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Canada's national laboratory
for particle and nuclear physics
and accelerator-based science

Prospects for THz/Infrared photon source powered by TRIUMF e-linac

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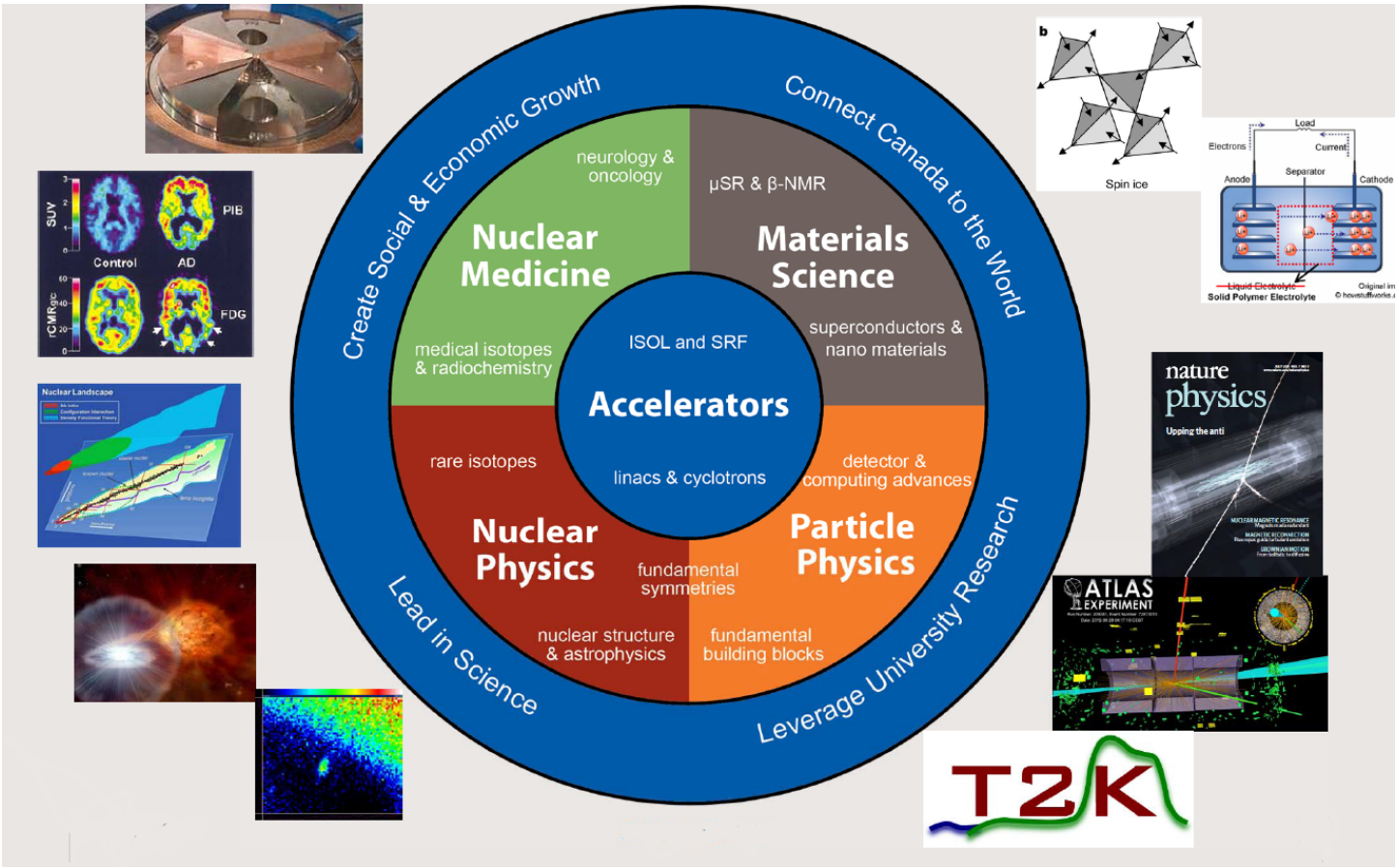
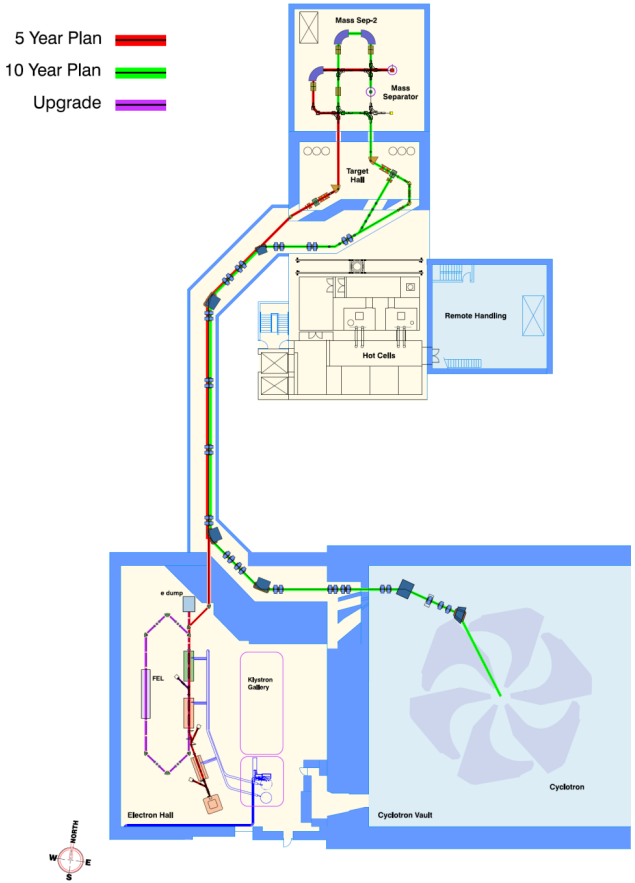
TRIUMF: Canada's National Laboratory

