

Reliability Analysis – Now What?

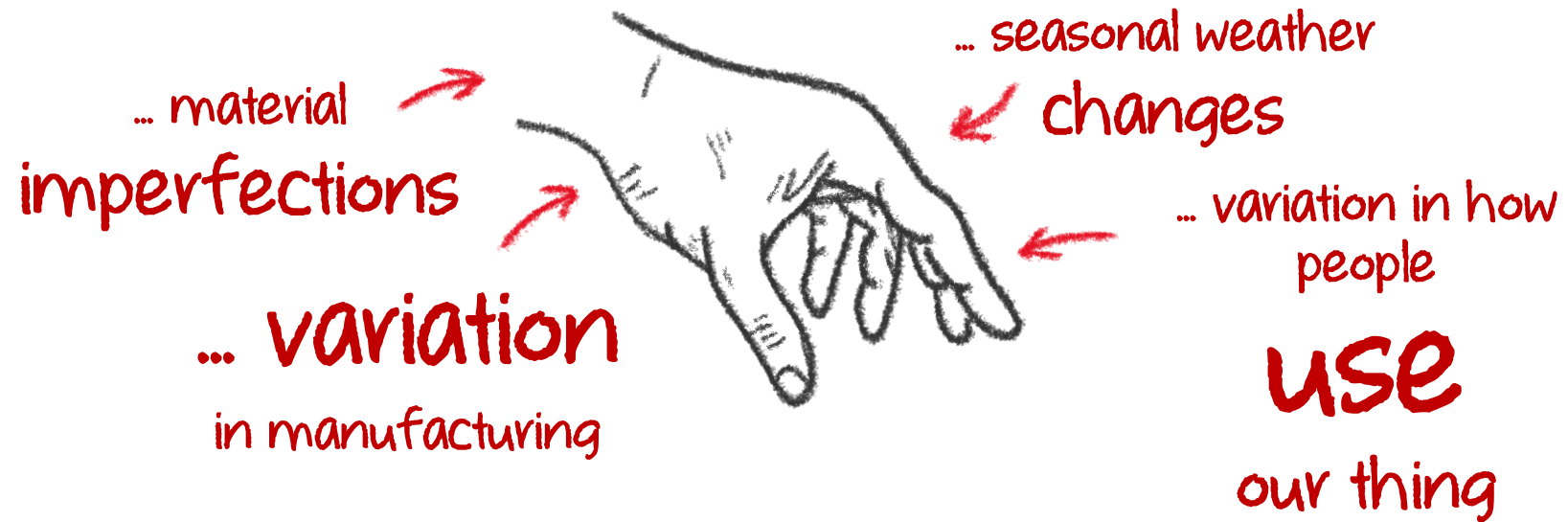
Reliability Analysis – Now What?

#4



... this represents
time to failure (TTF)

the (random) hand of failure

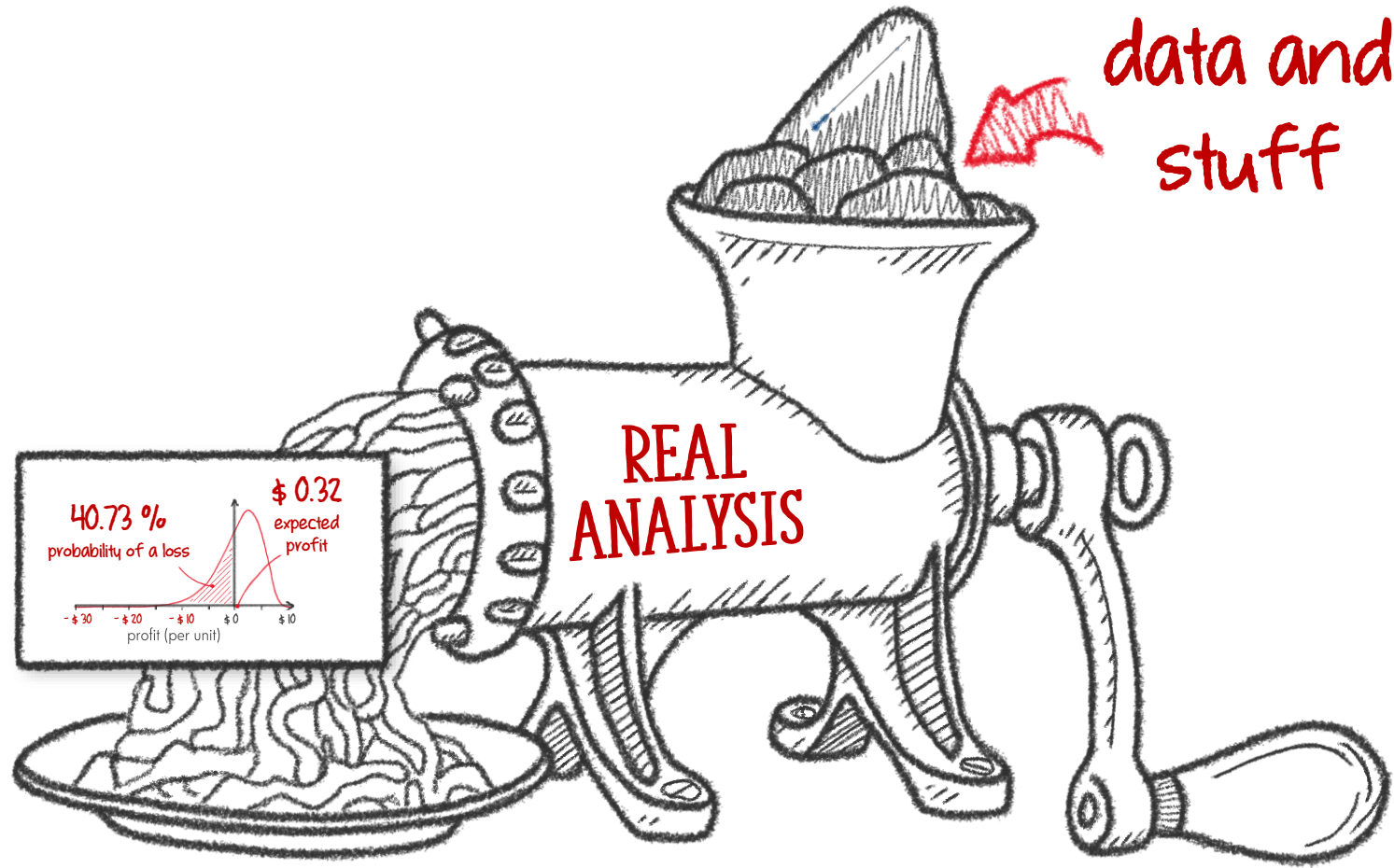


time to failure (TTF)

the (random) hand of failure



time to failure (TTF)



data and
stuff



40.73 %
probability of a loss

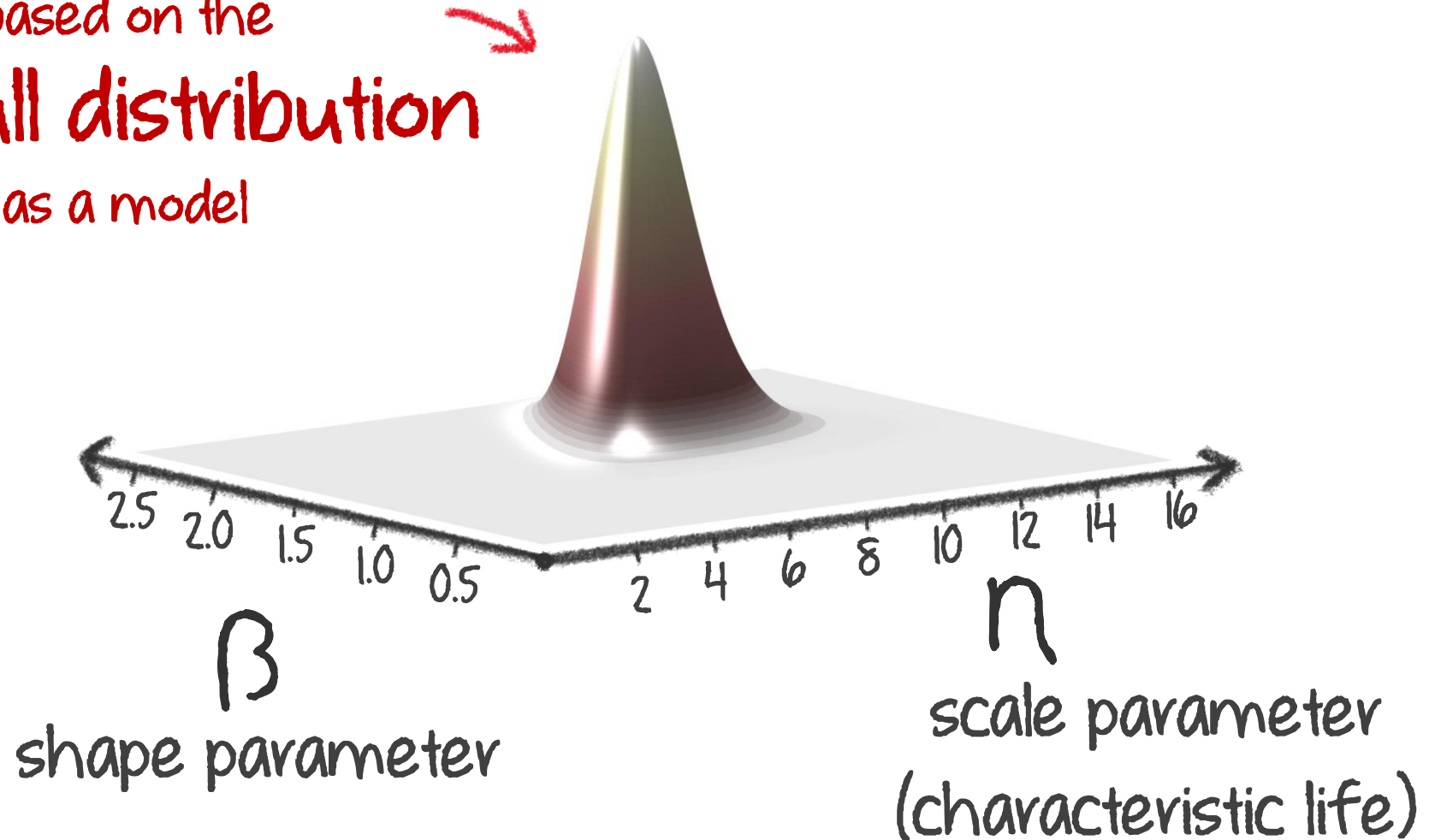
\$ 0.32
expected
profit



... but first ...
a little *MCMC*
revision

the
'classic' random walk
algorithm

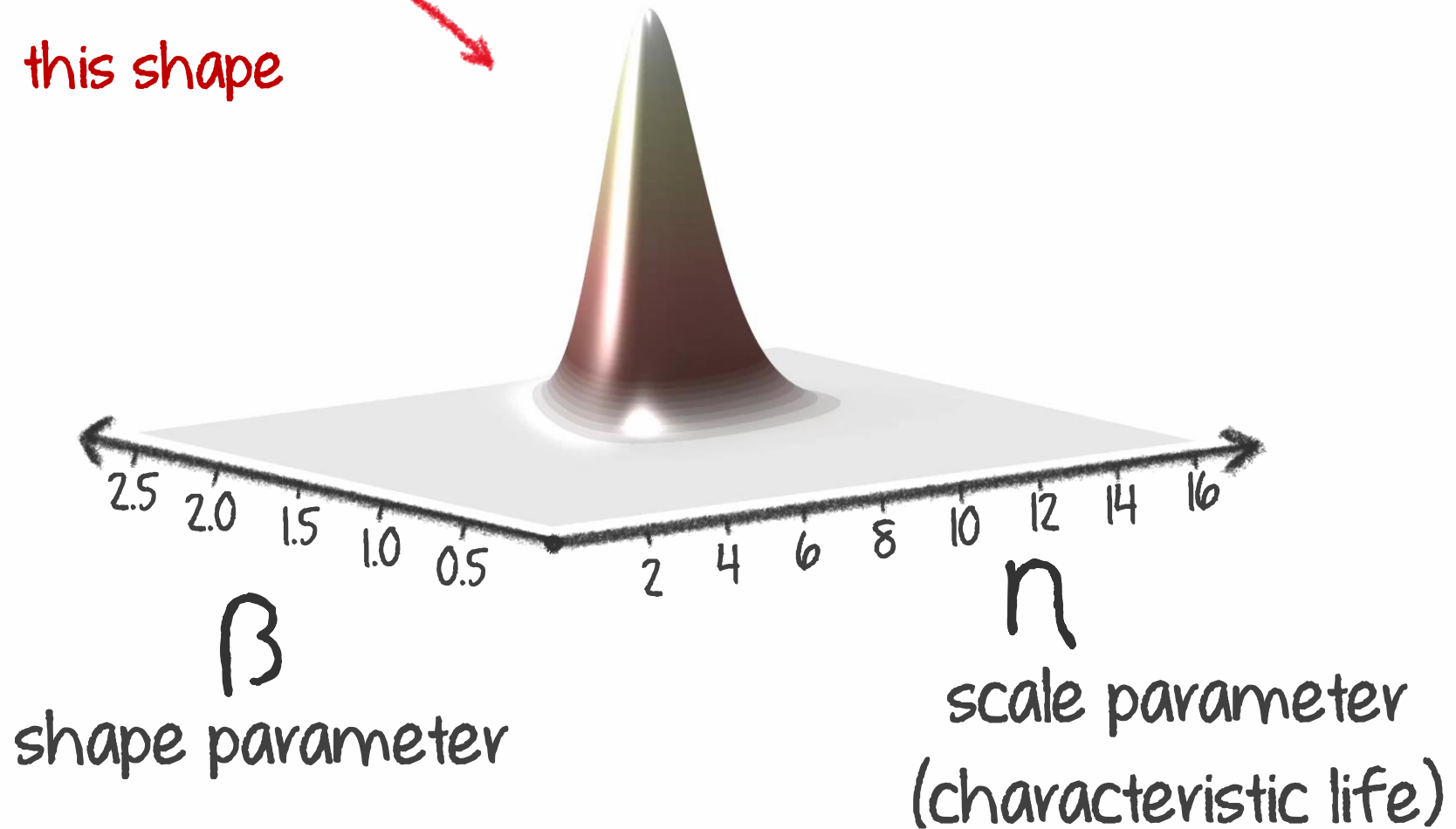
this is the
likelihood function
based on the
Weibull distribution
as a model



