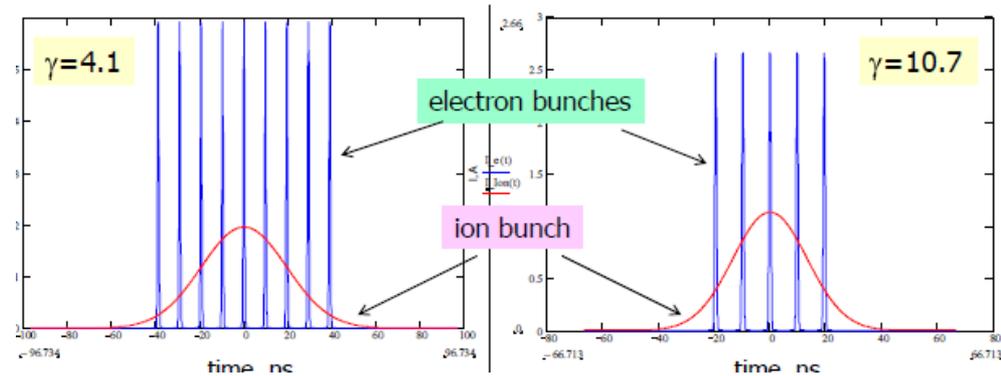


Low-energy RHIC electron Cooler (LEReC)

February 26, 2014

Low-energy RHIC electron Cooler (LEReC)



Present baseline

(accelerator design in progress):

cooling with “trains” of electron bunches:

-frequency of bunch trains 9.4 MHz

-frequency of bunches within train 704 MHz

Present design (704 MHz/ERL) is based on already available hardware:

704 MHz SRF gun and 704 MHz SRF cavity from R&D ERL

March 2014: Physics approach/accelerator design – fix elements and lattice

March 2014: White paper on ERL-based LEReC

March 2014: Engineering baseline, start working on layout in RHIC tunnel

April-June: WBS, cost estimate, risk assessment, PEP, safety, etc.

DOE Technical/Cost/Management Review: July 9-11

2014 Engineering systems PDR, systems specifications, building requirements/system loads.

2014-2015 Detailed design – long lead procurements.

FY2015 Support building modification design/contracts (2015 shutdown modifications)

FY2016 Receive and test LEReC beamline and cryogenic components

Summer 2016: Start Installation LEReC beamline and cryogenic components

FY2017 Installation, engineering commissioning of beamline and cryogenic components

(moving of ERL components starting Fall of 2016)

FY2017 Final installation and commissioning of SRF accelerator.

FY2018 Cooling commissioning and operations (Run-18)

LEReC developments

4

We have studies of some parts of the design not yet of a full concept:

- No gun: bunch stretching, energy correction (D.Kayran) -done
- Simulations starting with ERL gun (J. Kewisch)

ERL adds additional constraints on location of accelerating cavity

- Physical constraints for installation of ERL SRF gun and cryo lines.
- Location of SRF-gun has to be fixed to start working on LEReC accelerator layout and beam transport optimization.

ERL concept

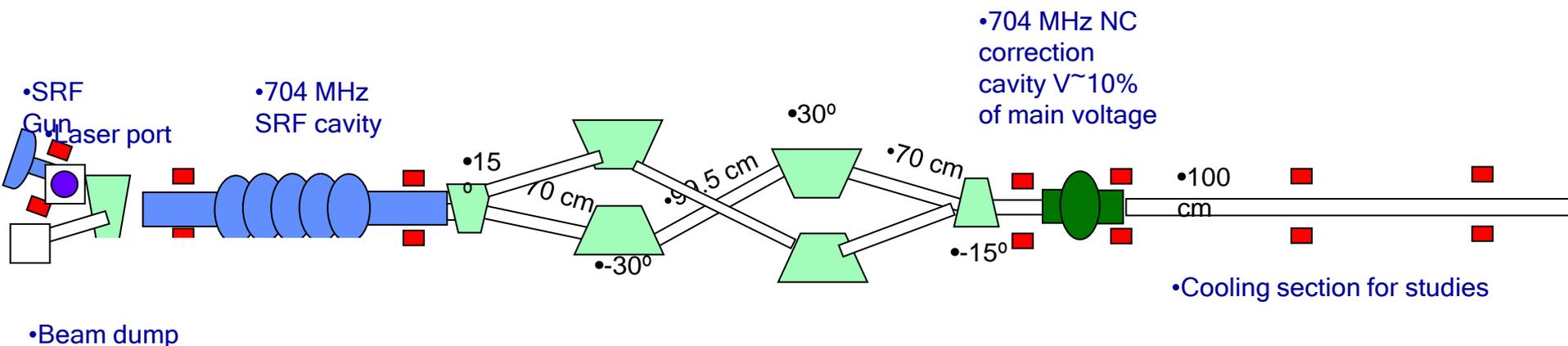
- ERL with the loop: requires different approaches for different energies
- Going back through the cavity

Accelerator design urgent tasks

5

- **Need to estimate both ERL's concepts ASAP and make a design choice**
- **Need to merge present ERL's gun-cavity simulations with the rest of beam lines providing beam quality needed for cooling in both RHIC rings.**
- **Define all missing accelerator components (704 MHz warm correction cavity, etc.)**
- **Stretching chicane**
- **U-turn design**
- **ERL length path : adjustable U-turn or return loop.**
- **Starting working on layout in RHIC tunnel**
- **Have preliminary electron beam lattice from gun to dump**

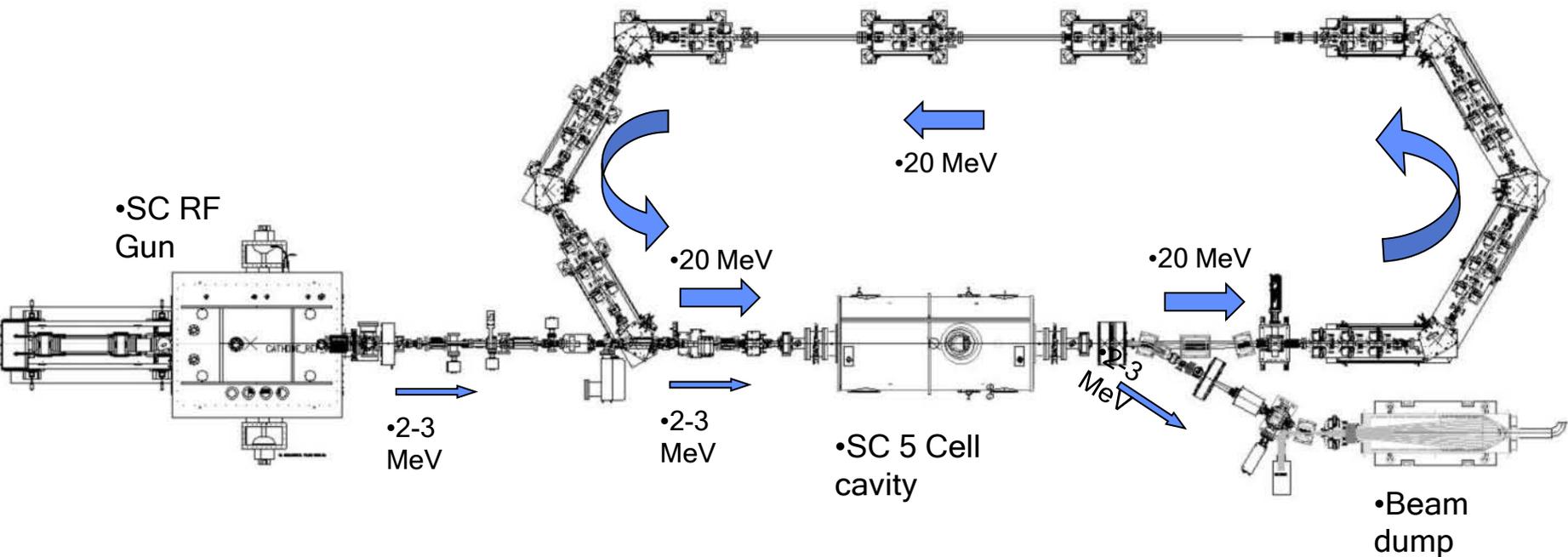
LER eCooler beam dynamics simulation setup based on SRF 704 MHz gun



Concept 1:

Going back through the same cavity:

- beam-beam collisions, estimate effect on e-beam
- Electron beam going through cavity with offset?