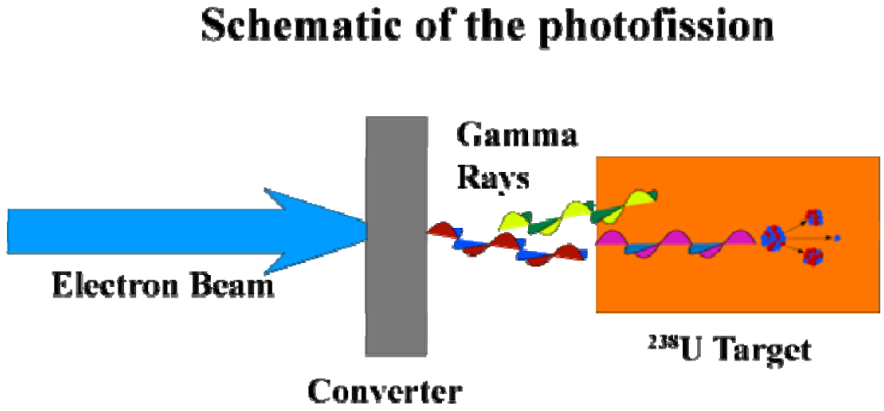
TRIUMF was founded in 1968 and has delivered nearly 50 years of accelerator-based science and innovation for Canada, and is engaging the World.

TRIUMF Research Program





- ISAC limitation: three experimental areas and 15 experimental stations but only one radioactive beam
- Advanced Rare IsotopE Laboratory (ARIEL) goal is to provide **3 simultaneous RIB** with
  - new electron linac driver for photo-fission
  - new target stations and front end
  - new proton beamline



E-linac Accelerator overview

Source:
300keV 650 MHz
Thermionic Gun

High power CW 10mA superconducting RF linac

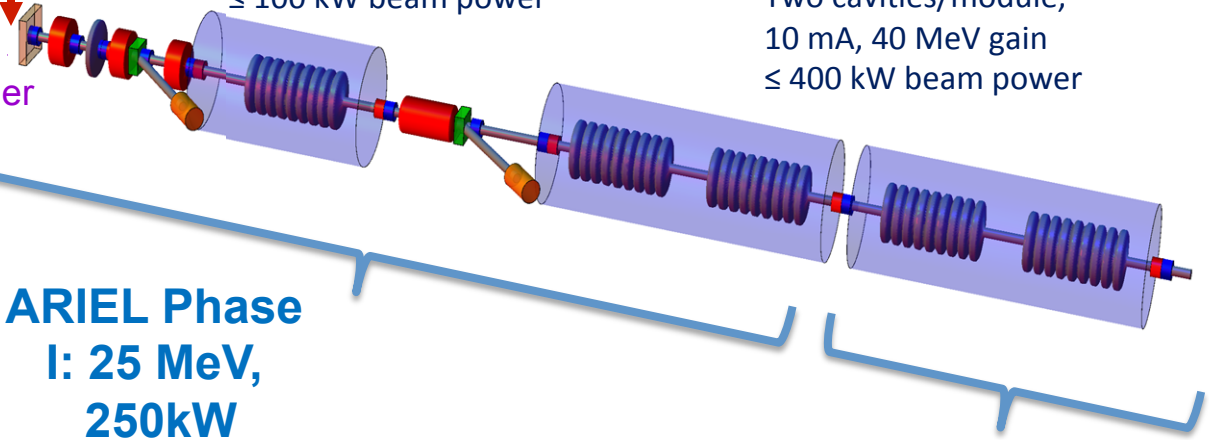
1.3GHz Injector:

