

Step response of pressure gauges

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Dynamic response of pressure gauges

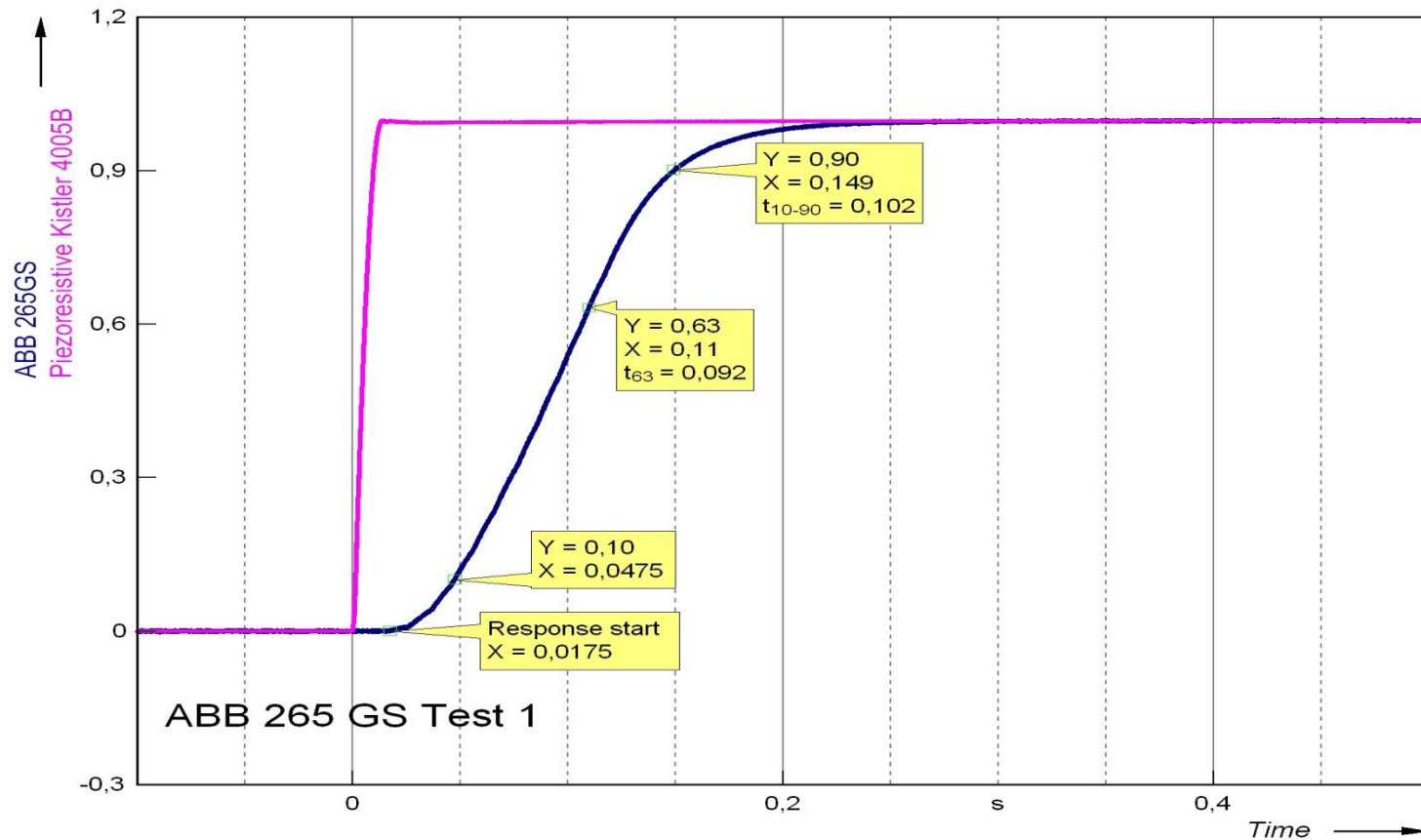
- Started several years ago on industrial pressure transmitters
- Some simple tests made with fast-opening valve
- Test of negative step response on vacuum gauges
- Shock tube measurements

Early tests

- Testing industrial pressure gauges and transmitters
- Relatively slow, typically around 1s
- “Fast” piezoresistive pressure gauge as reference sensor
- Fast opening valve as step generator
- Pressure levels around 200kPa

