BERTHOLD WEBINAR
Optimize your radiometric steel level measurement
to increase accuracy, profitability and safety
Your presenter
Albert Rödfalk
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Albert Rödfalk

Expert for measurement solutions in the steel industry

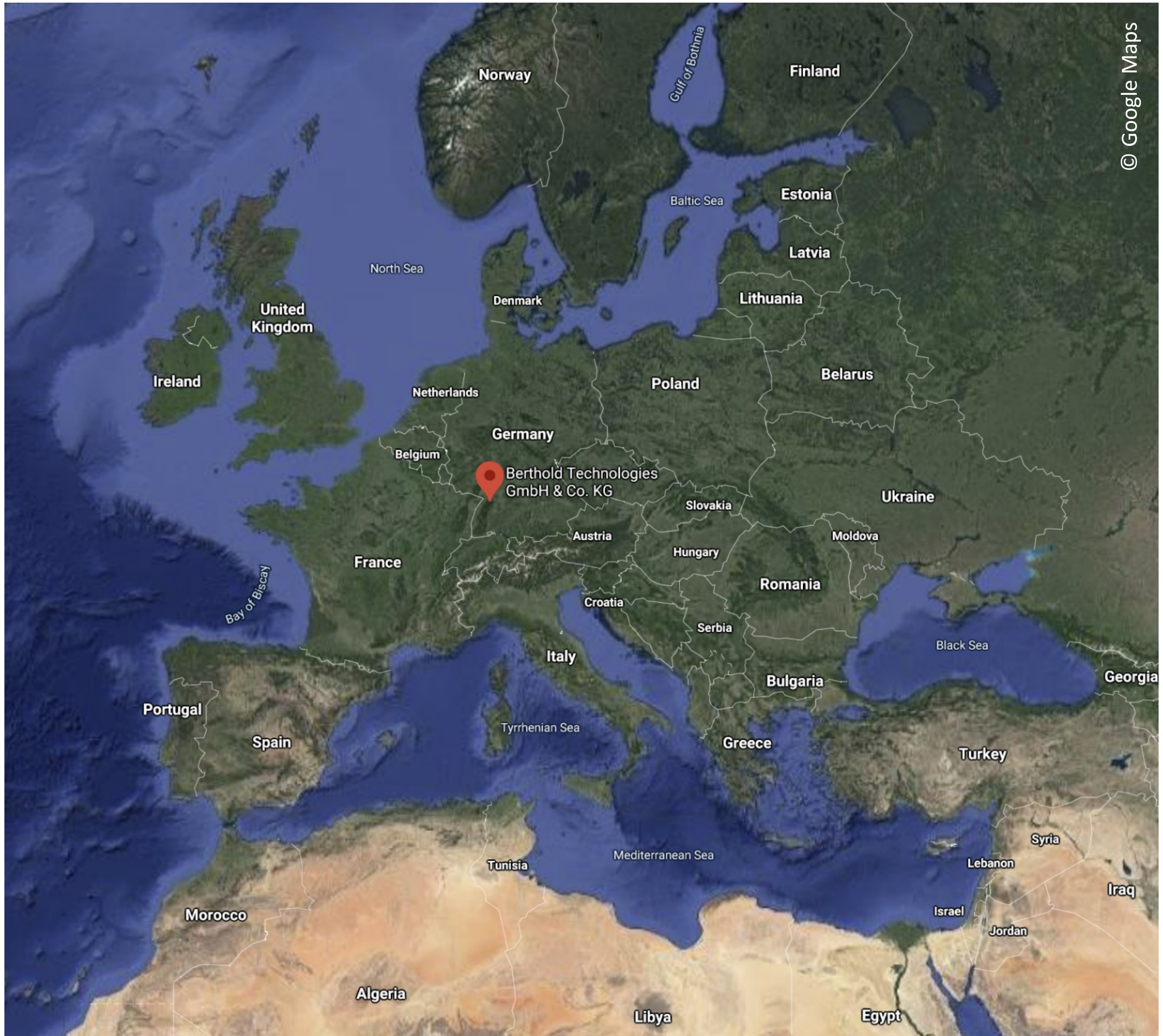
- M. Sc. in Chemical engineering.
- Worked with development of process equipment for the ferro- and non-ferrous industry for 15 years.
- Works for Berthold since five years as Global Product Manager for mainly the steel business.

Agenda

1. Background
2. Statistical variation and response time
3. How to calculate the expected theoretical precision
4. How to verify the calculated precision in reality
5. Optimal source
6. How to test and resolve noise from EM stirrers and brakes
7. How to reduce cross-talk, if any, between adjacent strands
8. How to minimize powder influence
9. How to suppress mold oscillation influence
10. How to resolve the most common user issues
11. Question and answer session

Who we are?

