nHCal July 8, 2025

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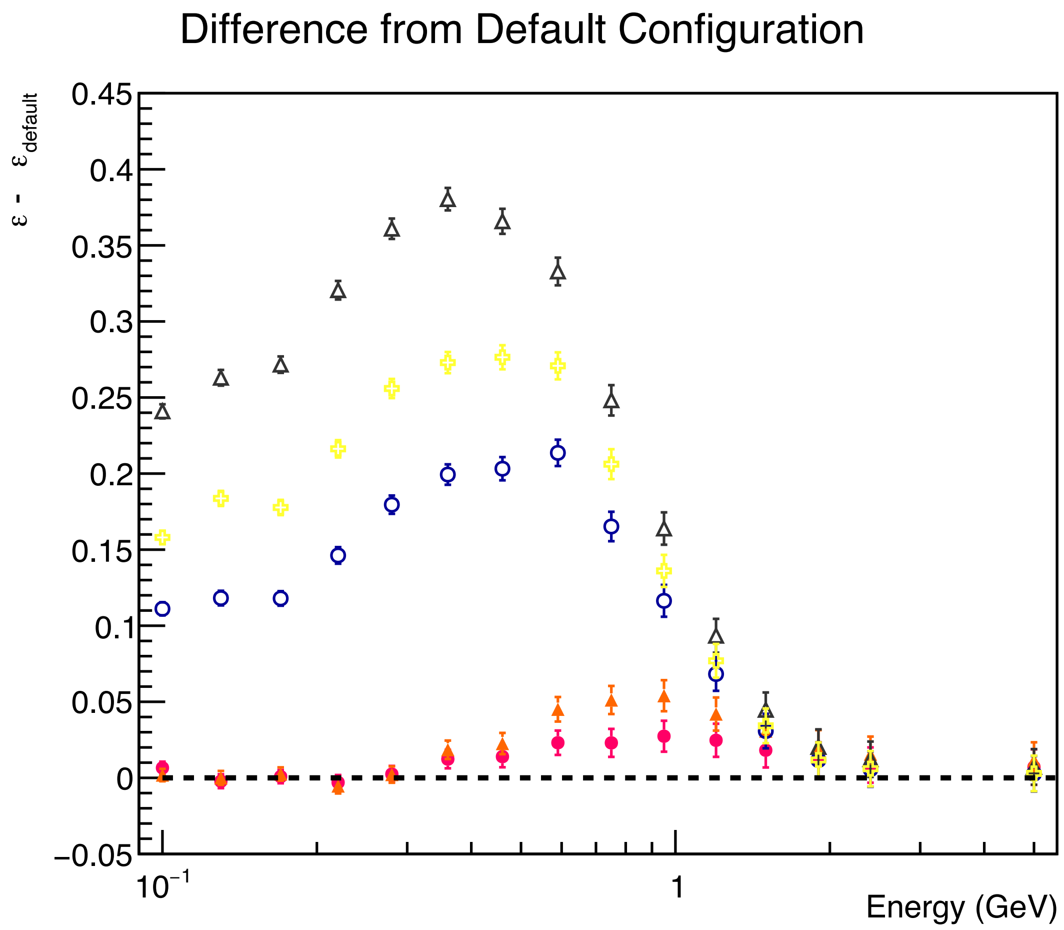
Optimizing nHCal Configuration

From my previous study:

- Changing $R = \frac{L_{sci}}{L_{abs}}$ has the largest effect on neutron detection efficiency.
- Number of layers has an important, but much smaller effect.



Default: R=0.1

- 12 layers, 4 cm abs., 4 mm sci., 10x10 cm tiles
R=0.1

- 15 layers, 4 cm abs., 4 mm sci., 10x10 cm tiles
R=0.1

- 20 layers, 2 cm abs., 4 mm sci., 10x10 cm tiles
R=0.2

- 20 layers, 2 cm abs., 8 mm sci., 10x10 cm tiles
R=0.4

- 25 layers, 1.52 cm abs., 4 mm sci., 10x10 cm tiles
R=0.26

Optimizing nHCal Configuration

We see a huge effect of increasing R, but we never saw a maximum!