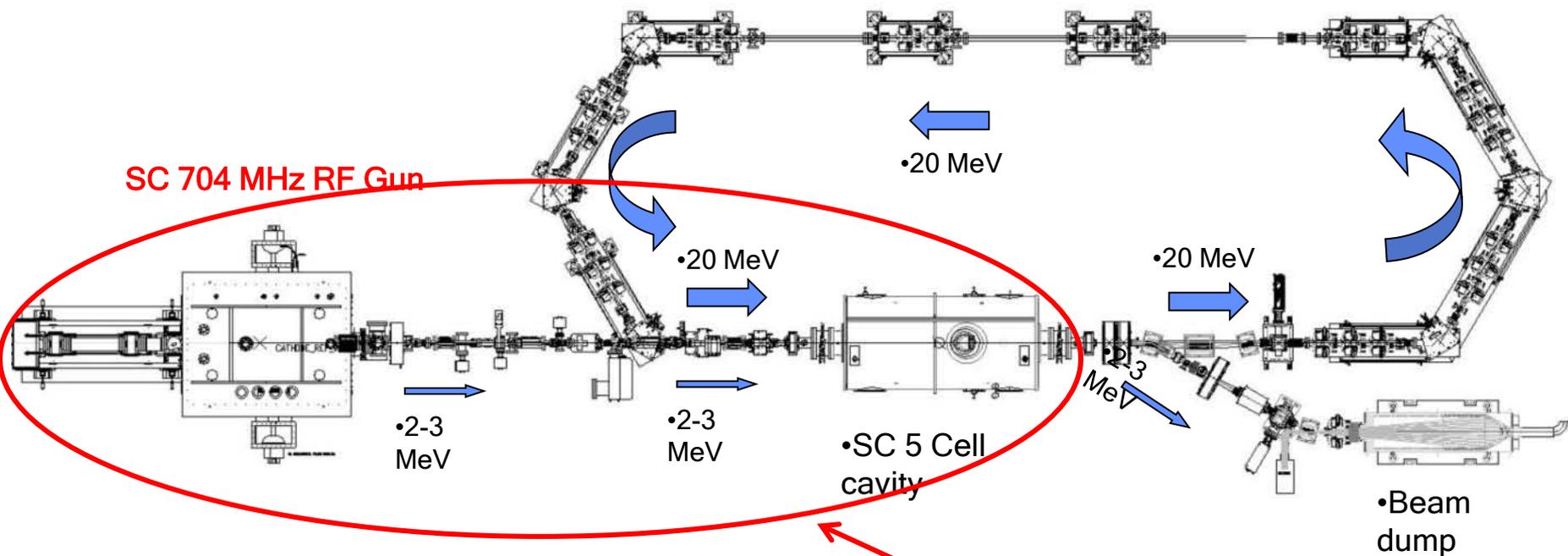


Concept 2:

ERL with the loop (problem with beam separation):

- Up to 2 MeV: just gun to dump
- from 2MeV: gun at 600kV, returning beam 2MV+

R&D ERL at BNL



SC 704 MHz RF Gun

•20 MeV

•20 MeV

•20 MeV

•2-3 MeV

•2-3 MeV

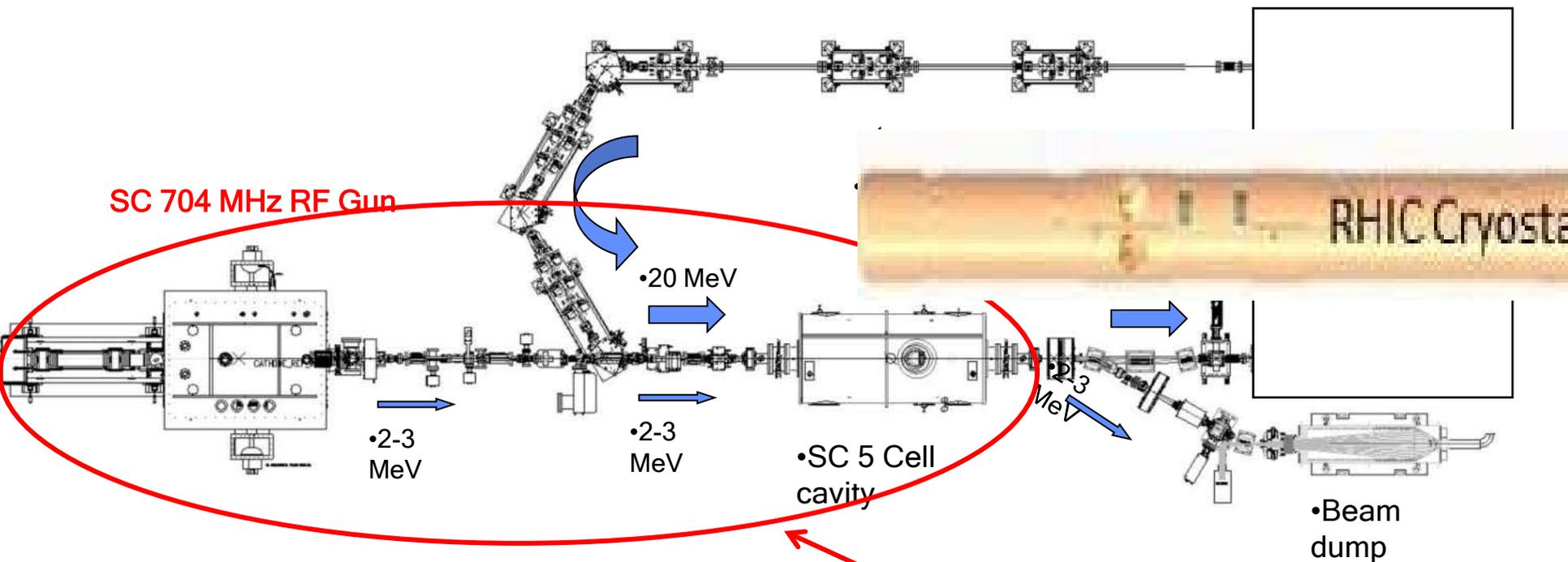
•SC 5 Cell cavity

•2-3 MeV

•Beam dump

LEReC
SRF accelerator

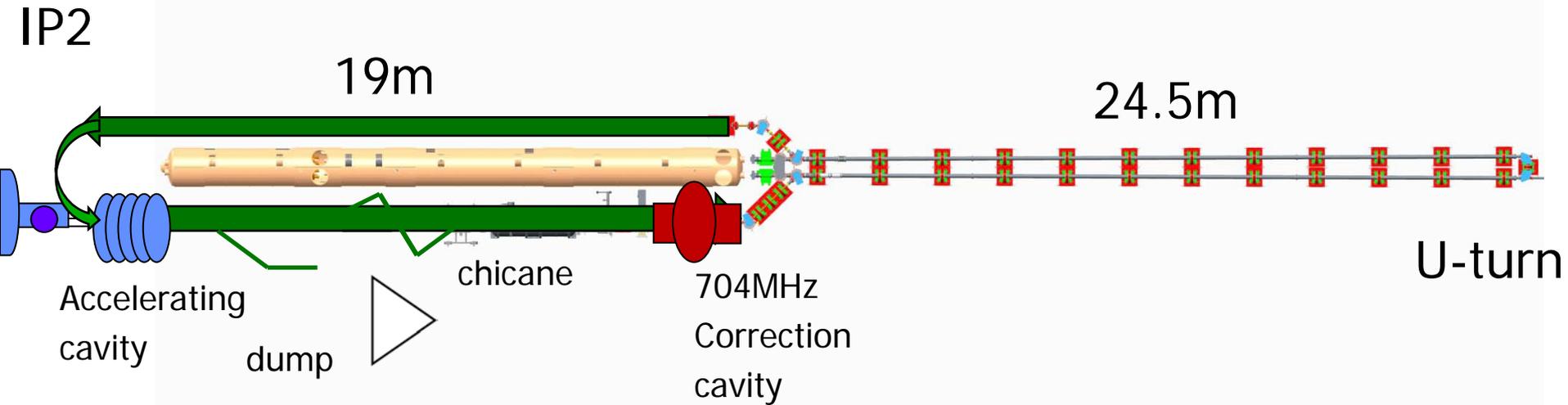
ERL in LEReC



LEReC
SRF accelerator

Option 1

10



Cavity around 19m from IP2:

Total path: $24.5 \times 2 + 19 \times 2 + 1 + 2 \times 4 = 96\text{m}$

ERL constraint:

Path from the cavity and back multiple of 32m

Cooling in Yellow and Blue:

Constraint on U-turn location from IP.

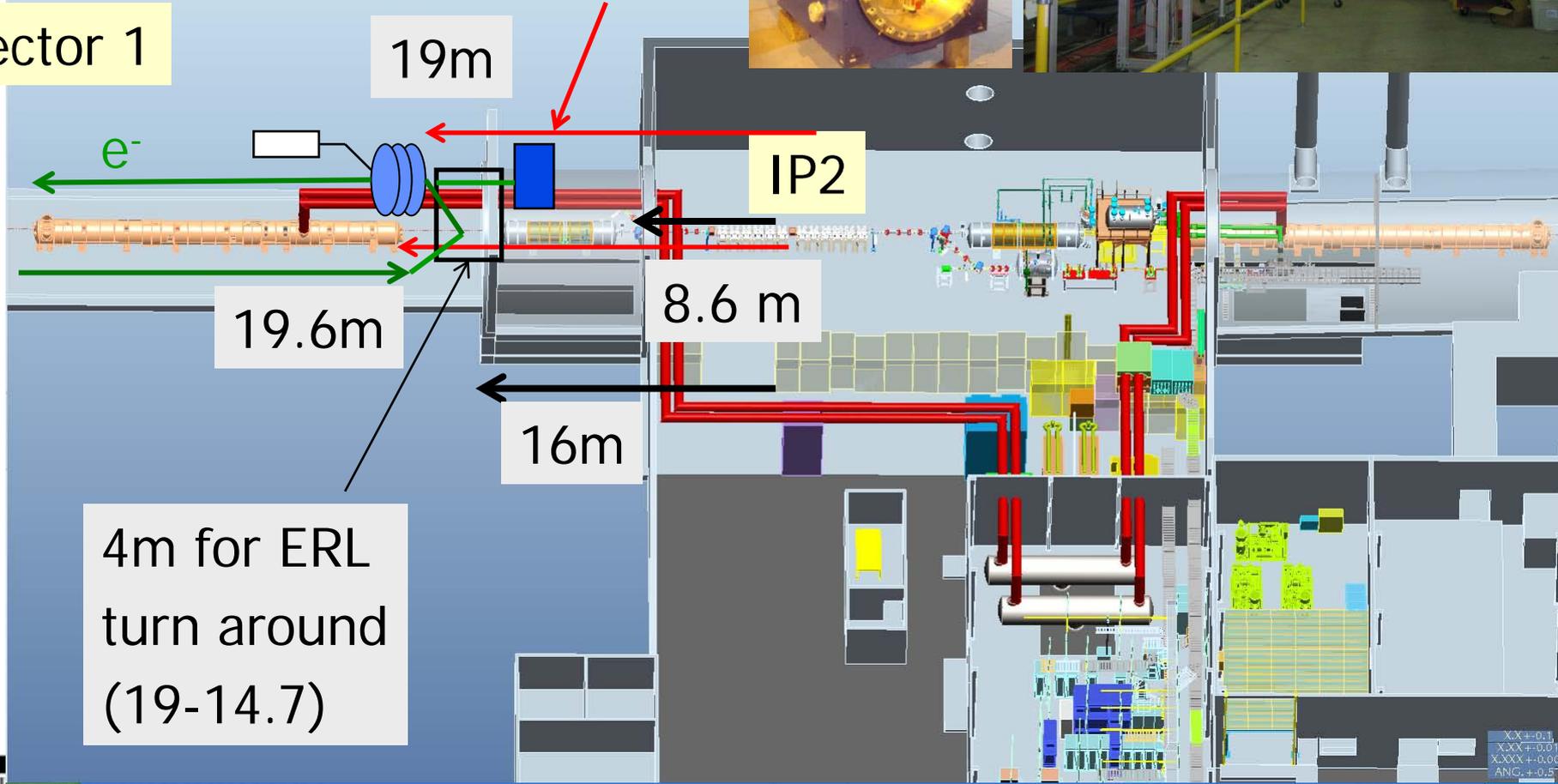
