EMF exposure assessment through an online application: time and frequency domain data acquisition and processing

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Institute of Applied Physics "Nello Carrara“ (Italian National Research Council)

BRIC: 2017-2022

A collaborative research call

- Entrusted by INAIL (National Institute for Insurance against Accidents at Work)
- to CNR-IFAC (“Nello Carrara” Institute for Applied Physics of the Italian National Research Council)
- Italian National Institute of Health (ISS)
- "Scientific Hospitalization and Care Institute" Policlinico San Matteo
- Local Health Authority of Tuscany

INAIL
ISTITUTO NAZIONALE PER L'ASSICURAZIONE CONTRO GLI INFORTUNI SUL LAVORO

IFAC

ISTITUTO SUPERIORE DI SANITÀ

OSPITALE DI S. MATTEO PAVIA

SST Azienda USL Toscana centro
Servizio Sanitario della Toscana

IFAC

U.R.S.I.

BRIC: 2017-2022

A collaborative research call: 3° started in June 2023

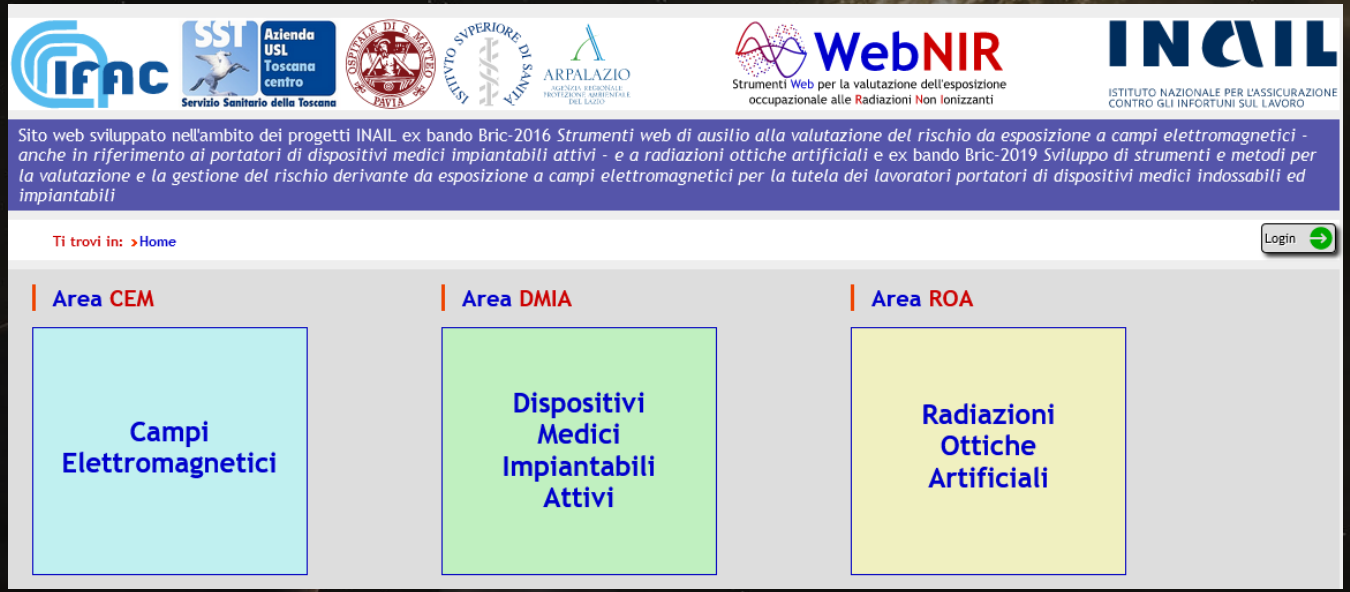
Risk assessment and management deriving from exposure to new electromagnetic field sources for the protection of workers wearing active wearable and implantable medical devices

https://webnir.eu

The web portal

Exposing different resources:

- Web tools
- Documents
- Procedures



https://webnir.eu

The web portal

3 main sections:

- Electromagnetic fields
- Artificial optical radiation
- Active implantable medical devices

https://webnir.eu

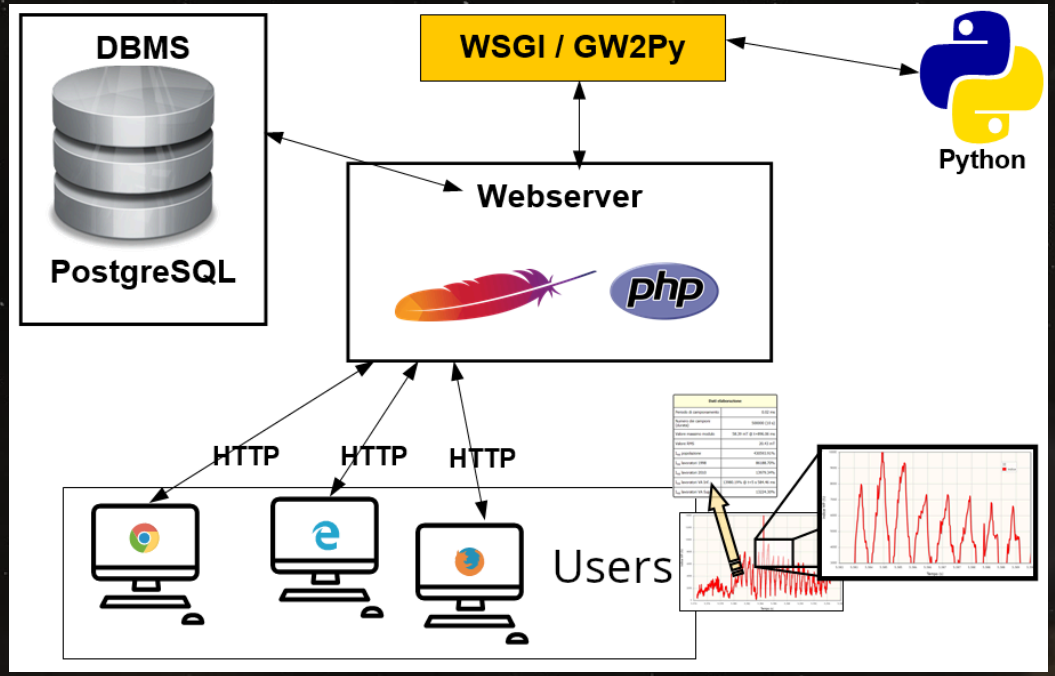
The web portal

Several EMF subsections:

- General aspects (regulatory limits…)
- Calculation of the distance of respect
- Characterization of sources in the external environment
- Applications to support reduction to compliance
- Processing data files from exposure measurements
- …

https://webnir.eu

How does it work?



- **Web interface**: HTML, Javascript, jQuery
- **Server side**: PHP, Python
- **Gw2Py**: POST data to server, get data from server
- **DBMS**: PostgreSQL
- **JSON** as a standard data exchange format

https://webnir.eu

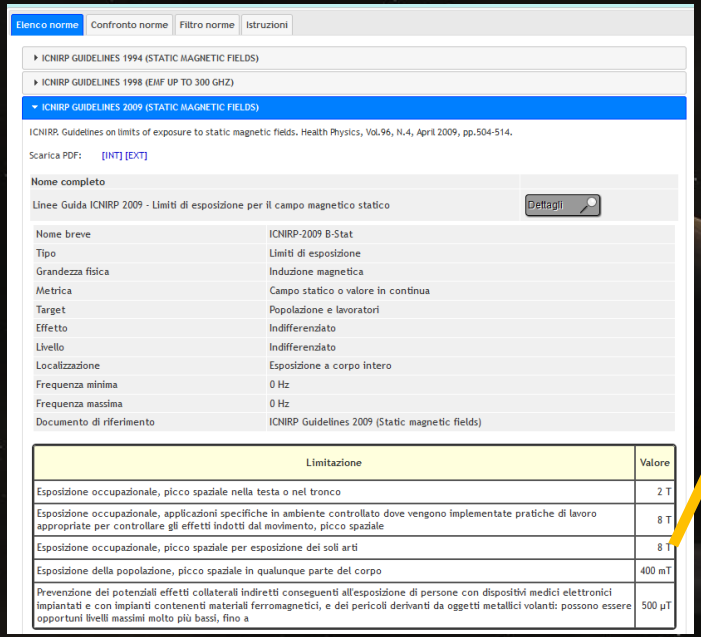
What shall we see?

