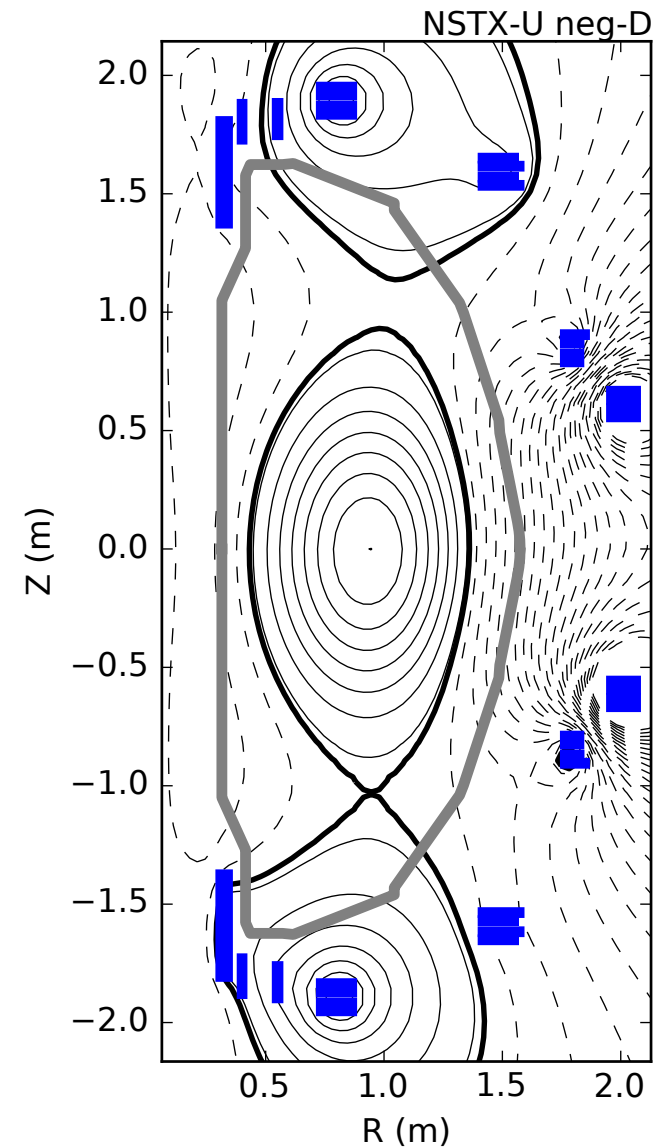# Resistive Stability and Shape Optimization Research on NSTX-U

By:

C. Paz-Soldan

Columbia University

Presented to:

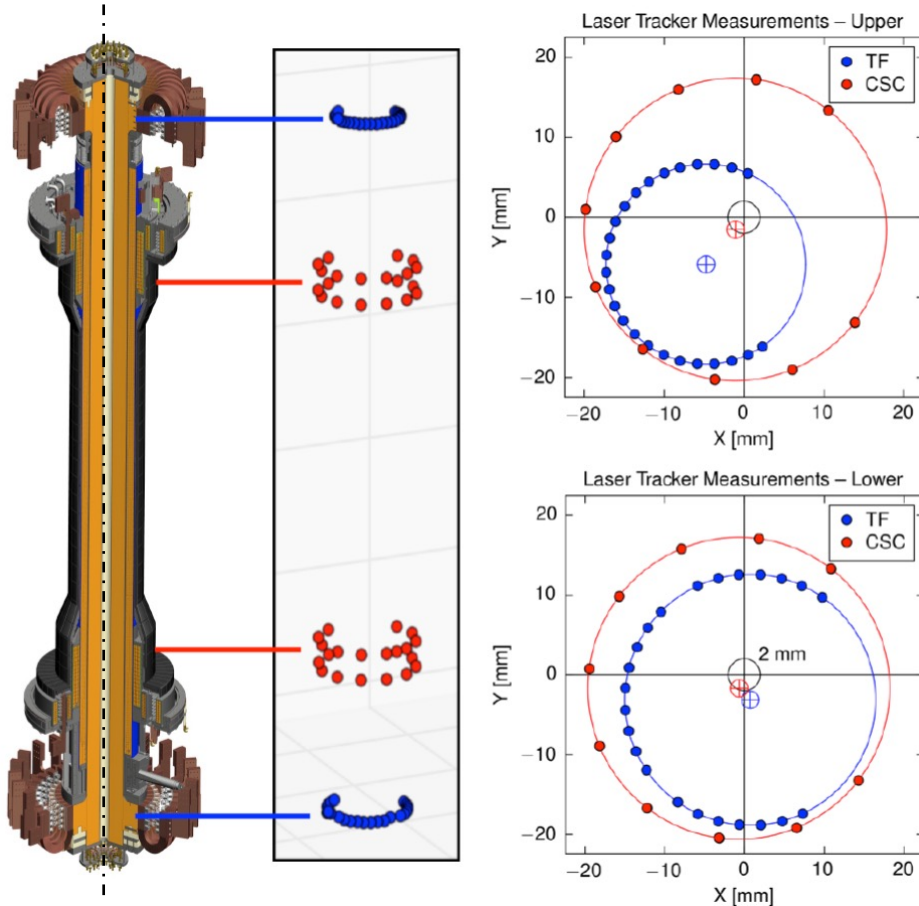NSTX-U Research Meeting

Oct 4th 2021
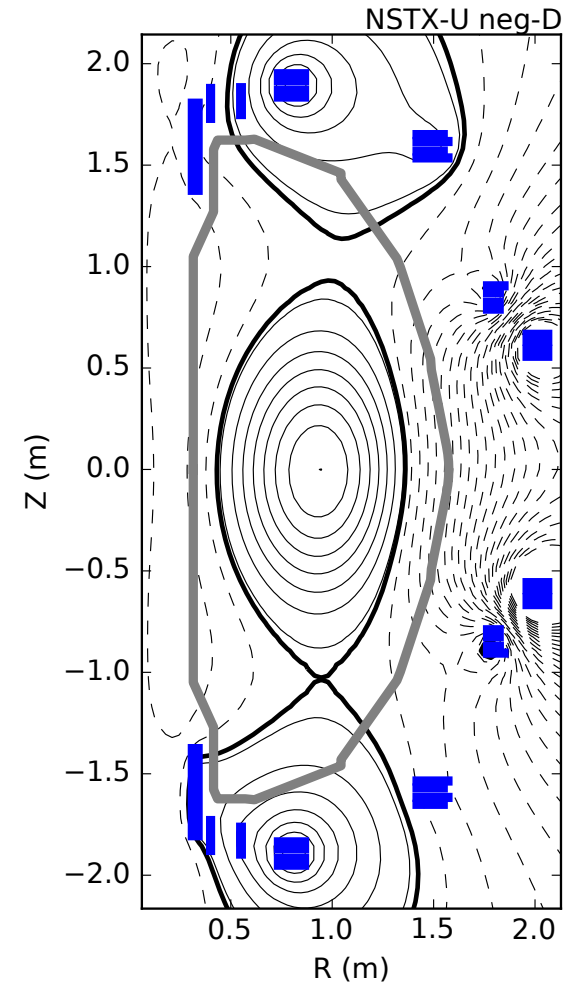

NSTX-U neg-D

Project Consists of Two Central Topics

1: Error Field Physics
Enable NSTX-U performance

2: Negative Triangularity
Explore alternative scenarios

Error Field Overview:

Why do we care?