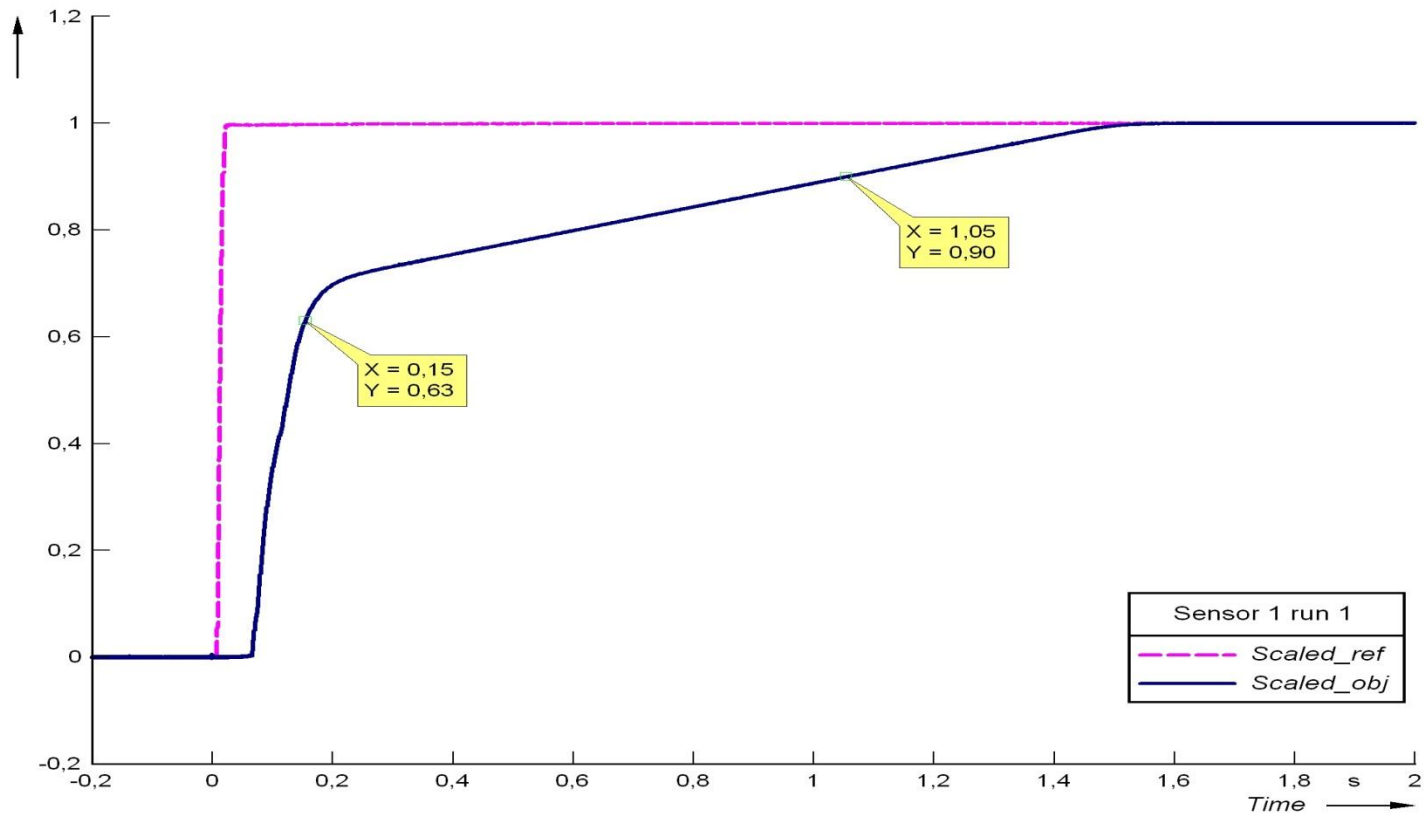
Early test

- Step response tests on industrial pressure gauges
- Long response times, around 1s



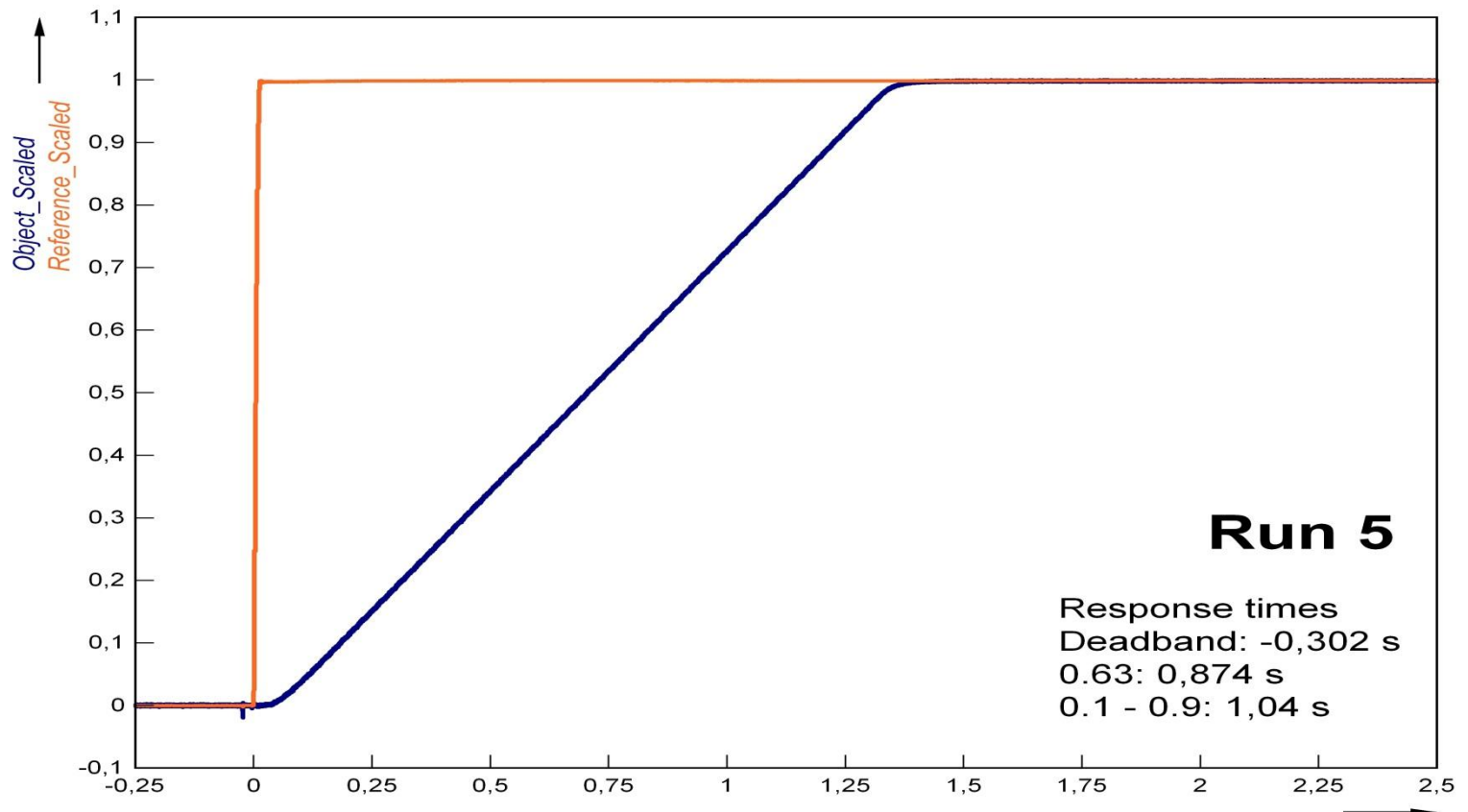
Early tests

- Strange behaviours on some gauges



Early tests

- Strange behaviours on some gauges



Step response on vacuum gauges

- Negative step from 100kPa(abs) to around 50Pa(abs)
- Using static expansion
- Volume ratio $\sim 1/2500$
- Valve conductance $\sim 4,8\text{l/s}$
- Piezoresistive reference sensor
- CDG for determining pressure in expansion volume
- Step times around 0.1s



