Summary of FD Calibration Session

Auger Collaboration Meeting

Malargue, Argentina

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1. "All" the pieces

2. New results:

   i) $\langle PE/FADC \rangle$ "PMT/electronics" calibration

   ii) γ's $\leftrightarrow$ FADC "end to end" calibration

⊕ piece by piece effecuencies consistent w/ absolute FI calebration "already" at ~ 10% precesion!!

3. The "next" 5%!

Fluorescence Detector Calibration

"$\gamma \rightarrow$ FADC$_{i=1,440}$"

Optics $\otimes$ PMT/electronics$|_{i=1,440}$ = $\varepsilon(\lambda, i)$ Relative

4 reports using "all" techniques

$\varepsilon(\lambda, i)$ end-to-end

2 reports using Rayleigh scattering

Drum Illuminator

- ✓ need drum absolute calibration
- ✓ need drum characterization $\oplus$ ray trace fine tuning

Laser (M.S.) Light

- ✓ Rayleigh scattering
- ✓ laser intensity absolute calibration

$\Downarrow$

$\varepsilon(\lambda, i)$

$\Uparrow$

- ✓ Piece by piece calibration (λ) (P.E.'s/γ.)

"Fiber A" plus geometrical correction

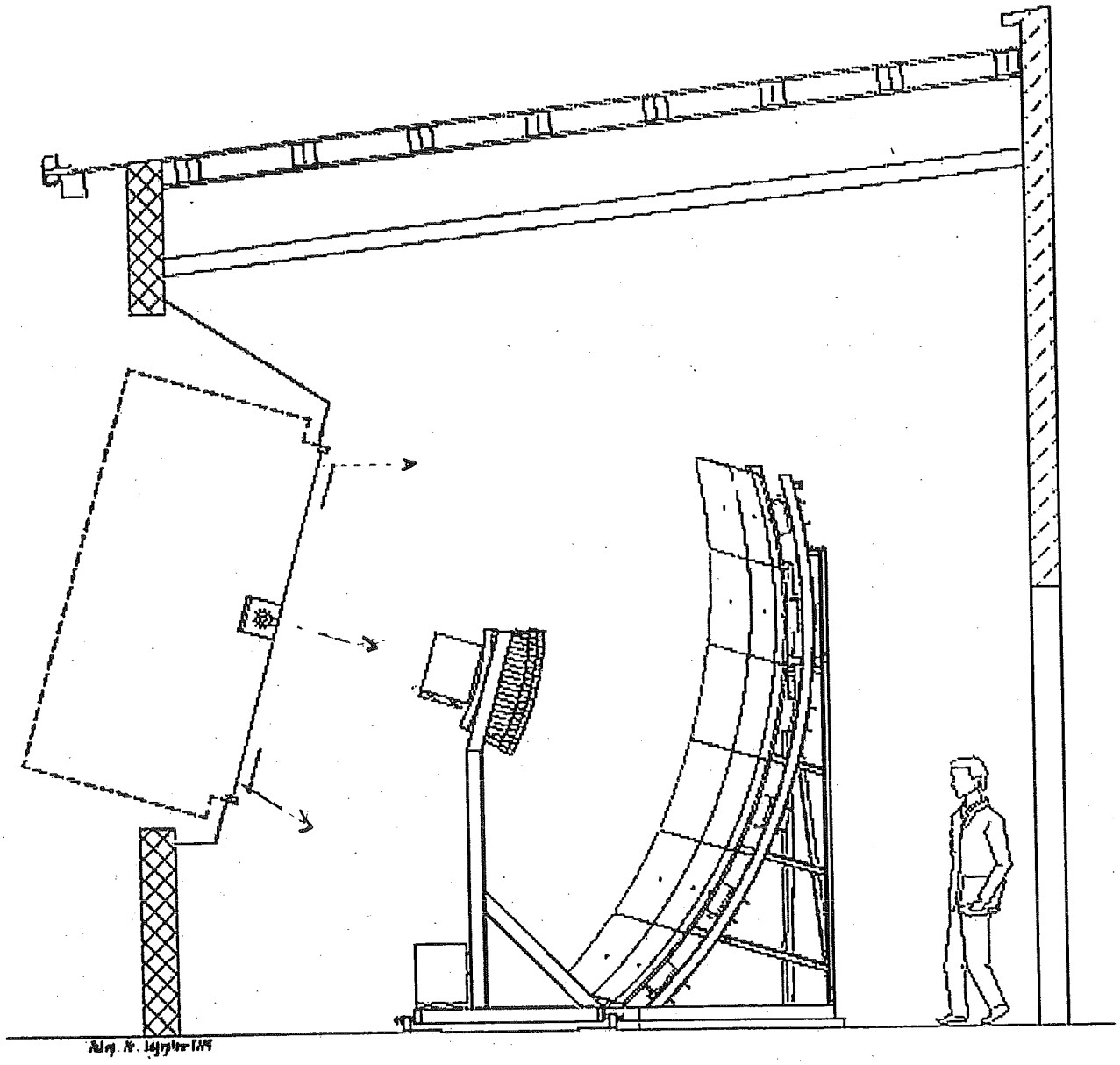
$\Downarrow$

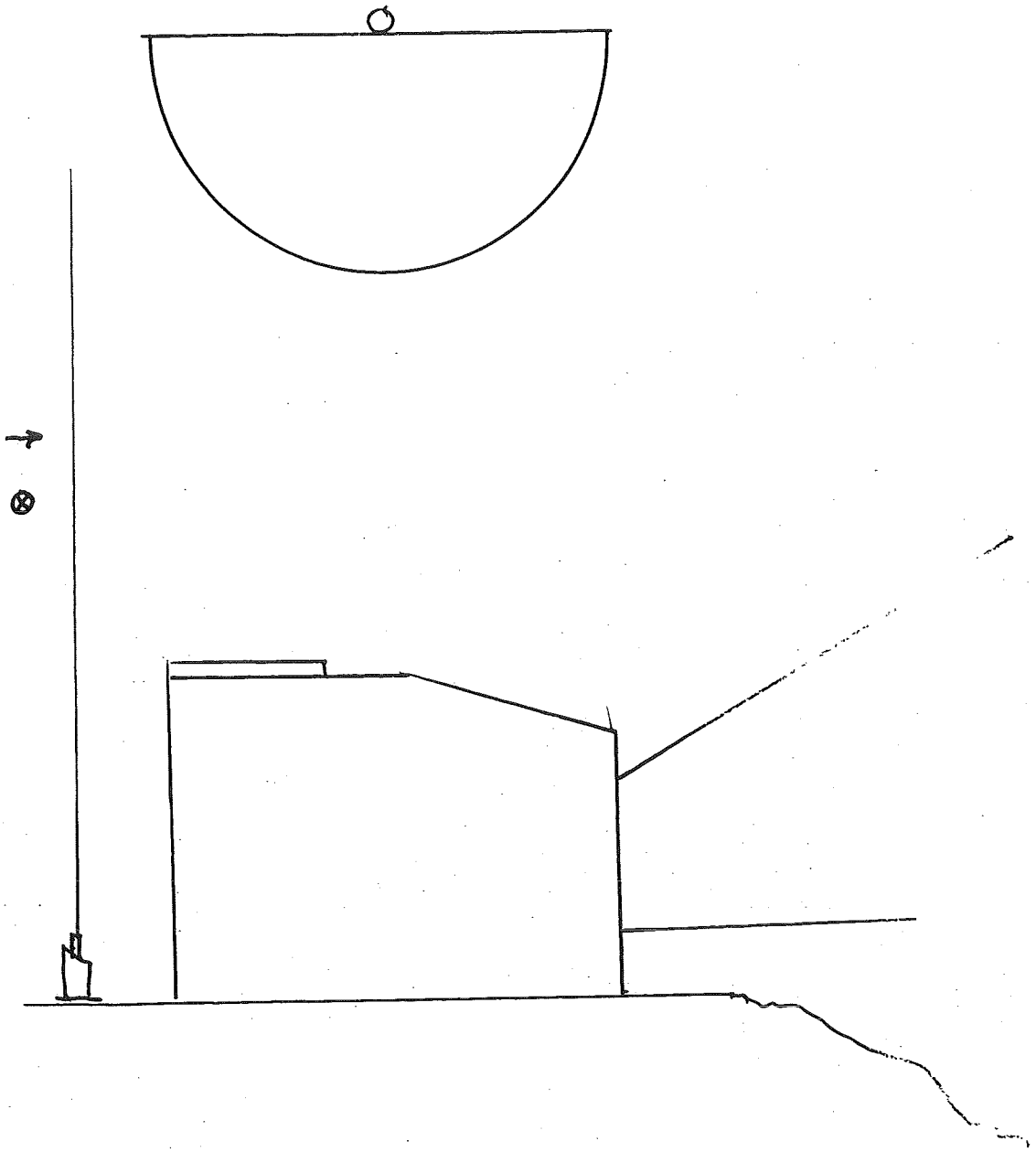
$\varepsilon'(\bar{\lambda}, i)$

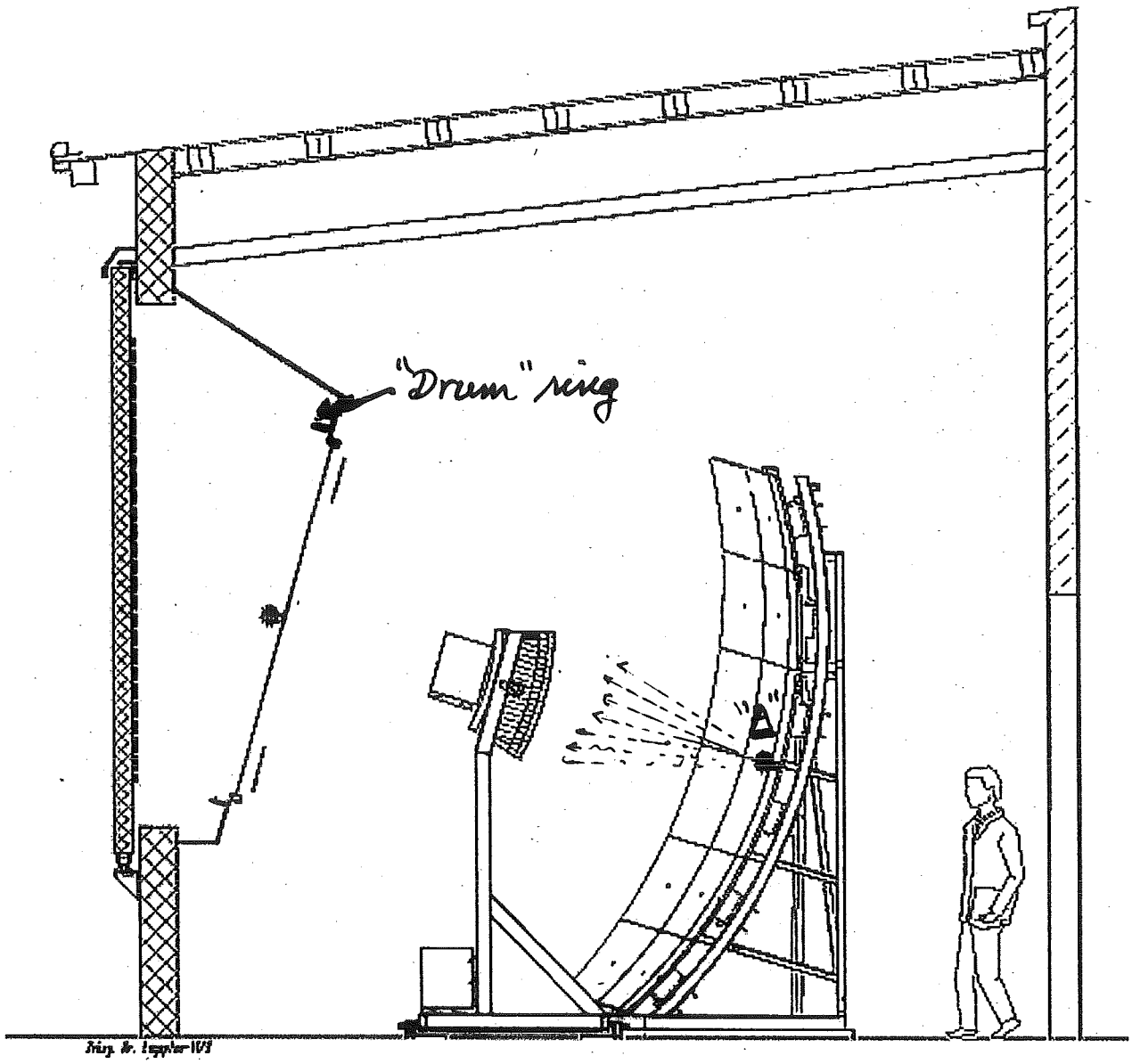
"flat fielding" the camera

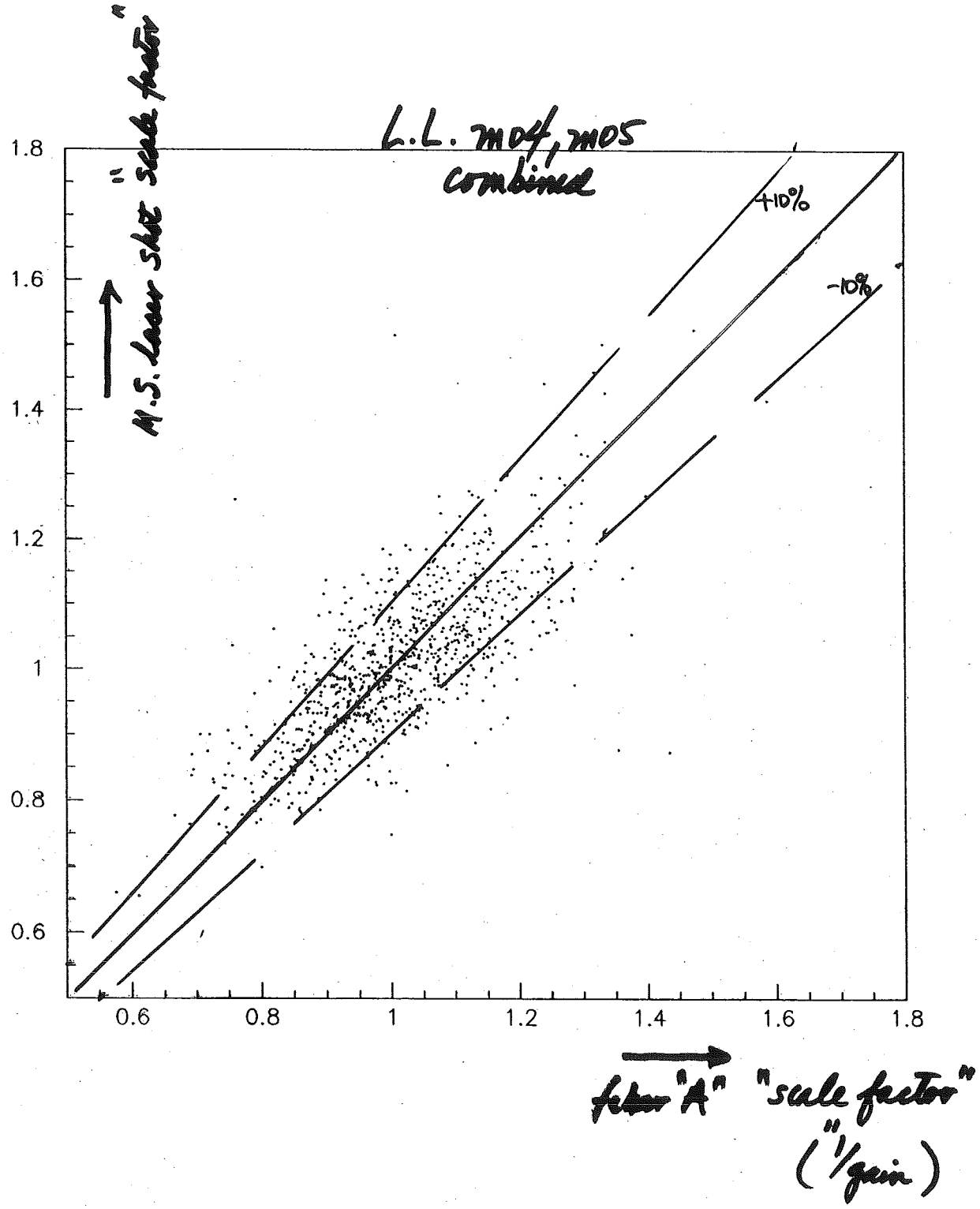
P.E. statistics $\oplus$ PMT, electronics characterization (or modeled)

2 reports using different analyses






"Drum" ring


L.L. MOS, MOS combined
+10%
-10%
M.S. Laser shot scale factor
1.8
1.6
1.4
1.2
1
0.8
0.6
0.6
0.8
1
1.2
1.4
1.6
1.8
"scale factor" ("1/gain")

