NCSX
Transport Status

M. Zarnstorff
Z. Lin, H. Mynick, M. Redi, D. Spong

PPPL, ORNL

NCSX Design Pt. Definition & Planning

Overview

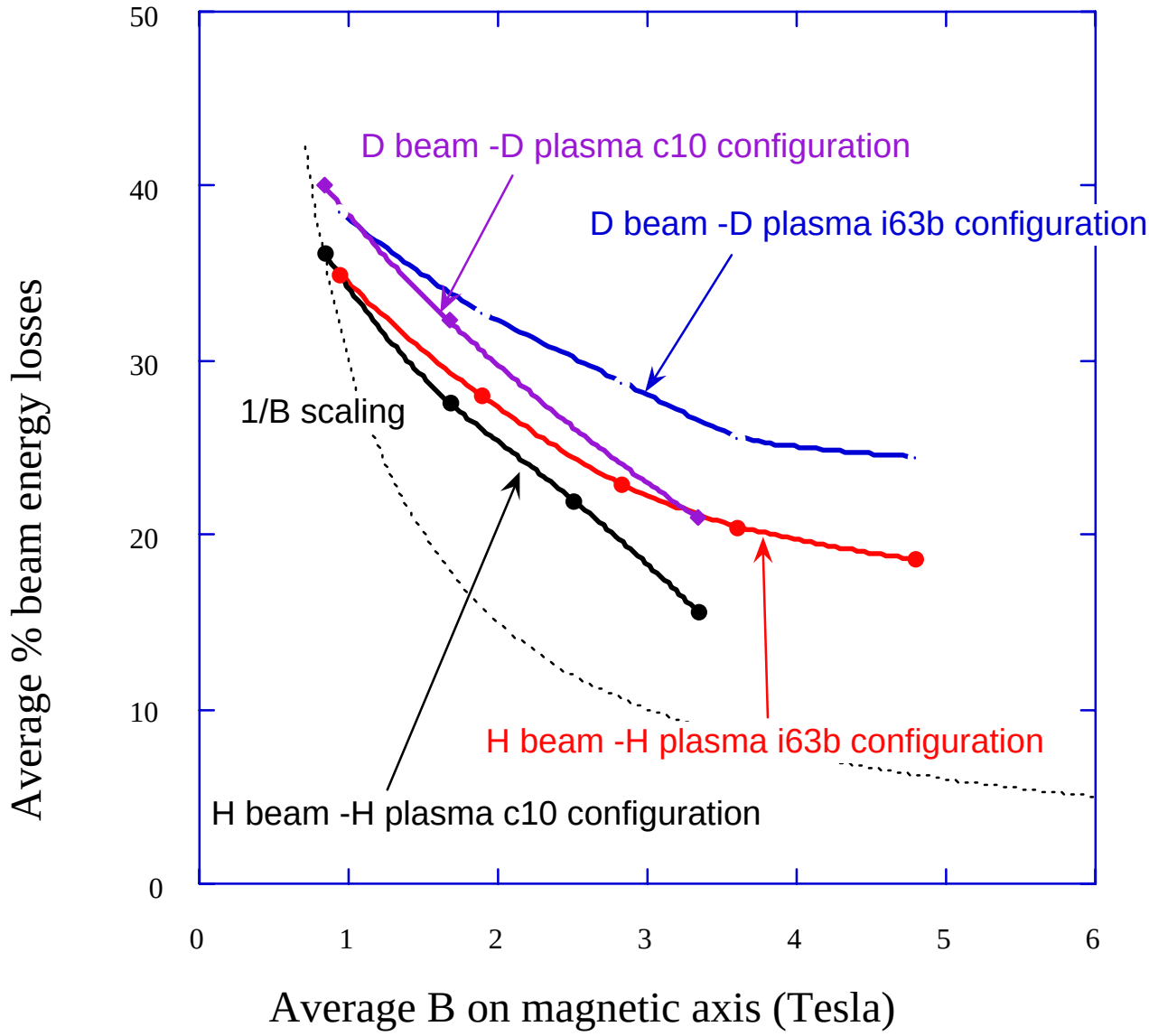
- C10 & I63 analyzed
- Fast ion confinement
- Thermal confinement
- Operating points

- C10 looks better than I63
- C10 has close to acceptable transport for NCSX
  H -> H

- C10 needs better fast ion confinement for a reactor

Neutral beam energy losses as a function of magnetic field and mass for c10 and i63b configurations

