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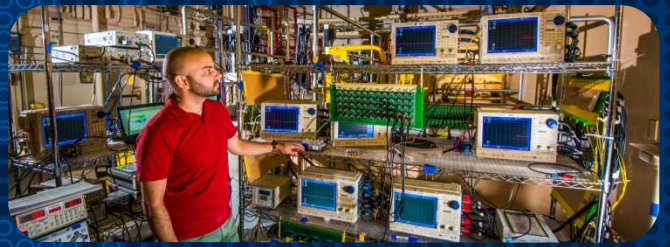

ElectroMagnetic Tour

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Nuclear weapons are designed & qualified to operate safely & reliably in multiple operating environments

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Example Environments

Environment	EM/Electrical	Radiation	Thermal	Mechanical
Normal	EM Radiation ESD Nearby Lighting DeGaussing		Climate	Shock Vibration Acceleration Aerodynamics
Hostile	EMP SREMP SGEMP TREE	Neutrons Gammas X-rays		Blast
Abnormal	Lighting External Power		Jet-Fuel Propellant Fire	Shock Crush

Nuclear weapons are designed & qualified to operate safely & reliably in multiple operating environments

Normal operating environments
- Electromagnetic Radiation (*DC to >50 GHz)*
- Electrostatic discharge
- Nearby lightning

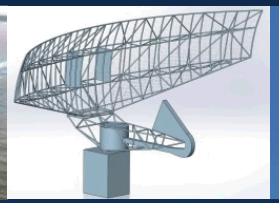
Abnormal environments
- Direct strike lightning (200kA, multi-pulse)
- Contact with unintended electric power

Hostile environments
- Nuclear weapon fratricide/counter-measures
- Directed energy weapons (HPM)

All weapon states
- In-flight path (delivery)
- Stored on delivery platform
- Being transported
- Maintenance/surveillance
- In storage

