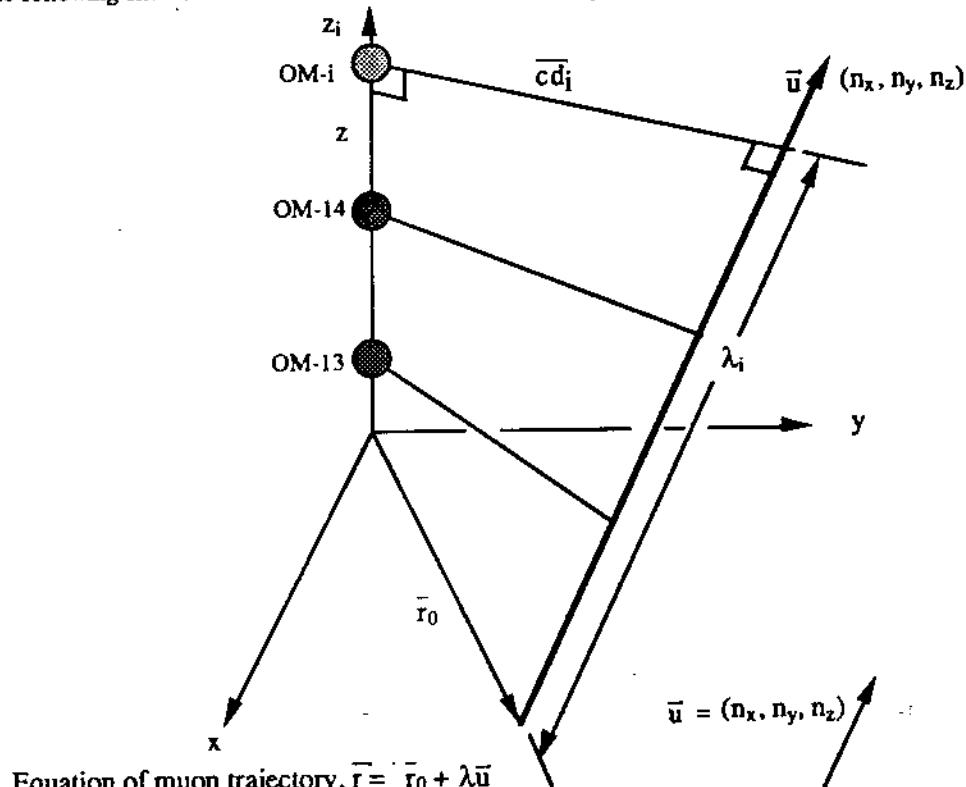


**A Gallery of Muon Trajectories and Their Cerenkov Arrival Times
at the Optical Modules of DUMAND II**

The following sketch and formulae describe the central string (#0) of Optical Modules (OM-1 to 24).

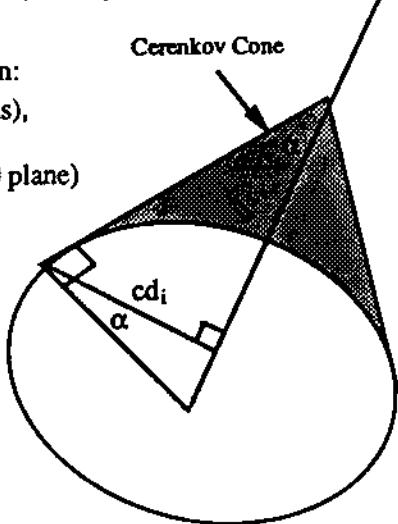


Arrival time of Cerenkov photon:
 $t_i = [\lambda_i + \underline{cd}_i \cot \alpha]/c = 0.3 \text{ m/ns}$,
 where, $\sin \alpha = (1/n = 3/4)$,
 (t is 0 when the muon crosses the $z = 0$ plane)

$$\lambda_i = n_z [(z_i - l_0(i - i_0)) - n_x x_0 - n_y y_0],$$

$$(\underline{cd}_i)^2 = r_0^2 + z_i^2 - \lambda_i^2$$

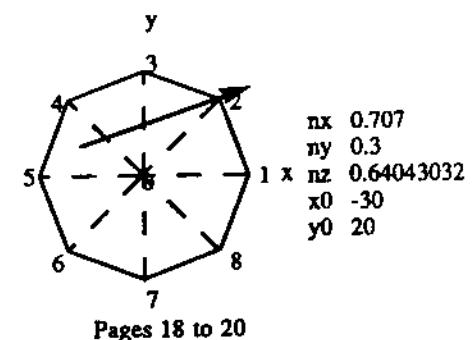
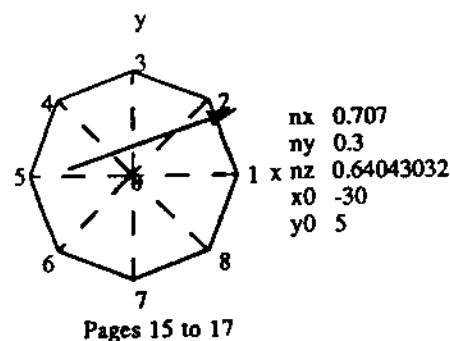
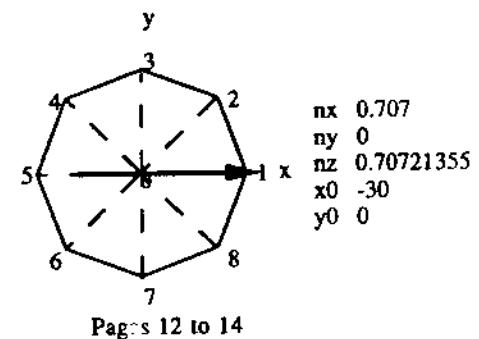
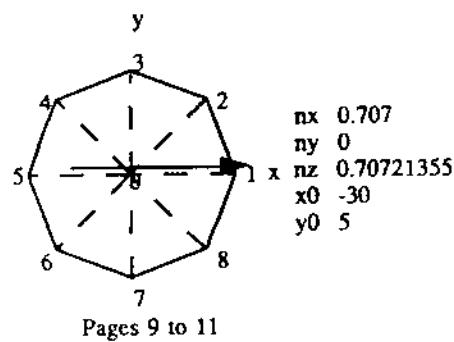
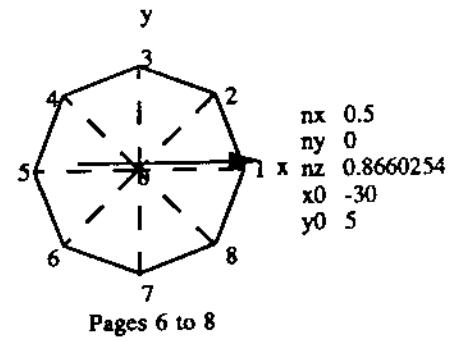
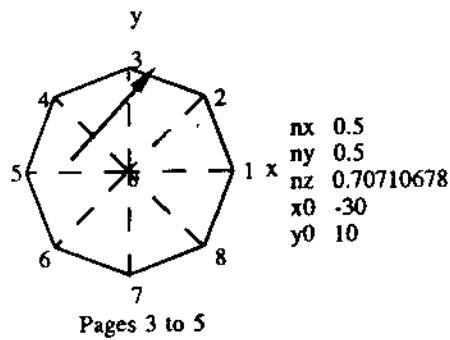
where, $i_0 = 12.5$, and $l_0 = 10 \text{ meters}$



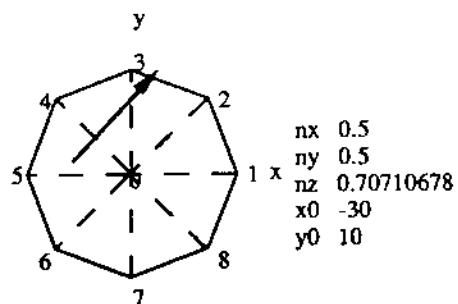
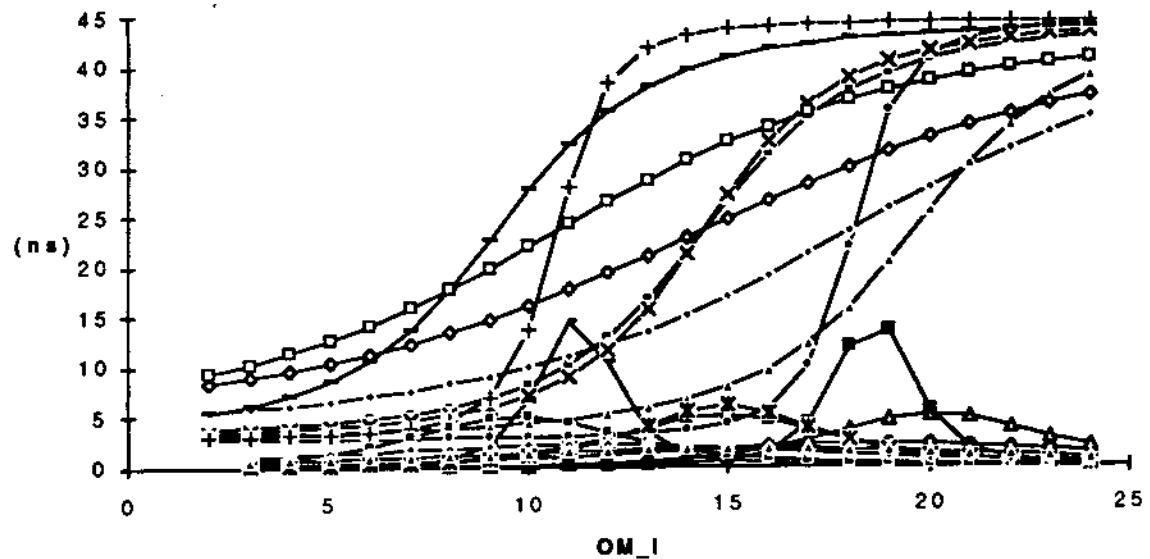
Each trajectory has 3 pages of graphs that show the times and their first, second and third derivatives. The ordinate is measured in nanoseconds(ns), and the abscissa is the optical module number. Also shown is the closest distance of approach, $\underline{cd}_{ij}(m)$ and # of PE's, for OM-i on string-j. The Cerenkov path length is $\underline{cd}_{ij}(m)(\sec \alpha=1.51)$. The position of string-j is specified by the vector, \vec{s}_0 , in the $z = 0$ plane of length, $s_0 = 20 \text{ m}/\sin(\pi/8) = 52.3 \text{ m}$.

$$t_{ij} = [\lambda_{ij} + \underline{cd}_{ij} \cot \alpha]/c, \text{ where } \lambda_{ij} = n_z l_0(i - i_0) + [(\vec{s}_0 - \vec{r}_0) \cdot \vec{u}], \text{ and } (\underline{cd}_{ij})^2 = (\vec{s}_0 - \vec{r}_0)^2 + (z_i)^2 - (\lambda_{ij})^2$$

