



# **Ground motion measurements at CERN : Overview of the last decade**

Michael Guinchard – CERN

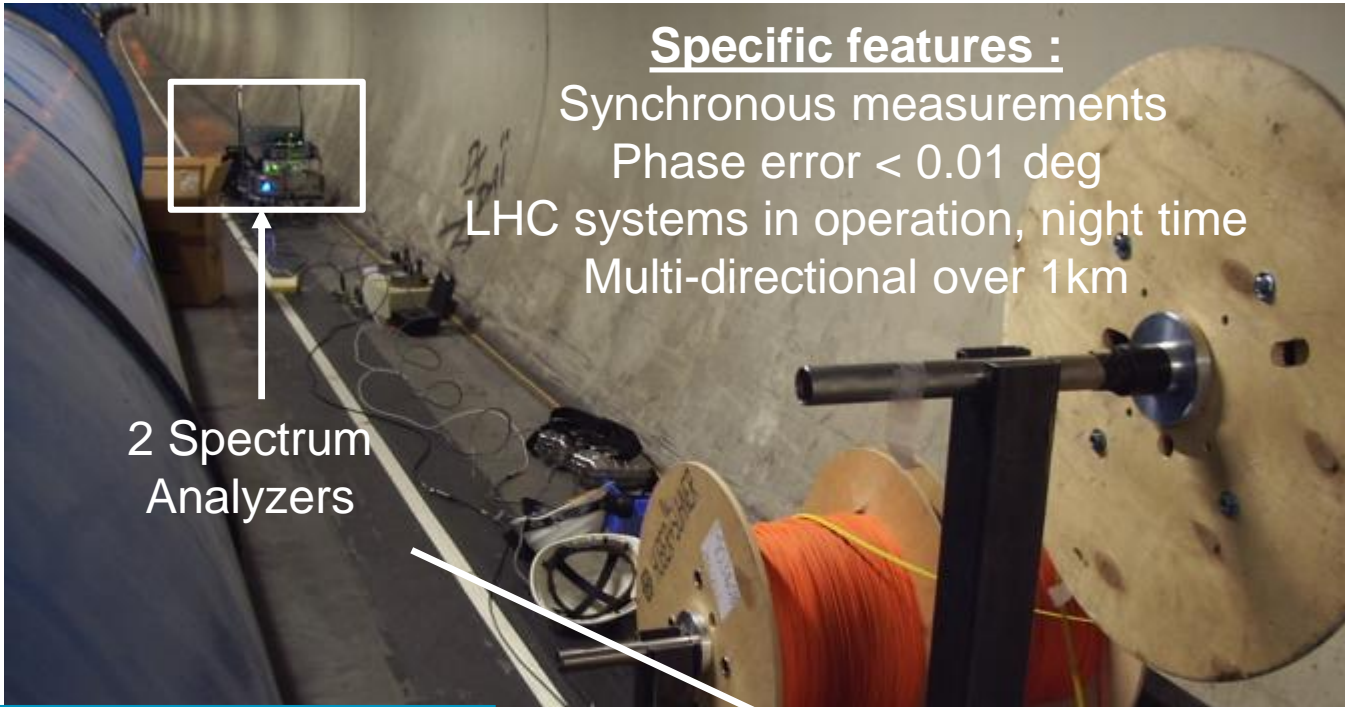
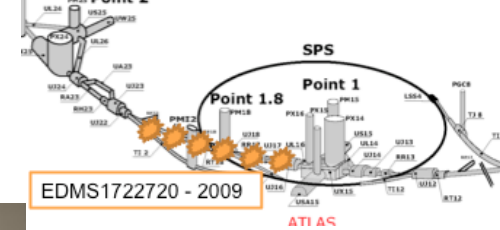
CERN – 29th September 2016

# Contents

- Ground motion measurement database
- Dynamic response of MQXA cold mass
- Seismic network status
- Conclusion



# Setup in sector 1-2

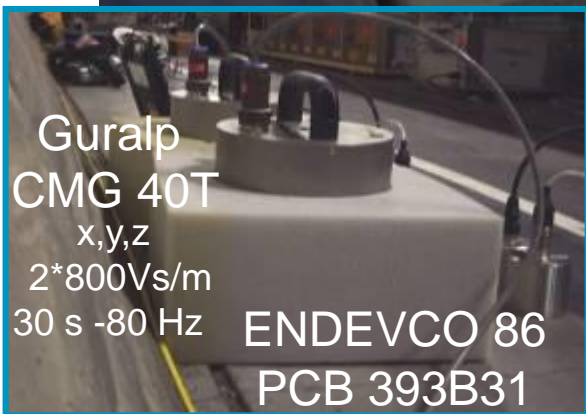


Specific features :  
 Synchronous measurements  
 Phase error < 0.01 deg  
 LHC systems in operation, night time  
 Multi-directional over 1km

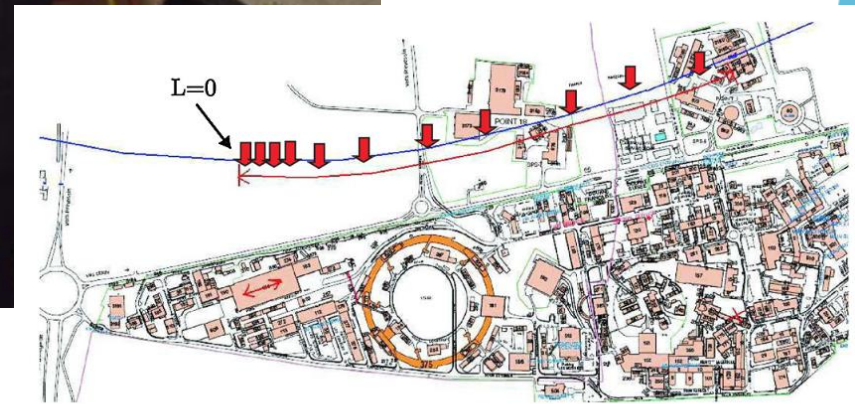
2 Spectrum Analyzers

## Parameters

Sampling rate  
**256 Hz**  
 Block duration  
**64 s**  
 Average  
**Lin - 50**  
 Overlap  
**66.7 %**