- Located in Bad Wildbad, South West Germany
- Family run company
- 350 employees worldwide
- Leader in process radiometric measurements
- Specialized in radiometric process measurements since 1949
- >20,000 nuclear gauges in operation



… and where we came from


1949
Prof. Dr. Rudolf Berthold founded the company „Laboratorium Prof. Dr. Rudolf Berthold"

1950
Development of the first industrial process measurement based on γ-Transmission (Level Switch - BASF)

1955
First density systems supplied

1959
Use of Rod shaped sources for highly accurate level measurements

1960


Dr. Fritz Berthold

1973
High-sensitive scintillators replaced Geiger-Müller technology

1989
Acquisition by EG&G

2000


Re-privatization renamed Berthold Technologies

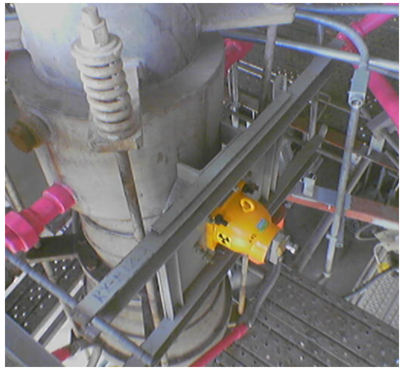
2003
SuperSENS most sensitive detector

2014
SIL2/3 certified detectors

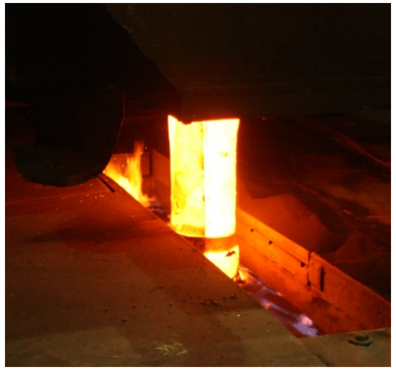
Where we are?

- Active Areas:

Refineries
e.g. Shell, Exxon Mobil, Total…



Chemical
e.g. BASF, Dow, Eastman, SABIC…



Steel industry – continuous casting
e.g. Arcelor Mittal, POSCO, Thyssen Krupp…

Mining and Alumina
e.g. BHP Billiton, Rio Tinto, VALE, Anglo American, Peabody

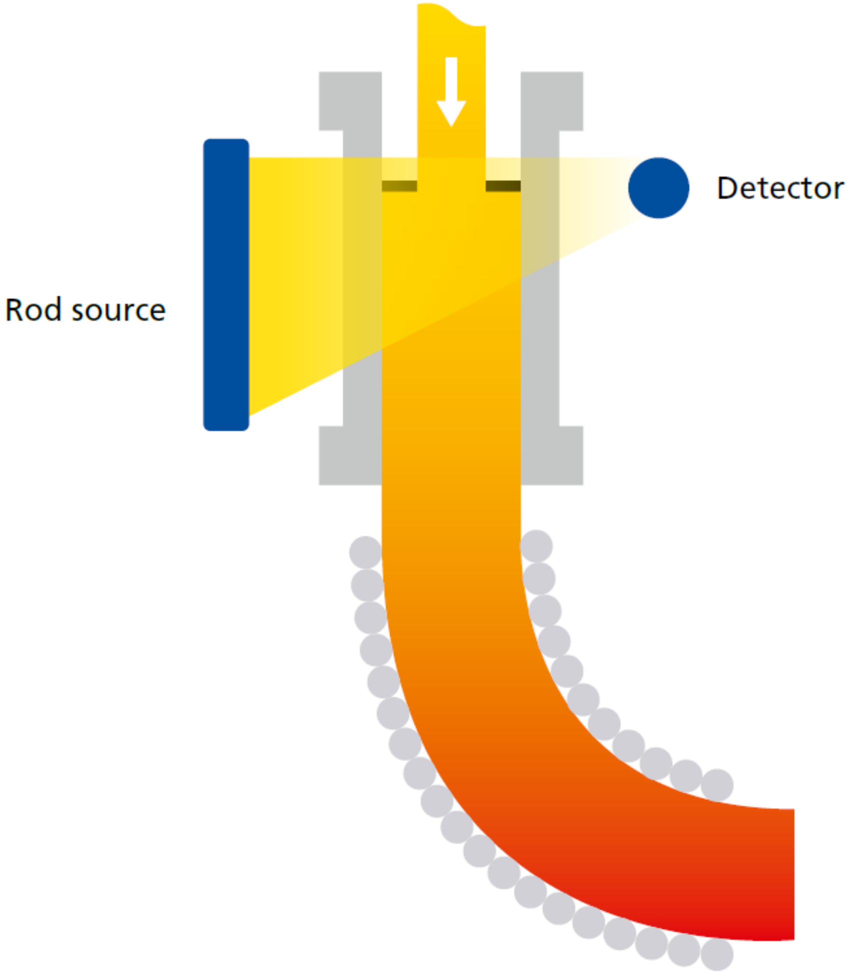
And many others: ***Oil offshore, Coal gasification, Power plants, Pulp & Paper, Cement, Sugar mills, Glass production, Wastewater etc.***

