



Results of regional surveys on High Voltage Line magnetic field exposures and broadcast telecommunication site with high exposure levels

Enrica Caputo – Arpa Piemonte, Radiation Department

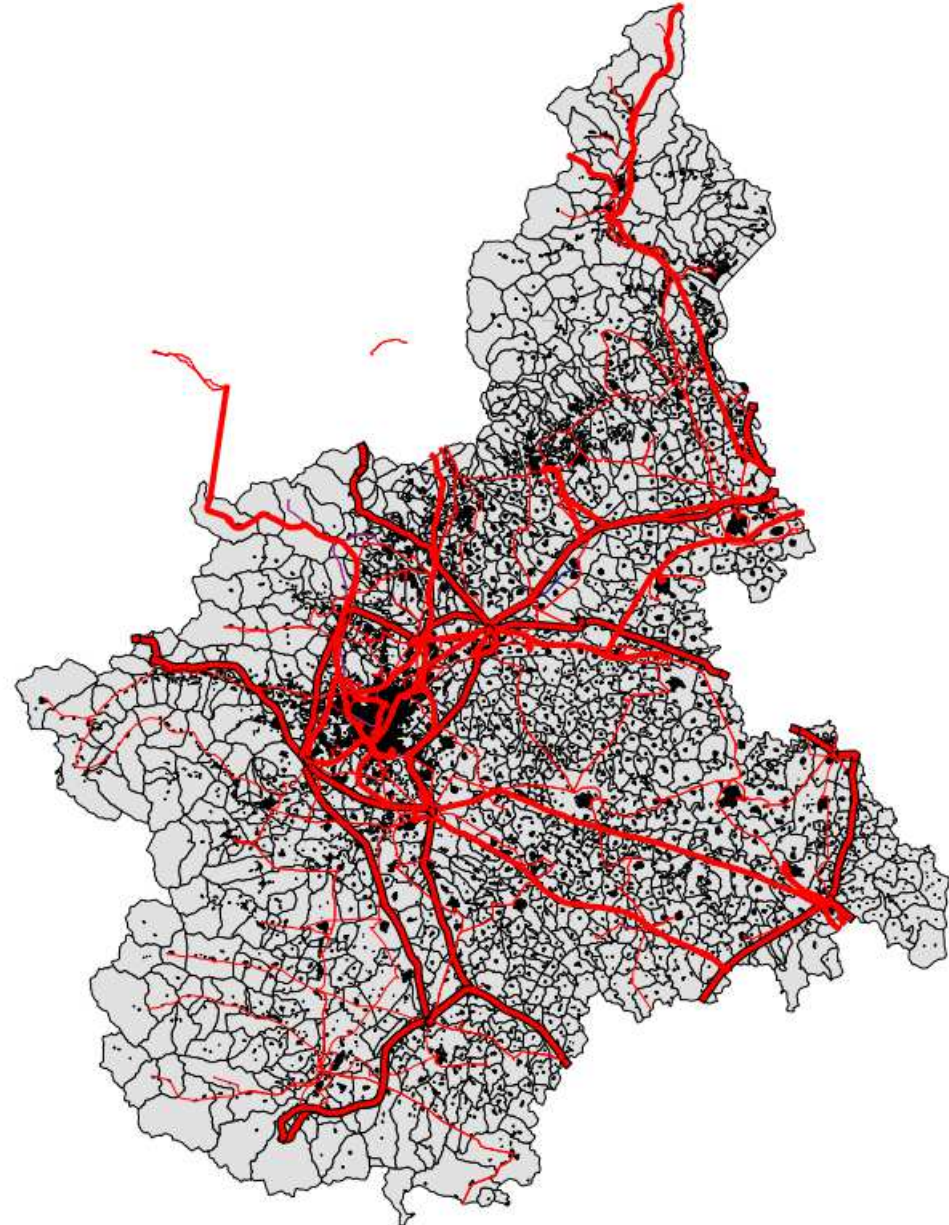


ELF SOURCES HIGH VOLTAGE LINES CROSSING PIEMONTE REGION

Region Area 25400 km²
Beijing Area 16801 km²

High Voltage lines
AC
(132 kV, 220 kV, 380 kV)

Total length of high
voltage
lines crossing Piemonte
region
~ 5600 km





ELF MAGNETIC FIELD MEASUREMENT

FIRST STEP - PLANNING

Investigation on the electrical network hot spot (high current SL, worst case pylon shape, multiple power lines, ...)

Search high level magnetic field levels areas due to power lines

High level magnetic field → DPCM
08.07.2003 (Italian law)



DPCM 08.07.2003

Exposure limit

$$B = 100 \mu\text{T}$$
$$E = 5000 \text{ V/m}$$

In addition, for magnetic fields, there are two further values:

$$B = 10 \mu\text{T} \text{ (24 h median)}$$

The attention value

Applies where exposure is for more than 4 hours per day

The quality target

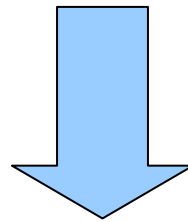
$$B = 3 \mu\text{T} \text{ (24 h median)}$$

Applies to new lines and to new homes only



Electrical network analysis

Electrical network knowledge
+
regional geographical structure knowledge



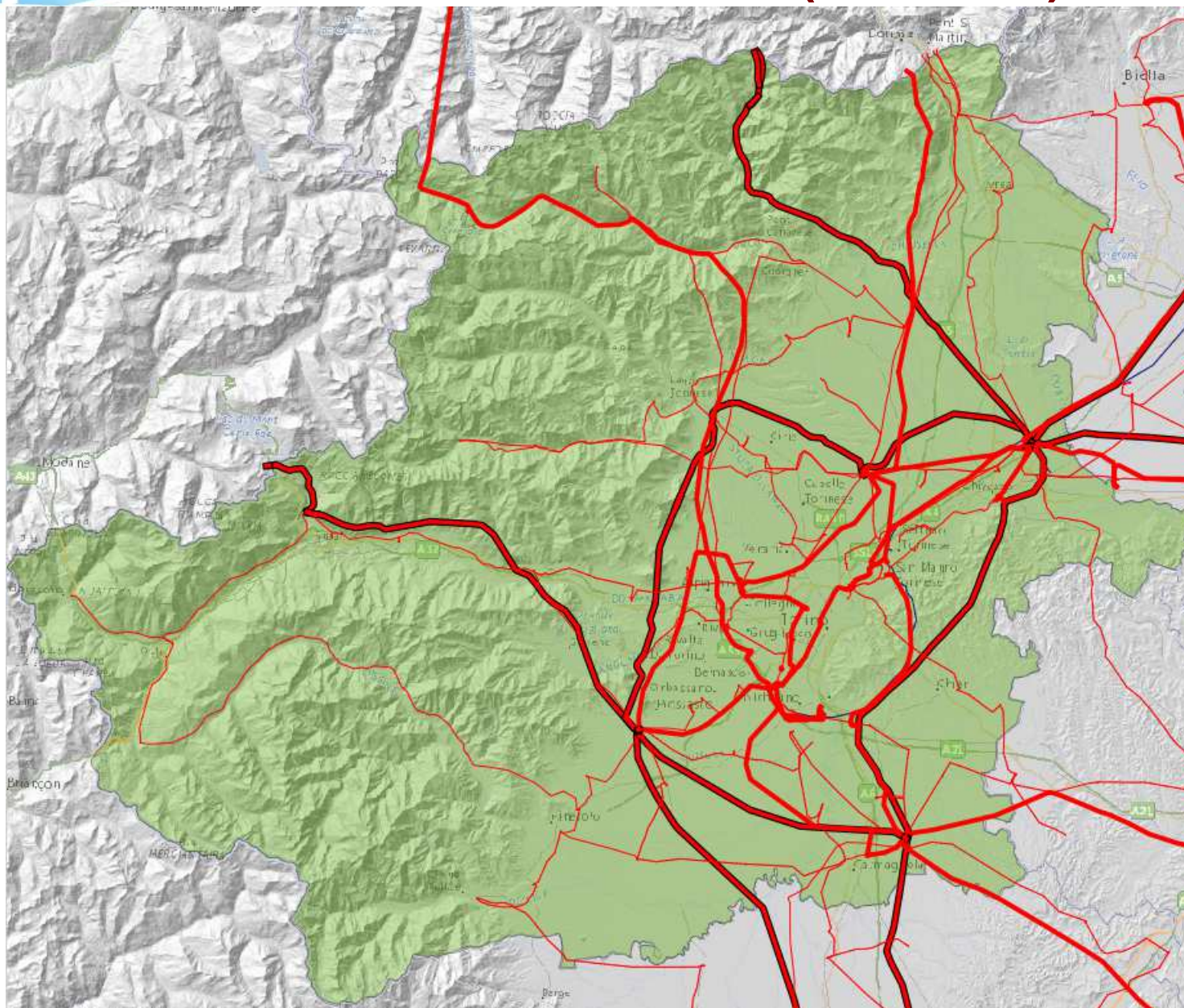
Possibility to work with general public exposure indicators that allow to identify critical areas to focus on.

In these areas we can concentrate specific measurements



Pilot: small area – Turin district (6821 km²)

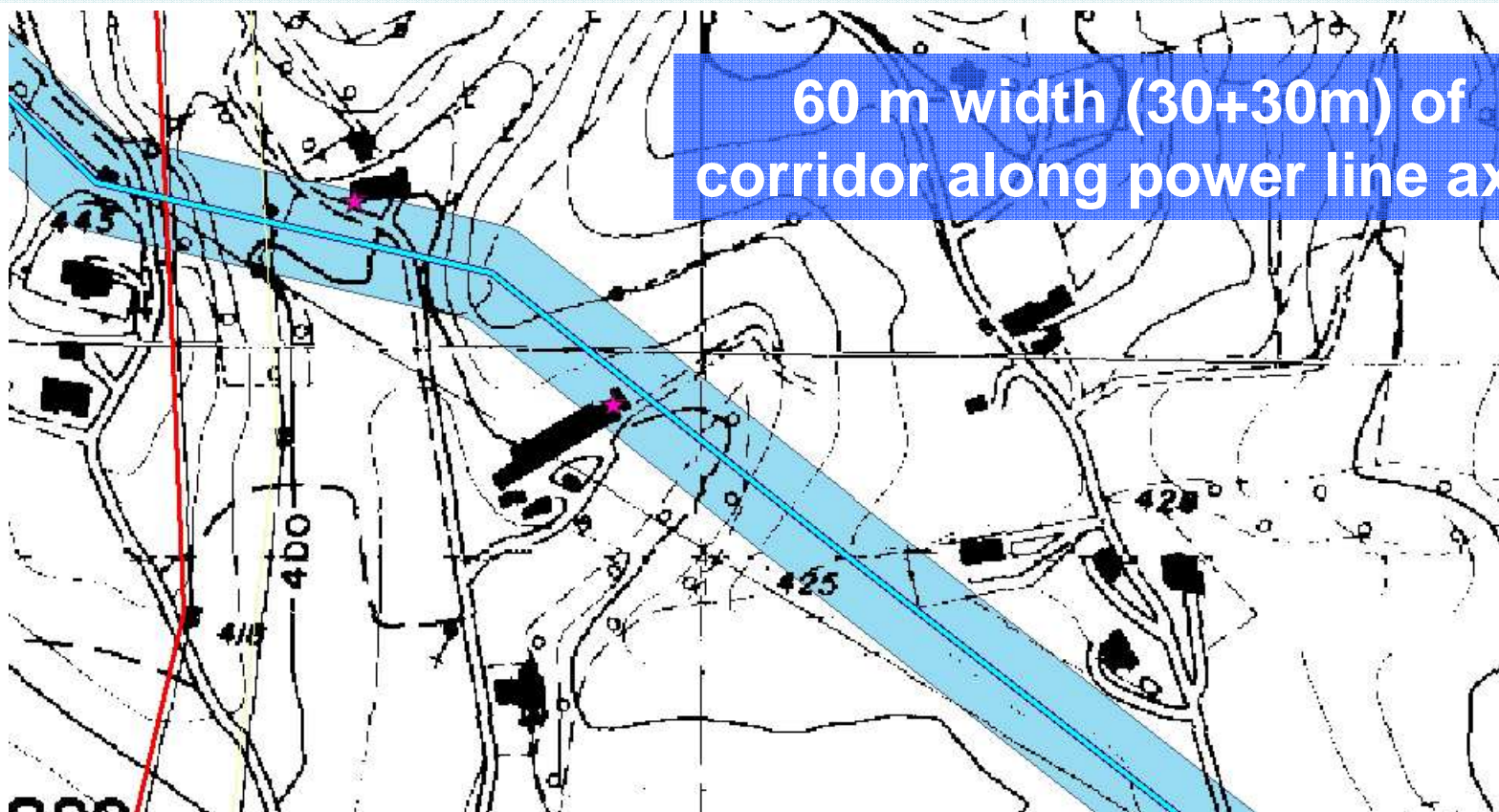
- 132 kV
- 220 kV
- 380 kV





Pilot: small area – Turin district (6821 km²)

Pre processing analysis of interference between power lines and residential areas



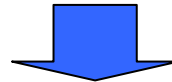
60 m width (30+30m) of
corridor along power line axis



690 hotspots in 120 Municipality
14% of municipality has more than 10 hotspots (average = 5)

