NSTX

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Summary of Free-Boundary TRANSP Equilibria for NSTX-Upgrade Studies Rev. 0

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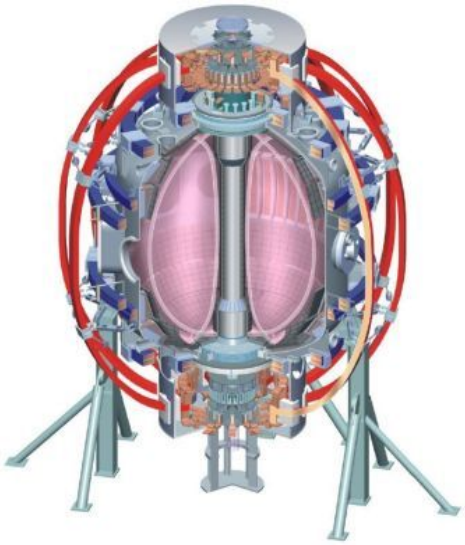

Culham Sci Ctr
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NIFS
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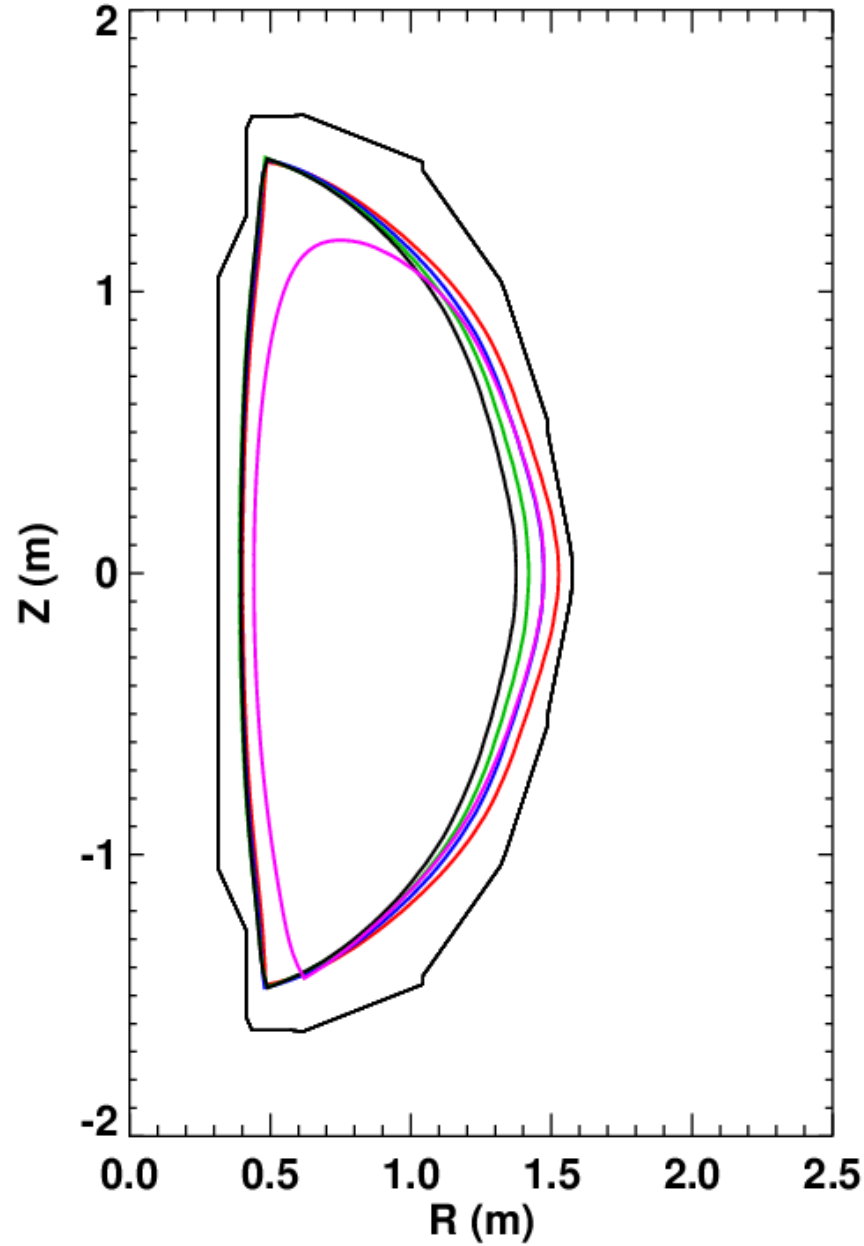
U Tokyo
JAEA
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITI
KBSI
KAIST
POSTECH
ASIPP
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec

Overview

- Summary of TRANSP runs is in a spreadsheet:
  - /p/nstxsdev/NSTXU/summary/Rev0/UpgradeScenarioModelling_RevX.xls
  - Sheet "OptimalScenarios" lists parameters of selected/***recommended*** TRANSP runs.
  - Other sheets have the complete listing of runs.
  - Each sheet is for a given plasma boundary shape and toroidal field:
    - Each sheet corresponds to a g-eqdsk file in: /p/nstxsdev/NSTXU/EquilibriumStudies/ISOLVERgFiles.
    - These files generate by idl ISOLVER using NSTX-U coils.
  - Within each sheet, sorted by the beam configuration, then by plasma current, beam voltages, other parameters.
- Equilibria in geqdsk format:
  - Directly from trxpl: /p/nstxsdev/NSTXU/StabilityStudies/TRANSP_gFiles
    - Note, parallel current profile at the edge can sometimes be funny in these.
  - Using corrected parallel current profile, fixed boundary: /p/nstxsdev/NSTXU/StabilityStudies/CHEASEOutput
    - Field outside the separatrix is incorrect.

Shapes Considered

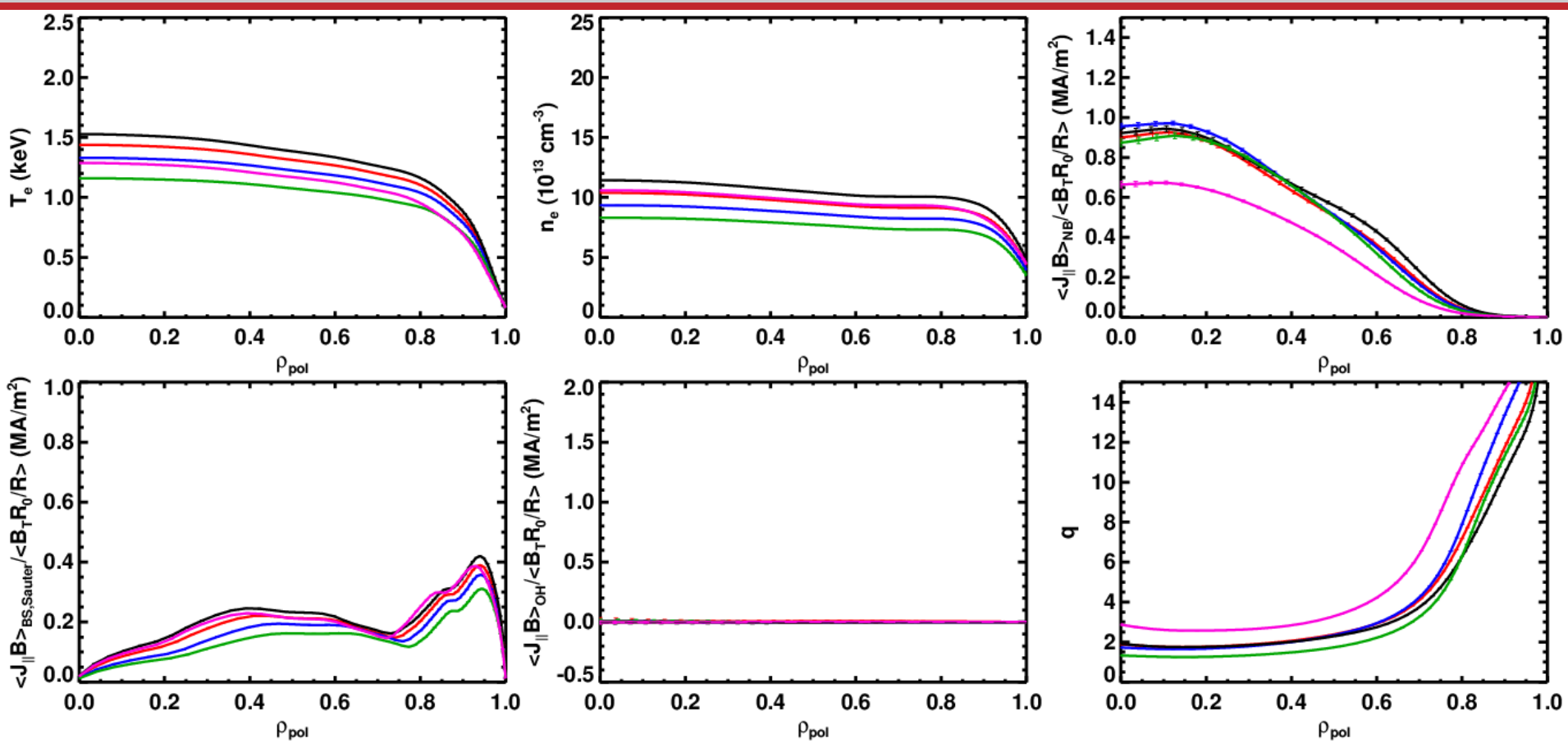
- Used 5 shapes in simulations:
  - 4 cases at high triangularity and various outer gaps.
  - These are aspect ratios 1.81,1.75,1.73,1.71, corresponding to 20,15,10, and 5 cm outer gaps.
- A single LSN case w/ 10 cm outer gap.
  - Highest aspect ratio of all considered.
- Actual shape generated by ISOLVER-TRANSP will deviate depending on the pressure and current profiles, coil currents.



