Powerful and Cost-Effective Elliptical Neutron Guide Designs for the ESS

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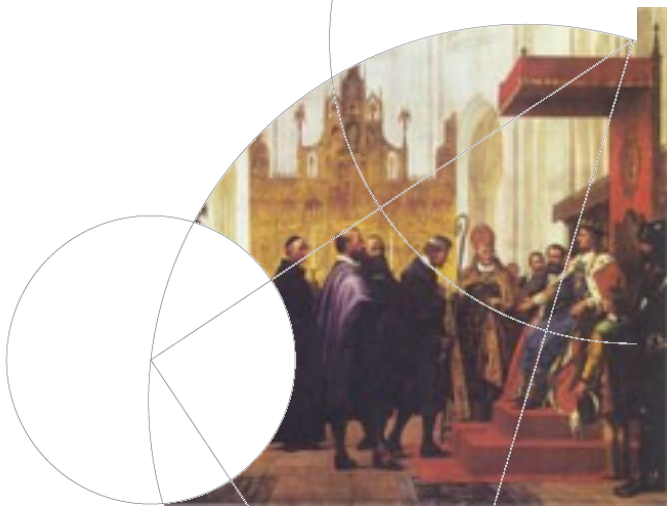


The Aim

- Maximum intensity on sample for 100 m and 300 m long ESS guides
- Cost efficiency

Hitting a 4x2 cm Sample at 300 m Distance

Why long guides?

Cons:

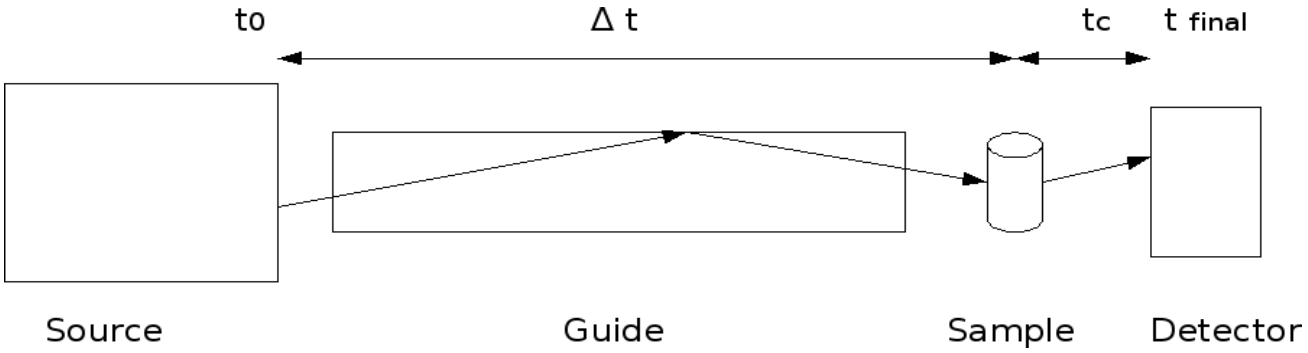
1) The further from the source, the lower the neutron intensity.

2) Long guides -> expensive instruments.

Pros:

Increased instrument resolution.

Time of Flight Energy Selection



$$\Delta t = t_{final} - t_c - t_0$$

$$v = \frac{L}{\Delta t}$$

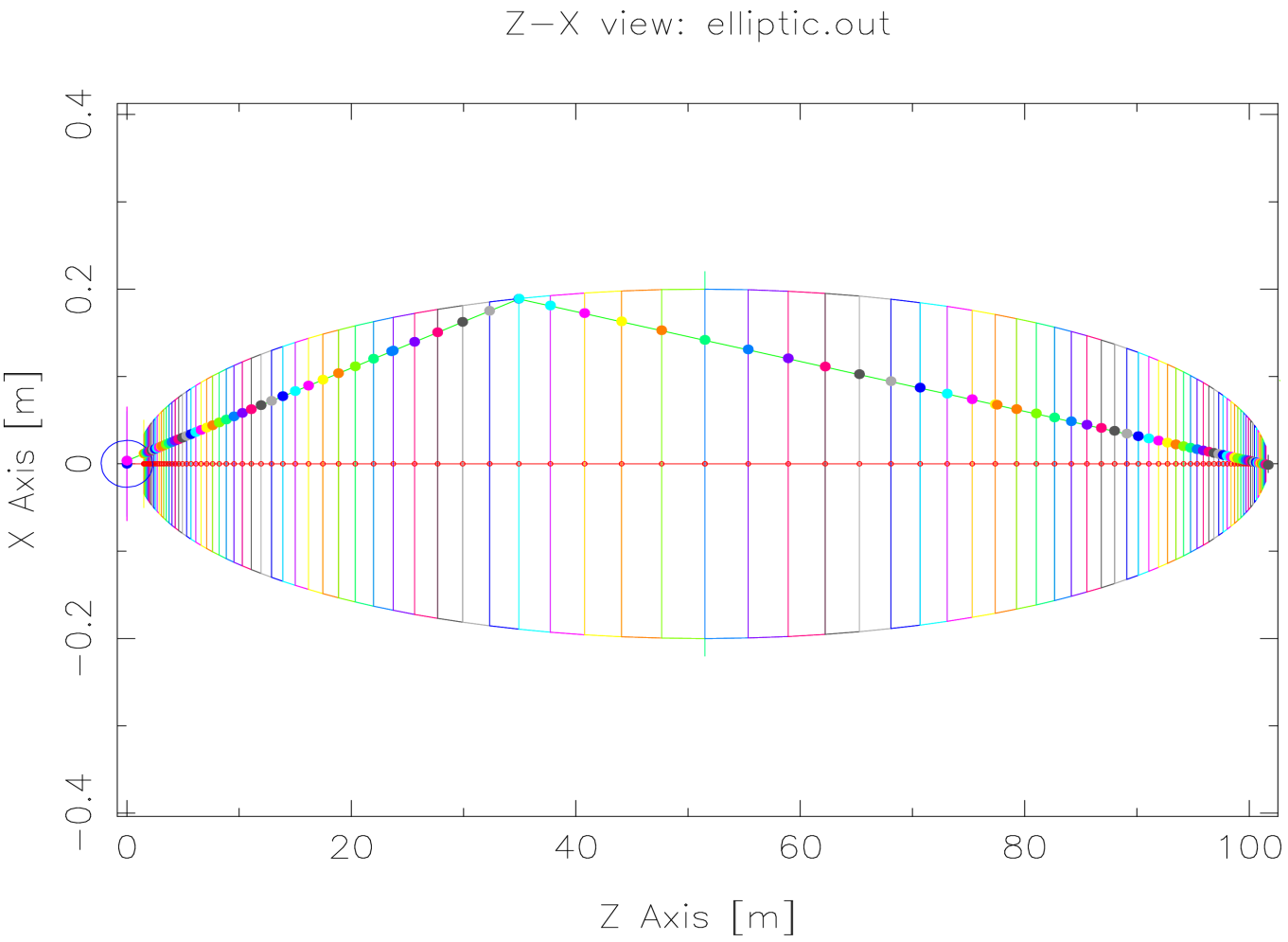
$$\Rightarrow v = \frac{L}{t_{final} - t_c - t_0}$$

