Summary of Innovative Concepts

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Fusion Power Associates Meeting
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OUTLINE

_____ Innovative Confinement Concepts (ICC)
   ICC workshop and proceedings summary
   FESAC TAP and MFE and HED Renew planning
   --> ICC Solicitation notice
Results of the ICC call: funded projects and non-renewals
The future for ICCs?

_____ Innovation at Woodruff Scientific Inc (WSI)
   WSI Progress
   P&S
   Proposed work

In total there were 38 invited talks, and 103 posters representing most of the CE level devices that are funded and in operation in the US, some from abroad, and some new ideas that were presented in a ‘New Concept’* session.

Contributions were organized by session:

- Mirrors: gas dynamic traps and rotating; Dipole
- Magnetized Target Fusion
- New Concepts
- FRC
- Spheromak
- RFP
- Stellarators and Helical systems
- Spherical torus

Program information: [http://www.iccworkshops.org](http://www.iccworkshops.org)
First time for anonymous peer review of contributions:
THANK YOU!
Renew for MFE (and also HED)

Arrangements
Al Oppenheimer

Workshop leadership
Richard Hazeltine (C)
David Hill (VC)
Hutch Nelson (OFES)

Web support
James DeKock
Emily Hooks

Burning plasma in ITER
Jim Van Dam (C)
Mickey Wade (VC)
John Mandrekas (OFES)

High-performance steady state
Amanda Hubbard (C)
Chuck Greenfield (VC)
Mark Foster (OFES)

Plasma material interface
Mike Ulrickson (C)
Rajew Mangu (VC)
Florin Dayagian (OFES)

Fusion power
Wayne Meier (C)
Rene Hafley (VC)
Barry Sullivan (OFES)

Magnetic configuration
John Saff (C)
Mike Zarnstorft (VC)
Gan Barish (OFES)

Control
Measurement
Off-normal events

Alpha particles
Reactor conditions
Self-healing

Integration
Modeling
Magnets
Auxiliary systems

Plasma-wall
PFC
Internal

Fuel cycle
Power extraction
Materials

Safety and environment
RAMI

Stellarator
ST
RFP
CT

ICCs now organized by scientific overlap, not by concept per se.
MFE Renew
Organization by Magnetic Configuration

Magnetic Fields vs Radius

Safety Factor vs. Radius

ST
RFP
Spheromak
MFE Renew
Common issues

NI startup and sustainment
Exhaust and power handling (divertors)
Confinement in symmetric systems
Control of profiles
Solicitation notice: DE-FOA-0000286

"The ICC program explores improved pathways to practical fusion power by addressing critical problems that hinder the tokamak concept, such as plasma disruption, heat load on internal components, and operational and maintenance complexity."

"Overall, support of research that can best help deepen the scientific foundations of understanding and improve the tokamak concept is an important focus area of this Announcement".
The results: funded

Auburn University, Stephen Knowlton  MHD Stability and Equilibrium in a Current-Driven Stellarator-Tokamak Hybrid
California Institute of Technology, Paul Bellan  Enhancing Fundamental Understanding of Magnetic Confinement
Columbia University, Gerald Navratil  High Beta Tokamak Research
Swarthmore College/ NRL, Michael Brown/Vyacheslav Lukin  Relaxation of 3D Magnetic Structures: SSX Experiments and Experimentally-Validated Simulations
UC Davis/SNL (CA), Hwang/ Buchenauer  Multiple Applications of Accelerated Compact Toroids in Magnetic Fusion Devices
University of Texas at Austin, Kenneth Gentle  Turbulence, Turbulence Suppression, and Controlled Fluid Flows in the Helimak
University of Washington, Thomas Jarboe  The Helicity Injected Torus (HIT) Current Drive Program
UWWashington/UWisconsin/Utah State University/NRL, Thomas Jarboe/Carl Sovinec/Eric Held/Vyacheslav Lukin  The Plasma Science and Innovation (PSI) Center at Washington, Wisconsin, Utah State, and NRL
University of Wisconsin, David Anderson  HSX: A Helically-Symmetric Toroidal Experiment
University of Wisconsin, Raymond Fonck  Non-Solenoidal Startup and Stability Limits at Near-Unity Aspect Ratio
University of Wisconsin, Chris Hegna  Targeted Optimization of Quasi-symmetric Stellarators
Oak Ridge National Laboratory (ORNL), Jeffrey Harris  ELMs and ELM-free Regimes in Stellarators and Tokamaks
ORNL, Rajesh Maingi  A Collaborative Program on the Lithium Tokamak Experiment
PPPL, Elena Belova  Advanced Simulation Studies of ICCs
PPPL, Samuel Cohen  Energy Confinement and Ion Heating in FRCs Generated by Odd-Parity Rotating Magnetic Fields
PPPL, Philip Efthimion  Off-Site University Research Support
PPPL, Richard Majeski  The Lithium Tokamak Experiment
PPPL/ORNL/LANL, George Neilson/Jeffrey Harris/Glen Wurden  Control of 3D Diverted Plasmas: A Partnership with Wendelstein 7-X
The results: not renewed

