ENGINEERING PROBLEMS AND TASKS
IN EARTHQUAKE PREDICTION PROBLEM

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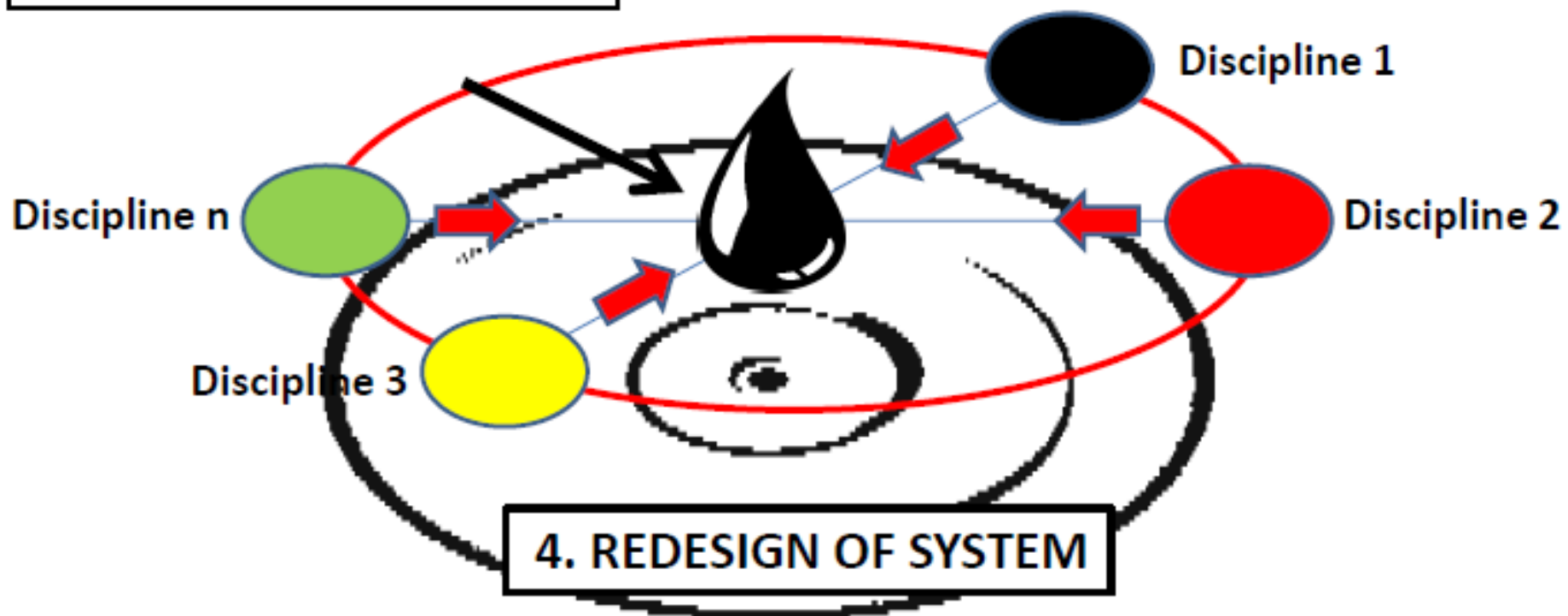**R. L. ACKOFF'S 4 STAGES OF INTERACTION WITH PROBLEMS** (Russell L. Ackoff The Art of Problem Solving)

