ADEPT

Innovative Tool to Reduce Worker Exposure

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IAEA
International Atomic Energy Agency
Atoms for Peace and Development

Outline

- **S**ource **T**erm **M**onitoring (**STM**) Program at CANDU Plants
- Outage Radiation Fields & Simulations
- **A**dvanced **D**ose **E**xposure **P**lanning **T**ool (ADEPT)
- Application of ADEPT

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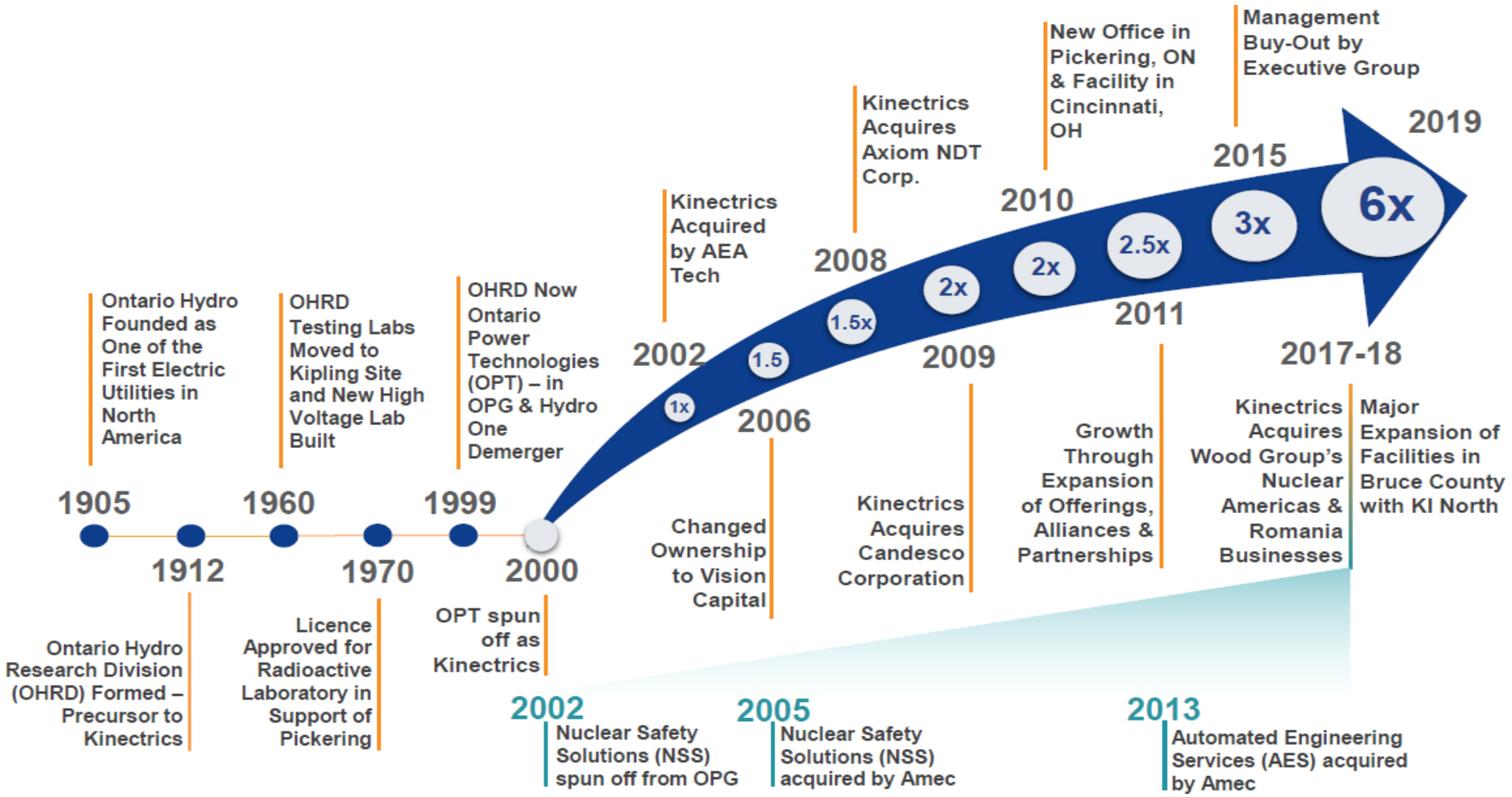
Kinectrics Company: History of Growth



