TYPE SYSTEM FOR ADAPTIVE DATA ANALYSIS

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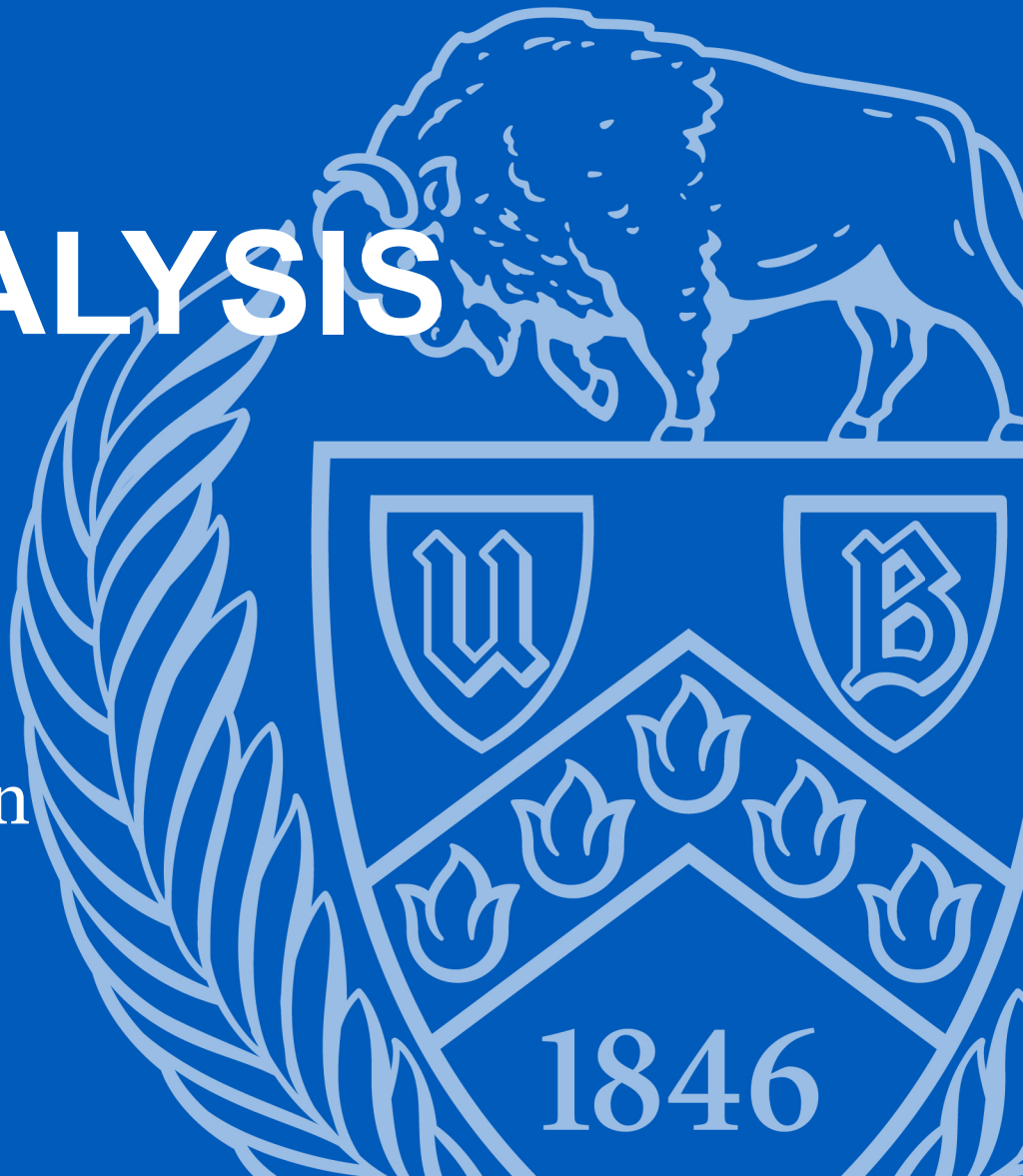
