



Artificial Intelligence & HEP: a perspective

February 13, 2020
Fermilab AI Jamboree!

Artificial intelligence

- AI has the potential to greatly accelerate discovery science across all aspects of particle physics

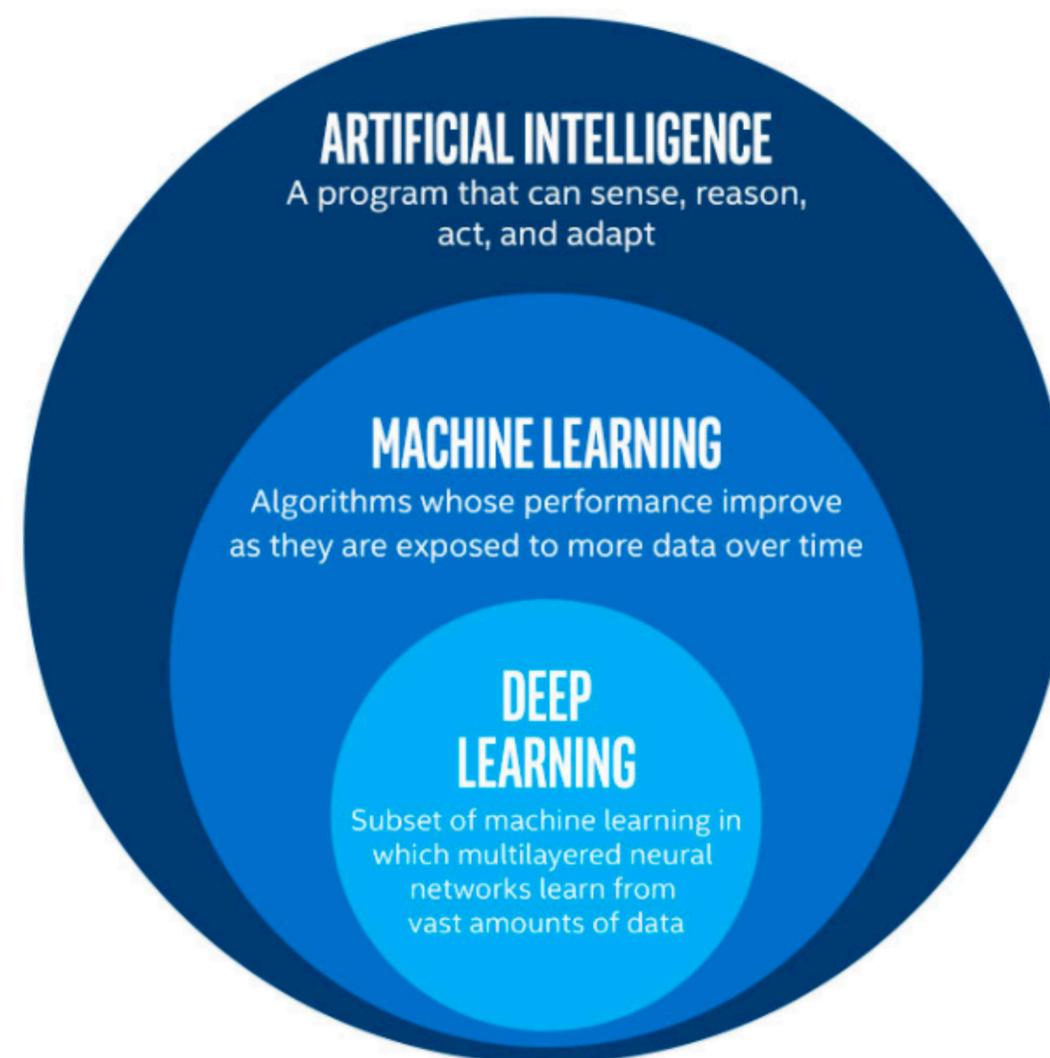
Artificial intelligence

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- AI vs ML

Insert snarky statement about AI vs. ML...

Artificial intelligence

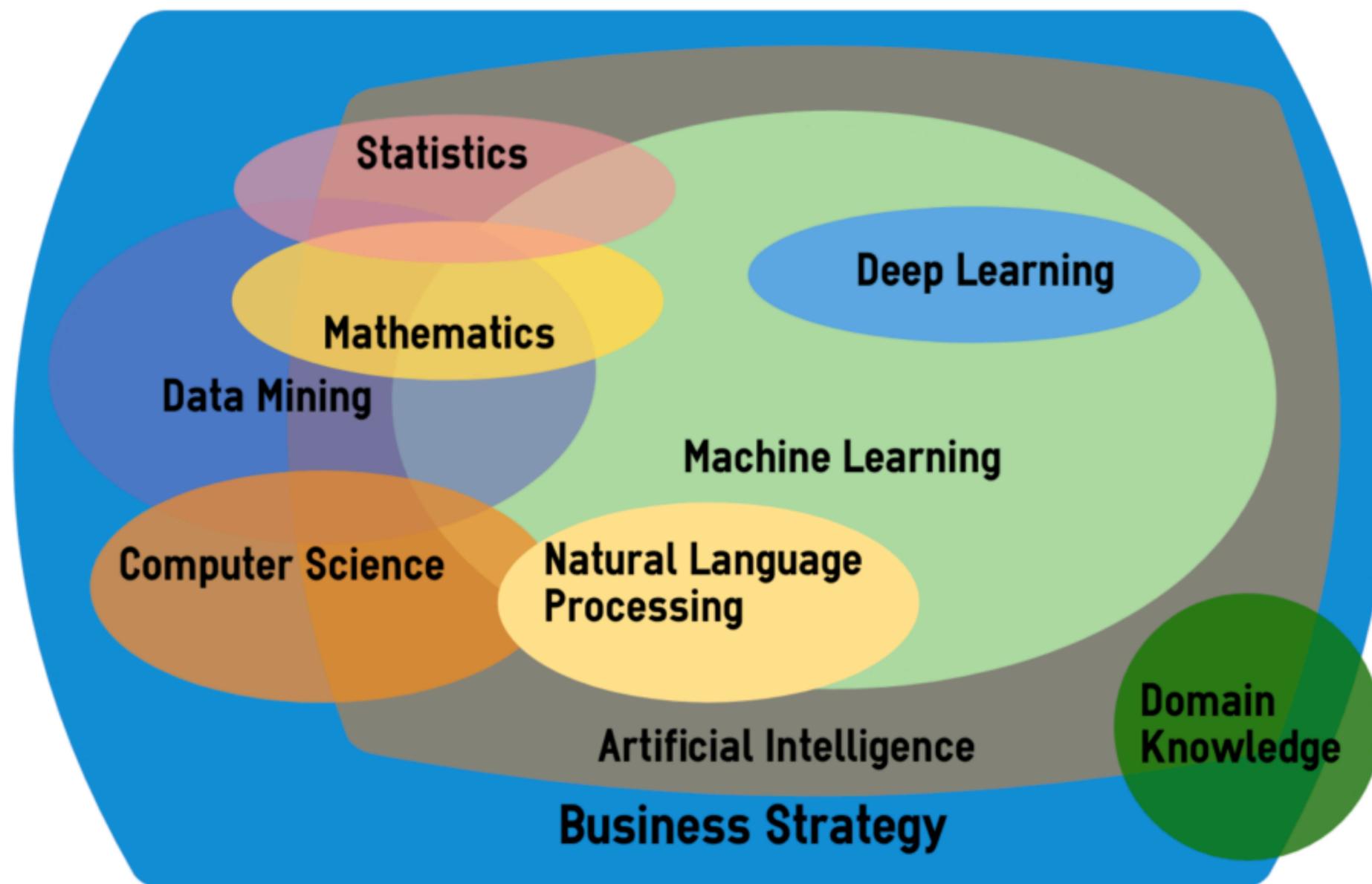
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Artificial intelligence