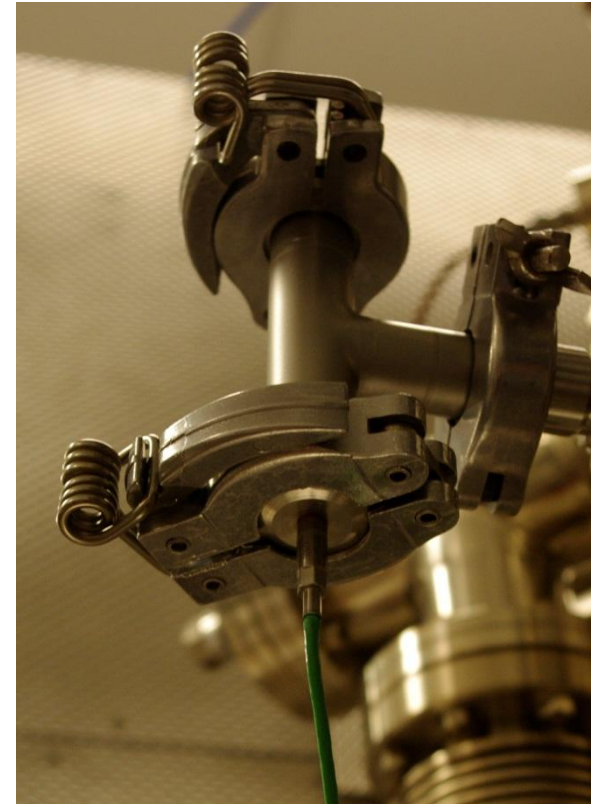
Valve and reference sensor

- Valve mounted directly to large vessel for fast response



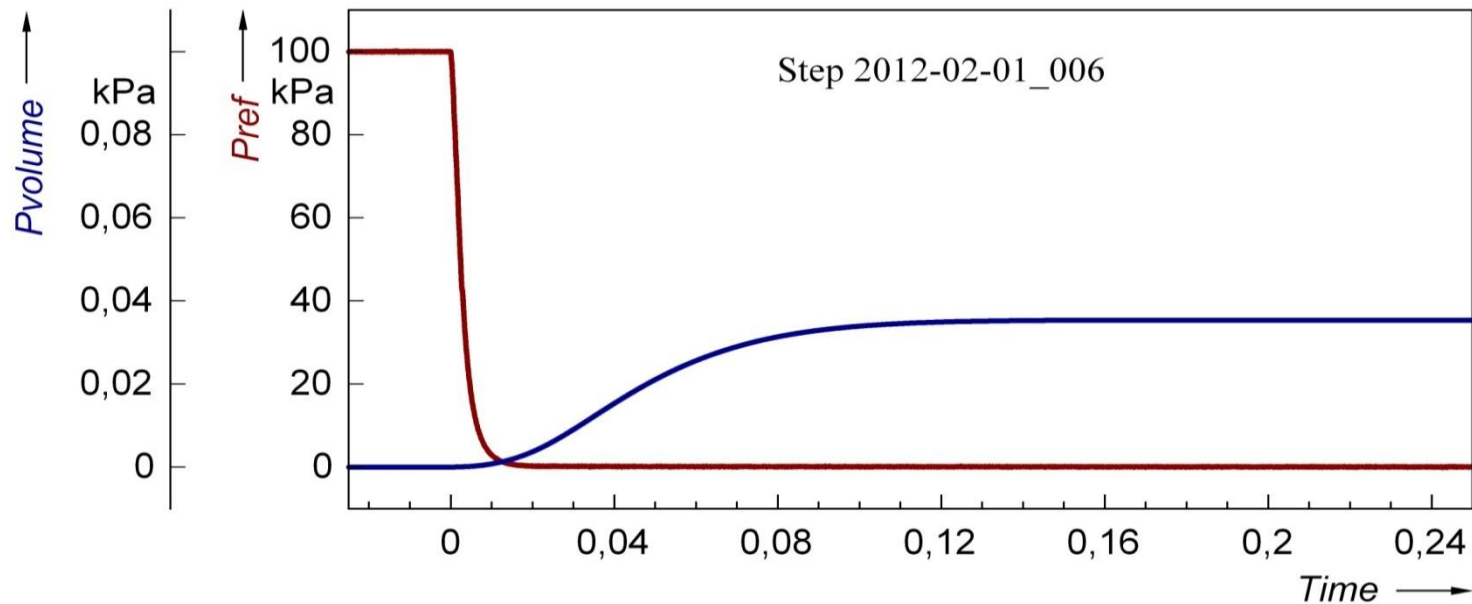
Details of sensor setup

Reference sensor outer diameter
5mm, almost flush mount gives an
negligible internal volume



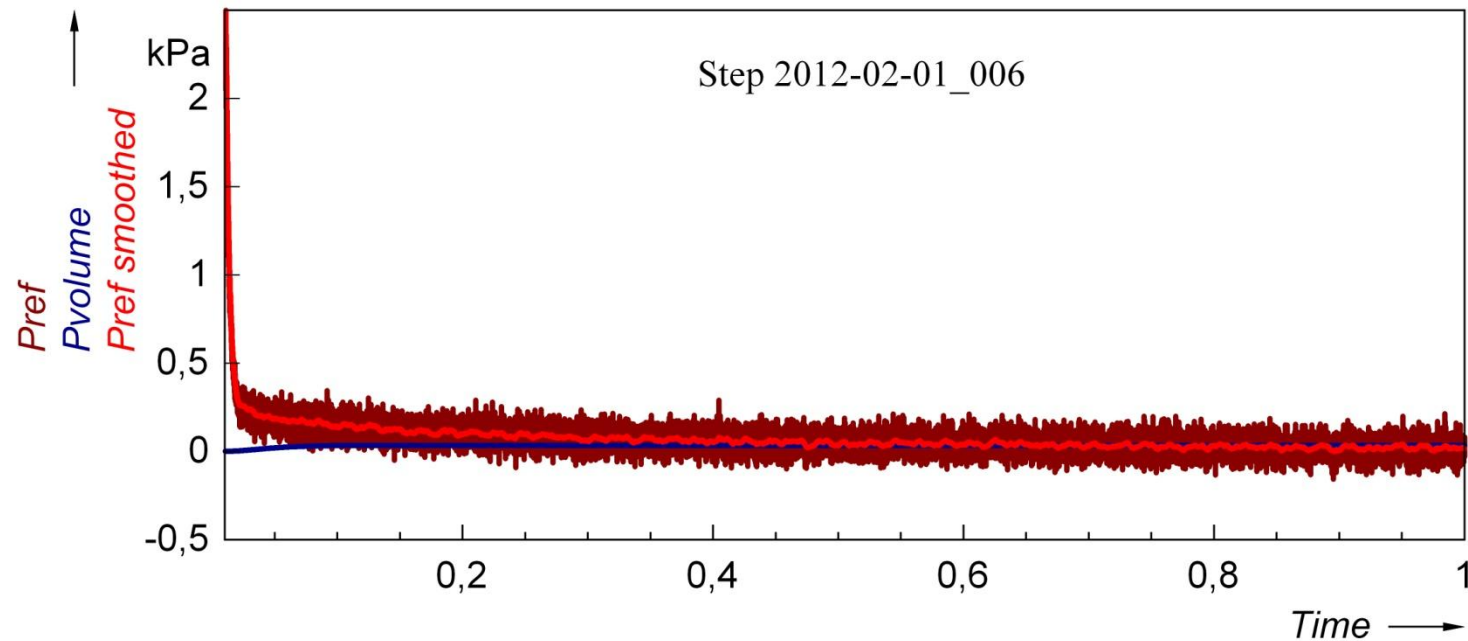
Almost total volume of the
volume to expand consists of
the T-piece needed for
mounting of test sensor

Step response of reference system



- Step times around 0.1s
- Final pressure around 50Pa
- Pressure stabilised in expansion vessel after about 0,15s

Second setup, results



- Noisy signal from P_{ref} at lowest pressure
- Smoothing P_{ref} gives a more comparable result showing very good agreement between P_{ref} and P_{volume} after stabilisation.

