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Los Alamos NATIONAL LABORATORY

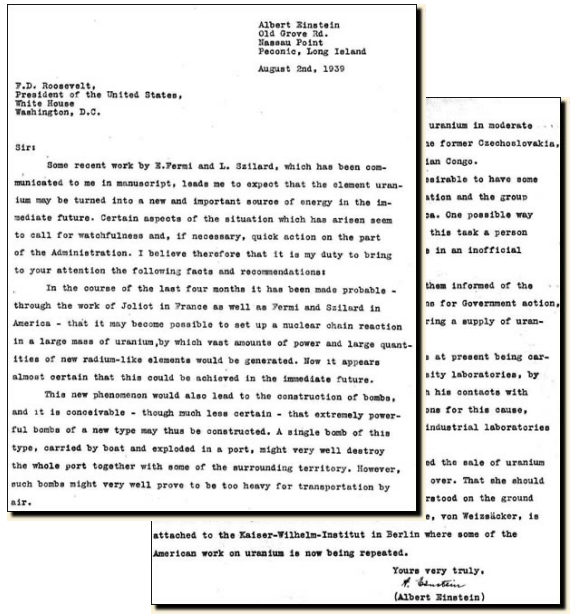
DARHT Overview

Jennie Schei Disterhaupt, J-4

July 18, 2022

History of Los Alamos

- Fission was first produced in Nazi Germany in late 1938.
- Albert Einstein, at the urging of Leo Szilard, wrote to President Roosevelt in August 1939.
- In September 1939 the Germans **and** the Soviets invaded Poland.
- Japan attacked Pearl Harbor on December 7, 1941.
- In April 1943, the first technical conference was held in Los Alamos.
- Two entirely different types of nuclear bombs were completed in ~27 months.
- The world's first nuclear test was conducted on July 16, 1945.
- The deployment of 2 nuclear weapons in 1945 helped end WWII.



Albert Einstein
Old Grove Rd.
Nassau Point
Peconic, Long Island

August 2nd, 1939

F.D. Roosevelt,
President of the United States,
White House
Washington, D.C.

Sir:

Some recent work by E.Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future. Certain aspects of the situation which has arisen seem to call for watchfulness and, if necessary, quick action on the part of the Administration. I believe therefore that it is my duty to bring to your attention the following facts and recommendations:

In the course of the last four months it has been made probable - through the work of Joliot in France as well as Fermi and Szilard in America - that it may become possible to set up a nuclear chain reaction in a large mass of uranium, by which vast amounts of power and large quantities of new radium-like elements would be generated. Now it appears almost certain that this could be achieved in the immediate future.

This new phenomenon would also lead to the construction of bombs, and it is conceivable - though much less certain - that extremely powerful bombs of a new type may thus be constructed. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory. However, such bombs might very well prove to be too heavy for transportation by air.