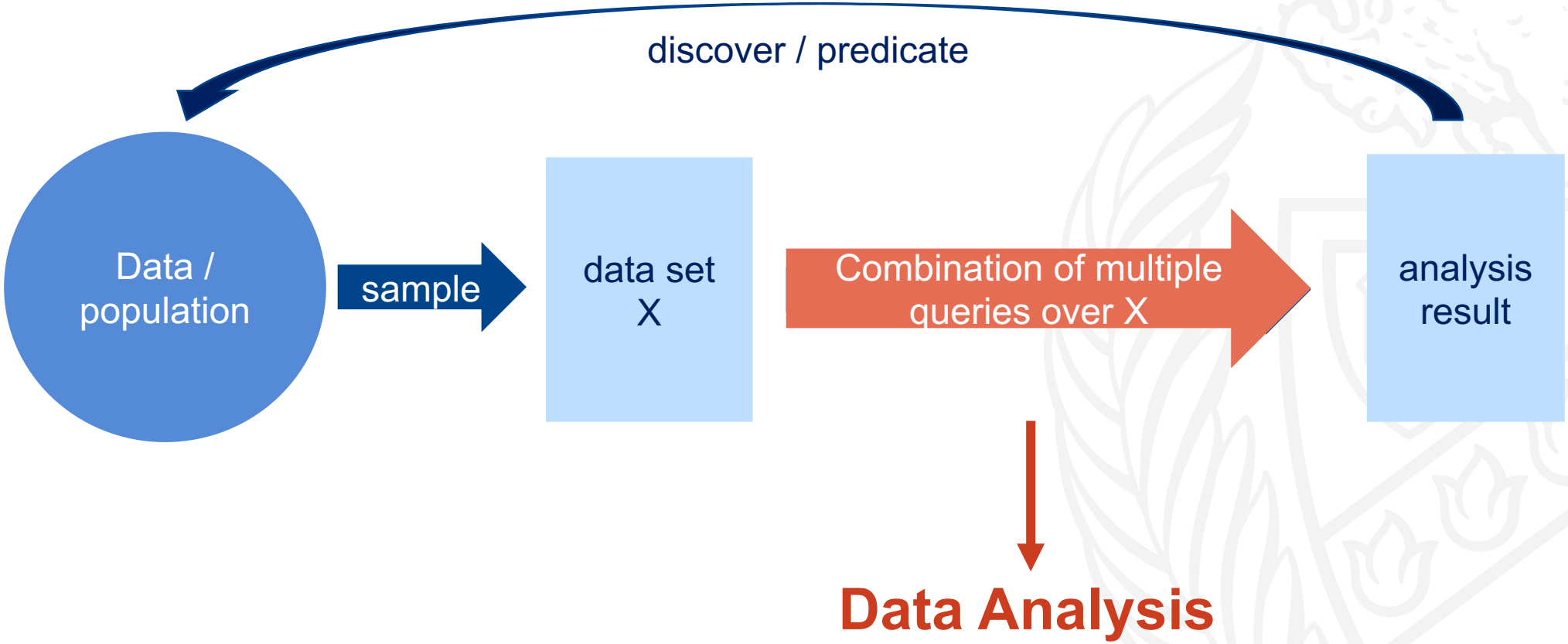
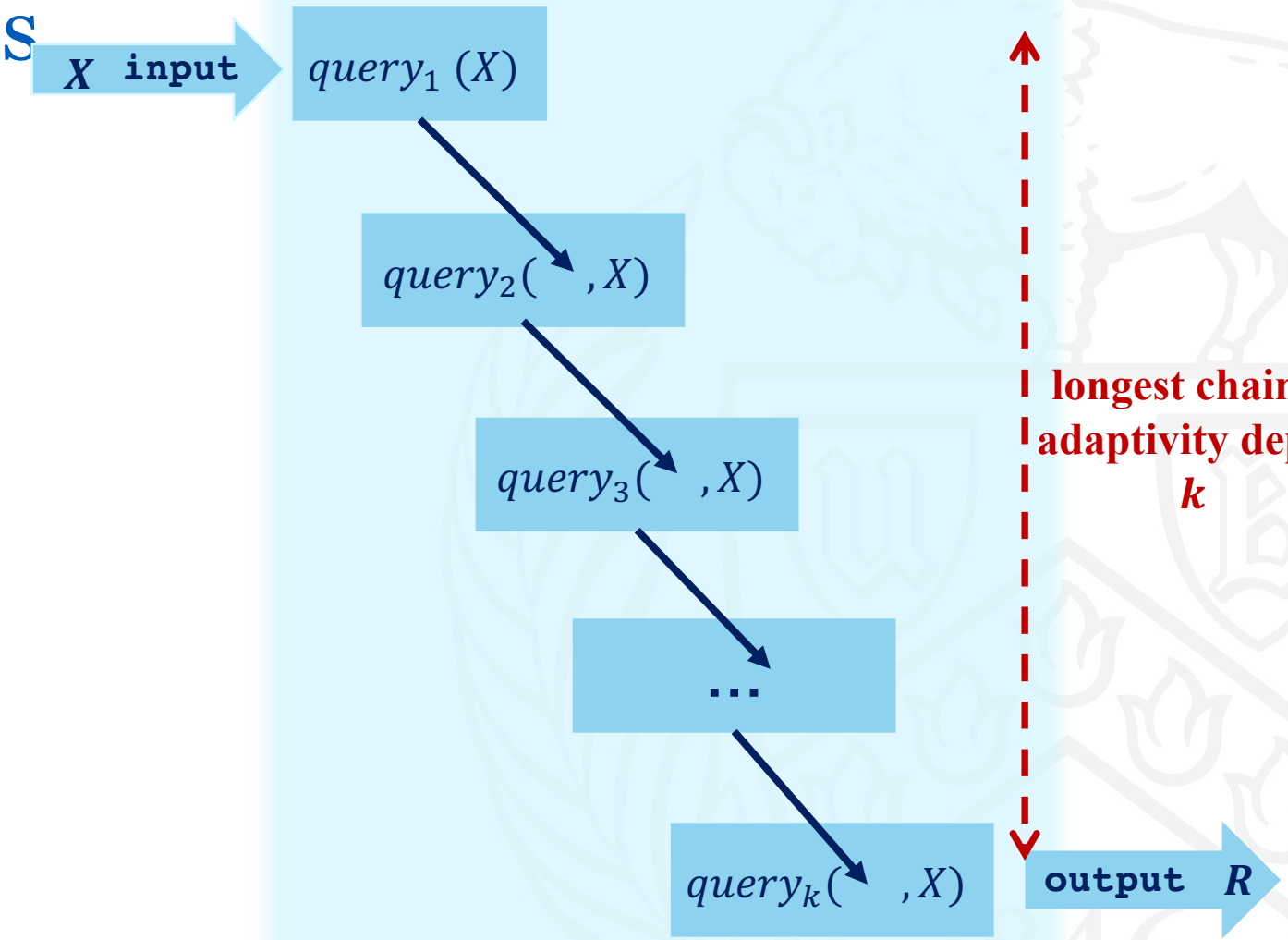