{json}

- Consultation and comparison of regulatory limits
- Interpolation of index measurements and calculation of the distance of respect with determination of uncertainty
- Processing data files from exposure measurements
- Case study: assessment of the exposure to gradient magnetic fields generated by MRI tomographs

EMF web tools

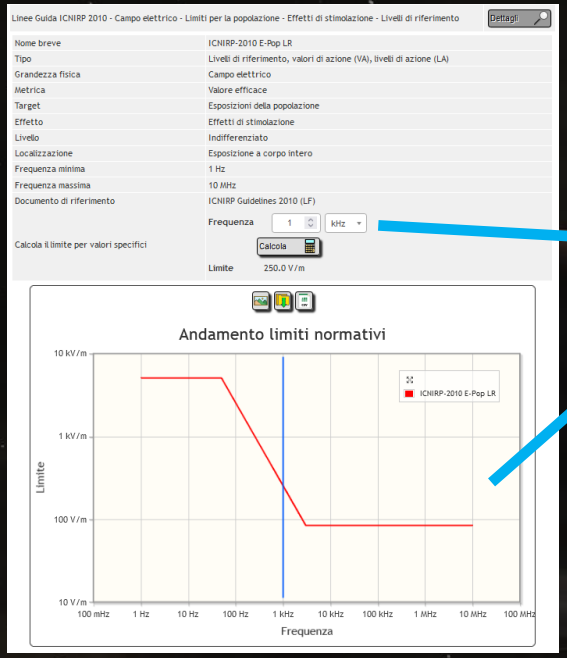
General aspects: Consultation and comparison of regulatory limits



- Limits are stored in a Database
- One ICNIRP guideline (or other document) displayed in a tab
- Fixed limits displayed in a table

EMF web tools

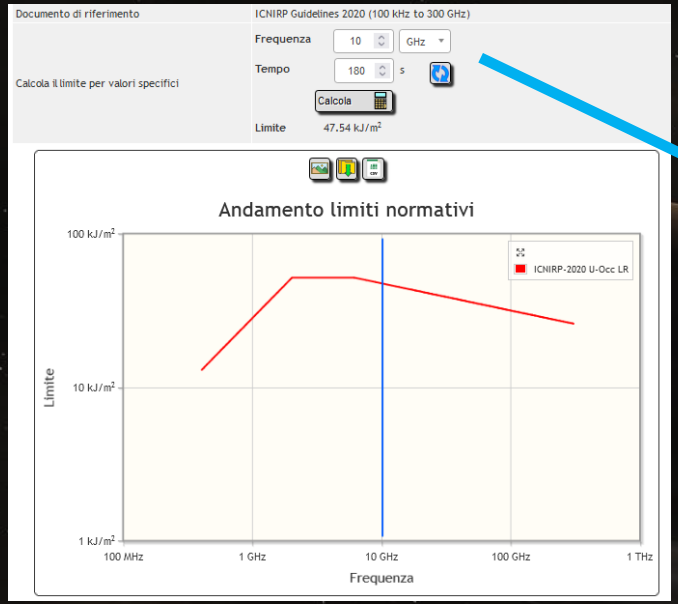
General aspects: Consultation and comparison of regulatory limits



- Limits are stored in a Database
- One ICNIRP guideline (or other document) displayed in a tab
- User can calculate limit depending on frequency
- Plot in function of frequency

EMF web tools

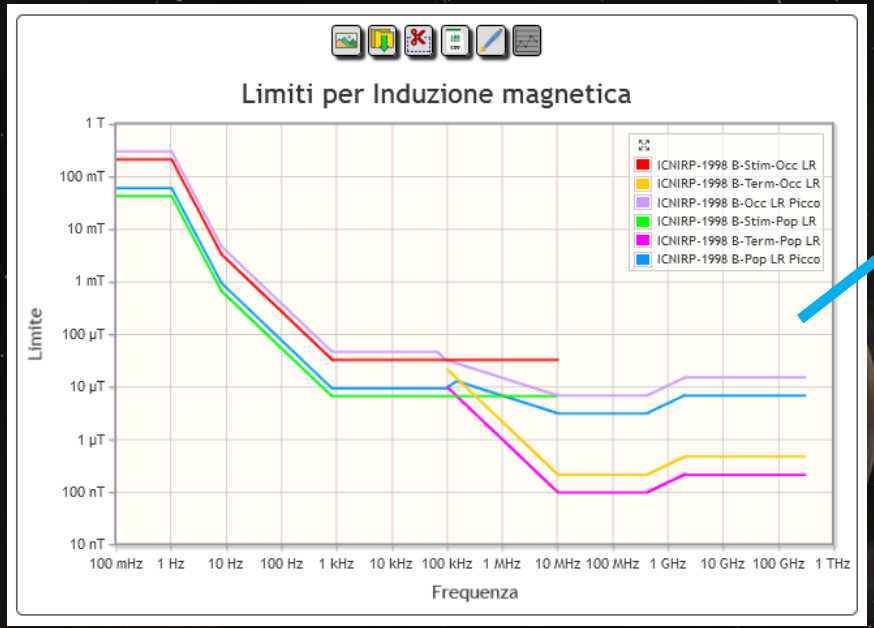
General aspects: Consultation and comparison of regulatory limits



- Limits are stored in a Database
- One ICNIRP guideline (or other document) displayed in a tab
- In ICNIRP guidelines 2020 limits depend both on time interval AND frequency value

EMF web tools

General aspects: Consultation and comparison of regulatory limits

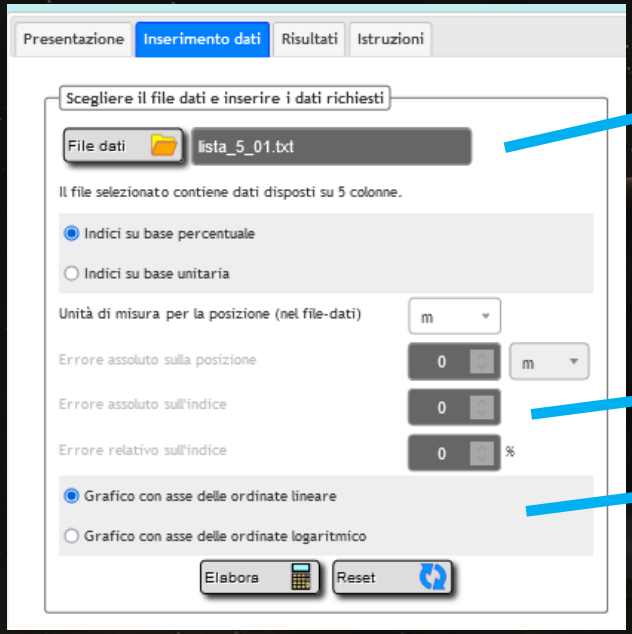


Comparison of limits:

- User can select a set of limits to compare
- Plot all of them (one physical quantity per graph)

EMF web tools

Interpolation of index measurements and calculation of the distance of respect with determination of uncertainty



1) Select a text file:

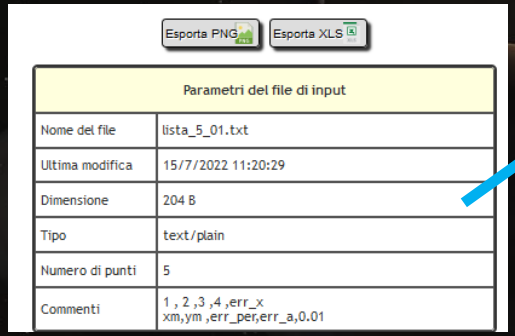
```
0.20,99.99
0.40,17.06
1.16,1.04
1.20,1.00
1.80,0.24
```

2) Insert distance unit and errors

3) Choose kind of graph (lin/log)

EMF web tools

Interpolation of index measurements and calculation of the distance of respect with determination of uncertainty



Esporta PNG Esporta XLS

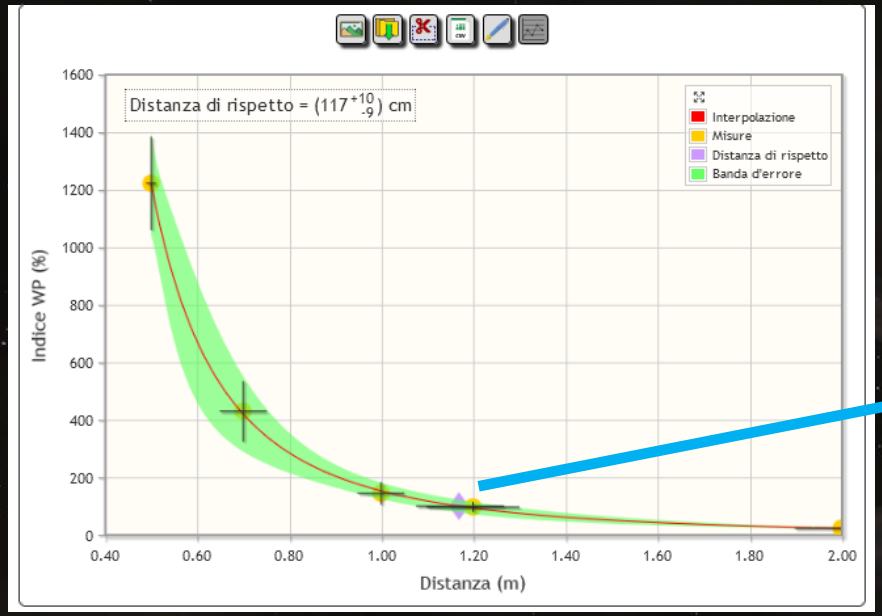
Parametri del file di input	
Nome del file	lista_5_01.txt
Ultima modifica	15/7/2022 11:20:29
Dimensione	204 B
Tipo	text/plain
Numero di punti	5
Commenti	1 , 2 ,3 ,4 ,err_x xm,ym ,err_per,err_a,0.01

1) Main data in a table

2) Interpolation with error bars and bands in a plot

EMF web tools

Interpolation of index measurements and calculation of the distance of respect with determination of uncertainty



1) Main data in a table

2) Interpolation with error bars and bands in a plot

Analysis of complex signals

Standard method

1. Compliance with the limit is given by this formula, in which an evaluation is made for each frequency component in relation to the limit referred to that frequency.
2. It is a very conservative approach, as it is not said that all the components have a maximum at the same instant (extremely improbable situation)

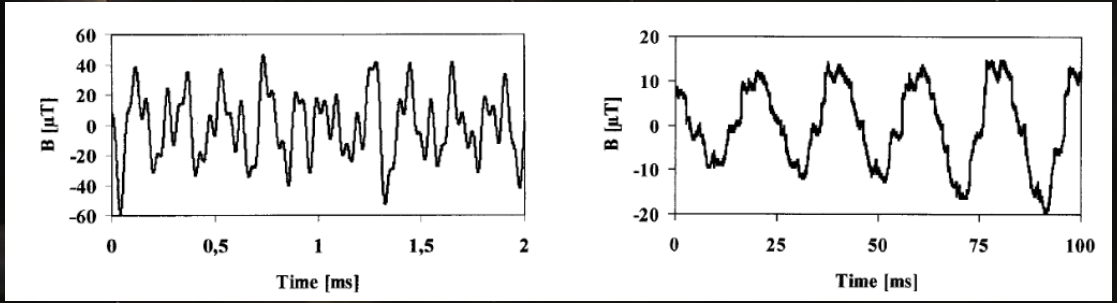
$$I_{MS} = \sum_{i=1}^{N} \frac{A_i}{L(f_i)} \leq 1$$

Analysis of complex signals

Weighted peak method (ICNIRP 2003-2010)

1. Differences in phases between different components are considered
2. Avoid overestimating the effect of the signal in an overly conservative manner
3. The approach can be shown to be valid for complex coherent and incoherent signals (complex non-sinusoidal waveforms, with or without phase coherence)

$$I_{WP} = Max\left|\sum_{i=1}^{N}\frac{A_i}{L(f_i)}\cos\left[2\pi f_i t + \vartheta_i + \varphi(f_i)\right]\right| \le 1$$



EMF web tools

Processing data files from exposure measurements

Various tools have been developed and made publicly available on the WebNIR platform.
They allow to acquire signals measured with various instrumental chains, automatically calculate the trend of the weighted peak index, and carry out other important evaluations.

EMF web tools

Processing data files from exposure measurements

3 tools:

1. Movement in a static magnetic field: Processing of perceived magnetic field measurements (Detected with Narda-Metrolab THM1176 probe)
2. Calculation of the weighted peak indices for low and intermediate frequency magnetic field sources (Data acquired with Narda ELT-400 probe and Agilent U2351A acquisition system)
3. Loading, recognition and processing of data files of measurements in time or frequency domain

EMF web tools

Processing data files from exposure measurements

3 tools:

1. Movement in a static magnetic field: Processing of perceived magnetic field measurements (Detected with Narda-Metrolab THM1176 probe)
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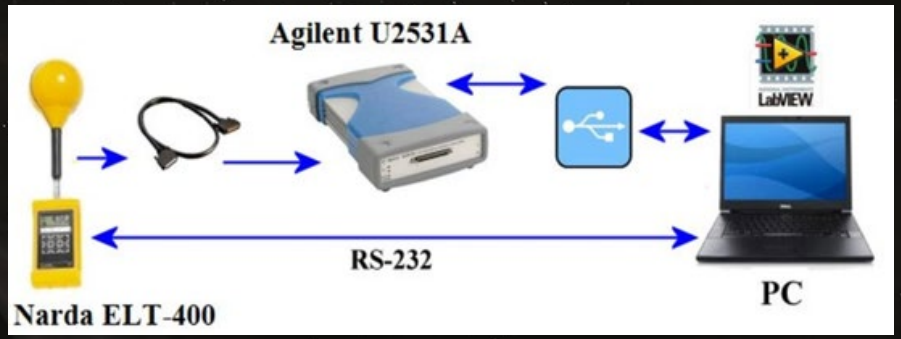
3. Upload, detection and processing of measurements data files of in time or frequency domain

