A Brief Outline Of Proposed ERLs

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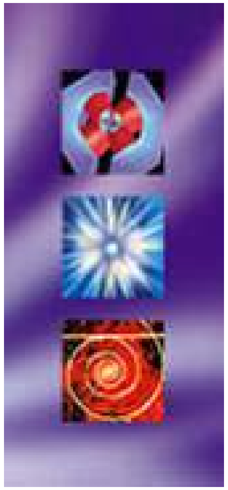
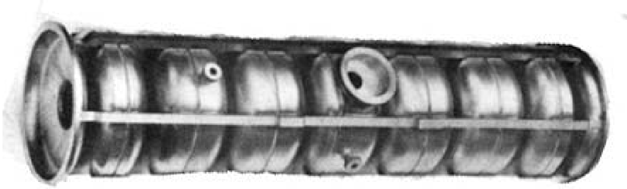


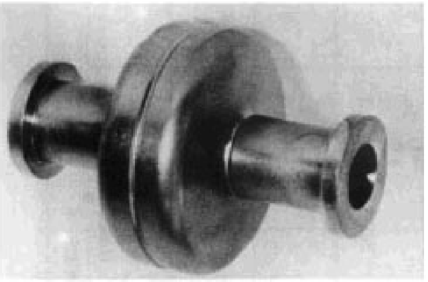
Background

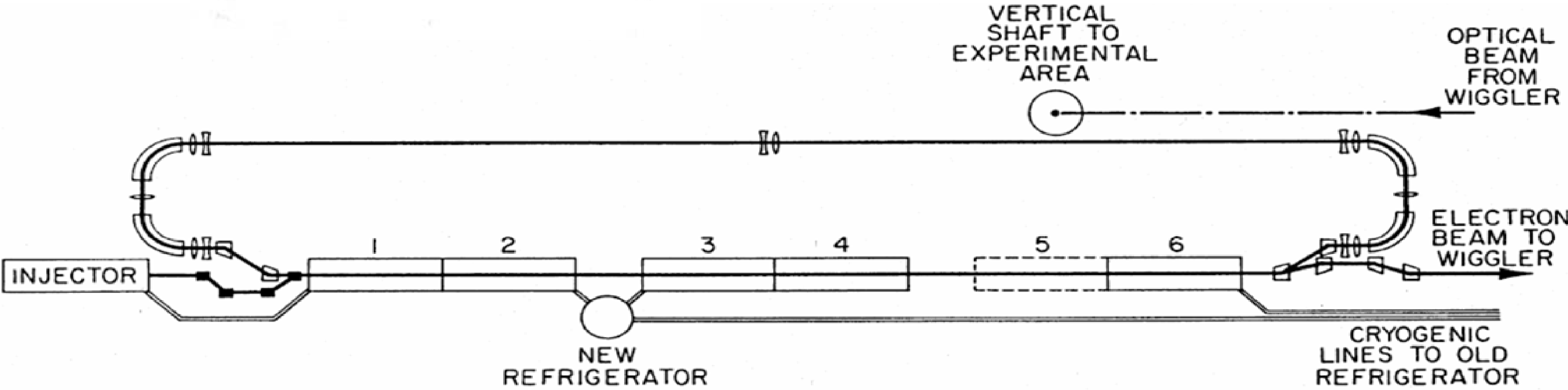
- Superconducting RF allows the possibility of Energy Recovery with **minimal wall losses.**
    - Projects to accelerate and then decelerate beams with a second linac were discussed.
- Several demonstrations of Energy Recovery
    - Stanford University. – SCA/FEL
    - Los Alamos National laboratories – FEL
    - TFNAF CEBAF Front End
- With the exception of the injector, the required rf power is nearly **independent of beam current**
    - Increased overall system **efficiency**
    - Reduced rf capital cost
- The electron beam power to be disposed of at beam dumps is reduced by ratio of E_{max}/E_{inj}
    - Thermal design of beam dumps is simplified
    - If the beam is dumped below the neutron production threshold, then the induced radioactivity (shielding problem) will be reduced.
- **Efficiency of storage rings with beam properties of linacs**

Stanford University – SCA- FEL

- Same cell energy recovery was first demonstrated in the SCA/FEL at the Stanford High Energy Physics Laboratory (HEPL) in July 1986
- Beam was injected at 5 MeV into a 50 MeV, 1.3 GHz SC linac
- Through recirculation HEPL doubled its energy
- All energy was recovered; I ~ 150 μA

