SnowMass2021

INDUSTRY CONNECTIONS & TECHNOLOGY TRANSFER: LESSONS LEARNT FROM SNOWMASS

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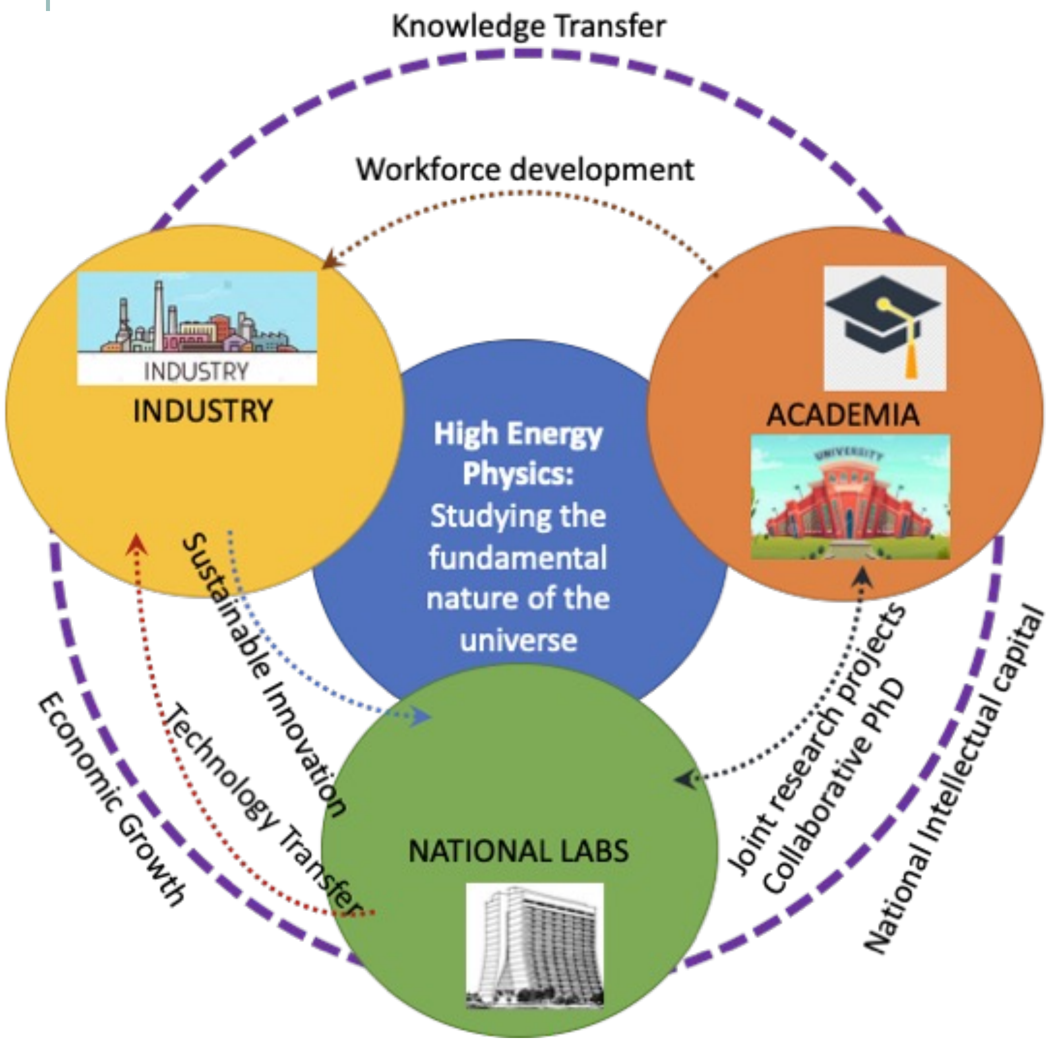
ECOSYSTEM: ACADEMIA-NATIONAL LABS-INDUSTRY



