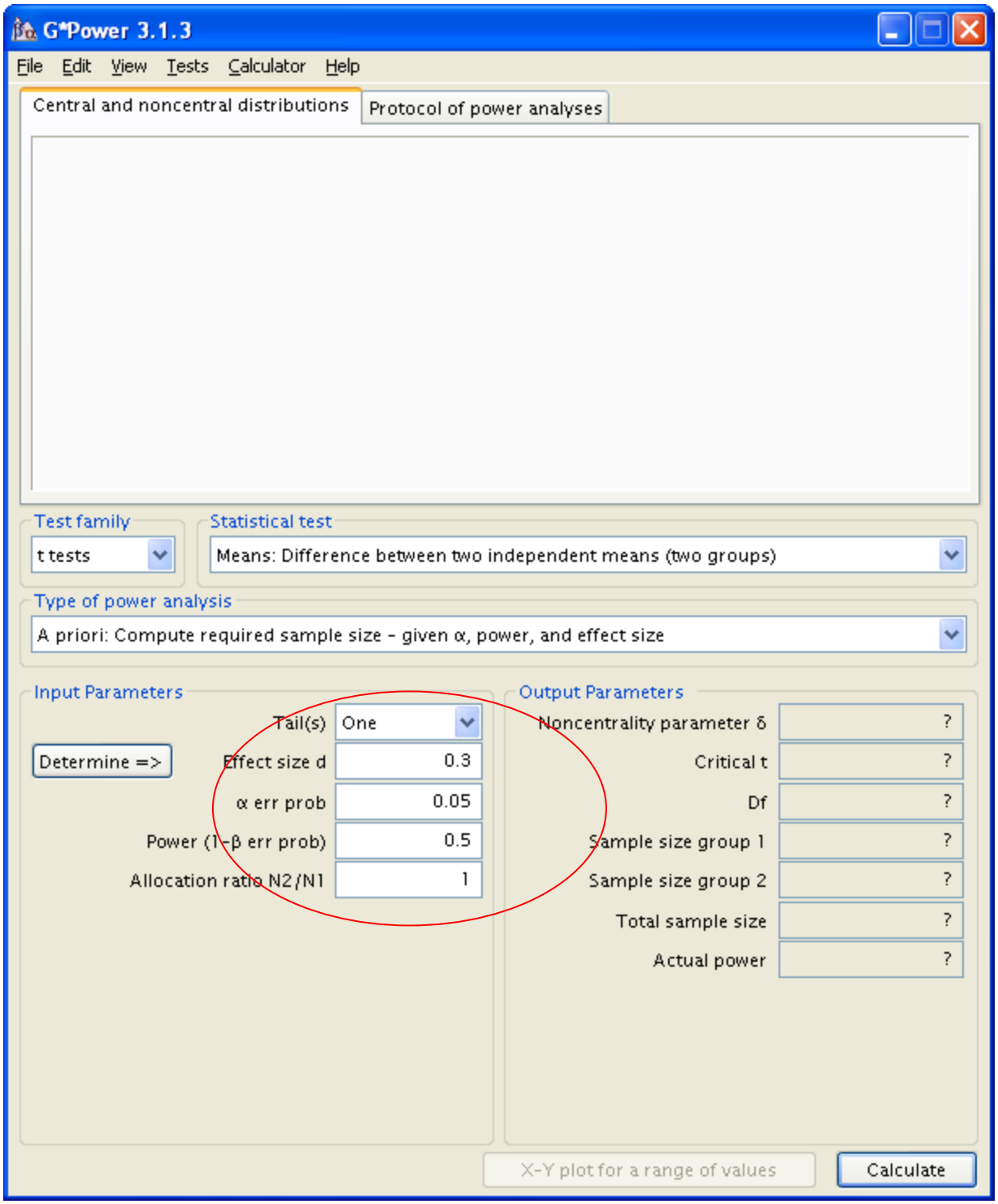
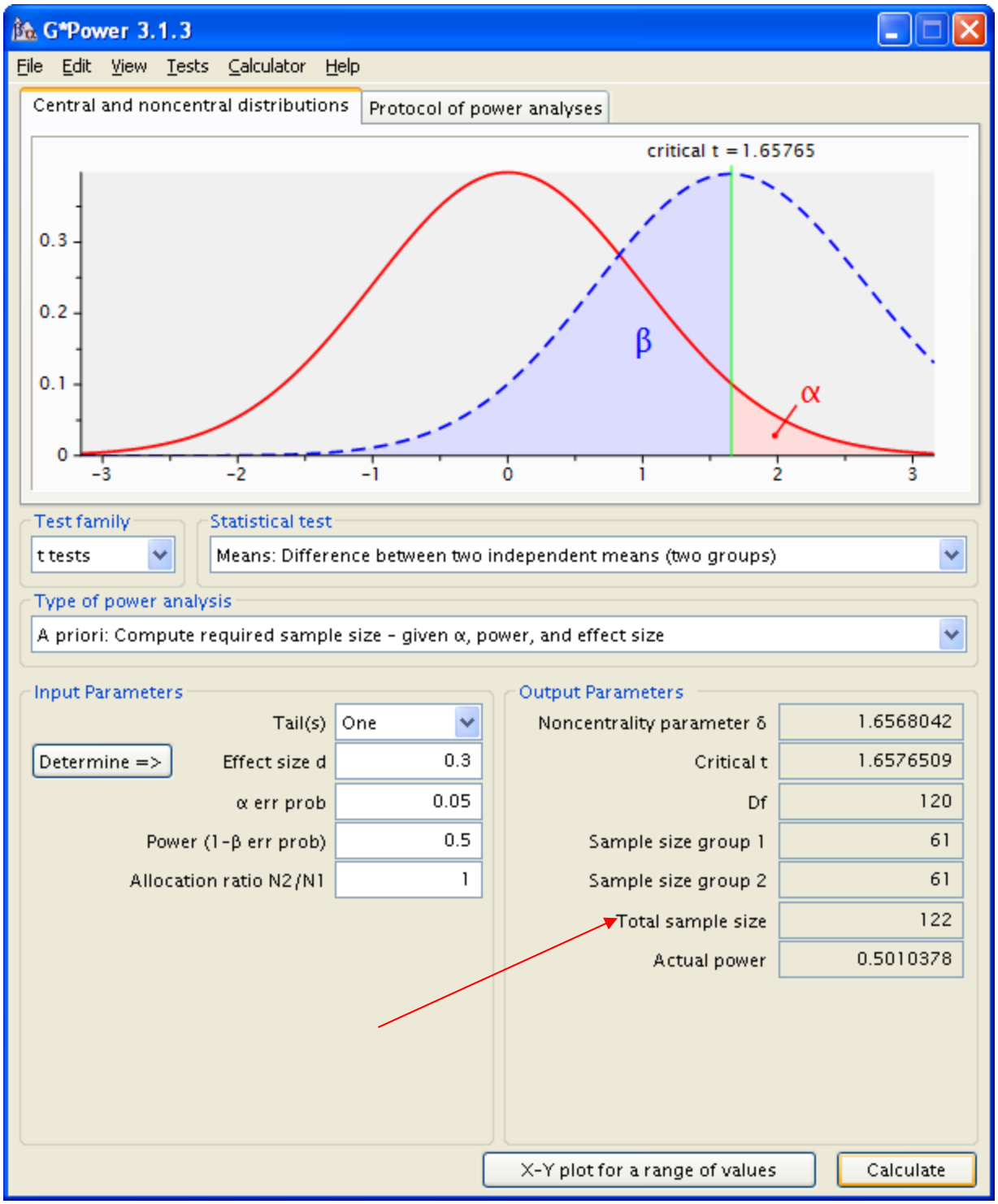
1. An experiment to study the effect of two training programs is to be conducted. A completely randomized design is to be used. An effect size of .30 is of interest and the researcher wants power to be at least .5. The researcher plans to use $\alpha = .05$ and a one-tailed test. How many subjects in total should the researcher plan to use? Answer the question again if a randomized block design is used and the correlation is expected to be .75.