Data Analysis

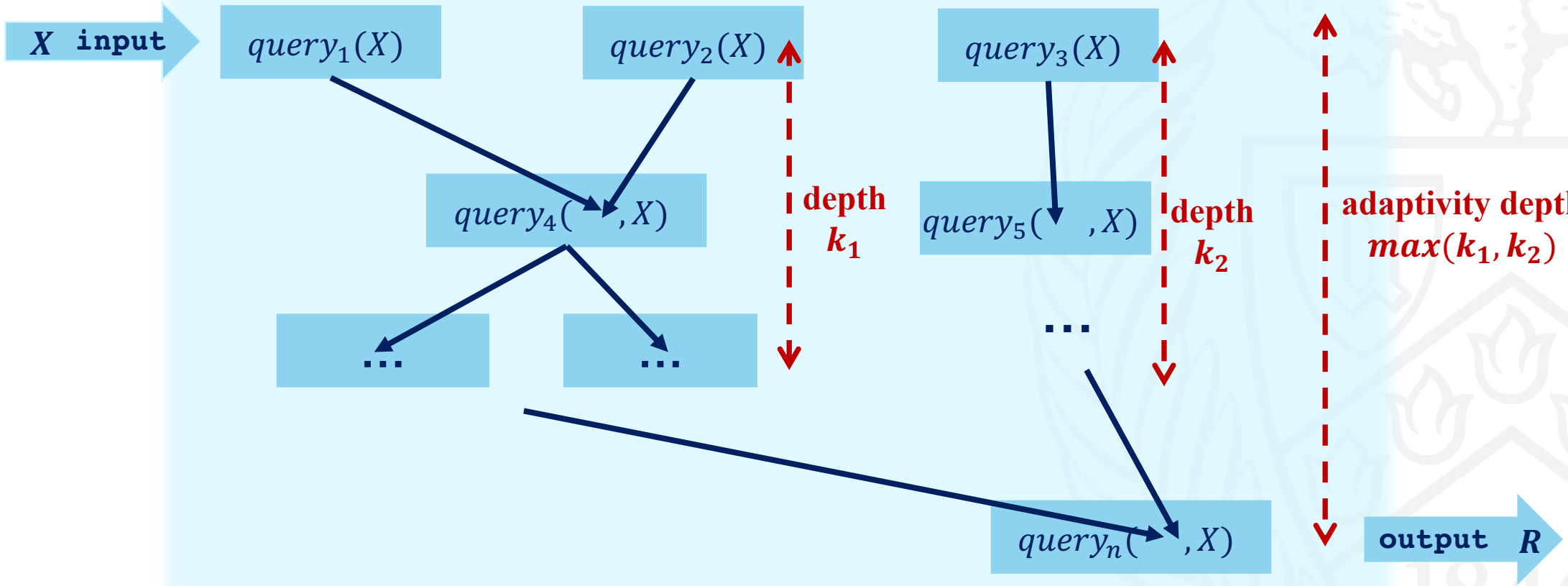


Adaptive Data Analysis

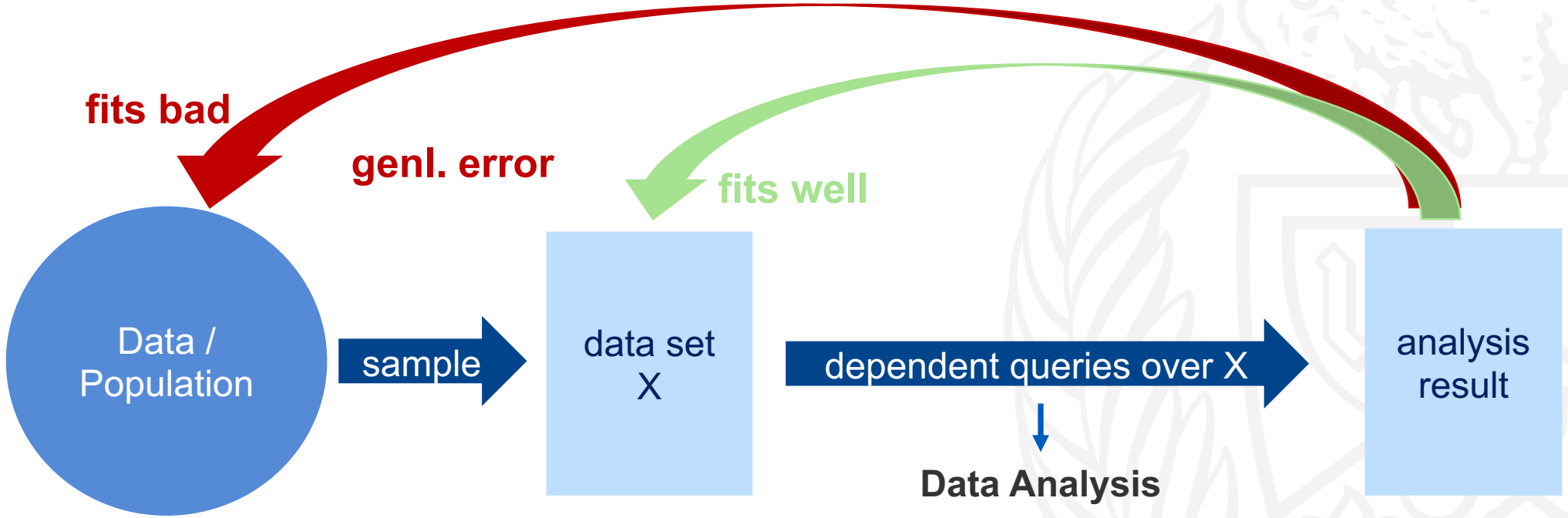
some queries rely on the results of other queries



