Office of Defense Nuclear Nonproliferation
Research and Development

University and Industry Technical Interchange (UITI 2016) Review Meeting

Treaty Verification: Characterizing Gaps and Emerging Challenges

CVT – Consortium for Verification Technology

June 6–9, 2016

Alexander Glaser
Princeton University

CONSORTIUM FOR VERIFICATION TECHNOLOGY

BACKGROUND

TWO WAYS OF APPROACHING THE VERIFICATION PROBLEM

Technology-focused and mission-focused approach;

CVT seeks to combine both; unique opportunities for synergisms given diversity of 13 + 9 CVT partner institutions and groups

POLICY RESEARCH THRUST: A TREATY ENABLING APPROACH

Emphasizes mission-focused dimension (as defined by existing and expected future treaties); support and guide CVT technology developments toward specific treaty applications; track emerging technologies

RELEVANT NUCLEAR ARMS CONTROL TREATIES

NUCLEAR NON-PROLIFERATION TREATY

Bans the acquisition of nuclear weapons by non-weapon states and commits the five weapon states to nuclear disarmament; verified by IAEA safeguards

COMPREHENSIVE TEST BAN TREATY

Bans all nuclear explosions in all environments and would be verified by extensive verification mechanisms (International Monitoring System, CTBTO)

FISSILE MATERIAL (CUTOFF) TREATY

At a minimum, treaty would ban fissile material production for weapons purposes;
Issue about treaty scope: Would it also cover existing stocks?

NEXT-GENERATION NUCLEAR DISARMAMENT TREATIES

Agreements that place limits on total number of nuclear warheads in arsenals would pose qualitatively new verification challenges

So … What Are the Existing Gaps and Emerging Challenges for Nuclear Verification ?

CVT SCOPING WORKSHOP

December 2015, “Nuclear Verification at Low Numbers”

APPROACHING THE PROBLEM

SELECTED SESSION QUESTIONS

THE PROBLEM IN CONTEXT

What are the expected (treaty) commitments and what are the political and technical concerns states may have with regard to possible verification?

MINDING THE GAPS

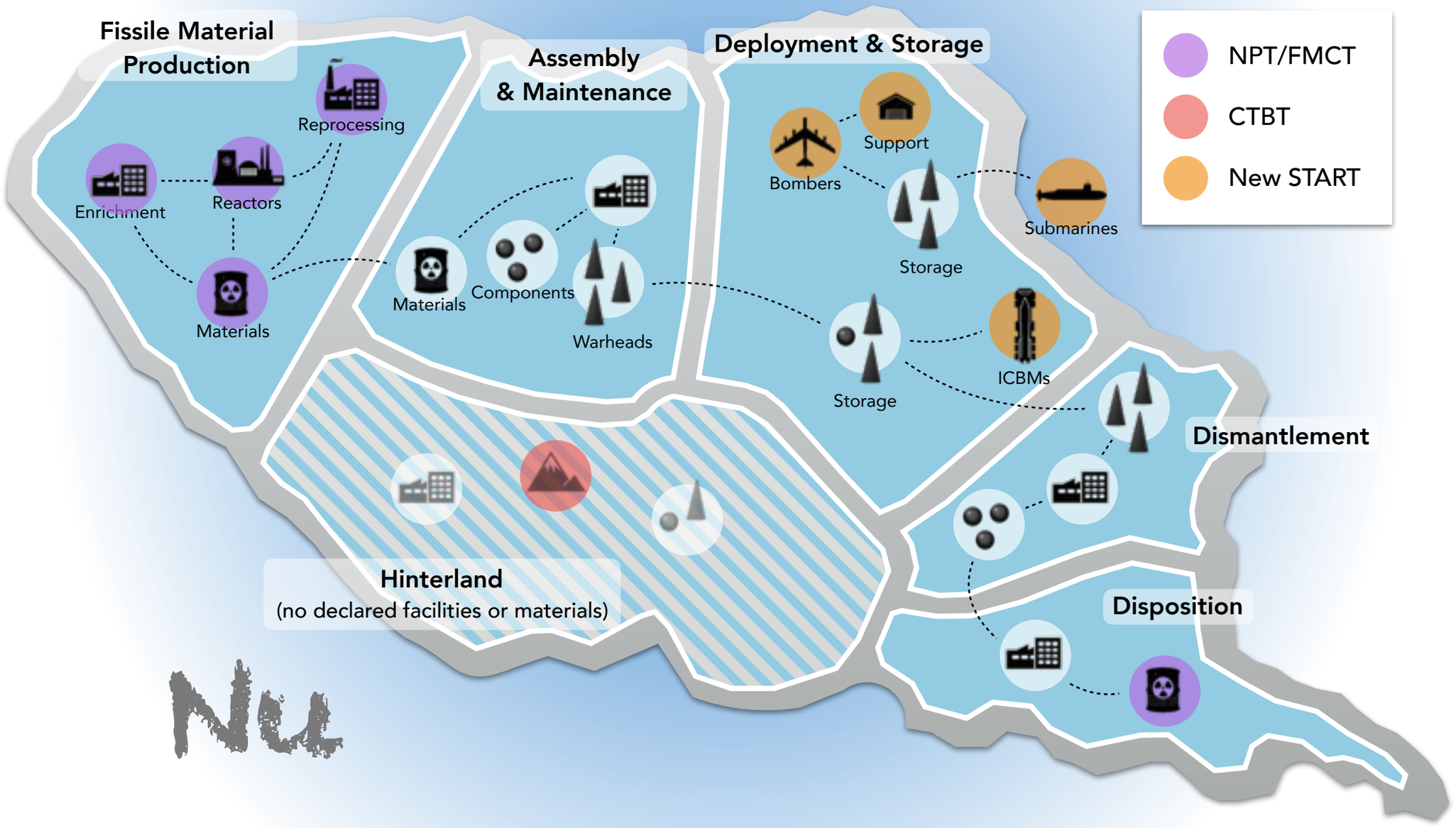
What are the key verification gaps, and how do they relate to important non-compliance scenarios? What are the main verification concepts and technologies that might help address them?

