U.S. Department of Energy's

Office of Science

Inertial Fusion Energy and High Energy Density Physics

Presentation to the FESAC Panel
on
Inertial Fusion Energy

Office of Fusion Energy Sciences
Excellent Science
Attractive Energy

www.ofes.fusion.doe.gov

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Review History

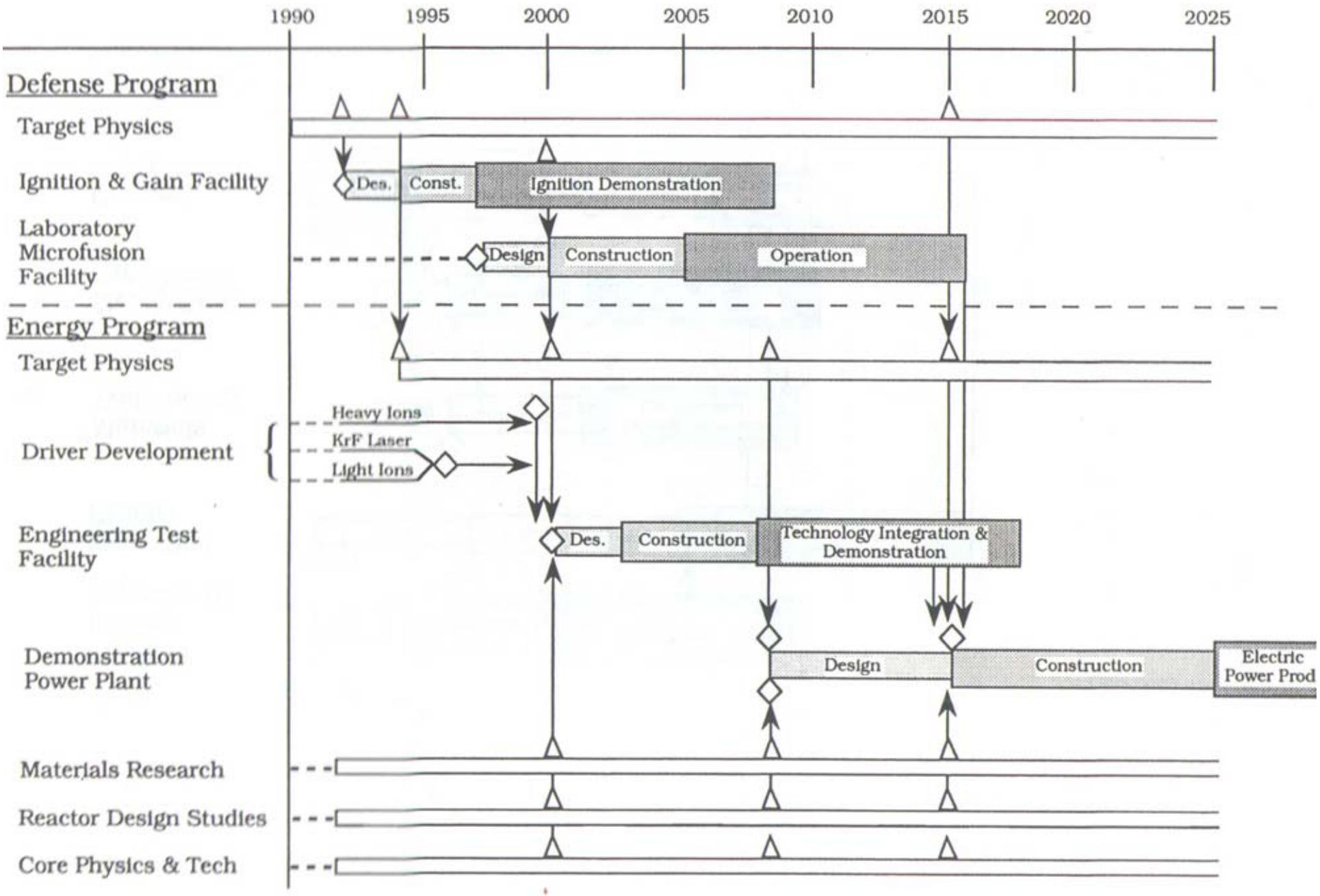
- 1990 FPAC Report recommending a program in IFE in parallel with MFE, transferring the HIF program from BES to OFE
- 1993 FEAC reviewed the IFE program in the context of new fiscal constraints
- 1996 FESAC reviewed IFE as a result of the Restructured U.S. Fusion Program
- 1999 FESAC reviewed and recommended balance and priorities in the U.S. fusion program
- 2003 FESAC Report on Development Path for Fusion
- 2003 Turner's NRC Report on Quarks to Cosmos and Davidson's NRC Report on High Energy Density Physics urge the nation to mount a multi-agency program in the emerging field of high energy density physics

1990 FPAC Report

- The 1990 Fusion Policy Advisory Committee Report reviewed the entire U.S. fusion program, and recommended:
  - A dual-path approach to fusion energy (MFE and IFE)
  - Priorities in IFE
    - Target physics largely from the DP program.
    - Collateral (OFE) program covering those areas not required for the DP program, e.g. repetition-rated, efficient drivers, high-gain targets that can be inexpensively produced, and practical reactor studies.
    - Recommended heavy ion beam as the preferred candidate driver, but with KrF lasers and light ion beam as alternates.
  - A full funding profile for a IFE Demo in 35 years starting 1990:

91	92	93	94	95	
8	38	54	64	64	$ M

IFE DEVELOPMENT PROGRAM



1993 FEAC Report

- 1993: FPAC charged to conduct a review focusing on the heavy ion beam approach to IFE
- Re-affirmed the findings and recommendations of the 1990 FPAC Report
- Found that “DOE had not established an IFE program that resembled remotely the one envisioned by FPAC”
- Recommended a balanced IFE program that included an experimental and analytical program for supporting IFE technologies, as well as accelerator development and beam physics program, with an annual budget of $17 M (1993 dollars): $14 M for accelerator, $3 M for supporting technologies

1996 FESAC Report on IFE in the Context of a Restructured U.S. Fusion Energy Sciences Program

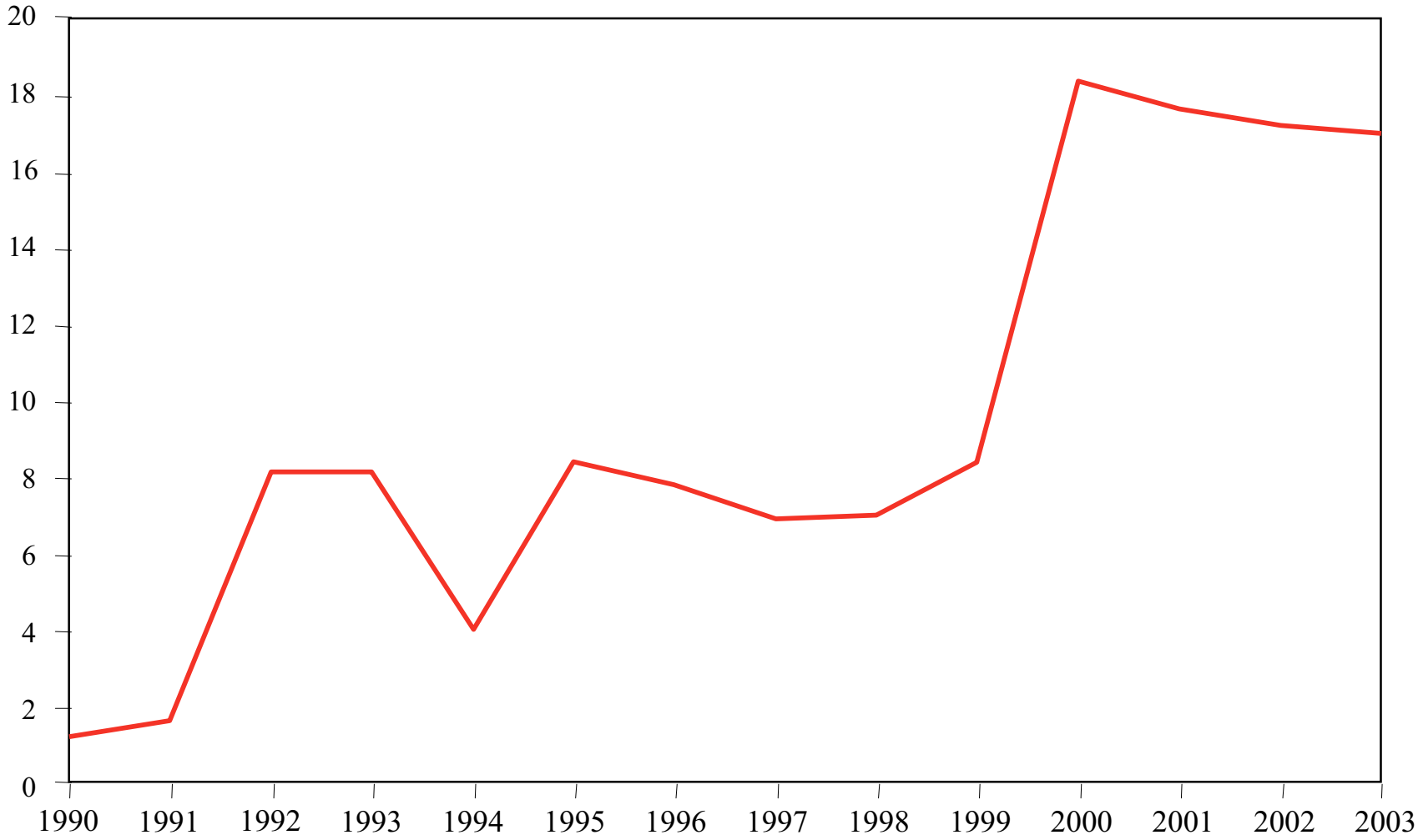
- Principal findings:
  - "Progress in IFE since the 1993 review has been good, despite its being funded at the $8 M per year level, instead of the recommended $17 M per year level."
  - "A strong IFE program is a proper and important component of the restructured OFES/DOE program."
- Recommendations:
  - Increase the total funding for the IFE program to about $10 M per year for the next few years, to strengthen the scientific and technological understanding of the prospects of IFE and to involve a wide range of institutions in these efforts.
  - Increase the funding of the non-driver part of the IFE program from ~ $1M to $2-3 M per year

1999 FESAC Report on Balance and Priorities

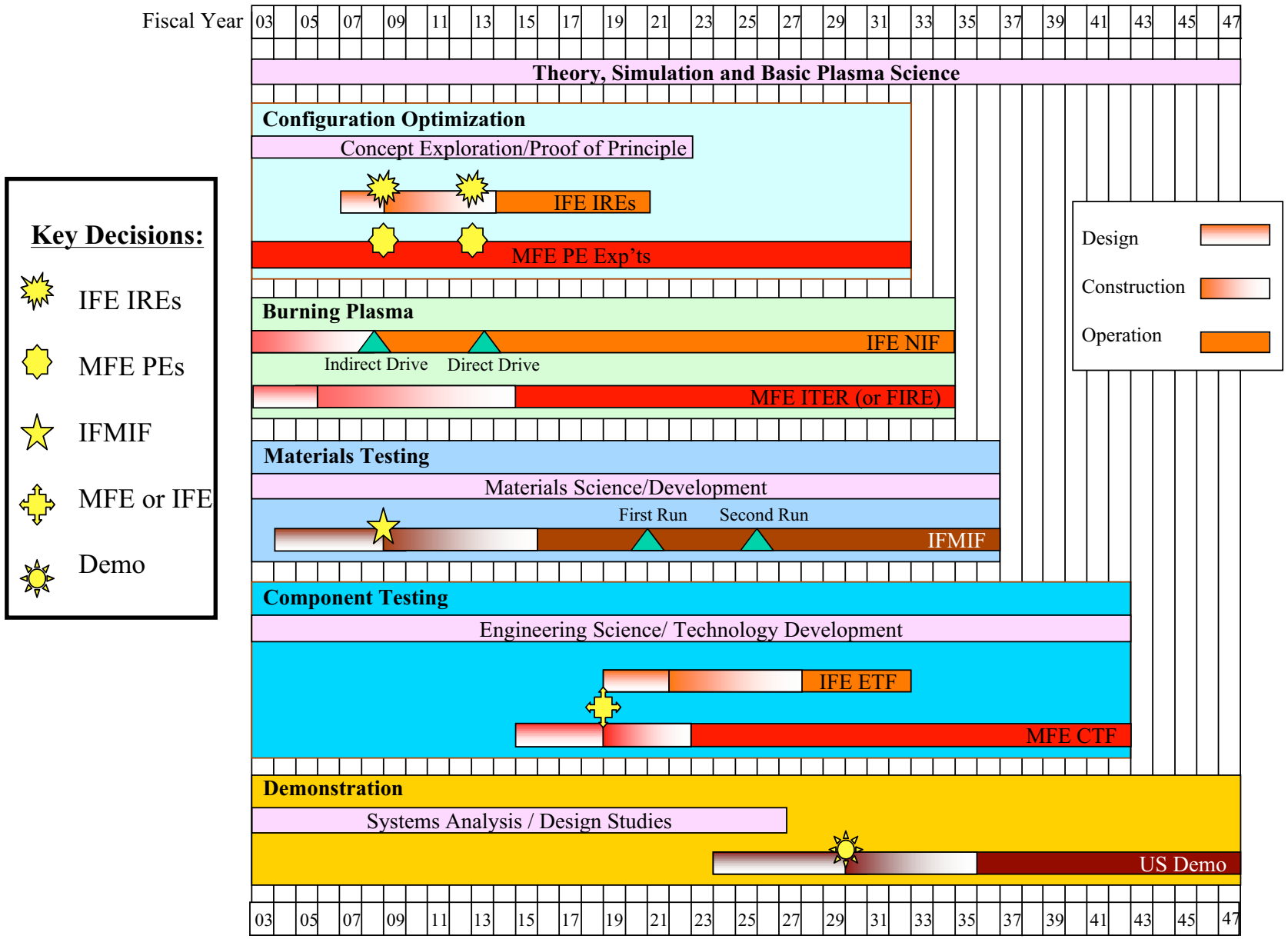
- The 1999 FESAC Report made recommendations on the priorities and balance of the whole U.S. fusion program
- Recommended a balance between MFE and IFE
- At $260 M total annual funding level for fusion energy sciences, FESAC recommended an annual funding of $30 M for IFE
  - $13 M for heavy ion drivers, $7 M for chamber technologies including target fabrication and injection, $10 M for HAPL development, with a few percent towards concept exploration, high energy density physics, and plasma theory
- At $300 M total funding level, FESAC recommended $50 M for IFE
  - $16 M for heavy ion drivers, $8 M for chamber technologies, $26 M for HAPL, with a few per cent towards concept exploration, high energy density physics, and plasma theory

Inertial Energy Funding in FES

($ in Millions)



The Fusion Energy Sciences Advisory Committee has Developed a Plan for Commercial Fusion by Mid-Century



FY 2004 Fusion Energy Sciences Budget

($ in Millions)

House Appropriations Committee	
President's Request	257.3
ITER and FIRE	+ 4.0
Fusion Technology	+ 5.2
Advanced Design and Analysis	+ 1.6
House Mark	268.1
High Average Power Laser Research in NNSA	+ 25.0

Senate Appropriations Committee	
President's Request	257.3
Senate Appropriations Committee	257.3

"…within available funds, the Department should…redress the imbalance…"

