GEM*STAR Demonstration Subcritical Reactor for Los Alamos County

to

Environmental Sustainability Board
County of Los Alamos
February 16, 2017

from

Charles D. Bowman, President
ADNA Corporation
Accelerator Driven Neutron Applications
Los Alamos, NM
Formed February 1997

Proposal to Los Alamos National Laboratory

from

ADNA Corporation

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Los Alamos, NM

Formed February 1997

for

LANSCE Beam Servicing Three NNSA/DOD Needs:

New Start tritium requirement

Demo W-Pu burning upholding U. S. Russia Treaty

100 % renewable diesel for the DOD

ADNA Corporation Proposal

Tritium production for New Start stockpile support (600 g/y)

Demonstration **for burning 34 tons of W-Pu required by U. S.- Russian treaty at no cost to NNSA (50 kg/year)**

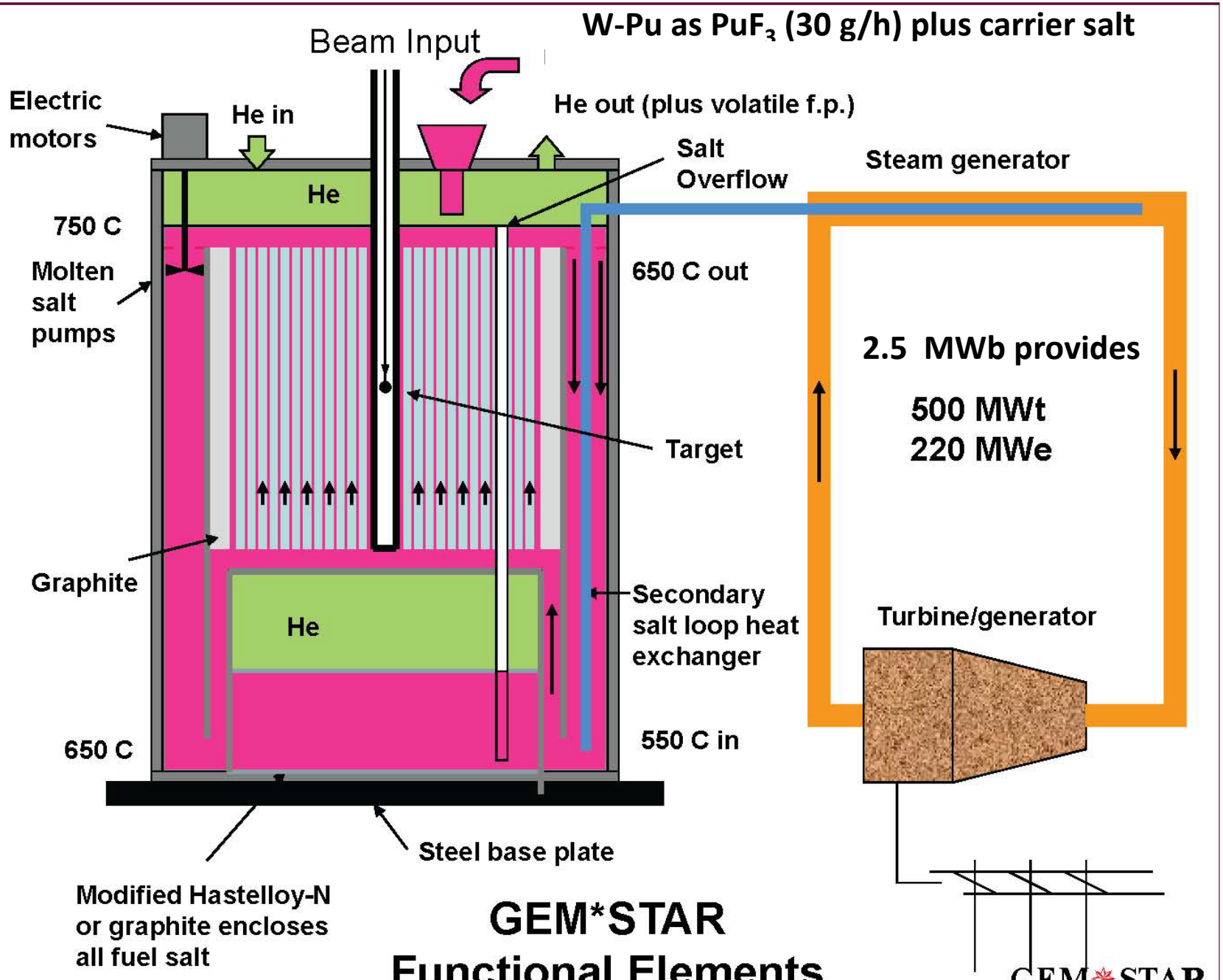
Production of 75 million gallons per year of 100% renewable diesel from byproduct cellulosic materials (wood refuse)

