Fermilab

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INTRODUCTION
PASI 2015

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NIU

Fermilab

YEARS/ANS CERN

ACKNOWLEDGMENT

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PASI Advisory/Organizing Committee

PASI 2015

- **WORKSHOP: the 3rd in a series. Forum to explore areas of UK-US collaboration on proton (ion) accelerator R&D**

- **Focus: collaborative development :**

  → **Multi-MW sources for science (neutrinos and neutrons)**
  → **Novel concepts and techniques of nonlinear dynamics of intense beams with self-fields**
  → **Innovations for translation to applications in health, energy, environment and industry.**

- **The U.S. program is centered on progressive development and implementation of high power proton accelerators (PIP → PIP II → PIP III), serving the future flagship international particle physics experiment (DUNE) involving multi-MW beams and viable targets, SCRF technology, novel accelerator test facilities (e.g. FAST/IOTA), industrial applications (IARC) and international collaborations (CERN-LHC, UK-MICE and India-PIP-II).**

PASI 2015 (cont'd)

- **The UK proton (ion) accelerator program and skills base are anchored in the high intensity proton accelerator development connected with the ISIS facility at Rutherford Appleton Lab and SCRF technology program at Daresbury Lab, with major contributions on HL-LHC at CERN, ESS, international MICE collaboration and novel developments for medicine, energy, environment and industry**

- **Within the context as above, there are accelerator challenges of mutual interest on both sides of the Atlantic. There is also room for new ideas that can lead to, or enable the exploitation of, even higher intensities, better control of beams, innovative concepts and compact cost-effective alternatives**

- **This meeting offers the opportunity for discussing ongoing collaborative efforts and their next steps, including exploring new areas of collaboration.**

US INSTITUTIONS

- **Fermilab**
- **National Lab Partners: SLAC, Jefferson Lab, ANL, BNL**
- **International Partners: CERN**
  STFC RAL, JAI and CI (UK)
  BARC, RRCAT, VECC (India)
  …….
- **University Collaborators:**
  Northern Illinois University, Univ. of Chicago, Illinois Institute of Technology, Univ. of Maryland, Univ. of California at Berkeley, University of Knoxville, MIT, Cornell University, Univ. of Oxford (UK), Imperial College London (UK), Hiroshima University (Japan)
  ……
- **Industry:**
  Illinois Accelerator Research Center (IARC), Radia-Beam, RadiaSoft, Tech-X, AEC, …

UK INSTITUTIONS

- **STFC: Rutherford Lab (ISIS) and Daresbury Lab (ASTeC)**

- **National lab/Institute Partners:**
  Cockcroft Institute, John Adams Institute,
  Huddersfield International Institute for Accelerator Applications

- **International Partners: CERN, ESS**

- **University Collaborators:**
  Oxford, Imperial College London, Royal Holloway, University College London, Liverpool, Lancaster, Manchester, Strathclyde, Huddersfield,…..

- **Industry:**
  CERN BIC, DSIC, HSIC, Shakespeare Engineering, e2v, ….

Fermilab Today:

- **Fermilab operates the largest Particle Physics proton accelerator laboratory in the U.S. and collaborates with CERN housing the largest proton accelerator complex in the world.**

- **Part of current operations/programs/projects:**

  - **Proton Improvement Plan (PIP), PIP-II and future PIP-III**
  - **Muons: Muon g-2, Mu2e, MAP (including MICE and Targets)**
  - **Neutrinos: LBNF, MicroBoone**
  - **LHC upgrades at CERN: HL-LHC (via LARP)**
  - **LCLS-II at SLAC (SCRF linac modules)**
  - **Novel Accelerator R&D and Test Facilities: FAST, IOTA, SRF Cavities, Magnets**
  - **Commercialization of our accelerator technologies (IARC)**

Fermilab operates a total of 16 km of accelerators and beamlines:

- A 400-MeV proton linear accelerator (0.15 km)
- An 8-GeV Booster synchrotron (0.5 km)
- An 8-GeV accumulator ring (3.3 km)
- A 120-GeV synchrotron (3.3 km)
- A Muon Campus Delivery ring (0.5 km) and soon Muon g-2 ring
- Transfer lines and fixed target beam lines (8 km)
- Two high power target stations, several low-power targets
- People: 660 (Accelerator Science, Technology and Engineering) – operations, projects, programs, R&D, program support, Work For Others