Scans in the Recommended Data Set

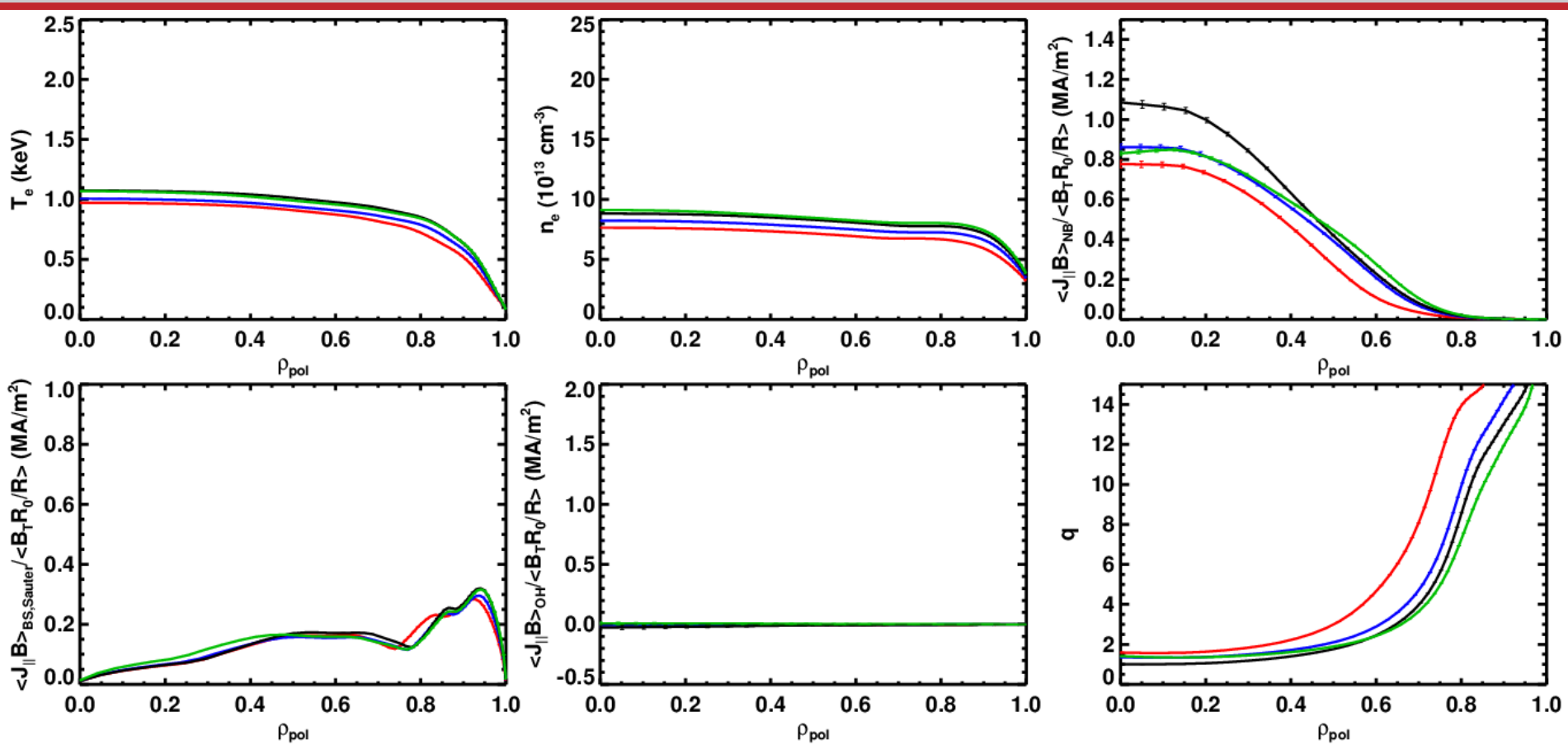
- 5 & 6 source fully non-inductive at 1.0 T.
  - 6-source, 1.0 T, 1.0 MA case 142301D48 may be considered “baseline”
- 4 source @ 1.0 T
  - Fully non-inductive cases with 4 beam configurations (I_P varies)
  - I_P=800 kA partial inductive with 4 beam configurations (f_{NI} varies).
- 4 source @ 0.75 T
  - Fully non-inductive cases with 4 beam configurations (I_P varies)
  - I_P=750 kA partial inductive with 4 beam configurations (f_{NI} varies).
- Higher current, partial inductive, q_{min}>1, cases with various beam voltages at 1.0 T.
- Injected power and f_{GW} scans at 2 MA, 1 T.
  - These often evolve to q_{min}<1.
- Sustained (q_{min}>1) high-β_T with B_T=0.55 T.
  - Various beam voltages and outer gap.

Recommended 5 and 6 Source f_{NI}=100% Scenarios at Various Fields, Currents, and Beam Voltages



142301D48	142301D51	142301D47	142301Q68	142301D59
15.8000<t (sec) <15.9500	15.8000<t (sec) <15.9500	15.8000<t (sec) <15.9500	15.8000<t (sec) <15.9500	7.80000<t (sec) <7.95000
R_{tan}=[50,60,70,110,120,130]	R_{tan}=[50,60,70,110,120,130]	R_{tan}=[50,60,70,110,120,130]	R_{tan}=[50,60,70,120,130]	R_{tan}=[50,60,70,120,130]
I_p=1.00 (MA)	I_p=0.90 (MA)	I_p=1.10 (MA)	I_p=0.80 (MA)	I_p=0.90 (MA)
B_T=0.99 (T)	B_T=0.99 (T)	B_T=0.99 (T)	B_T=0.74 (T)	B_T=0.99 (T)
A=1.77	A=1.77	A=1.76	A=1.77	A=1.79
κ=2.78	κ=2.78	κ=2.78	κ=2.78	κ=2.81
β_N=4.39	β_N=4.12	β_N=4.76	β_N=5.00	β_N=4.08
β_T=8.54 %	β_T=7.23 %	β_T=10.1 %	β_T=10.3 %	β_T=7.23 %
f_{BS}=66.5 %	f_{BS}=68.0 %	f_{BS}=64.9 %	f_{BS}=66.4 %	f_{BS}=74.5 %
f_{nicd}=98.9 %	f_{nicd}=100. %	f_{nicd}=100. %	f_{nicd}=99.7 %	f_{nicd}=99.7 %
f_{GW}=0.76	f_{GW}=0.76	f_{GW}=0.77	f_{GW}=0.77	f_{GW}=0.85
H_{98}=1.04	H_{98}=1.03	H_{98}=1.03	H_{98}=1.00	H_{98}=1.05
l_i=0.48	l_i=0.48	l_i=0.49	l_i=0.49	l_i=0.40
q_{95}=16.0	q_{95}=18.0	q_{95}=14.5	q_{95}=15.2	q_{95}=18.5
q_{min}=1.75	q_{min}=1.65	q_{min}=1.74	q_{min}=1.25	q_{min}=2.57
p_{inj}=12.0 (MW)	p_{inj}=10.5 (MW)	p_{inj}=15.0 (MW)	p_{inj}=10.0 (MW)	p_{inj}=10.0 (MW)
ν^*_e=0.13	ν^*_e=0.16	ν^*_e=0.10	ν^*_e=0.16	ν^*_e=0.22