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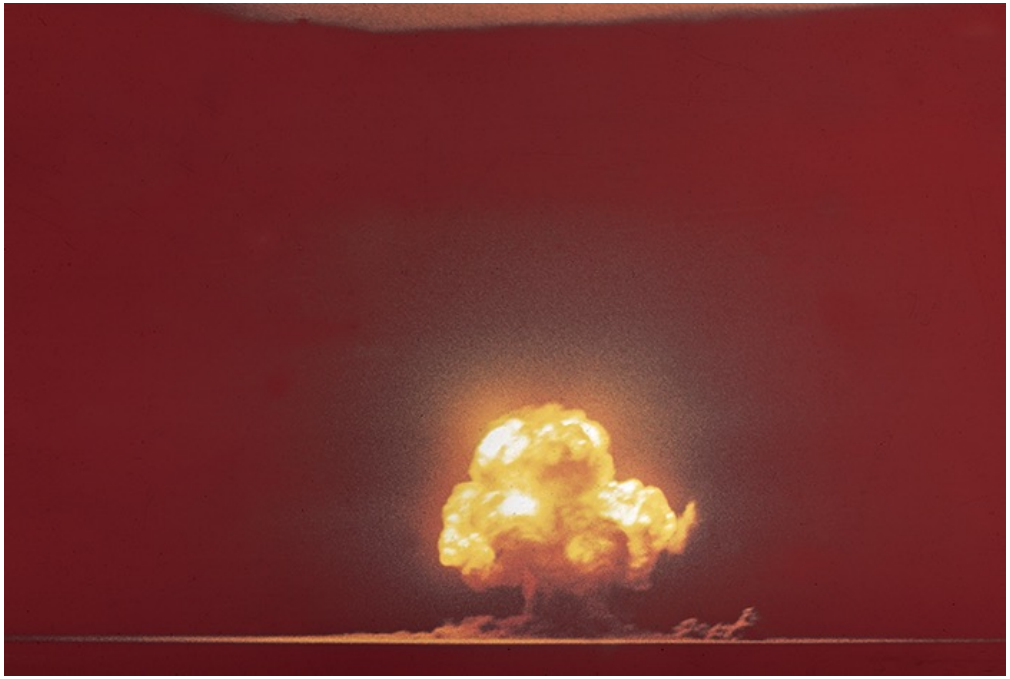
s, von Weizsäcker, is

attached to the Kaiser-Wilhelm-Institut in Berlin where some of the American work on uranium is now being repeated.

Yours very truly,
A. Einstein
(Albert Einstein)

Los Alamos Following WWII

- The first “Soviet” atomic bomb was tested in August 1949.
- Between 1945 and 1992, the United States conducted well over a thousand nuclear tests.
- The United States conducted its *most recent* nuclear test in September 1992.
- On October 2, President Bush announced a moratorium on testing.



Nuclear Deterrent

- Roles of U.S. Nuclear Weapons
  - Deter nuclear and conventional attack
  - Assure U.S. allies and partners
  - Achieve U.S. objectives if deterrence fails
  - Hedge against future uncertainty

"A strong, continuing deterrent is critical to our nation's security. Nuclear war cannot be won, and therefore it must never be fought. And so, to preserve the peace we must be ready for war."

- **Gen John Hyten, Vice Chairman, Joint Chiefs of Staff**

"The U.S. **nuclear deterrent** has been the cornerstone of our national security and global stability for more than 70 years, and its credibility serves as the **ultimate insurance policy** against a nuclear attack."

- Hon. Lisa Gordon-Hagerty, Former Under Secretary for Nuclear Security, DOE

Stockpile Stewardship

- In the absence of nuclear testing, we are tasked with assessing our stockpile.
- By law, Los Alamos Director reports on the state and health of the Nation's deterrent.

