

AFCI Reactor-Accelerator Coupling Experiments (RACE) Project Overview



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3rd Idaho ADSS Experiments Workshop

RACE is a multi-university ADSS project

- Idaho State University
 - » Idaho Accelerator Center
 - » “transportable” subcritical assembly
- University of Texas at Austin
 - » UT NETL TRIGA
- Texas A&M University
 - » TAMU NSC TRIGA
 - » Used fuel core
- UNLV & Michigan



Purpose--demonstrate the ability in the U.S. to:

- **Design, model, and conduct electron ADSS experiments**
- **Map source importance and adjoint flux**
- **Predict and measure subcriticality and subcritical multiplication with thermal feedback**
- **Predict and analyze unique subcritical source-driven transients**

Purpose continued

- Complement DOE's AFCEI international collaborations: MUSE and TRADE
- Create steady state and transient benchmarks
- Test new computational codes and methods
- Recruit, educate, & train students
- Transmute higher actinides or problem fission fragments in ADSS

MUSE (per George Imel 2003)

- Cadarache, fast assembly, zero power, D-D (2.5 MeV) and D-T (14 MeV) sources
- Investigate source importance to 14 MeV
- Investigate aspects of flux distributions in a fast spectrum
- Validate dynamic methods of zero-power reactivity measuring and monitoring (a major objective & challenge)
- But--mono-energetic, non-spallation, no power feedback

