Muons, Inc.

Goal of this Presentation

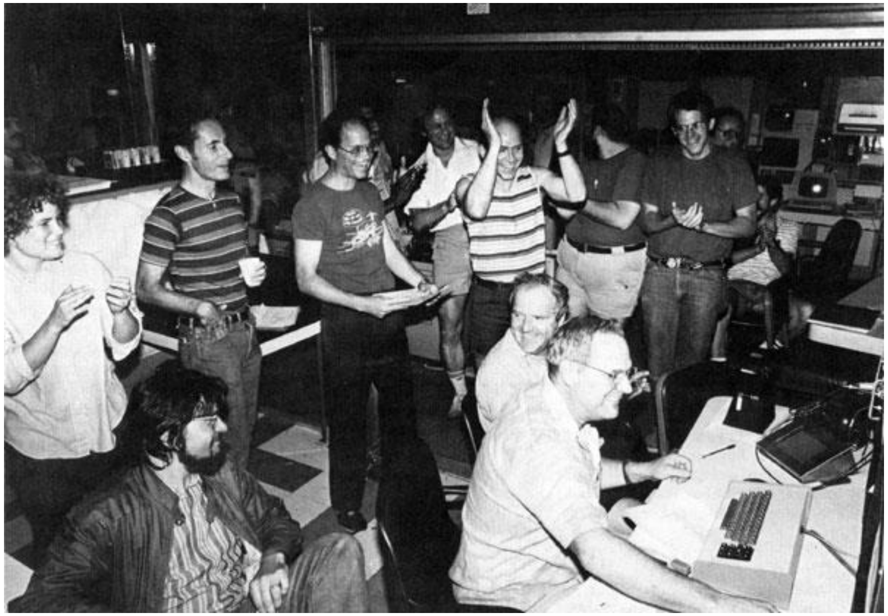
- How to make nuclear power desirable using
  - molten salt fuel – to eliminate accidental volatile releases
  - proton spallation – to allow subcritical operation
  - continuous-feed reactor - to divorce it from nuclear weapons proliferation
- NNSA first example of GEM*STAR
  - eliminate W-Pu –2000 U.S.-Russian Pu Management and Disposition Agreement
  - create clean diesel for the DOD–80 Billion gallons
- Generate interest to join the GEM*STAR team
  - Bruce Vogelaar- VA Tech, Martin Coster-FGA, Muons, ADNA

Muons, Inc.

GEM*STAR

Goal: Develop Intrinsically Safe Power
First Customers: NNSA, DOD, LLNL

Rolland P. Johnson, Ph. D.
President , Muons Inc.



512 GeV at Fermilab

Charles D. Bowman, Ph. D.
President ADNA Corporation
Accelerator-Driven Neutron Applications

Charlie at LANL

CV Highlights for

Charles D. Bowman

(born: May 23, 1935)

Ph. D. in Neutron Physics, 1961	Duke University
M.A Neutron Physics, 1958	Duke University
B.S. in Physics, Magna cum Laude, 1956	Virginia Tech

1997- Present	President, ADNA Corporation
1997-1999	French Atomic Energy Commission (CEA)
1982-1996	Los Alamos National Laboratory

- **Associate Division Leader for Basic Research**
- **Construction Project Manager for LANSCE**
- **Project Leader for the Los Alamos Accelerator-Driven Transmutation Technology (ADTT) program**
- **led Project 17 of the ISTC, which employed about 500 Russian scientists in the lead ADTT program**
- invited to almost every nation with significant programs in nuclear power giving talks too numerous to include

1972-1982	(NIST) National Bureau of Standards
1968-1968	Oak Ridge National Laboratory
1961-1972	Lawrence Livermore National Laboratory

Publications: 147+

1966-1982 Member of the U. S. Nuclear Data Committee

1969 Honored as a Fellow of the American Physical Society (recommended by Teller)

1973-1975 Secretary (Chairman) of the U. S. Nuclear Data Committee

1975 Organizer and Co-Editor of the Proceedings of the "International Conference on Nuclear Cross Sections and Technology," Gaithersburg, Md., March 5-7

1977 Organizer and Co-editor of the International Specialist's Symposium on "Neutron Standards and Applications," Gaithersburg, Md., March 28-31

1977 Co-Editor, Cross Sections and Yields for High Energy Neutron Source Reactions, Gaithersburg, Md.

1978 Admitted to the Senior Executive Service (civil equivalent to General/Admiral)

1980 Co-editor of the Proceedings of the International Conference on Nuclear Cross sections for Technology, Knoxville, Tenn., Oct 22-26

1981 Received the IR-100 Award for the development of Resonance Neutron Radiography

1982 Awarded the U. S. Department of Commerce Silver Medal

1984 Appointed Construction Project Manager for the LANSCE Experimental Halls

1990 Patent awarded; Neutron-Driven Gamma Ray Laser

1990 Los Alamos National Laboratory Recognition of Excellence Award, "7Be Working Group Leader"

1990 Patent awarded; "Nuclear Reactivity Control Using Laser-Induced Polarization"

1990 Patent awarded; "Apparatus for Nuclear Transmutation and Power Production Using an Intense Accelerator-Generated Thermal Neutron Flux"

1991 Honored as a Fellow of the Los Alamos National Laboratory

2001 Patent Awarded; "Apparatus for Transmutation of Nuclear Reactor Waste"

GEM*STAR

Green Energy Multiplier*Subcritical Technology Alternative Reactor

Charles D. Bowman R. Bruce Vogelaar, Edward G. Bilpuch, Calvin R. Howell, Anton P. Tonchev, Werner Tornow, R.L. Walter, "GEM*STAR: The Alternative Reactor Technology Comprising Graphite, Molten Salt, and Accelerators," Handbook of Nuclear Engineering, Springer Science+Business Media LLC (2010).

Bruce Vogelaar (Viginia Tech) also helped form the ADNA-Muons, Inc. collaboration

GEM*STAR burns the w-Pu and renders it ***permanently*** unusable for nuclear weapons

one 10 MW, 1 GeV proton accelerator feeding four GEM*STAR units burns 34T w-Pu to provide the US DOD with 80Bg green diesel fuel, enough for the next 30 years

Profits from producing (renewable) diesel fuel at <$2.00/gallon will inspire funding for a Conceptual Design Report prior to a 3-year demo construction project

DOD (US Navy) interest in 80 billion gallons of green diesel from burning 34 tons of w-Pu on a DOE site could expedite the project

Muons, Inc.
Who we are, what we want to do

Rolland P. Johnson
Muons, Inc. (http://www.muonsinc.com/)

For the first half of its 10 year existence, Muons, Inc. was obsessed with a Muon Collider, the next energy frontier machine to follow the LHC. We believe we helped revive the MC, now the long-range goal of Fermilab and US HEP

In the last few years, Muons, Inc. has emphasized developing general tools and technology for accelerators through DOE contracts and SBIR-STTR grants at seven US universities and seven National Labs

These have allowed us to build a strong, creative staff with a broad range of skills and experience for commercial products and services

We want to design and build a new kind of Accelerator-Driven Subcritical Reactor (ADSR) that is not only intrinsically safe, but can have large profits by producing synthetic diesel from natural gas and renewable carbon

The same ADSR can also safely burn weapons-grade plutonium or U233 to make diesel fuel for the DOD – a unique opportunity for a demo!

Completed Muons, Inc. Projects

Year	Completed Projects	SBIR-STTR Funds	Research Partner	Phase III
2002	Company founded			
2002-5	High Pressure RF Cavity	$600,000	**IIT (Kaplan)**	$445,000
2003-7	Helical Cooling Channel	$850,000	**JLab (Derbenev)**	$3,100,000
2004-5	MANX demo experiment	$95,000	**FNAL (Yarba)**	$22,230
2004-7	Phase Ionization Cooling	$745,000	**JLab (Derbenev)**	
2004-7	H2Cryostat - HTS Magnets	$795,000	**FNAL (Yarba)**	$1,400,000
2005-8	Reverse Emittance Exch.	$850,000	**JLab (Derbenev)**	
2005-8	Capture, ph. Rotation	$850,000	**FNAL (Neuffer)**	$198,900
2006-9	G4BL Simulation Program	$850,000	**IIT (Kaplan)**	$8,732,479
2006-9	MANX 6D Cooling Demo	$850,000	**FNAL (Lamm)**	$495,630
2007-10	Stopping Muon Beams	$750,000	**FNAL (Ankenbrandt)**	$410,488
2007-10	HCC Magnets	$750,000	**FNAL (Zlobin)**	$255,000
2007-8	Compact, Tunable RF	$100,000	**FNAL (Popovic)**	$23,400
2008-9	Rugged RF Windows	$100,000	**JLab (Rimmer)**	
2008-9	H2-filled RF Cavities	$100,000	**FNAL (Yonehara)**	$23,400
	Completed Projects	**$8,285,000**		**$15,084,297**

Muons, Inc.