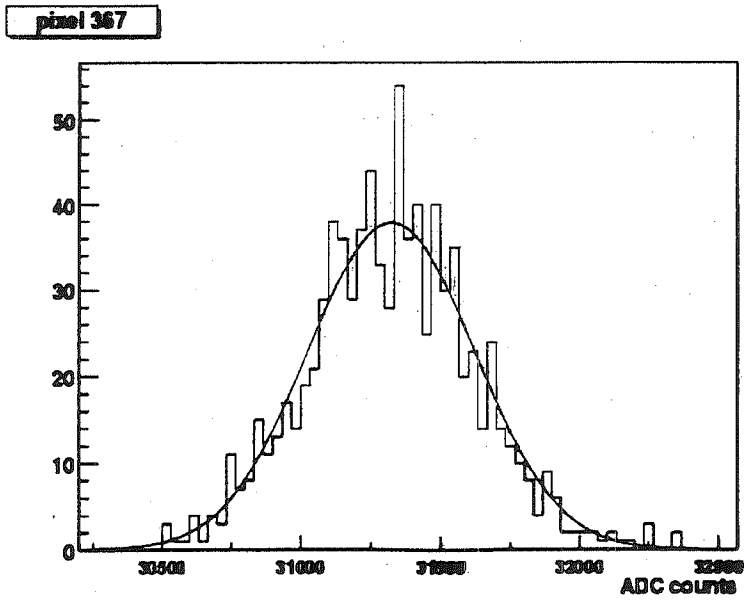
de Capoa
U. of Turin

ABSOLUTE CALIBRATION

Conversion ADC counts/ n photoelectrons

$$K = \frac{S_i}{\sigma^2_{S_i}} \cdot v_n \quad \rightarrow 1.413$$

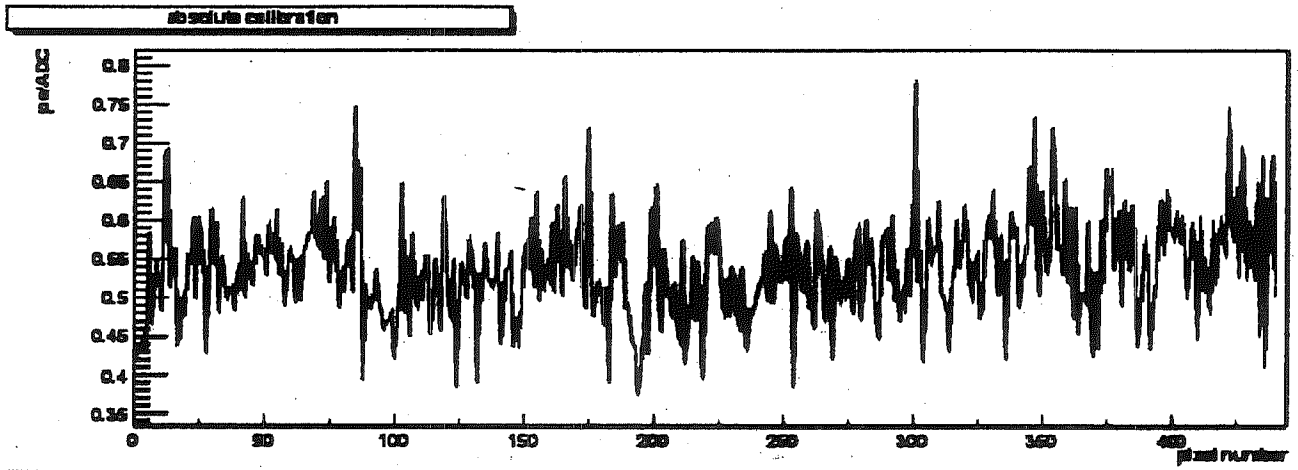
v_n from PMT simulation
in agreement w/ manufacturer

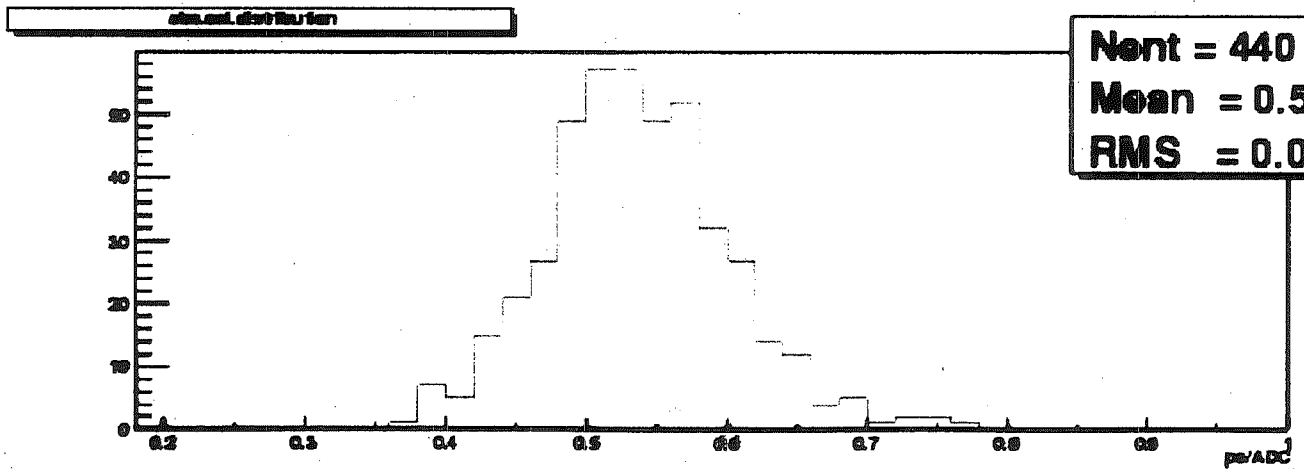


Assumes that only contribution to σ is from p.e. statistics and multiplication.