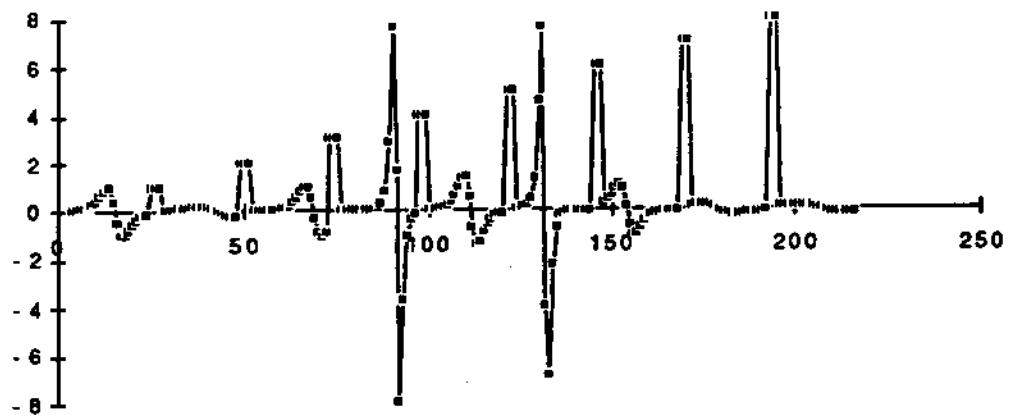
Summary of Muon Trajectories



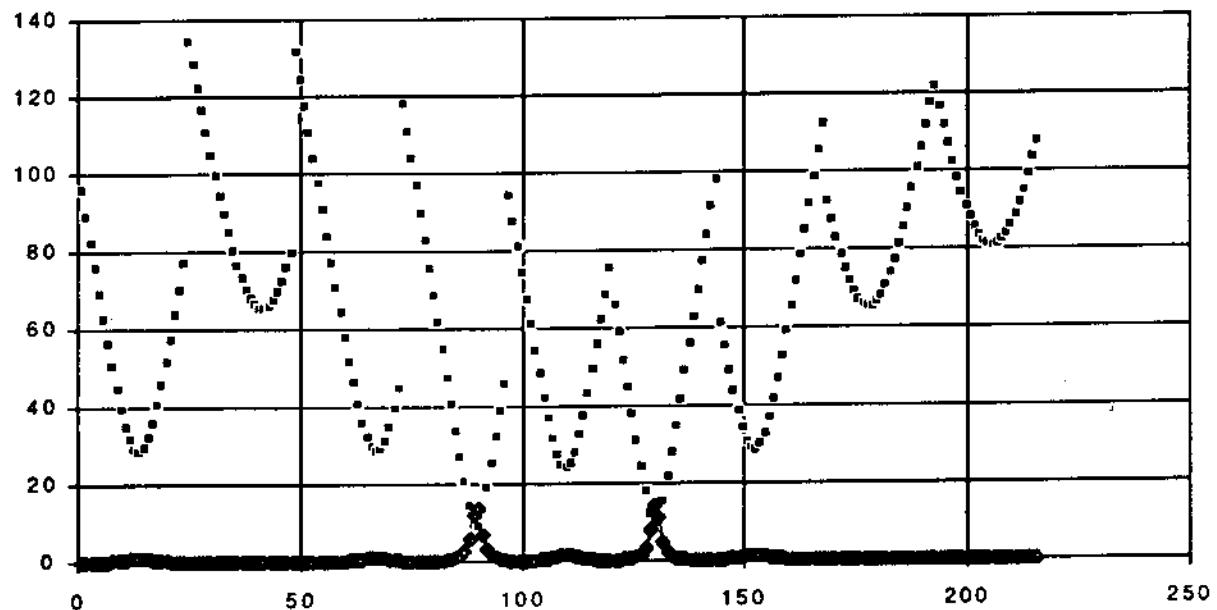
delt_ij and de/delt_ij of all strings_j overlayed vs OM_i



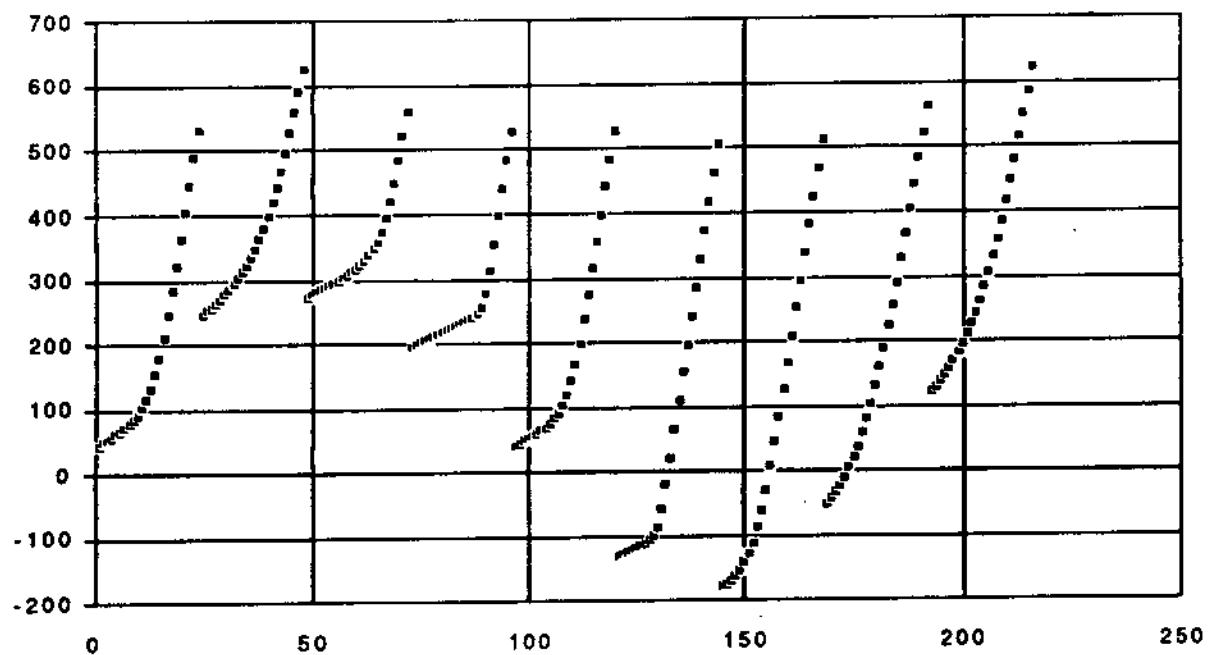
de/delt_ij



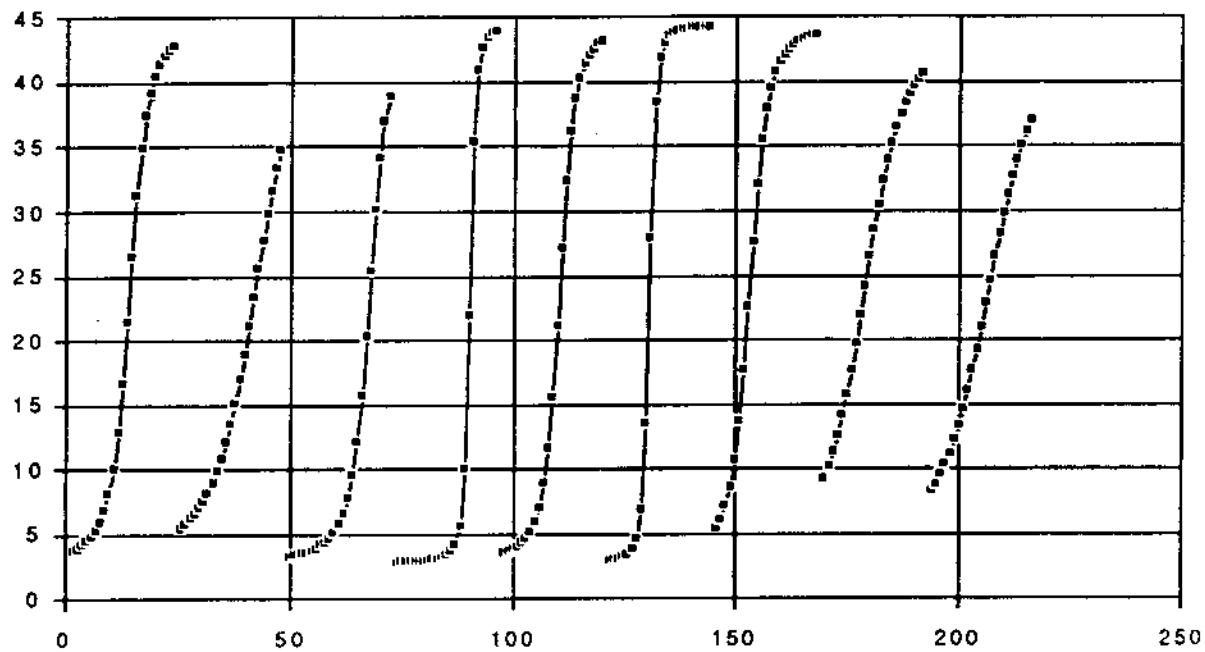
cd_ij(m) and Photoelectrons for Optical Module_i and String_j



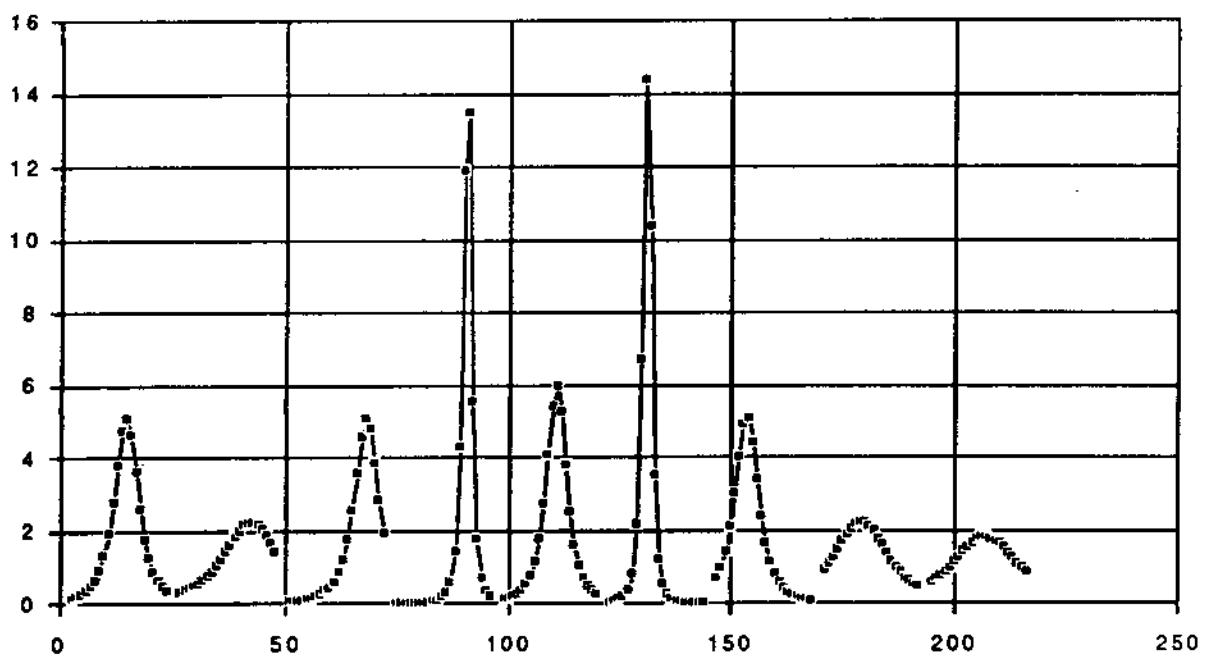
$t_{ij}(ns)$



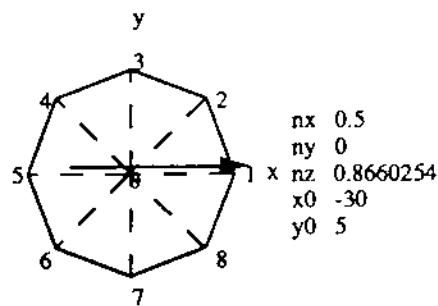
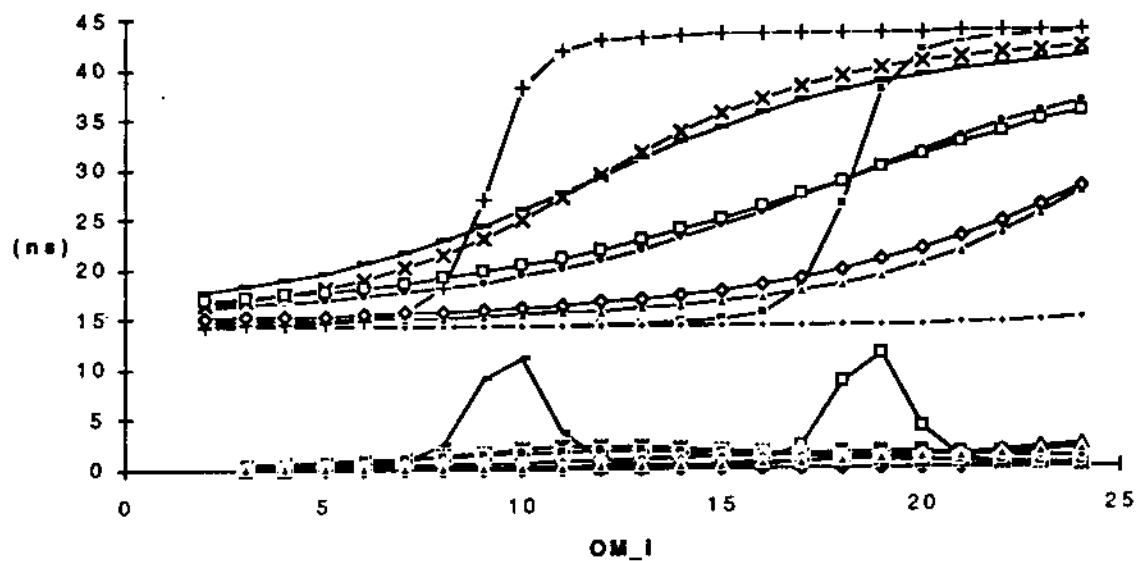
delt_ij



