EM-Enhanced HyPOR Loop for Fast Fusion Cycles

GAMOW Kickoff Meeting
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Team members and roles

- Oil Advancement/EM Thermocatalytic Process
  - George Larsen
  - Jay Gaillard
  - Mark Elvington
  - Tyler Guin

Savannah River National Laboratory®




- Radiation Effects and Analyses
  - Tim DeVol
  - Valery Bliznyuk

CLEMSON UNIVERSITY


- Catalyst Development
  - John Regalbuto

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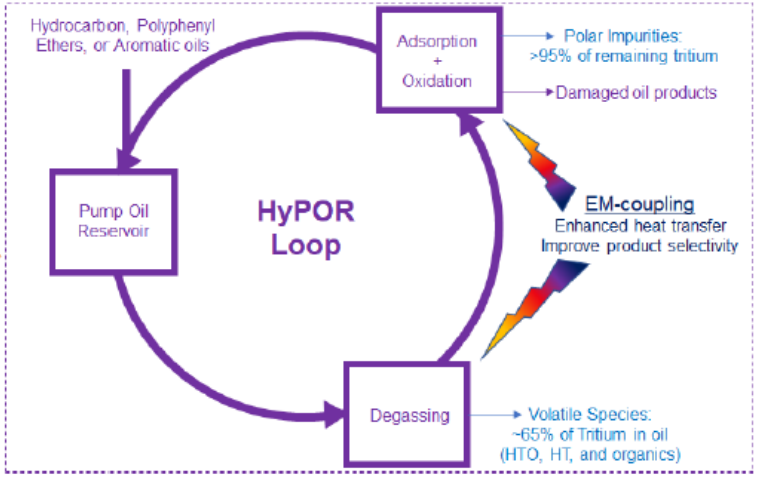
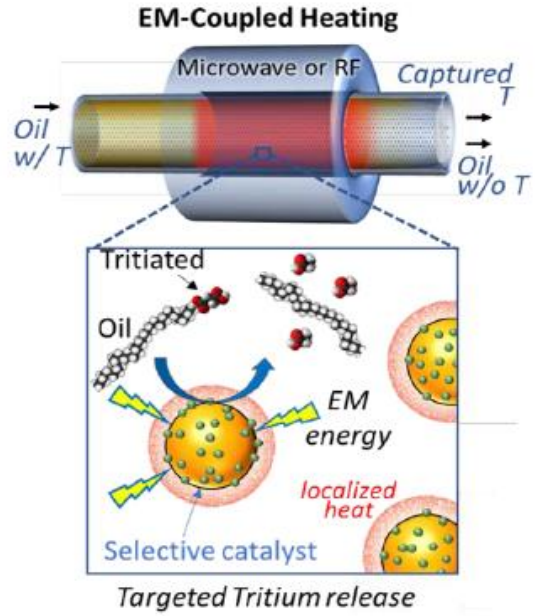
High-level motivation, innovation, and goals of the project

- **Motivation: Fuel cycle technology**
  - Continuous pumps are the most important component
    - *No viable solution for torus*
  - Commercial vacuum technology exists at scale - but use oils
  - *"Tritium and organics don't mix"*
    - Not entirely true
    - Need to be meticulous in choosing oil and additives …
    - … and develop a detritiation and recycling process

- **Innovation: Hydrocarbon Pump Oil Recycling Loop**



Goal: Selectively remove heavier H_2 isotopes from pump oil while also purifying the oil of radiation-induced damage.



EM-enhanced Thermocatalysis

- Precise thermodynamic control
- Efficient coupling
- Minimize thermal damage
- Cutting-edge catalyst synthesis

Major tasks, milestones, risks, and desired project outcomes

- Project outcome:
  - Integrated recycling and detritiation process
    - >99.5 % detritiation, with uptake of <0.1% of tritium throughput
    - Scalable to an oil throughput of 6 gal/day
    - Compatible with commercial vacuum pump systems that can achieve speeds of >100 m^3/s at 1 – 10 Pa

- Major tasks
  - Two prong approach
    - Optimize oil
    - Develop EM process
- Major Milestones:
  - Catalyst synthesis
    - *<5 nm bimetallic catalysts >1 wt% (Q4)*
  - Flow-through system
    - *Target: 120 g/hr at 150 W (Q6)*
  - Oil irradiation testing
    - *<5% viscosity; <2% impurities* (Q9)
  - Tritium testing
    - *Target: <0.1% uptake (Q10)*
- Risks:
  - Oil advancement/availability
  - Detritiation process

