NCSX Sizing Study

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Goal:

Determine (roughly) machine parameters to aim at (outside PBX-M) which satisfy constraints and minimize cost

Method:

Vary (R, a, B, n) to minimize Cost subject to:

$\beta \geq 4\%$ with $P_{heat} = 6MW$

$\tau_E = 2.3\ \tau_E^{ISS95}$

Reactor-like collisionality: $nR/T^2 \leq 2$

$n_e \leq$ Sudo-Density

$n_e \langle a \rangle \geq$ 1.98e19 m-2 $\Rightarrow$20% CX NB loss (Transp)

ψ_P sufficient for ≤20% orbit loss (calib. To Transp)
for 40keV D tangential NBI

$\tau_E^{neo} \geq 2\ \tau_E$

$\tau_{pulse} \equiv 3\ \tau_{L/R}$

$G = (j^2\ \tau\ )_{max} = (7kA\ cm^{-2})^2\ (1.4s)$

$J_{max} = P_j\ RB_T / \mu_0\ (R - \langle a \rangle / \langle \kappa \rangle - \Delta_{coil})$ with $P_j = 2.6$

$\Delta_{coil} = 0.2\ \langle a \rangle / 0.4$ scaling from present studies

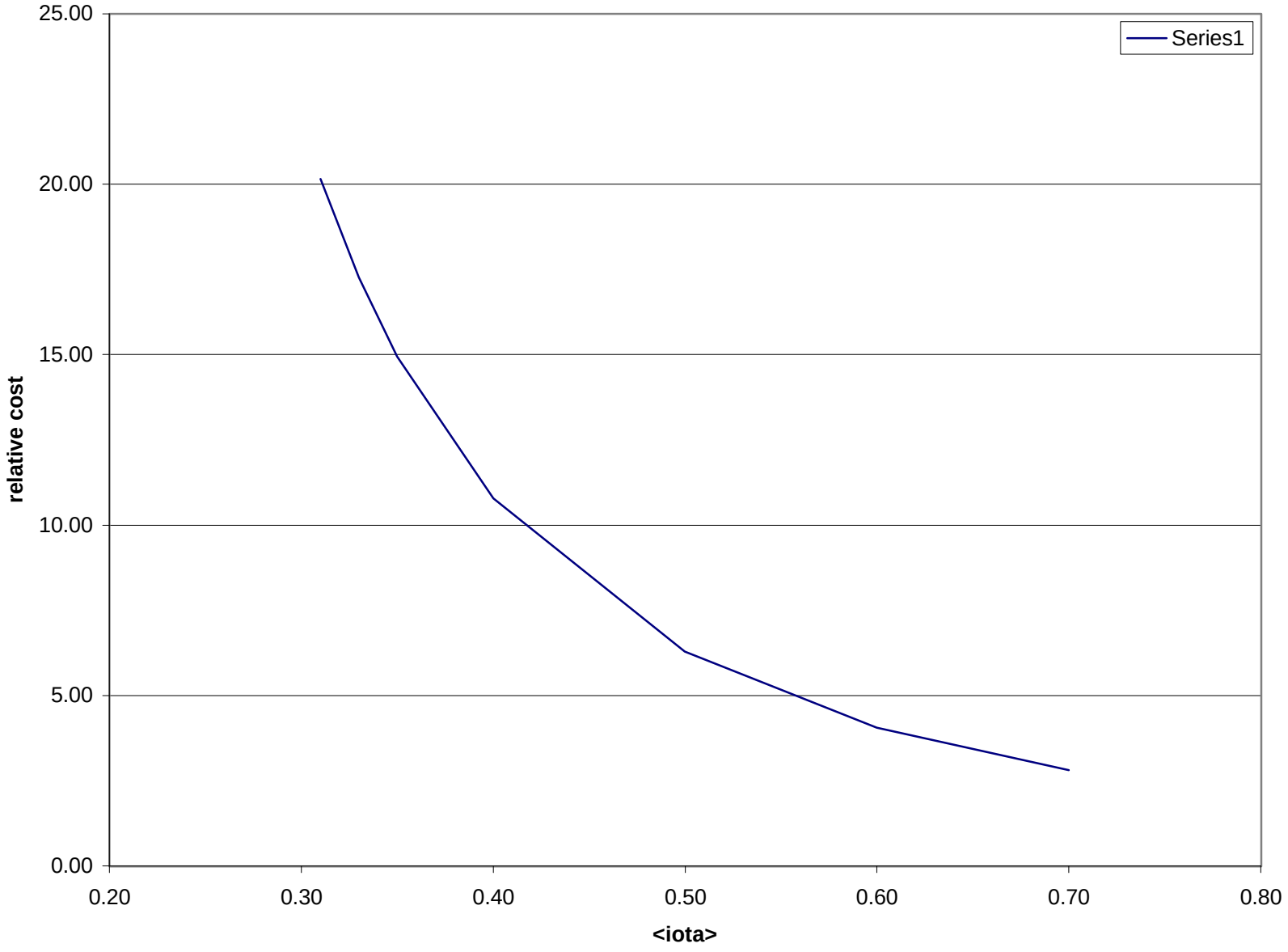
$\tau_{max} = G / [J_{max} / 2(\Delta_{coil} - 0.125)]^2$

