Summary of the session on Plasma current startup

[Research related to central-solenoid-free *plasma current initiation* for an ST]

R. Raman
University of Washington, Seattle

Joint Spherical Torus and the
US-Japan Exchange Meetings (STW 2002)

November 18 – 20, 2002

This summary will focus on the initial plasma current startup for an ST

9 stimulating presentations on plasma startup

Plasma current startup using CHI (3)

Raman, Redd (Univ. of Wash.,USA) – *HIT-II*
Mueller (PPPL, USA) – *NSTX*

Theory simulations (3)

Browning (UMIST, UK) – on the *n=1* mode during CHI
Kagei (Himeji Inst. Tech., Japan) – on flipped ST
Tang (LANL, USA) – CHI modeling

Startup using RF and or induction (3)

Tanaka (Kyoto Univ., Japan) – ECH on *LATE*
Takase (Univ. of Tokyo, Japan) – *JT60-U*
Ono (Univ. of Tokyo, Japan) – Merging experiments on *TS3* and *TS4*

Plasma current startup using CHI

Raman, Redd (Univ. of Wash.,USA) – *HIT-II*

- CHI start-up on HIT-II produces very reproducible plasmas, less sensitive to changing wall conditions than for inductive only plasmas.
- Results in volt-seconds savings and consistently outperforms inductive-only operation.
- Can be initiated, as the central solenoid is being pre-charged. (applicable to a transient burning plasma ST device)
- Performance enhancing results demonstrates existence of a physics solution to ST plasma start-up using CHI.

Mueller (PPPL, USA) – *NSTX*

- First test of CHI in a reactor relevant ST.
- Produced 400kA in 330ms pulses demonstrating CHI steady-state capability and applicability to a large ST.
- Technical (hardware related) issues identified (including very frequent absorber arcs). Engineering modifications to address issues are being implemented during present NSTX shutdown.

Theory simulations (3)

Browning (UMIST, UK) – on the *n=1* mode during CHI

- Noted the first (?) experiment on adding external toroidal field to a Spheromak discharge, producing an ST.
- Excellent presentation on the implications of the observed *n=1* mode in CHI driven systems.

Kagei (Himeji Inst. Tech., Japan) – on flipped ST

- HIST experiment has produced a flipped ST plasma configuration.
- MHD simulations consistent with experimental observations.

Tang (LANL, USA) – CHI modeling

- Detailed 3D MHD code simulations on the implications of the presence of strong plasma flows in the CHI injector and absorber region to equilibrium reconstructions that ignores this.
- Implications of transient versus steady-state CHI discharges. 2D reconnection that produces high central-q plasmas versus advantages of more favorable CHI discharges produced using relaxation activity.