Thirty years of LANSCE beam to ADNA with all current LANSCE programs continuing

ADNA capital into LANL TA-53 $280 million with 20 % from Investors and an 80 % small business loan at 6 % over 30 years

No *capital* cost from NNSA for tritium or W-Pu burning capability

Five percent of private investment already committed placing a present value on ADNA Corporation of $12.5 million


W-Pu as PuF_3 (30 g/h) plus carrier salt
Beam Input
Electric motors
He in
He out (plus volatile f.p.)
Salt Overflow
Steam generator
He
750 C
Molten salt pumps
650 C out
2.5 MWb provides
500 MWt
220 MWe
Target
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

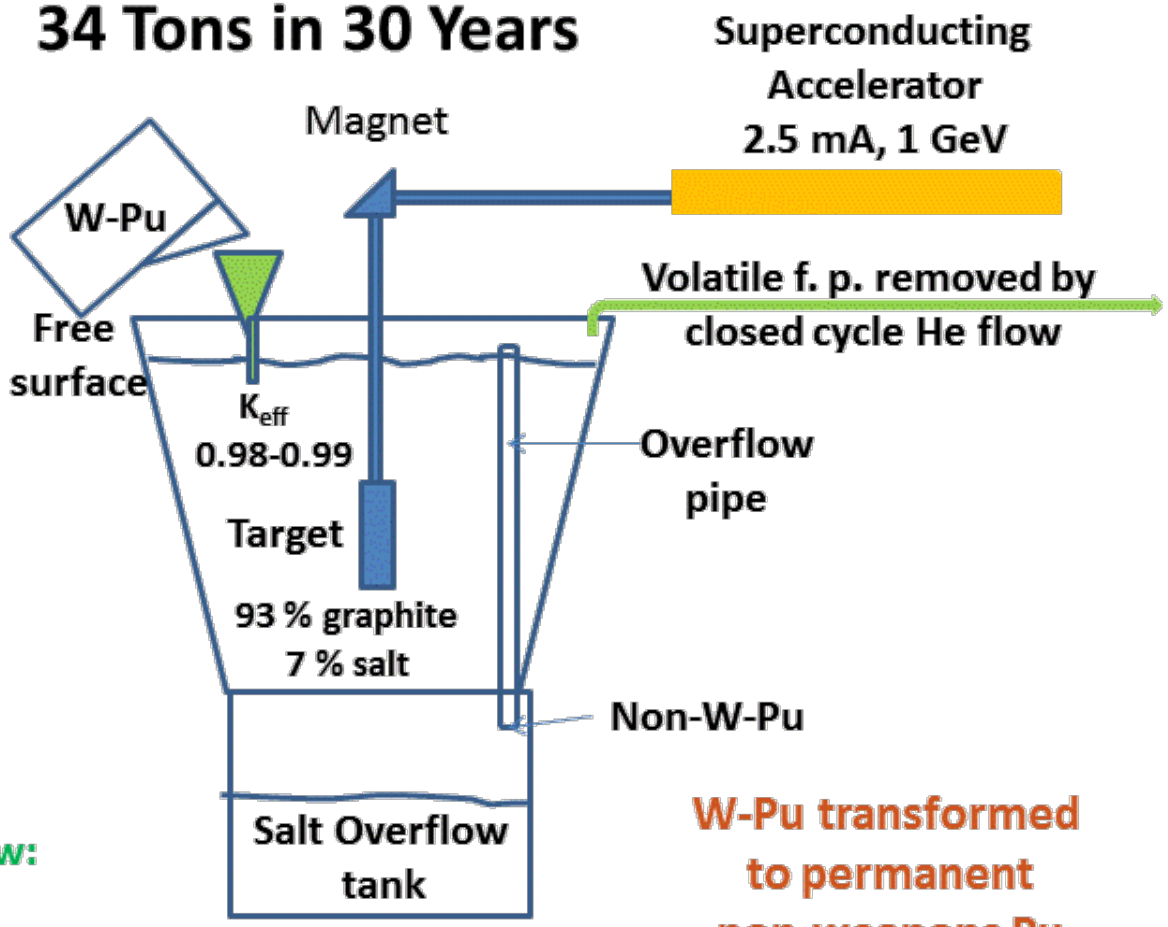
GEM*STAR Burns W-Pu Without U or Th

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



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

Fission power 500 MWt
Requires four units like this
driven by one 10 mA accelerator

