Conditions for High-Yield Muon Catalyzed Fusion

BETHE Kickoff Virtual Workshop
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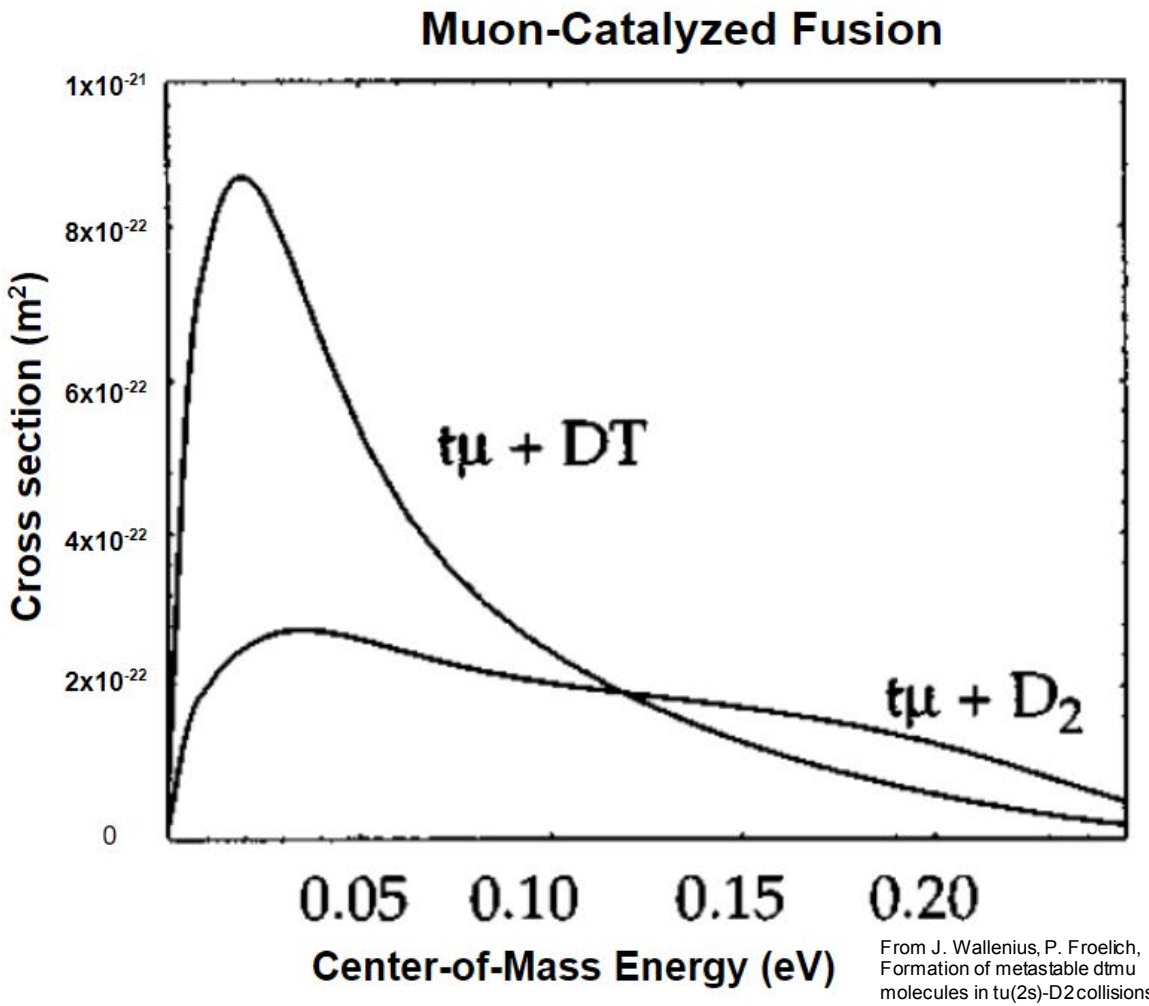
Team members and roles

- NK Labs, LLC
  - Experiment design
  - Simulation of experiment
  - Apparatus construction
  - Carry out experiment
- York College
  - Build physics process models of μCF processes for GEANT4
  - Help with design of experiment and interpretation of the results

