



Modelling for Film Replacement

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Outline

- ▶ **Motivation**

- ✓ Needs for Simulation

- ▶ **Simulation Tool for RT**

- ✓ Physics
- ✓ Implementation
- ✓ Simulation Examples

- ▶ **Summary and Outlook**

Film Replacement: The FilmFree Project

► Overview

- **The Goal:** development of novel digital radiography technology for film replacement
- **The Story:** industrial equivalent of the replacement of film-based camera photography with digital cameras
- **The Project:**
 - ✓ Sixth Framework Integrated Project NMP2-CT-2005-515746: Project is coordinated and managed by TWI Ltd. and is partly funded by the EC under the IP SME programme
 - ✓ Consortium: 33 participants (18 SMEs)
 - ✓ Total funding: 5.1 mio Euro
 - ✓ Total costs: 8.75 mio. Euro
- **The Contact:** www.filmfree.eu.com



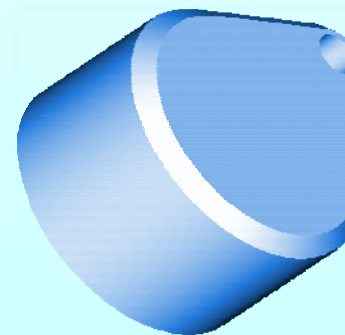
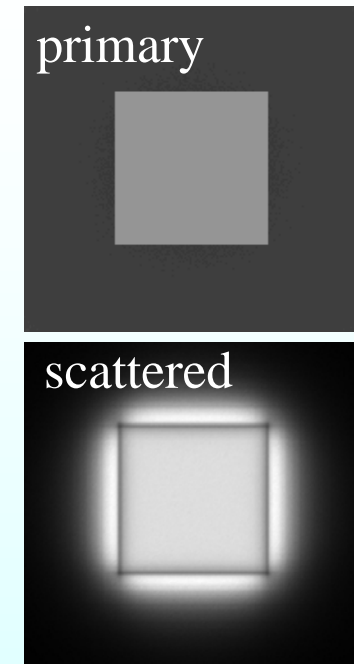
Needs for Simulation

▶ Aim of Simulation in RT

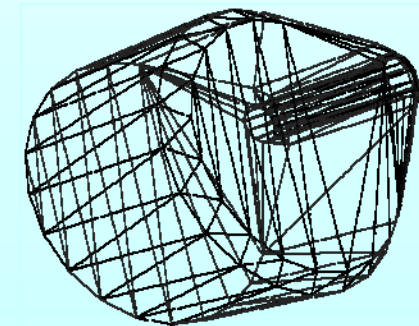
- prediction of system response
- understanding and optimization of NDT process
- prediction of system performance
- introduction into education process

▶ Engineering Process Integration

- virtual testing scenes
- handling of realistic object and flaw geometry
- industry standard STL part description

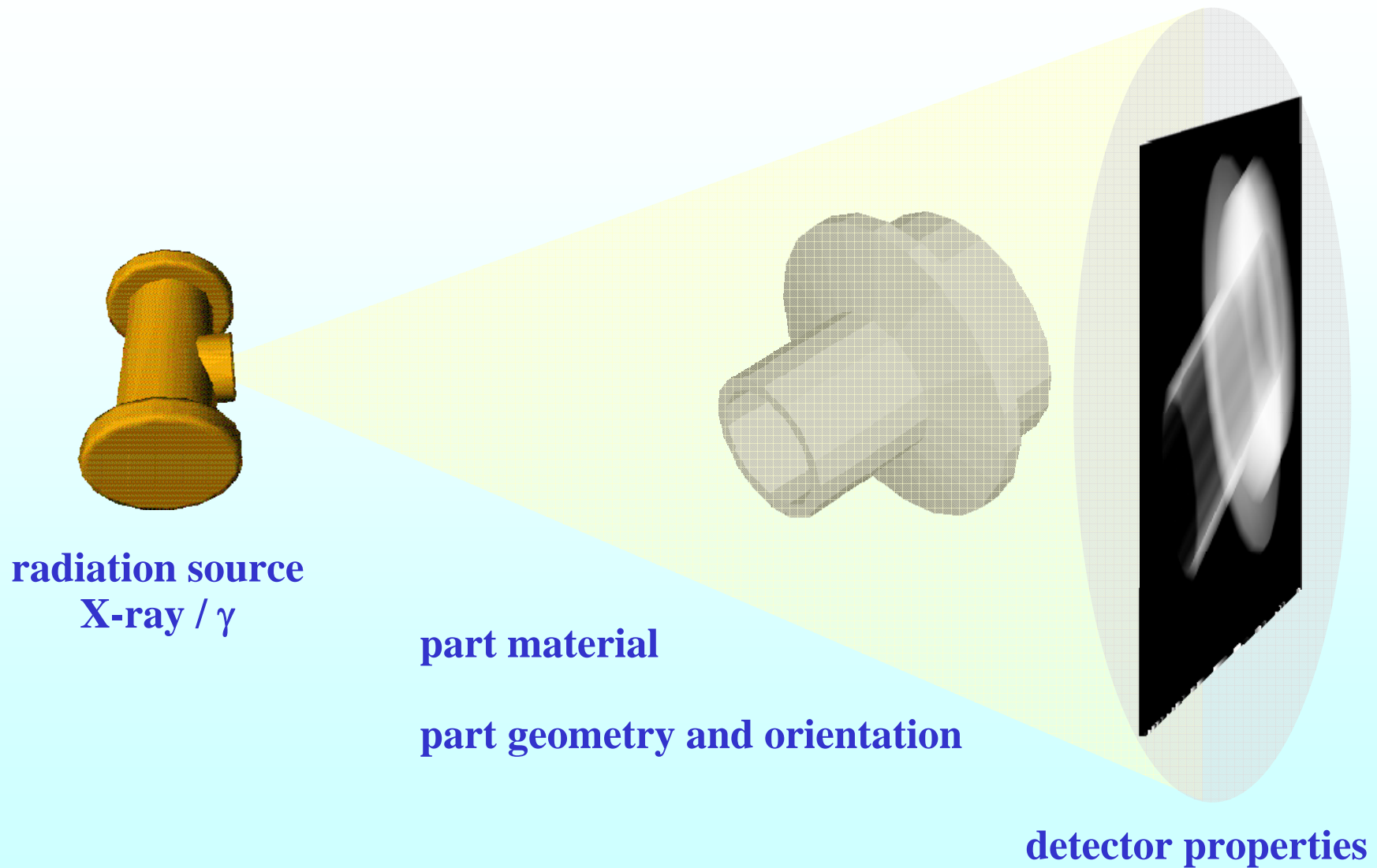


CAD part



triangles (wire frame)