University of Washington, Uri Shumlak ZAP flow pinch
University of Washington, Alan Hoffman TCSU FRC
University of Maryland, Adil Hassam Maryland Centrifugal Experiment
MIT, Jay Kesner Levitated Dipole Experiment
…list not complete.

CE devices were only meant to run for 3-5 years (if properly funded at ~5M/year).

At 5 years, reviewed and either shut down or evolved to the next development level.
The future?

Toroidal CEs now organized by scientific area, generally supporting larger systems.

What is missing though?

→ the opportunity to talk up cheaper, faster routes to fusion (suggestion: seriously try it).

→ a fusion ‘Skunkworks’. (well, Lockheed might complain)

→ CE and POP level devices investigated in their own right.

→ Whole devices that younger scientists can manage (design expts for, session lead, build and maintain).
The future?

What if one of the CE level devices showed promise?
--How would we know it? (Better performance than T3?)
--How to convince others of it? (Excellent publication?)
--How to develop it? (<20 years, < $1Bn = private sector?)

Suggestion for the future:
--manage CEs at one or maybe two institutions to offset fear of downselecting
--set clear guidelines for participating in the program
--fund properly, and prioritize next steps (roll-back planning).
Some are exploring fusion development in the private sector

Tri-Alpha Energy ($100M)  General Fusion ($20M)  Lawrenceville ($1.2M)
EMC2 ($9M)  MSNW  PLASMAK  ...
Woodruff Scientific Inc is also exploring fusion in the private sector

WSI has made huge strides in the last year.

Defined specialty

Defined business plan: products and services are finding customers.

Wide collaboration base.

Ready for growth: charting the path to success with much help.
We contributed to the discussion of spheromaks in both FESAC TAP and BPO Renew.

July 2010 paper appeared in JFE outlining opportunities for Compact Torus Research.
Compact tori

Two kinds:

Omit TF leg:
Possibly more compact, lower cost, modular power cores.
Code validation, small experiments.

WSI Team

Woodruff  Baerny  Marston

Stoulil  Interns!

Scientific Advisory Board

US PATENT PENDING U.S. Serial No. 12/706,963
Products and services

**Pulsed power**
--banks for pulsed power, controls, safety

**Vacuum**
--design and fab, controls

**Diagnostics**

**Integrated research systems**
--Turn key systems (controls, banks, diagnostics, safety)

**Computer simulations of key experimental results**
Facilities

2 expt. labs
1 workshop
1 computer lab

Clean room
Offices
Loading bay
Lots more room to expand into!
Projects in the pipeline

DOE SBIR (submitted 2 weeks ago):

1. Laser endoscope for remote optical monitoring and ablation of Be and C deposition on ITER first mirrors
2. Prototyping and Design of a Universal Validation Tool
3. Modeling for Spheromak Performance Metrics and Development Milestones
4. Concept Design of an Ultra Compact Volumetric Neutron Source (UCVNS)

Upcoming:

Ion heating in NI startup by merging (multi-group proposal).
After FESAC TAP and BPO Renew, ICC program redirected. Some closures, some refocusing. ICC workshop proceedings peer reviewed for the first time ~20 papers published.

WSI: working on growing company through P&S, contracting. Focus is on issues relevant to larger systems (validation effort) New work focuses on broader issues (inc. ITER).