Identifying high power breakdowns in accelerating structures with acoustic sensors

- Accelerating structures R&D
- Breakdowns
- Experimental setup
- Analysis and correlations

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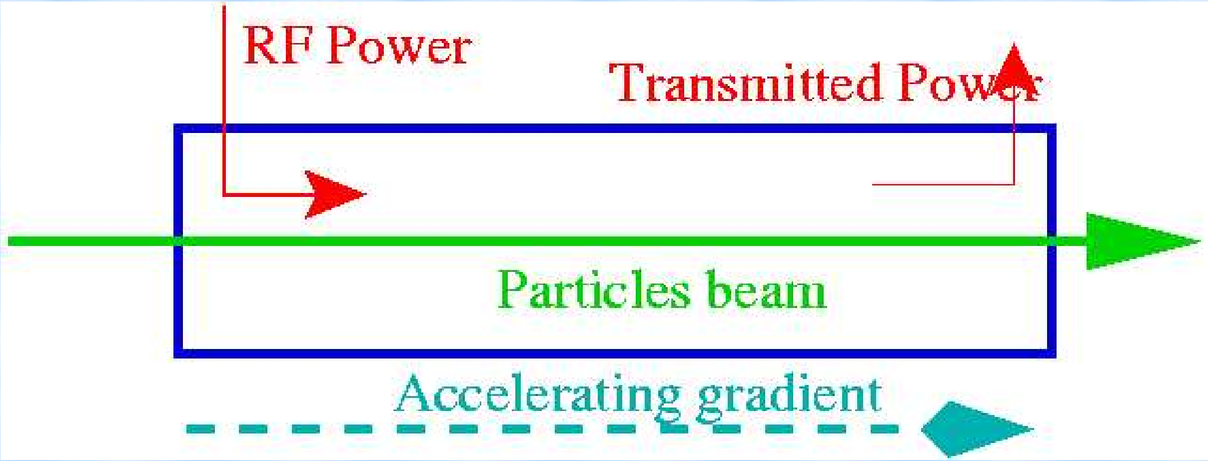
What is an accelerating Structure?

- Acceleration in a linac is provided by an accelerating structure
- These structures use high power at high frequency
KEK B: 40 MW at 3 GHz (S-band)
GLC : ~75 MW at 11 GHz (X-band)
- To increase the acceleration gradient you need to increase the power.



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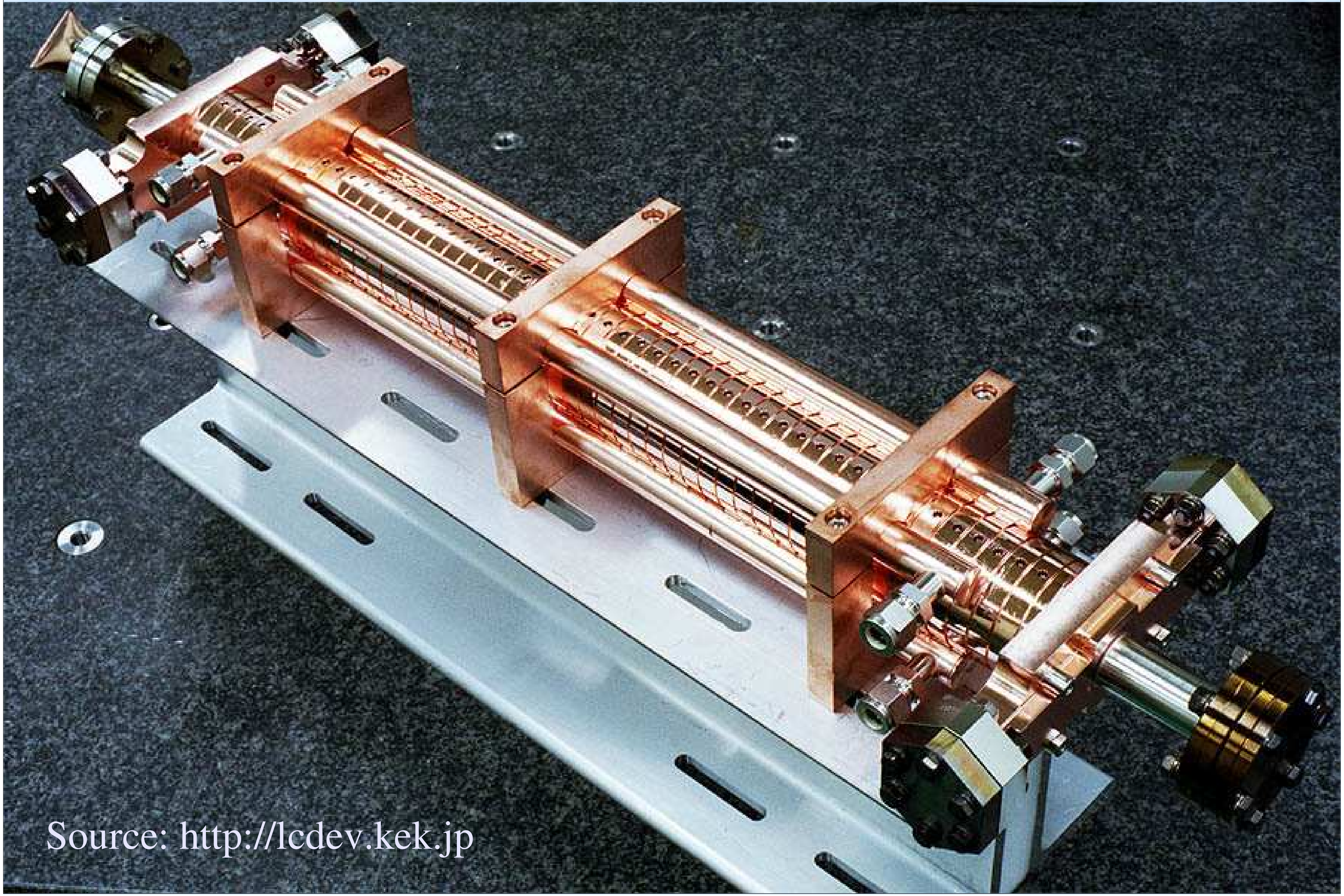
A X-band accelerating Structure



Accelerating structures R&D

- For Super KEK B, a higher accelerating gradient is needed to reach the higher luminosity planned
  = > Use new structures with higher gradient at higher frequency (6 MHz C-band)
  (see presentation given by Sugimura Takashi)
- X-band structures (for the GLC) had never been used in an accelerator before
  = > Structure at this power and energy are new.

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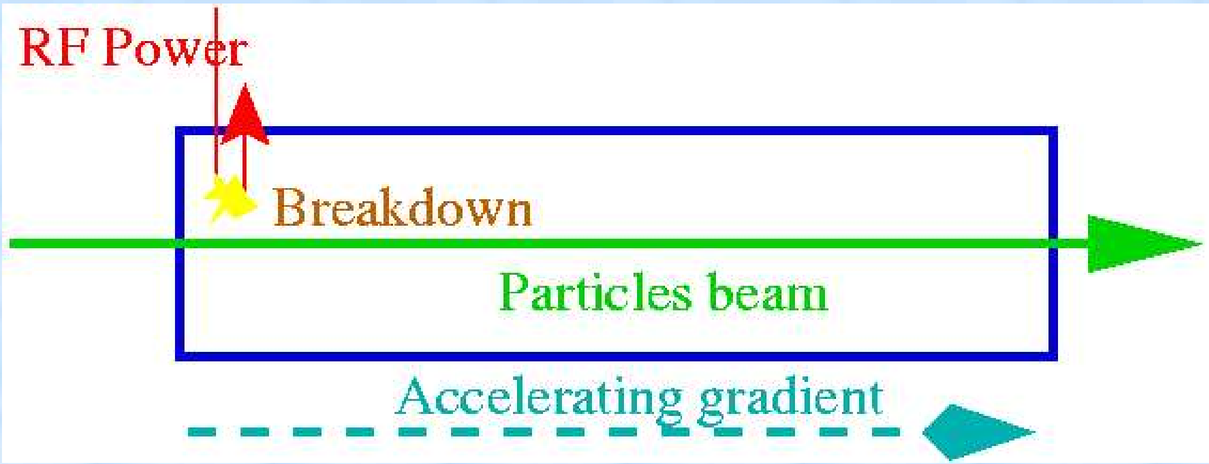
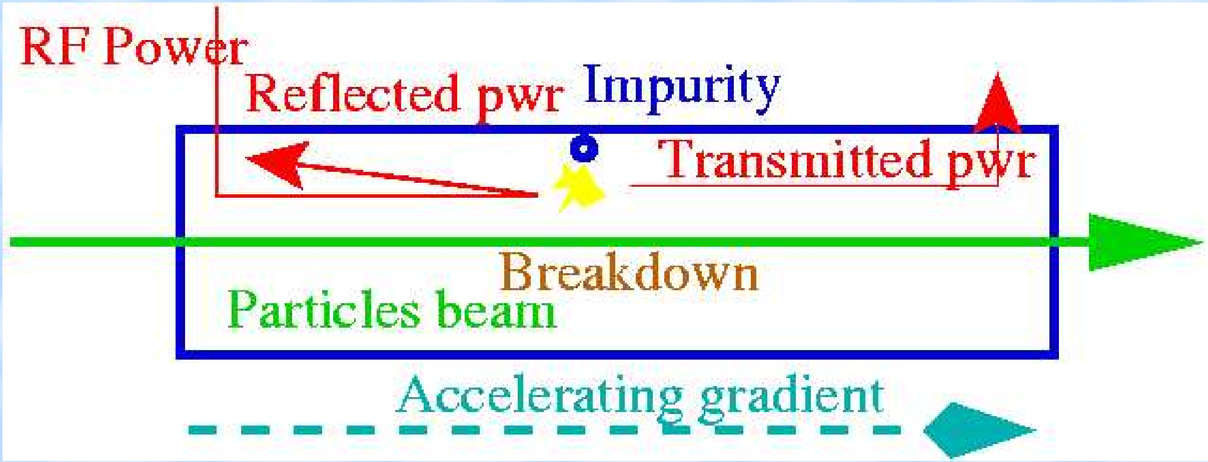
High power breakdowns

If the electromagnetic energy accumulated at one point is too high, a spark occur.