Source: IAEA Imagebank (top)

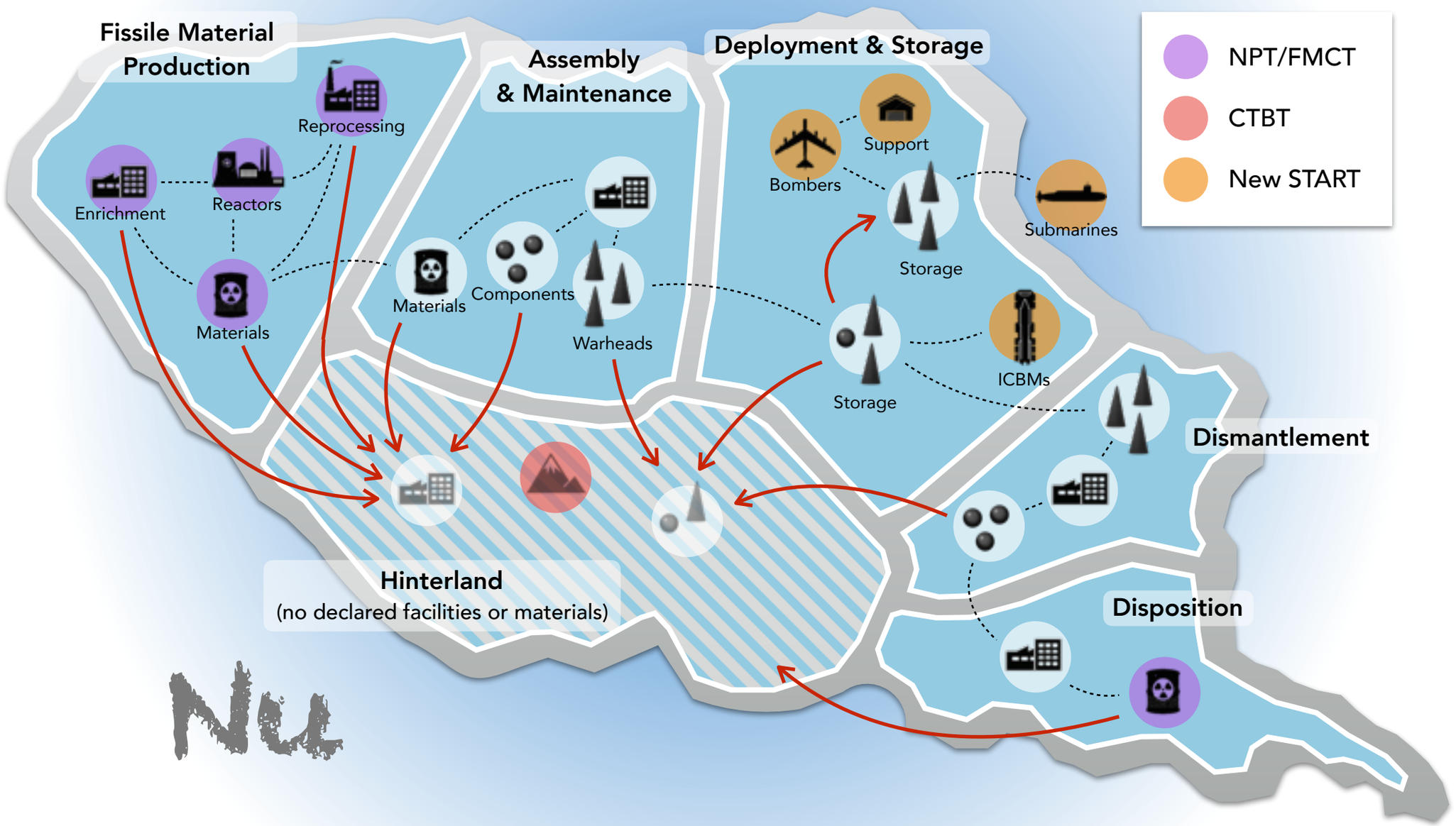
MAPPING NUCLEAR VERIFICATION

(verification.nu)

