Summary of the Tritium Town Meeting

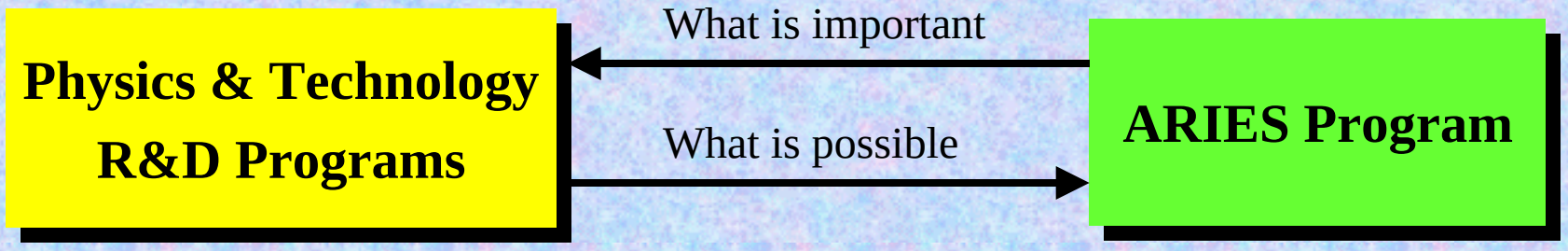
Presented by M. S. Tillack

ARIES Project Meeting
March 8-9, 2001
Livermore, CA

Purpose of Town Meetings

The ARIES program organizes town meetings to provide a forum for discussions between scientists from R&D programs and power plant studies:

- To help guide experimental programs towards solutions that lead to an attractive fusion power plant
- To help design studies develop concepts that are consistent with the understanding of scientists developing those technologies.



➢ **ARIES Mission Statement:**

Perform advanced integrated design studies of the long-term fusion energy embodiments to identify key R&D directions and provide visions for the program.

History of ARIES Town Meetings

Mar. 2-3, 1995	ANL	Workshop on Liquid Target Divertors	
May 10, 1995	ANL	Starlite Town Meeting on Structural Materials	*Starlite*
Jan. 31, 1996	UCSD	Starlite Town Meeting on Low Aspect Ratio Spherical Tokamaks	
June 19, 1997	UW	ARIES Town Meeting on Designing with Brittle Materials	*ARIES-RS*
May 6-7, 1998	UCSD	ARIES Town Meeting on ST Physics	*ARIES-ST*
Jan. 18-19, 2000	ORNL	International Town Meeting on SiC/SiC Design & Material Issues for Fusion Systems	*ARIES-AT*
March 6-7, 2001	**LLNL**	**Tritium and the DT Fuel Cycle**	*ARIES-IFE*

Tritium is pervasive in fusion power plants; understanding and controlling it is essential for the success of fusion energy

• Fuel self-sufficiency	10% margin
• Routine release	10 mrem/yr, 2-3 Ci/d
• Accidental release	1 rem, 15 gm T as HTO
• Inventory & recovery – in blanket, PFC's – in target factory	ITER: 4 kg on site, <1 kg in vessel many kg possible
• T burn fraction (impacts on-site, inventory and required TBR)	~30% in ARIES, but 0.5 % in ITER!

Tritium Town Meeting

Objective:

Bring together the design and R&D communities to exchange information, identify design-related critical issues, discuss latest R&D results, and provide guidelines to help focus future effort.

Organizers:

D. K. Sze, M. J. Gouge

Output:

Findings and recommendations on 4 main discussion topics:

Fuel cycle: fuelling, pumping, tritium processing/supply

PFC & blanket: inventory, recovery, containment, control

Safety: routine release, accidental release

IFE-specific: target factory inventory

Archive: *http://aries.ucsd.edu/MEETINGS/TTM*

Attendees:

N. Alexander, GA
R. Bastasz, SNLA
R. Causey, SNLL
L. El-Guebaly, UW
G. Federici, ITER-EU
P. Fisher, ORNL
D. Goodin, GA
M. Gouge, ORNL
J. Latkowski, LLNL
R. Mattas, ANL
W. Meier, LLNL
A. Molvik, LLNL
J. Perkins, LLNL
D. Petti, INEEL
R. Raffray, UCSD
S. Reyes, LLNL
K. Schultz, GA
C. Skinner, PPPL
(by phone)
D. K. Sze, ANL
M. Tillack, UCSD
S. Willms, LANL

Agenda

9:00-9:10	Welcome	Mike Gouge
9:10-9:30	Introduction and goals for the town meeting	Mark Tillack
Session 1	**Fuel cycle in and near the vessel** Chairman: Charles Skinner	
9:30-10:00	Recent development in plasma fueling and implications for ARIES	M. Gouge
10:00-10:30	Pumping system for FIRE and ARIES	P. Fisher
10:30-10:45	Break	
10:45-11:30	Tritium processing and supply	S. Willms
11:30-12:00	Discussion and summary	C. Skinner
12:00-1:15	Lunch	
Session 2	**Inertial Fusion Energy** Chairman: Ken Schultz	
1:15-1:45	High volume filling of IFE targets	N. Alexander
1:45-2:15	IFE target factory tritium inventory modeling	A. Schwendt/Willms
2:15-2:45	Advanced, tritium-lean target design	J. Perkins
2:45-3:15	Discussion and summary	K. Schultz
3:15-3:30	Break	
Session 3	**Chamber Armor (PFC) and Blanket Tritium Inventory, Recovery and Control** Chairman: Rene Raffray	
3:30-4:00	Tritium inventory and recovery experience in tokamaks	C. Skinner
4:00-4:30	Tritium issues for PFC	R. Causey
4:30-5:00	Tritium retention issues in the ITER-FEAT device	G. Federici
5:00-5:30	Discussion	

Agenda, cont'd.

