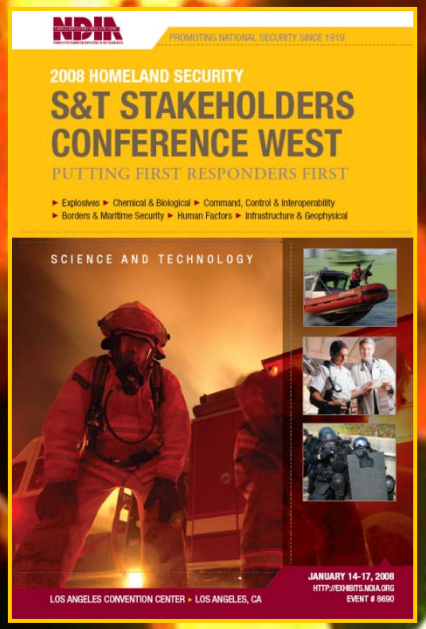
Detection Technologies Primer

An introduction to some current and emerging technologies



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U. S. Department of Homeland Security

"Putting First Responders First"

Homeland Security
Science & Technology

Introduction

- Types of Detection
- Common elements
- Detection technologies
- Conclusion

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Types of Detection

- Bulk Detection-requires a significant mass of material to interrogate.
  - Detection can be based upon
    - Statistical model (might be explosive)
    - Specific property (atomic, molecular, or crystalline structure)
- Trace detection
  - Uses analytical tools that identify specific molecules
  - Can detect residue

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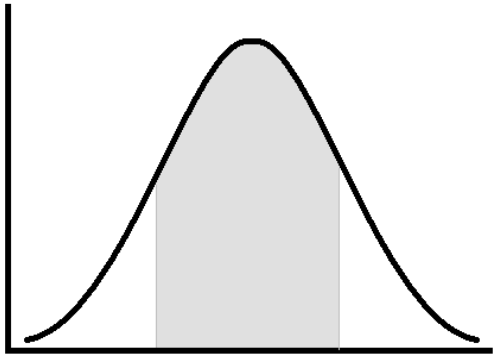
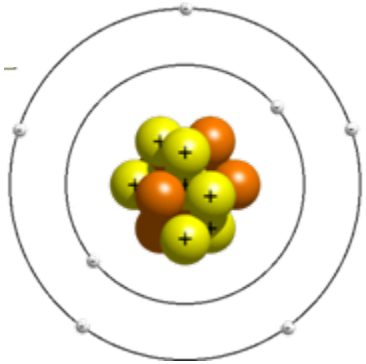
Bulk Detection

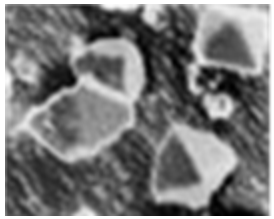
- By statistical model
  - Probability that interrogated material is a threat.



- By specific property
  - Molecular or atomic information



- By structure



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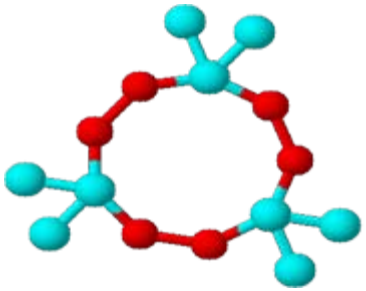
Trace Detection

- Can be solid (particulate) or gas (vapor) phase.
  - ppm, ppb, or even ppt
- Identifies explicit composition



TATP

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Common elements

- Many explosives contain Carbon, Hydrogen, Nitrogen, and Oxygen
  - CHNO
- Density
  - Explosives output is dependent upon multiple factors
    - Usually-higher density=higher velocity

Substance / Explosive	ρ (g/cm^3)	%C	%H	%N	%O
TNT	1.4	37	2	19	42
RDX	1.8	16	3	38	43
HMX	1.9	16	3	38	43
PETN	1.7	19	3	18	60
NG	1.6	16	2	19	63
EGDN	1.5	16	3	19	63
TATP	1.6	48	9	0	43

