



The CTBT IMS radionuclide network

—

a lookback to Fukushima and thoughts on its usefulness for
nuclear weapons dispersion assessment



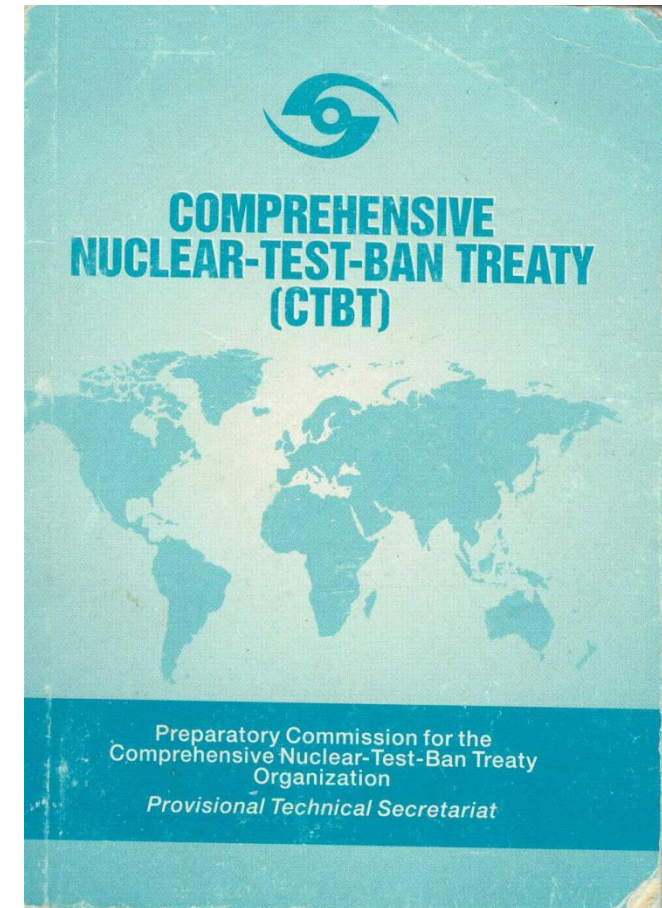
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Outline

- The Comprehensive Nuclear-Test-Ban Treaty (CTBT)
- The International Monitoring System (IMS)
- What happened after Fukushima
- What can we take home from this

The CTBT

- The Comprehensive Nuclear-Test-Ban Treaty (CTBT) 24.9.1996; prohibits all nuclear tests
- The Treaty will enter into force (EIF) when 44 specified states, with nuclear capabilities, have ratified it
- The compliance of the Treaty is monitored with the International Monitoring System (IMS), the data from IMS is transmitted to the International Data Centre (IDC) in Vienna, where it is analysed
- All IMS data and IDC products are available from the IDC to all member states

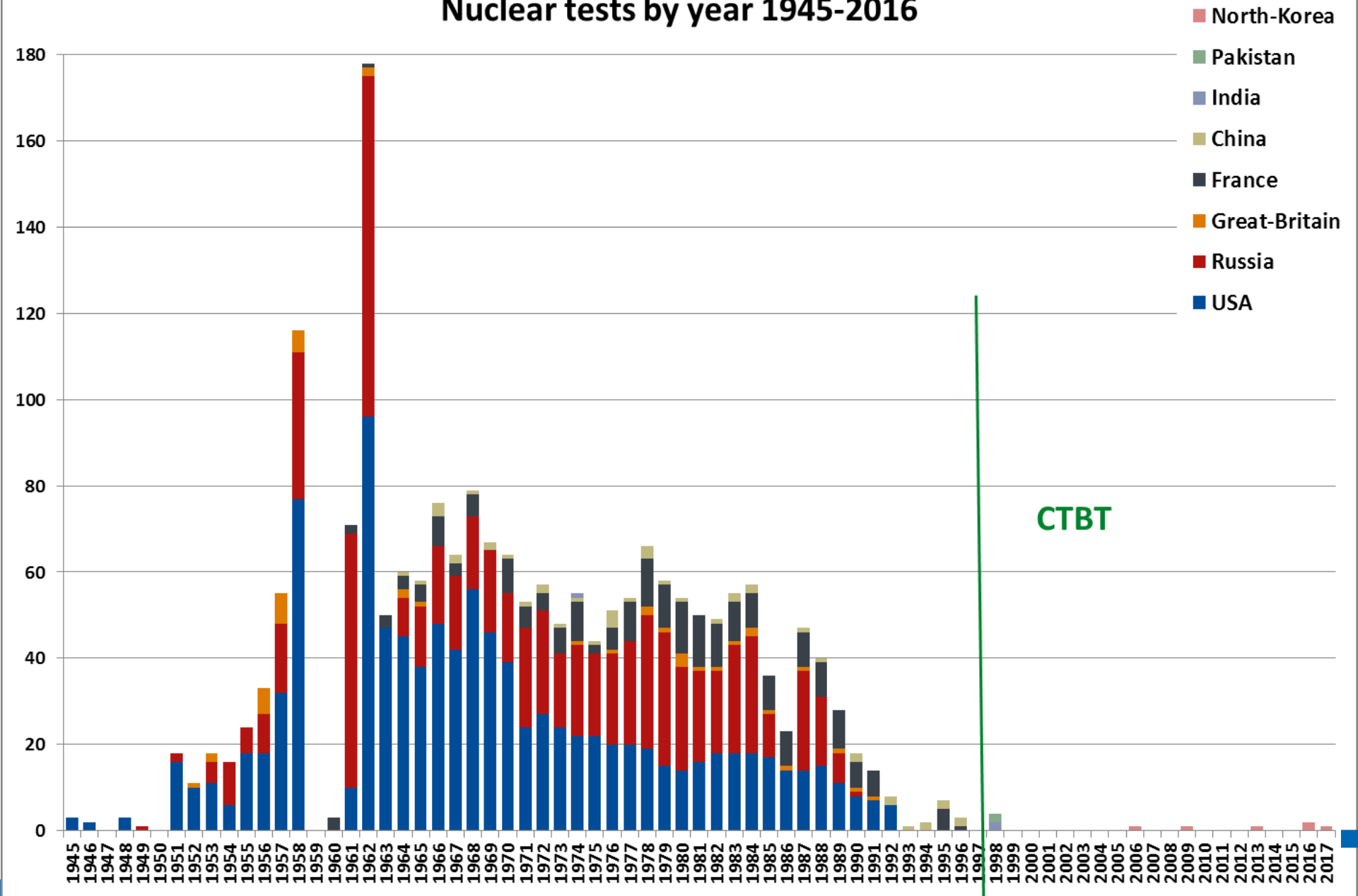


CTBT - Present situation (1.11.2021)

- 185 signatories, 170 ratifications
 - 41/36 of the 44 specified for EIF
 - Missing: **India, Pakistan, North-Korea**, USA, China, Iran, Israel, Egypt
- The Preliminary Technical Secretariat (PTS) is up and working (in test mode) in Vienna
- The International Monitoring System is largely working. About 90% of the stations are ready
 - 302/337 facilities certified

The treaty has effectively stopped the major part of nuclear testing, although it is not in force.