Interdependent and mutually beneficial

National labs and academic collaborations in Physics are very well setup. ☺

Engineering collaborations are not as well structured! ☹

Some universities are better than others at making industry connections 😑

National labs and industry engagement really needs more nurturing 😟

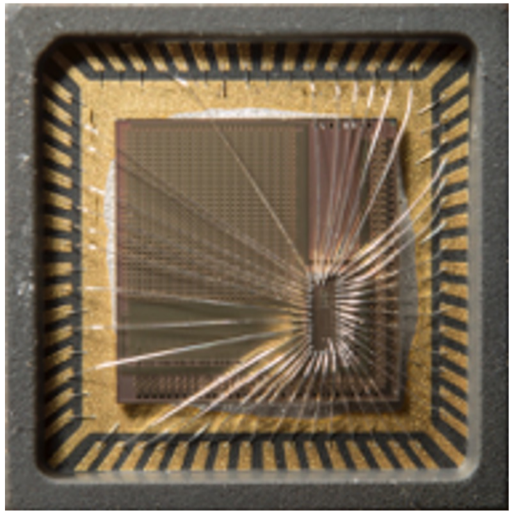
PARTICLE PHYSICS ENABLES NEXT-GEN TECHNOLOGY

TECHNOLOGY DEVELOPMENT AT NATIONAL LABS

ACADEMIC RESEARCH:

ADVANCE STATE-OF-ART

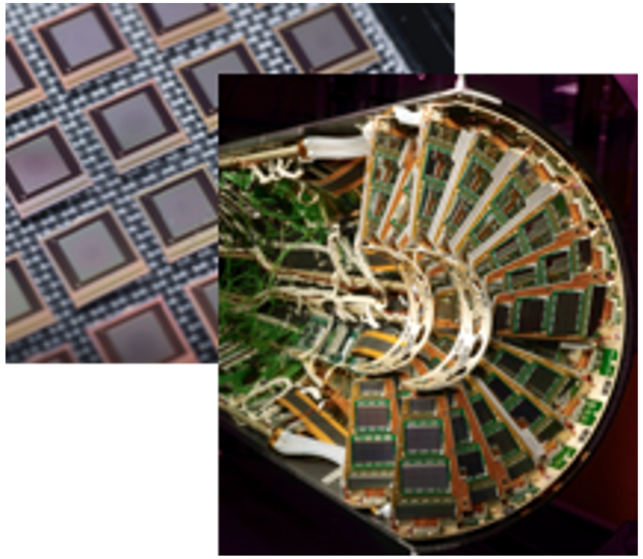
Foundational research



DOE NATIONAL LABS:

ADVANCED SCIENTIFIC INSTRUMENTATION

Robust Performance



INDUSTRY:

PRODUCT DRIVEN

Cost oriented production

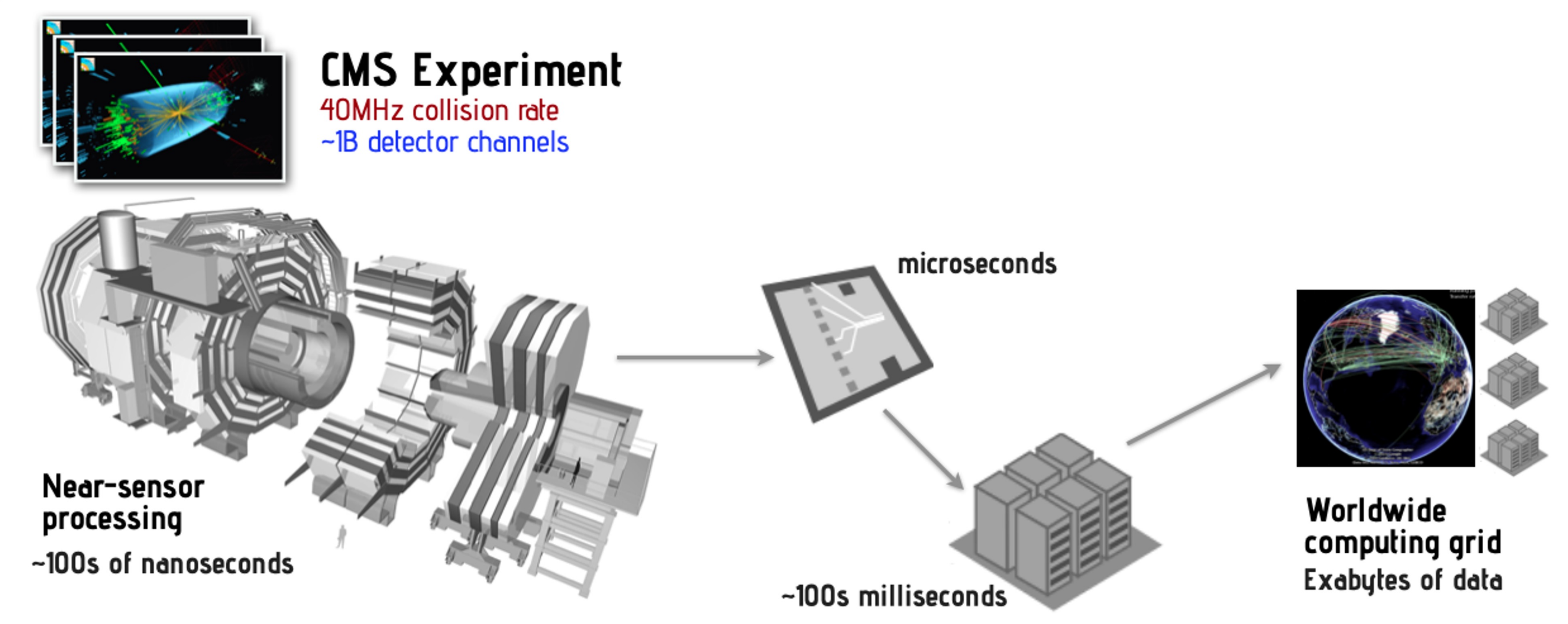
Ideal for accelerating lab to fab innovation

