

# Second Sound as an automated Quench Localisation Tool at DESY.

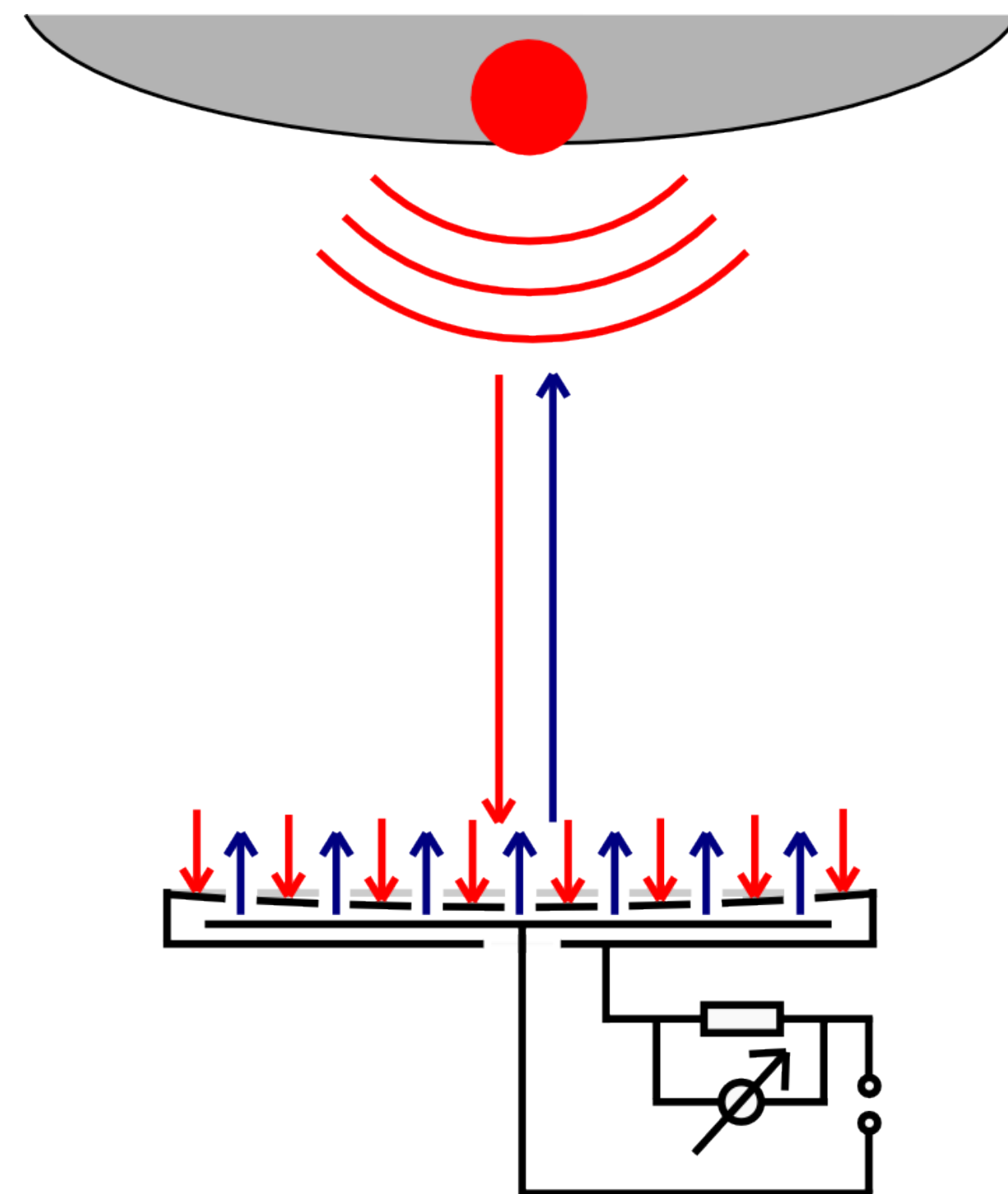
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## Motivation for quench localisation

Accelerator projects grow larger and larger and require a huge batch of cavities. The European XFEL requires up to 800 1.3 GHz 9-cell cavities, and the planned International Linear Collider ILC will need 16,000 of these cavities. For fast QA of those cavities it is mandatory to have reliable diagnostic tools. For example finding the quench location during a cold RF test is important to be able to check his location for defects that may have to be retreated. Second sound has been used first at Cornell University and this method is reasonably faster than temperature mapping (with a comparable resolution), since the setup is mounted to the cryostat insert and there is no need to reassemble it for every cavity test.