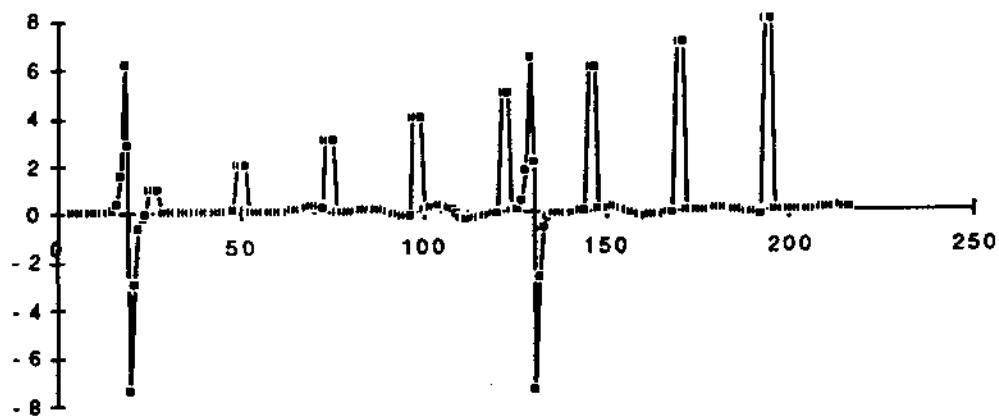
deldelt_ij



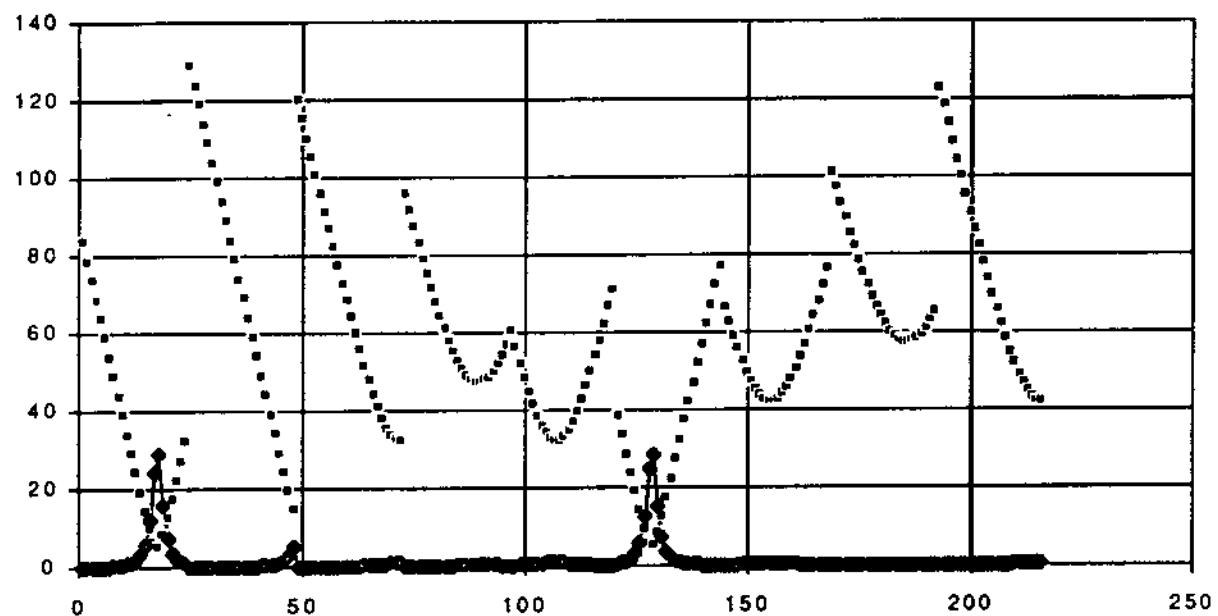
delt_ij and deldelt_ij of all strings_j overlayed vs OM_I



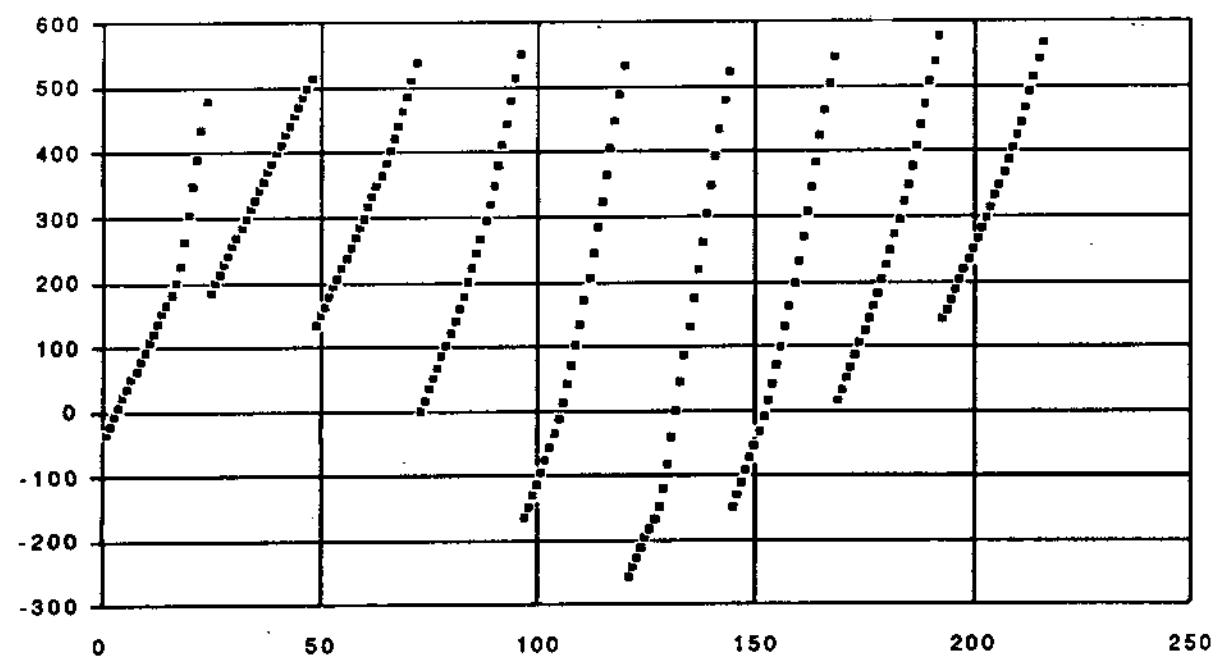
deldeldelt_ij



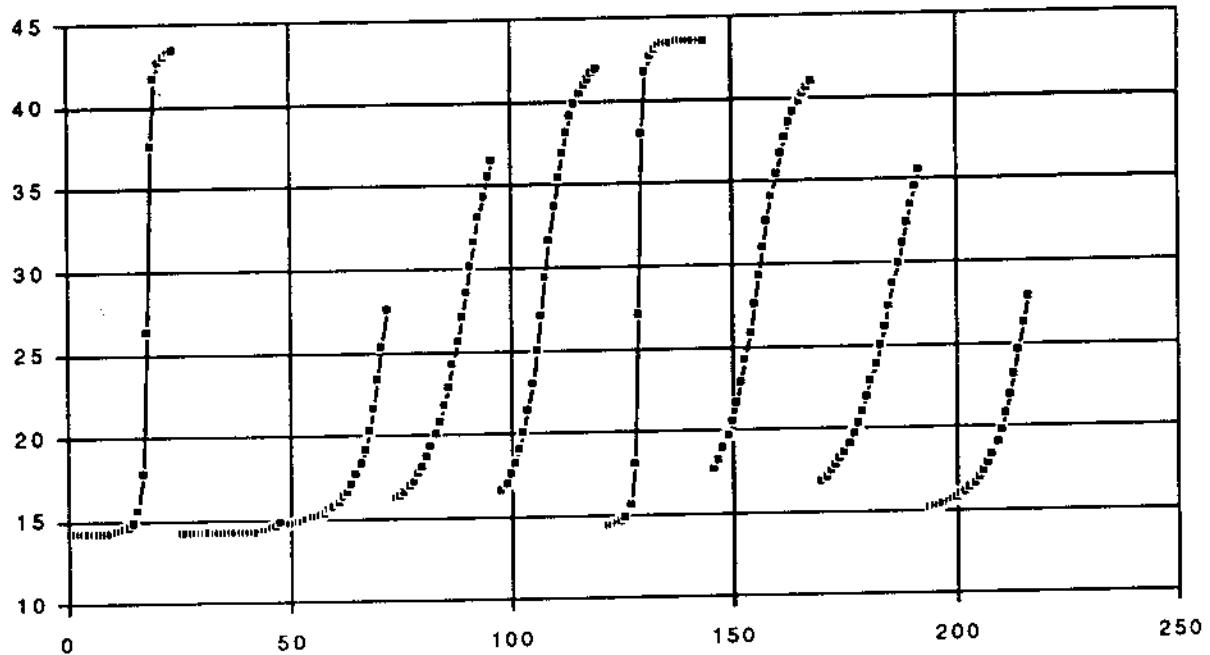
cd_ij(m) and Photoelectrons for Optical Module_i and String_j



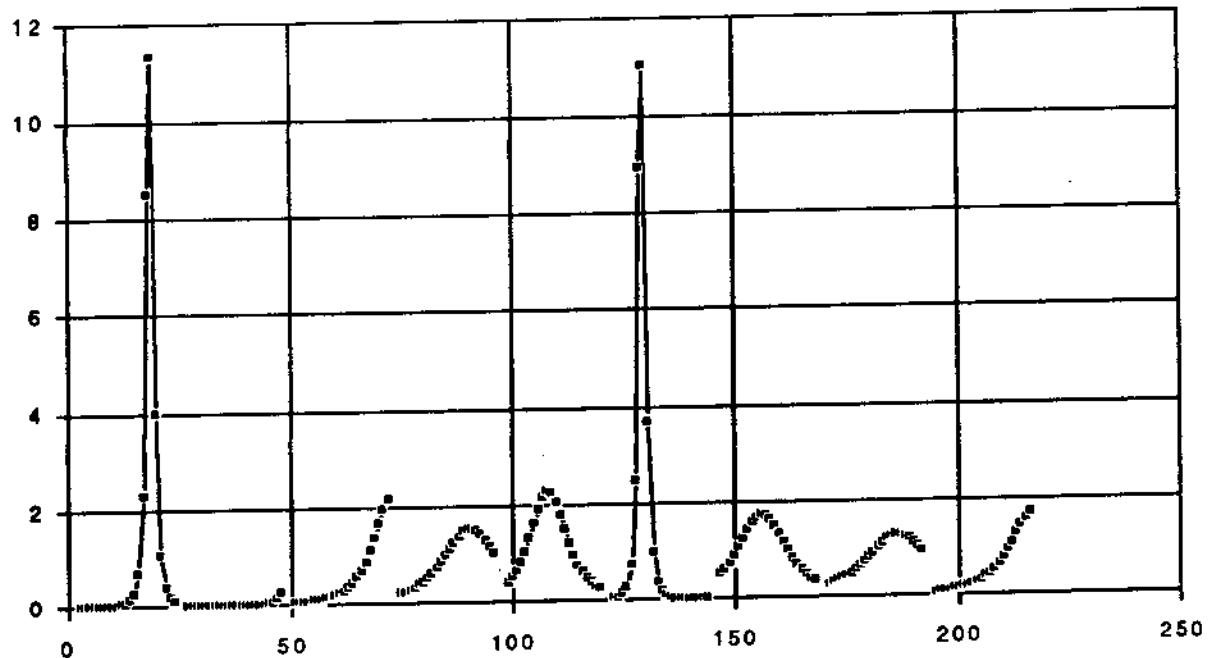
t_ij(ns)



