# Toward a Fast Simulation of Photon Transport in a PD Bar

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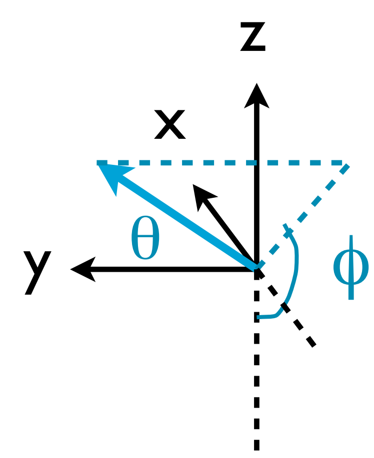
20 February, 2013

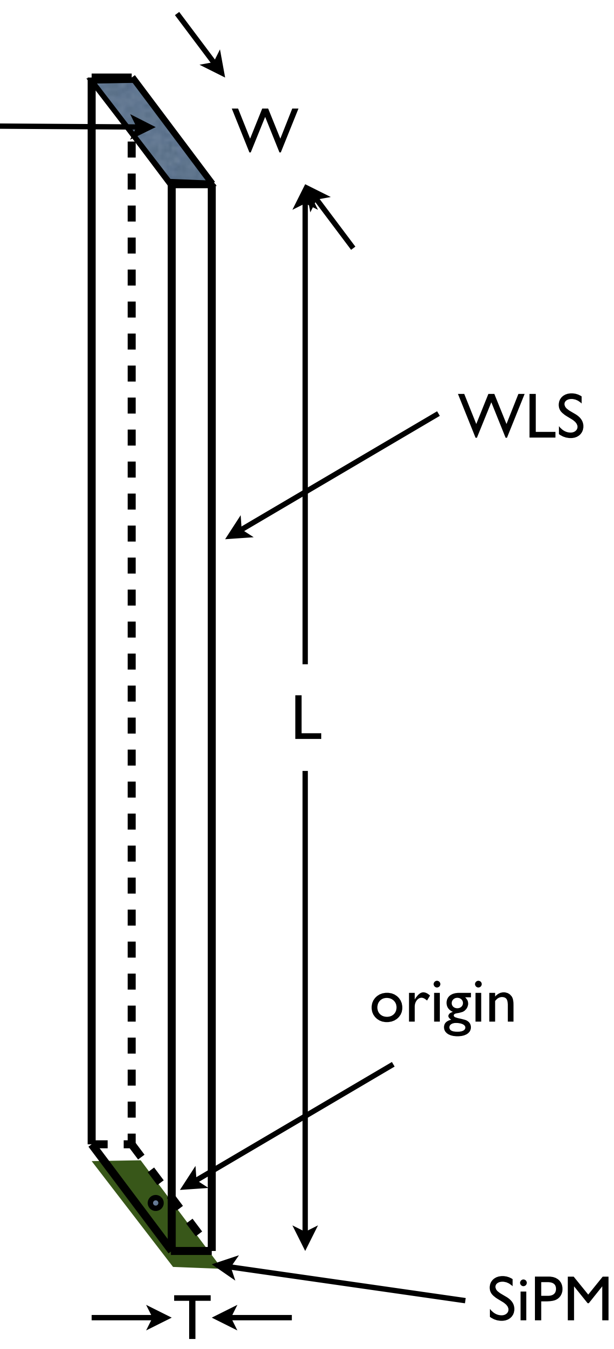
- **Overview**
- **First Results**
- **Prospects**

# Task

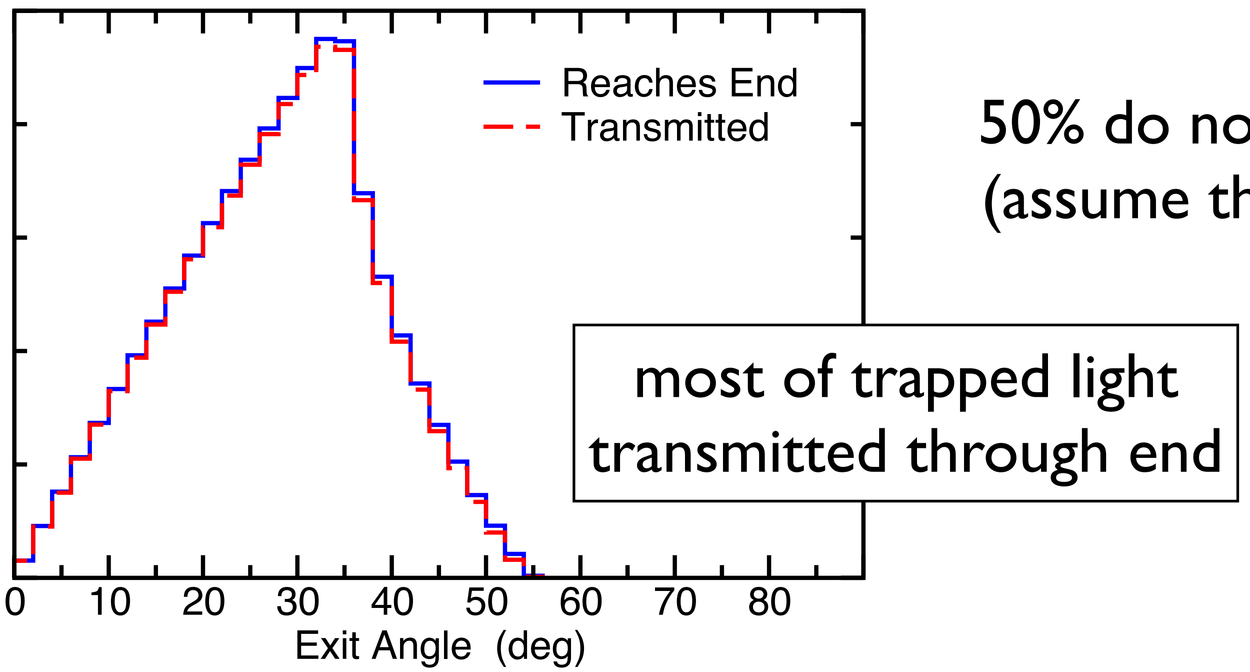
Determine the probability that a photon emitted by the WLS is detected, as a function of z

