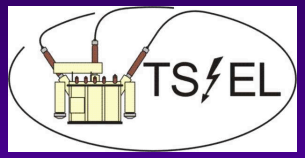


1st TS Workshop

Archamps, 4 – 6 May 2004

POWER QUALITY AND NETWORK DISTURBANCES

in CERN's electrical network

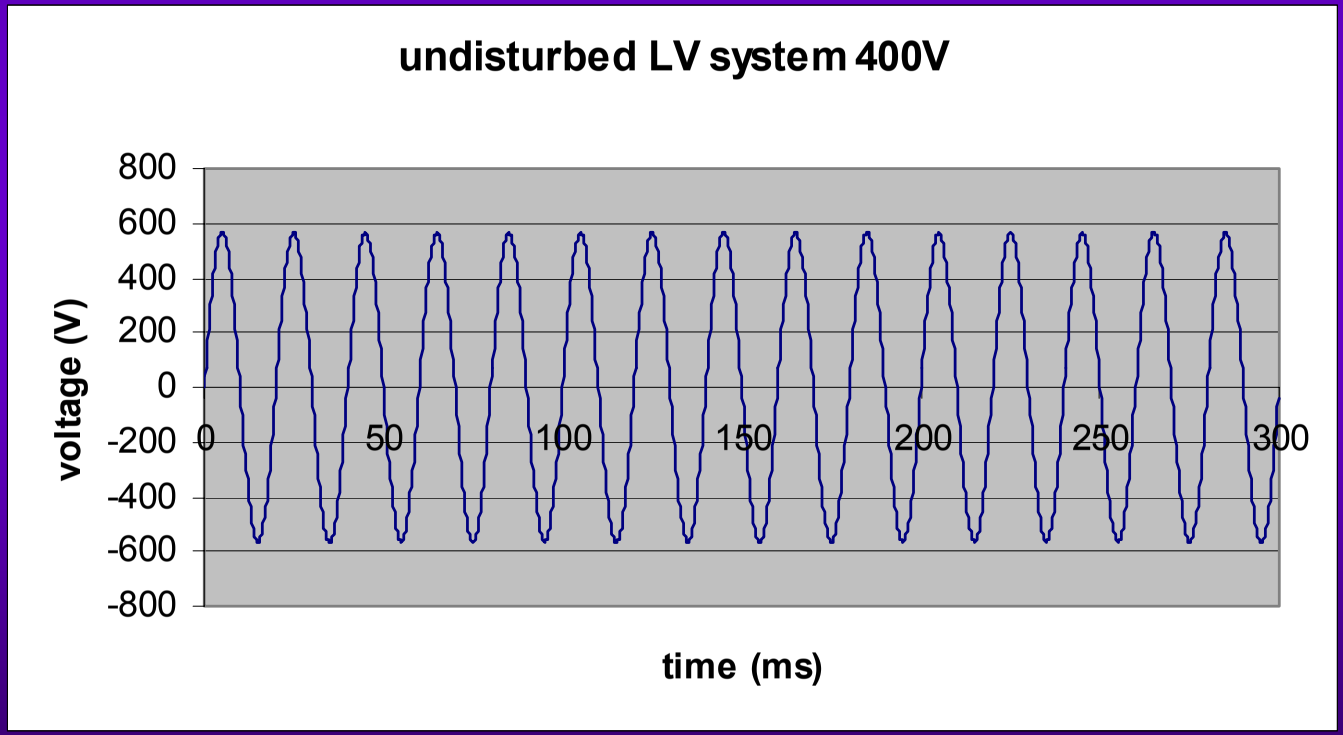
1. **Definition** of Power Quality and Network Disturbances
2. How to **measure** network disturbances ?
3. **Statistics** 2003
4. Computer **simulations**
5. **Reliability** of CERN's distribution network
6. **Conclusions**

K. KAHLE, TS-EL

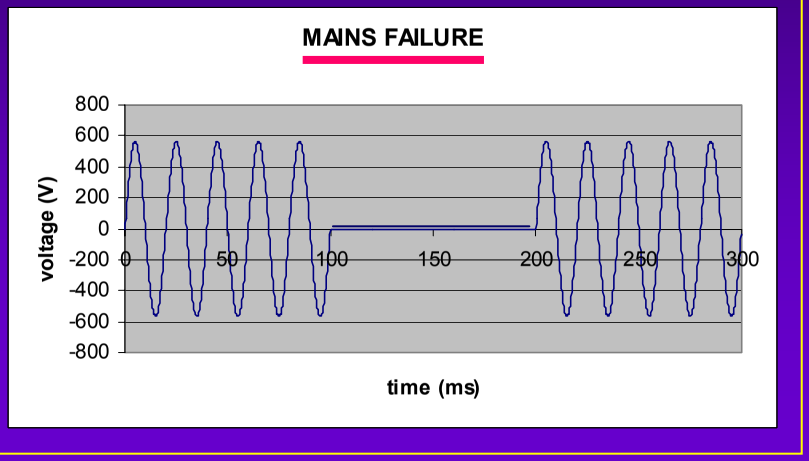
Diploma students R. Sternberger, M. Neubert