Session 3	**Chamber Armor (PFC) and Blanket Tritium Inventory, Recovery and Control** (cont.) Chairman: Rene Raffray	
9:00-9:30	Tritium breeding issues for MFE and IFE	L. El-Guebaly
9:30-10:00	Tritium recovery and confinement from breeding blanket	D. Sze
10:00-10:30	Discussion and summary	R. Raffray
10:30-10:45	Break	
Session 4	**Safety** Chairman: Dave Petti	
10:45-11:15	IFE tritium safety issues	J. Latkowski
11:15-11:45	Tritium safety	D. Petti
11:45-12:15	Discussion and summary	
12:15-1:30	Lunch	
1:30-3:30	Round table discussion on the issues on hydrogen (tritium) retention and helium pumping in liquid surfaces and the impact on fuel cycle. Chairman Rich Mattas	
3:30-4:30	Final discussion	

Findings and Recommendations: 1. Fuel Cycle

(Mike Gouge)

1. Fueling

- Innovations and R&D in fueling systems:
  - high field side launch
  - pellet-triggered L-H mode
  - disruption mitigation

2. Vacuum pumping technology

- Rotating snail cryopumps for continous regeneration
- Design systems in the pressure range 0.1-10 Pa (minimize dimensions)
- Optimize 30 K entrance duct for He ash compression (viscous flow regime)
- Cryogenic pellet forepump- no moving parts or oil

3. Tritium supply (a'la Rutherford): Not enough startup T on our timeline.

Findings and Recommendations: 2. Chamber armor and Blanket

(Rene Raffray)

1. PFC issues for MFE

- C, Be, W experience reviewed from existing machines and ITER
  - **C:** erosion and re-dep make it unacceptable for MFE power plant
  - **Be:** charge exchange erosion makes it unacceptable for MFE power plant
  - **W:** looks promising except for disruption melt layer

2. Applicability of MFE experience to IFE

- Off-normal MFE conditions (VDE, disruption) relevant to IFE,
- Carbon co-dep and macroscopic erosion need further examination for IFE

3. T breeding

- 10% margin, easier to achieve in IFE, methods to adjust TBR:
  - Li enrichment, thickness, vol. fractions

4. Blanket inventory and permeation

- <200 g achievable but <1-10 Ci/day very challenging (*very* low part. press.)
- ideas: double wall HX, permeation barriers, *etc.*

Findings and Recommendations: 3. Safety

(David Petti)

- **Normal operations:**
  - 10 mrem/year at site boundary tritium release < 2-3 Ci/d
  - We need solutions to minimize tritium permeation through heat exchanger
- **Occupational safety:**
  - Contamination control is a strong design driver
- **Accident safety:**
  - 1 rem site boundary limit tritium release < 15 g T as HTO for **conservative weather** conditions
  - Radiological confinement is a strong design driver, especially at penetrations
  - Design modifications (including new materials) may be needed to demonstrate satisfactory safety performance
  - For IFE, more engineering details are needed to demonstrate satisfactory safety performance

Findings and Recommendations: 4. IFE Specific

(Ken Schultz)

1. T_2 issues similar to MFE

- **Blanket** - except more interest in liquids, Flibe, adequate TBR is easier
- **Tritium processing** - except some unique impurities (fill gas, hohlraum, Flibe)
- **Chamber** - co-dep of T in C, extended vacuum boundary more challenging
- **Tritium** - perhaps the *dominant* public safety issue for IFE

Important to maximize synergies in cases of similarity

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2. T_2 issues unique from MFE

- Possible large T_2 inventory in target factory
  - Extrapolation from existing technologies looks bad, but ideas exist
- Options for tritium-lean (~1%) fuels

Still have opportunities to learn from one another!

Round Table Discussion on H and He in Liquid Surfaces

(Rich Mattas)

- "Lively" discussions on general feasibility, mixed materials effects, effects of cx flux and T-enhanced sputtering on operating window

- H(T) retention important only for Li
  - expect 100% retention, high-T low recycle (except recent PISCES result)
  - even at 100% retention, 200 g inventory is possible

- Other materials exhibit low retention of H(T) and He
  - He pumping is a key issue in any case – R&D is needed
  - SnLi appears intermediate between Sn and Li; segregation effects observed

- Comparison of MFE FW, divertor and IFE (thin and thick liquid) made. See summary report for more details.