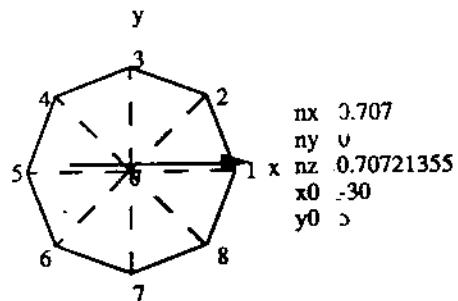
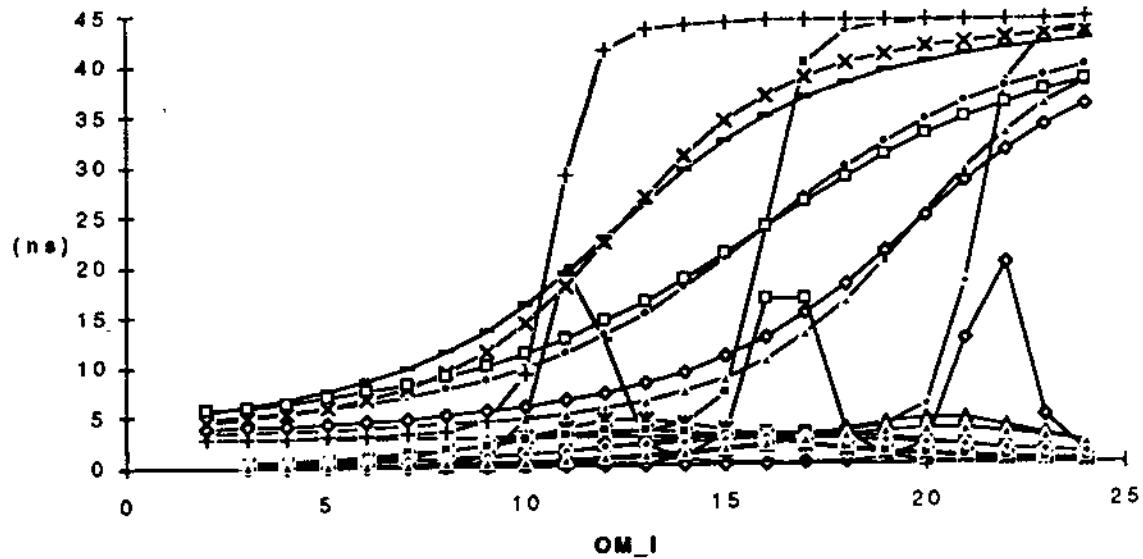
delt_ij



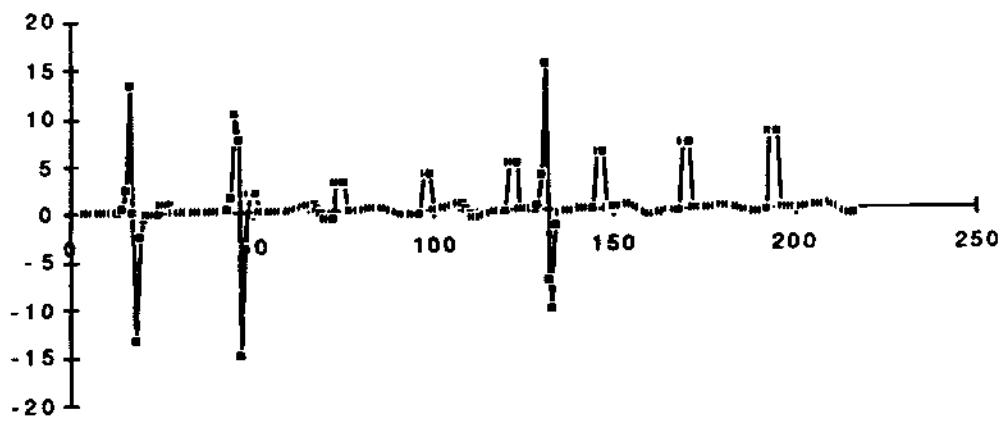
deldelt_ij



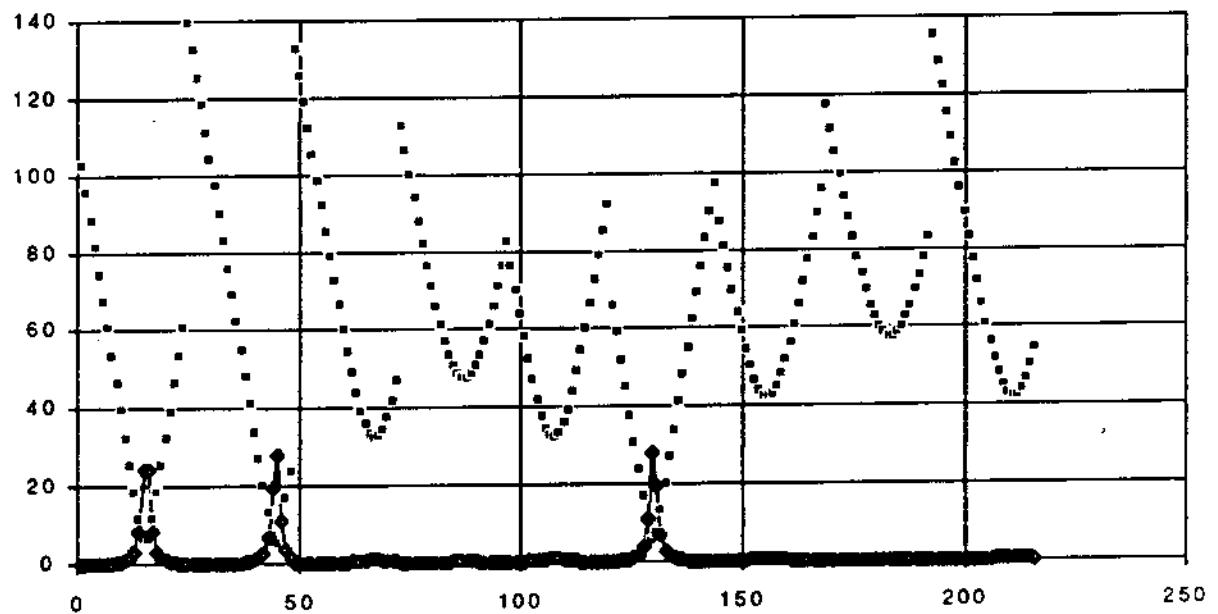
`delt_ij` and `deldelt_ij` of all `strings_ij` overlayed vs `OM_I`



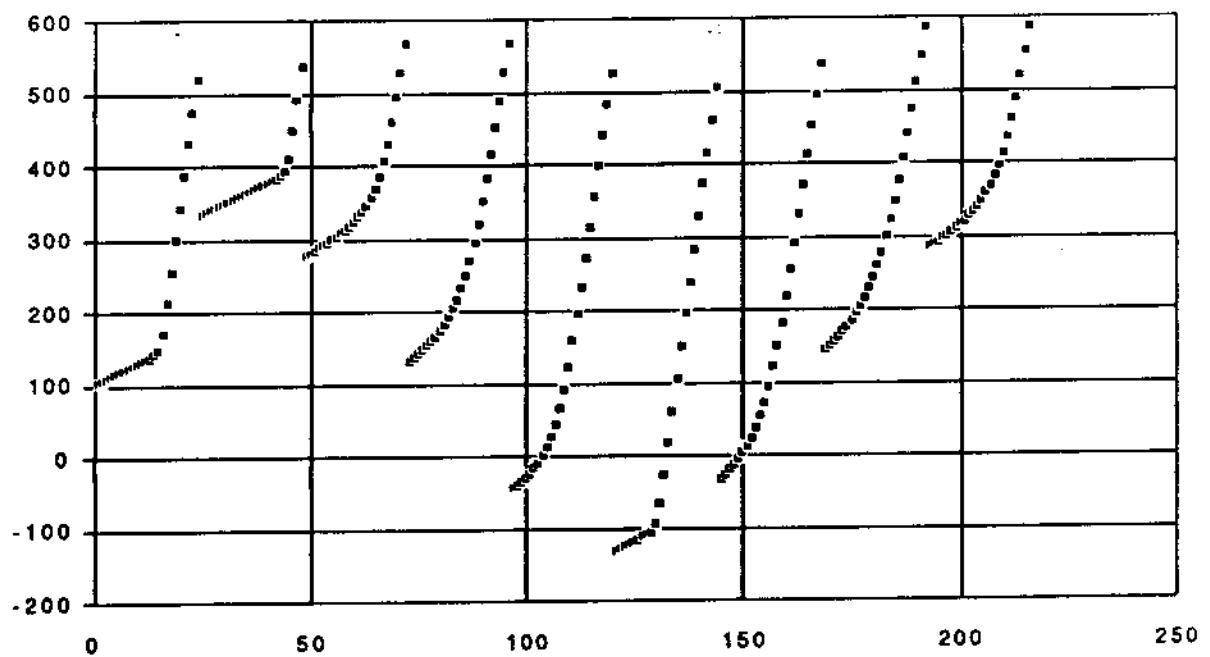
`deldelt_ij`



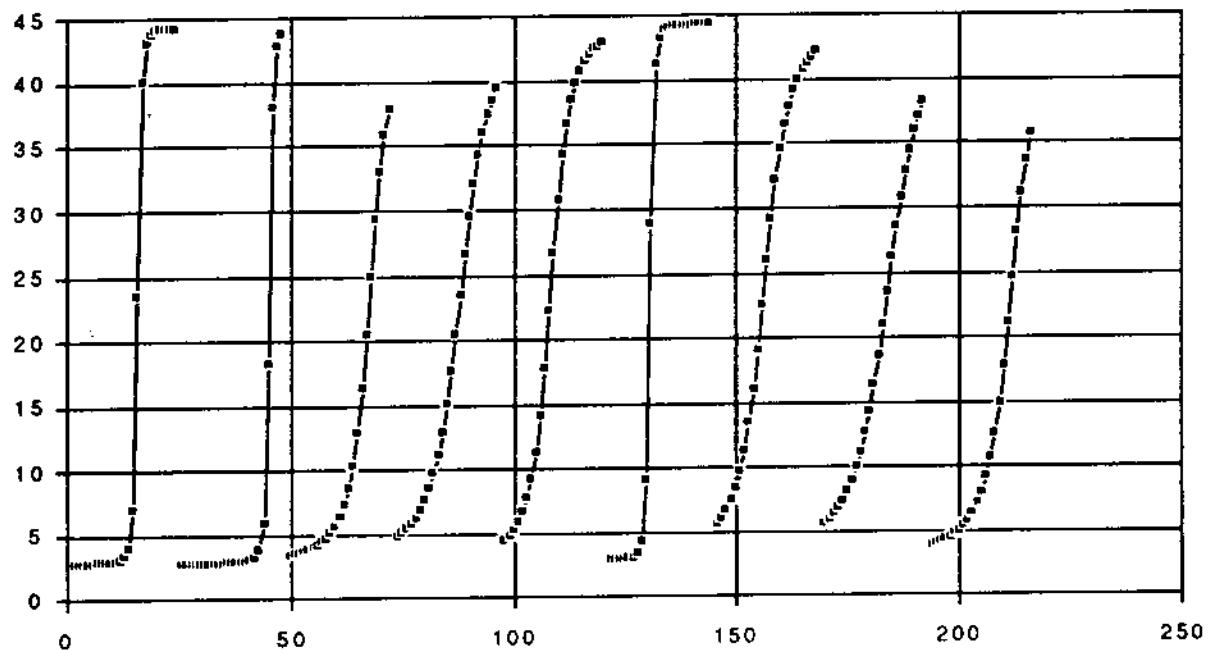
cd_ij(m) and Photoelectrons for Optical Module_i and String_j