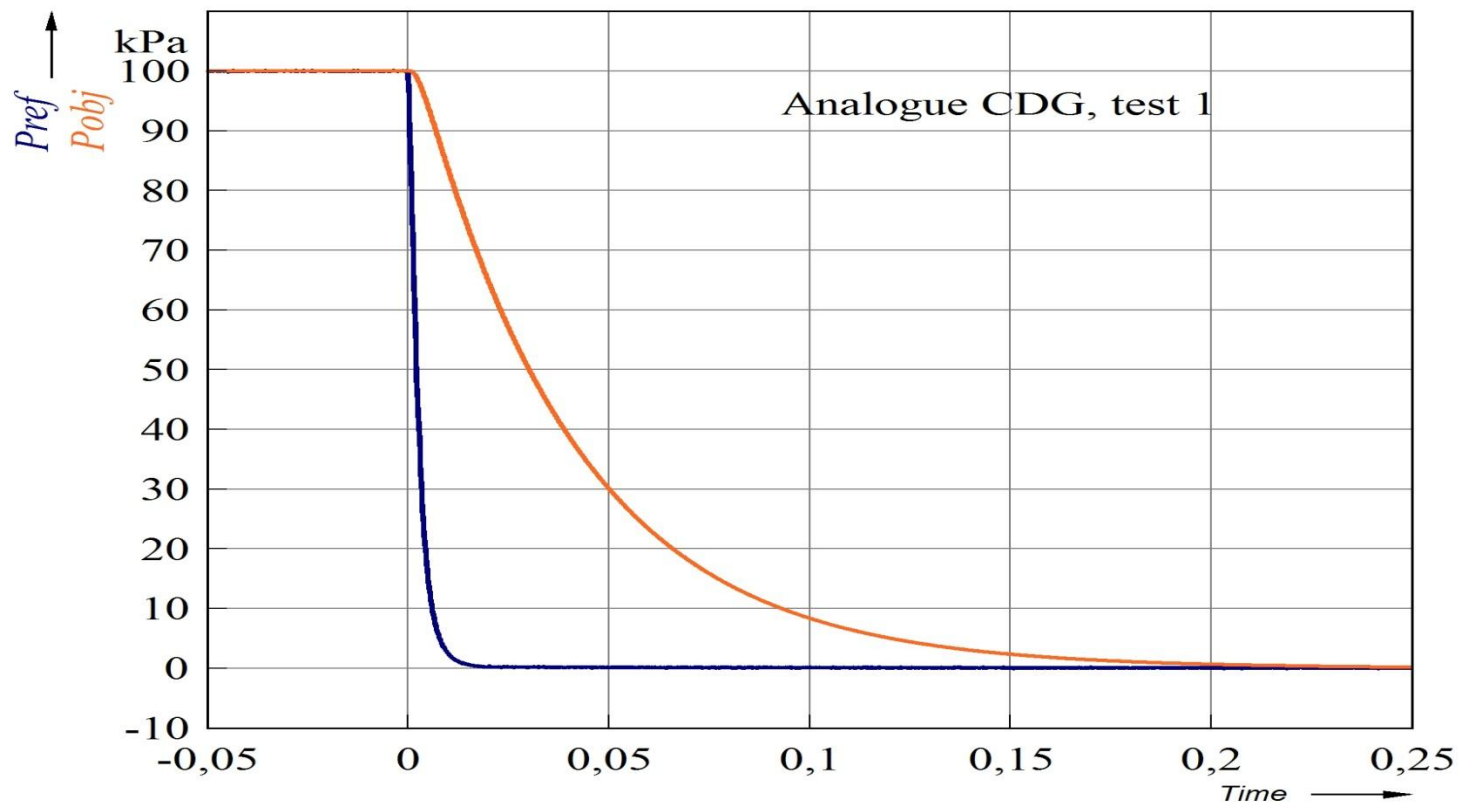
Test of vacuum gauges

A sample of gauges tested:

- Standard CDG with analogue signal conditioner
- Standard pirani gauge with analogue signal conditioner
- Active CDG with signal conditioner
- Active CDG without signal conditioner
- Active gauge with multiple sensors

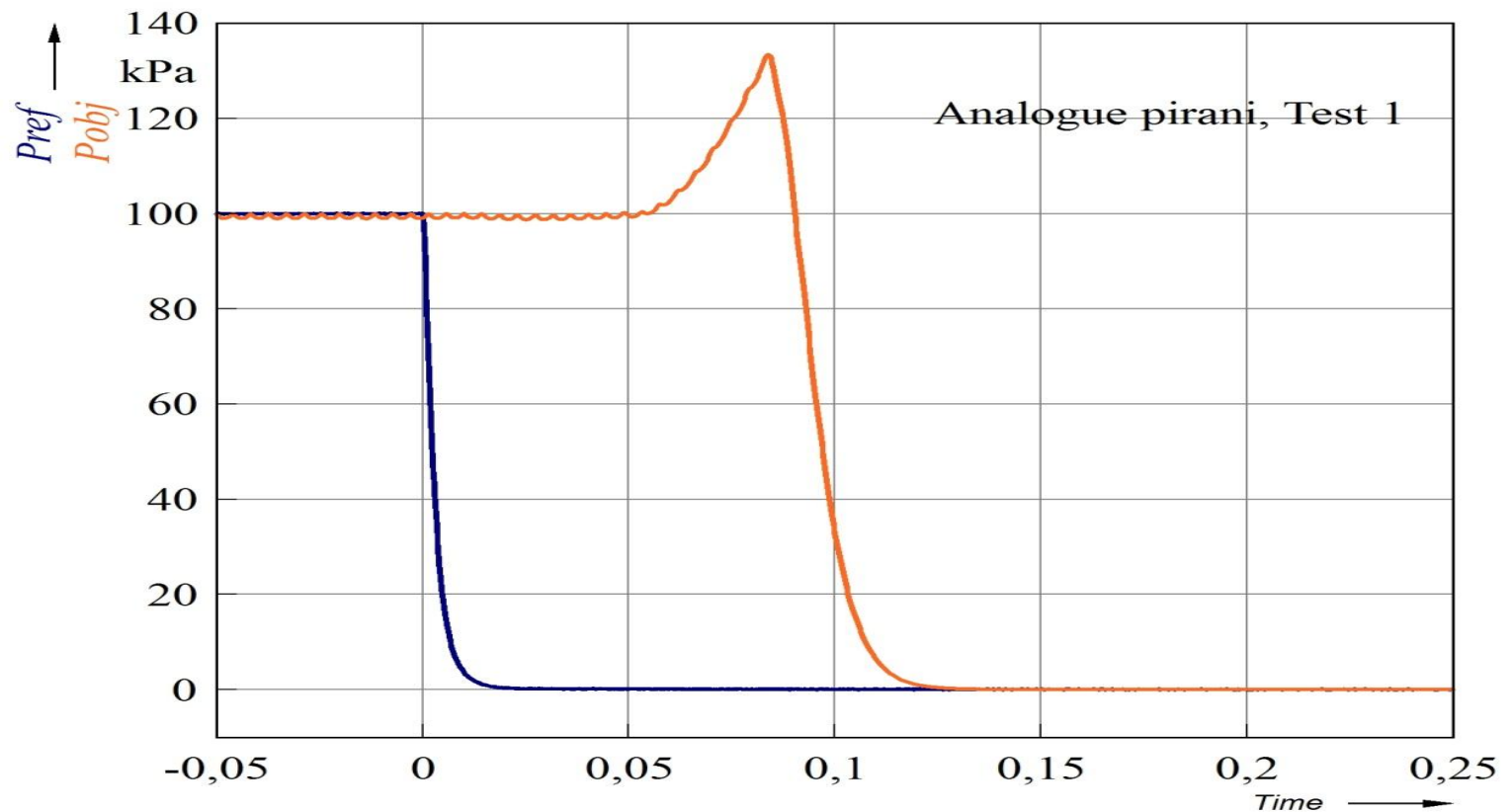
Test results: Analogue capacitance diaphragm gauge