To select spot and long term measurement points

- Municipality with high hotspot number;
- Municipality with high power lines number;
- Municipality near above ones

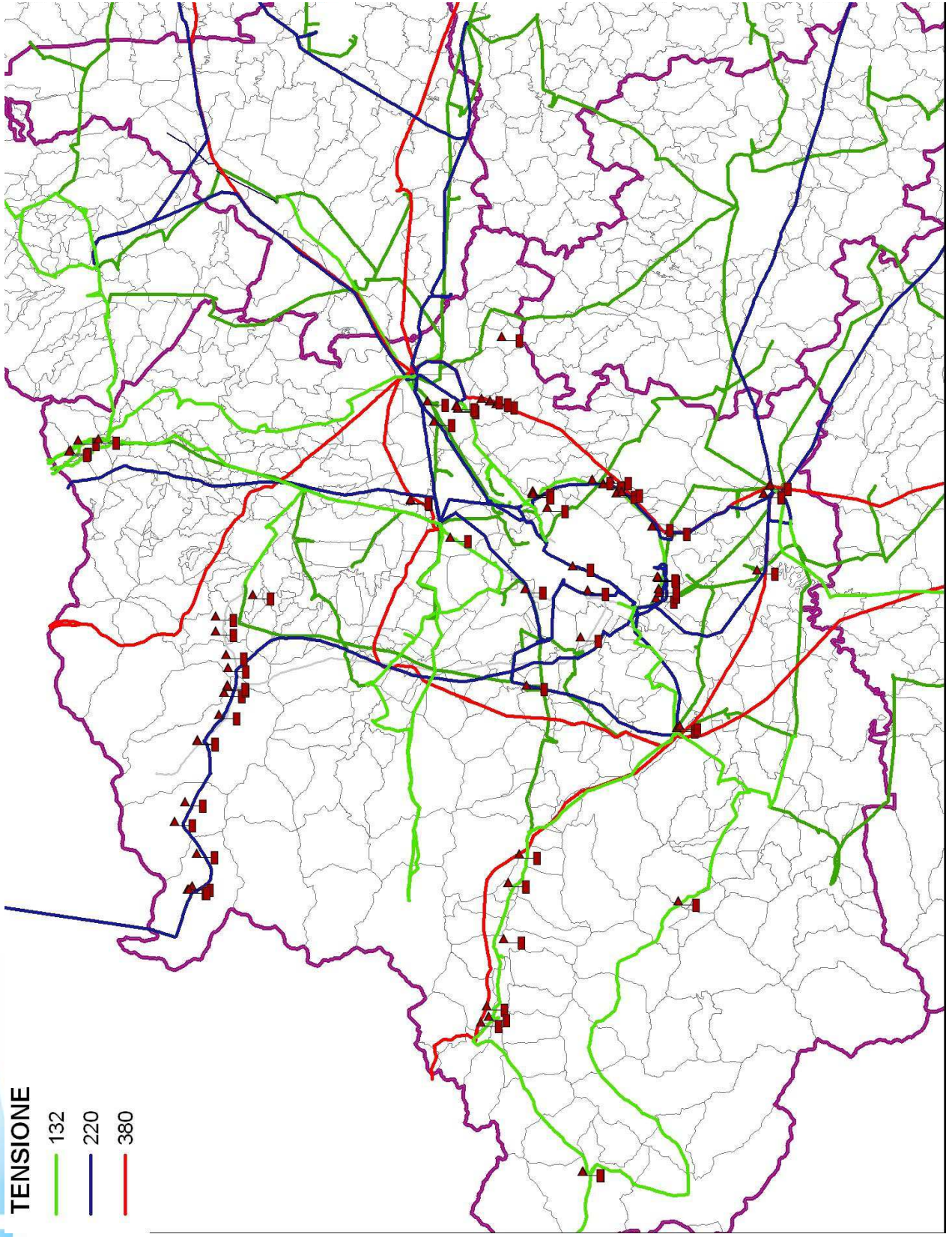


Measurement points in 22 Municipality, a total of 81 points and 34 different power lines



TENSIONE

- 132
- 220
- 380





Results

Electric field strength excess exposure limit \leftrightarrow 380kV power lines

Number of non-compliance $<$ 5% measurement points

**Very high magnetic field strength \leftrightarrow 220 kV power lines
(High currents and nearness of residential areas)**

**Magnetic field strength close to attention value (10 μ T) =
40% measurement points**

**Magnetic field strength higher to attention value $<$ 4%
measurement points**



Second step: Piemonte region

Hot spot analysis for power lines with high residential housing density

Residential housing density evaluation inside buffers centered in power lines axis : buffers amplitude is determined by power lines type. Inside buffers we predict higher magnetic field levels than normal levels in residential areas.

Buffers amplitudes:

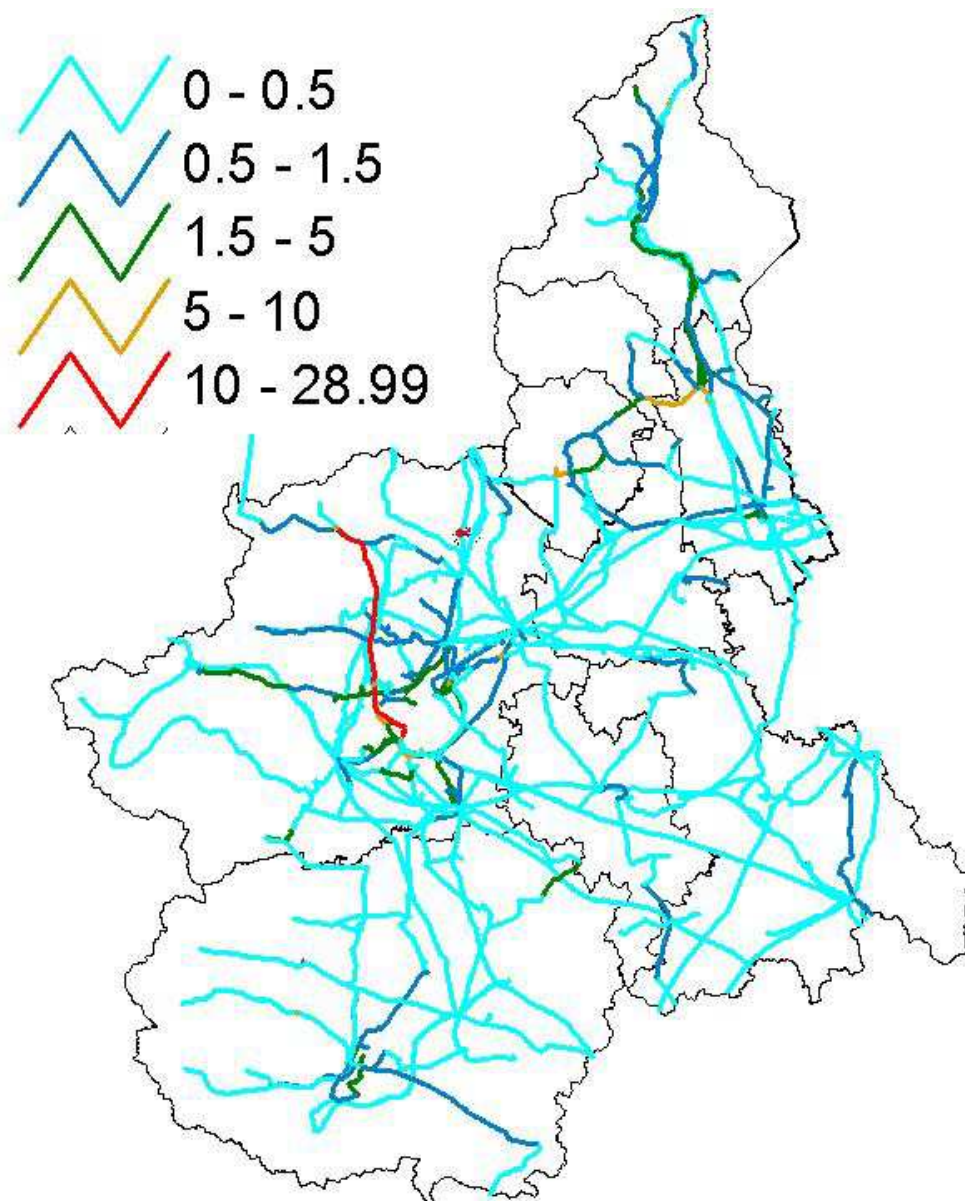
380kV Power lines- 80m buffer on each side

220kV Power lines- 50m buffer on each side

132kV Power lines- 30m buffer on each side

For each power line section we calculated total surface area of buildings inside buffers.

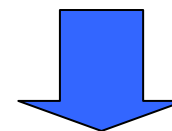
With this value we have calculated an indicator as buildings area divide by buffer area