$$E = 5.227 \frac{meV}{(km/s)^2} * v^2$$

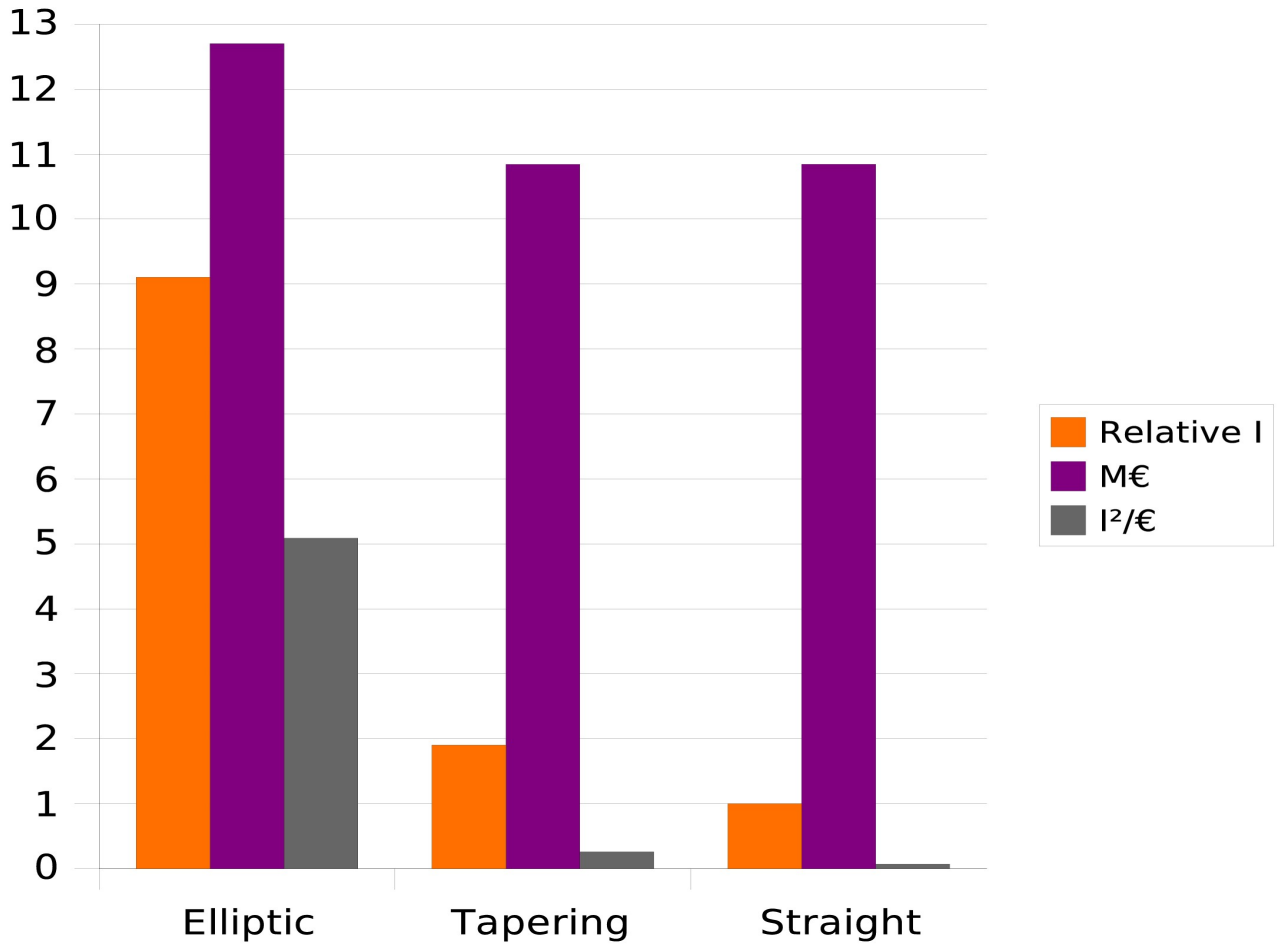
$$\Rightarrow E = 5.227 \frac{meV}{(km/s)^2} * (\frac{L}{t_{final} - t_c - t_0})^2$$

