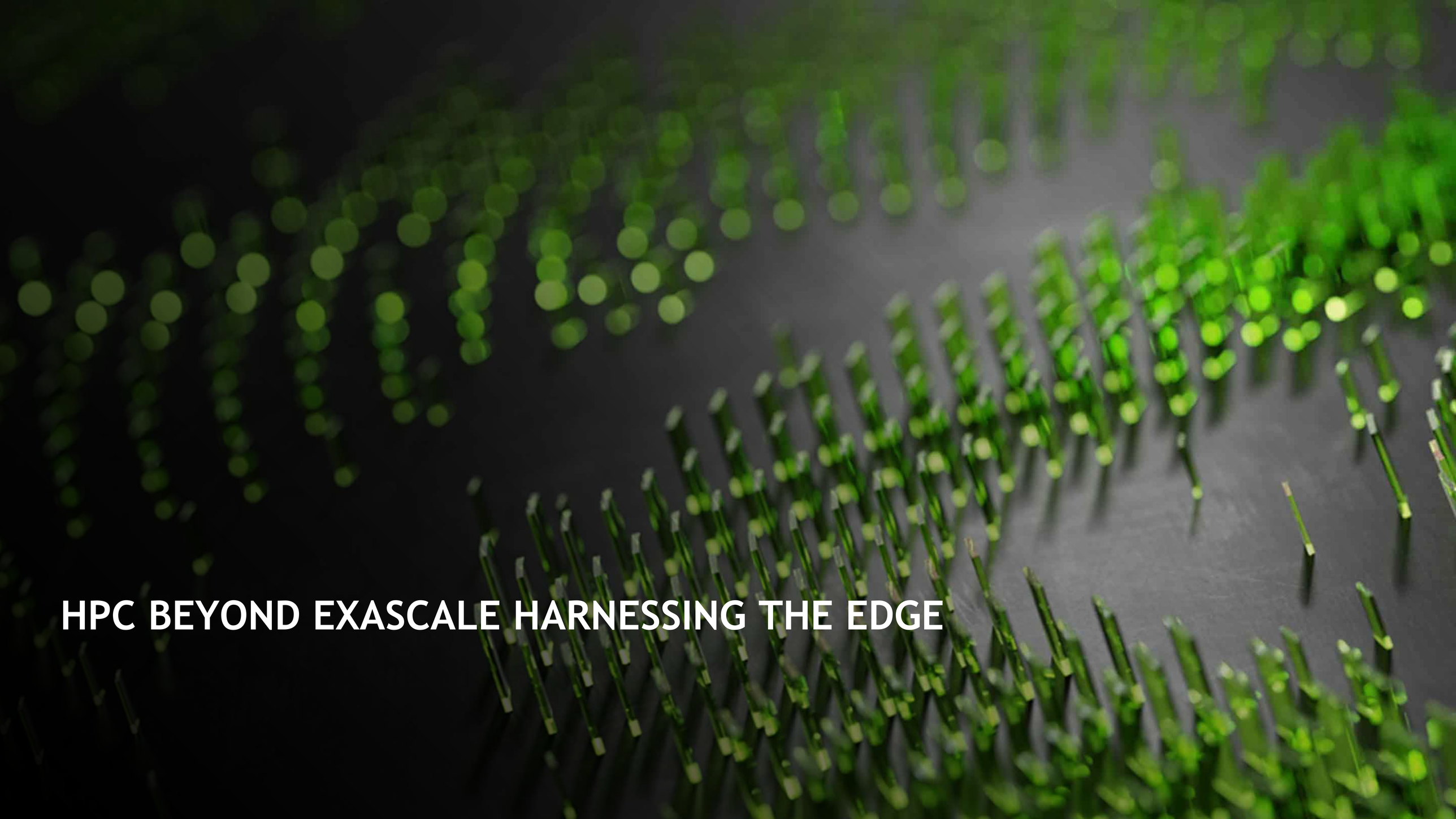
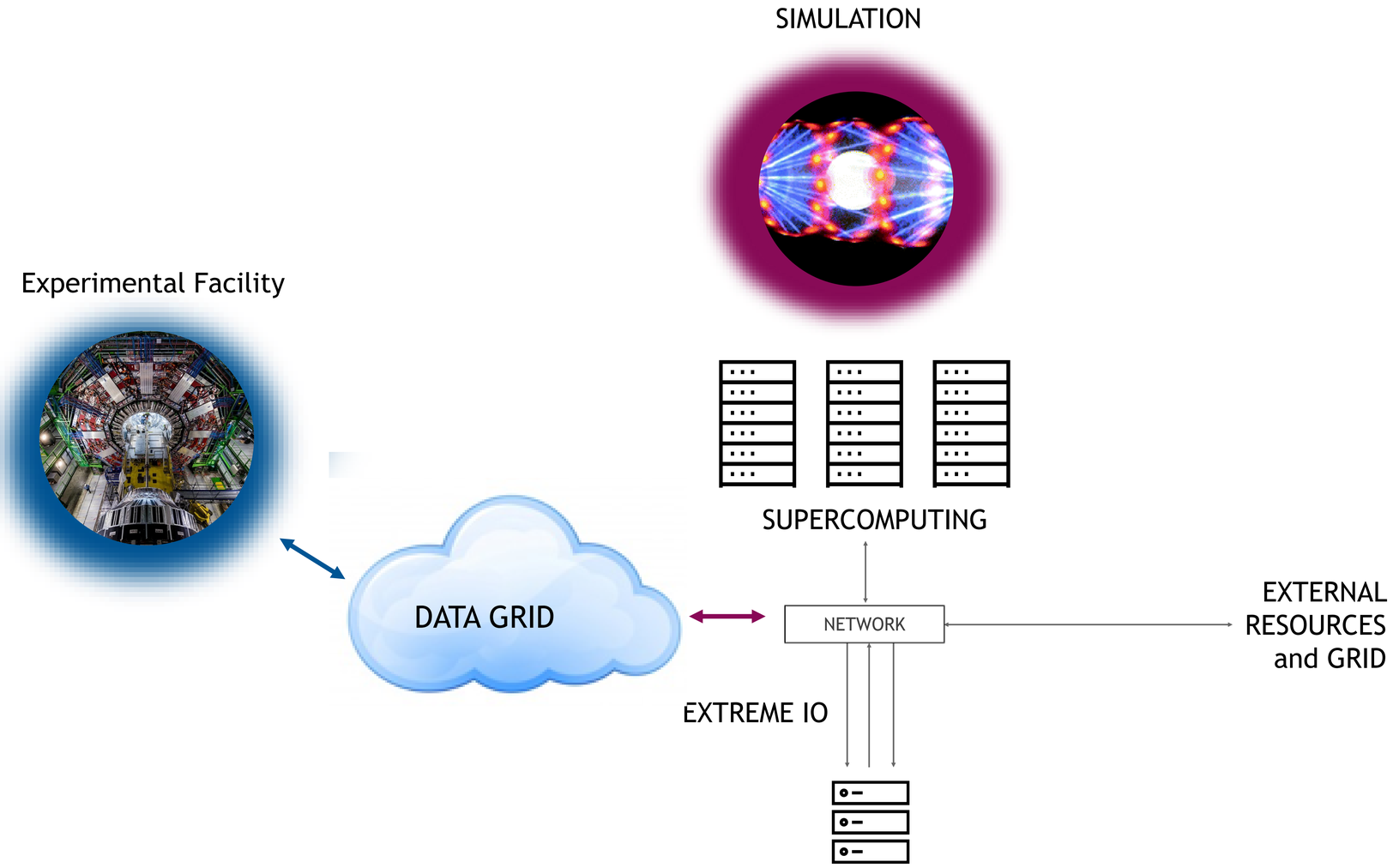
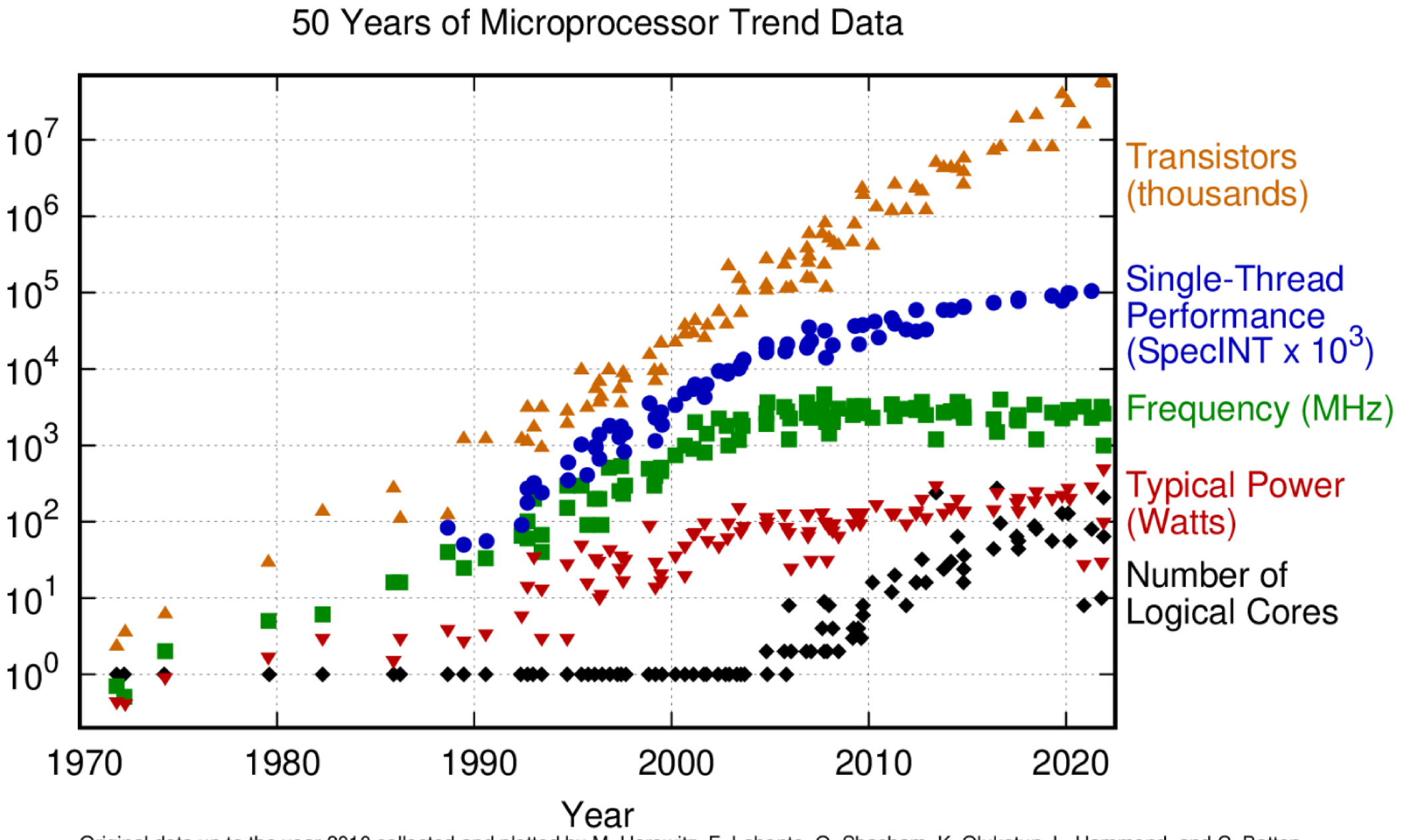

