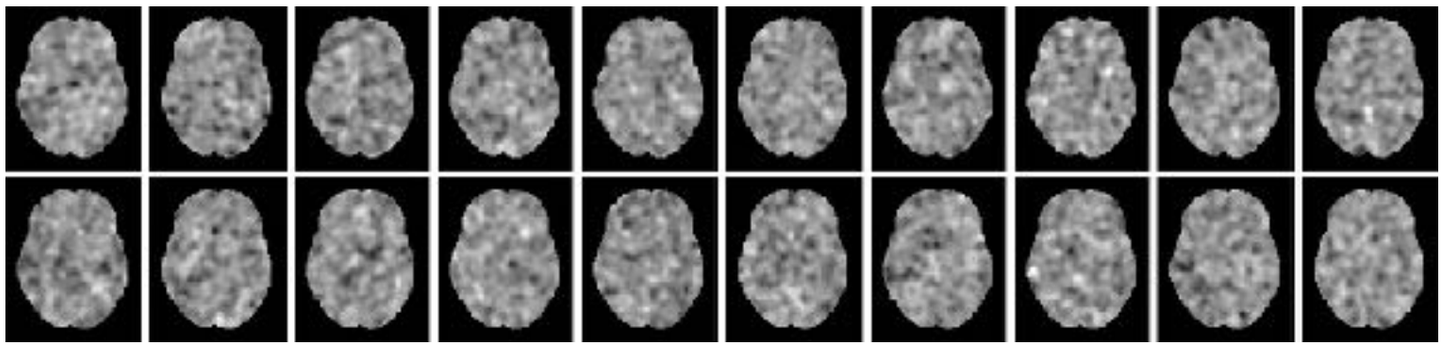
Inference

how surprising is your statistic? (thresholding)

But ... can I trust it?

Family-wise error

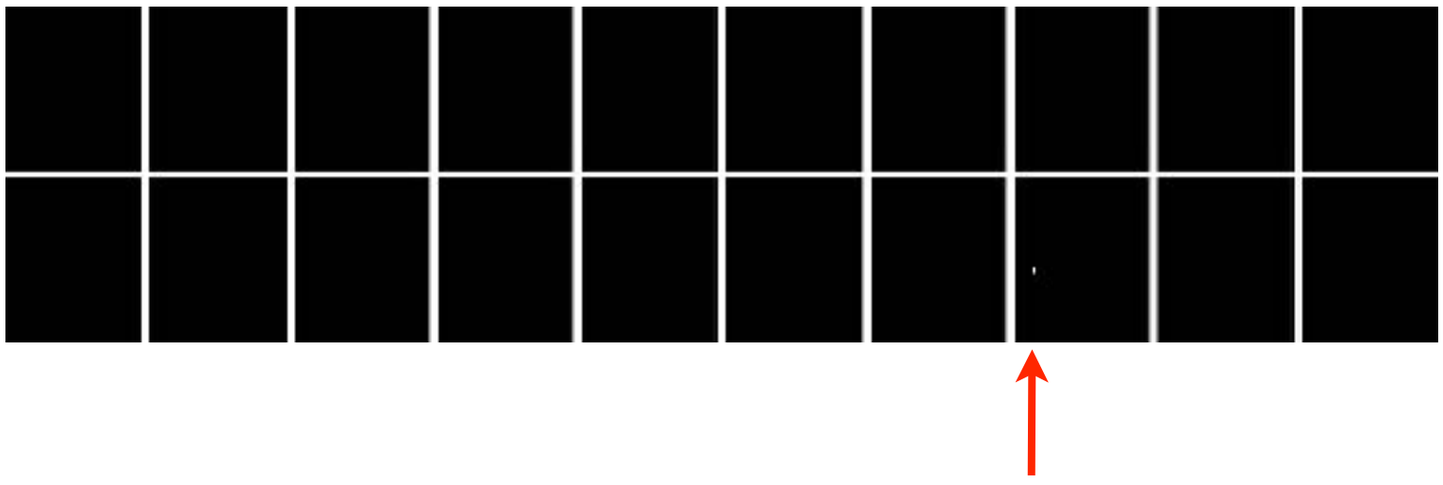
Let's say we perform a series of identical studies



Each *z*-map is the end result of a study

Let us further say that the null-hypothesis is true

We want to threshold the data so that only once in 20 studies do we find a voxel above this threshold



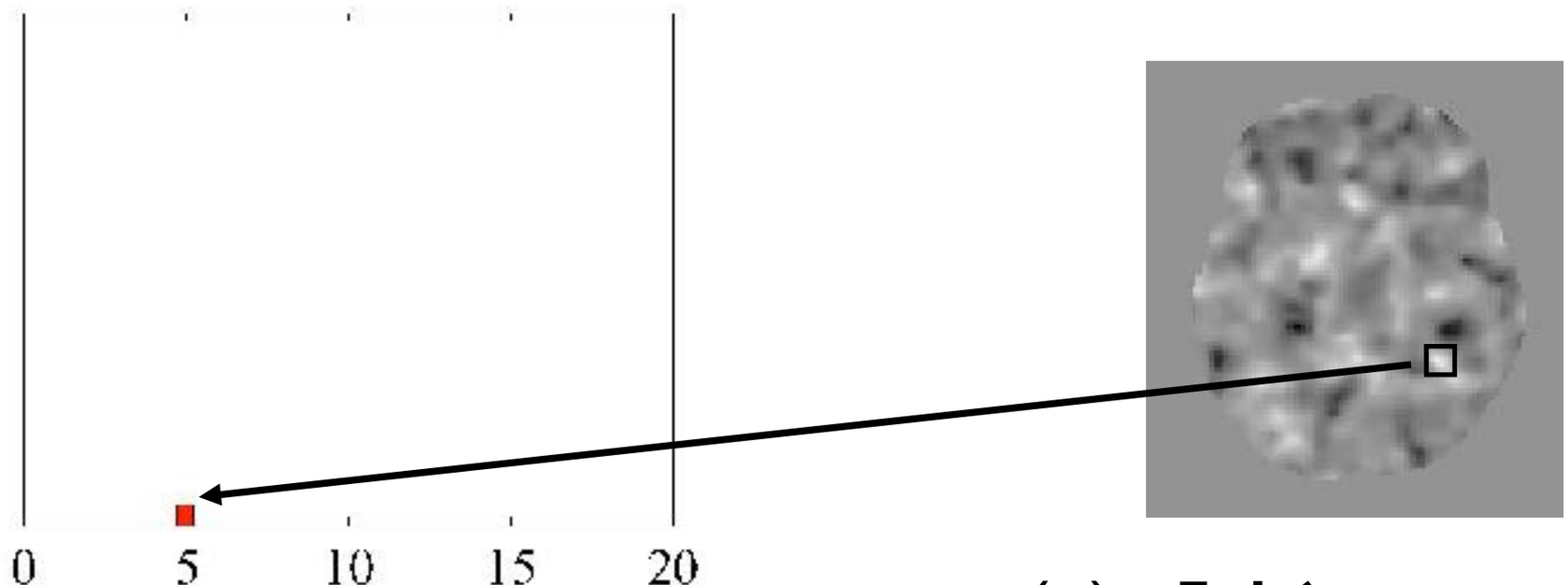
But how do we find such a threshold?

Outline

- Null-hypothesis and Null-distribution
- Multiple comparisons and Family-wise error
- Different ways of being surprised
  - Voxel-wise inference (Maximum z)
  - Cluster-wise inference (Maximum size)
- Parametric vs non-parametric tests
- Enhanced clusters
- FDR - False Discovery Rate

Maximum z

- When we want to control "family-wise error", what do we in practice want?
- If the null-hypothesis is true (no activation) we want to reject it no more than 5% of the time.
- And if we reject anything, we will definitely reject the most "extreme" value (max(z)) in the brain.



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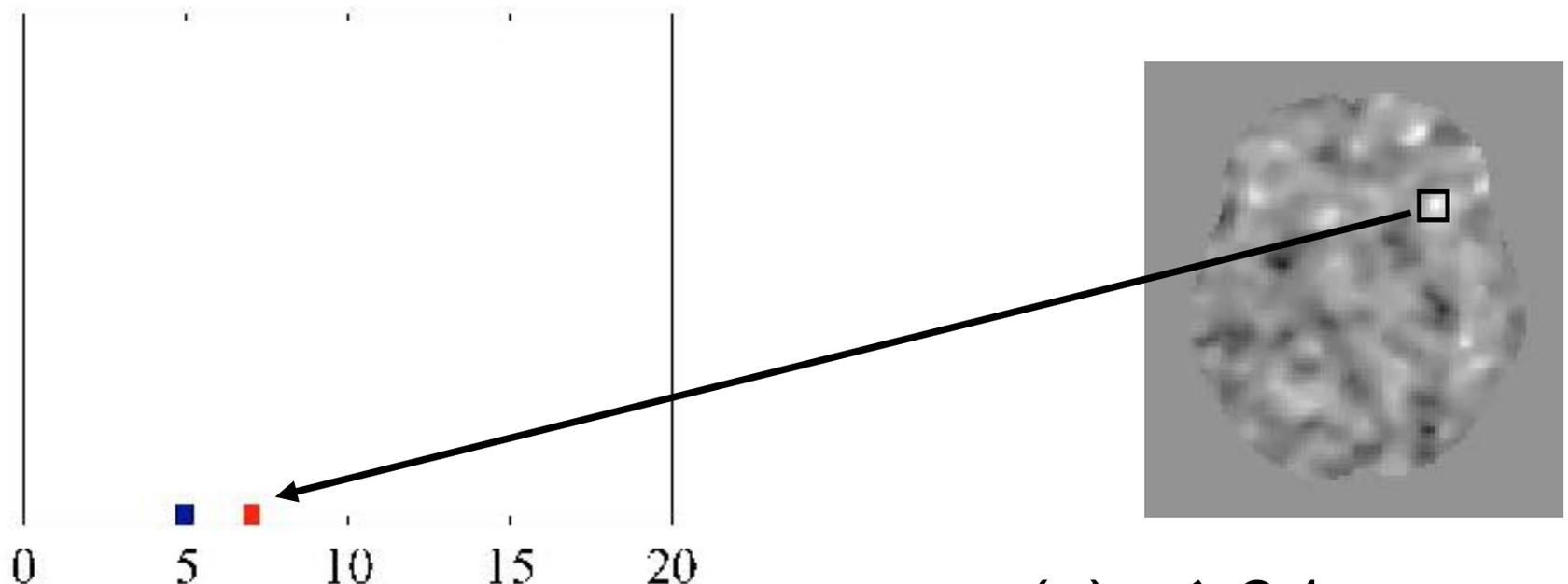

