PREAMBLE

I agree with many of the sentiments put forth by my IFE colleagues…

- Community collaboration to create IFE program
- Competition between concepts
- Integrated approaches
- Phase I: $200 M/year x 5 years is appropriate level
- Program pace/down select given by:
  - technical progress
  - *credible potential for an attractive reactor*

The need for a (n Inertial) Fusion Engineering Test Facility

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Naval Research Laboratory

Fusion Power Associates Meeting
December 3, 2010

Four light bulbs lit by the first electricity generated by a fission reactor
(EBR-1 at INL in 1951)

Basic Premise: The path to fusion energy should have an Engineering Test Facility

- Allow a potential investor to confidently evaluate the practicality of fusion energy

- Provide a research vehicle to address optimization, integration, and sustained operation in a nuclear fusion environment

Fusion is a way to make electricity..

There are already many ways to make electricity!






To be “taken seriously,” fusion must have some meaningful advantages over existing, *and future*, energy sources

Examples:

- Cost to Develop
- Cost to Build
- Cost to License
- Cost to Operate
- Cost to Decommission
- Environmental considerations
- Safety
- Availability
- Reliability
- Non-proliferation

An *Engineering Test Facility* is needed so a potential investor* can confidently evaluate these advantages

Show technologies that credibly lead to attractive:

Power Plant Issues

- Maintenance, Availability, and Reliability
- Costs of all kinds
- Safety, environment, licensing

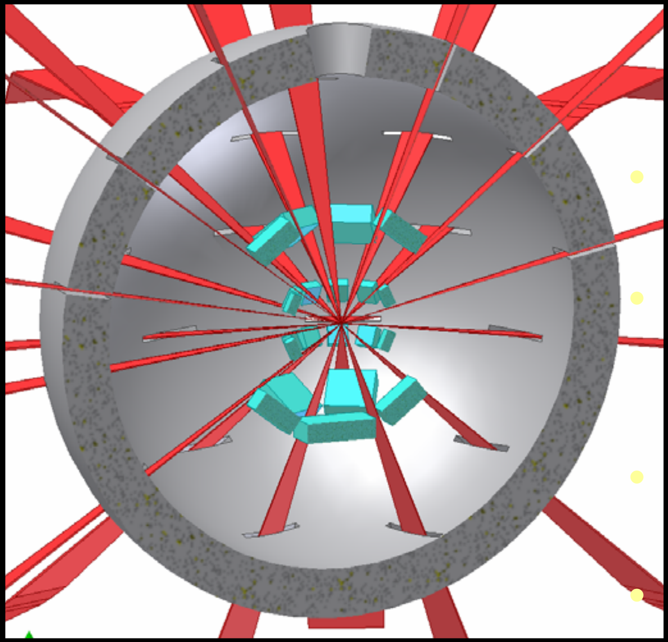
Fusion Issues

- Performance (gain)
- Required precision and integration
- Breeding, Refueling and Power Handling

*Investor could be Government, Industry or both

The Engineering Test Facility should also be a research tool.

- Optimize target performance
- Develop nuclear resistant materials and structures



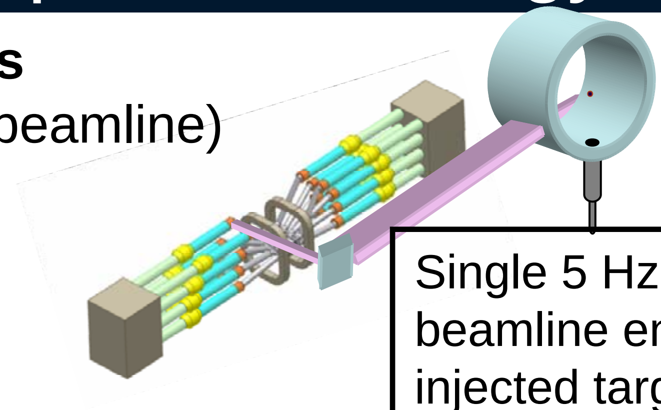
- Neutrons emitted by point source
- Chamber wall, far away, has long life (2 dpa/yr)
- Samples and structures close in get prototypical neutron exposures
- (up to 50 dpa/yr, 21 liter volume)