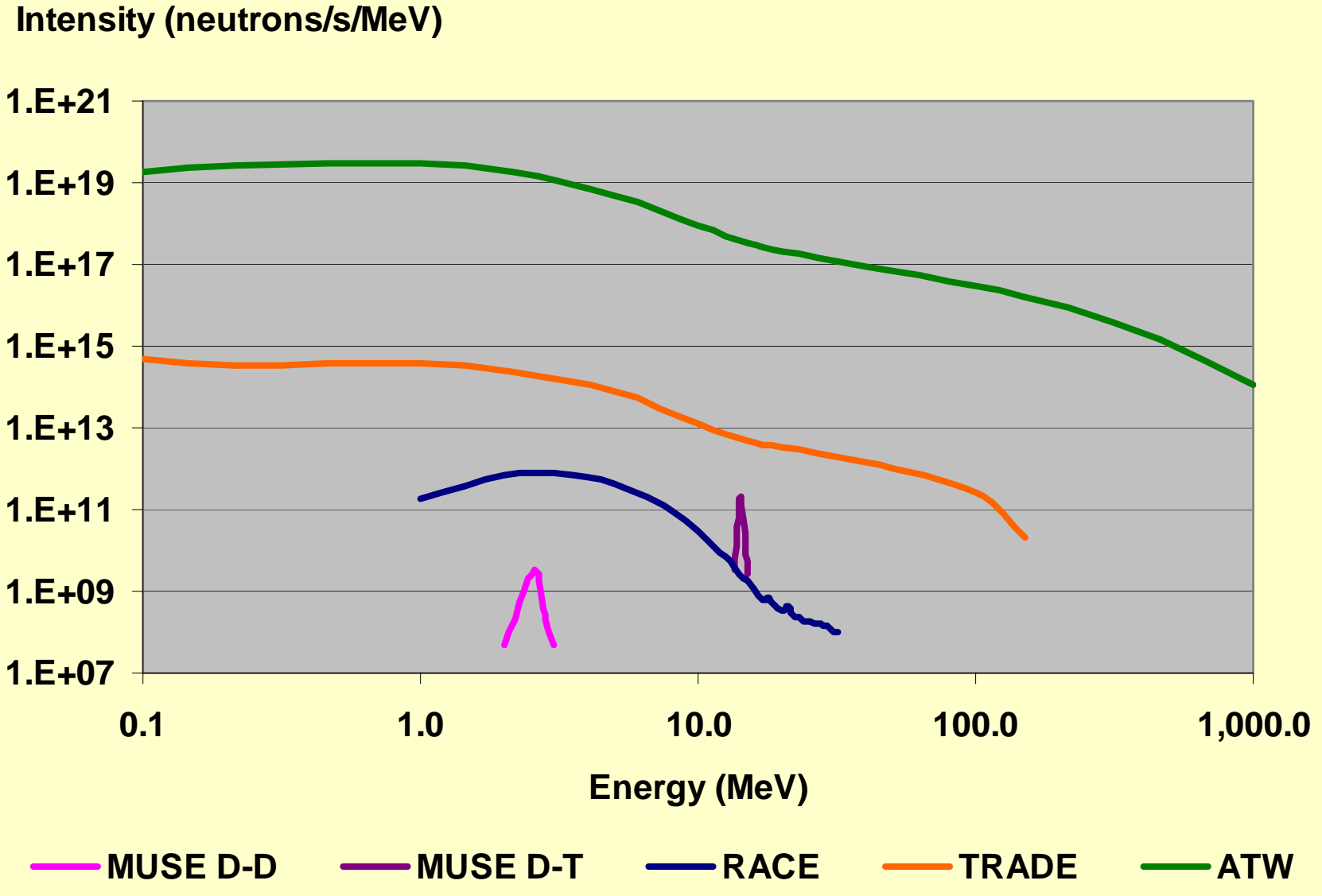
MUSE did not

- Investigate source importance above 14 MeV
- Investigate power/current/importance relations
- Study dynamic effects with power feedback
- Study operational procedures (startup/shutdown, reactivity swings)

In addition

- MUSE maximum source strength with DT at full current and maximum rep rate was $\sim 1.5 \times 10^{10}$ n/s.
- RACE maximum source strength could be $\sim 10^{13} - 10^{14}$ n/s.
- MUSE, RACE, TRADE, and others have different sources than ATW (intensity and spectrum) → May require many

Source spectral comparison



RACE uniqueness

- Electron-linac is mobile and the target is versatile
- RACE can map source importance at various locations in and around a core
- RACE systems will be diverse:
 - » Several fuel types and enrichments, core geometries, reflector configurations, and targets
- examine $k_{\text{eff}} = 1 - \beta$ to $1 + \beta$

Reactor Characteristics

University	nominal power (MWth)	peak power (MWth)	target location	fuel type	fuel composition	fuel enrichment	keff
ISU	0	0	various	plates	U-Al Alloy, Al clad	<20%	0.2-0.95
UT-Austin	1	1500	various	rods	U-ZrH	<20%	~0.92 to 1.0
Tx A&M 1	1	1000	various	rods	U-ZrH "FLIP" fuel	70%	? to 1.0
Tx A&M 2	1	1000	various	rods	U-ZrH	<20%	? to 1.0
Tx A&M 3	0	?	various	rods	U-ZrH	<20%	0.90 to 0.95?

Plus RACE-Fast (SPR-III, Godiva?)

More positives

- RACE includes five universities, many faculty, and many students
- International Technical Advisory Group
- Timing to support transition to larger systems, e.g. XT-ADS

RACE will help us advance technology

- Develop data for space-time correction
 - » A variety of systems
 - » Multiple source locations (importance mapping)
 - » Several different fuels
 - » Thermal feedback
- Develop on-line measurement & prediction
- Manage transients
 - » Power off and power on

ISU RACE (Phase I)

- Prof. Alan Hunt, ISU Physics
- Drs. Konstantin Sabourov and Jianwei Chen
- Prof. John Bennion, ISU NE
- IAC engineering & technical staff
- Current students:
 - » Vakho Makarashvili
 - » Carlos Maidana
 - » Josh Peterson



Texas RACE (Phase II-IV):

- Prof. Charlton, PI, Texas A&M
- Prof. Reece, A&M reactor supervisor
- Prof. O'Kelly, UT PI & reactor supervisor
- Students
 - » UT: Taylor Green
 - » A&M: Taraknath Woddi, Rob Candalino, and Daniel Speaker

Other RACE Participants

- Michigan: Prof. Lee, students Y. Chao and V. Kulik (graduated, post-doc at CEA Saclay)
- UNLV: Evgeny Stankovskiy & Tim Beller
- RACE TAG