PARTICLE PHYSICS CHALLENGE ACCELERATES DEVELOPMENT OF NEXT GENERATION OF TECHNOLOGY

Cutting edge particle detectors and accelerators create massive amounts of data which require powerful and energy efficient processing. The engineering design requirements for these detectors **exceed those associated with industry** including the Internet of Things for Industry 4.0, Smart cities, and Smart sensors for autonomous driving:

- The data generated per second in just one large collider physics experiment is equivalent to the average internet traffic across North America.
- Experiments require more than one billion individual sensors with edge computing and ultra-low power and low-latency communication. The time scale to make decisions are a few orders of magnitude faster than typically required for industry applications.

HEP EXPERIMENTS EQUIVALENT TO REAL LIFE APPLICATIONS



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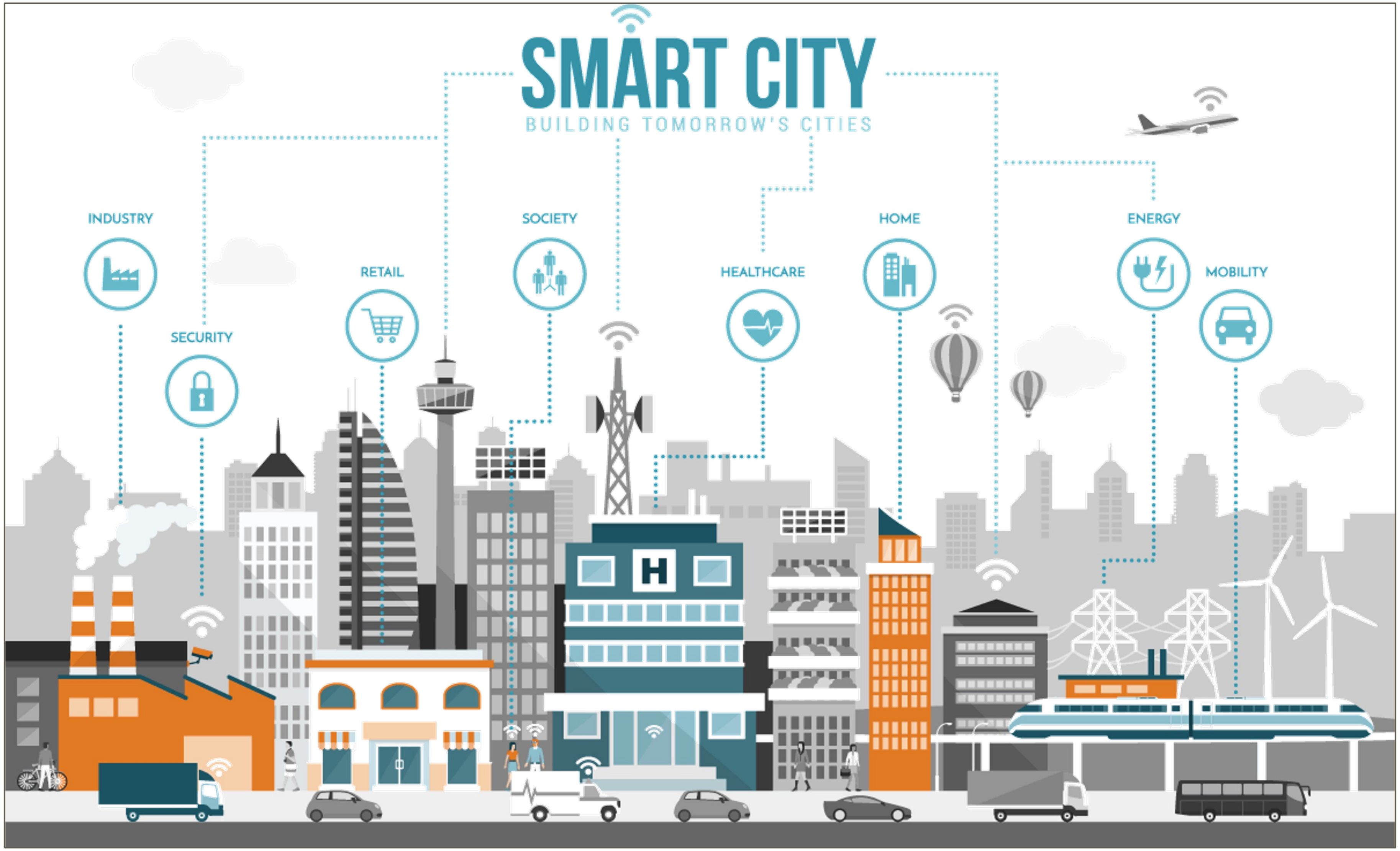
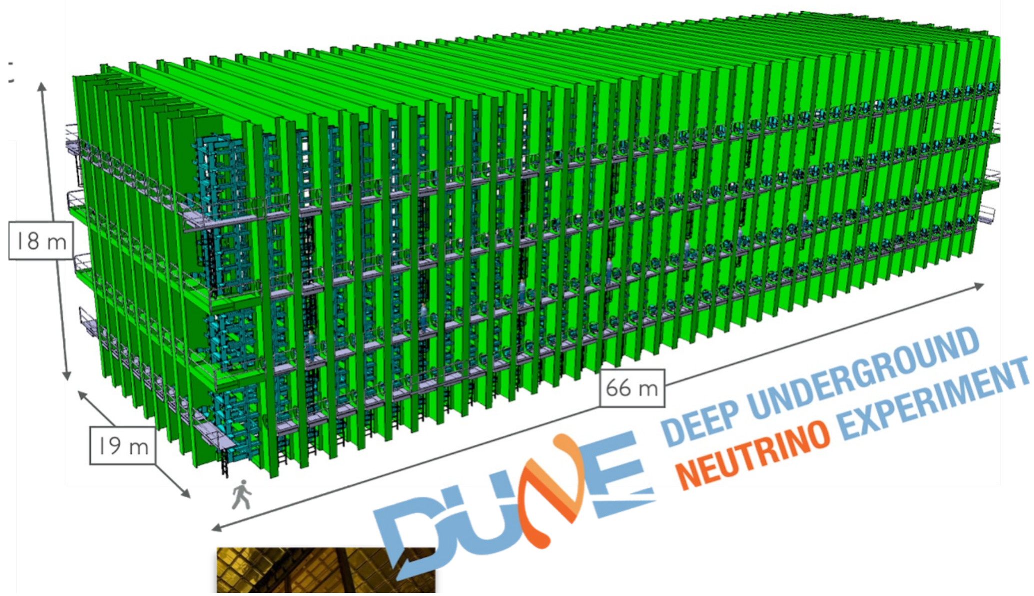


Quantum & AI present similar system engineering challenges.