Option 1: cavity 19m from IP

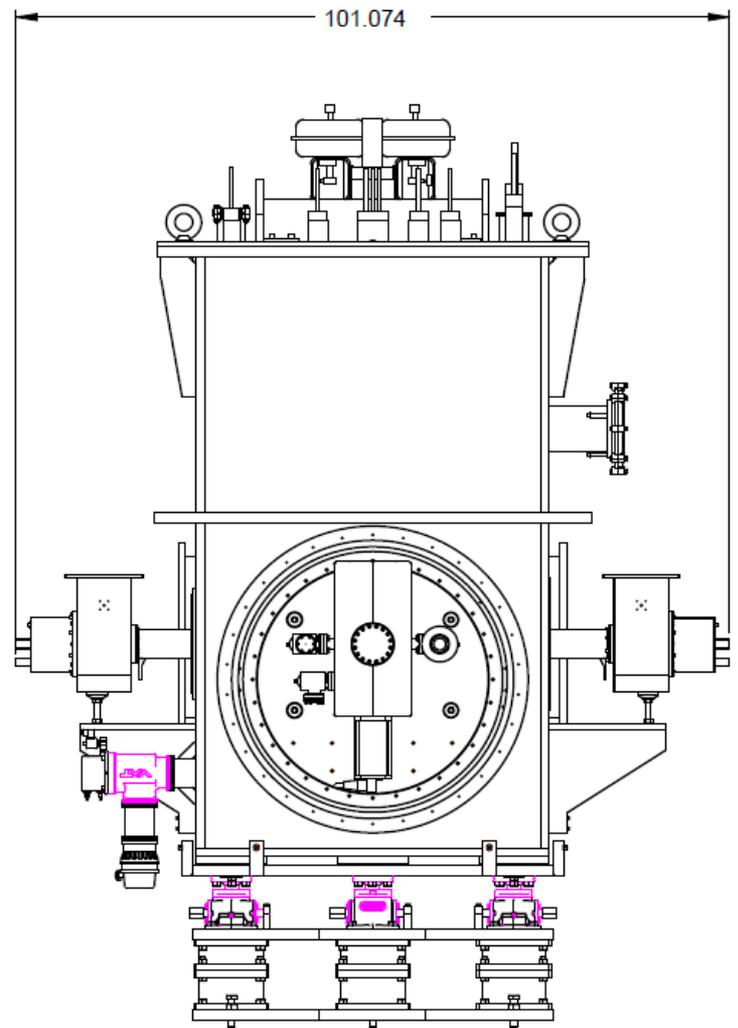
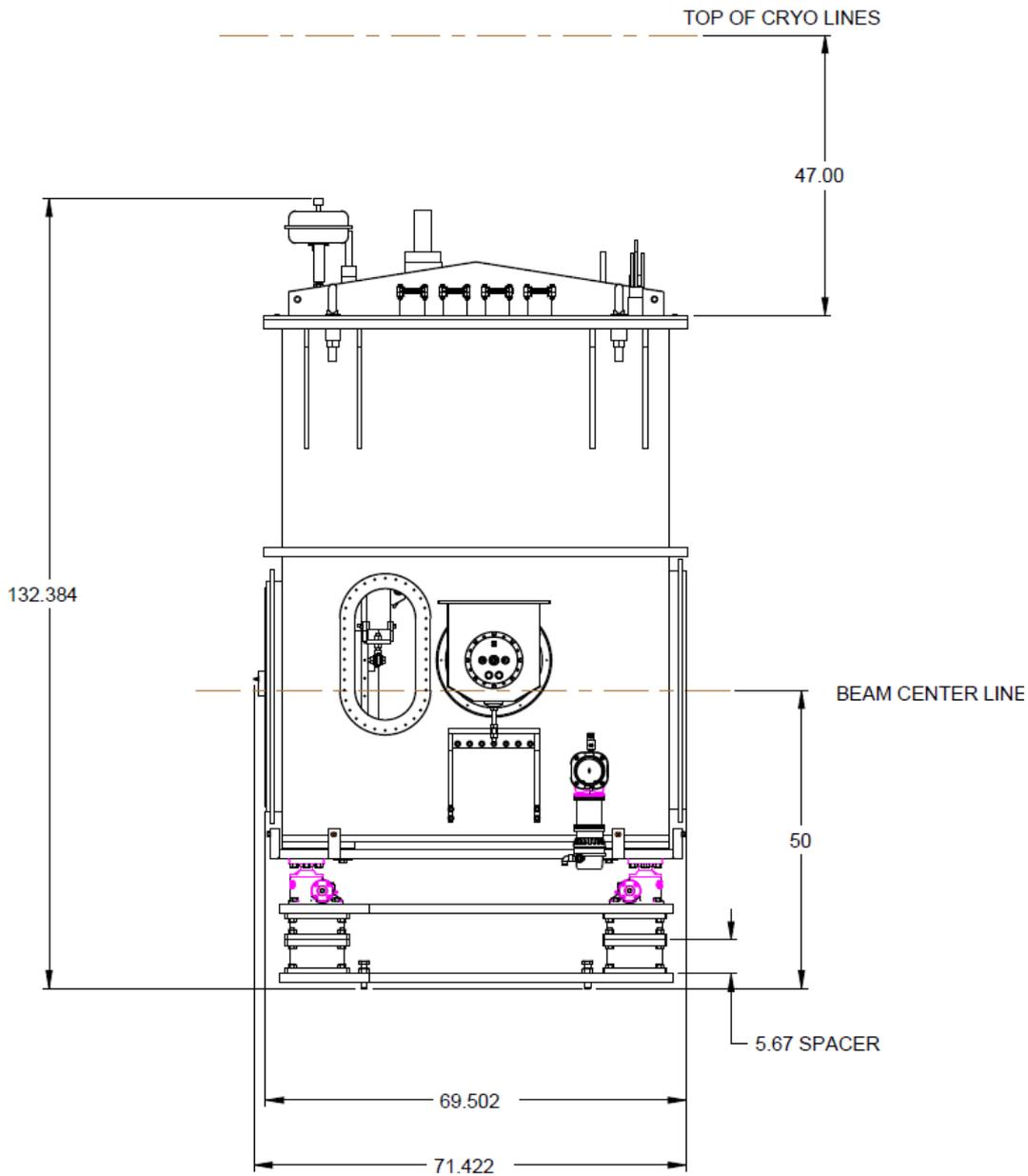
Does the gun fit with all the cryogenics ?

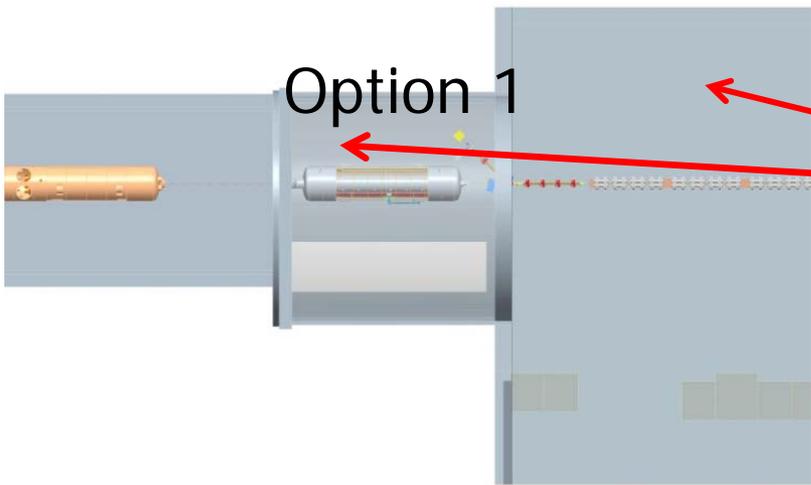
ERL gun near DX?