HPC BEYOND EXASCALE HARNESSING THE EDGE

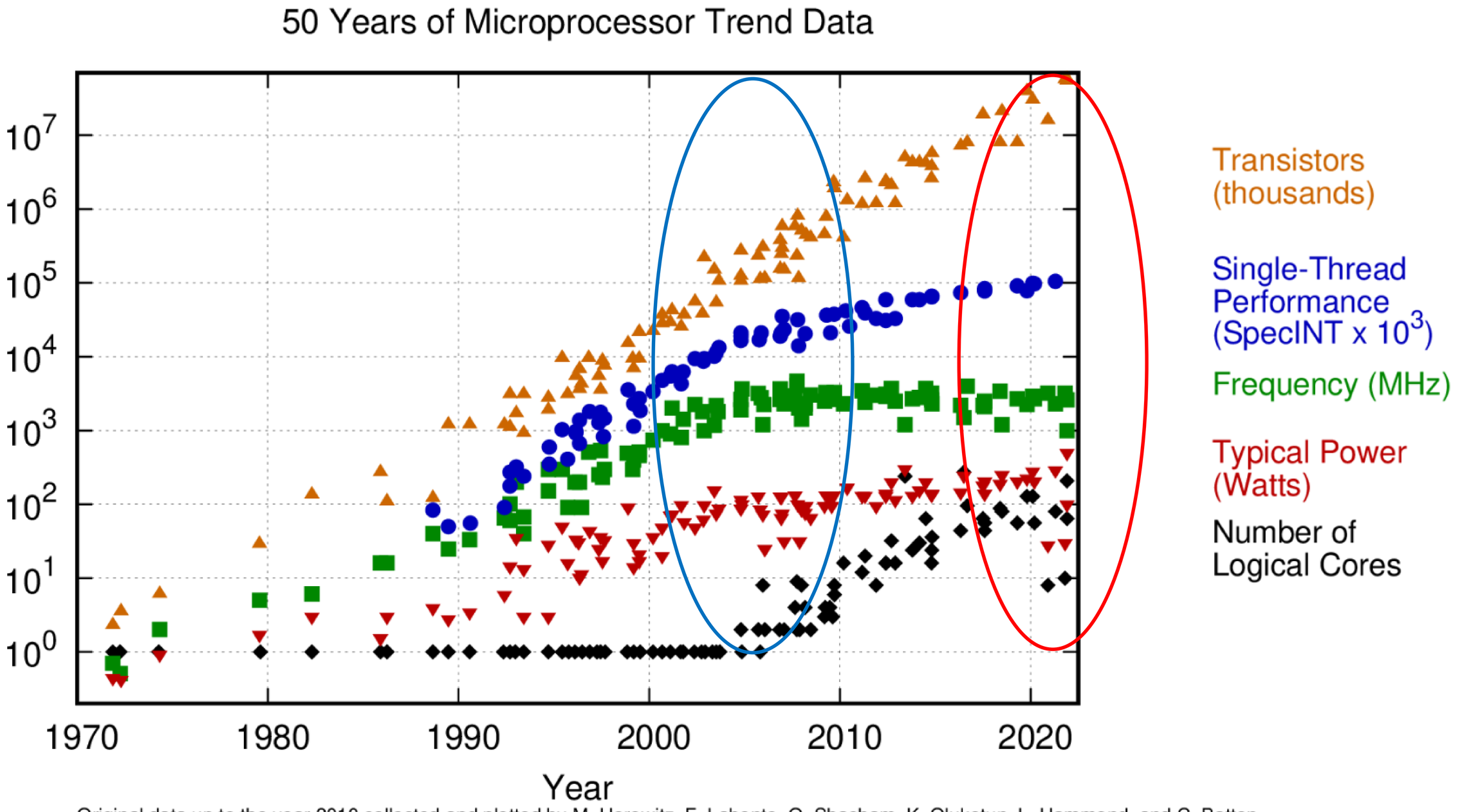
TRADITIONAL HPC ECOSYSTEM





Original data up to the year 2010 collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond, and C. Batten
New plot and data collected for 2010-2021 by K. Rupp

NVIDIA.



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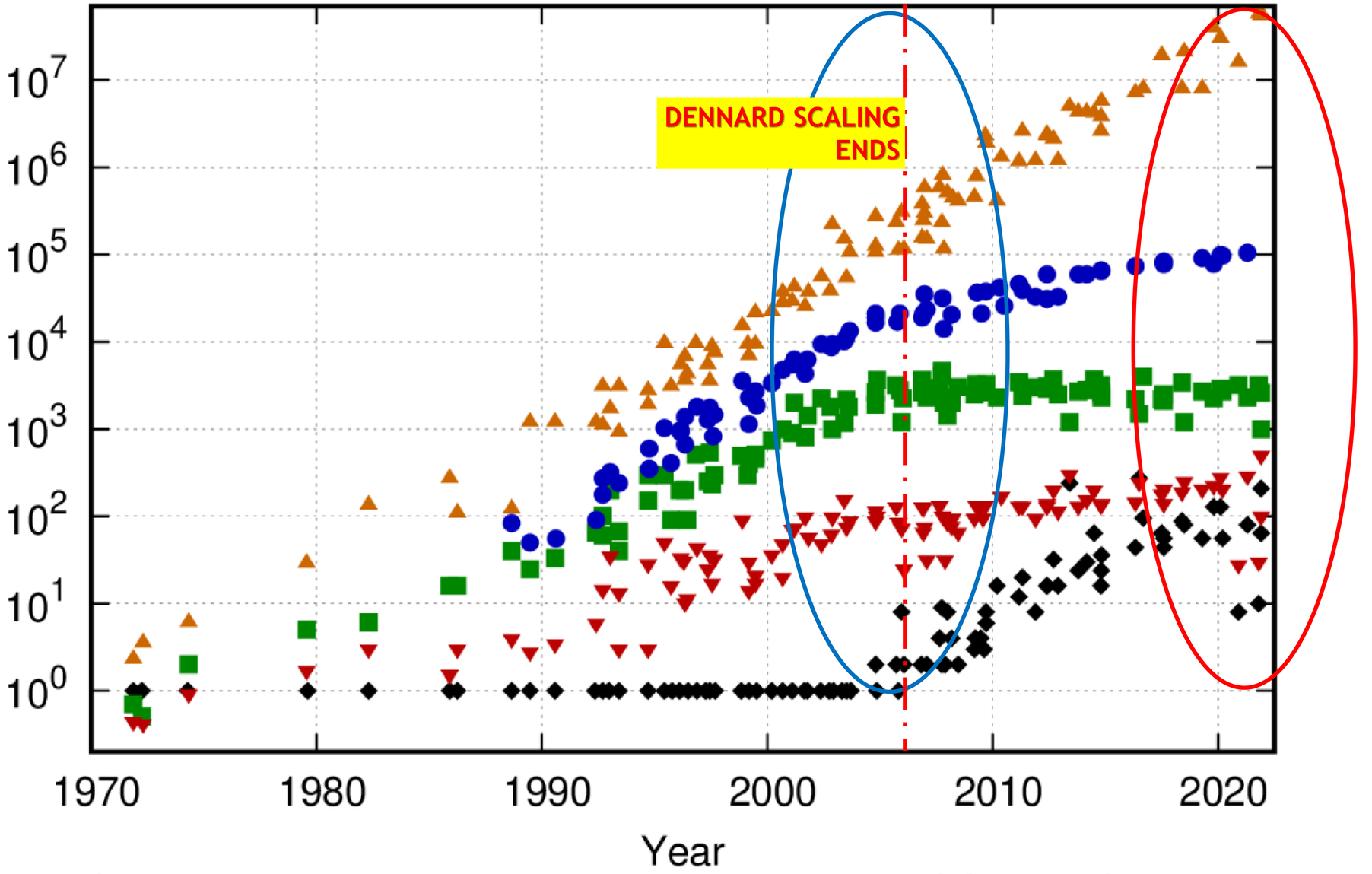
NVIDIA.

50 Years of Microprocessor Trend Data



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NVIDIA.

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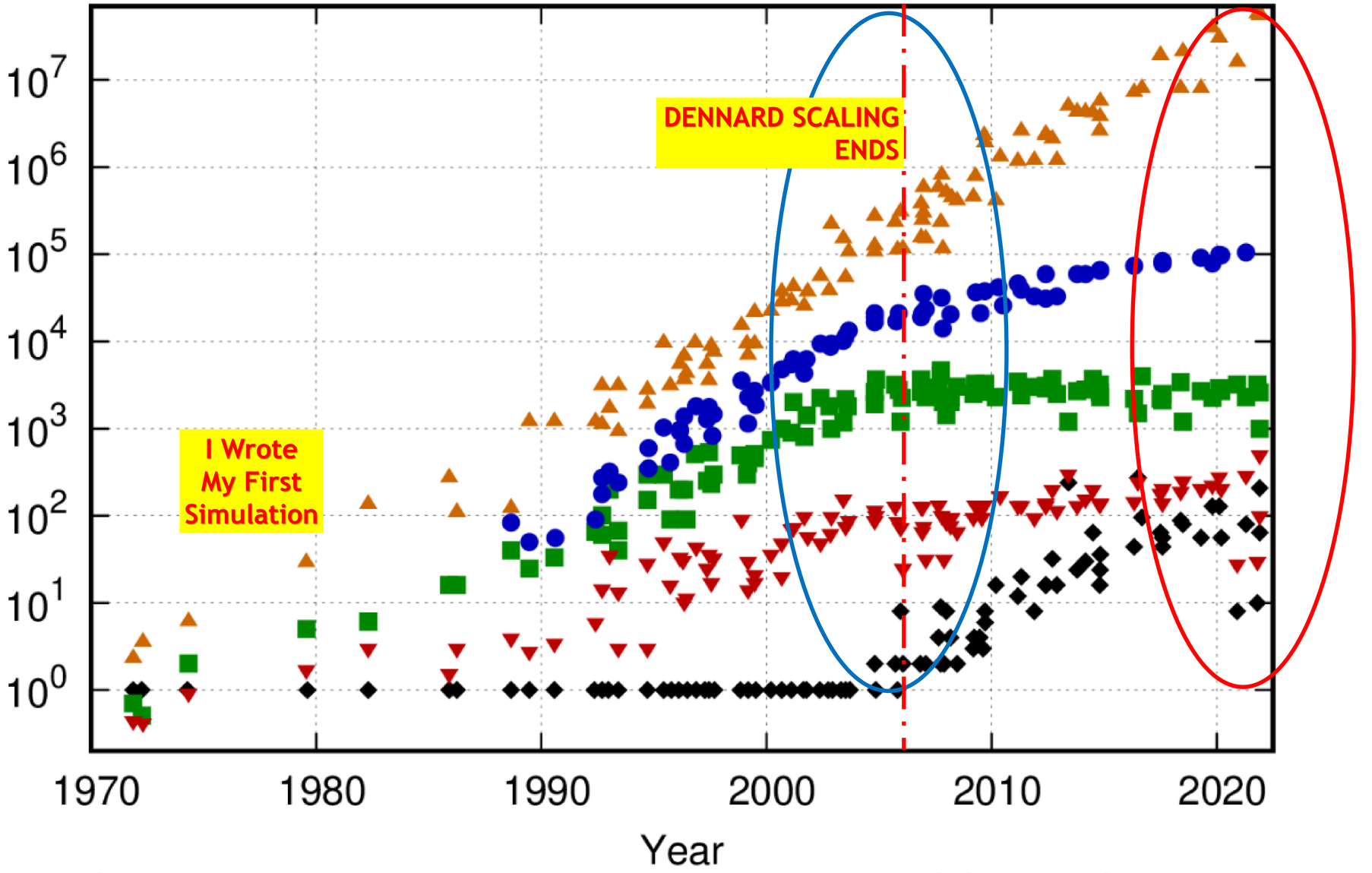

