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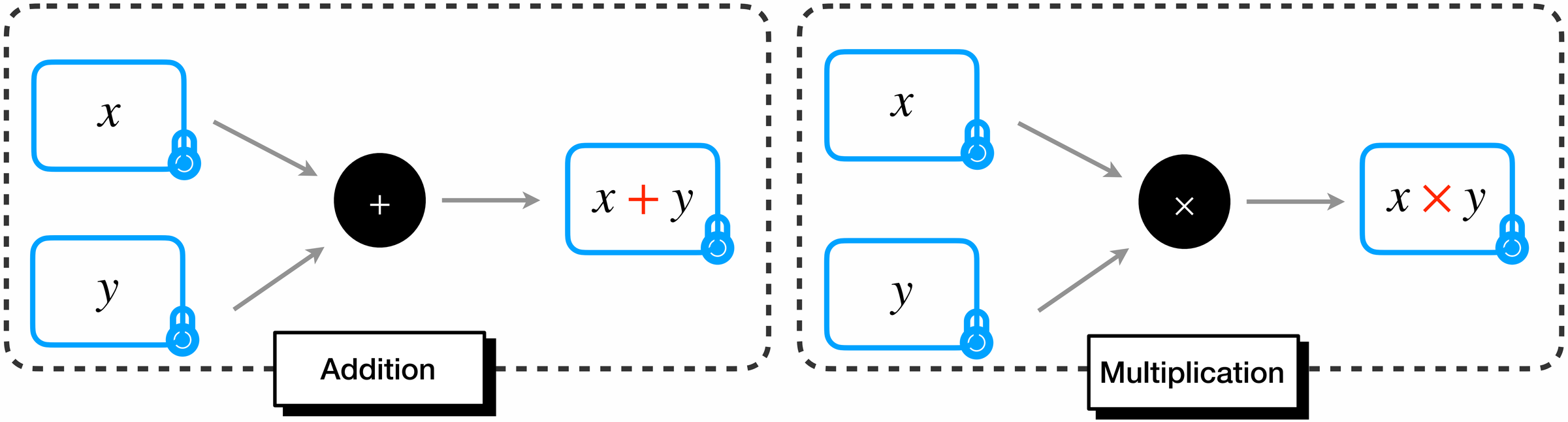
Adeline Roux-Langlois & Samuel Tap

