Optimal shape of the corrector ring
(Design – Summary)

Different methods = very similar solutions

Basic aspheric shape is described by three term equation

$$Z = A y^2 + B y^4 + C y^6$$

(source - Schmidt plate)

Proposed solutions :

I. Exact aspheric shape given by tree term equations.

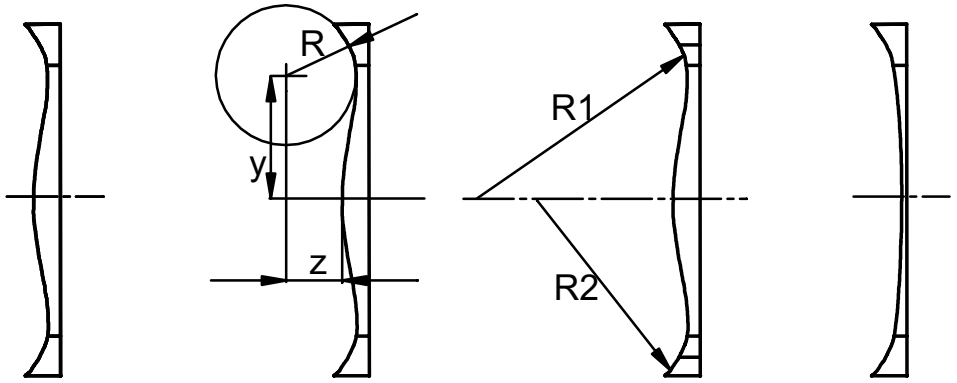
II. Approximation of outer part of solution I. (manufacturing reasons)

a) by off axis circle

b) by several on axis spheres (two)

III. NEW – Exact aspheric shape given by one term eguation only. (simplify math NOT manufacturing)

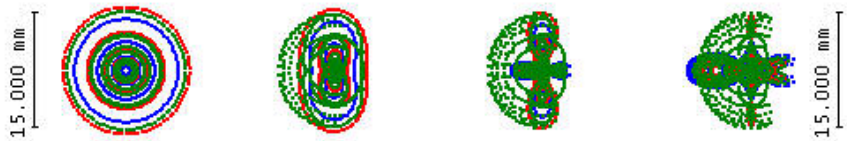
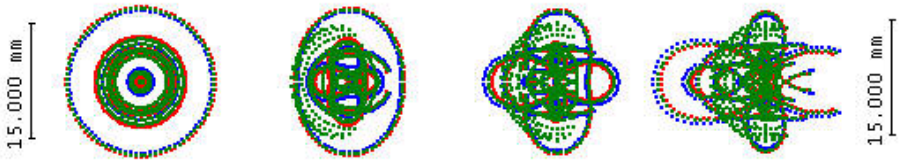
The corrector ring shape solutions summary.



Num.	Source	Shape	Equation
I.	GAP-2000-002 Czech	Modified Schmidt plate A	$Z = A y^2 + B y^4 + C y^6$ $A = 1.24385 \times 10^{-5}$ $B = -9.93722 \times 10^{-12}$ $C = -1.52375 \times 10^{-18}$
II.	GAP-2000-002 Czech	Modified Schmidt plate A	$A = 9.94816 \times 10^{-6}$ $B = -8.93826 \times 10^{-12}$ $C = -1.34721 \times 10^{-18}$
III.	GAP-2000-009 Brasil	Modified Schmidt plate A	$A = 1.24612 \times 10^{-5}$ $B = -8.6476 \times 10^{-12}$ $C = -2.0361 \times 10^{-18}$
IV.	GAP-2000-003 Czech	Approximation of meridian by off axis circle B	R = 8383 mm y = 795.27 mm z = 8380.9 mm
V.	GAP-2000-018 Mexico	Approximation by two on axis spheres C	R1 = 64 500 mm R2 = 29 550 mm
VI.	New design Czech	The most simple equation D	$Z = C y^6$ $C = -4 \times 10^{-18}$

The corrector ring shape solution comparison.

Field of view (degree)

	0	10	15	20
I. (Czech)				
II. (Czech)				
III. (Brasil)				
IV. (Czech)				
V. (Mexico)				
VI. NEW (Czech)				

The corrector ring influence on light losses near the focal plane

The study of ray bundles near the focal plane

Our succession :

I. **The ray tracing for FD with or without the corrector ring (graphical).**

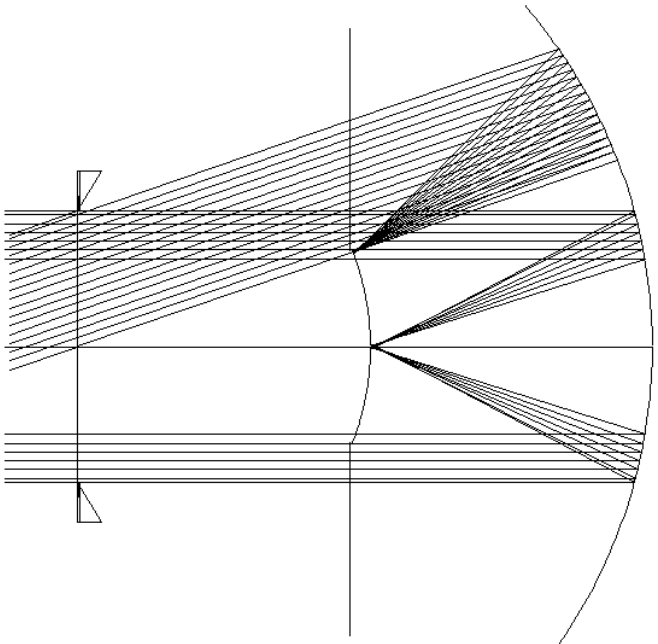
II. **Dependence of ray incidence angle at focal plane on the diameter of entrance aperture. The target was to find the maximum incidence angle.**