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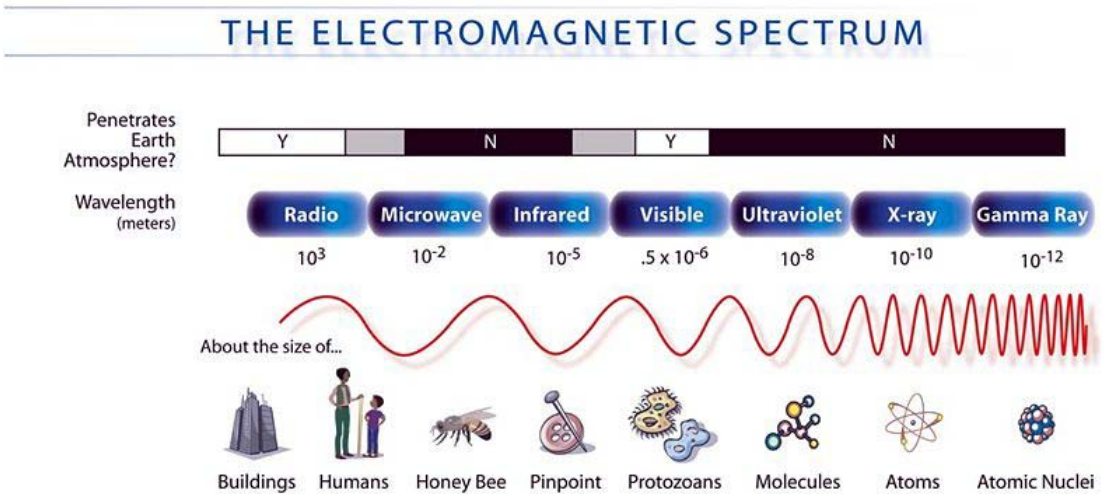
Detection technologies

- X-ray
- Gamma
- Neutron
- Vibrational
- Spectroscopy
- Visual



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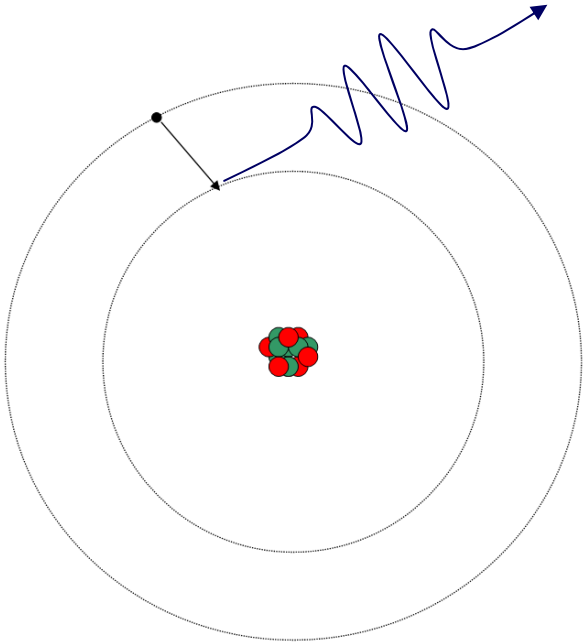
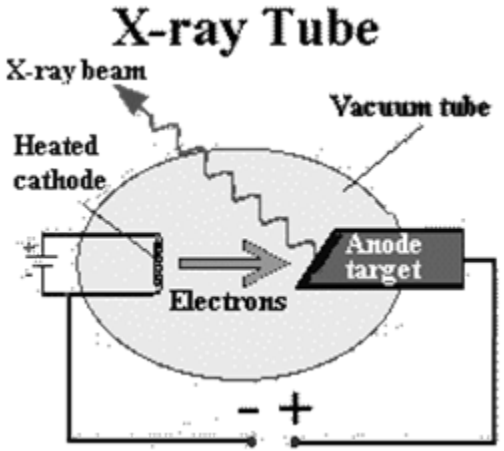
X-ray

- Transmission
- Computed Tomography
  - Single energy
  - Dual Energy
- Backscatter
- X-Ray Diffraction





