



The Idaho Accelerator Center: Research, Education and Economic Development.



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...but, I am also the Acting Chair

And this department, which I argue is the most successful department on campus, has a lot of issues that are currently being addressed:

- 1) Chair search, hopefully for a permanent Chair in January,
- 2) Lab space development – construction underway in basement,
- 3) Revitalizing graduate student recruiting,
- 4) Resolving student issues,
- 5) Curriculum and Class Overhaul.

What Student Issues?

- 1) Too many physics faculty, generally, are not around enough, do not hold regular office hours, fail to post office hours, teach irregularly or not at all, and are generally not sufficiently engaged with the students.
- 2) Banner: multiple students, mostly undergrads (about a half-dozen students), had complaints about the Banner registration and its blocking of registration for physics classes because of schedule conflicts. The schedule conflicts, in turn, are usually resolved by the instructor/students at the first class. However, by then Banner (or people thereof) have cancelled the class because of low enrollment – caused by Banner's block.
- 3) The department really needs to post (and stick to) a three-year schedule for upper-division courses so that students can plan their academic curricula.
- 4) Physics does not offer enough upper division electives.
- 5) The physics Junior Lab desperately needs an infusion of new equipment. Far too much of the equipment in that lab is broken.
- 6) Experimental/ad-hoc classes need to be better advertised and advertised in advance.
- 7) Student computers in computer lab are slow – not because they are inadequate in hardware, but because too many are infected with malware. They need to be wiped clean and software reinstalled.
- 8) Printer in student lab sucks.

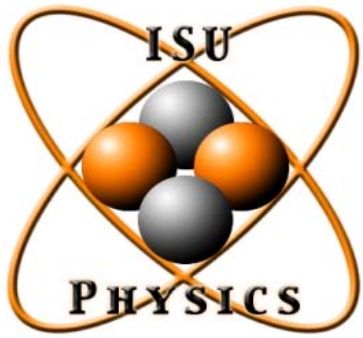
What Student Issues?

- 9) The students do not know who's in charge or who to turn to for problem resolution.
- 10) Faculty do not show up for colloquium.
- 11) The "level" of colloquium talks needs to drop to a reasonable level.
- 12) The Physics web-page ought to list colloquia talks past and future and, if possible, post electronic copies of the talks so that students can go over them and sort through that which they did not understand.
- 13) Physics should reinstitute the Friday Sack lunches.
- 14) Physics and IAC web-sites need major revisions. They are out of date. Things that they would like to see include updates of the research programs/groups, listings of which faculty contribute to which research programs, and some of the students are willing to help.
- 15) Undergrad and grad catalogs have many errors.
- 16) Engineering departments do not seem to be receptive to physics students taking their classes (some claims of being blocked by the departments).
- 17) Qual exam request – no professors that have their graduate students taking the exam should be involved in the exam.
- 18) Great concern was expressed about the department's relationship to the administration.
- 19) Great concern was expressed about the value of ISU degrees in light of ISU controversies

New Grads and All Grads Orientation

- 1) What courses should one take?
- 2) How does one find an advisor?
- 3) Who is who in the department?
- 4) What does the degree program of a Ph.D., M.S., M.N.S student look like? What are the expected steps, hurdles, milestones, and timelines?
- 5) Etc.

➔ There will be a Grad Student Orientation meeting later this week: watch for an e-mail from Sandra.



What is the Idaho Accelerator Center?



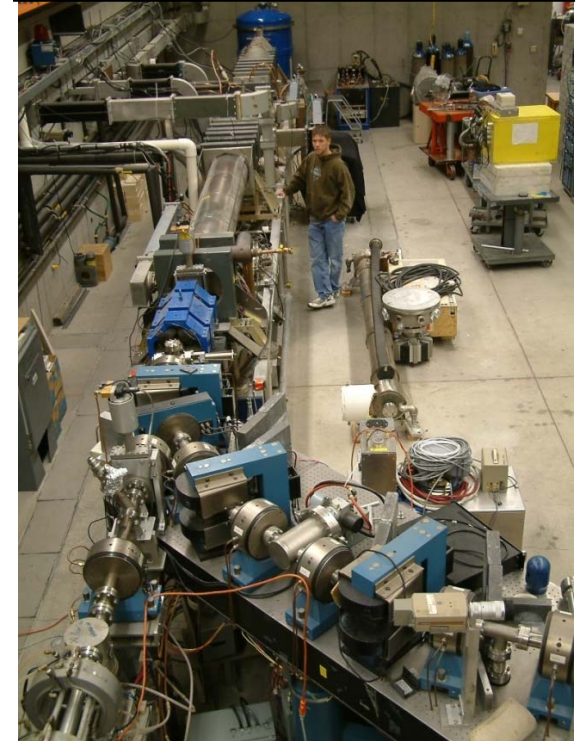
Founded in 1996 to support research, education and regional high-tech economic development, it is now one of the largest university accelerator centers in North America.



What is the Idaho Accelerator Center?