Recommended 0.75 T, f_{NI}=100% Scenarios with 4 Sources, 15 cm Outer Gap



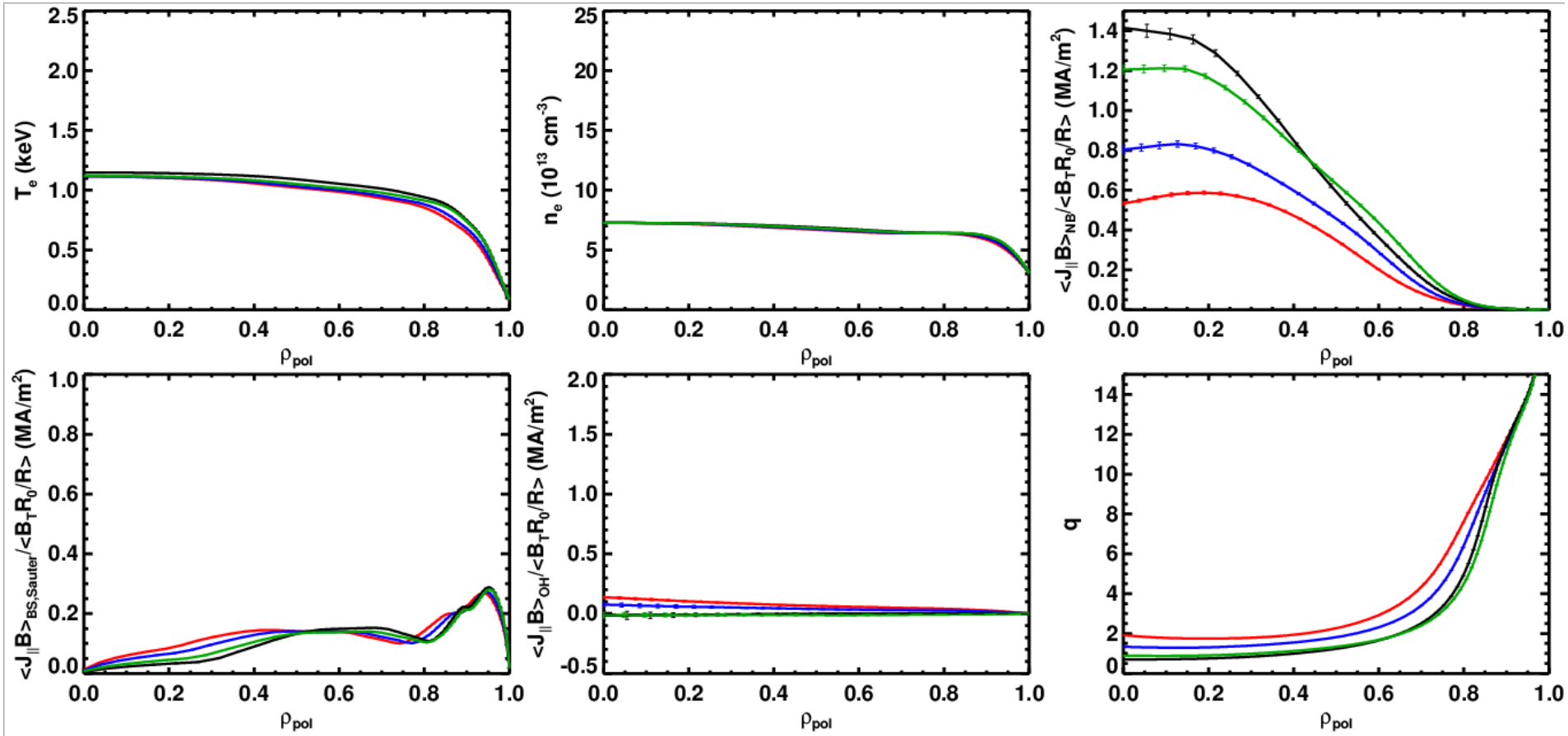
142301Q91
7.80000<t (sec) <7.95000
R_{tan}=[50, 60, 70,130]
I_p=0.65 (MA)
B_T=0.74 (T)
A=1.80
κ=2.82
β_N=4.33
β_T=7.43 %
f_{BS}=78.5 %
f_{nicd}=100. %
f_{GW}=0.85
H_{98}=1.00
l_i=0.36
q_{95}=19.8
q_{min}=1.57
p_{inj}=8.00 (MW)
ν^*_e=0.37

142301Q34
7.80000<t (sec) <7.95000
R_{tan}=[50, 60,120,130]
I_p=0.70 (MA)
B_T=0.74 (T)
A=1.79
κ=2.80
β_N=4.56
β_T=8.38 %
f_{BS}=73.9 %
f_{nicd}=100. %
f_{GW}=0.86
H_{98}=0.99
l_i=0.41
q_{95}=17.8
q_{min}=1.33
p_{inj}=8.00 (MW)
ν^*_e=0.29

142301Q74
7.80000<t (sec) <7.95000
R_{tan}=[60, 70,110,120]
I_p=0.75 (MA)
B_T=0.74 (T)
A=1.79
κ=2.79
β_N=4.79
β_T=9.40 %
f_{BS}=74.5 %
f_{nicd}=101. %
f_{GW}=0.86
H_{98}=1.02
l_i=0.42
q_{95}=16.4
q_{min}=1.00
p_{inj}=8.00 (MW)
ν^*_e=0.26

