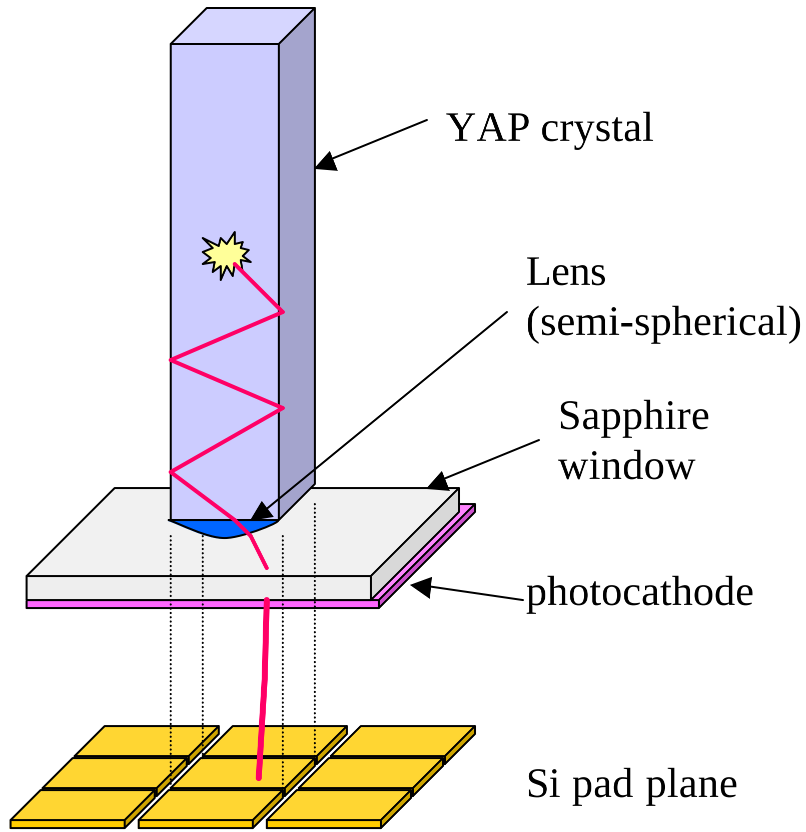
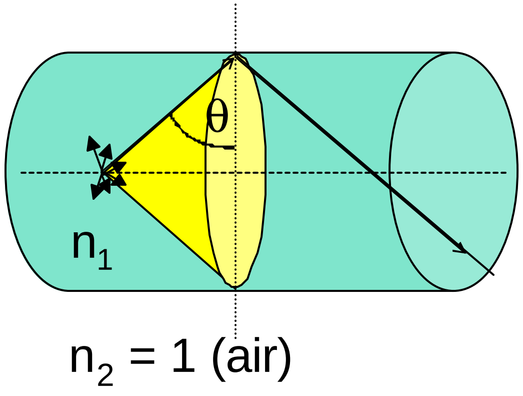
Ingredients of simulation

- Total internal reflection
- Refraction at refractive index change
- Loss due to refraction out of crystal
- Photon loss due to absorption
- Photon loss due to reflections (R < 1)
- HPD quantum efficiency
- HPD point spread function



Total internal reflection



$$\theta_C = a\sin(n_2 / n_1)$$

$$\varepsilon = \frac{1}{4\pi}\int_0^{\theta_C} \sin\theta \, d\theta d\varphi = \frac{1}{2}(1 - \cos\theta_C)$$

$$n_1 = 1.94 \quad \rightarrow \theta_C = 59^{\circ}$$

$$\rightarrow \varepsilon = 24.25\% \text{ per side}$$

Nice surprise !

Light transport efficiency through rectangular crystal bar (n=1.94)

Simulation: ε = 40.4% per side, i.e. 80.8% total.