10 mA, 5-10 MeV gain
≤ 100 kW beam power

1.3GHz Accelerator:

Two cryomodules
Two cavities/module,
10 mA, 40 MeV gain
≤ 400 kW beam power

1.3GHz NC Buncher



ARIEL Phase I: 25 MeV, 250kW

ARIEL Phase II: 50 MeV, 500kW

Installed Cryoplant for Phase I & II

E-linac Layout

Installation and Commissioning Timeline

July 19
5.5 MeV beam @ EMBD

July 28
EINJ moved to ISAC for cavity refurbishment

Sept 12
EACA @ 7 MV/m c.w. @ 2K

Sept 24
EACA @ 10 MV/m c.w.

3rd cavity installed

Sept 2018
Beam to the dump

January | May | June | July | August | September

2014

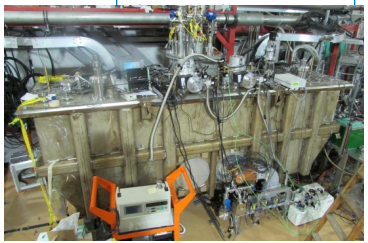
2015 -2016

2017 -2018

May 01
Injector in e-hall

June 26
EINJ @ 5.5 MV/m
Limited by field emission

August 29
EACA in e-hall on



Sept 16
EINJ in e-hall on beamline

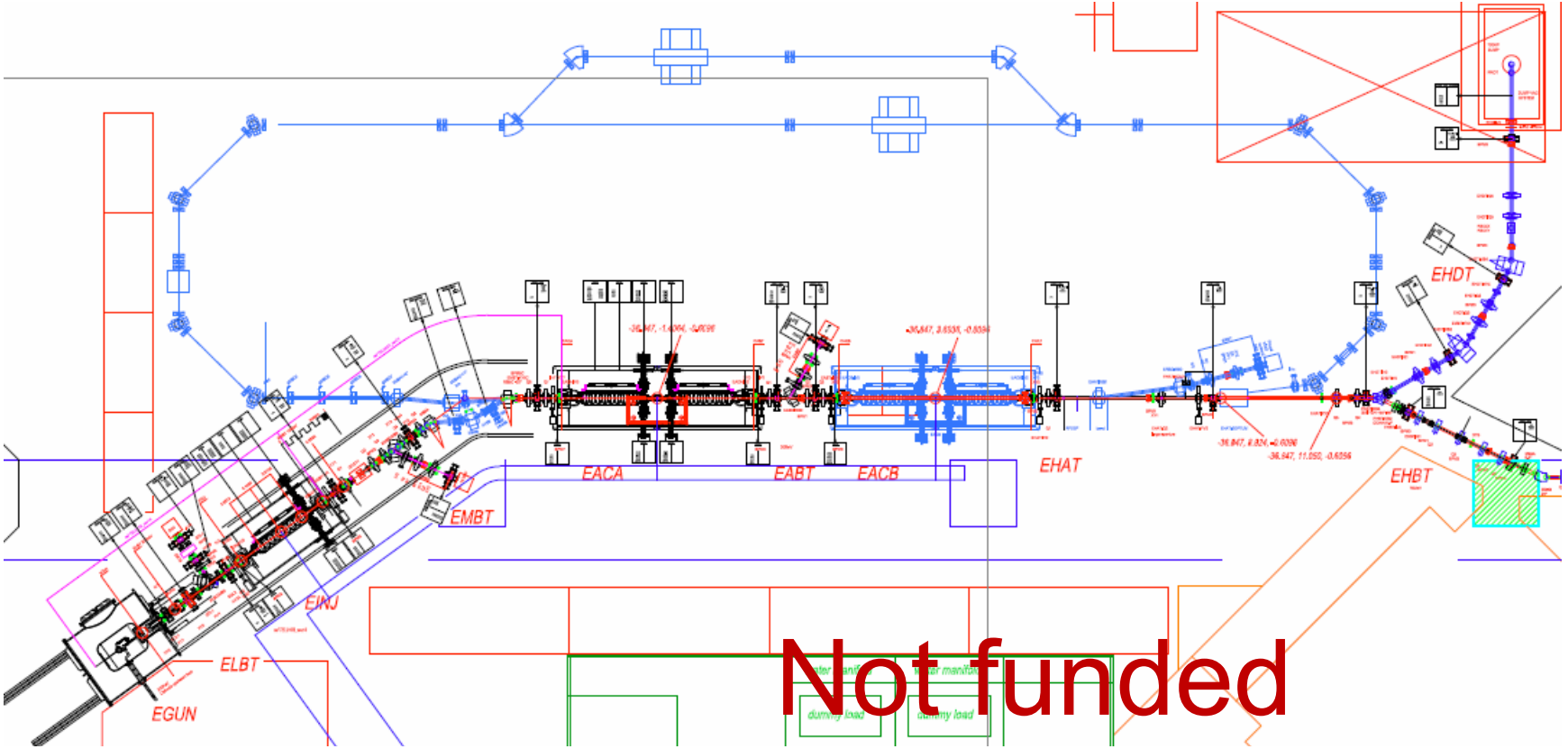
Sept 23
EINJ @ 12 MV/m c.w.
Limited by ...ler

