

PRELIMINARY INVESTIGATIONS AND PRE-RESEARCH SCHEME OF HIGH AVERAGE CURRENT ELECTRON INJECTORS AT IMP

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BACKGROUND: HIGH AVERAGE CURRENT ELECTRON INJECTOR

Abstract
High average current electron injectors are desired by high average beam power SRF linacs. With respect to the different linac applications, different beam qualities are required. Two kinds of the electron guns are planned for future projects at IMP, one is thermionic electron gun dedicated for high average current, and another type is photocathode guns for high average current and high beam quality or even with high polarization. Current status and development of the high average current electron sources are investigated and summarized. The thermionic gun studies are planned and the feasible types of guns for the future Electron ion collider of China (EicC) project are also proposed. The pre-research of these required electron injectors is schemed, which will be the start of high average current and high-quality electron source development at Institute of modern physics (IMP), Chinese academy of sciences (CAS).

Applications
high average power free-electron lasers (FEL), **medical isotope production**, industry application, **electron ion collider (EIC)**, **electron cooling** for high energy heavy ions and so on.

RF MODULATED THERMIONIC CATHODE HIGH VOLTAGE ELECTRON GUN

High repetition rate high average current electron gun with mediate beam quality.

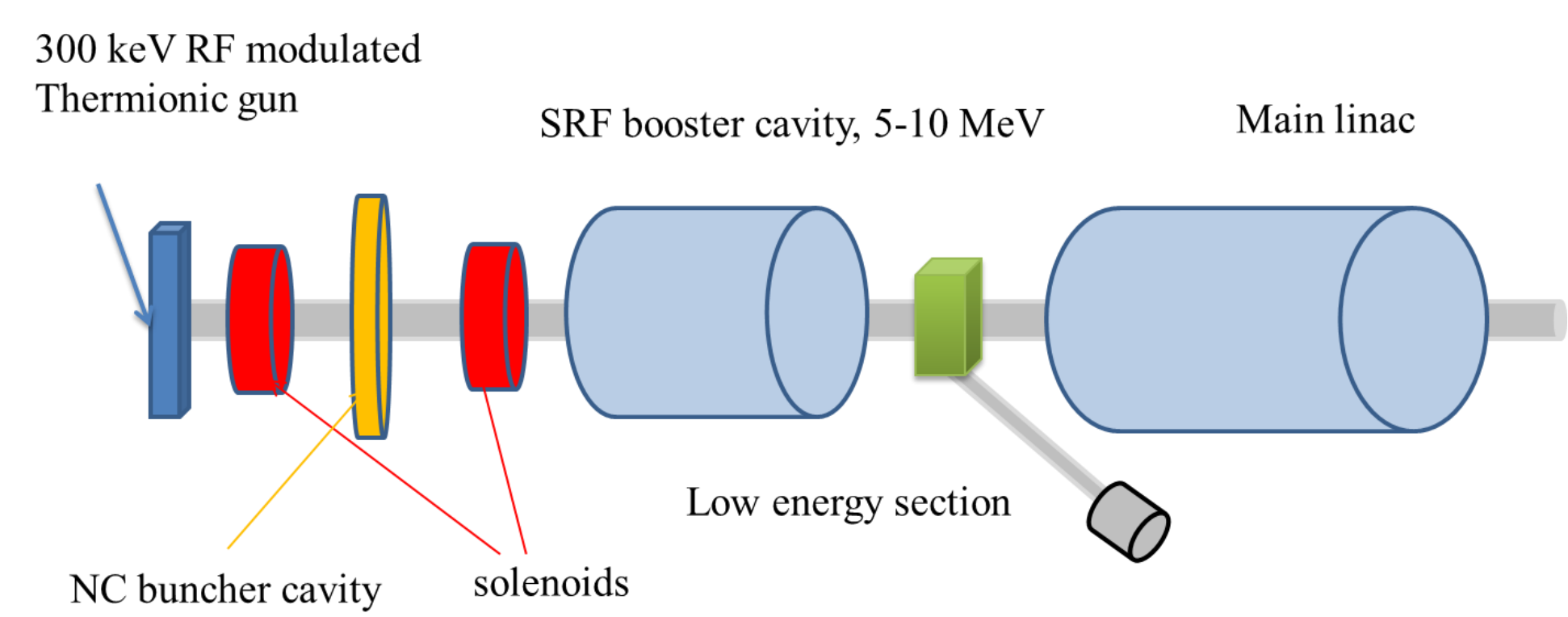


Figure 1: the sketch map of the high average power SRF linac injector based on the 300 keV RF modulated thermionic gun.

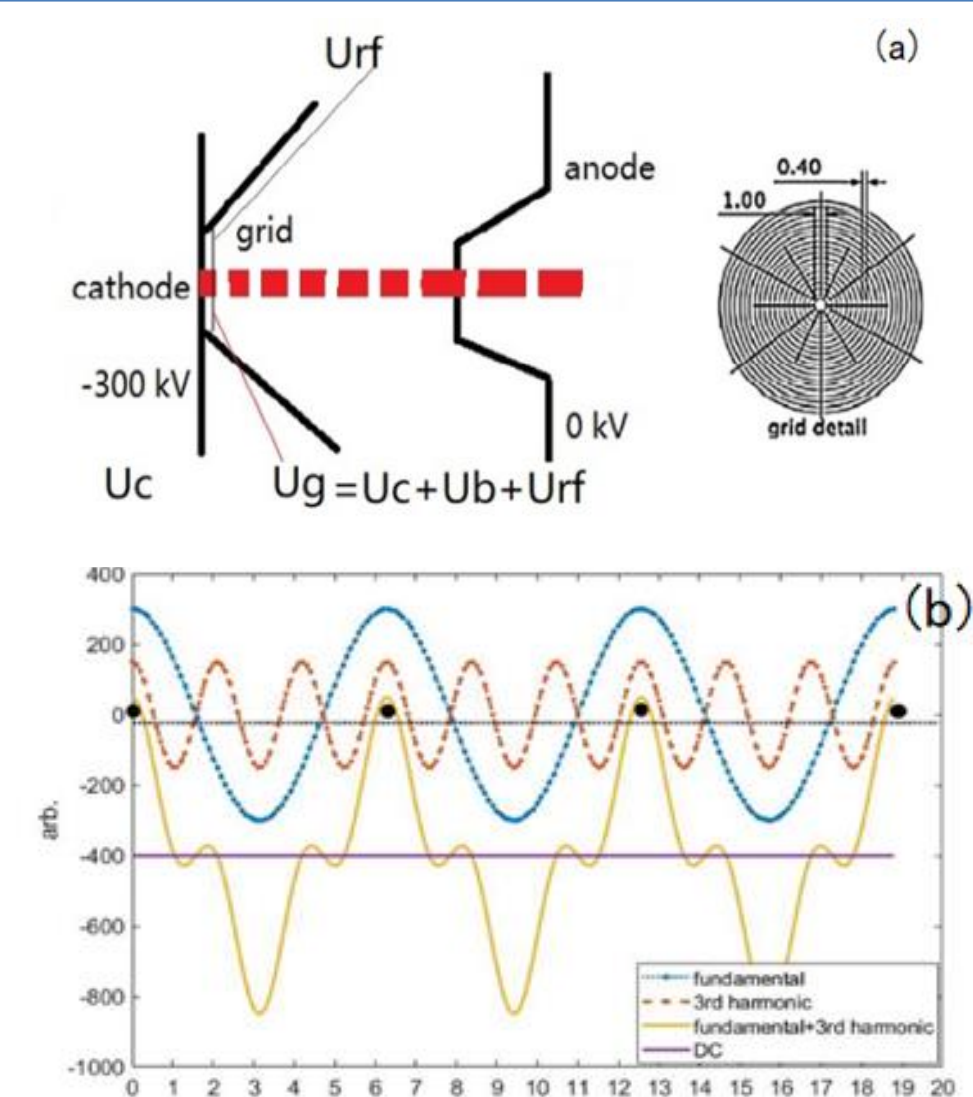


Figure 2: the sketch map and principle of RF modulated thermionic DC electron gun: (a) principles (b) grid RF voltage for gating the electron emission.