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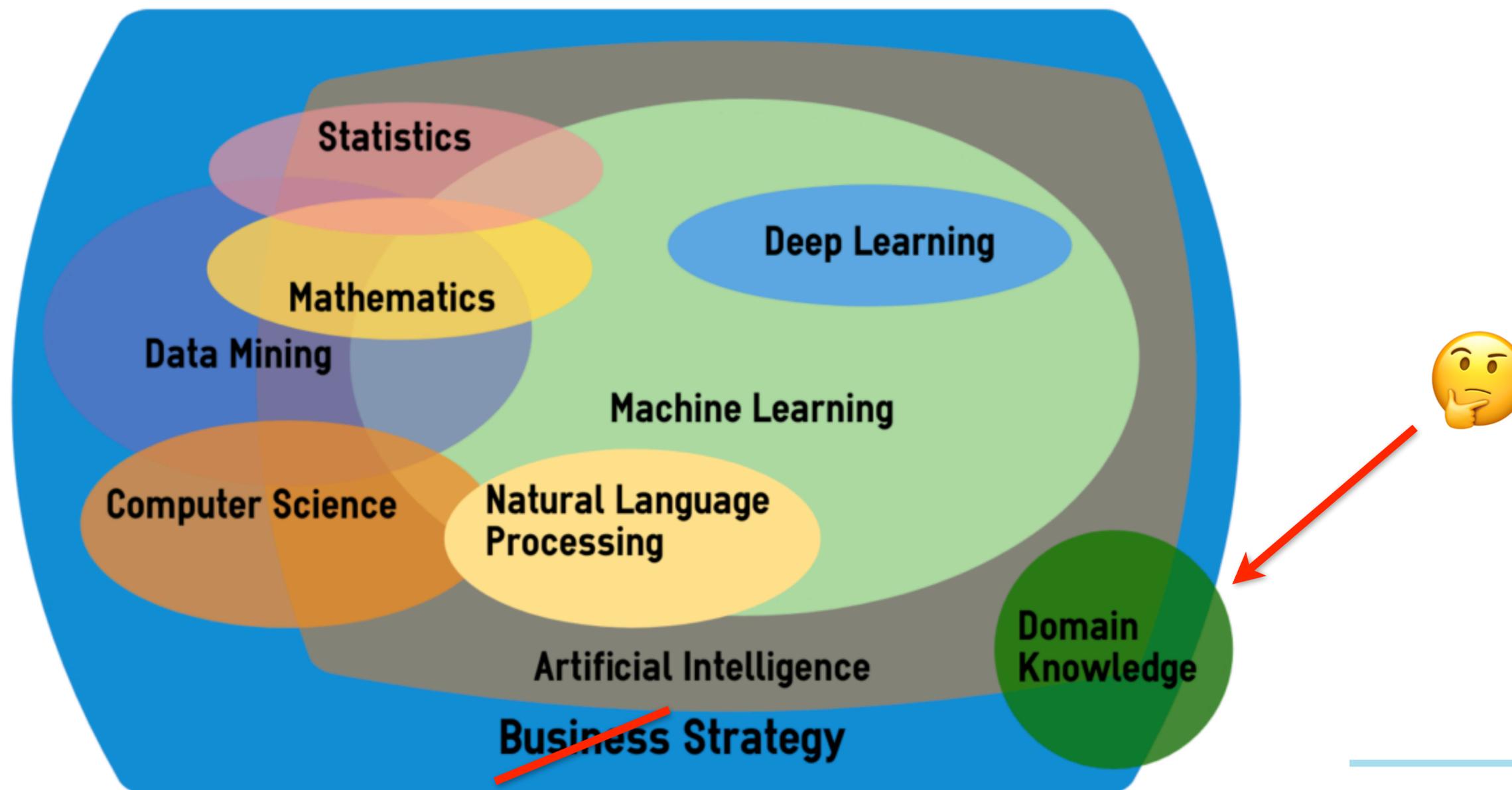
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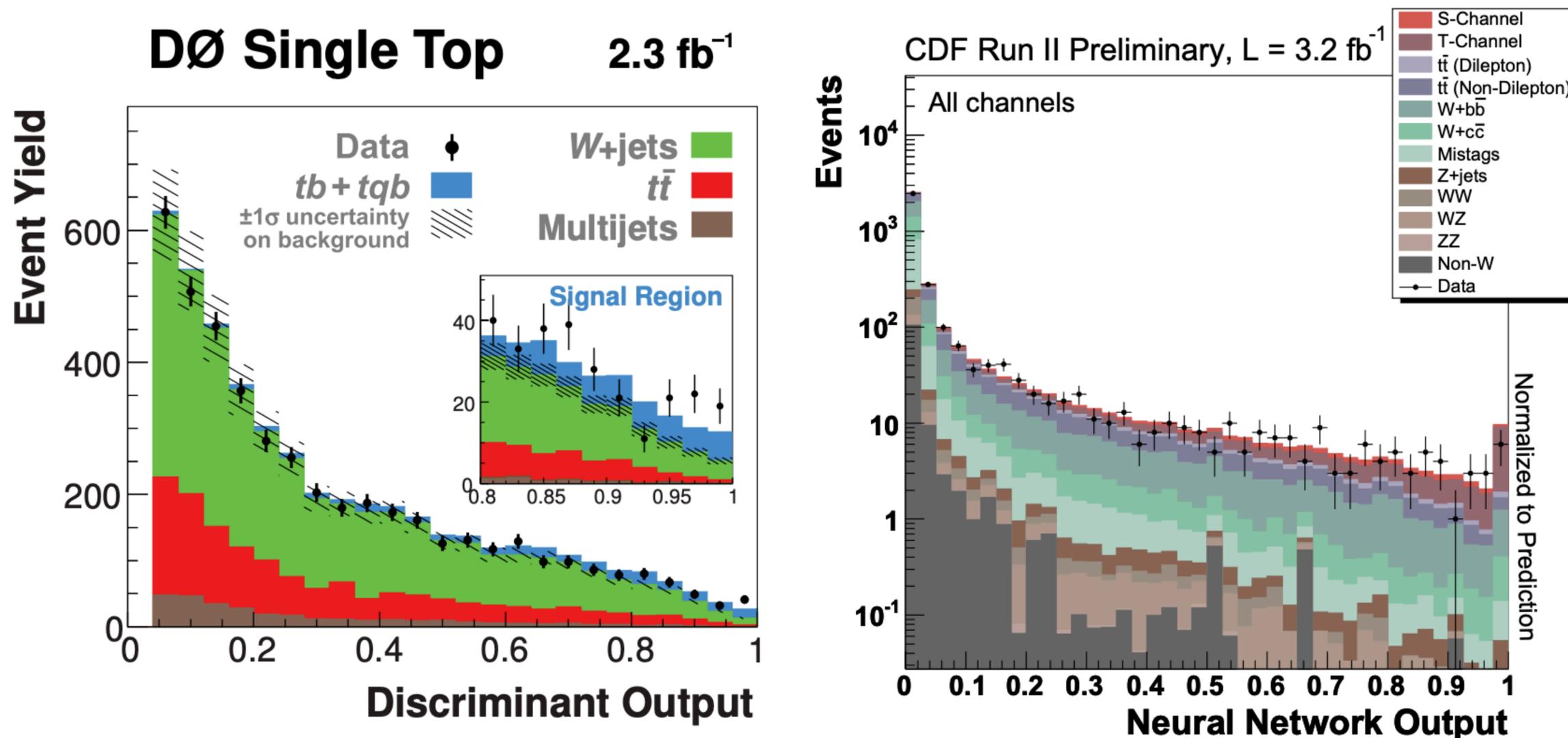
Artificial intelligence