This accumulation can happen at a location where the power concentrate (like the input of the structure)

or where there is an impurity at the surface of the structure.



Locating the breakdowns

Locating the breakdowns allows to know which parts of the structures need to be redesigned. Several methods are available:

- Studying the shape of the incoming, transmitted and reflected power wave.
- By detecting the noise of the breakdowns (acoustic sensors)
- *By detecting the X-rays emitted, ...*

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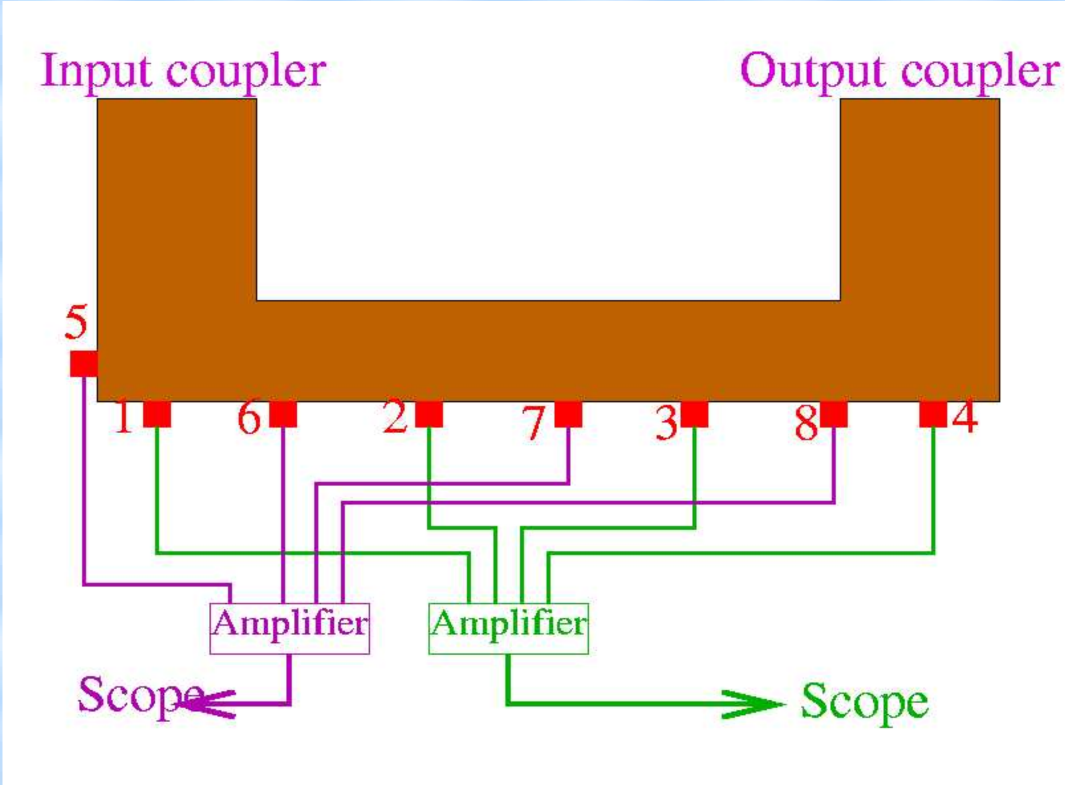
C-band structures R&D

This work is done with Kamitani Takuya and the Linac upgrade group.

8 acoustic sensors + RF information



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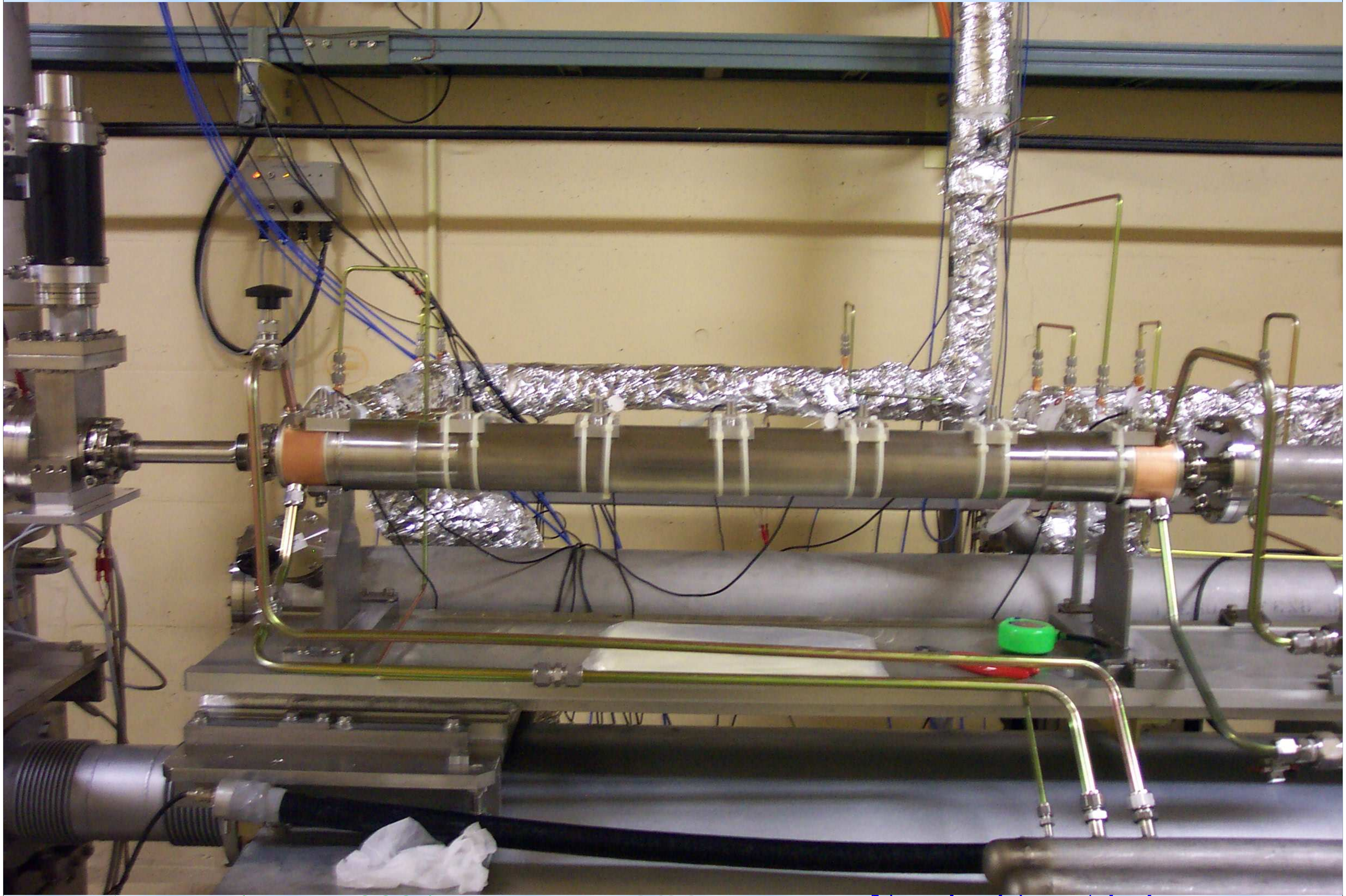
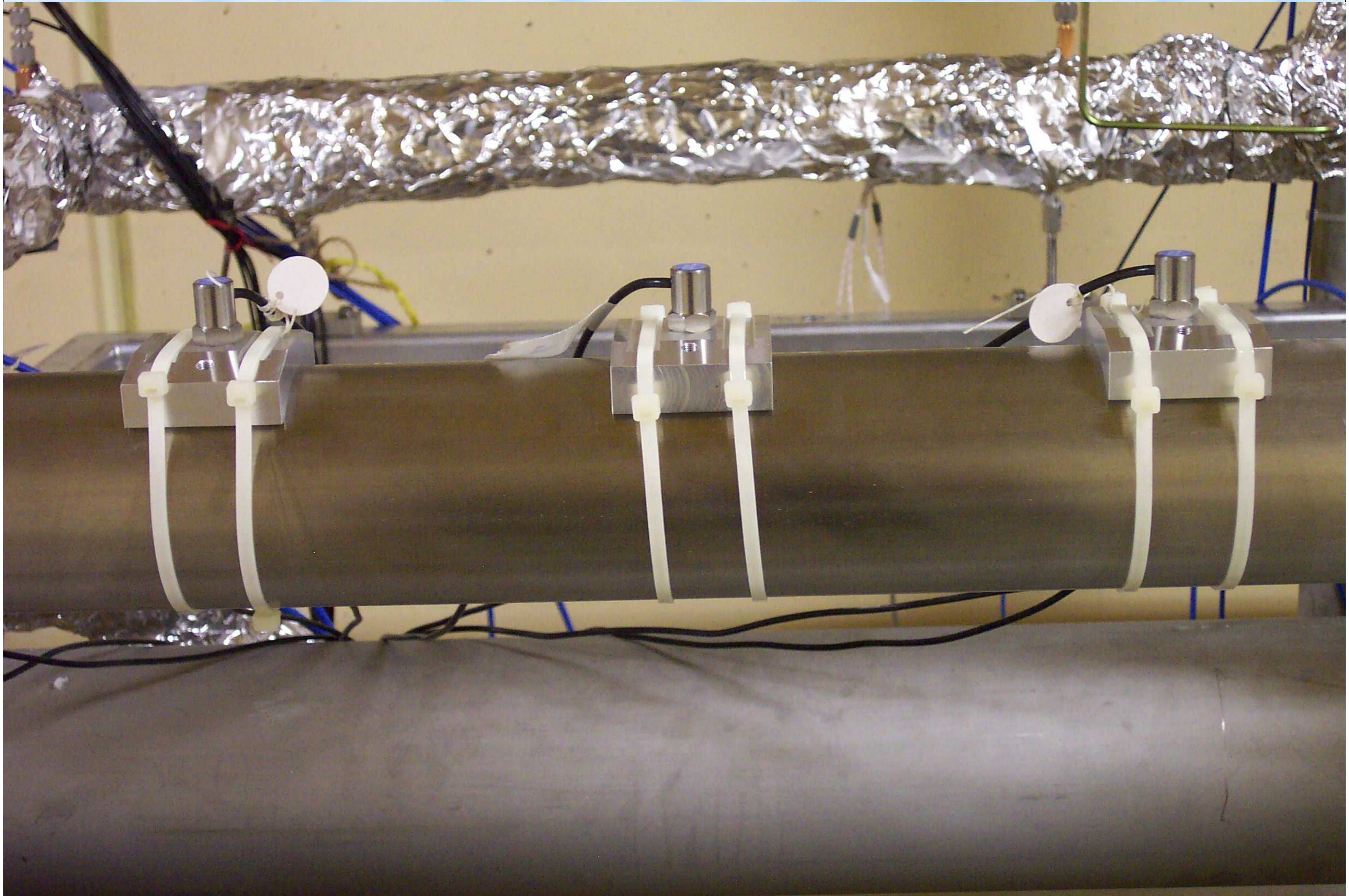
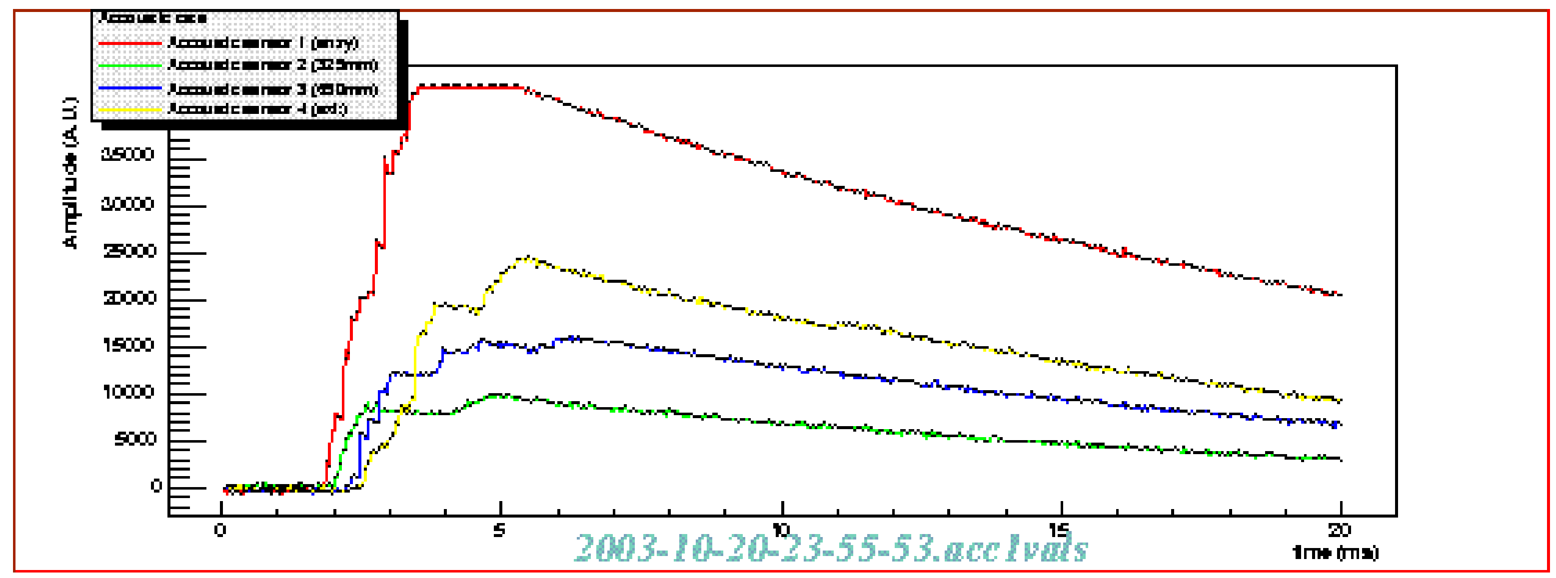