- Analogue voltage output taken from signal conditioner
- About 0.25 s response time
- Smooth and well predictable behaviour



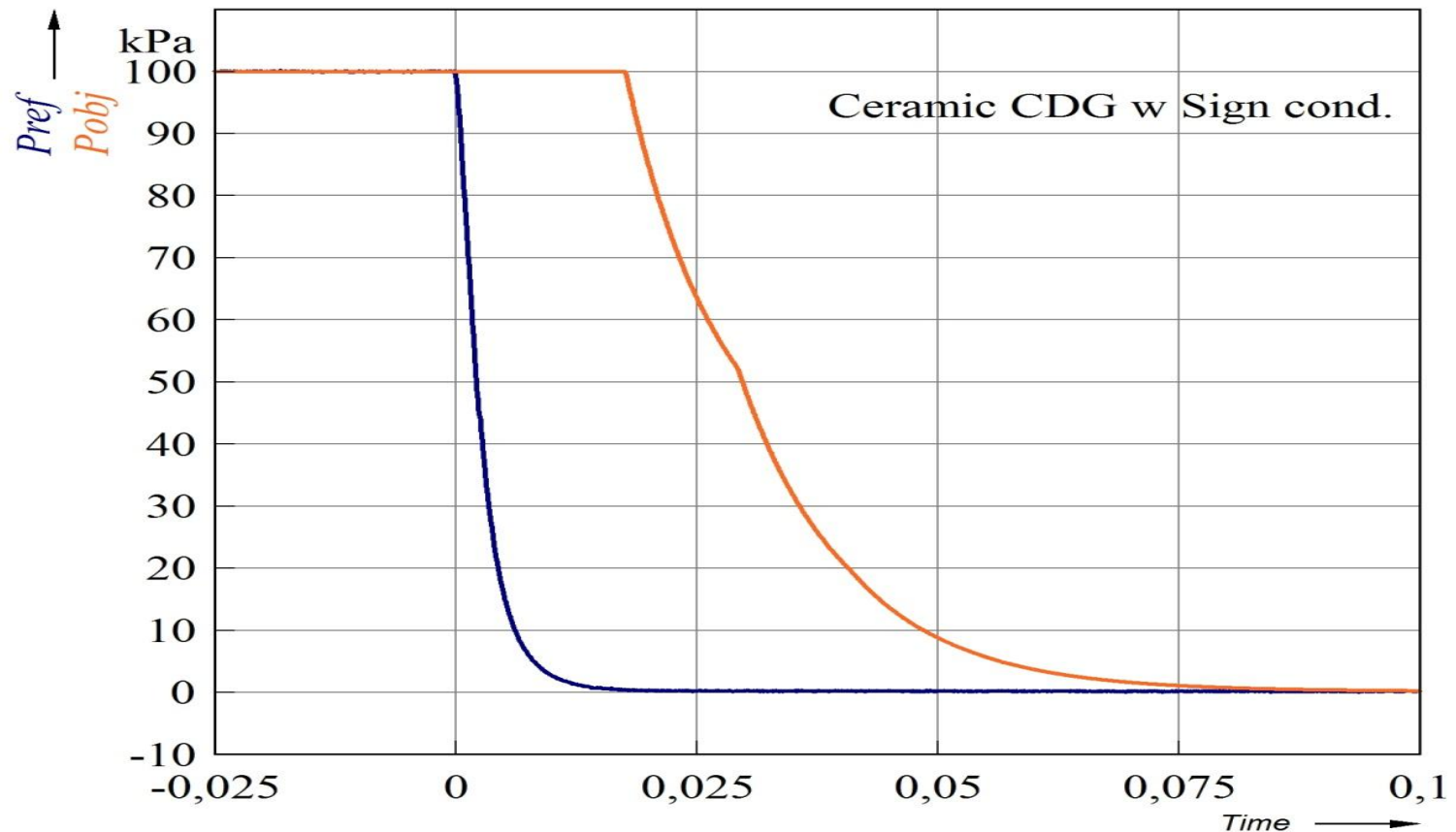
Test results: Analogue pirani gauge

- About 0,15s response time
- Large overshoot before slope