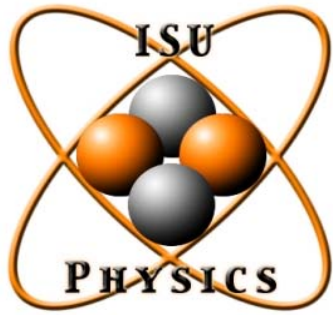
- **Electrons/Gammas**
 - 10 MeV Induction Accel. (~10 kA)
 - (4) 25 MeV e- LINACS
 - High Rep-Rate 15 MeV e- Linac
 - **44 MeV, 6 kW Short Pulse LINAC**
 - **In Storage: BOEING FEL (100 MeV, 100 mA, 1MW)**
- **Numerous X-Ray tubes and Neutron Sources**
- **Light Ions**
 - 2 MV Positive-Ion Van de Graaff
 - 4 MV Tandem Pelletron
- **Accelerators in Storage**
 - 20 Electron Linacs: P, L, S and X-band
 - 18 MeV Cyclotron
 - 20 MeV Betatron
 - Tandetron
- **Infrastructure**
 - ~3,500 m² Lab Space
 - Machine Shop
 - Electronics Shop

L-Band Traveling Wave Linac



Tandem 4 MV Pelletron





Nuclear Science and Engineering - Some Numbers...



■ ISU (Nuclear) Physics:

- Approximately 100 undergraduate majors (physics, health physics, nuclear engineering).
- Approximately 40 graduate students.
- 12 “nuclear” faculty (all nuclear in some respect: nuclear physics, nuclear engineering, accelerator physics, health physics, etc.)

■ IAC/Physics Funding:

- Approximately \$7 Million/yr in research and education funds
- Funding for students (Fellowships, Teaching Assistants, Research Assistants, Undergrads, etc.) are generally readily available.

What we do – and related opportunities...

- DoD Funding (\approx 3-4M/yr): DTRA, AFRRRI, AFRL, NRL
 - Chem-Bio Detection and Defeat, Nuclear Material Detection
 - Nano-tagants and nuclear forensics
 - NDT and portable accelerator systems for aircraft assessment
 - Radio-biology

- DOE Funding (\approx \$2-3M/yr): NE, NNSA, Off. Sci. (J-Lab, SNL, PNNL, INL, LANL, LLNL, ORNL)
 - Safeguards, Non-proliferation and Homeland Security, Stockpile Stewardship
 - Medical Physics – especially isotope production
 - NDT/materials for fuel cycle
 - Nuclear Physics

- NSF, DHS, Private Sector Funding (\approx \$1-2M/yr): (Lockheed-Martin, L3-Communications, GA, Battelle, TechSource Inc., Positron Systems, Bechtel, etc.)
 - Homeland Security
 - Nuclear Physics
 - Detector/Device Testing
 - NDT

Capabilities Today: 3 Labs

- Main Lab – just completed major construction upgrade:
 - 44 MeV, 6 kW fast-pulse e-linac
 - 25 MeV, 2 kW e-linac
 - 70 GW pulsed-power electron accelerator,
 - 4 MV Tandem Pelletron (positive ions)
 - Research focuses on high energy-density physics, device testing, nuclear physics, isotope production, non-proliferation/homeland-security and novel x-ray/gamma beams.
- Airport Lab:
 - X-ray machines (INL) and 25 MeV, mobile e-linac (INL).
 - Research, mostly led by INL, focuses on national/homeland security applications and testing ground.
- Physics Lab
 - High repetition-rate e-linac (20 MeV) and 2 MV positive-ion Van de Graaff
 - Research focused on materials, non-proliferation/homeland security applications, positron beam physics, and polarized gamma-beams.