Frank Goldner (DOE NE)

Tom Ward (TechSource)

Mike Cappiello (LANL)

George Imel (ANL-W)

Pino Palmiotti (ANL)

John Lee (U Mich)

Steven Clement (LANL)

Waclaw Gudowski (RIT)

Max Salvatores (FZK, ANL)



Accelerator and “large” vessel



ISU Electron Linac

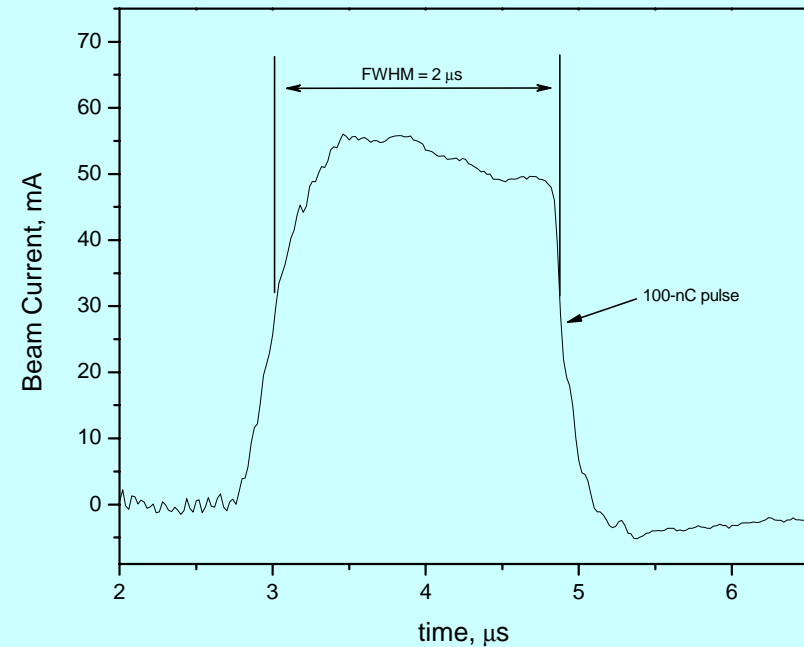
- **Characteristics:**

- » 25 MeV
- » 80-100 mA peak
- » 2-5 μs pulsewidth
- » 0 to 100 Hz

- $25 \text{ MeV} * 80 \text{ mA} * 5 \mu\text{s} * 100 \text{ Hz} = 1 \text{ kW}$

- $\sim 1 \times 10^{12} \text{ n/s}$

Electron Burst History, 18-MeV LINAC



W-Cu (75:25 w/o) target for ISU RACE 2 3/4" diameter x 3.5" long

- MCNPX: $\sim 10^{12}$ neutrons/s/kWe @ 25 MeV
- Also a prompt, strong high-energy gamma ray signal
 - » But minimal photo-fission



Linac for Texas (Phase II-III)

- 20 MeV
- 80-100 mA peak
- 2-10 μs pulse width
- 0 to 200 Hz
- To be tested in June



Tentative Experiment Schedule

- ISU RACE (Phase I)
 - » Design & licensing Aug '03 - Jun '05
 - » Experiments Jun-Jul '05
- UT-Austin RACE (Phase II)
 - » Accelerator Feb-Jun '05
 - » Experiments Summer-fall '05
- Texas A&M RACE (Phase III)
 - » TRIGA Summer '06
- High-Power ECATS RACE (Phase IV) '05-'06
- RACE-Fast (Phase V) '05-'06



Issues

- Time-dependent flux or reaction rate measurements
- Absolute calibration of accelerators & neutron production
- NRC license amendment
- Lack of DOE/Lab interest

RACE is a multi-university academic project in collaboration with DOE labs

- **ADSS Exp at ISU, UT, and Texas A&M**
- **Now thru 2007 & beyond**
- **Design, modeling, and execution**
- **Predict and measure subcritical multiplication, map source importance, and study subcritical transients (source on & off)**
- **Recruit, educate and train students**
- **Transmutation**