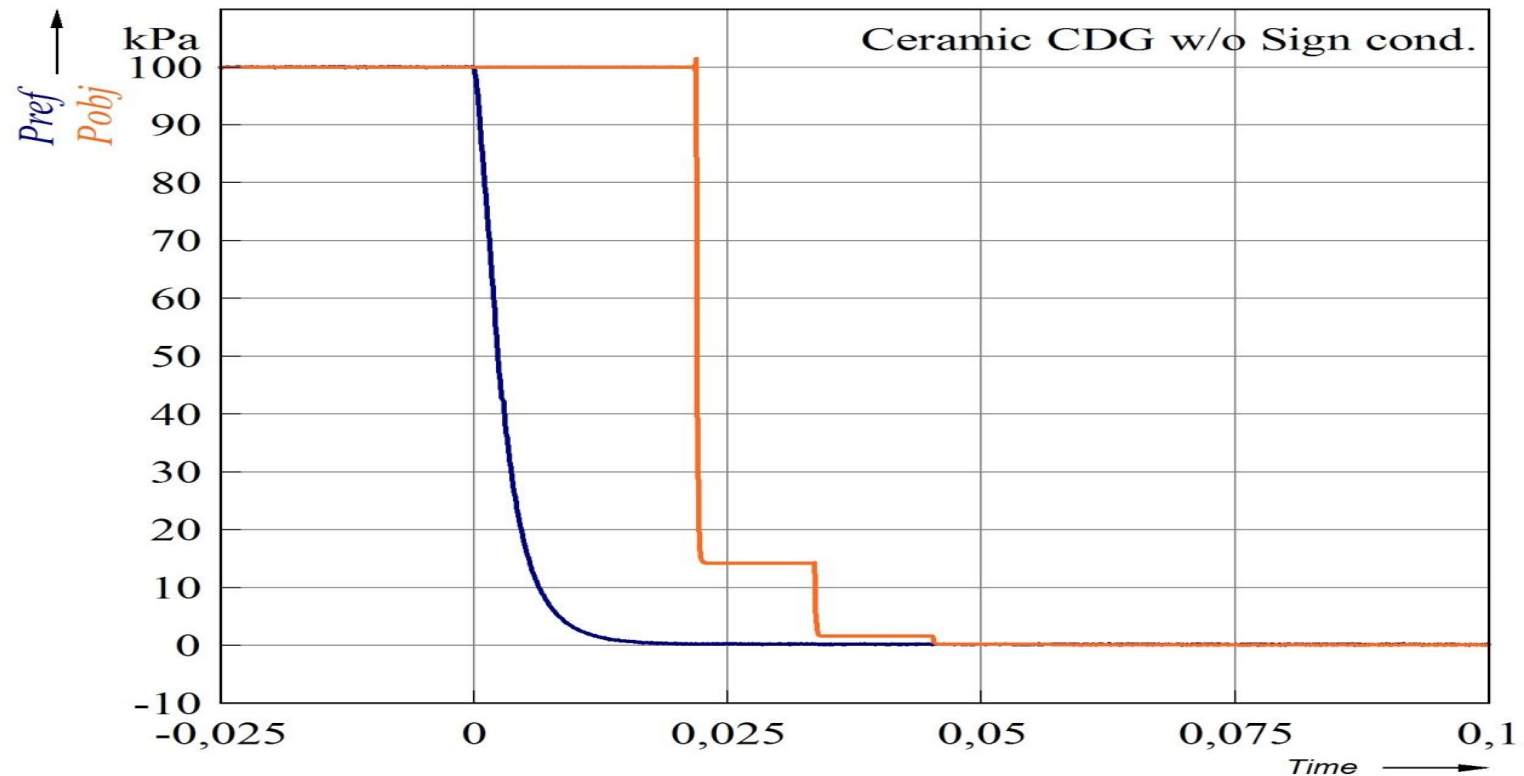
Test results: Active CDG with signal conditioner

- Faster than the active pirani but ...
- Similar behaviour regarding response time and smoothness



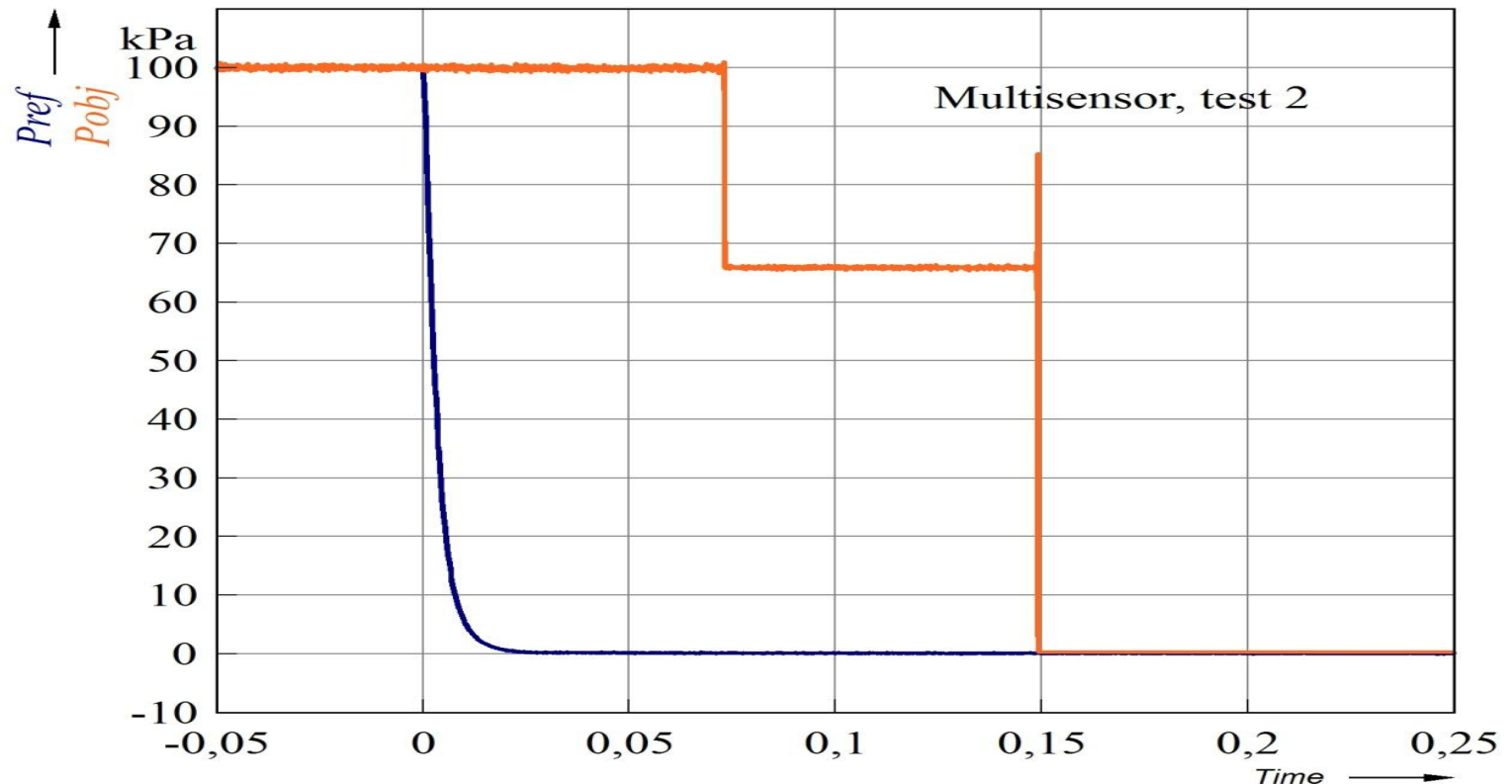
Test results: Active CDG without signal conditioner

