Statistical modelling of data from high density SNP genotypes in livestock
Wroclaw, Poland, 20-22 November, 2008

Economics of Genomic Breeding Programs In Dairy Cattle

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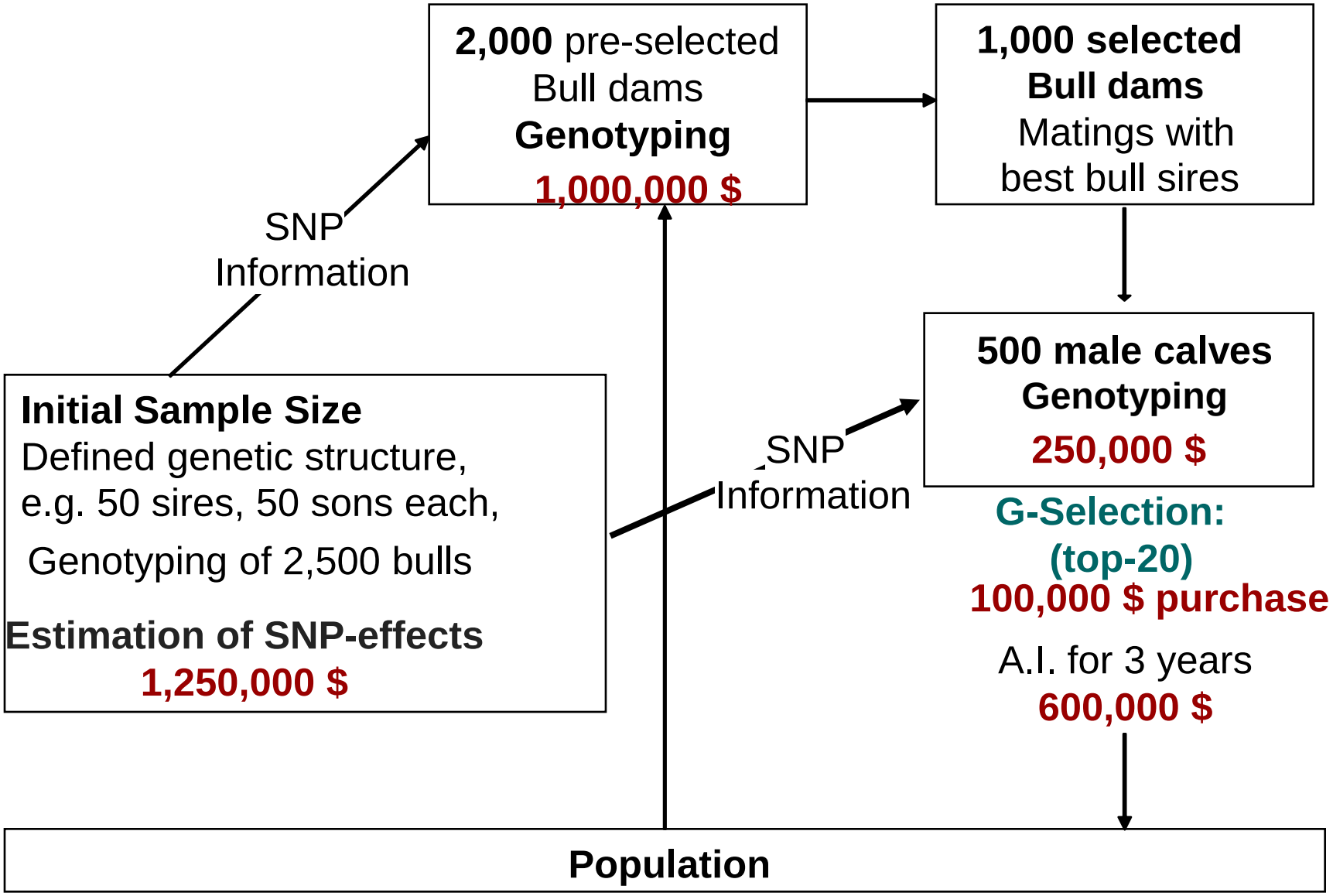
Schaeffer, L.R. (2006): Strategy for applying genome-wide selection in dairy cattle. Anim. Breed. Genet. 123: 218–223.



Comparison of genetic gain

Conventional dairy cattle breeding scheme with progeny testing

Path	Sel.%	i	r_{TI}	i x r_{TI}	ΔG
Bull Sire	5	2.06	0.99	2.04	6.50
Cow Sire	20	1.40	0.75	1.05	6.00
Bull Dam	2	2.42	0.60	1.45	5.00
Cow Dam	85	0.27	0.50	0.14	4.25
Genetic progress per year					4.68 /21.75 = 0.215σ_A

Genomic selection of bulls and bull dams

Path	Sel.%	i	r_{TI}	i x r_{TI}	ΔG
Bull Sire	5	2.06	0.75	1.54	1.75
Cow Sire	20	1.40	0.75	1.05	1.75
Bull Dam	2	2.42	0.75	1.82	2.00
Cow Dam	85	0.27	0.50	0.14	4.25
Genetic progress per year				4.55 /	9.75 = 0.467σ_A

1 : 2.17

Costs per genetic standard deviation

1. SEMEX conventional

(25 Mio. $ / Jahr) / (0.215 σ_a / year)
= 116 Mio. $ per genetic standard deviation

2. SEMEX genomic

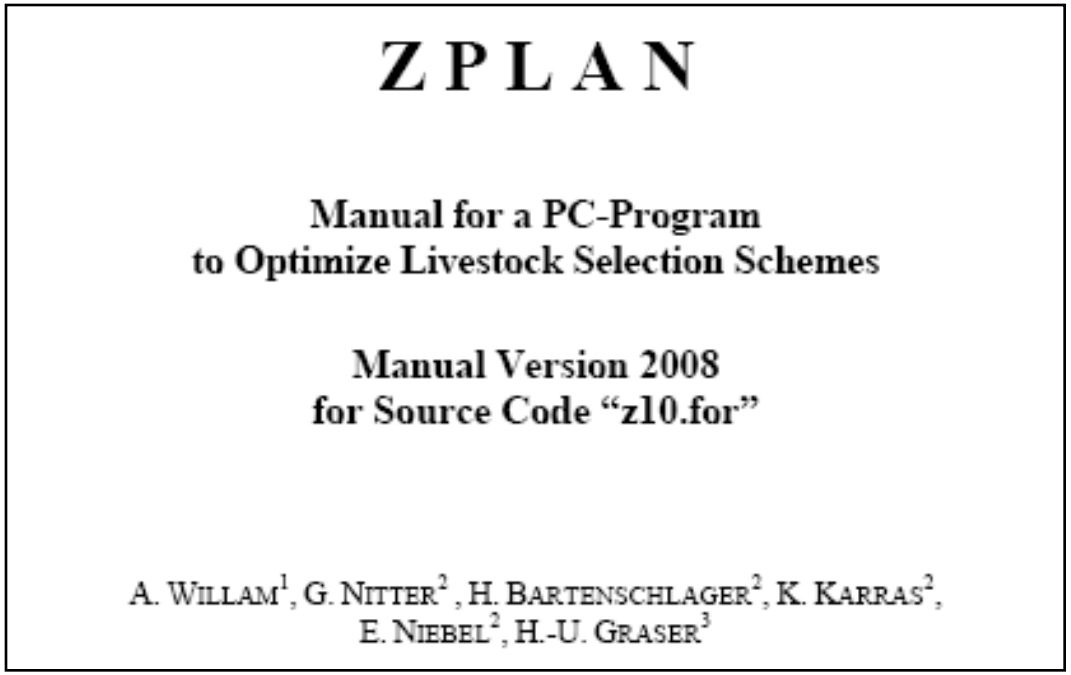
(2.2 Mio. $ / Jahr) / (0.467 σ_a / year)
= 4.8 Mio. $ per genetic standard deviation