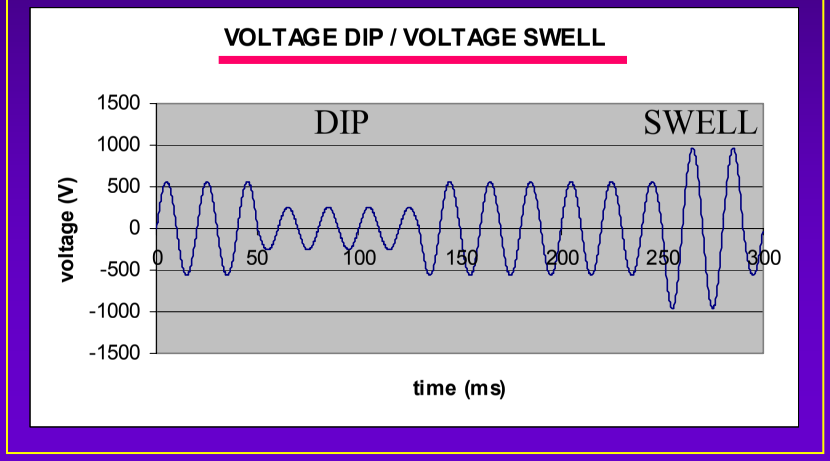
Power Quality

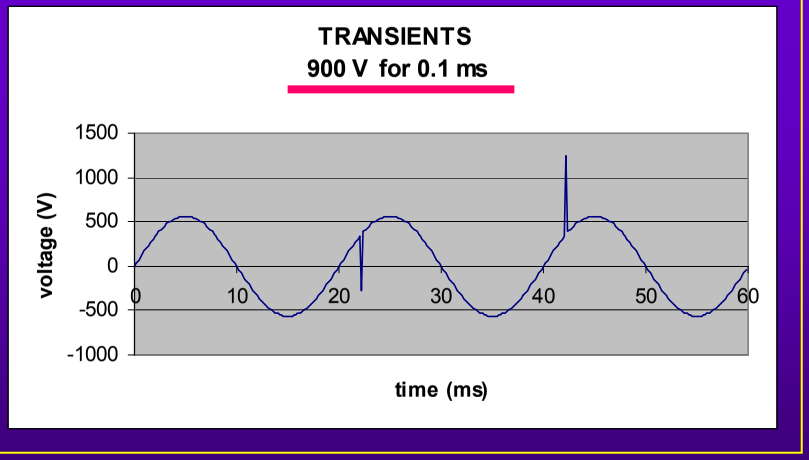
= Quality of electrical energy supplied

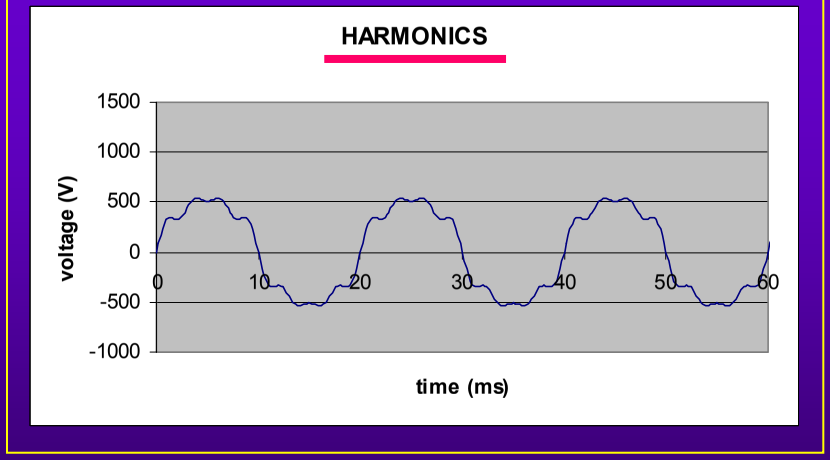


Types of network disturbances









Types of network disturbances

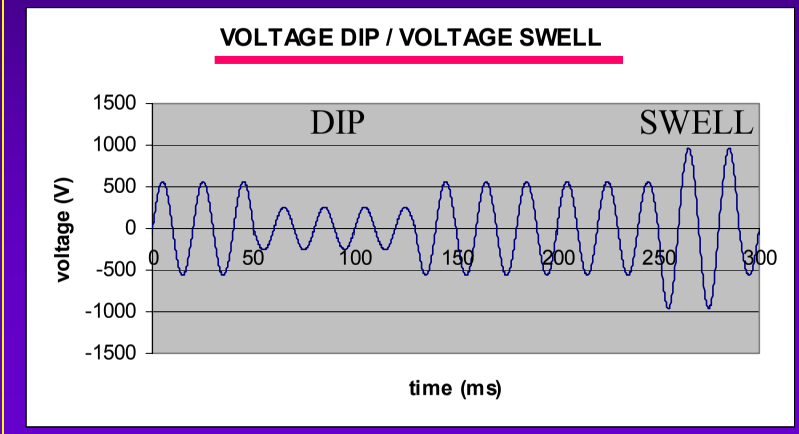
MAINS FAILURES

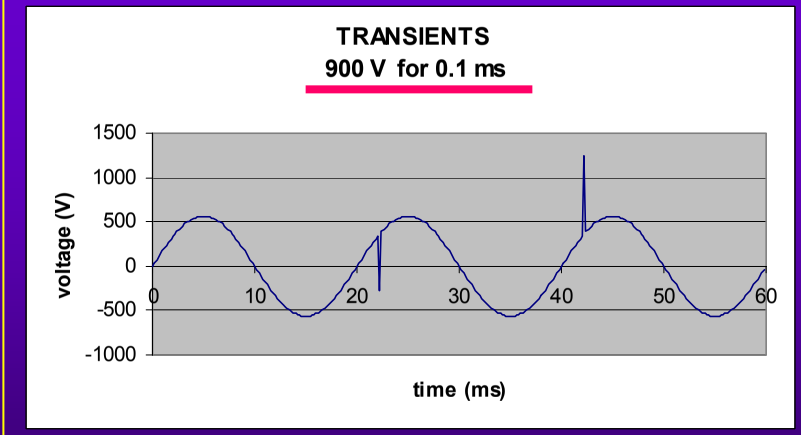
Causes:

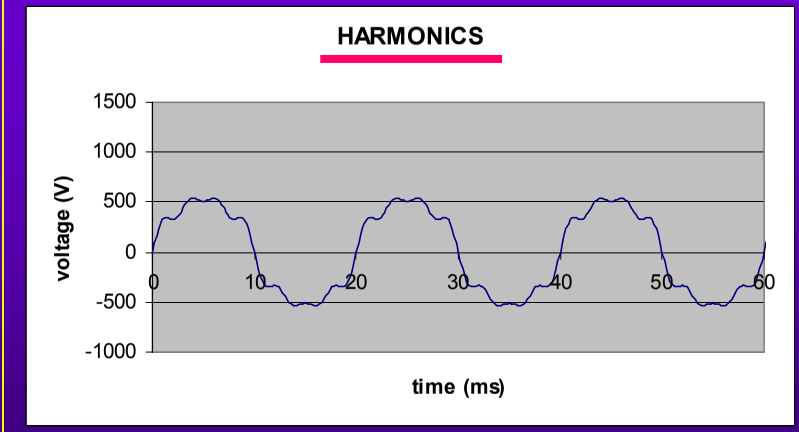
- thunder-storms
-short-circuit inside CERN
- Emergency Stop operation

Consequences:

- accelerator stop







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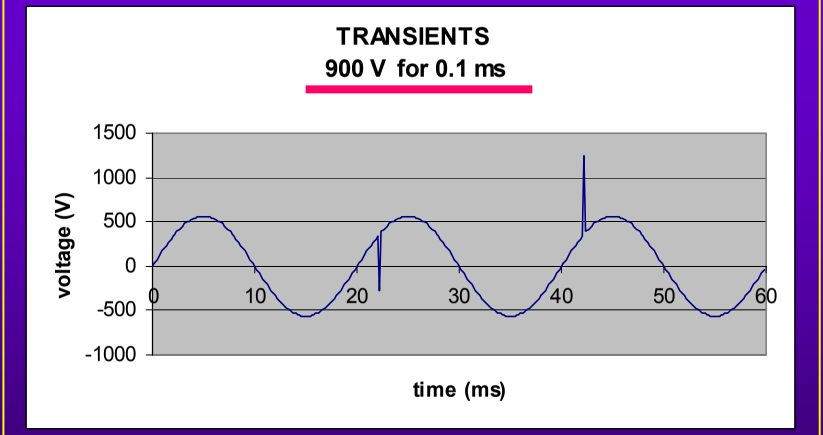
VOLTAGE DIP / SWELL

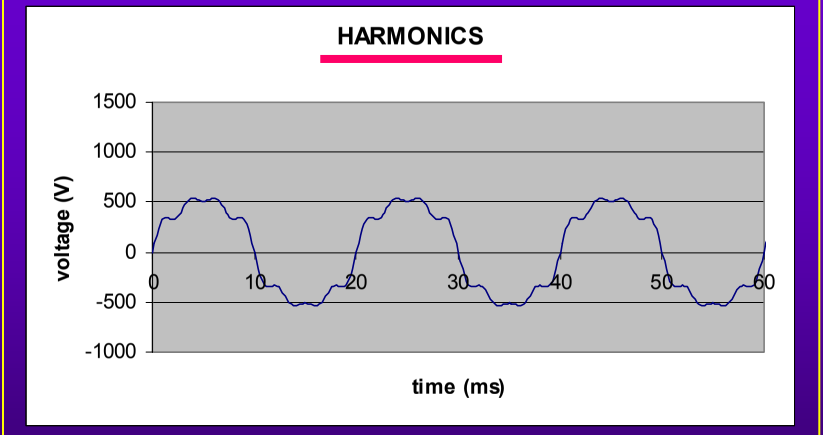
Causes:

- sudden change of load, inrush
- short-circuits inside & outside CERN
- thunder-storms

Consequences:

- sometimes accelerator stop





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TRANSIENTS

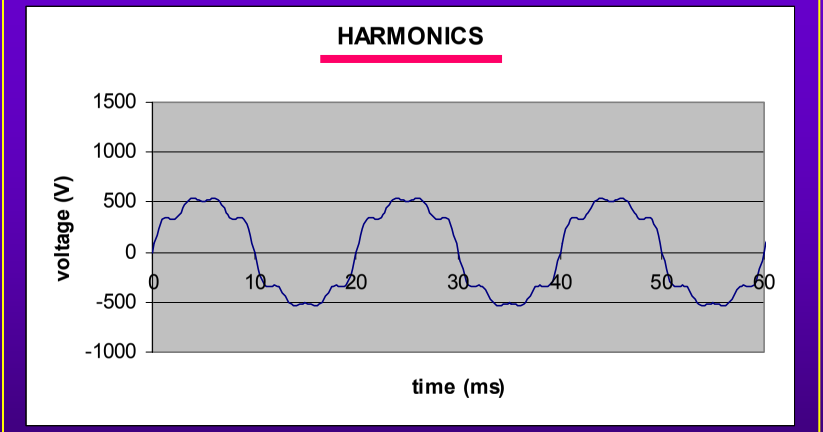
Causes:

- switching compensators ON
- power converters (thyristors)
- thunder-storms

Consequences:

- failure of electronics

HARMONICS



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HARMONICS

Causes:
- non-linear loads
  (office PC's, power converters etc.)

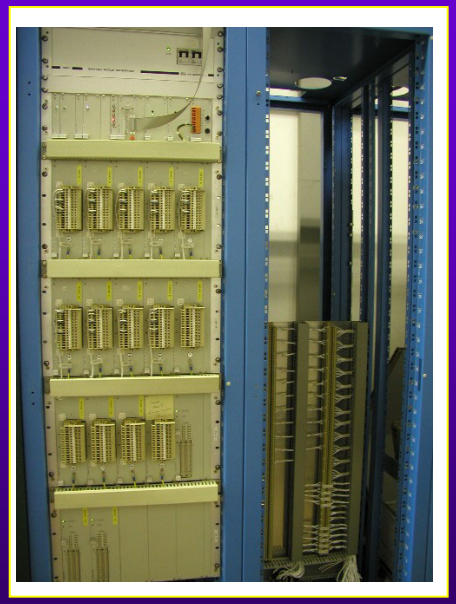
Consequences:
- malfunctioning of electronics