Acoustic sensor event



Signal from the breakdown can easily be distinguished from the background noise,

but

<u>how to identify the location of the breakdown?</u>

- The closest sensor should hear the signal first
- The closest sensor should receive the less attenuated signal...

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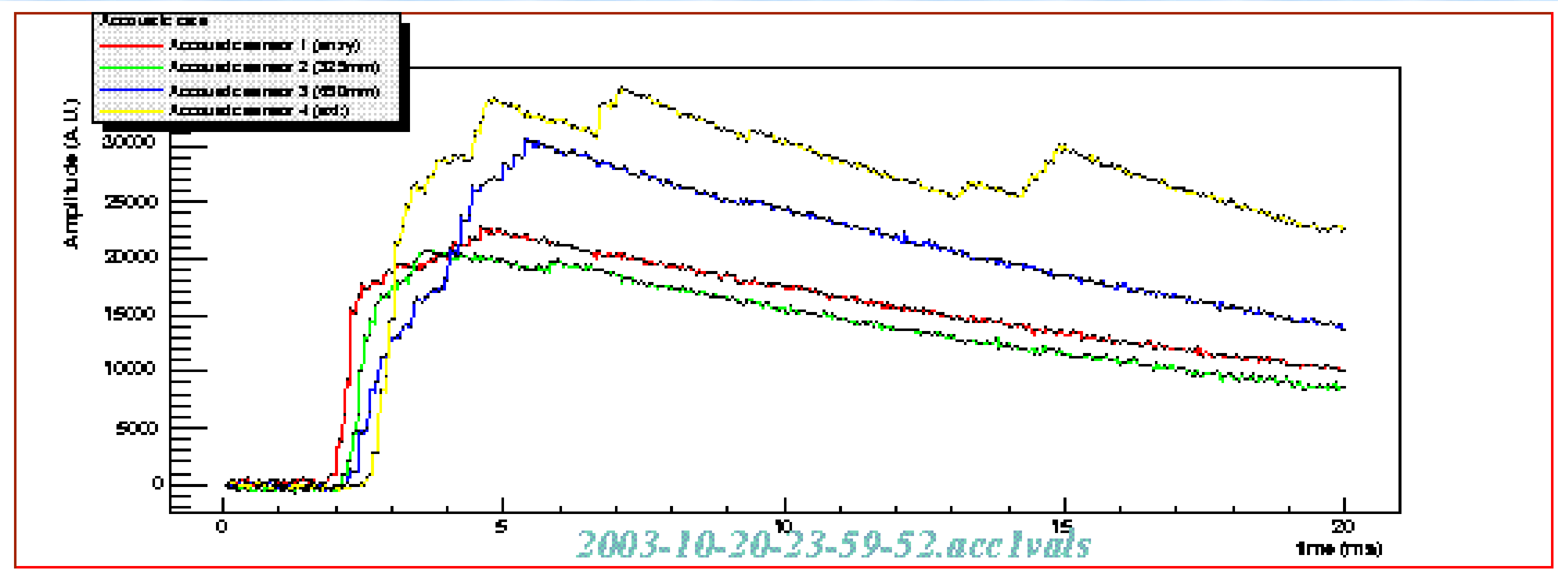
Identifying the breakdowns



- The first sensor to hear the signal does not always get the most intense signal.
- Sensors order is not always physical.

A double definition (time and intensity) of the breakdown location has thus been used.

Trying to compute the position of the breakdown between two sensors has been unsuccessful