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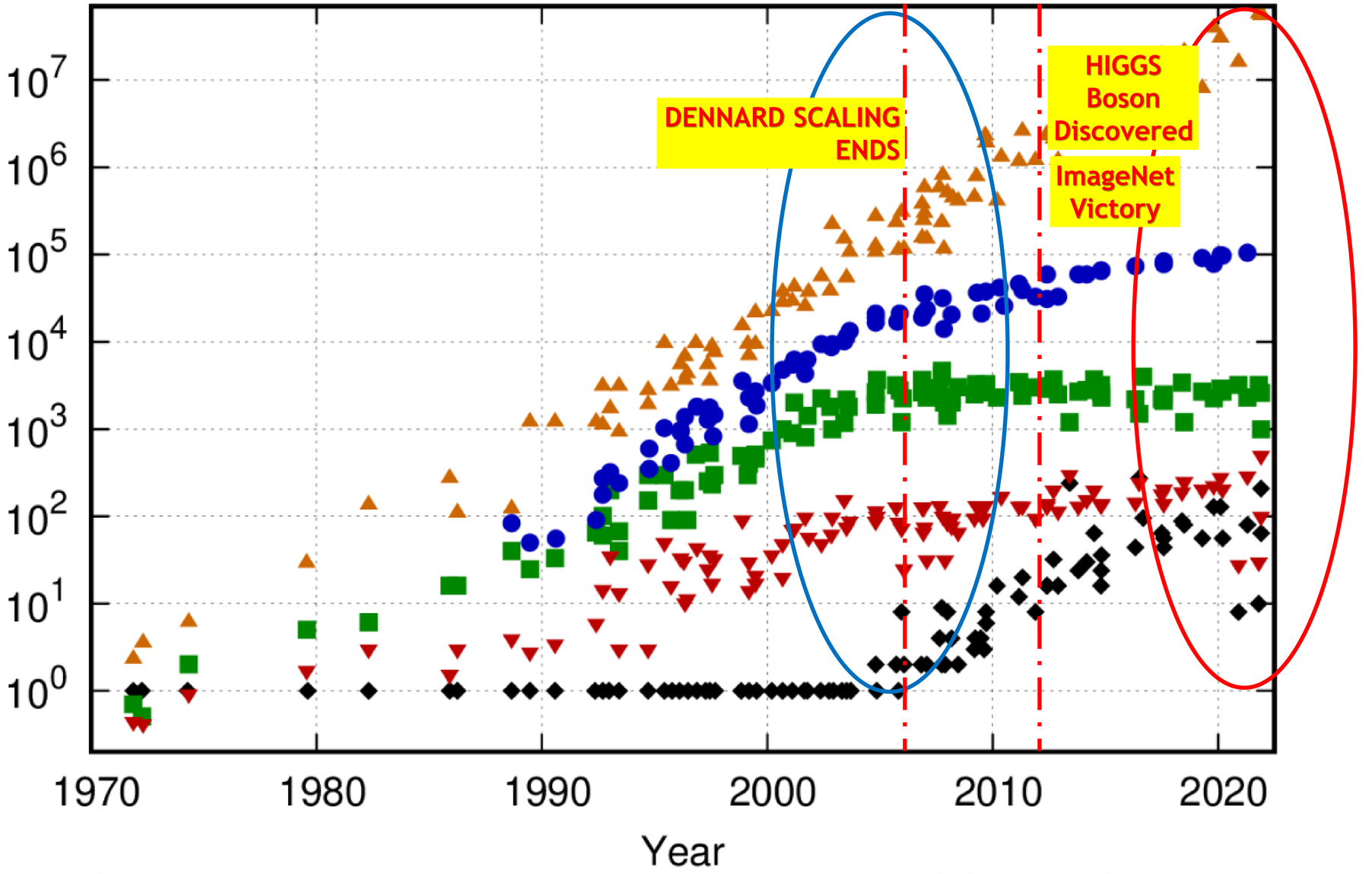

Transistors (thousands)

Single-Thread Performance (SpecINT x 10^3)

Frequency (MHz)

Typical Power (Watts)

Number of Logical Cores

Original data up to the year 2010 collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond, and C. Batten
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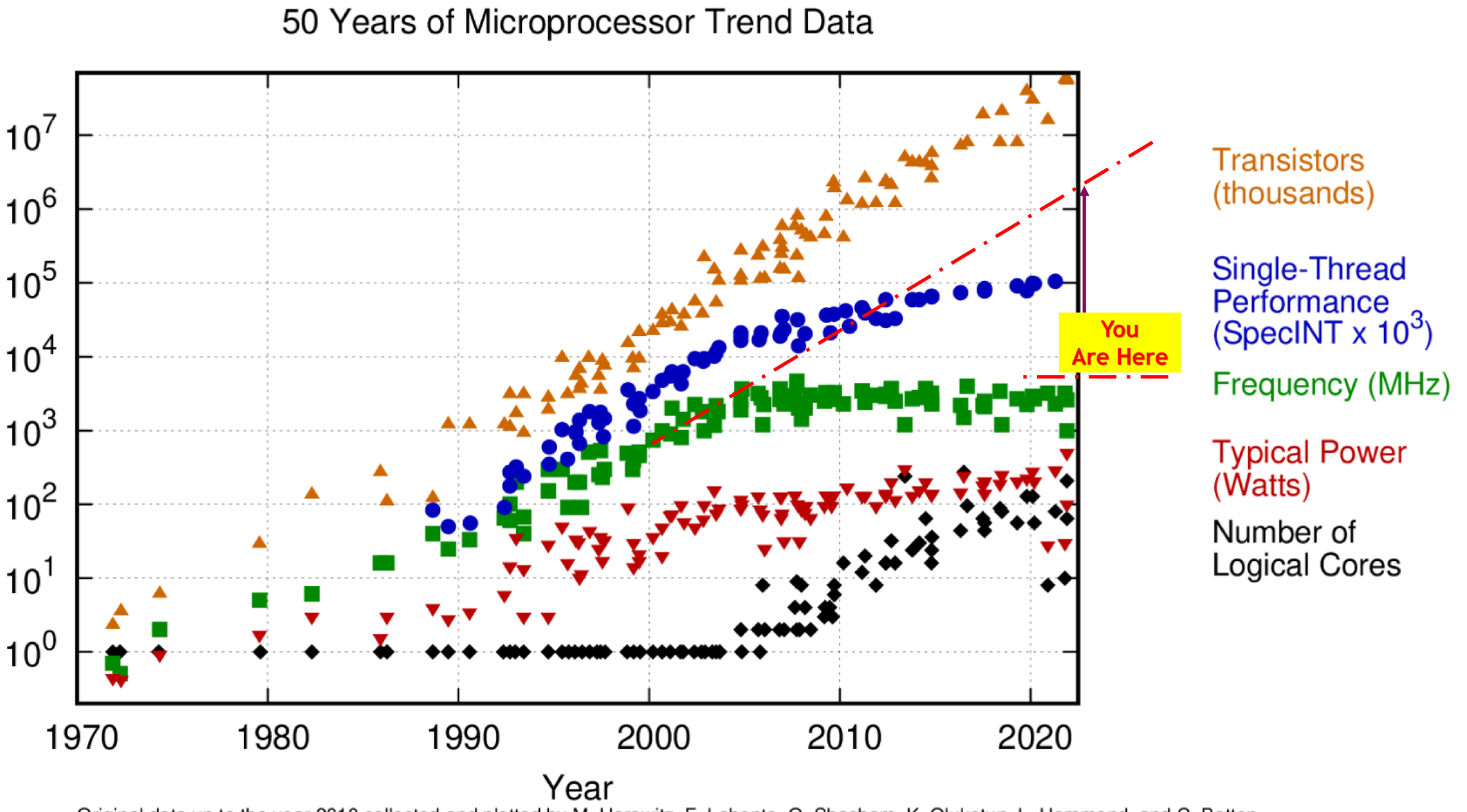
NVIDIA.


50 Years of Microprocessor Trend Data
10^7
10^6
10^5
10^4
10^3
10^2
10^1
10^0
1970
1980
1990
2000
2010
2020
Year
You Are Here
Transistors (thousands)
Single-Thread Performance (SpecINT x 10^3)
Frequency (MHz)
Typical Power (Watts)
Number of Logical Cores
Original data up to the year 2010 collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond, and C. Batten
New plot and data collected for 2010-2021 by K. Rupp

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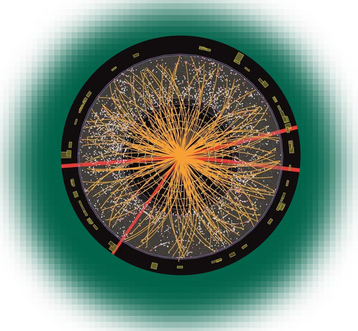
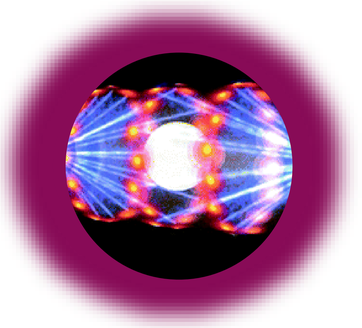
EXPANDING UNIVERSE OF HPC

