Fermilab

U.S. DEPARTMENT OF ENERGY | Office of Science

Illinois Accelerator Research Center

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FNAL Users Meeting

11 June 2014

What is IARC?

- The Illinois Accelerator Research Center (IARC) is a new facility currently under construction at Fermilab
- IARC will provide a state-of-the-art facility for testing high power accelerators and unique expertise for research, ***development and industrialization*** of particle accelerator technology.
- A major focus of IARC will be to develop partnerships with private industry for the commercial and industrial application of accelerator technology for energy and the environment, medicine, industry, national security and discovery science.
- IARC will also serve as the portal for industry into the larger accelerator infrastructure and capabilities at Fermilab

Why do this? Growing use of Accelerators

- About 30,000 accelerators are in use in the world
  - **Sales > $ 2 B/yr and growing, touch $ 500B/yr in products**

- Health and environment: medical accelerators for cancer treatment, medical isotopes, electron microscopes, etc.
- Digital electronics: all computers, cell phones, televisions, etc. use accelerators to implant ions to make IC's
- Industrial fabrication: Electron beam welders used for auto fuel injectors, transmissions, to harden gears, & in aircraft construction
- Industrial Processes: Radial tires are cured and your car under hood wiring is made heat resistant with accelerators, the ink on food packaging can be "instantly" cured with an electron beam (25 feet per second!)
- Sterilization: medical supplies & instruments
- Food industry: shrink wrap on your turkey, preservation of army field rations & Omaha steaks, irradiation of seeds to induce new variants, sterilize bee hives (to prevent colony collapse disorder)

Many future uses of accelerators are envisioned
Some examples

- Preservation of the Environment
  - **Coal:** removal of NOx and SOx from flue gas
  - **Municipal waste:** sterilization transforms sludge into Nitrogen/Phosphorus rich solid fertilizers vs hazardous land fill.
  - **Waste water:** accelerators can destroy pathogens, and pharmaceuticals in municipal waste water allowing its use liquid fertilizers vs algae blooms in rivers (volume➔ cost challenge)
  - **Nuclear:** Destruction of long-lived nuclear waste via ADS
  - **Oil and Gas:** Conversion of natural gas to liquid hydrocarbons $ 30 B/yr of natural gas flamed at well heads worldwide!
  - **Defense:** FEL based ship board missile defense

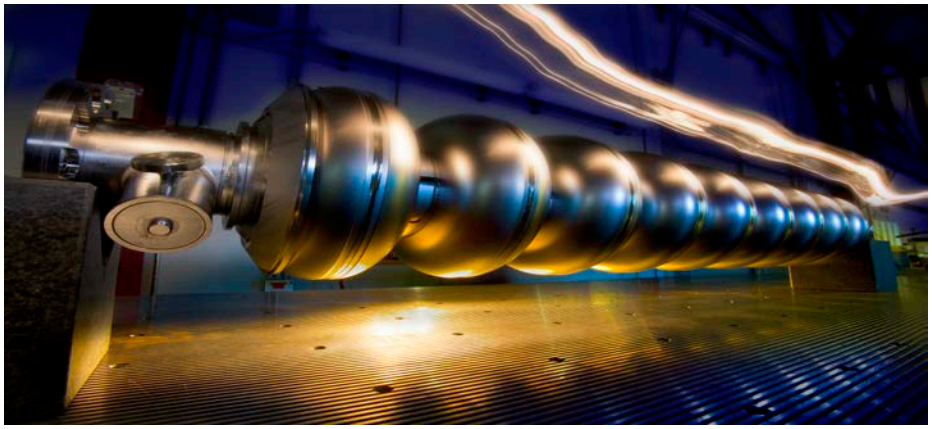
Many future uses of accelerators are envisioned