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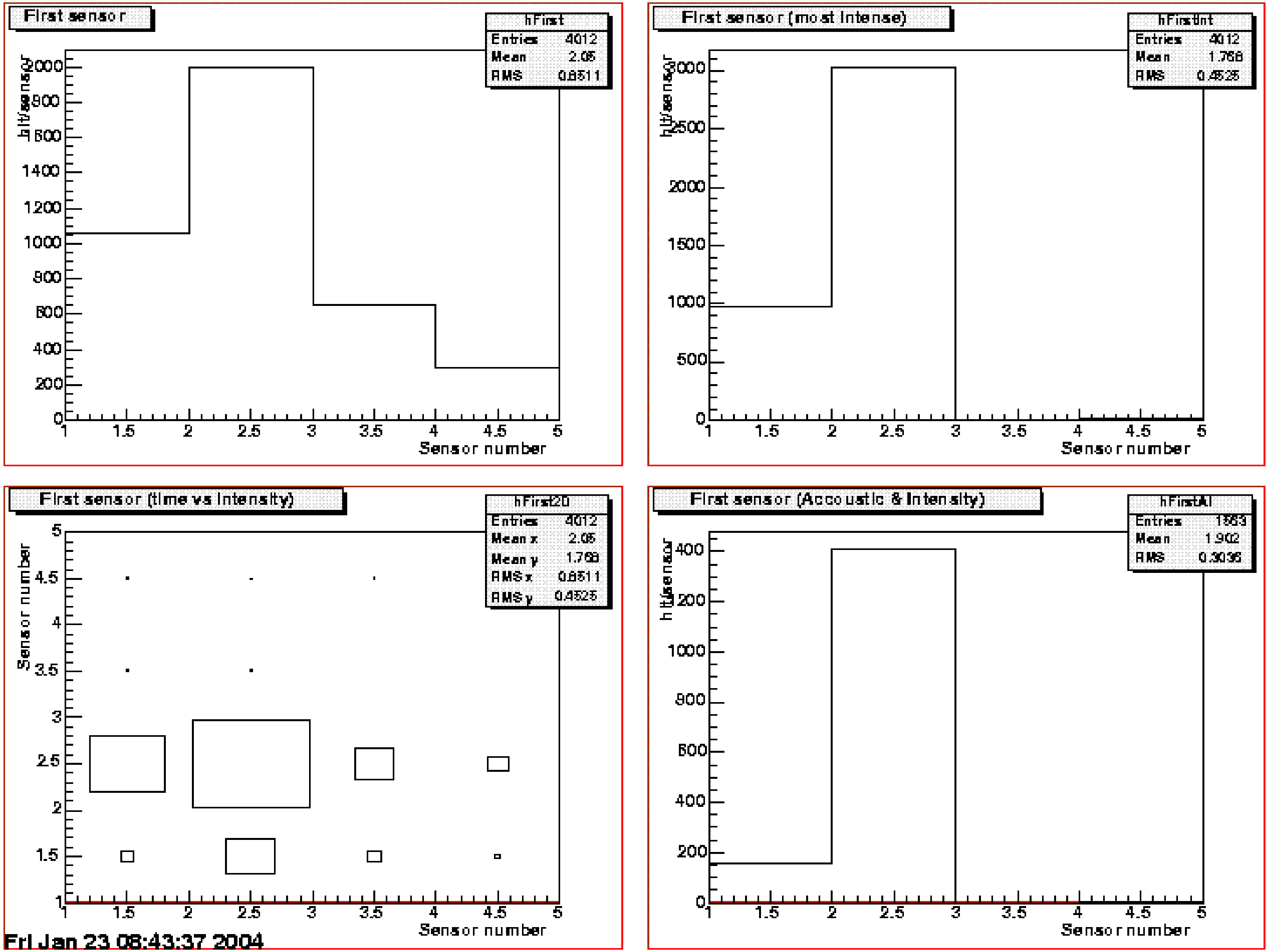
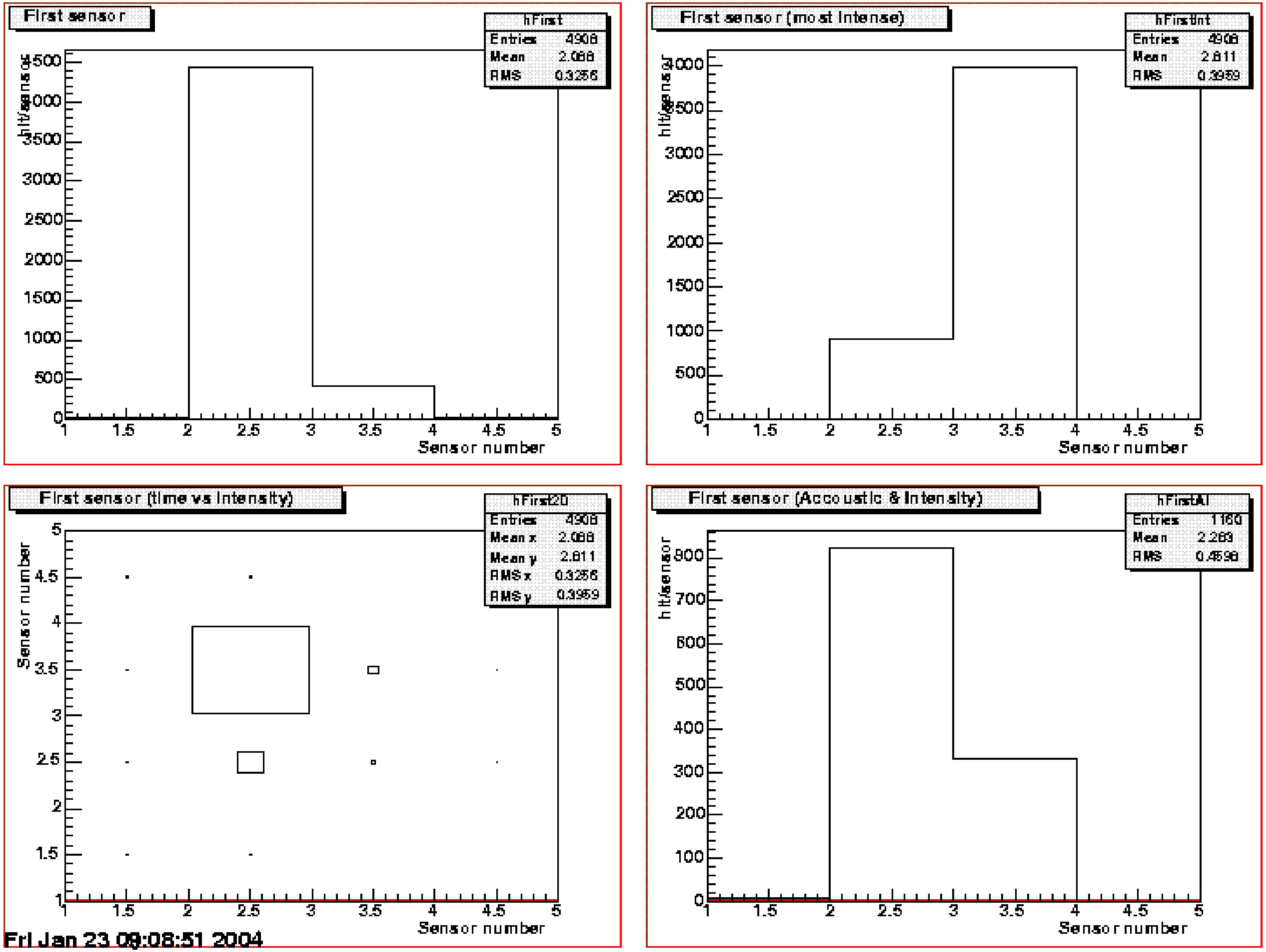
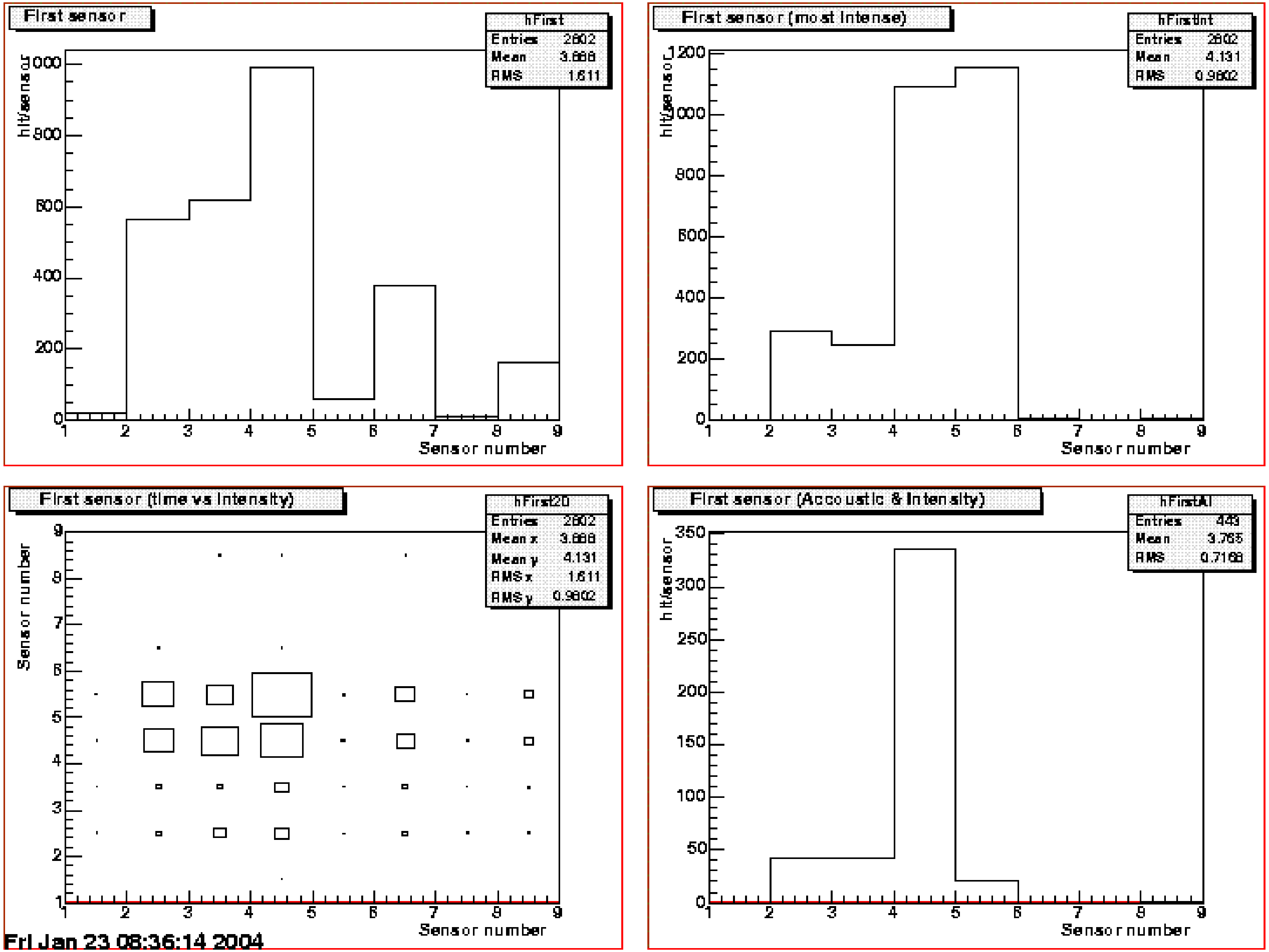
Analysis (1^{st} set)



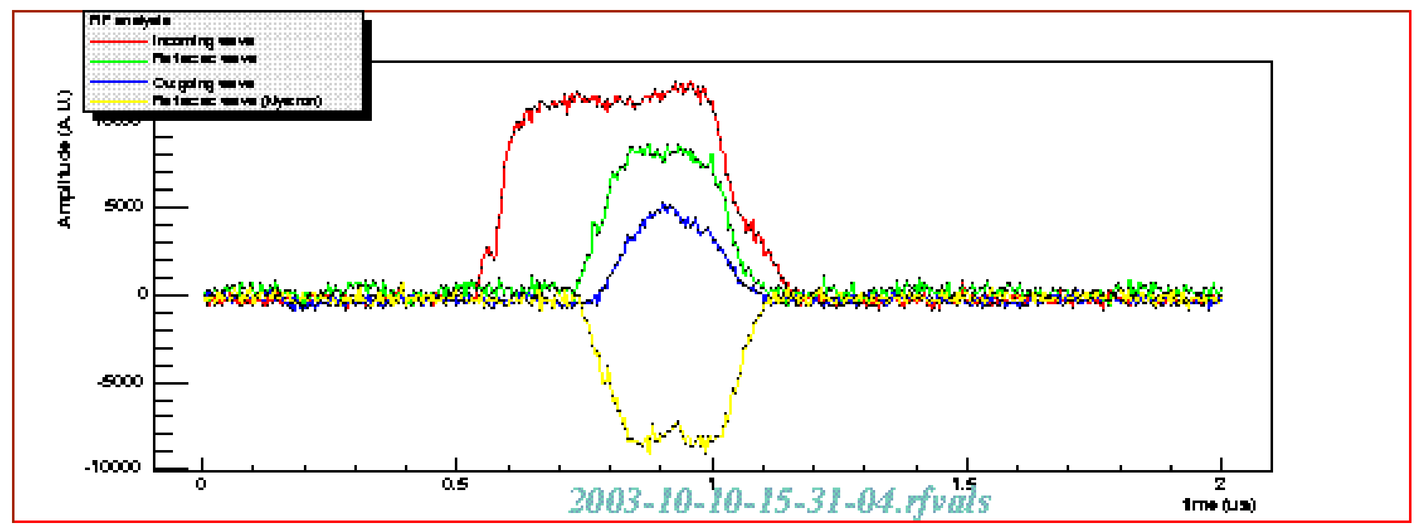
Analysis (2nd set)