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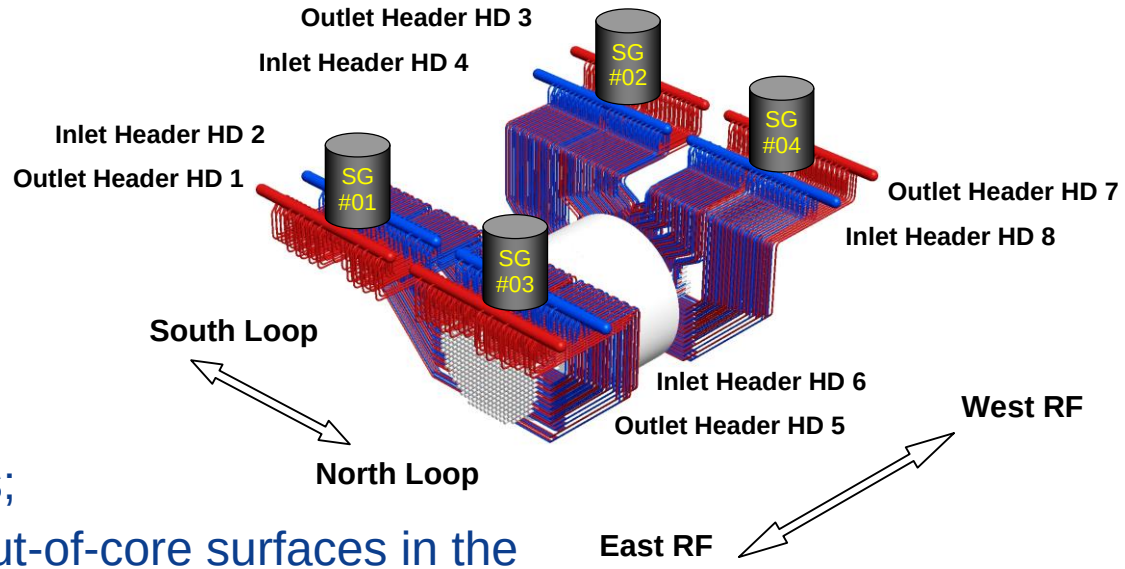
Background: CANDU Reactor Unit



CANDU Reactor Unit:

- 480 Fuel Channels, On-Power Refueling;
- Inspection & Maintenance Outages every 2-3 years;
- Radionuclides deposit into the magnetite layer of out-of-core surfaces in the Primary Heat Transport System (PHTS) forming the Outage Radiation Fields;
- Magnetite deposits acting as a “full-flow” purification system;
- PHTS surface area:
  - Steam Generators ~ 17,000 m^2
  - Feeders and Headers ~ 4,000 m^2 (main radiation source in the vault)
- Optimization of Radiation Protection requires detailed characterization and prediction of the outage radiation fields.

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Source Term Monitoring Program

Kinectrics routinely conducts STM for the CANDU fleet (21 Units).

Main activities include:

- **O**utage **A**ctivity **T**ransport **M**onitoring Surveys (OATM)
- Survey data integration and interpretation
- Radiation field trend analysis & predictions
- Impact analysis of unit service/operational conditions and system performance on the outage radiation fields
- Comprehensive characterization of Crud / Deposits / Reactor Artefacts