- New Sources of Carbon Free Energy
  - **Nuclear:** Accelerator Driven systems that burn Thorium and other new fissile materials (Safer, cleaner, more abundant)
  - **Wind:** SC generators based on accelerator magnet tech
- Medicine
  - Improved cancer treatment (reduce cost of Proton/Carbon ion beams)
  - Medical Isotopes like Moly 99 created locally at hospitals, without reactors, enriched uranium, or nuclear chemistry
- New industrial process applications (many!)
  - Conversion of natural gas to liquid fuels for transportation
  - Energy storage and carbon reuse:
    - $CO_2 + CH_4 + 2H_2O + (accel) \rightarrow 2CH_3OH + O_2$
  - Next generation(13.5 nm) euv light source for chip foundries
  - Extension of the lifetime of highways

IARC Mission and Vision

Mission

Partner with industry to exploit technology developed in the pursuit of science to create the next generation of industrial accelerators, products, and new applications.



Vision

IARC will be the preeminent national enabler of accelerator based products and services serving as the seed for industry growth.

Strategies

Partner with small and medium sized industries to commercialize accelerator technology based products

Joint Development with large strategic partners to develop new industrial applications

Harvest and market mature Fermilab IP and spin off new products and companies

Invest in IP maturation to attract private investment

Enable the program through State, Federal, and Private Partnerships

Role of IARC at Fermilab

Fermilab	IARC
Research Hub	Development Hub
Single Program	Multi-Program
Basic Science/Discovery Mission	U.S. Competitiveness Mission
Funds Out (Procurements)	Funds In: federal and state programs, private industry, venture
Publish	Patent/Copyright
Relevance to Scientific Community	Relevance to General Public & Elected Officials
Inflexible processes	Agile, industry friendly

The Need for a Business Entity at IARC

- A market survey by University of Chicago Booth Business School indicates strong interest in access to FNAL accelerator expertise and infrastructure from U.S. industry.
- A key concern: DOE bureaucracy (e.g complex/rigid rules; slow decisions)

- A business entity can in principle be more agile and handle interactions with the lab and DOE via blanket WFO/CRADA agreements
  - Can market and monetize IP created at the Lab creating license revenue
  - Can receive external funds in the form of grants or funds from private industry
  - Can use advice from the business community via a board to make solid business decisions on which projects to take on.
  - Can spin off new entrepreneurial companies

- The business entity by agreement would feed profits or license fees back to Fermilab with the goal of achieving IARC sustainability in 6 yrs
  - Sustainablility = no new State or Federal seed funds required for operations

IARC: Physical Plant

- The State of Illinois, Department of Commerce and Economic Opportunity (DCEO) provided a $ 20 M grant for the construction of a new building (Grant work complete in May)
- DOE/OHEP committed to $ 13 M for site prep and to outfit the new space (networks, partitions, furniture, etc. in progress) and a refurbished $ 38 M heavy assembly building at Fermilab
- Creating a $ 70 M complex to enable the IARC mission
- Status:
  - Building outfitting in progress, (partitions, IT networks, furniture)
  - CDF D&D ~ complete. (Huge Job by PPD … > 3000 T of equip)
  - Refurbishment of HAB has started (paced by available DOE funds)

Illinois Accelerator Research Center

Construction Status

New State funded addition (white) is complete, now outfitting it with partitions, furniture, etc.

Illinois Accelerator Research Center

Modern Design: Architects = Ross Barney

LEED Gold: Designed for Energy Efficiency

IARC: State funded building addition

48,000 gross square feet (lobby view)

IARC: State funded building addition

- One of two floors like this
- ~120 Offices total, Partitions, networks, furniture = DOE funds

IARC: State funded building addition

- Designed for IP protection (e.g. zoned IT networks, key card access)
- Next step is underfloor network and wiring to allow glass partition installation