Almost too nice to be true ! Check !

$$|q| > \pm a\cos\left(\frac{\cos(a\sin(1/n_1))}{\cos j}\right) \qquad -p \le j \le p$$

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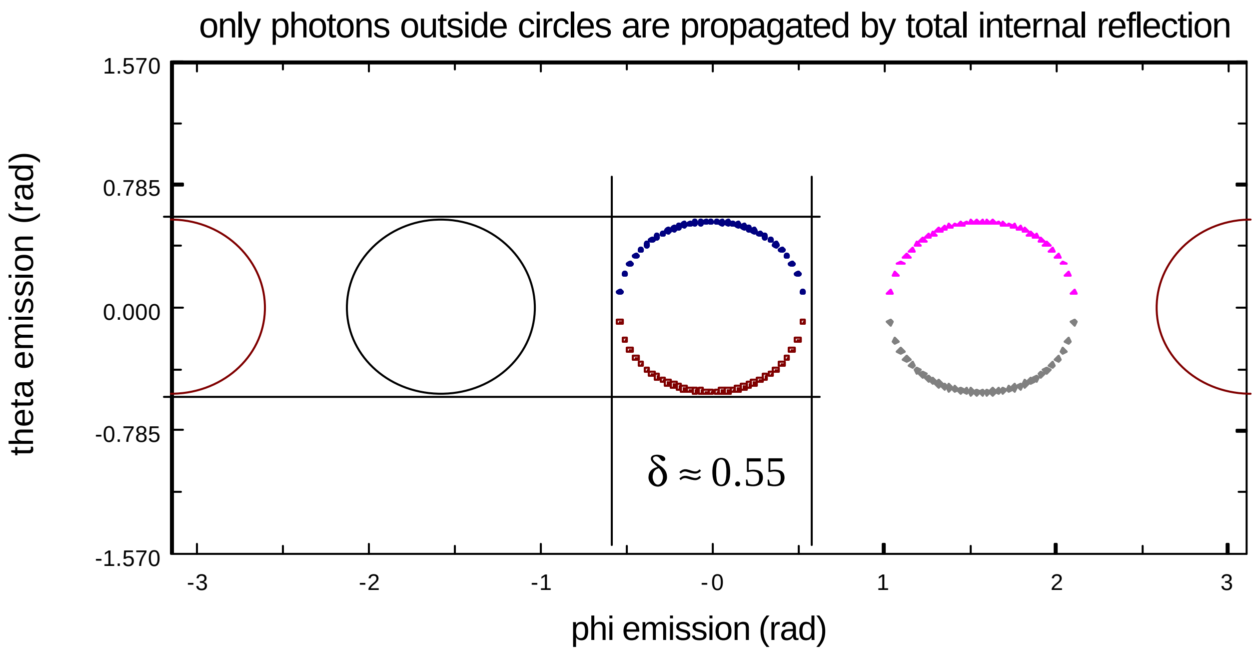
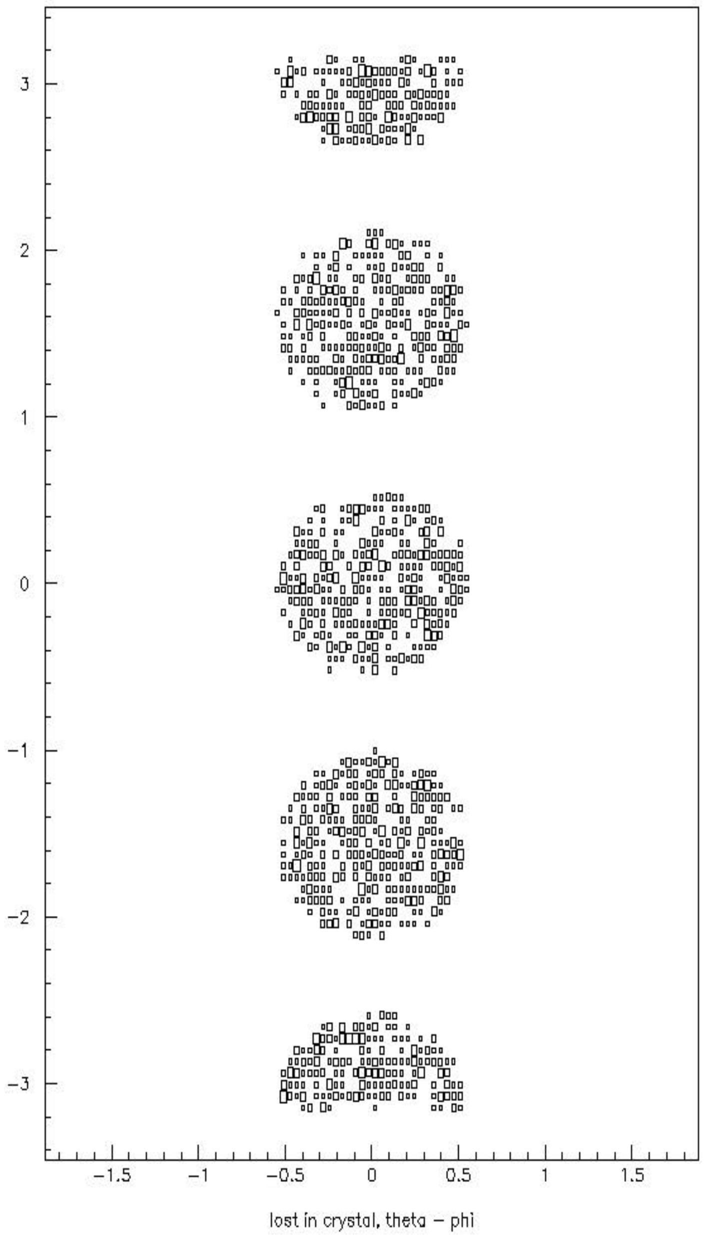


