Fluorescence Detector Calibration

Auger Collab. Meeting

Oct 24, 2001

1) What is the issue?

   a) no "natural calibration"

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

2) Techniques:

   a) "end-to-end" ≡ illuminate telescope w/ ~~known~~ (cross calibrated) light source $\Big|_{\lambda=375\,nm}$

   b) "piece-by-piece":
      i) important cross check
      ii) full λ dependence

   c) Rayleigh scattering ≡ closest to "natural calibration" $\Big|_{\lambda=355\,nm}$

John Matthews / U.N.M.

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

a) & b) combined:

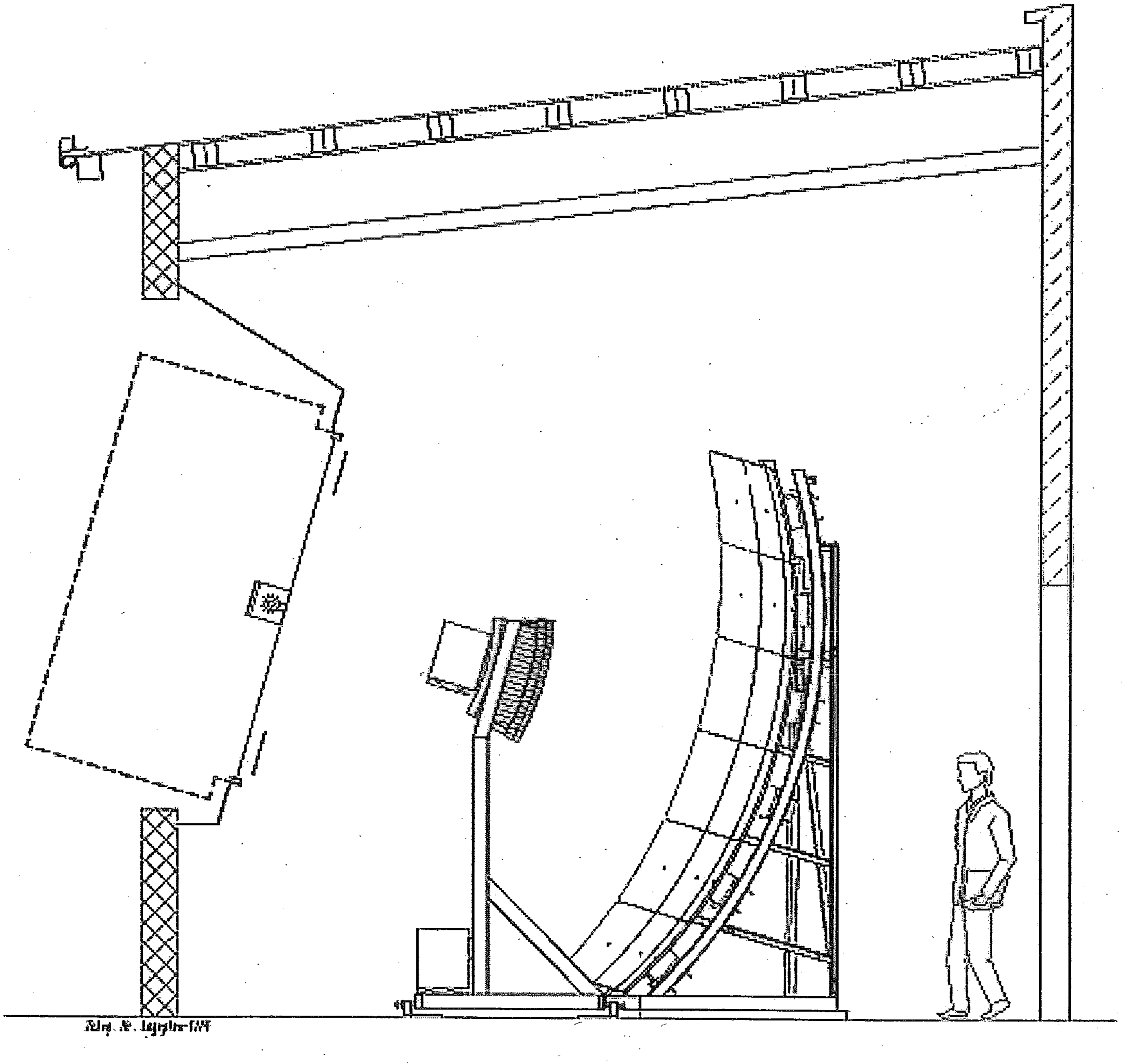
$$\gamma_{\underline{375nm}}(i) = \frac{\sum ADC_i - \sum \text{"PED"}_i}{\varepsilon_{ADC}(i, \underline{375nm})} \qquad i = 1, .., 440$$

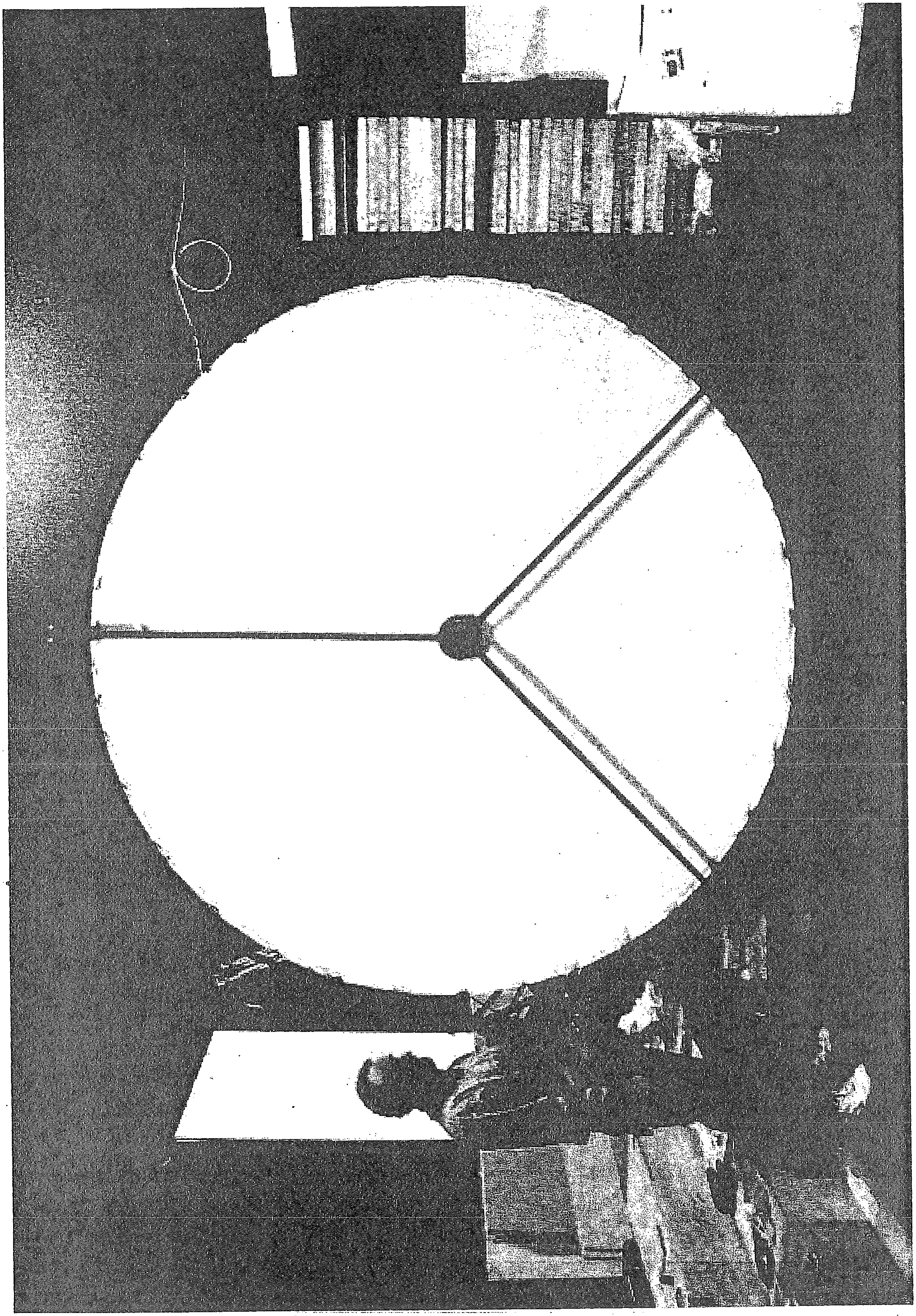
λ of UV LED in flat field illuminator "drum"