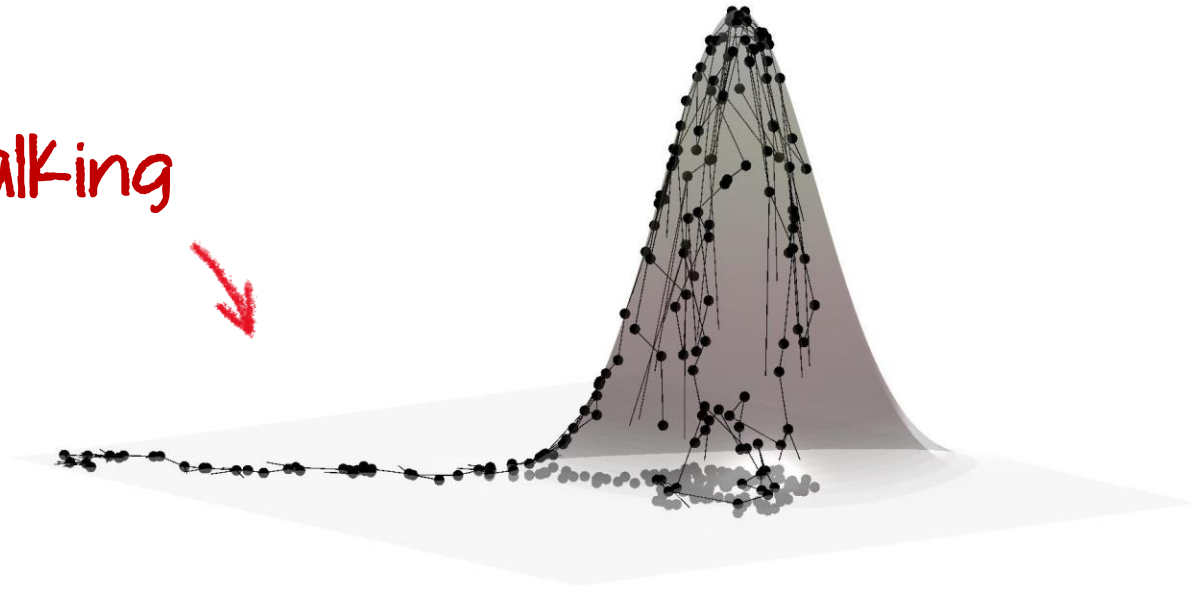
computers can't

see

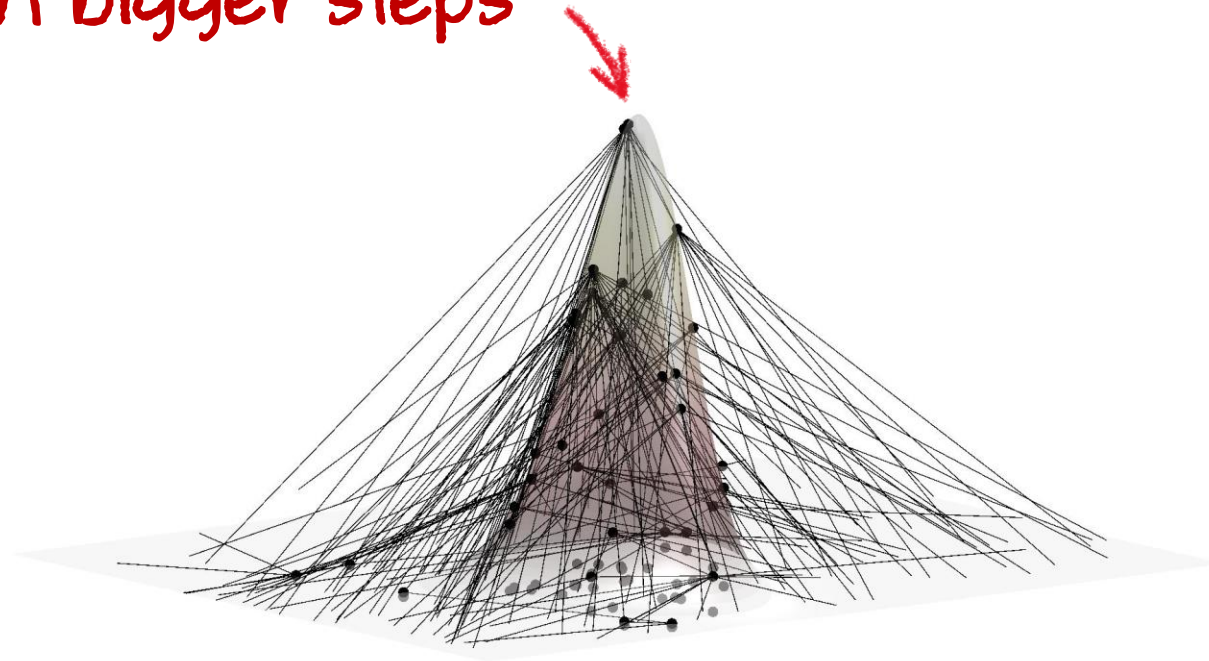
this shape



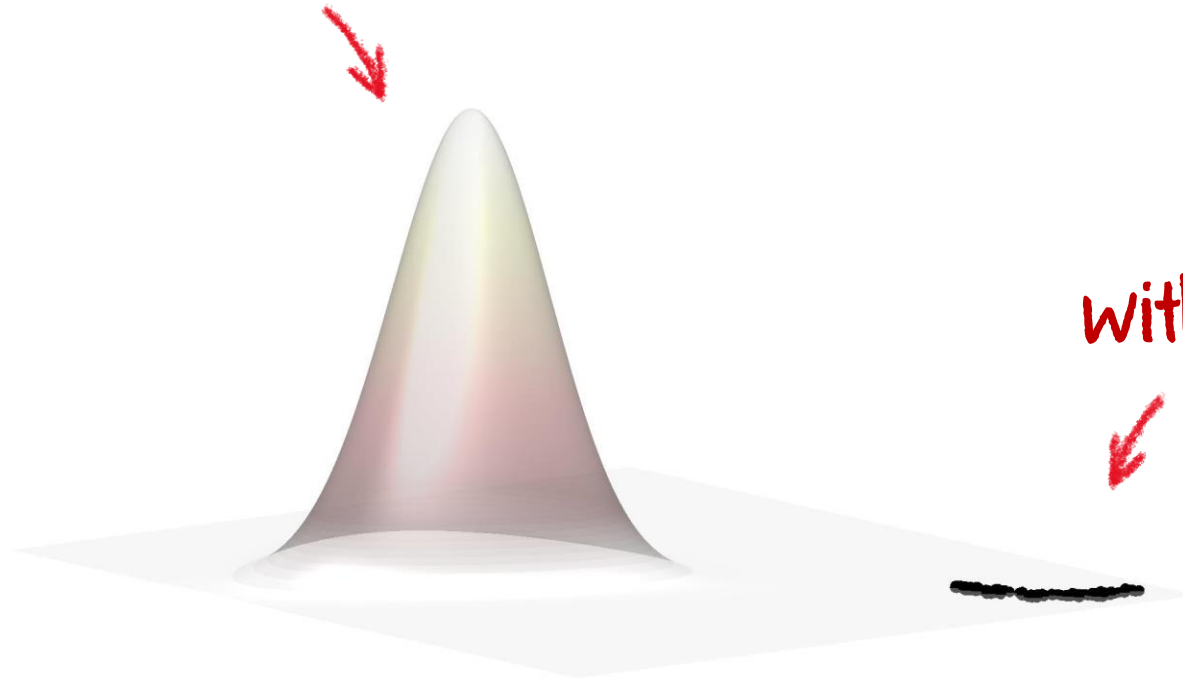
... random walking



... random walking
with bigger steps

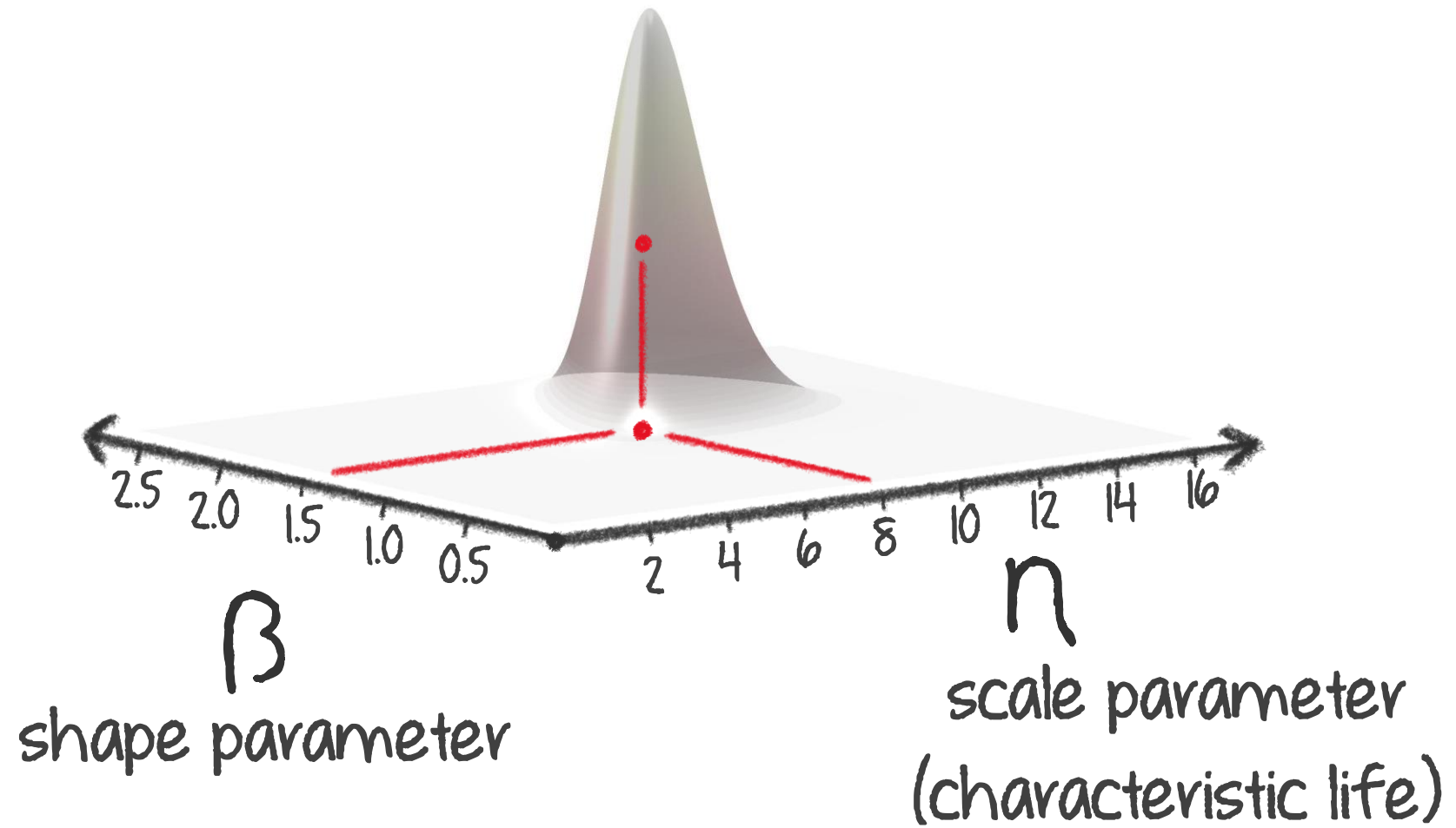


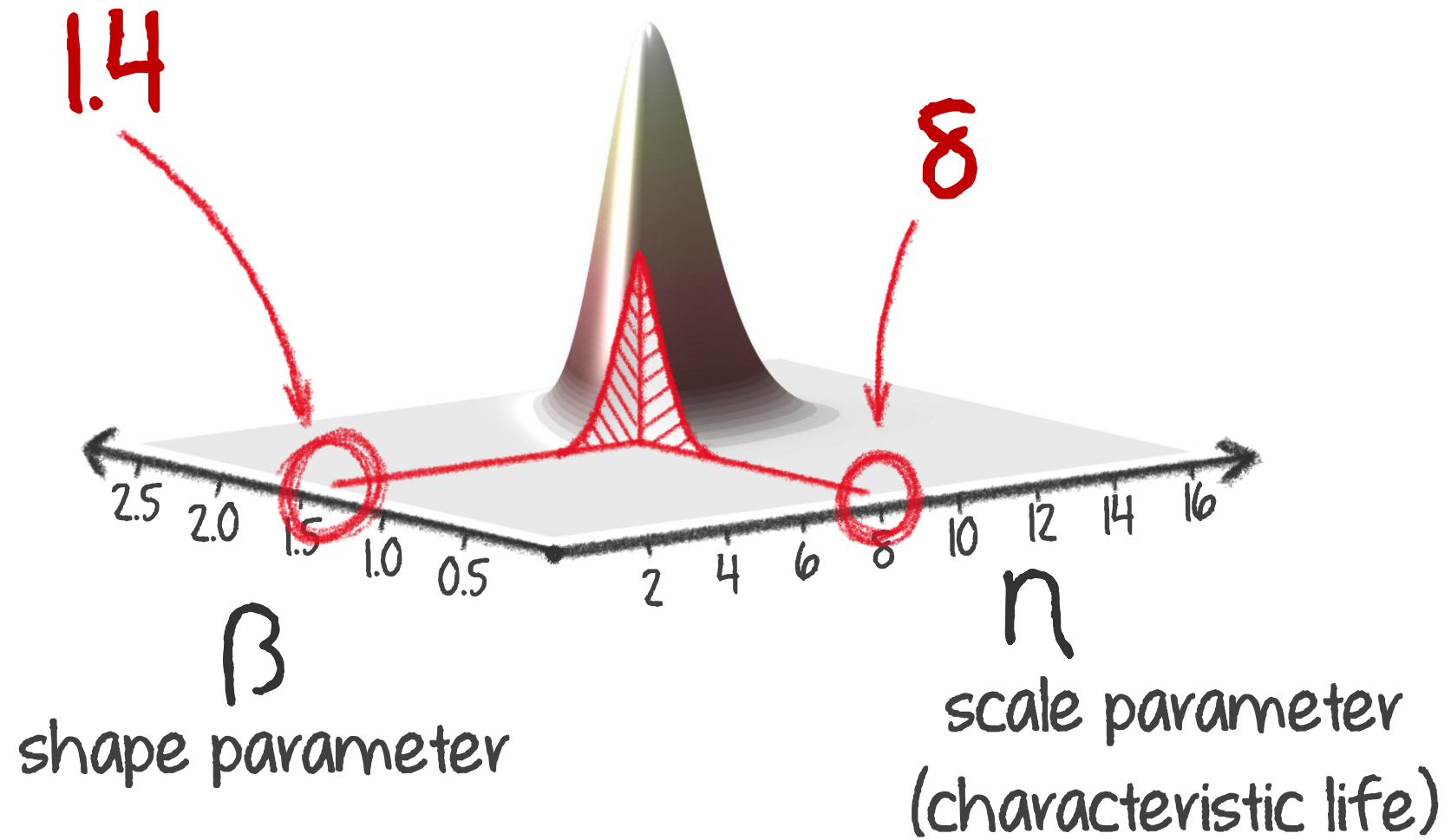
... so we never explore all the
likelihood function



... random walking
with smaller steps

... then there is
SLICE SAMPLING



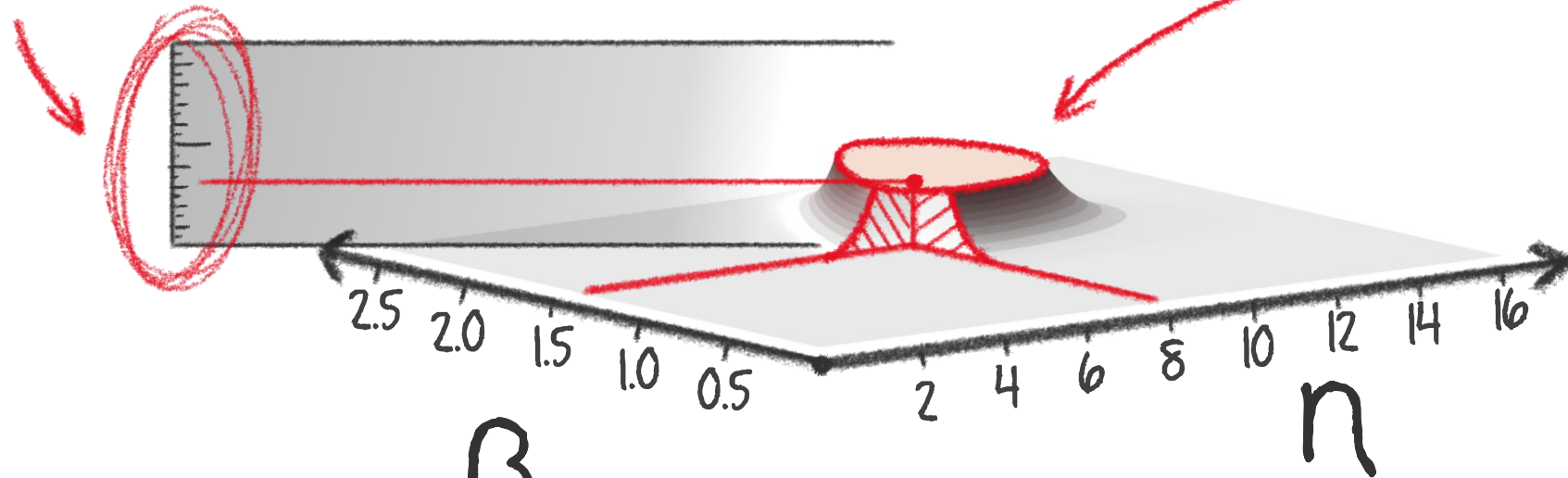


... randomly select a
value within the
likelihood

'height'
of our first point

... we use this randomly
selected value to create our

slice



β
shape parameter

n
scale parameter
(characteristic life)

