IAEA-CN301-147

ION BEAM USAGE IN ENVIRONMENTAL CHARACTERIZATION

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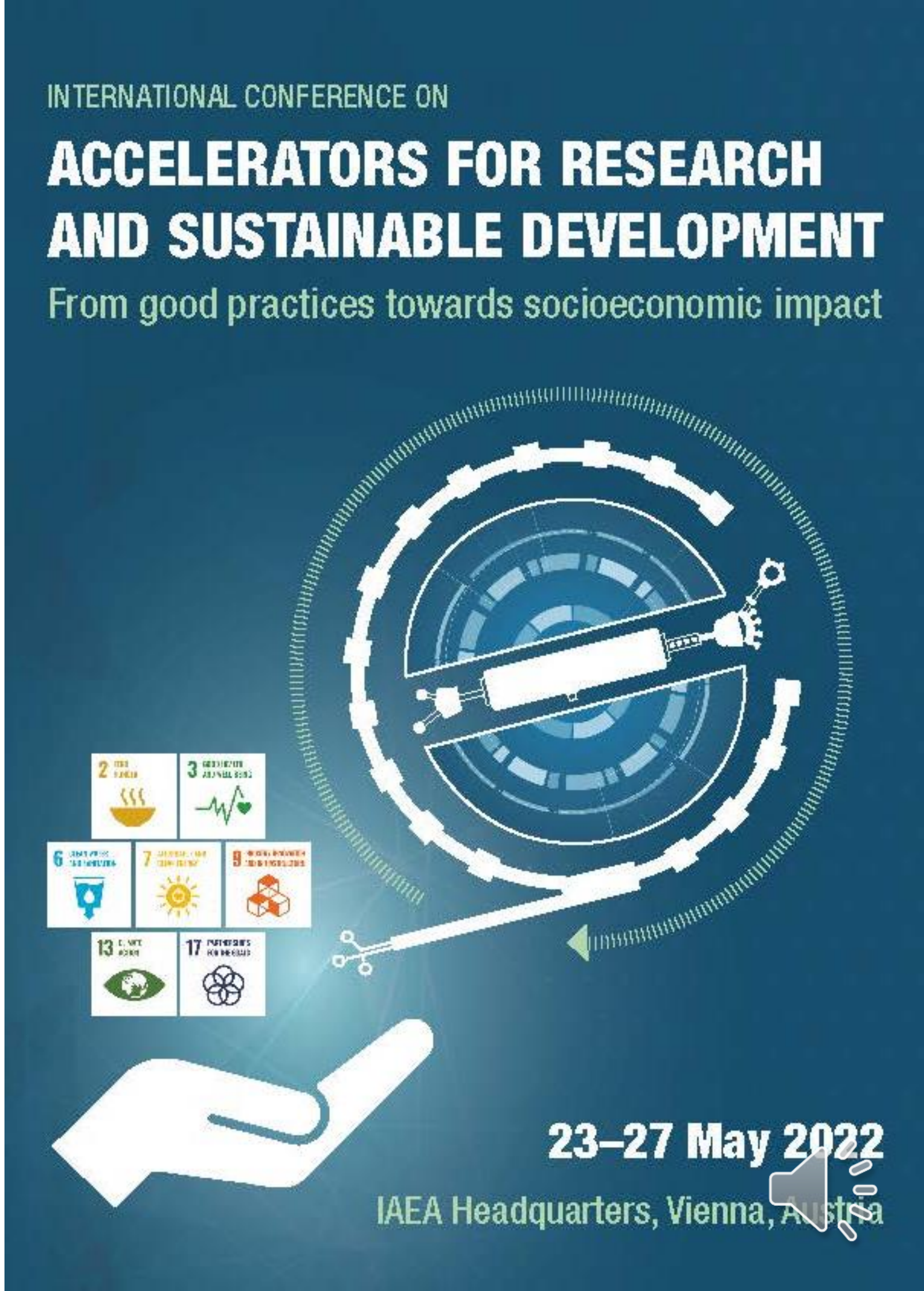
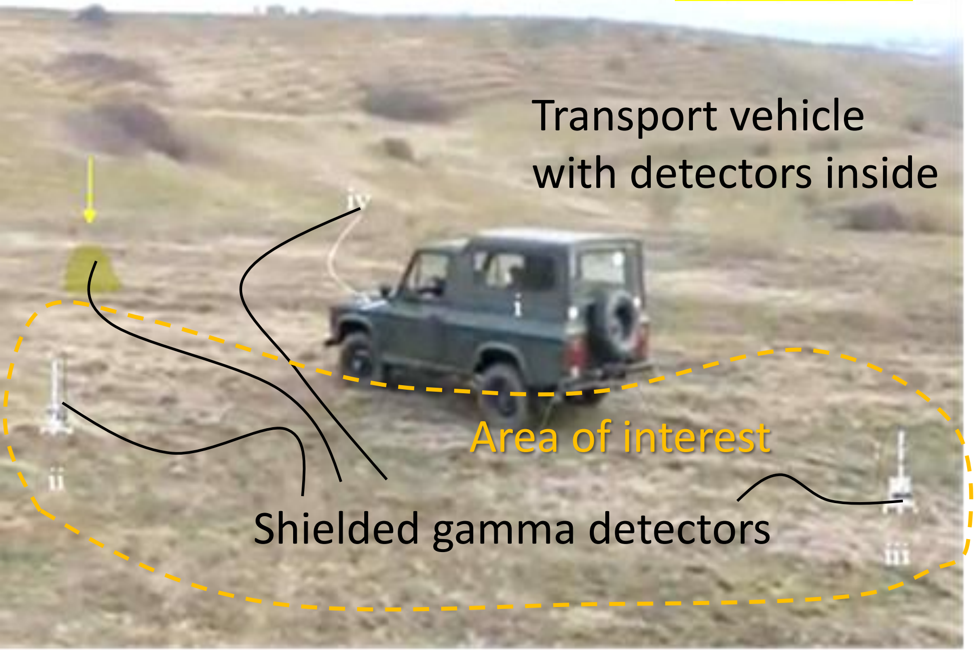
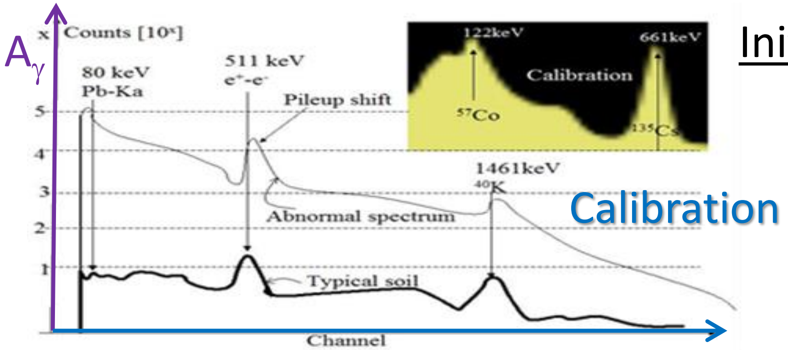
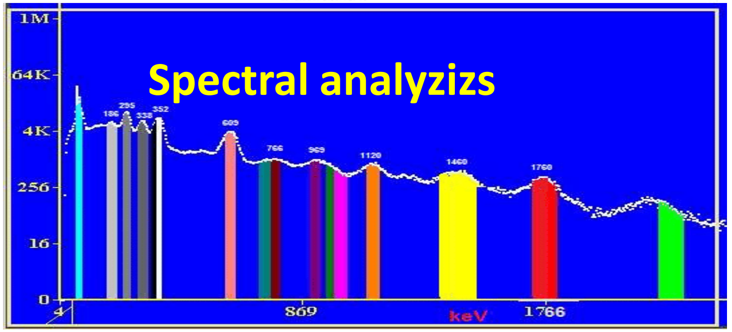


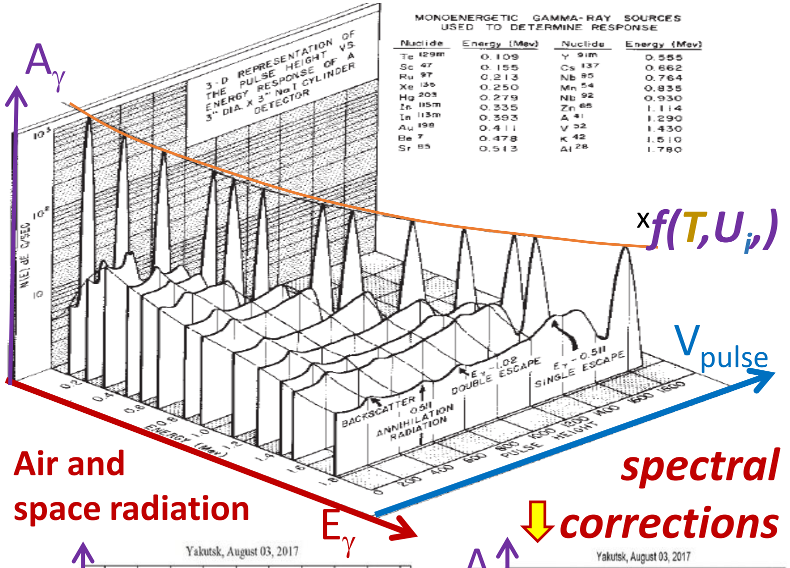
1980s –singular events

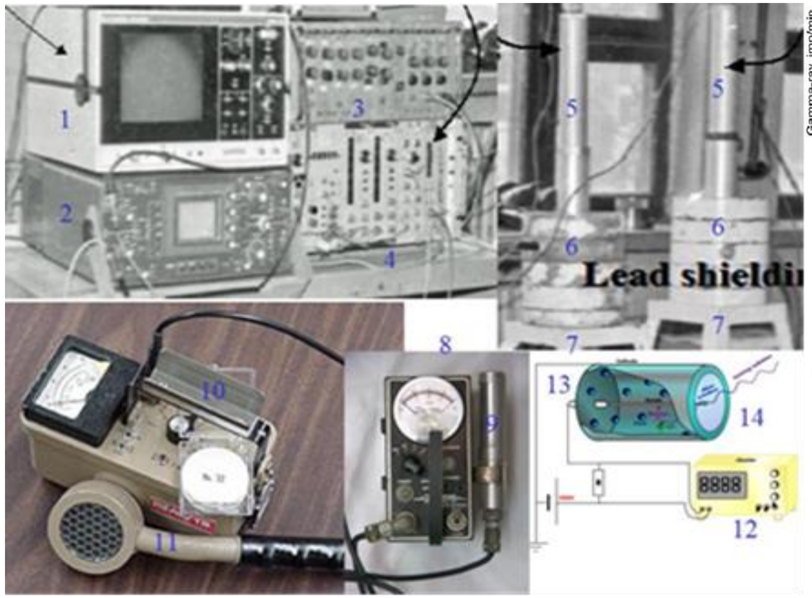
Initiation in Environmental Measurements

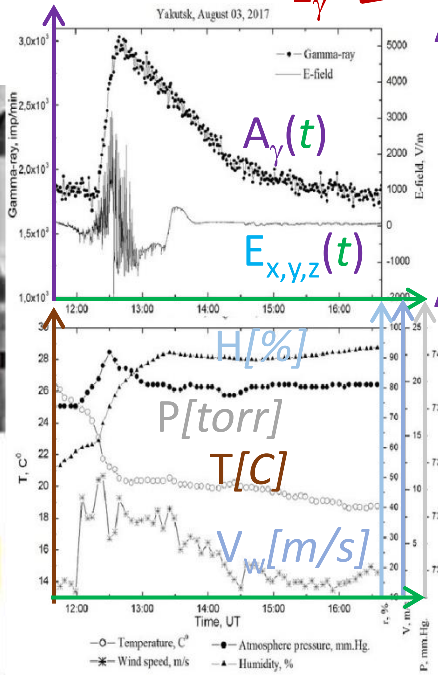


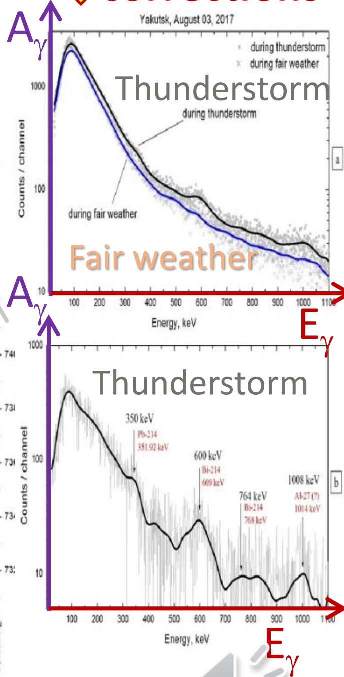












1980s Isotope Identification Measurements SWOT analysis

Strengths	Weakness
Exposure to the need of measuring radioactivity in real time in various locations, identifying isotopes and reasons they are there with short response time. Used and tested the functionality of various installations configurations and test protocols. Measuring the radioactivity and isotope composition in terrain. Identify the weakness and take corrective actions	No suitable equipment for the purpose – first handy – GM global radiation level monitoring systems Artisanal equipment using laboratory grade in harsh terrain conditions with high failure rate and limitations. No prior knowledge on pre-event status of radioactivity and real causes. Other technologic limitations
Opportunities	Threats
Take lesson learned and improve equipment and protocols by innovating Possibility of learning more from various encounters and failures translated in corrective actions, adaptation for the next event. Understand nature and real value of technology	Environment physical aggression threats from wild animals, farmers, local public, equipment malfunction, electrocution using 220Vca and <2 kV in open environments, other Producing wrong data interpretations Damage to equipment