III. **Reflection losses on entrance window of PMT. Fresnel equations.**

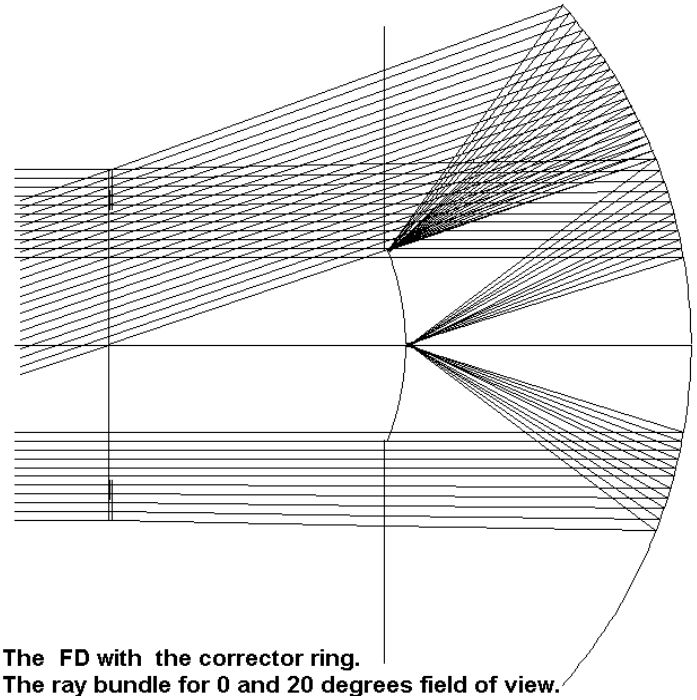
IV. **Ray incidence angle as a function of the mercedes walls slope.**

Analytic solution of optimal slope and height of mercedes walls to minimize reflective losses.

The ray bundles for FD without and with corrector ring. Meridian plane.

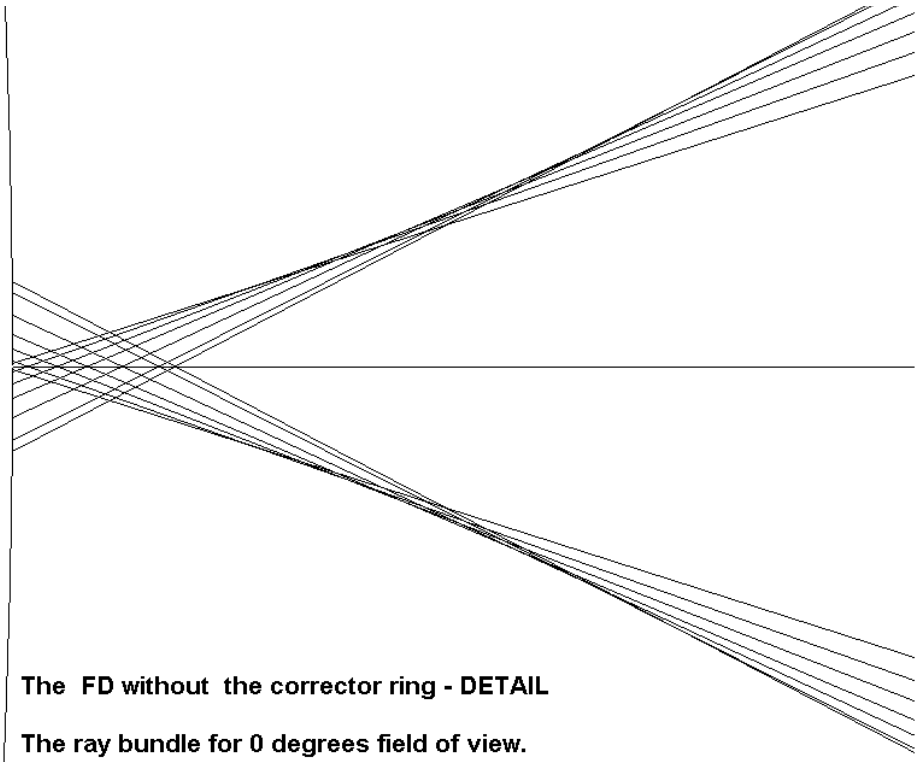


The FD without the corrector ring.
The ray bundle for 0 and 20 degrees field of view.



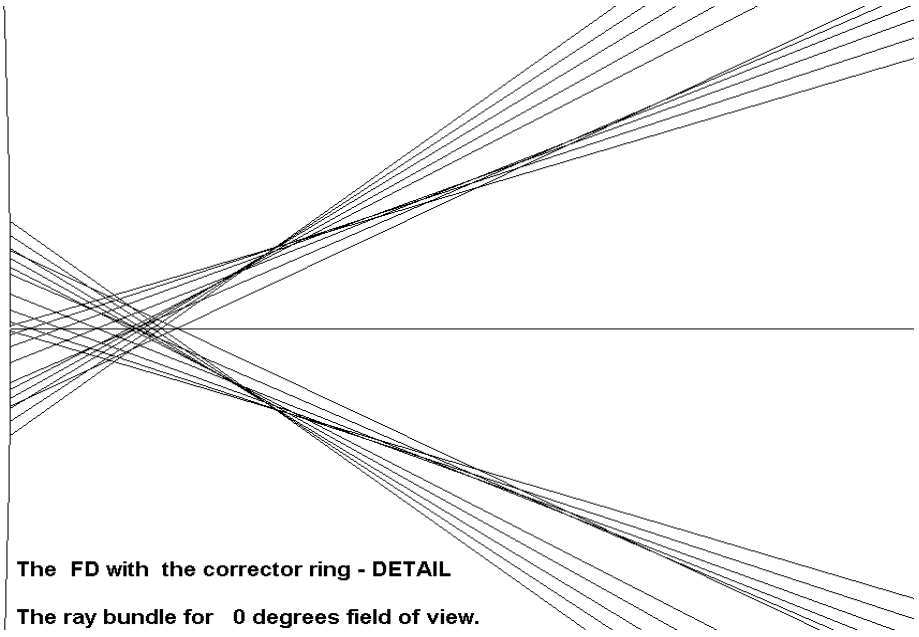
The FD with the corrector ring.
The ray bundle for 0 and 20 degrees field of view.