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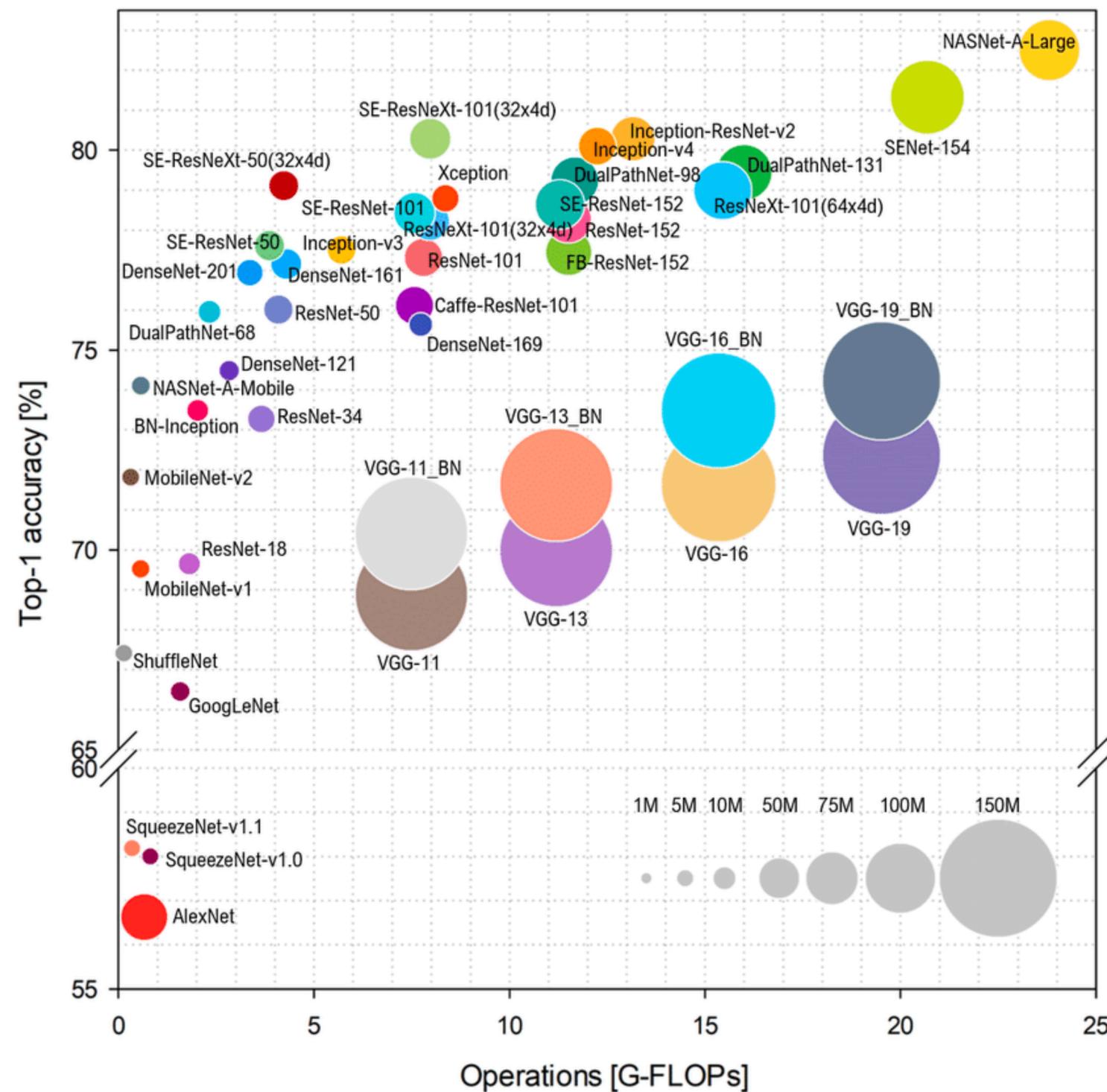
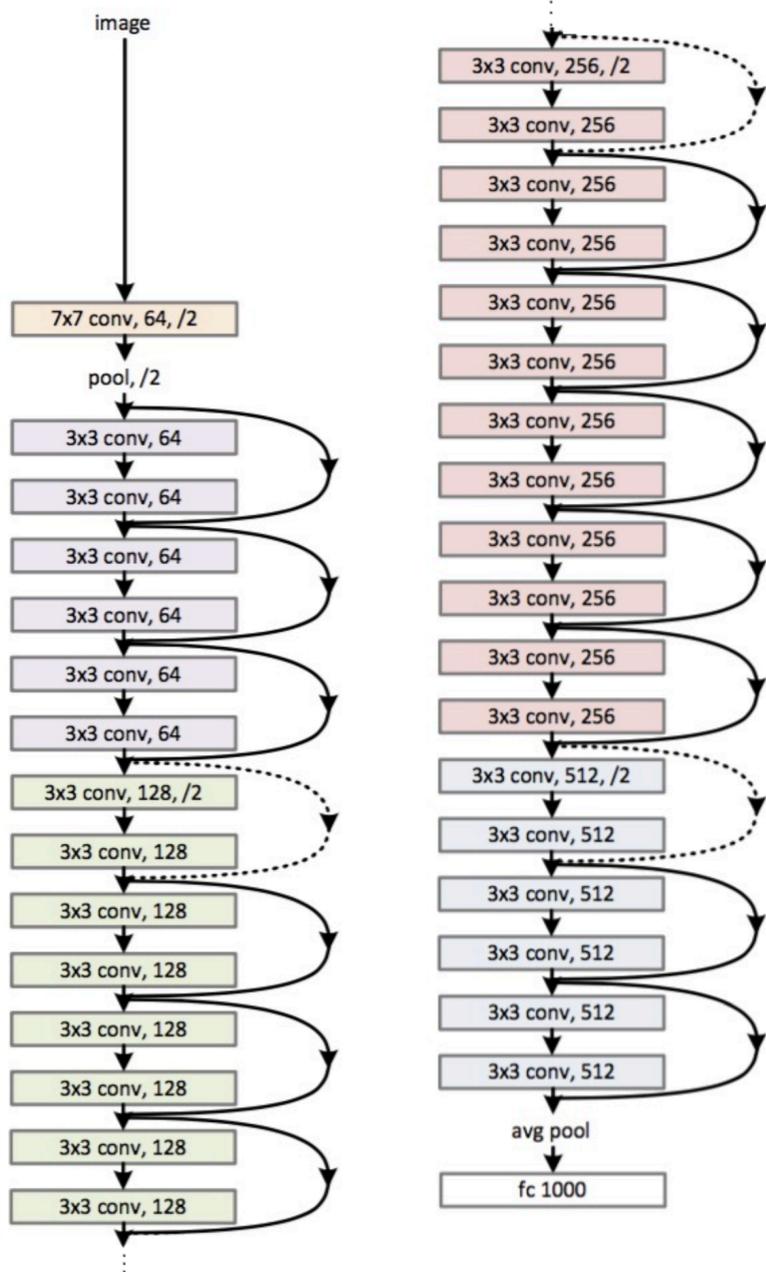