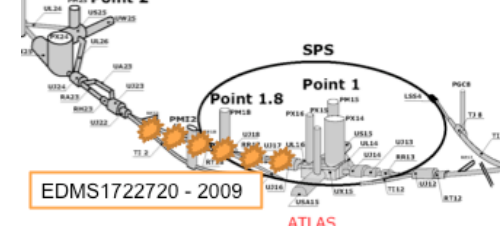


Guralp  
 CMG 40T  
 x,y,z  
 2\*800Vs/m  
 30 s -80 Hz  
**ENDEVCO 86**  
**PCB 393B31**

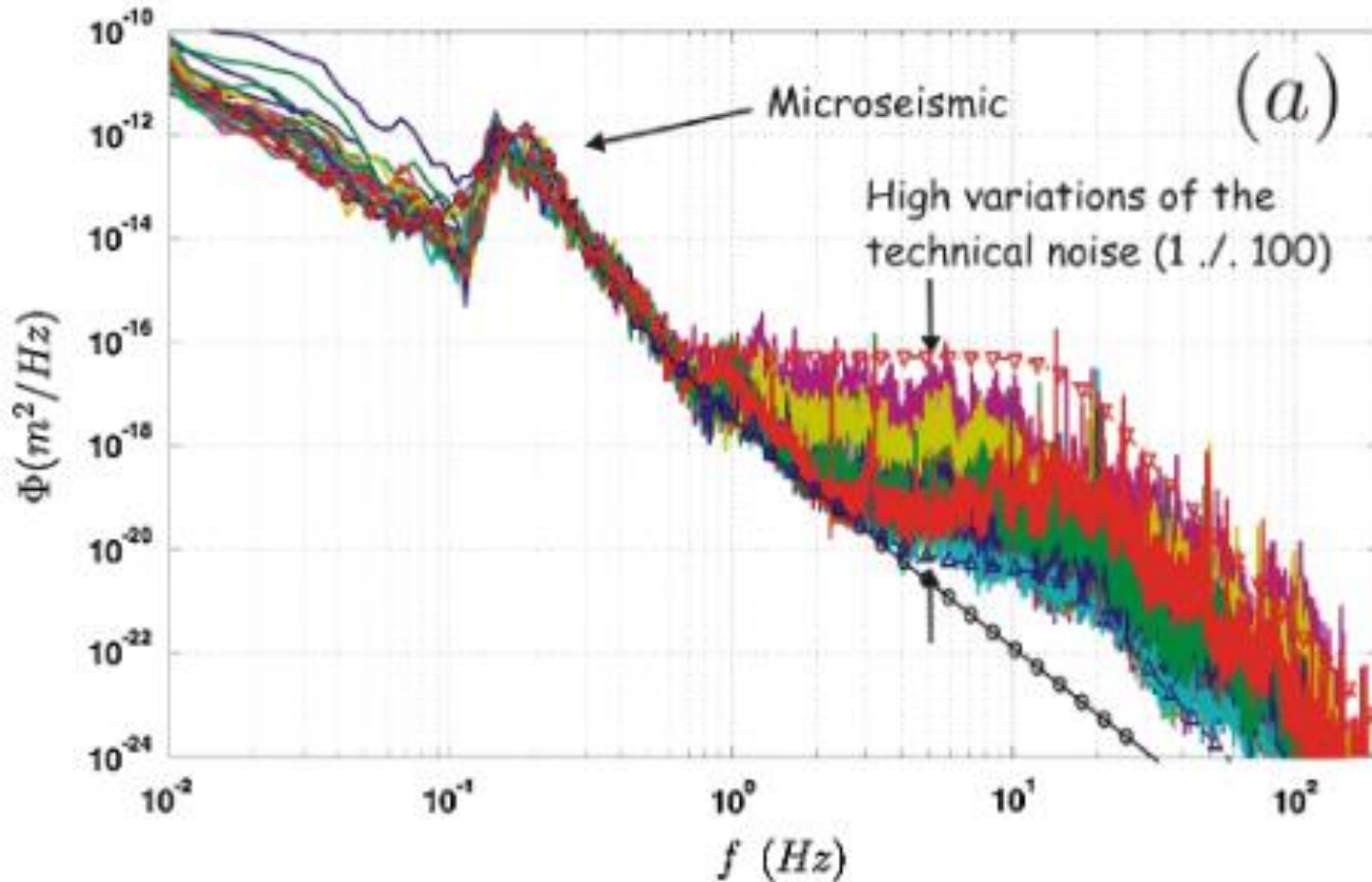


$L = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 20, 30, 38, 54, 108, 198, 306, 412, 509, 604, 706, 960\}$

# Results in sector 1-2



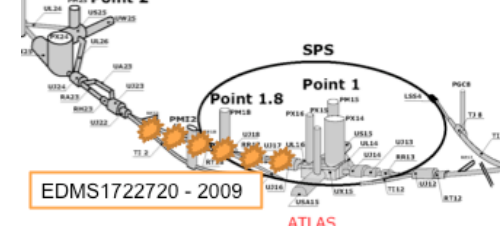
- Power spectral density over 1km distance