- Address integration issues
- Take care of everything else that comes up

Where the Engineering Test Facility fits in the path to develop fusion energy

<u>Stage I</u> : Develop full size components

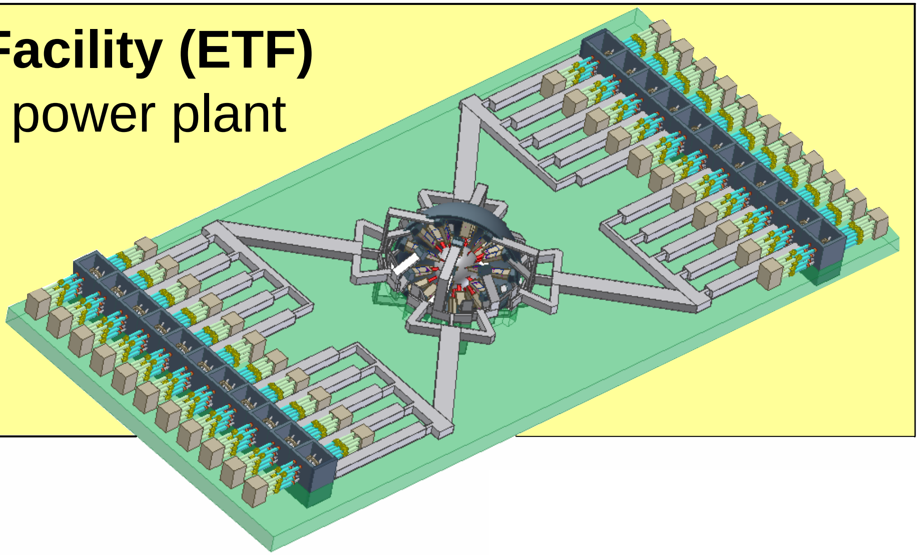
- Laser module (e.g. 17 kJ, 5 Hz KrF beamline)
- Target fabrication/injection/tracking
- Chamber, optics technologies
- Refine target physics
- Power plant/FTF design



Single 5 Hz FTF beamline engages injected targets

<u>Stage II</u> 100 MW Engineering Test Facility (ETF)

- Demo physics / technologies for a power plant
  - ηG: 7 - 10 , G: 100 - 140
- Tritium breeding, power handling
- Develop/ validate fusion materials
- Operating: ~2025



<u>Stage III</u> Prototype Power plant(s)

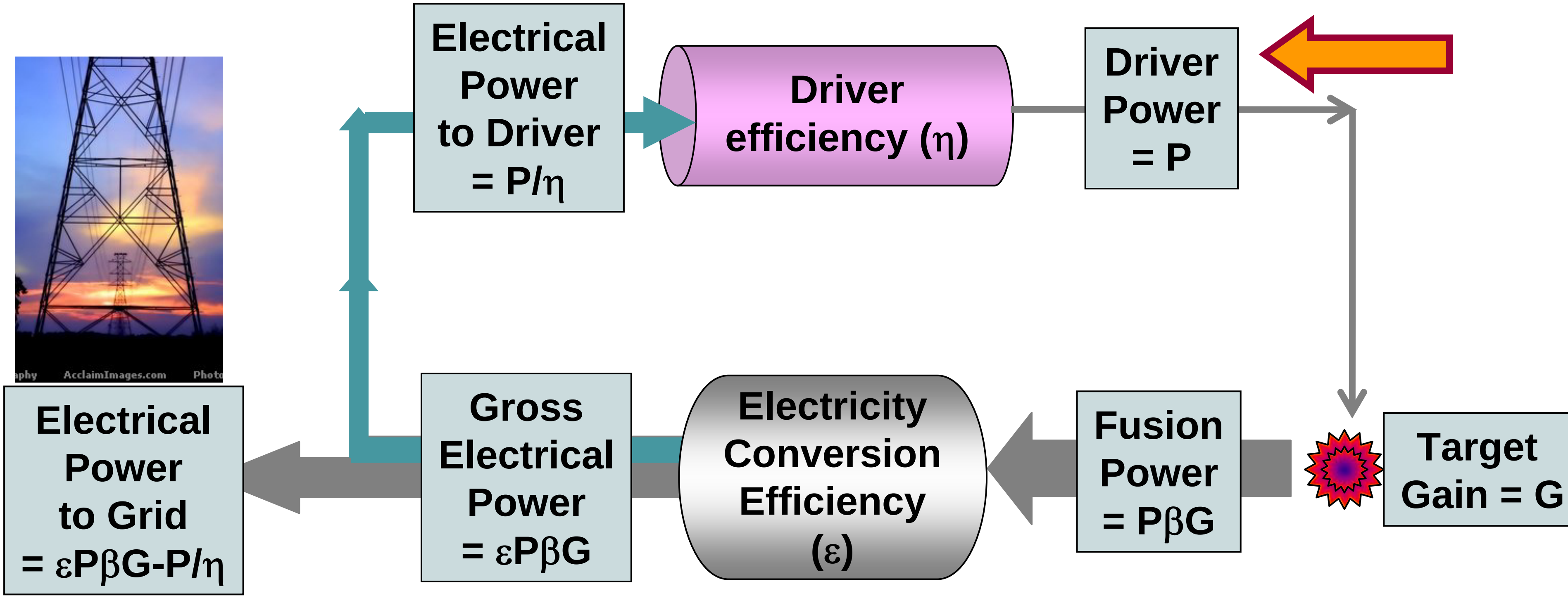
- Electricity to the grid
- Transitioned to private industry