Cost: $1-5k/day; continuously increasing equipment: $50-100k; 2 people task

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1980s Atmospheric corrosion Measurements SWOT analysis

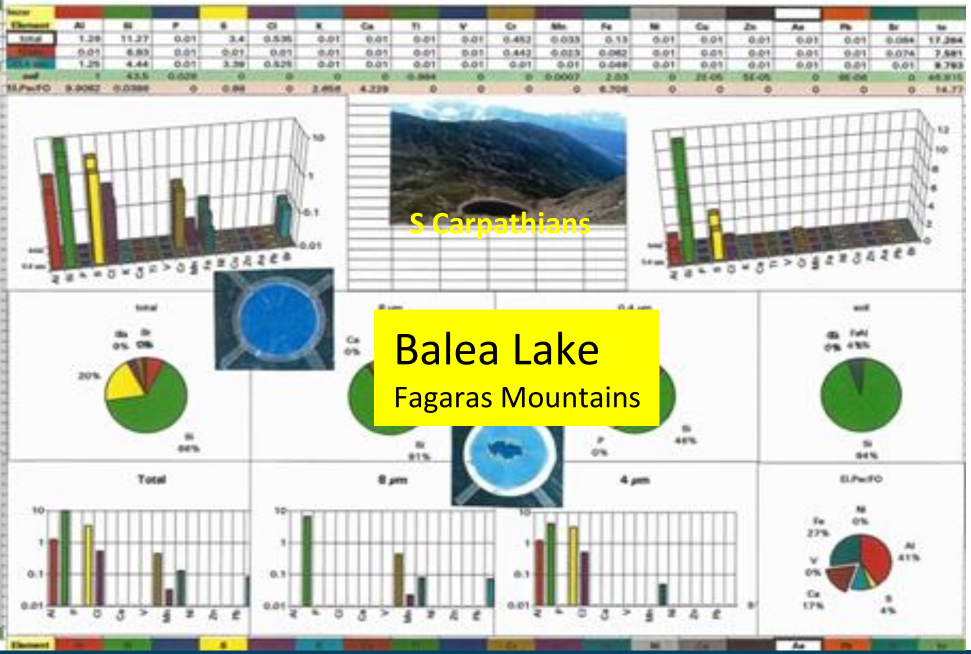
Strengths	Weakness
Shows in long duration what happens with atmospheric corrosion, and how some materials deteriorate while exposed to air, sun and weather.	Does not shows the cause -
Opportunities	Threats
To learn about atmosphere chemical and mechanical aggressiveness. Livovschi's observation triggered a material vs. ion beam dose test during 1990s and with observation that in the nuclear recoil stopping range a higher DPA generates defects that favors corrosion process. This is the limit of safe use of TLA.	Touching samples may modify their surface coating by finger acids. Performing it by radioactive labeling may affect material structure

Cost: $100 materials; Measurement: $50/session; 1-2 people task 8h/year

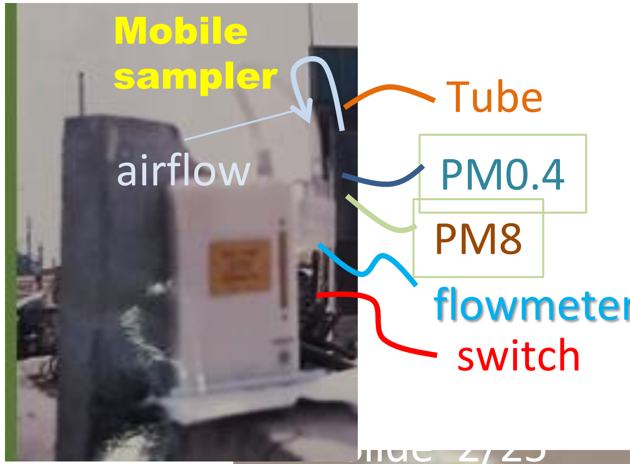

Bucharest
1994


Budapest

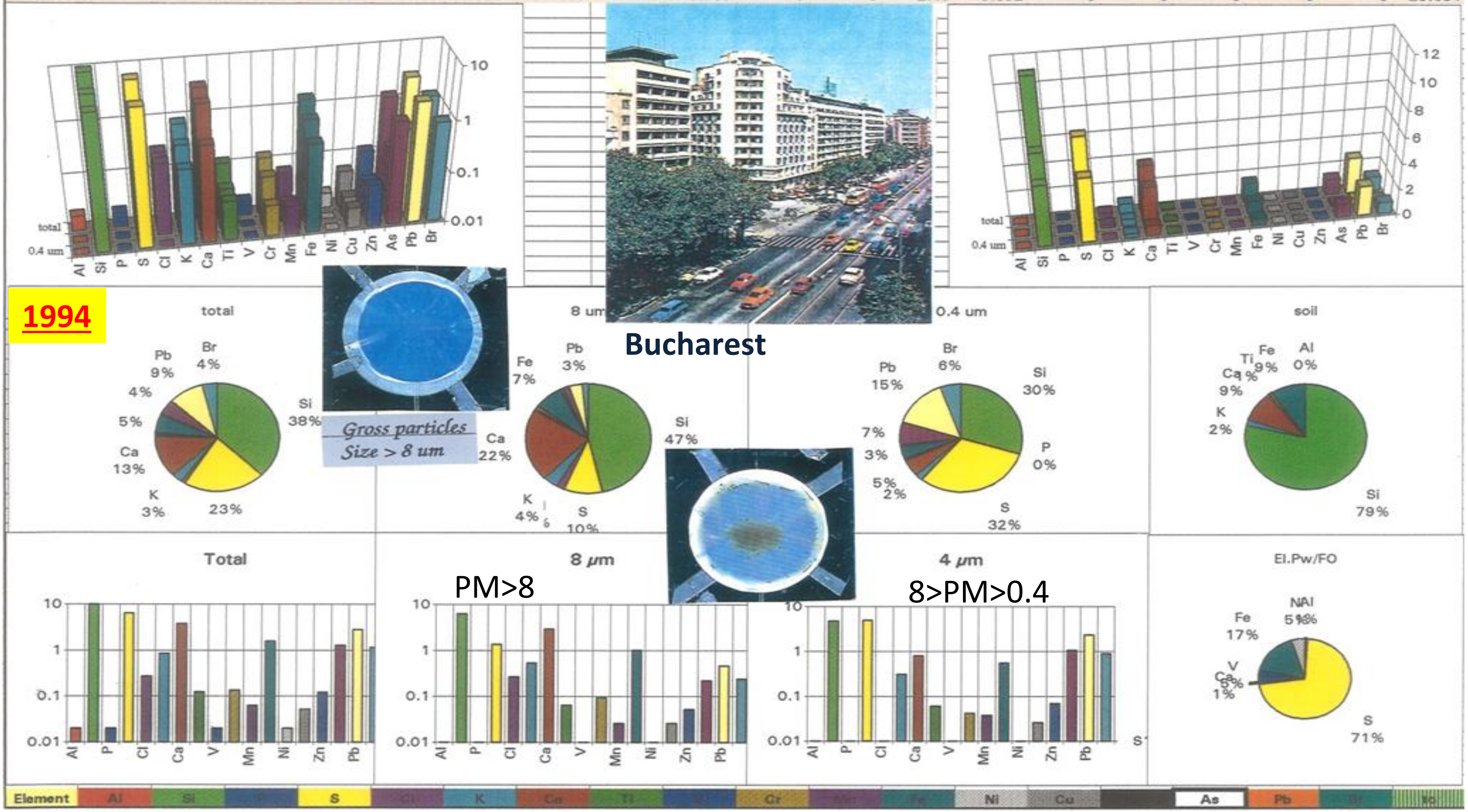

Neptune


S Carpathians
Balea Lake
Fagaras Mountains


Prof. Susumu Amemyia
Nagoya University, JP.
Dr. Petru Mihai Racolta
NIPNE-HH, RO
1994


Mobile sampler
airflow
Tube
PM0.4
PM8
flowmeter
switch

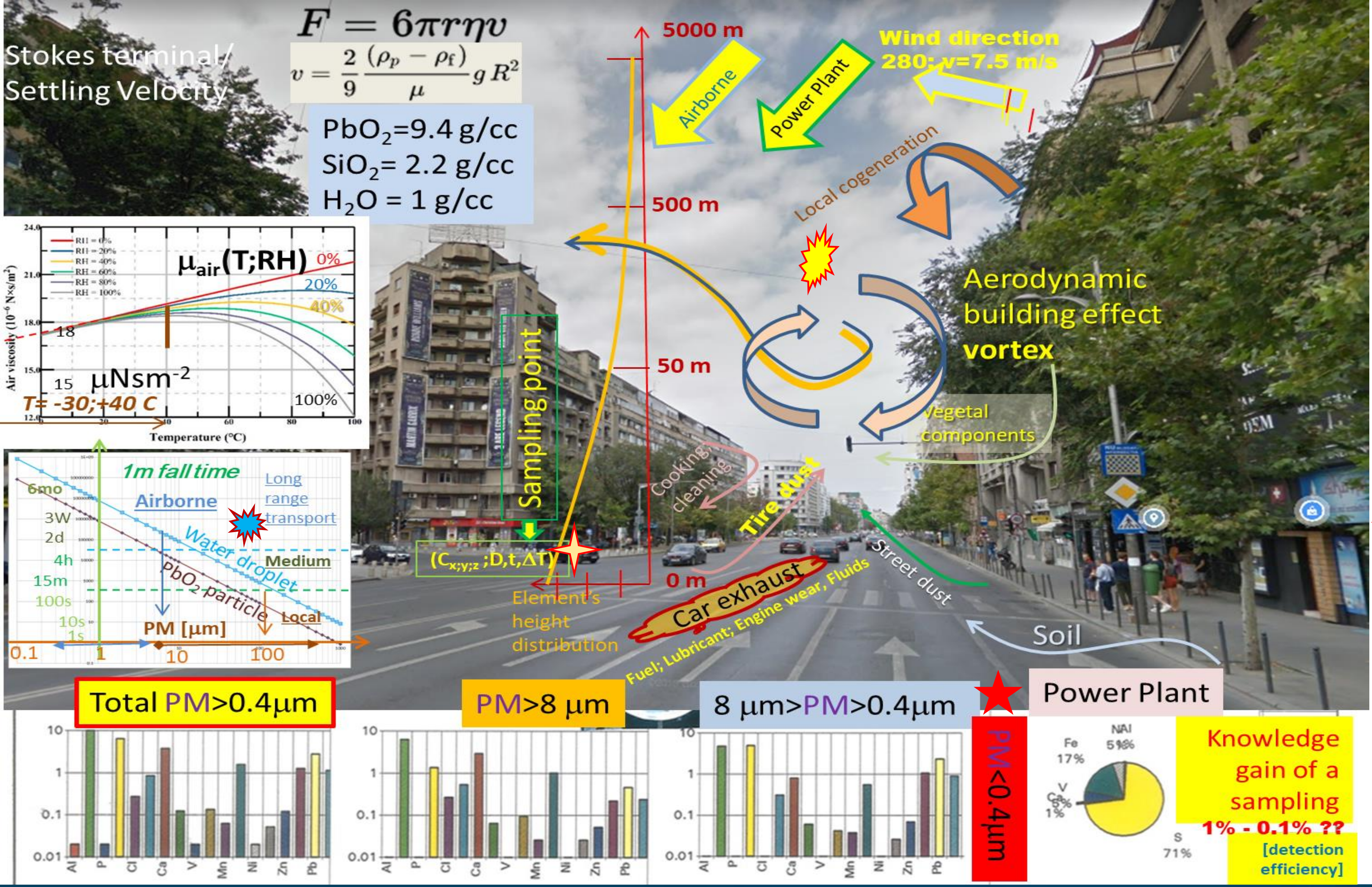
Bucuresti Element	Al	Si	P	S	Cl	K	Ca	Ti	V	Cr	Mn	Fe	Ni	Cu	Zn	As	Pb	Br	to
total	0.02	11.01	0.02	6.37	0.275	0.849	3.735	0.125	0.02	0.137	0.064	1.567	0.02	0.052	0.121	1.291	2.799	1.141	29.616
8 um	0.01	6.28	0.01	1.36	0.265	0.542	2.93	0.064	0.01	0.095	0.026	1.01	0.01	0.026	0.052	0.221	0.459	0.239	13.609
0.4 um	0.01	4.73	0.01	5.01	0.01	0.307	0.805	0.061	0.01	0.042	0.038	0.557	0.01	0.026	0.069	1.07	2.34	0.902	16.007
soil	0	35	0.056	0	0	0.8674	4.1412	0.6	0	0	0.001	4.06	0	2E-05	8E-05	0	2E-05	0	44.67
El.Pw/FO	0.1058	0	0	10.6	0	0.0083	0.1436	0	0.737	0	0	2.45	0.692	0	0	0	0	0	29.631



What we got is an instance of 1½ in a year (8766 h)

Measurements are enough to get scared but represent almost nothing to understand the origin, causes and take corrective action.