- Uncorrected error fields can **limit plasma performance**, ex: NSTX(-U)

- NSTX-U designed to have low error, but need to be ready just in case

- Opportunity to advance the error field state of the art
  - Demonstrate / deploy state-of-the-art control techniques for practical use
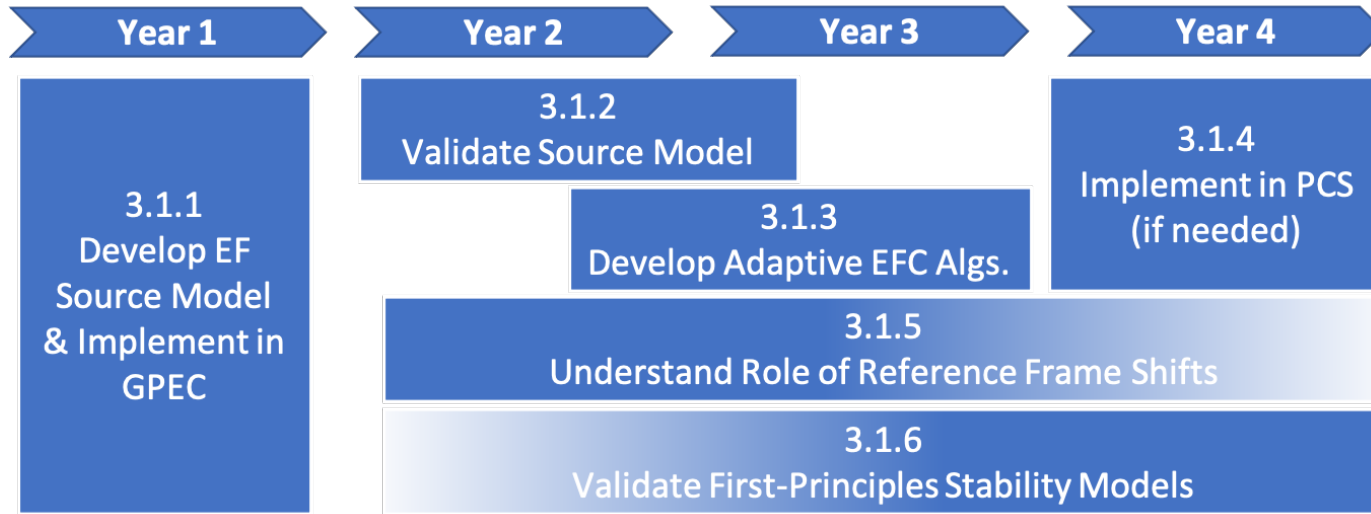
NSTX-U Objectives of Interest:

- Obj #2: Develop operation at large bootstrap and advance physics basis for high performance NI plasmas (w/o disruptions)

- If error fields are big, interaction with more of the program (gulp!)

Key Collaborators:

- S. Munaretto, N. Ferraro, J-K. Park, D. Boyer (PPPL), E. Kolemen (PU), A. Wingen (ORNL)

Error Field Project Sequence:

Year 1	Year 2	Year 3	Year 4

3.1.1 Develop EF Source Model & Implement in GPEC

3.1.2 Validate Source Model

3.1.3 Develop Adaptive EFC Algs.

3.1.4 Implement in PCS (if needed)

3.1.5 Understand Role of Reference Frame Shifts

3.1.6 Validate First-Principles Stability Models

- Source model: translate metrology data into a viable reduced model

- First Plasma: Validate EF source model against compass scan data w/ GPEC

- Adaptive algorithm: Use look-up tables/NNs to rapidly calculate correction

- IF error field is a big problem: implement algorithm into PCS
  - IF NOT: shift to study of classical / neoclassical tearing in later years

- Also pursue foundational studies of centerpost tilt/shifts to inform above

Error Field: Needs

- As-built metrology data
  - Generated by "East coast metrology" sub-contractors
- NSTX-U commissioning time
  - Validate model w/ compass scans (will happen anyway)
- IF Error Field "Big": PCS support to implement algorithms (down the line)

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Negative Triangularity Overview:

Why do we care?