Nuclear tests by year 1945-2016



The CTBT Organisation (CTBTO)

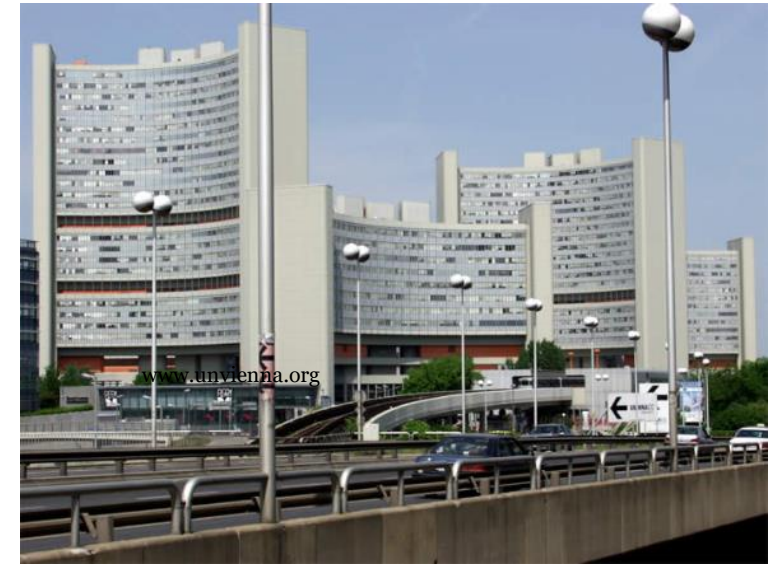
Verification

- IMS - the International Monitoring System
- IDC - the international Data Centre
- OSI - On Site Inspections
- Consultation and Clarification
- Confidence Building Measures

Organisation

- Conference of the States Parties
- Executive Council
- (P)TS - the (Provisional) Technical Secretariat

} **Preparatory
Commission**



The International Monitoring System (IMS)

—

In soil, air and water

- Underground
 - seismic, noble gases, (particulates)
- Underwater
 - hydroacoustic, noble gases, (particulates)
- Atmospheric
 - Infrasound, noble gases, particulates
- Outer space
 - ---

Goal - To detect any nuclear explosion larger than 1 kt

IMS monitoring - the four technologies

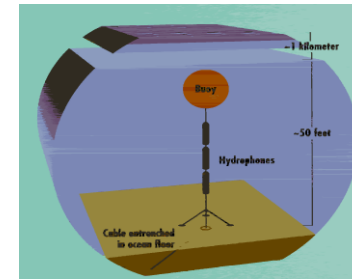
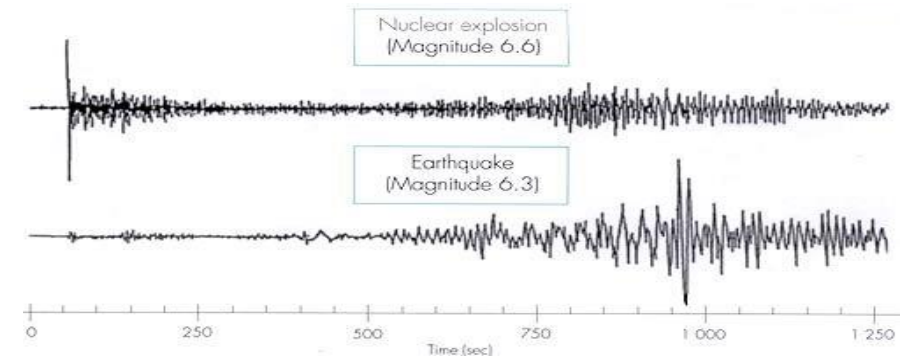
Waveform

- Seismic
 - 50 primary + 120 auxiliary stations
- Hydroacoustic
 - 11 stations
- Infrasound
 - 60 stations

Radionuclide

- Particulates monitoring
 - 80 stations
 - Noble gases
 - 40 stations in the preliminary phase
 - Co-located with particulate stations
- + 16 Laboratories (Particulates + Noble gases)
- + *Atmospheric Transfer Modelling (ATM)*

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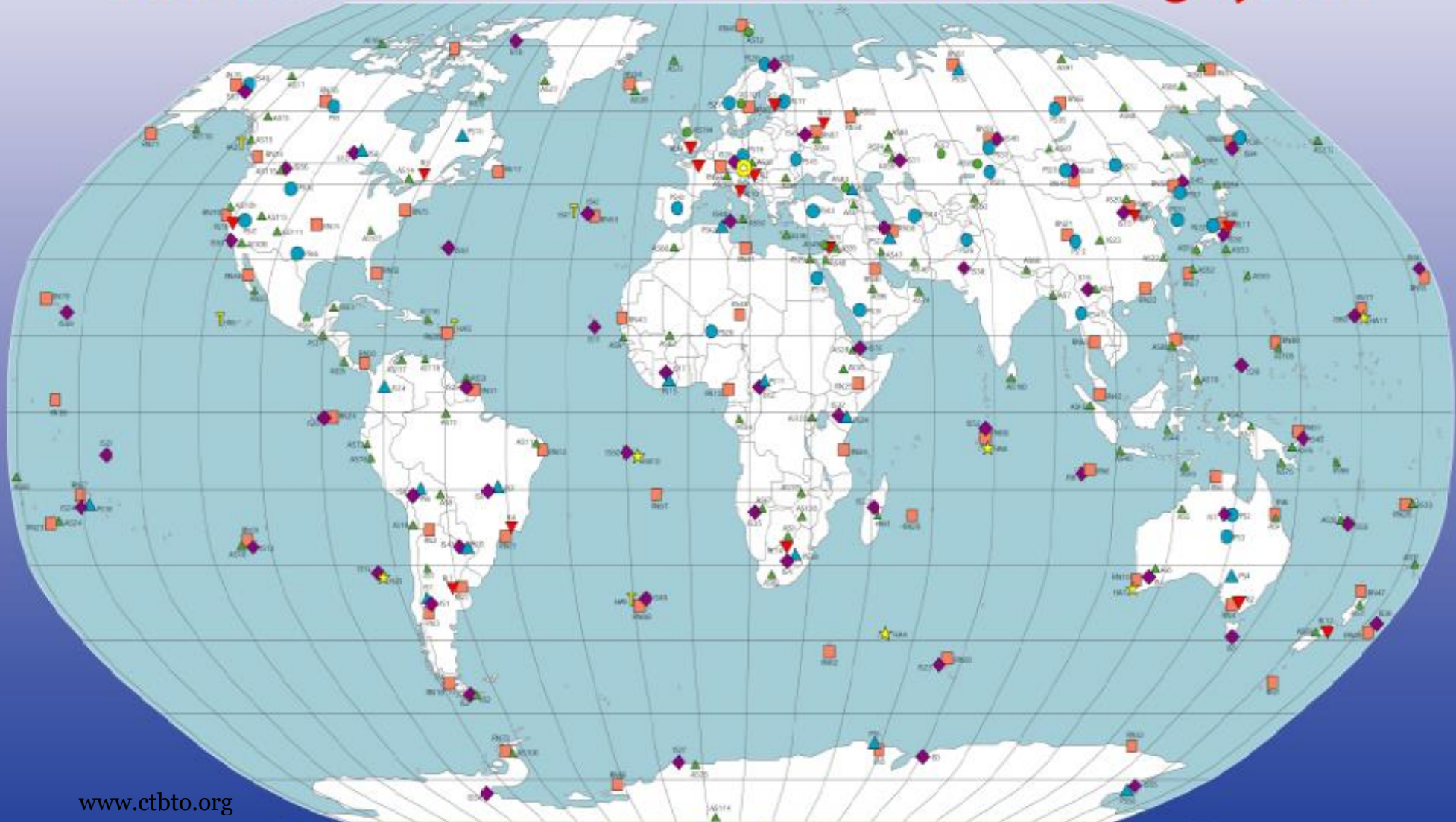