P=Percentage of built areas
under power lines buffers

$P < 1.5\%$ for more 80% of power
lines sections

$P > 10\%$ for only 3% of power
lines

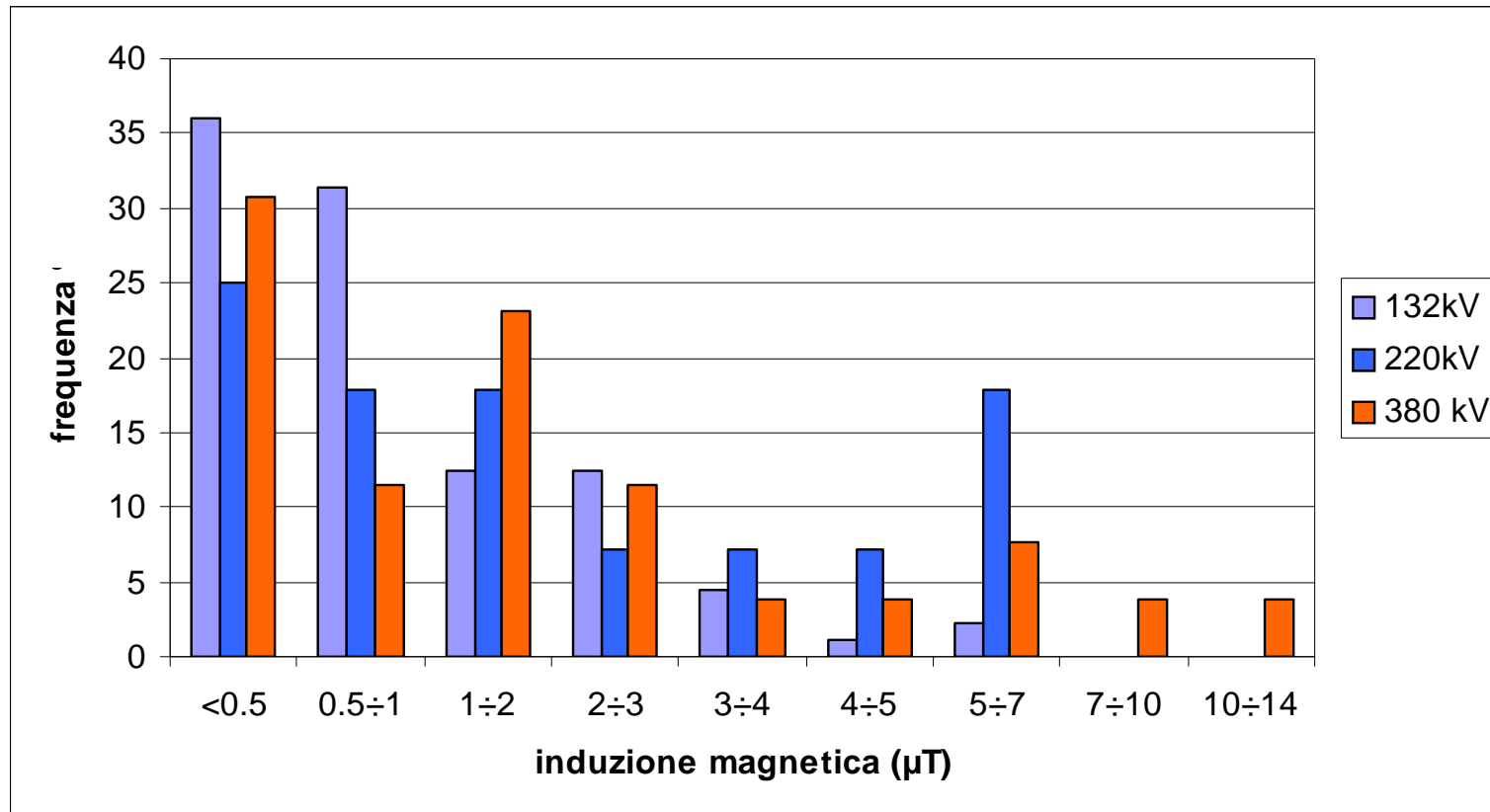


Hotspots for power lines with
higher P value

184 measure points for 132kV,
220 kV, 380 kV



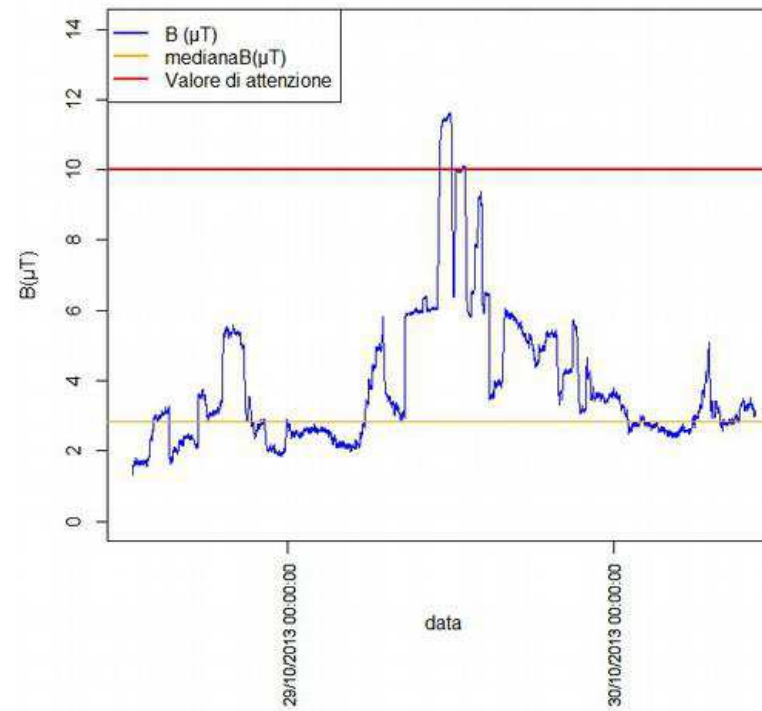
Some results



Distribution of values range from spot measurements



Some results

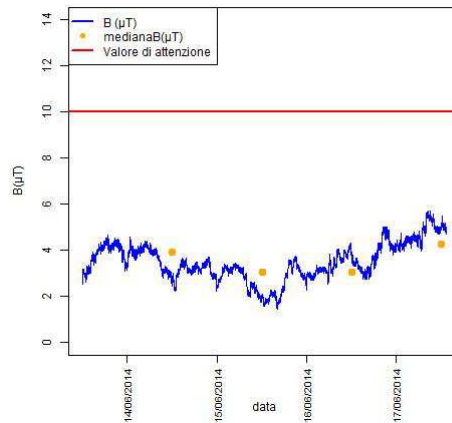


Example of long term monitoring measurement

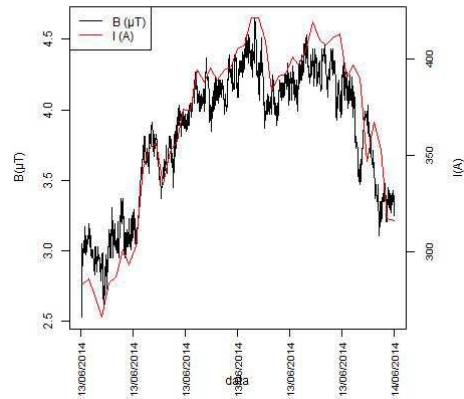


Some results

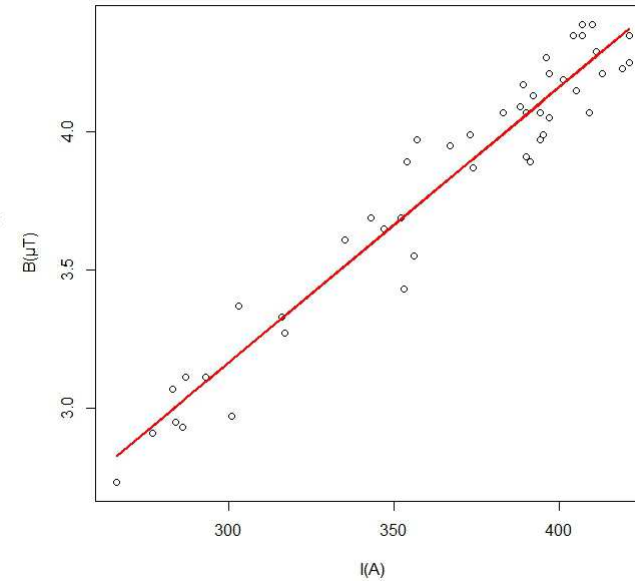
Three days
measurement
13/05/2014
17/05/2014