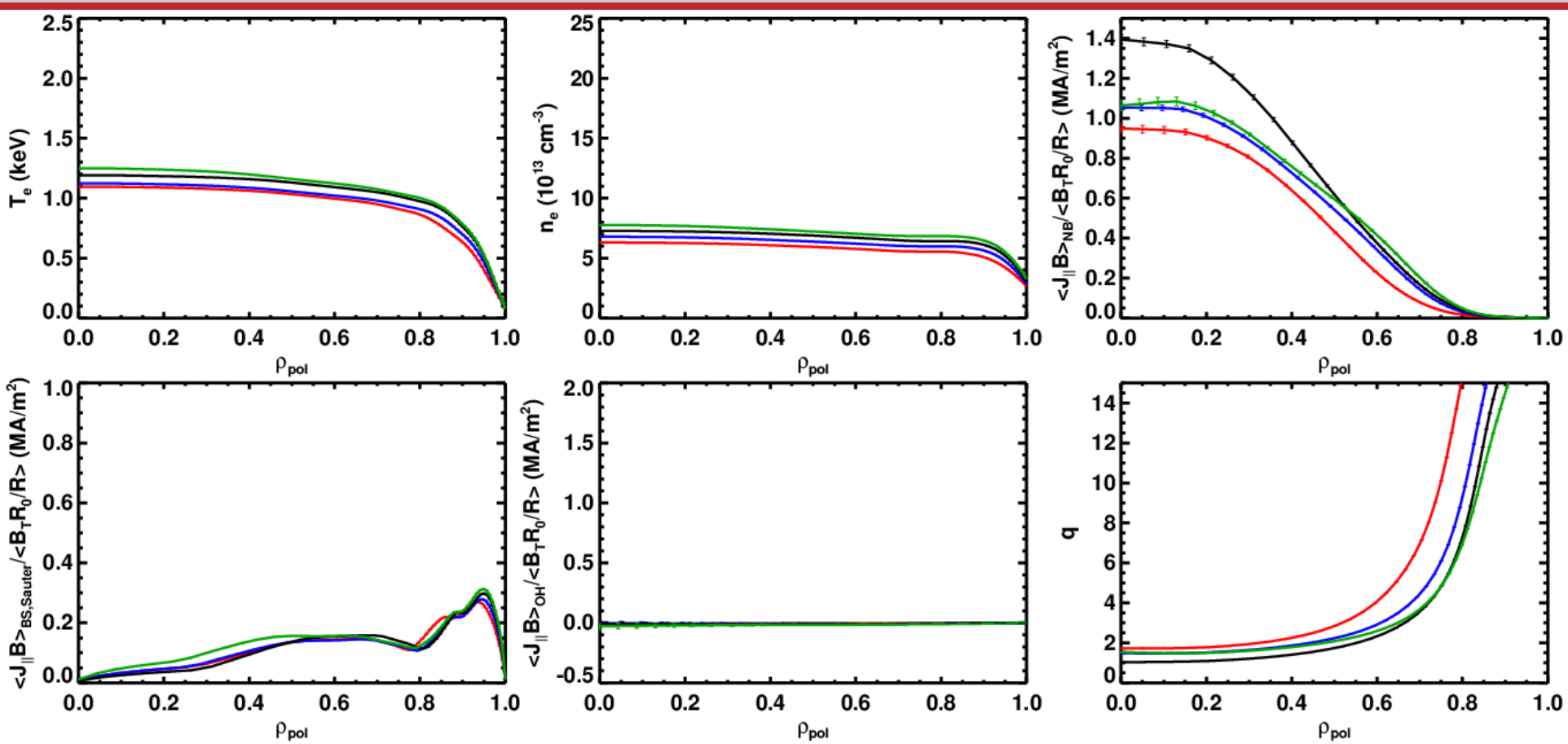
142301C51
3.80000<t (sec) <3.95000
R_{tan}=[70,110,120,130]
I_p=0.78 (MA)
B_T=0.74 (T)
A=1.78
κ=2.79
β_N=4.79
β_T=9.67 %
f_{BS}=69.5 %
f_{nicd}=99.2 %
f_{GW}=0.87
H_{98}=1.01
l_i=0.46
q_{95}=15.7
q_{min}=1.34
p_{inj}=8.00 (MW)
ν^*_e=0.22

Recommended Partial Inductive 0.75 T, 750 kA Scenarios with 4 Sources, 15 cm Outer Gap



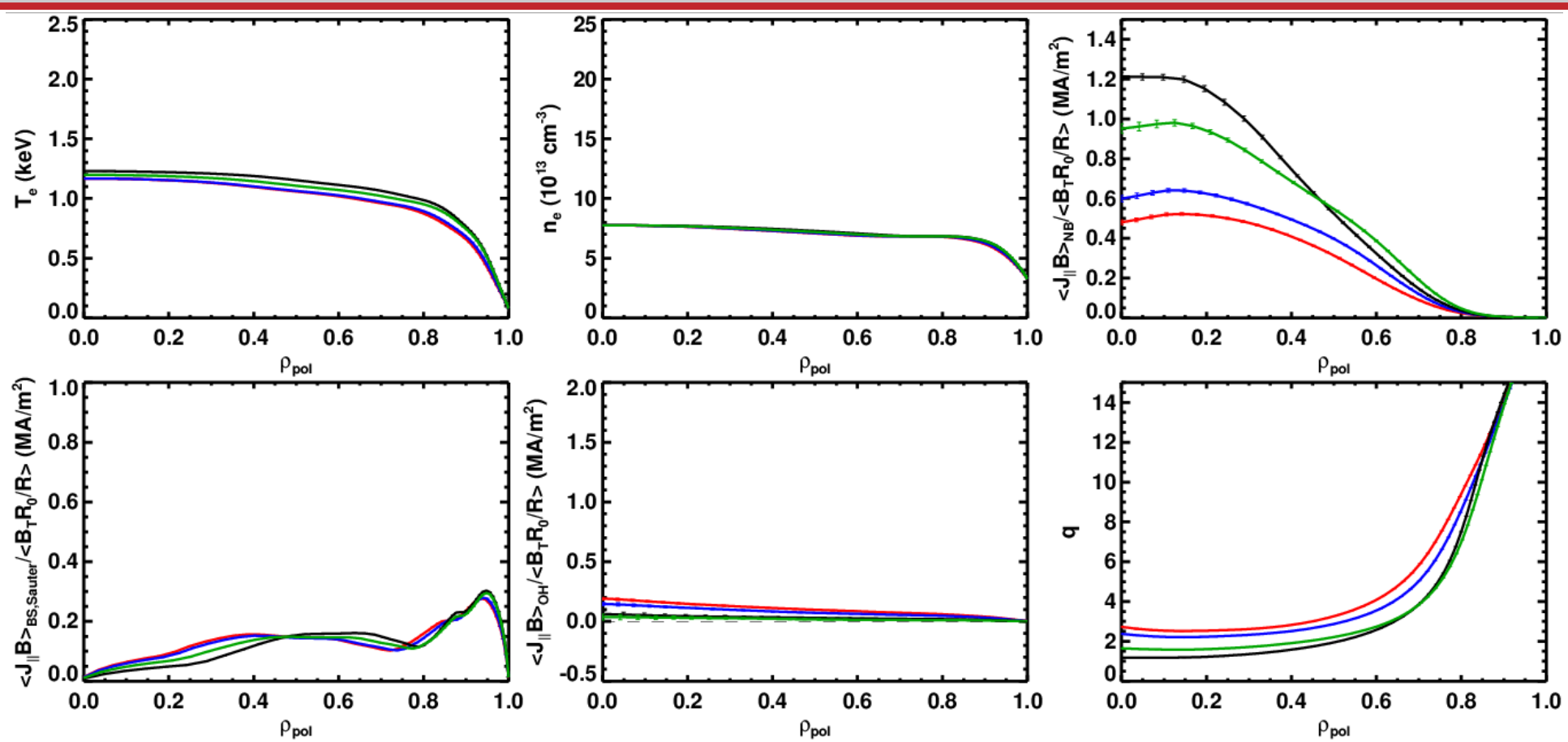
142301C60	142301C35	142301C42	142301C43
15.8000<t (sec) <15.9500	15.8000<t (sec) <15.9500	15.8000<t (sec) <15.9500	15.8000<t (sec) <15.9500
R_{tan}=[50, 60, 70,130]	R_{tan}=[50, 60,120,130]	R_{tan}=[60, 70,110,120]	R_{tan}=[70,110,120,130]
I_p=0.75 (MA)	I_p=0.75 (MA)	I_p=0.75 (MA)	I_p=0.75 (MA)
B_T=0.74 (T)	B_T=0.74 (T)	B_T=0.74 (T)	B_T=0.74 (T)
A=1.77	A=1.77	A=1.77	A=1.76
κ=2.78	κ=2.77	κ=2.76	κ=2.75
β_N=4.39	β_N=4.55	β_N=4.82	β_N=4.82
β_T=8.54 %	β_T=8.82 %	β_T=9.35 %	β_T=9.32 %
f_{BS}=61.2 %	f_{BS}=61.7 %	f_{BS}=65.6 %	f_{BS}=63.0 %
f_{nicd}=88.6 %	f_{nicd}=93.3 %	f_{nicd}=99.9 %	f_{nicd}=101. %
f_{GW}=0.71	f_{GW}=0.72	f_{GW}=0.73	f_{GW}=0.73
H_{98}=1.01	H_{98}=1.00	H_{98}=1.02	H_{98}=0.99
l_i=0.48	l_i=0.51	l_i=0.54	l_i=0.58
q_{95}=15.9	q_{95}=15.8	q_{95}=15.9	q_{95}=15.8
q_{min}=1.75	q_{min}=1.29	q_{min}=0.70	q_{min}=0.88
p_{inj}=8.00 (MW)	p_{inj}=8.00 (MW)	p_{inj}=8.00 (MW)	p_{inj}=8.00 (MW)
ν^*_e=0.16	ν^*_e=0.15	ν^*_e=0.15	ν^*_e=0.14