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Facilities of the CTBT International Monitoring System

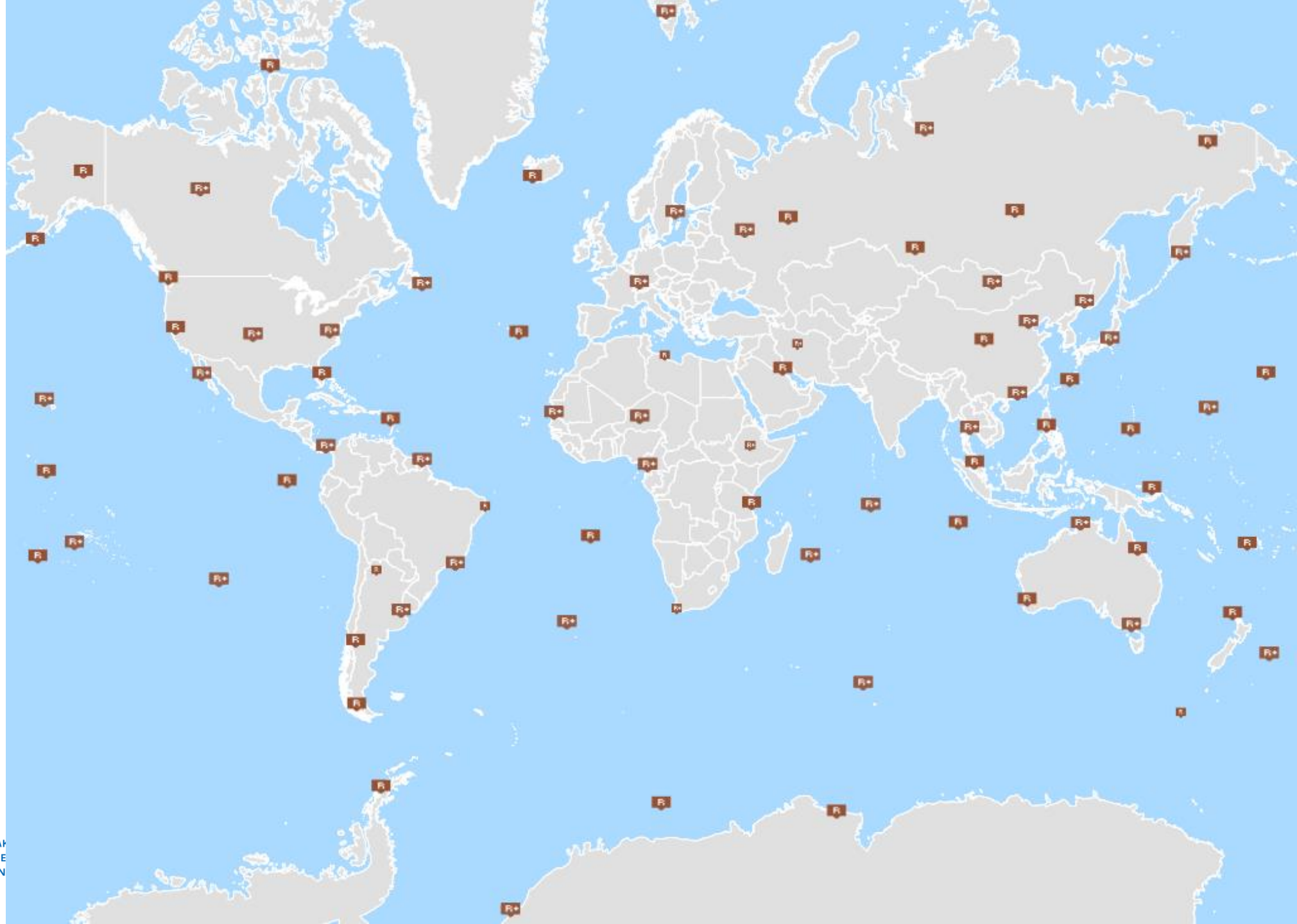


www.ctbto.org



- Seismic primary array (PS)
- ▲ Seismic primary three-component station (PS)
- ★ Hydroacoustic (hydrophone) station (HA)
- Radionuclide station (RN)
- Seismic auxiliary array (AS)
- ▲ Seismic auxiliary three-component station (AS)
- ⋈ Hydroacoustic (T-Phase) station (HA)
- ▼ Radionuclide laboratory (RL)
- ◆ Infrasound station (IS)
- International Data Centre, CTBTO PrepCom, Vienna

Radionuclide stations



The CTBT Verification Regime



5 Geostationary
Satellites

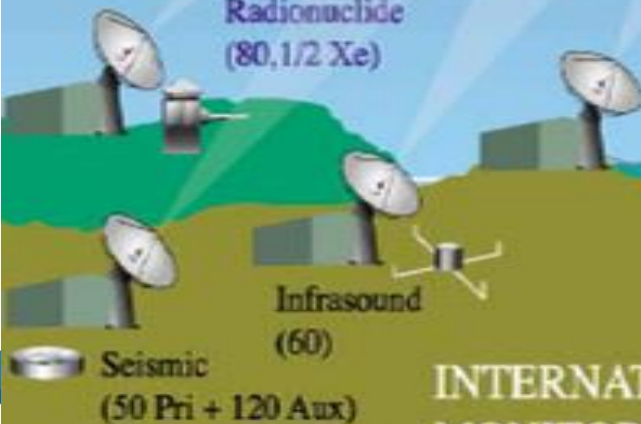


GLOBAL COMMUNICATIONS
INFRASTRUCTURE

INTERNATIONAL
DATA CENTRE

National
Authorities

Radionuclide
(80, 1/2 Xe)



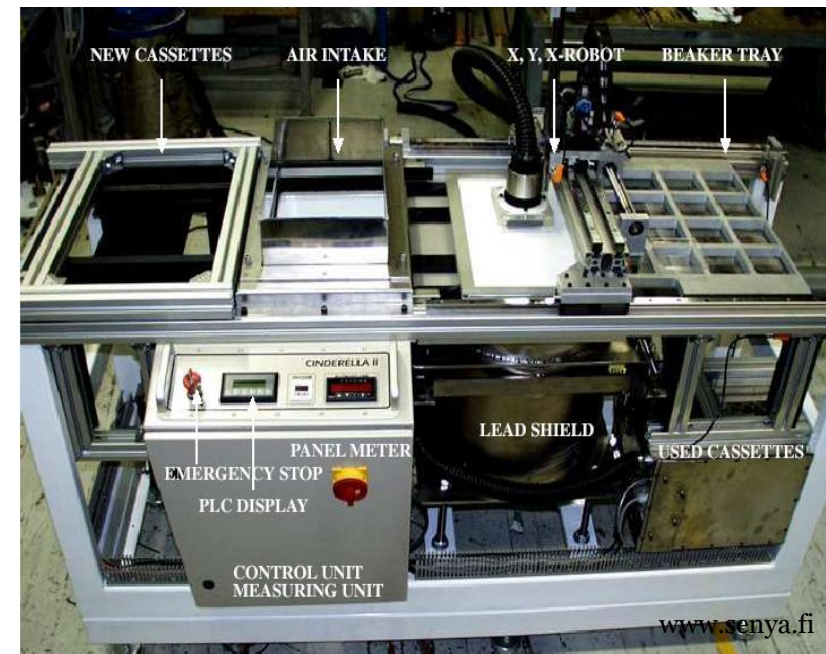
Hydroacoustic
(6 hydro, 5T)