AI in physics - single top discovery



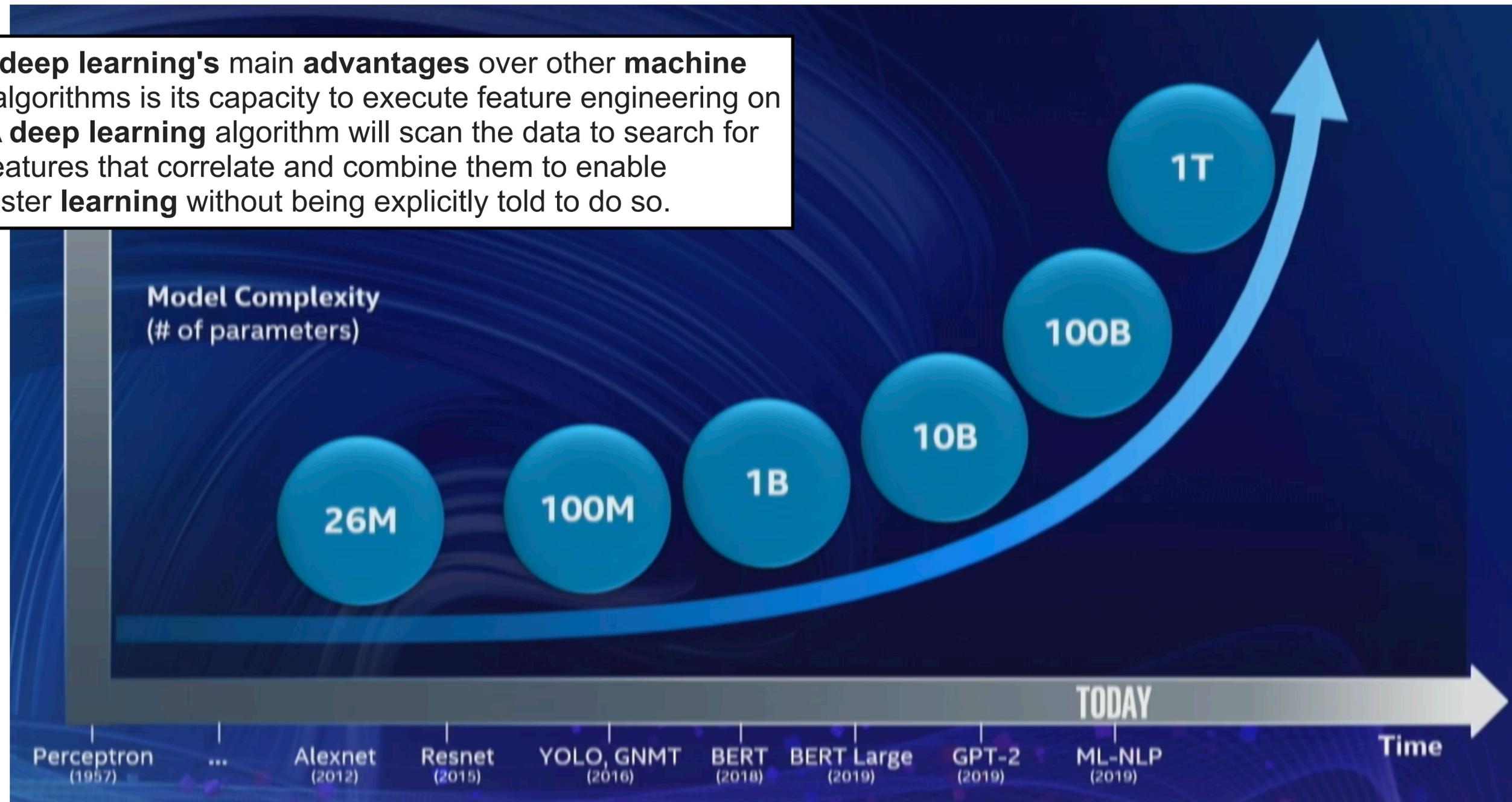
Deep learning

34-layer residual



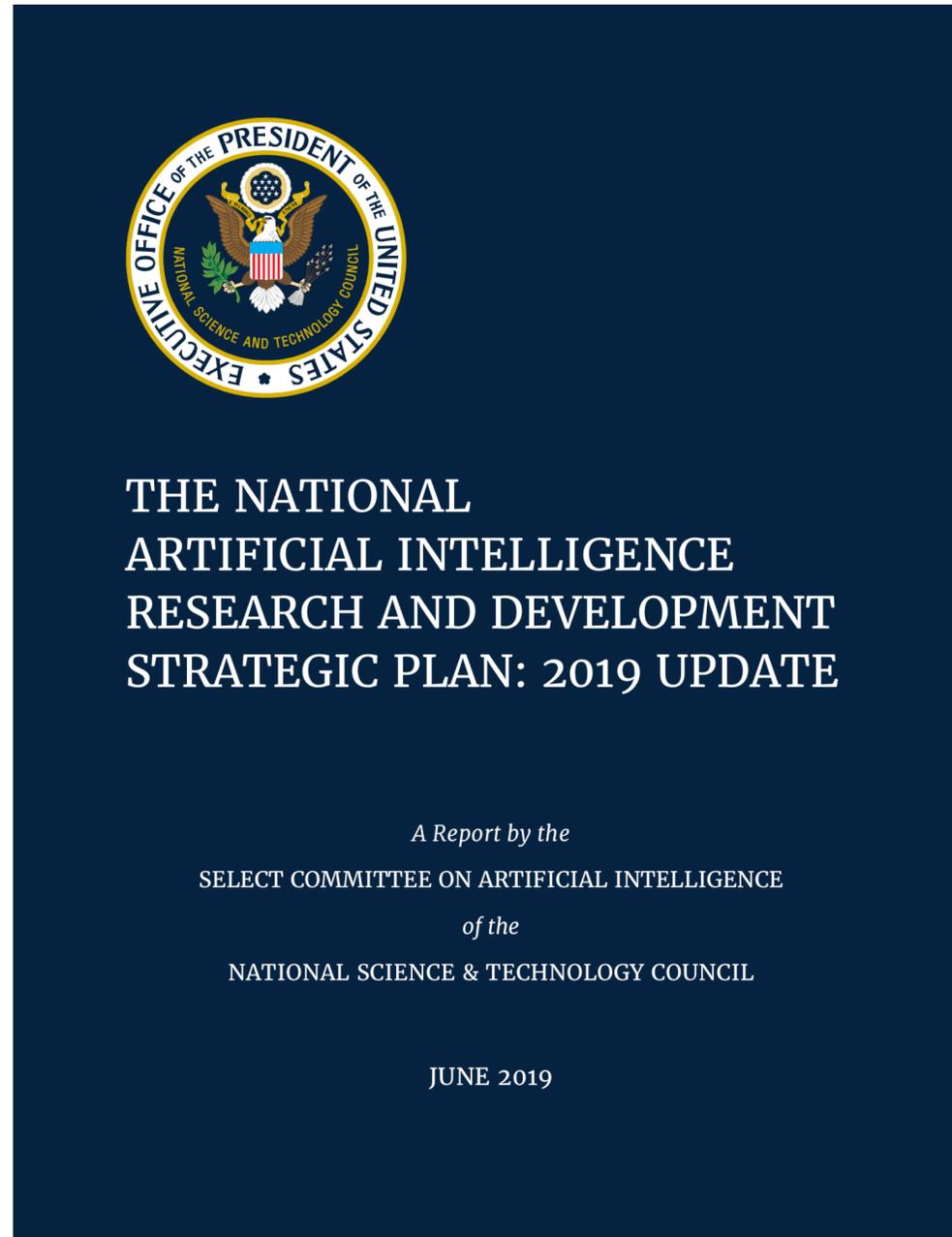
Deep learning

One of **deep learning's** main **advantages** over other **machine learning** algorithms is its capacity to execute feature engineering on its own. A **deep learning** algorithm will scan the data to search for features that correlate and combine them to enable faster **learning** without being explicitly told to do so.



HEP and AI in context

<https://www.nitrd.gov/pubs/National-AI-RD-Strategy-2019.pdf>



Interesting article on other AI strategies

<https://medium.com/politics-ai/an-overview-of-national-ai-strategies-2a70ec6edfd>

National AI strategic plan

Make Long-Term Investments in AI Research

- Data-focused methodologies for knowledge discovery;
- Understanding the perceptual capabilities, theoretical capabilities and limitations of AI
- Developing scalable AI systems; Advancing hardware for improved AI

Better Understand the National AI R&D Workforce Needs

Develop Effective Methods for Human-AI collaboration

- Developing AI techniques of human augmentation, visualization, and human-AI interfaces

Understand and Address the Ethical, Legal, and Societal Implications of AI

- Improving fairness, transparency, and accountability by design

Ensure the Safety and Security of AI Systems

- Improving explainability and transparency, enhancing verification and validation

Develop Shared Public Datasets and Environments for AI Training/Testing

- Make accessible datasets for diverse spectrum of AI interests; training and testing resources; develop open-source software libraries and toolkits

