# *Chapter 1 🡨 update the Ch. #*

# C:\Users\jmenard\Desktop\Picture1.jpg

# Chapter title goes here in 28pt font

* 1. **Level 1 – Main section heading – 20 pt bold**
     1. **Level 2 - 16 pt bold**
        1. **Level 3 – 12 pt bold (14pt bold also ok)**
           1. **Level 4 – 12 pt bold** (don’t use more levels than this!)

Guidance for the formatting of your chapter:

1. Replace the 2 figures above with something representative of your chapter
2. Text font: Times New Roman
3. Chapter number font: Bold Italic 32pt
4. Chapter title font: Bold 28pt
5. Section heading fonts and sizes: see examples above
6. Main text font size: 12pt
7. Main text spacing: 1.15 using the Word line-spacing option
8. Put the Figure and caption in a single text-box – do not “group” them.
9. Captions: 10pt italic, number according to the sub-section figure is in – see examples below
10. References: Put at end of each section or chapter, “References” section heading should be in 16pt bold-face. Use simple numbers in brackets: [1], [2-4] See end of template for style.
11. Paragraphs: no indentation in beginning of paragraph, 1 line separating paragraphs
12. Fully justify all text – both paragraphs and figure captions
13. To be clear and uniform in how/where the year-by-year plans are addressed at the ends of the various sections, use this phrase just before providing a year-by-year list of research plans:

“Summary of Research Plans by Year:"

and this can be extended to:

"Summary of Research Plans by Year for X:"

where "X" is a research topic or TSG thrust as you see fit.

Also, each of these year-by-year plans section headings should have a section/outline number associated with it so it is easily findable by the reader and appears in the ToC (see below)

1. Make sure it is crystal clear the "years" you are listing are 5 year plan years or operational years. A good way to be clear is for the first year in your list to include the absolute year in parentheses.

Example:

9.2.4.1 Summary of Research Plans by Year:

* + Year 1 (2014) - blah
  + Year 2 - more blah

….

* + Year 5 - finish blah, build FNSF

1. Every chapter needs a Table of Contents at the beginning of the chapter. This can/should be generated by MS Word for (more) consistent formatting. Include indices down to the level where the “Summary of Research Plans by Year” headings appear in the ToC.
2. In the text, avoid/remove phrases like “We will do X…”. Replace with “X will be studied” or assessed or investigated, or use “NSTX-U researchers will do X…”

Generally, the plan should avoid personal pronouns (we, I, you, they, them…) in order to keep it formal, scientific, and professional.

1. In the first paragraph of your chapter, explicitly state which (can be more than 1) of the 5 high-level 5 year plan research goals your chapter and thrusts are supporting. These are listed in chapter 1.
2. At the end of your chapter, you have the graphical timelines which include physics and tools (diagnostics, theory, facility). Since we are actually carrying out a research program in FY14 to complete NSTX analysis and prep for NSTX-U operation, it is important that the physics and (where appropriate) tools sections have boxes/entries in FY2014. Please use the plans in your own chapter for Year 1 = 2014 to generate this input where it does not exist in the timelines.

**Example 5 year plan text for NSTX**

The Spherical Torus (ST) concept is a low-aspect-ratio tokamak magnetic configuration characterized by strong intrinsic plasma shaping and enhanced stabilizing magnetic field line curvature. These characteristics are shown pictorially in Figure 1.2.1. These unique ST [1,2] characteristics enable the achievement of a high plasma pressure relative to the applied magnetic field and provide access to an expanded range of plasma parameters [3] and operating regimes relative to the standard aspect ratio tokamak [4-8]. NSTX has demonstrated that ST’s can access a very wide range of dimensionless plasma parameter space with toroidal beta t up to 40% (local ~), normalized beta N up to 7, plasma elongation  up to 3, normalized fast-ion speed Vfast/VAlfvén up to 5, Alfvén Mach number MA = Vrotation/VAlfvén up to 0.5, and trapped-particle fraction up to 90% at the plasma edge. All of these parameters are well beyond that accessible in conventional tokamaks, and these parameters approach those achievable in other high- alternative concepts.

