How Genomic BLUP Works

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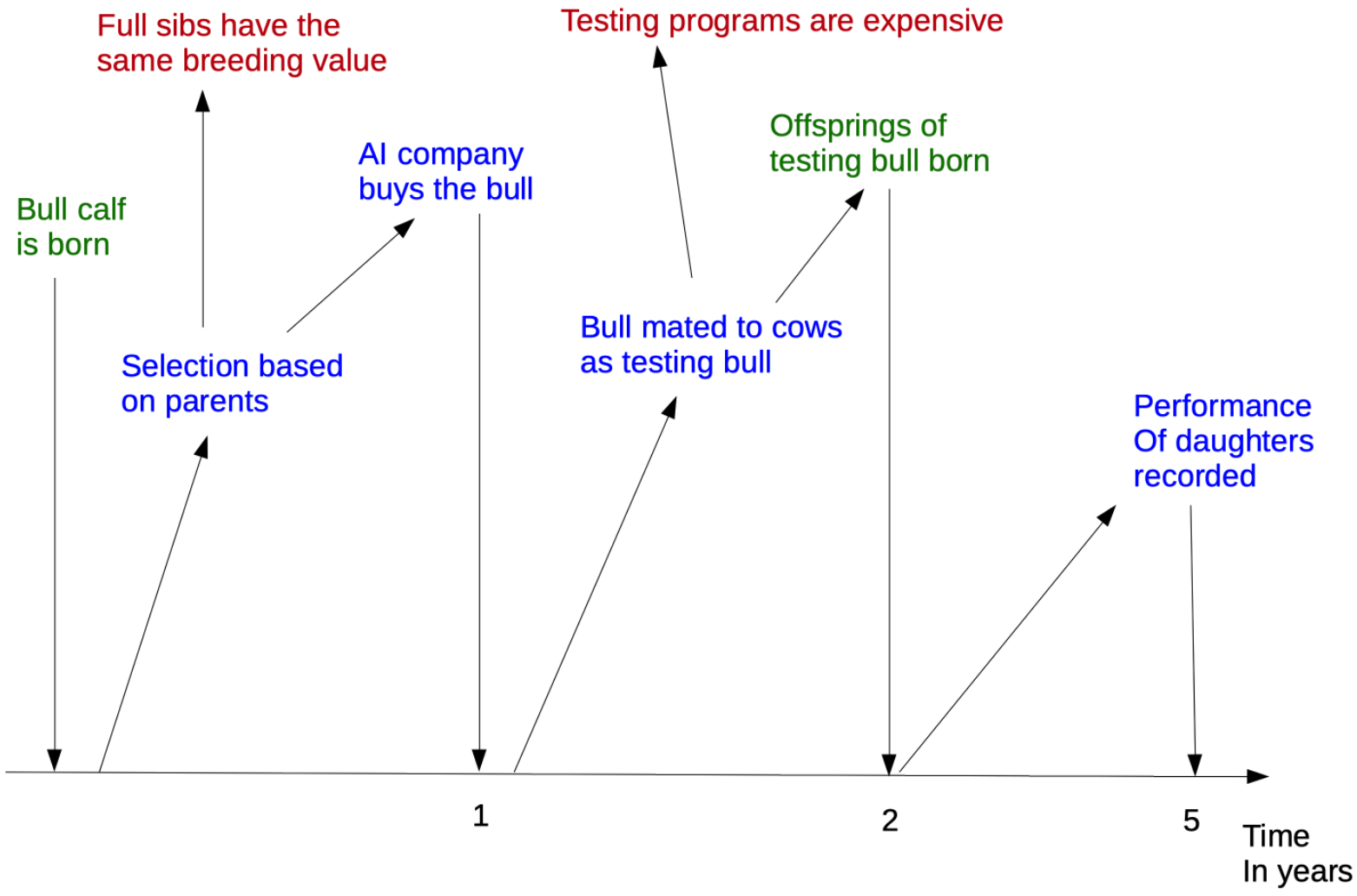
09.03.2020

Advantage of Genomic Selection

- Big advantage of genomic selection: **shorter generation interval**
- Old days: selection mainly based on performance tested sires
  - fine in species where generation inverval is low, e.g. pigs
  - problem when generation interval is long like cattle