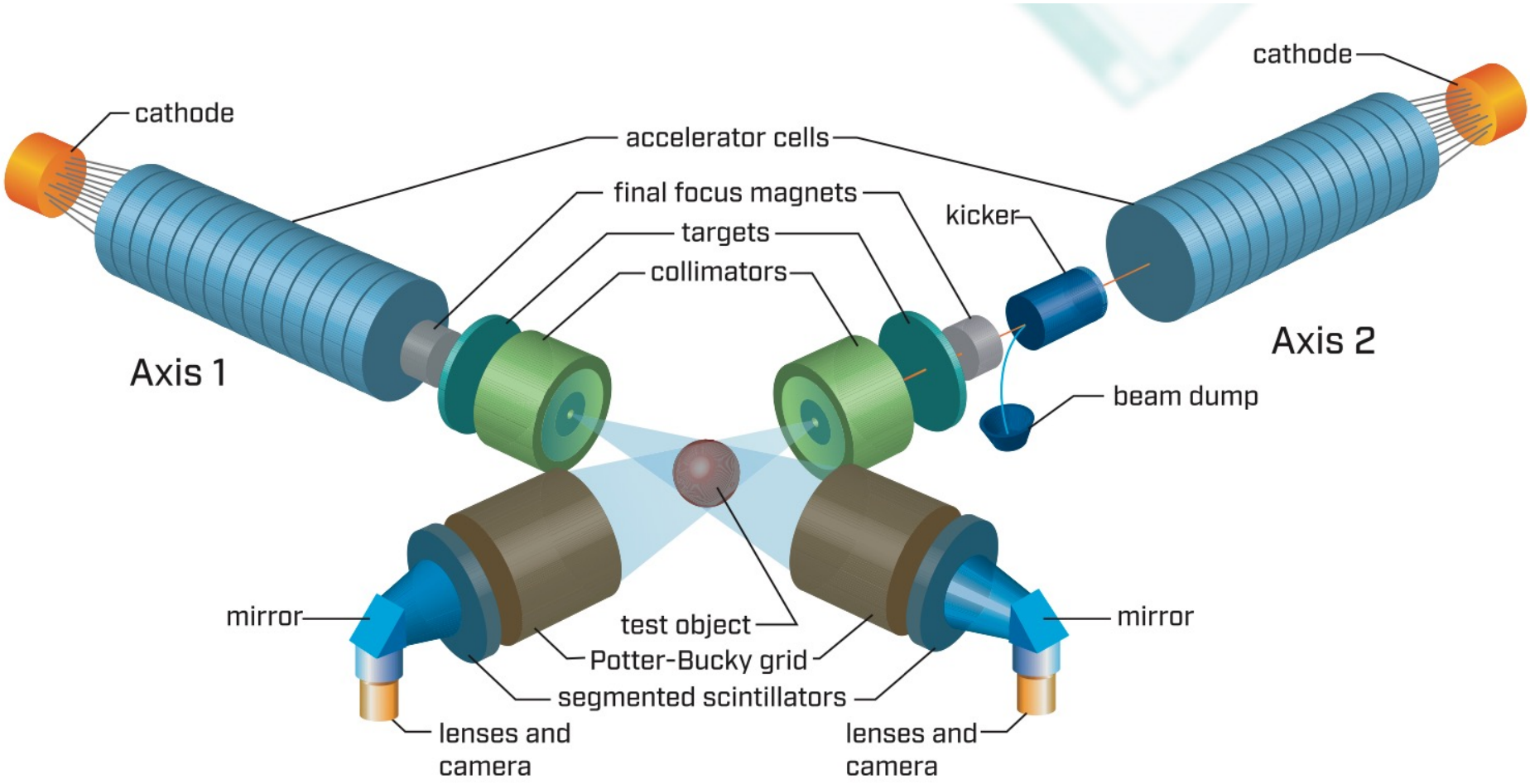
- **DOE/NNSA's annual Stockpile Stewardship and Management Plan:**
- Maintain the safety, security and effectiveness of the nation's nuclear deterrent
  - Experiments
  - Modeling and simulation
- Stockpile challenges are increasingly complex as systems continue to age

DARHT is a key facility for Stockpile Stewardship.

Dual Axis Radiographic Hydrodynamic Test Facility

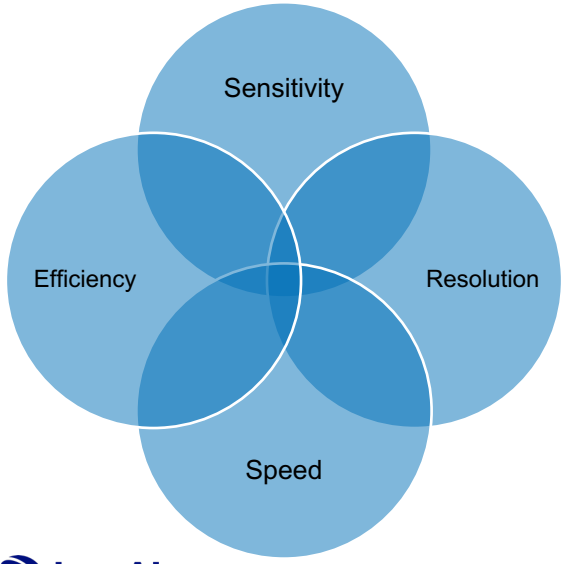
- World-class X-ray radiography for dynamic non-nuclear tests
- 2, orthogonal, Linear Induction Electron Accelerators
  - Axis 1: 60 ns, 20MeV, Single Pulse Machine
  - Axis 2: 1.6μsec,16.5MeV, Multi-Pulse Machine
- Provides crucial data to support the Department of Energy's Stockpile Stewardship Program

