Texas RACE

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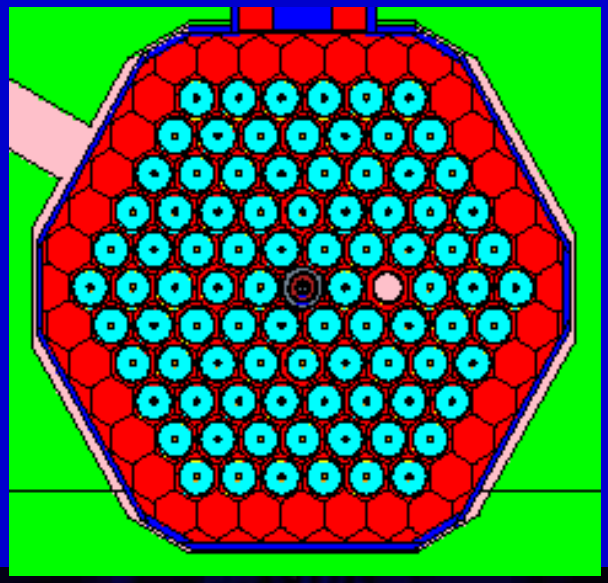
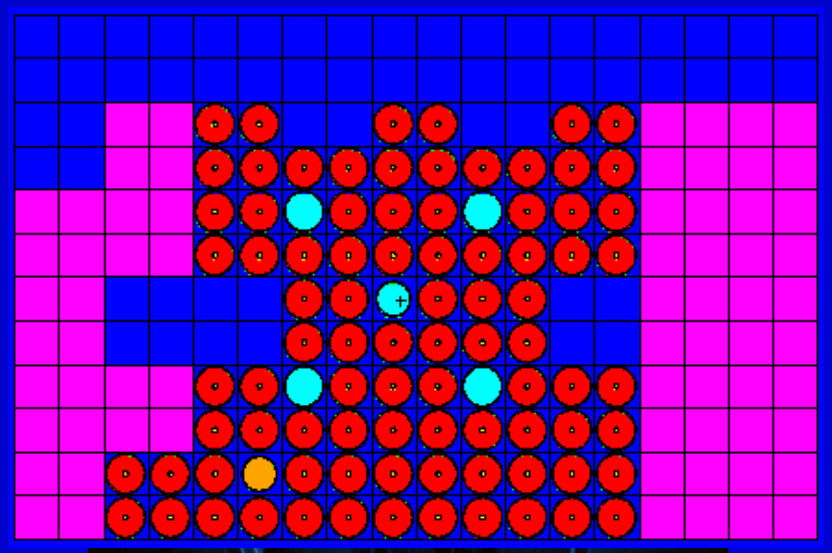
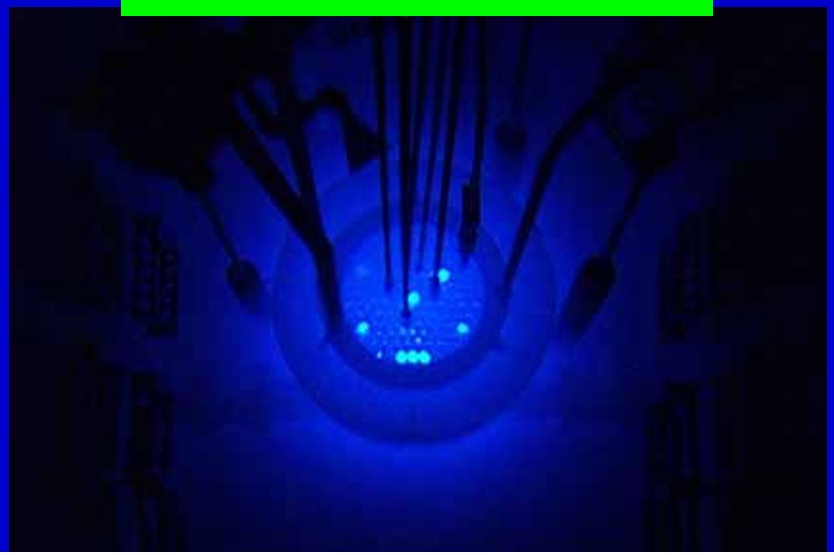
Introduction

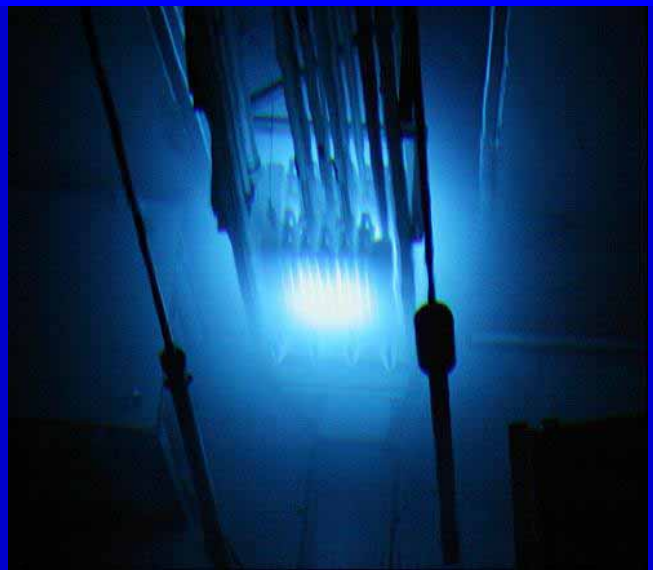
- Experiments are being planned at two research reactor facilities in Texas:
  - the 1-MW TRIGA reactor at the Nuclear Engineering Teaching Laboratory (NETL) ay the University of Texas (UT)
  - the 1-MW TRIGA reactor at the Texas A&M University (TAMU) Nuclear Science Center (NSC)
- Experiments are to provide
  - facility which makes use of thermal system with power levels sufficiently high to provide thermal feedback
  - teaching tool that can be used to educate the next generation in advanced nuclear science

Texas 1-MW TRIGA Reactors









TRIGA Fuel

- The nuclear fuel in these experiments is TRIGA reactor fuel
- Typical TRIGA fuel is uranium zirconium hydride (U-ZrH)
  - 8.5 wt% U content (enriched to 19.7 wt% U-235)
  - fuel length ~15 inches
  - clad in stainless steel
  - with graphite reflector “slugs” axially above and below the fuel “meat”
- The U-ZrH provides the moderation for the core

