GA’s target fabrication division designs, develops and produces targets as a partner in the ICF mission.

Magneto-RT target

Backlit implosion

Targets have played a central role in success of NNSA facilities.
GA is a leading developer of rep-rated and IFE target supply processes and target related systems.

- Making foam or fast ignition shells
- Robotic assembly
- Rapid insertion at Gemini
- Hit-on-fly demo for target tracking
- Inject targets (gas-gun or electromagnetic)
- Electrically steer targets
- Fill targets & layer in a cryogenic fluidized bed
GA Theory Program is Organized in Focus Areas to Support OFES Mission

- **Turbulence and Transport**
  - Focus on understanding mechanisms for particle and heat transport in magnetically confined fusion plasmas
  - Develop extensive simulation capabilities for nonlinear interactions between magnetized charged particles and electromagnetic waves

- **Integrated Modeling**
  - Focus on self-consistent integration of various physical components
  - Enable experimental interpretation, model validation and next step design work

**Strengths of GA Theory Program:**
- Strong collaboration with experiments
- Leaders in numerical simulations using high performance computers
- Extensive international collaborations
- Strong post-doc program
Newly developed synthetic diagnostic algorithms have been applied to massively parallel GYRO simulations of a DIII-D discharge to allow for direct comparisons with upgraded beam emission spectroscopy (BES, left) and new correlation electron cyclotron emission radiometry (CECE right) diagnostics.

- Simulations used > 3000 processor-hours on jaguar CRAY XT4 machine at NCCS.
New Predictive Physics Model (EPED1) for the Pedestal Developed and Tested

- **Formation of an edge barrier or “pedestal” allows high performance operation in tokamaks** [left]
  - Predicting pedestal height key to optimization of the tokamak
- **New EPED1 model combines two constraints to predict height and width of the pedestal**
  - Peeling-ballooning stability constraint calculated with the ELITE code [solid line]
  - Simple model of kinetic ballooning mode transport constraint [dashed line]
- **EPED1 highly successful in initial tests, including predictions made before a dedicated DIII-D experiment**
  - Predicted/Measured pedestal height = 1.02 ±0.13 (21 DIII-D, 16 JT-60U, 4 JET)
DIII-D is an International Research Program

- 100 institutions worldwide
- 430 scientific authors (2008 IAEA)
  - GA: 120
  - Collab: 310
- Students, post docs, and faculty from 53 universities
  - 18 PhD students
  - 18 Post Docs
DIII-D Mission: Establish the Scientific Basis for the Optimization of the Tokamak Approach to Fusion Energy Production
ELM-Suppression Using the DIII-D Internal Coils Has Led to the Design of Internal Coils for ITER
An International Team Recently Carried Out Experiments on DIII-D Simulating ITER-TBM Error Fields

Michael Schaffer  USA
Joseph Snipes  IO
Charles Greenfield  USA
Valery Chuyanov  IO
Alberto Loarte  IO
Naouki Oyama  Japan
Kouji Shinohara  Japan
Hogun Jhang  S Korea
Kwang-II You  S Korea
Xiang Gao  China
Songlin Liu  China
Yanjing Chen  China
Guoyao Zheng  China
Gabriella Saibene  Europe
Peter de Vries  Europe
Tuomas Tala  Europe
Filomena Nave  Europe
Anti Salmi  Europe
Oliver Schmitz  Europe
Marcin Jakubowski  Europe
Ruth Laengner  Europe
Henning Stoschus  Europe
R. Srinivasan  India
R. Narayanan  India
Punit Gohil  USA
Don Spong  USA
David Gates  USA
Jong-Kyu Park  USA
Gerrit Kramer  USA
GA Seeks to Apply its Experience with the ITER CS Model Coil to the ITER Central Solenoid
GA is the World Leader in ECH Transmission Lines and Components in the 100 GHz Range

JAPAN:
- JT-60U: 4 lines
- LHD: 2 + lines
- Gamma-10: 1
- TRIAM-1M: 1

EUROPE:
- TCV: 9
- Tore Supra: 6
- FTU: 4
- TJ-II: 1

U.S. / AUSTRALIA / KOREA:
- DIII-D: 6
- Haystack: 4
- H-1NF: 1
- KSTAR: 1

GA has delivered 42 lines / 3 km total

ITER: 56 lines / 4 km total
The Fusion Development Facility Mission: Show Fusion Can Produce Energy and its own Fuel

- **FDF will:**
  - Produce significant fusion power (100-300 MW)
  - Demonstrate fusion fuel self-sufficiency
  - Show fusion can produce high grade process heat and electricity
  - Provide a materials irradiation facility to develop low activation, high strength, high temperature, radiation resistant materials.
  - Enable research on high performance, steady-state, burning plasmas for Demo.
  - Obtain first data on fusion system operation, fuel management, reliability, availability, and maintainability to guide future fusion energy development.

- **By operating steady-state with**
  - Modest energy gain (Q <7)
  - Continuous operation for 30% of a year in 2 weeks periods
  - High neutron fluence (3-6 MW-yr/m²)
A Fusion Nuclear Science Facility, ITER, Superconducting Tokamaks, and a Materials Test Facility Enable DEMO

**Today's Tokamaks**
- DIII-D
- Alcator C-Mod
- NSTX
- JT-60U
- JET
- ASDEX-Upgrade
- Tore-Supra
- TEXTOR
- FTU
- TCV
- MAST
- T-10
- HT-7

**Fusion science and knowledge gained in high heat and neutron flux, fluence, and duty factor conditions to close the fusion fuel cycle**

**Superconducting Tokamaks**
- EAST
- KSTAR
- SST
- JT-60SA

**IFMIF**
- High fluence small sample material testing

**ITER**
- High energy gain burning plasma physics
- Reactor scale superconducting technology

**DEMO**
- High gain, advanced physics, steady-state high duty factor fusion power
Fusion Nuclear Science Needs to Become as Strong as the Other Two Existing Legs of the US Fusion Program

- Basic Plasma Confinement Physics Program
- Burning Plasma Program (ITER)
- Fusion Nuclear Science Program
Fusion Nuclear Science Program (FNSP): The Scientific Basis for Fusion Energy Applications
DIII-D and Other Tokamaks Can Solidify the Physics Basis for the FNSF in 2–3 Years

- Required stability values already achieved in 100% non-inductive plasmas in DIII-D (extend pulse length)
- RWM stabilization by rotation
- NTMs already stabilized
- ELMs gone - stochastic edge field
- ELMs gone - QH mode operation
- Confinement quality required already obtained in long pulse DIII-D plasmas
- Bootstrap fractions already achieved
- Far off-axis LHCD in H-mode
- Pumped, high triangularity plasma
- DIII-D plasma control system
- Power exhaust more challenging than DIII-D and comparable to ITER
- Main challenge is PFC tritium retention

Green = already achieved, Blue = near term, Red = main challenge
It is Time for Fusion

- We are ready to make the transition from fusion’s preparatory era (research with hydrogen and deuterium plasmas) to fusion’s nuclear science era (research with burning DT plasmas).