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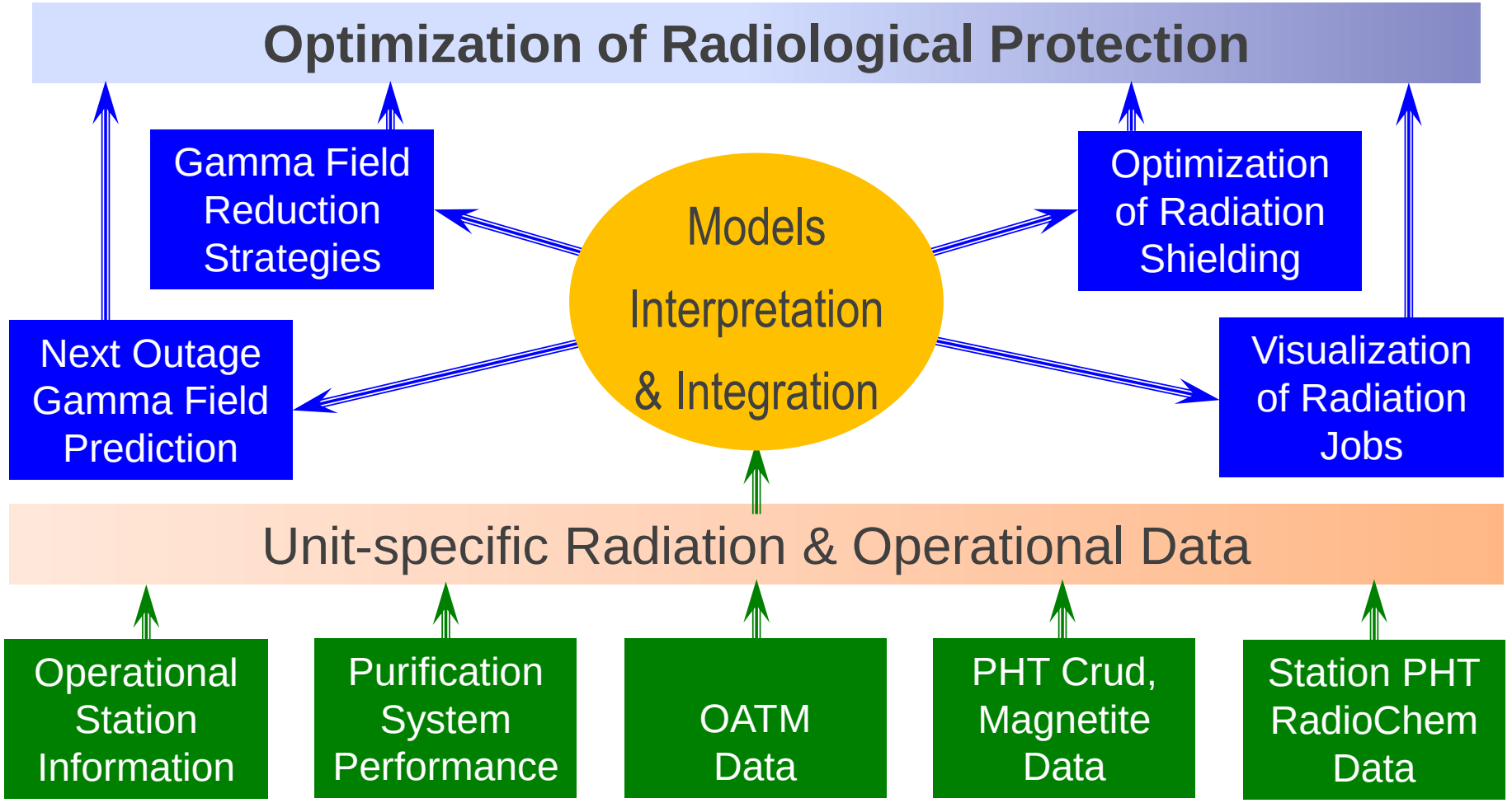
STM Methodology



