NCSX
Transport & Physics Requirements

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NCSX Design Pt. Definition & Planning

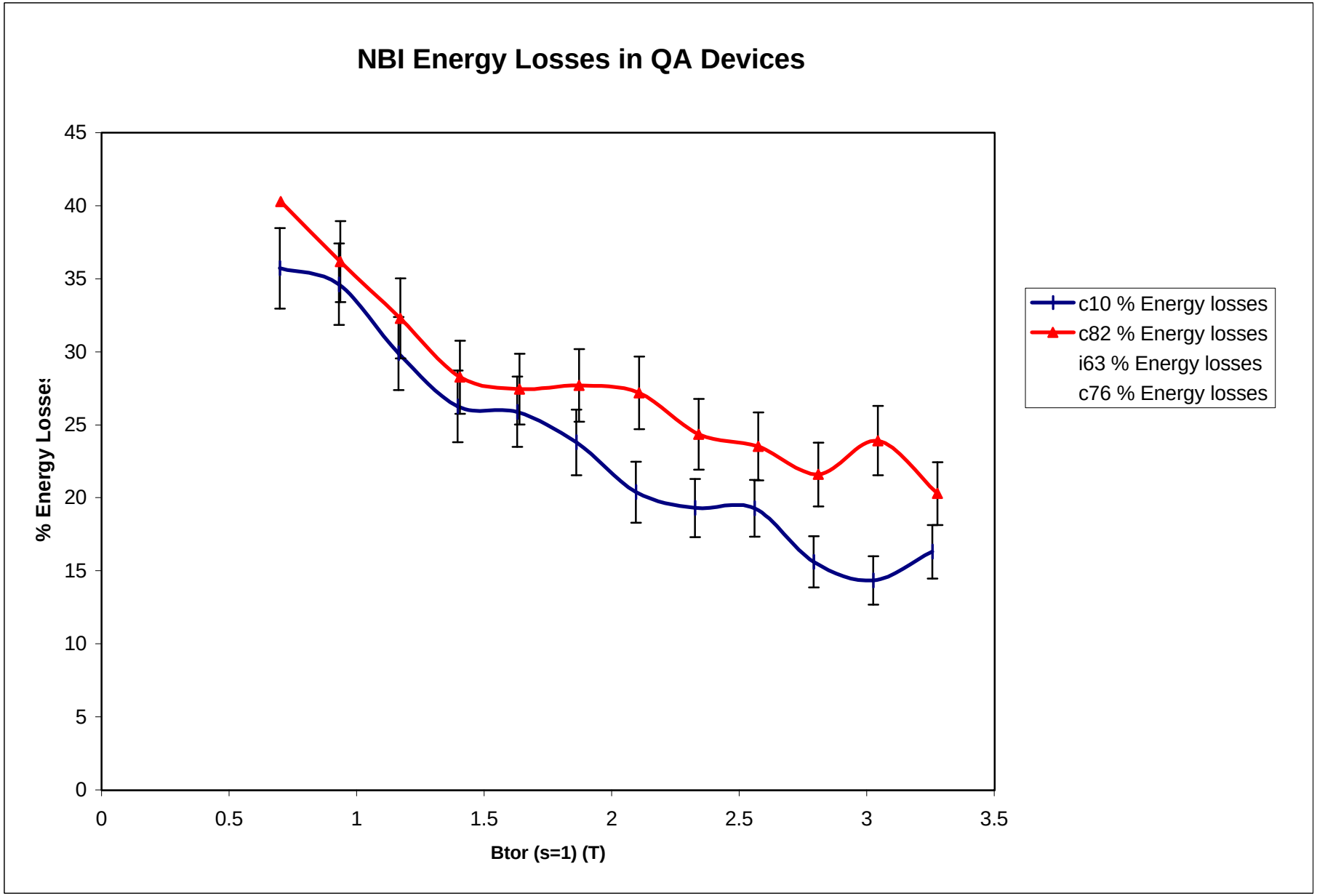