INTERNATIONAL
MONITORING SYSTEM

www.ctbto.org

Particulates Monitoring

- 80 airfilter stations
- 24+24+24 h cycle (sampling + cooling down + measurement)
 - 72 h delay in the data
 - Spectrums are sent every 2 h during acquisition
- The samples are measured (HPGe) at the station
 - > Spectrum file (~100kB)
- The data is analysed at the IDC
- "Interesting" samples re-measured at laboratories
- Difficulties:
 - Low level signals
 - Natural background peaks (always)
 - Interference from antropogenic releases (rare)
 - hospitals, NPP:s, accidents
- The technology is mature, but remote area applications are demanding



Xenon monitoring

- 40 stations (until EIF)
 - Co-located with particulates
- Varying measurement cycle, dependent on the technology
 - 30 or 48 h delay
- Complicated gas purification and HPGe or β - γ measurement at the station
- Data analysed at the IDC
- Laboratories in a QC role
- Difficulties:
 - Low level signals
 - little natural background because of gas purification
 - Lots of anthropogenic Xe in the northern hemisphere
 - Isotope ratios different in nuclear tests
- Technology reaching maturity
- + new development



SUMMARY CTBT/IMS

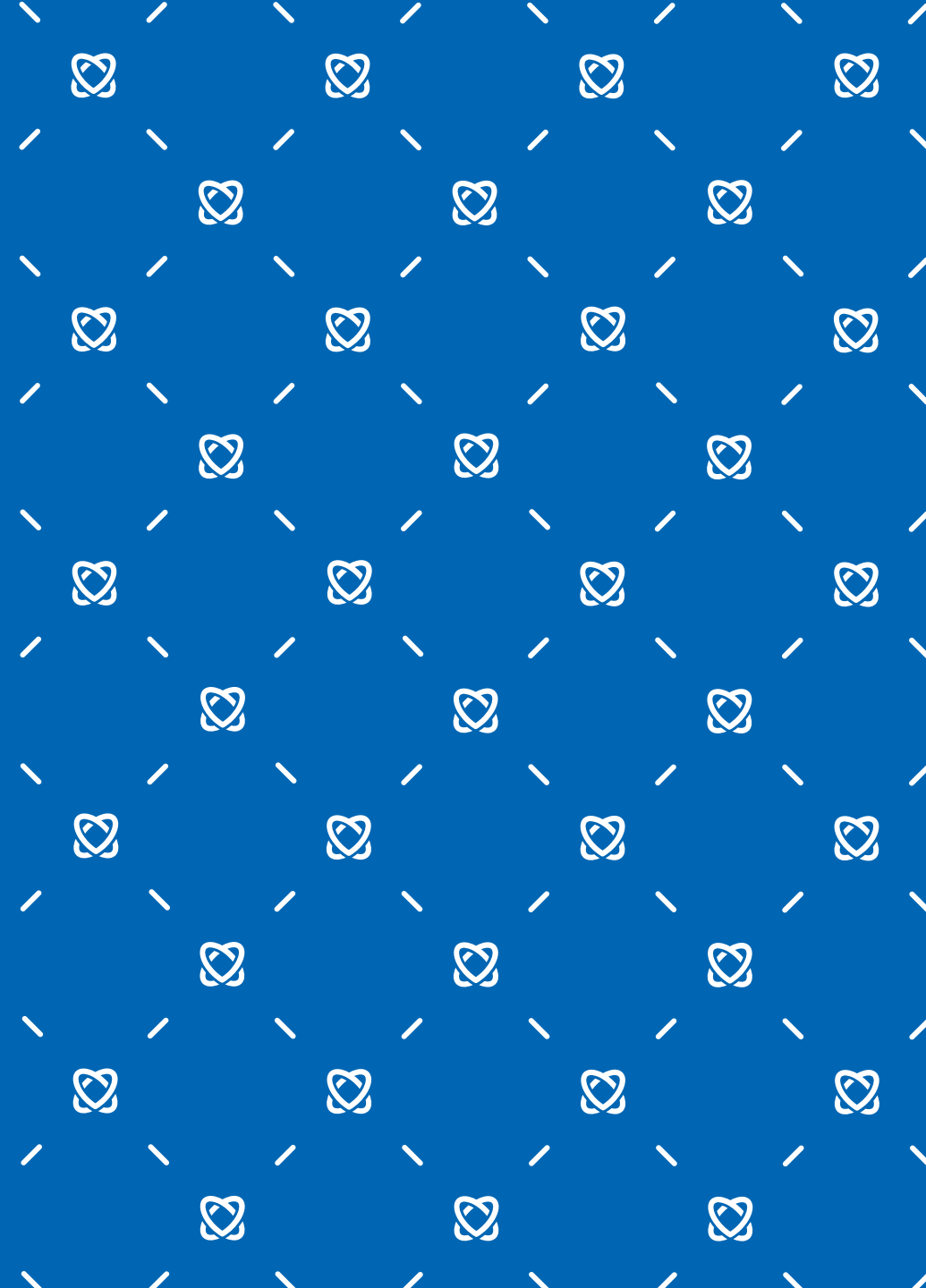
- Prompt detections possible through Waveform technologies
 - Delayed only by speed of sound in air/water/earth
- Sparse detection network of radionuclide stations
 - 80/40 stations (particulates/+Xenon)
 - Worldwide
 - Delayed by atmospheric transfer (hours-weeks)
 - Delayed by measuring mode (nominally 72 h particulates, 30-48 h, noble gases)
- All data "immediately" available at NDCs in every country
- High quality data

With all those delays, why am I giving this presentation?

What happened after Fukushima?