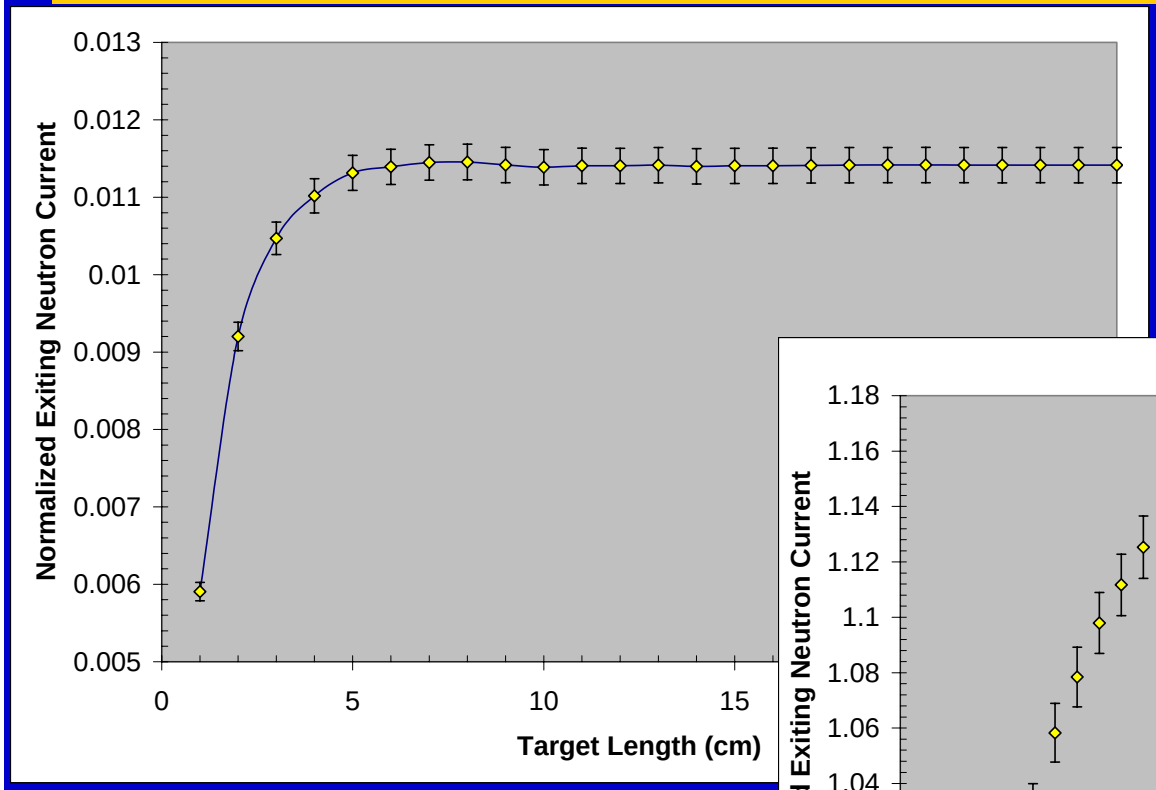
June 04 – May 05 Progress

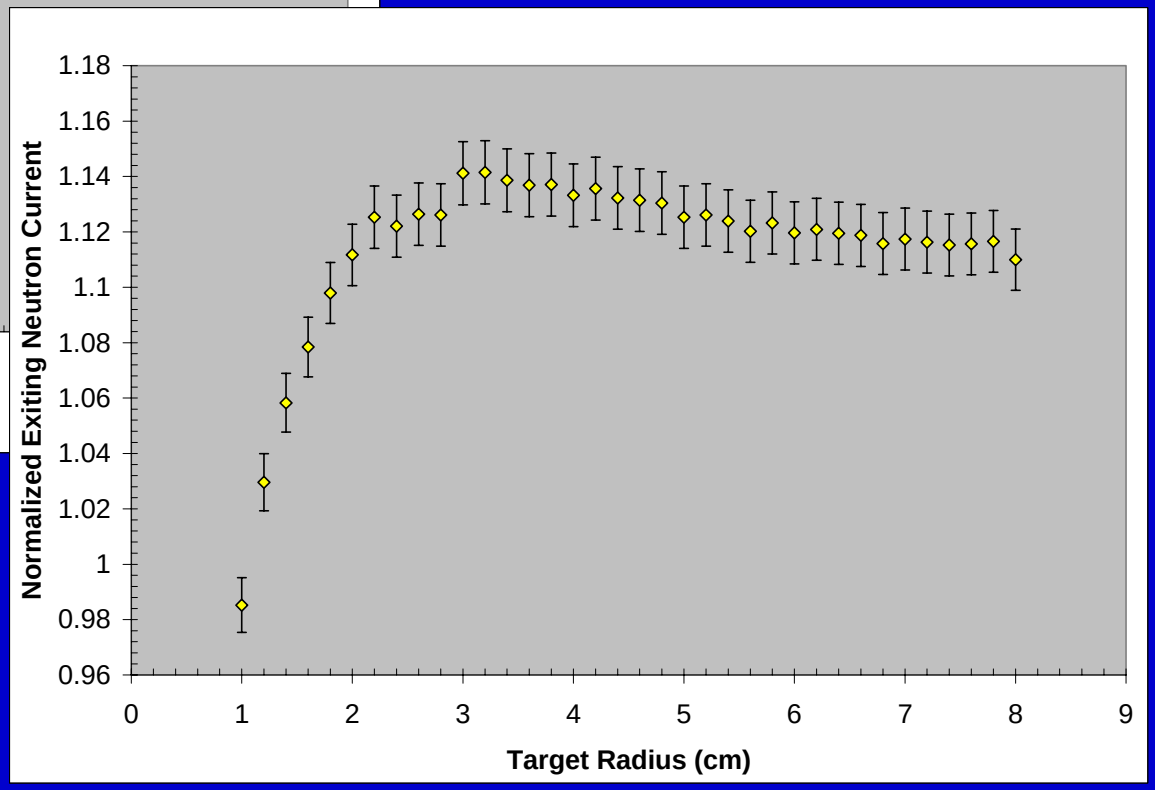
- New U target designs
- Heat generation rate calculations for
  - UT-NETL BP#5 Target
  - UT-NETL Central W-Cu Target
  - UT-NETL Central U Target
  - TAMU-NSC Central W-Cu Target
  - TAMU-NSC Central U Target
- Dose rate calculations
- Preliminary design work for TTS
- Completed one M.S. thesis (May 2005)

Neutron Source Evaluations

- We modeled several electron accelerator driven neutron sources
  - to determine exiting neutron currents as a function of source radius and source length
- Accelerator of interest:
  - 25-MeV electron beam
  - 1-cm diameter beam spot
  - 2.5 kW beam power
- These evaluations were intended for optimization
  - later found to be irrelevant since the target must be optimized within the reactor system (not bare)

