Renewable Low-Z Wall for Fusion Reactors with Built-in Tritium Handling

GAMOW Kickoff Meeting
January 21–22, 2021

PI: Eric Hollmann (UCSD)

Co-PIs: Jose Boedo (UCSD), Benjamin Spencer (INL)

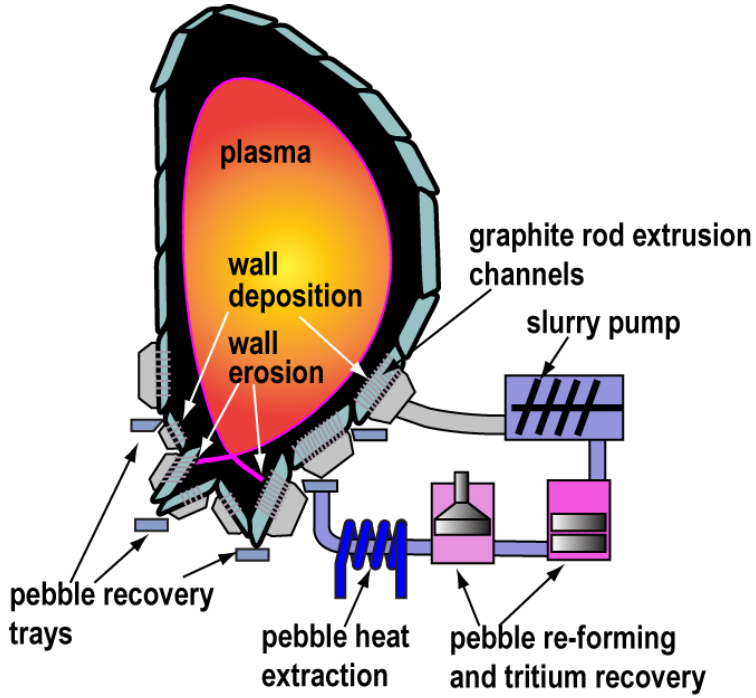
Team members and roles

- Eric Hollmann (PI, UCSD) – coordinate project.
- Jose Boedo (Co-PI, UCSD) – experimental guidance.
- Benjamin Spencer (Co-PI, INL) – lead simulation effort.
- Alborz Izadi (Postdoctoral researcher, UCSD) – perform experiments.
- Erick Loran (Postdoctoral researcher, UCSD) – perform experiments.
- Leo Chousal (Mechanical engineer, UCSD) – CAD and machine shop interface.
- Chris Jones (Electrical engineer, UCSD) – Instrumentation, electrical.
- Tianchen Hu (Graduate Student, Duke University) – perform simulations.

arpa·e
CHANGING WHAT'S POSSIBLE

Main goal: demonstrate essential technologies necessary for continuously renewing low-Z extruded fusion reactor first wall

- Propose to extrude low-Z first wall material (C, B, B_4C, or SiC) as sintered pebble rods at first wall.
- Pebbles are delivered to back of wall mixed with liquid binder to form slurry.
- Liquid binder is baked away close to hot walls.
- Extruded pebble rods at first wall disintegrate back into constituent pebbles, which are recovered by gravity.
- Pebbles rapidly carry away heat and tritium from first wall.
- Addresses multiple first wall issues: poor core performance, melting, transmutation, blistering, cracking, alloy formation (high-Z walls); erosion, migration, tritium retention (low-Z walls)