Overview

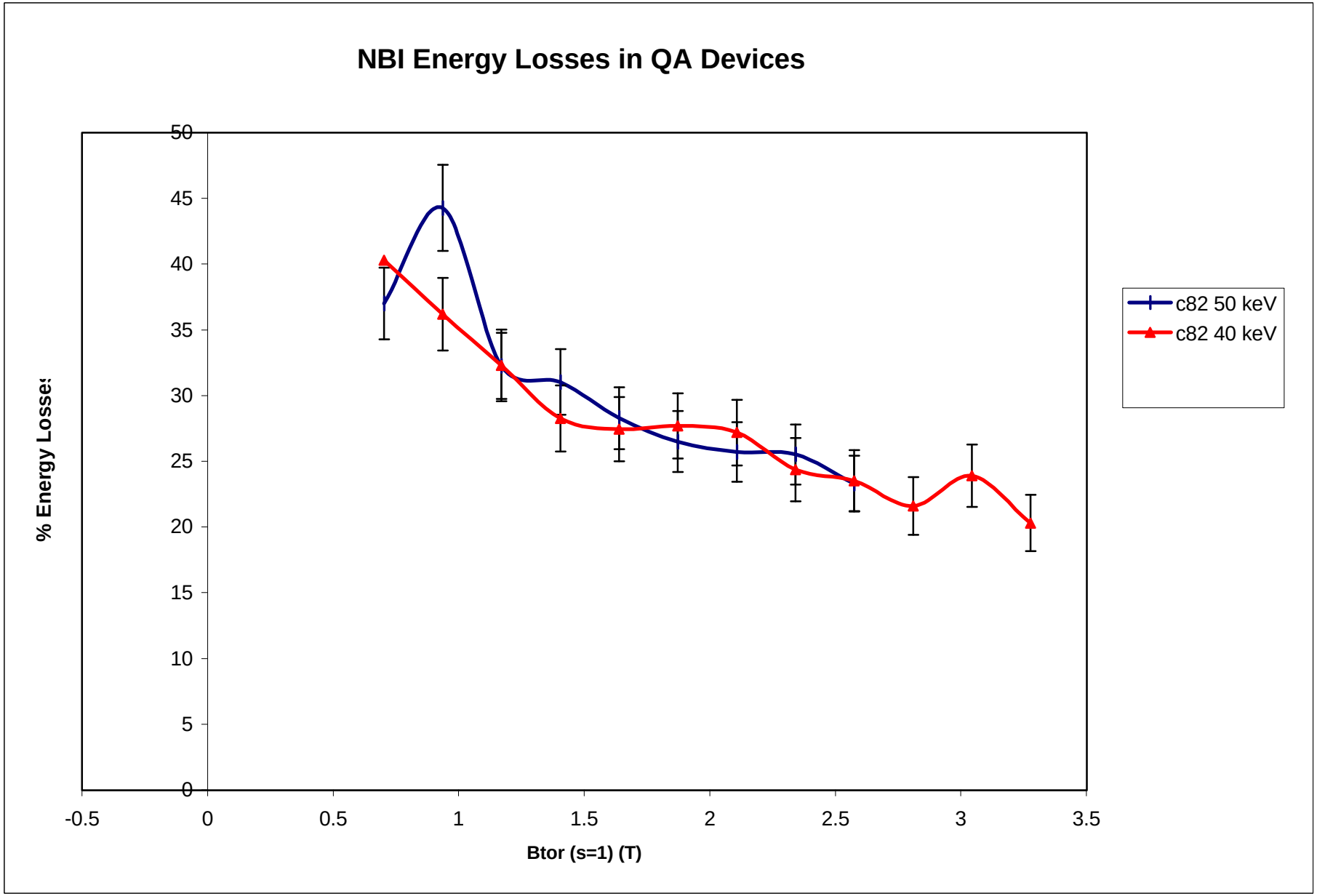
- C10 & C82 analyzed
- Fast ion (NB & alpha) confinement
- Thermal confinement
- Bootstrap
- Operating points