EDGE

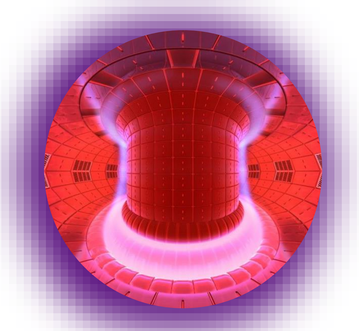
HPC * AI



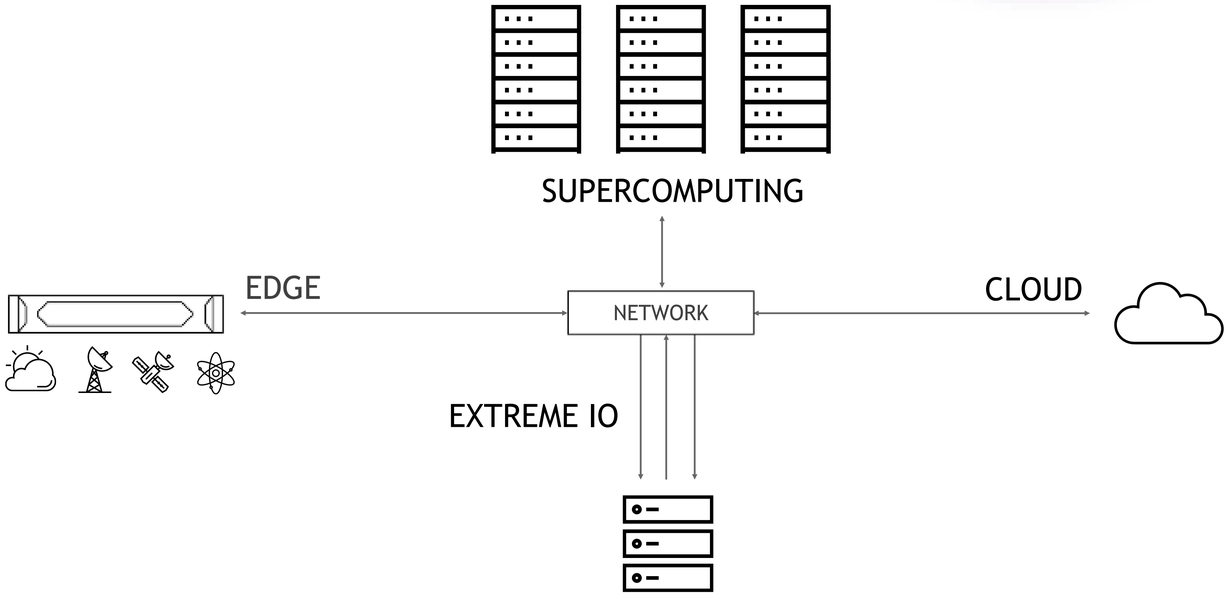
SIMULATION



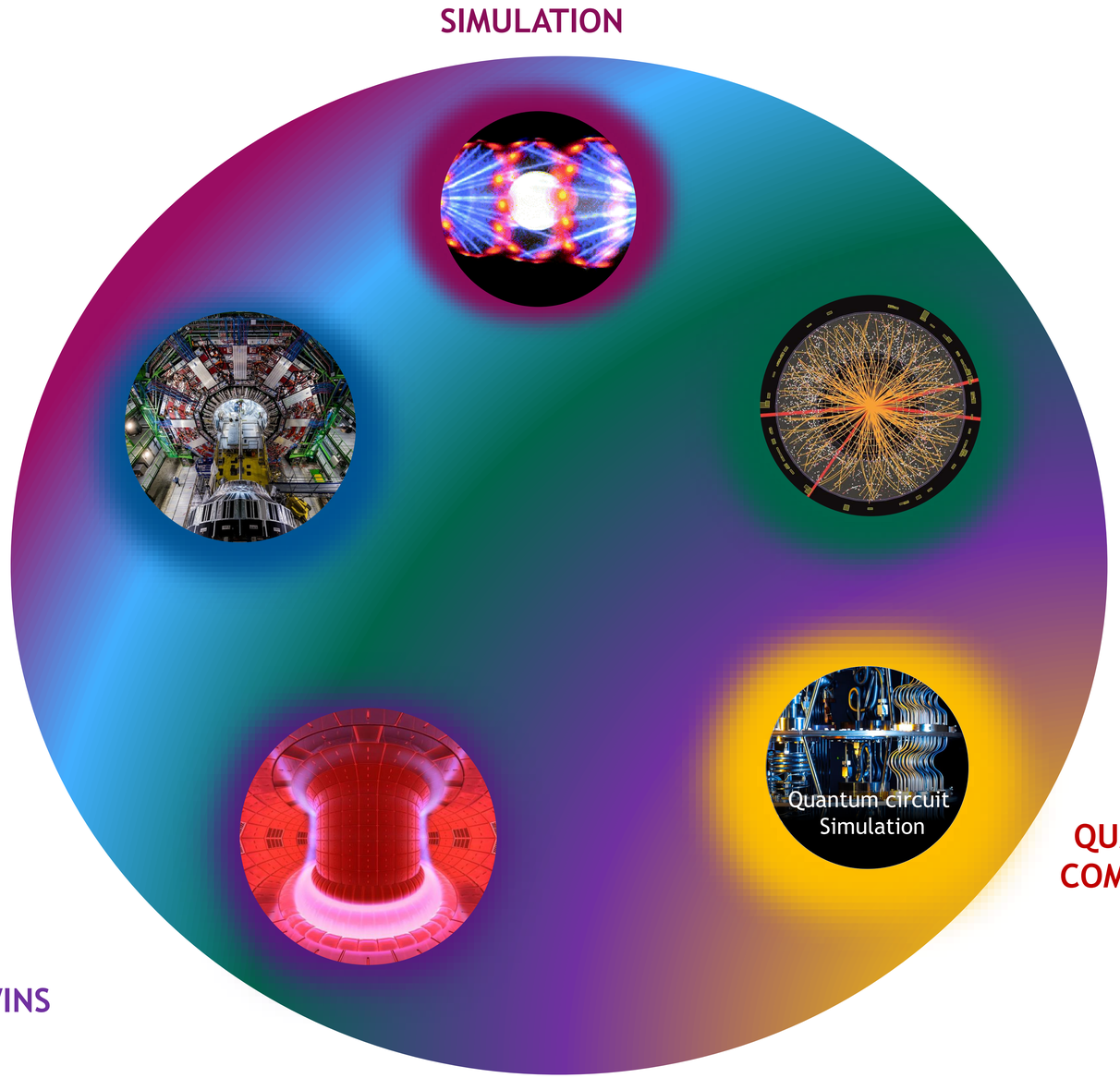
DIGITAL TWIN



QUANTUM COMPUTING



COMPOSITE WORKFLOWS EMERGE TO SOLVE GRAND CHALLENGES



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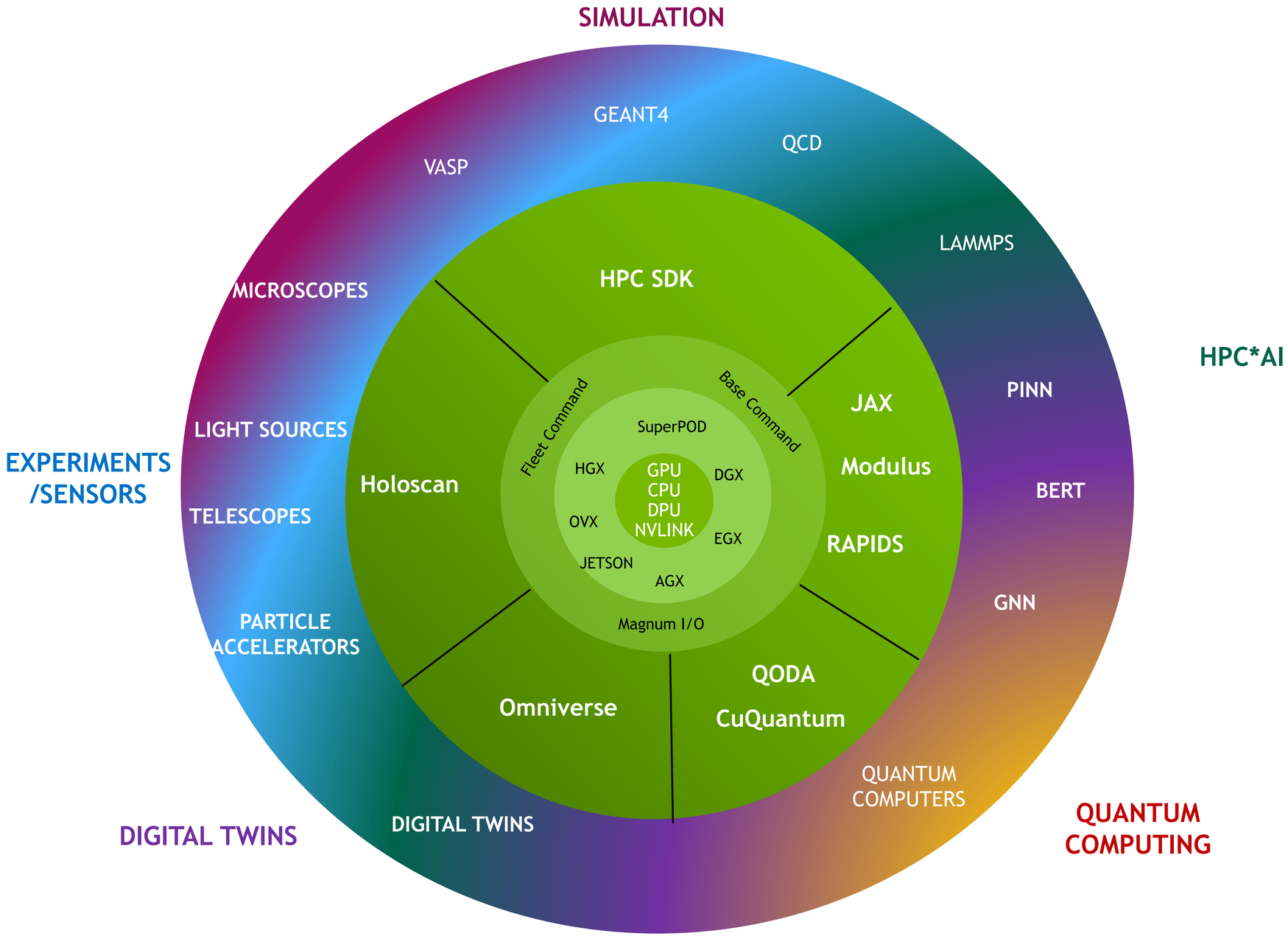
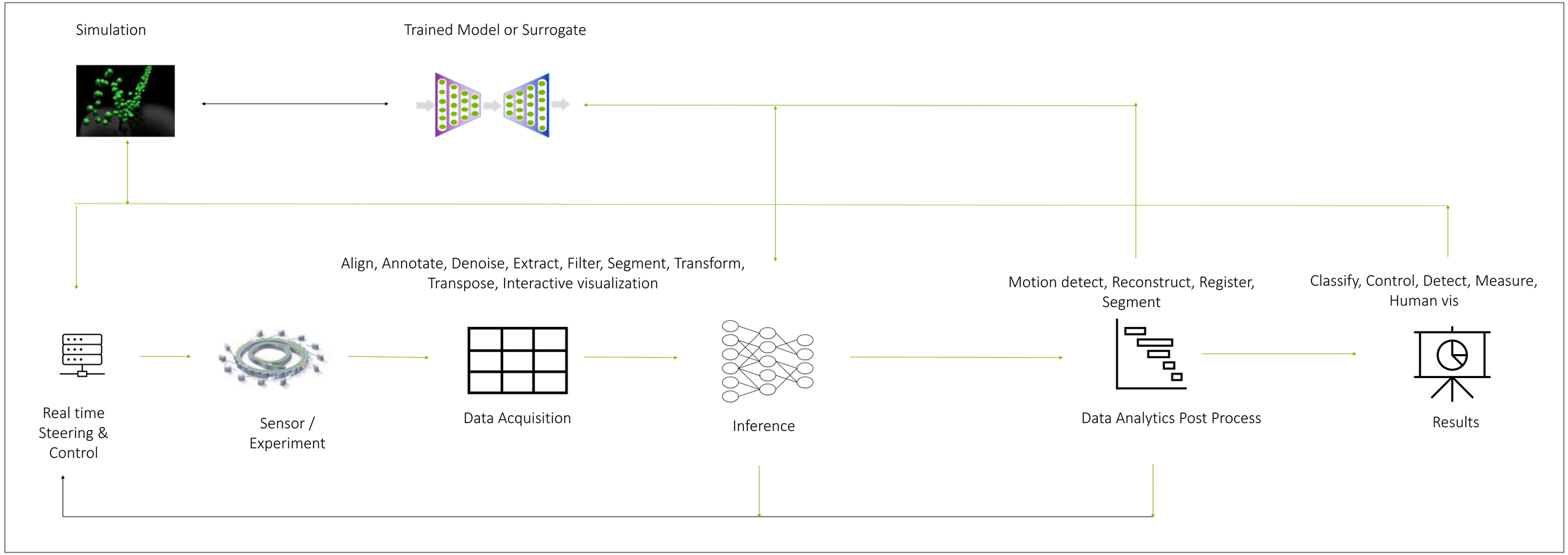
NVIDIA ROADMAP EVOLVING TO MEET THE CHALLENGE



SIMULATION & EXPERIMENT INTEGRATED WITH ML & AI



Integrated workflow with real-time analysis, steering and visualization for human in the loop

