eRHIC electron linac and ring

Cost estimate
May, 2003

J.B. van der Laan, M. Farkhondeh, W. Franklin, W. Graves, R. Milner,
C. Tschalaer, D. Wang, F. Wang, A. Zolfaghari and T Zwart

- Ring
  - Parameters
  - Costs
  - Power, Length, Scaling
- Linac
  - Costs
  - Various Injection Options

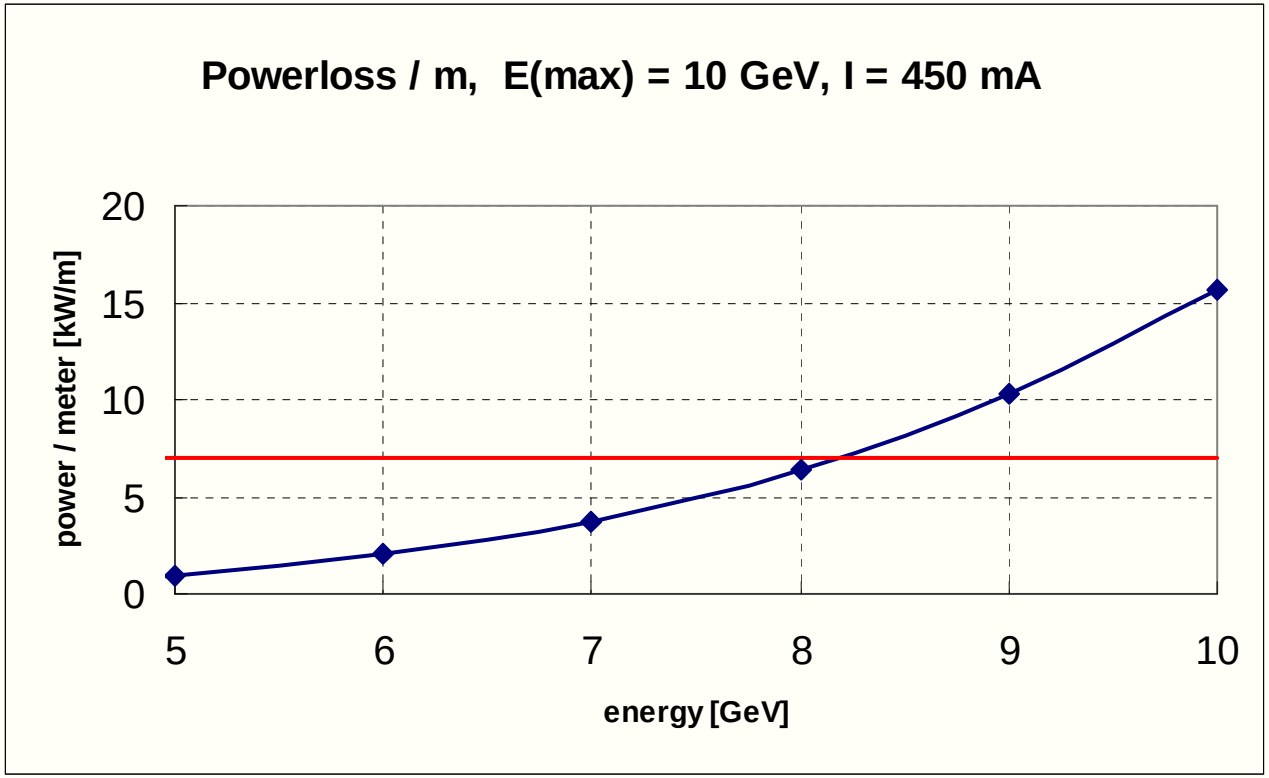
All estimates include:
- E D & I, Engineering, Design and Inspection
- M & S, Material and Service + Labor
- NO contingency