## Second Sound detection



Second sound signal detection by Oscillating Superleak Transducers (OSTs) induced into the liquid helium by local thermal breakdown.

- > The cavity quenches – heat is deposited locally into the helium bath
- > Heat propagates as second sound (phase transition) wave
- > The „normal“ liquid helium fraction acts on the membrane, so the applied voltage on the OST changes
- > The voltage change is measured and defines the arrival time

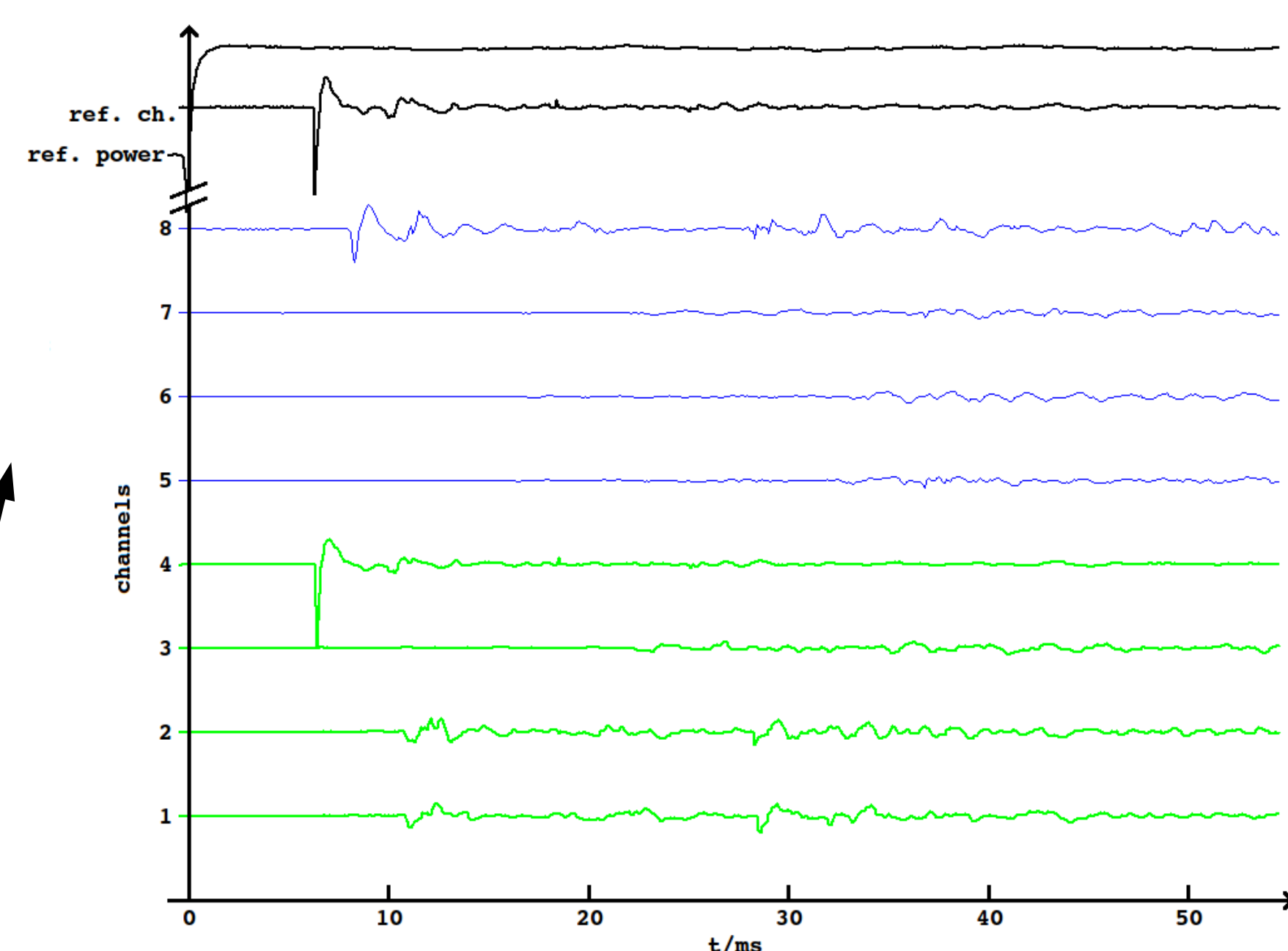
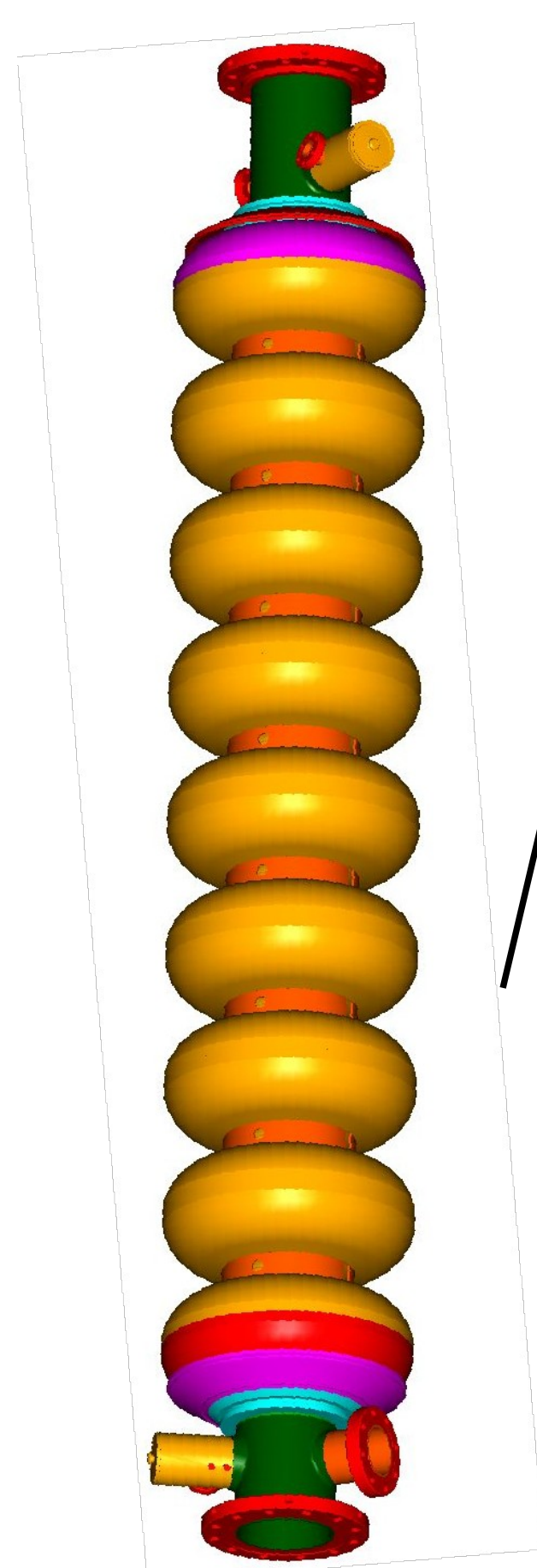