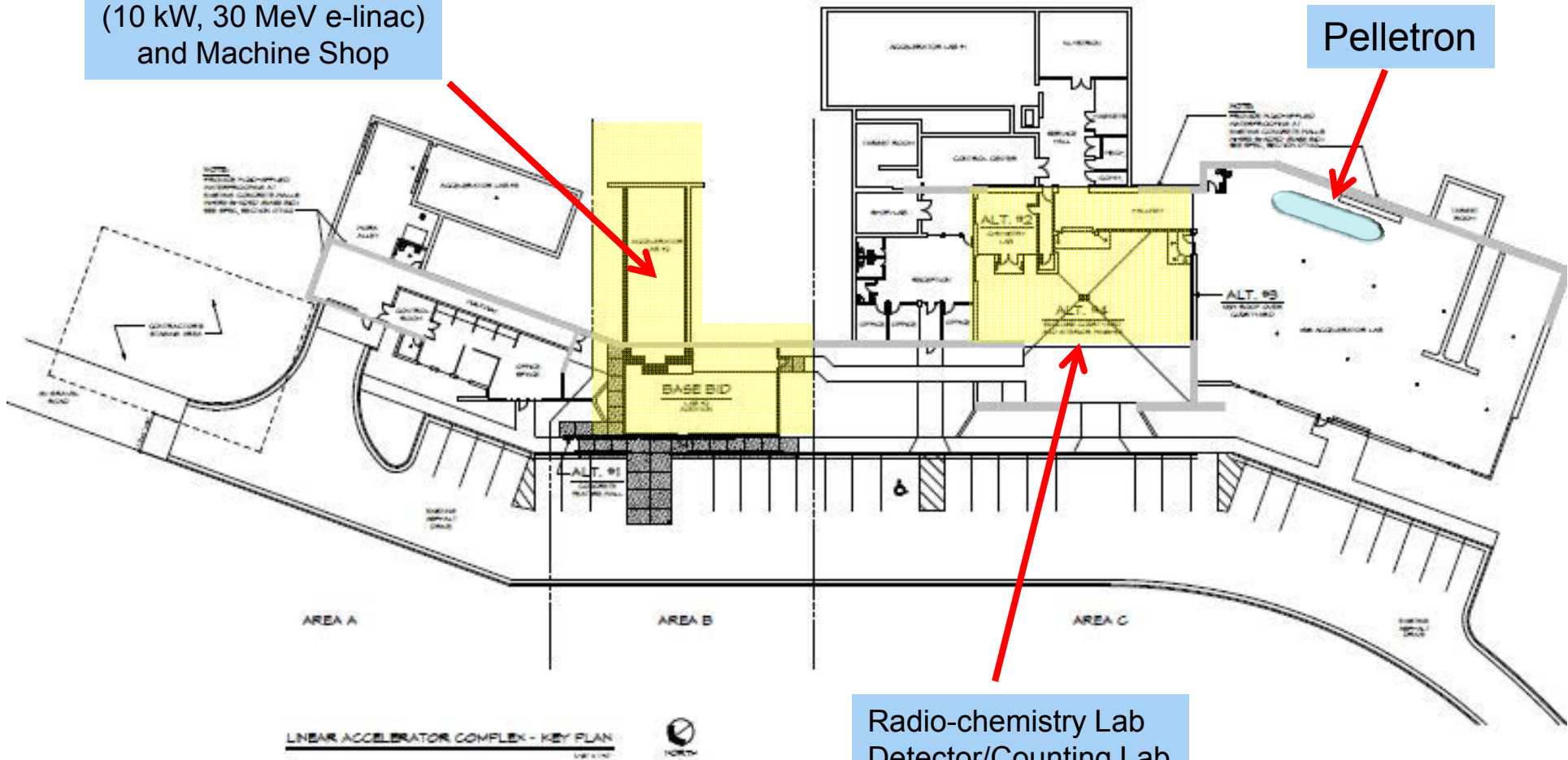
Capabilities Tomorrow: Main Lab

- 6 MV tandem Pelletron (INL):
 - Intense Neutron Source
 - NTOF and low-energy neutron cross sections
 - Materials irradiation, radiation effects on devices, ion beam analysis, positron annihilation spectroscopy, nuclear physics, radio-biology,
- 10 kW, 30 MeV e-linac – upgradable to ~ 50 kW:
 - Isotope production, photon activation analysis, Neutron-irradiation (the rough rule-of-thumb is $1E12$ fission-spectrum n/s per kW)
- Add-on to 44 MeV e-linac?:
 - Storage Ring and Tagger?
- New Lab Space:
 - New radio-chemistry lab, electronics shop, counting/detector lab
 - New machine shop, conference room, offices, library.

IAC New Additions...

High-power Cell
(10 kW, 30 MeV e-linac)
and Machine Shop

Pelletron



Radio-chemistry Lab
Detector/Counting Lab
Conference Room
Offices
Electronics Lab

Example:

Safeguards, Non-proliferation and Homeland Security:
(see Drs. Hunt, Dale)

What are the education, research and business opportunities?

Both nationally and internationally potential of commerce in contraband (nuclear, explosives, chemicals, biologicals, drugs...) leads to many challenges and related opportunities. At the IAC there are collaborations with:

L3-PS Communications

Lockheed-Martin

Valley Forge Composite Technologies

Battelle Memorial Institute

BEA

Raytheon

Security Concerns Driving Development of Inspection Technology



- Commerce → Movement of Goods
 - 95% Arrives by Ship
 - 22.5 Million Cargo Containers
 - 118 Million Vehicles
- Very Few Inspected
 - 2% of Containers Inspected

- Fissile Material Abundant
 - ~100 Tons in Storage
 - Located at 100's of Sites
 - Security at Some Sites is Lax
 - Some Material is “Missing”
- ~4 kg ^{239}Pu for a Crude Bomb
- Easy to Shield

A Nuclear Blast Would Alter Society as we know it –
how many nations are self sufficient in food, energy and medicine?

Passive Evaluation Has Been Deeply Problematic

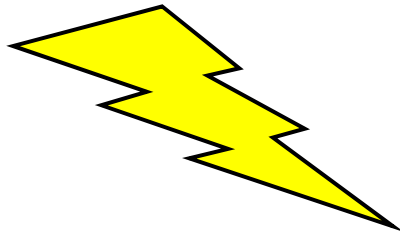


Plastic Scintillators
on PMTs

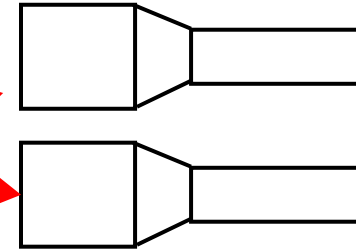
- Deployed at Ports in 2002 and 2003 by DHS
 - Mainly False Positives Have Been Recorded
 - Environment is Rich with Radiation
 - More Shipped Goods are “Radioactive”
 - Thresholds Raised or Alarms are Ignored
 - Weapons Material; Low Specific Activity and Easy to Shield
- Single Photon Counting
 - Simple Threshold
 - Time Averaging
 - Maybe “Coincidence”