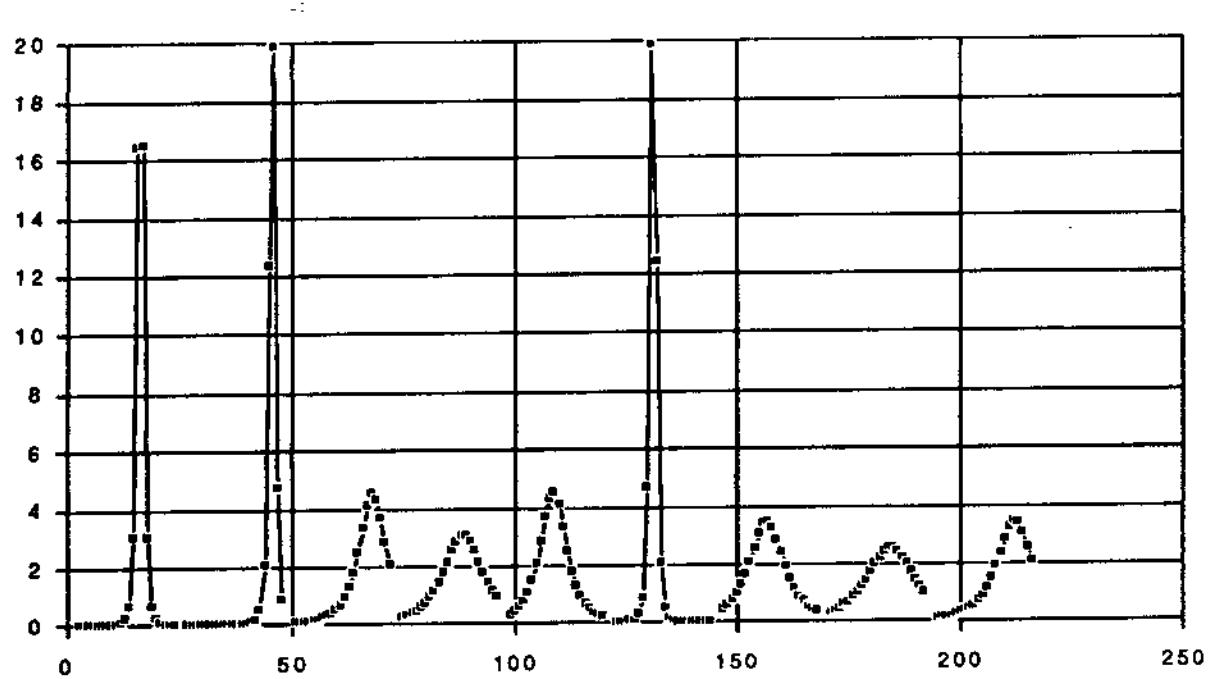
$t_{ij}(ns)$



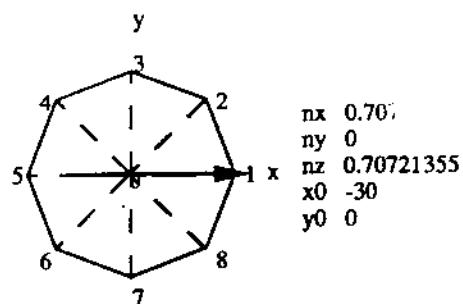
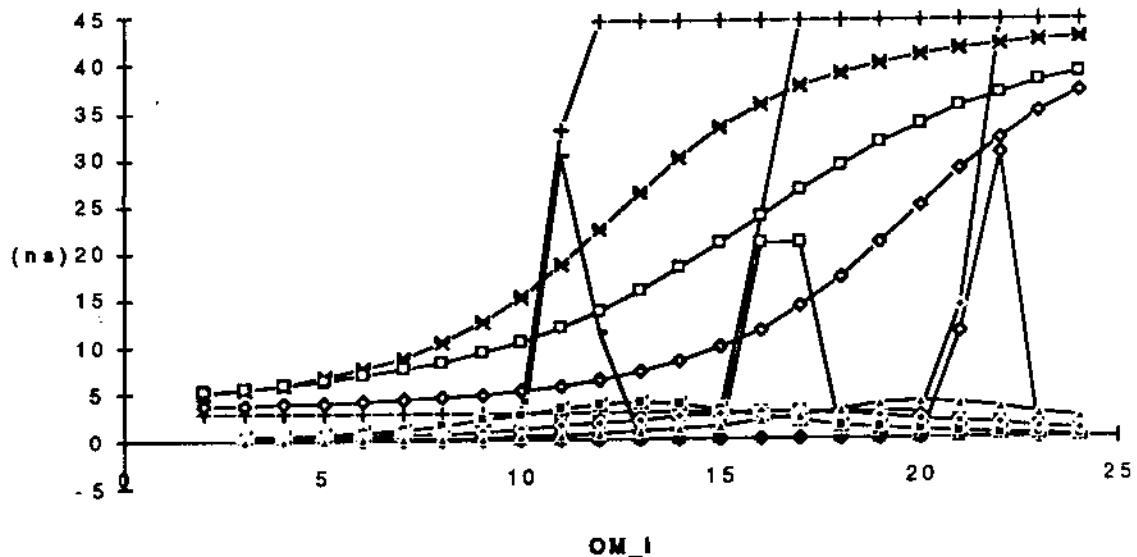
delt_ij



deldelt_ij



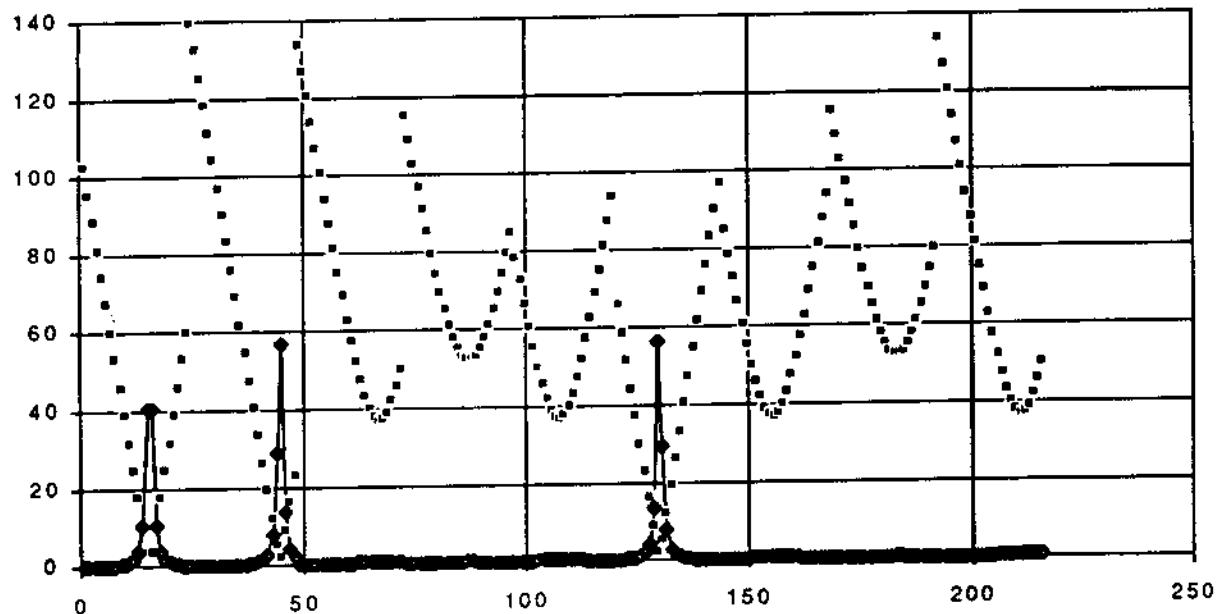
delt_ij and deldelt_ij of all strings_j overlayed vs OM_i



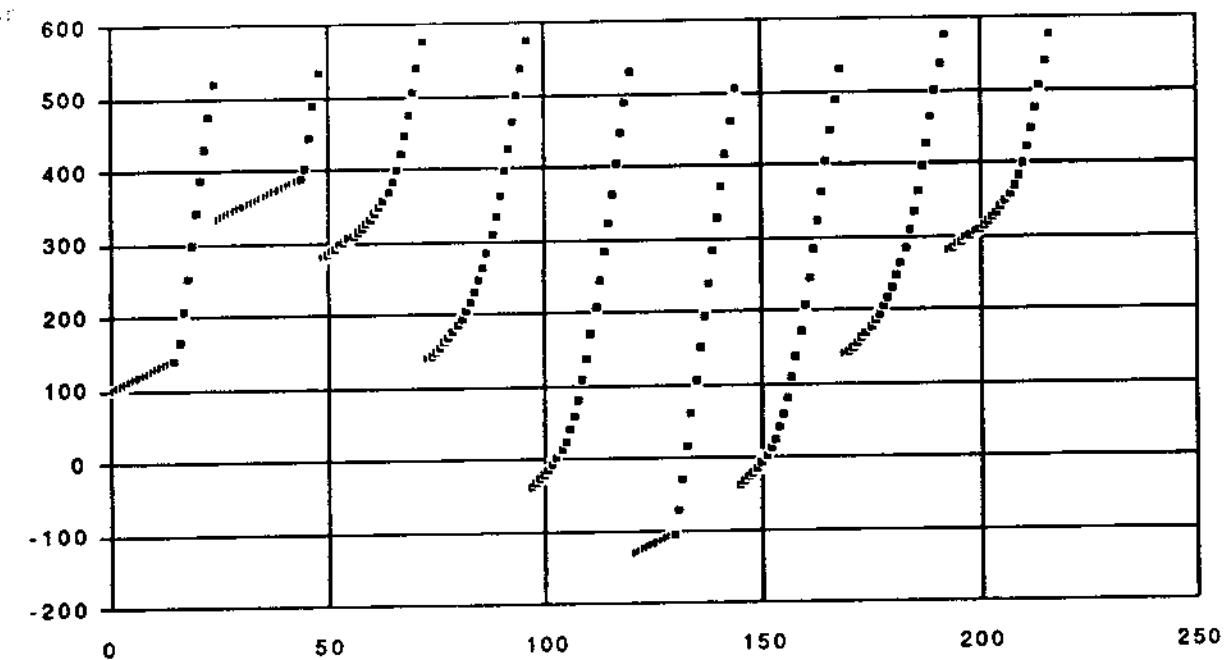
deldelt_ij



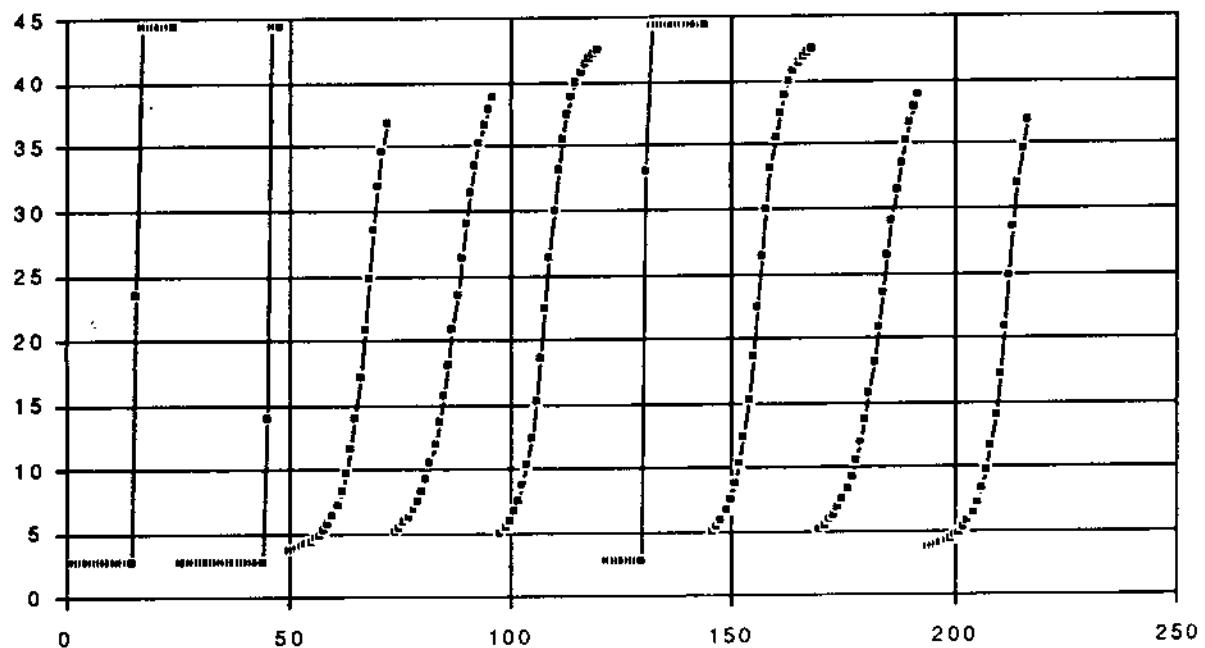
cd_ij(m) and Photoelectrons for Optical Module_i and String_j