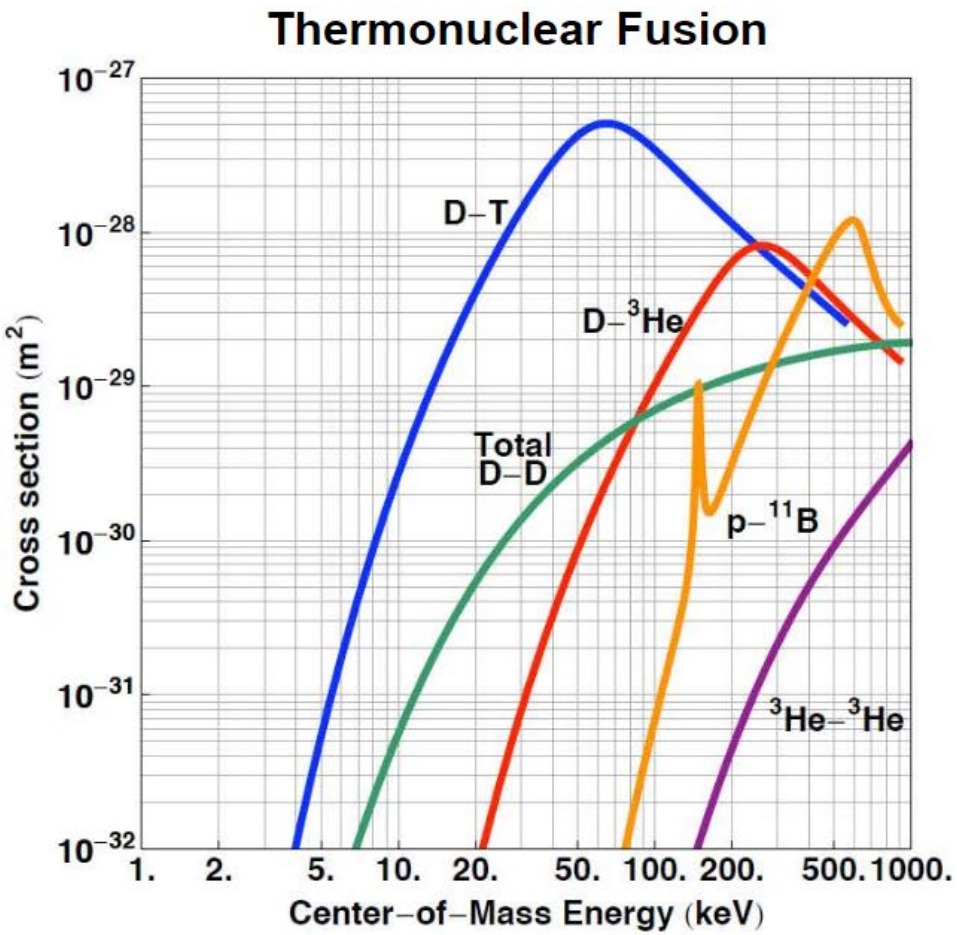
https://www.nklabs.com/

https://york.cuny.edu

High Level Motivation (Why μCF?)



From J. Wallenius, P. Froelich, Formation of metastable dtmu molecules in tu(2s)-D2 collisions, Physical Review A, Vol 54, No. 2, 1996



From Wikimedia Commons

Goals of the project

- Measure key rate and efficiency parameters at higher temperatures and pressures than have been explored previously