Modeling of dairy cattle breeding programs

1. A Conventional Progeny Testing Program (CPTP)

2. Different versions of Genomic Breeding Programs (GBP)

.....applying the computer program ZPLAN



ZPLAN

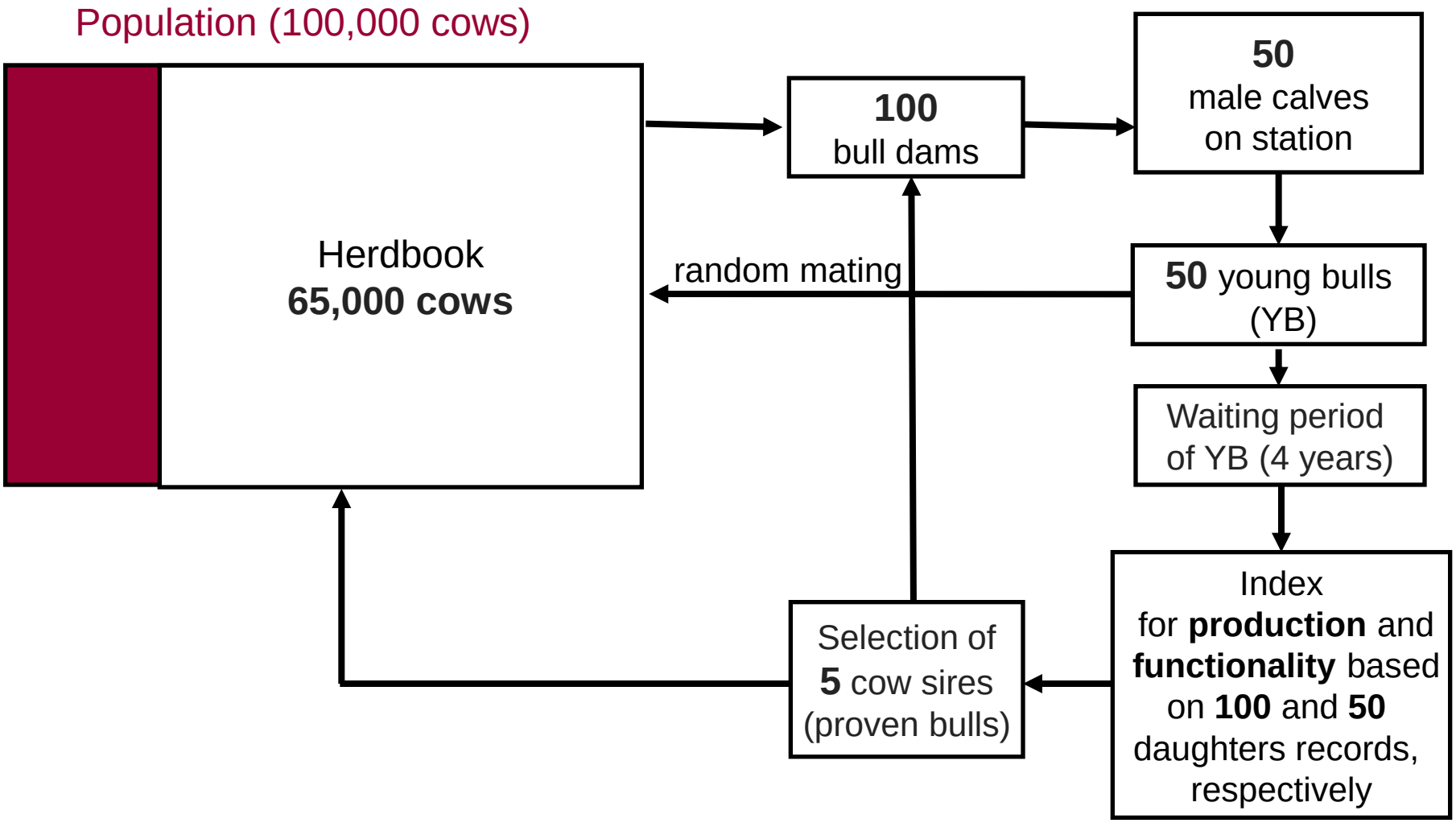
Manual for a PC-Program
to Optimize Livestock Selection Schemes

Manual Version 2008
for Source Code "z10.for"

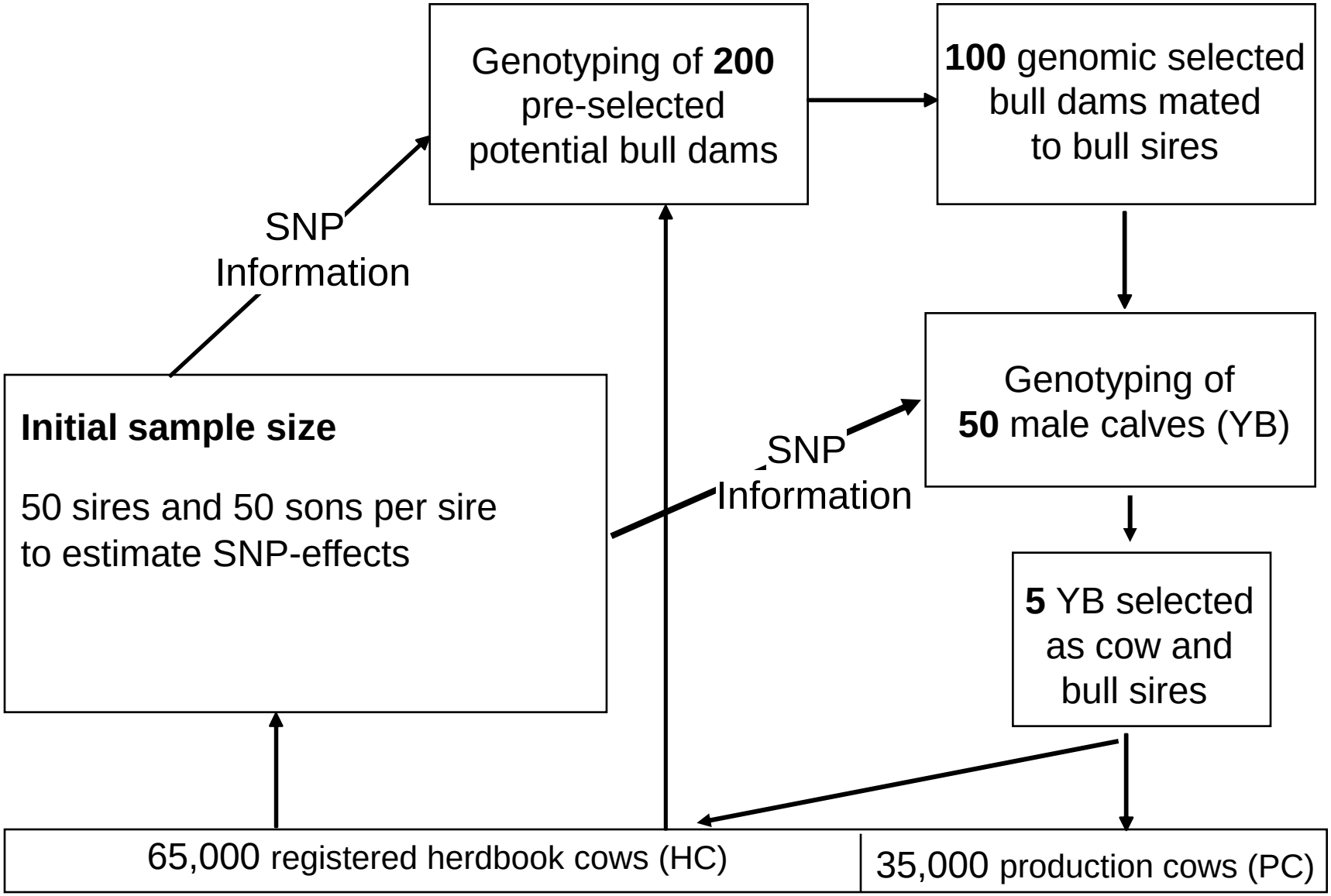
A. Willam[1], G. Nitter[2], H. Bartenschlager[2], K. Karras[2],
E. Niebel[2], H.-U. Graser[3]