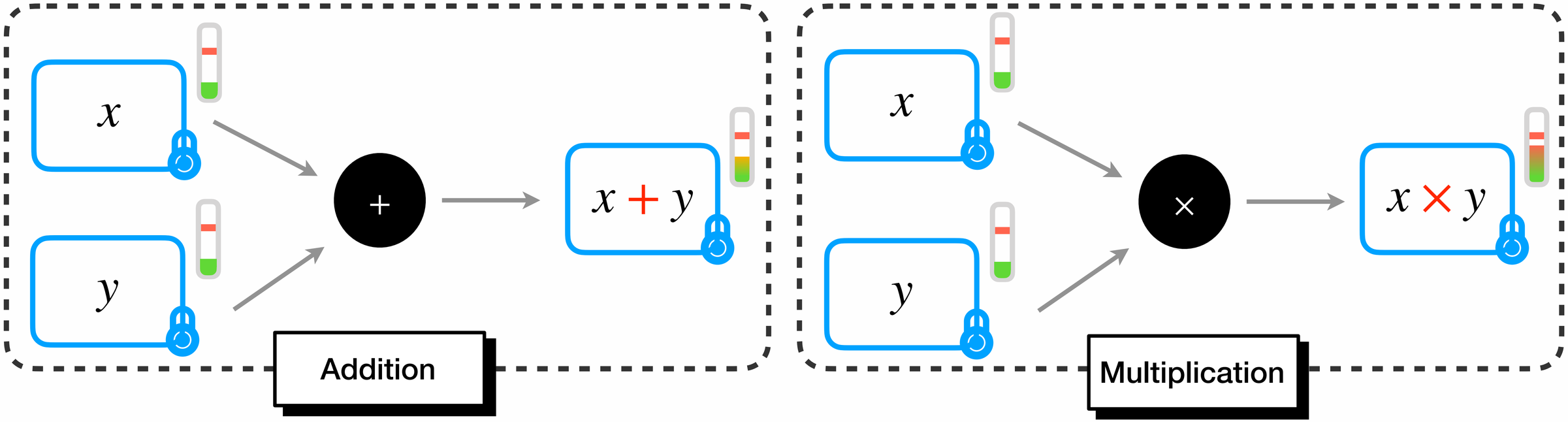
17 October 2023

Faster Secret Keys for (T)FHE

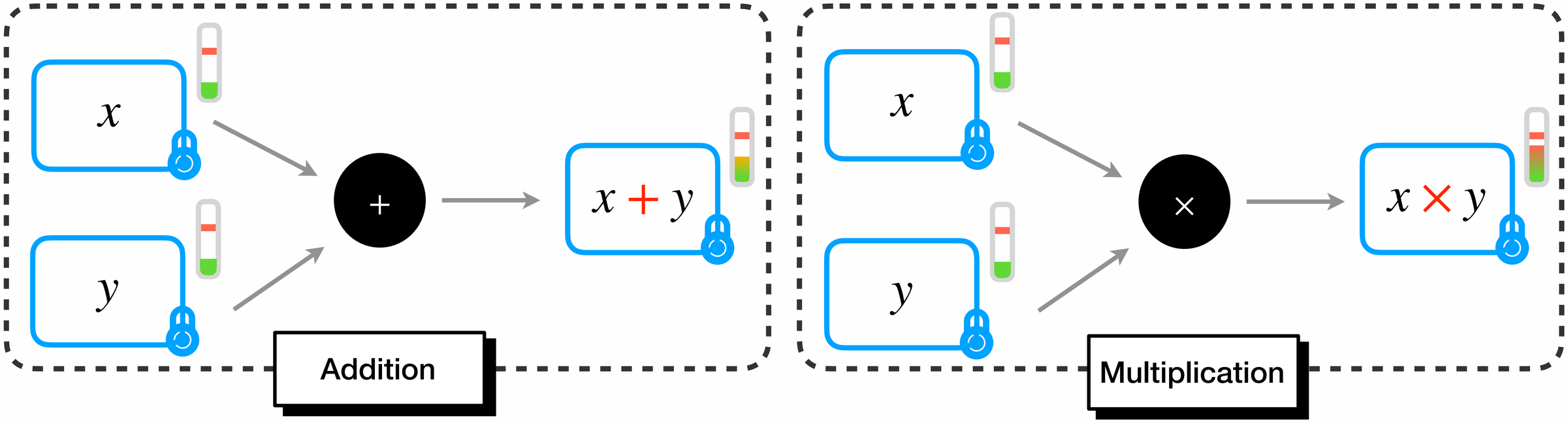
Homomorphic Encryption



Homomorphic Encryption

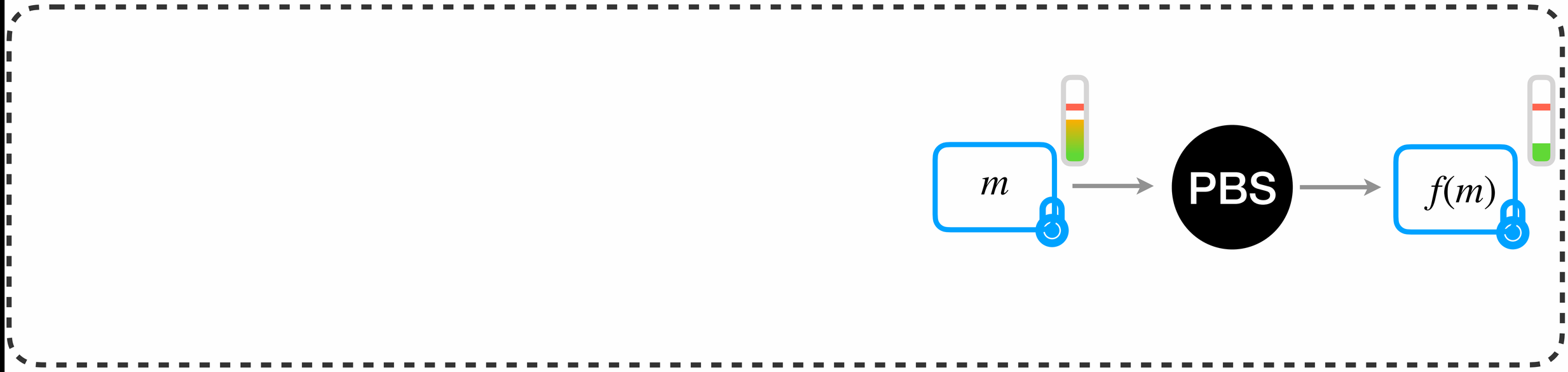


Homomorphic Encryption



too much noise $\Longrightarrow$ incorrect decryption

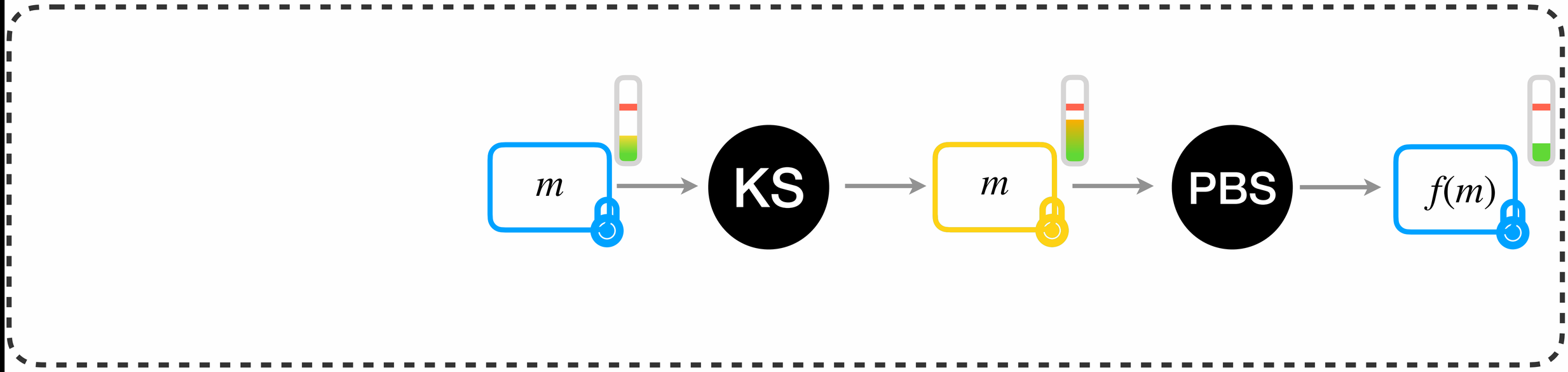
Bootstrapping graph



Programmable Bootstrapping

Evaluate univariate function,
Reduce the noise

Bootstrapping graph



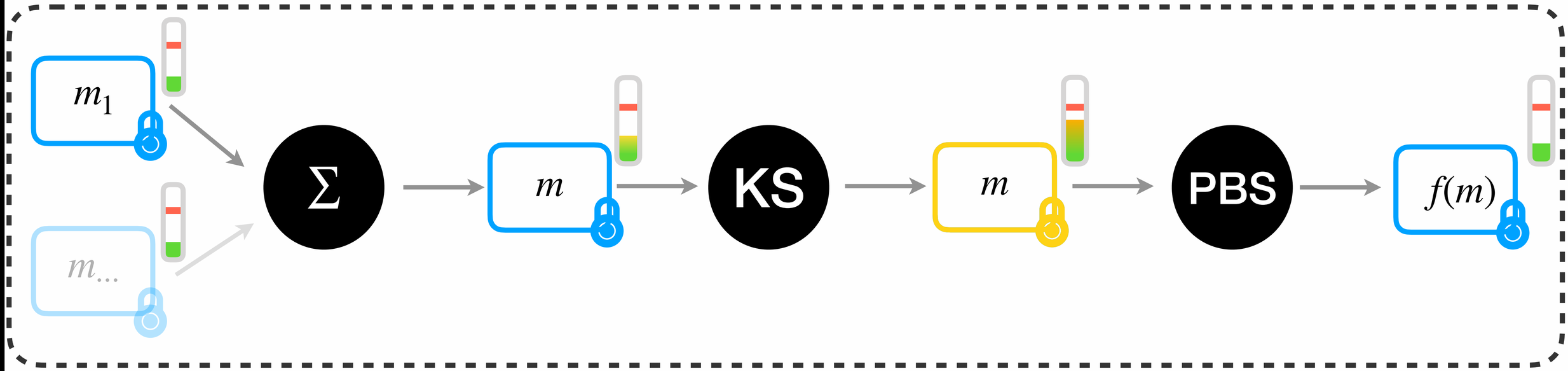
Keyswitching

Switch from a secret key s to another secret key s.