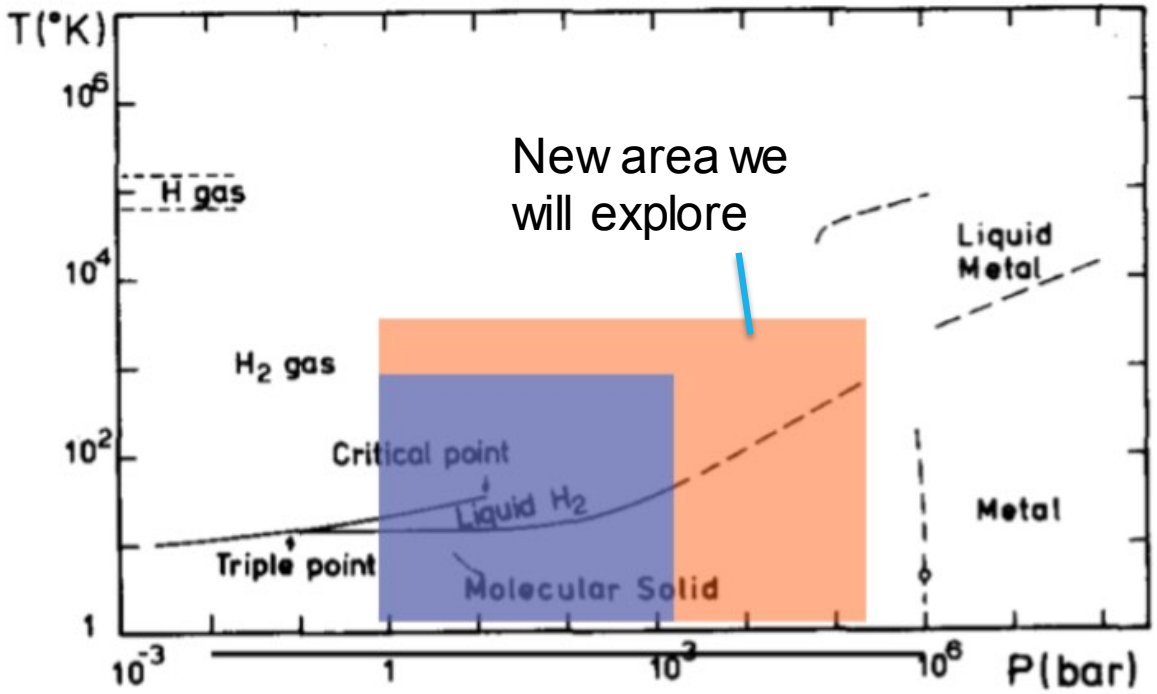


Diagram from Leung, W. B., March, N. H., & Motz, H. (1976). Primitive phase diagram for hydrogen. Physics Letters A, 56(6), 425–426.

- Create high-fidelity physics process models for GEANT4, to enable reactor design innovation