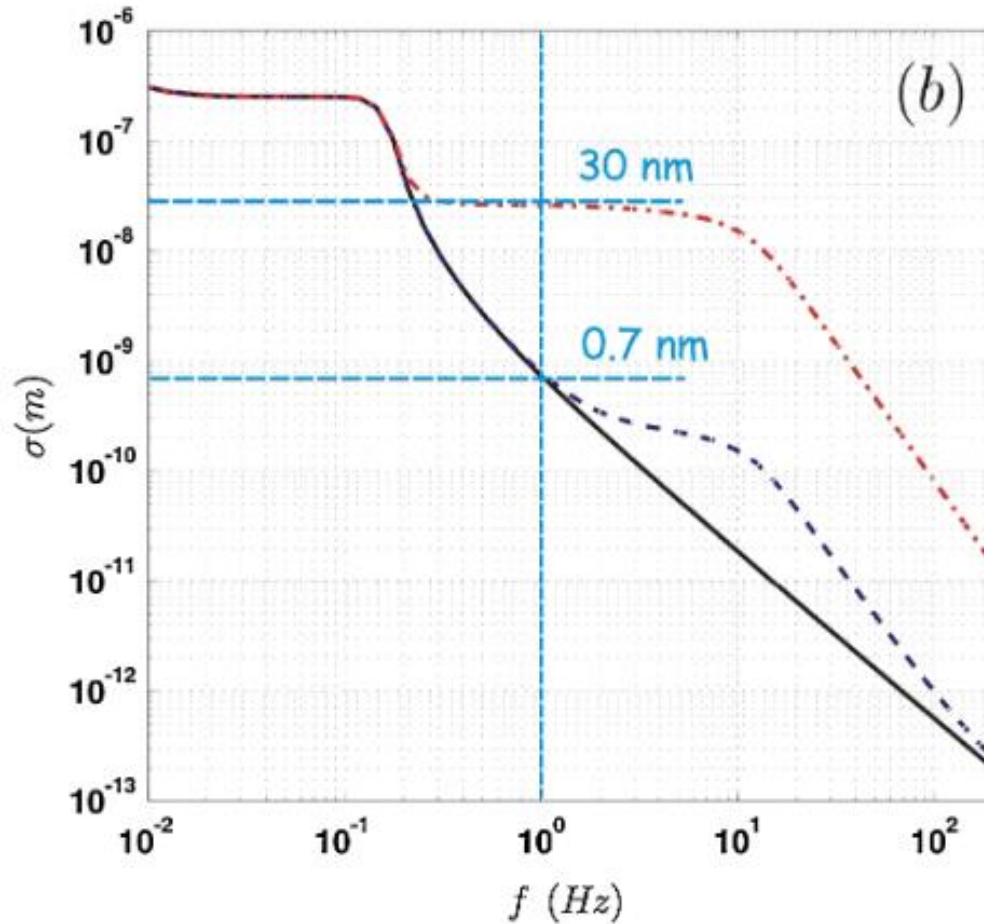
$$\text{psd} = \frac{|\text{FFT}(a)|^2}{\omega_o Q}$$



# Results in sector 1-2

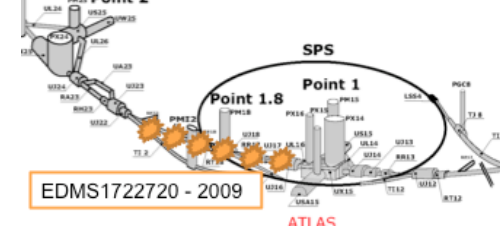


- RMS Integrated over 1km distance

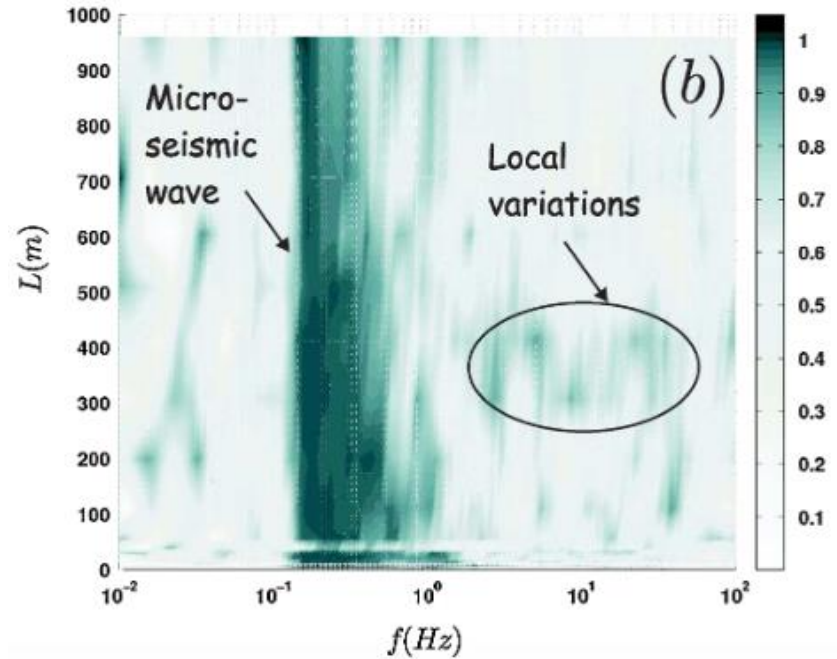
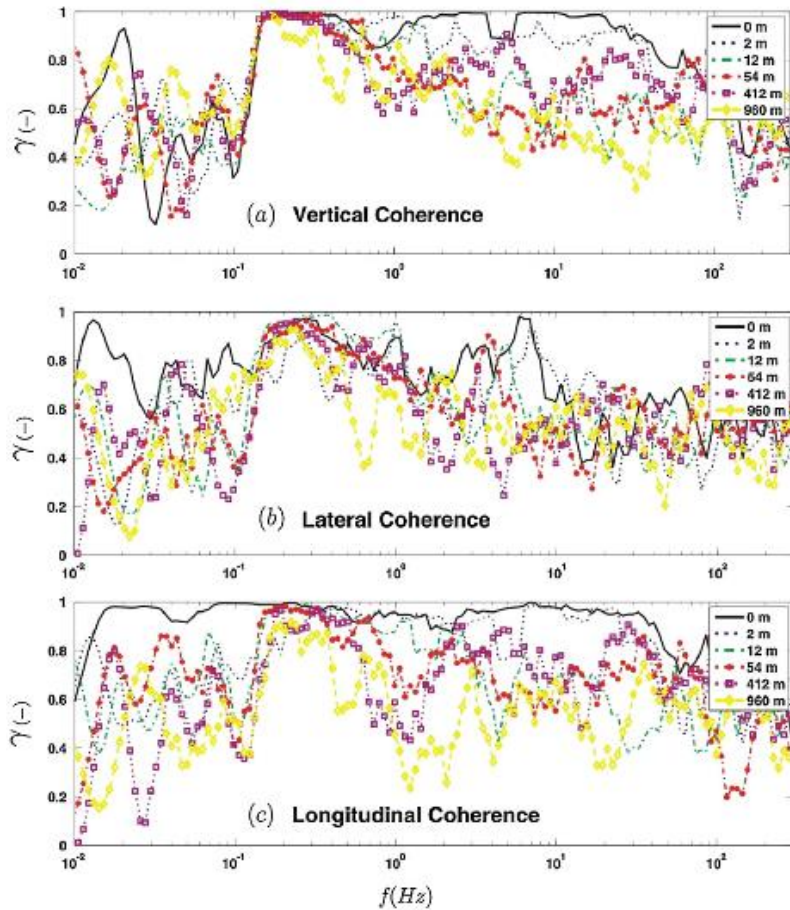