1. IGNORING THE PROBLEM

2. RESPONDING TO THE PROBLEM

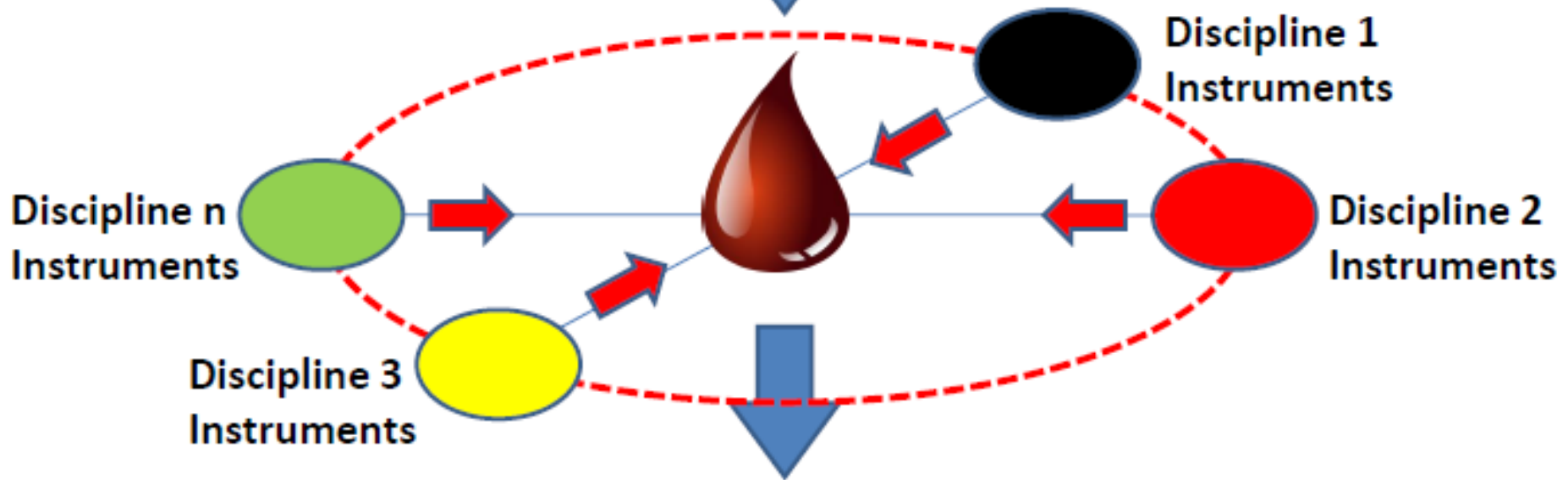3. STUDY OF THE PROBLEM

Discipline 1

Discipline n

Discipline 2

Discipline 3

4. REDESIGN OF SYSTEM

THE STUDY OF THE PROBLEM ⟹ REDESIGN OF KNOWLEDGE

STUDY OF THE PROBLEM

SYSTEM IDENTIFICATION = CRITICAL POINTS DETECTION

Discipline 1
Instruments

Discipline n
Instruments

Discipline 2
Instruments

Discipline 3
Instruments

REDESIGN OF SYSTEM = CRITICAL POINTS CONTROL

SPECIFIC INSTRUMENTS ELABORATION AND INVENTION + SPECIFIC TEAM BUILDING
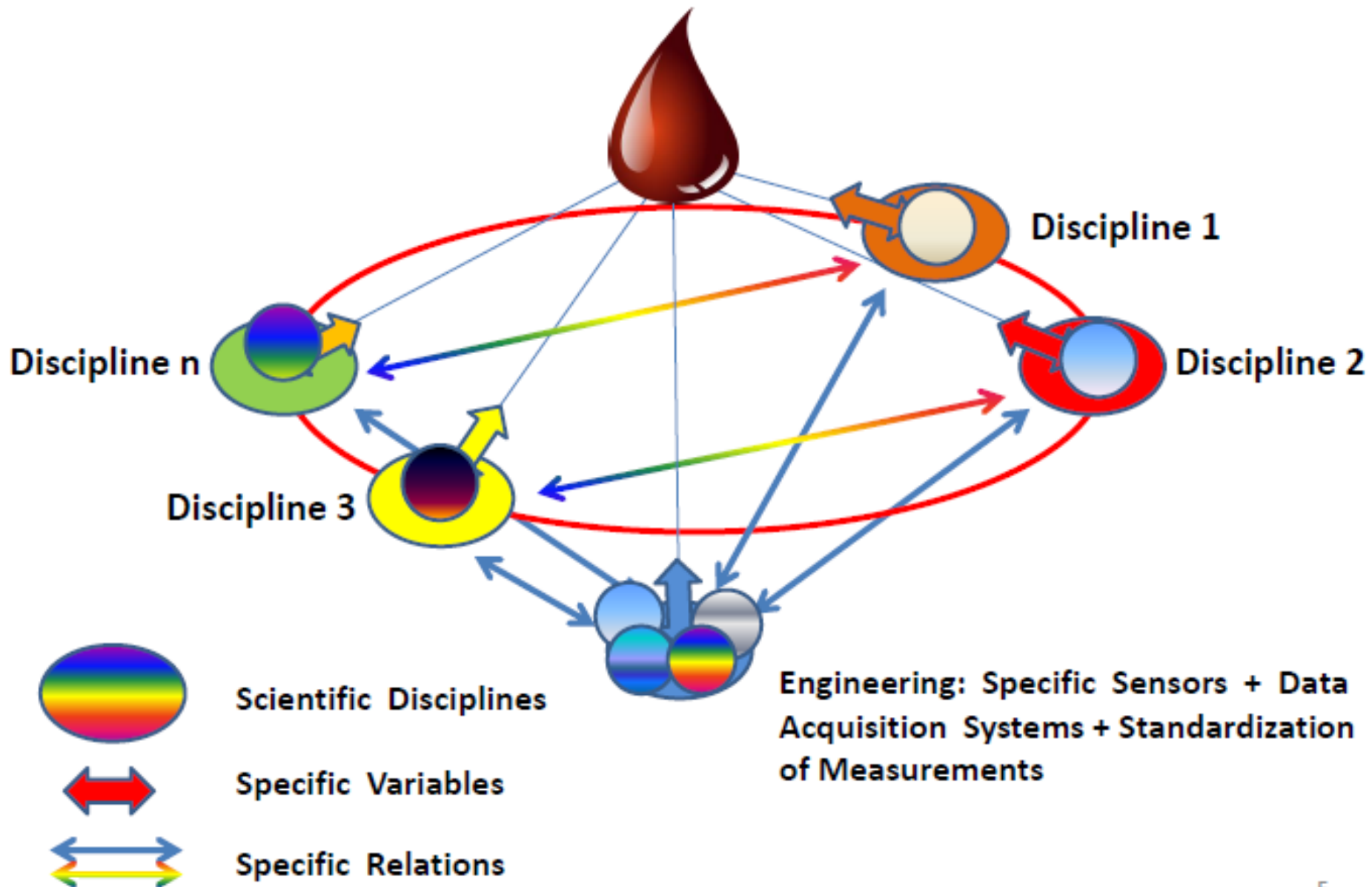
WHERE IS THE ENGINEERING

