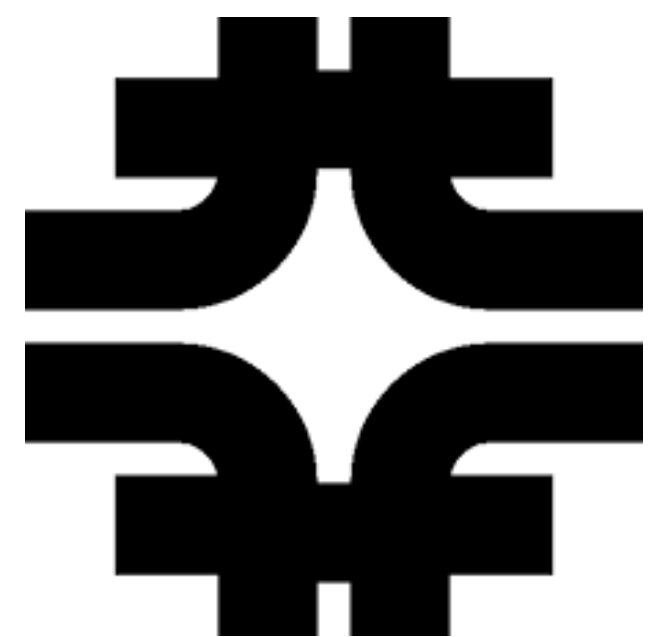# Fast ML to accelerate scientific discovery & the edge of tomorrow

Nhan Tran, Fermilab
March 6, 2024

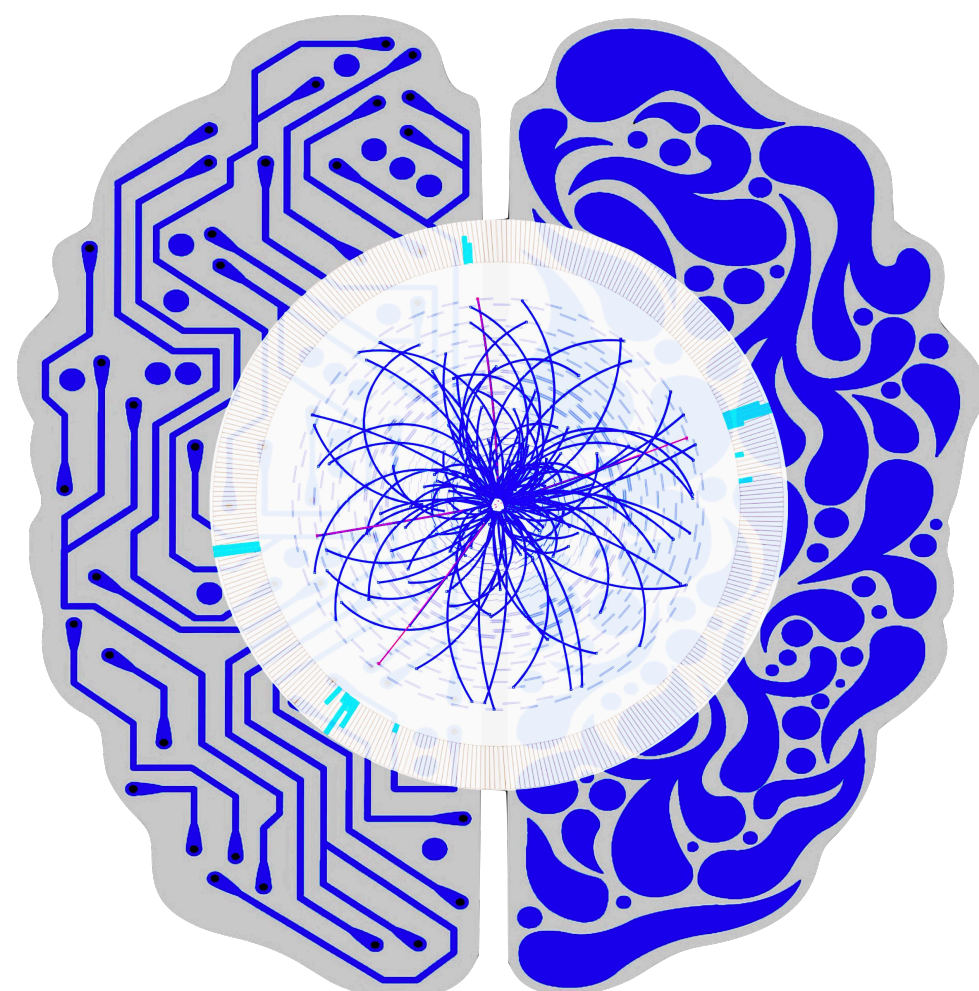# Jumping off point

Fast ML 2023 workshop (4th edition)
https://indico.cern.ch/e/fastml2023

Fast ML @ ICCAD (1st edition)
https://fastmachinelearning.org/iccad2023/

https://fastmachinelearning.org

https://a3d3.ai/

Scientific domain applications

Compute elements & systems

Science data pipelines

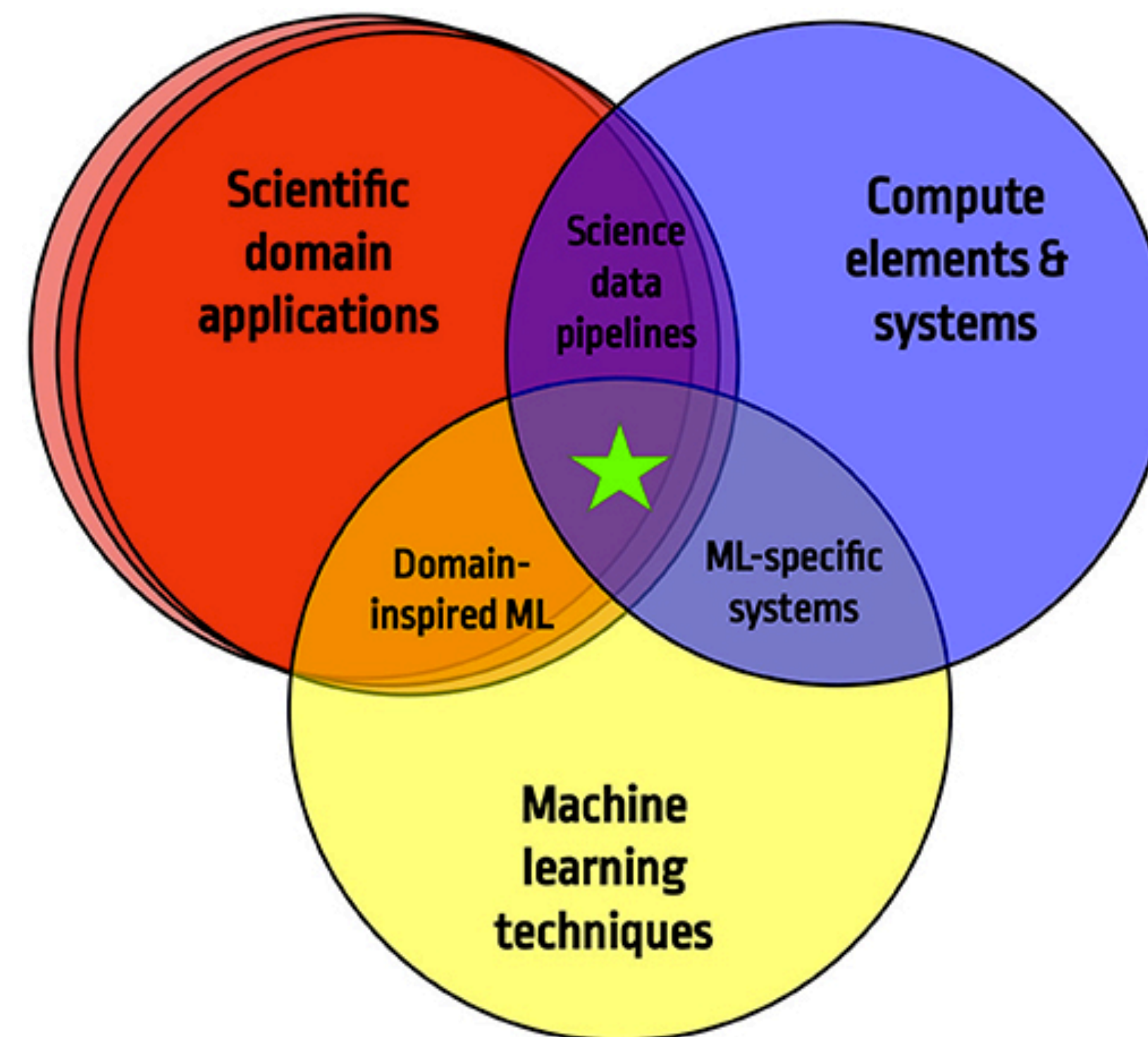Domain-inspired ML

ML-specific systems

Machine learning techniques

Applications and Techniques in
Fast Machine Learning for Science
https://www.frontiersin.org/articles/10.3389/fdata.2022.787421/full

Thea Aarrestad

Large Hadron Collider

Geneva

Geneva Lake

CMS

LHCb

ATLAS

ALICE
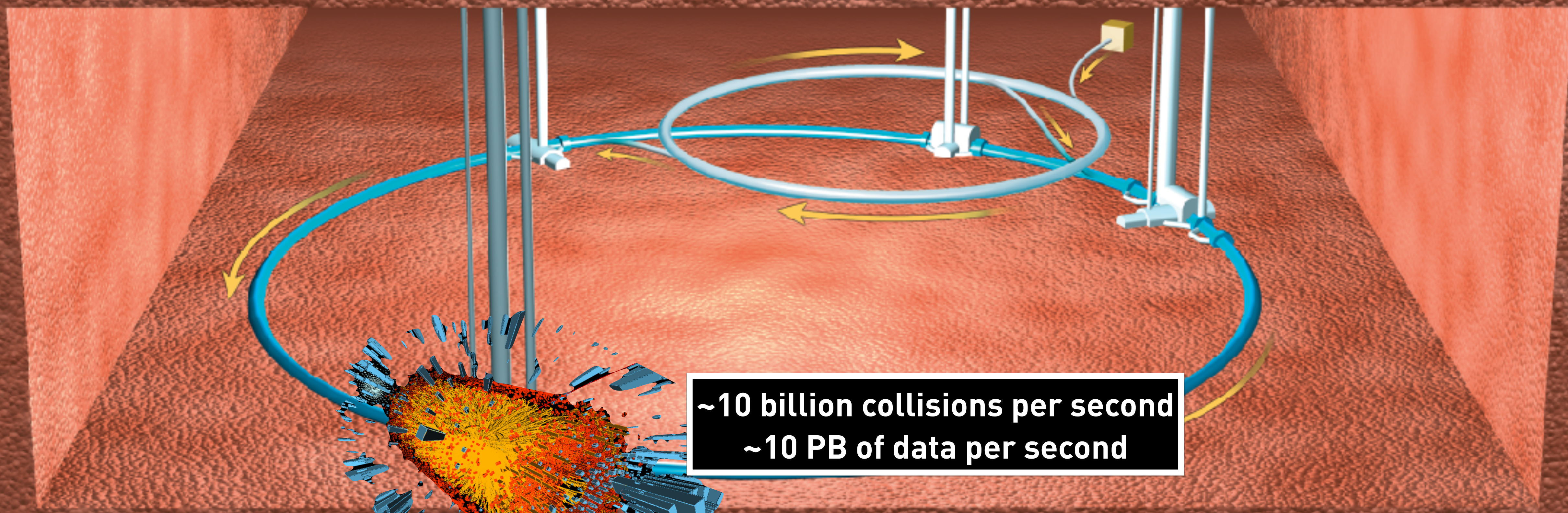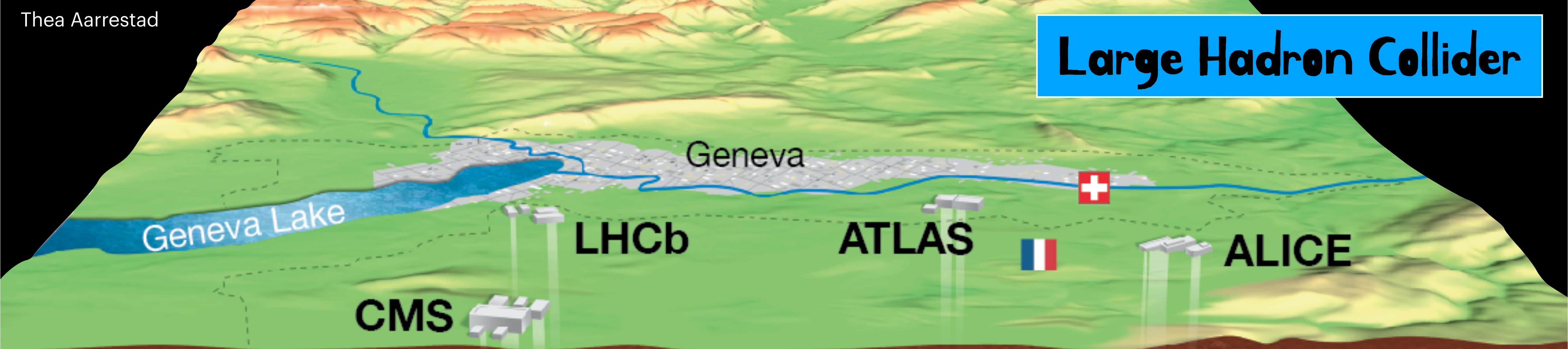
~10 billion collisions per second
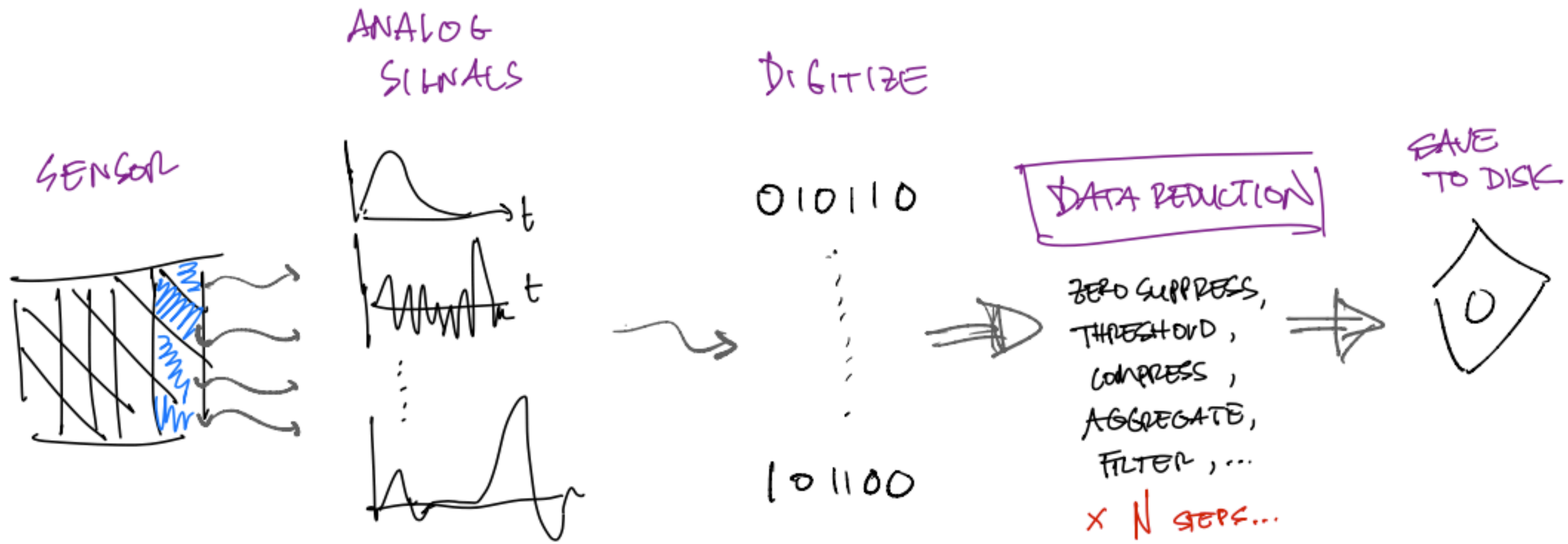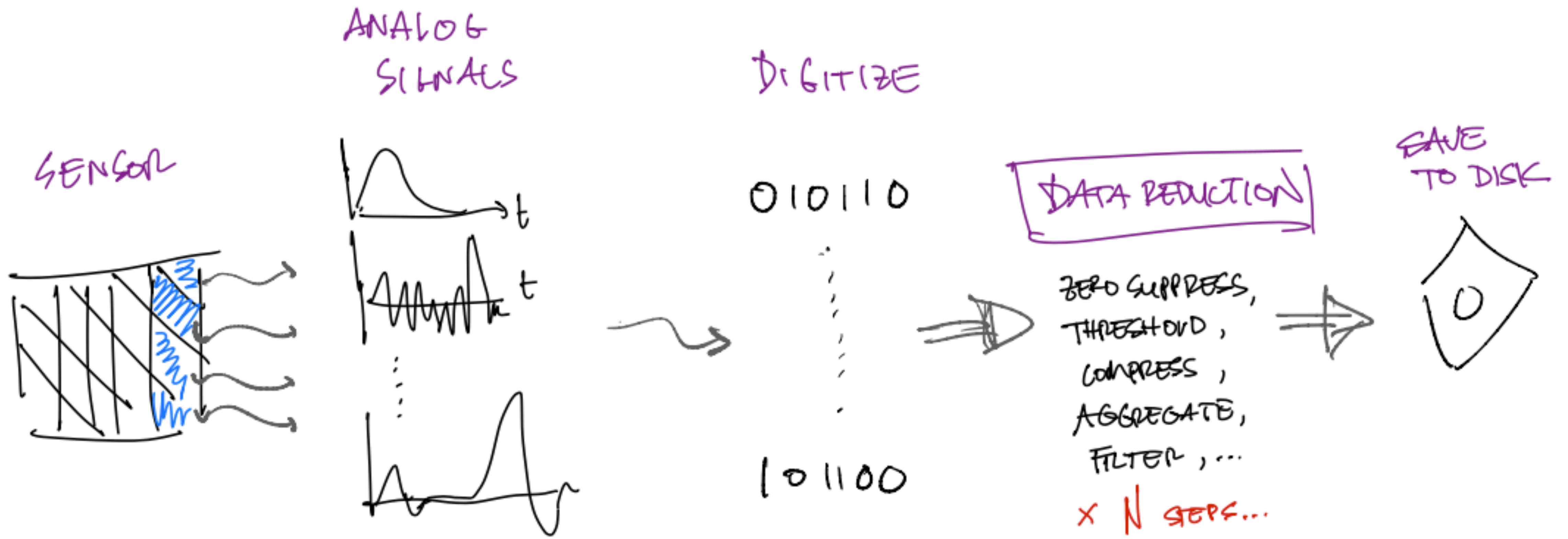~10 PB of data per second