Sept 30
20 MeV beam @ EABD

Commissioning resumed

Aug 2018
25 MeV beam @ EABD

ERL @ IR FEL .Original Proposal



Photon source project constraints and risks

Recently the proposal of constructing a THz/IR photon source received a new impulse but still in a very initial stage.

- Funding. Canadian Foundation for Innovations (CFI) requires complete design studies: 1.5-2 years.
- Available manpower and priority. Competing with ARIEL. Negotiation with the management are ongoing. Positive so far.
- Support from the User community. First user workshop was held in July at TRIUMF. Next to come in October at CLS.
- Simultaneous operation of an RIB driver and a photon source driver.
- Limited area around the linac to build FEL lines.

Project staging

Staged approach to the construction of the photon source is a path for a gradual evolution of the facility that enables conducting required developments of accelerator and (possibly) user areas at earlier times.

Essential preparation steps are

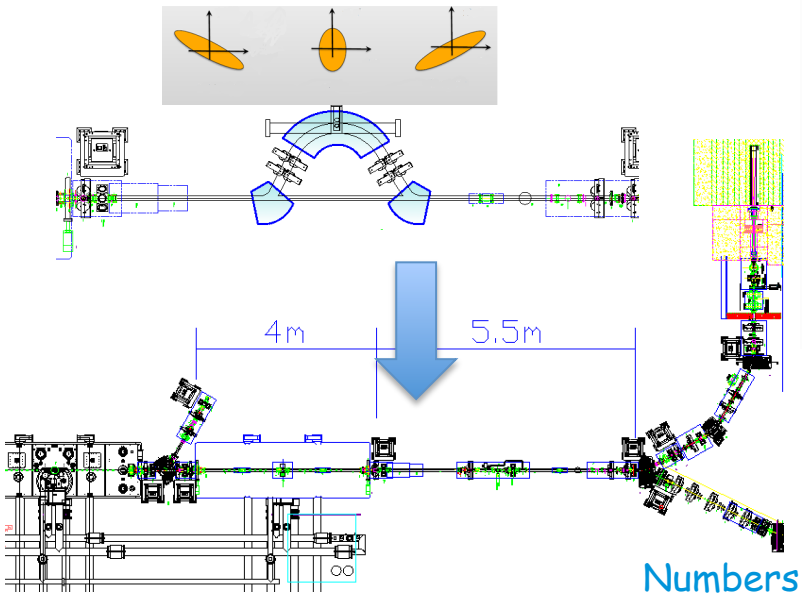
- Define the design parameters for both the electron beam and THz/IR radiation in collaboration with the user community
- Conduct design studies and required R&D (new electron source)
- Select appropriate technologies.
- Produce the conceptual design report.
- Engage the user community in design the end stations and user labs