Muons, Inc. Projects in Progress

Year	Projects In Progress	Funds	Research Partner	Phase III
2008-12	Pulsed Quad RLAs (NFE)	$850,000	**JLab (Bogacz)**	
2008-12	Fiber Optics for HTS (NFE)	$800,000	**NCSU (Schwartz)**	
2008-13	RF Breakdown Studies	$850,000	**LBNL (Li) ANL (Gai)**	
2009-12	HOM Absorbers	$850,000	**Cornell (Hoffstaetter)**	
2009-13	Quasi Isochronous HCC	$850,000	**FNAL (Neuffer)**	$198,900
2009-10	DC Gun Insulator	$100,000	**JLab (Poelker)**	
2009-13	H-minus Sources	$850,000	**ORNL/SNS (Stockli)**	
2009-13	Hi Power Coax Coupler	$850,000	**JLab (Rimmer)**	
2009-10	Hi Field YBCO Magnets	$100,000	**NCSU (Schwartz)**	
2009-13	Φ & f–locked Magnetrons	$850,000	**FNAL (Popovic)**	$198,900
2010-11	ps detectors for MCDE	$100,000	**U Chicago (Frisch)**	
2010-11	Crab Cavities	$100,000	**JLab (Rimmer)**	
2010-11	MC detector bkgnds	$100,000	**NIU (Hedin)**	
2010-13	Epicyclic PIC	$850,000	**JLab (Derbenev)**	
	Projects In Progress	**$8,100,000**		$397,800

Contracts with National Labs

			Phase III
2009-10	Mono-E Photons	2 contracts w **PNNL**	$172,588
2009-10	Project-X and MC/NF	contract w FNAL	$260,000
2009-10	MCP and ps timers	contract w **ANL**	$108,338
2010	MAP - L2 mngr	2 contracts w FNAL	$55,739
2010	805 MHz RF Cavity	contract w **LANL**	$230,000
2012	MAP - L2 mngr	contract w FNAL	$40,000
2012	PX cooling for Mu2e	contract w FNAL	$75,490
2012	g-2	contract w FNAL	$40,160
2012	ACE3P 12 GeV Upgrade Studies	contract w JLab	$50,000
			$1,032,315

Muons, Inc.

Recent Phase II Competition

2011-12	Adjustable Coax Coupler	$100,000	ANL (Nassiri)	
2011-12	SAW Photoinjector	$100,000	JLab (Poelker)	
2011-12	2-Stage Magnetron	$100,000	FNAL (Yakovlev)	$23,400
2011-12	Efficient H-minus Source	$100,000	FNAL (Bollinger)	$23,400
2011-12	Achromatic Low Beta	$100,000	JLab (Derbenev)	
2011-14	FRIB Separator Magnet	$1,100,000	BNL (Gupta)	
2011-14	FiberOptic Quench Detection	$1,100,000	NCSU (Schwartz)	
2011-14	HCC Engineering Design	$1,100,000	FNAL (Yonehara)	$23,400
		$3,800,000		$70,200

Newest Grants

2012-15	S-Band RF Load	$1,100,000	SLAC (Krasnykh)	
2012-13	Ribbon e Beam Monitor	$100,000	ORNL/SNS (Aleksandrov)	
2012-13	RF Photoinjector Cavity	$100,000	JLab (Rimmer) SLAC(Li)	MuPlus
2012-15	Complete Cooling Channel	$1,100,000	JLab (Derbenev)	MuPlus
2013	High MTBF Magnetron	$150,000	JLab (Wang)	
		$2,650,000		

Muons, Inc. Staff – CV Index

Muons, Inc. Staff	
Rolland P. Johnson, Ph. D.	President/CEO
Gene Flanagan, Ph. D.	COO
James Nipper, BEE, MBA	CFO
Charles M. Ankenbrandt, Ph. D.	VP Personnel Development
Mike Neubauer, MSEE	VP Engineering
Thomas J. Roberts, Ph. D.	VP Technology Development
Robert J. Abrams, Ph. D.	Senior Experimental Physicist
Alan Dudas, MSEE	Senior RF Engineer
Vadim Dudnikov, Ph. D.	Senior Accelerator Physicist
Stephen Kahn, Ph. D.	Senior Accelerator Physicist
Gigory Kazakevich, Ph. D.	Senior Accelerator Physicist
Frank Marhauser, Ph.D.	Senior Accelerator Physicist
Leonid Vorobiev, Ph. D.	Senior Accelerator Physicist
Mary Anne Cummings, Ph. D.	Experimental Physicist
Linda Even, MSCE	Environmental Engineer
Justin Rodriguez, BA	Computational Physicist
Cary Yoshikawa, Ph. D.	Computational Physicist

More People

- Under SBIR-STTR grants, Muons, Inc. supported or is supporting seven full-time junior Ph. D. accelerator scientists directly (Drs. Mohammad Alsharo'a, Kevin Beard, Gene Flanagan, Pierrick Hanlet, Masahiro Notani, David Newsham, Kevin Paul, and Cary Yoshikawa).

- and seven indirectly through subgrants, at Fermilab, JLab, IIT, NCSU, LBNL and ODU (Drs. Katsuya Yonehara, Shahid Ahmed, Guimei Wang, Vasiliy Morozov, Frank Hunte, Dan Bowring).

- Muons, Inc. supports Ph. D. students working on our projects: Ms. Mahzad BastaniNejad and Ms. Ana Samolov at ODU, Ms. Melanie Turenne at NCSU, and Mr. James Maloney at NIU. Other potential Ph. D. students are considering working on our projects as thesis topics.

- Melanie and Ana completed all requirements and received their Ph.D.s in 2012! Jim defended his this thesis earlier this year.

Muons, Inc.

Ultimate Goal – after the LHC: High-Energy High-Luminosity Muon Colliders

- precision lepton machines at the energy frontier
- achieved in physics-motivated stages that require developing inventions and technology, e.g.
  - MANX (a new version is in the works)
    - demonstrate HCC, HS, & EEX concepts (based on a prototype HCC segment)
  - high-intensity proton driver
    - simultaneous intense muon beams
  - stopping muon beams
    - useful 6D cooling w HCC, EEX
  - neutrino factory
    - HCC with RF, RLA in CW Proj-X
  - Z' factory
    - low Luminosity collider, HE RLA
  - Higgs factory ← (we have some new ideas on this!)
    - extreme 6D cooling, low beta, super-detectors
  - energy-frontier muon collider
    - more cooling, lower beta

new ideas for MCs first seen in our SBIR-STTR projects:

- H_2-Pressurized RF Cavities
- Helical Cooling Channel
  - Continuous Absorber for Emittance Exchange
- Parametric-resonance Ionization Cooling
  - Correlated Optics
- Reverse Emittance Exchange with Absorbers
- RF Capture, Phase Rotation, Cooling in HP RF Cavities
- Bunch Coalescing
  - to overcome space charge limitations
- High Field HTS Solenoids for transverse cooling
- Helical Solenoid magnets
  - NbTi 4-coil HS models
  - YBCO 6-coil HS models
  - Fiber optics for HTS quench protection
- p-dependent HCC
  - precooler
  - MANX 6d Cooling Demo
  - improved mu2e design
- Pulsed Quadrupoles in SRF Linacs for RLAs
  - Multipass arcs – c.f. Morozov et al.

New Nuclear Technology to Produce Inexpensive Diesel Fuel from Natural Gas and Renewable Carbon

Charles Bowman — *ADNA & CLF Corps*
Rolland P. Johnson — *Muons, Inc.,*

The long-range goal is to sell intrinsically safe and versatile nuclear reactors to address world energy needs.

The first application is an Accelerator-Driven Subcritical Reactor that burns non-enriched Uranium, Thorium, spent fuel from conventional nuclear reactors (SNF), or excess weapons-grade plutonium in a molten salt fuel to produce high-temperature heat to convert Natural Gas and renewable Carbon into liquid fuel for vehicles.

Requires development and interfacing between known technologies that

-use an SRF accelerator to produce an intense source of neutrons to

-generate process heat in GEM*STAR, a molten-salt-fueled subcritical reactor, to

-prepare methane and carbon for the Fischer-Tropsch generation of diesel fuel.