There are issues with sampling and measurement that have to be corrected.



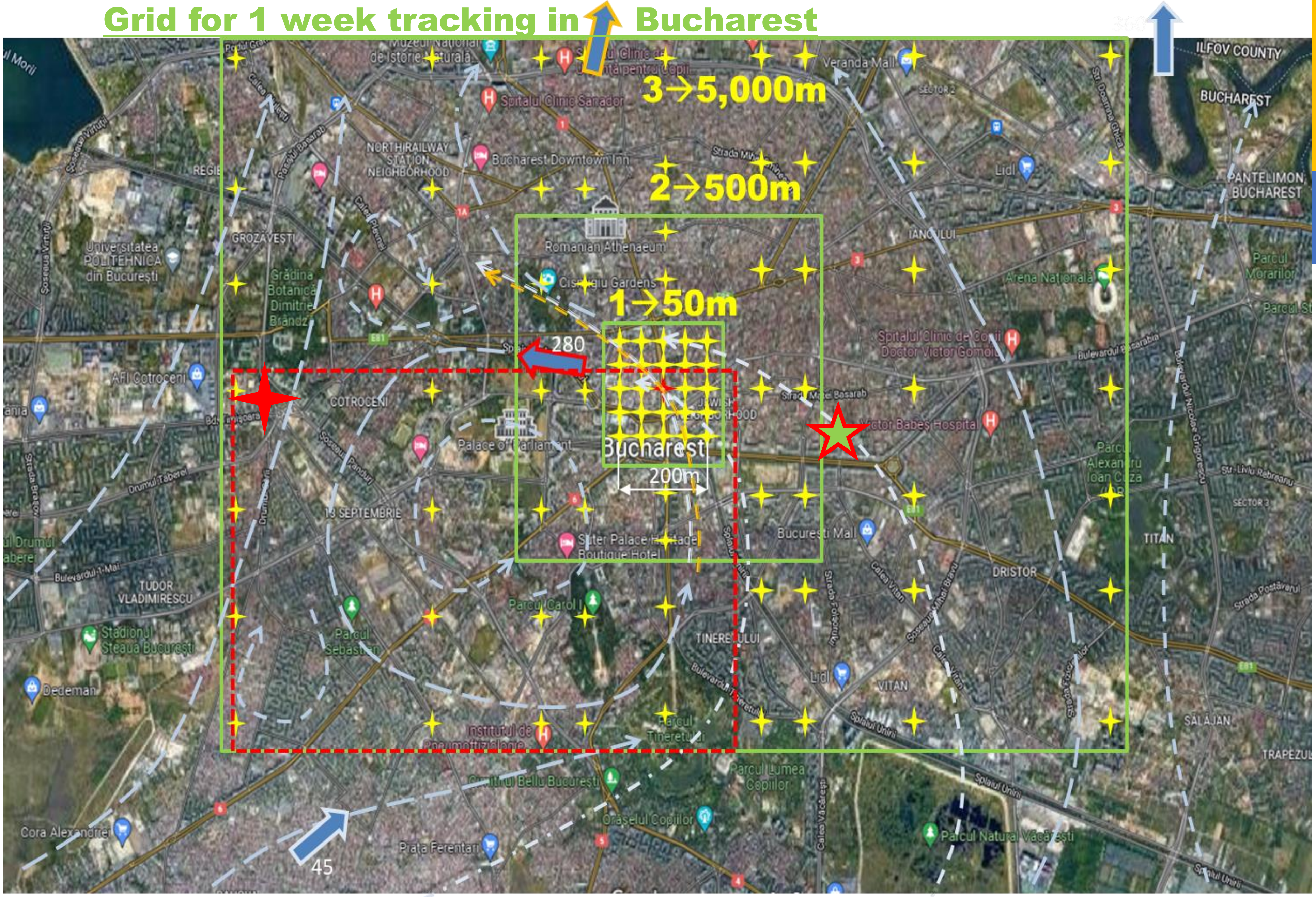
All particles smaller than 100 nm are airborne

We know nothing about PM<400 nm and gas composition

In urban environment air currents movement is very complex training even larger particles as street dust and vegetal matter.

The sampling unit is unable to record particle magnitude distribution variation and give enough info to make some correlations

Grid for 1 week tracking in Bucharest

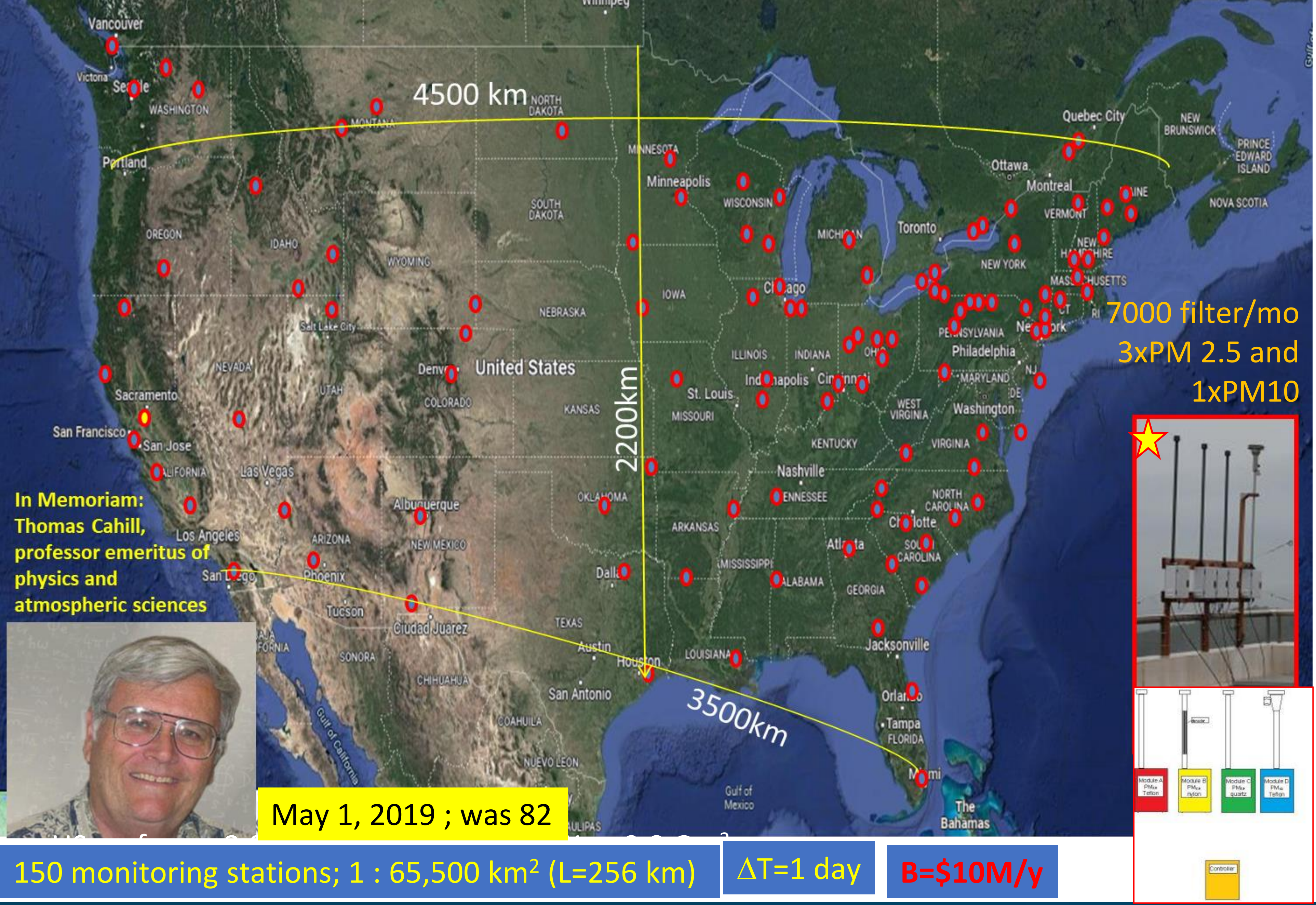


25 s→Tier1(200m); 16s→Tier 2 (2km); 48s→Tier3 (20 km) = total=90 samplers x 3 elevations=270

Total active samplers = 400 x 100 s/w= 40k s/w

As red rectangle shows even this ideal 100 to 300 simultaneous sampling units might not be enough to characterize an urban square of 20 x 20 km, due to complexity and variability of weather pattern.

The density of knowledge is proportional with the density of sampling stations, being maximal in the center; timing is an important factor too.



150 monitoring stations; 1 : 65,500 km^2 (L=256 km)

ΔT=1 day

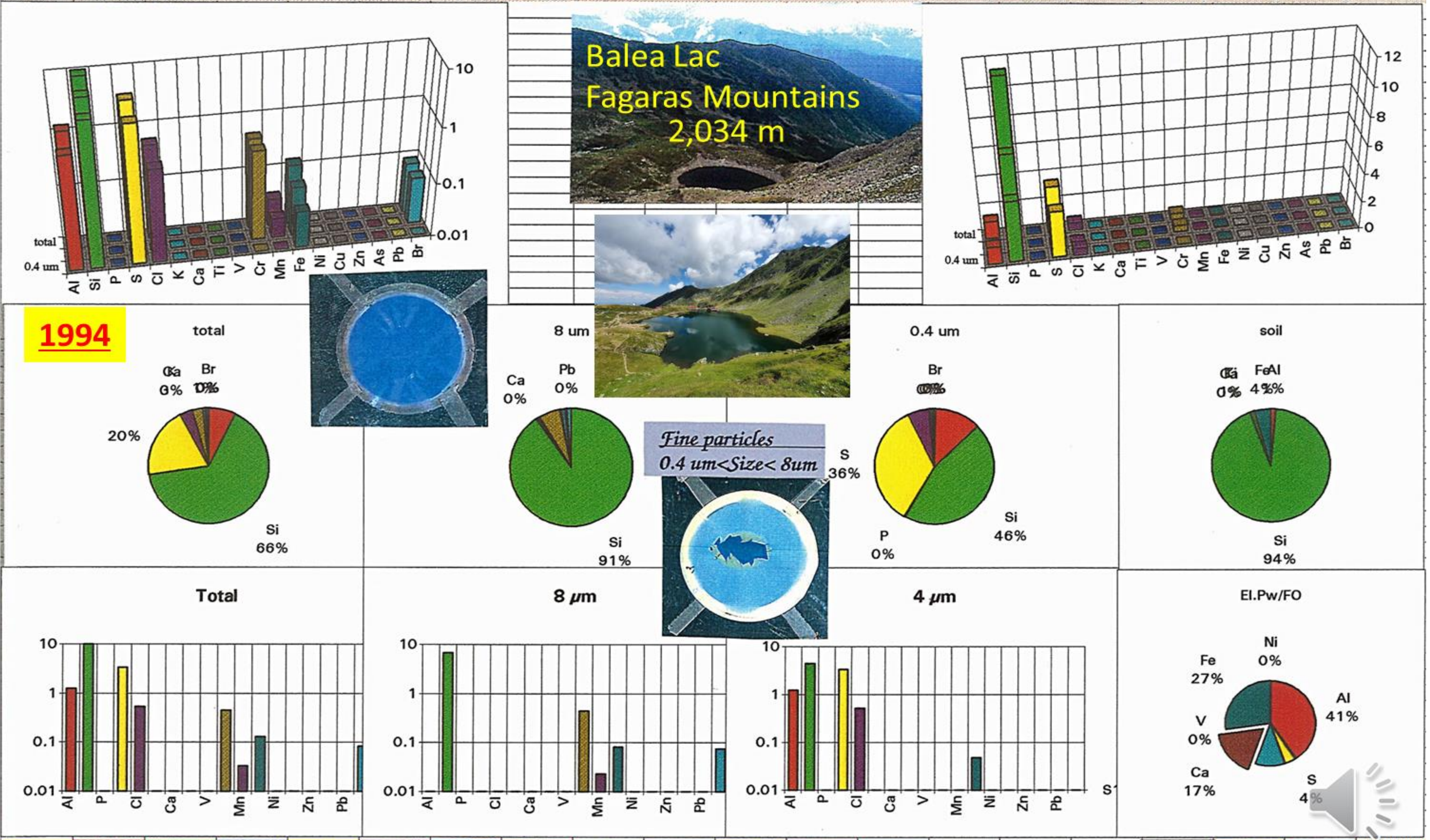
B=$10M/y

Prof. Thomas Cahill IMPROVE sampling network is an example of smart maximization of output and usage of resources in terrain in order to get a valuable package of information in realistic conditions.

The used samplers are more complex than what we have used, and our lack of appropriate funding prevented us to join his program, there remained a lot of room for improvement.

☆ My opinion is that more important for health is what we fail to collect = ultrafine particles (under 2.5/0.4 μm) and gases.