One day
simultaneous B
and I measurement



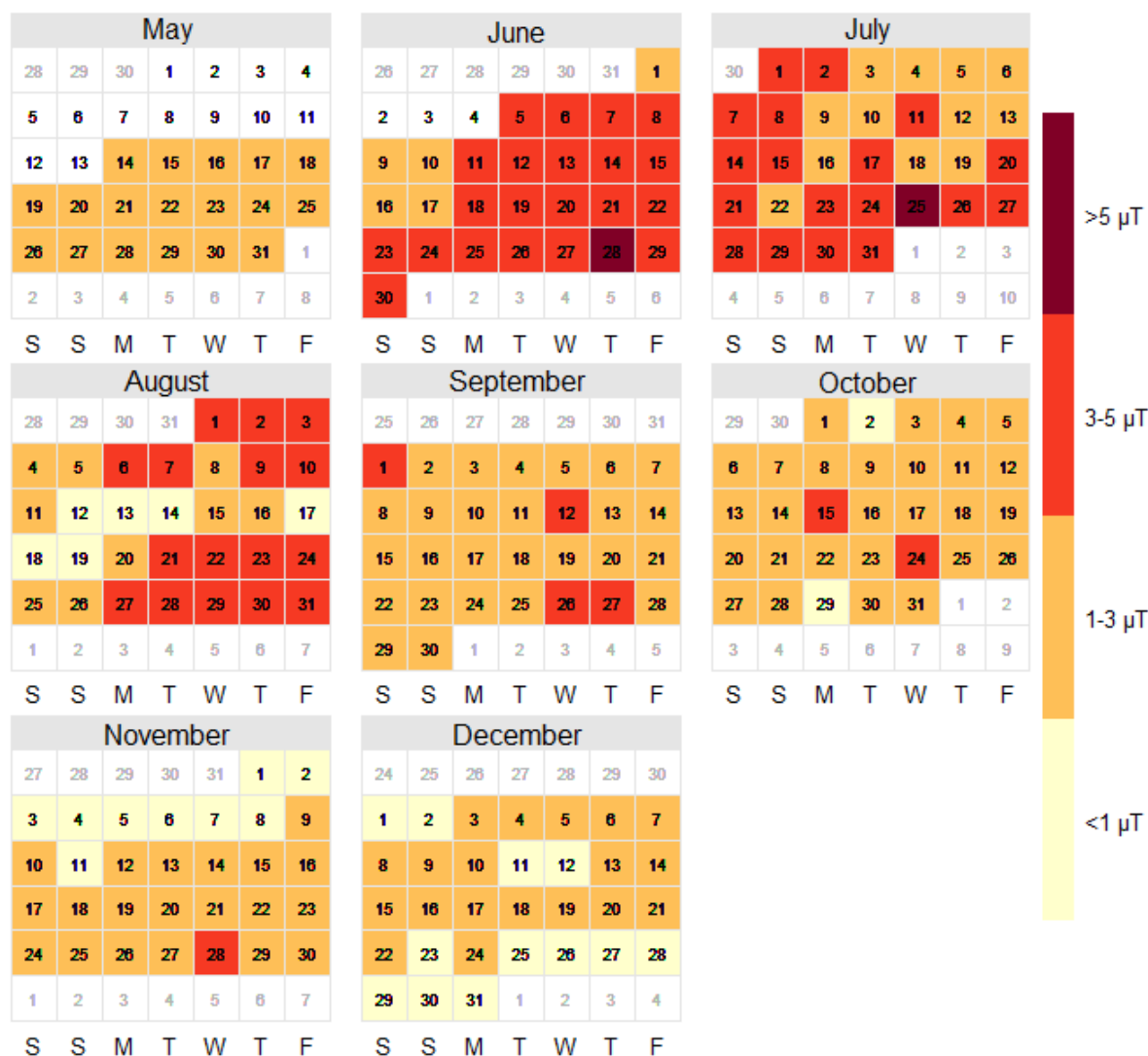
B/I linear regression
 $R > 0.9$



Example of long term measurement based
extrapolation

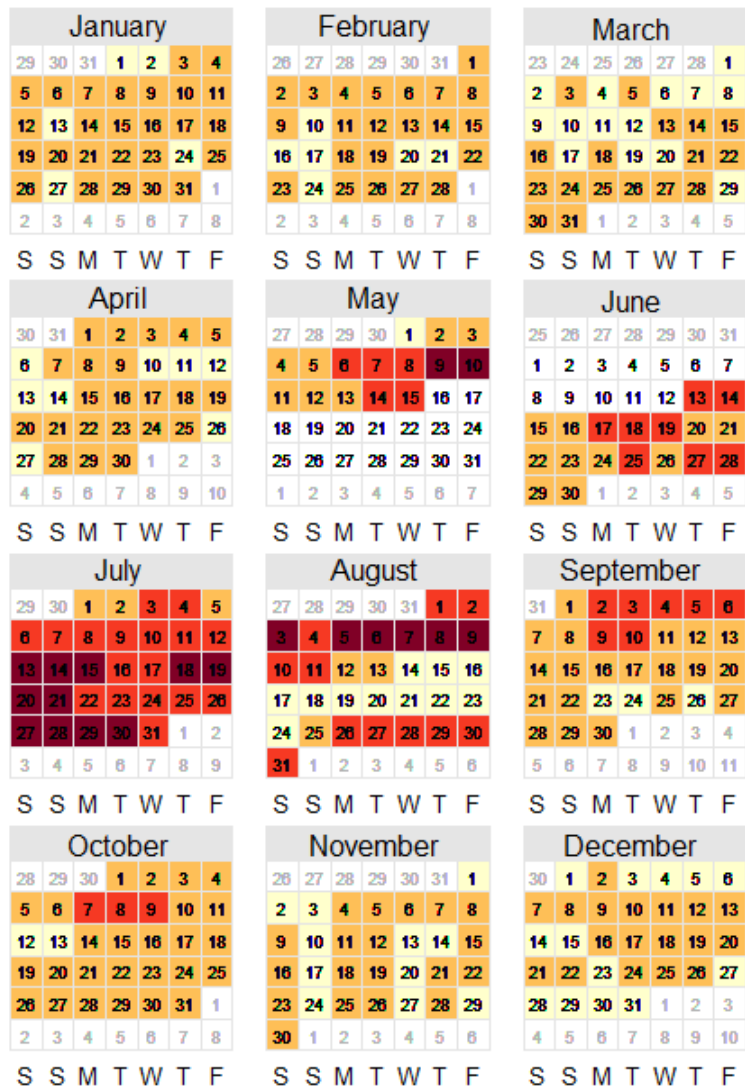
Some results

Power line T216 daily median B - year 2012

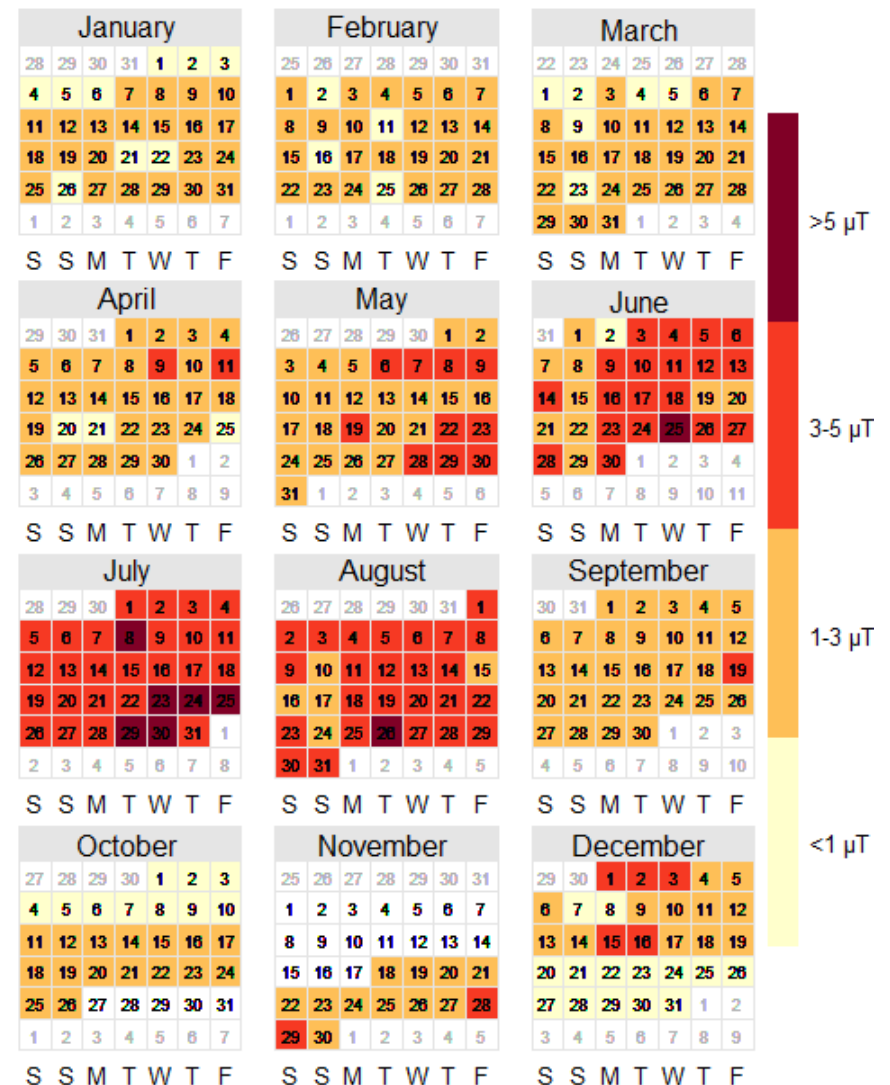


Some results

Power line T216 daily median B - year 2013

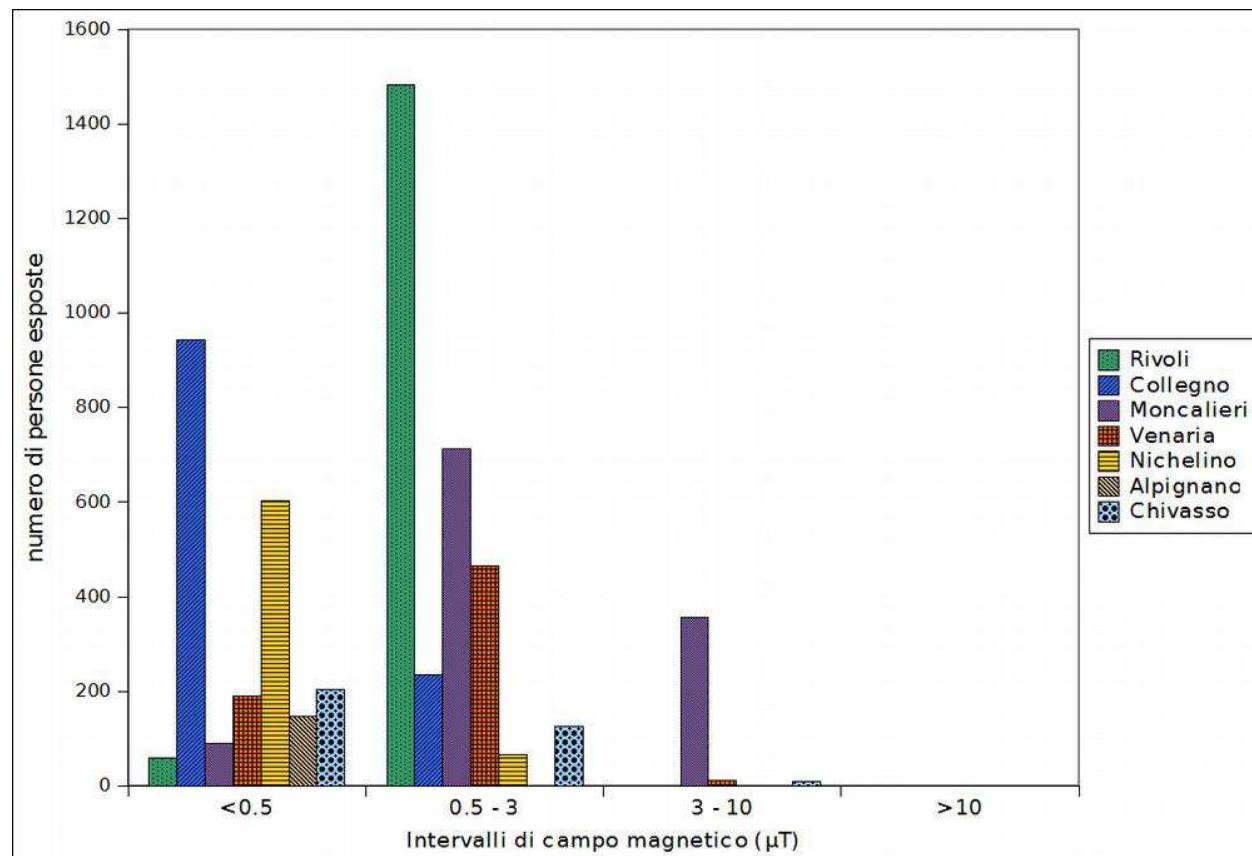


Power line T216 daily median B - year 2014



Some results

Merging measurement data with census data we can evaluate number of people exposed to a specific magnetic field level





RF ELECTROMAGNETIC FIELDS IN PIEMONTE



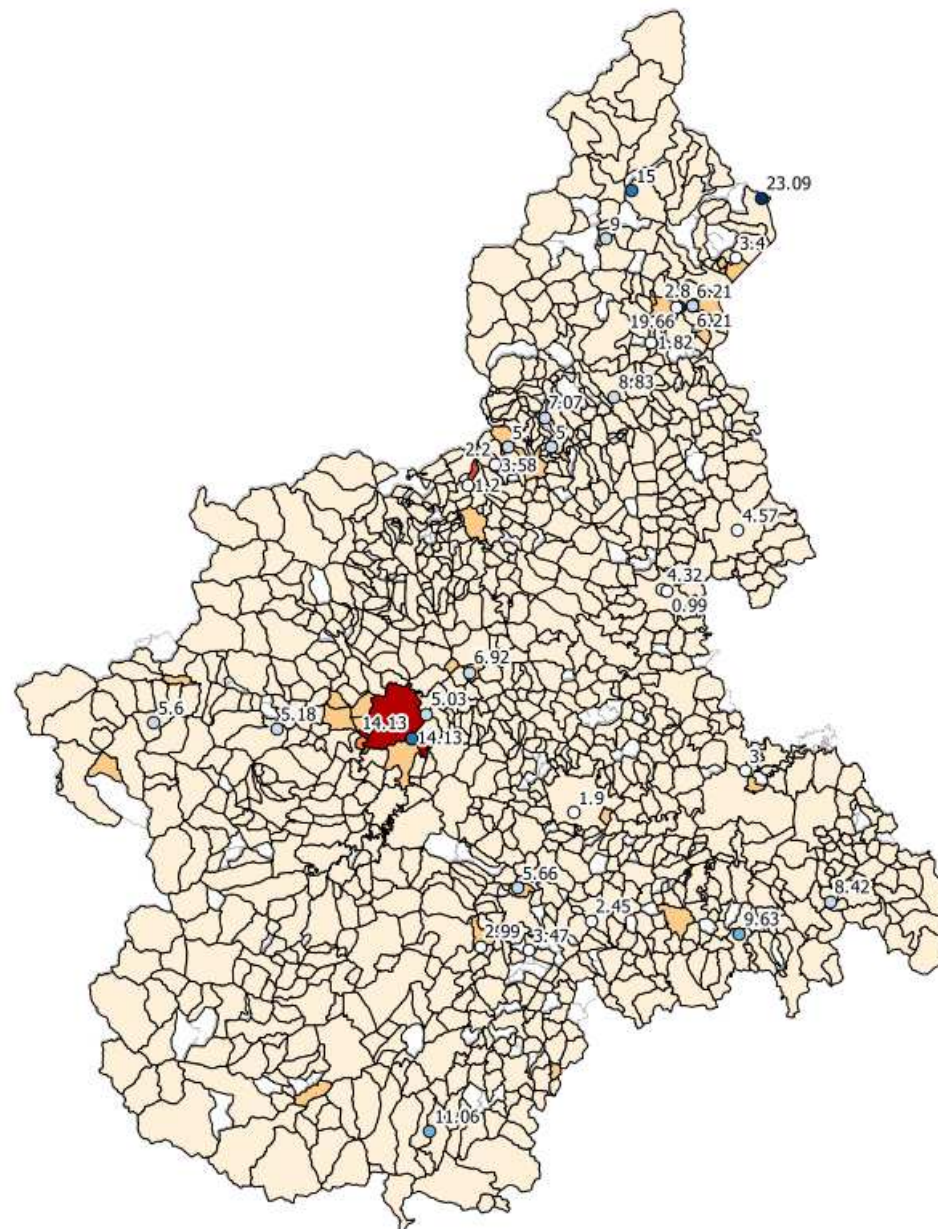
RF sites density by regional district



High level measurement point

+

Last broadband measurement

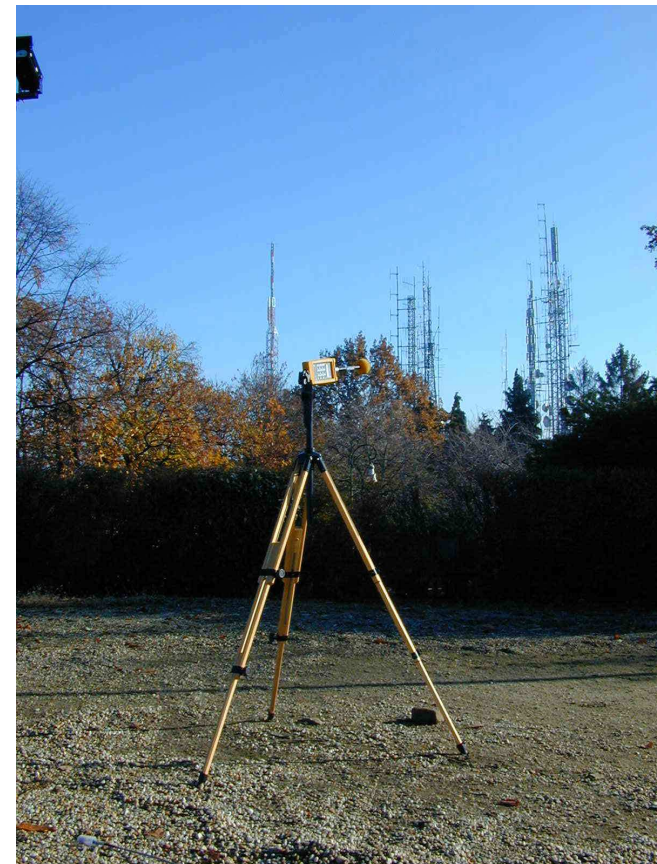




RF ELECTRIC FIELD MEASUREMENT

RESULTS OF MEASUREMENT CAMPAIGNS

Measurements of electromagnetic fields for compliance with standard limits (broad band and narrow band instrumental chains)





RF ELECTRIC FIELD MEASUREMENT

High level electric field → DPCM 08.07.2003 (Italian law)

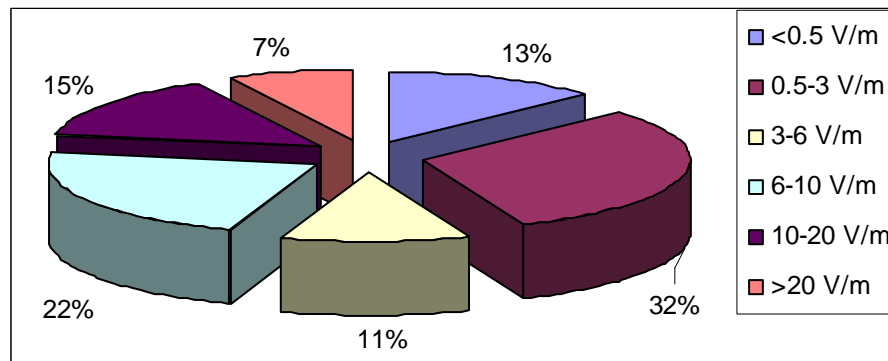
REFERENCE VALUES	FREQUENCY (MHz)	E (V/m)	CALCULATION METHOD AND EXPOSITION CONDITIONS
Exposure limits	$0.1 < f \leq 3$	60	6 minutes mean
	$3 < f \leq 3000$	20	
	$3000 < f \leq 300000$	40	
Attention value	$0.1 < f \leq 3$	6	24 hours mean
	$3 < f \leq 300000$		exposure > 4 hours per day
Quality target	$0.1 < f \leq 3$	6	24 hours mean
	$3 < f \leq 300000$		Intensely frequented areas



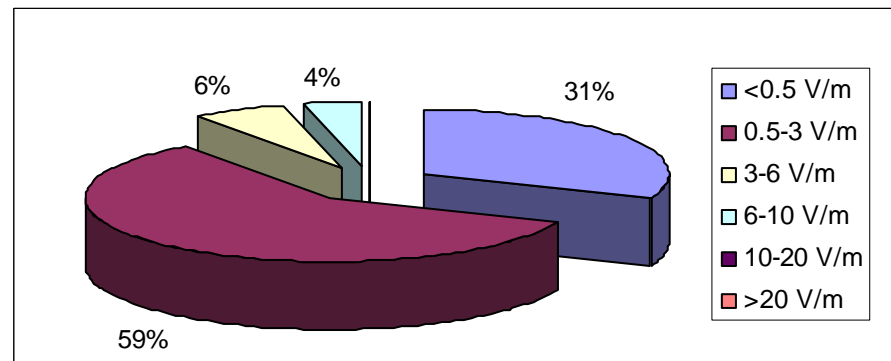
RESULTS OF MEASUREMENT CAMPAIGNS

Measurements of electromagnetic fields for compliance with standard limits (broad band and narrow band instrumental chains)

Electric field levels measured in the vicinity of Radio TV broadcast antennas



Electric field levels measured in the vicinity of radio base stations (mobile phone)