ADDRESSING THE SCALING CHALLENGE

From

To

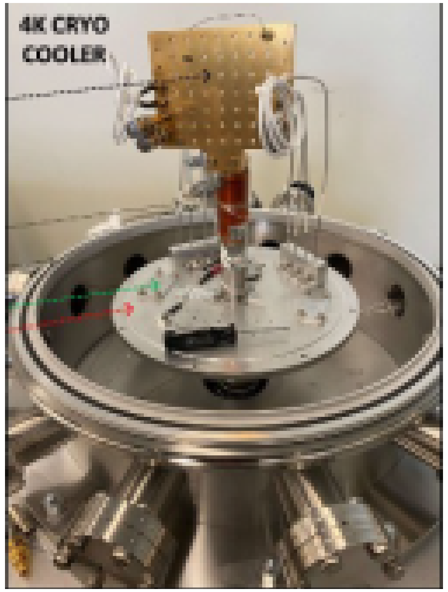


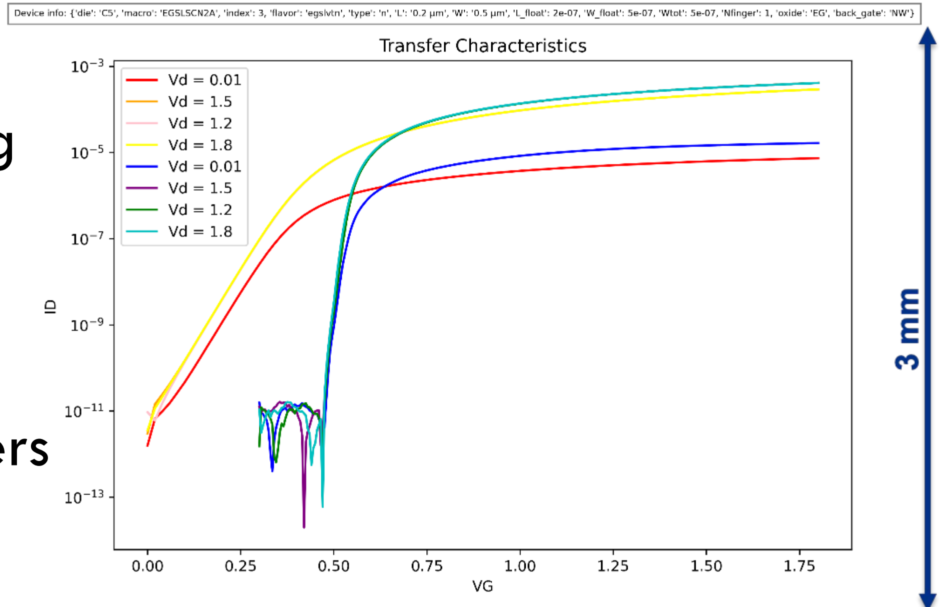
QUANTUM CONNECTIONS

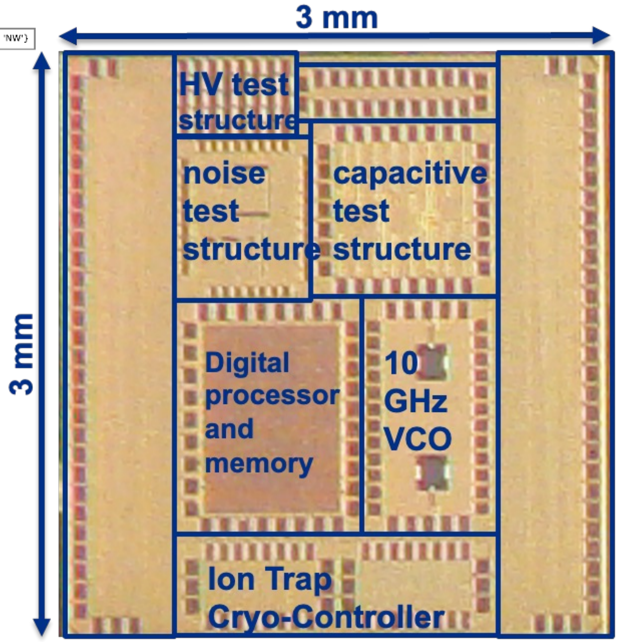
- Developing cryogenic models and Process Design Kit with EPFL, Global Foundries and Synopsys

- Working with Qolab for developing Quantum Support chips

- Working with Microsoft on next generation cryogenic data converters (forward looking)







PARTICLE PHYSICS CHALLENGE ACCELERATES LAB TO FAB MANUFACTURING

Rapid prototyping at scale requires us to evaluate competing technologies:

- We are **early adopters of technology** allowing us to assess and increase technology readiness level resulting in accelerated lab to fab innovation
- Some of our sensor arrays are almost twice the area of a basketball court requiring small volume prototyping. This gives us invaluable **statistical insight** into device properties, and influences improvements in material growth and fabrication.
- Deployment of compact detectors with lower size weight and power (SWaP) is a driver for **evaluating hybrid integration and advanced packaging solutions**