The following are the specifications for the first part of the questions:

Design	CRD
Number of levels	2
ES_{MAX}	.3
Power	.5
Alpha	.05
Test	Directional

We can use G*Power for Means: Difference between two independent means (two groups).


G*Power 3.1.3
File Edit View Tests Calculator Help
Central and noncentral distributions
Protocol of power analyses
Test family
t tests
Statistical test
Means: Difference between two independent means (two groups)
Type of power analysis
A priori: Compute required sample size – given α, power, and effect size
Input Parameters
Tail(s) One
Determine =>
Effect size d 0.3
α err prob 0.05
Power (1-β err prob) 0.5
Allocation ratio N2/N1 1
Output Parameters
Noncentrality parameter δ ?
Critical t ?
Df ?
Sample size group 1 ?
Sample size group 2 ?
Total sample size ?
Actual power ?
X-Y plot for a range of values
Calculate

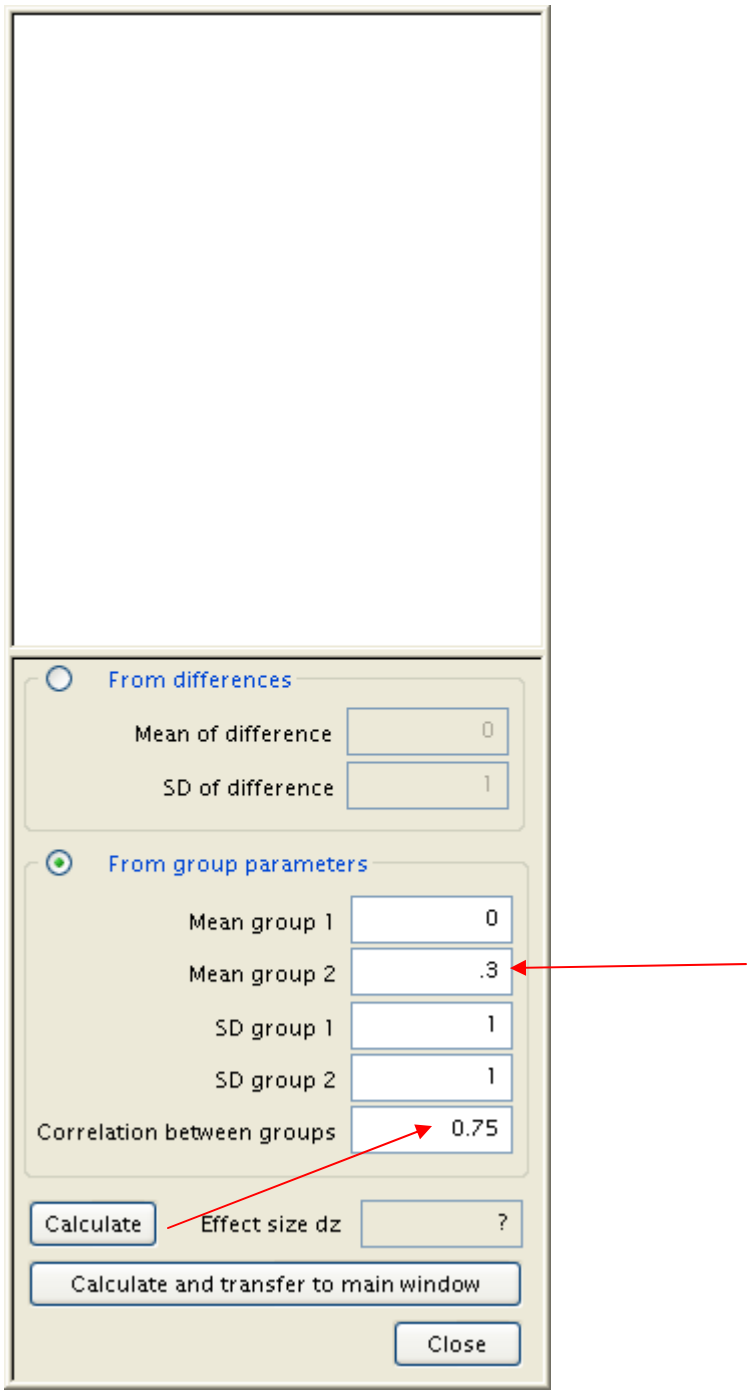


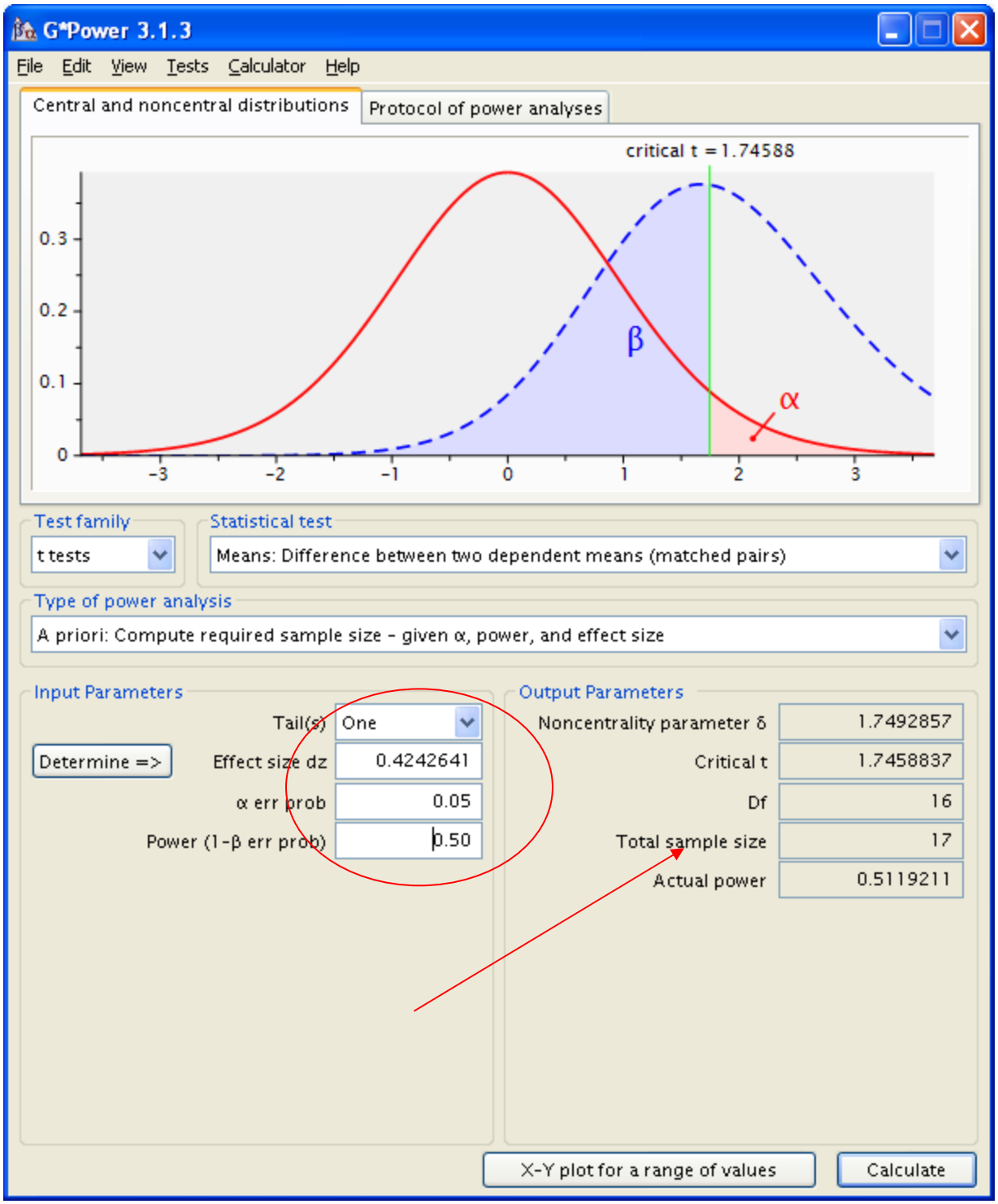
For a design with only between-subjects factors the Total sample size is the total number of subjects required for the design. Thus the total number of subjects required is 122.

For the second part of the question the design changes to a randomized block deign. We can use G*Power for Means; Difference between two dependent means (matched pairs).

The following shows the screen that appears after pressing Determine⇒

The arrows point to my inputs.




G*Power 3.1.3
File Edit View Tests Calculator Help
Central and noncentral distributions
Protocol of power analyses
critical t = 1.74588
0.3
0.2
0.1
0
-3
-2
-1
0
1
2
3
β
α
Test family
t tests
Statistical test