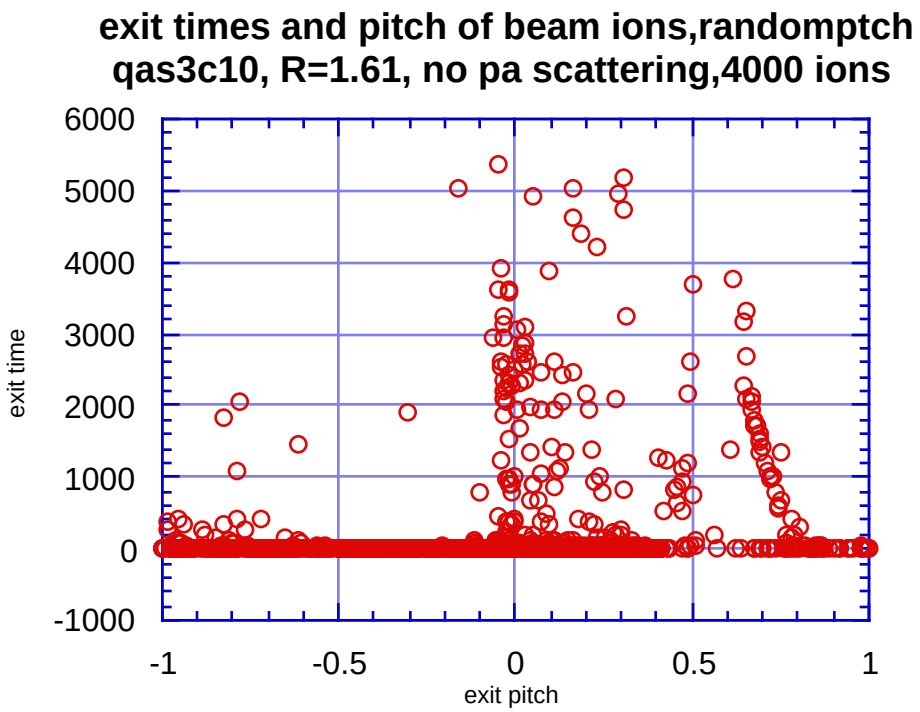
- C82 and C10 have almost identical transport properties

- C82 has close to acceptable transport for NCSX H -> H

- C82 needs better fast ion confinement for a reactor


NBI Energy Losses in QA Devices
% Energy Losses
Btor (s=1) (T)
0
5
10
15
20
25
30
35
40
45
0
0.5
1
1.5
2
2.5
3
3.5
c10 % Energy losses
c82 % Energy losses
i63 % Energy losses
c76 % Energy losses


NBI Energy Losses in QA Devices
% Energy Losses
50
45
40
35
30
25
20
15
10
5
0
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
Btor (s=1) (T)
c82 50 keV
c82 40 keV


exit times and pitch of beam ions,randomptch
qas3c10, R=1.61, no pa scattering,4000 ions
6000
5000
4000
3000
2000
1000
0
-1000
exit time
-1
-0.5
0
0.5
1
exit pitch

Alpha particle Confinement

Using OrbitMN (M.Redi):

R=7.5m B=5T, $n_e(0)$ = 1.e20

C10 and C82 give identical energy losses: 36%

R=7.5m, B=5T, $n_e(0)$ = 2.7e20

C10: 34% energy lost

Thermal Transport

Using Lin's gyrokinetic code:

- Electron neoclassical transport negligible compared to ion transport

  τ_{Ee}^{neo}= 0.22s for C10, 0.18s for C82

- Have only gotten one ion run done for C82
  B=1.26 T, D, relatively high Ti (early profile)