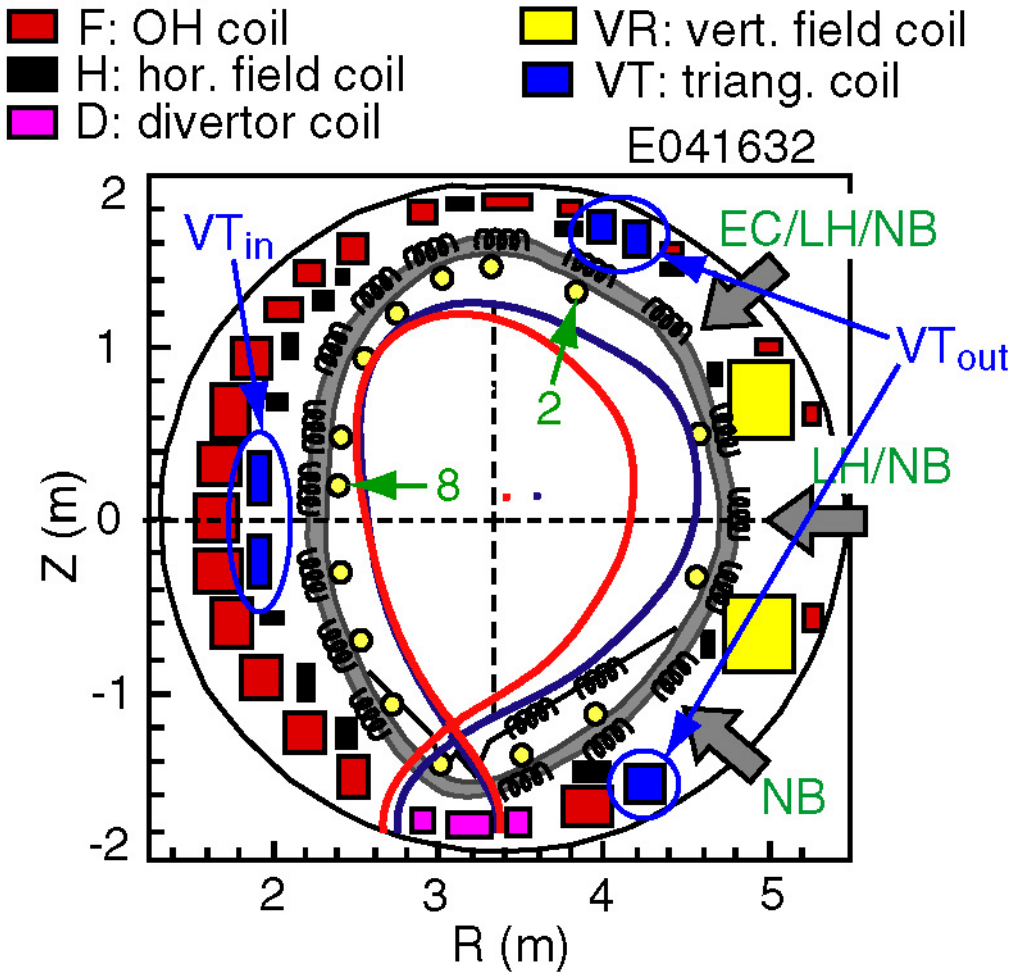
Startup using RF and or induction (3)