Oscillating Superleak Transducer with sputtered gold membrane (total diameter: 31.5 mm)

## Characteristics of the measurement facility and environment

| Implementation                                                                          |                                                      |
|-----------------------------------------------------------------------------------------|------------------------------------------------------|
| Cryostat inserts                                                                        | 4                                                    |
| Oscillating Superleak Transducers (OSTs)                                                | 32 (8 ea.)                                           |
| ADC                                                                                     | NI USB-6218; up to 250 kS/s multiplexed, 32 channels |
| Software                                                                                | MATLAB R2009b                                        |
| Measurement environment                                                                 |                                                      |
| Temperature                                                                             | 1.8 K                                                |
| Propagation velocity                                                                    | 19.9 m/s                                             |
| Resolution                                                                              | ± 10 mm                                              |
| Example for data acquisition (see below)                                                |                                                      |
| AC156, test, pi-mode:<br>$E_{acc}=30.6 \text{ MV/m}$ , $Q_0(E_{acc})=1.6 \cdot 10^{10}$ |                                                      |

## Data acquisition and evaluation

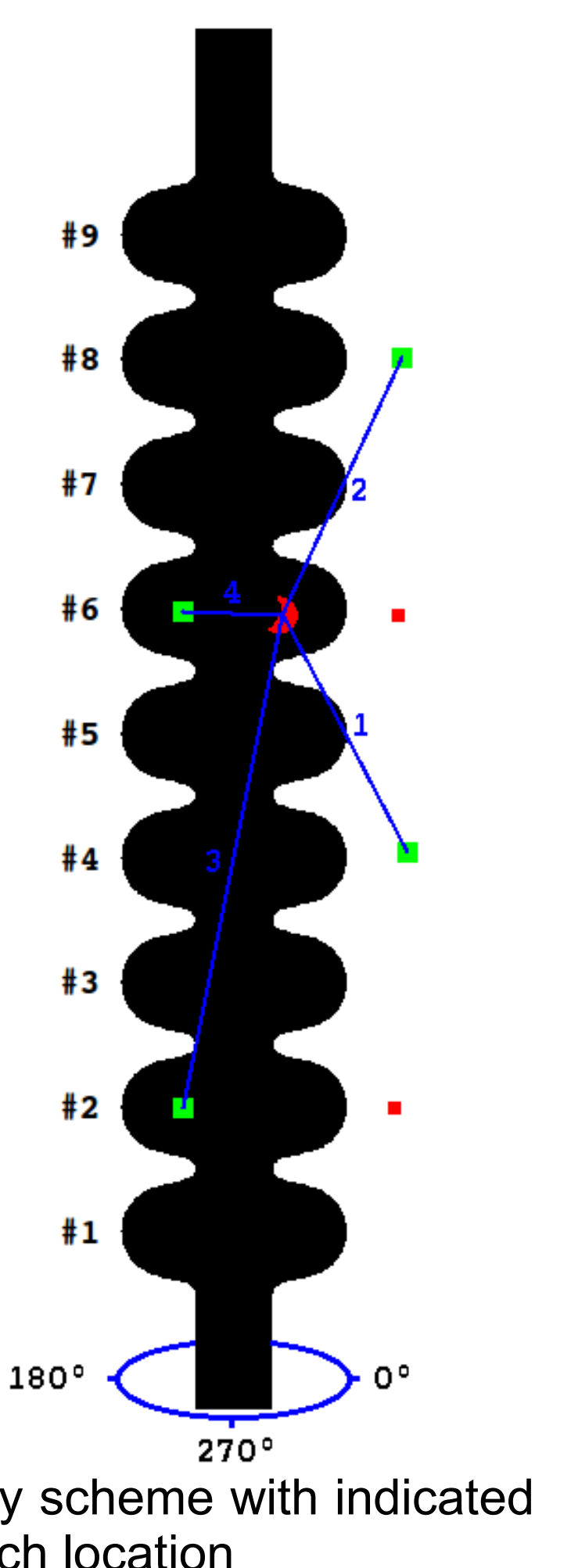
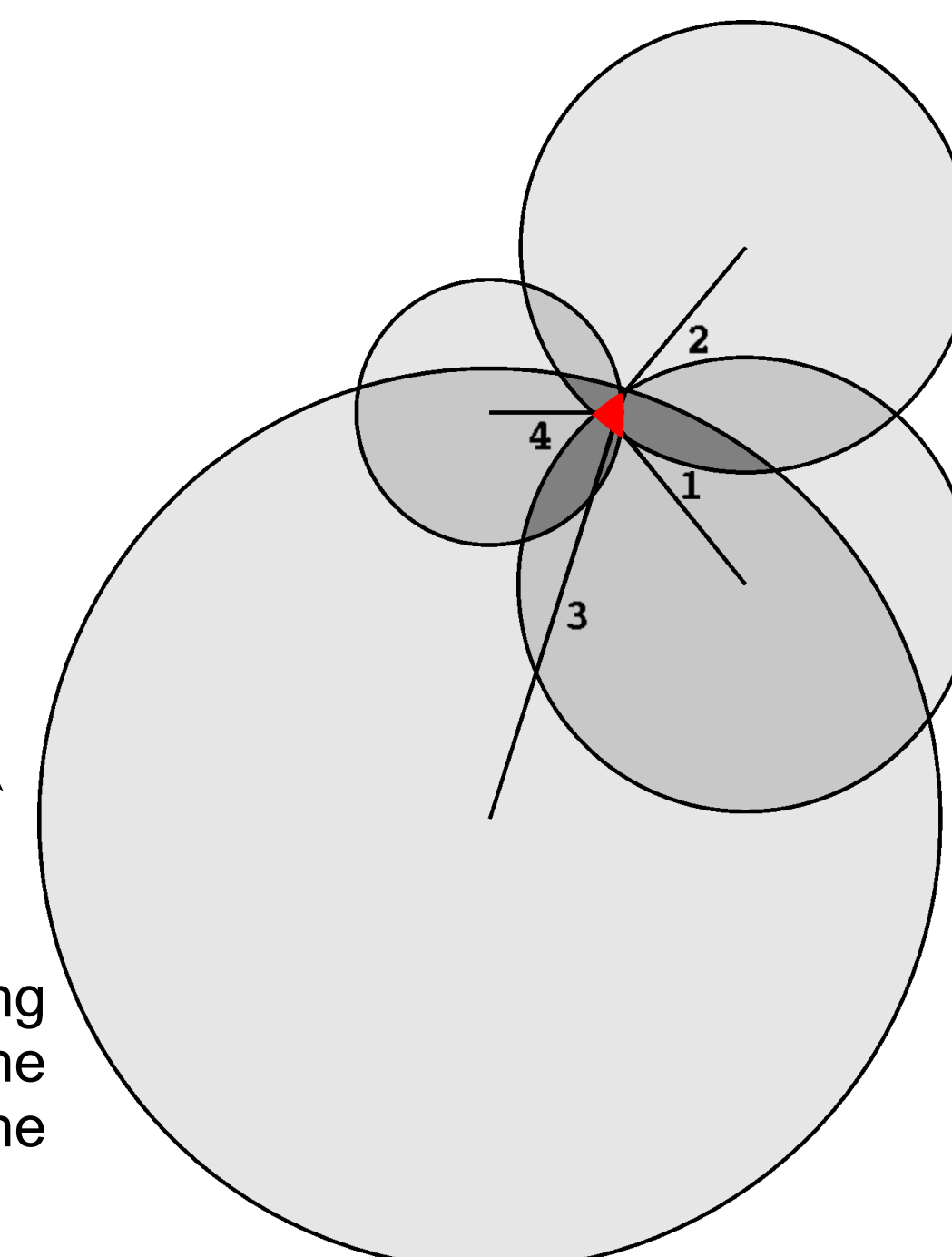