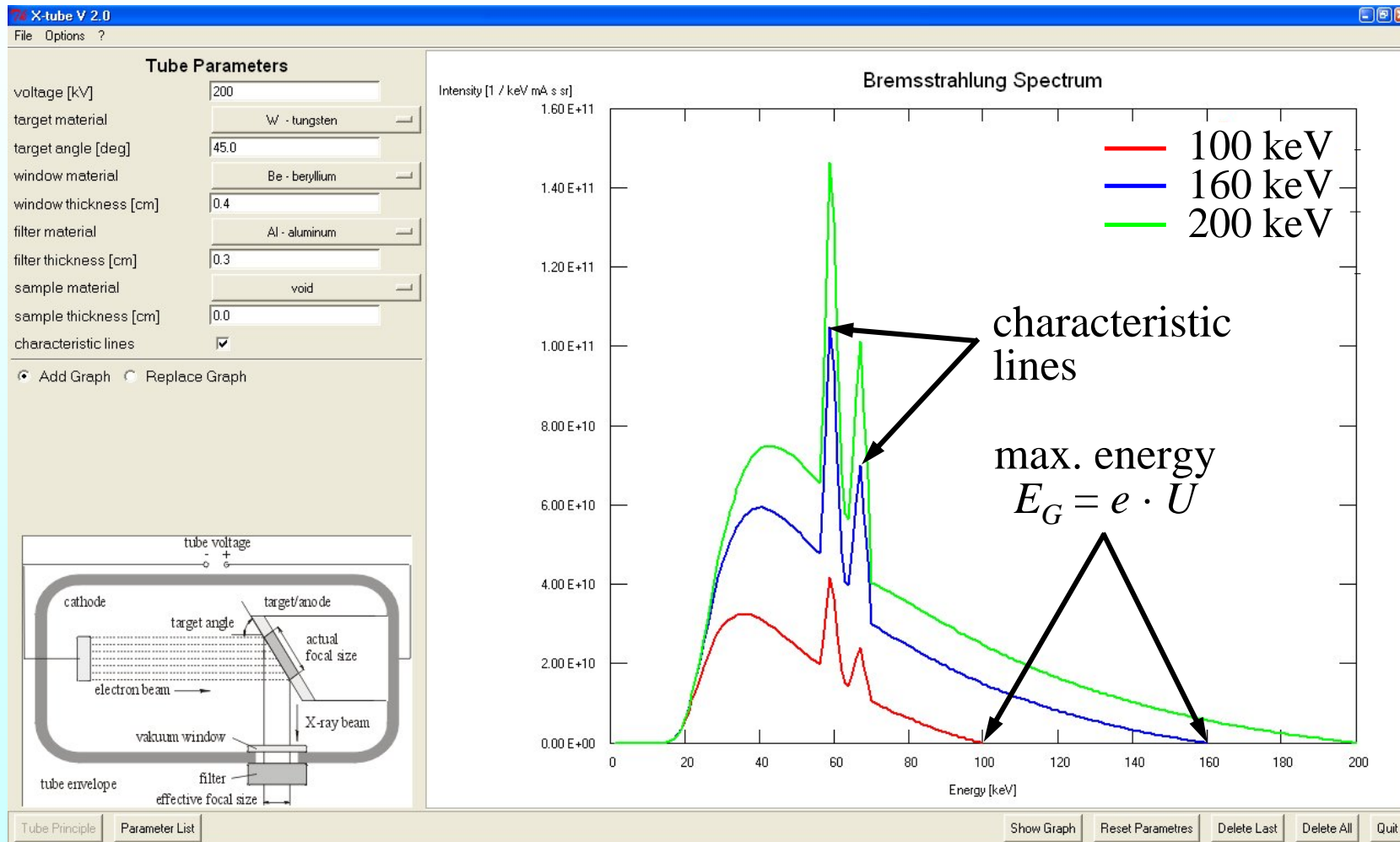
Elements Needed for Modeling RT



Elements Needed for Modeling RT

► Radiation Source: X-Ray

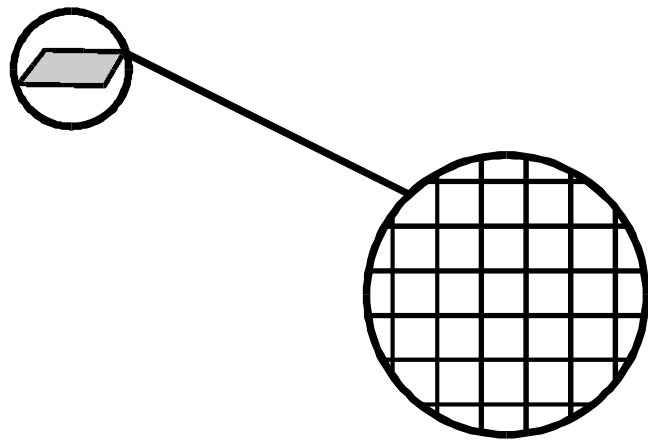
- source model based on Bremsstrahlung production cross sections