... the next step is to

randomly
select a value

in our slice

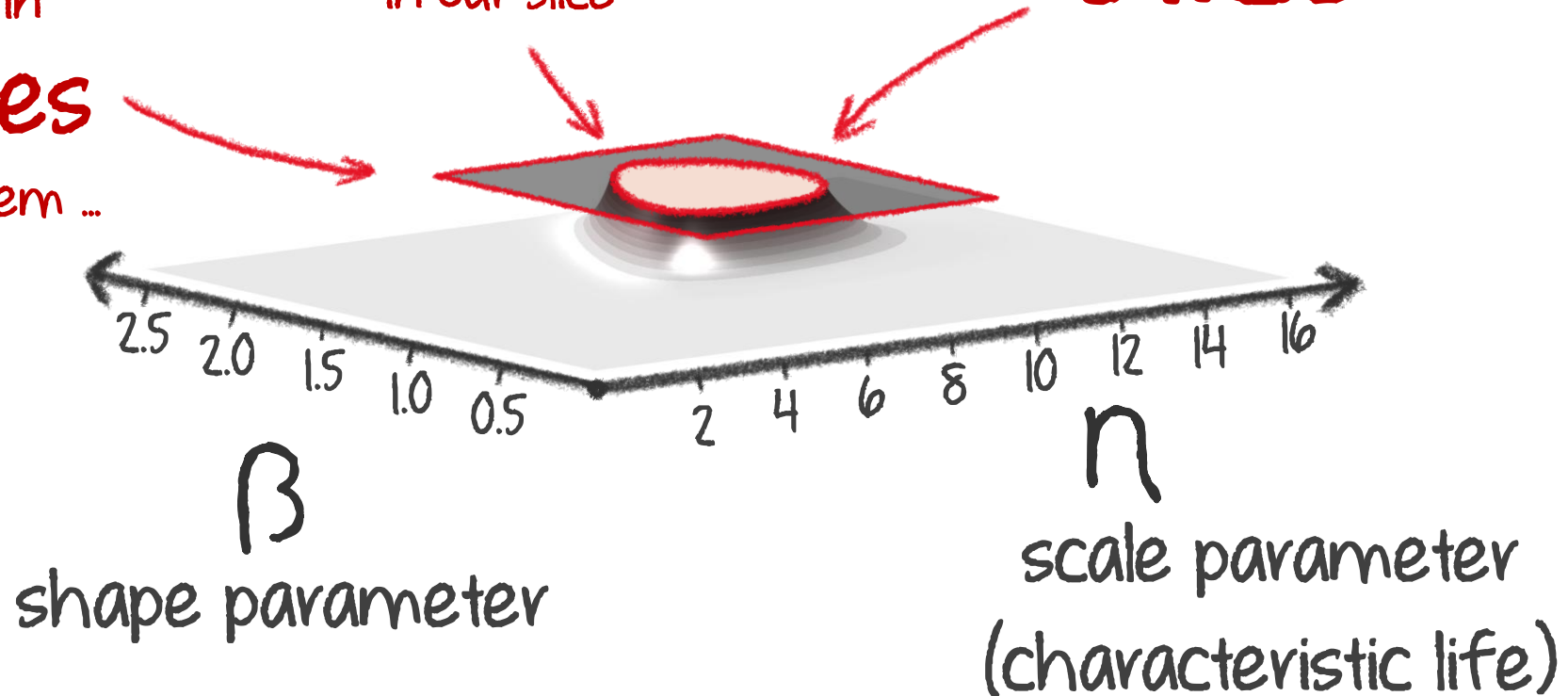
... we use this randomly
selected value to create our

slice

... but our computers
can only work in

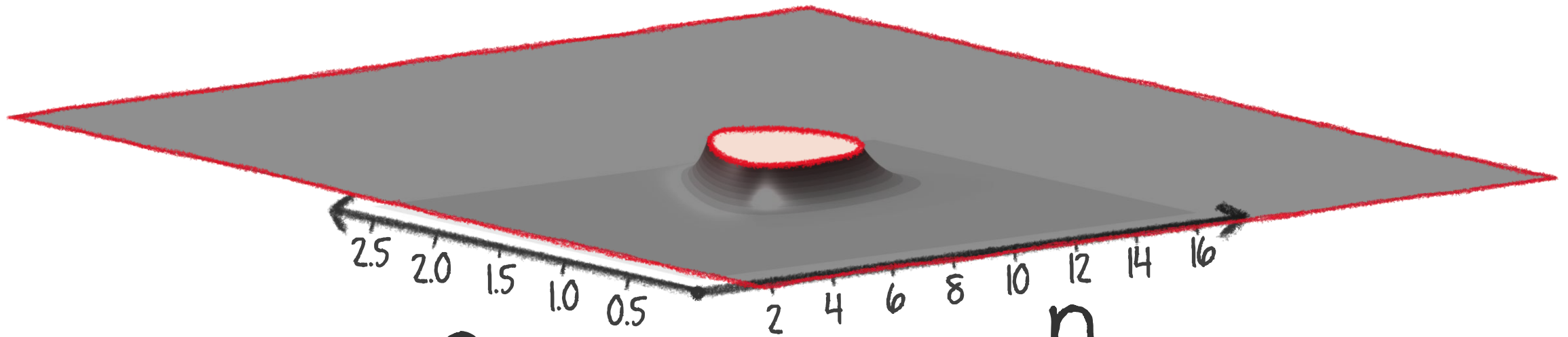
rectangles

we define for them ...



... we can help make sure
our slice is in this rectangle
by making it

big



β
shape parameter

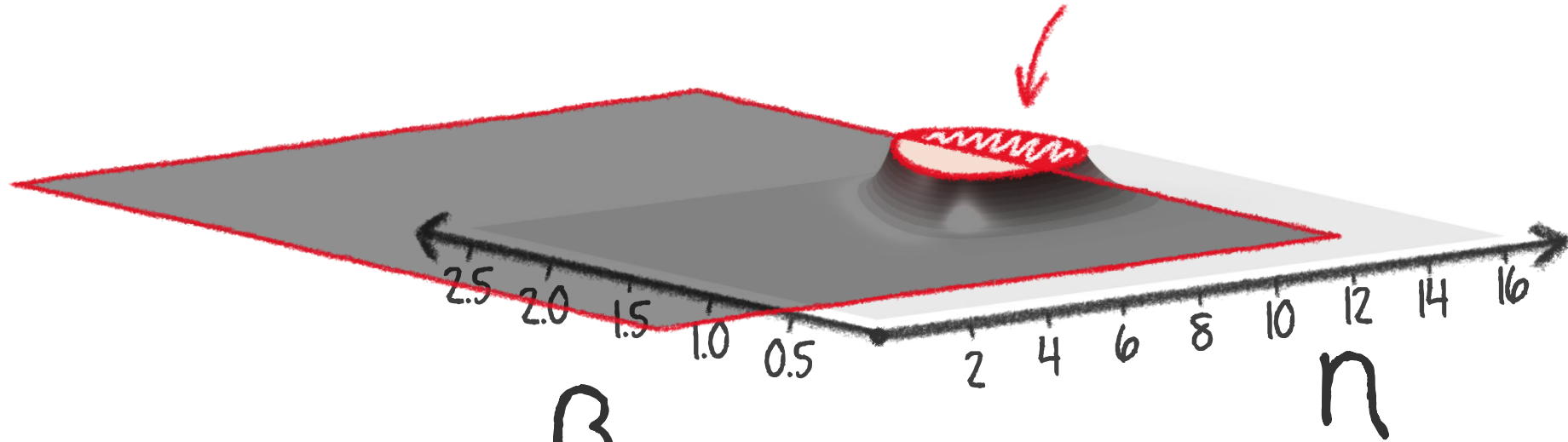
n
scale parameter
(characteristic life)

... we can help make sure
our slice is in this rectangle
by making it

big

... and we want to avoid

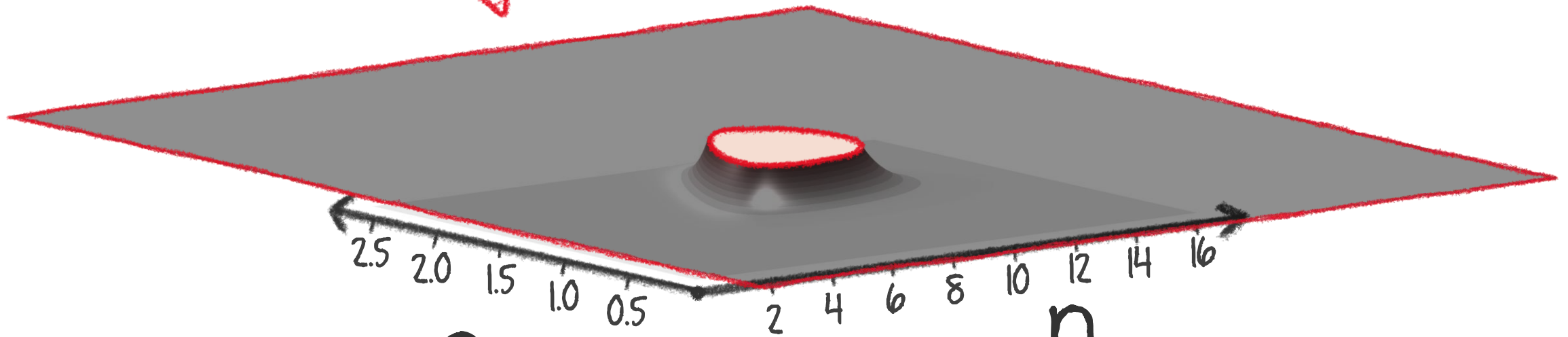
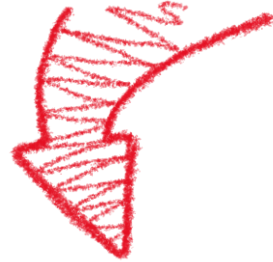
this



β
shape parameter

n
scale parameter
(characteristic life)

the rectangle of guess



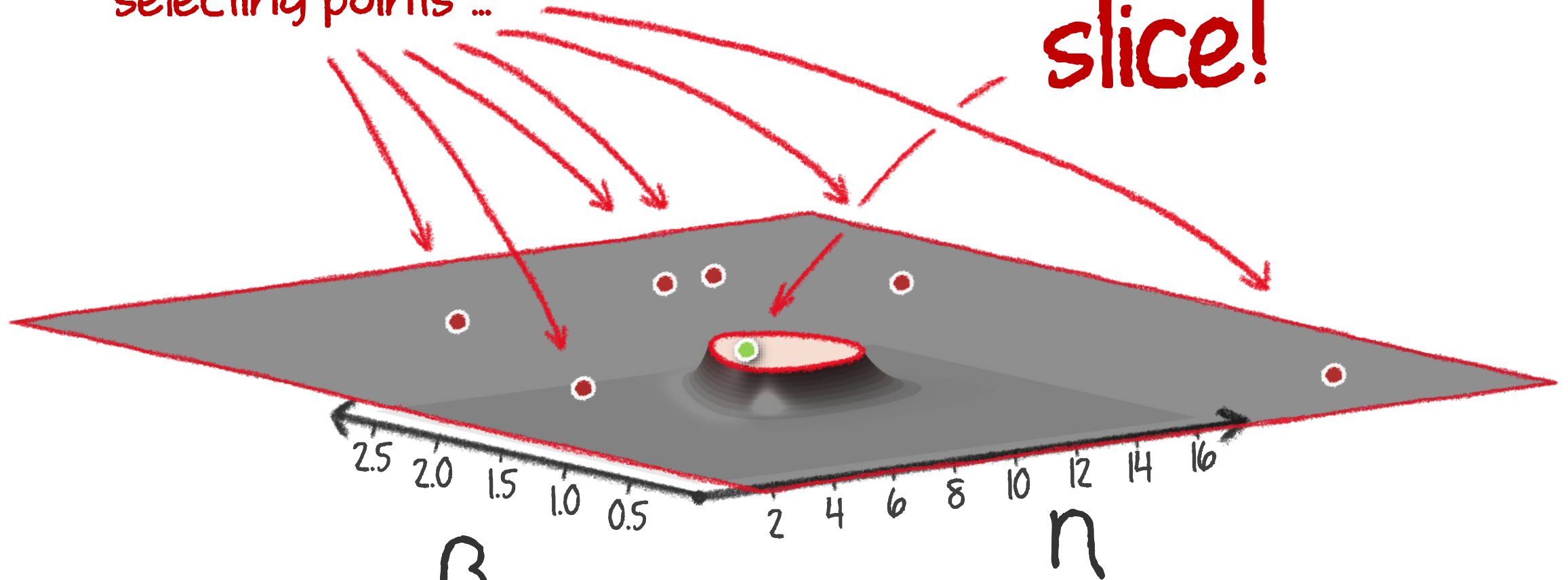
β
shape parameter

n
scale parameter
(characteristic life)

... randomly
selecting points ...