Discipline 1

Discipline 2

Discipline n

Discipline 3
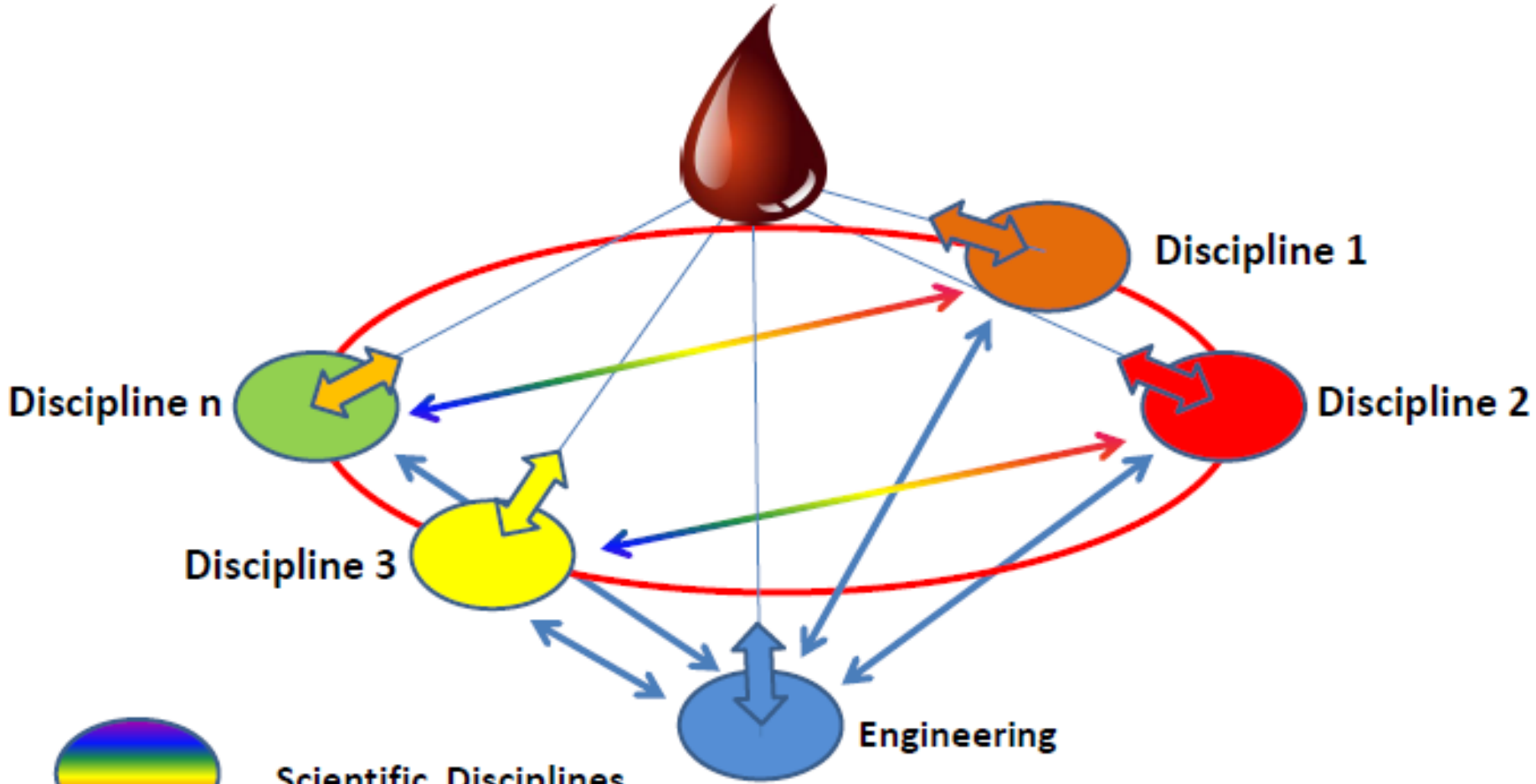
Engineering

Scientific Disciplines

Specific Variables

Specific Relations

AND WHAT IS IT DOING

Discipline 1

Discipline 2

Discipline n

Discipline 3

Engineering: Specific Sensors + Data Acquisition Systems + Standardization of Measurements
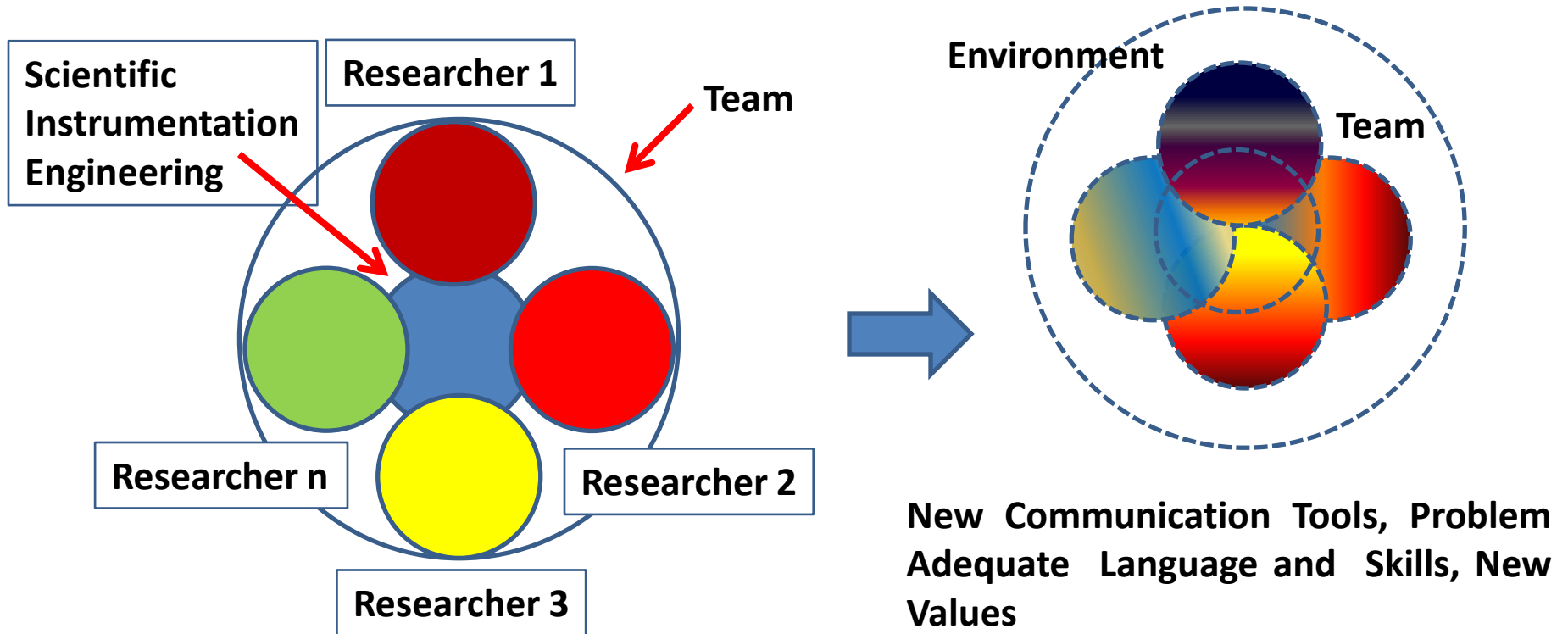
Scientific Disciplines

Specific Variables

Specific Relations

EARTHQUAKE PREDICTION PROBLEM FROM ENGINEERING POINT OF VIEW: TO DETECT CRITICAL POINTS OF PROBLEM.
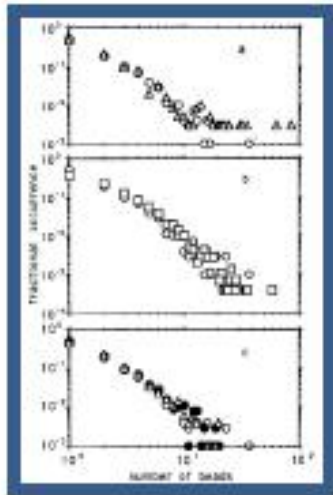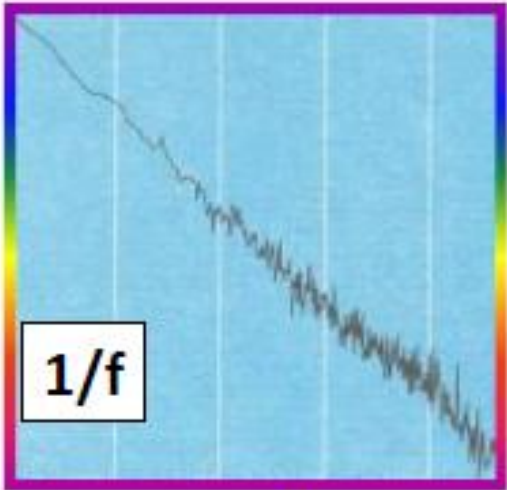
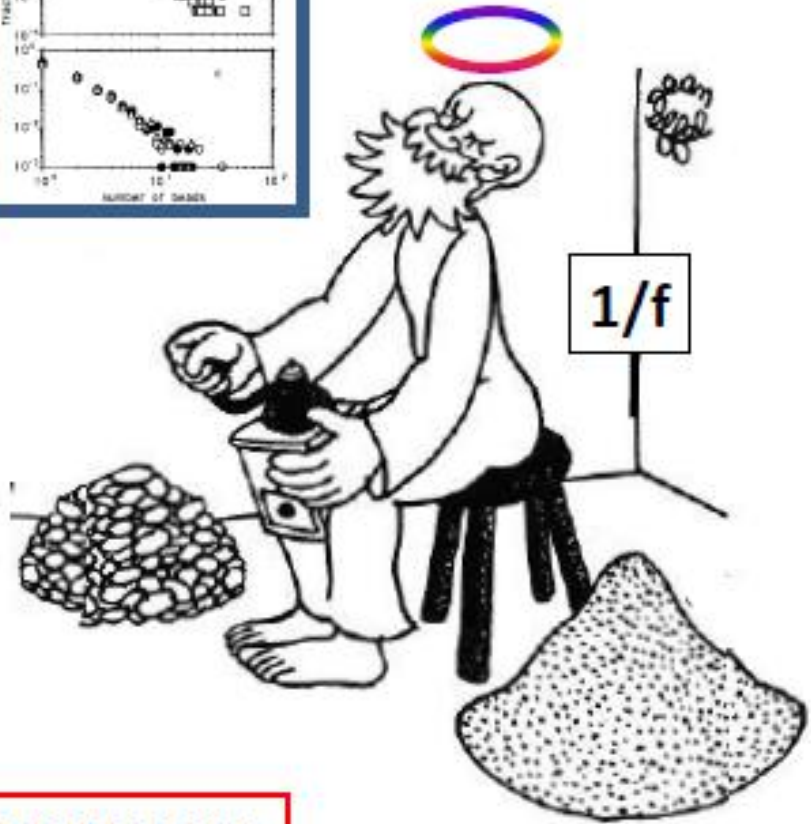# + SOLVE SPECIFIC INTERDISCIPLINARY TEAM BUILDING PROBLEM

