swissnuclear
Nuclear Energy Section of swisselectric

The Need of Physics-based Ground Motion Models for Hazard and Risk Assessment of Nuclear Power Plants

Luis A. Dalguer and Philippe Renault

Hazard and Structural Analysis

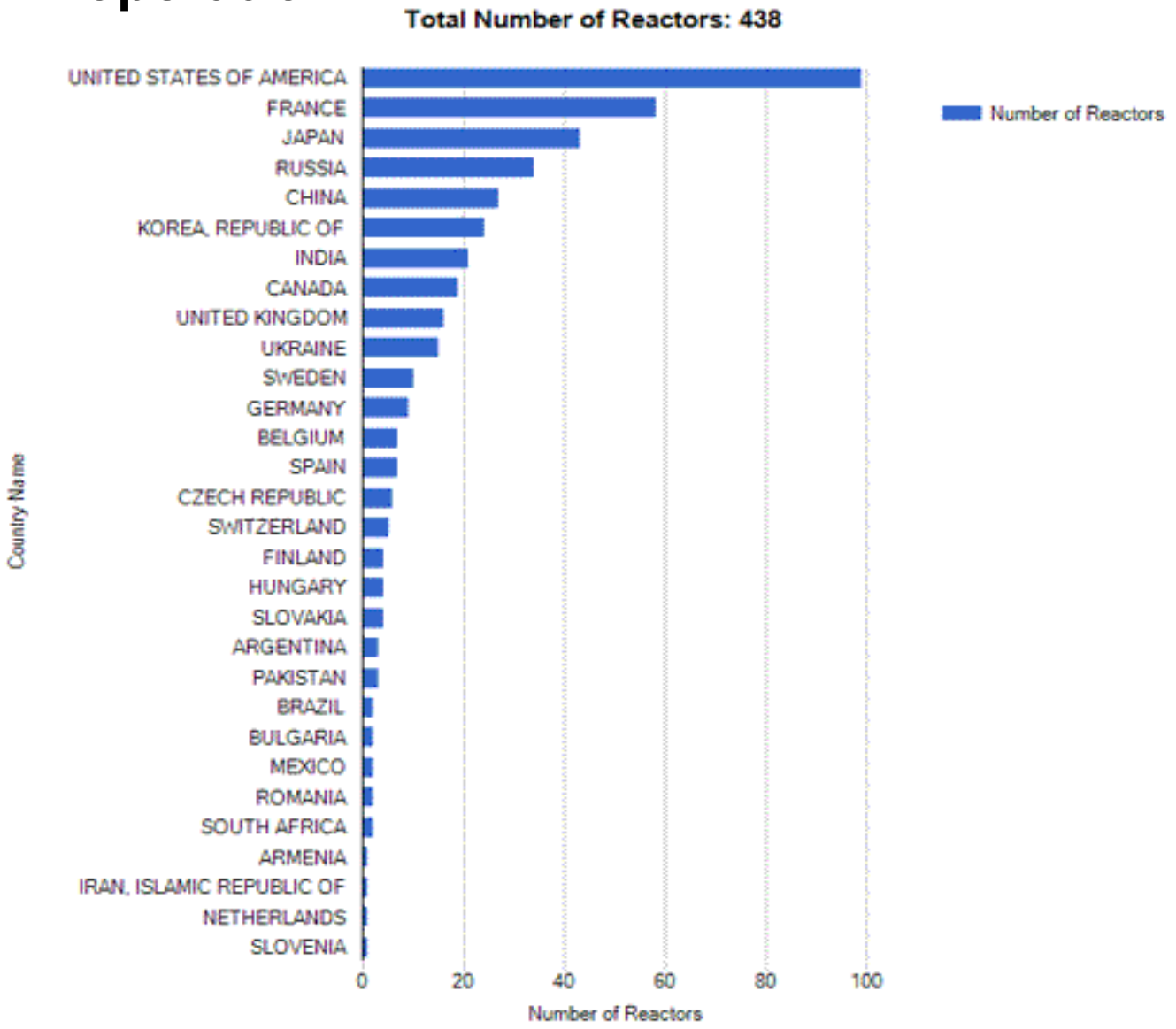
Swissnuclear, Switzerland

NMEM 2015, Smolenice, Slovak Republic, 5-9 July, 2015

Nuclear Industry Worldwide (IAEA, 2015)

swissnuclear
Nuclear Energy Section of swisselectric

Reactors in operation

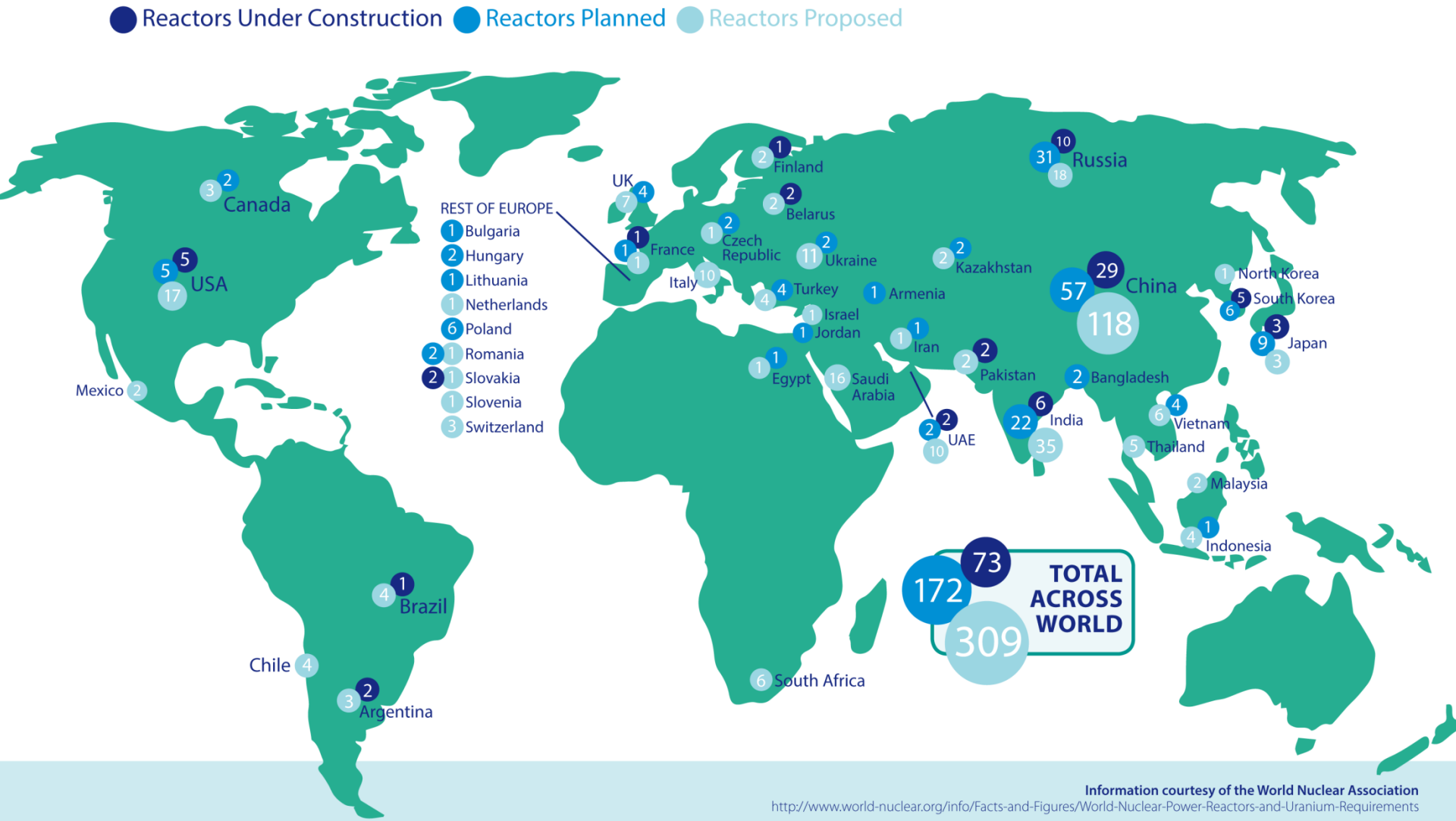


Nuclear Industry Worldwide (2014)

swissnuclear
Nuclear Energy Section of swisselectric

NUCLEARENERGY INSIDER

1 Reactors under construction, planned and proposed



Information courtesy of the World Nuclear Association
http://www.world-nuclear.org/info/Facts-and-Figures/World-Nuclear-Power-Reactors-and-Uranium-Requirements