ε_{ADC} ≡ end-to-end calibration (ie $\gamma_{375nm} \rightarrow ADC$)†

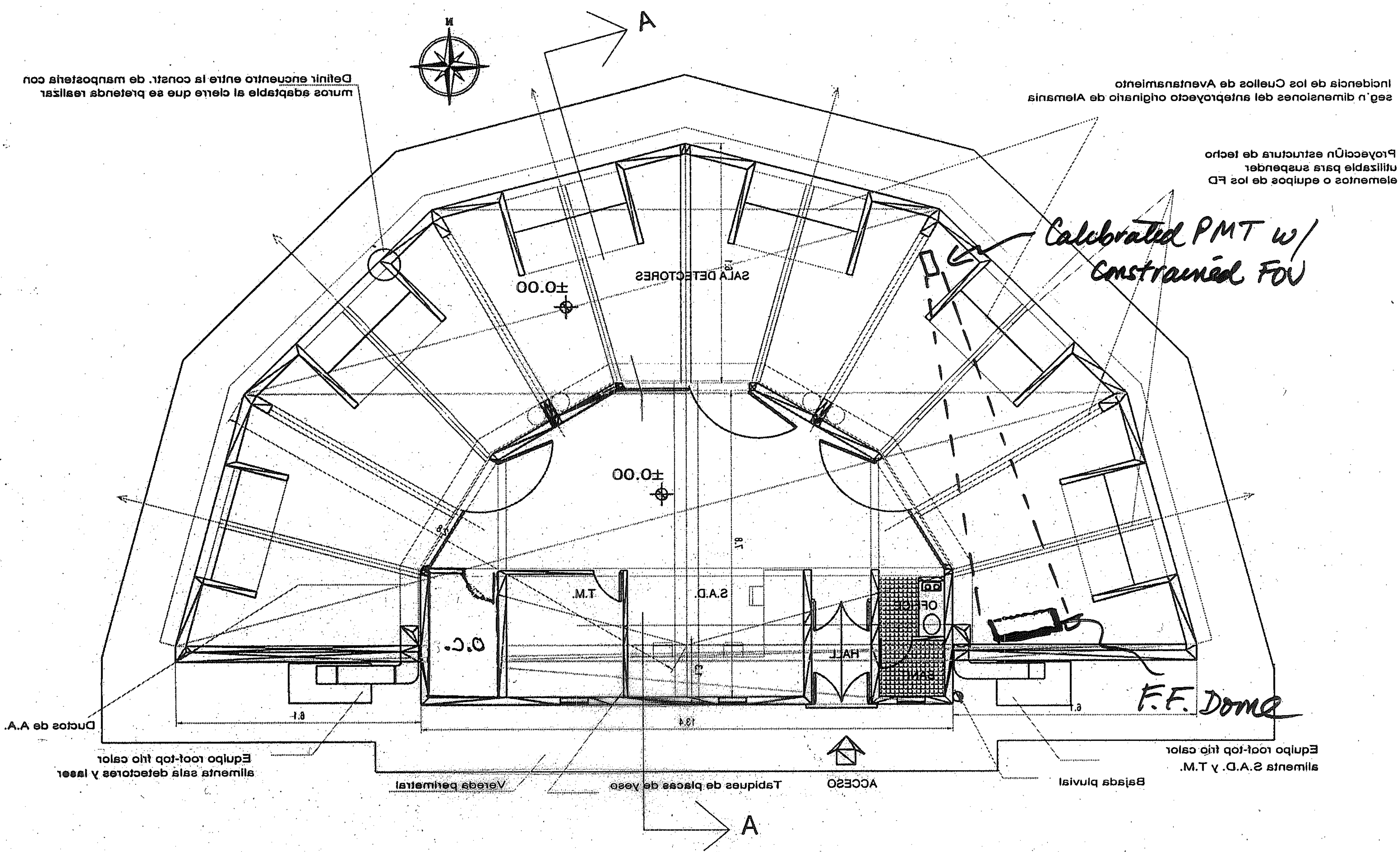
† $\varepsilon_{ADC}(i, 375nm) \Leftrightarrow \varepsilon(i, 375nm) * ADC/PE|_i$