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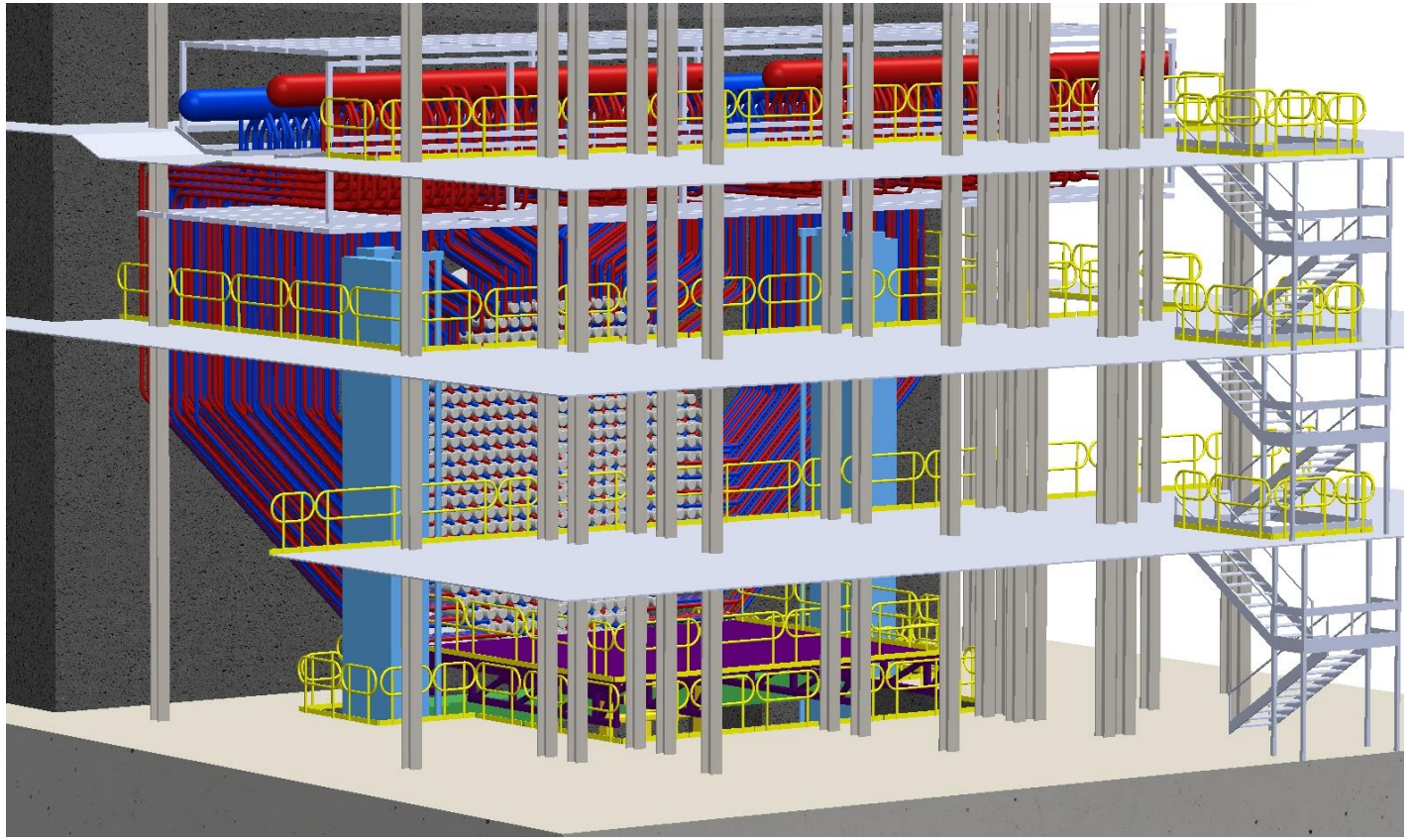
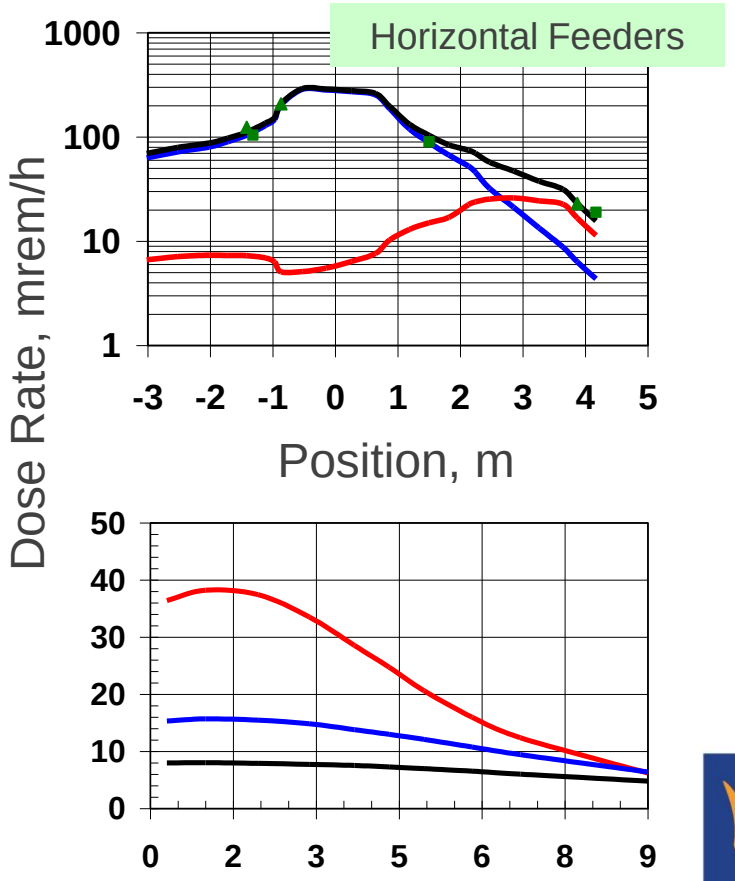
Reactor Vault Model & Radiation Fields