$$RMS_{int}(k) = \sqrt{\sum_{k1}^{k2} DSP(k) \Delta f}$$

# Results in sector 1-2



- Coherence length over 1km distance



PHYSICAL REVIEW SPECIAL TOPICS - ACCELERATORS AND BEAMS 13, 072801 (2010)

## Seismic response of linear accelerators

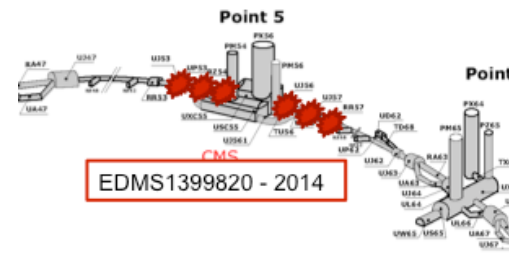
C. Collette, K. Artoos, M. Guinchard, and C. Hauviller  
 CERN, CH-1211 Geneva 23, Switzerland  
 (Received 20 November 2009; published 26 July 2010)



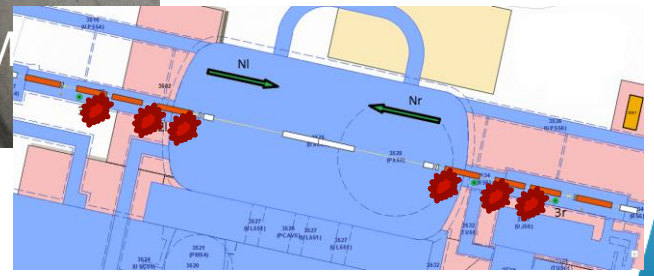
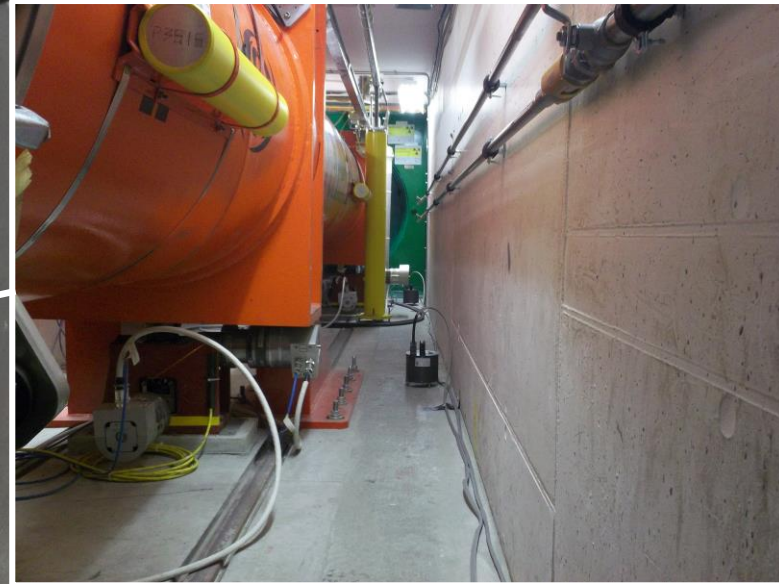
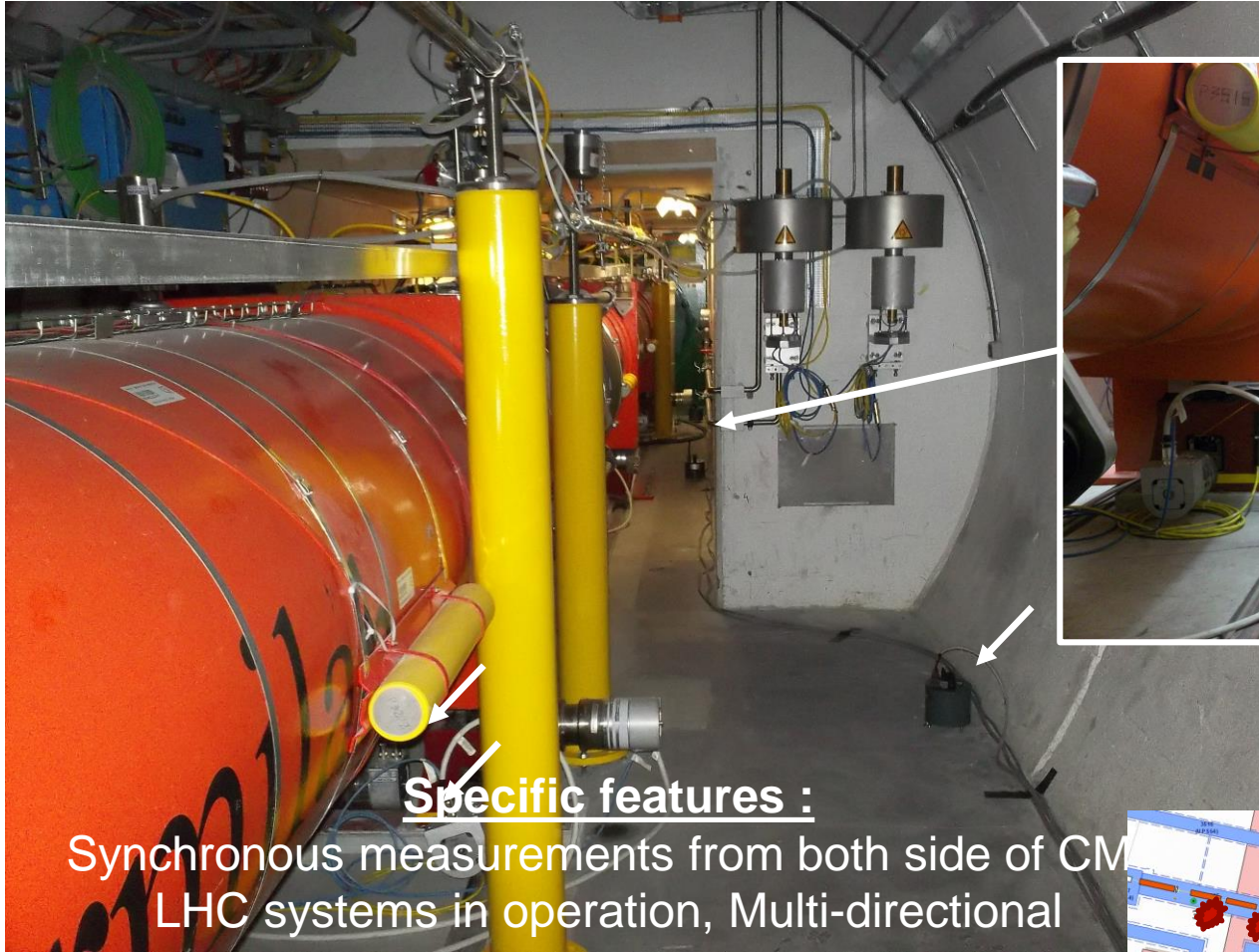
$$\hat{\gamma}_{yx}^2 = \frac{|\hat{G}_{yx}|^2}{\hat{G}_{xx}\hat{G}_{yy}} = \frac{(YX^*)(Y^*X)}{XX^*YY^*} = 1.$$