Idea: find the **best** (most efficient for neutron detection) configuration by simulating on a grid of R and N_layers.

To do this, I need to pick:

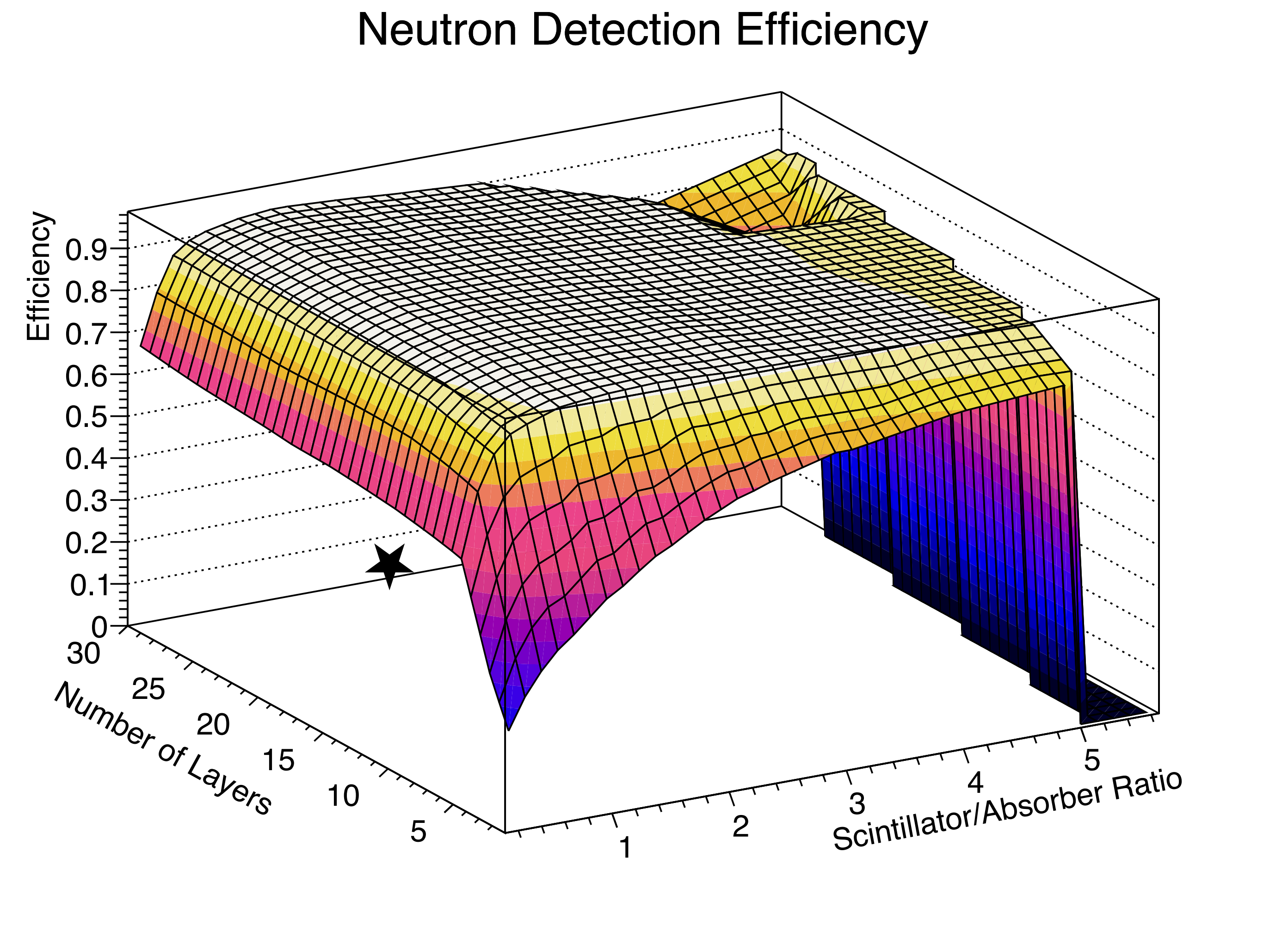
- Neutron energy=0.5 GeV to see largest difference between different R.
- Total depth of the detector: 65 cm
  - Increased from "default" design with 44 cm.