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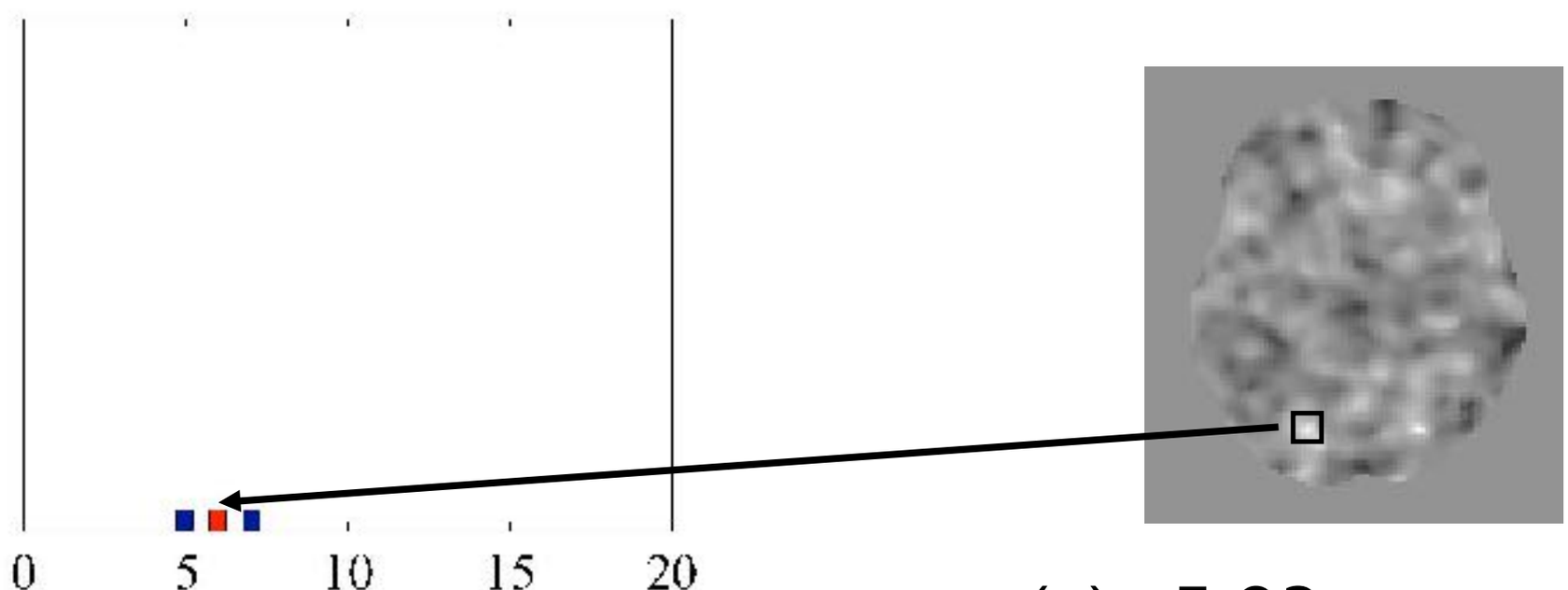

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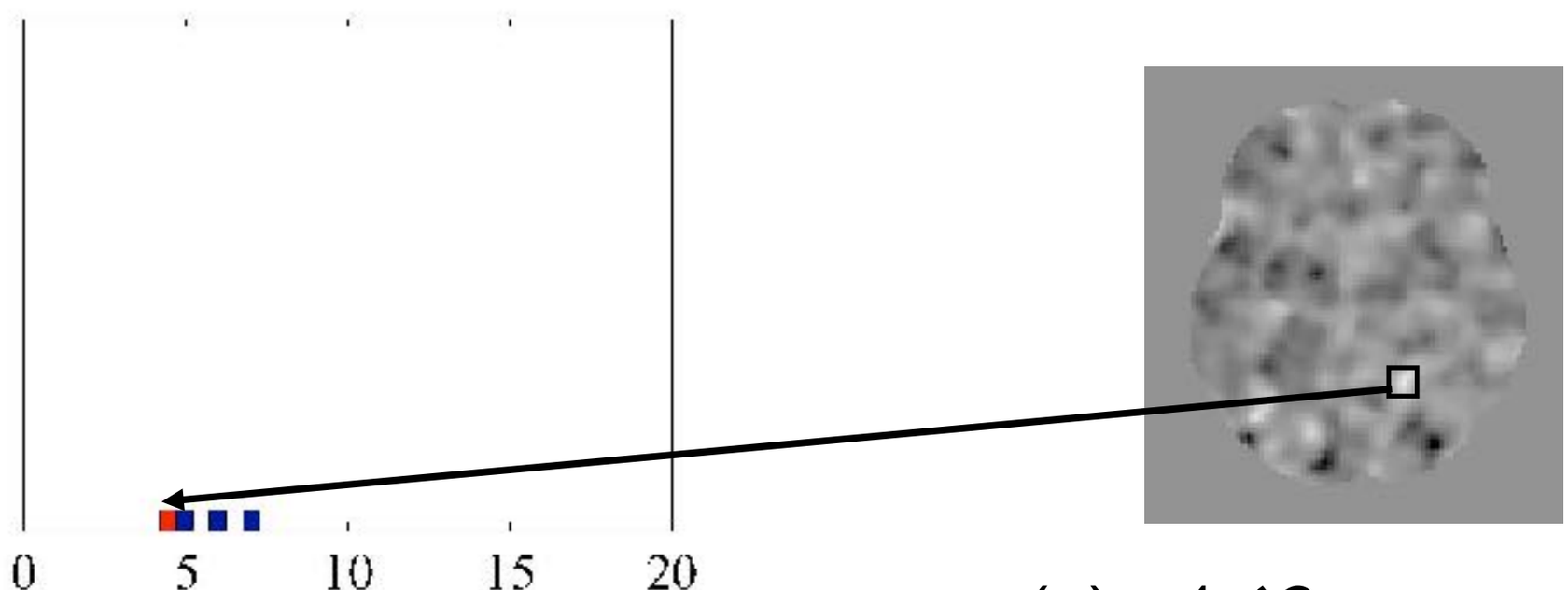

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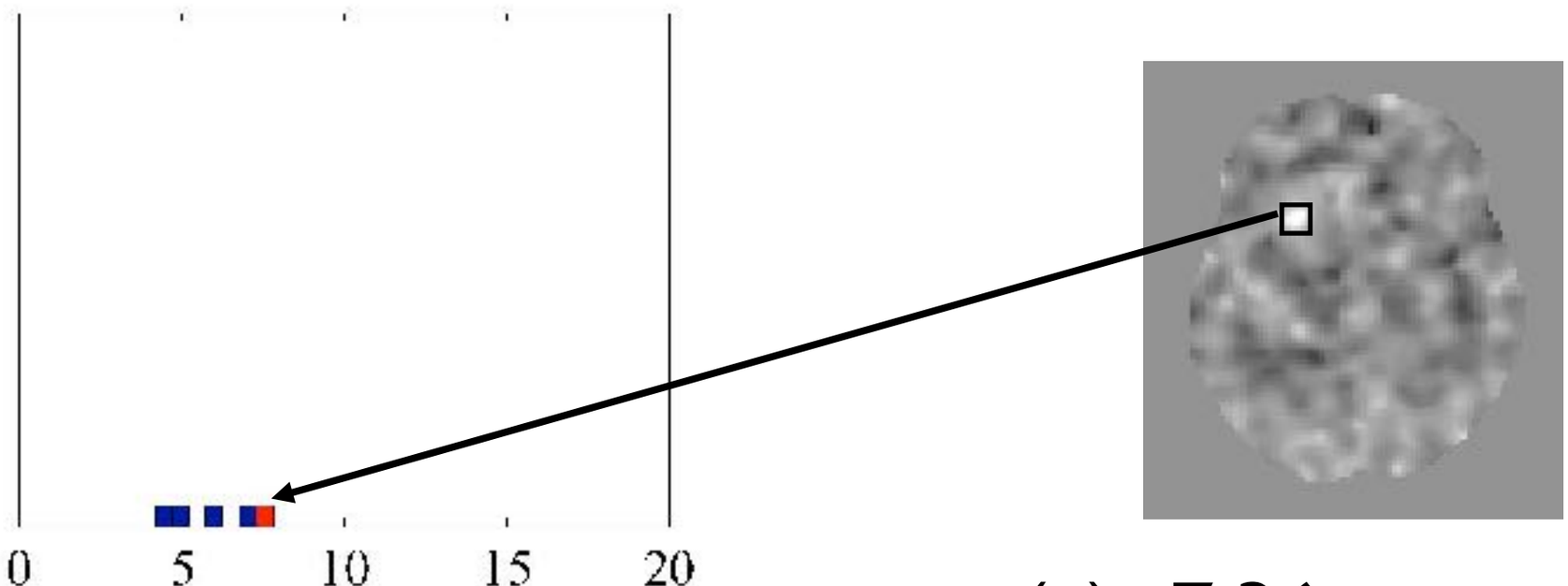

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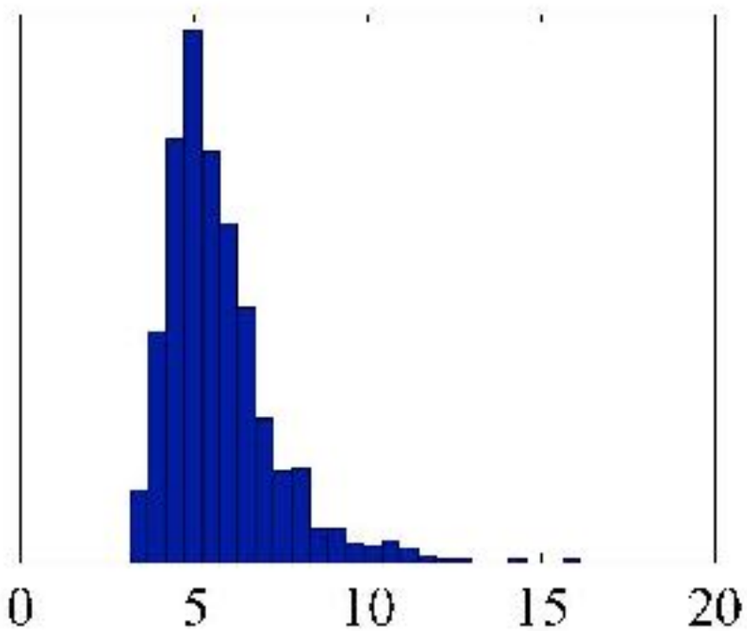

Etc…

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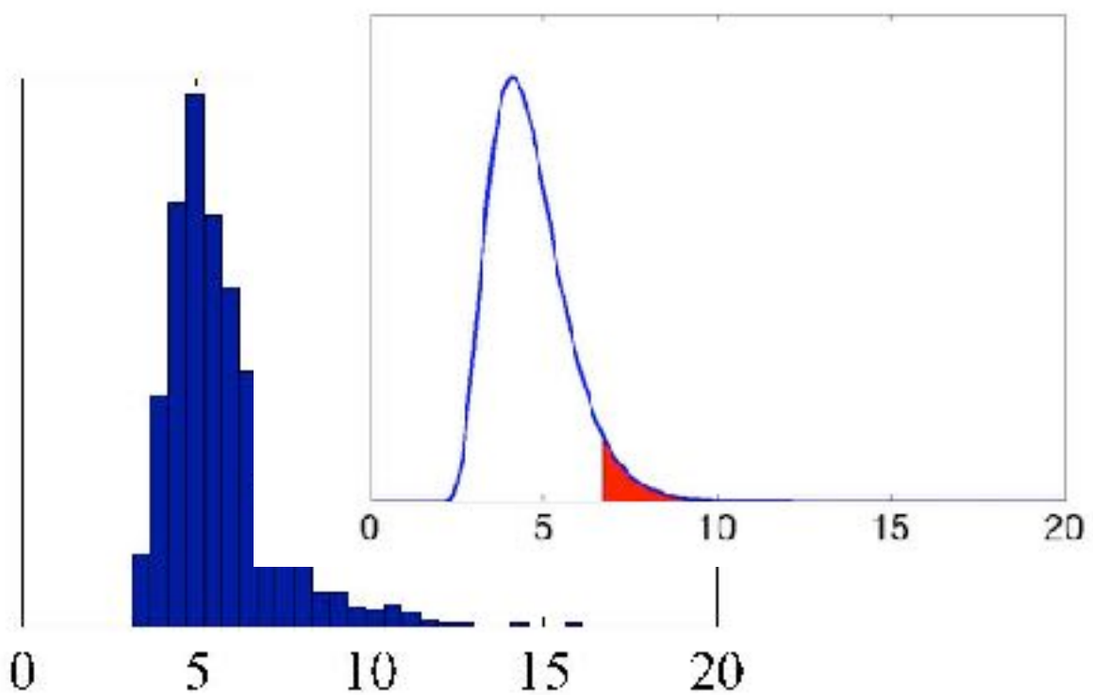

This is the distribution we want to use for our FWE control.