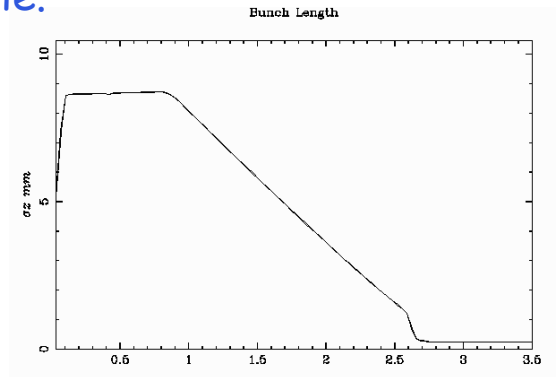
Stage 1: Produce first THz radiation with the present beam as a demonstration experiment

Stage 2:Through smaller grants develop/construct a new electron source and, possibly, procure an undulator/FEL. This will enable first pilot experiment

Stage 3: Depending on available funds full scale facility is implemented including FEL(s) and SRF gun, user areas

According to ASTRA simulations 16 pC bunch can be compressed from 120ps to ~ 800fs due to ballistic bunching.
Further bunch length reduction can be done with magnetic compressor. Bunch length in the range 300fs -100fs is eventually possible.





CSR, comes at essentially no cost.
It can be used to study the bunch compression and, possibly, conduct first THz experiment.

Type	Spectral Density @1THz, W/GHz	Average power in 0.1GHz-2THz range, W	Energy per bunch, nJ
CSR	0.007	12	110

Numbers in the table are estimates obtainable with 30MeV 50kW beam consisting of 16pC bunches compressed to 100fs.

New electron source is needed

Present TRIUMF thermionic electron source delivers 16pC bunches ~120ps long with 300keV of energy at 650 MHz.

-The charge is too low.
-Bunch is too long
-Repetition frequency is too high.

Electron source upgrade is required!

Laser driven electron sources are most suitable

- Offers better control over the bunch parameters
- and possibility of synchronization to external laser system

A dc gun is seen as a short to mid term solution with an SRF gun being a long term goal. The R&D has started.

A 500keV DC photogun

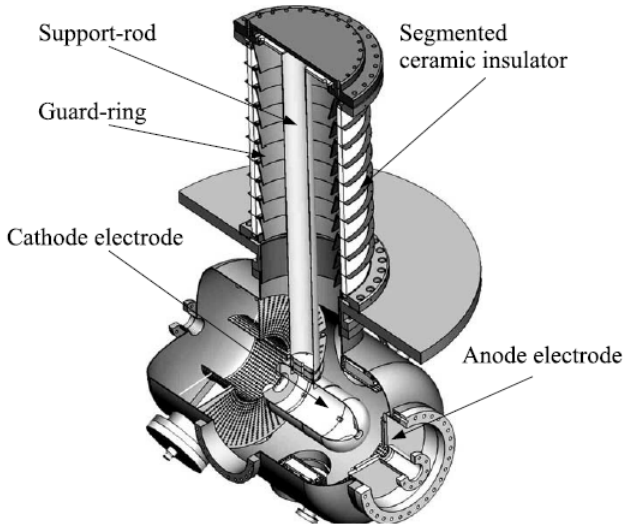


FIG. 4. Schematic view of the 500-kV dc photocathode electron gun.

R. Nagai et al, Rev. Sci. Instrum. 81, 033304 (2010) JAEA, KEK

K_2CsSb cathode commercial cathode from Photonis Inc.