Active Evaluation Uses Radiation to Probe Package

Radiation



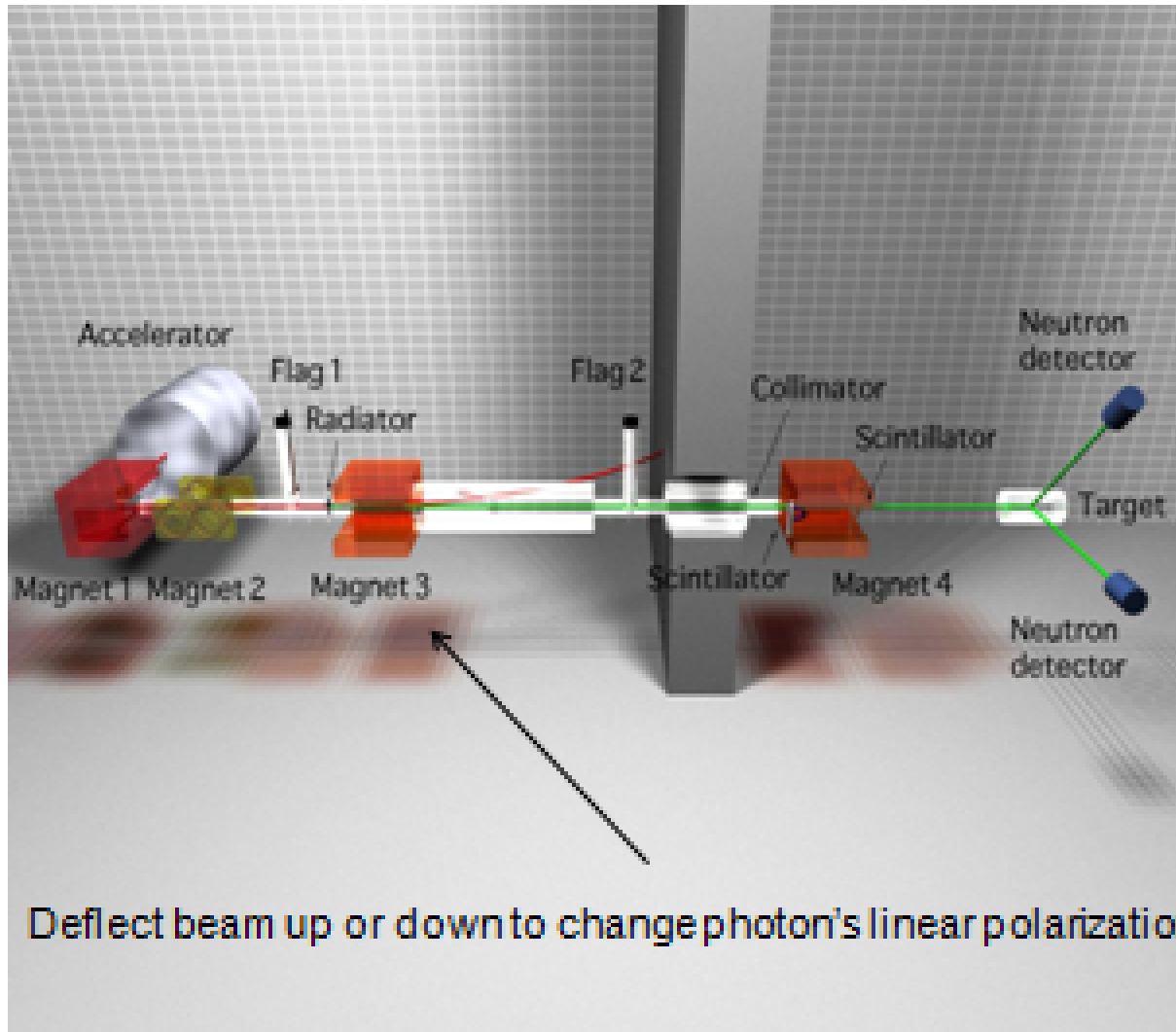
Detectors



- External Radiation Sources
 - Neutrons
 - Radioactive Sources
 - Accelerators
 - γ -rays
 - Accelerators (Bremsstrahlung)
 - Maybe Radioactive Sources (Accelerator Produced)
 - Exotic Sources (e.g. Laser Compton Backscattering)
- Monitor for Secondary Emissions

IAC-ISU just signed a contract with Valley Forge to build, debug and demo integrated accelerator/detector systems for cargo scanning. We expect the first system to be completed this summer.

ISU Linearly Polarized Photon Facility for Fissile Materials Detection



- (1) Photons induce fission.
- (2) Angular distribution of fission fragments depends on photon polarization.
- (3) Angular distribution of fission neutrons reveals presence of fission.

Deflect beam up or down to change photon's linear polarization.

Example:

High Energy-Density Applications:

What are the opportunities?