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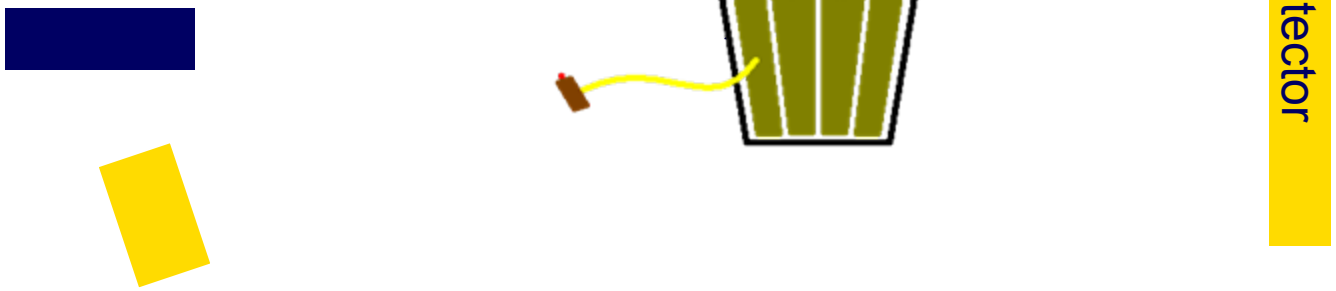
X-ray and Gamma Systems

Transmission
Tomography



Backscatter
Detector

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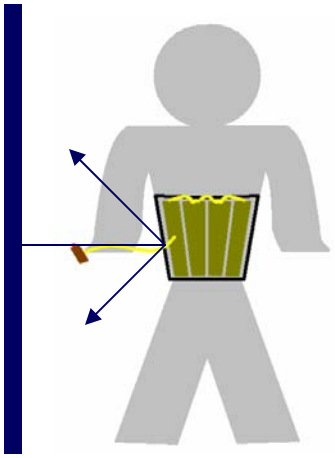
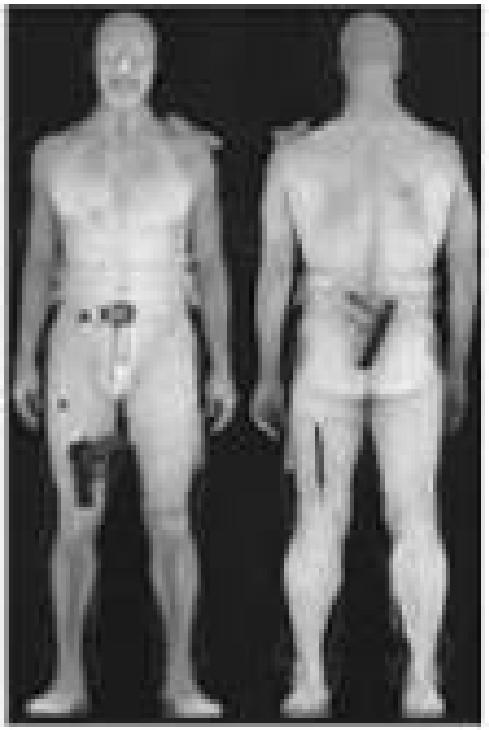
Backscatter

- X-Ray Backscatter
  - Imaging technology
  - Penetrates clothing (added benefit in detecting contraband)
  - Relatively small dose per scan (40keV X-rays)
  - Close proximity
  - Ethical issues





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Transmission

- Stationary source and detector array/film
- Imaging and “coloring” determine detection

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Computed Tomography

- 3-dimensional imaging
- Single energy vs. multiple energy
  - Added energies allow for additional information to determine composition of compound.
- Usually source and detectors rotate around item under inspection

