National Spherical Torus Experiment
Proof of Principle Opportunities

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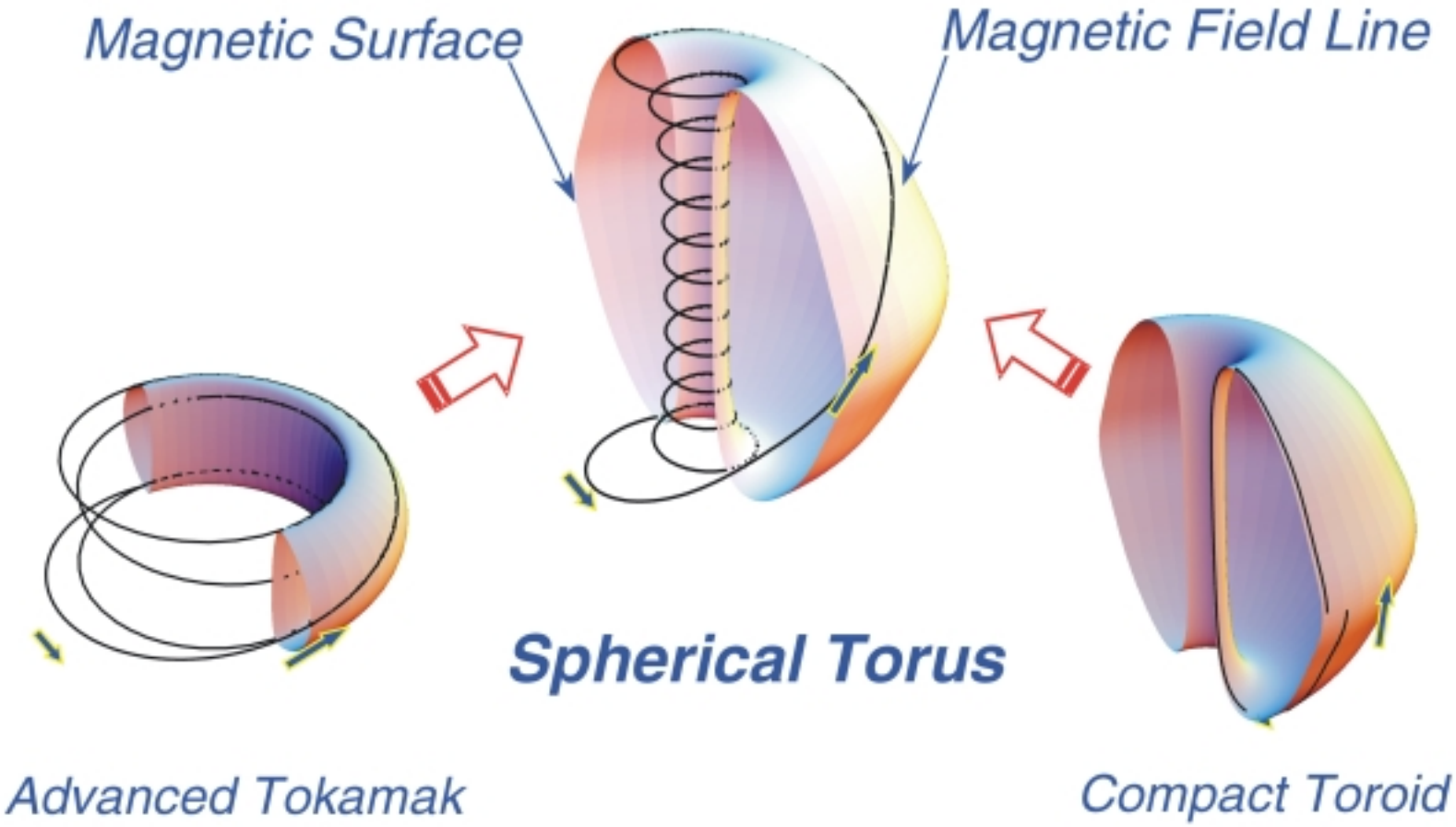
Spherical Torus Magnetic Configuration Builds on Tokamak and Compact Toroid Knowledge