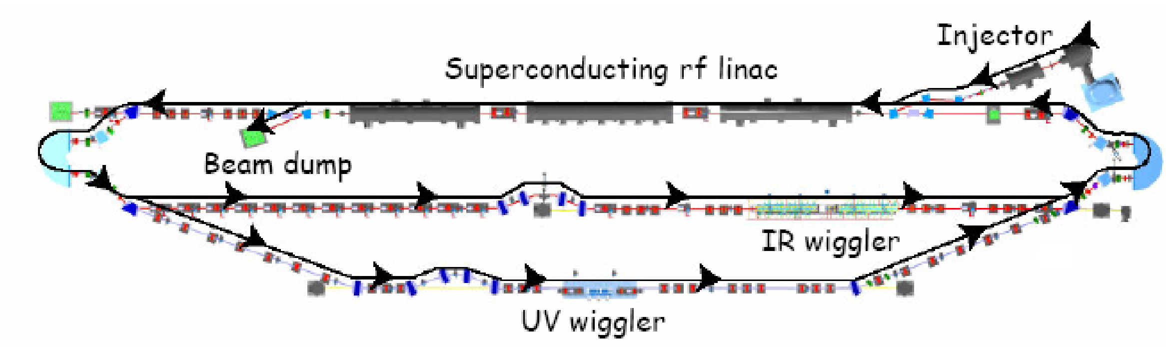


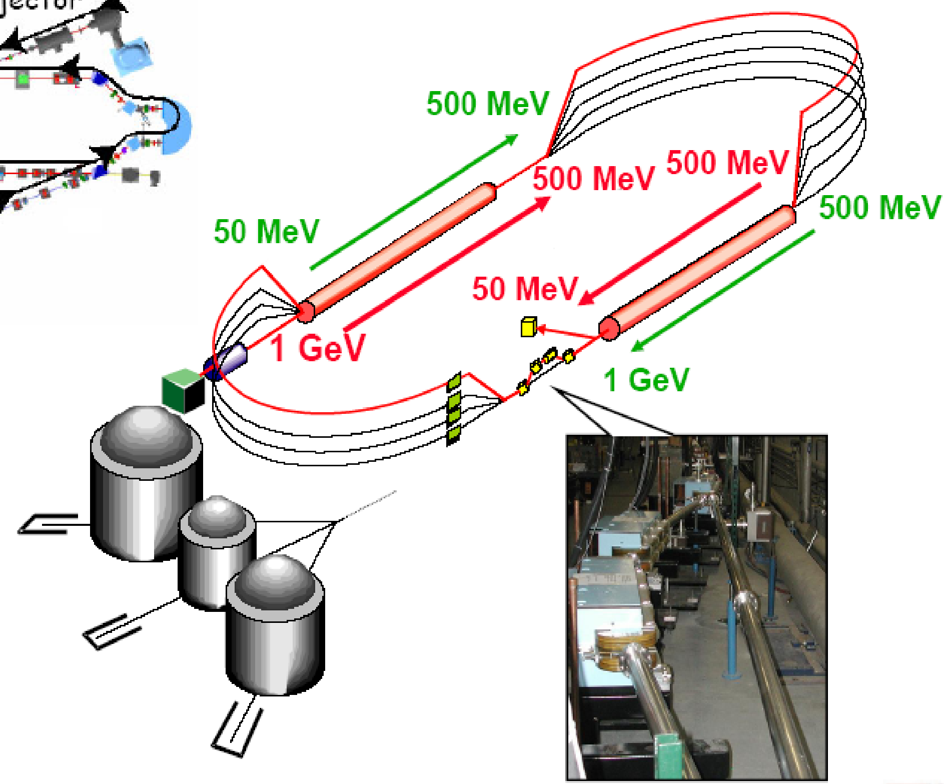




JLAB CEBAF – ER and IRFEL Demo

- Energy recovery up to 50 MeV has been achieved at the IR FEL.
- Energy recovered up to 5mA at 145 MeV, up to 9mA at 88 MeV
- Achieved 10 kW IR power

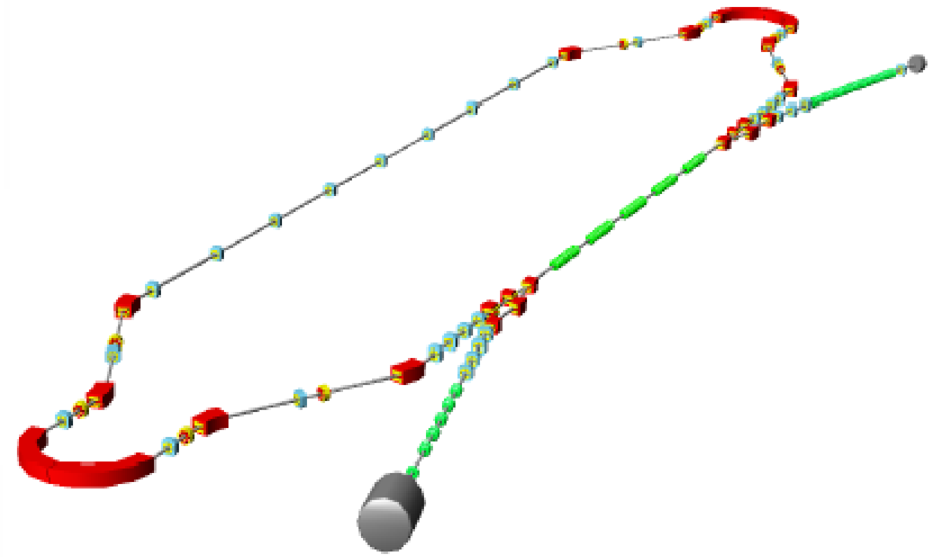


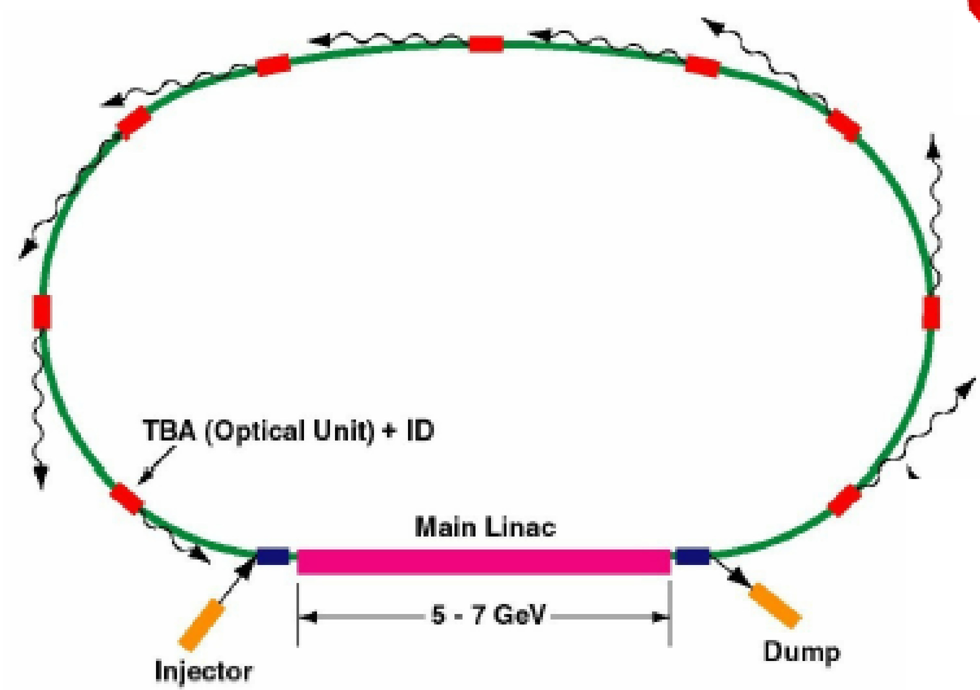


Special installation of a $\lambda_{RF}/2$ path length delay

Cornel ERL and Prototype

Beam Energy	100 MeV
Injection Energy	5 MeV
Beam Current	100 mA
Linac Frequency	1.3 GHz