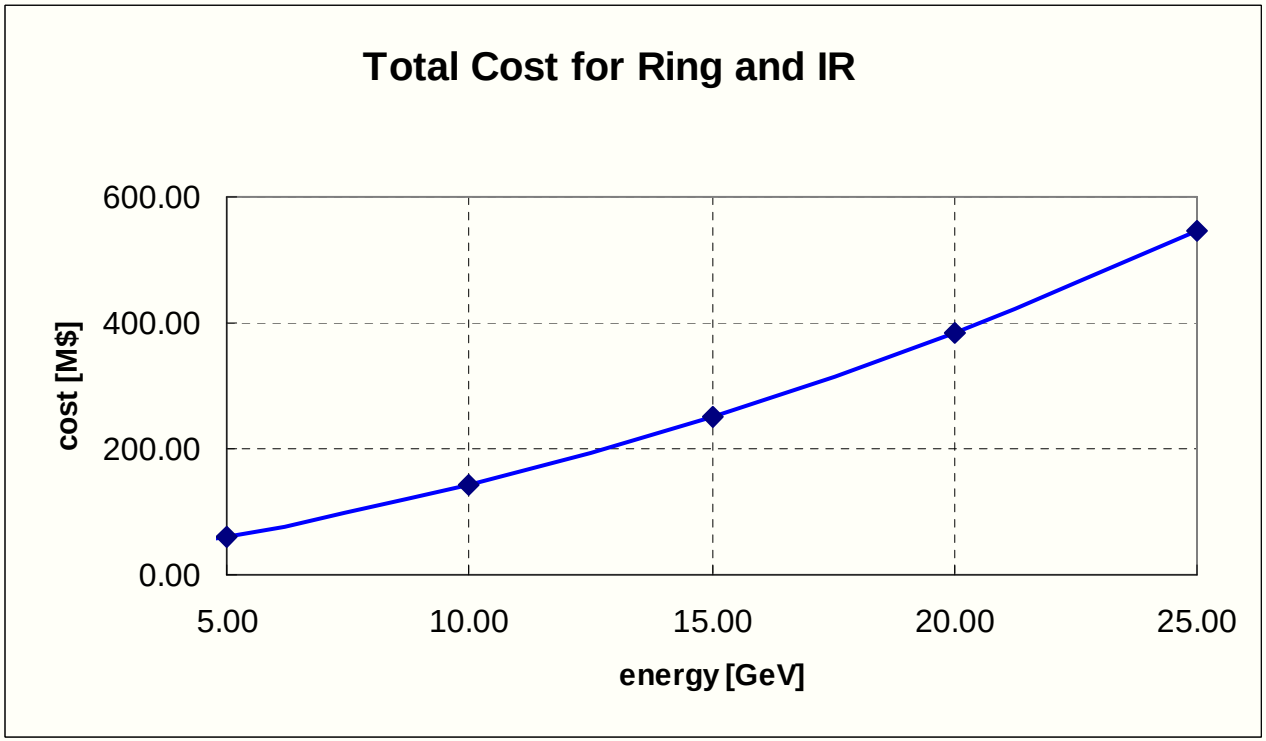
Electron storage ring for eRHIC

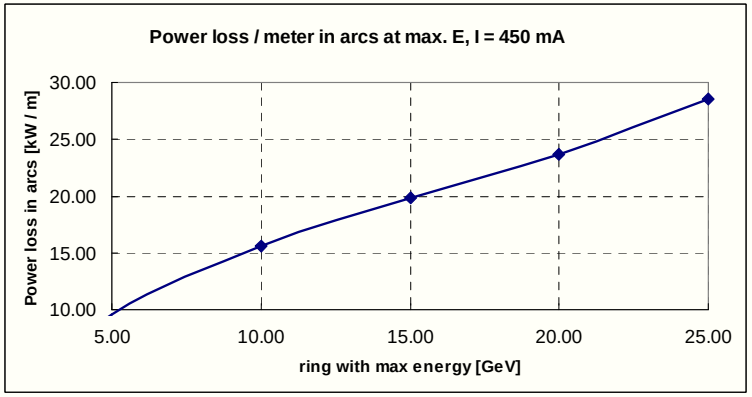
Main parameters for the RF system

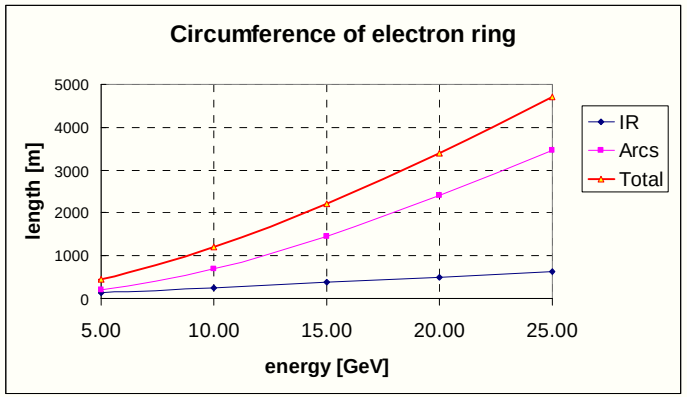
	Storage ring	
Circumference	1199	m
Energy	10	GeV
Rf frequency	364	MHz
Energy loss / turn	13	MeV
Gap voltage	30	MV
# of Cavities	20	
# of Klystrons	10	
Klystron power	10	MW

Storage Ring			
	Tunnel		15.0
	Magnets (incl. measurements)		38.0
	Support/Stands		4.0
	Installation		8.5
	Vacuum		30.2
	Power conversion		4.5
	RF		21.0
	Feedback (transv. + long.)		4.0
	Diagnostics		5.0
	Control System		7.5
	Subtotal Ring		***137.7***
Interaction Region			
	Magnets		4.5
	Power conversion		1.8
	Support/Stands		0.7
	Installation		1.5
	Vacuum		2.0
	Diagnostics		0.8
	Subtotal Interaction Region		***11.3***
Total Ring			**149.0**


Powerloss / m, E(max) = 10 GeV, I = 450 mA
power / meter [kW/m]
20
15
10
5
0
5
6
7
8
9
10
energy [GeV]


Total Cost for Ring and IR
600.00
400.00
200.00
0.00
cost [M$]
5.00
10.00
15.00
20.00
25.00
energy [GeV]


Power loss / meter in arcs at max. E, I = 450 mA
30.00
25.00
20.00
15.00
10.00
Power loss in arcs [kW / m]
5.00
10.00
15.00
20.00
25.00