ST benefits from and contributes to Tokamak and CT

Spherical Torus Promises Exciting Fusion Science towards Practical Energy

Promise: ***SCIENCE*** → ***ENERGY***

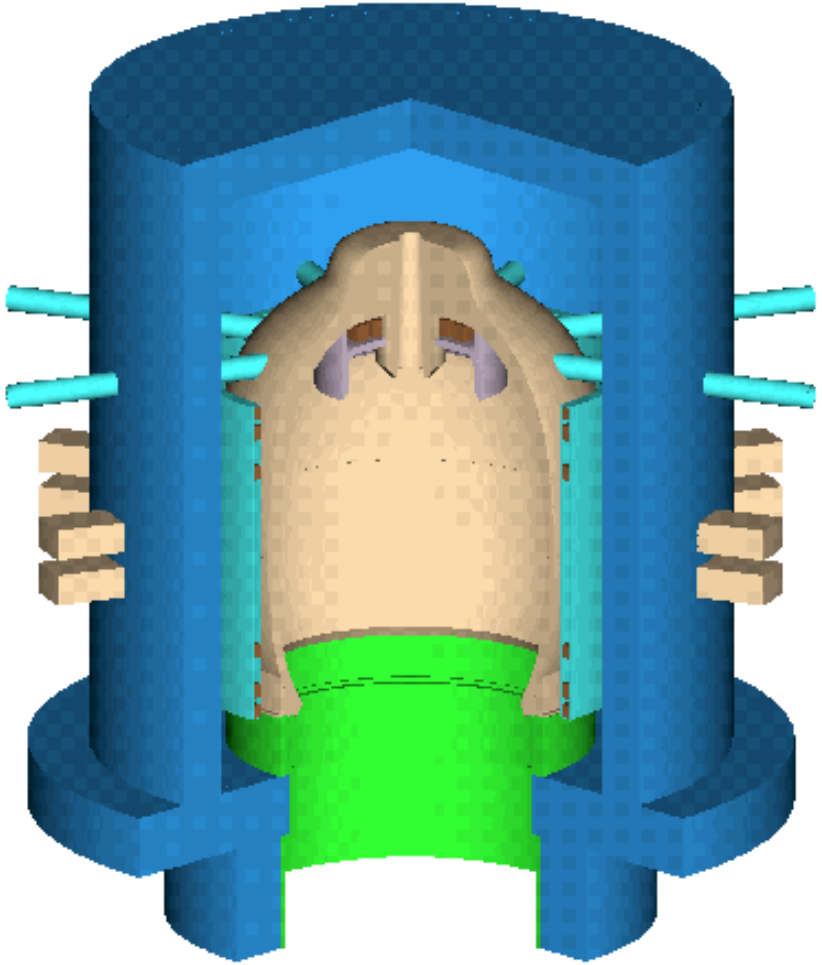
High Pressure, Low Field	→	Low Device Cost
Suppressed Turbulence	→	Small Unit Size
Dispersed Exhaust	→	Reliable First Wall
Self-Sustaining Current	→	Lowered Operating Cost
Startup Without Solenoid	→	Simplified Configuration