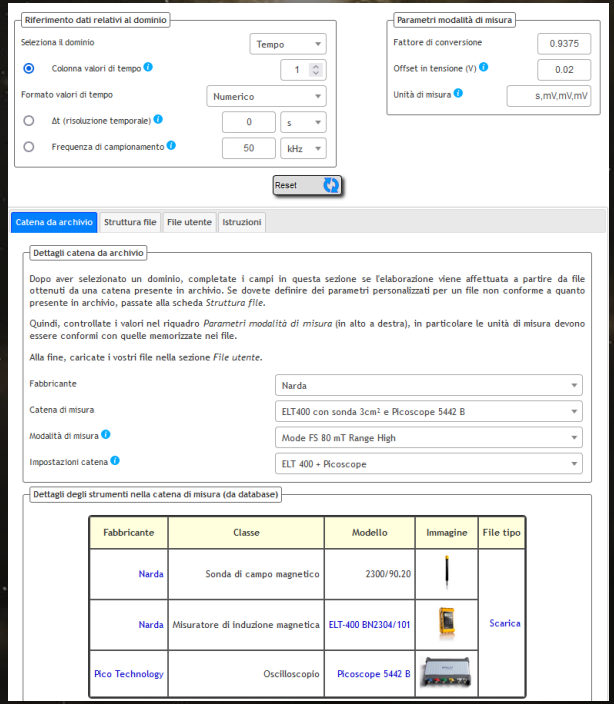


EMF web tools

Processing data files from exposure measurements

3 tools:

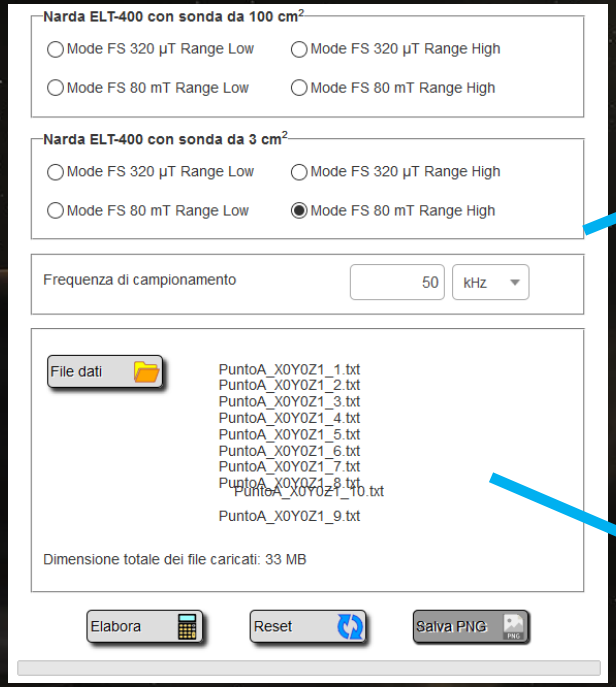
1. Movement in a static magnetic field: Processing of perceived magnetic field measurements (Detected with Narda-Metrolab THM1176 probe)
2. Calculation of the weighted peak indices for low and intermediate frequency magnetic field sources (Data acquired with Narda ELT-400 probe and Agilent U2351A acquisition system)
3. Upload, detection and processing of measurements data files in time or frequency domain (**ANY** measurement chain)



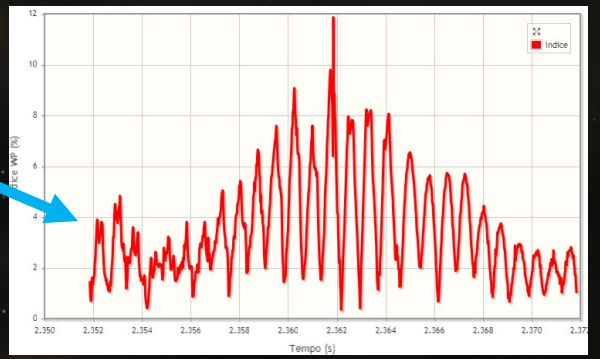
EMF web tools

Upload, detection and processing of measurements data files

- Select measurement chain
- Select measurement mode
- Set sample frequency
- Select and order data files
- Upload files and process
- Output as tables and plots



Dati elaborazione	
Periodo di campionamento	0.02 ms
Numero dei campioni (durata)	500000 (10 s)
Valore massimo modulo	58.39 mT @ t=896.06 ms
Valore RMS	20.43 mT
I_{WP} popolazione	430593.91%
I_{WP} lavoratori 1998	86188.70%
I_{WP} lavoratori 2010	13979.34%
I_{WP} lavoratori VA Inf.	13980.19% @ t=5 s 584.46 ms
I_{WP} lavoratori VA Sup.	13224.30%

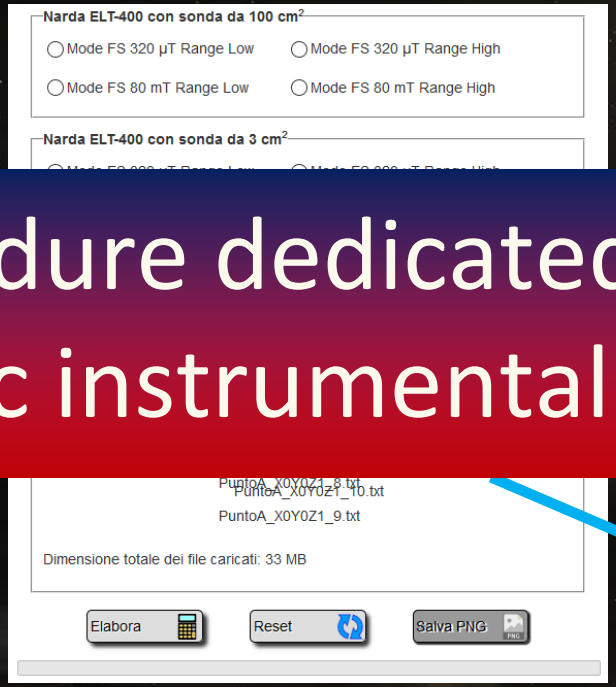


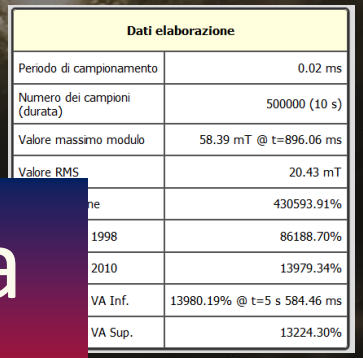
EMF web tools

Upload, detection and processing of measurements data files

- Select me
- Select me
- Set sampl
- Select an
- Upload fil
- Output as tables and plots

Procedure dedicated to a specific instrumental chain





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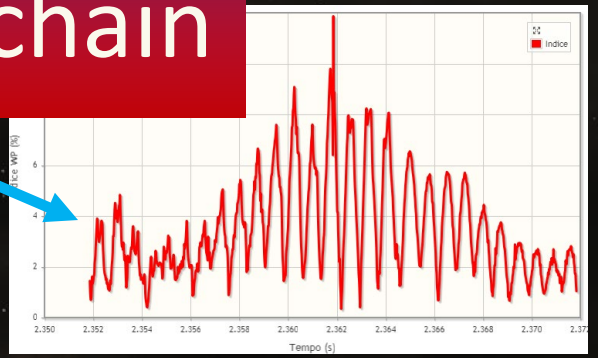