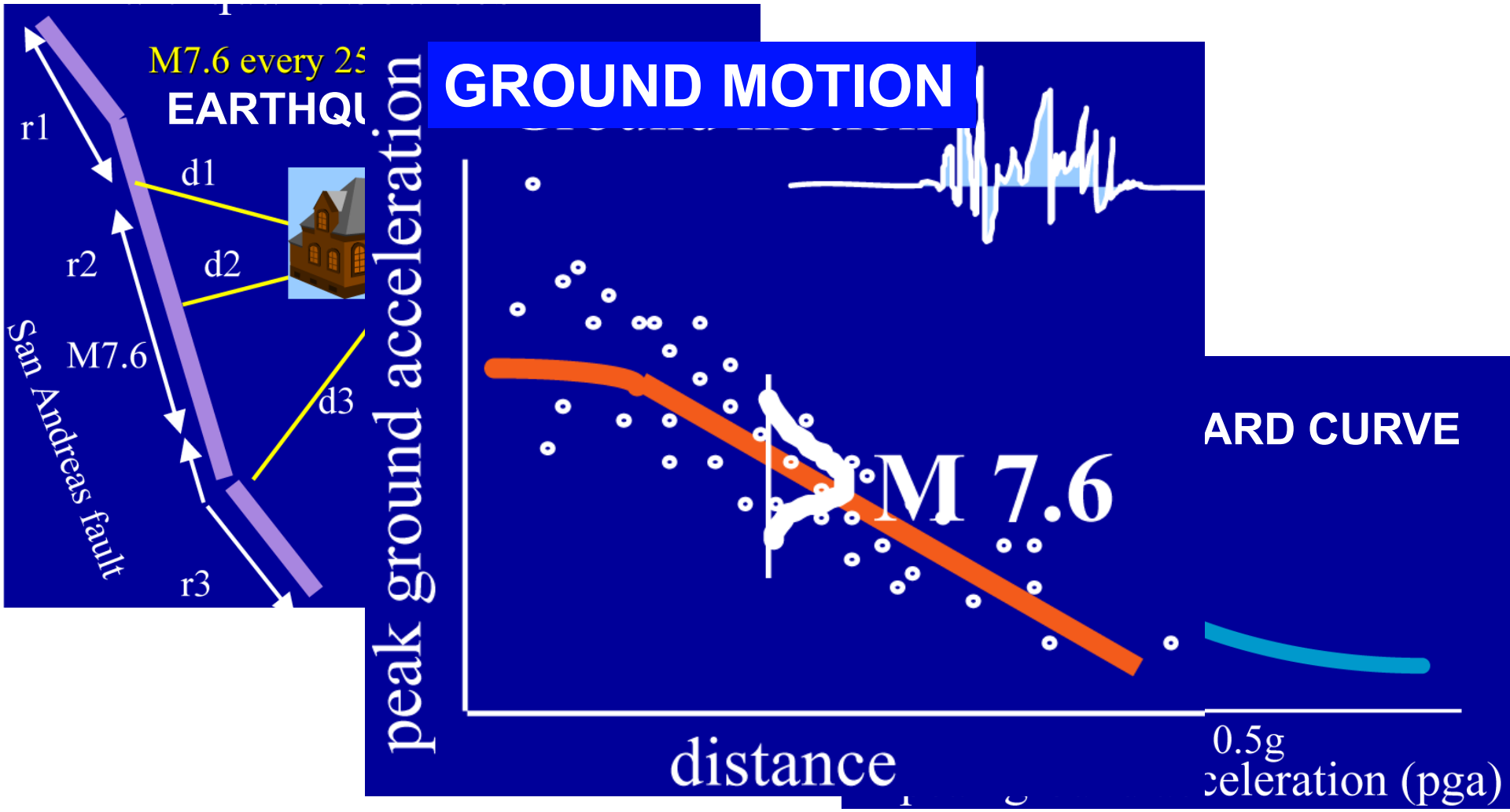
Some requirements for Nuclear Power Plants

swissnuclear
Nuclear Energy Section of swisselectric

- For existing Nuclear Power Plants (NPPs): need to develope site-specific seismic hazard assessment (SHA) periodically (~every 10 years).
- Before construction of new NPPs, the development of site-specific SHA is recommended by the nuclear authorities.
- The Uniform Hazard Spectra (UHS) is the final product of SHA. The UHS is used to select ground motion records (from a database) for the dynamic analysis of the structures and development of fragility curves for risk assessment.
- After Fukushima accident in Japan, the international nuclear authorities have revised the seismic safty regulations for existing and future NPPs
- Safety Margin Assessments (SMA) for **beyond** Design Basis Earthquakes (DBE) and Probability Safety Assessments (PSA) for **well beyond** DBE are recommended by the authorities.
- Existing Design Spectra are revised and proposed new ones.

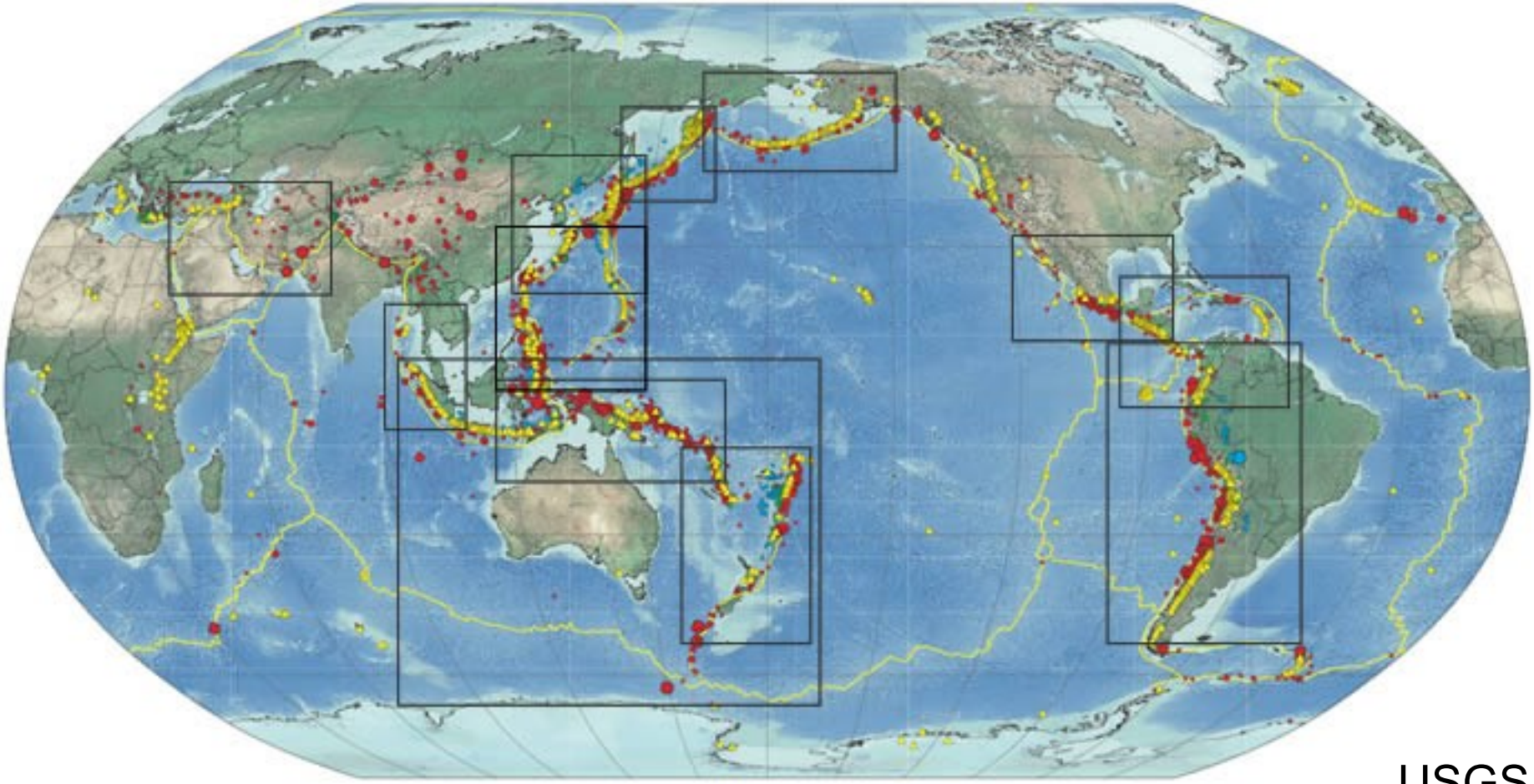
Probabilistic Seismic Hazard Assessment

swissnuclear
Nuclear Energy Section of swisselectric



Seismicity Worldwide (1900-2012)