Results

Black star is the "Default" configuration: 4cm abs, 0.4cm sci, 10 layers.

Remember: $R = \frac{L_{sci}}{L_{abs}}$.

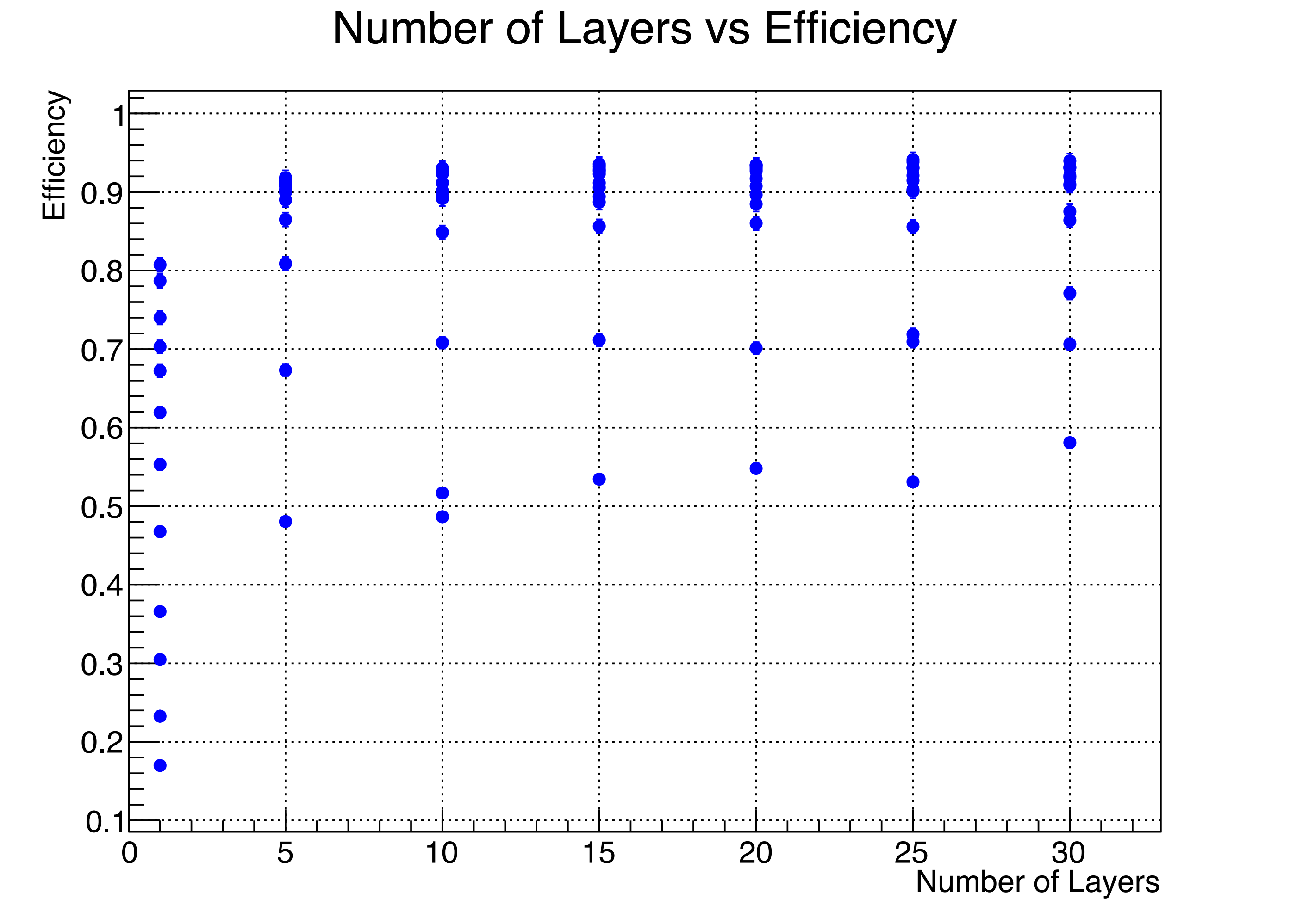
When $R = 1$ they have *equal* lengths, not 100% scintillator!