External EM/Rad environments


High power radars


High power microwaves

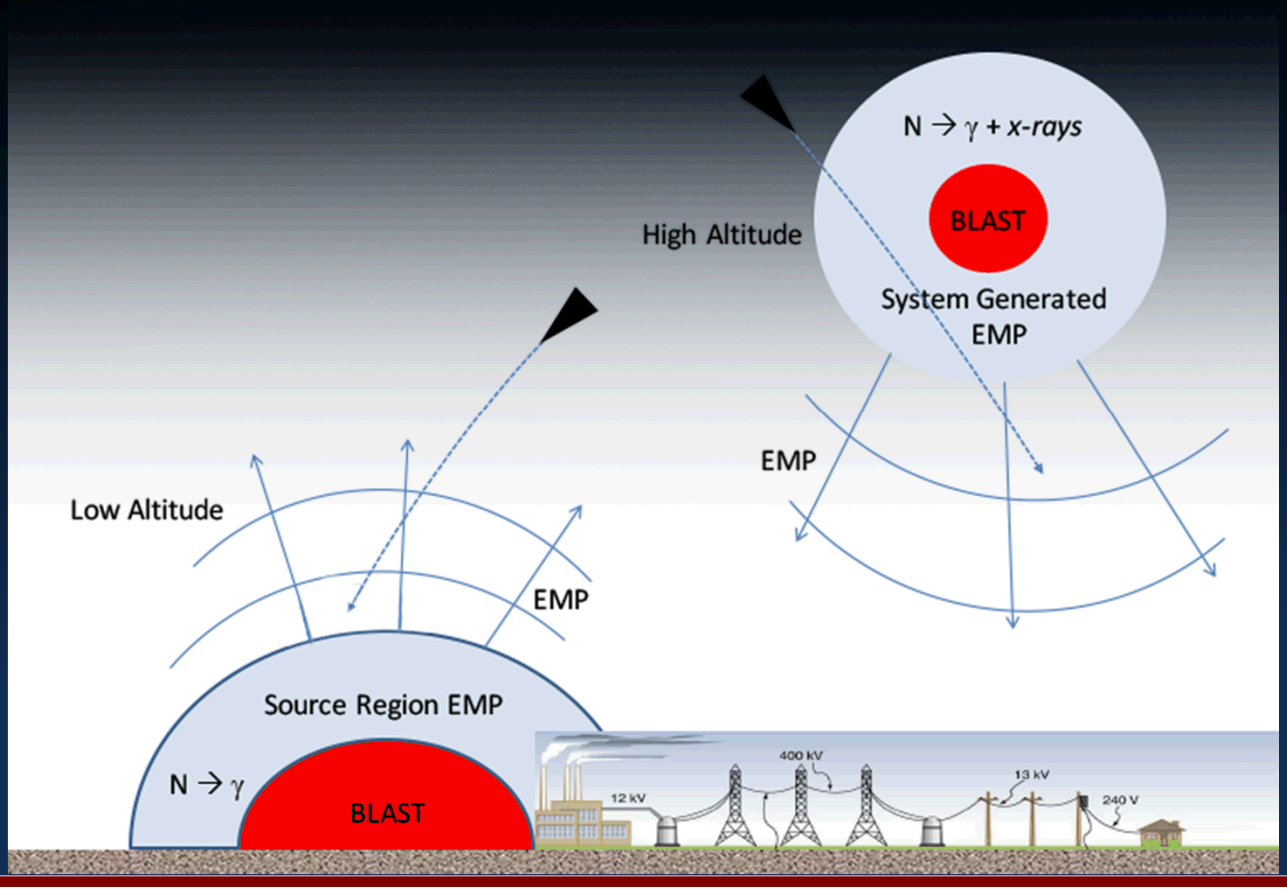

RF communications


Lightning electrostatic discharge


Submarine B-field degaussing


Nuclear fratricide/ counter measures

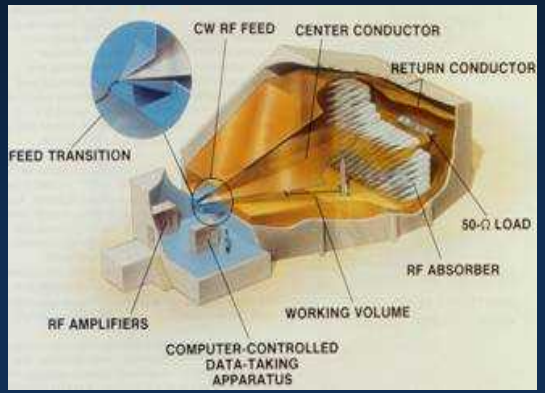
Nuclear driven radiation environments & EMP



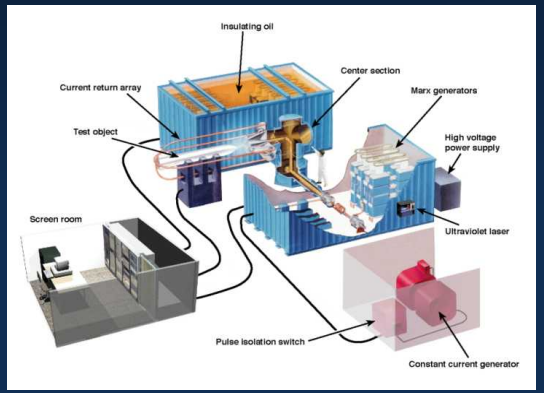
Unique EM test & experiment capabilities are required

Mode-Stir Chamber
- CW (200 MHz – 40 GHz)

Gigahertz Transverse ElectroMagnetic March 2016
- CW (DC – 18GHz) >130 V/m
- EMP (1 ns risetime) > 130 kV/m, HPM



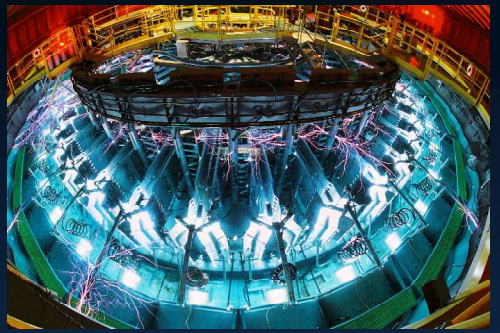
EMES Facility
- CW (100 kHz – 250 MHz) 125 V/m
- EMP (1 ns risetime) 250 kV/m



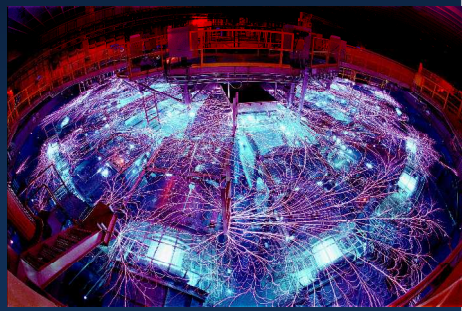
Extreme Lightning Simulator
- 200 kA peak
- Two pulse with continuing current (600 A)

Suite of capabilities address nuclear & non-nuclear EMP effects on large scale systems & urban environments

- Nuclear weapon source region characterization
- EMP, SGEMP, SREMP effects on NW systems
- Modeling and simulation
- Large-scale EMP and radiation simulators
  for effects testing and code validation
  - EMES, GTEM, Hermes III, Saturn, Z
- Utility-scale power systems effects
  - EMP line coupling, propagation
  - Coupling through transformers
  - Utility equipment response



Code	Physics
ITS	γ - e^- transport
SCEPTRE	γ - e^- transport
EMPHASIS /	EM-Plasma
NuGET	N - γ environment, fireball



We have a long history in EMP effects on Power Systems

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- EMP/EM penetration into enclosures and through electrical cable shielding (1994-present)
- EMP effects on SCADA and electronics equipment for the 2002 Congressional *EMP Commission*
- EMP propagation into facility electrical service-entrances (2003)
- EMP coupling and propagation on long transmission lines (2004)
- EMP/HPM effects on the Watts Bar and Fermi-II nuclear power plants for the NRC (2008-2010)
- EMP effects on urban infrastructure for the DOD (2012-2016)
- Fast simulation tool suite for EMP coupling to above ground and buried cable systems for DOE (2013-present)
- DOD-DOE collaboration on EMP and SREMP modeling capabilities for electrical grids and high voltage distribution equipment (2015-ongoing)

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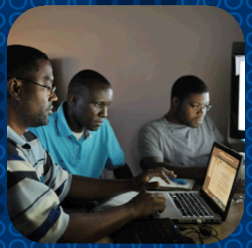

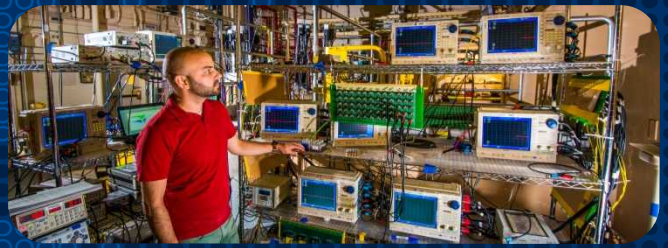

Thank you for coming!

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