Means: Difference between two dependent means (matched pairs)
Type of power analysis
A priori: Compute required sample size – given α, power, and effect size
Input Parameters
Tail(s) One
Determine =>
Effect size dz 0.4242641
α err prob 0.05
Power (1-β err prob) 0.50
Output Parameters
Noncentrality parameter δ 1.7492857
Critical t 1.7458837
Df 16
Total sample size 17
Actual power 0.5119211
X-Y plot for a range of values
Calculate

For a design with only within-subjects factors the Total sample size is the number of scores in one cell of the design. This is a diagram of the design, showing 17 scores in each level

Treatment	
A_1	A_2
17	17

Because the design is a randomized block design, we have subjects nested in levels and we require subjects 34 subjects.

D.2

2. An experiment is to be conducted to study the effects of two factors in a completely within-subjects design. Factor A has four levels and factor B has two levels. Blocked random assignment is to be used. Factor A is the primary factor of interest and the researcher is interested in detecting an effect size of .25 with power of .7. The correlation between the scores for any pair of cell variables is expected to be .65 and ε is expected to be .90. The researcher believes the mean configuration will be similar to the maximum range configuration. If the experimenter plans to use $\alpha = .05$, how many subjects should there be in total?

The following are the specifications

Design	4×2, completely within-subjects
Number of levels in factor of interest	4
Target Power	.70
Alpha	.05
Epsilon	.90
ES_{MAX}	.25
Correlation	.65