3

Fast ML for Science

"

Scientific discoveries come from groundbreaking ideas and the capability to validate those ideas by testing nature at new scales—finer and more precise temporal and spatial resolution. This is leading to an explosion of data that must be interpreted, and ML is proving a powerful approach. The more efficiently we can test our hypotheses, the faster we can achieve discovery. To fully unleash the power of ML and accelerate discoveries, it is necessary to embed it into our scientific process, into our instruments and detectors.
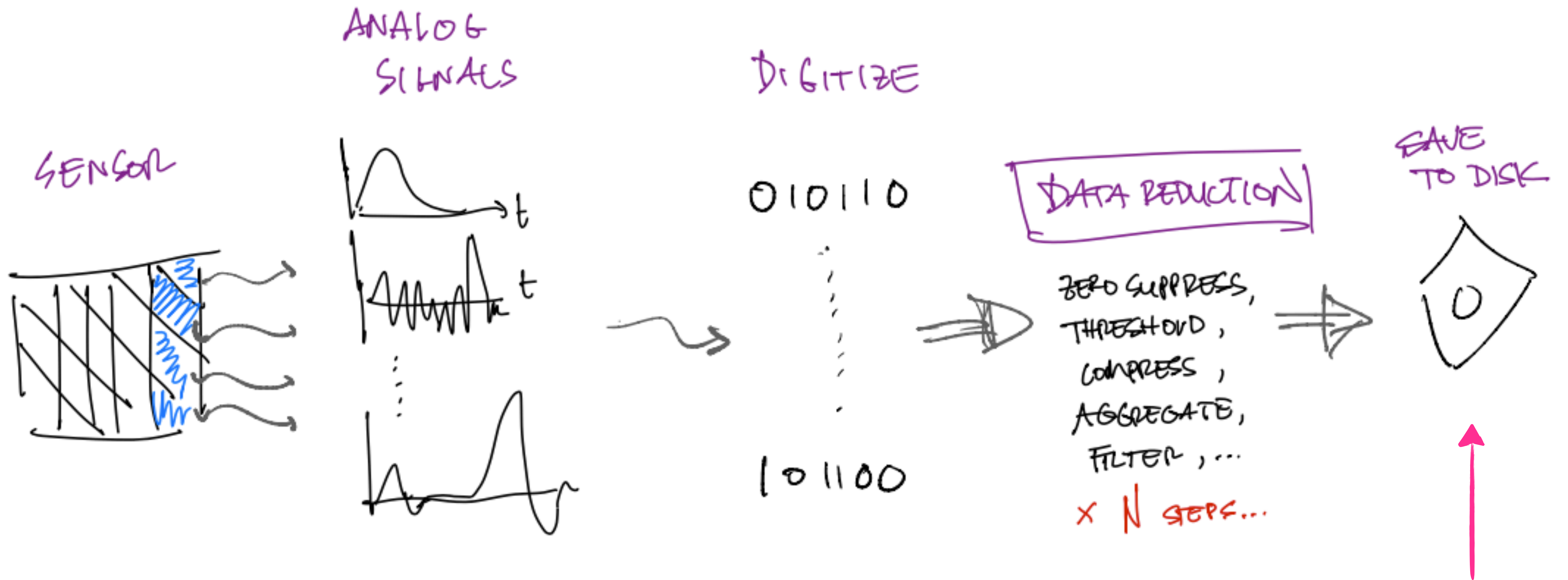
"

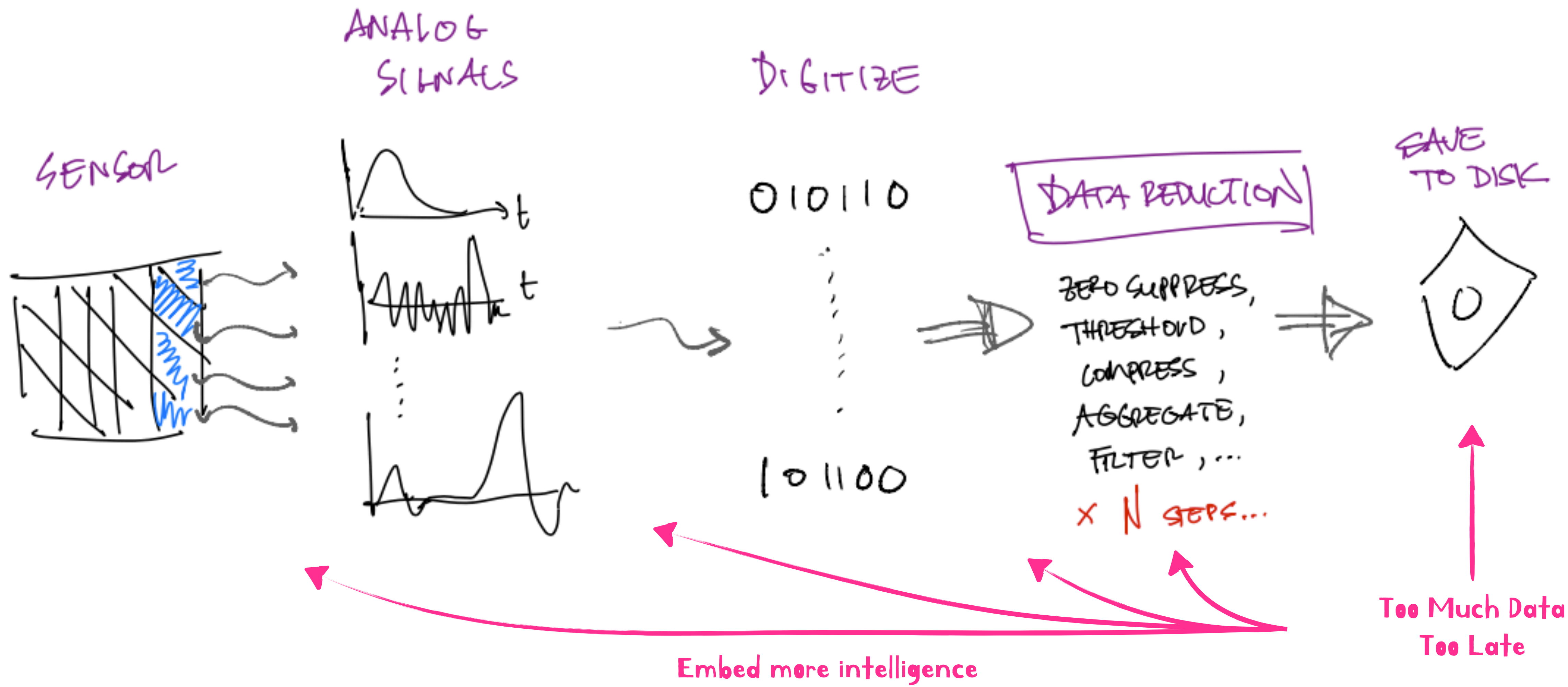Applications and Techniques for Fast Machine Learning in Science

SENSOR

ANALOG SIGNALS

DIGITIZE

010110

101100

DATA REDUCTION

ZERO SUPPRESS,
THRESHOLD,
COMPRESS,
AGGREGATE,
FILTER, ...
× N STEPS...

SAVE TO DISK

5

SENSOR

ANALOG SIGNALS

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010110

101100

DATA REDUCTION

ZERO SUPPRESS,
THRESHOLD,
COMPRESS,
AGGREGATE,
FILTER, ...

× N STEPS...

SAVE TO DISK

1 channel ~ 10b
1 channel, 1 MHz rate ~ 10 Mb/s
100k channels, 1 MHz rate ~ 1 Tb/s

5

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SAVE TO DISK

Too Much Data Too Late

1 channel ~ 10b
1 channel, 1 MHz rate ~ 10 Mb/s
100k channels, 1 MHz rate ~ 1 Tb/s

SENSOR

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DIGITIZE

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DATA REDUCTION

ZERO SUPPRESS, THRESHOLD, COMPRESS, AGGREGATE, FILTER, ...

× N STEPS...