MAPPING NUCLEAR VERIFICATION

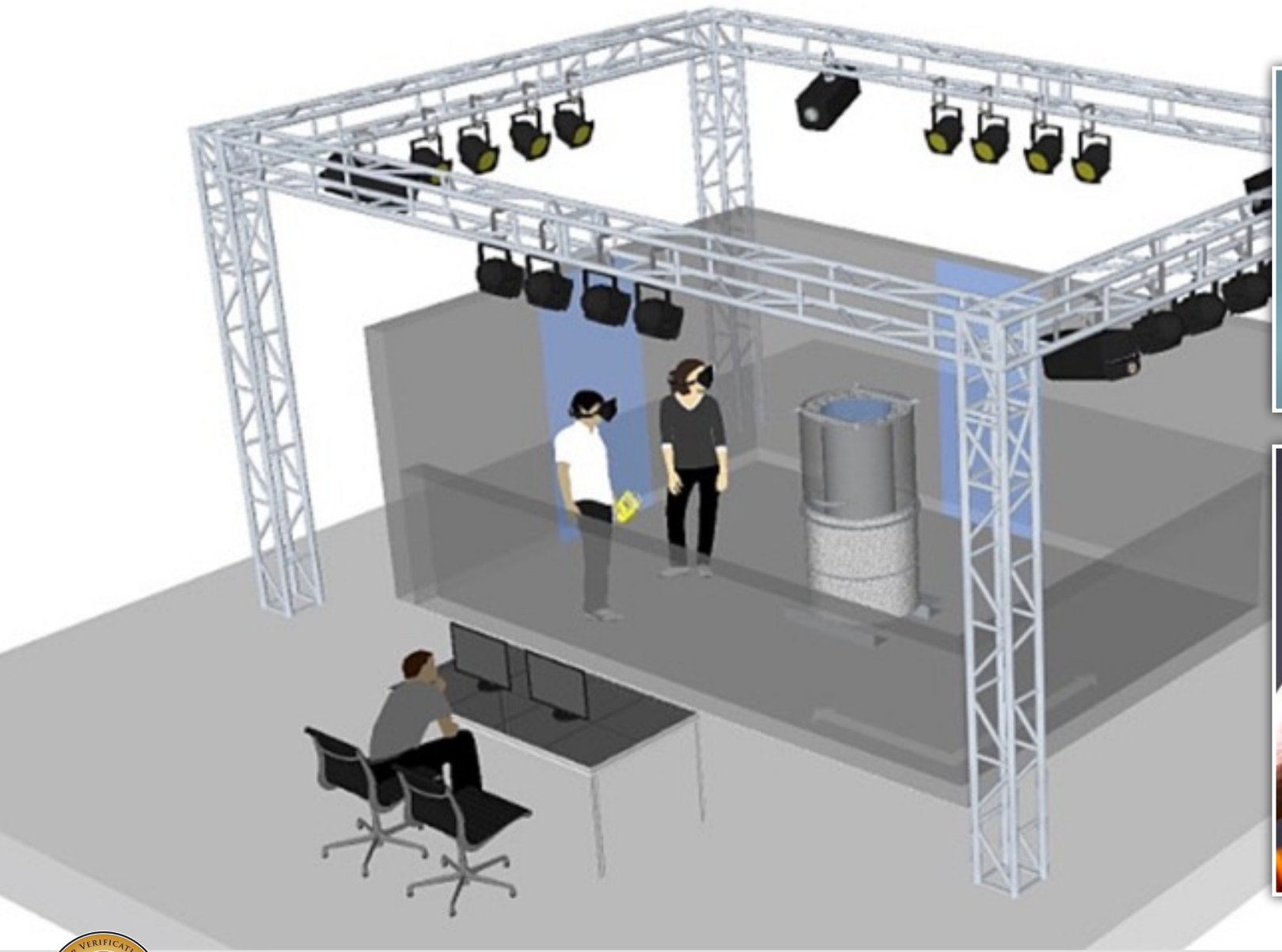


MAPPING NUCLEAR VERIFICATION



WARHEAD DISMANTLEMENT FACILITY & MANAGED-ACCESS SIMULATOR

FULL-MOTION VIRTUAL REALITY SYSTEM WITH REAL-TIME RADIATION FIELDS



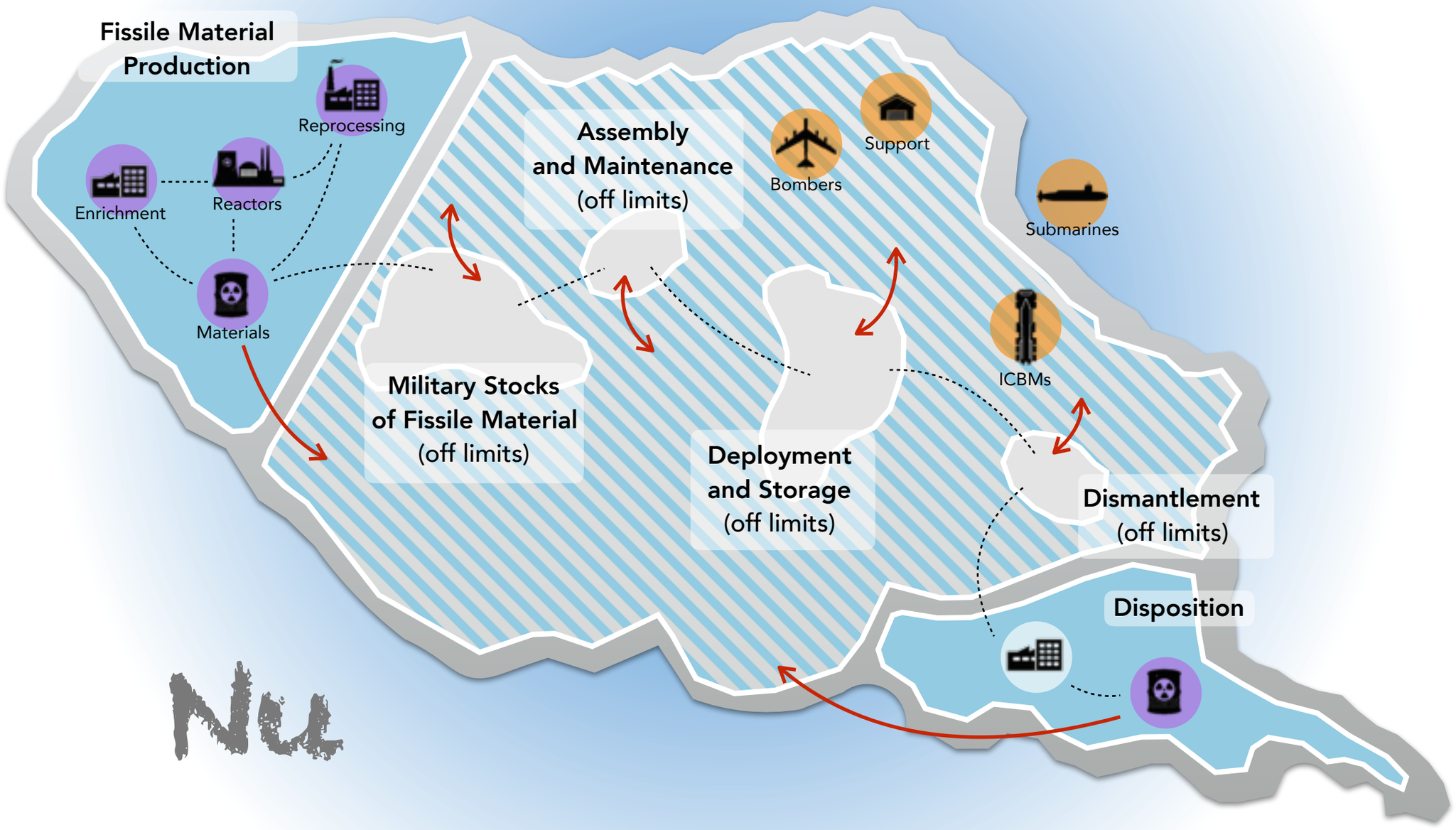
What's New Here?