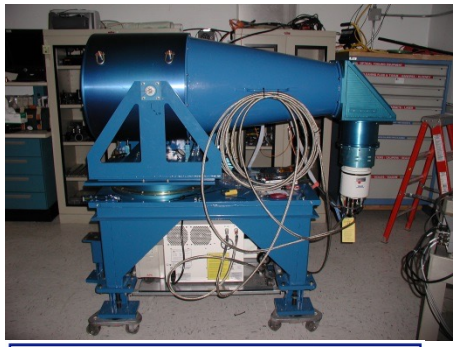
DARHT

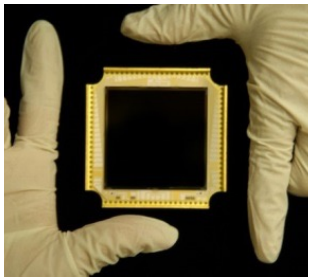

cathode
accelerator cells
final focus magnets
targets
collimators
Axis 1
cathode
kicker
Axis 2
beam dump
mirror
test object
Potter-Bucky grid
segmented scintillators
lenses and camera
mirror
lenses and camera

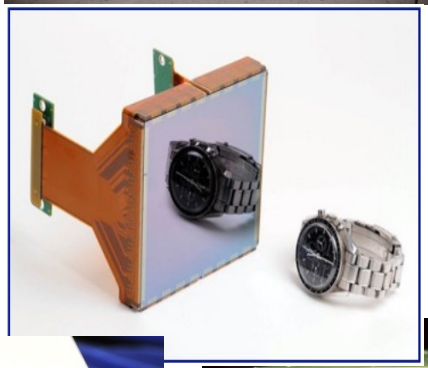
The Los Alamos Gamma Ray Camera (GRC)

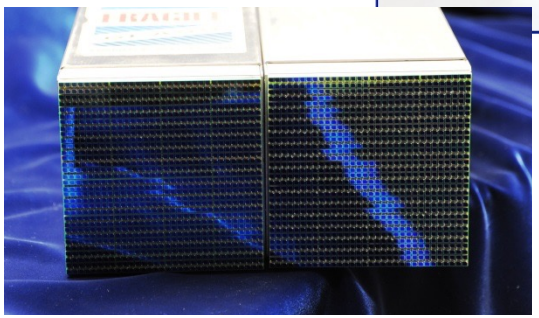
- LANL GRC's are the largest, fastest, and most sensitive detectors in the world and are capable of capturing sub-millimeter resolution radiographic images through more than a foot of steel.
- Combine resolution, speed, efficiency and sensitivity