- Same gauge as in previous slide
- Raw signal directly from gauge
- Time discretized signal with update interval of 10ms

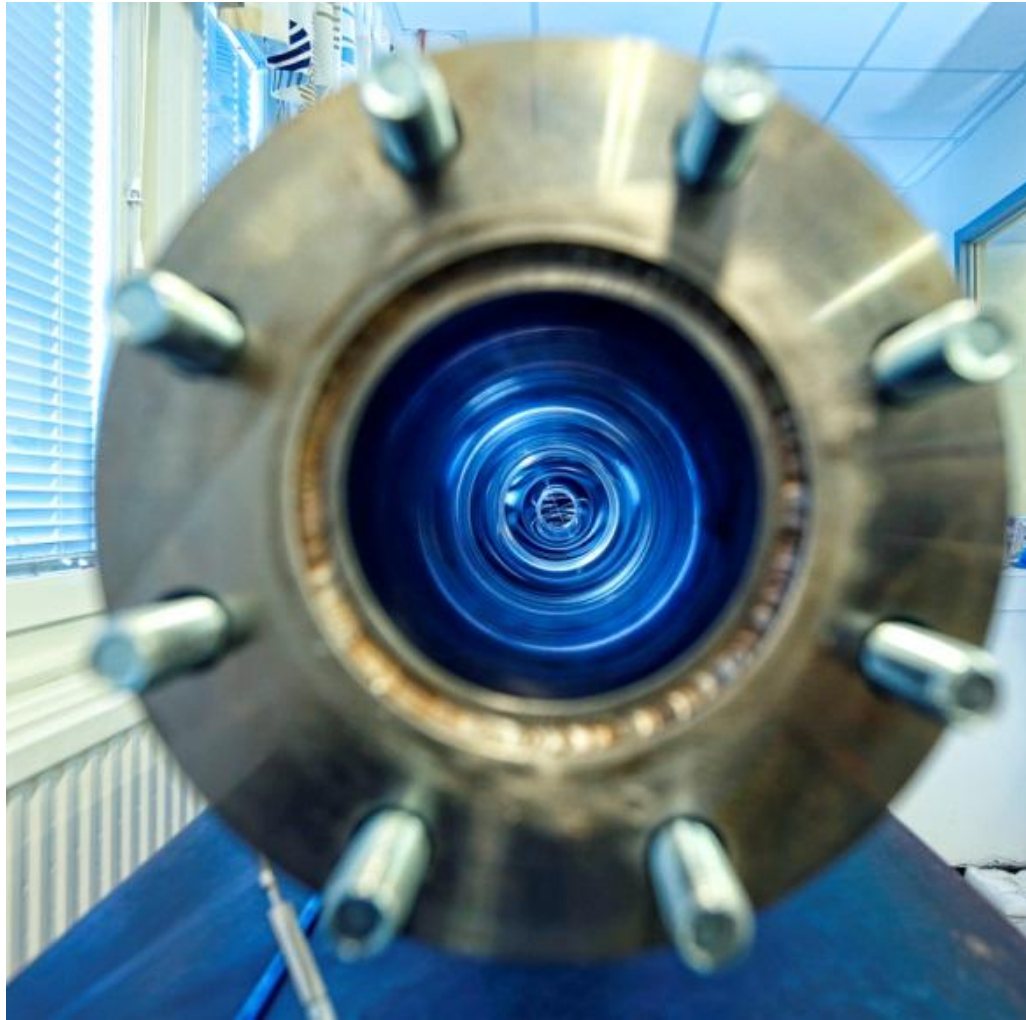


Test results: Active gauge with multiple sensors

- Time-discreet behaviour similar to previous gauge
- Update interval 75ms

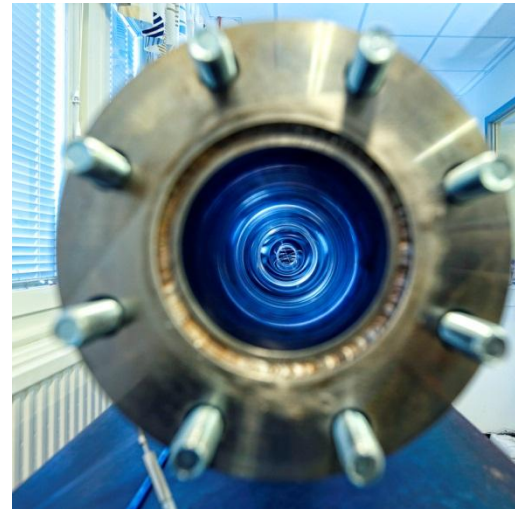


Positive step response



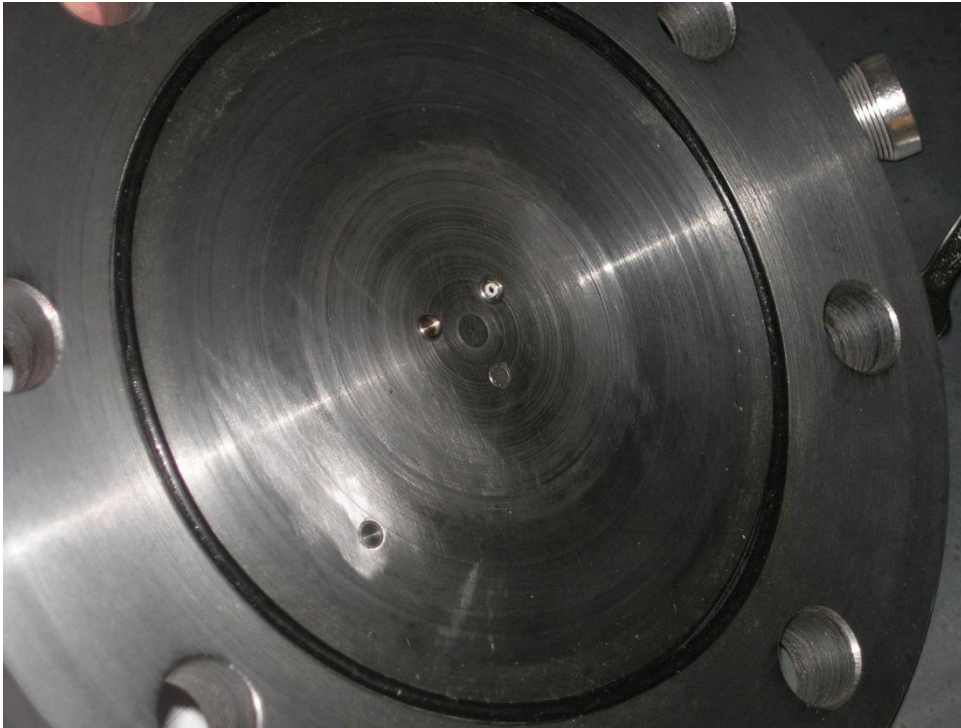
High pressure tests

- Using shock tube to generate extremely fast pressure pulses
 - Rise time well below $1\mu\text{s}$
 - Shock amplitudes used around 200kPa.
- Two gauges to determine shock speed (0,5m apart, close to end)
- High speed signal conditioner, PXI-based, 8 ch at 208kS/s, 2 ch at 100MS/s, simultaneous sampling.