Intensity Frontier Accelerators

Different merit matrix from colliders – instead of fb^{-1} of *∫Ldt* :

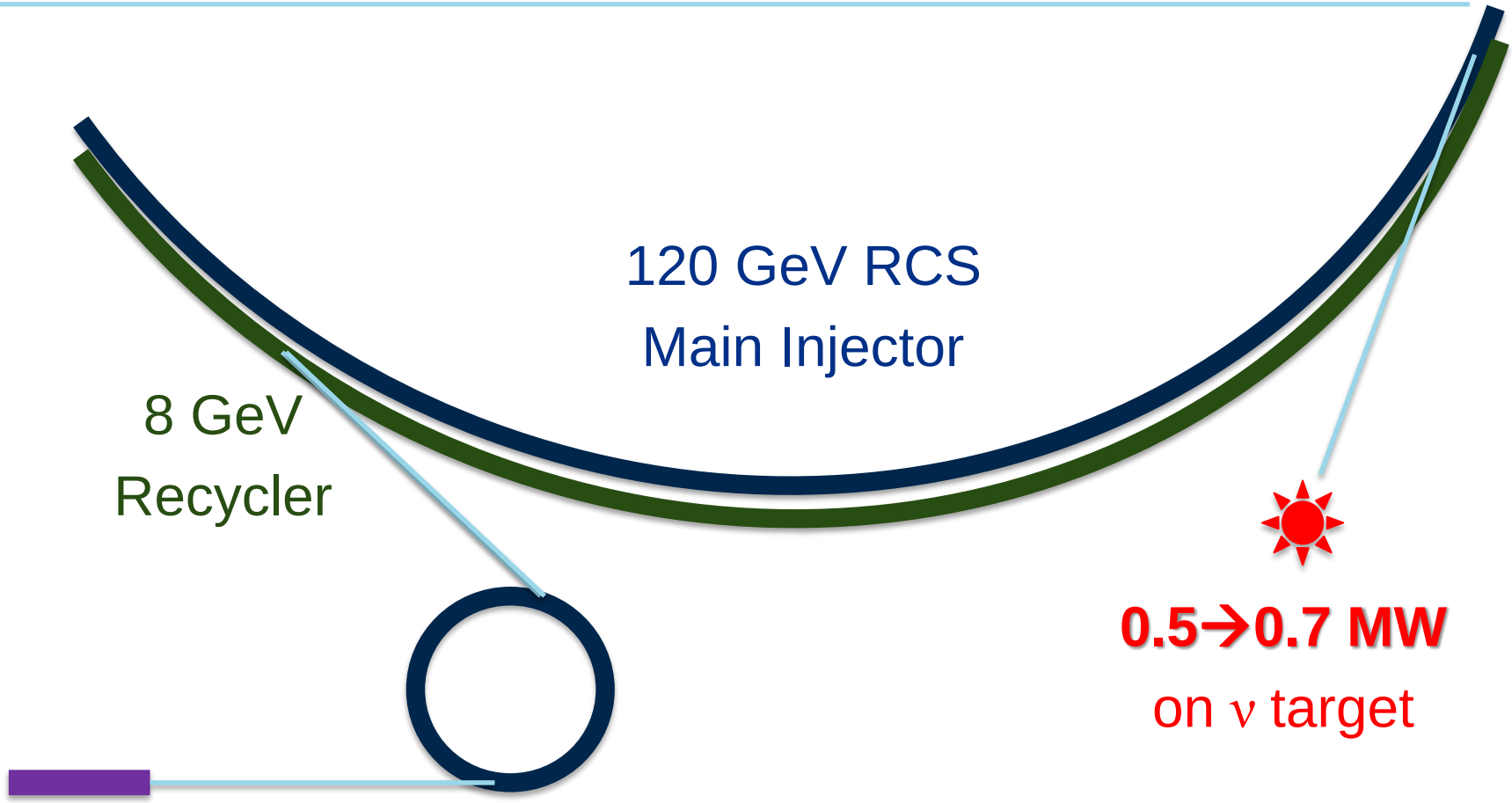
600 MW*kTon*years for DUNE experiment

PIP-II Beyond PIP-II (mid-term)