Iezer Element	Al	Si	P	S	Cl	K	Ca	Ti	V	Cr	Mn	Fe	Ni	Cu	Zn	As	Pb	Br	to
total	1.26	11.27	0.01	3.4	0.535	0.01	0.01	0.01	0.01	0.452	0.033	0.13	0.01	0.01	0.01	0.01	0.01	0.084	17.264
8 um	0.01	6.83	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.442	0.023	0.082	0.01	0.01	0.01	0.01	0.01	0.074	7.581
0.4 um	1.25	4.44	0.01	3.39	0.525	0.01	0.01	0.01	0.01	0.01	0.01	0.048	0.01	0.01	0.01	0.01	0.01	0.01	9.783
soil	1	43.5	0.028	0	0	0	0	0.684	0	0	0.0007	2.03	0	2E-05	5E-05	0	8E-06	0	46.815
El.Pw/FO	9.9082	0.0386	0	0.98	0	2.656	4.229	0	0	0	0	6.706	0	0	0	0	0	0	14.77



Element Al Si P S Cl K Ca Ti V Cr Mn Fe Ni Cu As Pb Br

This is another example of clean air scary sample. Because collateral information was so poor, we have been forced to be highly speculative in order to be able to say something more than deliver the charts.

~~Comments are like this:~~

What is worrying is the presence of

- S fine particles;
- Al in excess as fine part.;
- Cl as fine part.;
- Cr, Mn as coarse particles
- Br as coarse part.

No recollection of weather or wind direction

Al-Fe-Si might be OK as soil components

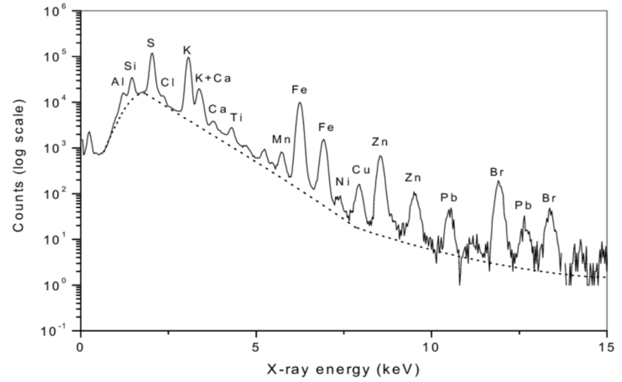
No idea about the rest!

There is a H_2SO_4 plant near by…(Victoria) **may be from there**

Aerosol sampling and PIXE Measurements SWOT analysis

Strengths	Weakness
Possibility to identify the pollutants and know the main elements. Mobile, light, short time samplers ΔT:=1-2h Identify the weakness and take corrective actions Possibility to use several units synchronously and correlate with weather High resolution, reliable identification, susceptible to use complementary measurements PIGE, RGA, AMS, RBS, CPAA, NAA	Does not detect light elements lighter than Oxygen, nor molecules. Need an accelerator to process the samples, with sophisticated technology Sample evaporates under vacuum and beam Expensive requires 10-30 min in beam time ≈$100-500
Opportunities	**Threats**
Take lesson learned and improve equipment and protocols by innovating Possibility of learning more from various encounters and failures translated in corrective actions, adaptation for the next event. Understand nature and real value of technology Possibility of using an RGA for molecular identification and light samples	Competition from XRF and spectroscopic methods Difficulty of collecting and handling the sample

Cost: $10-50k/day; continuously increasing equipment: $50-100/sample; 10 people task



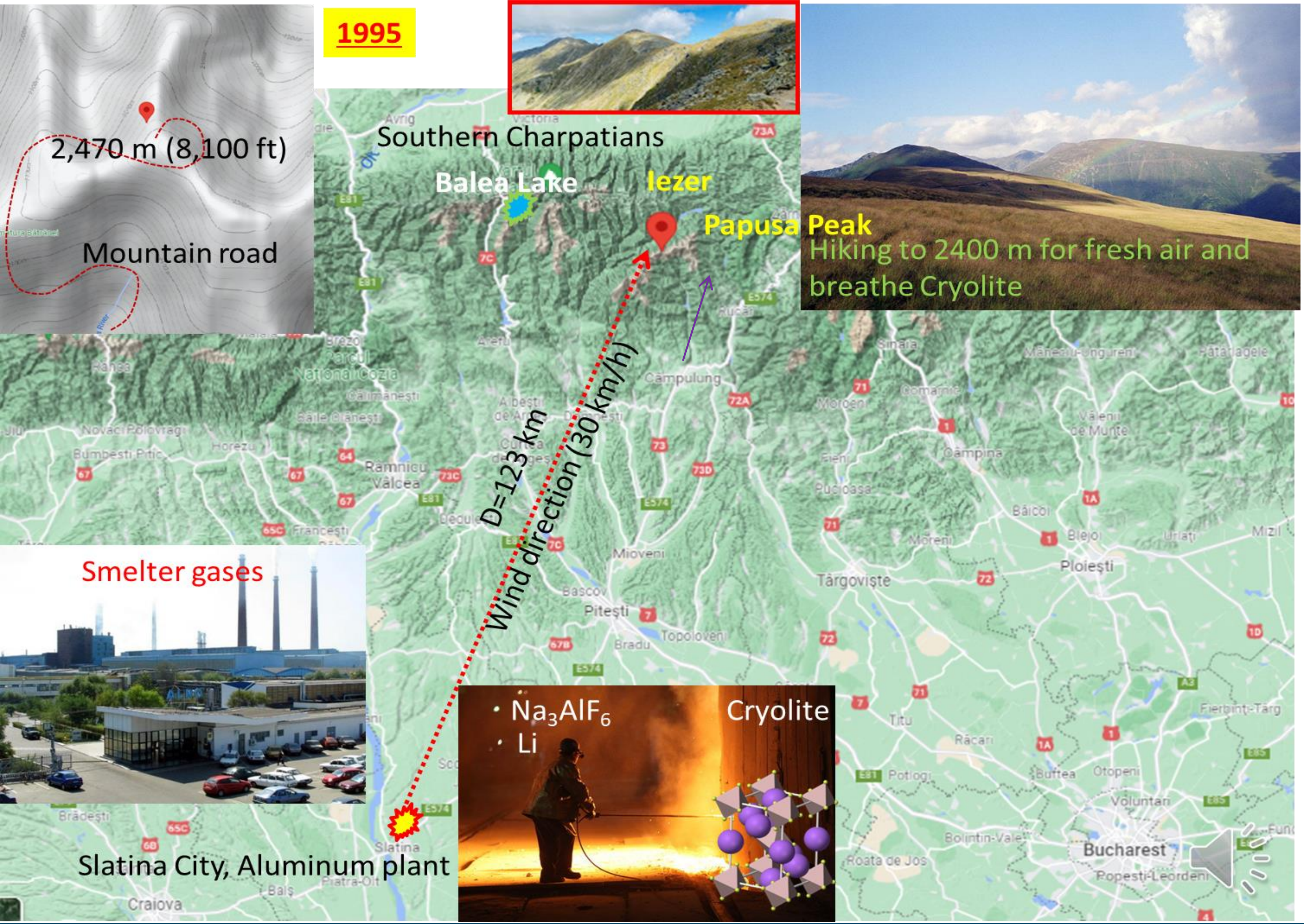
Pretty unhappy after obtaining “good enough” results!
We realized how much we do not know or do not control.

Doing better trends to be time intensive and that rises the cost per sample analysis.

Vacuum and beam power deposition is a big issue

Aerosols interaction and organic matter is not measured

Sampling time integration and lack of collateral data



Another outrageous speculation

By 1995 took a all terrain vehicle and climb the Papusa peak, took a sample by noon, and when measured we find something similar to Balea Lake, but much Al, less S and Br, but some coarse Cr.

We speculate and put the blame for Al, on an Al purification plat using cryolite, 123 km SSW, as this time we recorded wind direction, by wet finger and compass, but no clue for Cr.
We tried to blame a car factory but without any real data support. (see violet arrow)

Planned 5 Δ of 2h (1½ sampling+ ½ h relocation) Bucharest mapping 1995 (10-12-14-16-18)

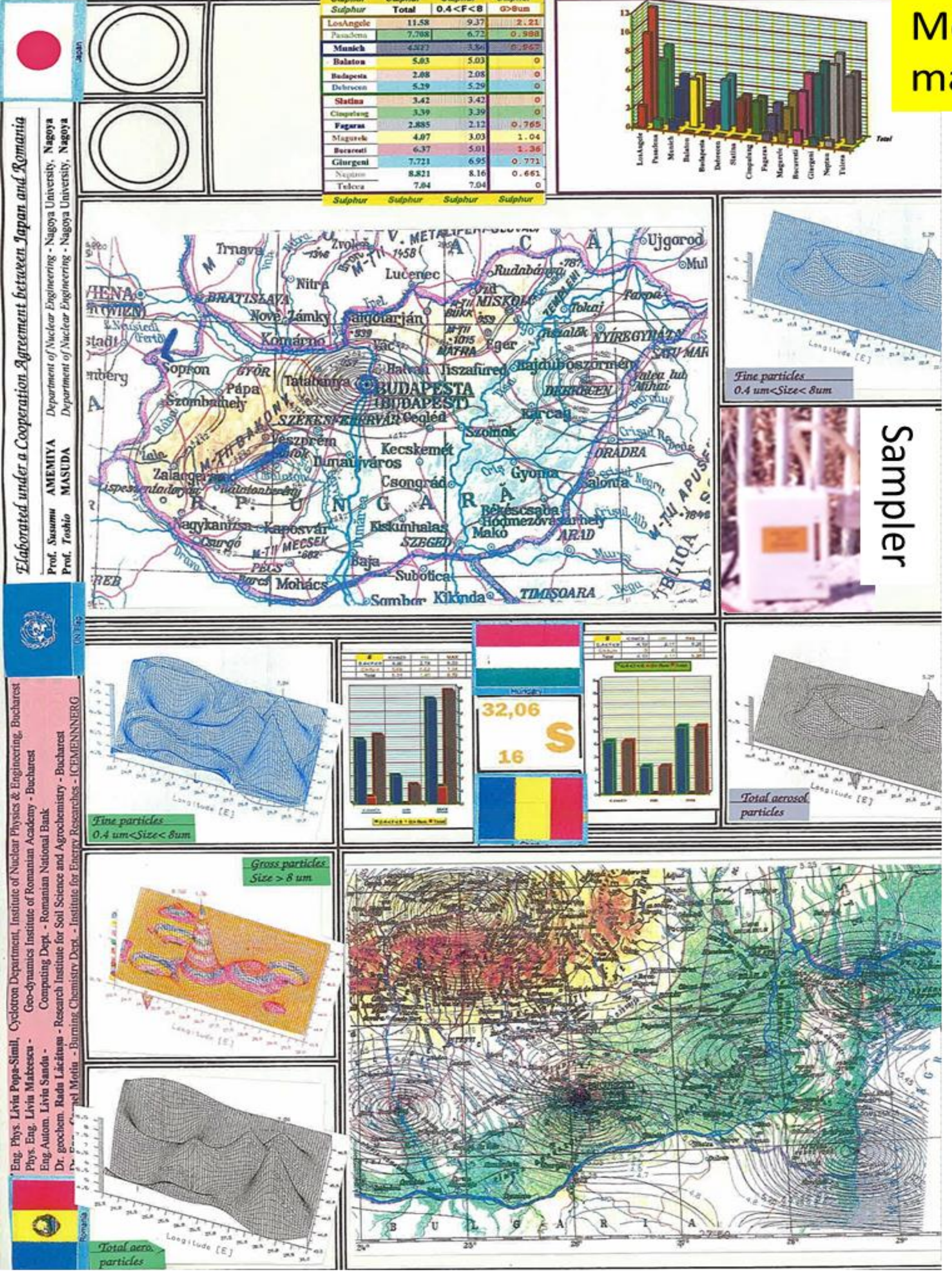
We liked more Susumu's mobile samplers as we had 3 of them and were more invasive than Improve protocol, and we tried to make an ad hock network in Bucharest with 3 teams and clock synchronization.