- Negative delta offers an alternate path to core-edge integration

- Move pressure gradient from the edge (no ELMs) to the core
  - Goal: L-mode edge with H-mode confinement

- What are the synergies with low-A? What can NSTX-U validate?
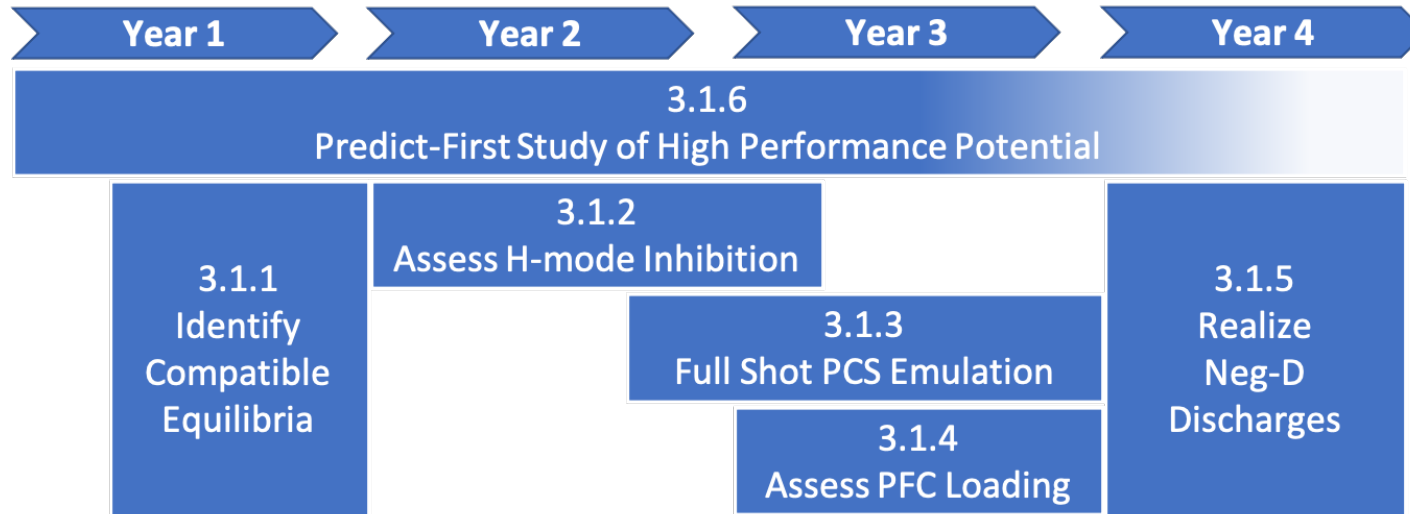
NSTX-U Objectives of Interest:

- Obj #3: Develop and evaluate conventional and innovative power and particle handling techniques to optimize plasma exhaust

Key Collaborators:

- D. Battaglia (PPPL), K. Thome, J. McCleneghan, O. Meneghini (GA), E. Unterberg (ORNL), S. Saarelma (CCFE)

Negative-Delta Project Sequence:

NSTX-U

Year 1	Year 2	Year 3	Year 4

3.1.6
Predict-First Study of High Performance Potential

3.1.1
Identify Compatible Equilibria

3.1.2
Assess H-mode Inhibition

3.1.3
Full Shot PCS Emulation

3.1.4
Assess PFC Loading

3.1.5
Realize Neg-D Discharges

- Predict first: Int. model to see what low-A neg-D plasmas look like
- Equilibria: GSdesign to see what's compatible with NSTX-U coils
- H-mode inhibition: Deploy n=inf stability model to NSTX-U geometries
- PCS emulation: combine GSdesign and GSevolve in emulation models
- PFCs: Deploy HEATS (ORNL) model to assess PFC limit (passive plates)
- Realization(?): Up-down asymmetric (regular divertor) or symmetric shots