EMF web tools

Upload, detection and processing of measurements data files

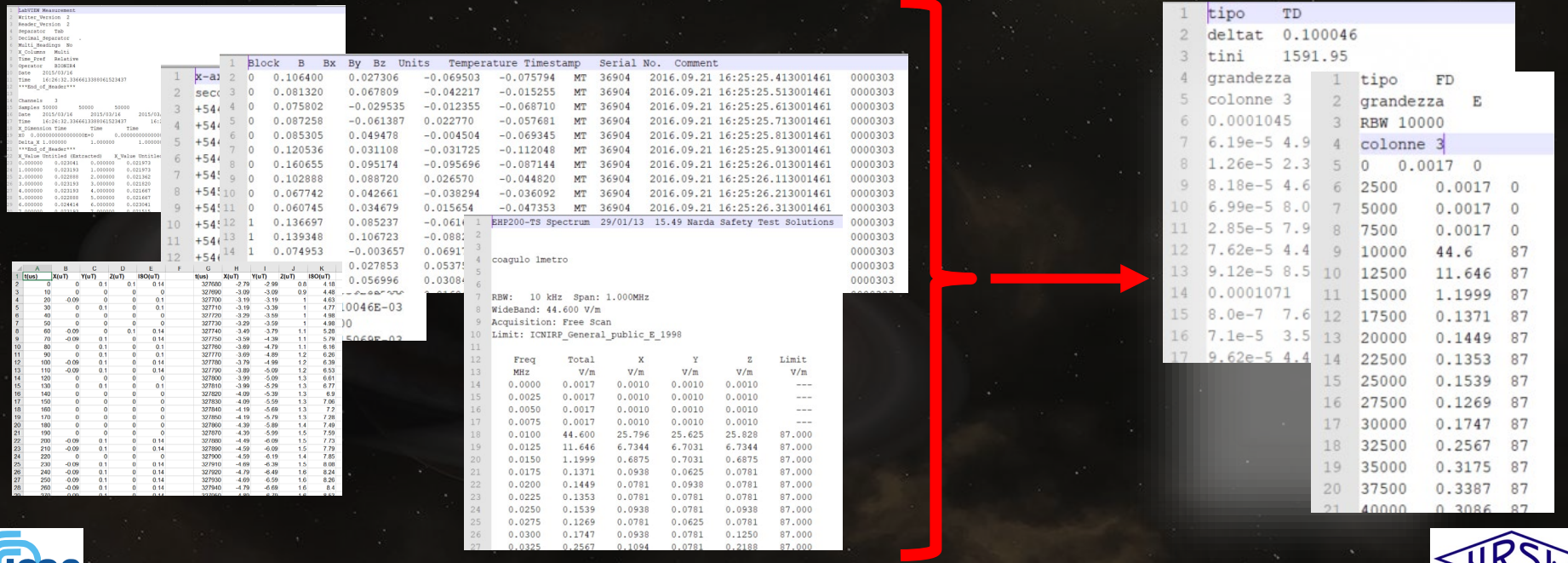
General procedure: 3 options

1. Specific measurement chain procedure
2. Measurement chain present in our database, but no specific procedure: generalized data file acquisition system
3. Measurement chain not present in database: user must provide data file structure info

EMF web tools

Upload, detection and processing of measurements data files

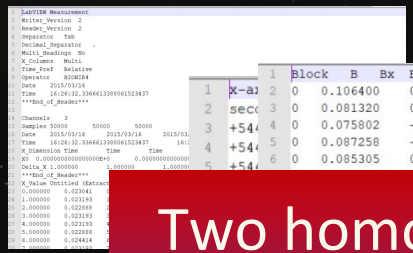
Creating homogeneous format files

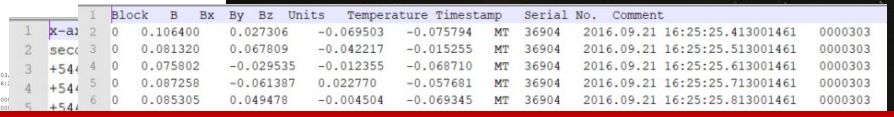


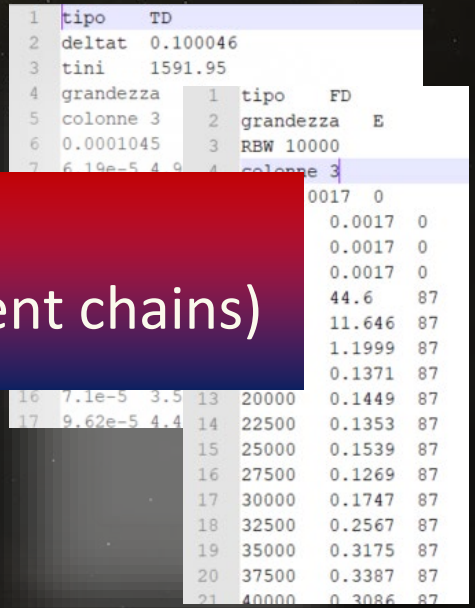
EMF web tools

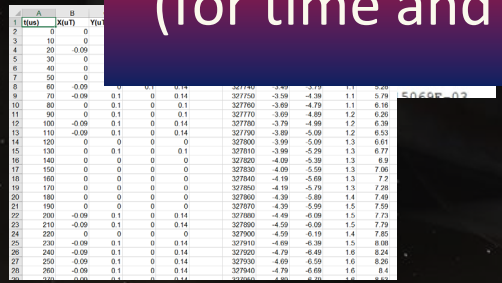
Upload, detection and processing of measurements data files

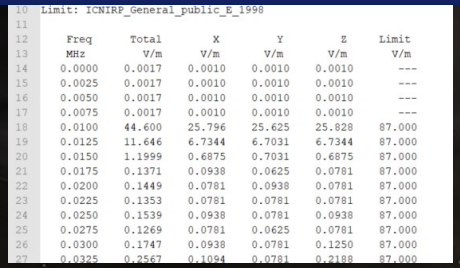
Creating homogeneous format files









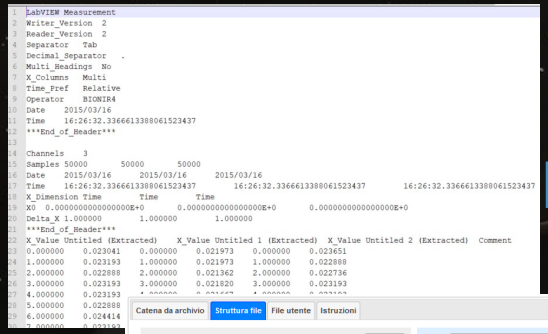


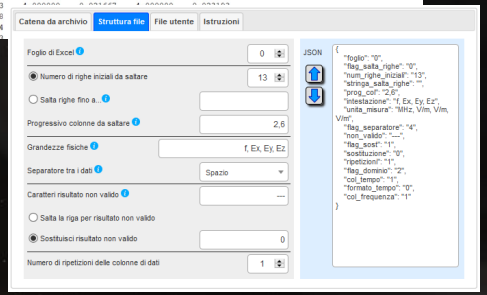
Two homogeneous formats are created
(for time and frequency operating measurement chains)