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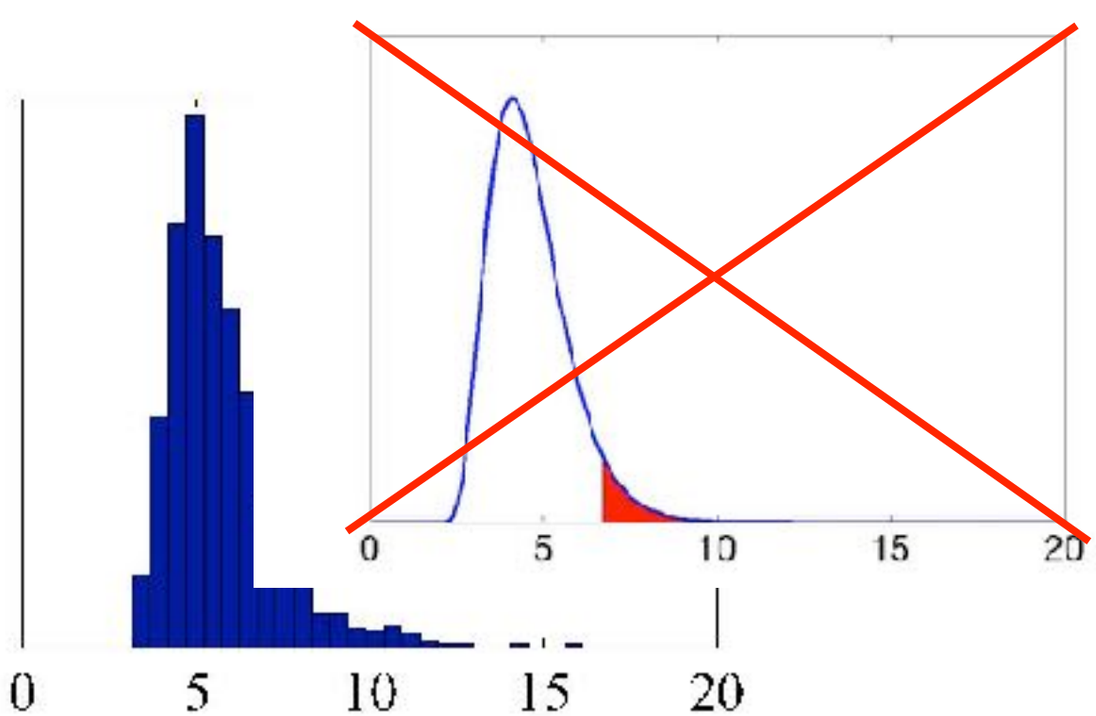

This is the distribution we want to use for our FWE control.
But there is no known expression for it! ☹

Outline

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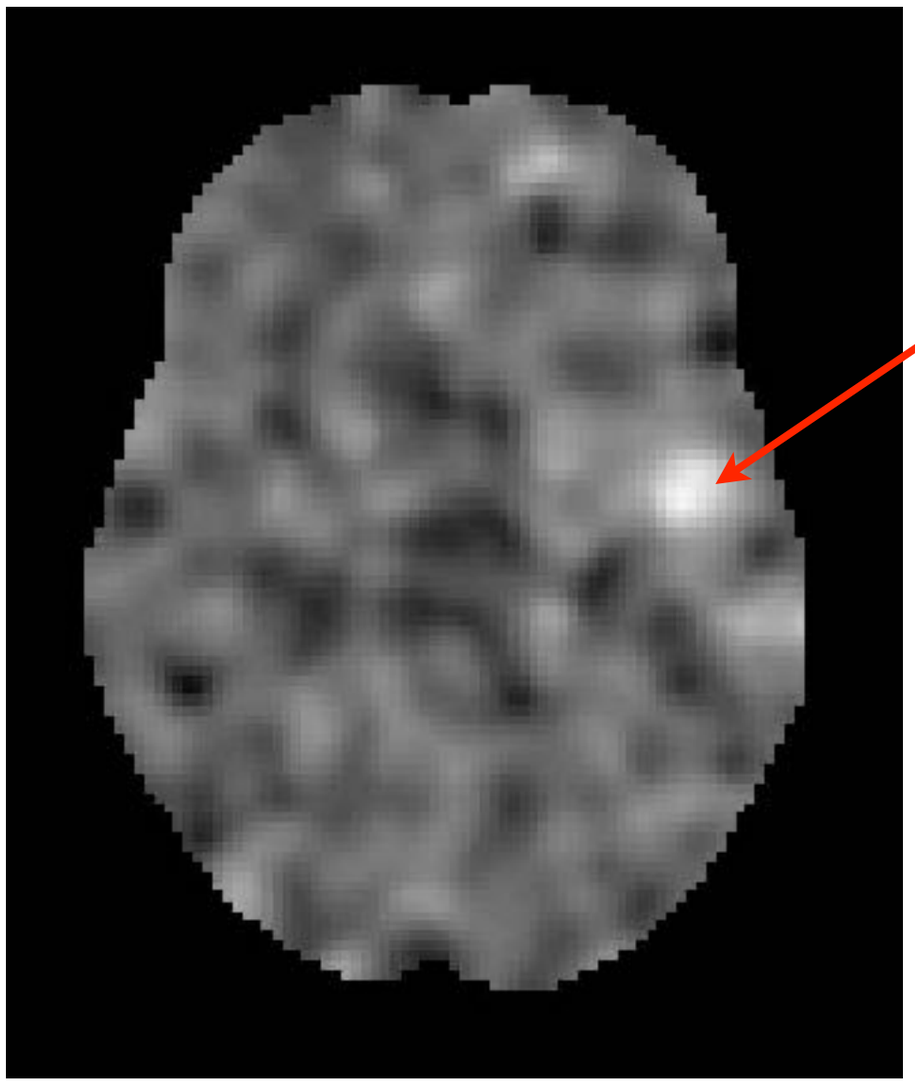
Spatial extent: another way to be surprised

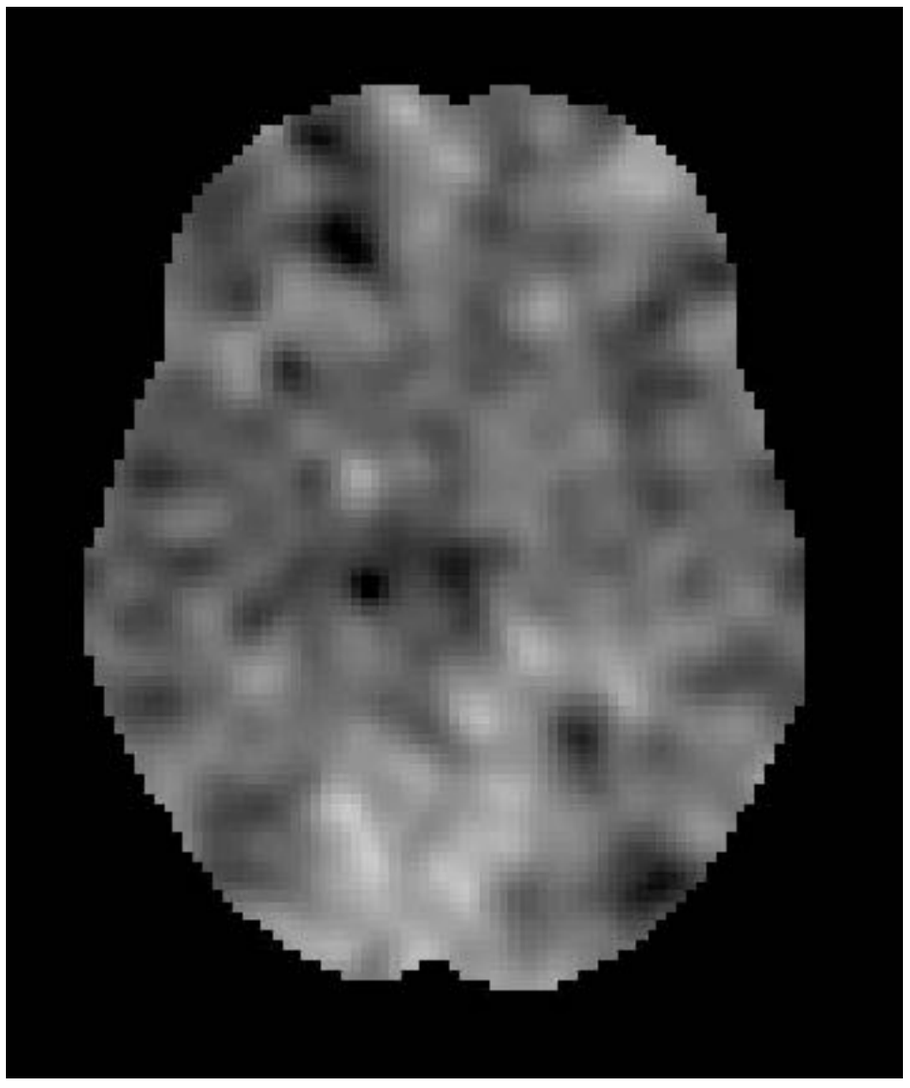
This far we have talked about voxel-based tests



We say: Look! A z-value of 7. That is so surprising (under the null-hypothesis) that I will have to reject it. (Though we are of course secretly delighted to do so)

Spatial extent: another way to be surprised

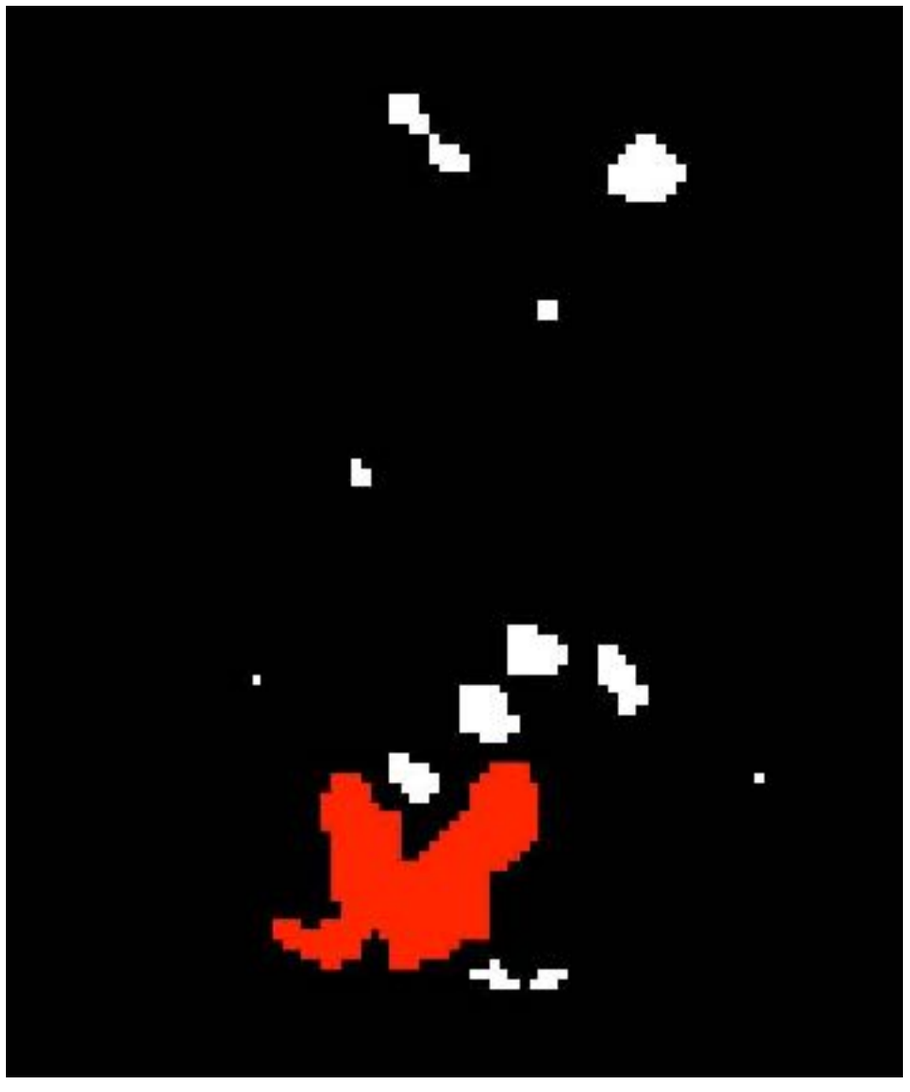
But sometimes our data just aren't that surprising.



