if $d > a$

$$R = \frac{\sqrt{a^2 + d^2}}{4a}$$

$$\theta = \arcsin\left(\frac{d/2}{R}\right)$$

fraction of full circle is $2\theta/(2\pi)$

if $d < a$

$$R = \frac{d}{2}$$

$$\theta = \frac{\pi}{2}$$

fraction of full circle is 0.5
from ATLAS Tile Cal TDR (loss with fiber wound a full circle):

Do a linear fit, loss at full circle with radius $R(<10\text{cm})$ is:

$$5.3\% \times (10\text{cm} - R)$$

i.e., loss is
- 40% at $R=2.5\text{cm}$ or diameter 5cm;
- zero at $R=10\text{cm}$ or diameter 10cm.

**Figure 5-24** Relative light output for some fibres as a function of bending diameter.
Distance between our fiber holes to center of module: