

PEGASUS-III Experiment

Presentation GO03.00002

The New PEGASUS-III Experiment

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Presentations at: https://pegasus.ep.wisc.edu

Department of Engineering Physics
UNIVERSITY OF WISCONSIN–MADISON

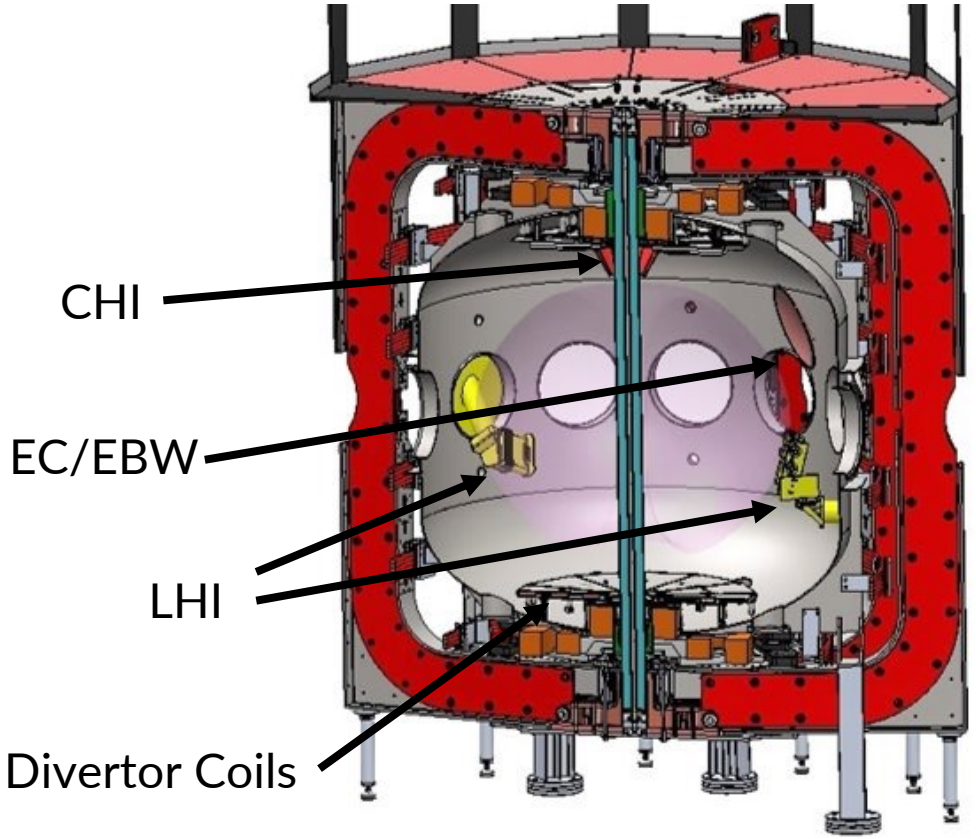
PEGASUS-III Provides Bold Test of Non-Solenoidal ST Startup Using Power Plant Relevant Technology

- Future ST designs call for solenoid-free operation
  - Minimize/no OH due to shielding/cost
- Mission: Solving solenoid-free startup
  - Advanced Local Helicity Injection (LHI)
  - Floating Coaxial Helicity Injection (CHI)
  - RF assist, sustainment and startup
- Research program provide predictive understanding of solenoid-free techniques
  - Extrapolatable techniques to MA-class STs (and ATs)

CP11.00040 – M. Bongard
CP11.00041 – J. Goetz
CP11.00046 – M. Nornberg

PEGASUS-III features:

- **No solenoid**
- 4x toroidal field
- Advanced control
- Expanded diagnostics



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Projecting LHI to High-Performance Facilities Requires Tests at Increasing B_T

- Critical physics issues:
  - Verify I_p scaling with higher B_T
  - Understanding confinement/transport processes
  - Coupling LHI plasmas to noninductive sustainment

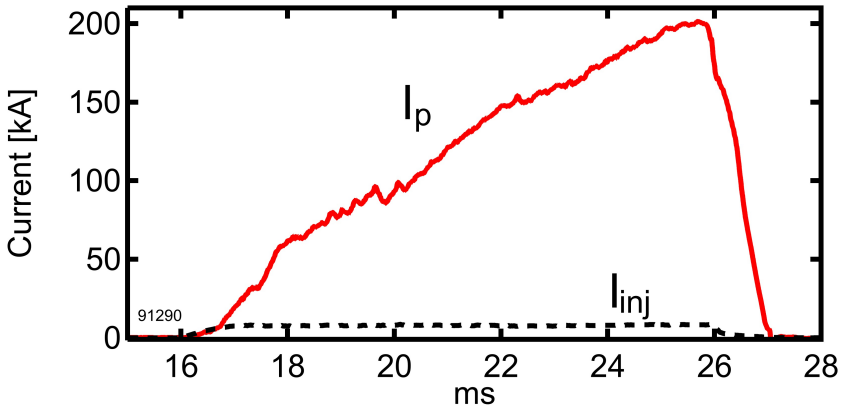
$$I_{p,TL} \propto \sqrt{\frac{I_{inj} I_{TF}}{w_{inj}}}$$

- Utilize two injector configurations
  - Two arrays: 2x4 cm^2 circular injectors
  - Advanced non-circular injector

Goal: routine I_p ~ 0.3 MA

CP11.00045 – A. Sontag
CP11.00047 – C. Schaefer
CP11.00048 – R. Sassella

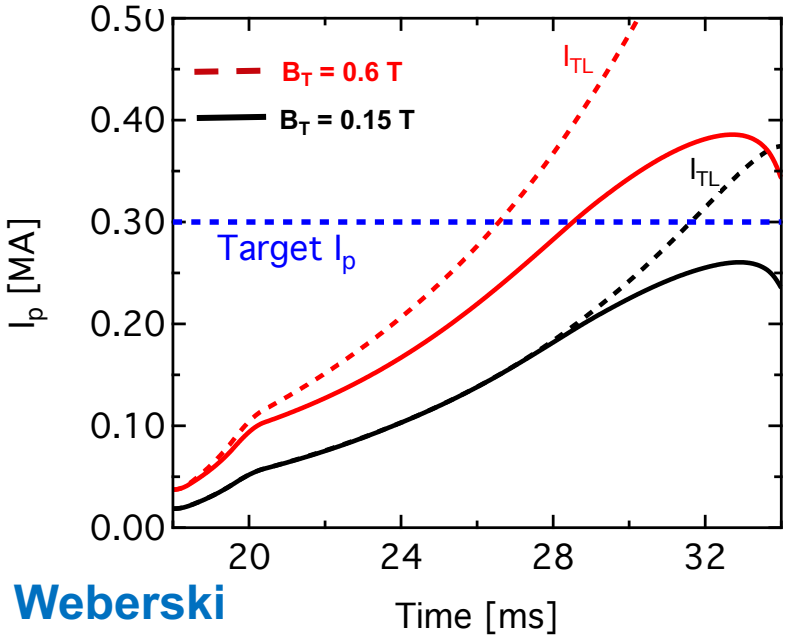
LHI Produces High-I_p = 0.2 MA Tokamak Plasma (I_{inj} ≤ 8 kA)



Monolithic LHI Injector



PEGASUS-III Projection



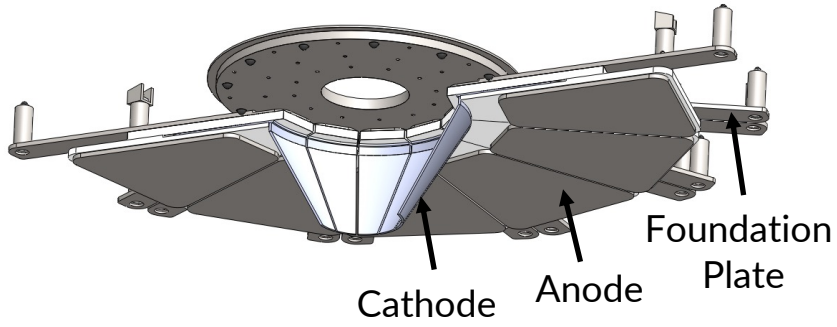
CP11.00049 – J. Weberski

Novel, Flexible CHI Enabled by Increased B_T of PEGASUS-III

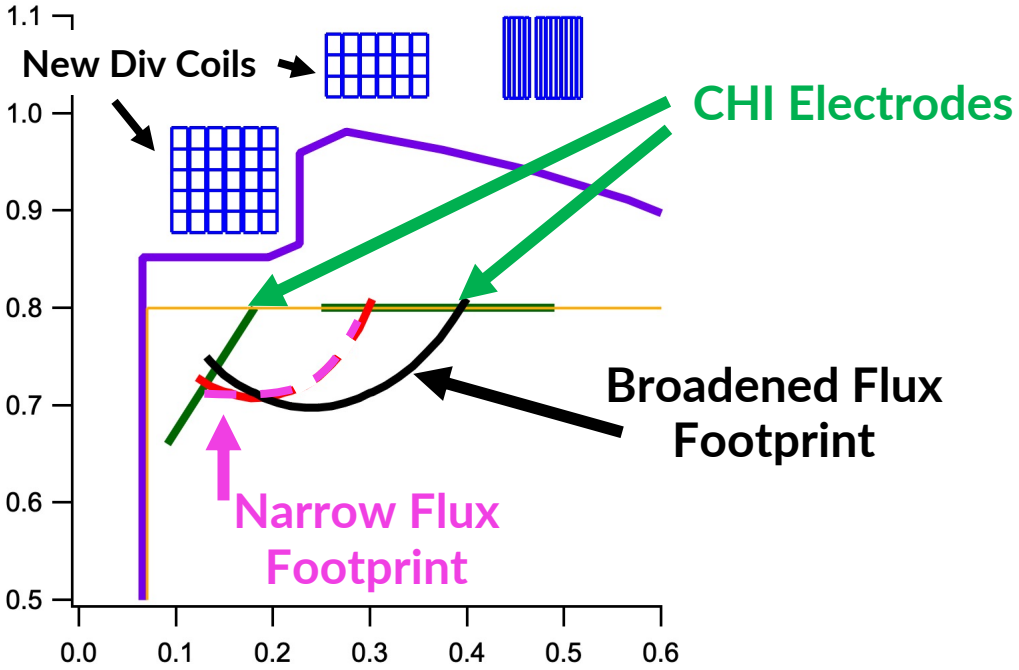
- Address critical physics and direct comparison to LHI
  - Flux conversion efficiency
  - Role of footprint in efficiency
  - Comparison and synergies with other methods
  - Role of non-axisymmetric current flows & structures
- Validate projection to ≥1 MA system
  - Test bubble burst and Taylor limit up to 0.3 MA
- Two floating electrodes
  - Transient and sustained CHI
- Longstanding goal to test auxiliary heating of HI plasmas

CP11.00044 – J. Reusch
CP11.00053 – J. Rogers

3D Sketch of Electrode Plate Concept



Floating electrodes, high field divertor coil system



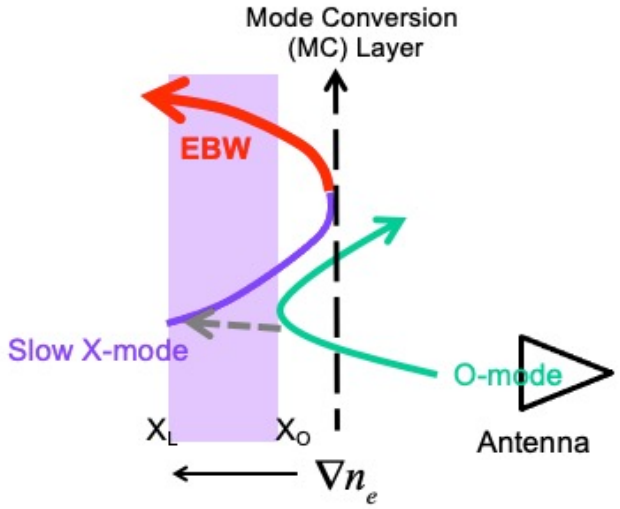
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RF Heating and Current Drive Can Enhance Helicity Injection, Provide Standalone Startup

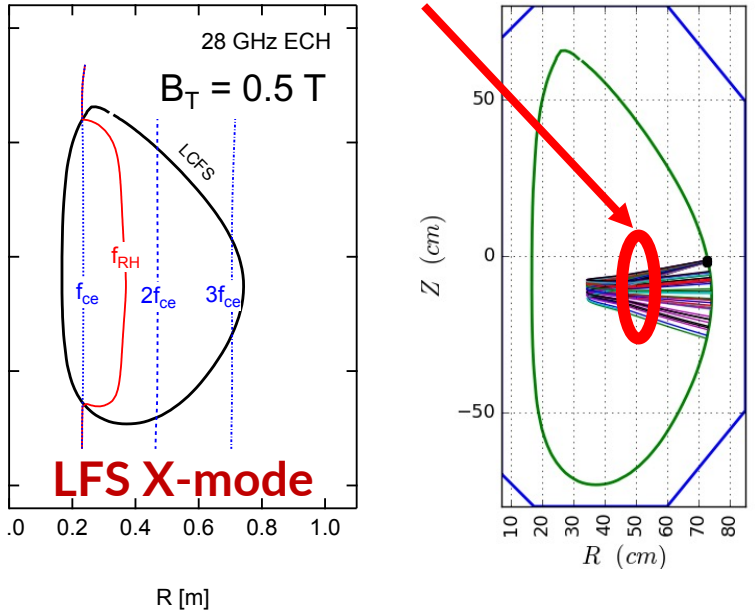
- RF heating synergistic with LHI/CHI through:
  - Increase T_e to reduce helicity dissipation
  - Freezing low-inductance helicity-driven current profile
  - Providing $J(R)$ tailoring for improved MHD stability

- Near-term focus on EBW emission measurements to design, deploy RF system
  - Characterizing EBW emission during/post HI plasmas
  - Collaboration with the University of York

- Initial PEGASUS-III experiments with 0.2 MW, 28 GHz RF system
  - ECH/ECCD for lower n_e scenarios
  - Electron Bernstein wave (EBW) via O-X-B mode conversion for overdense ST plasmas for heating



ECH Absorption region



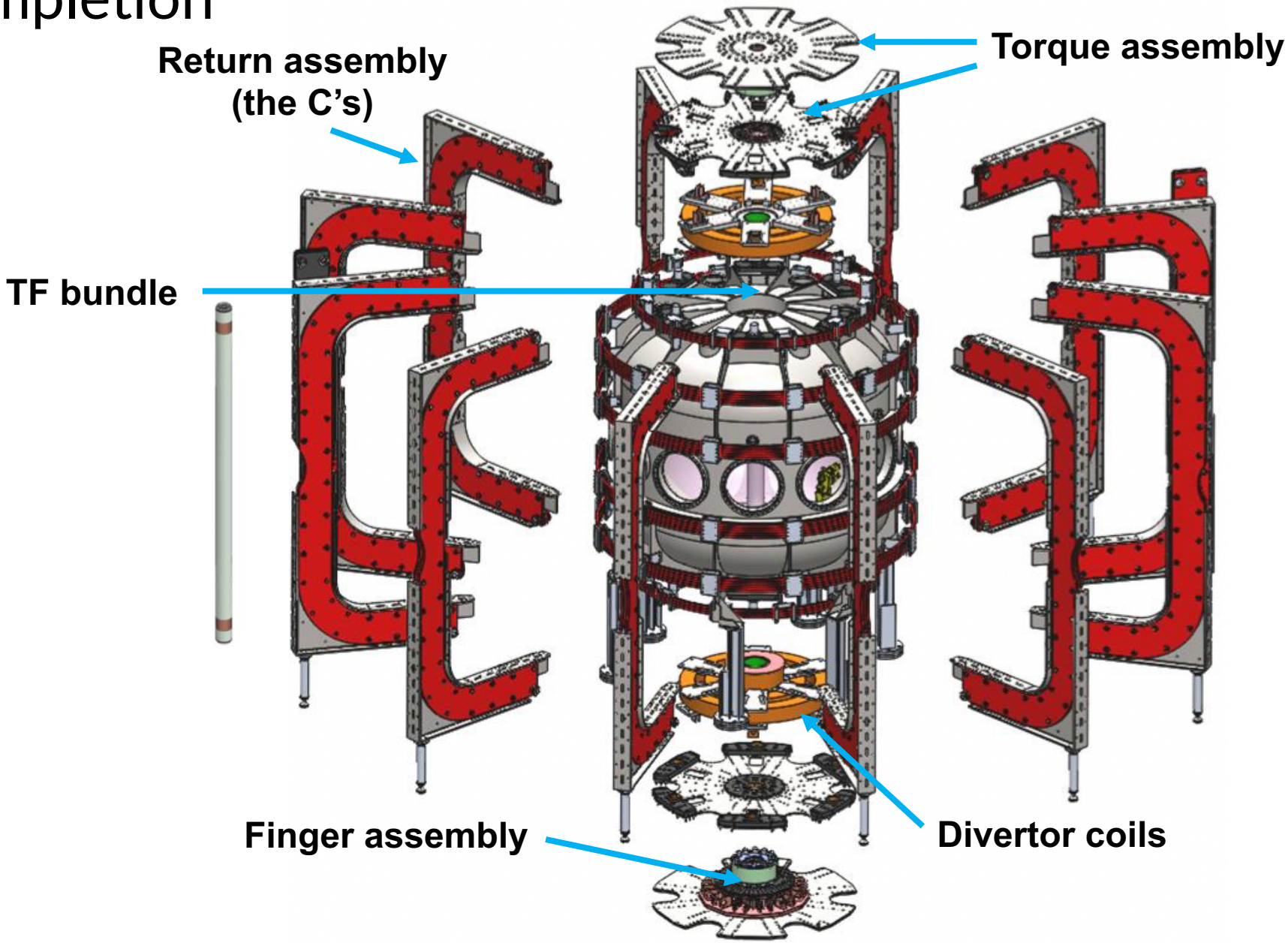
O-X-B coupling

CP11.00042 – J. Peery

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All Major PEGASUS-III Upgrade Sub-Assemblies Nearing Completion

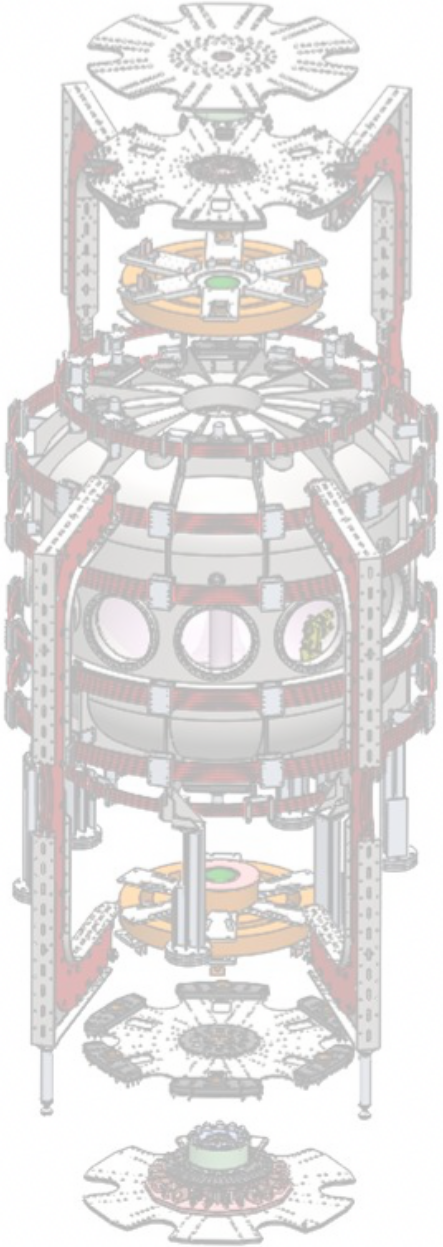


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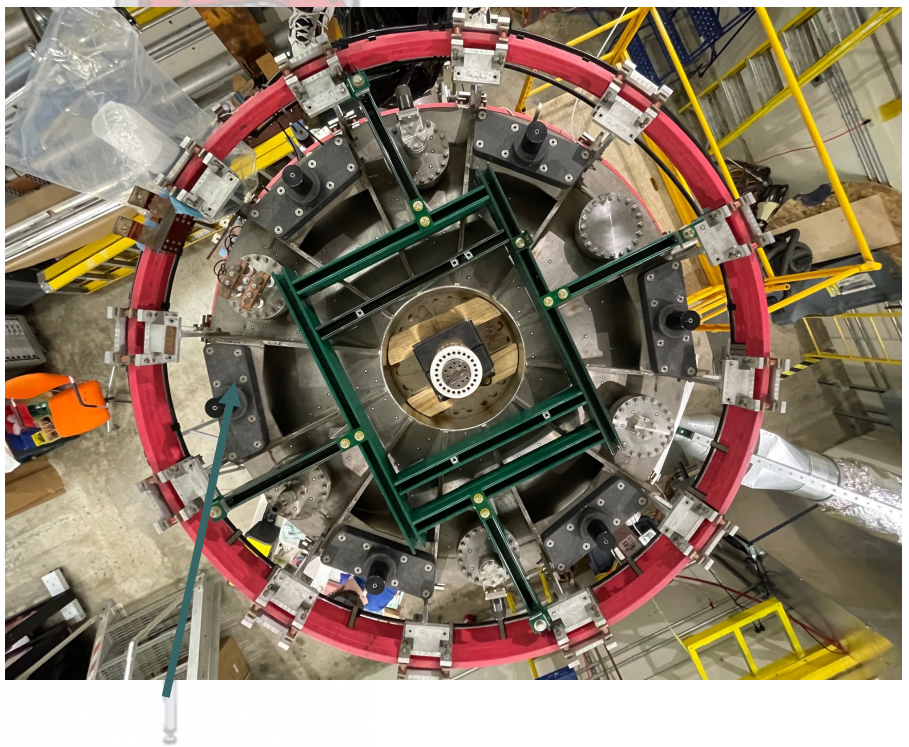
TF bundle installed in vacuum wall



Contact - indexing area



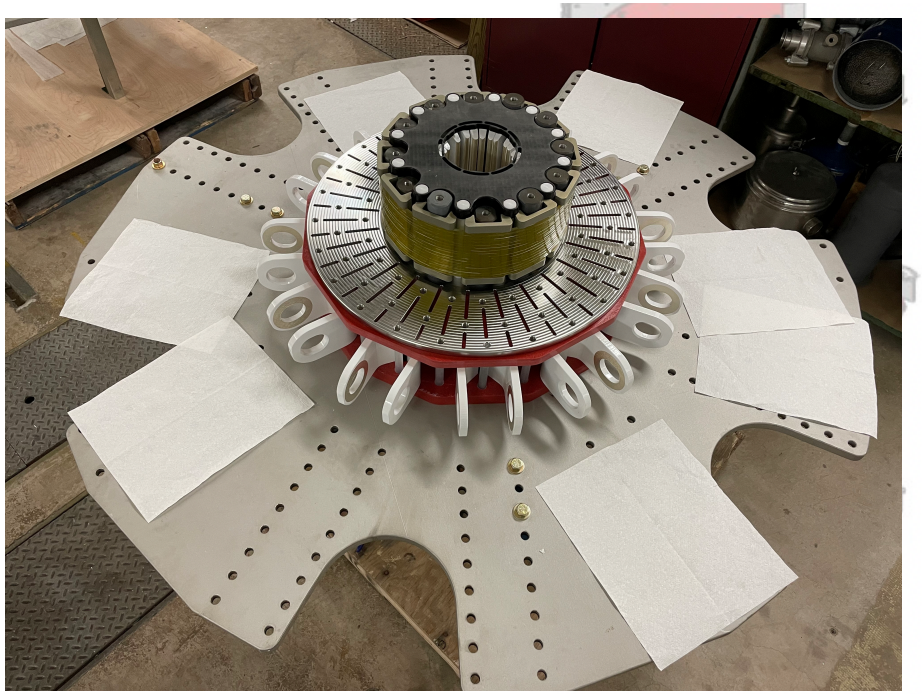
Six pin blocks and pins installed on vessel (top shown here)

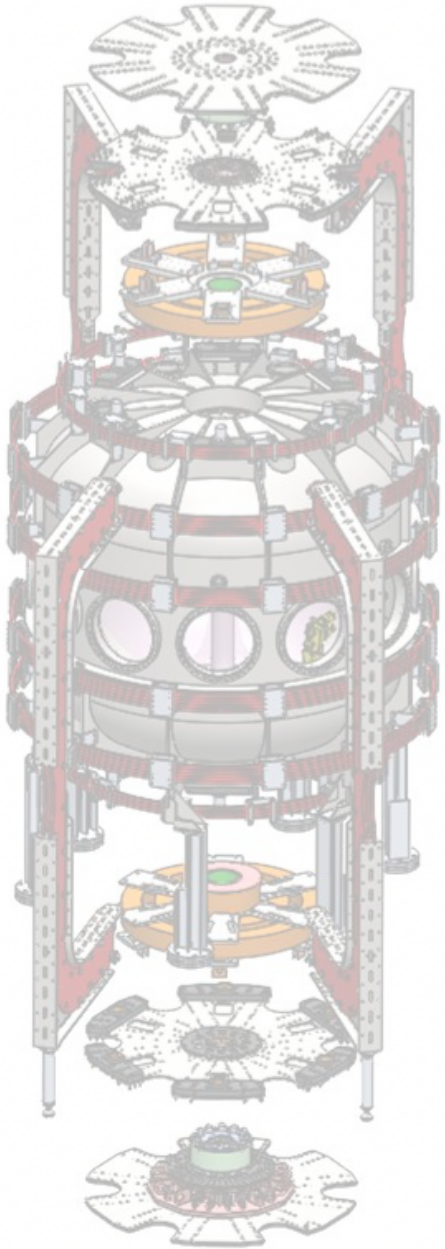


Pin block with pin attached to gusset plate reinforced ribs

All Major PEGASUS-III Upgrade Sub-Assemblies Nearing Completion

Test fit of finger assembly on torque plate & finger assembly compression check

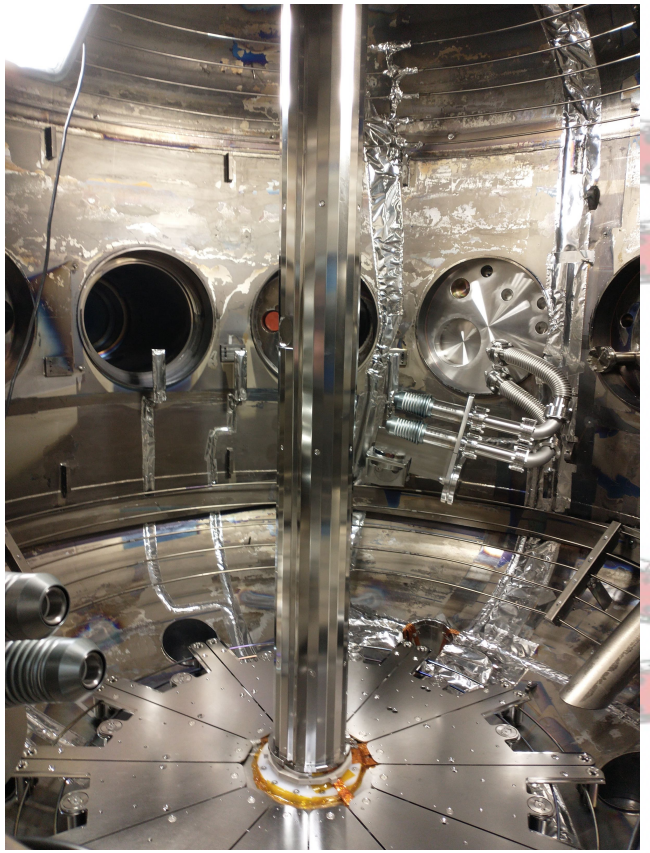




Test fit and alignment of upper divertor coils

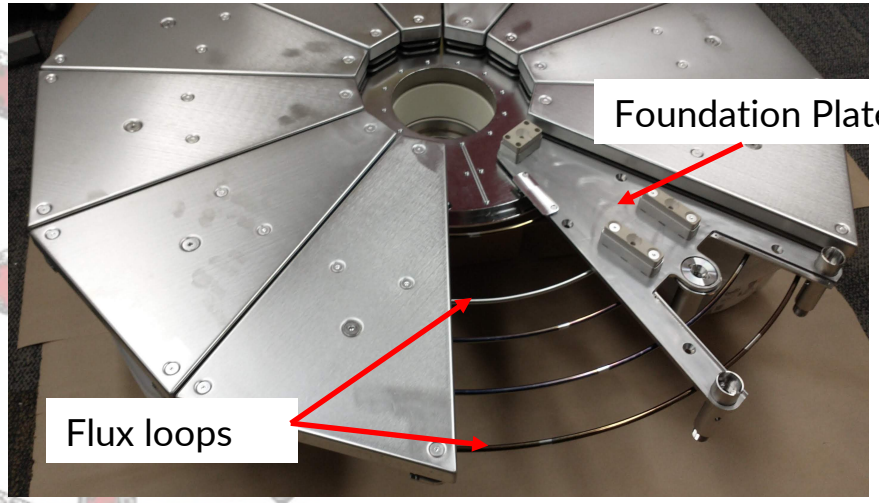


All Major PEGASUS-III Upgrade Sub-Assemblies Nearing Completion



Interior of vacuum vessel showing new vacuum wall covered in core armor and new LHI hardware

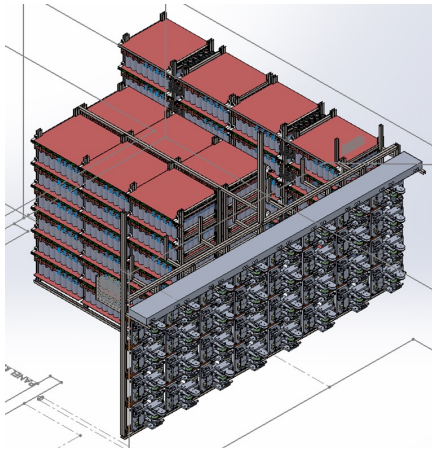
Test fit of divertor assembly, CHI foundation



175 MVA of Switching Power Amplifiers Commissioned for Electromagnets, Helicity Injection Systems

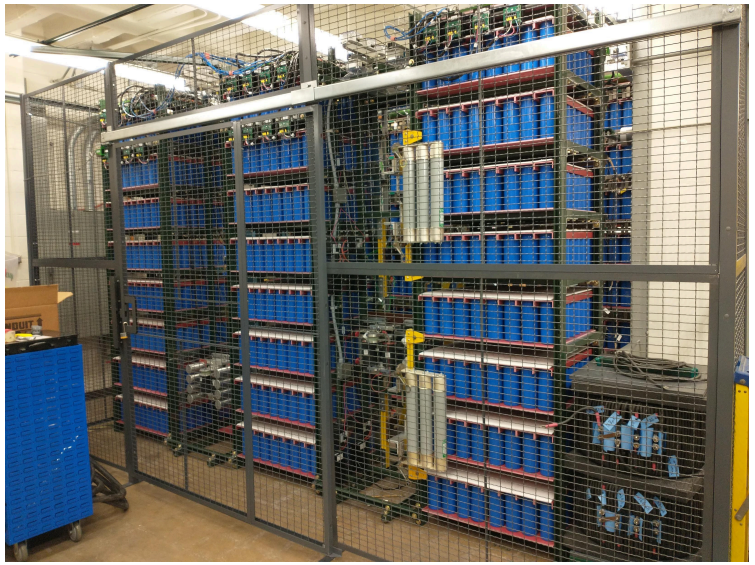
- 32 modular 4 kA, 0.9 kV supplies for coils
  - Expansion to 40 units planned
- Replaced and expanded stored energy
  - 7 MJ of new stored energy built for TF, PF, LHI
- 43 MVA voltage controlled LHI power supply
  - Multilevel buck converter
- Fully digital facility timing, control, and protection

New TF/PF Energy Storage and Switchyard Built





New LHI Arc and Bias Energy Storage and Switchyard Built



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Elimination of Solenoid Greatly Simplifies ST Design, Requires Non-Inductive Startup Pathway

PEGASUS-III at assembly, commissioning stage



Poster Presentations:

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