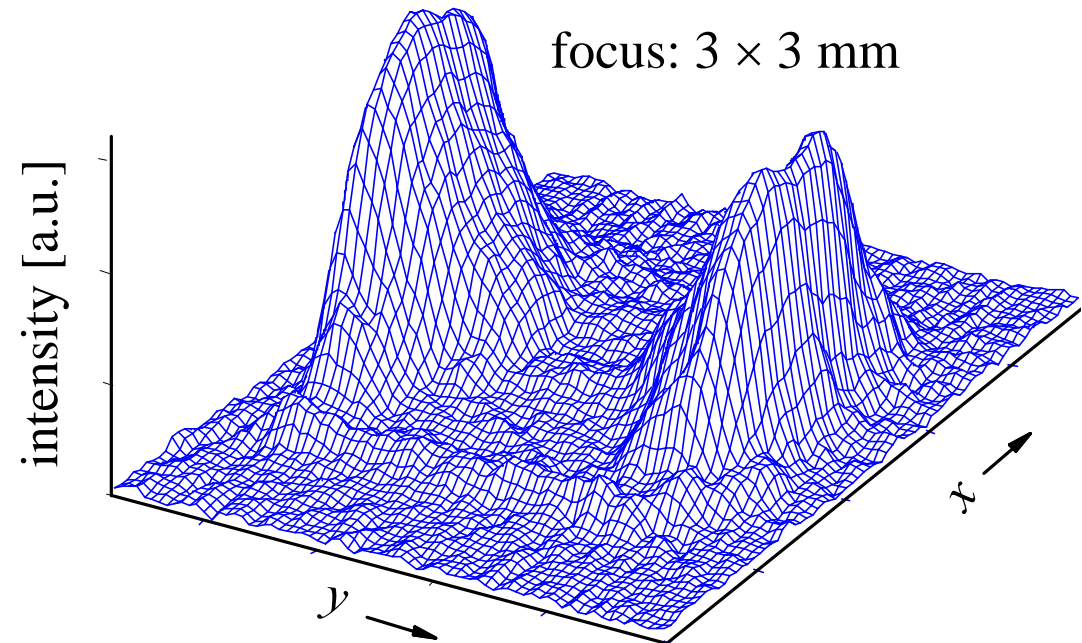
Elements Needed for Modeling RT

▶ Radiation Source

- X-Ray source
 - focal spot including intensity distribution



discretization
of focal spot



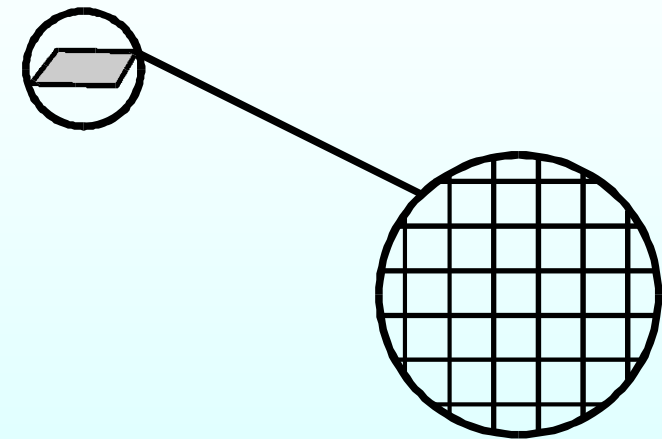
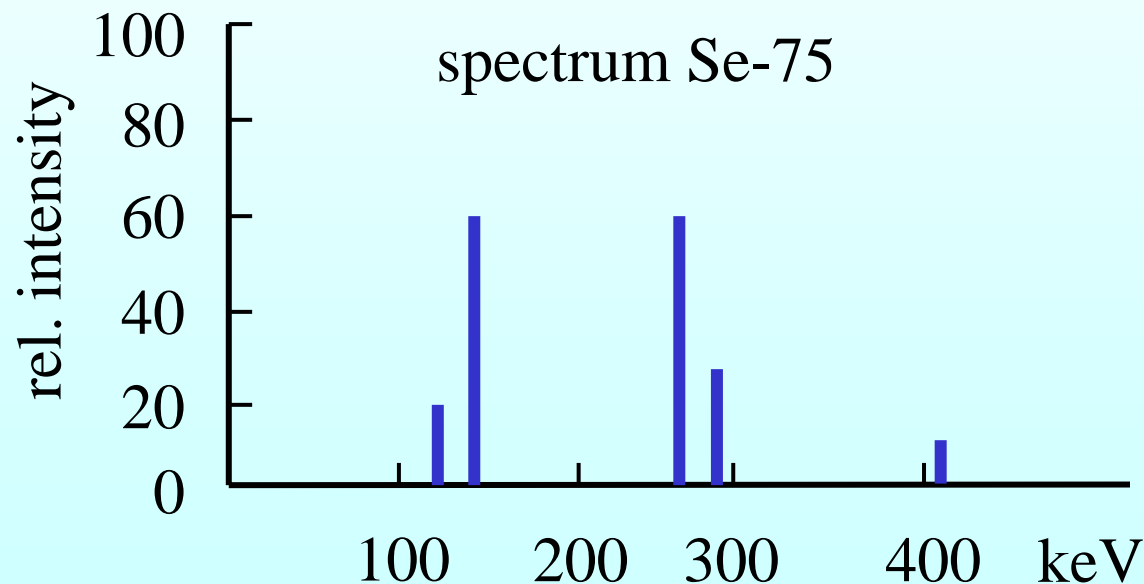
ISOVOLT 320 bei 80 kV

U. Ewert, BAM VIII.3

Elements Needed for Modeling RT

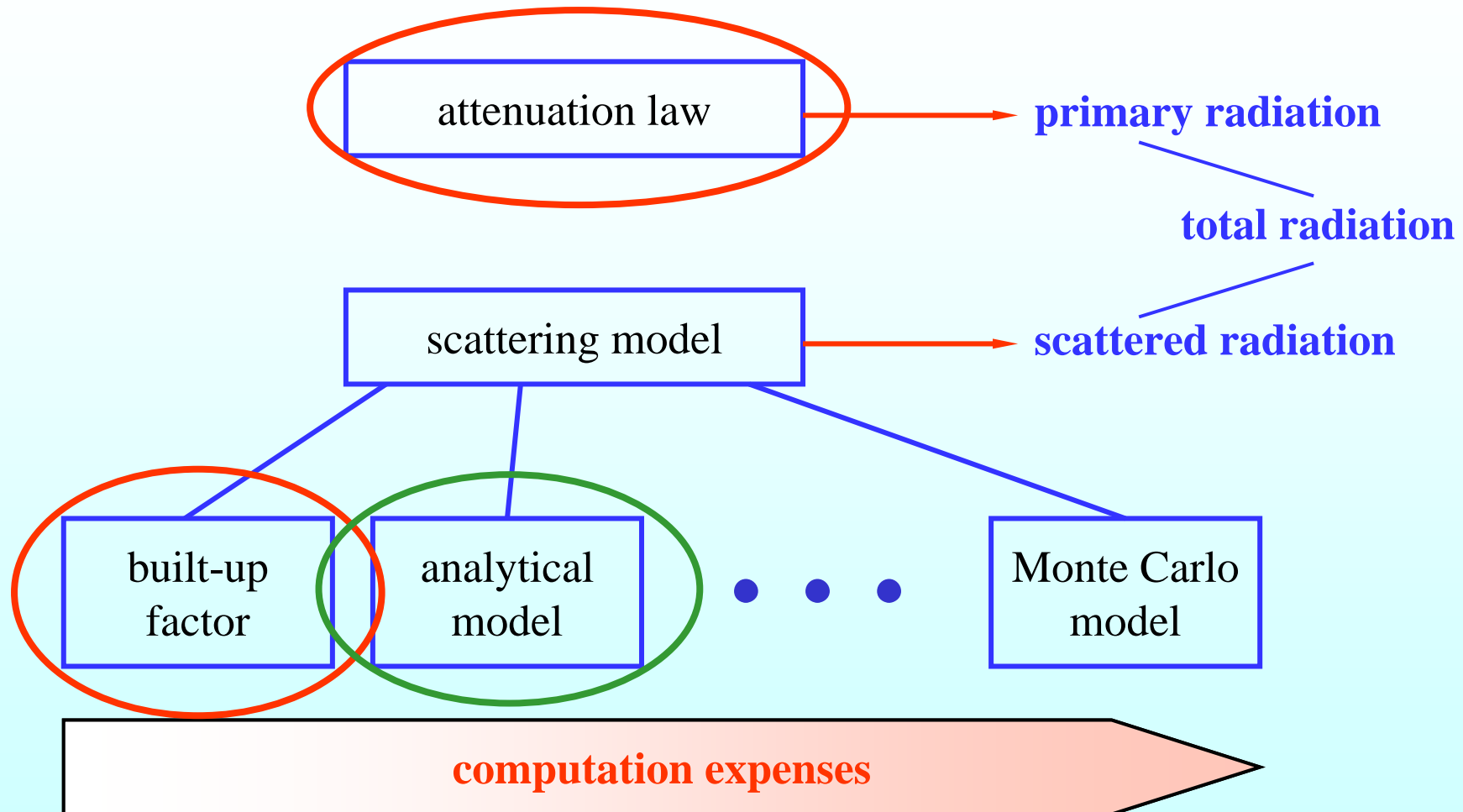
► Radiation Source

- γ source
- discrete spectrum
- focus



discretization
of source with
constant
intensity distribution

Attenuation Mechanisms



Elements Needed for Modeling RT

▶ Detector Model

➤ **response function** ⇒ transfer properties of detector including screens/filters (e.g. linear + LUT for CR)