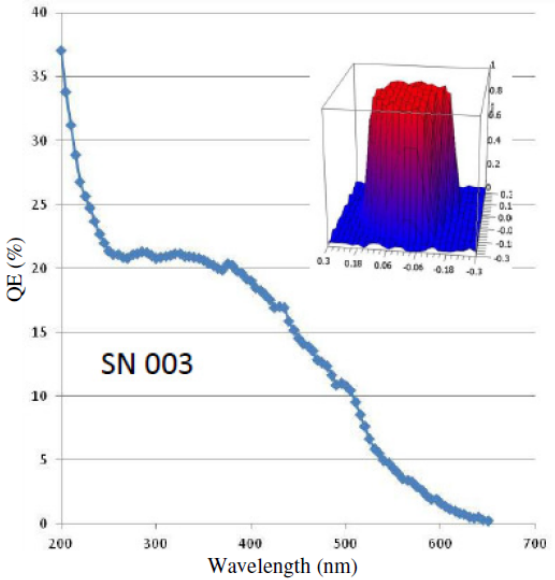
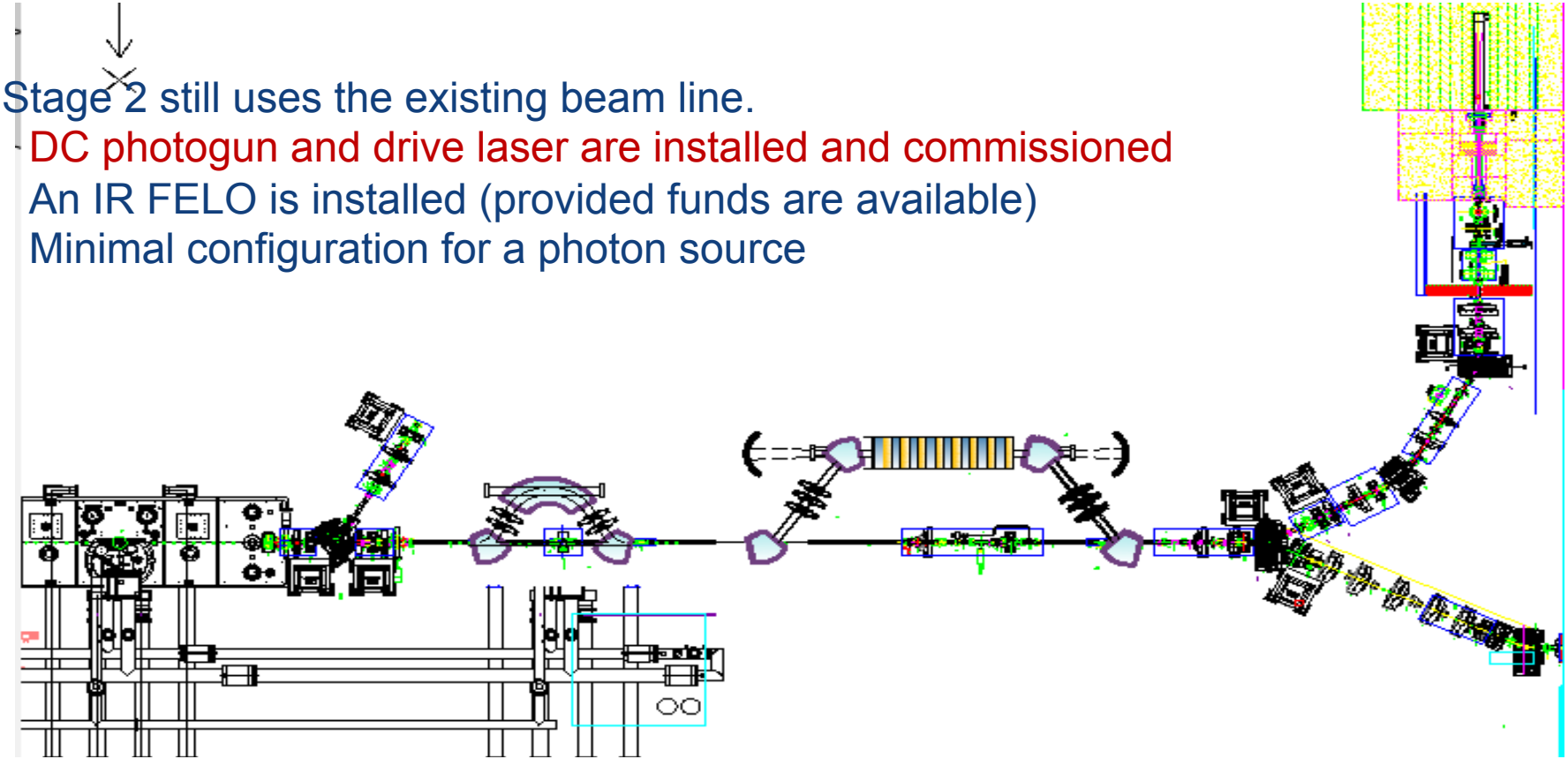