Programmable Bootstrapping

Evaluate univariate function, Reduce the noise

Bootstrapping graph



Leveled Operations

Scalar multiplication,
Addition

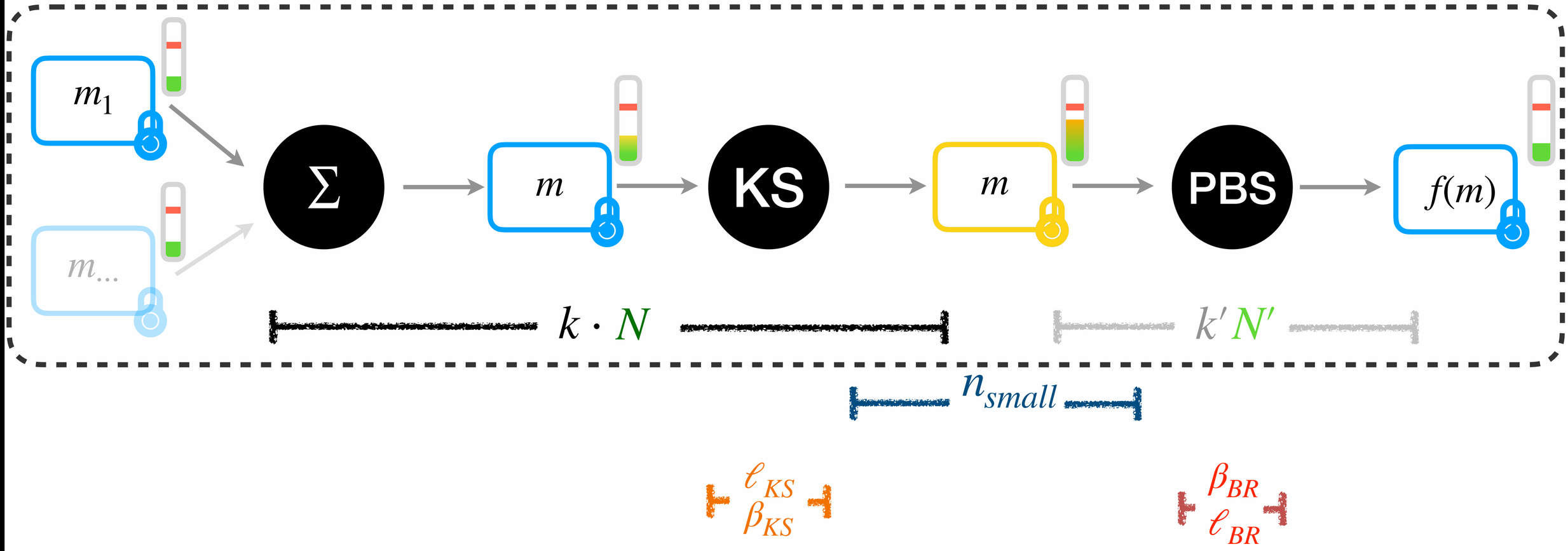
Keyswitching

Switch from a secret key s to
another secret key s.

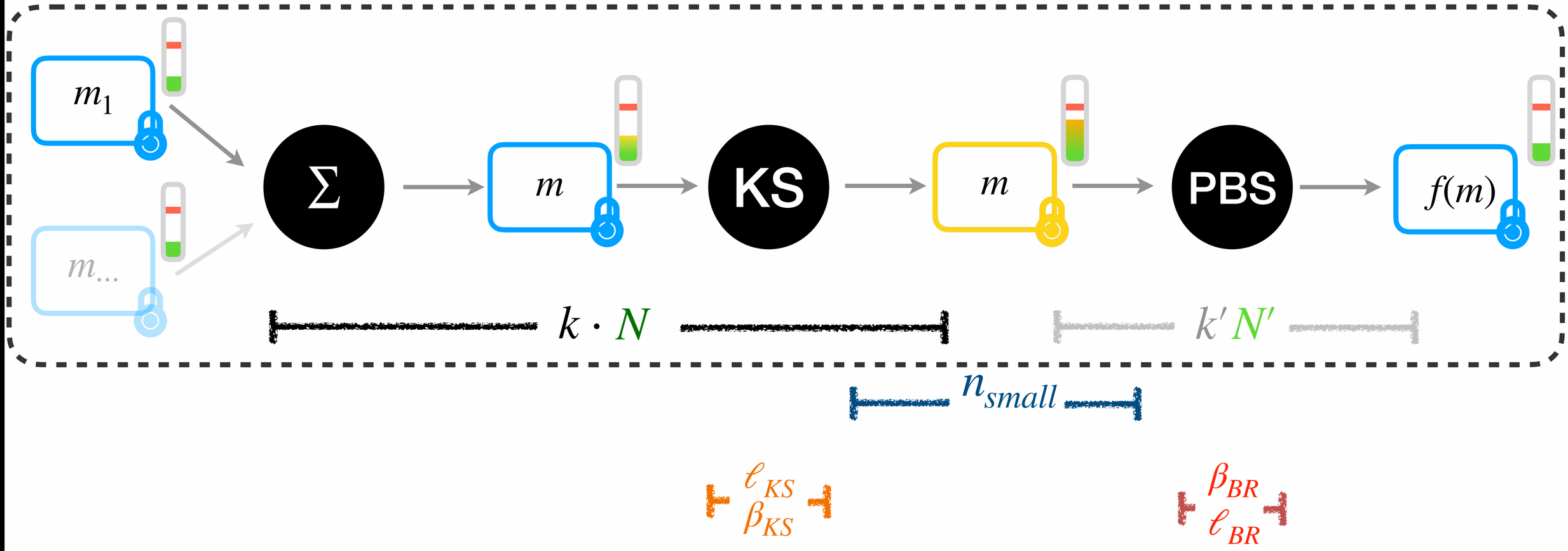
Programmable Bootstrapping

Evaluate univariate function,
Reduce the noise

Bootstrapping graph



Bootstrapping graph



A lot of parameters, changing <u>one</u> parameter impact :
the <u>correctness</u>, the <u>other parameters</u> and the <u>execution time</u>.

Ideas

Bootstrapping graph is fast but still slow ($\simeq$10ms)

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Can we explore new assumptions to improve the bootstrapping graph ?

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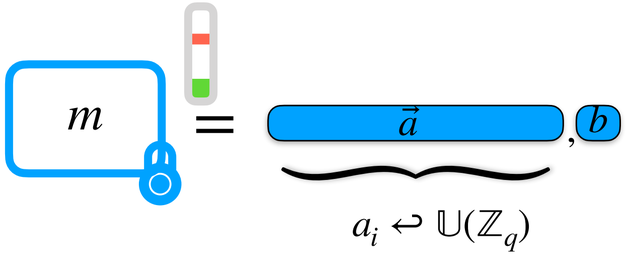
Can we explore new assumptions to improve the bootstrapping graph ?

Explore new assumption for the secret keys

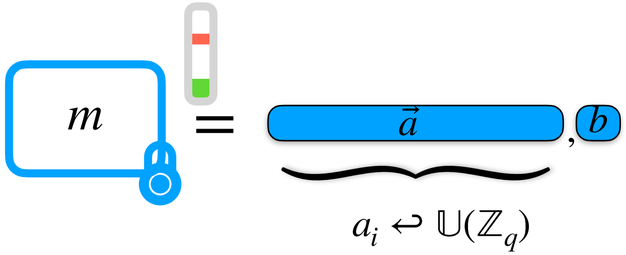
LWE ciphertext

Encrypt:

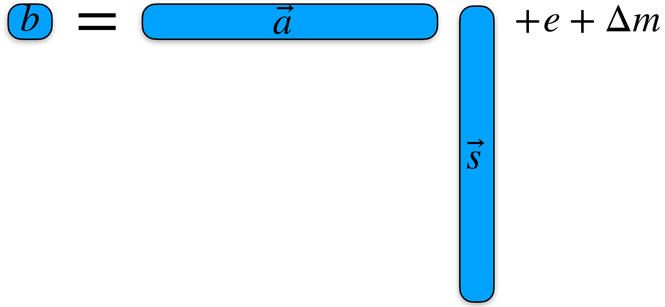


LWE ciphertext

Encrypt:

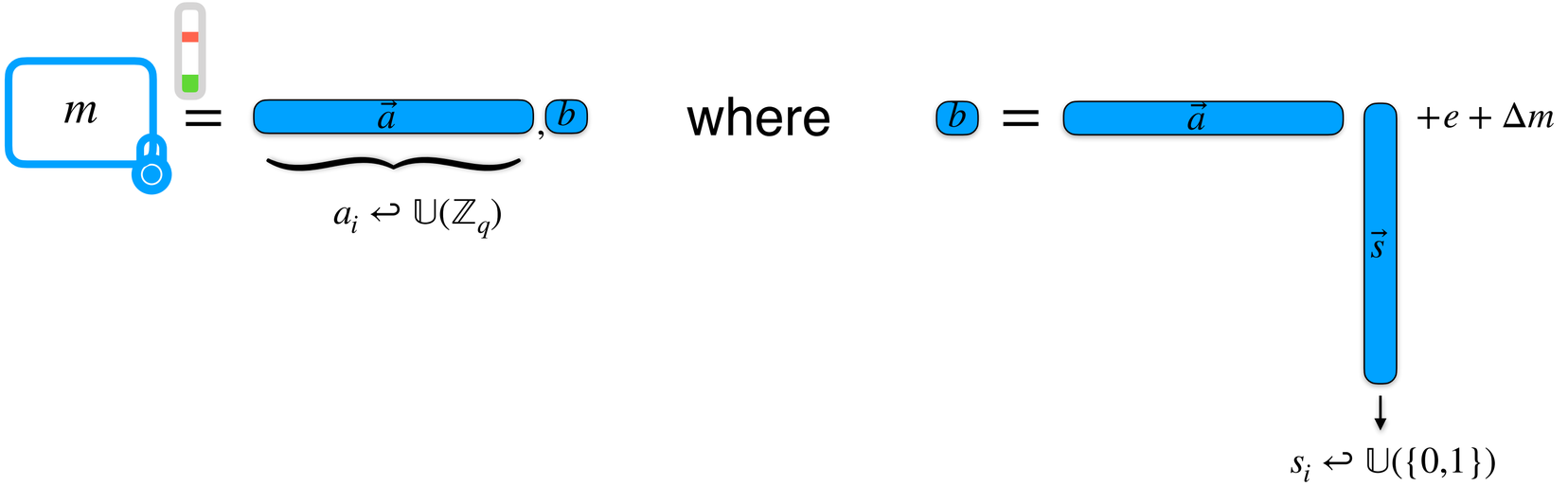


where



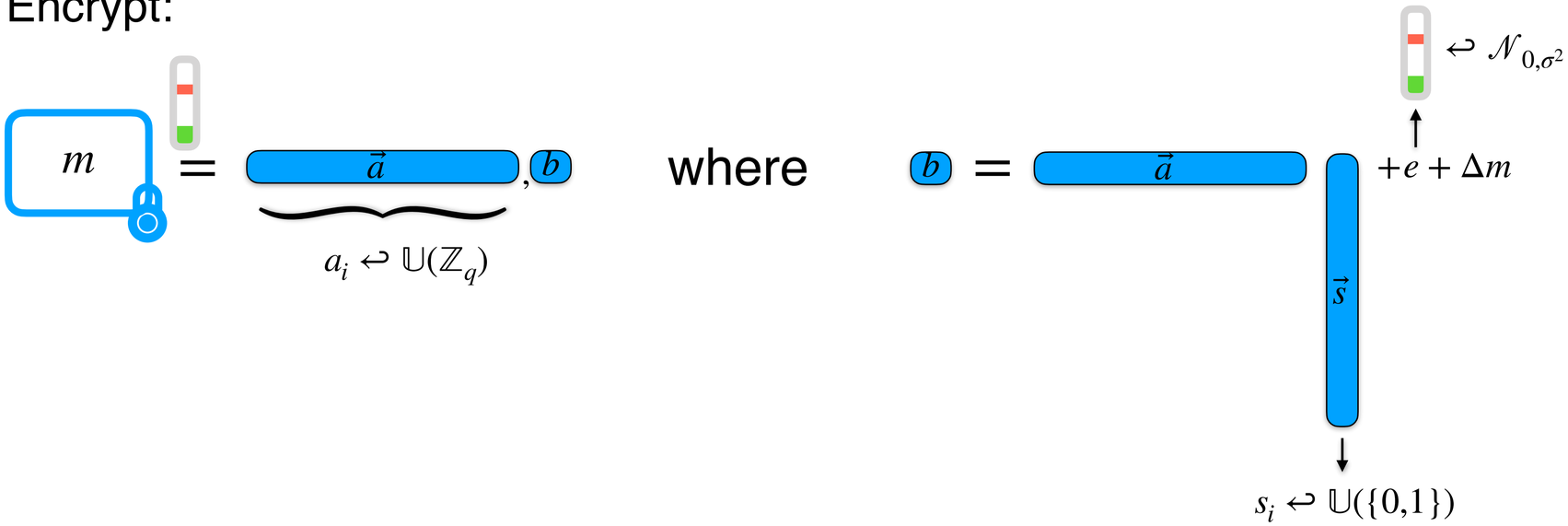
LWE ciphertext

Encrypt:

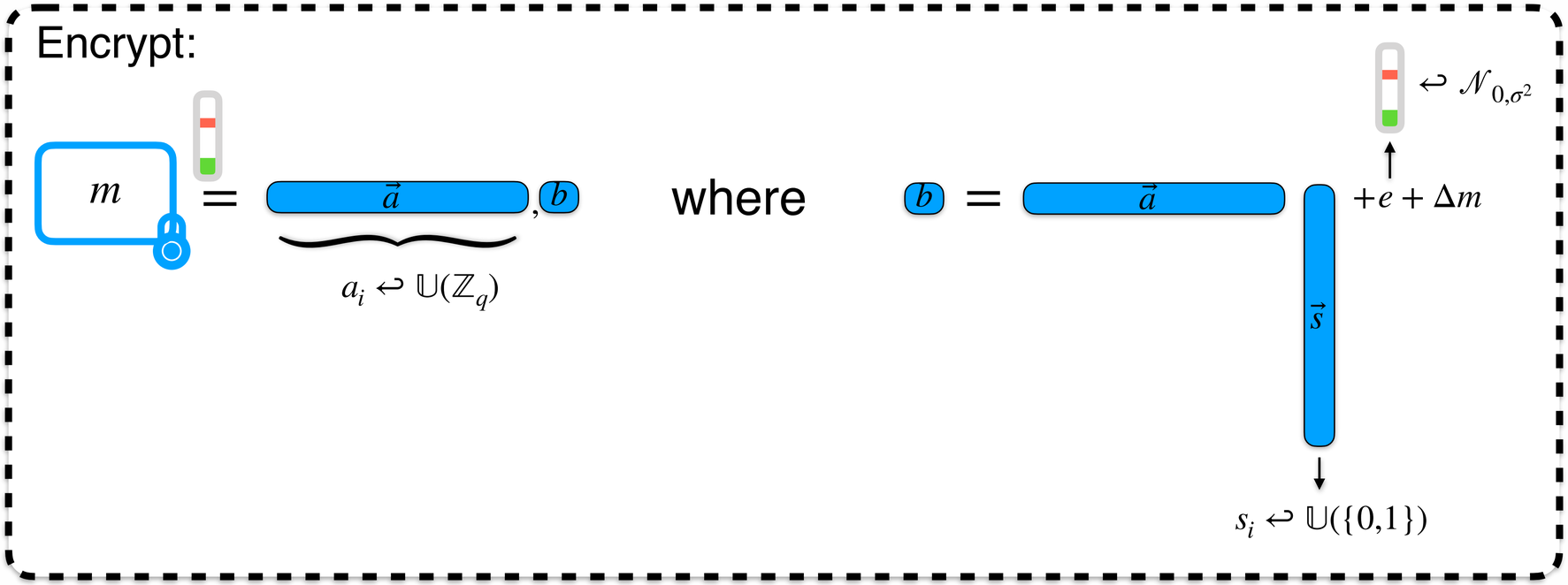


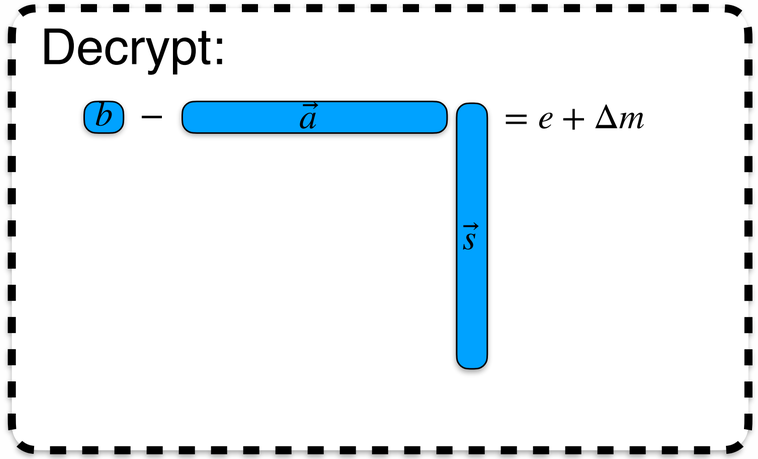
LWE ciphertext

Encrypt:

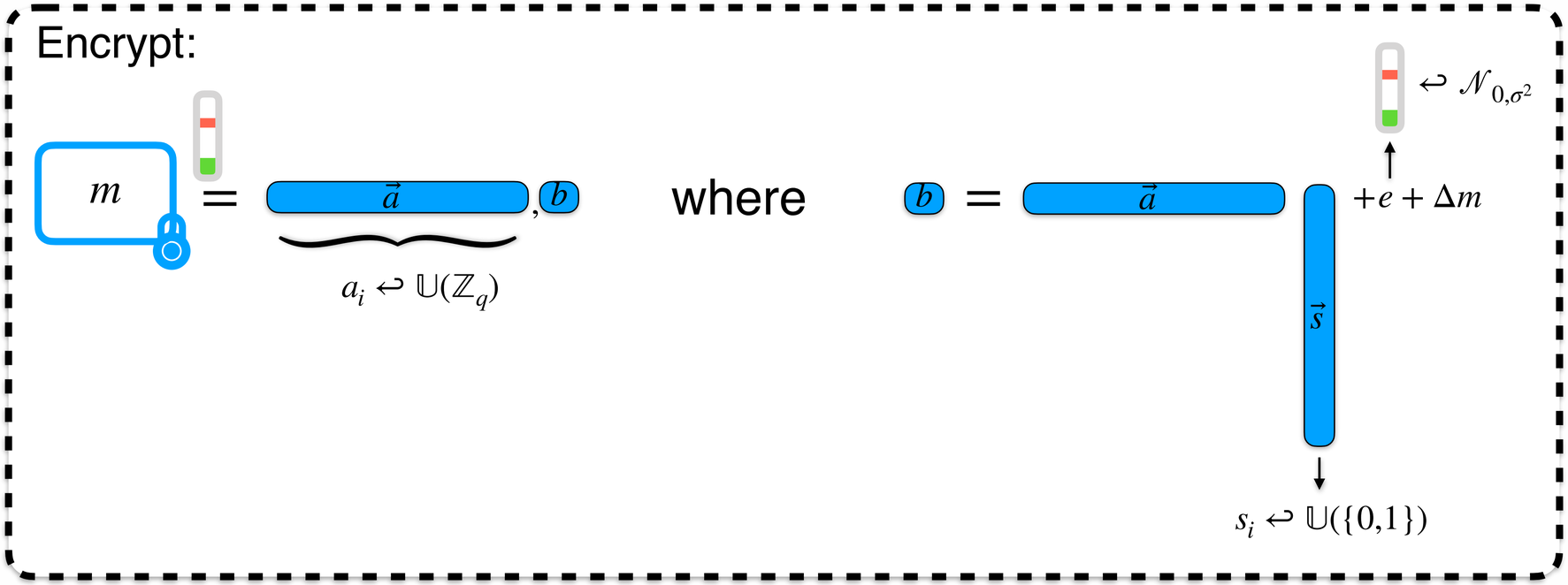


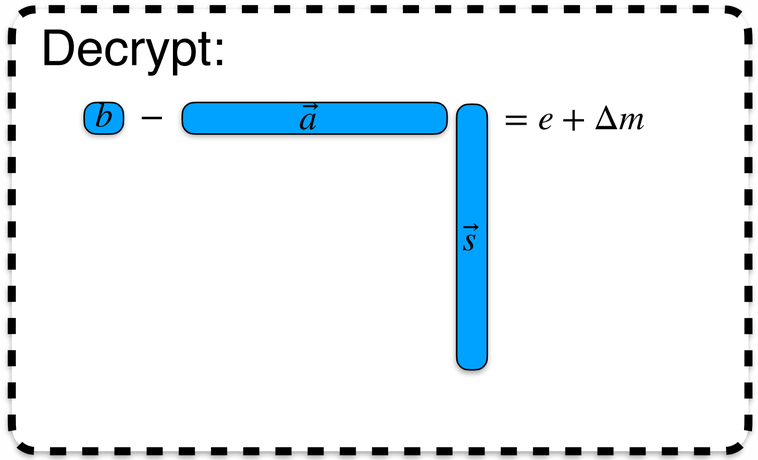
LWE ciphertext

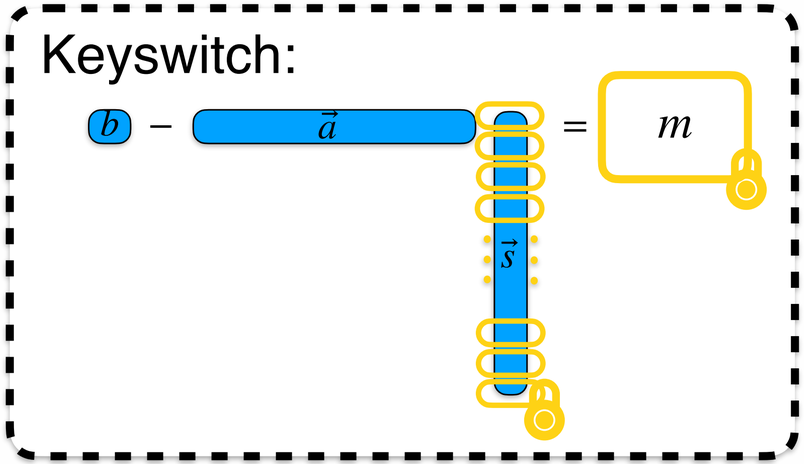




LWE ciphertext







Our Contributions

Two new types of secret keys

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Shared randomness secret keys