FROM HENOTIC INTEREST TO UNITING CULTURE

ἐνωτικός (henōtikós, "serving to unite").
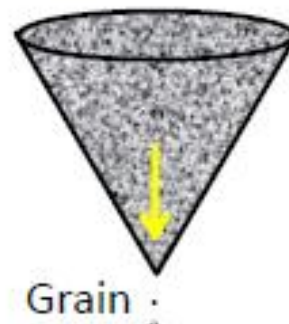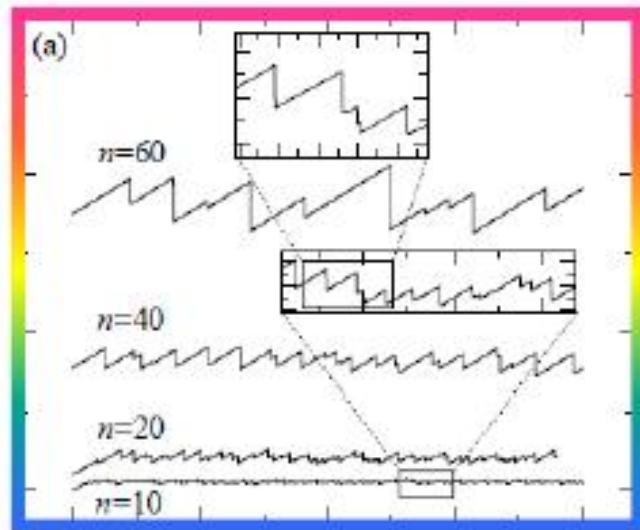
CRITICAL POINT 1

1/f

Gutenberg–Richter law
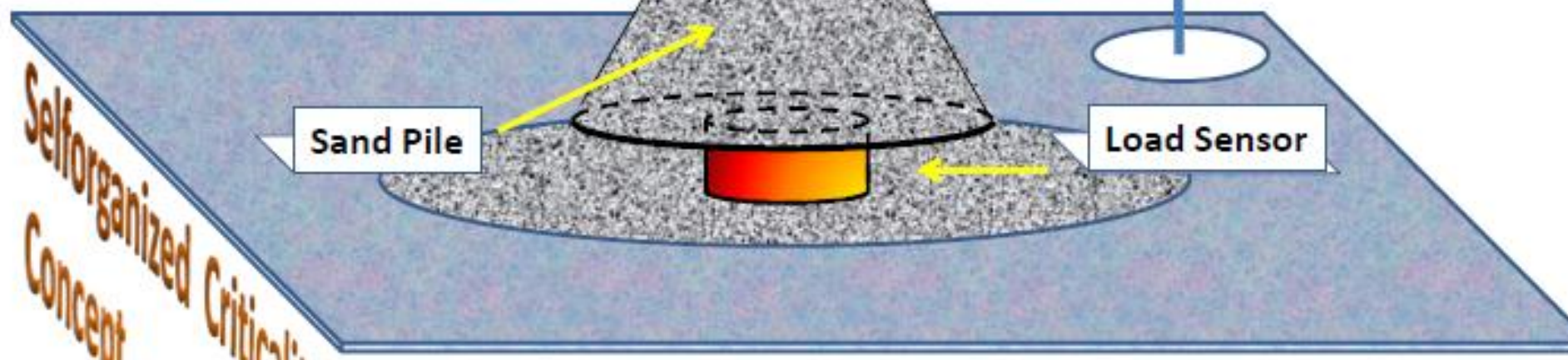

1/f

SAND PILE PARADIGM

8

CRITICAL POINT 1

SAND PILE PARADIGM UNPREDICTABLE!

(a)

$n=60$

$n=40$

$n=20$

$n=10$

Grain

Sand Pile

Load Sensor

Selforganized Criticality Concept

Self-Organized Criticality: An Explanation of 1/f Noise. Per Bak, Chao Tang, Kurt Wiesenfeld. Phys. Rev. Lett., 1987, V 59, No 4, 381-384. Experimental Study of Critical-Mass Fluctuations in an Evolving Sand pile. G. Held, D.Solina, H.Solina, D.Keane, W.Haag, P. Horn, and G. Grinstein, Phys. Rev. Lett., 1990, V 65, 1120-1123.

EARTHQUAKE PREDICTION PROBLEM FROM ENGINEERING POINT OF VIEW: TO DETECT CRITICAL POINTS OF PROBLEM. CRITICAL POINT 2
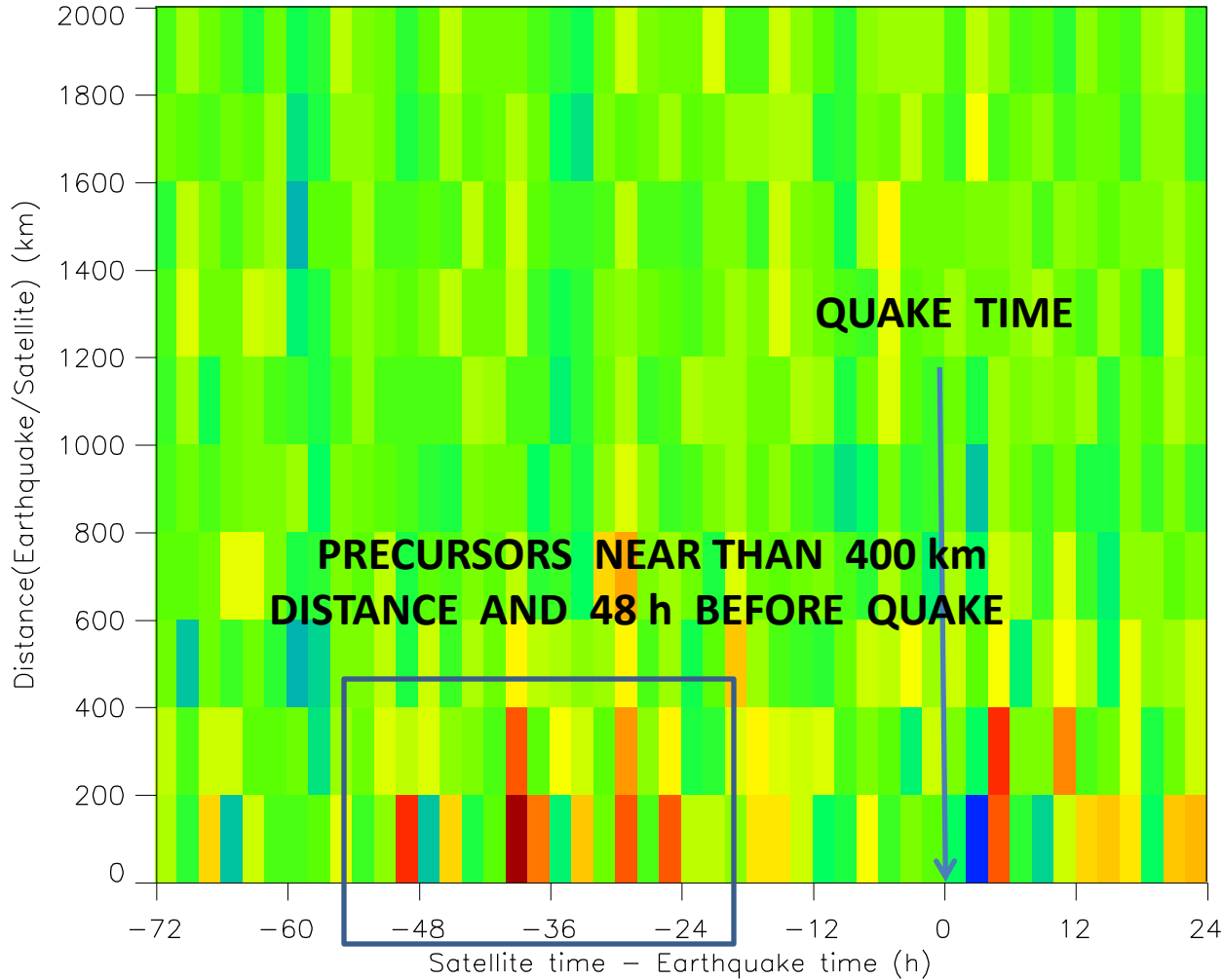
DEMETER (**D**etection of **E**lectro-**M**agnetic **E**missions **T**ransmitted from **E**arthquake **R**egions)
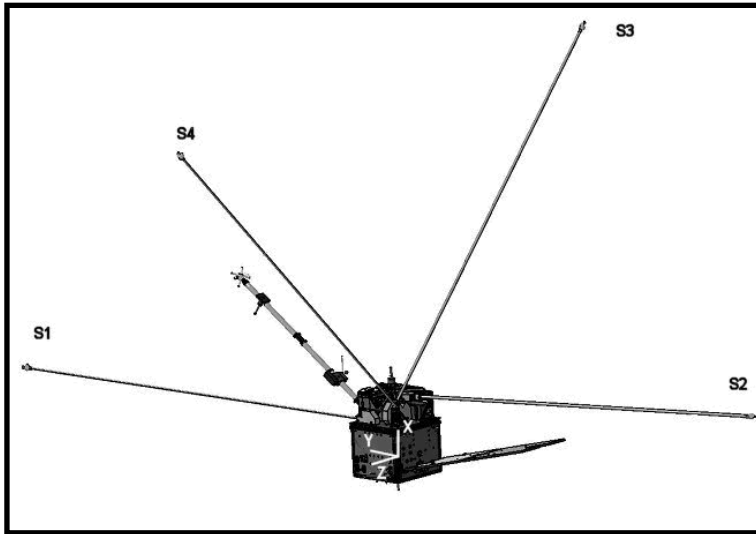
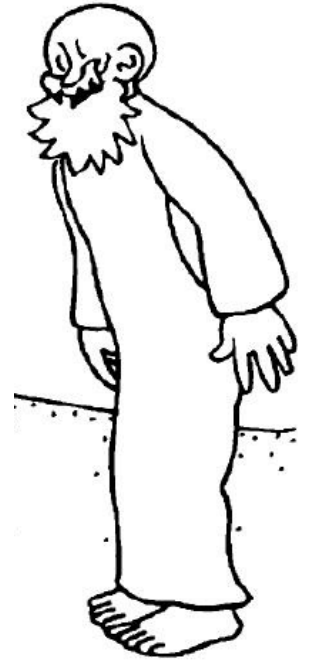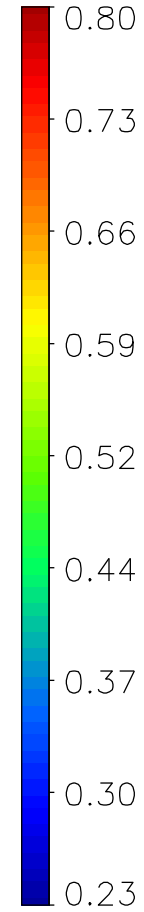## French micro-satellite, operated 2004 - 2010