Background

A radiometric based mould level system consists of three main parts:

- A radioactive source
- A scintillation counter (Detector)
- An evaluation unit

- The source emits gamma radiation that hits the detector.
- **The steel in the mould attenuates radiation, thus less gamma radiation hits the detector.**
- The detector outputs the pulses to the evaluation unit that in turn converts the information into a mould level value active calibration curve.



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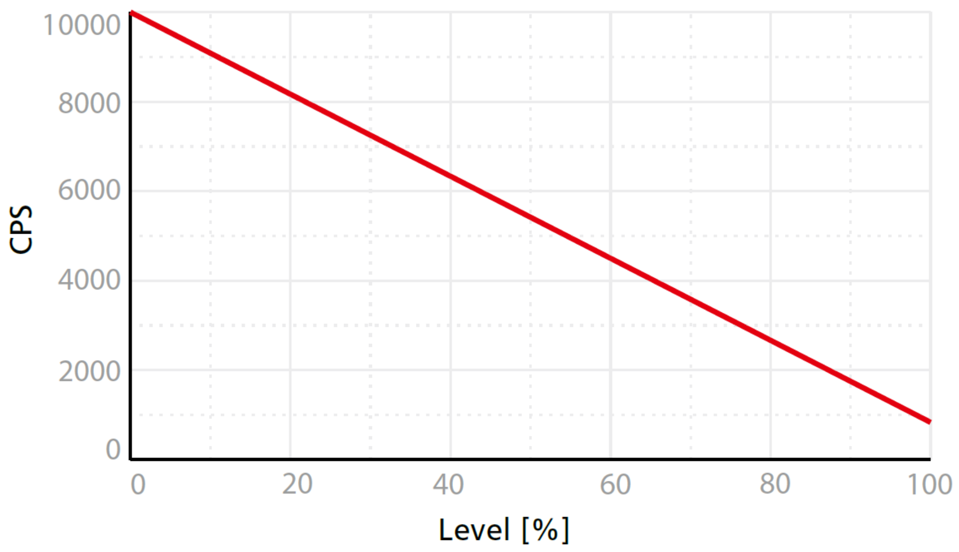


Statistical variation and response time

- Radioactive radiation is generated by statistical distributed decays of radioactive materials.
- This means that even at constant mould level, the output signal undergoes statistic deviation.
- The relative size of the standard deviation can be expressed using the following formula:

$$\frac{\sigma_N}{N} = \frac{1}{\sqrt{2 * N * \tau}}$$

Where:

- N = impulses per second
- τ = time constant (s)