Measurement of disturbances at CERN

HV: 400kV, 66kV, 18kV

OSCILLOSTORE

- 140 channels operating
- central data analysis
- online 365 days / year

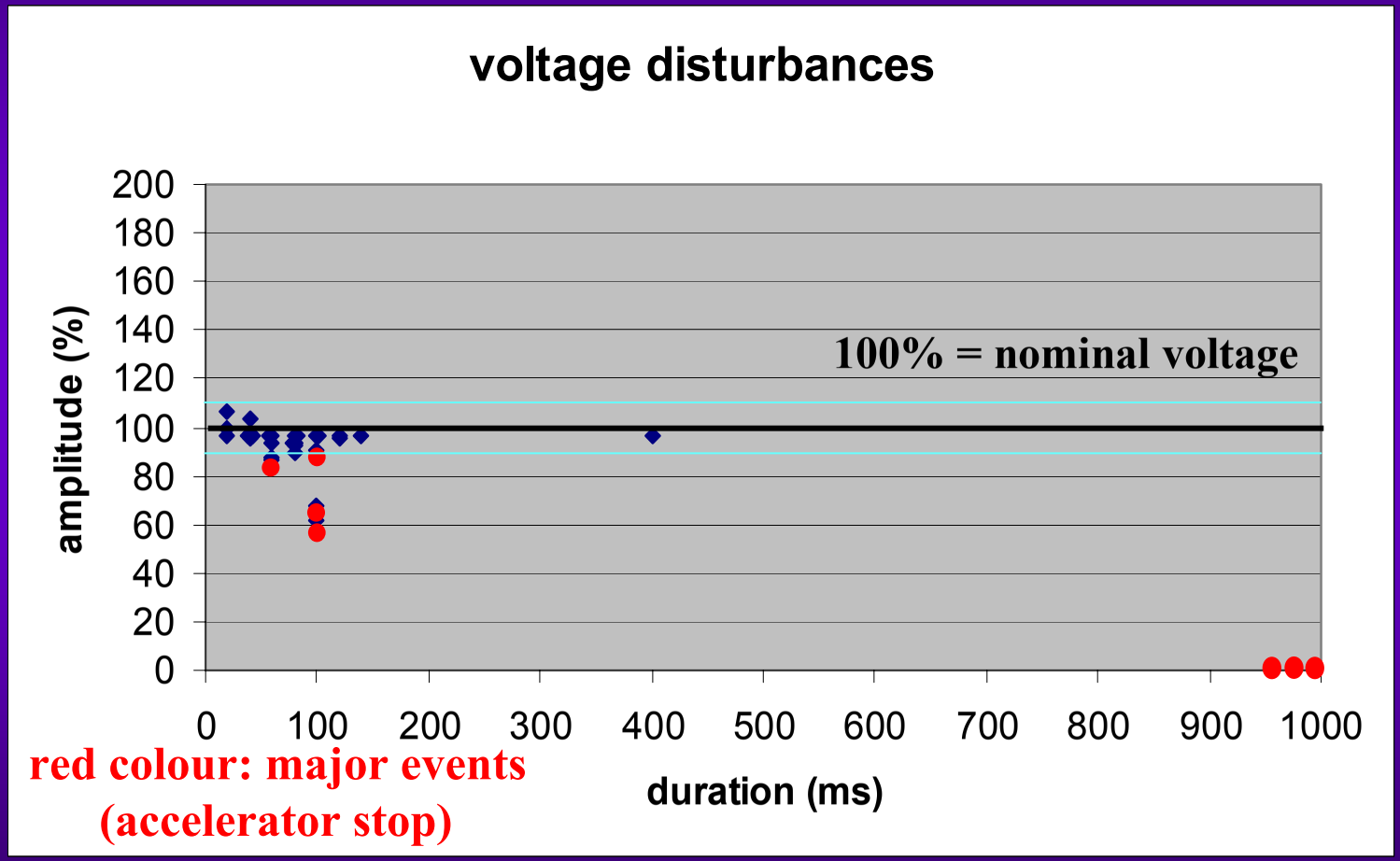


LV: 400V

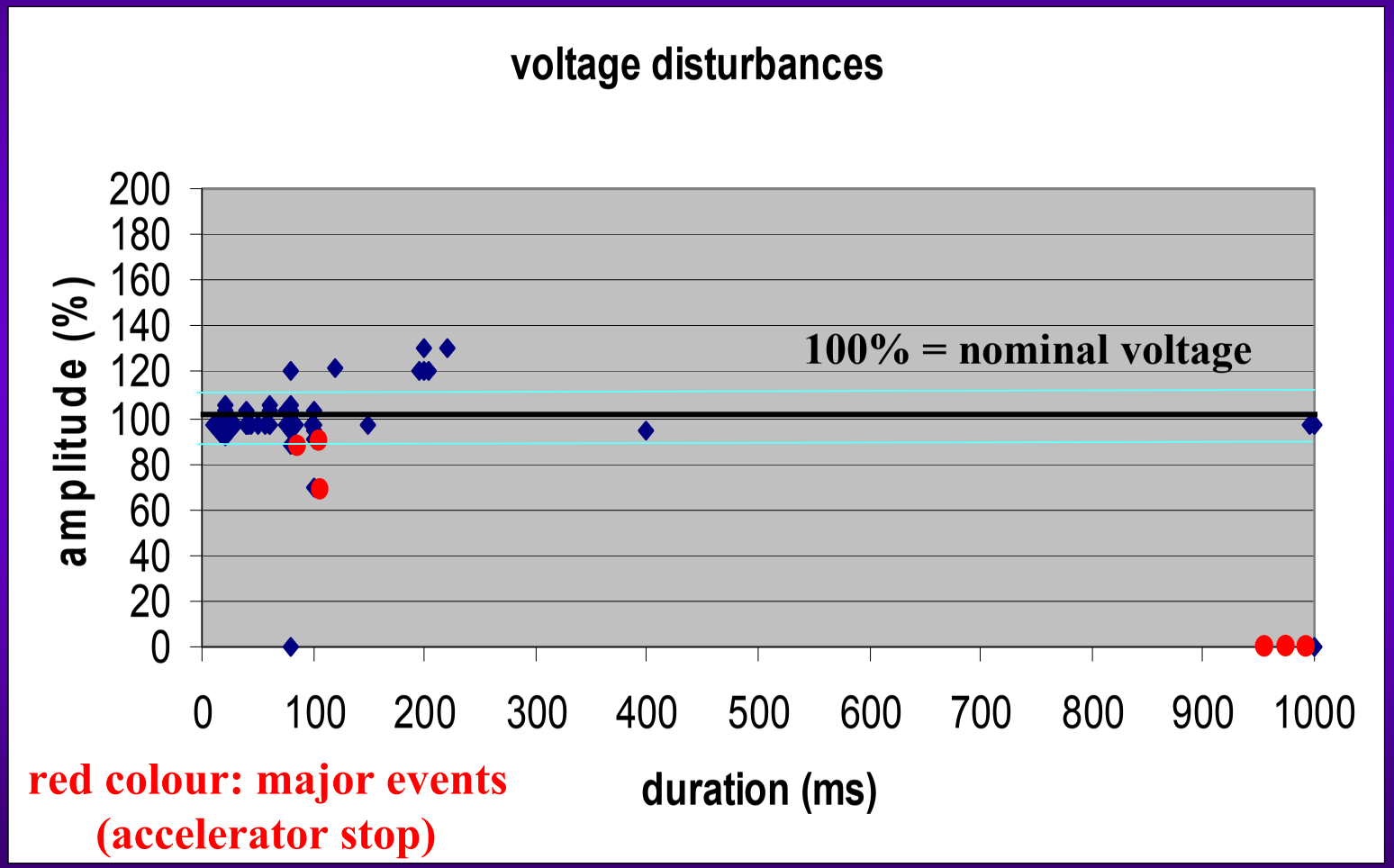
FLUKE devices

- 20 channels operating
- plug-in 230V socket
- online 365 days / year
- low cost

