8^{th} Meeting of Executive Committee for the IEA Implementing Agreement on ST

Chaired by Dr. Jonathan Menard

Princeton Plasma Physics Lab, USA

25th Fusion Energy Conference (FEC 2014)
Saint Petersburg, Russia
15 October 2014, 5PM local time

1. Agenda

1. Roll-call / introduction of meeting participants, listing of agenda items
   - J. Menard/Y. Takase (5 mins)
2. Approval of meeting minutes from 7th ExComm meeting of ST IEA Implementing Agreement
   - ExCom (10 mins)
3. Report on the Forty-Third Meeting of FPCC (held January 28-29, 2014 in Paris, France)
   - S. Eckstrand, J. Menard, any other attendees/participants (5 mins)
4. Status reports from international ST programs
   - Japan –Yuichi Takase (20 mins)
   - UK/EU – B. Lloyd (25 mins)
   - U.S. – S. Eckstrand / J. Menard (25 mins)
5. Collaborative activities - status and proposals
   - Japan –Yuichi Takase (10 mins)
   - UK/EU – B. Lloyd (10 mins)
   - U.S. – S. Eckstrand / J. Menard (10 mins)
6. Discussion of plans for International ST Workshop 2015 (to be hosted by U.S./PPPL)
   - J. Menard and ExCom members (15 minutes)
7. Discussion of outreach to non-member countries (China, Russia, Korea)
   - ExCom (10 mins)
8. Discussion of Preparation of the 2014 Annual Report to IEA
   - ExCom members to discuss status (10 mins)
9. Discussion of next ExComm chairperson, new members
   - ExCom (5 mins)

1. ST-IA Executive Committee Roll Call

- Present membership:
  - Y. Takase (JA)
  - A. Komori (JA)
  - B. Lloyd (EU)
  - TBD (EU)
  - J. Menard (US)
  - S. Eckstrand (US)

- Possible Observers
  - Vasily K. Gusev (Russia)
  - Young-Hwa Ahn, Yong-Su Na, Yong-Seok Hwang (Korea)
  - Zhe Gao (China)

Need a volunteer to take notes/minutes for the meeting – Yuichi, Brian, Steve?

2. Overview of 7th ExCo meeting

- 7th ExCo meeting was held on 16 September 2013 in York, UK during first day of International ST Workshop 2013
  - Report on the 42nd meeting of FPCC
  - Status reports
  - Annual Report
  - Secretariat update
  - Collaborative activities
  - Outreach to non-member countries (in particular China)
- Minutes of meeting follow – we need to vote to approve

APPENDIX I

Minutes of the 7th Executive Committee of the IEA Implementing Agreement for Co-operation on Spherical Tori

IAEA IA on ST ExCo Mtg No. 7
Alfvén Room, York Plasma Institute, University of York, UK
16th September 2013 9.00 – 11.30am

Attendees:
Martin Peng (US, Chair)
Jon Menard (US) – substitute for Steve Eckstrand (US)
Yuichi Takase (JA)
Brian Lloyd (EU)
Kieran Gibson (EU) – invited for item 1
Zhe Gao (China) – observer

Apologies:
Akio Komori (JA)
Steve Eckstrand (US)
Carrie Pottinger (IEA)

The chairman welcomed Prof. Zhe Gao as an invited observer from China.

(1) International Spherical Tokamak Workshop
Kieran Gibson summarised the final arrangements for ISTW 2013. The ExCo invited the U.S. delegates to propose a venue for ISTW 2015.

(2) Minutes of ExCo Mtg No. 6
The Minutes had been finalized and incorporated as an Appendix to the Annual Report for 2012. B. Lloyd reported that the EU member to replace Ruggero Giannella has still not been nominated and he agreed to look into it.

(3) Report on the 42nd meeting of the FPCC, Paris 22 – 23 Jan. 2013
A brief report on the 42nd Meeting of the Fusion Power Coordinating Committee was given by Y. Takase. Key points:

- The EU Fusion Roadmap was presented by F. Romanelli. As yet there is no common Fusion Roadmap.
- Energy R & D – the strategy should not be decided independently of energy policies.
- SSO Co-ordination Group – informal working group encompassing the different IAs and now co-chaired by Mutoh and Sips (see item (4) below).

- ITER update was given by the Director Prof. Motojima.
- Broader Approach update was given by Dr. Takatsu. JT-60SA first plasma is expected in 2019.
- Annual Reports of individual IAs – W7-X completion is now scheduled for 2014.

(4) Co-operation on Steady State Operation of Fusion Devices

Activities are covered by Annex III of the IA. K. Hanada is our representative on the SSO Co-ordination Group. The following activities have been proposed and accepted by the SSOCG:

- Particle balance studies (QUEST)
- Investigation of tungsten and/or other metal dust formation (QUEST)

The following activities are under consideration but have not yet been proposed:

- Mitigation of heat loads using newly developed divertor concepts (NSTX, MAST, QUEST)
- Fully non-inductive current drive and start-up (LATE, TST-2, TS-3, TS-4, HIST, QUEST, NSTX, MAST)

(5) Status Reports & Collaborative Activities

Status and near-future plans were reported from the three Contracting Parties.

- status, highlights and plans of the JA program (Takase)
- status, highlights and plans of the EU program (Lloyd)
- status, highlights and plans of the US program (Peng)

The reports also included summaries of on-going collaborative activities under the IEA Implementing Agreement.

(6) Preparation of Annual Report

Y. Takase reminded ExCo that the Annual Report must be submitted to IEA by 1 December 2013 and needs to be in the format adopted for the 2012 report. Presenters of the status reports agreed to submit a short written summary for inclusion in the Annual Report.

(7) Outreach to non-OECD member countries

The chair had initiated the process of inviting Russia and China to join the Implementing Agreement and Prof. Gao (China) was attending the ExCo meeting as an observer. Prof. Gao noted that Prof. He was involved in the Co-ordinated Tokamak Programme (CTP) Implementing Agreement and said that he would consult Prof. He regarding the process of progressing Chinese involvement in the Spherical Tori Implementing Agreement.

(8) AOB

It was noted that so far there had been limited activity on Annex II - Co-operation on the Physics and Technology of Future Spherical Torus Devices. It was agreed to review the status of Annex II and begin exploratory exchanges between partners before the next meeting of the ExCo.

3. Report on the Forty-Third Meeting of FPCC

(held January 28-29, 2014 in Paris, France)

- EU:
  - MAST M9 Campaign physics results
  - MAST Upgrade construction progress
  - Proto-Sphera construction progress
- US:
  - Pegasus helicity injection results successfully modelled w/ NIMROD
  - LTX lithium wall results (higher confinement w/ solid Li vs. liquid)
  - NSTX Physics results, NSTX Upgrade Progress
- Japan:
  - QUEST – full non-inductive CD with 28GHz EC/EBW
  - TST-2 – Ip Start-up by LHW: Comparison of 3 Antennas
  - HIST – Direct ion heating in double-pulsing CHI on HIST
  - TS-4 – First NBI injection into very high beta ST
  - LATE – Preparation for first ion beam probe measurements

3. A3 Foresight Summer School and Workshop on Spherical Torus (ST) 2014

June 30- July 4, 2014 Kensington Resort, Jeju, Korea

- ST Overview – Peng (USA)
- Basic Fusion Plasma Physics – Na (SNU)
- RF Heating and CD – Takase (U. Tokyo), Kim (KAERI)
- EC/EBW H&CD – Maekawa (Kyoto Univ.)
- Plasma Diagnostics – Ejiri (U. Tokyo)
- Principles of RF H&CD – Gao (Tsinghua Univ.)
- Helicity Injection – Hwang (SNU)
- Tokamak Simulation – Fukuyama (Kyoto Univ.)
- Fusion Energy Applications – S. Konishi (Kyoto Univ.)
- NBI heating and CD – Inomoto (Univ. Tokyo)
- Merging Start-up of ST – Y. Ono (Univ. Tokyo)

4. Status reports from international ST programs

- Japan –Y. Takase
- UK/EU – B. Lloyd
- U.S. – S. Eckstrand / J. Menard

ST Research Status Report for 2014 (Japan)

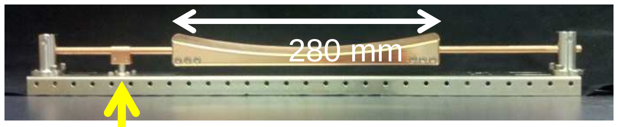
Yuichi Takase
The University of Tokyo

Eighth IEA ST ExCo meeting, York, UK
15 October 2014

Successful I_p Start-up by Lower Hybrid Wave

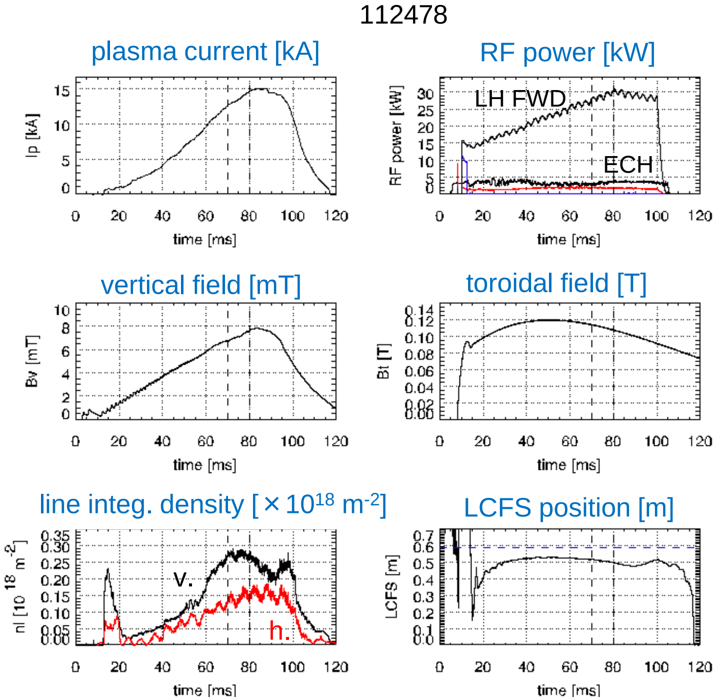
TST-2

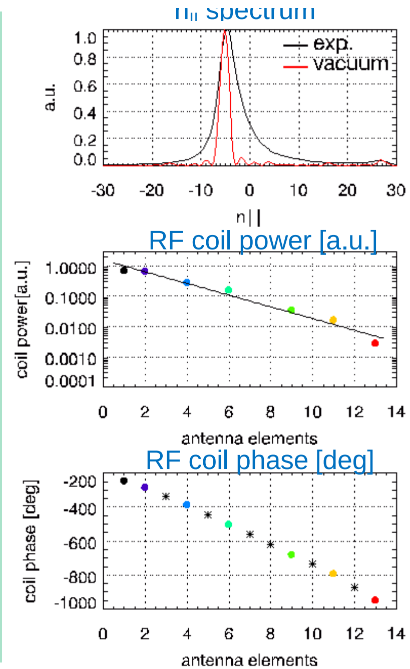
Capacitively-coupled combline (CCC) antenna



feeder at 50Ω input impedance

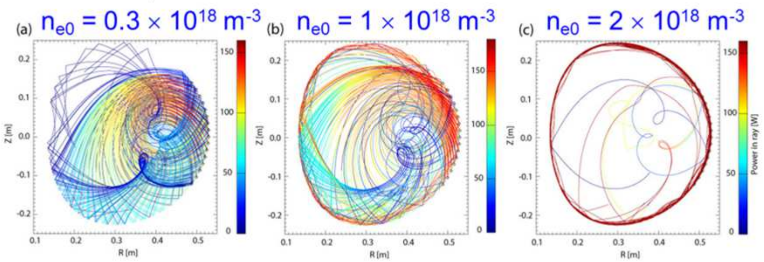
excites uni-directional LHW with sharp $k_{||}$ spectrum



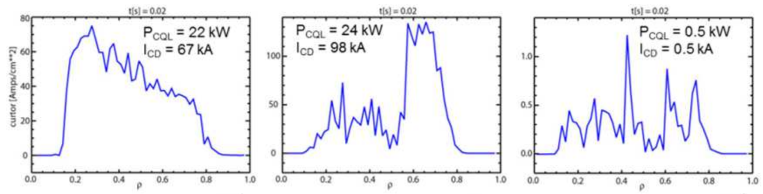


must maintain low density (< 10^{18} m^{-3})

B_t = 0.1 T; I_p = 12 kA; f_{RF} = 200 MHz; P_{RF} = 25 kW; T_{e0} = 0.1 keV

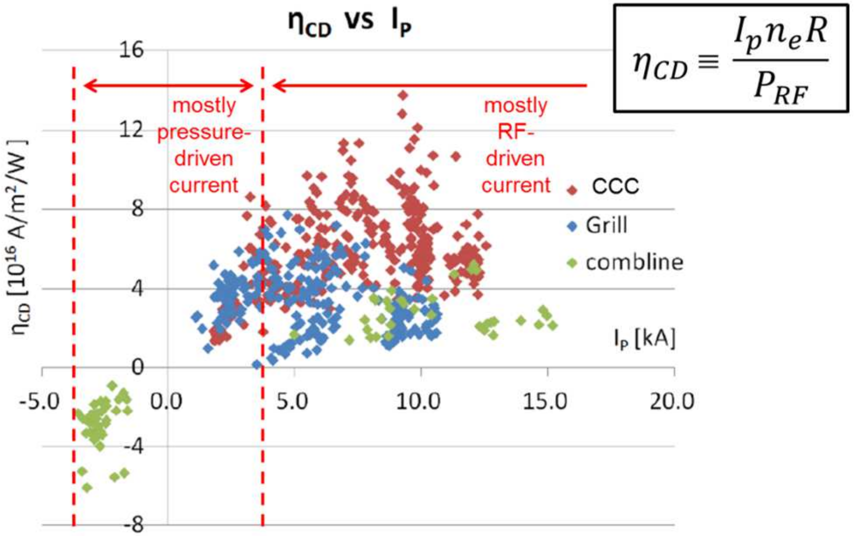


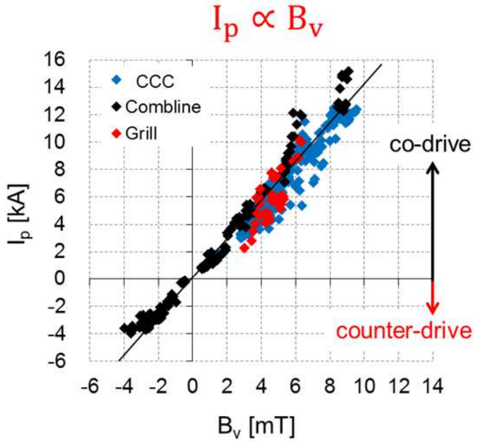
j (ρ)

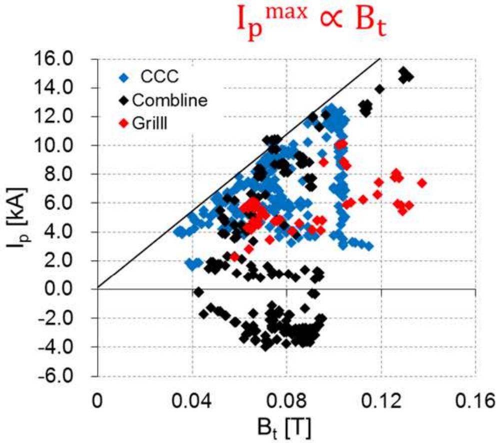


Higher CD Efficiency Expected at Higher B_t

TST-2

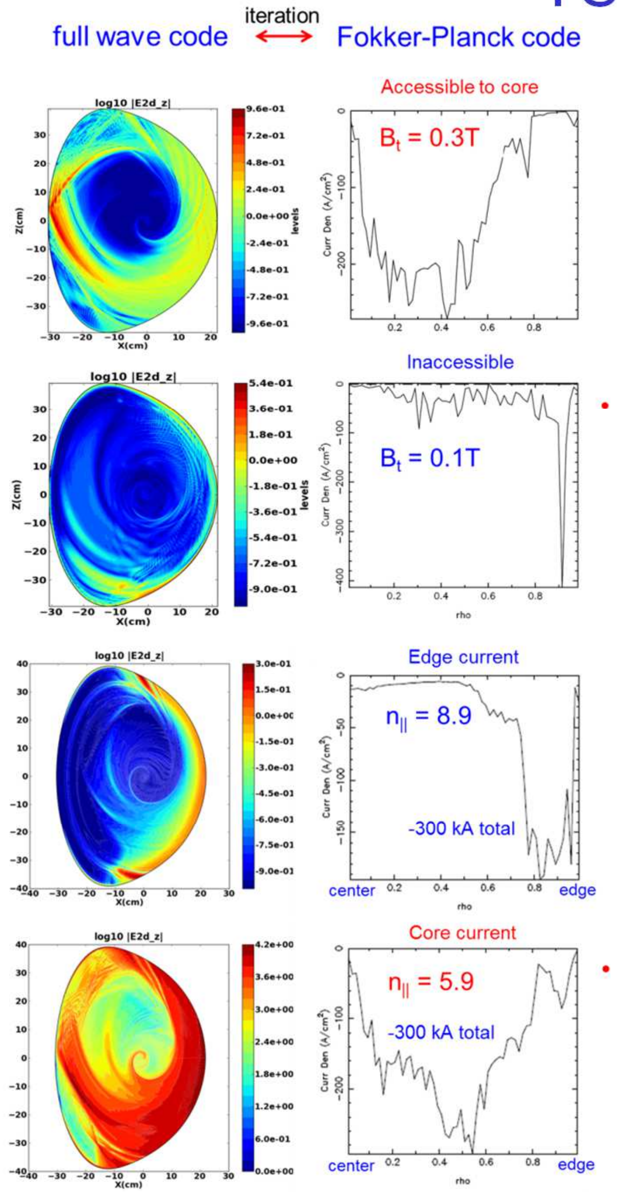






An order of magnitude improvement in η_{CD} may be possible by suppression of edge wave power loss and fast electron loss

$\rightarrow$ operation at higher B_t, n_e, I_p , P_{RF}, T_e



n_{e0} = 1 × 10^{18} m^{-3}
T_{e0} = 0.2 keV
$n_{||}$ = 4.5

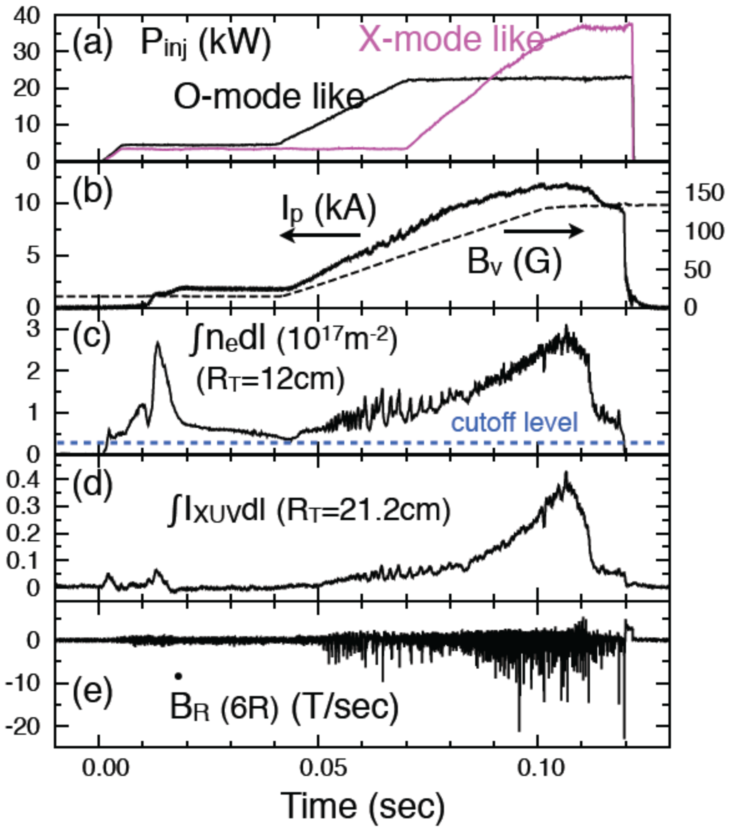
- B_t must be high enough to ensure LHW accessibility to the plasma core.

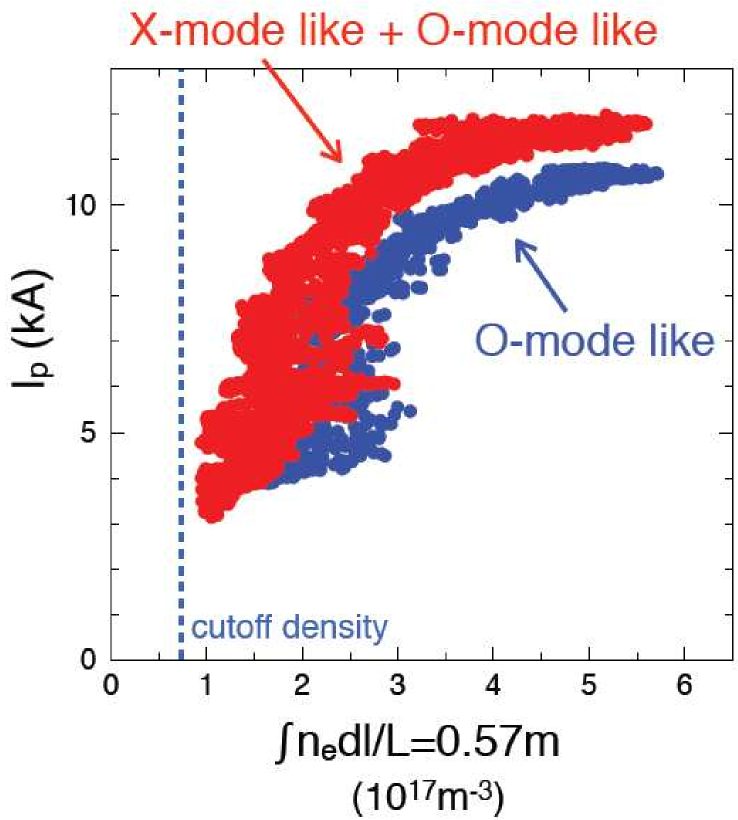
n_{e0} = 10^{18} m^{-3}
B_t = 0.3 T
T_{e0} = 0.2 keV
P_{RF} = 100 kW

- $n_{||} = ck_{||}/\omega$ must be lower to avoid edge absorption of LHW.

collaboration with Bonoli, Wright (MIT, US)

Non inductive Startup of a Highly Overdense Spherical Torus Plasma using Polarized Waves for EB Wave Heating and Current Drive





* Total injection power of 60 kW from four 2.45 GHz magnetrons.
* X-mode like polarization and O-mode like polarizations have been compared.
* O-mode like polarizations can generate a highly over dense ST plasma.
* Combination of both polarizations is better for current ramp up .
* Fast magnetic activity arises in the last stage and deteriorates the discharge.

Future Plan for LATE

- Total injection of 80 kW from four 2.45 GHZ 20kW magnetrons using fully polarized waves for EB wave Heating/Current Drive in highly over dense plasmas.

- Suppression of fast magnetic activity by increasing vertical elongation of the plasma cross section.

- Potential measurement in highly overdense plasmas using a rubidium ion beam probe.

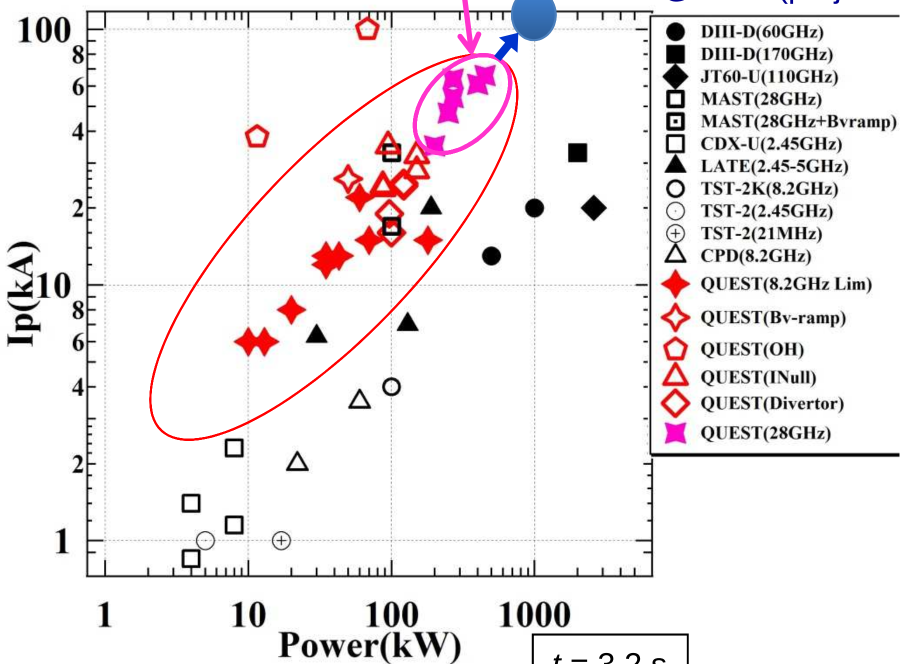
Achievements of QUEST plasma

QUEST Advanced Fusion Research Center

2010.2 ~10 kA 0.8 sec
2012 ~ 35 kA
2013 ~52-66 kA

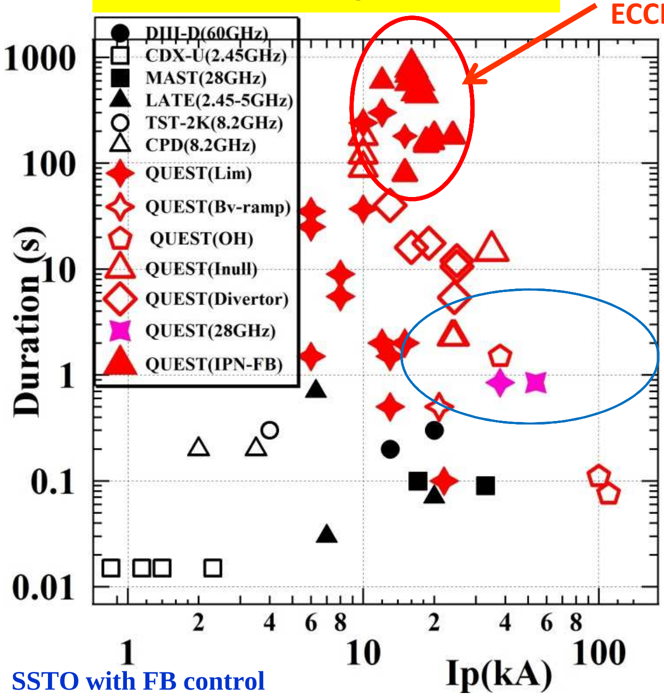
In collaboration with U. Tsukuba
(2nd harmonic off-axis 28 GHz ECCD)

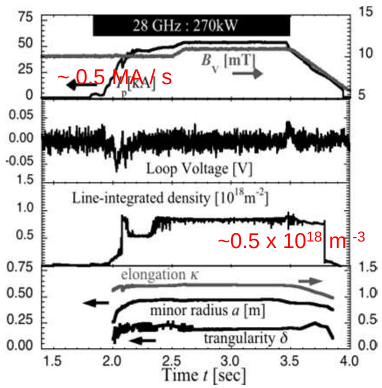
100 kA @1MW (projection)

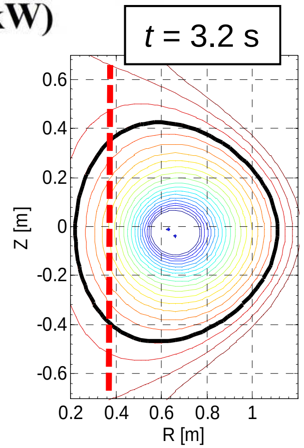


2010.2 ~10 kA 0.8 sec
2012-13 300sec @ ~10 kA
2014 810 sec @ 16 kA

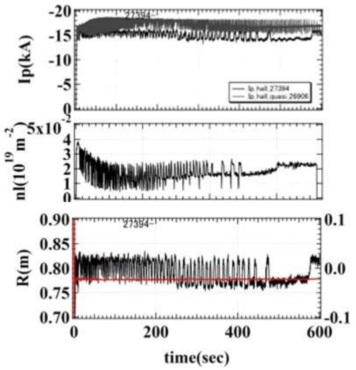
SSTO by 8.2GHz ECCD/EBCD

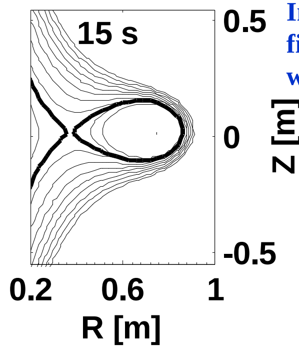






SSTO with FB control of recycling flux



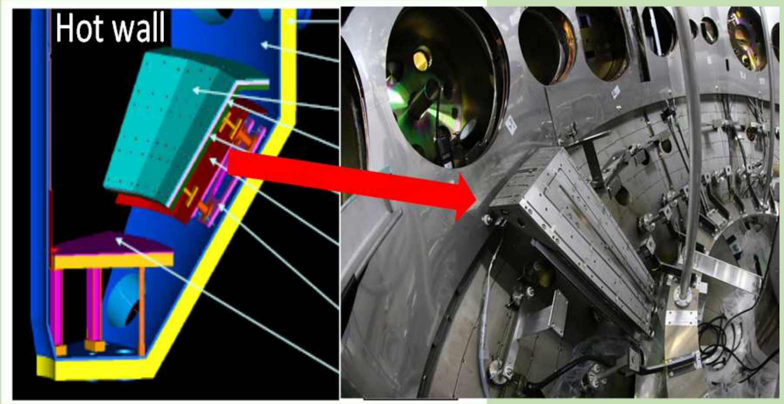


Inboard poloidal field null config. with high β_p (> 3)

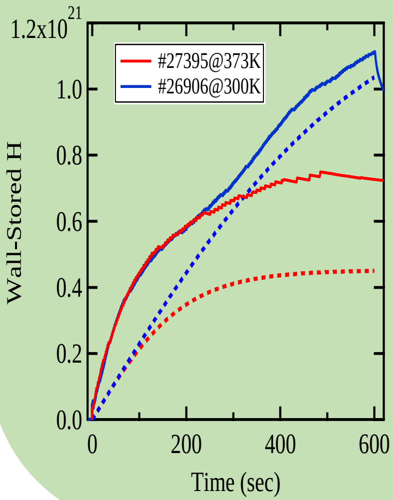
Future Plan of QUEST

Improvement of controllability of wall-pumping

Hot wall experiment supported by JSPS



Dependence of wall-pumping rate on wall temperature in QUEST long duration plasmas



QUEST wall model decided by reconstruction of TDS after D_2^+ ion implantation

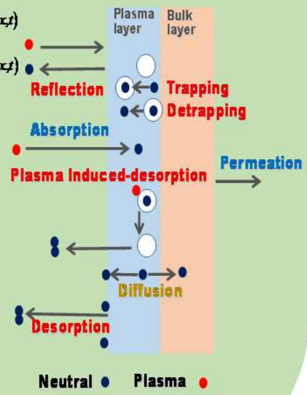
$$\begin{cases} \frac{\partial C_W(x,t)}{\partial t} = D\frac{\partial^2 C_W(x,t)}{\partial x^2} + G(x,t) - \frac{\partial C_{TA}(x,t)}{\partial t} - \frac{\partial C_{TB}(x,t)}{\partial t} - k_A C_{TA}(x,t)G(x,t) - k_B C_{TB}(x,t)G(x,t) \\ \frac{\partial C_{TA}(x,t)}{\partial t} = \beta_A C_W(x,t)F_A(x,t) - k_A C_{TA}(x,t)G(x,t) \\ \frac{\partial C_{TB}(x,t)}{\partial t} = \beta_B C_W(x,t)F_B(x,t) - k_B C_{TB}(x,t)G(x,t) \end{cases}$$

$$\begin{cases} \left.\frac{\partial C_W(x,t)}{\partial x}\right|_{x=0} = kC_W^2(0,t) \\ \left.\frac{\partial C_W(x,t)}{\partial x}\right|_{x=x_{max}} = -kC_W^2(x_{max},t) \end{cases}$$

$$G(x,t) = G_0 e^{-(x-x_0)^2/s_r^2}$$

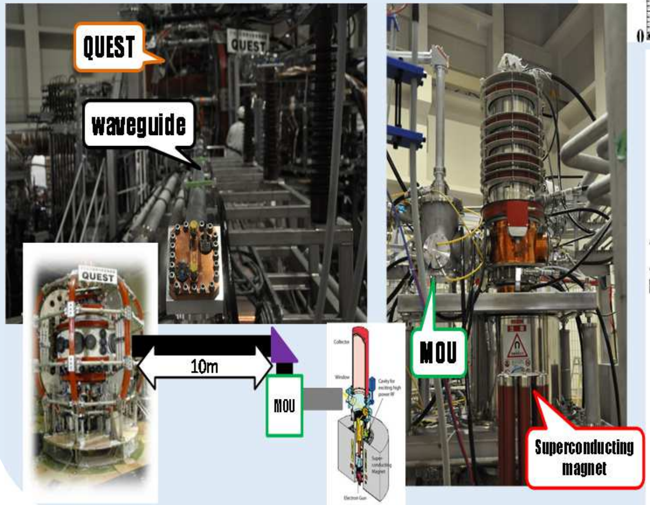
$$F_A(x,t) = \begin{cases} 1 - \frac{C_{TA}(x,t)}{C_{TA}^0} & C_{TA}(x,t) < C_{TA}^0 \\ 0 & C_{TA}(x,t) \geq C_{TA}^0 \end{cases}$$

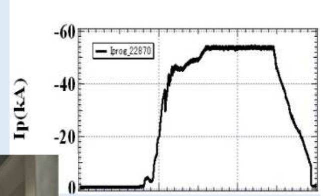
$$F_B(x,t) = \begin{cases} 1 - \frac{C_{TB}(x,t)}{C_{TB}^0} & C_{TB}(x,t) < C_{TB}^0 \\ 0 & C_{TB}(x,t) \geq C_{TB}^0 \end{cases}$$

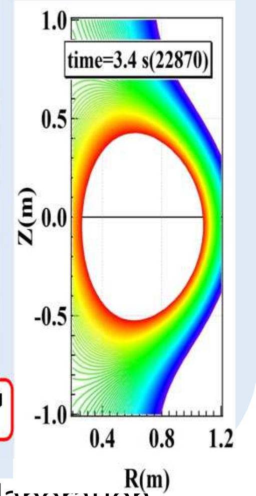


Improvement of controllability of core and SOL plasma

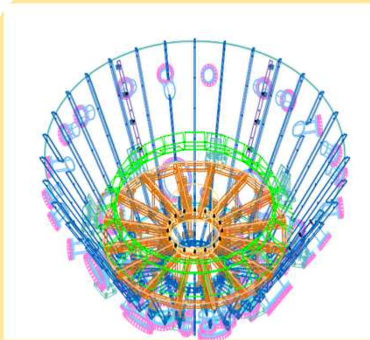
28GHz ECCD experiment with Tsukuba University and NIFS

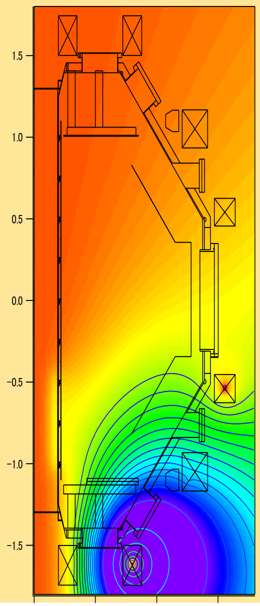


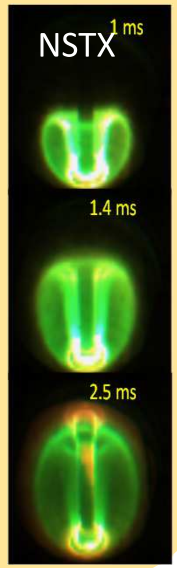




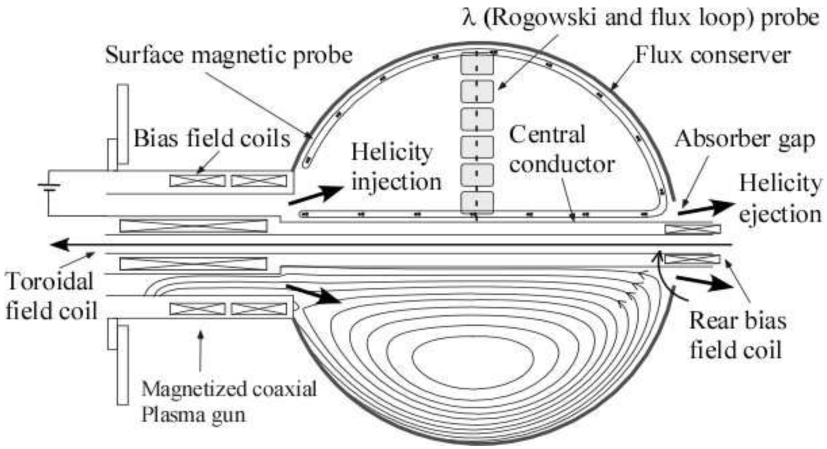
CHI experiment of QUEST-NSTX-U collaboration

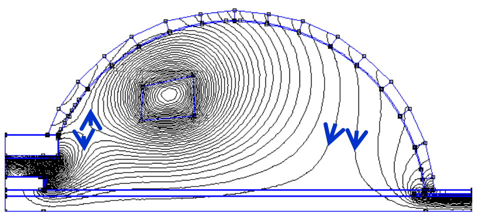


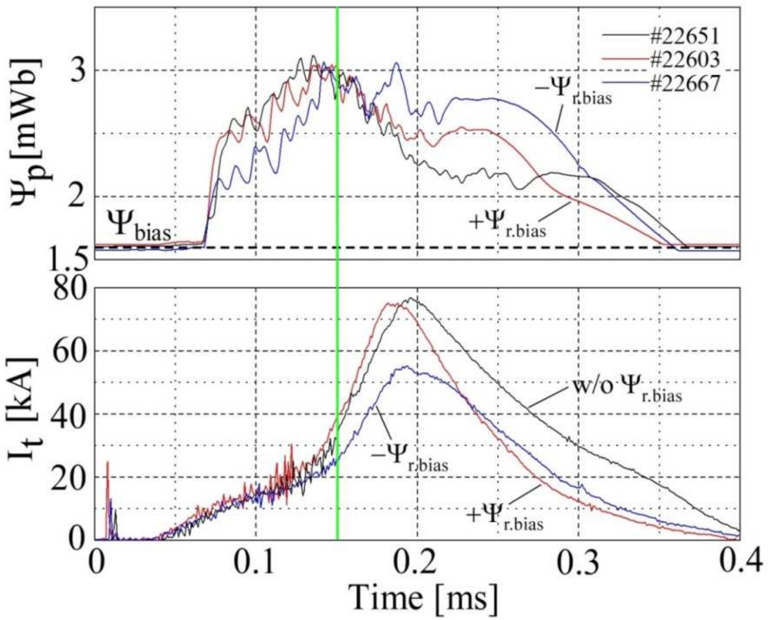




Transient CHI experiments on HIST





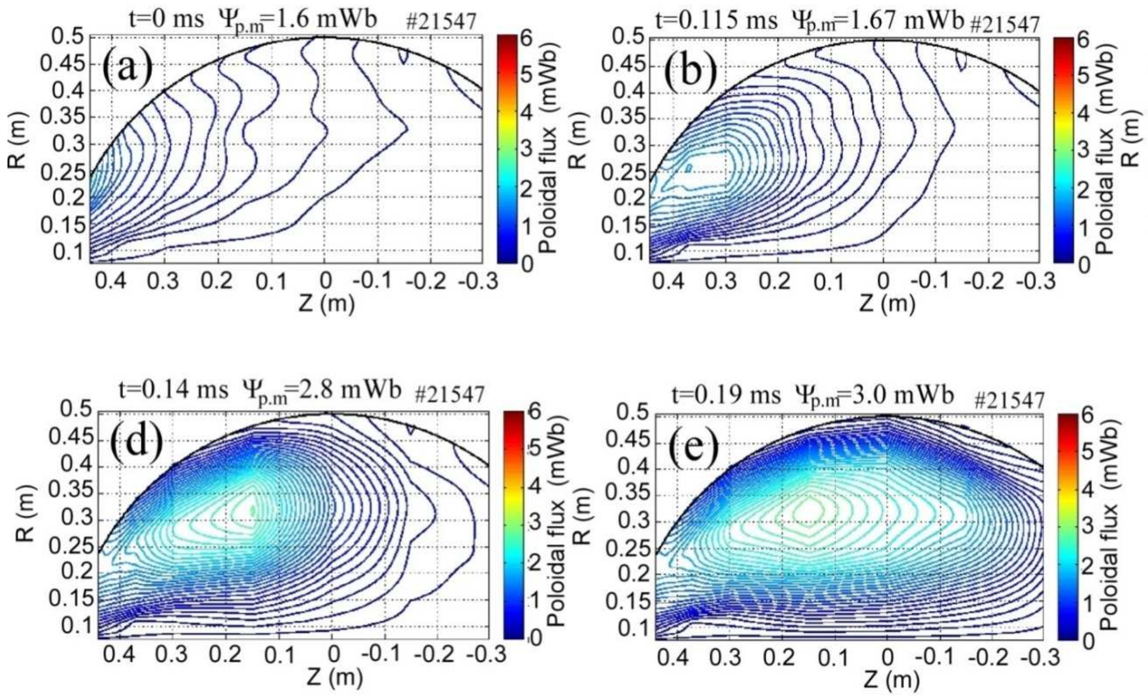


Rear Bias Field (Negative direction, $-\Psi_{r.bias}$)

- Transient coaxial helicity injection (T-CHI) has been successfully demonstrated on HIST as well as HIT-II (UW) and NSTX (PPPL) for solenoid-free plasma start-up in a ST.

- To avoid the arcing phenomena at the absorber gap of the FC, we applied the bias flux around the rear gap of the FC. The Application of rear bias flux with a negative polarity reduced the arcing, leading to the longer stable maintenance of the poloidal flux.

Verification of closed poloidal magnetic flux (Flux closure) generated by T-CHI on HIST



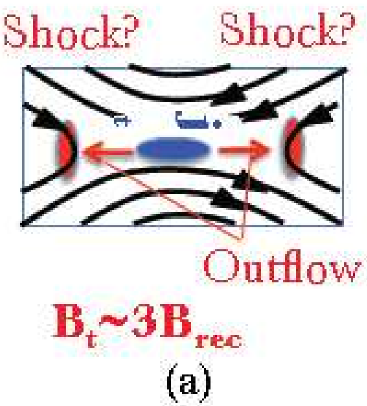
$\Psi_{p.closed} / \Psi_{p.total}$=43%

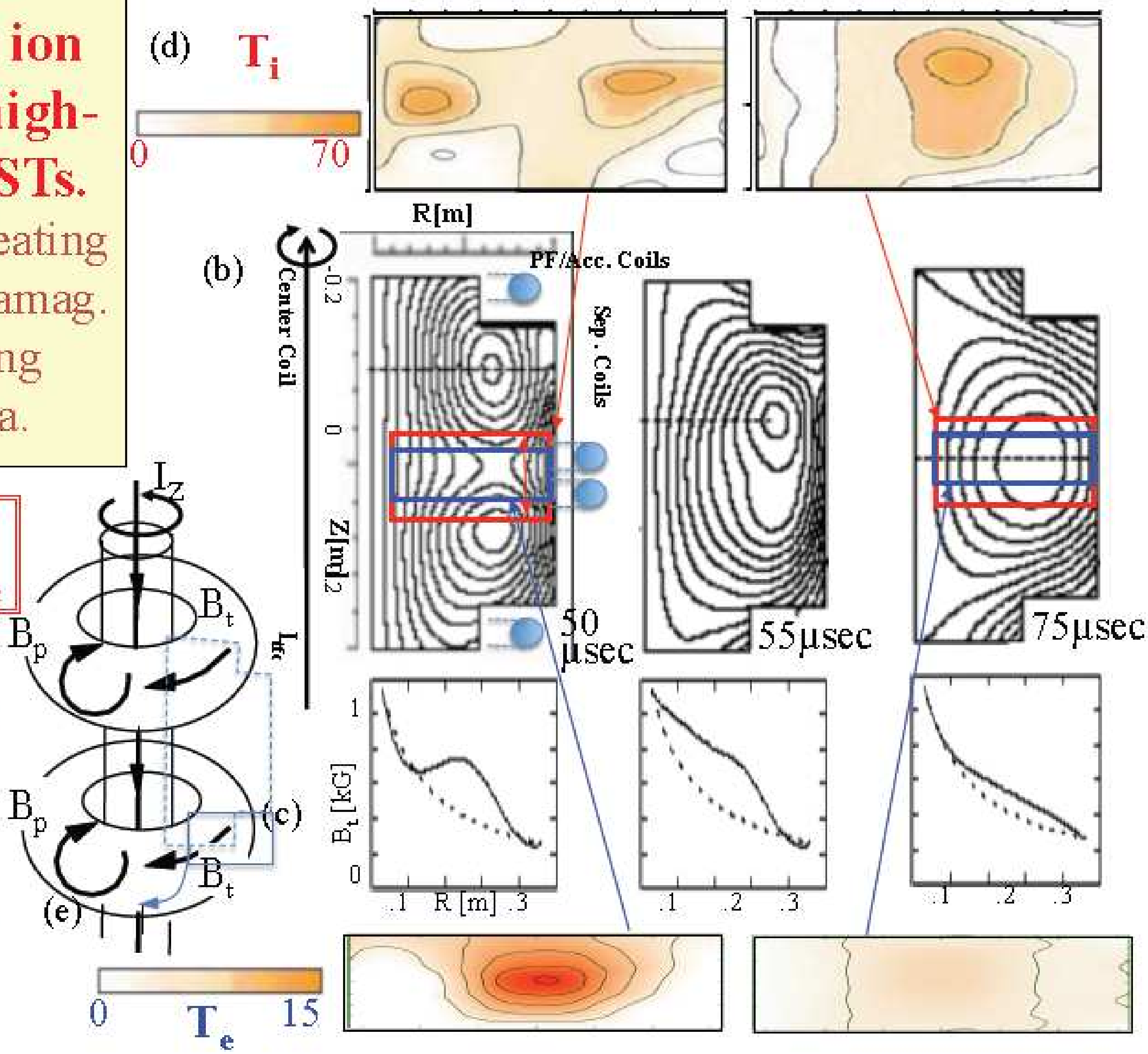
- The internal magnetic field measurements have verified the formation of the closed flux surfaces (flux closure) during the start-up phase.
- The formation of an X-point after bubble burst has been generated by magnetic reconnection event.
- The closed poloidal flux increases proportionally with the toroidal current I_t as increasing the injection voltage V_{inj}.

Significant ion heating of high-q merging STs.

High power heating suppresses paramag. B_t, increasing plasma beta.

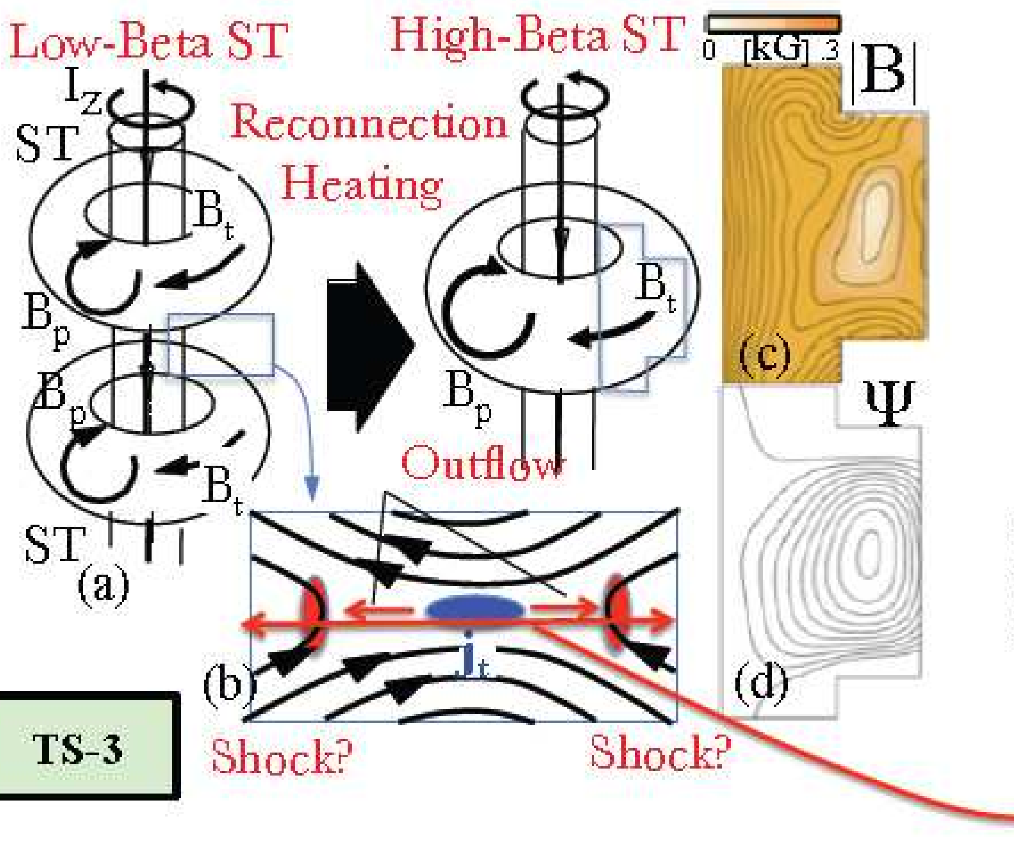
Ono PRL11
TS-3 $B_t \approx 5B_{rec}$

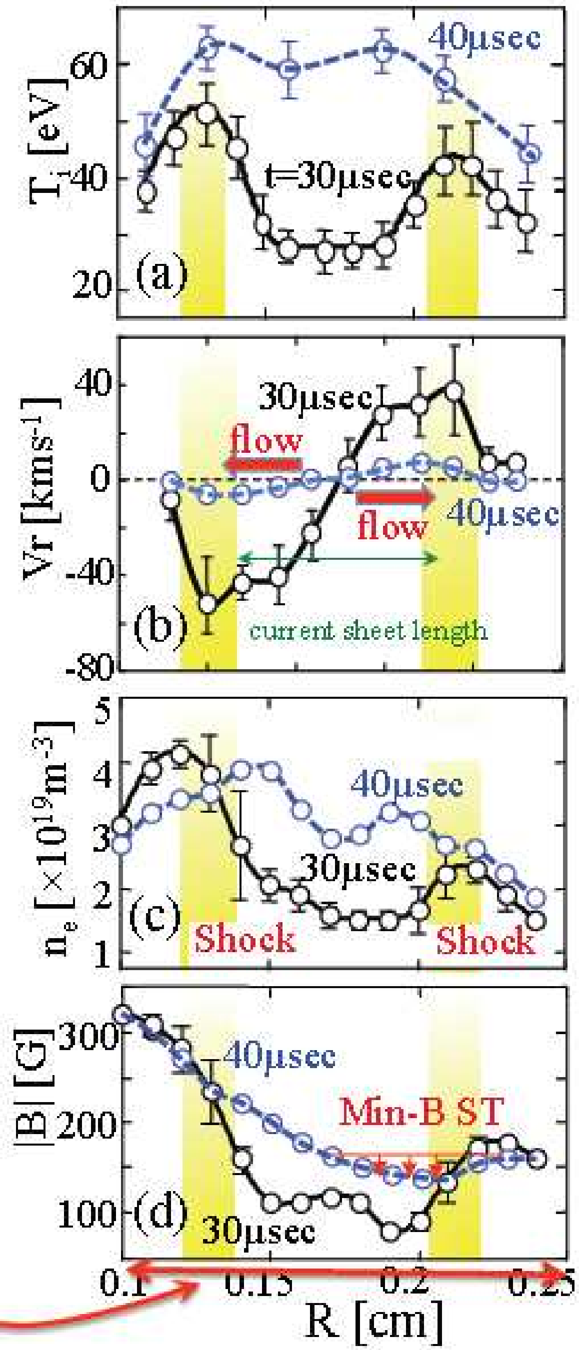




Merging formation of high-ß ST TS-3

Merging/rec. heating for abs. min-B formation

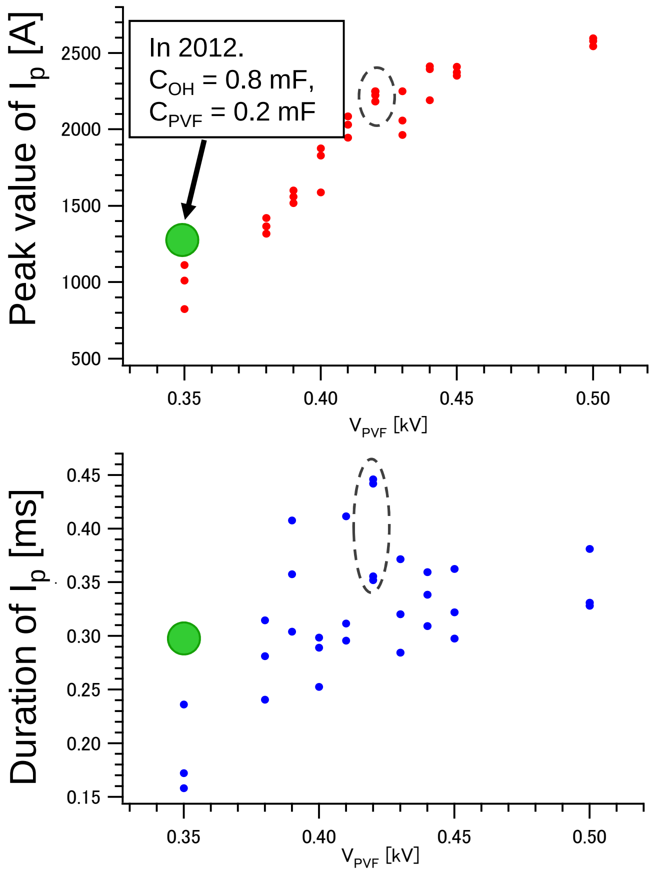




Spherical Tokamak-Stellarator Hybrid (TOKASTAR-2) experiment in Nagoya University

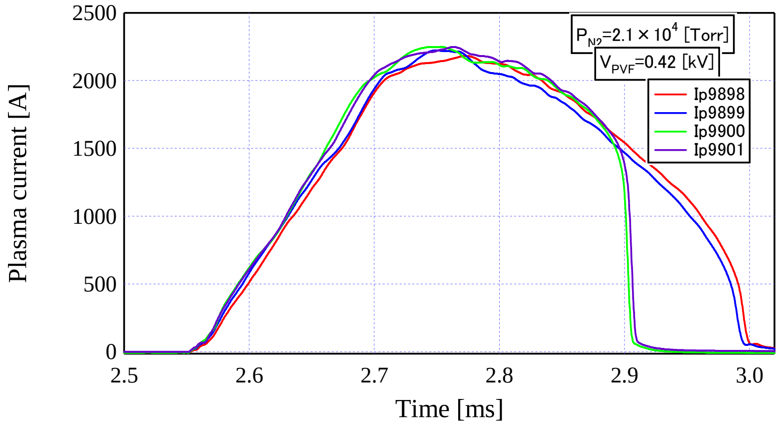
FUJITA Lab.

Data in 2014
wtih C_{OH} = 0.4 mF, C_{PVF} = 0.2 mF



Voltage of capacitor for PVF coil circuit [kV]

- Waveform of the vertical field was optimized by changing C_{OH} and C_{PVF} (capacitance of capacitors for the OH and PVF coil circuits).
- Higher plasma current (I_p ≤ 2.5 kA) with longer duration (≤ 0.45 ms) was achieved.
- Further optimization of the vertical field (n-index and/or waveform) is planned to produce lower A (2-2.5) plasmas closer to the outer helical field coils.



I_p waveform for 4 shots with V_{PVF} = 0.42 kV.

Tokastar-2 parameters
- Working gas : Helium or Nitrogen
- R_p ~ 0.12 m, a <~ 0.05 m
- B_t ~ 0.0875T at R = 0.08 m
- ECW (2.45GHz) for pre-ionization and heating.

IEA ExCo Oct 2014

EU Status

Brian Lloyd

CCFE

Research Councils UK Energy For a Low Carbon Future

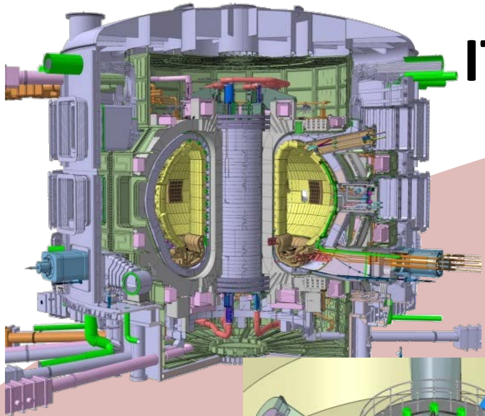
CCFE is the fusion research arm of the **United Kingdom Atomic Energy Authority**

Jointly funded by EURATOM & RCUK Energy Programme

CCFE CULHAM CENTRE FOR FUSION ENERGY

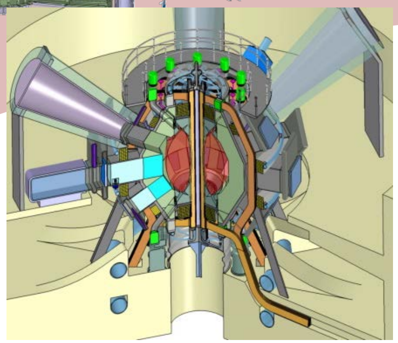
MAST Mission

MAST advances physics understanding to support fusion energy development

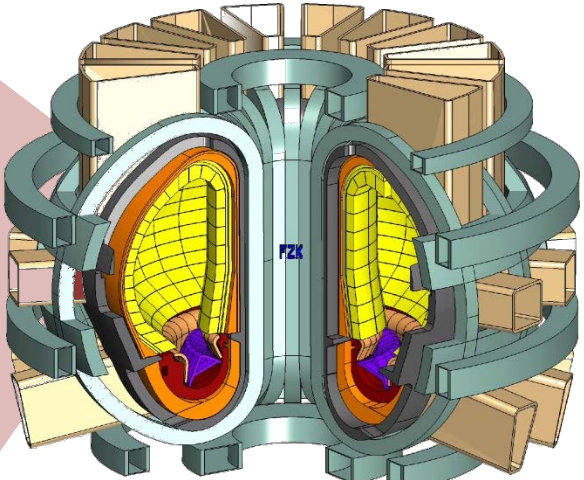


ITER

1. Understanding key physics issues for ITER



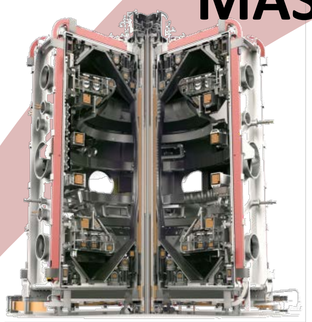
CTF



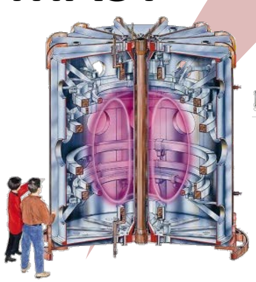
DEMO

2. Guiding DEMO and reactor design (including via an ST-CTF)

MAST-U



MAST



3. Innovation and advancing fusion prediction

MAST M9 campaign

Final MAST campaign (M9) was completed on 27th Sep 2013

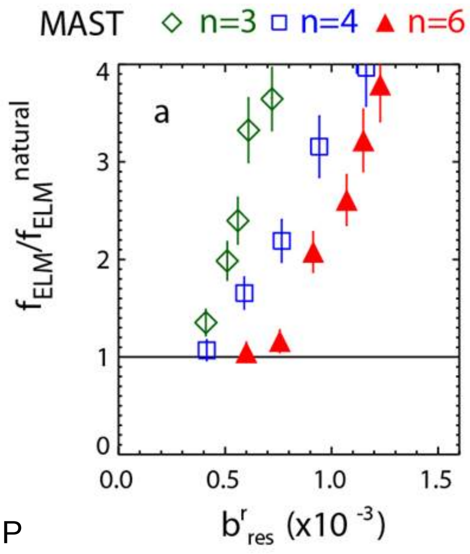
Good progress was made on all the M9 headlines agreed with MAST PAC*

- ELM control with 3D magnetic perturbations
- Evolution and stability of the edge pedestal
- Role of ion-scale turbulence in core transport
- Development of integrated scenarios for the MAST upgrade
- Development and benchmarking of edge modelling tools in support of the divertor upgrade
- Fast-ion transport to guide profile and heating optimisations

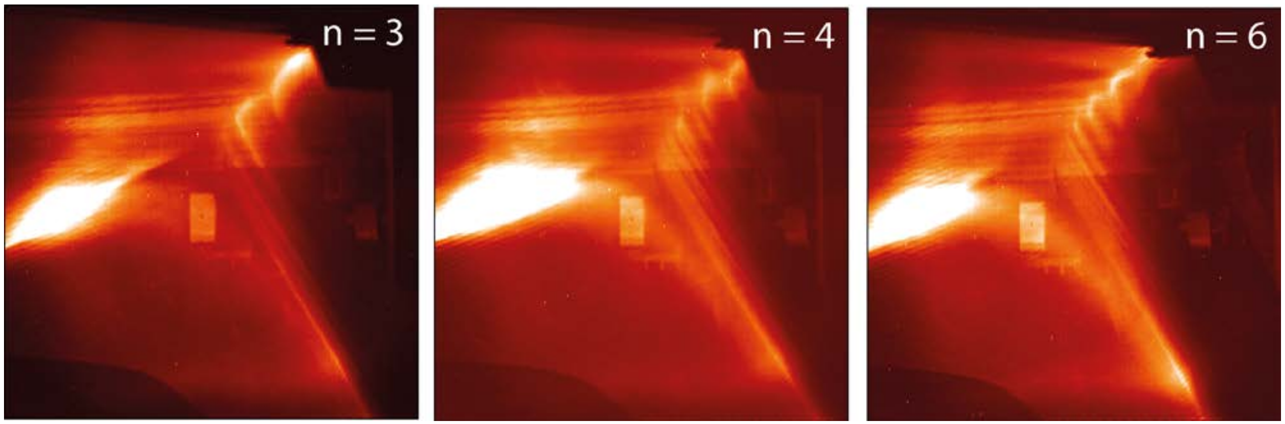
** See presentations/papers at IAEA FEC 2014*

Controlling ELMs with RMPs

- MAST is uniquely placed to assess the merits of different RMP configurations with n=2,3,4,6
- Threshold to mitigate ELMs is lower for lower n_{RMP}



- Lobes radially extended & poloidally local for higher n_{RMP}



- Access to H-mode, fast ion losses, rotation braking and plasma boundary corrugation optimised for n=3,4

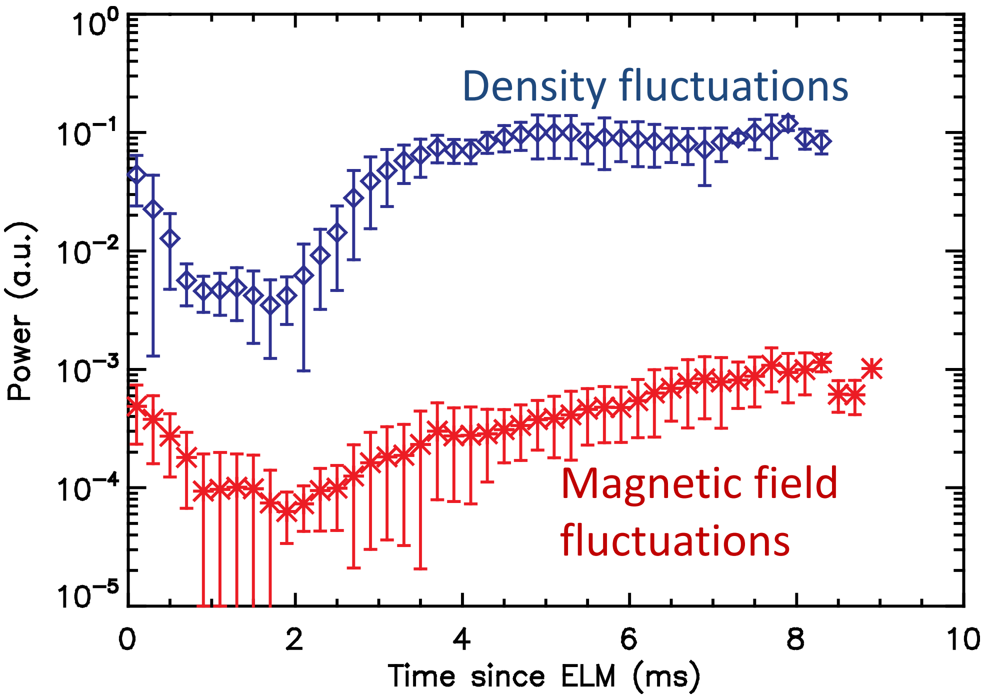
MAST M9 campaign

M9 was characterised by strong UK university and international collaborator involvement including provision of *new* diagnostics:

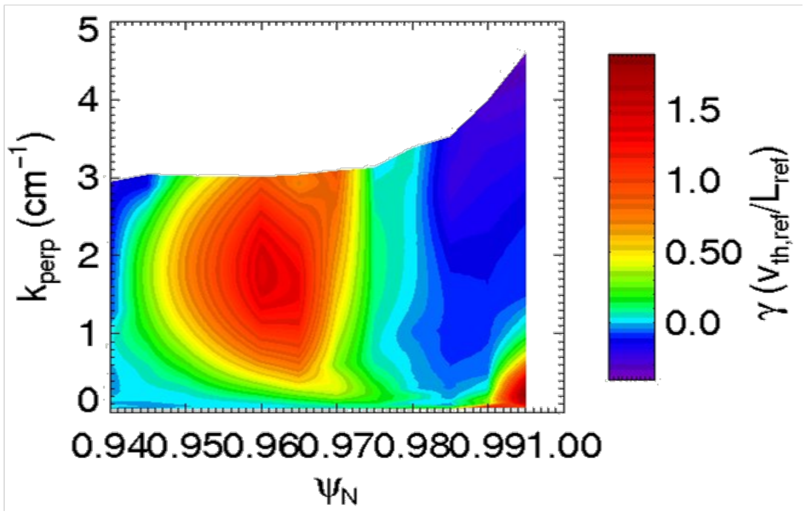
- Coherence imaging (with Australian National University, Durham University);
- Proton detector (with Florida International University, PPPL);
- Doppler back-scattering (with University of California, Los Angeles);
- Ball-pen probe (with University of York)
- Pellet imaging (with NIFS, Japan)

Mid-k turbulence mediates pedestal evolution

- Cross-polarization Doppler Backscattering used to measure local, internal magnetic field fluctuations
- MTMs and ETG predicted unstable at pedestal top by GS2 gyrokinetic code at same position and similar wavenumber



- Increase in density fluctuations consistent with arresting n_e recovery



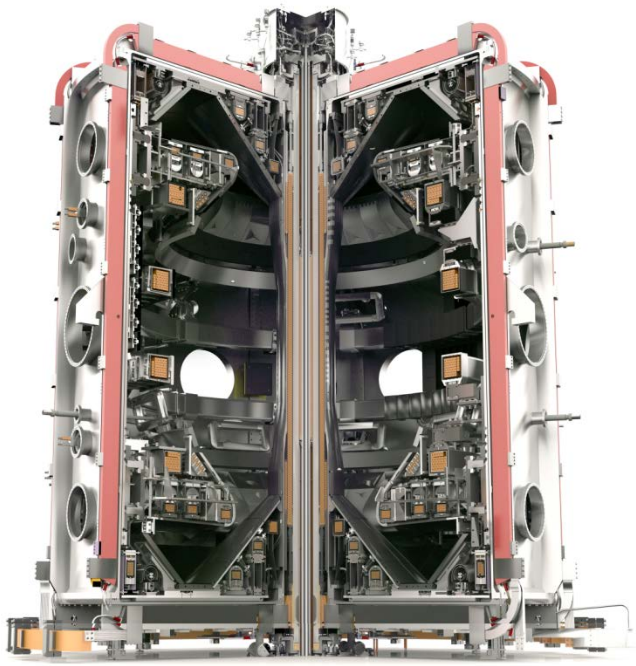
MAST Upgrade

Goals

- ❑ Test a range of novel exhaust concepts including the Super-X divertor
- ❑ Contribute to the ITER/DEMO physics base to improve predictive capability
- ❑ Explore the physics viability of a ST– based Component Test Facility

Features

- ❑ New centre column incl. solenoid
  - up to 50% higher toroidal field & plasma current ($\leq$ 2MA)
  - longer pulse length (0.8s $\rightarrow$ 5s)
- ❑ 19 new poloidal field coils
  - better shape control, higher κ, δ
  - allows advanced divertor configurations, e.g. Super-X, snowflake
- ❑ Closed, cryopumped, divertor chamber
  - lower main chamber neutral pressure
- ❑ Increased power (up to 10MW NBI, 2MW EBW)
  - better profile control (e.g. adaptable beam geometry)
  - fully non-inductive operation possible



MAST Upgrade

Increased TF
Improved confinement

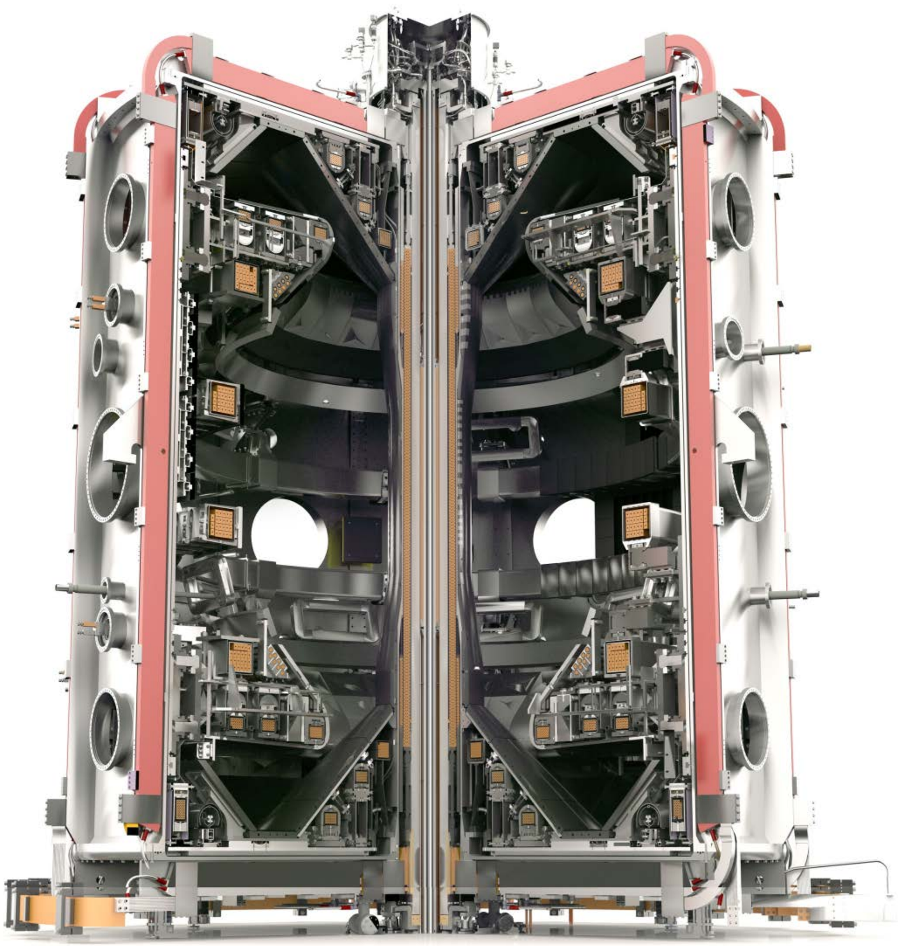
New Solenoid
Greater I_p, pulse duration

19 New PF Coils
Improved shaping

Super-X Divertor
Improved power handling

Off-Axis NBI
Improved profile control

MAST-Upgrade after initial construction ("core scope")



MAST Upgrade

Increased TF
Improved confinement

New Solenoid
Greater I_p, pulse duration

19 New PF Coils
Improved shaping

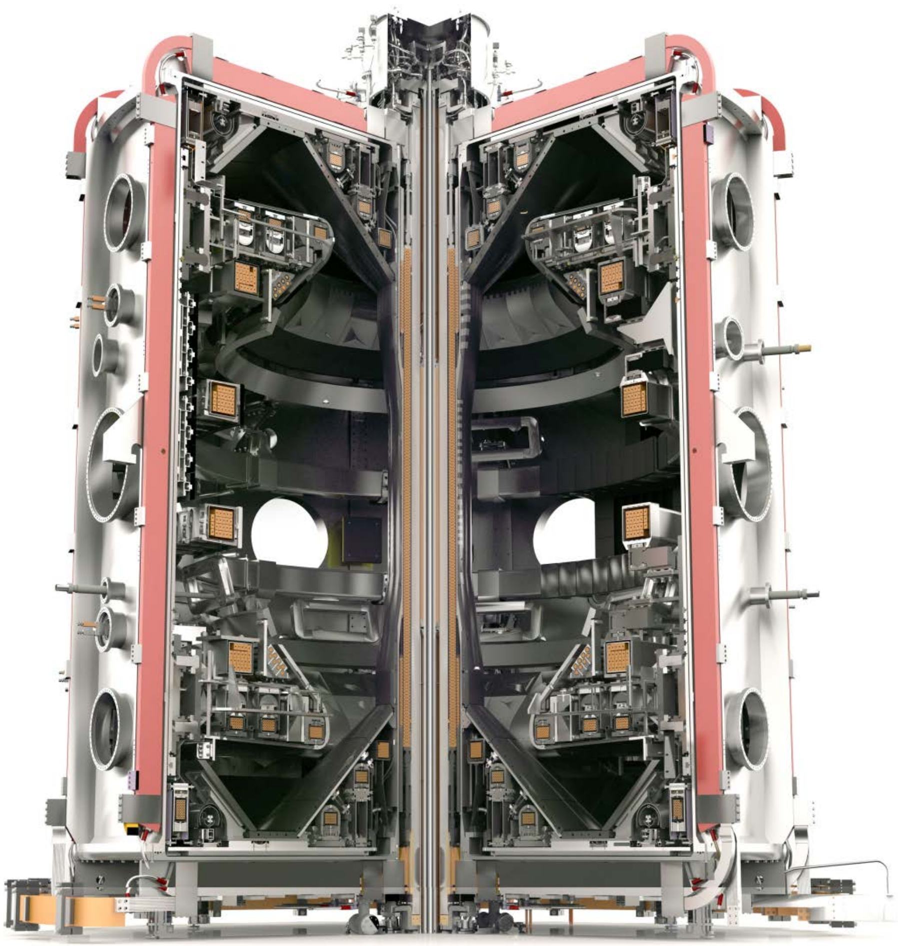
Super-X Divertor
Improved power handling

Off-Axis NBI
Improved profile control

Cryoplant
Divertor particle control

Double NBI Box
Increased auxiliary heating

MAST-Upgrade after Stage 1



MAST Upgrade

Increased TF

New Solenoid

19 New PF Coils

Super-X Divertor

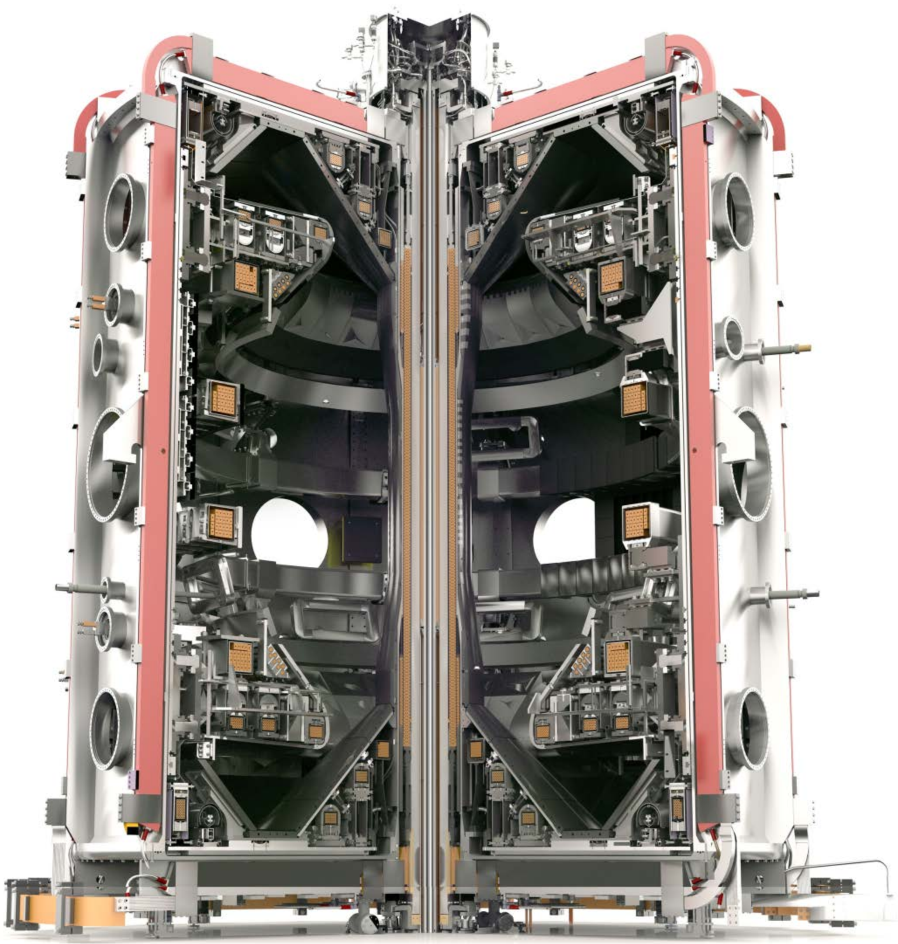
Off-Axis NBI

Cryoplant

Double NBI Box
2nd PINI in beam box

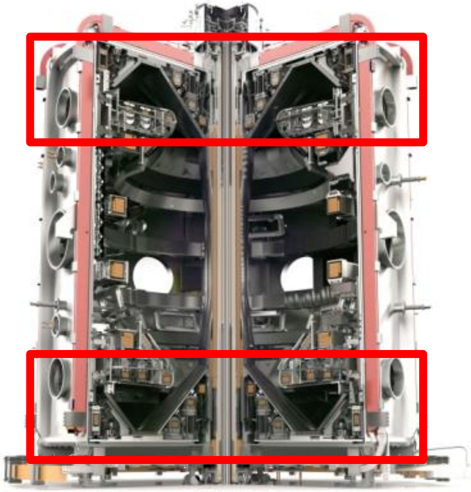
2MW EBW Heating
Solenoid-free startup
Increased auxiliary heating

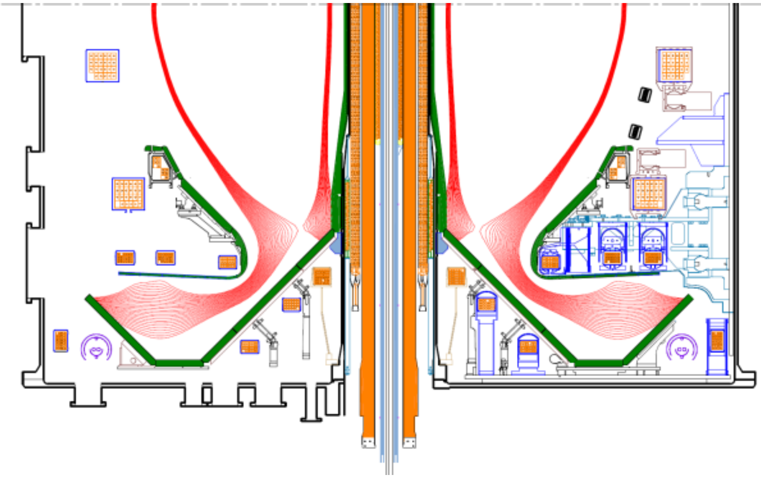
MAST-Upgrade after Stage 2

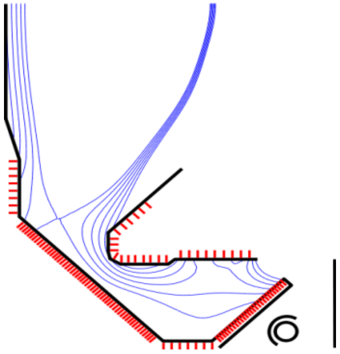


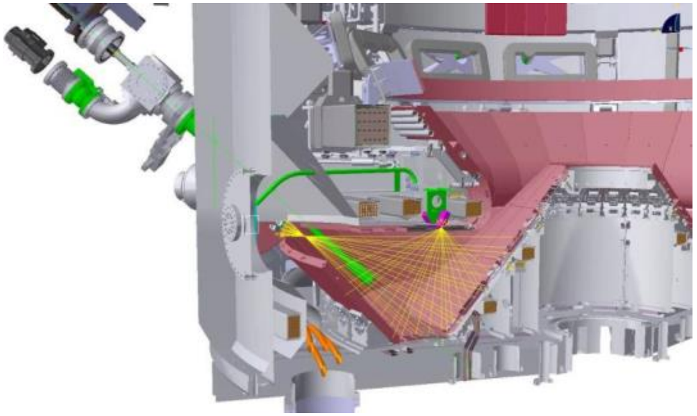
MAST Upgrade

- Divertor
  - Highly flexible
    - 8 sets of shaping coils for each divertor
    - Wide range of strike point locations
  - Well diagnosed
    - > 500 Langmuir probes
    - > 400 Pick up coils
    - Comprehensive bolometry
    - Divertor Science Facility
    - Divertor Thomson scattering



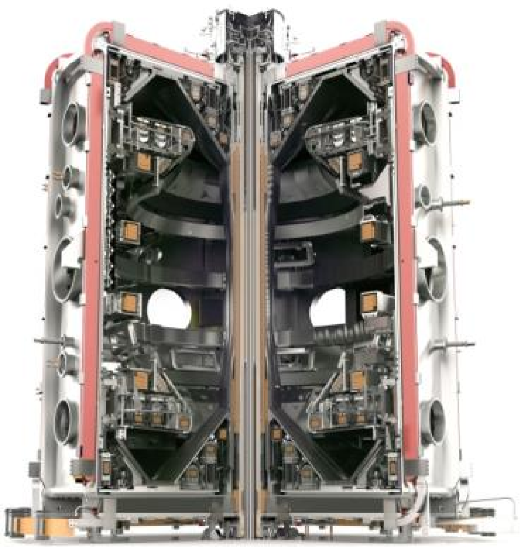


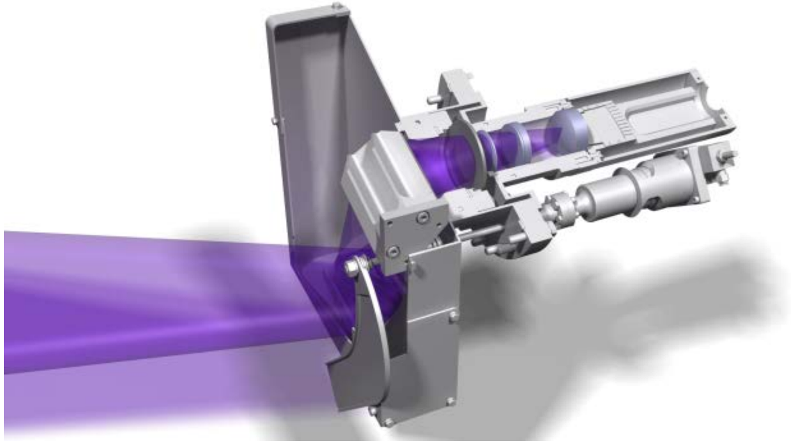




MAST Upgrade

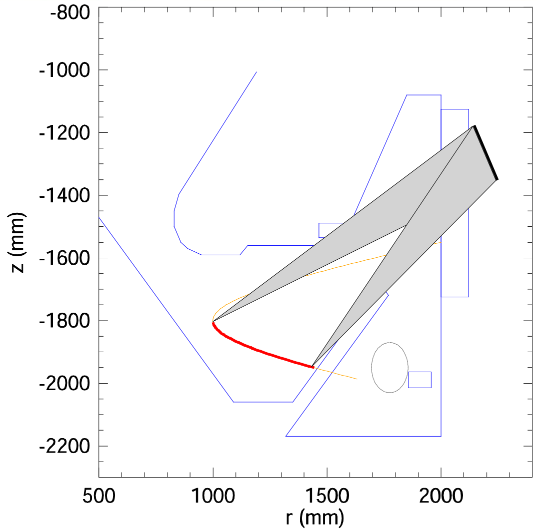
- Diagnostic capability
  - Over 50 systems, including:
  - Reciprocating probes
  - Multi-point Thomson scattering
  - High resolution beam spectroscopy – MSE, FIDA, CXRS, BES
  - Neutron Camera
  - Microwave diagnostics (Doppler Back Scattering, Synthetic Aperture Microwave Imaging)

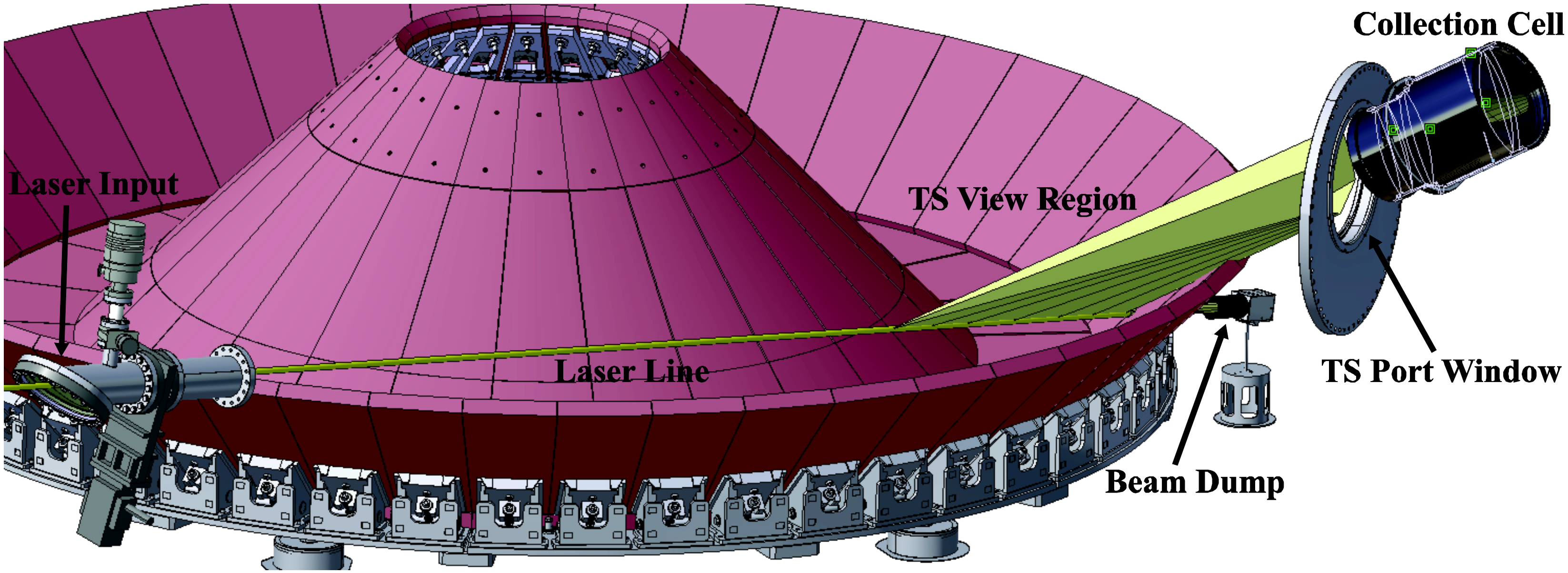




MAST-U Diagnostics – Thomson Scattering

- Divertor TS system to measure to low T_e (~1eV) in the extended Super–X region.
- Up to 4x30Hz lasers to allow for continuous measurements & bursts.
- Collection lens elements are currently being machined and low T_e spectrometers being manufactured.





Other MAST Infrastructure Projects

In parallel with the formal MAST Upgrade project, a range of other MAST infrastructure projects is underway to improve capability and reliability. These include:

- ❑ Power supplies – e.g. new switchgear, refurbishment of transformers etc
- ❑ Air conditioning upgrades
- ❑ NBI upgrades – bend magnets, RIDs, control systems
- ❑ Diagnostic upgrades – e.g. BES, bolometer electronics, Langmuir probe power supplies, divertor TS
- ❑ Miscellaneous refurbishments – gate valves, pumping systems etc
- ❑ ………………… etc

Project timeline

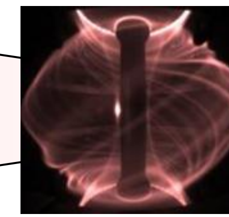
Conceptual Design

Scheme Design

Detailed Design

Construction

2008 2009 2010 2011 2012 2013 2014 2015 2016



Jan 2008, MAST-U + Super-X Divertor, Scoping studies and Conceptual Design started

April 2010, MAST-U Construction Approved

Oct 2013, MAST Operations finish, Strip out starts

March 2014, MAST-U rebuild underway

Sept 2015, Latest Pump down projection, Start of Integrated commissioning

Early 2016, First MAST-U Plasma

First physics campaign

- First plasmas (and physics results) will be obtained during restart in the first half of 2016. The first full physics campaign should begin mid-2016 and will include time allotted for EUROfusion MST1 experiments.

- There will be some operating restrictions during the first physics campaign:

  The solenoid and TF coils will not be chilled, reducing safe operating limits to P1 = +/- 45 kA (55kA max) and TF = 100kA (135 kA max)

  The NBI injectors will be limited to 2.5s in length until power supply limitations are addressed and beam duct power handling capability is assessed.

- There will be a MAST Research Forum in 2015 to discuss the first physics campaign with collaborators

Scientific Goals of MAST-U (Core Scope)

- Improving the understanding of exhaust physics
  - Closure and connection length
  - Flux expansion at the divertor targets
  - Volumetric losses and detachment

- Fast ion physics and current drive
  - Tailoring super-Alfvenic fast ion distribution
  - High elongation plasmas with reduced fast ion redistribution

- Other high-priority ITER, DEMO and CTF needs
  - RMP ELM control
  - Pedestal & core turbulence at low collisionality

Establishing the scientific basis for fusion energy and understanding the plasma universe

U.S. Spherical Torus Program Progress and Plans

Stephen Eckstrand

Program Manager, Office of Science

Fusion Energy Sciences

Presented to the
IEA ST Executive Committee
October 15, 2014

U.S. DEPARTMENT OF ENERGY

Office of Science

Strategic Planning for the U.S. Fusion Program

Strategic Planning: excerpts from the FESAC charge letter

"The FY 2014 Omnibus Appropriations Act requires the Department to submit a strategic plan for the FES program by January 2015 with the following guidance:

> 'The ten-year plan should assume U.S. participation in ITER and assess priorities for the domestic fusion program based on three funding scenarios with the fiscal year 2014 enacted level as the funding baseline: (1) modest growth, (2) budget growth based only on a cost-of-living-adjusted fiscal year 2014 budget, and (3) flat funding. The January 2013 Nuclear Science Advisory Committee report on priorities for nuclear physics used similar funding scenarios and should serve as a model for assessing priorities for the fusion program.'"

Strategic Planning: excerpts from the FESAC charge letter (2)

"Based on this direction, we are asking FESAC to address the following three scenarios with the FY 2014 appropriation for the domestic program as the baseline ($305M):

1. Modest growth (use +2.0 percentage points above the published OMB inflators for FY 2015 through FY 2024)
2. Cost of living (use the published OMB inflators for FY 2015 through FY 2024)
3. Flat funding

We are also asking FESAC to consider a fourth scenario with the FY 2015 President's Request for the domestic program as the baseline ($266M):

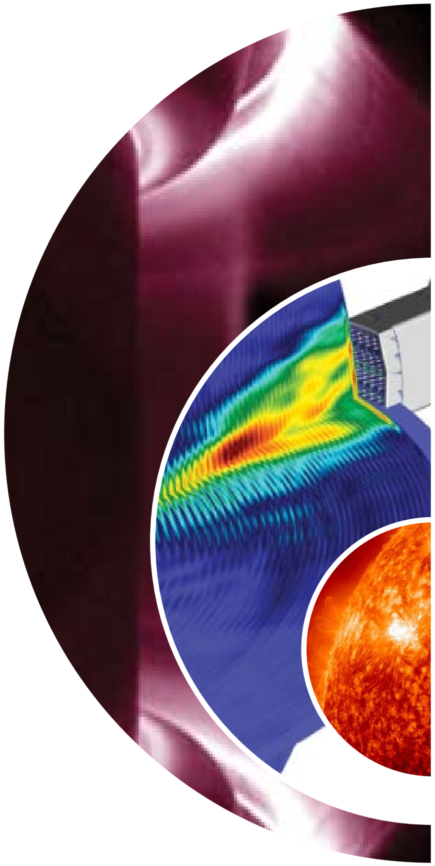
4. Cost of living (use the published OMB inflators for FY 2015 through FY 2024)"

Strategic Planning: excerpts from the FESAC charge letter (3)

"We ask FESAC to assess the priorities among continuing and potential new FES program investments required to ensure that the U.S. is in a position to exert long term leadership roles within and among each of the following areas:

- *Burning Plasma Science: Foundations* – the science of prediction and control of burning plasmas ranging from the strongly driven to the self-heated state;
- *Burning Plasma Science: Long Pulse* – the science of fusion plasmas and materials approaching and beyond ITER-relevant heat fluxes, neutron fluences, and pulse lengths;
- *Discovery Plasma Science* – the study of laboratory plasmas and the high energy density state relevant to astrophysical phenomena, the development of advanced measurement for validation, and the science of plasma control important to industrial applications."

New budget structure organized by scientific topics has been approved



Burning Plasma Science

Foundations Focusing on domestic capabilities; major and university facilities in partnership, targeting key scientific issues. Theory and computation focus on questions central to understanding the burning plasma state

Challenge: Understand the fundamentals of transport, macro-stability, wave-particle physics, plasma-wall interactions

Long Pulse Building on domestic capabilities and furthered by international partnership

Challenge: Establish the basis for indefinitely maintaining the burning plasma state including: maintaining magnetic field structure to enable burning plasma confinement and developing the materials to endure and function in this environment

High Power ITER is the keystone as it strives to integrate foundational burning plasma science with the science and technology girding long pulse, sustained operations.

Challenge: Establishing the scientific basis for attractive, robust control of the self-heated, burning plasma state

Discovery Science

Plasma Science Frontiers & Measurement Innovation

General Plasma Science, Exploratory Magnetized Plasma, High Energy Density Laboratory Plasma, and Measurement Innovation

FESAC Recommended Four Initiatives

Tier 1:

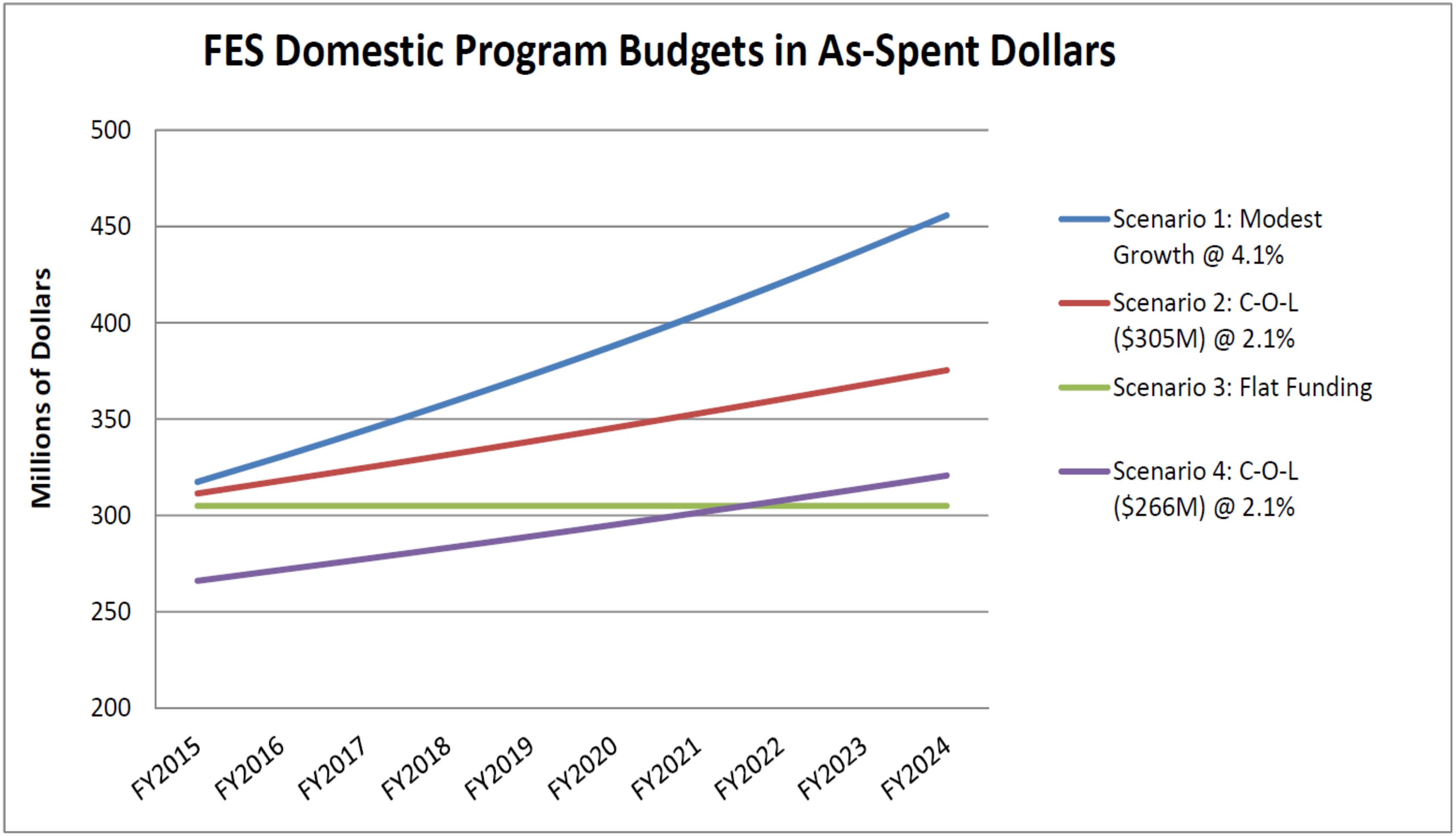
- Control of deleterious transient events
- Taming the plasma--material interface

Tier 2:

- Experimentally validated integrated predictive capabilities
- A fusion nuclear science subprogram and facility

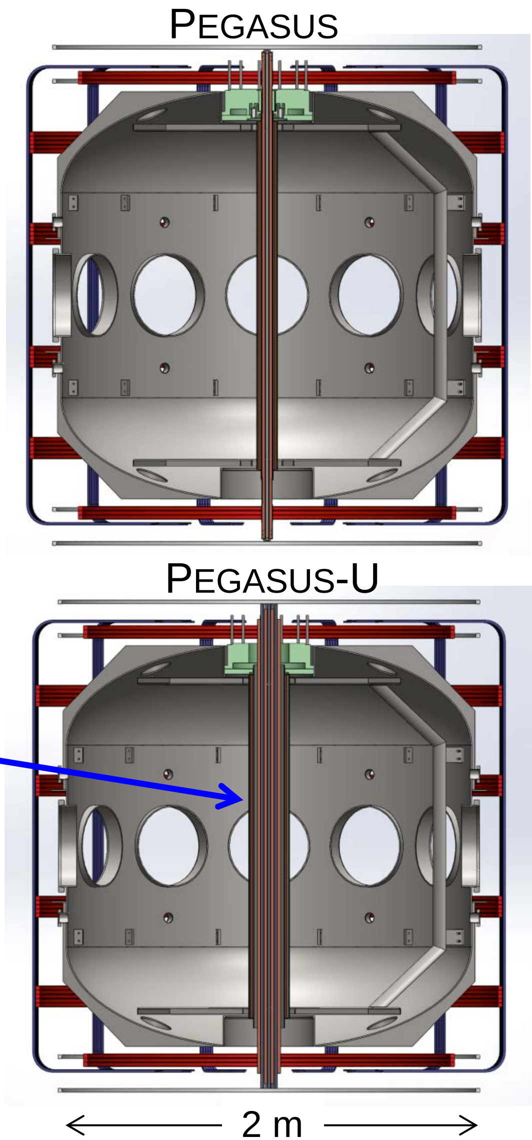
Tier 1 initiatives are higher priority than Tier 2 initiatives.
Within a tier, the priorities are equal.

The four budget scenarios



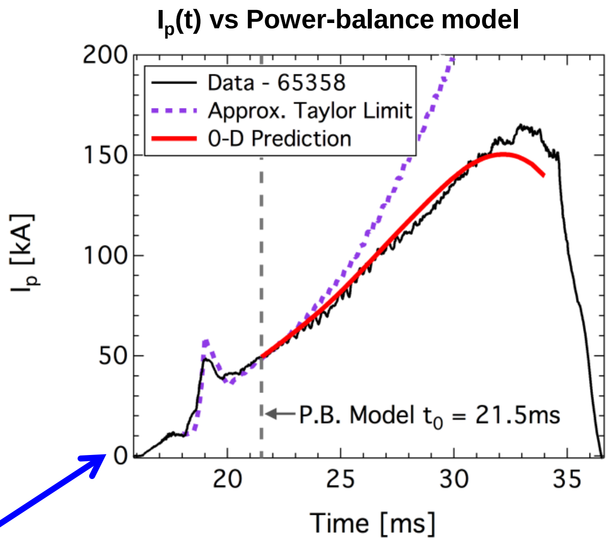
Proposed PEGASUS-U Initiative: Advancing Non-Solenoidal Startup and AT Physics

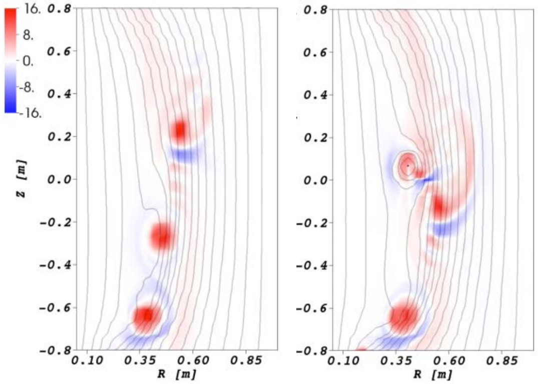
- Mission
  - Physics and technology of LHI
    - For NSTX-U and beyond (FNSF)
  - Nonlinear ELM dynamics, H-mode physics
  - Tokamak stability limits: A~1 high β_T regime
- Facility enhancements
  - New centerstack assembly
    - B_{TF} increases 5x
    - Δt_{pulse} ~ 100 msec
    - V-sec increases 6x (*solenoid from PPPL*)
    - Improved separatrix operation
  - NSTX-U relevant LHI injector arrays
    - Helicity input rate increases 2x
  - Diagnostics: multipoint TS; CHERS via DNB



Local Helicity Injection (LHI) Uses Strong Current Sources in SOL to Inject Helicity & Drive I_p

- Unstable streams relax to "tokamak"
  - Taylor relaxation, helicity conservation limit I_p
  - To date: $I_p \sim 0.18$ MA with $I_{inj} \sim 6$ kA
  - Extensive current source technology development
- Approaching predictive $I_p(t)$ model
  - Energy conservation; lumped parameter model
- Details of LHI dynamics emerging
  - NIMROD: Reconnecting current streams inject axisymmetric current rings into core plasma
- Technique scales to NSTX-U, FNSF



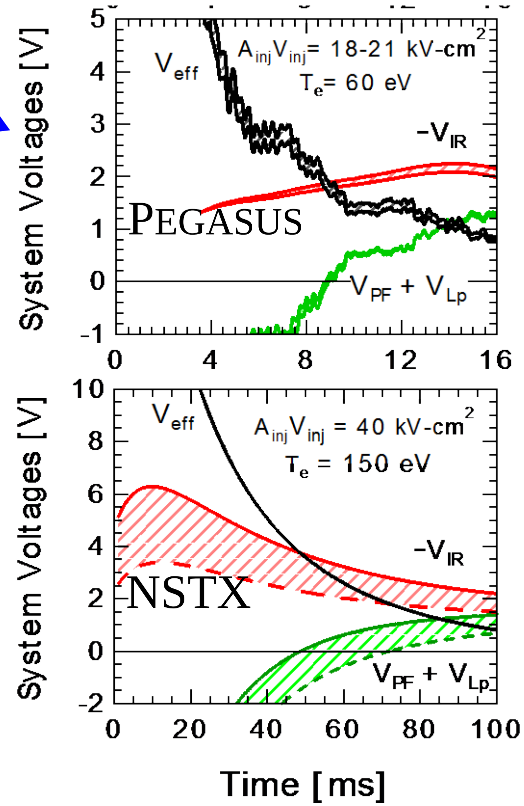


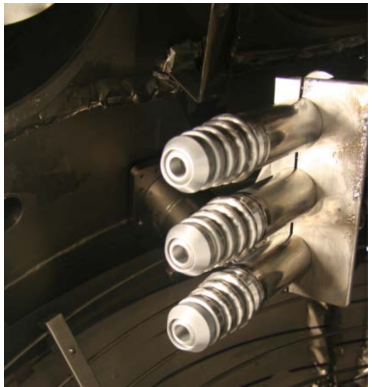
[O'Bryan Phys Plas.**19**, 2012]

PEGASUS-U Initiative: Develop & Validate LHI-Startup for NSTX-U and Beyond

- Critical physics issues
  - Confinement behavior and helicity dissipation
  - Edge λ=J/B, J penetration processes
  - Injector geometry optimization
- Technology development
  - Long-pulse, large-area injectors in high B_{TF}
- Models & predictive understanding
  - 0-D Power Balance $I_p(t)$ model
  - NIMROD
  - TSC

PEGASUS @ 0.3 MA = same regime as NSTX-U @ 1MA:





"Pagoda-style" injectors sustain $V_{inj} \leq 1.5$ kV, $I_{inj} \sim 2$ kA with no PMI effects within 1-2 cm of LCFS

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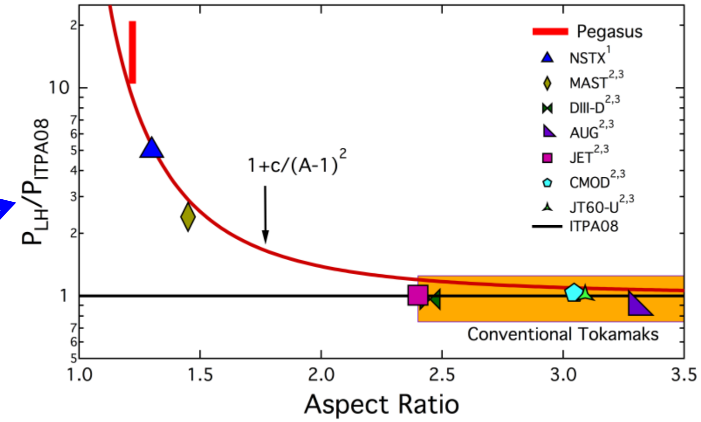
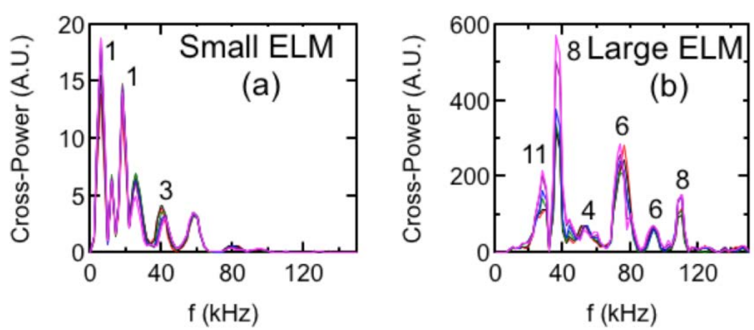
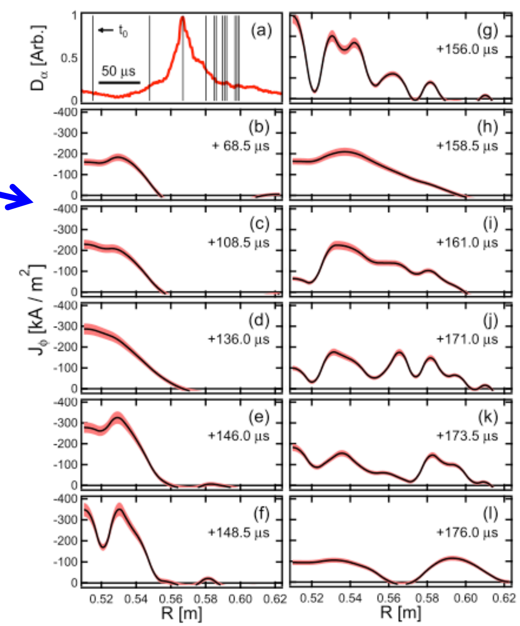
A~1 Access to AT Physics: H-mode, J_{edge} Dynamics, High-β, etc.

- Low B_{TF} => very low $P_{L\text{-}H}$
  - With unique diagnostic access
- Ohmic H-mode plasmas
  - $H_{98} \sim 1$
  - Strong A-scaling of $P_{L\text{-}H}$
  - Measured pedestal in $J_{edge}(R,t)$



- ELM physics studies
  - J(R,t) evolution through ELM collapse
  - Type I: n = 5-15; Type III: n ~1
    - Opposite high-A plasmas





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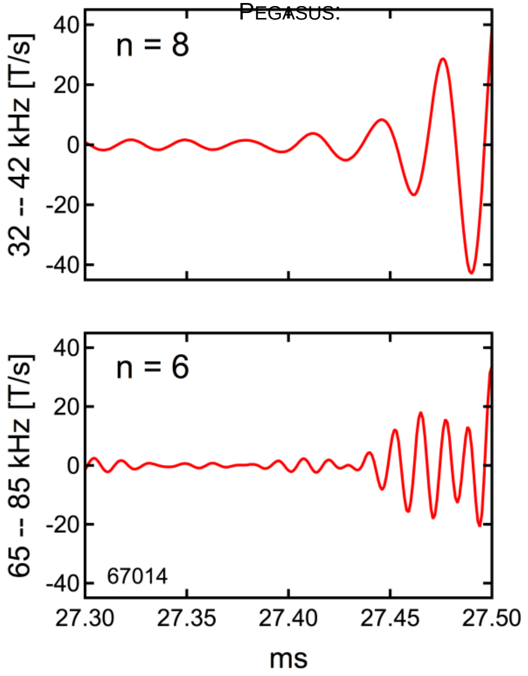
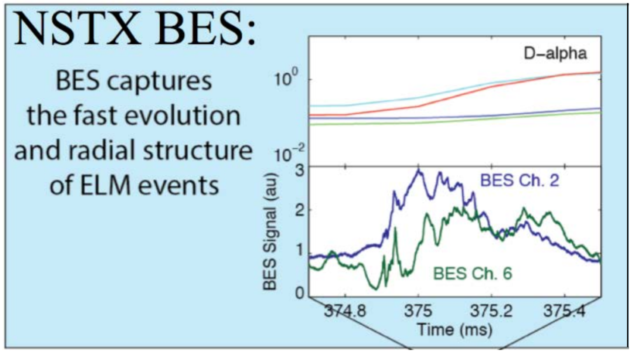
PEGASUS-U Initiative: Nonlinear ELM Studies and H-mode Physics

- P(r,t), J(r,t), v_ϕ(r,t) through ELM cycles
  - Nonlinear evolution of magnetic structures
- ELM, H-mode modification and mitigation
  - Vary J_{edge}(r), modify edge v_ϕ and shear via LHI
- Synergistic studies with BES on NSTX-U, DIII-D
  - Entry point for grad students to large facilities
- Models to test
  - NIMROD
  - BOUT++
  - EPED

Nonlinear Evolution of ELM Magnetic Toroidal Modes in PEGASUS:





Comparison of J(r,t), N_e(r,t), T_e (r,t) on Pegasus to detailed N_e(r,t) on NSTX-U will aid interpretation of BES ELM studies on NSTX-U & DIII-D

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PEGASUS-U Enables Further Initiatives for Latter Part of Decadal Period

- Non-solenoidal startup
  - PEGASUS-U, NSTX-U LHI program for ~ 1 MA startup demonstration
  - New non-solenoidal startup studies: Stellarator windings; Iron core, EBW…
- Current sustainment with LHI via MHD control
  - Passive or active injector feedback system
- ELM modification and mitigation
  - C-pellet injection for tests of models for ELM-pacing (w/ORNL)
- Neoclassical physics tests
  - J_{BS} model tests: Test Sauter model if sufficient edge pressure achieved
- High β_t plasma studies at $I_p/I_{TF} \geq 3$

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Results and near-term plans for the Lithium Tokamak eXperiment (LTX)

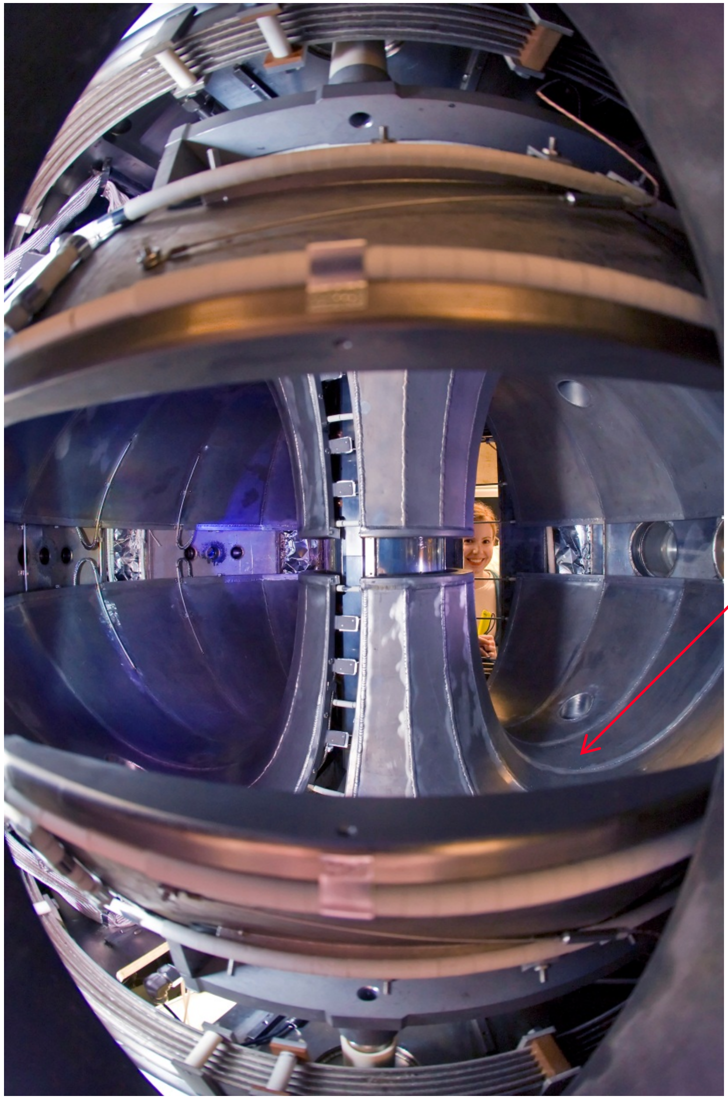
Dick Majeski and the LTX team

- Demonstrate compatibility of a tokamak plasma with liquid lithium walls

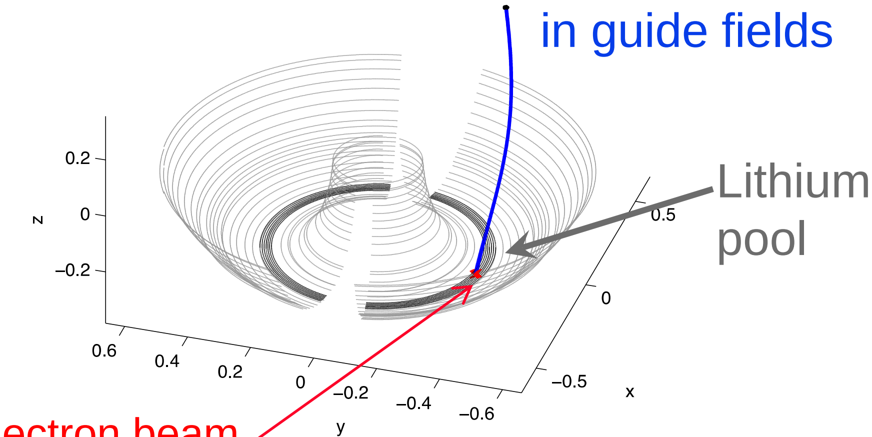
- Investigate changes in tokamak confinement and equilibrium with low recycling (lithium) walls

- Plans: Extend studies to high auxiliary heating power and core neutral beam fueling

New electron beam-based fast lithium deposition system on LTX enables high performance discharges

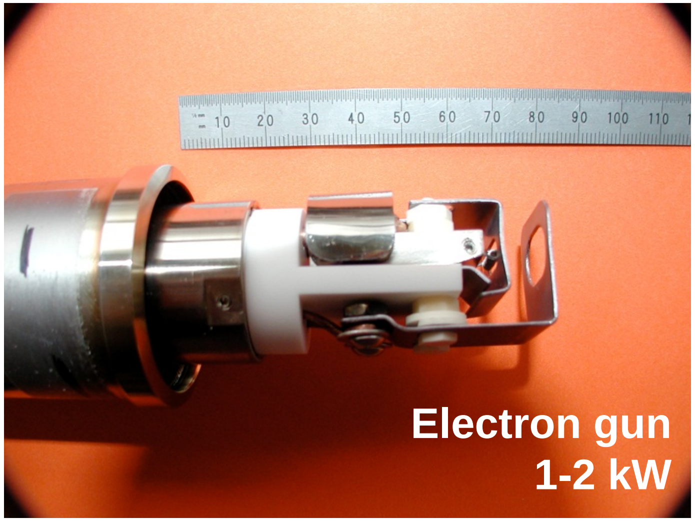


Beam system is mounted on upper vacuum vessel



Electron beam magnetically guided to lower shell lithium reservoir

Half ($2m^2$) of liner coated with liquid lithium at present

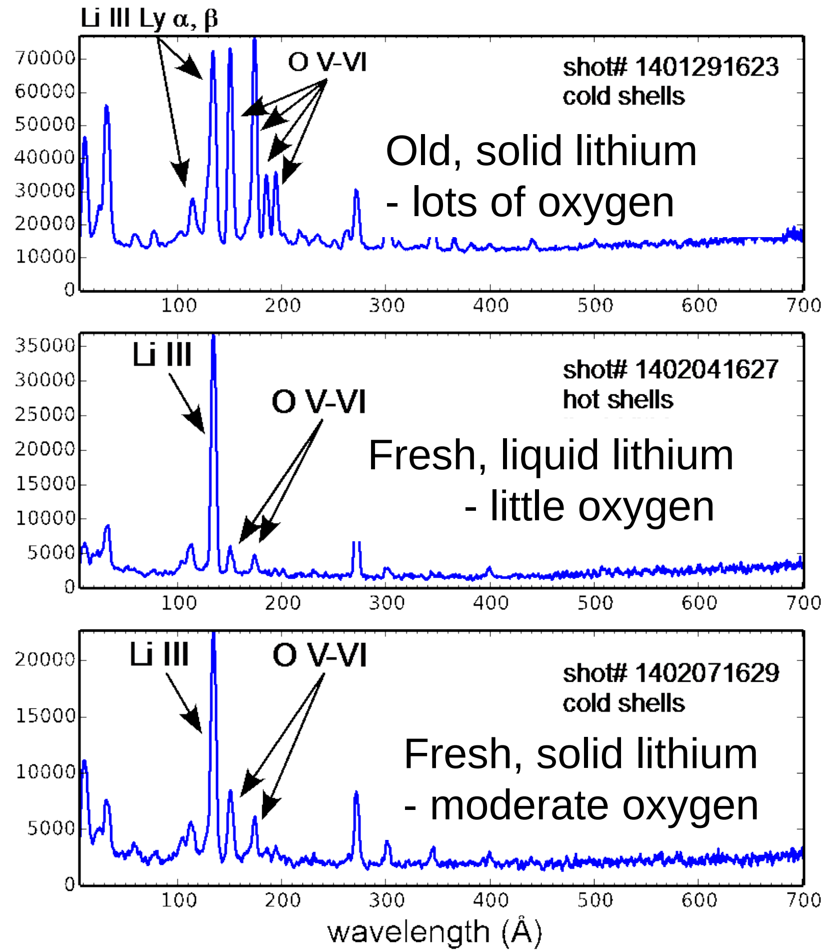


Inner heated high-Z shell (explosively bonded SS on copper)

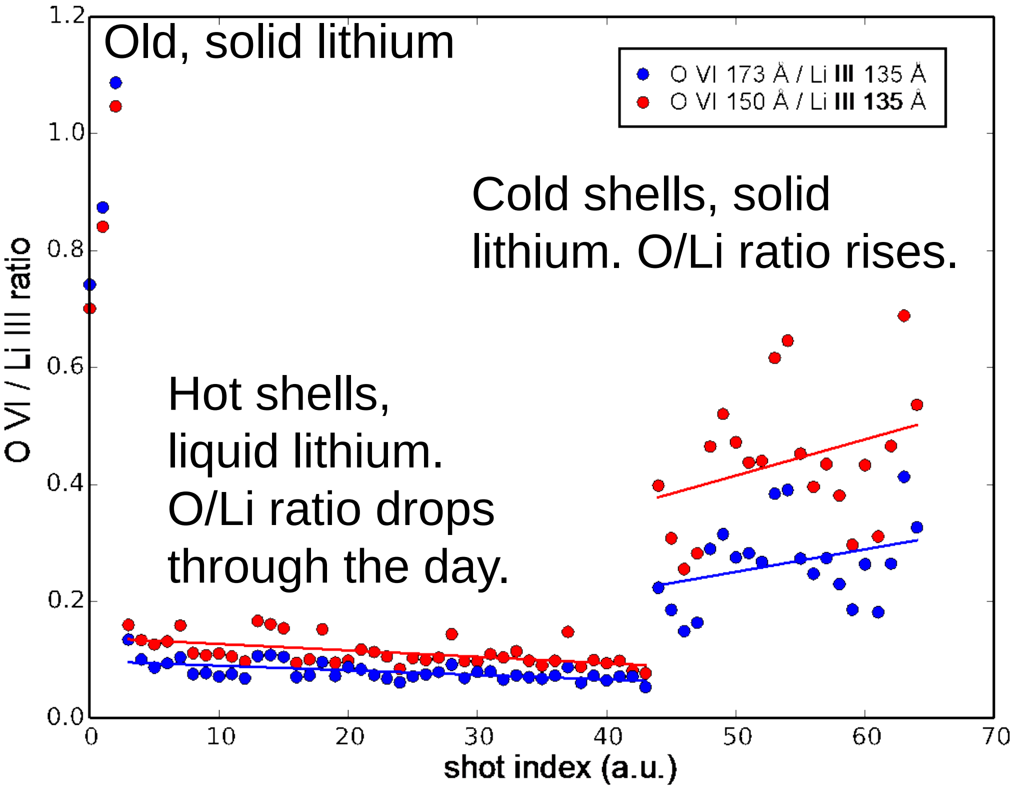
➡ 2014: Fast (5 minutes for ~1000 Å) Li coating via electron beam evaporation

Oxygen impurities in discharge are now suppressed with liquid lithium PFCs in LTX

Spectra from JHU transmission grating instrument

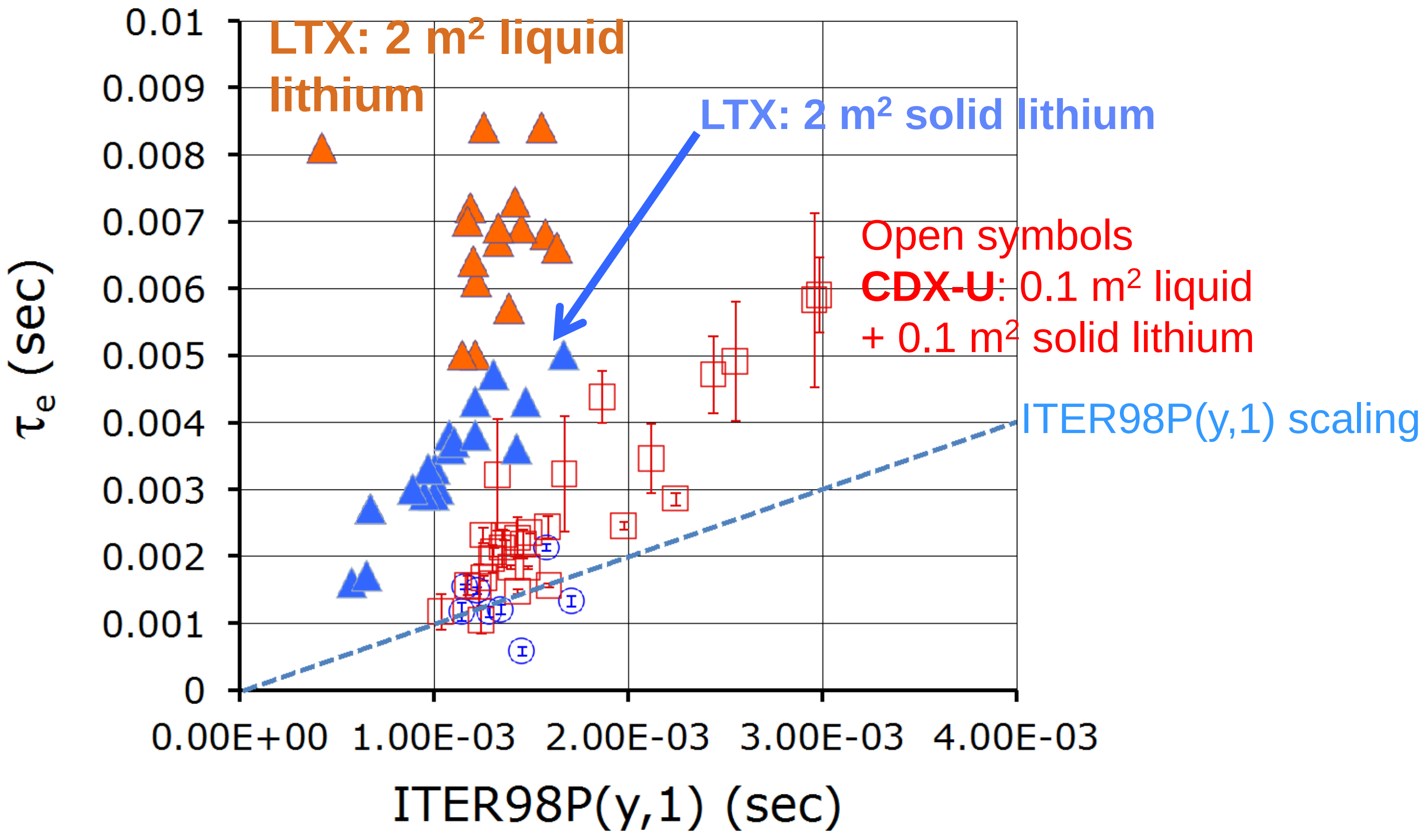


Lithium/oxygen line ratio – shot history from JHU TG EUV spectrometer



JOHNS HOPKINS UNIVERSITY

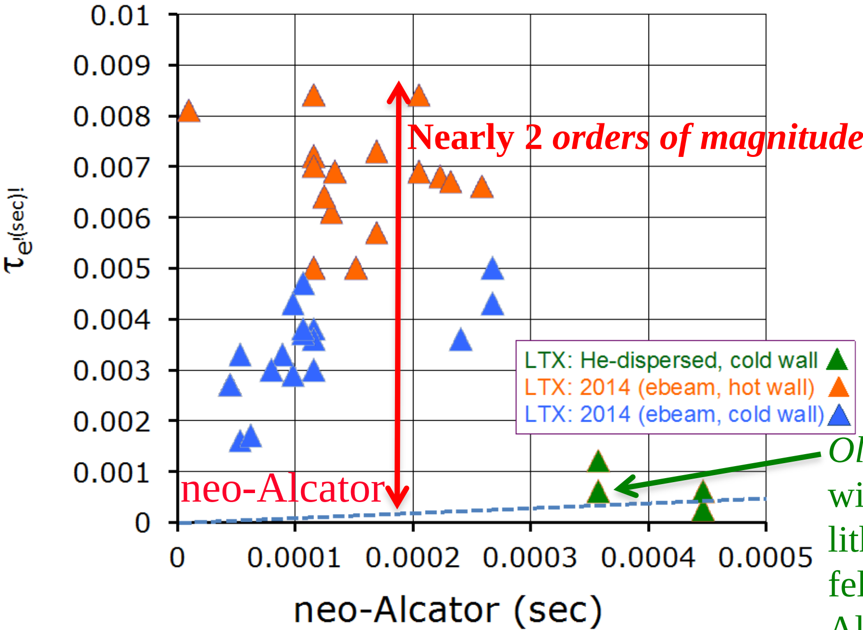
Confinement increases with lithium coverage
⇒*Liquid* lithium PFCs more effective



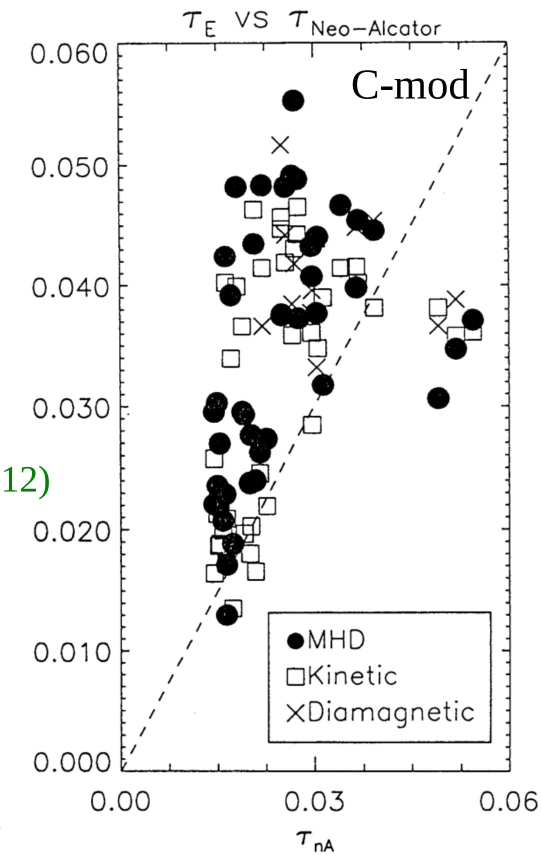
- ➢First operation of any tokamak with large area liquid lithium walls
- ➢2 m^2 of liquid lithium coated wall; 40% of plasma-facing surface
- ➢**Ready for experiments with full (4 m^2) liquid lithium coverage**

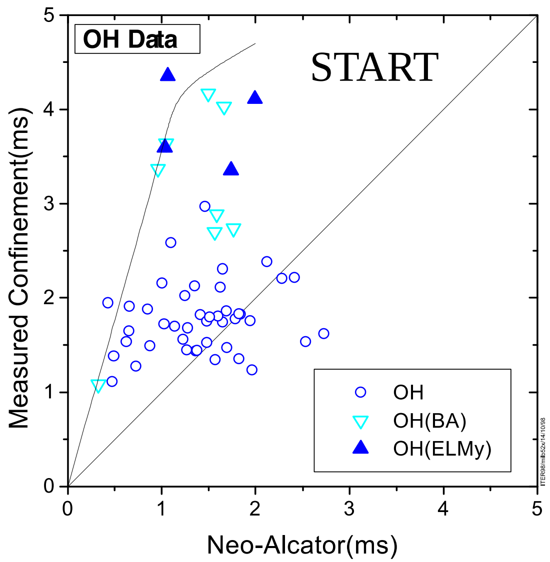
Compared now greatly exceeds neo-Alcator scaling

- Ohmic scaling, without an input power dependence



Older LTX data with He-dispersed lithium coatings (2012) fell close to neo-Alcator





Ohmic confinement data from START exceeded neo-Alcator confinement, but by less than a factor of 2 (open circles) (M.J. Walsh et al., 1998 APS-DPP)

Ohmic discharges in C-mod also exceeded neo-Alcator scaling, but again by less than 2× (I. Hutchinson et al., Phys. Plas. 1, (1994) 1511))

Plans for LTX

Near term:

- Expanded electron beam operation with hot and cold walls
  - Second e-beam system now installed, under test
- Thomson scattering re-aligned; calibrated via Rayleigh scattering
  - Thomson data recently acquired – increased stray light
  - Analysis routines undergoing modifications
- Improved equilibrium reconstructions recently obtained
- Implement profile reflectometer for time-resolved $n_e(r)$ (UCLA)