SAVE TO DISK

Too Much Data Too Late

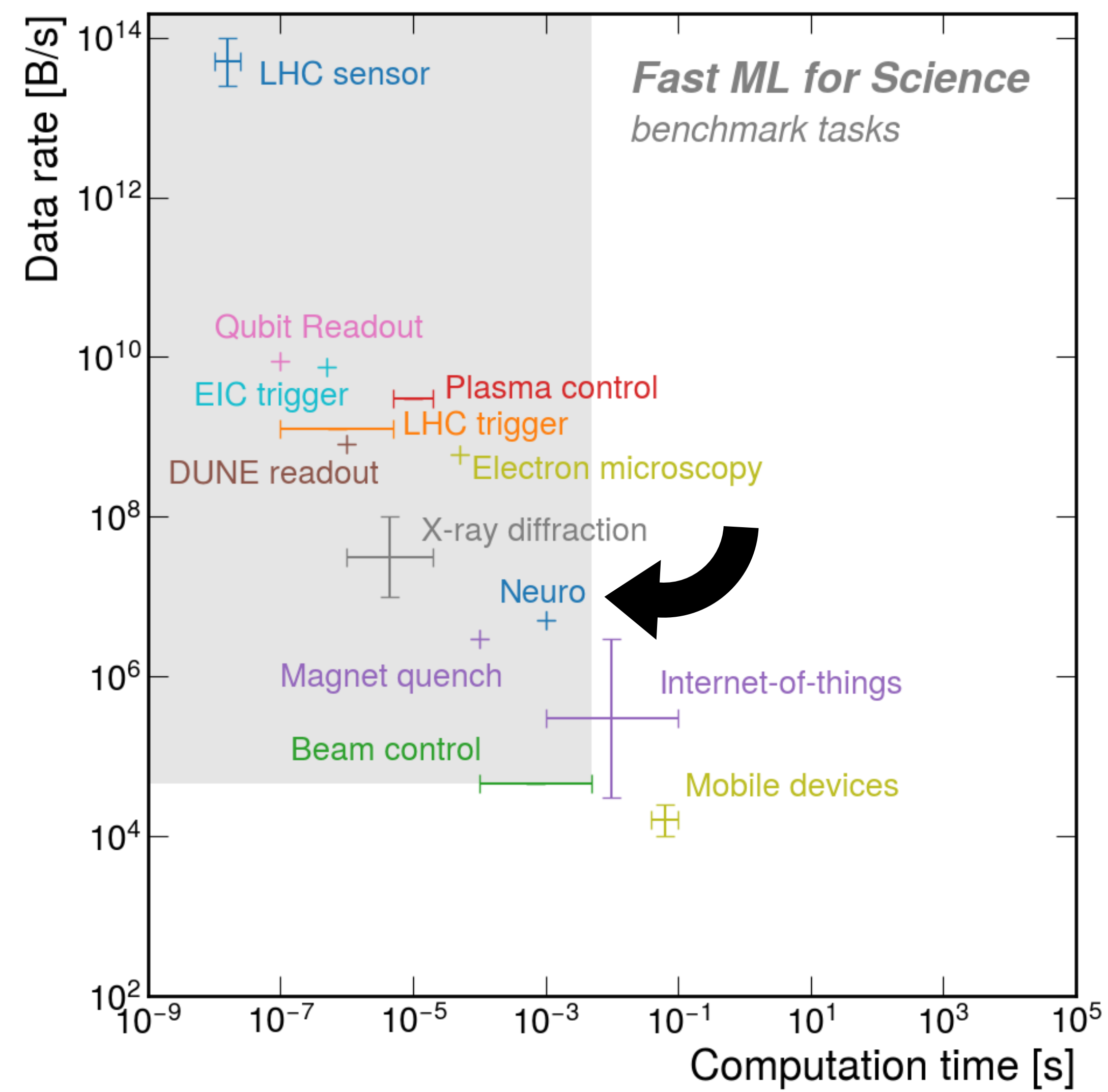Embed more intelligence

5

Fast ML for Science

Benchmarks bring innovation,
Grand challenges spark imaginations!
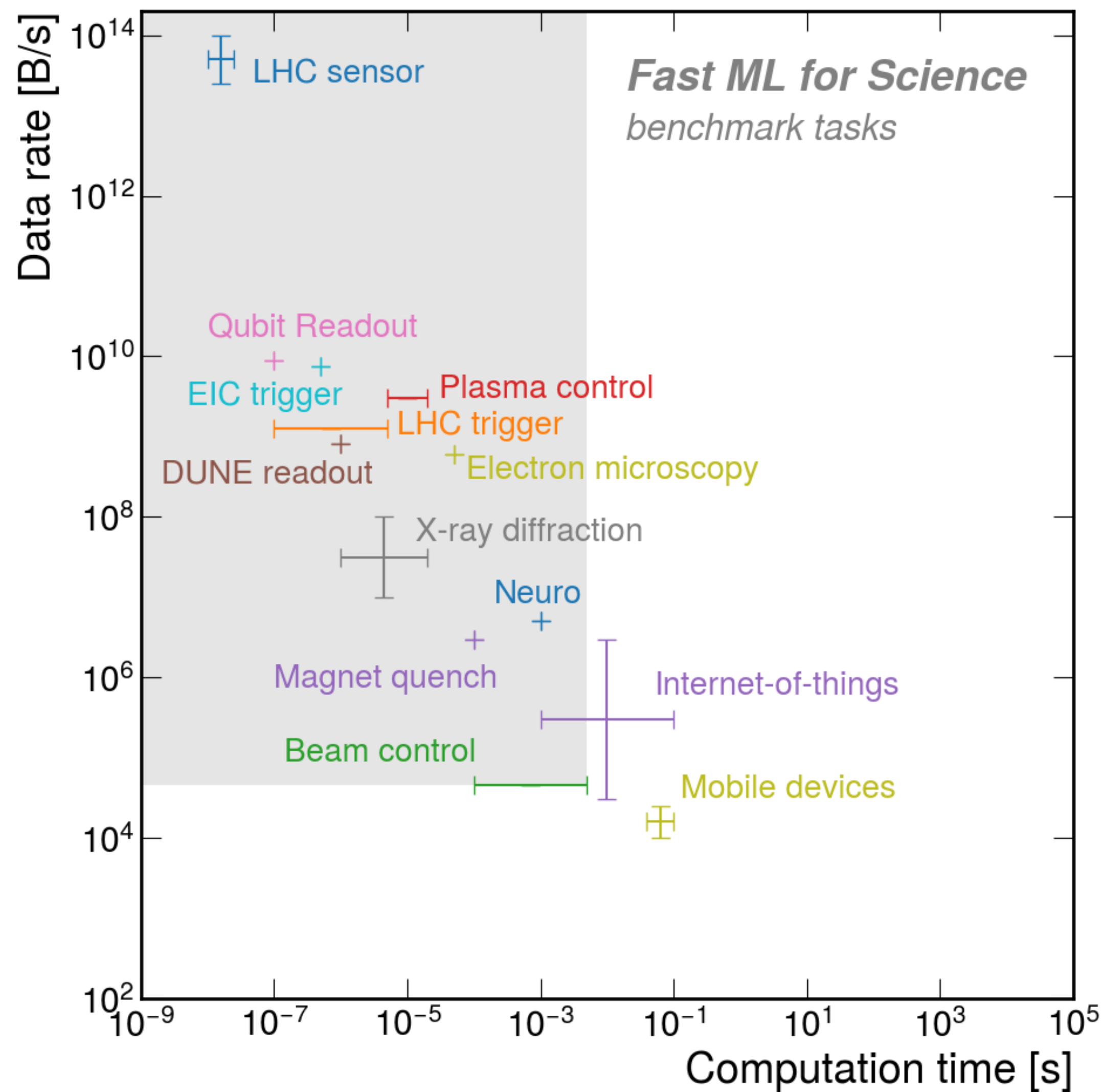
Fast ML for Science

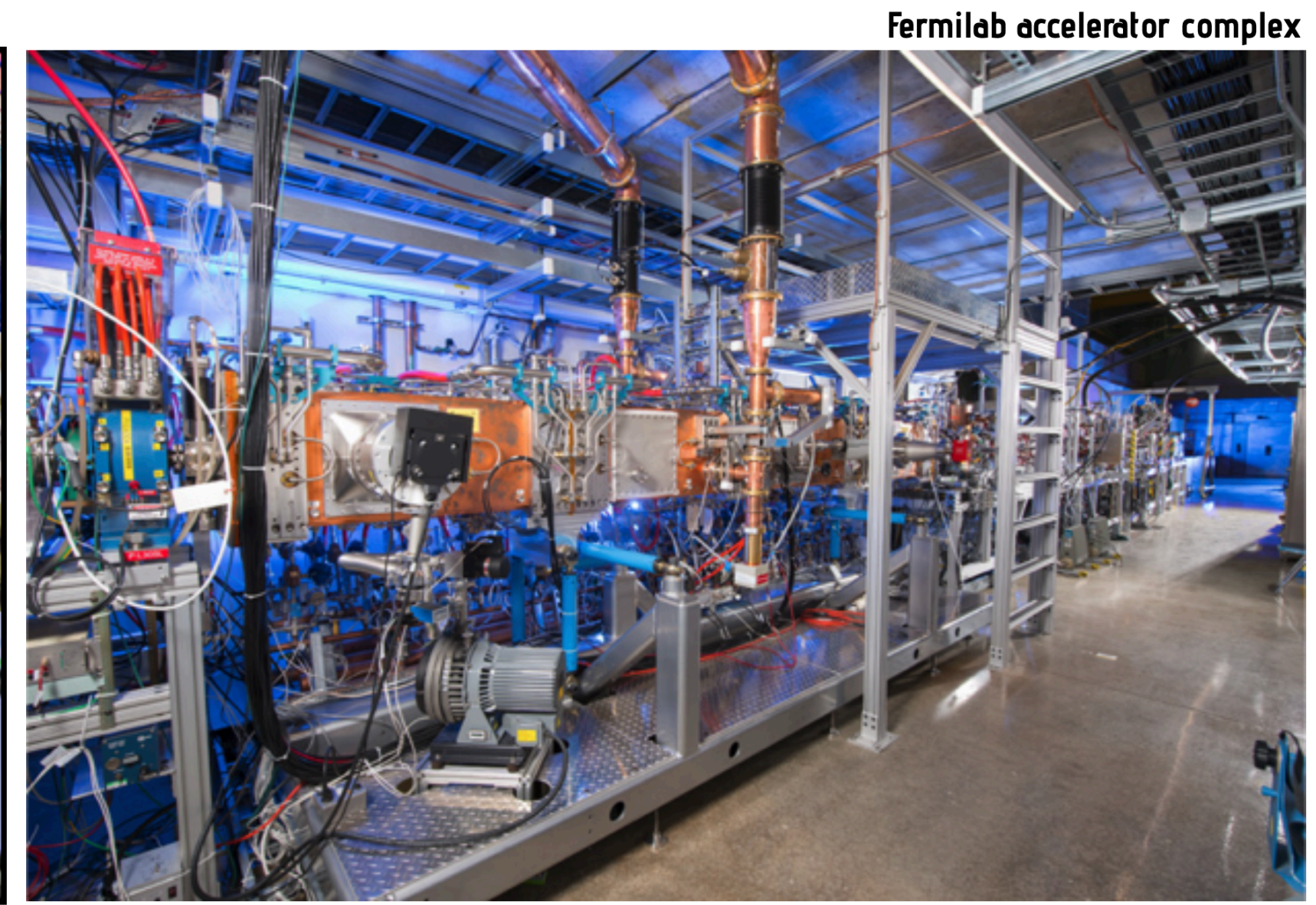Benchmarks bring innovation,
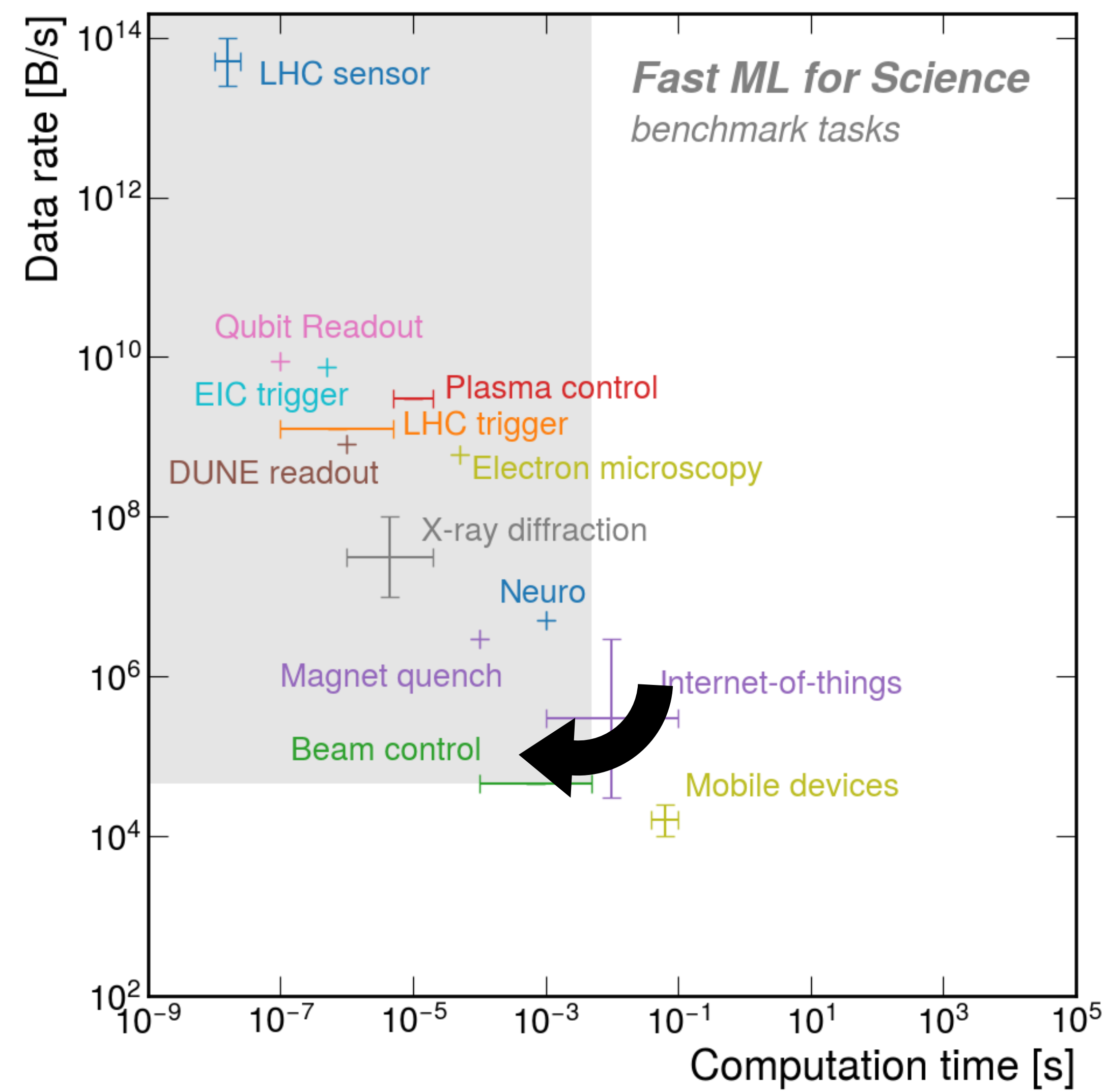Grand challenges spark imaginations!
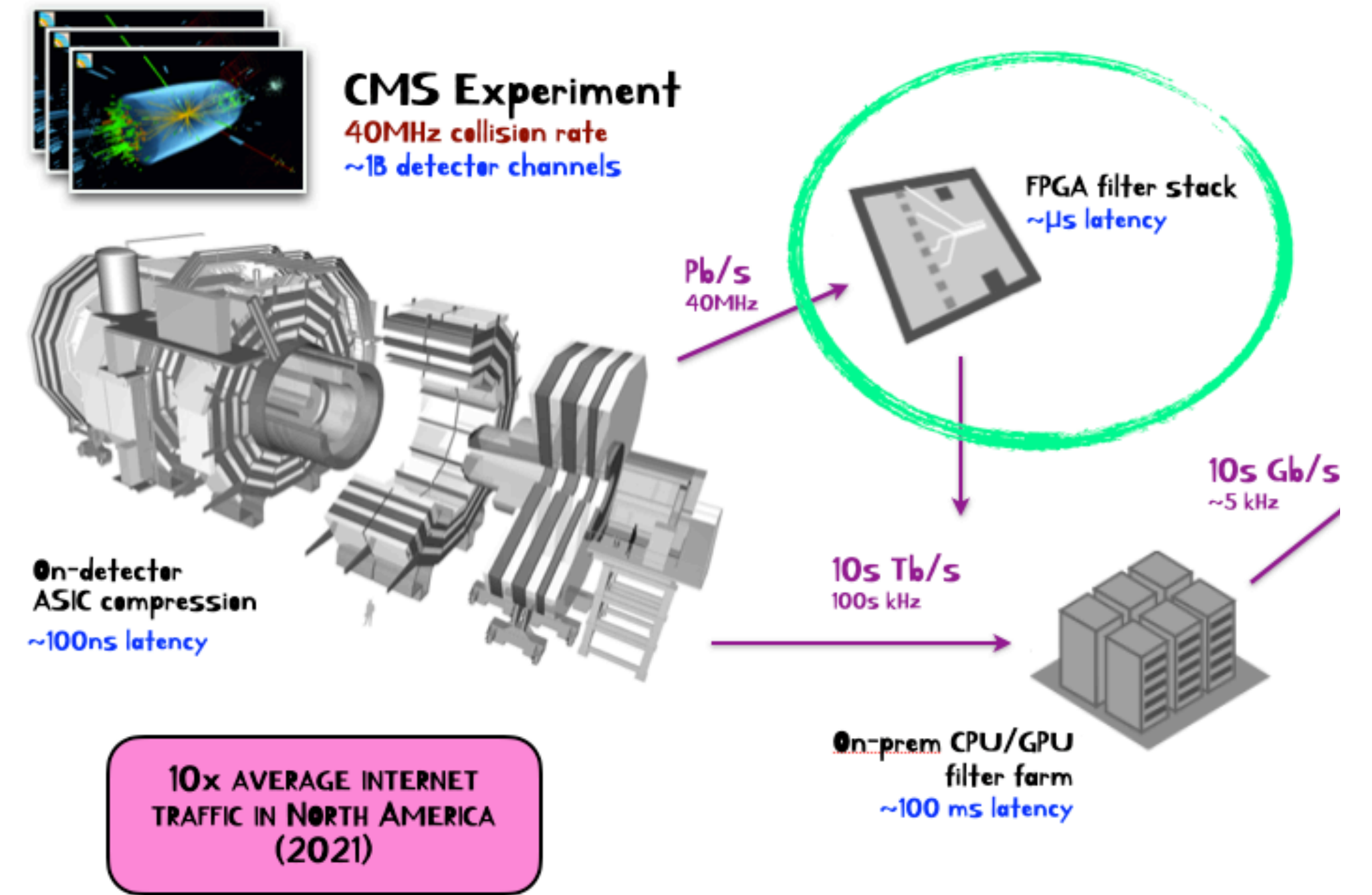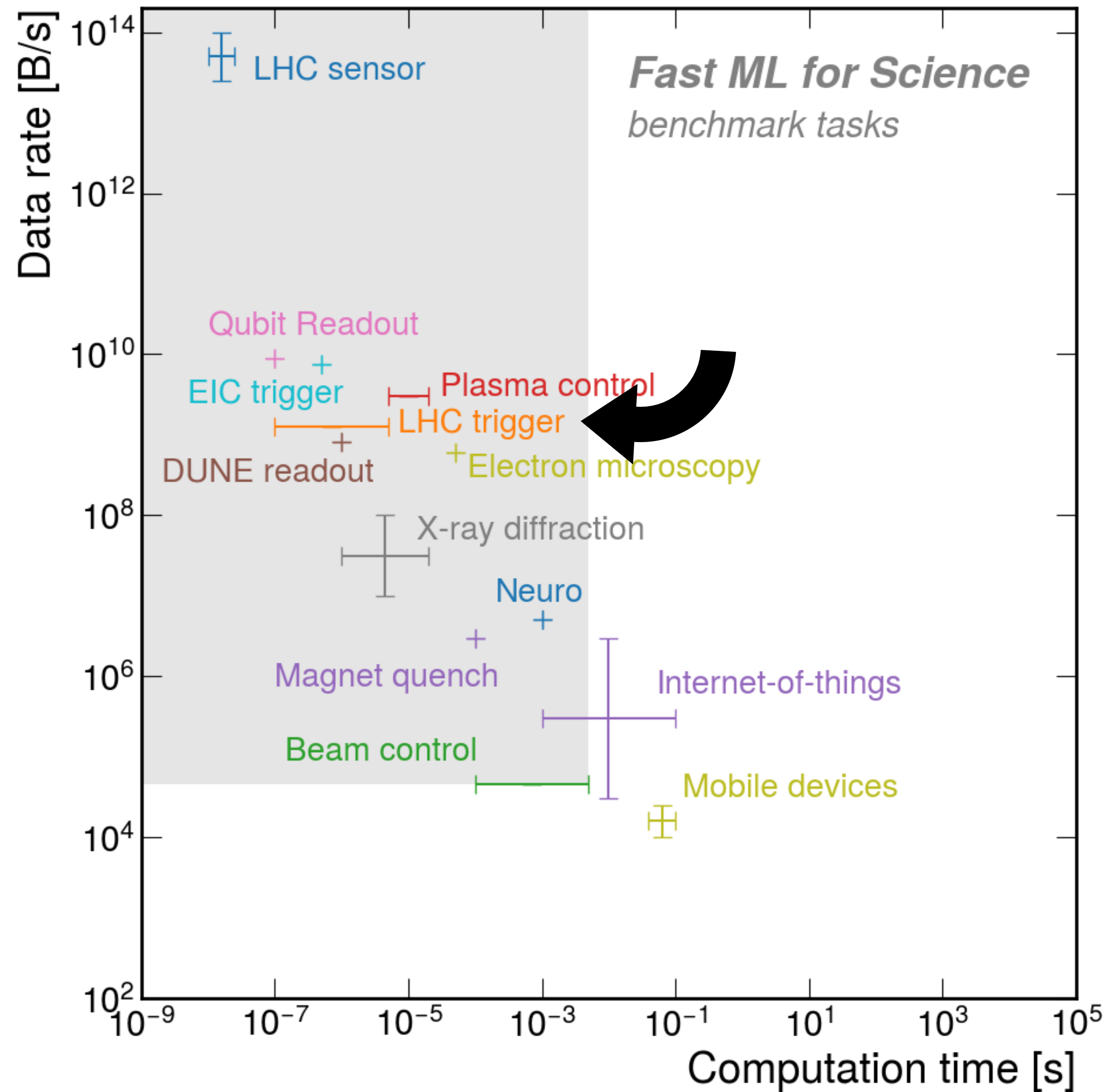
Fast ML for Science