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RADIATION AND NUCLEAR SAFETY AUTHORITY



March 15, 2011 (UTC)

JPP38

• ~0:55-2:55 plume arrival

• 2:55/3:15 P009
• (first signal)

• 4:55/5:15 P010

Acq.end/timestamp
20 min gap

• 6:30/6:30 FULL
38201103120611

• 8:55/9:03 PREL
38201103130611

10:54/11.15 P001



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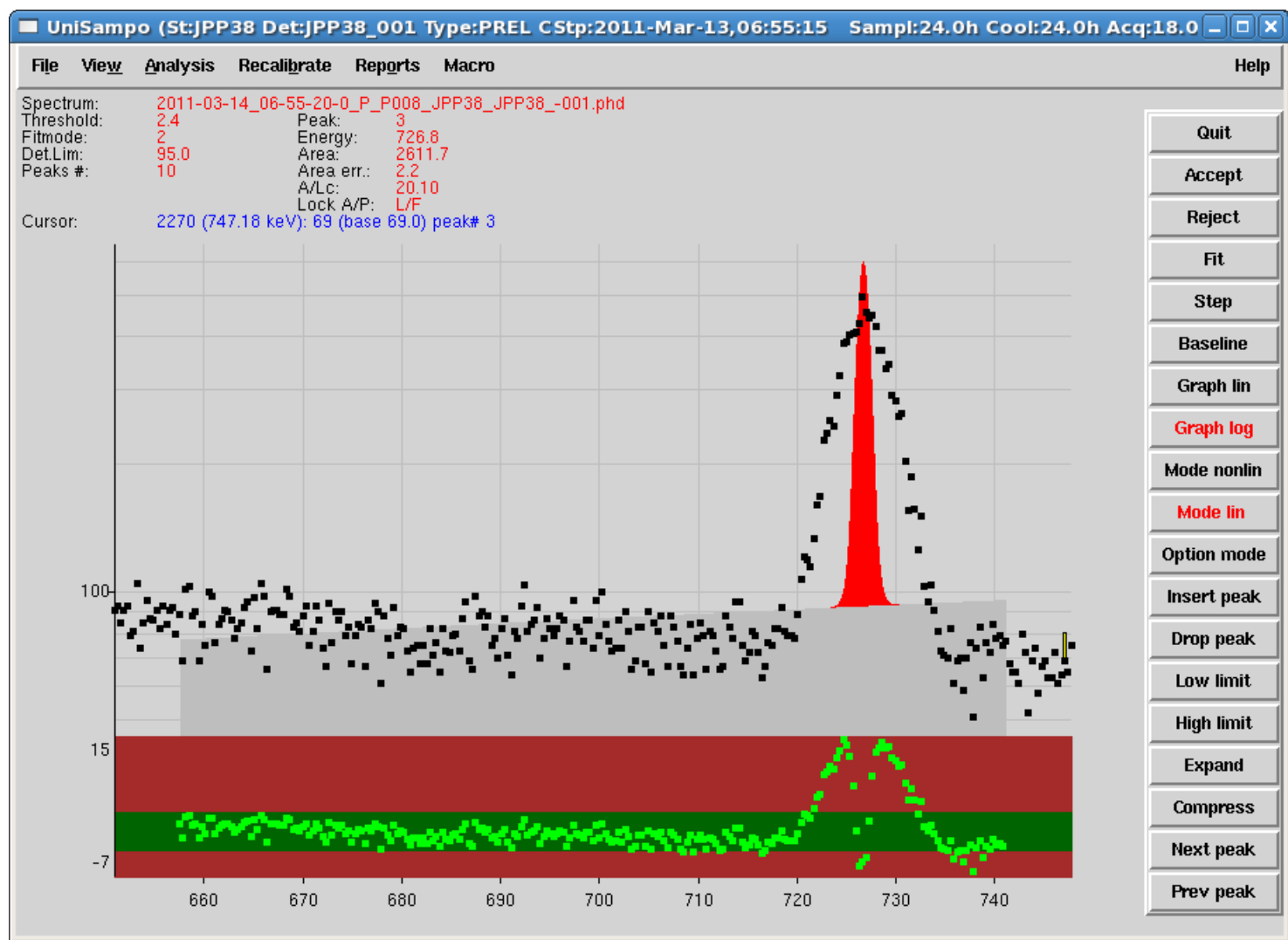
FiNDC

- 03:29 P009 Arrive at NDC – no Alarm
– 38201103120611
- 05:24 NDC analysis E-mail Alarm JPP38 P010
 - I-131, I-132, Cs-137
- ~06:00 *I arrive at work*
- 6:32 I send a message (Alarms are false)!
- 6:40 E-mail Alarm #2 from JPP38 FULL
- *I attend an unrelated meeting, Aleksi M looks at IDC ARR and alerts me again*
- 8:01 I send an In house message –
“Detector is measuring I and Cs In-situ”
- 9:10 PREL arrive at NDC – Only < 200keV
- 10:22 Message to international colleagues “Maybe some confusion can be avoided...”
- 11:26 Alarm #3 from JPP38 P001