"Mapping Nuclear Verification" allows exploring strengths and weaknesses of different verification approaches

A DIFFERENT PERSPECTIVE ON NUCLEAR VERIFICATION

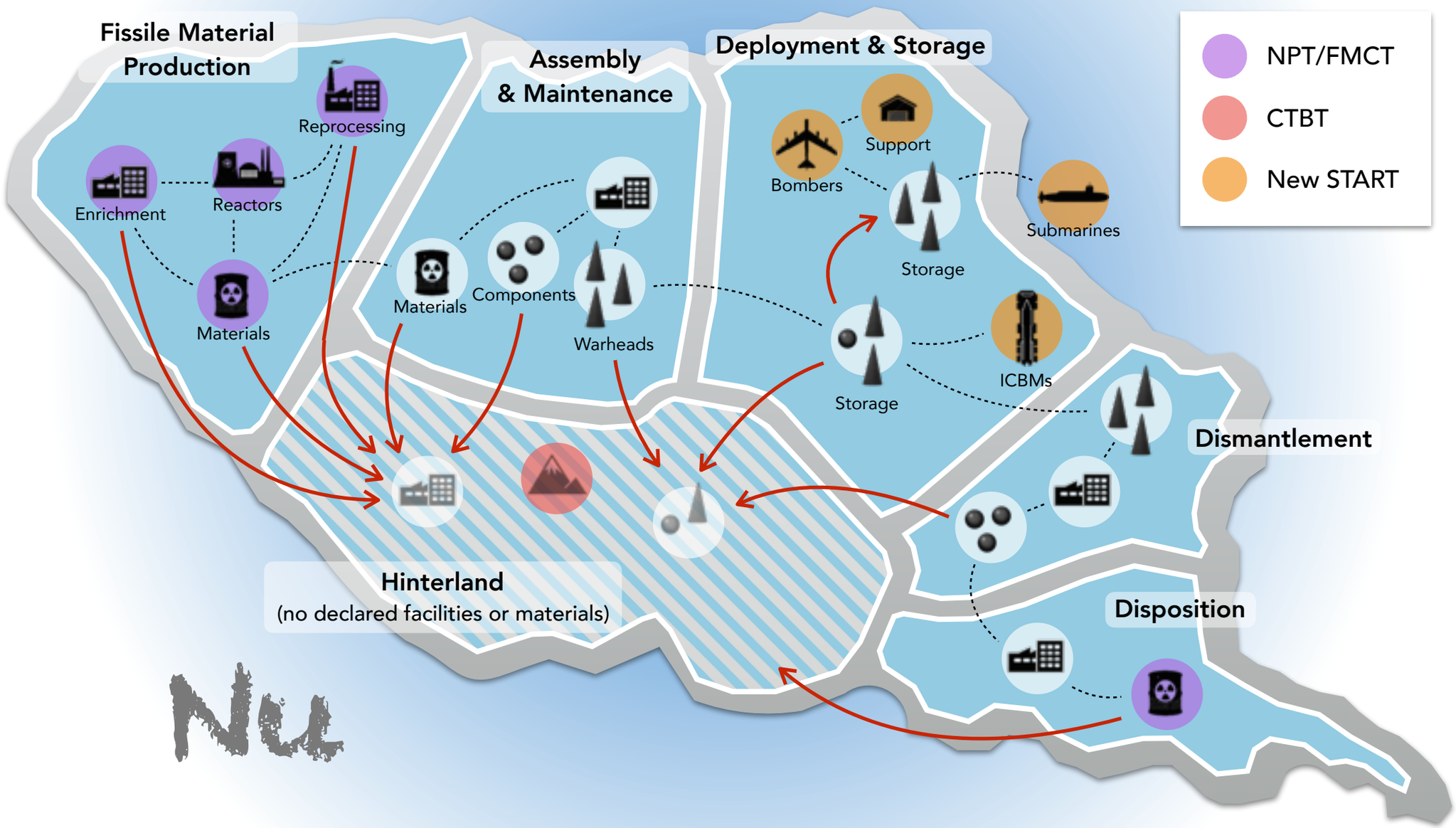
Some weapon states might seek minimal inspection activities at military nuclear sites