The details of ray bundles for FD without and with corrector ring. The field of view is 0 degrees.



The FD without the corrector ring - DETAIL

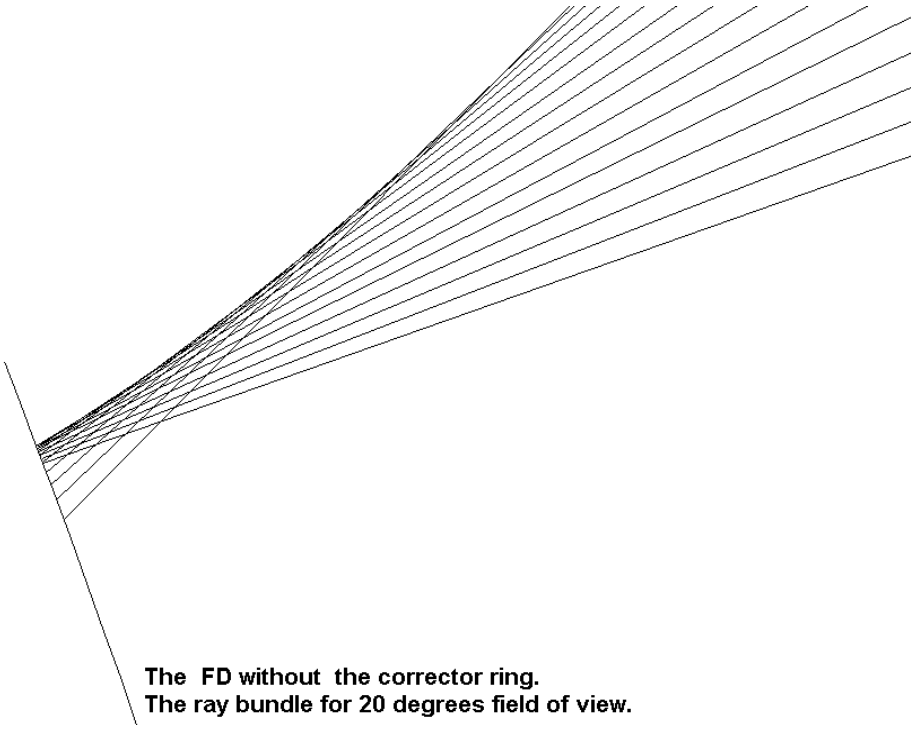
The ray bundle for 0 degrees field of view.



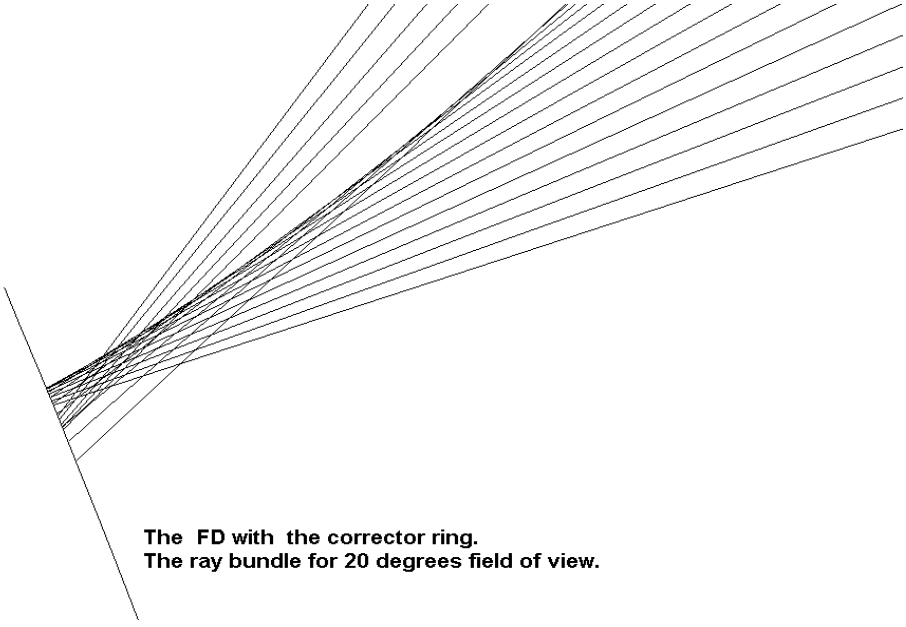
The FD with the corrector ring - DETAIL

The ray bundle for 0 degrees field of view.

The details of ray bundles for FD without and with corrector ring. The field of view is 20 degrees.

