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Title: Progress in X-ray Simulation and Validation at High X-ray Energies

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Progress in X-ray Simulation and Validation at High X-ray Energies

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Abstract

Radiographic simulation codes are becoming increasingly popular for personnel training, inspection technique development, and improved product design. While codes are routinely validated for simple applications at low energies, validation data for higher energy applications is scant. An x-ray simulation study was conducted on a solid model of a penetrometer used to determine contrast and exposure sensitivity of x-ray film and flat panels. The simulation results are compared to actual x-ray film and flat panel images exposed in the laboratory under nearly identical conditions. We used XRSim-pro-Mev as the simulation program since it 1) is able to accept ASCII .stl files generated from most commercial CAD packages as input to the code and 2) contains attenuation values for all of the materials of interest, models of higher energy x-ray machines (450 kVp – 20 MeV), and models of commercially available films as well as a model of a Varian digital x-ray panel. To validate the simulation, test specimens were radiographed at various energies and the resulting film density or image intensity was compared to the simulation results. The simulated x-ray machine output was then adjusted to give identical results to the model and other parameters were varied.

Keywords: X-ray simulation, penetrometer, MCNPX, XRSim

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NDE at Los Alamos supports many activities:

- Maintain certification of the current stockpile
- Improve our stockpile stewardship capabilities for the future
- Rapid Response: Nuclear Incident Response Program
- Pu pit inspection is vital to US nuclear deterrent
- Conversion of HEU to Reactor Fuel
- Hydrodynamic tests
- Position open (radiography) US citizen

<http://www.hr.lanl.gov/FindJob/>

Los Alamos nuclear weapons make up 67% of the nation's active stockpile.



Why Simulate:

Competent codes now available

Limited access to parts/ one off shot

Classified part storage/ CREM

Radioactive hazardous materials

Actual tests can be expensive

Optimization and feasibility

MCNPX



ENIAC
MANIAC

...
SSC

Some of Our Favorite Simulation Codes:

	Particles	COTS	CAD import	Scatter	CT	Win	GUI
MCNPX	n,x,p...	no	TOPACT	yes	MYO*	yes	no**
XRsim	x	yes	yes	WIP	yes	yes	yes
Geant	zoo	no	no	yes	MYO	no	MYO
CIVA	RT x-ray	yes	yes	MC	?	yes	yes

Hades, Artist...

*lanl

** underdeveloped

High Energy Sources:

Sources:

> 450 kV to 22 MV

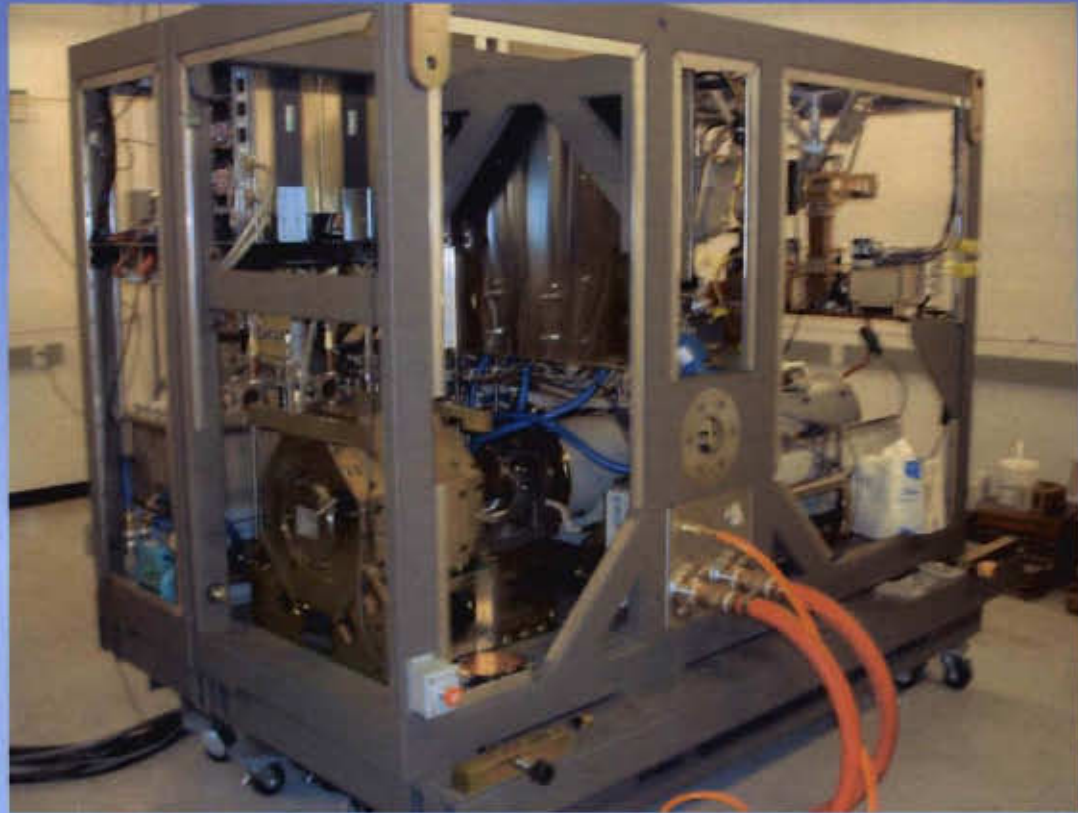
Phillips 450

Portac 2 - 6 MV

Betatrons 6 MV

Los Alamos Microtron 22 MV

Varian K15



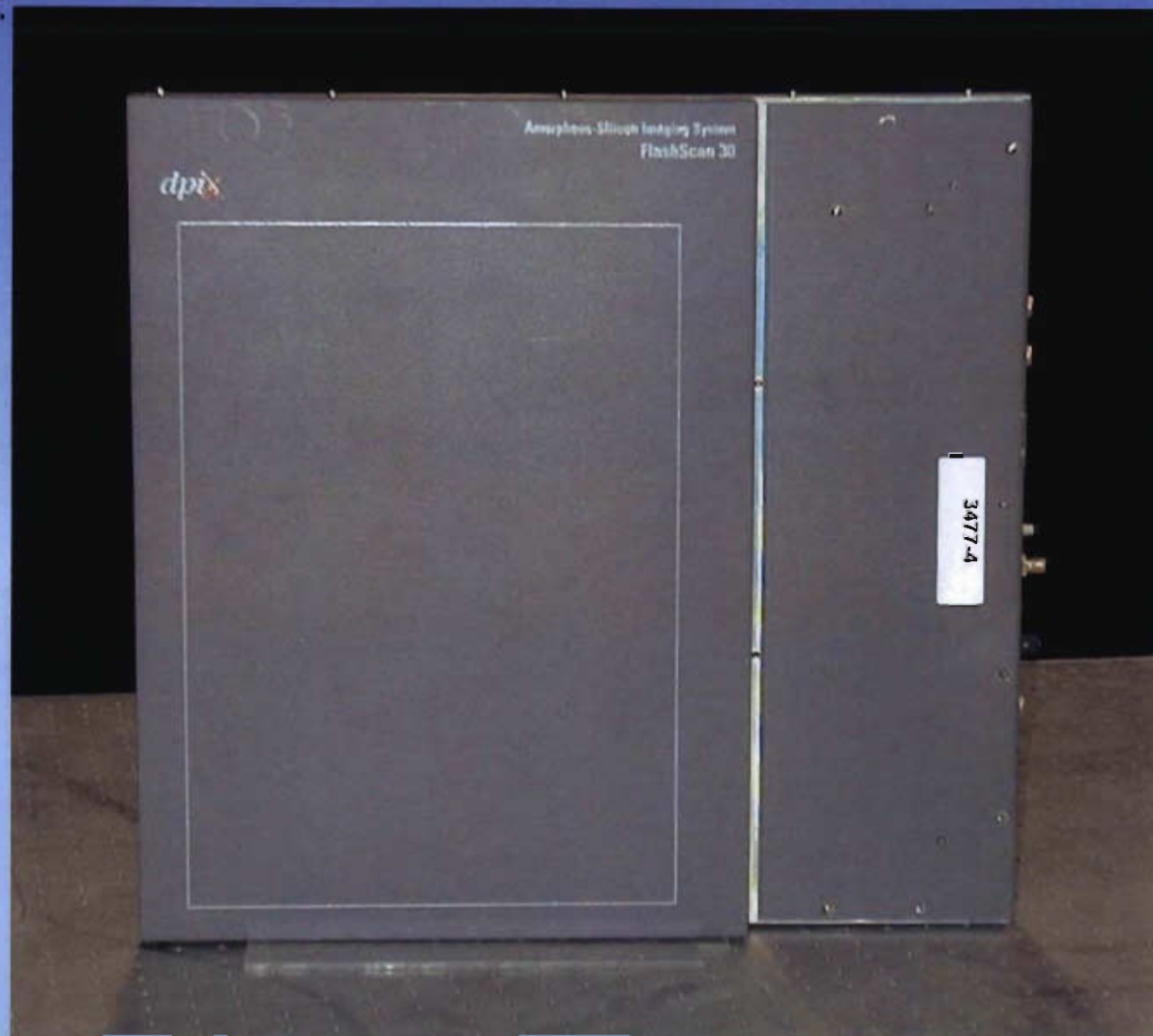
High Energy Detectors:

Films

Storage Phosphors

Cameras

Flat Panels



Our Top Issues with Simulation :

Ease of use and setup

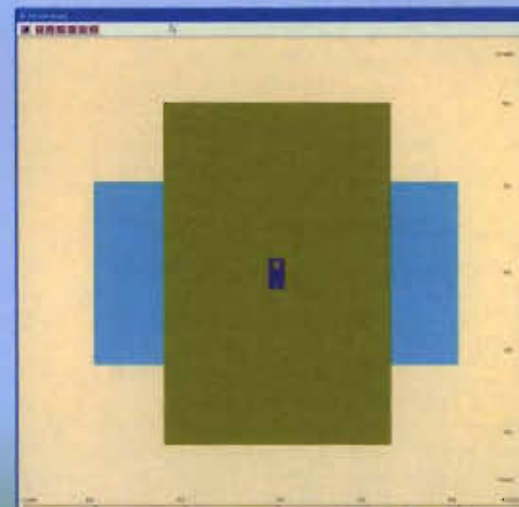
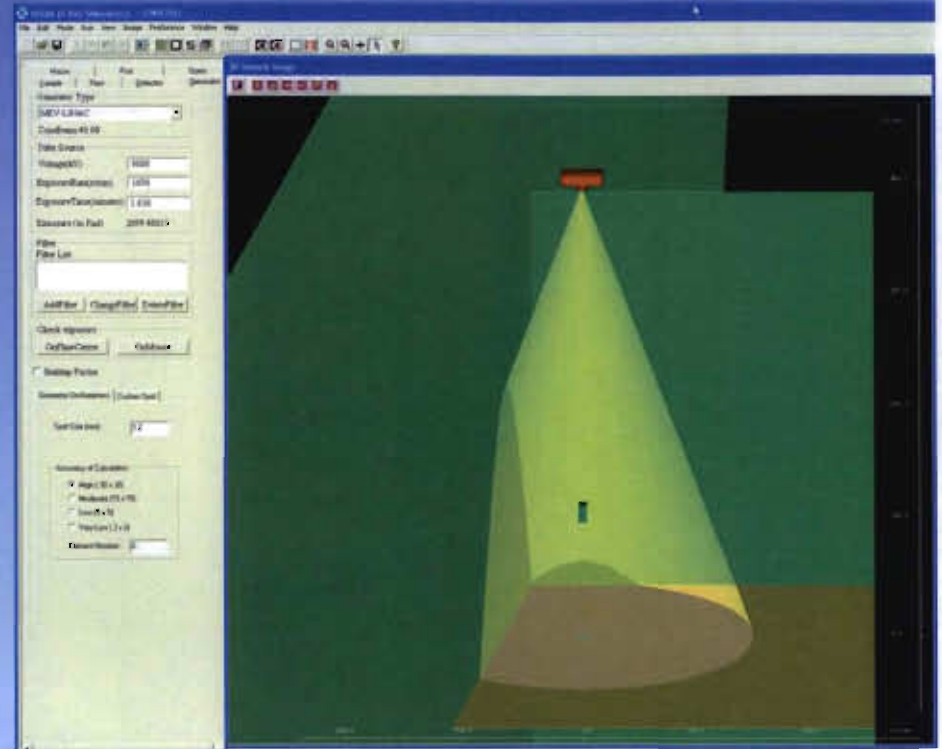
Time required from start to result