Adaptive Data Analysis - example



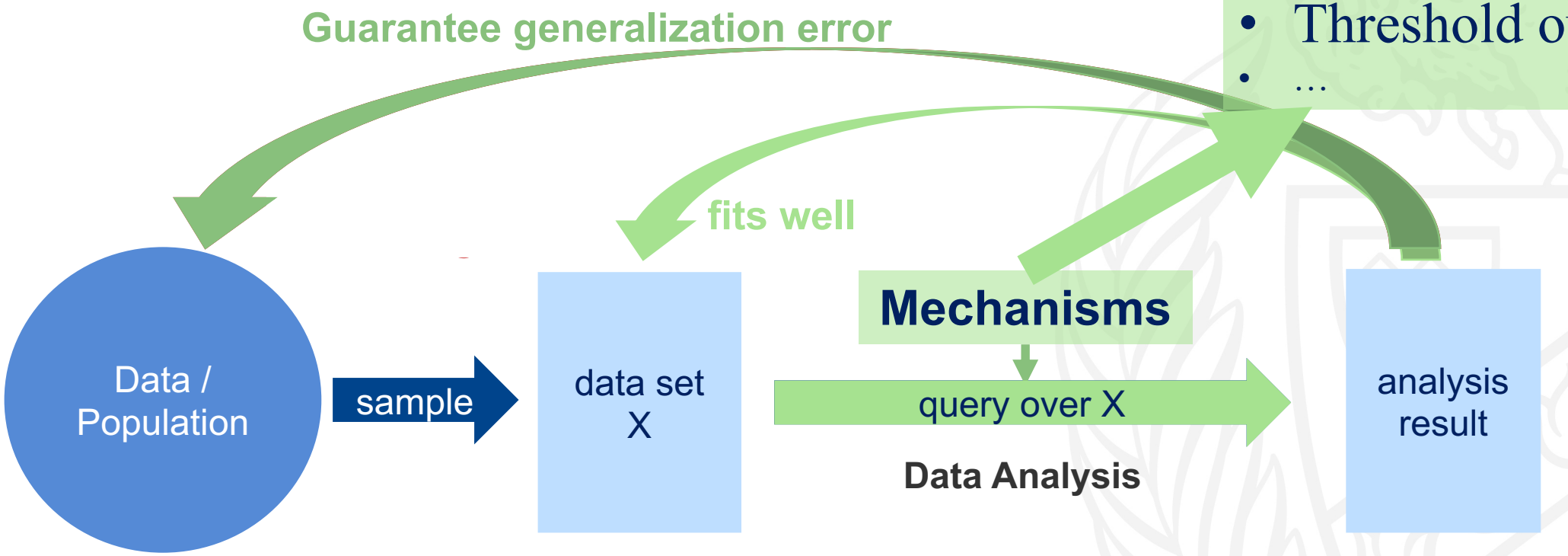
Motivation
– Generalization Error / Overfitting



[Adaptivity in analysis will propagate the overfitting]

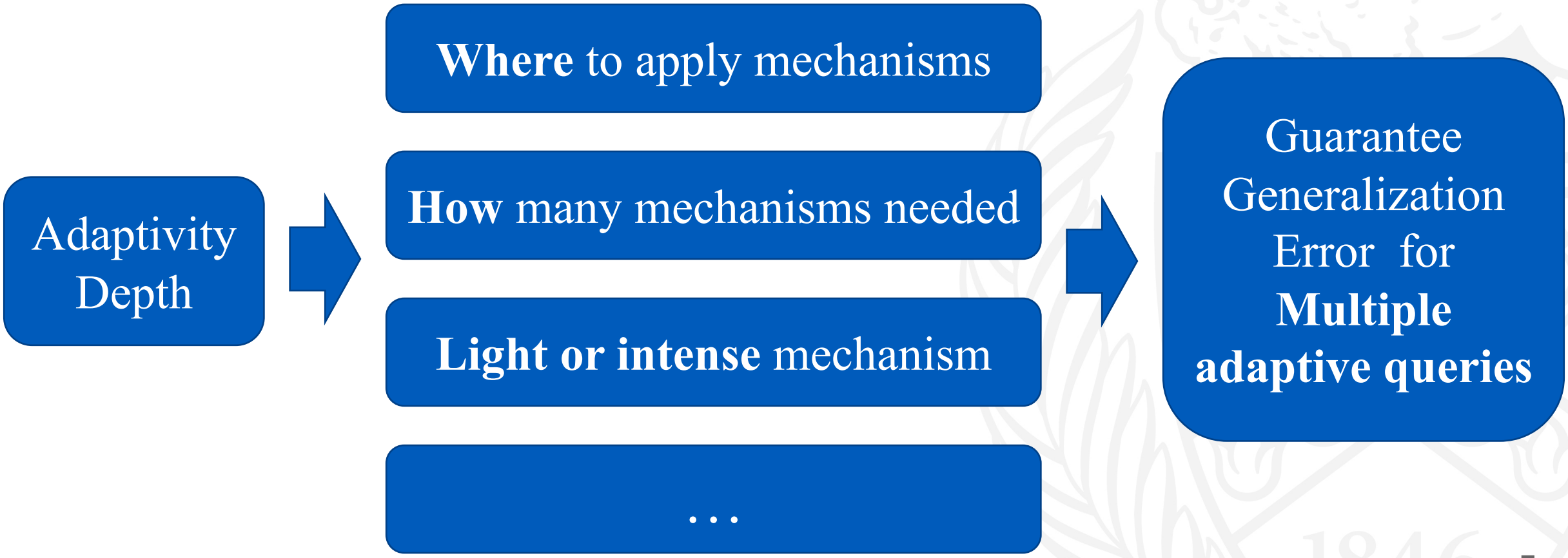
Existing Methods – 1 Query Guarantee

- Gaussian Mechanism
- Laplace Mechanism
- Threshold out
- …



[Guarantee will lose in multiple adaptive queries]