Nothing surprising here! The largest z-value is ~4. We cannot reject the null-hypothesis, and we are **devastated**.

Spatial extent: another way to be surprised

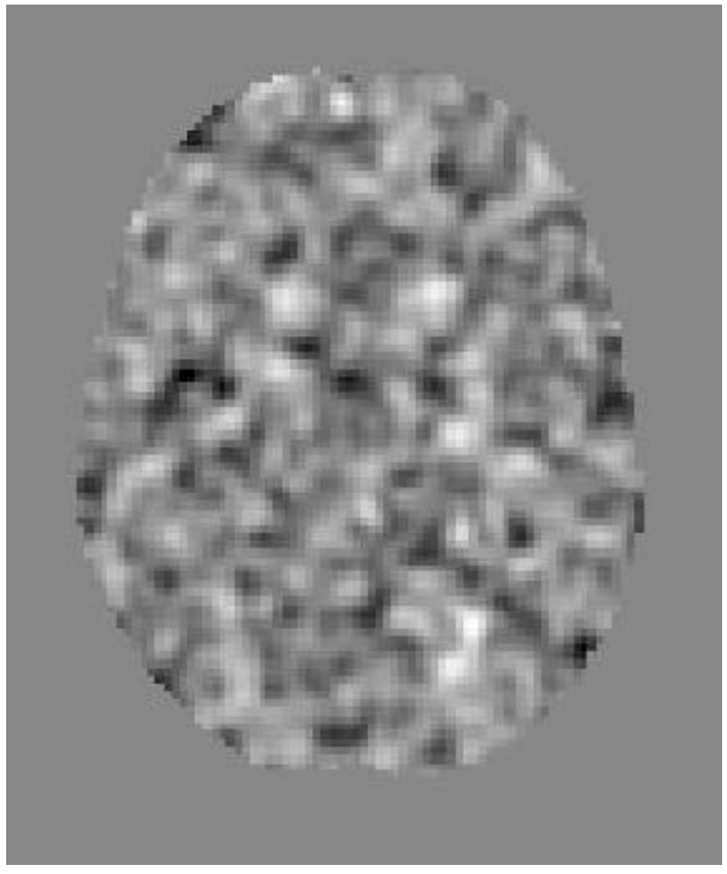
So we threshold the z-map at 2.3 (arbitrary threshold) and look at the spatial extent of clusters



We say: Look at that whopper! 301 connected voxels all with z-values > 2.3. That is really surprising (under the null-hypothesis). I will have to reject it.

Distribution of Max Cluster Size

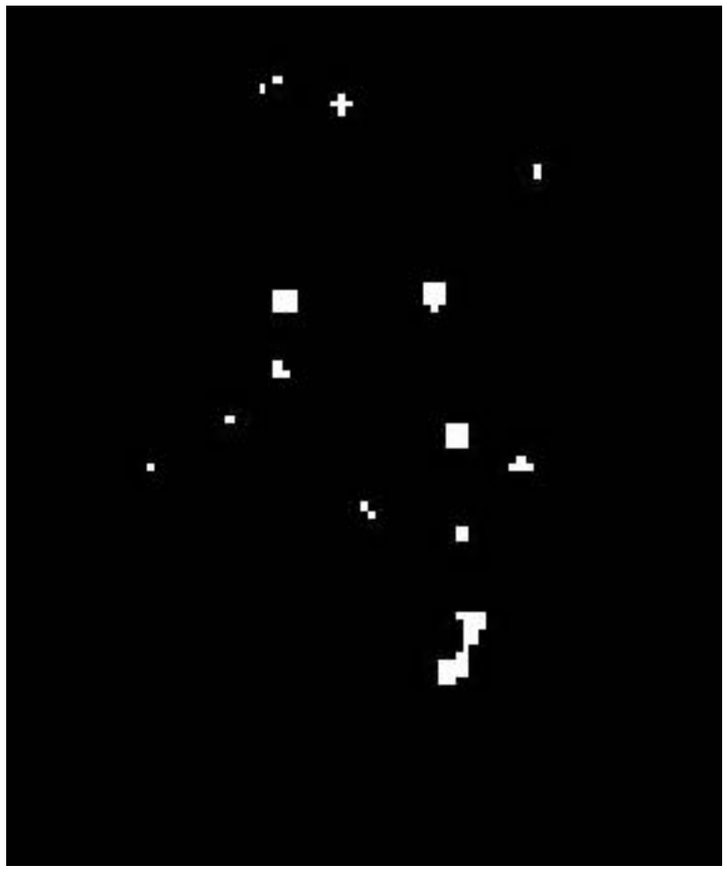
As with the *z*-values we need a "null-distribution". What would that look like in this case?



Let's say we have acquired some data

Distribution of Max Cluster Size

If we reject any cluster we will reject the largest. So what we want is the distribution of the largest cluster, under the null-hypothesis.



Threshold the z-map at 2.3 (arbitrary)

Distribution of Max Cluster Size

If we reject any cluster we will reject the largest. So what we want is the distribution of the largest cluster, under the null-hypothesis.

Locate the largest cluster anywhere in the brain.

Distribution of Max Cluster Size

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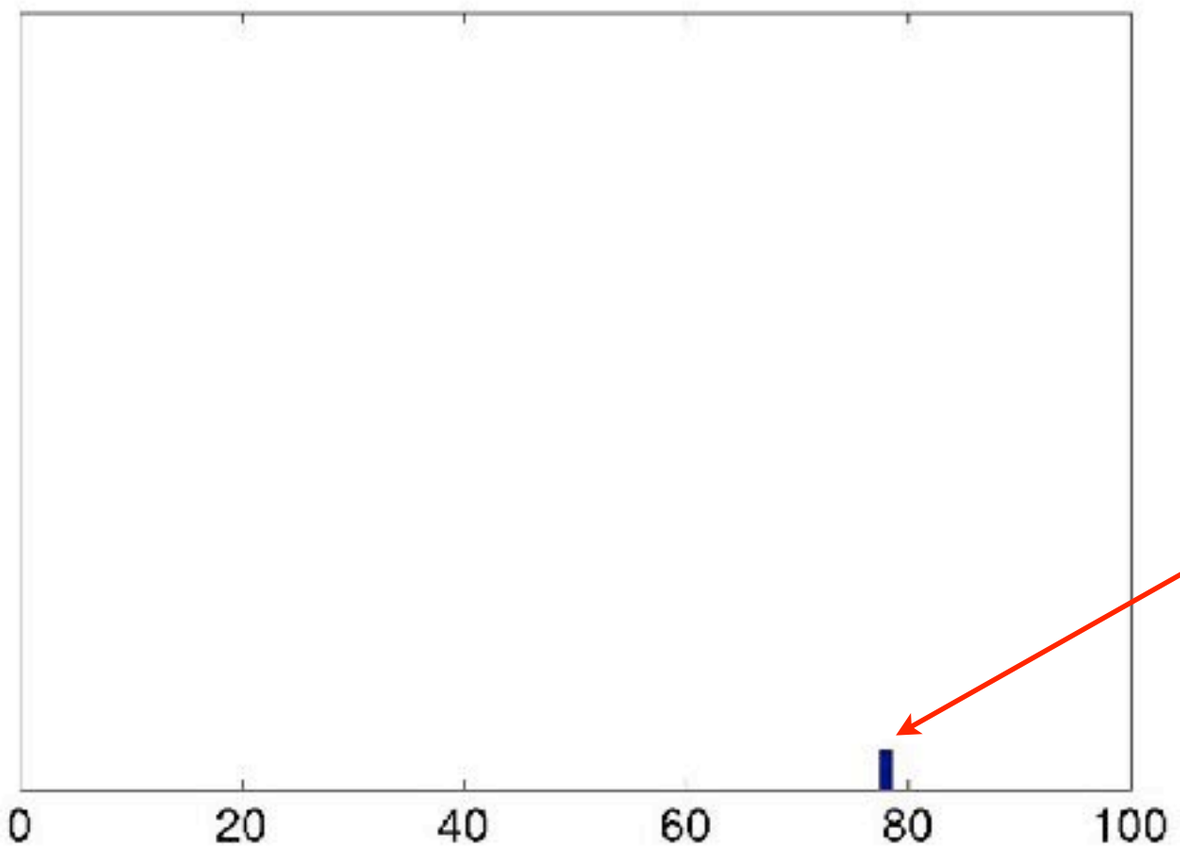

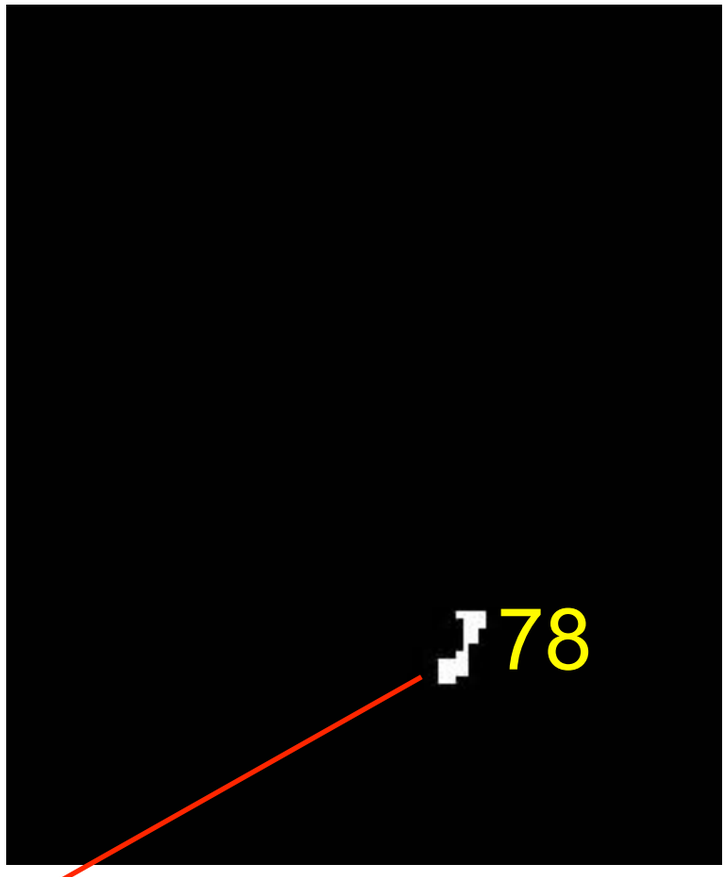

And record how large it is.