Statistics 2003: 400kV network

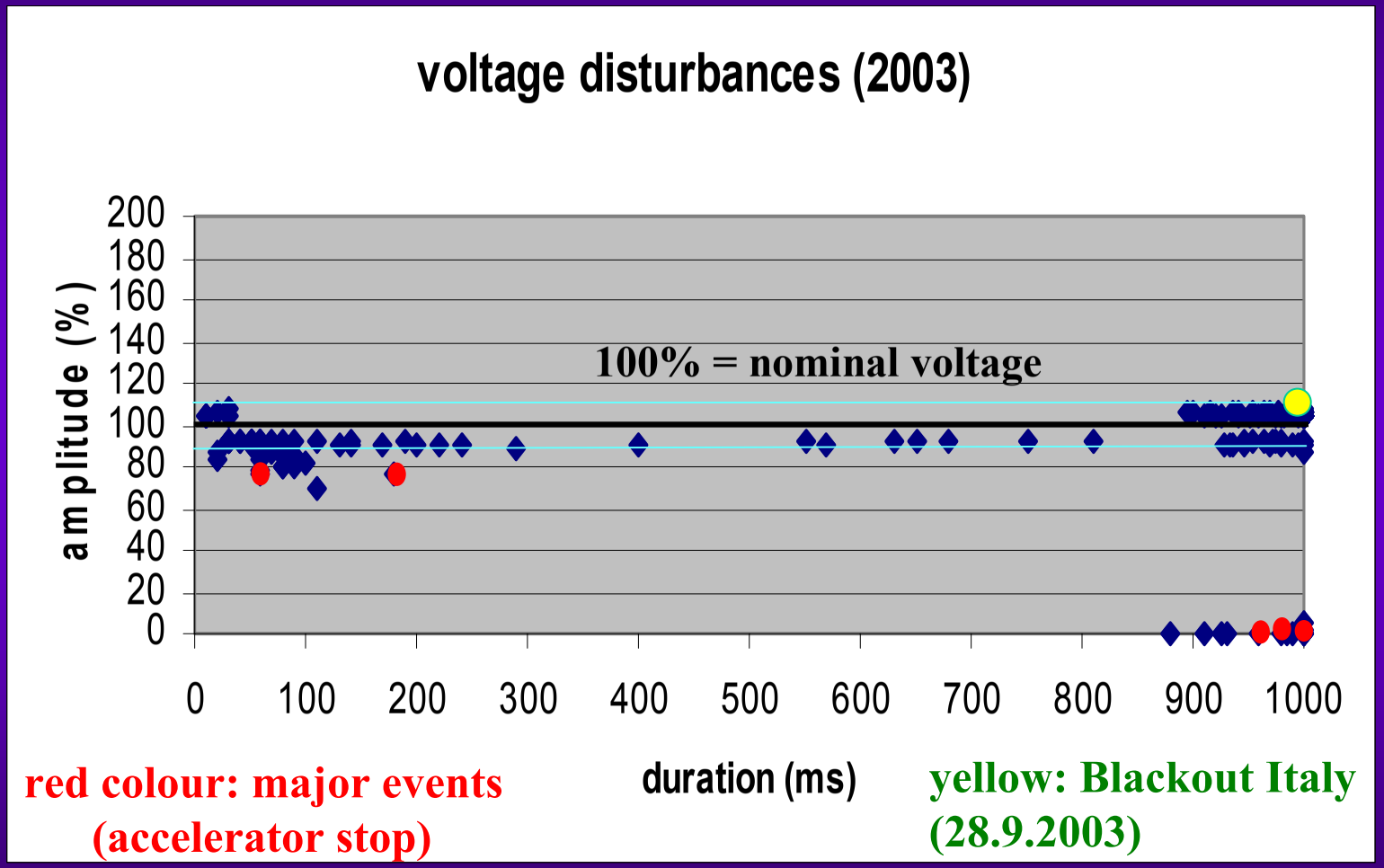


Statistics 2003: 18kV network



red colour: major events (accelerator stop)