end to end evaluation — piece by piece evaluation



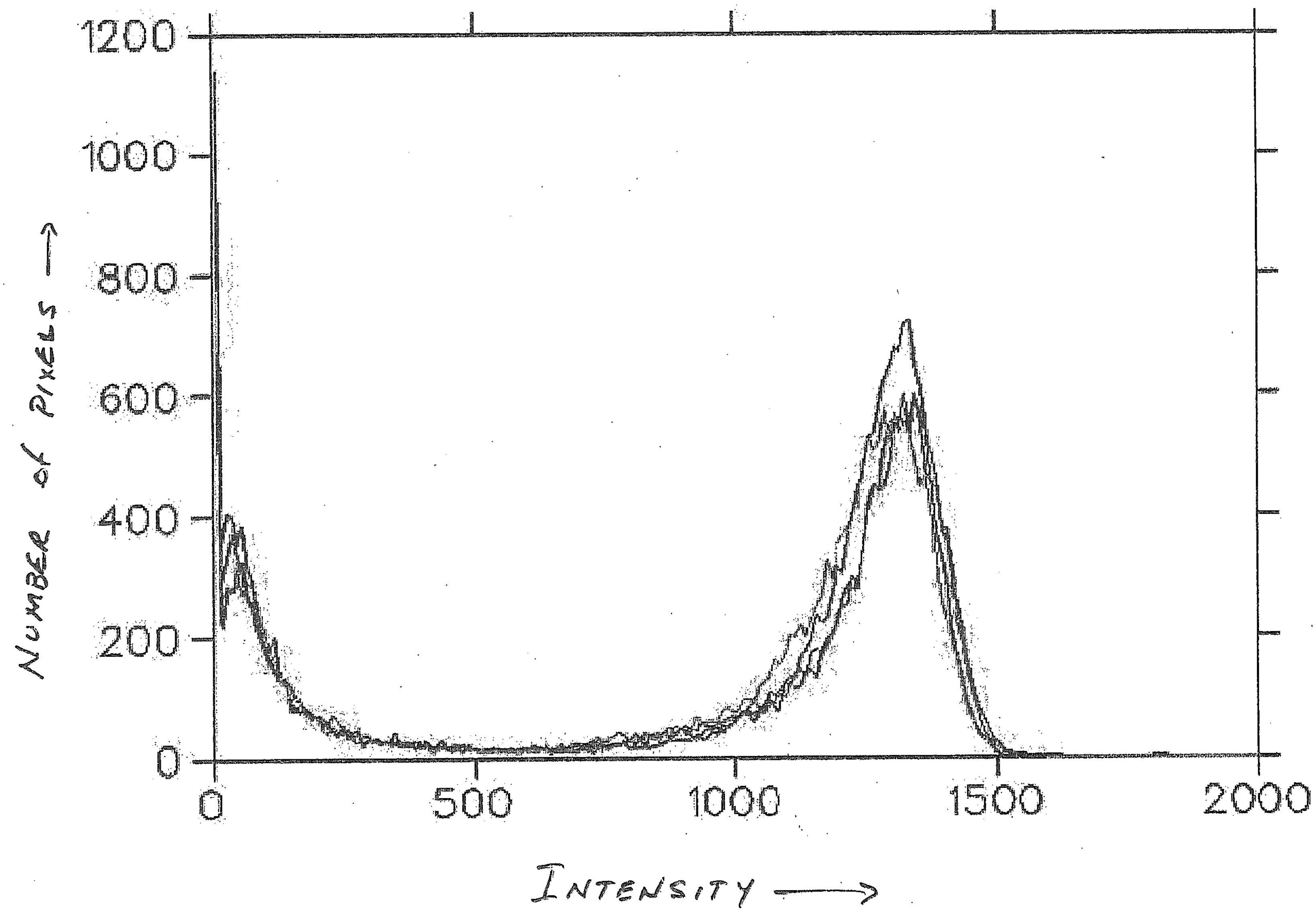


Dome Calibration in Los Leones F.D. Building

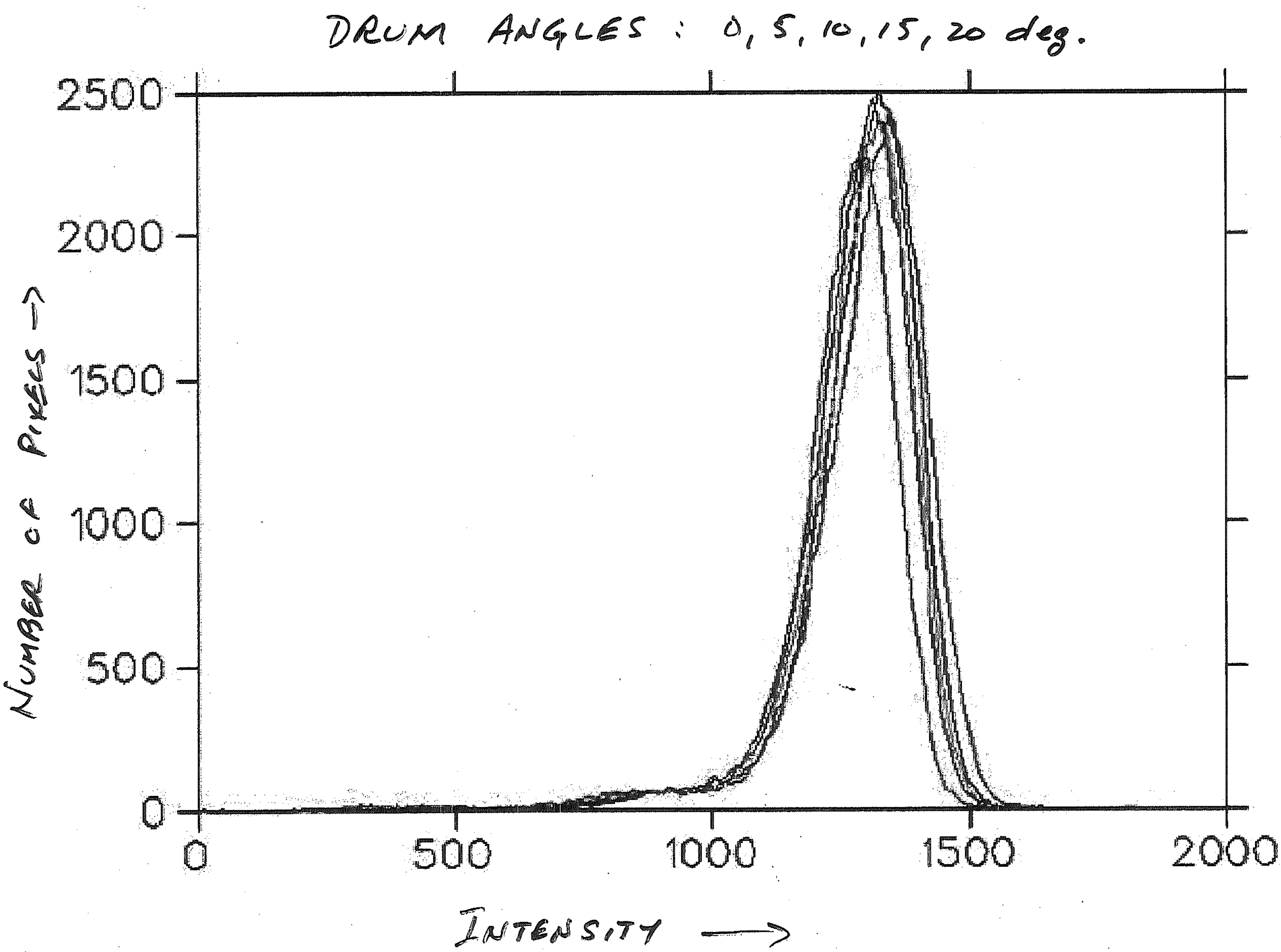


17/

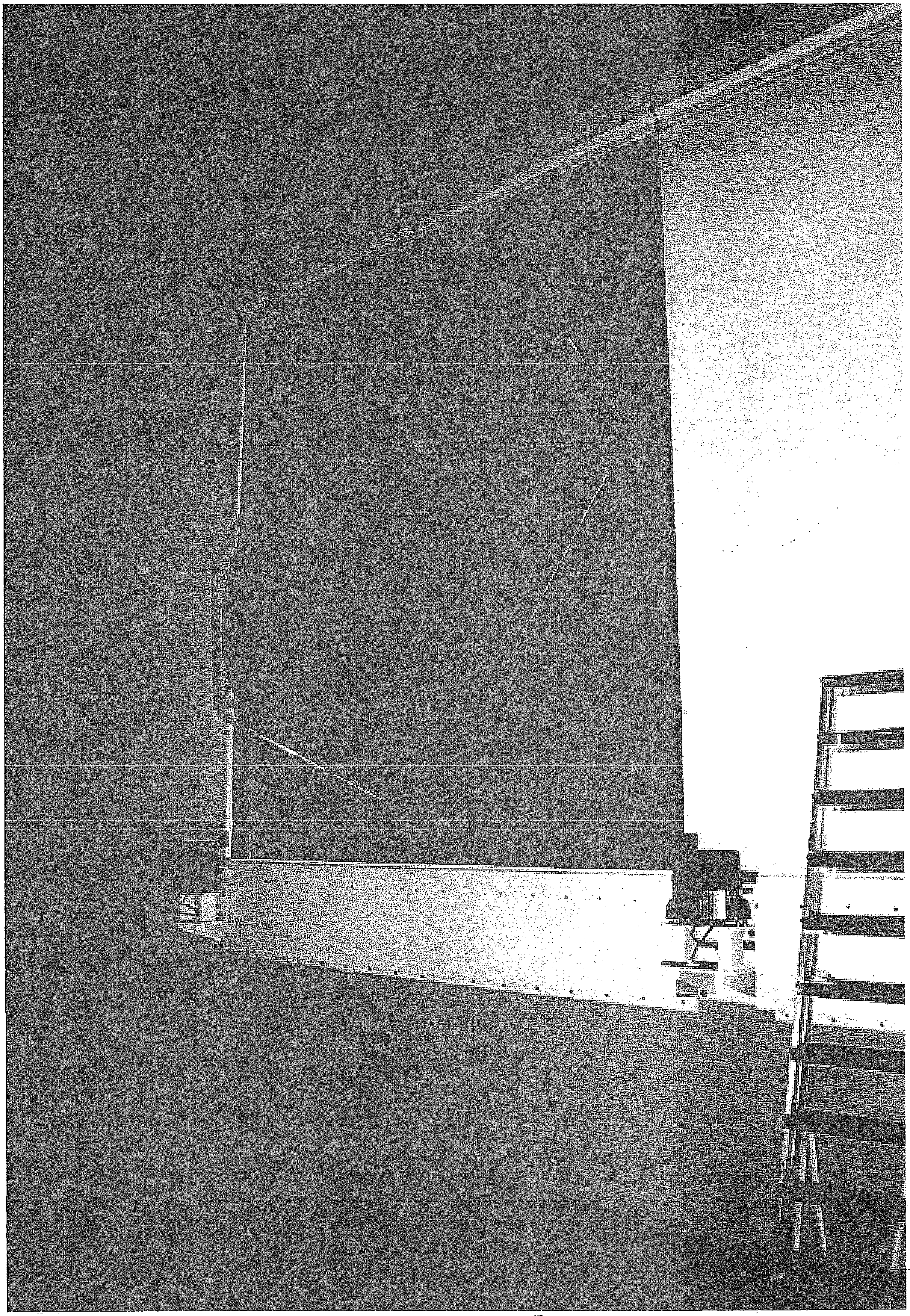
QUADRANTS : 15 deg drum angle

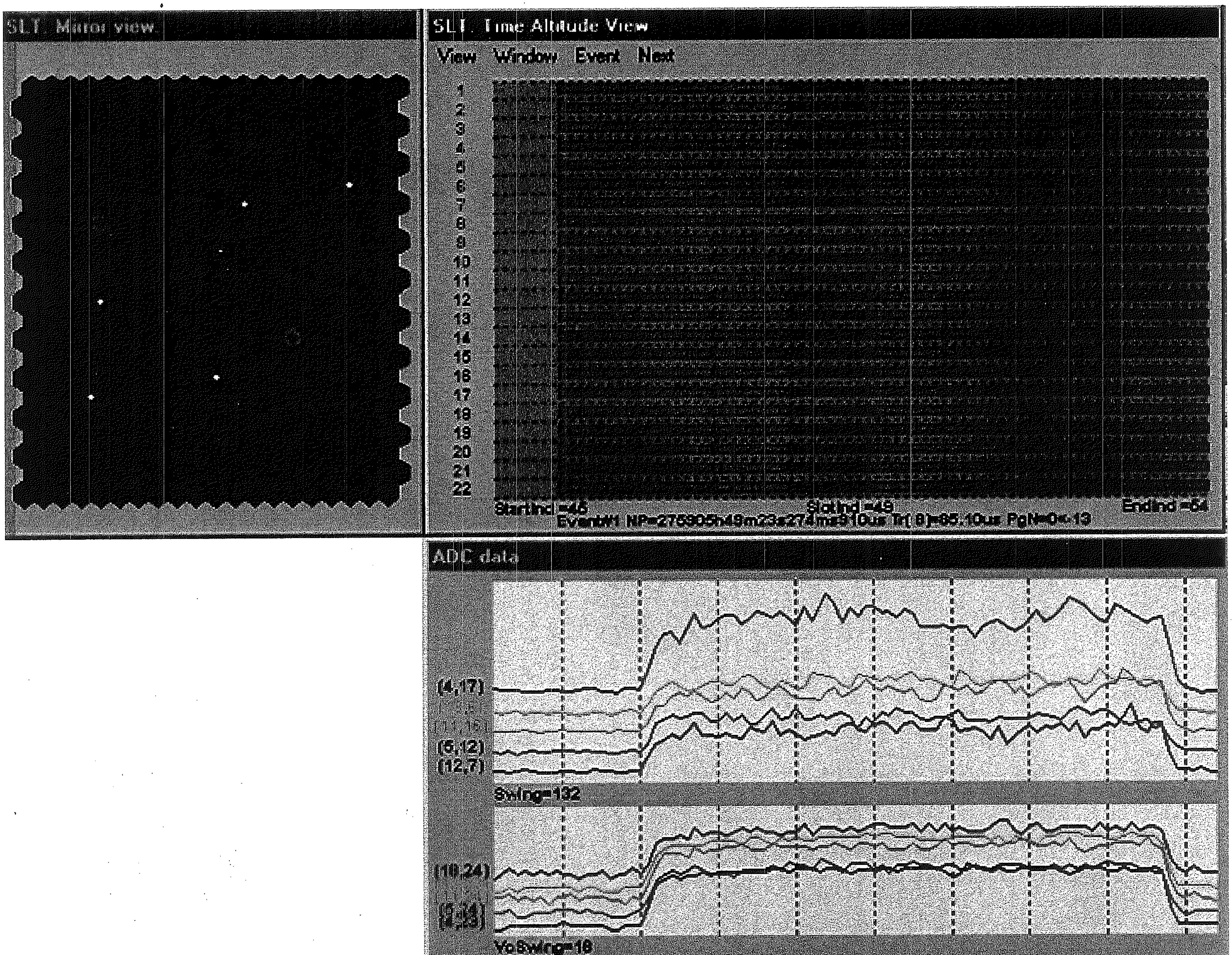


QUADS


DRUM ANGLES : 0, 5, 10, 15, 20 deg.
2500
2000
1500
1000
500
0
NUMBER OF PIXELS →
0
500
1000
1500
2000
INTENSITY →

Theta




SLT. Mirror view.
SLT. 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 =46
SlotInd =49
EndInd =64
ADC data
(4,17)
(6,12)
(12,7)
Swing=132
(10,24)
YoSwing=18