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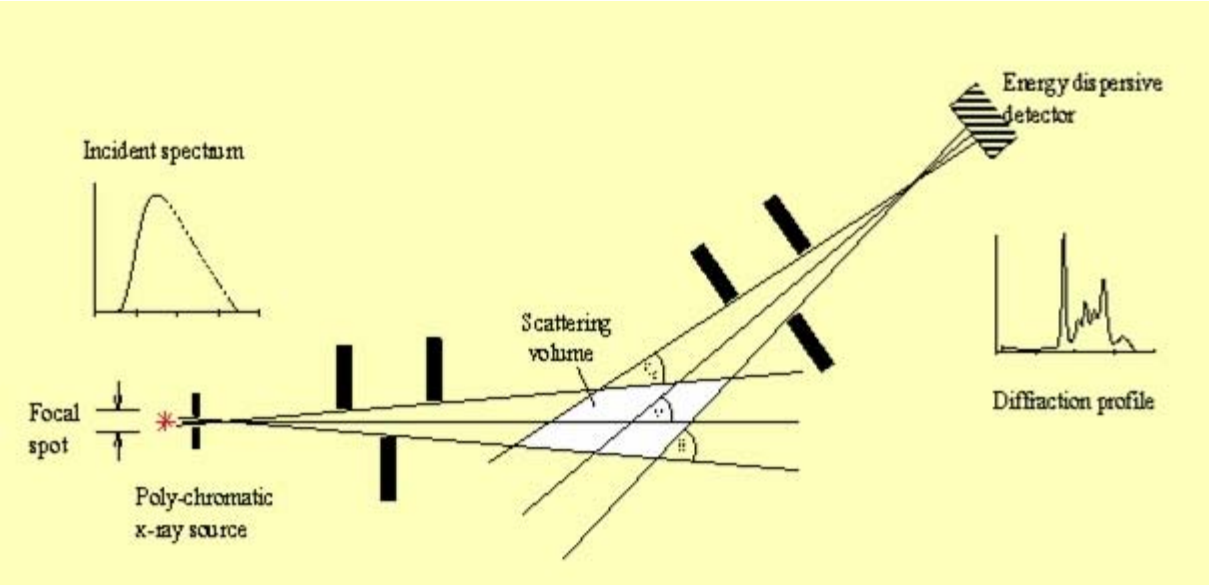
X-Ray Diffraction

- Broad signal source
- Produces unique diffraction profile



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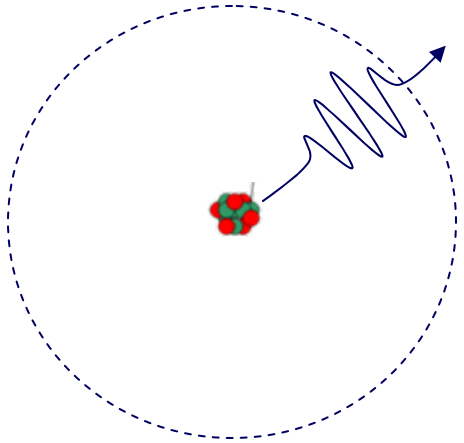
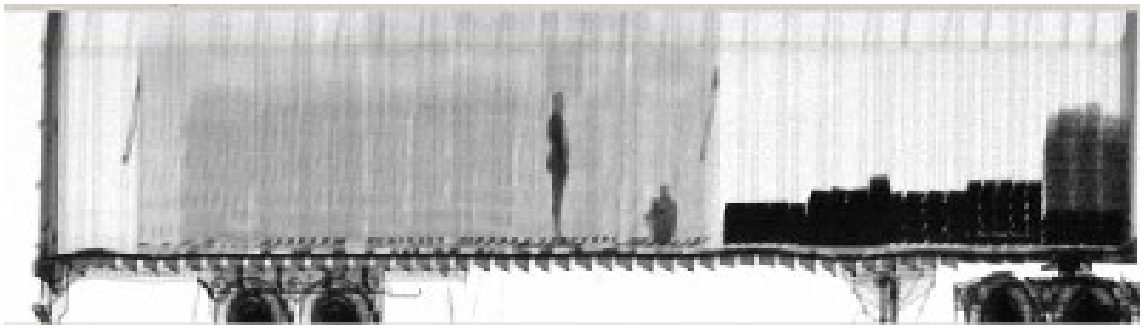
Gamma (γ)



- Transmission & backscatter
- Radioactive source
  - Usually Cobalt 60
  - Heavily shielded
  - Exposed to image
  - Can't turn material off and on



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Neutron

- Neutron source to produce neutrons
  - Radioactive Source
    - Californium-252, Americium-241
  - Neutron Generators
    - Small Accelerators