Guide Geometry

Elliptic Guide



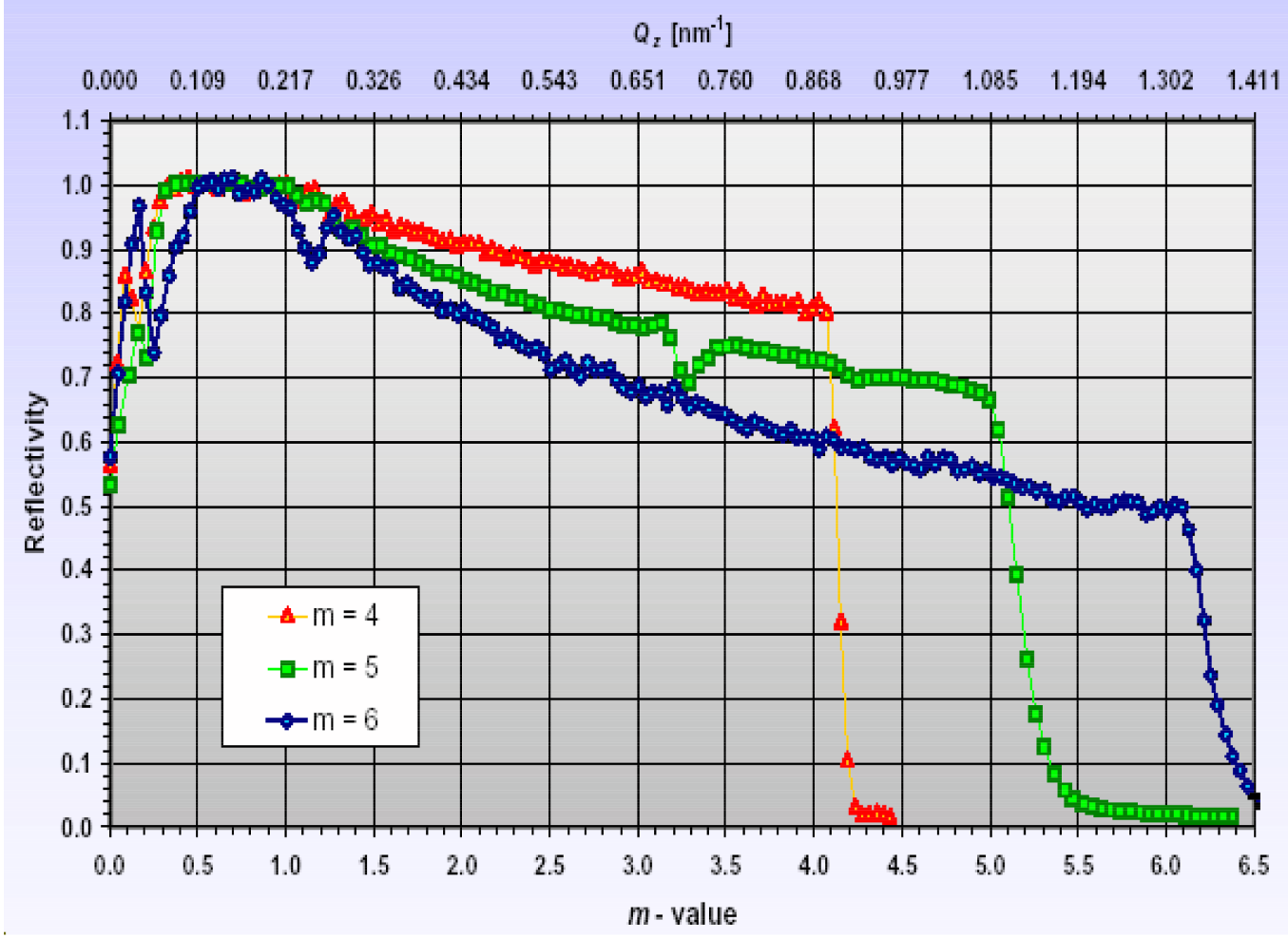
Performance of 100 m Guide Shapes



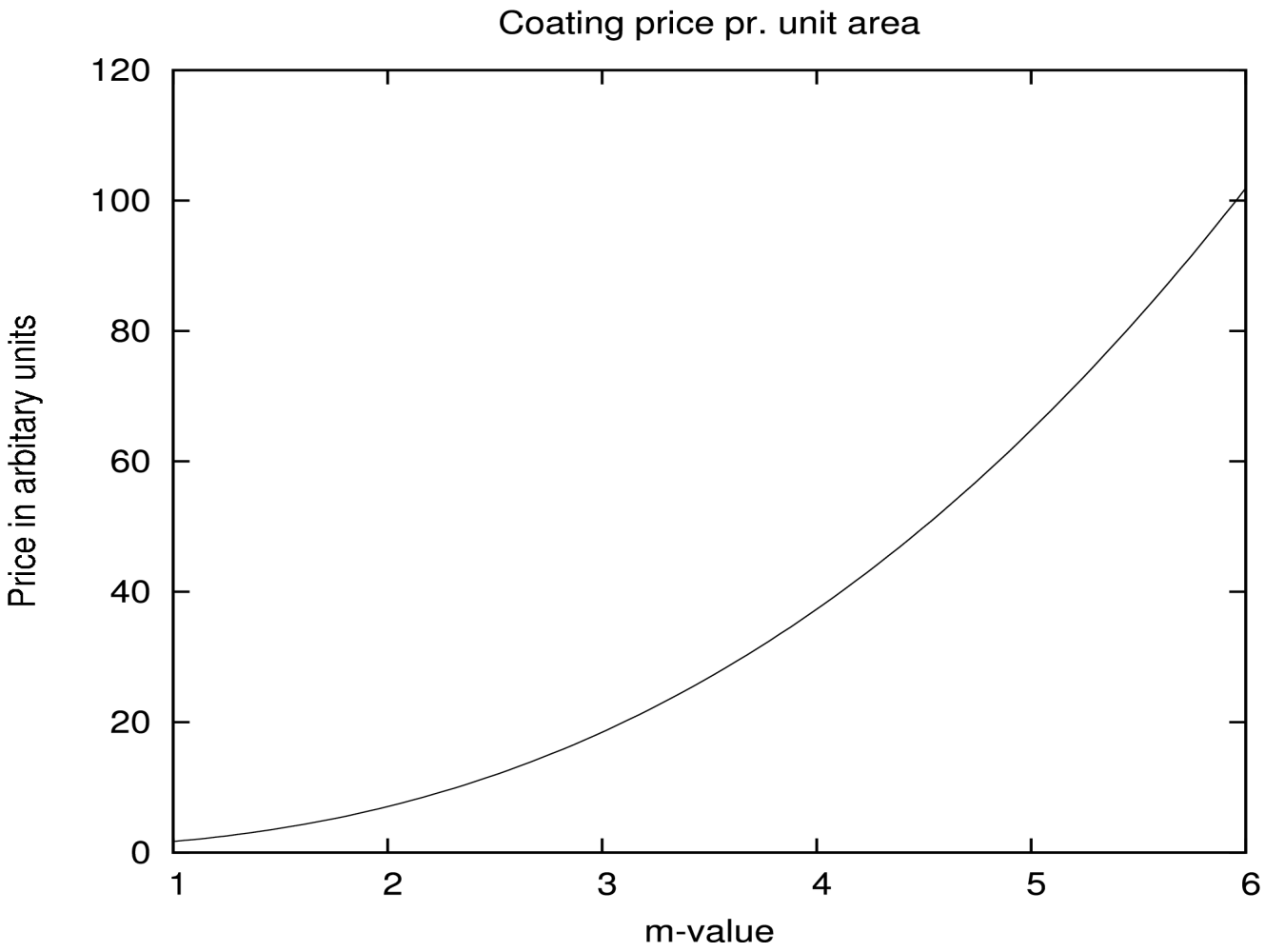
(Coating is m=2)