Table 1: designed RF modulated thermionic cathode DC gun parameters

| Beam parameters | Designed values |
|---------------------------|-----------------|
| Beam energy | 300 keV |
| Average current | 5 mA |
| Beam repetition rate (CW) | 325 MHz |
| Bunch charge | 16 pC |
| Energy spread | 1% |
| Normalized rms emittance | <5 mm mrad |

PHOTOCATHODE INJECTORS FOR EicC

Future Electron ion collider of China (EicC) (Preliminary design layout)

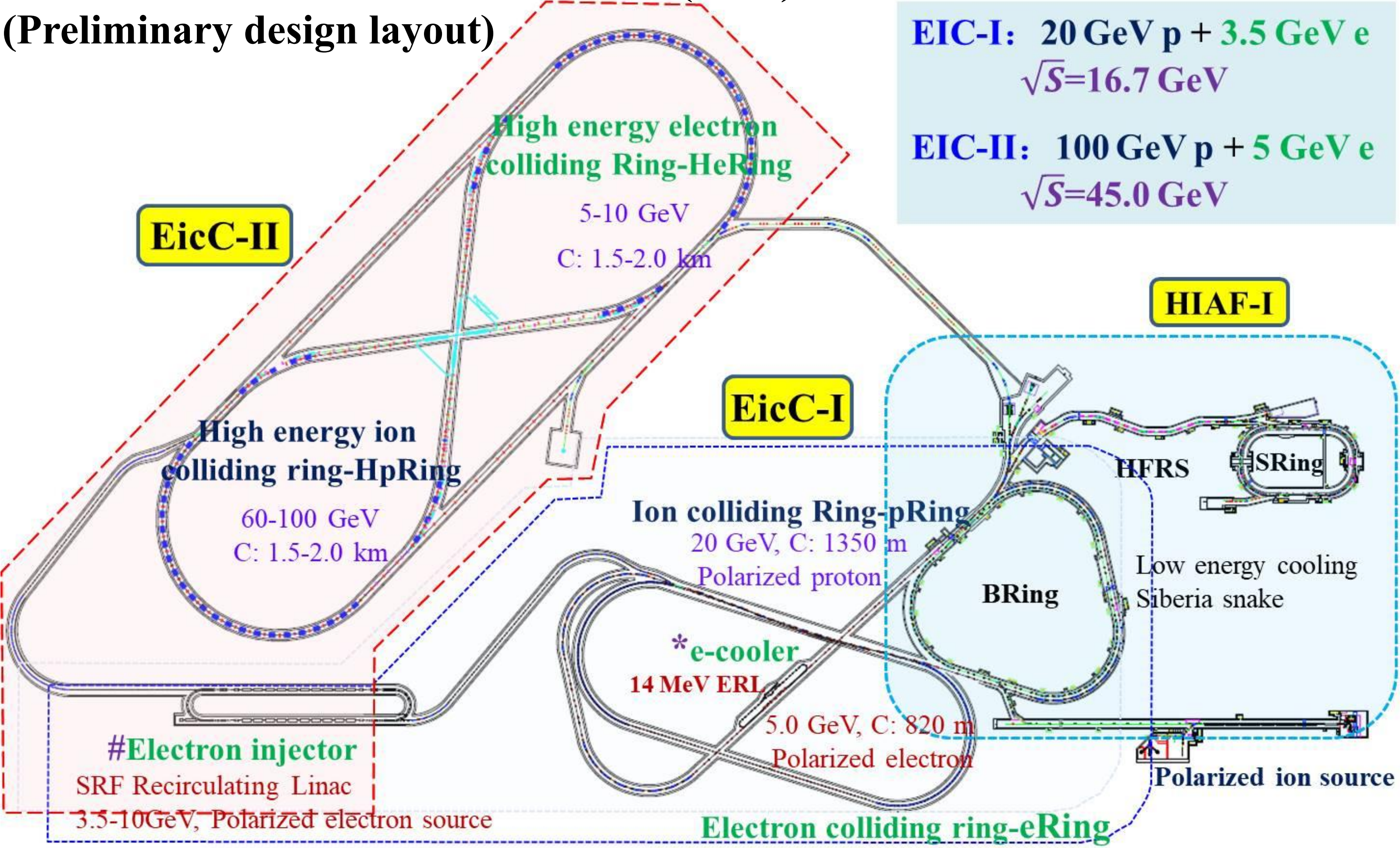


Figure 3: the preliminary design blueprint of the EicC project and some basic parameters. [Courtesy of J.C. Yang and G.D. Shen].

