



TRIUMF

ISAC



ISAC II OPERATION and FUTURE PLANS

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*CANADA'S NATIONAL LABORATORY FOR
PARTICLE AND NUCLEAR PHYSICS*

*Owned and operated as a joint venture by a
consortium of Canadian universities via a contribution
through the National Research Council Canada*



Outline

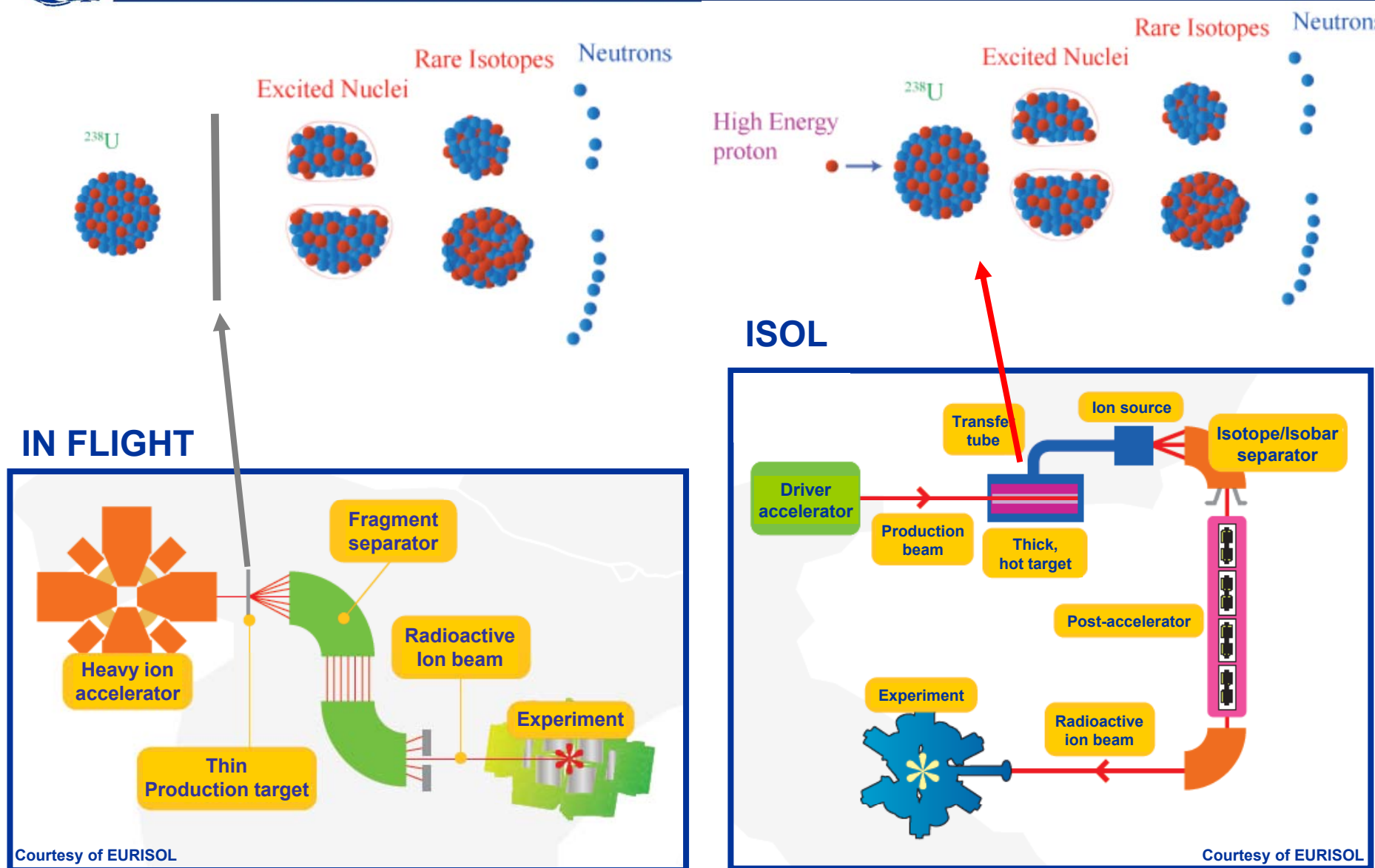
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- Radioactive Ion Beam
 - Production method
 - ISAC facility
- ISAC II operation
- ISAC II linac upgrade
- Future plans



RIB production

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RIB in the WORLD

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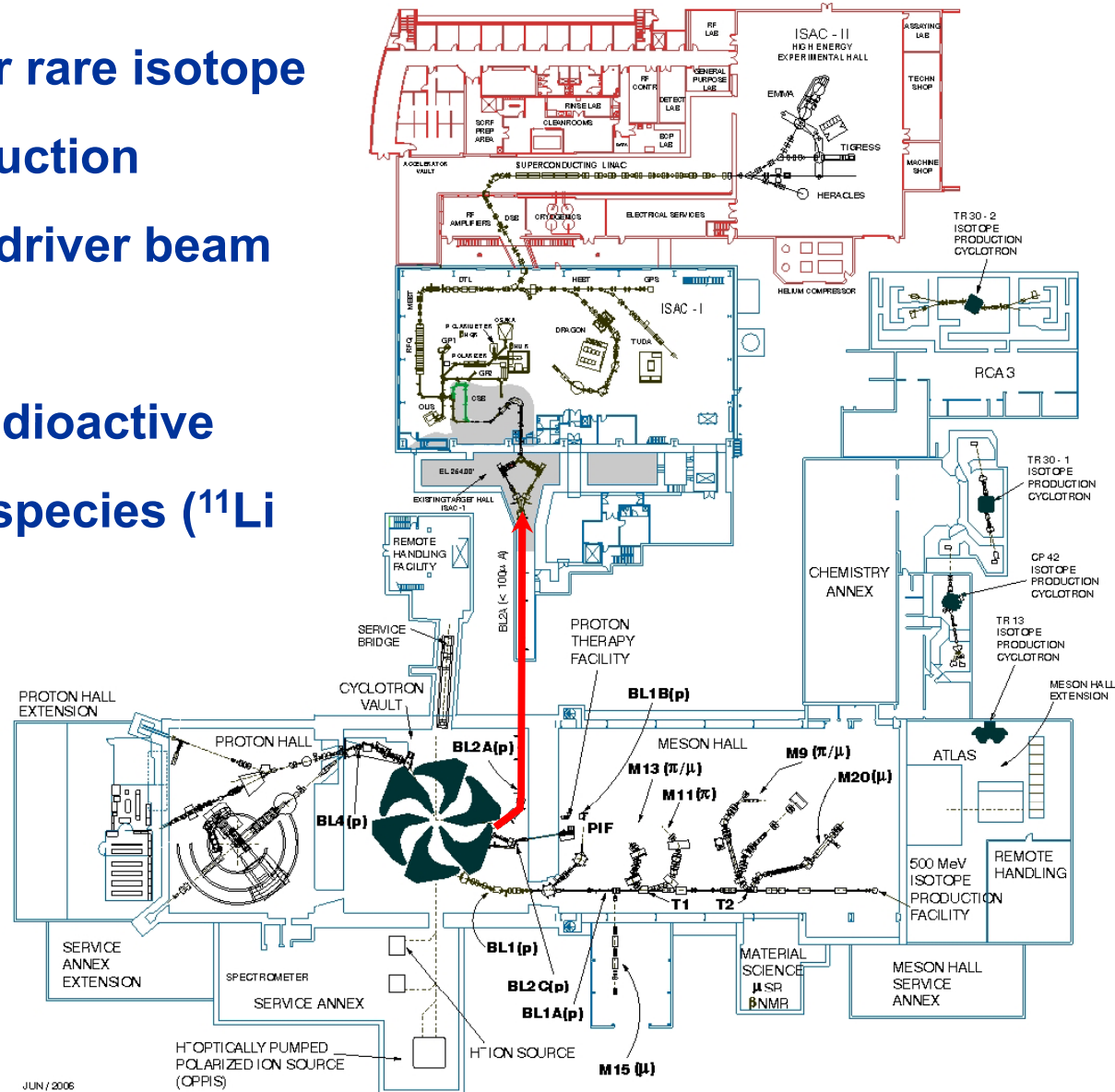




ISAC at TRIUMF

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- ISOL facility for rare isotope beam (RIB) production
- Highest power driver beam (50 kW)
- Most intense radioactive beam of certain species (^{11}Li halo nucleus)