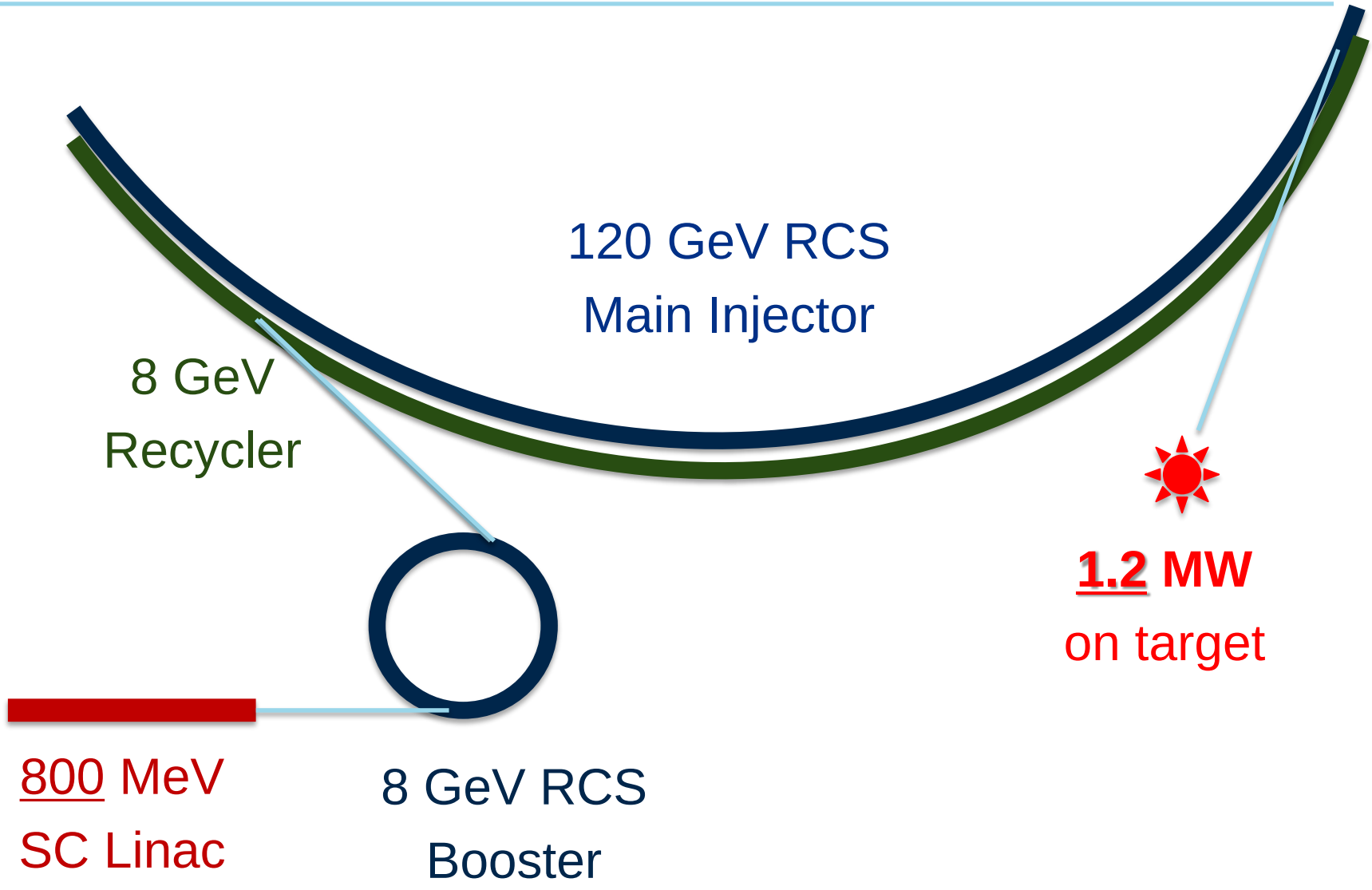
	1st 10 years	2nd 10 years		
To Achieve :	100 kT-MW-year	500 kT-MW-year		
We combine :		Option 1	Option 2	Option 3
Mass	10 kT	50 kT	20 kT	10 kT
Power	1 MW	1 MW	2.5 MW	5 MW

- **Thrust for Megawatts of beam power → challenges:**
  - **High intensity sources, Efficient acceleration without losses, Halo control and collimation, Advanced injection and extraction, Novel high-power beam targets and focusing systems**
  - **Cost efficient accelerator *MW/$$* vs detector *kTons/$$***