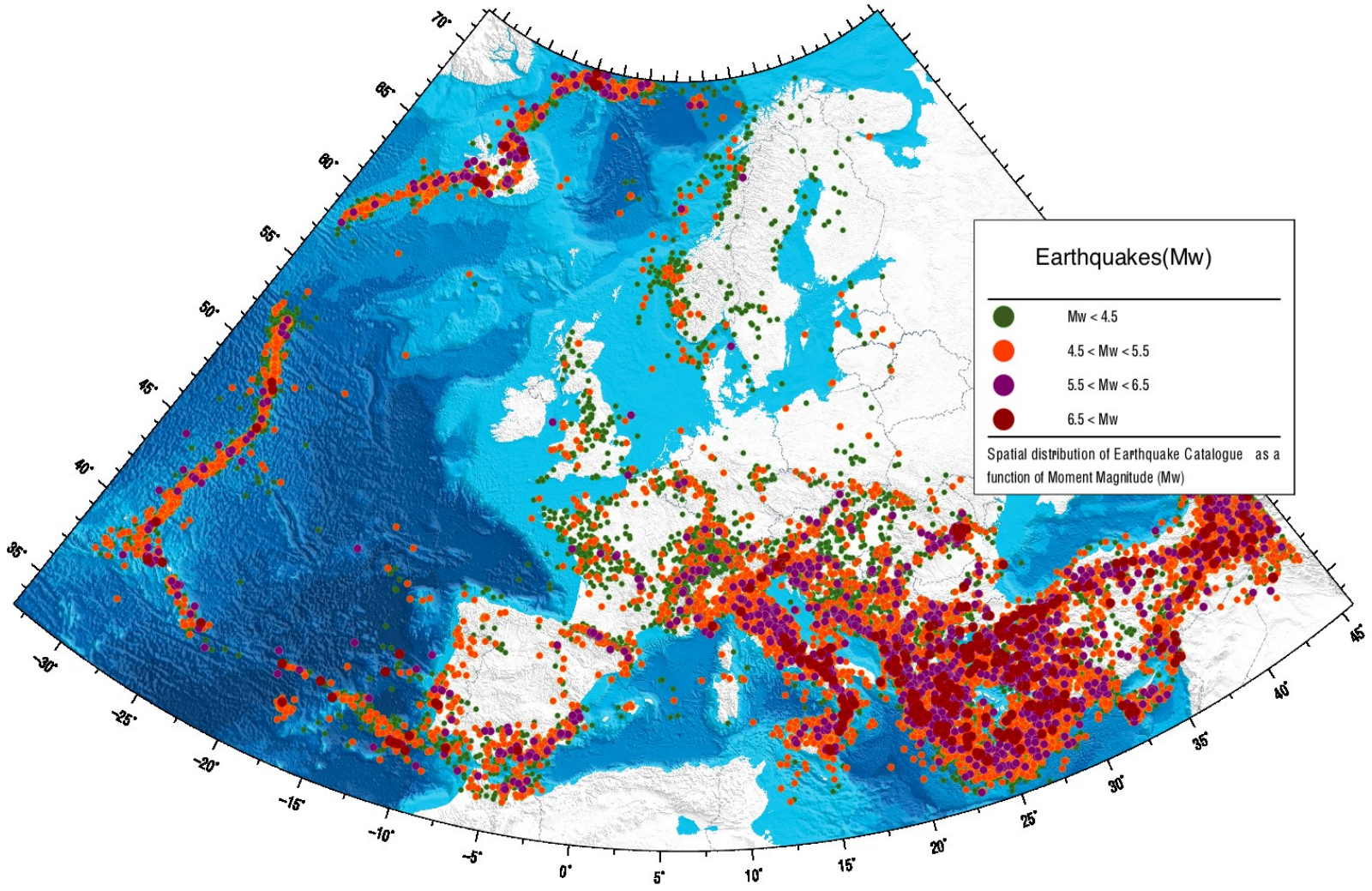
swissnuclear
Nuclear Energy Section of swisselectric



USGS

SHARE European Earthquake Catalog

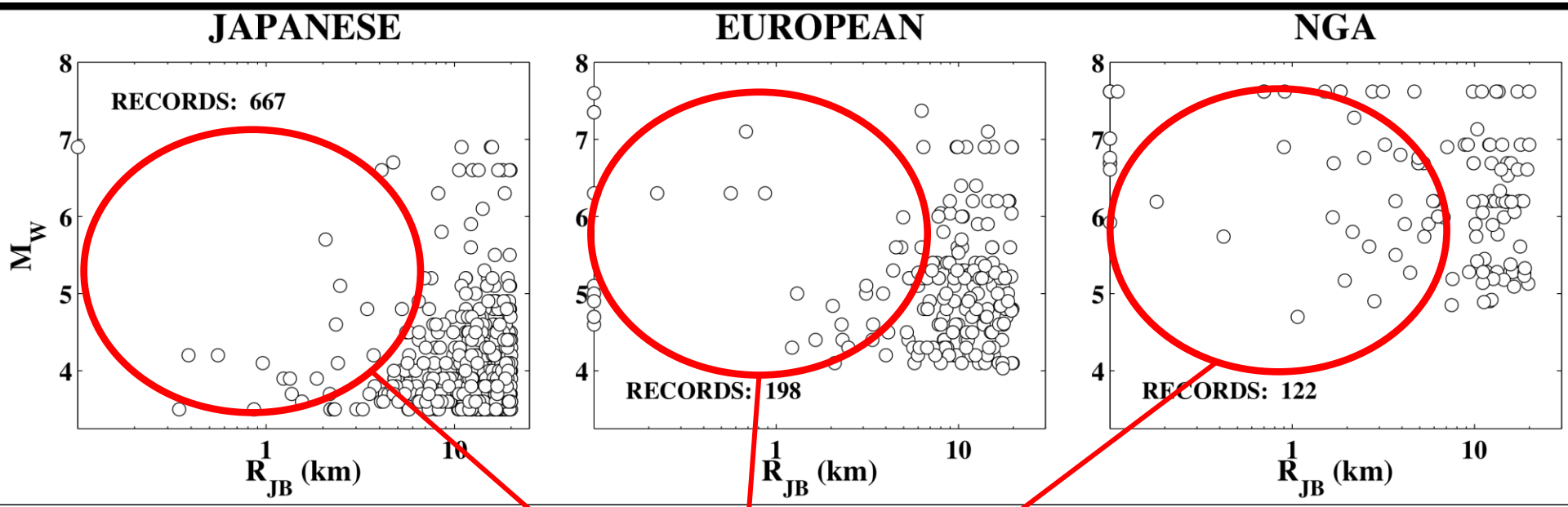
swissnuclear
Nuclear Energy Section of swisselectric



Near-Source Ground Motion Data Base

swissnuclear
Nuclear Energy Section of swisselectric

($R_{JB} \leq 20km$)



(Laurendeau et al. 2012)

(Akkar, 2012)

(Chiou et al., 2008)

Lack of data: R < 7-10km, Mw > 7
Need to fill this lack of data!!

Lack of data!!

swissnuclear
Nuclear Energy Section of swisselectric

- With exception of high seismicity zones, the reality is that we do not have so much data

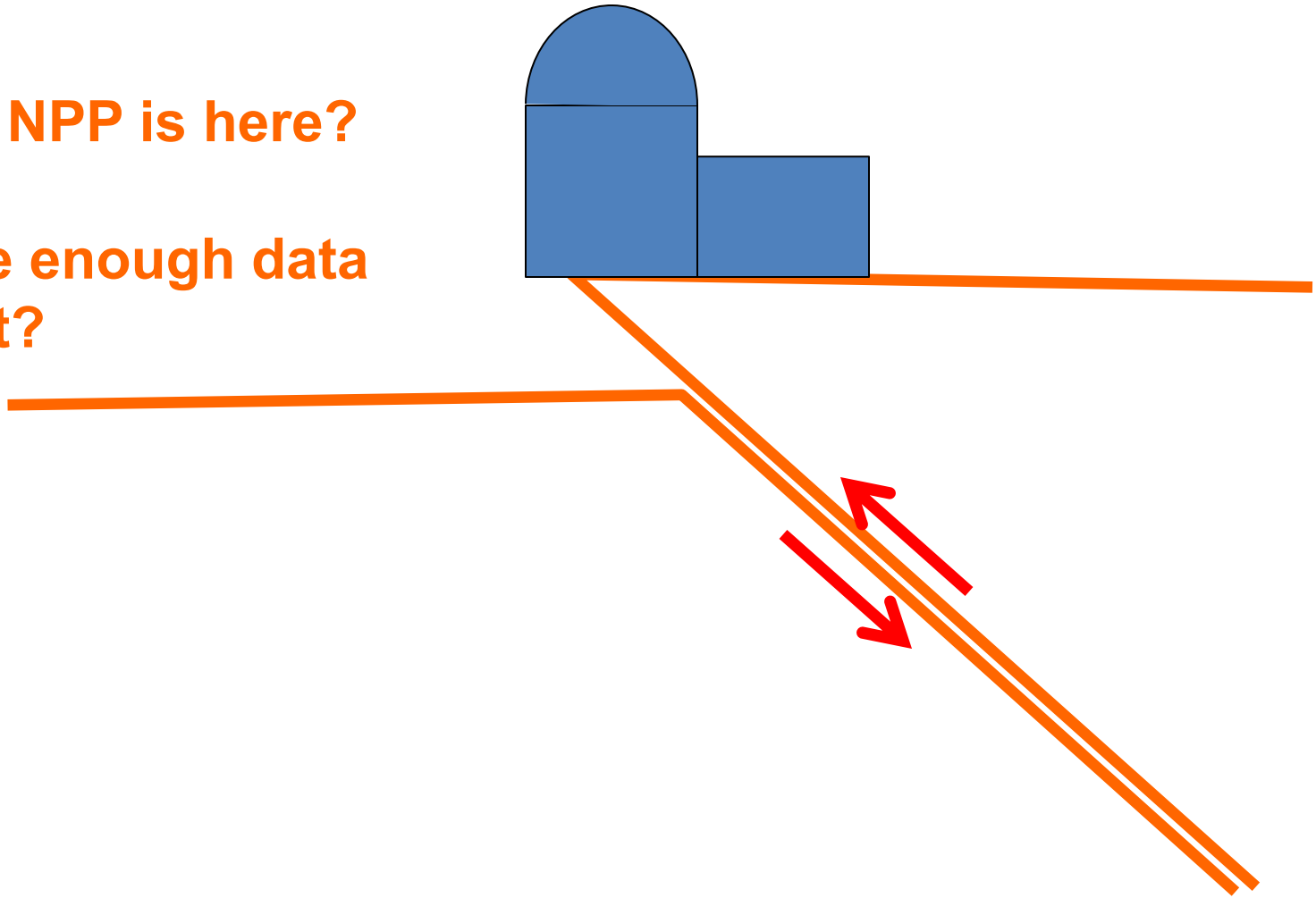
- Even in high seismicity zones, data near the source and for earthquakes M>~7 are sparse