New Challenge: ***Science and Technology for***

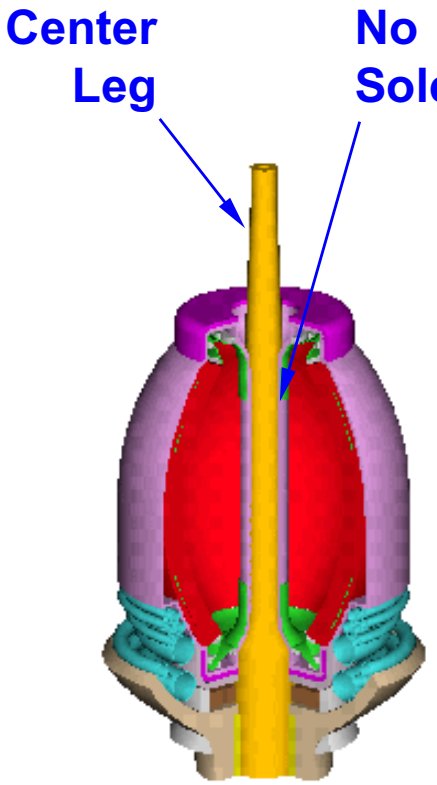
Startup Without Solenoid	→	Noninductive Startup
	→	Single-Turn Center Conductor
	→	Recirculating Power, Lifetime

Highly Modular Designs Are Envisioned for Future Spherical Torus Power Plant (UCSD)

ARIES



Fixed Components



Replaceable Components

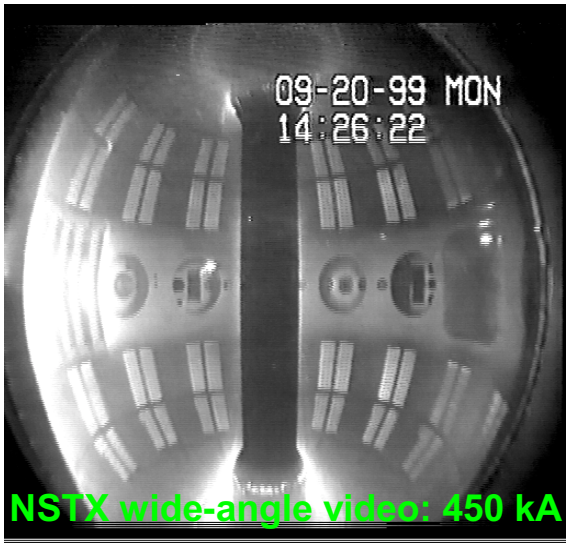
Slender and Modular Center Leg Components Permits Faster NSTX Installation and Upgrades

November 1998

Excellent Researchers from Many Institutions Work Together in National Research Team

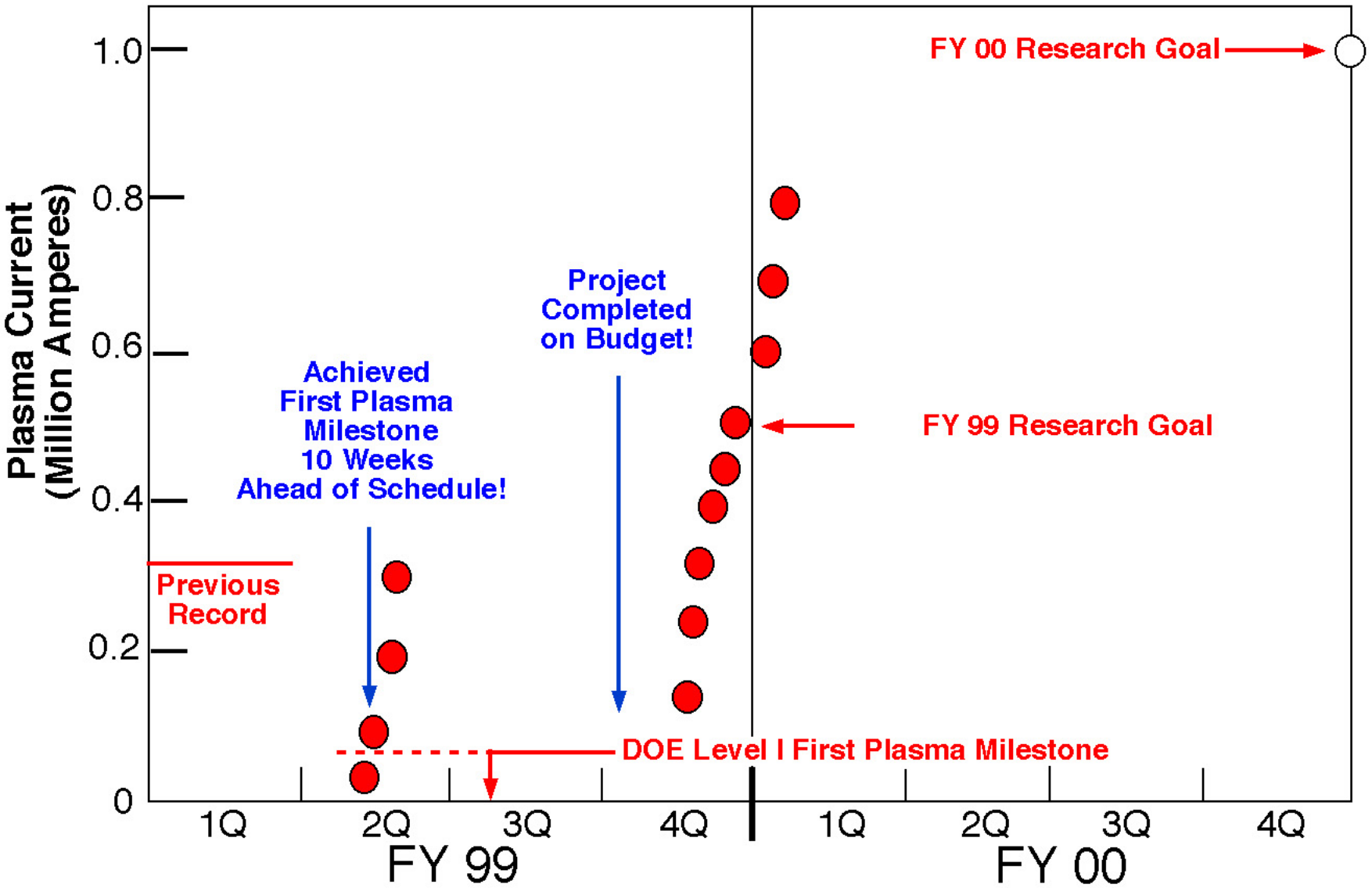
Columbia University
Fusion Physics & Technology, Inc.
General Atomics
Johns Hopkins University
Lawrence Livermore National Laboratory
Los Alamos National Laboratory
Massachusetts Institute of Technology
Oak Ridge National Laboratory
Princeton Plasma Physics Laboratory
Sandia National Laboratory
University of California at Davis
University of California at Los Angeles
University of California at San Diego
University of Washington
University of Wisconsin

New U.S. Spherical Torus Experiments Came on Line at Budget and Ahead of Schedule