Guide Coating

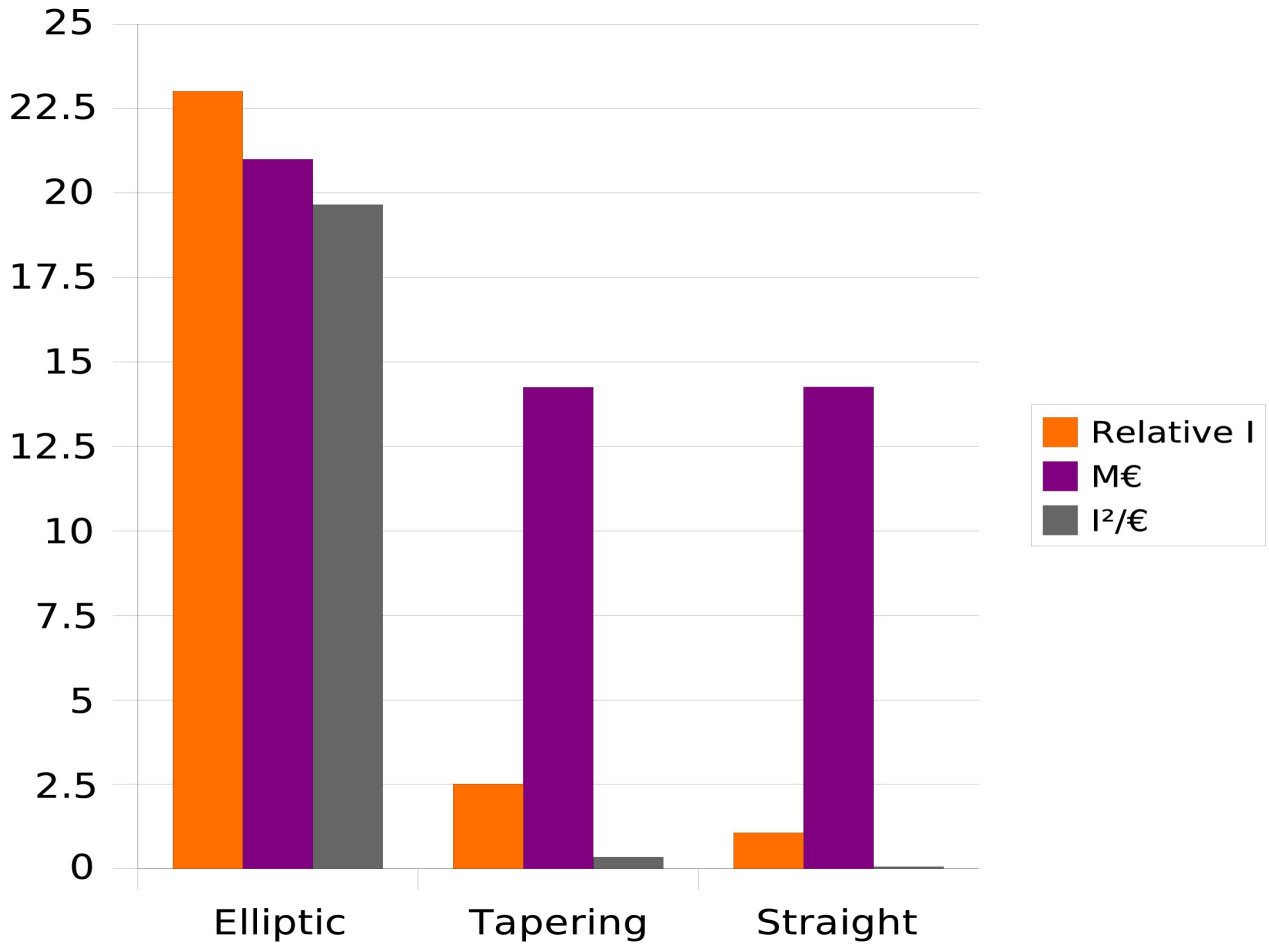
Coating Reflectivity Curves



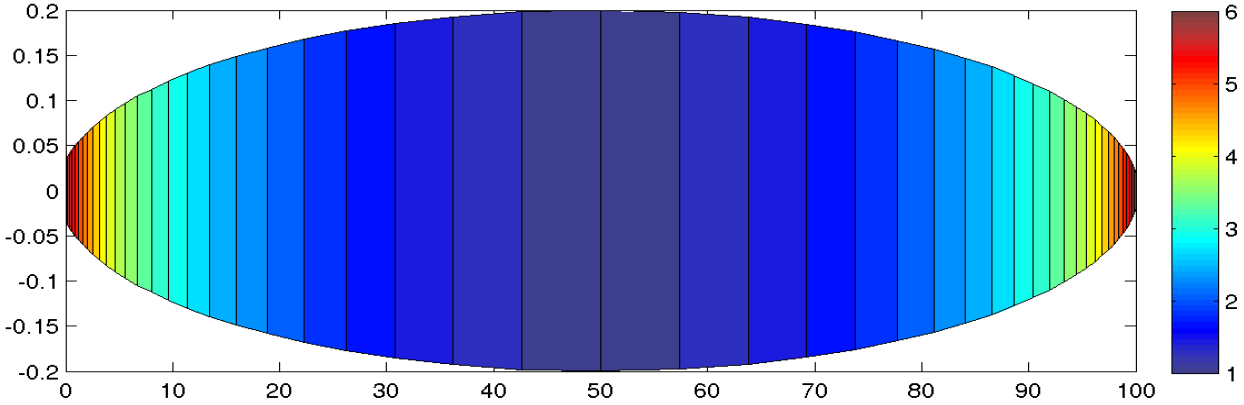
Good guide coating is expensive!

