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Proceedings of the 1999 Fusion Summer Study July 11-23, 1999 Snowmass, Colorado

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Opening Plenary

Agenda

- *Welcome.* M. E. Mauel
- *Setting the Stage for Snowmass.* H. Grunder
- *My Preconceived Notions and Prejudices.* M. Rosenbluth
- *Considerations to the EU Fusion Program.* F. Wagner
- *A Rationale for Fusion Energy Development in Japan.* M. Kikuchi
- *Reflections on Fusion's History and Implications for Fusion's Future.*
R. Conn
- *Deep Restructuring in Fusion.* D. Ryutov
- *Thoughts on Fusion Priorities.* D. Baldwin
- *Meeting the Challenge for Fusion Energy.* M. Campbell
- *Science, Innovation, and Collaboration in MFE.* R. Goldston

Working Group Summary Talks

On the last day of the Summer Study, each working group presented summaries of their technical activities and discussions. These presentations are referenced below.

Agenda

- *Opening Comments.* R. Hawyrluk
- *Magnetic Fusion Concepts.* T. Taylor
- *Inertial Fusion Concepts.* C. Olson
- *Emerging Fusion Concepts.* D. Barnes
- *Plasma Science Issues.* A. Kritz
- *Technology Issues.* M. Abdou and S. Milora
- *Energy Issues.* F. Najmabadi and R. Stambaugh
- *Closing Comments.* G. Logan

Magnetic Fusion Concepts

- *Summary of the Magnetic Fusion Concepts Working Group.* T. S. Taylor, M. Greenwald, J. Sarff, E. Strait, C. Hegna, B. Lipschultz, T. Ronglien, S. Allen, H. Neilson, E. Synakowski, R. Nazikian, W. Houlberg, M. Zarnstorff, S. Luckhardt
- *Transport and Turbulence.* D. R. Baker, G. Bateman, M. Beer, A. Boozer, B.E. Chapman, J. DeGroot, W. Dorland, E. Doyle, P. Efthimion, C. Greenfield, M. Greenwald, G.W. Hammett, B. Hooper, J. Kesner, M.W. Kissick, J-N. LeBoeuf, Z. Lin, G. McKee, D. Newman, J. Sarff, G. Staebler, L. Steinhauer, E. Synakowski, P. Terry, D. Thomas, R. Town, A. Ware
- *Pursuing Burning Plasmas.* R. Nazikian, W. Houlberg, H. L. Berk, D. Ernst, I. Hutchinson, R. La Haye, D. Mueller, N. Sauthoff, A. Turnbull, J. Wesley
- *MHD Stability.* E.J. Strait and C.J. Hegna, and S. Knowlton, E.J. Strait, M.W. Kissick, S. Sabbagh, R. Nebel, L. LoDestro, L. Steinhauer, A.G. Kellman
- *Achieving Steady State.*
- *Plasma Boundary and Particle Control.* A. Mahdavi, S. Pitcher, R. Maingi, A. Leonard, P. Mioduszewski, D. Den Hartog, L. Schmitz, T. Jarboe, T. Rognlien, D. Ryutov, L. Steinhauer
- *MFE Concept Integration and Performance Measures.* M.C. Zarnstorff, D. Gates, E.B. Hooper, S. Jardin, H. Ji, S.C. Luckhardt, J. Lyon, J. Sarf, T. Simonen, T. Thorson

Inertial Fusion Concepts

- *Summary of the Inertial Fusion Energy Working Group.* Craig Olson, Max Tabak, Jill Dahlburg, Rick Olson Steve Payne, John Sethian, John Barnard, Rick Spielman Ken Schultz, Robert Peterson, Per Peterson Wayne Meier, John Perkins
- *Summary reports of the Subgroups.*
Subgroup 1: *Targets.* Max Tabak, Jill Dahlburg, Rick Olson
Subgroup 2: *Drivers and Standof.* Steve Payne, John Sethian, John Barnard, Rick Spielman
Subgroup 3: *Inertial Fusion Power Plant Concepts.* Ken Schultz, Robert Peterson, Per Peterson
Subgroup 4: *IFE Metrics and Development Paths.* Wayne Meier, John Perkins