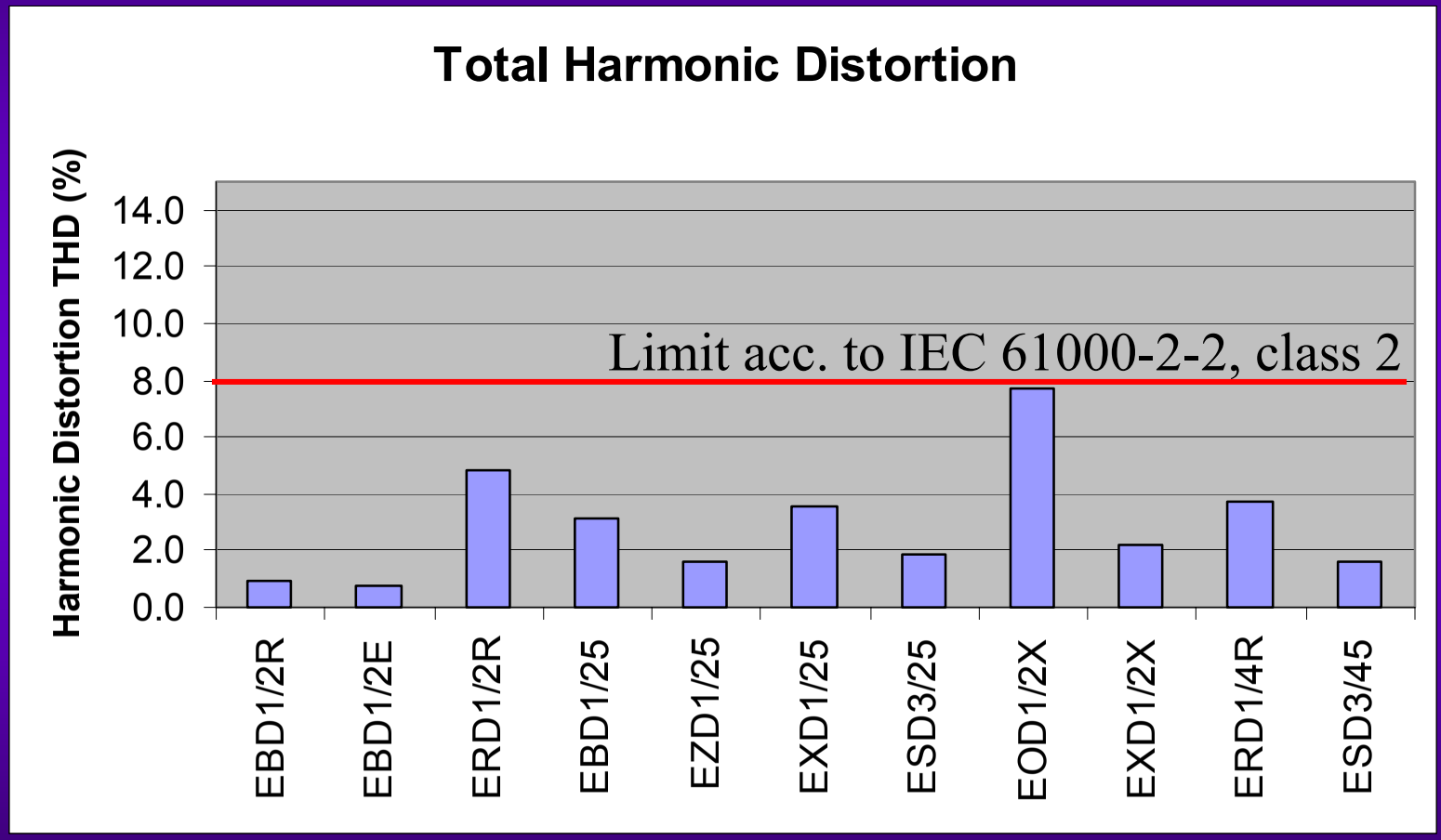
Statistics 2003: 400V network

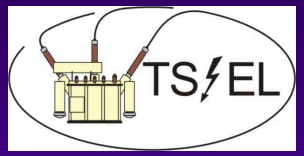


red colour: major events (accelerator stop)

yellow: Blackout Italy (28.9.2003)

Statistics: Harmonics 400V network





Statistics 2003: Causes of disturbances 400V

consequences increase

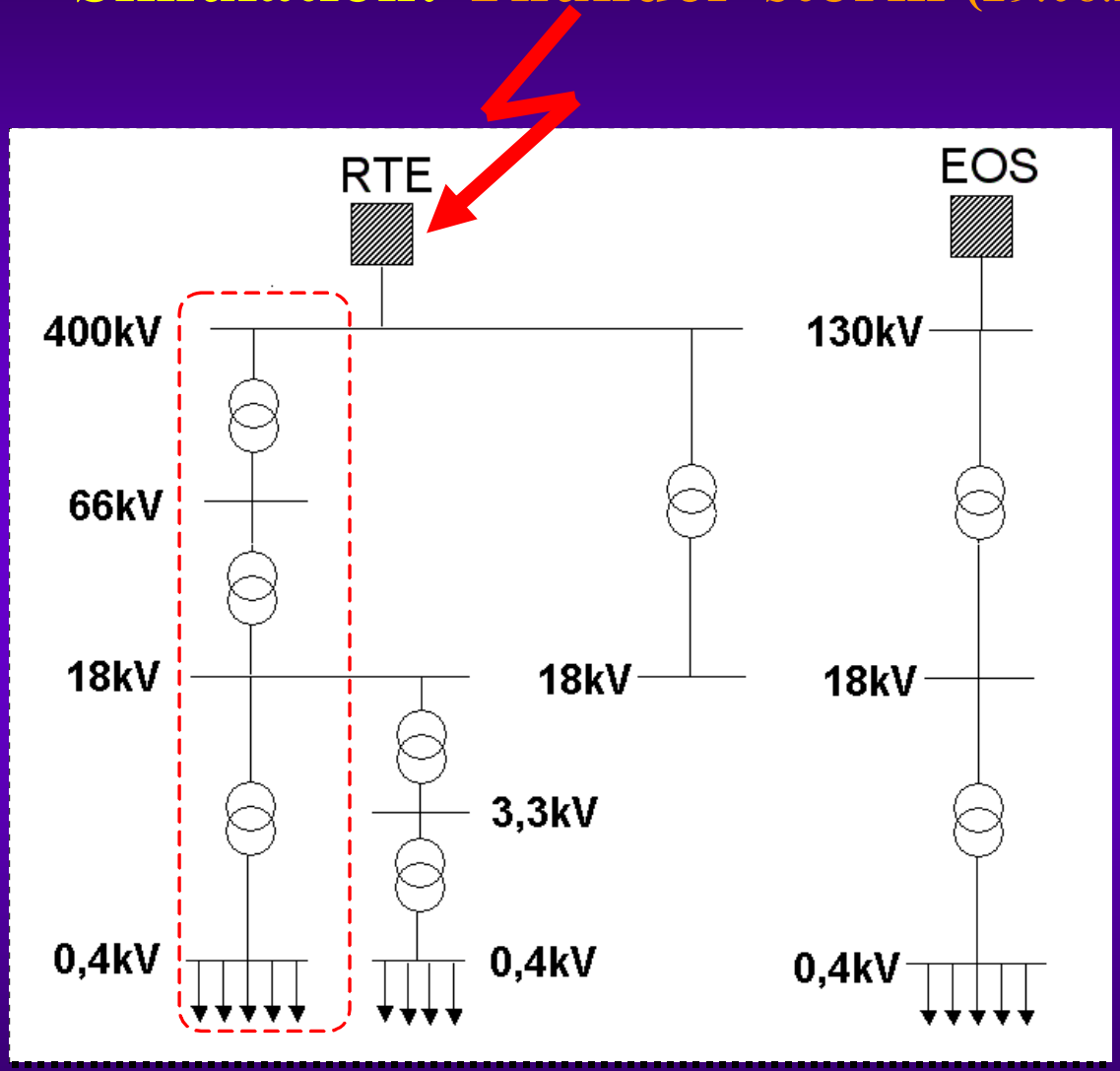
Mains failures:	0.3%	extern: thunder-storms
	0.1%	intern: Emergency Stop, short-circuit
Voltage dips:	50%	sudden change of load (inrush, switching ON)
	5%	short-circuits inside and outside CERN
	4%	thunder-storms
Voltage swell:	10%	thunder-storms and short-circuits, no-load
Transients:	20%	power converters (commutation)
	5%	Compensator switching ON
	5%	thunder-storms and short-circuits
Total	100%	

Statistics: network disturbances

The MAJORITY of network disturbances is caused WITHIN CERN.