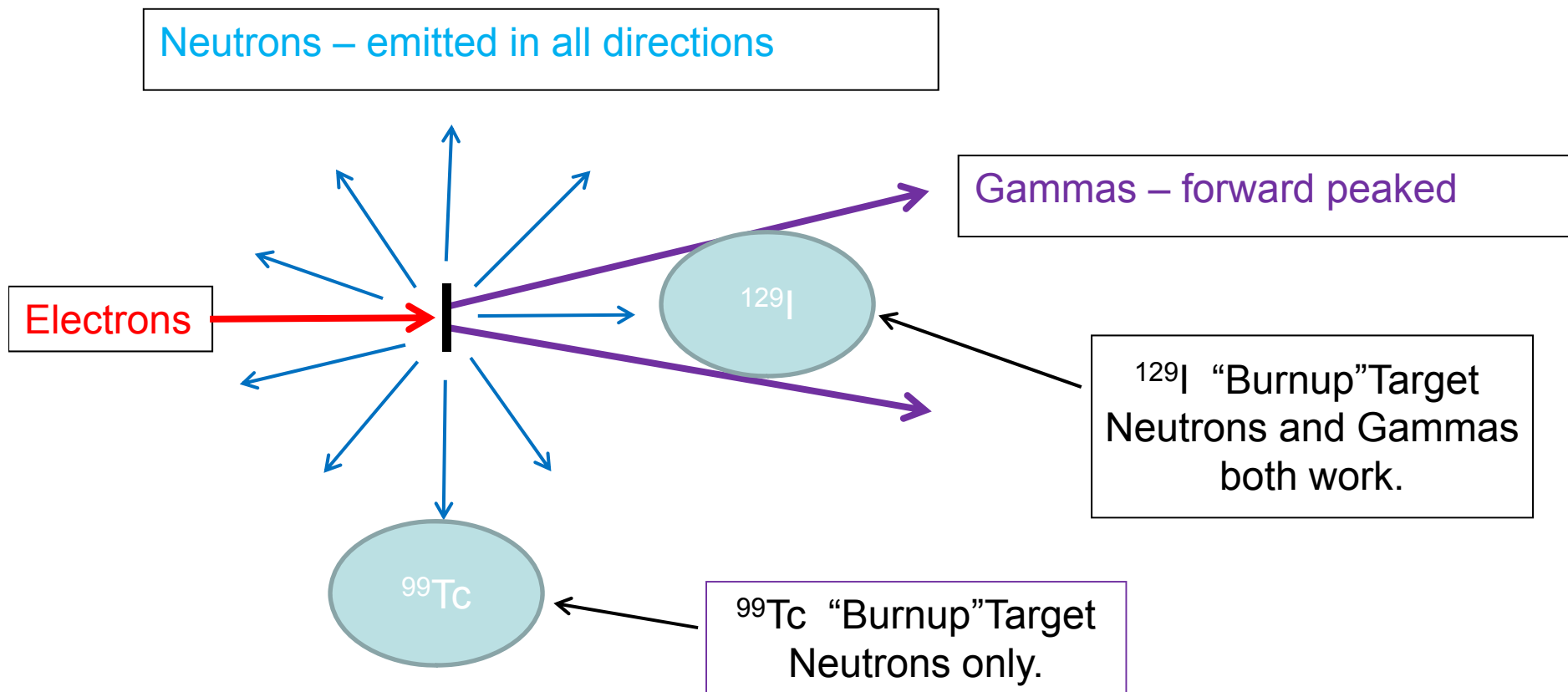
Nuclear Waste “Burnup” (^{99}Tc , ^{129}I)

Plasma Physics

Fuels “aging” and materials irradiation

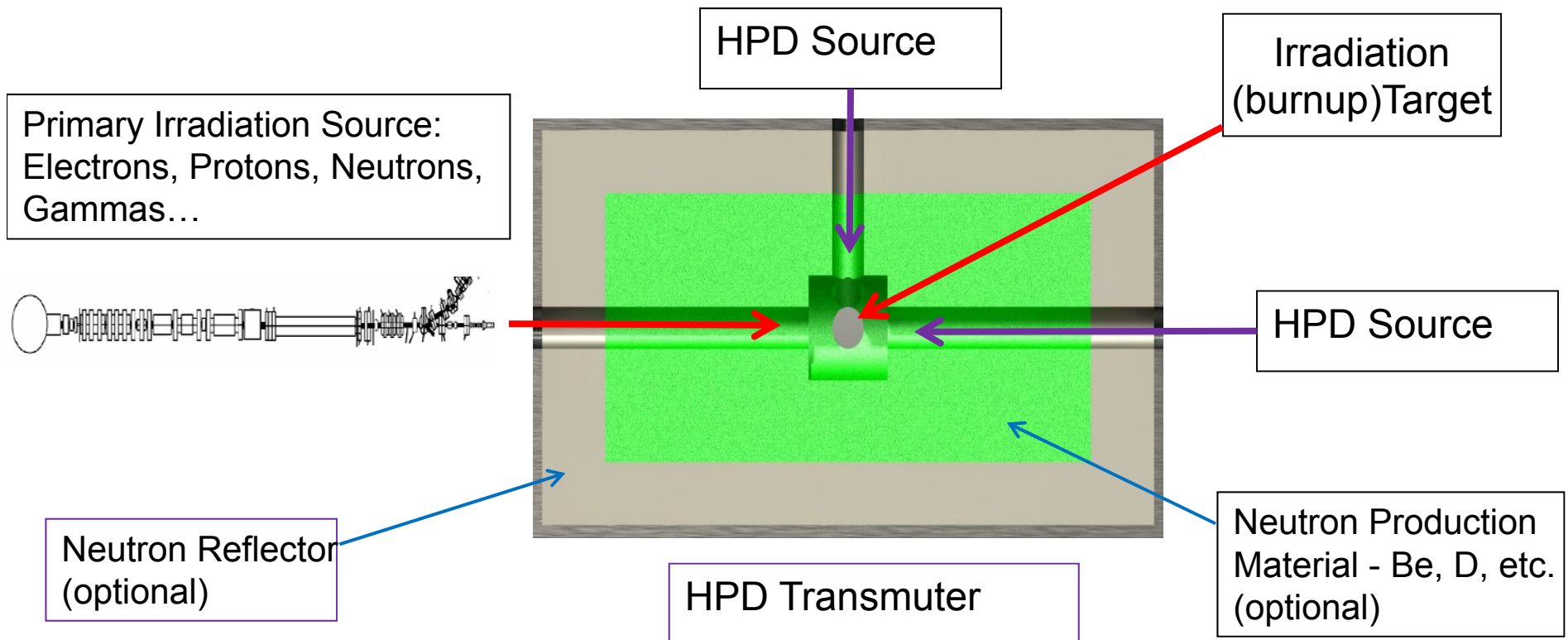
Ultra-high dose rates

High Power-Density (HPD) Transmutation (see Dr. Kook + Harmon/Wells)



- Photo-nuclear burnup of ^{129}I and ^{99}Tc with a 100 kW, 50 MeV beam can transmute these species (pure targets) at a rate of approximately 25 kg/yr. U.S. spent fuel ^{129}I inventory is ~ 2,500 kg → 10 such facilities could transmute this in ten years. These rates can be boosted considerably with neutron production/reflectors (especially advisable for ^{99}Tc).