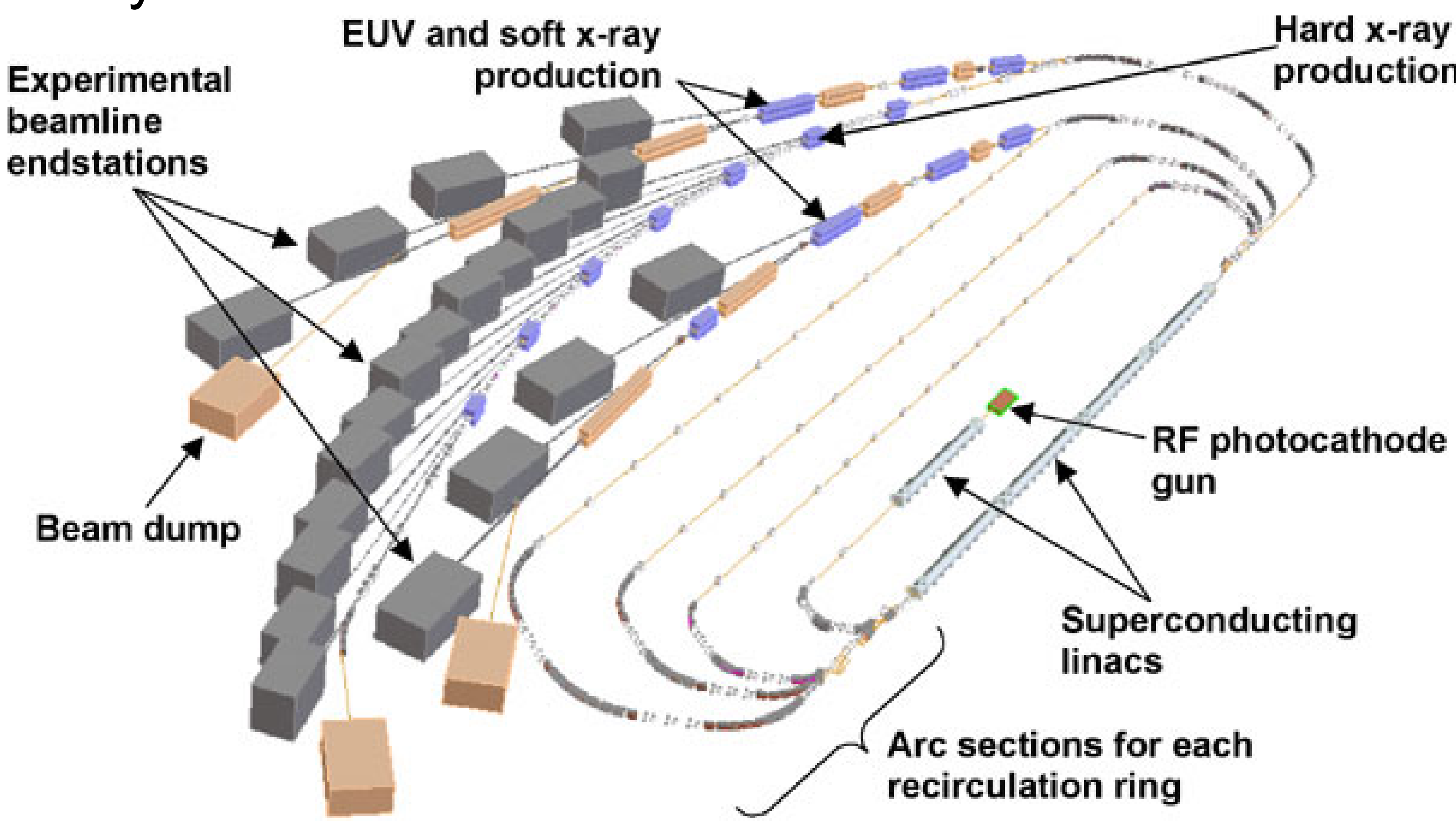


Beam Energy	5-7 GeV
Injection Energy	10 MeV
Beam Current	100 mA
Linac Frequency	1.3 GHz

LBNL – LUX

Beam Energy	2.5 GeV
Injection Energy	10 MeV
Beam Current	40 mA
Linac Frequency	1.3 GHz