Current Versus W-Cu Target Length and Radius

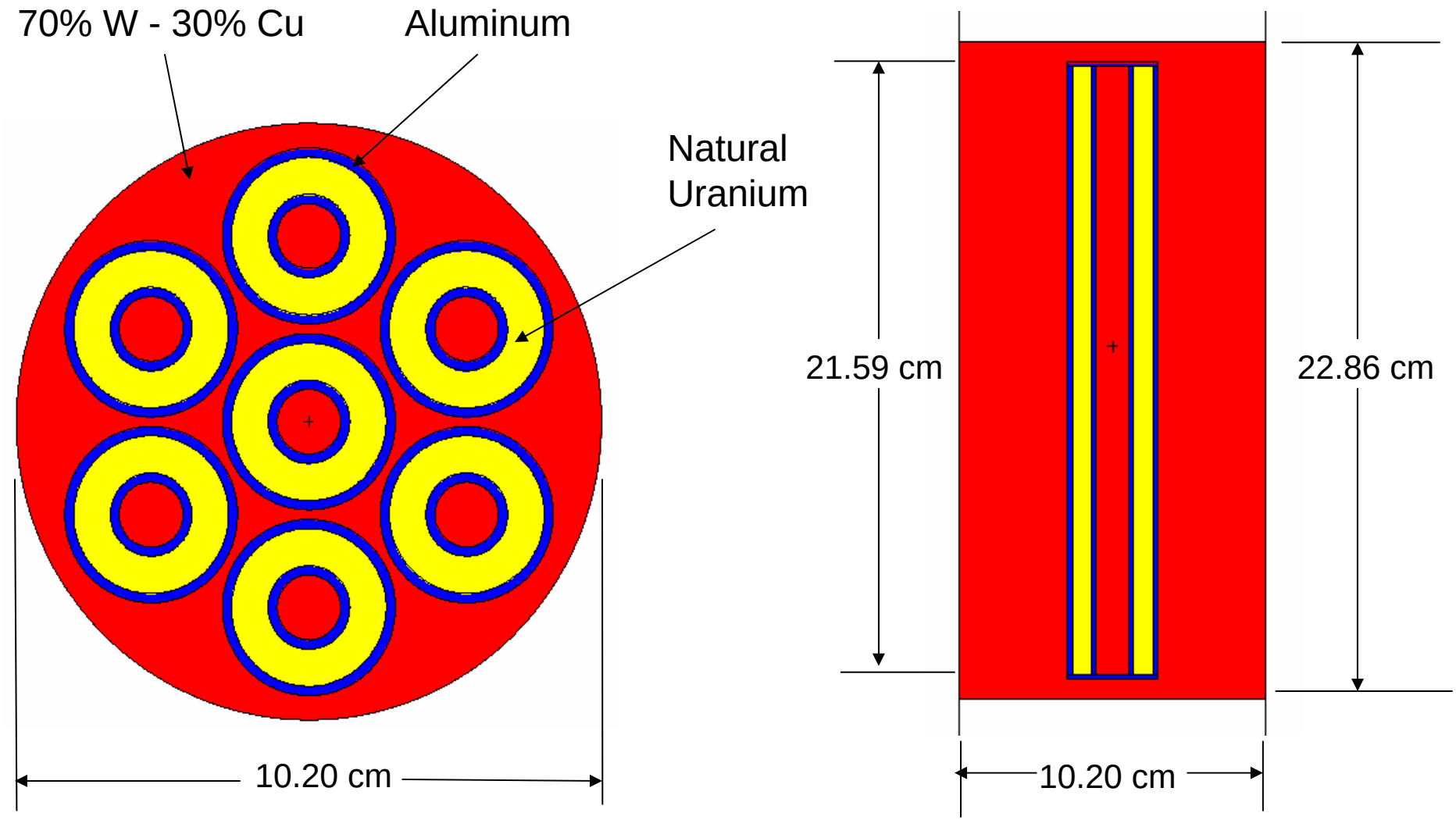




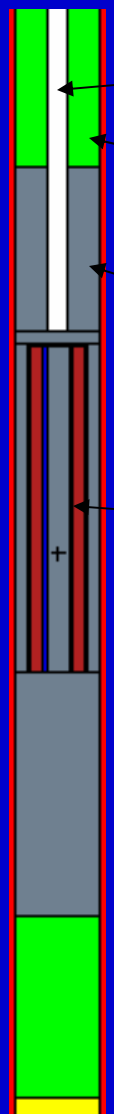
Uranium Slug Target

- TAMU has 2.5 MT of natural uranium (about 600 slugs) in inventory
  - in the form of 8.5” long natural uranium slugs clad in aluminum (thickness of 1/16”)
  - each slug is annular in shape
  - outer diameter of 9/8”
  - inner diameter of 7/16”
- Several different target arrangements were considered