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

ADNA Corporation Advances and Implementations 1997 to 2016

Molten salt continuous flow*

Vector graphite for higher moderator performance*

Indirect spallation target*

- **Lower proton energy with same neutron efficiency**
- **More efficient target cooling**
- **Much longer target life**

Cellulosic biomass to 100 % renewable diesel*

UF_4 fuel and viability of unlimited ocean uranium*

^7Li isotopic separation by centrifugation*

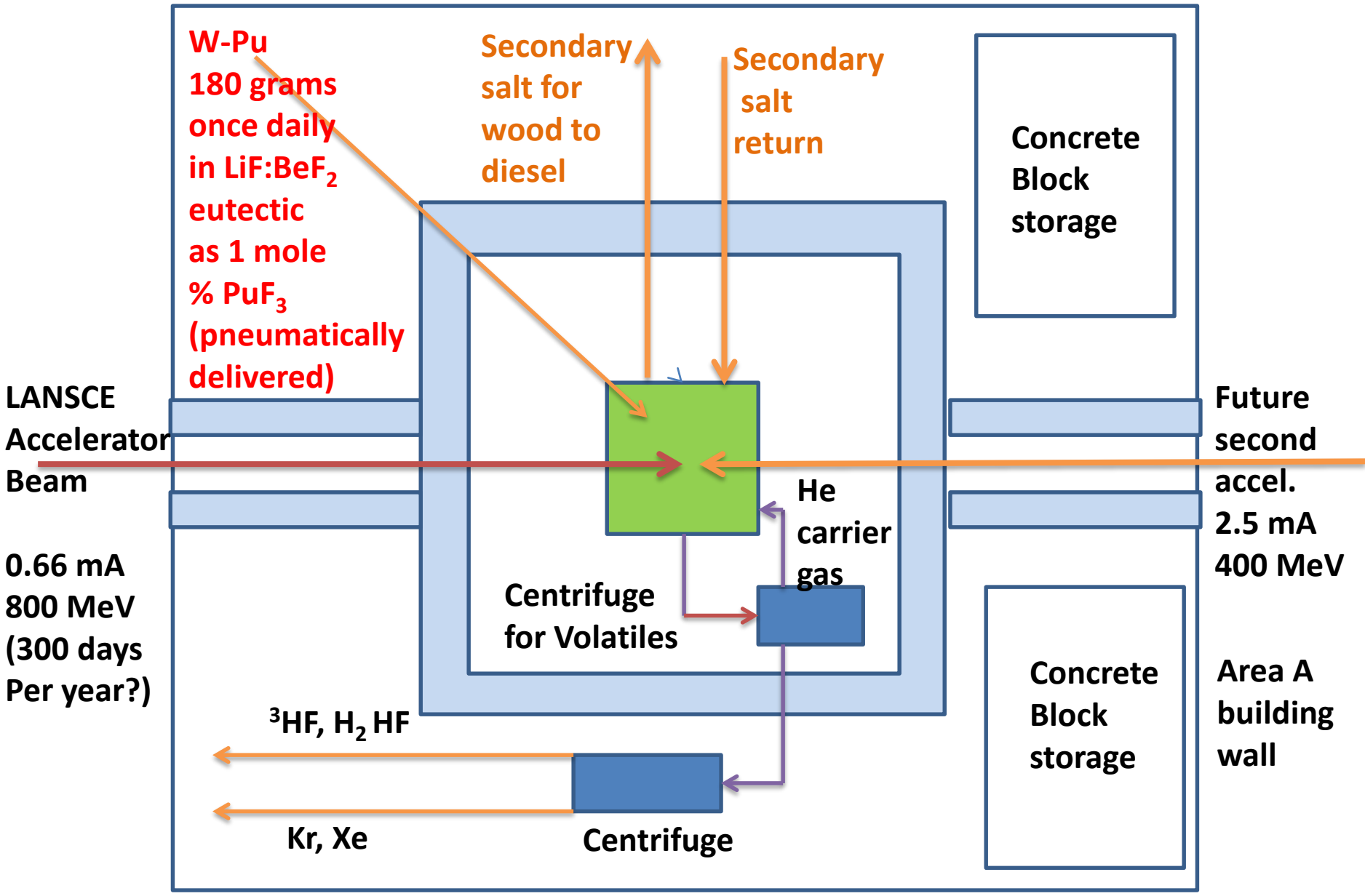
Superconducting accelerator gradient to 10 MeV/m