1. The present system

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

*Reference standard is NIST-calibrated Si photodiode

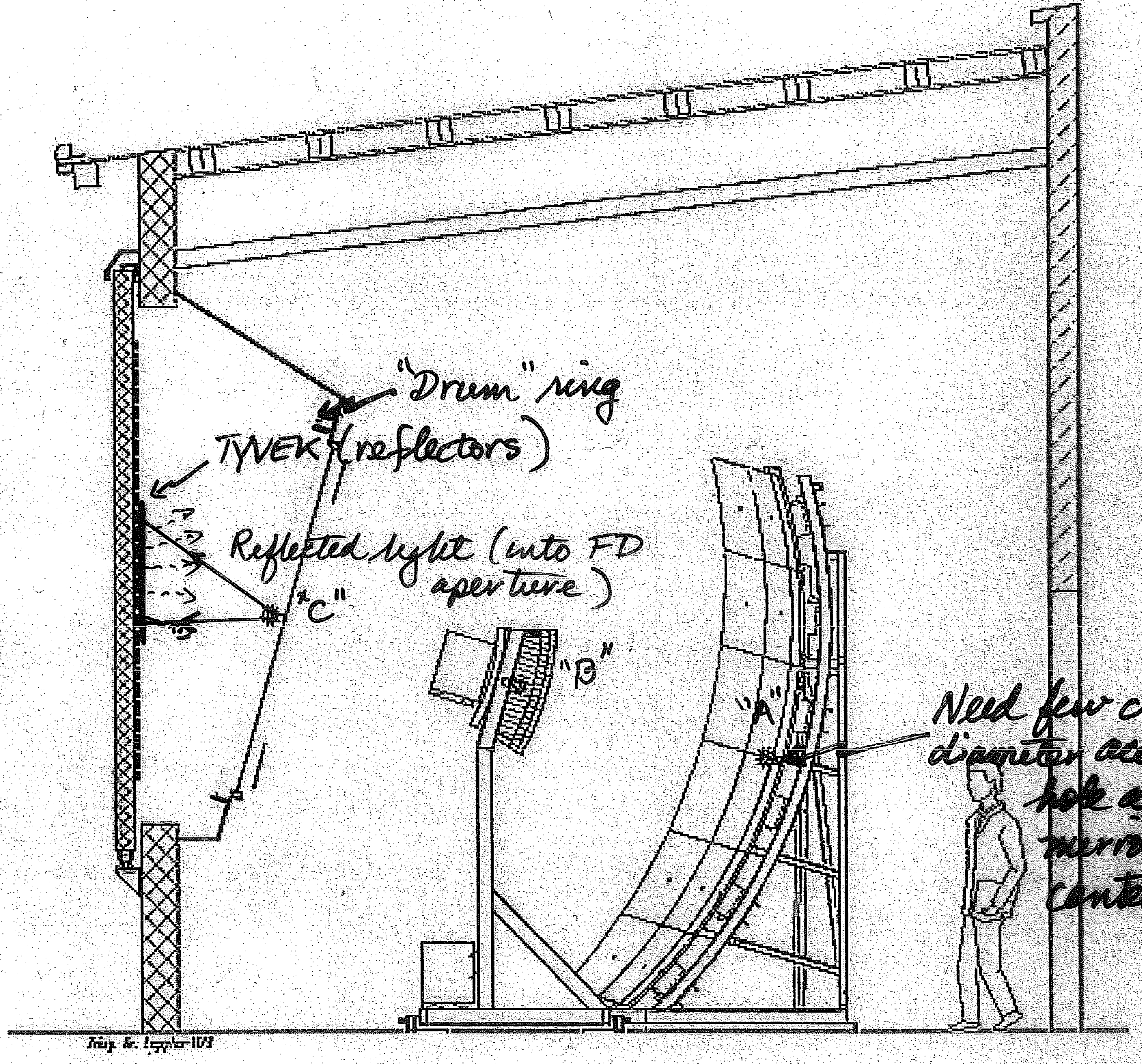
*Calibration is transferred
- a) from Si to PMT
  - Uses scanning monochromator:
  - deuterium light source
  - beam splitter
    - Si on one beam
    - PMT on other beam w/ 10**3 attenuation (ND filter)
  - data acquisition
    - ADC integration box (BB IV102 chip)
    - calibrated channel for Si detector
    - (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: 3~~2~~75 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