- written in Fortran
- deterministic calculations
- essential subroutines:
  - gene flow (Hill, 1974)
  - selection index

The CPTP for 50 test bulls per year



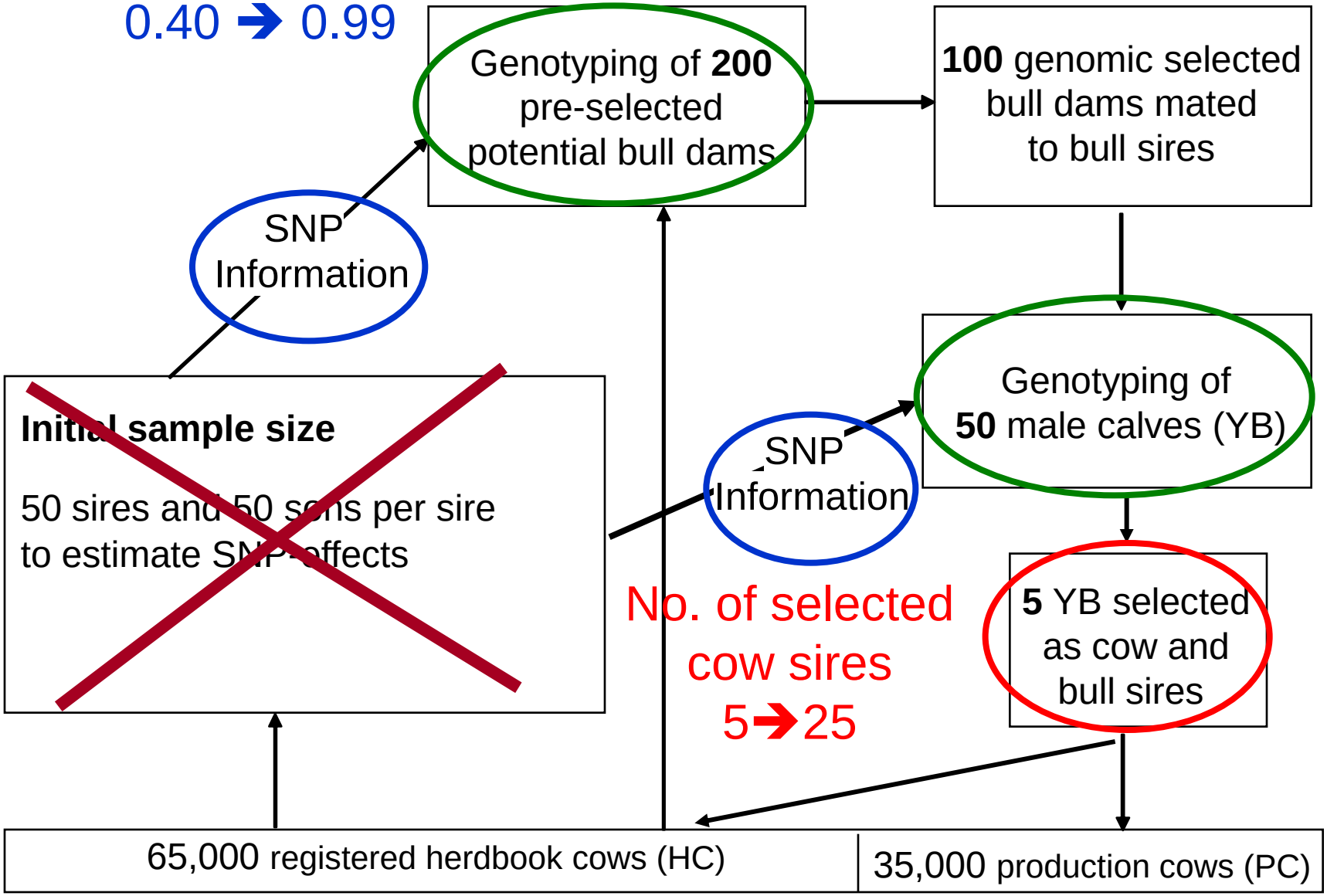
The GBP for 50 „test bulls“ per year



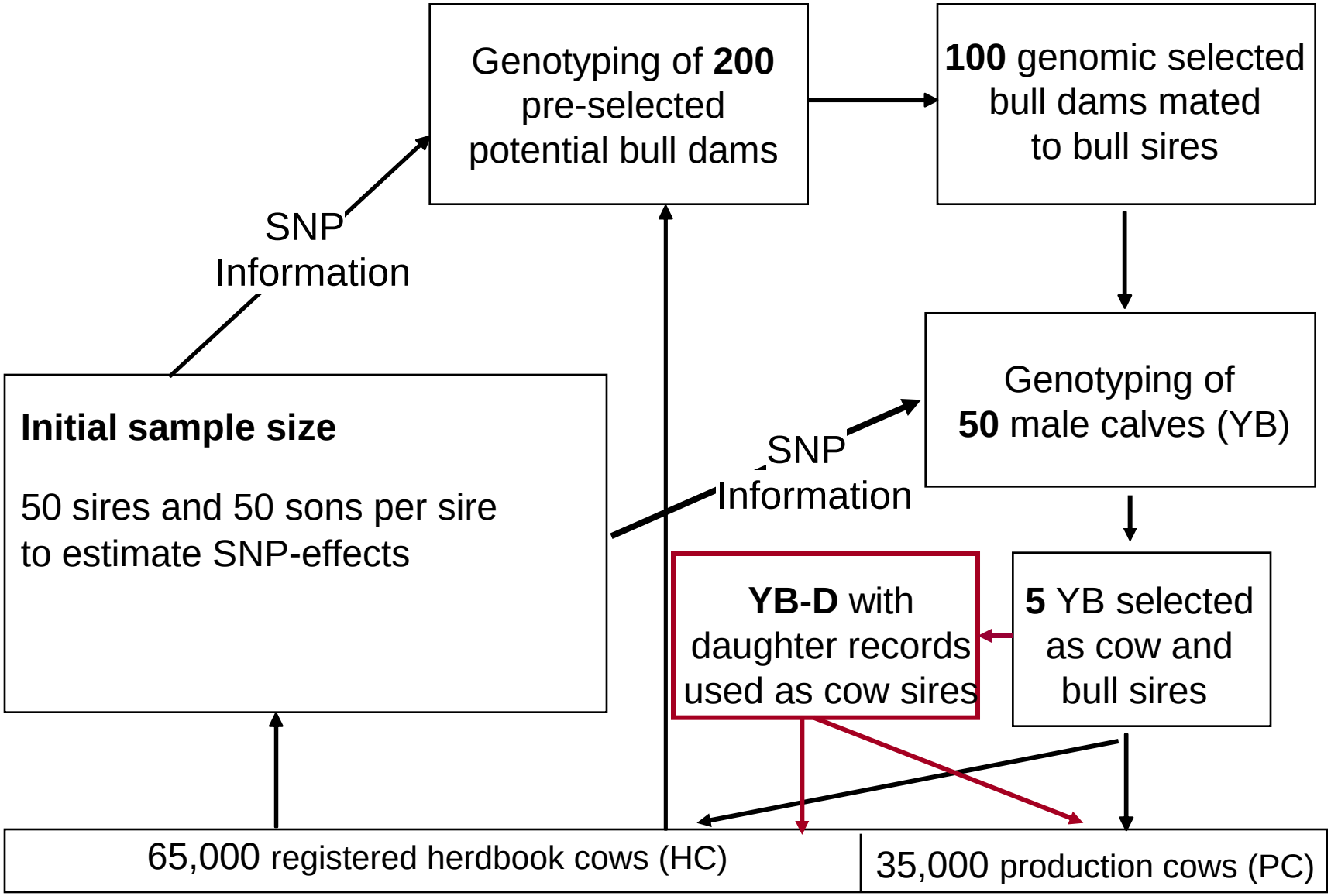
Scenarios of the GBP

Accuracy of genomic index
0.40 ➔ 0.99

Costs for genotyping
50 € ➔ 500 €



Proportion of AI with genotyped YB having daughter records (YB-D)



Gene flow matrix for CPTP

	Selection groups		
	Proven bulls (PB)	Herdbook cows (HC)	Production cows (PC)
PB	1.PB → PB	2. HC → PB	-
HC	3.YB → HC	5. HC → HC	-
	4.PB → HC		
PC	6. PB → PC	-	7. PC → PC

Gene flow matrix for GBP-YB / GBP-YB-D

	Selection groups		
	Young bulls (YB)	Herdbook cows (HC)	Production cows (PC)
YB	1.YB → YB	2. HC → YB	-
HC	**3.YB** → HC	5. HC → HC	-
	4. YB-D → HC		
PC	**6.YB** → PC	-	8. PC → PC
	7. YB-D → PC		

Accuracy of aggregate genotypes (r_{TI}): modeling via selection index calculations

2 traits in the overall breeding goal
with equal economic weights per genetic SD
1 production trait
1 functional trait

	Prod.	Func.
Prod.	**0.30**	-0.20
Func.	-0.10	**0.05**

r_{TI} for selection groups in **CPTP**: according to information sources

r_{TI} of genomic indices for selection groups in **GBP-YB / GBP-YB-D**:
Fix for all genotyped groups, i.e.
1.YB $\rightarrow$ YB, 2.HC $\rightarrow$ YB ,3.YB $\rightarrow$ HC, 4.YB-D $\rightarrow$ HC, 6.YB $\rightarrow$ PC, 7.YB-D $\rightarrow$ PC

Not genotyped: 5.HC $\rightarrow$ HC and 8.PC $\rightarrow$ PC (only own performance and performance of dam as information sources)