➤ **point spread function** ⇒ inner unsharpness

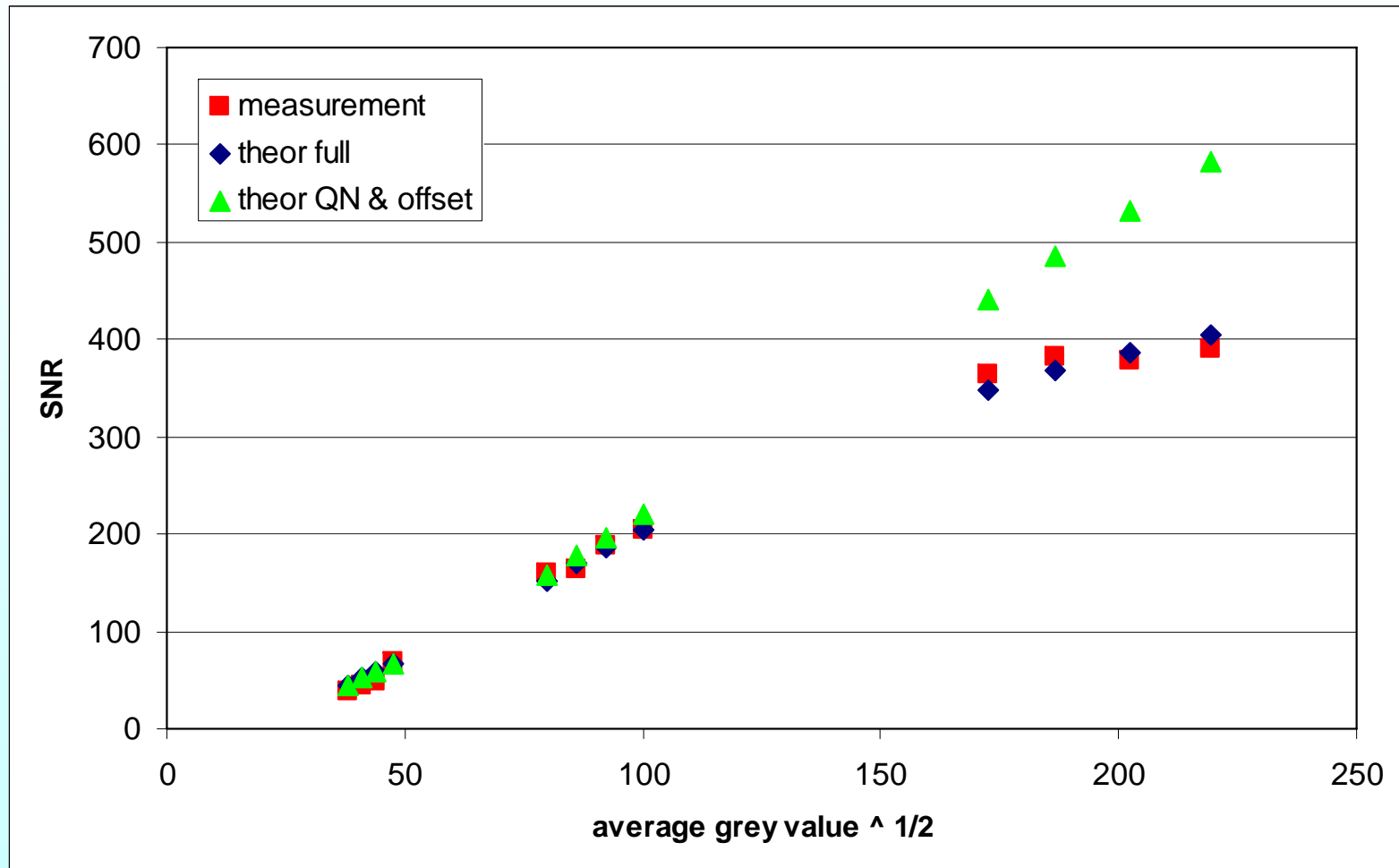
➤ **noise** ⇒ system noise

$$\sigma_{tot}^2 = \sigma_{offset}^2 + \sigma_{quantum\ noise}^2 + \sigma_{structural\ noise}^2$$

(a) offset: const.
(b) quantum noise: linear
(c) structural noise: quadratic (max. SNR)

Elements Needed for Modeling RT

▶ Example: System Noise for Linear Detector



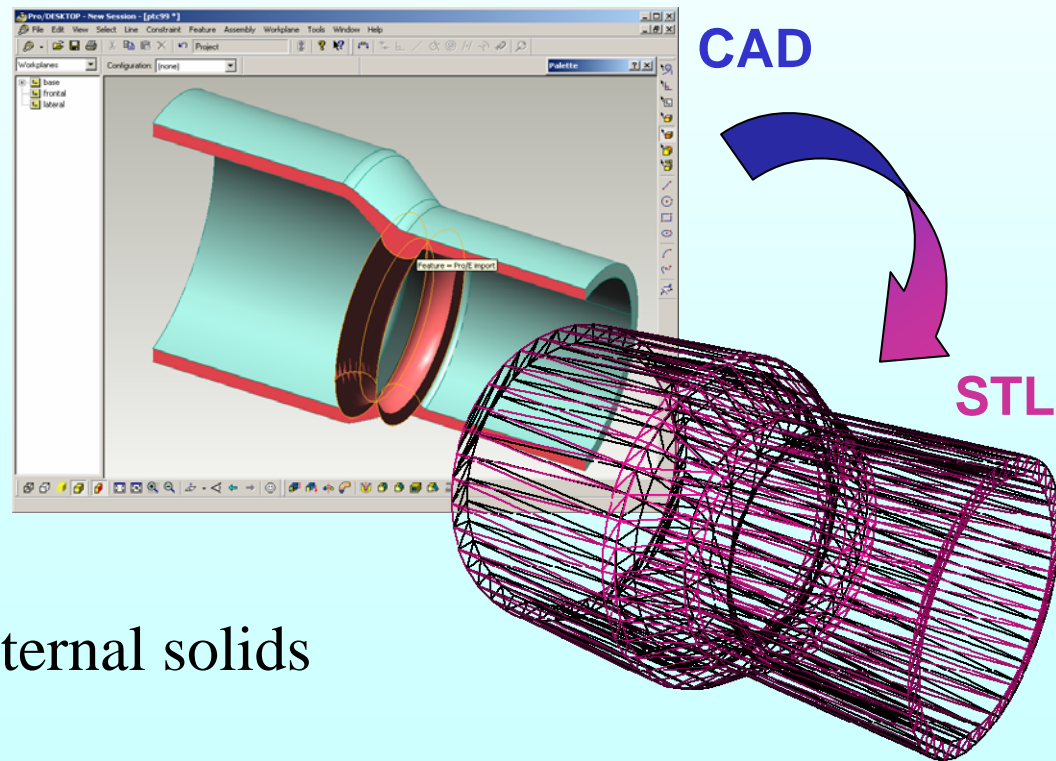
Geometrical Representation

▶ Boundary Representation

- Interface to CAD
- Separation of homogeneous regions
- Arrangement of several b-reps in virtual scene

▶ Geometry Model

- surface description with plane polygons
- simple mathematical treatment of single facets (ray tracing)
- approximation of curved surfaces
- STL as standard exchange format
- sources: CAD / CT / internal solids