ring with max energy [GeV]


Circumference of electron ring
5000
4000
3000
2000
1000
0
length [m]
5.00
10.00
15.00
20.00
25.00
energy [GeV]
IR
Arcs
Total

Copper Linac (1 – 10 GeV) Costs

Copper Electron Linac energy [GeV]		1	2	5	10
		M$	M$	M$	M$
Injector					
	Polarized injector	0.7	0.7	0.7	0.7
	Injector RF	0.6	0.6	0.6	0.6
	diagnostics & Install	0.3	0.3	0.3	0.3
	Subtotal Injector	***1.6***	***1.6***	***1.6***	***1.6***
RF System					
	Klystrons	1.6	3.2	7.9	15.8
	Modulators	2.2	4.4	11.1	22.1
	Waveguides	0.8	1.6	3.9	7.8
	Power Conversion	2.5	5.0	14.4	25.2
	Subtotal RF System	***7.1***	***14.2***	***37.3***	***70.9***
Accelerator System					
	Accelerator Structure	2.8	5.7	14.2	28.4
	RF cavities (SLED)	0.8	1.6	4.0	7.9
	High Power Loads	0.2	0.4	1.1	2.2
	Subtotal Acc. System	***3.9***	***7.7***	***19.3***	***38.5***
Miscellaneous					
	Tunnel	1.1	1.8	3.7	6.9
	Supporst/Stands	0.3	0.6	1.5	3.0
	Magnets	0.7	0.9	1.5	2.4
	Vacuum system	0.8	1.2	2.2	3.8
	Diagnostics	0.6	0.7	1.0	1.5
	Installation	1.4	1.8	3.0	5.0
	Control System	2.3	2.6	3.4	4.8
	Subtotal Miscellaneous	***7.2***	***9.5***	***16.2***	***27.4***
Total Accelerator		**19.8**	**33.0**	**74.3**	**138.4**