Results in 1D (N_layers)

Weak dependence on N_layers above 10 layers.

To really optimize this, I should pick a different neutron energy (N_layers has largest effect around 0.9 GeV).

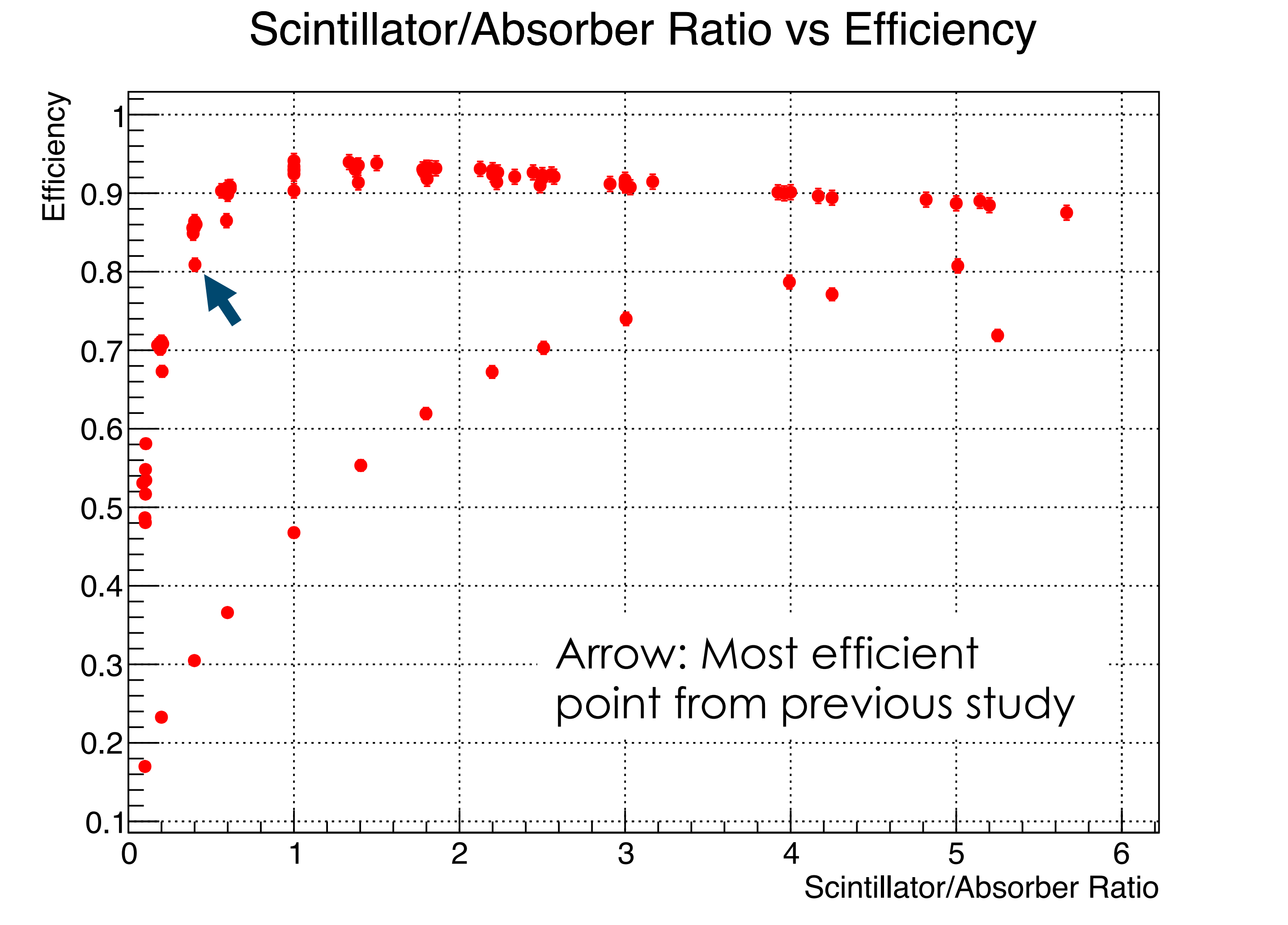


Results in 1D (R)

R dependence is quite strong.