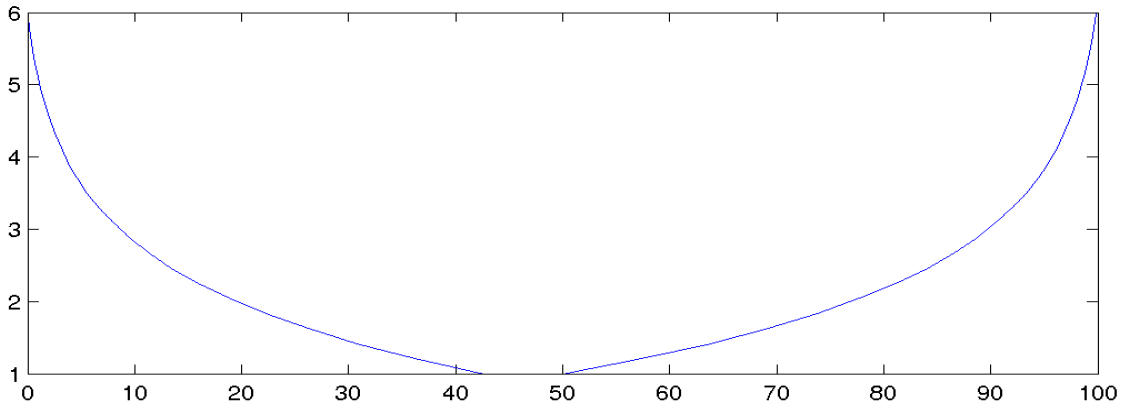


Performance of m=4 100 m Guide Shapes

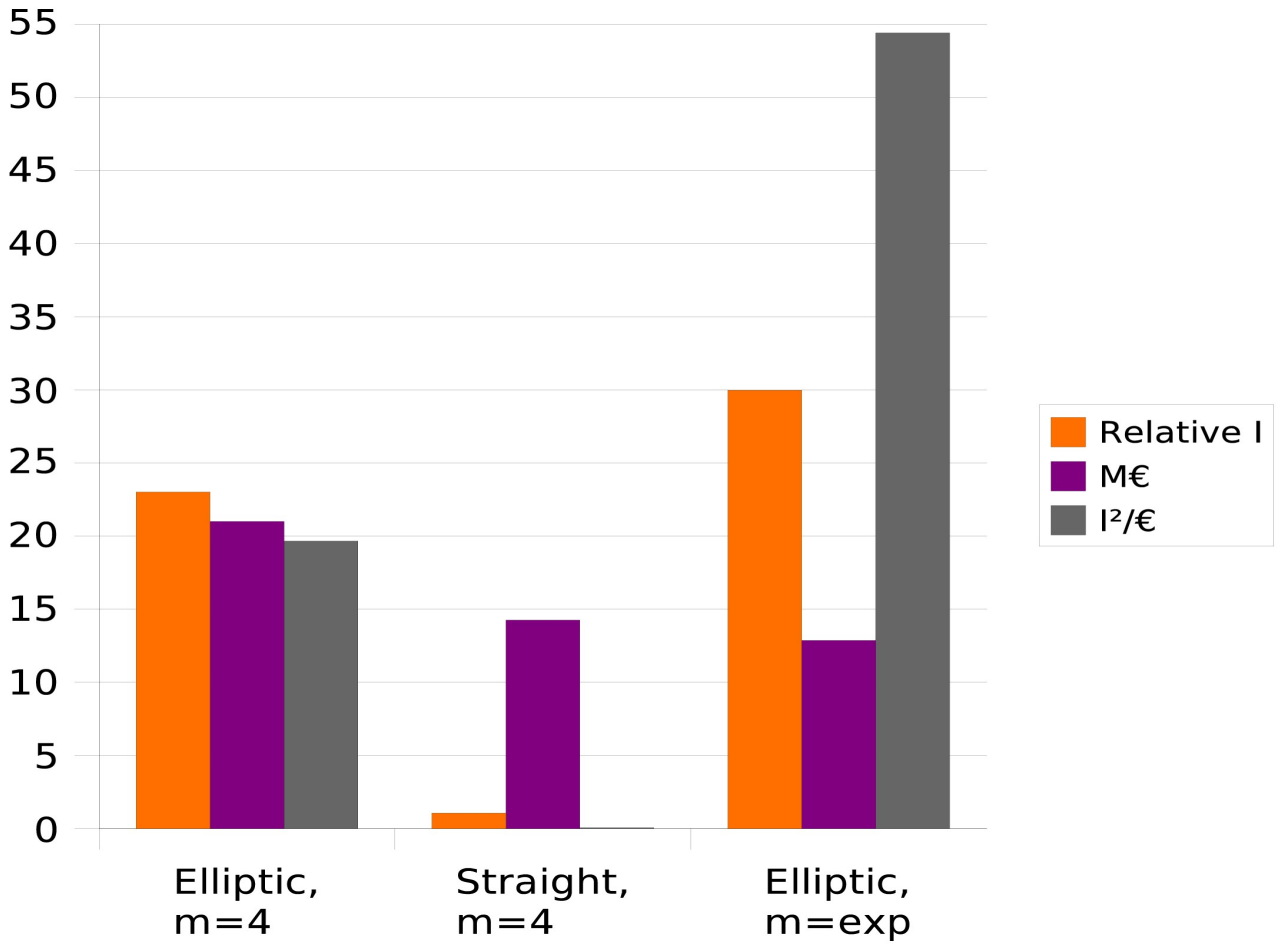


Non-uniform Coating Distribution

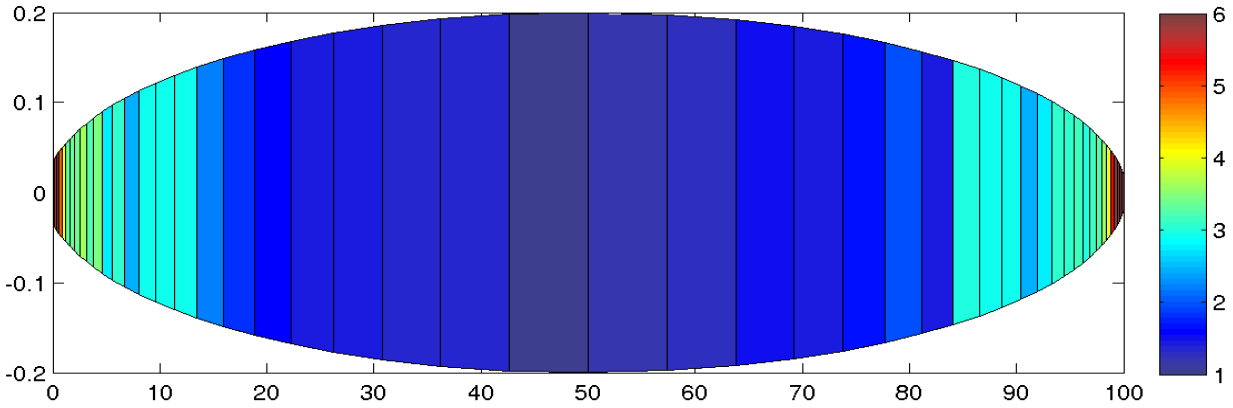


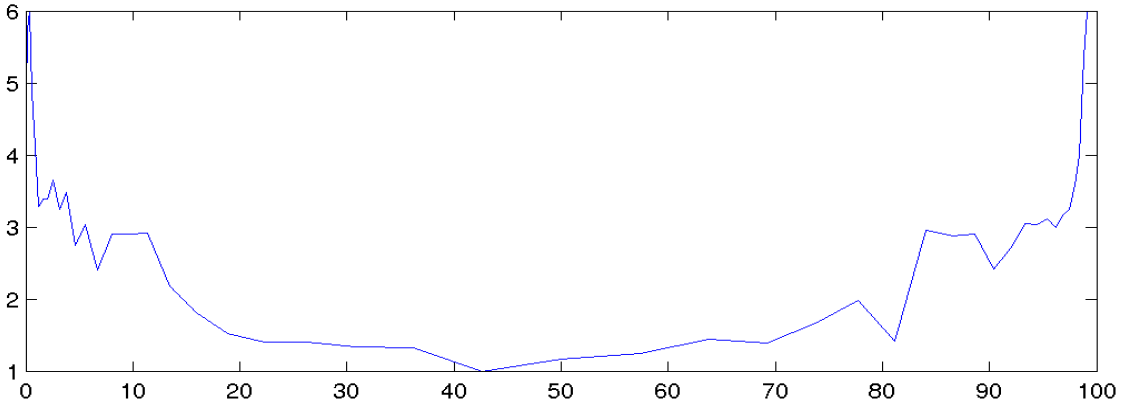


The Advantage of Non-uniform Coating

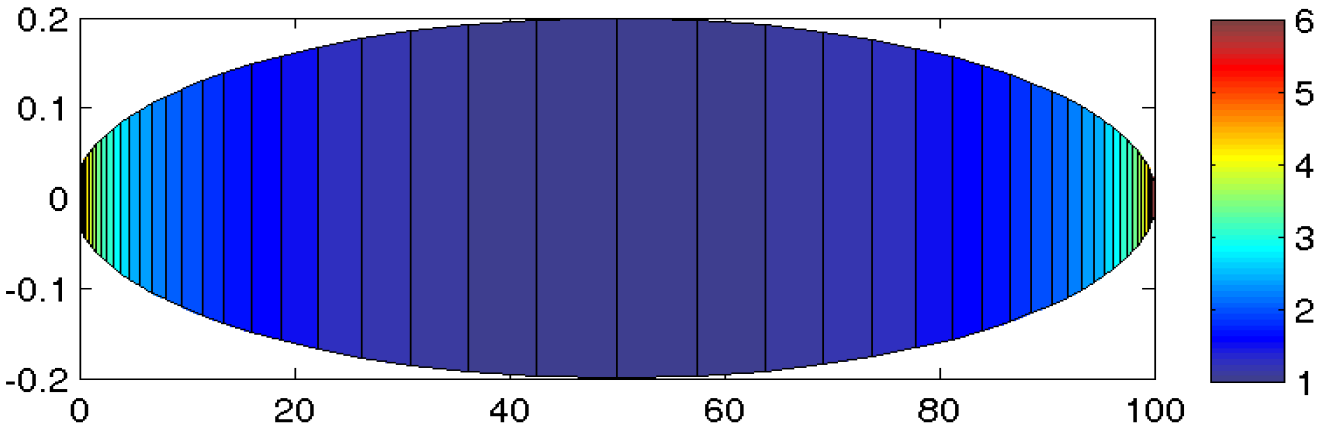