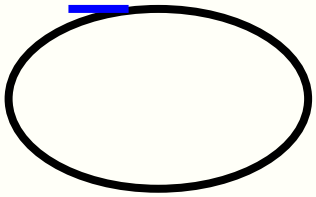
SC Linac (1 – 10 GeV) Costs

SC Electron Linac energy [GeV]		1	2	5	10
		M$	M$	M$	M$
Injector					
	Polarized injector	0.7	0.7	0.7	0.7
	Injector RF	0.6	0.6	0.6	0.6
	diagnostics & Install	0.3	0.3	0.3	0.3
	Subtotal Injector	***1.6***	***1.6***	***1.6***	***1.6***
RF System					
	Klystrons	1.2	2.4	6.0	12.0
	Modulators	0.5	1.0	2.5	5.0
	Waveguides	0.8	1.6	3.9	7.8
	Power Conversion	2.5	5.0	14.4	25.2
	Subtotal RF System	***5.0***	***10.0***	***26.8***	***50.0***
Accelerator System					
	Cavities incl Quads & BPMs	17.5	35.0	87.5	175.0
	Cryo	0.4	0.8	2.0	4.0
	Subtotal Acc. System	***17.9***	***35.8***	***89.5***	***179.0***
Miscellaneous					
	Tunnel	1.1	1.8	3.7	6.9
	Supporst/Stands	0.3	0.6	1.5	3.0
	Magnets	0.7	0.9	1.5	2.4
	Vacuum system	0.8	1.2	2.2	3.8
	Diagnostics	0.6	0.7	1.0	1.5
	Installation	1.4	1.8	3.0	5.0
	Control System	2.3	2.6	3.4	4.8
	Subtotal Miscellaneous	***7.2***	***9.5***	***16.2***	***27.4***
Total Accelerator		**31.7**	**56.9**	**134.1**	**258.0**

Booster Ring (10 GeV) Costs

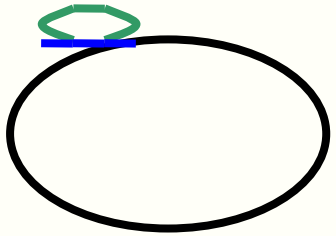
Booster Ring		
	Tunnel	5.0
	Magnets (incl. meas.)	14.0
	Support / Stands	1.5
	Installation	3.0
	Vacuum	9.0
	Power conversion	8.5
	RF	38.6
	Feedback (transv. + long.)	2.0
	Diagnostics	1.5
	Control System	2.5
Total Booster		***85.6***

2 GeV Copper Linac
2-10 GeV Ramping Ring



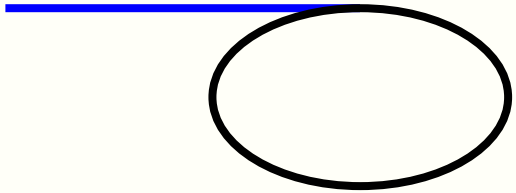
Injector & Linac	33
Ring & IR	149
Radiation & Damping Wigglers	15
Total	197

1 GeV Copper Linac
One Recirculation
2-10 GeV Ramping Ring



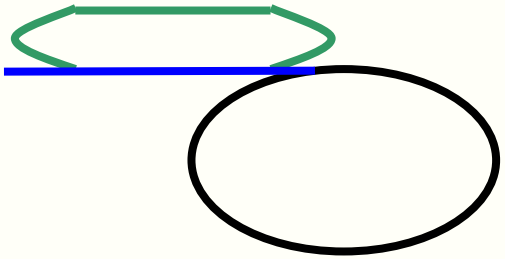
Injector & Linac	20
Recirculator	10
Ring & IR	149
Radiation & Damping Wigglers	15
Total	194

10 GeV Copper Linac
5-10 GeV Static Ring



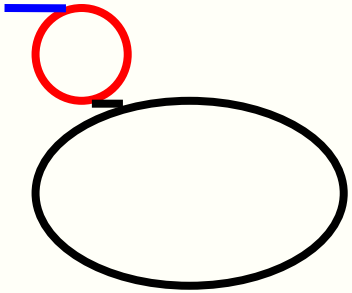
Injector & Linac	138
Ring & IR	149
Total	287