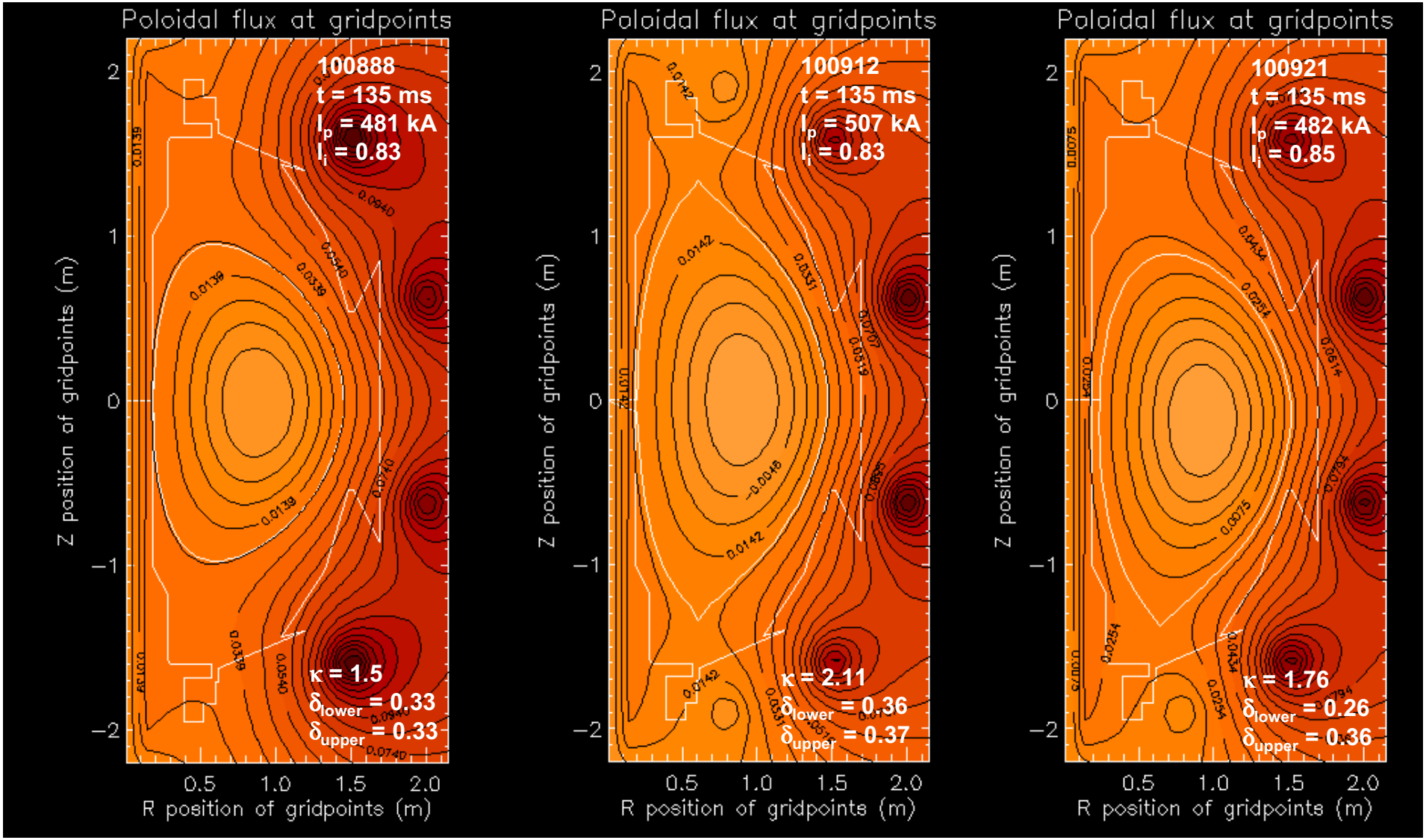


CY 1996 | 1997 | 1998 | 1999 | 2000

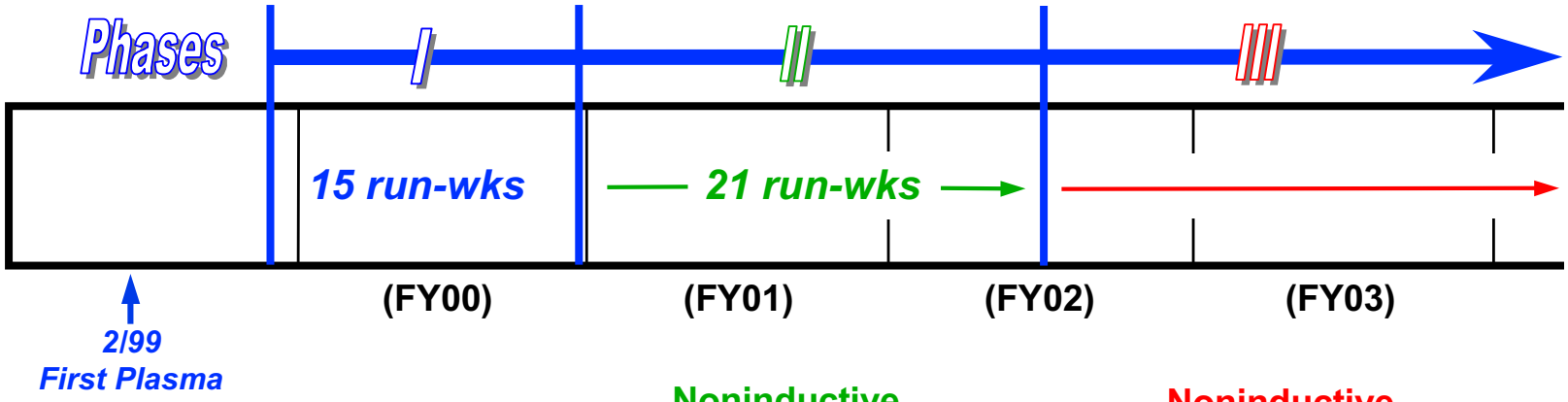
Good News From NSTX!



Various Plasma Cross Sections Are Produced in NSTX and Modeled with EFIT (Sabbagh, Columbia U)