Expand Public-Private Partnerships to Accelerate Advances in AI

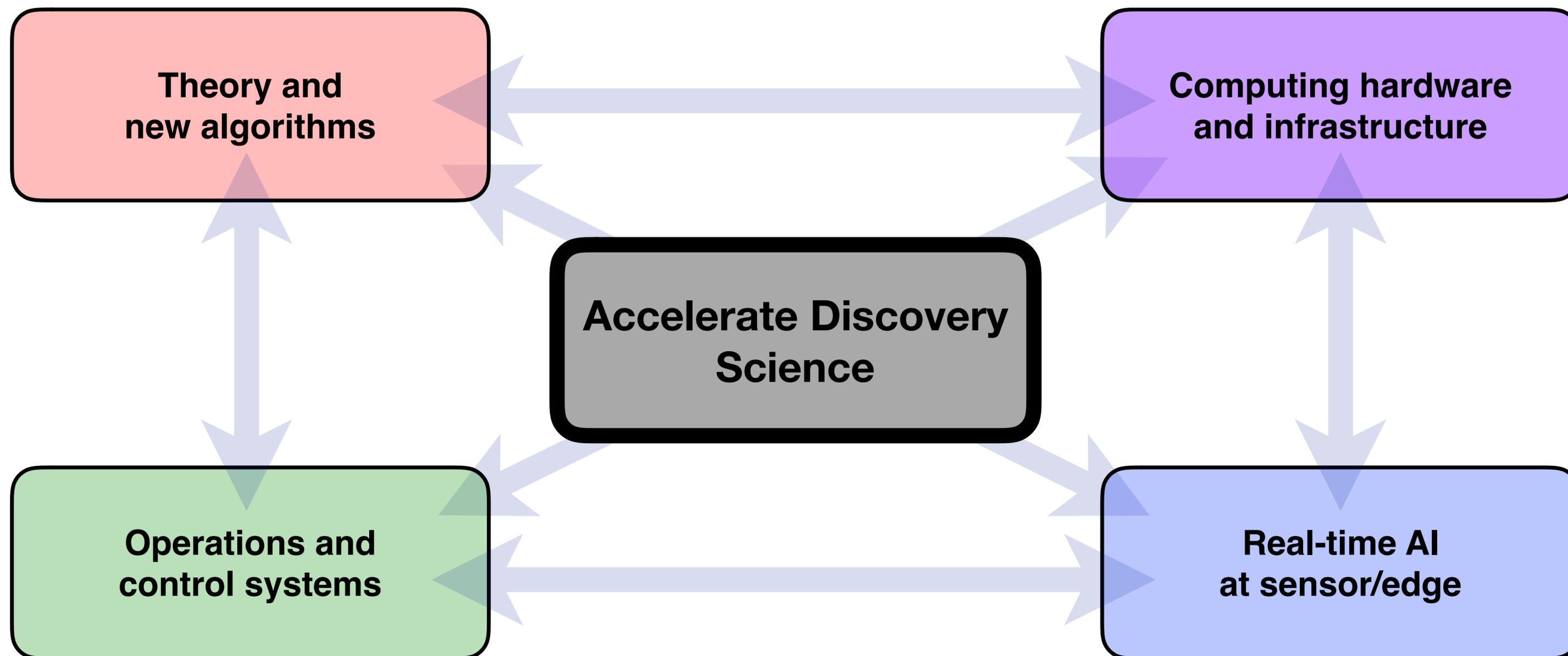
Considerations

AI Ecosystem

**Unique HEP
capabilities and
strategic AI areas**

**HEP technology
& science**

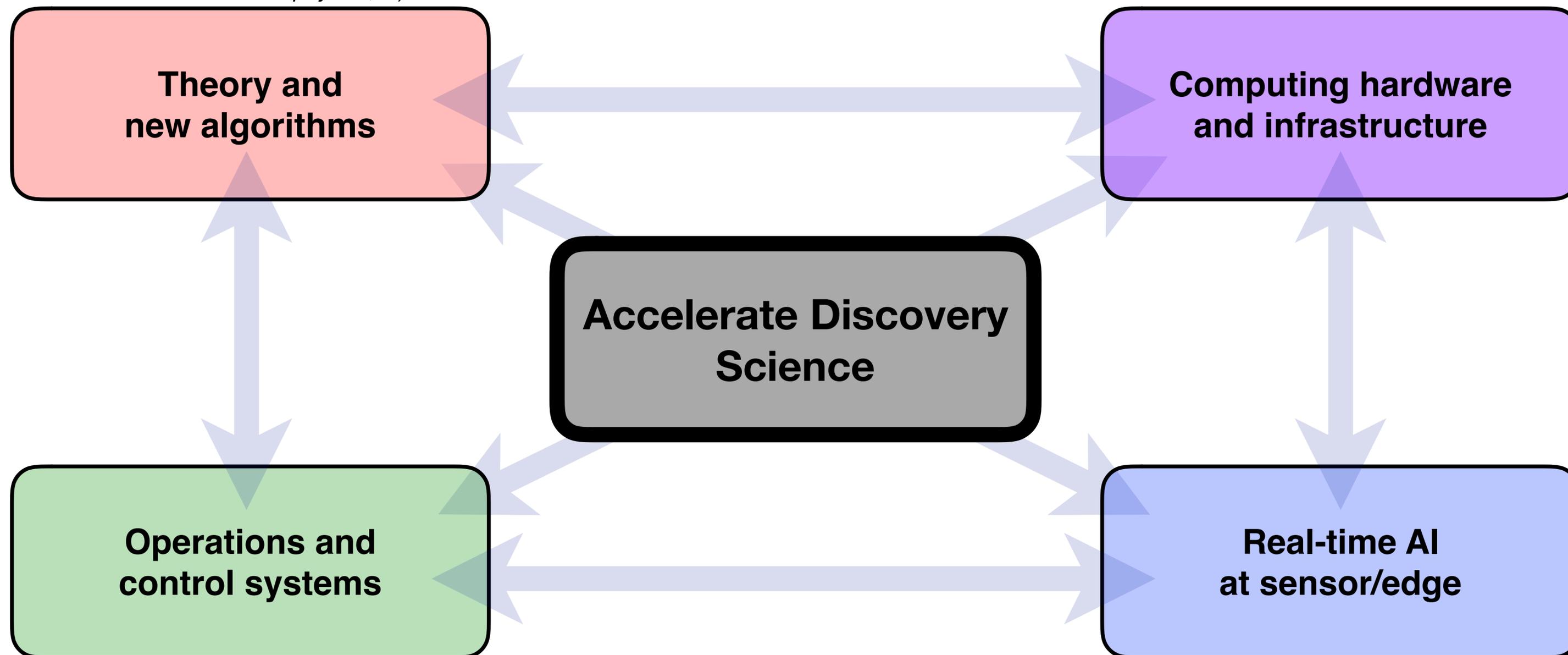
AI Capabilities for particle physics



AI Capabilities for particle physics

☑ Requirements for real science (uncertainty quantification, models with embedded physics,...)

☑ Processing and simulating massive datasets



☑ Large, integrated operations and data management

☑ Real-time processing and high-rate data acquisition edge/sensor systems

Every main element of future cosmic experiments will be accelerated by AI.