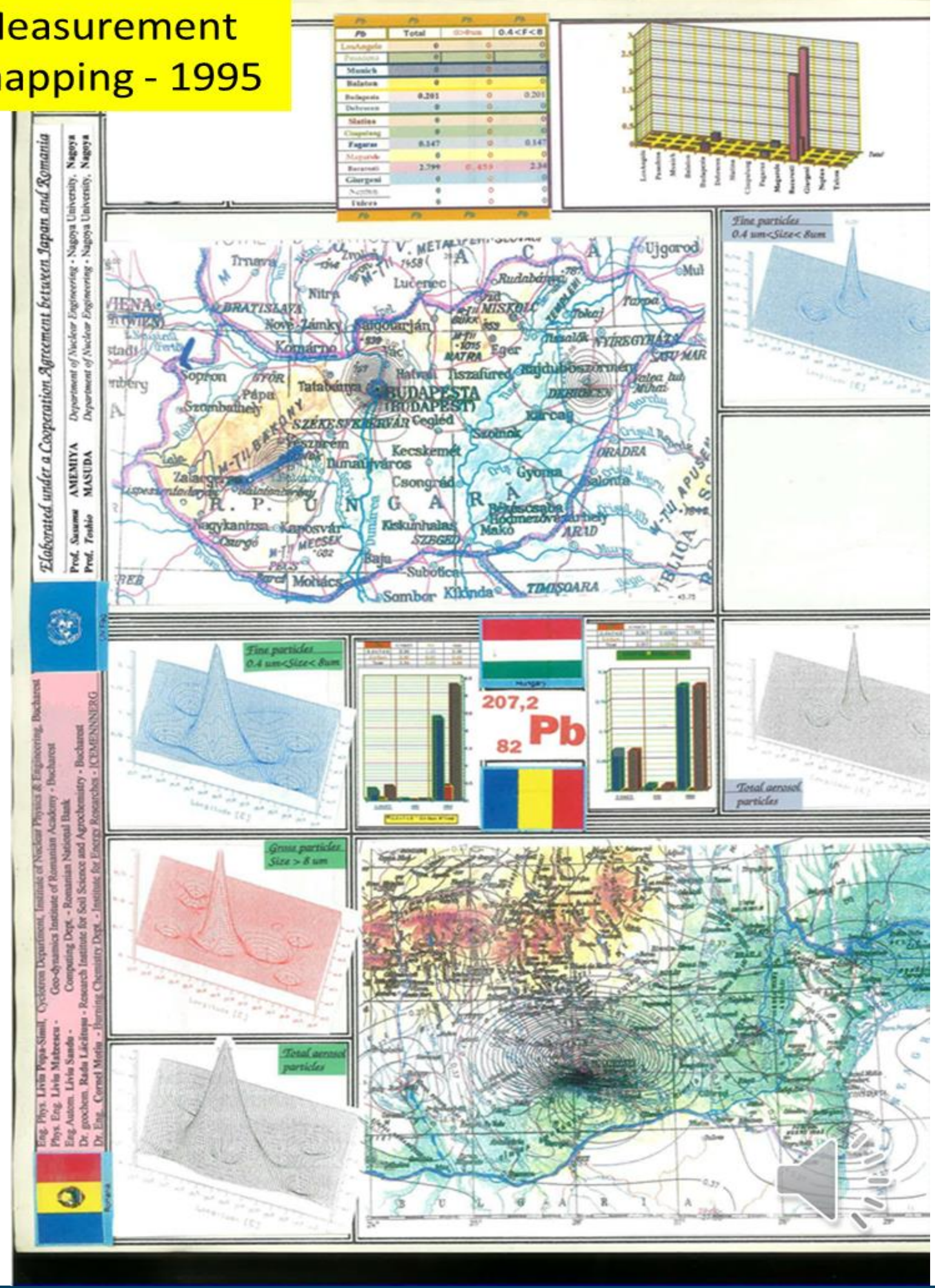
We failed timing sync. according to plan due to various incidents, and took 2 days to make the sampling.

We had variable weather and wind which we do not know how to interpret, so we ignored.

We got something complex that we did not knew how to explain so we used lots of imagination and specuation.

Measurement mapping - 1995





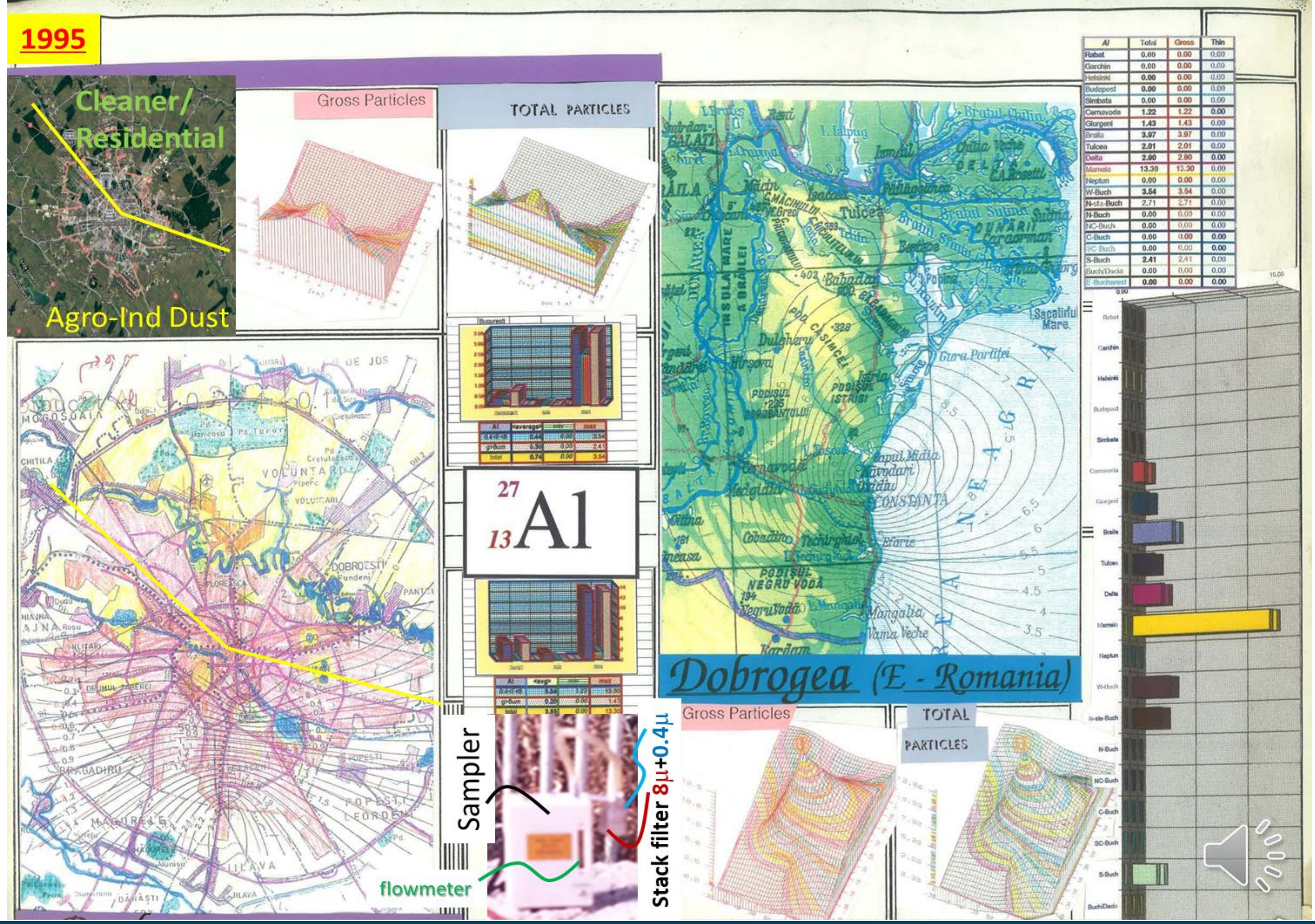
We got maps of 20+ elements for SE Romania and Hungary

We interpolated in 3D to see the terrain distribution of each element.

We got the cone shaped distribution as sign that network was not dense enough.

We noticed that for grid larger than 10 km the interpolation does not work well, or it is meaningless.

Need to read the cone profile as point values only.



Al	Total	Gross	Thin
Rabat	0.00	0.00	0.00
Garchin	0.00	0.00	0.00
Helsinki	0.00	0.00	0.00
Budapest	0.00	0.00	0.00
Simbata	0.00	0.00	0.00
Cernavoda	1.22	1.22	0.00
Giurgeni	1.43	1.43	0.00
Braila	3.97	3.97	0.00
Tulcea	2.01	2.01	0.00
Delta	2.90	2.90	0.00
Mamaia	13.30	13.30	0.00
Neptun	0.00	0.00	0.00
W-Buch	3.54	3.54	0.00
N-sta-Buch	2.71	2.71	0.00
N-Buch	0.00	0.00	0.00
NC-Buch	0.00	0.00	0.00
C-Buch	0.00	0.00	0.00
SC-Buch	0.00	0.00	0.00
S-Buch	2.41	2.41	0.00
Buch/Dacia	0.00	0.00	0.00
E-Bucharest	0.00	0.00	0.00

Interpolation for the measurements in Dobrogea and Bucharest

Again: lots of data with fuzzy explanations

Distance of 40 km Constanta-Neptun s about maximum that can be used on very good weather –no wind to get a grid reliable sampling.

Grid in Dobrogea was not good due to poor logistics

Grid in Bucharest was acceptable, better logistic but weather was variable, so data integrity was affected.

The qualitative observation is OK in spite quantitative evaluation was affected by rain in N.

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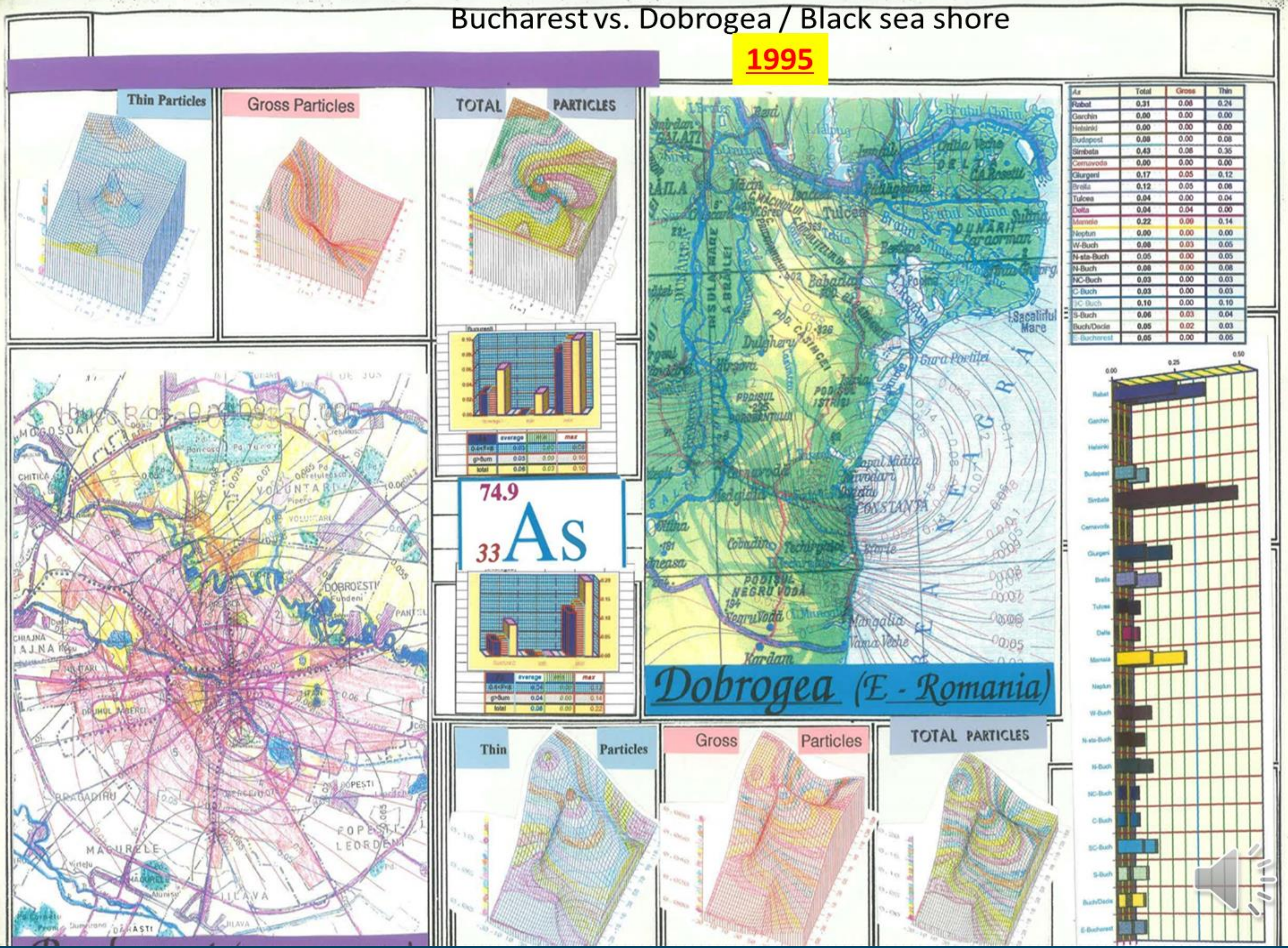


As	Total	Gross	Thin
Rabat	0,31	0.08	0.24
Garchin	0,00	0.00	0.00
Helsinki	0,00	0.00	0.00
Budapest	0,08	0.00	0.08
Simbata	0,43	0.08	0.35
Cernavoda	0,00	0.00	0.00
Giurgeni	0,17	0.05	0.12
Braila	0,12	0.05	0.08
Tulcea	0,04	0.00	0.04
Delta	0,04	0.04	0.00
Mamaia	0,22	0.09	0.14
Neptun	0,00	0.00	0.00
W-Buch	0,08	0.03	0.05
N-sta-Buch	0,05	0.00	0.05
N-Buch	0,08	0.00	0.08
NC-Buch	0,03	0.00	0.03
C-Buch	0,03	0.00	0.03
SC-Buch	0,10	0.00	0.10
S-Buch	0,06	0.03	0.04
Buch/Dacia	0,05	0.02	0.03
E-Bucharest	0,05	0.00	0.05

Another 3D maps, for Arsenic, resembling previous Al map with about the same problems:

It is a lot, and we do not know where it is coming from?

So let's start speculating:

In nature it may be found in :

insecticides, (did they sprayed for mosquitoes?) May be!

arsenopyrite (FeAsS), realgar (AsS) and orpiment (As_2S_3)

byproduct of the smelting process for: cobalt, gold, lead, nickel, and zinc; In dobrogea there is steel mill at Braila-Galati, but in Bucharest there are very few, little plants

in paints and dyes for clothes, paper, and wallpaper, but how do it get airborne?