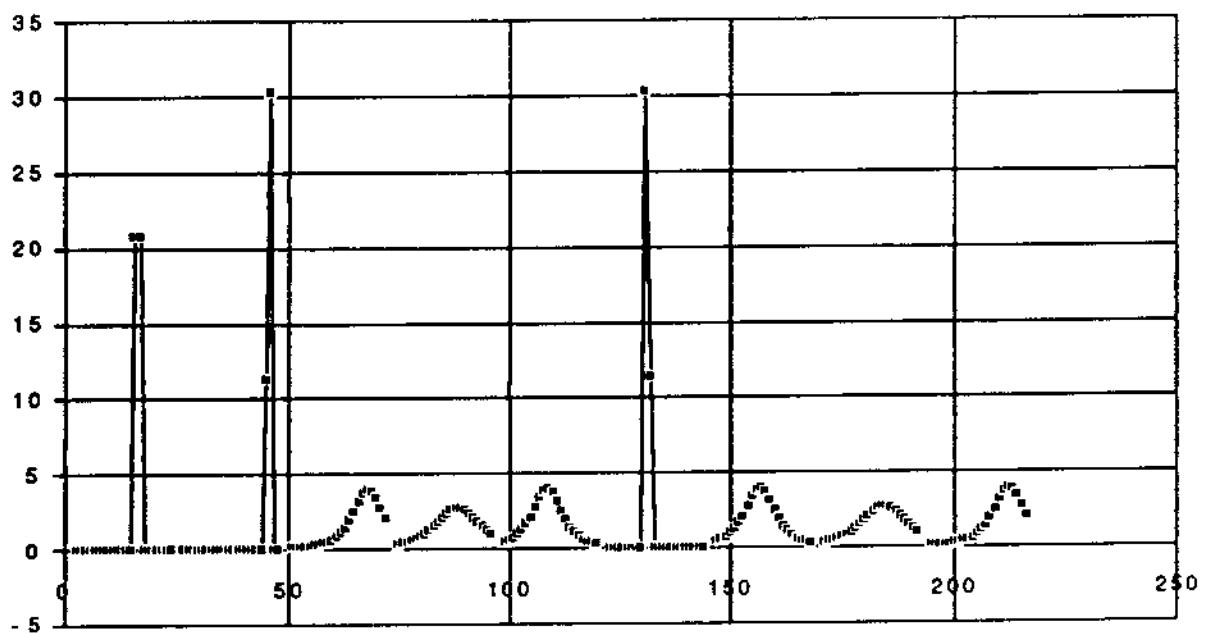
$t_{ij}(ns)$



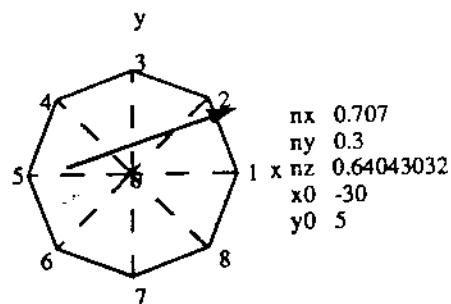
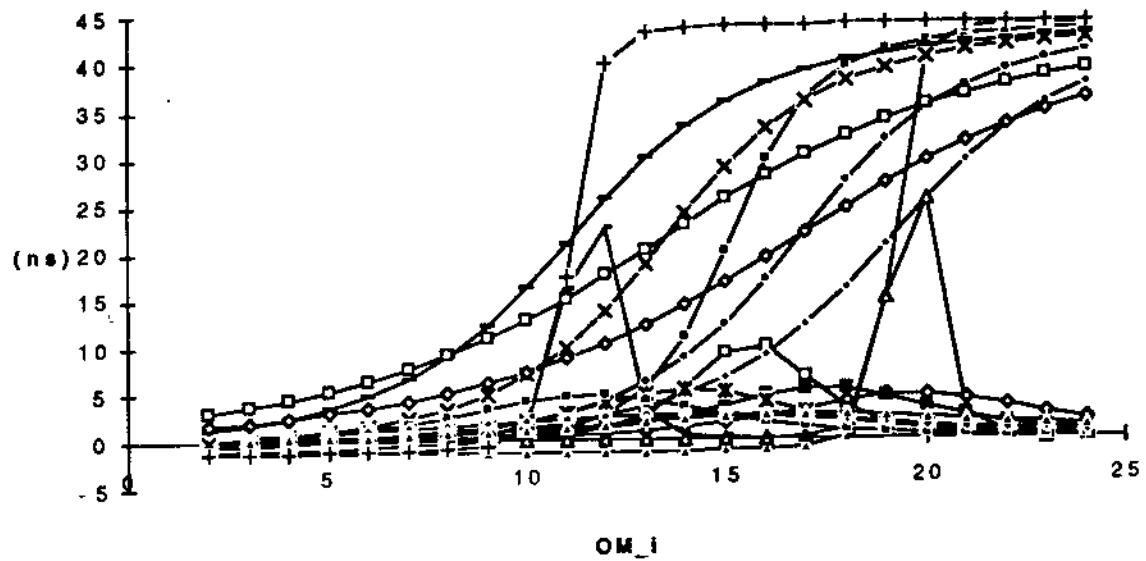
delt_ij



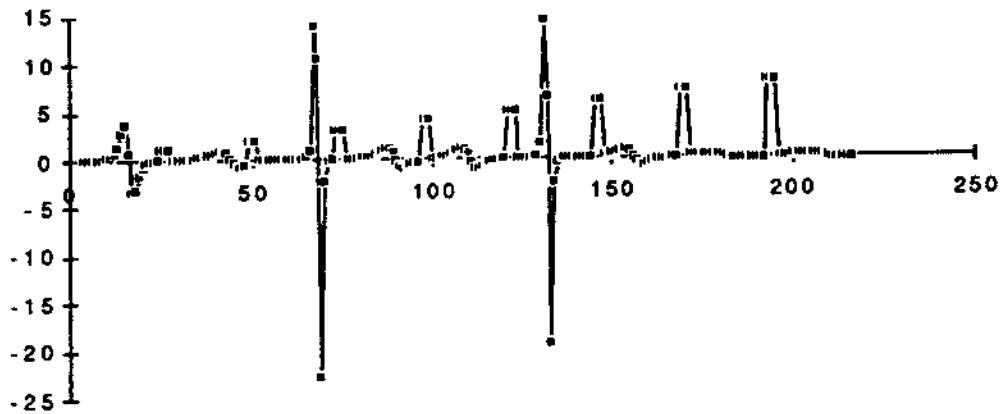
deidelt_ij



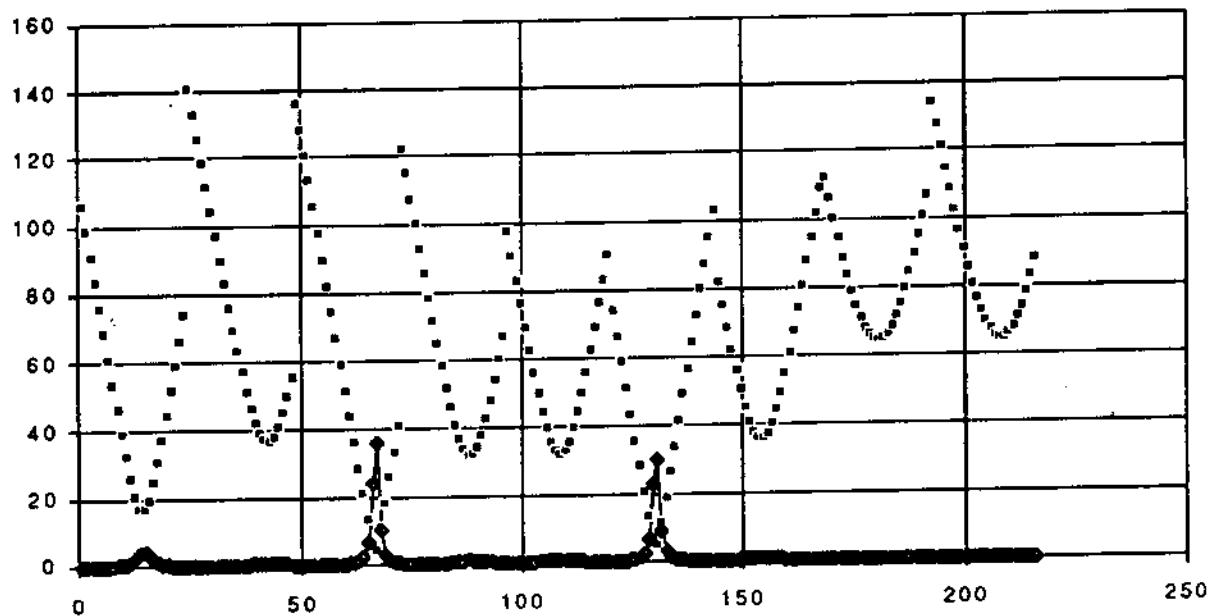
`delt_ij` and `deldelt_ij` of all strings_i overlayed vs OM_i