*Table 3: preliminary electron injector parameters requirement for EicC electron cooling

| Beam parameters | Required values |
|--------------------------|-----------------------|
| Beam energy | 6 MeV |
| Bunch charge | 4 nC |
| rms bunch length | 100 ps |
| Pulse repetition rate | 0.3 – 3 MHz |
| Normalized rms emittance | <2.5 mm mrad |
| rms energy spread | <5 × 10 ⁻⁴ |

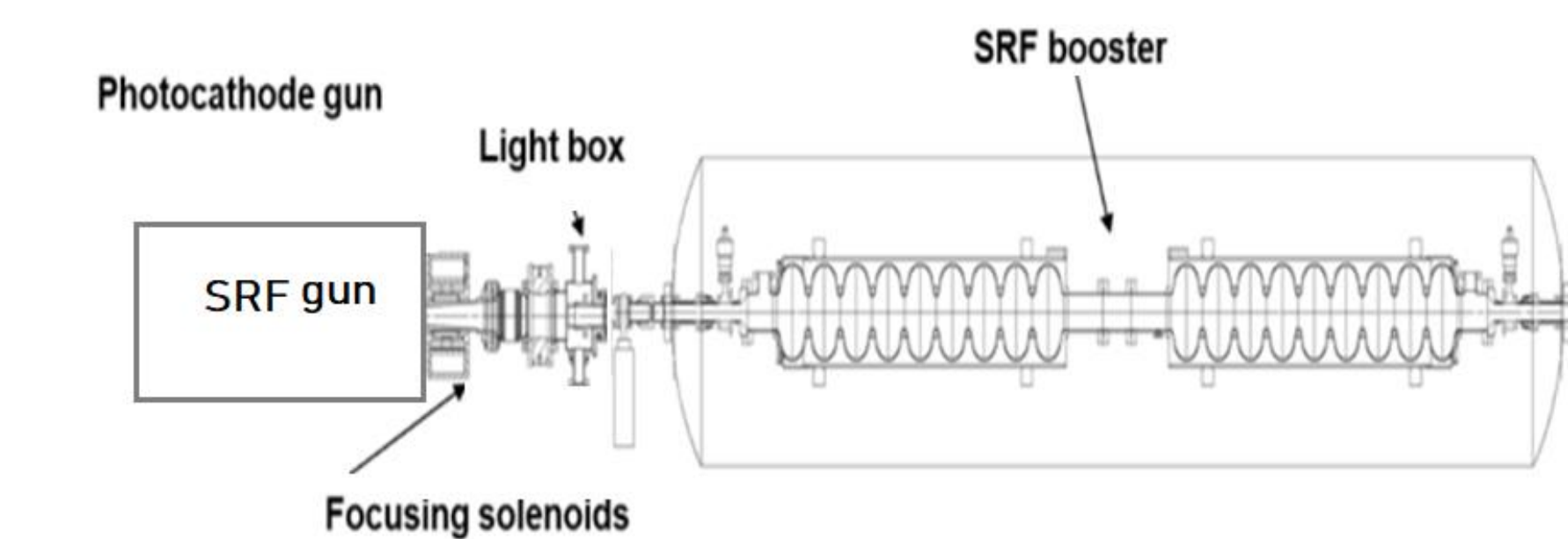


Figure 5: electron injector general layout based on SRF photocathode gun. (the solenoid can also be superconducting and put in the gun cryomodule)