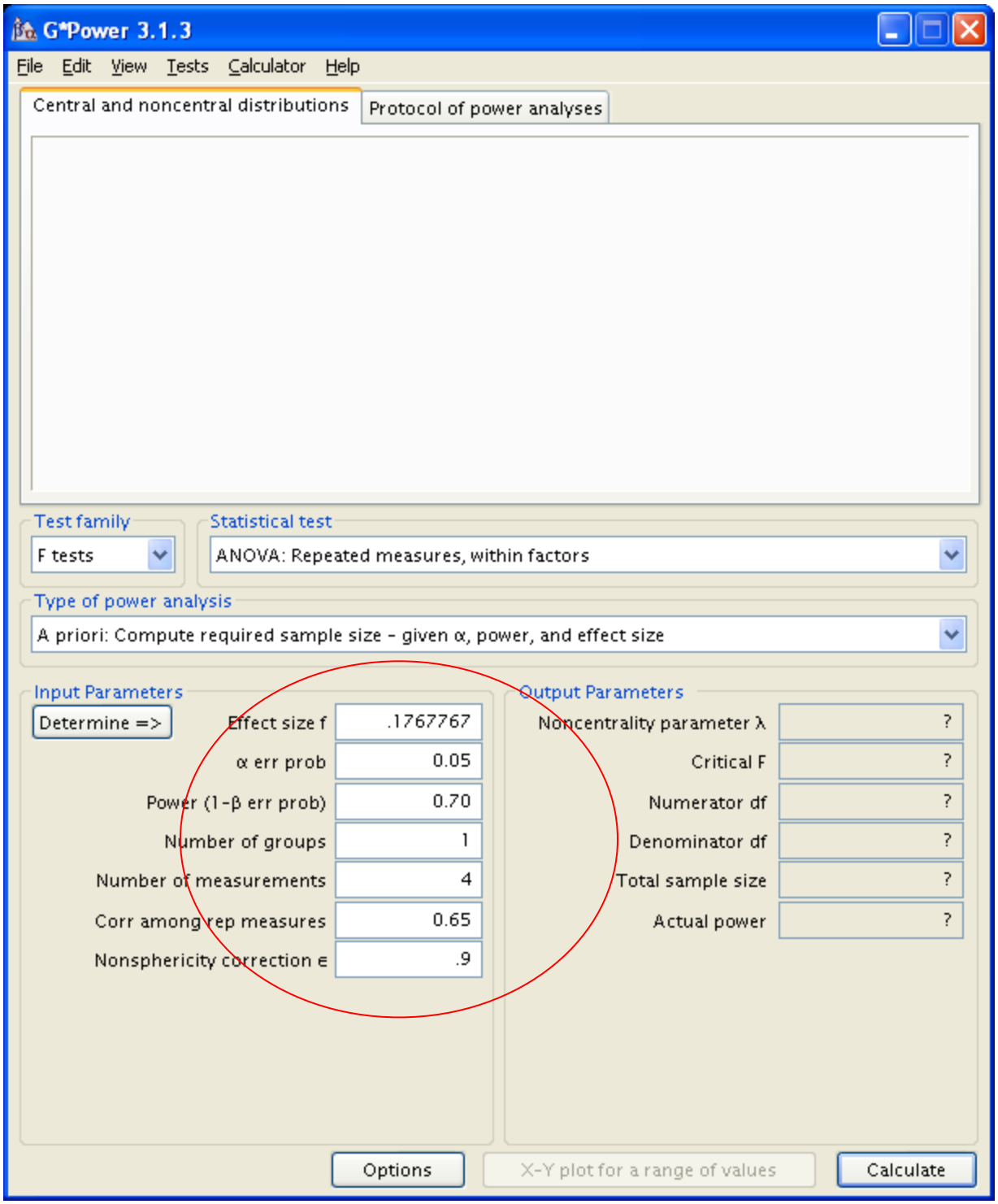
I used this program to calculate *f*. Note that es_max is .25, levels is 4 and M is 2. A value for M other than $M = 1$ is only required in a design that has no between-subject factors and more than one within-subject factors.

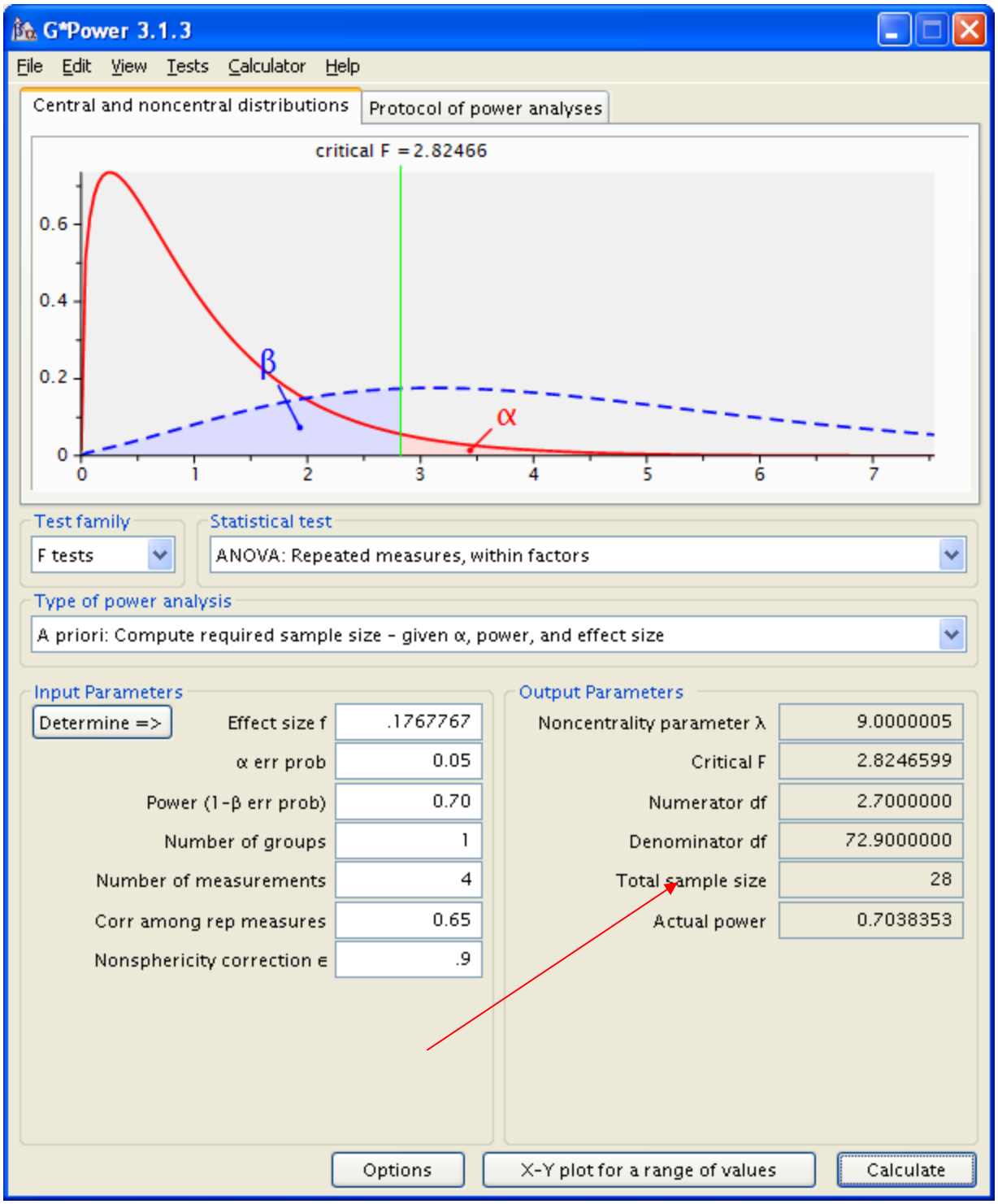
```
data;
format f 10.7;
input es_max levels M;
remainder= MOD(levels, 2);
if remainder=0 then do;
mean_configuration='maximum variability';
f=(sqrt(M))*es_max/2;
output;
end;
if remainder^=0 then do;
mean_configuration='maximum variability';
f=sqrt(M*levels**2-1)*es_max/(2*levels);
output;
end;
mean_configuration='two extreme';
f=sqrt(M*2*(levels-2))*es_max/levels;
```

```
output;
mean_configuration='one extreme';
f=sqrt(M*(levels-1))*es_max/levels;
output;
mean_configuration='equally spaced';
f=sqrt(M*(levels+1)/(12*(levels-1)))*es_max;
output;
mean_configuration='minimum variability';
f=sqrt(M/(2*levels))*es_max;
output;
datalines;
.25 4 2
proc print;
var mean_configuration levels es_max f;
run;
```

