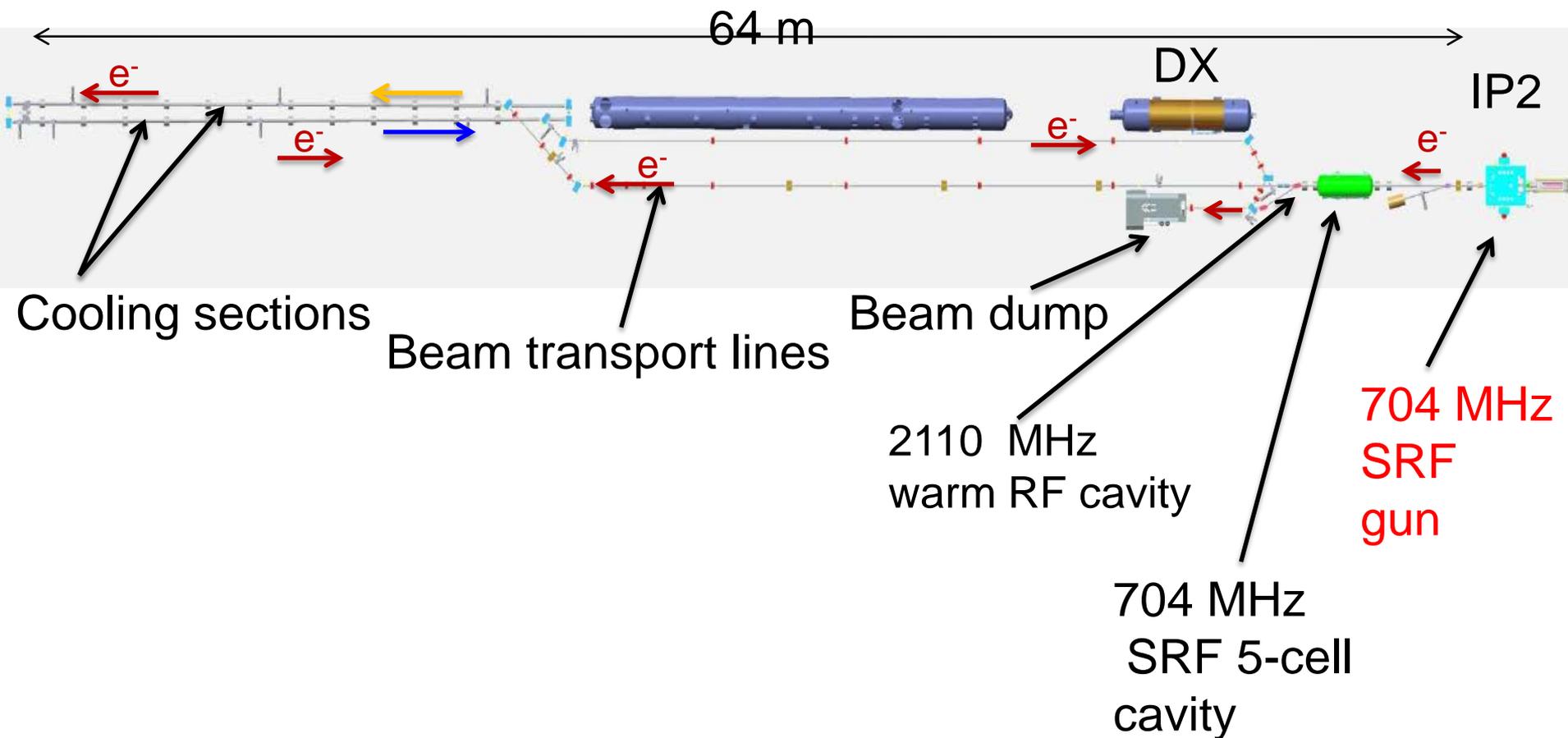

Low-energy RHIC electron Cooler (LEReC) Update

November 17, 2014



LEReC Phase-I (up 2 MeV electrons): July 2014 baseline



Recent activities

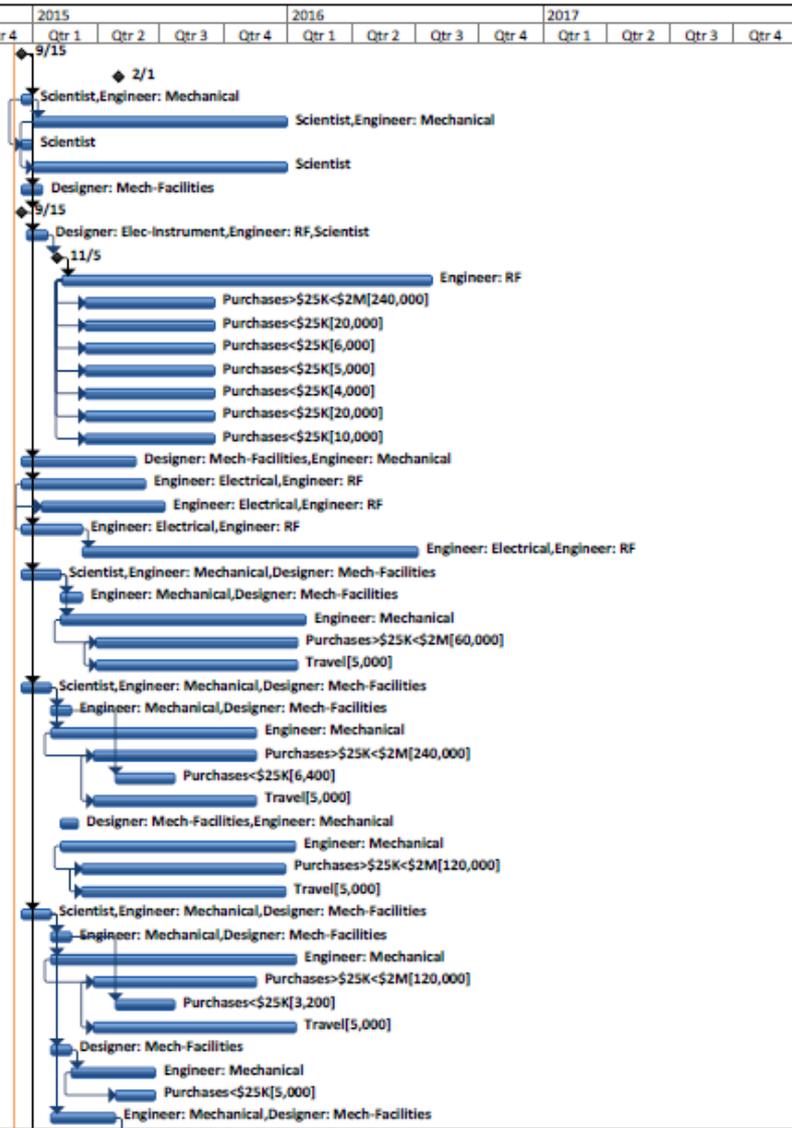
SRF-gun based design (July 2014 baseline):

- Completed contingency bottom up analysis with risk factors.
- Established full resource loaded schedule (RLS).
- Created list of high-priority tasks to begin before January 2015.
- Work on accelerator design based on the DC gun from Cornell.
- Discussion with Cornell on contract for the DC gun started. RHIC Ops funds to be used for the contract.
- Accelerator design for LEReC injector to be compatible both with SRF and DC guns.
- **New LEReC baseline design: November 2014**



