THE DECISION SUPPORT SYSTEM LASAIR: NEW FEATURES FOR EVALUATING DIRTY BOMB SCENARIOS

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Varna, Bulgaria

Hartmut Walter, Gerhard Heinrich
Federal Office for Radiation Protection
Ingolstaedter Landstrasse 1
D - 85764 Oberschleissheim

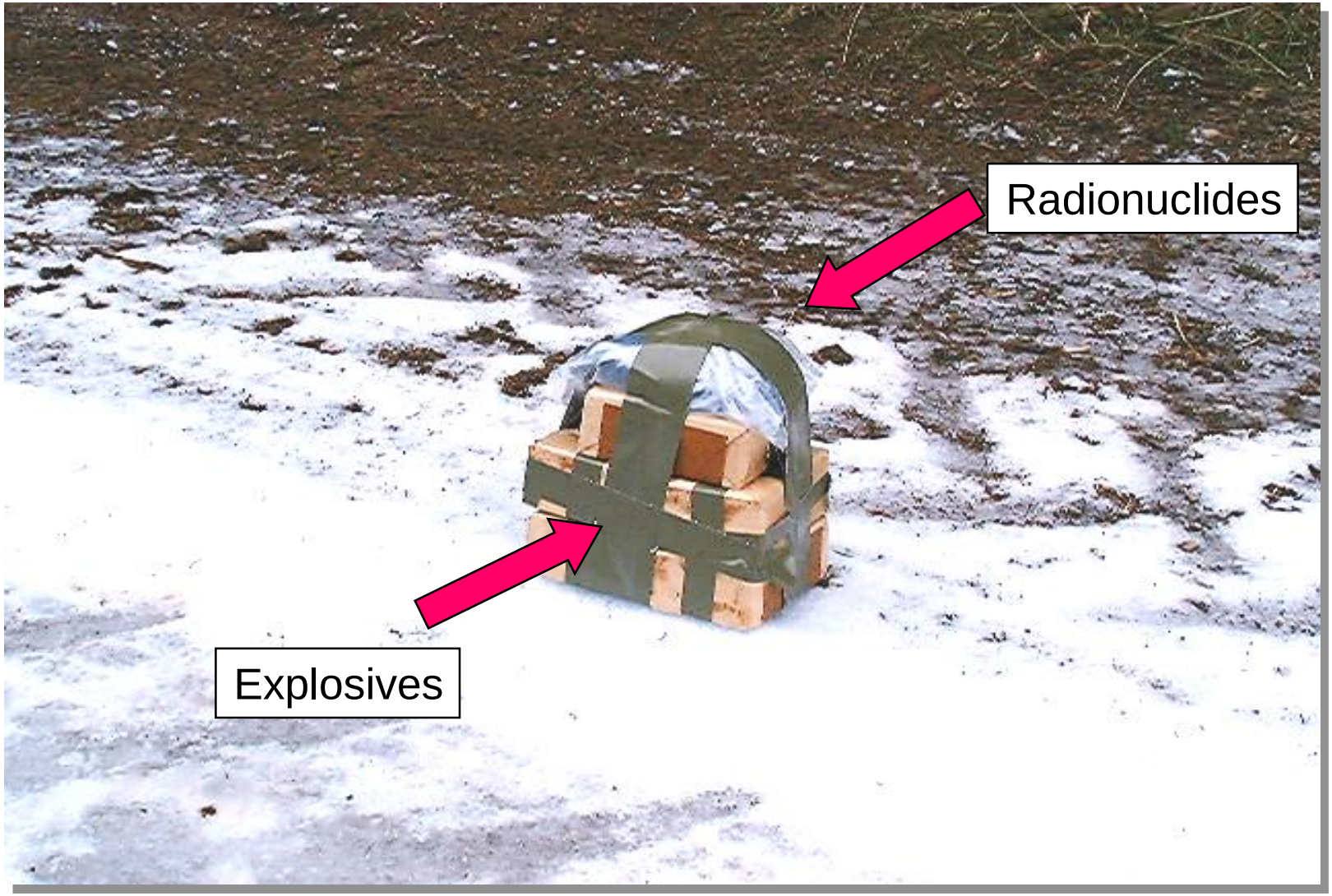
Dirty bomb, a realistic thread ?

- **What is a “dirty bomb”**

- **Thread?**
  What others say…

  Nuclear Summit The Hague, March 2014

What is a Dirty Bomb ?



Is it a thread? What others say…..

Nuclear Security Summit in The Hague, 2014

(Obama, Xi Jinping, …, Merkel,….)

58 leaders, 5000 delegates,….

Results

- **Reducing the amount of dangerous nuclear material in the world**
- **Improving the security of all nuclear material and radioactive sources**
- **Improving international cooperation**

LASAIR background:
Effects after a „dirty bomb“ explosion

public scene

dirty bomb (RDD)

radiation exposure

Questions in a „dirty bomb“ scenario

- What is the radiation exposure?
- What‘s the size of the affected area?
- How long will the radioactive cloud be in that area?
- Have people to be evacuated ?

Development of a decision support system

LASAIR

Programme system for the Lagrange-Simulation of the dispersion (*German: Ausbreitung*) and Inhalation of Radionuclides

Lagrange := meteorological mathematical procedure

LASAIR (Version 4) basic model features

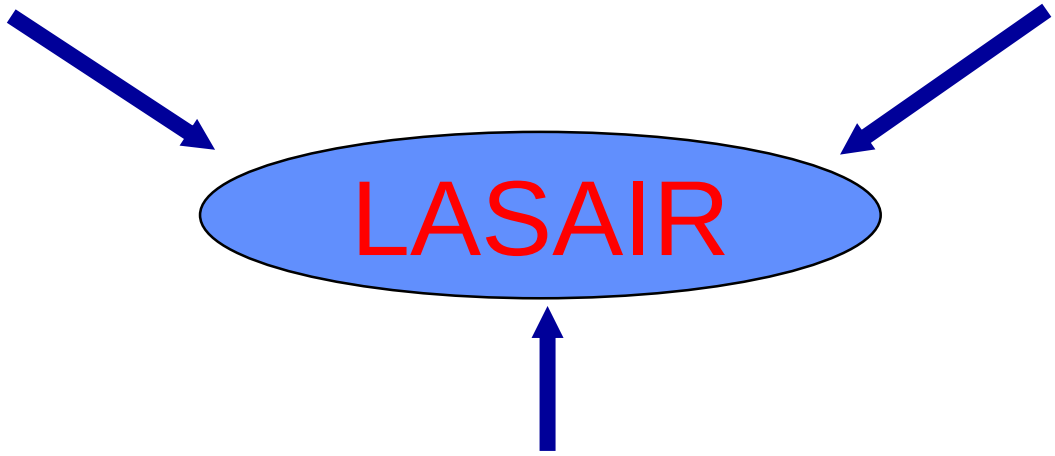
- Lagrange particle model (500.000 particles),
- simulation area 40 x 40 km^2,
- 3-dimensional flow model with orography,
- individual characterisation of topography,
- very quick response time (1 – 10 minutes).

LASAIR input

Meteorology
- **wind speed**
- **wind direction**
- **stability class**

Kind of release
- **short term release**

  or
- **continuous release**



Orography, Topography
- **individual roughness length**

LASAIR output

Radionuclides

- max. 5 radionuclides (out of 800),
- activity concentration in base layer,
- deposition on the surface,
- cloud arrival time.

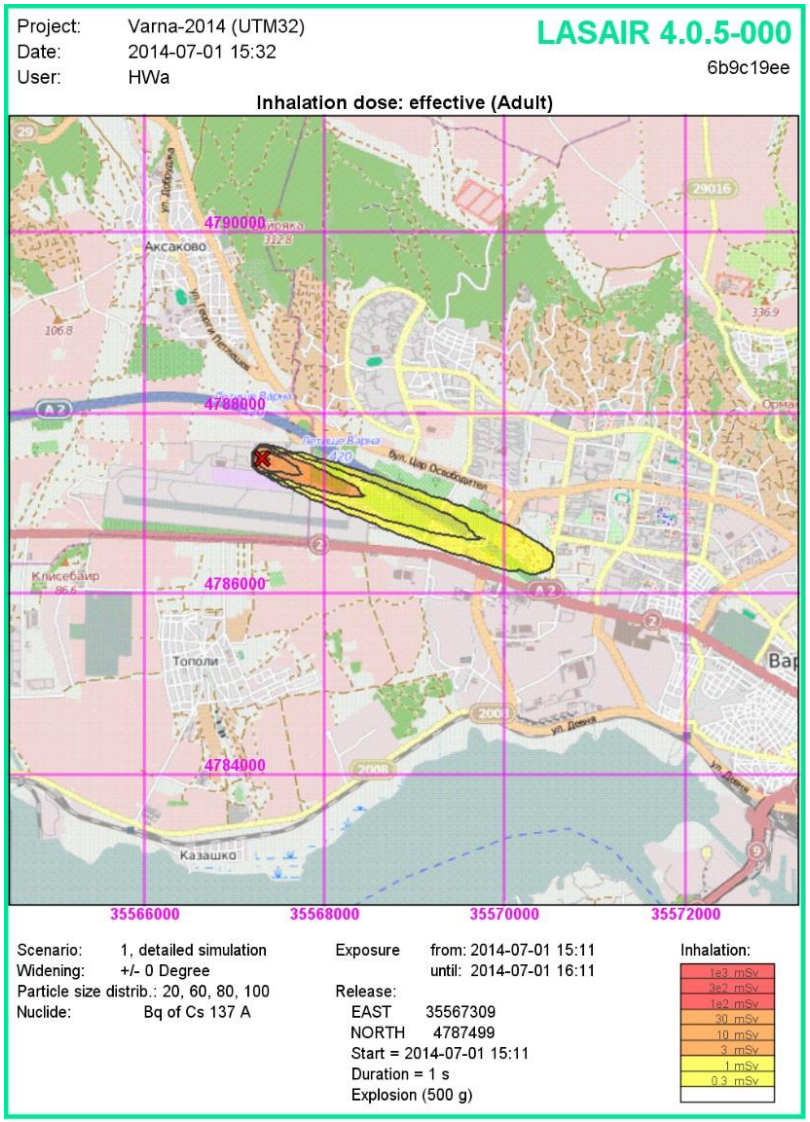
Exposure

- inhalation,
- groundshine,
- cloudshine.

Decision Support System LASAIR

- **LASAIR 4**

Example
Varna Airport



LASAIR special features and model validation

- parameterisation of the explosion cloud as initial volumina (LASAIR source term)
- consideration of spectral aerosol distribution
- validation (EMRAS*, MODARIA**, Kamenna experiments)

  * Environmental Modelling for Radiation Safety, IAEA project

  ** Modelling and Data for Radiological Impact Assessments , IAEA project

- air flow influenced from buildings or orography (Version 4)

LASAIR Harmonisation (turbulence parametrisation)

- **Harmonisation of turbulence parameterisation**

  VDI, Association of German Engineers

  Environmental meteorology –
  Turbulence parameters for dispersion models supported by measurement data

  VDI 3783, Blatt 8, 17.Vorentwurf, 2014-08-01

- **Used within Germany, but can be used elsewhere**

LASAIR Harmonisation (turbulence parametrisation)

- **Association of German Engineers**
  Turbulent Diffusion Coefficients $K_{u,v,w}$

$$K_{u,v}(z) = A_v \cdot F_{u,v} \cdot \frac{h_m}{10} \cdot \frac{\sigma_{u,v}}{f_{u,v} \cdot u_*} \cdot u(z)$$

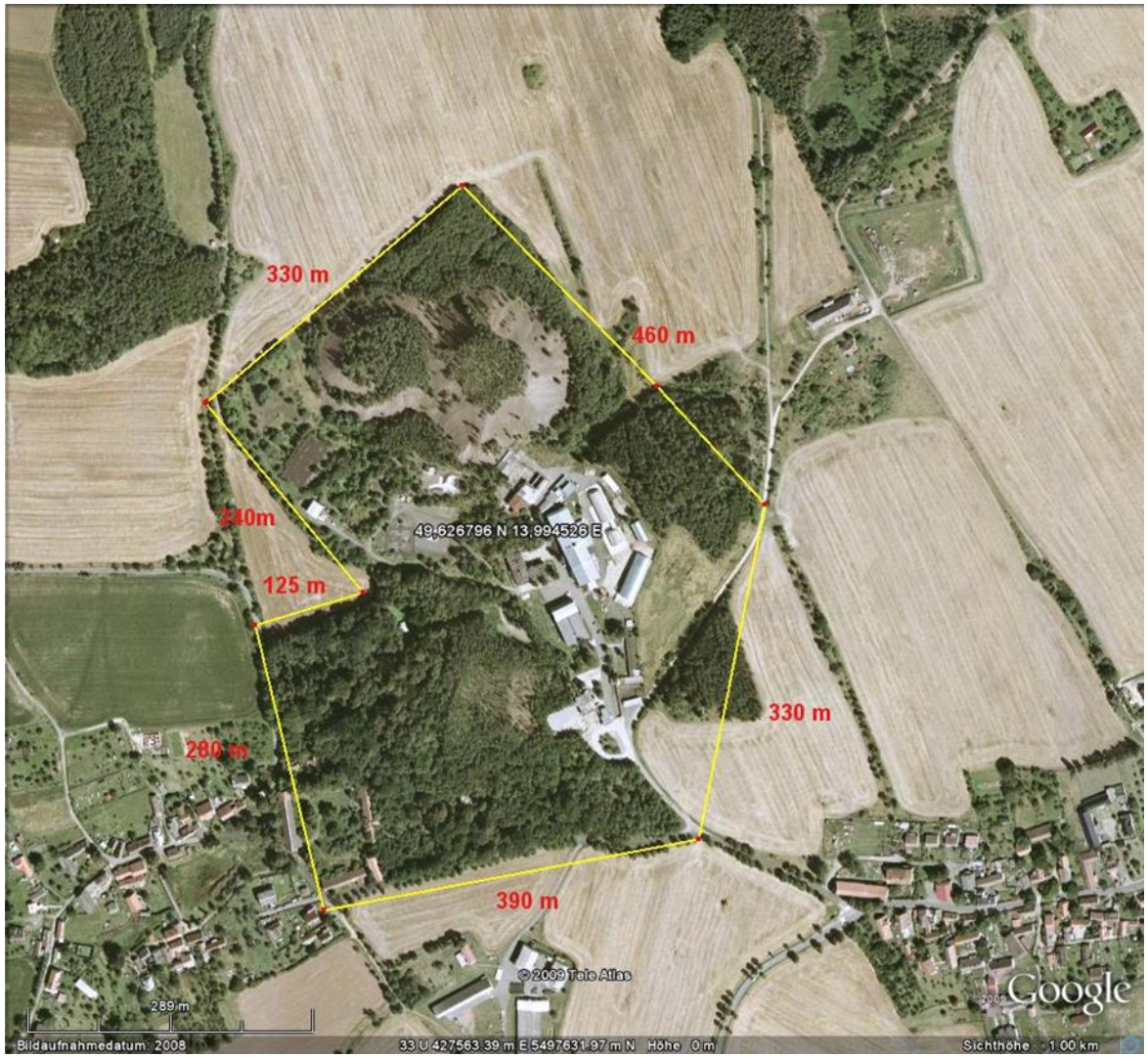
$$K_w(z) = \kappa \cdot u_* \cdot z \cdot \frac{1}{1 + p_s \cdot z / L_M} \cdot e^{-6\alpha z / h_m}$$