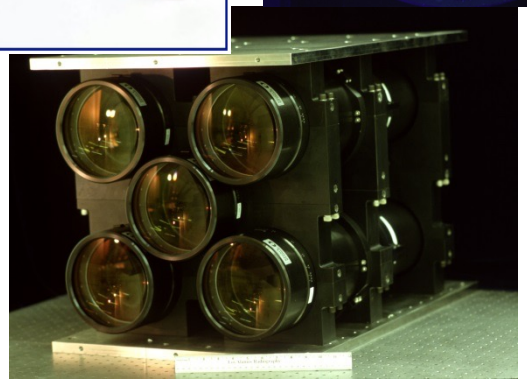






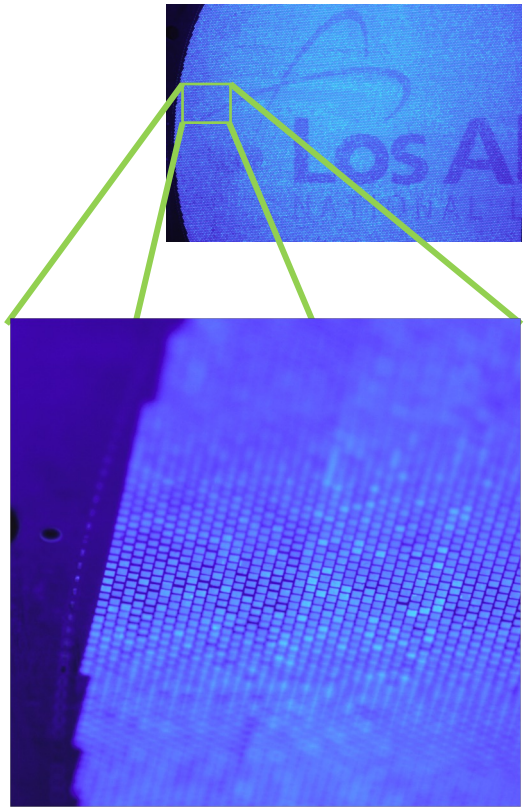






Lu_2SiO_5:Ce (LSO) Segmented Scintillator

- 45 cm diameter, 1.1mm pitch, 4cm thick
- Focused
  - Reduced Parallax
- High Light Output
  - 30,000 photons/MeV
- High Density
  - 7.4 g/cc
  - High Conversion Efficiency
- Fast Decay
  - Single, 40nsec component
- Low Index of Refraction
  - Efficient Lens Coupling



Efficiency of Film is 0.1%, while LSO is >50%

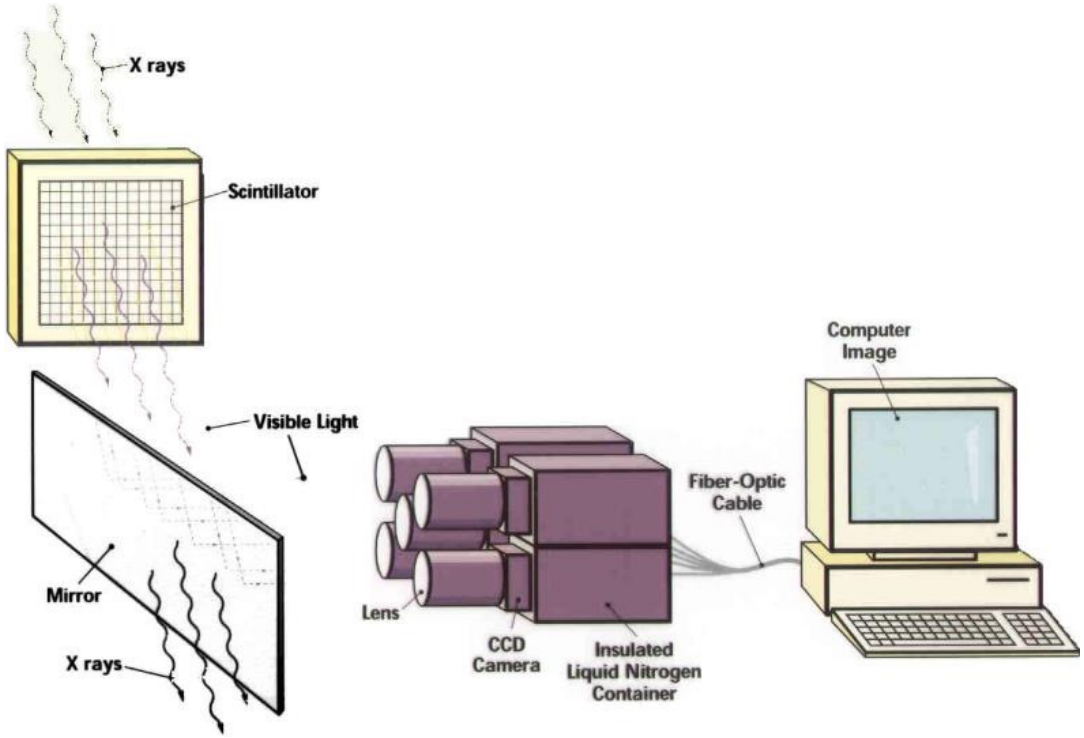
DARHT uses the 3 largest segmented scintillators in the world