Partial secret keys

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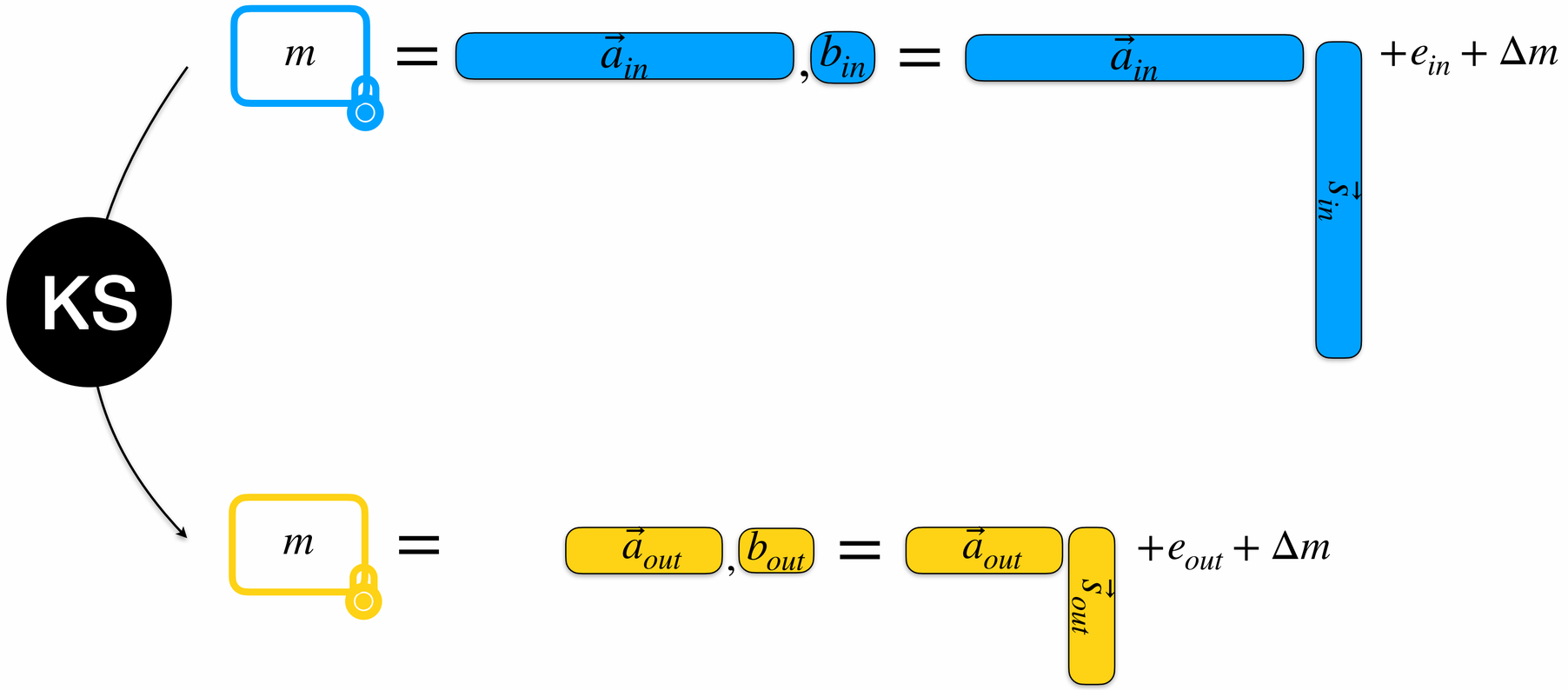
Partial secret keys