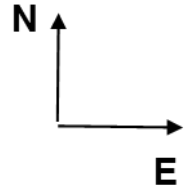
$$K_w(z) = \kappa \cdot u_* \cdot z \cdot \left(e^{-12\alpha z / h_m} + p_1 \cdot \left(\frac{-z}{L_M} \right) \cdot \left(1 - \frac{z}{h_m} \right)^4 \right)^{1/2}$$

Lit.: VDI 3783, Blatt 8, 17.Vorentwurf, 2014-08-01, to be published in 2015

LASAIR Verification: Kamenna experiments

- **Kamenna**





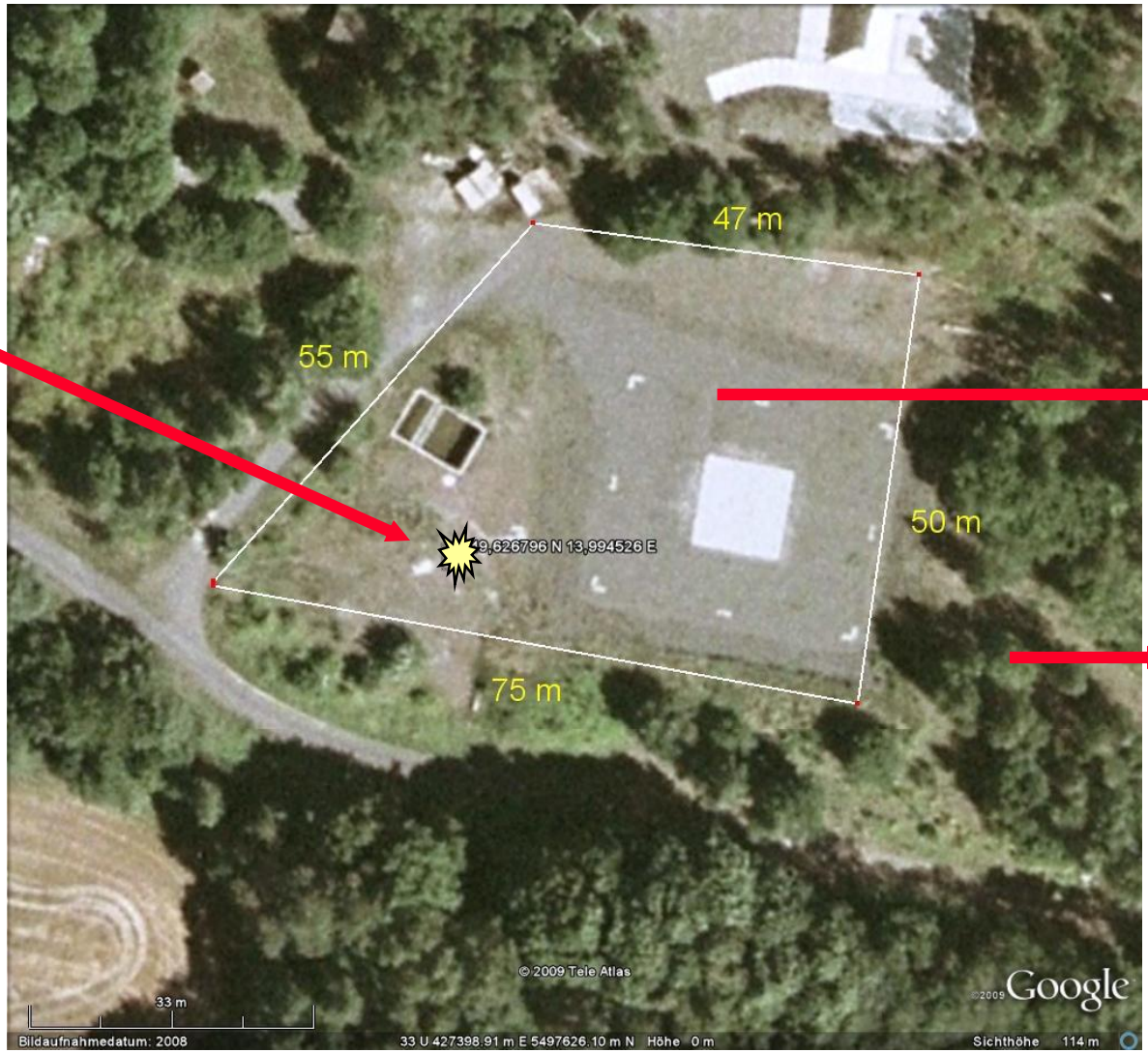
LASAIR Verification: Kamenna experiments

release position

49,626796° N

13,994526° E

(explosion)



roughness length

3 areas

z_0 = 0,1 m
(center and far vicinity)

z_0 = 1,0 m
(trees in close vicinity)

z_0 = 1,5 m
(obstacles [bus])

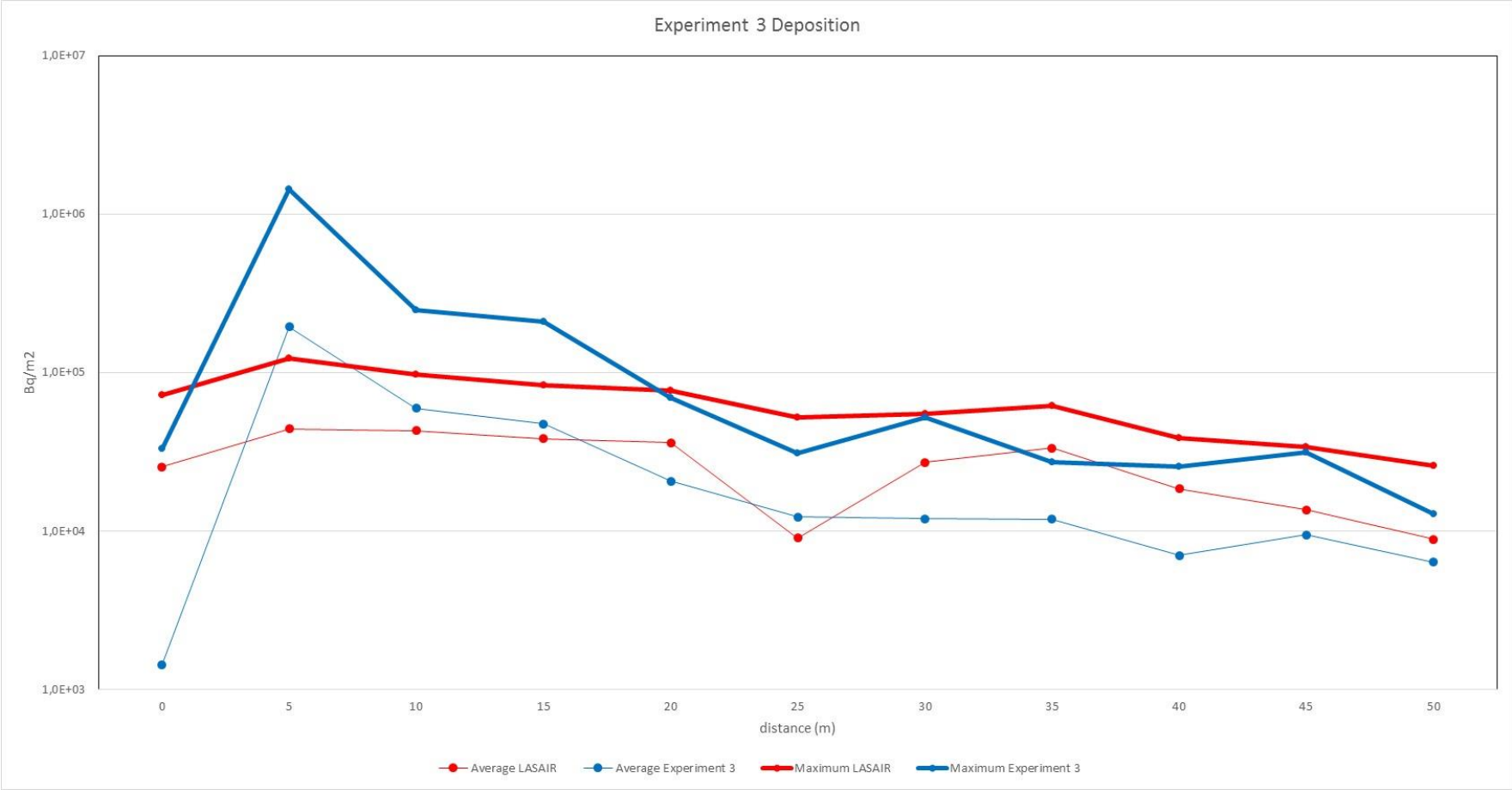
LASAIR Verification: Kamenna experiments (Nr. 4)

SURO, Czech Republic

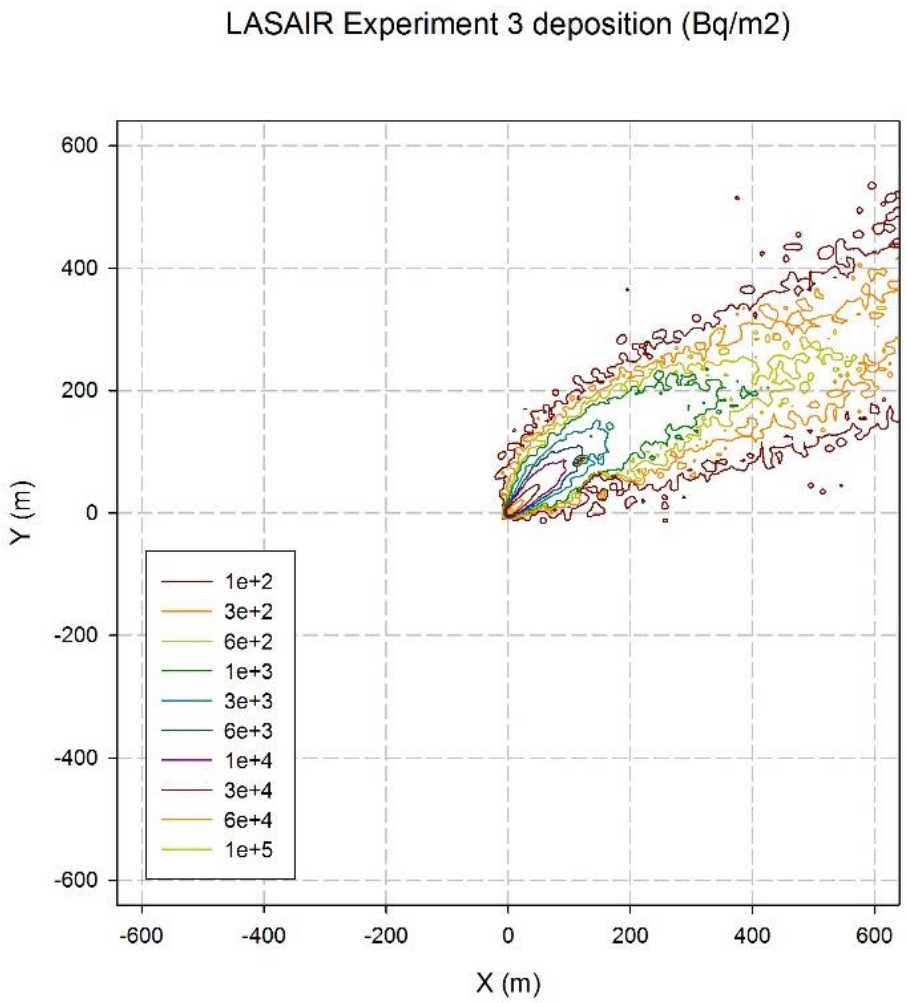
LASAIR Verification with 6 Kamenna experiments

- **Kamenna Experiment 3, good results**
- **Kamenna Experiment 4, poor results**