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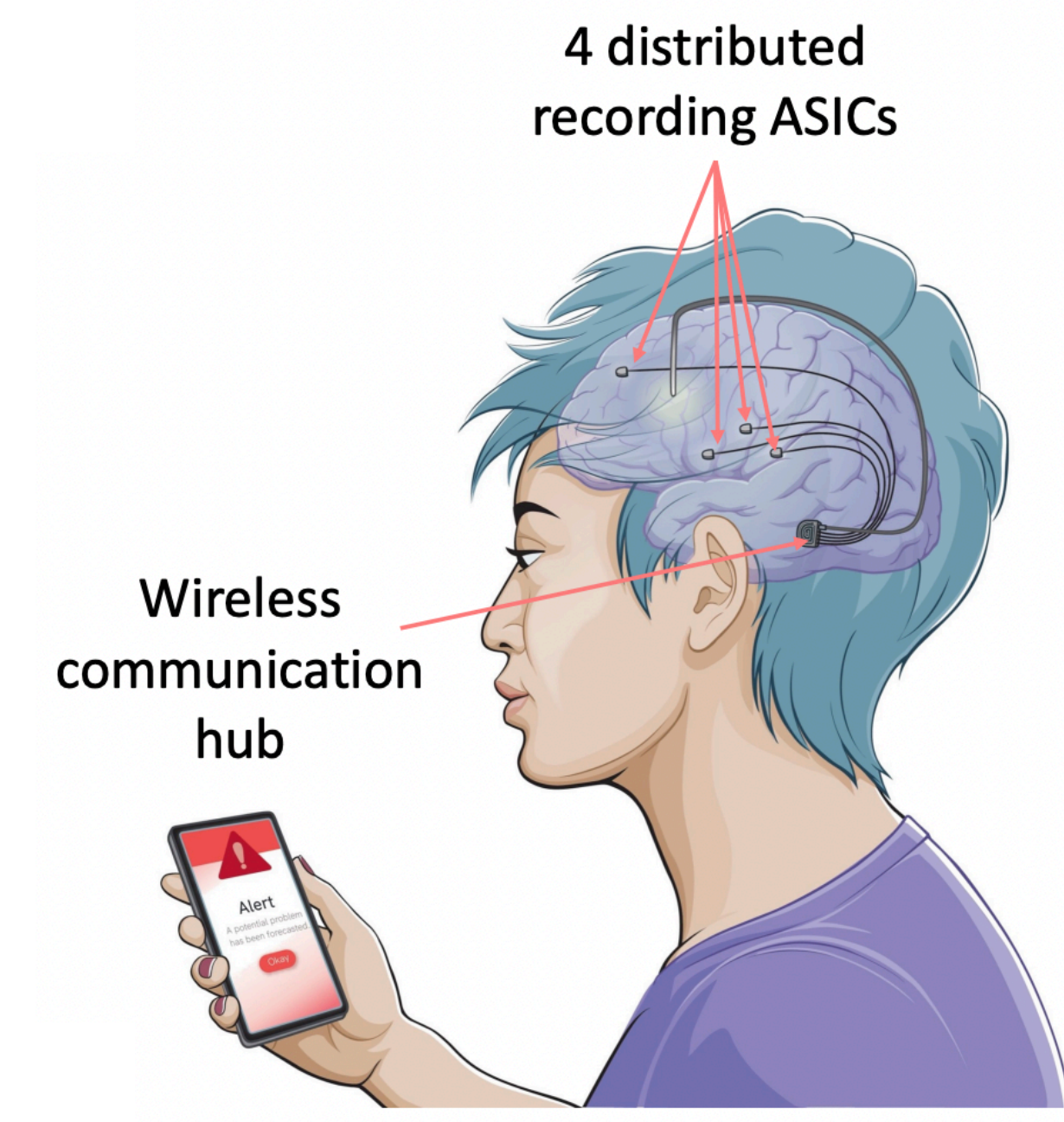
Real-time seizure detection
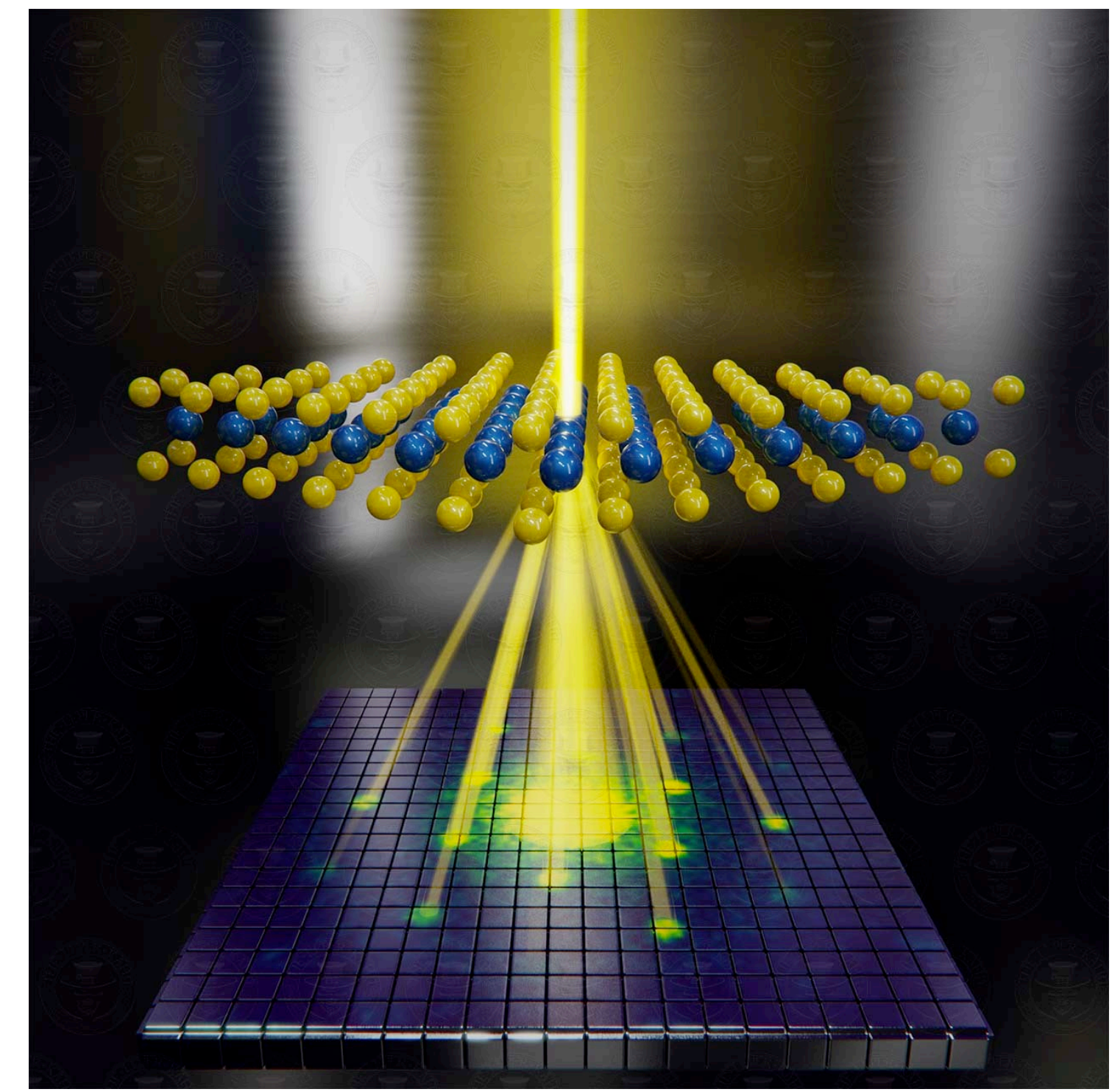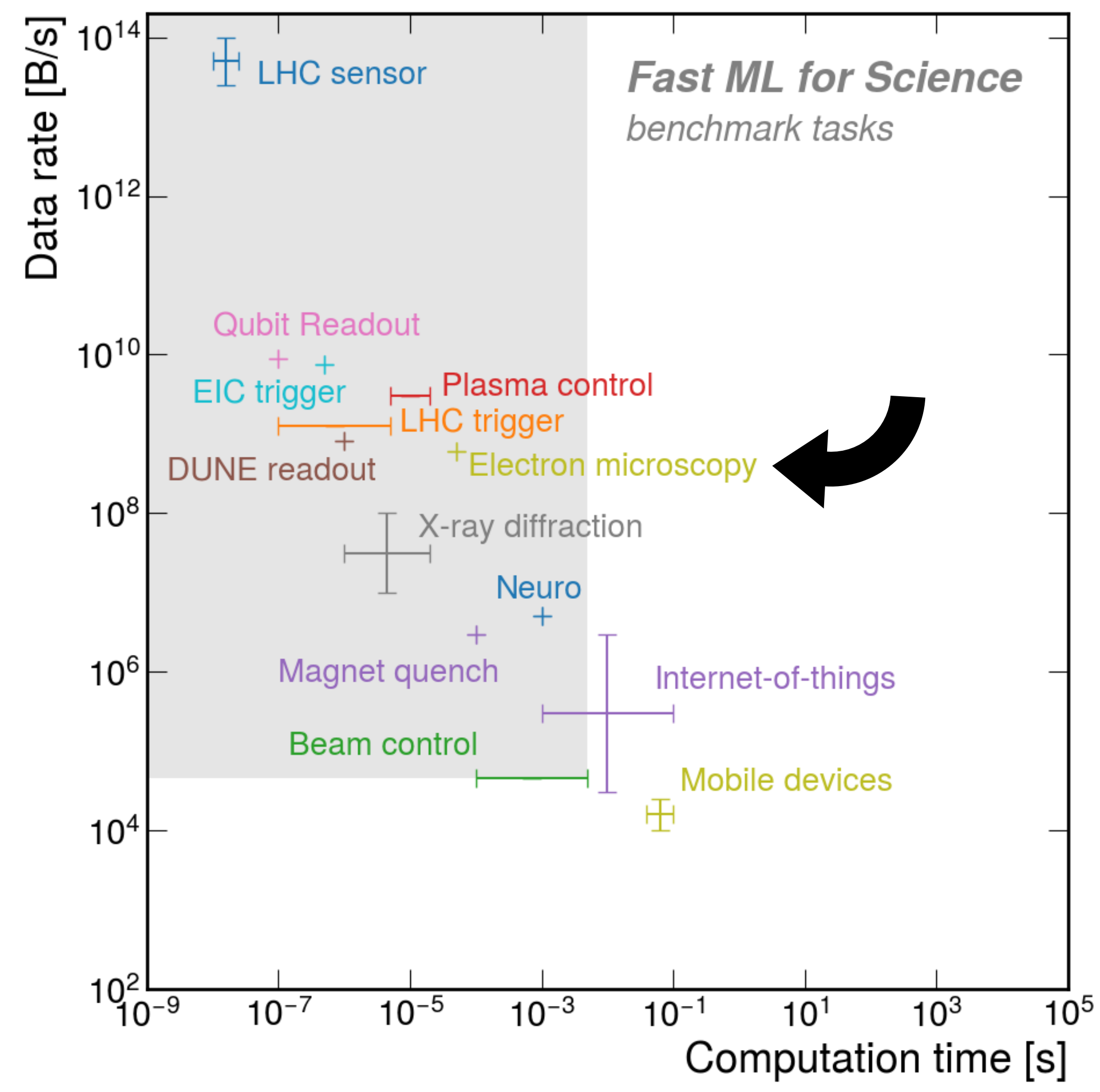Talk by W. Lemaire