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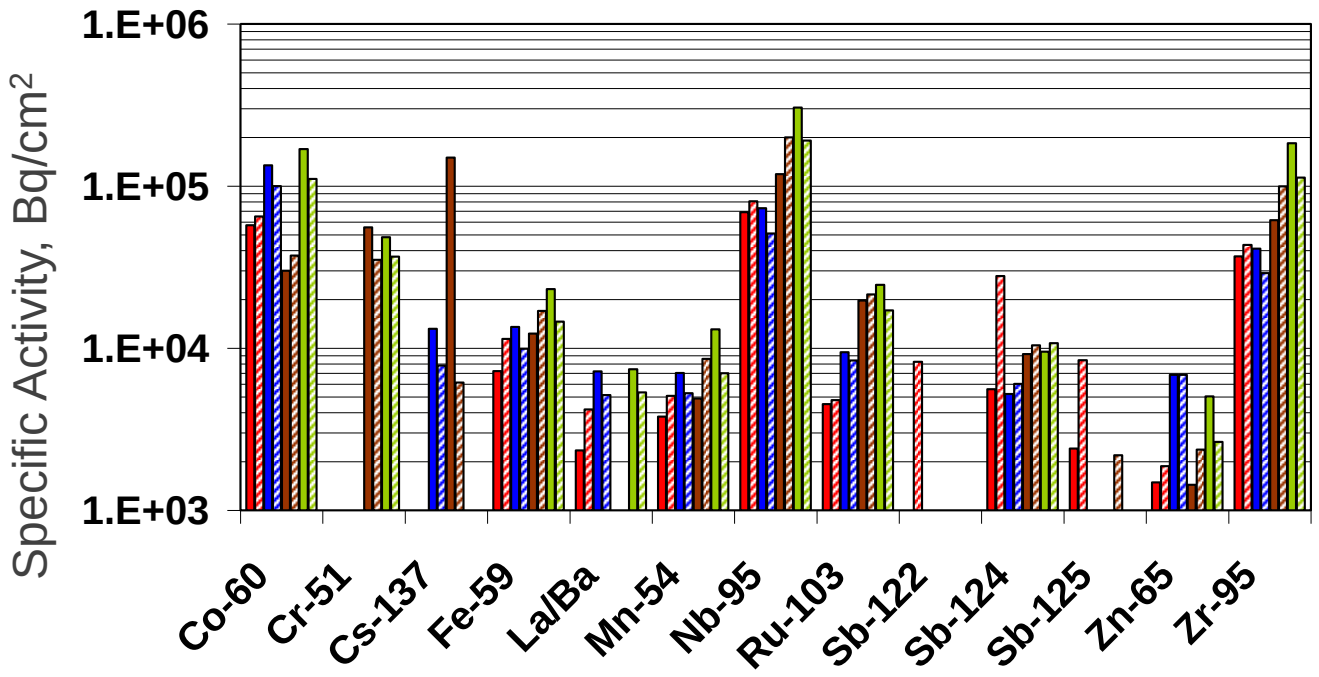
RF Dose Rate Map & Radionuclide Distributions