(based on Monte Carlo slowing down model - 256 particles followed for 100 msec)



Fast Ion Confinement

Using OrbitMN (M.Redi):

D -> D, one slowing down time, B=1T

C10: 44 +/- 4 % loss

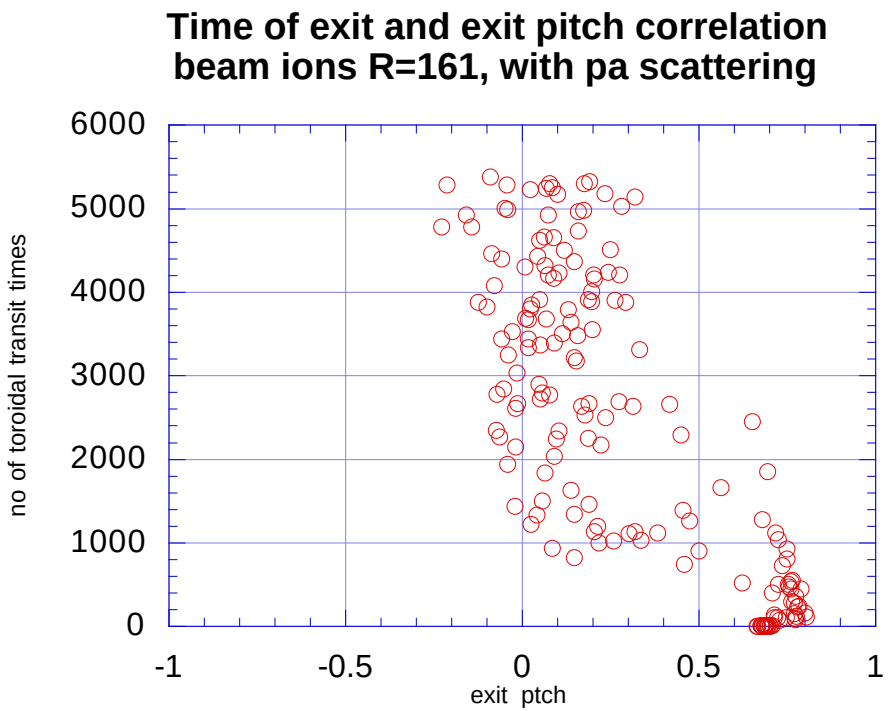
I63: 48 +/- 4 % loss

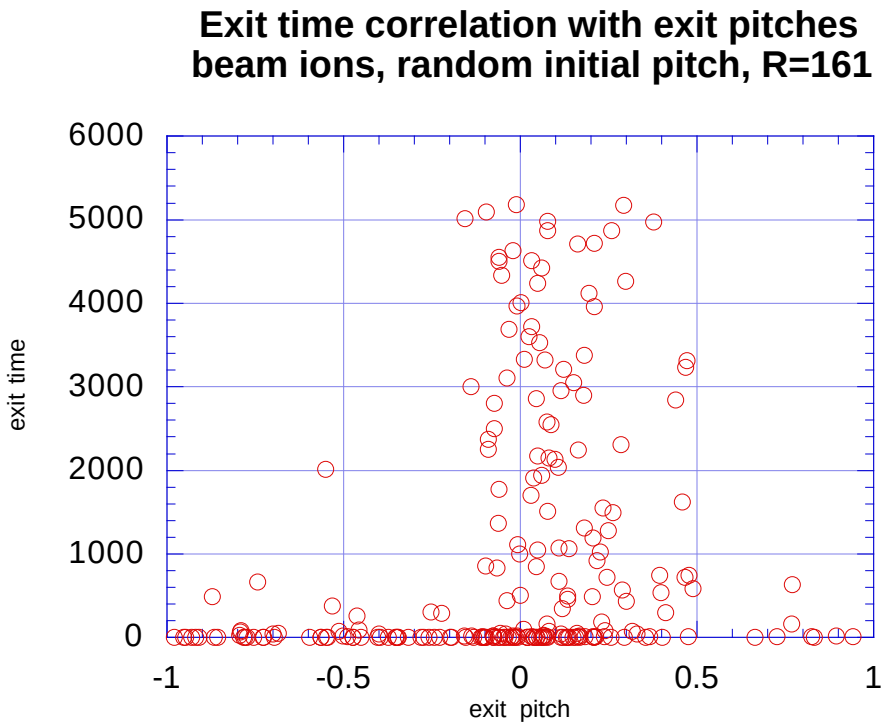
Alpha losses, B=5T, R=7.5m

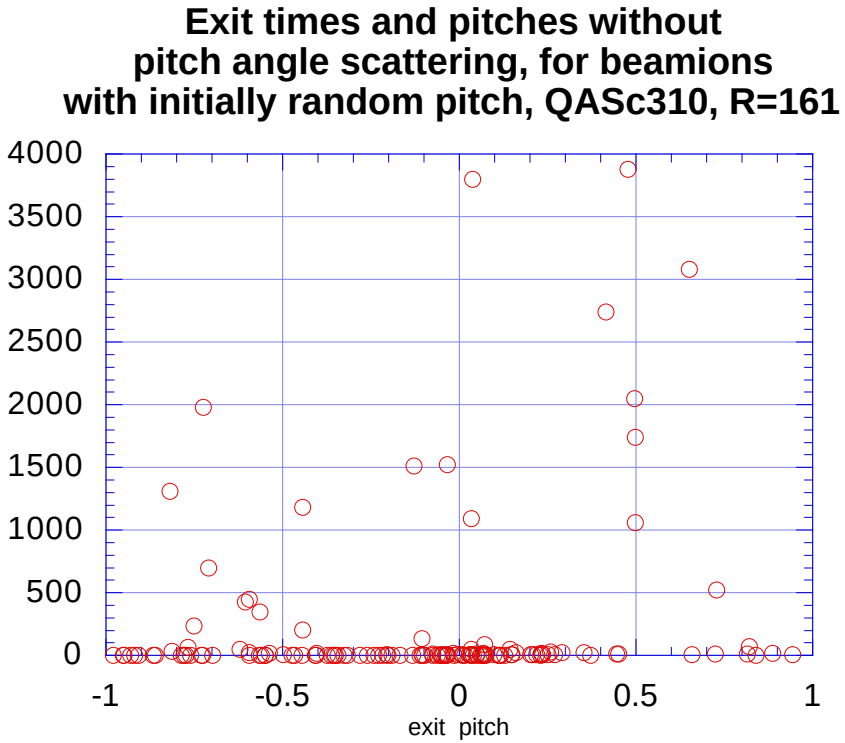
$N = 10^{20}\ m^{-3}$, $\langle T \rangle = 10keV$

C10: 36% loss in one slowing down time

Dominant effect appears to be stochastic ripple diffusion of trapped fast ions.


Time of exit and exit pitch correlation
beam ions R=161, with pa scattering
no of toroidal transit times
6000
5000
4000
3000
2000
1000
0
-1
-0.5
0
0.5
1
exit ptch


Exit time correlation with exit pitches
beam ions, random initial pitch, R=161
6000
5000
4000
3000
2000
1000
0
exit time
-1
-0.5
0
0.5
1
exit pitch


Exit times and pitches without
pitch angle scattering, for beamions
with initially random pitch, QASc310, R=161
4000
3500
3000
2500
2000
1500
1000
500
0
-1
-0.5
0
0.5
1
exit pitch

Thermal Transport

Using Lin's gyrokinetic code:

- Electron neoclassical transport negligible compared to ion transport
- For self-consistent profiles, α=1 ($e\Phi = T_i$) increases confinement by ~30%