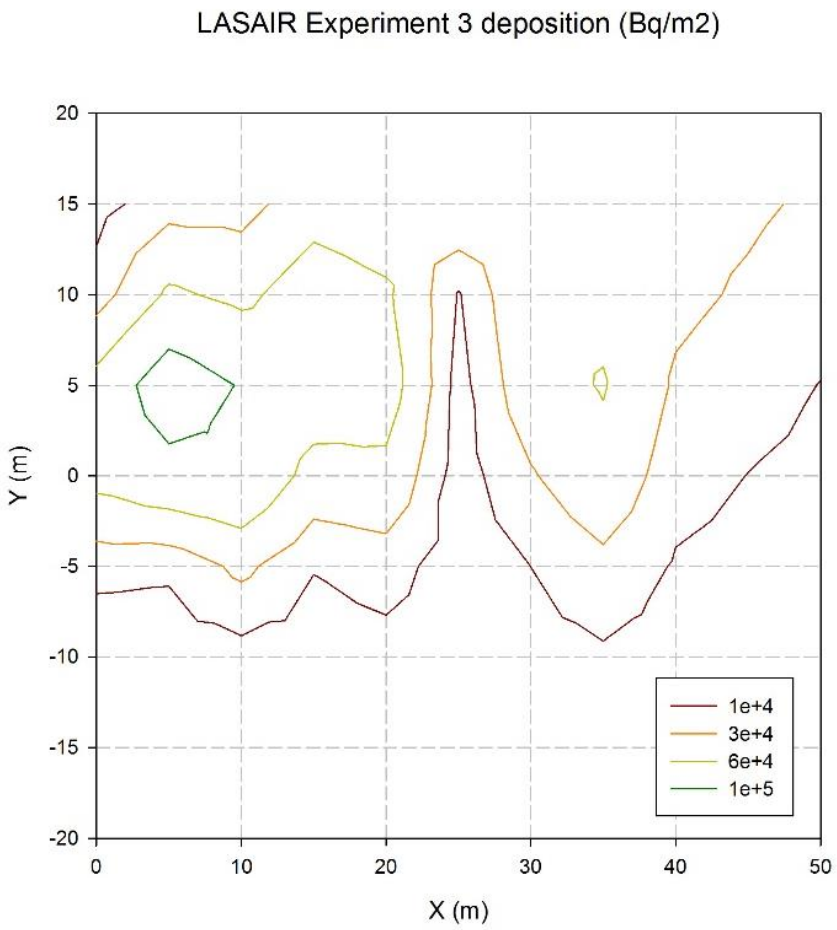
LASAIR4, Experiment 3, deposition [Bq/m^2], 0-60 min

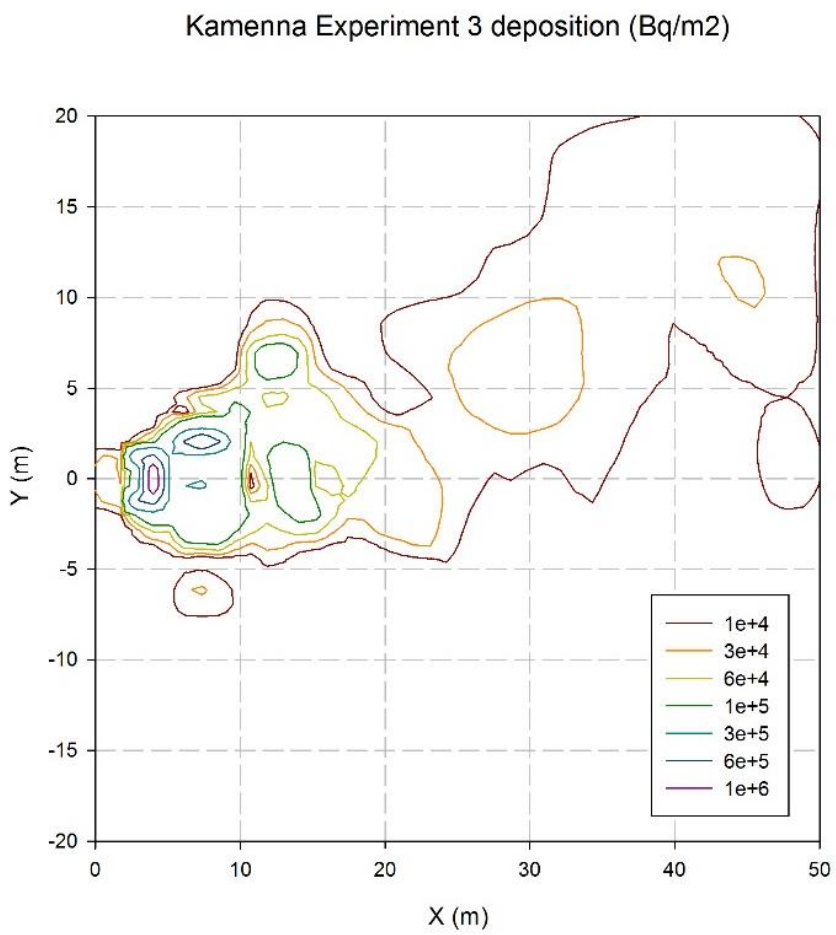


LASAIR4, Experiment 3, deposition [Bq/m^2], 0-60 min



LASAIR4, Experiment 3, deposition [Bq/m^2], 0-60 min





LASAIR Verification Kamenna experiments

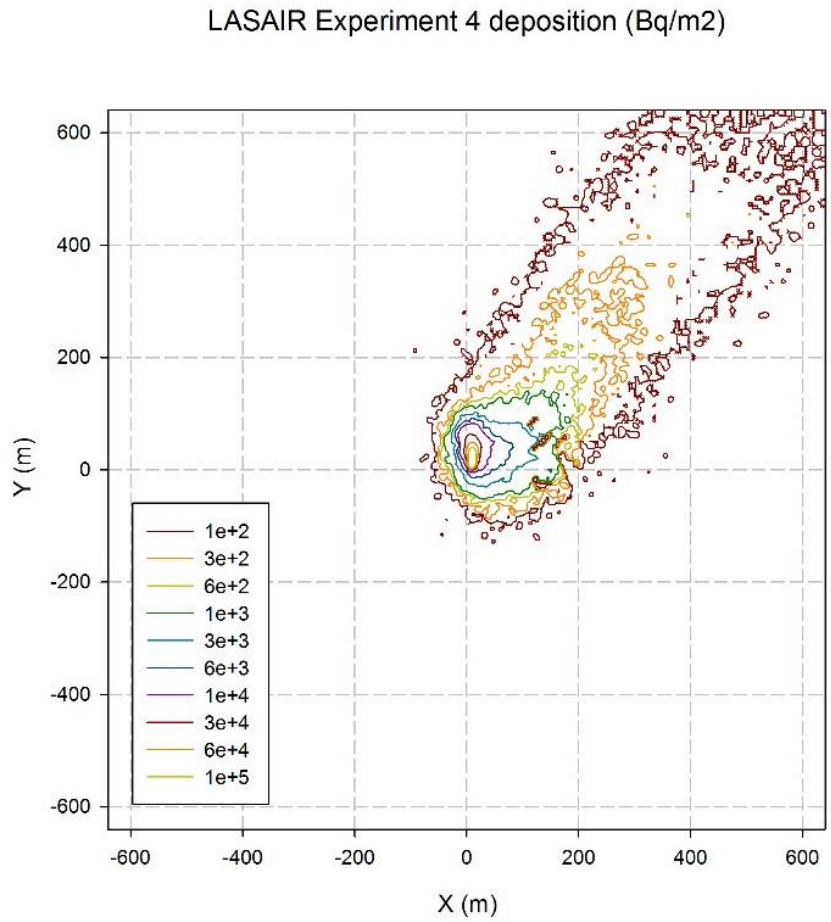
- **Kamenna Experiment 4, poor results**

LASAIR4, Experiment 4, deposition [Bq/m²], 0-60 min

Jet

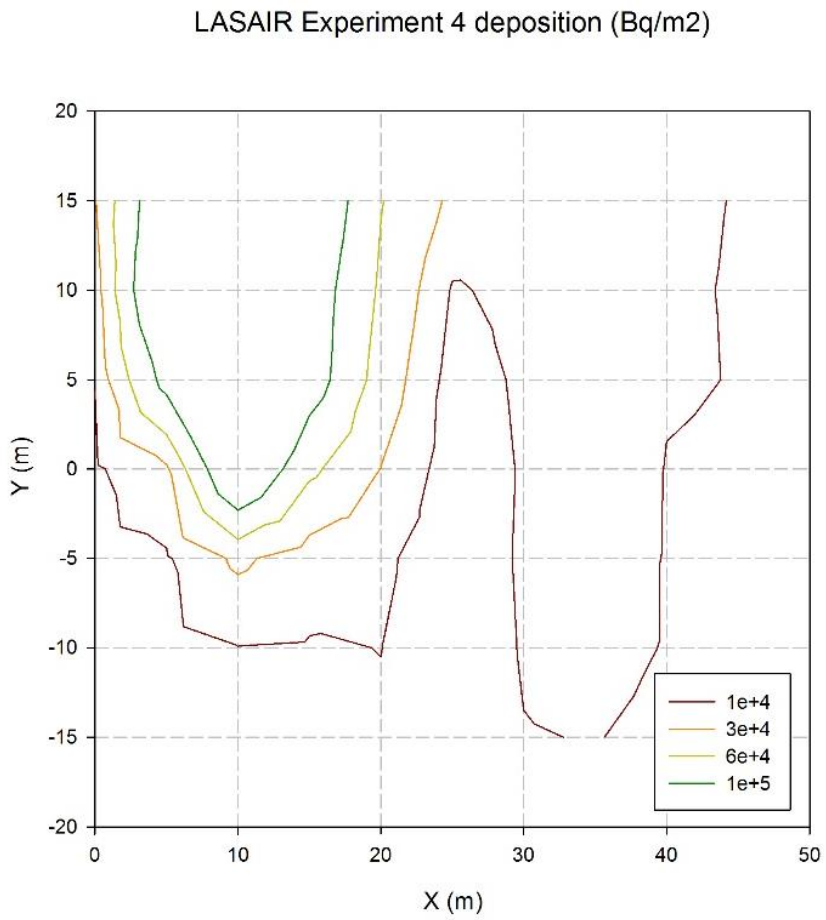
LASAIR4, Experiment 4, deposition [Bq/m^2], 0-60 min