IARC: State funded building addition

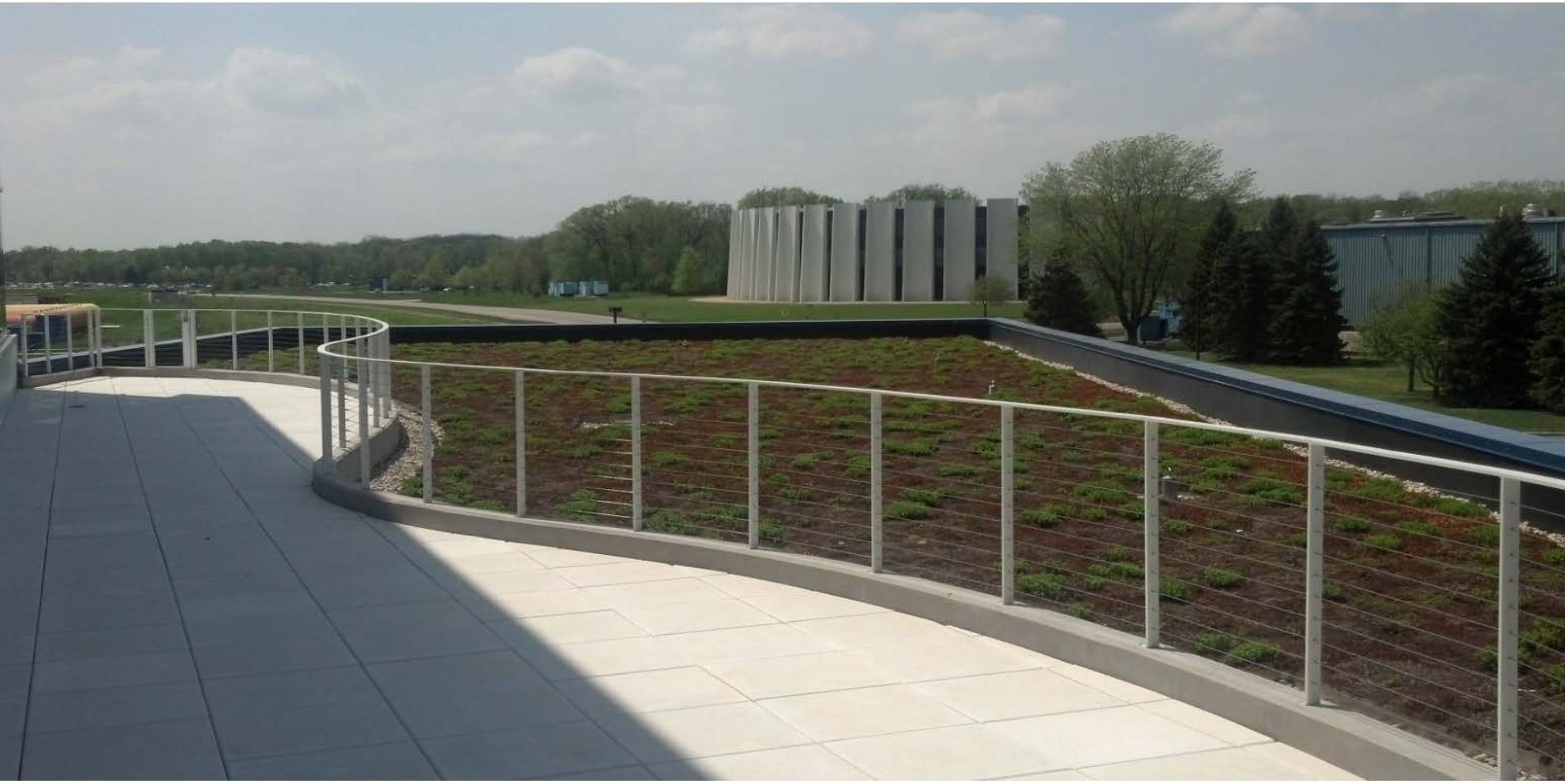
- One of two floors like this

IARC: State funded building addition

- Common space for coffee or lunch

IARC: State funded building addition

- Green Roof, outdoor spaces , geothermal wells, lots of natural light, etc.
- Extensive of local and recycled materials



IARC: State funded building addition

- 175 seat meeting room, (Strategy maximize bricks and mortar!)

