Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

Evaluation and organization of comparisons in fluid flow

Current activities and experiences

17th International EMATEM-Summer School
29.09 . – 30.09.2021
Kloster Seeon

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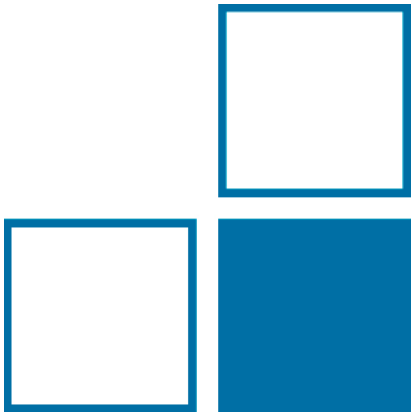

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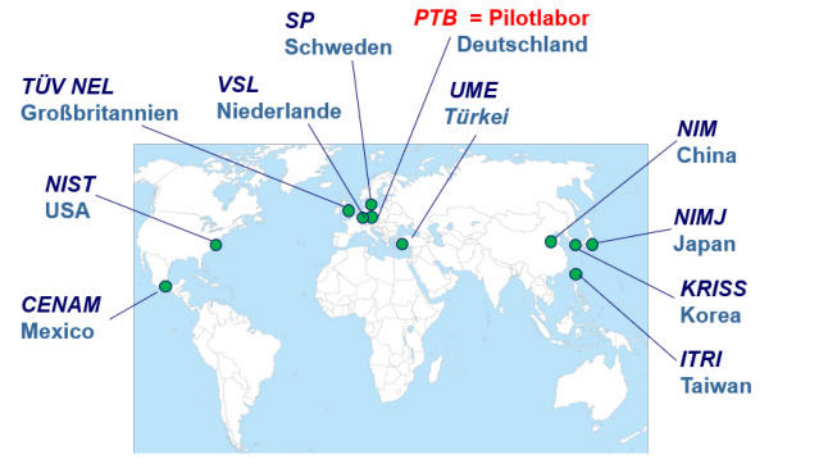
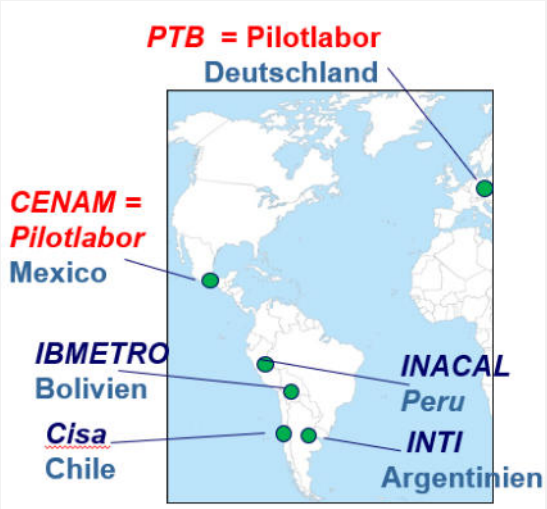
Comparisons - Current activities of AG 1.52