assume 0.125m PFC+VV+SOL,etc

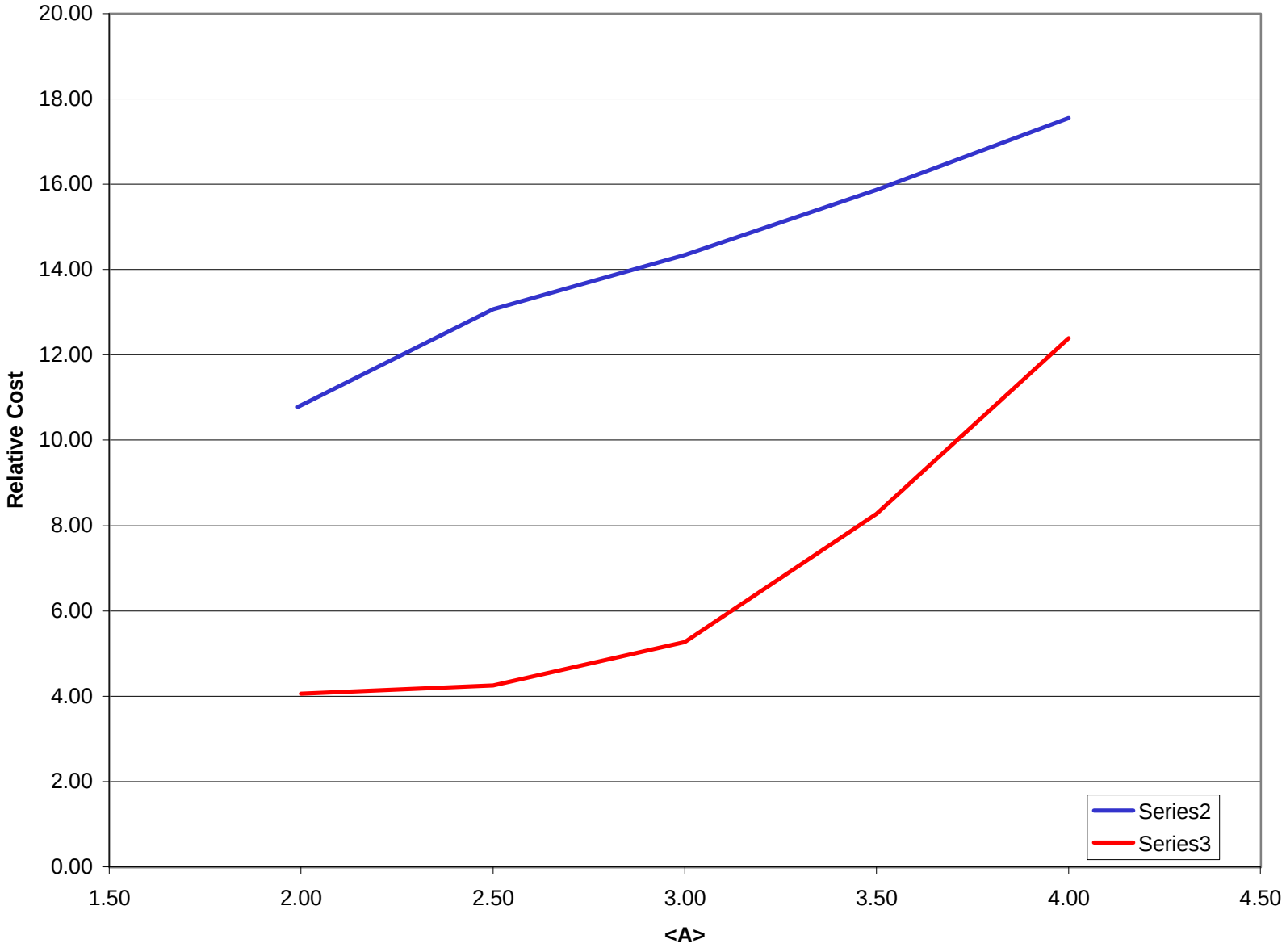
$Cost_{max} = 2\pi\ RBt/\mu_0\ \ 2\pi\ (\langle a \rangle + \Delta_{coil})\ \kappa^{1/2}$ (A m)