Wood passivation with copper chromated arsenate (CCA),very little

Network sampling PIXE Measurements SWOT analysis

Strengths	Weakness
The sampling unit is cheap $1k and small 2liter, 1kg easy to transport. With multiple units and many people is easy to make an ad-hock network and synchronize the sampling, considering weather data May sample before and after an weather event and see the changes May compare places at different dates	Sample handling and analysis procedure is complex, requires synch. Requires the use of an accelerator for analysis purposes PIXE, PIGE, RBS, etc. Expensive a sample may take ¼ -1/2 h of beam time $100-500/sample, and there are 2 samples in 1 measurement / location
Opportunities	Threats
Observe things that other vise is hard to anticipate with certitude as: rain atmosphere cleaning effect; Presence of smelter gas and cryolite on mountains peaks, differences between locations and towns. We also observed as pollution inside houses is frequently reaching higher levels than the average pollution in street because of window opening habits.	Mobile units on alternative methods. Lack of interest for the results and lack of levers for corrections makes the knowledge useless. High cost of sampling equipment.

Cost: $0.1-1k/day/person; continuously increasing equipment: $50-100k; many people task
Requires accelerator beam, data acquisition and multi-level analysis.

Lesson learned

Sampling planning has to consider all real terrain and human factors to succeed.

Grid step magnitude depends of the complexity of the area

Need to acquire a lot of collateral information about the area in order to perform educated guesses at data interpretation.

Weather and air mass trajectories are important to be known with knowledge on what happens up-flow too.

Synchronous sampling and inter-correlations are important

Understanding airborne particulate-aerosol interaction

Now let’s look at 4 together:

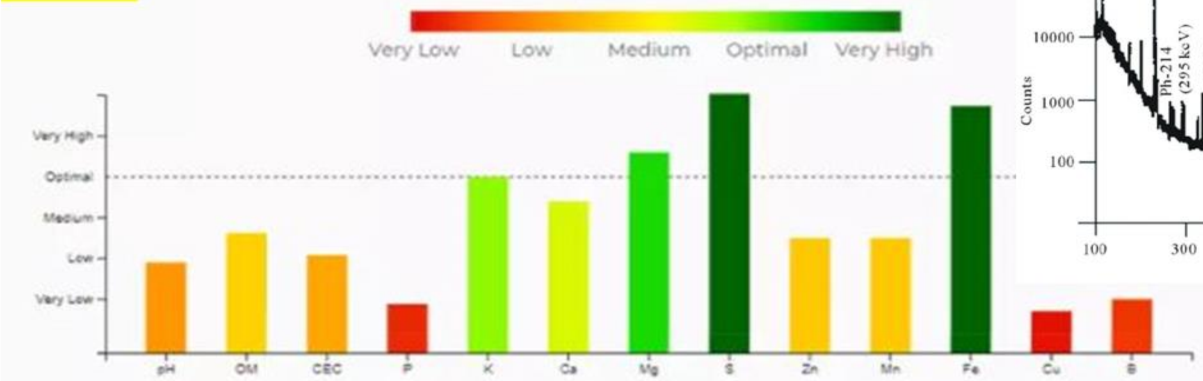
4 large towns, 2 in eastern EU, one in middle EU and one in USA on the opposite side of Earth (10h time-shift)

They have different pollution pattern, normally; they are different cultures, social structures, industry, transportation, etc.

Some may be explained, but most of the differences remain in supposition realm: Pb → Eastern EU uses lead ethylated gasoline, more in Bucharest, while west uses Ethanol mix in gasoline

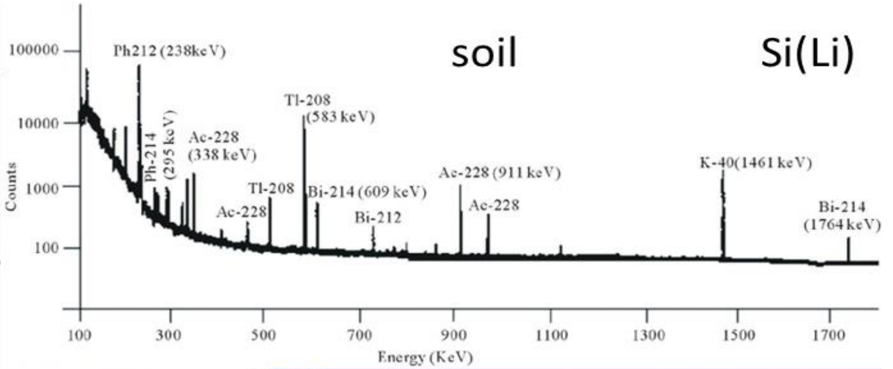
Munich is the cleanest, due to German habits

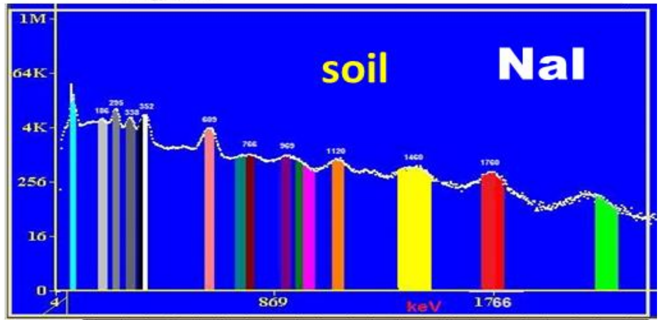
1997

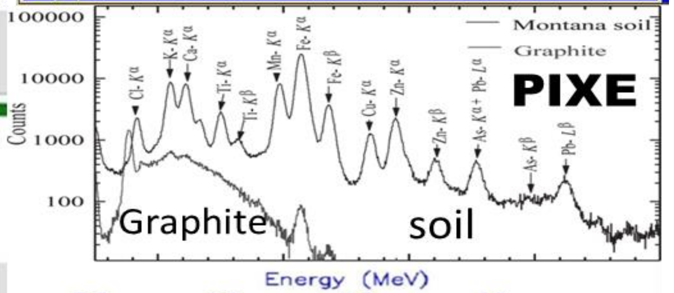


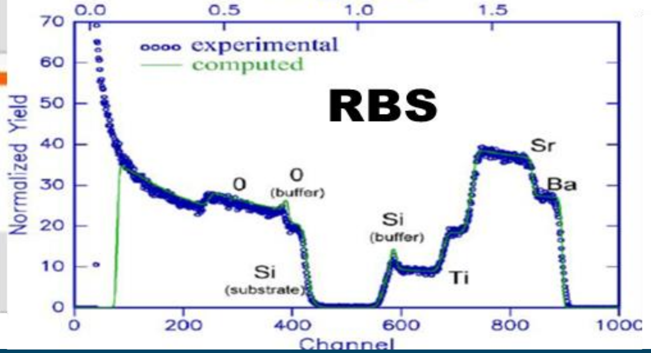
Soil PH (pH) 5.6 Optimal Range 6.2 - 6.8	Organic Matter (OM) 4.7% Optimal Range 5% - 6.9%	Capacity to Retain Nutrients (CEC) 7.7 Optimal Range 11 - 16

Phosphorus (P) 6 Optimal Range 42 - 68 ppm	Potassium (K) 103 Optimal Range 89 - 107 ppm	Calcium (Ca) 54.8% Optimal Range 70% - 85% pbs	Magnesium (Mg) 17.5% Optimal Range 15.1% - 25% pbs	Sulfur (S) 93 Optimal Range 29 - 36 ppm
Zinc (Zn) 1.1 Optimal Range 3.5 - 8.1 ppm	Manganese (Mn) 4 Optimal Range 21 - 51 ppm	Iron (Fe) 57 Optimal Range 11 - 51 ppm	Copper (Cu) 0.2 Optimal Range 1.6 - 3.1 ppm	Boron (B) 0.1 Optimal Range 1.3 - 2.6 ppm









Some details that may be used to improve measurements quality and usefulness

Knowing nearby soil composition with high accuracy is important to distinguish and take out soil contribution.

We need to use XRF, PIXE, PIGE, RBS and γ-spectrometry with Si(Li); Ge(li); NaI, and we have to use AMS for rare isotopes, and RGA to deal with low saturated vapor pressure materials, that are not suitable for vacuum and beam power application and sublimate and are taken out by vacuum system.

AEROSOL ELEMENTAL CONCENTRATION MEASUREMENTS SWOT ANALYSIS

Strengths	Weakness
Exposure to the need of measuring radioactivity in real time in various locations, identifying isotopes and reasons they are there with short response time. Used and tested the functionality of various installations configurations and test protocols. Measuring the radioactivity and isotope composition in terrain. Identify the weakness and take corrective actions	No suitable equipment for the purpose – first handy – GM global radiation level monitoring systems Artisanal equipment using laboratory grade in harsh terrain conditions with high failure rate and limitations. No prior knowledge on pre-event status of radioactivity and real causes. Other technologic limitations
Opportunities	Threats
Take lesson learned and improve equipment and protocols by innovating Possibility of learning more from various encounters and failures translated in corrective actions, adaptation for the next event. Understand nature and real value of technology	Environment physical aggression threats from wild animals, farmers, local public, equipment malfunction, electrocution using 220Vca and <2 kV in open environments, other Producing wrong data interpretations Damage to equipment

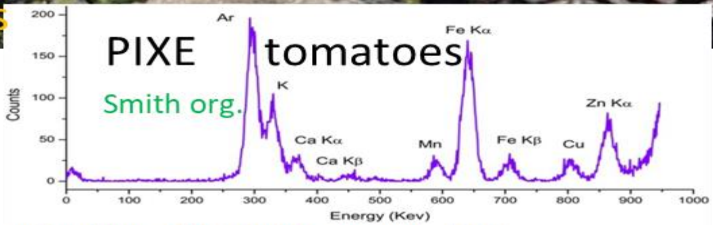
Cost: $1-5k/day; continuously increasing equipment: $50-100k; 2 people task

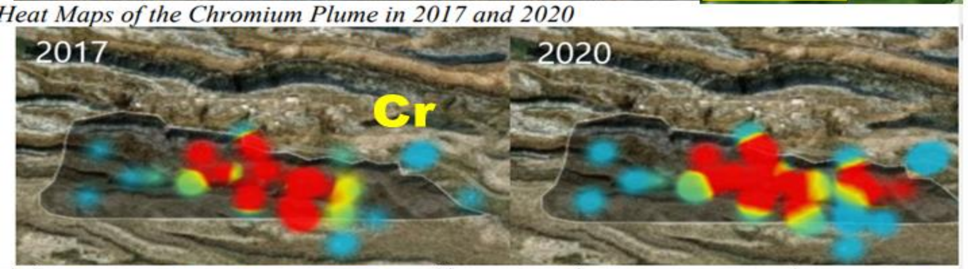
Lessons learned

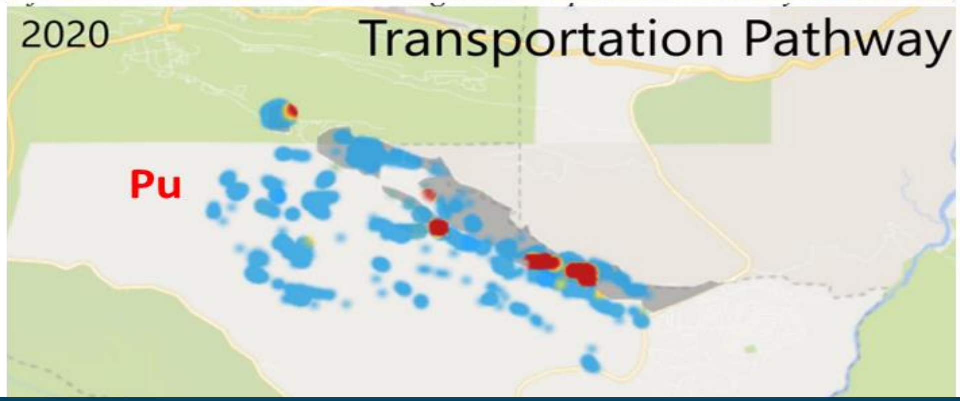
It is clear that the accelerator based measurements have to be improved too, in order to deal with aerosolized watery droplets interacting with solid particles.