Other possible sources of broadening

- Integral calculation
- Baseline calculation
- Noise

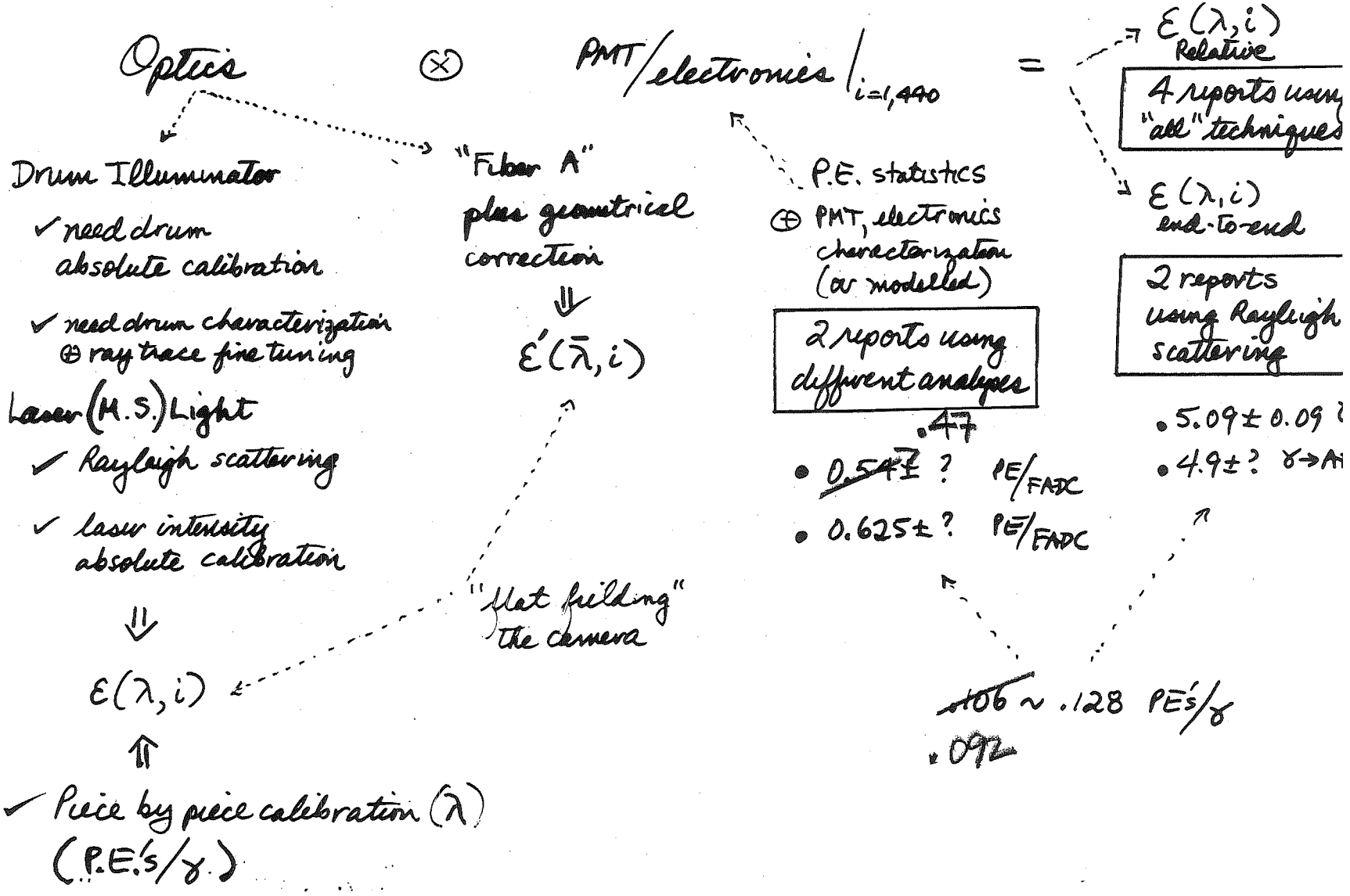


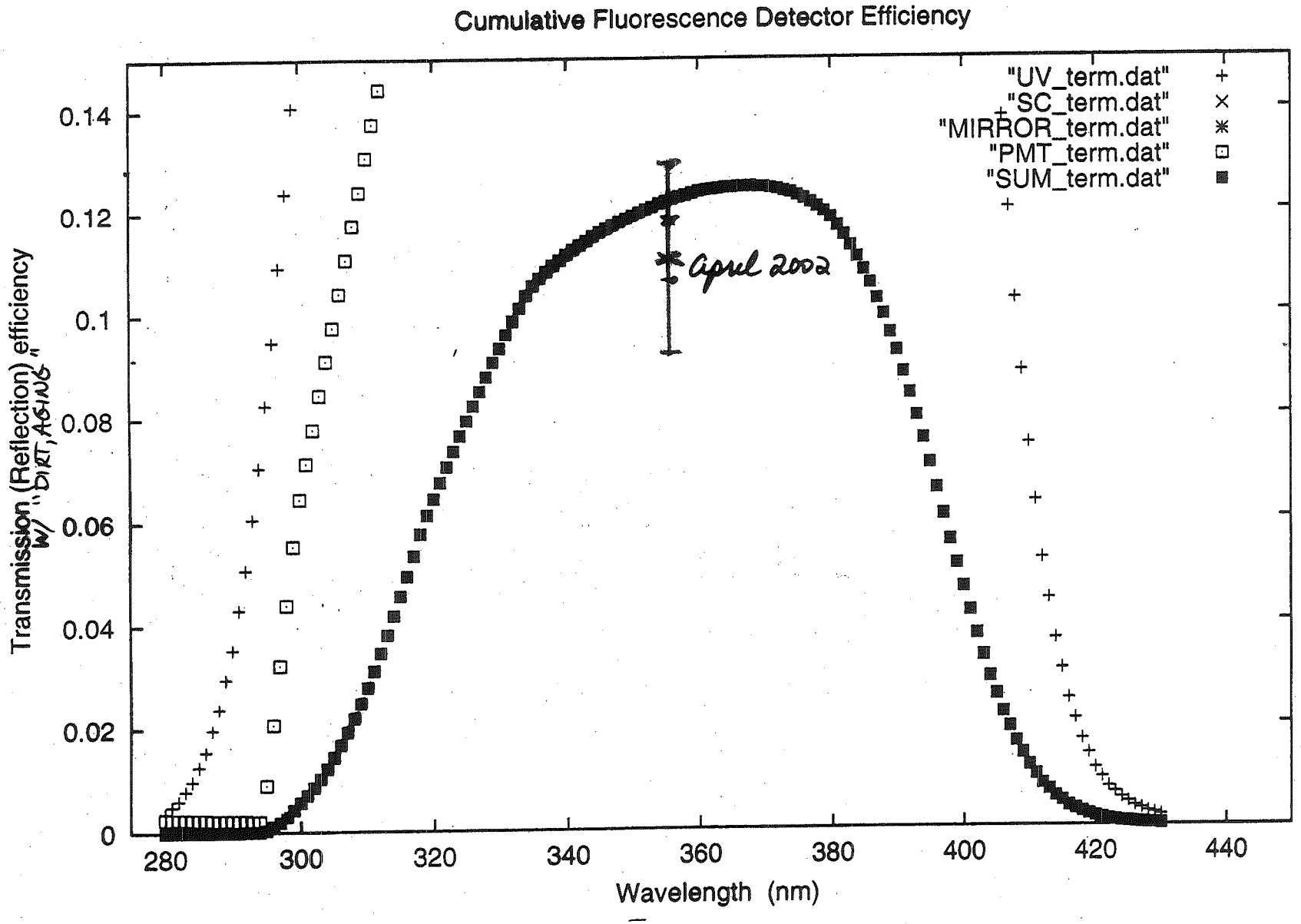


← PE's/FADC
"electrons/PMT"
calibration

Fluorescence Detector Calibration

"$\gamma \rightarrow FADC_{i=1,440}$"