T2M and aspirational follow-on plans

- Techno-economic metrics

Fuel Cycle Pumping Concept	Tritium Inventory (g)
Batch Cryopumps (Baseline - ITER process)	2030
Batch Cryopumps (with 90% recycling via Pd-Ag permeators)	899
HyPOR loop-enabled oil pumps (with 90% recycling via Pd-Ag permeators)	480

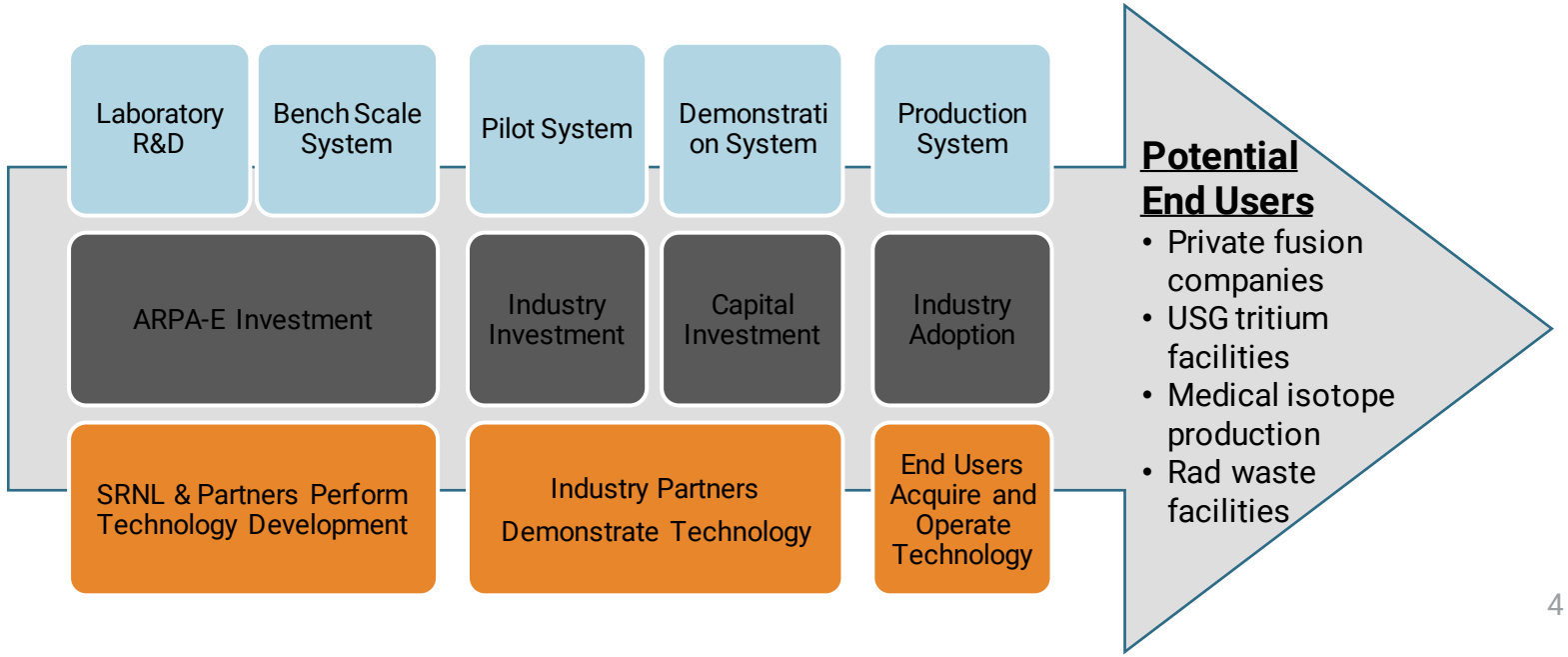
>4× reduction in tritium inventory

Tritium inventory costs >$30k per gram

Metric	State of the Art	Proposed
Vacuum electric consumption	2.8 MW	0.25 MW
Vacuum residence time	27 min, Batch	<1 sec, Continuous
Detritiation process times	48 – 66 hours	<1 hour
Oil cost, based on lifetime	>$14.5 million/year	$103k/year

>10× reduction in auxiliary electrical consumption; >50× reduction in pump costs; >140× reduction pump operational costs

- Test & deployment plans/aspirations
  - Enables any concepts and industries that require tritium and vacuum pumps



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