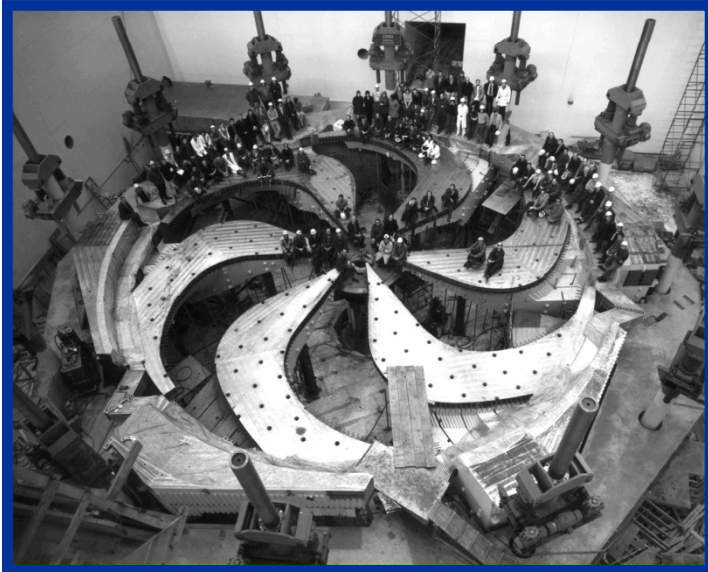


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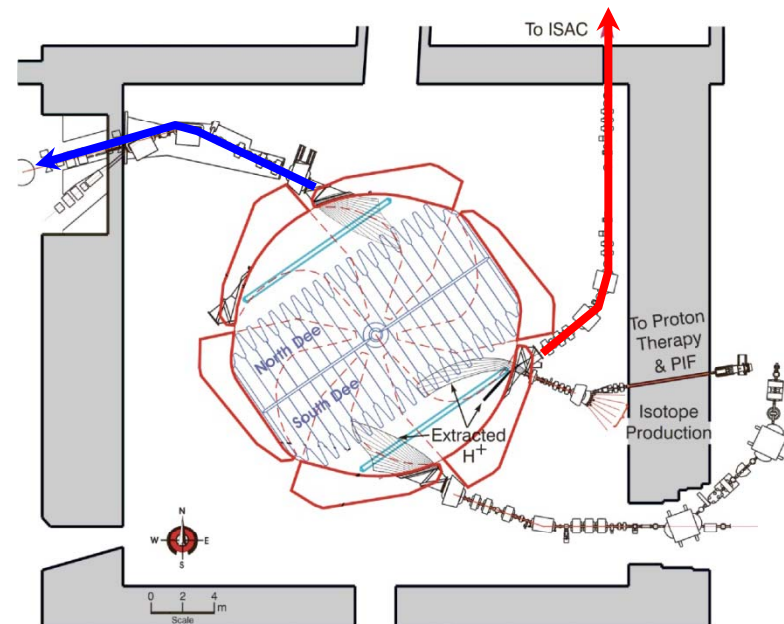
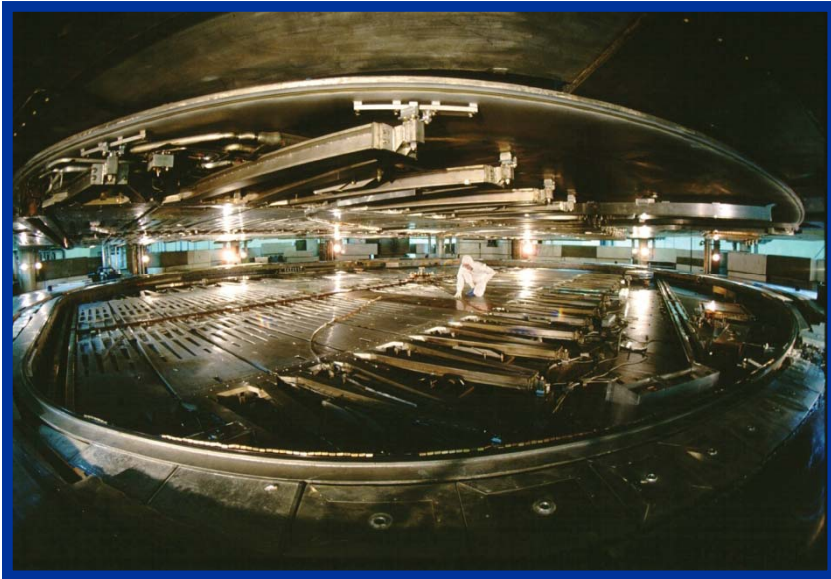


ISAC driver

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- H⁻ cyclotron as proton driver;
- ISAC proton accelerated to 500 MeV up to 100 μ A;
- Five Year Plan 2010-2015: one more proton line for RIB production.

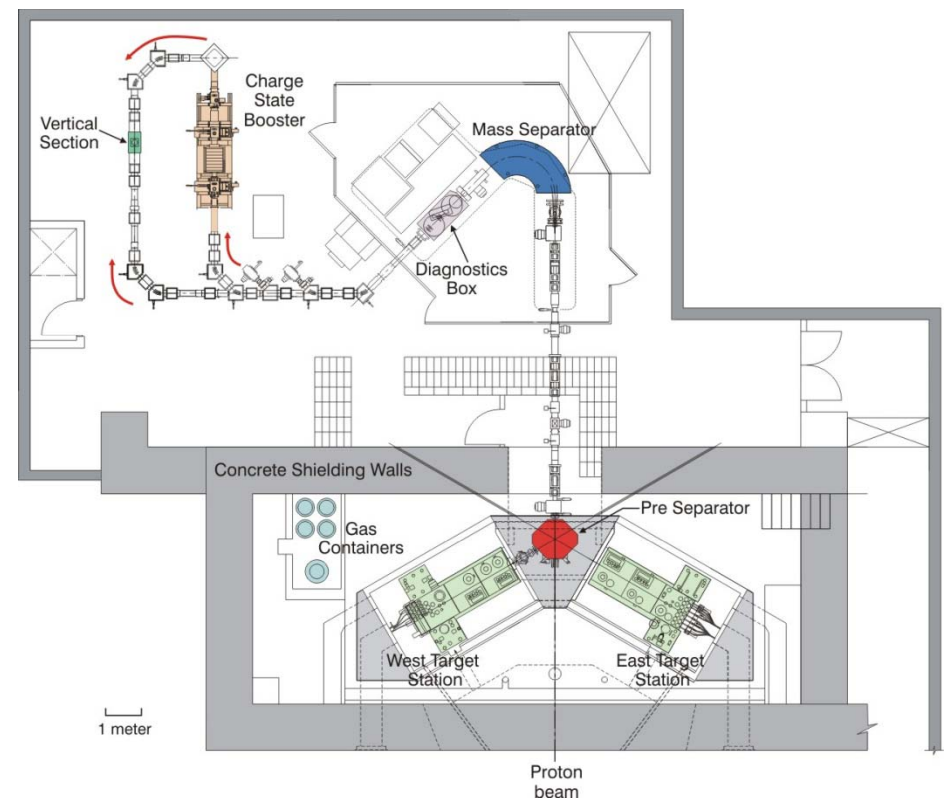




Target station and Mass separator

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- Two underground target stations;
- Proton beam sent to one target station while servicing the other
- Pre-separator inside the shielded area
- Mass separator on bias platform
- Charge breeder option available