Fast ML for Science

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Fermilab accelerator complex

Particle accelerator controls
Talk by J. Mitrevski

Fast ML for Science

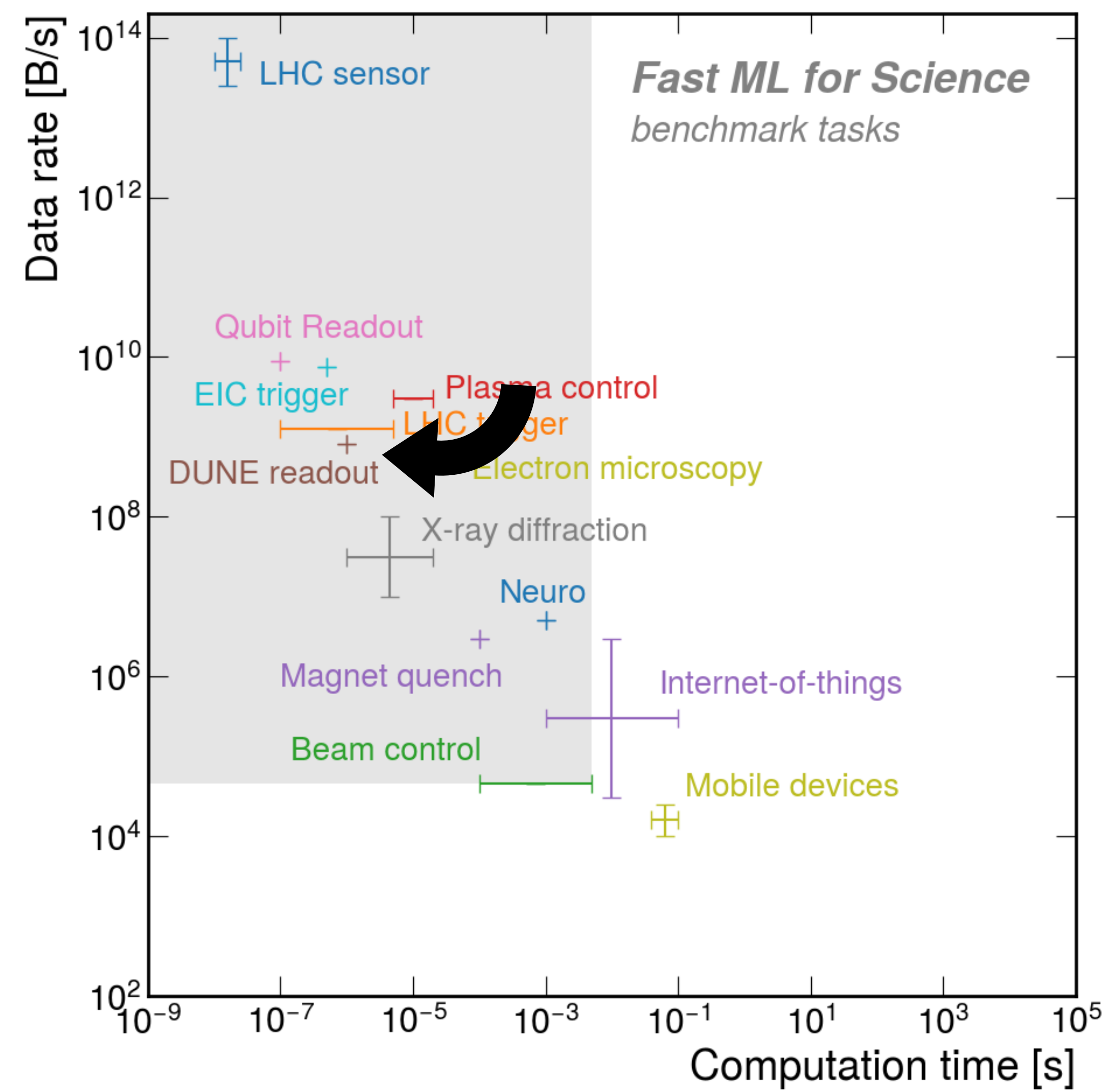Benchmarks bring innovation,
Grand challenges spark imaginations!

New materials for quantum and energy
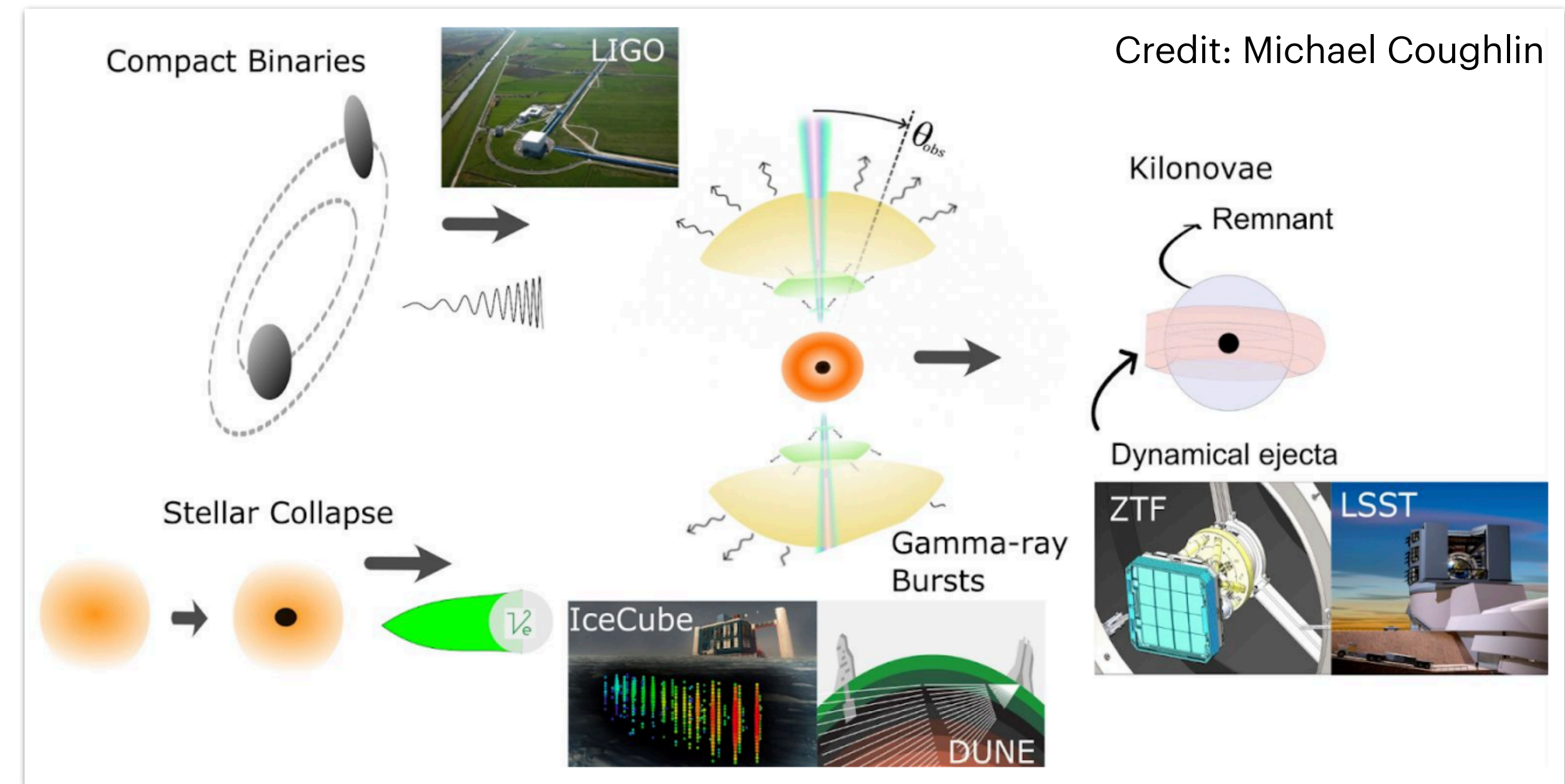Talk by J. Agar