As pilot lab – international comparisons

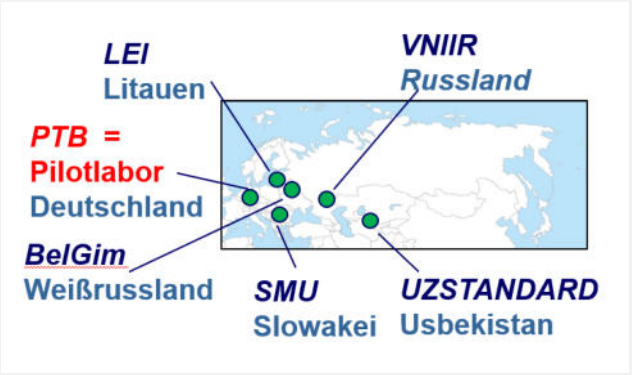
Worldwide
CCM.FF-K1.2015



South Amerika
SIM.M.FF-S9



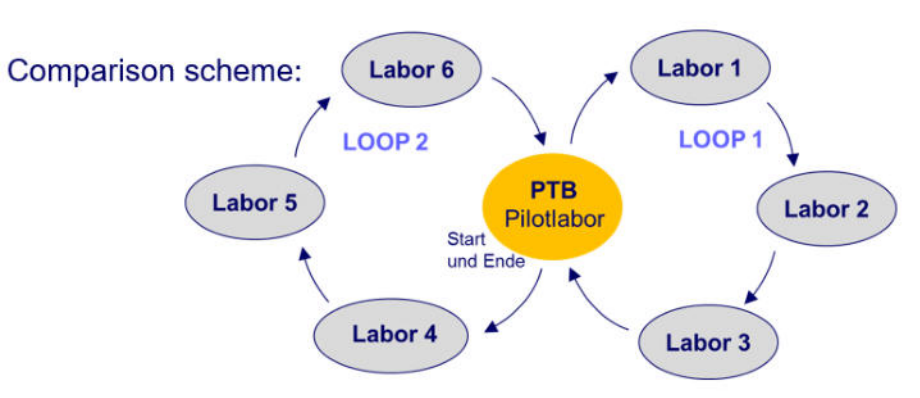
Osteuropa/Asien
COOMET.M.FF-S2



Comparisons - Current activities of AG 1.52

Pilot lab – national comparison - *DKD-Ringvergleich Flüssigkeiten*

- *first official comparison in Germany in fluid flow between manufacturers*
- **Objective:** Verification of accredited laboratory uncertainties
- **Participants:** 6 DAkkS-laboratories
- **Calibration period:** 2017 - 2018



Duration of comparisons - Examples

PTB fluid flow - as pilot laboratory (organisation and reporting)

- *CCM.FF-K1.2015* (Wasser, DN100) ➔ 6 years
- *COOMET.M.FF-S2* (Wasser, DN25 + DN 80) ➔ 11 years
- *SIM.M.FF-S9* (Wasser, DN 80) ➔ 6 years
- *DKD-Ringvergleich Flüssigkeiten* ➔ 4 years

Bilateral with PTB

- *as calibration lab* ➔ 10 months

Organsised by other NMI`s or other departments

- *CCM.FF-K2.2011 (VSL)* ➔ 8 years
- *EURAMET.M.FF-K6 (Gas/PTB)* ➔ 4 years
- *CCM.FF-K1 (KRISS)* ➔ 4 years

Duration of comparisons

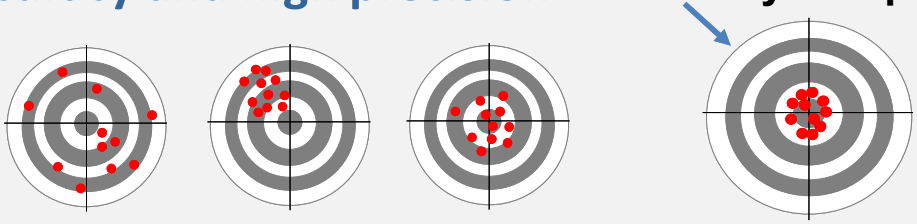
(potential) Reasons for long durations

- Long search for a suitable transfer meter, including characterisation measurements
- A standardised evaluation procedure is not existing
- Calibration procedure - to extensive
- Comparisons - not always a top priority in participating labs
- Time intensive organisation and reporting
- Trouble-shooting e.g. during transportation of the setup, crew change, limited human resources
- Review process – could take a long time, but it is import for acceptance

But: Comparisons are essential for quality management of a calibration laboratory

Why comparisons?

High accuracy and high precision - Aimed by comparisons



➔ Confirmation of a calibration laboratory to guarantee the quality of reliable and valid measurements

➔ **Essential for accredited laboratories** and claimed by DIN EN ISO/IEC 17025:2018

➔ Evaluation is based on a reference value and analysis (E_N-value)

➔ Important documents:

DAkkS 2014-06 71 SD 0 010 und Anhang 1 + 2 oder ILAC P9 2014-06

Summarised during PTB workshop “Nachweis von Messunsicherheiten im Rahmen der Akkreditierung von Laboratorien im Durchflussbereich“ 10/2019

=> *https://www.ptb.de/cms/de/ptb/fachabteilungen/abt1/fb-15/seminaretagungen/workshop-messunsicherheit.html*