US Industry can take nuclear waste or excess plutonium and produce energy from it

- Molten-salt Reactor Experiment (MSRE) 1965-1969
  - continuous purging of volatile radioactive elements – no zircaloy
- Accelerator-Driven Subcritical Reactors (ADSR)
  - reactor concept uses molten salt fuel (e.g. UF_4 ,ThF_4, or PuF_3)
  - GEM*STAR
    - Avoids nuclear weapon proliferation concern of reprocessing for 200 years
- The next step is a prototype ADSR machine to inspire industry
- Inexpensive natural gas changes things in the US
  - New Nuclear Power cannot compete with 4.5 c/kW-h from natural gas
  - ADSR process heat can make synthetic diesel out of natural gas and carbon
- GEM*STAR technology can
  - Turn excess weapons-grade plutonium into process heat,
  - with remnants useless for weapons,
  - to provide the DOD with inexpensive, green diesel fuel

We want to use proton accelerators to make spallation neutrons to create fissile materials and/or effectively control the fission process:

fertile β^- β^- *fissile*

- $n + {}^{238}U_{92} \rightarrow {}^{239}U_{92} \xrightarrow[24\ m]{} {}^{239}Np_{93} \xrightarrow[2.4\ d]{} {}^{239}Pu_{94}$
- $n + {}^{232}Th_{90} \rightarrow {}^{233}Th_{90} \xrightarrow[22\ m]{} {}^{233}Pa_{91} \xrightarrow[27\ d]{} {}^{233}U_{92}$

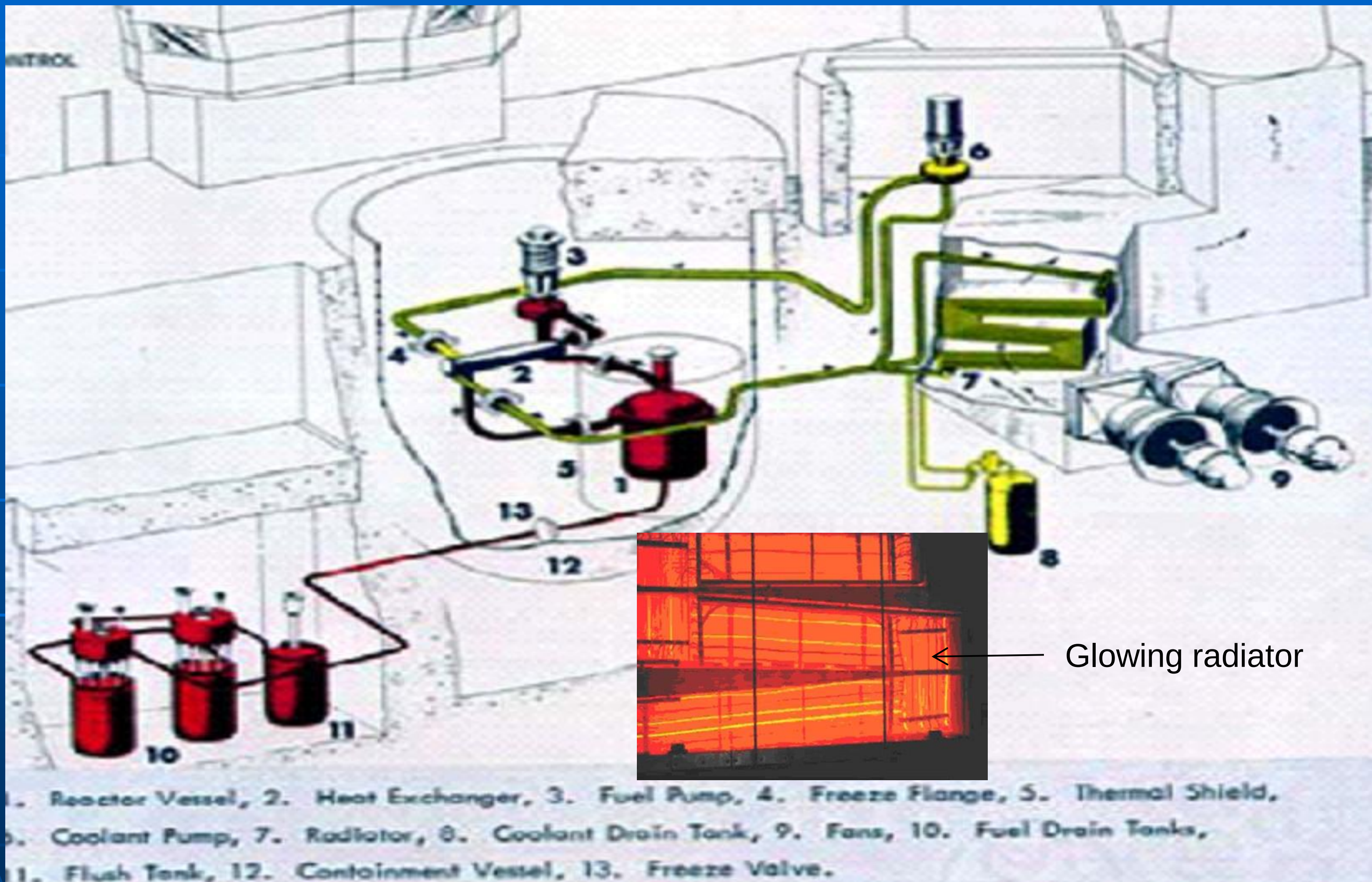
- The extra neutrons needed to convert fertile elements can be provided by:
  - A fast or Breeder reactor using fissile U-235 or Pu-239, above criticality or
  - A particle accelerator – very hot topic 20 years ago!

What is new:

- SRF Proton Linacs can now provide extraordinary neutron flux and
  - ADSR - safer than BRs,
    - That operate at criticality, with many critical masses of fissile material, and fewer delayed neutrons
  - ADSR - more weapons proliferation resistant than BRs
    - which require enrichment and reprocessing
  - ADSR - probably less expensive than BRs
- Molten salt fuel is an advantage over solid fuel pins
  - allows continuous purging of volatile radioactive elements
  - without zircaloy, that can lead to hydrogen explosions
- Molten salt fuel eases accelerator requirements – no solid fuel fatigue
- Subcritical ADSR operation has always been appreciated
  - fission stops when the accelerator is switched off

- An intrinsic safety problem for conventional reactors is enclosed solid fuel.
- a natural solution is to use molten-salt fuel
- that is also well suited to accelerator-driven subcritical reactors.
  - A major difficulty is fatigue of UO_2 fuel in rods caused by accelerator trips – no such problem for molten salt fuel
- The technology of molten-salt fuel was developed in the 1960s in the Molten-Salt Reactor Experiment (MSRE) at ORNL.
  - Use of molten salt fuel was later abandoned
    - not enough Pu-239 for bombs?
    - President Nixon?
      (See MSRE on wikipedia for nice summary)

Molten-Salt Reactor Experiment

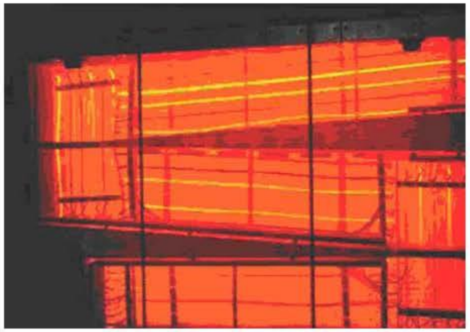


Molten-salt Reactor Experiment

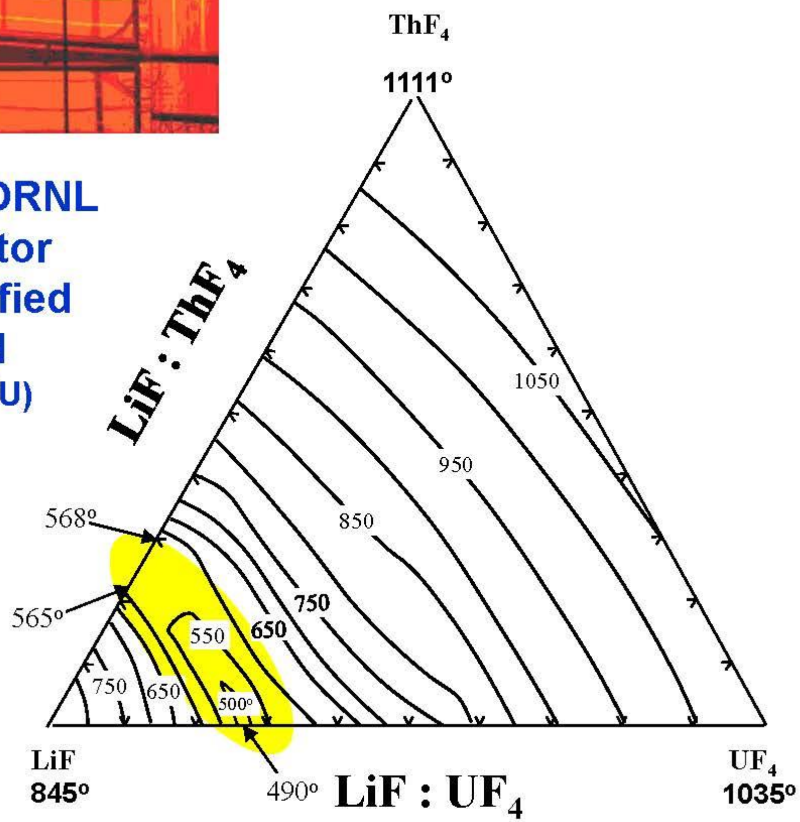
Invent
the
Future

ADNA & GEM*STAR Consortium

Molten Salt Eutectic Fuel



Proven in ORNL MSRE reactor using Modified Hastelloy-N
(^{235}U, ^{239}Pu, ^{233}U)



Uranium or Thorium fluorides form eutectic mixture with ^{7}LiF salt.