High-priority tasks

ID	WBS	Name	Cost	Start	Finish	2015				2016				2017				
						Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3
2	1.1.1	High Priority Items Start	\$0	Mon 9/15/14	Mon 9/15/14													
3	1.1.2	Full Project Start	\$0	Sun 2/1/15	Sun 2/1/15													
12	1.1.11	Project management, Reporting, Status FY14	\$0	Mon 9/15/14	Tue 9/30/14													
13	1.1.12	Project management, Reporting, Status FY15	\$0	Wed 10/1/14	Wed 9/30/15													
17	1.2.1	Physics Support FY14	\$0	Mon 9/15/14	Tue 9/30/14													
18	1.2.2	Physics Support FY15	\$0	Wed 10/1/14	Wed 9/30/15													
41	1.3.3.1	Design	\$0	Mon 9/15/14	Wed 10/15/14													
54	1.3.5.1	Physics for Laser Complete	\$0	Mon 9/15/14	Mon 9/15/14													
55	1.3.5.2	Design	\$0	Mon 9/22/14	Wed 10/22/14													
56	1.3.5.3	Laser Design Review	\$0	Wed 11/5/14	Wed 11/5/14													
58	1.3.5.4.1	Specifications, SOW, Vendor Requisition and Support	\$0	Wed 11/12/14	Mon 4/25/16													
59	1.3.5.4.2	Laser Modulator & Pre-Amplifier	\$283,540	Mon 12/15/14	Thu 6/18/15													
60	1.3.5.4.3	Frequency Doubling Module	\$25,683	Mon 12/15/14	Thu 6/18/15													
61	1.3.5.4.4	Diagnostics: Cameras & Lenses	\$7,705	Mon 12/15/14	Thu 6/18/15													
62	1.3.5.4.5	Diagnostics: Power Meters	\$6,421	Mon 12/15/14	Thu 6/18/15													
63	1.3.5.4.6	Diagnostics: Photo Detectors	\$5,137	Mon 12/15/14	Thu 6/18/15													
64	1.3.5.4.7	Materials for Pulse Generators	\$25,683	Mon 12/15/14	Thu 6/18/15													
65	1.3.5.4.8	Power Amplifier Components	\$12,842	Mon 12/15/14	Thu 6/18/15													
75	1.3.6.1	Design	\$0	Mon 9/15/14	Wed 2/25/15													
117	1.4.2.1	Design	\$0	Mon 9/15/14	Wed 3/11/15													
129	1.4.3.1	Design	\$0	Mon 10/13/14	Wed 4/8/15													
144	1.4.5.1	Design (See Note)	\$0	Mon 9/15/14	Tue 12/11/14													
146	1.4.5.2.1	Specifications, SOW, Vendor Requisition, Bid, Place & Support	\$0	Thu 12/11/14	Tue 4/5/16													
157	1.5.1.1	Design, Magnet 90° Dipole	\$0	Mon 9/15/14	Mon 11/10/14													
158	1.5.1.2	Design, Stands for Magnet 90° Dipole	\$0	Mon 11/10/14	Thu 12/11/14													
160	1.5.1.3.1	Specifications, SOW, Vendor Requisition and Support (Note)	\$0	Mon 11/10/14	Tue 10/27/15													
161	1.5.1.3.2	Procure 90° Dipole Magnet	\$71,055	Tue 12/30/14	Thu 10/15/15													
169	1.5.1.7	Travel - Vendor Surveillance	\$6,436	Tue 12/30/14	Thu 10/15/15													
171	1.5.2.1	Design Transport 6" Solenoids	\$0	Mon 9/15/14	Mon 10/27/14													
172	1.5.2.2	Design Transport 6" Solenoid Stands	\$0	Mon 10/27/14	Tue 11/25/14													
174	1.5.2.3.1	Specifications, SOW, Vendor Requisition and Support	\$0	Mon 10/27/14	Mon 8/17/15													
175	1.5.2.3.2	Procure Transport Solenoids, .2K Gauss	\$284,102	Fri 12/26/14	Mon 8/17/15													
178	1.5.2.3.5	Procure Stand Components	\$8,240	Tue 1/27/15	Wed 4/22/15													
183	1.5.2.7	Travel - Vendor Surveillance	\$6,434	Fri 12/26/14	Mon 8/17/15													
186	1.5.3.2	Design 45° Dipole Stand	\$0	Mon 11/10/14	Fri 12/5/14													
188	1.5.3.3.1	Specifications, SOW, Vendor Requisition and Support	\$0	Mon 11/10/14	Mon 10/12/15													
189	1.5.3.3.2	Procure 45° Dipole	\$141,841	Wed 12/10/14	Mon 9/28/15													
197	1.5.3.7	Travel - Vendor Surveillance	\$6,424	Wed 12/10/14	Mon 9/28/15													
199	1.5.4.1	Design Matching Solenoid	\$0	Mon 9/15/14	Mon 10/27/14													
200	1.5.4.2	Design Matching Stand	\$0	Mon 10/27/14	Tue 11/25/14													
202	1.5.4.3.1	Specifications, SOW, Vendor Requisition and Support	\$0	Mon 10/27/14	Tue 10/13/15													
203	1.5.4.3.2	Procure Transport Solenoids, 1.5K Gauss	\$142,051	Fri 12/26/14	Mon 8/17/15													
206	1.5.4.3.5	Procure Stand Components	\$4,120	Tue 1/27/15	Wed 4/22/15													
211	1.5.4.7	Travel - Vendor Surveillance	\$6,434	Fri 12/26/14	Tue 10/13/15													
213	1.5.5.1	Design Dipole Stands	\$0	Mon 10/27/14	Tue 11/25/14													
218	1.5.5.3.1	Specifications, SOW, Vendor Requisition and Support	\$0	Tue 11/25/14	Wed 3/25/15													
219	1.5.5.3.2	Procure Stand Components	\$6,438	Tue 1/27/15	Wed 3/25/15													
225	1.5.6.1	Design, Magnet 60° Dipole Stand	\$0	Mon 10/27/14	Tue 1/27/15													