Sector 1

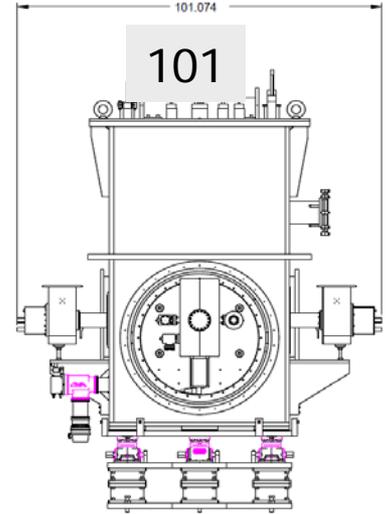




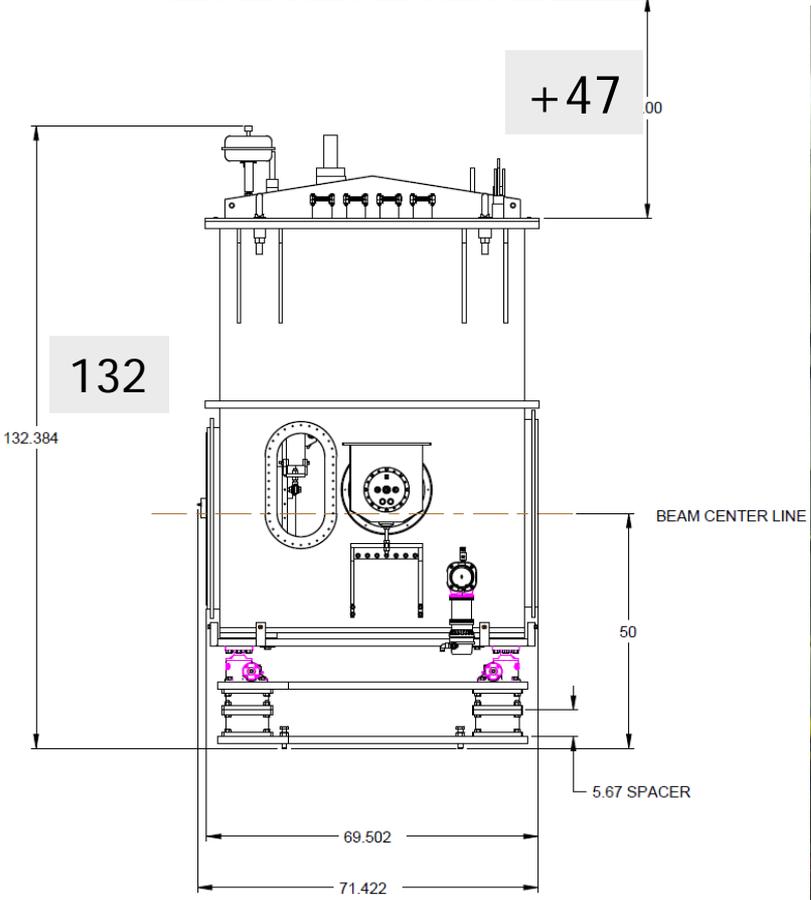


Option 2

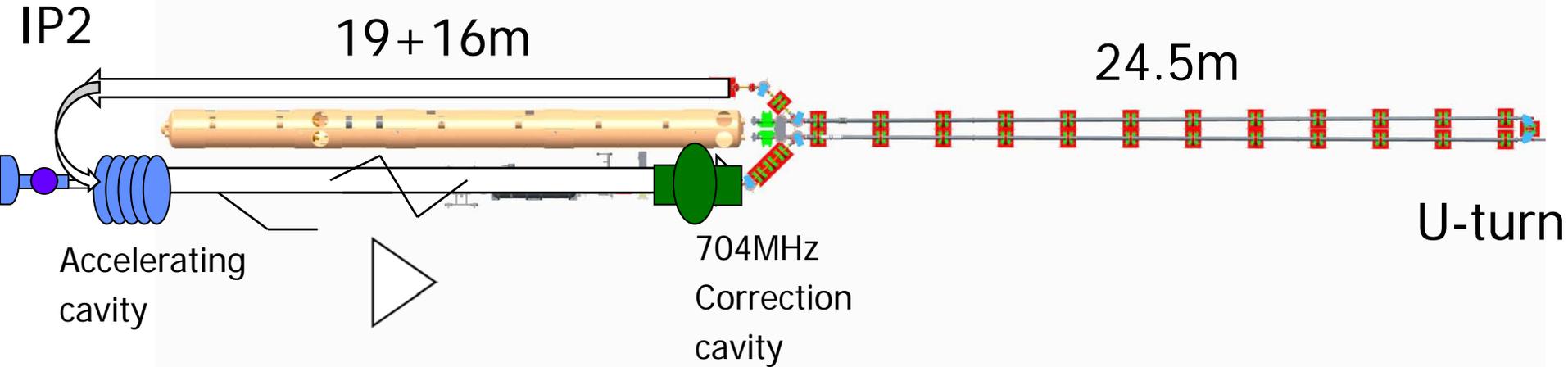
Option 1



TOP OF CRYO LINES



Option 2



Cavity around 3m from IP2:

Total path: $24.5 \times 2 + 19 \times 2 + 1 + 2 \times 4 + 16 \times 2 = 128\text{m}$

ERL constraint:

Path from cavity and back multiple of 32m

Cooling in Yellow and Blue:

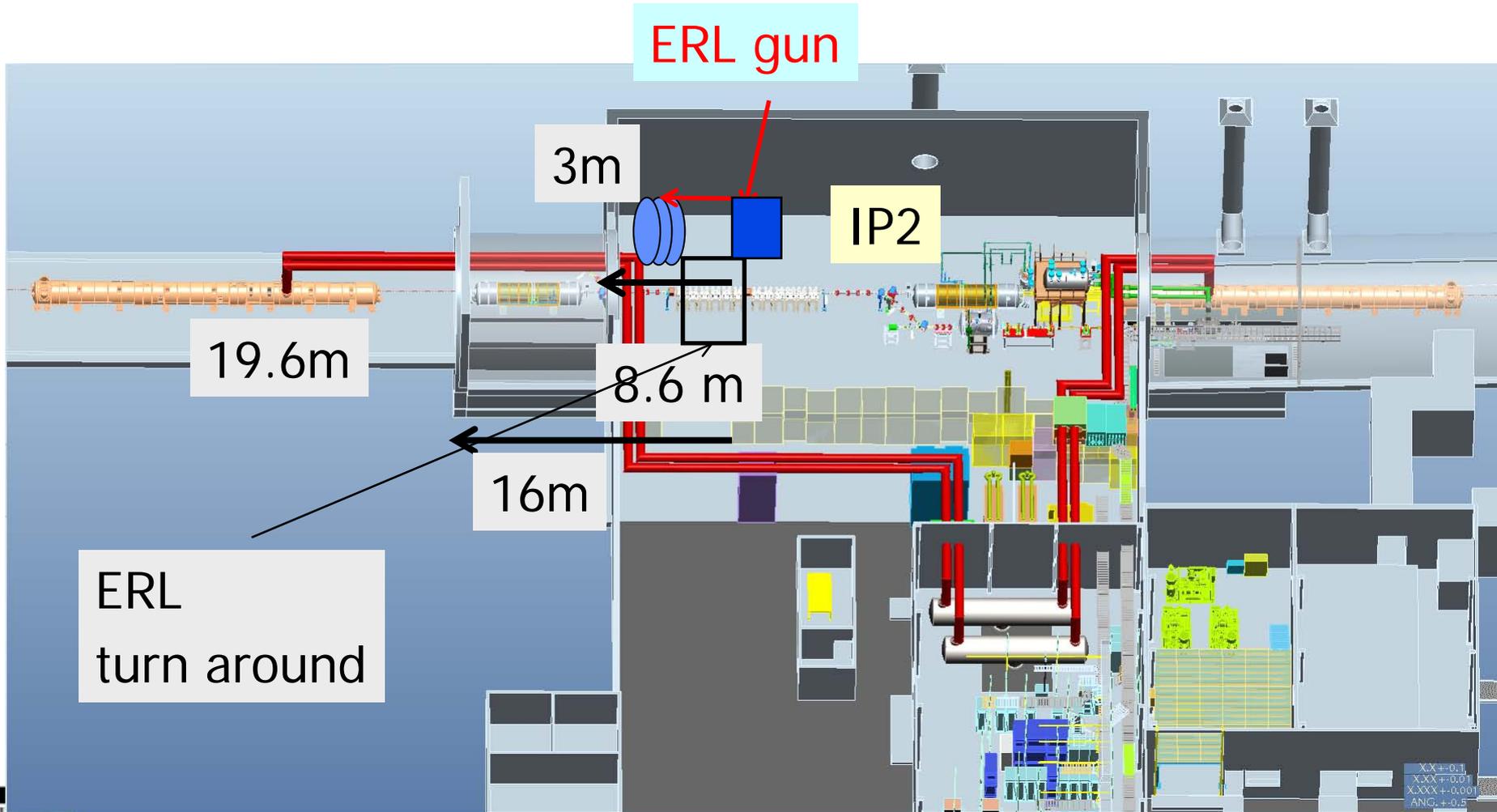
Constraint on U-turn location

Puts SRF gun exactly at IP

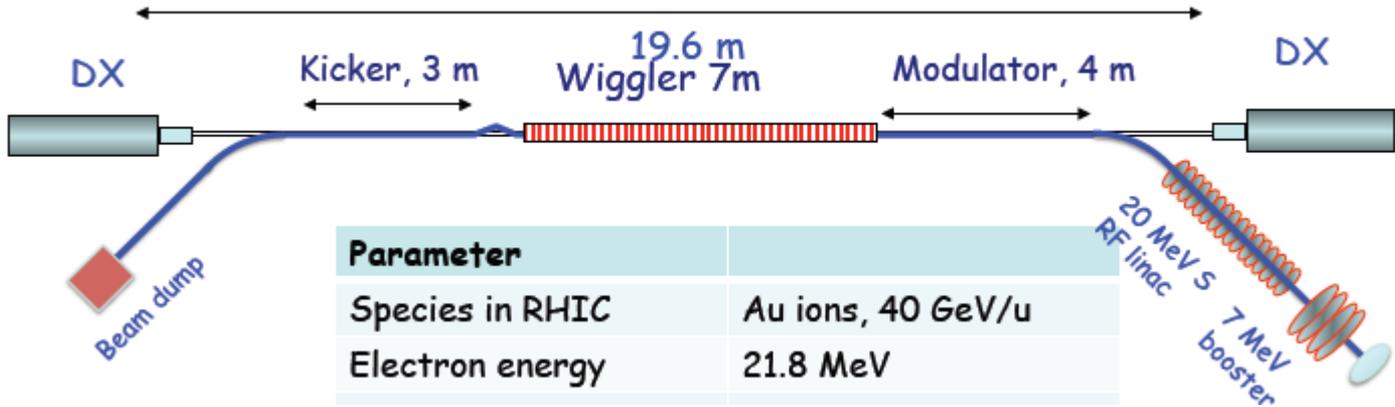
Option 2: 704MHz cavity around 3 m from IP