# Setup around CMS experiment



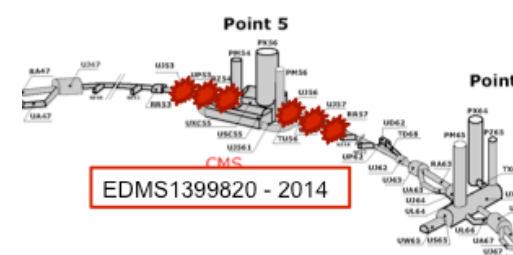
EDMS1399820 - 2014



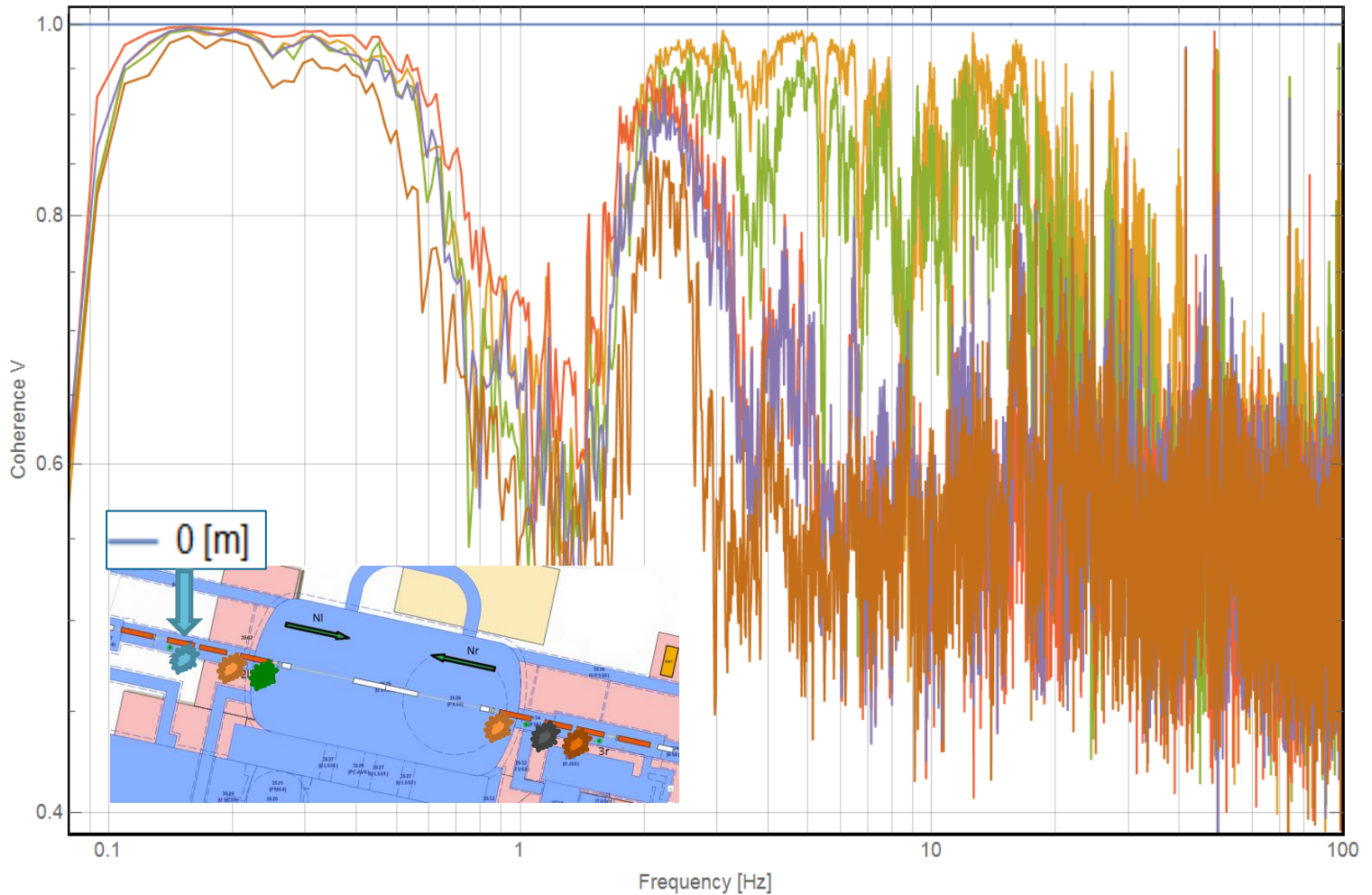
**Specific features :**  
 Synchronous measurements from both side of CMS  
 LHC systems in operation, Multi-directional