High boiling point → low vapor pressure

GEM*STAR

From 1969 MSRE Report Abstract

"The MSRE is an 8-MW(th) reactor in which molten fluoride salt at 1200°F (650 C) circulates through a core of graphite bars. Its purpose was to demonstrate the practicality of the key features of molten-salt power reactors.

Operation with 235U (33% enrichment) in the fuel salt began in June 1965, and by March 1968 nuclear operation amounted to 9,000 equivalent full-power hours. The goal of demonstrating reliability had been attained - over the last 15 months of 235U operation the reactor had been critical 80% of the time. At the end of a 6-month run which climaxed this demonstration, the reactor was shutdown and the 0.9 mole% uranium in the fuel was stripped very efficiently in an on-site fluorination facility. Uranium-233 was then added to the carrier salt, making the MSRE the world's first reactor to be fueled with this fissile material. Nuclear operation was resumed in October 1968, and over 2,500 equivalent full-power hours have now been produced with 233U.

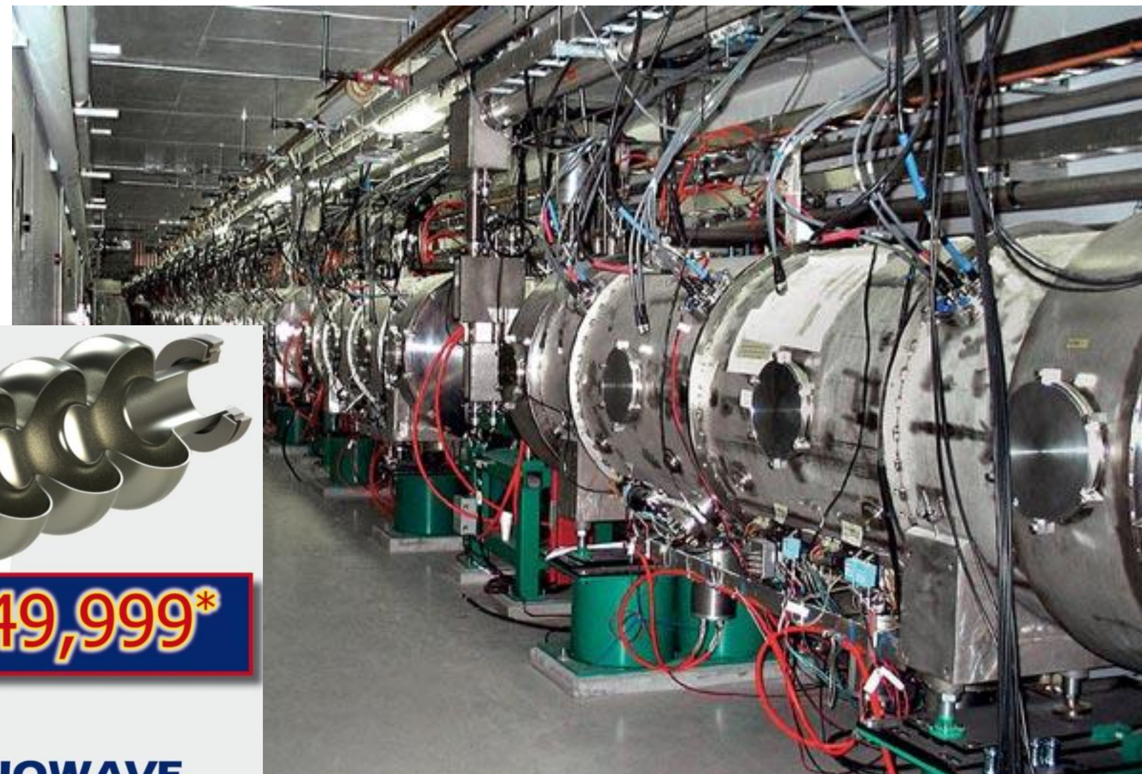
The MSRE has shown that salt handling in an operating reactor is quite practical, the salt chemistry is well behaved, there is practically no corrosion, the nuclear characteristics are very close to predictions, and the system is dynamically stable. Containment of fission products has been excellent and maintenance of radioactive components has been accomplished without unreasonable delay and with very little radiation exposure.

The successful operation of the MSRE is an achievement that should strengthen confidence in the practicality of the molten-salt reactor concept."

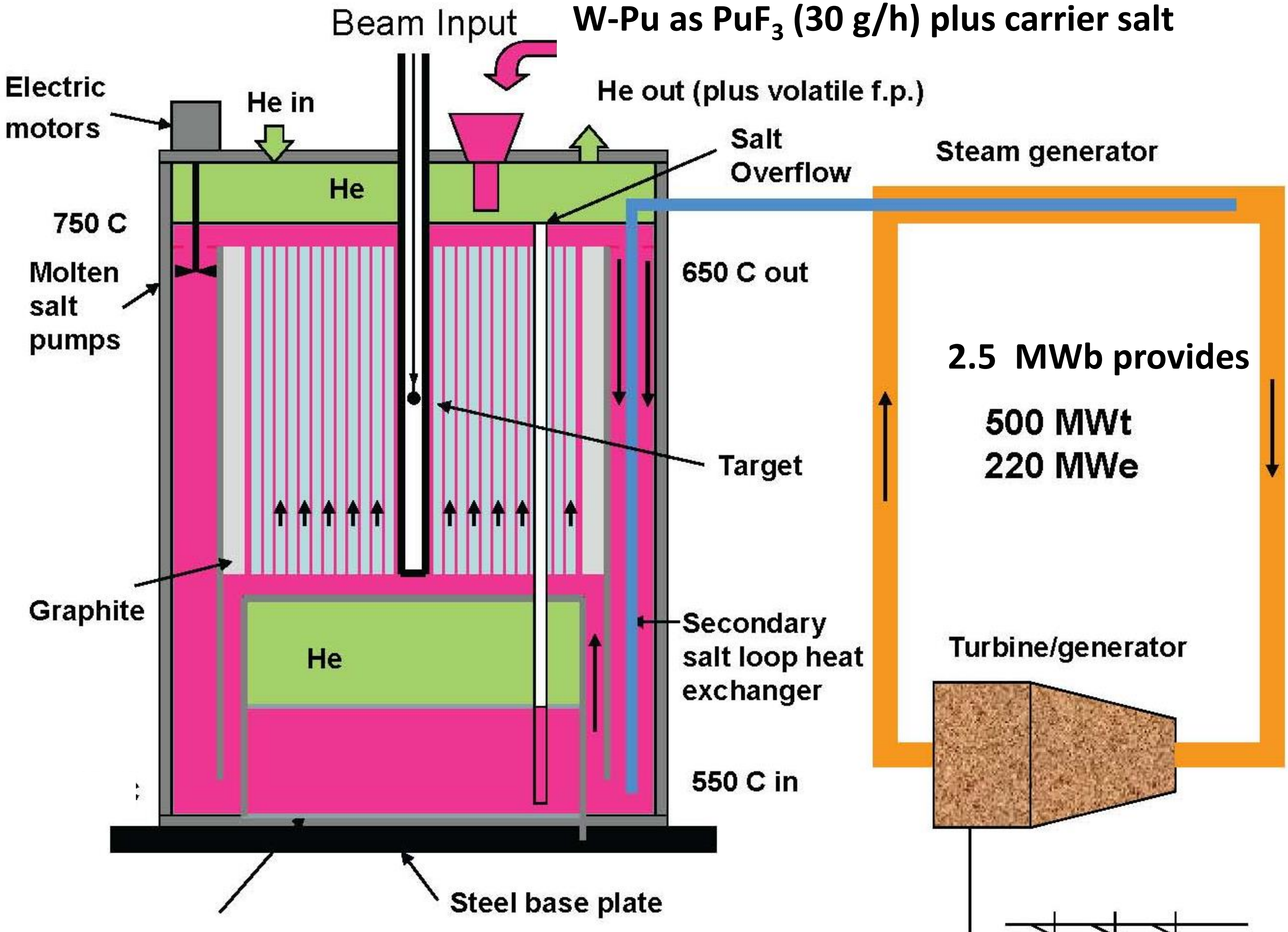
NOW FAST FORWARD 40 YEARS and add an accelerator

New Accelerator Technology Enables GEM*STAR

OAK RIDGE, Tenn., Sep. 28, 2009 — The Department of Energy's 1 GeV Spallation Neutron Source (SNS), breaks the one-megawatt barrier! Operating at <10% duty factor, this corresponds to >10 MW at CW. Based on Superconducting RF Cavities, available from U.S. Industry:



W-Pu as PuF_3 (30 g/h) plus carrier salt



GEM*STAR Functional Elements

GEM*STAR

Invent the Future

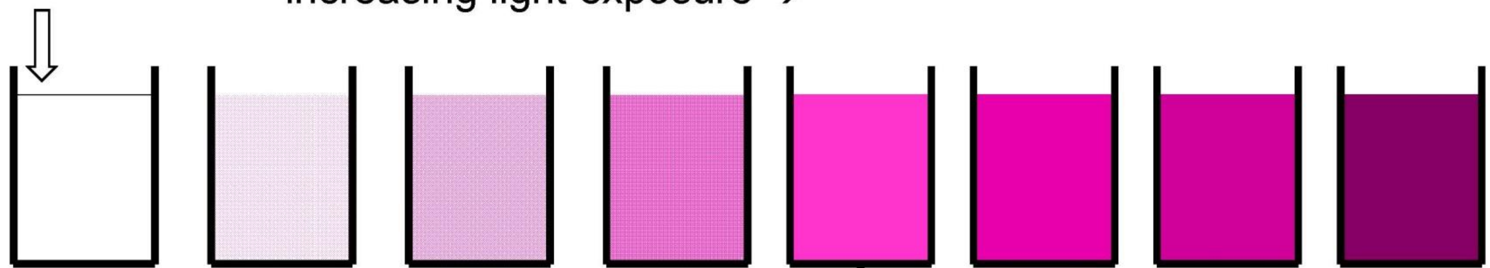
ADNA & GEM*STAR Consortium

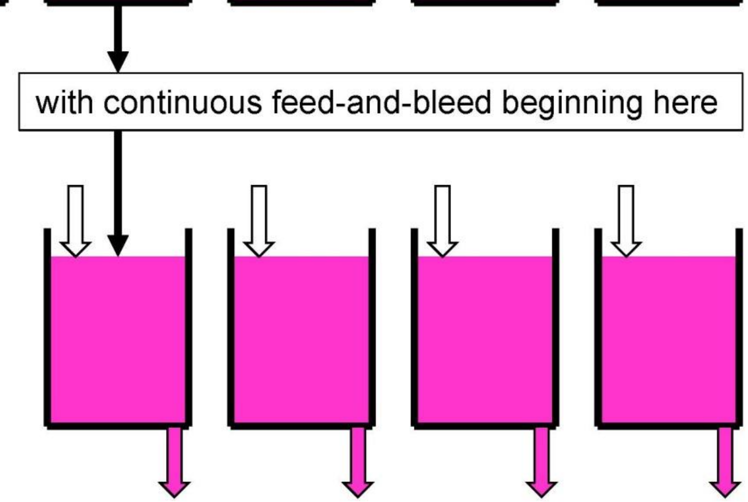
31

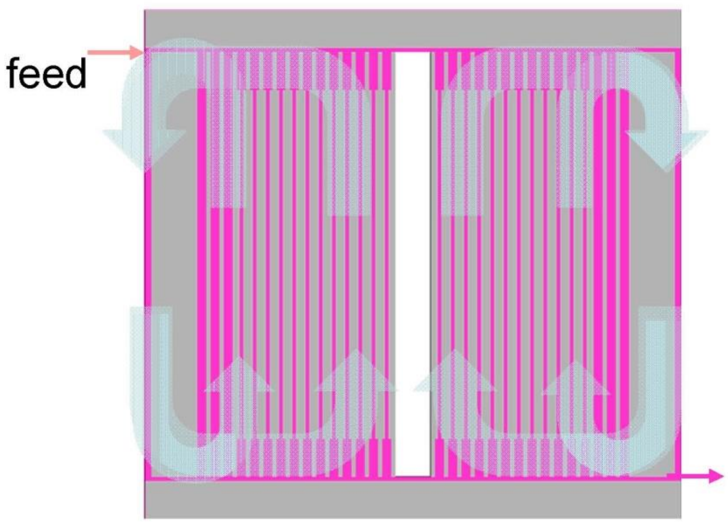
consider a clear liquid which releases heat when exposed to light, eventually turning a dark purple

Initial fill

increasing light exposure →







fast internal mixing

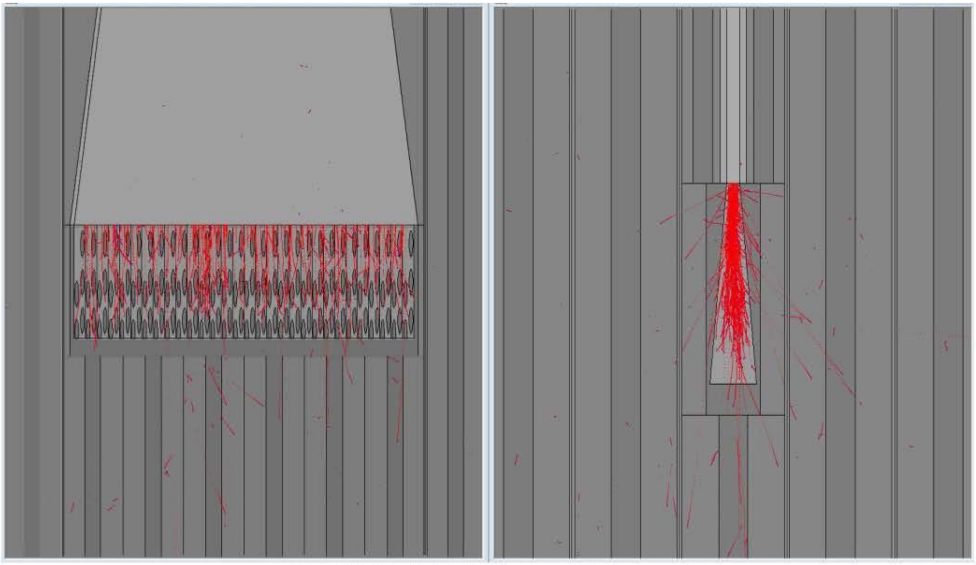
color and heat output remains constant indefinitely