Clustered points are the ones with the same R but different N_layers. Low efficiency curve is the 1 layer case.

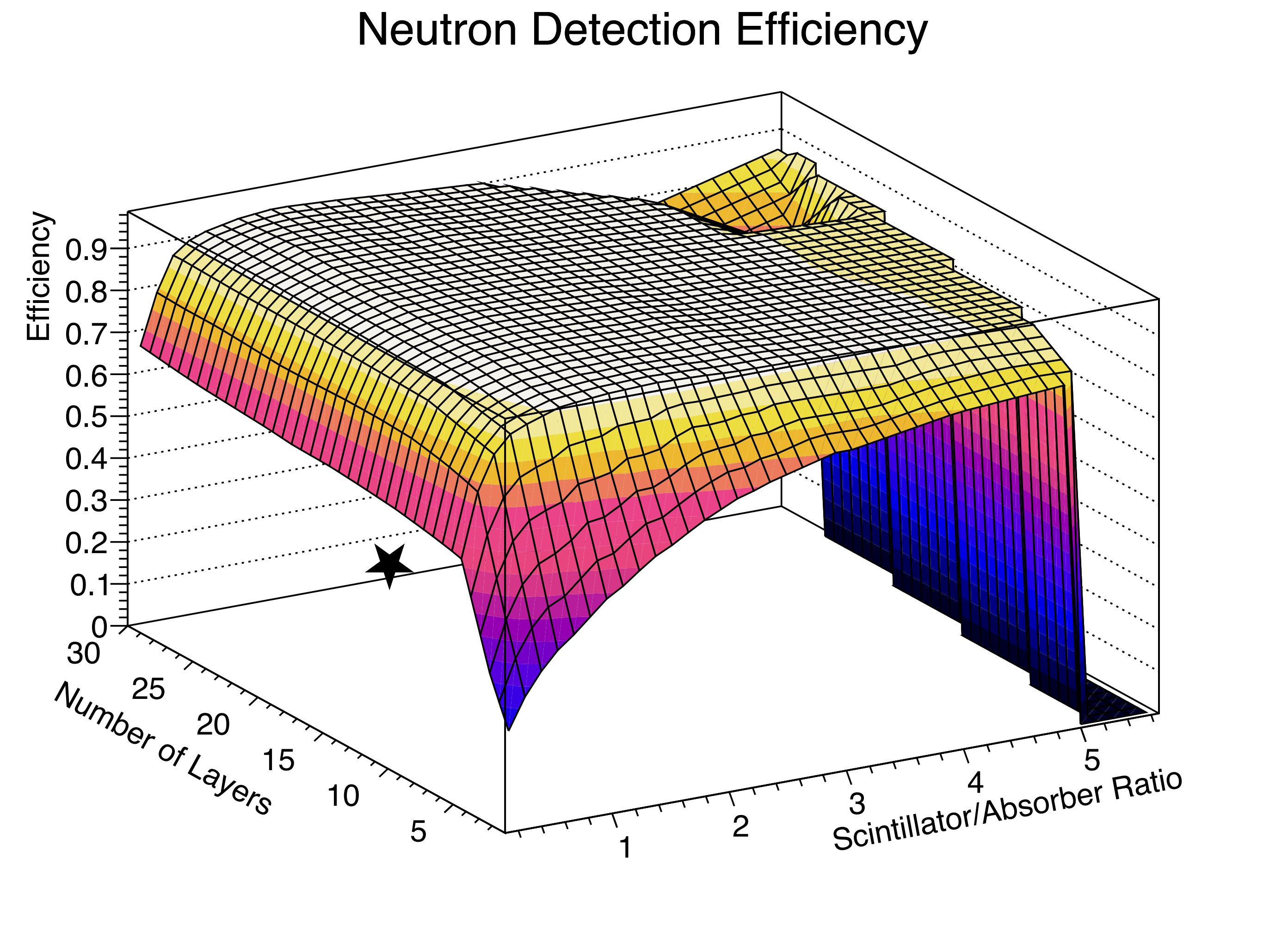
Maximum at $R \approx 1.5$!