Doubling efficiency of r. f. power generation

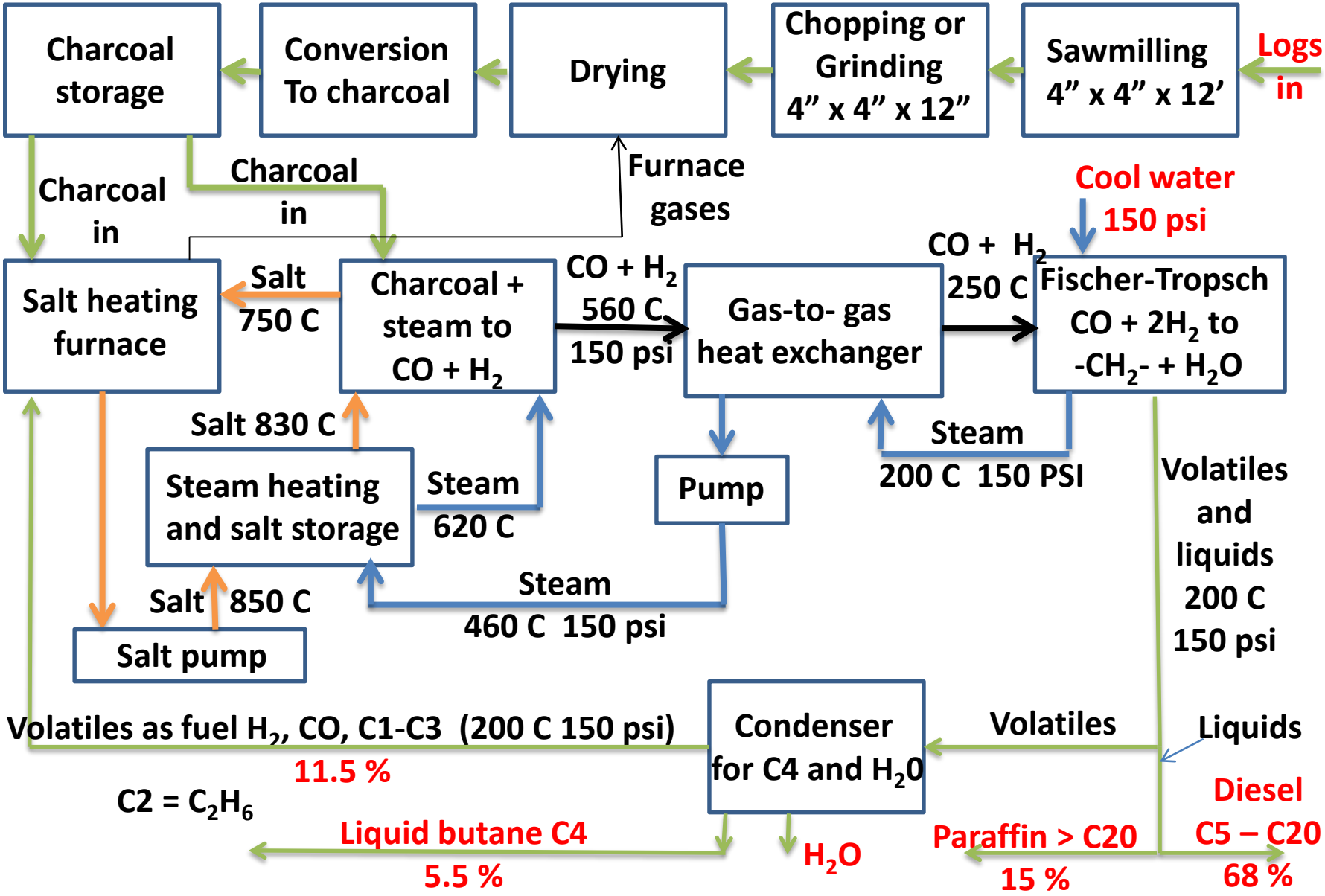
*** ADNA Patents in Process**

ADNA's GEM*STAR Subcritical Demo 125 MWt

75 million gal. diesel/year + 600 grams tritium/year



Wood to 100 % Renewable Liquid Fuels



ADNA's GEM*STAR Demo Economics

Demo Income

75 million gal/y of renew. diesel @ $2.50/gal	$188 million
600 grams per year of tritium @ $30k/gram	18 million
Total	$206 million

Demo Operations

Labor costs for reactor and diesel	
Average $83.00/hr for 150 workers 2000 hr/y	25 million
Loan repayment $232 million @6% for 12 years	26
Wood input for 75 million g/y diesel	65
$0.43/gallon wood delivery price	
$0.43/gallon wood processing price	
NM Gross Receipts tax @ 7.5 % on ADNA Corp.	15
Total	$131 million