Preliminary Look at Performance

- Use STEP (TGYRO, CHEASE) to evaluate NT performance in spherical tokamaks
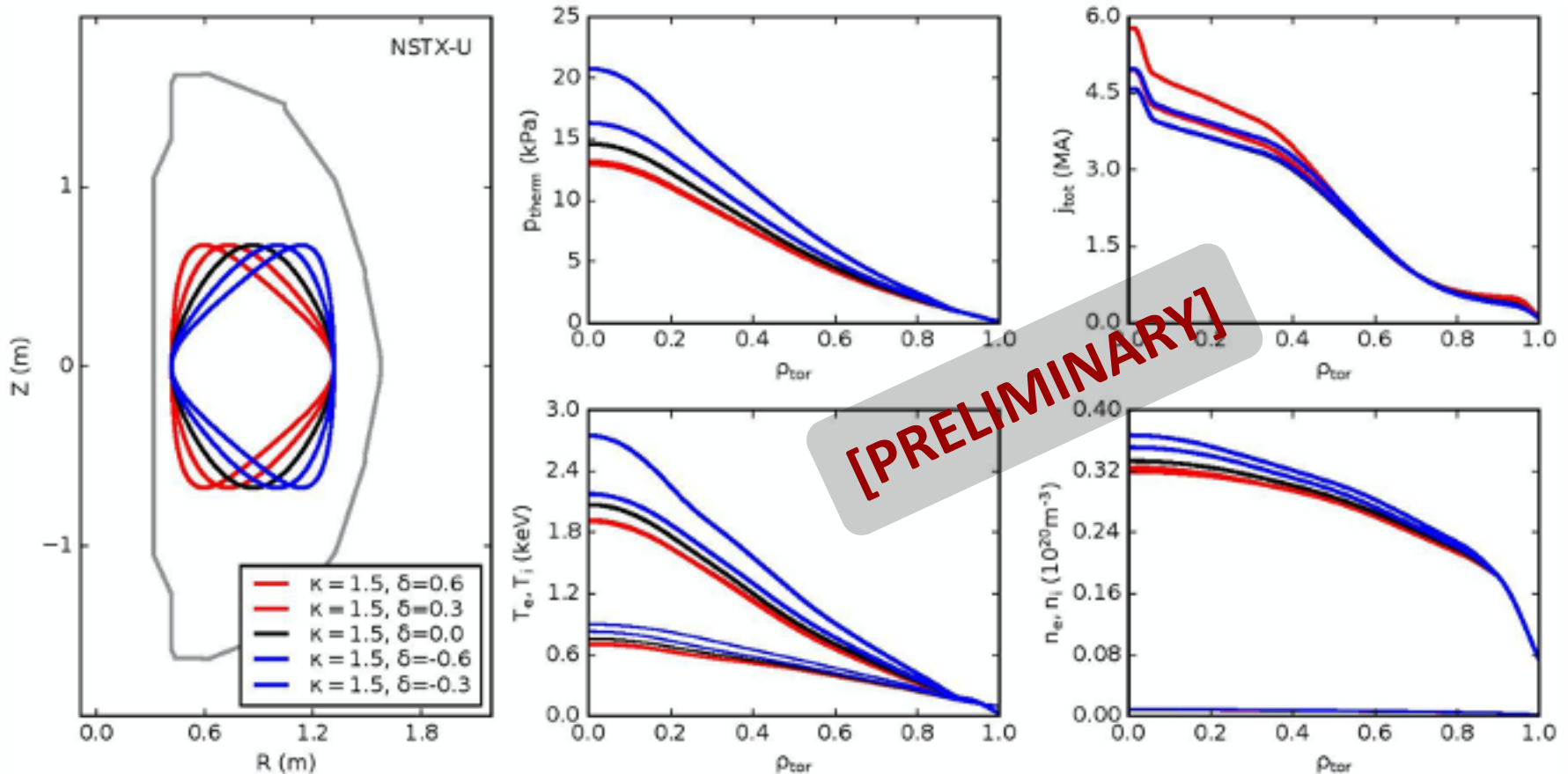
Negative-Delta Needs:

- Assistance to get modeling tools up and running (already happening)

- Propose experiments down the line (where sensible)
  - Asymmetric shape shape uses regular divertor structures

Project Team / Staffing:

**Carlos Paz-Soldan
(PI)**

**Oak Nelson
(Post-doc, 0.5 FTE)**

**Matthew Pharr
(PhD, EFs)**

**Haley Wilson
(PhD, Neg-D)**

Looking forward to working together !

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