Recommended 1T f_{NI}=100% Scenarios with 4 Sources, 15 cm Outer Gap



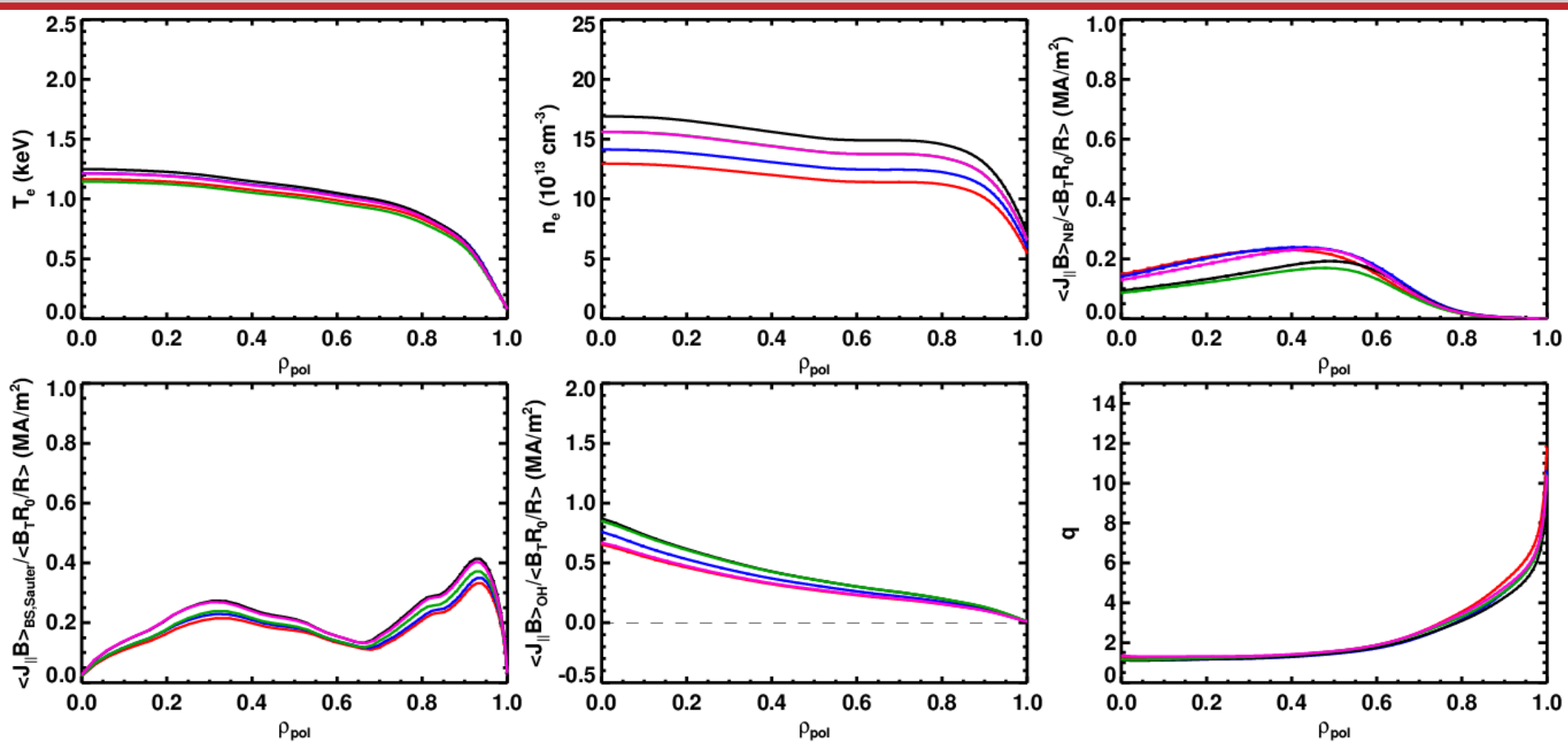
142301F83	142301F53	142301F59	142301F67
15.8000<t (sec) <15.9500	11.8000<t (sec) <11.9500	11.8000<t (sec) <11.9500	15.8000<t (sec) <15.9500
R_{tan}=[50, 60, 70,130]	R_{tan}=[50, 60,120,130]	R_{tan}=[60, 70,110,120]	R_{tan}=[70,110,120,130]
I_p=0.65 (MA)	I_p=0.70 (MA)	I_p=0.75 (MA)	I_p=0.80 (MA)
B_T=0.98 (T)	B_T=0.98 (T)	B_T=0.98 (T)	B_T=0.99 (T)
A=1.80	A=1.78	A=1.77	A=1.77
κ=2.80	κ=2.78	κ=2.77	κ=2.76
β_N=3.37	β_N=3.56	β_N=3.73	β_N=3.82
β_T=4.33 %	β_T=4.88 %	β_T=5.45 %	β_T=5.93 %
f_{BS}=73.6 %	f_{BS}=68.8 %	f_{BS}=68.6 %	f_{BS}=66.1 %
f_{nicd}=100. %	f_{nicd}=101. %	f_{nicd}=101. %	f_{nicd}=102. %
f_{GW}=0.71	f_{GW}=0.72	f_{GW}=0.72	f_{GW}=0.72
H_{98}=0.99	H_{98}=0.98	H_{98}=1.01	H_{98}=1.03
l_i=0.41	l_i=0.48	l_i=0.51	l_i=0.53
q_{95}=26.4	q_{95}=23.6	q_{95}=21.6	q_{95}=20.1
q_{min}=1.72	q_{min}=1.47	q_{min}=1.03	q_{min}=1.48
p_{inj}=8.00 (MW)	p_{inj}=8.00 (MW)	p_{inj}=8.00 (MW)	p_{inj}=8.00 (MW)
ν^*_e=0.30	ν^*_e=0.23	ν^*_e=0.20	ν^*_e=0.16

Recommended Partial Inductive 1.0 T, 800 kA Scenarios with 4 Sources, 15 cm Outer Gap