Net $75 million/year

GEM*STAR at LANSCE Economics If W-Pu Unavailable

Adjustment: Use natural uranium fuel instead

Agreement: if NNSA provides no W-Pu, the $55 million is not due

Requires : 0.1 tons ^{7}Li per year at 0.999 isotopic purity	**$ 1.0 M**
Consumes: 3.7 tons per year of natural UF4	**0.5**
Eliminates: Cost of W-Pu 10 million/year eliminated	**10.**

Result: Production rate and cost of 100 % renewable diesel about the same as with burning W-Pu

Loss: Tritium production and sale to NNSA

Gross income from diesel	**$188**
Operations costs	**143**
Annual return on a $58 million investment	**$ 45 million**
With P/E ratio of 15, ADNA Corp. value in 2022	**$675 million**

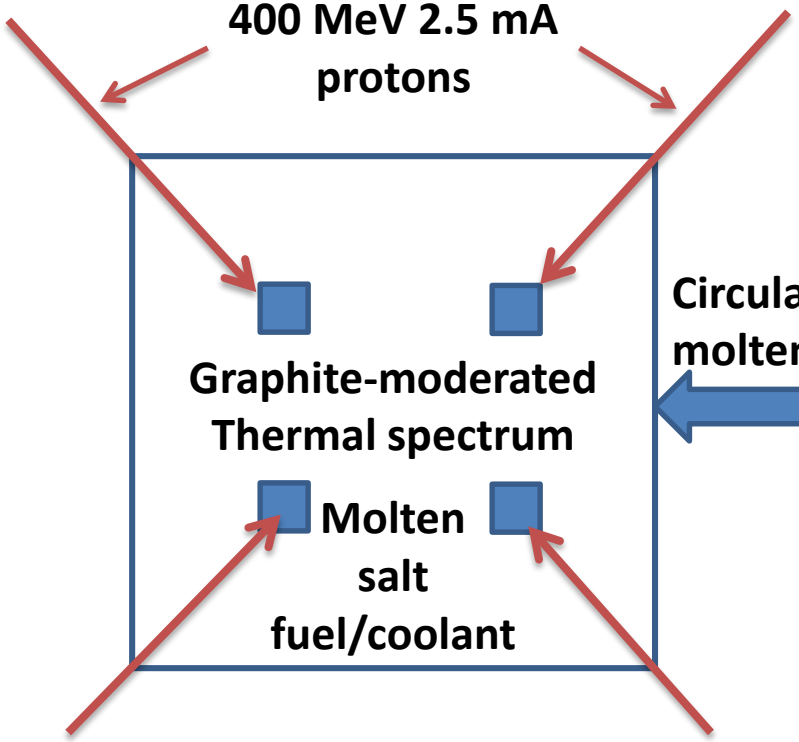
For Private investor:

ADNA Corp. investment at LANSCE remains attractive even if W-Pu is not made available for tritium production

Standard GEM*STAR Module at 500 MWt

With four super conducting proton accelerators and four targets

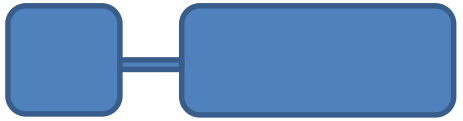
Same graphite reactor size as at LANSCE



220 MWe

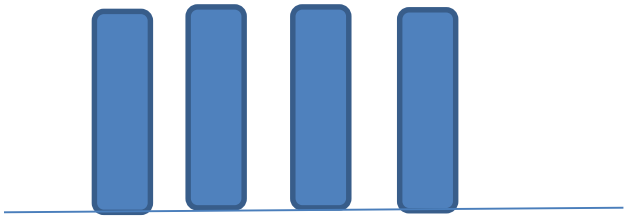
<u>$96 million/year gross</u>

@ 6 cents/kwh



Circulating molten salt

Or



<u>LANSCE Accelerator</u>

800 MeV
1 MeV/meter
1000 meter length
0.8 MW beam power
15 % bussbar to beam

<u>GEM*STAR accelerator</u>

400 MeV
10 MeV/meter
50 meter length
1.0 MW beam power each
50 % bussbar to beam

300 million gal./year diesel

100 % renewable

<u>$750 million/year gross</u>

@ $2.50 per gallon

GEM*STAR W-Pu Burning at TA-21

Subcritical core same size as LANSCE Demo
Four accelerators for 2.5 mA protons at 400 MeV
Total accelerator power 8 MWe
Fission power 500 MWt (about 1/8 of a new LWR)
Tons of W-Pu burned in 40 years is 8.5 tons
Forest fire wood input per year 5.1 million tons
from 200,000 burned acres
Western forests burned per year 130 million acres
Remnant charred logs per year 3 billion tons
300 million gallons of diesel per year selling for $2.50/gal
Gross receipts tax of $56 million on $750 millions sales
600 employees at TA-21
1000 employees in northern NM forests
With enriched ^{7}Li, tritium recovery low and uneconomic