# Results around CMS experiment

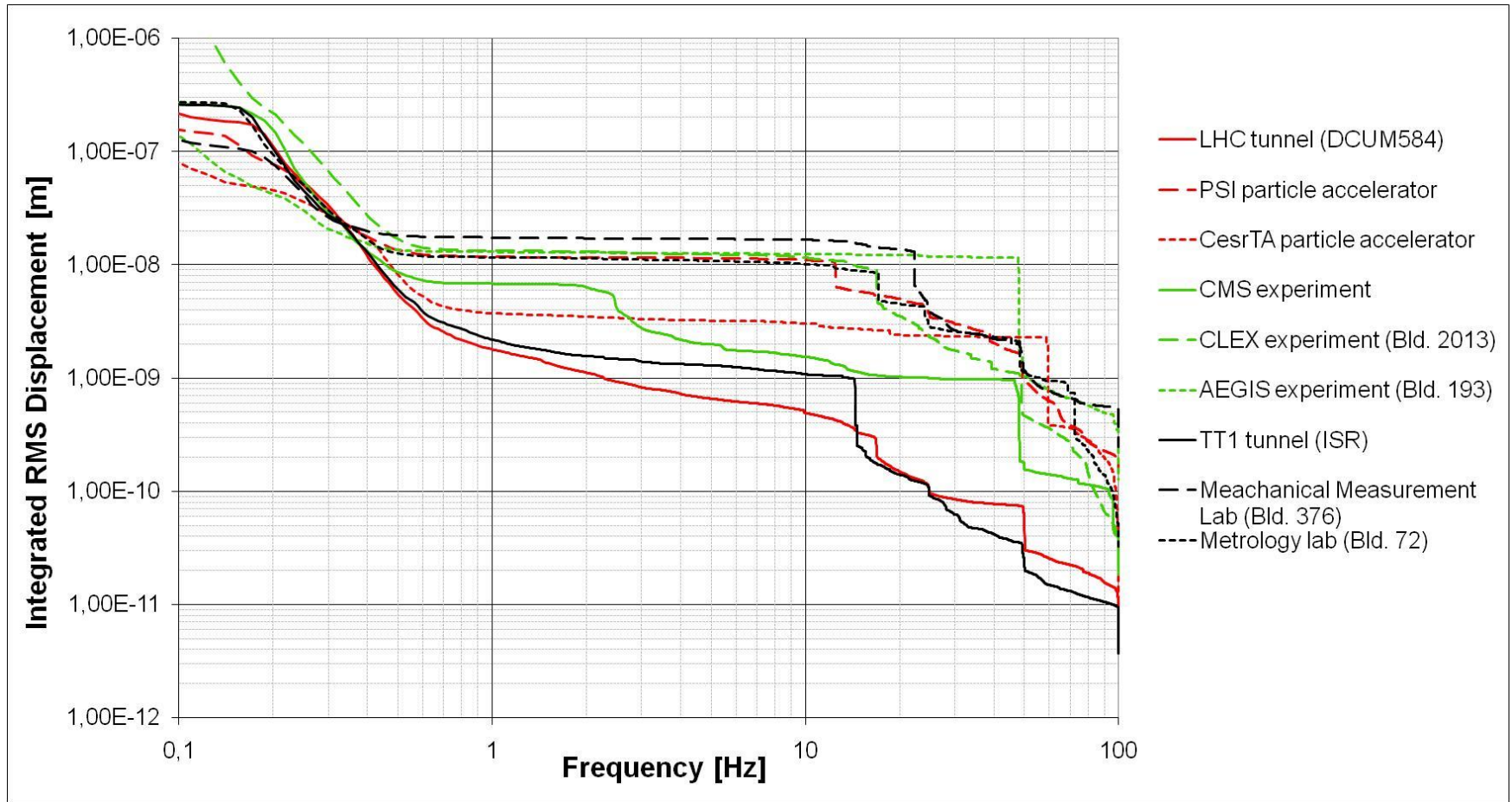


## ■ Coherence length results



# Ground motion results since 2005

## ■ Underground site vs surface site

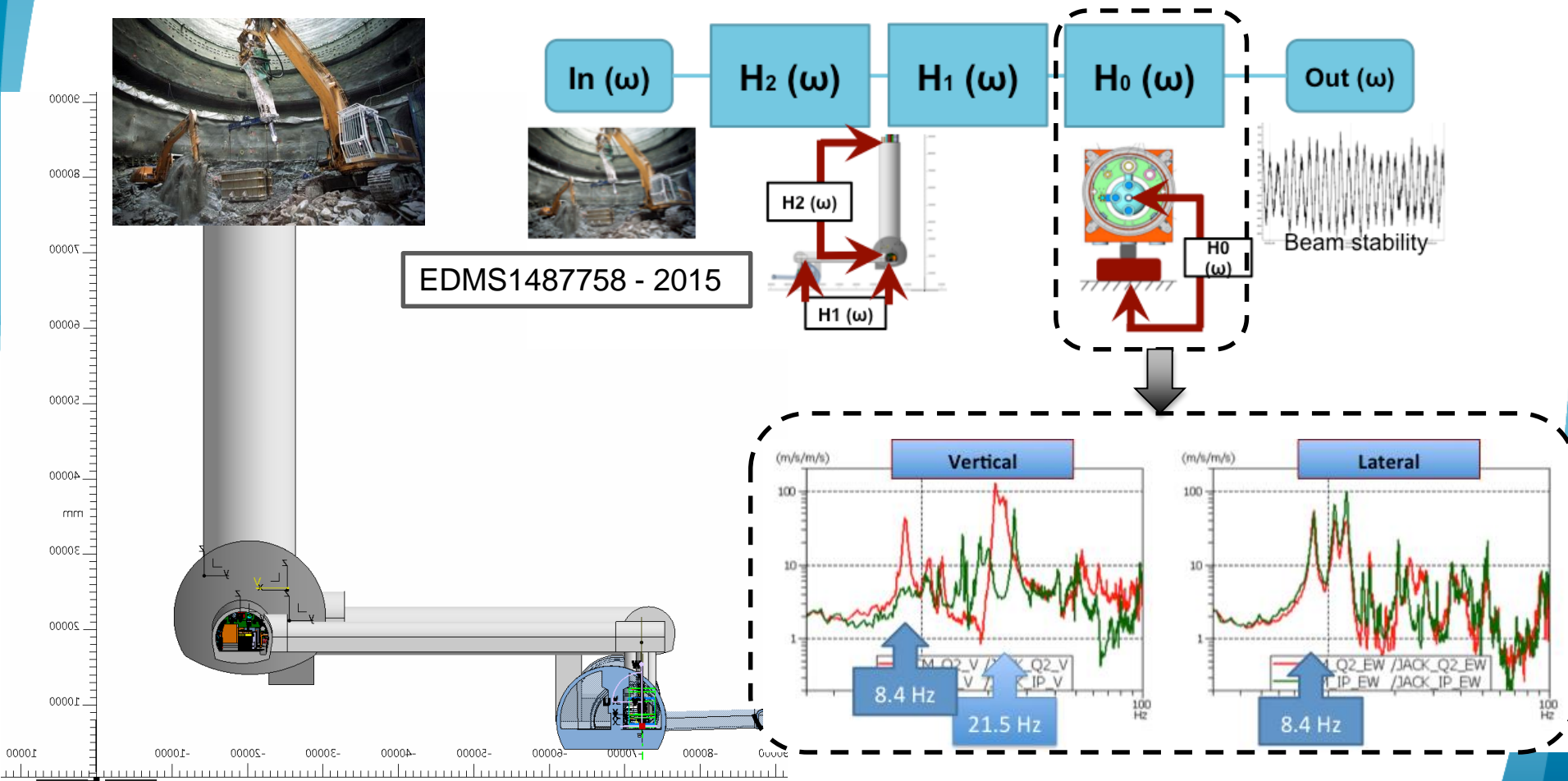


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# Dynamic response of MQXA cold mass

- Previous study done for civil engineering activities





# Dynamic response of MQXA cold mass

- Where do these frequencies come from ?  
Cold mass, vacuum vessel, or...  
→ Experimental modal analysis on MQXA cold mass