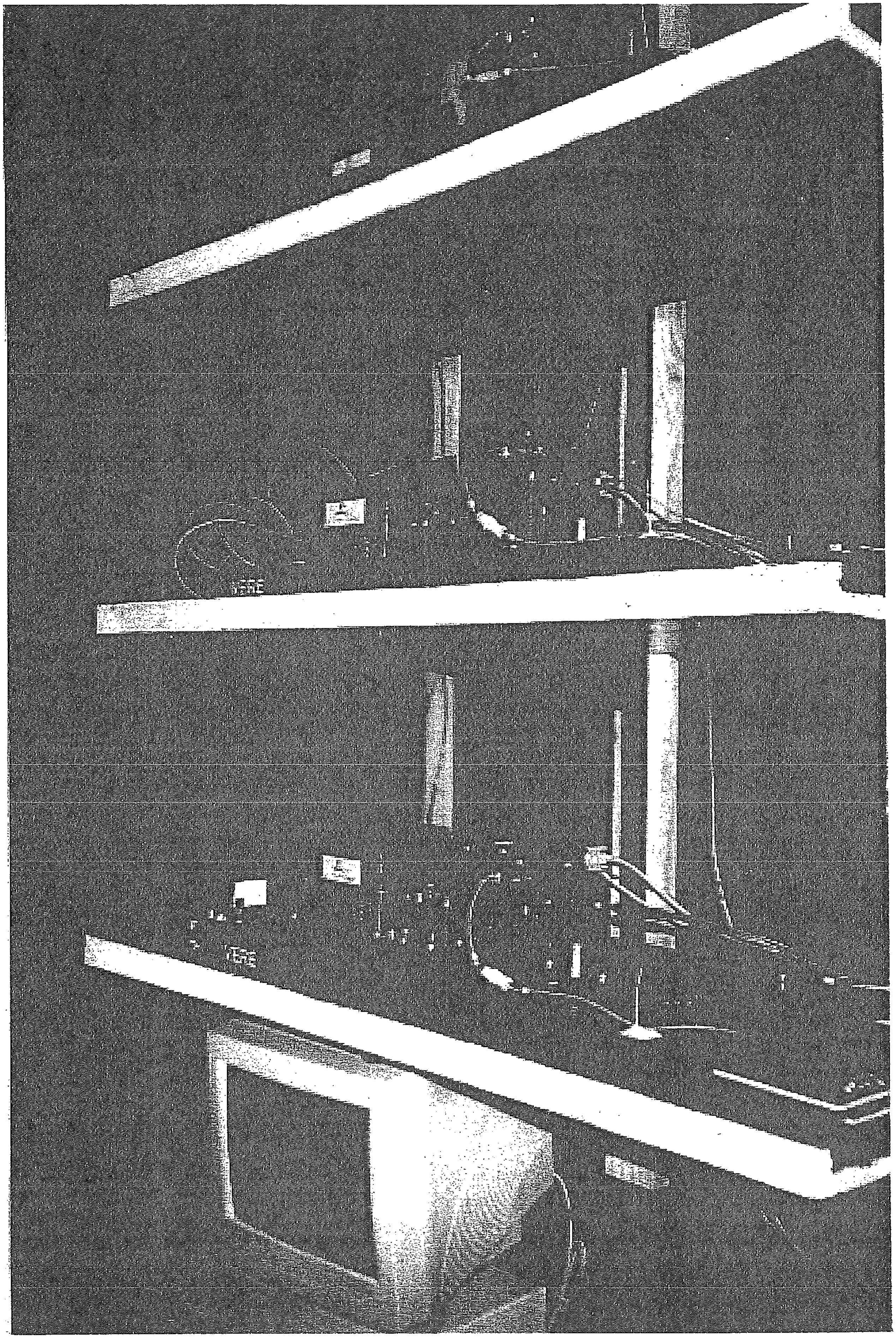
*Procedure
- Mount drum in aperture
- Pulse drum source
- Fill aperture with known flux of photons
- All PMTs in camera go above threshold
- Compare camera ADC outputs to drum flux gives calibration

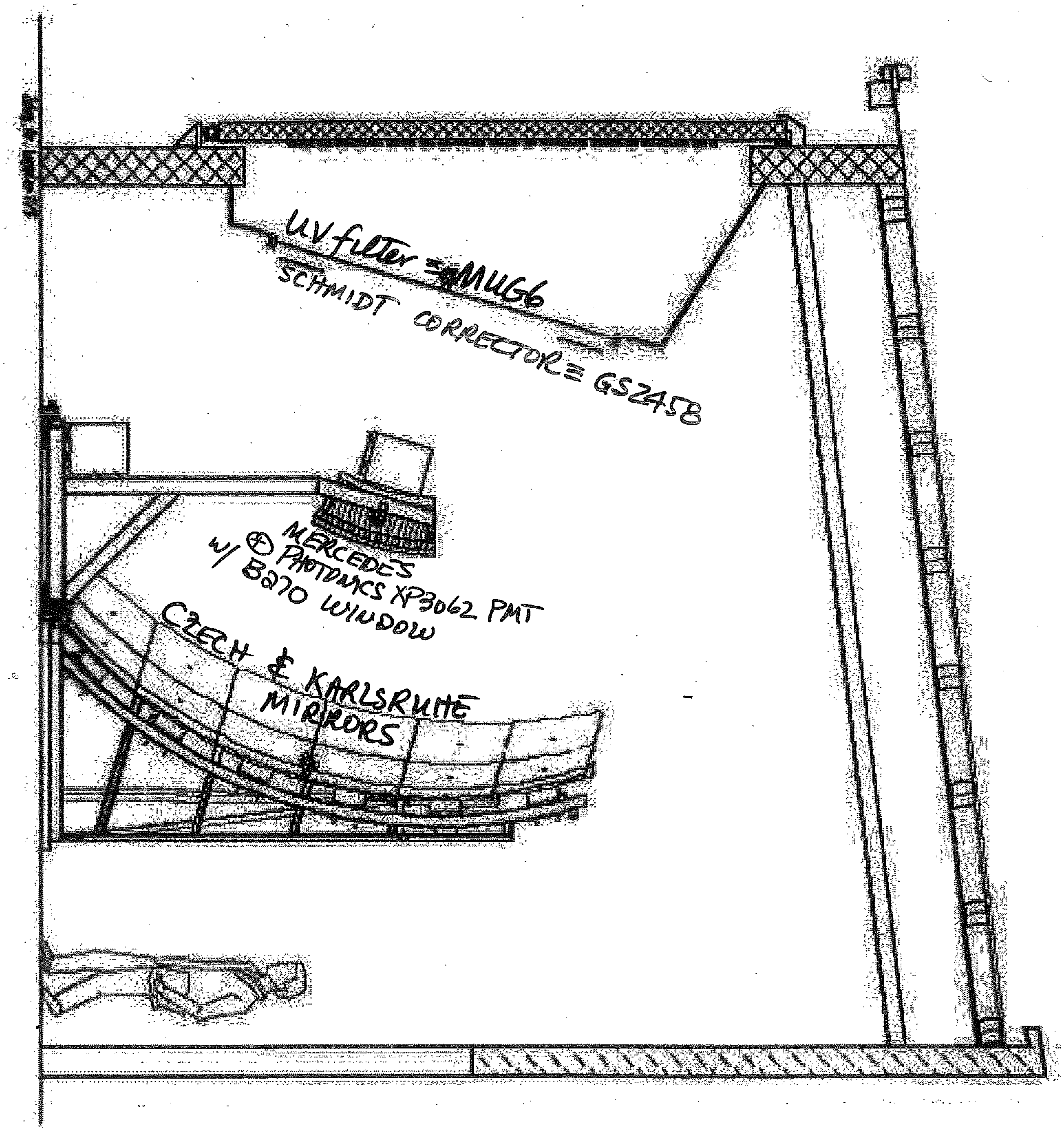
*Use this one-w.l. absolute calibration to normalize calculated full curve
- Full curve comes from combining curves measured individually at various collaborator's laboratories for:
  - window
  - corrector plate
  - mirror
  - mercedes cones
  - PMT QE
  - PMT gain
  - ADC conversion
  - ether, etc.