Seven Element Target



1-Element Uranium Target



beam tube

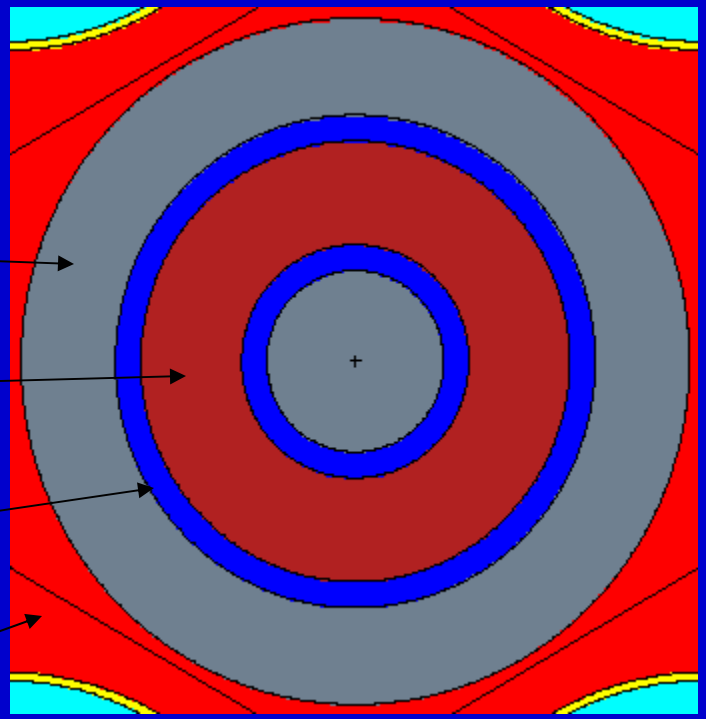
graphite

W-Cu

U

Al

water

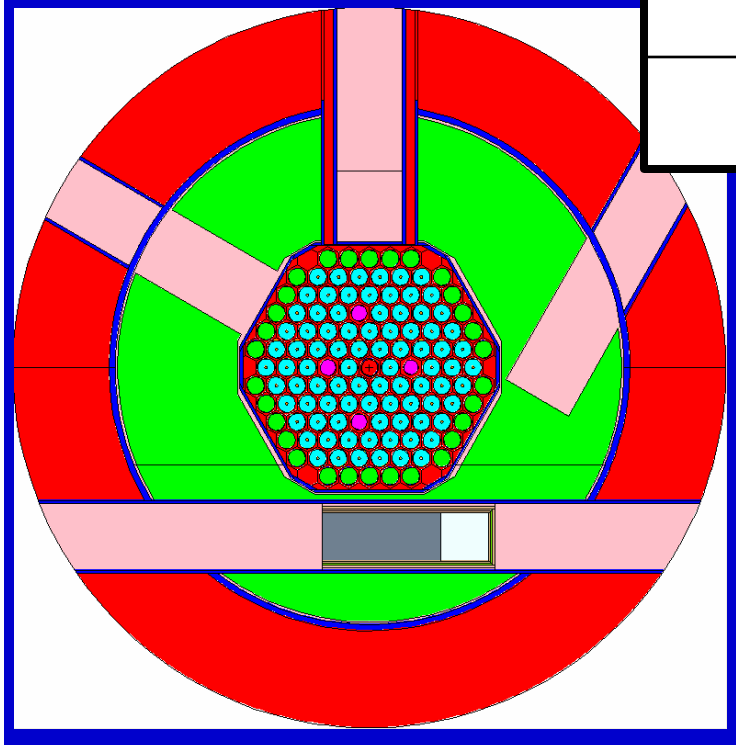


UT NETL Simulations

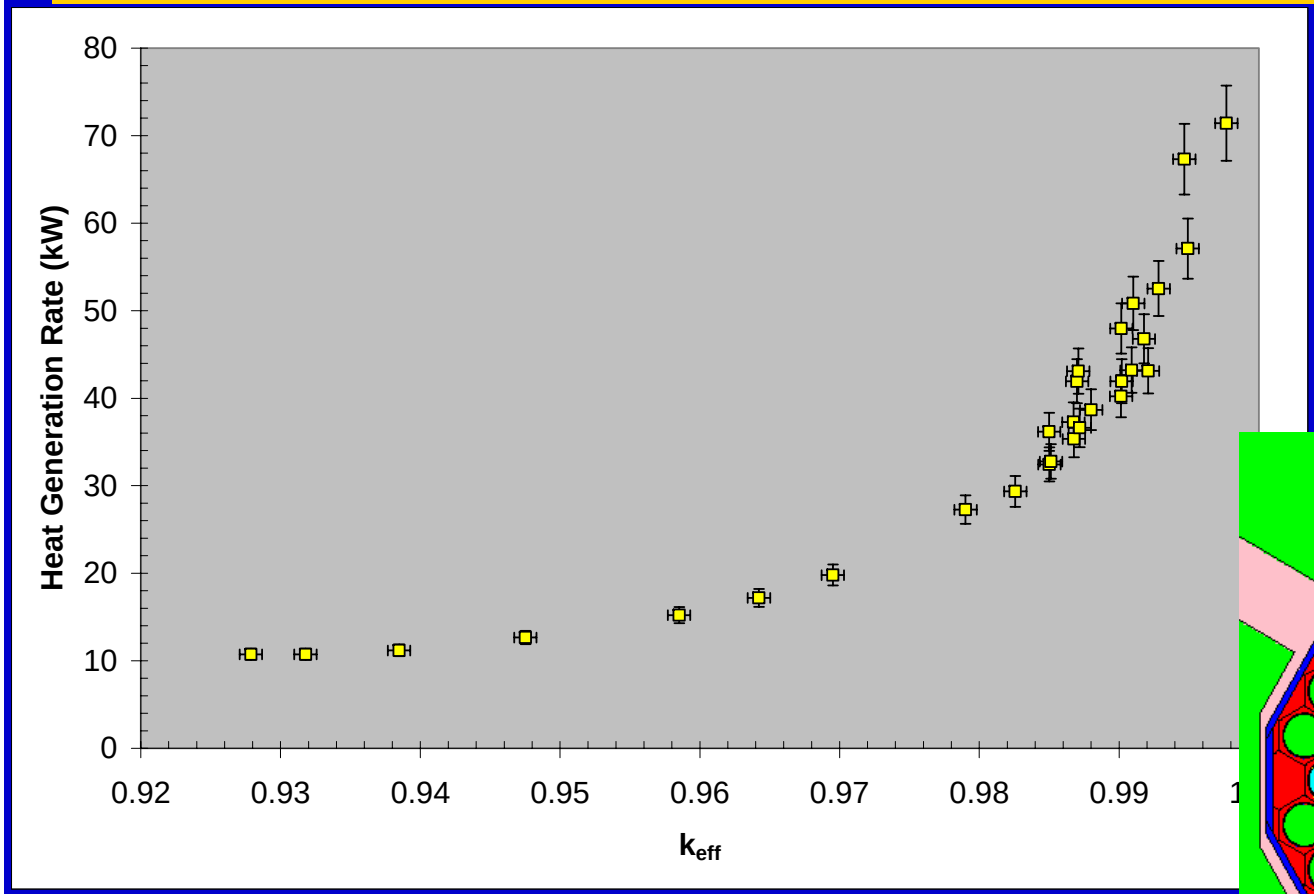
- UT-NETL core was explicitly modeled using MCNP-5 in a coupled electron/photon/neutron problem
  - used photonuclear data from T-16 at LANL
- Electron source was a 25 MeV beam with a 1-cm diameter beam spot
  - assumed a 25 kW beam power
- Simulations were used to predict heat generation rates in fuel, neutron and γ-ray fluxes in detectors, and dose rates to personnel

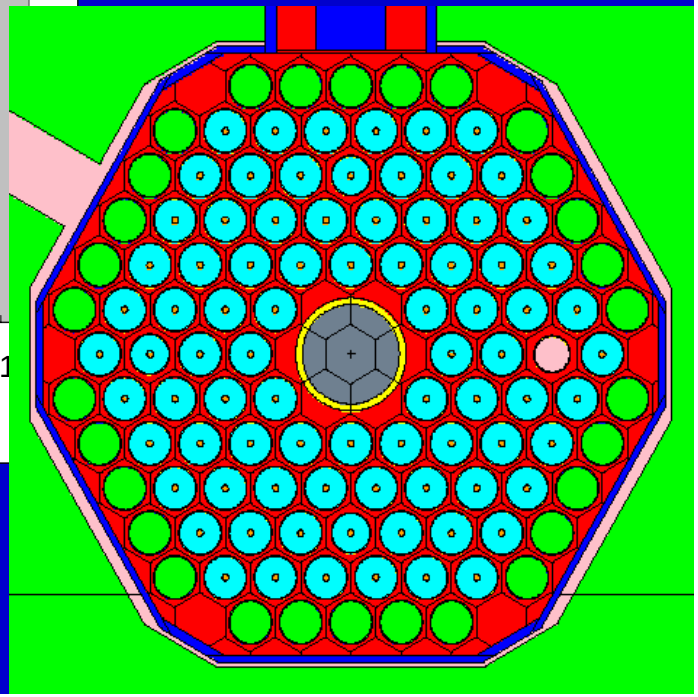
Heat Generation Rates in UT NETL with BP#5 W-Cu Target