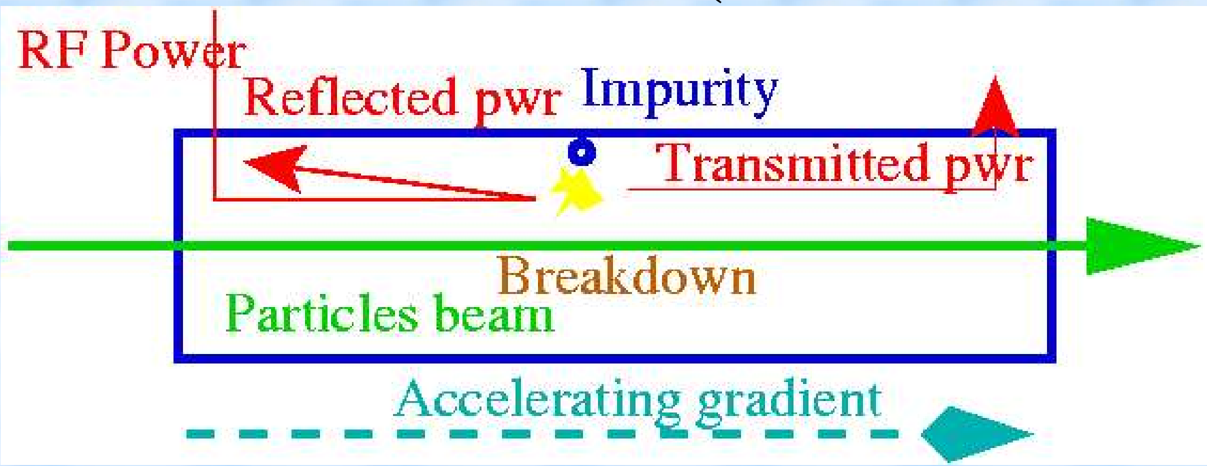
Analysis (combined)



RF data analysis



Difference between the end of the outgoing wave and the arrival of the reflected wave gives the position of the breakdown (t>0 = > bkdn close from input)



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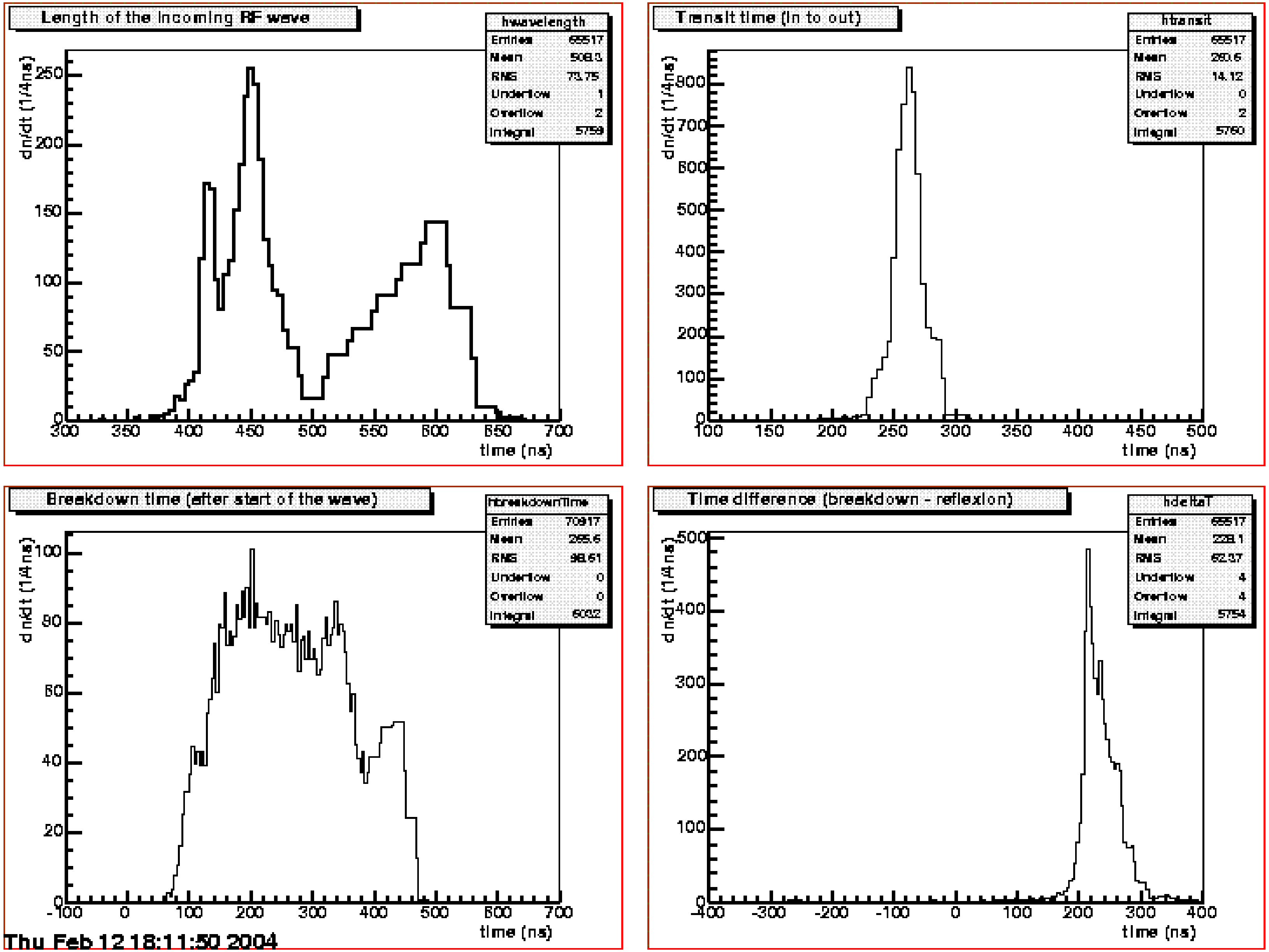
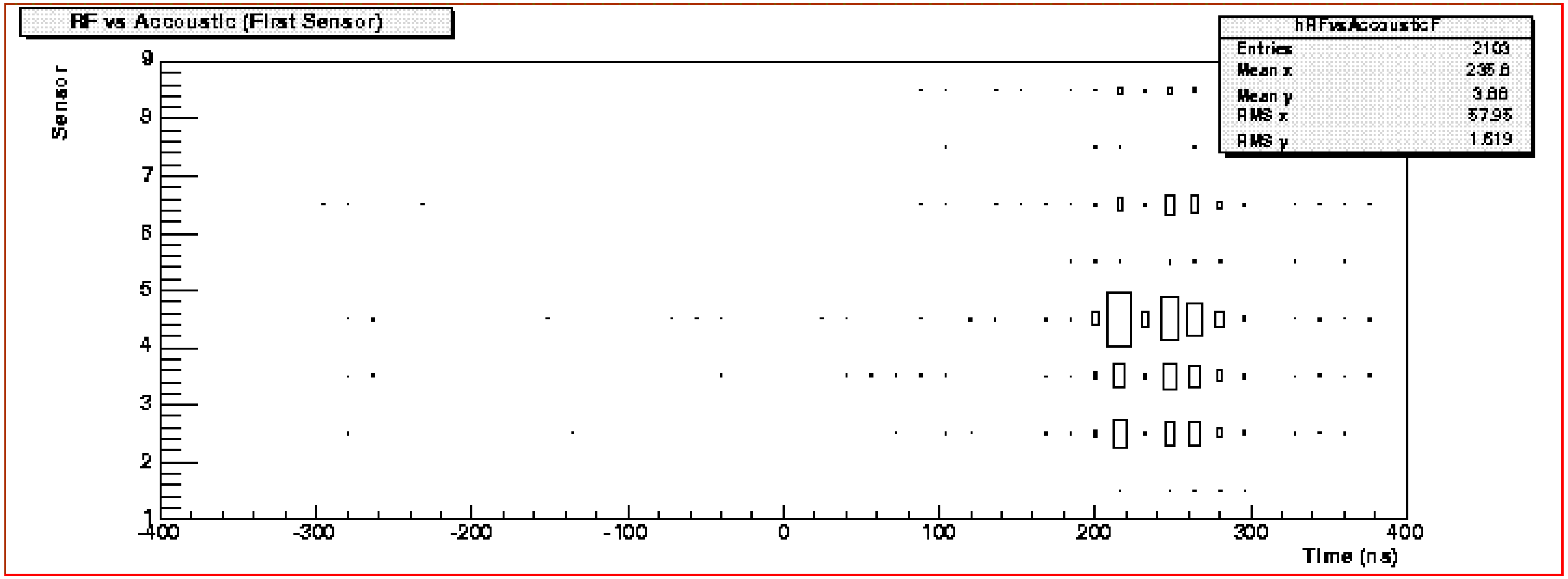
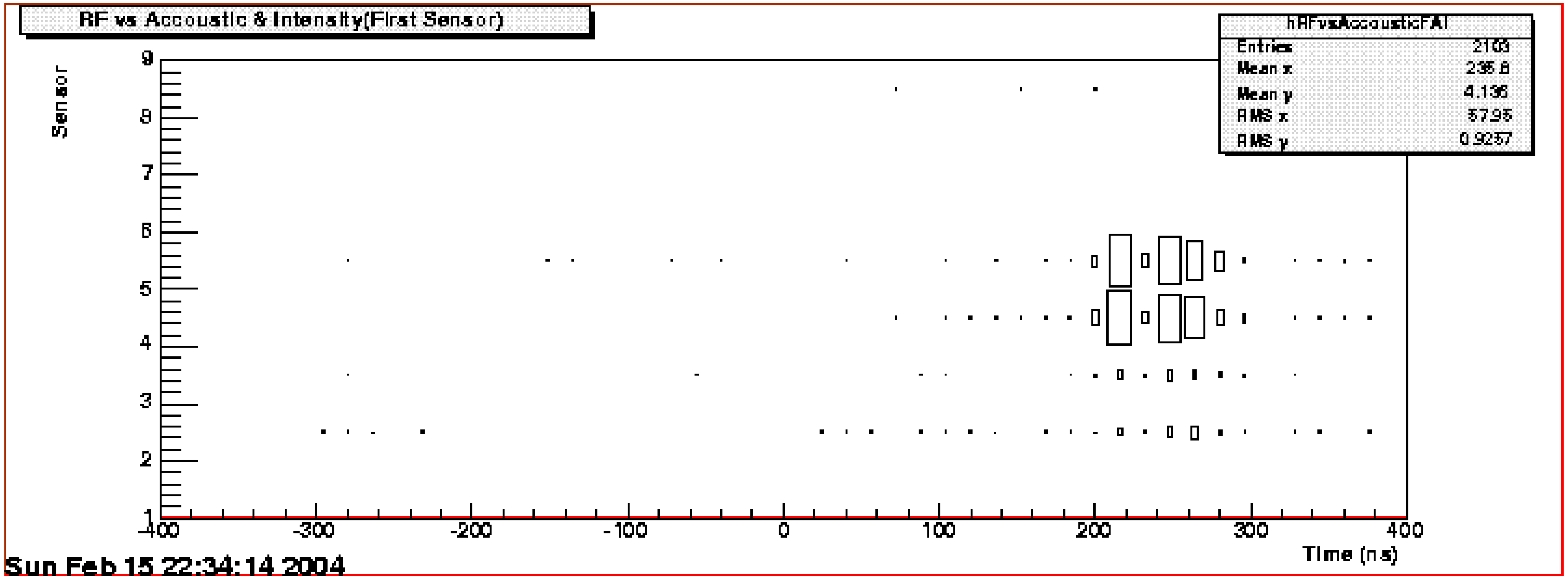
Analysis (RF signal)