Watching the sky

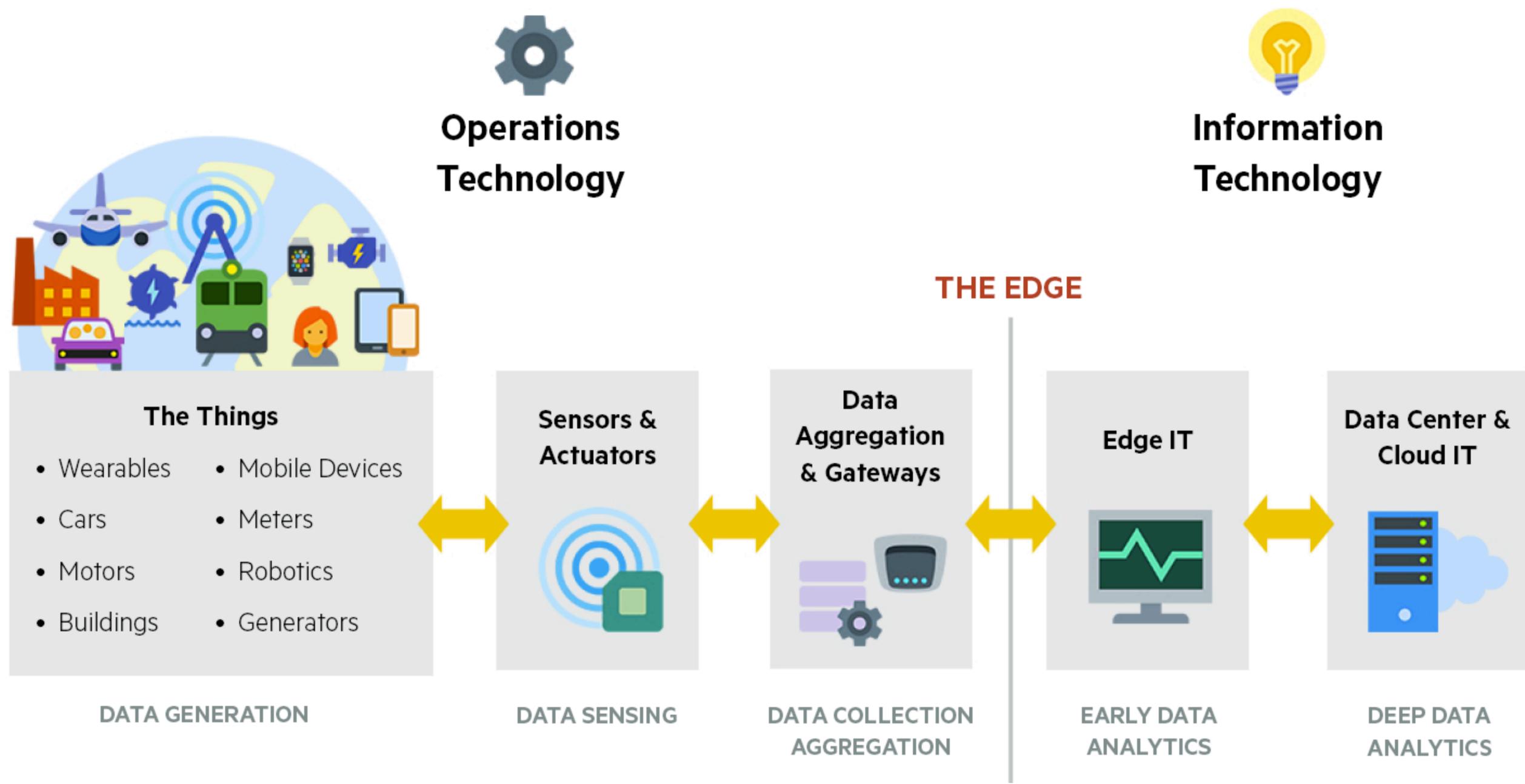


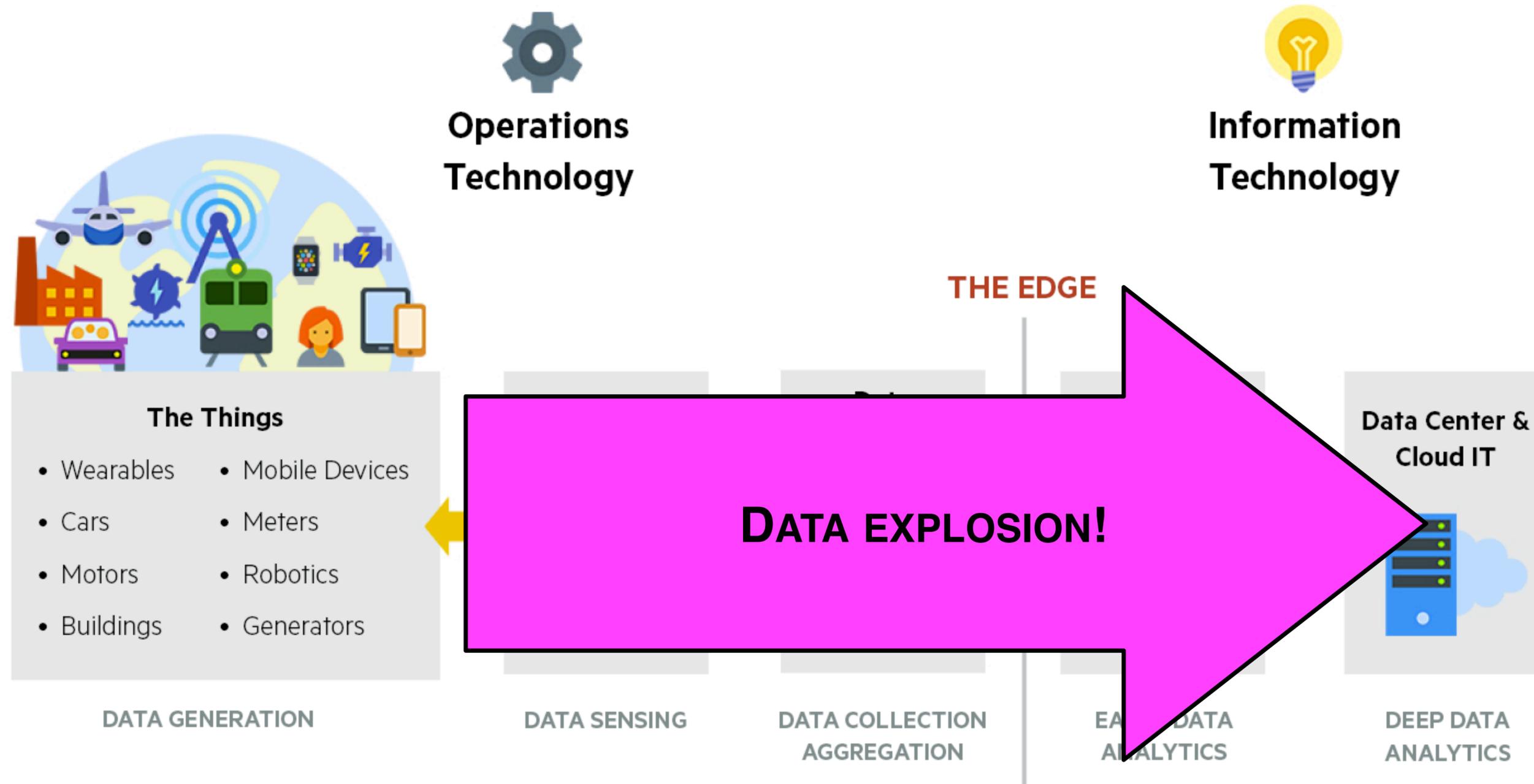
Simulating the Universe



Analyzing Galaxies





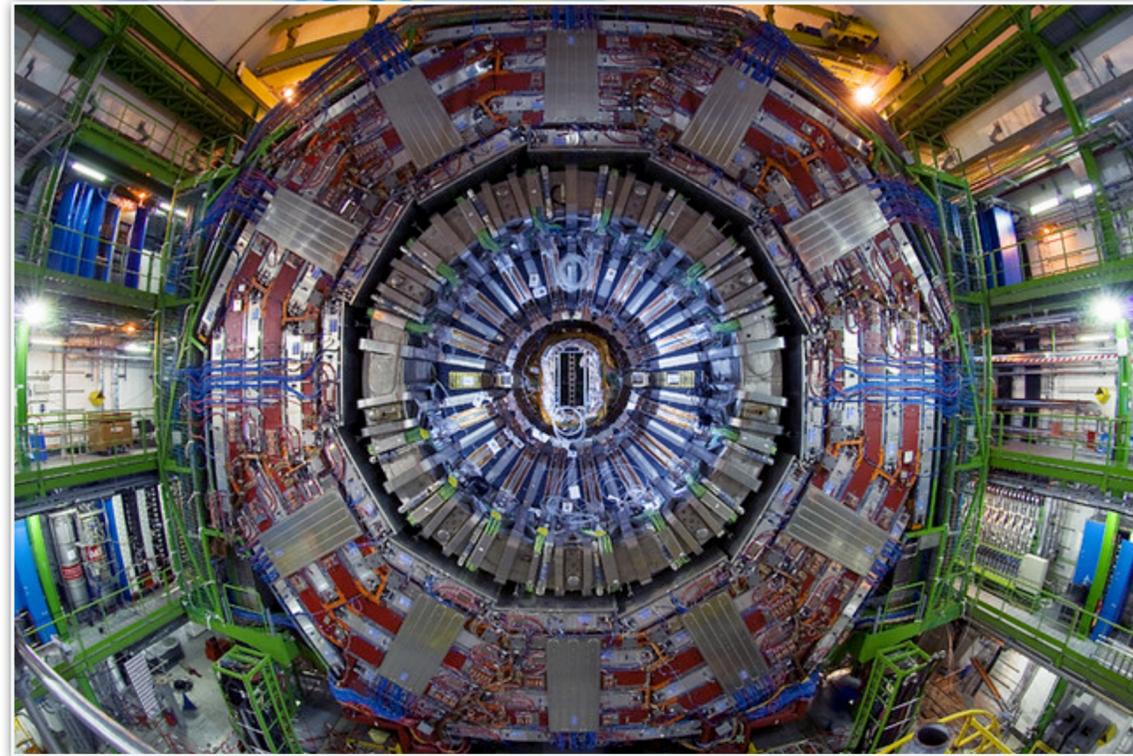


Intelligent data reduction at the sensor level is a very familiar HEP challenge




Operations
Technology


Information
Technology



DATA GENERATION

DATA SENSING

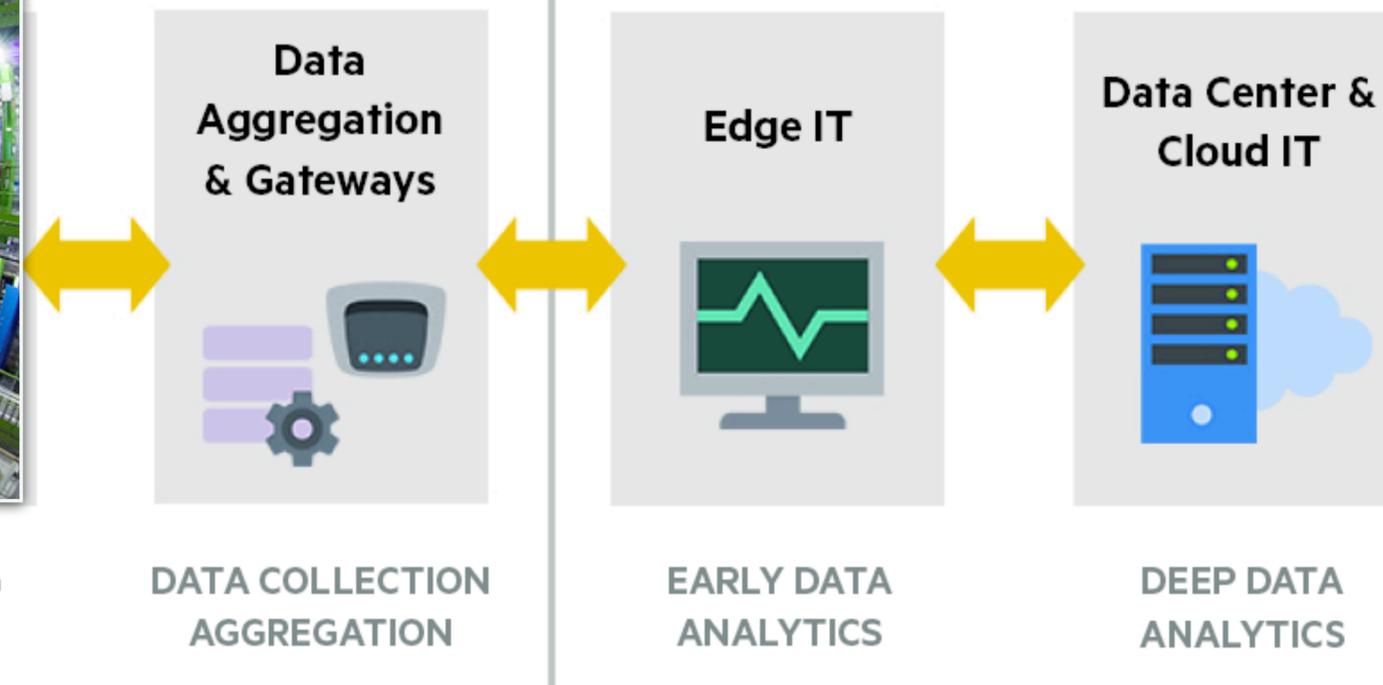
LHC at CERN

40 MHz collision rate, ~20 hrs/day

Compact Muon Solenoid (CMS)