Signals detected by the second sound setup

- > The step in the reflected power signal indicates the time of the quench and the most excited OST signal is chosen as a reference signal
- > If the signal-to-noise ratio is very low, a second measurement is done with cutting the rf signal (improper grounding of the measurement rack may lead to noise), using the reference signal to calculate the other propagation times
- > Choose the „proper“ OSTs

- > The green marked signals provide the required propagation times
- > The distances between the OSTs and the quench location can be calculated by  $d_i = v(T) \cdot t_i$  (the propagation velocity is a known function of the bath temperature  $T$ )
- > Knowing the OST positions relative to the cavity, a minimisation procedure can be carried out (cavity surface as constraint)
- > The intersecting volume of the spheres created by the radii indicates the position of the quench with an average error of ± 10 mm

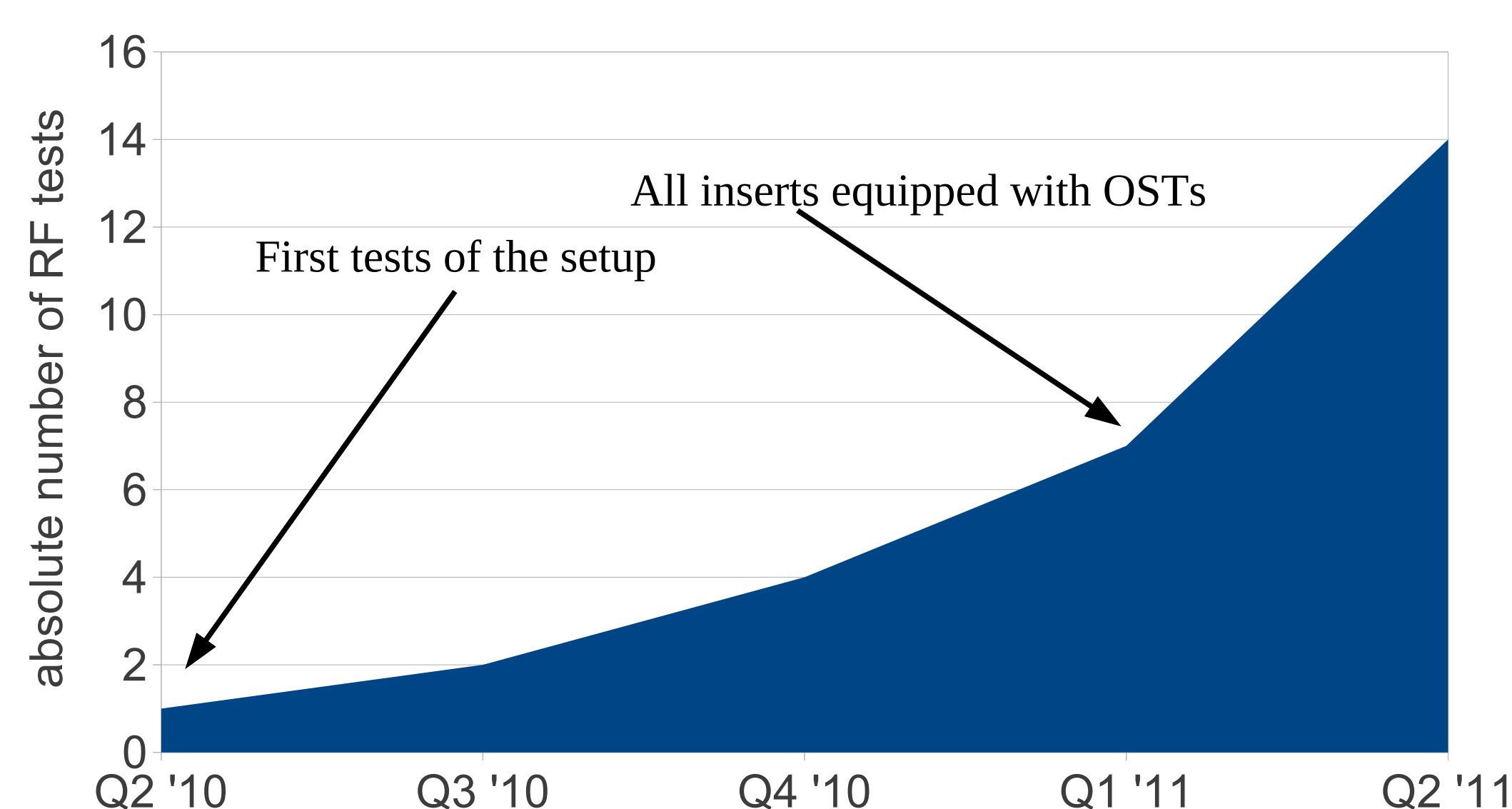
Right: Schematic drawing how to determine the intersecting volume of the signals.



Cavity scheme with indicated quench location

## Usage of Second Sound at DESY

- > Assembly of 10 OSTs and the electronics in early 2010
- > First tests at one of the cryostat inserts in mid 2010 with an setup of 8 OSTs
- > Assembly of 50 OSTs and equipment of the remaining 3 cryostat inserts in winter 2010/11
- > Tests with second sound detection on a regular basis since the beginning of 2011