→ equilibrated isotope fractions throughout core and throughout time

10^{-6} less volatile fission-product build-up in core

ADNA & GEM*STAR Consortium

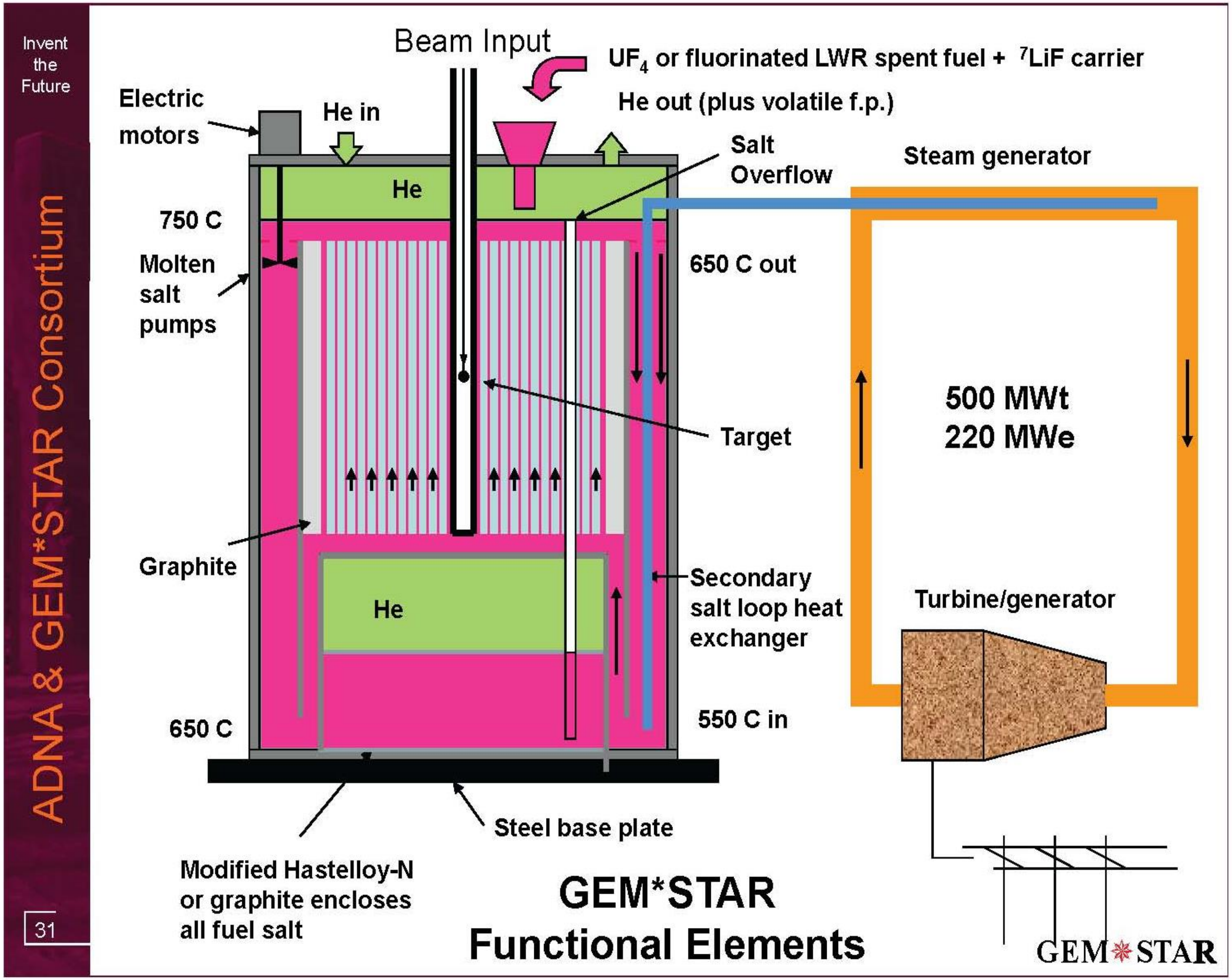
Target Considerations

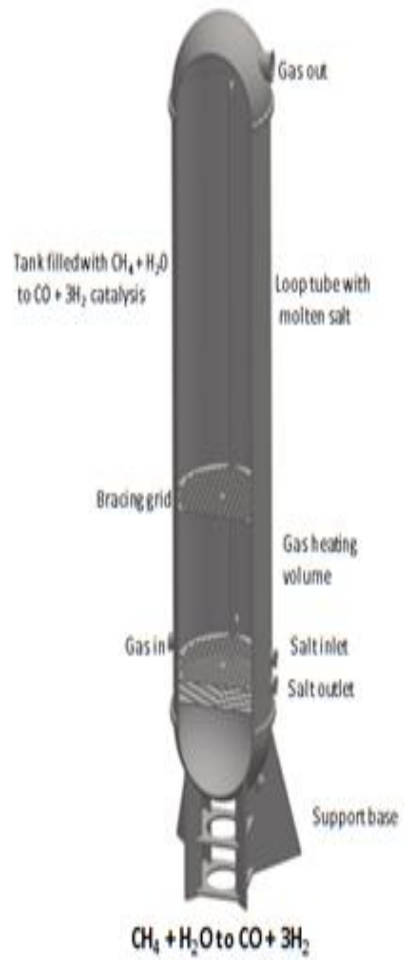


GEM*STAR Internal Target

- diffuse (or multiple) beam spots
- molten salt used for heat removal
- high neutron yield from uranium
  (but minimize target fission)
- spent target fluorinated and used as fuel
- minimize impact on local reactivity

GEM*STAR


Invent the Future
ADNA & GEM*STAR Consortium
31
Beam Input
UF_4 or fluorinated LWR spent fuel + ^7LiF carrier
He out (plus volatile f.p.)
Electric motors
He in
He
Salt Overflow
Steam generator
750 C
Molten salt pumps
650 C out
Target
500 MWt
220 MWe
Graphite
He
Secondary salt loop heat exchanger
Turbine/generator
650 C
550 C in
Steel base plate
Modified Hastelloy-N or graphite encloses all fuel salt
GEM*STAR
Functional Elements
GEM*STAR


Gas out
Tank filled with $CH_4 + H_2O$ to $CO + 3H_2$ catalysis
Loop tube with molten salt
Bracing grid
Gas heating volume
Gas in
Salt inlet
Salt outlet
Support base
$CH_4 + H_2O$ to $CO + 3H_2$

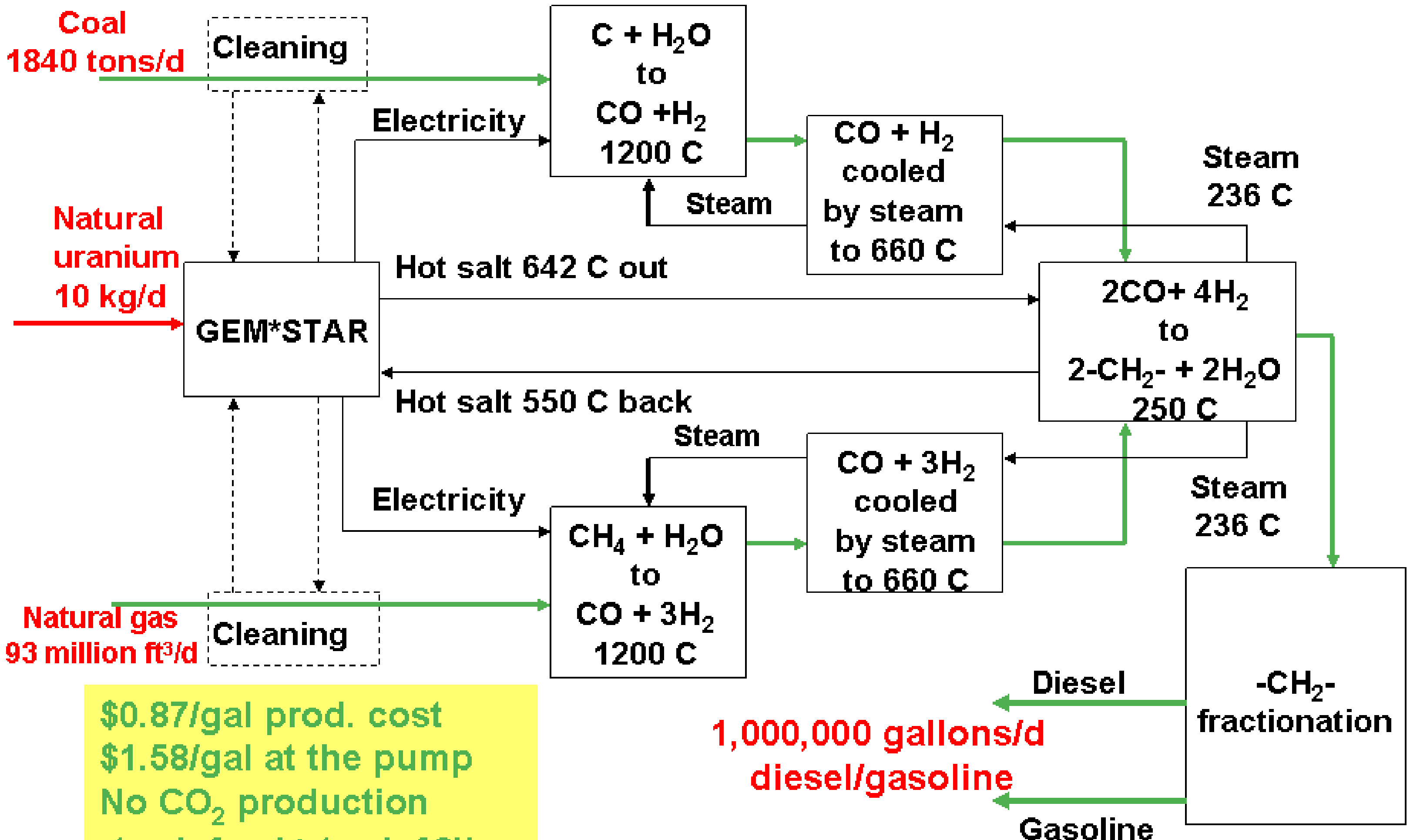
High Temperature MS Advantages over LWRs

- no high-pressure containment vessel
- 34% → 44% efficiency for thermal to electric conversion (low-pressure operation)
- match to existing coal-fired turbines, enables staged transition for coal plants, addressing potential “cap-and-trade” issues
- synthetic fuels via modified Fischer-Tropsch methods – very attractive (much more realistic than hydrogen economy)

Invent
the
Future

ADNA & GEM*STAR Consortium

Coal and Natural Gas to Diesel/Gasoline with GEM*STAR at 500 MWt (~3.4MW on target)