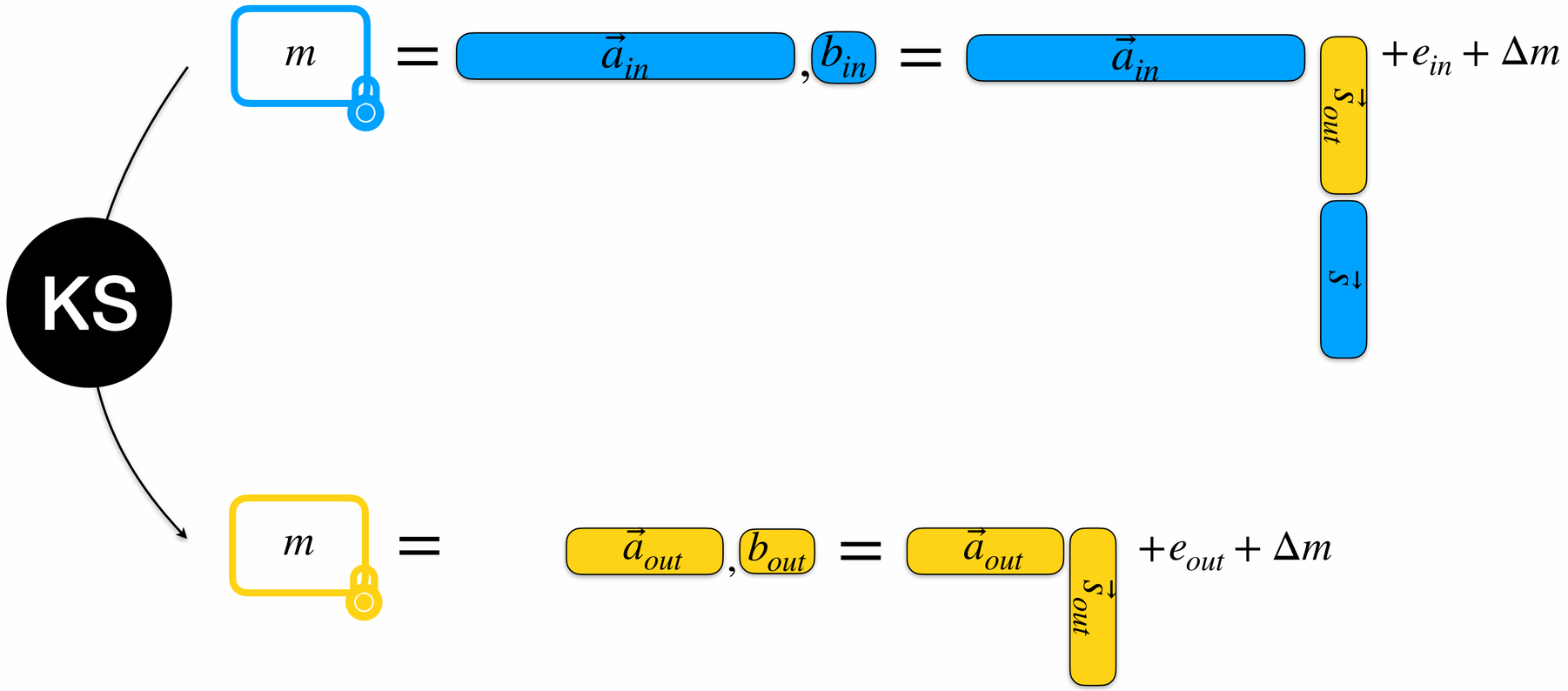
This both keys can be combined

Shared Randomness Secret Keys

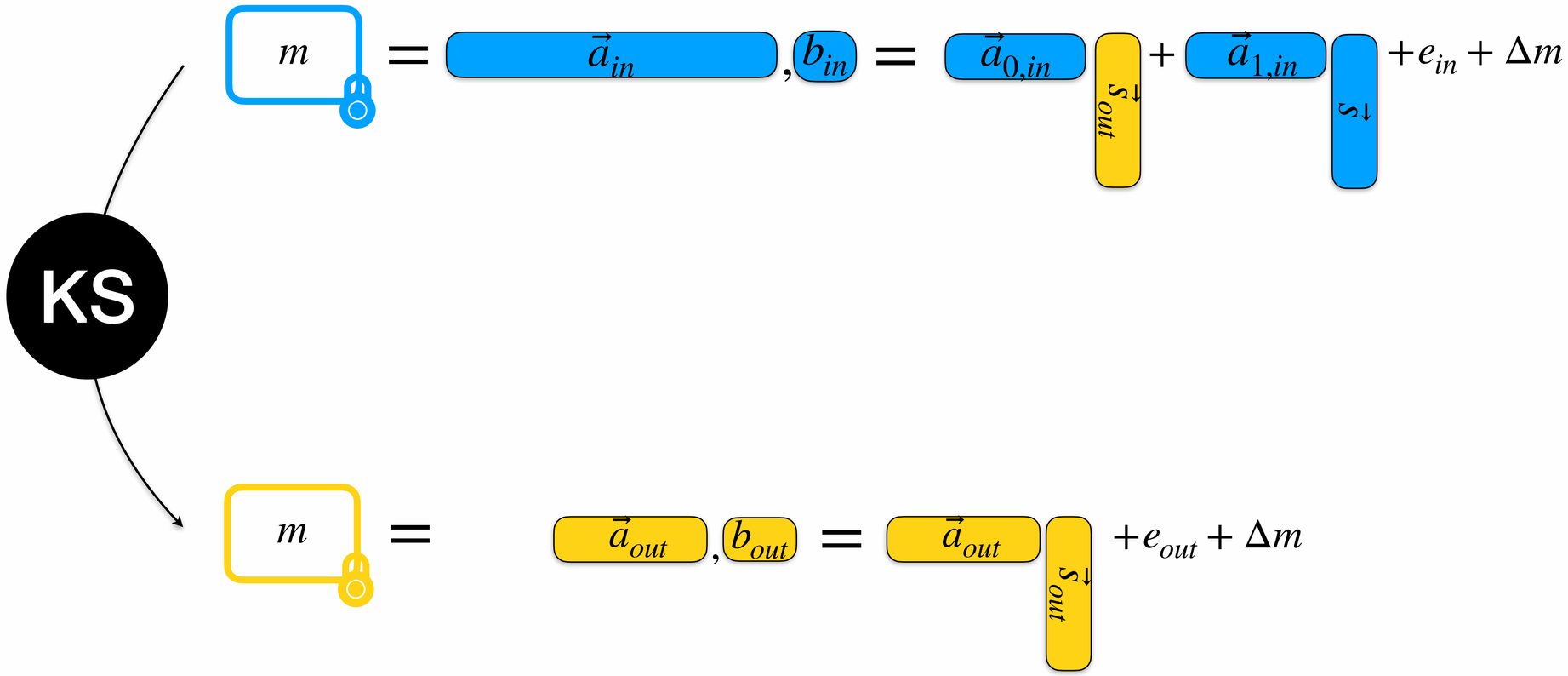
Shared Randomness Secret Keys



Shared Randomness Secret Keys



Shared Randomness Secret Keys



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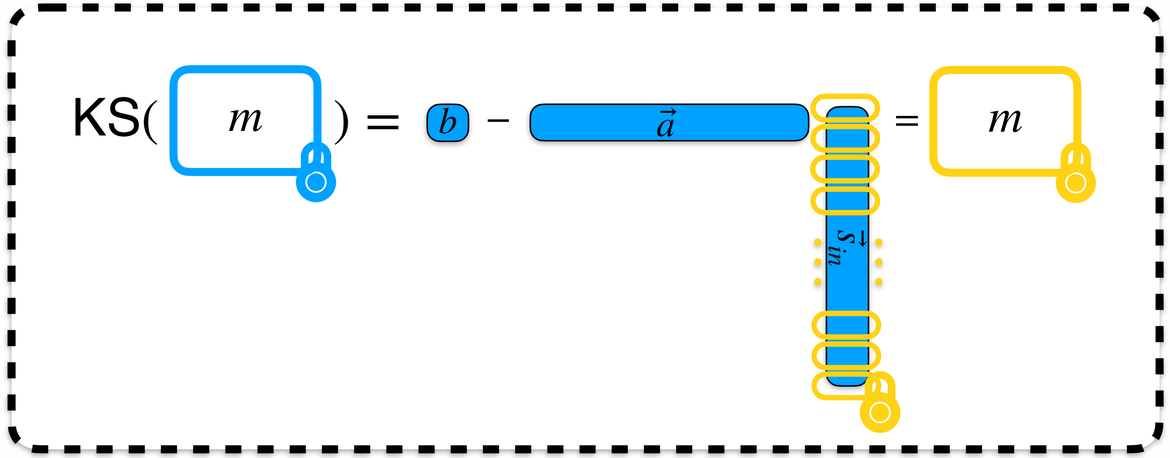