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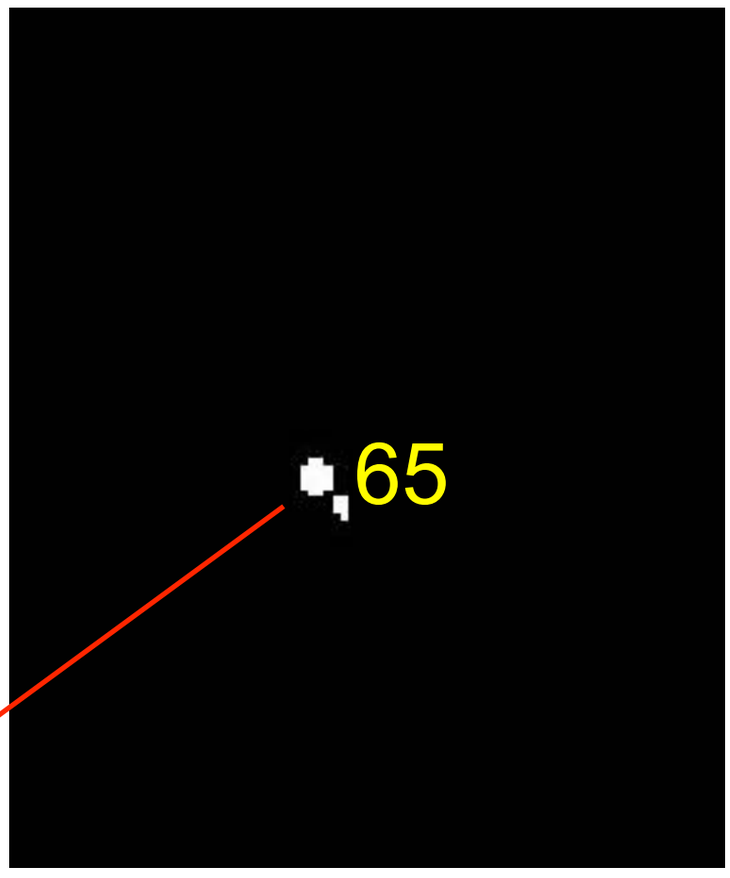
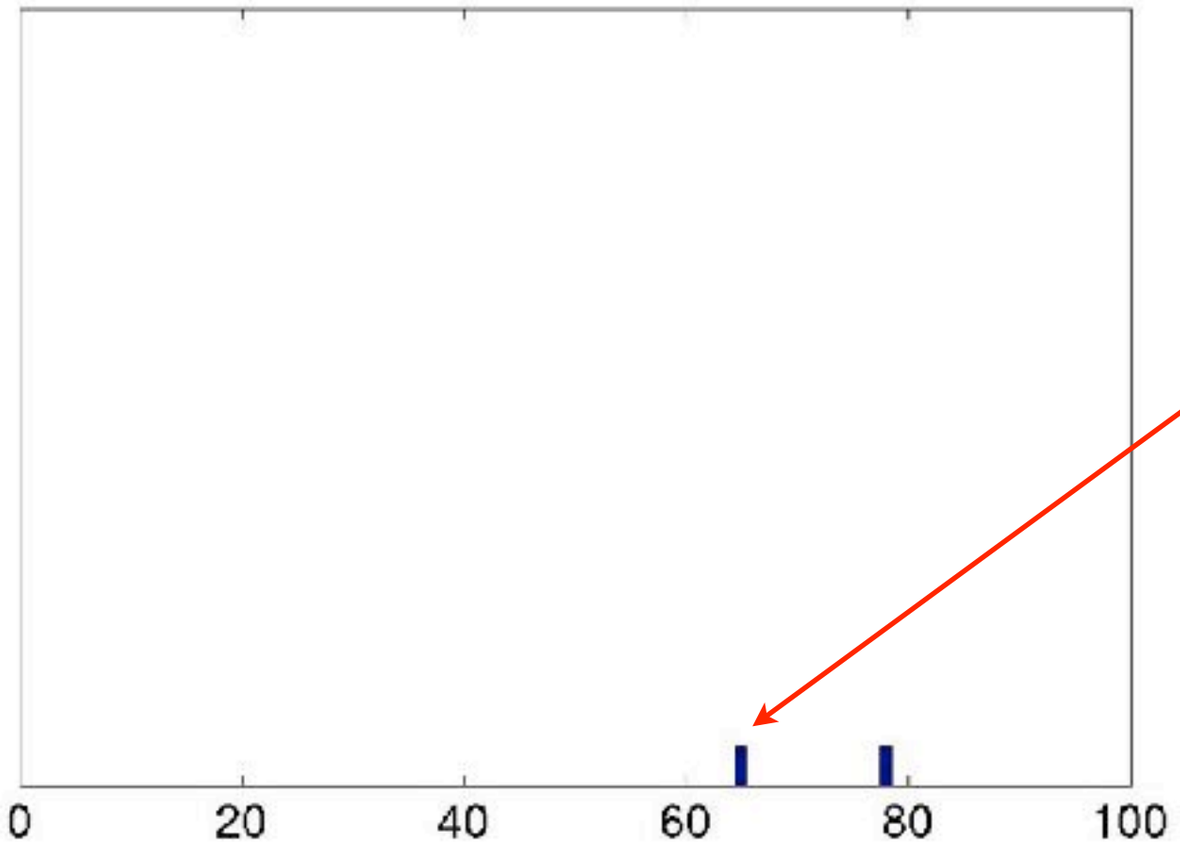


And do the same for another experiment...



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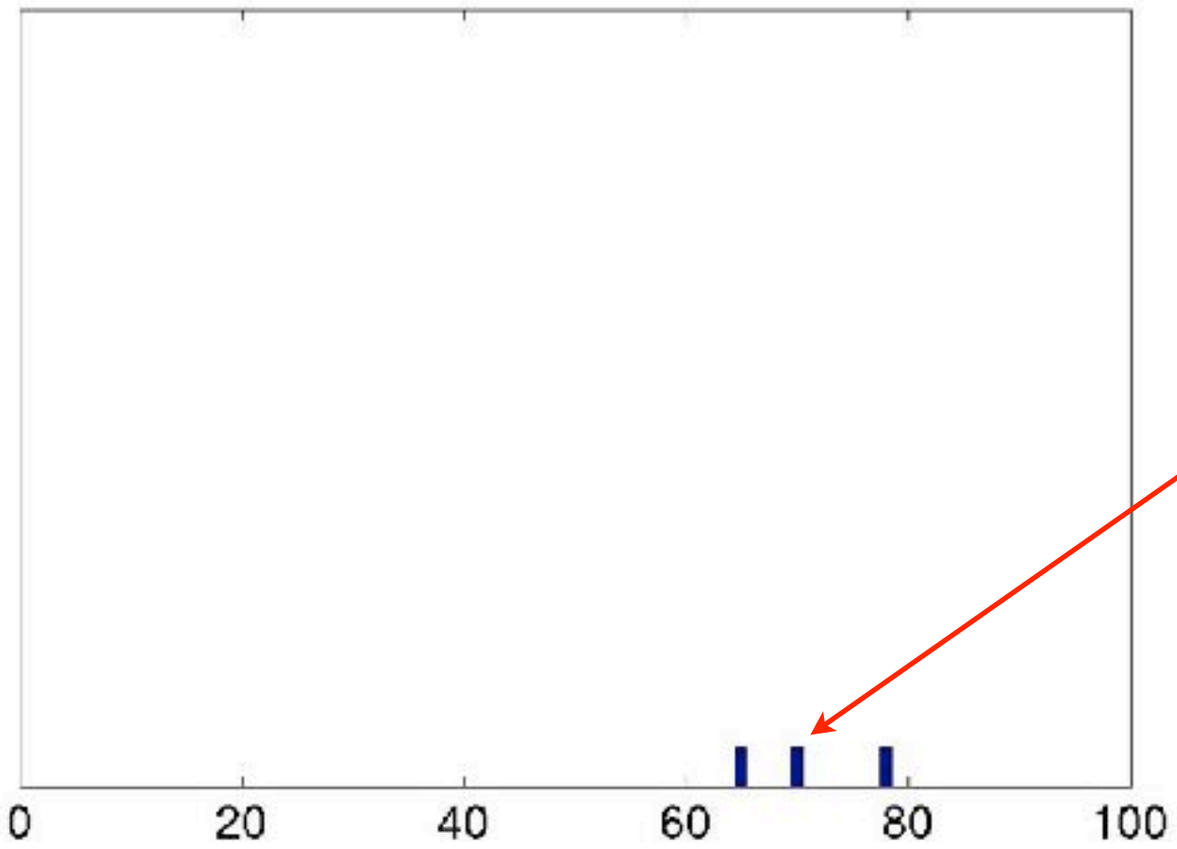

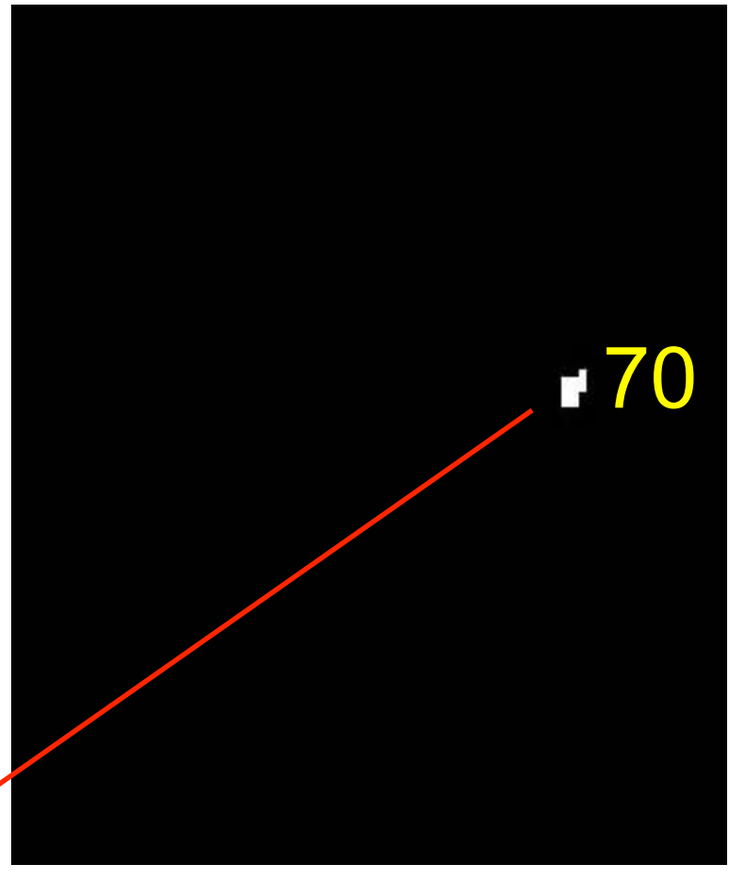

Etc ...

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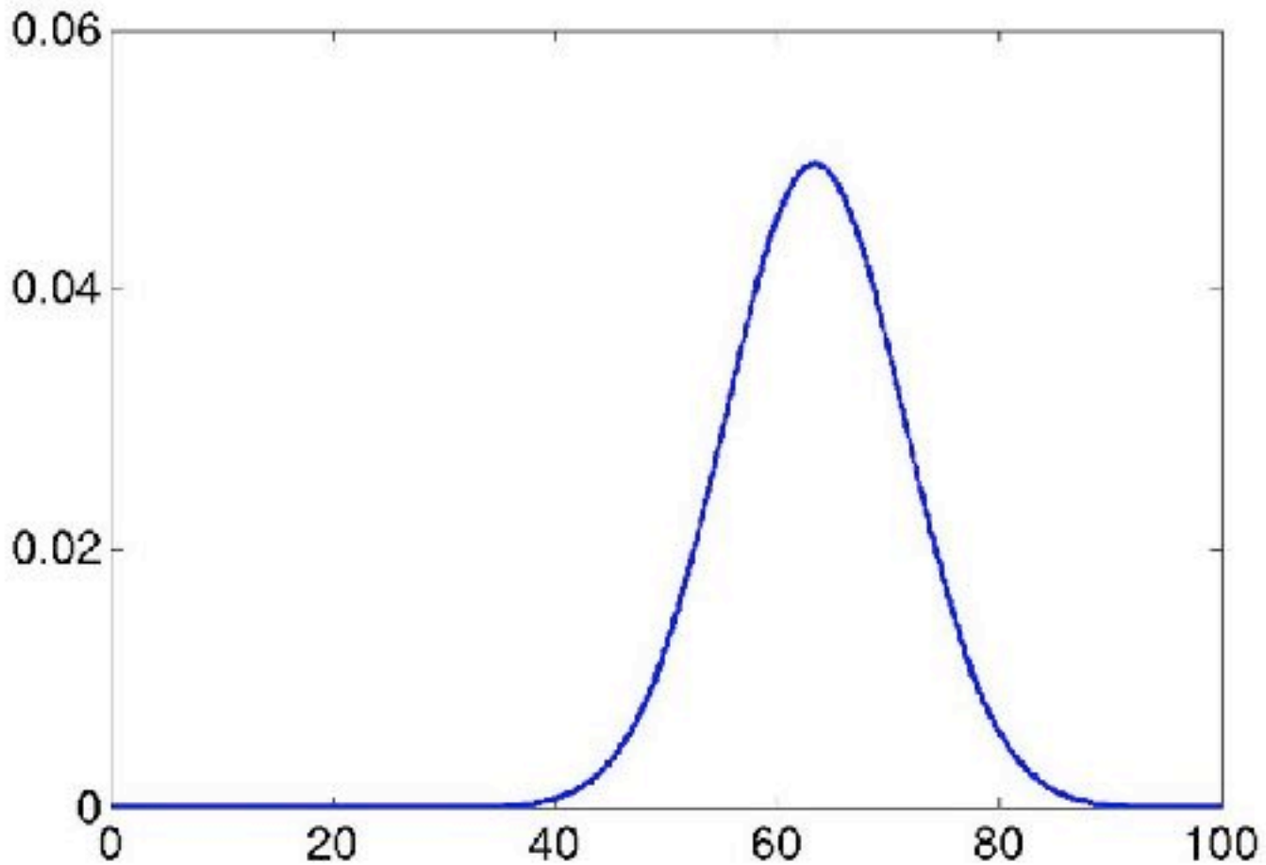