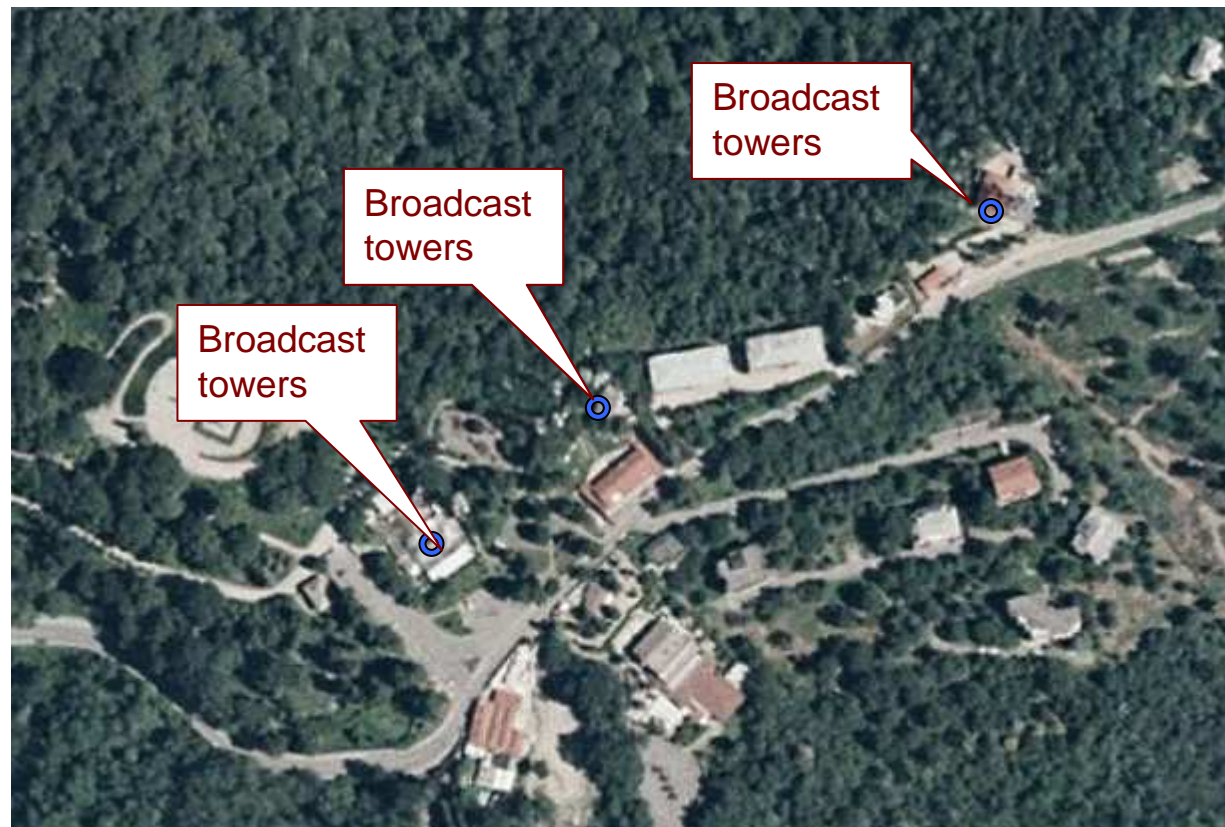


RESULTS OF MEASUREMENT CAMPAIGNS

BROADCAST ANTENNA SITE (Maddalena hill – Torino)

About 100 radio
TV broadcast
antennas

Average antenna
power about 4-5 kW



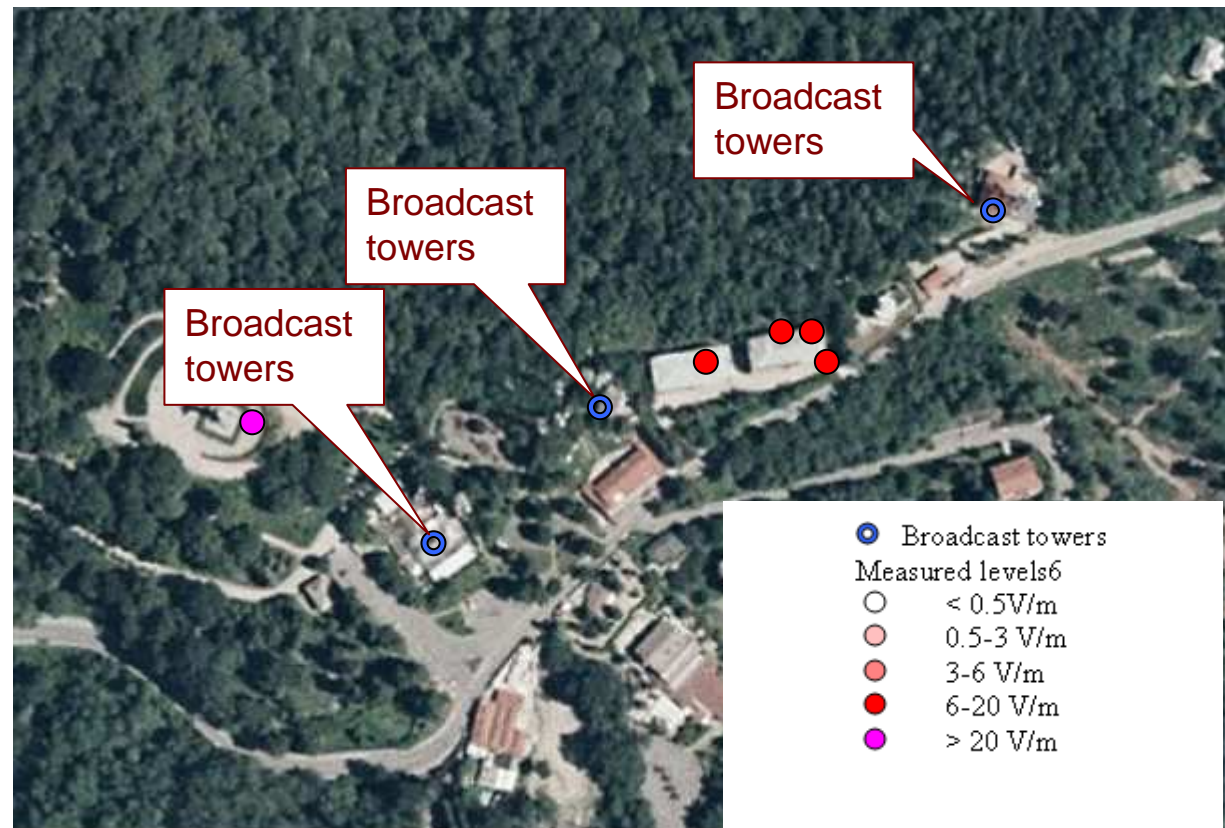


RESULTS OF MEASUREMENT CAMPAIGNS

BROADCAST ANTENNA SITE (Maddalena hill – Torino)

Narrow band and broad band measurements

National exposure limits not respected

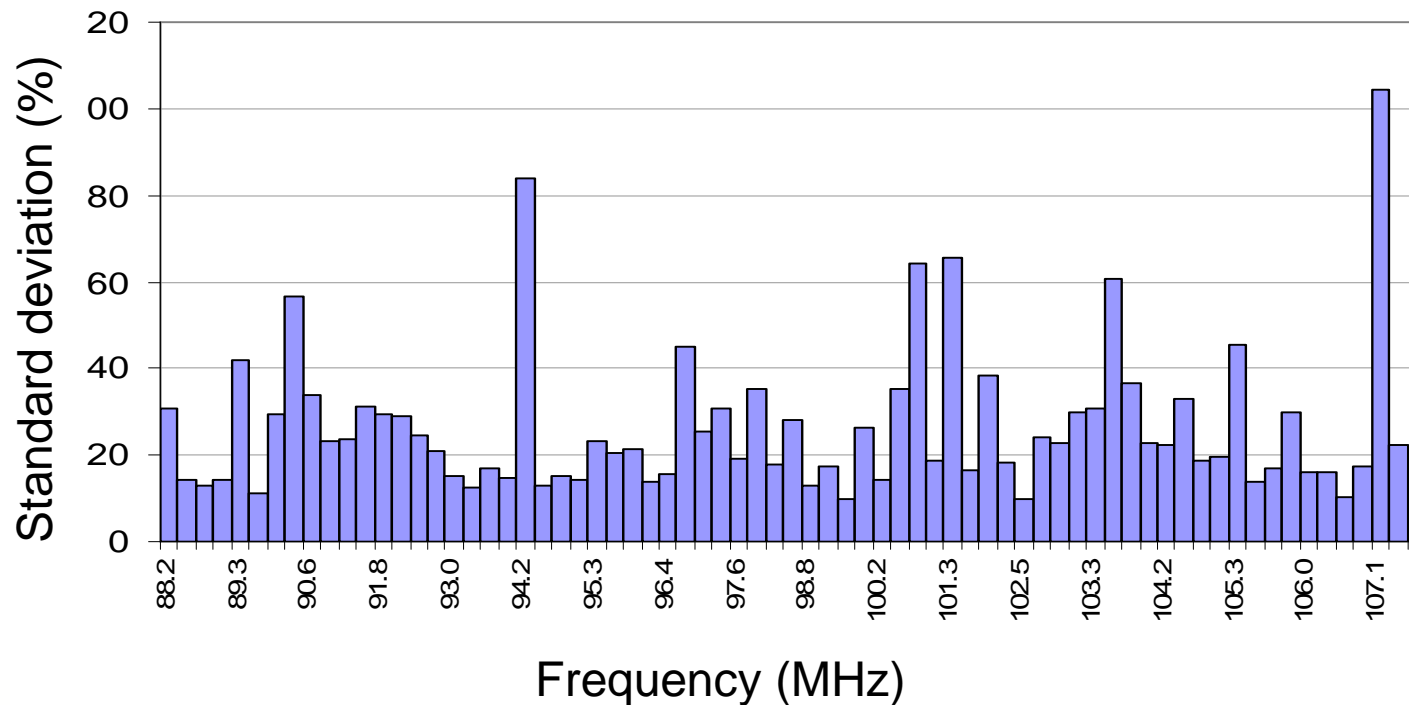




RESULTS OF MEASUREMENT CAMPAIGNS

BROADCAST ANTENNA SITE (Maddalena hill – Torino)

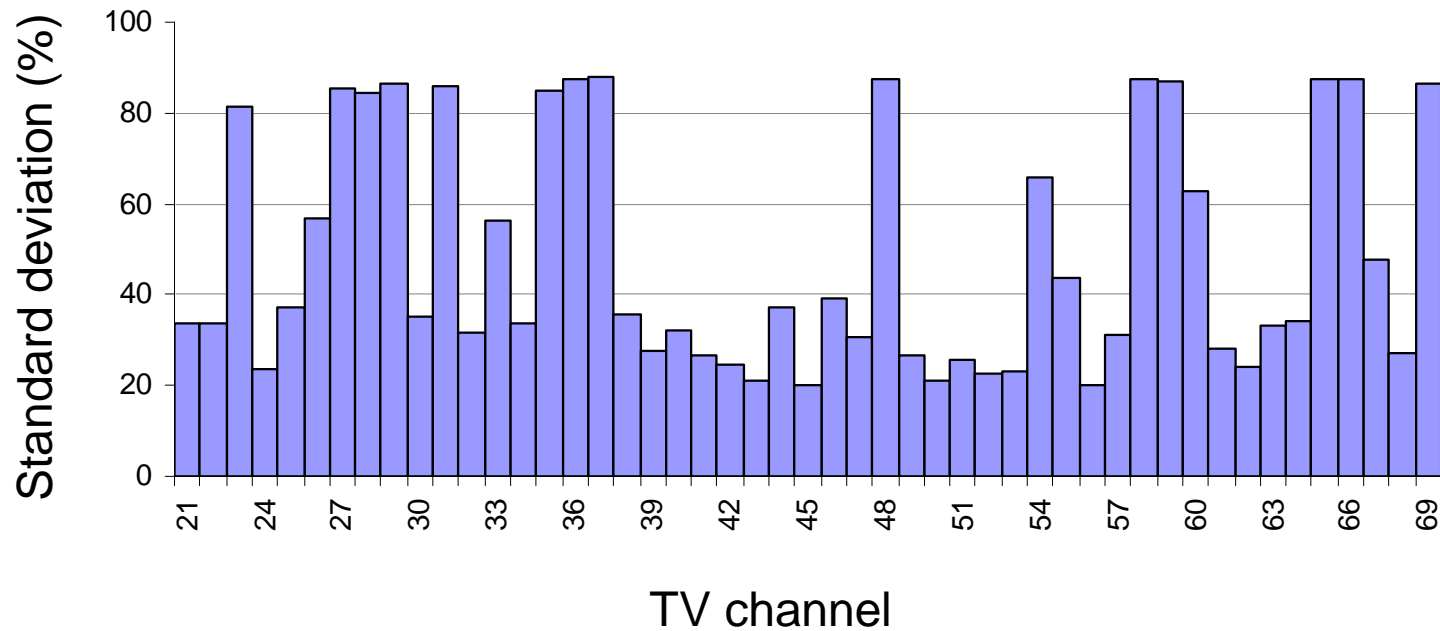
Time variation of measured electric fields – FM broadcast antenna





RESULTS OF MEASUREMENT CAMPAIGNS

Time variation of measured electric fields – TV broadcast antenna





AUTOMATIC MONITORING SYSTEMS OF RF ELECTROMAGNETIC FIELD EMITTED FROM BROADCAST SITES

Monitoring system consists in a calibrated omnidirectional receiving antenna connected to a computer controlled spectrum analyzer