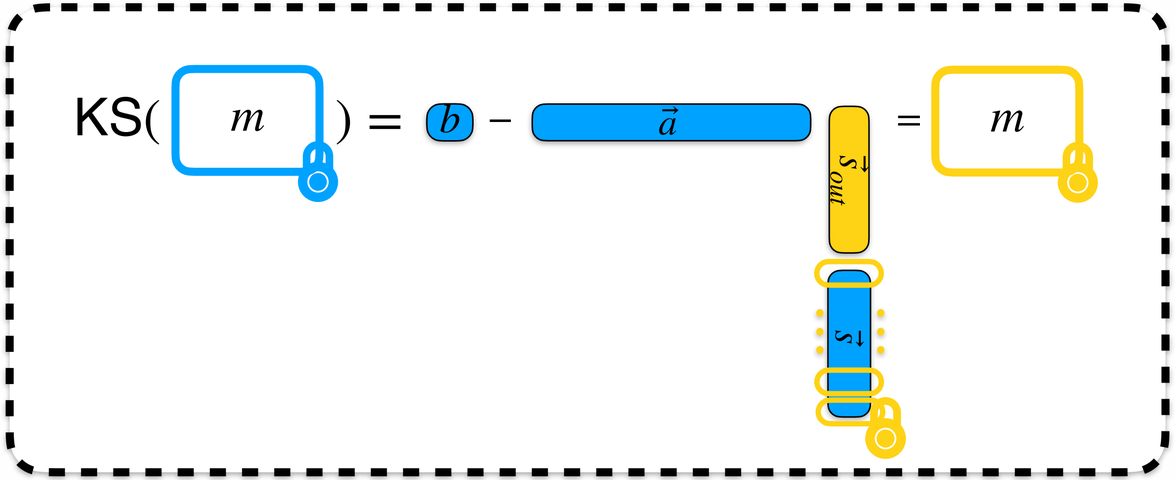

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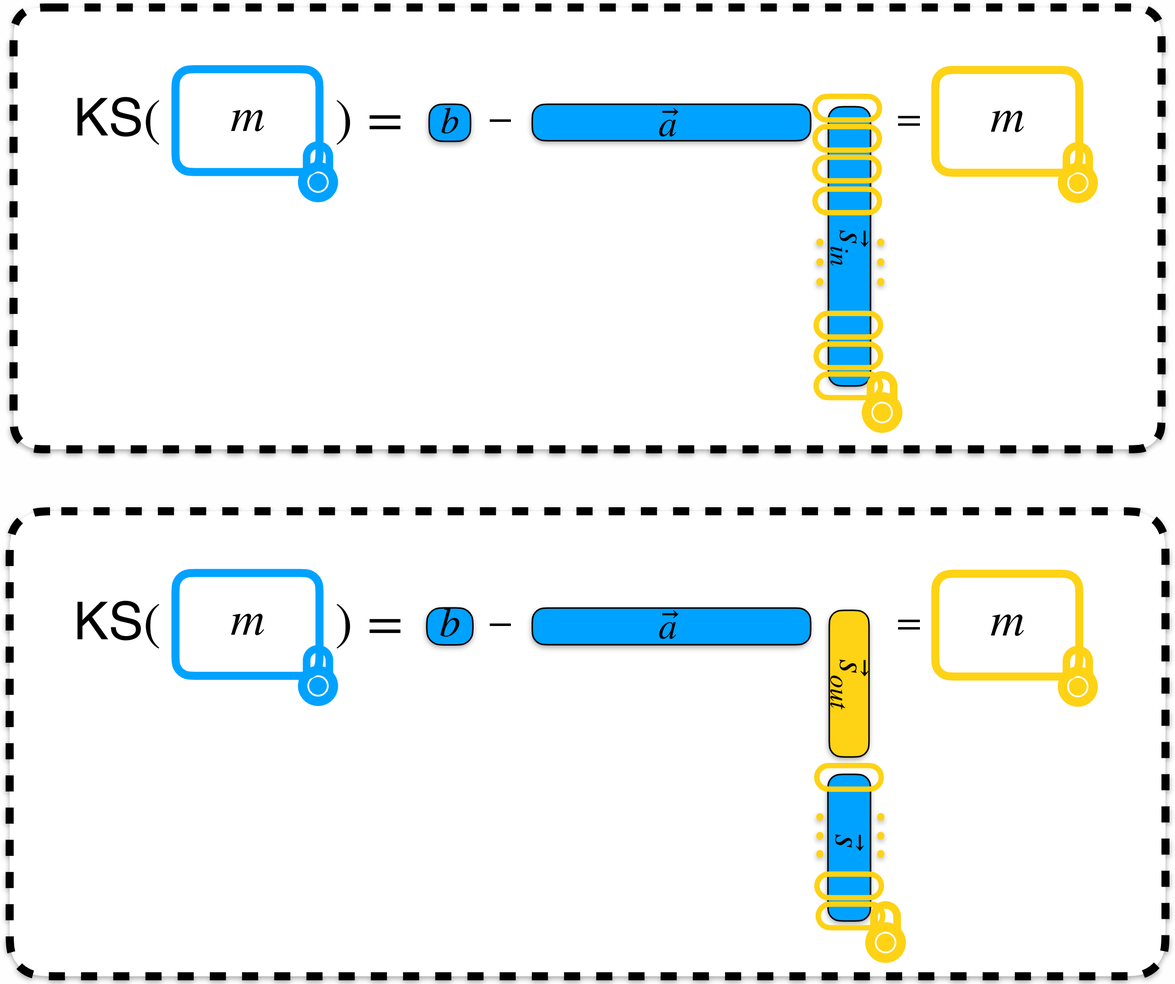

Less computations

Smaller public keys

Less noise

Recap & Generalization

Generalization of the keys to the polynomials (RLWE , GLWE)

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New (G)LWE assumptions and Security

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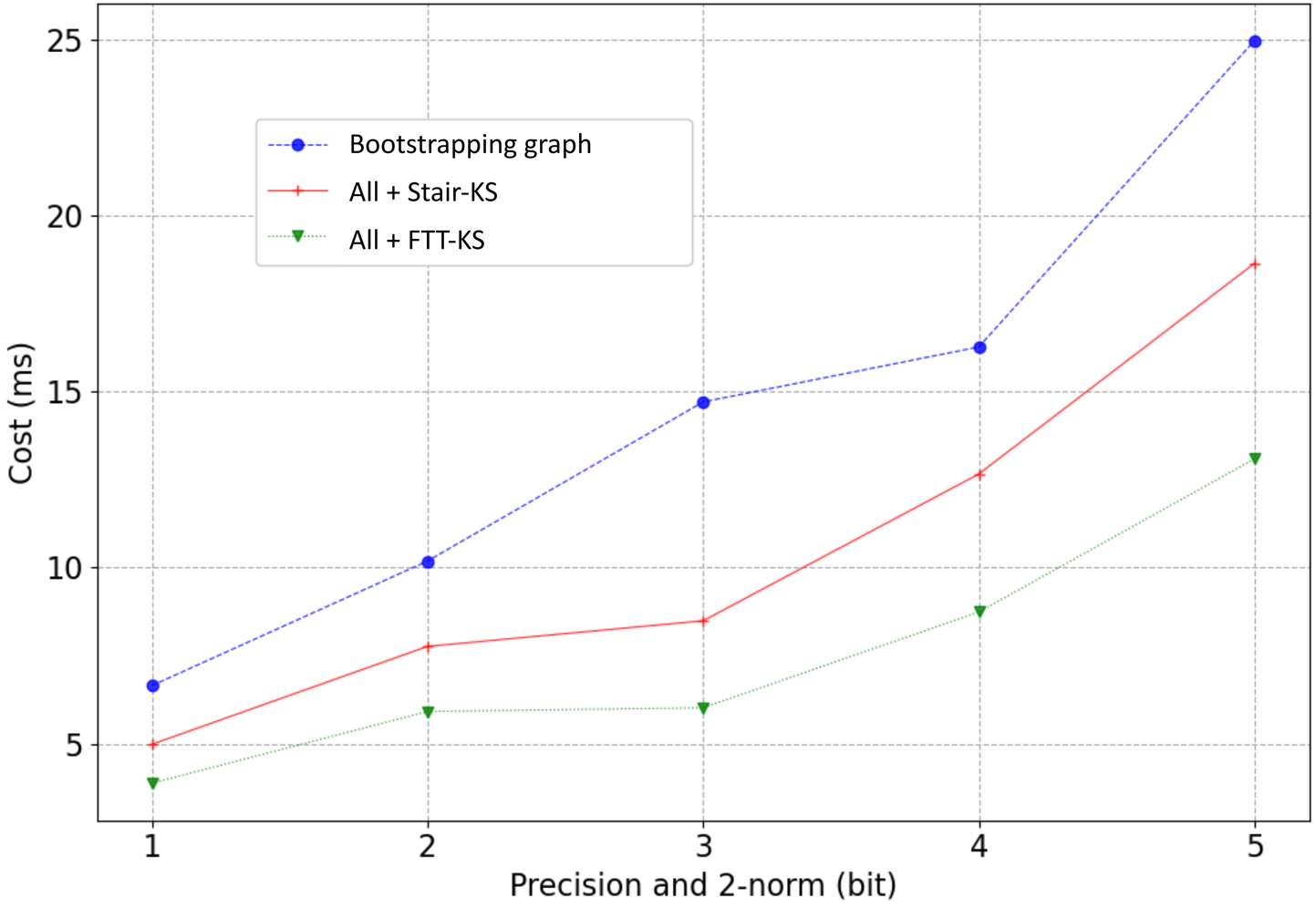
Generalization of the keys to the polynomials (RLWE , GLWE)

New (G)LWE assumptions and Security

Keyswitch with Shared and Partial secret Keys
=> less noise and faster algorithms
=> Bootstrapping graph becomes faster

Practical Results

Results



speed-ups between **1.3** and **2.4**

Conclusion

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Partial Secret Keys

Shared Randomness
Secret keys

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New algorithms

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Security Analysis

Reduction of the size of the public material

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Thank you.

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