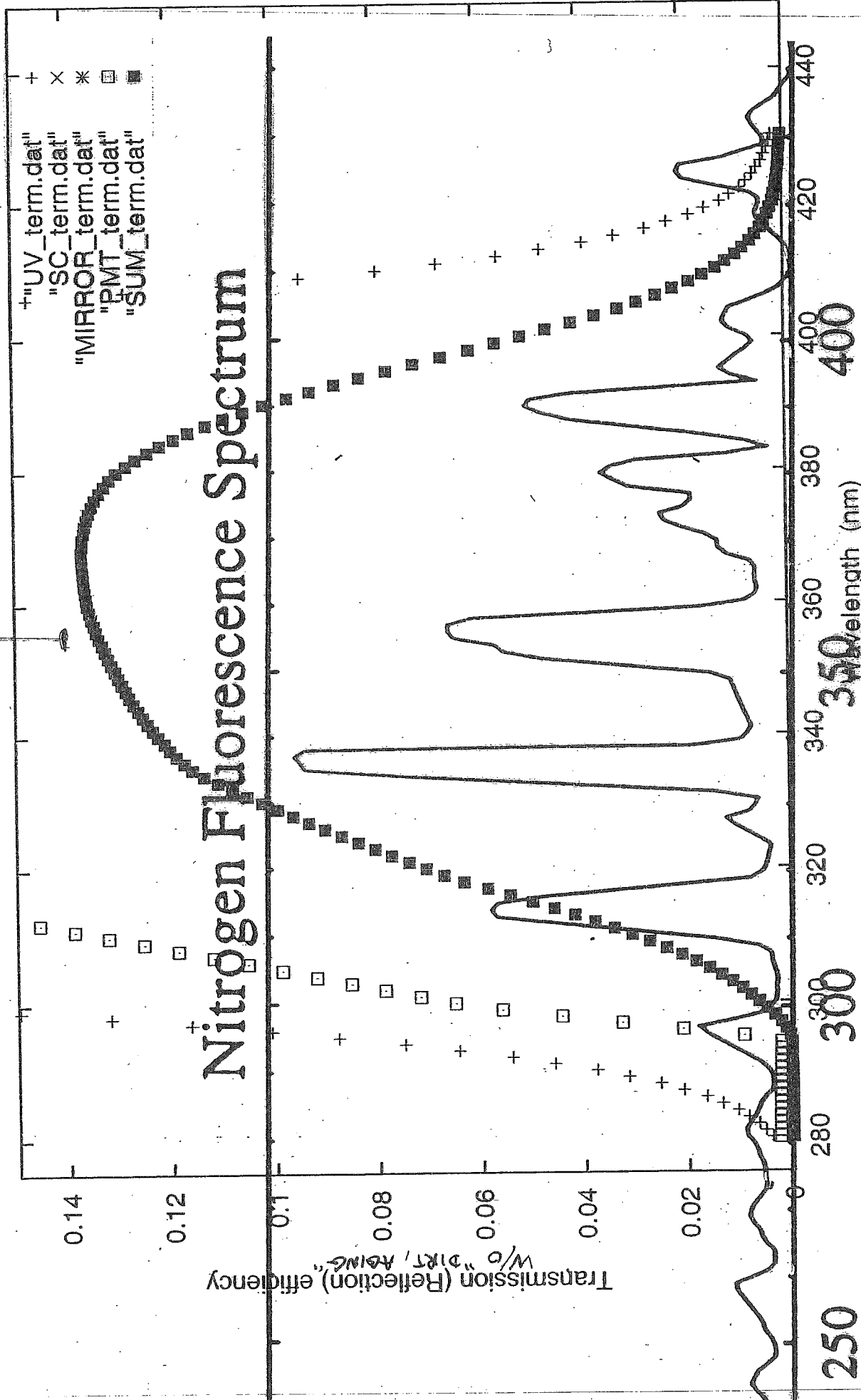


B. Dawson, P. Sommers et al
 w/ $g_{\text{am}} \approx 0.5 \text{ PE/ADC}$ [$\pm 20\%$ drawn]



B. Dawson, P. Sommers *et al.*
 w/ $g_{\text{am}} \approx 0.5 \text{ PE/Hz}$ [$\pm 20\%$ drawn]}

Cumulative Fluorescence Detector Efficiency



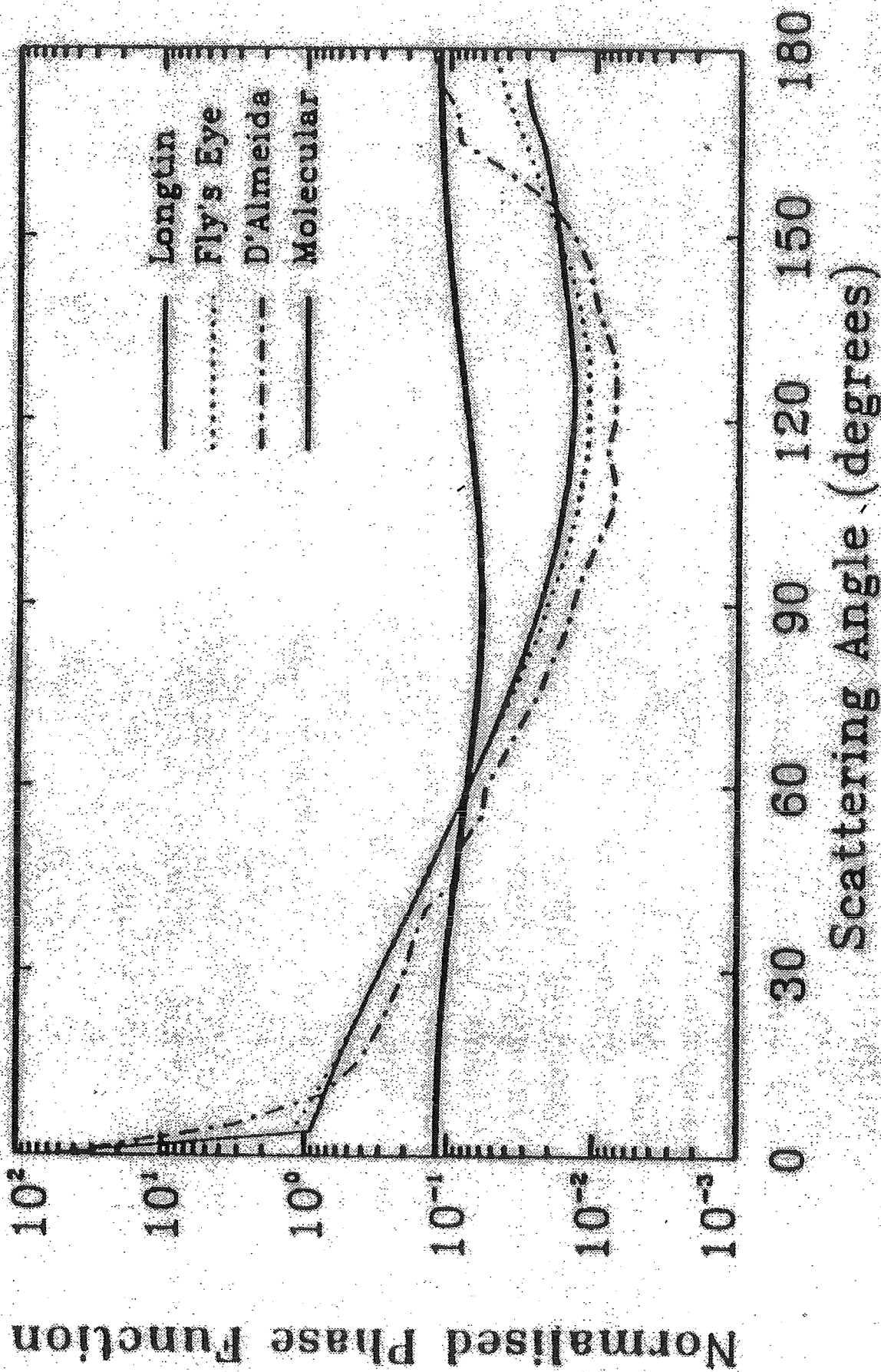


Figure 2: Examples of aerosol phase functions obtained with Mie theory (assumes all aerosol particles are spherical). Also shown is the Rayleigh (molecular) phase function. For typical aerosol densities the sideways scattering (90° to 120°) is dominated by well known Rayleigh scattering cross section

Corrections to the (raw) data [piece-by-piece]:
approach

a) "gain" correct:

PEDISTAL ⊕ night sky background

$$P.E.(i) = \frac{\sum ADC_i - \sum "PED" i}{ADC/P.E. |_i} \quad i=1, \dots, 440$$

"
"gain"
(assuming linear)

b) "flat field":

$$\chi_{360nm}(i) = \frac{P.E.(i)}{\sum(i, 360nm)} \quad i=1, \dots, 440$$

nominal
wavelength
(for flat field
illuminator
use 375nm?)

piece-by-piece
efficiency

(ie $\chi_{360nm} \rightarrow P.E.$)

Fluorescence Detector Calibration

"Summary"

- 1) Three techniques proposed:
 - end to end $\Leftrightarrow$ flat field drum
 - piece by piece $\Leftrightarrow$ helps enforce Q.A.
 - Rayleigh $\Leftrightarrow$ natural spin off of atmospheric monitoring technology
- 2) and "proof of principle" or better achieved for all three techniques.
- 3) Realistic goal of next few months is calibration at $\leq 20\%$ level.

John Matthews/UCM