Longer term:

- Add NBI:
  - 700kW, 20 keV, 100 msec system from Tri-Alpha Energy
- ORNL: beam would permit active CHERs
- Investigate equilibria with reduced recycling + NB fueling
  - Confinement with $P_{aux} \sim 10\times P_{ohmic}$ and low recycling liquid wall
    - Establish confinement scaling for low recycling regimes

NSTX-U

Supported by U.S. DEPARTMENT OF ENERGY | Office of Science

NSTX-U Project and Program Update

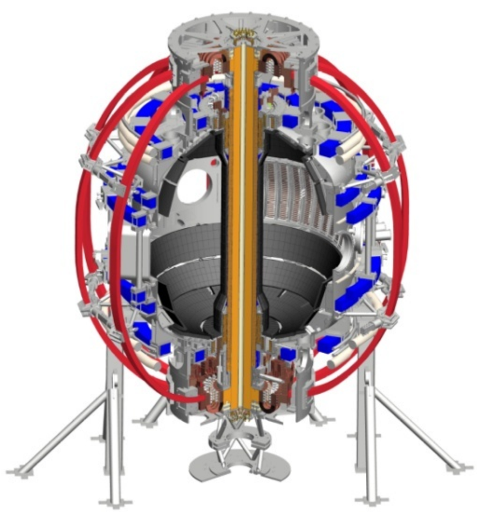
J. Menard (PPPL)

NSTX-U Program Director

Coll of Wm & Mary
Columbia U
CompX
General Atomics
FIU
INL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Lehigh U
Nova Photonics
Old Dominion
ORNL
PPPL
Princeton U
Purdue U
SNL
Think Tank, Inc.
UC Davis
UC Irvine
UCLA
UCSD
U Colorado
U Illinois
U Maryland
U Rochester
U Tennessee
U Tulsa
U Washington
U Wisconsin
X Science LLC

8th Meeting of Executive Committee for the IEA Implementing Agreement on ST

25th Fusion Energy Conference (FEC 2014)
Saint Petersburg, Russia
15 October 2014
17:00 local time

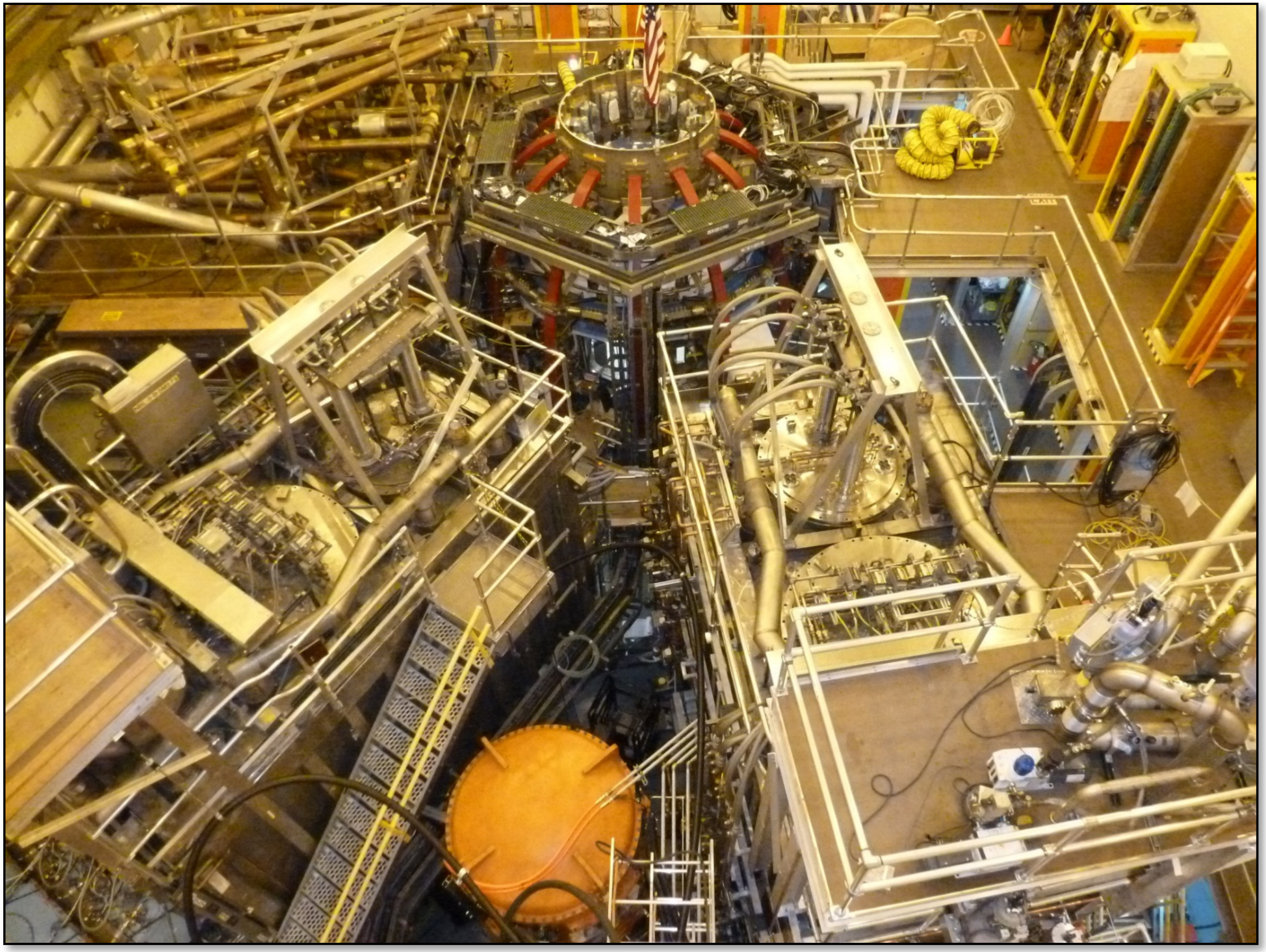


Culham Sci Ctr
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAEA
Inst for Nucl Res, Kiev
Ioffe Inst
TRINITI
Chonbuk Natl U
NFRI
KAIST
POSTECH
Seoul Natl U
ASIPP
CIEMAT
FOM Inst DIFFER
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep

Outline

- Upgrade Project update
- Program status and plans

NSTX Upgrade Project nearing completion

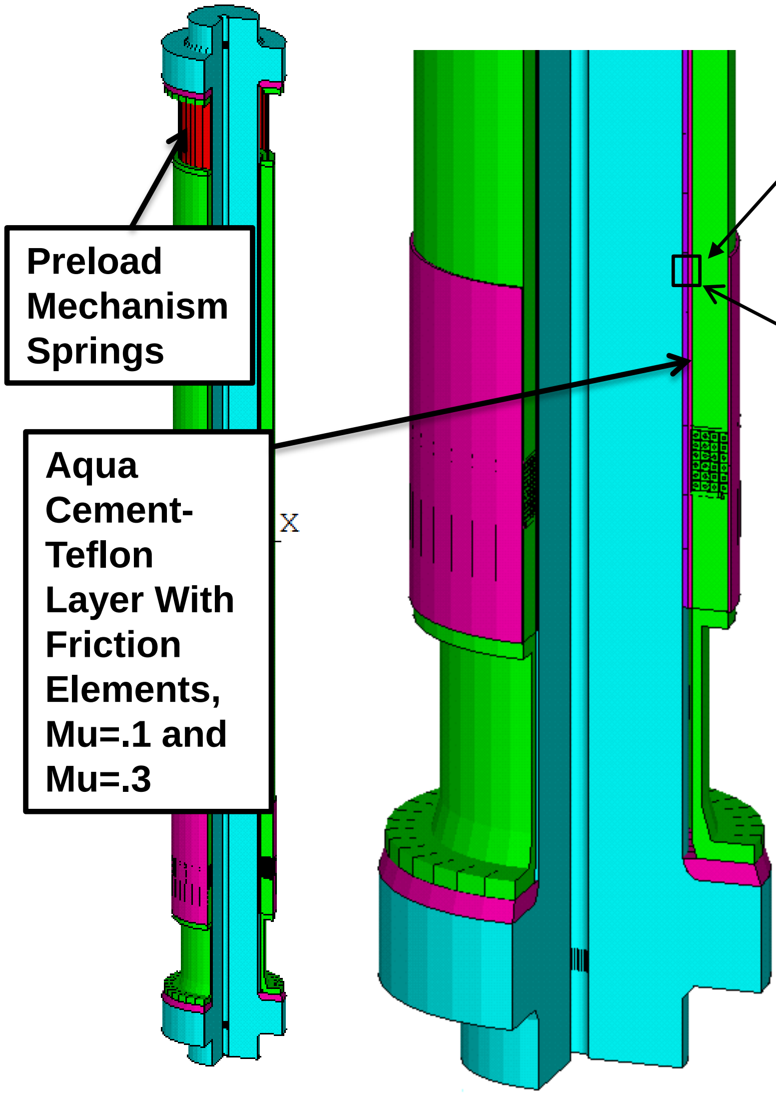


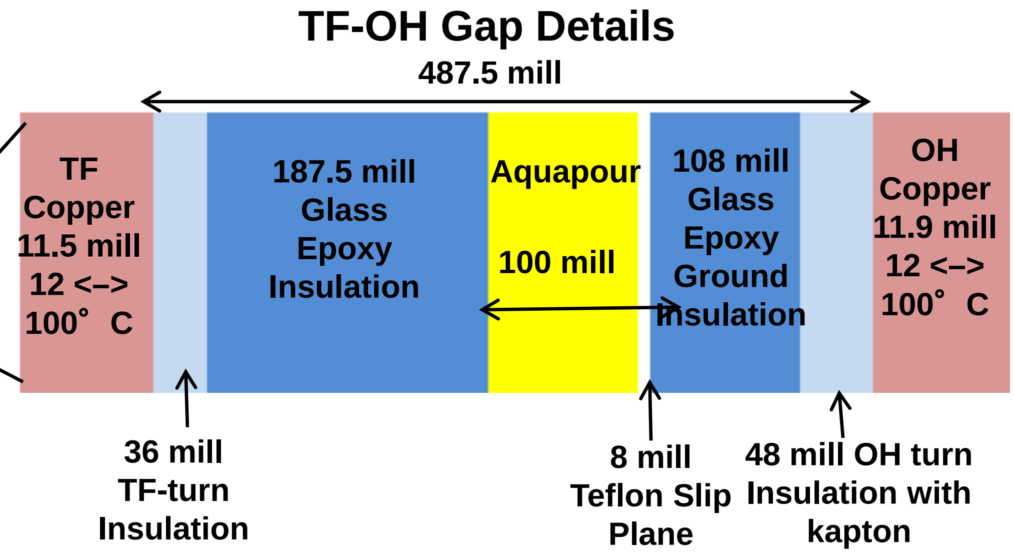
Good progress on construction, assembly, & installation

- **Centerstack Fabrication & Assembly**
  - Visual inspection of VPI = no dry spots
  - Hydro and flow test cooling passages (200 psi operating pressure)
  - Megger to = 13kV (oper voltage 6kV)
  - Major risk retired !
  - Sanding complete to remove excess resin
  - Aqua pour removal – UNSUCCESSFUL
    - Epoxy resin infiltrated the porous aqua pour
    - Could not flush out with water
    - Used mechanical chisels on ends in an attempt to break through end-plug
    - Attempted heating/cooling the OH/TF respectively to open gap and demonstrate the OH moved independent of the TF
    - Decision to live with the "Aquament"

Schematics of OH-TF bundle configuration

100 mill gap between OH and TF to provide free OH-TF operation





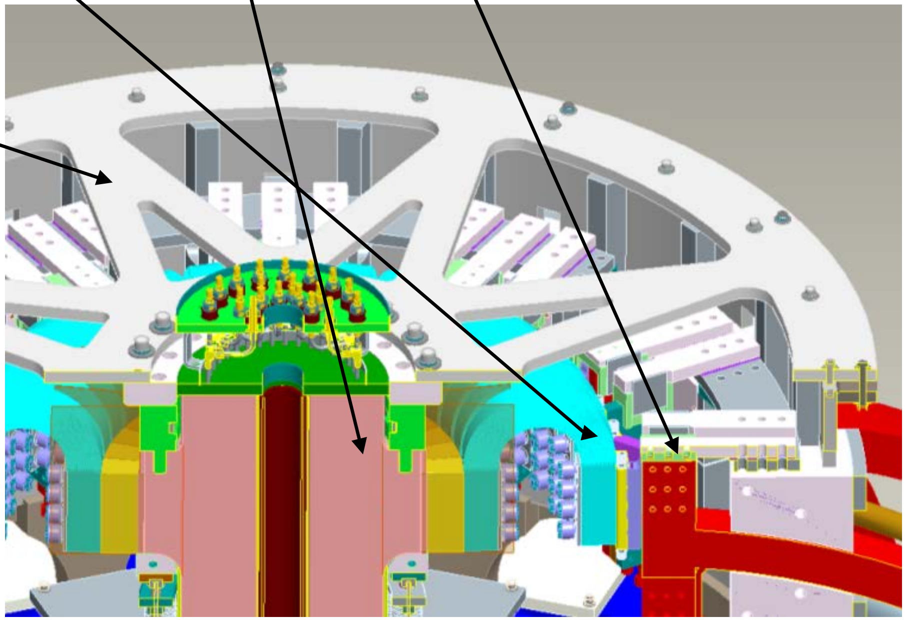
Both TF and OH expand about 12 mills during the full parameter operation reaching ~ 100 ° C from 12 ° C.

If TF expands more than OH, the gap region could be compressed leading to insulation stress as the TF and OH grow radially and axially.

- The full 1 T, 2 MA, 5 sec (third year) scenario maybe affected since TF temperature could exceed OH by as much 19° C which could cause insulation stress.
- Bringing the temperature gap down to 0-10° C range reduces the stress to acceptable range.
- **Will pre-heat the OH w.r.t. the TF by ~ 10-30° C and/or raise OH T_{max} to 110-120° C → Recover nearly all previously planned operating space**

Remaining Construction Work in NSTX Test Cell

- Install PF 1a coils and Microtherm blanket
- Insert CS magnet assy into casing
- **Install Centerstack Assy – October**
- Install bus inside umbrella and back to racks
- Install new TF flex bus
- Field measure space between centerstack and all TF flags
- Fabricate 72 unique centerstack to TF flag links
- Install umbrella lid support rings
- Install new umbrella lids
- Clean, photo, close vessel
- Pumpdown
- Leak check
- Bakeout

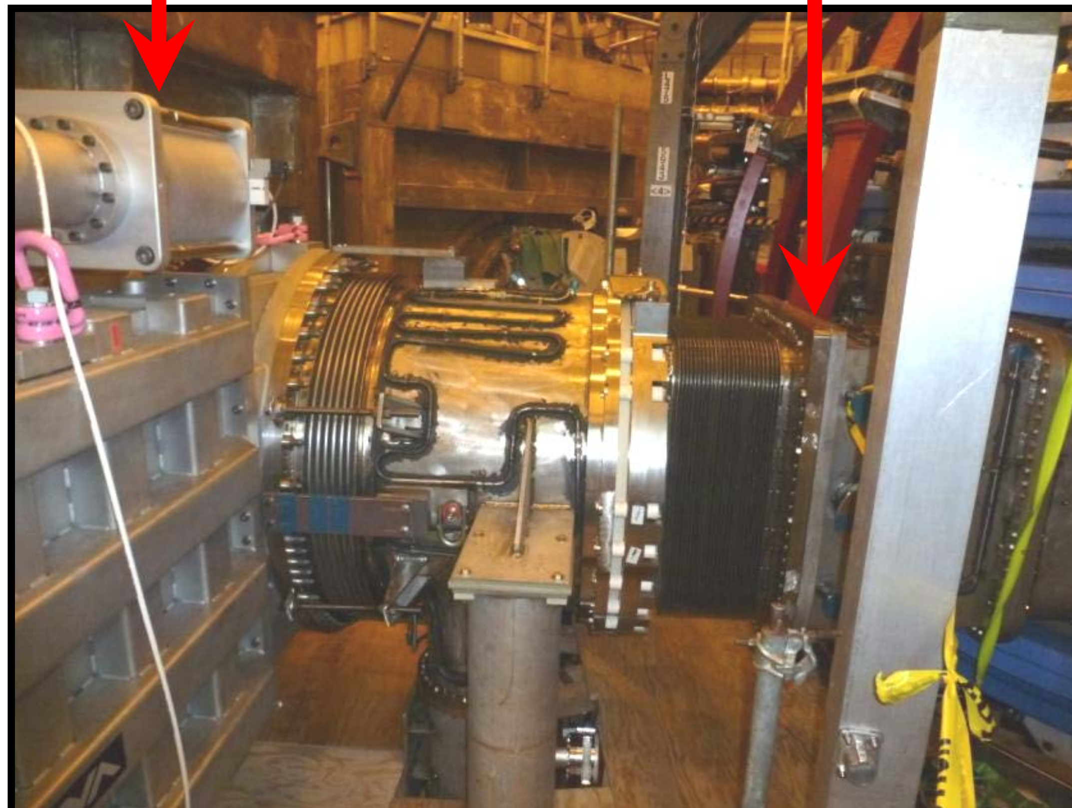


Neutral beam component installation largely complete

- *Neutral Beam connecting duct assembly (bellows(2) ,VPS duct) being lowered into position*
- *Entire assembly leak tested prior to installation*

Neutral Beam & TIV valve

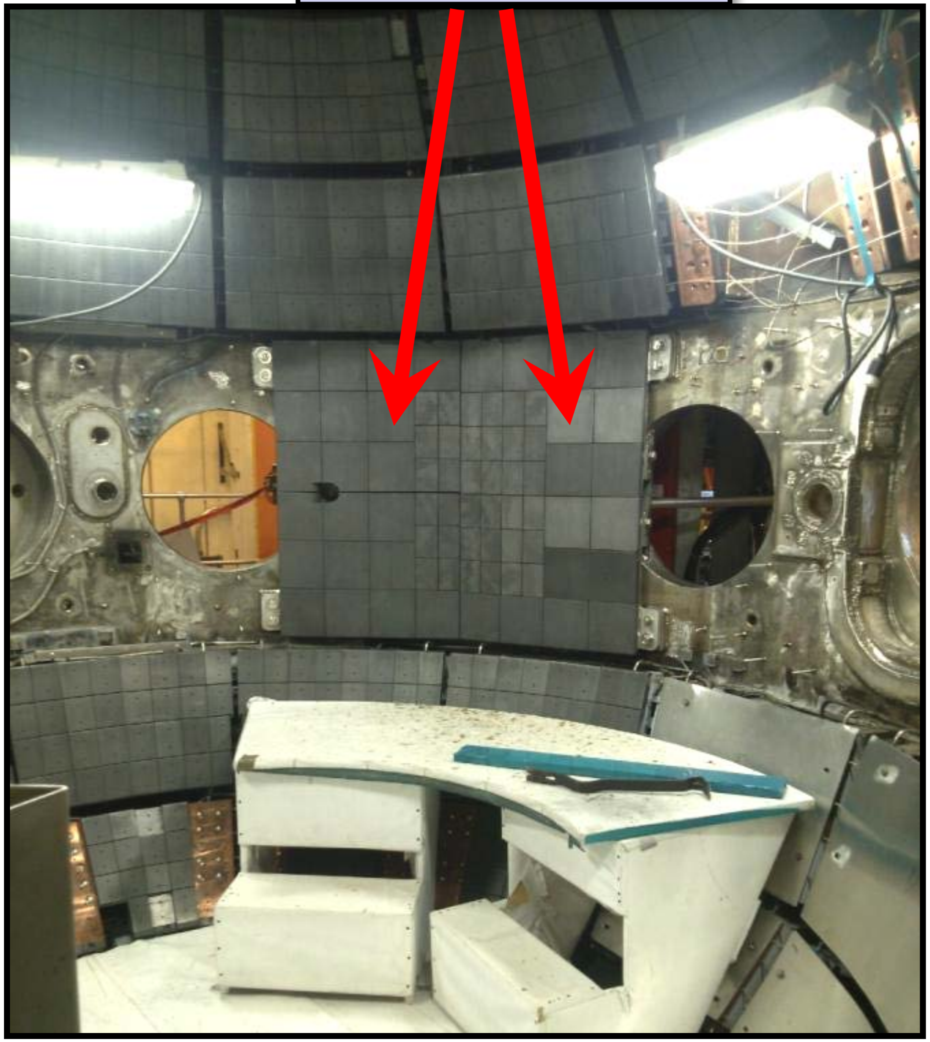
Vacuum Vessel Bay J/K port



Neutral beam component installation largely complete

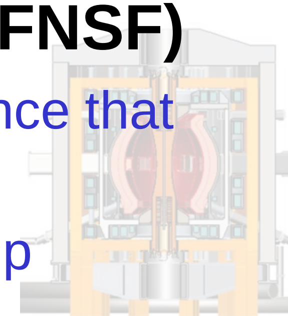
Transmission line installation

Neutral Beam Armor Installed

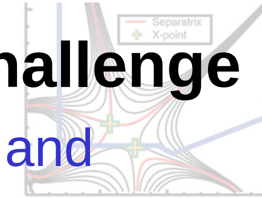


5 highest priority goals of NSTX-U 5 year plan:

- **Advance ST for Fusion Nuclear Science Facility (FNSF)**
  1. Demonstrate 100% non-inductive sustainment at performance that extrapolates to ≥ 1MW/m^2 neutron wall loading in FNSF
  2. Develop and understand non-inductive start-up and ramp-up (overdrive) to project to ST-FNSF with small/no solenoid



- **Develop solutions for plasma-material interface challenge**
  3. Develop and utilize high-flux-expansion "snowflake" divertor and radiative detachment for mitigating very high heat fluxes
  4. Begin to assess high-Z PFCs + liquid lithium to develop high-duty-factor integrated PMI solutions for next-steps