Basic Lens-Coupled Camera

- Convert x-rays to visible light
- Fast, dense scintillator required
- Lens couple light to a detector
- Direct coupling and fiber coupling also possible
- High gain in the scintillator mitigates light loss due to lens

$$DQE \propto \frac{1}{1+\frac{1}{n}}$$

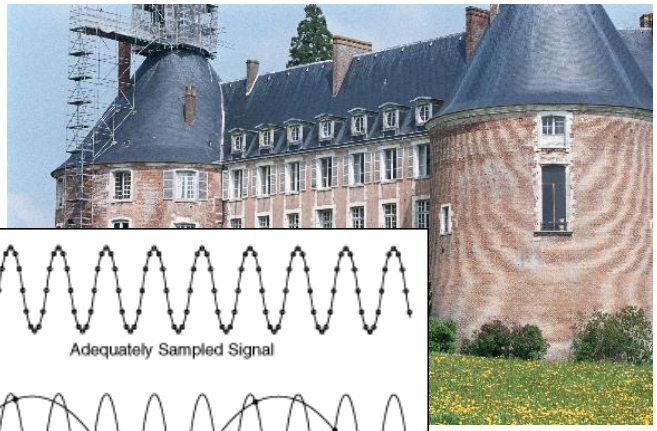
where n is the number of photons recorded per x-ray absorbed in the scintillator