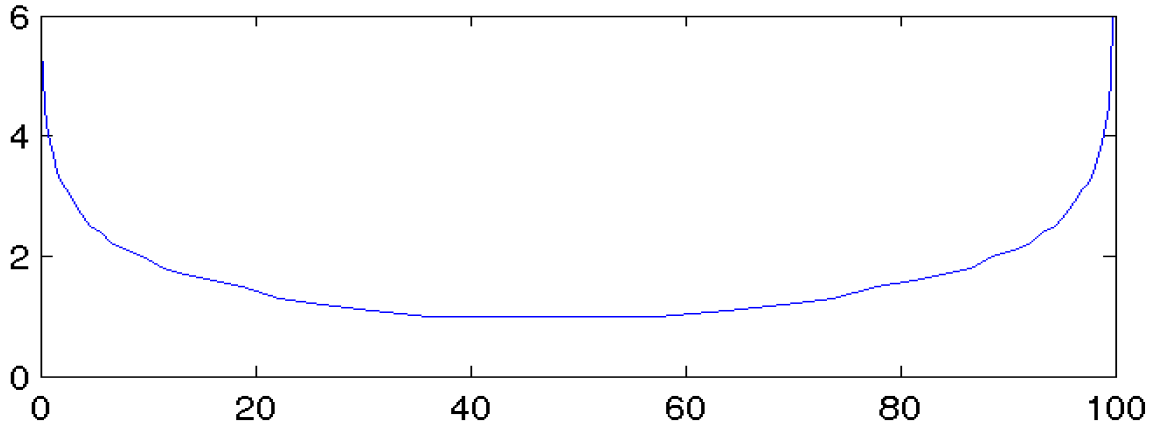
Computer Optimized Coating Distribution



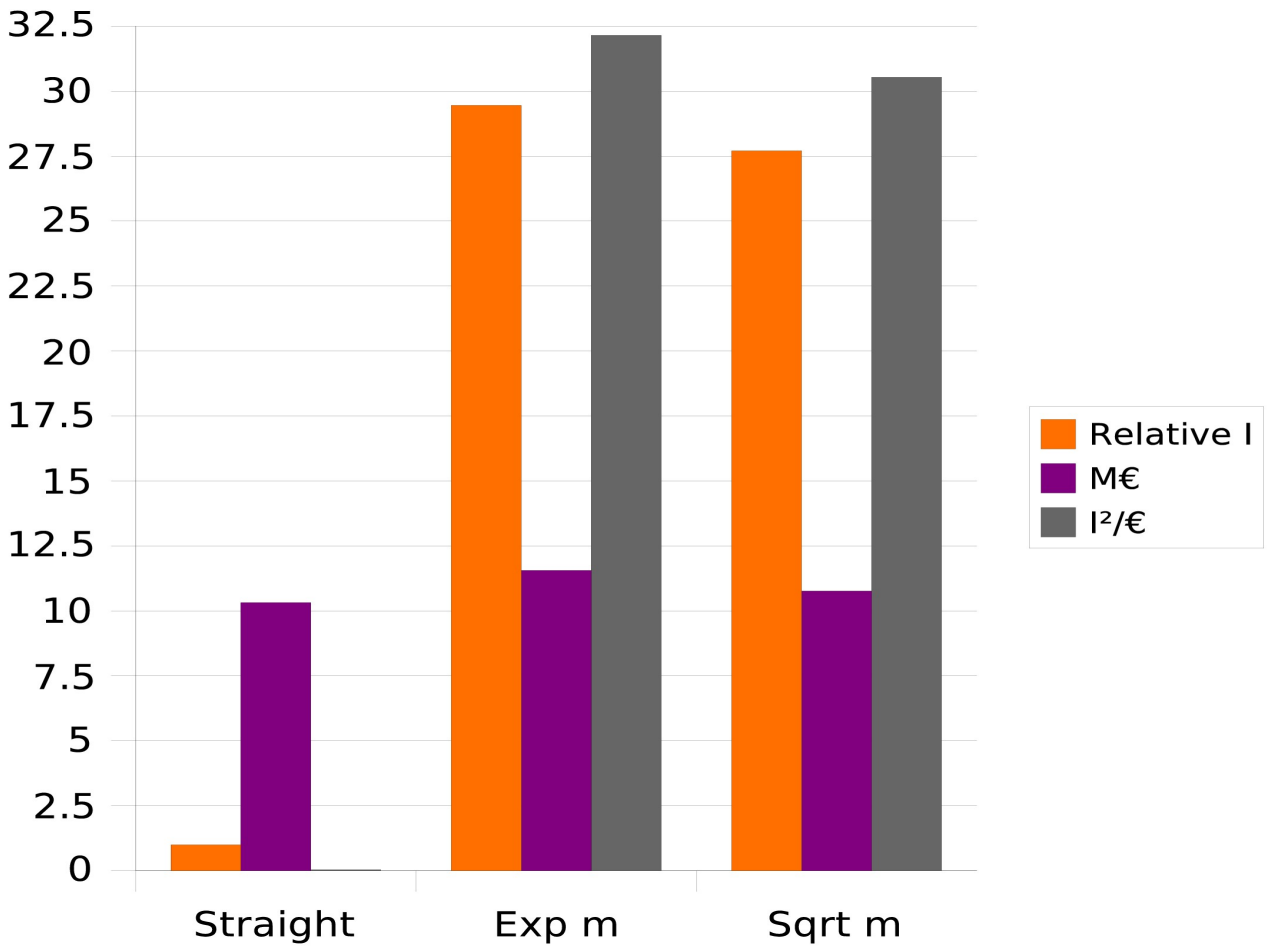


Refined Coating Distribution

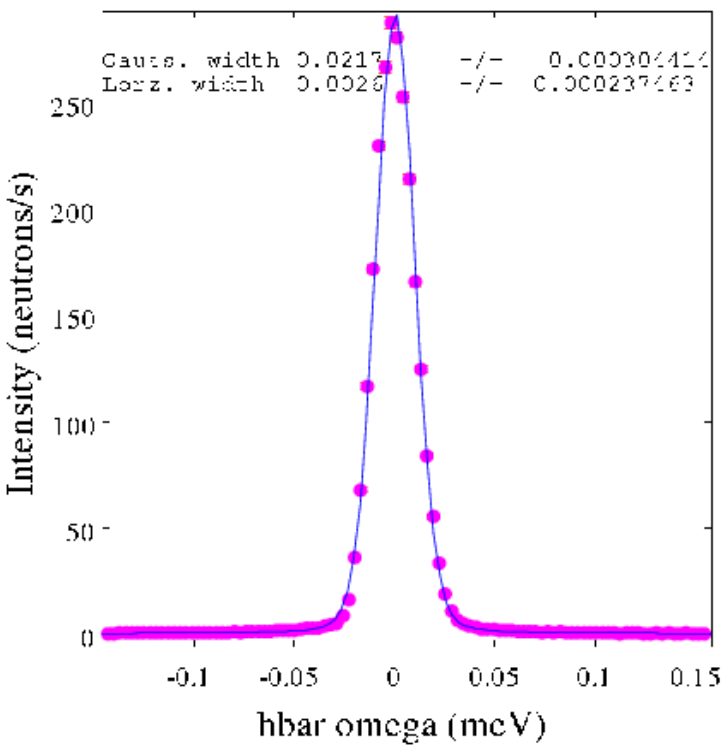




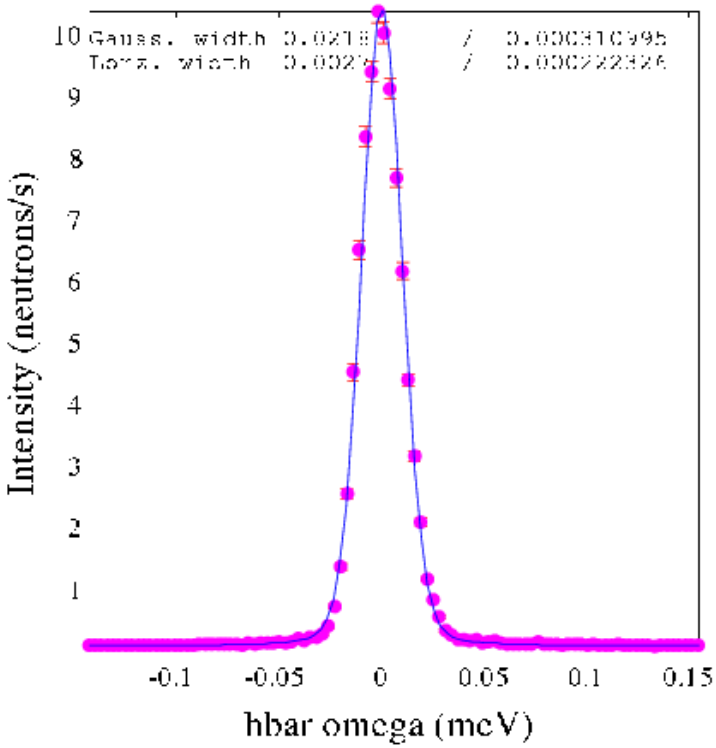
Even Better?


32.5
30
27.5
25
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