- 700 MeV gain per linac pass
- 20 MV/m



BNL ERL

Be

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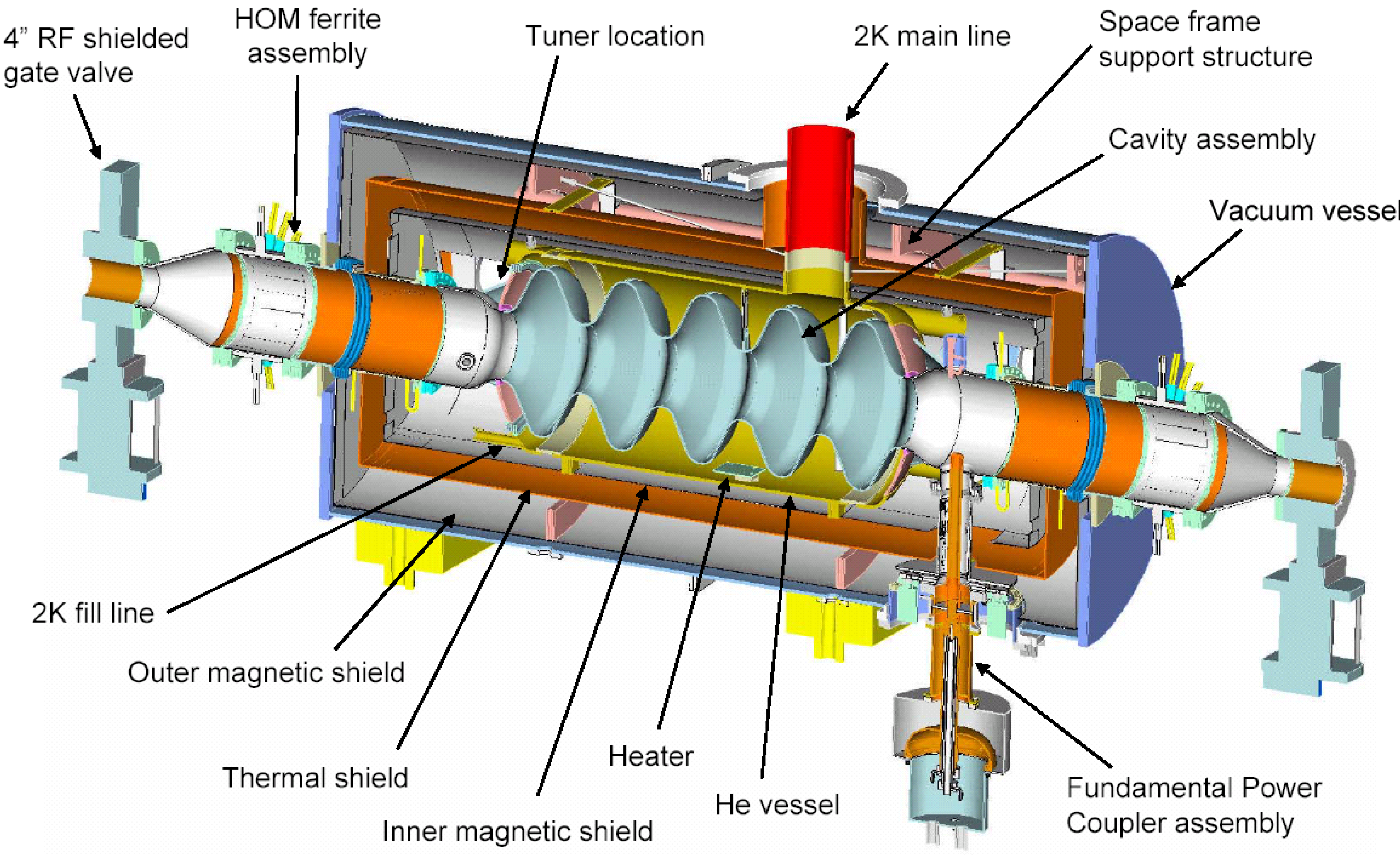
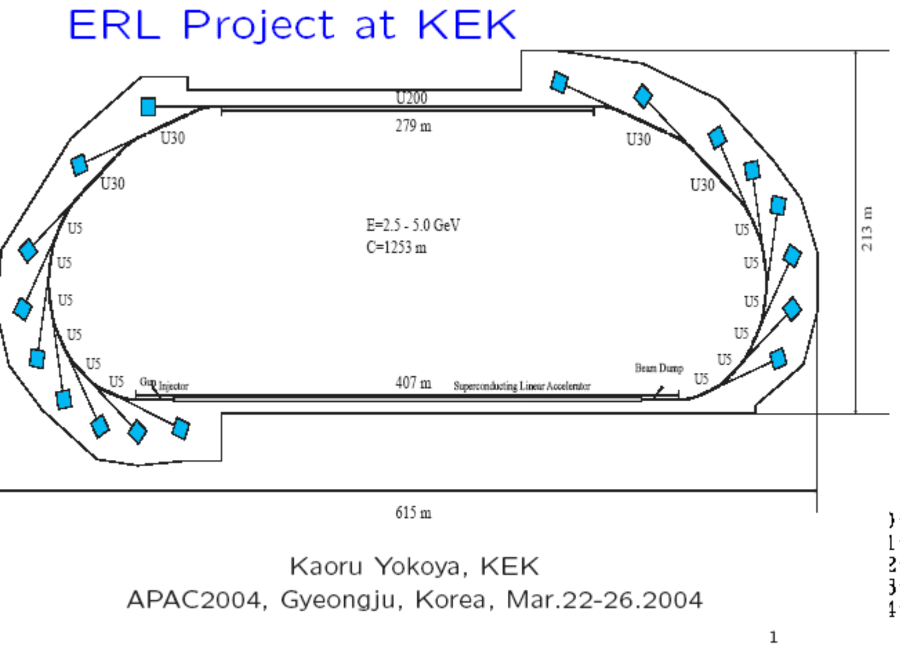
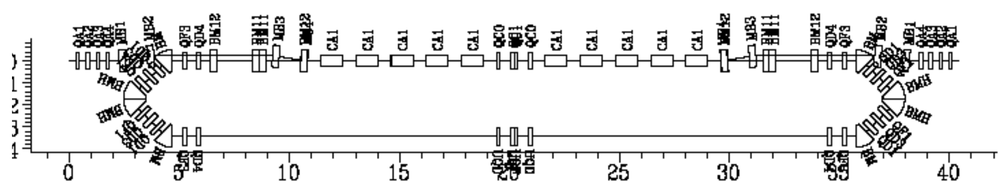


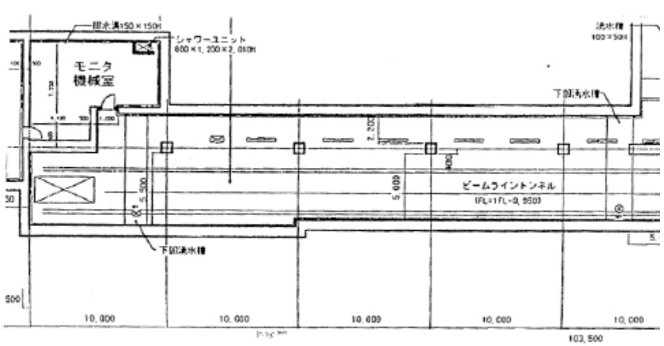
KEK ERL & Prototype



Beam Energy	2.5 -5 GeV
Injection Energy	10 MeV
Beam Current	100 mA
Acc Gradient	10-20 MV/m
Linac Frequency	1.3 GHz