Emerging Fusion Concepts

- *Summary of the Emerging Fusion Concepts Working Group.* D. C. Barnes, J. Hamme, A. Hassam, D. Hill, A. Hoffman, B. Hooper, J. Kesner, G. Miley, J. Perkins, D. Ryutov, J. Sarff, R. E. Siemon, J. Slough, M. Yamada
- *Summary of Physics Aspects of Some Emerging Concepts.* J. Kesner and A. Hassam
- *Emerging Concepts Reactor Subgroup Summary.* J. Hammer and R. Siemon
- *Technical Opportunities Subgroup Emerging Concepts.* G. H. Miley and J. Slough

Plasma Science

- *Plasma Boundary Sciences.* G D Porter, M. A. Mahdavi, P. Mioduczewski, S. Krashinennikov, J. Albritton, M. Ulrickson, R. Cohen
- *Magneto/Hydrodynamic and Beam Equilibrium and Stability.* R. Betti and E.J. Strait
- *Plasma Science of Wave-Particle Interactions.* D. Batchelor, W. Kruer, R. Nazkian, H. Berk, B. Breizman, V. Chan, G. Fu, J. Greenly, R. Harvey, M. Hermann, S. Knowlton, R. Majeski, H. Mynick, R. Nazikian, C. Phillips, R. Pinsker, M. Porkolab, R. Prater, R. Wilson
- *Transport and Turbulence.* D. R. Baker, G. Bateman, M. Beer, A. Boozer, B.E. Chapman, J. DeGroot, W.Dorland, E. Doyle, P. Efthimion, C. Greenfield, M. Greenwald, G.W. Hammett, B. Hooper, J. Kesner, M.W. Kissick, J-N. LeBoeuf, Z. Lin, G. McKee, D. Newman, J. Sarff, G. Staebler, L. Steinhauer, E. Synakowski, P. Terry, D. Thomas, R. Town, A. Ware

Technology

- *Summary of the Technology Working Group.* M. Abdou, R. Callis, S. Milora, M. Ulrickson
- *Report of the Technology Working Group.*
Organizer: M. Abdou
Subgroup Leaders: M. Abdou, R. Callis, S. Milora, M. Ulrickson.
Topics & Discussion Leaders:
Liquid Walls. R. Moir, N. Morley
Solid Walls. R. Mattas, M. Ulrickson
Availability/Reliability/Maintainability. M. Tillack, B. Nelson
Testing Conditions and Facilities. S. Zinkle, A. Ying
Radioactive Waste Minimization. D. Petti, E. Cheng
Tritium Self-Sufficiency. M. Sawan, S. Willms
Materials. S. Zinkle, M. Billone
Heating/Current Drive/Fueling Technologies. D. Swain, R. Temkin
Magnets. J. Schultz, R. Woolley
IFE Target. K. Schultz, W. Steckle

Energy Issues

- Subgroup A: Long-Term Visions for Fusion Power.
 - * Summary report. *Long-term Visions for Fusion Power.* D. Barnes, L. Bromberg, B. Chapman, T. Dolan, A. L. Hoffman, F. Najmabadi, W. Nevins, R. Parker, J. Perkins, D. Ryutov, J. Schmidt, R. E. Siemon, D. Steiner, D. Thomas
- Subgroup B: Development Path Issues for Fusion Energy.
 - * Summary report. *Development Path Issues Overall Summary.* W. Meier, G. Navratil, N. Sauthoff, R. Stambaugh
 - * *Prospectus of the Energy B subtopical discussion group.*
 - * *Subgroup plan.*
 - * *Subgroup recommended reading list.*
 - * *Subgroup agenda.*
 - * *Subgroup guidelines.*
 - * Presentations made during the plenary sessions of Energy Subgroup B:
 - + *An Integrated Research Experiment (IRE) for Heavy Ion Fusion.* R. O. Bangerter
 - + *Inertial Fusion Energy Development Plan Strategy.* E. Michael Campbell
 - + *Burning Plasma Physics Issues in a Possible JET Upgrade.* C. Gormezana, J. Jacquinot, E. Joffrin, G. Saibene, R. Sartori
 - + *NIF Update.* W. Hogan
 - + *Status of Next Step Option Study on Fusion Ignition Research Experiment.* D. Meade
 - + *IFE Engineering Test Facility (ETF)--Opportunities for Reducing Fusion Development Costs.* W. Meier

Energy Issues (cont.)