$0.87/gal prod. cost
$1.58/gal at the pump
No CO_2 production
1 mol of coal + 1 mol of CH_4 yields 2 mols of diesel/gasoline

affordable diesel without CO_2 production

GEM*STAR

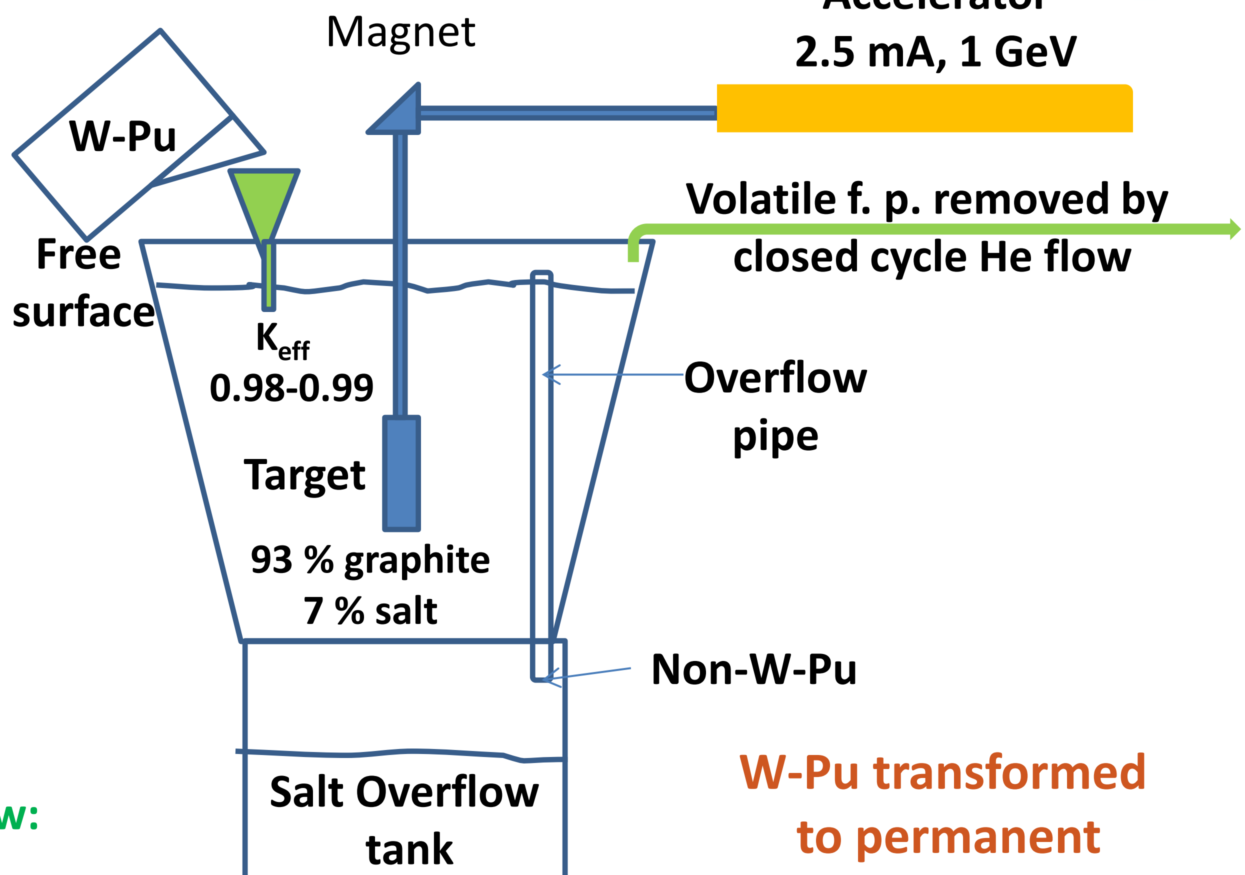
Is W-Pu a Killer Application?

- 34 metric tons of excess weapons-grade plutonium slated to be destroyed by the troubled 2000 U.S.-Russian Plutonium Management and Disposition Agreement (PMDA)[2]
- GEM*STAR allows a better solution than either MOX (US) or BR (Russia)
- <7% Pu240 vs >19%

GEM*STAR Burns W-Pu Without U or Th
34 Tons in 30 Years

Hourly fill:
30 g W-Pu
as PuF_3 +
carrier salt

Inflow W-Pu:
93 % ^{239}Pu
7 % ^{240}Pu



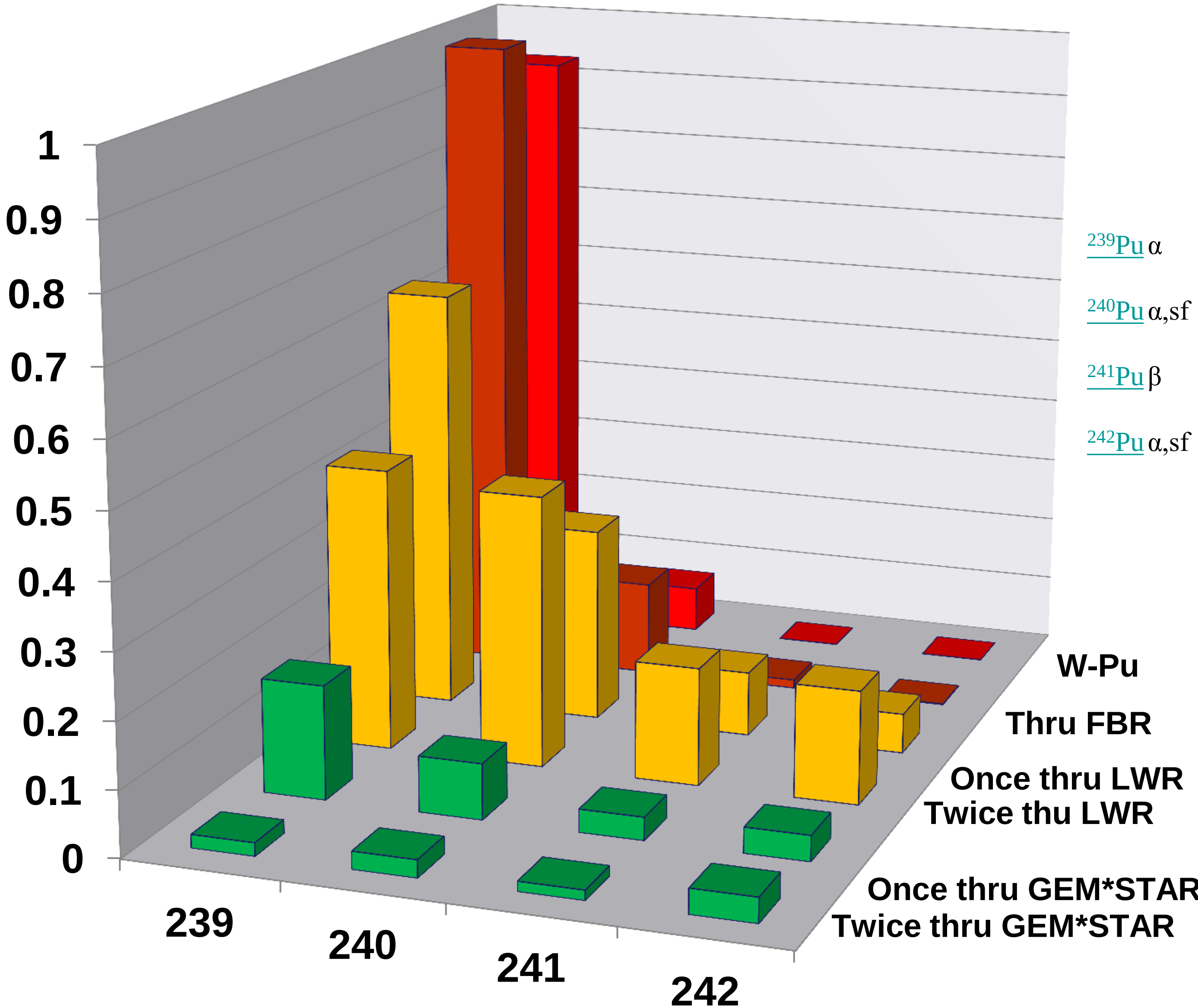
Fission power 500 MWt

Hourly overflow:
7.5 g as PuF_3 +
carrier salt +
22.5 g of fission product

Non-weapons Pu Outflow:
52.4 % ^{239}Pu
25.4 % ^{240}Pu
10.6 % ^{241}Pu
11.7 % ^{242}Pu