Some functional requirements for the Engineering Test Facility

- Performance (ηG and G)
- Breeding
- The keys to economical availability and reliability

Power Flow in a Fusion Reactor

ε = conversion efficiency, η = driver efficiency, G = gain, β = Burnup in blanket

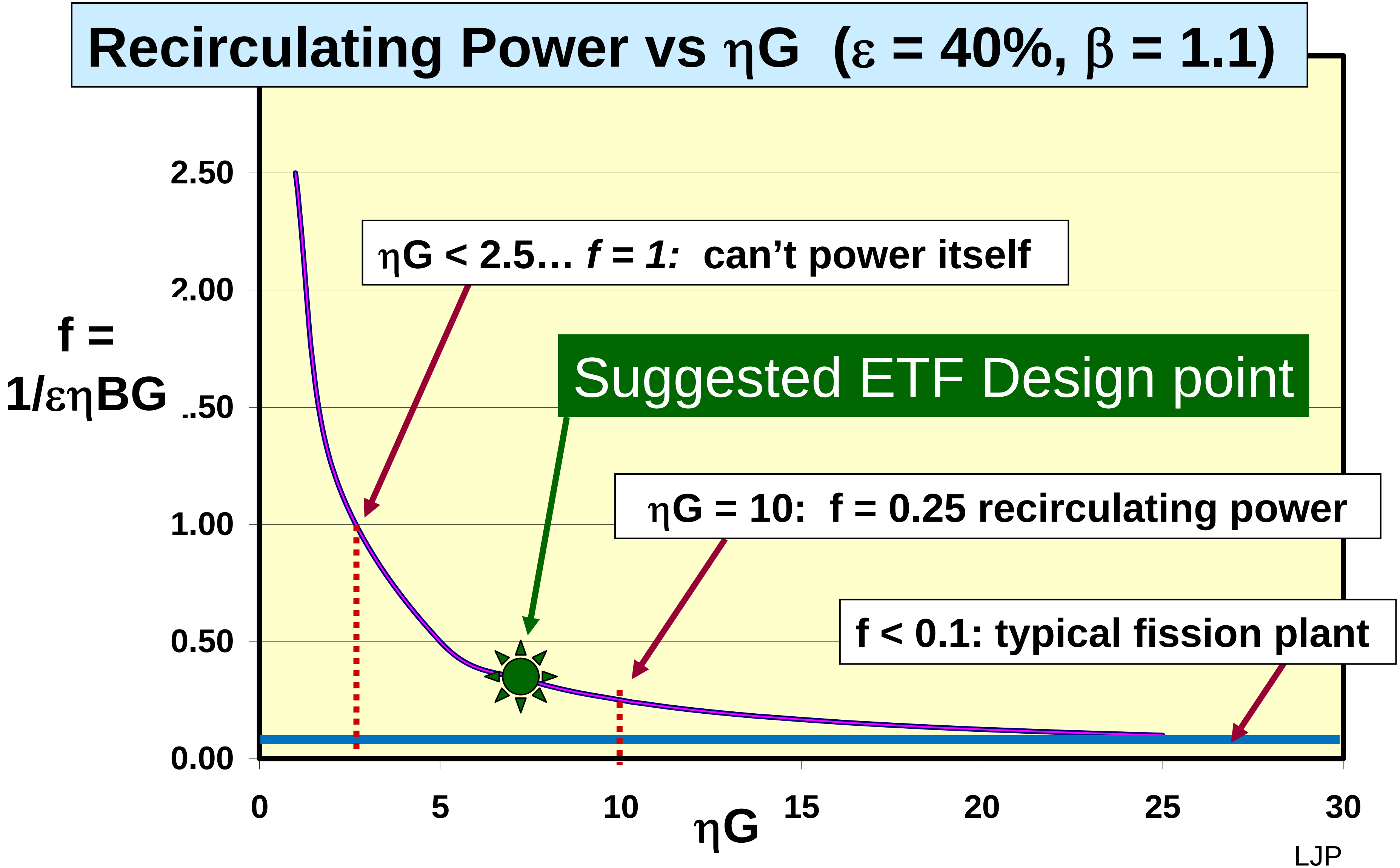


Electrical Power to Grid = $P/\eta\ ((1/f) - 1)$

$f = 1/\varepsilon\, \eta\, \beta G$

$\equiv$ Recirculating Power Fraction

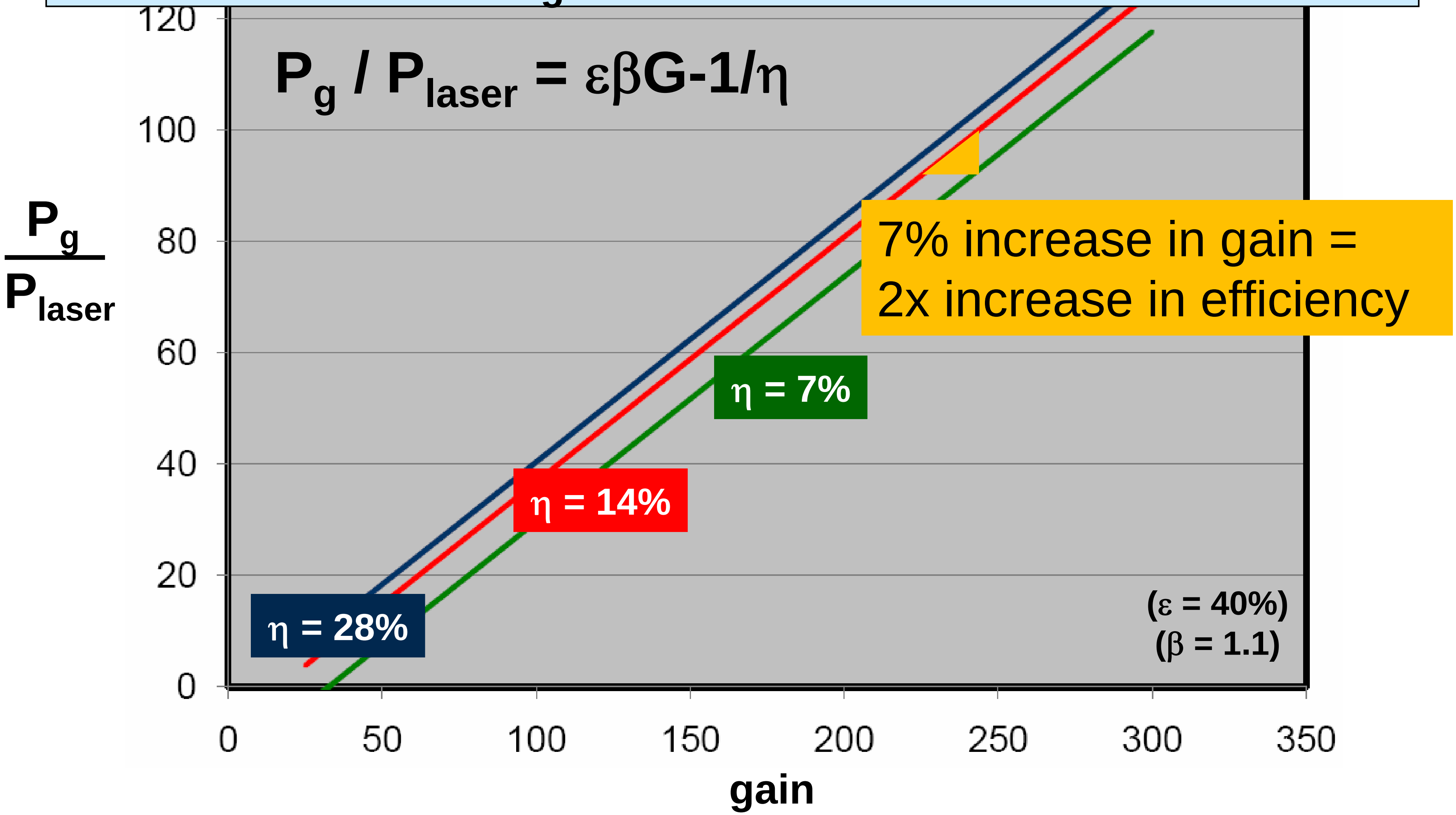
Lower cost and higher performance favors lower recirculating power fraction (f = 1/εηβG)