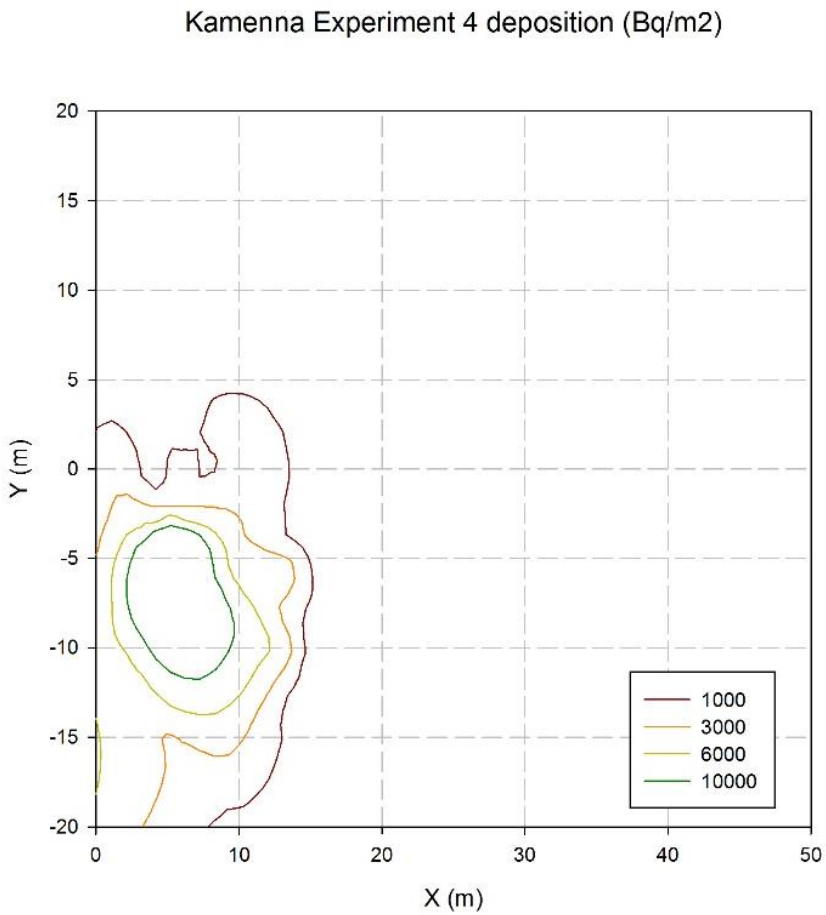
Jet



LASAIR4, Experiment 4, deposition [Bq/m^2], 0-60 min

Jet



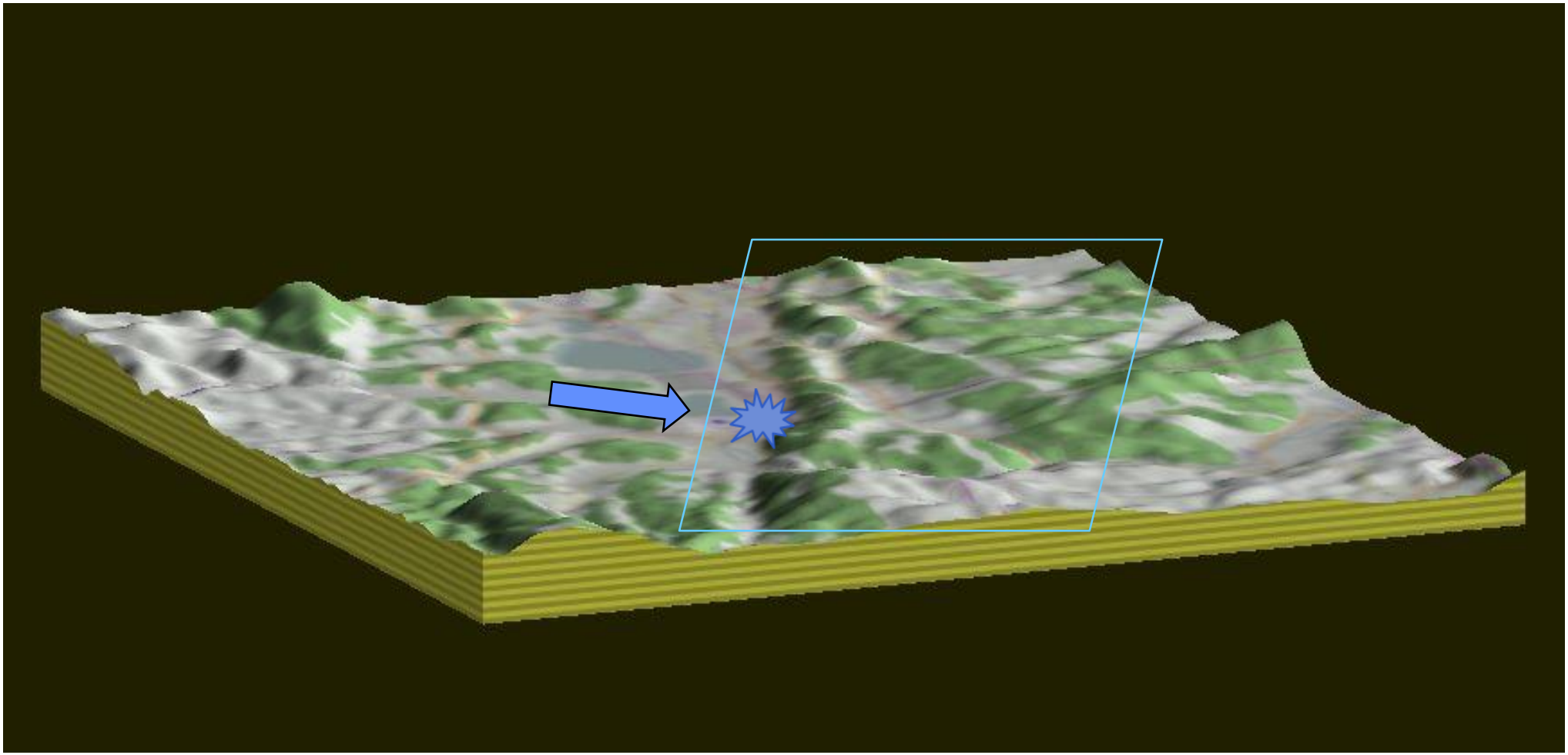


LASAIR Orography

- **Orography, example (Sostanj, Slovenia)**

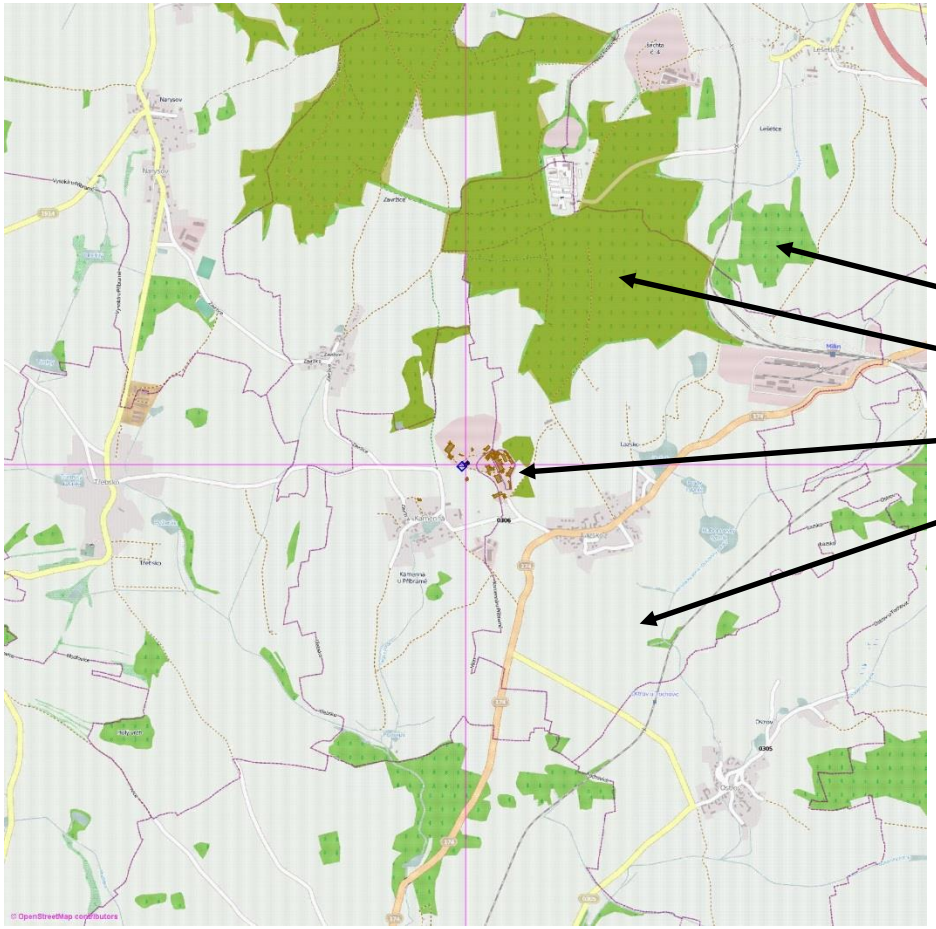
LASAIR Orography

- Orography, example (Sostanj, Slovenia)



LASAIR Topography

- **Topography characterisation**

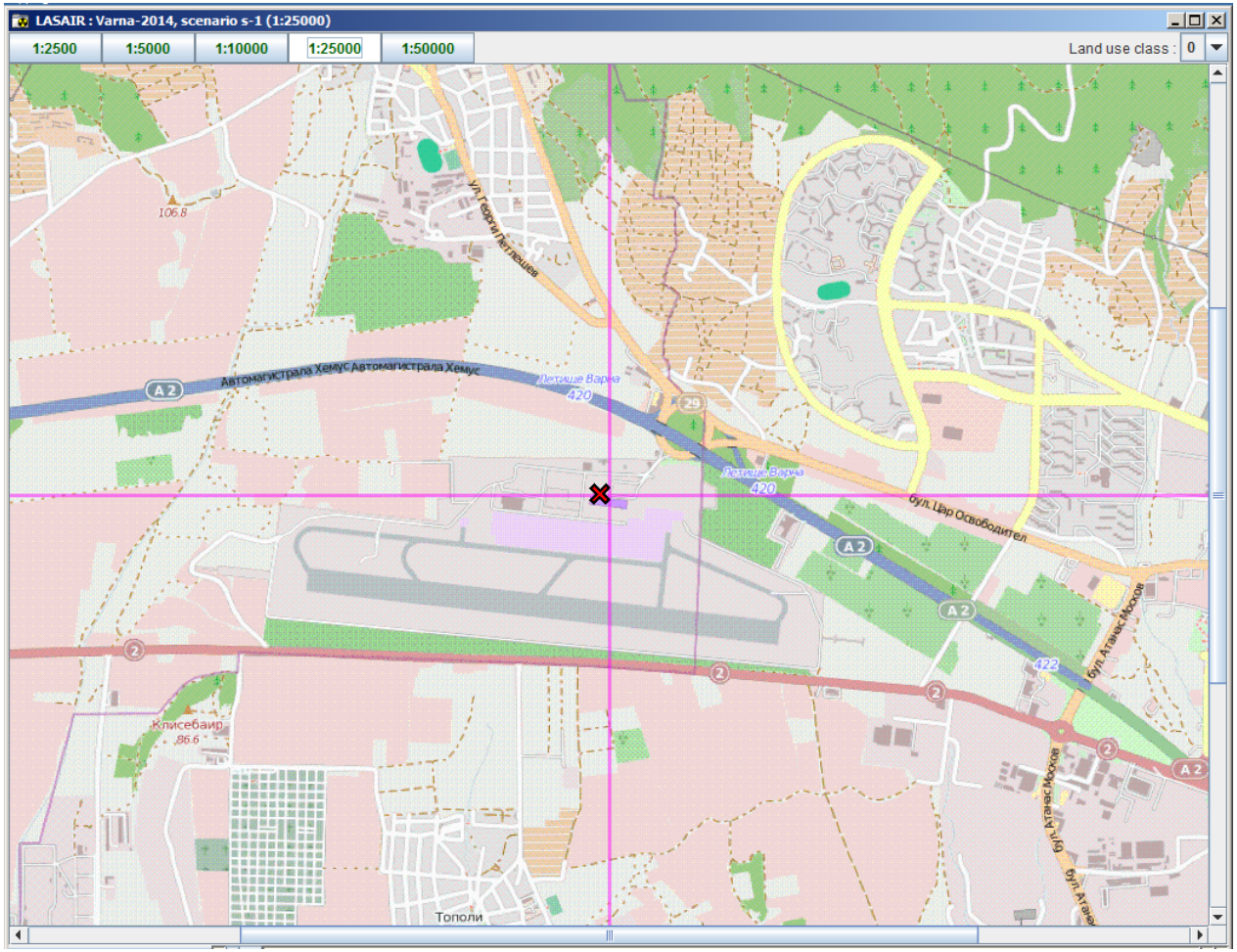


Individual definition of topography

- meadow,
- forest
- city, hamlet
- crop field

LASAIR Harmonisation with Open Street Maps

- **OSM: use world wide is possible (e.g. Varna airport)**



LASAIR Harmonisation with Open Street Maps

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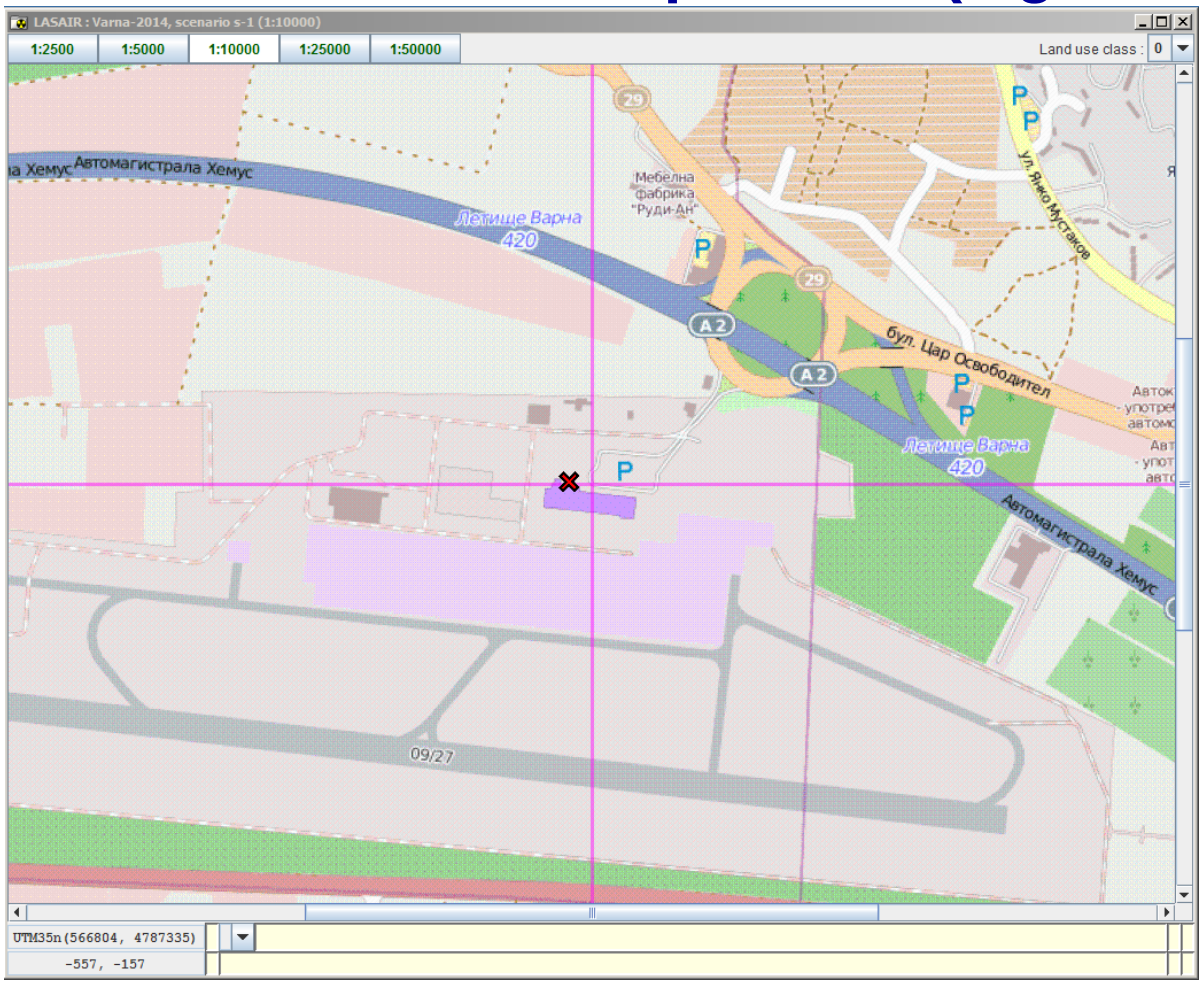
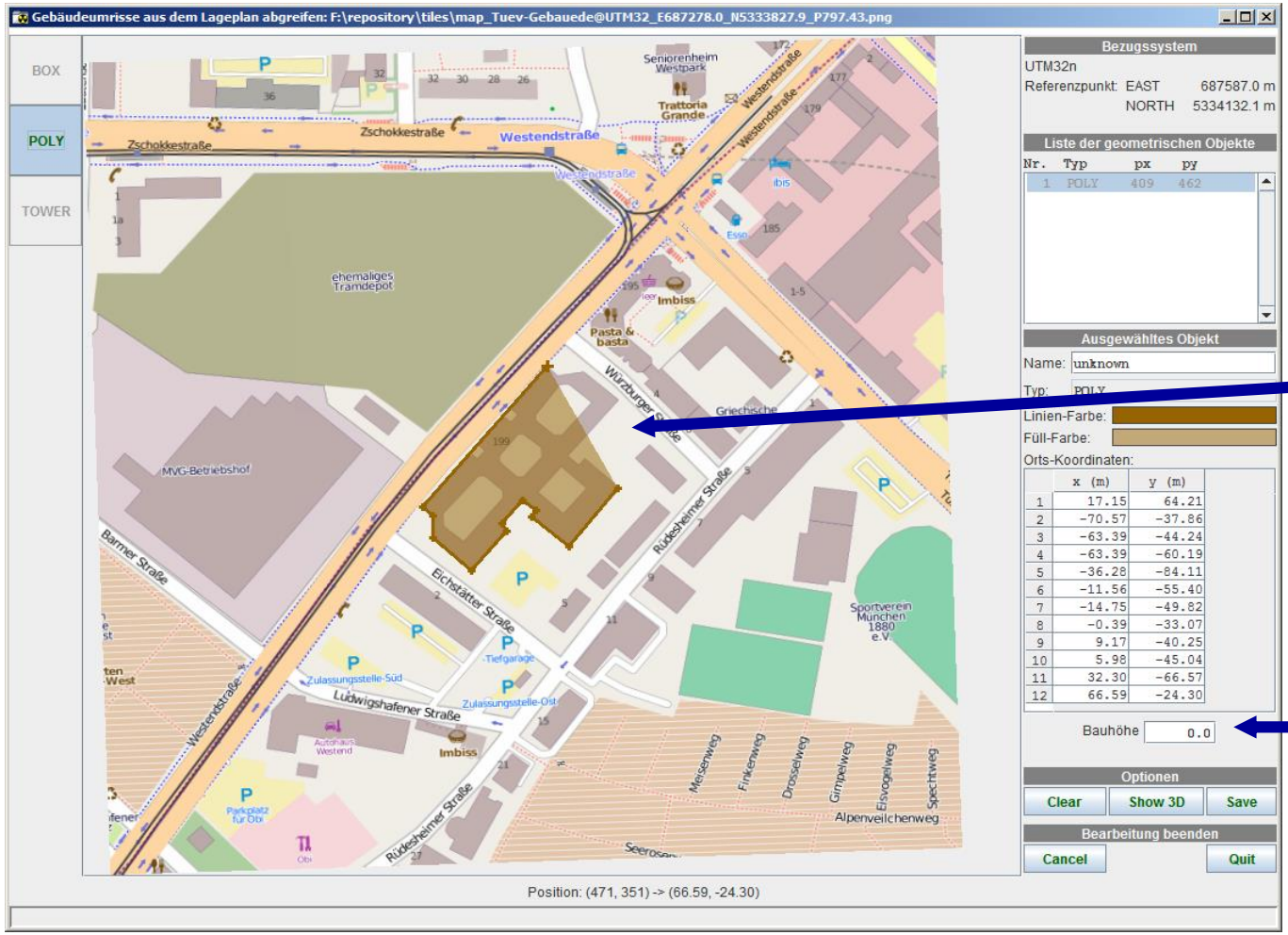