Receiving antenna is in line of sight with broadcast site





AUTOMATIC MONITORING SYSTEMS OF RF ELECTROMAGNETIC FIELD EMITTED FROM BROADCAST SITES

A dedicated software was realized to acquire and to store in a database amplitude levels of each radio frequency signal (one acquisition per hour)

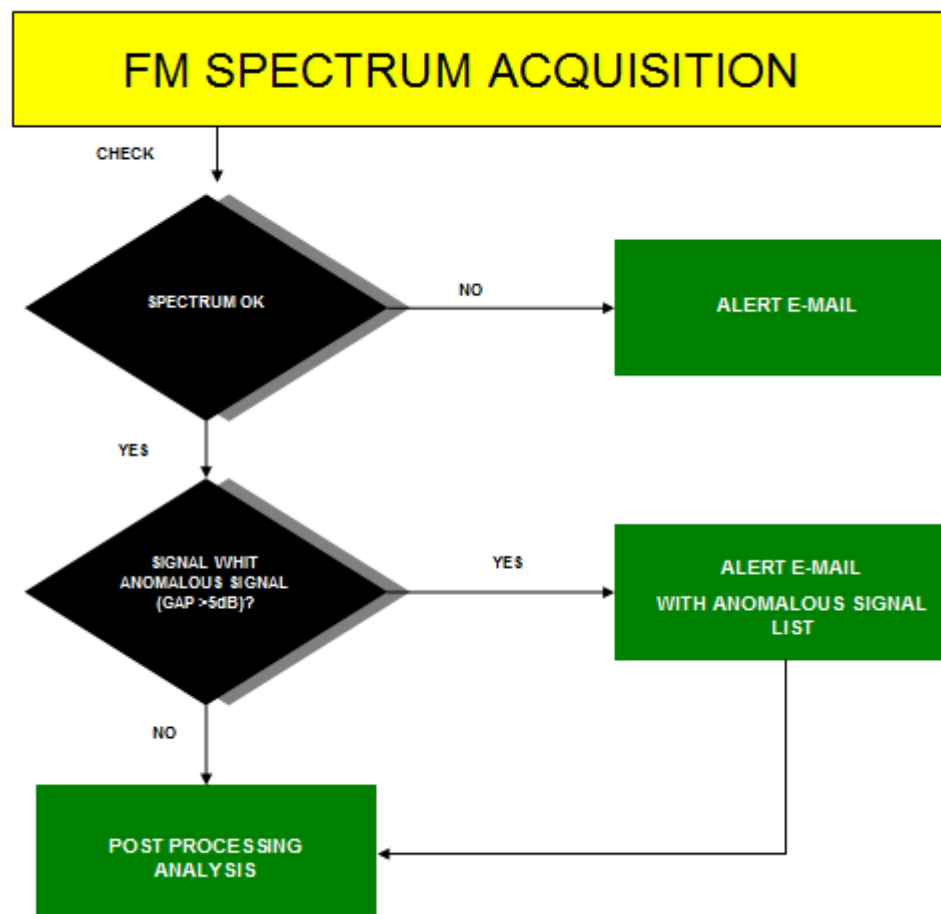
Data acquisition is continuous h24 with hourly remote download spectra (parameters set: span 10 MHz, RBW 30 kHz, VBW 30 kHz)

Anomalous time variation of signal levels are remotely notified by email

Every day a specific automatic script analyses time variation of signal levels on 24 h and creates graphical images for signal with amplitude gap >5dB

AUTOMATIC MONITORING SYSTEMS OF RF ELECTROMAGNETIC FIELD EMITTED FROM BROADCAST SITES

Anomalous time variation of signal levels are remotely notified by email





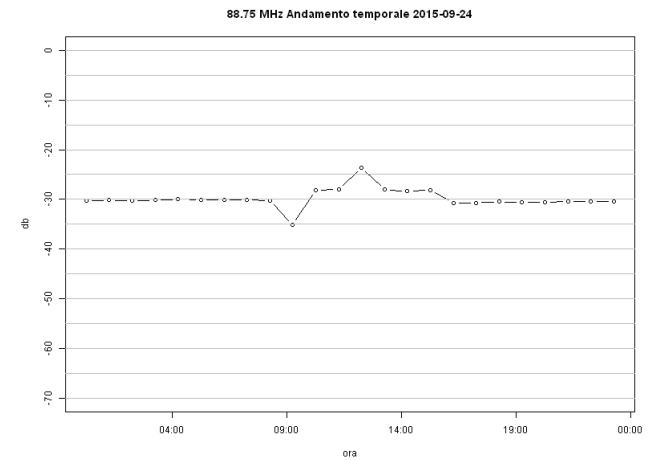
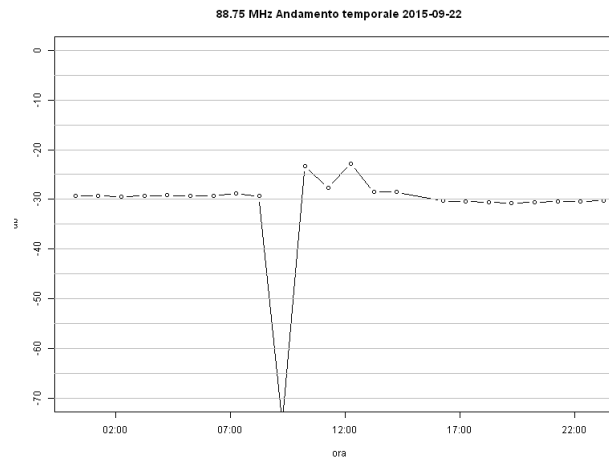
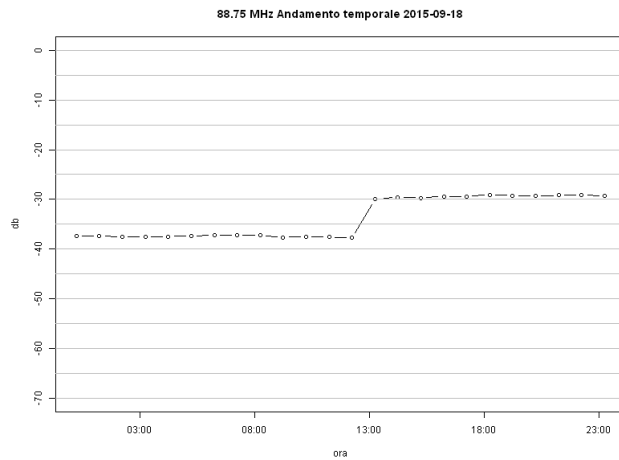
AUTOMATIC MONITORING SYSTEMS OF RF ELECTROMAGNETIC FIELD EMITTED FROM BROADCAST SITES