Importation of CAD models/
data base of models

Confidence in output /validation

Output type/format

Post Processing , POD etc.



Issues and improvements :

Validation (simulation results vs. real data)

XRSim – emphasis on high energy (450 kV – 20 MeV)

Improve scatter models

Expansion of x-ray source spectra models and extension to NDE-specific inspection equipment (sources, detectors), materials, components, assemblies & systems

Include digital detector models (spatial frequency response (MTF), conversion efficiency, radiation/light transport)

Include dose calculator

Recent Uses of Modeling:

XRSIM Penetrator hole detectability

Varied x-ray parameters to determine optimal settings

XRSIM Fuel Pellet Weld inspection

XRSIM dense parts inspection optimization

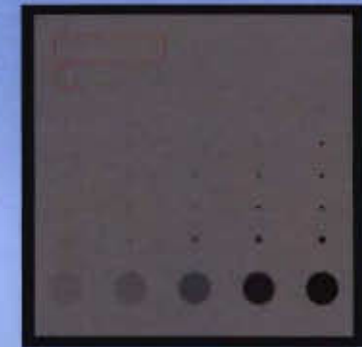
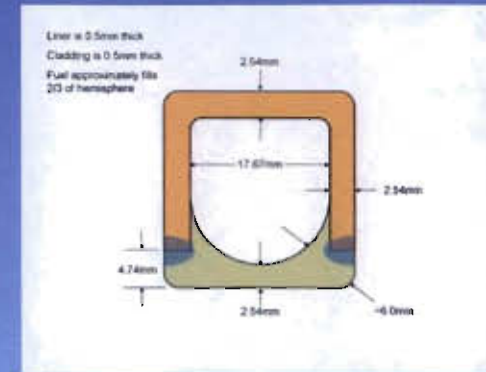
Determined inspection parameters required to detect critical flaws