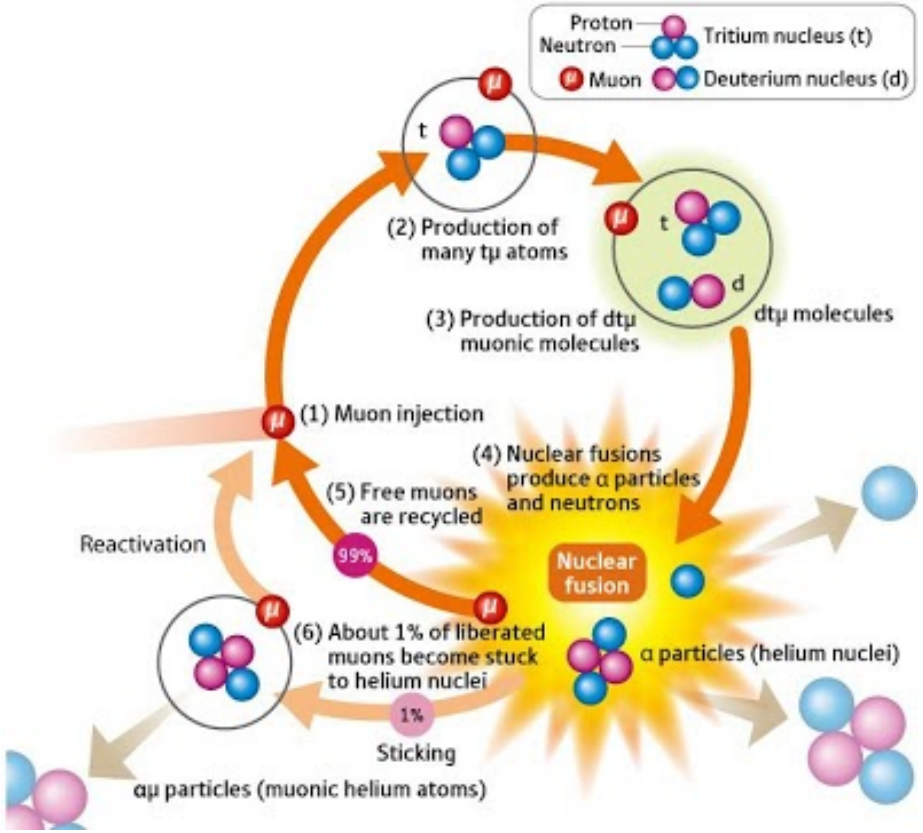


Figure: B. Wang, 2009

Major tasks (and technical risks), milestones, and desired project outcomes

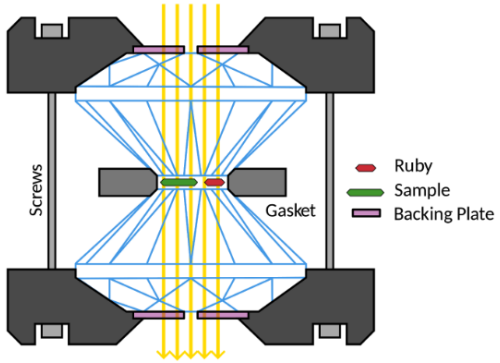
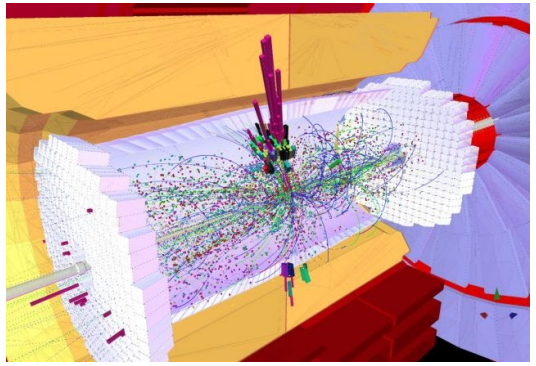
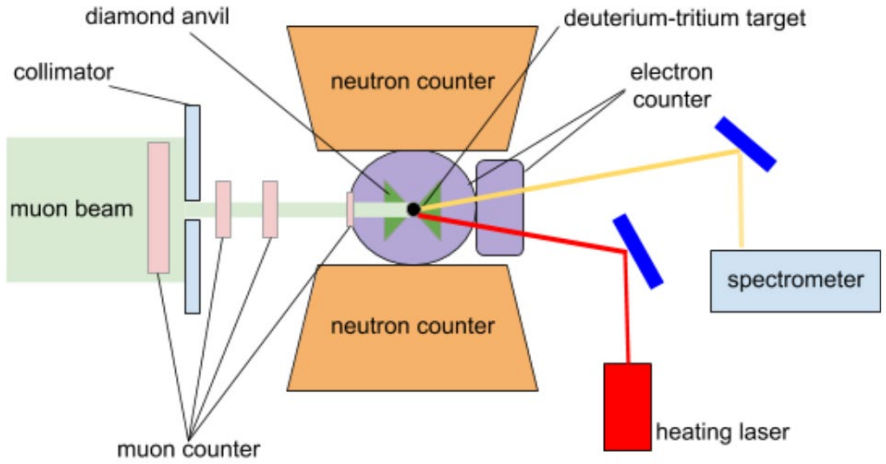


Figure 4: A diamond anvil cell, from [Tobias84].