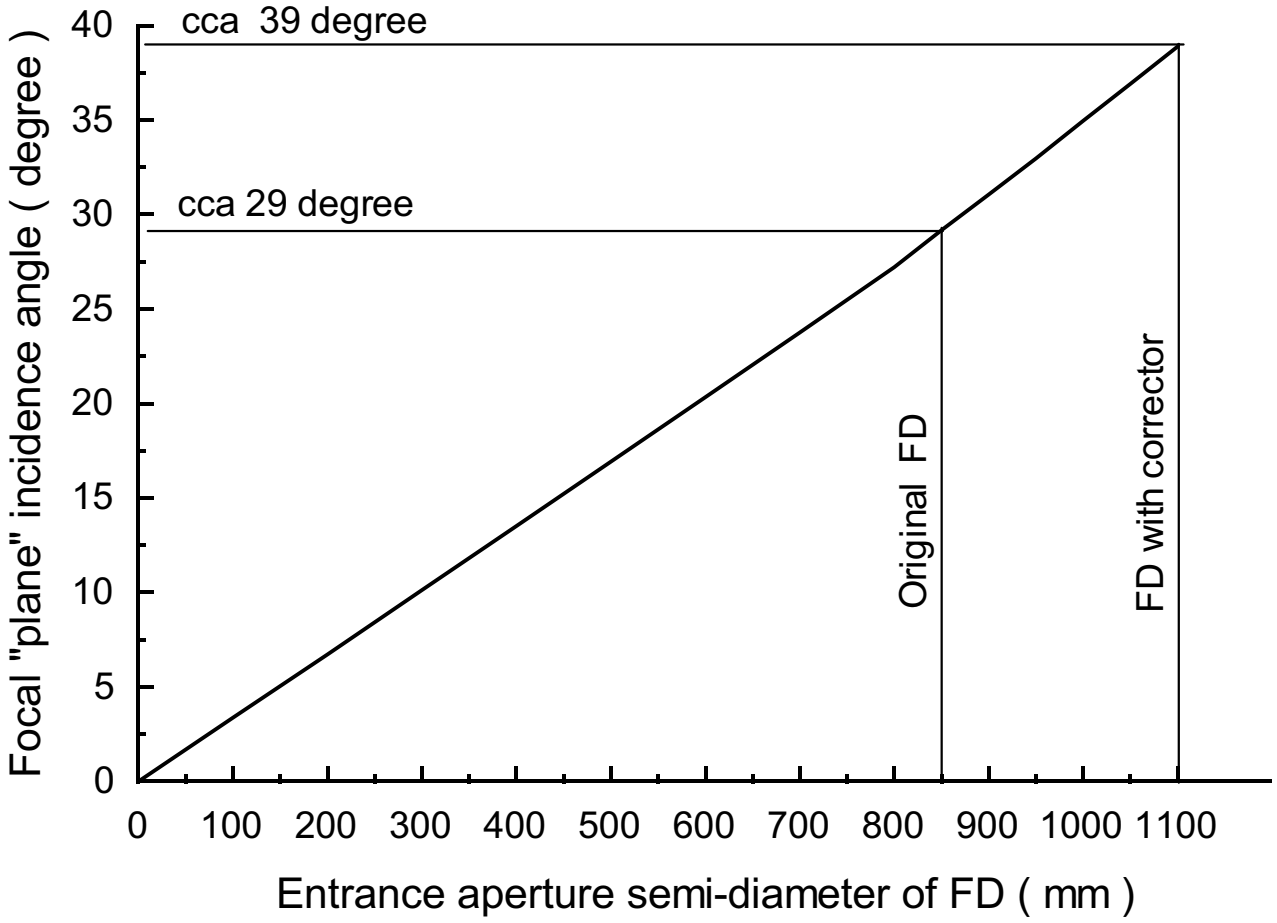


The FD without the corrector ring.
The ray bundle for 20 degrees field of view.