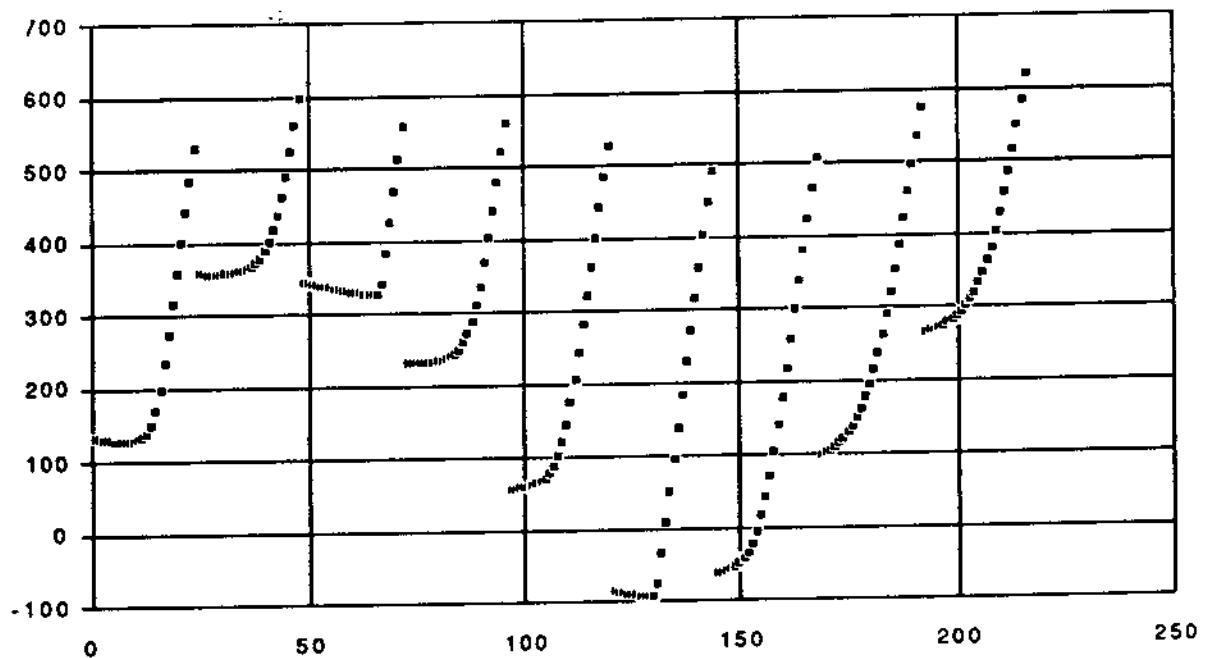
`deldeldelt_ij`



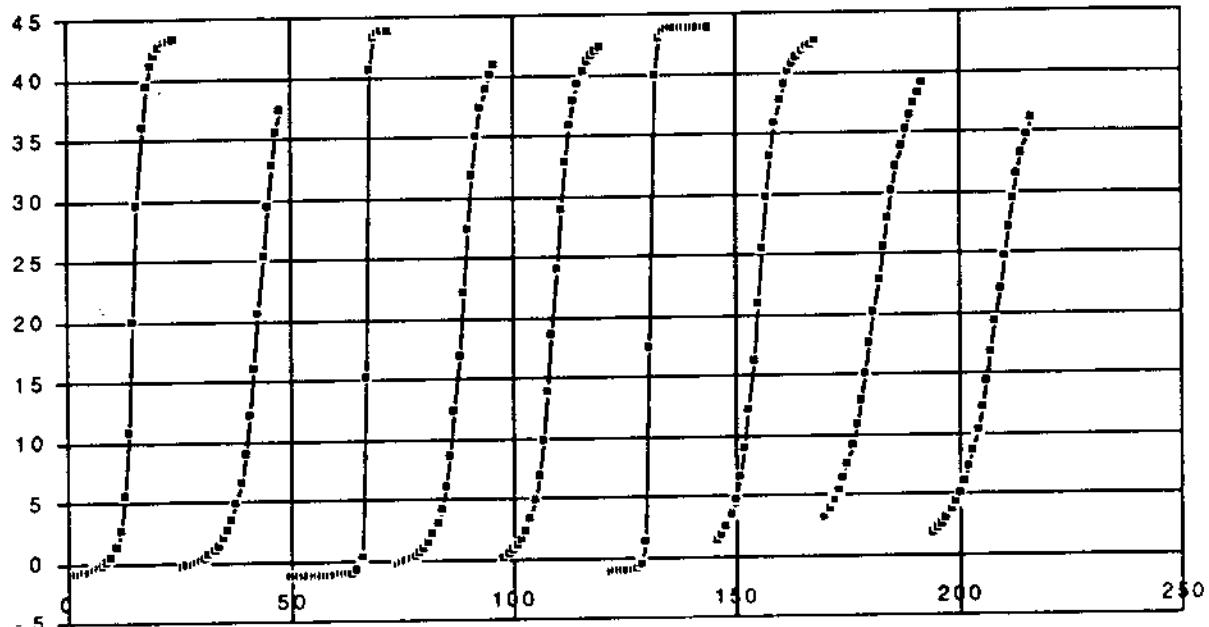
cd_ij(m) and Photoelectrons for Optical Module_i and String_j



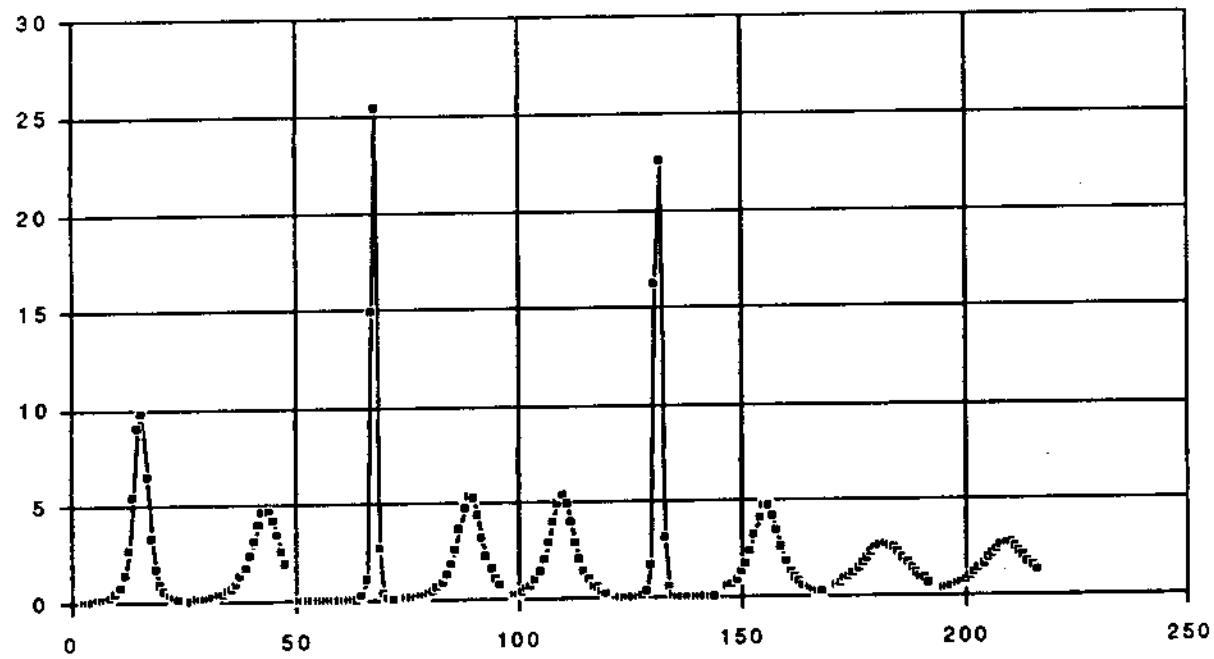
$t_{ij}(ns)$



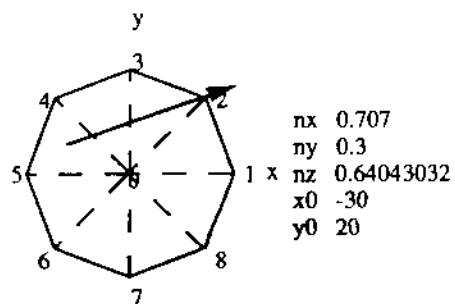
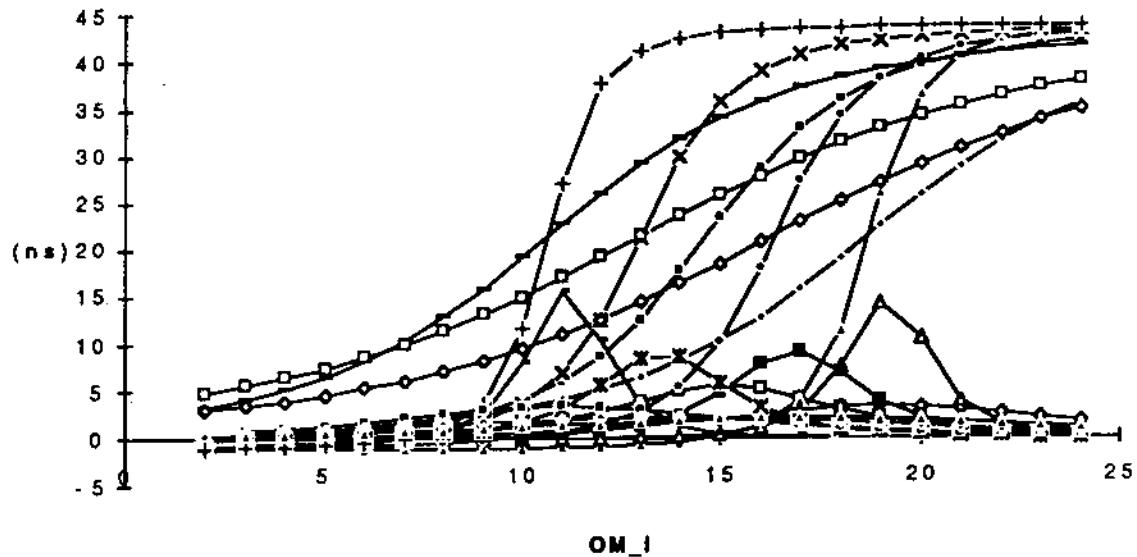
delt_ij



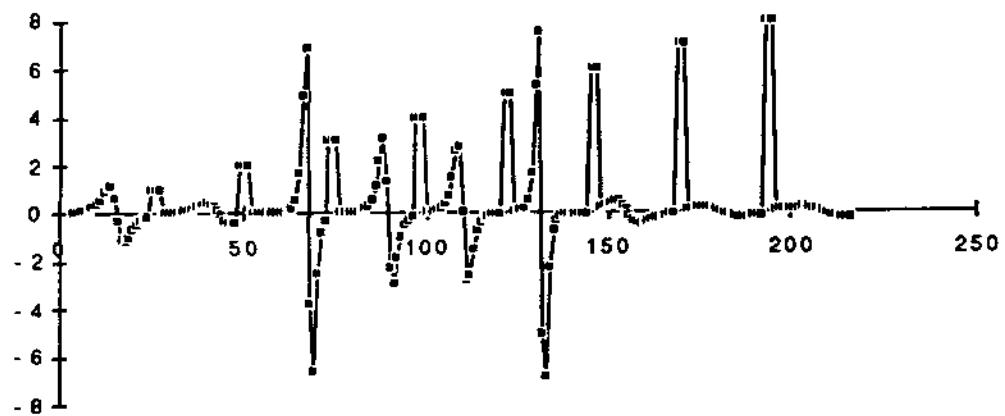
deldelt_ij



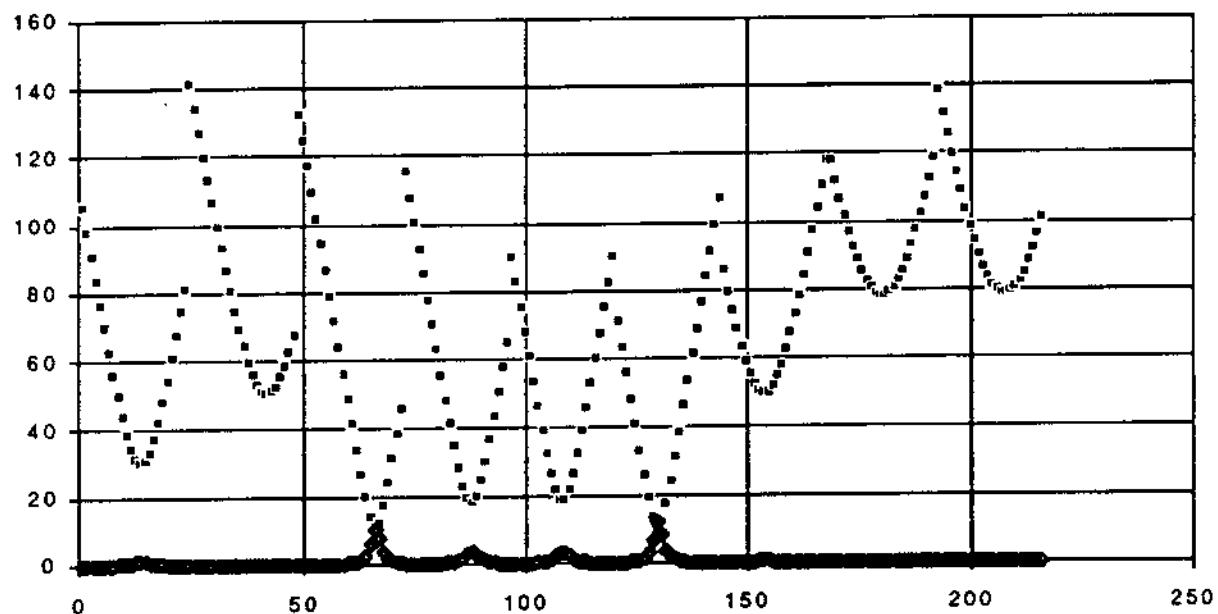
delt_ij and deldelt_ij of all strings_i overlayed vs OM_I