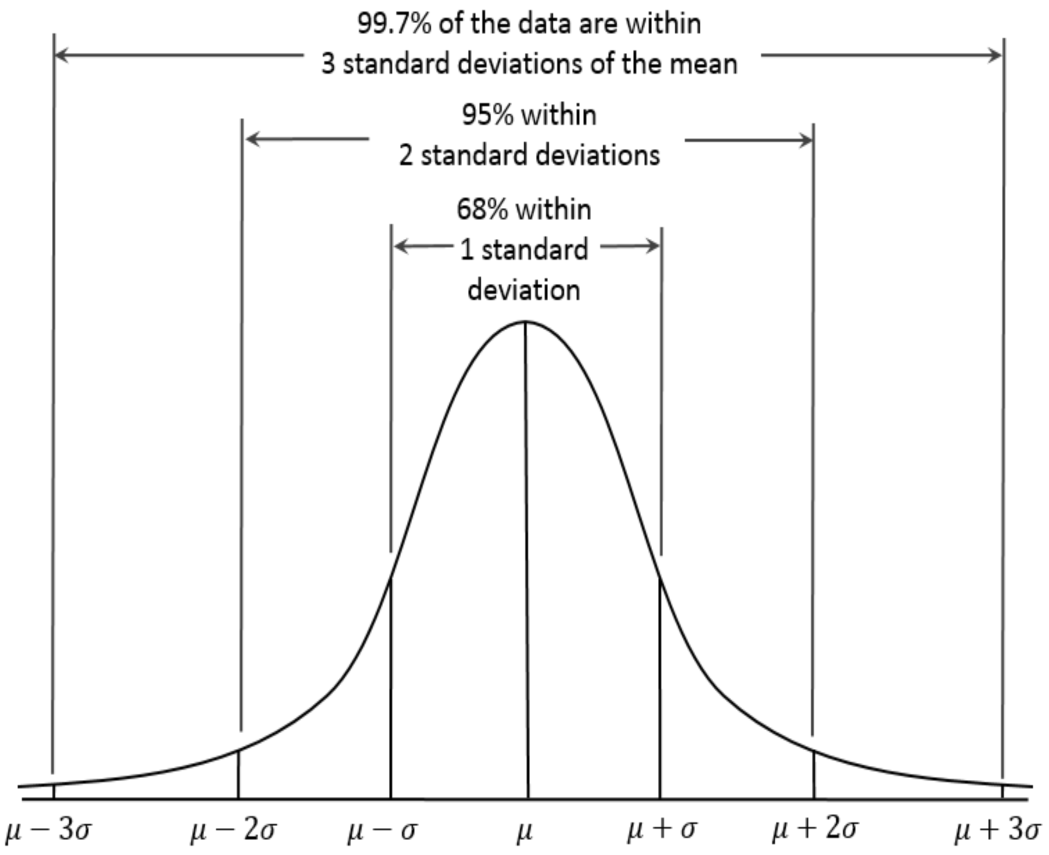
Statistical variation and response time

- Including the total measuring range (L_t), the casting set point (L_{sp}), and using the empty mould count rate (N_{empty}), yields the following formula for the system standard deviation at casting set point in millimeters.

$$\sigma_L = L_t \sqrt{\frac{1 - \frac{L_{sp}}{L_t}}{N_{empty} * 2 * \tau}}$$

- Applying this expression, for quite some normal conditions, for a small cross section caster:
  - N_{empty} = 10.000 counts per second
  - τ = 0,8 s
  - L_{sp} = 112,5 mm (75 % of the total measuring range, L_t)
  - L_t = 150 mm
- Yields the follow table:

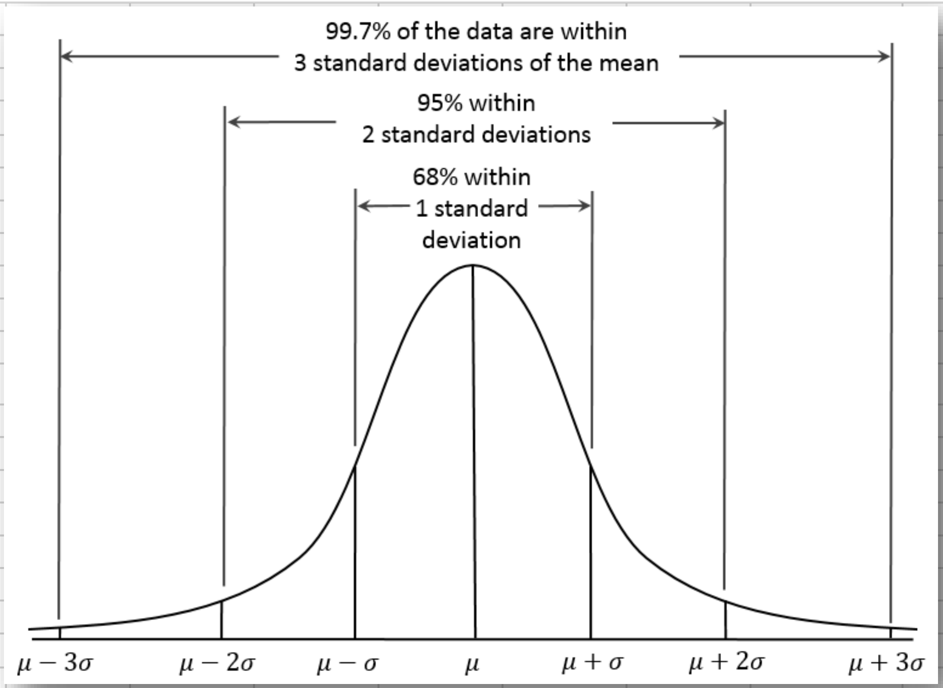
Standard deviation	Deviation in mm
1σ	0,6
2σ	1,2
3σ	1,8



How to calculate the expected theoretical precision

Simple Excel tool available from Berthold.