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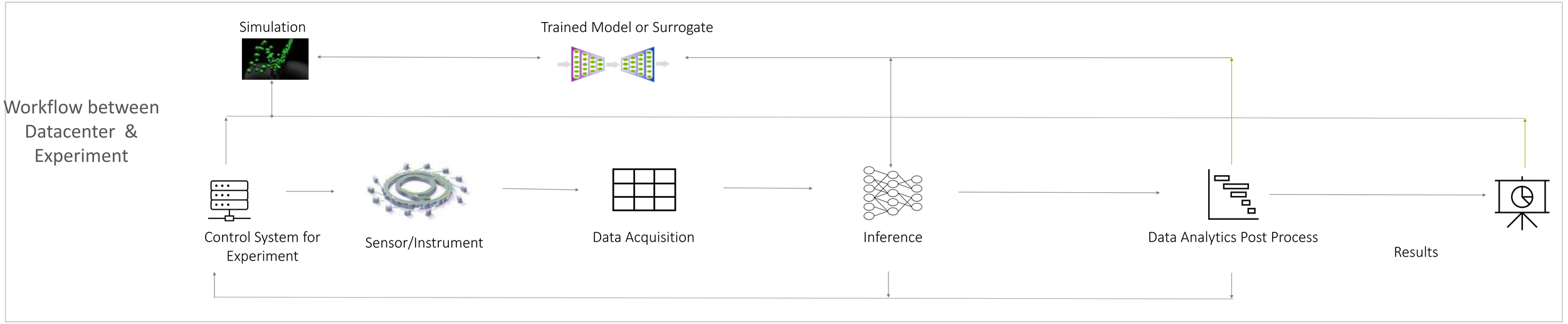
GLOBAL ENGAGEMENTS ON CONVERGED WORKFLOWS



Workstreams | Instrument to Edge ⟷ Data Transmission ⟷ Sim + DM/A + AI

ALS/LBNL

Optimizing Ptychography pipeline

CNMS/ORNL

Automating Microscopy

DIAMOND LS UK

Accelerated ptychography and tomography

DIII-D/GA

AI surrogate, Simulation, Control Digital Twin

LHCb/CERN

Design complete for using NVIDIA A40 for HLT

HED Physics/LLNL

HRR HED laser plasma experiments workflow

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EXPANDED ECOSYSTEM CHALLENGES

10X – 100X MORE DATA

50+ GIANT SCALE INSTRUMENTS WW

ELT ESO

ALS @LBNL

LIGO

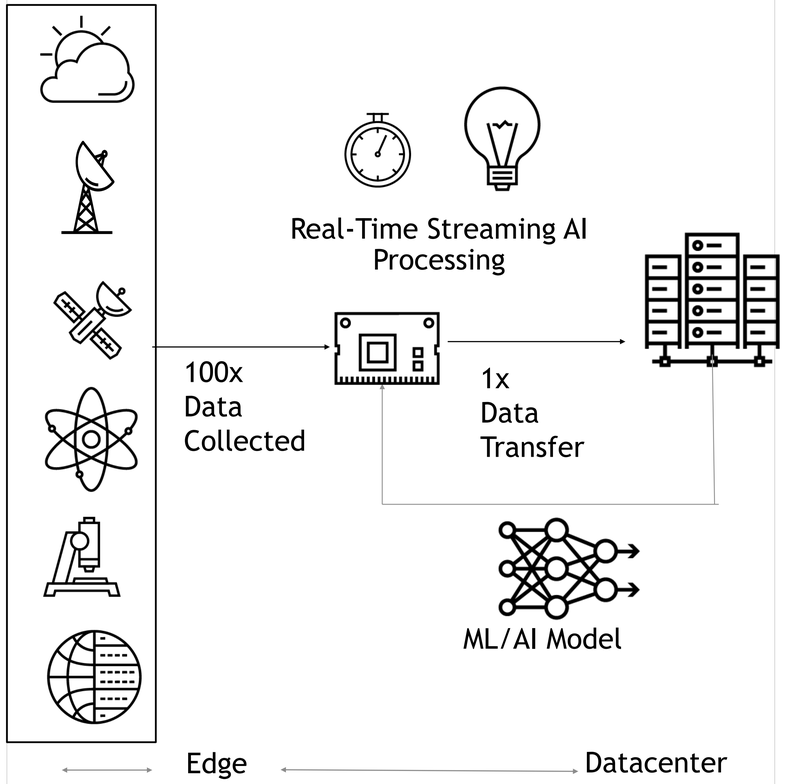
APS @ANL

SKA

Diamond, UK

AI SUPERCOMPUTING AT THE EDGE

ENABLES REAL-TIME INSIGHTS AND CONTROL



STREAMING DATA POSES NEW CHALLENGE

FOR DATA SCIENTISTS, RESEARCHERS AND DEVOPS

Streaming Data Performance

Developer Ease-of Use

Easily Scale Implementation

Combining multiple datastreams

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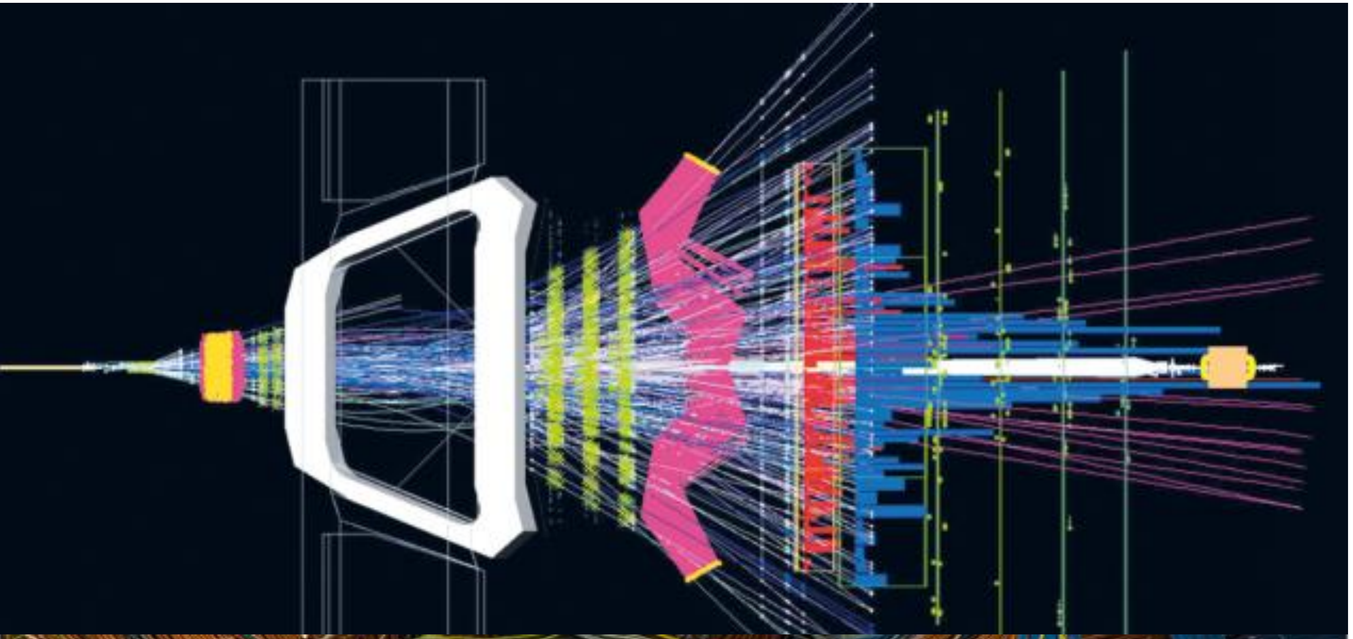
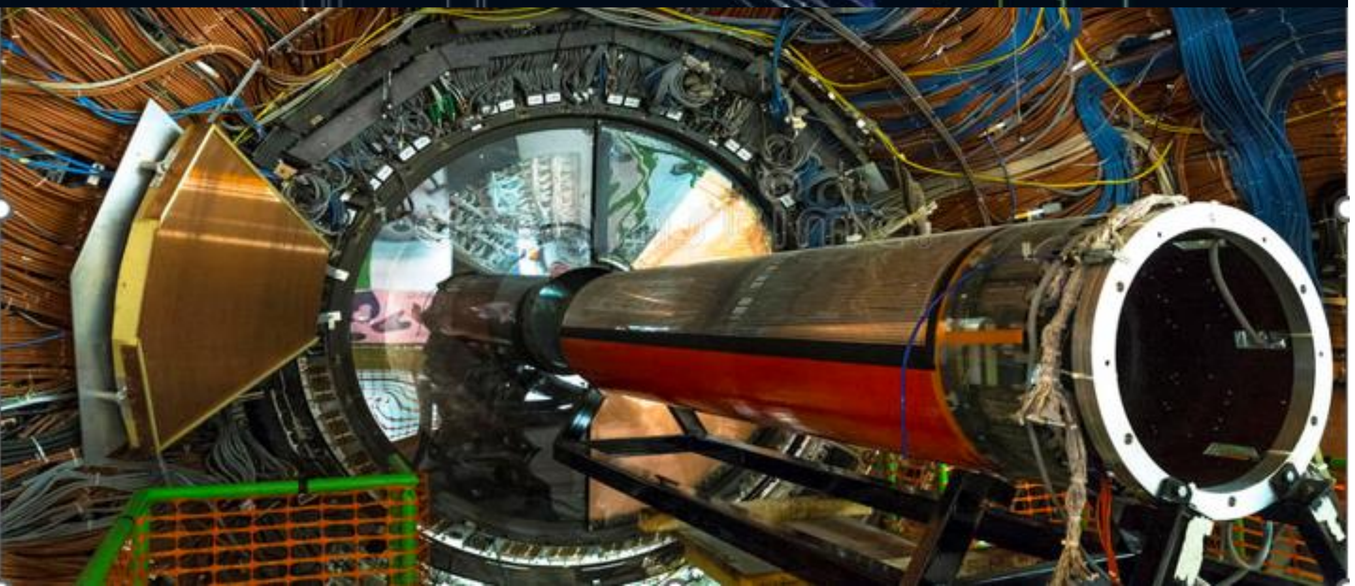
LHCB INTRODUCES ALLEN FOR REAL TIME TRIGGER AND TRACKING AT THE EDGE





Challenge
Apply conventional FFT and KALMAN Filter methods to perform trigger and tracking in the same process step for the LHCb Upgrade