Heavy Assembly Building

- Used for the construction of the CDF experiment (42,000 sq ft)
- 50 T crane; 10 T crane
- Deep pit ideal for radiation shielding of high power accelerators;
- 1.5 MW of installed electrical Power (upgradeable)
- 2.0 MW of industrial, Low conductivity, and chilled water systems
- 600 W @ 4 K cryogenic refrigerator (upgradeable)
- Light tech space, machine shop, 40 offices, high speed IT network

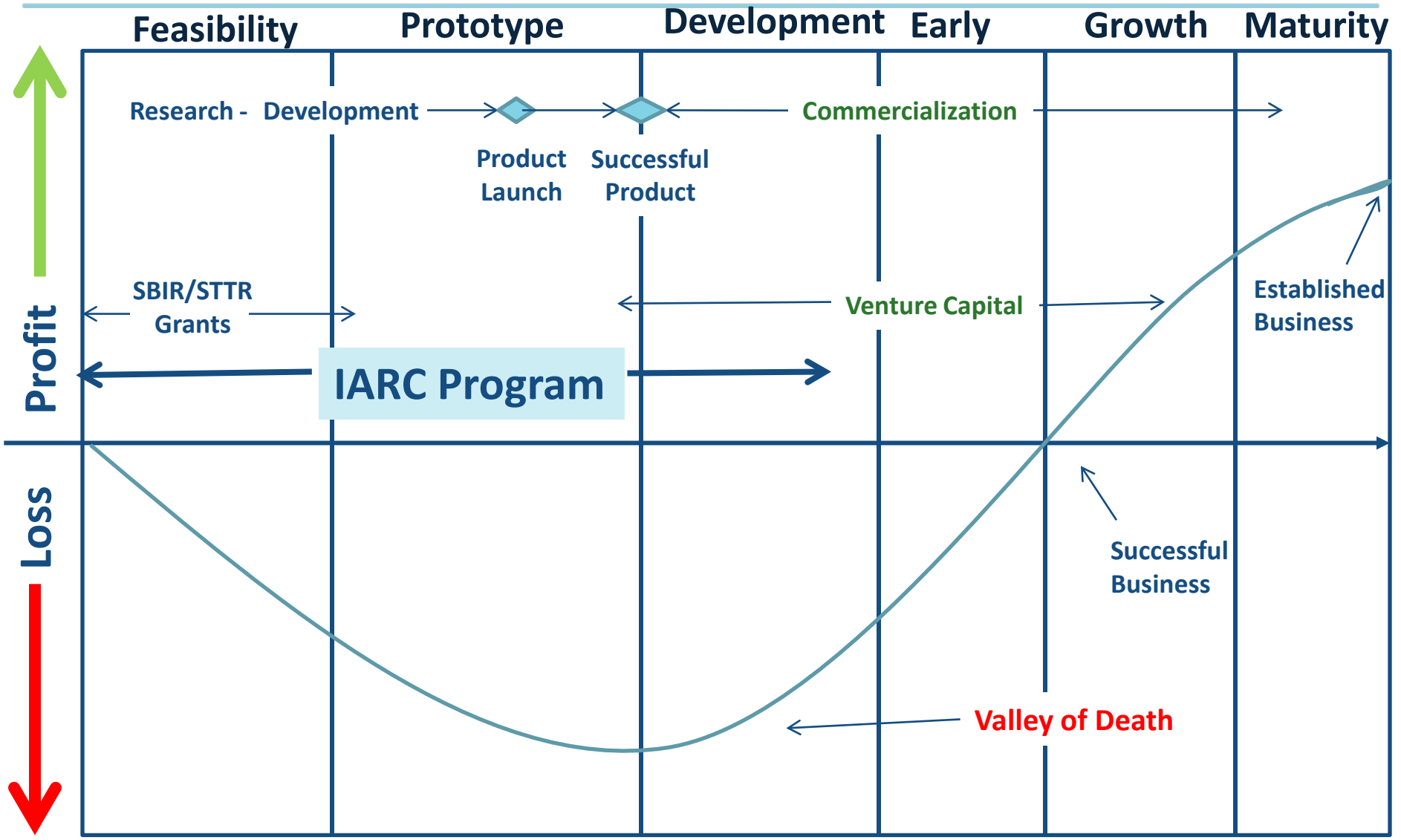
What Industry Really Gets Excited About

- CDF D&D nearly complete, Great job by PPD!
- Building refurbishment just starting