Implementation and Software Platform

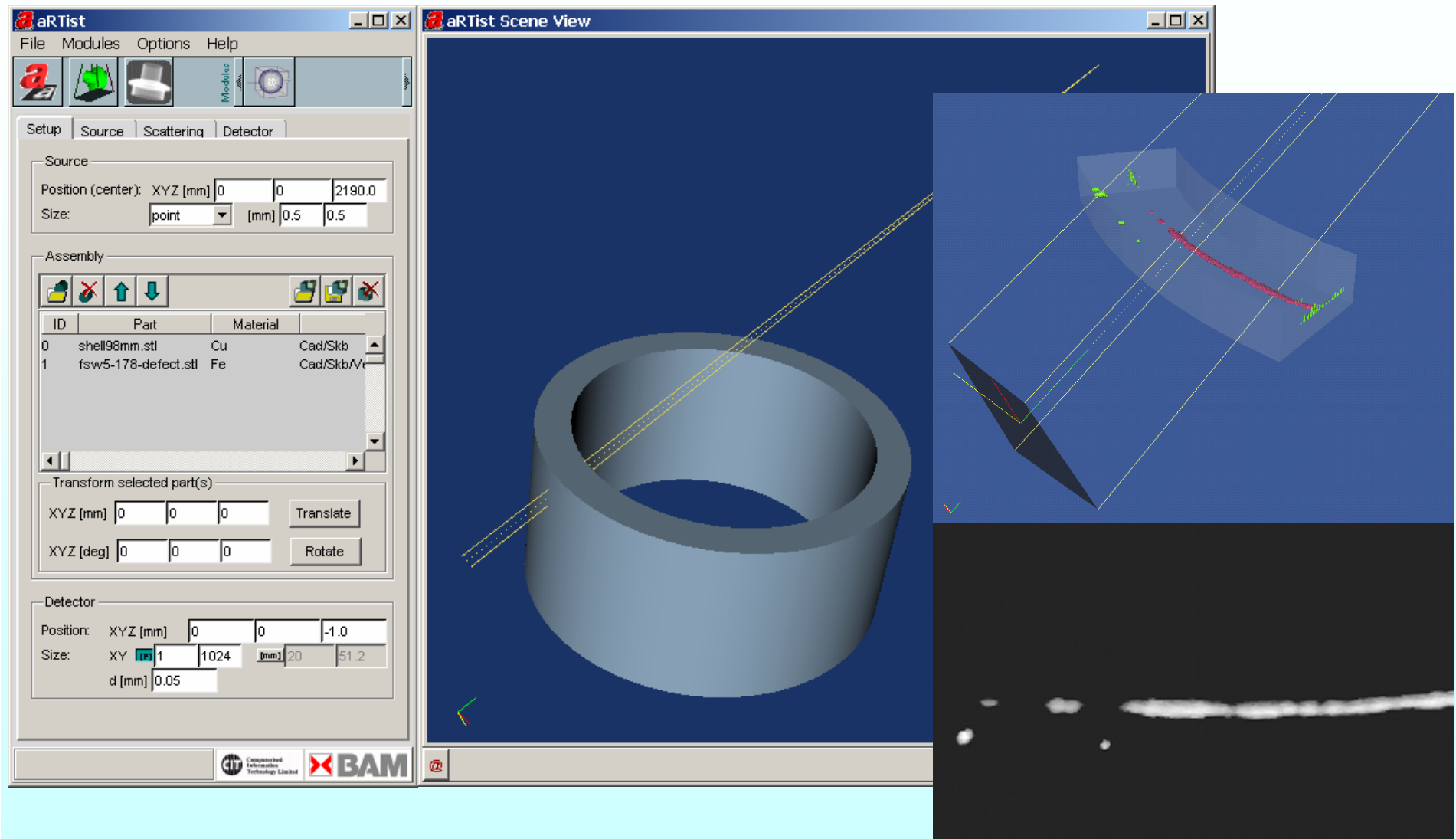
▶ System Requirements

- MS Windows 2000/XP
- minimum recommended hardware
 - ✓ Pentium III 1 GHz PC with 512 MB RAM
 - ✓ 50 MB free disk space
 - ✓ USB
 - ✓ display resolution: 1024x768

▶ Implementation

- programming language:
 - ✓ Tcl/Tk
 - ✓ C ++
 - ✓ FORTRAN
- software packages used:
 - ✓ visualization: VTK www.vtk.org
 - ✓ script language: Tcl/Tk www.tcl.tk
 - ✓ materials data: XCOM physics.nist.gov/PhysRefData

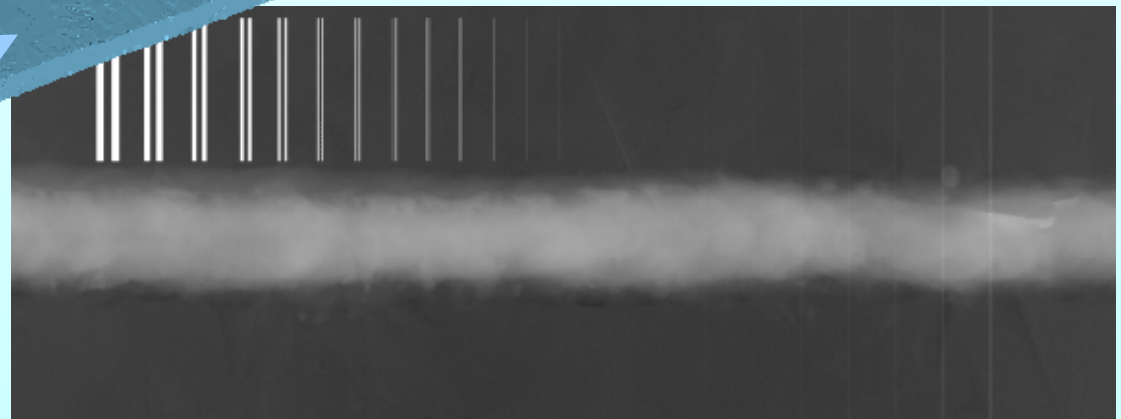
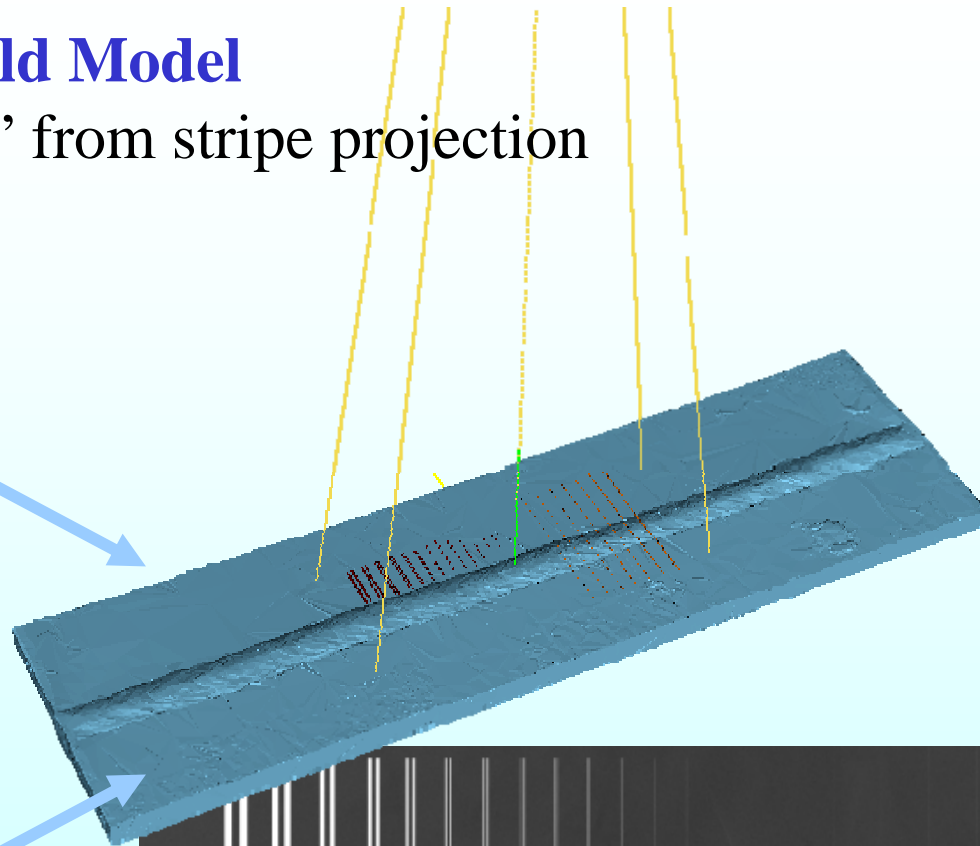
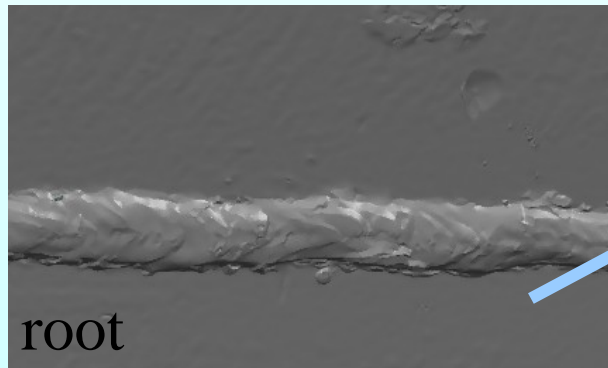
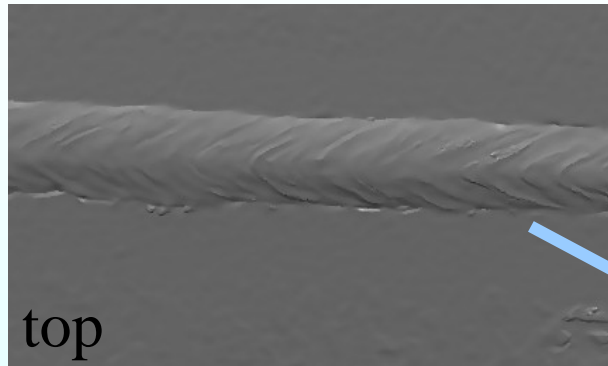
aRTist : RT Simulation Tool