W-Pu Burning Options

	LANSCE 66 % of beam 125 MWt	Green field initial 125 MWt	Green field expanded 500 MWt
Capital			
Investment	$ 56	$101	$129
Loan 6%, 12 years	$224	$404	$516
Total	$280 million	$505 million	$645 million
Income			
diesel	$188 million/y	$188 million/y	$750 million/y
W-Pu (50 Kg/y)	00	00	00
tritium (600 g/y)	18	18	72 (2400 g/y)
Total*	$206 million/y	$206 million/y	$822 million/y
Operations costs	$124 million/y	$150 million/y	$600 million/y
Net income	$ 82 million/y	$ 56 million/y	$222 million/y
Ann. Net/Investment	1.5	0.55	0.97
Value P/E ratio of 15#	$1.2 billion	$0.84 billion	$3.3 billion
Value/Invest. (5 years)	21	8	14

***100 % renewable diesel @ $2.50/gal; Tritium @ $30,000/g;**

 # After 5 years 2022

GEM*STAR Cost Components for W-Pu Burning

Elements	LANSCE 125 MWt	Green Field Phase I 125 MWt	Green Field Phase II Add. 500 MWt
Building cost	$ 000 million	$75 million	$ 25 million
Accelerator cost	000	150	450
Reactor cost	130	130	70
Diesel facility cost	150	150	450
Capital total	$280 million	$505 million	$995 million
Annual operating costs			
^{7}LiF	$ 1 million	$ 1 million	$ 4 million
W-Pu (PuF_3)	10	10	20
Labor	25	35	75
Gross receipts tax 7.5 %	20	20	65
Accelerator beam	30	0	0
Area A building and infra.	15	0	0
Debt retirement 6 % 30 years	16	26	63
Electricity	0	3	9
Byproduct wood	65	65	260
Operation total	$182 million	$160 million	$496 million