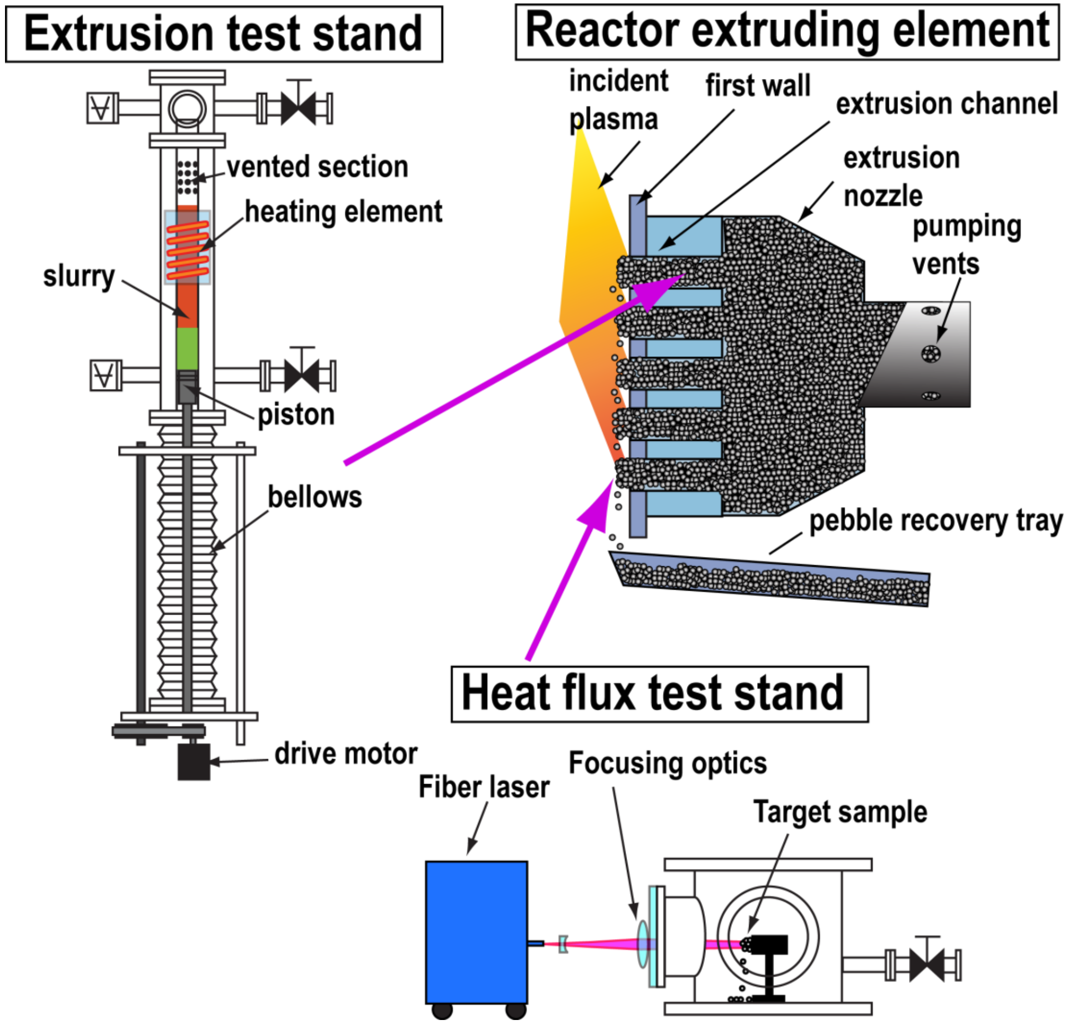


- Provides increased resistance to any permanent wall damage from transients (disruptions, ELMs) and also provides faster recovery (startup) after these events.

arpa·e
CHANGING WHAT'S POSSIBLE

Top priority: demonstrate "tunable" disintegration of extruded low-Z pebble rods

- Will assemble test stand to test disintegration of pebble rods under high heat flux.
- Fabricate different pebble rods which can achieve disintegration at ~0.5 cm/s at reactor-relevant perp heat fluxes 5 – 40 MW/m^2. (0.5 - 4 kW laser power on 1 cm^2 sample).
- "Tunability" achieved with varying composition of pebbles and binder (varying quantity of low-Z ceramic pebbles added).
- Second test stand to test extrusion properties of pebble rods: friction with channel (desire low chemical binding), outgassing (desire < 1 Torr-L/s/m^2).
- Extrapolation to neutron environment with finite-element simulations.



T2M and aspirational follow-on plans

- Relevant techno-economic metrics:
  - Increased max per heat flux handling: expect 40 MW/m^2 (vs 20 MW/m^2 for W mono-block).
  - Increased transmutation lifetime: expect >10 years vs 3 years for W.
  - Increased T inventory lifetime: expect ~10 years (~0.2 kg/year retention) vs 2 years (~ 1kg/year retention) for W or < 0.5 year for C (~2 kg/year retention).

- Test & deployment plans/aspirations
  - Focus is on tokamak lower single null geometry but concept could be useful for other magnetic fusion geometries (e.g. stellarator, FRC).
  - Test PMI issues (e.g. hydrogen retention) on linear plasma device first before confinement device.
  - Have initiated discussions with interested people (PMI experts) at DIII-D tokamak.
  - Open to partnerships with private sector with companies pursuing tokamak-based reactors.