$$e = 1 - \frac{4pd^2}{2p \cdot p} = 0.8074$$

Plot only photons which got lost in crystal

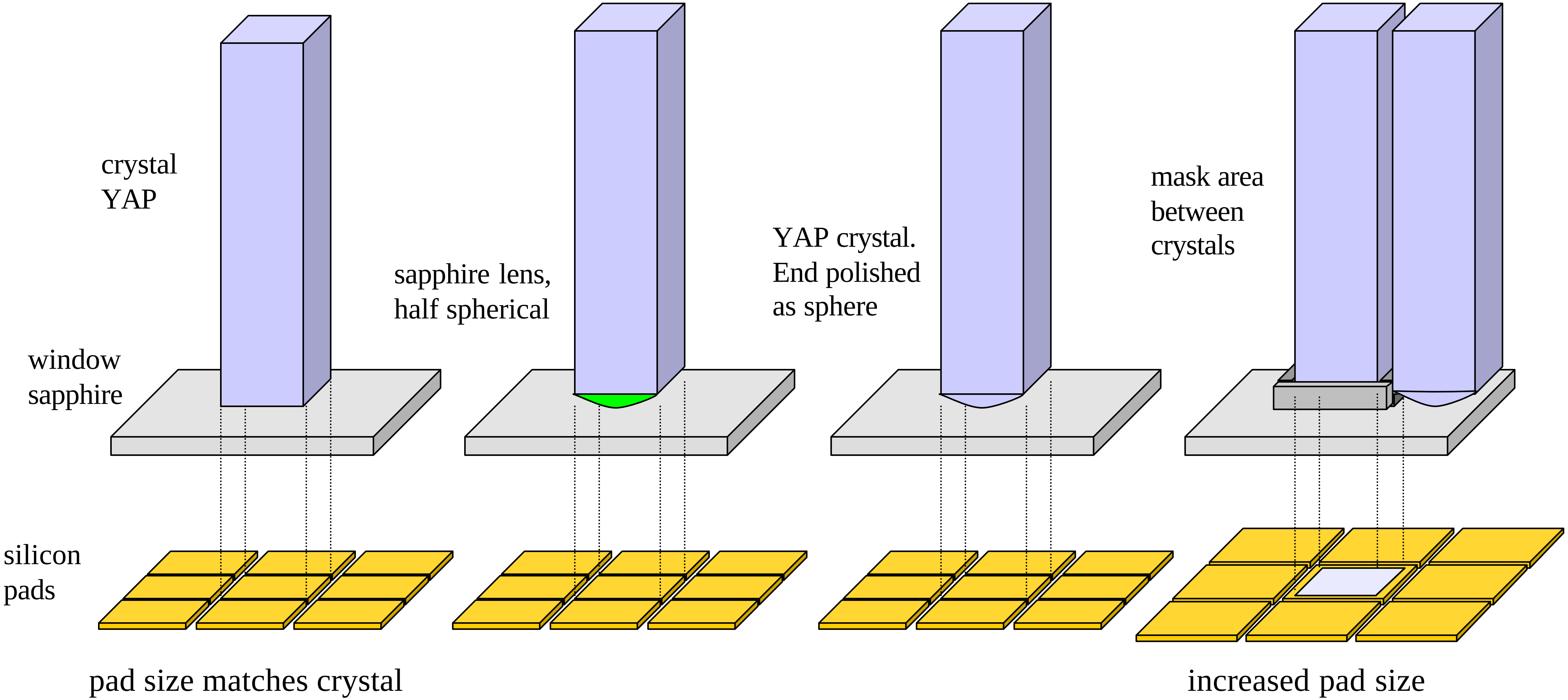
($\lambda_{YAP} = \infty$)