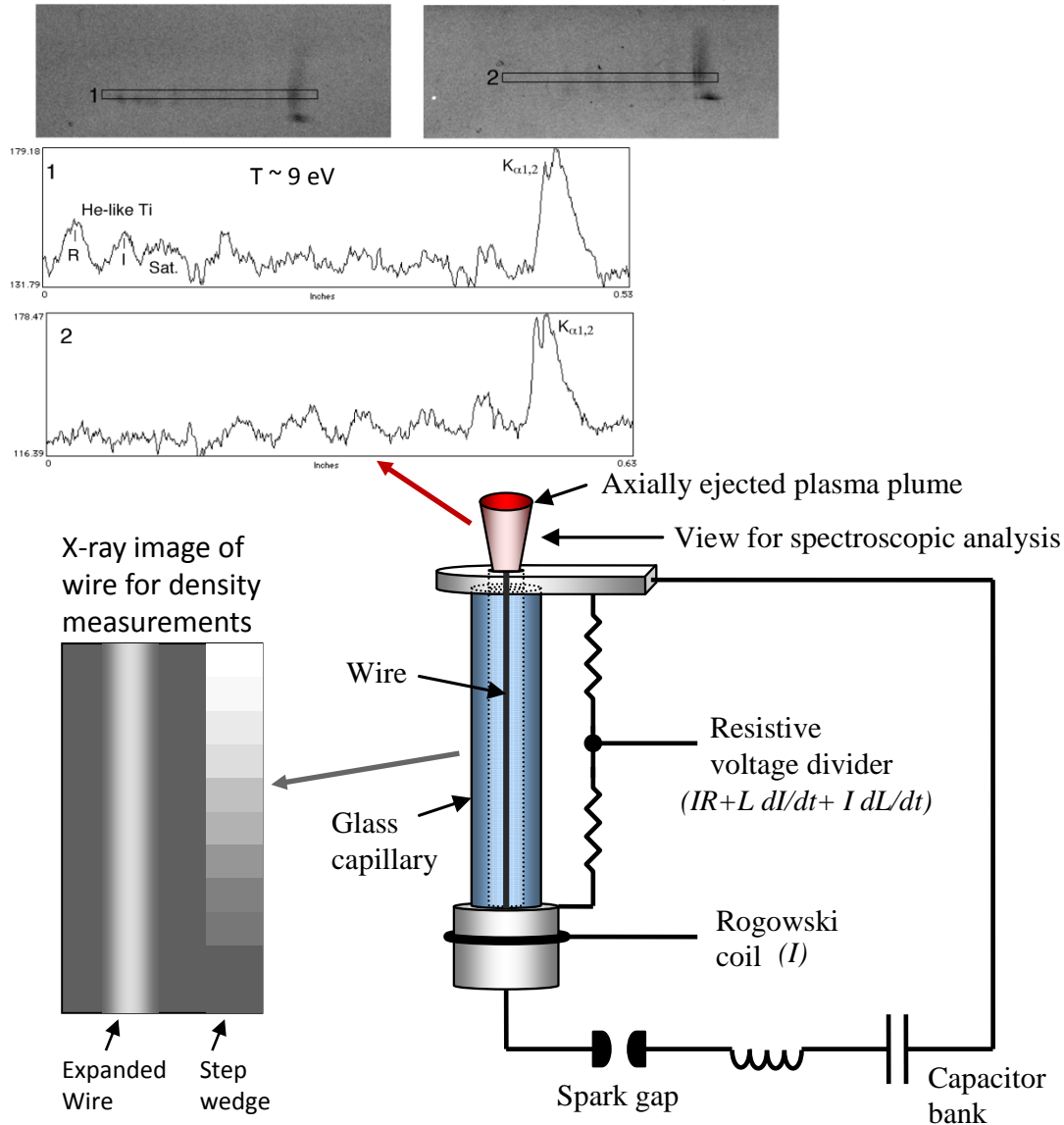
High Power-Density (HPD) Transmutation (Photo-nuclear burnup +)



- Novel burnup schemes all exploit high power density (HPD) physics that create enormous electric field gradients, accelerate ions to tens of MeV and induce nuclear reactions that cause transmutation.
- Sources include lasers, electrons and others.
- In principle such schemes could boost burnup rates considerably, but further research and a test facility is needed.

Equations of State for Warm Dense Matter (see Dr. Chouffani + Mitchell and Chandler)