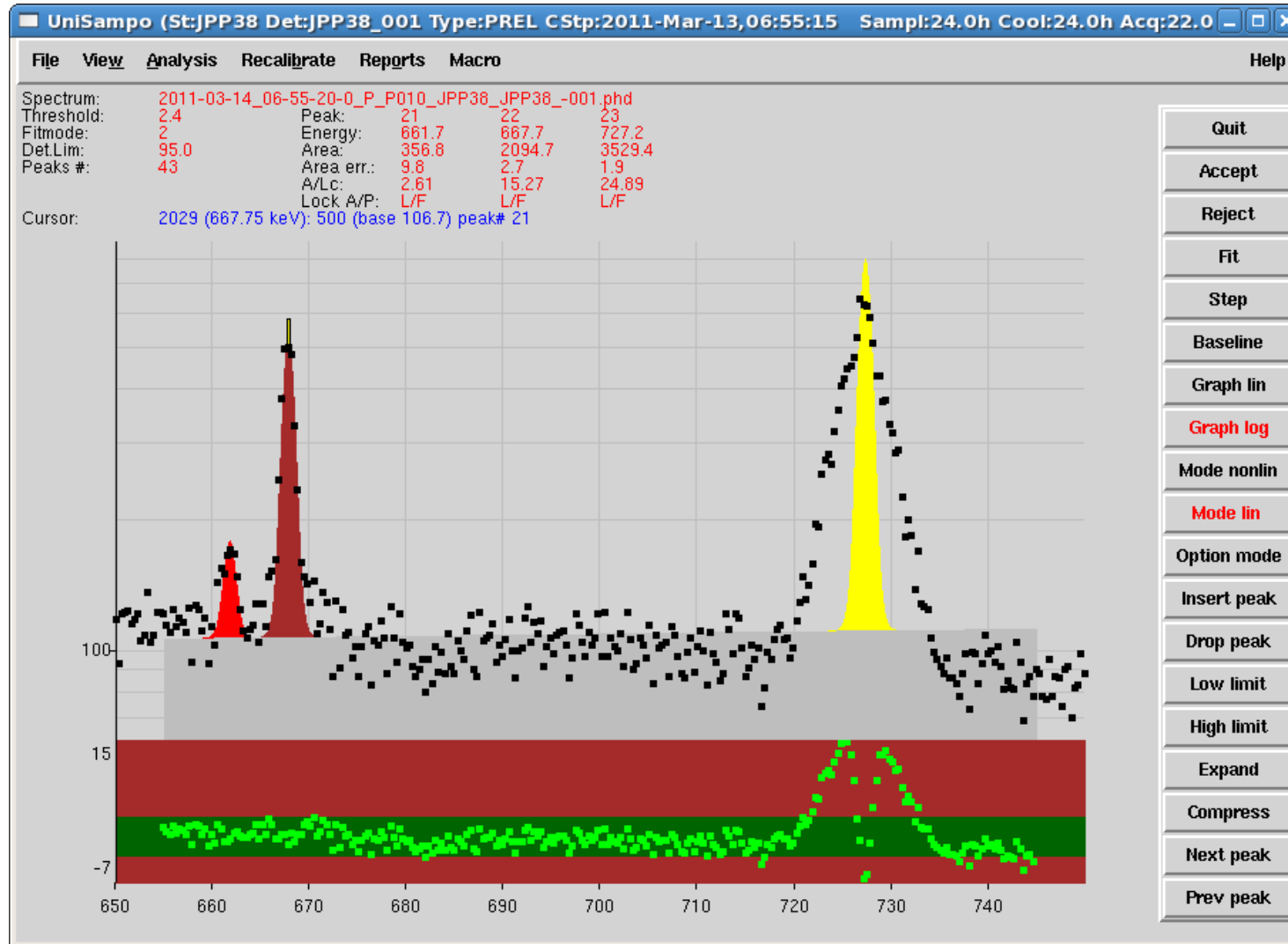
... how do we conclude "In-situ" mode

- Preliminary spectrums every 2h (12 spectrums)
 - PREL, P001, P002, ... P010, FULL
 - 2h , 4h , 6h , ... 22h , 24h
- No pulses in peaks of anthropogenic nuclides before P009 (20 h of measurements)
 - Conclusion: There is no measurable anthropogenic activity in the sample
- Clear peaks of anthropogenics from P009-FULL (20-24h)
 - These have to come from somewhere = ambient air and/or fallout
- No reliable estimate of concentration possible

P008 (18 h), Bi-212 peak only (very broad peak)