Realistic Weld Model

▶ Result: 3D CAD Weld Model

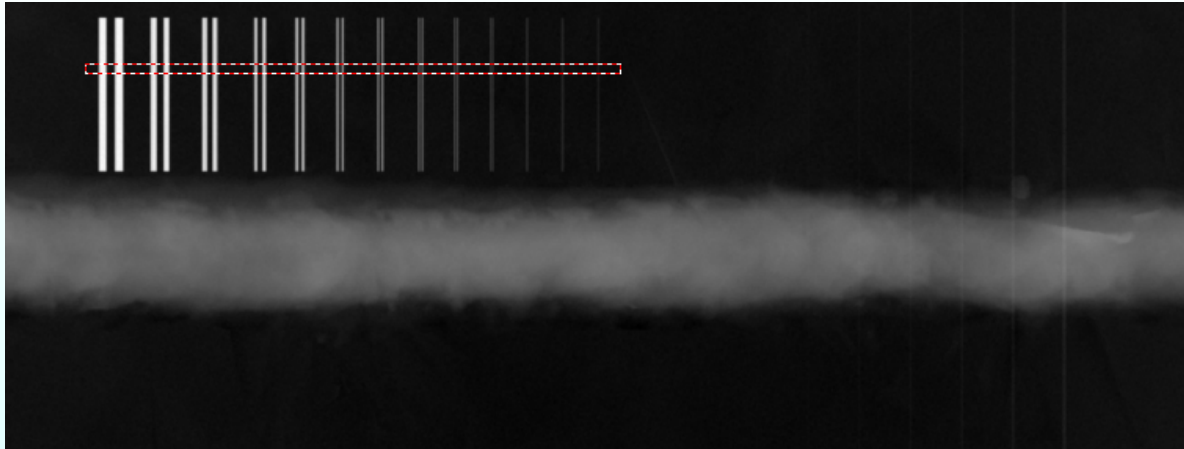
- STL of “BAM 3” from stripe projection



Realistic Steel Weld

▶ Welded Steel Component

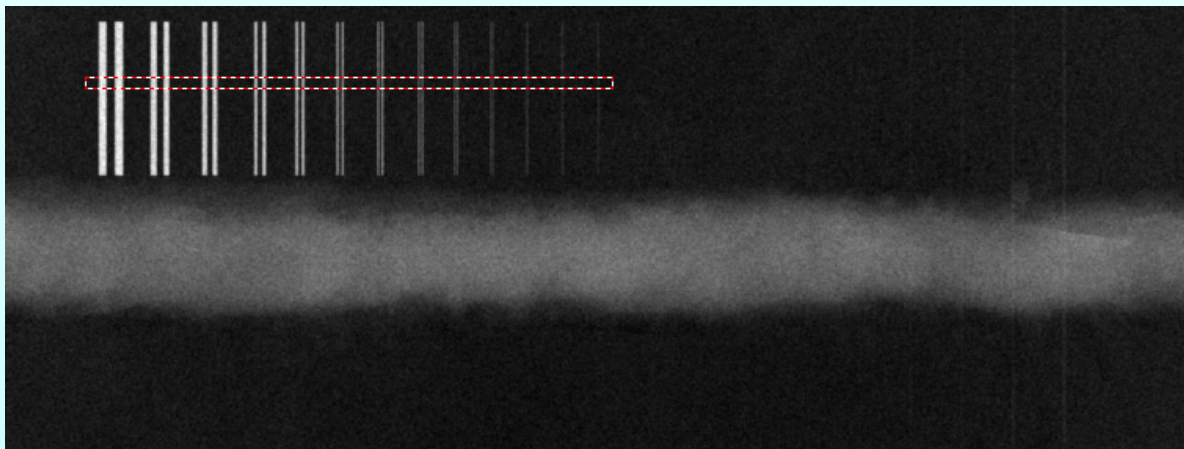
- exposure time variation and IQI sensitivity (duplex wire)