  C82: τ_{Ei}^{neo} = 20ms preliminary

  C10: = 21ms with same profiles
  (Ti not consistent with τ_{Ei}^{neo})

  From before, B=1 T, τ_{Ei}^{neo}

	D	H
C10	16ms	28ms

For C10: scales as ~ B^2

Spread Sheet Optimizaions

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

	QAS3-c82		
R/a	3.43	3.43	3.43
R (m)	1.45	1.45	1.45
<a> (m)	0.42	0.42	0.42
B(T) edge	1.00	1.20	1.40
	5.11	5.11	5.11
P(MW)	6.5	6.1	7.2
Pabs (MW)	4.0	4.0	4.9
n (10^19/m^3)	7.93	10.75	12.91
tauE = 2.3*ISS95 (s)	0.032	0.044	0.048
tauE-I-neo (s)	0.061	0.090	0.124
tauE assumed	0.031	0.044	0.048
To (2<T>) (keV)	1.25	1.33	1.51
n R / T^2	7.30	8.79	8.22

Zeff=2 assumed
Does not include beam-beta

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

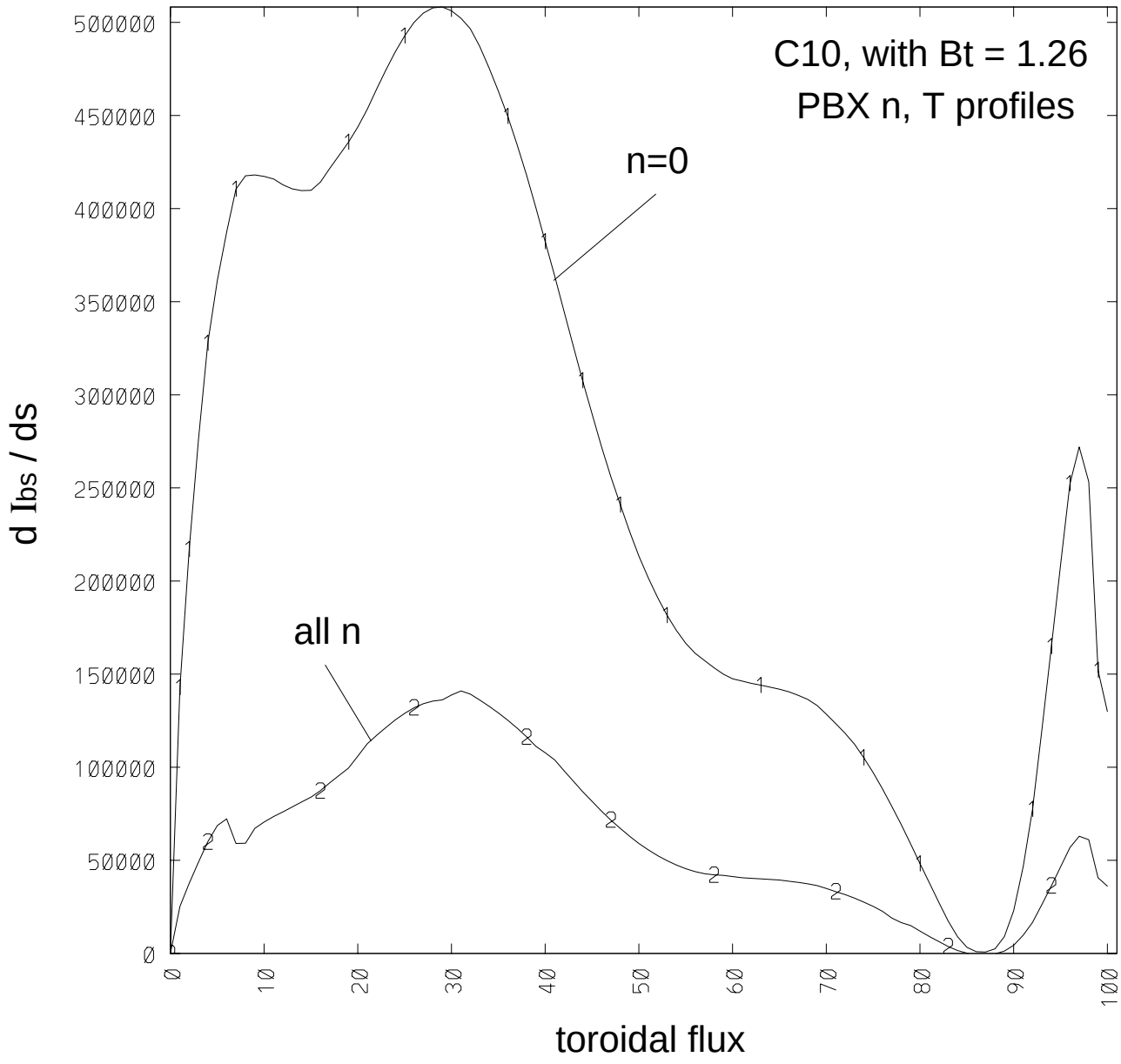
  can be deposited on electrons via HD mode conversion, but requires inside launch.