Important points of consideration

- Independent **pilot lab, clear responsibilities** for evaluation and transfer meter
- **Questionnaire** for all participants - flowrates, method, uncertainties etc.
- Detailed **Technical Protocol**
- **Type of comparison** – recalibration at pilot lab
- Detailed protocol of each laboratory, including data reporting is essential
- Definition of
  - ⇒ Final publication
  - ⇒ “Worst-case-szenario”, what happened when…
  - ⇒ Costs, time schedule
  - ⇒ Evaluation criteria

Example - Missing evaluation criteria

- **Evaluation criteria and analysis procedures are not specified** in advance

  e.g. E_N-criteria = 1,00 or E_N = 1,20

  how to consider the uncertainty of the transfer meter

  => this do always leads to discussion

  => a clear definition of the rules makes the things much easier!

- **Recommended evaluation criteria (by WGFF / BIPM)**

  => Chi-squared test

  => using E_N-values 1,20 (= warning level) and 1,00

  => verification of conclusive calibrations (including transfer meter) u_{comp}/u_{base}

Reliability and validity of the laboratory

Suitability of transfer meter and calibrations

Example - A to complex calibration program

… like practiced in a supplementary comparison COOMET.M.FF-S2

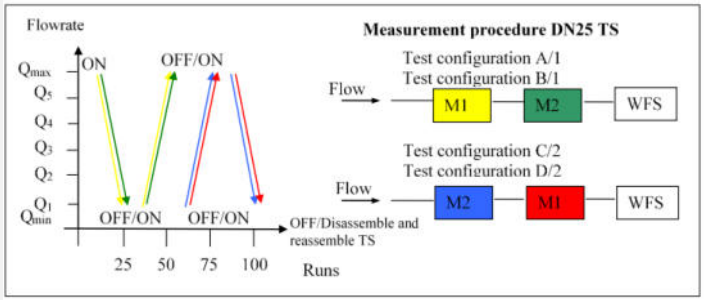


Fig. 2 Measurement procedure A1/B1and C2/D2 for DN25 transfer standards

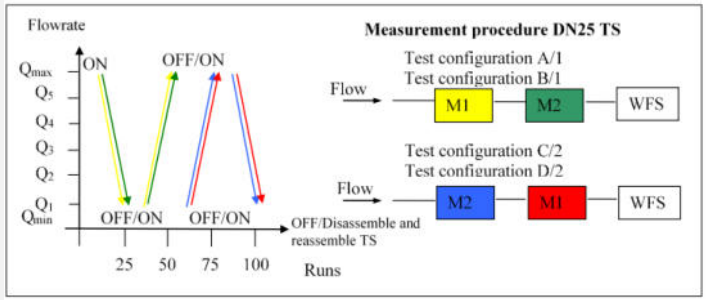


Fig. 2 Measurement procedure A1/B1and C2/D2 for DN25 transfer standards

…this was actually a meter characterisation

=> To complex for calibration and much to complex for data evaluation

=> Finally, which data should be used for comparison?

Suggestion for a calibration program

=> as simple as possible (e.g. no changes in setup)

=> at least 5 calibrations per flowrate, max. 1 x upward and 1 x downward

Search for a suitable transfer meter

- **Basically:**

  the lower the laboratory uncertainty, the better the transfer meter must be

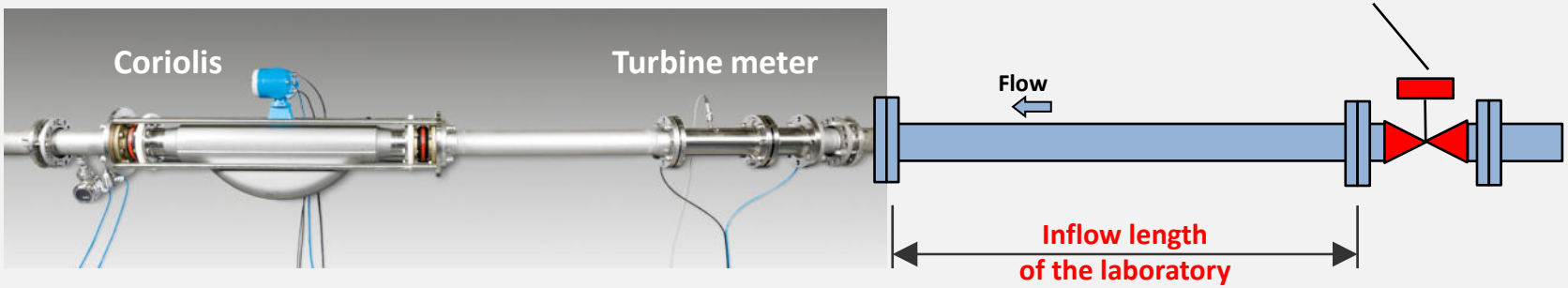
  ➔ uncertainty (laboratory) ≥ $\frac{\text{uncertainty (Meter)}}{2}$