Exposure 1



exposure time
five times higher



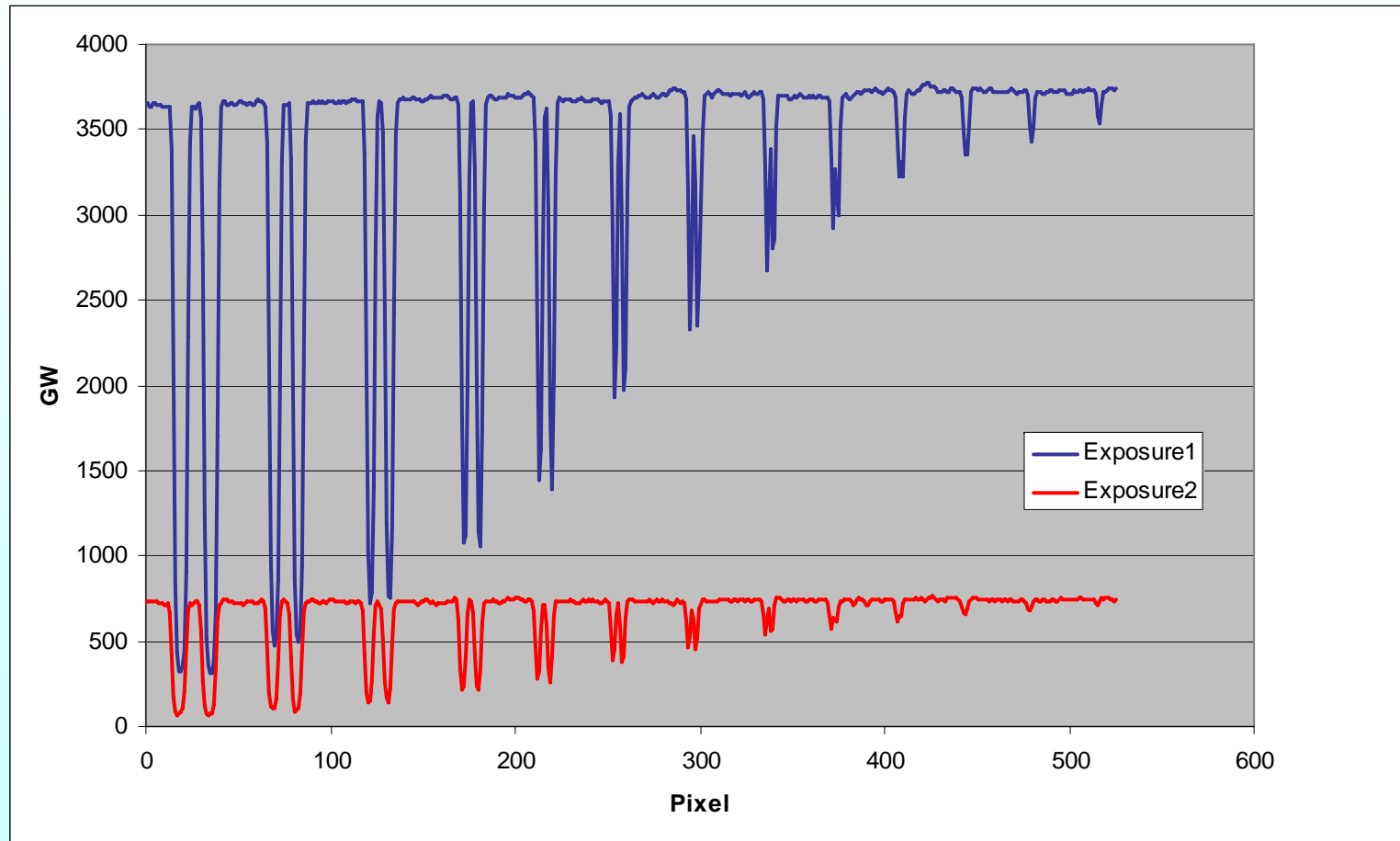
Exposure 2

10 mm Fe
150 KeV
IP (130 μ m)

Realistic Steel Weld

▶ Welded Steel Component

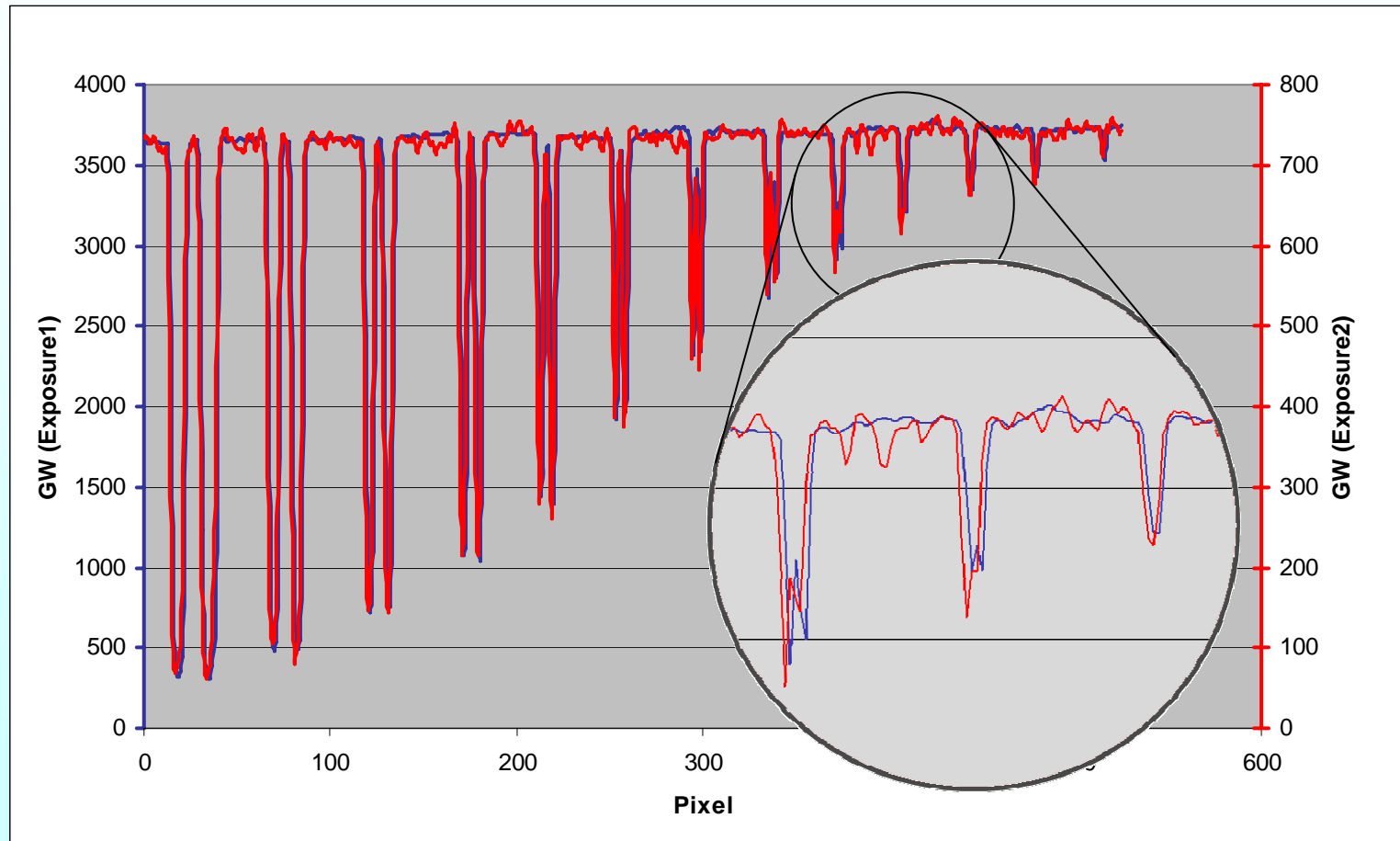
- exposure time variation and IQI sensitivity (duplex wire)