$Cost = Cost_{max}\ (\tau_{pulse} / \tau_{max})^{1/2}$

	X 3c10 b			iota scan								<iota> in PBXM
<iota>	0.40	**0.4**	**0.60**	**0.31**	**0.33**	**0.35**	**0.40**	**0.50**	**0.60**	**0.70**		0.46
R (m)	1.45	2.94	2.23	0.95	0.96	0.98	1.01	1.06	1.10	1.14		**1.45**
<a> (m)	0.40	1.47	1.30	0.48	0.48	0.49	0.51	0.53	0.55	0.57		**0.40**
R/a	3.63	1.99	1.71	1.98	1.99	1.99	1.99	2.00	2.00	2.00		3.63
q(a)	2.22	2.22	1.54	2.78	2.63	2.50	2.22	1.82	1.54	1.33		1.96
n (10^19/m^3)	5.00	1.34	1.52	8.14	7.73	7.36	6.60	5.51	4.77	4.23		5.22
B(T)	1.00	0.31	0.23	1.23	1.14	1.06	0.90	0.68	0.55	0.45		0.99
beta	####	8.03%	14.75%	4.28%	4.65%	5.03%	6.00%	8.09%	10.34%	12.75%		4.20%
tau_pulse = 3*L/R	2.70	23.09	15.99	4.00	4.00	4.00	4.00	4.00	4.00	4.00		2.76
Rel Cost	14.15	5.40	2.45	20.15	17.27	14.94	10.78	6.28	4.06	2.81		13.97


25.00
20.00
15.00
10.00
5.00
0.00
relative cost
0.20
0.30
0.40
0.50
0.60
0.70
0.80
<iota>
Series1

	X 3c10 b	<A> scan					<A> scan					
<iota>	0.40	**0.40**	**0.40**	**0.40**	**0.40**	**0.40**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**	**0.4**
R (m)	1.45	1.01	1.16	1.38	1.59	1.80	1.10	1.36	1.45	1.63	1.86	2.94
<a> (m)	0.40	0.51	0.46	0.46	0.45	0.45	0.55	0.54	0.48	0.47	0.47	1.47
R/a	3.63	1.99	**2.50**	**3.00**	**3.50**	**4.00**	2.00	**2.50**	**3.00**	**3.50**	**4.00**	1.99
q(a)	2.22	2.22	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54	2.22
n (10^19/m^3)	5.00	6.60	7.12	6.20	5.51	4.98	4.77	4.02	4.11	4.25	4.25	1.34
B(T)	1.00	0.90	0.98	0.99	1.00	1.01	0.55	0.56	0.63	0.74	0.85	0.31
beta	####	6.00%	6.13%	5.29%	4.67%	4.20%	10.34%	8.64%	7.24%	5.74%	4.67%	8.03%
tau_pulse = 3*L/R	2.70	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.35	3.52	3.89	23.09
Rel Cost	14.15	10.78	13.07	14.34	15.88	17.55	4.06	4.26	5.27	8.27	12.40	5.40


20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Relative Cost
1.50
2.00
2.50
3.00
3.50
4.00
4.50
<A>
Series2
Series3

Conclusions:

1) most sensitive parameter is ⟨iota⟩
   increasing ⟨iota⟩ ⇒ lower Cost

2) a solution cannot be obtained in the PBX-M
   constraints without increasing ⟨iota⟩ to ~0.46

3) decreasing ⟨A⟩ decreases Cost

   ⟨iota⟩ = 0.6, ⟨A⟩~2.5 would
   decrease Cost by factor of ~3.5 rel. to 3-c10B