At B=1 T, τ_{Ei}^{neo}

	D	H
C10	16ms	28ms
I63	24ms	33ms

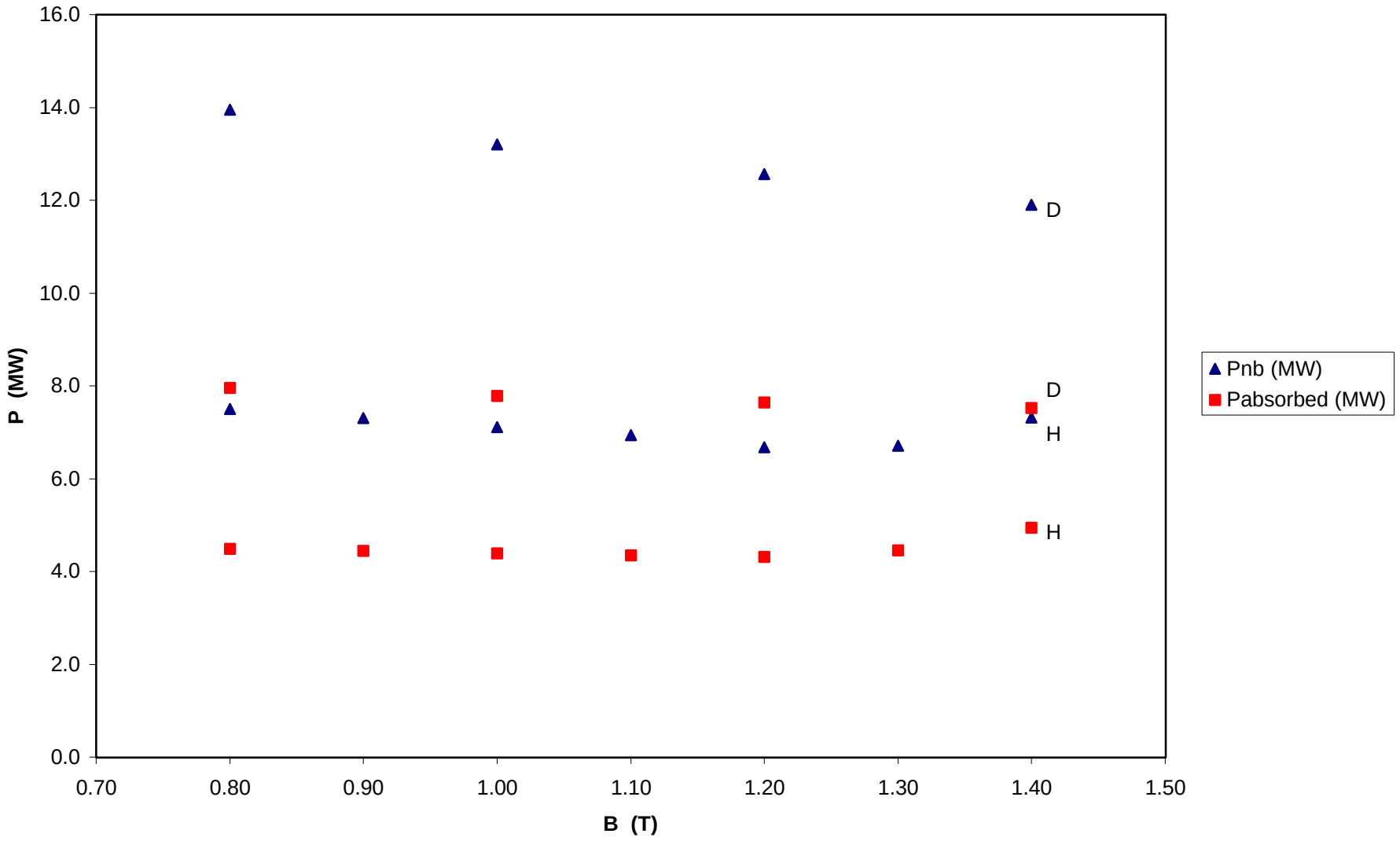
For C10: scales as ~ B^2

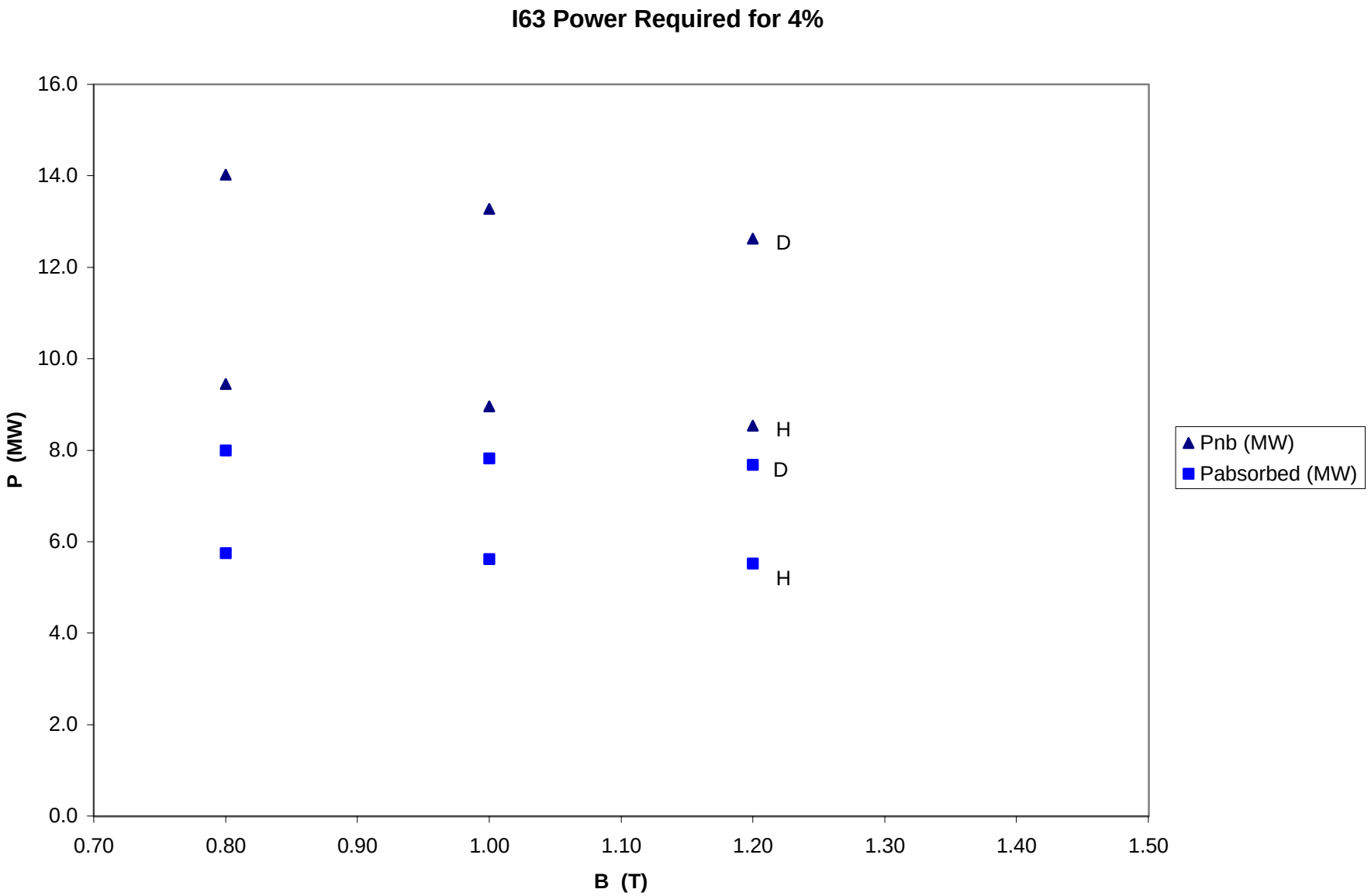
Spread Sheet Optimizaions

min power for 4% beta (H->H)

	QAS3-c10		QAS3-i55	
R/a	3.43	3.43	2.76	2.76
R (m)	1.45	1.45	1.45	1.45
<a> (m)	0.42	0.42	0.52	0.52
B(T) edge	1.00	1.20	1.00	1.20
	5.11	5.11	7.86	7.86
P(MW)	7.11	6.68	8.96	8.54
Pabs (MW)	4.39	4.31	5.62	5.52
n (10^19/m^3)	7.93	11.17	8.49	8.93
tauE = 2.3*ISS95 (s)	0.031	0.043	0.044	0.053
tauE-I-neo (s)	0.028	0.041	0.033	0.049
tauE assumed	0.028	0.041	0.033	0.049
To (2<T>) (keV)	1.25	1.28	1.17	1.60
n R / T^2	7.30	9.86	8.98	5.04

Zeff=2 assumed


c10 Required Power for 4%
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
P (MW)
0.70
0.80
0.90
1.00
1.10
1.20
1.30
1.40
1.50
B (T)
D
D
H
H
Pnb (MW)
Pabsorbed (MW)


I63 Power Required for 4%
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
P (MW)
0.70
0.80
0.90
1.00
1.10
1.20
1.30
1.40
1.50
B (T)
D
H
D
H
Pnb (MW)
Pabsorbed (MW)

Available Power

- Present NBI beam lines:
  D: 6 MW @ 50 keV
  H: 4.5 MW @ 50 keV

- With cryopanel upgrade:
  D: 7 MW
  H: 5.3 MW $\Rightarrow$ still too little, need 6.5 MW

- ICRH:
  6 MW

  can be deposited on electrons via HD mode conversion, but requires inside launch.

  High harmonic has too low absorption in low β target plasma

  W-7AS: ICRF coupling efficiency ~90%
  Heating efficiency ~90%
  $\Rightarrow$Overall efficiency: ~80%

  $\Rightarrow$ would need 5.1 MW