MCNPX facility design

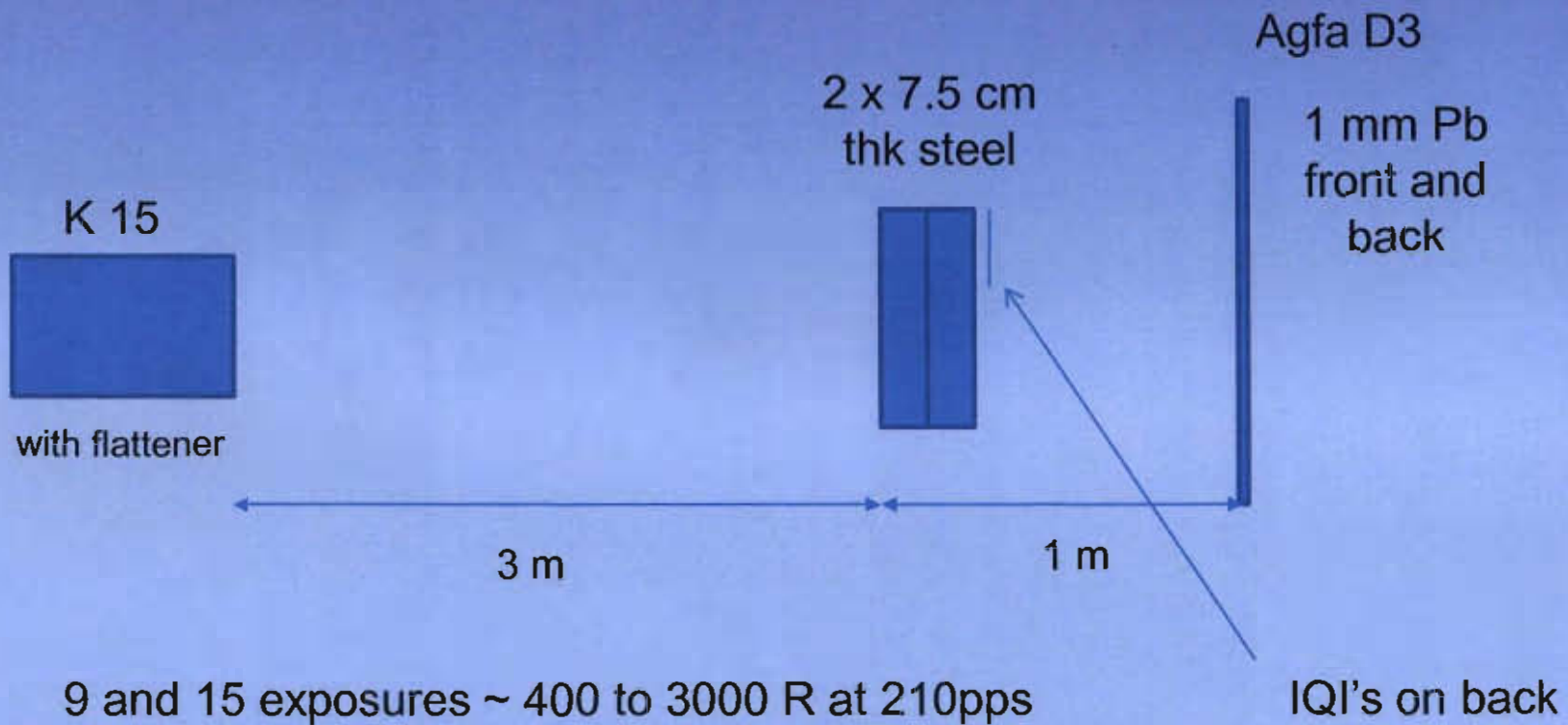
Modeled scattering to determine minimum facility dimensions and to assess scatter reduction methods

MCNPX digital radiography detector panel design

Modeled panel to determine optimal materials and thicknesses



Varian Setup



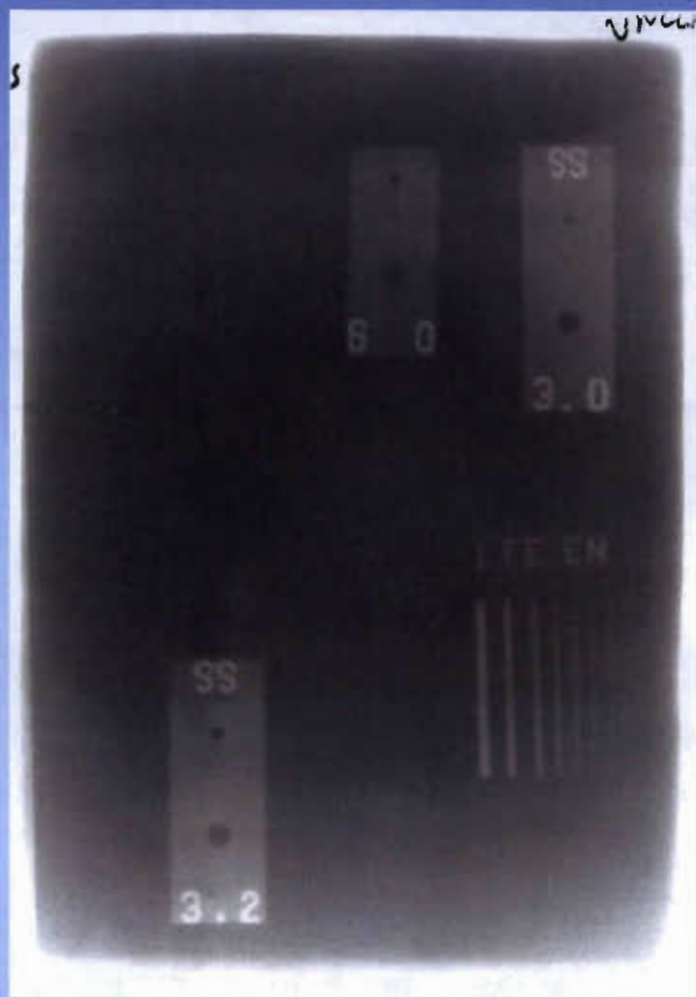
Tests:

9 MV	2700 R	15 cm	2.0 OD
15 MV	1920 R	15 cm	2.45 OD
15 MV	420 R	7.5 cm	2.0 OD



15 MV 7.5 cm

Digitized films:



9 MV at 15 cm OD 2.0
2700 R CR~ 0.03



15 MV at 15 cm OD 2.45
1920 R

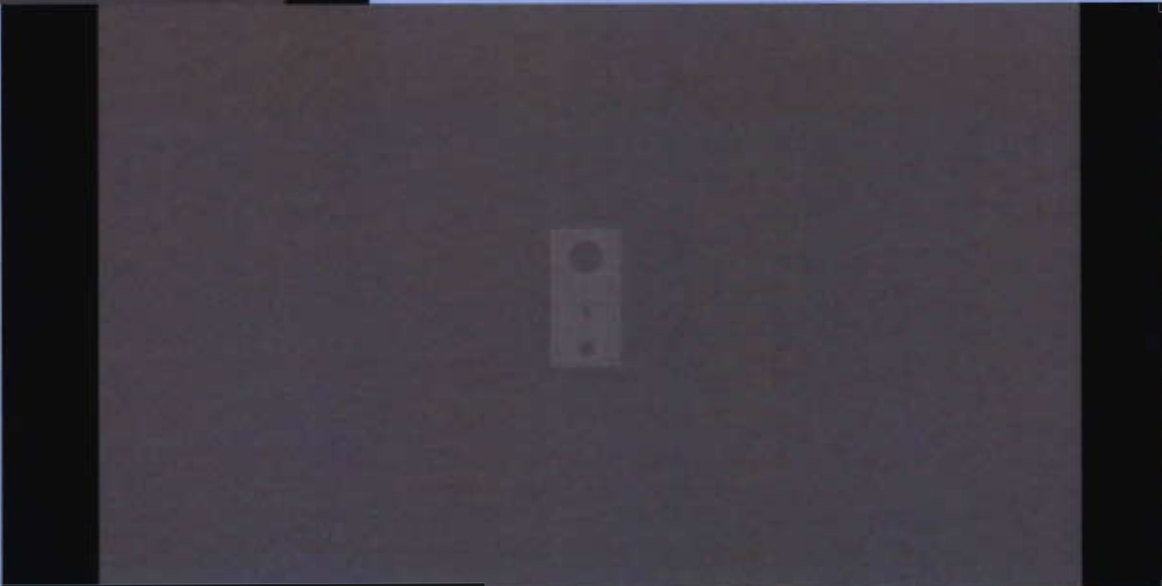
Microtek scanmaker 1000xl

XRSim Output:



9 MV D7 film with Pb
OD 2.6 at 2700 R
CR= 0.056

9 MV D7 film no Pb
OD 2.1 2700 R
CR= 0.024



Conclusions:

Additional Validation Required

Scatter an issue

Documentation needs work

Flexibility in creating detectors/ sources/

Code development ongoing

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