→ > 1 billion channels

THE EDGE



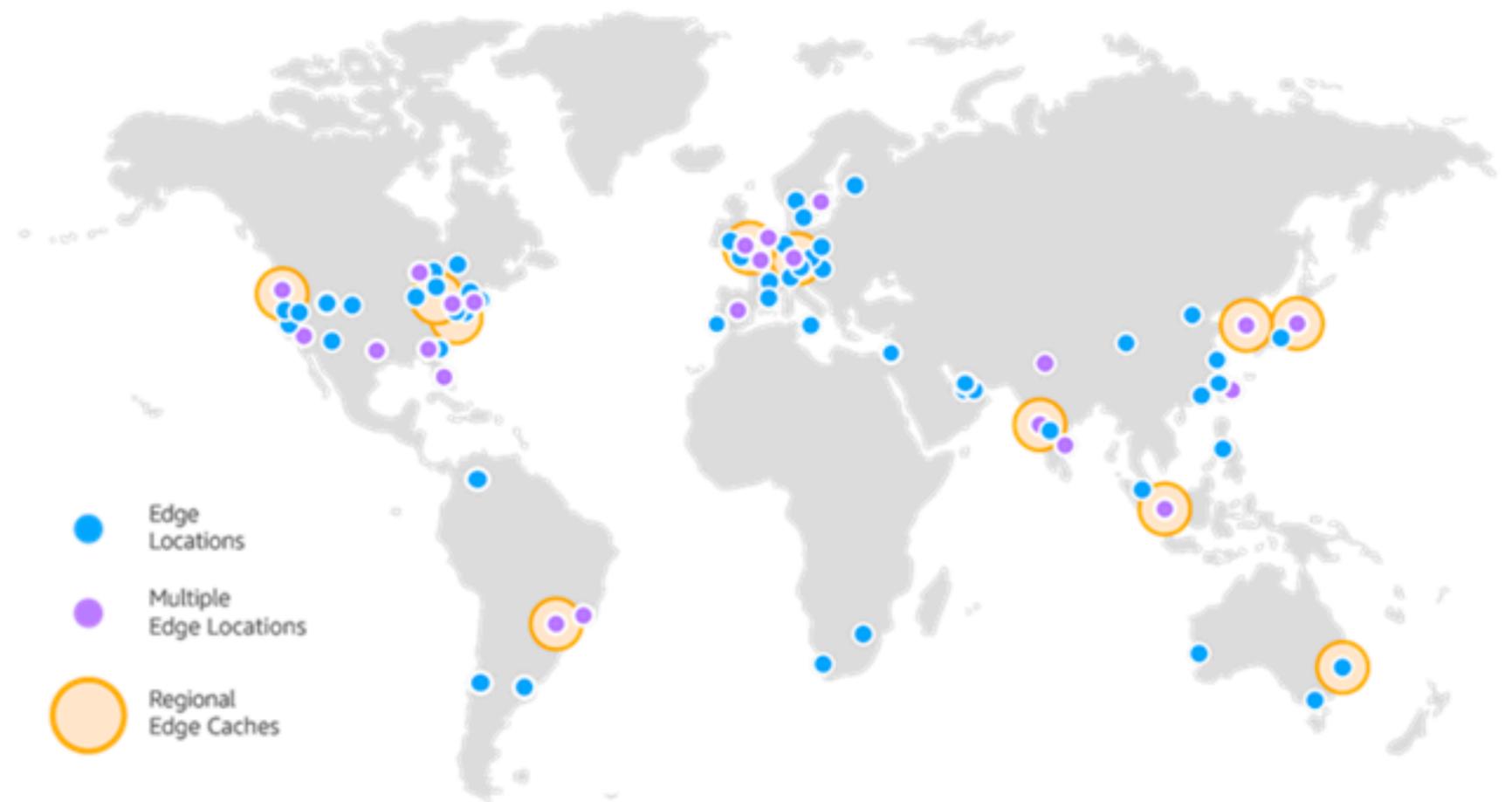
DATA COLLECTION
AGGREGATION

EARLY DATA
ANALYTICS

DEEP DATA
ANALYTICS

→
~1 PB/S

→
~1 PB/DAY



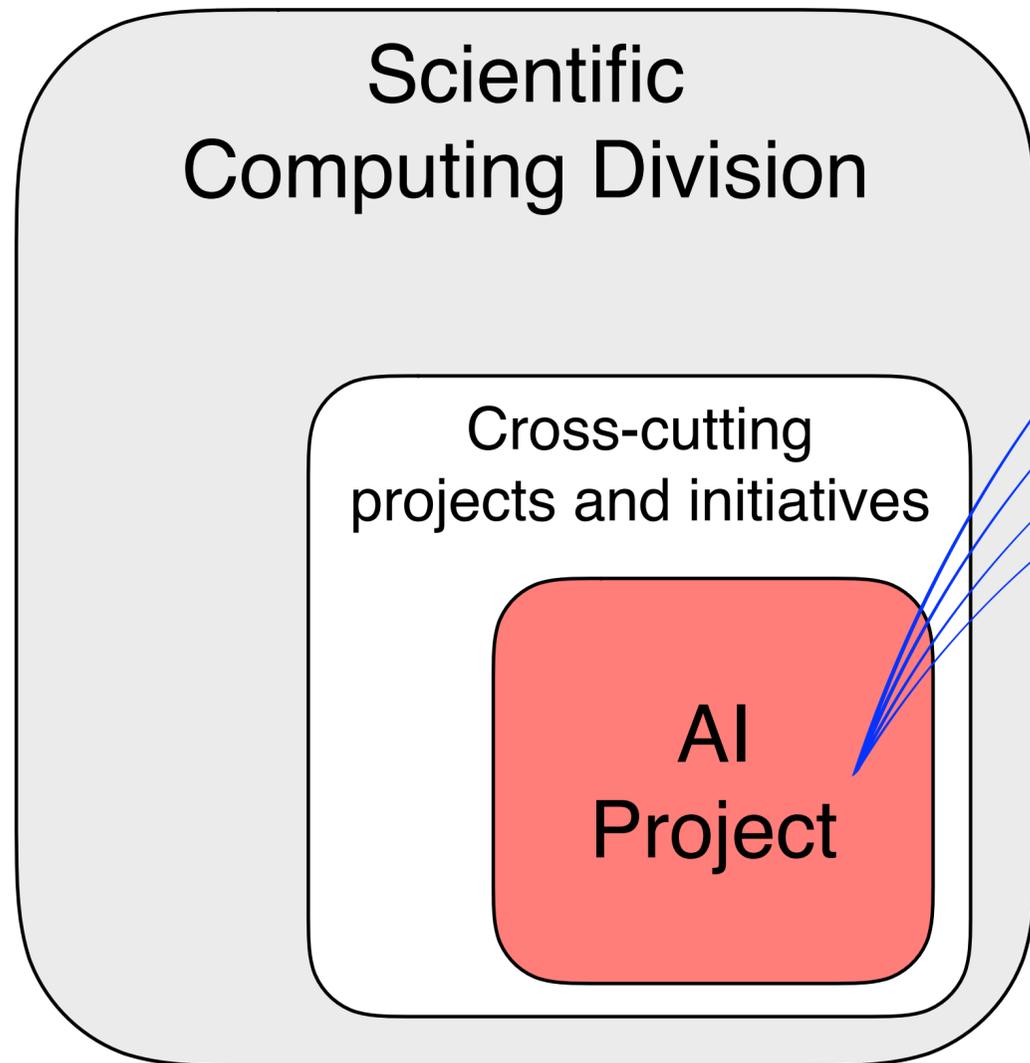
Goals for the Jamboree

- Open communication line about AI activities and applications
 - Build up a dialogue across a very diverse community!
 - One of the beauties of AI, it's a common *language* for data analysis and interpretation

Goals for the Jamboree

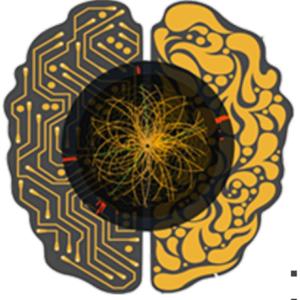
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 - One of the beauties of AI, it's a common *language* for data analysis and interpretation
- This talk: a short introduction to AI & particle physics
 - n.b. a somewhat personal perspective, form your own opinions
- ⚡ **Lightning talks:** how people are using AI to advance the scientific mission and develop AI capabilities
 - Q&A afterwards, specific or general questions
- ☁ **Idea Incubator** ... the experiment
 - Exchange ideas, talk to domain experts

The AI organization at Fermilab



Lab-wide initiative
 Formal home in SCD,
 but engaging the entire laboratory

Artificial Intelligence



Artificial intelligence has the potential to be a transformative technology that benefits nearly all aspects of society. At Fermilab, we are committed to artificial intelligence research and development investments in order to enhance the scientific mission of particle physics.

The unique challenges at the heart of high-energy physics research present opportunities for advancing artificial intelligence technologies. From massive and rich data sets to building and operating some of the world's most complex detector and accelerator systems, the technologies we are developing have potential connections to a broad domain of cutting-edge AI research.