High-priority near-term purchases

	burdened costs
Purchases<\$25K	
1.3.5.4.3	Frequency Doubling Module \$25,683
1.3.5.4.4	Diagnostics: Cameras & Lenses \$7,705
1.3.5.4.5	Diagnostics: Power Meters \$6,421
1.3.5.4.6	Diagnostics: Photo Detectors \$5,137
1.3.5.4.7	Materials for Pulse Generators \$25,683
1.3.5.4.8	Power Amplifier Components \$12,842
1.5.2.3.5	Procure Stand Components \$8,240
1.5.4.3.5	Procure Stand Components \$4,120
1.5.5.3.2	Procure Stand Components \$6,438
1.5.7.2.2	Procure Stand Components \$2,575
1.9.8.2.2	Quad Chamber w/RF Bellows \$2,575
1.9.8.2.3	Dipole Chamber Turn Around, 2 ea \$12,875
1.9.8.2.4	Series 10 Gate Valves 4.6", 2 ea \$7,725
1.9.8.2.5	Dipole Wye Chamber, 2ea in/out \$12,875
1.9.8.2.7	NEG Pipe Mods \$1,288
1.9.8.2.8	RF Shielded Bellows 6.75 Fl, 14ea \$27,038
1.9.8.2.9	Beampipe Supports \$1,288
Purchases>\$25K<\$2M	
1.3.5.4.2	Laser Modulator & Pre-Amplifier \$283,540
1.5.1.3.2	Procure 90° Dipole Magnet \$71,055
1.5.2.3.2	Procure Transport Solenoids, .2K Gauss \$284,102
1.5.3.3.2	Procure 45° Dipole \$141,841
1.5.4.3.2	Procure Transport Solenoids, 1.5K Gauss \$142,051
1.9.8.2.6	Heating Jackets \$29,613
Travel	
1.5.1.7	Travel - Vendor Surveillance \$6,436
1.5.2.7	Travel - Vendor Surveillance \$6,434
1.5.3.7	Travel - Vendor Surveillance \$6,424
1.5.4.7	Travel - Vendor Surveillance \$6,434

Cooling section installation
Items: solenoids, dipoles, correctors, diagnostics?, etc. Laser.