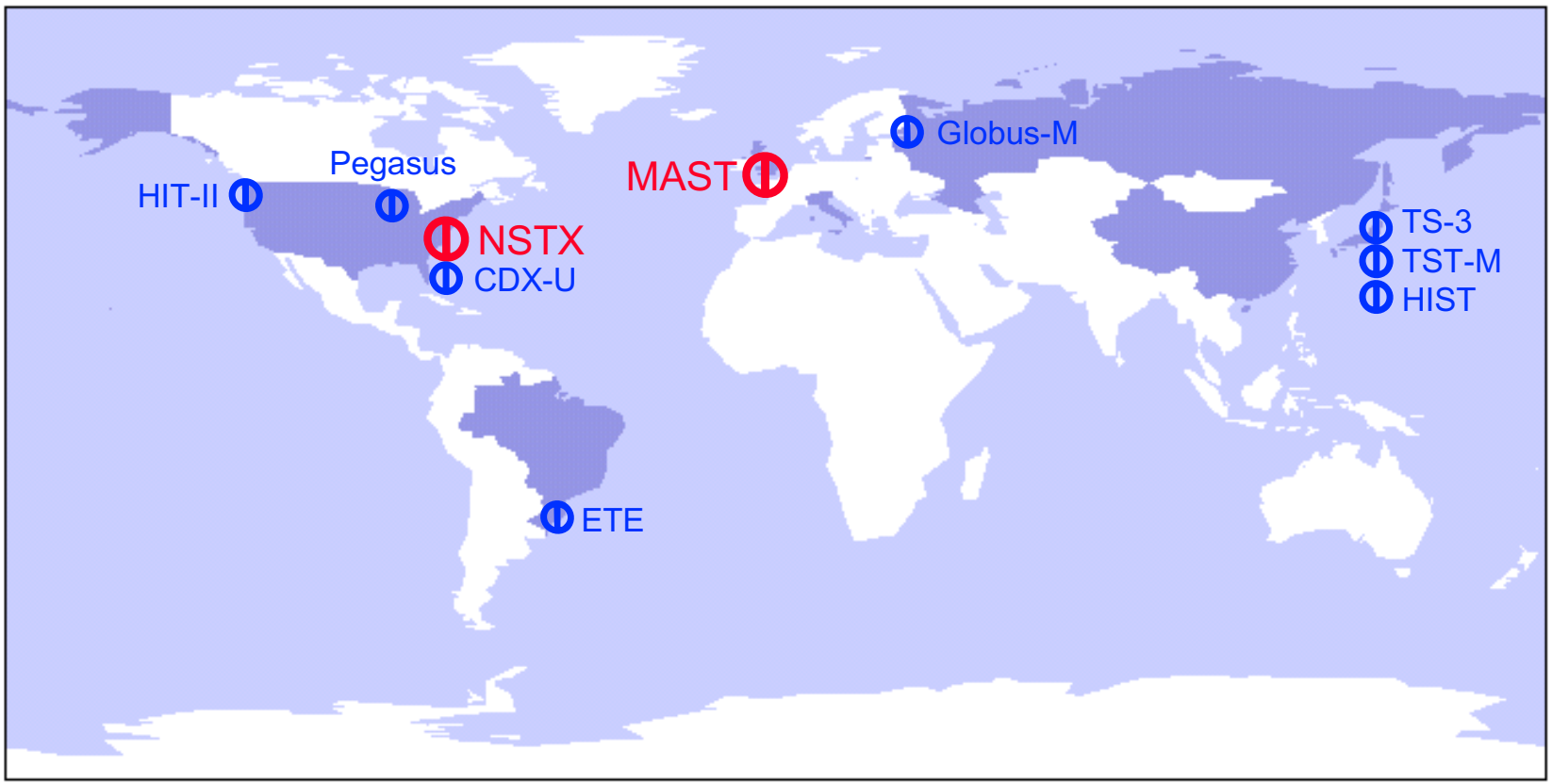


NSTX Plans to Investigate in 4–5 Years ST Physics Issues of Critical Interest

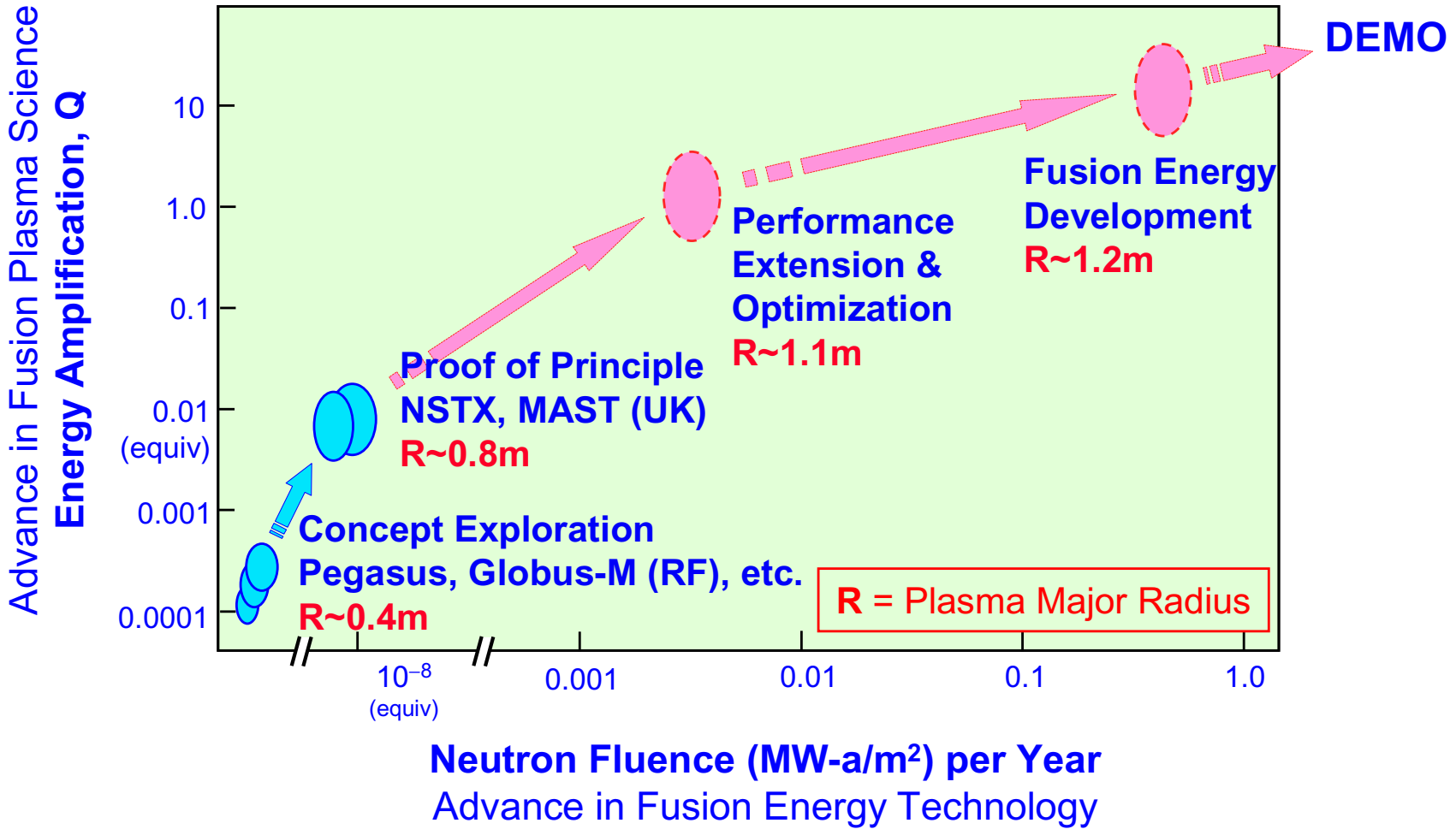


	Inductive	Noninductive Assisted	Noninductive Sustained
• **Toroidal Beta, β_T**		• → 25% (no-wall limit)	• → 40% (wall stabilized)
• **Bootstrap Current**		• → 40% (no-wall limit)	• → 70% (wall stabilized)
• **Current**	• → 0.5 MA	• → 1 MA	• ~ 1 MA
• **Pulse**	• → 0.5 s	• → 1 s	• → 5 s
• **HHFW Power**	• → 4 MW	• ~ 6 MW	• ~ 6 MW
• **NBI Power**		• → 5 MW	• ~ 5 MW
• **ECH Power**	• ~ 30 kW	• → 0.4 MW (incremental)	• ~ 0.4 MW
• **CHI Startup**	• → 0.2 MA	• → 0.5 MA	• ~ 0.5 MA
• **Measure**	• $T_e(r)$, $n_e(r)$	• j(r), $T_i(r)$, flow, edge	• **turbulence**

World ST Program Has Grown Rapidly Since 1990