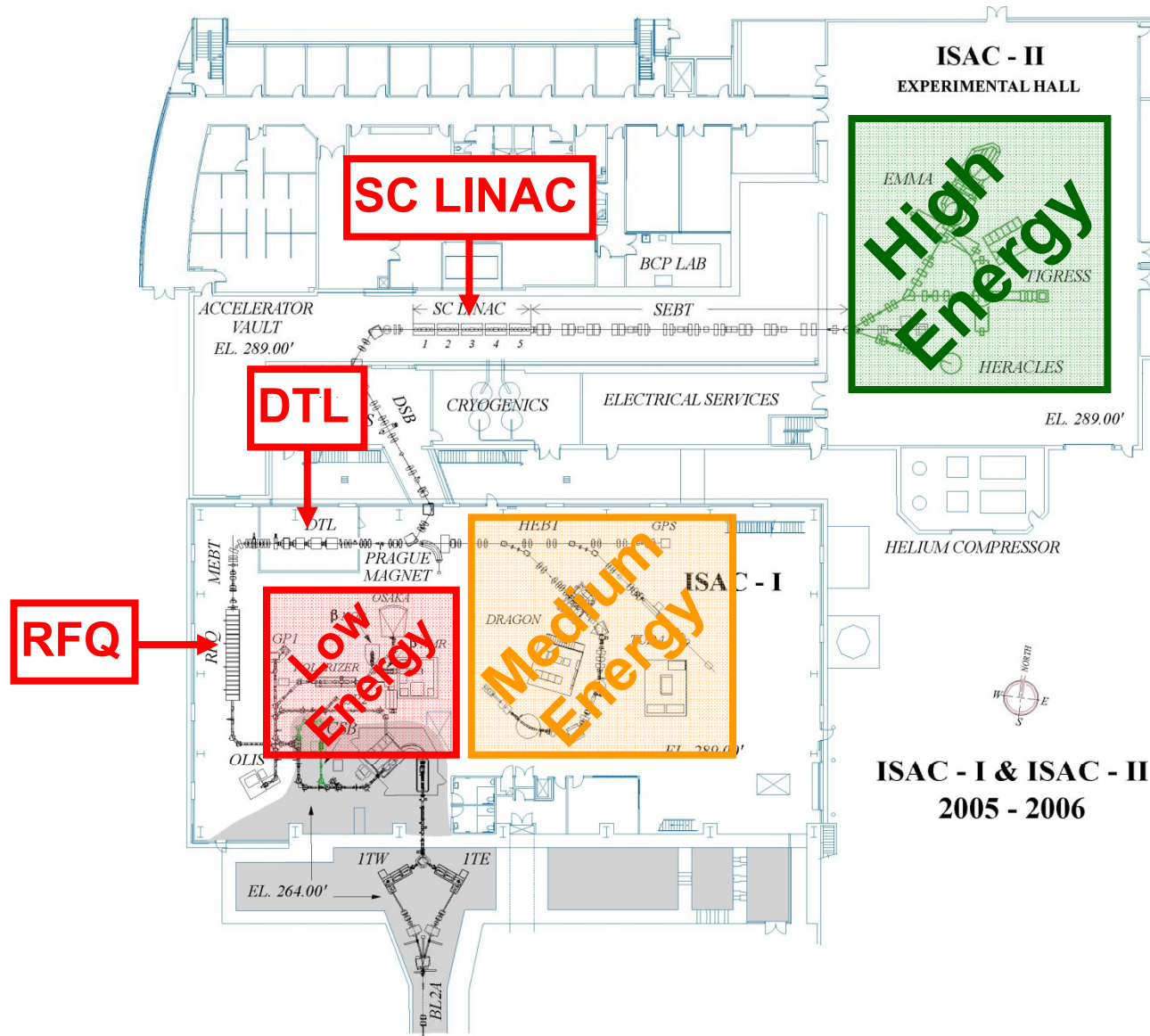


**Presentation on Thursday
morning TH201 by F. Ames**



ISAC overview

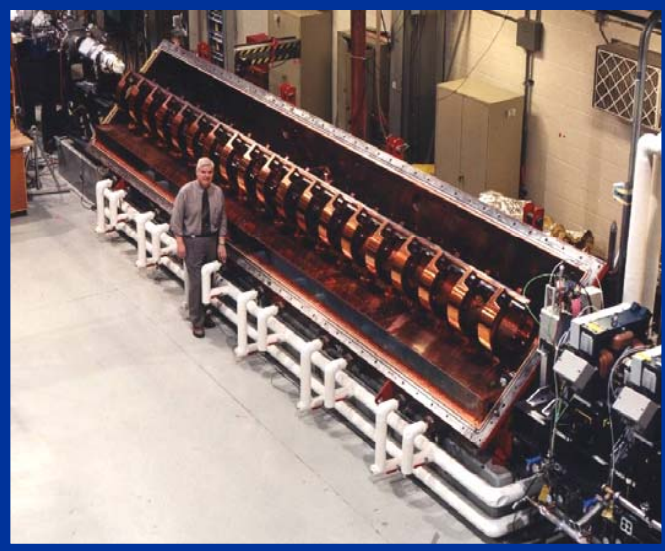
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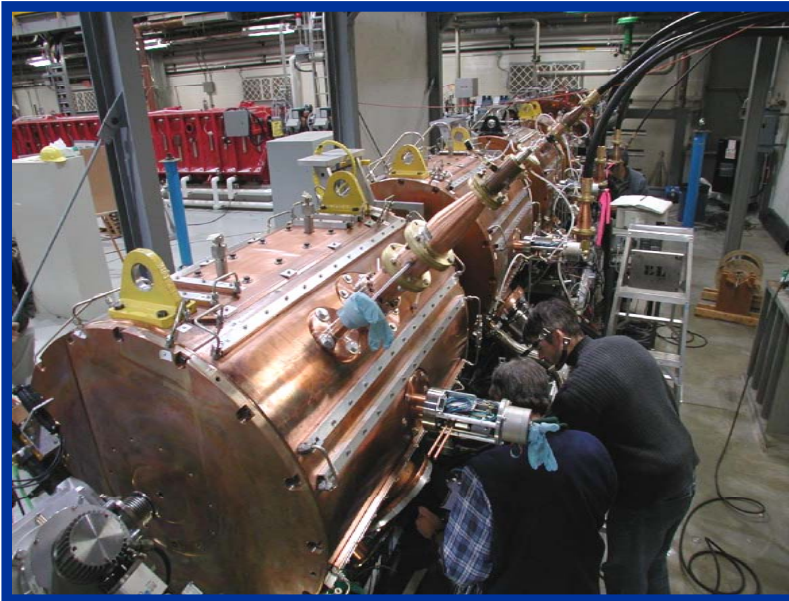
ISAC I Linac

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- RFQ
 - 8m long CW machine
 - 150 keV/u, $3 \leq A/Q \leq 30$
 - high quality longitudinal emittance

- DTL
 - Separated functions
 - Five IH interdigital RF cavities
 - Three split-ring bunchers
 - Variable energy machine
 - 150 keV/u $\leq E \leq 1.8$ MeV/u, $2 \leq A/Q \leq 6$
 - ISAC II injector 1.5 MeV/u

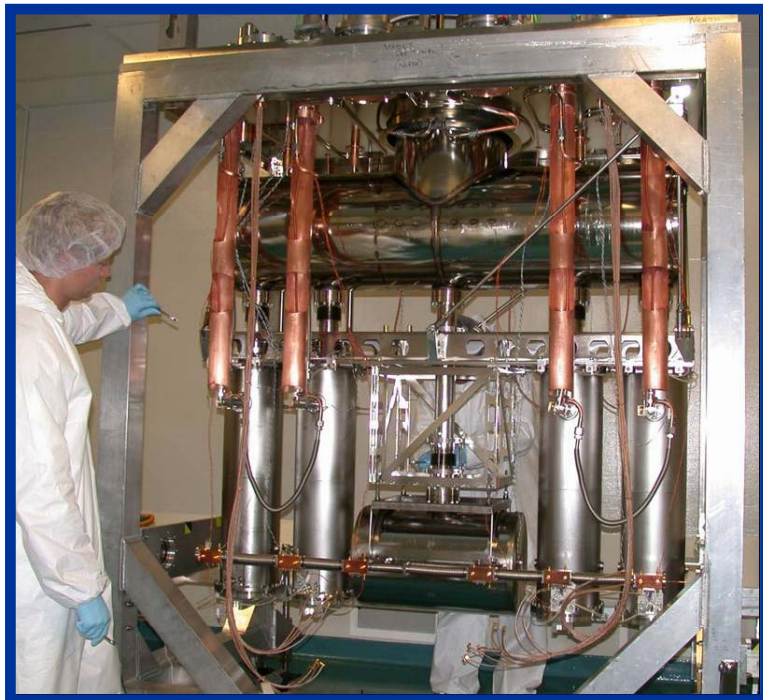
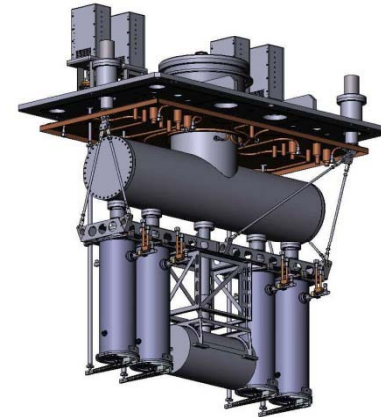




ISAC II Linac

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- Five cryomodules:
 - Four bulk niobium superconducting cavities per cryomodule (20 cavities)
 - One superconducting solenoid