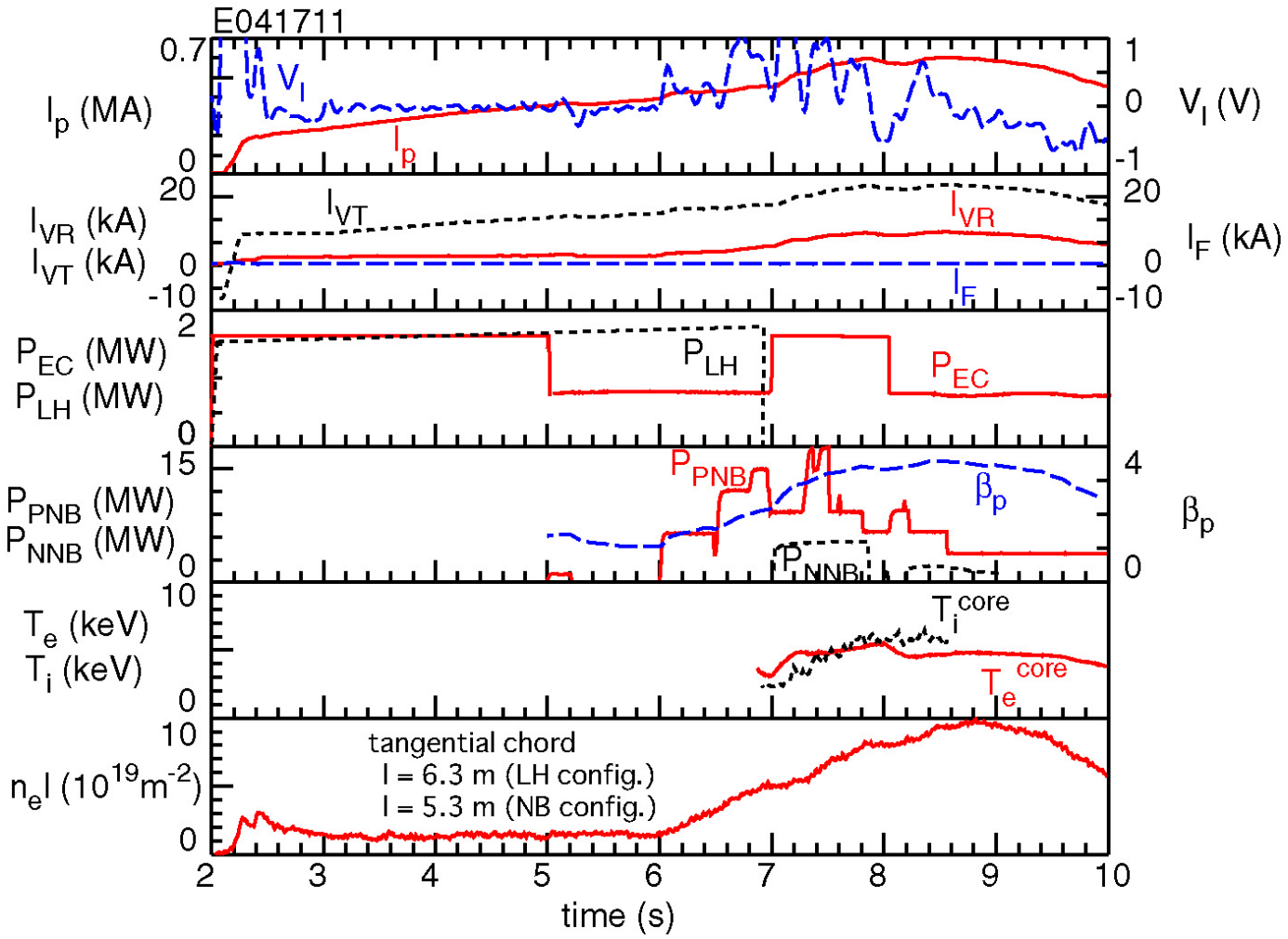
Tanaka (Kyoto Univ., Japan) – ECH on *LATE*

- Produced 5kA using about 20 to 50kW of ECH power.
- Low target densities probably not an issue.

Takase (Univ. of Tokyo, Japan) – *JT60-U*

- Encouraging results. Current initiated in a large tokamak without using solenoid, Inboard VT coils assist startup.





- VT coil ramp assists in current generation (t ~ 2.2 to 2.4s).

Ono (Univ. of Tokyo, Japan) – Merging experiments on *TS3* and *TS4*

- Several plasma formation methods tested (Spheromak merging to from FRCs, Spheromaks and STs).
- Proposed inductive merging scheme is similar to START/MAST merging compression method but with coils outside vessel.

Recommendations:

HIT-II: Demonstrate on a large ST. Higher current initiation may require technology solutions consistent with that needed for a reactor (possibly improved W divertor, local pre-ionization in injector).

NSTX: After initial CHI startup demonstrations, consider technology solutions to ramp CHI current to high levels and conduct reactor relevant design studies. Consider reactor relevant experiments (high TF reduces injector current, no neutron streaming as in NBI/RF ducts).

UMIST: Continue to help with theoretical/experimental understanding of CHI. Consider CHI related experimental work that can directly assist MAST. Work with other CHI groups.

HIST: Applicability to plasma startup of an ST.

3DMHD Simulations (Tang): Helps with interpretation of NSTX CHI results. Ideas tested, new ideas suggested by simulations. Implement NSTX geometry.

JT60-U: ST reactor will not have inboard coils. Implications of startup without using the VT coils.

LATE: Increase current as planned (look forward to 5GHz, ≥100kA results).

TS3/4: Conduct experiments as planned. Compatibility of method to a reactor (i.e., with blanket and other structures).