IARC - Some Examples of Big Opportunities

- **EBFGT:** Partnership with PAVAC to develop accelerator based EB flue gas treatment; market is many hundreds of millions per yr to outfit coal fired plants to meet new EPA regulations
- **euvL**: Create a consortium of labs (LBNL,ANL,SLAC), universities,and priviate industry to partner with chip industry (Sematech, etc), to create next generation 13.5 nm light source derived from SRF linac based FEL: Market: ~40 euv light sources at $500 M each and follow-on service
- **Highways**: Partner with industry to extend life of asphalt highways with accelerator based polymerization of bitumen; Market scale is few % of ~ $ 80 B annual cost of U.S. asphalt road const & repair
- **Gas to Liquids:** Partner with oil industry to convert $ 30 B of methane flared annually at well heads to liquid fuels using accelerators
- **Municipal Waste:** Partner with industry to sterilize effluent water and sludge from municipal waste treatment plants allowing water reuse and creating fertilizer; Market is hundreds of millions per year

Valley of Death for Accelerator Applications



So What Happens Next ?

- Outfit new building with IT networks, partitions, IP control, and furniture… 1st Occupants ~ Nov 2014
- Refurbish Heavy Assembly building… in process…high bay available in FY15, complete in FY16 (funds limited)
- Complete and gain approval for IARC business model by the end of FY14

- Launch first Projects in FY15
  - Some HEP base program activity (PIP-II HQ, PIP-II SSR1 CM, mu2e coils)
  - Accel projects selected based upon business case

Summary

- Exciting new opportunity for FNAL & Industry
- Steady Progress on the IARC physical plant
- Working with DOE to converge on the business model, business entity, funding, & “rules”
- Interesting challenges as we try to invent successful approach to the IARC program within the DOE systems…but strong support from FNAL Director, DOE, and Congress
- Even without a “formal” IARC program announcement there is lots of interest from Industry. To learn more or submit an EOI…

  Check out the Web site IARC.fnal.gov
- For more on Accelerator Applications watch for an upcoming APT seminar (to be scheduled)

extras

What is the Problem?

- New applications of accelerator technology seem to die for one of several reasons
  - Feasibility not proven: Inadequate resources: (financial, personnel, infrastructure) in industry, universities, or labs to demonstrate the basic feasibility of an idea
  - During transition from small scale technology demonstration to a commercial product (may require large investments & infrastructure)
  - Judged not economically viable reliability of technology, capital investment required, or operating costs are not demonstrated vs other approaches
  - Lack of acceptance of the new technology by potential customers that is cured only by large scale demonstrations that lower perceived risk and demonstrate costs
- IARC is intended to lower the barriers for new accelerator applications by providing both a facility for testing accelerators and access to Fermilab's accelerator experts and infrastructure

IARC Background

- FNAL realized that accelerator technology developed in the pursuit of science has an increasing economic impact
  - $ 2 B/yr in accelerator sales, touches $ 500 B/yr in products
- **2007: Proposal to the State of Illinois and DOE**
  - State DCEO realized they could leverage expertise at Fermilab to create high tech jobs and industry in Illinois
  - DOE realized this could contribute to US competitiveness
- **2009: Accelerators for Americas Future** symposium hosted by the DOE. Report: http://www.acceleratorsamerica.org/
  - Provided strong support: Bottom line =
    - Accelerators already important to our economy but …
    - Many future Accelerator applications could be realized or commercialized in the future
- **2010: IARC Construction funded by the State**