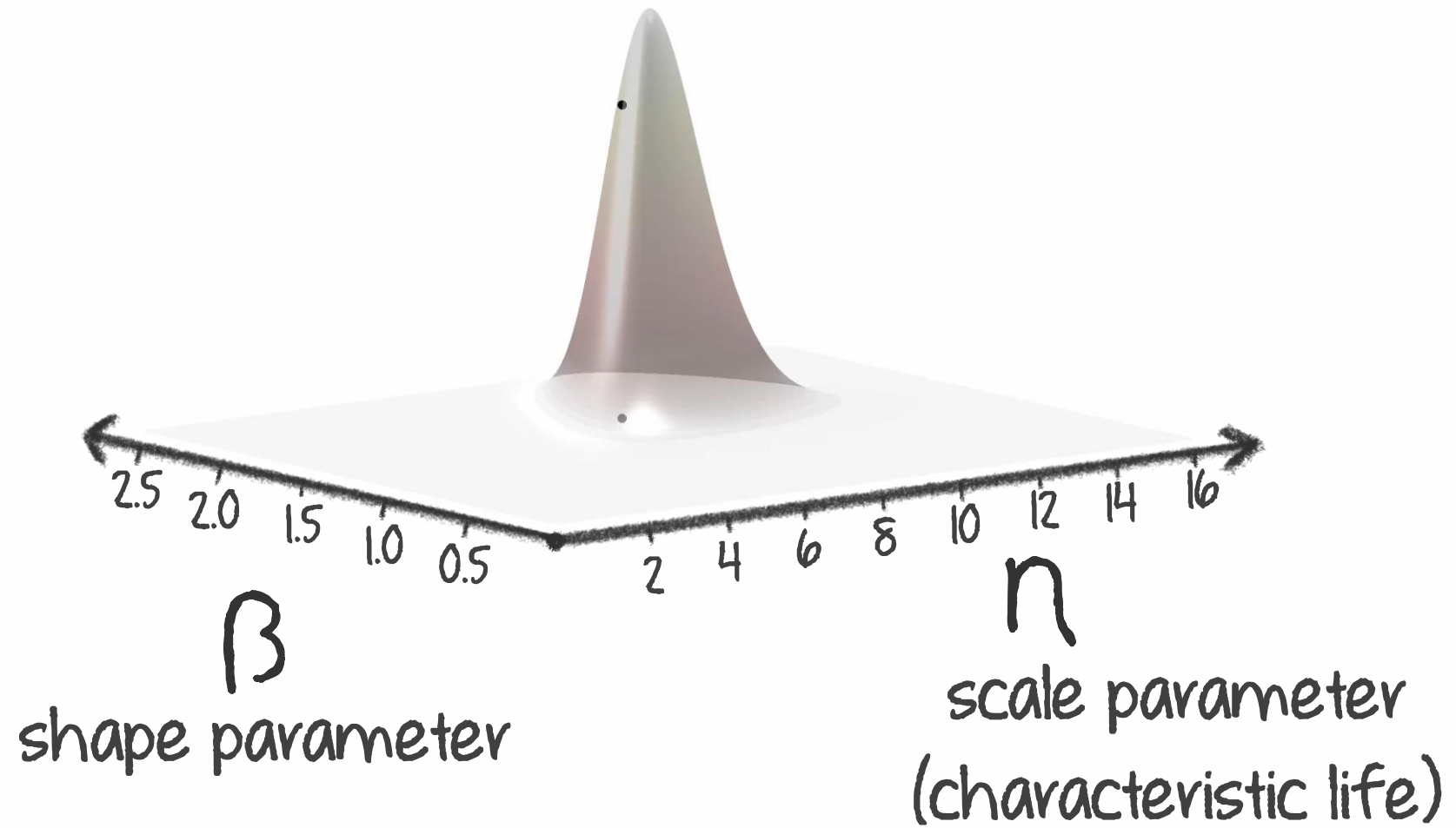
... until we find one in our

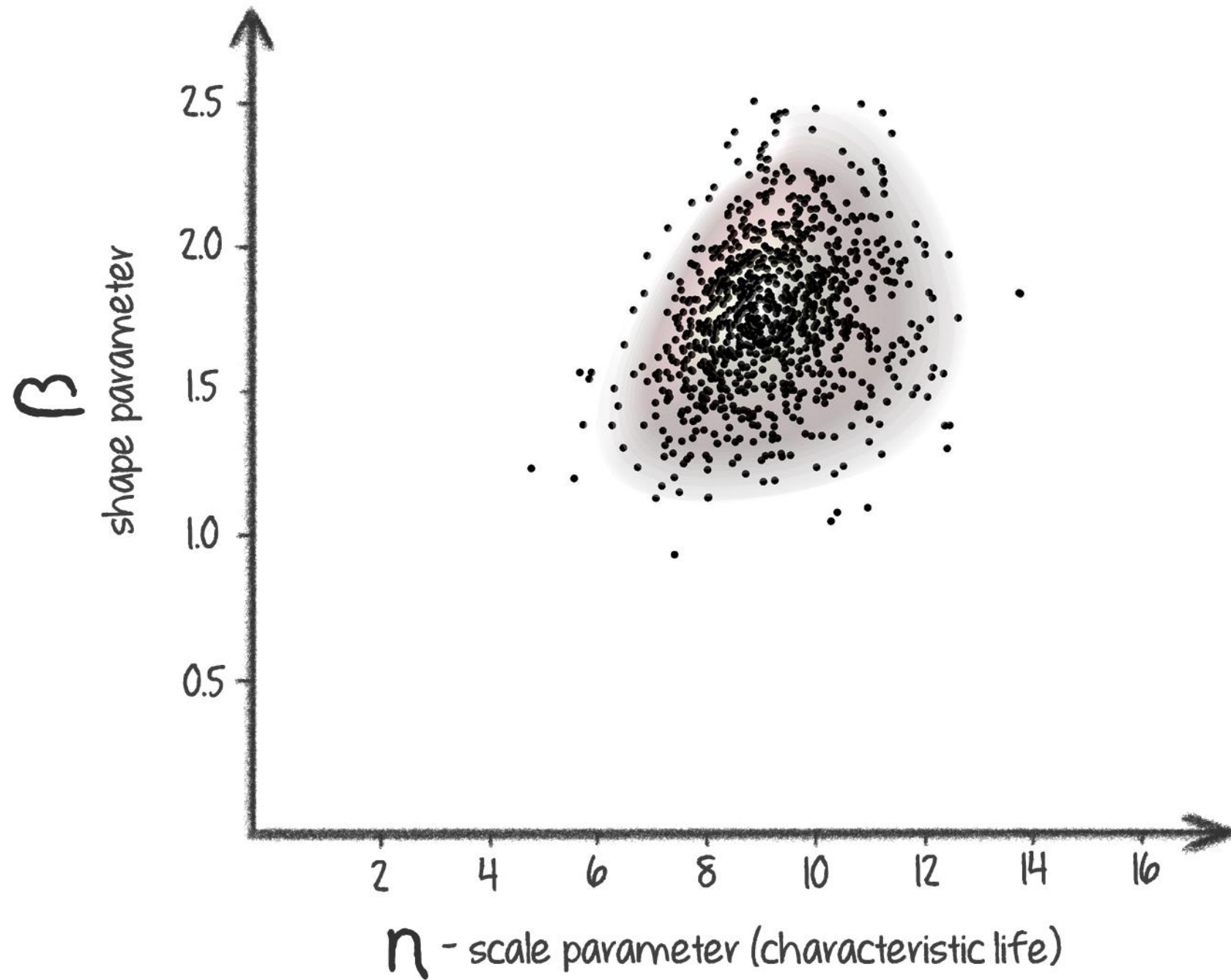
slice!



β
shape parameter

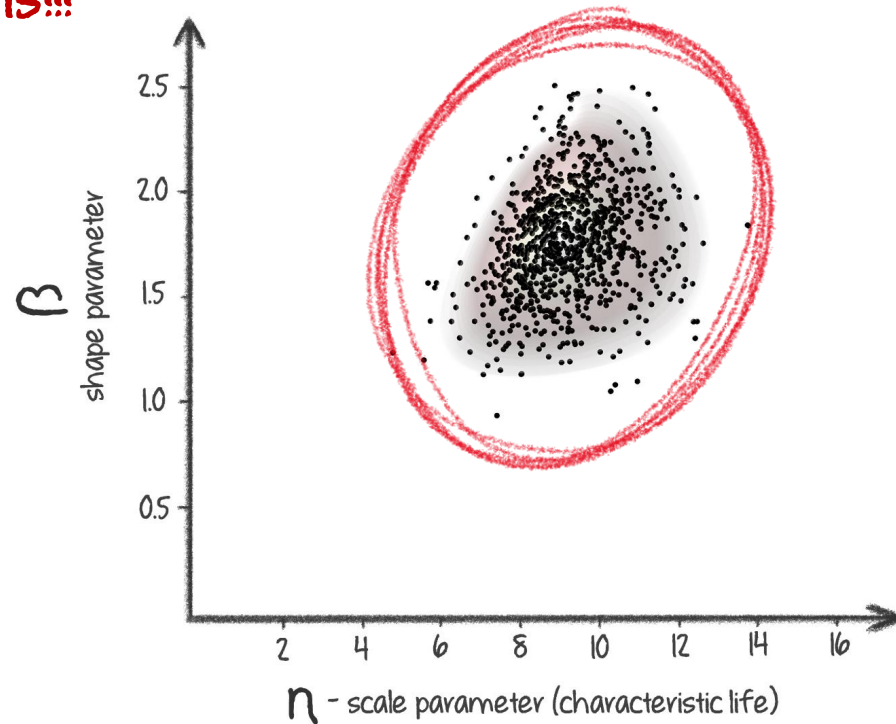
n
scale parameter
(characteristic life)



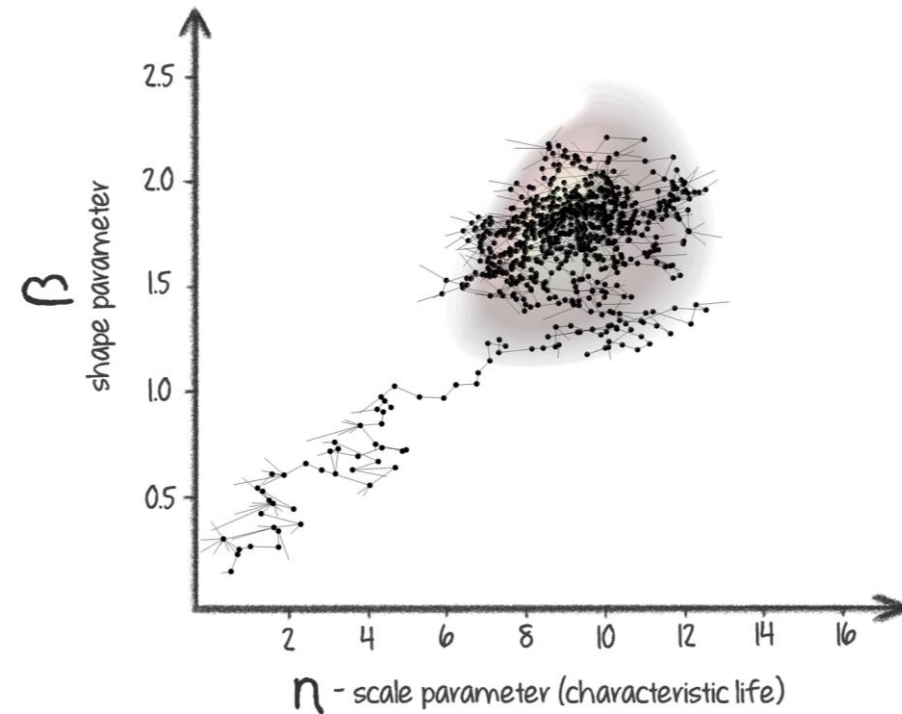


... how much
better
is this!!!

slice sampling



Metropolis-Hastings algorithm



let's do

this ...

1. Put your data in
2. Roughly estimate likely parameter values
3. Create a log likelihood function
4. (... if you want) find the MLE
5. Create slice sampling widths
6. SAMPLE!
7. Use those samples

1. Put your data in

the (random) hand of failure



time to failure (TTF)

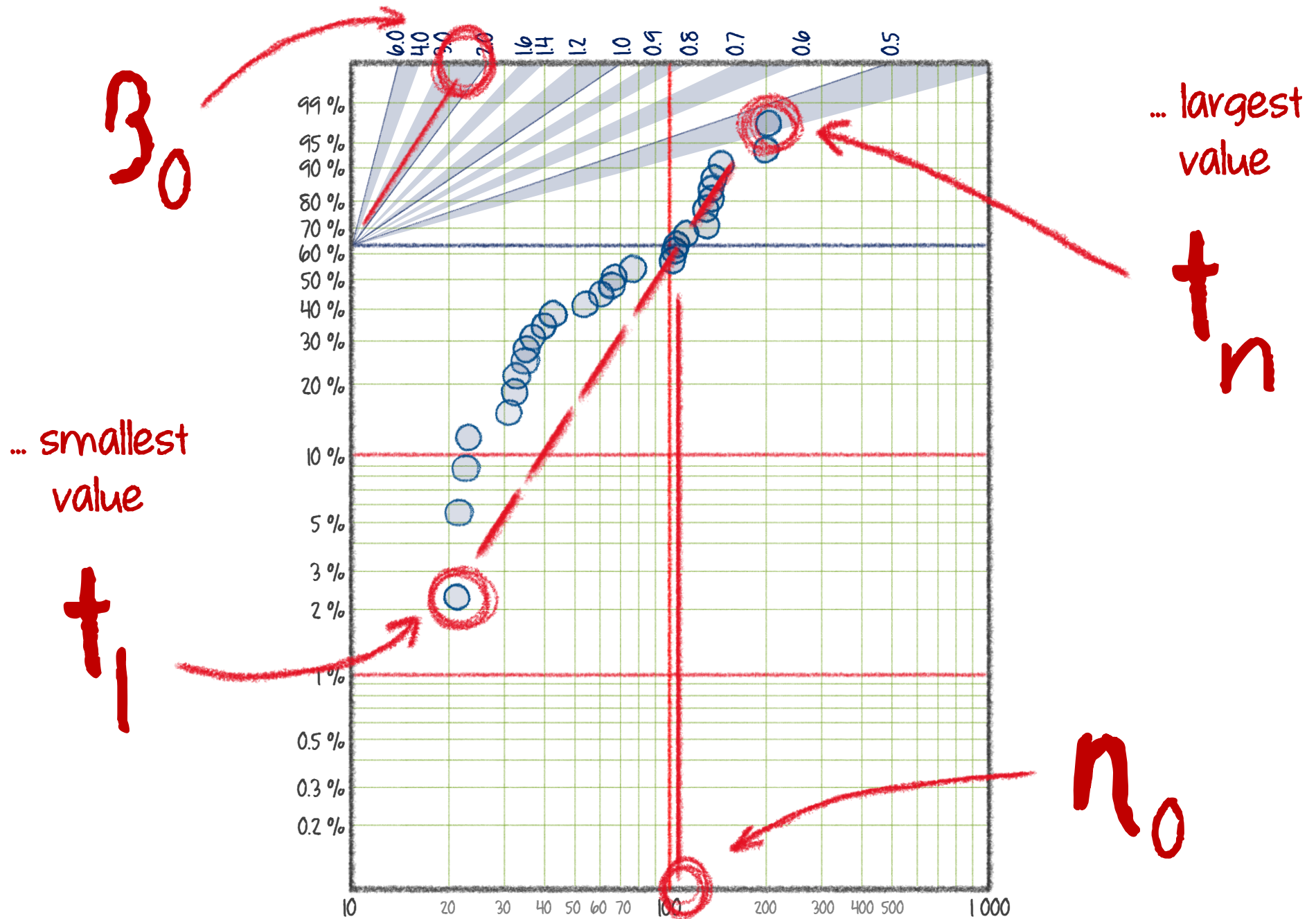


```
t =  
[ ... all your  
  observed  
times to failure  
  ... ]
```



```
t = matrix(  
+ c(... all your  
observed times to  
failure ... )  
+ nrow = ?  
+ ncol = ?)
```

2. Roughly estimate
likely parameter
values



beta0 =

```
[log(log(n + 0.4) - log(n - 0.3)) -  
log(log(n + 0.4) - log(0.1))] ...  
/  
...  
(log(t1) - log(tn))
```

```
eta0 =  
    exp(log(t1) + ...  
    ( (log(1) - (log(log(n + 0.4) -  
        log(0.1))) ) / beta0 ) )
```

3. Create a log
likelihood
function



```
>> logL0 = @(p) ...  
    log(p(2)) + ...  
sum((p(2)-1).*log(t)) - ...  
    (p(2)*log(p(1))) - ...  
    sum((t./p(1)).^ p(2))  
  
>> option = ...  
    {logL0 @(p) -Inf}  
  
>> logL = @(p) ...  
option{1 + (min(p) <= 0)}(p)
```



```
logLik <- function(eta ,  
    beta , t) {  
+ if(eta <= 0 || beta <= 0  
    ) {  
    + result = -Inf}  
+ if (eta > 0 && beta > 0) {  
    + result = log(beta) +  
sum((beta-1)*log(t)) -  
    (beta*log(eta)) -  
sum((t./eta)^ beta) } }
```