Fast ML for Science
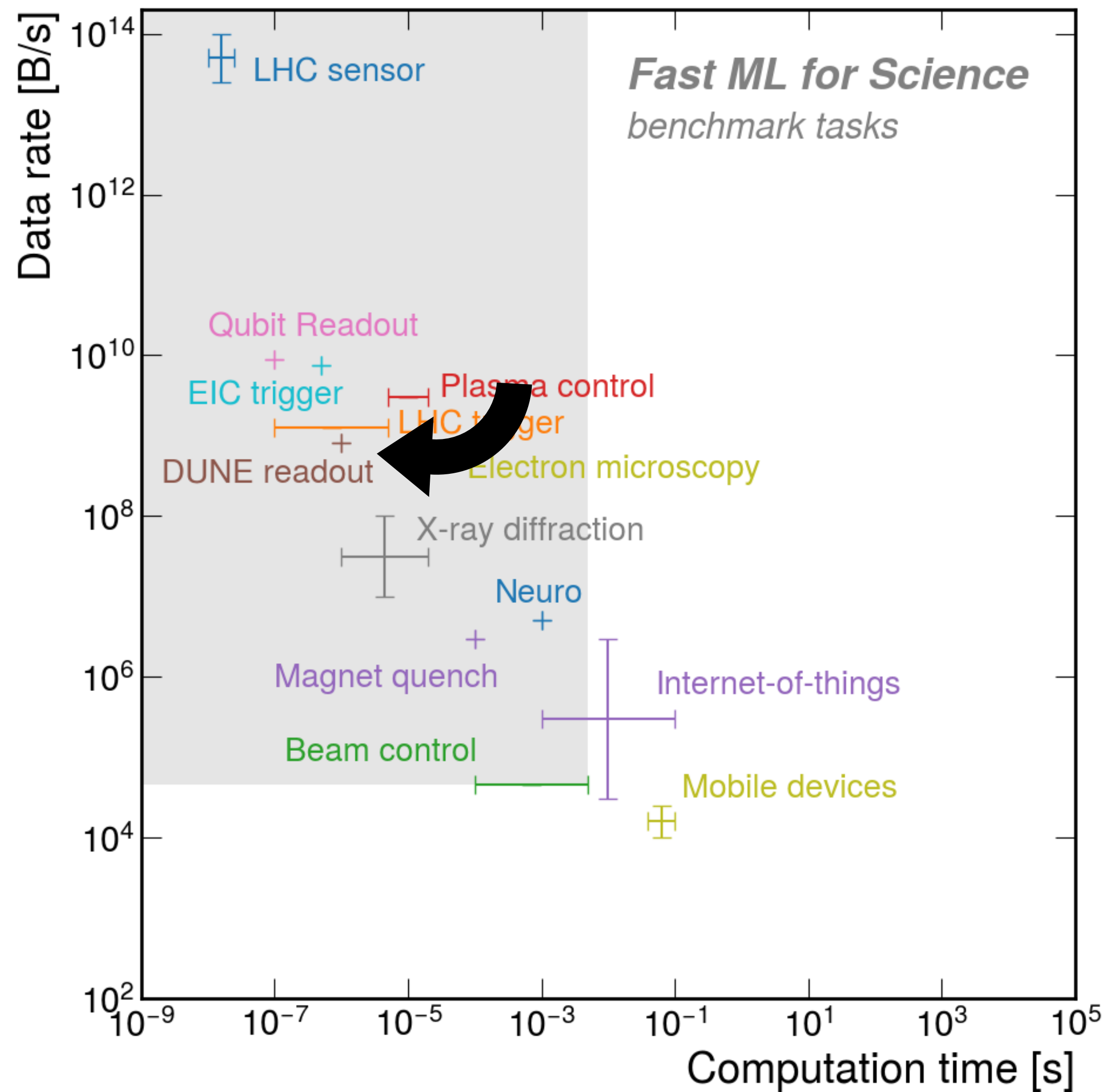

Benchmarks bring innovation,
Grand challenges spark imaginations!
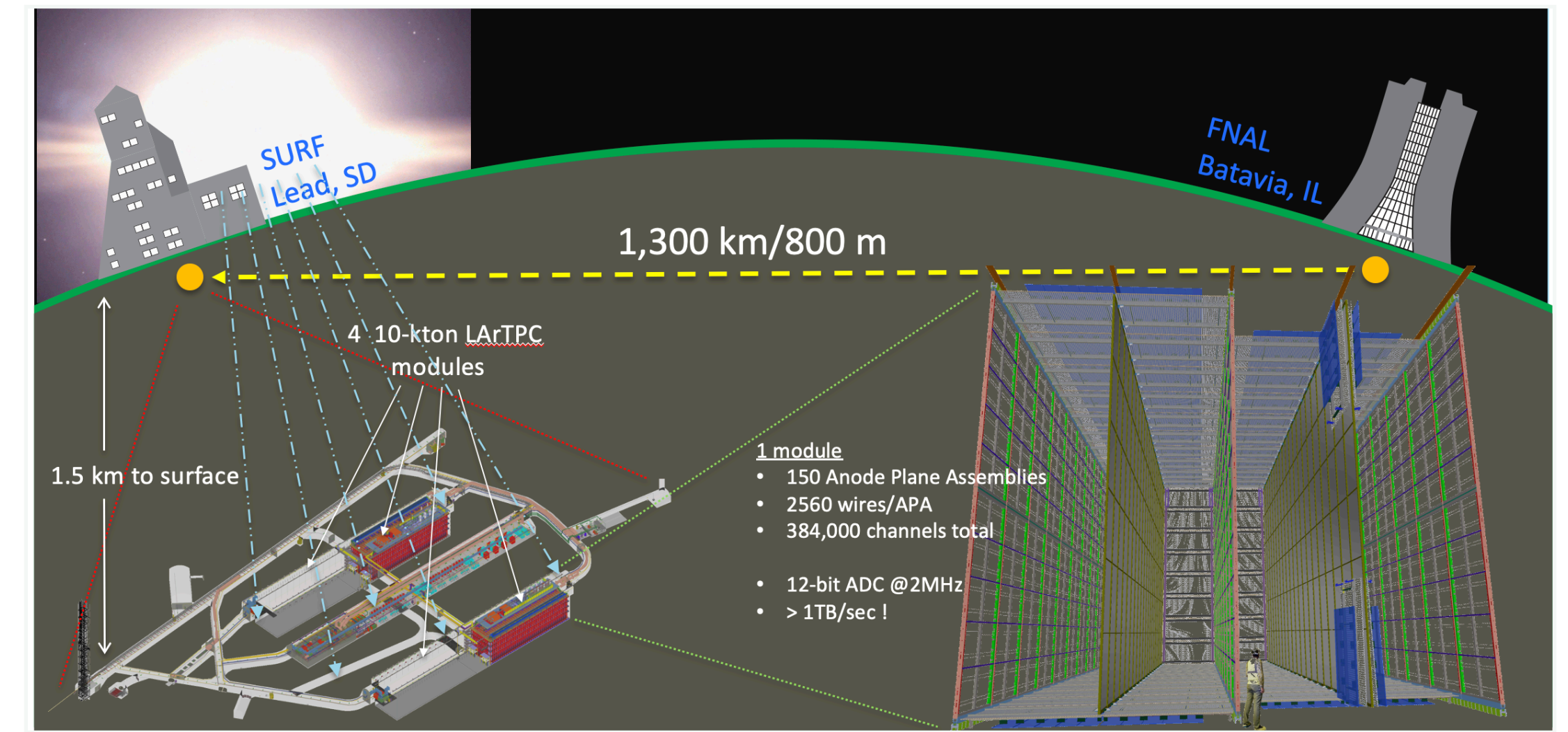
Supernova detection and multi-messenger astronomy
Talk by M. Kahn

Fast ML for Science

Benchmarks bring innovation,
Grand challenges spark imaginations!

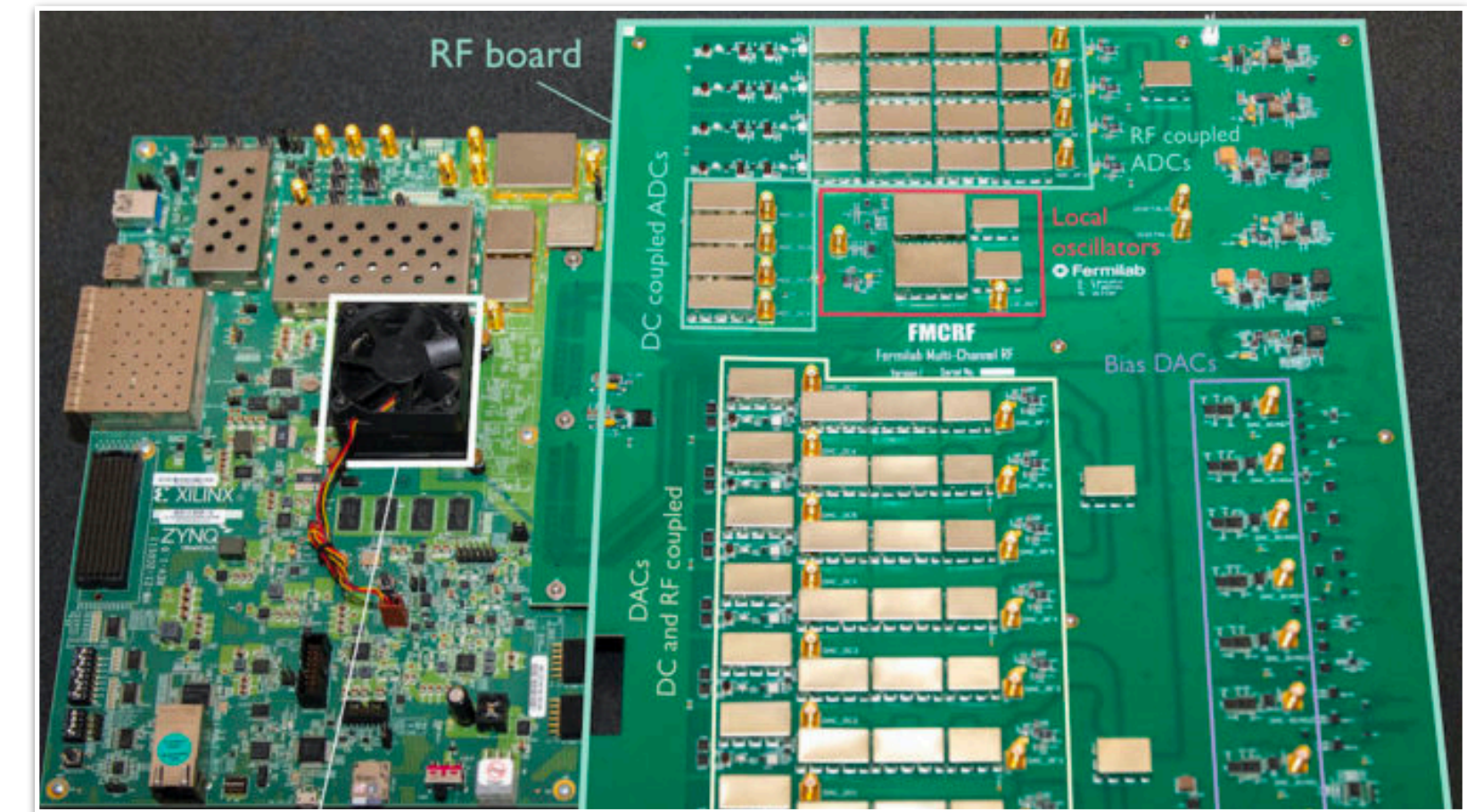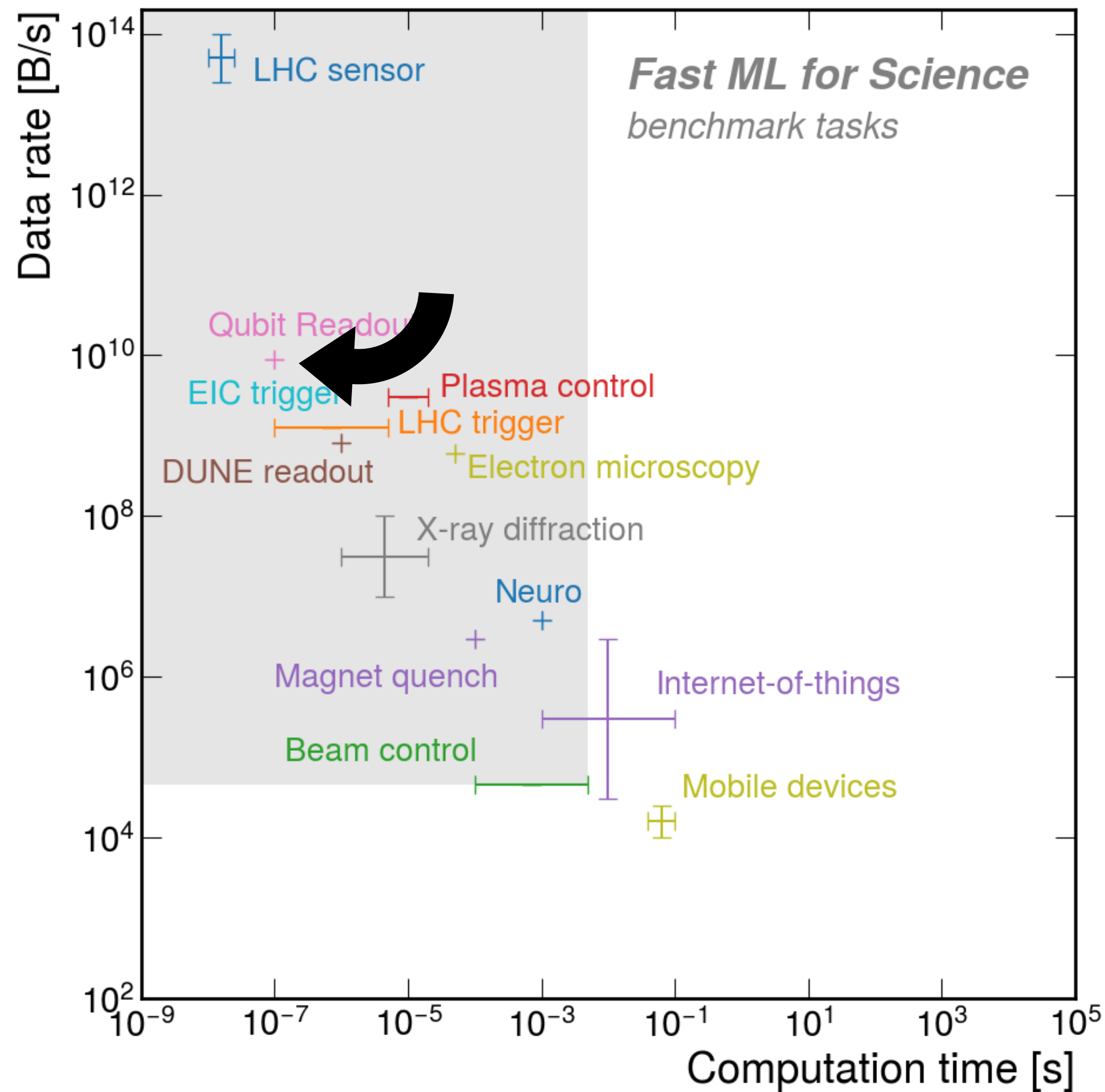Credit: Michael Coughlin

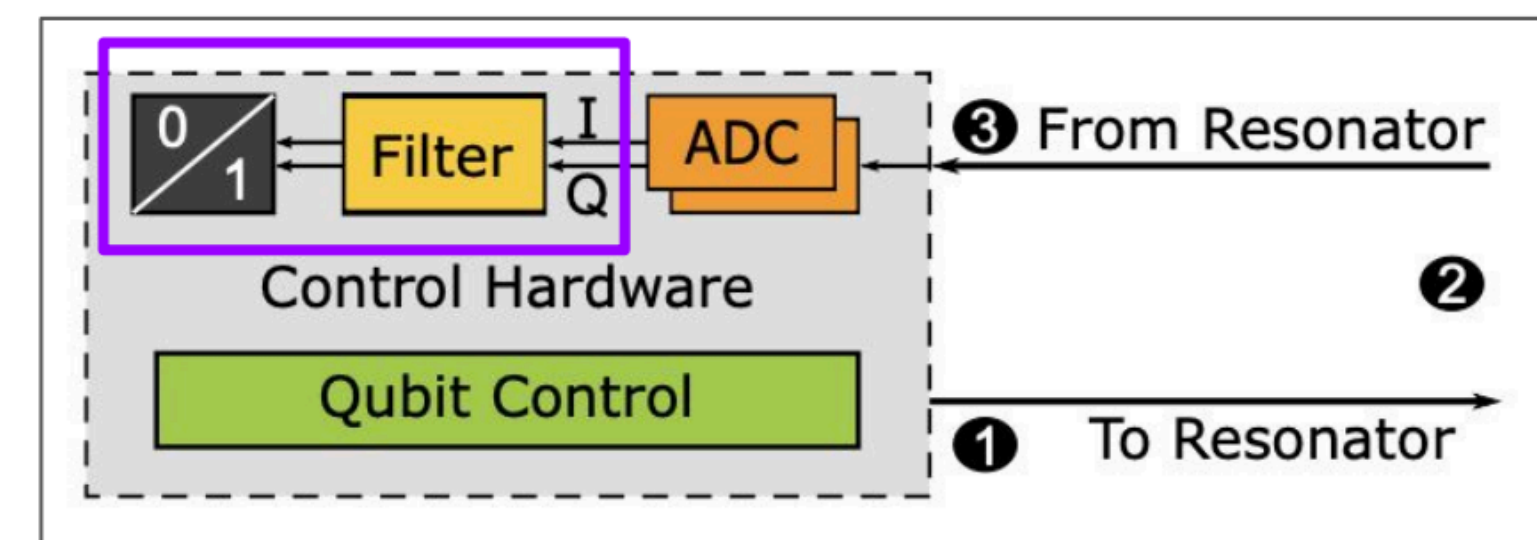**Supernova detection and multi-messenger astronomy**
Talk by S.C. Hsu