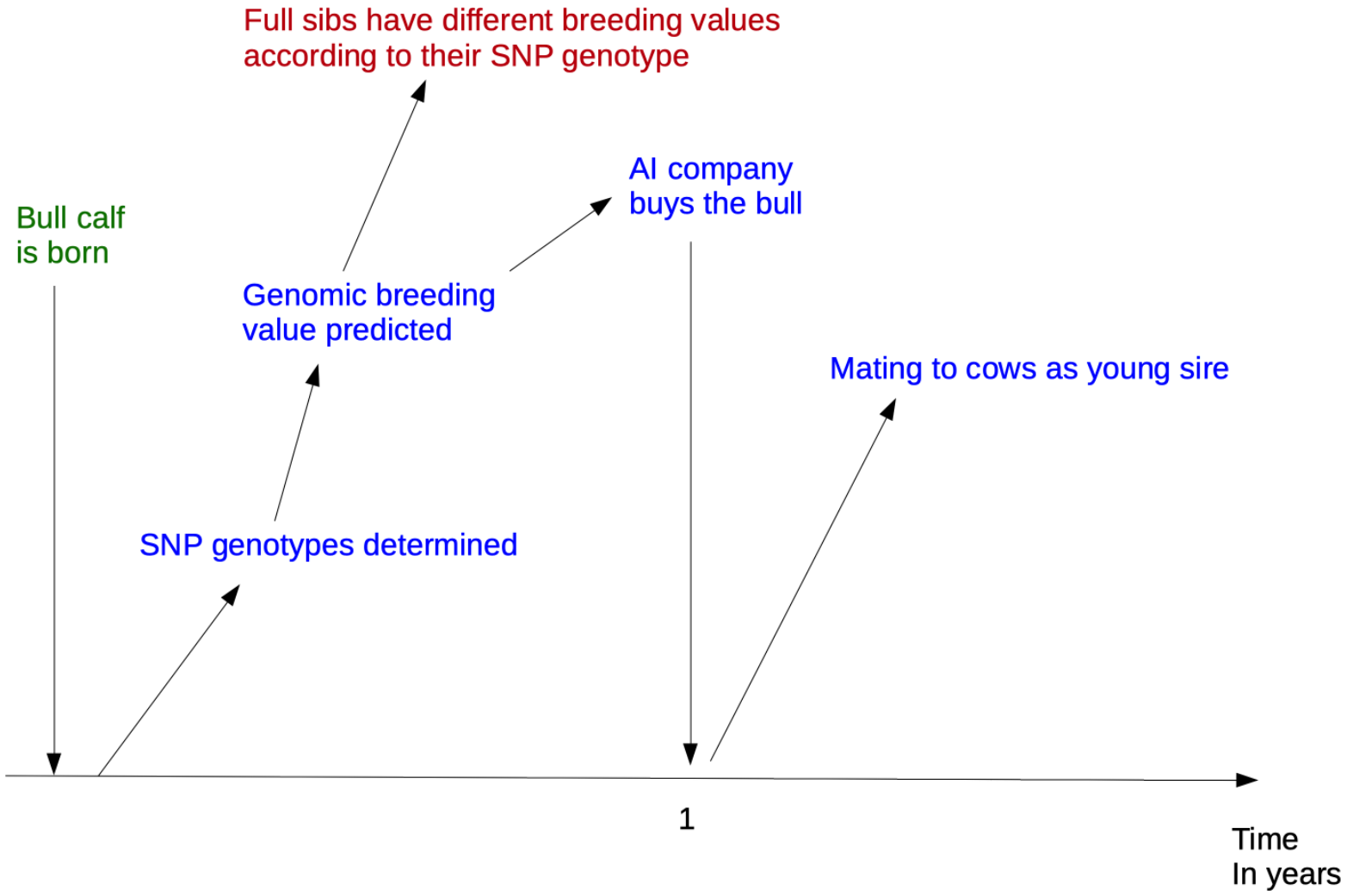
Performance Testing



Genomic Selection

- SNP Genotype can be determined when calf is born
- Genomic Breeding value can be computed as soon as SNP genotype is determined
- Full sibs get different genomic breeding values $\rightarrow$ increase accuracy

Genomic Selection (II)