Obs	mean_configuration	levels	es_max	f
1	maximum variability	4	0.25	0.1767767
2	two extreme	4	0.25	0.1767767
3	one extreme	4	0.25	0.1530931
4	equally spaced	4	0.25	0.1317616
5	minimum variability	4	0.25	0.1250000

The value of *f* to use is 0.1767767


G*Power 3.1.3
File Edit View Tests Calculator Help
Central and noncentral distributions
Protocol of power analyses
Test family
F tests
Statistical test
ANOVA: Repeated measures, within factors
Type of power analysis
A priori: Compute required sample size – given α, power, and effect size
Input Parameters
Determine =>
Effect size f .1767767
α err prob 0.05
Power (1-β err prob) 0.70
Number of groups 1
Number of measurements 4
Corr among rep measures 0.65
Nonsphericity correction ε .9
Output Parameters
Noncentrality parameter λ ?
Critical F ?
Numerator df ?
Denominator df ?
Total sample size ?
Actual power ?
Options
X-Y plot for a range of values
Calculate



For a design with only within-subjects factors the Total sample size is the number of scores in one cell of the design. Following is a diagram of the design, showing 28 scores in each cell.

	Factor B	
Factor A	B_1	B_2
A_1	28	28
A_2	28	28
A_3	28	28
A_4	28	28

The design is randomized block so we need 28 subjects in each of eight cells. The total sample size is $8(28) = 224$.

3. An experiment is to be conducted to study the effects of two factors in a design in which Factor A is between-subjects and has three levels; Factor B is within-subjects and has two levels. For Factor B subjects are used as their own controls. The correlation between the scores in any two cells is expected to be .50. Epsilon is 1.0 because the within-subjects factor only has two levels.

A. The researcher is most interested in the A main effect and expects the spacing of the marginal means to be similar to an equally spaced configuration. An effect size of .40 is of interest. How many subjects should there be in each level of A if the target power is .6 and $\alpha = .05$? Answer the question again assuming the researcher wants to be very cautious in planning the study.

The following are the specifications

Design	3×2 split-plot; the factor with 2 levels is within-subjects
Number of levels in factor of interest	3
Target Power	.6
Alpha	.05
ES_{MAX}	.40
Correlation	.50

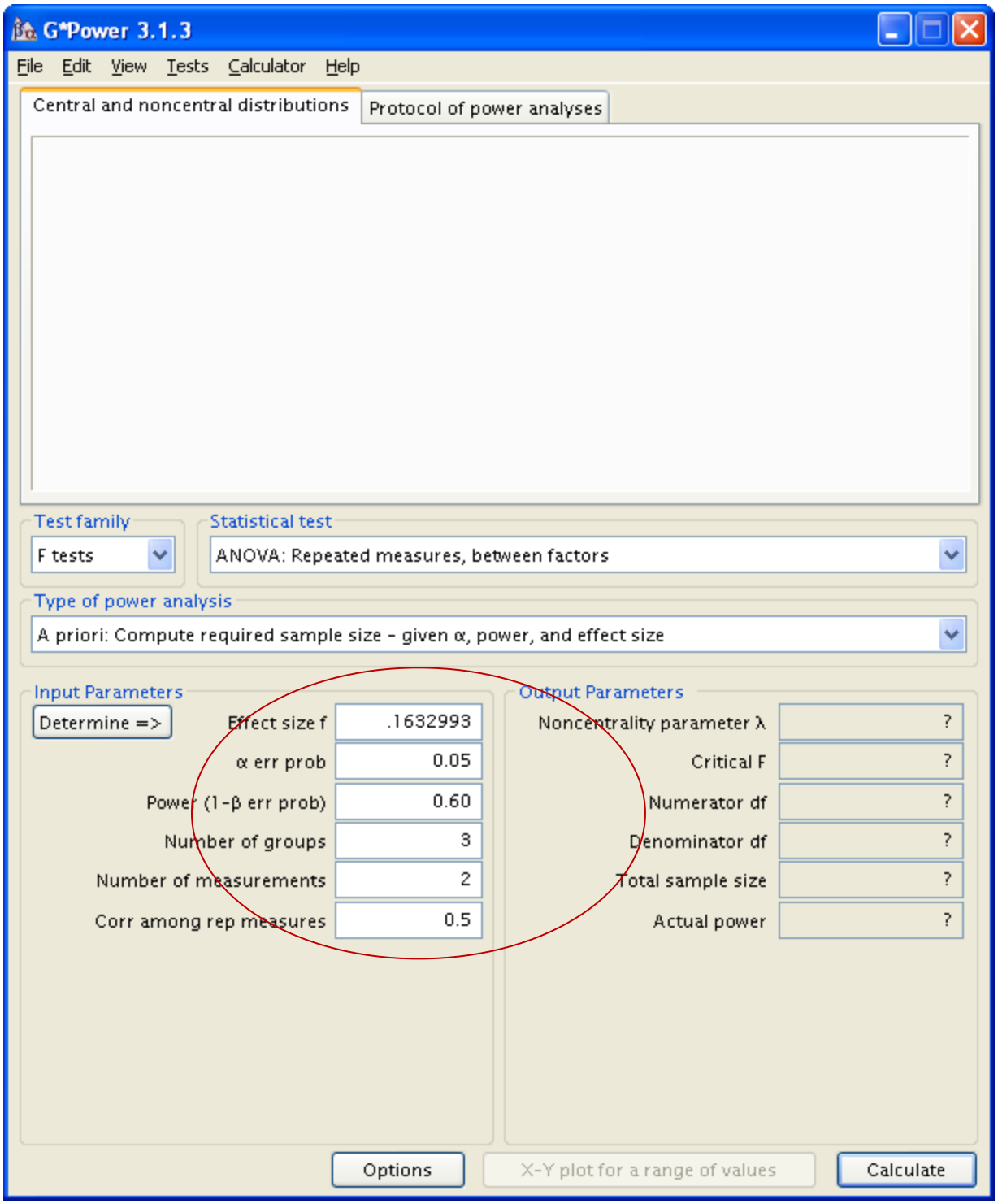
We can use G*Power for ANOVA: Repeated measures, between factors.