Motivation – Multiple Queries Guarantee

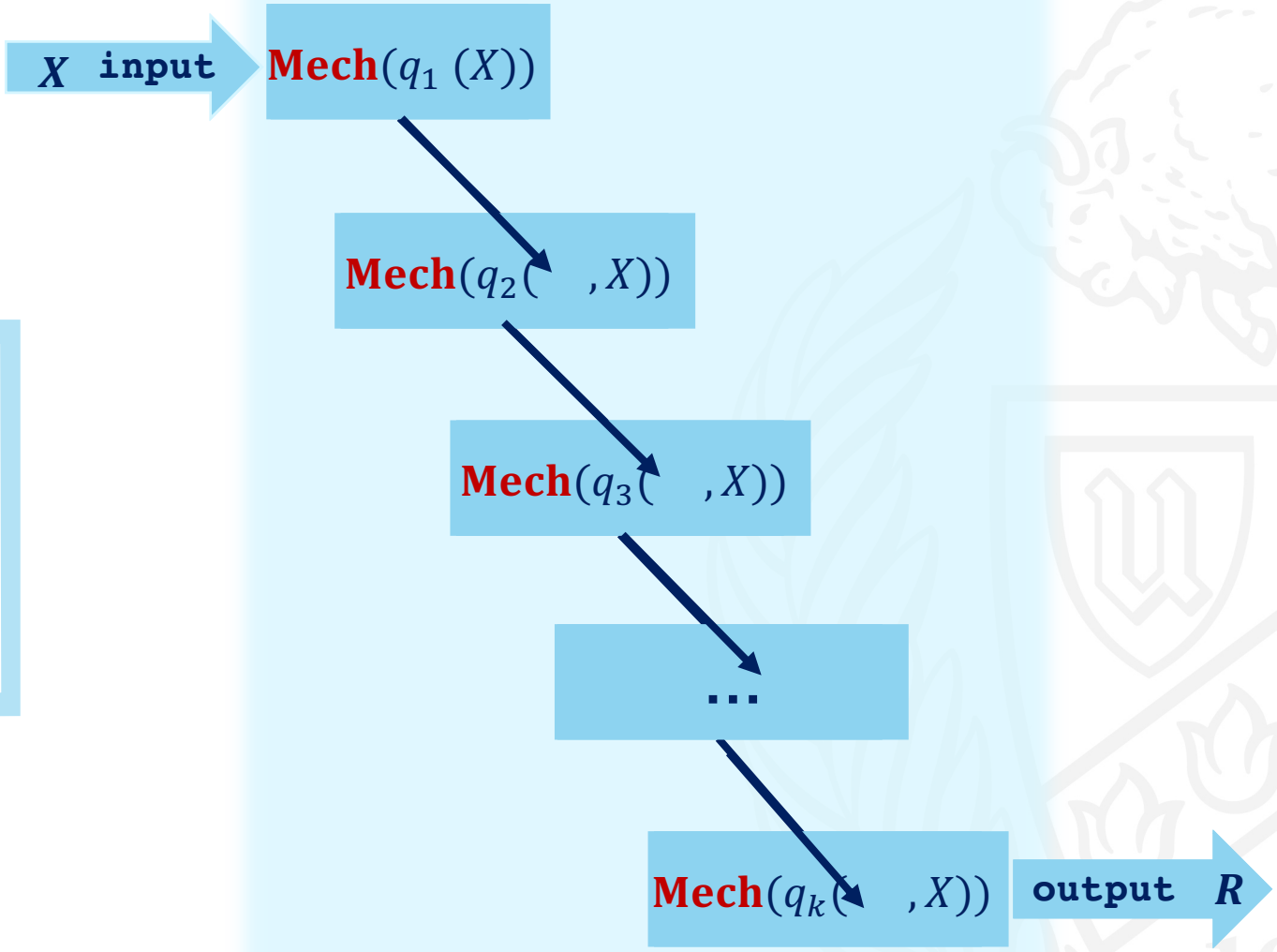


OUR WORK

analyze the *adaptivity depth*
for data analysis program.

Novelty

use mechanism to encapsulate queries and combine them.