Accelerator Complex Now

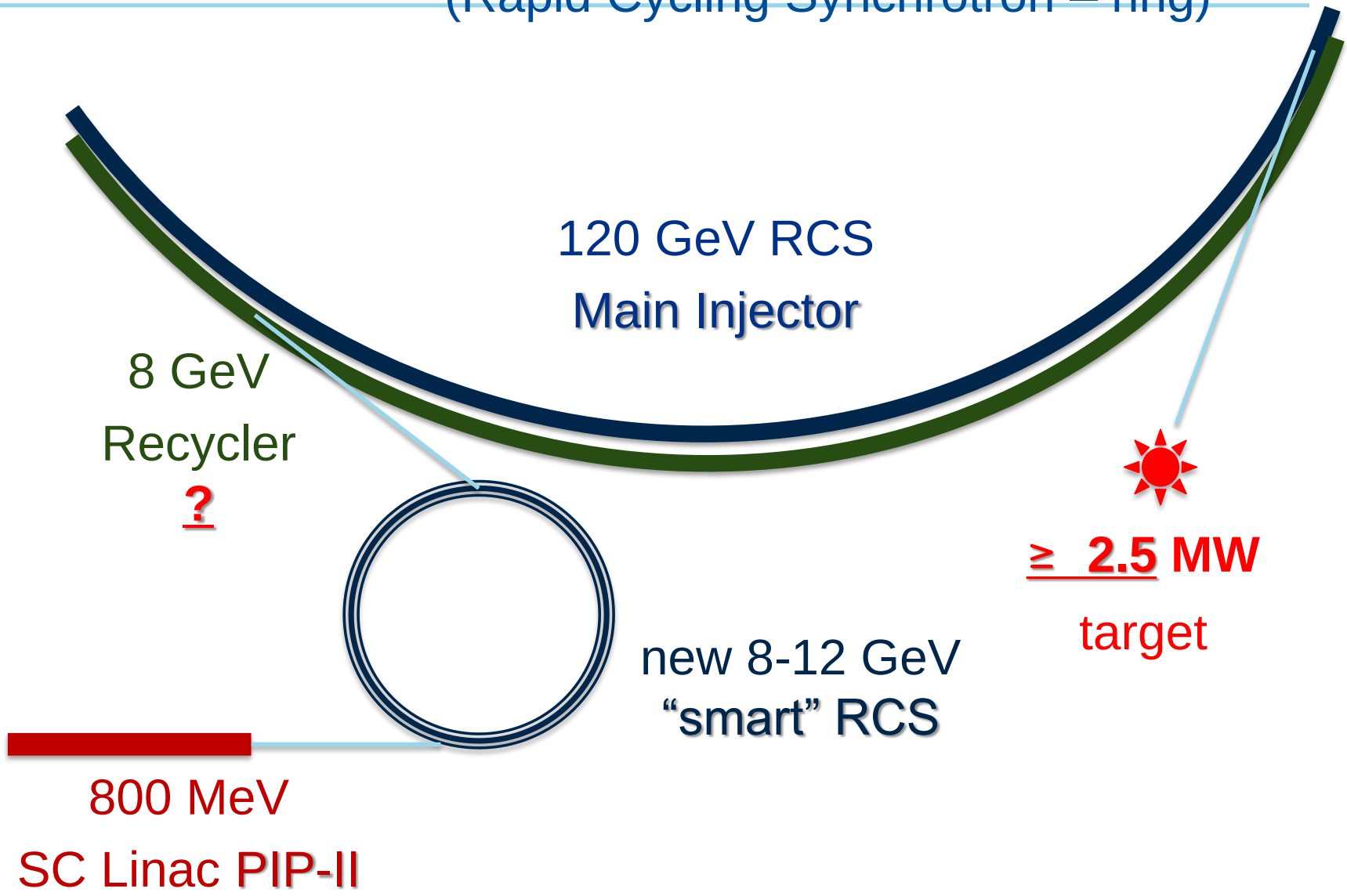


“Near future”, PIP-II , ca 2023-24



PIP-III "multi-MW"- Option A: 8+ GeV smart RCS

(Rapid Cycling Synchrotron – ring)