  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

Boostrap Benchmark



- NIFS code (C. Kessel)
- Same profiles as used in gyrokinetic calculations by Lin and White (assuming Ti=0), where they got no significant differences between ‘all n’ and only ‘n=0’ !!!
- More benchmarking to come…

Plans: Near Term

for Transport work:

- Develop module for optimizing fast-ion confinement
  - initially using fast Monte-Carlo calc.
    (Zatz, White)

- Calculate self-consistent Er and transport for c82
  - using Lin's code (Mynick, Lewandowski, Lin)
  - iterate transport solution via Transp (Zarnstorff)

- Finish benchmarking of bootstrap calculation
  - Ti=0 in Nifs code
  - what is different about previous benchmark?
  - other configurations
  - Toliver's code?

  analytic understanding?

- Modify Lin's code to routinely calculate self-consistent solutions code (Lin, Lewandowski?, Mynick)

- Analyze trial configurations, as requested
  (Spong, Mynick, Zarnstorff)
  - physics configurations
  - coil configurations

- ICRF & ECRF heating scenario evaluation
  - antenna requirements
  - startup scenarios
  (Majeski & ?)

Configuration Requirement Plans

- develop conducting wall/eddy-current limits
  - due to configuration evolution => islands
  - due to kink-stability & disruptivity testing goals
  - with MHD and engineering groups
    (4 - 6 weeks)

- develop space requirements for particle/power handling
  - localized limiters
  - possible future divertors
  - refine requirements after receiving candidate coils
    (ORNL, UCSD...)

<u>After candidate coils:</u> <u>robustness</u>

- configuration testing
  - vacuum, low-beta, high beta, w/ & w/o CD
  - how to use coils to get needed physics qualityfor each reference configuration.

- flexibility testing
  - range of current and pressure profiles
  - startup evolution
  - range of shapes accessible for physics studies
  - auxiliary coil (e.g. PF) and power supply requirements

- collaboration of all group

Conducting wall/eddy-current Study

<u>Tasks</u>

1) Equilibrium evolution, for candidate engineering designs:

- Spark calculation of eddy currents, assuming linear evolution between reference plasma configurations
- calculate resonant perturbed fields => islands due to eddy currents

  - ensure induced islands small enough

2) Effect on Kink stability & disruptions

a) NCSX strategy

- can we have a credible kink & disruption experiment with a thick conducting wall τ(wall) ~ τ(pulse)
  - brainstorm with MHD group
  - set requirement on τ(wall) for kink eigenfunction
  - requirements for testing disruptivity at high beta

b) calculate kink δB eigenfunction for phyics configurations

- need to examine range of profiles

c) for each candidate engineering design strategy:

- Spark calculation of penetration of kink eigenfunction