Sector 1

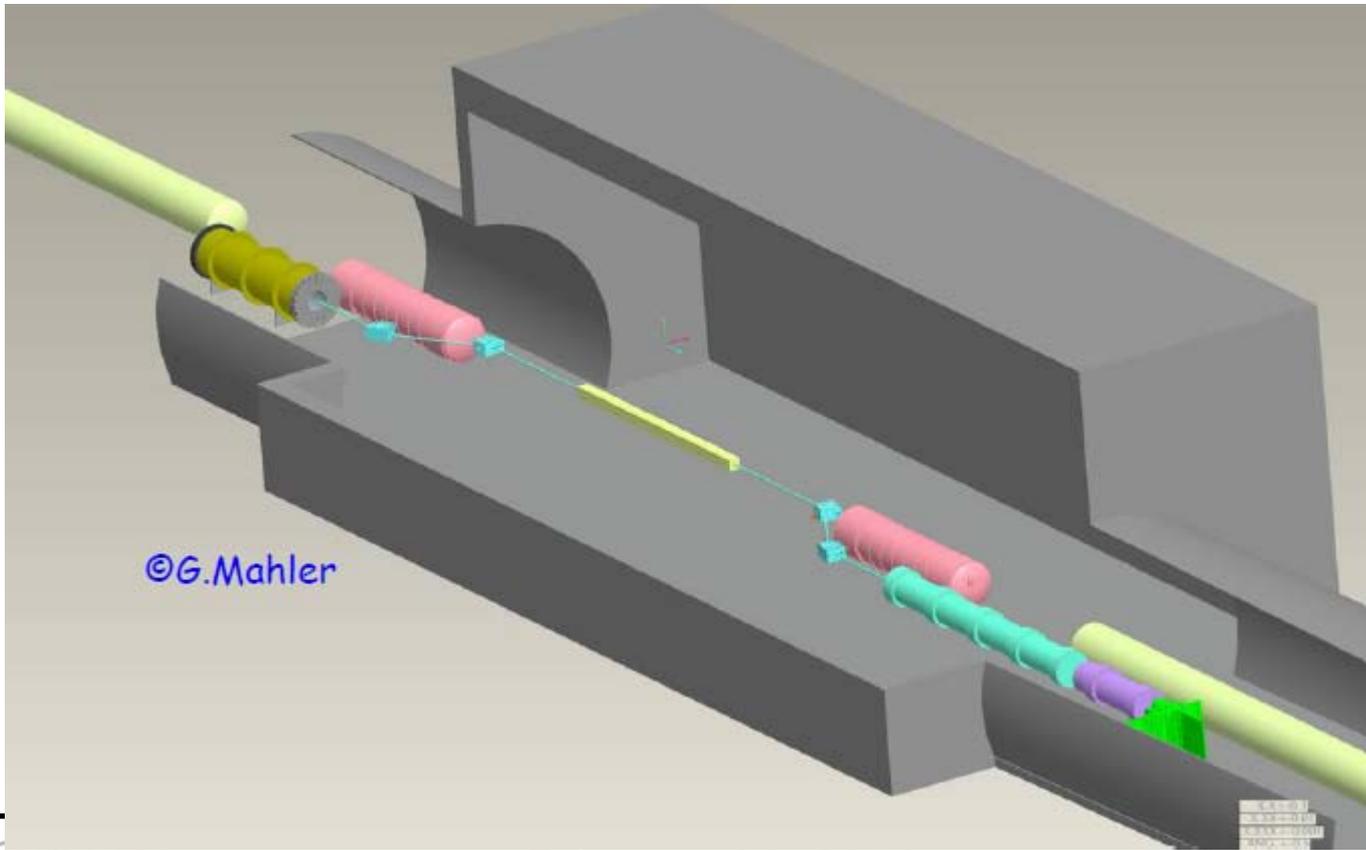
Sector 2



CEC

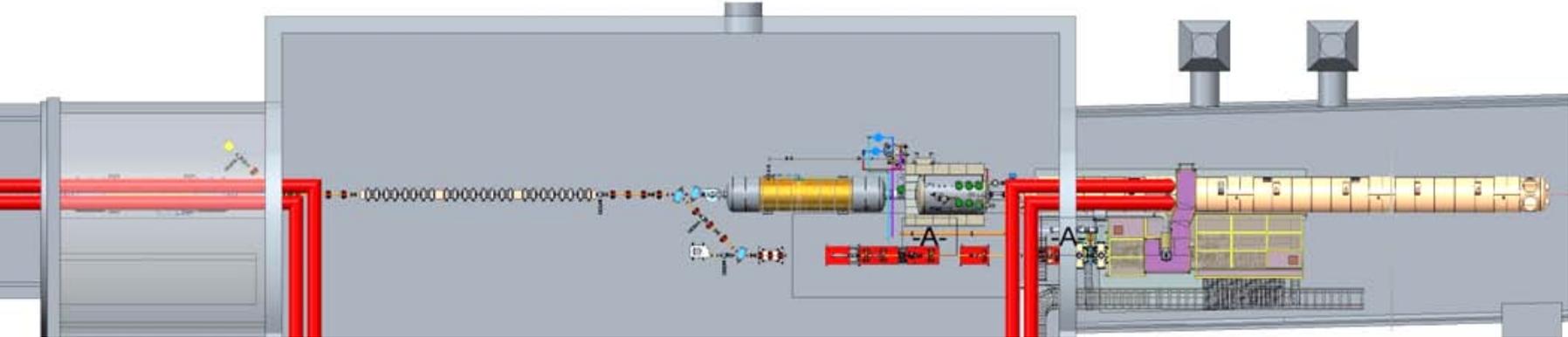


Parameter	
Species in RHIC	Au ions, 40 GeV/u
Electron energy	21.8 MeV



©G.Mahler