Results

Best choice for neutron efficiency:

- **R=1.5**
- **N_layers=25**
- Depth=65 cm
- Absorber layer thickness: 1.0 cm
- Scintillator layer thickness: 1.5 cm
- 0.1 cm gap between layers
- **Efficiency: ≈ 94% at 0.5 GeV!**



37.5% less absorber than "default" design, even with 50% longer detector!

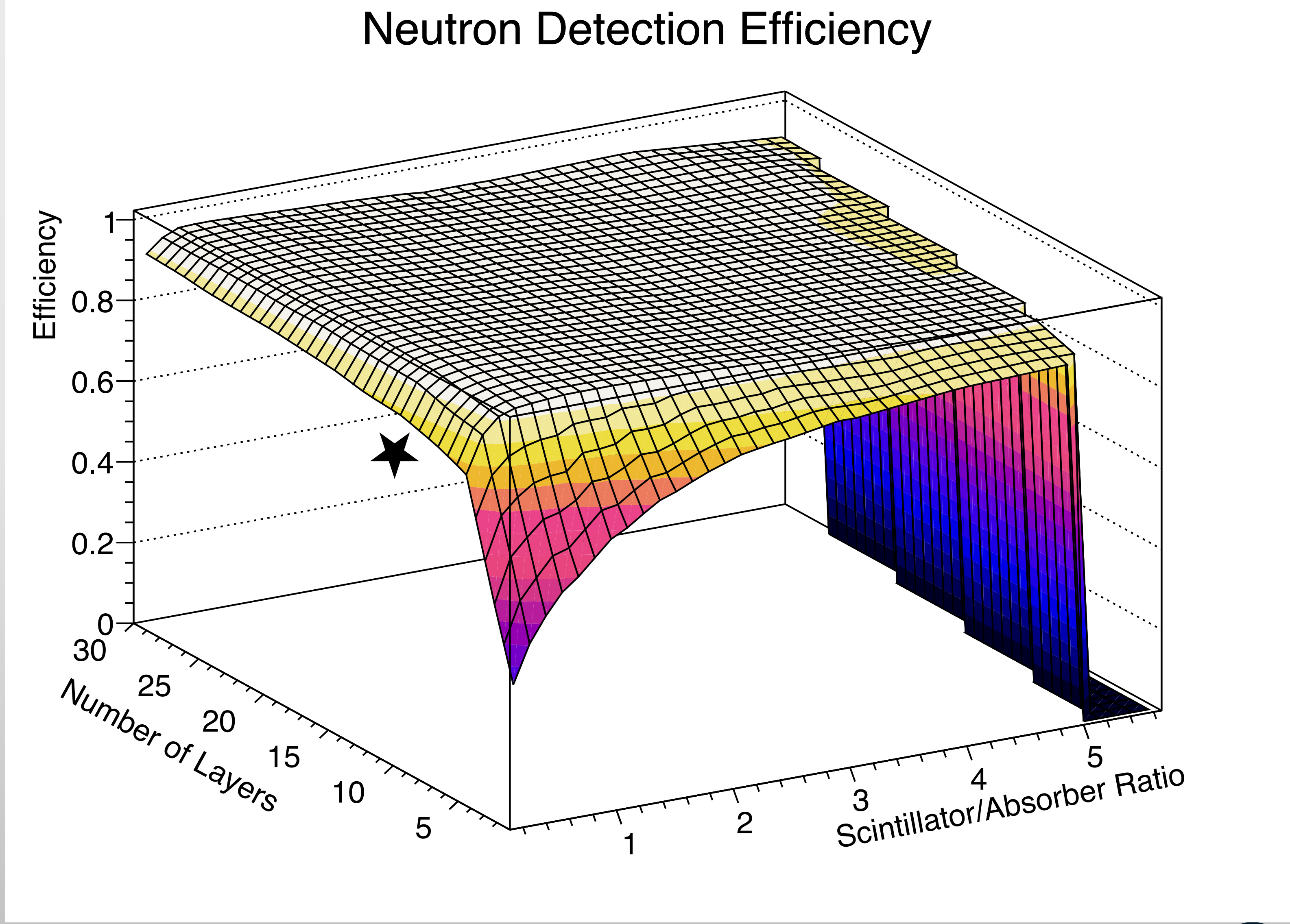
Next Step: Repeat for 0.9 GeV neutrons

Same plots for 0.9 GeV neutrons.