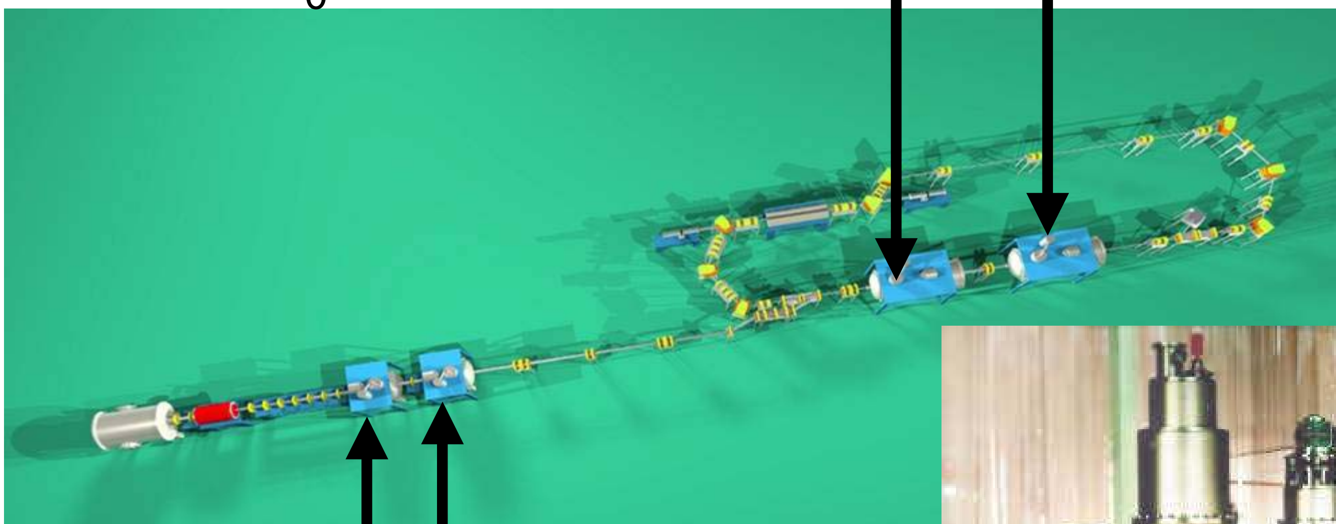
Beam Energy	200 MeV
Injection Energy	5 MeV
Beam Current	40 mA
Linac Frequency	1.3 GHz



JAERI-FEL

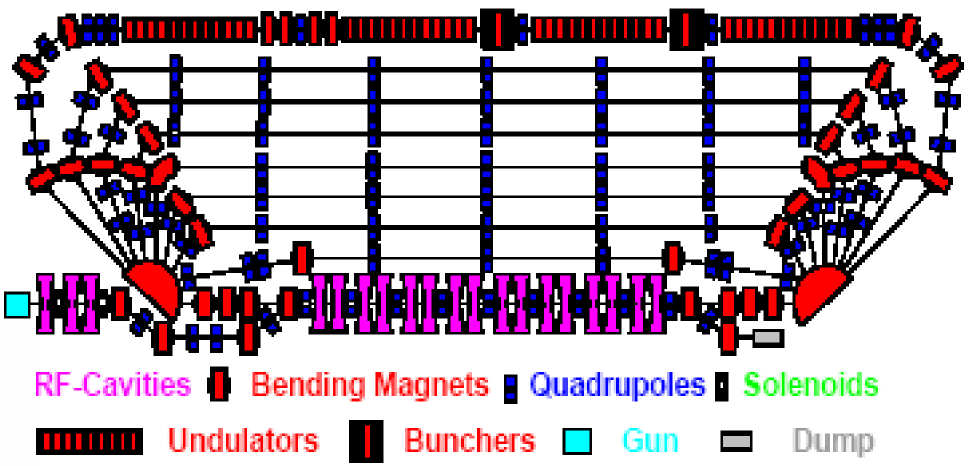
Beam Energy 17 MeV
Injection Energy 2.5 MeV
Beam Current 40 mA
E_{acc}> 5 MV/m at Q_0 $2x10^9$

5-Cell 500 MHz Superconducting RF Cavities



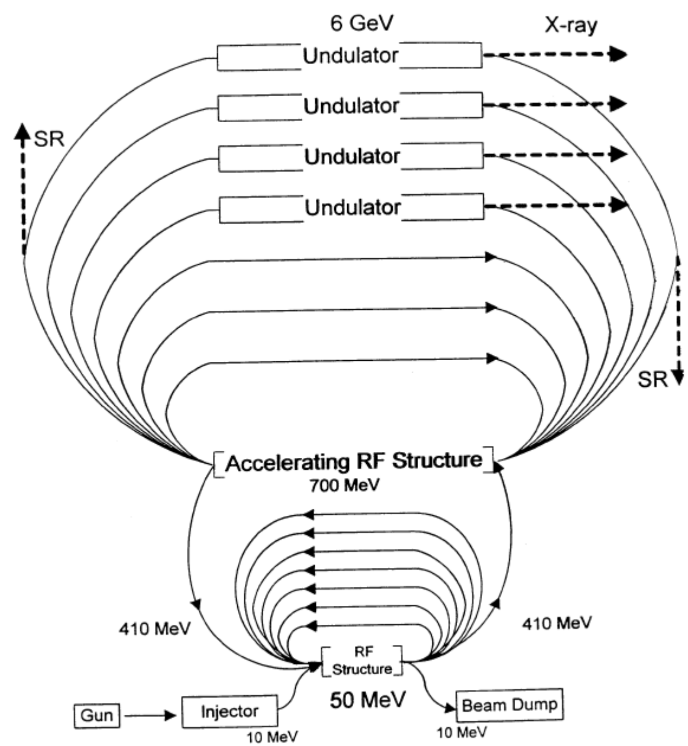
Single Cell 500 MHz Superconducting RF Cavities