Measuring range	200	**mm**
Count rate (at empty mould)	10 000	**counts per second (CPS)**
Time constant	1	**s**
Set point at of measuring range (μ)	75	**%**
Deviation at set point		
Statistical error in +/- mm		
1 σ	**0,7**	mm
2 σ	**1,4**	mm
3 σ	**2,1**	mm
Statistical error in +/- %		
1 σ	**0,4**	%
2 σ	**0,7**	%
3 σ	**1,1**	%
Statistical error in +/- CPS		
1 σ	**35**	CPS
2 σ	**71**	CPS
3 σ	**106**	CPS



1 σ = within 68% of the time.
2 σ = within 95% of the time.
3 σ = within 99,7% of the time.

"Golden rules" for accuracy for radiometric mold level measurement

1) Higher empty count rate gives better accuracy in the whole measuring range.
2) Higher time constant gives smoother level signal, but slower response time.
3) Higher set point gives higher measuring accuracy.

How to verify the calculated precision in reality

The way we recommend to verify the accuracy of a radiometric mould level system:

1. Prepare a system at mould in casting position with source and detector.
2. Calibrate the system.
3. Place the calibration block in the mould at casting level.
4. Open the source and chart the mould level signal for some minutes.
5. Compare the charted mould level signal with the calculated one – their deviations should virtually match.

- With this procedure, one knows with what accuracy the mould level system operates.
- Deviations outside the verified accuracy of the mould level system do not likely origin from the mould level measurement. For these deviations other sources for the problems must be examined, like e.g:
  - the level control system
  - flow control system
  - rate of strand withdrawal out of the mould
  - bulging issues

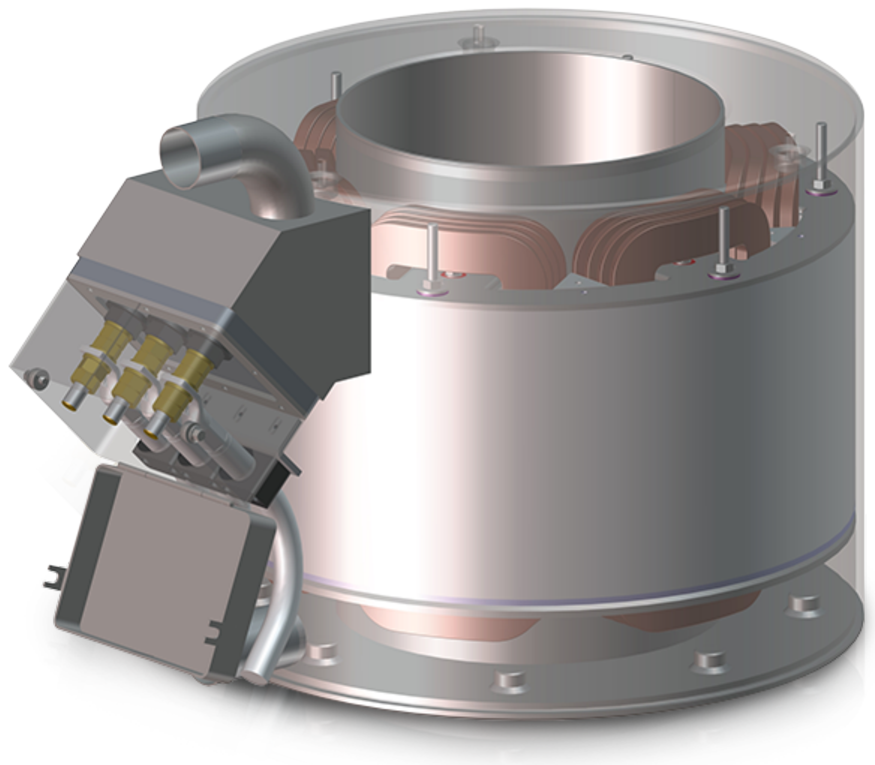
How to test and resolve noise from electromagnetic stirrers and brakes

- Electromagnetic stirrers and brakes operates with very strong, non/low frequency EM-fields.
- Such EM-fields can cause the flying electrons inside a PMT to deviate from its trajectory – causing lost counts.
- The way we recommend to elucidate if the radiometric mould level system is influence by the stirrer or brakes in very straight forward.

1. Prepare a system at mould in casting position with source and detector.
2. Open the source and chart the mould level signal for some minutes.
3. Turn on the EMS/EMBr and chart the signal for some minutes.
4. Compare the deviations for the two charted signals, with EMS/EMBr turned off and on.