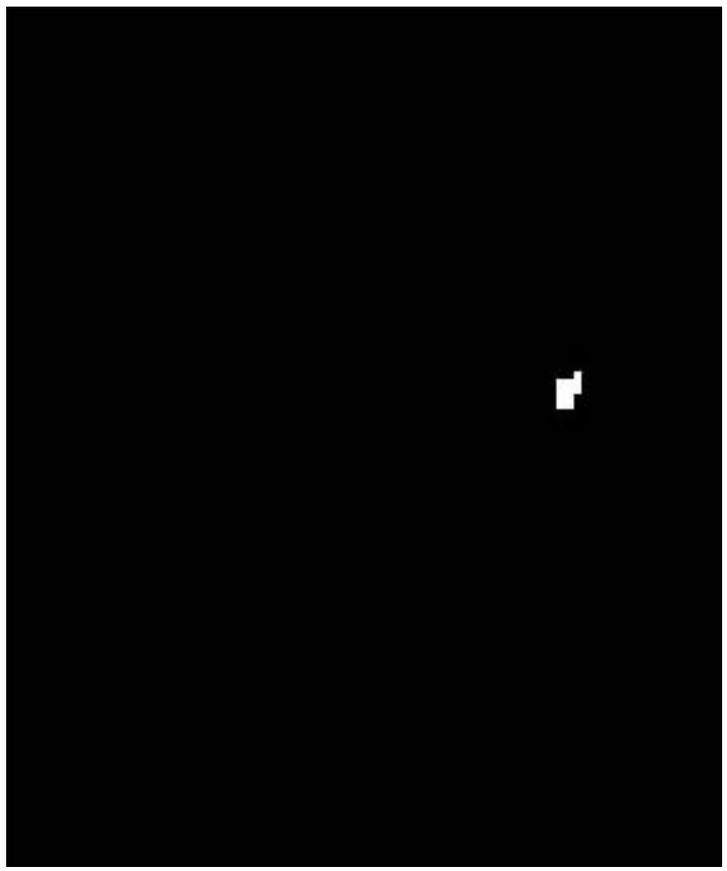

Until we have ...

Distribution of Max Cluster Size

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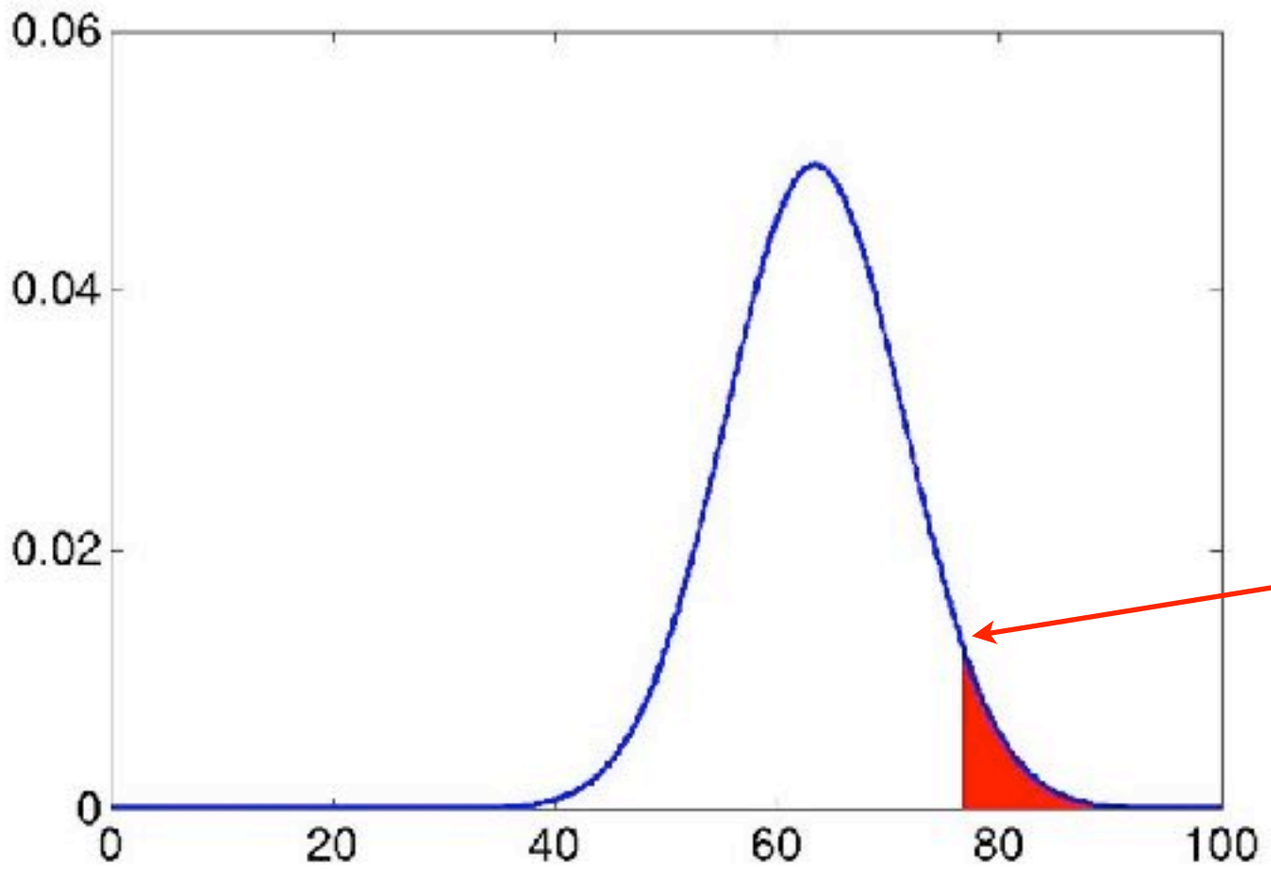
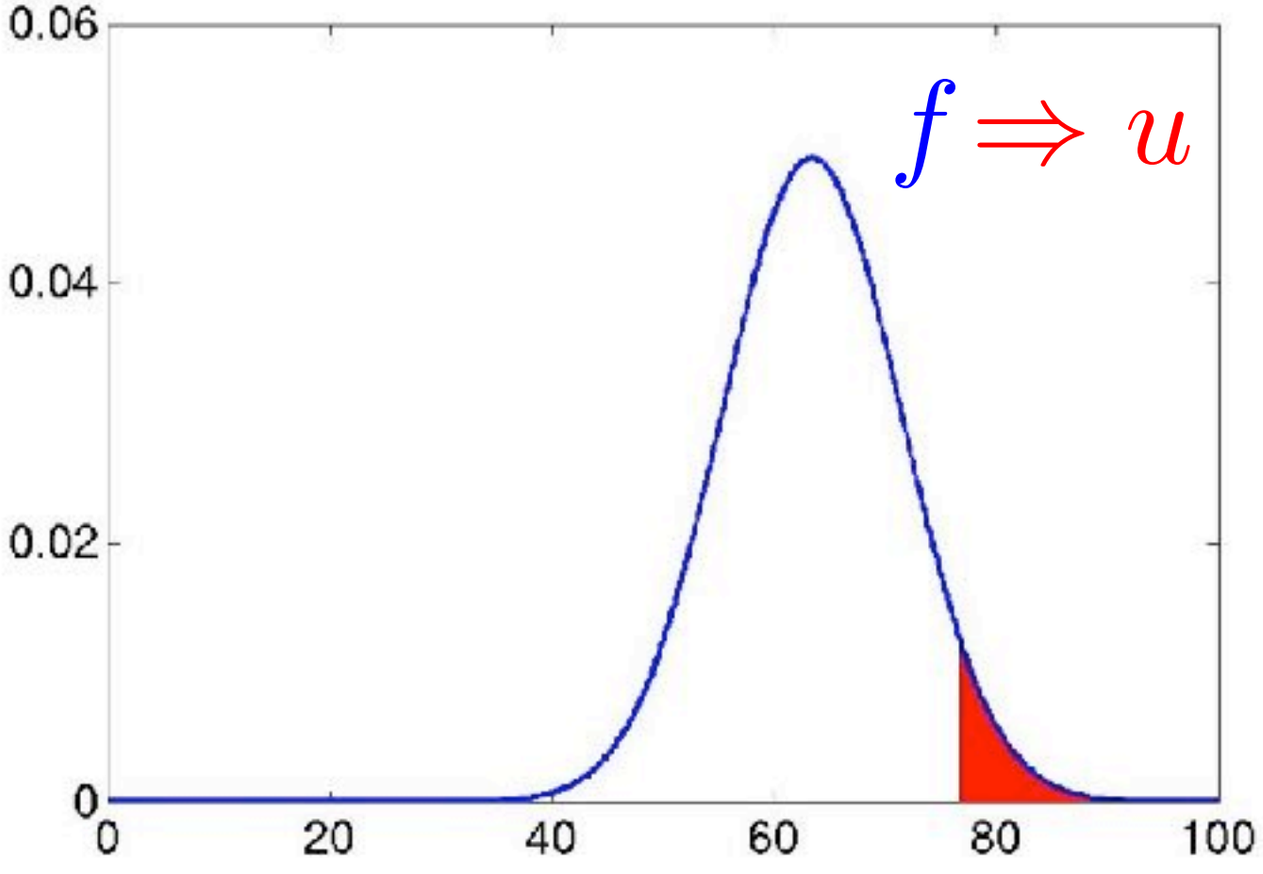


If we find a cluster larger than 76 voxels we reject the null-hypothesis.

And this (76) is the level we want to threshold at

Distribution of Max Cluster Size

So, just as was the case for the t-values, we now have a distribution f that allows us to calculate a Family Wise threshold u pertaining to cluster size.



But what does f and u crucially depend on?

Distribution of Max Cluster Size

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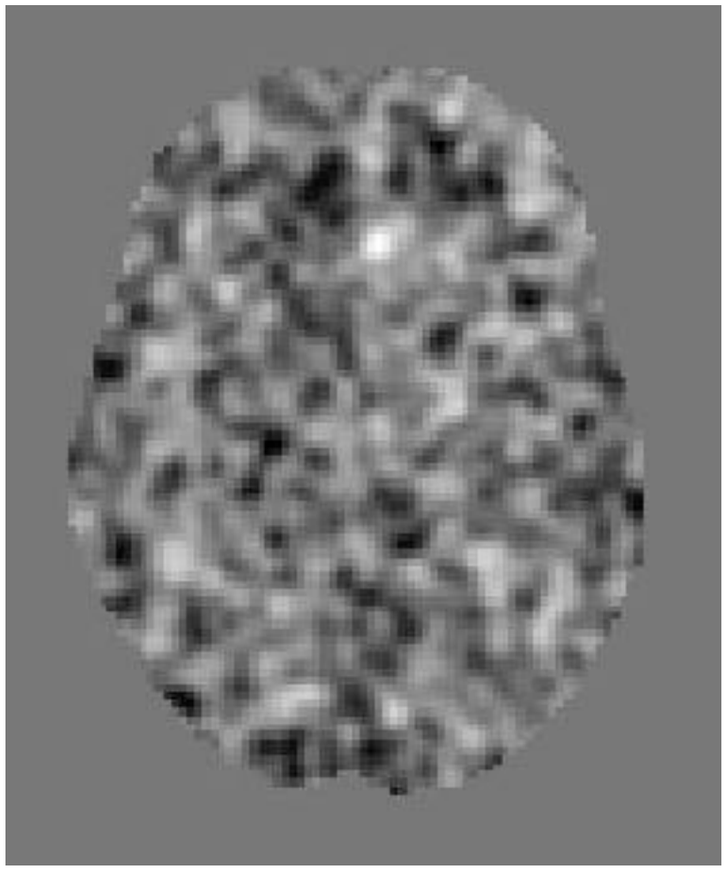
f depends crucially on the initial "cluster-forming" threshold?