Some parameters of the breeding program.....

Input parameters	Numbers or costs
Population parameters	
Population size	100,000
Proportion of registered cows	0.65
Proportion of A.I.	1.00
Test capacity (i.e. proportion of recorded cows mated with test bulls)	0.25
Young bulls tested per year	50
Proven bulls selected per year, out of these	5
Inseminations per daughter lactation record	10
Biological and technical coefficients	
Average calving interval (in years)	1.15
Inseminations per pregnancy	2.40
Proportion of losses during raising (female)	0.15
Use of proven bulls (years)	3.00
Use of bull dams (years)	2.50
Mean generation interval (years)	4.66
Cost parameters (EURO)	
Milk recording costs per cow	31
Inspection bull dam per selected bull dam	100
Keeping test bull on station per year (fixed and variable costs)	5,000
Herdbook registration per cow	1.5
Interest rate return	0.06
Interest rate costs	0.04
Investment period (years)	15

Essential differences in biological and technical coefficients and breeding costs when comparing CPTP and GBP

	Biological / technical coefficients			Costs
Breeding program	Cows mated to YB	Gen. interval for YB → HC	Gen. interval for PB → HC	Genotyping
CPTP	25 %	2.1 years	6.2 years	–
GBP-YB	100 % (YB + YB-D)	2.1 years for YB 6.2 years for YB-D	–	250 € per animal

Evaluation criteria

1. **Genetic gain** (ΔG) per year for single traits

2. **Monetary genetic gain** per year
   $\Sigma(\Delta G$ * economic weights)

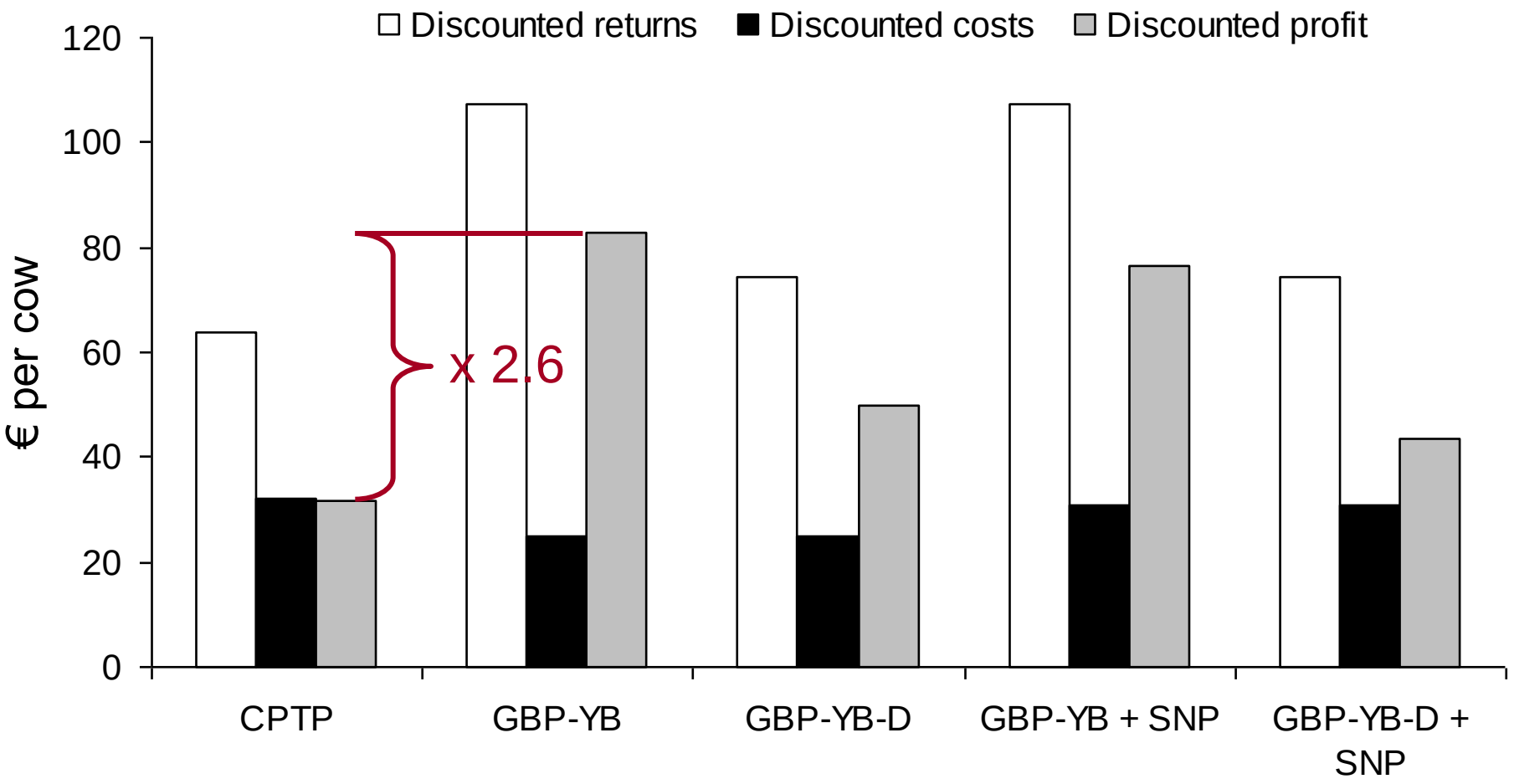
3. **Discounted returns** per cow over the whole investment period
   (monetary genetic gain * SDE-values)