Near-Source (Hanging wall)

swissnuclear
Nuclear Energy Section of swisselectric

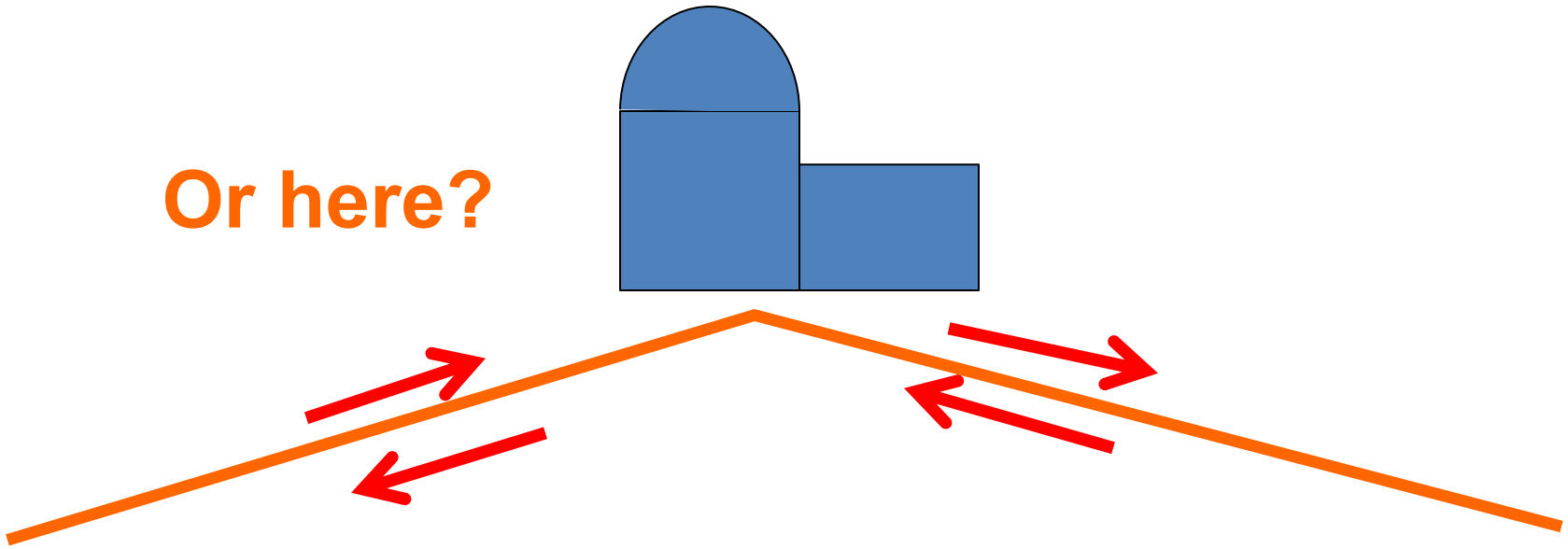
What if the NPP is here?

Do we have enough data to predict it?



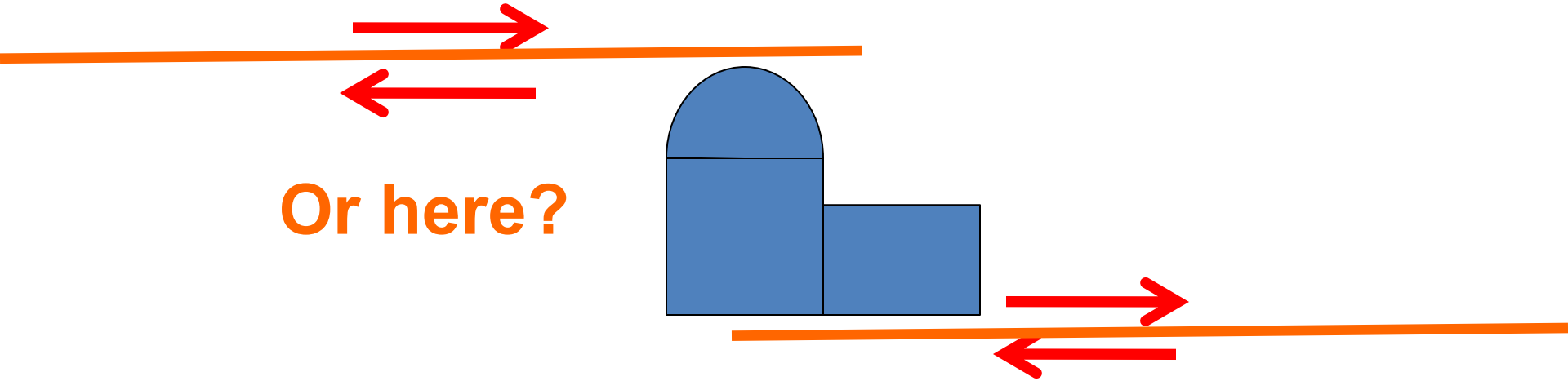
Near-Source (kink faults)

swissnuclear
Nuclear Energy Section of swisselectric



Near-Source (step over faults)

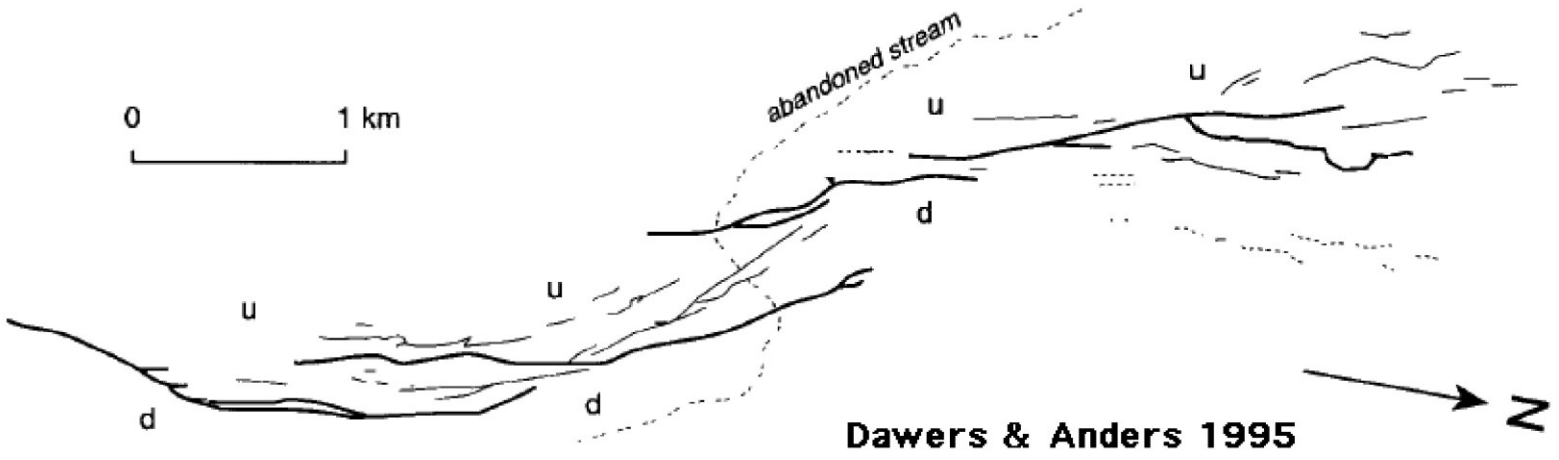
swissnuclear
Nuclear Energy Section of swisselectric



Near-Source (Faults are complex!!)