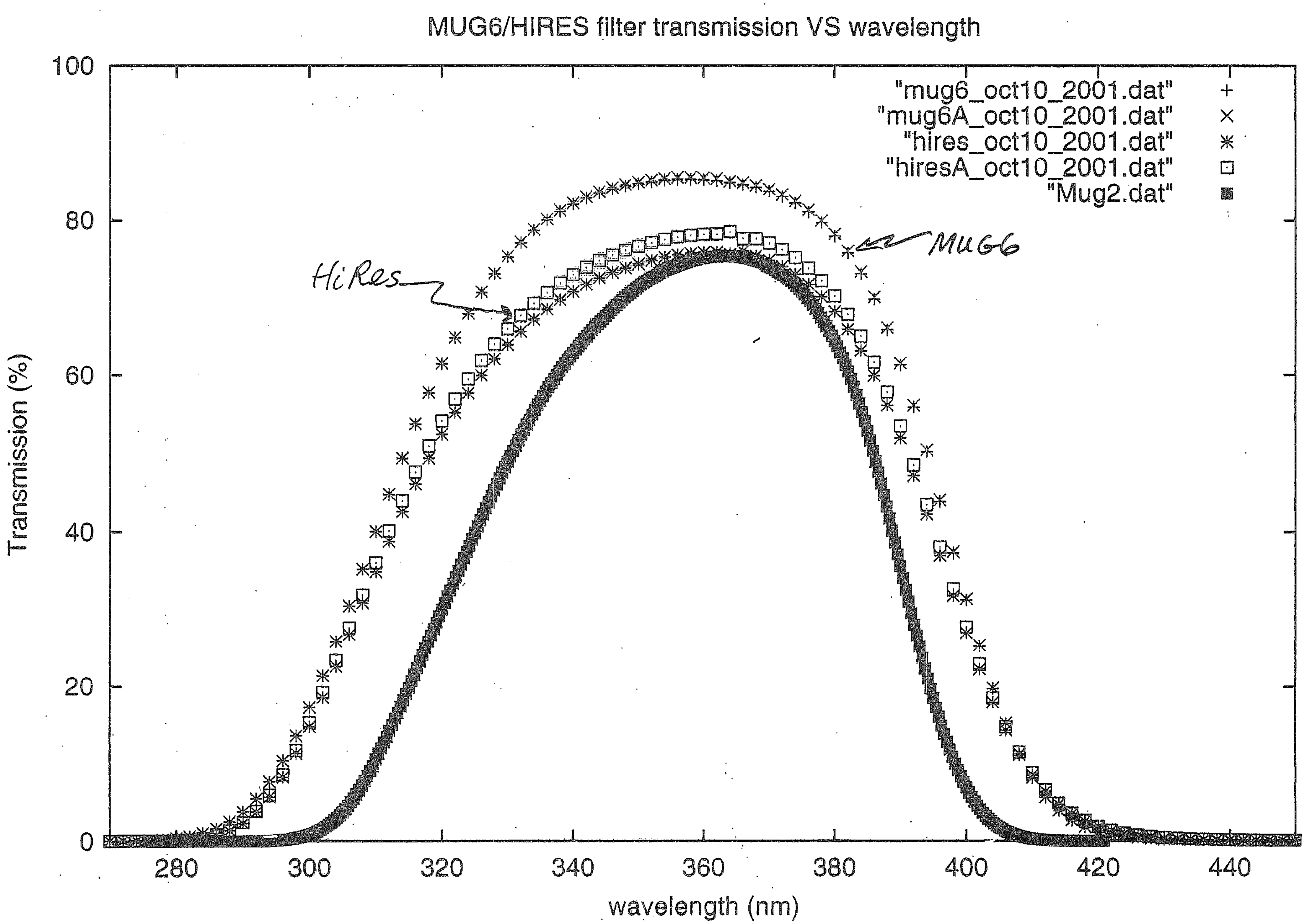
***> Need these curves (w/uncertainties) from each institution