$z = 2.3$

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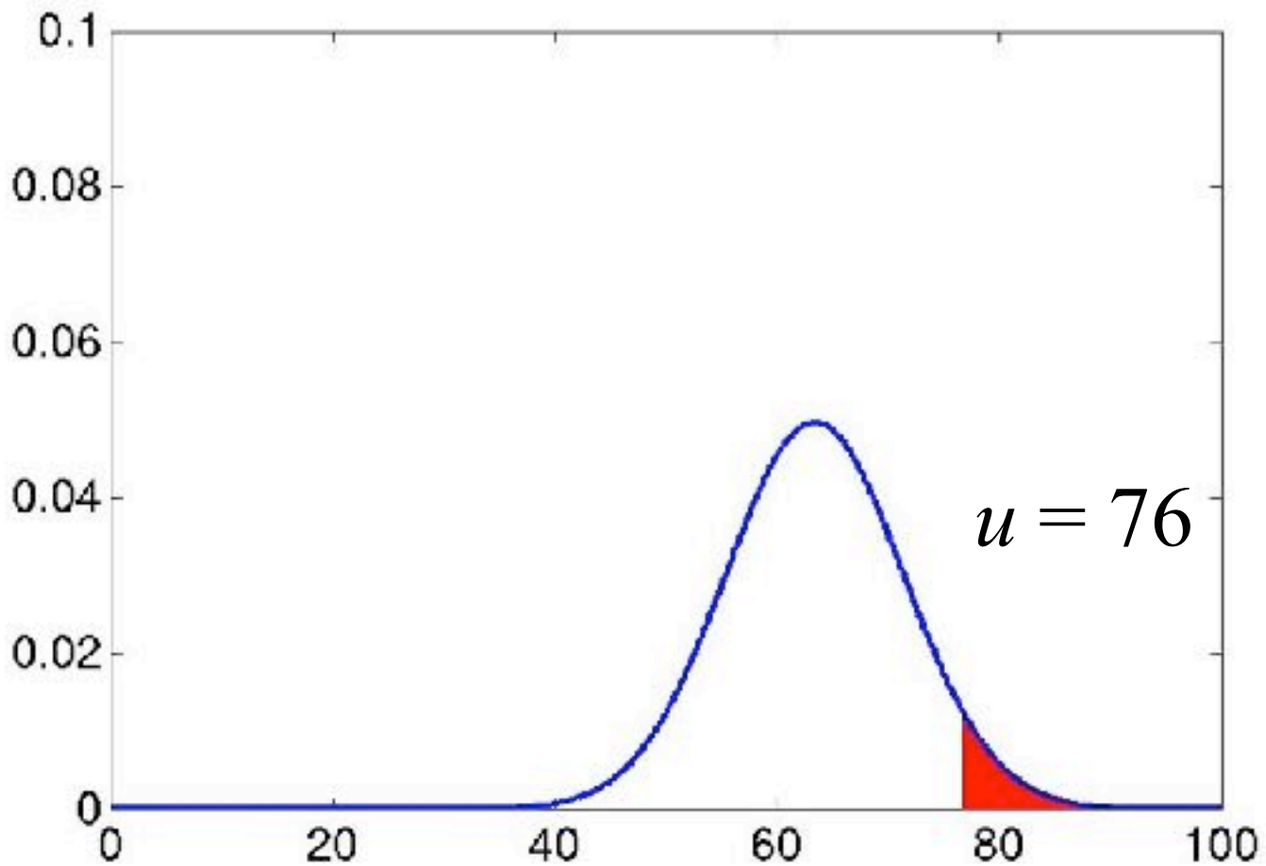

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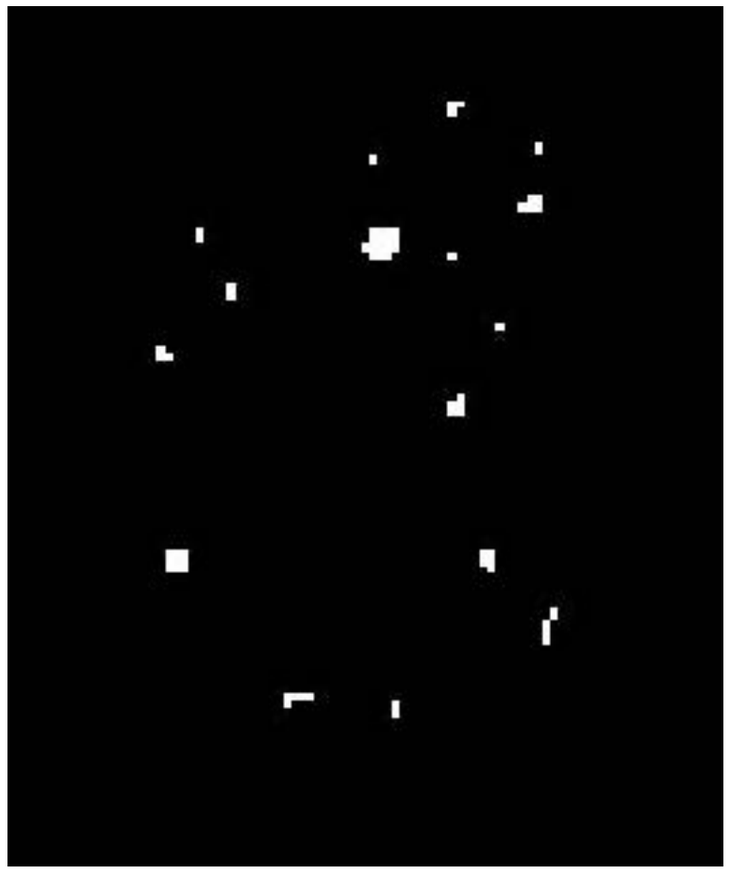

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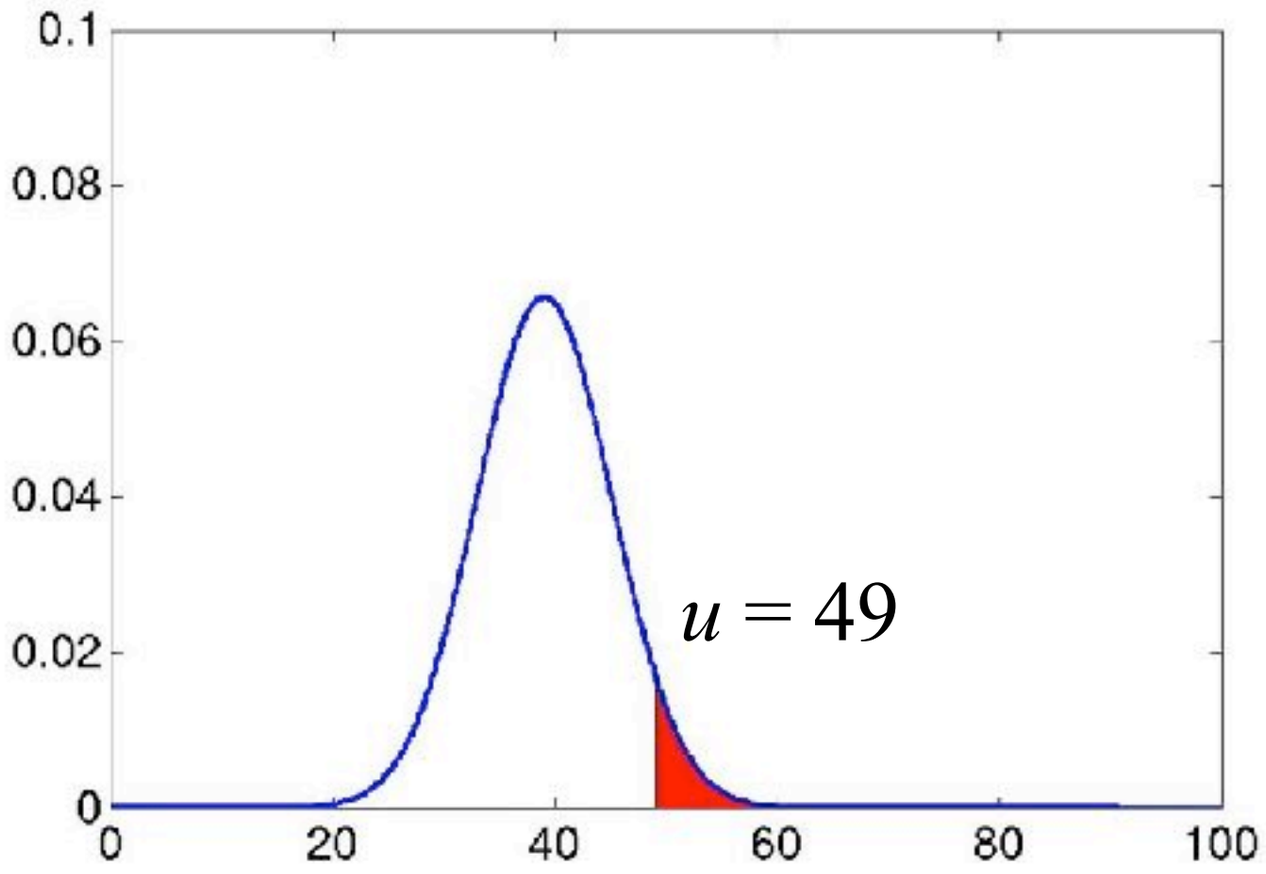

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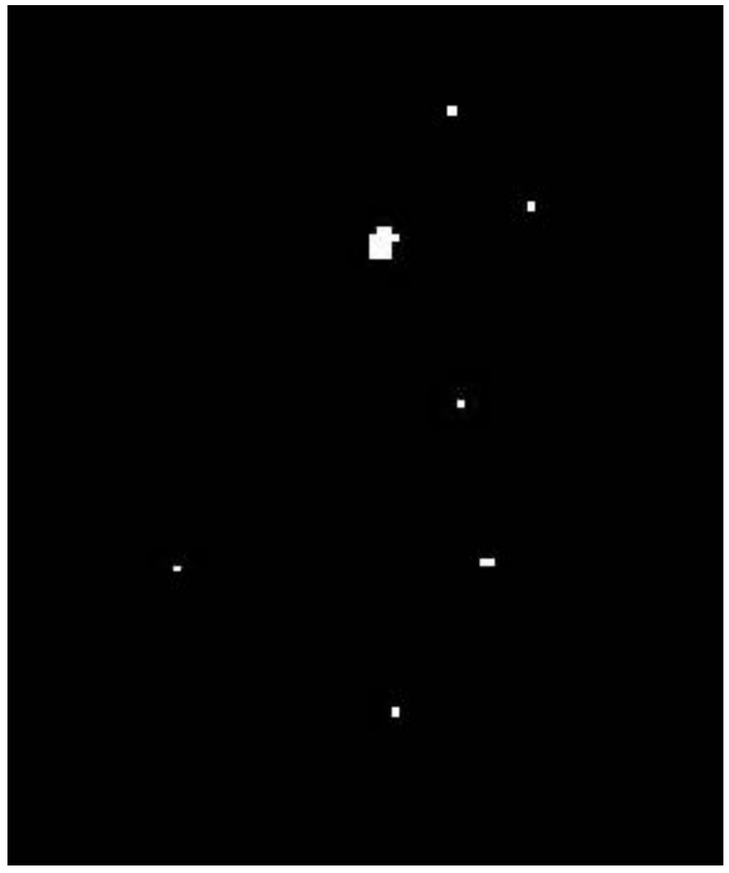