Much less intrusive, but highly dependent on effective perimeter control



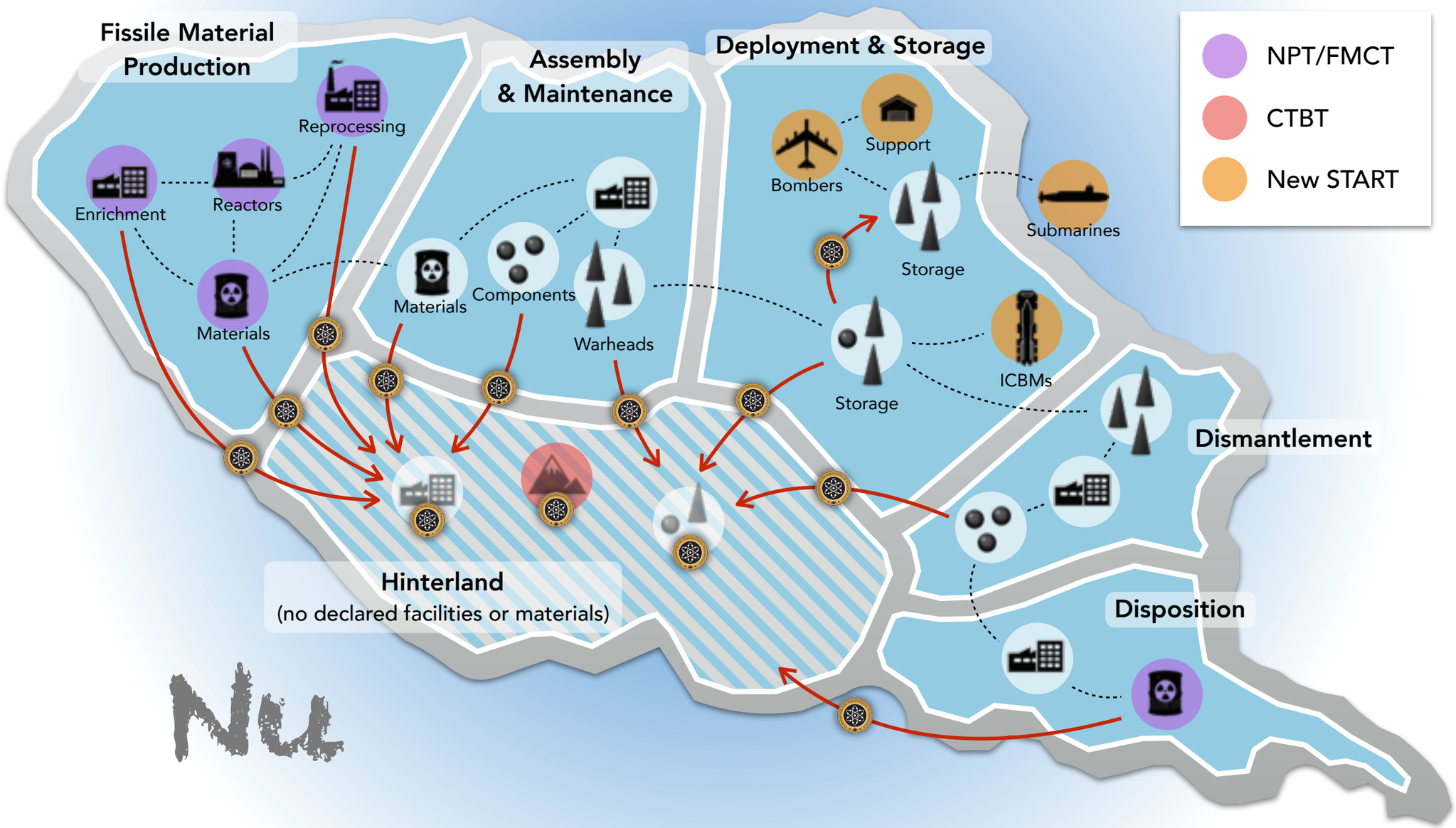
MAPPING NUCLEAR VERIFICATION

CVT projects help strengthen existing verification technologies and approaches, close the remaining gaps, and address emerging challenges



MAPPING NUCLEAR VERIFICATION

CVT projects help strengthen existing verification technologies and approaches, close the remaining gaps, and address emerging challenges

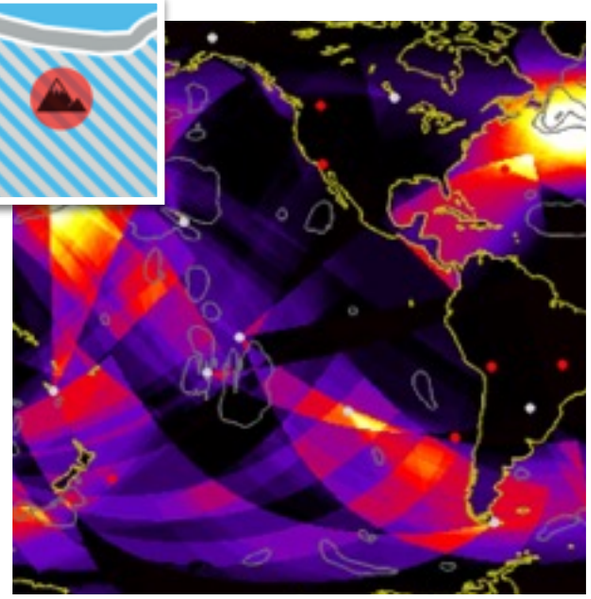


Locating CVT Projects

(Selected Examples)

COMPREHENSIVE TEST BAN TREATY

GAPS AND CHALLENGES



WAVEFORM TECHNIQUES: SEISMIC AND INFRASOUND SIGNATURES

Paul Richards (Columbia), Milton Garcés (U Hawaii)

- Detect very low-yield explosions and discriminate against other sources
- Potential for improved event location and identification through the integration of infrasound with seismic monitoring

RADIONUCLIDE SIGNATURES

John Lee (U Mich), Abi Farsoni (Oregon State), Michael Schöppner (Princeton)