k_{eff}	Heat Generation Rate (kW)
0.99	7.2 ± 0.5
0.98	4.0 ± 0.3
0.95	1.8 ± 0.2

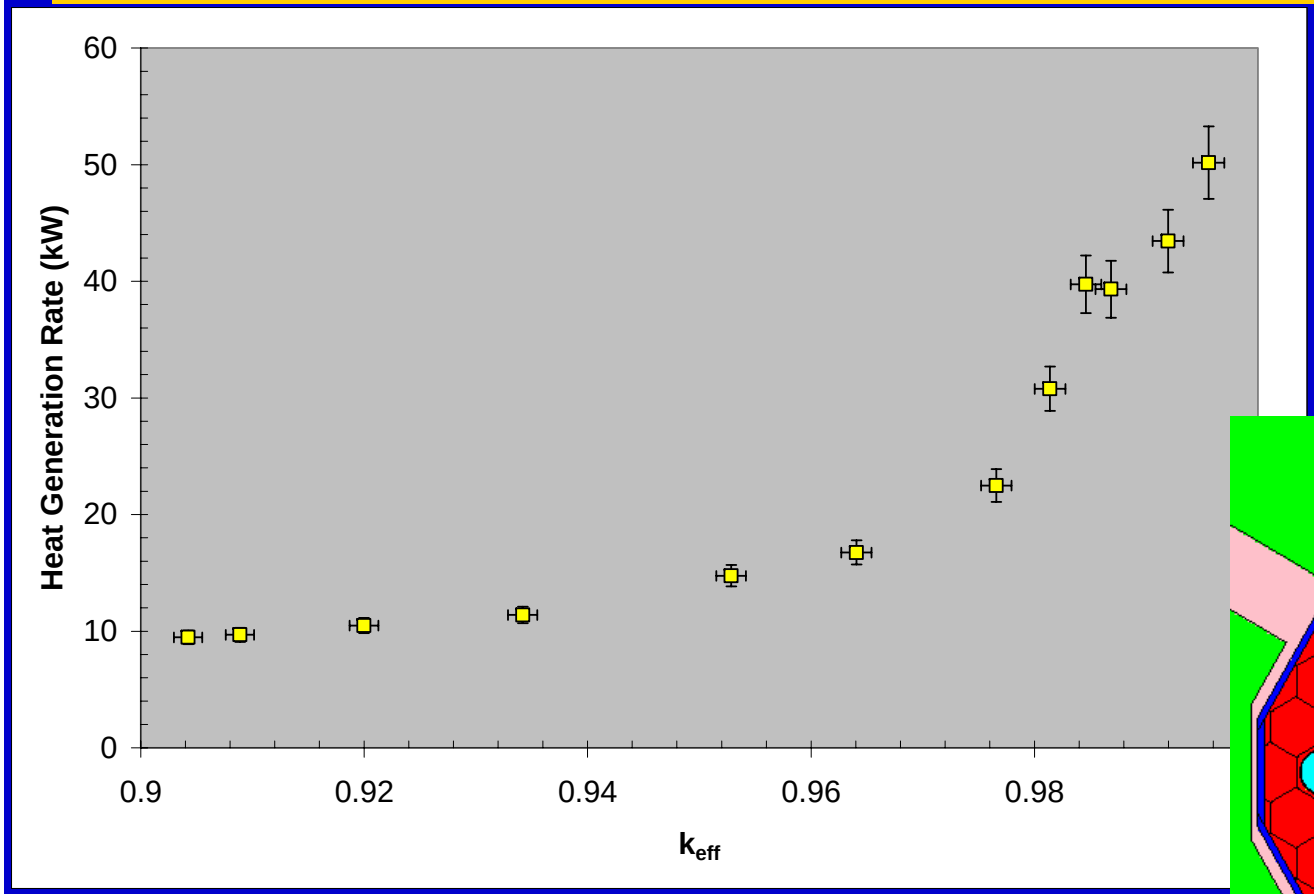


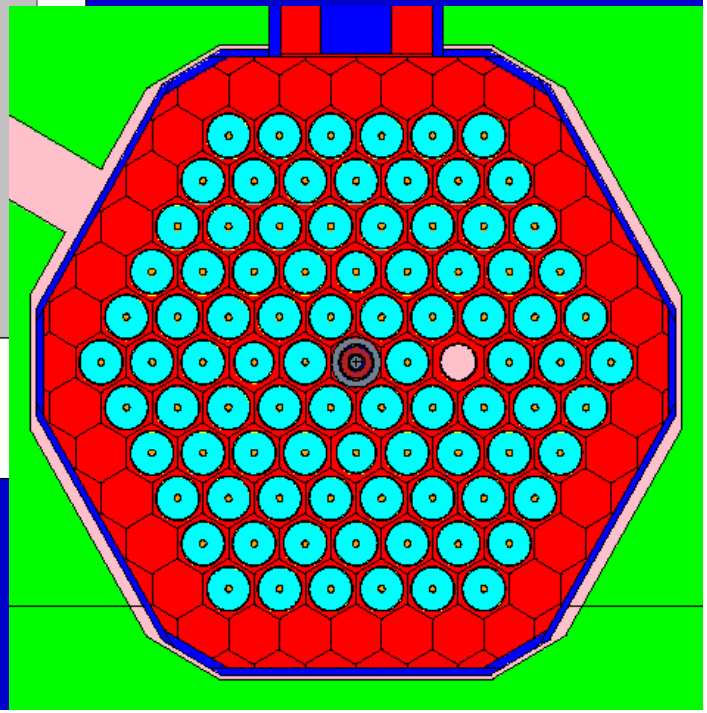
Heat Generation Rates in UT NETL with Central W-Cu Target