#Table 2: preliminary beam parameters requirement for EicC electron injector

| Beam parameters | Required values |
|-----------------------------|-----------------|
| Beam energy | 6-10 MeV |
| Bunch charge | 0.1 – 0.5 nC |
| Micro-pulse repetition rate | 30 MHz |
| Macro pulse length | 50 us |
| Macro pulse repetition rate | 20 Hz |
| Normalized rms emittance | <2 mm mrad |
| rms beam energy spread | <0.1% |
| rms bunch length | <50 ps |
| polarization | >80% |

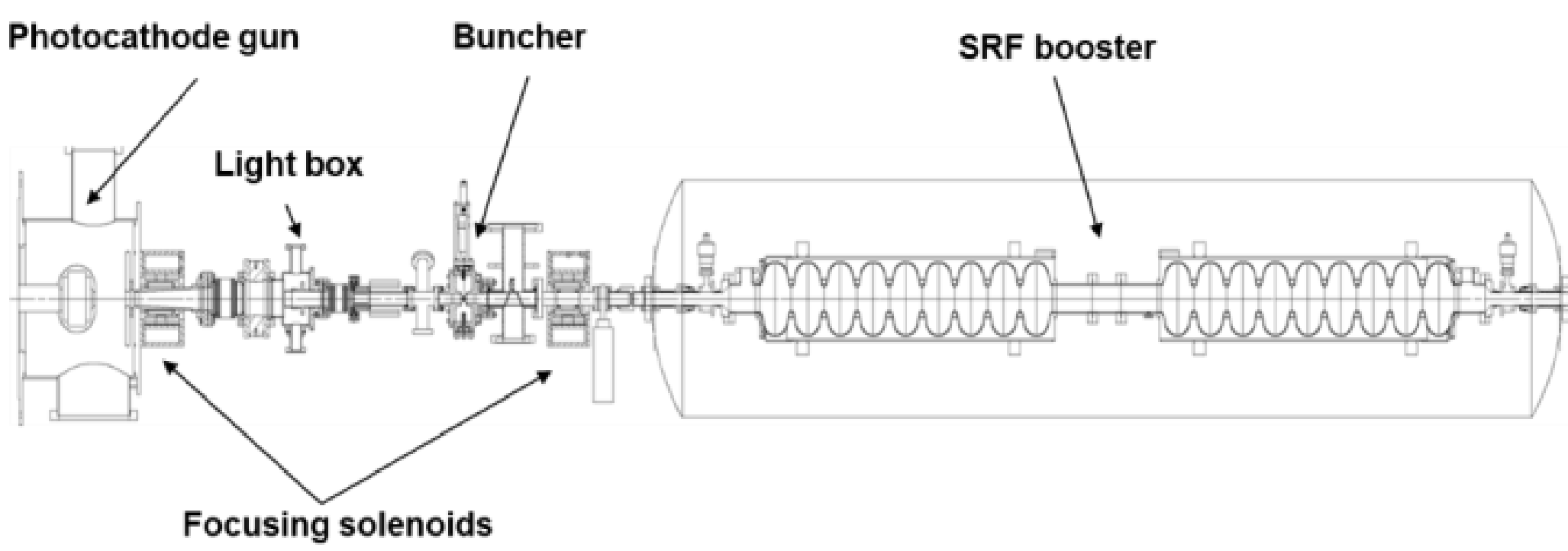


Figure 4: DC/SRF booster injector general layout(ALICE injector layout).