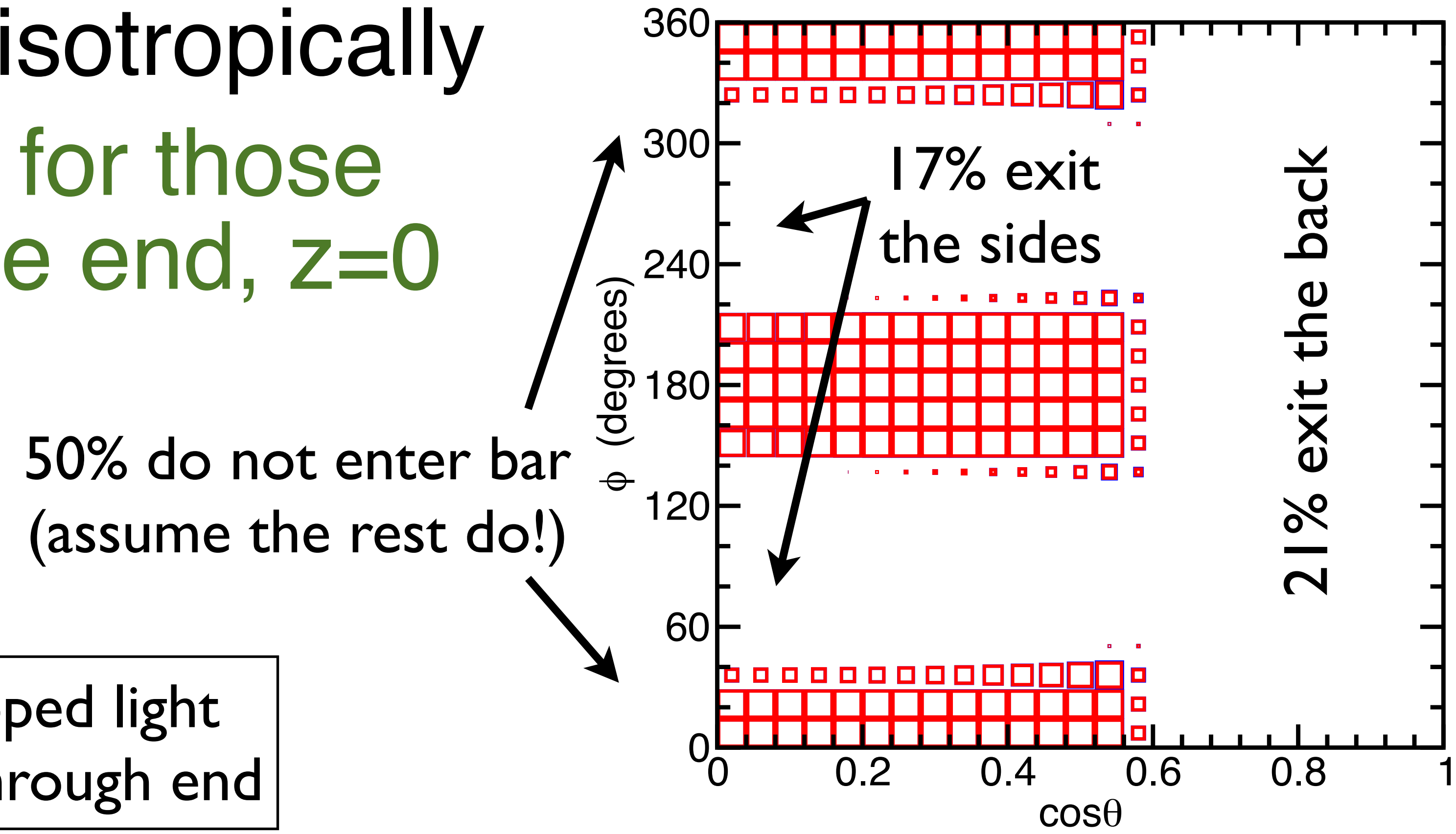
- Method:
  - → dust off some old code
  - → adapt to this application
- This is ~a fast simulation
  - → test against real sim, understand both
  - → fast turnaround for design studies
- Assumptions for today:
  - → rectangular acrylic bar immersed in LAr
    $n_{bar} = 1.495$, $n_{LAr} = 1.22$
    $\Rightarrow \theta_{critical} = 54.7°$
  - → L = 225 cm, W = 2.54 cm, T = 0.496 cm