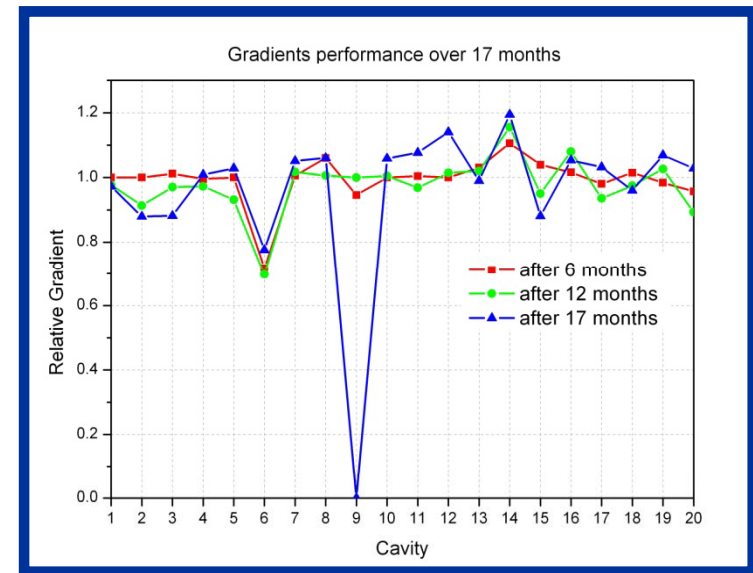
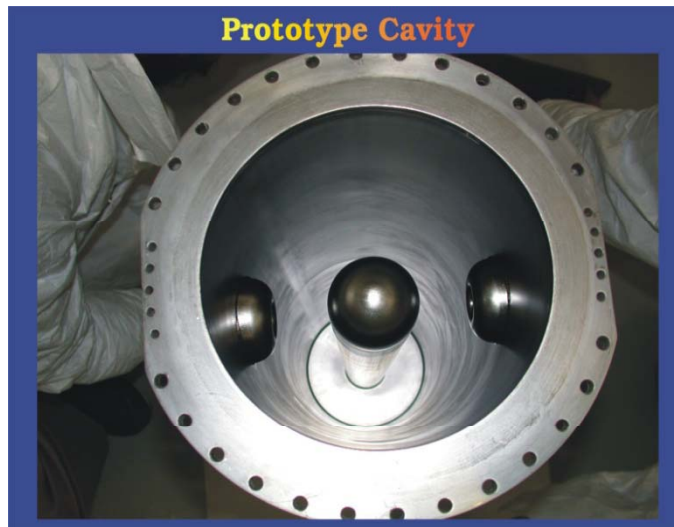
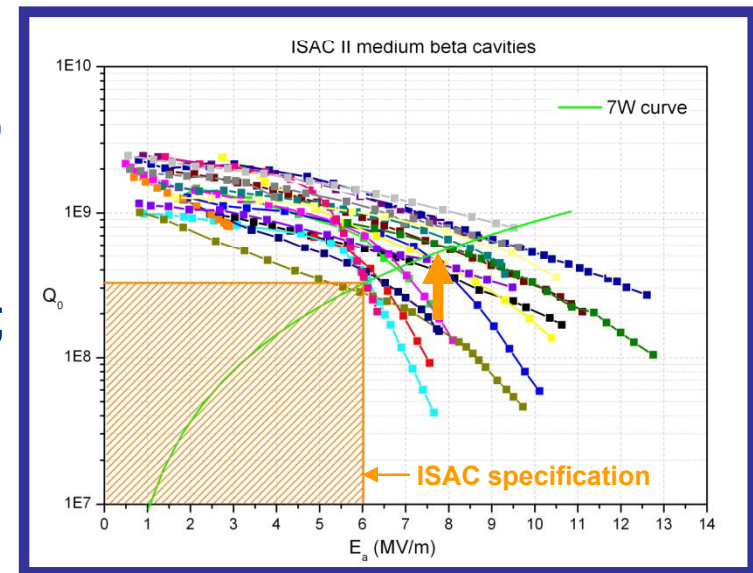




Medium Beta SC cavity

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- Quarter wave resonator at 106.08 MHz;
- CW operation: $E_{\text{peak}} = 35 \text{ MV/m}$ ($E_a = 7 \text{ MV/m}$)
@ 7W (spec. 6MV/m @ 7W);
- Medium beta section total voltage of 20 MV;
- Unique LLRF controls (Poster THP100 by K. Fong);
- No degradation in gradient performance.





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- Radiative Ion Beam
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- **ISAC II operation**
- ISAC II linac upgrade
- Future plans



Beam delivery group

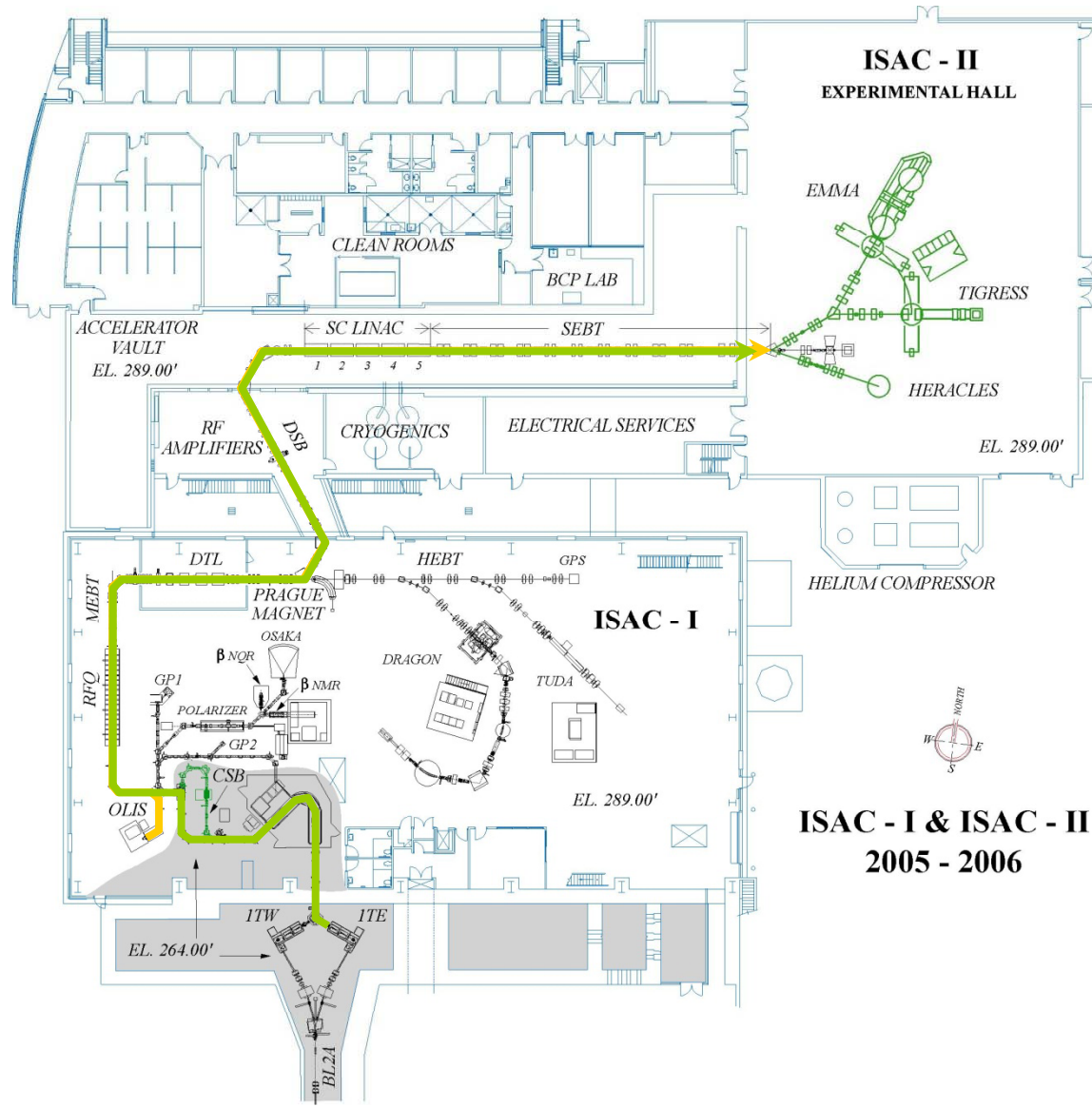
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- Delivery of RIB is challenging. Delivering chain:
 - Driver (three simultaneous extracted beam in CW, 90% availability);
 - Target (high power target, 90% availability);
 - Post accelerators (three linacs in series, 98% availability);
- Beam Delivery Group formed by experts:
 - Beam dynamics and accelerator tuning;
 - Sources and Targets;
 - Diagnostics (**Poster TUP071 by A. Mitra**);
 - High level application (**Poster MOP052 by M. Marchetto**);
- Purpose: minimize downtime and maximize integrated beam current for an experiment.