$$n = \frac{T_{Lens} g M^2 QE_{CCD}}{8\eta_{sc}^2 F_{\#}^2 (1+M)^2}$$

$$F_s = 2B$$

Radiographic System Design



Key Design Variables and Limitations

Magnification $\propto$ Object Resolution & Source Blur

Source Geometry and Size $\propto$ Source Blur

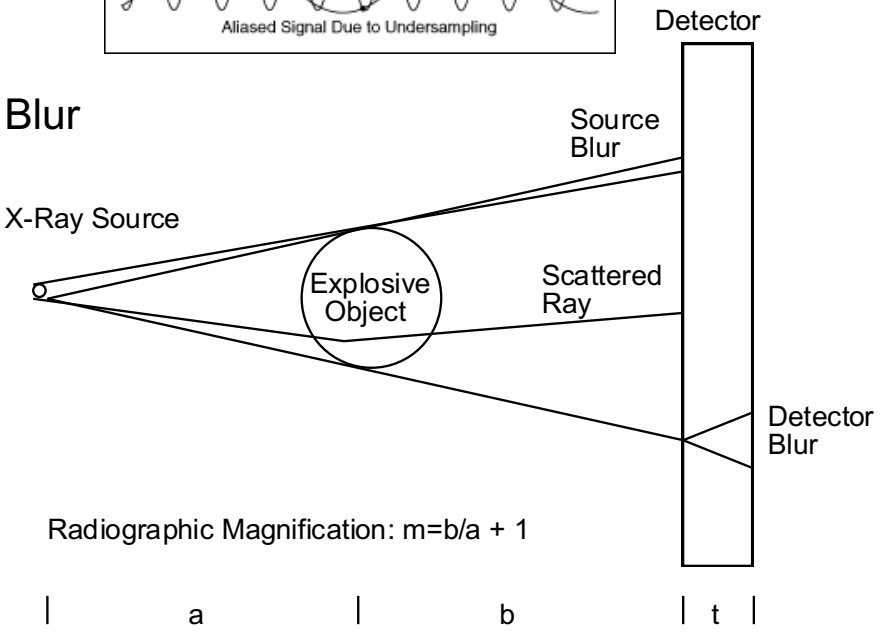
Source Duration $\propto$ Motion Blur

Object Velocity $\propto$ Motion Blur

Detector Pixel Geometry (d_x,d_y,d_t) $\propto$ Detector Blur

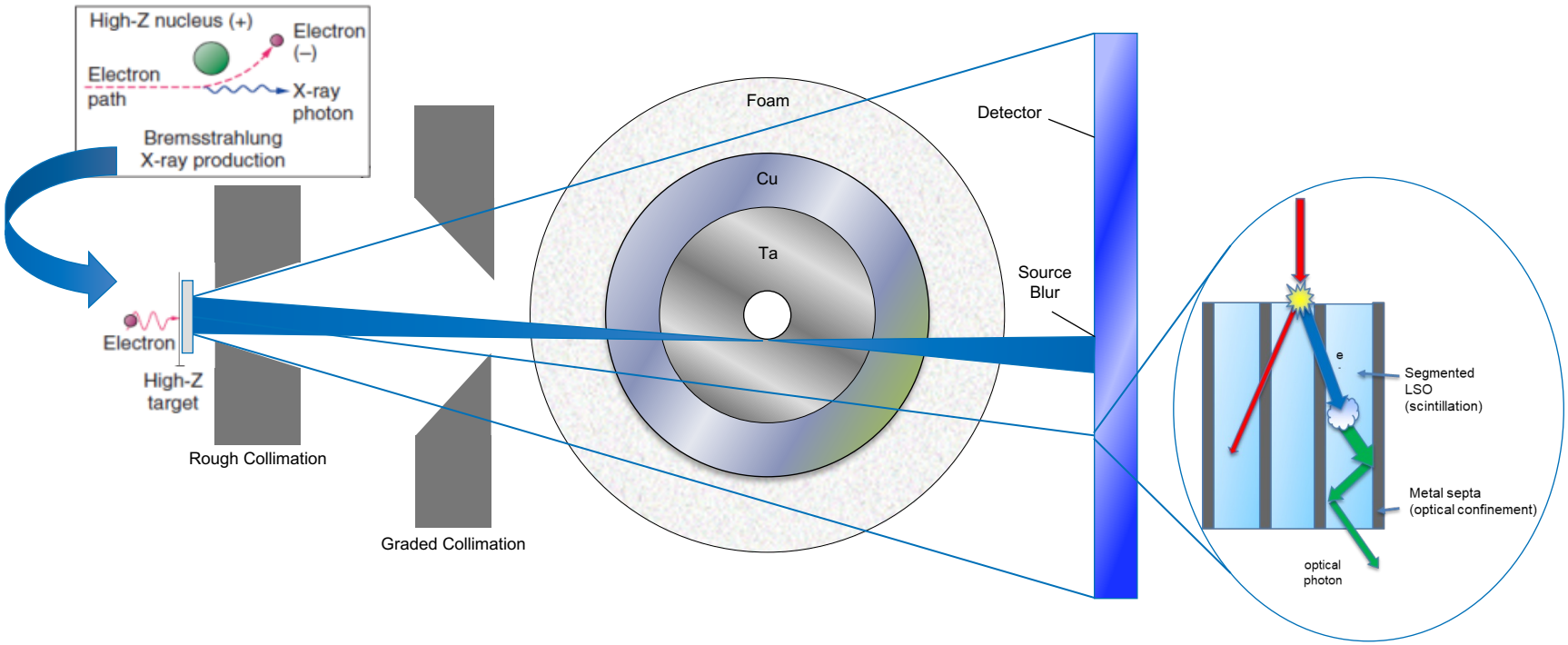
- Detector Pixel Size $\propto$ Aliasing
- Object feature size $\propto$ Aliasing
- Magnification $\propto^{-1}$ Aliasing