Challenges in Language Design

adaptivity depends on the **Runtime Information**

represent the **probabilistic computing**

provide precise **Upper Bound** for adaptivity depth

Refinement Types

singleton type: **int[I]**

representing the run time information

index term: indicate the value of an integer

domain: $\mathbb{N}$

Expressions

$\delta(q)$

represent the mechanism δ applied over a query q

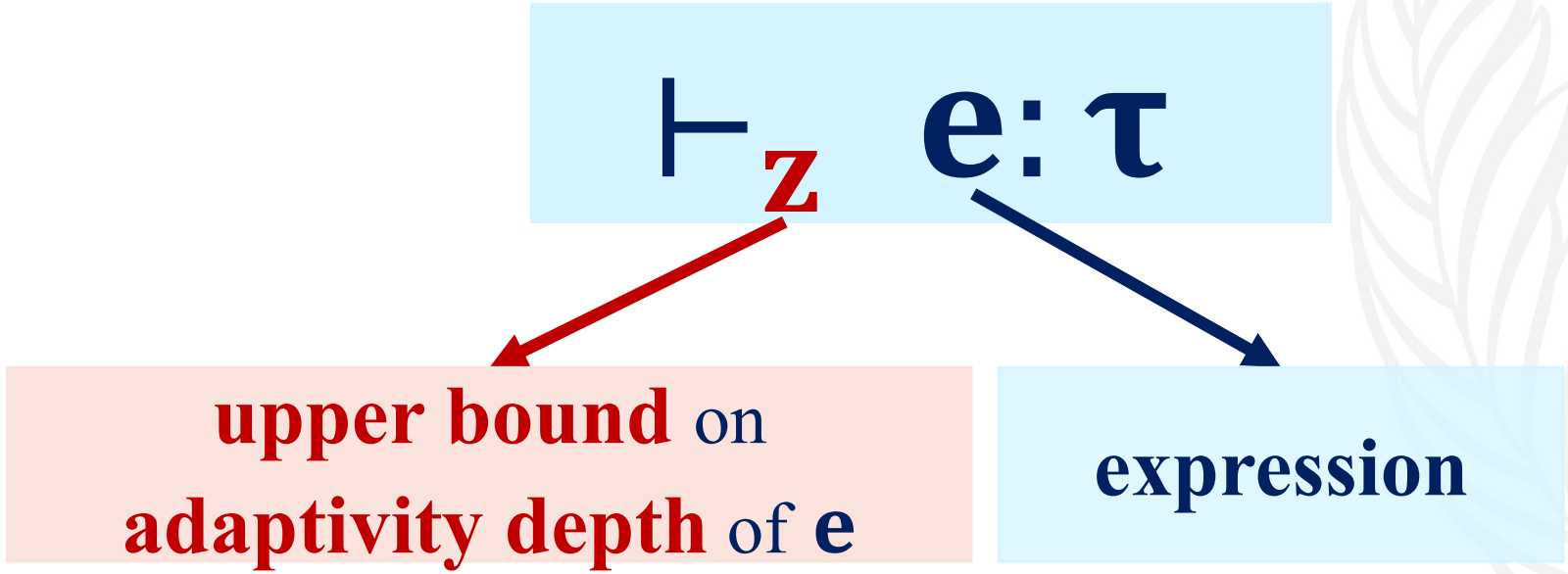
uniform v_1 v_2

parameterized const represents values sampled from distributions

the range $[v_1, v_2]$, where sample from

Typing Judgement

Annotated typing judgement:
approximates an **upper bound** on **adaptivity depth** of expressions



Typing Judgement

Important rule for calculating the adaptivity:

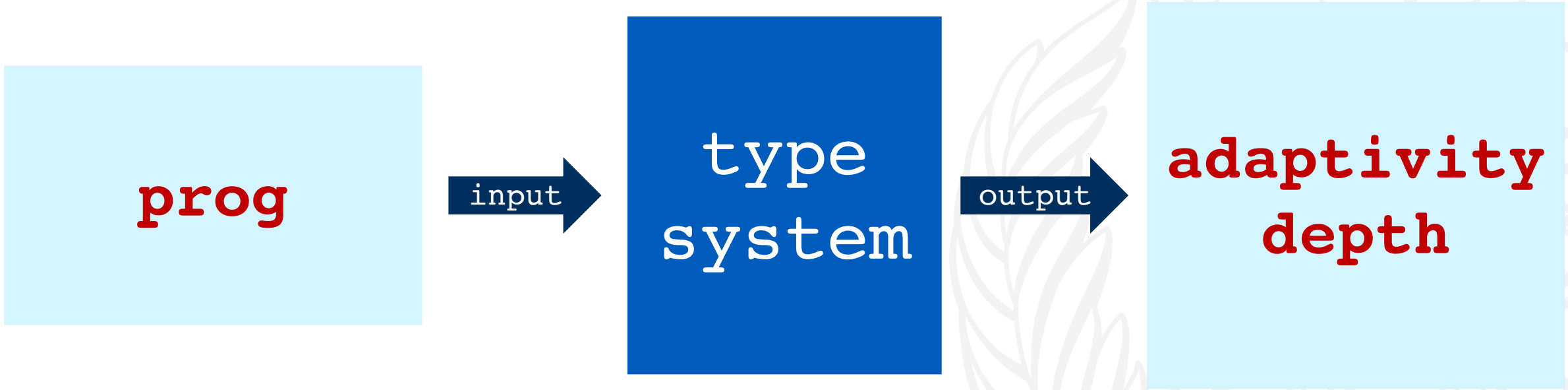
$$\frac{\vdash_{z} q : \tau}{\vdash_{z+1} \delta(q) : \tau}$$