More layers→more efficient.

Largest impact for lower R

The difference is negligible above 10 layers for $R \geq 0.6$



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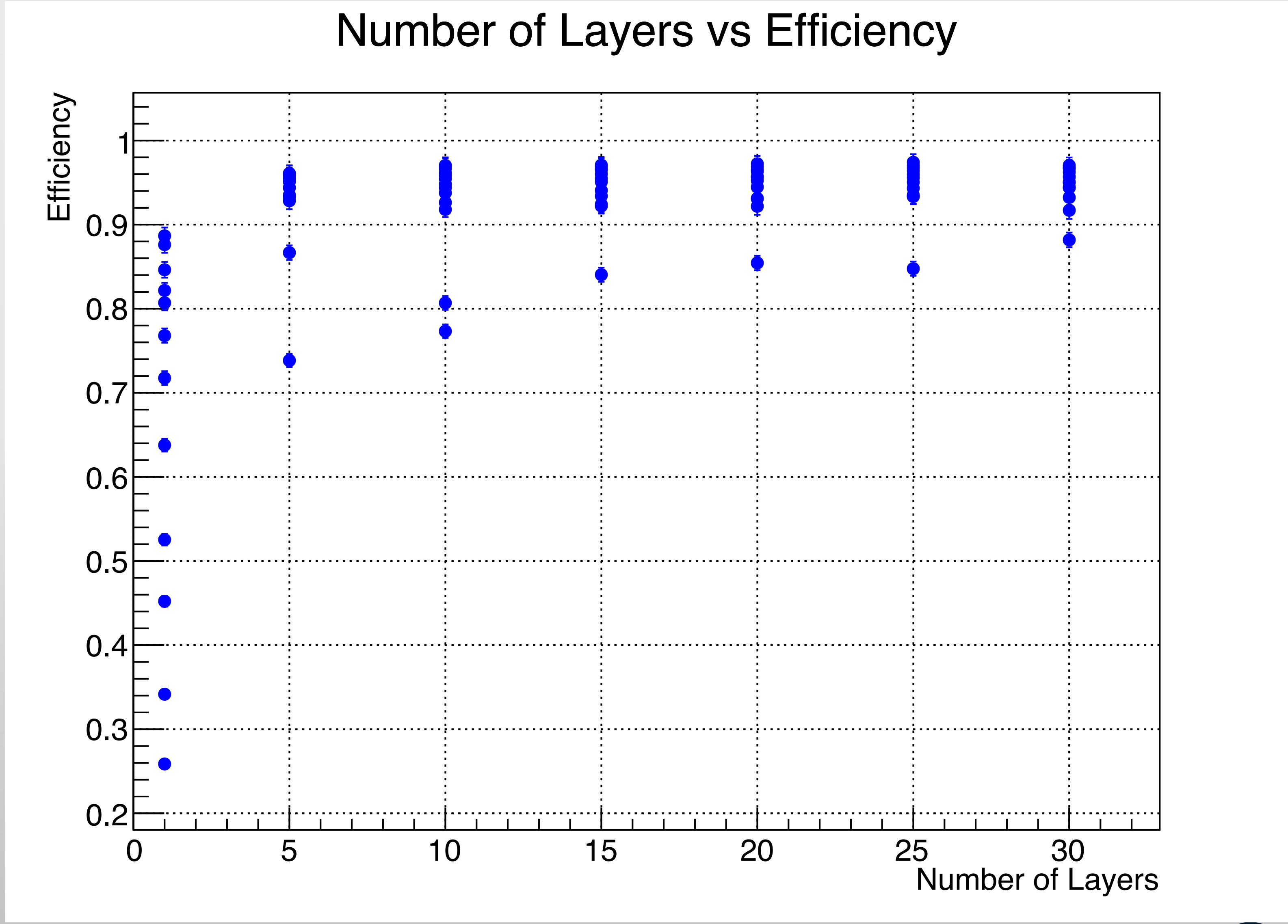