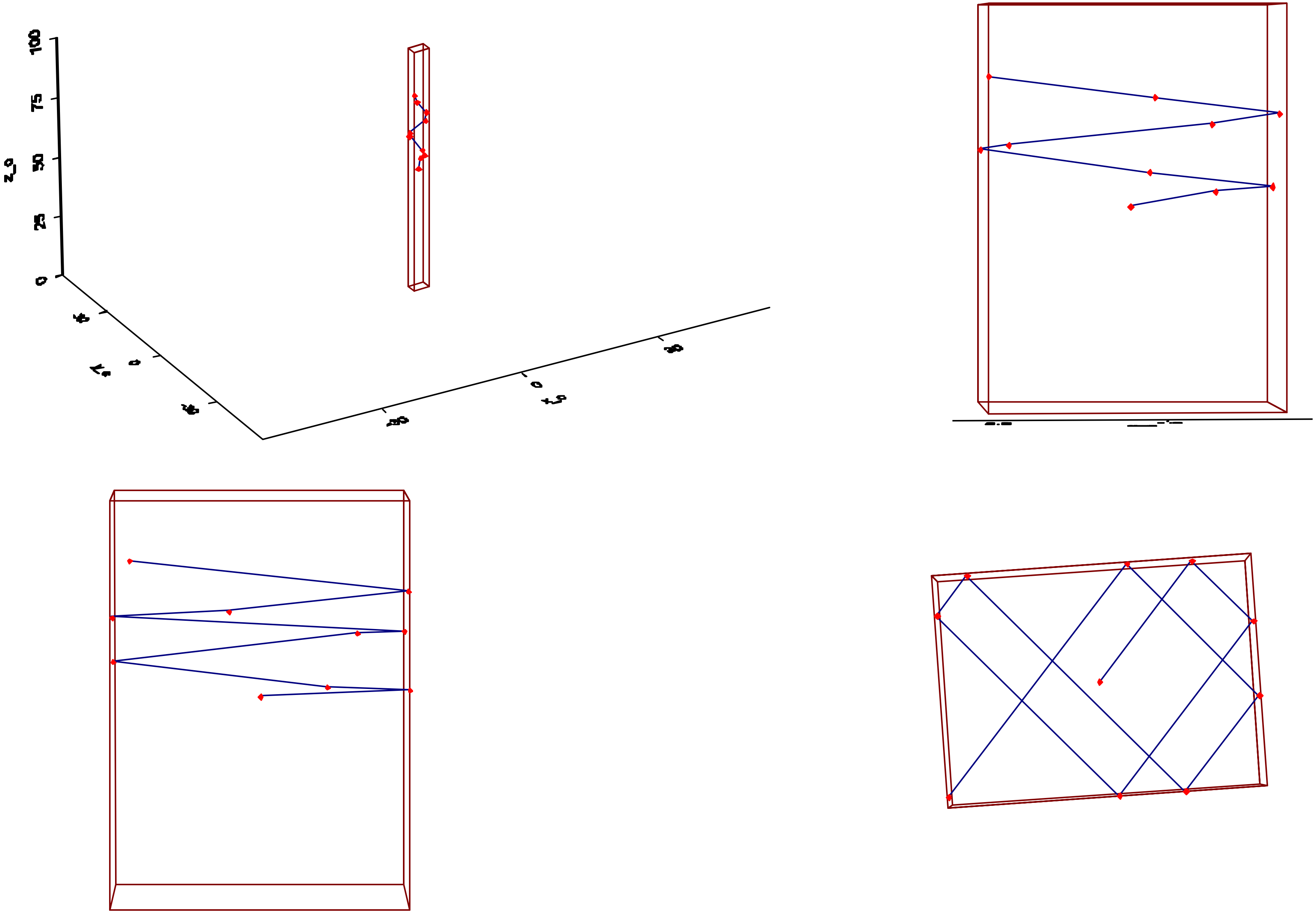
ϕ

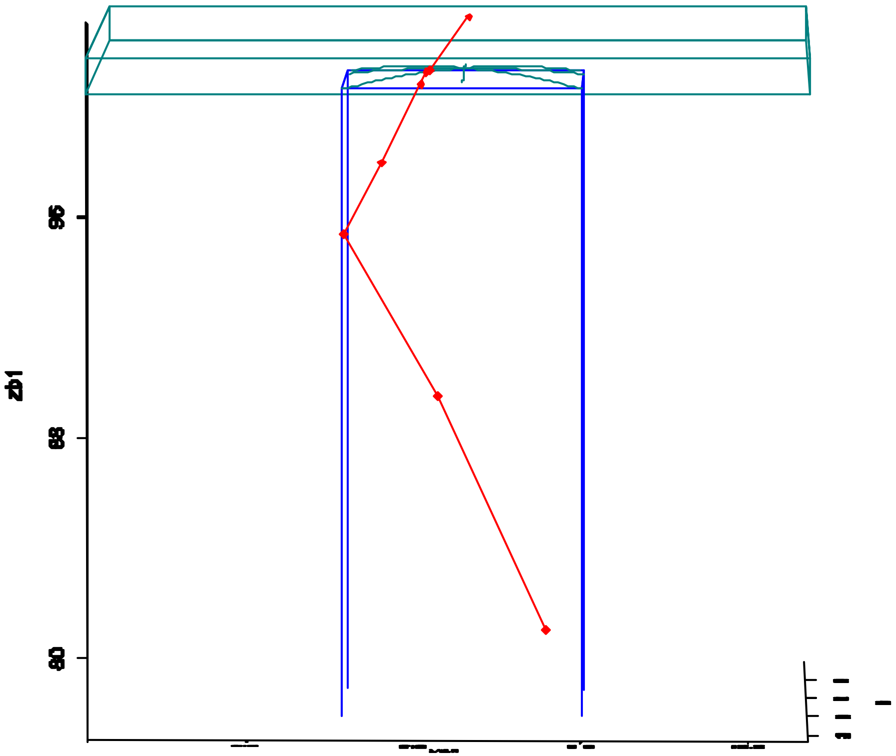


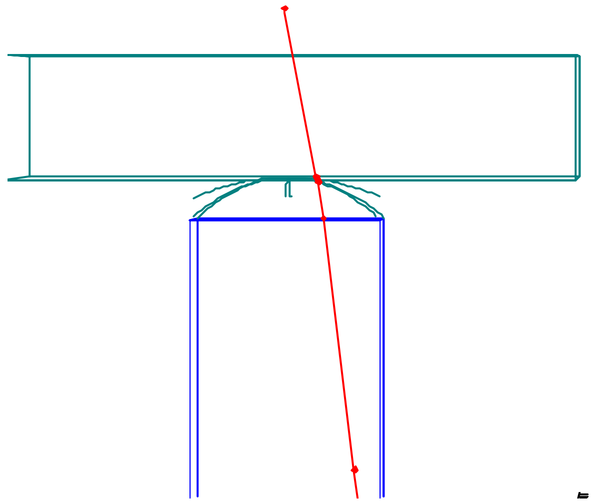
θ

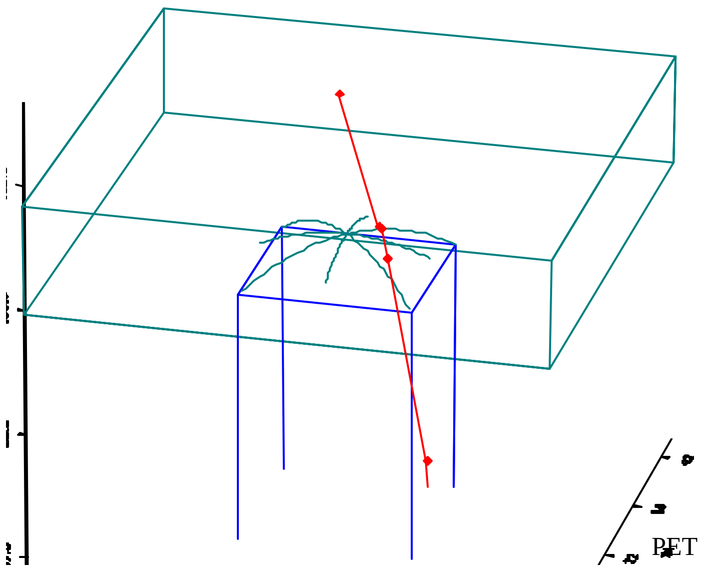
Dimensions: x_c = 3.2 mm, y_c = 3.2 mm, z_c = 100 mm

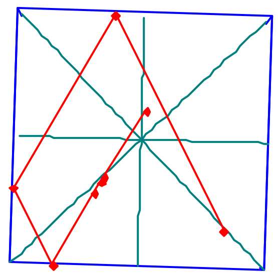



100
75
50
25
0
z_0









PET – HPD 17-Apr-2002 C. Joram

	lens	pad size (mm)	d_{window} (mm)	RMS_x (mm)	$N_{p.e.}$(total)	$N_{p.e}$ (central)	Fraction
1	no lens	3.5	1.8	1.624	1097	662	0.603
2	no lens	4.0	1.8	1.624	1101	751	0.682
3	sapphire lens (R=2.26 mm)	3.5	1.8	2.03	654	315	0.481
4	Sapphire lens (R=6 mm)	3.5	1.8	1.11	600	463	0.772
5	"YAP lens" (R=6 mm)	3.5	1.8	1.10	596	465	0.780
6	"YAP lens" (R=7mm)	3.5	1.8	1.09	597	468	0.784
7	"YAP lens" masked (R=6 mm)	3.5	1.8	0.95	536	458	0.854
8	"YAP lens" masked (R=6 mm)	4.0	1.8	0.95	536	492	0.917
9	"YAP lens" masked (R=6 mm)	4.0	1.3	0.90	536	511	0.953