Cumulative Fluorescence Detector Efficiency
"UV_term.dat"
"SC_term.dat"
"MIRROR_term.dat"
"PMT_term.dat"
"SUM_term.dat"
April 2002
Transmission (Reflection) efficiency
w/ "DIRT, AGING"
Wavelength (nm)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
280
300
320
340
360
380
400
420
440

The "next" 5%:

(1) Calibrated and characterized drum illuminator(s)

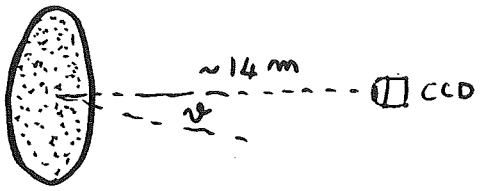
(2) Better characterized and calibrated (roving) laser ⊕ simultaneous atmospheric monitoring

(3) Tuned ray tracing programs:
   i) match drum illuminator signals
   ii) " diffuse laser "δ" signals
   iii) " fiber "A" signals

   ⊕ data base of transmission/reflection VS λ for all (new) telescope components

(4) Stable camera response ⊕ time dependent PE's/FADC|$_{i\text{-all channels}}$

* **STARTING POINT:**
DRUM CCD PICTURES AT DIFFERENT ϑ (J. Batch)
Rich



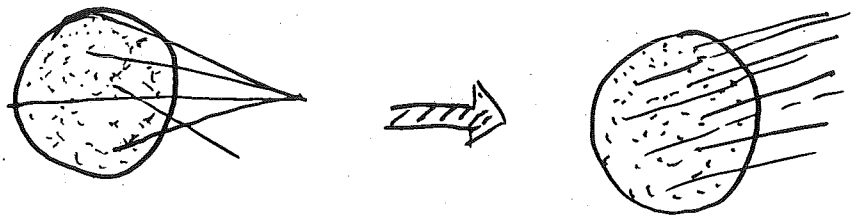
* **FROM CCD PICTURE TO DRUM AT THE APERTURE**
CCD PIXEL $\longrightarrow$ $d\varphi_x\ d\varphi_y$

ϑ, CCD TO DRUM DISTANCE, DRUM RADIUS ARE KNOWN
MINIMIZE TO FIND $d\varphi_x\ d\varphi_y$

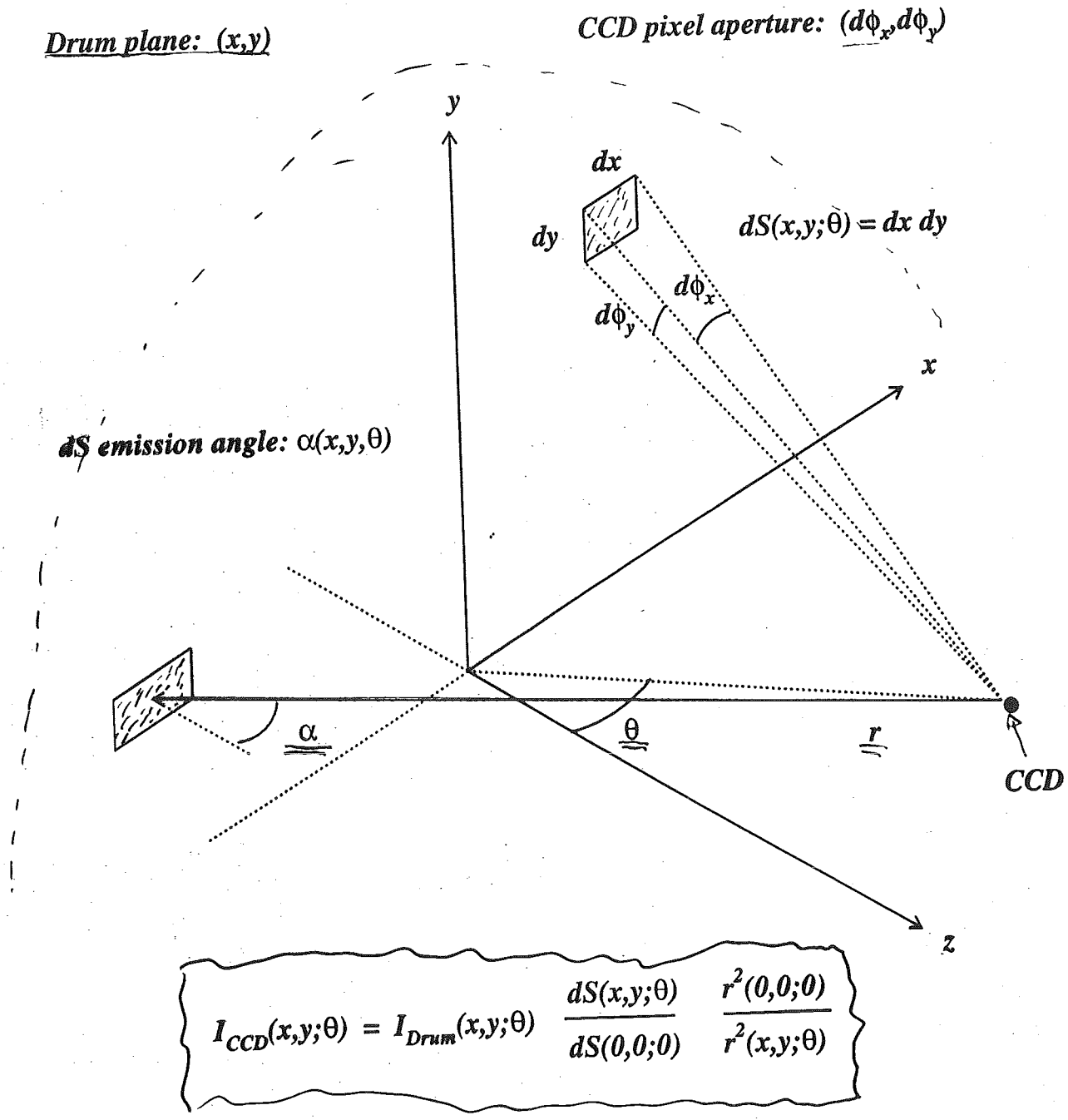
$\Rightarrow$ R_{DRUM} CORRECTLY RECOVERED WITHIN 1 cm