swissnuclear
Nuclear Energy Section of swisselectric

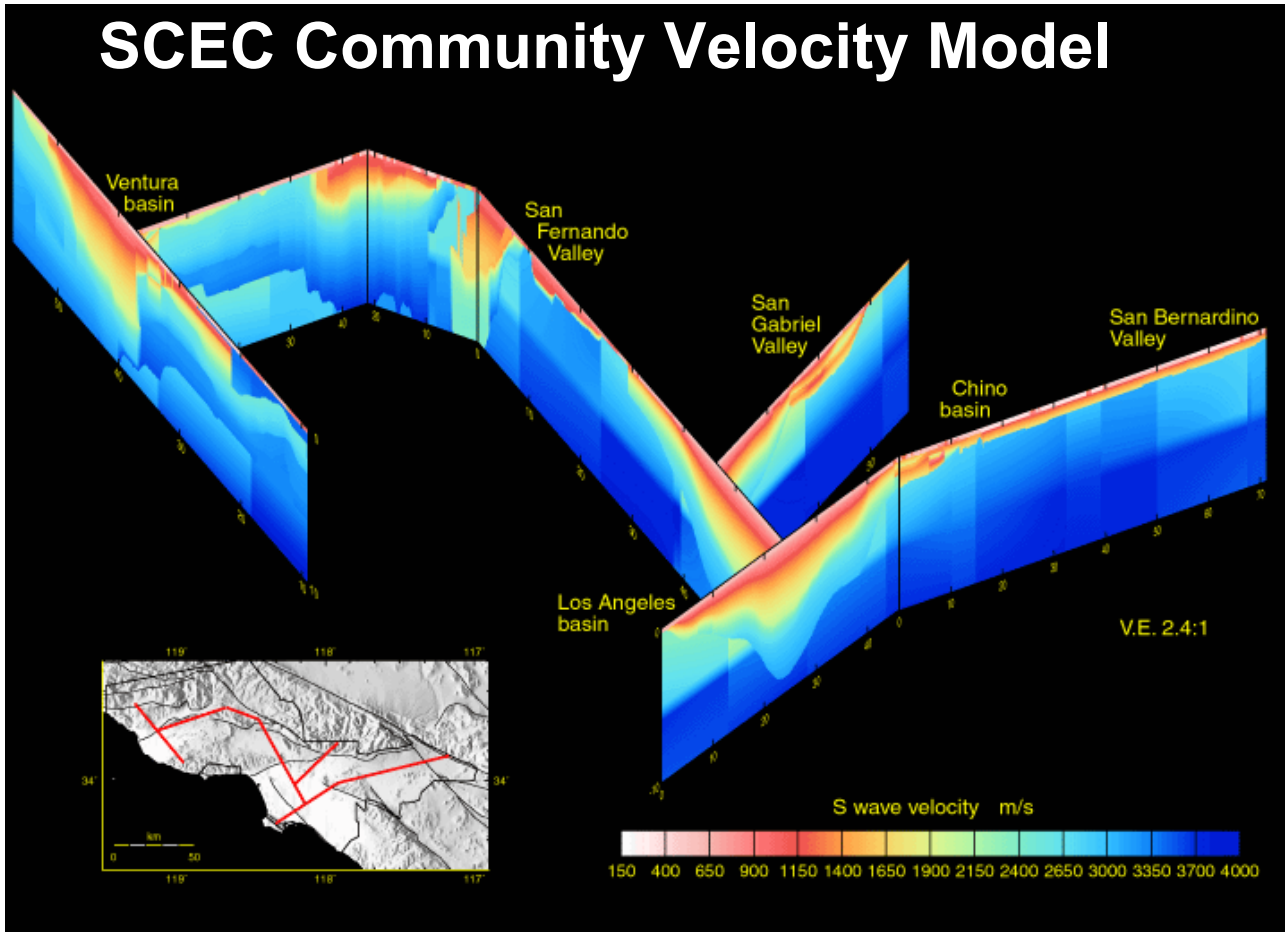
Faults are geometrically complex at all scales
We need to understand ground motion produced by them



swissnuclear
Nuclear Energy Section of swisselectric

Shallow 3D earth structure is complex

-With current technology and seismological method we can get information from earth structure



Current practice use GMPEs

swissnuclear
Nuclear Energy Section of swisselectric

-Empirical models (GMPEs) are insufficient for the prediction of near-source ground motion for use in seismic hazard and risk assessment.

-GMPEs are based solely on recorded data which are sparse in the near field.

-GMPEs do not incorporate the source, path and site complexities.

-In areas of low seismicity, there are no empirical GMPEs

- Then hazard and risk assessment need to rely on numerical modeling to adequately assess the hazard in the zone of interest.

-For meaningful prediction in areas where there is no data (**near source, Mw > 7 and low seismicity zones**), simulations have to be based on well defined physics.

Ground Motion Selection

Goal

- Provide set of response spectra and ground motion time histories for engineering application evaluations, such as seismic structural response and risk assessment for NPPs.
- The selected set of ground motions need to be compatible with the target Uniform Hazard Spectra (UHS) obtained from the hazard analysis.

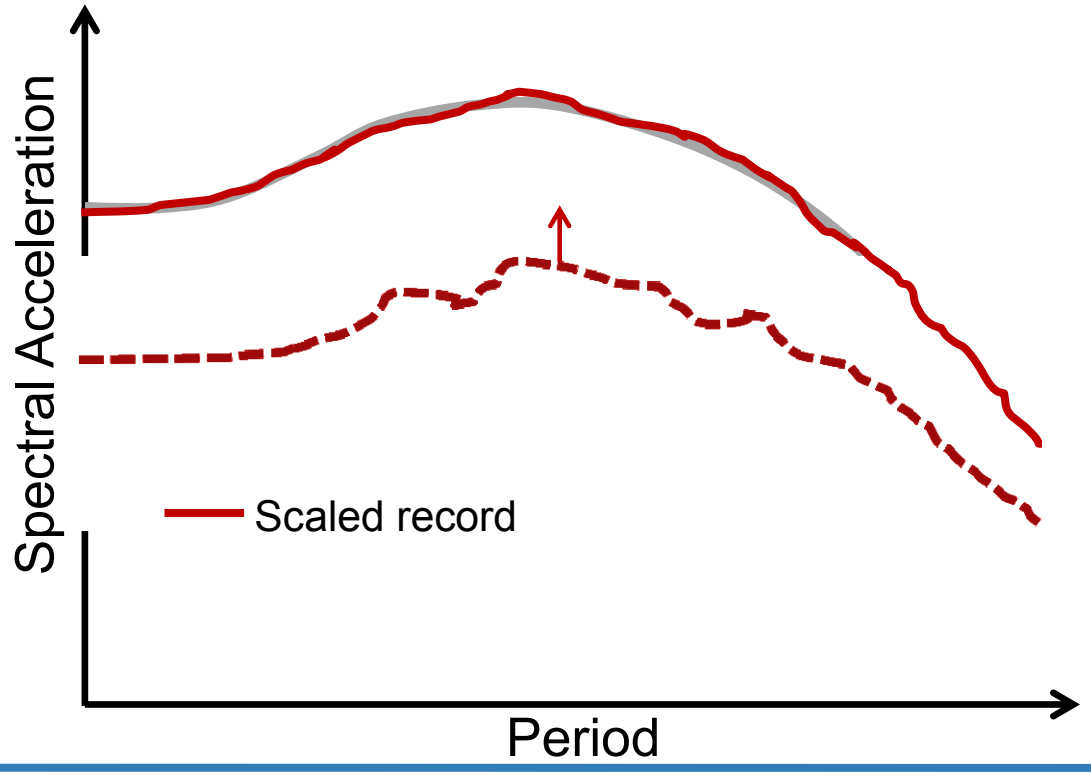
Ground Motion Selection

swissnuclear
Nuclear Energy Section of swisselectric

- **UHS Spectral Matching approach:**

-Select acceleration records from controlled earthquake magnitudes and distance of the hazard (Deaggregation)

-Each individiual record is scaled manually in the frequency domain to match the mean of UHS. (frequency content and time change)