	North Loop												South Loop												
	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
A	110	118	125	122	128	127	139	118	105	95	98	83	93	89	100	94	105	141	162	167	175	171	169	162	A
B	112	119	129	126	131	132	140	118	105	94	98	84	96	89	101	95	109	143	165	171	175	171	172	163	B
C	111	122	131	124	117	108	100	120	104	105	91	102	104	100	89	97	91	106	110	158	176	175	180	169	C
D	111	119	135	115	103	104	129	128	120	98	119	83	102	79	106	78	89	100	114	111	159	175	180	172	D
E	106	116	115	91	87	112	91	135	90	116	85	97	84	89	135	83	69	110	78	93	103	158	170	171	E
F	107	102	99	84	96	84	117	94	99	87	110	83	104	81	232	67	67	69	95	78	94	104	139	158	F
G	96	88	97	117	101	107	79	112	79	95	82	117	89	92	123	154	62	68	65	80	72	89	100	140	G
H	96	79	101	81	118	80	96	89	105	88	109	83	103	82	96	65	58	59	62	60	77	72	92	130	H
J	95	95	95	104	90	91	76	100	79	101	88	141	150	122	107	76	62	64	60	68	62	76	85	130	J
K	87	73	123	82	105	84	100	91	100	82	106	75	105	66	119	59	60	57	64	62	79	77	79	97	K
L	72	82	86	98	84	103	84	118	78	100	79	88	73	70	61	58	55	61	59	77	62	101	73	95	L
M	76	78	115	82	103	80	110	83	91	79	94	73	86	62	67	56	59	58	69	78	89	90	92	87	M
N	76	97	97	110	87	105	87	106	79	92	75	92	71	68	59	62	57	62	62	70	69	92	70	87	N
O	81	75	119	72	106	79	108	85	104	73	98	71	77	63	62	62	67	59	93	122	107	120	104	88	O
P	73	90	86	97	87	108	93	115	86	102	75	94	69	62	60	66	61	69	63	128	63	135	76	91	P
Q	88	90	112	79	100	79	113	92	122	78	95	76	79	63	64	60	62	58	64	61	65	70	80	84	Q
R	82	101	89	94	78	113	86	113	86	105	76	89	74	66	58	62	54	57	58	65	58	74	71	93	R
S	119	77	112	70	103	74	105	92	109	72	81	74	105	57	60	53	57	53	58	54	68	66	81	115	S
T	118	97	89	102	78	125	94	129	91	112	83	104	107	82	65	66	56	62	58	68	61	74	78	125	T
U	120	84	91	69	82	72	104	80	93	91	115	95	273	81.3	65	56	55	54	69	59	79	77	84	122	U
V	109	104	66	92	63	99	80	127	95	142	1358	166	678	138	81	68	56	66	58	78	64	95	94	124	V
W	115	127	116	69	85	84	113	100	134	1156	751	393	539	2162	130	75	76	61	76	75	79	93	116	119	W
X	106	127	137	111	65	105	96	133	119	177	558	346	518	278	103	89	62	72	69	82	98	121	119	115	X
Y	89	113	127	129	129	105	143	122	255	746	486	379	2258	5116	332	88	83	66	93	89	115	113	12	103	Y
	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	

Color Coding	< 75	75 - 88	88 - 102	102 - 155	HS > 155



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Advanced **D**ose **E**xposure **P**lanning **T**ool

- Planning and Evaluation of Radiation Protection
- Procedural Training for New and Existing Staff
- Planning of Inspection and Maintenance Activities
- Pre-job Briefings and Post-job Reviews
- Benchmarking
- Support for ALARA Initiatives

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Radiation Job Simulations

- Fueling Machine Platform (Video)

- Reactor Vault (Video)