ST Development Path to Fusion Energy Science & Technology May Be More Affordable



FESAC Defines Exciting, Challenging Goals for U.S. Spherical Torus Research

Spherical Torus research in FESAC report

- **5 years (Goal #1)**: (advance fundamental understanding)
- **(Goal #2)**: make preliminary determination of the attractiveness of the ST, by assessing high-beta stability, confinement, self-consistent high-bootstrap operation, and acceptable divertor heat flux, for pulse lengths >> τ_E
- **10 years (Goal #2)**: assess the attractiveness of extrapolable, long-pulse operation of the ST for pulse lengths >> τ_{skin}
- **(Goal #3)**: assess potential of ST as a basis for burning plasma studies and/or fusion-nuclear component testing
- **15 years (Goal #2)**: assess attractiveness of one or more of the above configurations at an extended performance level
- **(Goal #3)**: demonstrate high-gain burning plasma operation in a plasma regime relevant to the practical production of fusion power

The 21st Century Promises Exciting Progress in MFE Concept Innovation, ST Being an Example

- Builds on Tokamak and CT knowledge, and should contribute to their progress
- Promises exciting fusion science towards practical energy, and offers new challenges
- Envisions highly modular power plant design
- Shows exceptional success in research preparation
- Plans to investigate in 4-5 years critical physics issues, given adequate funding
- World ST research has grown rapidly since 1990
- May offer more affordable development path
- FESAC has defined exciting, challenging goals for ST research