IARC Background

- **2011 First DOE const. funding (extends through FY15)**
- **2011: President emphasizes important of tech transfer from Federal Research to U.S. Industry**
- **2012 Senate Water and Energy bill language**
  - Requests Accelerator stewardship plan from OHEP
- **2014 Draft Senate Legislation**
  - Acting on recommendations from the report *"Turning the page, Reimagining the National Labs in the 21st century innovation Economy"*
  - Part of Lab mission = technology that drives the economy
- **FY14 HEP Stewardship Program launched**
  - 1st "new" Stewardship funding in FY15
  - RFI: Accelerator Applications for Energy and Environment

➔ **IARC is well Aligned with National and HEP Priorities**

IARC: The Opportunity for Fermilab & DOE

- Opportunity to put substance behind the claim that HEP is the developer/steward of accelerator technology within the Office of Science
- Opportunity to function as a center for accelerator based projects in the Office of Science and to partner with industry and labs (e.g. nearby ANL) on new accelerator applications
- Opportunity to increase our role in accelerator technology education
- Opportunity to establish additional funding sources outside DOE-HEP or with industry to create intellectual property (patents, royalties)
- Opportunity to develop technologies that benefit society bringing recognition to the DOE SC laboratories and to Fermilab creating support for our basic science mission

IARC: The Opportunity for Industry

- Fermilab has:
  → a world-leading accelerator engineering and scientific staff that have the potential to make an impact beyond the field of high-energy physics. (with addition resources at nearby ANL)

  → core capabilities and infrastructure that are unique, and that can be used for applications beyond the field of high-energy physics.

  → the IARC physical plant and the largest concentration of Accelerator Scientist and engineers in the world

  → Strong State support (DCEO) with incentives to encourage high tech businesses to locate in Illinois; growing support from DOE

- Industry can leverage these assets to create new accelerator based products and capabilities

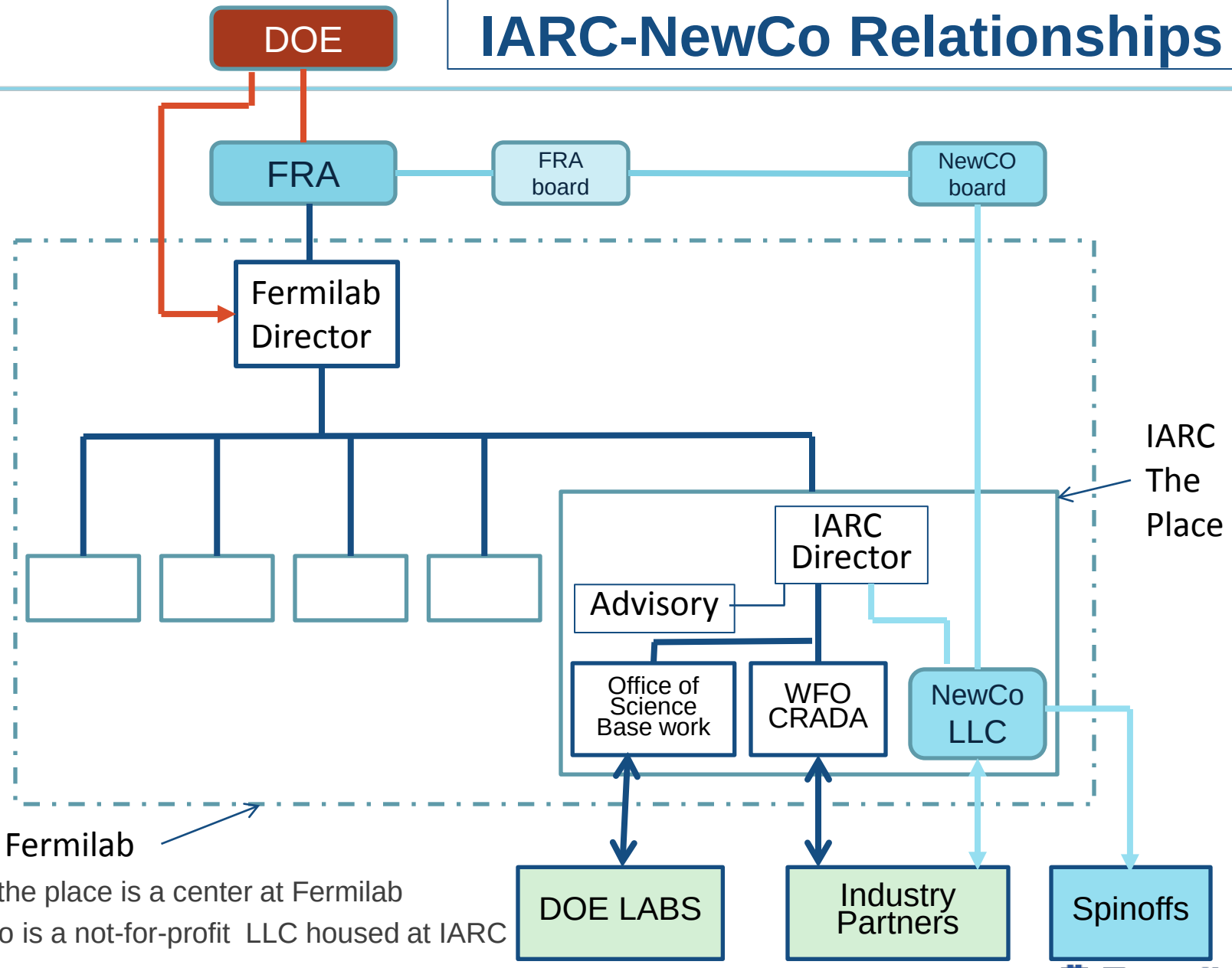
IARC: The Opportunity for Entrepreneurs (you!)