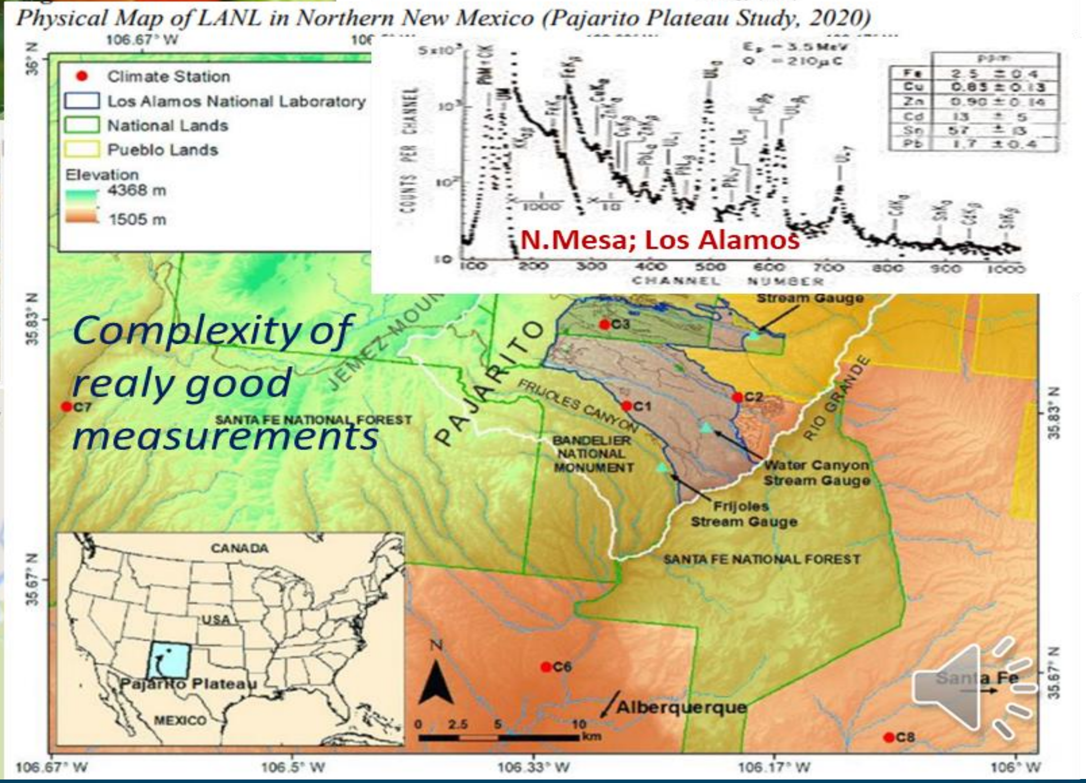
Sample storage and processing before applying beam is important and has to be RGA with double stage assisted.

Sampler has to be improved in order to be able to measure particles magnitude for each particle and store in event mode, to create distributions, and have associated a weather station nearby.









Understanding the nature ways of spreading pollution in environment via measurements

The case of "atomic legacy" in Los Alamos

Home grown Tomatoes composition case

N Mesa tomatoes are as tasty as after Chernobyl tomatoes, containing lots of elements compared to groceries shop tomatoes, which are tasteless organic structures.

A holistic study of isotope distribution has to be considered.

International Conference on Accelerators for Research and Sustainable Development
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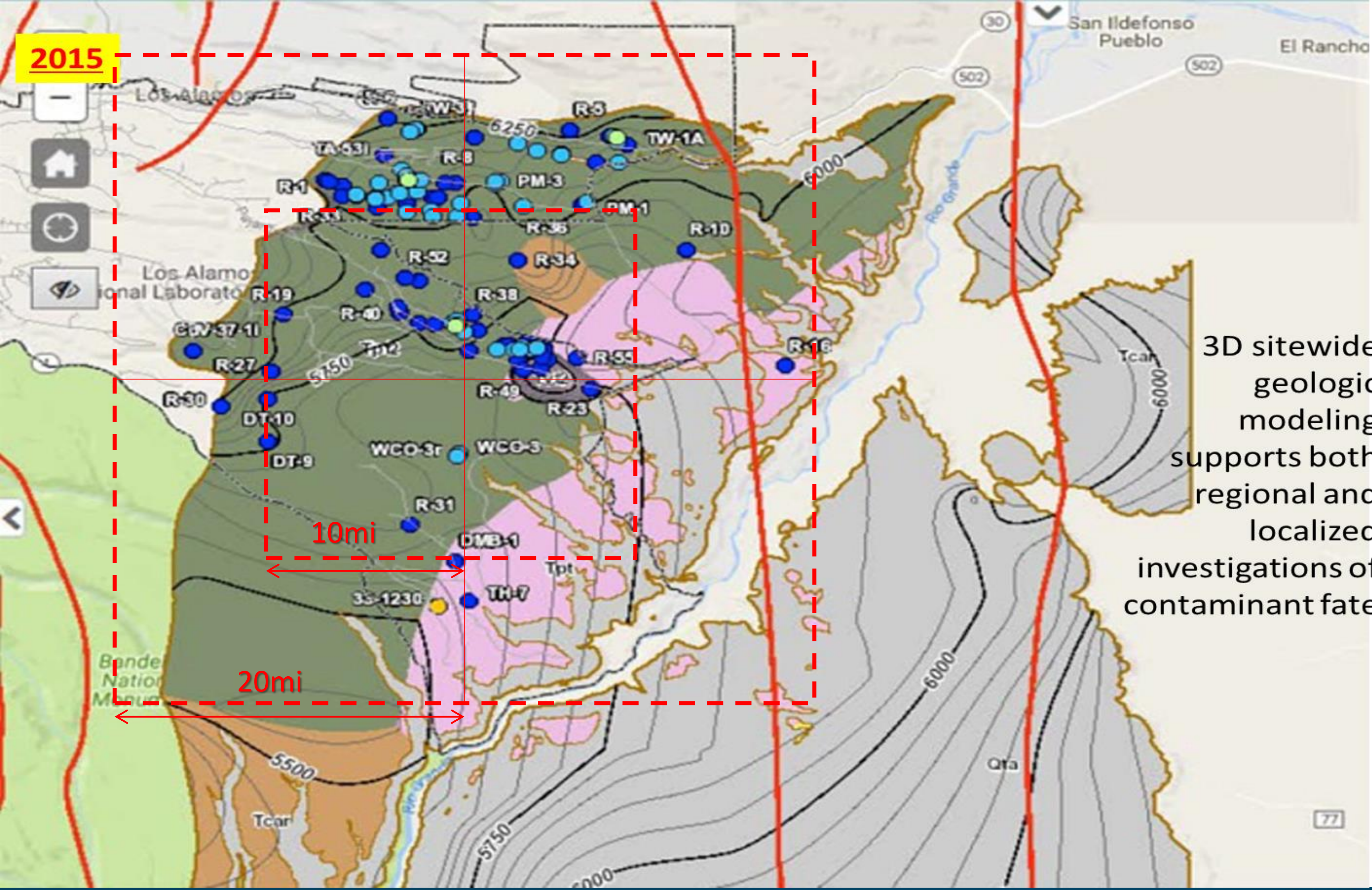


Example of groundwater water measurement

3D sitewide geologic modeling supports both regional and localized investigations of contaminant fate

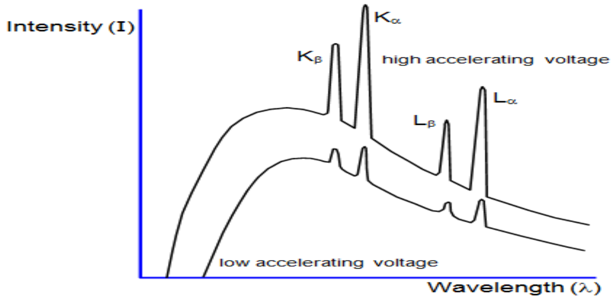
Contamination was made 70 years ago on the surface and diffused underground by water carrier.

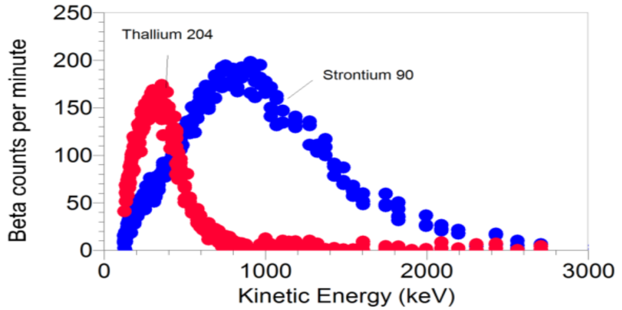
To understand their movement a reliable geologic model is needed to integrate all measurements.

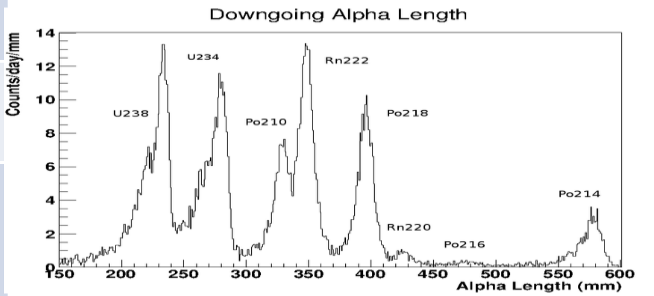
Similar we have to proceed with holistic environment measurements

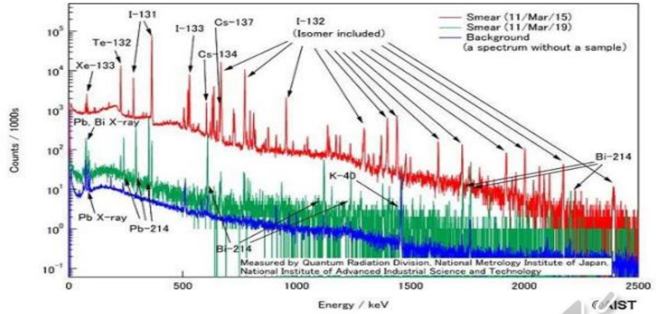
Measuring contamination from “Nuclear Legacy”

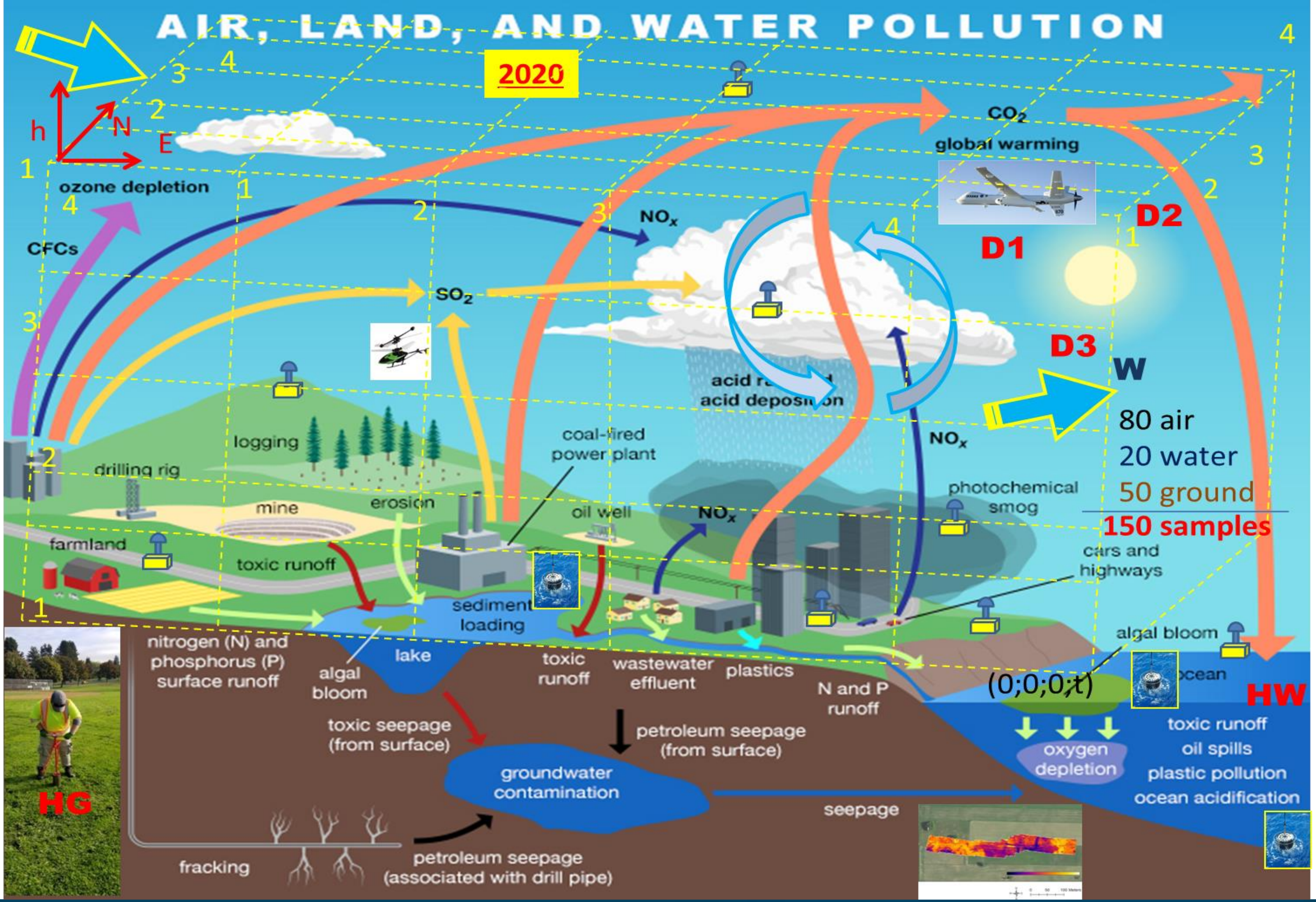
Strengths	Weakneses
The designed method, done in part on random basis exposed this inconvenient problem. Used and tested the functionality of various installations configurations and test protocols. Measuring the radioactivity and isotope composition in terrain. Identify the weakness and take corrective actions	No suitable equipment for the purpose – first handy – GM global radiation level monitoring systems No prior knowledge on pre-event status of radioactivity. Other technologic and financial limitations
Opportunities	**Threats**
Take lesson learned and improve equipment and protocols by innovating. Possibility of learning more from various encounters and failures translated in corrective actions, adaptation for the next event. Understand nature and real value of technology	It is about disclosing inconvenient facts, the government fights to cover-up, and discloses only when caught “red-handed”. In many cases may create more discomfort than good actions.