Spectra of axial plasma plume

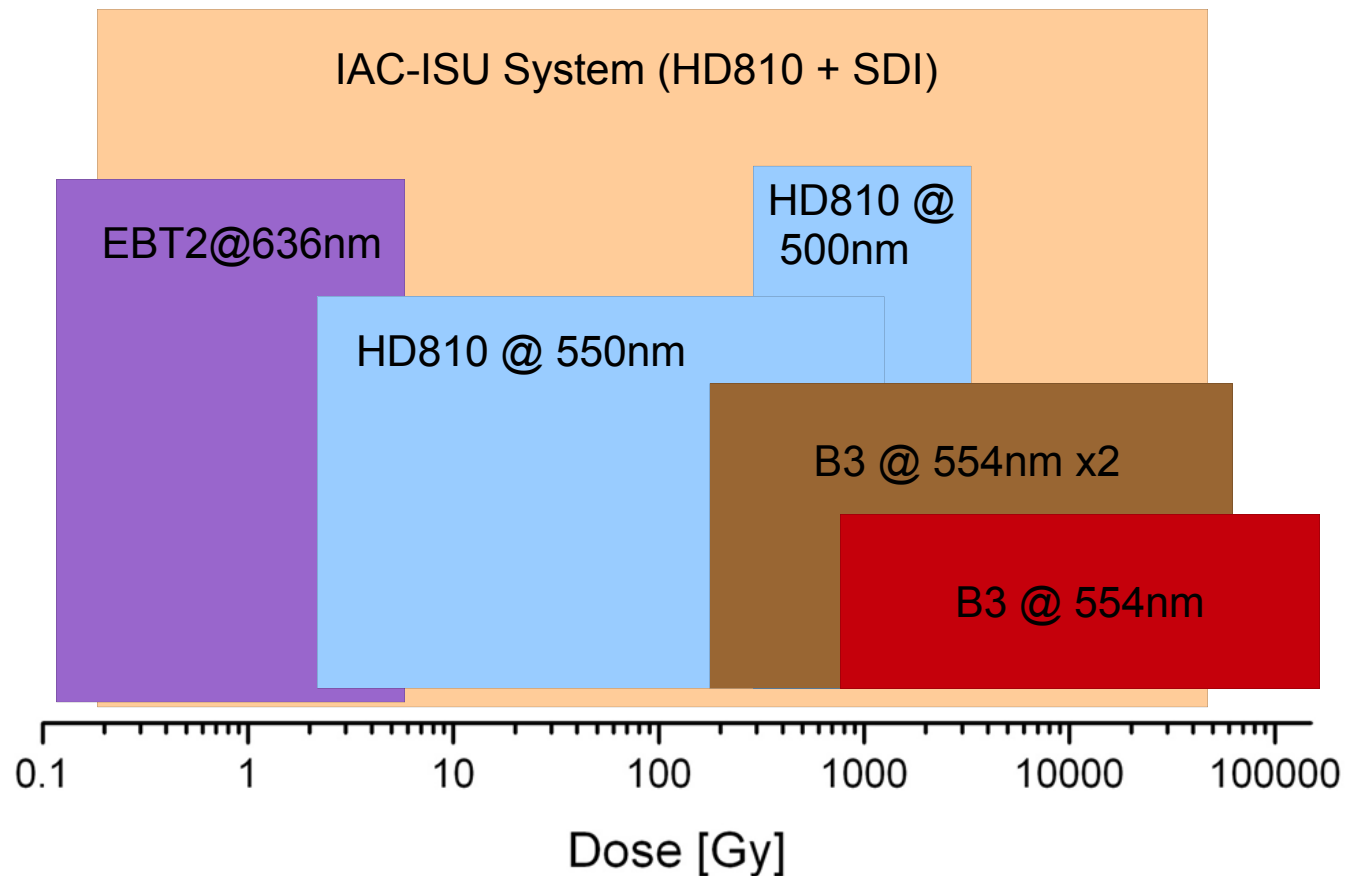


Warm Dense Matter (WDM):
The partially ionized state of matter
between gas and plasma

- WDM state is not well characterized.
- Equations of State (EOS) are needed to predict transition from standard temperature and pressure to high-energy-density plasmas.
- EOS are needed to simulate plasma radiation sources relevant to inertial confinement fusion (to save time and \$).
- We are experimentally correlating temperature, pressure, density, and resistivity to build EOS.

Advanced Radiochromic Film Dosimetry System
(see Dr. Dimitrov) project funded by DTRA:
Multiple wavelength readout + scattered data interpolation

*Dynamic range of different radiochromic film dosimetry systems
for equivalent precision:*



Example:

Non-destructive testing of structural alloys and composites:
(see Drs. McNulty, Hunt, Gagliardi or Wells)

Structural Materials failure cost the U.S. economy approximately \$50 Billion/year. Non-destructive testing for thick structural materials is a multi-billion dollar industry, yet current techniques are not capable of reliably detecting the “approach to failure” of thick composites and many alloys. IAC-invented techniques in accelerator-based materials characterization are now being used in DoD-sponsored demonstration projects in collaboration with four private sector partners:

Wyle Inc.

Axter Inc.

TechSource Inc.