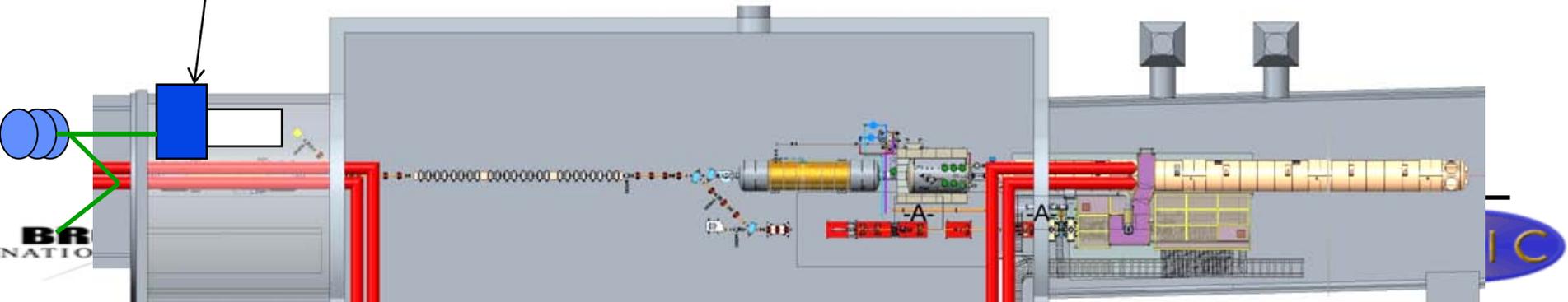
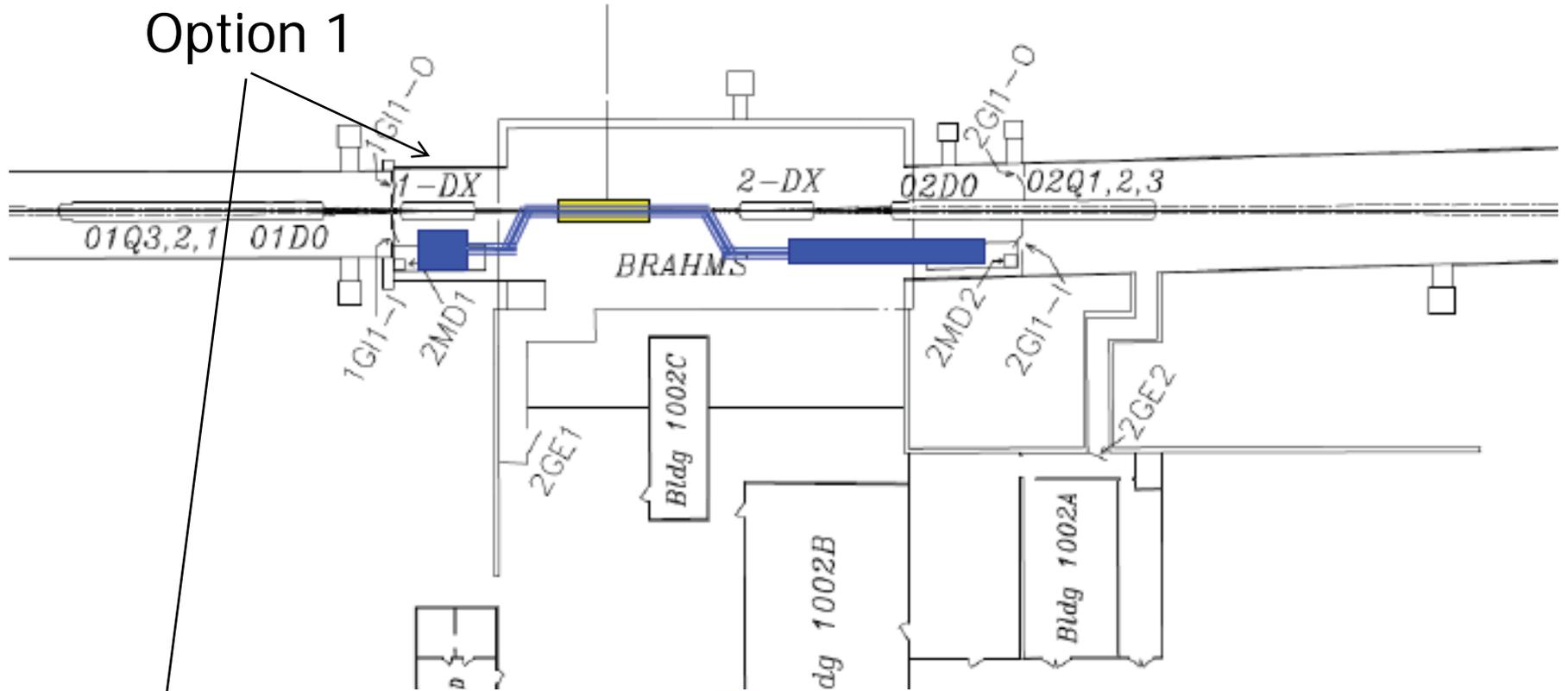
CEC'2014



Option 1

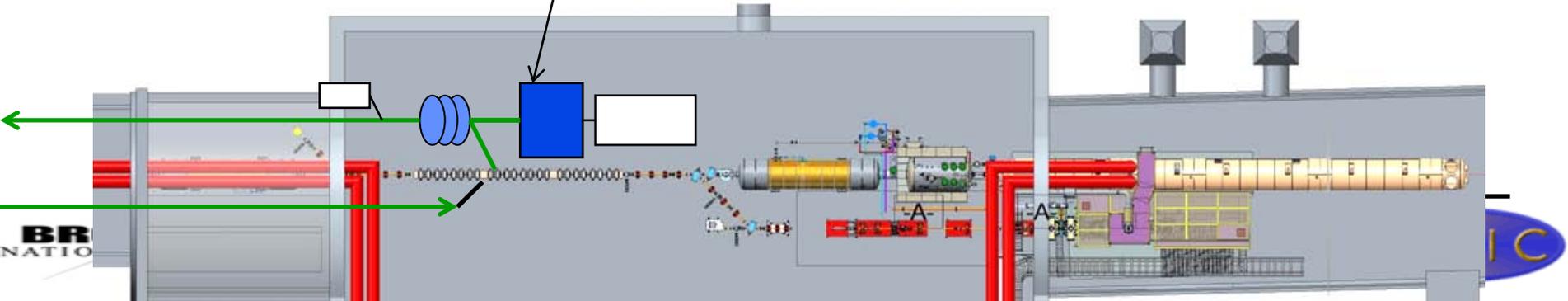
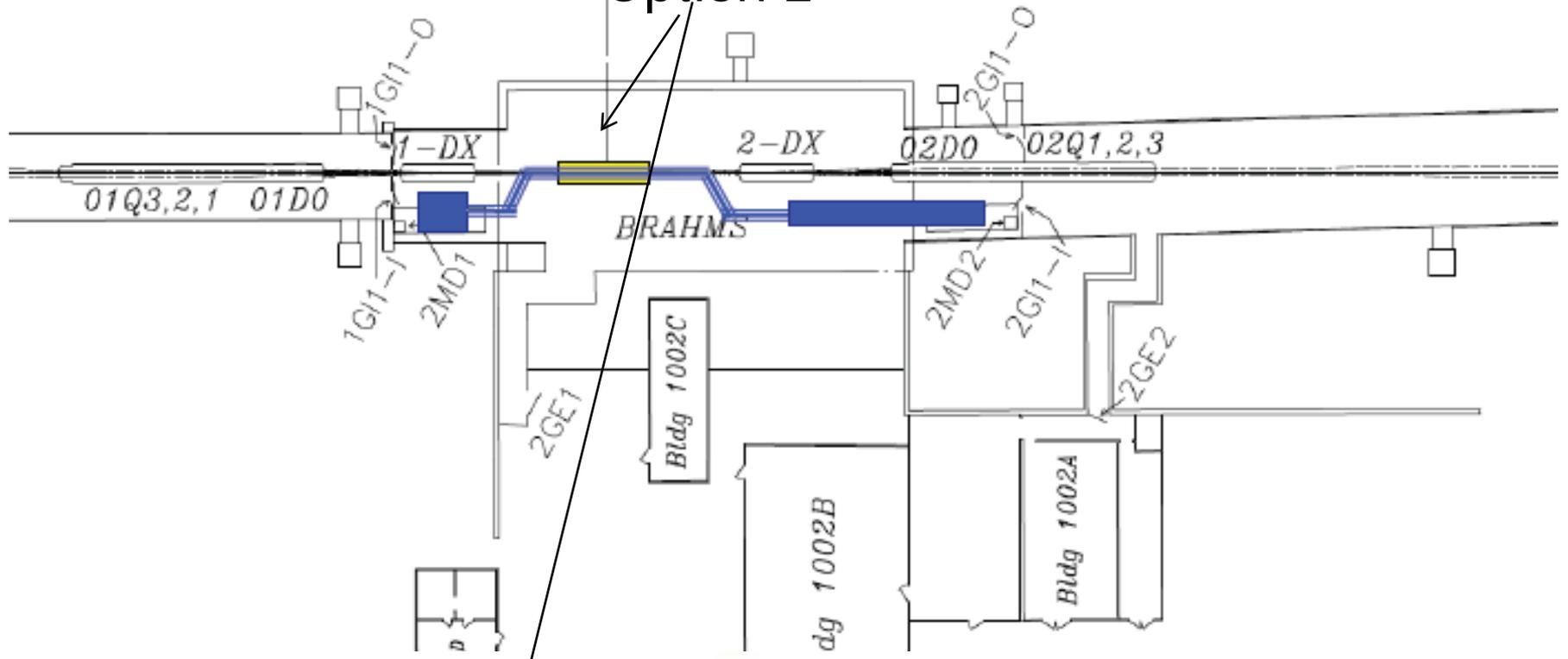
ERL gun