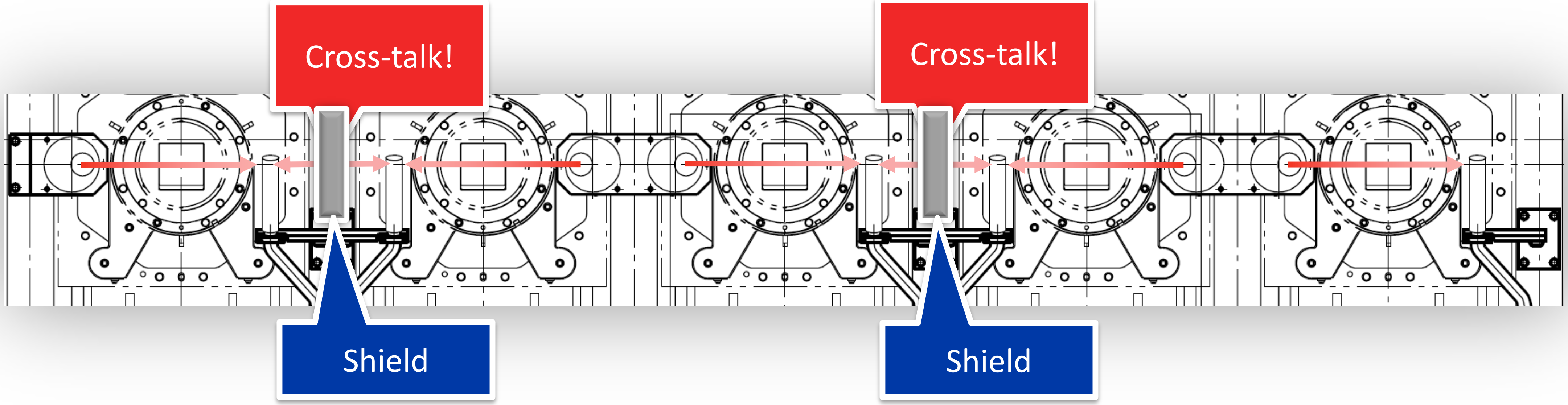
- In case the mould level system is negatively affected by the EM-field generated by the EMS/EMBr, there are two main options to handle this:

1. Change detector to a SiPM-based detector.
2. Increase the EM-shield by adding ferromagnetic steel around the detector.



How to reduce cross-talk, if any, between adjacent strands

- Some old caster where designed with all sources in a straight line.



- Resolution: Add high density (e.g. Lead or steel) shields between the strand.

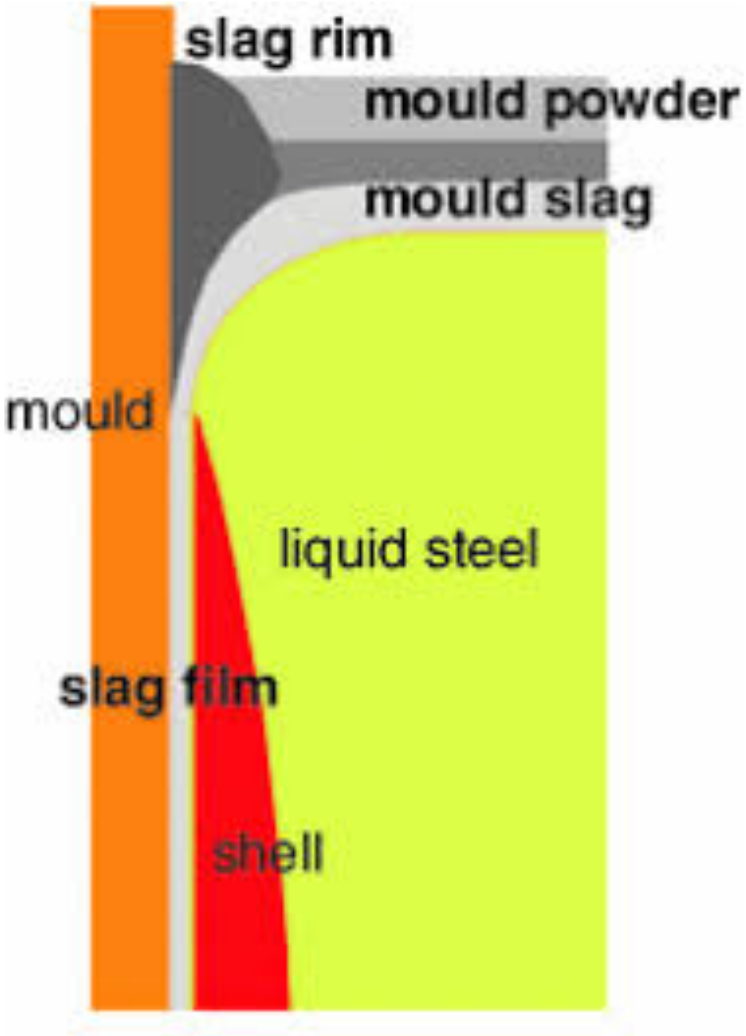
How to reduce cross-talk, if any, between adjacent strands

- Half-value layer (HVL) for Co-60 for some materials.