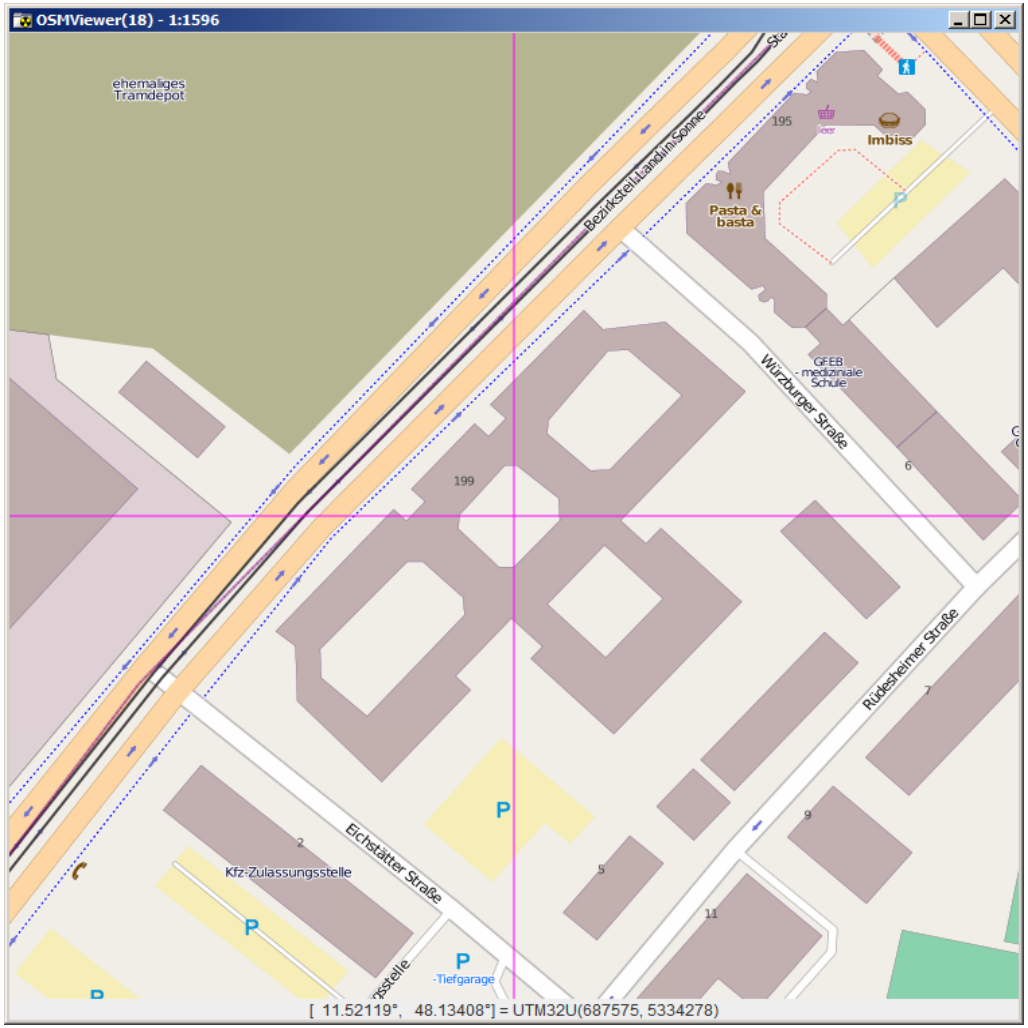
LASAIR Urban structures

- **Rapid online integration of urban structures**

LASAIR buildings, „definition“ 2 d + height

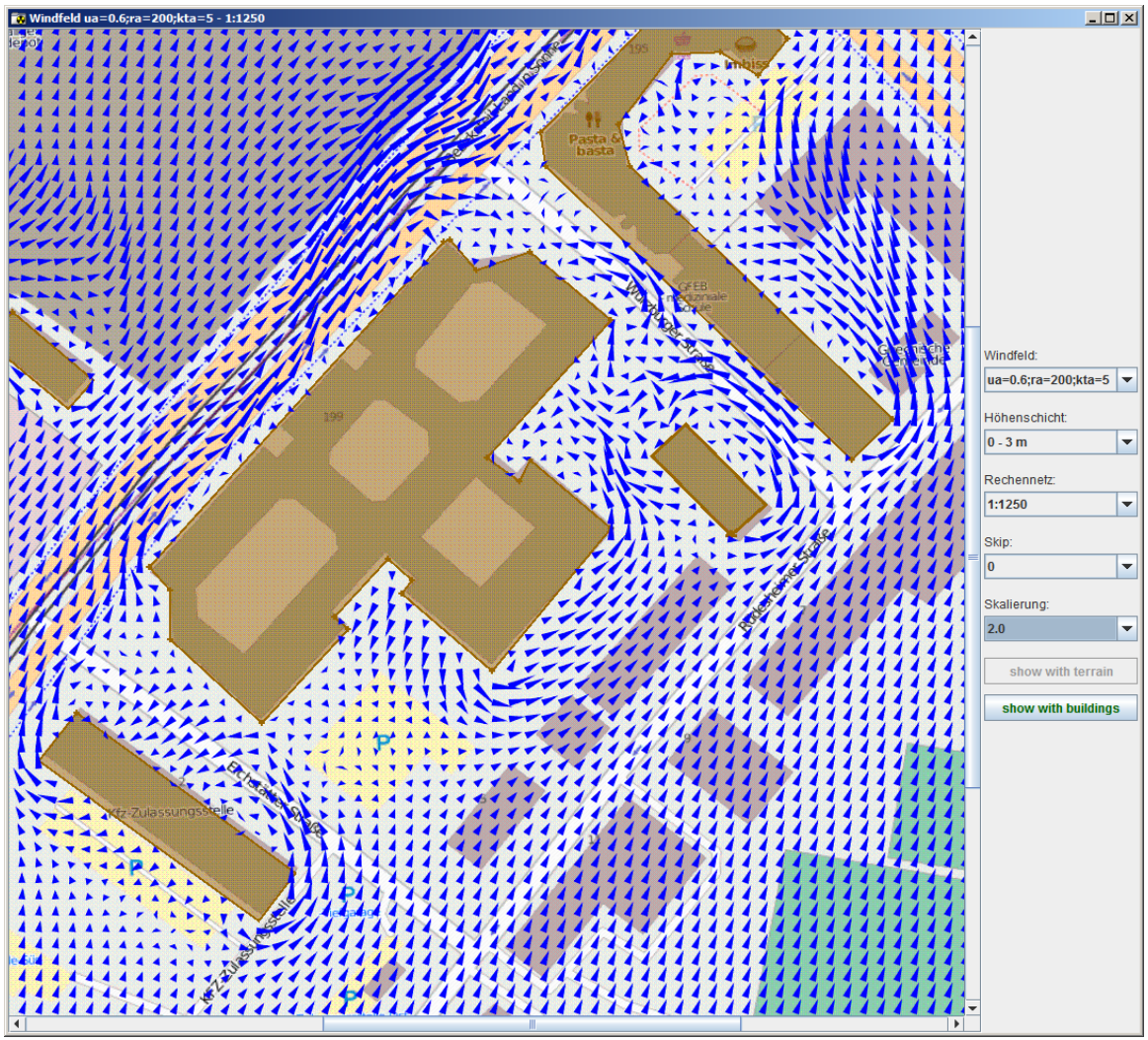


LASAIR building effects, Open Street Map, close view



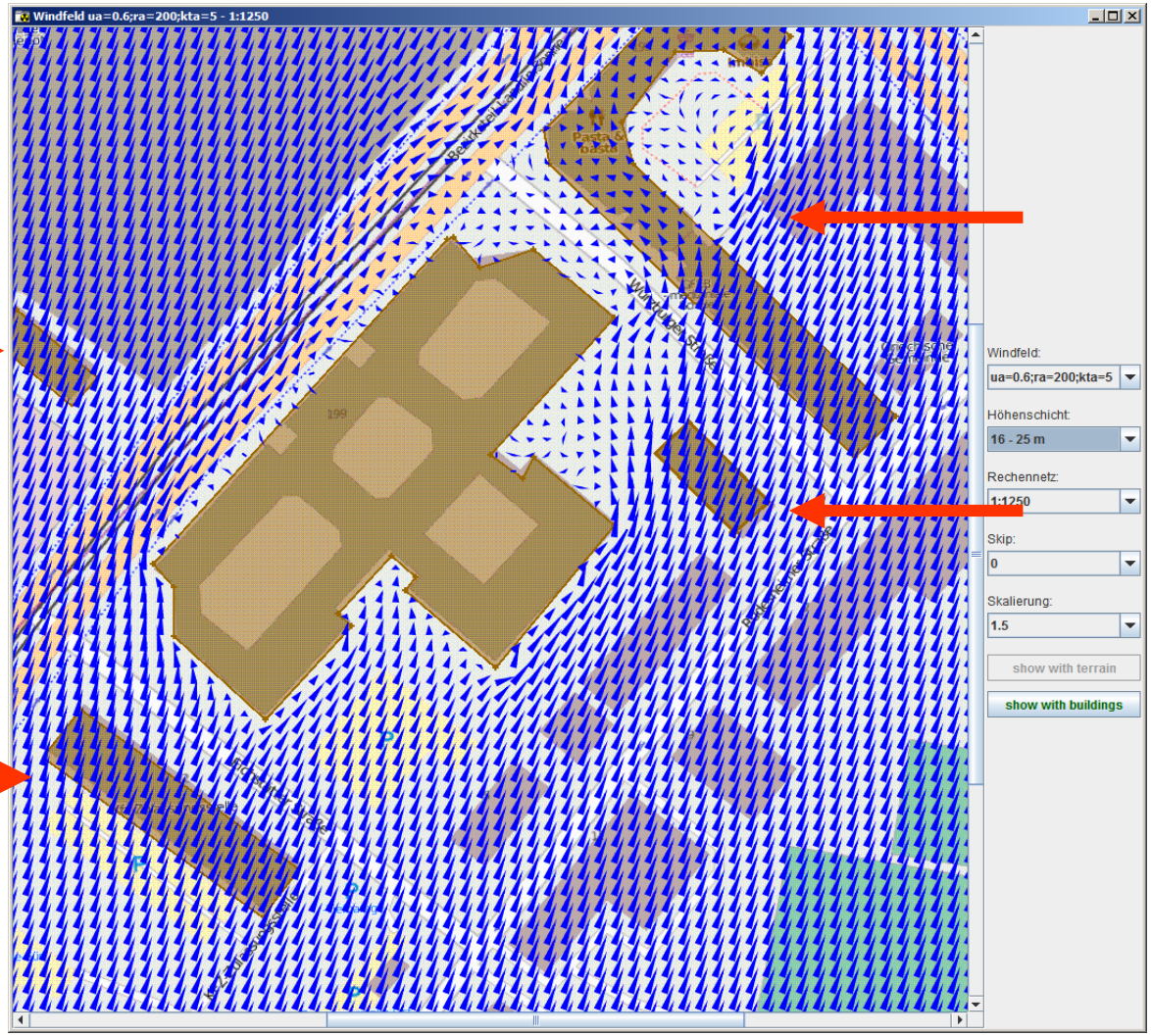
LASAIR buildings, 3 dimensional

LASAIR with buildings, windfield, surface



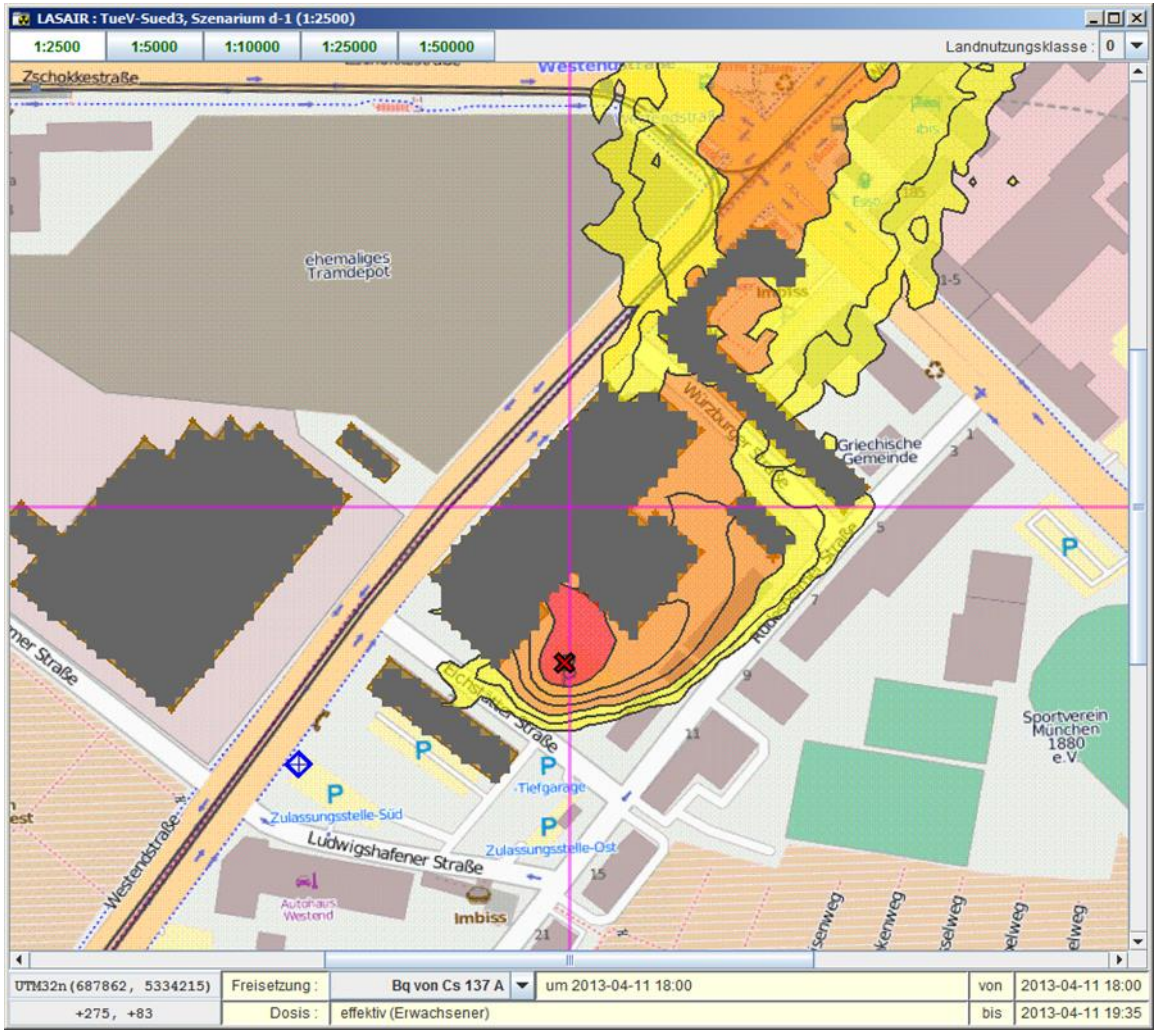
Wind direction
220°

LASAIR with buildings, windfield at building height



Wind direction
220°

LASAIR Inhalation dose



Summary

- LASAIR has proven to be quick and easy usable decision support system
- LASAIR is able to handle microscale effects (urban areas, topography, orography)