IFE Z Studies + 5.0 in NNSA

FY 2004 OFES Budget
Current Financial Plan for Continuing Resolution

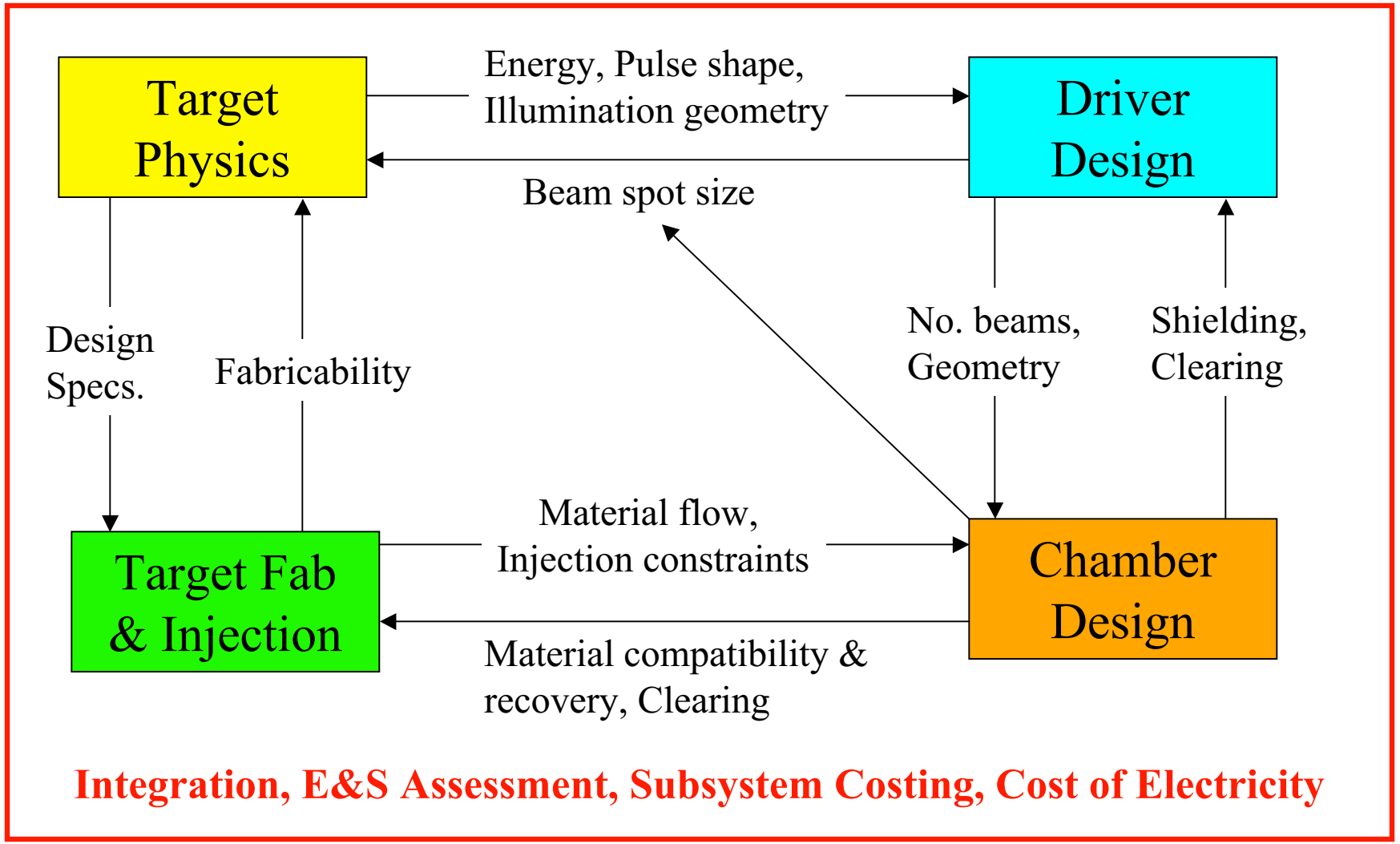
- $257.0M (lowest of the three possible numbers) minus a Tax, plus the Senate constraints to "redress the imbalance"
- Conference scheduled for October 29, 2003
- Principles for Current Financial Plan Development
  - Minimize personnel disruptions
  - Support ITER Transitional Arrangements, modest effort on FIRE
  - Rebalance science and technology elements, to some extent
  - Continue NCSX project
  - Support for Fusion Science Centers Solicitations
  - Support National Lab portion of the successful NSF Science Center proposal lead by University of Wisconsin
  - Partially restore cuts to International Collaborations
  - Increase operation of facilities over FY 2003 level (~18 weeks)