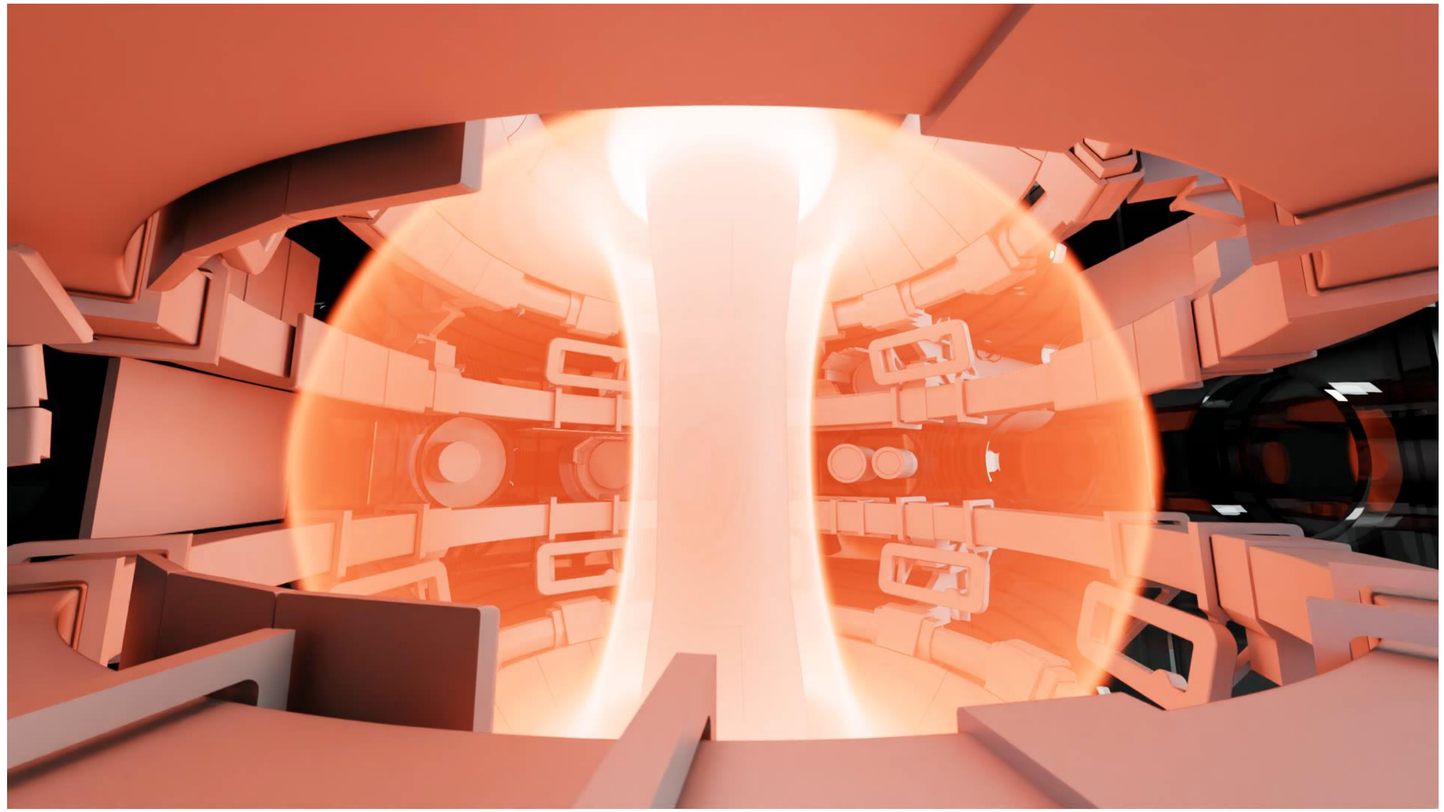
Solution
An optimized suite of algorithms was developed by CERN with support from NV to

Impact
Throughput with trigger and tracking of >60kHz was demonstrated

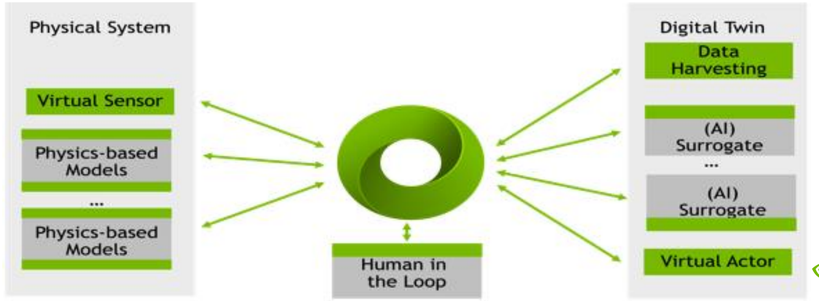
The full experiment can be supported with 500 GPUs

Run 3 commenced this quarter with 10x processing throughput

GYROKINETIC FUSION REQUIRES THE EXPANDED ECOSYSTEM AT THE EDGE

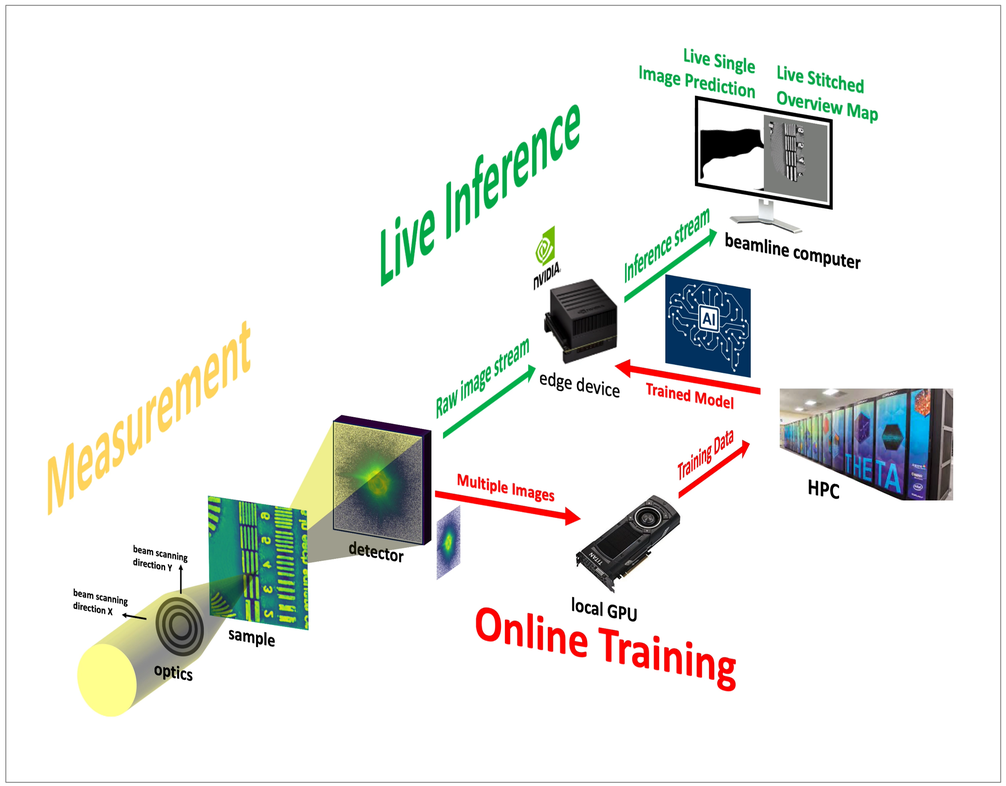


- Accelerated Simulations
  - GTC, XGC, GENE, CGYRO … 10x + unaccelerated
- Surrogate Models
  - SGTC six orders of magnitude faster than GTC
  - QualikNN 4 orders of magnitude faster than Qualikiz
- Control System Prediction for Disruption at the Edge
  - At DIII-D
  - FRNN 86% accuracy based on diagnostics from JET experiment with live testing at DIII-D underway
  - GatedRNN and Random Forest ML in control system now
  - At TCV
  - Reinforcement Learning applied with DeepMind and DIFFER
- Digital Twin
  - Early Demonstration with MAST Experiment at UK AEA



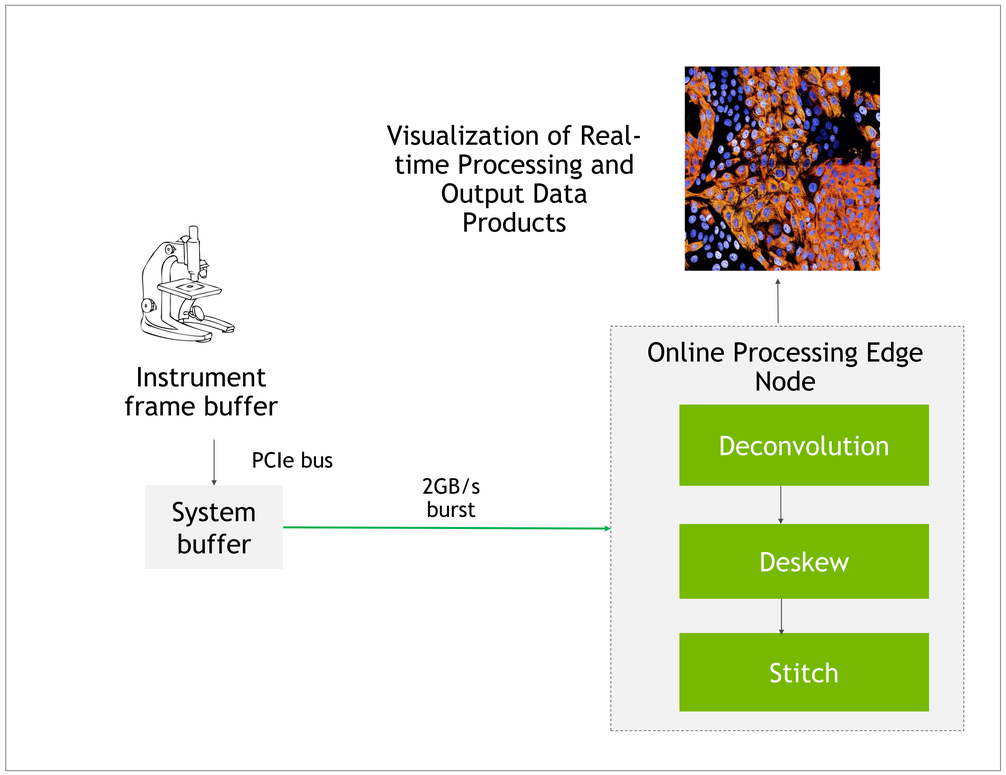
SUPERCHARGING SCIENCE EXPERIMENTS AND INSTRUMENTS

ANL/ APS ACCELERATES X-RAY PTYCHOGRAPHY 300X WITH PTYCHONN



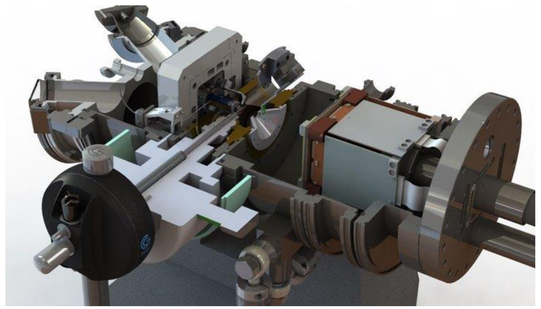
PtychoNN paper: AI-enabled high-resolution scanning coherent diffraction imaging

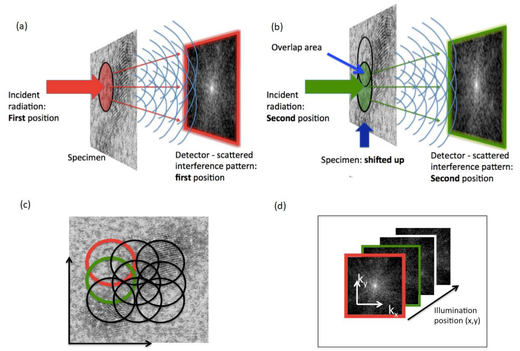
ADVANCED BIOIMAGING CENTER @UC-BERKELEY REAL TIME LIVE CELL IMAGING LIGHT SHEET MICROSCOPY

