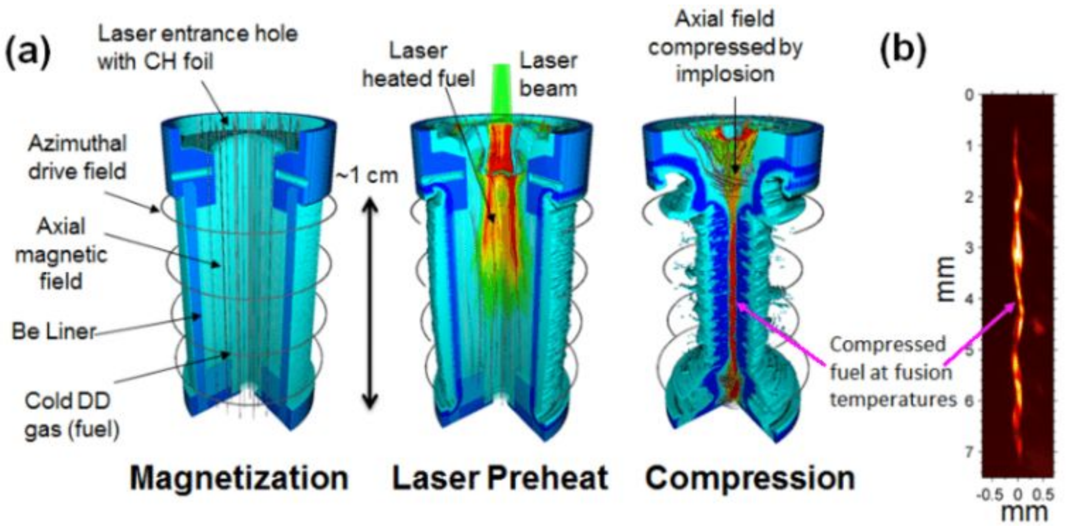
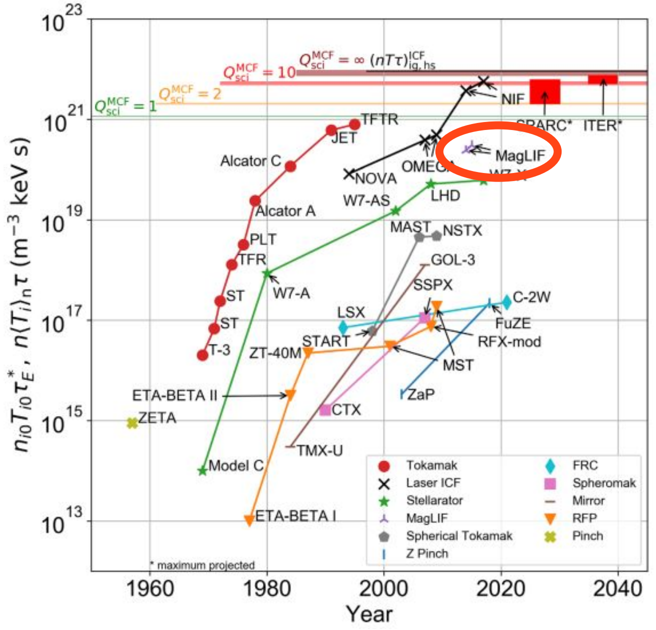
Accelerating the world's transition to fusion energy

Magnetized Liner Inertial Fusion (MagLIF) is well suited to pulsed power drivers and reduces fusion requirements

Currently being championed by Sandia on the Z pulsed power facility



Courtesy of Sandia, modified from Gomez *et al* *2014 Phys. Rev. Lett.* 113 155004



Wurzel & Hsu *2022 Phys. Plasmas* 29, 062103

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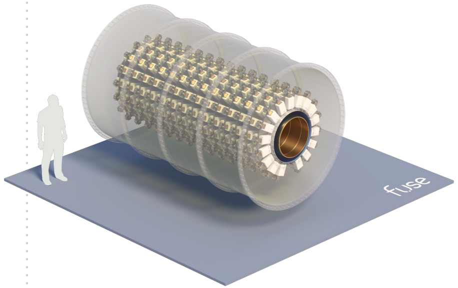
GTM

Master plan to a GW-scale plant Before 2030

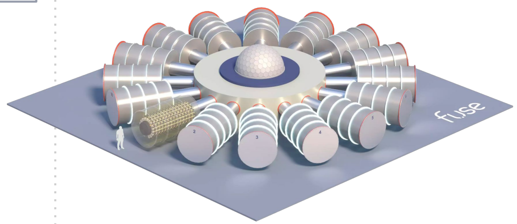
Focused, Fast, Scrappy, Milestones-based roadmap to de-risk the plan

1 TITAN // Q1 ‘24



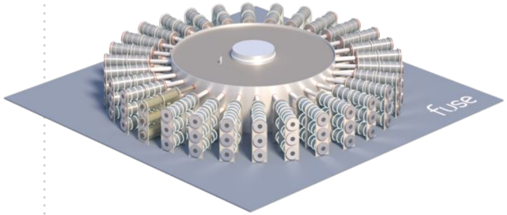
- Built TITAN
- Prove driver tech
- Prelim economic model for Apeiron-I

2 Z-STAR



- Build Z-Star (15 TW)
- Couple driver to the target
- Integrate system tech
- Run 1000 shots / year
- Secure fission partners for initial tests