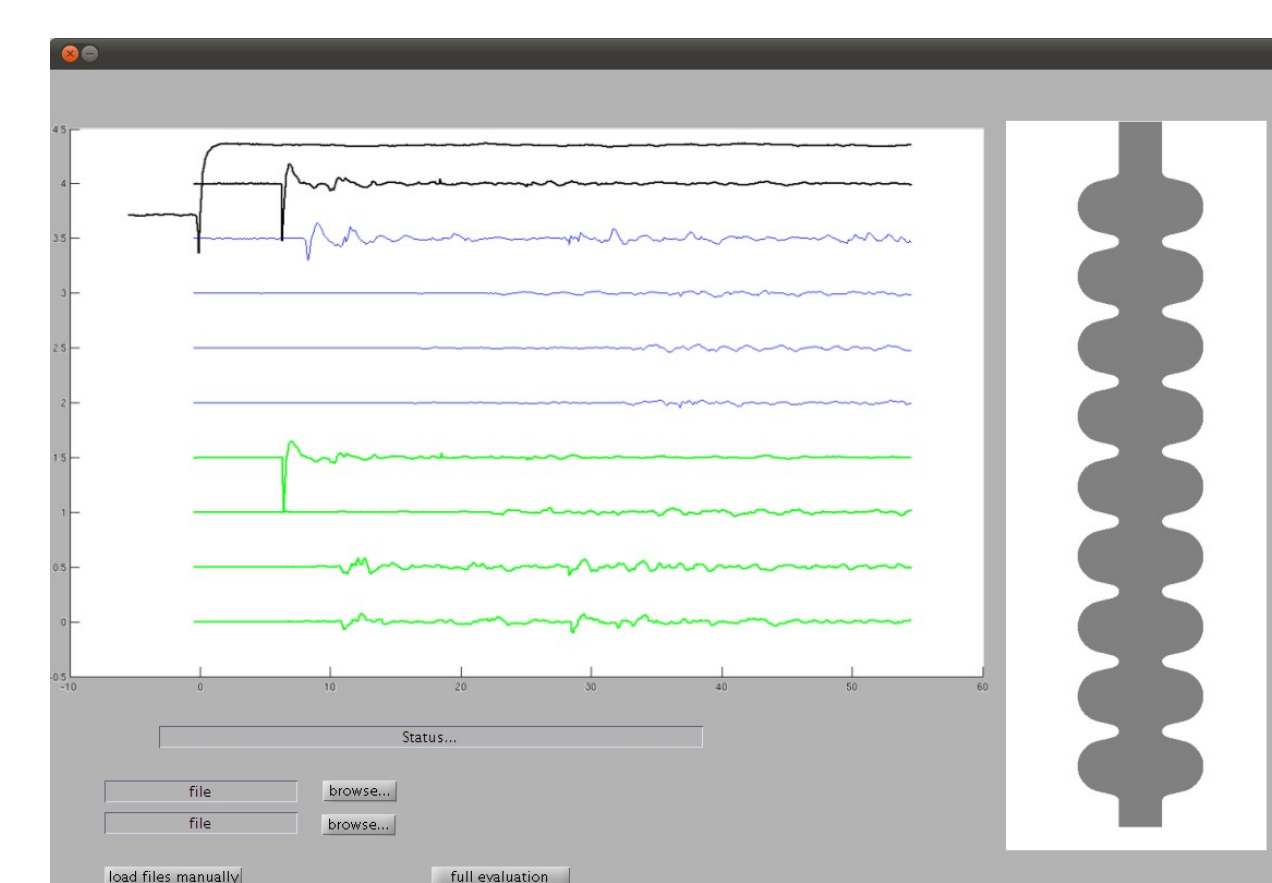
Timeline with the number of RF tests done supported by second sound measurements

## Outlook, Summary, Acknowledgements

### Outlook

- > A graphical user interface (GUI) for fully automated or manual acquisition and evaluation of second sound data is under development

- > Apply further hardware improvements



The Graphical User Interface in its current Form displays the quench location

### Summary

DESY has successfully implemented the second sound measurement in the rf vertical test procedure:

- > The accuracy achieved so far is comparable to the accuracy of the temperature mapping system used at DESY
- > All tests of cavities without helium vessel are accompanied by second sound measurements
- > Statistics are rapidly growing

### Acknowledgements

Special thanks to the staff working in the cavity test area (hall 3) for support and help on the setup and measurements.

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