Beam delivery

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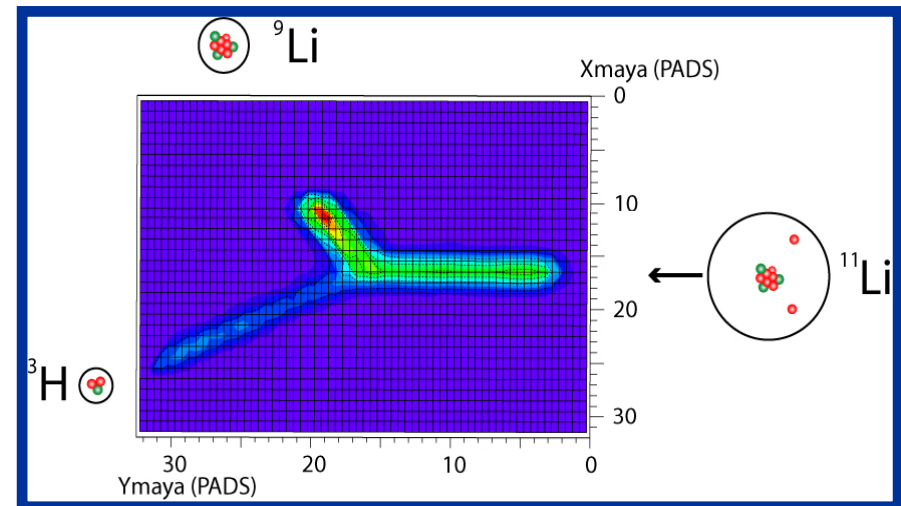
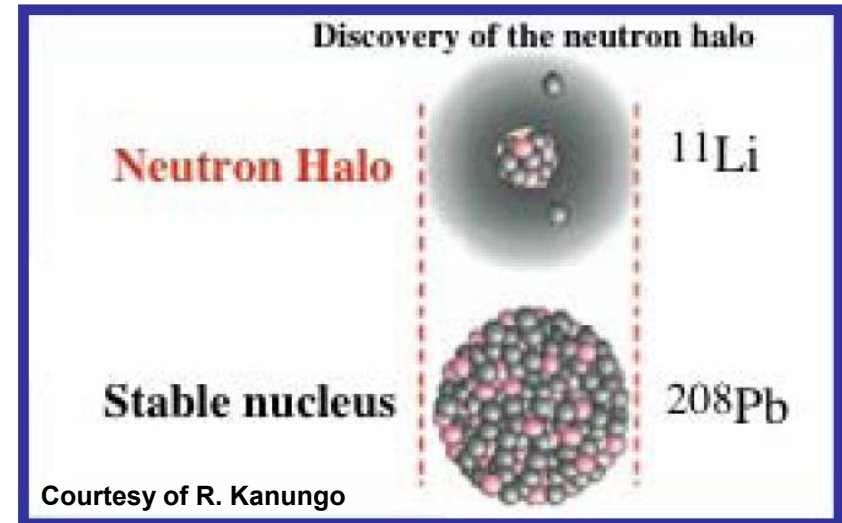
- RIB are very low intensity beam 10^3 - 10^6 particle/s;
- Pilot beam of stable ions matching RIB A/Q;
- Low intensity diagnostic.



Beam delivery success

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- Linac accelerators operate with high reliability >98%;
- Several key experiments completed successfully :
 - Maya experiment (GANIL) using ^{11}Li most intense in the world:





Outline

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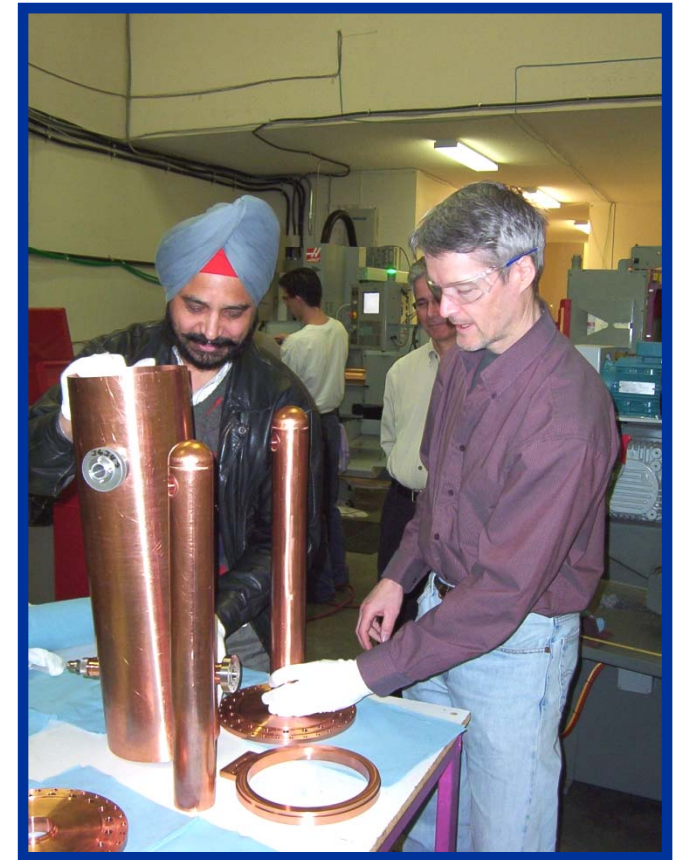
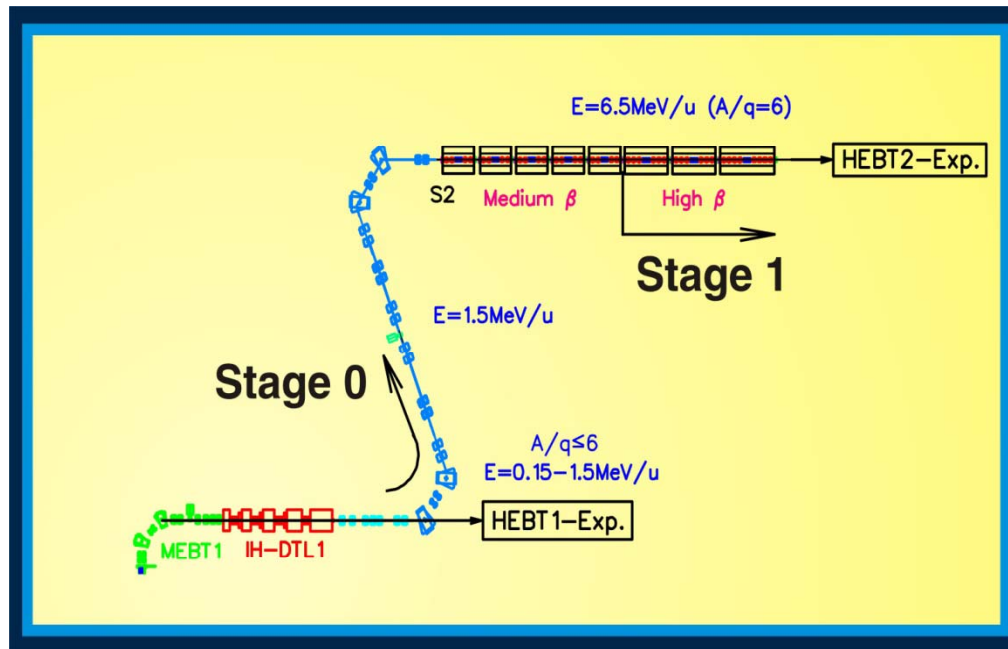
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ISAC II linac upgrade

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- Add 20 more cavities housed in three cryomodules;
- 141 MHz bulk niobium quarter wave;
- High beta section commissioned at the end of 2009.



Poster MOP018 by R. Laxdal

Poster MOP109 by R. Keitel

Poster THP004 by A. Mitra



141 MHz QWR fabrication

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- TRIUMF is collaborating with a local company, PAVAC Industries, to fabricate the cavities (**Poster THP003 by R. Laxdal**)
- First step was building two copper models
- Then two bulk niobium prototypes
- Etching done at TRIUMF