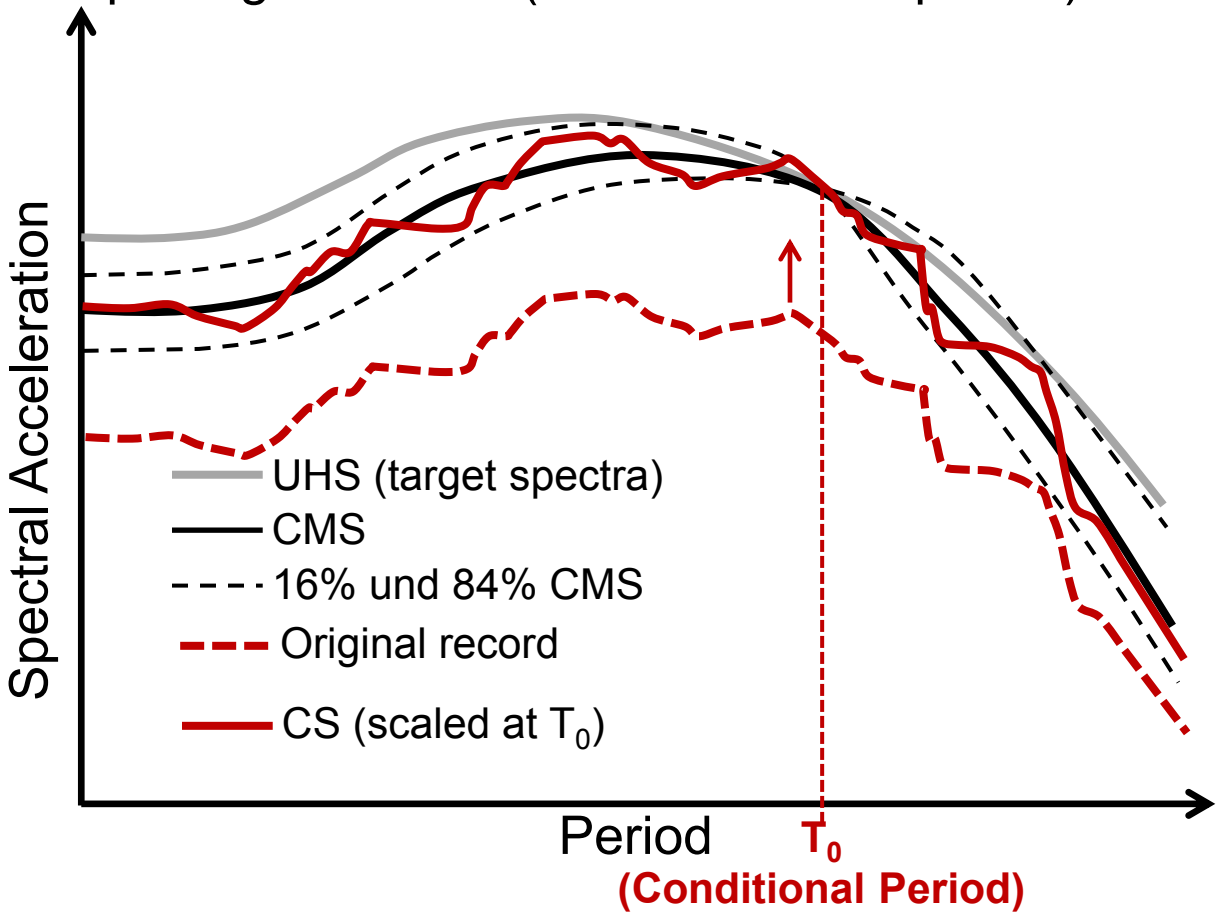
Ground Motion Selection

swissnuclear
Nuclear Energy Section of swisselectric

- **Conditional Spectrum (CS) approach**:

-Built a Conditional Mean Spectra (CMS), anchored to the UHS at the conditional period (T_0), from deaggregation for different hazard levels.

-Select a subset of N spectra and scale them to T_0, so that has the best likelihood of capturing the CMS. (more realistic spectra)



Ground Motion Selection

swissnuclear
Nuclear Energy Section of swisselectric

Issues

- The original record is manipulated, mainly in the frequency domain
- Scaling factor can go up to 100
- Observed data from database, usually do not correspond to the site of tinterest. Because there are no data or not enough data for the magnitude of interest
- In order to overcome these issues, synthetic data can be used from physis-based models. And combine them with observed data that are consistent with the site of the interest

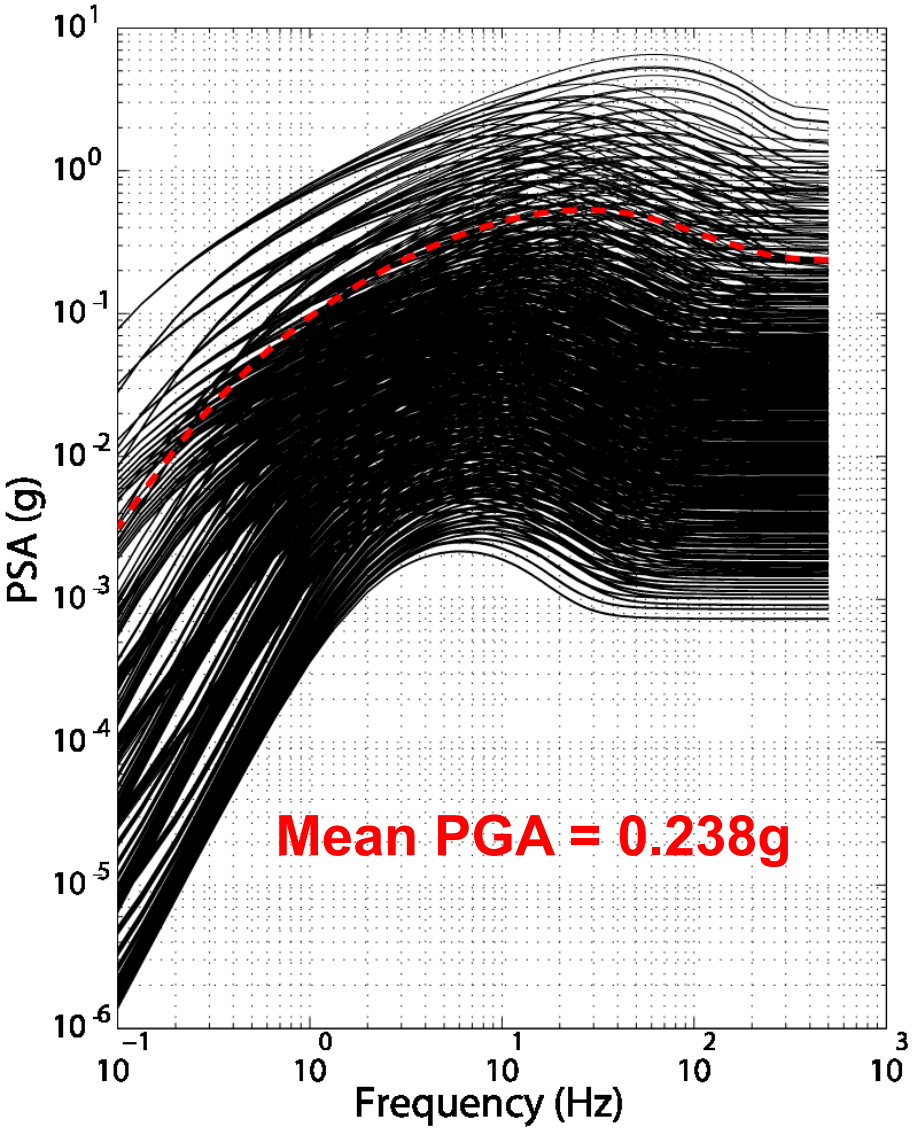
Design Spectra for very hard rock (>2000m/s)

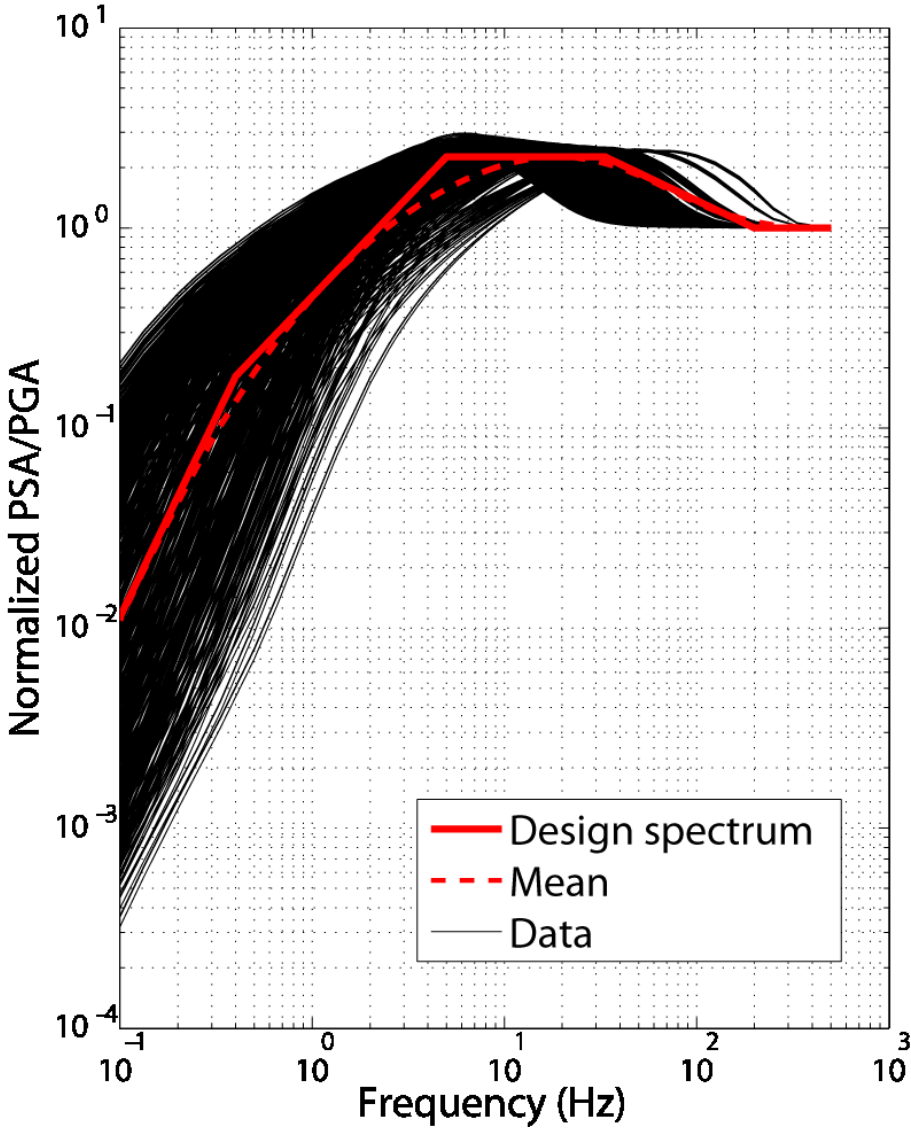
swissnuclear
Nuclear Energy Section of swisselectric