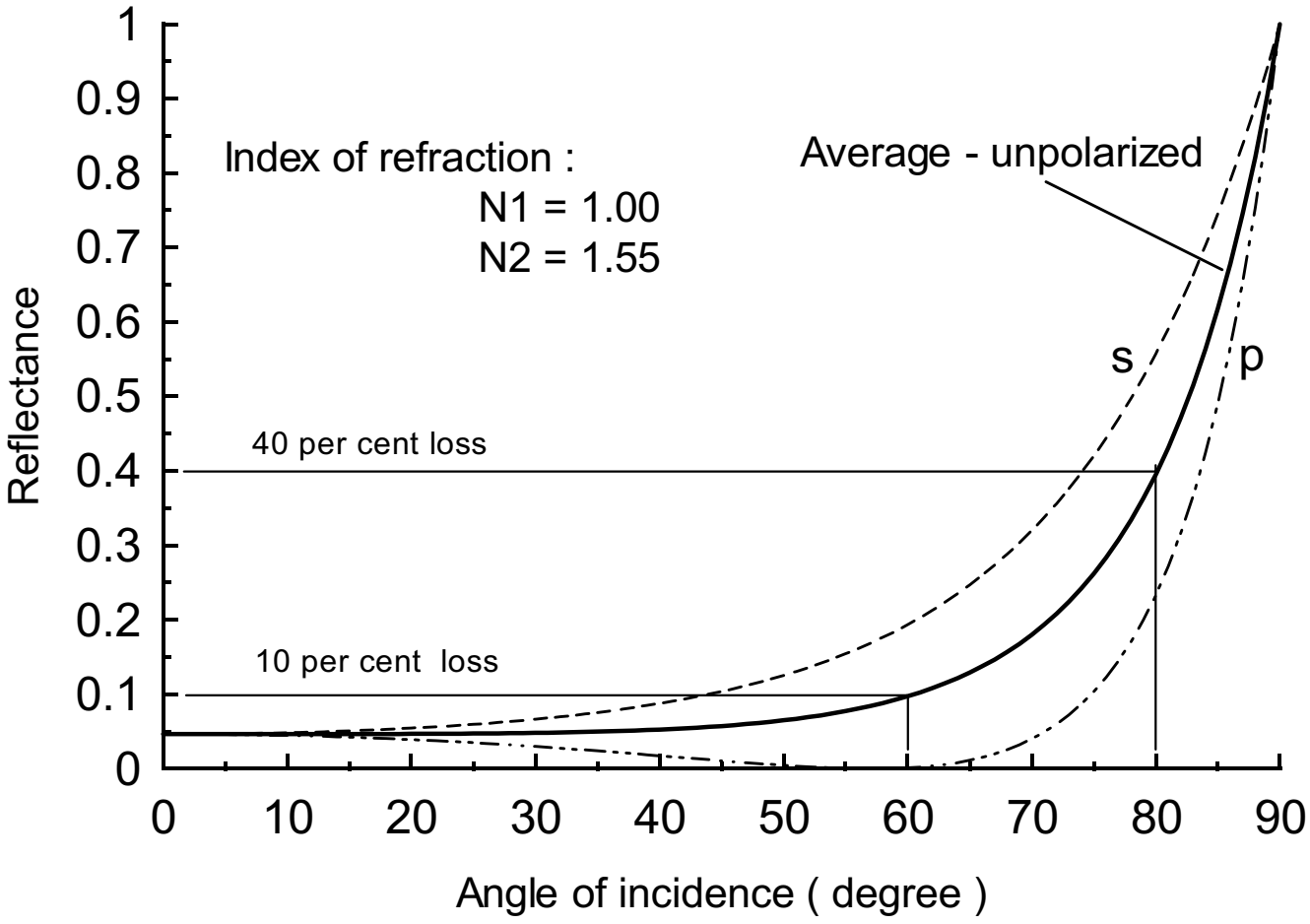


The FD with the corrector ring.
The ray bundle for 20 degrees field of view.

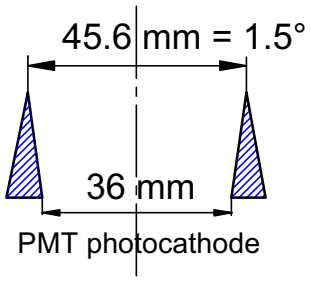
Focal plane incidence angle as a function of the diameter of FD entrance aperture

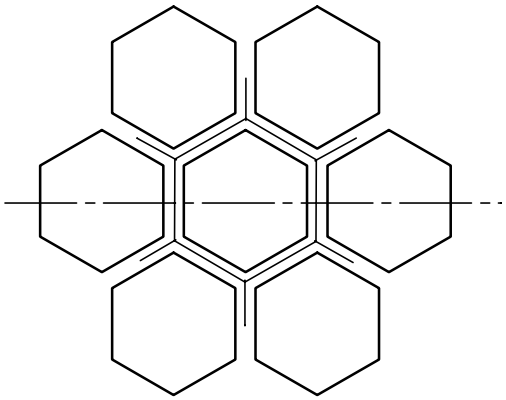


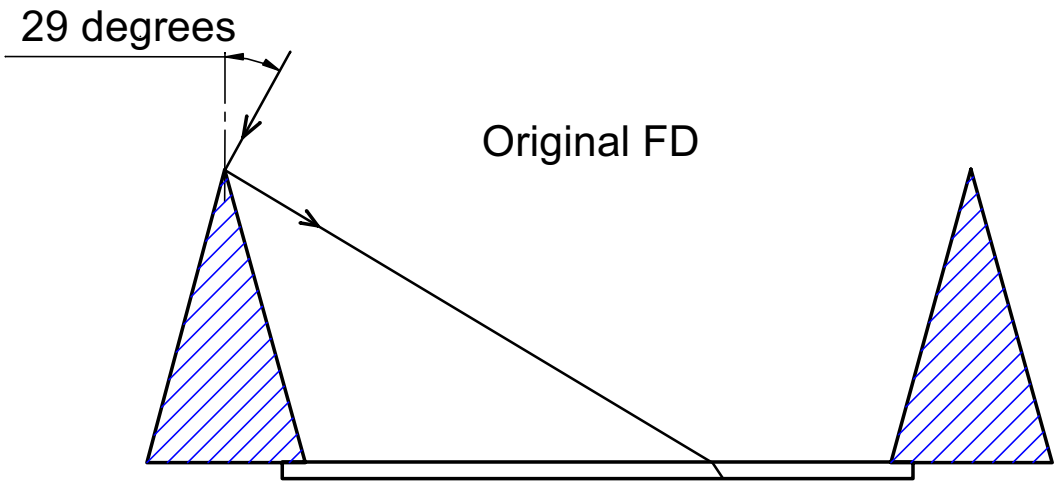
Optical properties of PMTs entrance window