FY 2004 Fusion Energy Sciences Budget

($ in Millions)

	FY 2004 Cong.	FY 2004 Nov. Fin Plan
Science	138.1	141.0
Facility Operations	87.7	81.2
Enabling R&D	24.9	28.2
SBIR/STTR	6.6	6.6
OFES Total	*257.3*	*257.0*
DIII-D	56.7	54.3
C-Mod	22.7	21.5
NSTX	35.2	33.5
NCSX	16.7	16.7

A self-consistent vision for IFE requires a balanced program to address a wide range of interconnected science and technology issues



Present OFES Program in IFE

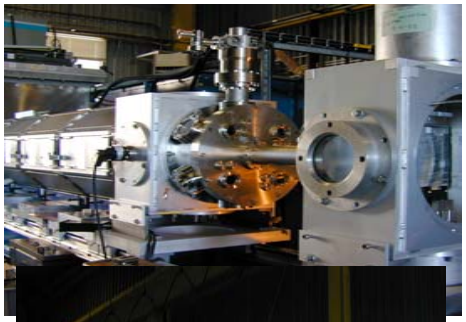
- The emphasis is in developing the heavy ion beam approach to IFE
- For heavy ion fusion, high flux (> 10^{16} particles), medium energy (~ GeV), heavy ion (e.g. K^+) beams are required
- Accelerator physics ($11 M)
- Fast ignition ($0.72 M)
- IFE relevant target physics, design, fabrication and injection ($1.69 M).
- IFE chamber technologies, system study and safety analysis ($1.2M)

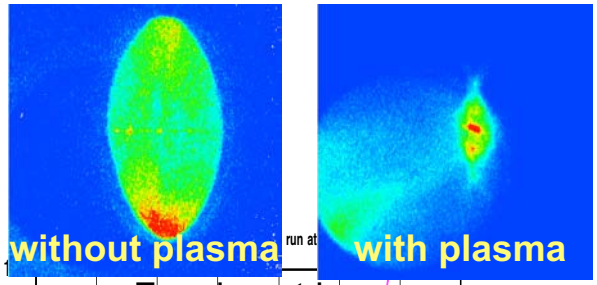
Current Experiments in Heavy Ion Drivers ($11 M FY04)

Accelerator physics investigates the generation, injection, acceleration, transport, compression and focusing of heavy ion beams

Neutralized Transport Experiment(NTX)

LBNL



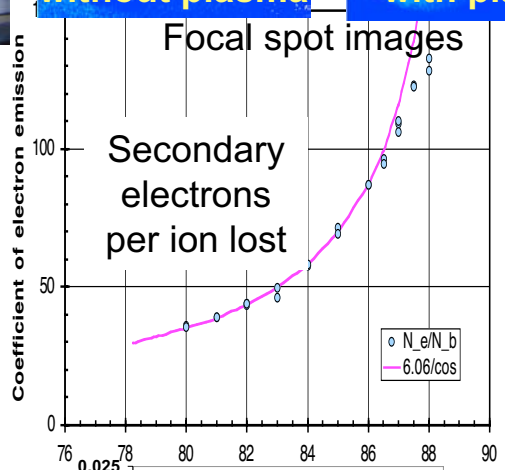


Focal spot images

NTX plasma control techniques and diagnostics help determine optimum final focus/chamber design.

High Current Experiment (HCX)

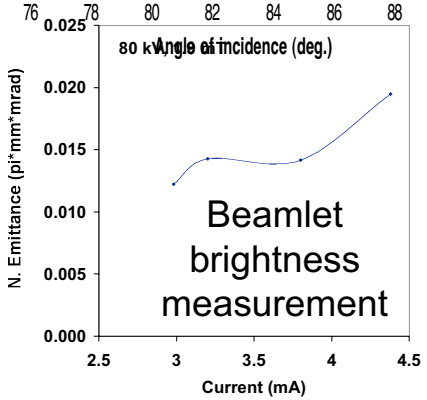
LBNL



HCX measurements of envelope control sensitivity, halos, and gas/secondary electron effects help determine focusing, vacuum and pulse length constraints.