4. **Discounted costs** per cow over the whole investment period

5. **Discounted profit** per cow over the whole investment period
   = (Discounted returns – discounted costs)

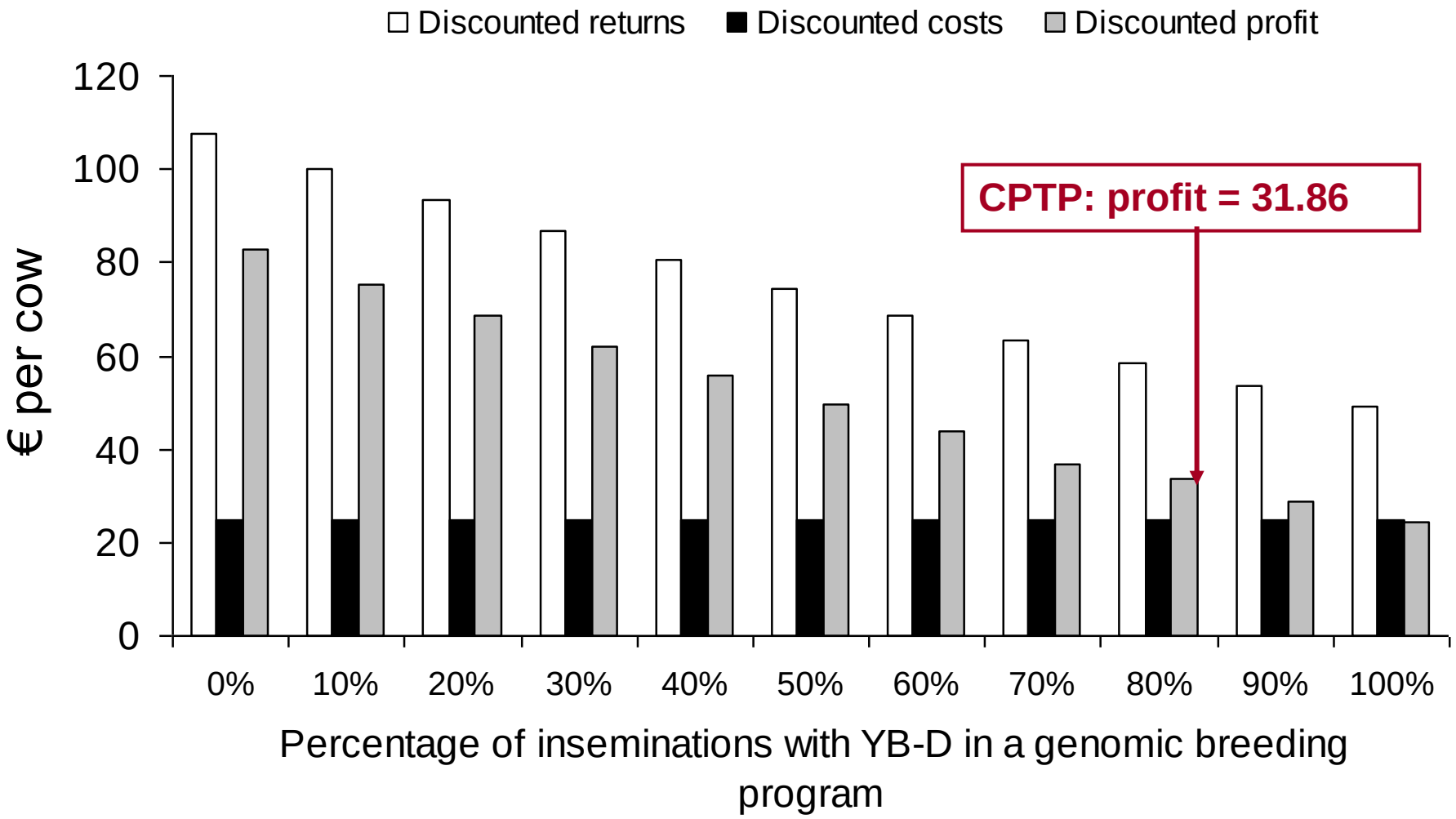
CPTP versus GBP-YB and GBP-YB-D

(r_{TI} of genomic index = 0.70, GBP-YB-D = 50% AI with YB-D, costs for genotyping = 250 €)