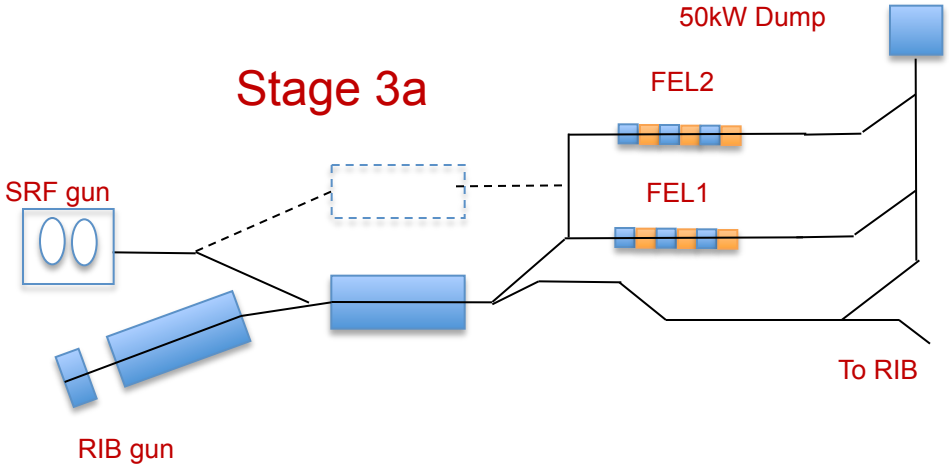
Figure 2: Spectral response of Photonis photocathode within the sealed tube. Inset shows spatial uniformity.

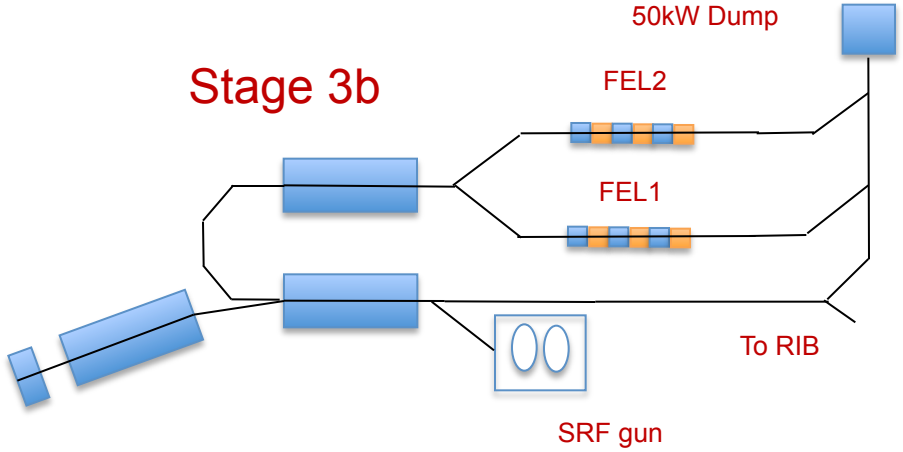
J. Smedley et al. proceedings PAC2013, Pasadena, CA, USA, 1178 (2013) BNL, LBNL, Argonne, Stony Brook

- Stage 2 still uses the existing beam line.
- DC photogun and drive laser are installed and commissioned
- An IR FELO is installed (provided funds are available)
- Minimal configuration for a photon source