Simulation of CMS Detector using GEANT (from GEANT4 web site)



Proposed experiment at high temperature and pressure

- **Task 1: Experiment**
  - Experiment Design and Simulation
  - Apparatus Design and Construction
  - Apparatus Dry Run
  - First Beam Time (D-D)
  - Second Beam Time (D-T)

- **Task 2: Modeling**
  - EM and muon transfer processes
  - Muon catalyzed fusion
  - Muon reactivation pathway
  - Validation with Experimental Data
  - Submit for release as part of GEANT4

Key techno-economic metrics of the project, and commercial fusion-energy application

- Fusion Gain and Sticking Fraction

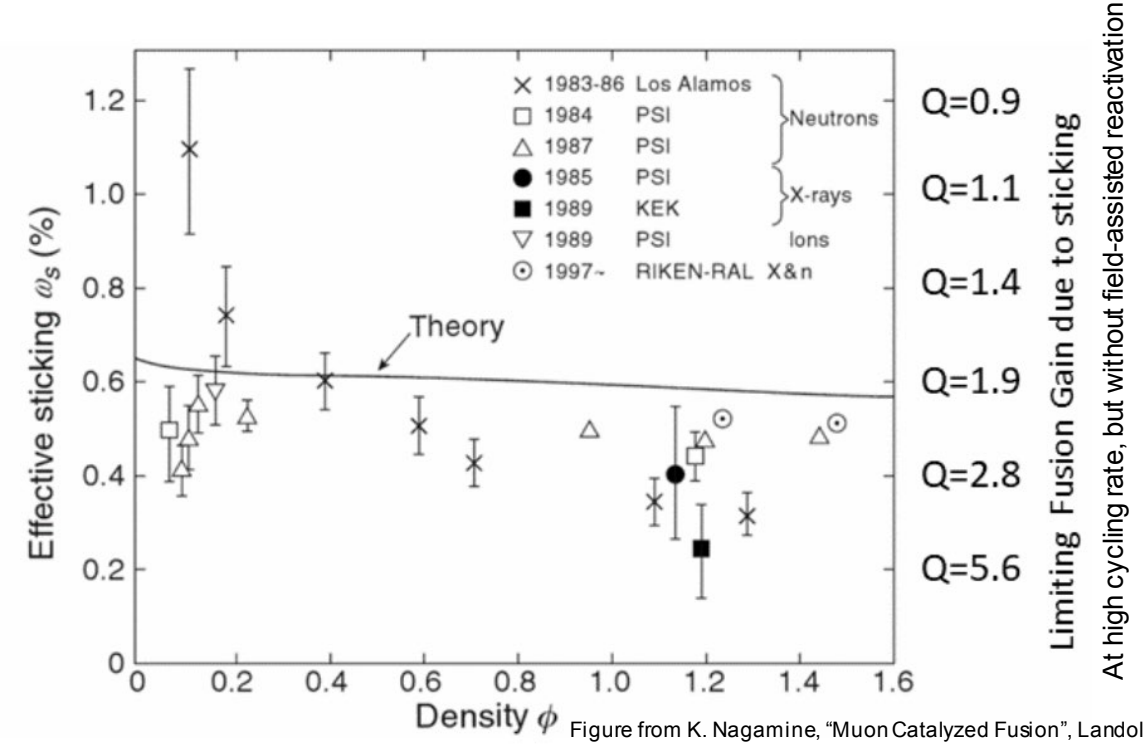
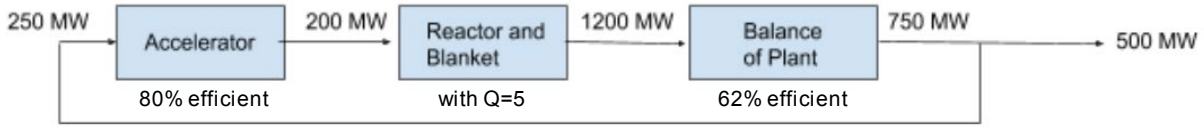


Figure from K. Nagamine, "Muon Catalyzed Fusion", Landolt-Bornstein New Series VIII/3B, p.579, with added right-hand scale bar)



Hypothetical power flows for a reactor with 500 fusions per muon, and triton beam-beam muon production, with 1.8 GeV beam energy per muon.

- **Commercial Fusion Energy Application**
  - Models and data produced will allow simulation of advanced reactor concepts, including those with E-field assisted muon reactivation and in-situ muon production
  - New, simpler, lower-cost reactor concepts may be made possible in the as-yet unexplored area of parameter space.