5 GeV Superconducting Linac
One Recirculation
5-10 GeV Static Ring



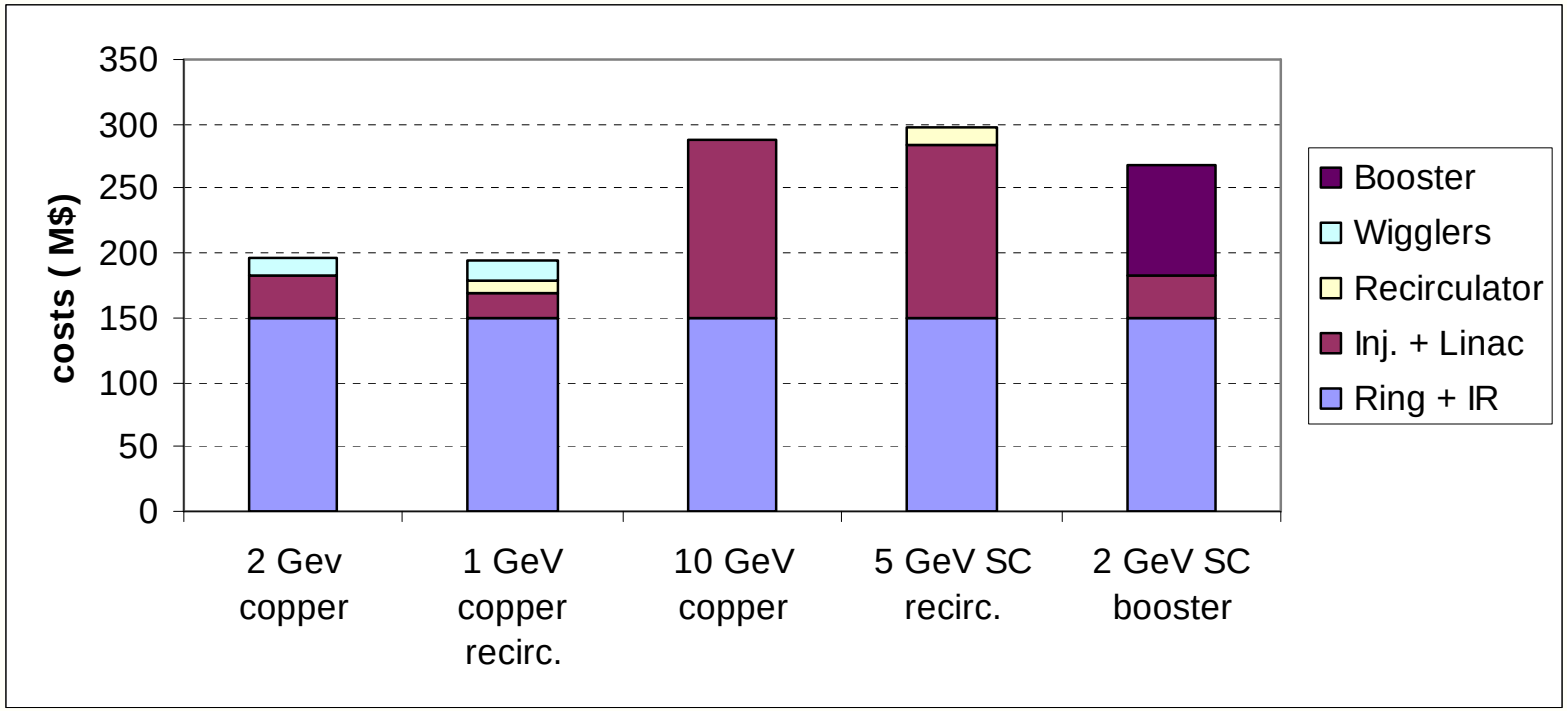
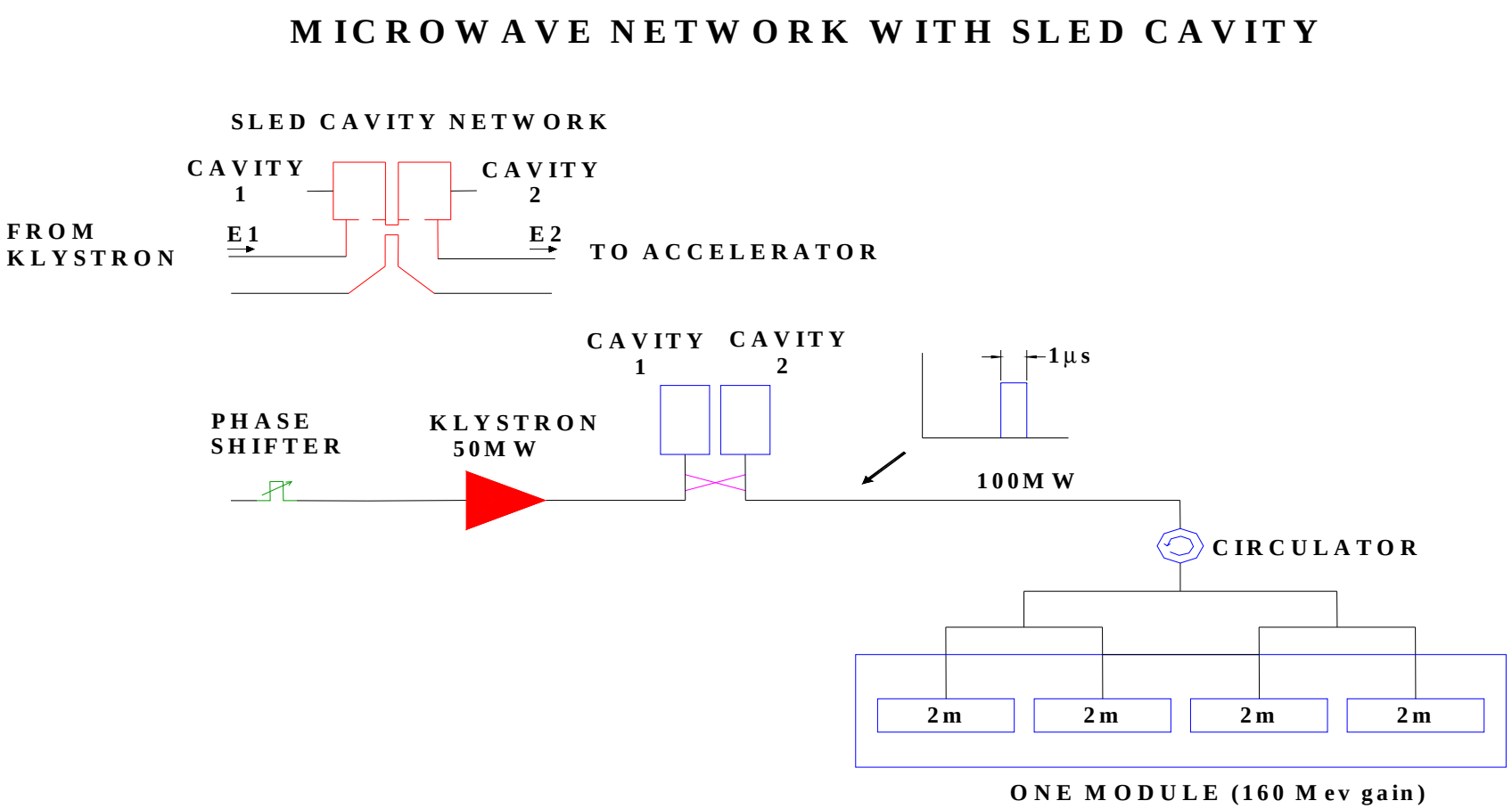
Injector & Linac	134
Recirculator	15
Ring & IR	149
Total	298

2 GeV Copper Linac
2-10 GeV Ramping Booster Ring
5-10 GeV Static Ring



Injector & Linac	33
Booster	86
Ring & IR	149
Total	268

Various Injection Schemes



SLED cavities