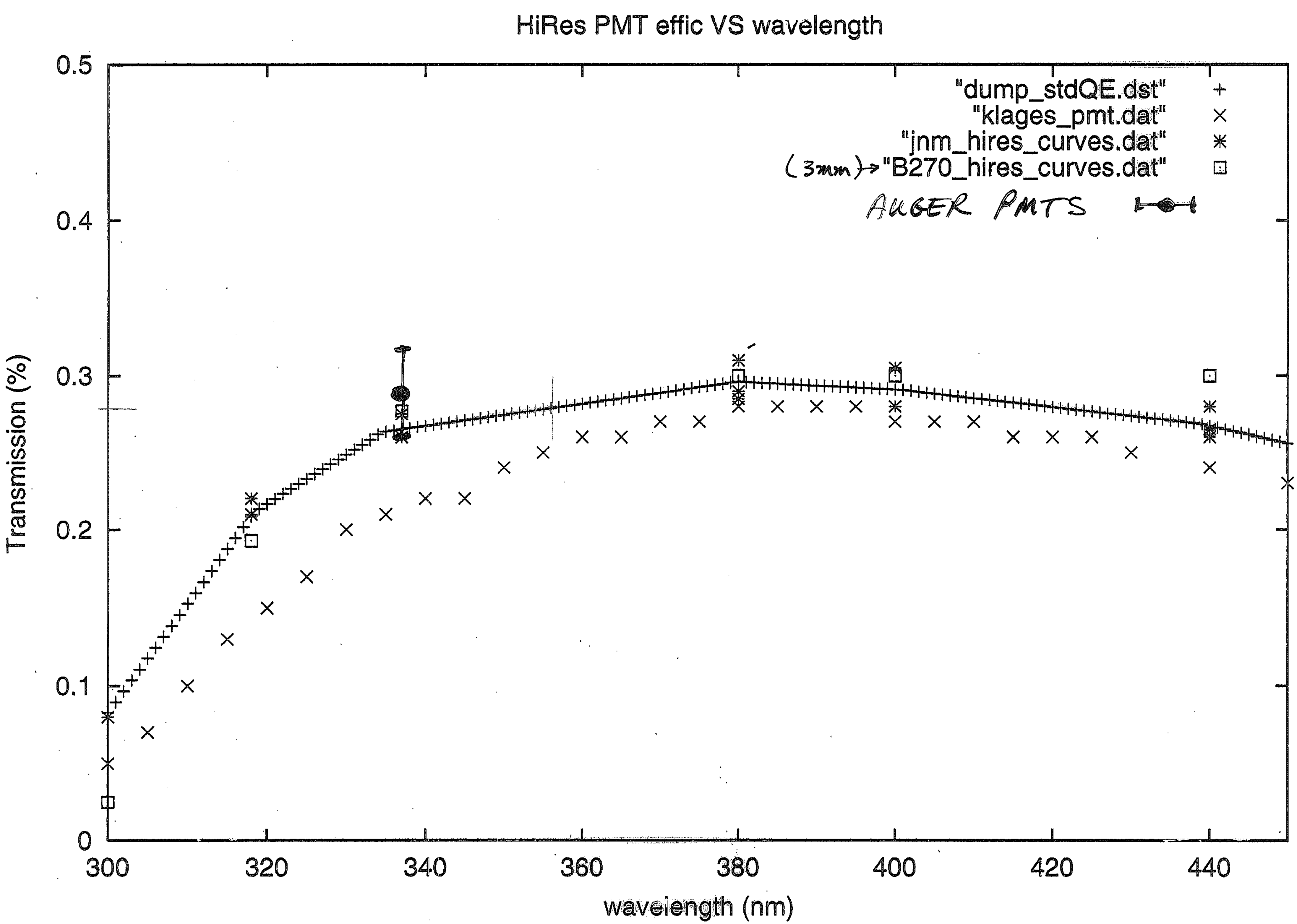


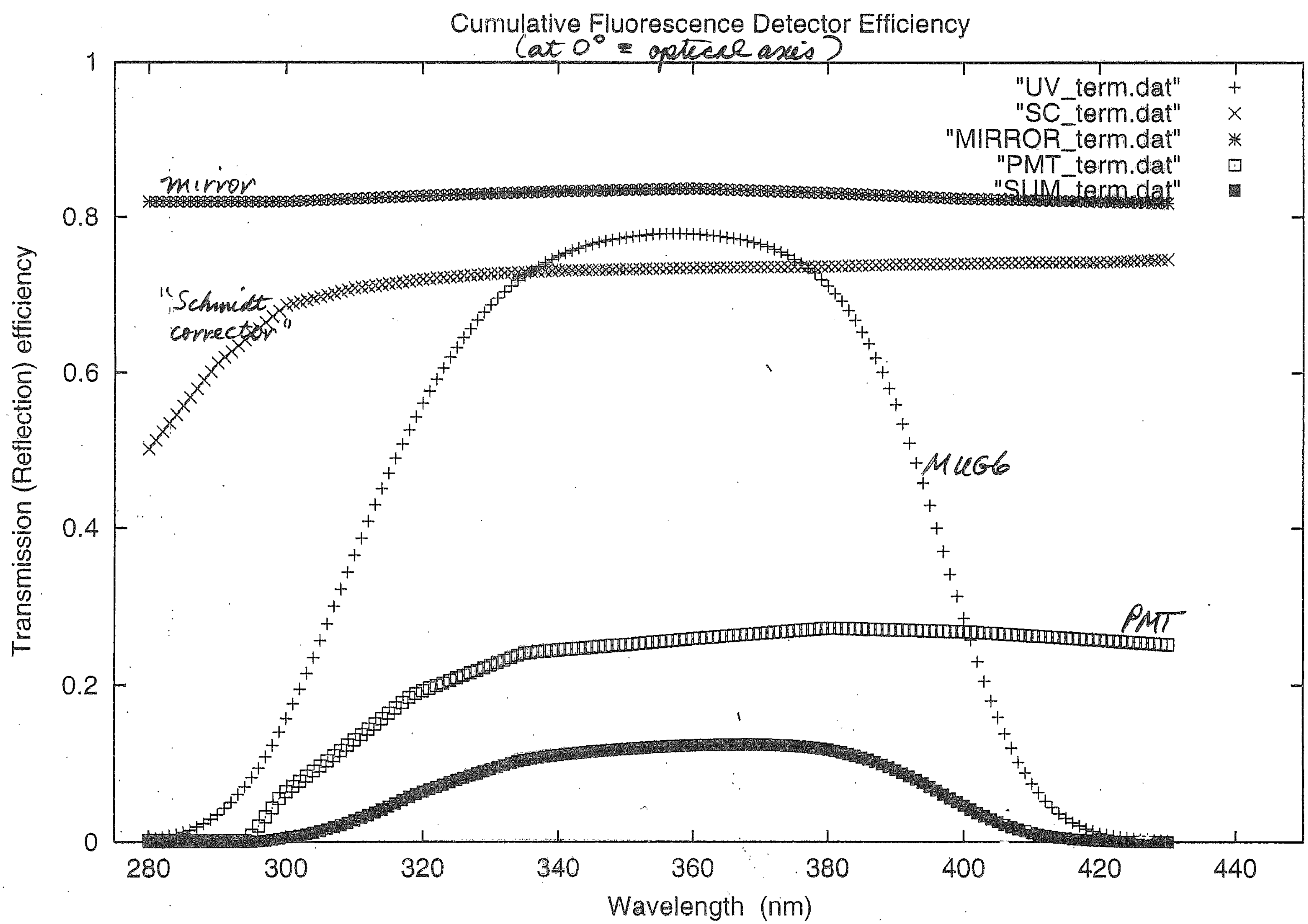
TYVEK reflectors on Polish Shutters

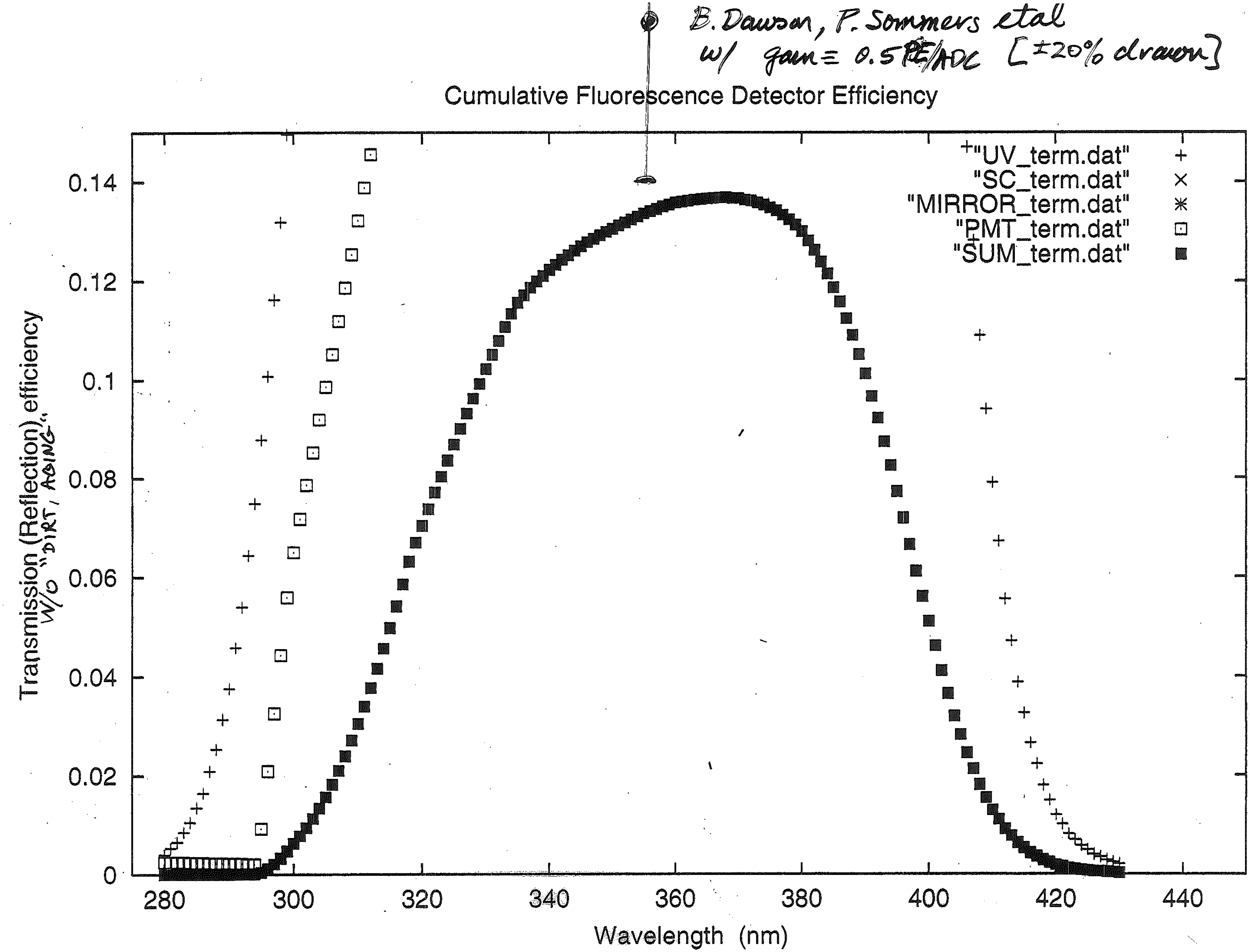


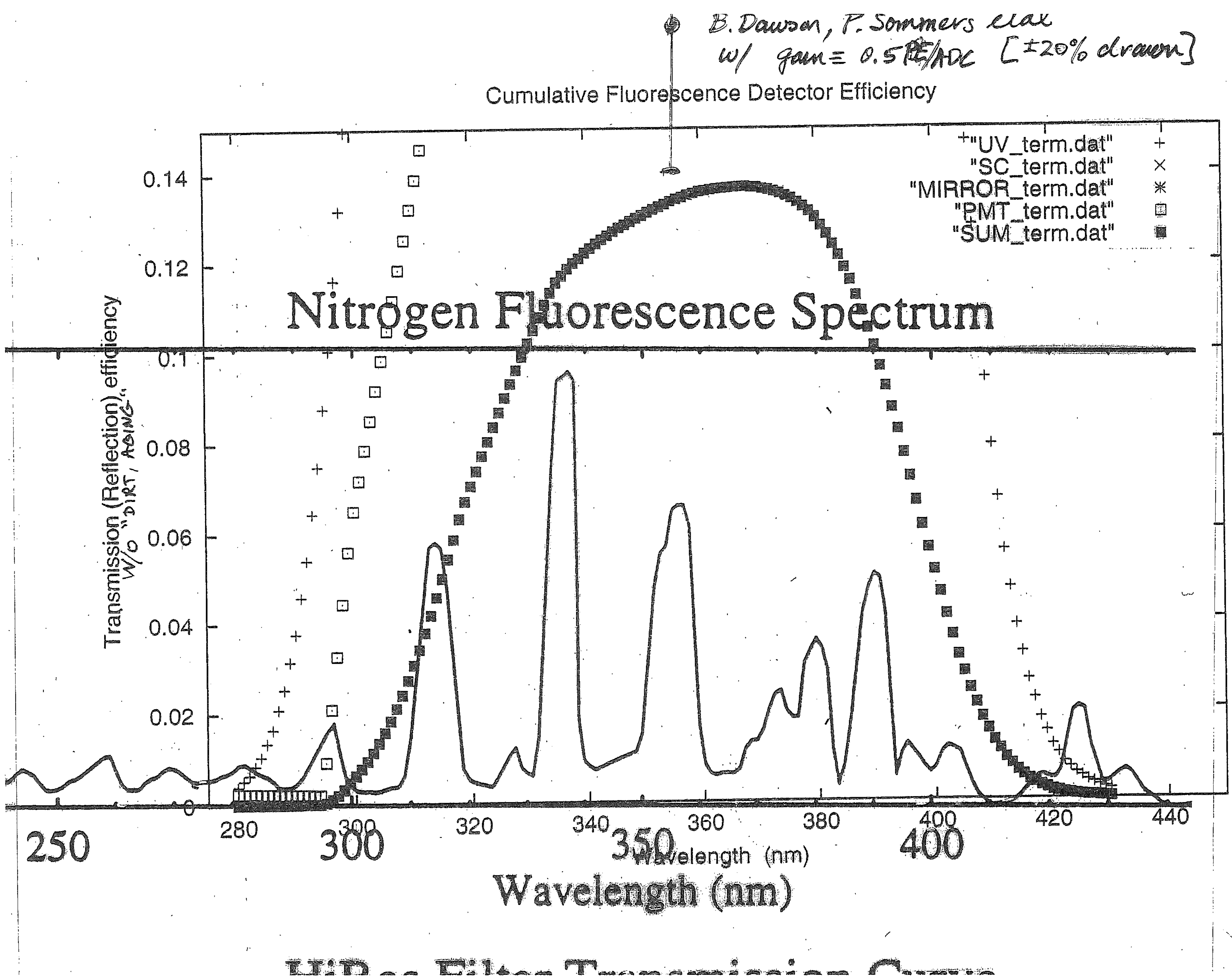

UV filter = MUG6
SCHMIDT CORRECTOR = GS2458
MERCEDES
+ PHOTONICS XP3062 PMT
w/ B270 WINDOW
CZECH & KARLSRUHE
MIRRORS


MUG6/HIRES filter transmission VS wavelength
"mug6_oct10_2001.dat"
"mug6A_oct10_2001.dat"
"hires_oct10_2001.dat"
"hiresA_oct10_2001.dat"
"Mug2.dat"
HiRes
MUG6
Transmission (%)
wavelength (nm)
100
80
60
40
20
0
280
300
320
340
360
380
400
420
440


HiRes PMT effic VS wavelength
"dump_stdQE.dst"
"klages_pmt.dat"
"jnm_hires_curves.dat"
(3mm)→"B270_hires_curves.dat"
AUGER PMTS
Transmission (%)
0
0.1
0.2
0.3
0.4
0.5
300
320
340
360
380
400
420
440
wavelength (nm)


Cumulative Fluorescence Detector Efficiency
(at 0° = optical axis)
"UV_term.dat"
"SC_term.dat"
"MIRROR_term.dat"
"PMT_term.dat"
"SUM_term.dat"
mirror
"Schmidt corrector"
MUG6
PMT
Transmission (Reflection) efficiency
0
0.2
0.4
0.6
0.8
1
280
300
320
340
360
380
400
420
440
Wavelength (nm)


B. Dawson, P. Sommers etal
w/ gain = 0.5 PE/ADC [±20% drawn]
Cumulative Fluorescence Detector Efficiency
"UV_term.dat"
"SC_term.dat"
"MIRROR_term.dat"
"PMT_term.dat"
"SUM_term.dat"
Transmission (Reflection), efficiency
W/O "DIRT, AGING"
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
280
300
320
340
360
380
400
420
440
Wavelength (nm)


B. Dawson, P. Sommers et al
w/ gain = 0.5 PE/ADC [±20% drawn]
Cumulative Fluorescence Detector Efficiency