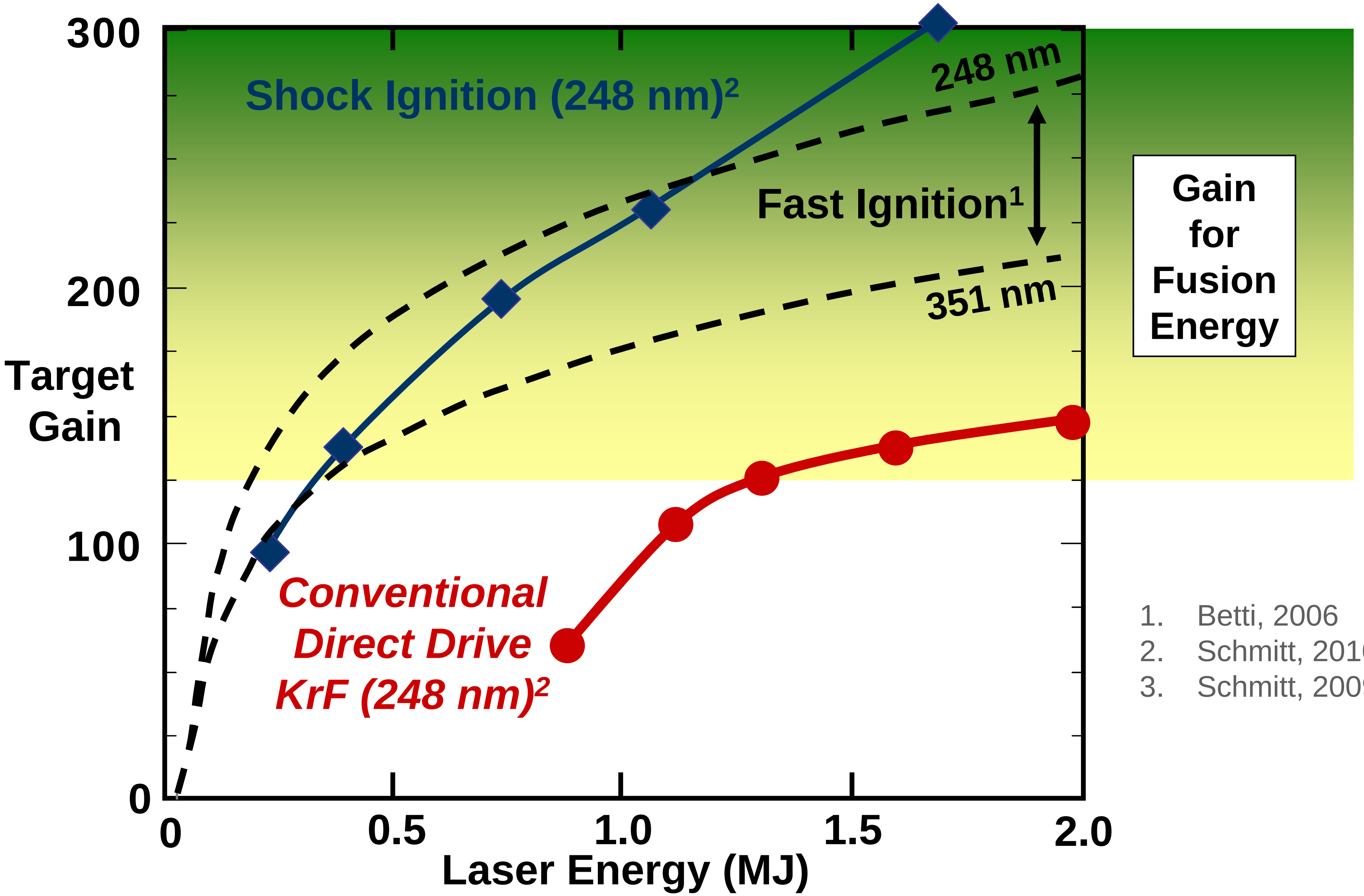
Higher gain (G):