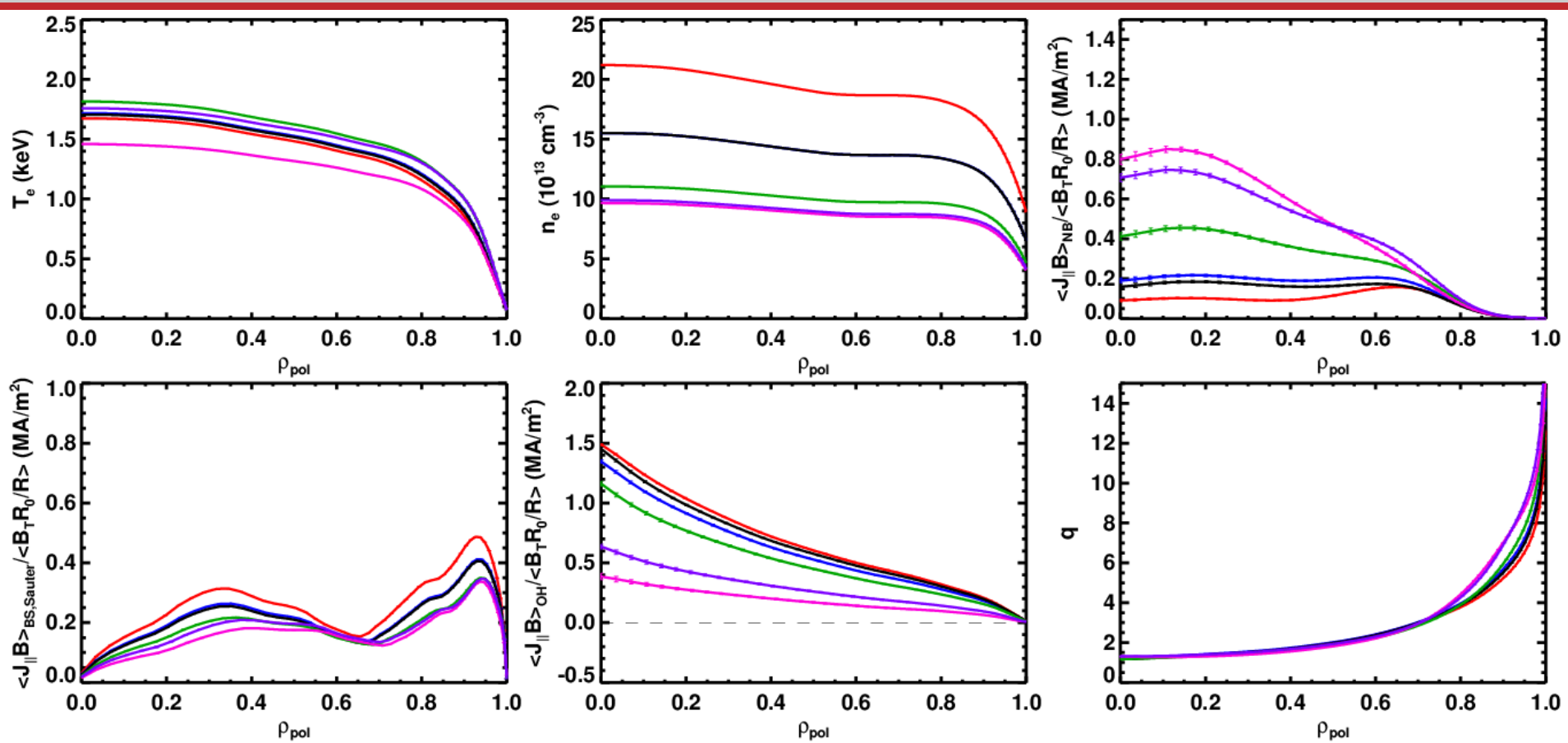
142301F33	142301F18	142301F62	142301F66
11.8000<t (sec) <11.9500	11.8000<t (sec) <11.9500	15.8000<t (sec) <15.9500	15.8000<t (sec) <15.9500
R_{tan}=[50, 60, 70,130]	R_{tan}=[50, 60,120,130]	R_{tan}=[60, 70,110,120]	R_{tan}=[70 110,120,130]
I_p=0.80 (MA)	I_p=0.80 (MA)	I_p=0.80 (MA)	I_p=0.80 (MA)
B_T=0.99 (T)	B_T=0.99 (T)	B_T=0.99 (T)	B_T=0.99 (T)
A=1.76	A=1.76	A=1.77	A=1.76
κ=2.78	κ=2.77	κ=2.76	κ=2.76
β_N=3.35	β_N=3.44	β_N=3.70	β_N=3.68
β_T=5.19 %	β_T=5.32 %	β_T=5.74 %	β_T=5.69 %
f_{BS}=58.8 %	f_{BS}=58.9 %	f_{BS}=64.7 %	f_{BS}=61.8 %
f_{nicd}=83.7 %	f_{nicd}=87.8 %	f_{nicd}=95.4 %	f_{nicd}=97.2 %
f_{GW}=0.72	f_{GW}=0.72	f_{GW}=0.73	f_{GW}=0.72
H_{98}=0.99	H_{98}=0.98	H_{98}=1.02	H_{98}=1.00
l_i=0.49	l_i=0.51	l_i=0.52	l_i=0.55
q_{95}=19.4	q_{95}=19.4	q_{95}=19.7	q_{95}=19.6
q_{min}=2.52	q_{min}=2.21	q_{min}=1.17	q_{min}=1.58
p_{inj}=8.00 (MW)	p_{inj}=8.00 (MW)	p_{inj}=8.00 (MW)	p_{inj}=8.00 (MW)
ν^*_e=0.18	ν^*_e=0.17	ν^*_e=0.18	ν^*_e=0.16

Recommended Sustained High-β_T Scenarios with Relaxed q_{min}>1 and β_N<$\beta_{N,with\text{-}wall}$



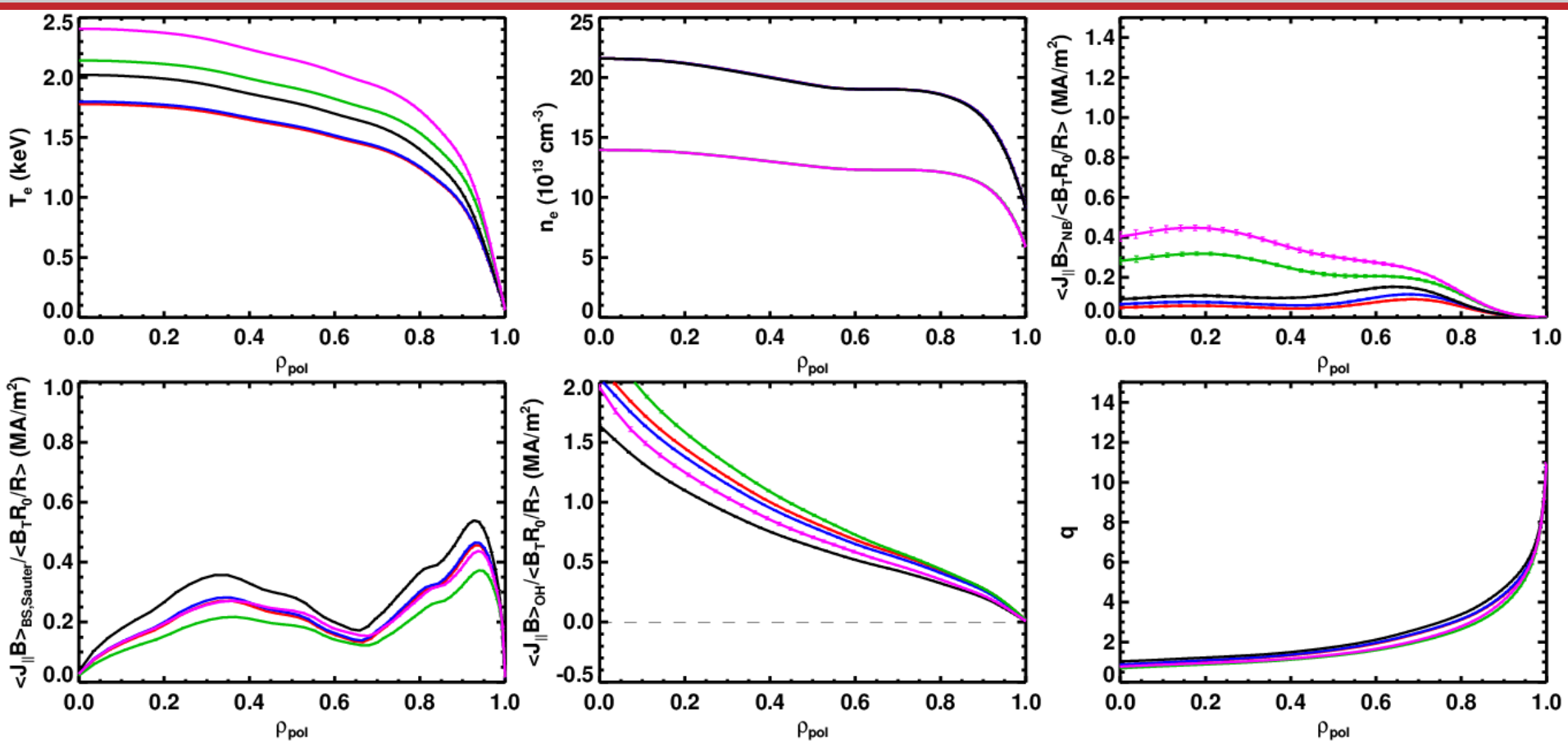
142301T58	142301T56	142301S65	142301S26	142301S45
3.80000<t (sec) <3.95000	3.80000<t (sec) <3.95000	7.80000<t (sec) <7.95000	7.80000<t (sec) <7.95000	7.80000<t (sec) <7.95000
R_{tan}=[50,60,120,130]	R_{tan}=[50,60,120,130]	R_{tan}=[50,60,120,130]	R_{tan}=[50,60,120,130]	R_{tan}=[50,60,120,130]
I_p=1.10 (MA)	I_p=1.20 (MA)	I_p=1.30 (MA)	I_p=1.20 (MA)	I_p=1.20 (MA)
B_T=0.55 (T)	B_T=0.55 (T)	B_T=0.55 (T)	B_T=0.55 (T)	B_T=0.55 (T)
A=1.73	A=1.73	A=1.77	A=1.77	A=1.78
κ=2.76	κ=2.76	κ=2.92	κ=2.91	κ=2.92
β_N=6.06	β_N=6.38	β_N=6.55	β_N=5.95	β_N=6.49
β_T=23.0 %	β_T=26.4 %	β_T=30.8 %	β_T=25.8 %	β_T=28.3 %
f_{BS}=48.4 %	f_{BS}=46.1 %	f_{BS}=47.1 %	f_{BS}=46.1 %	f_{BS}=50.6 %
f_{nicd}=67.1 %	f_{nicd}=66.2 %	f_{nicd}=65.4 %	f_{nicd}=62.2 %	f_{nicd}=70.2 %
f_{GW}=0.88	f_{GW}=0.89	f_{GW}=0.88	f_{GW}=0.89	f_{GW}=0.88
H_{98}=1.04	H_{98}=1.00	H_{98}=1.00	H_{98}=1.00	H_{98}=1.00
l_i=0.50	l_i=0.51	l_i=0.49	l_i=0.50	l_i=0.48
q_{95}=7.17	q_{95}=6.53	q_{95}=5.98	q_{95}=6.42	q_{95}=6.59
q_{min}=1.23	q_{min}=1.12	q_{min}=1.11	q_{min}=1.15	q_{min}=1.30
p_{inj}=8.00 (MW)	p_{inj}=10.0 (MW)	p_{inj}=10.0 (MW)	p_{inj}=8.00 (MW)	p_{inj}=10.0 (MW)
ν^*_e=0.11	ν^*_e=0.10	ν^*_e=0.11	ν^*_e=0.13	ν^*_e=0.11