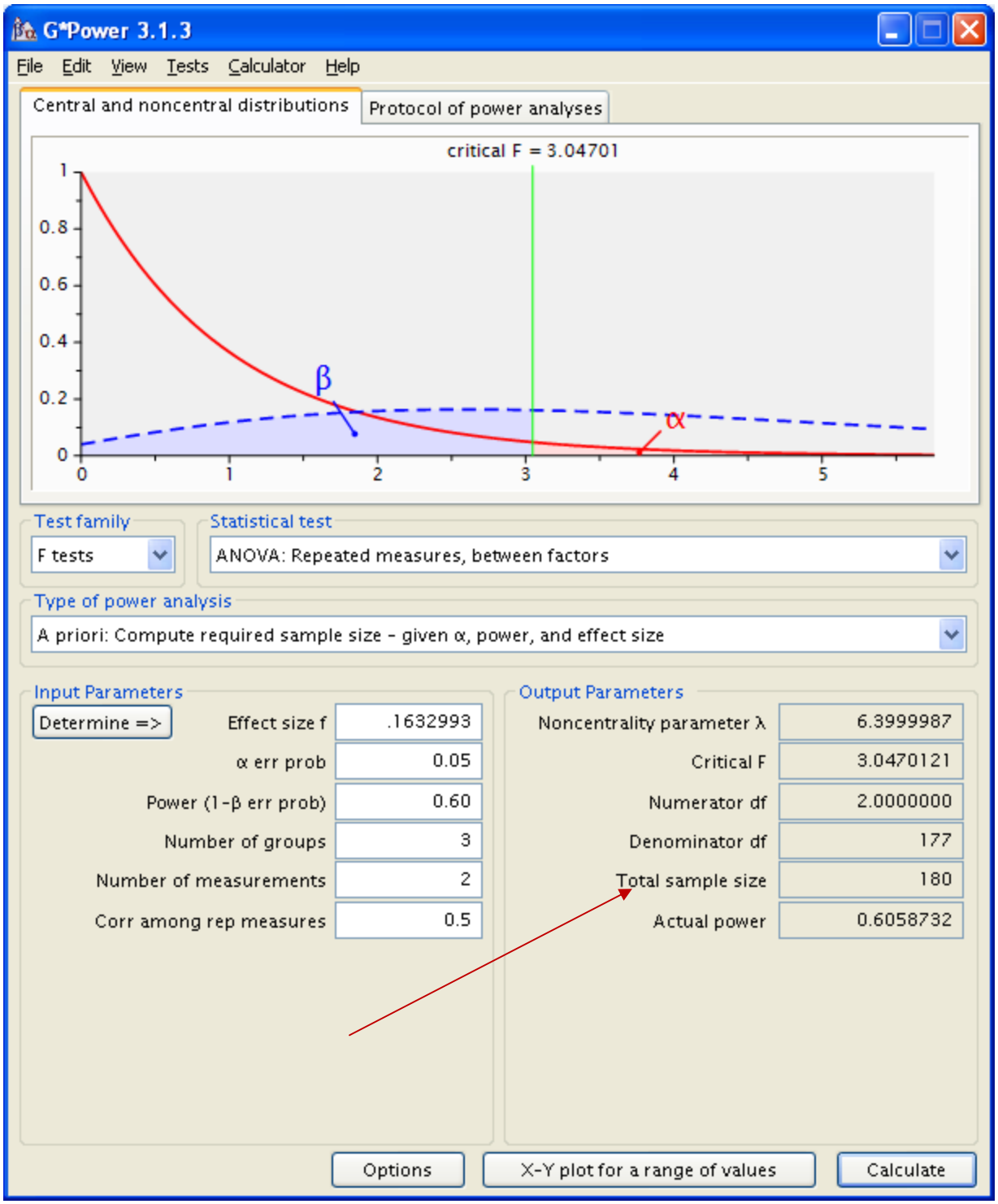
I used this program to calculate *f*. Note that es_max is .40, levels is 3 and M is 1.

```
data;
format f 10.7;
input es_max levels M;
remainder= MOD(levels, 2);
if remainder=0 then do;
mean_configuration='maximum variability';
f=(sqrt(M))*es_max/2;
output;
end;
if remainder^=0 then do;
mean_configuration='maximum variability';
f=sqrt(M*levels**2-1)*es_max/(2*levels);
output;
end;
mean_configuration='two extreme';
f=sqrt(M*2*(levels-2))*es_max/levels;
output;
mean_configuration='one extreme';
f=sqrt(M*(levels-1))*es_max/levels;
output;
mean_configuration='equally spaced';
f=sqrt(M*(levels+1)/(12*(levels-1)))*es_max;
output;
mean_configuration='minimum variability';
f=sqrt(M/(2*levels))*es_max;
output;
datalines;
.40 3 1
proc print;
var mean_configuration levels es_max f;
run;
```

Obs	mean_configuration	levels	es_max	f
1	maximum variability	3	0.4	0.1885618
2	two extreme	3	0.4	0.1885618
3	one extreme	3	0.4	0.1885618
4	equally spaced	3	0.4	0.1632993
5	minimum variability	3	0.4	0.1632993