Soundness

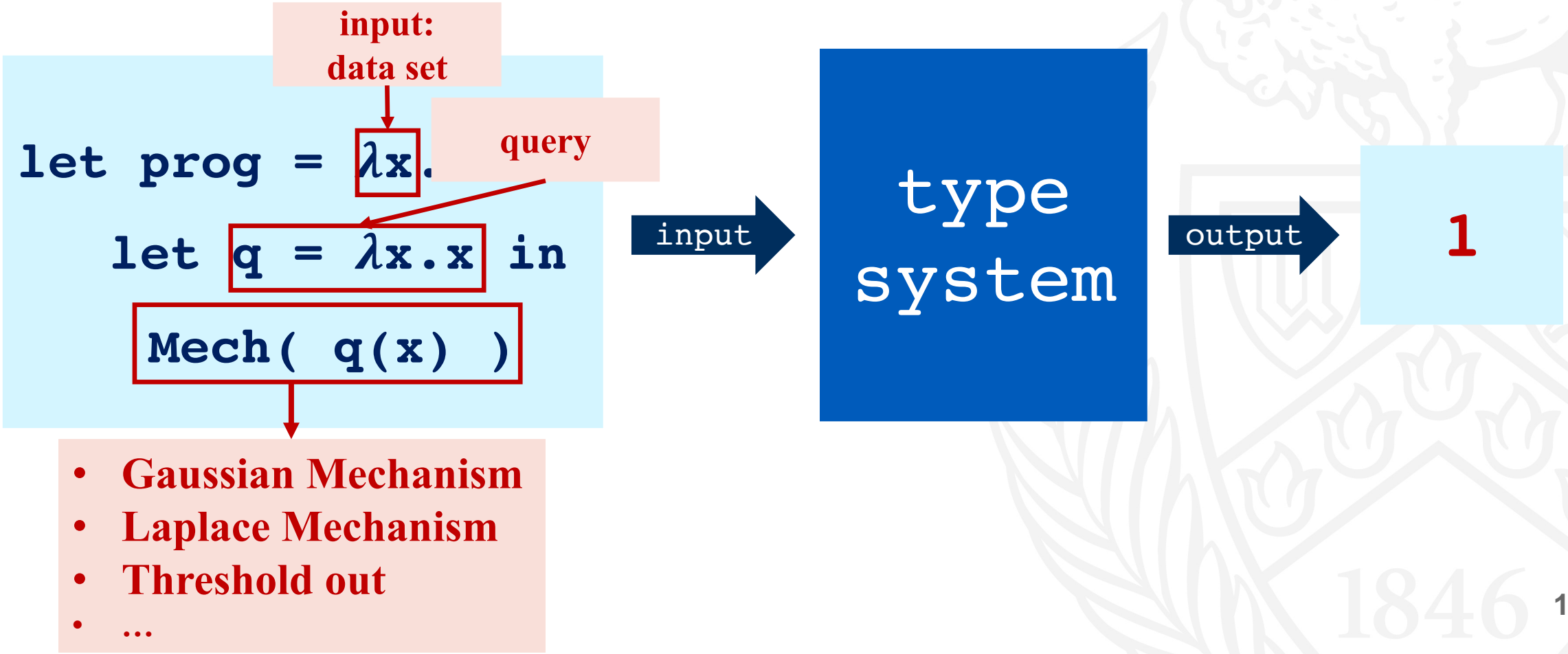
step-indexed logical relations → $[\![\tau]\!]_v$ $[\![\tau]\!]_e^Z$

fundamental theorem → if $\vdash_z e : \tau$ then $e \in [\![\tau]\!]_e^Z$

System Overview



System Overview – Simple Example



THANKS