Fast ML for Science

Benchmarks bring innovation,
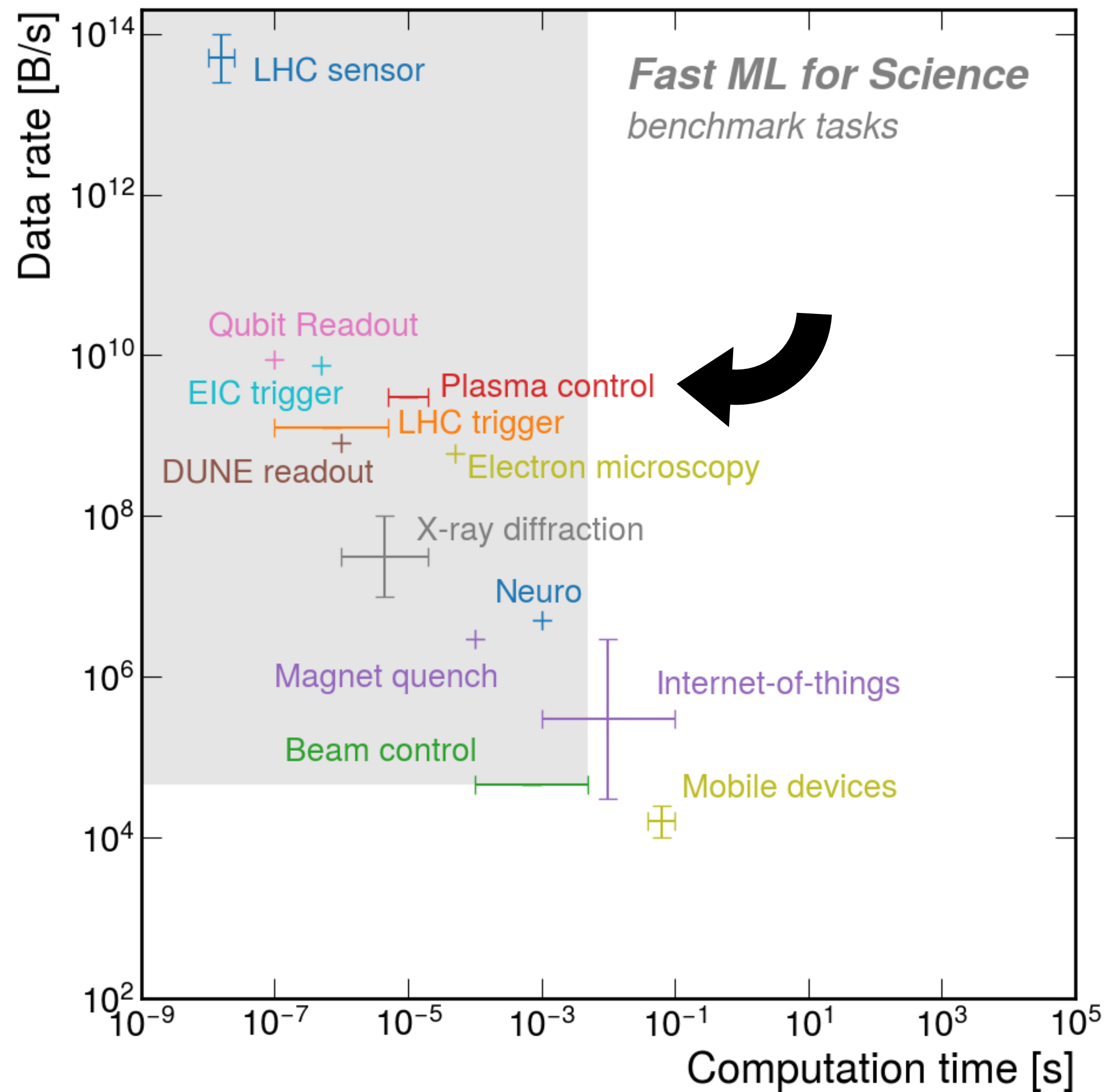Grand challenges spark imaginations!

QICK

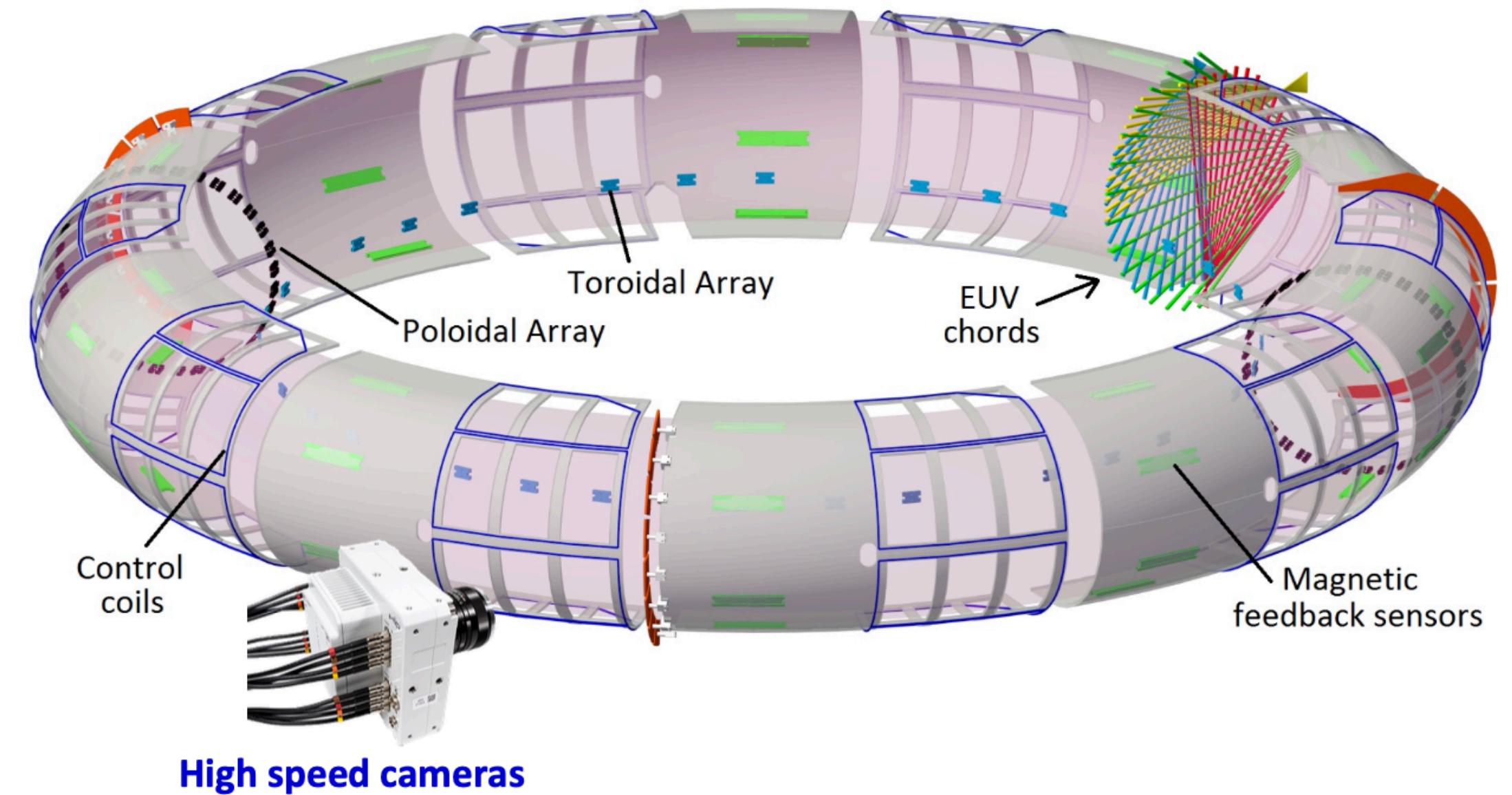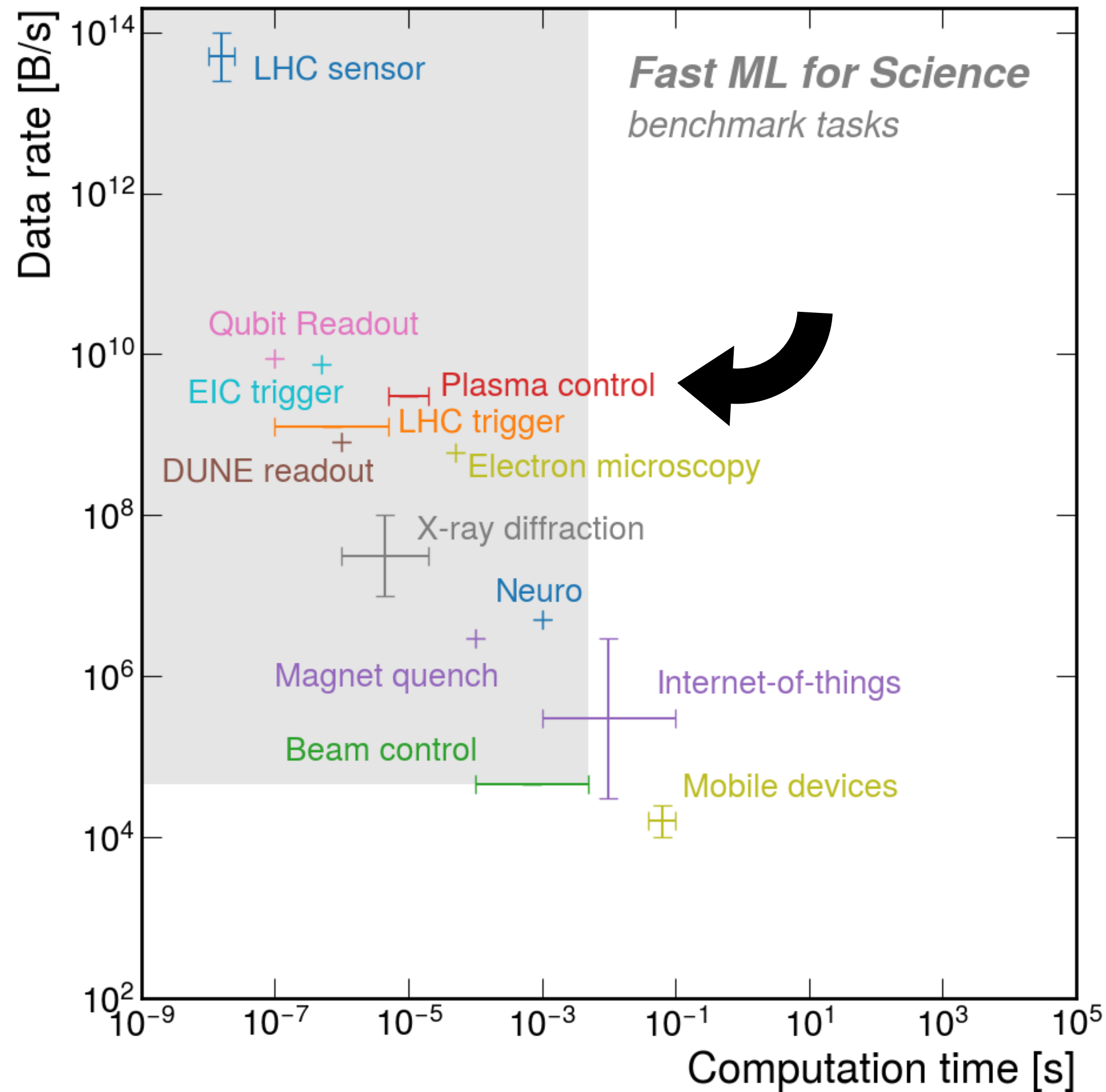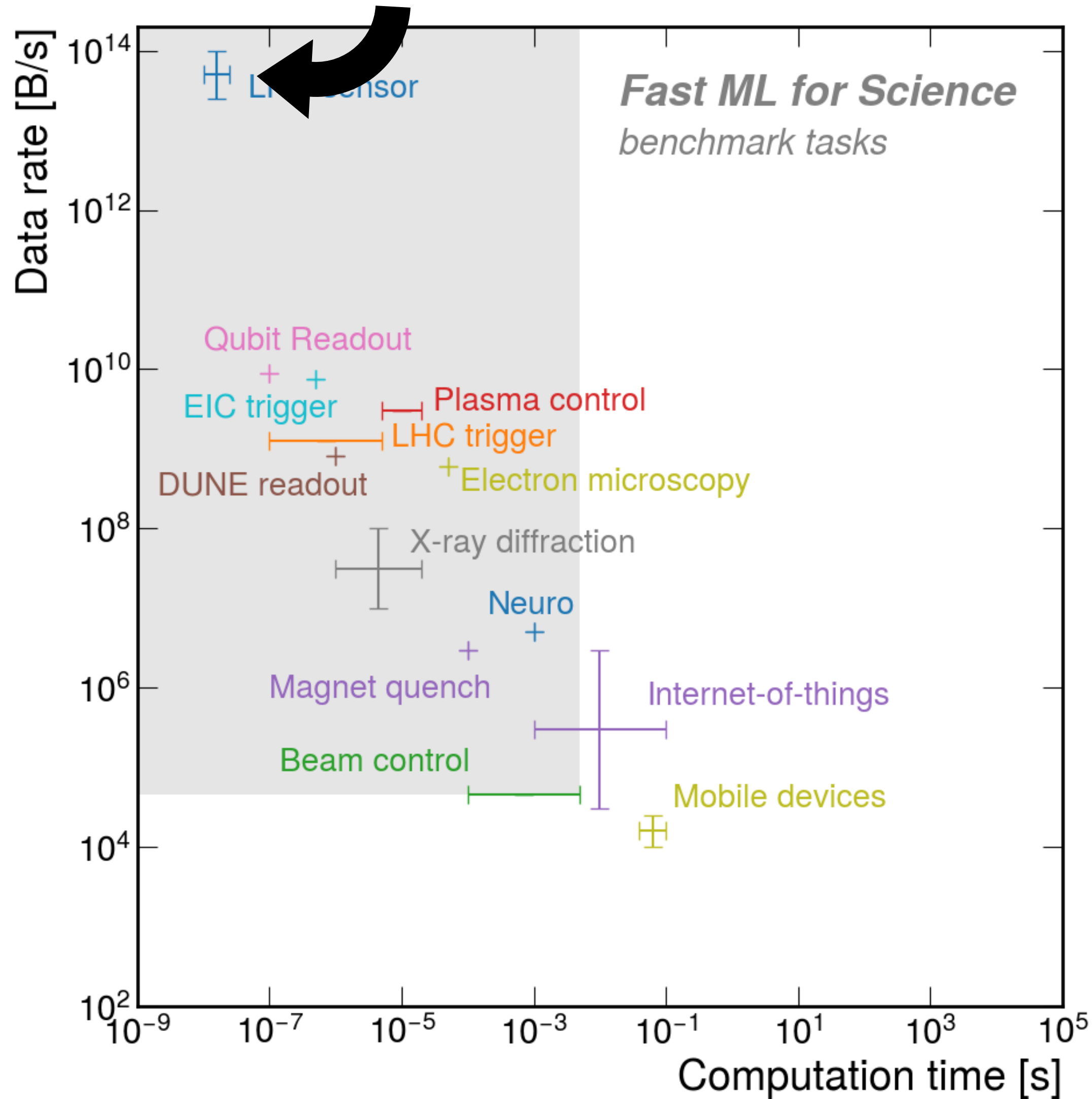**Qubit readout and control**
Talk by J. Campos