- Mw magnitudes of interest: 5.5 to 7.5
- Rupture Distances (km): 0-100km
- **No data or very sparse for this case**
- **Solution:** Current practice uses stochastic point-source model (e.g. from Boore, 1996) to genarate synthetic ground motion acceleration

Results for all scenarios

swissnuclear
Nuclear Energy Section of swisselectric

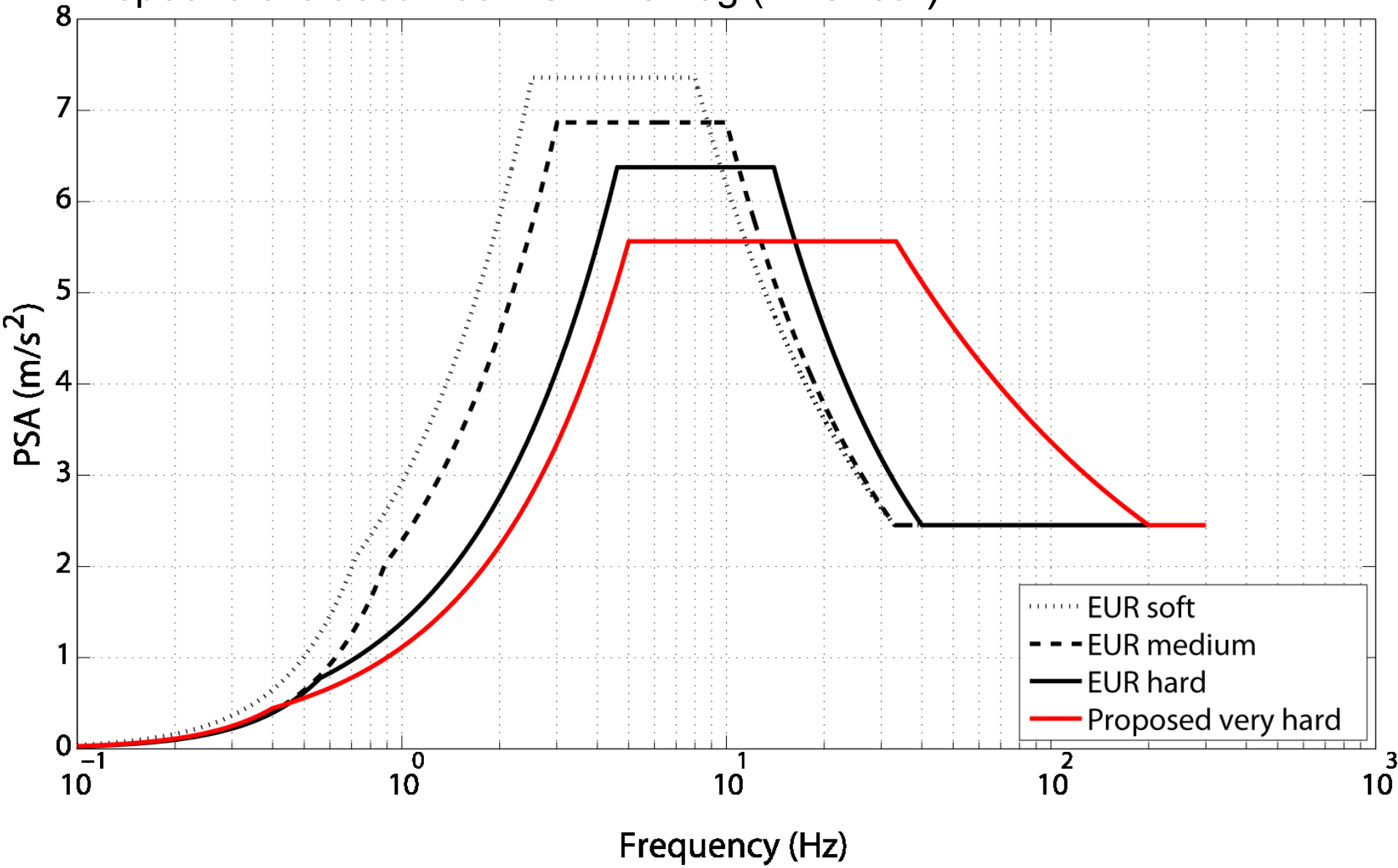




Comparison with EUR design spectra (PSA)

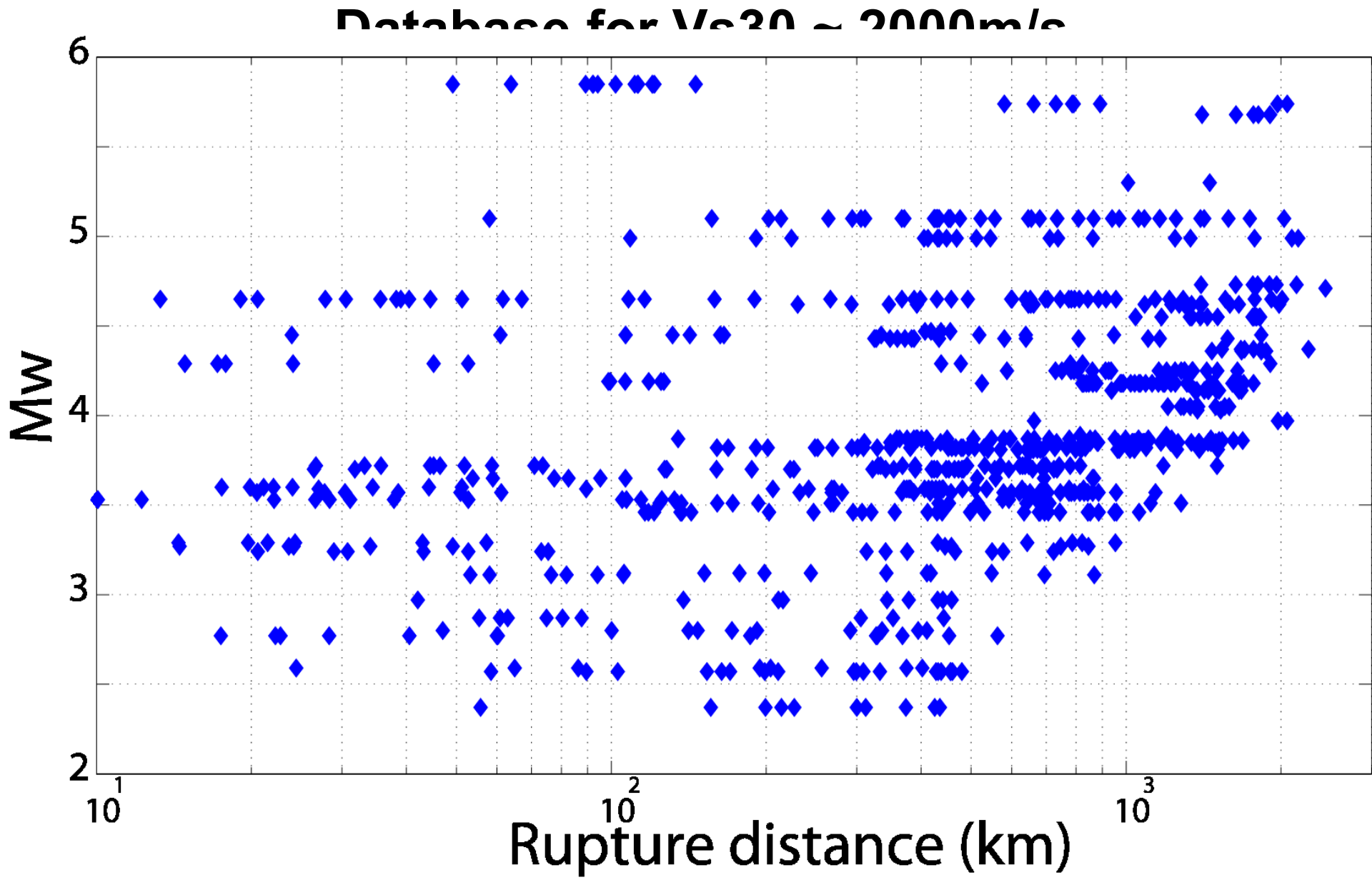
swissnuclear
Nuclear Energy Section of swisselectric