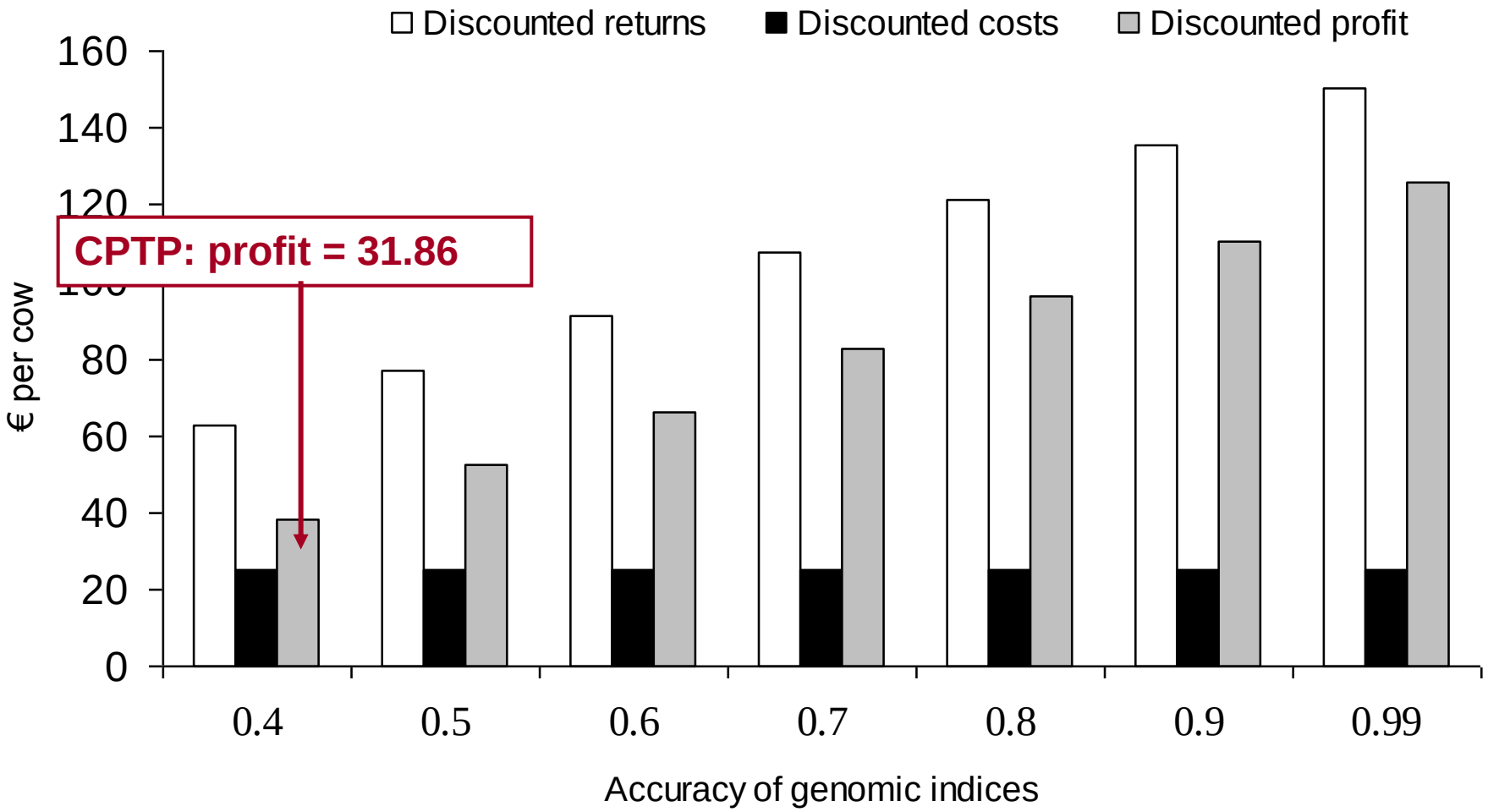
Altering percentage of AI with YB-D

(r_{TI} of genomic index = 0.70, costs for genotyping = 250 €, no estimation of SNP-effects)



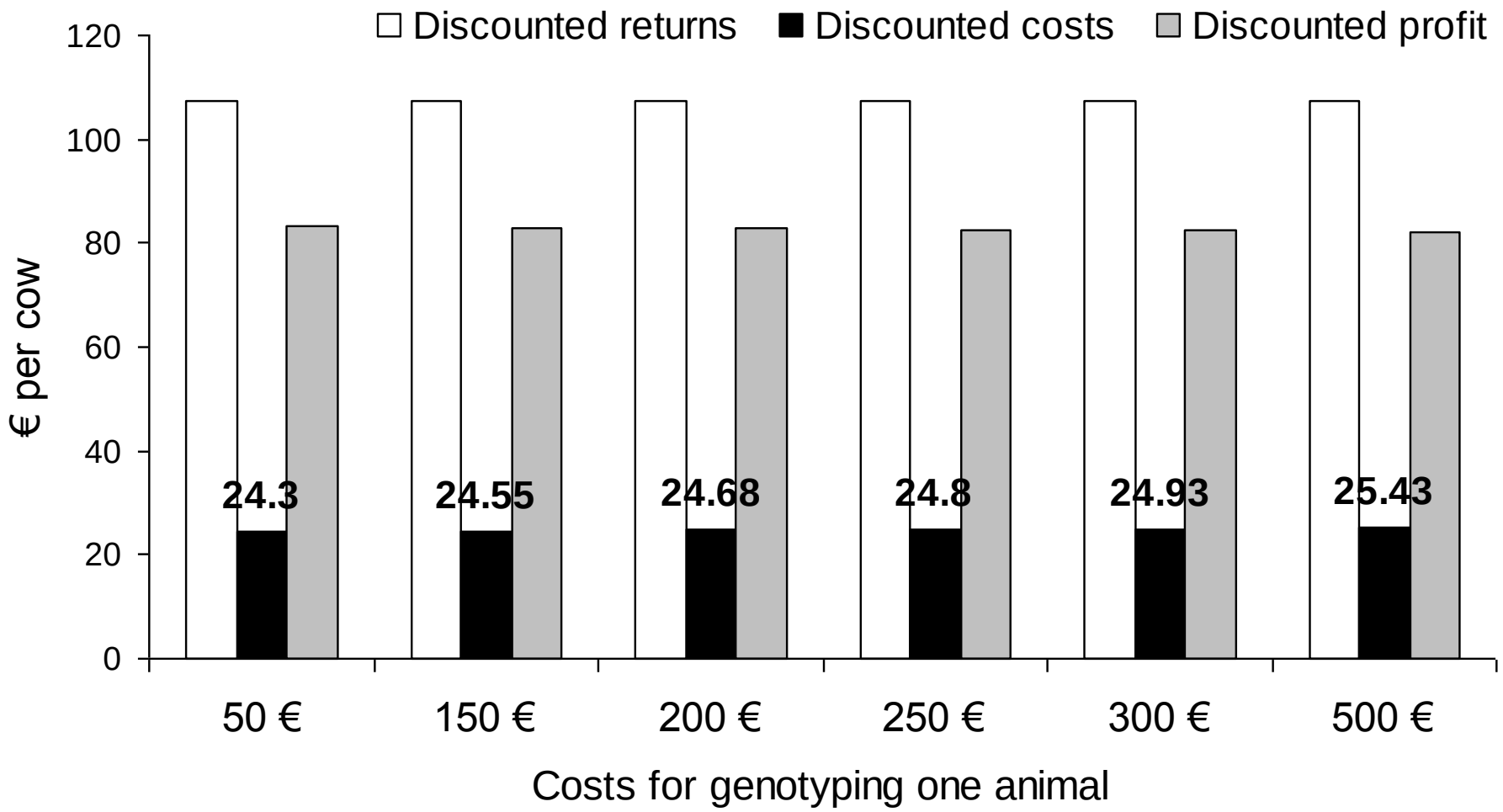
Altering accuracies of genomic inidices

(percentage of AI with YB-D = 50%, costs for genotyping = 250 €, no estimation of SNP-effects)



