Agenda: Wednesday, October 14th

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7:00	8:30 PM	Poster session at hotel

Meet the ARPA-E Team

Eric Rohlfing
Deputy Director for Technology

Patrick McGrath
Program Director

Ryan Umstattd
Senior Commercialization Advisor

Colleen Nehl
Tech SETA for ALPHA, Booz Allen Hamilton

Kevin Thompson
Programmatic SETA for ALPHA, Booz Allen Hamilton

JC Zhao
Program Director

Jonathan Burbaum
Program Director

Ron Faibish
Senior Advisor to the Director

Nate Gorence
Technology to Market Advisor

Michael Kane
Fellow

Addison Killean Stark
Fellow

Introduction to ALPHA

Dr. Patrick McGrath, Program Director, ARPA-E

October 14th, 2015

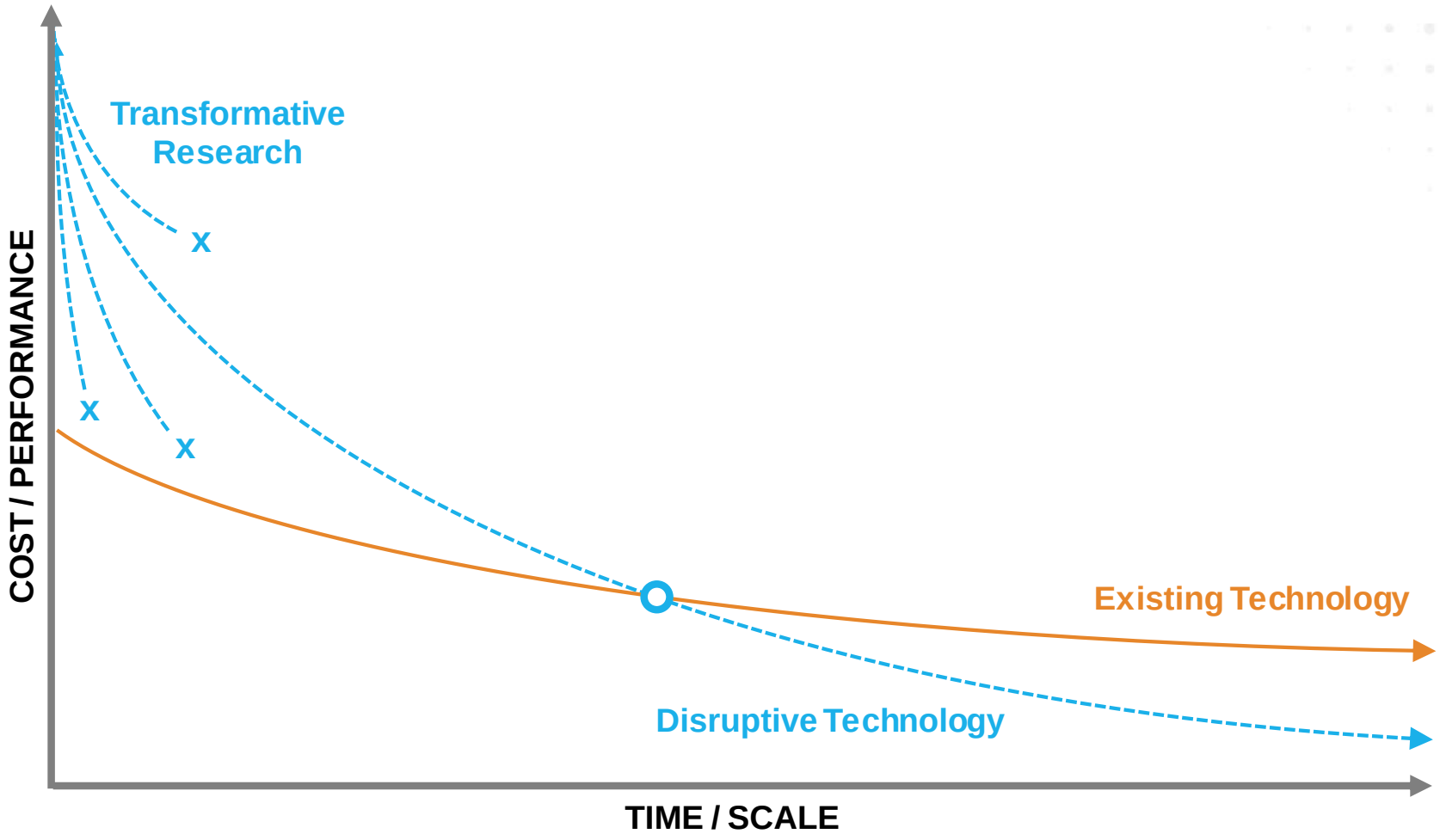
Why are we doing this?

	D-T Fusion	Natural Gas (USA)
Emissions (kg CO_2/kWh)	10^{-5}	0.55
Fuel Reserves (years)	10^{8}	250
Fuel Cost per kWh ($)	10^{-6}	0.02
Capital Cost per kW ($)	???	978

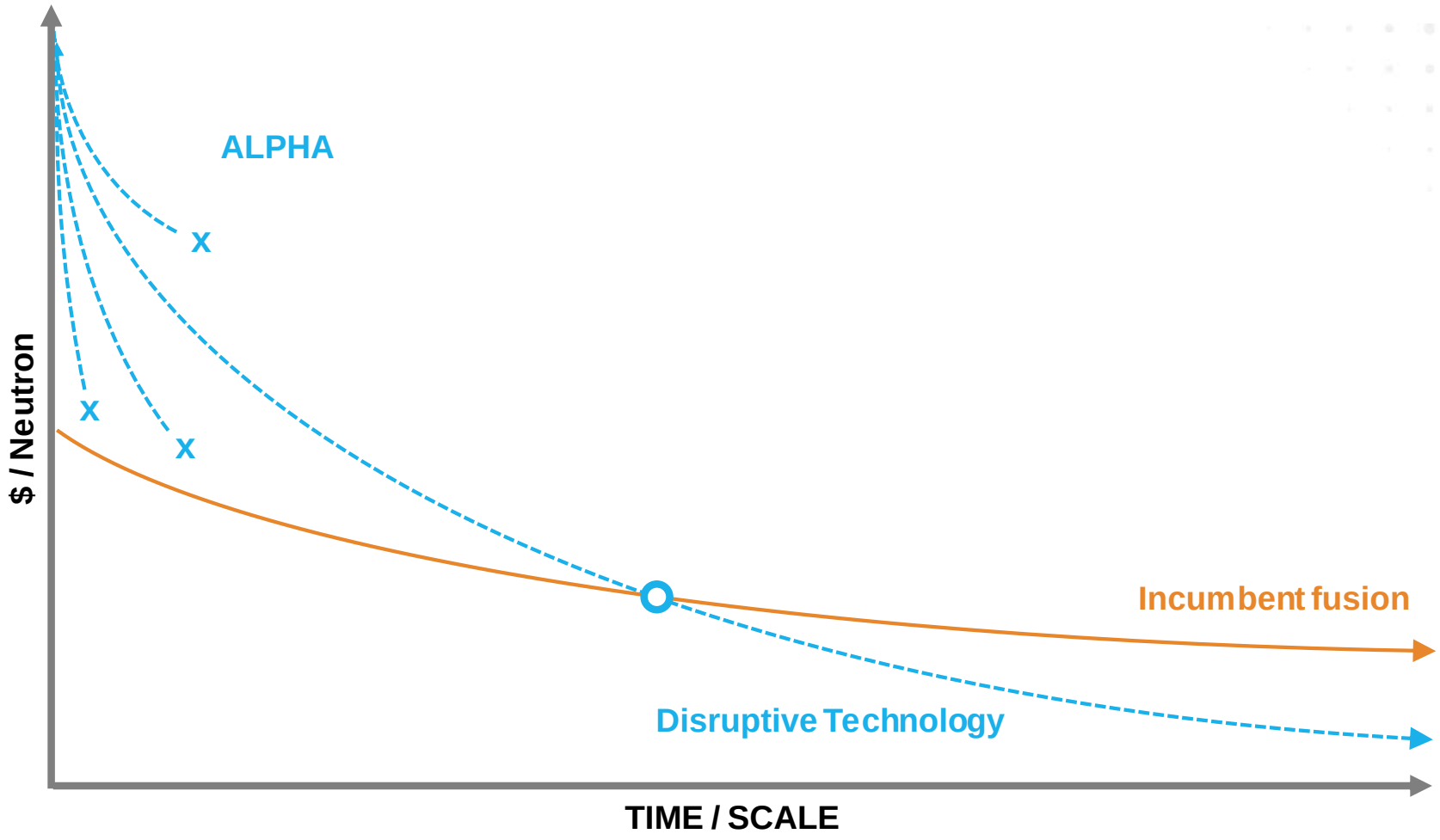
http://www.eia.gov/forecasts/aeo/pdf/0383(2013).pdf
http://physics.ucsd.edu/do-the-math/2012/01/nuclear-fusion/
http://www.iter.org/sci/fusionfuels
http://www.sigmaaldrich.com/catalog/product/aldrich/368407
http://www.eia.gov/tools/faqs/faq.cfm?id=58&t=8

** Includes proved and unproved reserves. <20 years of proved natural gas reserves. High-end of shale estimates could extend domestic natural gas reserves to 120 years*

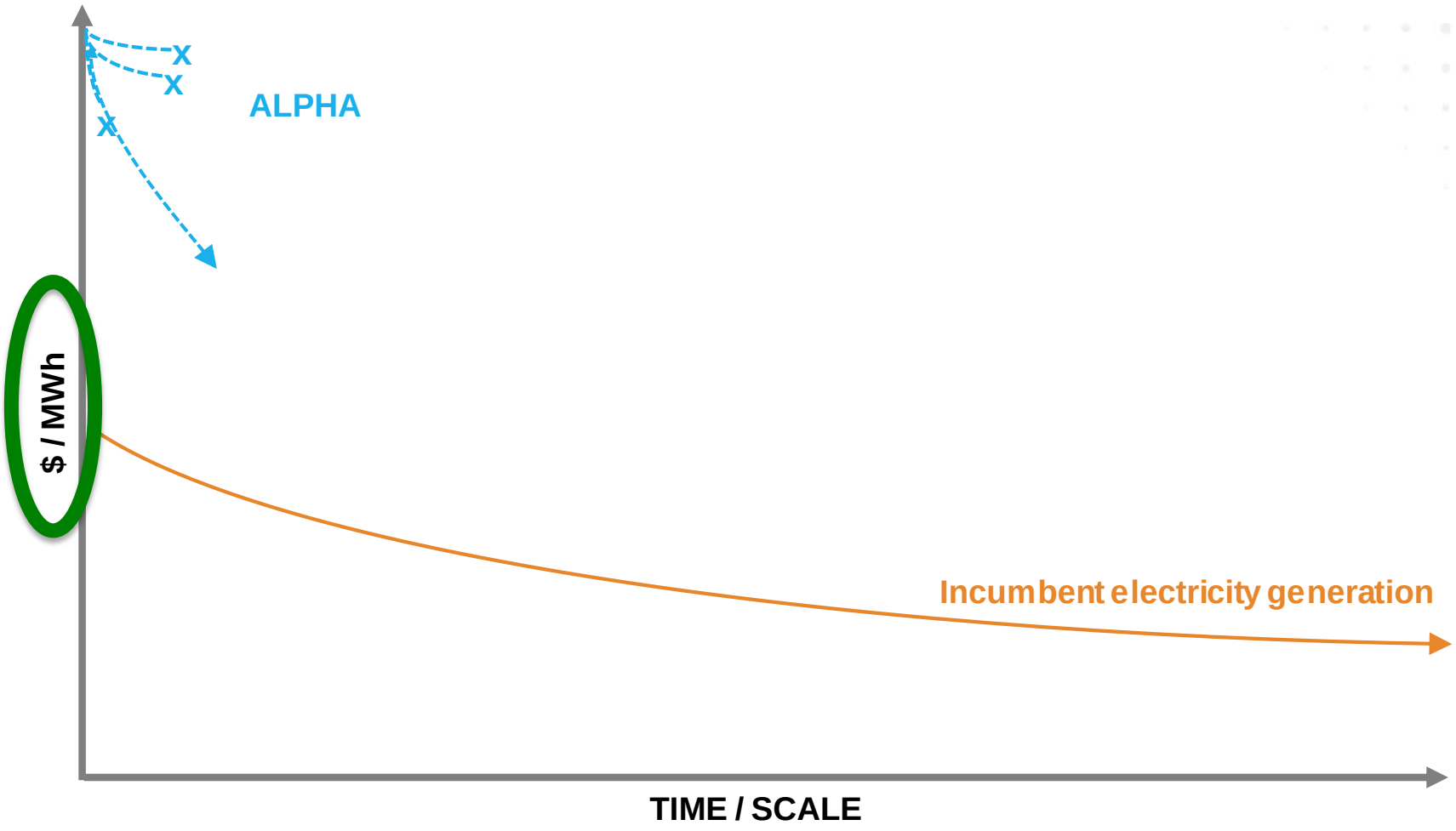
Transformative R&D to disruptive technology



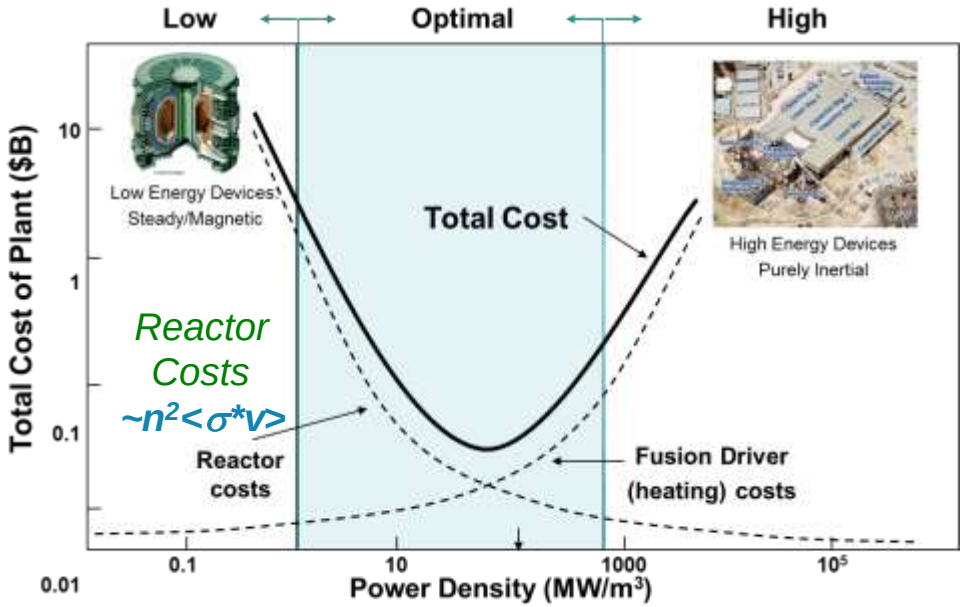
Learning curves for fusion…

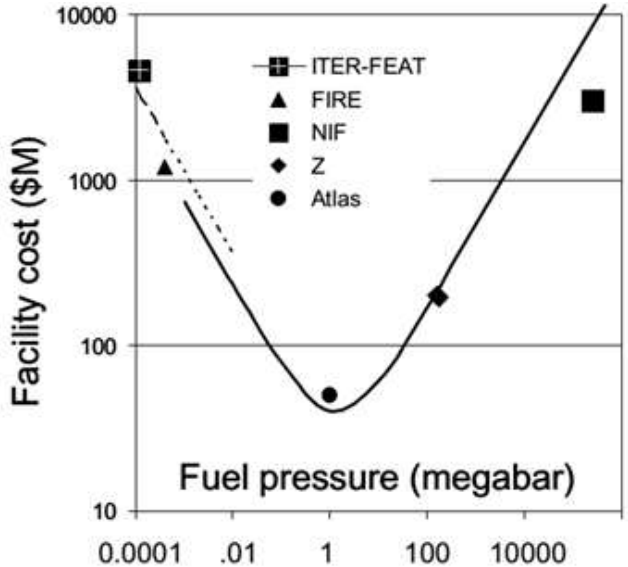


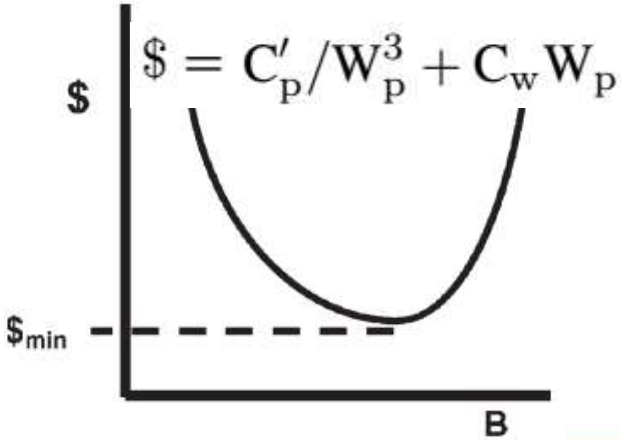
…and for the real prize

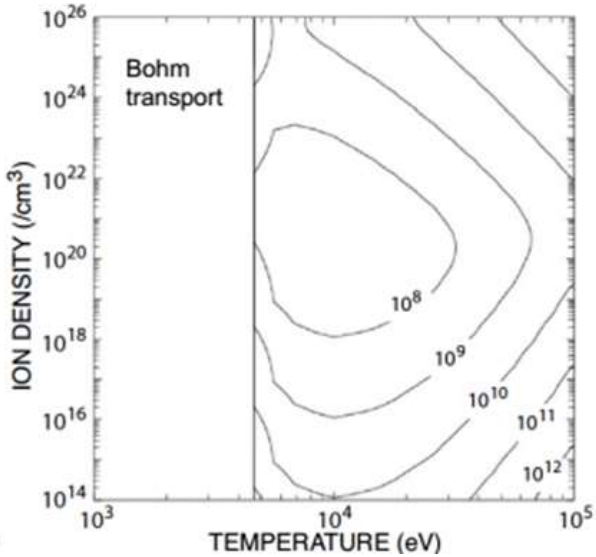


Why do we think this is even possible?









TL: Kirtley & Slough, ALPHA Kickoff, http://arpa-e.energy.gov/sites/default/files/KIRTLEY.pdf
BL: Turchi *IEEE Trans Plasma Sci* 2008

TR: Siemon "ATLAS for magneto-inertial fusion" 03/2005
BR: Lindemuth and Siemon *Am. J. Phys.* 2009

Of course, it always helps to have data

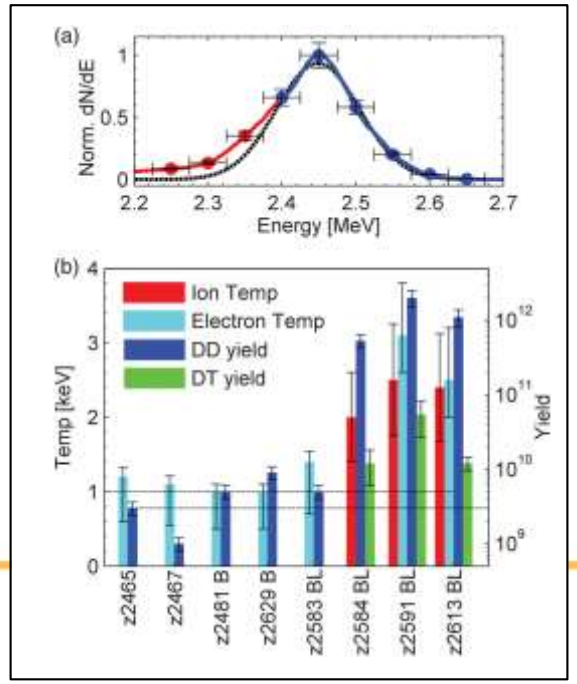
PRL **113,** 155003 (2014) PHYSICAL REVIEW LETTERS week ending 10 OCTOBER 2014

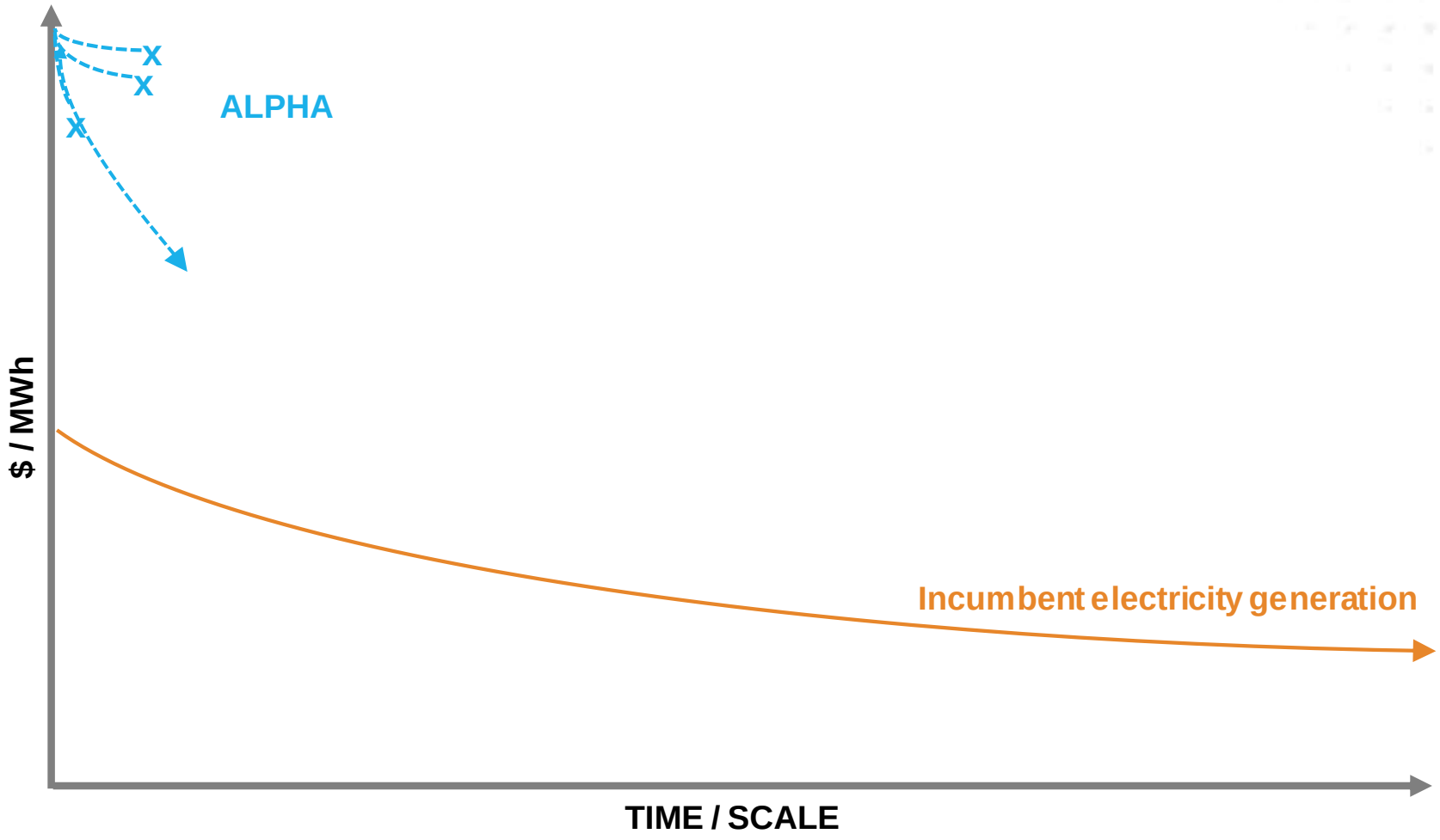
Experimental Demonstration of Fusion-Relevant Conditions in Magnetized Liner Inertial Fusion

M. R. Gomez, S. A. Slutz, A. B. Sefkow, D. B. Sinars, K. D. Hahn, S. B. Hansen, E. C. Harding, P. F. Knapp, P. F. Schmit, C. A. Jennings, T. J. Awe, M. Geissel, D. C. Rovang, G. A. Chandler, G. W. Cooper, M. E. Cuneo, A. J. Harvey-Thompson, M. C. Herrmann, M. H. Hess, O. Johns, D. C. Lamppa, M. R. Martin, R. D. McBride, K. J. Peterson, J. L. Porter, G. K. Robertson, G. A. Rochau, C. L. Ruiz, M. E. Savage, I. C. Smith, W. A. Stygar, and R. A. Vesey

Sandia National Laboratories, P.O. Box 5800, Albuquerque, New Mexico 87185, USA

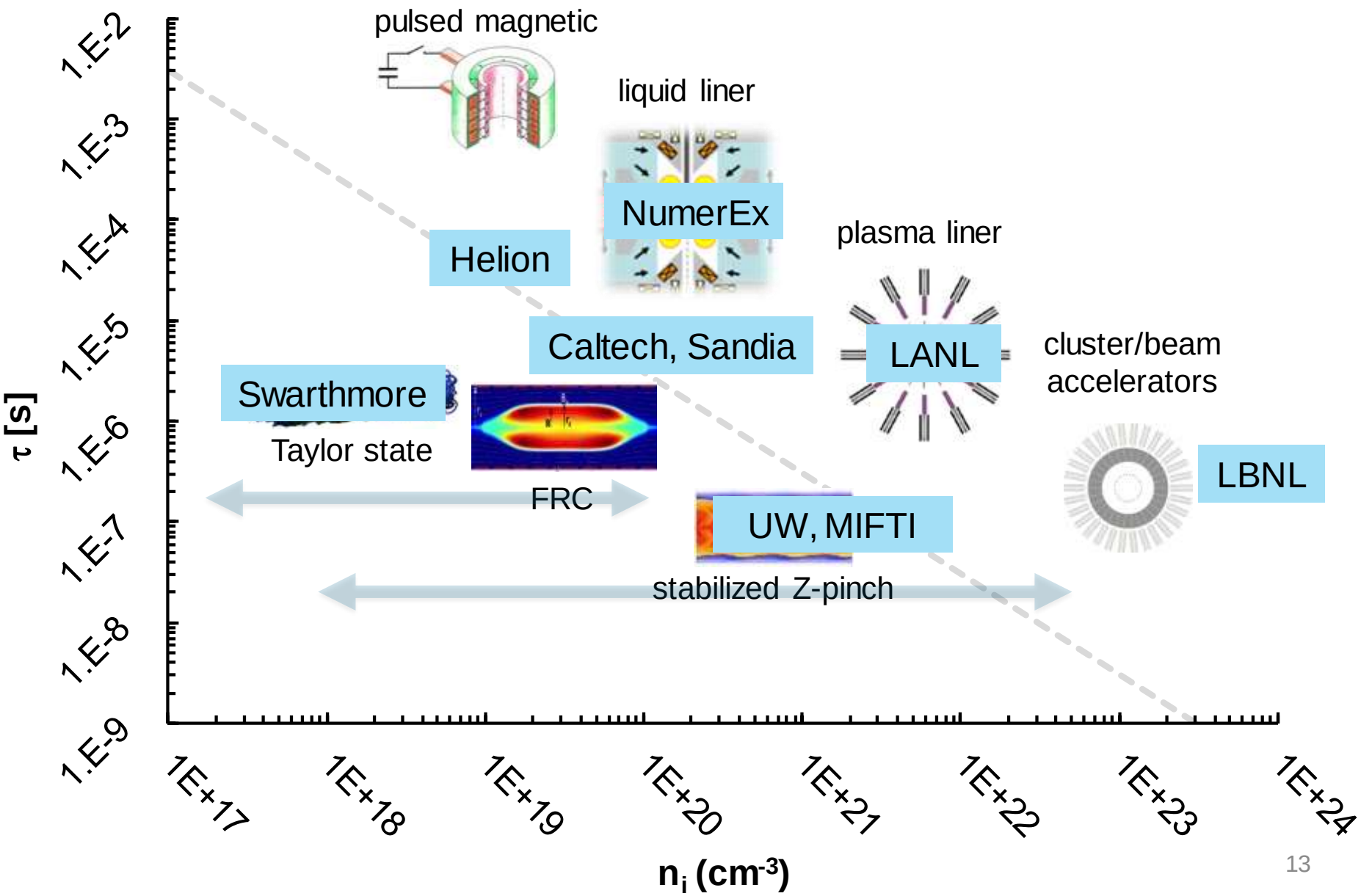
(Received 18 June 2014; published 6 October 2014)




ALPHA
Incumbent electricity generation
$ / MWh
TIME / SCALE

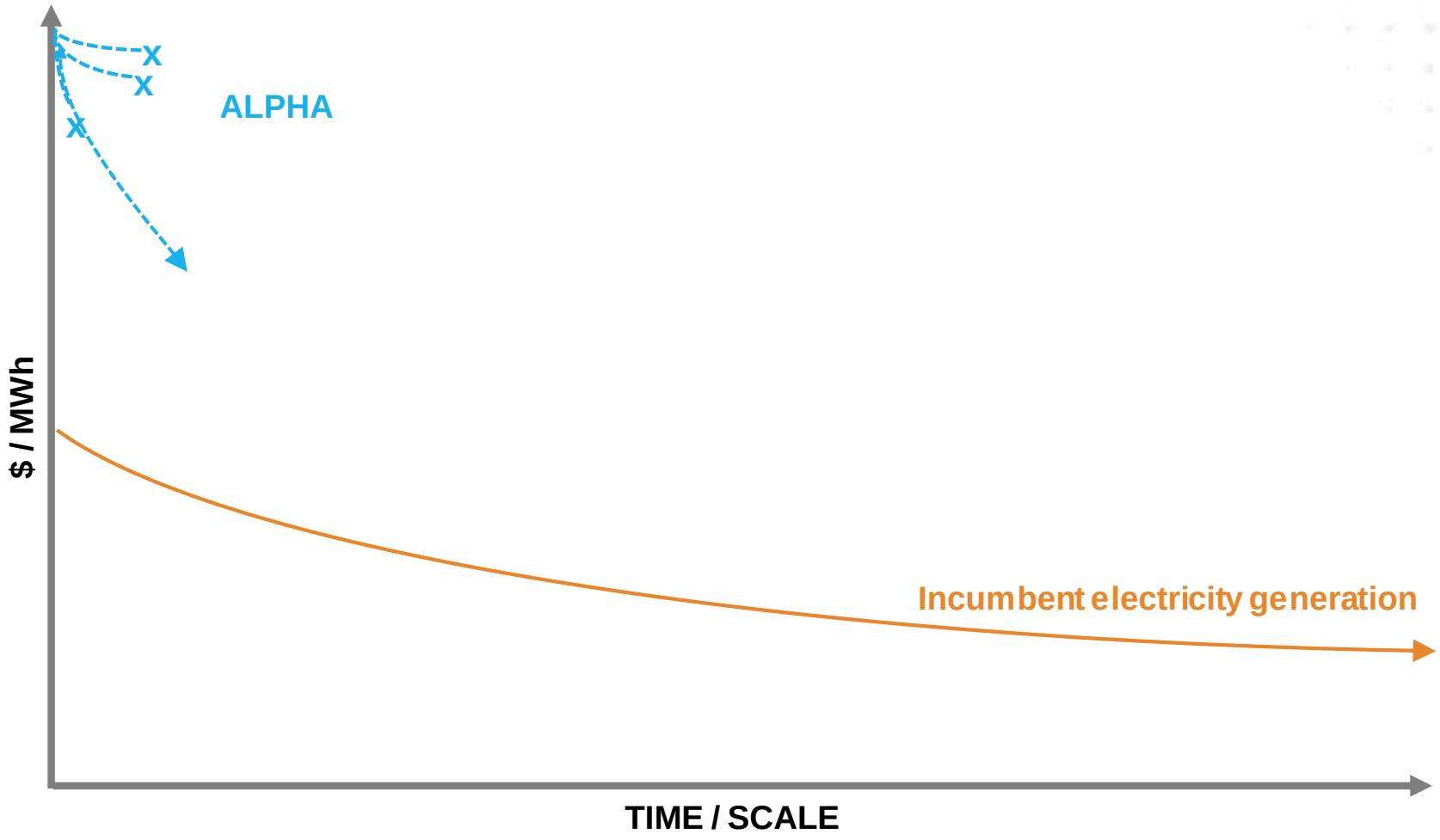
More players in the field

Breadth of portfolio



ALPHA teams

- *3 University Leads*
- *3 Small Business Leads*
- *3 Nat'l Lab Leads*


ALPHA
Incumbent electricity generation
$ / MWh
TIME / SCALE

The goal of ALPHA is to develop the tools needed to enable low-cost fusion energy.

Is it possible to achieve thermonuclear fusion using only technologies that are significantly lower cost than those currently employed in the mainline fusion program?

This an inherently higher risk line of research than the mainline fusion program. The answer to the question above may be no, but a "yes" would be truly transformational. Both the risk and the potential impact make it appropriate for ARPA-E.

The proposed program will build and demonstrate component technologies and push them through an aggressive "crash course" to determine if they can achieve performance levels required to achieve thermonuclear fusion.

If any approaches on this program succeed, an integrated demonstration of a fusion reactor would require a follow-on program (from ARPA-E or otherwise).

If no approaches prove viable, ARPA-E will close out the program and move on.

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www.arpa-e.energy.gov

Day 2: Nuts and Bolts

Dr. Patrick McGrath, Program Director, ARPA-E

October 15th, 2015

Agenda: Thursday, October 15th

Start	End	
8:00	8:30 AM	Day 2 Introduction Dr. Patrick McGrath, *Program Director, ARPA-E* Dr. Ryan Umstattd, *Senior Commercialization Advisor, ARPA-E*
8:30	8:00 AM	IP Considerations Dr. Karina Edmonds, *Executive Director for Corporate Partnerships, Caltech*
9:00	9:15 AM	VC and Foundation Landscape Mr. Nathaniel Gorence, *Technology to Market Advisor, ARPA-E*
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4:45	5:00 PM	Concluding Discussion
	5:00 PM	**Adjourn**

Project Management

Activity	Frequency	Details
Invoicing	Varies	Submit SF-270 and documentation to VIAS and ARPA-E. ARPA-E will review and ask questions (if needed). Invoices are generally paid within 30 days.
Quarterly Technical Reports	Quarterly	Must upload to ePIC by 1/31; 4/30; 7/31; 10/31.
Quarterly Technical Reviews	Quarterly	May be held in person or via teleconference. Expect in-person visits to occur soon after critical technical milestones.
ARPA-E Summit	Annually	February/March in Washington, DC.
Annual ALPHA Review	Annually	Reviews will be held near program "centers of gravity," e.g. New Mexico, Seattle, Los Angeles.
Informal Discussions	Sporadically	Contact your PD and Tech SETA with interesting results. Expect informal discussions at conferences (e.g. APS DPP).

Questions? Email Kevin Thompson: kevin.thompson@hq.doe.gov,

When are PD approvals or contract mods needed?

No battle plan survives the first shot.

When things change, please give us a call before seeking any contractual actions. We may be able to resolve it quickly and easily.

Give us a call if…	Contract Mod may be needed if…
Your team has a slight change in approach, but overall goals are unchanged.	You see a need to pivot to a different goal from the negotiated technical milestones.
Spending in particular categories is not as expected. "Minor" re-budgeting may be required.	You need a major (>25%) change adjustment between budget categories.
You foresee a schedule slip.	Your team needs more time to complete the project (i.e. no-cost extension).
You want to travel internationally on ARPA-E funding.	You are bought out.

Questions? Email Kevin Thompson: kevin.thompson@hq.doe.gov,

Collaborative Exercise

Part 1: 30 Minutes

- Prepare "elevator speech" for other ALPHA teams
  - Round robin (1 summarize 2, 2 summarize 3, 3 summarize 1)
- Summarize each of the three teams in another group with 3-5 bullets on:
  - What the team is trying to do (i.e. project goal and/or how they will accomplish it)
  - Why is this important?
  - Why now—what is new and/or different about the approach?
  - Why it is hard? What are the critical challenges the team must overcome?

Part 2: 45 Minutes

- A representative (or three) from each group will present.
- PI feedback:
  - Was the slide accurate? Did you get your team's message across? Why or why not?
- 5 minutes will be allocated to each project:
  - Elevator speech: 1 min
  - Feedback from the project PI: 1 min
  - Feedback from Andrew
- *Afterwards, we'll open up for any PI who wants to redo their own elevator speech*

Group 1	Group 2	Group 3
Swarthmore	Caltech	University of Washington
NumerEx	Helion	MIFTI
Los Alamos Nat'l Lab	Lawrence Berkeley Nat'l Lab	Sandia Nat'l Lab

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Upcoming Meetings

Meeting	Date(s)	Location
American Physical Society, Division of Plasma Physics	November 16-20, 2015	Savannah, GA
Fusion Power Associates	December 16-17, 2015	Washington, DC
EPR 2016	February 23-26 2016	Auburn, AL
ARPA-E Summit	February 29-March 2, 2016	Washington, DC
Quarterly Reviews	TBD	Varies
International Conference on Plasma Science (ICOPS)	June 19-23, 2016	Banff, Alberta, Canada
Technology of Fusion Energy (TOFE)	August 22-25	Philadelphia, PA
ALPHA Annual Review Meeting	August 2016 (poll will be circulated)	Western United States
American Physical Society, Division of Plasma Physics	October 31-November 4, 2016	San Jose, CA
ARPA-E Summit	TBD, ~February 2017	Washington, DC

Backups

May 11, 2016

When are my Quarterly Reports Due?

- Reporting aligns to the quarters of the fiscal year. Reports are due on:
  - January 15th, April 15th, July 15th, October 15th
- ***Your first quarterly report is due January 15th, 2016.***
  - The January 15th report will cover work from your start date until December 31st.
- ***Quarterly technical reviews will be held.***
  - In-person reviews will be scheduled after critical technical milestones (e.g. go/no-go milestones) or other important events (i.e. new equipment is in operation, surprising technical results, etc.)
  - When in-person reviews are not necessary we will hold a teleconference/WebEx to review your technical progress.
  - Traditionally, the PI arranges to host the quarterly technical review.

Questions? Email Kevin Thompson: kevin.thompson@hq.doe.gov,

Workshop Attendees

Last Name	First Name	Company/Organization
Barnard	John	LLNL
Barnes	Dan	Coronado Consulting
Betti	Ricardo	University of Rochester
Boysen	Dane	ARPA-E
Branz	Howard	ARPA-E
Campbell	Mike	Logos Technologies
Candler	Rob	UCLA
Cassibry	Jason	Univ. of Alabama, Huntsville
Cohen	Sam	PPPL
Cuneo	Mike	Sandia National Lab
Dean	Stephen	Fusion Power Associates
Degnan	Jim	AFRL
Fowler	Kenneth	Univ. of California, Berkeley
Glenzer	Siegfried	SLAC
Henestroza	Enrique	LBNL
Herrmann	Mark	Sandia
Hsu	Scott	LANL
Kirtley	David	Helion Energy
Kwan	Joe	LBNL (retired)
Laberge	Michel	General Fusion
Lal	Amit	Cornell
Latkowski	Jeff	Terrapower, Inc.
Leemans	Wim	LBNL
Leeper	Ramon	LANL
Lindemuth	Irv	Univ. of Nevada, Reno

Last Name	First Name	Company/Organization
McGrath	Patrick	ARPA-E
Miley	George	U. Illinois, Urbana- Champaign
Nehl	Colleen	Booz Allen Hamilton
Pouy	Mark	Booz Allen Hamilton
Putterman	Seth	UCLA
Regan	Will	ARPA-E
Rohlfing	Eric	ARPA-E
Rosenzweig	James	UCLA
Ryutov	Dmitri	LLNL
Schenkel	Thomas	LBNL
Sethian	John	NRL
Short	Geoff	Booz Allen Hamilton
Siemon	Richard	University of Nevada, Reno
Sinars	Dan	Sandia
Slough	John	University of Washington
Tantawi	Sami G	SLAC/Sanford University
Thio	Francis	DOE OFES
Thompson	John	FAR-TECH
Trevithick	Matt	Venrock Capital
Turchi	Peter	LANL (retired)
Welch	Dale	Voss Scientific
Willson	Bryan	ARPA-E
Witherspoon	F. Douglas	HyperV Technologies Corp.
Woodruff	Simon	Woodruff Scientific, Inc.
Wurden	Glen	LANL
Zisman	Michael	DOE-HEP

The ALPHA Portfolio

Category 1: Drivers	
Los Alamos Nat'l Laboratory	Spherically Imploding Plasma Liners as a Standoff Magneto-Inertial-Fusion Driver
NumerEx	Stabilized Liner Compressor for Low-Cost Fusion
Lawrence Berkeley Nat'l Laboratory	Mems Based Ion Beam Drivers for Magnetized Target Fusion

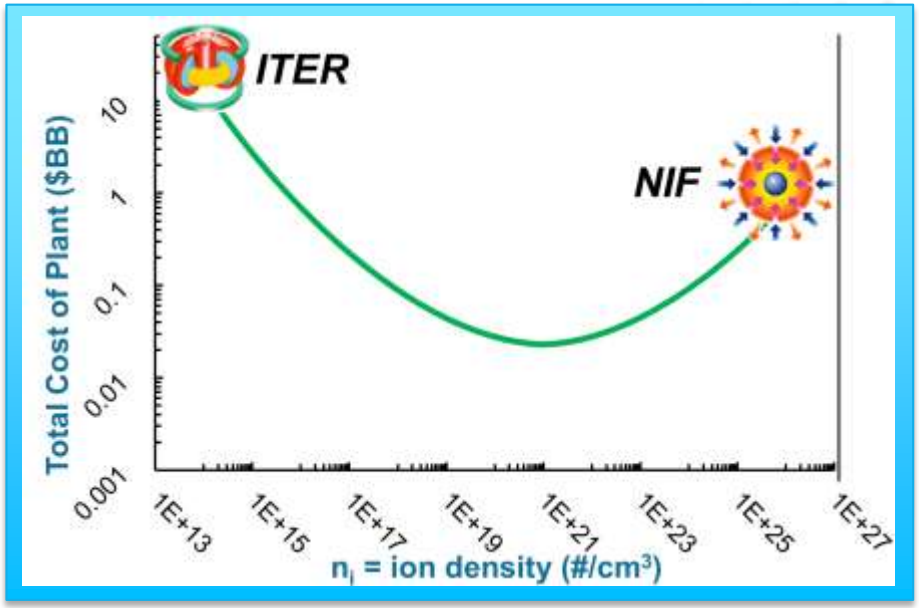
Category 2: Targets	
Sandia Nat'l Laboratories	Demonstrating fuel magnetization and laser heating tools for low-cost fusion energy
Magneto-Inertial Fusion Technologies	Staged Z-Pinch for Fusion
University of Washington	Development of a Compact, Fusion Device based on the Flow Z-Pinch
Swarthmore	Plasma Accelerator on the Swarthmore Spheromak Experiment

Category 3: Drivers and Targets	
Helion	Staged Magnetic Compression of FRC Targets to Fusion Conditions
Caltech	Prototype Tools to Establish the Viability of the Adiabatic Heating and Compression Mechanisms Required for Magnetized Target Fusion

What are we trying to do?

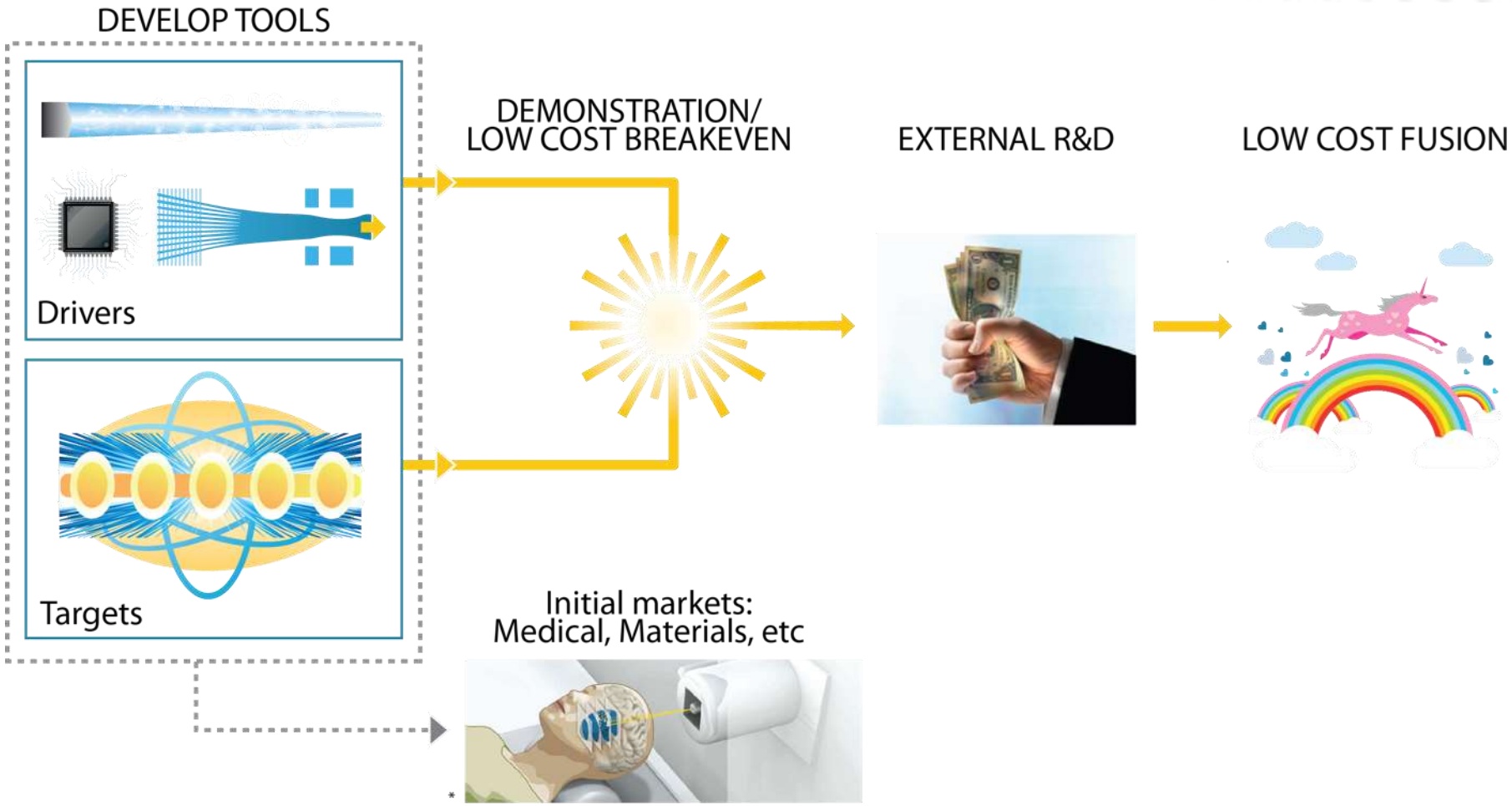
ARPA-E will support R&D on new tools to accelerate progress toward low-cost fusion alternatives.

- Low-cost fusion development requires:
  - Intrinsically low-cost technologies to heat and confine plasma
  - High shot rate for rapid learning
  - Intermediate density regimes for optimal balance of energy costs and power costs



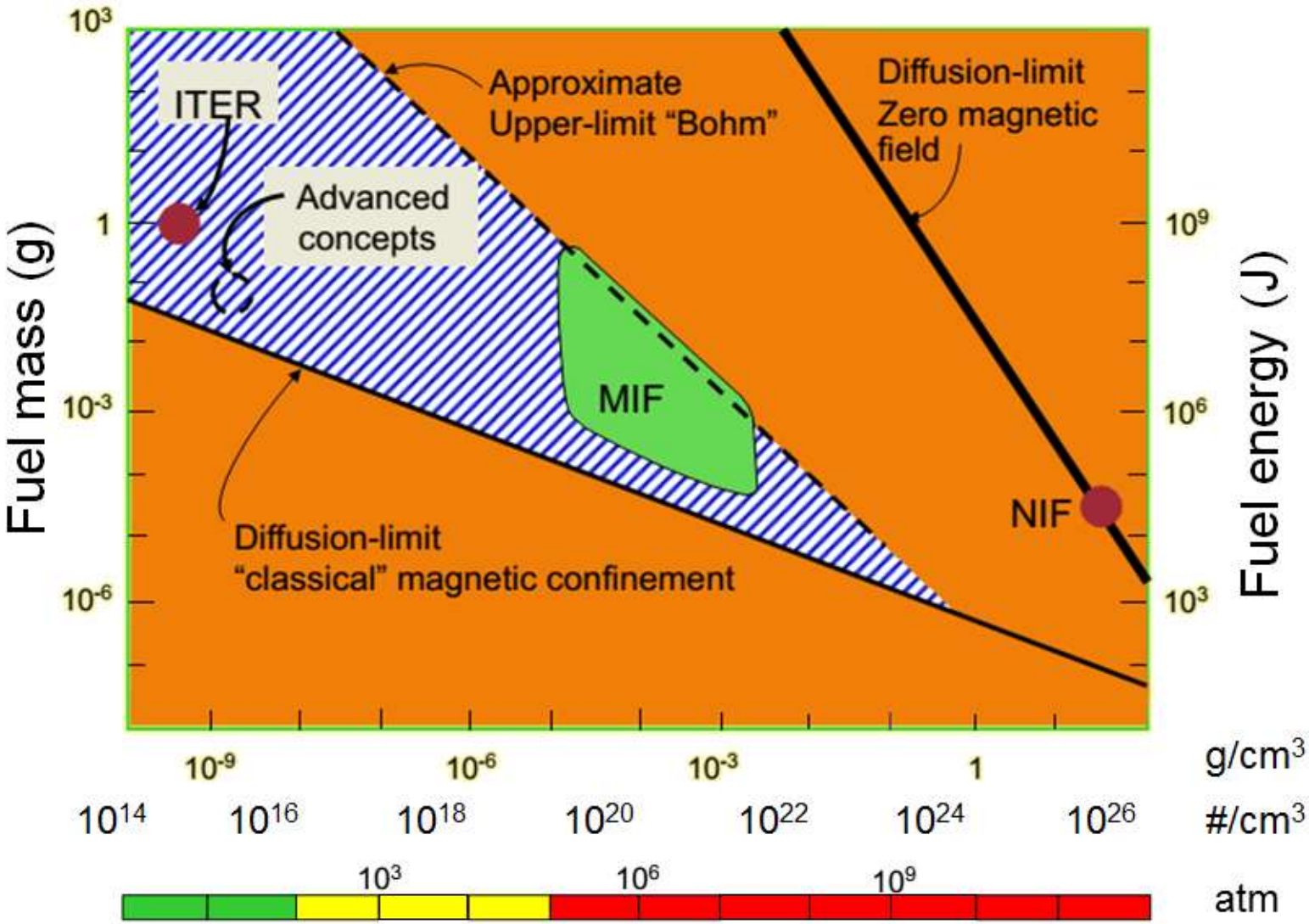
- ARPA-E program will develop low-cost tools to:
  - Exploit physics of intermediate density regime
  - Enable development and demonstration for full-scale reactors
  - Build community and provide foundation for fusion reactors at 1-2 orders of magnitude lower cost than existing approaches

Summary Program Vision



* Source: Heidelberg Ion-Beam Therapy Center

Minimum size (m, E) depends strongly on n_i and B



Source: F. Thio talk at ARPA-E "Transformative Research Opportunities in Small Fusion: Magneto-Inertial Fusion" Feb 6, 2013

ALPHA Portfolio

- *3 University Leads*
- *3 Small Business Leads*
- *3 Nat'l Lab Leads*

Drivers

Los Alamos NATIONAL LABORATORY

NumerEx

BERKELEY LAB

Targets

California Institute of Technology 1891

Helion Energy

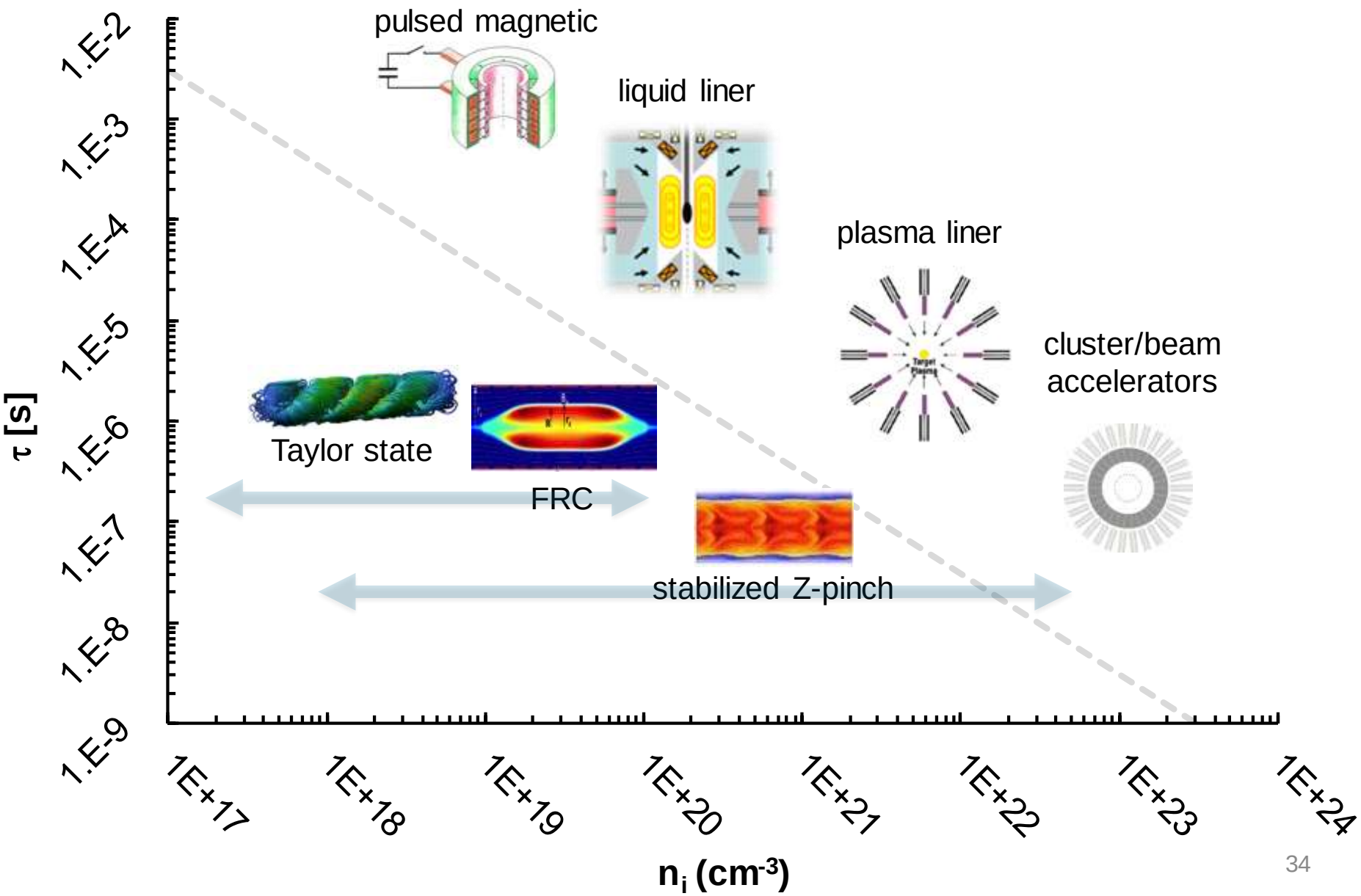
Sandia National Laboratories

UNIVERSITY of WASHINGTON

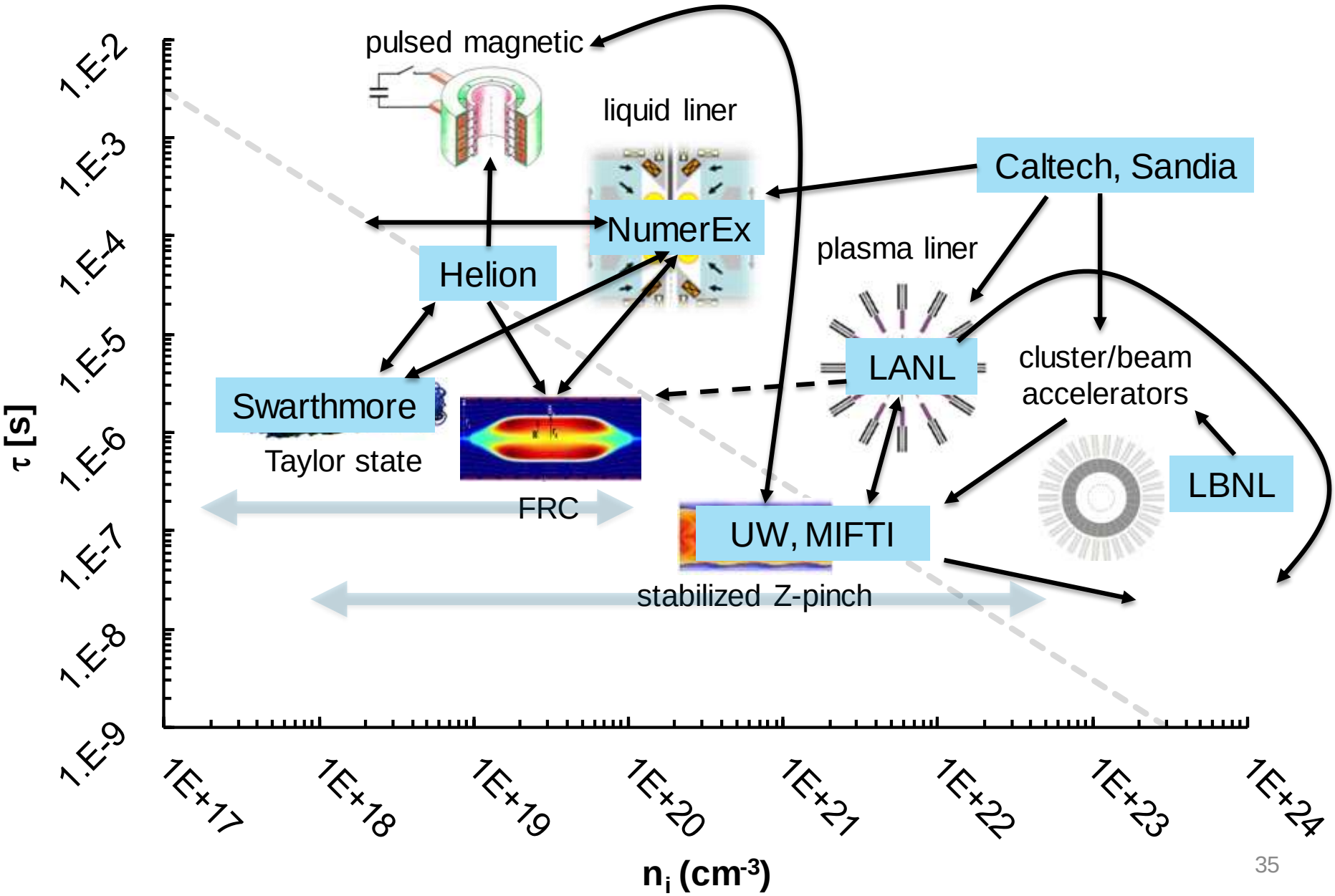
SWARTHMORE

MIFTi Clean Energy

Breadth of portfolio



Breadth of portfolio

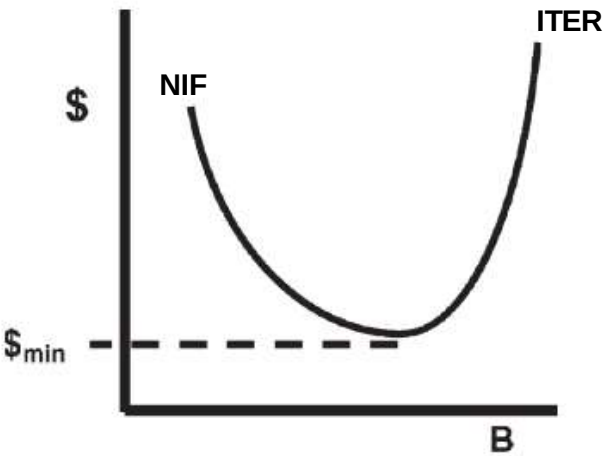


More players, more shots

- Confluence of scientific opportunity and new players in the field.
- Don’t know the winner. Need more data. Lots more data.
- Can’t get more data without more shots.
  - Cheap matters
  - Speed matters

What did we learn at the workshop?

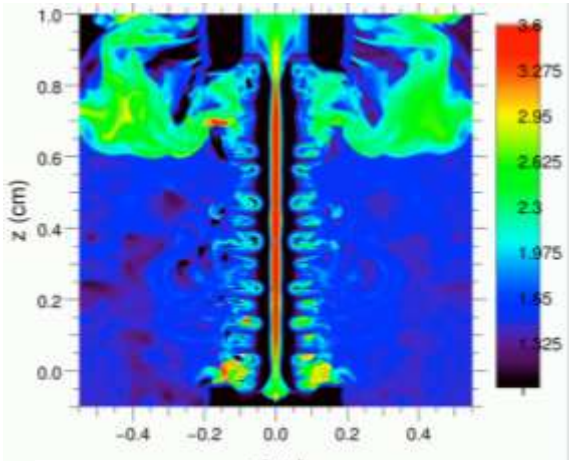
Low cost pathways to fusion



Facility cost vs. equivalent magnetic field

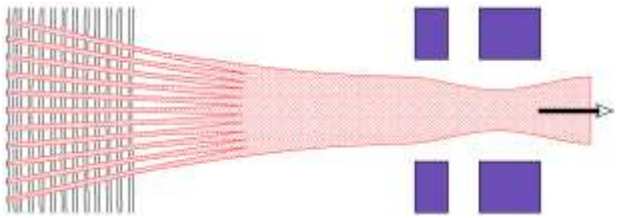
Ref. Turchi, *IEEE Transactions on Plasma Science*, 2008

Promising work in new fusion regimes



Temperature model from Sandia "MagLIF"

Low cost tools for fusion development



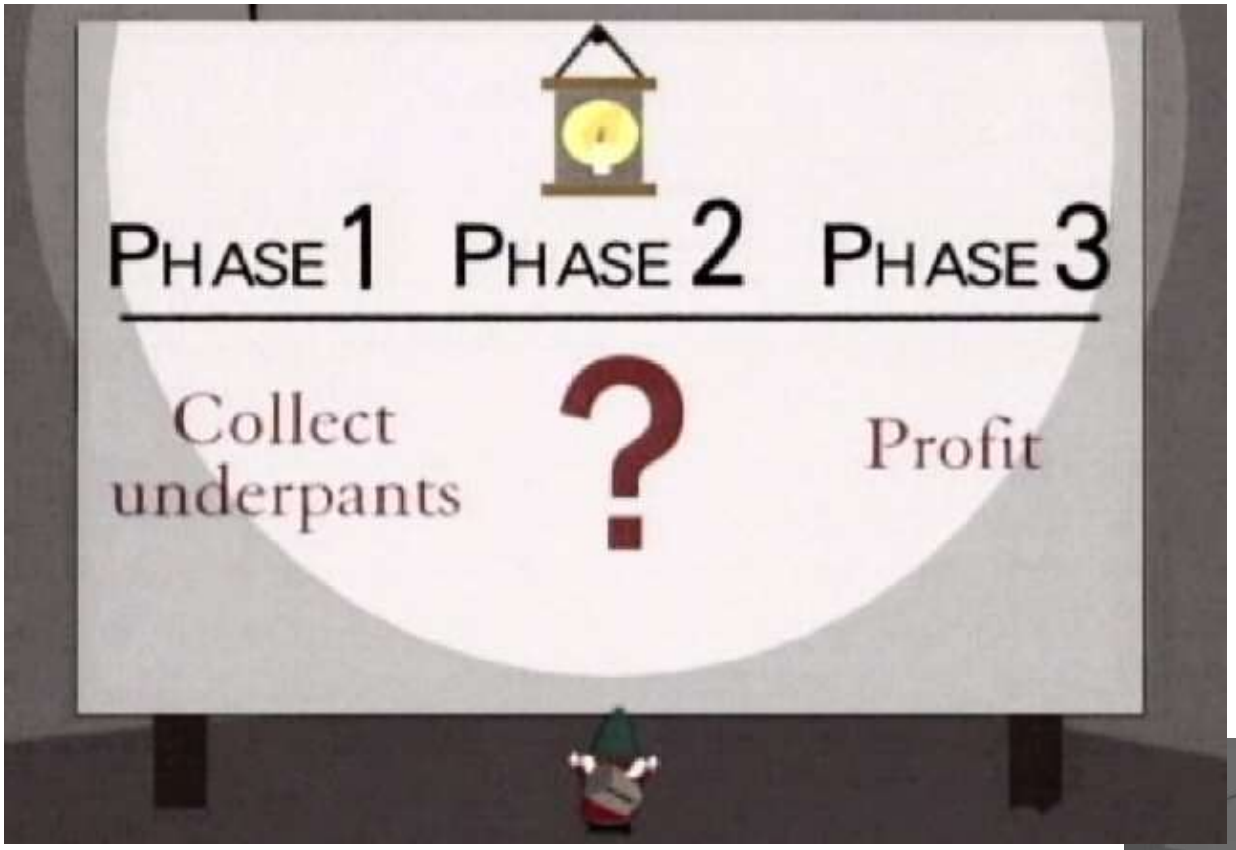
Merging beamlets concept (LBNL)

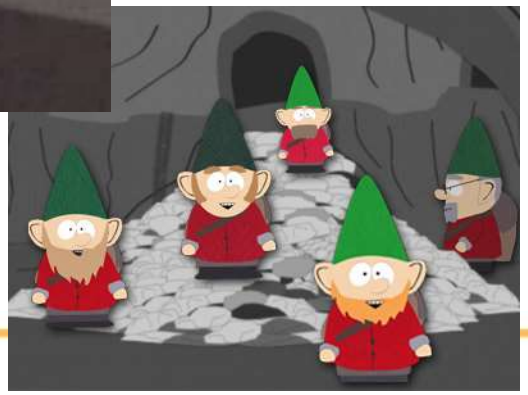
What does the program look like?

- Projects at a mix of universities, national labs, small and large companies
- Efforts focused on enabling component technologies
- Teams must demonstrate:
  - High shot rate for rapid learning
  - Viable pathway to Lawson conditions (density, temperature and duration) verified by modern plasma codes
  - Control of relevant plasma parameters and performance levels of component technologies (e.g., efficiency, power density, plasma lifetime)
  - Scalability of technology

ALPHA teams must prove the viability of their approaches

The “Underpants Gnome” problem





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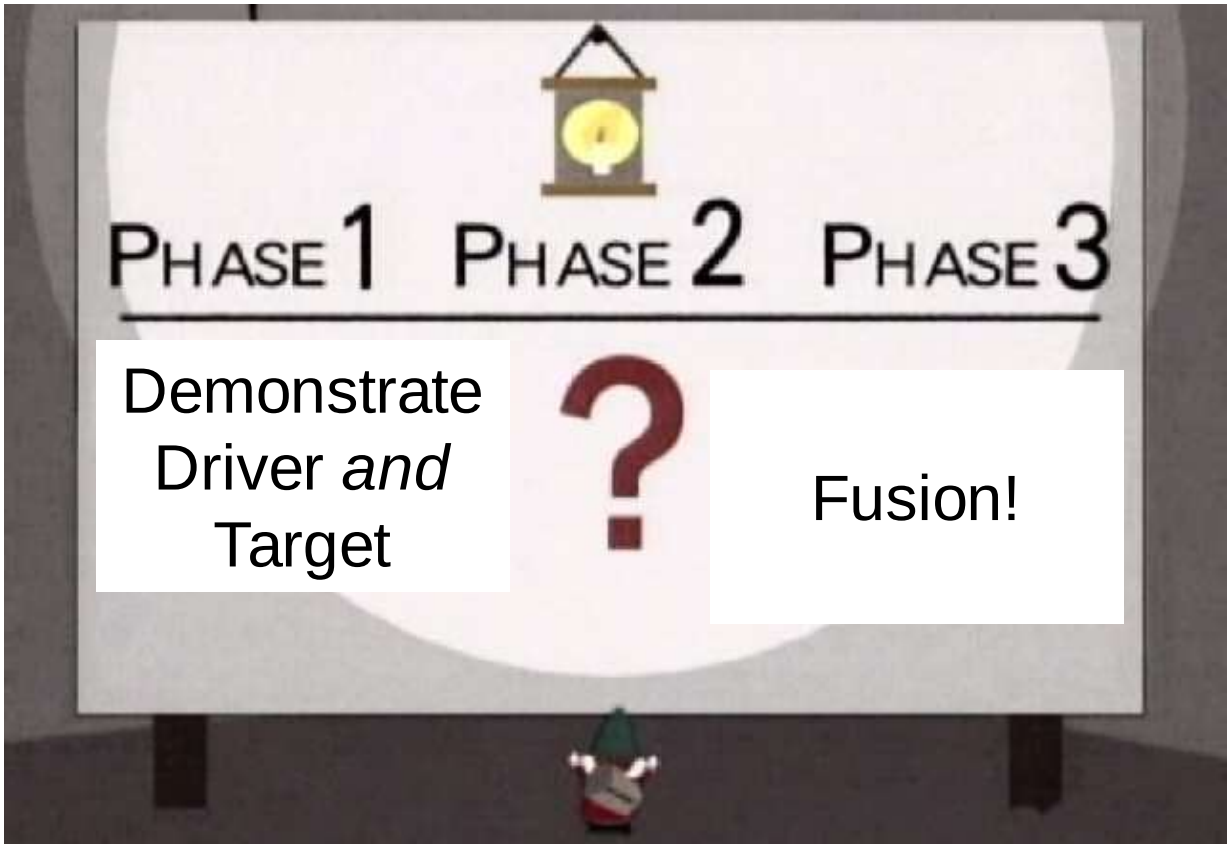
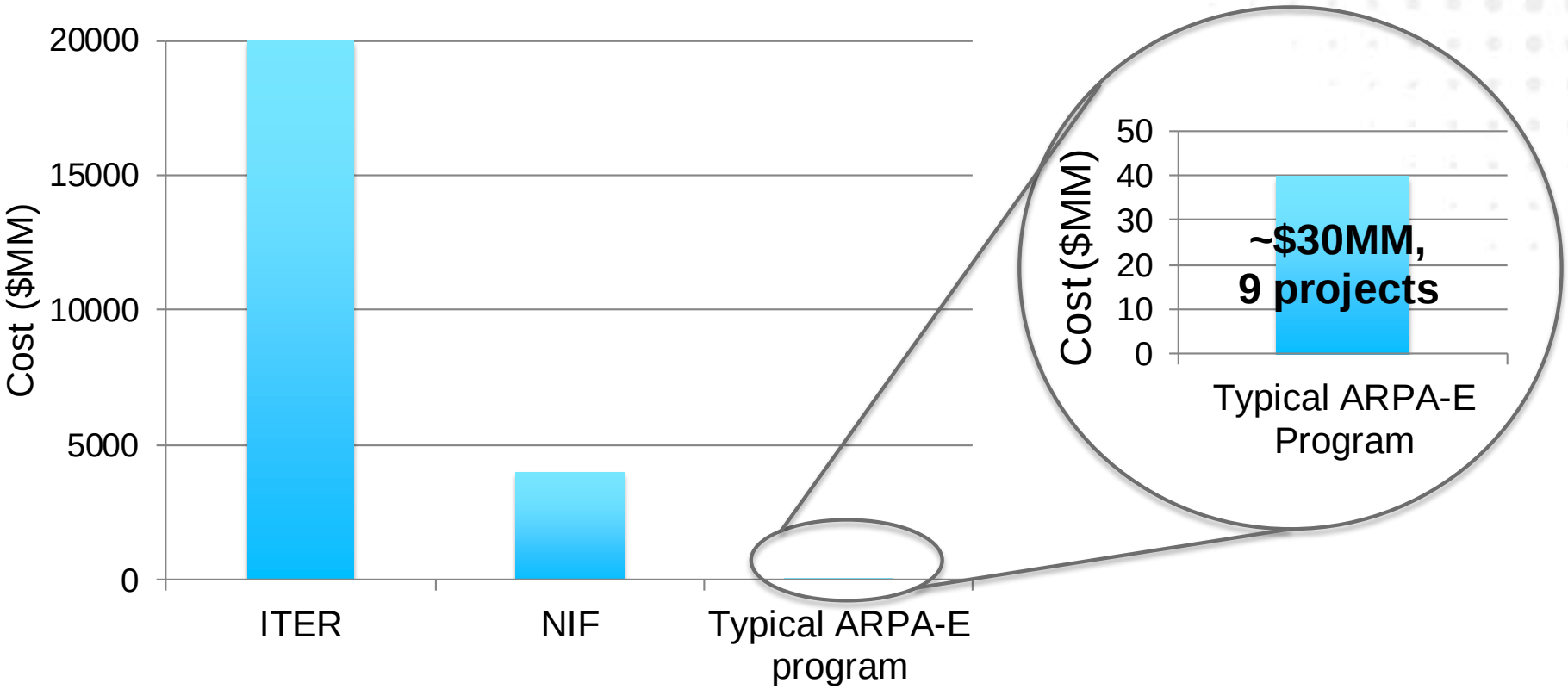


A reminder…



- We need to change the cost equation in fusion research to open the field.