Correlations: Acoustic / RF



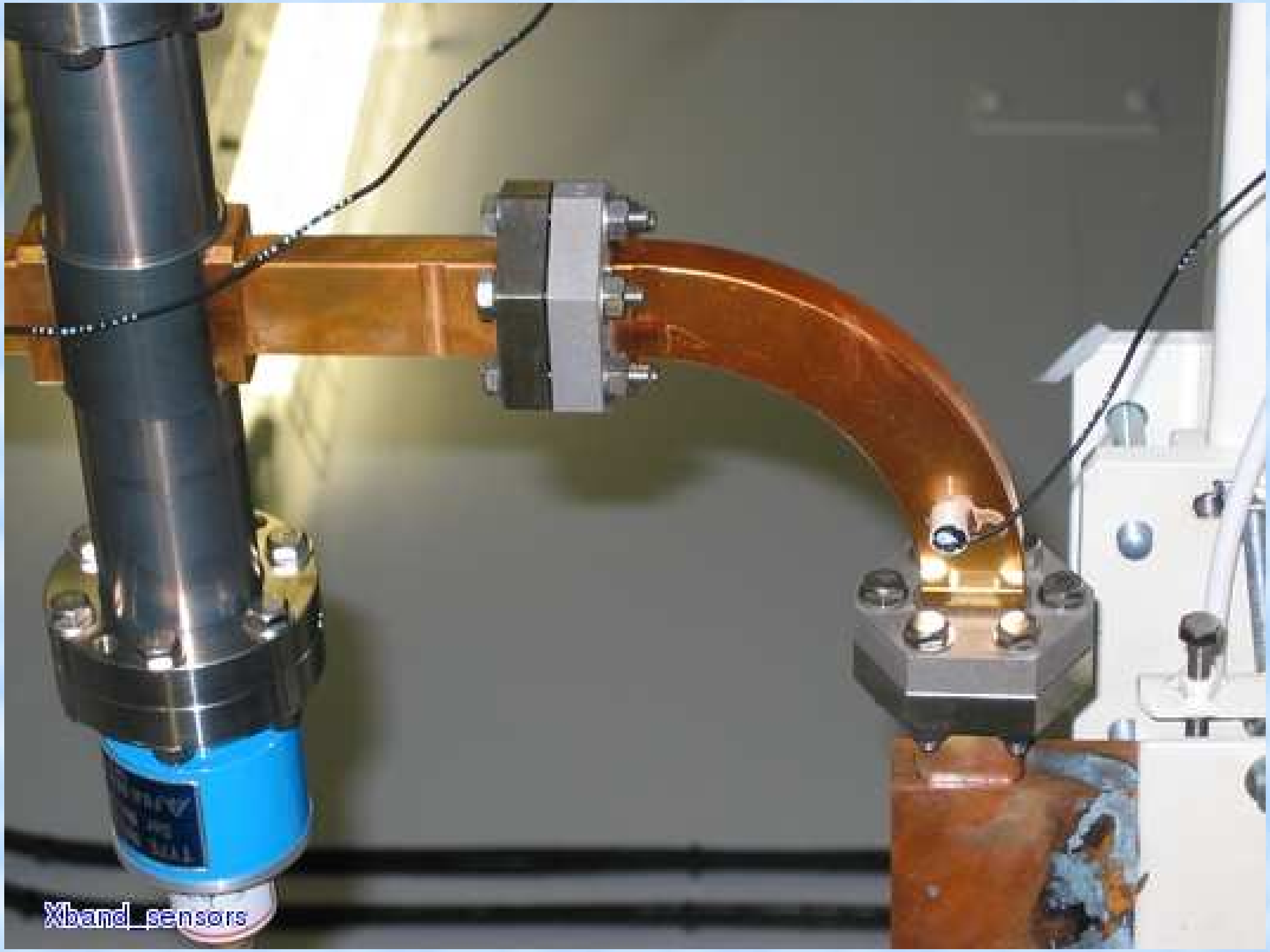


RF and acoustic information are correlated!!!

X-band structures R&D

- Work done with Higo Toshiyasu and the GLCTA collaboration.
- Based on SLAC expertise
- 16 sensors at the moment, goal is 400 sensors.
- Data acquisition with a VME module provided by SLAC
- Data acquisition software and Data analysis software written at KEK
- Before structures tests, the test stand must be validated => structures on the waveguides


Xband_sensors



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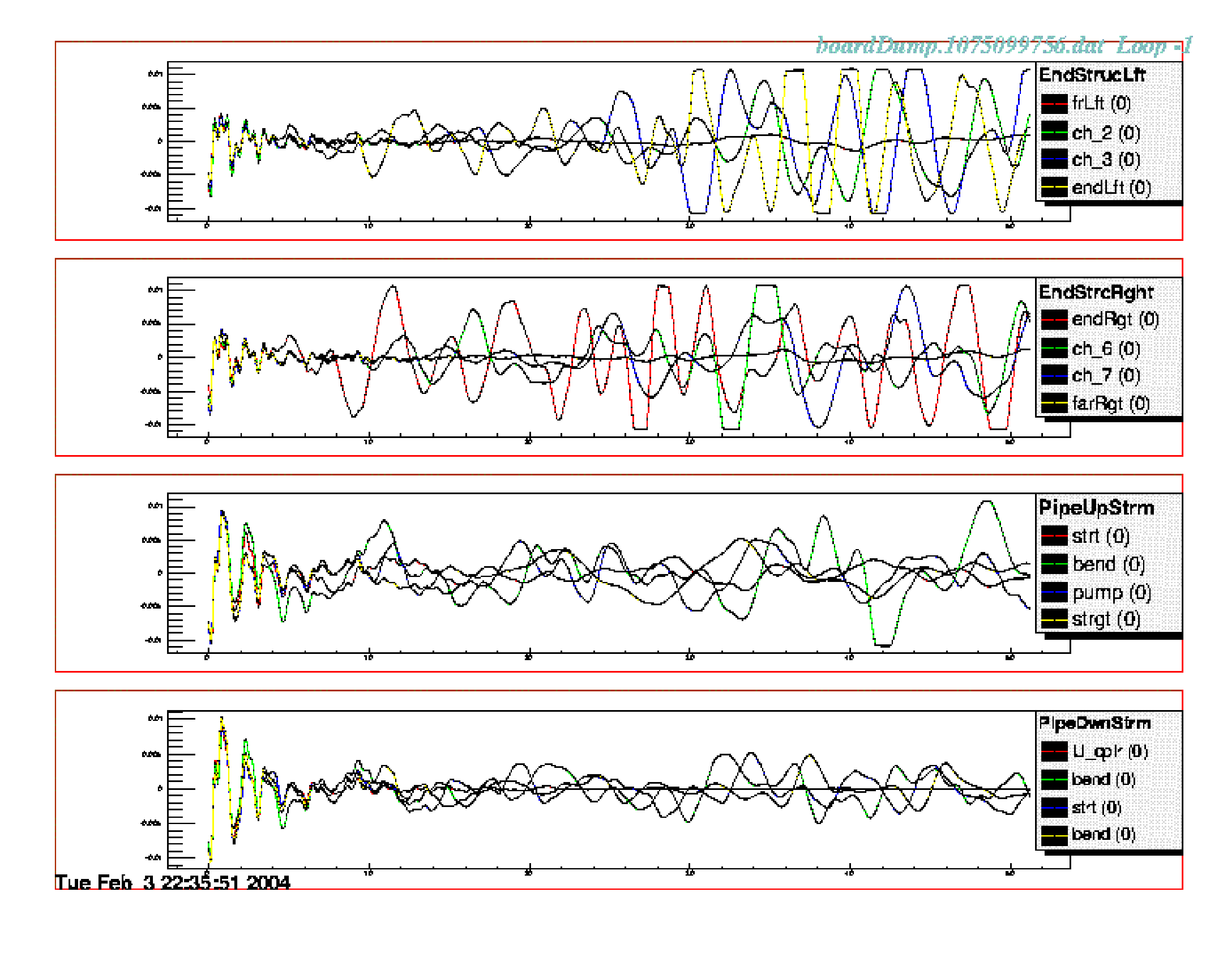
Typical event



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How to define a breakdown?