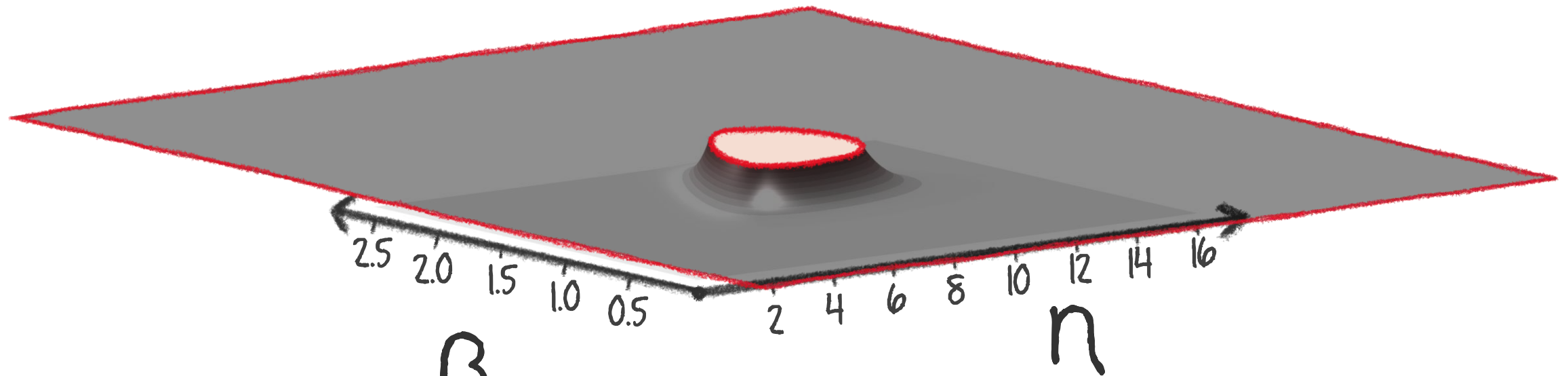
4. (... if you want)

find the MLE

**5. Create slice
sampling widths**

... we can help make sure
our slice is in this rectangle
by making it

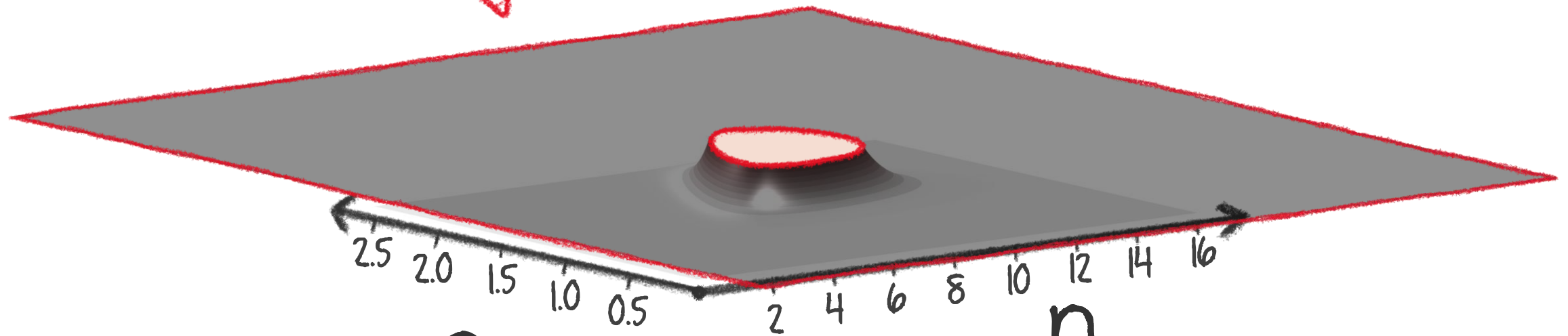
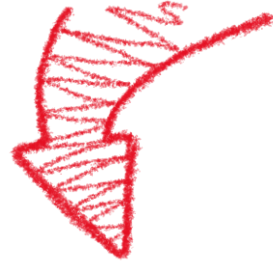
big



β
shape parameter

n
scale parameter
(characteristic life)

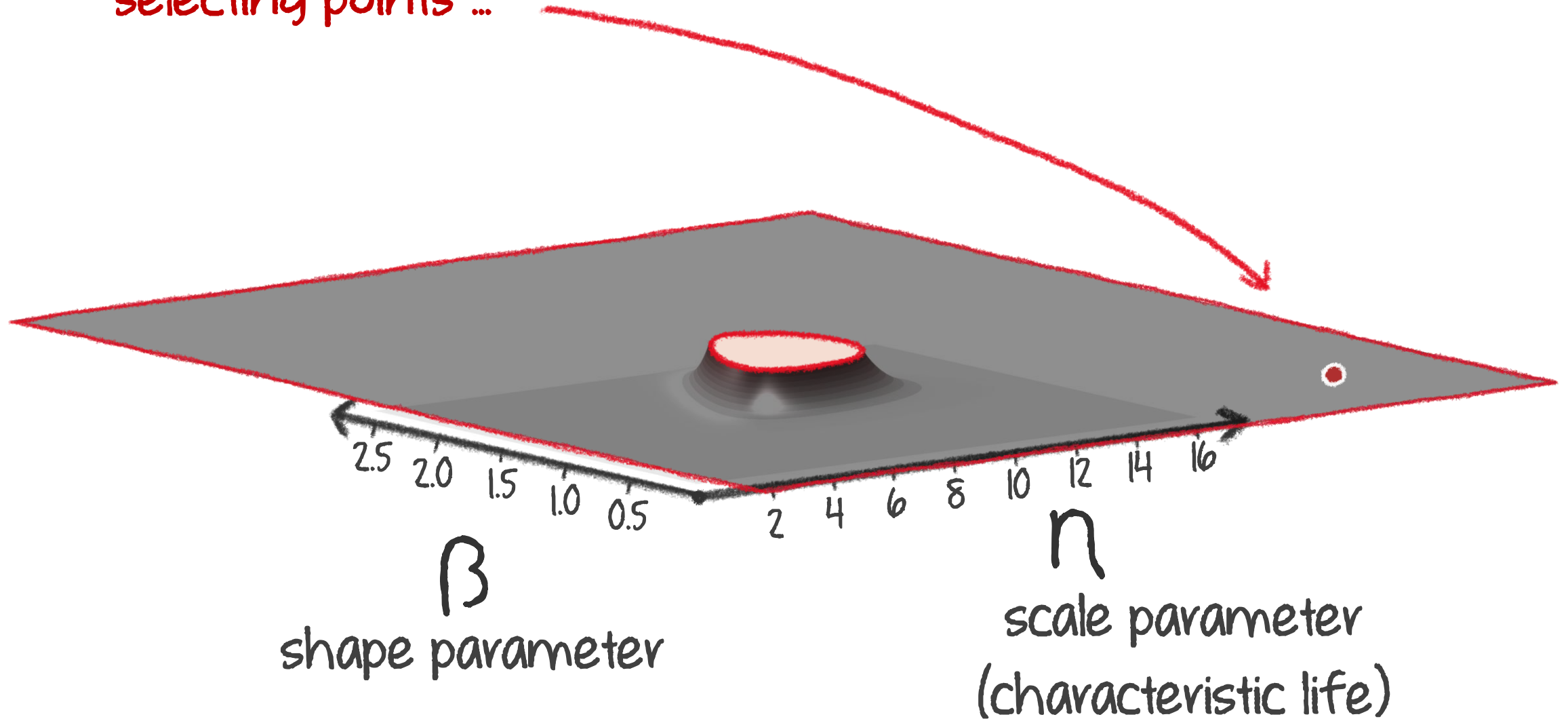
the rectangle of guess



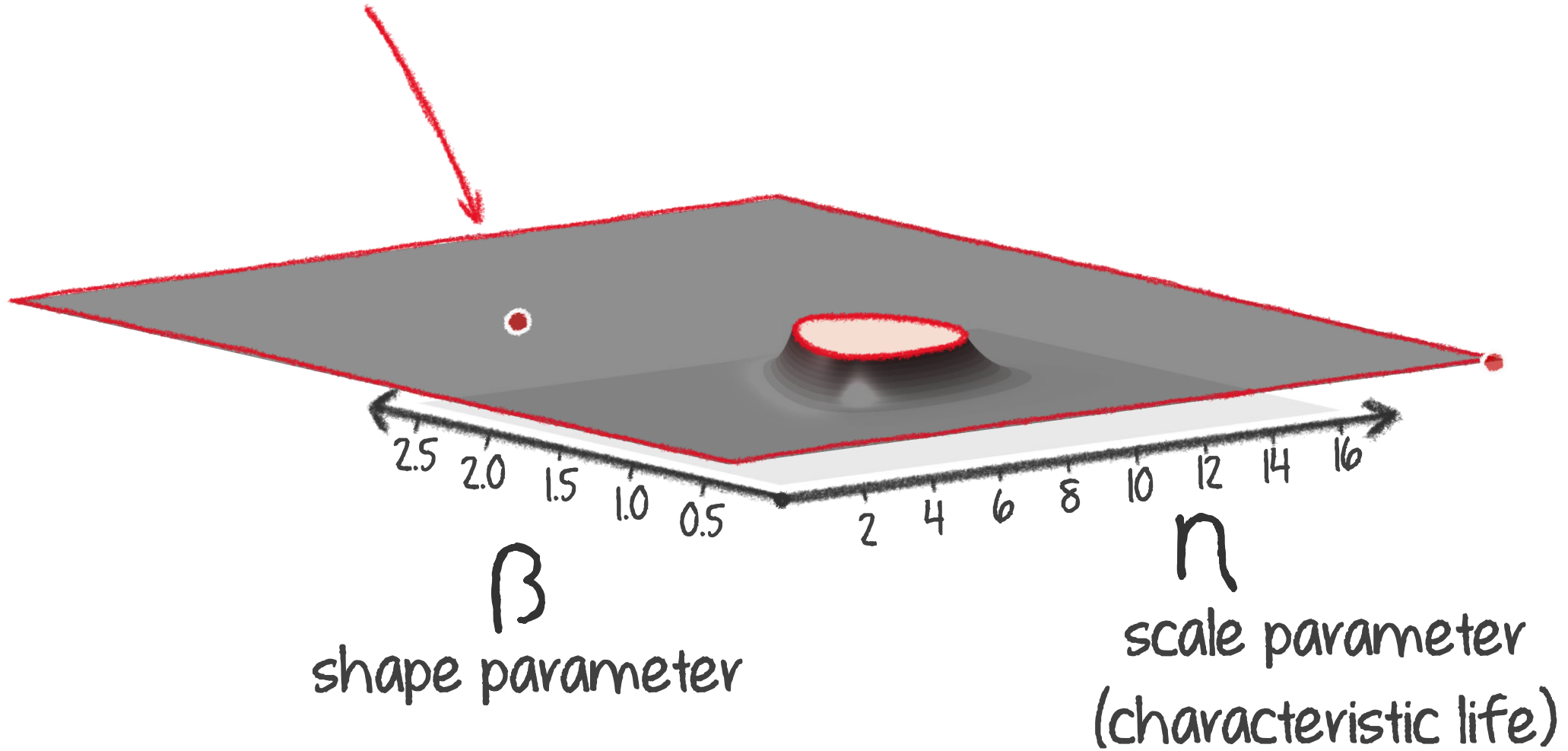
β
shape parameter

n
scale parameter
(characteristic life)

... randomly
selecting points ...

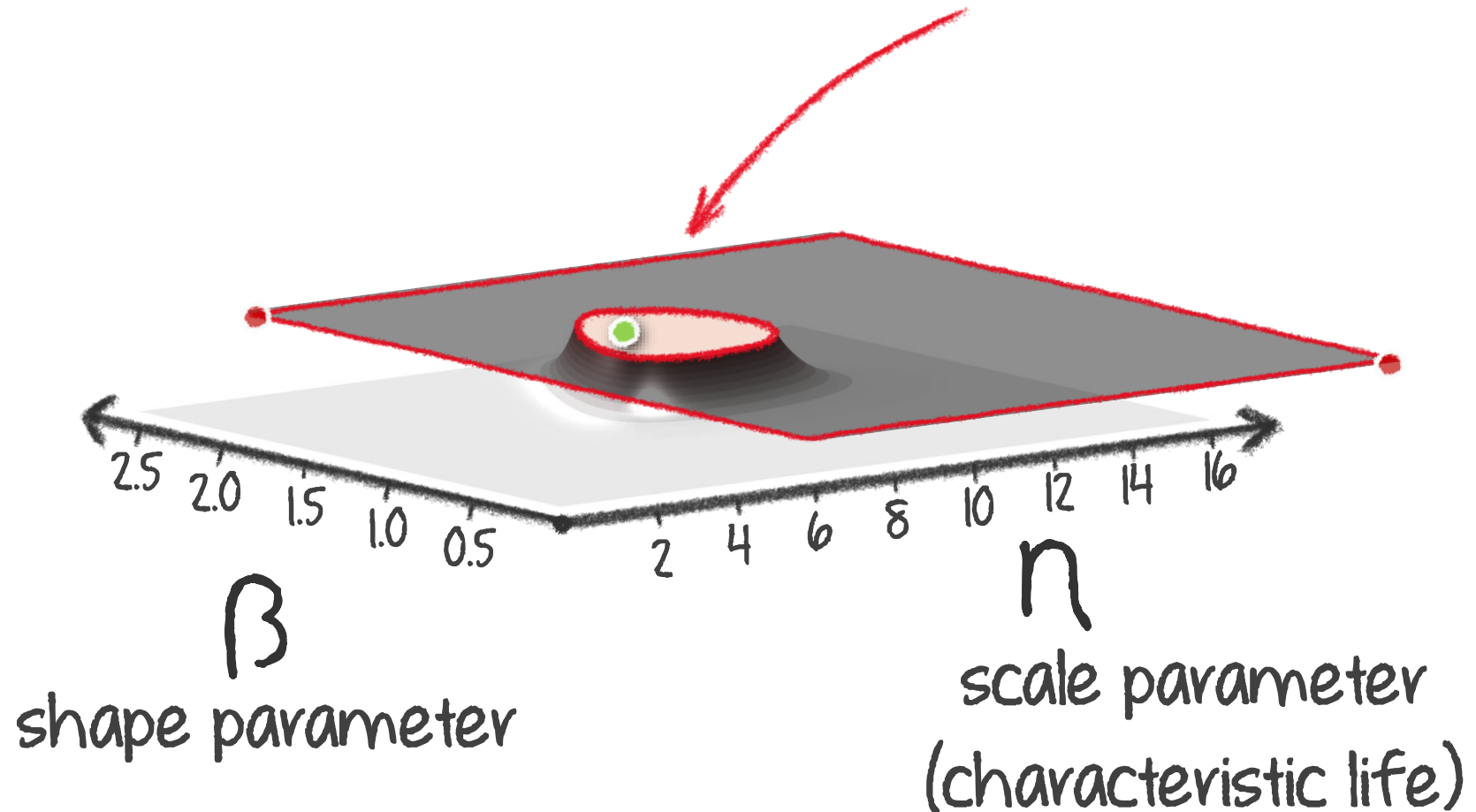


... randomly
selecting points ...



... randomly
selecting points ...

... until we find one in our
slice!

