# Specific Proposals around Breeder Blankets

A list of project proposals, informed by my research area interests around nuclear fusion.

These were informed by my skills:

- Strong general python skills (lots of placement experience in building large projects, data analysis, some ML experience etc.)
- Simulation experience (including using openMC for monte-carlo in python)
- Nuclear Fusion (placement)

And my strong general interest in the nuclear fusion field. Lots of these concepts were already discussed with some of the scientists at the fusion plant I worked at (Tokamak Energy), but none of them are a continuation of my project there (which was in plasma - diagnostic optics).

1. **Neutron Transport and Tritium Breeding Analysis in Advanced Blanket Geometries (e.g., Functionally Graded Materials / Novel Materials)**

💡 **Description**:

- Investigate non-uniform material distributions (e.g., functionally graded lithium-lead blankets).
- Simulate neutron interactions in advanced materials (e.g., lithium ceramics, liquid lithium, high-entropy alloys).
- Compare results to standard homogeneous blankets for TBR and neutron economy.
- Use OpenMC to model neutron transport in these complex geometries.

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2. **Coupled OpenMC + Thermal-Hydraulics Simulations for Breeder Blanket Performance Assessment**

💡 **Description**:

- Integrate neutron transport simulations (OpenMC) with thermal-hydraulics tools (e.g., OpenFOAM, ANSYS Fluent).
- Study how coolant flow affects neutron absorption and tritium production.
- Optimize cooling efficiency while maintaining a high tritium breeding ratio.

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3. **Neutron Transport Analysis of implementing Neutron Reflector Materials to Reduce Fusion Ignition Point.**

💡 **Description**:

- Use OpenMC to model neutron transport for Materials / Breeder Blankets with deliberately high reflectivities materials ( potentially artificially set high reflectivities / scattering cross section ).
- Compare results to standard homogeneous blankets for TBR and neutron economy.
- By increasing reaction chamber neutron flux, investigate any non-negligible reduction in ignition factor.
    - This is a personal idea that I discussed on an internship, perhaps too novel an idea.

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### 4. Multi-Objective Optimization of Breeder Blanket Design Using Optimsiation (Genetic) Algorithms

💡 **Description**:

- Use genetic algorithms to optimize breeder blanket parameters such as material composition, coolant flow, and geometry.
- Define multiple objectives: tritium breeding ratio (TBR), neutron economy, and structural integrity.
- Implement optimisation within OpenMC coupled with Python-based optimization algorithms to converge to an optimal solution based on a defined cost function(e.g., DEAP or SciPy etc. ).

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### 5. Machine Learning for Surrogate Modeling of Breeder Blanket Neutron Transport

💡 **Description**:

- Train a machine learning model (e.g., neural networks (keras / tensorflow / pytorch), Gaussian processes) to predict neutron transport in breeder blankets / points of highest thermal load / TBR for certain input parameters (dimensions / aspect ratio of reactor).
- Use OpenMC to generate training data, then develop a faster predictive model
    - Would be ideal if pre-existing fusion data was found to train model on, training data would be critical for the project.
- Applications: Real-time optimization and uncertainty quantification in reactor design.