BINP Accelerator-Recuperator / MARS



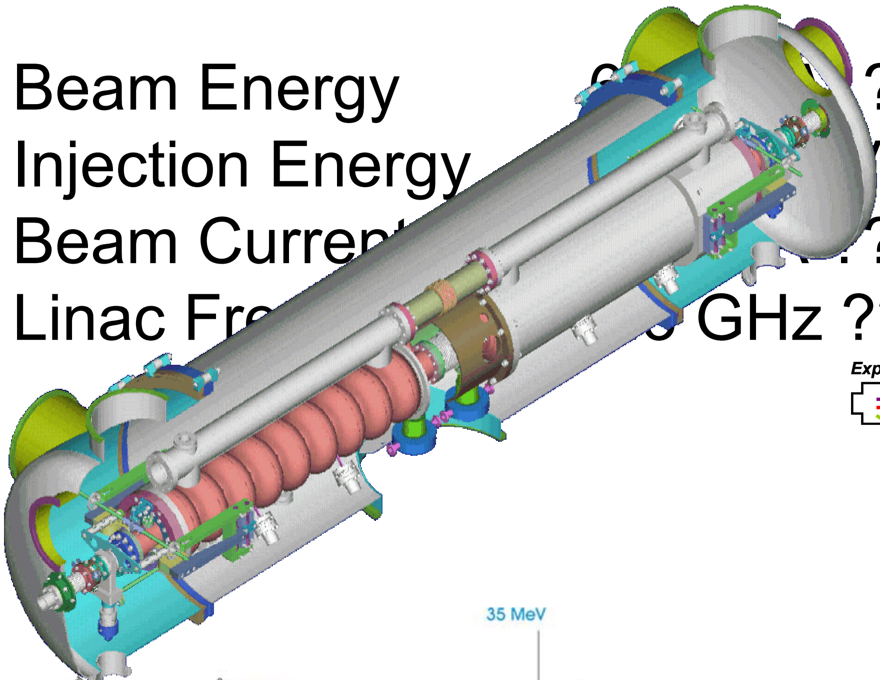
Beam Energy	98 MeV
Injection Energy	2 MeV
Beam Current	4-50 mA
Linac Frequency	181 MHz

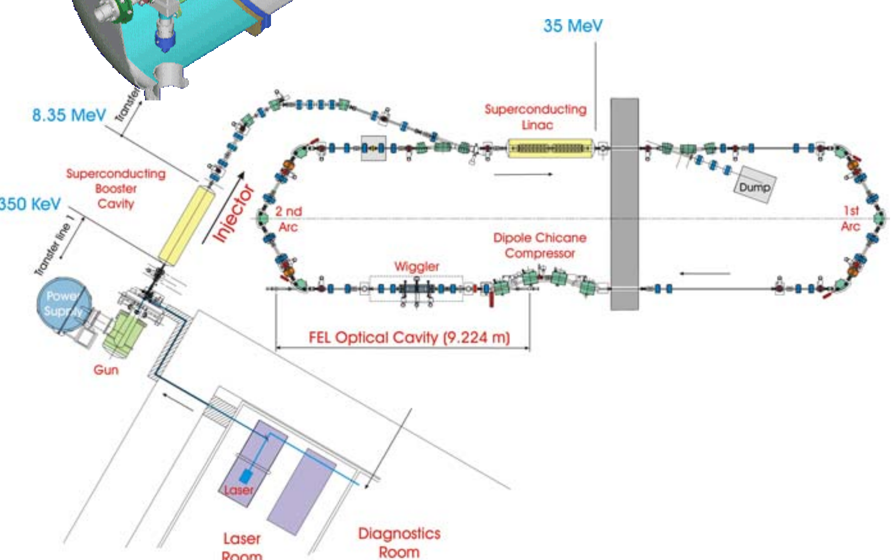
Beam Energy	6 GeV
Injection Energy	410 MeV
Beam Current	1 mA
Linac Frequency	181 MHz

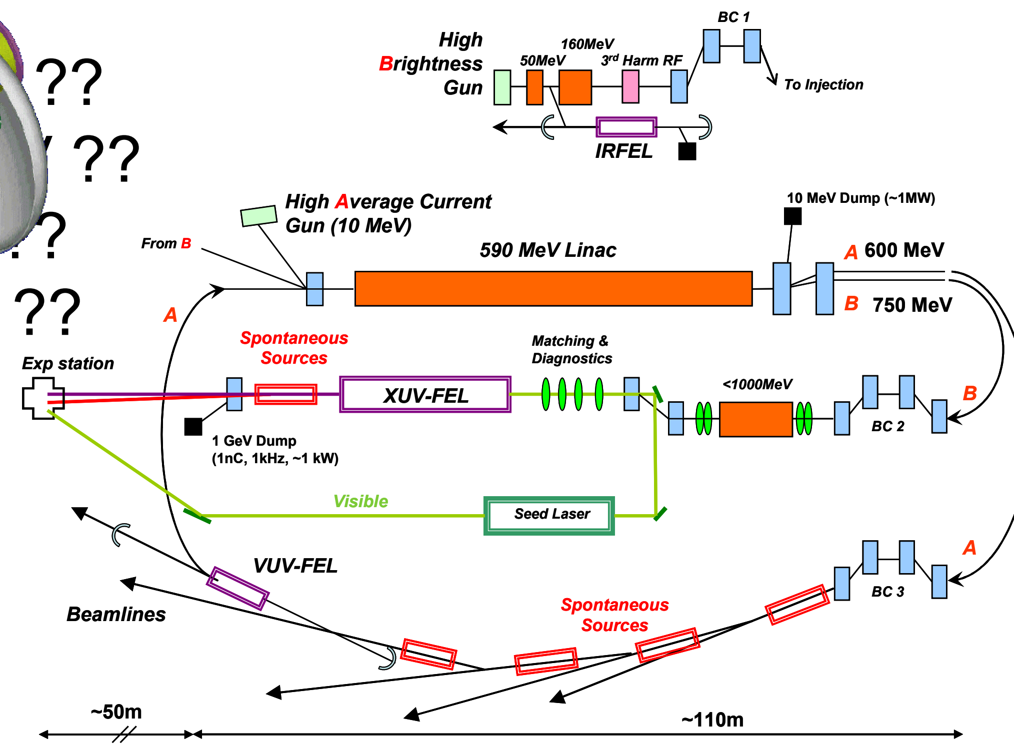


Daresbury Laboratory ERL Prototype and 4GLS

Beam Energy ??
Injection Energy ??
Beam Curren ??
Linac Fre GHz ??