EMF web tools

Upload, detection and processing of measurements data files

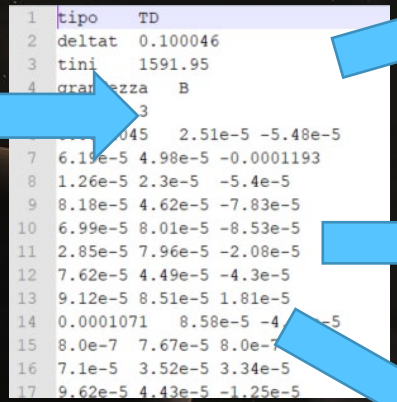
Data file

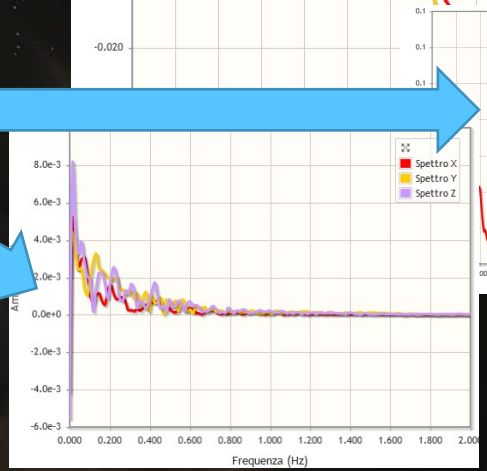


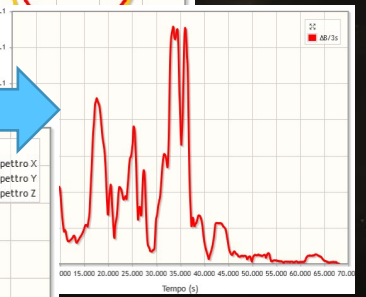


Information on file structure

Standard file



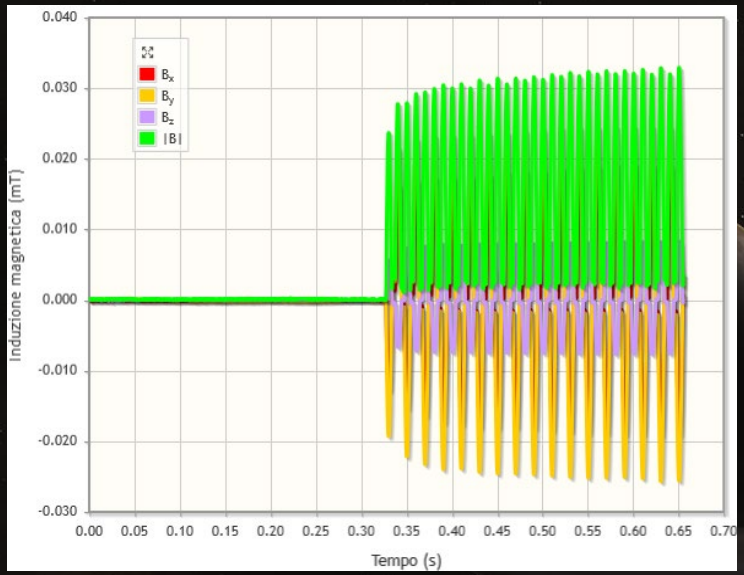


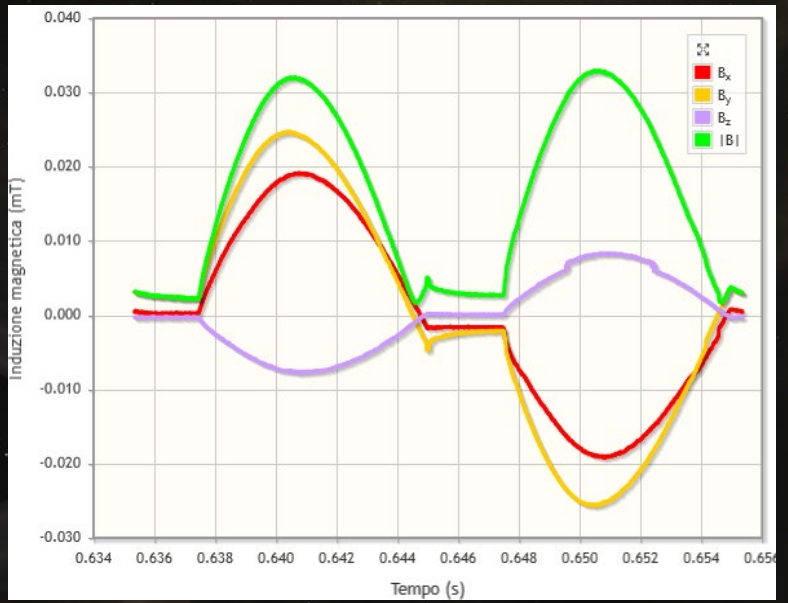


EMF web tools

Upload, detection and processing of measurements data files

Data output: components and module of H/B/E fields (condensed or all-data modes)



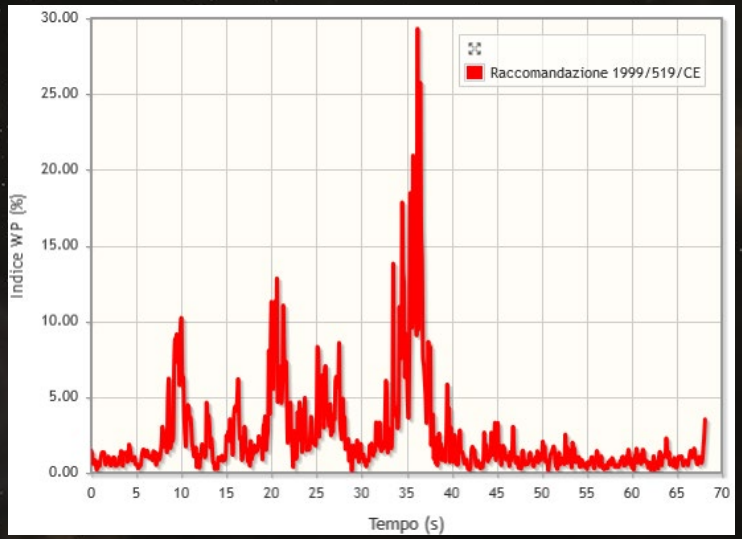


EMF web tools

Upload, detection and processing of measurements data files

Data output: wheighted peak indices, according to different regulations

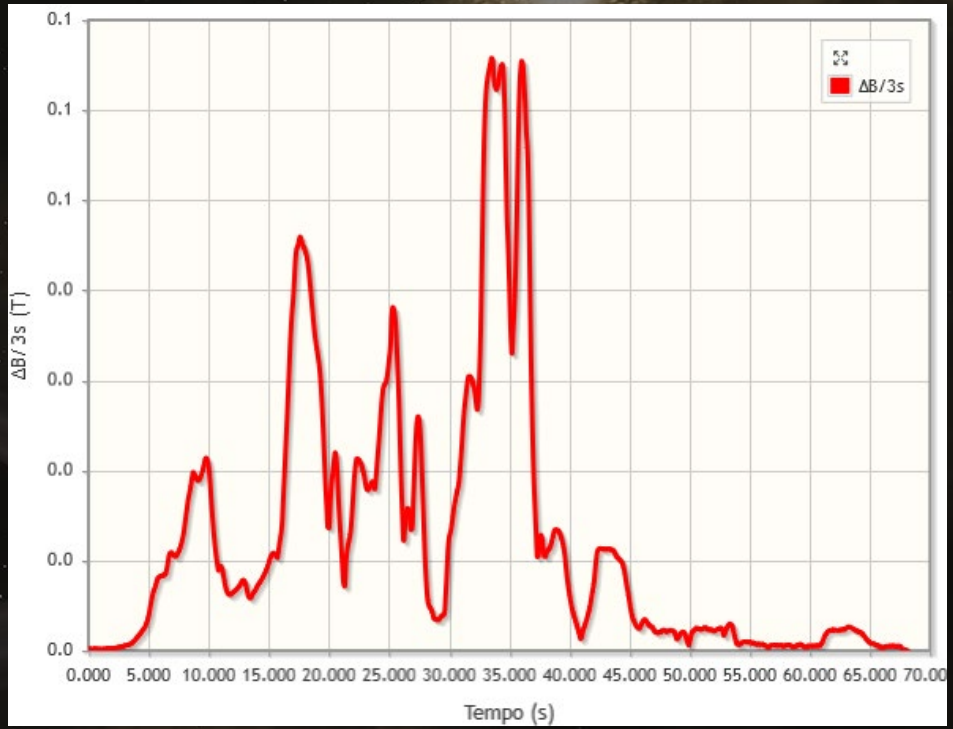
Indici WP	
Raccomandazione 1999/519/CE	29.3%
ICNIRP 1998 Lavoratori	5.8%
ICNIRP 2010 Lavoratori	5.8%
D.Lgs.159/2016 VA inferiori	7.6%
D.Lgs.159/2016 VA superiori	3.7%
D.Lgs.159/2016 VA negli arti	1.2%