First Frequency Tuning



Forming and Machining



EB Welding



Pre-weld Etching - TRIUMF

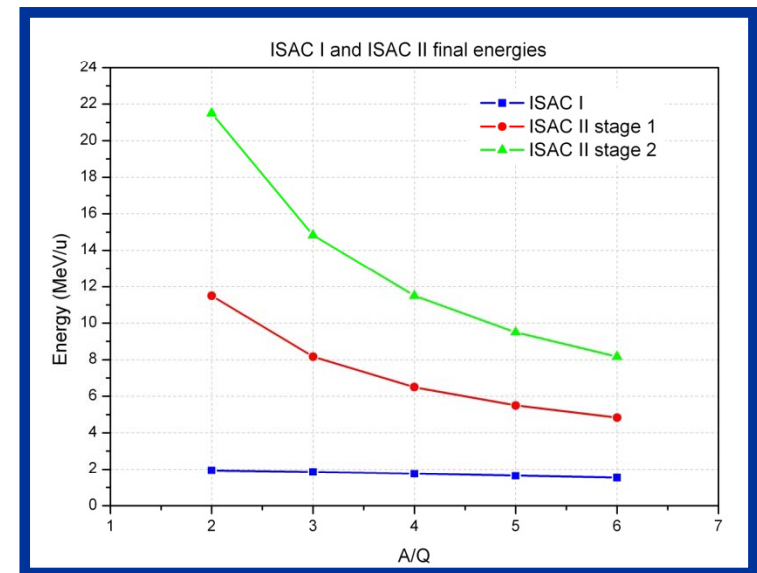
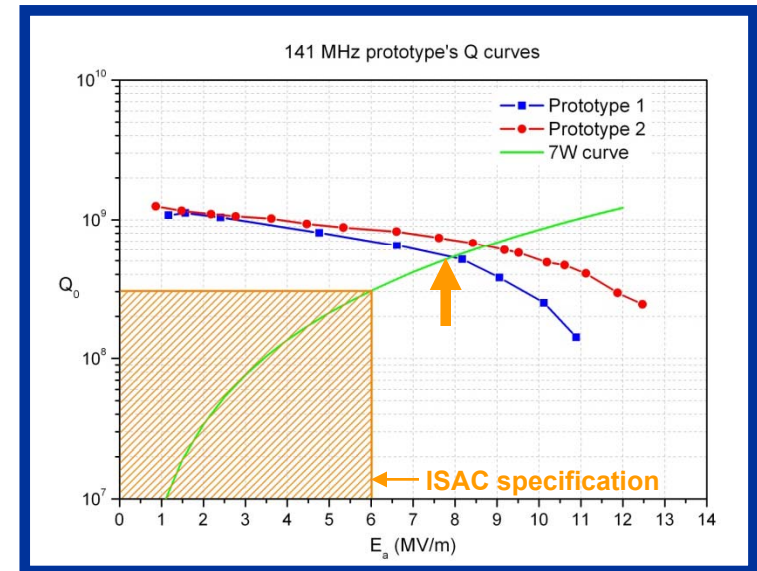




141 MHz QWR test

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- Two prototypes are already completed and tested
- Both cavities achieve ISAC-II specifications; $E_a = 6 \text{ MV/m}$ for $P_{\text{cav}} \leq 7 \text{ W}$ (Cavity $R_0 \sim 15 \text{ n}\Omega$)





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FIVE YEAR PLAN

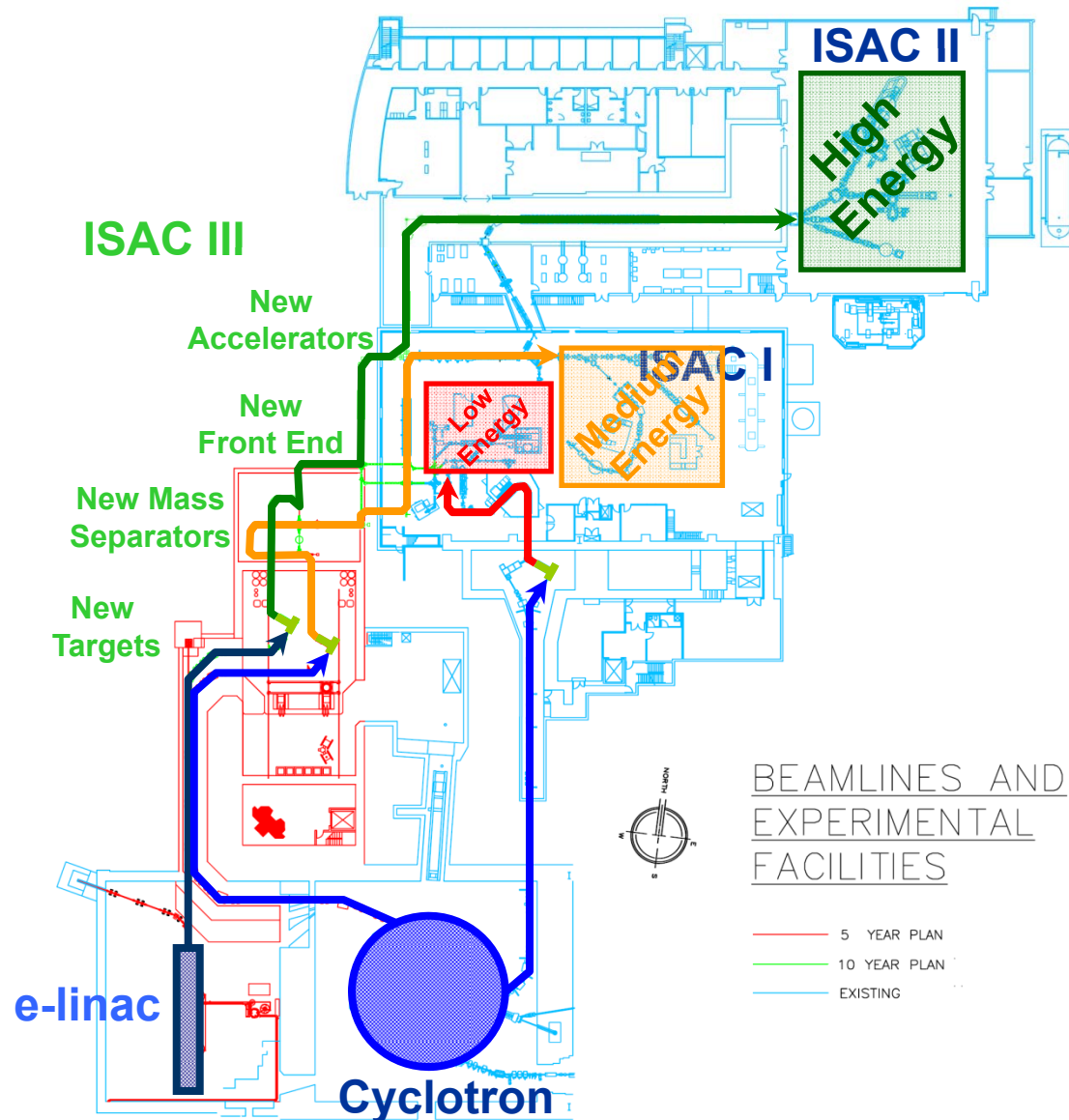
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- TRIUMF is funded in 5 years cycle (just printed the FYP 2010-2015);
- TRIUMF is not just RIB: nuclear medicine, isotope production, material science, technology transfer;
- Motivation: TRIUMF wants to further expand its global roles;
- ISAC wants to be the leading ISOL RIB facility:
- Issues:
 - Single operating target station (2900 hours RIB delivered over 4500 driver availability);
 - 12 experimental stations and 1 available RIB at the time;
 - Development of new RIB shares time with running experiment;
- Solution: Three RIB available at the same time one for each experimental area.



FUTURE PLANS

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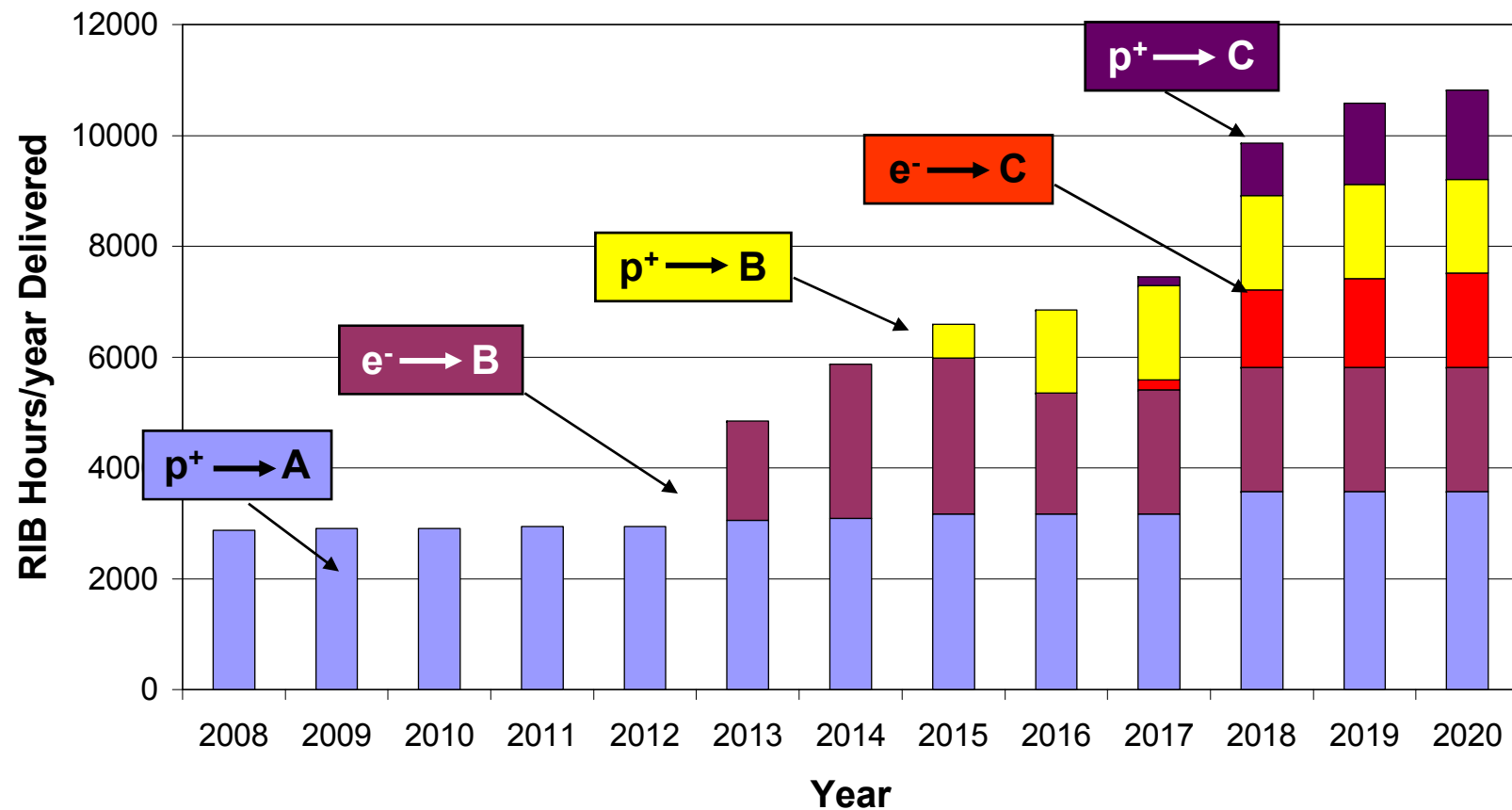
- Goal: three simultaneous radioactive beams
- New complementary driver (e-linac): electron driver for Photo-Fission
- New target stations and mass separators
- New front end and post accelerators
- Staged installation