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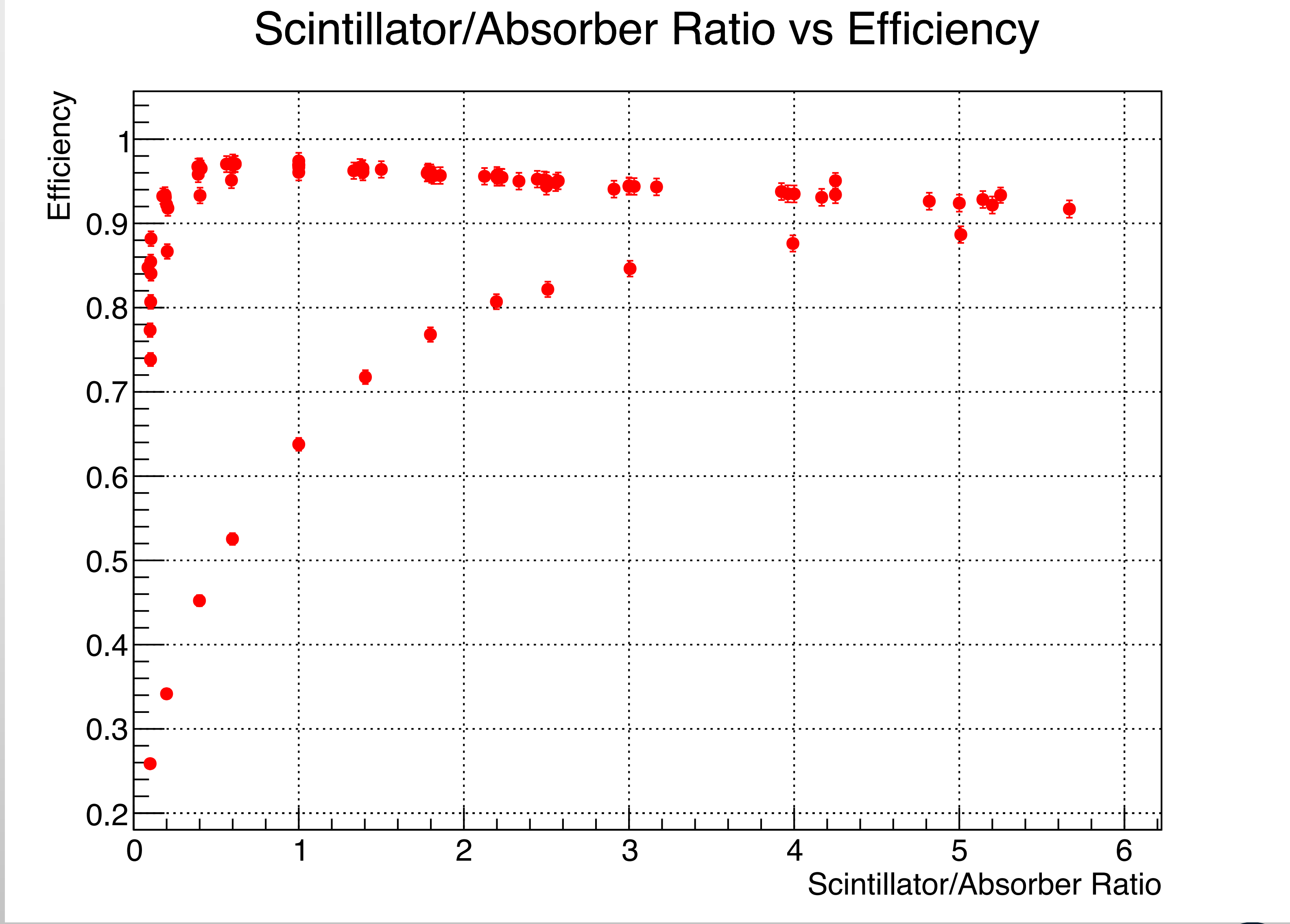

Bottom line: anything with 10 or more layers and $\mathbf{R \geq 0.6}$ has a $\mathbf{\geq 90\%}$ efficiency for 0.5 GeV neutrons

Next step:

- Get efficiency vs. energy for this geometry.
- Collect some more optimization criteria and find the geometry that