GEM*STAR Burn-up of 34 tons of W-Pu for Diesel

LANSCE Burn-up Demo
50 kg/y, 75 M gal./y and Start II tritium

LANL
Area TA-21
200 kg/y 300 M gal/y

SRS
Aiken /SC
200 kg/y, 300 M gal./y

Residual salt
12 % ^{242}Pu
retained by
ADNA Corp.
for
future reburn

ORNL
Oak Ridge, TN
200 kg/y, 300 M gal/y

Hanford
Tri Cities, WA
200 kg/y, 300 M gal./y

INEL
Idaho Falls, ID
200/kx/y, 300 M gal/y

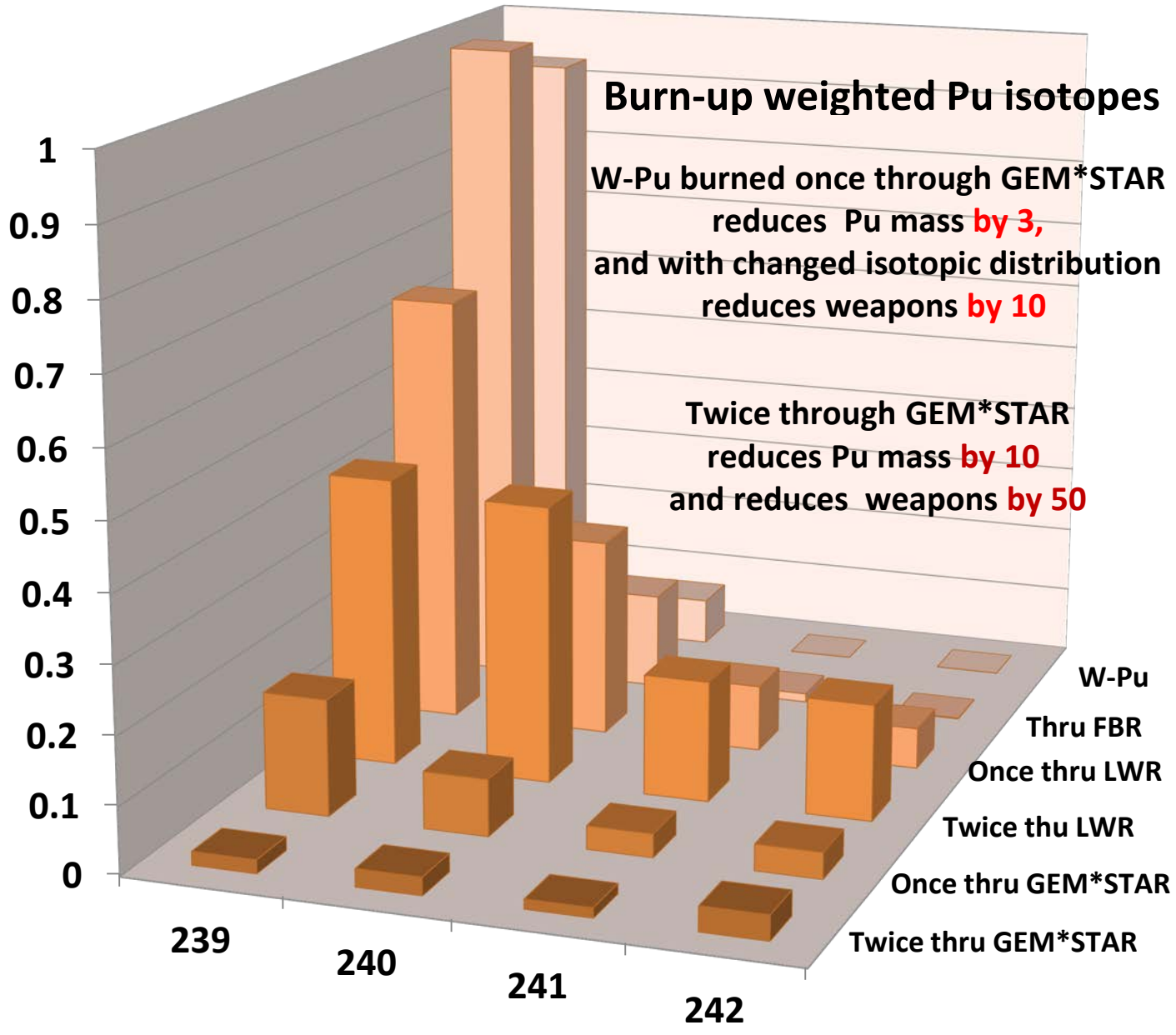
Life cycle

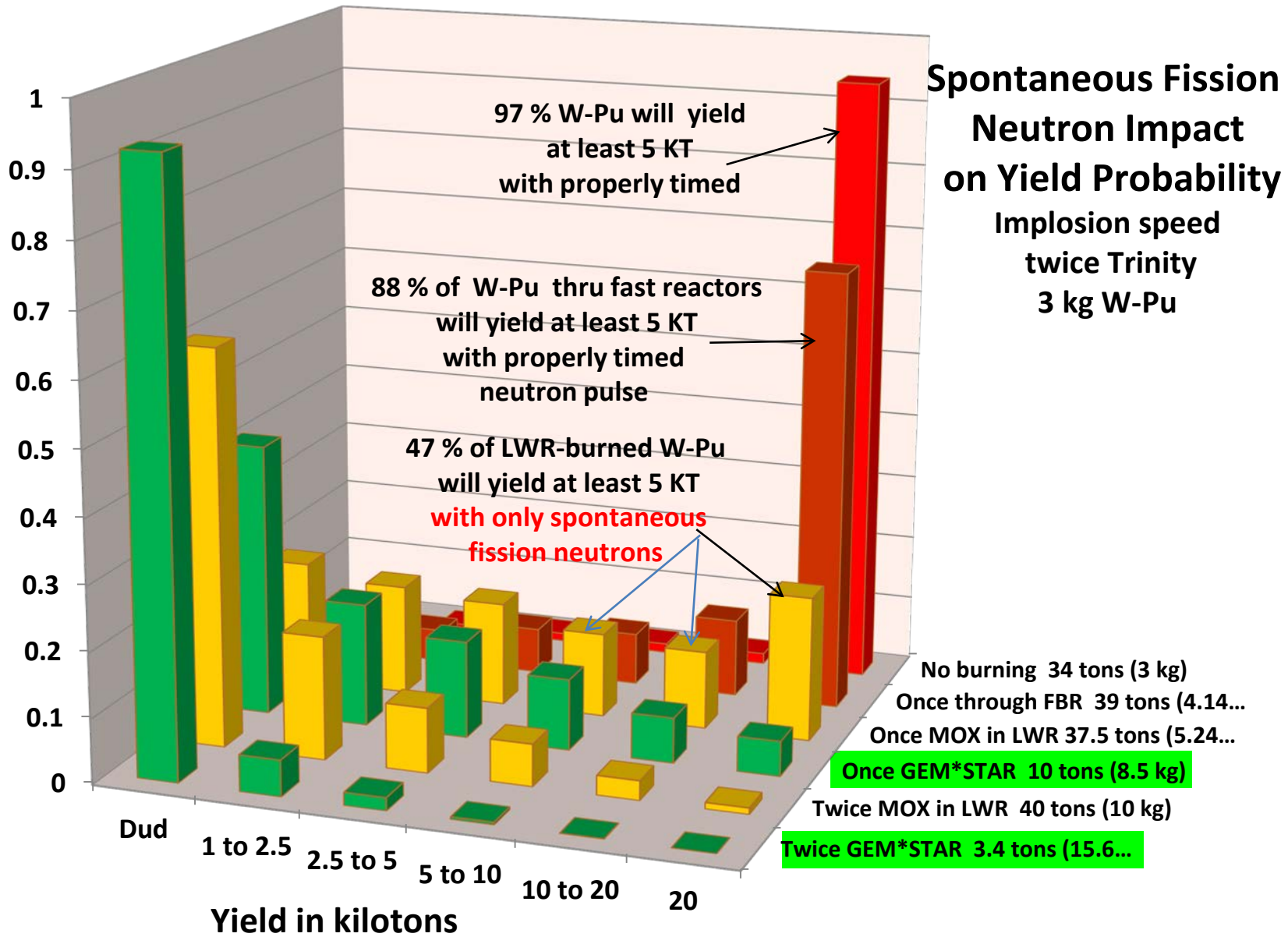
34 tons W-Pu burned in 34 years; Diesel selling for $122 B;
Start II tritium; 5000 new ADNA jobs