1.15M approved by DOE Nov. 6 2014:

“choose some of the most important activities and identify their completion or start date as milestones, then submit to DOE. Update your resource loaded schedule . DOE will start monitoring this long-lead effort more carefully at your monthly AIP calls.”

\$1,148,438

Other efforts/RHIC upgrades related to LEReC

- New RHIC 9 MHz RF system upgrade: ongoing project from Capital funds.

LEReC design assumes that such RF systems will be fully operational

- **New AIP to upgrade infrastructure at 2:00 o'clock RHIC region:**

The RHIC Interaction Region 2 now serves as a general area for RHIC upgrades and accelerator R&D. Formerly used by the BRAHMS experiment it is suited for various installations due to the available space and power connection. To make it usable for machine improvements, accelerator upgrades and R&D use a number of infrastructure upgrades are necessary including building, access, and access control improvements, berm penetrations, power, cooling water and cryogenic distribution upgrades, and communications. **The new AIP will also reduce the cost of the LEReC AIP, as already reflected in the full RLS.**

New AIP approved by DOE.



Accelerator design changes from July 2014 baseline

1. DC gun (Cornell) – baseline (SRF gun backup)
2. 5-cell SRF cavity: modification to work as booster cavity
3. Warm 704 MHz (250kV) RF cavity (LEReC Phase-I, 2MeV).
4. Warm 704 MHz (400kV) RF cavity (**LEReC Phase-II, 5MeV**)*.
5. Warm 2.1 GHz: voltage reduced to 70-100kV
6. RHIC 9 MHz bouncer cavity from RHIC.
7. Cooling section solenoids every 3m instead of previous 2m.
8. BPMs next to each solenoid.
9. Compensating dipoles for ion beams (possibly from NSLS)
10. U-turn: 180 deg. Dipole instead of two 90 deg. Dipoles

***Note Well: Phase II (FYI only) is not in this estimate exercise.**



LEReC DC gun requirements

Operating voltage: 400-500 kV (Cornell)

Charge per bunch (LEReC Phase-1, 2017-18): 100pC (CU)

Average current (LEReC Phase-1, 2017-18): 30mA (CU)

Charge per bunch (LEReC Phase-II, 2018-19): 300pC (CU)

Average current (LEReC, Phase-II, 2018-19): 50mA

Rms normalized emittance < 2 mm mrad for charges up to 300pC
(from the gun), CU – demonstrated October 2014

RMS energy spread < 2e-4 (from gun/ripple contribution)

Stable 24/7 operation

Cathodes exchanging mechanism for quick cathode replacement
without significant delay on operation.



LEReC-I and II

- **LEReC-I (1.6-2MeV), installation complete in 2017:**

DC gun

SRF 5-cell cavity as booster cavity (1.2-1.6MeV)

704MHz warm cavity for energy spread correction (250kV, PA: 15 kW)

2.1 GHz warm cavity (100kV, PA: 10kW)

9 MHz RHIC bouncer cavity (2kV)

Beam dump (60kW)

- **LEReC-II (up to 5MeV), installation complete in 2018: ***

ERL “push-pull” mode

+Possible additional 704 MHz booster cavity

+704MHz warm cavity for energy spread correction (400kV, PA: 34 kW)