Estimated RIB Production

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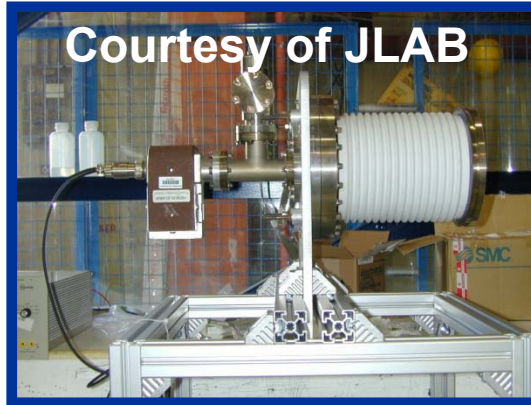
- Target B - The e-linac turns on in 2013, the new proton line starts delivering in 2014; more than doubles RIBs delivered by the end of the first five year plan
- Target C - RIB hours more than triple over the course of the full ten year plan starting in 2018



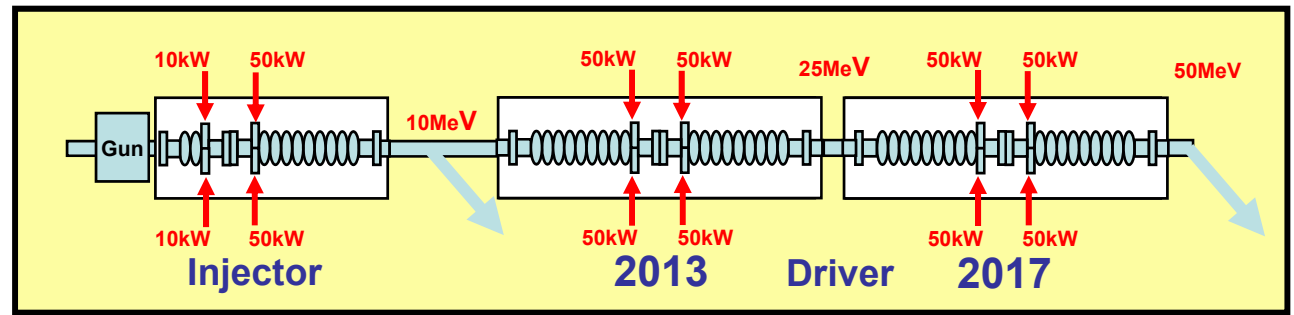
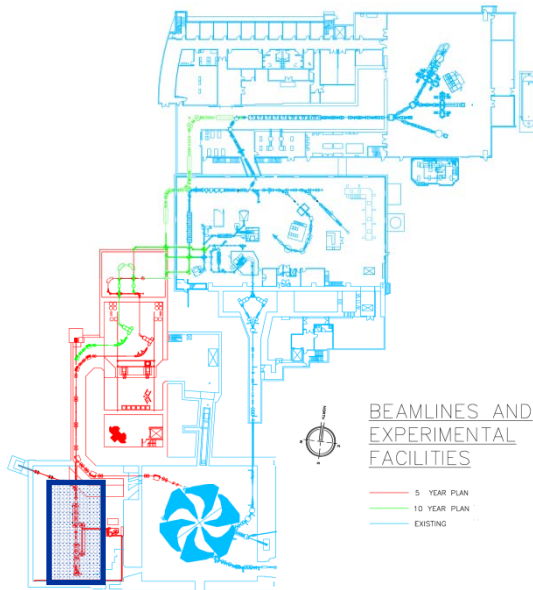


e-LINAC

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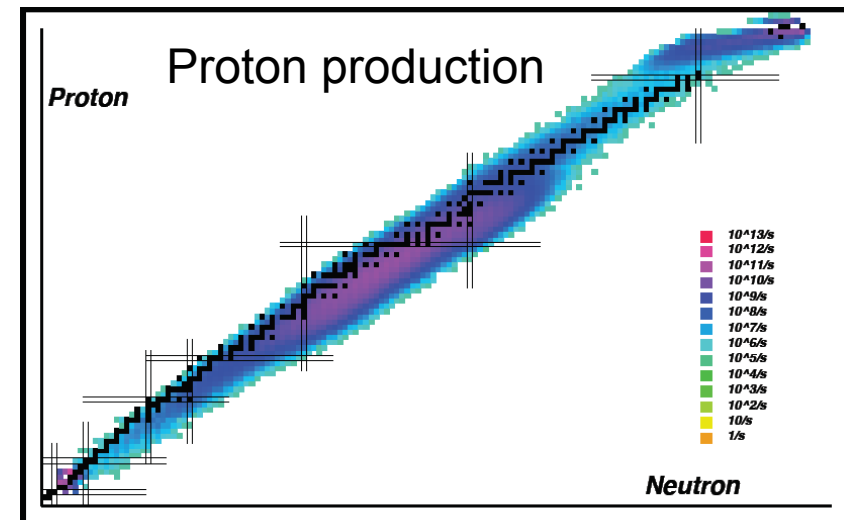
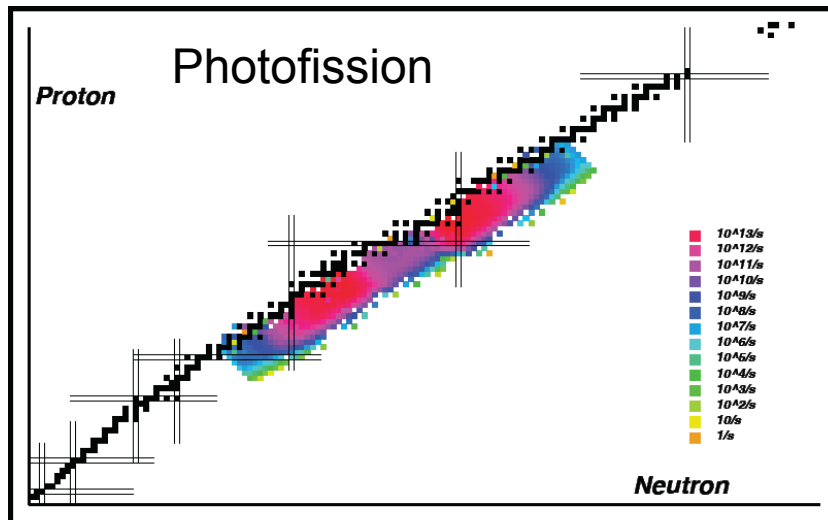
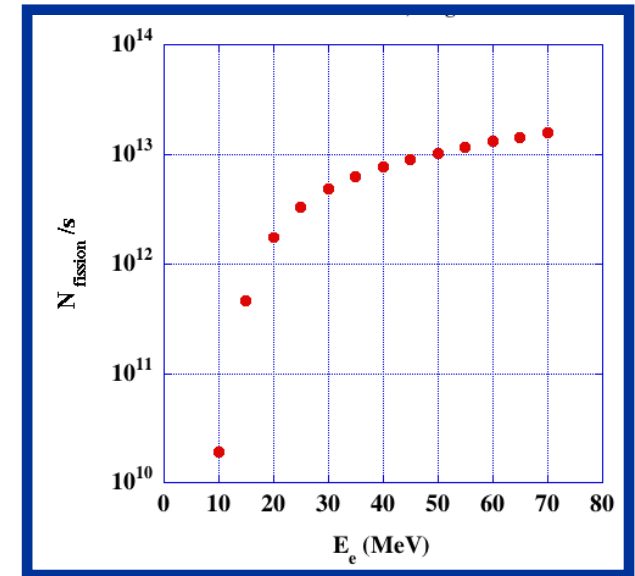
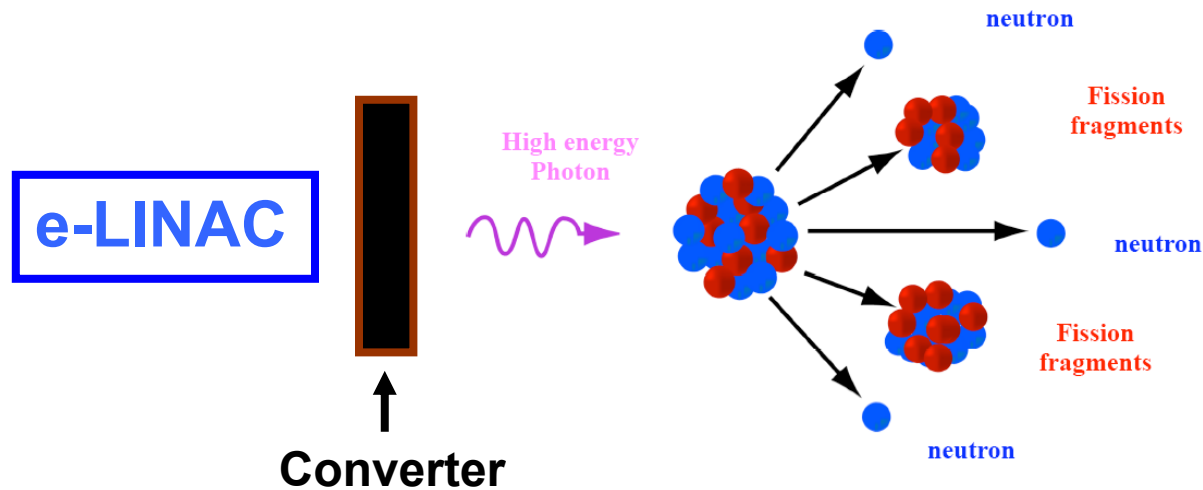
- Electron driver for photofission: independent and complementary;
- Elliptical cavities at 1.3 GHz ;
- Operation mode CW (limited gradient at 10 MV/m);
- Final energy 50 MeV;
- $I_{\text{average}} = 10 \text{ mA}$;
- $\frac{1}{2} \text{ MW}$ beam power.