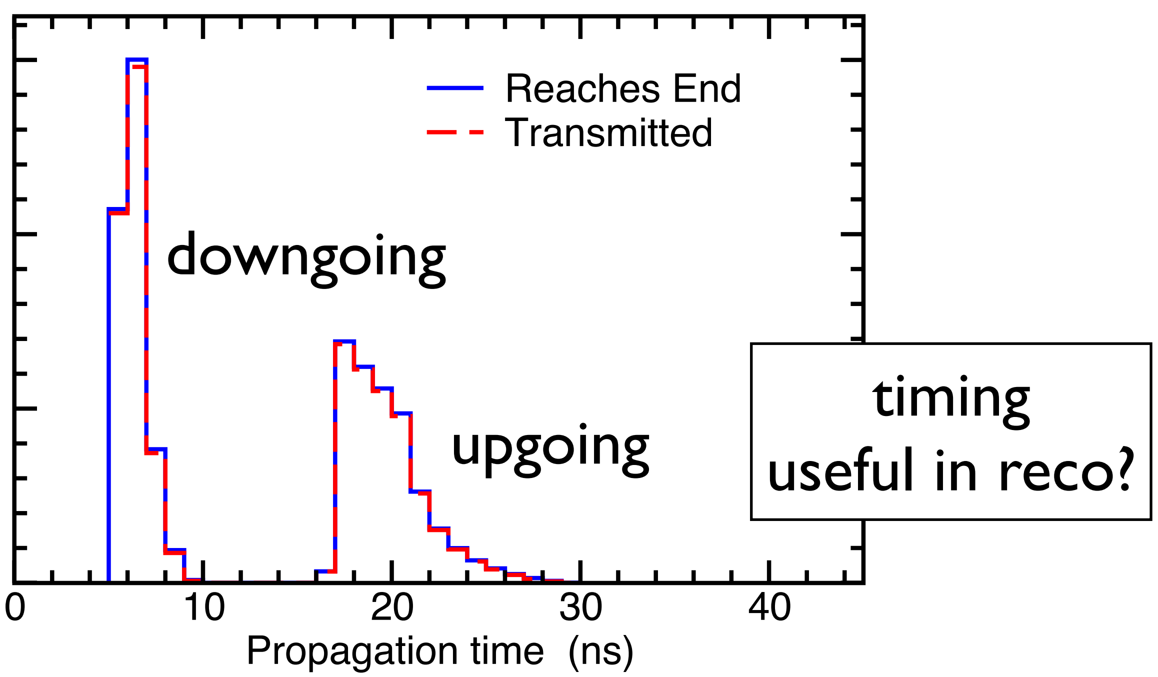


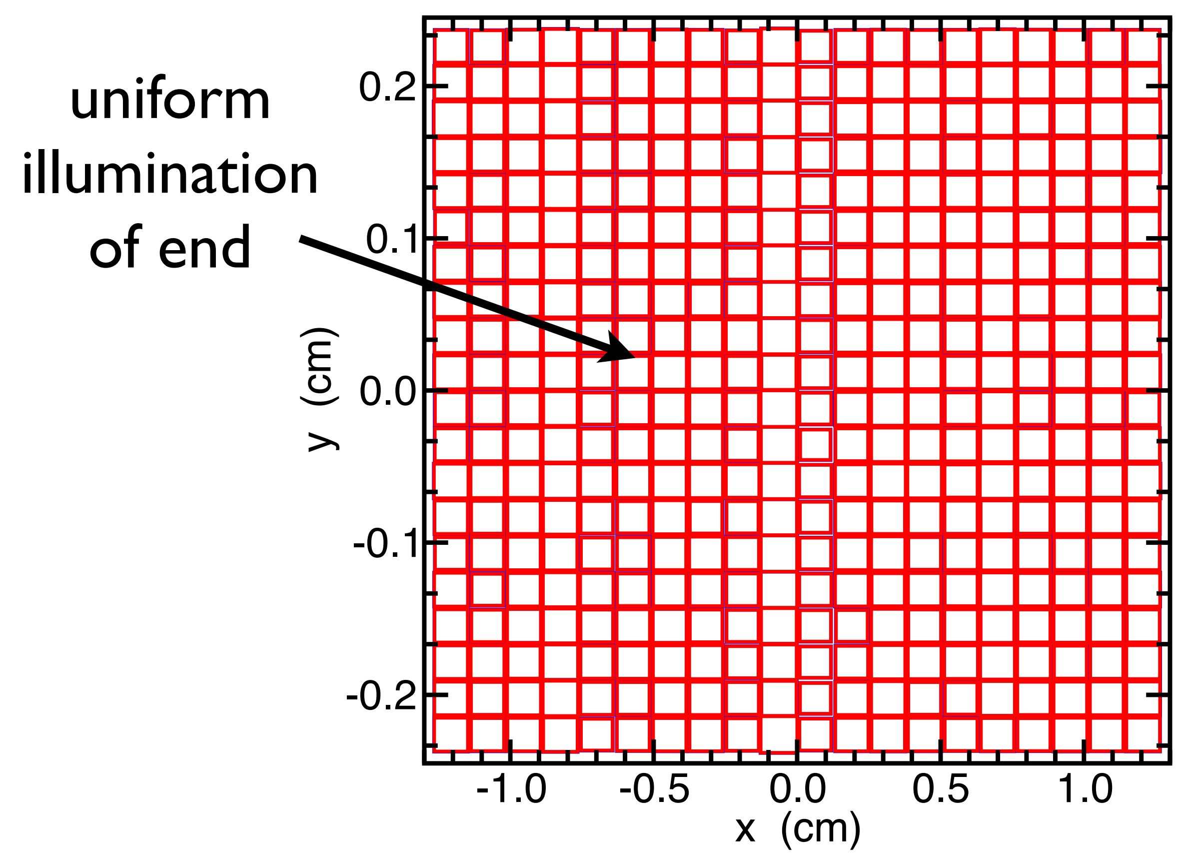



- Consider a perfect bar
  - → take a point about halfway along the bar (0,−T/2,110)
  - → generate photons isotropically
  - → some distributions for those reaching (exiting) the end, z=0