Realistic Steel Weld

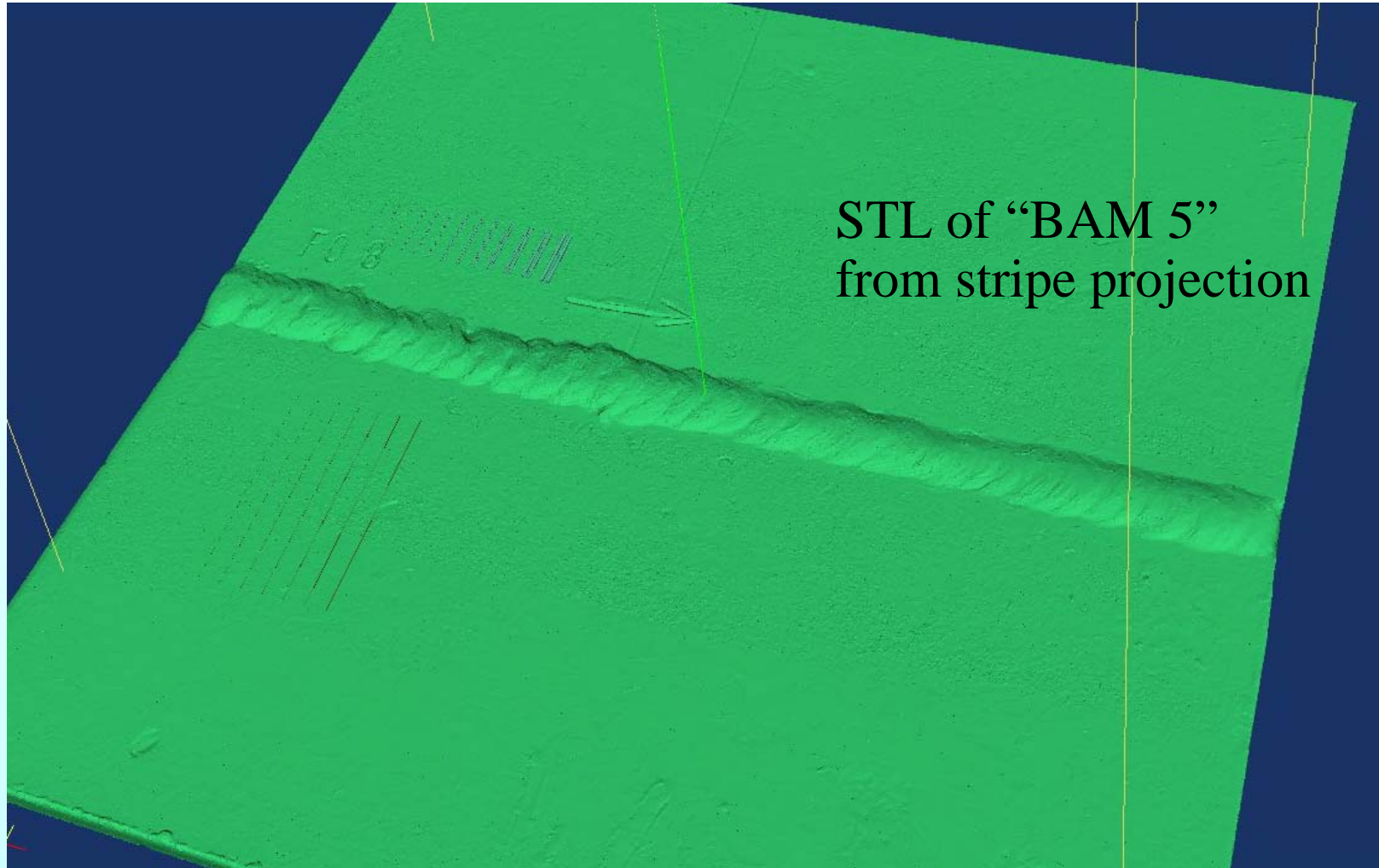
▶ Welded Steel Component

- exposure time variation and IQI sensitivity (duplex wire)



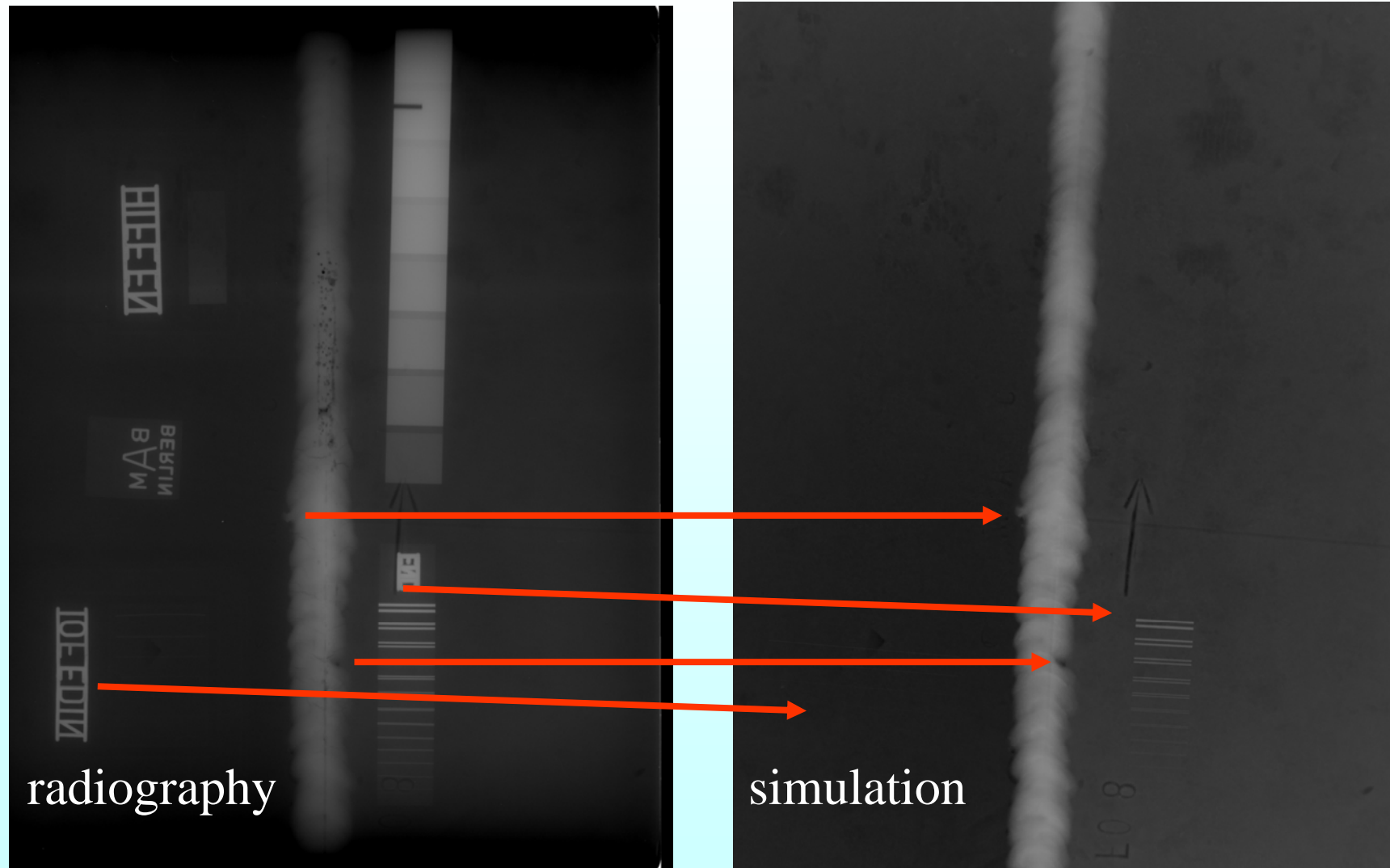
Realistic Steel Weld

▶ Welded Steel Component (BAM 5)



Realistic Steel Weld

▶ Welded Steel Component (BAM 5)



Summary

▶ Ray tracer RT model

- based on attenuation law
- effective and fast tracer
- capable to predict RT image with high accuracy
- can be coupled with various scattering models

▶ Contact information for software distribution:

- Subash Sood

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