- + *Future of LHD-type Device.* N. Ohyabu
- + *RC ITER: An Opportunity to Study Burning Plasmas and Develop Fusion Technology in a Reactor Relevant Device.* R. Parker
- + *An Integrated Research Experiment (IRE) for Diode-Pumped Solid State Lasers.* H. T. Powell
- + *Krypton Fluoride Laser Development-the Path to an IRE.* J. Sethian
- + *A Description of the Spherical Torus Machine in the Fusion Development Facility.* R.D. Stambaugh
- + *A Fusion Development Facility Based on the Spherical Torus,* R.D. Stambaugh, D.E. Baldwin, and V.S. Chan
- + *Ignitor.* L. E. Sugiyama, B. Coppi, and the Ignitor Team
- + *The Steady State Tokamak.* K. Thomassen

Contributed Papers

- *U.S. Stellarator Program Plan.* D. Anderson, et al
- *Some Simple Arguments about Cost Externalization and its Relevance to the Price of Fusion Energy.* R. Budny and R. Winfree
- *A Strong Basic Plasma Science Program is Essential for the Fusion Energy Sciences Program.* J. R. Cary, et al
- *Self-Magnetic Fields.* T. J. Dolan
- *Potential Methods For Improving Pedestal Temperatures and Fusion Performance.* G. W. Hammett, W. Dorland, M. A. Beer, M. Kotschenreuther
- *Measurement of Beam Divergence Angle which is Small Enough to Encourage our Future Development of Medium Mass Ion Driver.* K.Kasuya, Y.Kishi, T.Kamiya, M.Funatsu, S.Saitoh, T.Renk, D.Hanson, B.Turman, R.Leeper T.Mehlhorn, J.Quintenz
- *Synergism between Liquid Metal Walls, Tokamak Physics Performance, and Reactor Attractiveness.* M. Kotschenreuther
- *2d and 3d Imaging and Visualization of Plasma Modes and Turbulence: Grand Diagnostic Challenge 2000-2010.* S. C. Luckhardt
- *Can Fusion Research be Revitalized by Embracing a Fission Fusion Hybrid Reactor?* W. Manheimer
- *Inertial-Electrostatic Confinement (IEC) of a Fusion Plasma with Grids.* Jon Nadler
- *Energy Futures: An Alternate View.* R. A. Nebel
- *Role of Feedback Control in Fusion Energy Research.* A. K. Sen.
- *A Community-based R&D Roadmap for Magnetized Target Fusion.* R. Siemon, K. Schoenberg, D. Ryutov, I. Lindemuth, P. Turchi, G. Wurden, T. Intrator, J. Degnan, and others
- *The Case for Fast Ignition as an IFE Concept Exploration Program.* R. B. Stephens, M. Key, W. Meier, R. Moir , and M. Tabak
- *Critical Physics Issues for Ignition Experiments: Ignitor.* B. Coppi and L. E. Sugiyama

Contributed Papers (cont.)

- *Magnetized Target Fusion in a Spheroidal Geometry With Standoff Drivers.*
Y. C. F. Thio, E. Panarella, R. C. Kirkpatrick, C. E. Knapp, F. Wysocki,
P. Parks, G. Schmidt

Elements of the Snowmass WebPages

- Snowmass Poster
- Announcement
- Purpose and Planning
- Second Bulletin
- How to get the Most from Snowmass
- Organizers, Working Group Leaders, Convenors

Other Contributions and References

- Group Photograph of the Participants of the 1999 Fusion Summer Study:
 - * *Group Photo*
- *Participant List.*
- *Daily Schedules.* A record of the detailed schedule of all of the working groups, subtopical discussion groups, and plenary sessions.
- Reference Reports:
 - * *Report of FESAC Panel on U. S. Participation in ITER and the Extended-EDA Interim Period (January 1998).*
 - * *Letter from Dr. Martha A. Krebs (Director, Office of Energy Research) to Dr. John Sheffield (Chair, Fusion Energy Sciences Advisory Committee) (October, 1998).*
 - * *Opportunities in the Fusion Energy Sciences Program, FESAC, (June 1999).*
 - * *Opportunities in the Fusion Energy Sciences Program Appendix C: Topical Areas Characterization, FESAC, (June 1999).*
 - * *Realizing the Promise of Fusion Energy, Final Report of the SEAB Task Force on Fusion Energy, (August, 1999).*
 - * *Fusion Science Assessment Committee Interim Assessment, National Research Council Plasma Science Committee Interim Report, (August 31, 1999).*
 - * *Report of the FESAC Panel on Priorities and Balance, FESAC, (September, 1999).*
- *The Skit at Snowmass.*
- *Results from the Post-Snowmass Survey.*
- *Summary and Open Discussion of the Summer Study conducted Tuesday Evening, November 16, 1999, at the APS-DPP Meeting in Seattle, WA, M. Mauel.*