- At the moment most of the sensors are installed on different waveguide (and noise does not propagate from one to another).
- Setting a high threshold may miss some low intensity breakdown or misidentify the first sensor that receive the noise.
- A low threshold may catch some normal noise.

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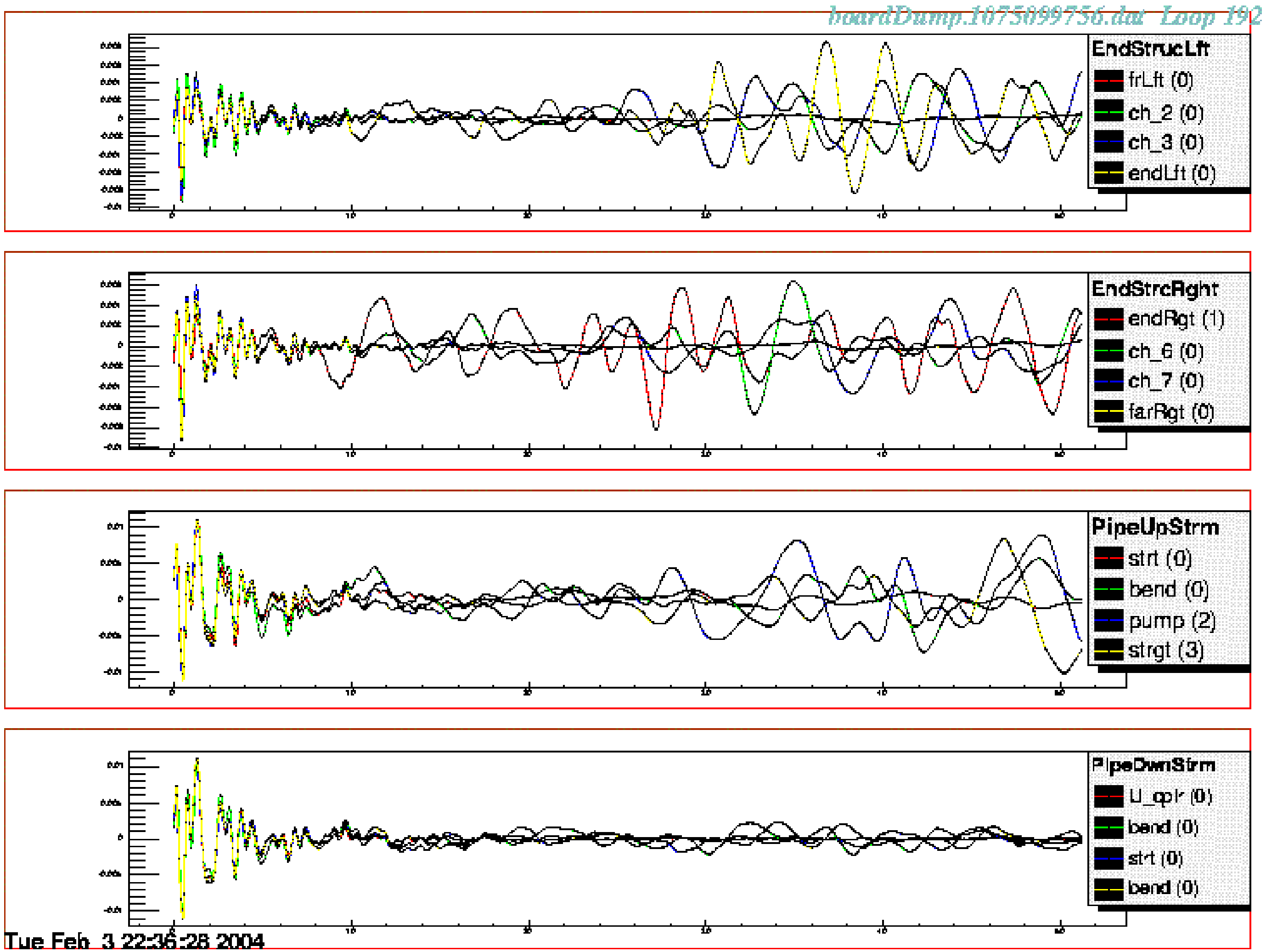
Non-breakdown noise



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How to define a breakdown? (2)

- 3 threshold have been defined to identify the breakdowns
- For each threshold 3 level of breakdown have been defined:
  - Simple (the signal passes the threshold)
  - Long (the signal remains above the threshold for a given time)
  - Extended (the signal remains above the threshold for a longer period)
- To avoid systematic noise, each record is compared with the average of 200 records

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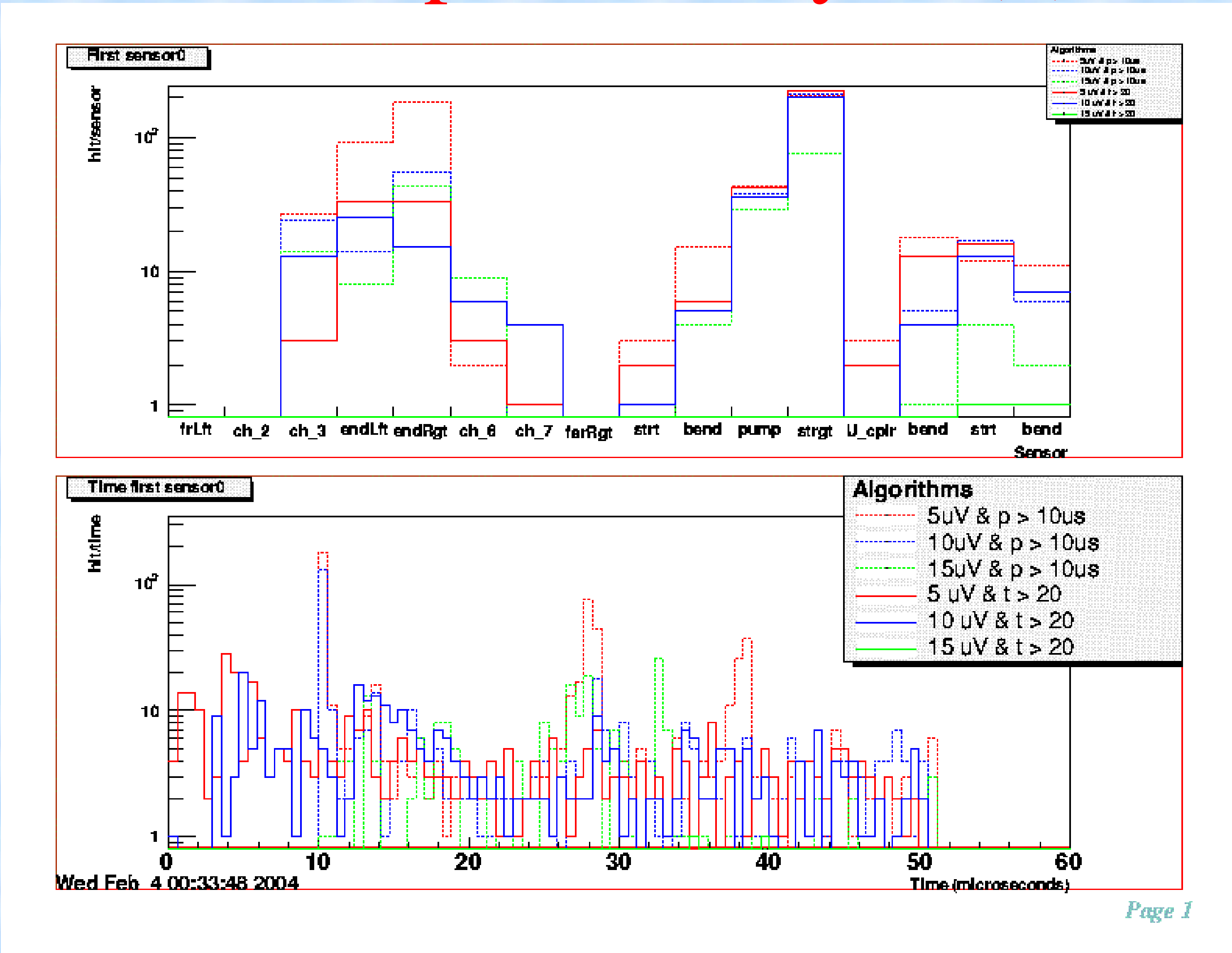
Example of analysis (1)



The frequency of breakdowns by waveguide shows which components are faulty.