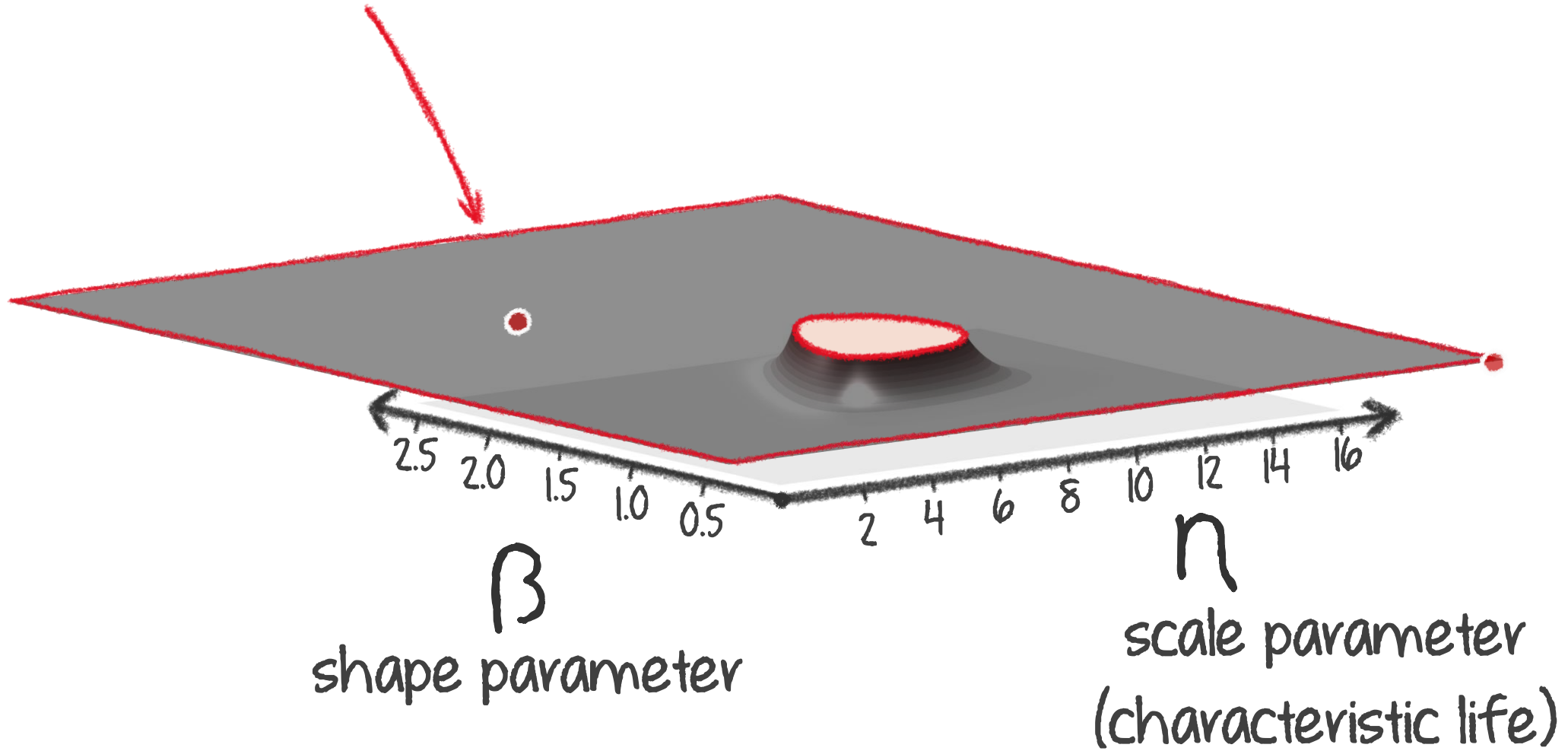


... so let's try

3

times our initial
parameter
estimates

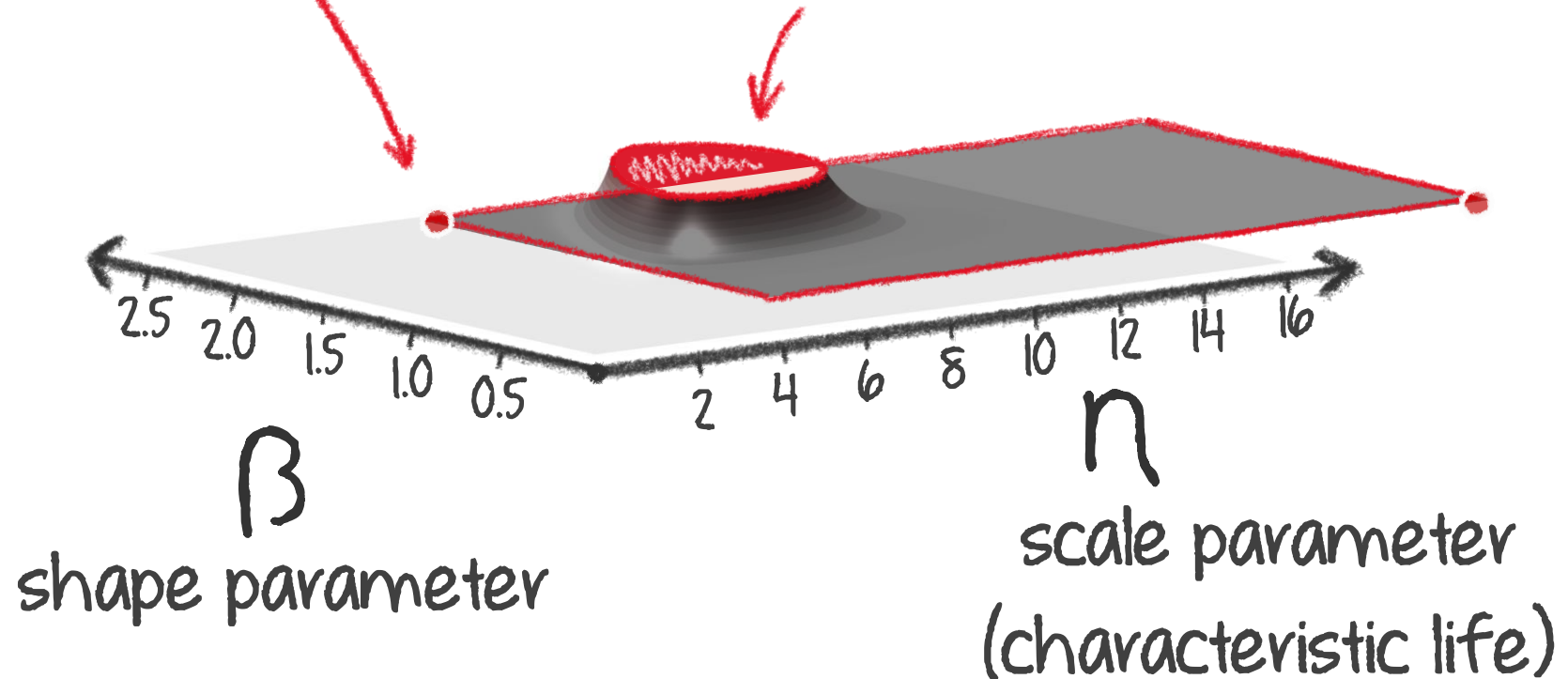
... randomly
selecting points ...



... randomly
selecting points ...

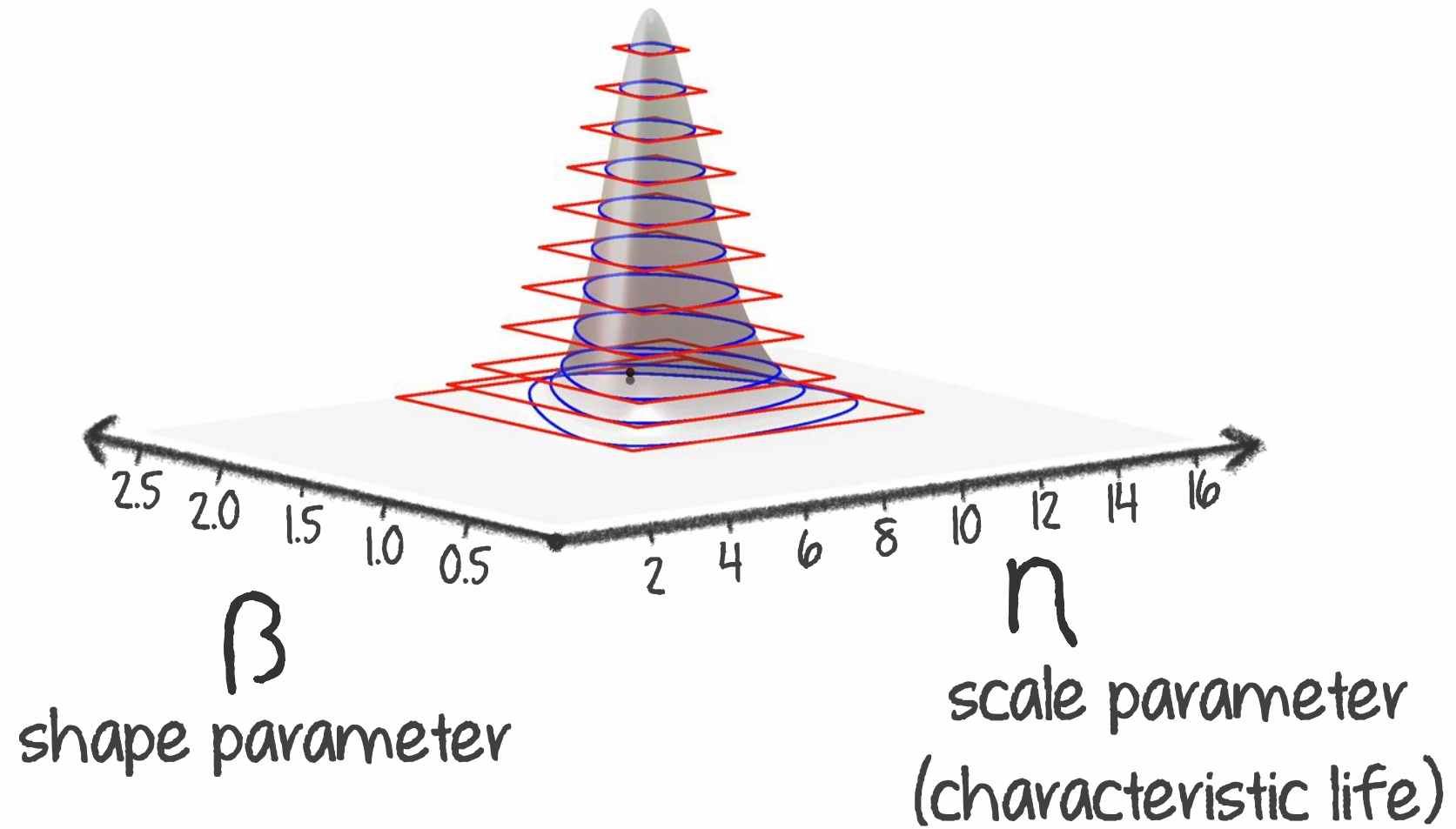
... and we want to avoid

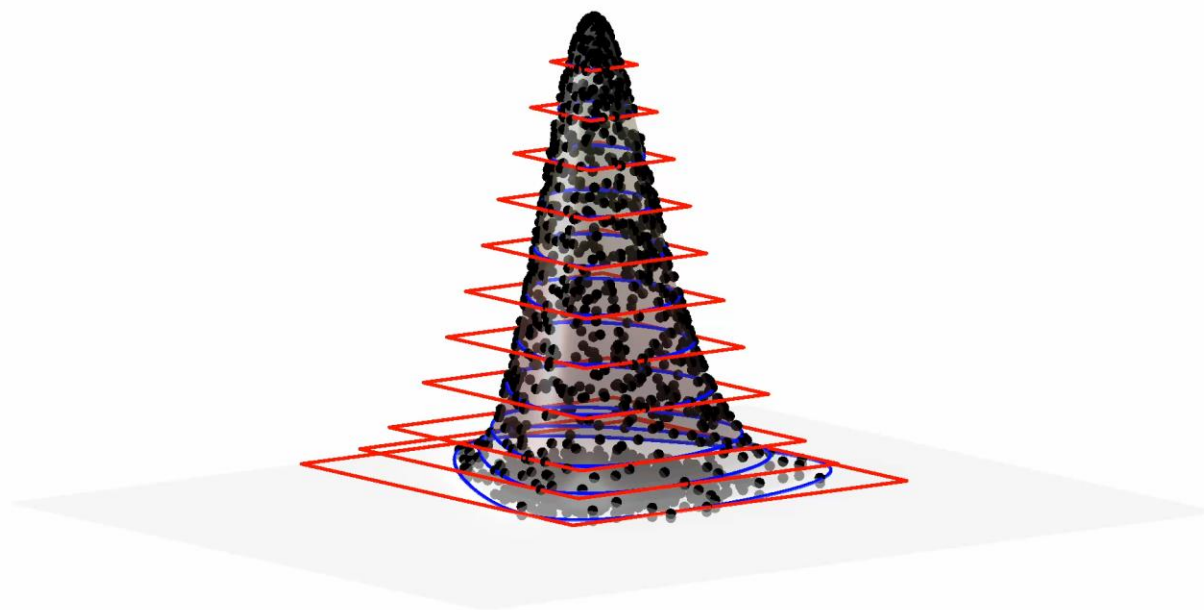
this

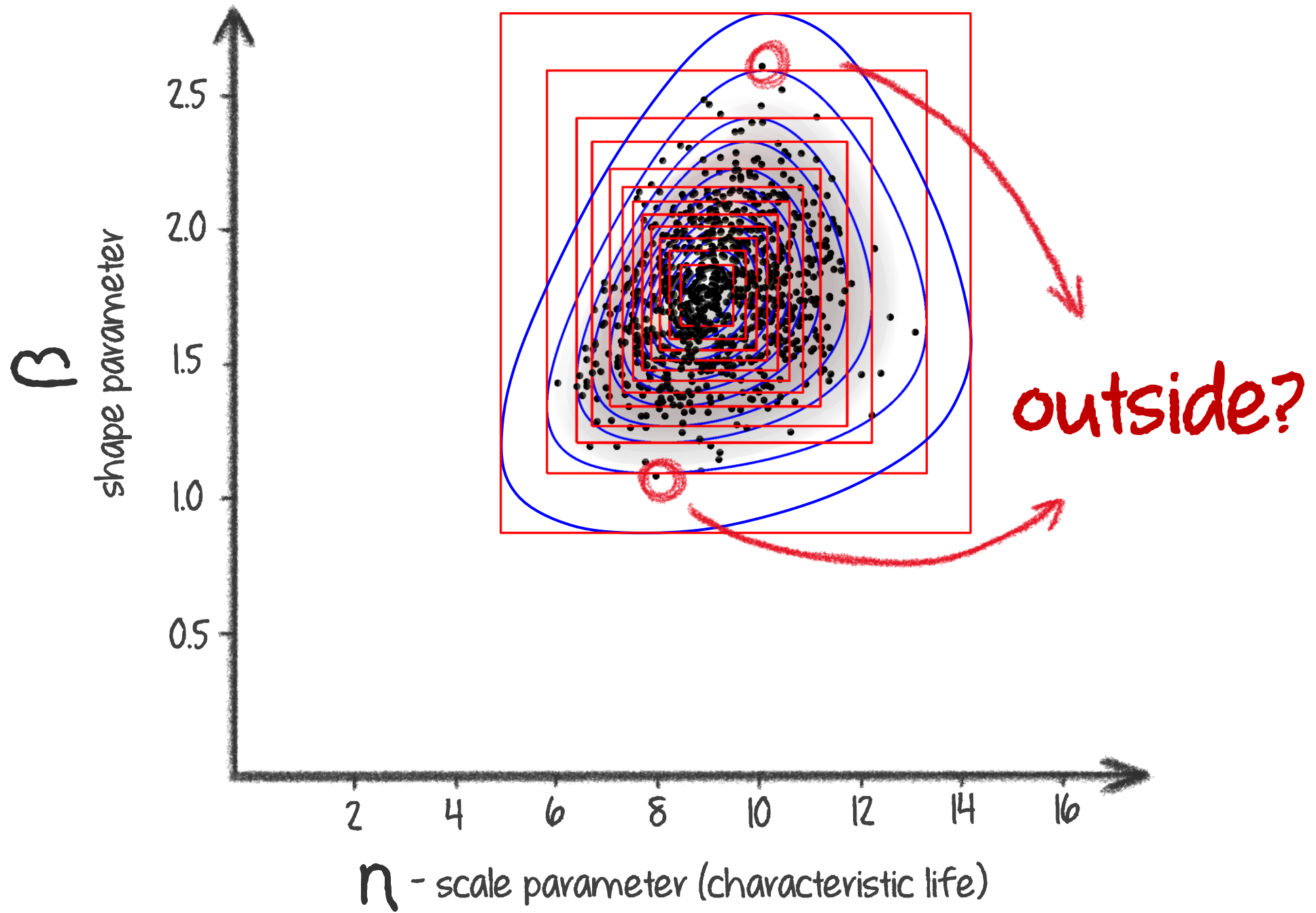


... so what does

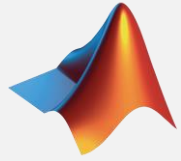
chvis do?







6 . SAMPLE !