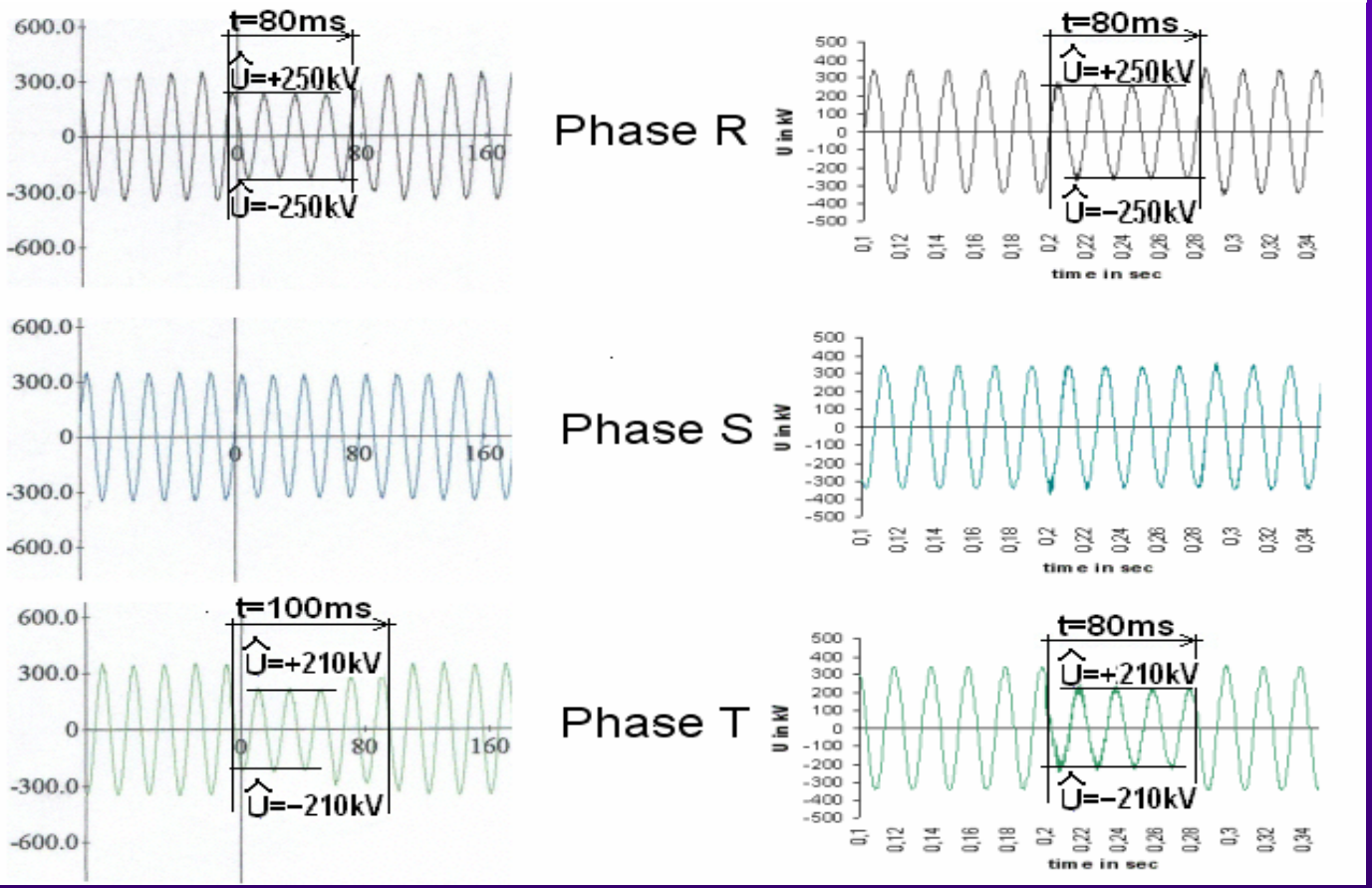
The MAJORITY of network disturbances has no consequences.

Simulation: Thunder-storm (29.08.2003 01:14:32)

