Completing the Puzzle: Is Fusion Energy Coming of Age?
Key points

• With complexity comes opportunity
  • Literature from 1970s is full of possibilities, from 1990s it’s all about two machines
  • There has been a fundamental change in computational power
  • Trinity of experimental-theoretical-numerical

• Start ups are changing the possible timescales
  • This wouldn’t be possible without 50 years of mainstream research
  • How, again simulation capability
  • Plants don’t have to be GW scale

• Fusion is not the same as fission
  • No high-level waste
  • No meltdown risk
  • No weapons grade material
Physics of fusion

How do you get energy gain in the first place?
FUSION IS THE ULTIMATE SOURCE OF ENERGY IN THE UNIVERSE
Magnetic Fusion
JET (UK)
ITER (France)
Steady state

Inertial Fusion
National Ignition Facility – LLNL (USA)
Implosion
So why don’t we have gain?

The problem is stability
NO LONG LIVED WASTE

NO WEAPON MATERIALS

NO MELTDOWN RISK


$180 bn
Engineering of a fusion plant

How do you capture the energy?
Tritium Handling

Tritium Handling

Target Delivery

Target Delivery

Blanket

Heat exchanger
Turbine
Recirculation of driver energy
Connection to grid
and so on ...

Target Design

Target Design

Target Chamber

Target Chamber

Exhaust

Exhaust

Driver

Driver

The Reactor

The Reactor
There are some fusion specific engineering challenges, but solutions exist

- **Tritium breeding**
  - Every neutron needs to produce one tritium
  - Reaction with Be then Li produces tritium and He
  - Many proposed solutions, no one can test them yet
  - Solid angle is crucial

- **Material science**
  - Neutron damage
  - Heat flux (very difficult for MCF, 50 MW/m²; re-entry is ~2 MW/m²)
Plant scale

• Fusion requires confinement time, which can be rewritten as a length scale
  • Bigger is easier
  • As nameplate capacity increases, the engineering gets harder; as nameplate capacity decreases the fusion physics gets harder
  • Capital cost vs. levelised cost

• Mainstream projects are 1+ GW
  • DEMO would be 2-4 GW

• Start ups are looking as low as 50 MW
  • Although, some start ups don’t have very good answers for “how?”
First Light’s proposal

Exquisite understanding of target physics, brutally simple driver
Blanket

- Heat exchanger
- Turbine
- Recirculation of driver energy
- Connection to grid
- and so on …

Exhaust

Core Technology

Tritium Handling

Target Delivery

Target Manufacture

Driver

Target Chamber

Target Design

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The physics challenge

• First Light’s target designs work with instability
  • Inspired by a natural phenomenon, genuinely new method for plasma formation
  • The company started with a world-class simulation capability
  • We design with the full complexity of the real world
  • “Advanced target design” workstream is very important

• These designs have unlocked a low cost projectile driver
  • Electromagnetic launch of a projectile can be 50% efficient
  • At least 10x cheaper than the mainstream
  • Substantially simpler target interaction physics
The engineering challenge

- Tritium cycle challenge
  - Solid angle available could be 99%

- Material science challenge
  - Projectile driver unlocks size as the lever to reduces the heat load
  - Projectile driver unlocks liquid first wall
  - No influence of first wall on plasma

- Liquid first wall can catch the projectile and recycle material
Reactor concept

• We believe that the most likely FOAK seeks to minimise capital cost not levelised cost
  • Higher energy, lower repetition rate
  • Simultaneously addressing physics and engineering difficulty
  • Unlocked by cheaper driver technology

• We believe in the value of flexibility
  • Higher energy, lower repetition rate means you can turn it up later
  • Improvements in target design will feedthrough immediately
  • Add a second turbine later
Fusion and the energy landscape

If the FOAK turns on in 2035, will we need it?
Inertial fusion can provide flexible baseload

• Centralised generation
  • By Clayton Christensen’s definitions, fusion is a “revolutionary sustaining technology”
  • Flexible baseload is likely to be gas, this is what fusion is competing with …
  • … unless fusion can directly compete on price

• Timeliness
  • First Light believes there will be opportunity for fusion for a long time …
  • .. but the opportunity will diminish

• Increased rate of learning
  • I believe there will be more than one fusion technology
A FOAK needs a supportive environment

• The social and political environment is also important
  • Fusion is not fission, but it is the regulator who will decide
  • Government support is very likely to be essential
  • Public opinion could have a significant influence

• First Light has a proactive strategy
  • We believe early engagement can ensure these points are not blocks
Panel Discussion

20 min: panel

20 min: open questions