$$u^2_{Gerät} = u^2_{Drift} + u^2_{Temp} + u^2_{Druck} + u^2_{Reprod} + u^2_{Hysterese} + u^2_{Autozero} + u^2_{Einlaufbed.}$$

- Early start of searching for a suitable meter
- For meter selection - consideration of different meter characteristics (Coriolis, turbine meter, MID etc.) and taking account into long term stability of a meter
- Characterisation of the transfer meter - before starting the comparison

Example - Sensitivity of turbine meter to inflow conditions

Key Comparison CCM.FF-K1.2015 - setup
Water flow 30 m³/h - 200 m³/h



Observed effects:

- reported inflow lengths of participated labs: 2,5 m … 15,0 m
- reported differences in meter error to PTB data: up to 0,25 %
- lab investigations at PTB **(after finishing of comparison)**
  => detection of significant inflow sensitivity (up to +/- 0,17 %)

➔ **Turbine meter was not suitable for the confirmation of lab uncertainties**

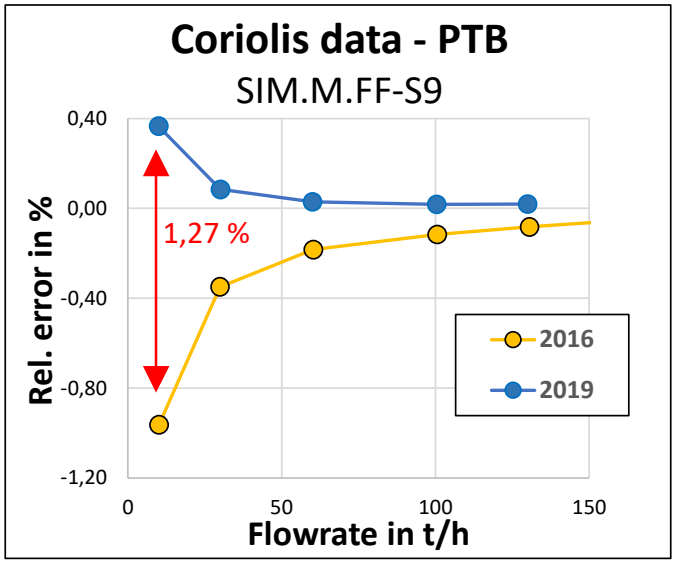
Example - Autozero effect of Coriolis meter

Supplementary Comparison SIM.M.FF-S9
Water flow 10 t/h - 130 t/h
Coriolis meter as a transfer standard

Observed effects:

- strong meter drift of up to 1,27 %
- interpreted as instability of auto zero

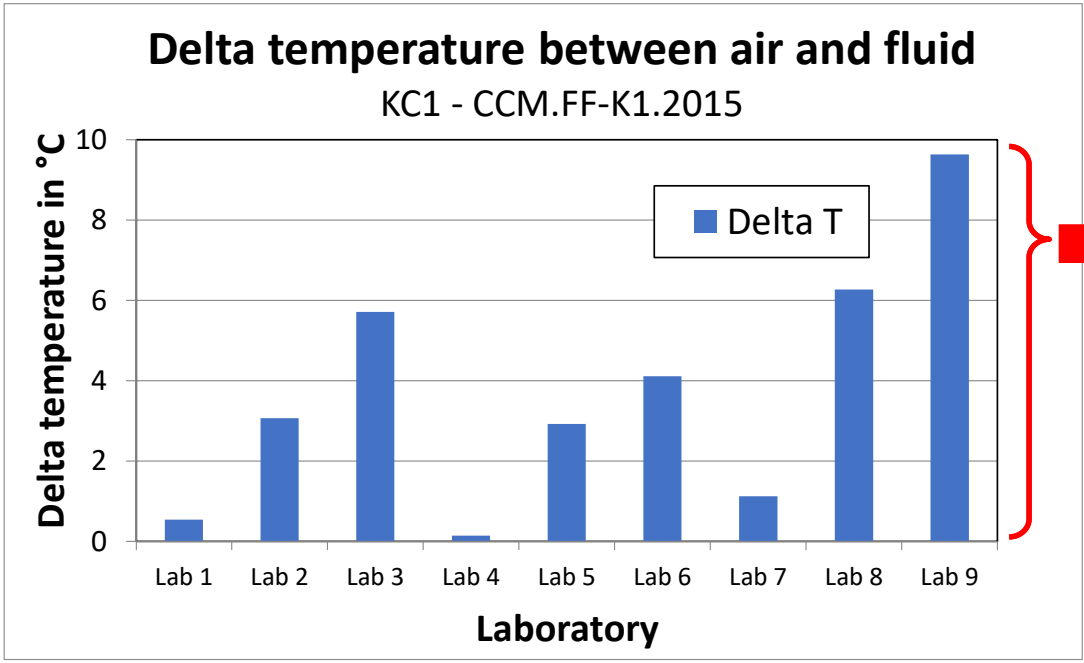
➔ **Coriolis meter was not suitable for a confirmation of lab uncertainties**



➔ **Solution: Coriolis data were corrected for pilot labs => “zero missetting value”**

Example - Ambient conditions and transfer meter

Motivation: strong discussions during comparisons => influence of ambient conditions to meter uncertainties



Example:

Comparison KC1 – CCM.FF-K1.2015

Differences between fluid and air temperature up to 9,7 K

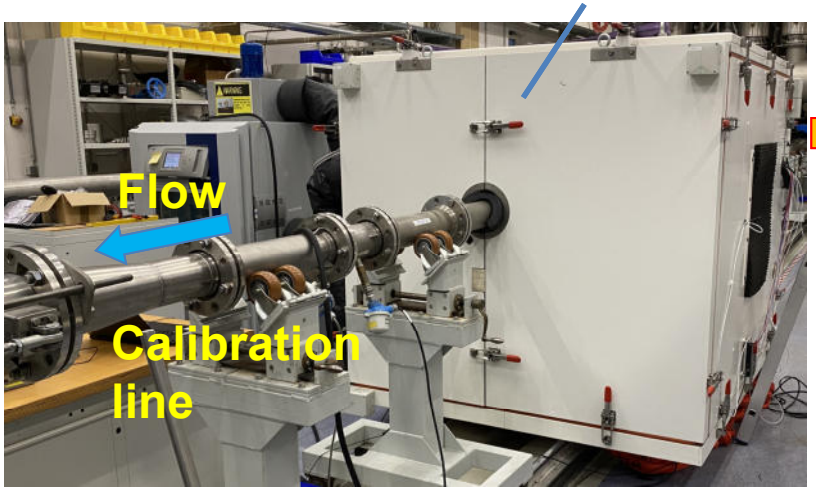
? Cause for differences in meter calibration ?

Example - Ambient conditions and transfer meter

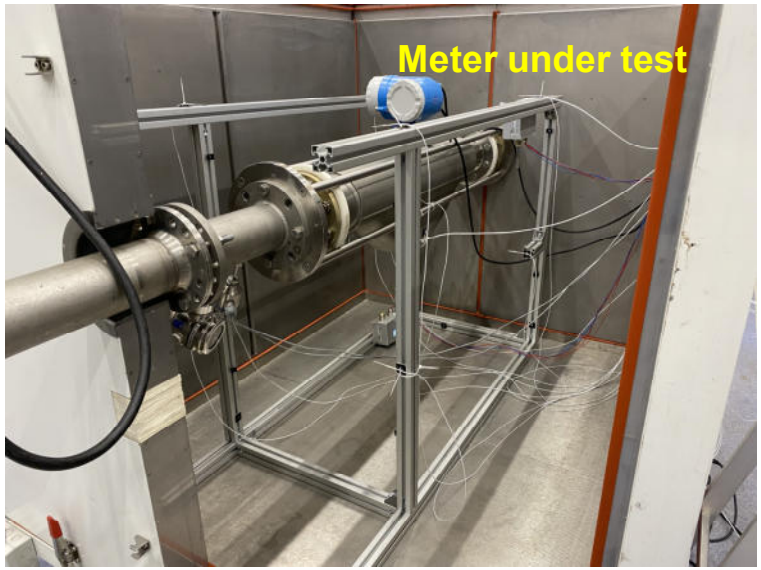
Motivation: strong discussions during comparisons => influence of ambient conditions to meter uncertainties