All spectra are assumed PGA = 0.25g (2.45m/s^2)



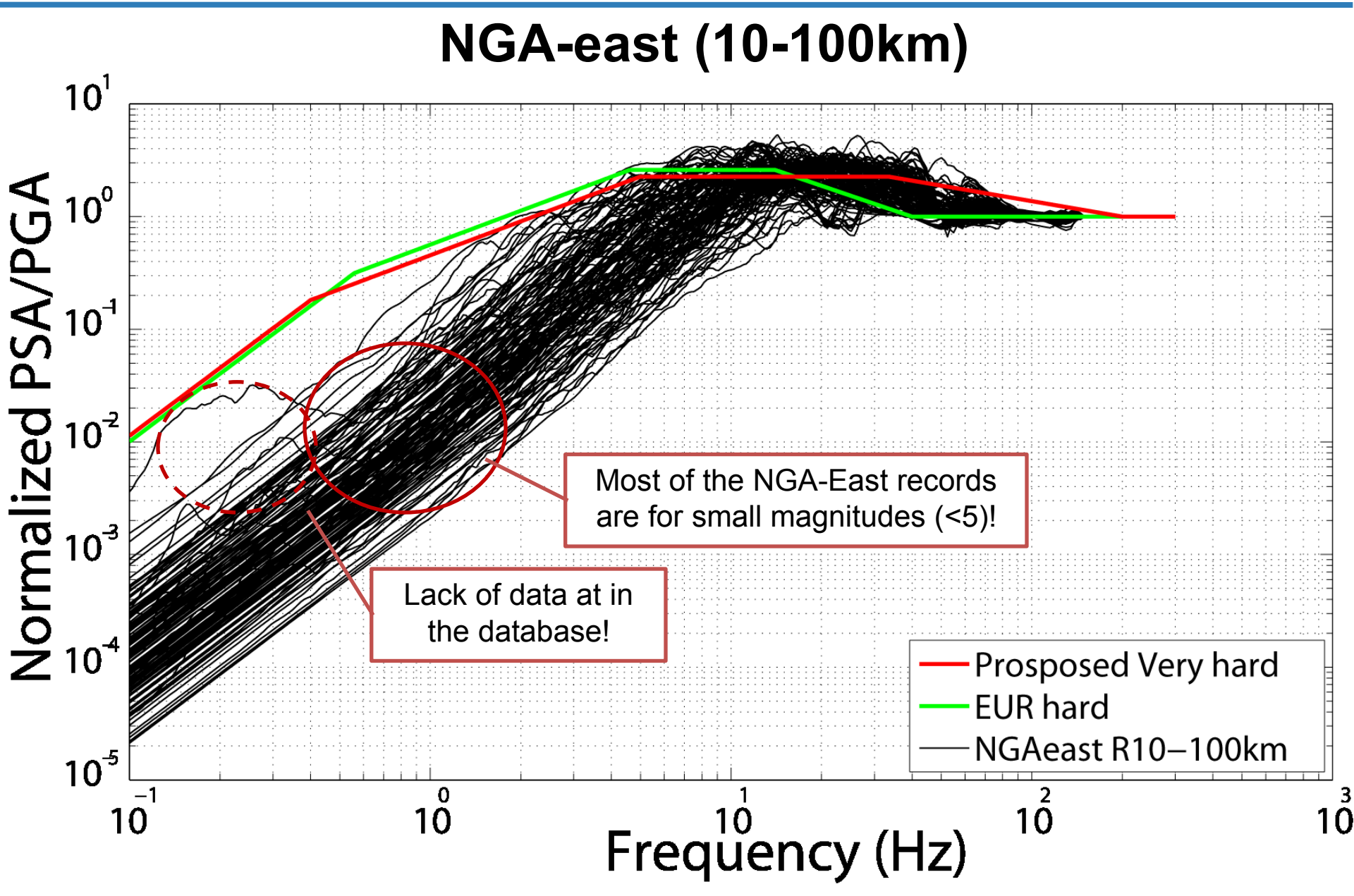
Comparison with NGA-East database

swissnuclear
Nuclear Energy Section of swisselectric



Comparison with NGA-East database

swissnuclear
Nuclear Energy Section of swisselectric



Conclusions

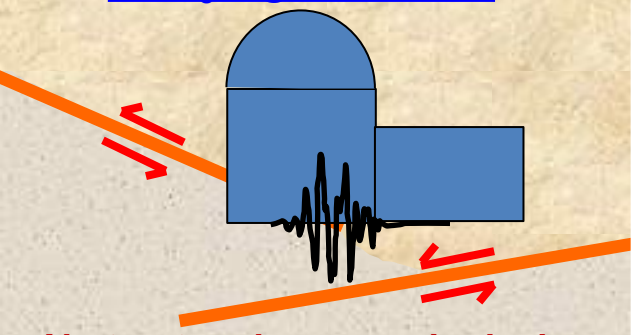
swissnuclear
Nuclear Energy Section of swisselectric

-Physics-based ground motion modeling is needed for meaningful hazard assessment, meaningful ground motion selection, and meaningful construction of design spectra when no data available.
-This and other issues, such as source characterization (kinematic and dynamic), path (wave propagation in complex structure), site (no-linearity, etc.) will be discussed in a workshop we are organizing on 18-20 November

Key deadlines

-Abstract submission : **Extended to 30 July**
-Full paper submission: **31 August 2015**
-Registration: **10 September 2015**
-Workshop: **18-20 November 2015**
-Field trip (optional): **21 November 2015**
A preliminary plan is to visit nuclear installations and fault trenches

Note: For pre-abstract submission contact Dr. Luis A. Dalguer
e-mail: luis.dalguer@swissnuclear.ch



Abstract and paper submission

Participant willing to present his/her work as oral or poster must submit an abstract (max 300 words). After acceptance of the abstract and the type of presentation, we will encourage to submit a full paper. The minimum size of the paper is 6 pages, and it is recommended to be no longer than 15 pages. This is a guideline and not an absolute limit.

Registration

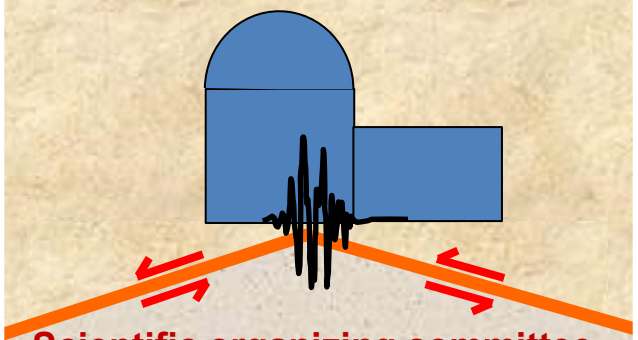
Free of charge

Language

The official language is English

IAEA Contact persons

Scientific Secretary:
Mr Yoshimitsu Fukushima.
International Seismic Safety Centre
Division of Nuclear Installation Safety
International Atomic Energy Agency
Vienna International Centre
PO Box 100, 1400 VIENNA, AUSTRIA
Tel.: + 43 1 2600 21956
Email: Y.Fukushima@iaea.org



Scientific organizing committee

Luis A. Dalguer (Chair)
Swissnuclear, Switzerland
Email: luis.dalguer@swissnuclear.ch
Philippe Renault
Swissnuclear, Switzerland
Kojiro Irikura
Aichi Institute of Technology, Japan
Changjiang Wu
Nuclear Regulation Authority, Japan
Yoshikazu Suzuki
Japan Nuclear Safety Institute, Japan
Jon Ake
Nuclear Regulatory Commission, USA

Conference website

http://www-pub.iaea.org/iaeameetings/50896/BestPSHANI

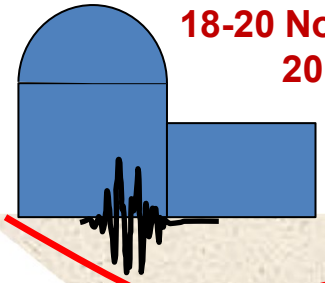
International Workshop on Best Practices in Physics-based Fault Rupture Models for Seismic Hazard Assessment of Nuclear Installations

First Announcement

Best PSHANI $\tau \leq \tau_c$

Vienna International Centre
Board Room, M building
Vienna, Austria

18-20 November 2015



IAEA International Atomic Energy Agency
swissnuclear Nuclear Energy Section of swisselectric
NRA, Japan Nuclear Regulation Authority
U.S.NRC
JANSI Japan Nuclear Safety Institute

Workshop:
"Best Practice in Physics-based Rupture Models for Seismic Hazard Assessment of Nuclear Installations"

Date: 18-20 November 2015
Venue: VIC, IAEA, Vienna
Important dates:
Abstract submission deadline: Extended to July 30
Full paper submission deadline: August 2015
Registration deadline : 10 September 2015