Photofission

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SCRF at TRIUMF

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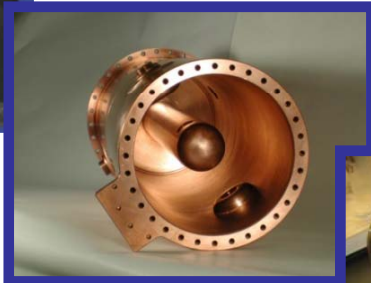
ISAC II Phase I
106 MHz
 $\beta = 0.057, 0.071$
 $E_p = 35$ MV/m

ISAC II Phase II
141 MHz
 $\beta = 0.11$
 $E_p = 35$ MV/m

E-linac/VECC
1.3 GHz
 $\beta = 1$
 $E_p = 20$ MV/m

SPL
704 MHz
 $\beta = 0.65, 1$
 $E_p = 50$ MV/m

ILC
1.3 GHz
 $\beta = 1$
 $E_p = 63$ MV/m



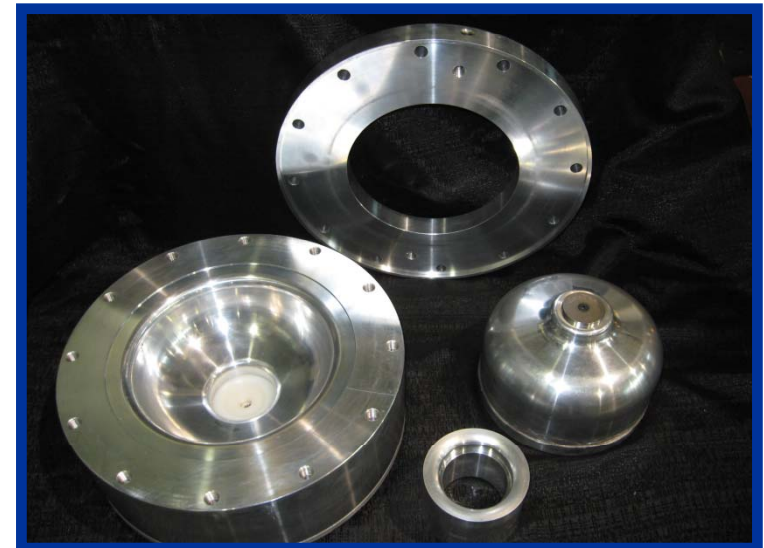
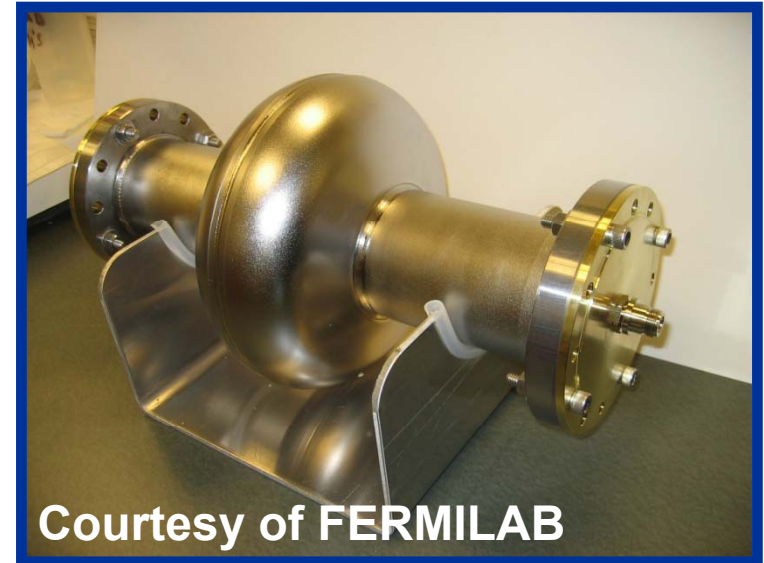


New SCRF activities

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- New single cavity cryostat for 2K operation of 1.3 GHz elliptical cavity
- RRR measurement setup
- Single cell elliptical cavity test
- Elliptical cavity fabrication (PAVAC industries)
- New collaborations:
 - Fermilab
 - University of Toronto
 - VECC laboratory

**Poster THP002 by
A. Grassellino**

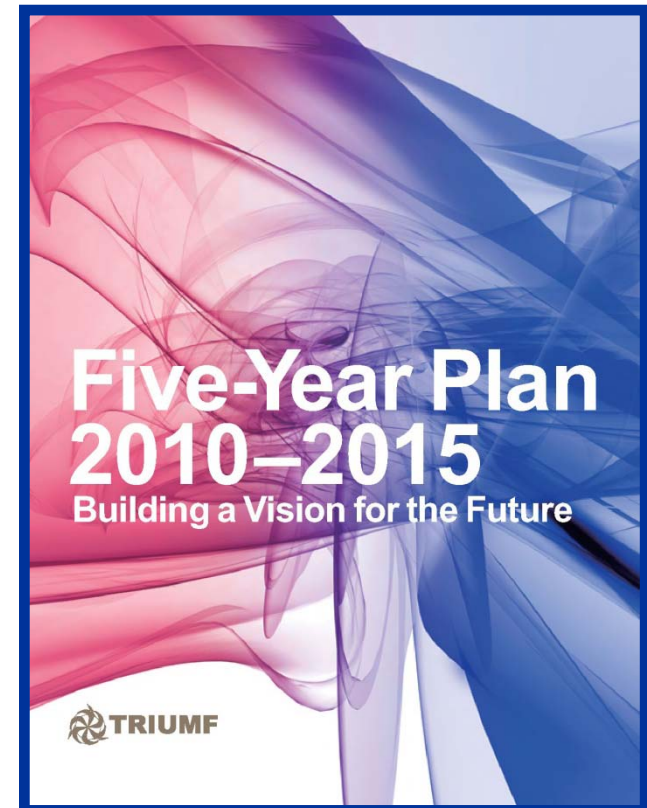




Conclusion

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- Medium beta section of the ISAC II linac is operating for two years with no degradation in performance
- Upgrade of the ISAC II linac is underway increasing the voltage capability to 40MV
- 1.3 GHz SCRF program started at TRIUMF
- Future plan to expand the facility published in the Five Year Plan



Talk FR204 by N. Lockyer



Thanks

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