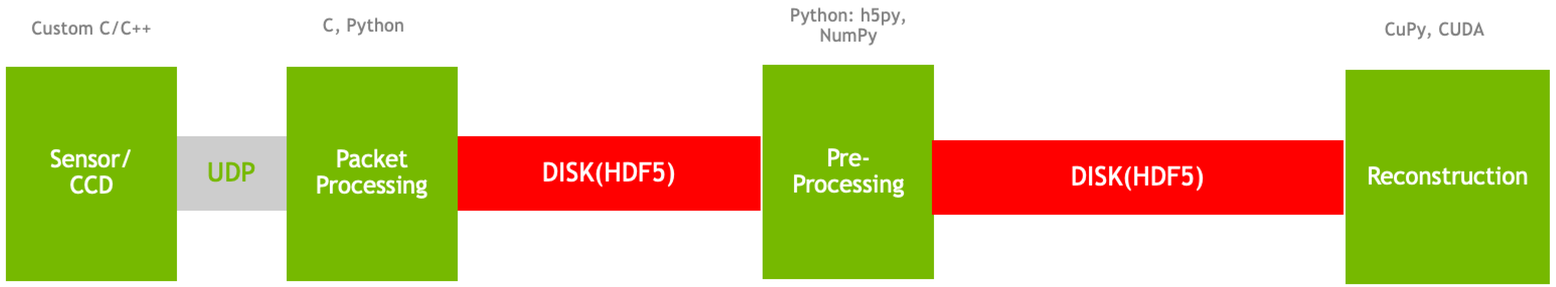


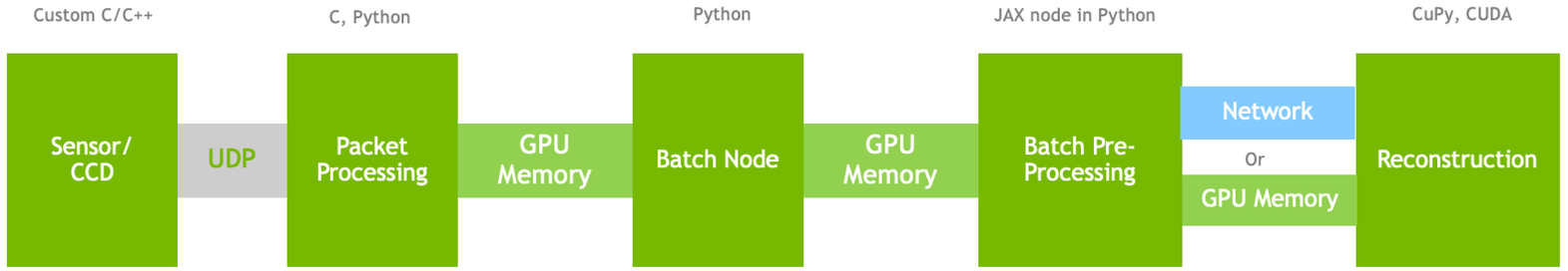
Link to keynote video - https://youtu.be/rXG27G3bWzY

ADVANCED LIGHT SOURCE : @ LBNL









From ~105 seconds to 12 seconds

- For more details watch : Accelerating Sensor Processing Pipelines with NVIDIA Toolkits
- The GTC talk may reference SRF as ”Neo” which was the internal name used during initial development

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COMPOSING AN HPC STREAMING DATA PIPELINE USING STREAMING REACTIVE FRAMEWORK (SRF*)

SRF* is a reactive, network-aware, flexible, and performance-oriented streaming data framework that standardizes building modular and reusable pipeline mixing C++, Python, JAX

- Asynchronous computation and mitigation of I/O and GPU blocking
- Distributed computation with message transfers over RMDA using UCX
- Dynamic reconfiguration to scale up and out at runtime
- Designed to mitigate backpressure with concurrent blocking queues between stages
- Hybrid HPC and Cloud Native

*SRF is under development. Final name subject to change

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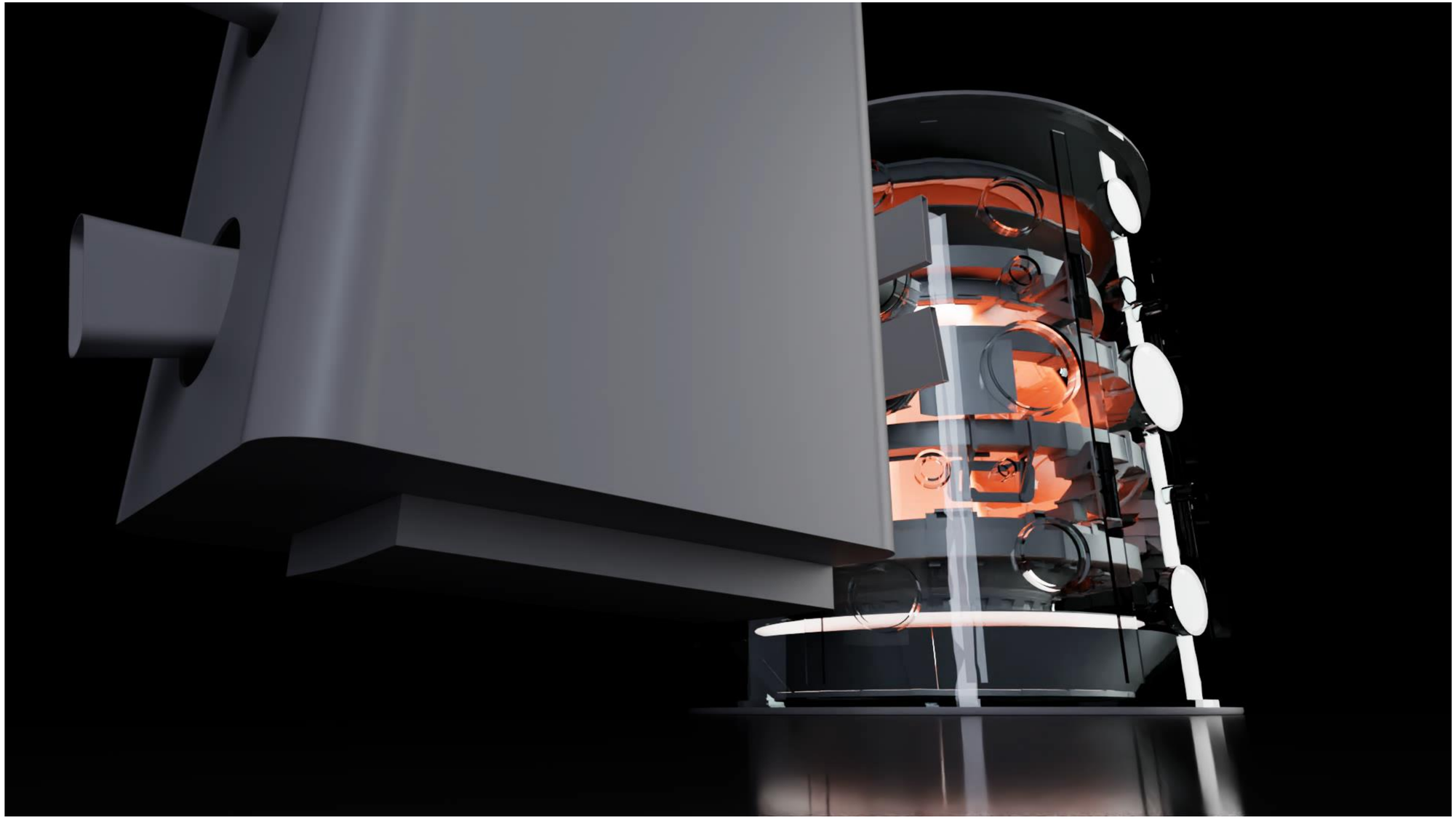
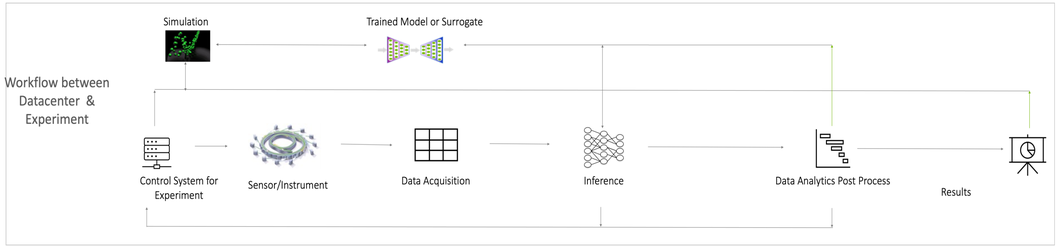
UKAE EARLY VERSION OF DIGITAL TWIN FOR TOKAMAK REACTOR

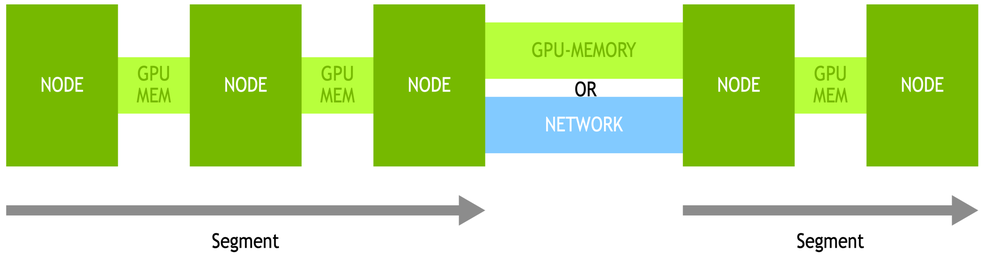


PREPARING FOR THE NEXT DECADE OF SCIENTIFIC COMPUTING

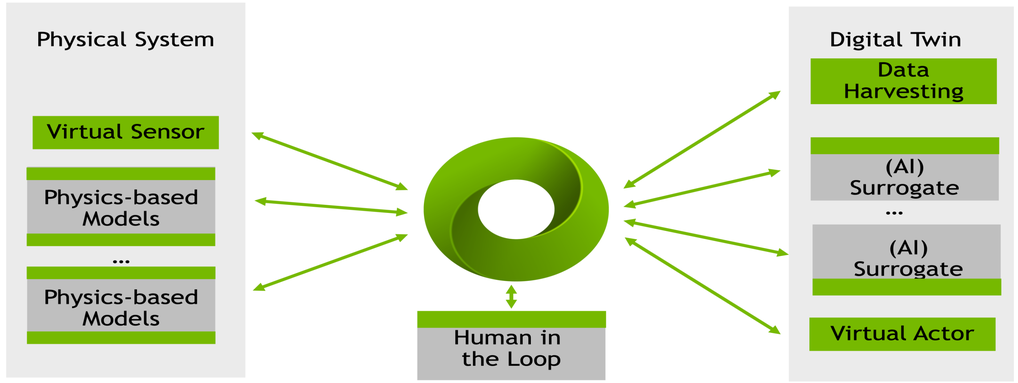
INTEGRATING THE SIMULATION +AI AND EXPERIMENT WORKFLOW