Source-Injector test facility (STS)

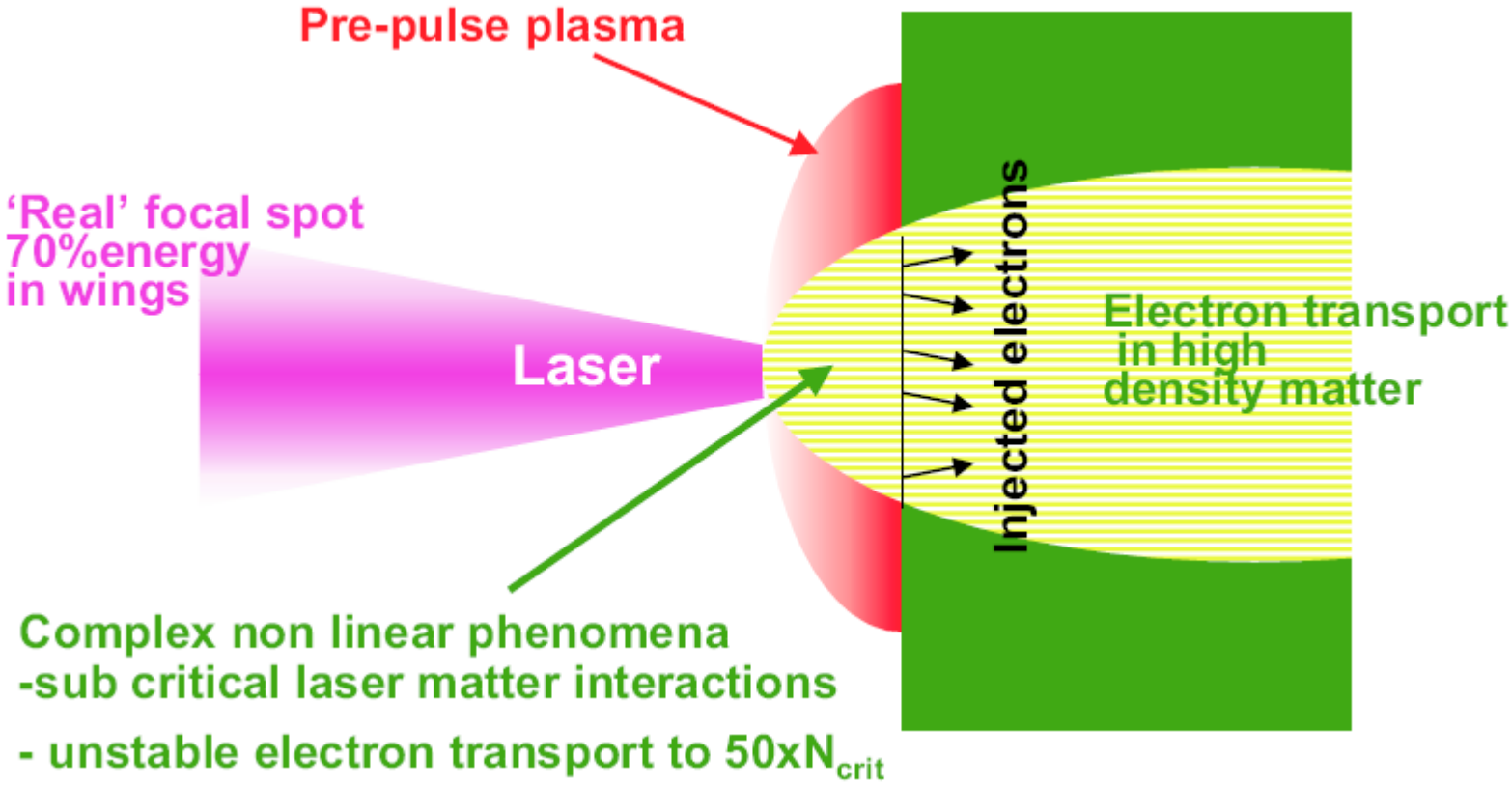
LLNL



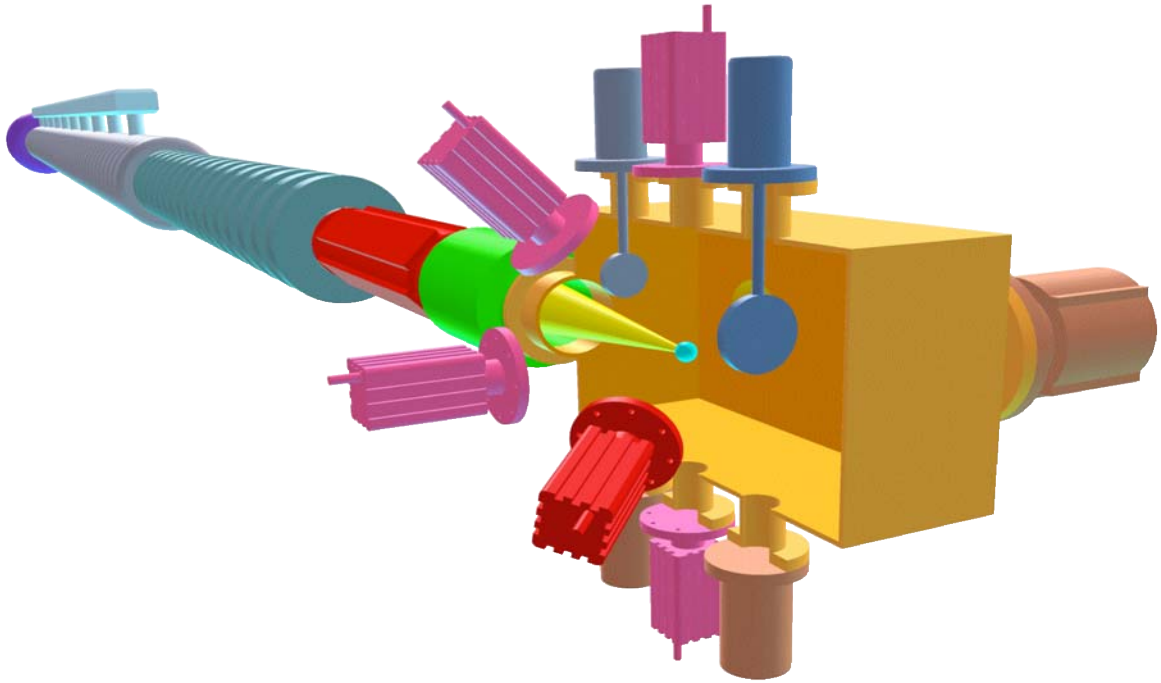
Source and injector experiments will help optimize initial beam brightness.

Fast Ignition ($0.72M FY04)

- Need numerical models benchmarked against experiments
- Provide low-cost access to some regimes of high energy density physics.



IBX: Integrated Beam Experiment to study source-to-target physics with a high-current heavy ion beam of IFE-relevant brightness to optimize target focusing.



→ An IBX capability for integrated acceleration, compression and focusing of high-current, space-charge-dominated beams would be unique- not available in any existing accelerator in the world.

High Energy Density Physics (HEDP)

- Two NRC studies (Turner's "Connecting Quarks with the Cosmos", Davidson's "Frontiers in High Energy Density Physics") urge a national, multi-agency program in HEDP
  - An emerging field amenable to laboratory studies relevant to interpreting astrophysical observations and other applications of national importance
- NSF is leading an interagency working group to develop a science driven roadmap for a balanced, comprehensive program in HEDP
  - A steering committee of members of the scientific community is being formed to guide this process
- DOE and NSF are called upon to strengthen the university activities in the HEDP field