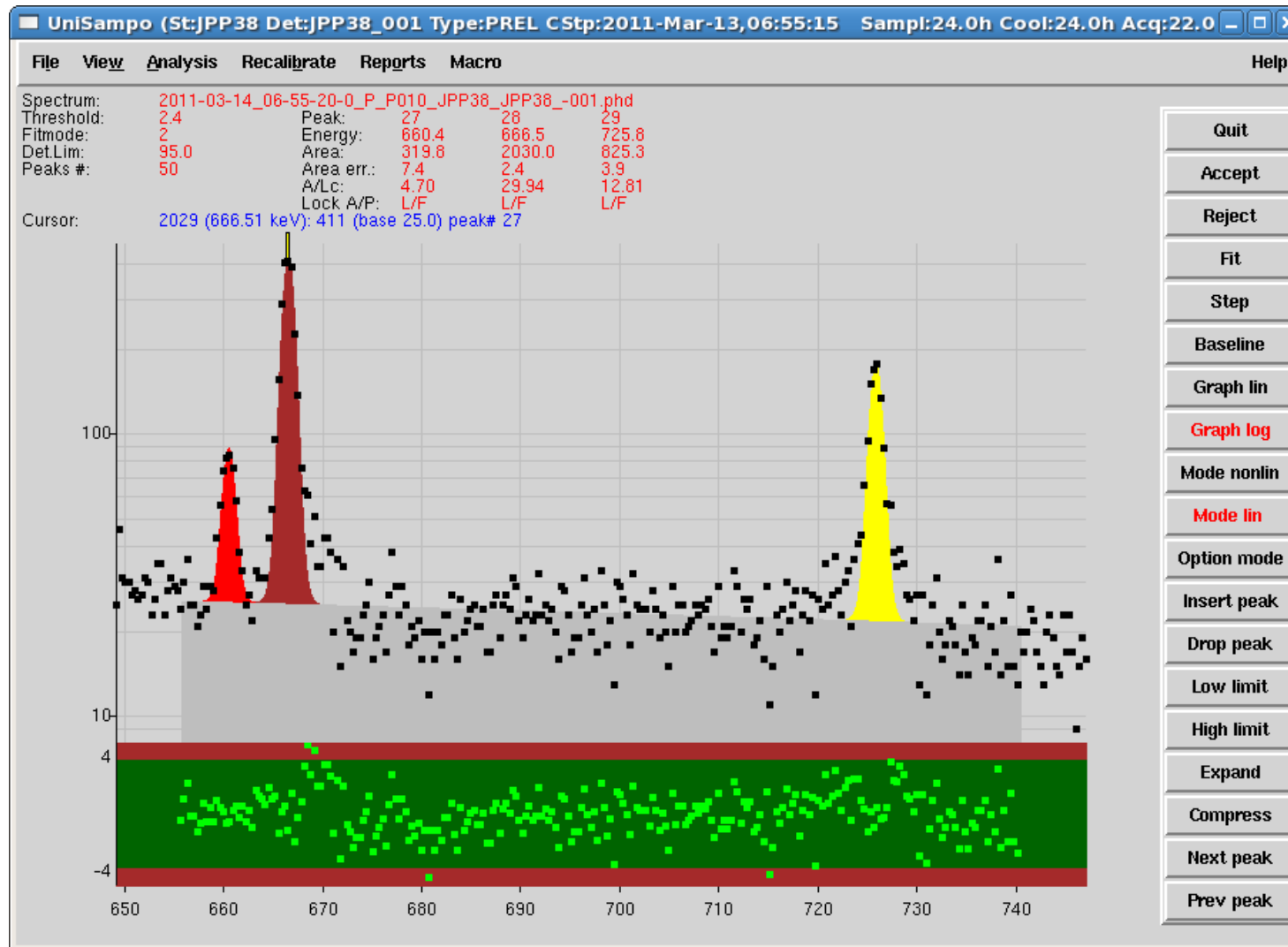


P010 (22h), Cs-137 (662), I-132 (667)... and Bi-212 (727) keV

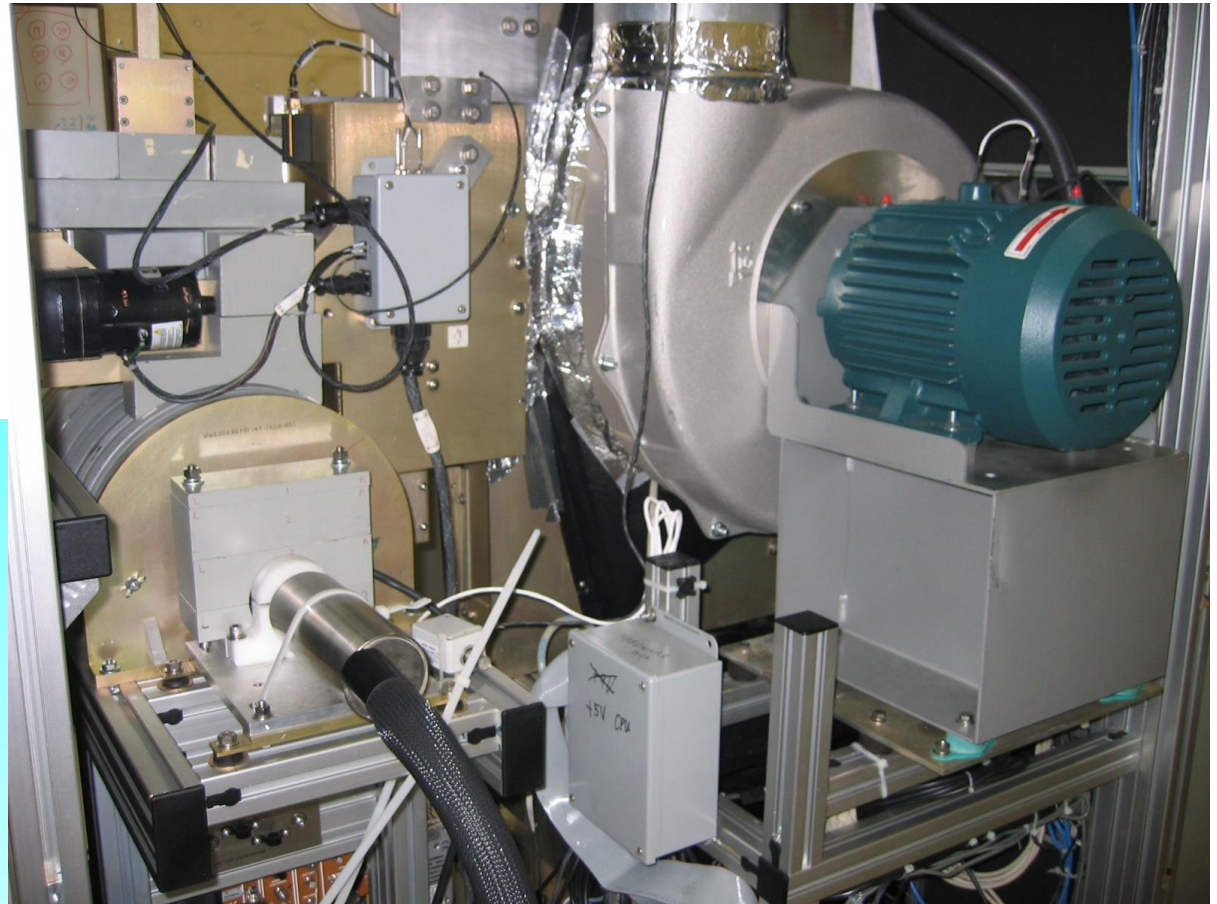
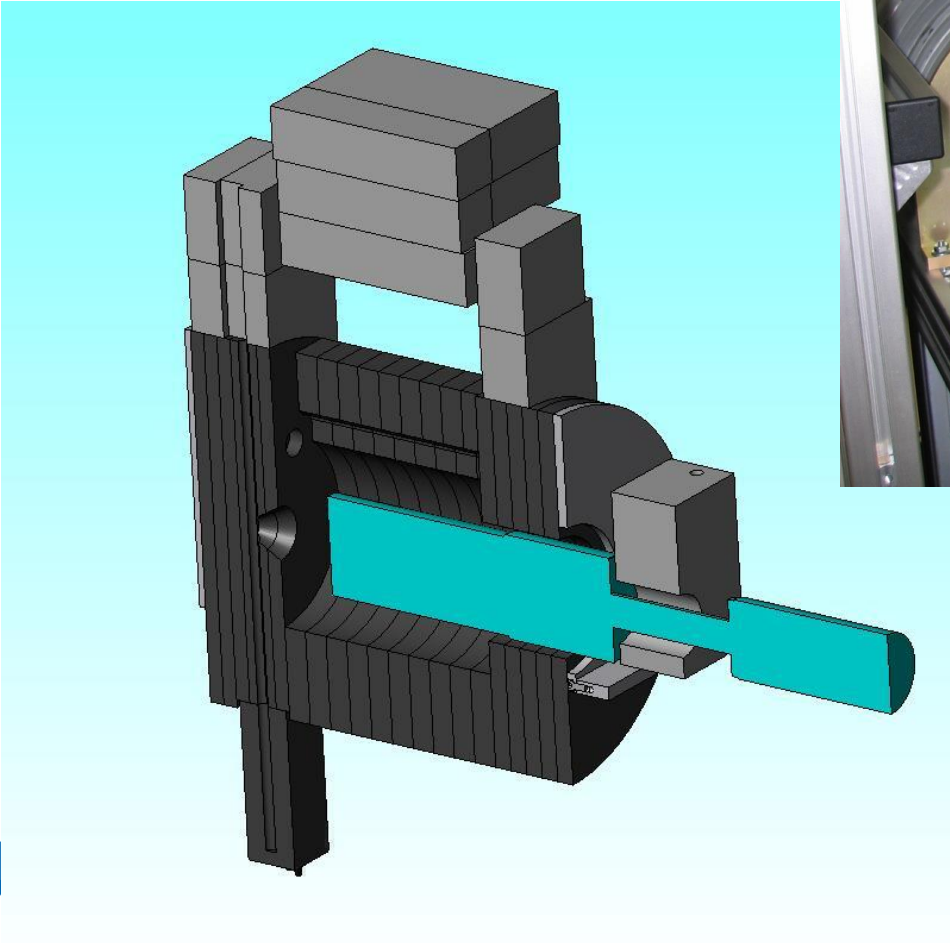


Difference spectrum P010-P008 (4h)

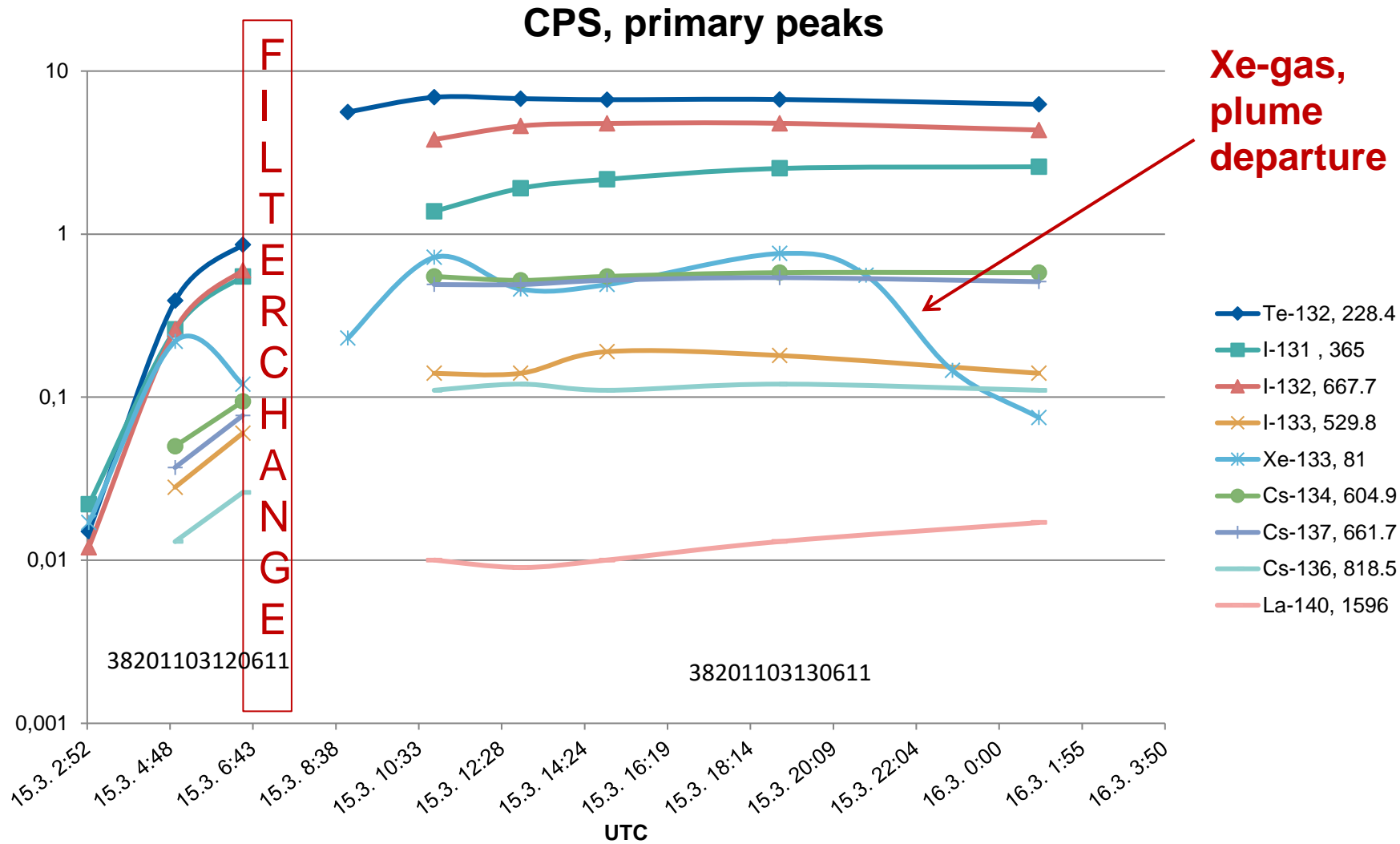
all peaks are narrow, Iodine peak largest