High Current, Elevated q_{min} (q_{min}>1) for A=1.75, 1 T, 5 & 6 Source Operation, Different Beam Voltage



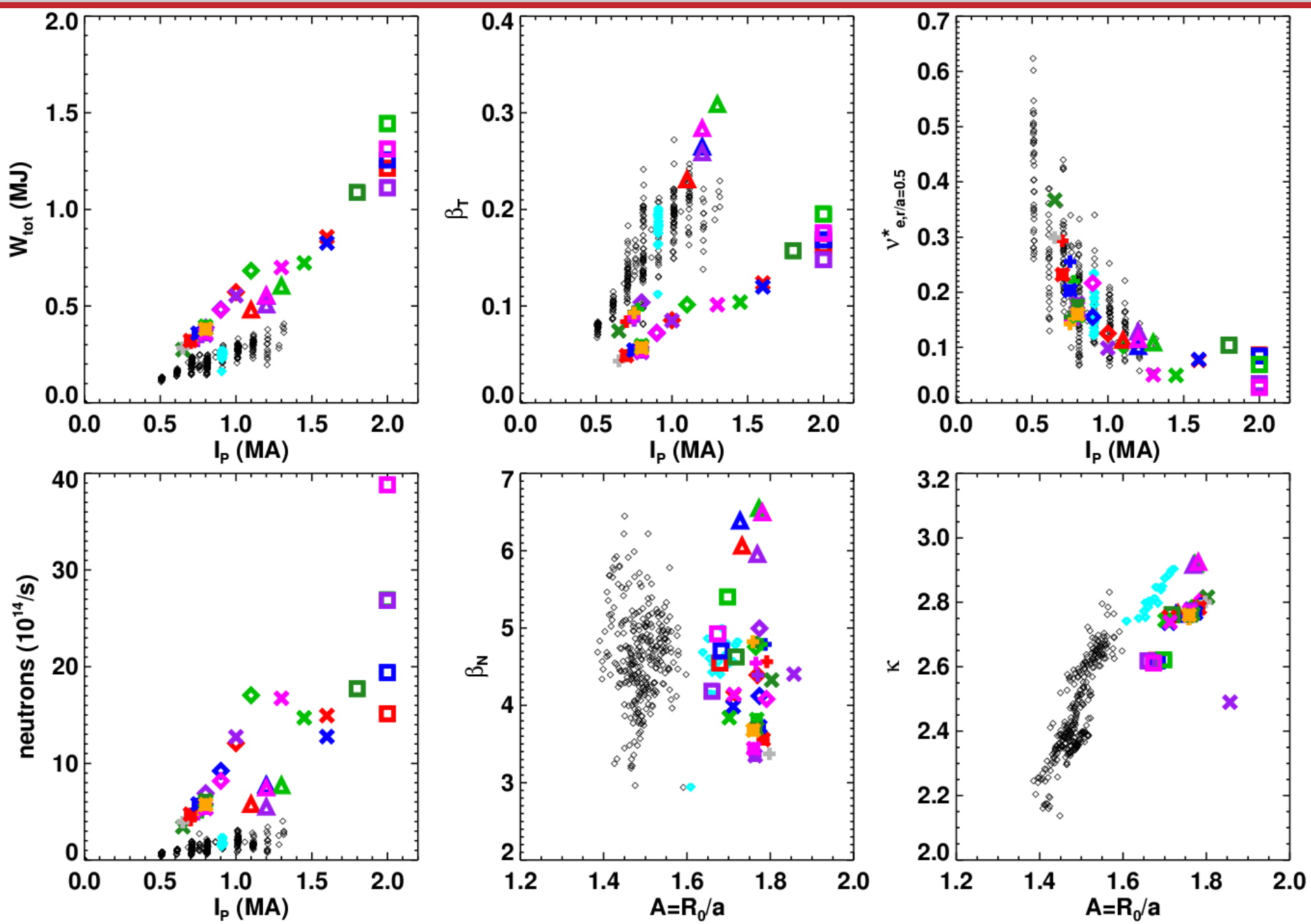
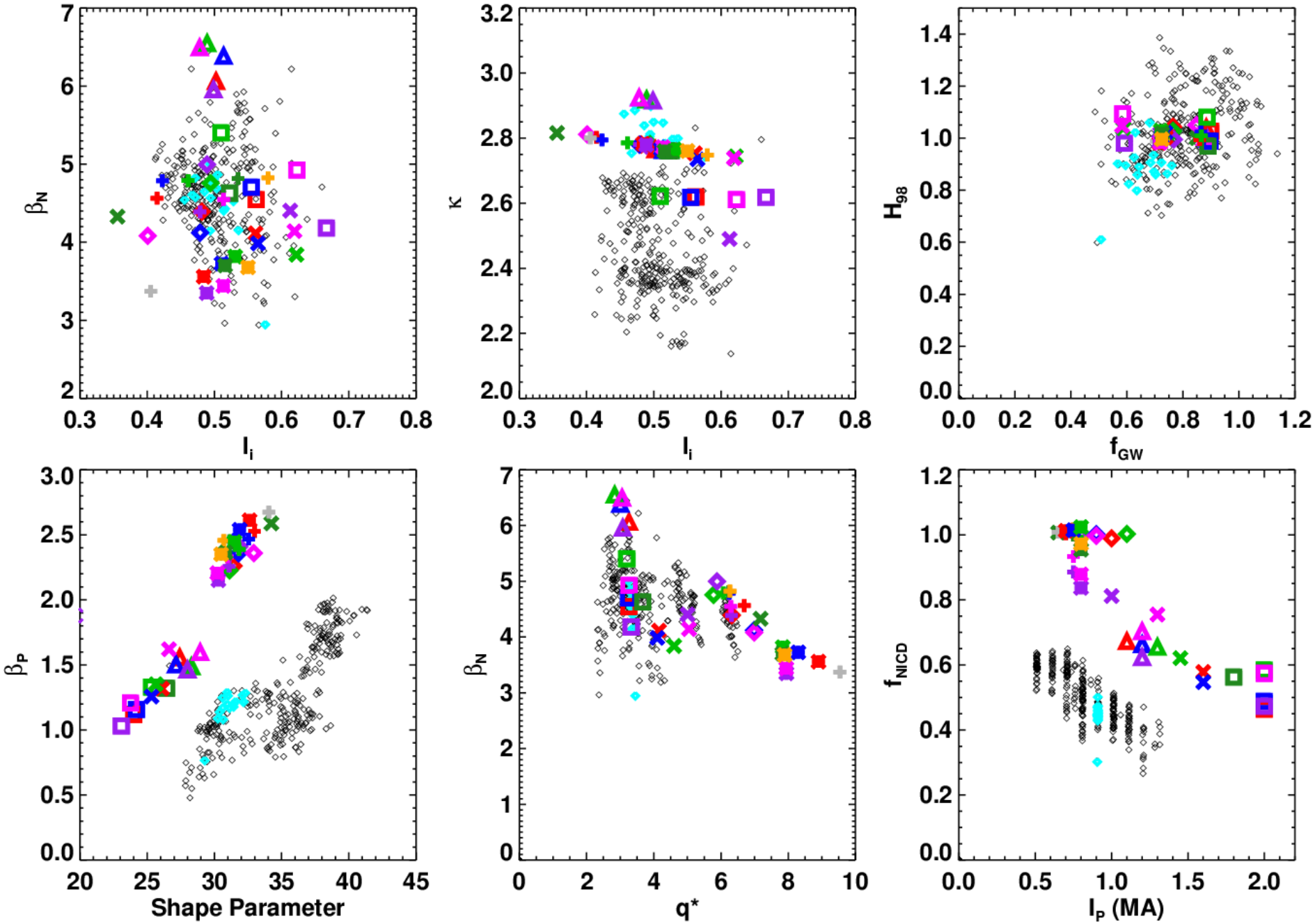
142301O96	142301O84	142301D64	142301D14	142301R84	142301N33
7.80000<t (sec) <7.95000	11.8000<t (sec) <11.9500	11.8000<t (sec) <11.9500	15.8000<t (sec) <15.9500	11.8000<t (sec) <11.9500	15.8000<t (sec) <15.9500
R_{tan}=[50,60,70,110,120,130]	R_{tan}=[50,60,70,110,120,130]	R_{tan}=[50,60,70,110,120,130]	R_{tan}=[50,60,70,110,120,130]	R_{tan}=[50,60,70,110,120,130]	R_{tan}=[50,60,70,110,120,130]
I_p=1.80 (MA)	I_p=1.60 (MA)	I_p=1.60 (MA)	I_p=1.45 (MA)	I_p=1.00 (MA)	I_p=1.30 (MA)
B_T=1.01 (T)	B_T=1.01 (T)	B_T=1.01 (T)	B_T=1.01 (T)	B_T=0.99 (T)	B_T=1.01 (T)
A=1.72	A=1.71	A=1.71	A=1.70	A=1.86	A=1.71
κ=2.76	κ=2.75	κ=2.73	κ=2.74	κ=2.49	κ=2.74
β_N=4.63	β_N=4.11	β_N=3.98	β_N=3.84	β_N=4.41	β_N=4.14
β_T=15.7 %	β_T=12.3 %	β_T=11.9 %	β_T=10.4 %	β_T=8.50 %	β_T=10.1 %
f_{BS}=43.3 %	f_{BS}=41.7 %	f_{BS}=40.4 %	f_{BS}=39.6 %	f_{BS}=48.3 %	f_{BS}=44.6 %
f_{nicd}=56.2 %	f_{nicd}=57.8 %	f_{nicd}=54.7 %	f_{nicd}=62.0 %	f_{nicd}=81.2 %	f_{nicd}=75.5 %
f_{GW}=0.89	f_{GW}=0.74	f_{GW}=0.74	f_{GW}=0.59	f_{GW}=0.72	f_{GW}=0.58
H_{98}=0.97	H_{98}=1.00	H_{98}=1.02	H_{98}=1.04	H_{98}=1.02	H_{98}=1.05
l_i=0.52	l_i=0.56	l_i=0.56	l_i=0.62	l_i=0.61	l_i=0.62
q_{95}=7.75	q_{95}=8.64	q_{95}=8.38	q_{95}=9.42	q_{95}=10.1	q_{95}=10.8
q_{min}=1.19	q_{min}=1.22	q_{min}=1.16	q_{min}=1.16	q_{min}=1.27	q_{min}=1.31
p_{inj}=15.0 (MW)	p_{inj}=12.0 (MW)	p_{inj}=10.5 (MW)	p_{inj}=10.5 (MW)	p_{inj}=12.0 (MW)	p_{inj}=12.0 (MW)
ν^*_e=0.10	ν^*_e=0.08	ν^*_e=0.08	ν^*_e=0.05	ν^*_e=0.10	ν^*_e=0.05