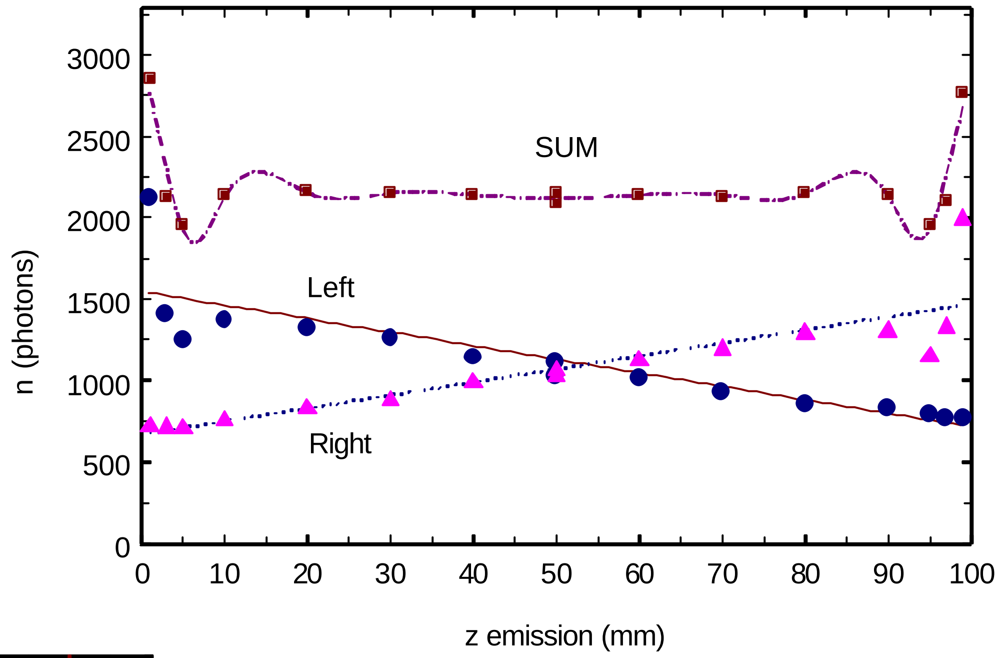
RMS_x (ideal, without lens) = 3.2 mm / sqrt(12) = 0.923 mm

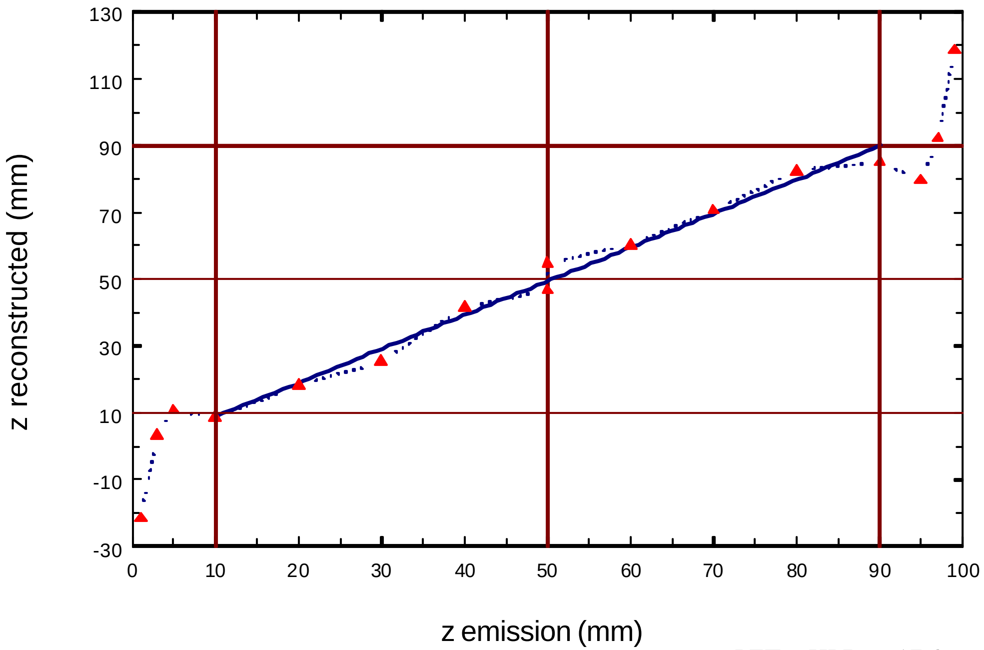
Z scan

x,y centred, isotropic emission

YAP lens (R=6mm), masked,
$d_w = 1.8$ mm

1 single γ, 9200 photons





$$z \propto \frac{L}{2} \cdot \left(1 + \frac{Q_R - Q_L}{Q_R + Q_L}\right)$$

Here: $$z = 0.3 \cdot \frac{L}{2} \cdot \left(1 + \frac{Q_R - Q_L}{Q_R + Q_L}\right)$$

Linear fit is ok for $10 < z < 90$ mm

Resolution to be studied.