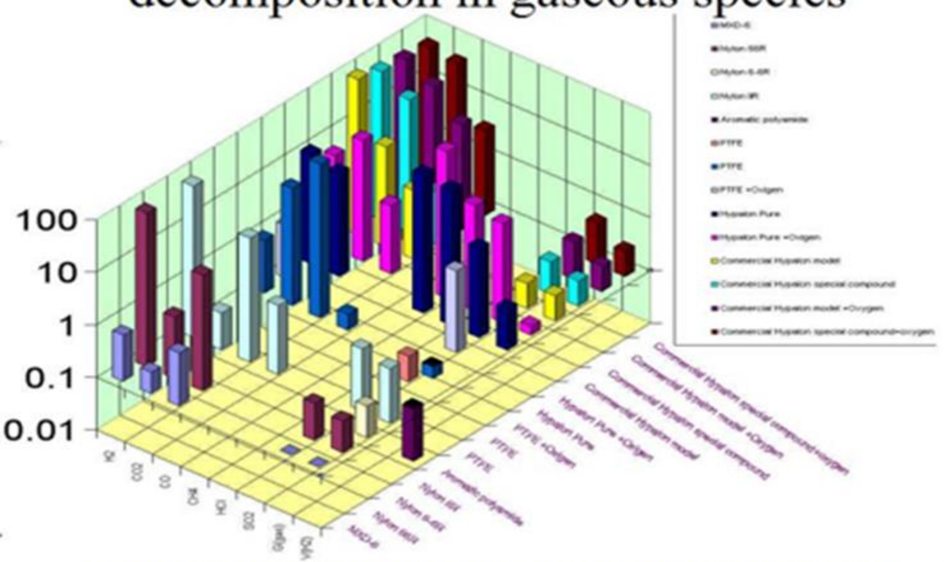
This is what might be needed to do a real time complete set of measurements in a volume of environment.

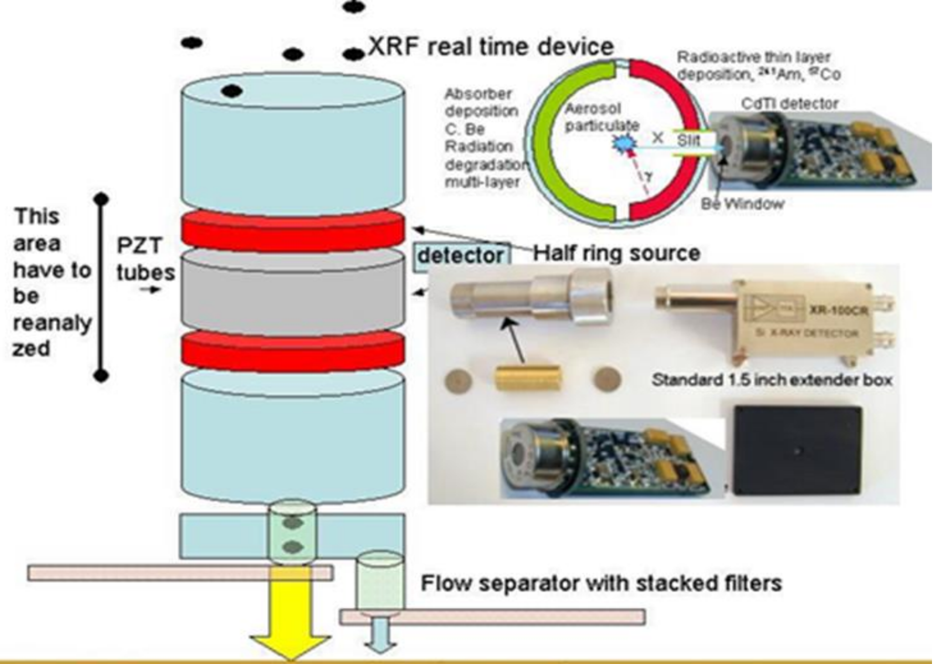
To have 1 day only of measurements it is a very costly endeavor

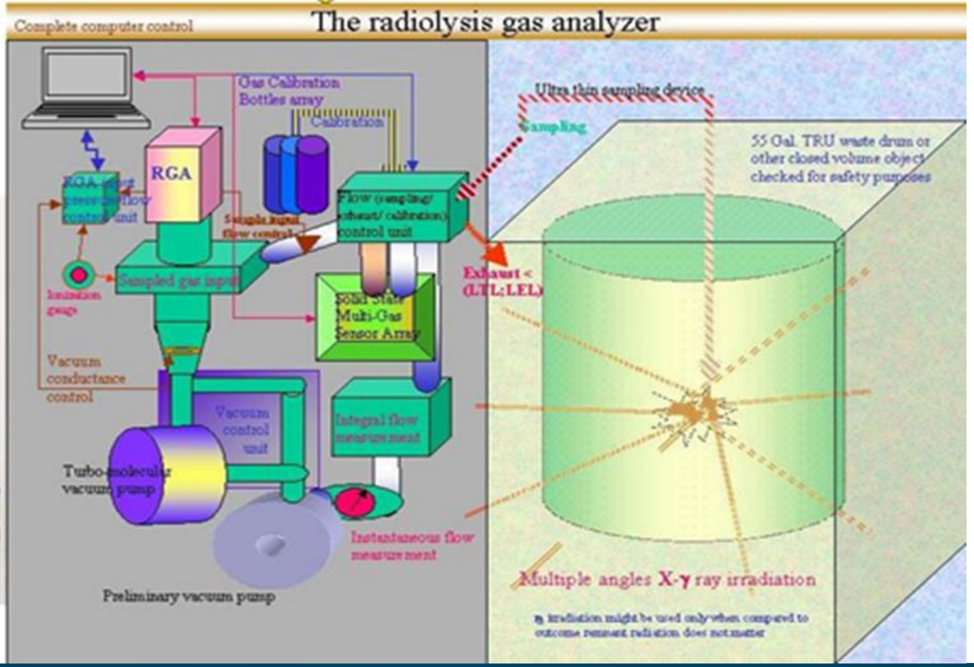
1 day is not enough to surprise all the element I action and measure their effects

The problem is: what is the value of the acquired knowledge and what is it good for; what problems may be identified and solved and what in the income and profit after these actions.

The weight factors of the various polymers decomposition in gaseous species

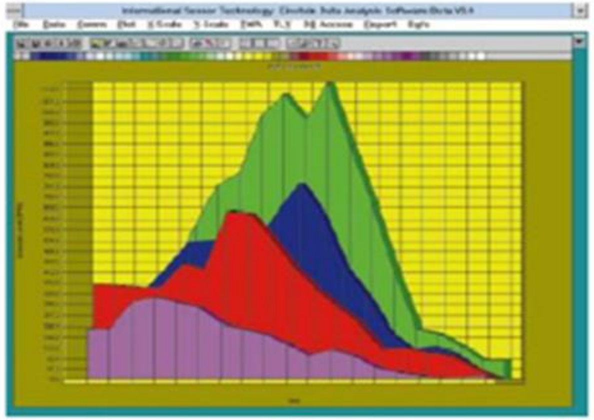






Multi-gas detection unit

Determines up to 100 different gases and their evolution in 4 specialized continuous monitoring plots using solid-state sensors.



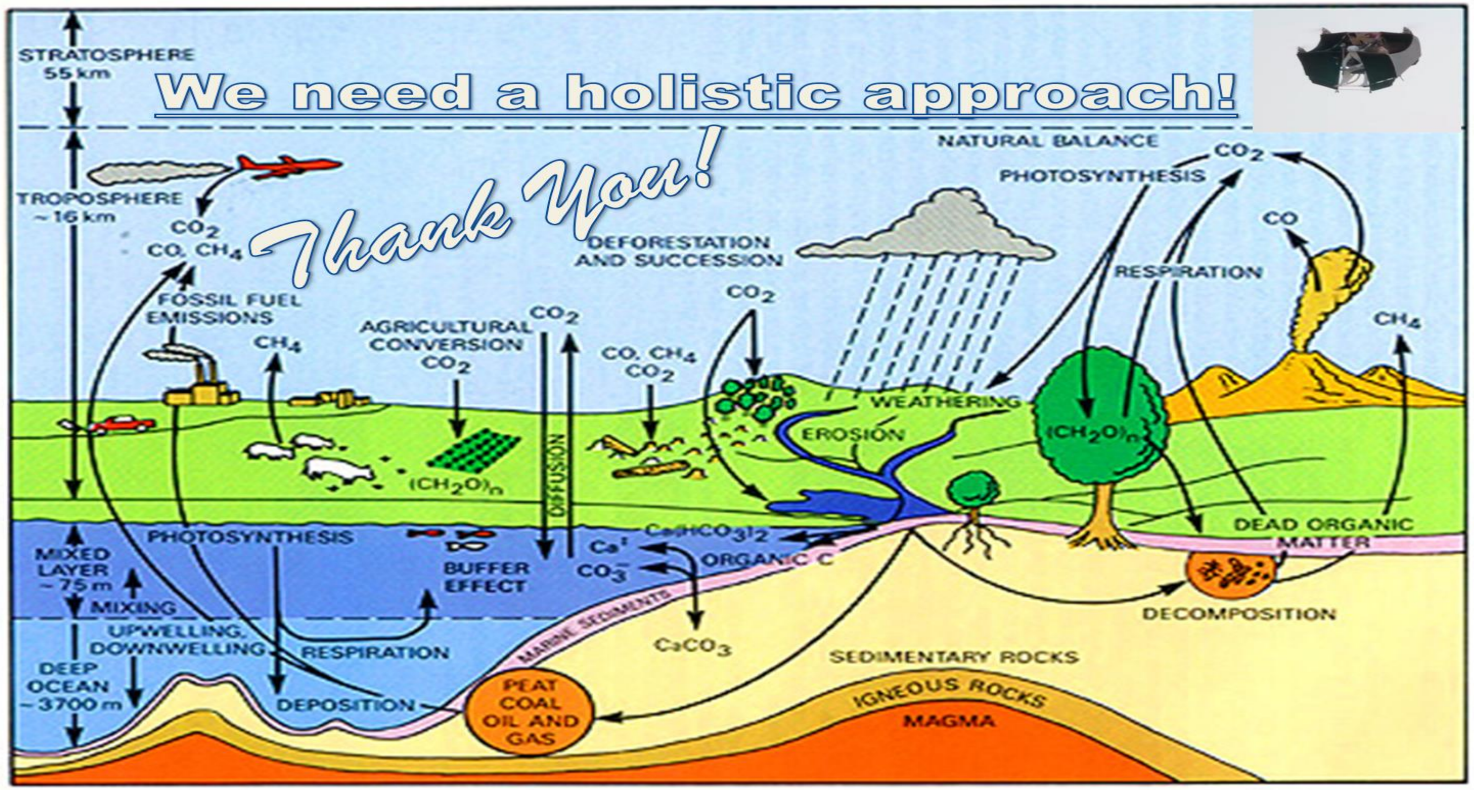
Mega-Gas and IQ-1000 are produced by IST Inc. CA.

A special environment monitoring system was conceived for anti-terrorism operation for DTRA and DHS and involves the accelerators to initiate radiolysis of various materials, as explosives to identify them inside enclosures, has a real time multi-gas detection unit, an online XRF triggered by electron beam, and online particle magnitude, and uses a special accelerator setup for micro-beam IBA.

CONCLUSIONS:

1. No. of measurements for 1 environment woxel is **150 samples** at minimum
2. Time “t” and duration dt of the measurement impacts the data quality and is determined by the number of samples taken in parallel an the rate of change of main parameters
3. The dimensions of the Environment voxel (Ev) D1; D2; D3; Hw; HG; W(h; φ; ϕ; ΔxV); H%, etc. are determined as function of complexity in Ev, and the desired quality level QL
4. The duration dt of sampling is given by the amount needed for measurement of the sample with the desired error/uncertainty of each instrument.
5. It is desired that all measurements to be done simultaneously at the same time t, but that requires at least 60 flying drones with sampling/ measurement equipment onboard.
6. Same for water and ground, where it is supposed that rate of change in ground is smaller and sequential measurements do not alter the data congruence
7. Complementary measurements has to be used in order to characterize the Ev:
    1. - Remote Spectral Imaging sys. And gas measurements by LIDAR and at air sampler
    2. - Weather data for each sampling point inside Ev and outside
    3. - Optical, chematographic and chemical analysis
    4. - Other methods available for organic mater characterization, EM fields, Power flux
    5. - Optical and electronic microscopy, particle counting, radioactivity measurements
8. The use of IBA accelerators delivering, XRF, PIXE, PIGE, AMS, CPAA, NAA, RBS and direct beam applications for radiolysis and prompt (p;γ;n) supplementary measurements.

This will deliver a complete image at a moment in time t;dt and needs to be repeated in order to get dynamics inside, and that makes a very high cost, but rewards the effort. And needs to be optimized based on pragmatic value of knowledge vs. capabilities.



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