Where is ADNA Corporation Headed with GEM*STAR

Demo of W-Pu burning at LANSCE for 600 g/y tritium for NNSA and 75 million gal/y of 100% renewable diesel for the DOD	2022
Eight standard 500-MWt GEM*STAR units each burning 200 kg/y of W-Pu at DOE/DOD green field sites for a total of 2.4 billion gal/y of 100 % renewable diesel for the DOD. 34 tons burned in 21 years	2027
NRC licensing for GEM*STAR for diesel sale into the commercial sector	2028
Operation of the first GEM*STAR on the site of a closed LWR at 500 MWt burning natural UF_4 for 300 million gal/y	2029
Beginning conversion of LWR spent fuel from oxide to fluoride salt at the modified SRS MOX plant	2030
Operation of the first GEM*STAR for burning LWR spent fuel on an existing LWR site	2031
Completing the burning of 100,000 tons of U. S. LWR spent fuel in 600 GEM*STARs for 180 billion gal/y of 100 % renewable diesel and gasoline (all of U. S. liquid fuel consumption) from byproduct biomass	2071

Other potential GEM*STAR fuels include naval reactor spent fuel, ocean uranium, depleted uranium, and thorium


Burn-up weighted Pu isotopes
W-Pu burned once through GEM*STAR
reduces Pu mass by 3,
and with changed isotopic distribution
reduces weapons by 10
Twice through GEM*STAR
reduces Pu mass by 10
and reduces weapons by 50
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
239
240
241
242
W-Pu
Thru FBR
Once thru LWR
Twice thu LWR
Once thru GEM*STAR
Twice thru GEM*STAR


Spontaneous Fission Neutron Impact on Yield Probability
Implosion speed twice Trinity
3 kg W-Pu
97 % W-Pu will yield at least 5 KT with properly timed
88 % of W-Pu thru fast reactors will yield at least 5 KT with properly timed neutron pulse
47 % of LWR-burned W-Pu will yield at least 5 KT with only spontaneous fission neutrons
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Dud
1 to 2.5
2.5 to 5
5 to 10
10 to 20
20
Yield in kilotons
No burning 34 tons (3 kg)
Once through FBR 39 tons (4.14…
Once MOX in LWR 37.5 tons (5.24…
Once GEM*STAR 10 tons (8.5 kg)
Twice MOX in LWR 40 tons (10 kg)
Twice GEM*STAR 3.4 tons (15.6…

LANL-NNSA-DOD Benefits from LANSCE Accelerator

NNSA life-cycle cost for burning 34 tons of W-Pu

In commercial LWR using SRS- MOX	**$50 billion**
No-burning storage at WIPP	**$17 billion**
ADNA Corporation	**$00 billion**

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After 5 years 2022