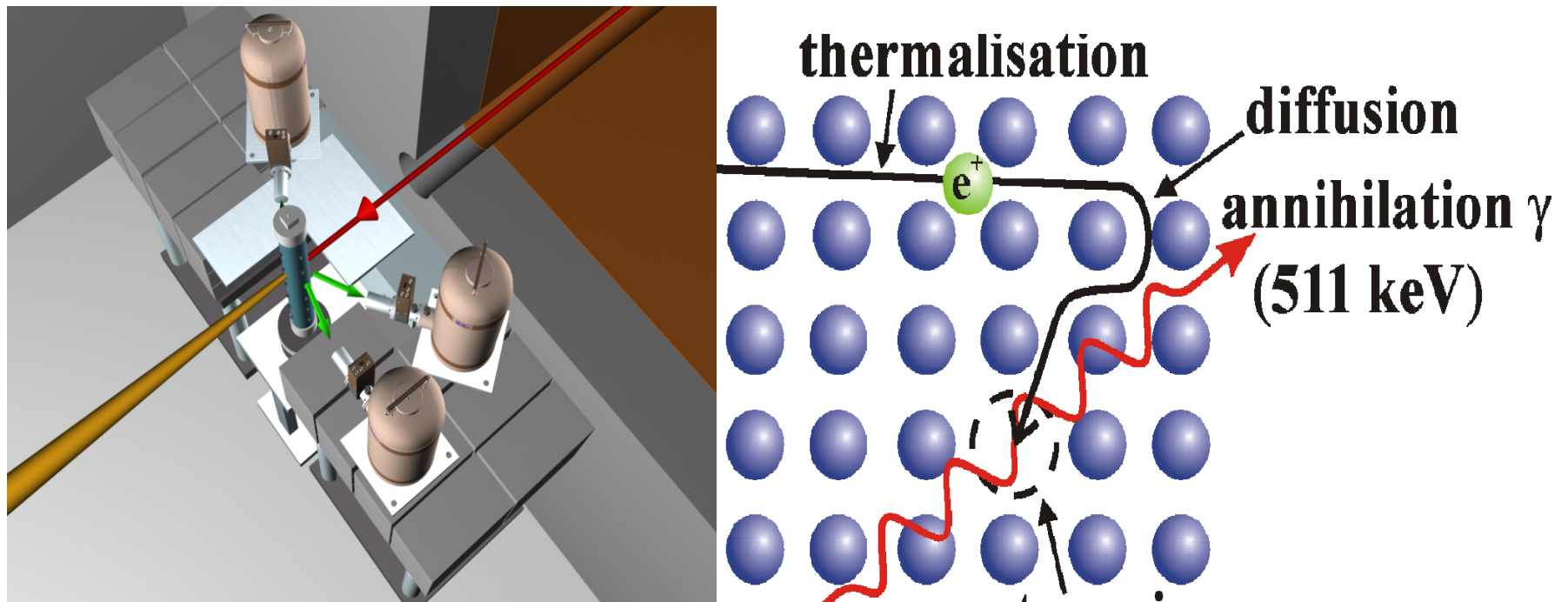
Positron Systems Inc.

Material failures cost
lives, money and jobs.



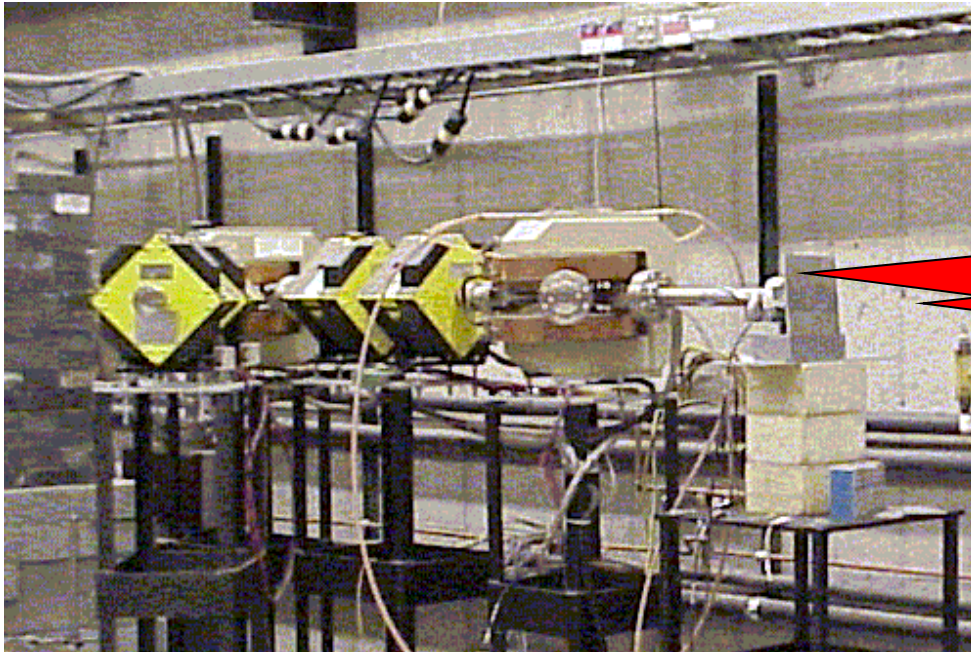
Accelerator-produced “radiations” gammas, x-rays, neutrons and positrons all have particular sensitivity to “defects” in matter.

Shown below is one scheme that is under investigation for the *in situ* detection of defects in aircraft parts





Radiation Microbiology at ISU (see Dr. DeVeaux)



Bug zapper
(Electron Linac)



From Bugs to
→ Dead Bugs
(Microbial cells)

ISU Accelerator Physics (see Dr. Kim)



DOE, DOD, Jefferson Lab, and PNNL related Research

Construction of a **15-50 MeV CW Racetrack Microtron** for future IAC & PNNL projects
Development of **CW Positron Source** for Jefferson Lab CEBAF & MEIC projects
Polarized Positron Source (PEPPo) experiments for Jefferson Lab CEBAF & MEIC projects
Development of Digital Beam Feedback Systems for Jefferson Lab MEIC project

Femtosecond (or Attosecond) Electron Beam and Photon Beam Related Research

Design of 1 GeV Soft X-ray Free Electron Laser (XFEL) Facility @ ISU
Development of a Coherent Terahertz Light Source Facility @ ISU
Development of a Compact Accelerator for the Ultrafast Electron Diffraction (UED)

High Brightness Electron Source Related Research

Development of Dual Mode (Photo & Thermionic) RF Gun for future IAC projects
Development of RF photoinjector for future IAC projects

Other IAC Accelerator Related Research

Development of Beam Diagnostic Systems
Development of Linear Accelerator Structure
Novel Radiation Beams
Compact, High-power Beams



Thank You!

Questions?