EDMS1689099 - 2016

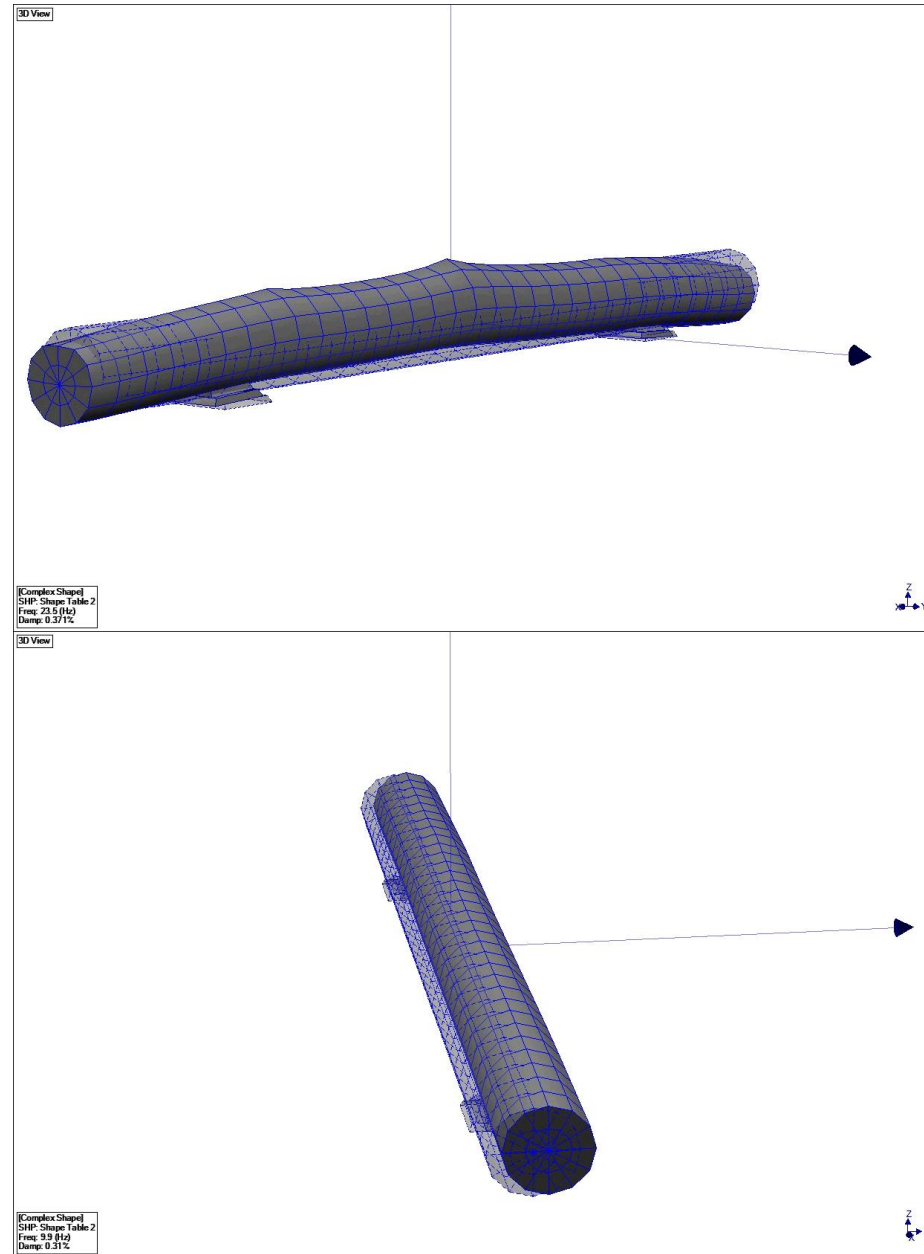


# Dynamic response of MQXA cold mass

## ■ Main results

Frequency [Hz]	Damping [%]	Mode shape
8.9	0.31	Rigid Lateral
19.2	0.764	Rigid
20.1	0.556	Rigid
23.5	0.371	<b>Vertical 1<sup>st</sup></b>
25.7	0.165	<b>Lateral 1<sup>st</sup></b>
36.2	0.447	Lateral
40.3	0.256	Vertical
44	0.0847	Vertical
63.4	0.222	<b>Lateral 2<sup>nd</sup></b>

→ Specific frequencies measured previously are mainly linked to the cold mass behavior.



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# Seismic network status

- Proposal approved by LMC :  
[LMC seismic network proposal.pdf](#)
- Funding are fully identified ;
- Transfer data to SED is running
- No particular issues
- Pt1 and Pt5 will be installed during EYETS (ECR approved)
- Surface station is under installation :
  - Vault construction : OK
  - Sensor installation : October