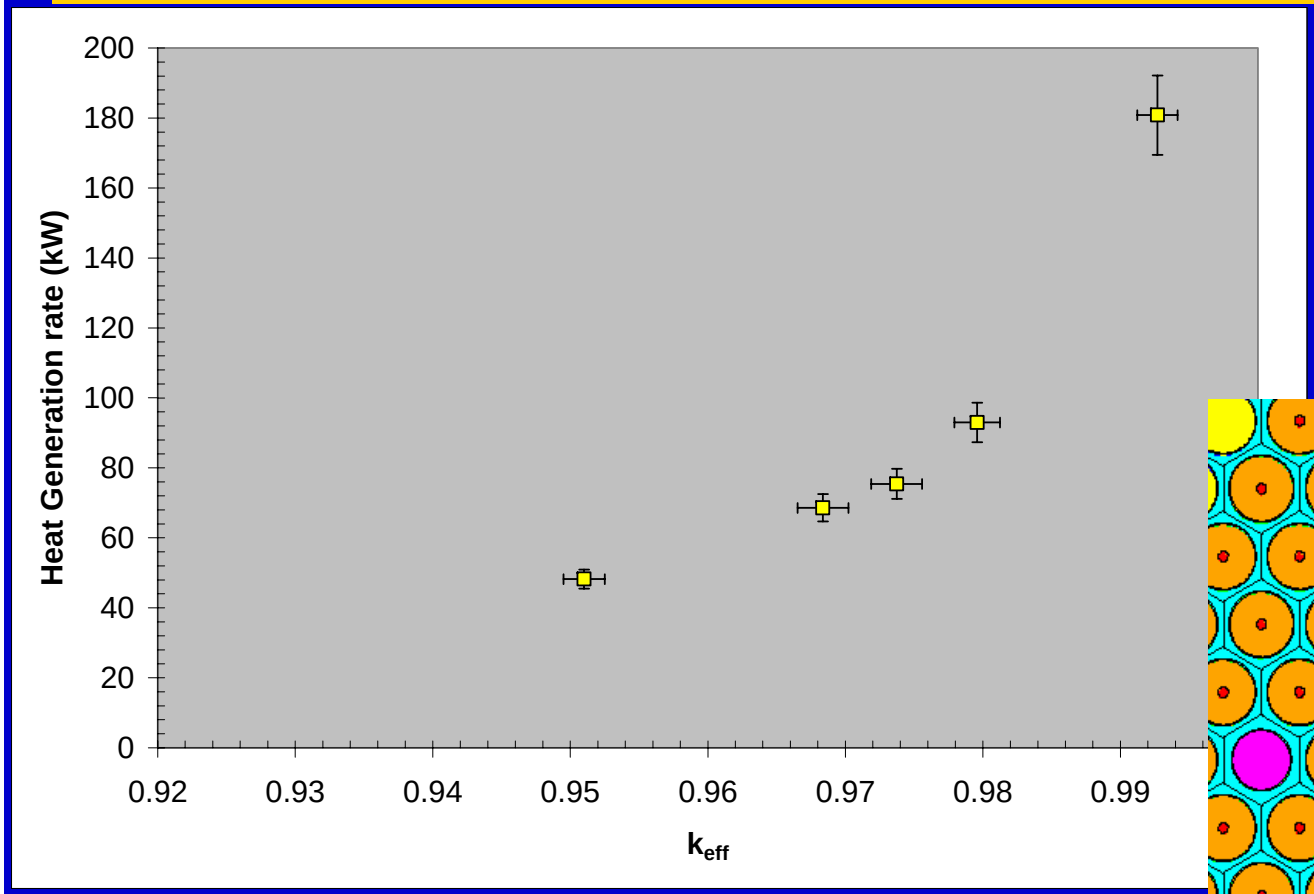


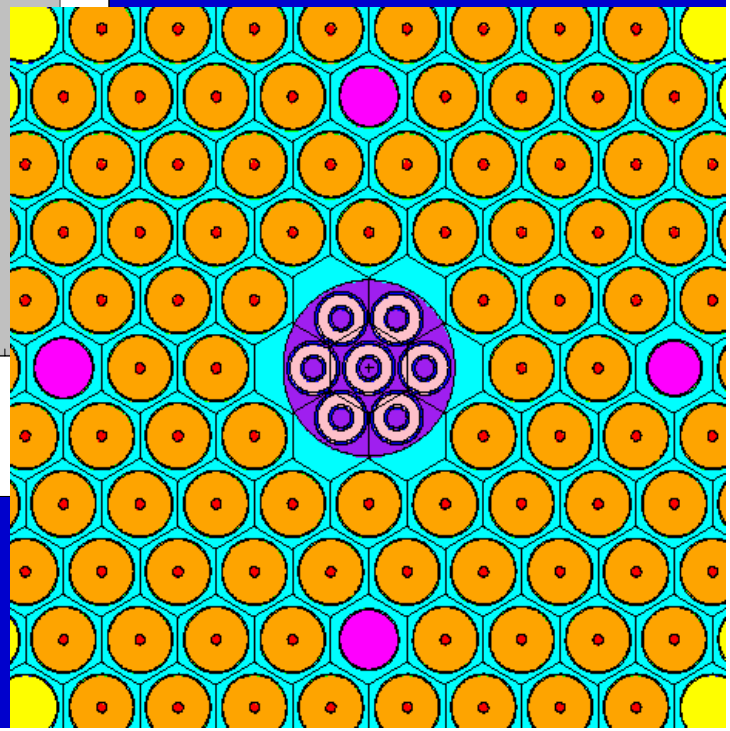
Heat Generation Rates in UT NETL with Central 1-Element U Target



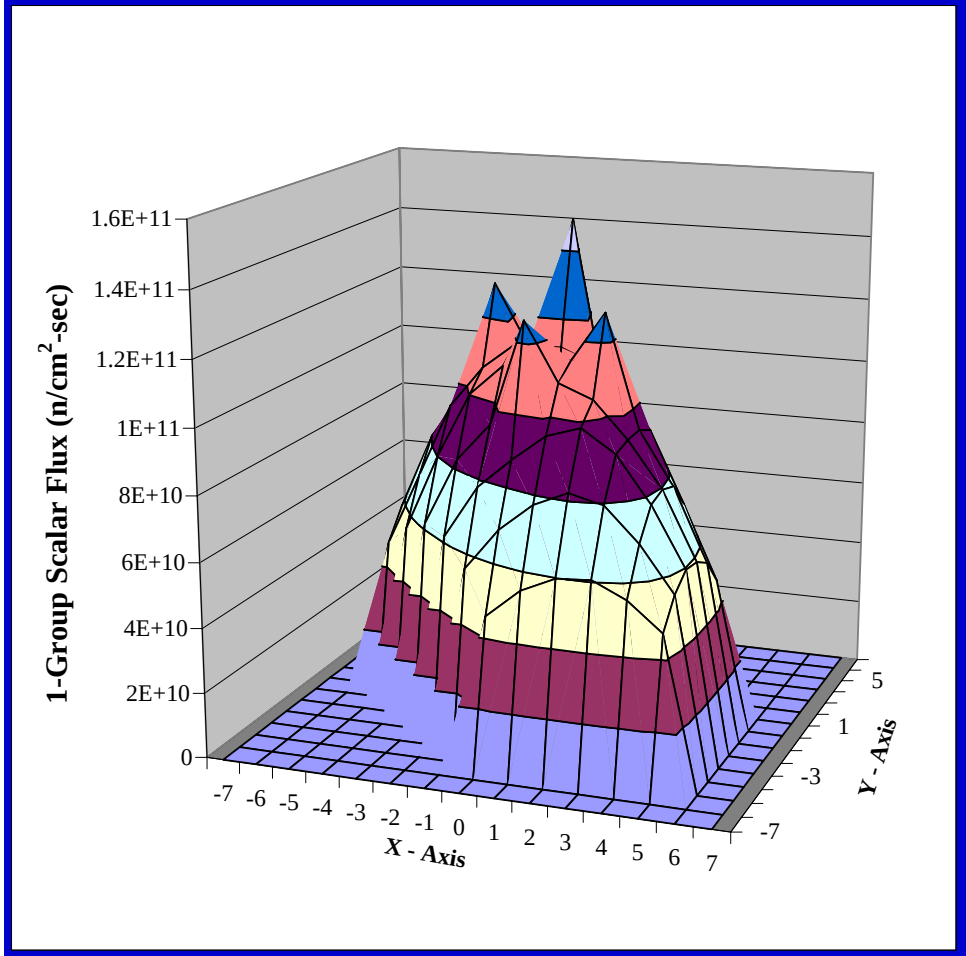


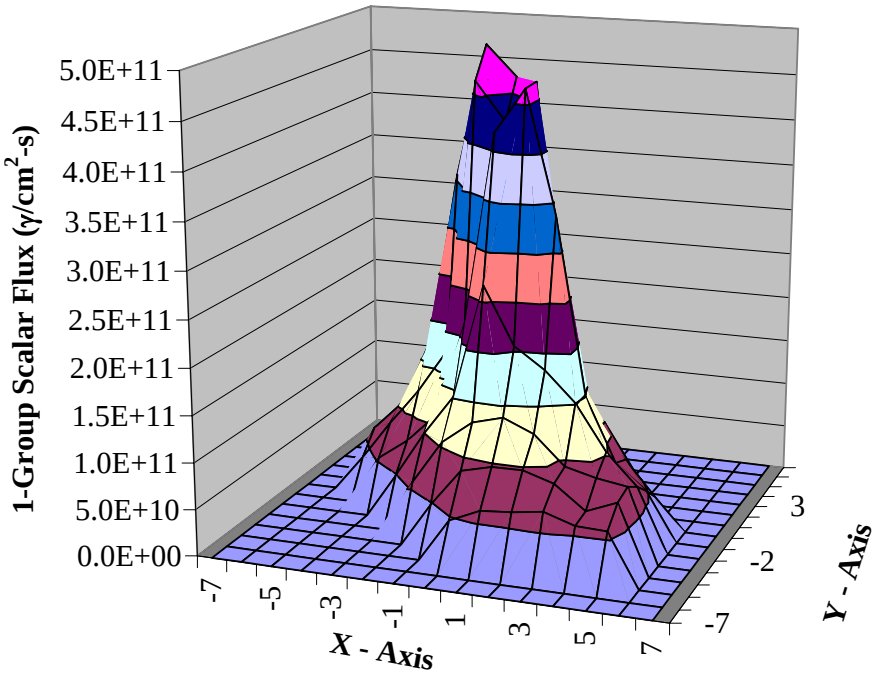
Heat Generation Rates in UT NETL with Central 7-Element U Target