Fermilab's Artificial Intelligence Project aims to

- Accelerate science with the goal of solving the mysteries of matter, energy, space and time
- Develop AI capabilities within the national ecosystem that build on high-energy physics challenges

and technologies

- Build community around cross-cutting problems in order to share the work of Fermilab and the high-energy physics community's AI work with the world

Project team

- Farah Fahim
- Burt Holzman
- Brian Nord
- Gabriel Perdue
- Nhan Tran, project lead
- Domain AI experts who serve as liaisons from across Fermilab

Email the project team

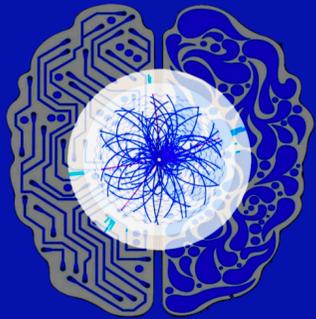
ai.fnal.gov

Fermilab AI Jamboree!

February 13, 2020

Wilson Hall, Curia II

1:00PM - 4:30PM



Agenda:

- Overview of AI & HEP
- Example applications
- Panel Q&A
- Idea Incubator

LEARN MORE

Find out about the connections between HEP & AI and a few on-going applications across Fermilab

Local Organization:

- Aisha Ibrahim
- Kyle Hazelwood
- Burt Holzman
- Marco Mambelli
- Brian Nord
- Bill Pellico
- Gabriel Perdue
- Jason St. John
- Nhan Tran

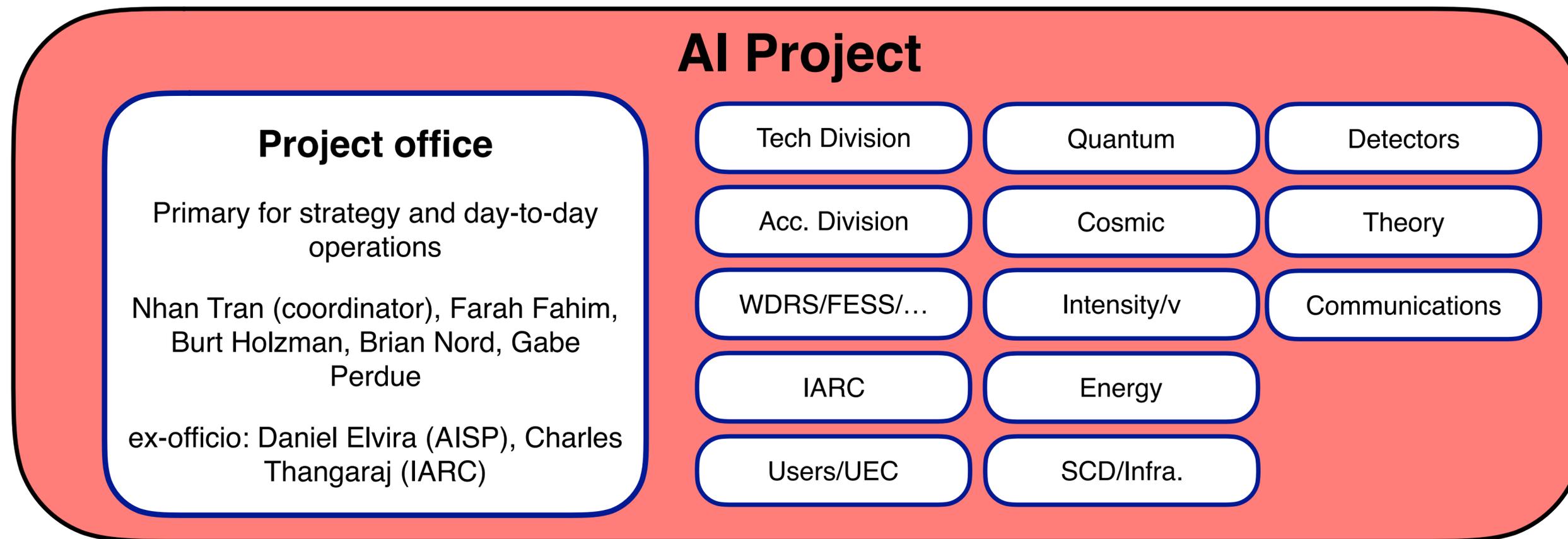
IDEA INCUBATOR

Stick around for coffee and snacks, and share your AI work or discuss your interesting applications with experts and enthusiasts by making an AI flyer!

Learn more and register at indico.fnal.gov/event/23008

Jamboree in conjunction with PI week (Feb. 17 - Feb. 21)

The AI initiative



Liaisons: link across the laboratory

Our goals

Questions? Email: ai@fnal.gov

- **Help you to deploy AI solutions for your applications**
 - Enabling AI to accelerate our science
- **Make AI accessible**
 - Seminars and tutorials
 - Connect with experts and like-minded applications
 - Provide computing resources, e.g. GPUs
- **Share your AI successes with the world!**