* **PIXEL INTENSITY MUST BE CORRECTED FOR THE SOLID ANGLE**
$\longrightarrow I(x,y)$

* **FROM DRUM IMAGES TO $I_{DRUM}(\vartheta)$**

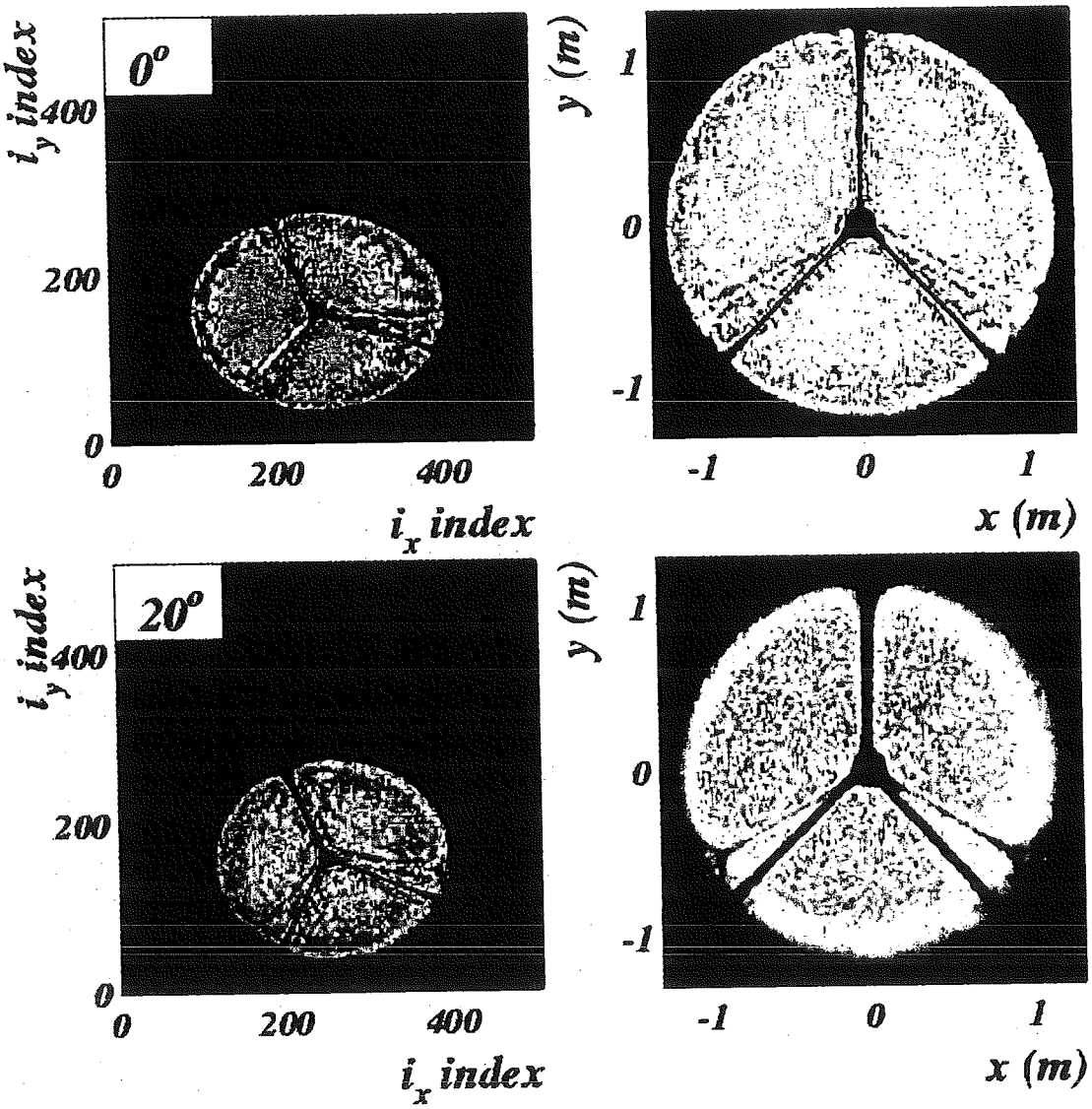


Paolo Privitera
et al



$$I_{CCD}(x,y;\theta) = I_{Drum}(x,y;\theta) \frac{dS(x,y;\theta)}{dS(0,0;0)} \frac{r^2(0,0;0)}{r^2(x,y;\theta)}$$

CCD Drum images



✳ FROM APERTURE TO PIXEL

- CAMERA SHADOW — OK
- CORRECTOR RING — IN PROGRESS
- MIRROR — IN PROGRESS
- MERCEDES — IN PROGRESS
- PMT ε VS RAY ANGLE — IN PROGRESS