HETEROGENOUS 3D INTEGRATION

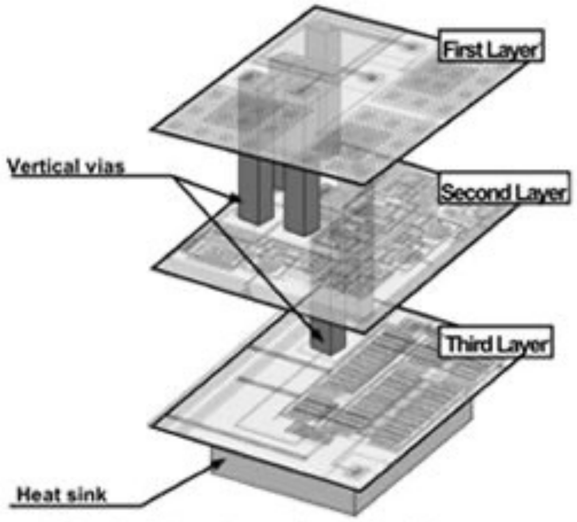
Started investigating for HEP in 2007

Worked with various vendors (RTI International/Micross, Tezzaron/Nhanced, Global Foundries, Novati, Skorpios, Ziptronix

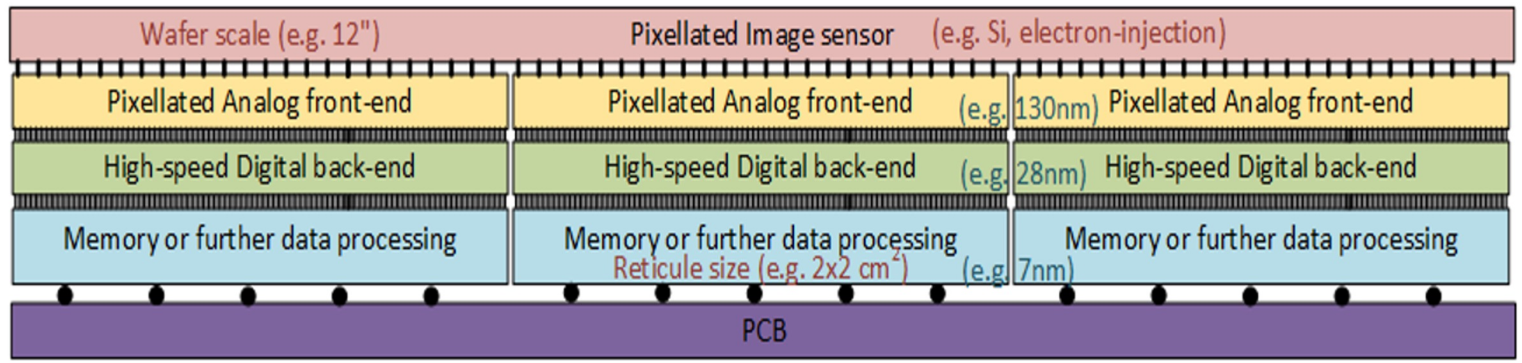
Assess technology maturation (Streamline the most promising method - DBI)

Market for large volume prototyping did not exist. Lab to Fab innovation takes several decades to become viable

In 2022, US Government is investing in technology development by establishing a national program through the Chips Act



Physical structure with vertical vias



TECHNOLOGY TRANSFER
WHY IS COMMERCIALIZATION DIFFICULT?

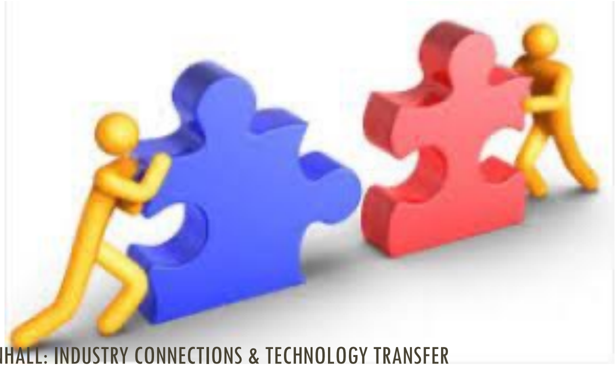
CHALLENGES

- No direct DOE funding for **deep-tech** commercialization

- SBIR/STTR program "Projects must have the potential for commercialization and meet specific DOE mission-specific R&D needs" DOE essentially is the customer. Phase II funding is also rather low for deep tech which requires advanced manufacturing

- For Venture Capital funding: Need strong market driver TODAY (not 10 years from now). High return on investment: At least 10x with a large market growth probability

- Conflict of Interest!