  - First measurement : November



# Seismic network status



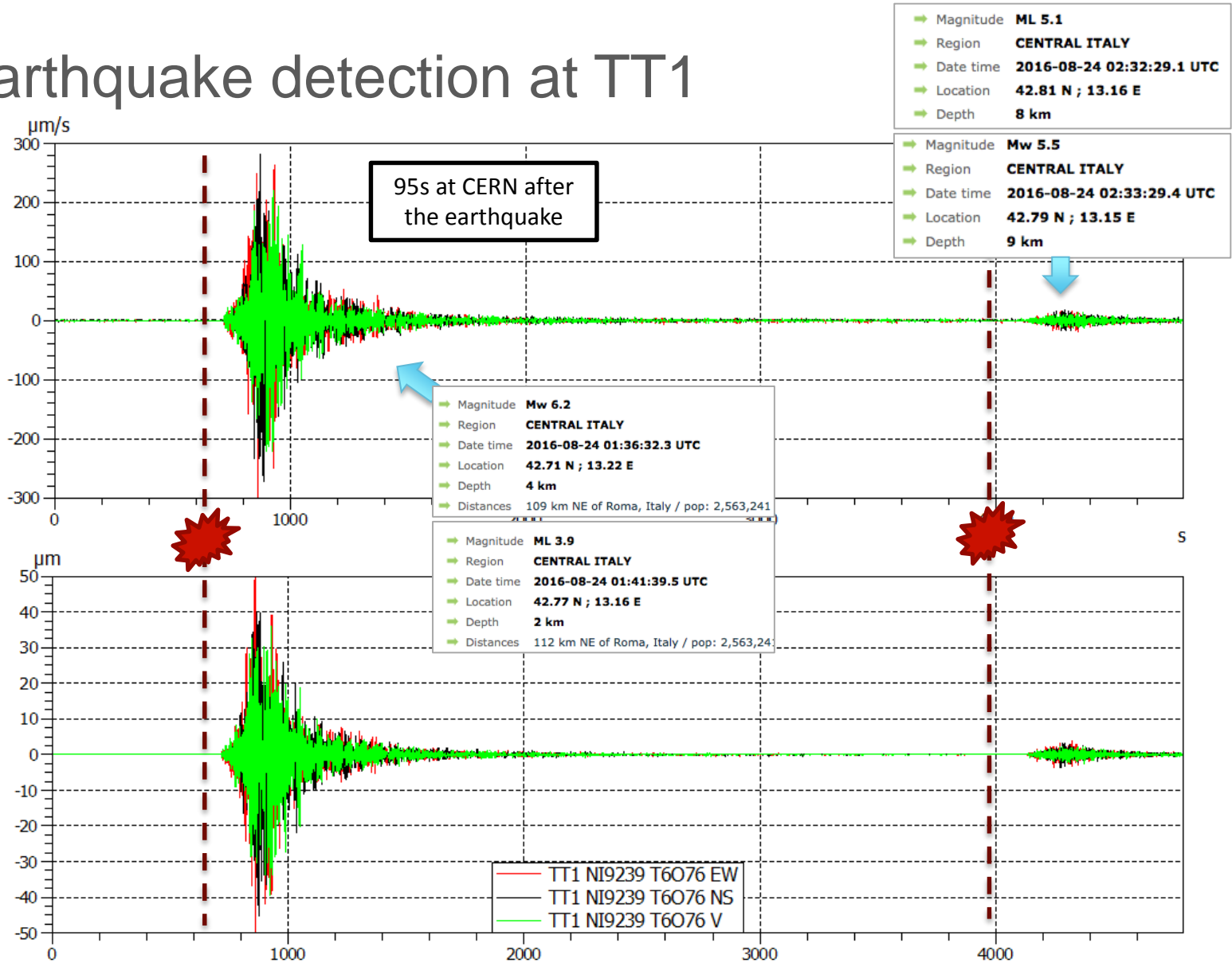
- Surface station is under installation :



n)

# Seismic network status

## Earthquake detection at TT1





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# Conclusion

- Lot of ground motion measurements were performed at CERN over the last decade ;
- Ground motion excitations are coherent over a short distance and on a very limited frequency band (0.1 to few Hz);
- After several metres, only the micro-seismic excitation is coherent;
- Experimental modal analysis of MQXA cold mass has confirmed the dynamic response measured during previous study. Improvement of the cryostat stiffness should not affect much the dynamic response of the coldmass;
- Seismic network installation is in progress as planned.



**Thank you !**

**Questions**