$z = 2.7$

Distribution of Max Cluster Size

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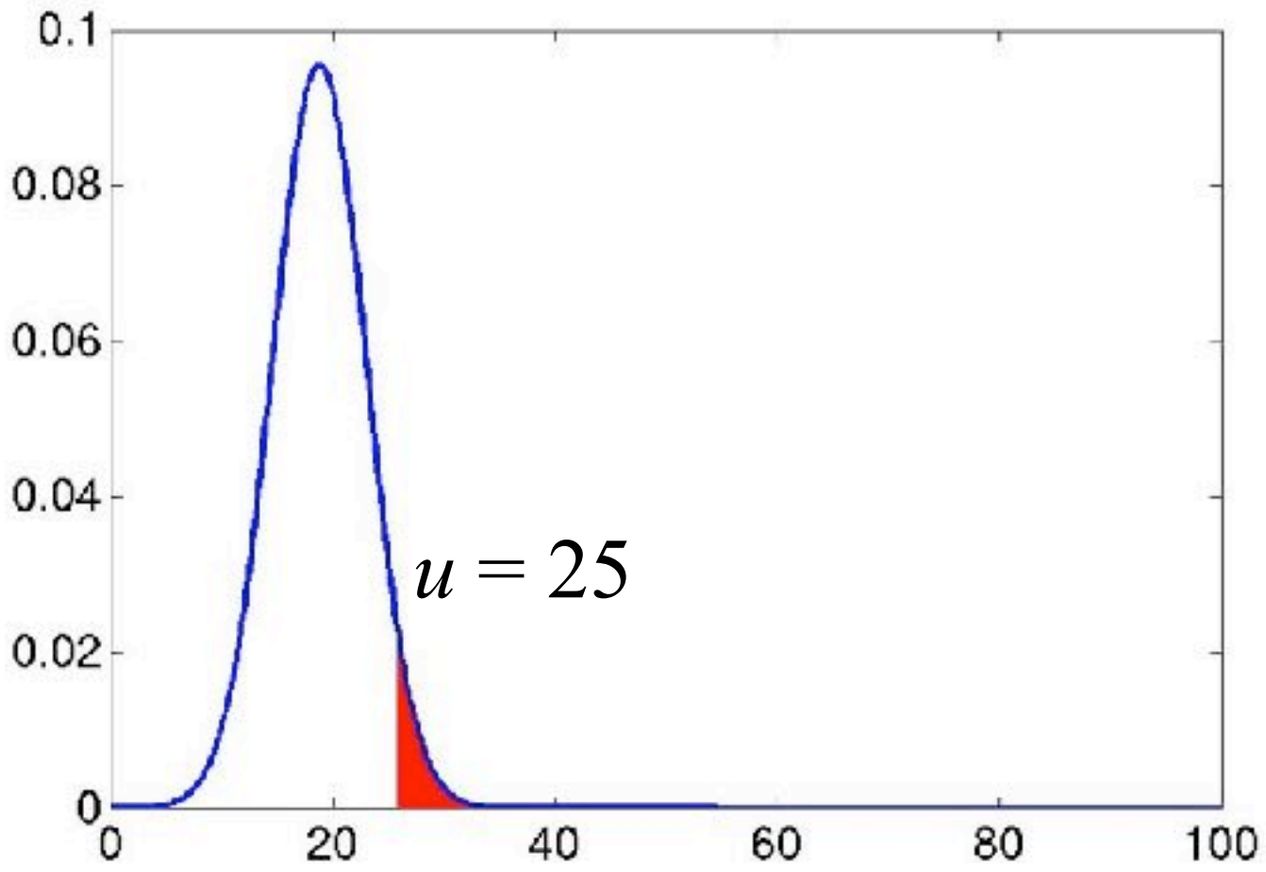

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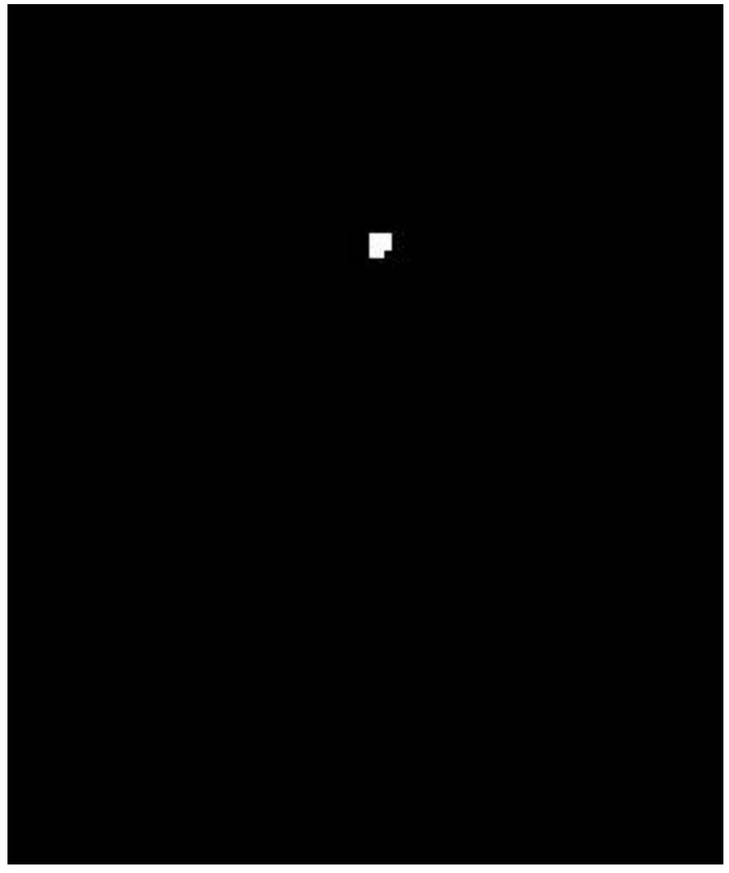
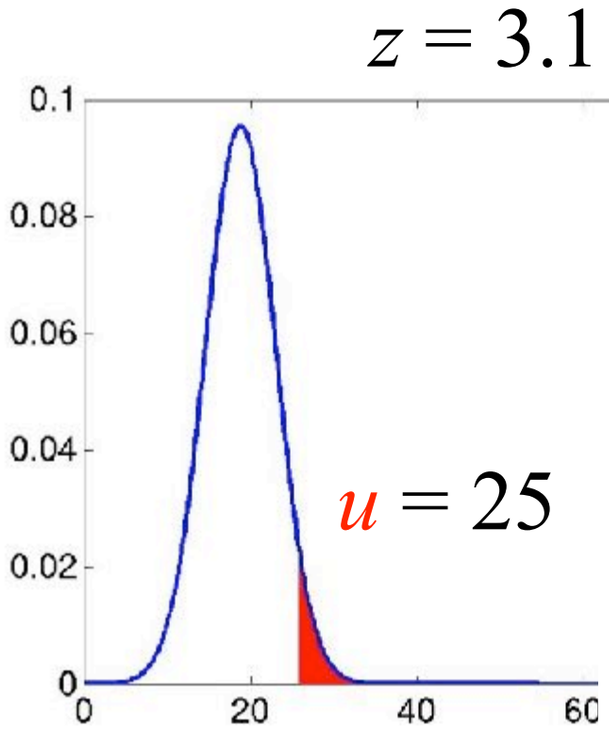
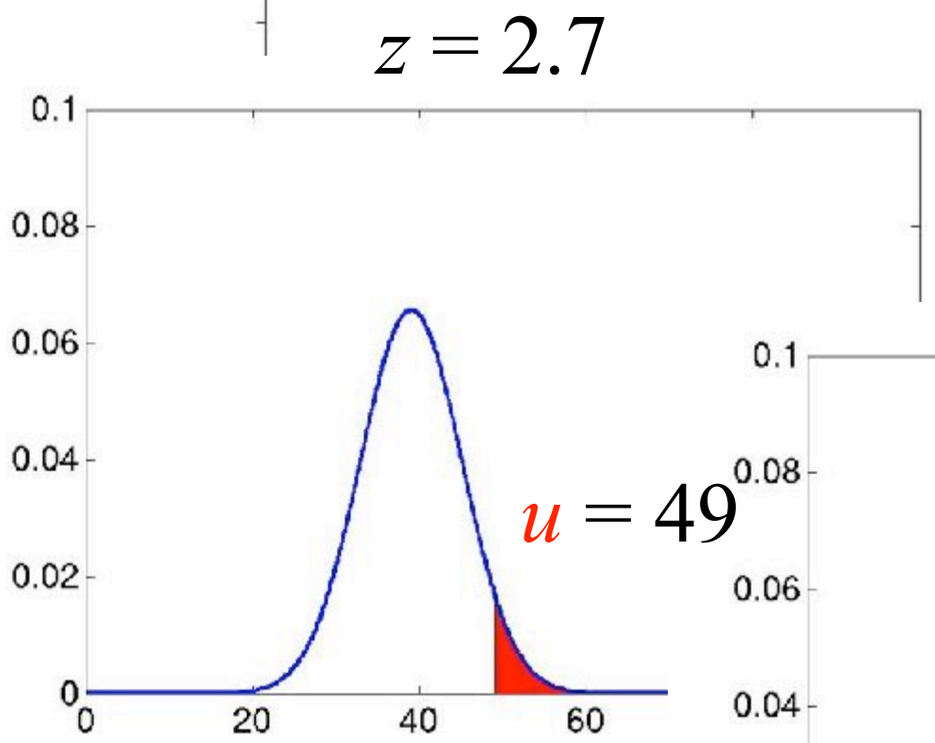


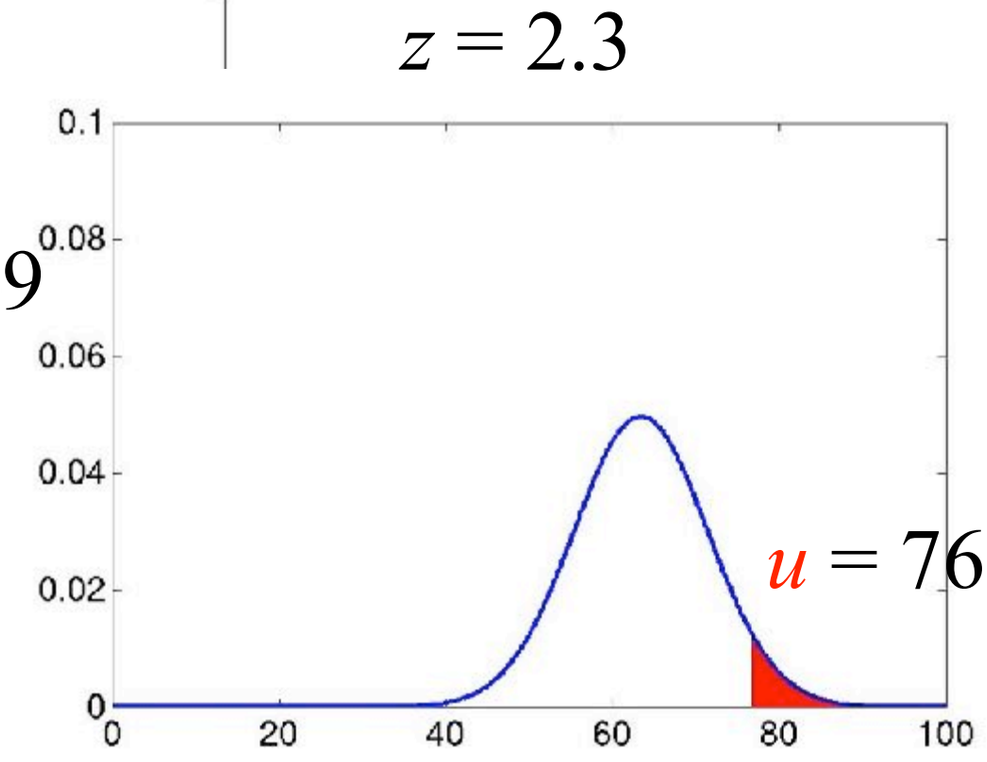
$z = 3.1$

Distribution of Max Cluster Size

Hence the distribution for the cluster size should really be written $f(z)$ and the same for $u(z)$







But as before we don't have an expression for these distributions.