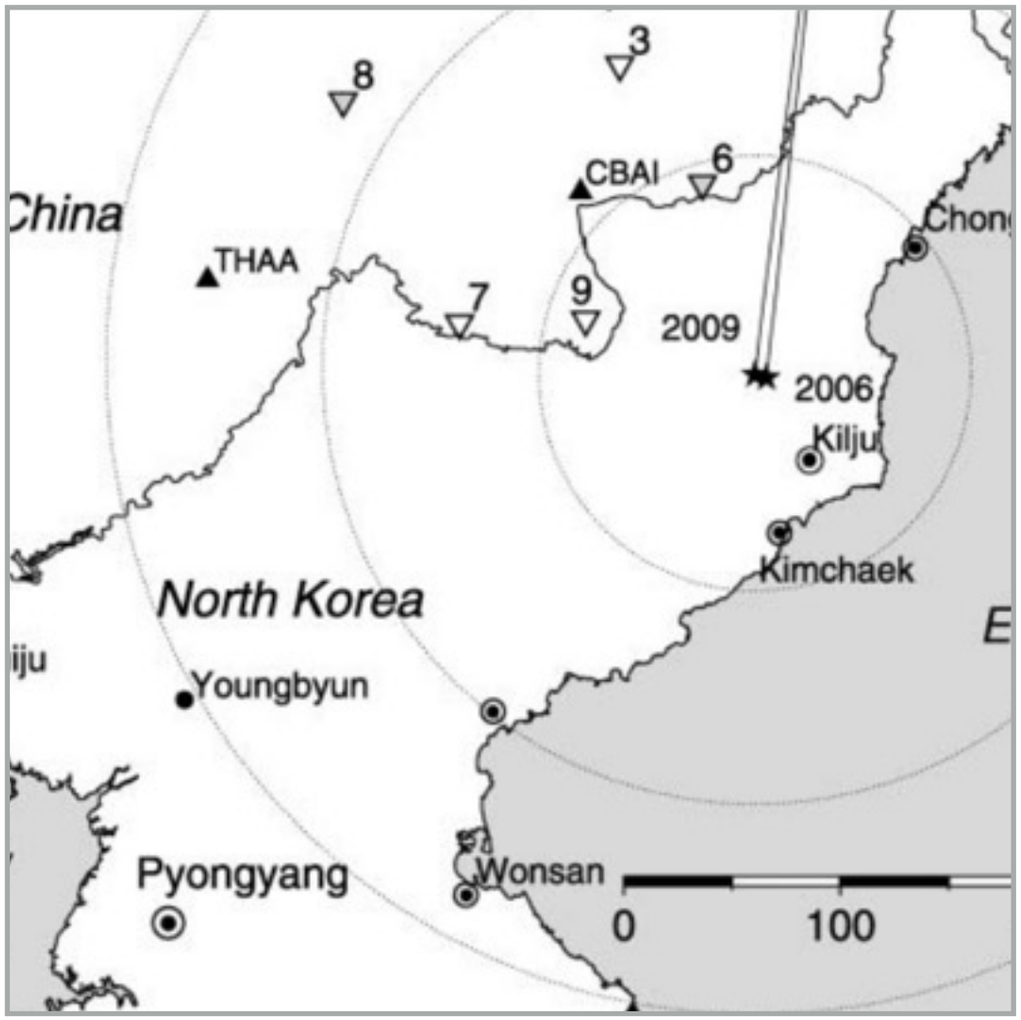
- Advanced detector technologies (higher energy resolution; lower MDC)
- State-of-the-art ATM, backward and forward

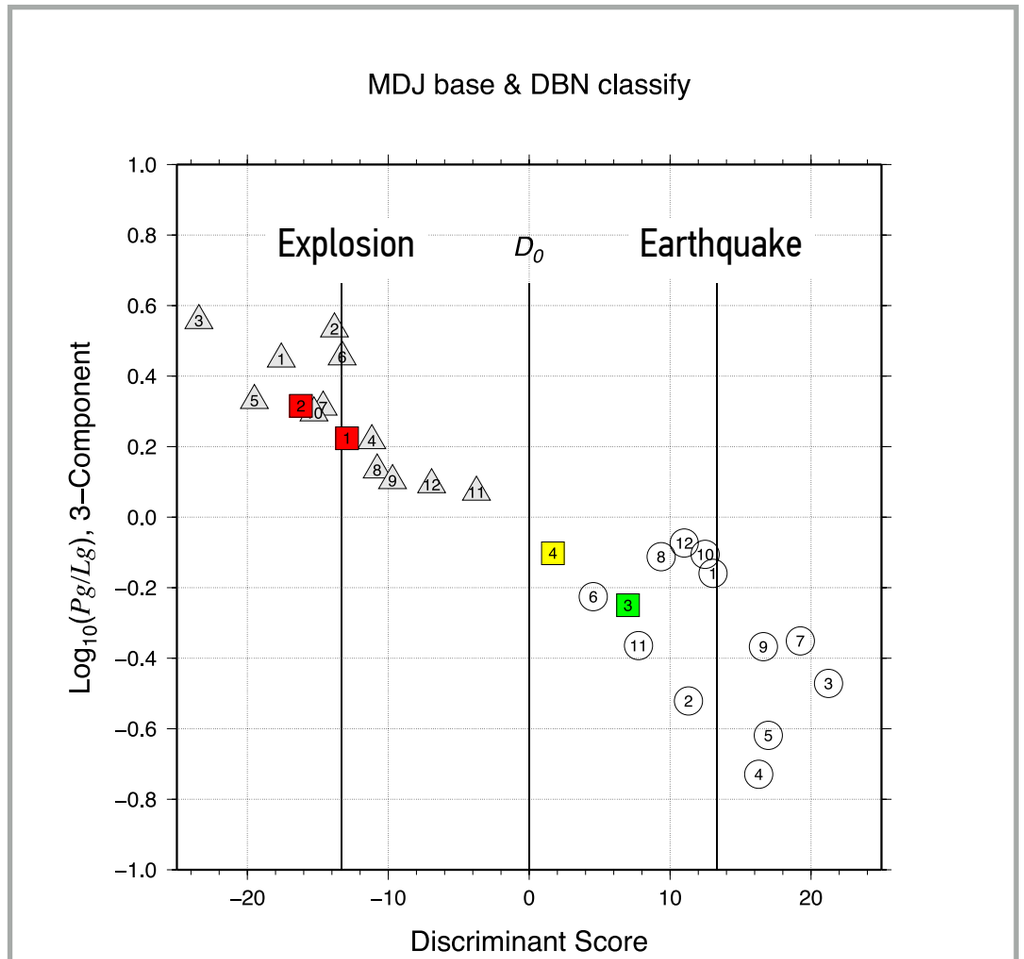
  Finding the origin of a release versus “catching the plume”

Source: Milton Garcés (top) and Radionuclide Station RN56, Russian Federation, www.ctbto.org (bottom)

DISTINGUISHING NUCLEAR EXPLOSIONS FROM EARTHQUAKES

DEVELOPMENT OF ADVANCED METHODS (USING ALL THREE COMPONENTS OF RECORDED MOTION) TO DISTINGUISH SEISMIC SIGNALS FROM (VERY SMALL) NUCLEAR EXPLOSIONS FROM (VERY WEAK) EARTHQUAKES