} RAY TRACING

⇒ PREDICTION OF PIXEL SIGNAL

✳ COMPARISON OF DRUM DATA AND SIMULATION

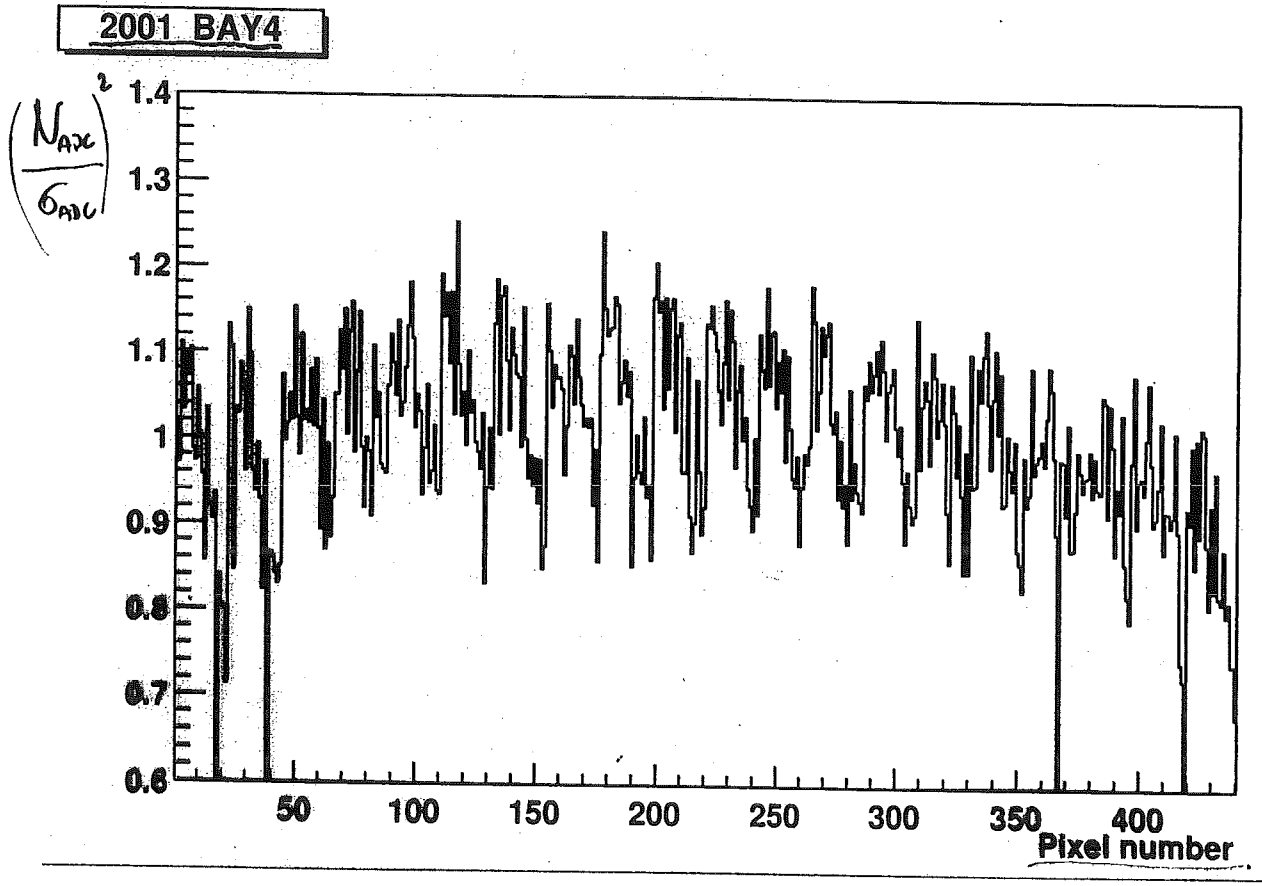
$$\left(\frac{N_{ADC}}{\sigma_{ADC}}\right)^2 \sim \frac{(1+V_G)}{P_{MT}} n_\gamma$$

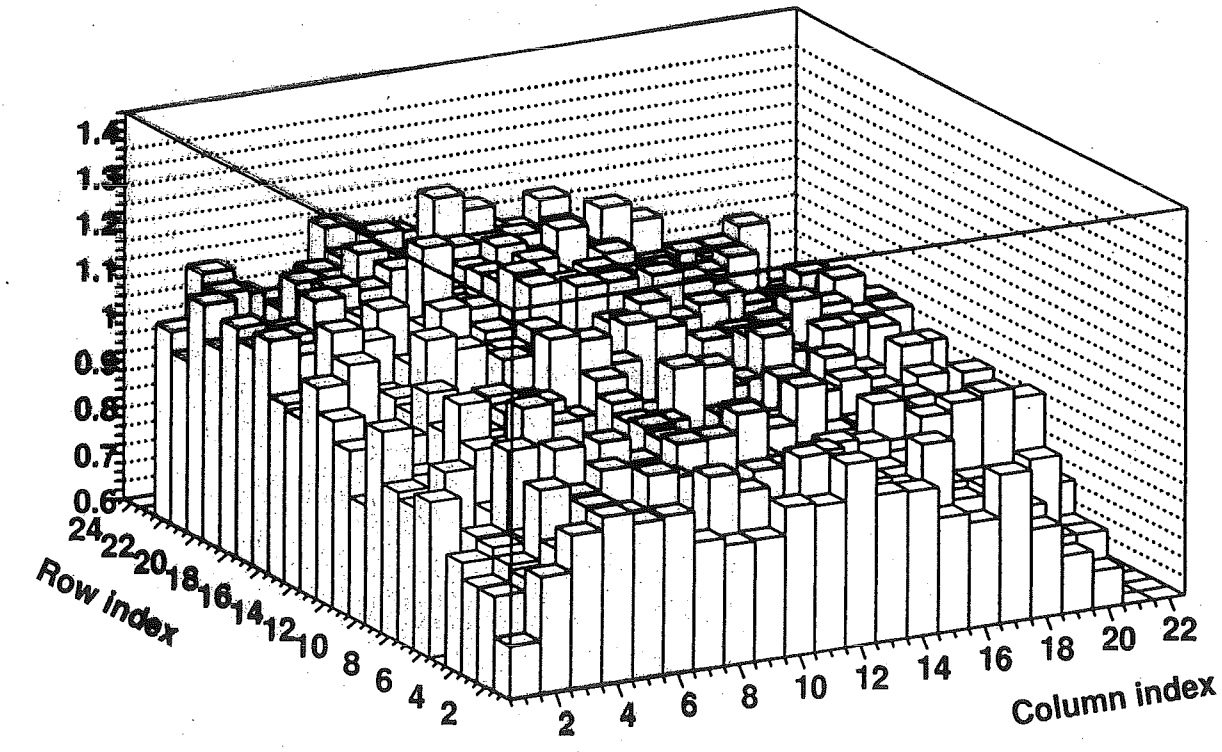
BAY 4: LEFT - RIGHT ASYMMETRY — QUALITATIVE AGREEMENT
UP - DOWN ..

BAY 5: ~ FLAT

✳ NOTE: FROM PMT TEST BOX MEASUREMENTS

$$\sigma^2 \sim (1+V_G)\, G \cdot S$$


2001 BAY4
$\left(\frac{N_{AX}}{\sigma_{ADC}}\right)^2$
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
50
100
150
200
250
300
350
400
Pixel number


1.4
1.1
1
0.8
0.7
0.6
24
22
20
18
16
14
12
10
8
6
4
2
Row index
2
4
6
8
10
12
14
16
18
20
22
Column index