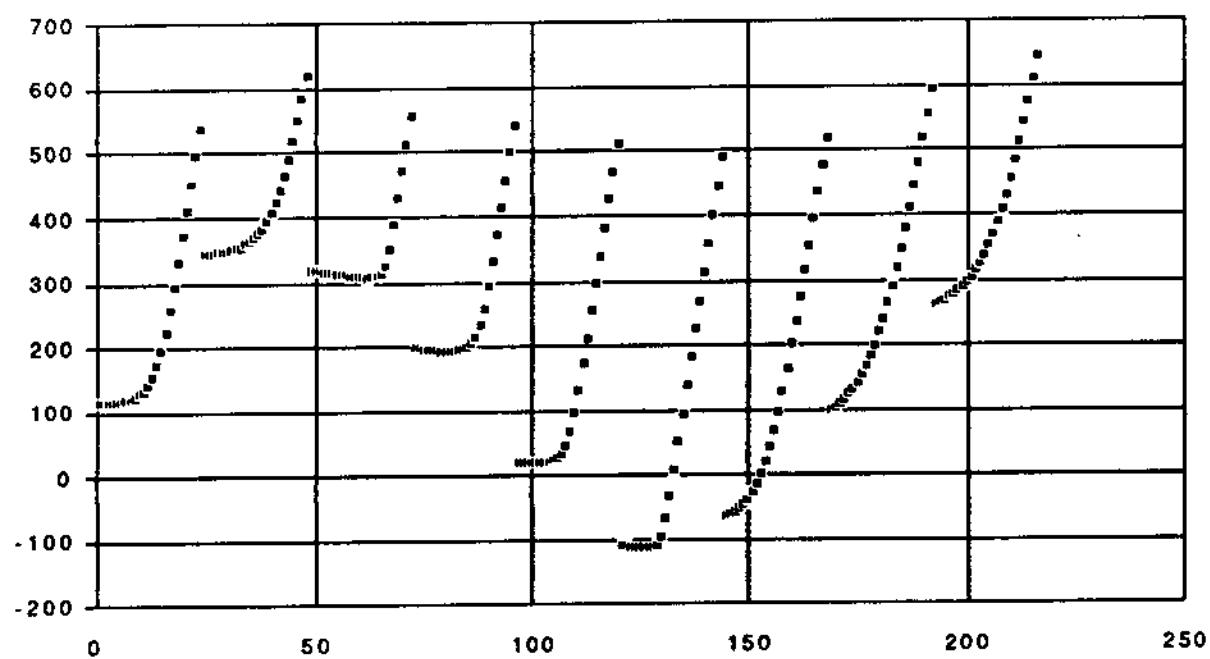
deldelt_ij



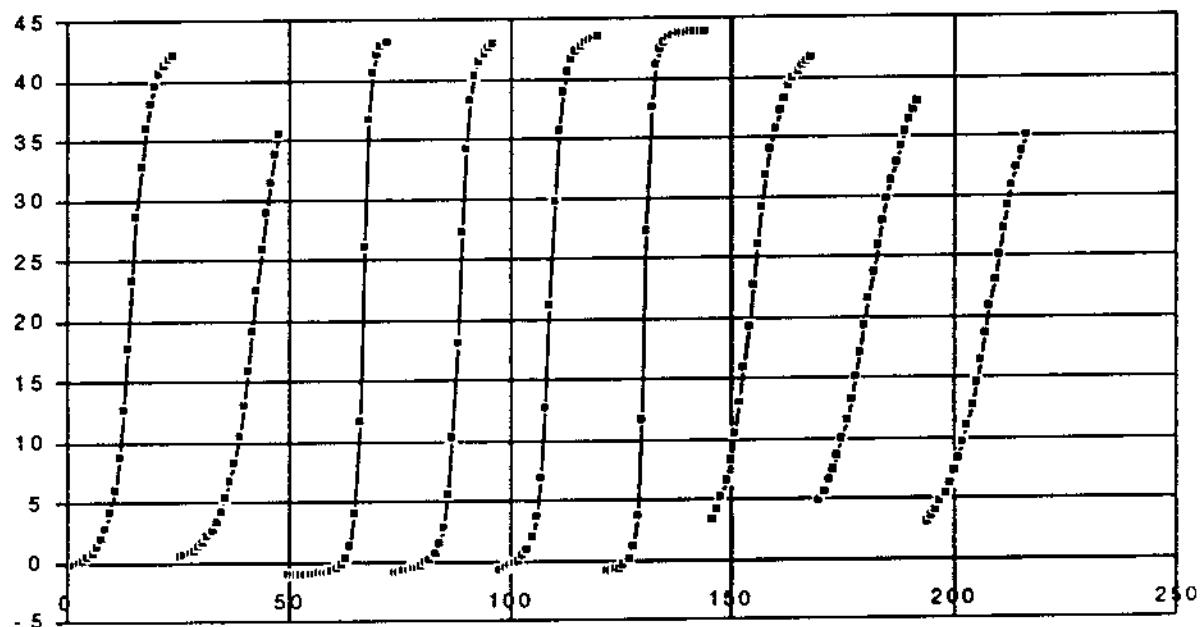
$cd_{ij}(m)$ and Photoelectrons for Optical Module_i and String_j



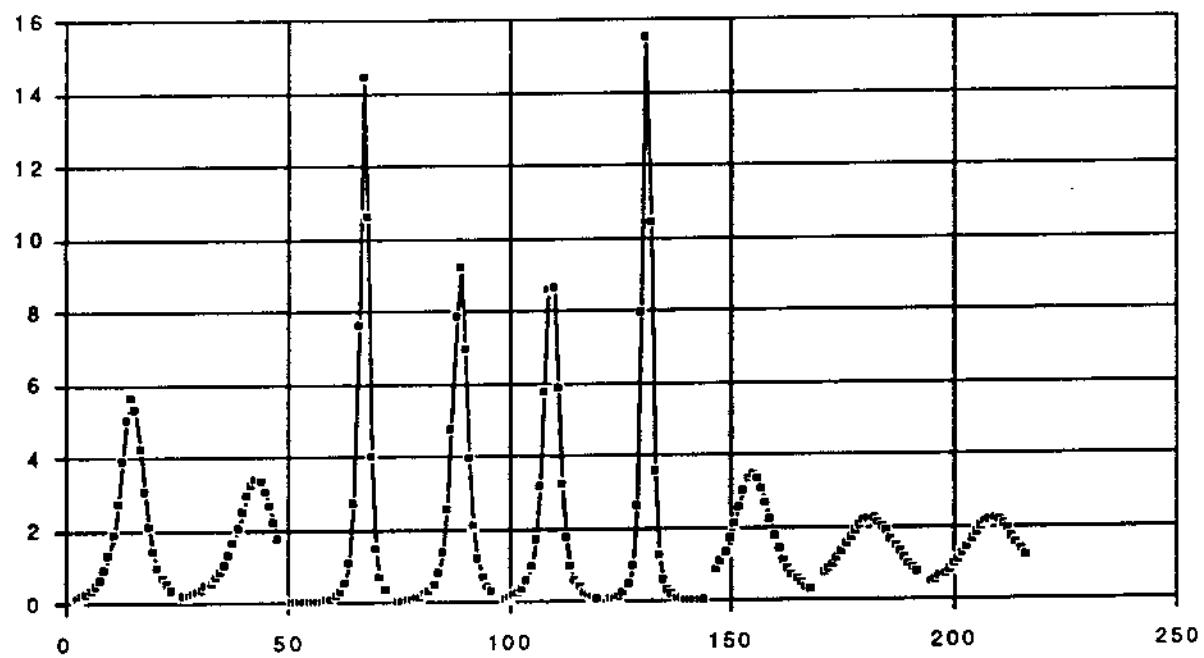
$t_{ij}(ns)$



delt_ij



deldelt_ij



Appendix

Fit of John Learned's "Attenuation of Cerenkov Photons in the Ocean", HDC 81-10 4/81

I fit the dashed curve of his fig. 4, labelled "New calculation and fit with effects of glass and quantum efficiency", with a sum of three exponentials;

$$PE/m^2(d) = 3981 \cdot e^{-d} / 4.444 + 251 \cdot \exp^{-d} / 14.44 + 53.7 \cdot \exp^{-d} / 25.64,$$

where d is the perpendicular distance (or closest distance of approach) in meters. The open squares of the following Fig.A is my fit to his. There is almost complete overlap.

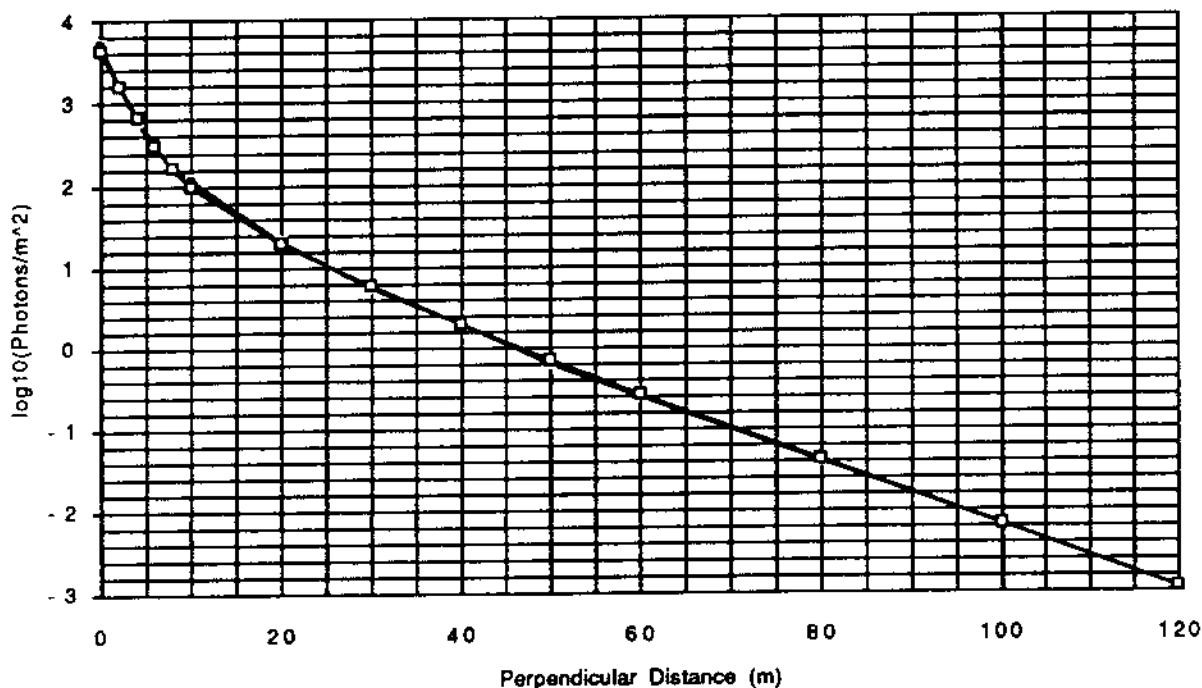


Fig.A

For 14" phototubes (area = 0.0993 m²), my fit of the number of photons as a function of the perpendicular distance is the lower curve in the following figure.

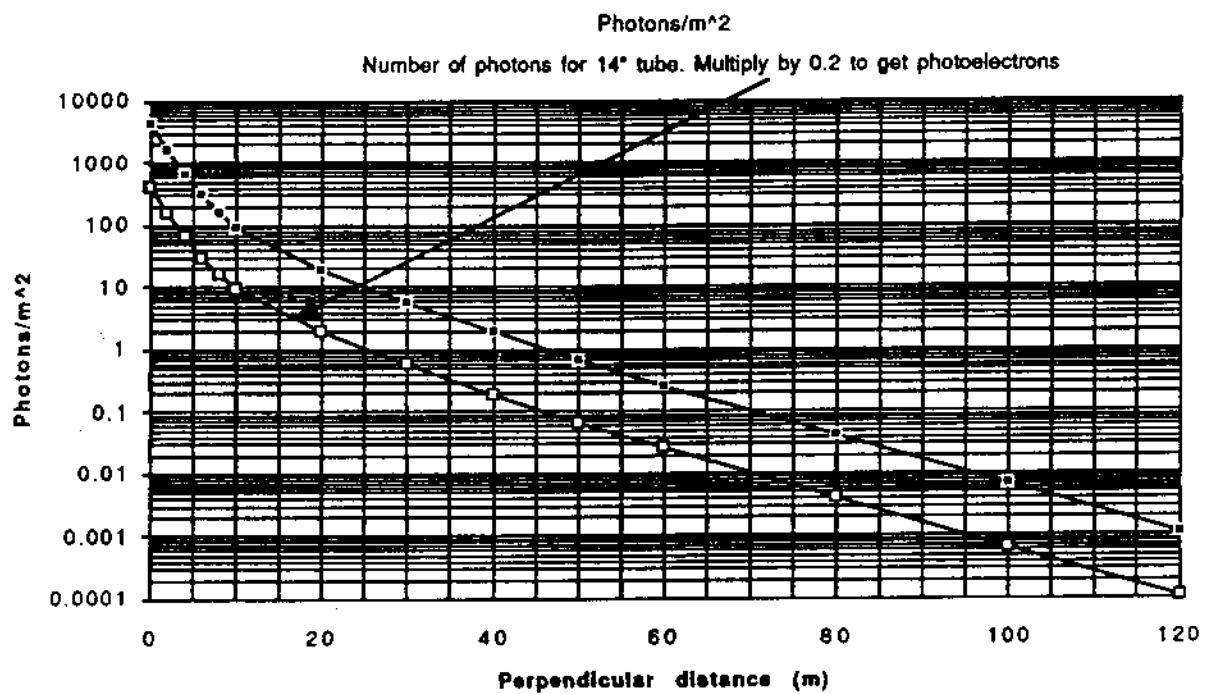


Fig.B