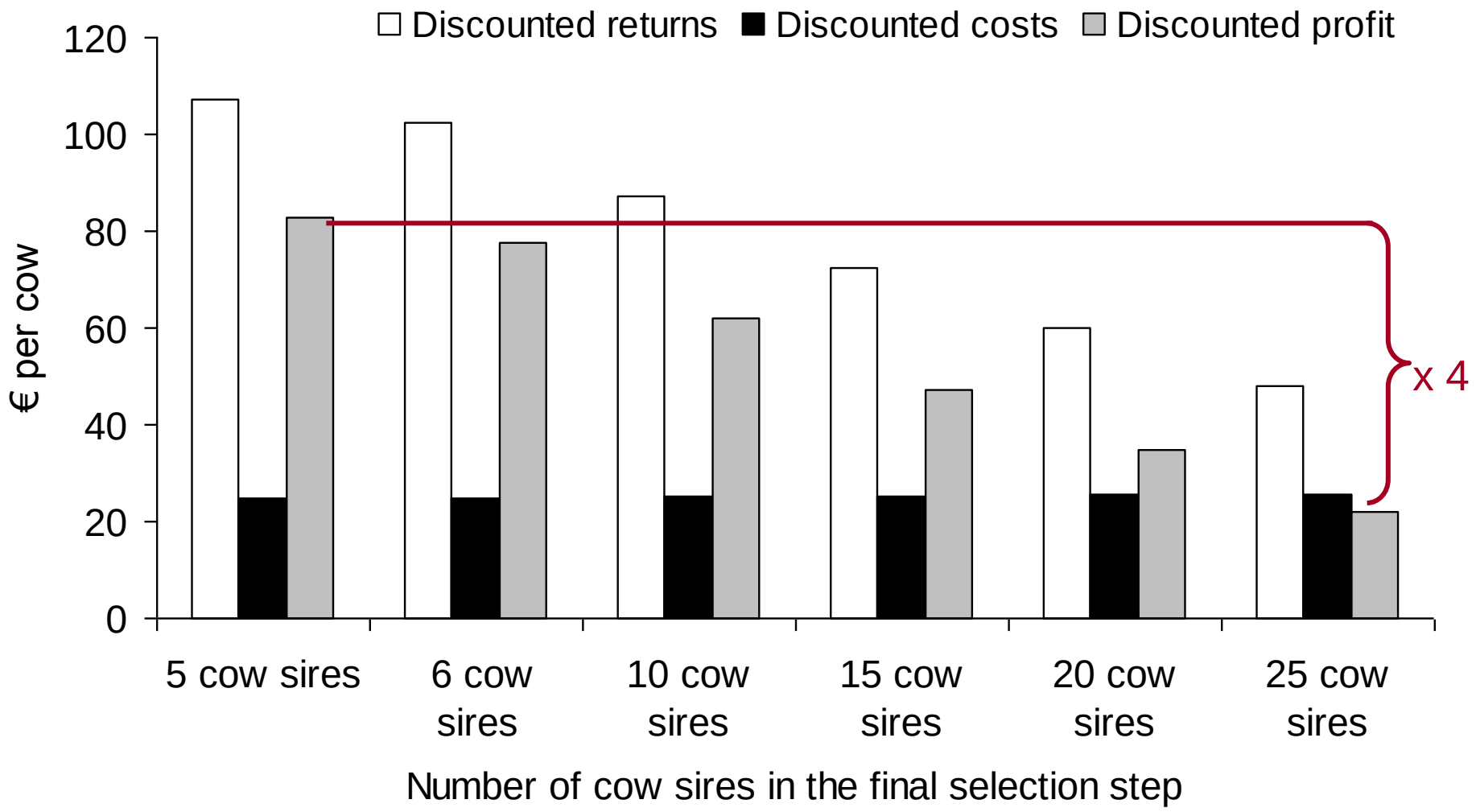
Altering costs for genotyping

(r_{TI} of genomic index = 0.70, no estimation of SNP-effects, no YB-D)



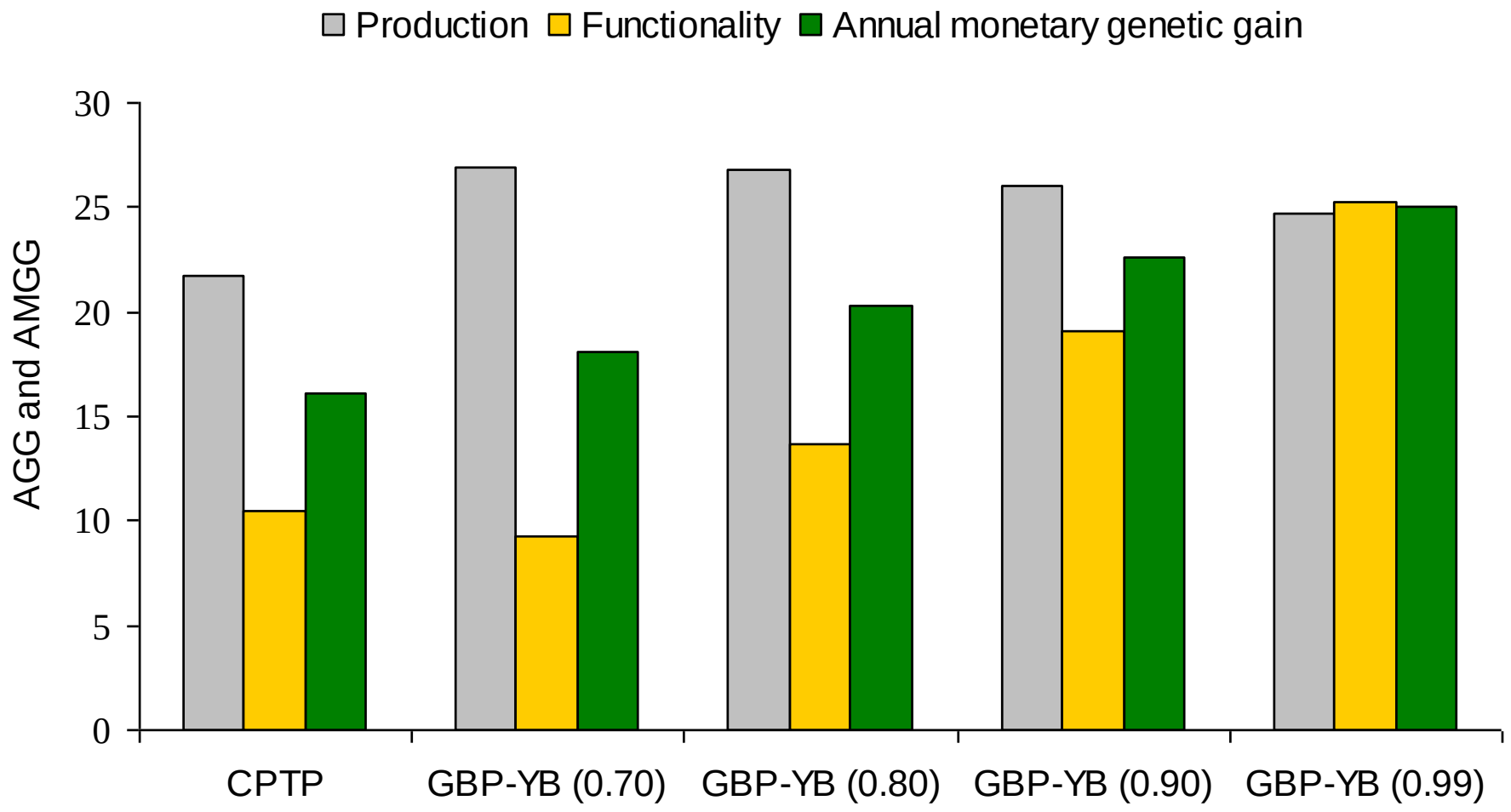
Altering no. of selected cow sires

(r_{TI} of genomic index = 0.70, costs for genotyping = 250 €, no estimation of SNP-effects, no YB-D)



Annual genetic gain (AGG) and annual monetary genetic gain (AMGG)

(no estimation of SNP-effects, costs for genotyping = 250 €, no YB-D)