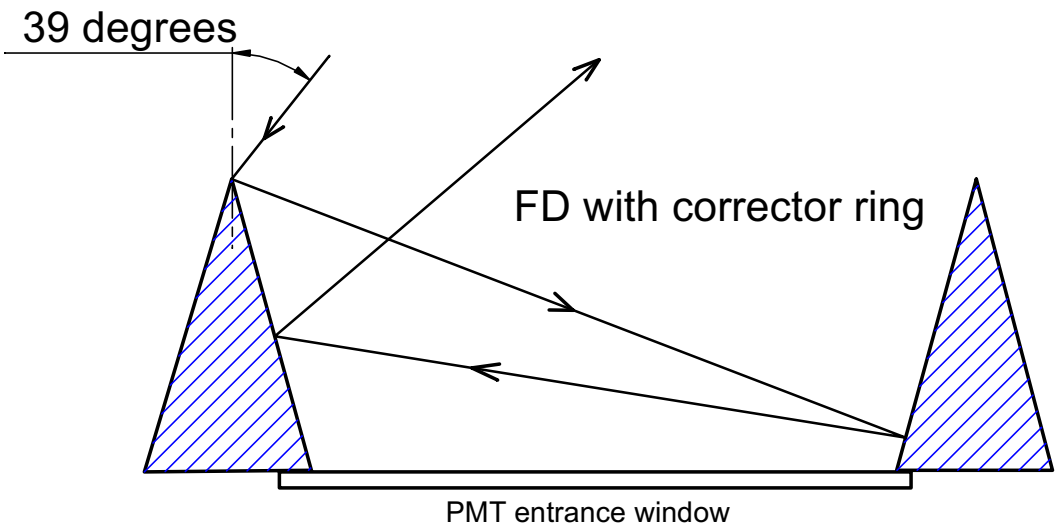


Mercedes walls





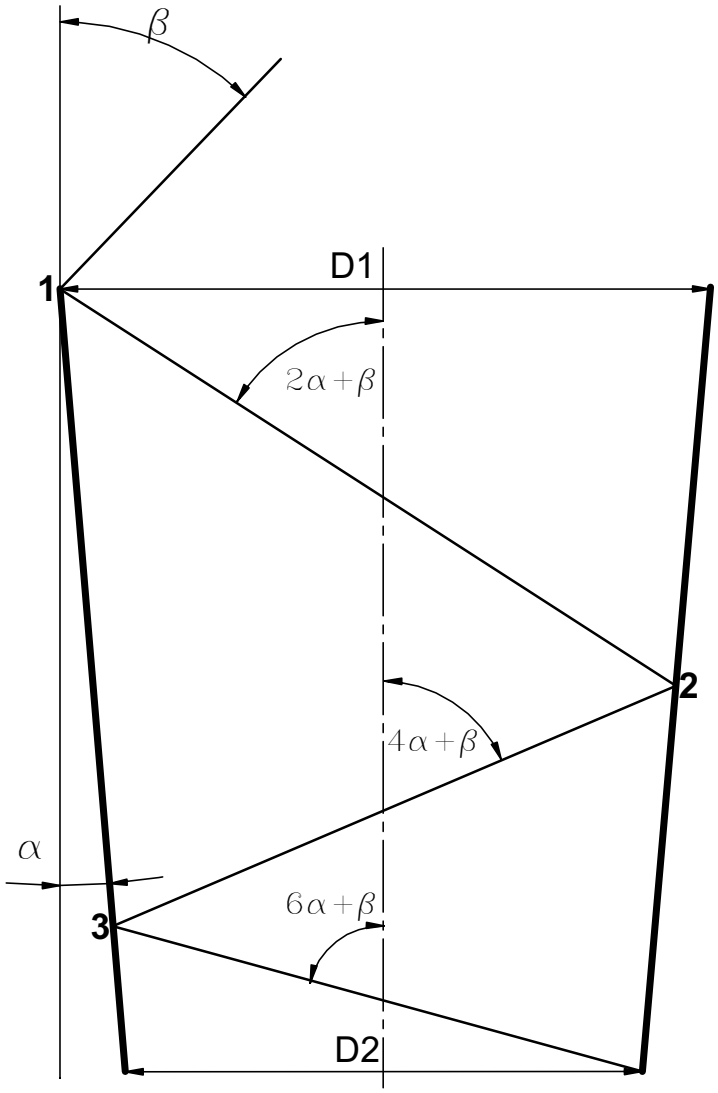




Mirror trough ray tracing.

"Concentration" ratio :

$$C = D1/D2$$



Angle of incidence after **n** reflections is :

$$\gamma_n = 2n\alpha + \beta$$

Ray continues downward toward the base only when :

$$\gamma_n < 90 \text{ degrees}$$

Maximum incident angle β_n as a function of apex angle of the trough α

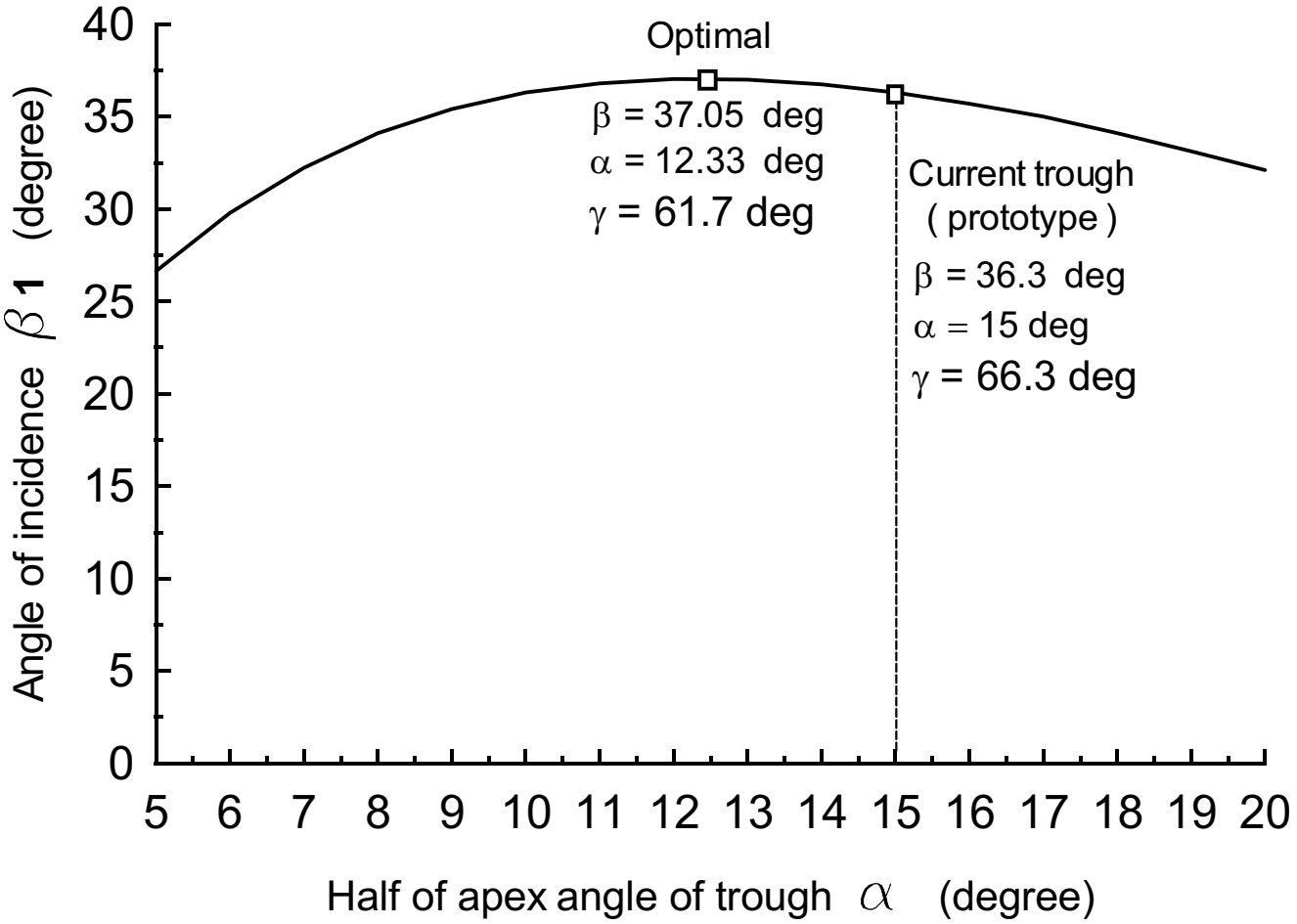
$$\beta_n = \text{atan}\left((\sin(N\alpha) - C\sin\alpha)/(C\cos\alpha - \cos(N\alpha))\right)$$