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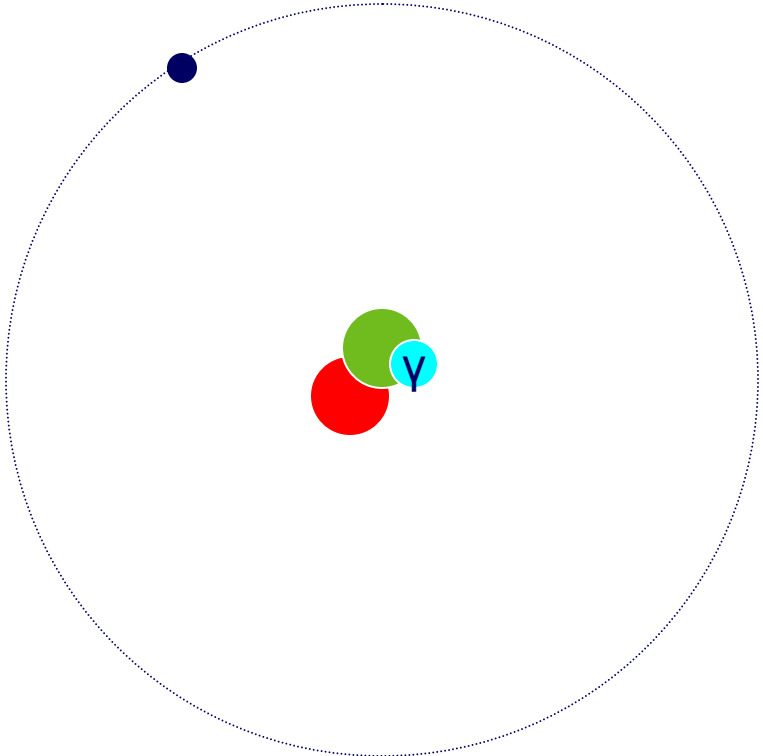
Thermal Neutron Methods

- Determines composition of target substance
- “captures” incoming neutron and emits a specific γ
- Usually used for Nitrogen or Hydrogen signature

Neutron



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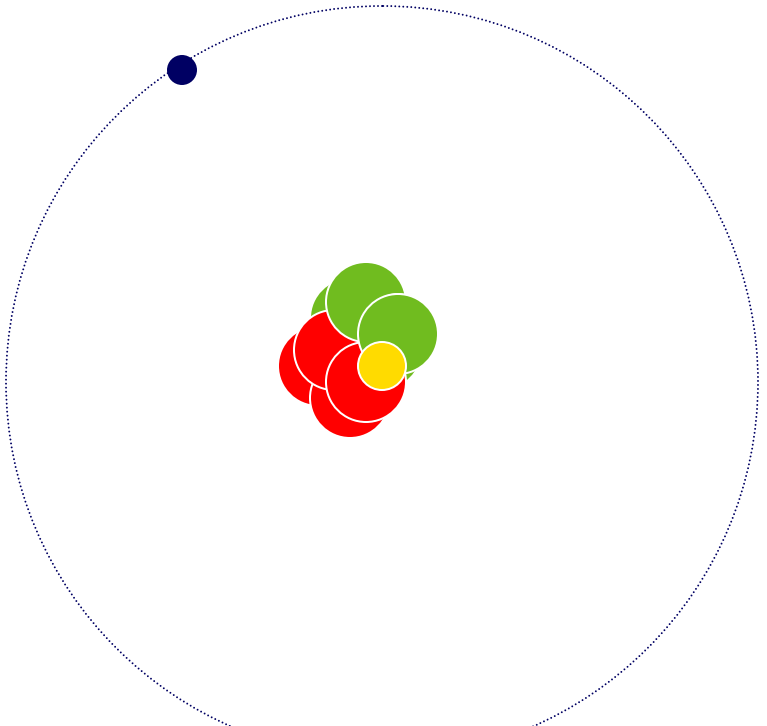
Inelastic Scatter Methods

- Fast Neutrons “hit” nucleus and “knocks” a neutron and distinct gamma energy free.
- Pulsing fast neutrons with relatively consistent speeds, location may be identified.