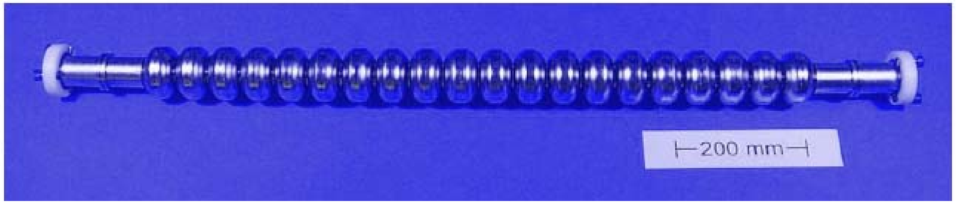


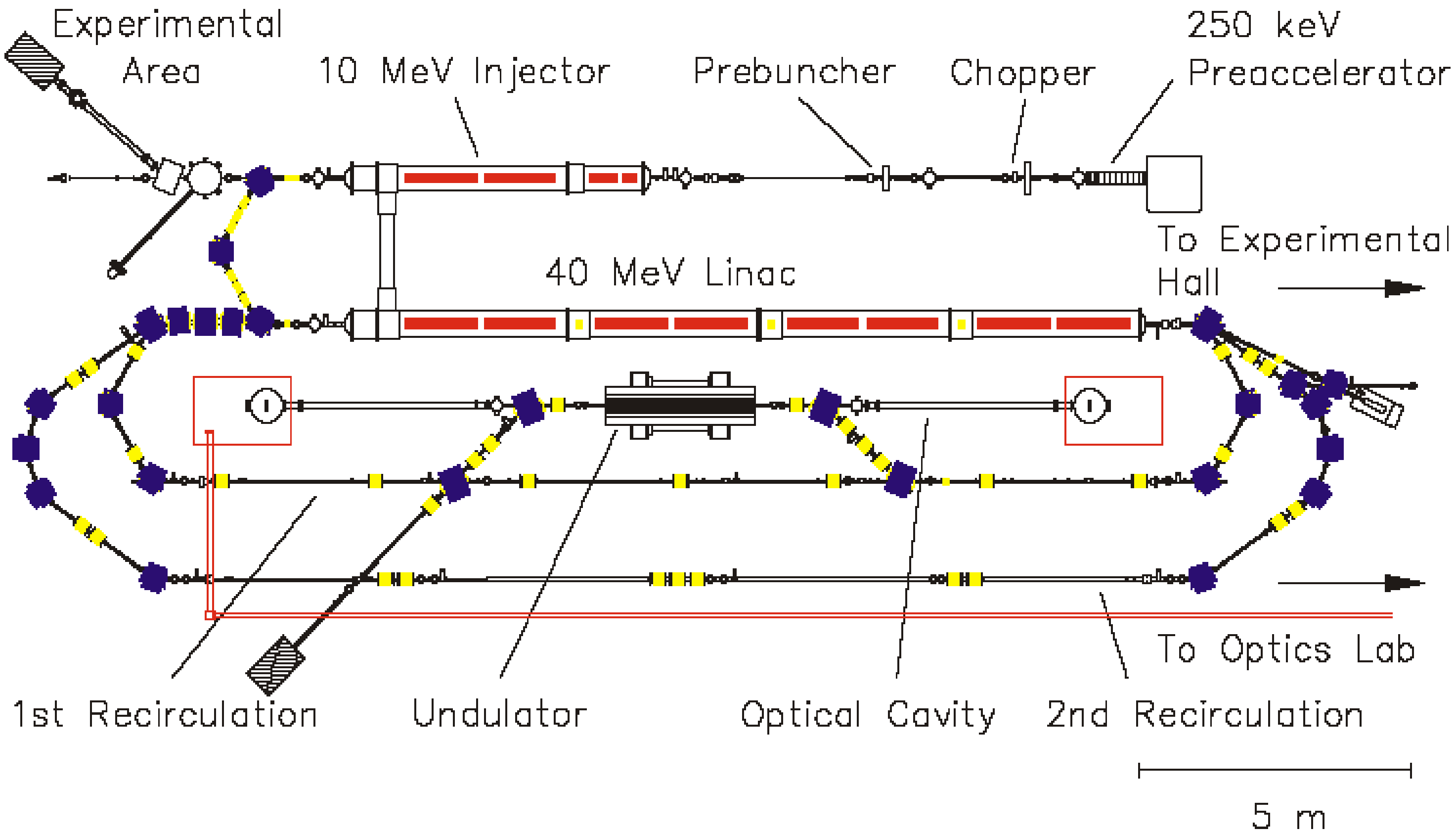


Beam Energy	35 MeV
Injection Energy	8.35 MeV
Beam Current	60 µA
Linac Frequency	1.3 GHz