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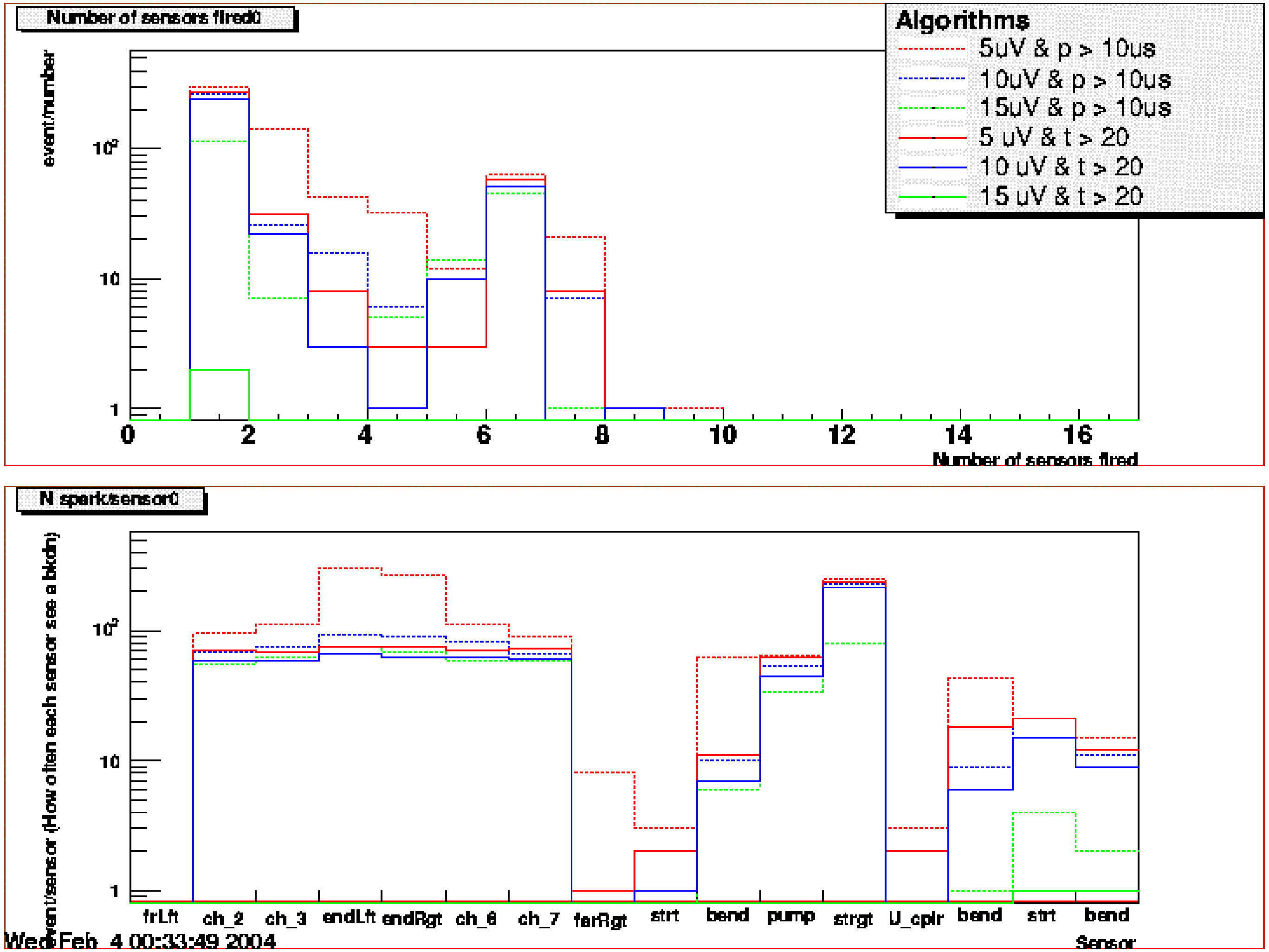
Example of analysis (1) cont



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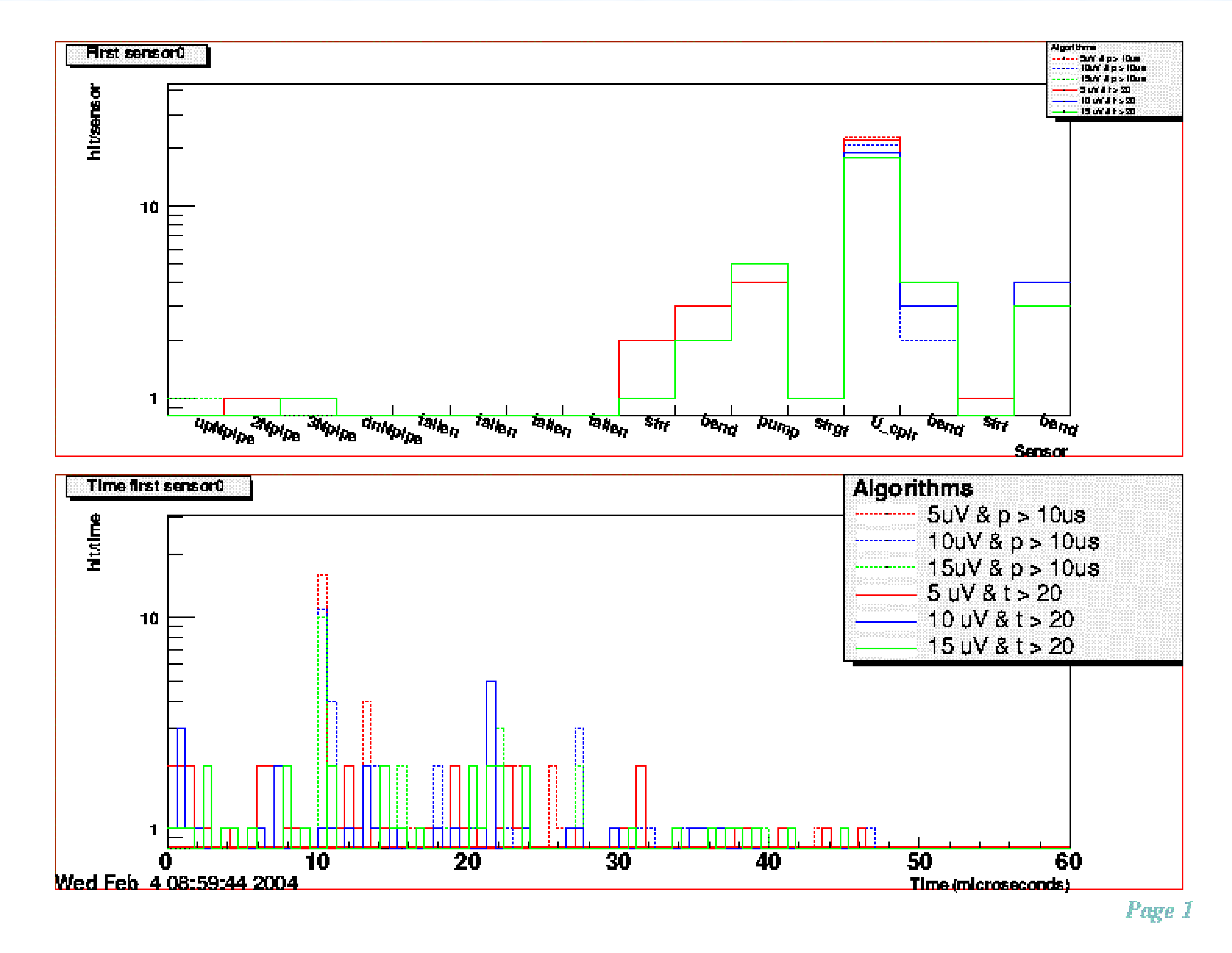
Example of analysis (2)



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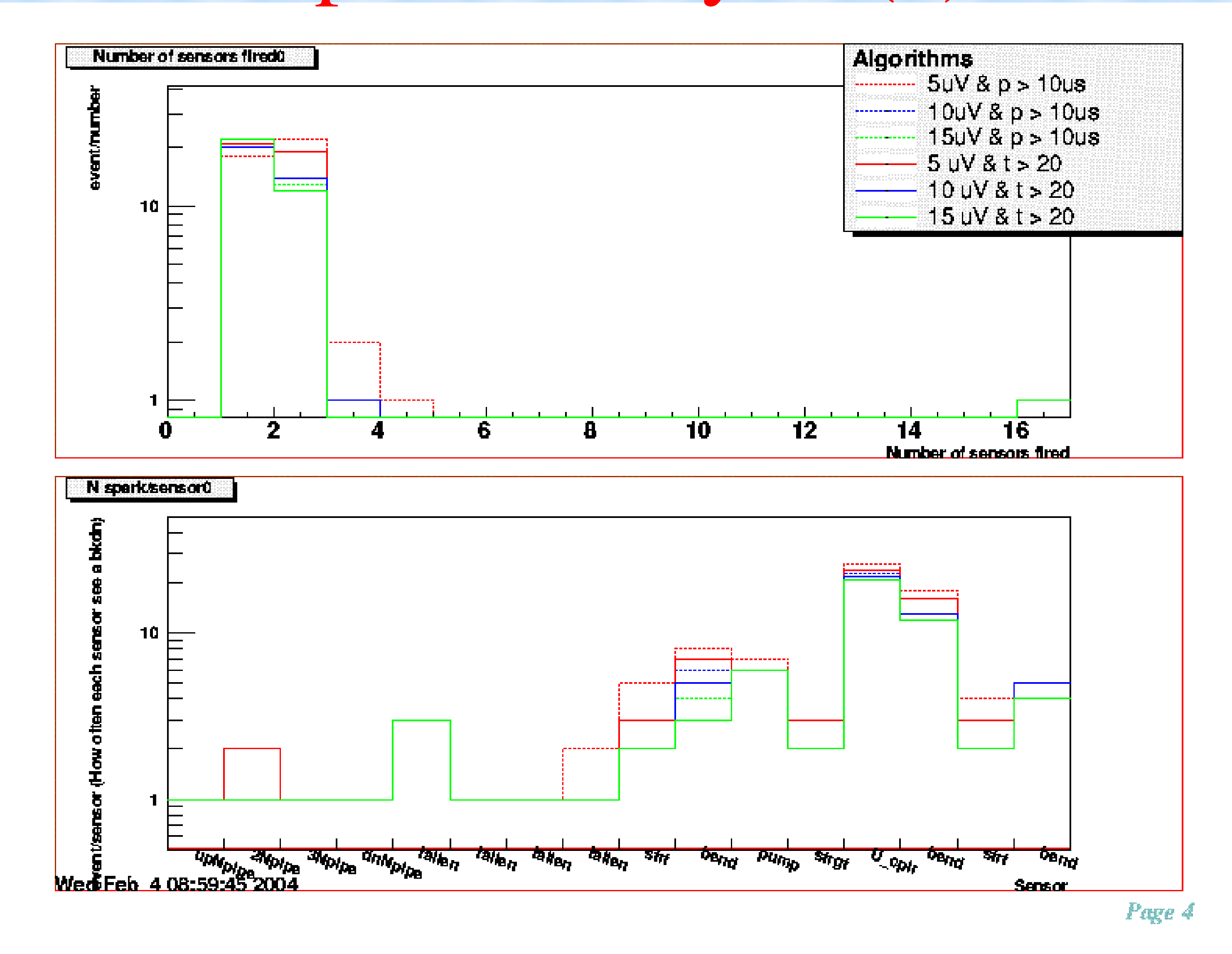
Example of analysis (2) cont



No independent verification available but faulty components are the oldest...

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Conclusions

- Acoustic sensors provide information of the location of the breakdowns
- Installation is easy
- The sensors can easily be moved to survey different suspect area
- Resolution is limited by the number of sensors
- Information provided by the sensors is correlated with the information coming for other methods or for prior knowledge

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