TECHNOLOGY COMMERCIALIZATION PATH

Identify the target market and viable customer base

Design/prototype to demonstrate proof of principle

Raise funds to support NRE development costs and establish supply chain

Market value proposition and sell the disruptive product

We mostly get stuck here

- Participate in entrepreneurship programs
- Requires innovator to be actively involved
- But conflict of interest policies hinder active participation

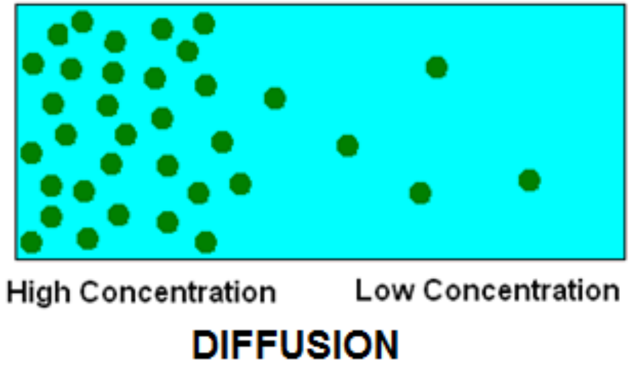
- Deep tech commercialization funds are not available within DOE
- Reduction of manufacturing cost has to be demonstrated
- VC funding is not available at this stage

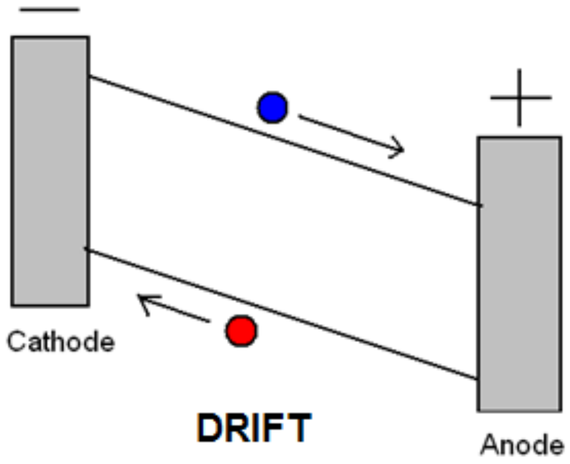
- Apply for VC funding
- Complete all Non-recurrent engineering
- Engineer the product
- Identify supply chain

- Establish customer support and service arrangements
- Move from product development to product adoption

TECHNOLOGY COMMERCIALIZATION DOES HAPPEN

- Really long-time frames
  - Extremely slow osmosis
  - Highly motivated individual is a key driver





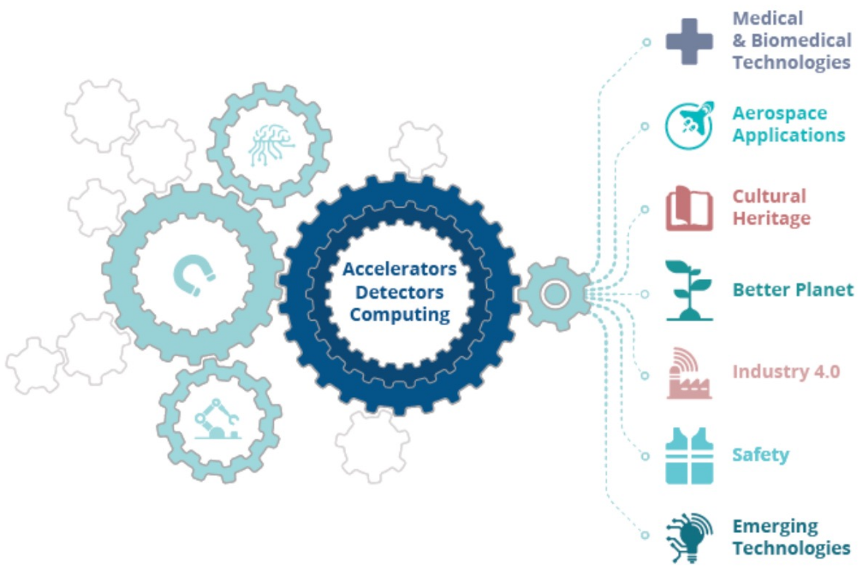
IT IS NOT ENOUGH!

- We need to lower the barrier and make it easy for technology commercialization
  - Funding
  - Industry partnership
  - Co-development with other applications

GLOBAL SOLUTIONS

From CERN technologies to society

Below, you can see how CERN's various areas of expertise translates into impact across industries beyond CERN. Read more about this at the from CERN technologies to society.



RIKEN Innovation, Co., Ltd. Established to Increase Collaboration with Private Sector

December 17, 2019

Dec. 17, 2019 — On September 5, RIKEN established a fully-owned subsidiary, RIKEN Innovation, Co., Ltd., which will work to improve communication between private industry and RIKEN, and to support collaborative projects. This move was made possible by a new law passed in January of this year which allows National Research and Development Institutes such as RIKEN to establish subsidiaries to carry out work related to licensing technologies and conducting joint research with the private sector.