Fast ML for Science

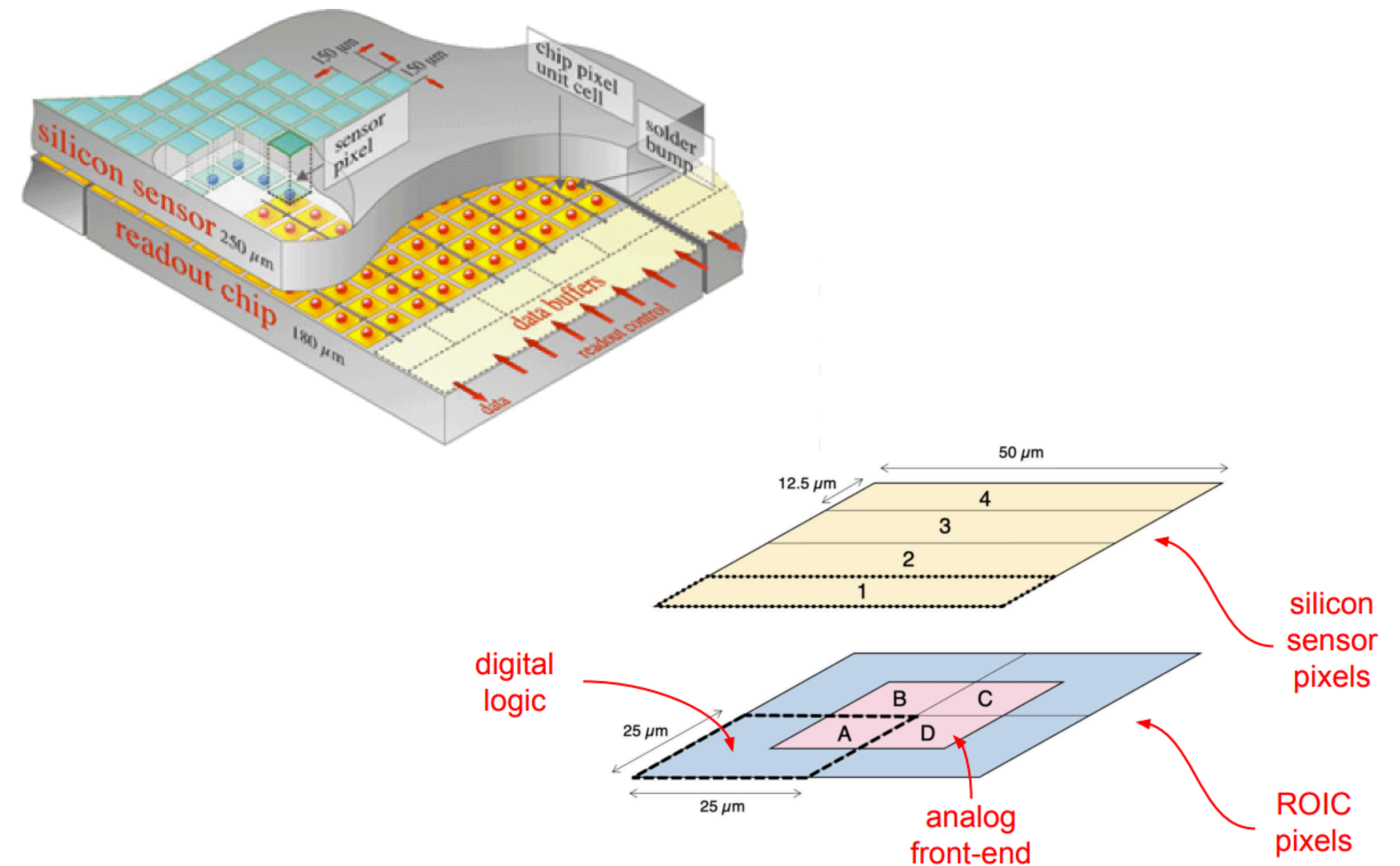Benchmarks bring innovation,
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Fast ML for Science

Benchmarks bring innovation,
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Fast ML for Science

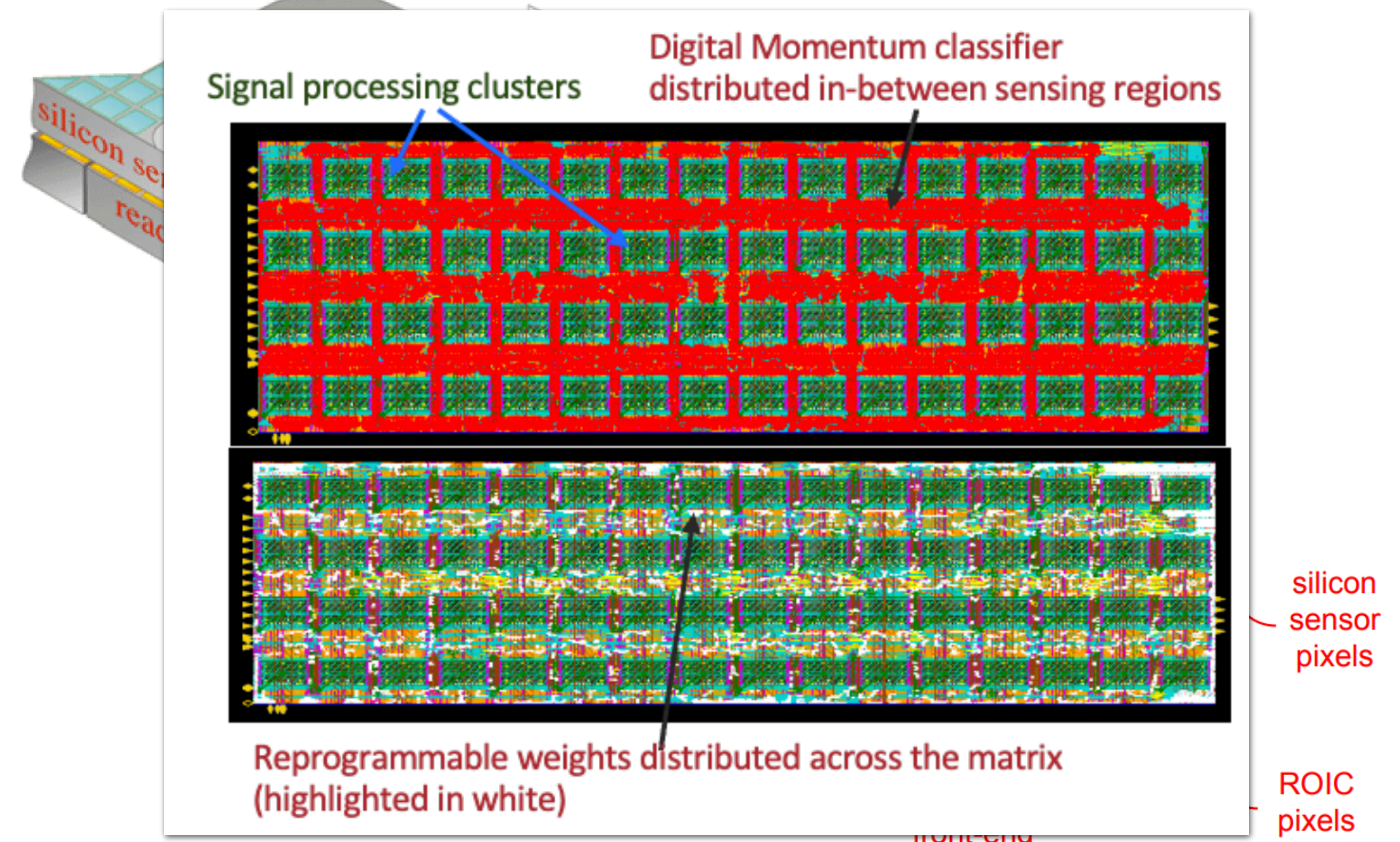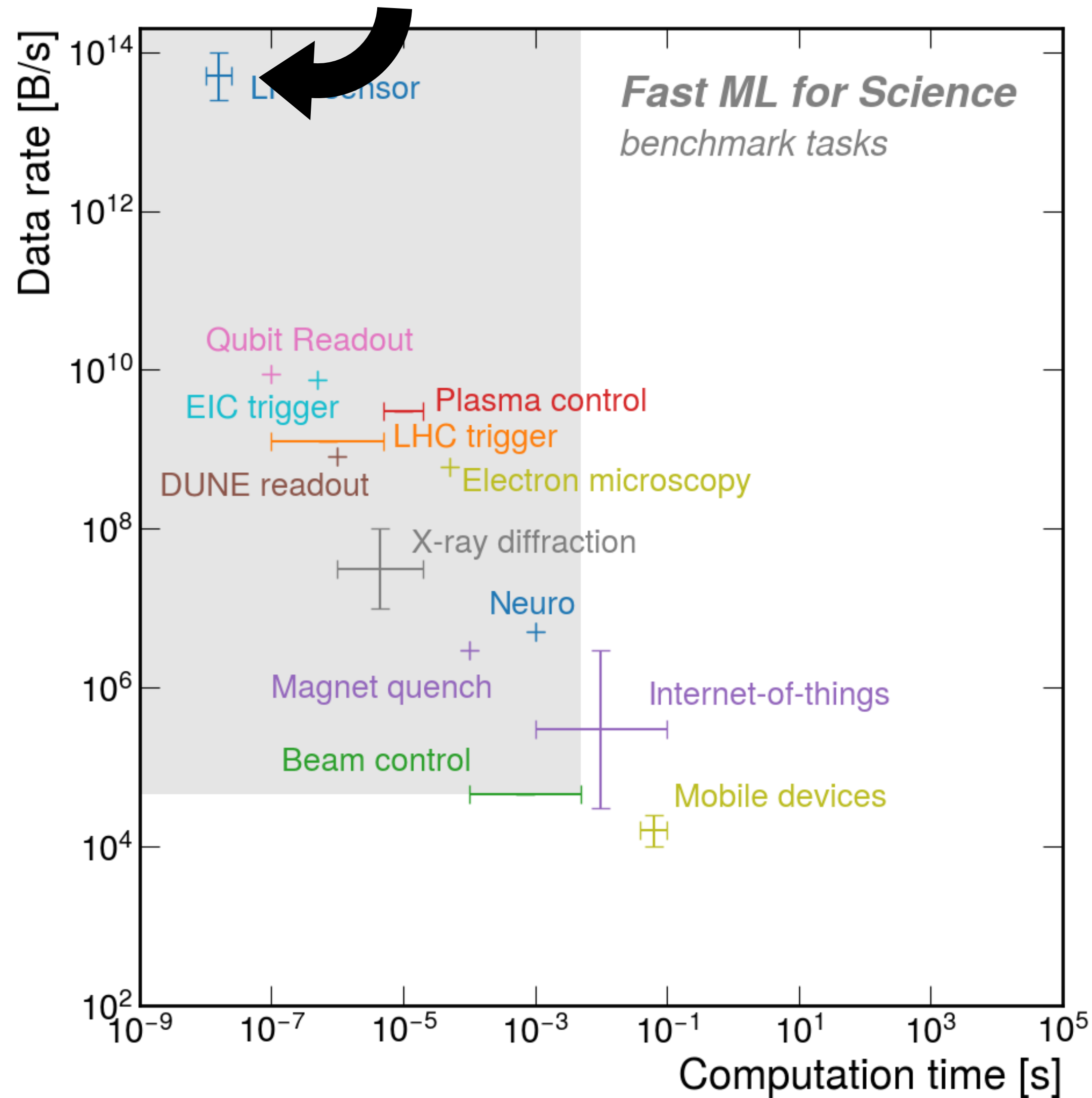Benchmarks bring innovation,
Grand challenges spark imaginations!

Full 40 MHz readout with smart pixel detectors
Talk by G. Di Guglielmo

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Fast ML for Science

Benchmarks bring innovation,
Grand challenges spark imaginations!

Signal processing clusters

Digital Momentum classifier
distributed in-between sensing regions

silicon sensor pixels

Reprogrammable weights distributed across the matrix
(highlighted in white)

ROIC pixels

Full 40 MHz readout with smart pixel detectors
Talk by G. Di Guglielmo