Neutron and Gamma-ray Flux Calculations





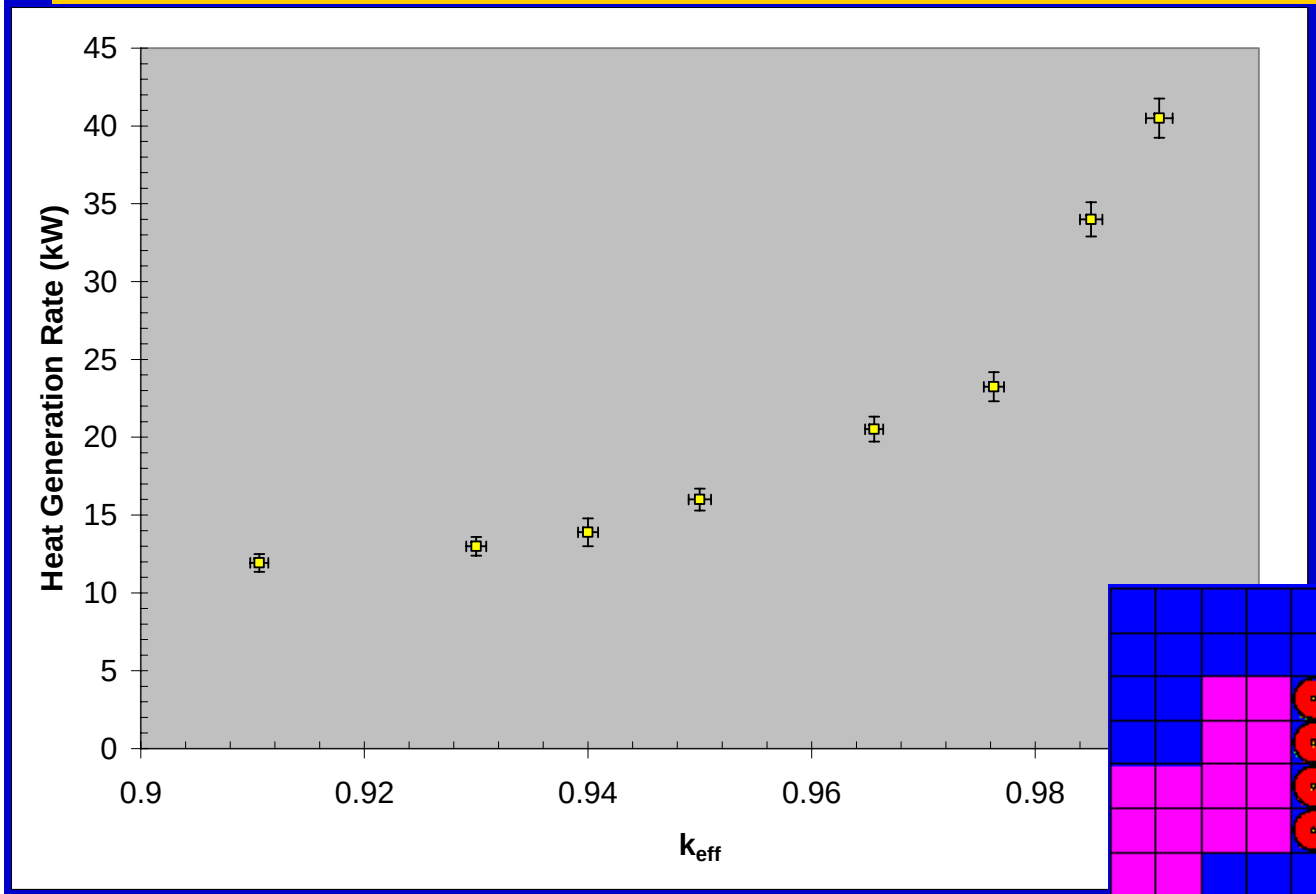
Flux and Dose Calculations

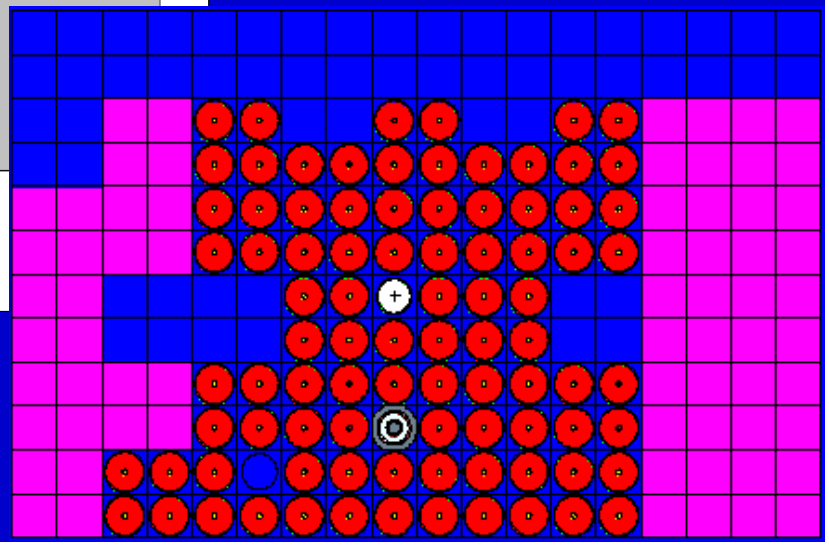
- Flux calculations:
  - neutron fluxes are small compared to gamma-ray fluxes especially close to the target
- Dose rate calculations:
  - dose rates outside BP#5 with BP#5 source were calculated to be less than 1 mrem/hr
  - dose rates at bridge level with central W-Cu or U target were calculated to be less than 1 mrem/hr
  - dose rate calculations did not include dose from accelerator directly or any streaming paths through BP#5 cave

TAMU NSC Simulations

- Heat generation rate simulations have been performed for the TAMU NSC reactor with the single slug U target in several core locations
  - for FLIP (70% enriched) fuel only
- Results are qualitatively similar to UT-NETL results
  - however more source positions were evaluated
- Sometime in the future the TAMU core will be fully reloaded with fresh 30/20 fuel
  - exceptional benchmark opportunity
  - simulations for this fuel are just beginning