EMF web tools

Upload, detection and processing of measurements data files

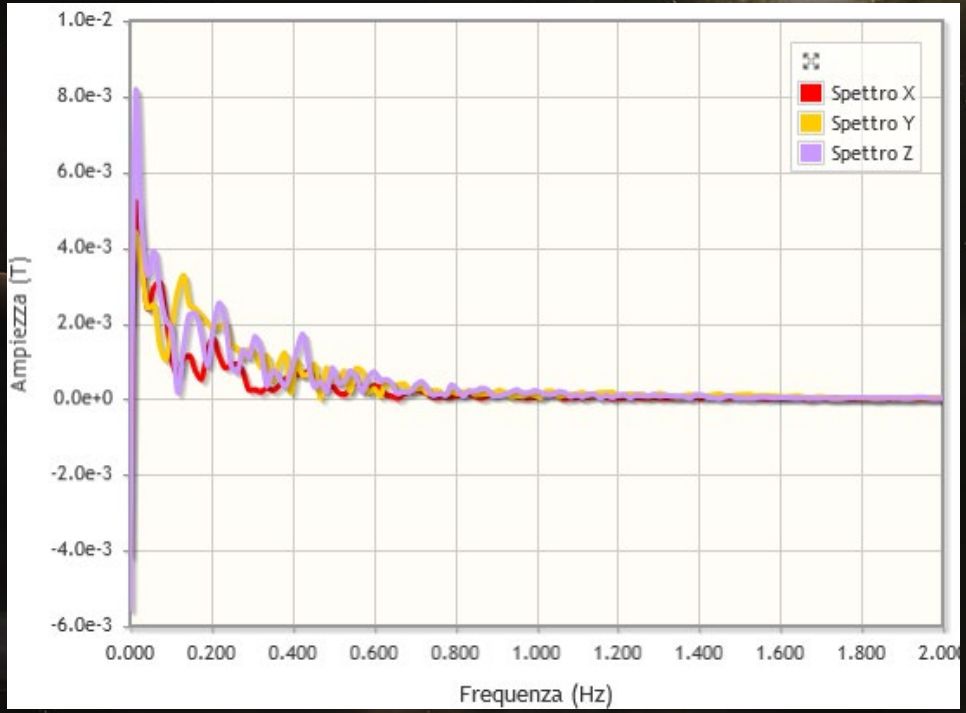
Data output: Max ΔB/3s and its trend over time



EMF web tools

Upload, detection and processing of measurements data files

Data output: spectrum in continuous/discrete format



EMF web tools

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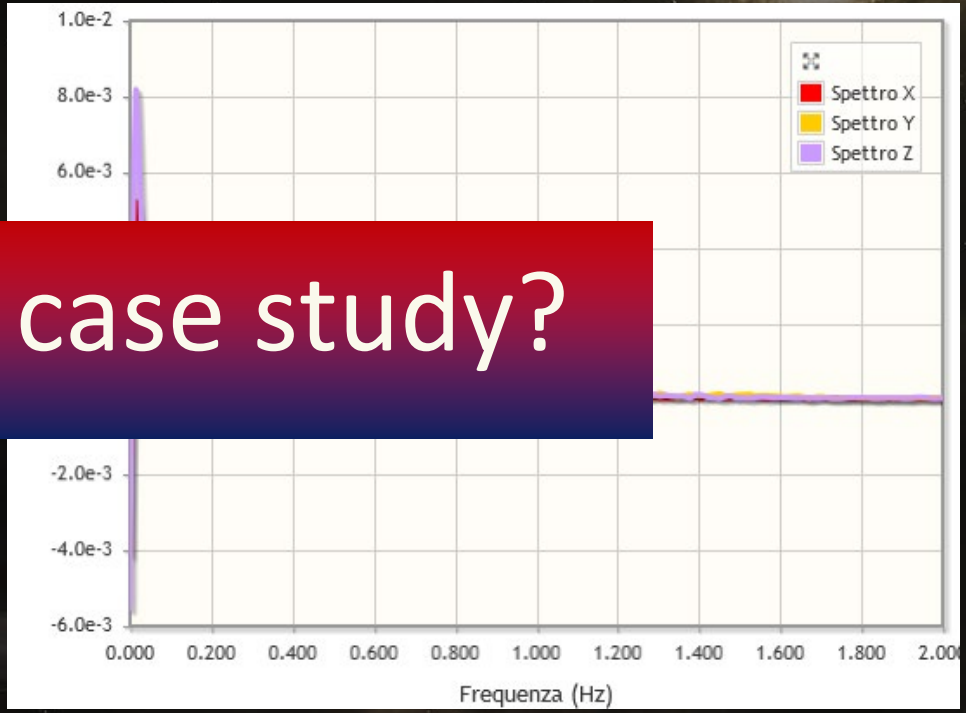
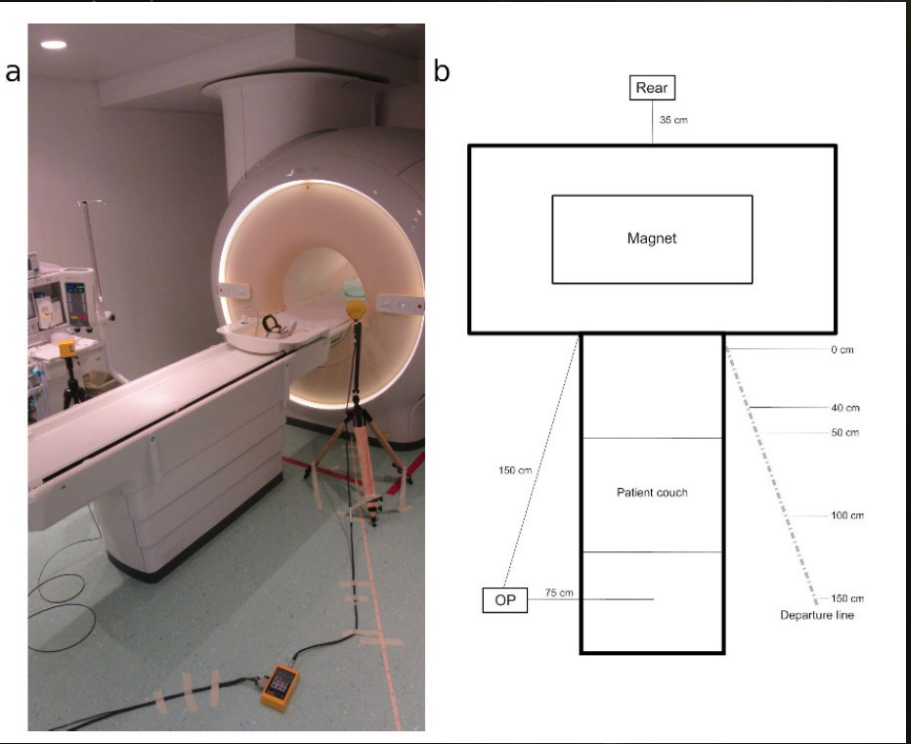


Any case study?