Neutron



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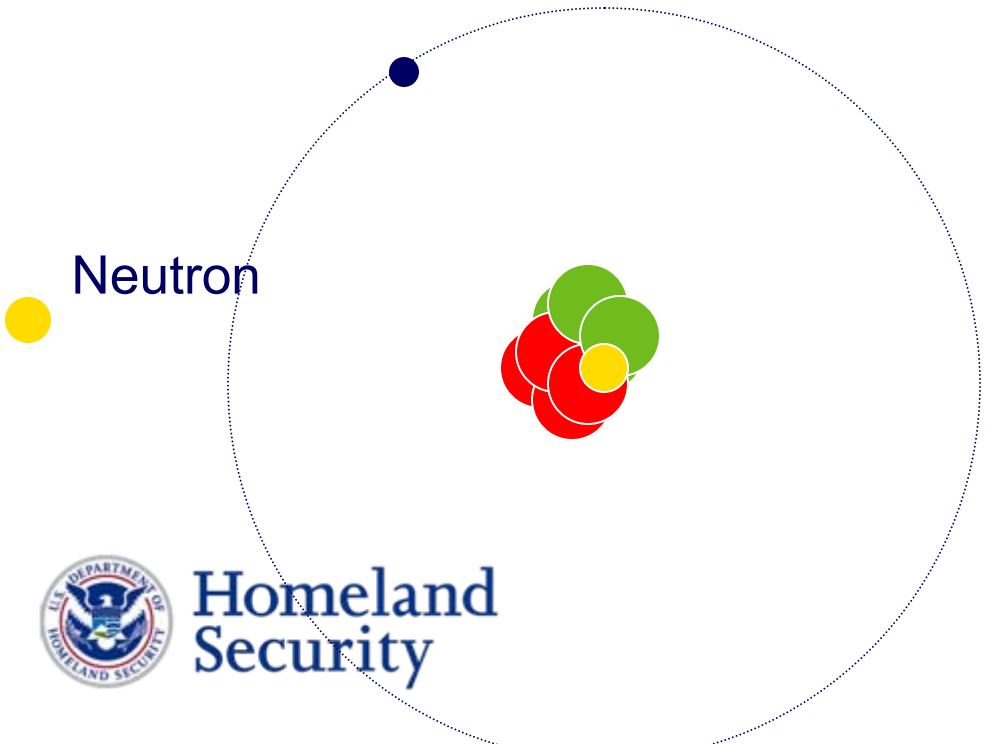
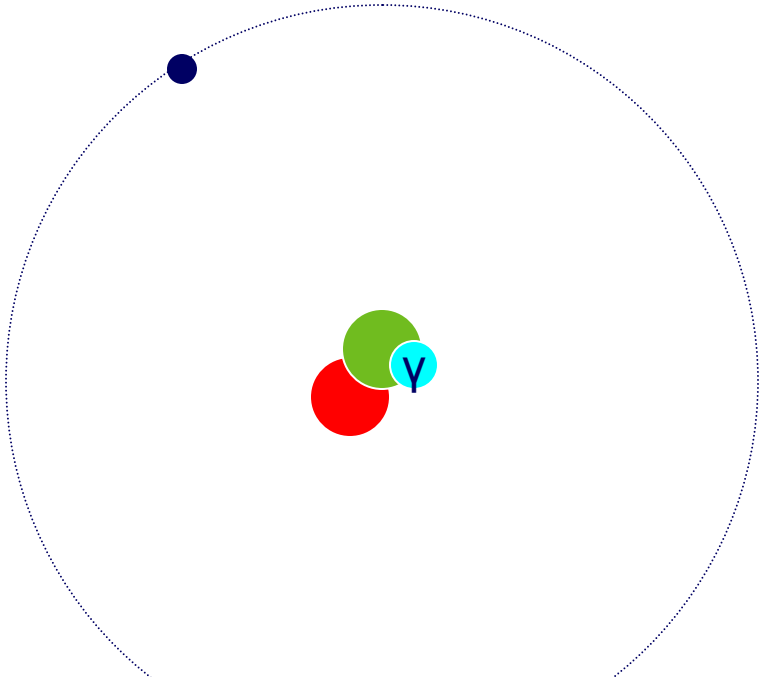
Combination Methods

- Pulsed fast (as in inelastic scatter) then wait for the emitted neutron to thermalise as in thermal)