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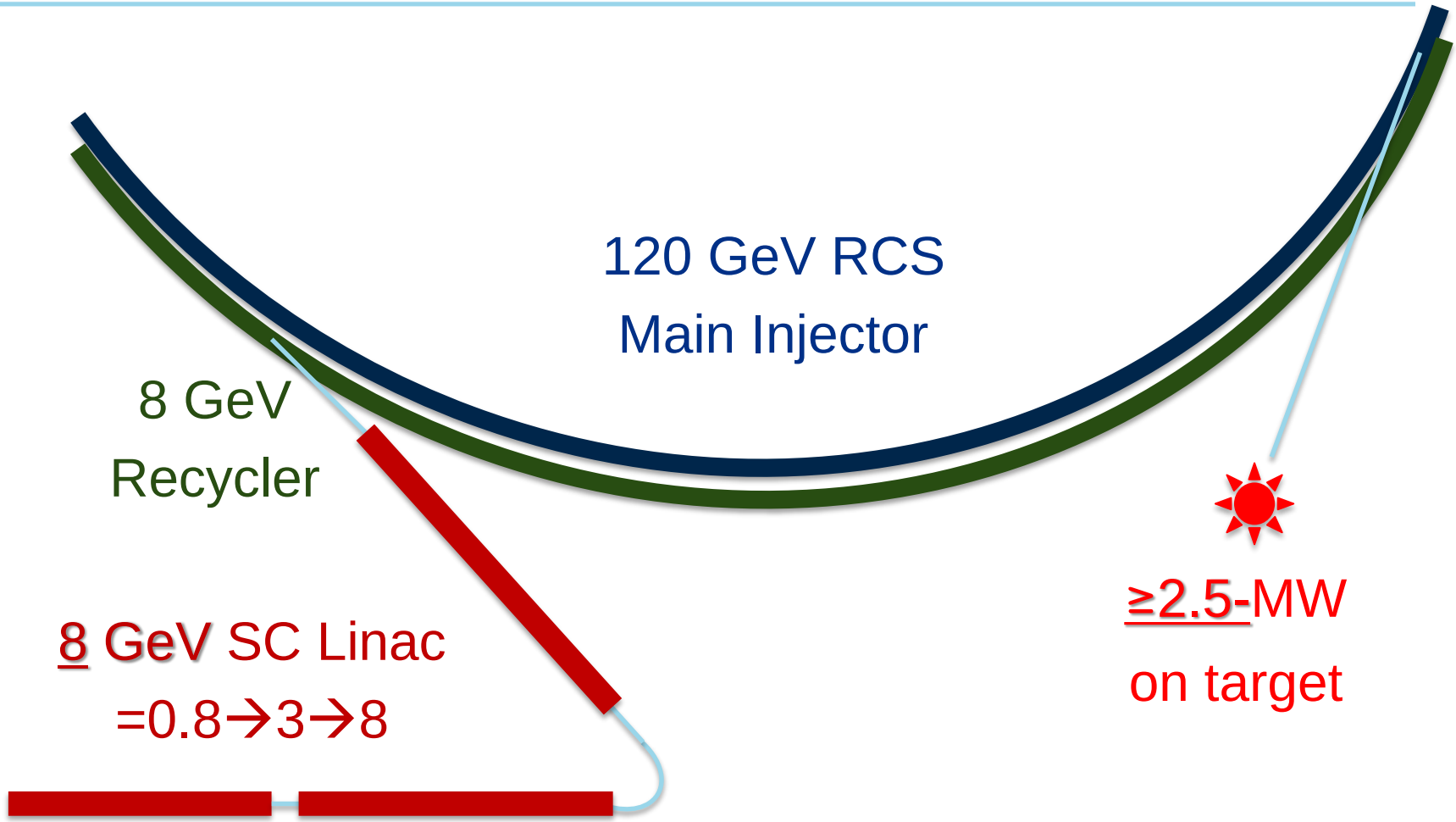
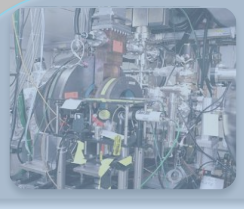
PIP-III "multi-MW" - Option B: 8 GeV linac



Fermilab Accelerator Program: P5-Aligned

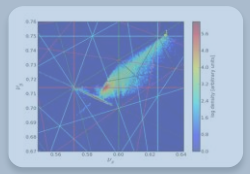
Operational Support and Complex Upgrade (PIP-II)

- Provide accelerator physics and technology support for operation and upgrades of the Fermilab's accelerator complex, ν and μ experiments