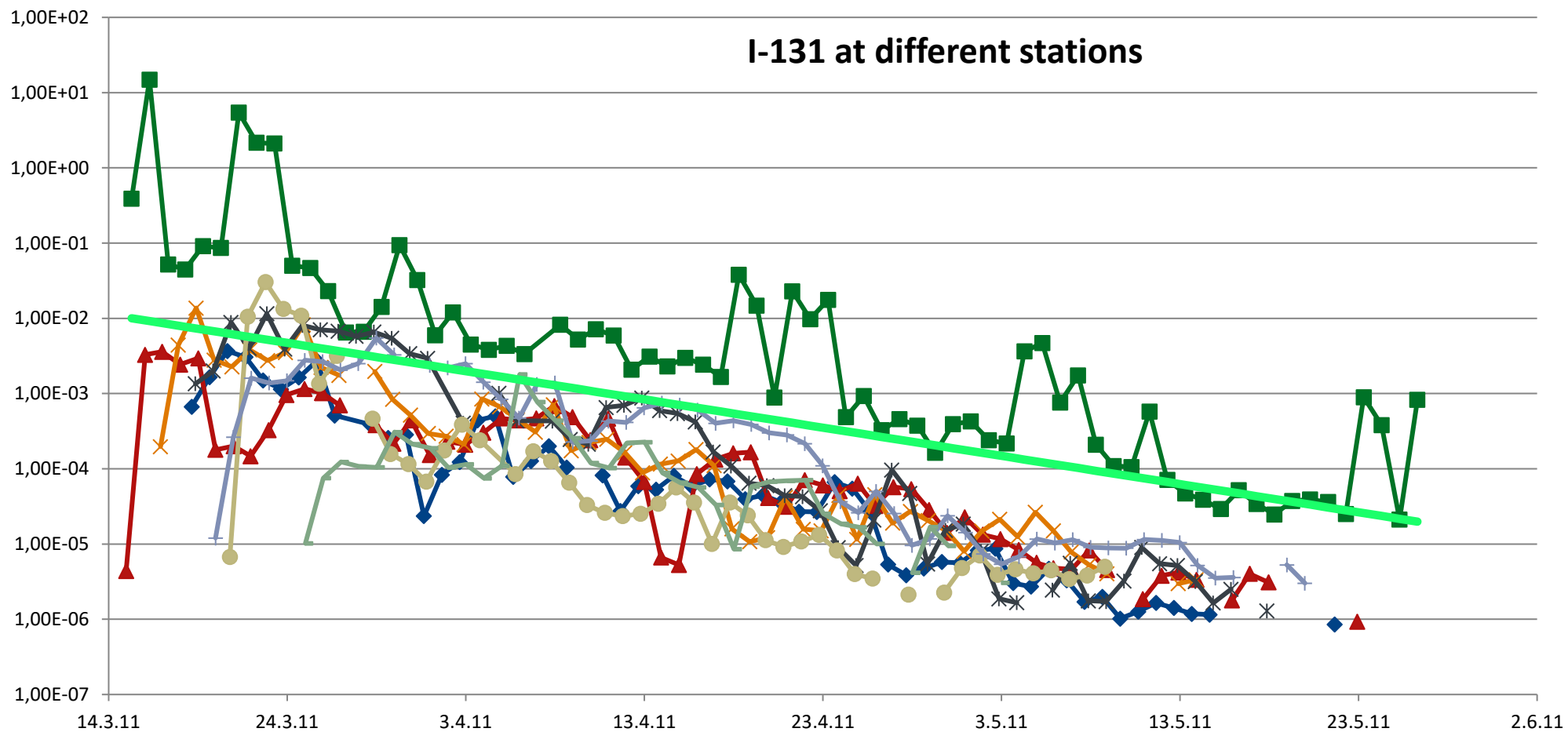
Rasa Shield and Detector



JPP38, 2h , measurement of a contaminated filter/station



International cooperation



What about an explosion?



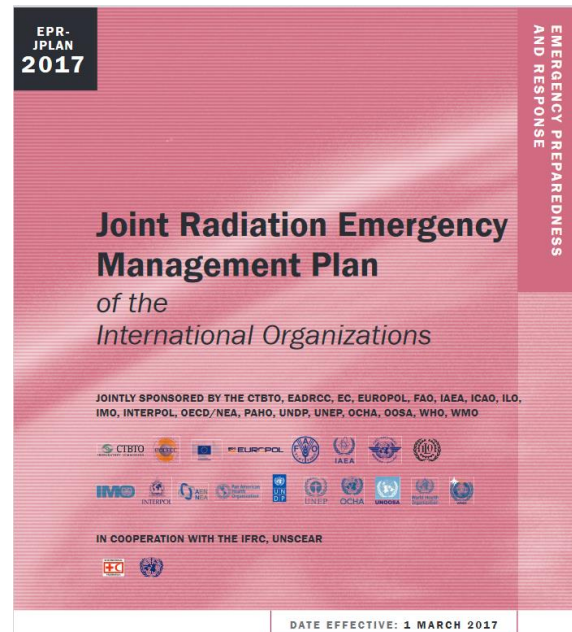
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SUMMARY IMS and Nuclear Explosions

- Prompt detections possible through Waveform technologies
 - Delayed only by speed of sound in air/water/earth
 - Would require automated alarm systems
- Radionuclide Network
 - Sparse network -> probably not helpful if explosion nearby, but useful worldwide
 - Days-weeks atmospheric dispersion before a probable hit at a station
 - High probability of HPGe In-situ mode, if dose rates are high
 - No further delay
 - Very high quality data of plume passage further away (when the measured activity is actually in collected samples)
 - 24 h resolution (particulates), 12-24 h Noble gases (40 stations)
 - 26-50 h delay (as every interesting nuclide can be seen in the first 2 h measurement slice)
 - Contamination of detectors and filters must be accounted for



- All data "immediately" available at requesting NDCs in every country
 - For treaty verification purposes!
 - Legally available for disaster mitigation through the IAEA, according with the EPR/JPLAN
- Will the satellite network be functional?



Spectrum analysis will be demanding

- Make sure you have tools and people that can cope and give the essential information fast