- Harmonisation process in LASAIR (past and future)
- Model validation of local scale effects within IAEA project EMRAS/MODARIA has proven good results

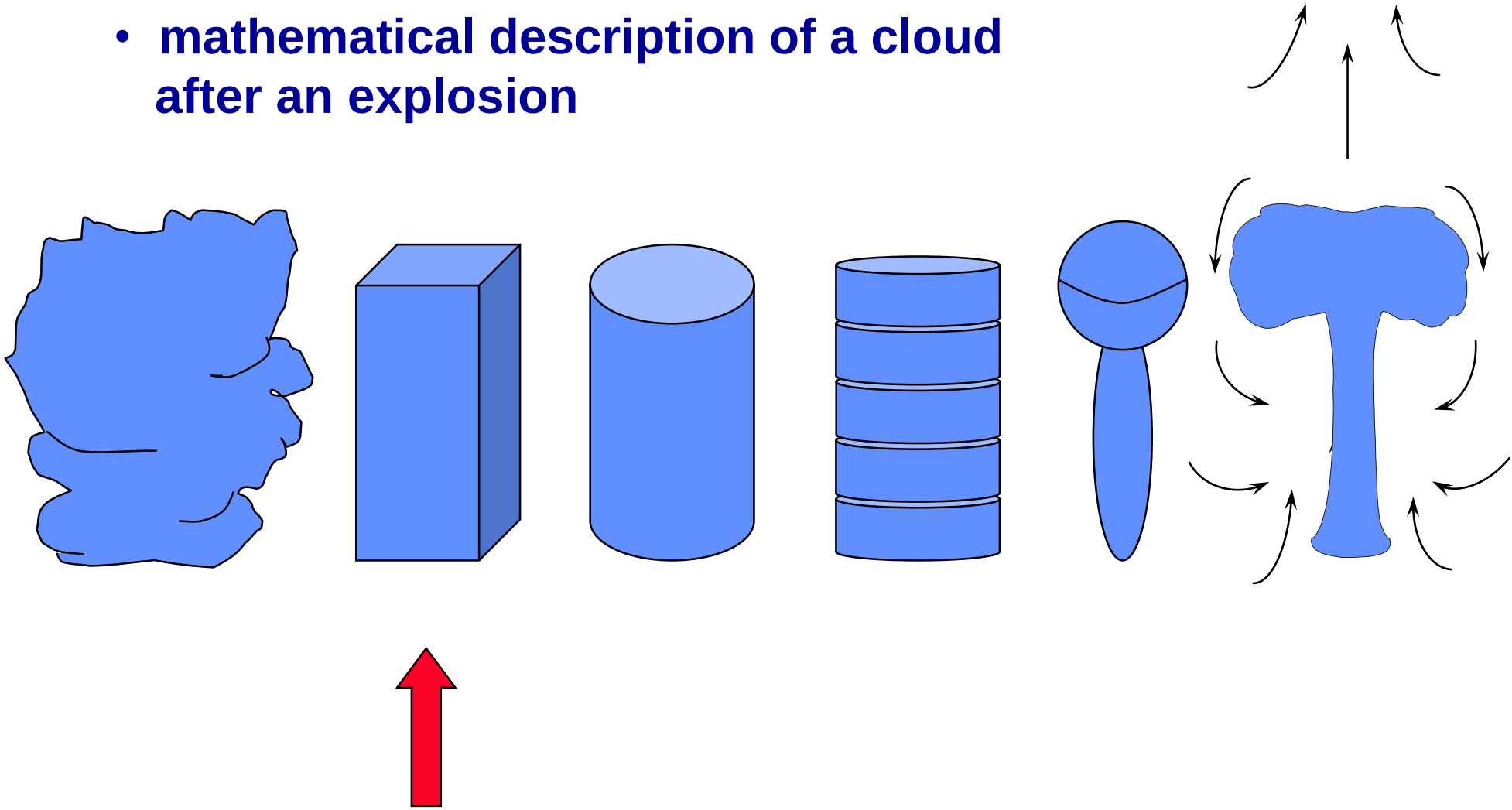
Backup

LASAIR special feature

- **parameterisation of the individual cloud as initial volumina (LASAIR source term)**

Initial cloud parametrisation

- **mathematical description of a cloud after an explosion**



German Army test site, explosives

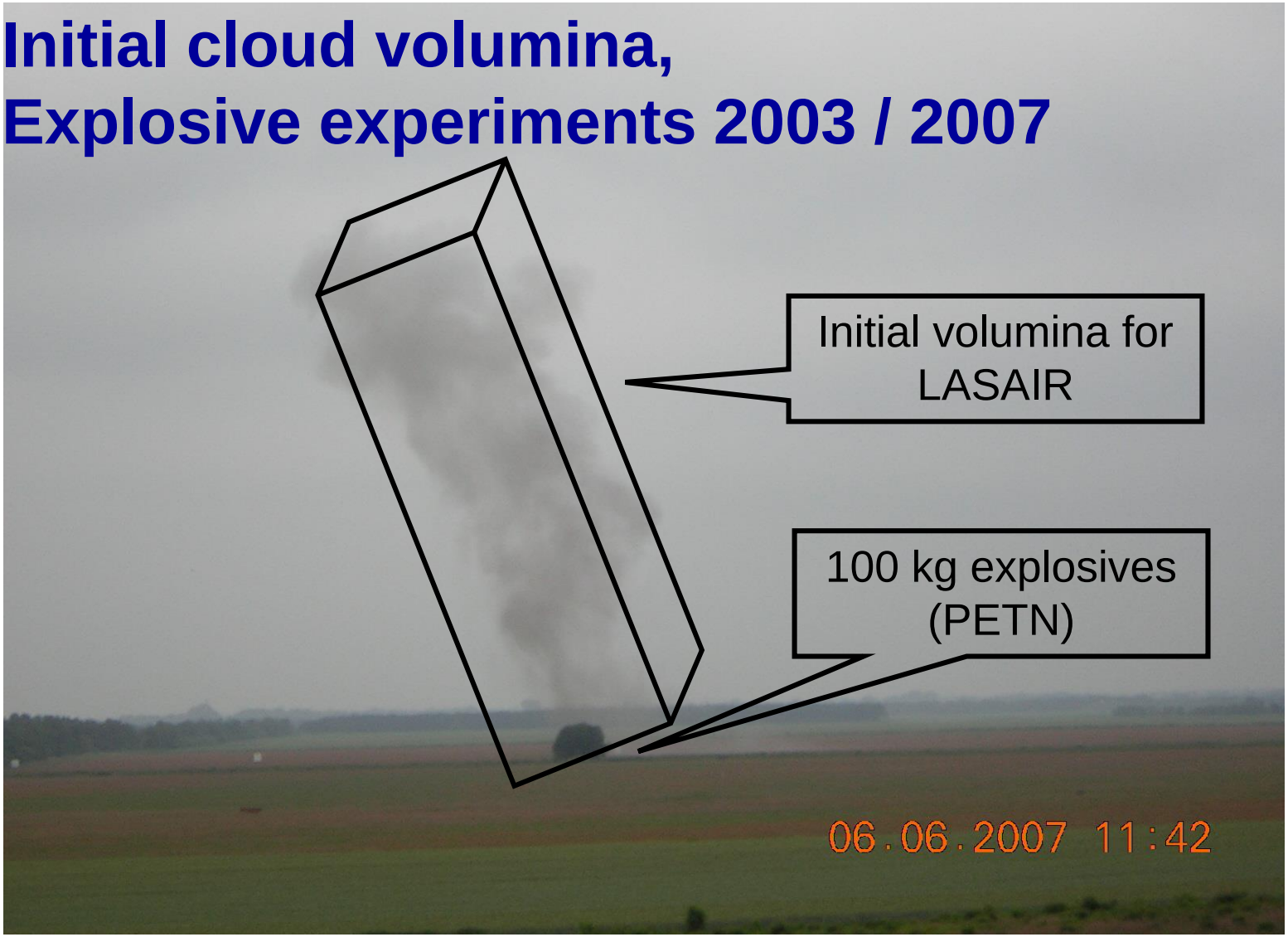
German Army test site, explosives


06.06.2007 14:30

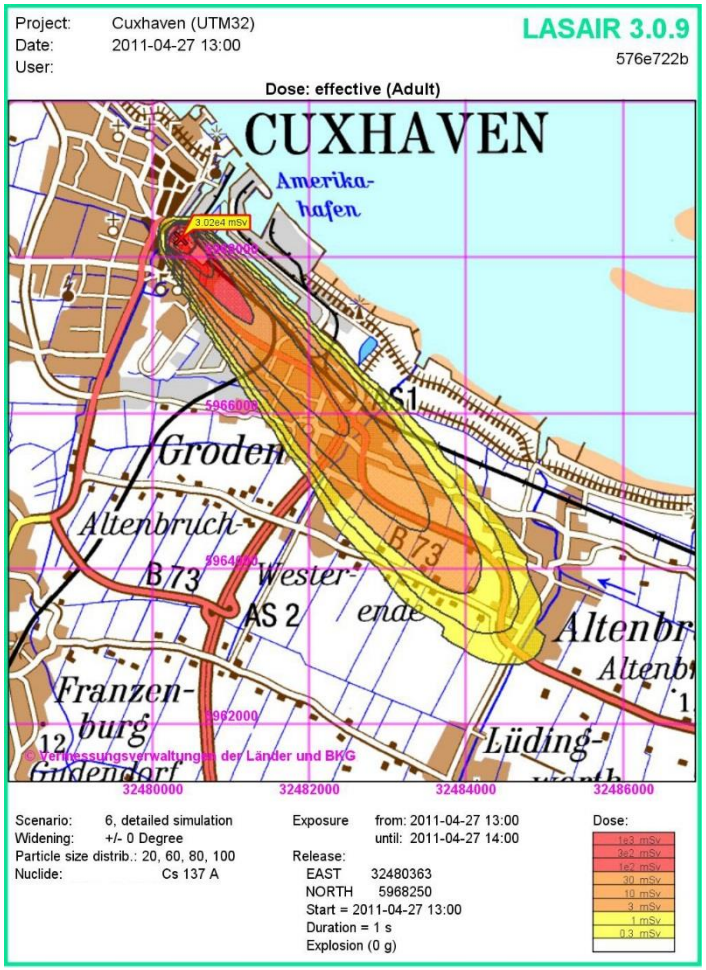
Initial cloud volumina with investigation marks