Anomalous daily time variation of F=88.75 MHz
Automatic graphical images

Day 1
 $\Delta = 8.06$ dB

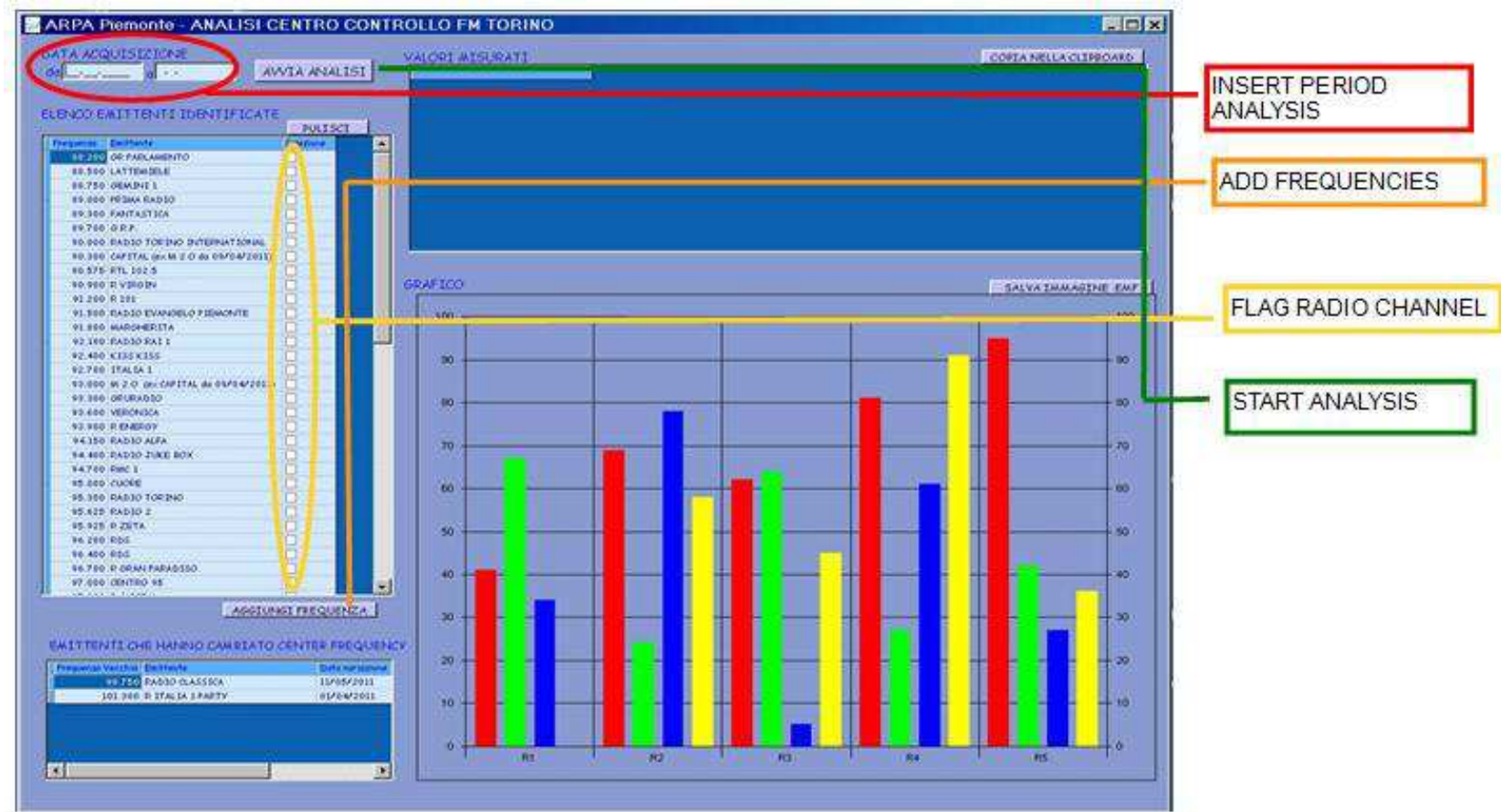
Day 2
+ 7.15 dB

Day 3
+ 6.91 dB

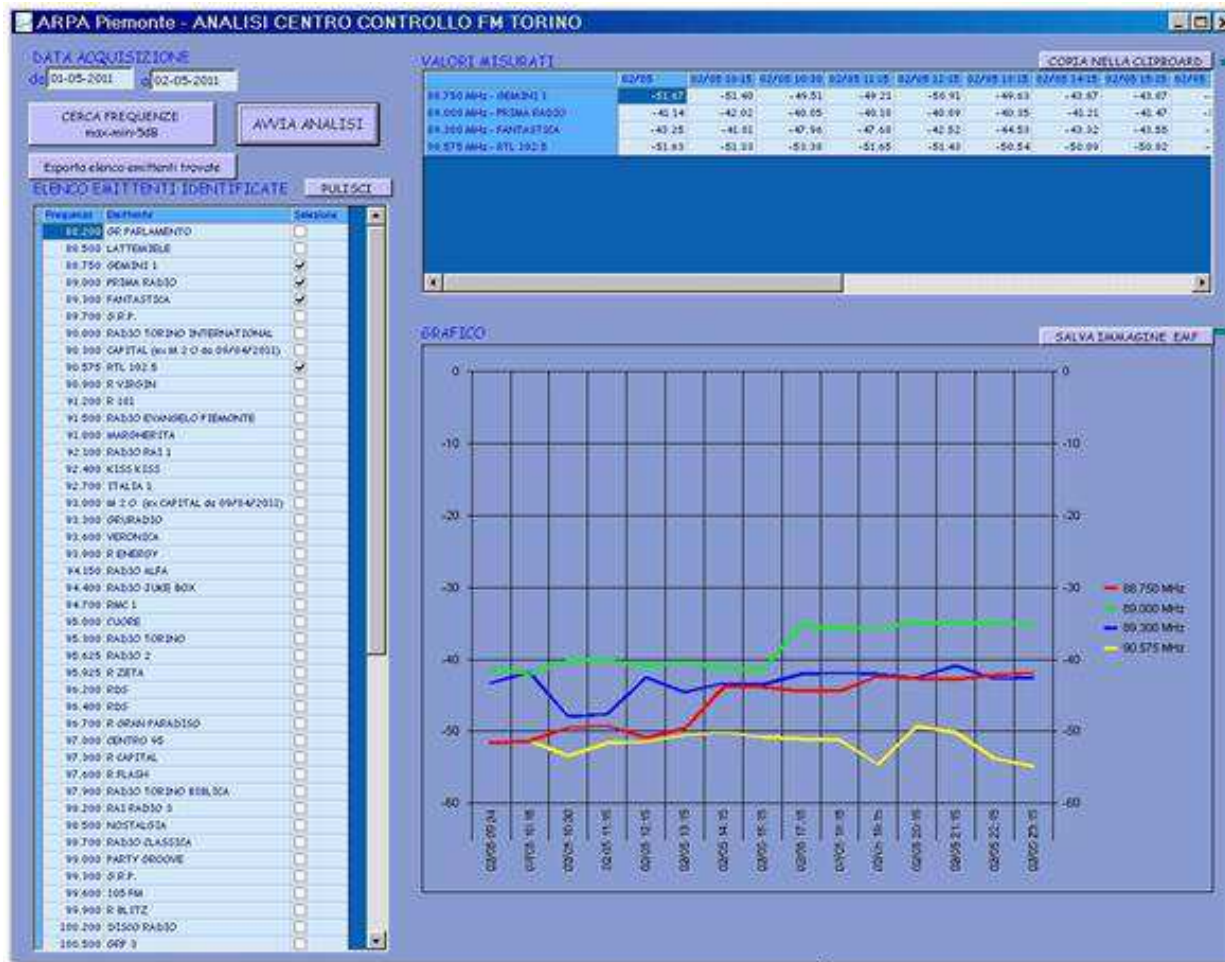




AUTOMATIC MONITORING SYSTEMS OF RF ELECTROMAGNETIC FIELD EMITTED FROM BROADCAST SITES



AUTOMATIC MONITORING SYSTEMS OF RF ELECTROMAGNETIC FIELD EMITTED FROM BROADCAST SITES



EXPORTING DATA

EXPORTING GRAPH

4 RF BROADCAST SIGNALS SELECTED

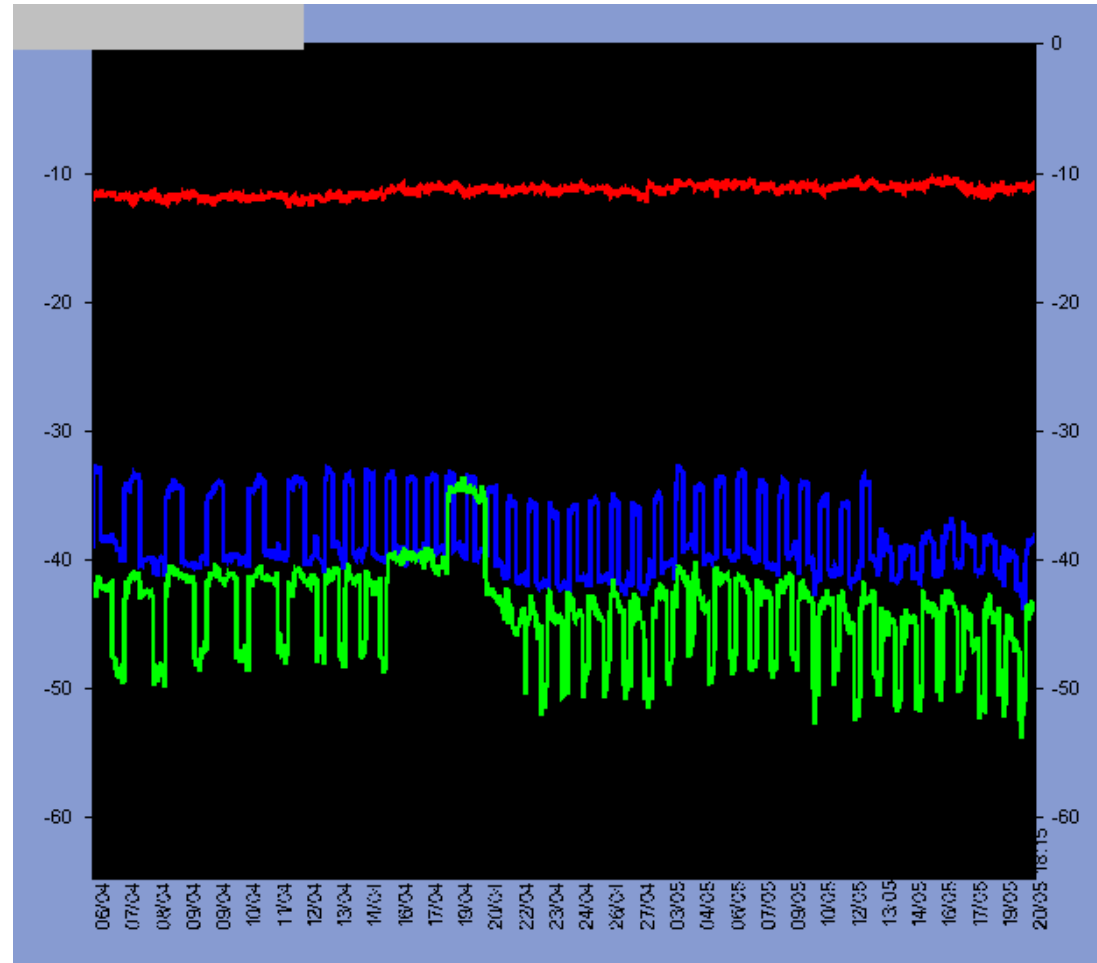


AUTOMATIC MONITORING SYSTEMS OF RF ELECTROMAGNETIC FIELD EMITTED FROM BROADCAST SITES

Signals emitted from 2 broadcast transmitters show daily time variation

In the nighttime rf power provided to transmitters was lowered of about 6 dB

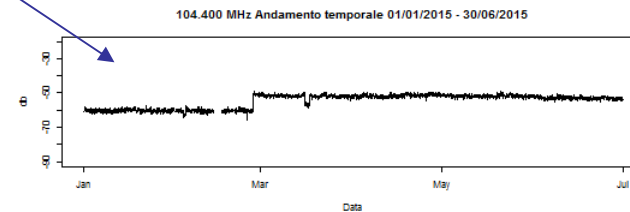
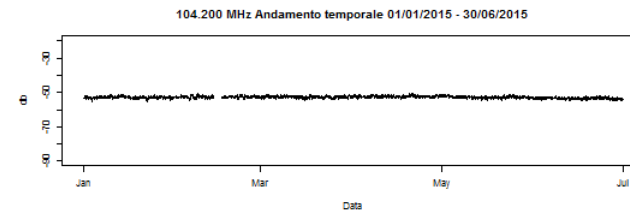
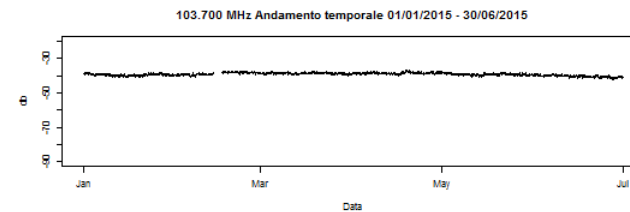
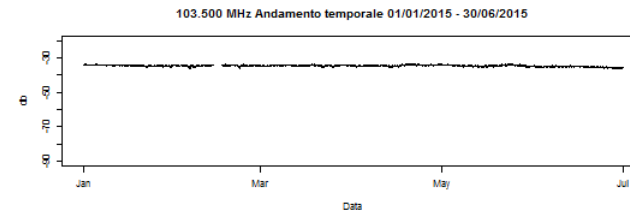
Real working conditions of telecommunication systems are known





AUTOMATIC MONITORING SYSTEMS OF RF ELECTROMAGNETIC FIELD EMITTED FROM BROADCAST SITES

Extracting long period data
we can analyze immediately
Anomalous signals



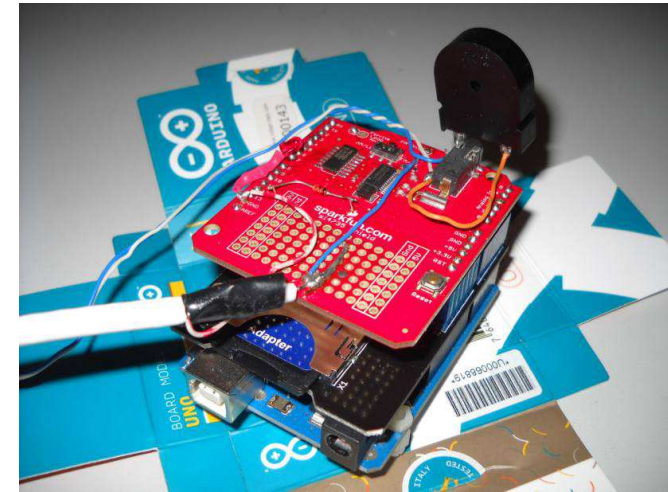
AD HOC SYSTEM OF DECODING FM BROADCAST SIGNALS INFORMATION

Low cost portable system which gives information on FM radio signals.

It's an Arduino based system which decodes RDS signal by radio stations and memorizes 24h/24h several parameters (Frequency, PI code, RDS, signal/noise level and Received signal strength indication).

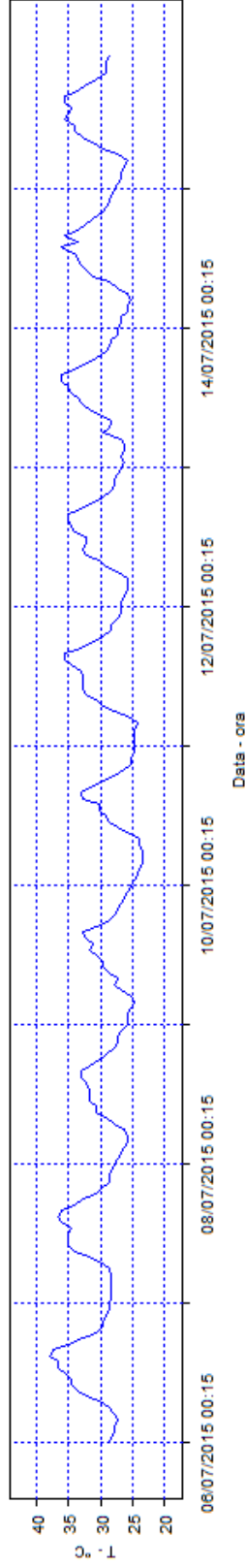
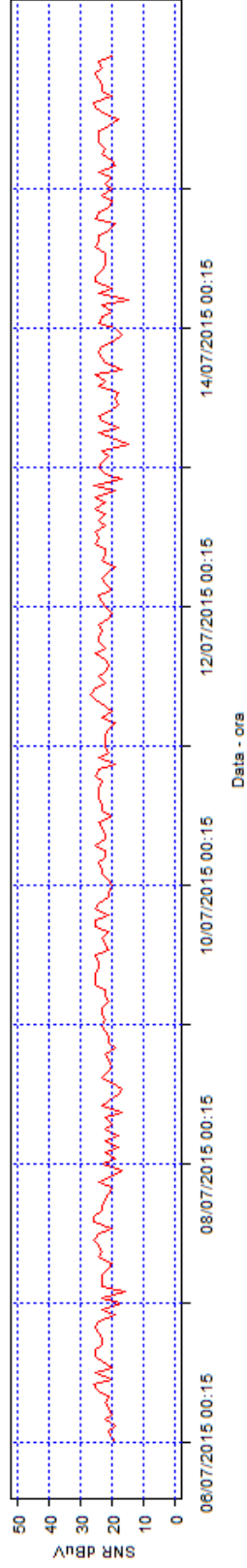
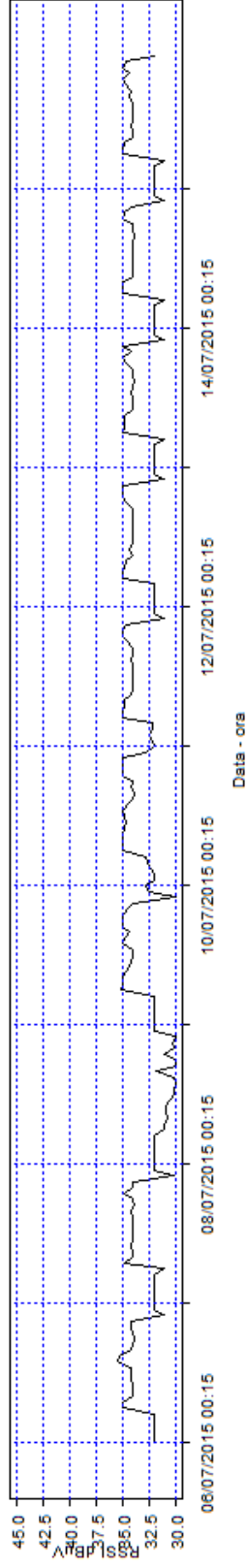
Data are stored in a SD memory card.

Each component is in a watertight box (IP65) with external alimentation .