where N = 2n+1 , n ... number of allowed reflections

C = "concentration" ratio of the trough

β_n is max. when :

$$\cos[(N-1)\alpha] = (N + C^2)/[(N+1)C]$$



Mirror trough ray tracing

Properties :

After every reflection light losses increase by reason of :

I. **Finite reflectivity of mirror walls**

II. **Reflectivity of PMT entrance window (strong angular dependence)**

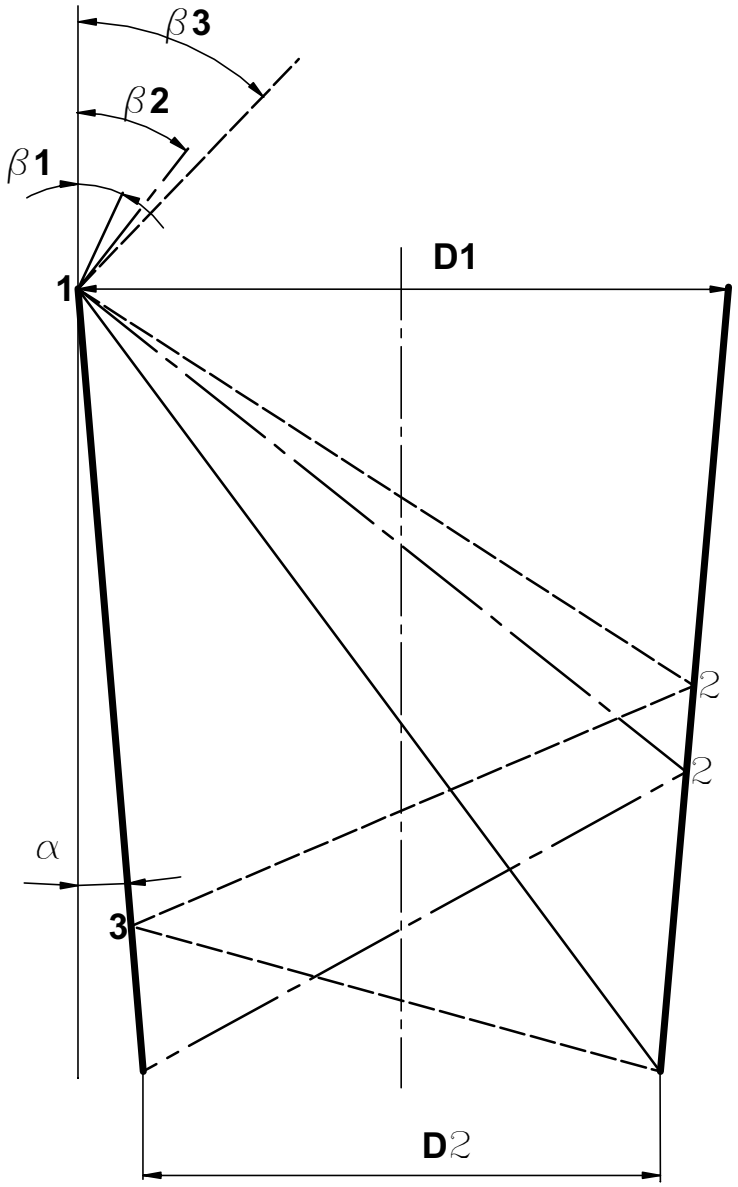
Optimal design of mirror trough minimizes