3 APEIRON-I // Before 2030

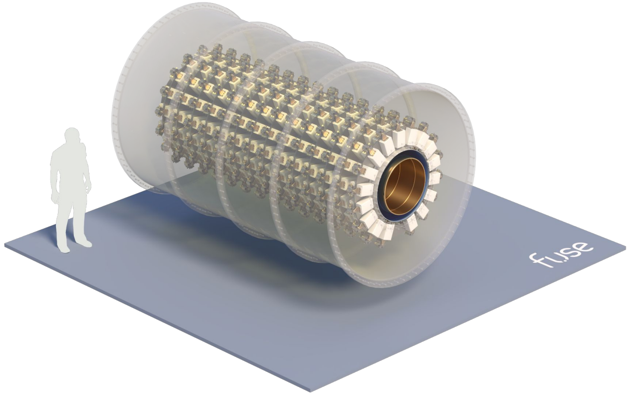


- Build Apeiron I (20 MJ)
- Couple with fission system
- Spit out first electron

TITAN

World's first, highest power (1TW), and most compact pulsed power driver.

- TITAN is an Impedance-matched Marx Generator (IMG), a new class of prime-power source first conceptualized by Sandia
  - Smaller
  - Higher efficiency
  - Better pulse shaping
  - Less complex
  - Longer lifetime
- The fundamental building block of an IMG is a brick, which consists of two capacitors connected electrically in series with a single switch
- Each stage consists of roughly 20 Bricks in parallel.
- Each module consists of roughly 15 stages in series.



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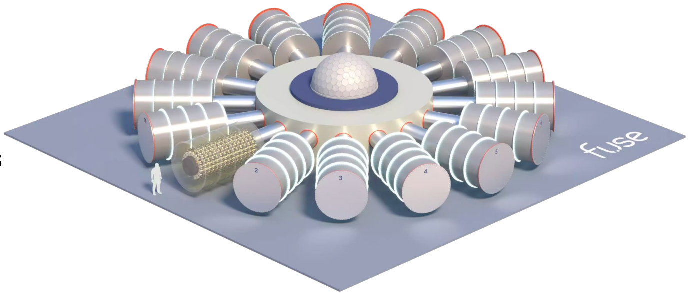
World's first IMG-based MagLIF pulsed power facility

Lifetime of an IMG-based pulsed power machine is 10x higher than traditional pulsed power,
Allowing for over 50,000 shots, 1,000 shot per year.

Objectives:

- Demonstrate the IMG-based PP MagLIF architecture based on the TITAN driver
- Fire 1,000 shots per year
- Develop critical supply chain for next generation, large-scale pulsed power facilities

De-risk: shot frequency, hardware cost, waste/debris management, RTL, and activation



Z STAR would enable:

- Delivering greater than 12 MA and 600 kJ to a range of dynamic loads for a variety of MagLIF and high energy-density physics (HEDP) research
- Generate unique electrical pulses by pulse shaping via independent triggering of the modules
- Novel physics experiments in tandem with unique diagnostic techniques capabilities

APEIRON-I

Fusion core to recycle nuclear waste and turn it into **clean energy**

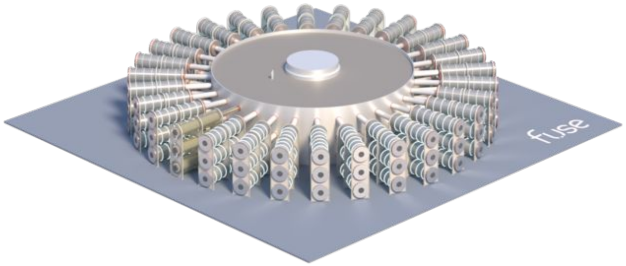
320 TW facility inspired by Z300 machine design.

Objectives:

- Output roughly 20 MJ to drive hybrid power plant concept
- Achieve thermonuclear ignition: $Q_{scientific} > 4$
- Burn fission waste to produce electricity

Design targets:

- 50 MJ storage energy petawatt-class accelerator (320 TW) that generates a 100-ns, ~50 MA electrical power pulse at twice the energy efficiency of Z
- Possibility to separately couple a range of target designs for maximum flexibility (i.e. traditional MagLIF, Auto-Mag, dynamic hohlraum, etc.)
- Deliver 5 MJ of kinetic energy to the load to produce 20 MJ fusion yield



MagLIF Specific Technical Challenge Areas

- **Impedance-matched Marx Generators (IMGs)-** Deployment of high-current IMG systems with a focus on performance, cost reduction, and ensuring reliability, manufacturability, and sustainability.
- **Magnetically Insulated Transmission Lines (MITL)-** Optimization of MITL designs which align with the IMG drivers and specific load types required for an energy concept.
- **Recyclable Transmission Lines (RTL)-** R&D on RTL's as a means to repetitively drive Z pinches at high repetition rates, with a focus on performance optimization and mass production.
- **Target design-** MagLIF target optimization for performance, robustness to instabilities, and mass production.
- **Current delivery and applied magnetic field capability-** Optimization of designs for current delivery and magnetization consistent with high-yield, high-rep rate shots (i.e. Auto Magnetization).
- **Shock mitigation and debris management-** Envisioned fusion yields are large compared to other IFE approaches and requires unique shock mitigation and debris management to protect the main chamber walls (i.e. thick liquid walls/jets).