Option 1

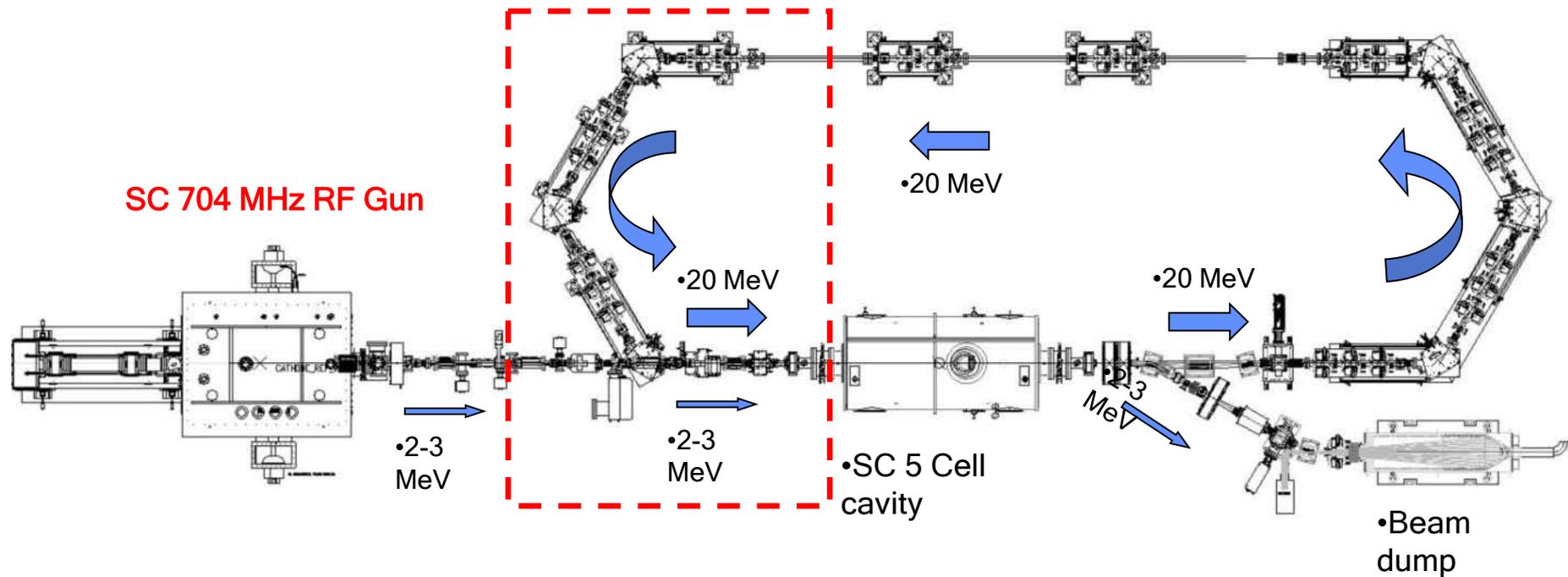


Option 2

ERL gun
Option 2



ERL path length adjustment



LEReC beam structure in cooling section gamma 10.7

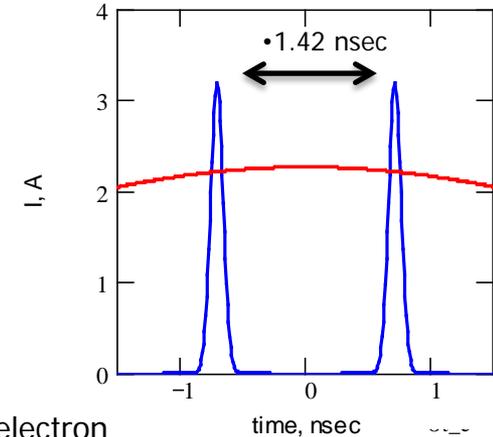
electron beamprofile

- Ions structure:
- 120 bunches $f_{\text{rep}} = 120 \times 77.854 \text{ kHz} = 9.342 \text{ MHz}$
- $N_{\text{ion}} = 1.5 \times 10^9$
- Rms length = 1 m
- Electrons:
- $F_{\text{SRF}} = 703.489 \text{ MHz}$
- Rms length = 1.5 cm
- $Q_e = 400 \text{ pC}$

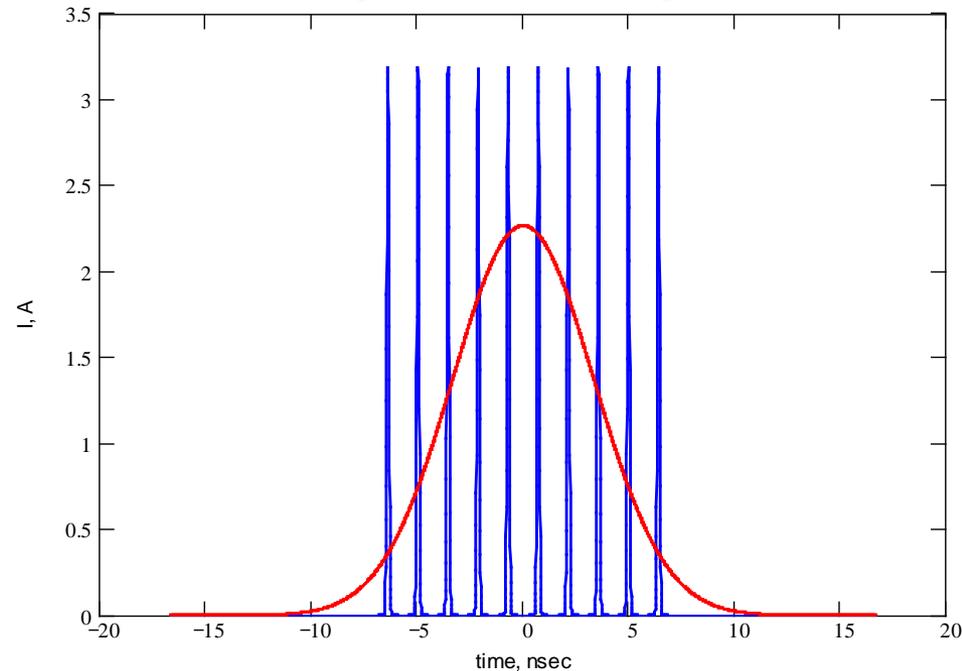
ERL loop, m	50.2116	50.278
T_loop	1.72704E-07	1.6845E-07
Lambdas	121.5002174	118.500356

For ER:

Switching from $g = 4.1 - 10.7$ path
 length adjustment: 6.64 cm
 $\gamma = 2.7 - 10.7$: 27cm



• 10 electron bunches



Accelerator design urgent tasks

22

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- **Define all missing accelerator components (704 MHz warm correction cavity, etc.); White Paper**
- **Stretching chicane**
- **U-turn**
- **ERL length path : adjustable U-turn or return loop.**
- **Starting working on layout in RHIC tunnel**
- **Have preliminary electron beam lattice from gun to dump**

Low Energy RHIC based on 704MHz trains (SRF-gun/ERL approach)

3/14/2014

Electron beam requirement:

gamma=4

- Full charge (using new 9.4 MHz RF): 3 nC (30x100pC)
- Average current: ~ 30 mA
- Normalized rms emittance: < 2.5 mm-mrad
- RMS Energy spread: < 5E-4

gamma=10.7

- Full charge (using new 9.4 MHz RF): 6 nC (18x333pC), 56 mA
- Full charge (using 28 RHIC RF): 4nC (10x400pC), 38 mA
- Can use present 28 MHz RF with h=360: gamma=7.8-10.7.