+Dipole magnets for several chicane

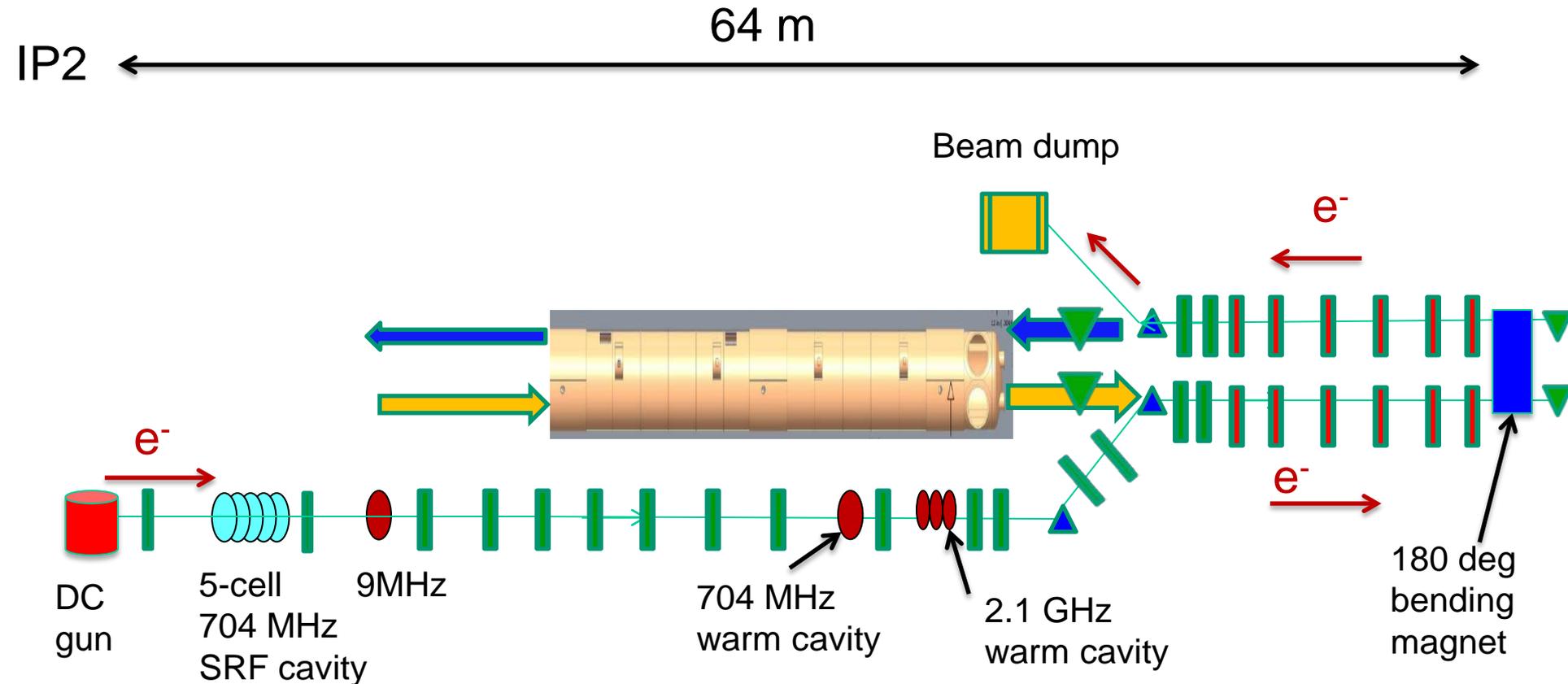
+Return electron beam line with more magnets and diagnostics