The value of *f* to use is 0.1632993


G*Power 3.1.3
File Edit View Tests Calculator Help
Central and noncentral distributions
Protocol of power analyses
Test family
F tests
Statistical test
ANOVA: Repeated measures, between factors
Type of power analysis
A priori: Compute required sample size – given α, power, and effect size
Input Parameters
Determine =>
Effect size f .1632993
α err prob 0.05
Power (1-β err prob) 0.60
Number of groups 3
Number of measurements 2
Corr among rep measures 0.5
Output Parameters
Noncentrality parameter λ ?
Critical F ?
Numerator df ?
Denominator df ?
Total sample size ?
Actual power ?
Options
X-Y plot for a range of values
Calculate


G*Power 3.1.3
File Edit View Tests Calculator Help
Central and noncentral distributions
Protocol of power analyses
critical F = 3.04701
β
α
Test family
F tests
Statistical test
ANOVA: Repeated measures, between factors
Type of power analysis
A priori: Compute required sample size – given α, power, and effect size
Input Parameters
Determine =>
Effect size f .1632993
α err prob 0.05
Power (1-β err prob) 0.60
Number of groups 3
Number of measurements 2
Corr among rep measures 0.5
Output Parameters
Noncentrality parameter λ 6.3999987
Critical F 3.0470121
Numerator df 2.0000000
Denominator df 177
Total sample size 180
Actual power 0.6058732
Options
X-Y plot for a range of values
Calculate

For a design with one–between-subject factor and one within-subjects factors the Total sample size is the number of subjects in one level of the between-subjects factor multiplied by the number of levels of the factor. That is $180 = 60(3)$. Thus we need 60 scores in each cell of the design.

This is a diagram of the design, showing 60 scores in each level

	Factor B	
Factor A	B_1	B_2
A_1	60	60
A_2	60	60
A_3	60	60

The design is 3×2 with repeated measures on the second factor. Thus we need a total of 180 subjects.

The most conservative configuration is minimum range. For $J = 3$ equally spaced and minimum range are equivalent, so we would need a total of 180 subjects for this design.

B. The researcher is most interested in the B main effect. An effect size of .25 is of interest. How many subjects should there be in total if the target power is .80 and $\alpha = .05$?

The following are the specifications

Design	3×2 split-plot; the factor with 2 levels is within-subjects
Number of levels in factor of interest	2
Target Power	.80
Alpha	.05
ES_{MAX}	.25
Correlation	.50
Epsilon	1.0

We can use G*Power for ANOVA: Repeated measures, within factors.

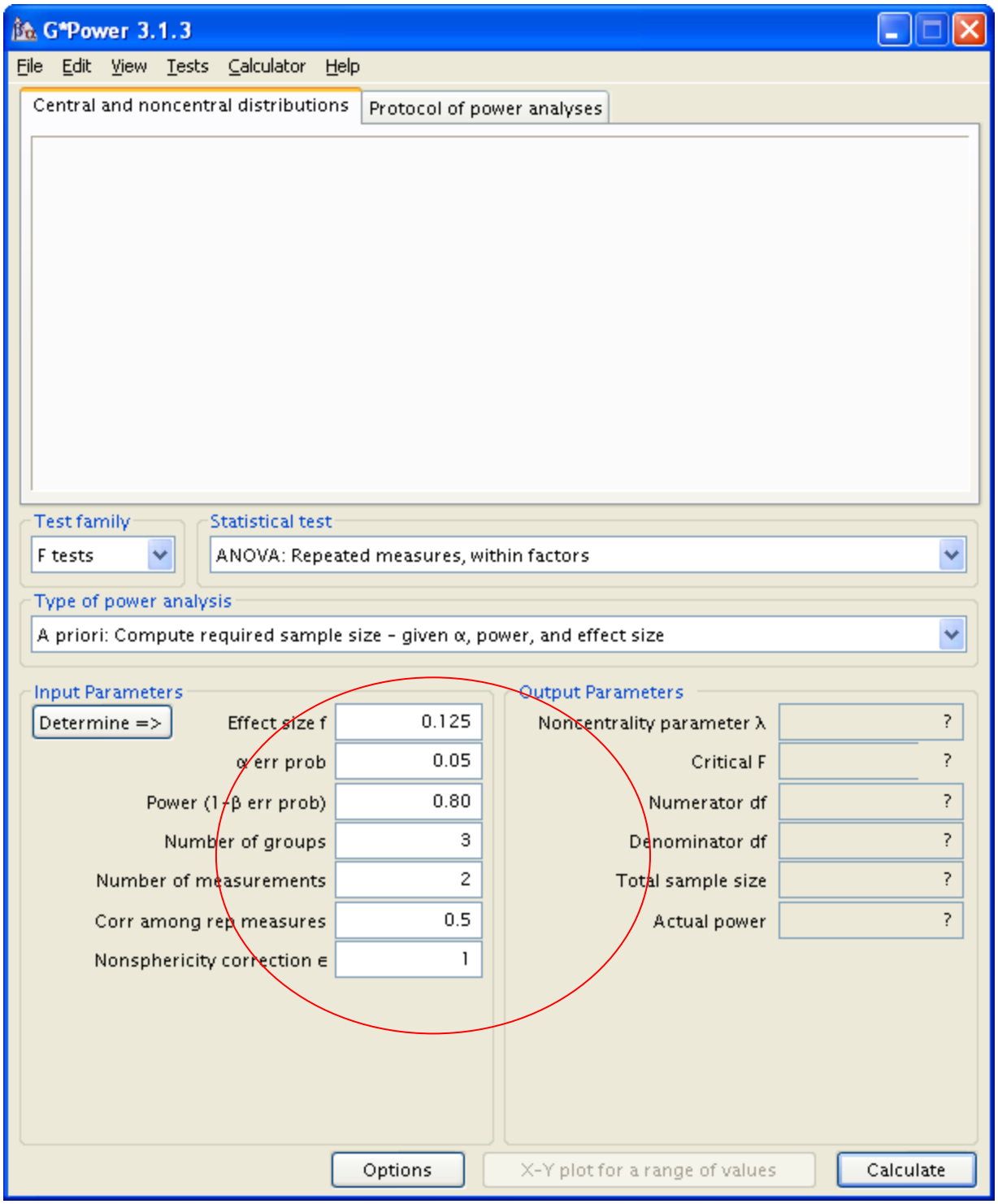
I used this program to calculate *f*. Note that es_max is .25, levels is 2 and M is 1.