W-Pu transformed to permanent non-weapons Pu immediately upon adding and mixing

FB BN800 MOX-LWR GEM*STAR

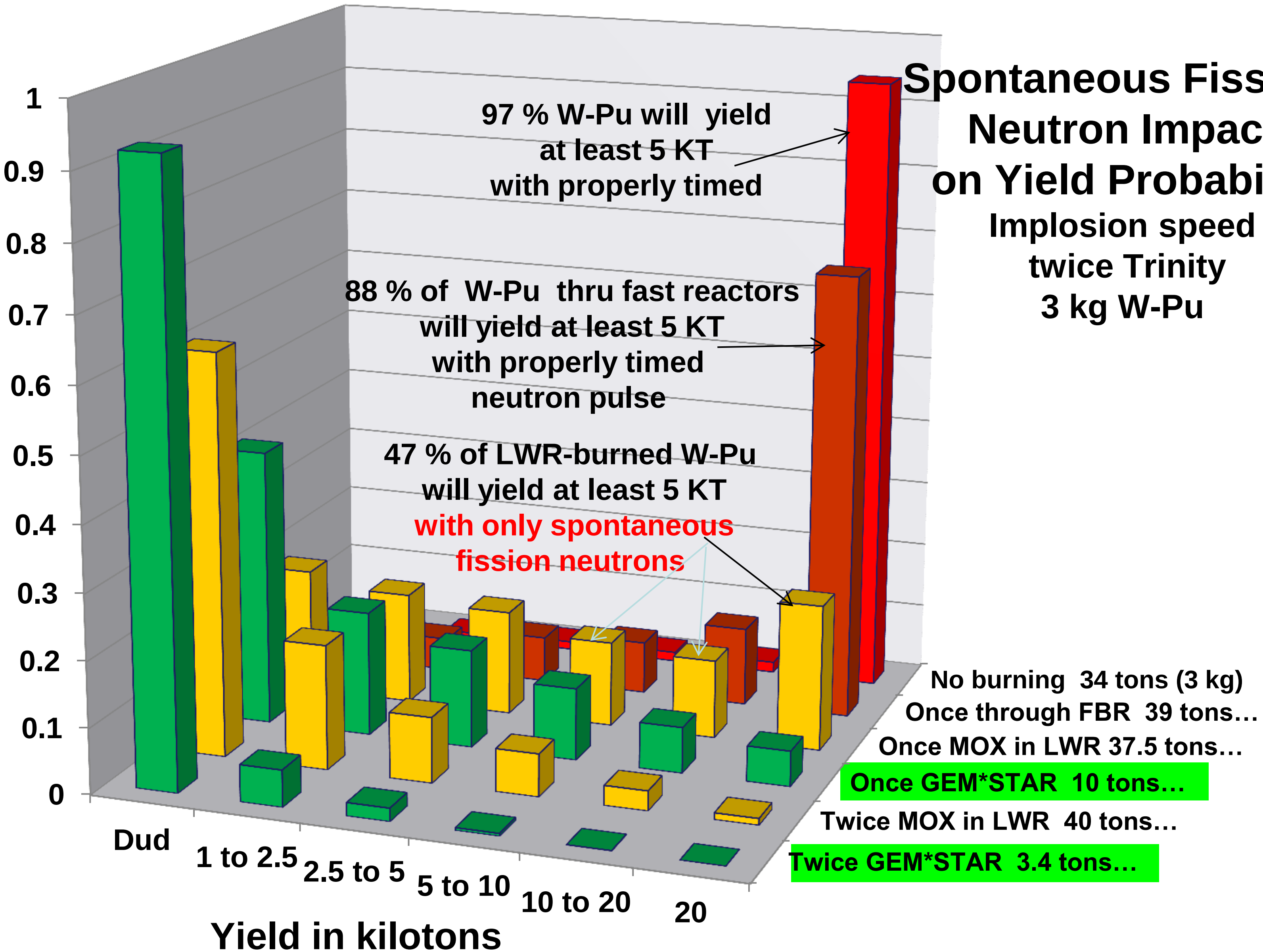


^{239}Pu	α	24,110 years
^{240}Pu	α,sf	6,561 years
^{241}Pu	β	14.325 years
^{242}Pu	α,sf	373,300 years

GEM*STAR Consortium

Spontaneous Fission Neutron Impact on Yield Probability

Implosion speed
twice Trinity
3 kg W-Pu



GEM*STAR

Benefits of GEM*STAR for W-Pu

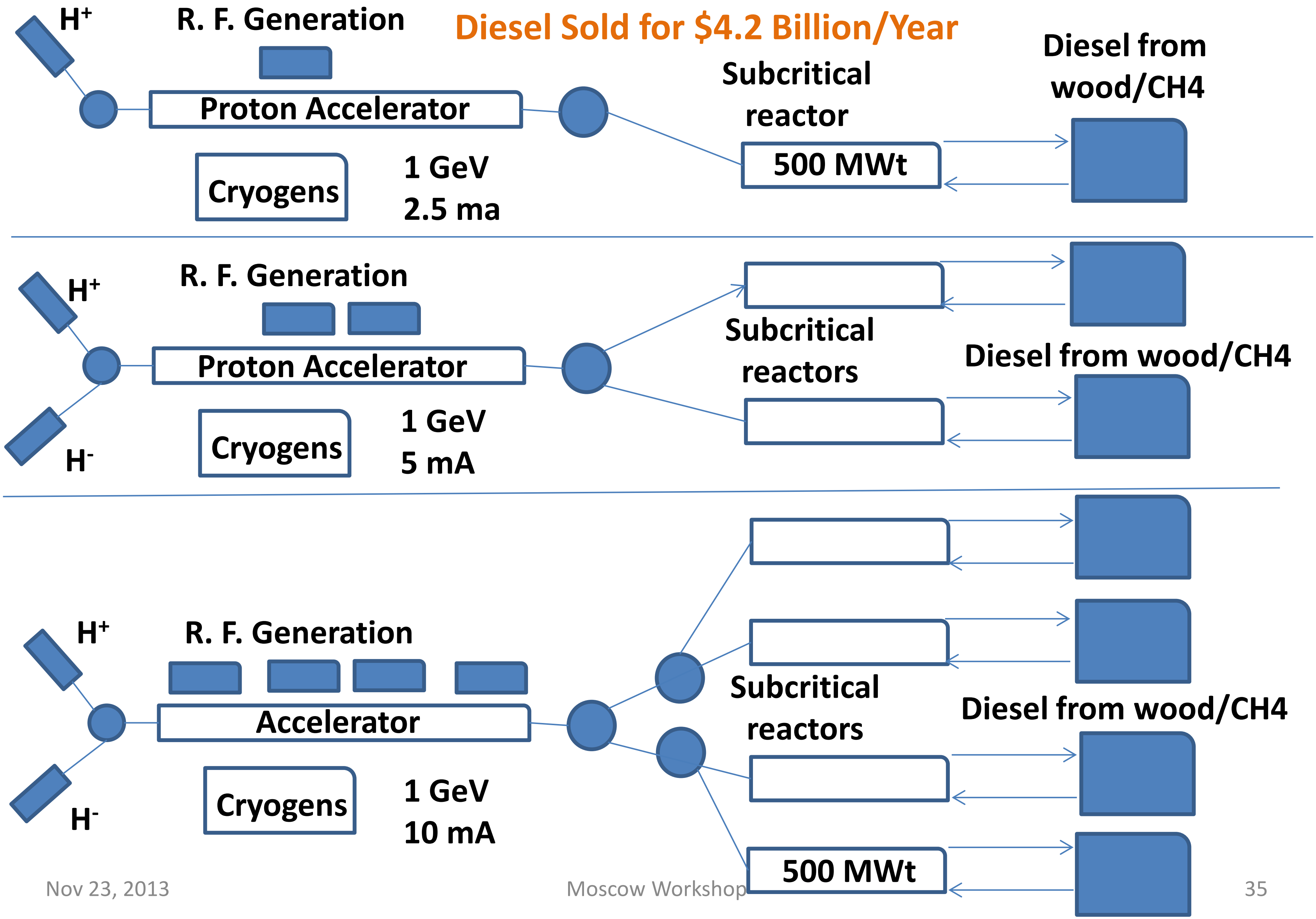
Burned W-Pu never useful for weapons
Burned W-Pu never decays to back to weapons useful material
Conversion to non-W-Pu in minutes
Pu isotopic mixture can be reduced from 34 tons to 0.2 tons if desired
Also converts C-Pu to-non-weapons-useful material
Never requires a critical mass so no control rods
No reprocessing or enrichment required
No conversion to MOX; simple conversion of Pu metal and PuO_2 to PuF_3
Fission energy converted to diesel and sold as green fuel to DOD
No stored large volatile fission product inventory as in LWRs (Fukushima)
Liquid fuel moved by He pressure; no radiation exposure to humans
No pressure vessel
Passive recovery from loss of coolant (LOCA)

Eliminating problems
avoids the need for
Defense in Depth

W-Pu Burned for Diesel in Three Const. Stages; 34 Tons Burned in 30 Years

350,000,000; 700,000,000; 1400,000,000 Gal/Year

Diesel Sold for $4.2 Billion/Year



Schedules

ADNA-Muons for W-Pu

Time	***ADNA-Muons for W-Pu***
2014	**$25M invested for Conceptual Design Report (CDR)**
2015	
2016	**$CDR complete - $500M invested for W-Pu demo**
2017	
2018	
2019	**W-Pu demo on line: Los Alamos?**
2020	
2021	
2022	**W-Pu first plant: Savannah River**
2023	**(Also first LWR spent fuel burner on line)**
2024	**(Also first natural uranium burner on line)**
2025	**W-Pu second plant: Carlsbad, NM?**
2026	
2027	
2028	**W-Pu third plant: Amarillo, TX?**

A Perfect Storm of Opportunities?

- US Plan to use MOX plant and LWRs
  - SRS Plant overspent: $2B -> $5B -> asking for $2B more,
  - No LWR ready to accept w-Pu MOX fuel =>
  - Obama MOX budget on hold while alternatives examined
    - May be opportunity to redirect SRS MOX effort to GEM*STAR
- Pressure to Eliminate w-Pu
  - Opportunity for Lavrov and Kerry to extend cooperation
  - First Syrian chemical weapons , then really address
  - 2000 Plutonium Management and Disposition Agreement
    - (DOE Secretary Moniz was major proponent of PMDA)
- US DOD potential interest
  - Navy adds nuclear power expertise, and location for demo
  - Solves Navy long-range synthetic fuel need