Picture: Thielen, GRS

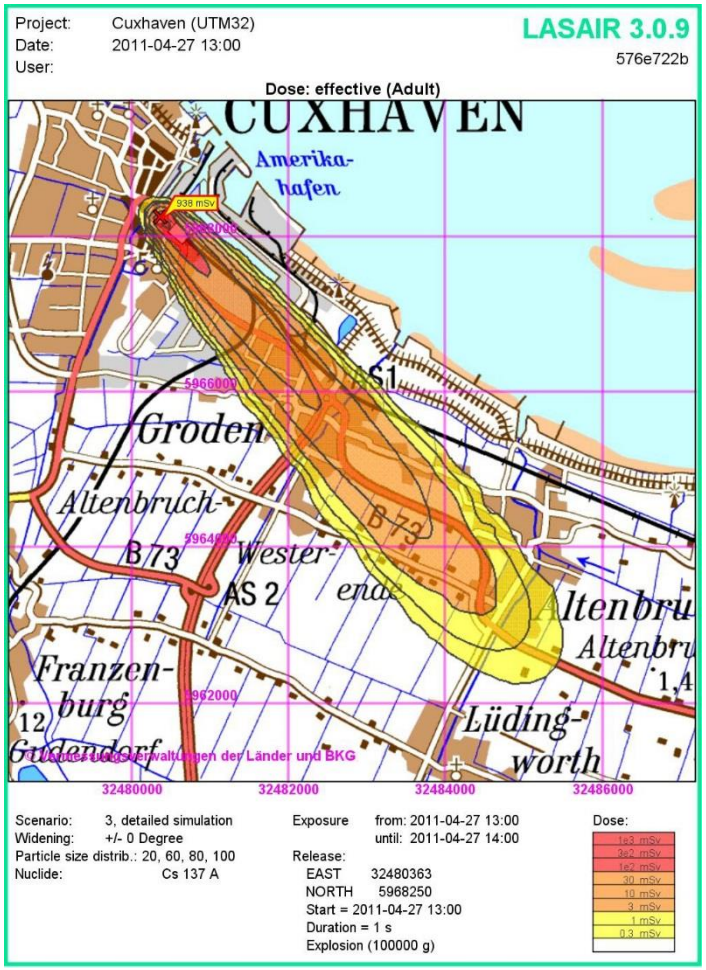
Initial cloud volumina, Explosive experiments 2003 / 2007



LASAIR Effects of different initial clouds



single point source



volume source (100 kg explosives)

Simulation
Not real !

LASAIR Effects of different initial clouds (point source – volumina source)

Difference for inhalation dose at maximum:

factor 32

LASAIR aerosol spectra

- **LASAIR standard aerosol size ranges and related deposition velocities**

Aerosol size range (µm)		Deposition velocity (10^{-4} m/s)
0 – 2,5		10
2,5 - 10		100
10 - 50		500
> 50		2000

LASAIR aerosol spectra, fraction of respirable aerosols after the explosion

Metallic samples

fraction depends on the size of the metal sample
less than 5 % is dispersed in the atmosphere

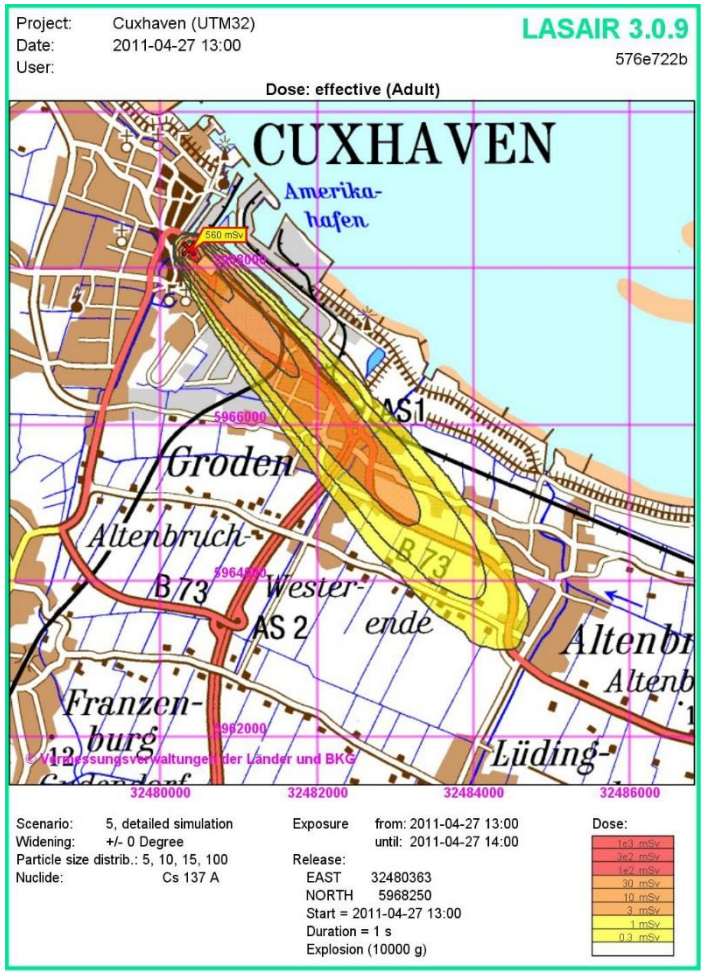
Liquids

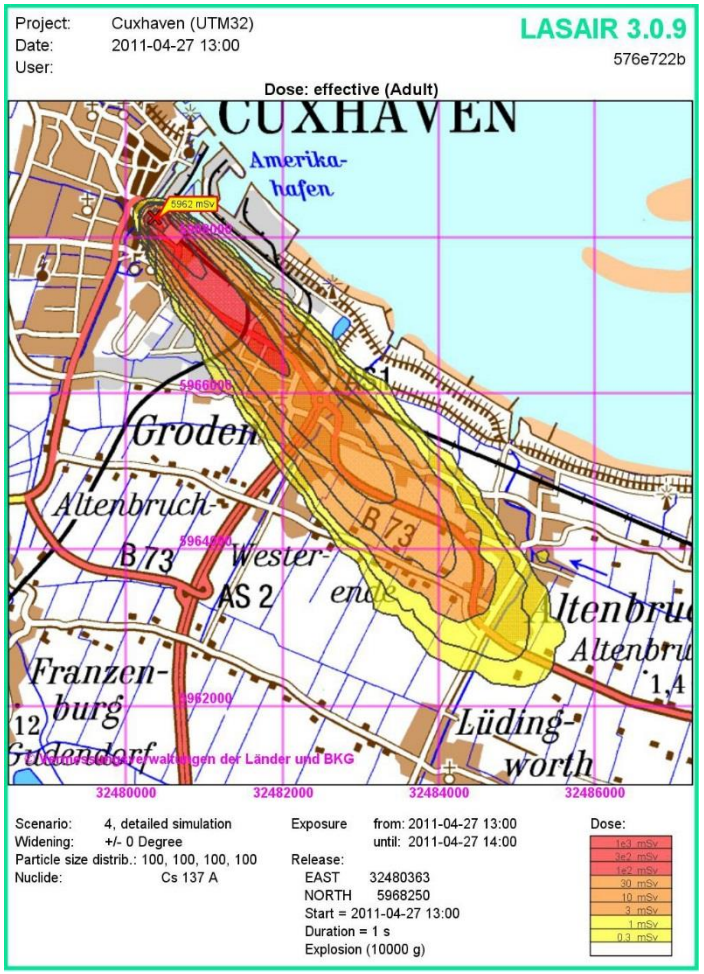
fraction differs from 10 – 50 %

Ceramics

differs between roughly 0.1 % and 50 %
depending on the compressive strength of the material

LASAIR aerosol spectra





Simulation
Not real !

Different aerosol spectra

Aerosol completely respirable

LASAIR Effects of different aerosol spectra

Difference for inhalation dose at maximum:

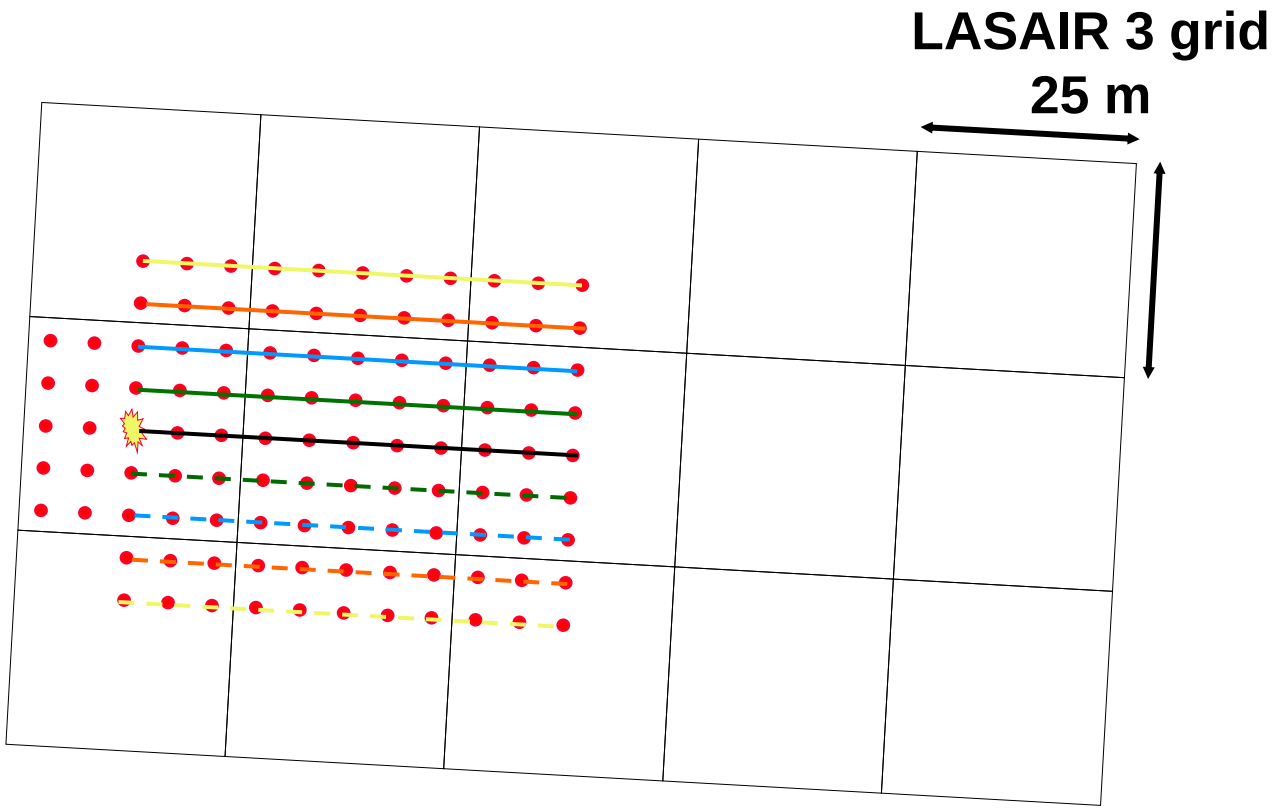
factor ≈ 11

(! But range can be wider depending on the real material !)