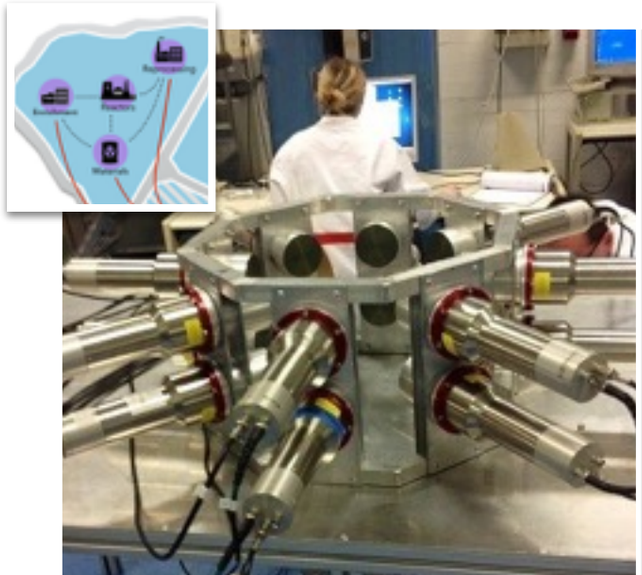




Ongoing CVT work by Paul Richards et al., Columbia University

NPT AND FISSILE MATERIAL CUTOFF TREATY

GAPS AND CHALLENGES



REAL-TIME CHARACTERIZATION OF NUCLEAR MATERIALS

Sara Pozzi, Zhong He, Igor Jovanovic (all U Mich), John Mattingly (NCSU), James Baciak (U Florida), and others

- Determine mass, enrichment, and location of nuclear materials
- Possibility of combining instruments with information barrier

DETECTING CLANDESTINE FACILITIES (AND ACTIVITIES)

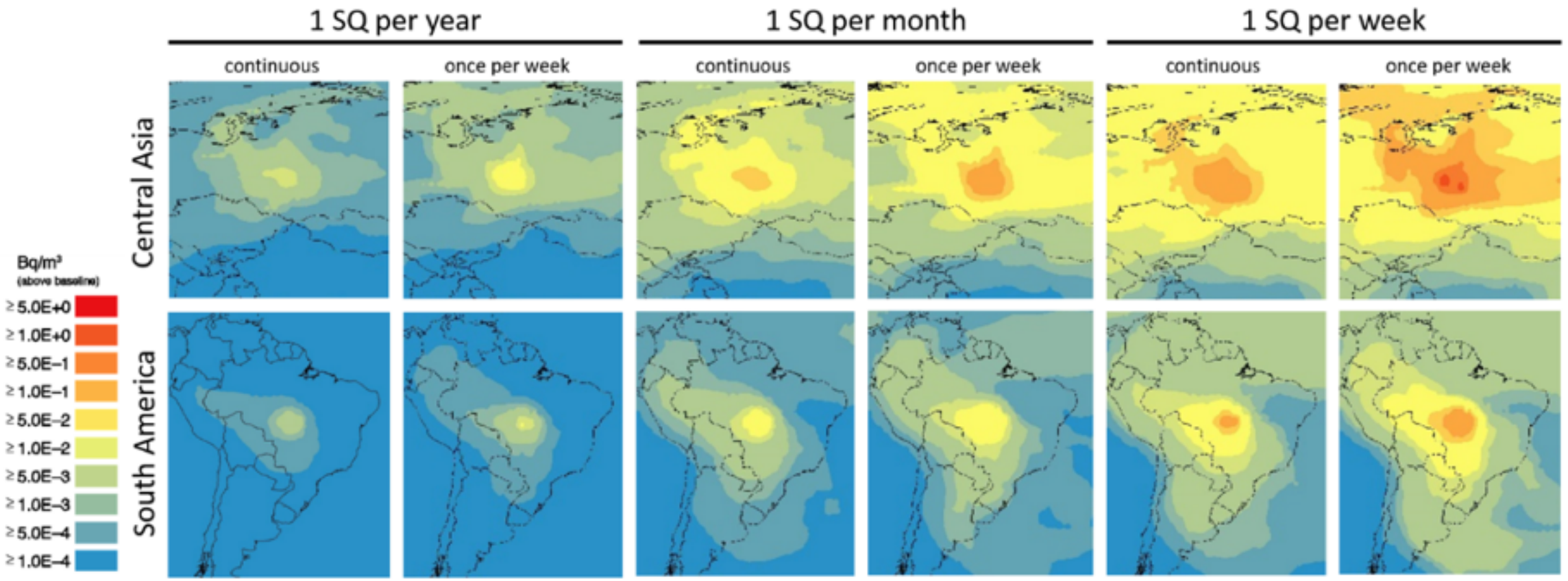
Paul Wilson (U Wisconsin); Al Hero (U Mich), John Fisher III (MIT), and others

- Fuel cycle anomalies (CYCLUS)
- Data analytics
- Emission source terms and atmospheric transport modeling

Source: U Michigan (top) and Google Earth (bottom)

DETECTING CLANDESTINE PLUTONIUM SEPARATION WITH KRYPTON-85

MODERN ATMOSPHERIC TRANSPORT MODELS CAN BE USED TO ESTIMATE PLUME DISPERSION FROM (RANDOMLY PLACED) FICTIONAL REPROCESSING PLANTS TO DETERMINE REQUIREMENTS FOR DETECTION



Michael Schöppner and Alexander Glaser, "Present and Future Potential of Krypton-85 for the Detection of Clandestine Reprocessing Plants for Treaty Verification," under review (Journal of Environmental Radioactivity)

NEXT-GEN DISARMAMENT TREATIES

GAPS AND CHALLENGES

PROTECTING SENSITIVE INFORMATION

Clair Sullivan (Illinois), Dave Wehe (U Mich), and others

- Inherent information barriers: spectral/spatial, software/hardware
- Minimally intrusive verification approaches
- Confirming numerical limits (e.g. using new tagging techniques)