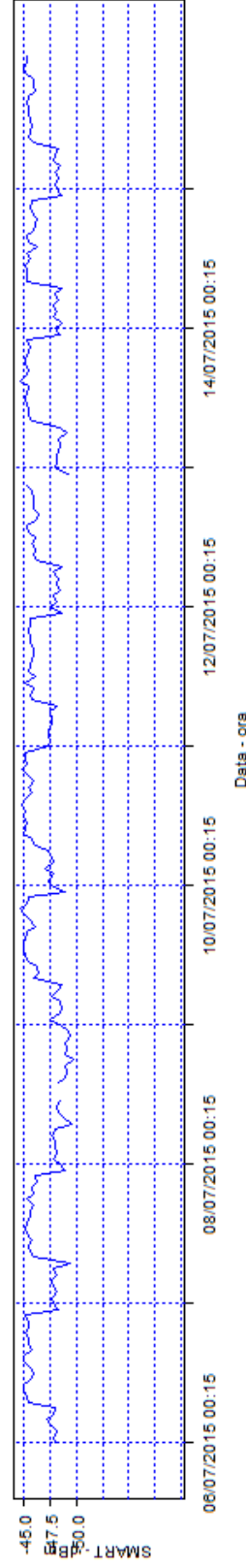




Andamento RSSI - SNR - temperatura - frequenza 98.7 MHz



Valori rilevati da SMART - frequenza 98.7 MHz



RF ELECTROMAGNETIC FIELDS MONITORING NETWORK

- Not fixed monitoring points \Rightarrow Moving monitoring stations
- Long term measurements \Rightarrow Time analysis of emf exposure levels
- Total number of network points \Rightarrow Number of monitoring stations – Duration of monitoring in each point.





RF ELECTROMAGNETIC FIELDS MONITORING NETWORK

AIMS OF NETWORK

- **Control of the sites with several co-located transmitters, where exposure limits for population could be exceeded**
- **Give information to population on RF emf exposure levels;**
- **Activate procedures to reduce the exposure levels when they exceed the attention thresholds**



CRITERIA FOR POSITIONING OF MONITORING STATIONS

- Regional territory divided in a grid of 10 km X 10 km cells. One monitoring station located in each cell containing a city where is installed at least one radio base station for mobile phone (about 270 monitoring points);
- One monitoring station positioned in the vicinity of broadcast site located near residences. (about 140 monitoring points corresponding to 70 % of the total broadcast sites in Piemonte region);
- One long term monitoring with duration of three months in the areas where the exposure limits were exceeded (about 150 monitoring points);
- One monitoring point per 7500 residents in cities with more than 15.000 inhabitants (about 300 monitoring points)



MONITORING NETWORK IN PIEMONTE REGION

800 Monitored areas

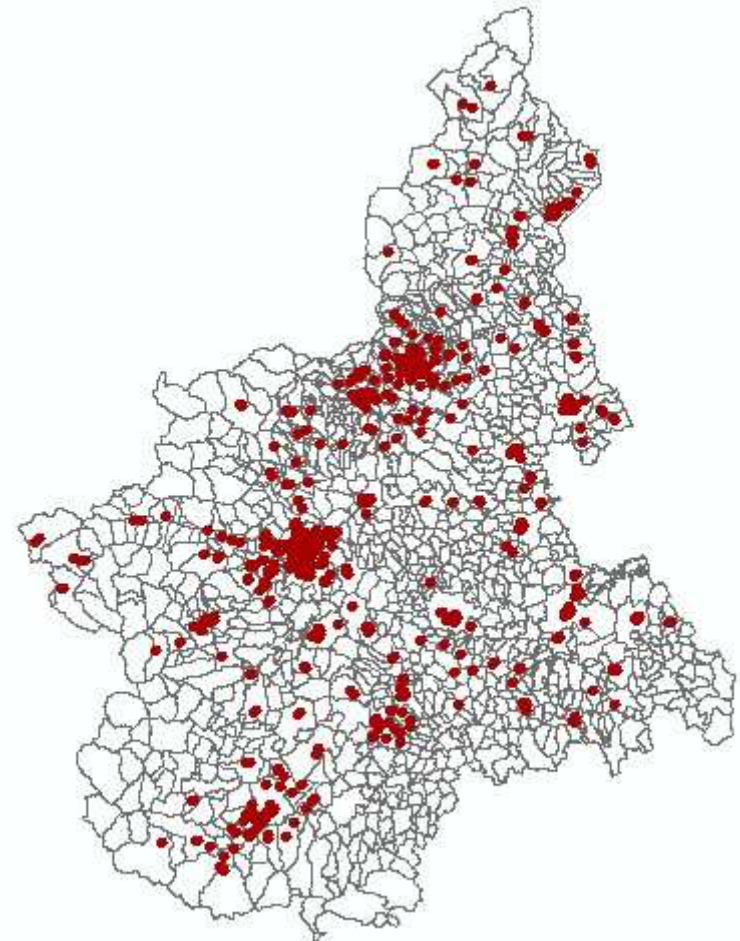
650 in the vicinity of RBS sites

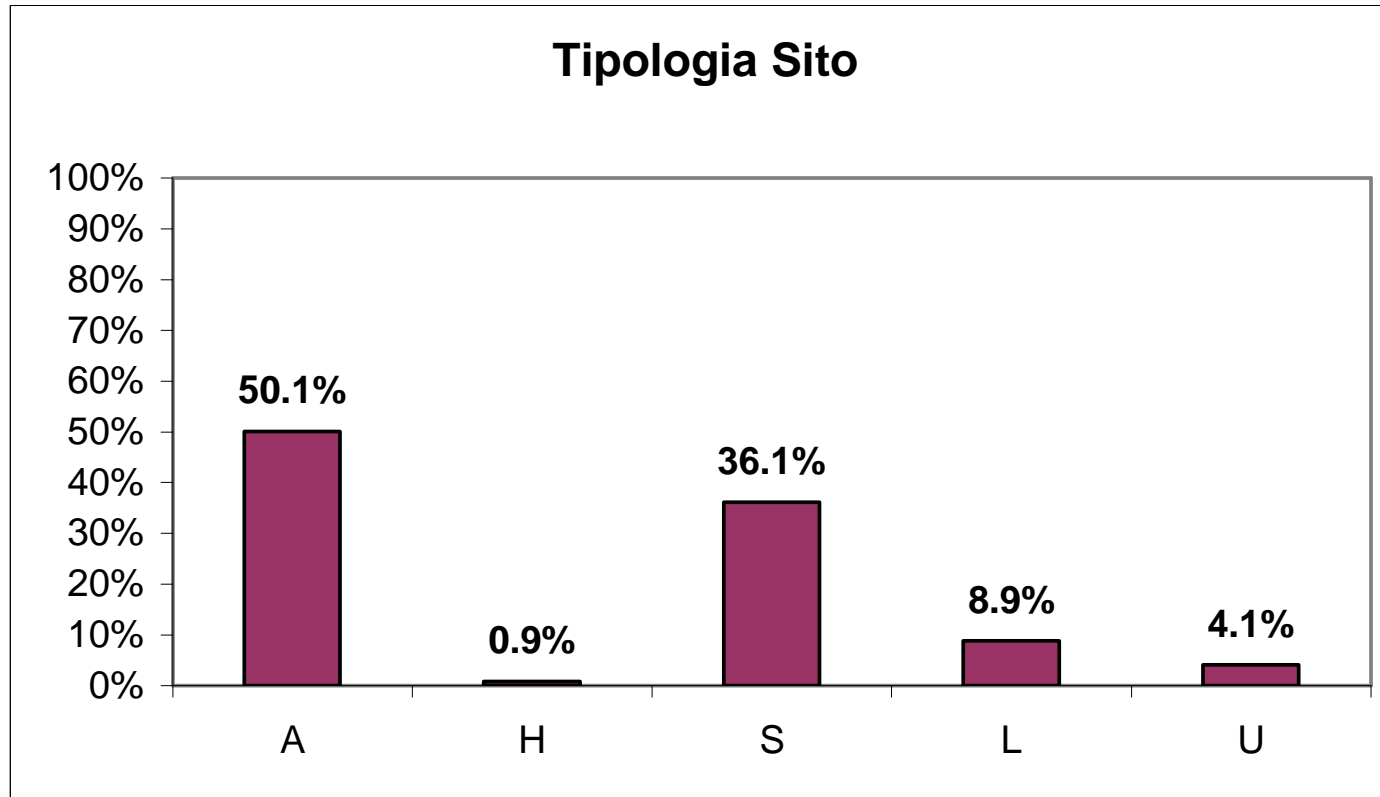
150 in the vicinity of Radio TV broadcast sites

95 MONITORING STATIONS

Average monitoring time

35 gg

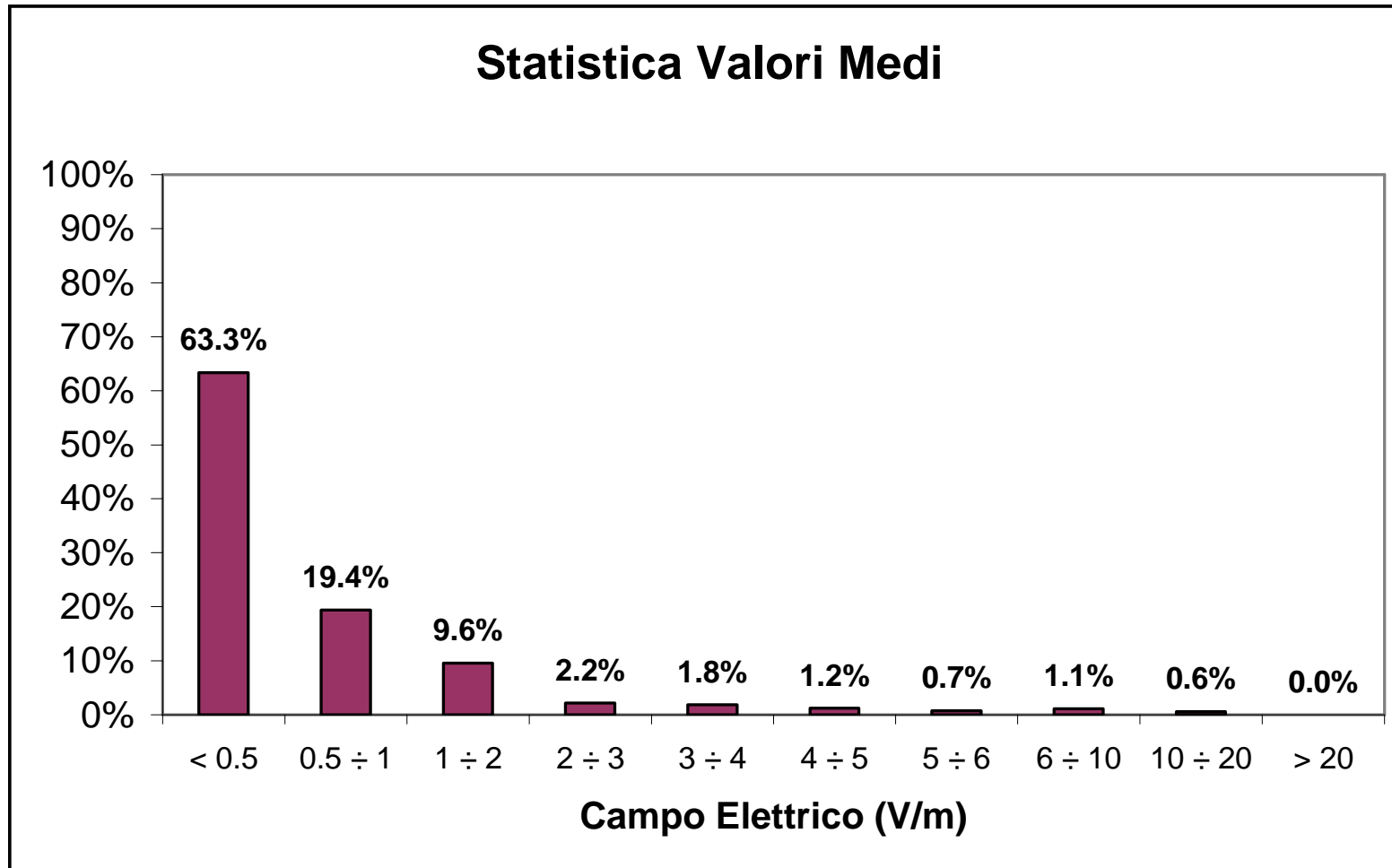




A – Residences; H – Health Structures; L – Public buildings
S – Schools; U – Offices or workplaces



Statistica Valori Medi



94 % < 3 V/m



MONITORING STATIONS NETWORK PERFORMANCE

- In 90 % of cases differences between mean electric field values measured by monitoring stations in the measurement period and instantaneous electric field values measured by broad band meter at time of positioning of removing of the monitoring stations are within 3 dB
- We observed that 85% of spot measurements made by broad band meters at time of positioning of removing the monitoring stations fall within the maximum and minimum of electric fields values detected by monitoring stations in the overall measurement period



MEASUREMENTS BY MONITORING STATIONS

ADVANTAGES

- ✓ Time variation analysis of RF emission levels from controlled telecommunication antennas;
- ✓ By a network of monitoring stations we can know the RF exposure levels in different points at the same time. So exposure levels measured in different points can be correlated (difficulties in performing measurements in places where access is limited such as in private residences)
- ✓ remote control allows to realize monitoring of environmental RF electromagnetic field by reducing on site surveys (to rationalize human resources in monitoring activities)



MEASUREMENTS BY MONITORING STATIONS

DISVANTAGES

- ✓ Monitoring stations measurements are less accurate than spot measurements by portable broad band meters;
- ✓ Results of monitoring stations measurements cannot be used for verifying compliance with human exposure limits (operators don't attend measurements)
- ✓ Long term monitoring stations can be considered as alert systems useful to notify when anomalous situations occur



谢谢