Heat Generation Rates in NSC with 1-Element Central U Target

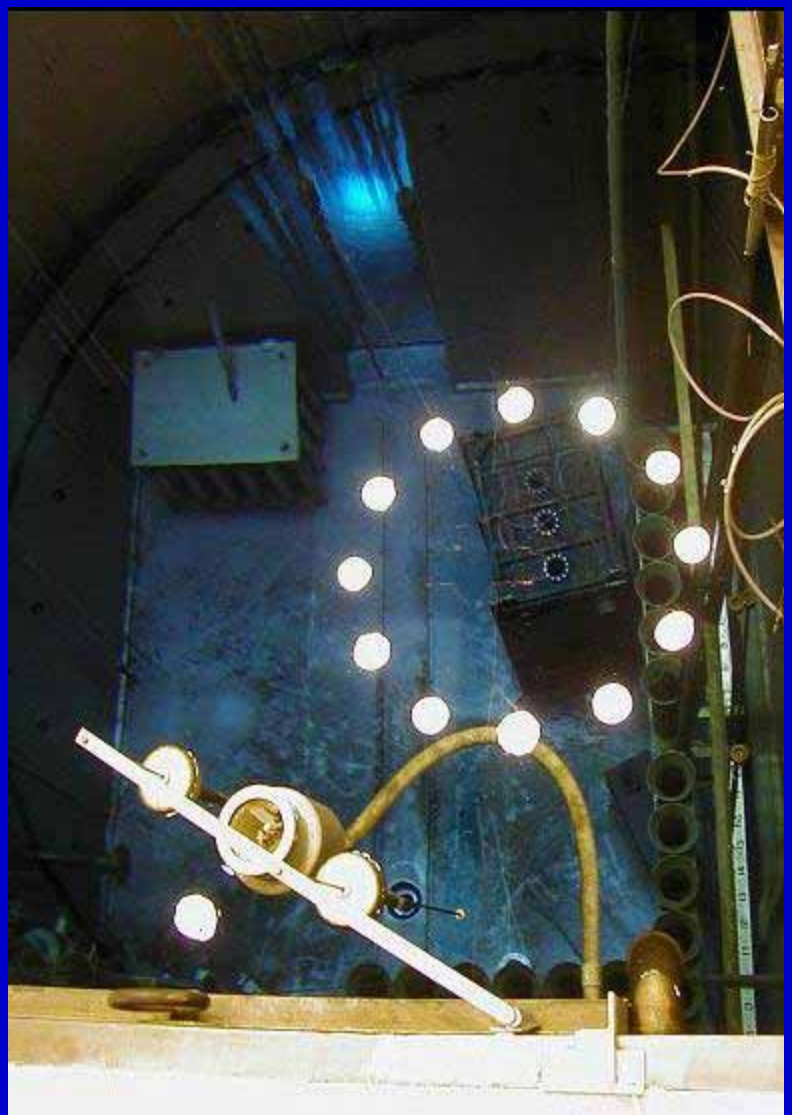


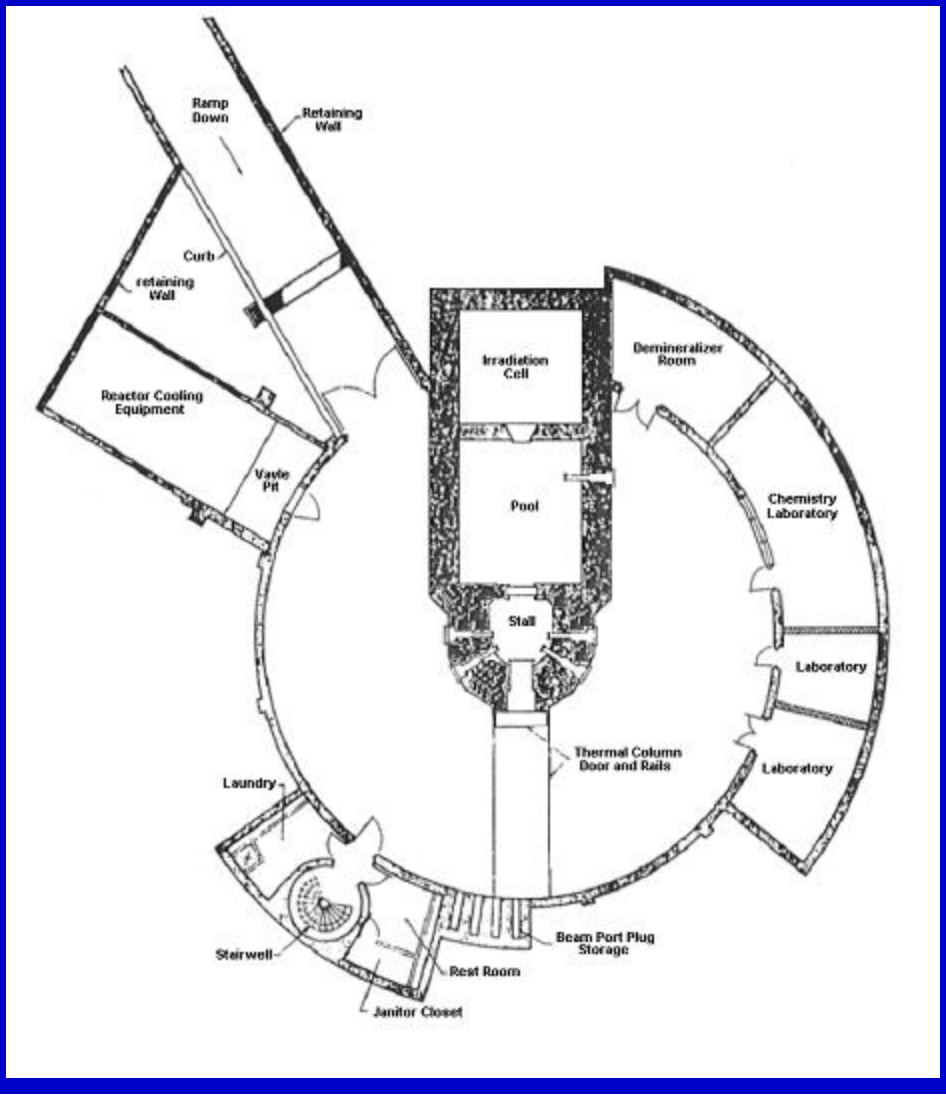


Texas Transmutation System (TTS) Design

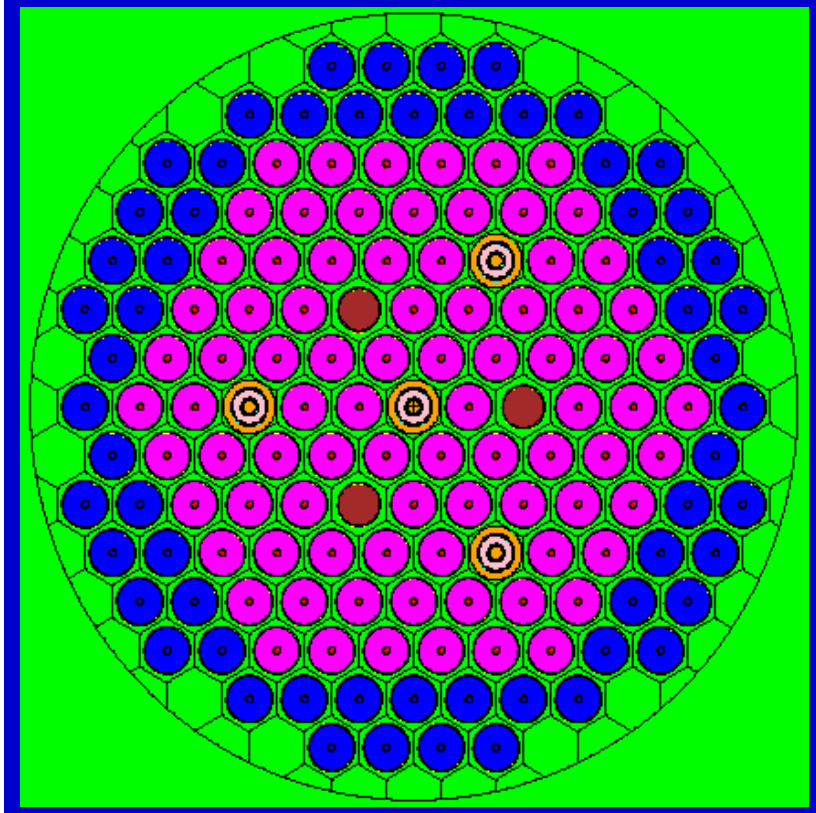
- A complete spent fuel core is currently located at the TAMU NSC
- Designs are underway to build a subcritical array of spent TRIGA fuel with multiple target locations
- System will be a dedicated ADS and will allow for:
  - data measurement, method development, and training of operators and students on accelerator driven systems

TAMU NSC Pool





TTS Design and Results



	k_{eff}	
	0.98	0.85
Target 1	22.7±1.2	3.65±0.09
Target 2	16.7±1.0	3.58±0.08
Target 3	16.1±1.2	3.59±0.08
Target 4	16.5±1.0	3.59±0.08
Total	72.0±4.4	14.37±0.32

*Assumes a 25-MeV, 25-kW beam on each target

Conclusions

- The multi element U target provides best heat generation
- Heat generation rates still need some improvements
  - target design optimization
  - target cooling
  - increasing of beam energy from 25 to 30+ MeV
- TAMU core will be replaced sometime next year with a complete fresh LEU TRIGA core