CRITICAL POINT 2

Relative values of the power densities of E

QUAKE TIME

PRECURSORS NEAR THAN 400 km
DISTANCE AND 48 h BEFORE QUAKE

Distance(Earthquake/Satellite) (km)

Satellite time − Earthquake time (h)

UNPREDICTABLE!?

I never say the word "unpredictable"

EARTHQUAKE PREDICTION PROBLEM FROM ENGINEERING POINT OF VIEW: RESPONSES ON CRITICAL POINTS
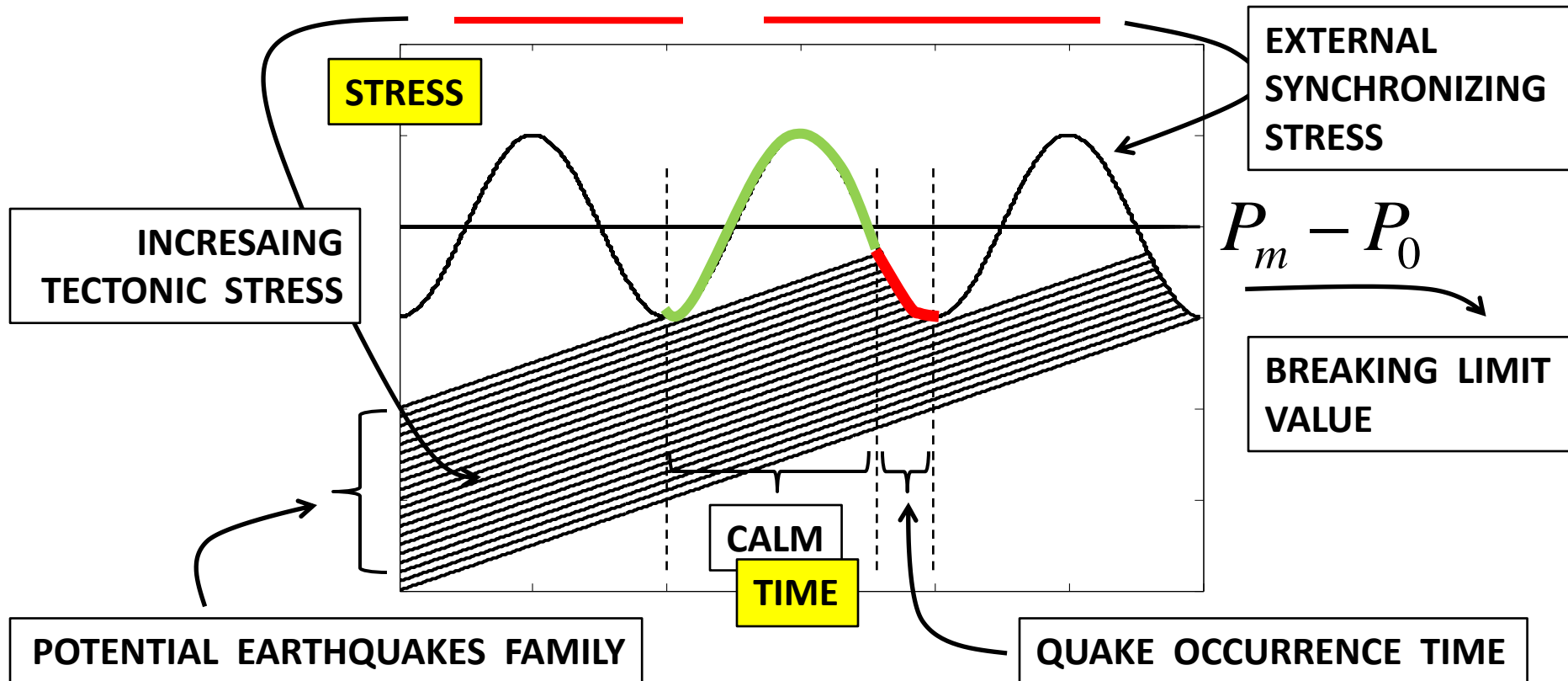
RESPONSE 1. The "Attack" on the Paradigm : Development of Alternative - <u>External Synchronization Approach</u>, <u>Reveal and Study of Synchronizing Factors in Caucasus Region</u>.

RESPONSE 2. Natural Signals and Sensor Systems Analysis; Instrumentation Development, Standardization and Manufacturing; Regional Monitoring Network Development.