Tests at PTB – calibration of transfer meter under different ambient conditions
(temperature and humidity)

Climate chamber (closed)

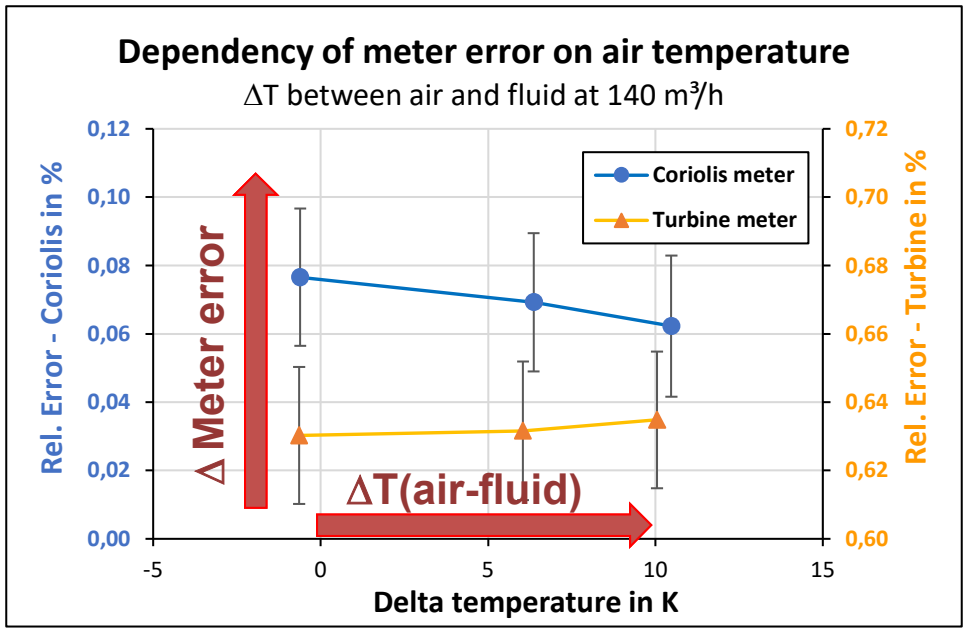


Inside of the Climate chamber



Example - Ambient conditions and transfer meter

Example: Comparison KC1 – CCM.FF-K1.2015



If the fluid and air temperature differs of up to 11 K

not clear effects were found in meter error, but a tendency

changings in meter error

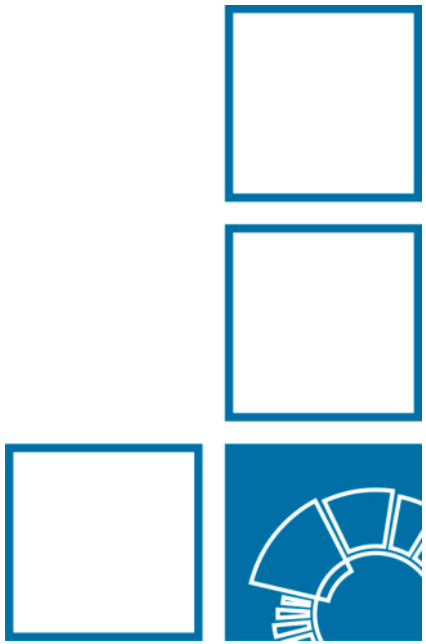
Turbine meter	Coriolis
< 0,005 %	< 0,015 %

Preliminary results

Thanks to: Dzulfikr Islami

Summary

- A comparison needs time
- But, take the time you need – e.g. for meter selection and characterisation, Technical Protocol
- Pilot lab should be involved in any step of the comparison
- Be open for new technical and analysis approaches



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