Beam Voltage and f_{GW} Scan at Highest Field and Current, 10 cm Outer Gap



142301M74	142301M79	142301K54	142301M79	142301K54
7.80000<t (sec) <7.95000	7.80000<t (sec) <7.95000	7.80000<t (sec) <7.95000	15.8000<t (sec) <15.9500	15.8000<t (sec) <15.9500
R_{tan}=[50,60,70,110,120,130]	R_{tan}=[50,60,70,110,120,130]	R_{tan}=[50,60,70,110,120,130]	R_{tan}=[50,60,70,110,120,130]	R_{tan}=[50,60,70,110,120,130]
I_p=2.00 (MA)	I_p=2.00 (MA)	I_p=2.00 (MA)	I_p=2.00 (MA)	I_p=2.00 (MA)
B_T=1.01 (T)	B_T=1.01 (T)	B_T=1.01 (T)	B_T=1.02 (T)	B_T=1.01 (T)
A=1.68	A=1.68	A=1.70	A=1.66	A=1.67
κ=2.62	κ=2.62	κ=2.62	κ=2.62	κ=2.61
β_N=4.55	β_N=4.70	β_N=5.40	β_N=4.18	β_N=4.93
β_T=16.2 %	β_T=16.8 %	β_T=19.5 %	β_T=14.8 %	β_T=17.5 %
f_{BS}=36.8 %	f_{BS}=37.8 %	f_{BS}=44.9 %	f_{BS}=30.5 %	f_{BS}=36.3 %
f_{nicd}=46.4 %	f_{nicd}=48.8 %	f_{nicd}=58.4 %	f_{nicd}=47.3 %	f_{nicd}=57.4 %
f_{GW}=0.90	f_{GW}=0.90	f_{GW}=0.89	f_{GW}=0.59	f_{GW}=0.59
H_{98}=1.03	H_{98}=0.99	H_{98}=1.08	H_{98}=0.98	H_{98}=1.09
l_i=0.56	l_i=0.56	l_i=0.51	l_i=0.67	l_i=0.62
q_{95}=6.68	q_{95}=6.73	q_{95}=6.97	q_{95}=6.50	q_{95}=6.64
q_{min}=0.85	q_{min}=0.88	q_{min}=1.04	q_{min}=0.69	q_{min}=0.77
p_{inj}=12.0 (MW)	p_{inj}=15.0 (MW)	p_{inj}=17.4 (MW)	p_{inj}=15.0 (MW)	p_{inj}=17.4 (MW)
ν^*_e=0.09	ν^*_e=0.08	ν^*_e=0.07	ν^*_e=0.03	ν^*_e=0.03

Comparison of Scenarios to Existing Data (I)



Comparison of Scenarios to Existing Data (II)