Scatter $\propto$ Object Density

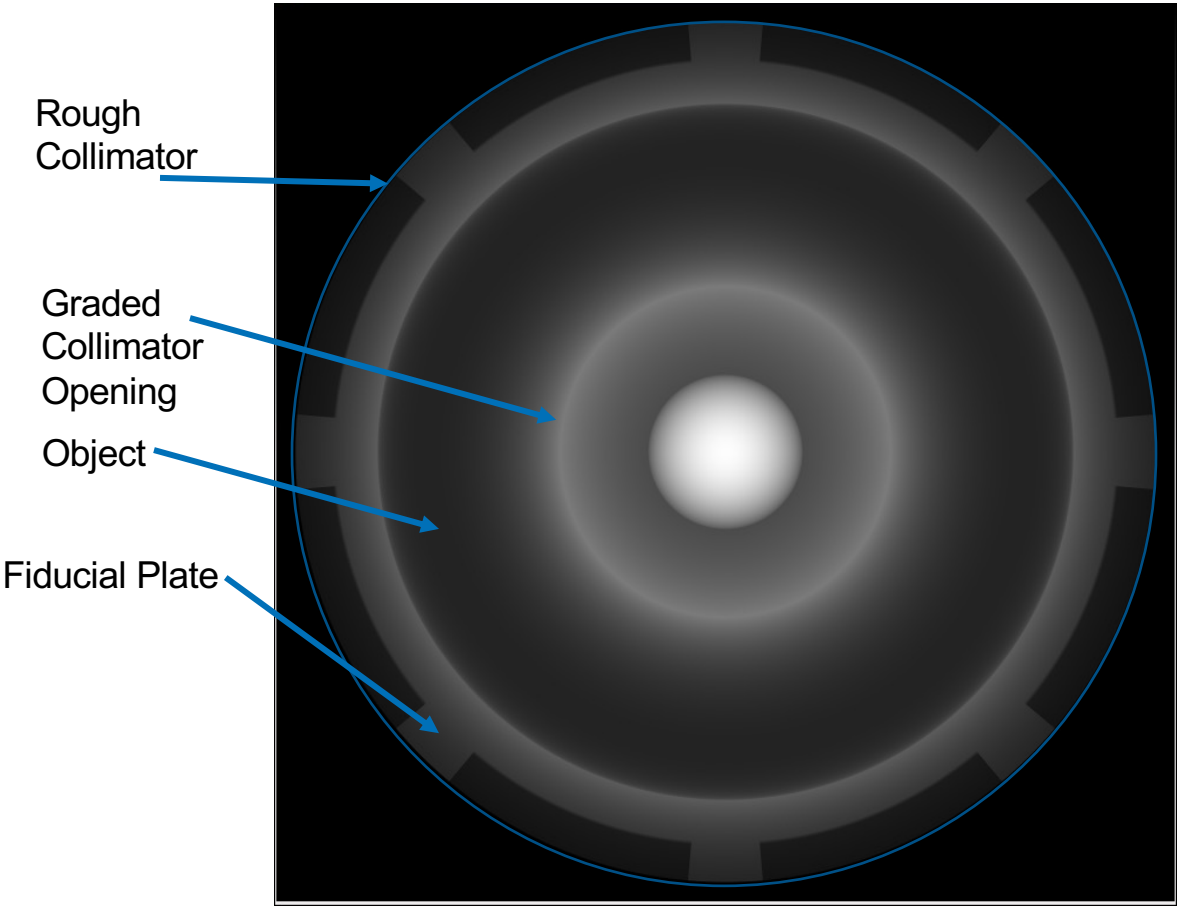


Biker Velocity=1.5 ft./sec
Shutter Duration=1 sec
1.5 ft. of blur @ Object

Radiographic Chain



Typical Test Object Radiograph



DARHT Video

- We are trying to image and reconstruct dynamic material behavior under extreme conditions.
- https://www.youtube.com/watch?v=FOCJCsC8gl4