Test gauge mounting

- Test gauge(s) flush mounted at tube end
- Possibility to mount several gauges in symmetrical positions



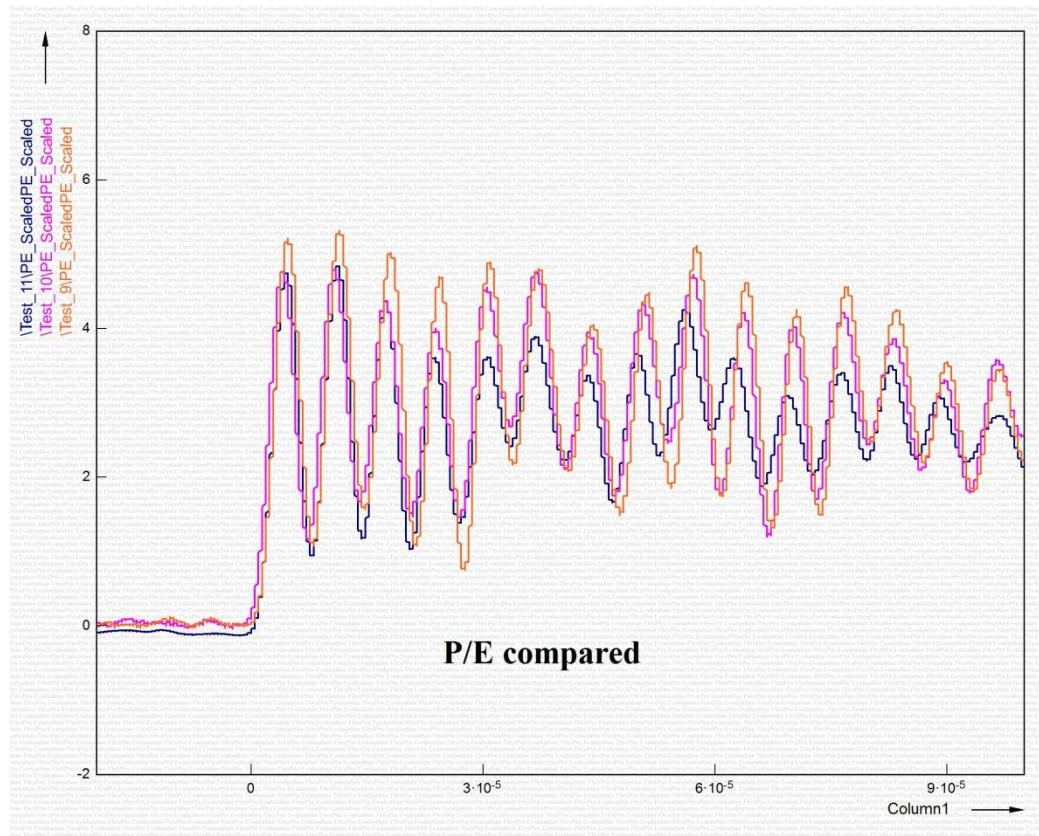
Repeatability

- The pressure shock repeats very well
- Three consecutive tests:

50MS/s

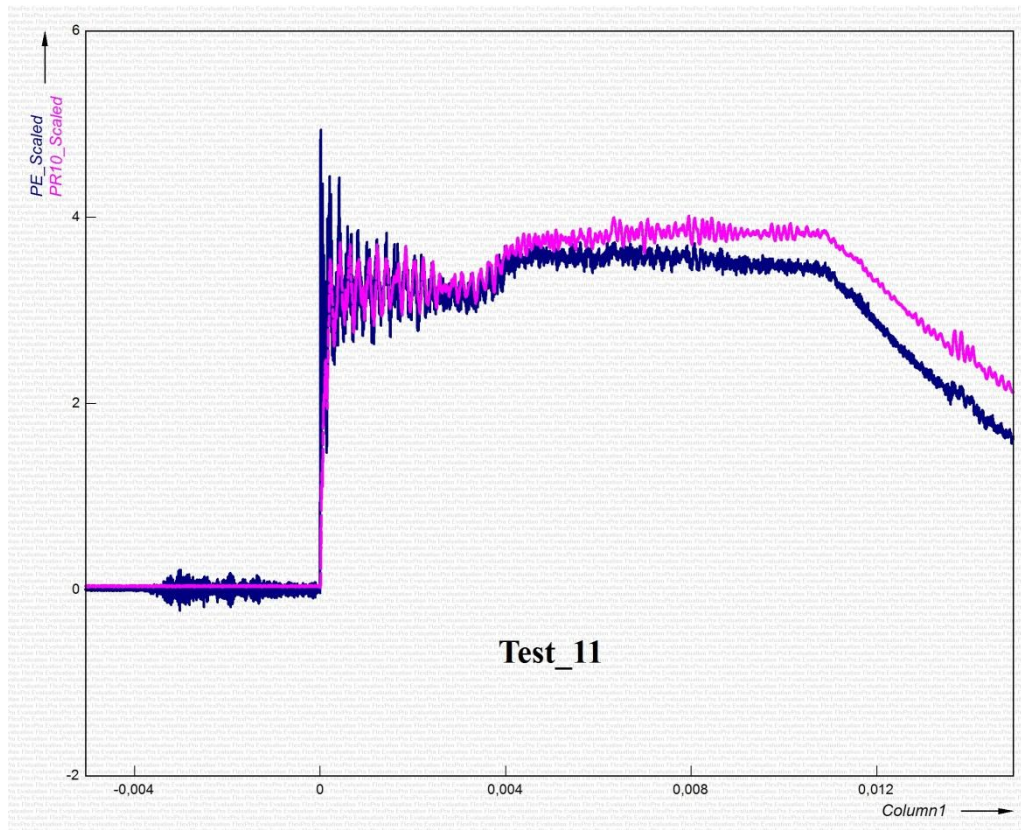
1 piezoelectric
Gauge

3 consecutive
bursts



Difference between piezoresistive and piezoelectric gauge

- Discharge of piezoelectric gauge?
- Heating effects seen on piezoresistive gauge?
- Pre-shock noise due to vibrations in tube



Conclusions and future

- Working system for step response of vacuum gauges down to ~50Pa
- Very repeatable results on shock tube
- Still some problems with fibre optic sensor, mainly due to signal conditioning.
- Future work involves improving shock tube performance, different membrane materials and solving the problem with the fibre optic sensor.