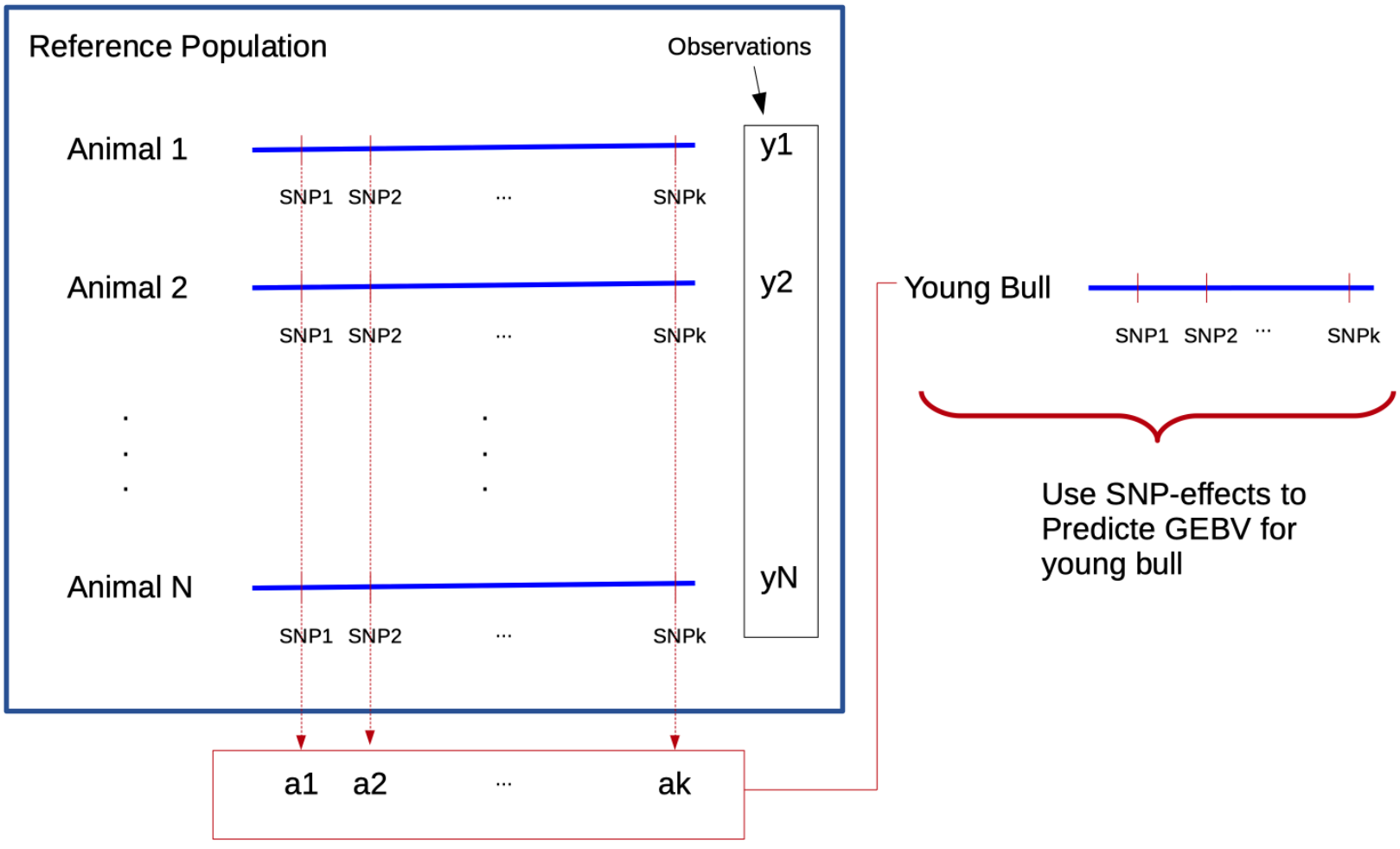


Prediction of Genomic Breeding Values

Genomic breeding values can be predicted using either

- Two step approach or
- Single step GBLUP

Two Step Approach



Single Step GBLUP

- Use a mixed linear effect model
- Genomic breeding values g are random effects

$$y = Xb + Zg + e$$

with

- $E(e) = 0$, $var(e) = I * \sigma_e^2$
- $E(g) = 0$, $var(g) = G * \sigma_g^2$
- Genomic relationship matrix G

Solution Via Mixed Model Equations

- All animals have genotypes and observations

$$\begin{bmatrix} X^T X & X^T Z \\ Z^T X & Z^T Z + \lambda * G^{-1} \end{bmatrix} \begin{bmatrix} \hat{b} \\ \hat{g} \end{bmatrix} = \begin{bmatrix} X^T y \\ Z^T y \end{bmatrix}$$

with $\lambda = \sigma_e^2 / \sigma_g^2$.

Animals Without Observations

- Young animals do not have observations
- Partition $\hat{g}$ into
  - $\hat{g}_1$ animals with observations and
  - $\hat{g}_2$ animals without observations
- Resulting Mixed Model Equations are (assume $\lambda = 1$)

$$\begin{bmatrix} X^T X & X^T Z & 0 \\ Z^T X & Z^T Z + G^{(11)} & G^{(12)} \\ 0 & G^{(21)} & G^{(22)} \end{bmatrix} \begin{bmatrix} \hat{b} \\ \hat{g}_1 \\ \hat{g}_2 \end{bmatrix} = \begin{bmatrix} X^T y \\ Z^T y \\ 0 \end{bmatrix}$$

Predicted Genomic Breeding Values

- Last line of Mixed model equations

$$G^{(21)} \cdot \hat{g}_1 + G^{(22)} \cdot \hat{g}_2 = 0$$

Solutions

- Solving for $\hat{g}_2$

$$\hat{g}_2 = -\left(G^{(22)}\right)^{-1} \cdot G^{(21)} \cdot \hat{g}_1$$