TIDAL SYNCHRONIZATION CONCEPT

$$P_0 + b(t - t_0) + a\cos(\varpi t + f) = P_m$$

STRESS

EXTERNAL SYNCHRONIZING STRESS

INCRESAING TECTONIC STRESS

$$P_m - P_0$$

BREAKING LIMIT VALUE

CALM TIME

POTENTIAL EARTHQUAKES FAMILY

QUAKE OCCURRENCE TIME

13

EARTHQUAKE PREDICTION PROBLEM FROM ENGINEERING POINT OF VIEW: RESPONSE ON CRITICAL POINT 1
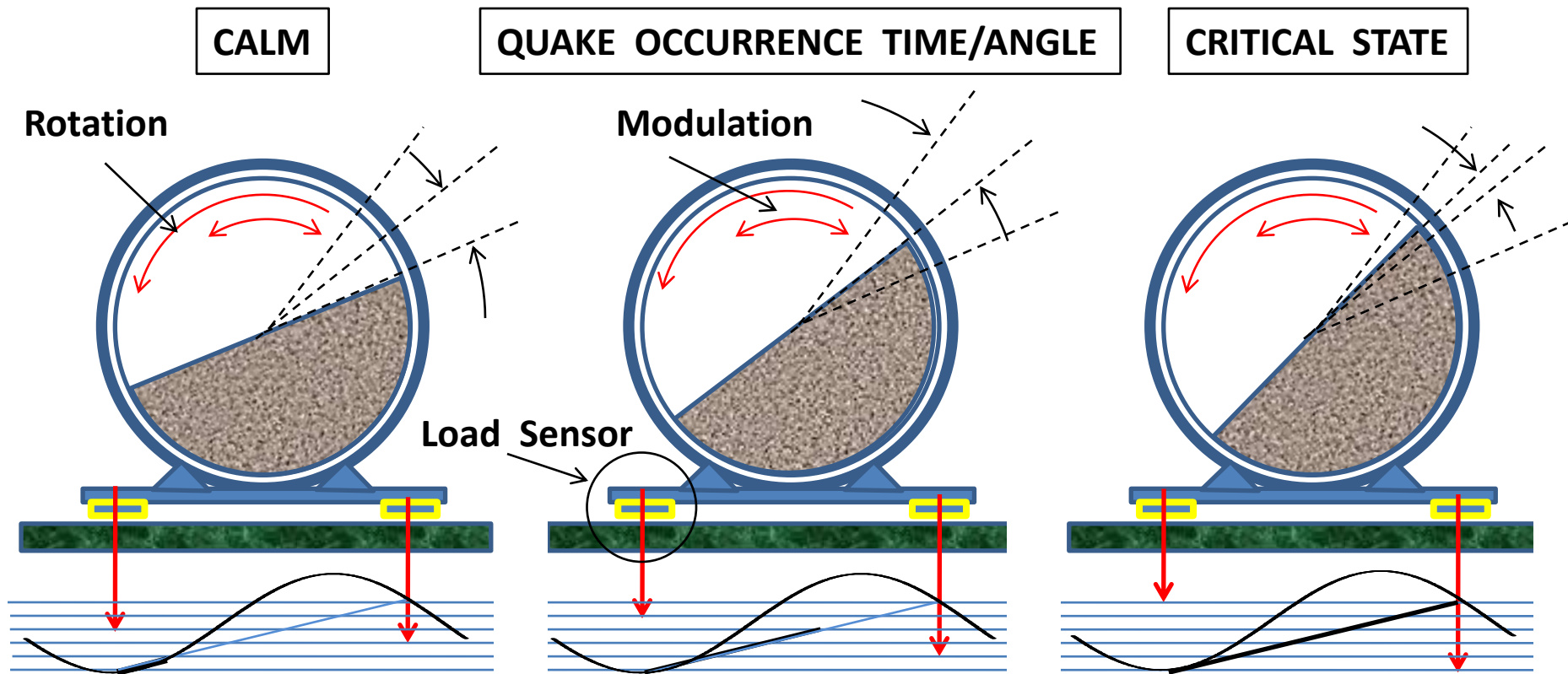
Synchronizing Factors in Caucasus Region

Period (days)	Calm width ($\Delta T / T\%$)	Astronomical sense	Frequency calculation	Comment
**9 Significant Tidal Components Derived from Caucasus M > 6 Earthquakes**
27.303	34.2	Lunar sidereal month	s	Rotation frequency of: Moon –s, Perigee–p, Earth – h, Ascending Node – N.
13.65	25.2	1/2 of Lunar sidereal month	$2s$	
27.5449	27.9	Lunar anomalistic month	$s-p$	
29.513	30.0	Lunar synodical month	$s-h$	
347.93	31.6	Eclipse year	$h+N$	
173.56	25.7	1/2 of Eclipse year	$2(h+N)$	
411.18	30.2	Anomalistic year	$h-p$	
3177	21.5	Lunar orbit perigee revolution period	p	
1588.8	29.8	1/2 of Lunar orbit perigee revolution period	$2p$	

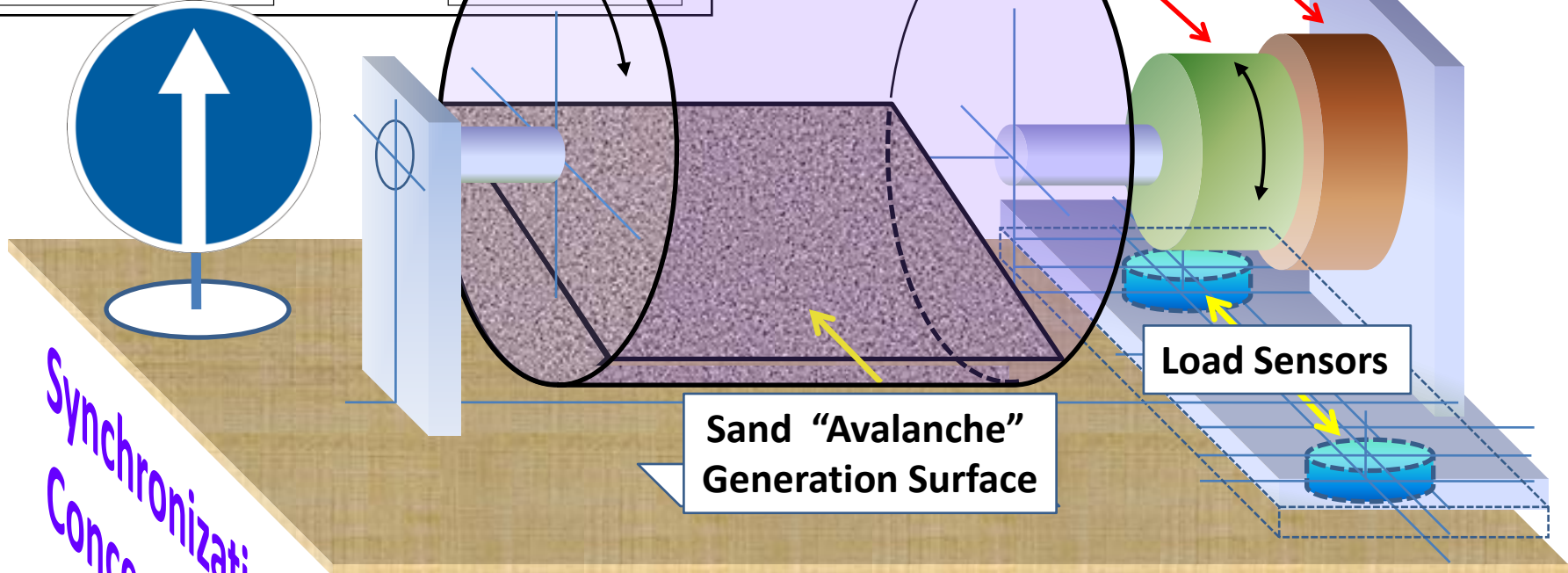## CONCLUSION: POSSIBLE EARTHQUAKE OCCURRENCE TIME INTERVALS FOR CAUCASUS REGION CAN BE CALCULATED
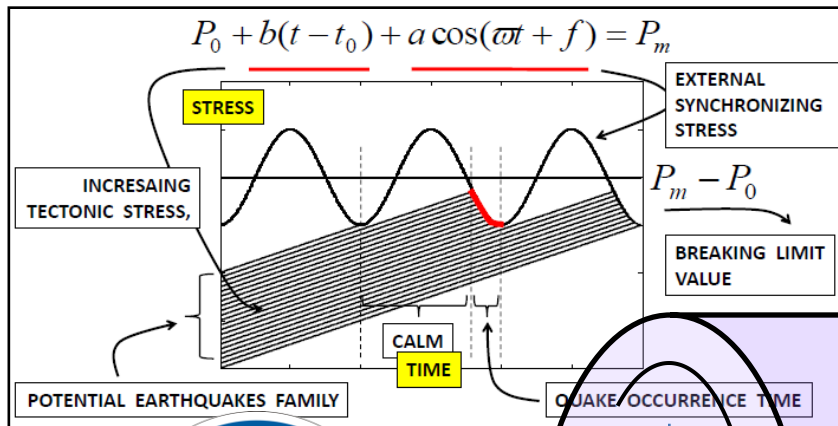
EARTHQUAKE PREDICTION PROBLEM FROM ENGINEERING POINT OF VIEW: RESPONSE ON CRITICAL POINT 1