MATLAB

```
p =  
    slicesample ...  
    ([eta0 , beta0] , ...  
     10000 , ...  
     'logpdf' , logL , ...  
     'width' , 3 * [eta0 , beta0])
```



```
p <- mcmc(logL,  
c(eta0 , beta0),  
      10000,  
      3 * (eta0 , beta0))
```

... find and research your
own package!

p =

... this column contains the **scale** parameters (η)

... this column contains the **shape** parameters (β)

... each row contains the parameters of a **sampled** Weibull distribution

1.3126	1.8121
1.2381	2.1264
1.172	2.0913
0.7563	1.9265
1.1949	1.9385
1.1358	1.6517
0.8186	1.9352
0.895	1.8561
0.8963	1.8714
0.9315	1.8856
0.9353	1.721
0.8678	1.4534
0.8218	1.4308
0.8126	1.3933
0.7864	1.5750

... and there are **1000** rows (or samples) in total

`p =`

... no estimate for
rectangle width

`slicesample`

... just a random
guess at where
to start

`( [1, 1],`

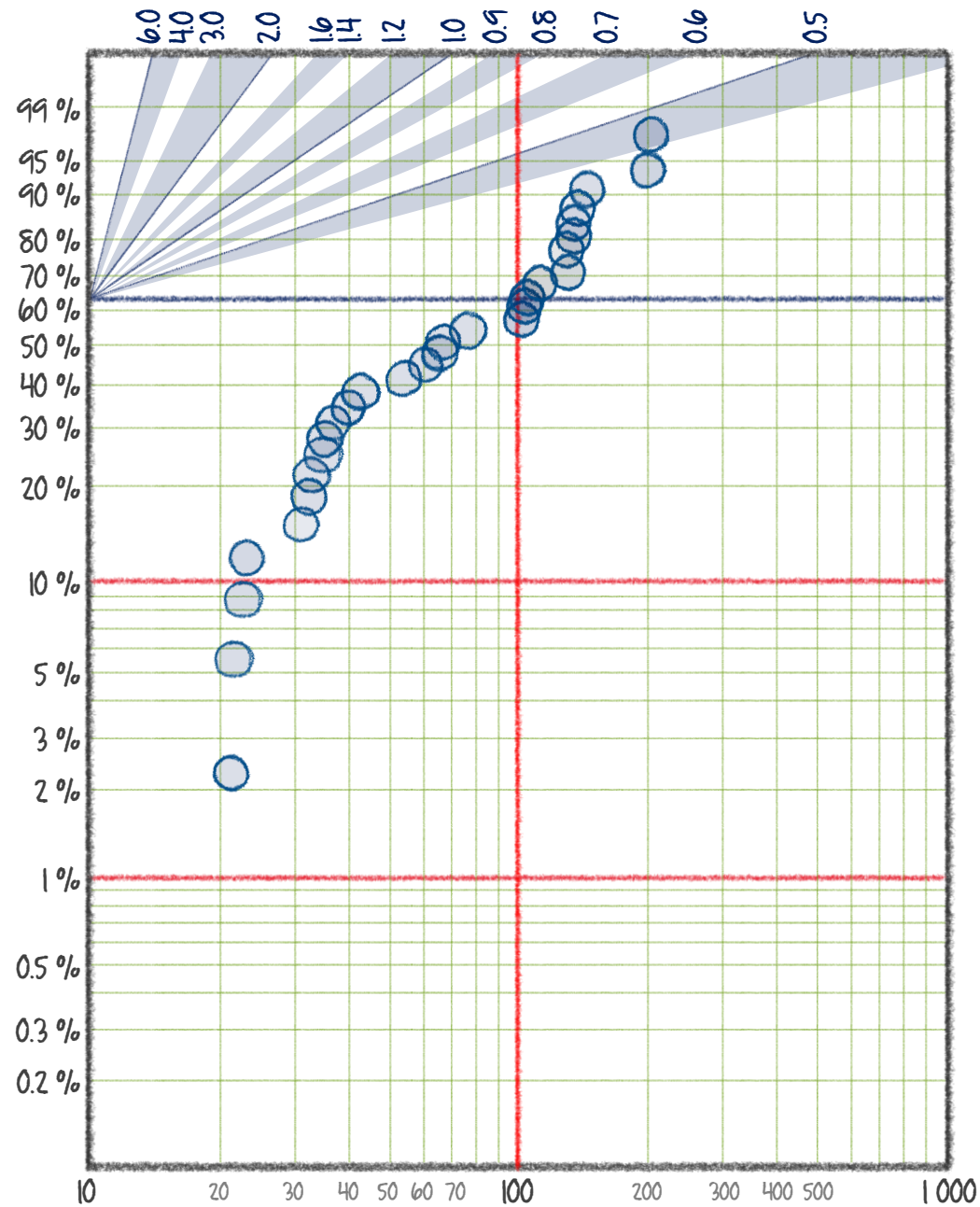
`10000,`

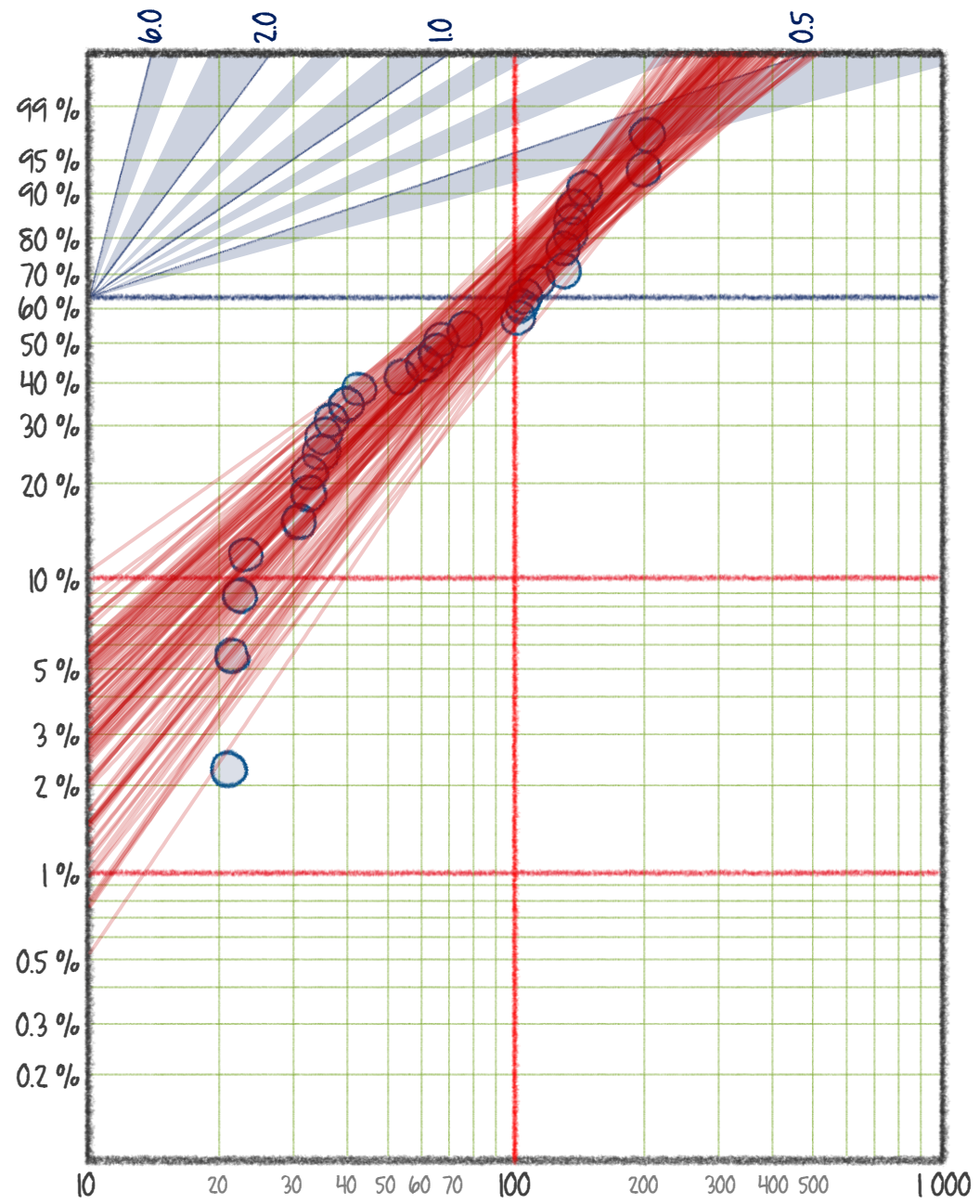
`'pdf',`

... didn't use the
log-likelihood

`@(p) prod(wb1pdf(x, p(1), p(2)))`

probability of failure





7. Use those samples



```
F =  
wblcdf(2,p(:,1),p(:,2))
```



```
F =  