The new company will work in four major areas: strategic management and transfer of RIKEN's intellectual property, support for RIKEN start-ups working for the commercialization of RIKEN technologies, support for large-scale collaboration, and co-creation with industry using RIKEN's vast knowledge.

Regarding the establishment of the new company, RIKEN President Hiroshi Matsumoto says, "The image of RIKEN is that we are an institute focused on theoretical research, but the reality is that many of our breakthroughs are being used by industry, and our papers are frequently cited in patent applications by private companies."

"Thanks to the efforts of many people," he continues, "a law was enacted giving us the ability to invest in an innovation company. I believe that this will help strengthen our ties with industry. We will work with the new company to further accelerate the application of our research findings with the goal of contributing to Japan's development as a Designated National Research and Development Institute."

COMMUNITY FEEDBACK

PROGRAMS TO ENABLE DEEP TECH COMMERCIALIZATION

- Policies to enable **inventors to become entrepreneurs**
  - Establish an entrepreneurial leave program which allows a graded transition from scientist to entrepreneur
  - Standardize an inventor royalty program across all the labs
  - Increase technology transfer educational opportunities targeted to HEP researchers
- Early identification of **dual-use innovations**
  - Co-development with other applications
  - Funding source for commercial prototyping
- Engaging with **partnership intermediaries** to accelerate commercialization
  - A Partnership Intermediary (PI) is a non-profit entity with specialized skills that can assist federal agencies and laboratories in commercialization functions
- Establish facilities based on **public-private partnerships** for accelerating HEP innovations
- Extending other transaction authority to labs to engage industry directly in research

https://doi.org/10.48550/arXiv.2203.15128

https://doi.org/10.48550/arXiv.2210.01248

RECOMMENDATIONS: SNOWMASS SUMMARY REPORT

SNOWMASS KEY RECOMMENDATIONS: P5 ASK

Create Public – Private Partnerships (Industry – National labs – Academia)

Create programs, consortiums, centers that bring the various stakeholders together. An example is the DOE National Quantum initiative. HEP needs to lead initiatives on Microelectronics and AI

Develop technology roadmaps to highlight synergies and technology readiness levels

Academia, National Labs and Industry form a spectrum from foundationa research, advanced instrumentation to mature production. Create commor engineering goals and roadmaps to **accelerate technology** readiness ensuring interaction with all the stakeholders at various stages of development.

SNOWMASS KEY RECOMMENDATIONS: P5 ASK

Deep tech transfer initiatives

Establish programs that enable deep tech commercialization with appropriate incentives, **funding and time scales**. Consolidate and/ or establish entrepreneurial programs for employees across the National lab system.

Collective all of DOE approach for engagement

Employ an all of DOE approach instead of lab silos for procurement of common industry tools and services. Set DOE wide common terms and conditions with the flexibility for each lab to make a choice specific to their program.

Establish cross-agency initiatives

Establish application driven/ technology development engagement programs which have synergies with other funding agencies – across OSC and all federal agencies. **Cross cutting programs** enable translational technology research. Hence focus on fundamental technology rather than fundamental science

SNOWMASS KEY RECOMMENDATIONS : P5 ASK

Prioritize and simplify high risk, high reward opportunities

In some technical areas (i.e., FLASH radiotherapy), the high impact technology incubation by HEP ecosystem can produce significant, and occasionally disruptive, benefits to the society, within a decade timeframe. In these scenarios, we recommend to prioritize and simplify access by all domestic stakeholders to HEP facilities, expertise, and resources.

Direct industry programs

There is also a growing interest in the community to improve support to the domestic industrial vendors providing critical technological capabilities to the HEP ecosystem. We recommend that DOE takes a proactive approach in establishing **critical technology needs**, and work directly with the qualified vendors to maintain and develop critical industrial capabilities, relevant to these needs.

PERSONAL LESSONS LEARNT

- Technology transfer is a long and arduous journey. You fail more often that you succeed
- The networks that you create leads to pathways that one does not anticipate

- Actively collaborating with industry for Quantum, AI & Microelectronics
- Co-development with other applications in conjunction with industry
- Can lead to a virtuous cycle in accelerating research

- The idea that if you are the best, industry will just come to you does not work. You have to actively make the connections
- Conflict of interest must be redefined to create opportunities for aligned interests!