Straight
Exp m
Sqrt m
Relative I
M€
I²/€

A Full Virtual Experiment with McStas



Elliptical guide

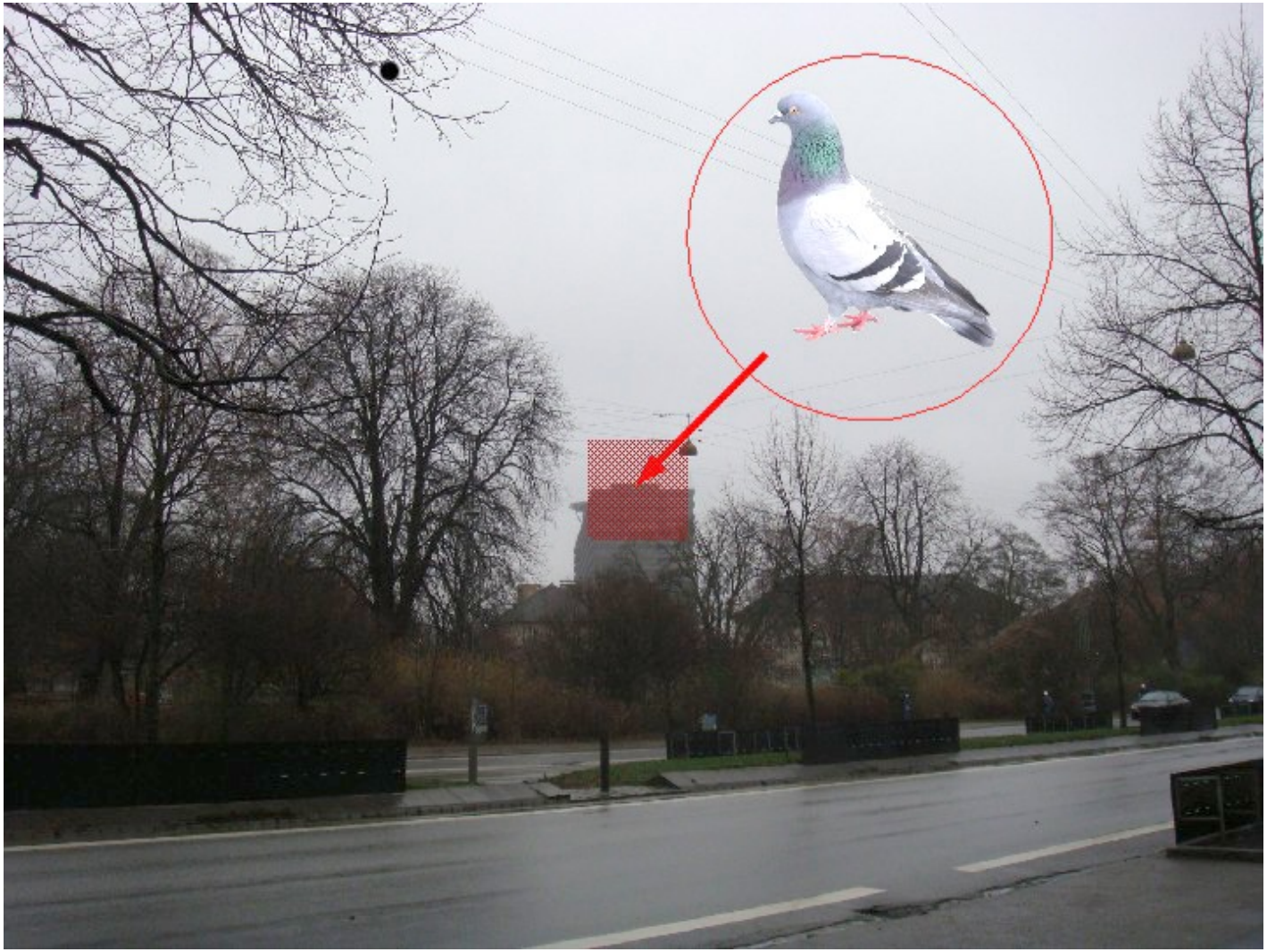


Straight guide

Conclusions

- Elliptic guides with non-uniform coating have 30x superior transmission compared to straight guides, over both 100 m and 300 m distances.
- This can be achieved with a cost increase of only 5 %.

1 in 8 neutrons hits the target over 300 m!



Thank you!

Collaborators:

Kim Lefmann, University of Copenhagen
Peter K Willendrup, Risø, Technical University of Denmark
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Emmanuel Farhi, Institut Laue-Langevin