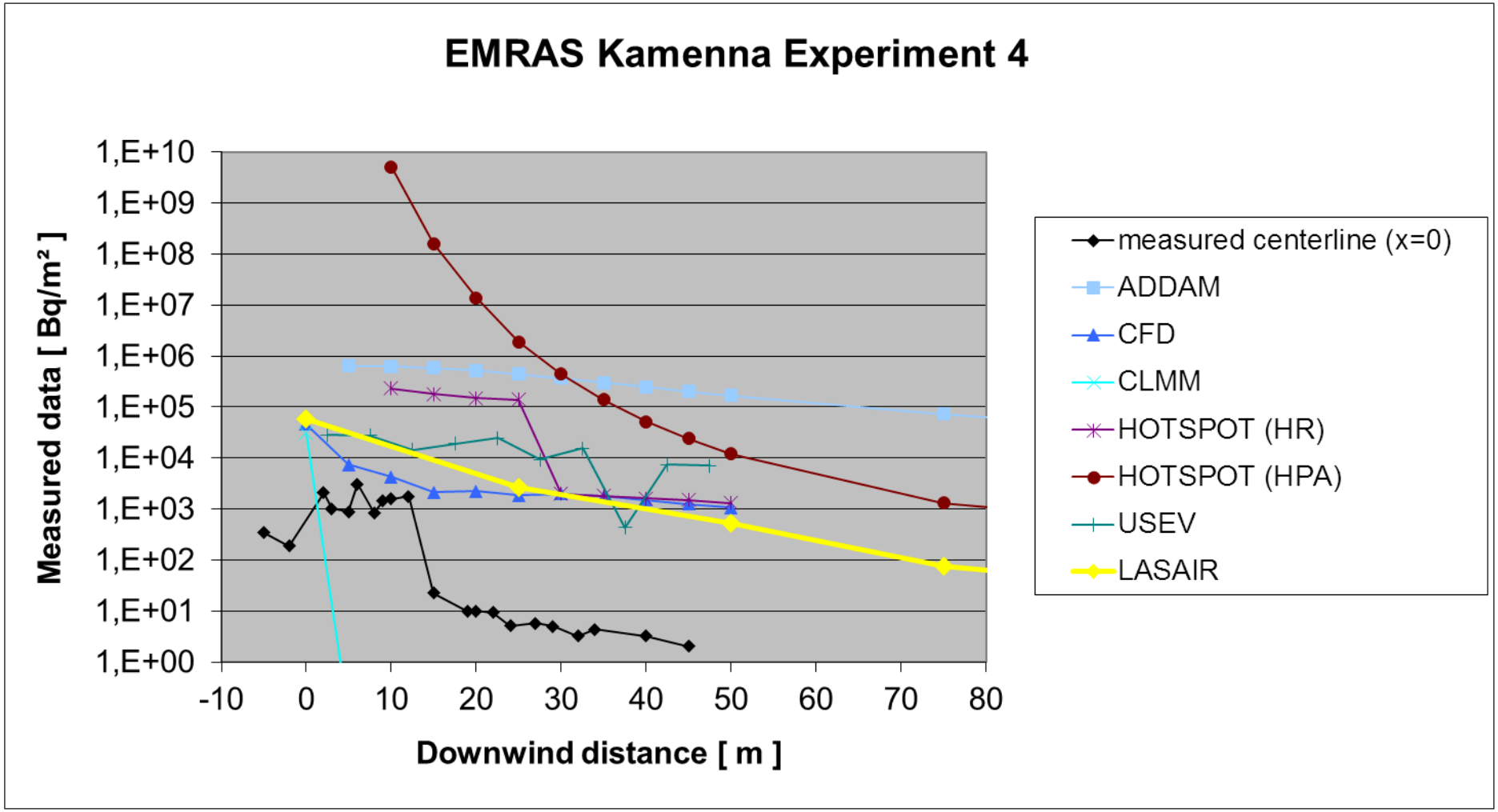
Grids Kamenna-Experiments – LASAIR 3 grid

Kamenna grid

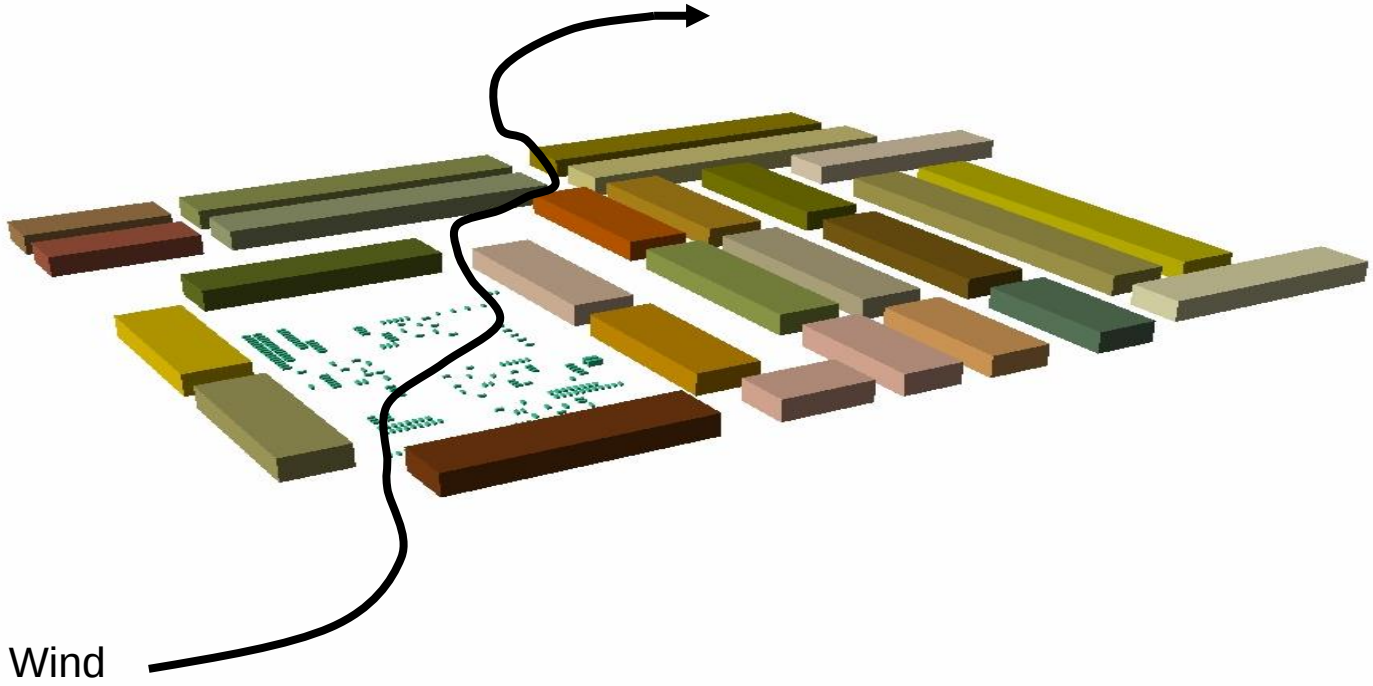
red bullets represent measurements



LASAIR results for EMRAS („Kamenna-Experiments“)

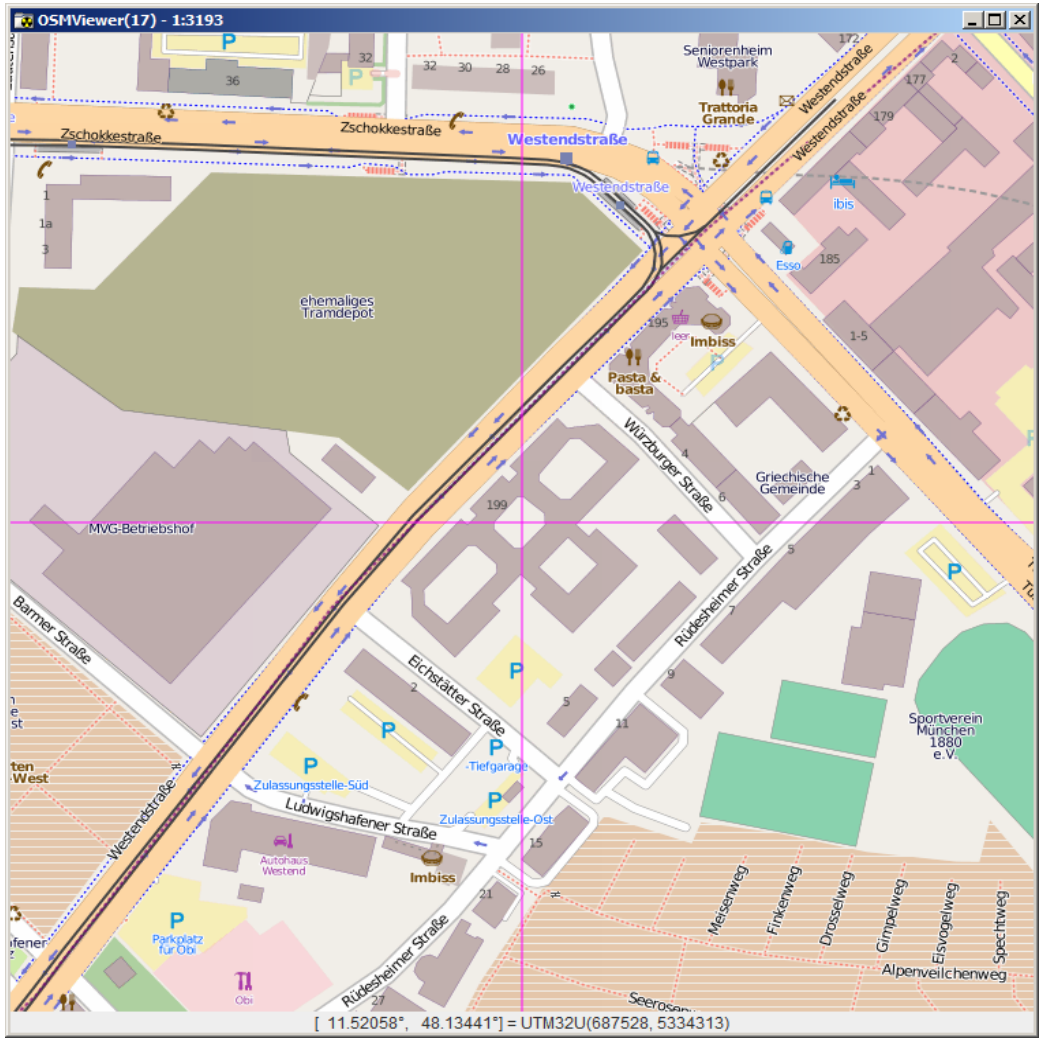


LASAIR building effects

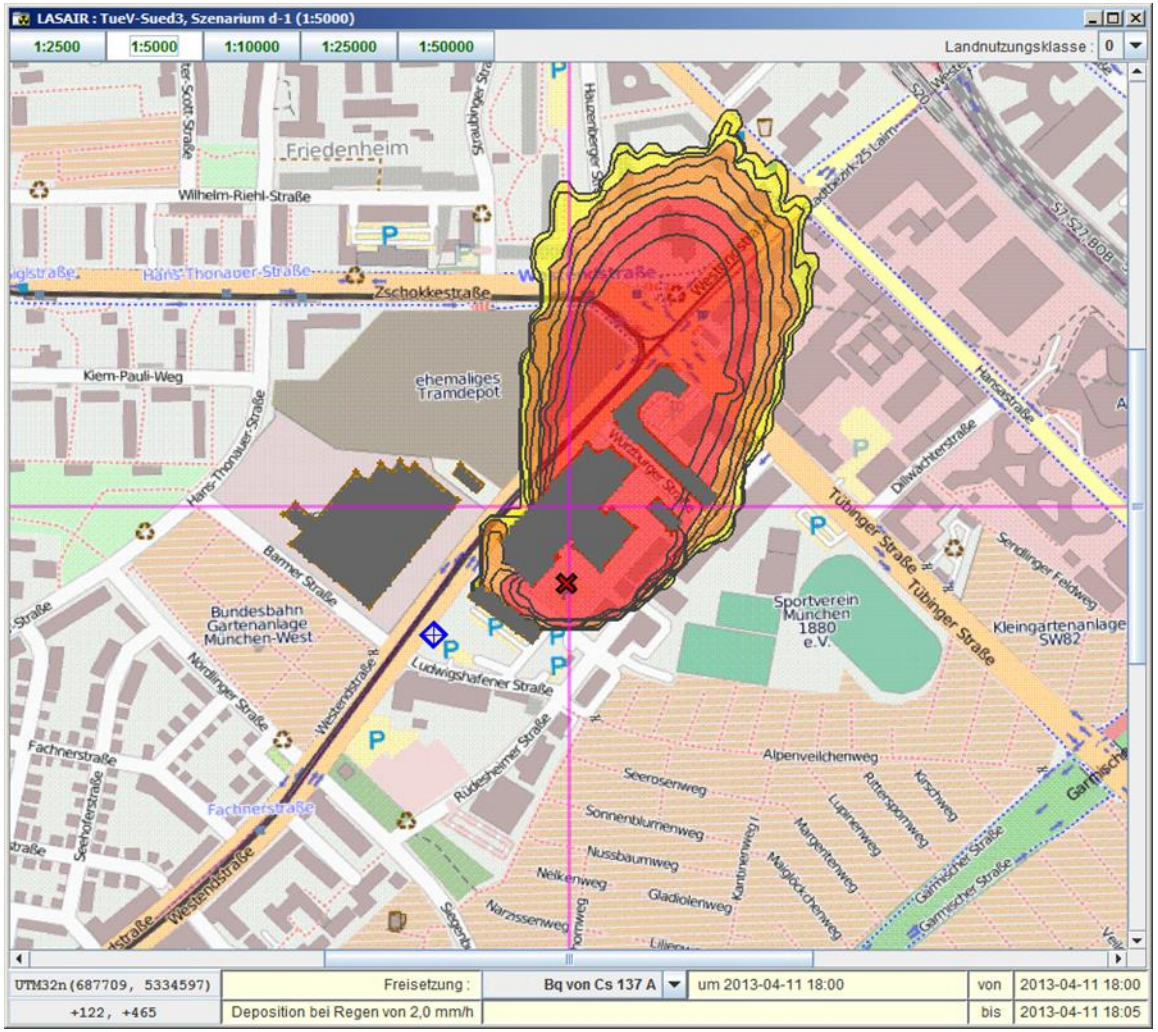


Quelle: Fv. TÜV Süd, von Haustein, Rall, 2000

LASAIR building effects, Use of Open Street Map



LASAIR Deposition



LASAIR Deposition, close