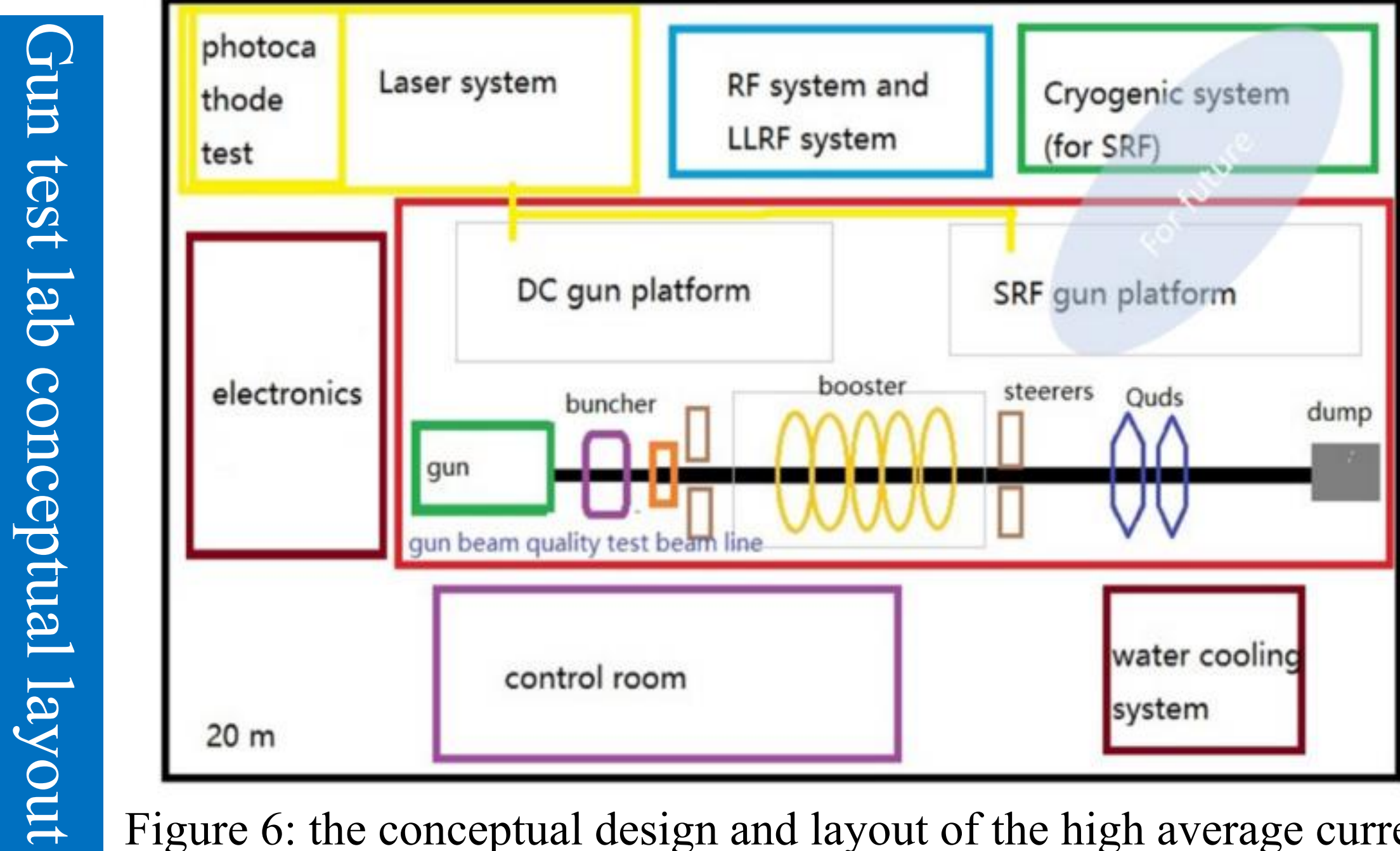


Figure 6: the conceptual design and layout of the high average current electron injector test lab.