the number of reflections n

the apex angle of the trough α

for given maximum incidence angle β

Mirror trough

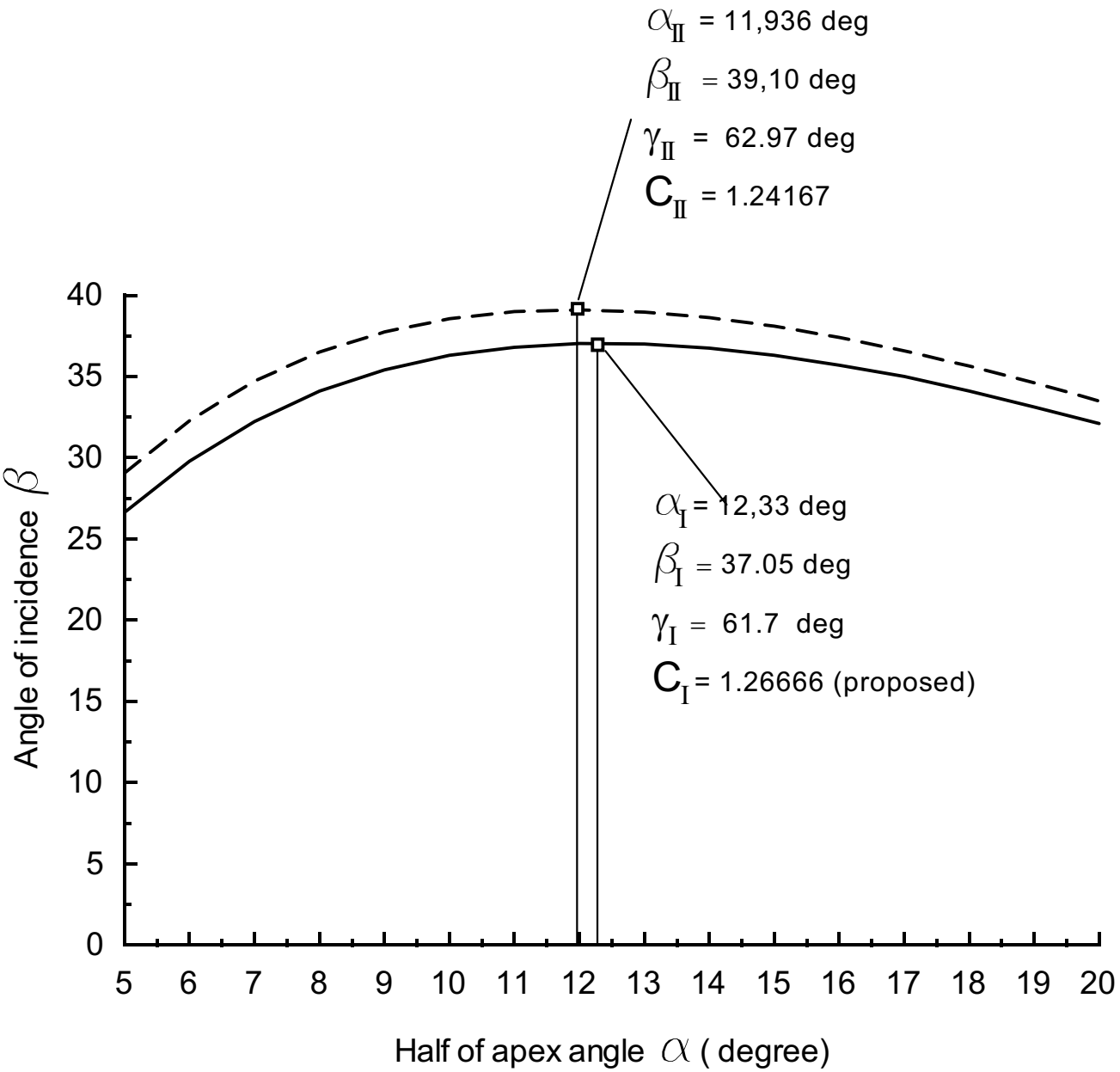


β_n maximum incident angle for **n** allowed reflections

α half of apex angle of trough

Optimal shape parameters of mirror trough for FD with corrector ring (Mercedes walls)

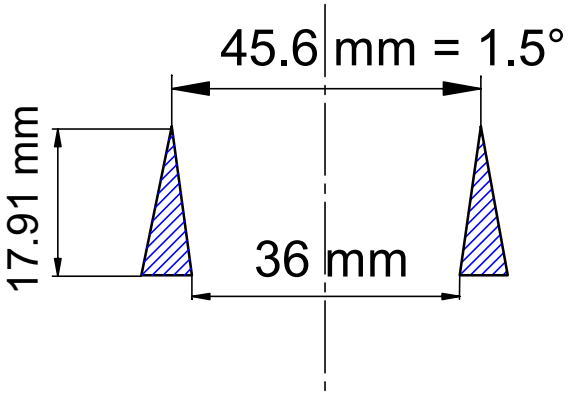
Change of "concentration" ratio C is only solution for acceptance of incident angle β = cca 39 degree.



Conclusion

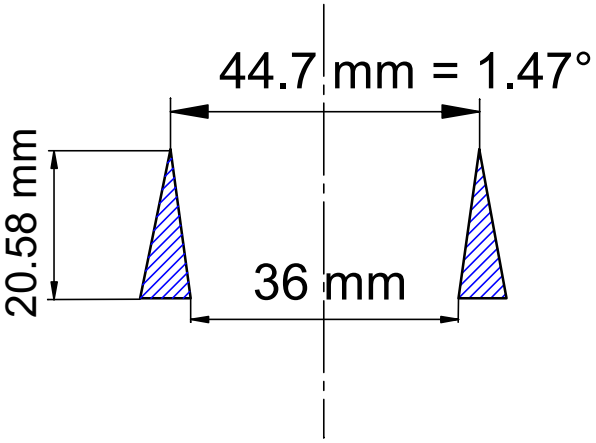
Mercedes walls

Realised



α = 15 degrees

Proposed



α = 11.94 degrees

Unfortunately the proposal requires to change the resolution of the FD camera from 1.5 degree to 1.47 degree