Half-Value Layer, mm (inch)				
Source	**Concrete**	**Steel**	**Lead**	**Tungsten**
Cobalt-60	60.5 (2.38)	21.6 (0.85)	12.5 (0.49)	7.9 (0.31)

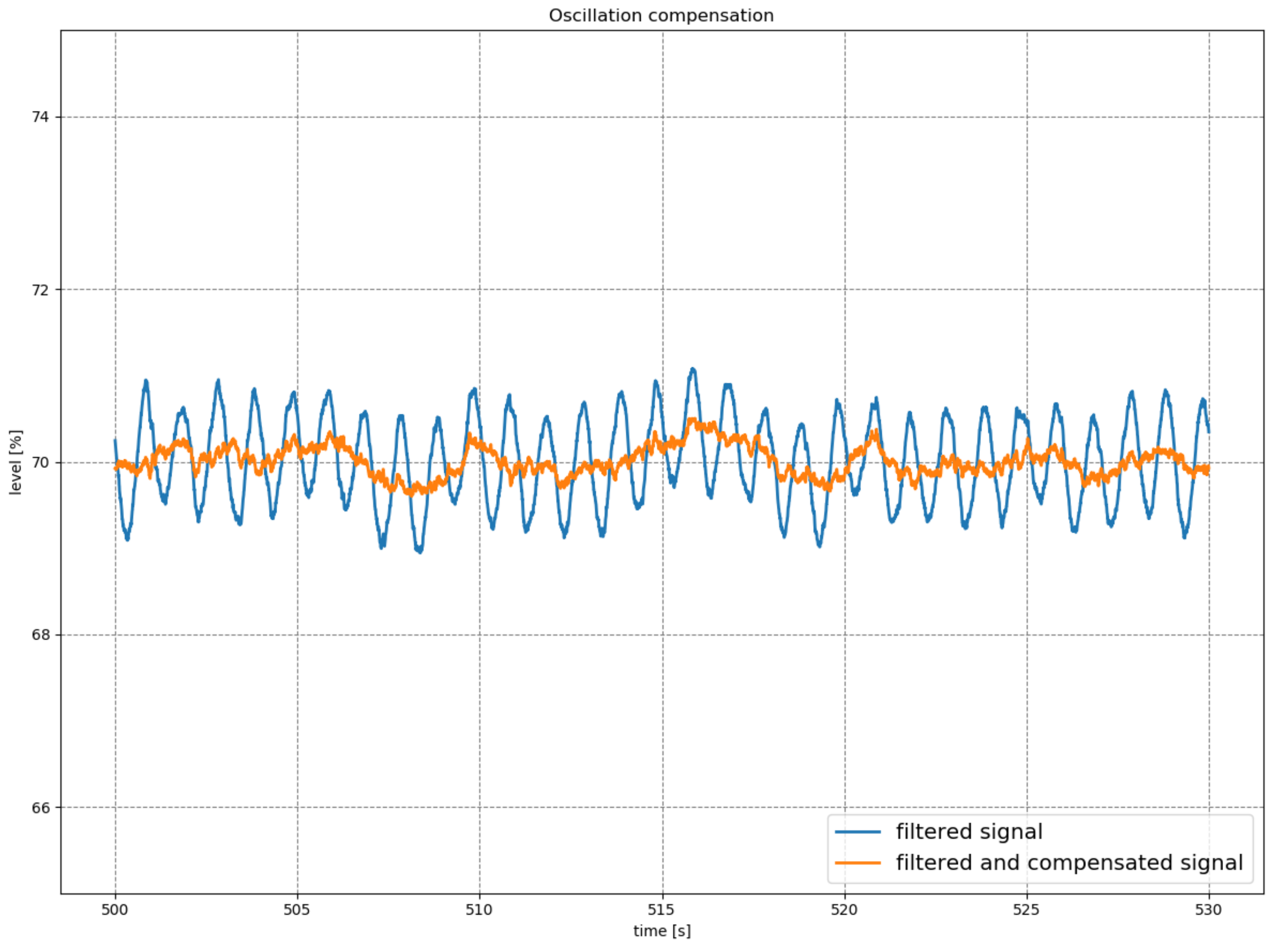
How to minimize negative influence from casting powder

- Casting powders has a density of about 0.7 to 0.9 g/cm^3, which correspond to about $1/10^{th}$ of the density for molten steel.
- For small mould approximately 10 mm of casting powder will correspond to 1 mm of steel and push the steel level down accordingly.
- For large mould the power effect becomes bigger due to the increased pathway of the radiation in the powder.
- Using Co-60 as source will provide much less powder influenced mould level signal.
- For a recent product release we have exploited the radiation attenuating effect from the casting powder and can now offer a product that measures both the steel and the powder level simultaneously.