TIDAL SYNCHRONIZATION MODEL

CALM

QUAKE OCCURRENCE TIME/ANGLE

CRITICAL STATE

Rotation

Modulation

Load Sensor

Modulation and Load Difference Signals

$$P_0 + b(t - t_0) + a\cos(\varpi t + f) = P_m$$

STRESS

EXTERNAL SYNCHRONIZING STRESS

INCREASING TECTONIC STRESS,

$P_m - P_0$

BREAKING LIMIT VALUE

CALM TIME

POTENTIAL EARTHQUAKES FAMILY

QUAKE OCCURRENCE TIME

Synchronization Concept

Synchronization Machine

| Rotation Motor | Modulation Motor |

Load Sensors

Sand "Avalanche" Generation Surface

Detecting Quasi-Harmonic Factors Synchronizing Relaxation Processes: Application to Seismology. Lursmanashvili Otar, Paatashvili Tamar, Gheonjian Lev. Synchronization and Triggering: from Fracture to Earthquake Processes. Springer, Geoplanet: Earth and Planetary Sciences, vol. 1, pp. 305-322, 2010.
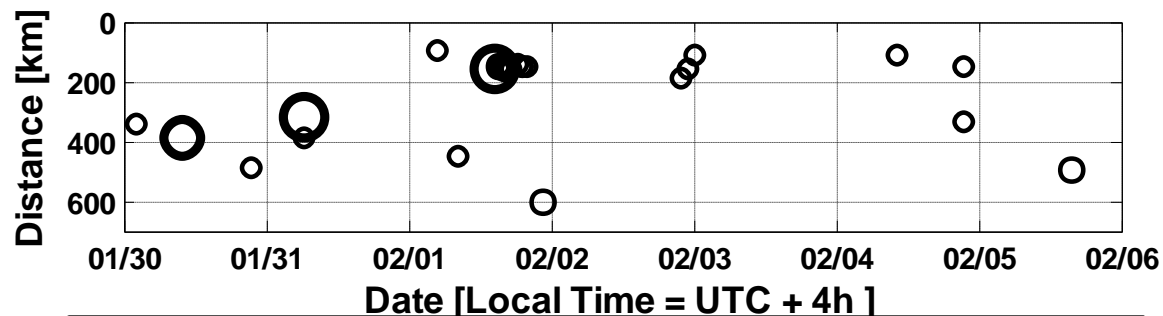
IEEE TSU VLF MONITOR