***Note Well: Phase II (FYI only) is not in this estimate exercise.**



LEReC-I (2MeV): Gun to dump

11/17/14



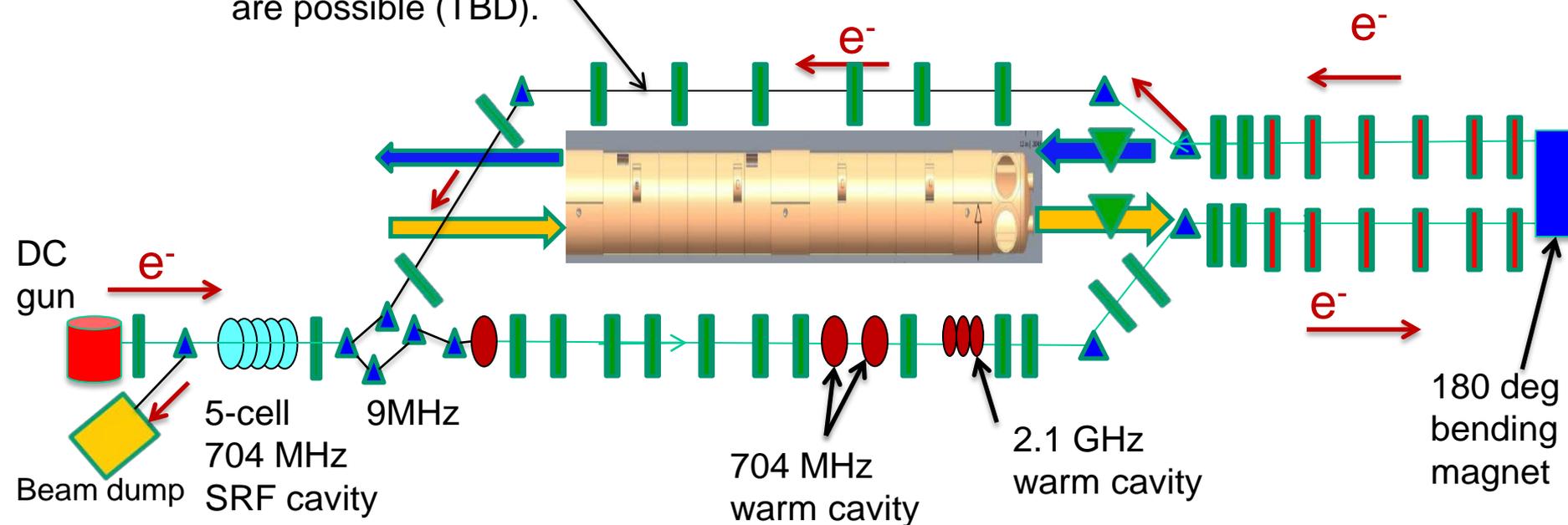
Not in this cost estimate exercise

64 m

IP2 ← →

Several possibilities for the return pass are possible (TBD).

Beam dump



Present effort: new LEReC-I (Nov. 17 2014 baseline)

- **LEReC-I (1.6-2MeV), 2017:**

DC gun (Cornell University)

+SRF 5-cell cavity modification as booster cavity without ERL

+704MHz warm cavity for energy spread correction (250kV, PA: 15 kW)

- Reduced voltage for 2.1 GHz warm cavity (100kV, PA: 10kW)

9 MHz RHIC bouncer cavity (2kV), available from RHIC

+ New beam dump (60kW)

-No return electron beam transport line with magnets/diagnostics

-Less cooling section solenoids

+More BPMs for cooling section

+Solenoids for electron beam transport line

- Less civil construction: new AIP project on infrastructure



New baseline LEReC-I

- **LEReC-I (1.6-2MeV), 2017:**

Significant cost changes in:

- SRF (no SRF gun modifications; **5-cell cavity modifications**)
- Warm RF cavities (reduced voltage 2.1GHz, **new 704MHz**)
- Power amplifiers (**new 65kW for 5-cell SRF cavity, no PAs for the gun, solid state 10kW for 2.1 GHz**)
- Magnets (**10 solenoids for transport line**)
- Power supplies (less)
- Diagnostics (less, no return beam line)
- Vacuum (less)
- Beam dump (new)
- Civil (**less, new separate AIP started**)
-



Cooling section

- 45 deg. Merger dipoles (gap=10cm): 4 magnets
- 180 deg. U-turn dipole (gap=10cm): 1 magnet
- Small aperture merger solenoids (1.5kG): 2
- Large aperture cooling section matching solenoids (1.5 kG): 4
- Large aperture cooling section weak solenoids (200 G): 12
- H and V correctors inside each solenoid
- Large aperture cooling section BPMs: 14
- Profile monitors: 6



Timeline for Cost Estimate Update: very short!!

November 24: Updated cost estimates are due !!!

November 25-Dec. 5: Review of cost estimates

December 12: Resource Loaded Schedule is final

December 22: Project Execution Plan and other docs are final

January 7: Dry run for LEReC review

January 12-13: LEReC DOE review