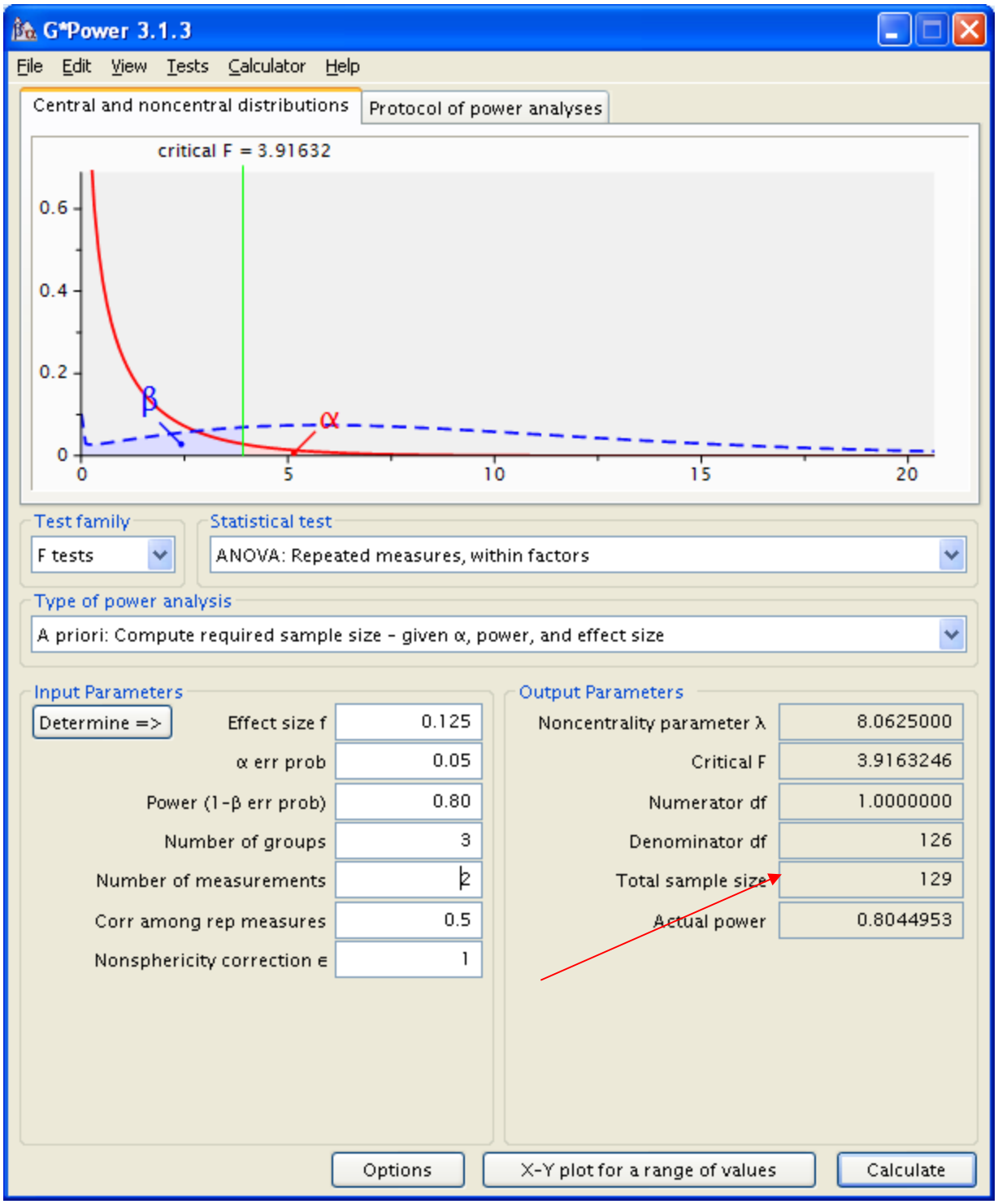
```
data;
format f 10.7;
input es_max levels M;
remainder= MOD(levels, 2);
if remainder=0 then do;
mean_configuration='maximum variability';
f=(sqrt(M))*es_max/2;
output;
end;
if remainder^=0 then do;
mean_configuration='maximum variability';
f=sqrt(M*levels**2-1)*es_max/(2*levels);
output;
end;
mean_configuration='two extreme';
f=sqrt(M*2*(levels-2))*es_max/levels;
output;
mean_configuration='one extreme';
f=sqrt(M*(levels-1))*es_max/levels;
output;
mean_configuration='equally spaced';
f=sqrt(M*(levels+1)/(12*(levels-1)))*es_max;
output;
```

```
mean_configuration='minimum variability';
f=sqrt(M/(2*levels))*es_max;
output;
datalines;
.25 2 1
proc print;
var mean_configuration levels es_max f;
run;
```

1	maximum variability	2	0.25	0.1250000
2	two extreme	2	0.25	0.0000000
3	one extreme	2	0.25	0.1250000
4	equally spaced	2	0.25	0.1250000
5	minimum variability	2	0.25	0.1250000

Because there are two levels to the factor of interest the two-extreme means configuration is not applicable and all the other configurations have the same value for *f*. So *f* should be .125.


G*Power 3.1.3
File Edit View Tests Calculator Help
Central and noncentral distributions
Protocol of power analyses
Test family
F tests
Statistical test
ANOVA: Repeated measures, within factors
Type of power analysis
A priori: Compute required sample size – given α, power, and effect size
Input Parameters
Determine =>
Effect size f 0.125
α err prob 0.05
Power (1-β err prob) 0.80
Number of groups 3
Number of measurements 2
Corr among rep measures 0.5
Nonsphericity correction ε 1
Output Parameters
Noncentrality parameter λ ?
Critical F ?
Numerator df ?
Denominator df ?
Total sample size ?
Actual power ?
Options
X-Y plot for a range of values
Calculate



For a design with one–between-subject factor and one within-subjects factors the Total sample size is the number of subjects in one level of the between-subjects factor multiplied by the number of levels of the factor. That is $129 = 43(3)$. Thus we need 43 scores in each cell of the design.

This is a diagram of the design, showing 43 scores in each level

	Factor B	
Factor A	B_1	B_2
A_1	43	43
A_2	43	43
A_3	43	43

The design is 3×2 with repeated measures on the second factor. Thus we need a total of 129 subjects.