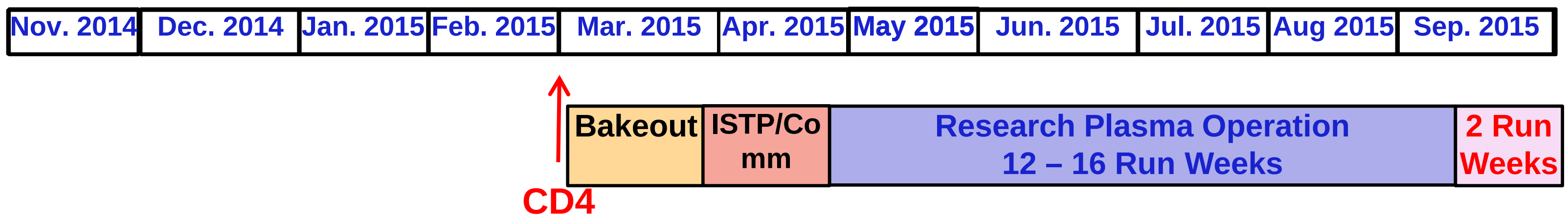


- **Explore unique ST parameter regimes to advance predictive capability - for ITER and beyond**
  5. Access reduced ν^* and high-β combined with ability to vary q and rotation to dramatically extend ST physics understanding

Aiming for Extended Research Operation in FY15

Research operation preparation on going in parallel with Upgrade Project

Run Plan for FY 2015



- **Aquapour issue caused a CD-4 delay of ~ 3 weeks**
- **CD-4 in late February still allows scheduling of the research campaign up to 18 run weeks (Base – 12 - 16 run weeks and Incremental – 2 run weeks)**
- **~ 2 month period is allocated between CD-4 and the research plasma operation**

Overview of FY2015-16 NSTX-U research activities

- FY2015
  - Complete CD-4 for NSTX Upgrade Project in Feb/Mar 2015
  - **Research Forum to solicit experimental proposals for FY2015 run campaign → planned for Feb 24-27, 2015**
  - Obtain first data at 60% higher field/current, 2-3× longer pulse:
    - Re-establish sustained low l_i / high-κ operation above no-wall limit
    - Study thermal confinement, pedestal structure, SOL widths
    - Assess current-drive, fast-ion instabilities from new 2nd NBI
- FY2016
  - Extend NSTX-U performance to full field, current (1T, 2MA)
    - Assess divertor heat flux mitigation, confinement at full parameters
  - Access full non-inductive, test small current over-drive

NSTX-U research milestones target exploitation of new Upgrade capabilities, exploration of new regimes in FY15-16

	FY2014	FY2015	FY2016
Expt. Run Weeks:	0	12-16 / Up to 18	16 / 20
Macroscopic Stability	R14-1 Assess access to reduced density and ν^* in high-performance scenarios (with ASC, BP TSGs)		
Transport and Turbulence		R15-1 Assess H-mode τ_E, pedestal, SOL characteristics at higher B_T, I_P, P_{NBI} (with BP, M&P, ASC, WEP TSGs)	R16-1 Assess τ_E and local transport and turbulence at low ν^* with full range of B_T, I_P, and NBI power
Boundary Physics		Develop snowflake configuration, study edge and divertor properties (with ASC, TT, MP) IR15-1	R16-1 Assess scaling, mitigation of steady-state, transient heat-fluxes w/ advanced divertor operation at high power density
Materials & PFCs			R16-2 Assess high-Z divertor PFC performance and impact on operating scenarios
Waves+Energetic Particles	R14-2 Assess reduced models for *AE mode-induced fast-ion transport	R15-2 Assess effects of NBI injection on fast-ion f(v) and NBI-CD profile (with SFSU, MS, ASC TSGs)	R16-3 Assess fast-wave SOL losses and core thermal and fast ion interactions at increased B_T, I_P
Solenoid-free Start-up/ramp-up			R16-4 Develop high-non-inductive fraction NBI H-modes for ramp-up & sustainment (Joint ASC+SFSU)
Adv. Scenarios and Control	R14-3 Assess advanced control techniques for sustained high performance (with MS, BP TSGs)	R15-3 Develop physics+operational tools for high-performance discharges (with CC, ASC, MS, BP, M&P TSGs)	
ITER Needs + Cross-cutting			
Joint Research Target	Quantify plasma response to non-axisymmetric (3D) magnetic fields in tokamaks	Quantify impact of broadened current and pressure profiles on tokamak confinement and stability	Assess disruption mitigation and warning / prediction techniques (+ additional theory contribution)

5. Collaborative activities - status and proposals

- Japan –Y. Takase
- UK/EU – B. Lloyd
- U.S. – S. Eckstrand / J. Menard

ST-IA Collaborative Activities

Topics	Collaborating institutions
EBW Start-up, EBW Emission	CCFE (EU) U. Tokyo, Kyoto U., Kyushu U. (JA) ORNL, PPPL (US)
Merging Start-up, Thomson Scattering	CCFE (EU) U. Tokyo (JA)
Two-Fluid MHD	ORNL (US) U. Tokyo, Niigata U. (JA)
LH Travelling Wave Antenna	U. Tokyo (JA) General Atomics (US)
LHW Simulation, Diagnostic, Parametric Decay	U. Tokyo (JA) MIT (US)
Current Density Measurement	U. Tokyo (JA) U. Wisconsin (US)
Transient CHI, CT Injection	U. Hyogo, Kyushu U. (JA) U. Washington (US)

+ Other collaborations with RF, CN, KO, IN

MAST ST collaborations

EU-JA -US

- EBW start-up – ORNL, PPPL, U. Tokyo, Kyoto, Kyushu
- Pellet ablation – NIFS
- Reconnection – U. of Tokyo
- Doppler Back-Scattering (DBS) - UCLA
- Proton detector measurements – Florida Int. U., PPPL
- FAST ion D-alpha measurements – U. California, Irvine
- ST physics (transport, pedestal, fast ion physics, EBW etc) - PPPL
- Innovative divertors – U. of Texas

EU-other parties

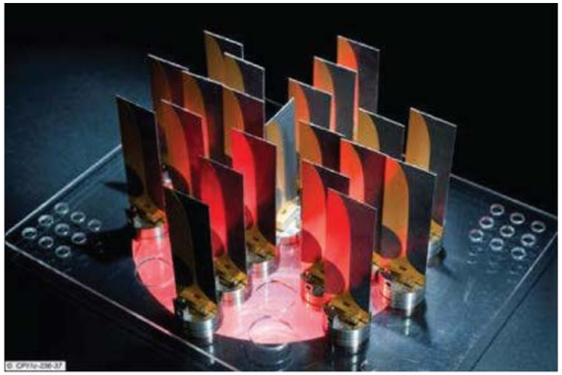
- ST physics – Ioffe Inst., Russia
- Coherence imaging – Australian National University
- Turbulence, Thomson scattering – KSTAR, S. Korea
- ECRH – J-TEXT, China
- ELM control – EAST, China
- Divertor physics, ELM control, diagnostics – SWIP, China

In addition, there are broader collaborative activities which have direct relevance to the ST programme

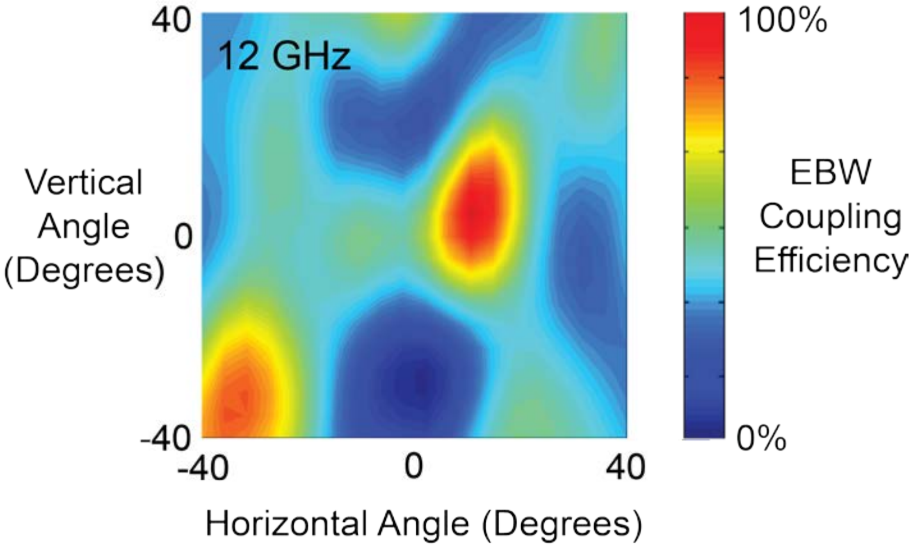
FY2015 Goal: Synthetic aperture microwave imaging (SAMI) diagnostic to image EBW emission

- Assess O-X-B coupling efficiency versus poloidal and toroidal angle
  - Important for EBW heating design (mirror aiming)
- Image Doppler reflectometry to measure edge plasma flows
- Can observe density fluctuation on millisecond timescale
- Will measure magnetic pitch near edge region

[Collaboration with University of York and CCFE



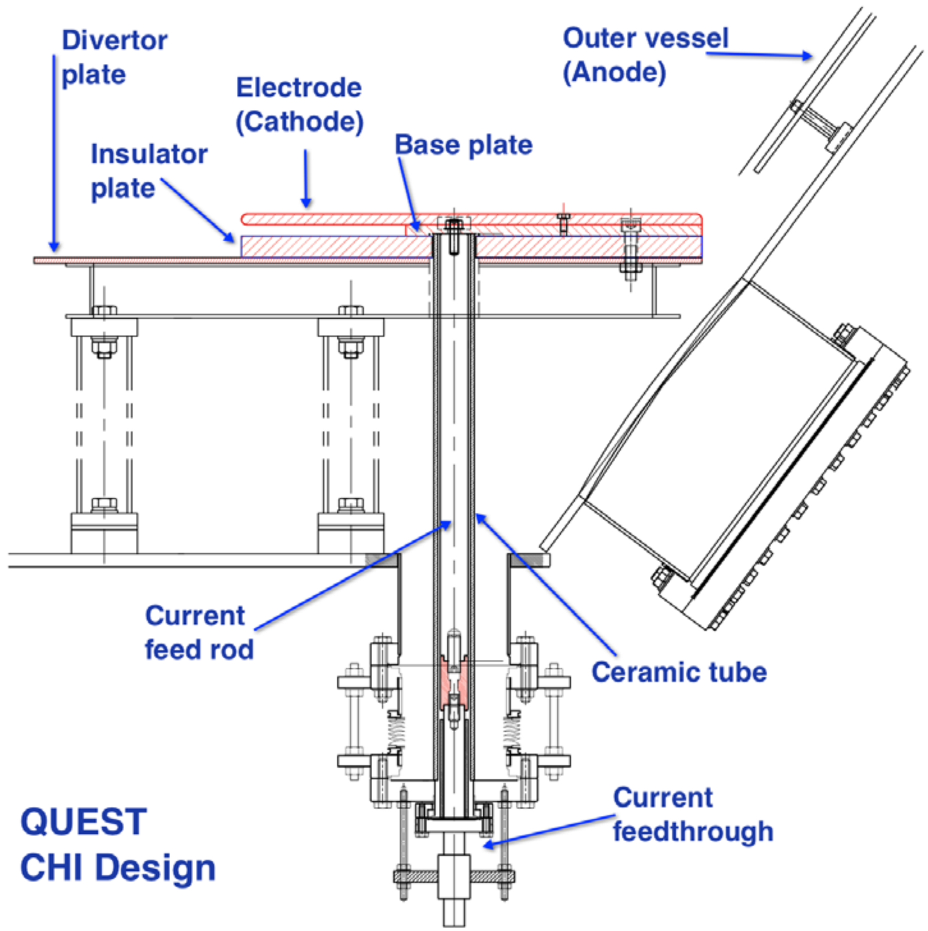
SAMI Antenna Array



MAST SAMI EBW Emission Data

New CHI Electrode Design to be Tested on QUEST (Collaboration with Japan)

- Provides early test of ECH heating of CHI plasma for NSTX-U/FNSF
- CHI design completed (March 2014)
  - CHI installation later during 2014
- Electrode mounted on top of divertor plate
- Electrode-based CHI may be applicable to FNSF
- US Contribution to project
  - Primary insulators
  - Capacitor bank power supplies
  - Gas injection systems



QUEST CHI Design

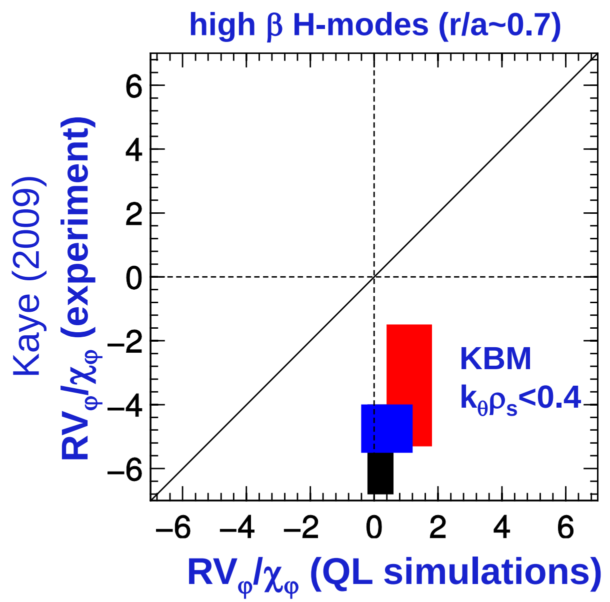
Momentum transport predictions being used to help constrain theory

#1 **#2** **#3** **#4** **#5**

$$\Pi_\varphi = \chi_\varphi u' + V_\varphi u + Cuu' + \chi_{\varphi\perp}\gamma_E + \Pi_{RS}$$

- Coriolis pinch (**#2**) for ITG generally describes conventional aspect ratio results
  - Microtearing (MT) & kinetic ballooning modes (KBM) predicted in NSTX H-modes, calculated pinch is inconsistent

Investigating centrifugal effects (**#3**) in FY14, collaboration with U-Bayreuth, GKW (Buccholz)

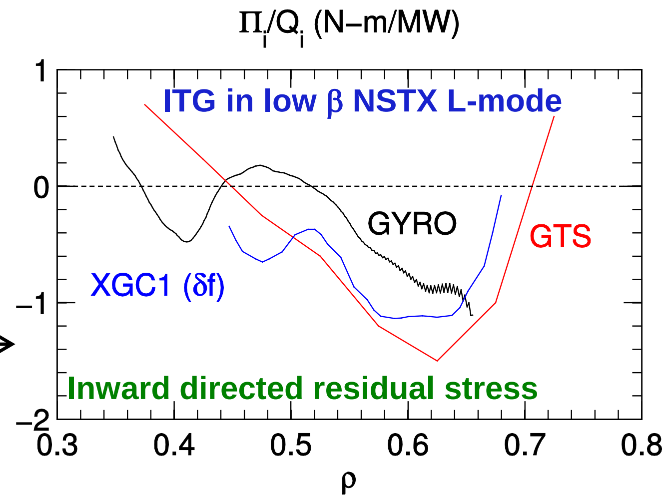


- Simulation challenges at high β motivated analysis in low β L-modes
  - Nonlinear simulations with E×B shear (**#4**) predict weak pinch, even for low β ITG
  - Led perturbative L-mode experiments at MAST using 3D δB fields (2013) – analysis ongoing

Collaboration with CCFE

- Investigating finite-ρ_* effects for momentum transport in low-β L-mode
  - Global GTS, GYRO & XGC1 (δf) simulations predict inward directed residual stress (**#5**) in absence of flow ($u=u'=\gamma_E=0$)

Ongoing global benchmark in FY14-15



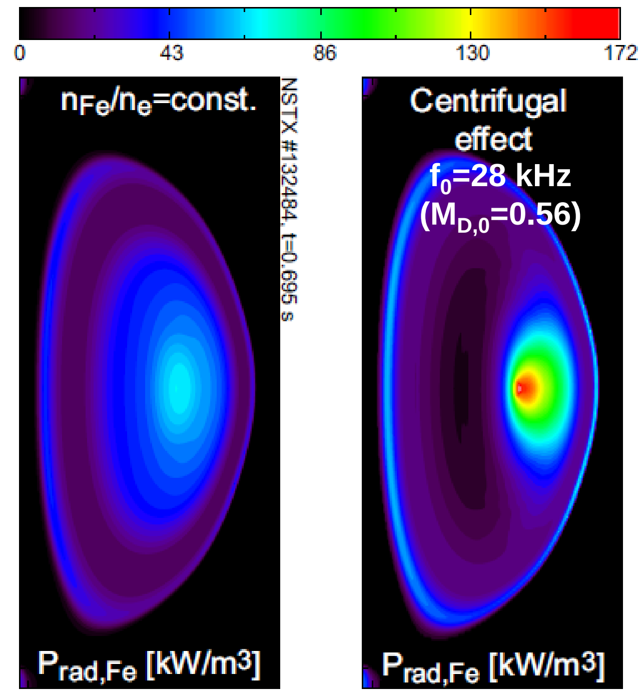
NSTX-U will study low- and high-Z impurity transport prior to significant high-Z PFC coverage in FY17+

- Impurity transport studies will be accomplished using gas-puff (Ne, Ar), laser blow off (Ca, Mo, W – FY16, LLNL/JHU) and many diagnostic enhancements:
  - Survey x-ray spectrometers (LLNL)
  - XCIS: $V_{\varphi,Z}$, T_Z, n_Z (Ca, Ar, Mo, W) (PPPL)
  - 1D tangential mid-plane + 2D poloidal bolometers (PPPL)

Collaboration between LLNL, JHU, PPPL

$$n_j = n_{j,0} \exp\left(\frac{\frac{1}{2}m_j\omega^2(R^2 - R_0^2) - eZ_j\Delta\Phi}{k_B T_j}\right)$$

- Will investigate whether high-Z transport follows neoclassical
  - Including toroidal rotation + centrifugal effects on poloidal asymmetry
  - Using 2[nd] NBI + NTV to vary rotation



Delgado-Aparicio, HTPD (2014)

- Plan to investigate particle transport using edge neutral measurement (D_α from MSE, BES; D_β camera) + DEGAS2 calculations
  - Assess perturbative capability using TS, ME-SXR
  - Perturbative particle transport measurements led on MAST in 2013 (Ren) – analysis ongoing

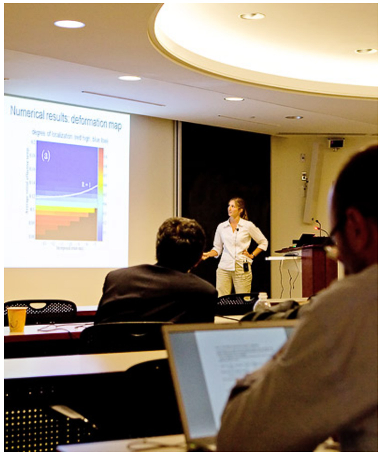
Collaboration with CCFE

6. Tentative plans for International ST Workshop 2015

- Will be hosted by U.S. – PPPL
- September is generally a good month for meeting
  - After summer vacations
  - Before APS/fall meeting season, possibly before classes resume
  - Weather good, temperatures not so hot (by mid September…)
- Possible/likely weeks:
  - August 31 – Sept 4 – if on main campus – to avoid beginning of classes
  - Week of September 7 or 21
    - Week of Sept 14 is: 12th International Symposium on Fusion Nuclear Technology – Jeju Island Korea

6. Options for International ST Workshop 2015 (1)

- Option 1: Princeton Center for Theoretical Science
  - On main campus – 4th floor of physics department
  - Very nice meeting space
  - Walkable - 0.7 mi from downtown hotel(s), restaurants, theatre, museums



- Issues:
  - Only one walkable hotel in town, and may be expensive (checking…)
  - Not close to PPPL – may reduce # of PPPLers who participate
  - Lunch restaurants not so close… may need to cater lunch

6. Options for International ST Workshop 2015 (2)

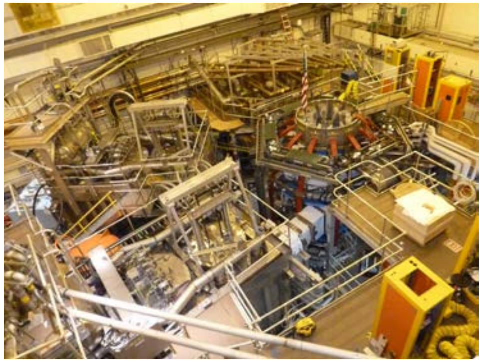
- Option 2: Friend Center at Princeton University
  - On main campus – near Computer Science / Engineering
  - Very nice meeting space, should be space for posters
  - More walkable - 0.5 mi from downtown hotel(s), restaurants
  - Lunch restaurants closer – 0.2-0.3 miles

- Issues:
  - Only one walkable hotel in town, and may be expensive (checking…)
  - Not close to PPPL – may reduce # of PPPLers who participate
  - Lunch restaurants not so close… may need to cater lunch

6. Options for International ST Workshop 2015 (3)

- Option 3: Princeton Plasma Physics Lab
  - Several meeting spaces (large auditorium, or smaller B318)
  - Many more hotel options on/near Route 1 – including shuttle service
  - Good space for posters outside auditorium
  - Lunch easier – go to cafeteria (or could drive to Forrestal Village)
  - Easy tours of NSTX-U, other facilities
  - More PPPL researcher participation





- Issues:
  - NOT walkable – need a car or to take hotel shuttle
  - Fewer restaurant options in short distance (need to drive various places)
  - Less “picturesque” than campus / down-town Princeton

7. Discussion of outreach to non-member countries

- Several observer/participants invited to the ExComm meeting
  - Russia, Korea, China

- Possible perspectives:
  - IEA facilitates collaboration and related discussion among members, so if our guests determine there is value in joining, we would work to include new members and welcome them

  - On the other hand, there are other modes of collaboration, include lab-to-lab bilateral agreements / memoranda of understanding

  - Which is best depends on the situation… – IEA may be best suited for representing collaboration interests of smaller groups / universities (?)

- Thoughts, discussion?

8. Discussion of Prep of 2014 Annual Report to IEA

- Annual report due mid-December
- ~10 pages of status and plans information
- I will solicit input next month (November)

- Here: should discuss status, future plans w.r.t. IEA:
  - Annex II
    - Co-operation on the Physics and Technology of Future ST Devices
  - Annex III
    - Co-operation on Steady State Operation of Fusion Devices
  - The next International ST Workshop will be hosted by PPPL
  - Are there other meetings, plans, needs? (website?)

9. Discussion of next ExComm chair, new members

- Next person in rotation would be from EU… Brian?
  - Do we need 2nd person from EU
- When should transition to next chair occur?
- … and Steve Eckstrand should comment on his plans

10. The end