Conclusions

1. Discounted profit increases by factor 2.6 mainly due to substantial reduction in generation intervals

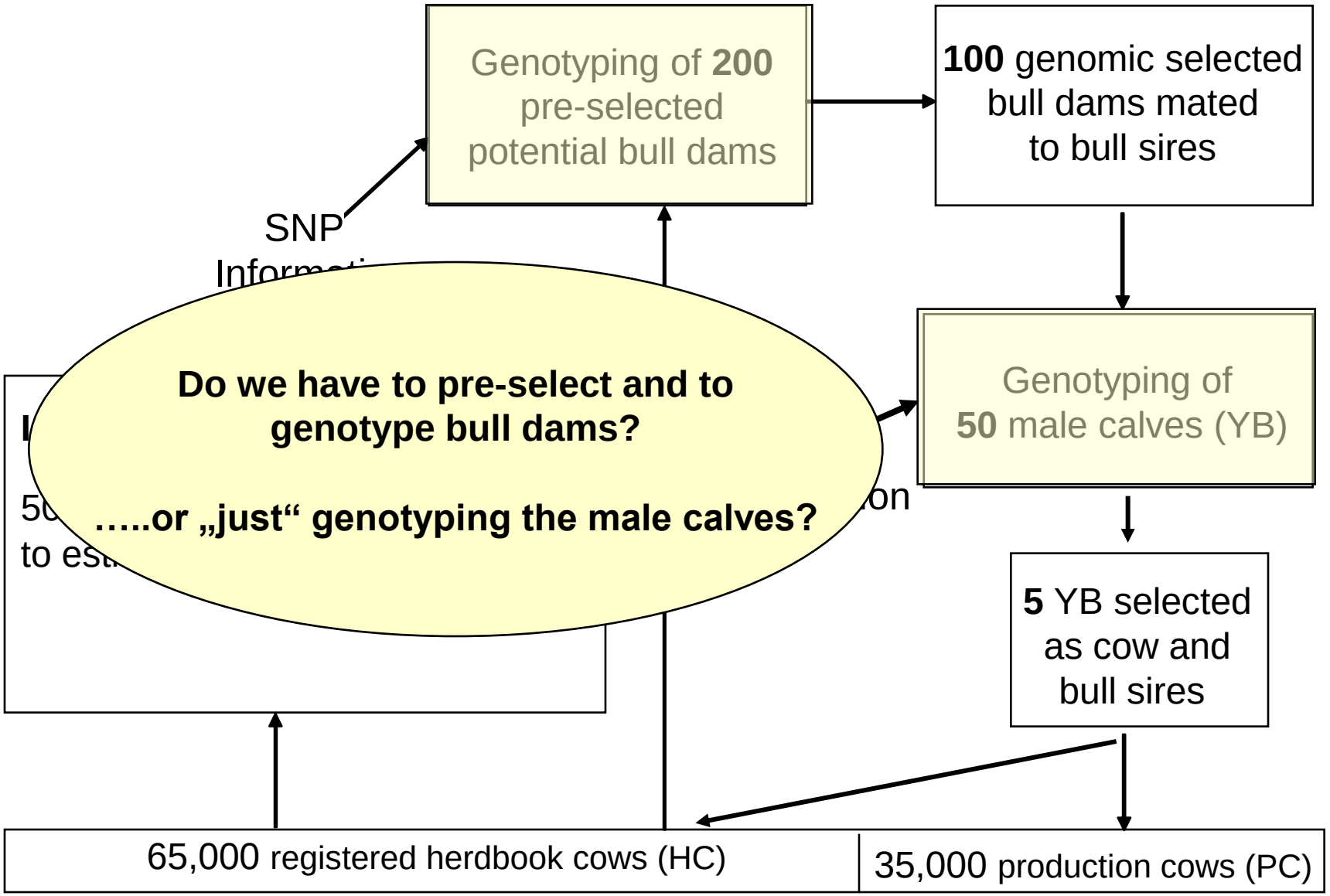
2. Costs for genotyping have a marginal contribution when focussing on a population wide perspective

3. The important question is: Will farmers use GEBVs without knowledge of daughter information?

4. Genomic selection has the potential for a substantial change of dairy cattle breeding programs

Actual results always lagged behind theoretical expectations (MOET, MAS)

Limitations of our work – ideas for new work



Limitations of our work – ideas for new work

Input parameters	Numbers or costs
Population parameters	
Population size	100,000
Proportion of registered cows	0.65
Proportion of A.I.	**1.00**
Test capacity (i.e. proportion of recorded cows mated with test bulls)	0.25

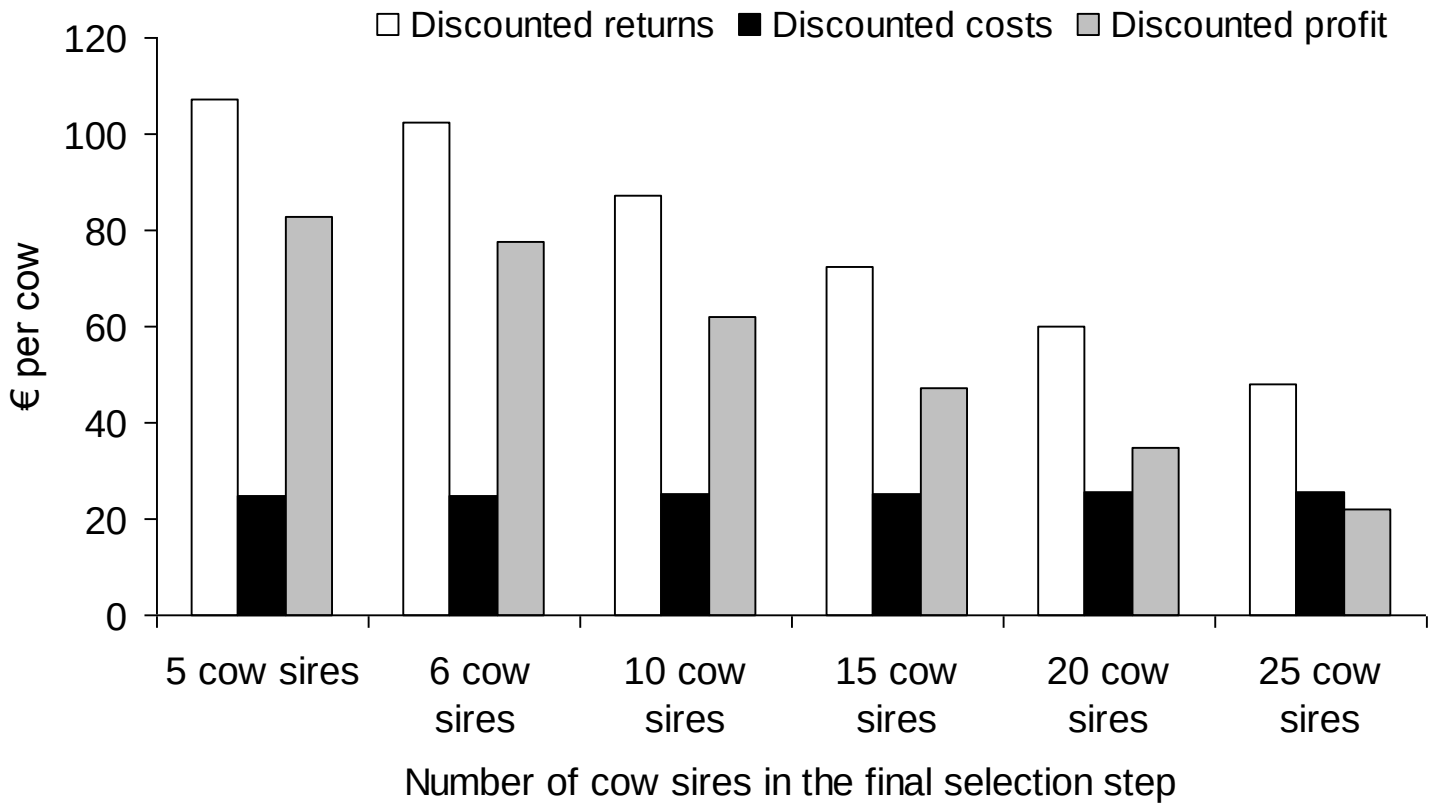
What is the result?

Competition between practical breeders and A.I. – stations

➔ decrease of A.I.

> 25 cow sires

➔ substantial decrease of genetic gain



……more detailed work in the field of genomic selection will raise more ideas / raise more questions

This will ensure continuation of scientific work