1) More electrical power output
2) Smaller (lower cost) driver
3) Trumps driver efficiency

Electric Power (P_g) / Laser Power (P_{laser}) vs gain

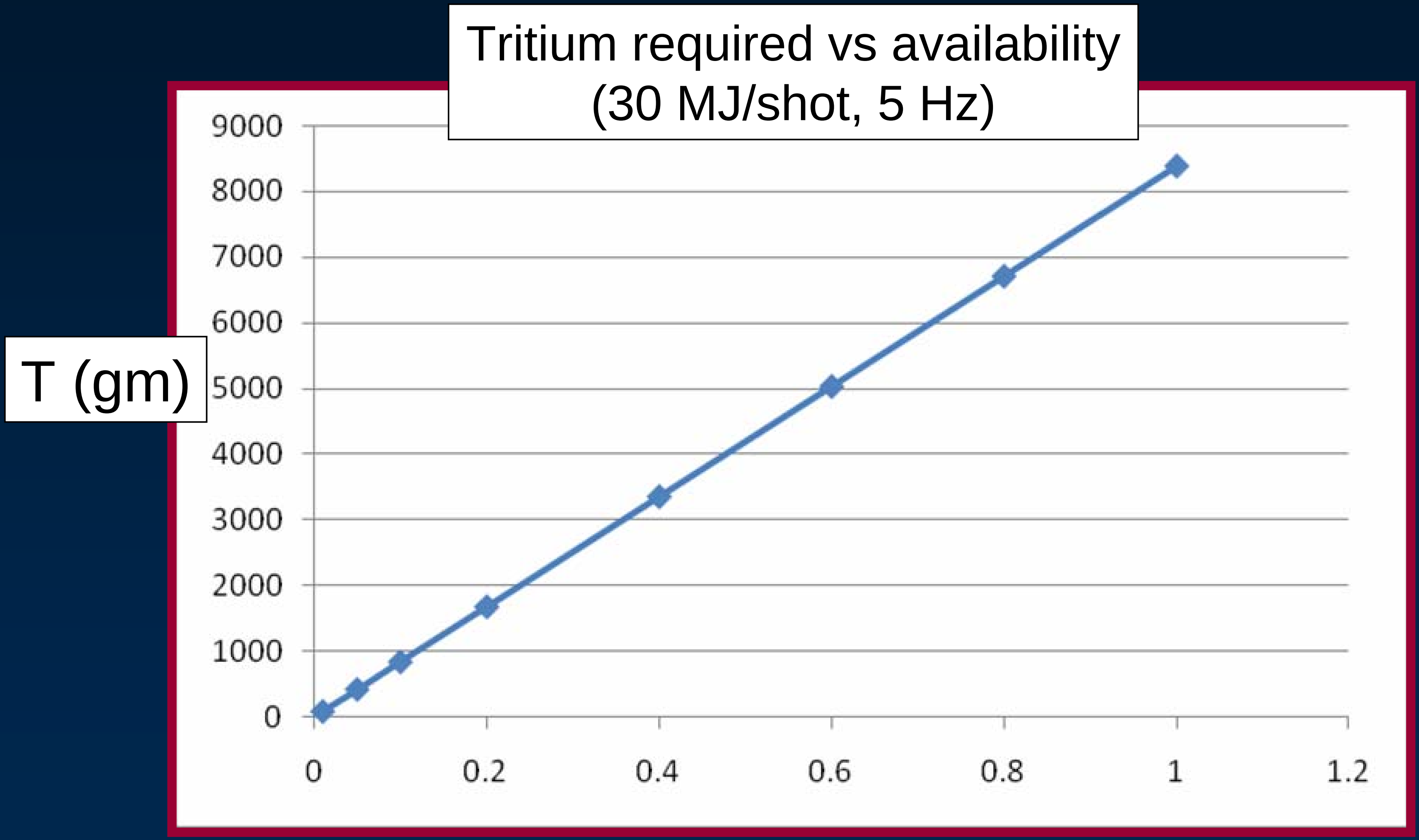


EXAMPLE: New Direct Drive Designs predict enough gain for energy:



1. Betti, 2006
2. Schmitt, 2010
3. Schmitt, 2009

The need to breed



The two keys to *economically attractive*
Availability and Reliability
are

Simplicity and Durability

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