Advanced Accelerator R&D Towards Next Generation Machines

- Develop and explore transformative concepts and technologies for beyond next-generation multi-MW accelerators at FAST/IOTA and in the area of SRF



Accelerator and Beam Physics

- Contribute to the fundamental understanding of beam dynamics through experiment, simulation and theory

Exploratory Long-term R&D

- e.g. assess feasibility and demonstrate technologies for future 100 TeV pp collider and conclude ionization cooling demo for possible future muon facility

Accelerator Training and Education

- Train the next generation of accelerator designers and builders through the USPAS and Fermilab programs

FAST

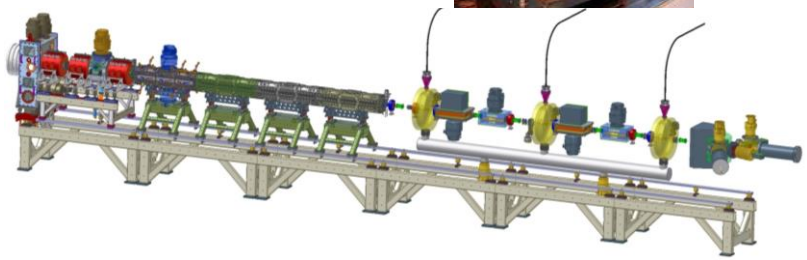
FERMILAB ACCELERATOR SCIENCE AND TECHNOLOGY FACILITY

UK Proton Program

- ISIS Operations and Upgrade
- Front-End Test Stand and MICE at RAL
- HL-LHC at CERN and ESS at Lund builds on work of CI/JAI and others
- Superconducting RF at Daresbury Lab
- Novel R&D: Paul Traps, Laser-related proton acceleration, Compact Sources
- ADS, ADSR/FFAGs, Material Irradiation and Medical Accelerators
- Possible contributions to PIP-II, PIP-III and novel R&D on FAST/IOTA
- Already a collaborator on LBNFand DUNE

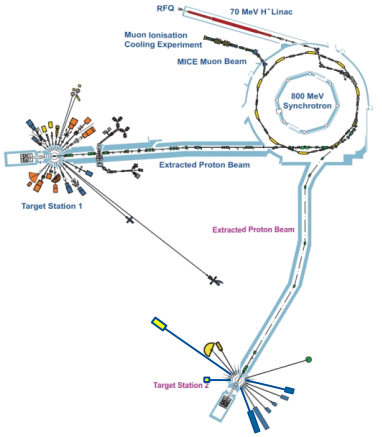
UK Accelerator and SCRF Facilities at RAL and DL

Front-end test stand

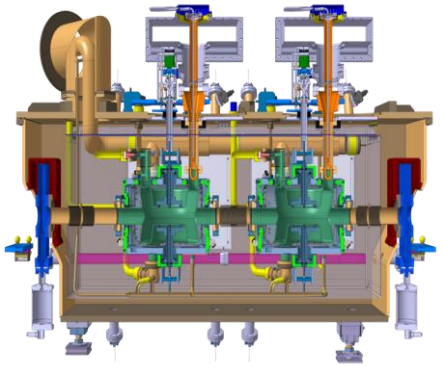


MICE

ISIS

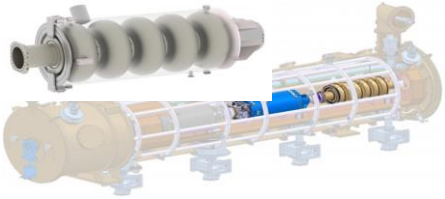


HL-LHC Crab Cryomodule



at CERN by 2020

ESS High-β Cavities



SRF Thin Films

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PASI 2015: OUTLOOK

- **There are accelerator challenges of mutual interest on both sides of the Atlantic. There is also room for new ideas that can lead to, or enable the exploitation of, even higher intensities, better control of beams, innovative concepts and compact cost-effective alternatives for SCIENCE, HEALTH, ENERGY, ENVIRONMENT and INDUSTRY**

- **The FOUR Working Groups in this workshop have been very carefully formulated by the organizers for us to focus on the specifics of these topical areas of relevance**

- **This meeting offers the opportunity for discussing ongoing collaborative efforts and their next steps, including exploring new areas of collaboration**

- **Wish you a SUCCESSFUL three days of workshop!!!!**