"UV_term.dat"
"SC_term.dat"
"MIRROR_term.dat"
"PMT_term.dat"
"SUM_term.dat"
Nitrogen Fluorescence Spectrum
Transmission (Reflection) efficiency
W/O "DIRT, AGING"
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
280
300
320
340
360
380
400
420
440
250
300
350
400
Wavelength (nm)
Wavelength (nm)

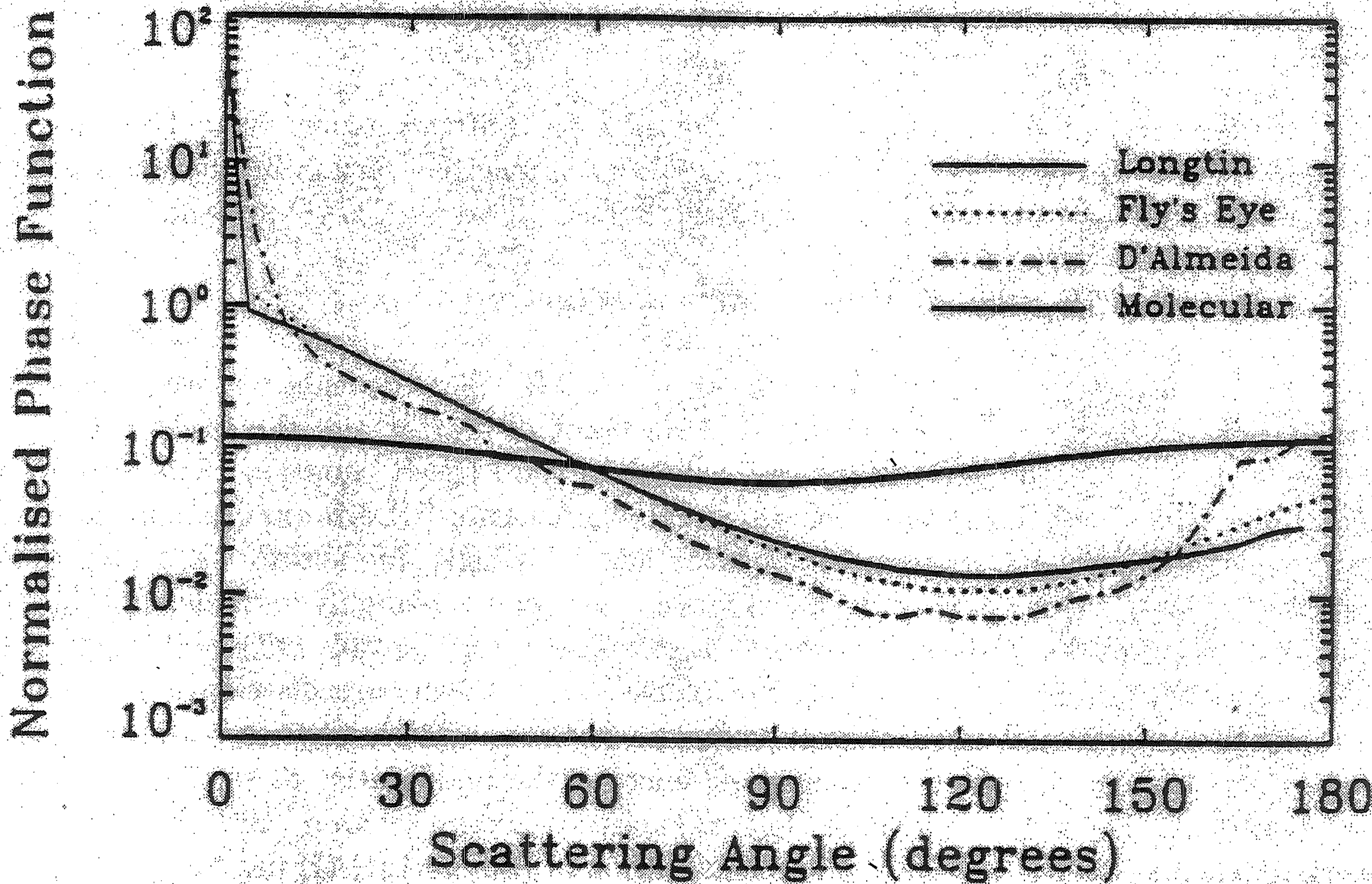


Figure 2: Examples of aerosol phase functions obtained with Mie theory (assumes all aerosol particles are spherical). Also shown is the Rayleigh (molecular) phase function. For typical aerosol densities the sideways scattering (90° to 120°) is dominated by well known Rayleigh scattering cross section

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

a) "gain" correct:

PEDESTAL ⊕ night sky background

$$P.E.(i) = \frac{\Sigma ADC_i - \Sigma \text{"PED"}_i}{ADC/P.E.\big|_i} \qquad i=1,..,440$$

"gain" (assuming linear)

b) "flat field":

$$\gamma_{\underline{360nm}}(i) = \frac{P.E.(i)}{\varepsilon(i, \underline{360nm})} \qquad i=1, \ldots, 440$$

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

piece-by-piece efficiency

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

Fluorescence Detector Calibration
"Summary"

1) Three techniques proposed:
   - end to end <=> flat field drum
   - piece by piece <=> helps enforce Q.A.
   - Rayleigh <=> natural spin off of atmospheric monitoring technology

2) and "proof of principle" or better achieved for <u>all</u> <u>three</u> techniques.

3) Realistic goal of next few months is calibration at ≤ 20% level.

John Matthews / UNM