EMF web tools

Assessment of the exposure to gradient magnetic fields generated by MRI tomographs

- Tests carried out on different tomographs (1 and 1.5 T)

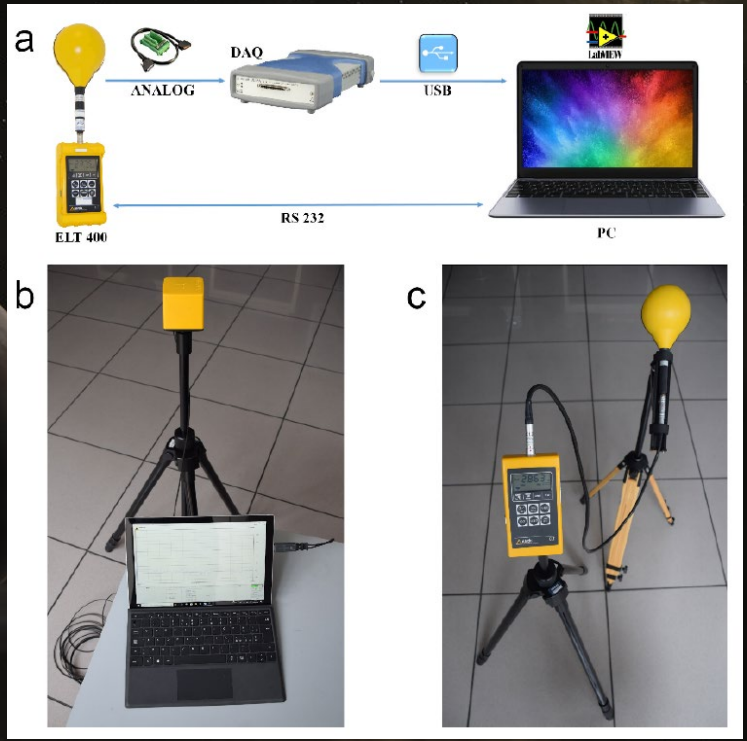


EMF web tools

Assessment of the exposure to gradient magnetic fields generated by MRI tomographs

Different instrumental chains:

- Narda ELT-400 probe, data acquired via Agilent ADC
- Narda ELT-400, stand alone setup
- Narda EHP-50F



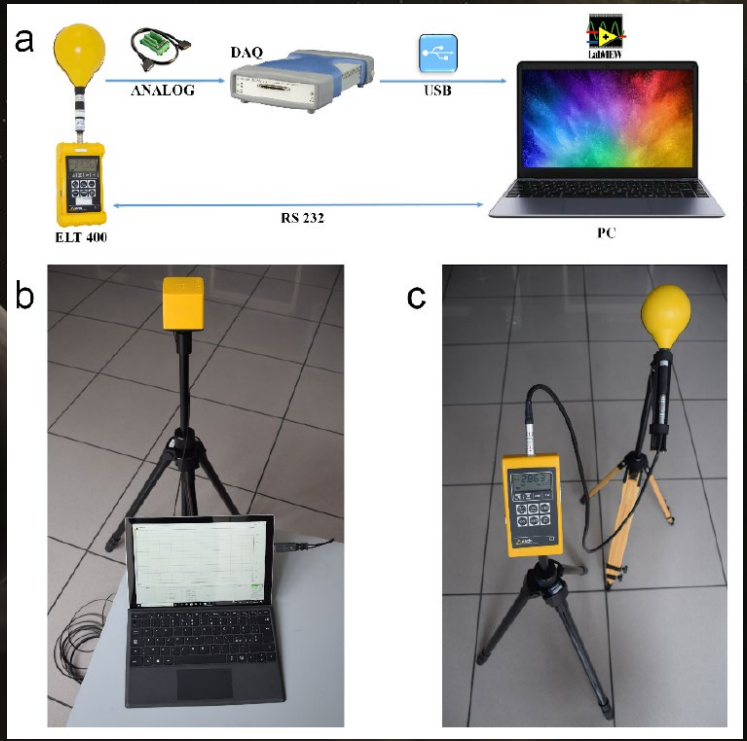
EMF web tools

Assessment of the exposure to gradient magnetic fields generated by MRI tomographs

Different instrumental chains:

- Narda ELT-400 probe, data acquired via Agilent ADC: provides raw data (analog output), skilled personnel required for data analysis

- Narda EHP-50F: Provides indexes, but no further analysis is possible



EMF web tools

Assessment of the exposure to gradient magnetic fields generated by MRI tomographs

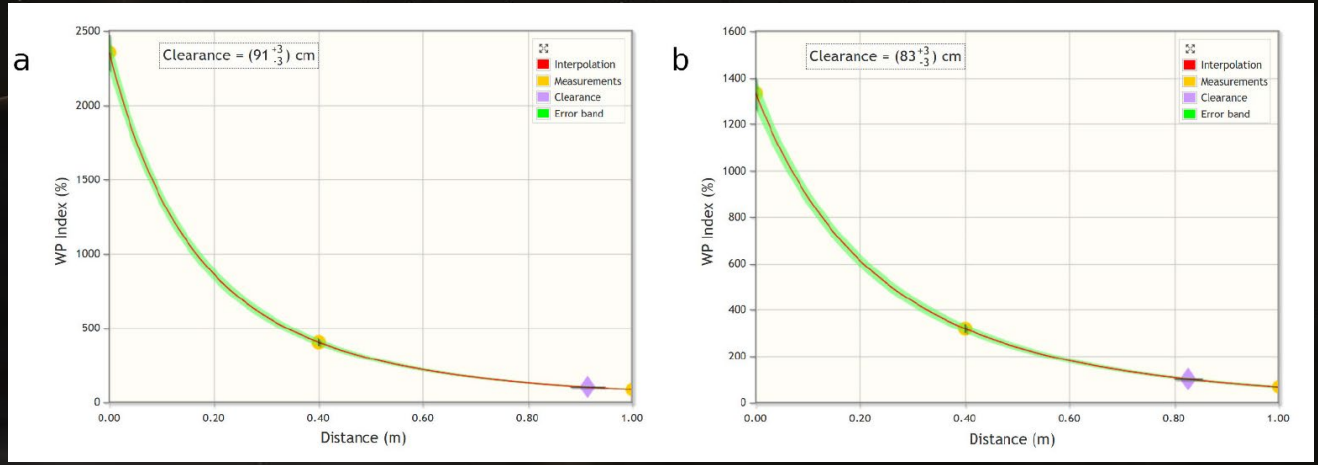
- I_{WP} calculated at every distance

Sequence	Distance (cm)	Height (cm)	RLs 1999/519/EC	Low ALs 2013/35/EU	High ALs 2013/35/EU
B1	0	100	1389%	45.0%	45.6%
	OP		22.5%	0.70%	0.60%
B2	0	100	2356%	76.0%	72.5%
	40		401%	13.0%	12.0%
	100		83%	2.50%	2.10%
	OP		51%	1.57%	1.25%
	0	160	1332%	40.1%	40.8%
	40		317%	9.70%	9.17%
	100		66%	2.00%	1.65%

EMF web tools

Assessment of the exposure to gradient magnetic fields generated by MRI tomographs

- Interpolation of indices to get a compliance area



https://webnir.eu

What else?

A few open problems:

1. Website in Italian language only
2. Not responsive
3. Some important features are missing
4. …

https://webnir.eu

What else?

Solution (almost done):

1. Developing a portal creation system
2. Based on Bootstrap (responsivity)
3. Search tool
4. Multilanguage
5. Authentication system

https://webnir.eu

What else?

And:

Using the same infrastructure on other topics (Ionizing radiations, middle-age manuscripts db management, air pollution…)
Anyone interested in joining a new project?

Thanks

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