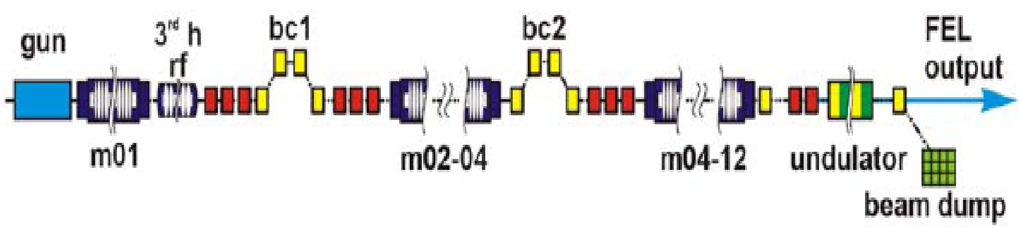
S-DALINAC

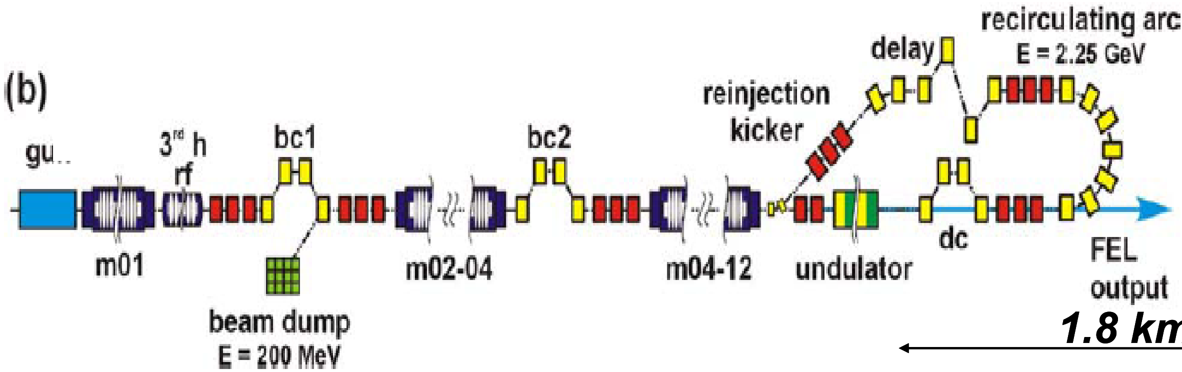
Beam Energy	40 MeV
Injection Energy	10 MeV
Beam Current	60 µA
Linac Frequency	30 GHz

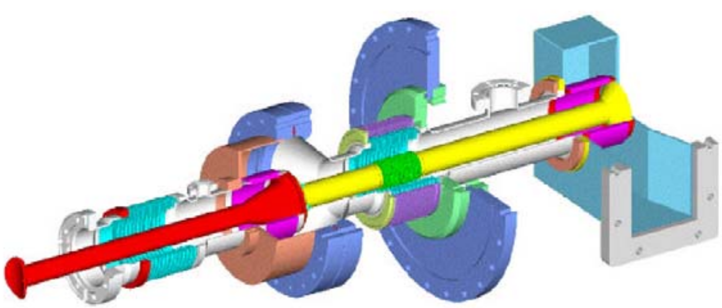


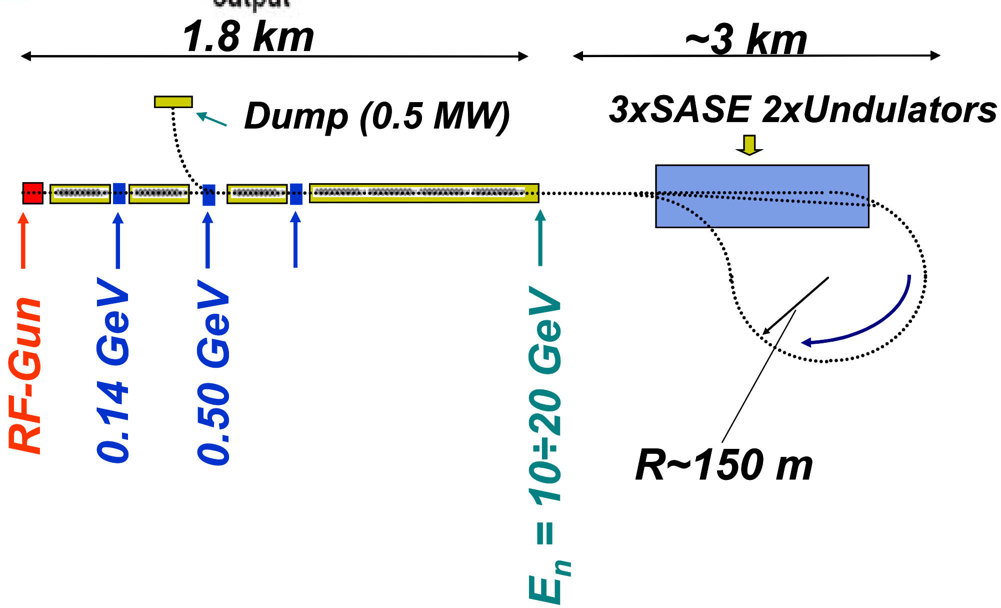


BESSY FEL & X-FEL – Energy Recovery Options









Conclusion

Parameter	SCA/ FEL	CEBAF	JLAB IR-FEL	ELRP	4GLS	Cornel ERL	JAERI-FEL	S-D	MARS	KEK Prot	BNL	LUX
Energy	50 MeV	5.7 GeV	48 – 210 MeV	35 MeV	600 MeV	0.1 – 7 GeV	17 MeV	120 MeV	6 GeV	200 MeV	40 MeV	2.5 GeV
Average Current	150 µA	100 nA – 100 µA	5 - 10 mA	60 µA	100 mA	100 mA	5.2 – 40 mA	60 µA	1 mA	40 mA	200 mA	10 µA
Bunch Charge		<0.2 pC	60 – 270 pC			77 pC	500 pC	6 pC			10 nC	1 nC
Bunch length		50 µm – 170 fs	1 ps	3 ps		0.1 – 5 ps	< 5 ps	1.9 ps				20 ps
Coupler	Own	WG	WG	SU	TBD	Own design					Coax	
Power Source	10 kW Klystron	Klystron	10 kW Klystron	20kW IOT	???	???	Klystron		Klystron		50 kW IOT/klystron	10 kW Klystron
Linac Type	Pre-Tesla	CEBAF	CEBAF	Tesla	Tesla/ Cornell???	Tesla	CESR		Own		High I	
Linac Frequency	1.3 GHz	1.5 GHz	1.5 GHz	1.3 GHz	1.3 GHz ???	1.3 GHz	500 MHz	3 GHz	181 MHz	1.3 GHz	703.75 MHz	1.3 GHz

Challenges

- Finding the optimum
  - Frequency
  - Gradient v's Q
  - Number of cells
  - 100-200 mA operation
  - Energy
  - Power into HOMs
  - Multipass or single pass
  - Multiple lines with different energies
- Current Targets
  - 1.3 GHz
  - 20 MV/m, Q_0 10^{10}
  - 7 cells
  - 200 mA
  - 7 GeV