CONFIRMING AUTHENTICITY OF NUCLEAR WARHEADS

Richard Lanza (MIT), Francesco d'Errico (Yale), Alex Glaser (Princeton)

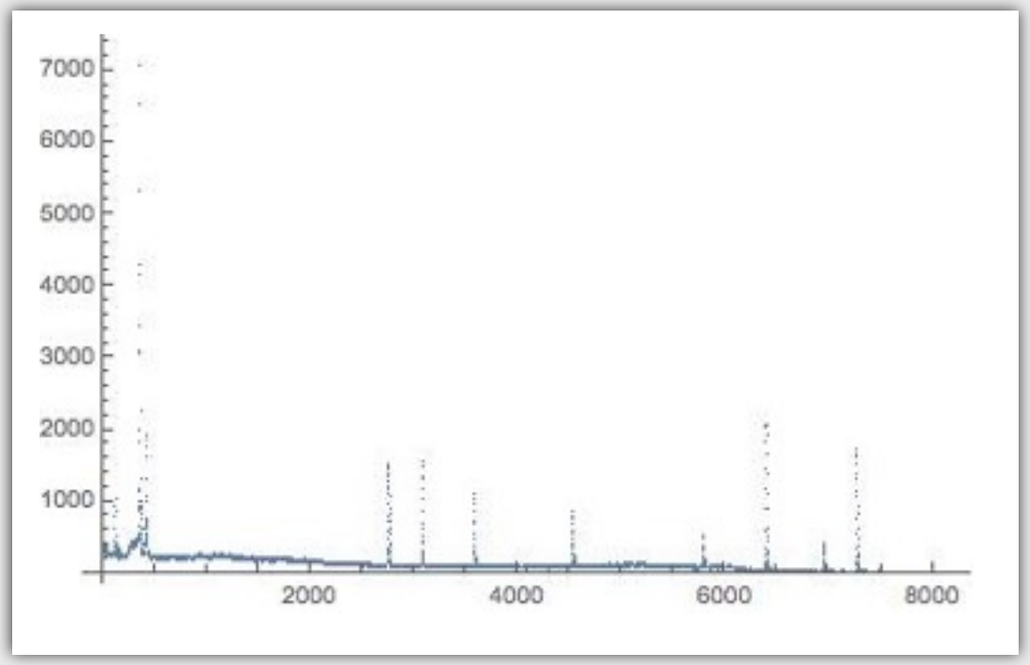
- Advanced gamma-spectrometry detection systems
- Nuclear resonance fluorescence
- Neutron radiography and fission signatures

Source: Paul Shambroom (top) and U.S. Department of Energy (bottom)

INFORMATION BARRIERS

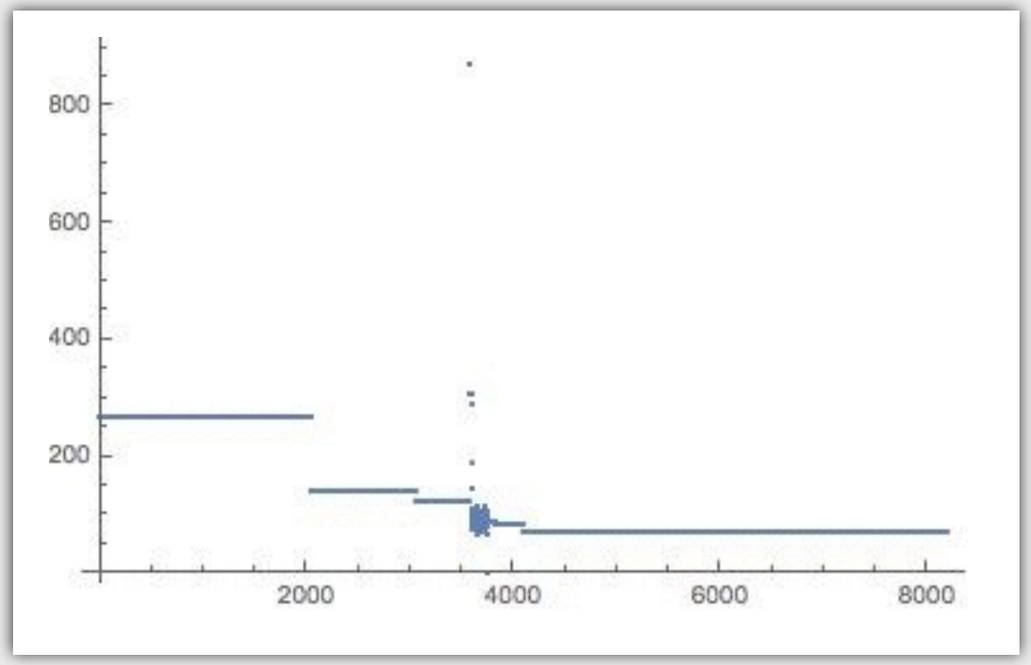
REMOVING SENSITIVE INFORMATION VIA HARDWARE AND SOFTWARE

ORIGINAL (HIGH-RESOLUTION) SPECTRUM



Measured spectrum from combined Cs-137, Co-60, Na-22, Bi-207 calibration sources; but only Cs-137 allowable

"FEATURELESS SPECTRUM"



Output spectrum preserves allowable energy information; all other spectral information appears as background

Ongoing CVT work by Fred Buhler, David Wehe, and Mike Flynn at U Michigan

CLOSING VERIFICATION GAPS AND ADDRESSING EMERGING CHALLENGES

SUMMARY

Understanding the expected treaty commitments treaty is critical for exploring the potential role of different verification technologies and approaches

Numerous promising technologies under development (as part of CVT and elsewhere); key is to understand how they can “fit into the big picture”

PROGRESS IN 2015–2016

Mapping Nuclear Verification as a tool to explore alternative and to facilitate discussions between thrust areas

Several new collaborations between research groups in different CVT thrust areas (involving both university partners and national laboratories)