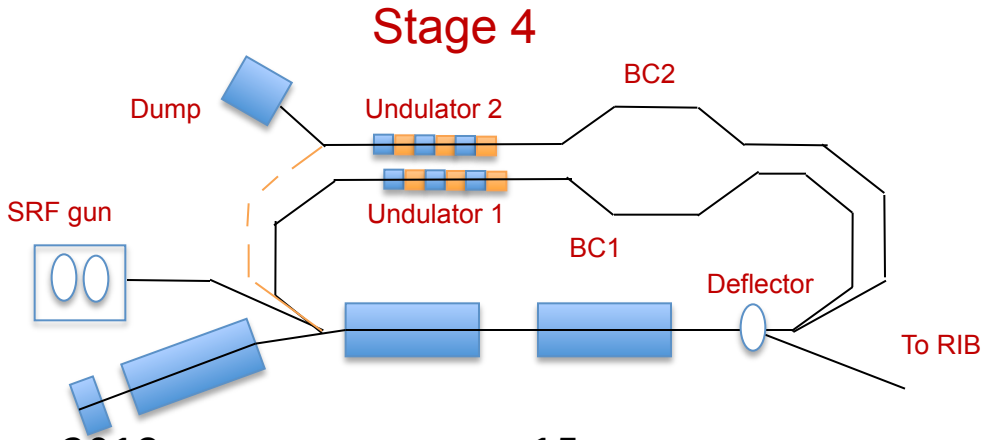
Stage 3 and beyond



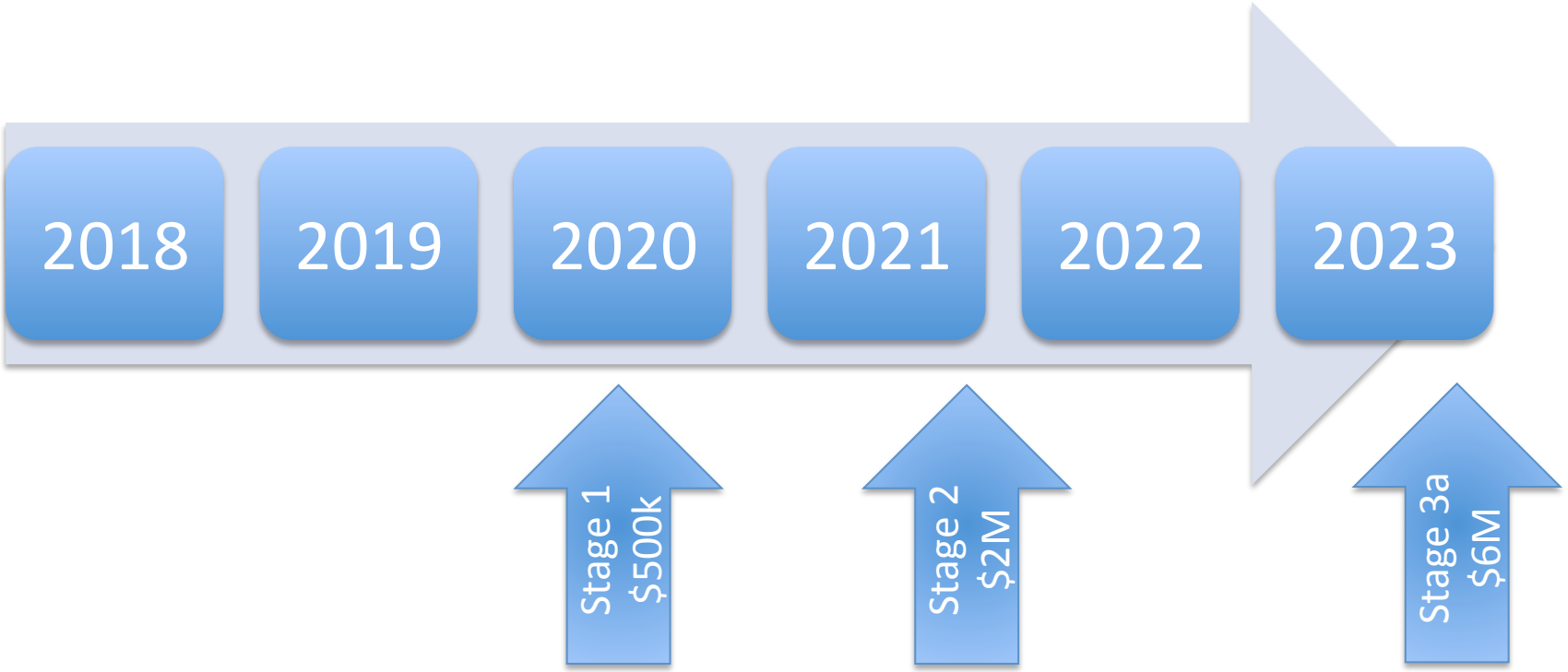


Stage 3 includes several FEL and coherent sources. Covers wide range of wavelengths and fully developed user area. Simultaneous Operation RIB and FEL highly desirable.

Stage 4 targets ERL/RLA operation and requires much more thoughts. Reward is a very high power and efficiency.



Timeline and budget



User end stations excluded

Summary

- A 30-MeV 10mA CW electron linac has been constructed and is being commissioned at TRIUMF .
- Although the main application of the accelerator is radioactive isotope production, it can be also used as a THz/IR photon source.
- Several modifications, such as new photon driven electron source(s) and bunch compressor(s) are required.
- Given various constraints to the design a staged approach might be most optimal.
- Contacts with the Canadian IR community are established.
- The design and first R&D are about to start.

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Thank you!
Merci!

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