- FNAL Office of Partnerships and Tech Transfer now exists, new lab and DOE encouragement to connect with businesses and create/capture IP
- IARC will have a strong connections to the University of Chicago Booth Business school:
  - → UofC grants and soon FNAL LDRD funds will become available to demonstrate feasibility of new ideas
  - → Chicago Innovation Fund provides grants for financial support for startups from the UofC, ANL, FNAL community
  - → UChicagoTech provides business advice from experienced & successful entrepreneurs (to launch companies)
  - → Provides connections to angel investors
- University and lab entrepreneurs will be encouraged to leverage these assets to create new products, capabilities, and/or to launch new businesses

Who is interested in using IARC ?

- Even in the absence of an official announcements, many partners have contacted me about working at IARC (red = IARC EOI, SBIR, WFO, proposal)
  - ACSI……..SRF linac booster on existing Medical Accelerator
  - AES, UC Irvine……SBIR's, Water Treatment with accelerators
  - Euclid……..SBIR phase II's several ,including PX SRF cavities
  - Faraday……SBIR continued joint work on bipolar EP
  - Highways……..FNAL IP, exploration with IdeOn, EBTech
  - LLNL……...test accelerators funded by DTRA and/or DARPA
  - Muons Inc……SBIR/STTR's, Muon Collider/ADS R&D, ion implanter
  - National Instr……..accelerator instrumentation and controls
  - Niowave……SBIR phase II for medical isotope machine, LHC crab CM
  - Northwestern……Electronic and Detector development center in IARC
  - NIU: ……...Source Development, SBIR/STTR, new RF sources, education
  - Omega-P……...SBIR Phase II: MB klystron for Project X
  - PAVAC……...Flue gas test accelerator, Several SRF based SBIR ideas
  - Radiabeam…….SBIR, euv light source for chip foundry
  - RUSH spinoff…….Medical imaging
  - Tandell systems….accelerator reliability, integration, and simulation
  - UC Irvine…… Water treatment with accelerators
  - Walter Reed, UTSW, Mayo, etc ..Carbon ion medical accelerator
  - Varian Medical……test cell for medical machines, water treatment ?
- Recurrent theme: funding, clear program rules, IP protection, predictable schedule and processes, access to deep pit & infra to test accelerators!

IARC-NewCo Relationships



- IARC the place is a center at Fermilab
- NewCo is a not-for-profit LLC housed at IARC