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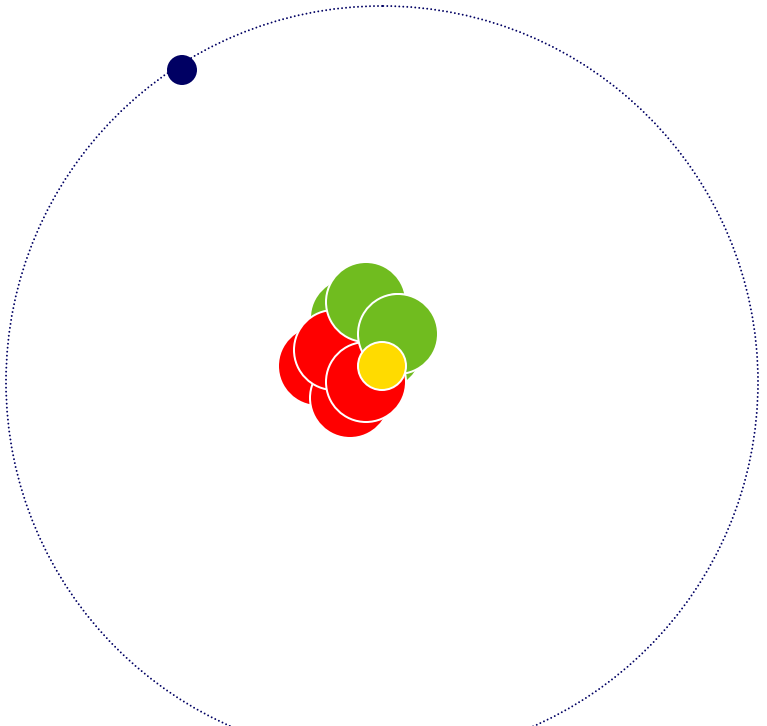
Associated Particle

- “Tagging” neutrons by associated particles allows for locating target

Neutron

Alpha particle detector



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Non-radioactive Nuclear Method

- NQR/NMR (zero field)
  - Uses Radio frequency to excite nucleus
  - As nucleus returns to lower energy state unique RF signal is emitted

Radio Frequency

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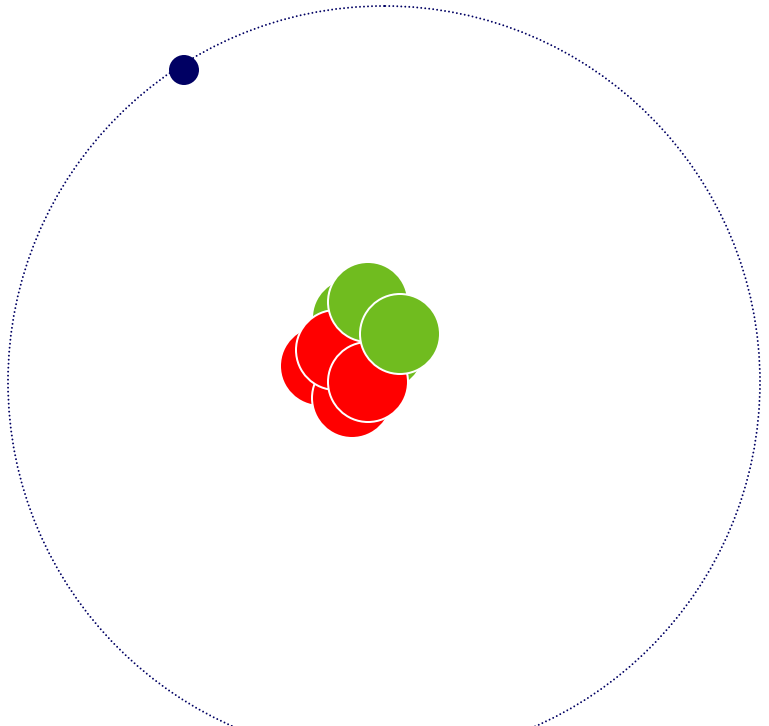
RF Detector



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Conclusion

- Types of Detection
- Common elements
- Detection technologies
- Conclusion

- Questions?

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