1-exp(-(2/p(:,1))^p(:,2)))
```

F =

0.0325

0.0205

0.0245

0.0742

0.0308

0.0552

0.0633

0.0601

0.0586

0.0535

0.0679

0.1117

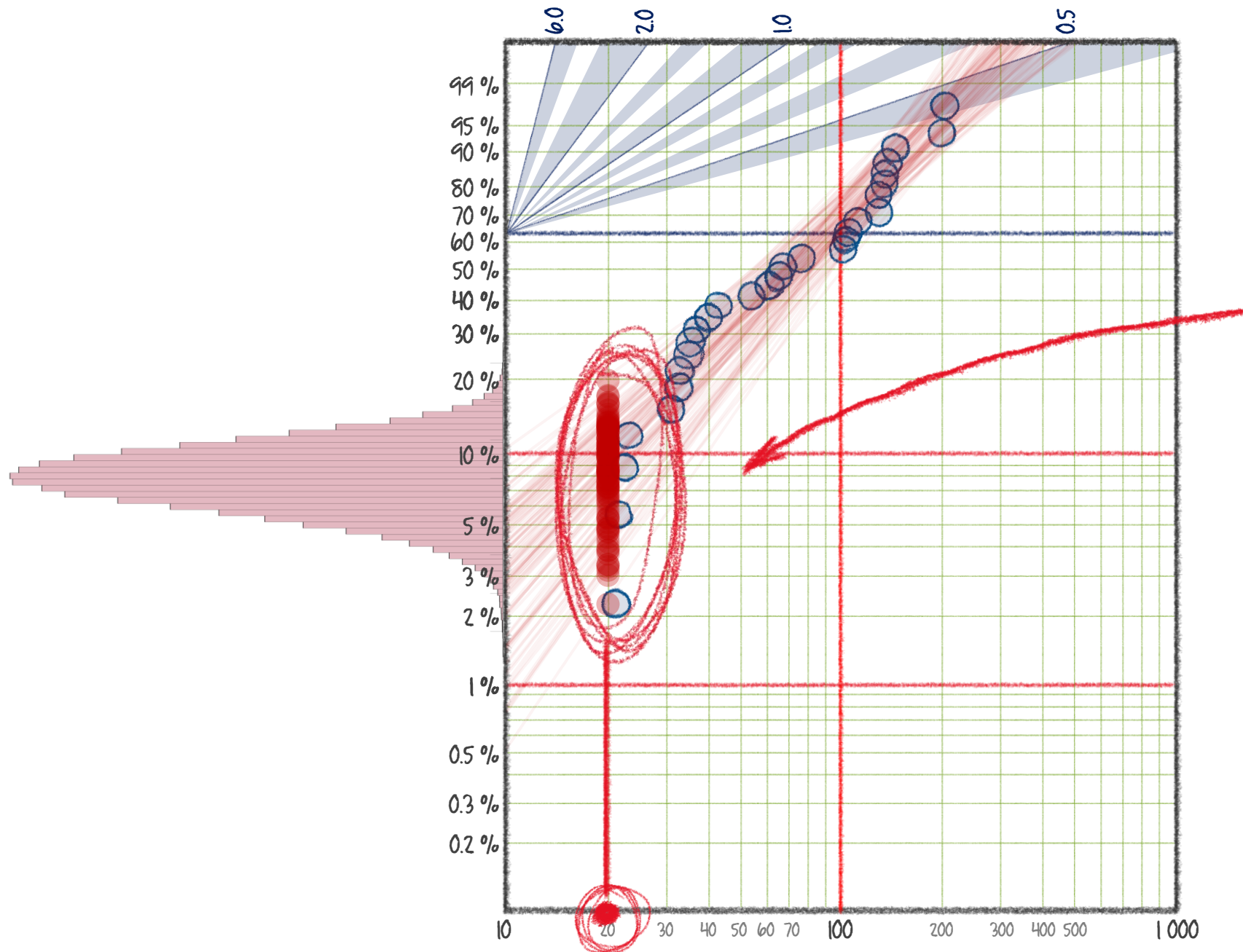
0.124

0.1322

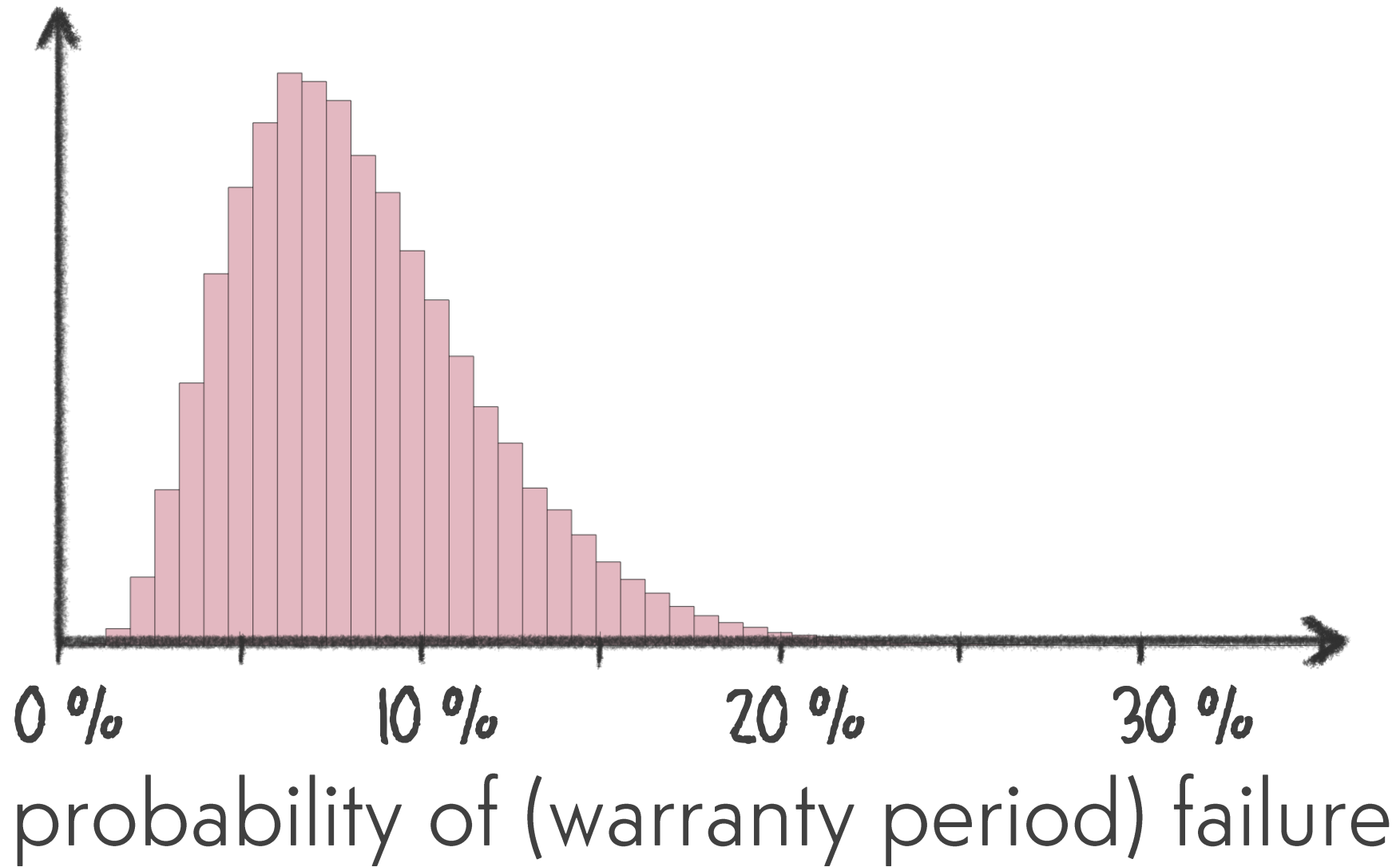
0.1071

... each row contains a
sampled
failure probability
at 2 years





our
100
samples
of
reliability
at 2 years



$$\text{warrantyCost} = F * 115$$

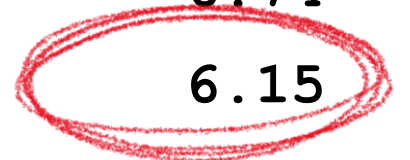
warrantyCost =

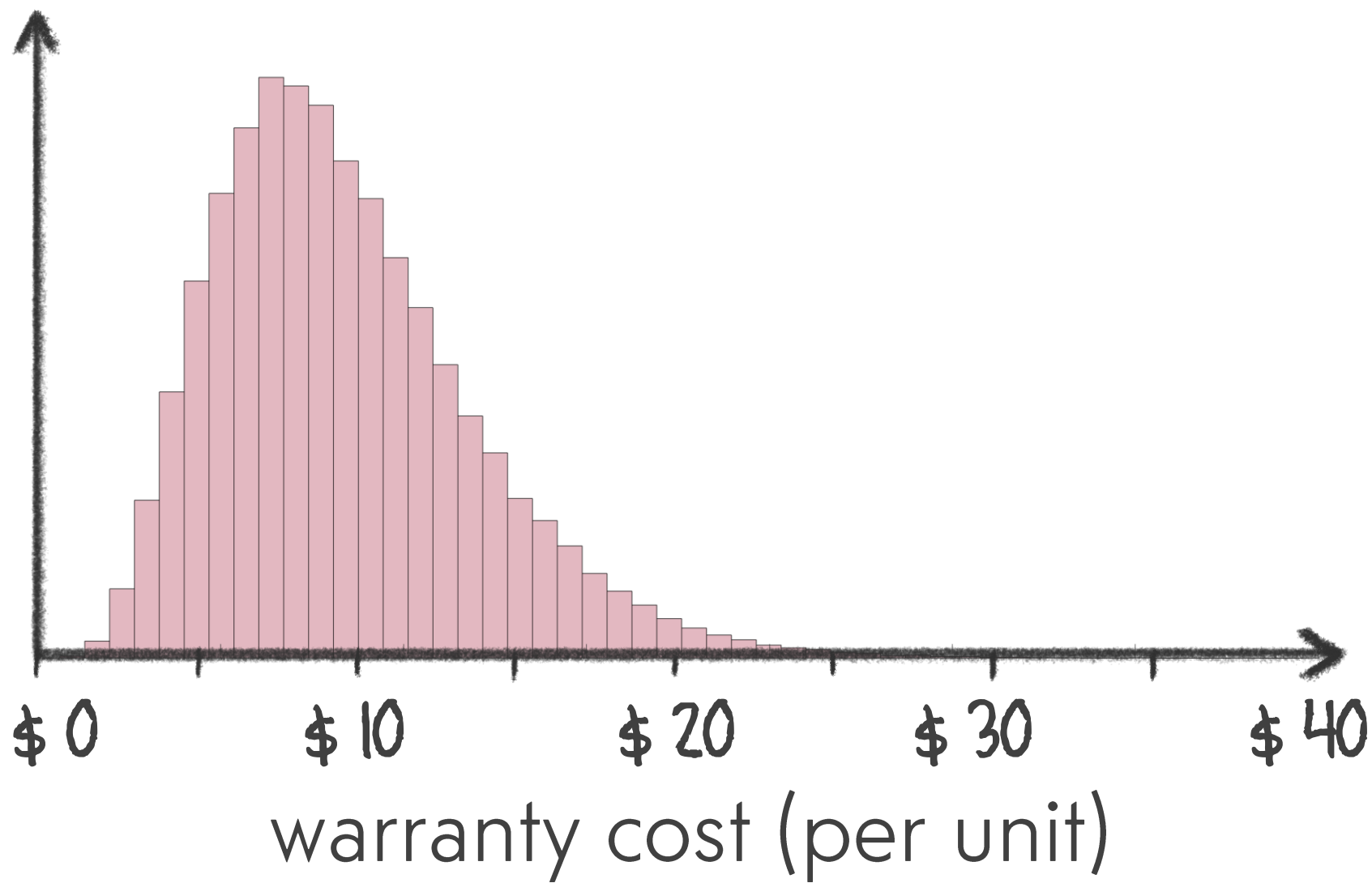
\$	3.74
\$	2.36
\$	2.81
\$	8.53
\$	3.54
\$	6.35
\$	7.28
\$	6.91
\$	6.74
\$	6.15
\$	7.81
\$	12.85
\$	14.26
\$	15.20

... each row contains a

sampled

warranty cost



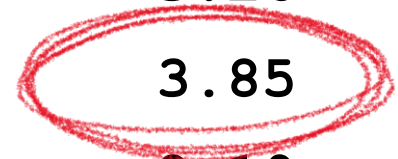


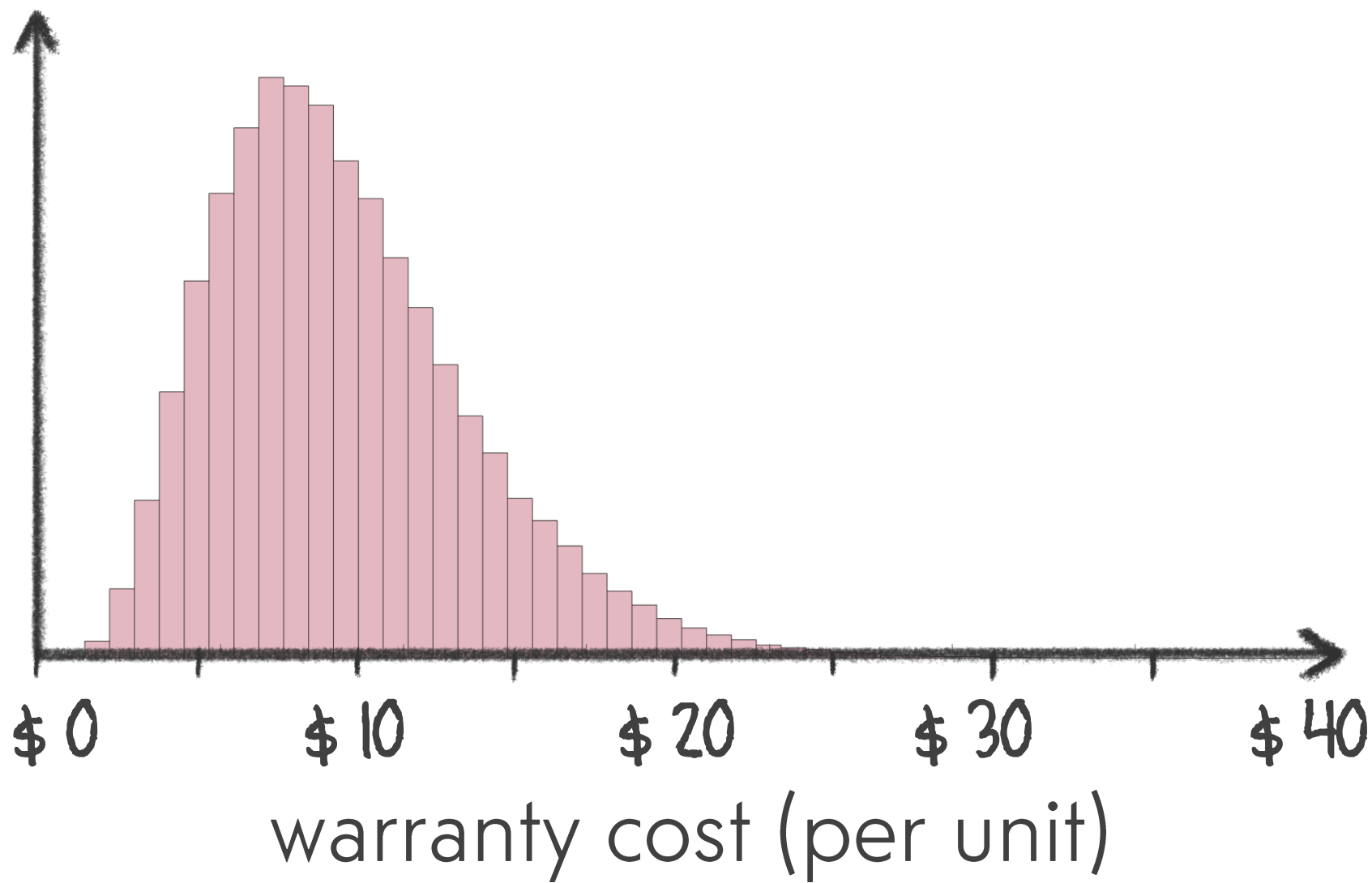
```
profit =  
10 - warrantyCost
```

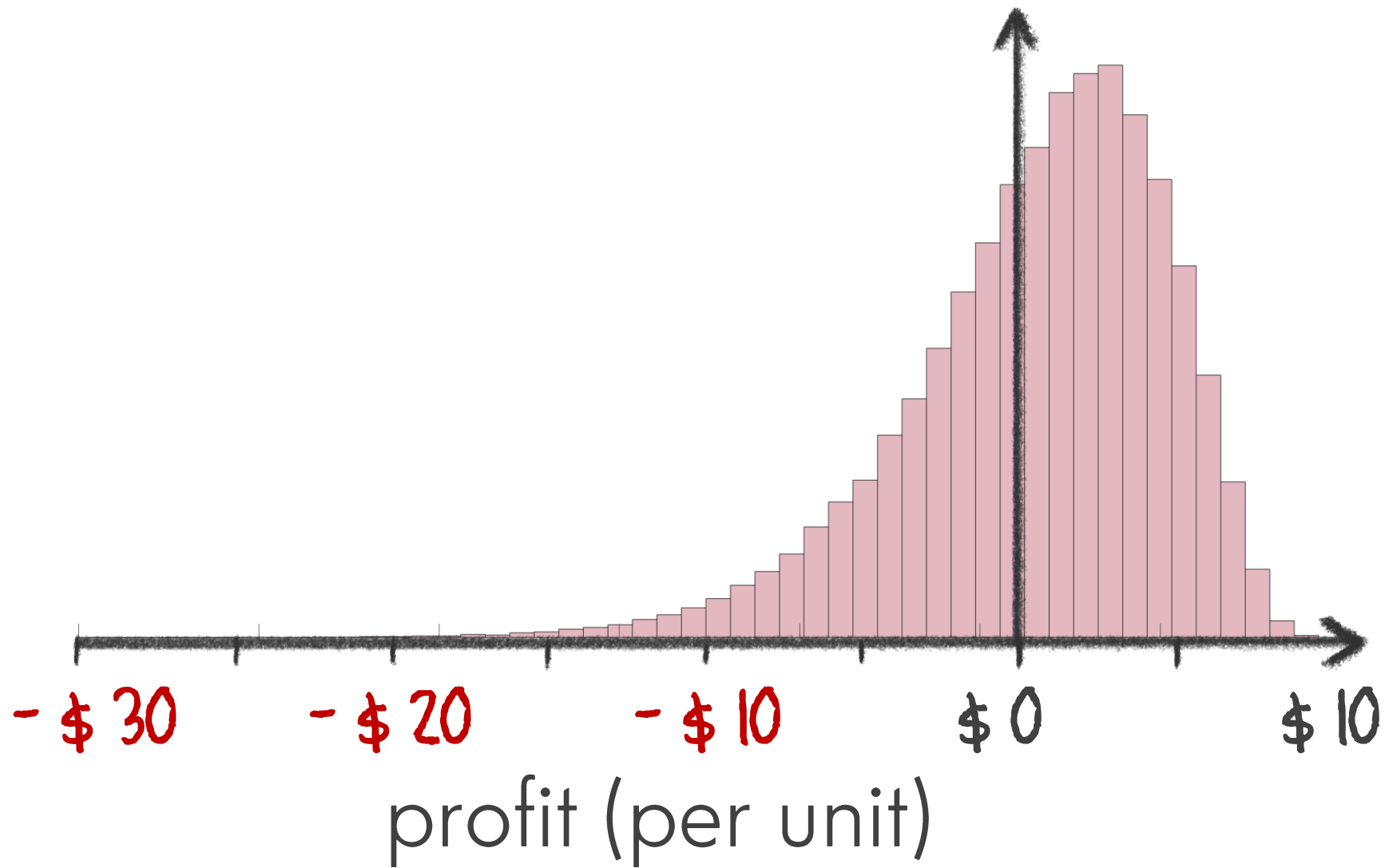
profit =

\$	6.26
\$	7.64
\$	7.19
\$	1.47
\$	6.46
\$	3.65
\$	2.72
\$	3.09
\$	3.26
\$	3.85
\$	2.19
-\$	2.85
-\$	4.26
-\$	5.20

... each row contains a
sampled
profit

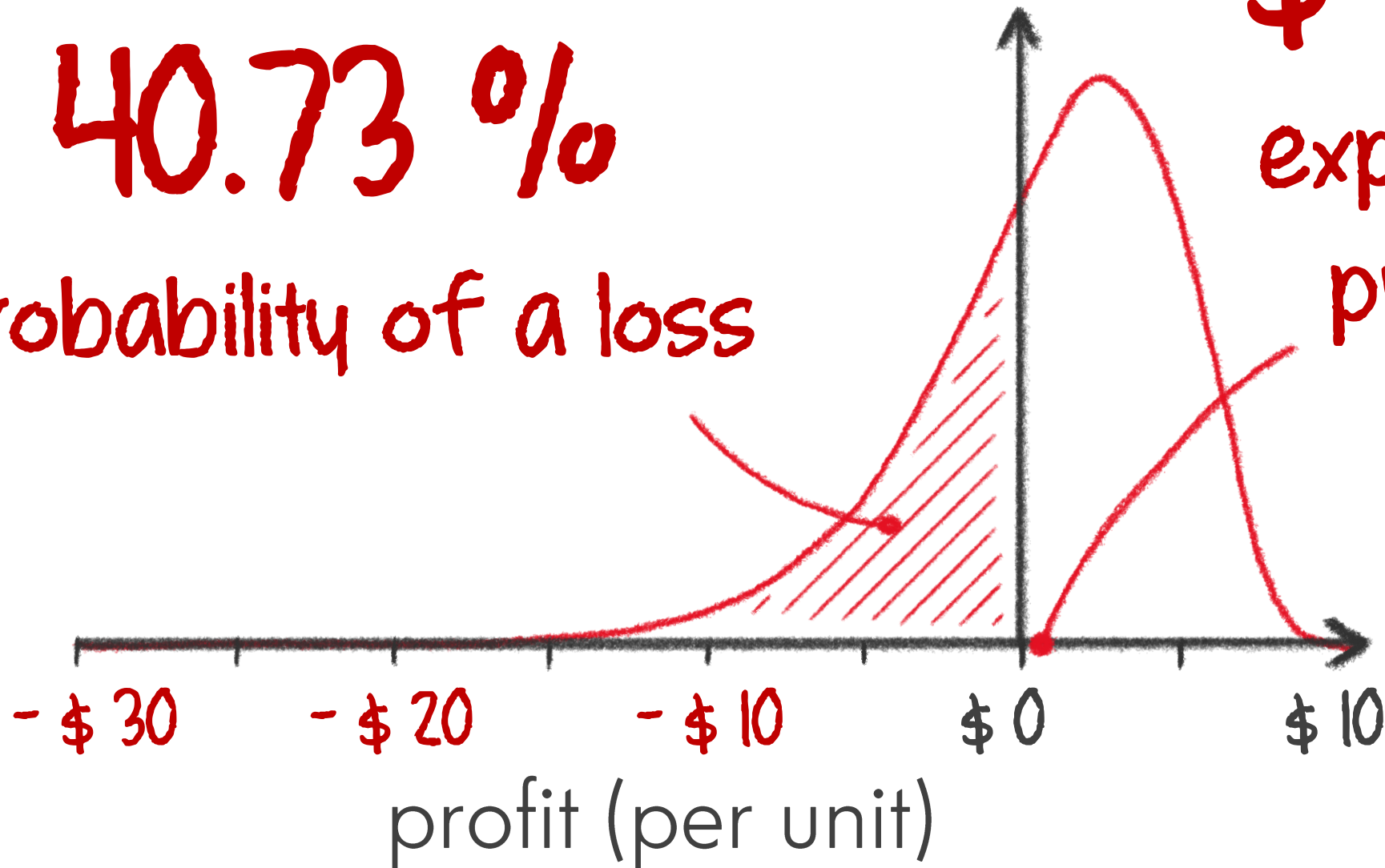






40.73 %
probability of a loss

\$ 0.32
expected profit



... so what
is next?

... go and turn

DATA

... into

INFORMATION