QUAKE OCCURRENCE DISTURBED TIME INTERVAL

CALM TIME INTERVAL
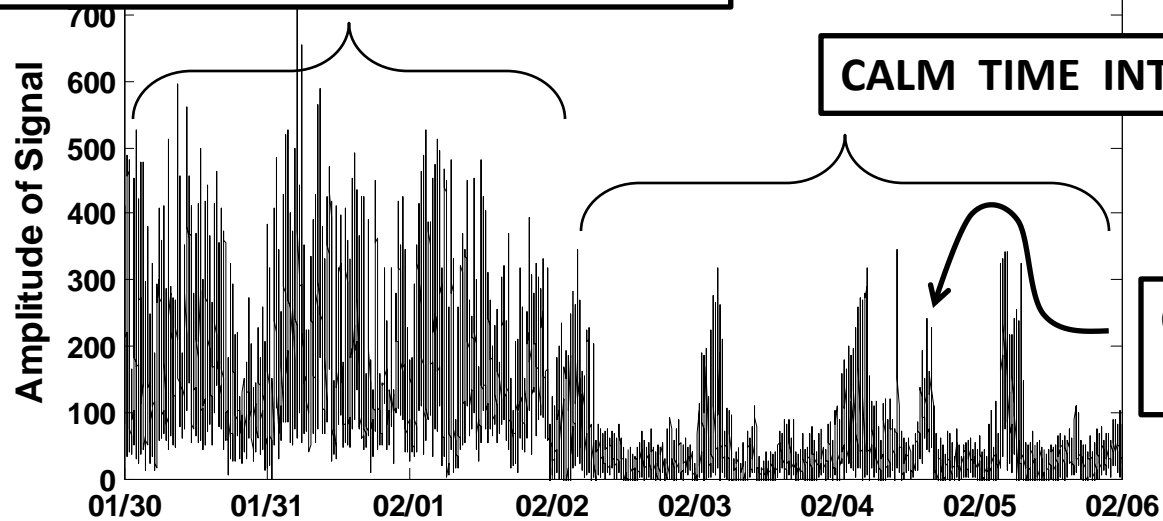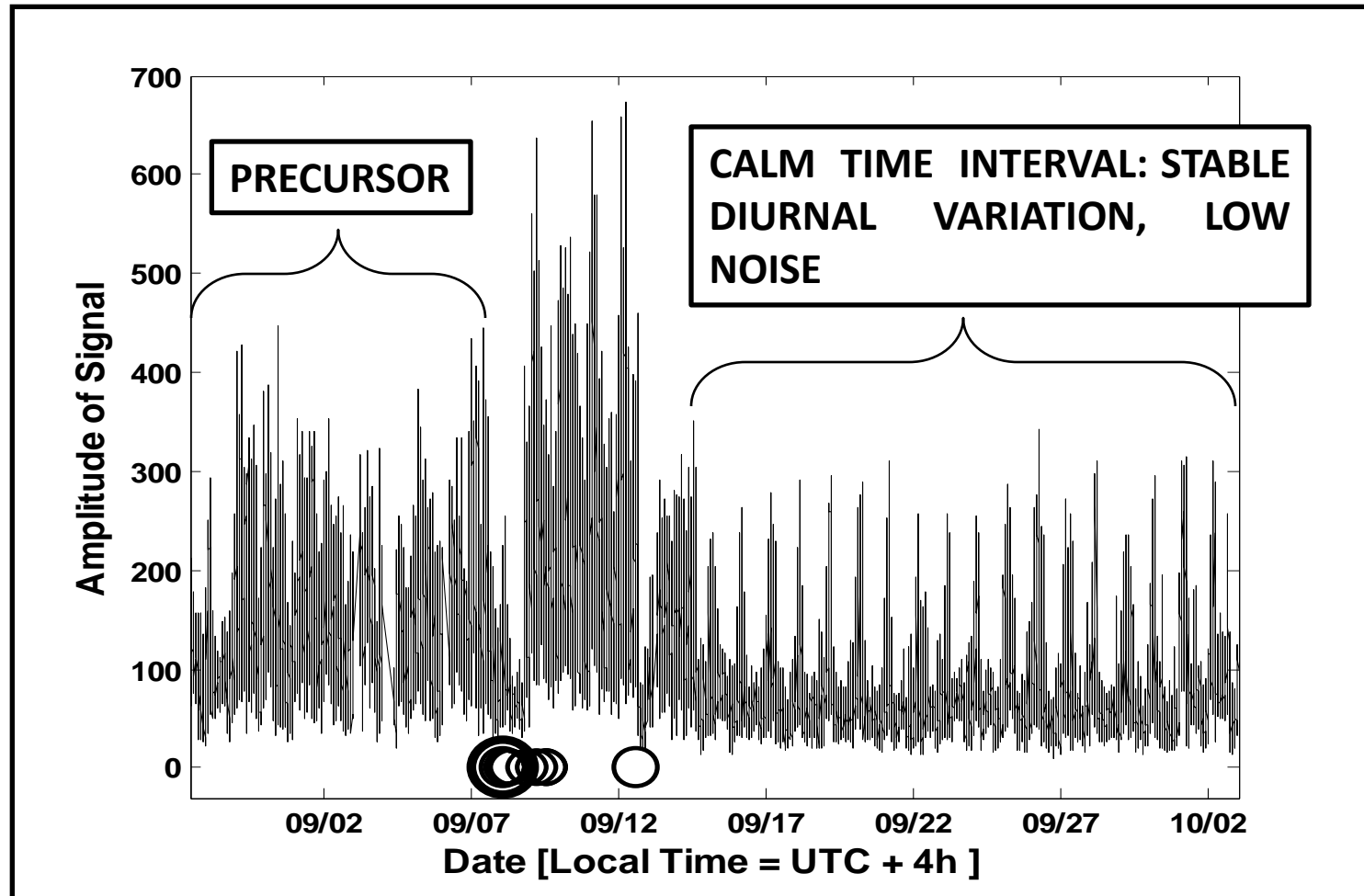
CORONAL MASS EJECTION
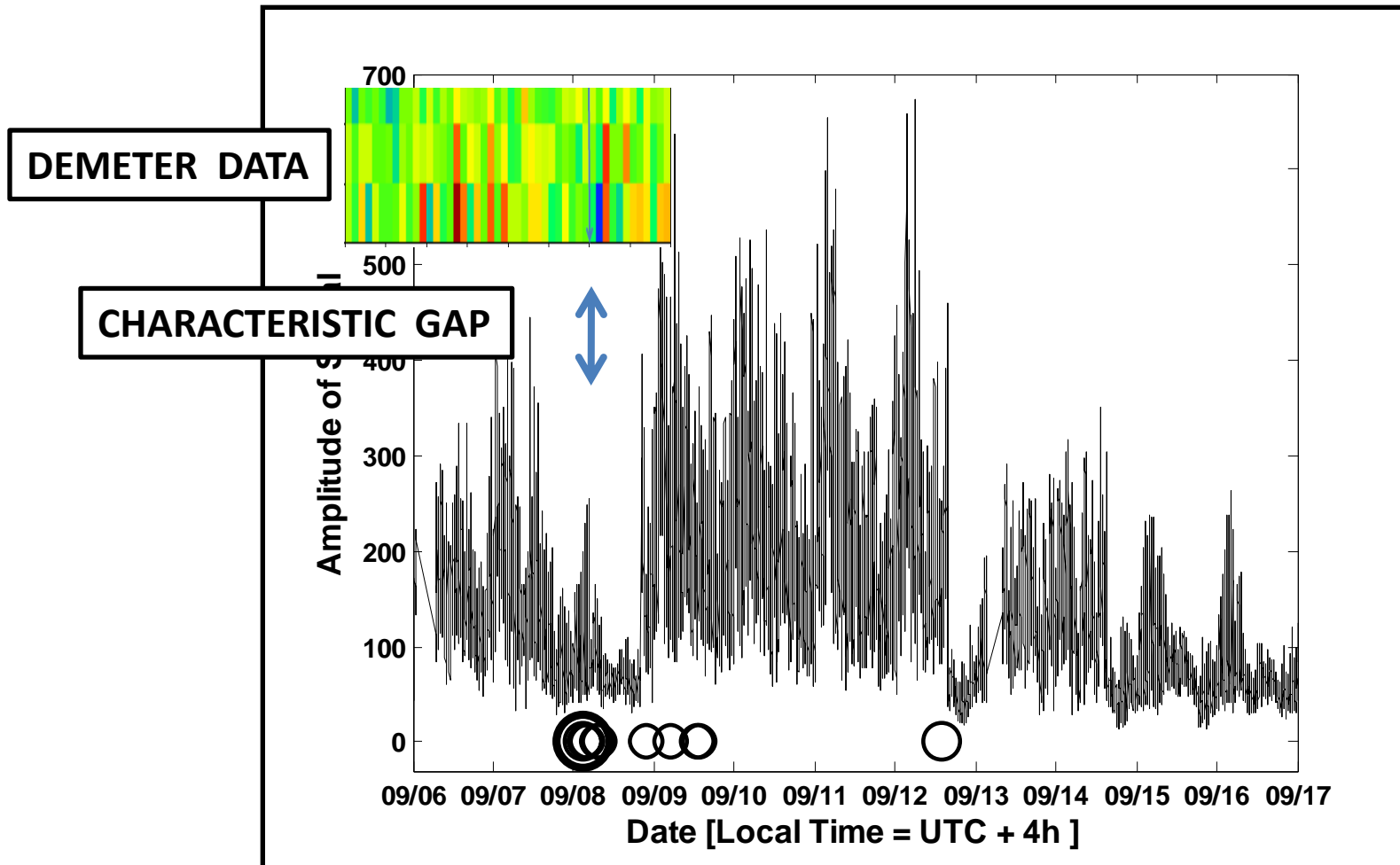
VLF MONITOR DATA REPRESENTATION FORM

EARTHQUAKE PREDICTION PROBLEM FROM ENGINEERING POINT OF VIEW: RESPONSE ON CRITICAL POINT 2

M 6.0 EARTHQUAKE PRECURSOR, ONI, 07.09.2009, 100 km DISTANCE

DEMETER DATA

CHARACTERISTIC GAP

EARTHQUAKE PREDICTION PROBLEM FROM ENGINEERING POINT OF VIEW: RESPONSE ON CRITICAL POINT 2

2016 STEPS

4 IEEE TSU VLF MONITORS INSTALATION IN 2016.
DETERMINATION OF NETWORK CELL OPTIMAL SIZE.