These characteristics therefore allow ST research to complement and extend standard aspect-ratio tokamak science while providing low-collisionality, long pulse-duration, and well-diagnosed plasmas to address fundamental plasma science issues – including burning plasma physics in ITER. The ST addresses fundamental issues in magnetic fusion energy science in the areas of: macroscopic stability, turbulence and transport, wave-particle interactions, boundary physics, and solenoid-free current formation and sustainment. For fusion applications, the high , compact geometry, accessibility, modularity, and simplified magnets of the ST are potential advantages for plasma material interaction studies at high heat flux, nuclear component testing, and for a fusion power reactor.



*Figure 1.2.1: Comparison of magnetic field-line trajectories, aspect ratio, elongation, and safety factor parameters for a tokamak (left) and spherical torus (right).*

NSTX is the world’s highest performance ST research facility and is the centerpiece of the U.S. ST national research program. As illustrated below in Figure 1.2.2, NSTX is an essential element in the program to advance the understanding and development of the ST concept while also complementing and accelerating the development of all DEMO concepts.



*Figure 1.2.2: (left) U.S. ST research facilities, (middle) next-step STs to complement tokamaks and ITER burning plasma research by addressing key PMI and neutron fluence gaps between ITER and DEMO, and (right) spherical torus (ST), advanced tokamak (AT), and compact stellarator (CS) DEMO/reactor concepts developed by the ARIES reactor studies group (http://www-ferp.ucsd.edu/aries/).*

The three overarching mission elements of the NSTX research program for 2009-2013 are:

**(1)** Determine the physics properties of the ST - utilizing its low aspect-ratio (A ~ 1.5) and very high ratio of plasma pressure to magnetic pressure (up to order-unity beta) - to advance toroidal plasma science.

1. Provide unique ST data to the tokamak knowledge-base in support of ITER final design activities and preparation for burning plasma research in ITER through participation in the International Tokamak Physics Activity (ITPA) and U.S. Burning Plasma Organization (USBPO), while also benefiting from tokamak and ITER R & D.

**(3)** Develop the S…

The remainder of this chapter first describes the unique parameter regimes accessed in NSTX (Section 1.3) to provide context for understanding NSTX contributions to tokamak physics and ITER (Section 1.4) and, most importantly, for motivating fusion energy science applications of the ST (Section 1.5) and identifying scientific gaps (Section 1.5) and opportunities (Section 1.6). Section 1.7 briefly summarizes the NSTX 10 year scientific research objectives, and Section 1.8 describes the scientific organizational structure of the NSTX national research team.

* 1. **Parameter Regimes Accessed by NSTX**

Intro text…

* + 1. **Macroscopic Stability**

The fundamental fusion advantage and scientific opportunity enabled by low aspect ratio A ≡ R/a (see Figure 1.2.1) is…. Just as the enhanced toroidicity (low aspect ratio) and increased natural shaping of NSTX plasmas can suppress macroscopic instabilities, these ST characteristics are also expected to…

**References**

[1] G. De Temmerman, et al., J. Vac. Sci. Technol. A **30** (2012) 041306.

[2] M.A. Jaworski, et al., Fusion Eng. Des. (2012) *in press.*

[3] Summers, H. P. (2004) The ADAS User Manual, version 2.6 http://www.adas.ac.uk

[4] J. Zeigler, et al., Nucl. Instrum. Methods B **268** (2010) 1818-1823.

[5] H.W. Kugel, et al., Fusion Eng. Des. (2011) *in press.*

[6] M.A. Jaworski, et al., J. Nucl. Mater. **415** (2011) S985-S988.

[7] V.A. Evtikhin, et al., J. Nucl. Mater. **307-311** (2002) 1664-1669.

[8] M.A. Jaworski, N.B. Morley and D.N. Ruzic, J. Nucl. Mater. **390-391** (2009) 1055-1058.