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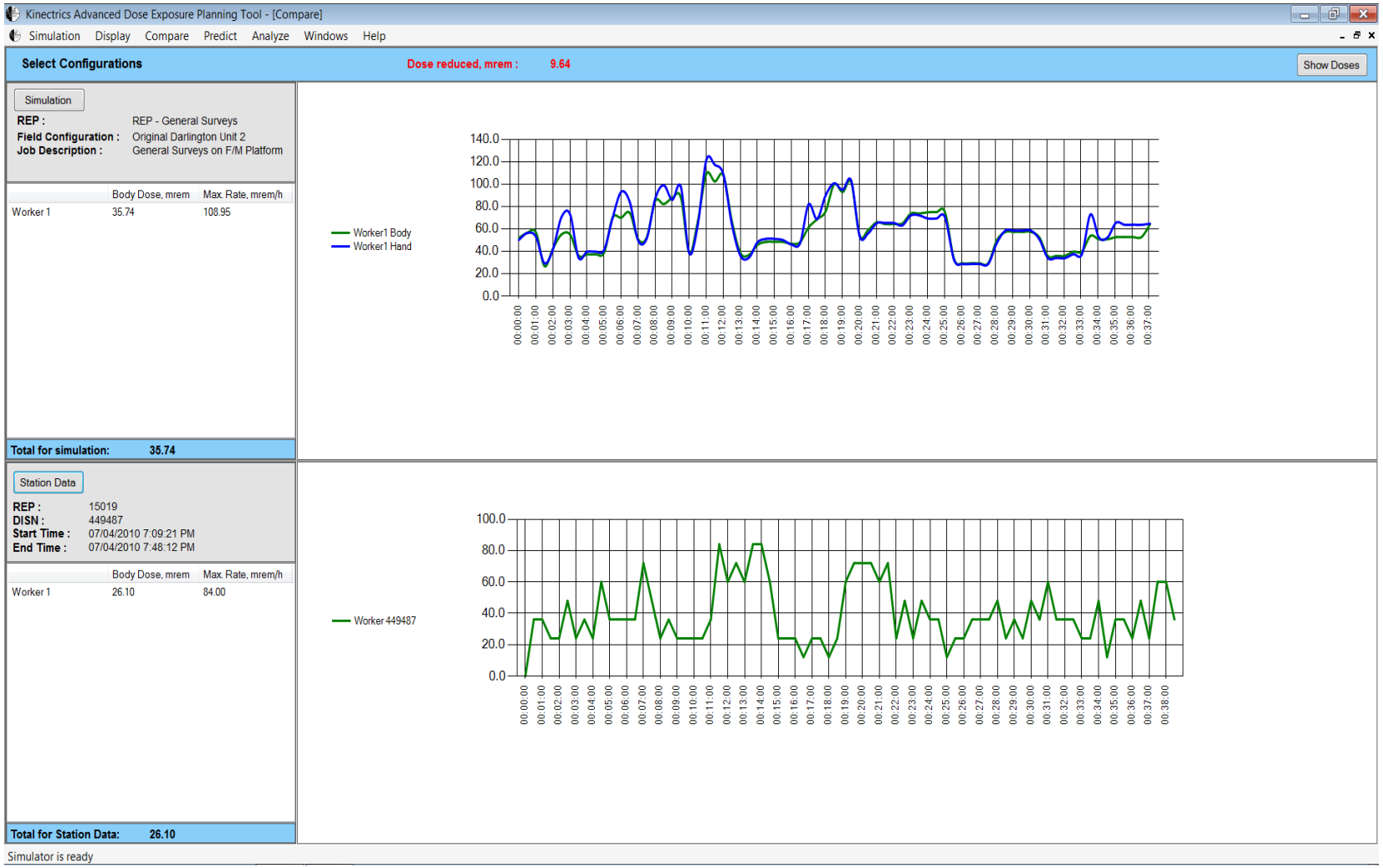
Simulations vs Station Data



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ADEPT - Interface

- OKULUS Virtual Reality
- Leap Motion

Hand Tracking Technology

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ADEPT – Key Features

- Fully customizable real-time 3D virtual reality job simulation in a CANDU reactor environment based on the OATM data
- Live display of whole body and extremity dose rates, as well as doses of simulated workers
- Recording of radioactive job procedures for future analysis
- Instant estimate of shielding option effects
- Multiple dosimeters take the accuracy of effective worker dose estimations to a new level

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ADEPT - Benefits

- Visualizes work environments for staff in great detail
- Provides options for elaborate planning to help reduce workers dose & save time on the Critical Path
- Enables an opportunity to evaluate the impact of working in different configurations and scenarios
- Demonstrates the effects of Source Term Reduction

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Questions?

Thank you for your attention

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