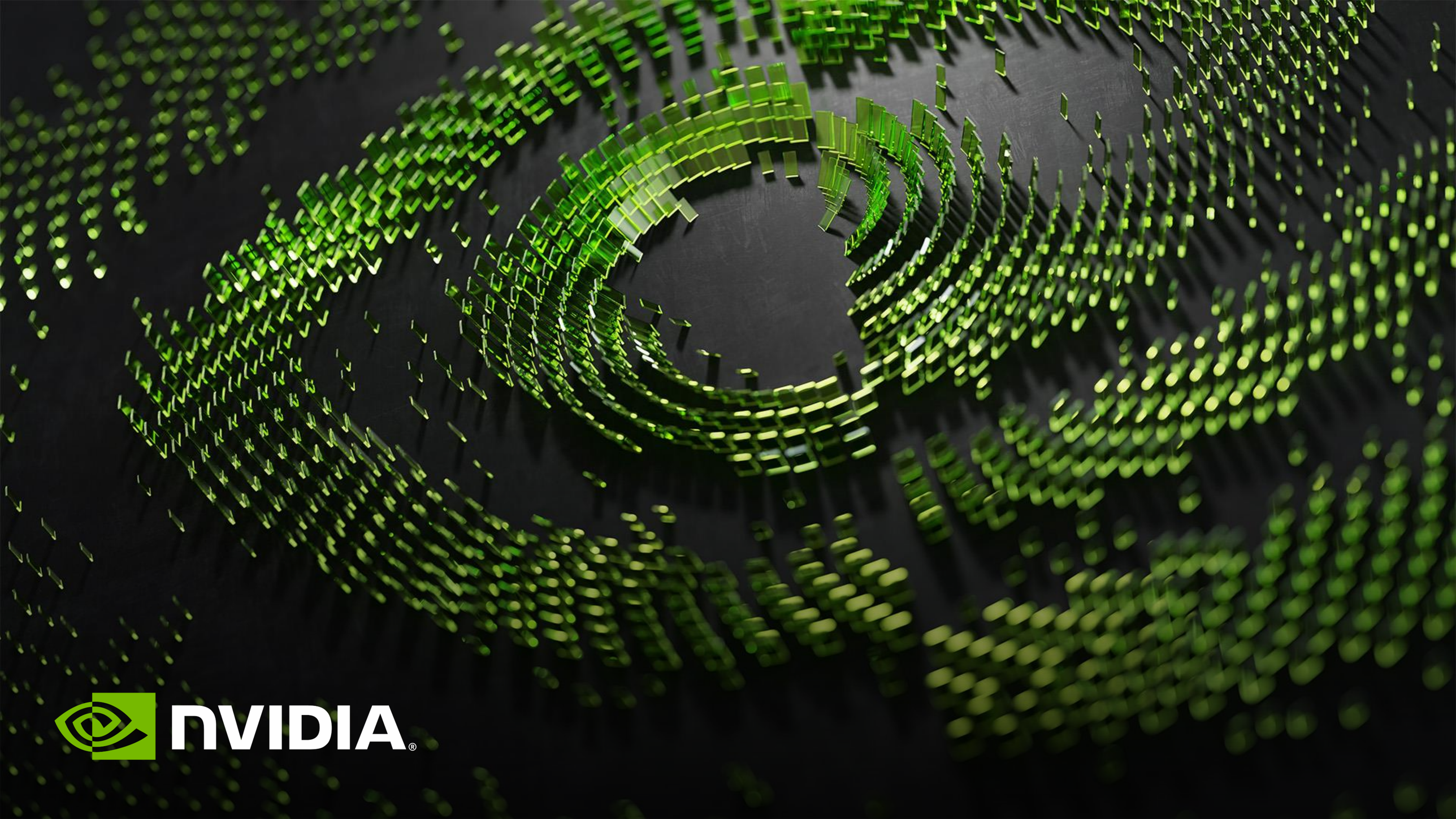


ACCELERATING THE SENSOR /EXPERIMENT DATA PROCESSING



BUILDING A DIGITAL TWIN TOWARDS A SCIENCE GRAND CHALLENGE

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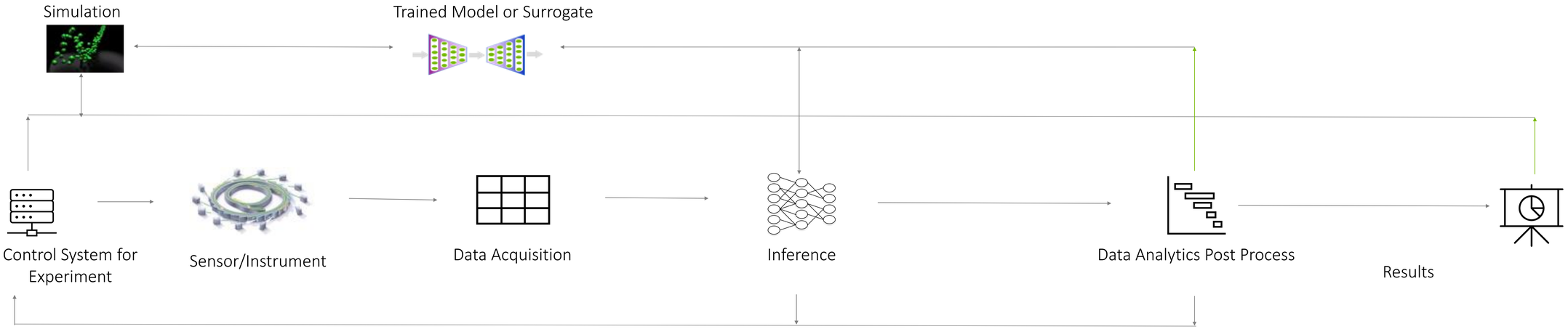
WORKFLOW TO WORKSTREAMS

Workflow between Datacenter & Experiment



Workstreams	Instrument to Edge	Data Transmission	Sim + DM/A + AI

Optimize and bring the best solution to that create the integrated workflow

NV SW	RAPIDS Triton/TensorRT Holoscan, Morpheus, Issac, UCF	Aerial DOCA Morpheus	HPC SDK, RAPIDS, DL FW, Omniverse, Modulus, UC
NV HW	Jetson, AGX,EGX DGX Station/Server	DPU MetroX	DGX Server/SuperPOD HGX

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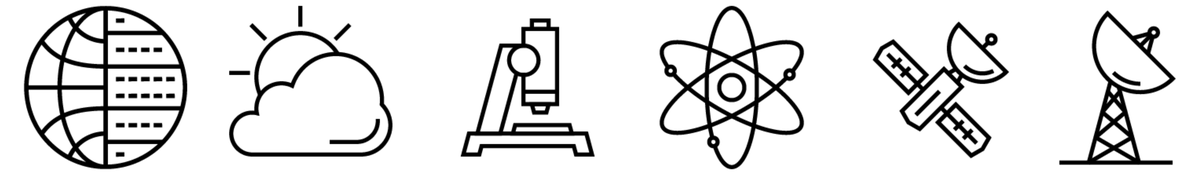
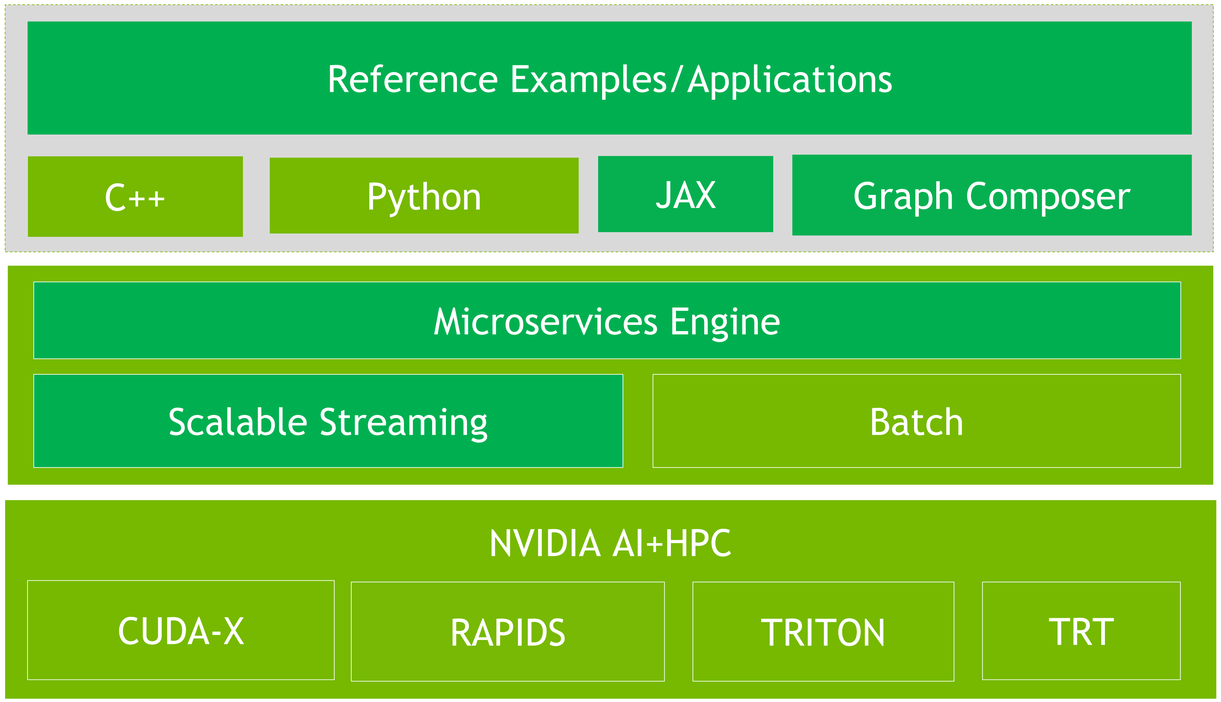
HOLOSCAN SDK : INTEGRATING DATA STREAMING FROM THE EDGE TO THE DATACENTER





- Build their applications using a mix of C++, Python, JAX
- Develop AI microservices combining low-latency data streaming while passing more complex tasks to data center resources
- Scale from embedded to datacenter

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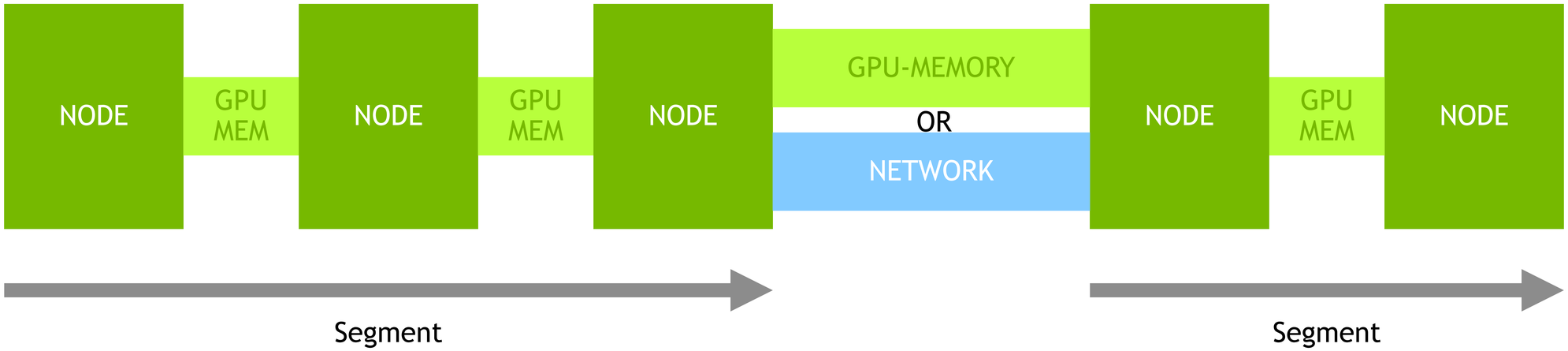
ANATOMY OF A SRF PIPELINE



Definitions

- A SRF pipeline is composed of Segments
- Segments are composed of Sources, Sinks, and Nodes (Source + Sink)
- Segments also guaranteed compute within a single node, can connect nodes via network (Edge, Cloud, or Datacenter), and contain MPI support
- Nodes process an input stream, create an output stream, and can be implemented with Python or C++
- Components are linked by Edges which are implemented as Channels
- Channels move data from sources to sinks and provide a backpressure policy

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TO LEARN MORE ABOUT SENSOR DATA PROCESSING

- Blog Facing the Edge Data Challenge with HPC + AI
- GTC Spring 2022 High Performance Geospatial Image Processing at the Edge*
  - Geospatial image analysis using DPUs in an edge device designed to meet the Size-Weight-and-Power requirements for aircraft deployment.
- PtychoNN paper: AI-enabled high-resolution scanning coherent diffraction imaging
  - The Advanced Photon Source at Argonne National Laboratory runs PtychoNN on an Orin AGX at the x-ray detector. It is available for use at other light sources around the world.
- GTC Spring 2022 Accelerating Sensor Processing Pipelines with NVIDIA Toolkits*
  - Faster imaging pipelines by using JAX and SRF to processing streaming data with applications in Ptychography and Micrsocopy
- See the SRF description above and the GitHub page

*The GTC talk may reference SRF as ”Neo” which was the internal name used during initial development

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