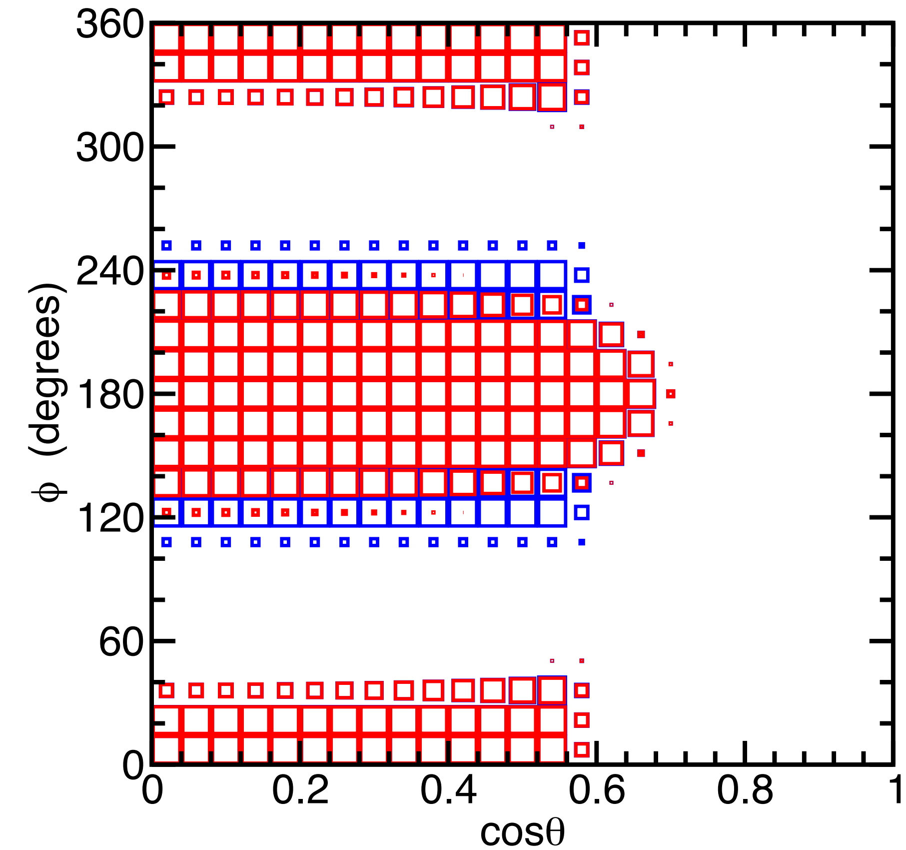


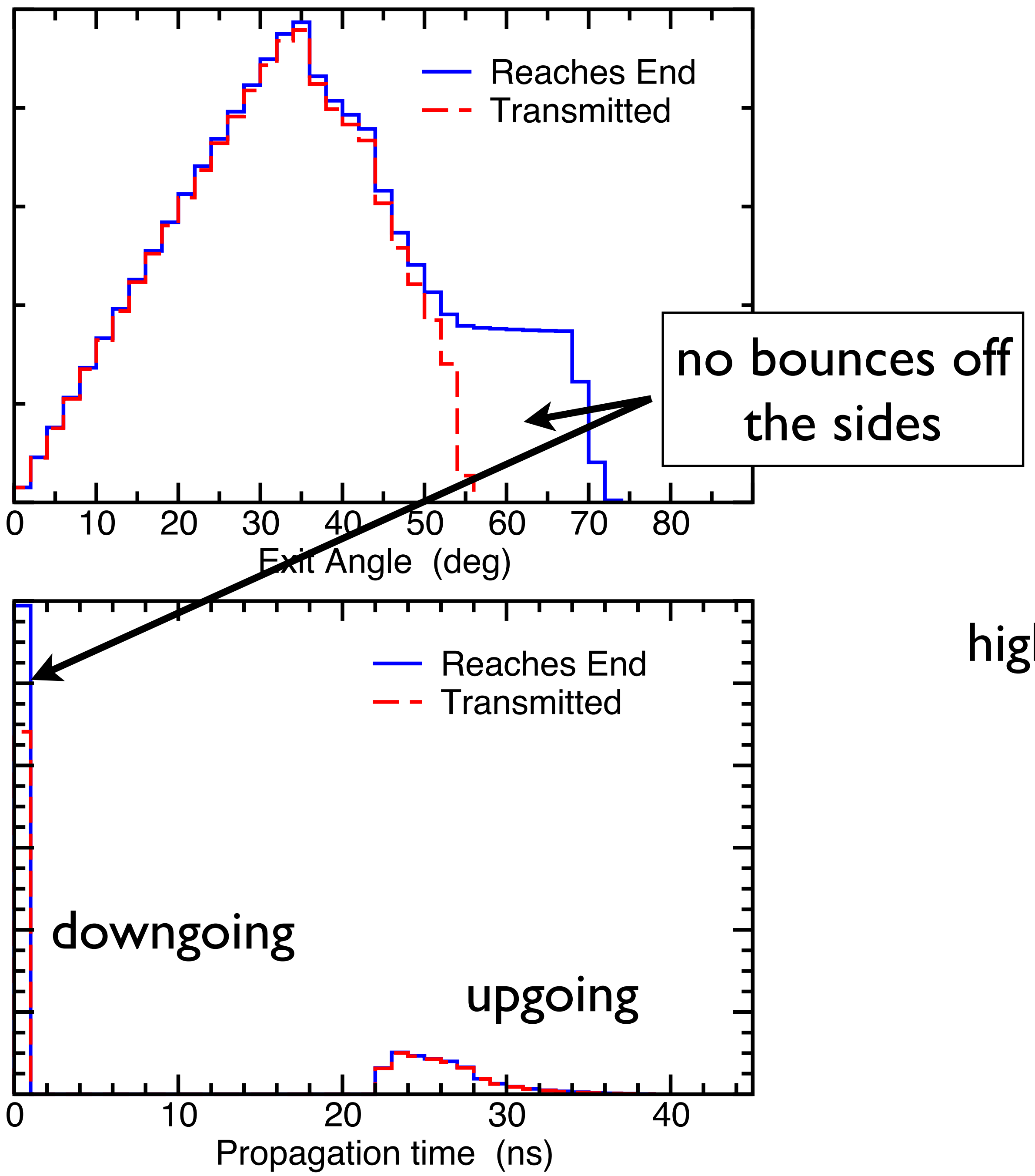



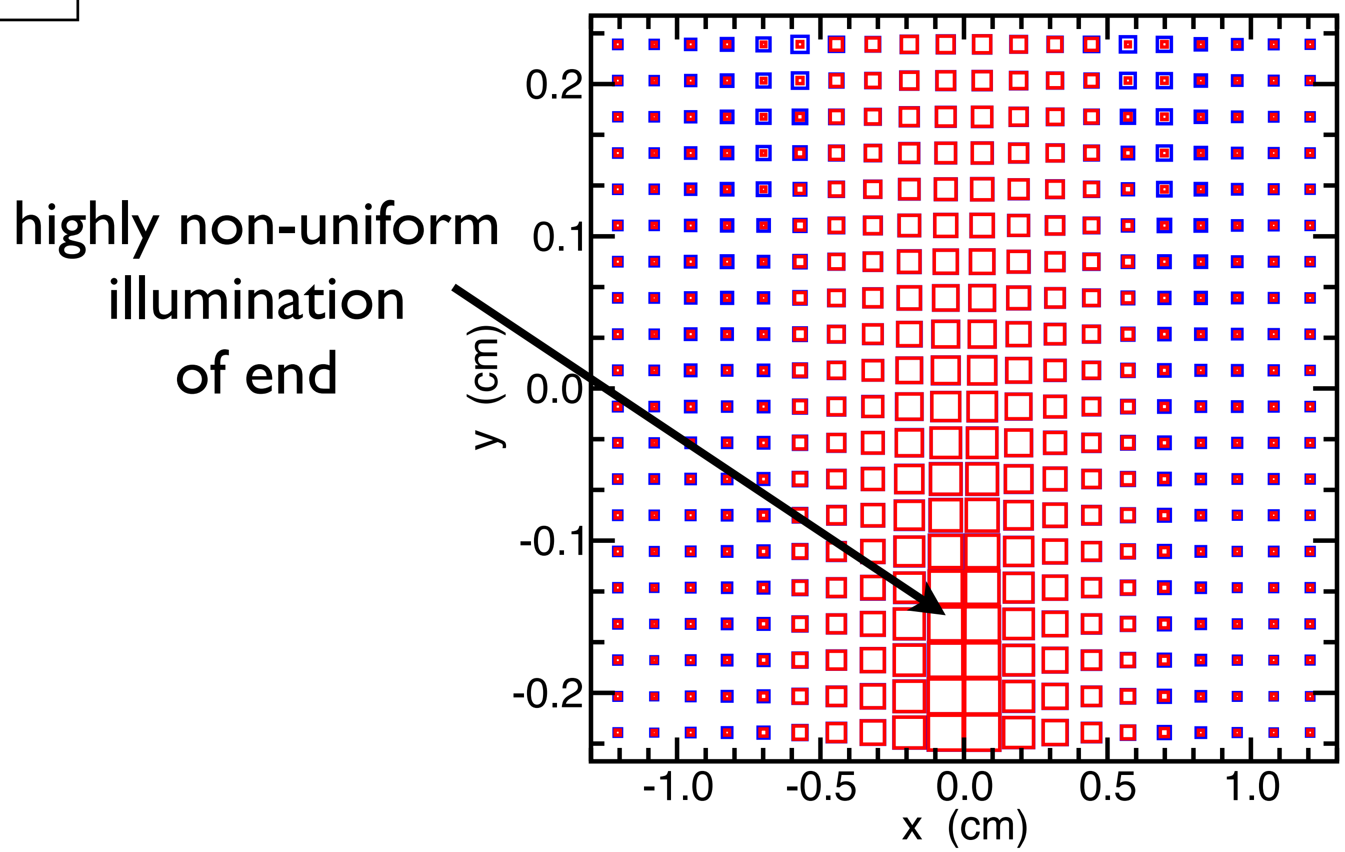



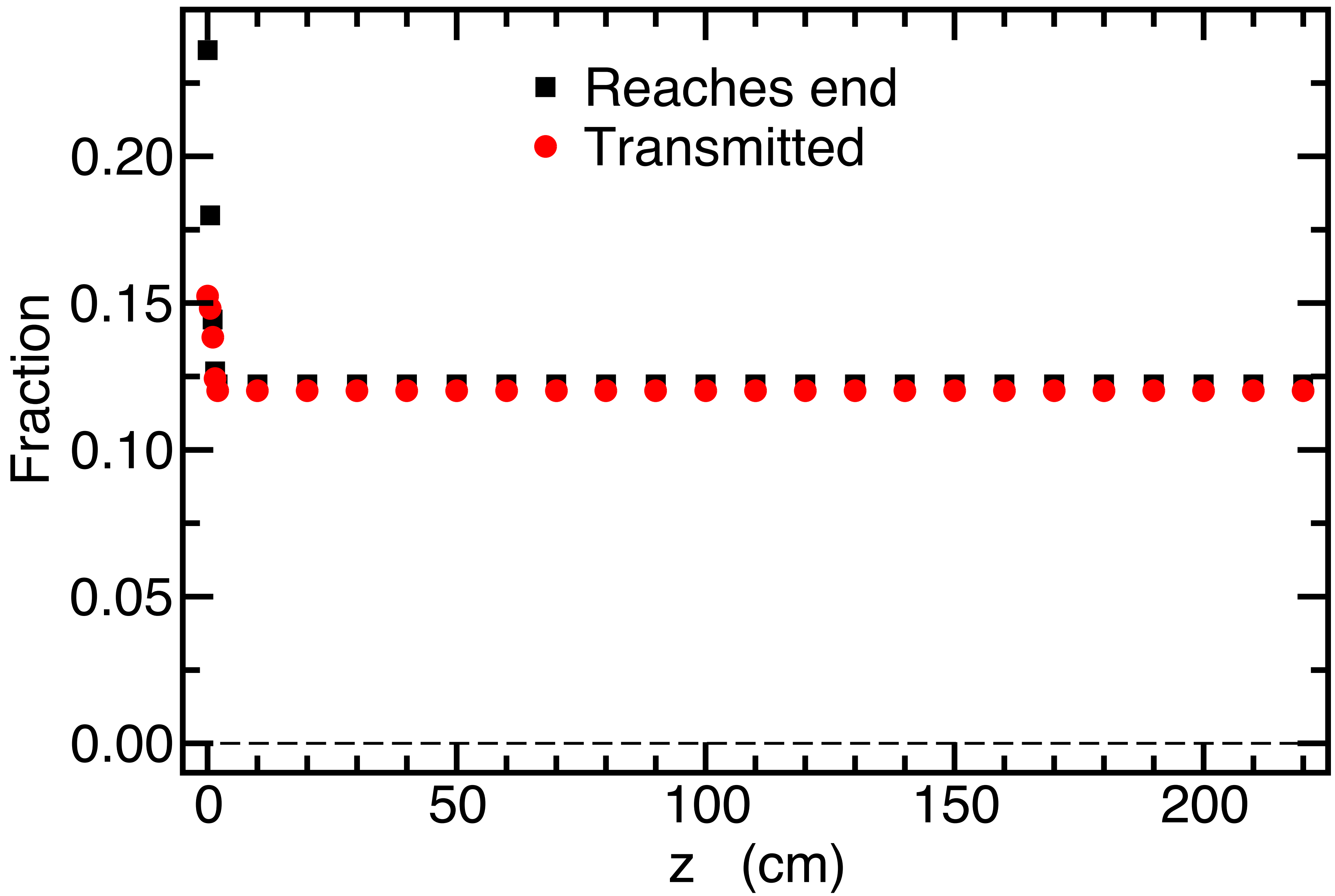
- Consider a perfect bar
  - → move to a point close to the end (0,−T/2,0.5)
  - → generate photons isotropically
  - → some distributions for those reaching (exiting) the end, z=0



- total efficiency vs. z:




Q=116
114

# detected rel. to WLS-coated SiPM of area WxT

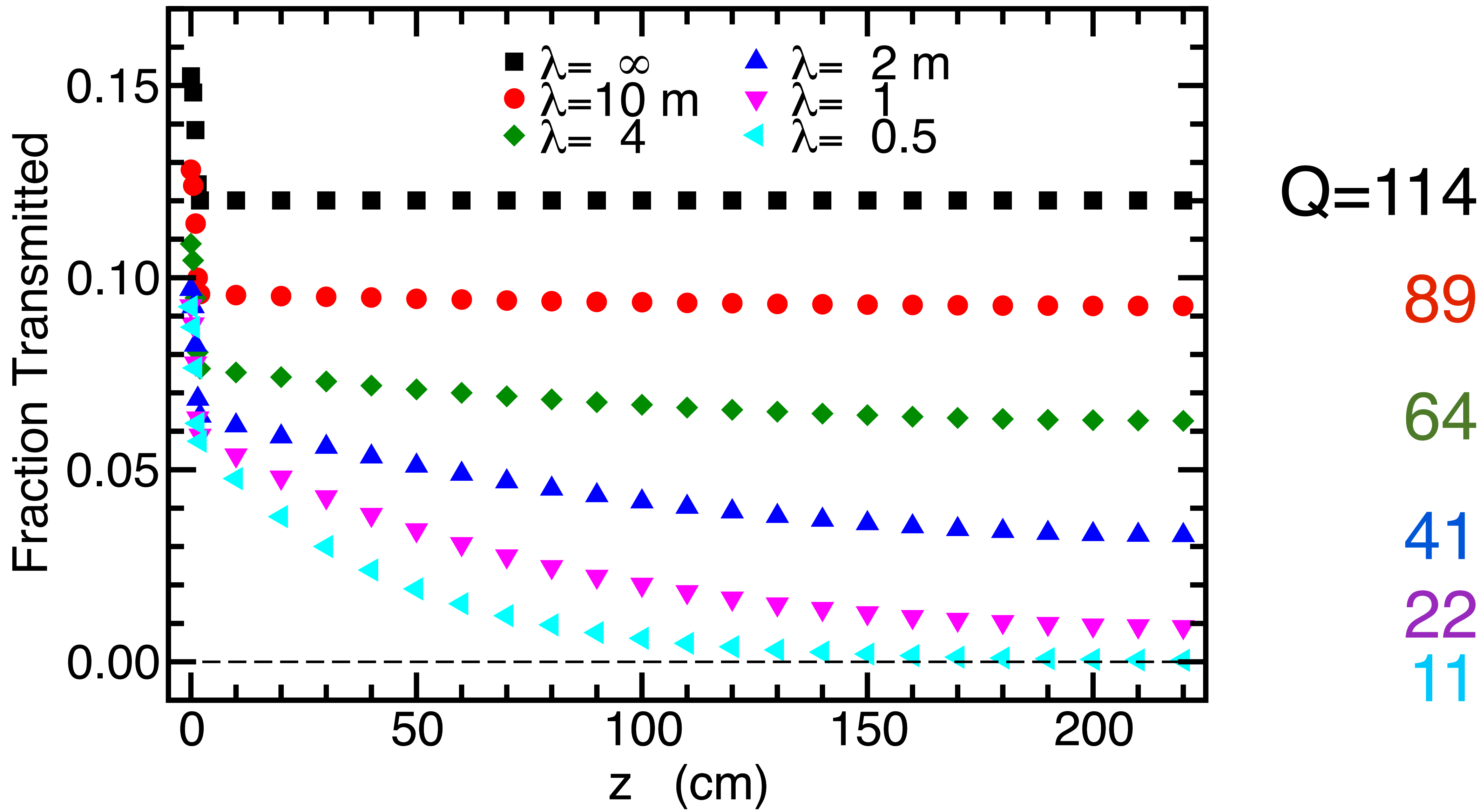
→ about 12%

→ z-dependence very small for z>2T

→ small loss in transmission through end for z>2T

→ from here on, take red points as reference

- now add a finite bulk absorption length:



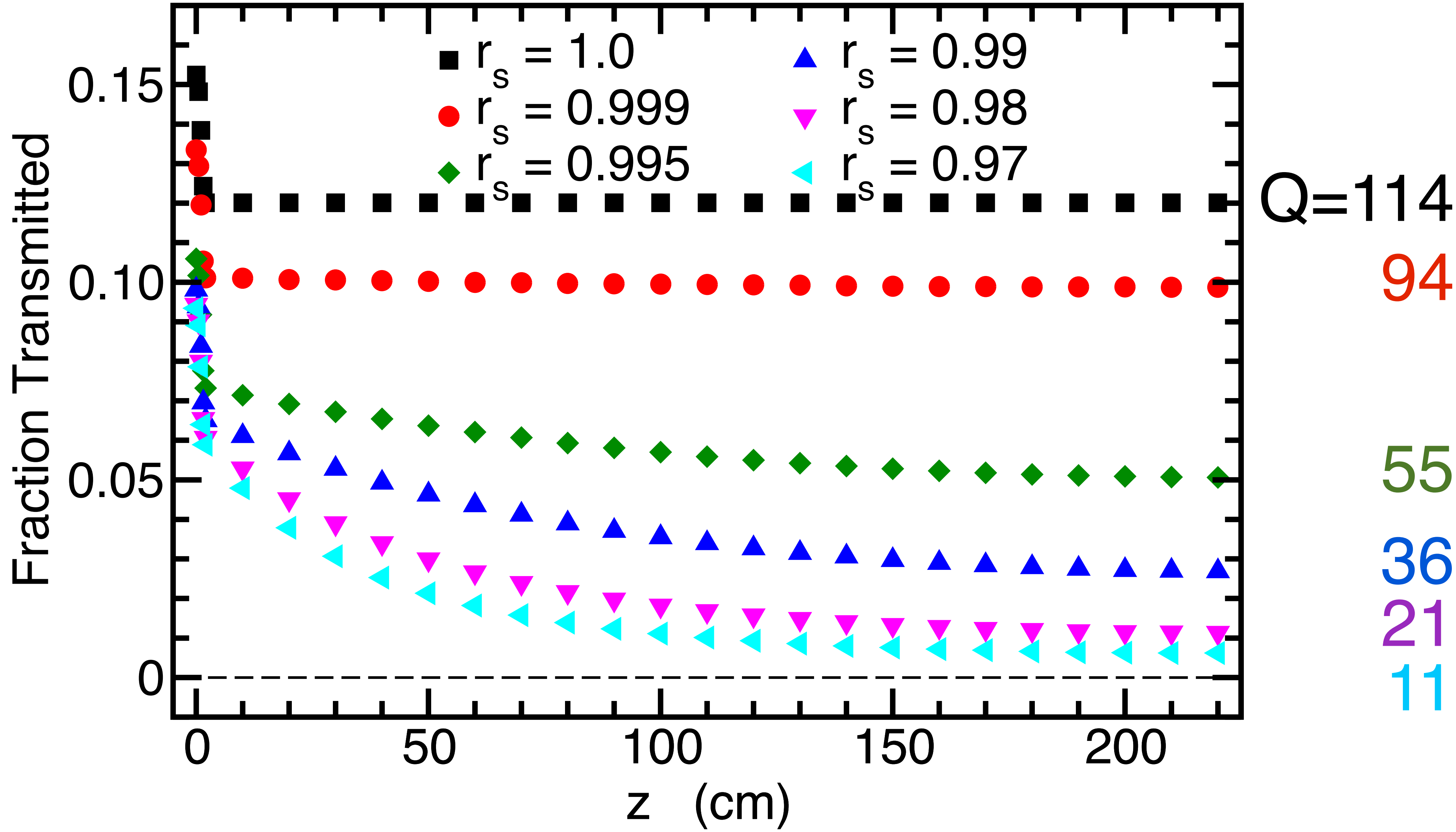

→ loss is substantial even for long λ

→ z-dependence small for λ>2L, param with line

→ but large for λ<L, param needs 2-3 exponentials

→ need clearest possible acrylic

- or finite reflectivity off the sides:




→ loss is substantial even for very high $r_s$

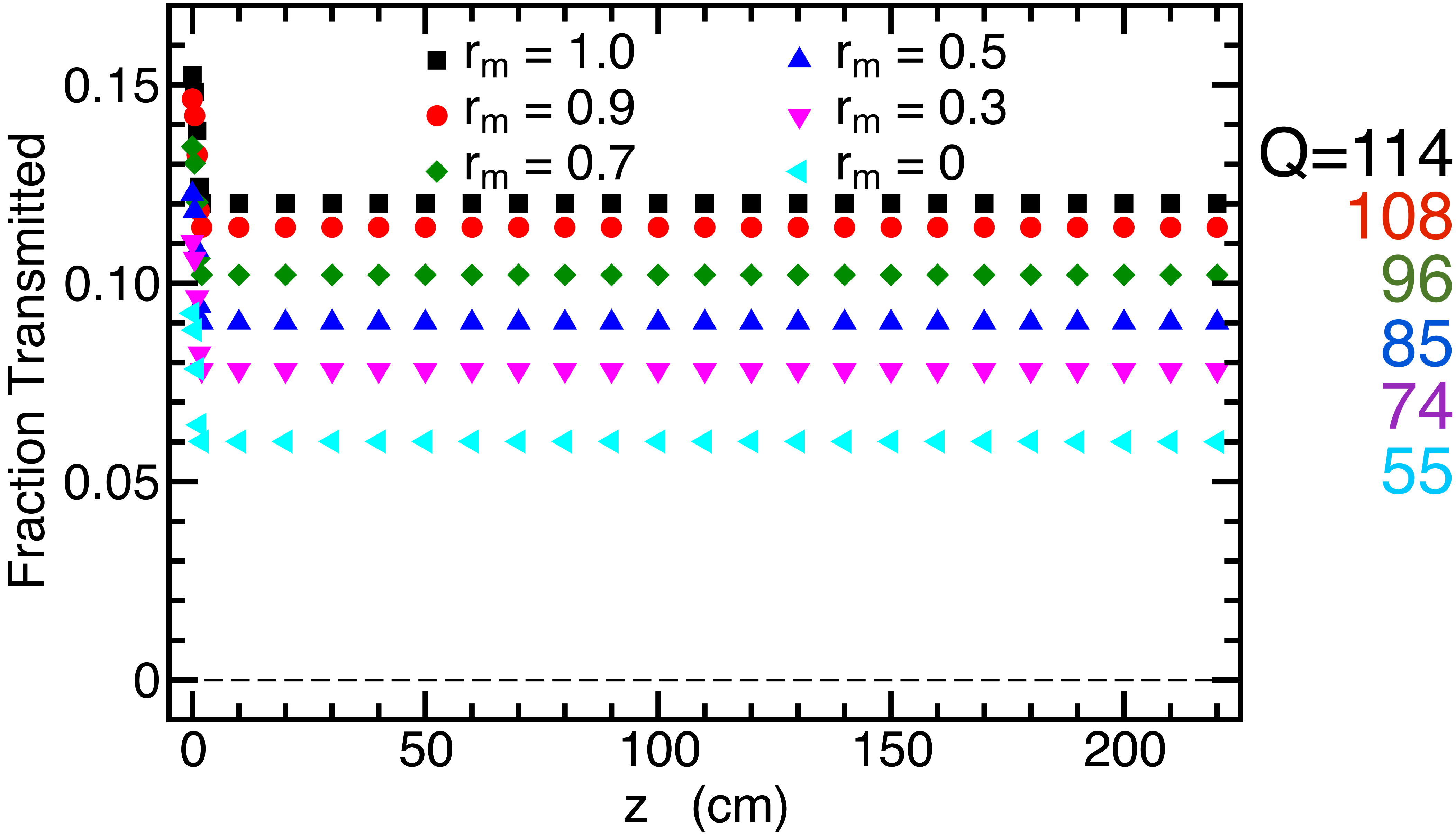
→ z-dependence small if typical # of bounces $<1/(1-r_s)$

→ both increase rapidly as $r_s$ decreases

→ ...though it flattens at high z – harder to param

→ need nicest possible acrylic surface

- or finite reflectivity off the mirror:



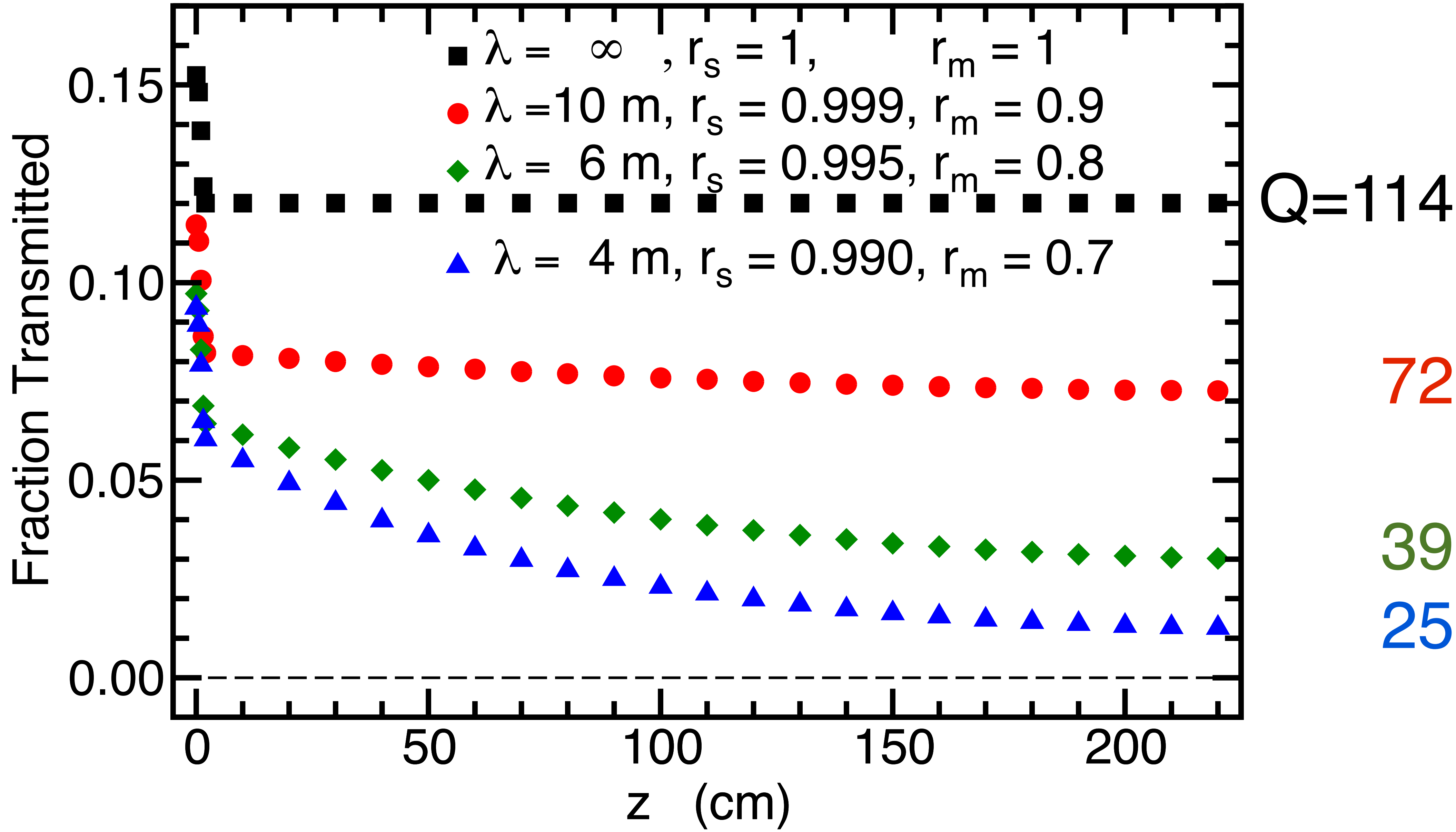

→ for perfect $\lambda$, $r_s$, loss is $(1-r_m)/2$ (except for low z)

→ … with no z-dependence, easy to param

→ becomes relatively less important as $\lambda$, $r_s$ decrease

→ put modest effort into mirror

- of course, these things add up:
  - → a few random examples

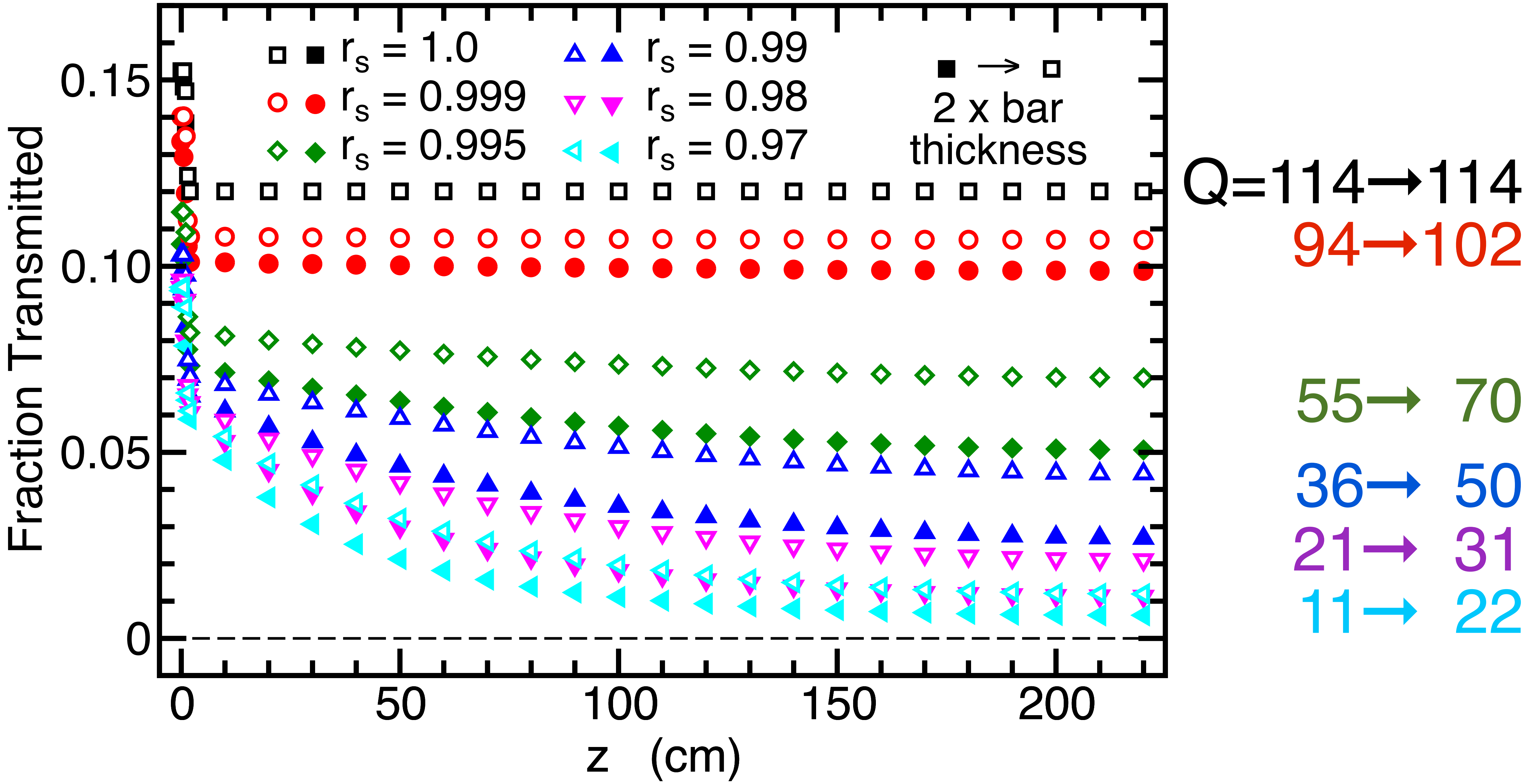



→ generally fairly rapid variation at low z

→ … flattening at higher z

- what if we change the bar thickness?

→ affects number of bounces; for perfect λ, $r_m$, T→2T




→ no effect for $r_s$=1

→ the relative effect increases rapidly with decreasing $r_s$: 10% at $r_s$=0.999

→ 2x for $r_s \gtrsim 0.97$

# Summary

- decent start on a fast sim for photon transport
  - → need correct/appropriate input values
  - → welcome your input, requests for studies, improvements, etc.
  - → need to test against a real simulation
- can turn on / implement:
  - → different front/back/side reflectivities
  - → WLS spectrum/dispersion
  - → (small) scattering in bulk, at surfaces
- not (yet) considered:
  - → WLS efficiency, chance of photon entering bar
  - → SiPM efficiency
  - → number of photons reaching the WLS