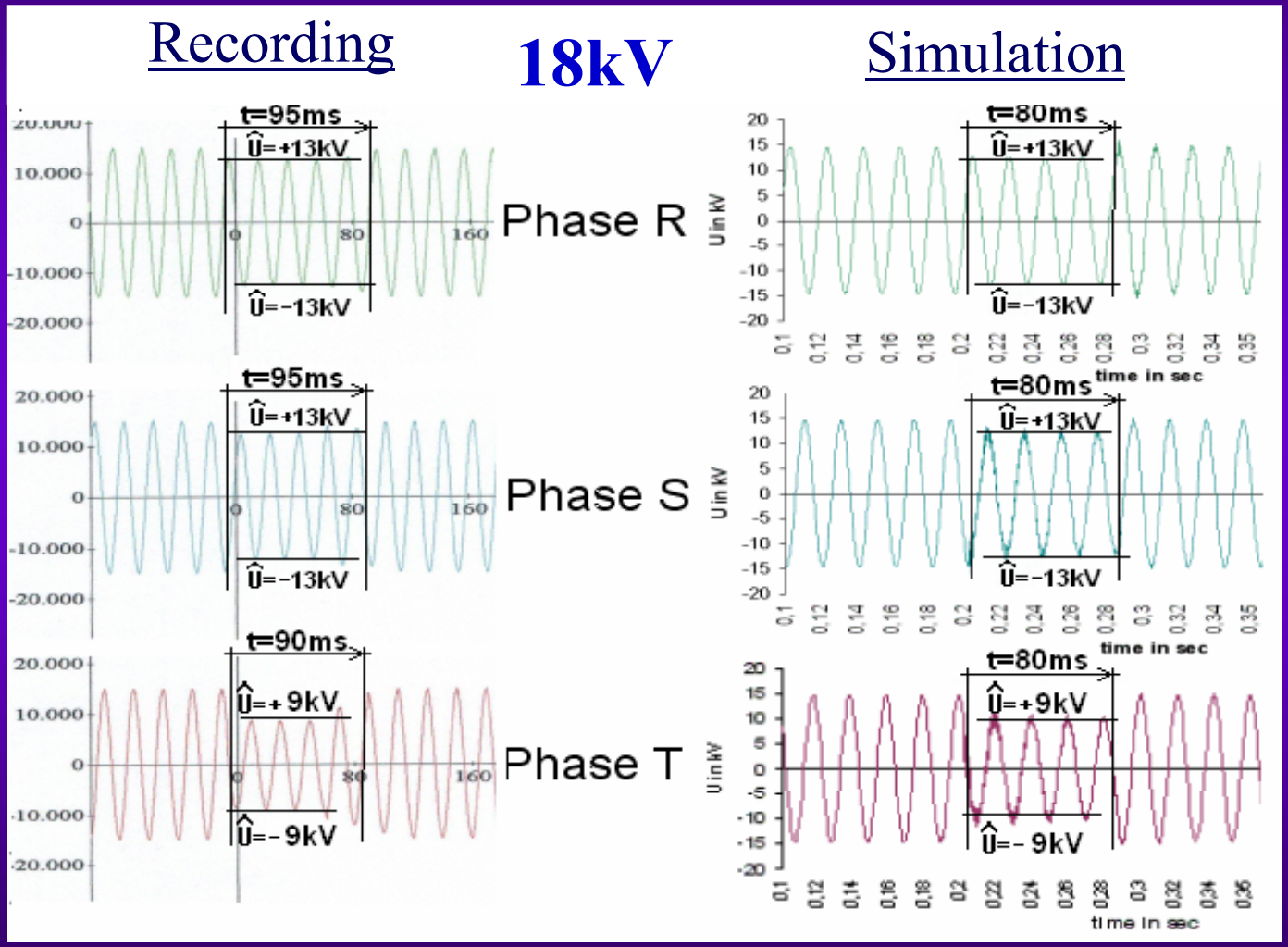


Simulation: Thunder-storm (29.08.2003 01:14:32)

Recording **400kV** Simulation



Simulation: Thunder-storm (29.08.2003 01:14:32)



Simulation: Thunder-storm (29.08.2003 01:14:32)

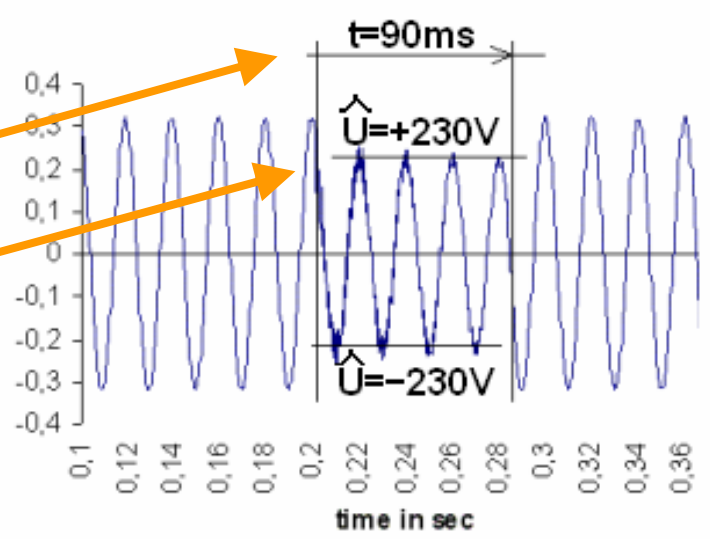
Recording

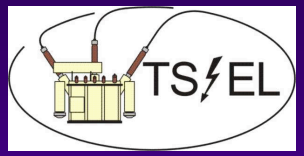
400 V

Simulation

H-N Sag	162 Vrms	5.5 cycles = 110ms

U = 162Vrms → $\hat{U}$ = 229V





Reliability: Mains failures 130kV / 400kV

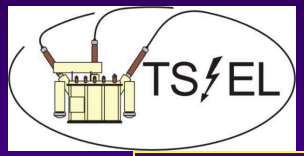
For SPS, LHC and experiments:

- 400kV overhead line to GENISSIAT power station, H.-SAVOIE
- 400kV line from CHAMOSSON hydro station, VALAIS

CERN Automatic Source Transfer System
(AUTOTRANSFER, 20 sec)
Power limited to 60MVA

Back-up supply for LHC general services:

- 130kV line to VERBOIS, GE



Reliability of CERN's 400V networks

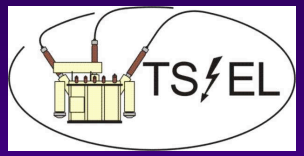
Reliability increases

Normal supply network (switchboards EBDxx/xx):
- supplied by 400kV grid
- load sees all perturbations typical for industrial networks

Assured supply network (switchboards EADxx/xx):
- as Normal Supply, but with diesel generator back-up, 45sec
- switched off by Emergency Stop

Secured supply network (switchboards ESDxx/xx):
- as Assured Supply
- **not** switched off by Emergency Stop

Uninterrupted supply network (switchboards EODxx/xx):
- supplied by UPS systems
- load does not see any disturbances



Conclusions 1/3

Our know-how:

We have now comprehensive recording equipment operational.

We possess detailed statistics on Power Quality at CERN.

We are able to simulate major disturbances and
assess their effects on accelerator operation.

Power Quality at CERN is better than the IEC requirements.

Conclusions 2/3

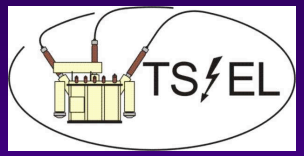
Mains failures:

Effort is made to limit the effect of mains failures:

- Autotransfer 20sec
- Diesel generators 45sec
- manual back-up EDF 20kV, 1h

For critical loads (safety) :

- UPS systems (LHC cryo. control and Computer Center B.513)
- sometimes two redundant UPS in parallel



Conclusions 3/3

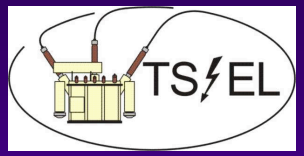
Transient events:

* Not possible to eliminate transient disturbances
  - causes out of our control (e.g. lightning strikes, inrush etc.)

* To assure the functioning of equipment through disturbances, definition of tolerance levels for user's equipment:

LHC Engineering Spec. EDMS113154 (28.07.2000)
"Main Parameters of the LHC 400/230V Distribution System"

* All equipment should preferably be in conformity with this Engineering Specification.



Questions ?

Thank you.