How to suppress mould oscillation influences

- For a mechanical installation where the mould level system oscillates with the mould, some influences can occur on the mould level signal.
- This is true for oscillation frequencies below 3 Hz (180 rpm), which normally corresponds to bloom or slabs formats.
- By enabling the mould oscillation filtering in the LB452 such influences can be filtered out with no reduced system response time.



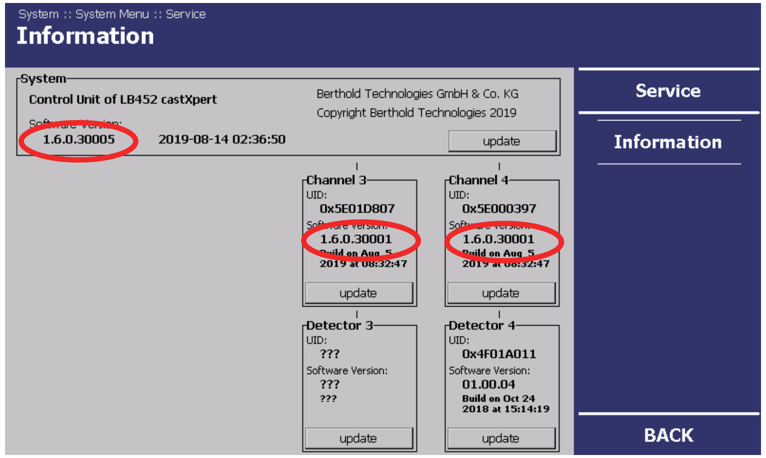
Optimal source

- There are virtually two different elements, with their specific isotopes, used for radiometric mold level measurement being Cs-137 and Co-60.
- Berthold always recommend Co-60 for mold level applications for obvious reasons

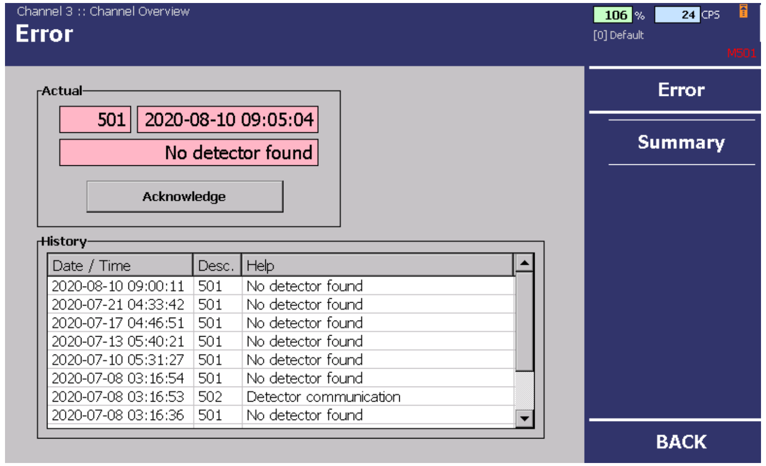
	Cs-137	Co-60
Specific energy	660 keV	1173/1332 keV
Source activity	Higher (up to 5 times)	Lower
Casting powder influence	High	Low
Physical from	Ceramics point sources	Metal wire
Rod style	Multiple points	Continuous
Pricing	High	Most economic
Calibration	Always non-linear	Linear
Half lifetime	30,18 years	5,27 years
Legislation lifetime	National legislation	National legislation
Designed lifetime	10 (-15) years	10 (-15) years

Most common user issues

1. A new channel card can not be found by the LB 452 unit.
   - Reason: The LB 452 and the channel cards have different SW revisions.
   - Resolution:
     - Upgrade the LB 452 to the latest software.
     - Upgrade all channel cards to the latest software.



2. Frequent M501 and M502 errors reported by the LB 452 unit.
   - Reason: Connection between the LB 452 and the detector is not stable and is sometimes lost.
   - Solution: Check cabling and replace broken parts.



Question and answer session

Thank you
for your attention!