XXIII IMEKO World Congress “Measurement: sparking tomorrow’s smart revolution”
August 30 - September 3, 2021, Yokohama, Japan

Necessity of Common Data Format for Curves of Instrumented Indentation Testing (IIT) and Review of Independent Analysis Program tangentGo

K. Miyahara (National Institute for Materials Science, Japan)

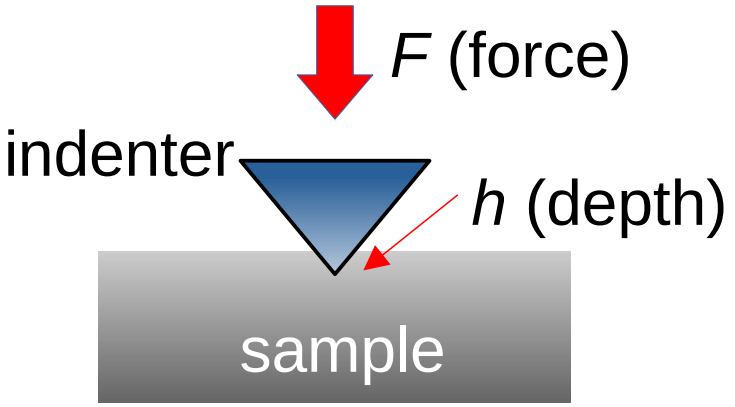
E-mail: MIYAHARA.Kensuke@nims.go.jp

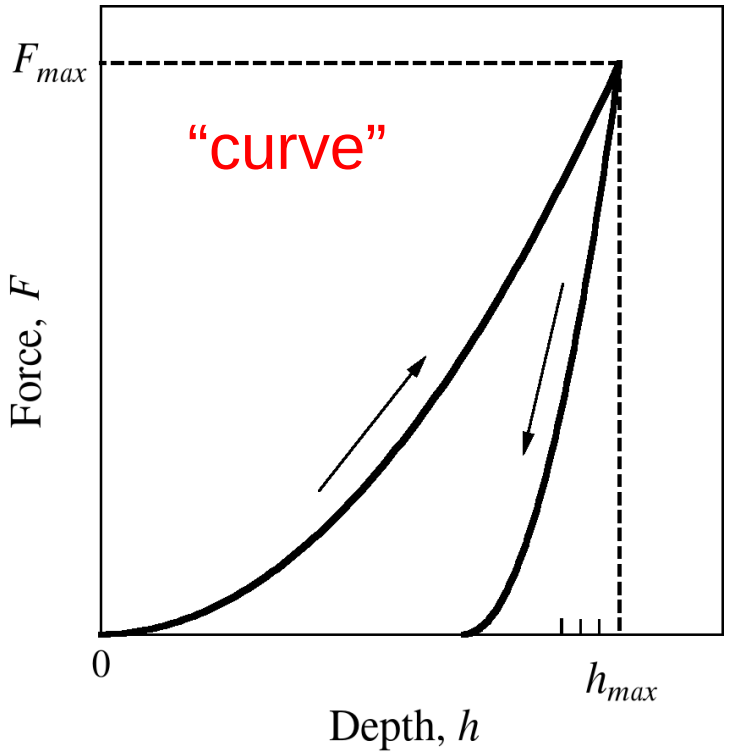
T. Yamamoto (Yamamoto Scientific Tool Laboratory, Japan)

Today's talk

Point: Common data format is necessary in IIT.

IIT (Instrumented Indentation Testing)





Index

1. Background
2. Data flow in IIT – *reason for common data format*
3. Analysis – *example of analysis program, "tangentGo"*
4. Conclusion

1. Background

Instrumented Indentation Testing (IIT) - ISO14577

- Young's modulus (*E*)
- Hardness (HM, H_{IT})
- other parameters

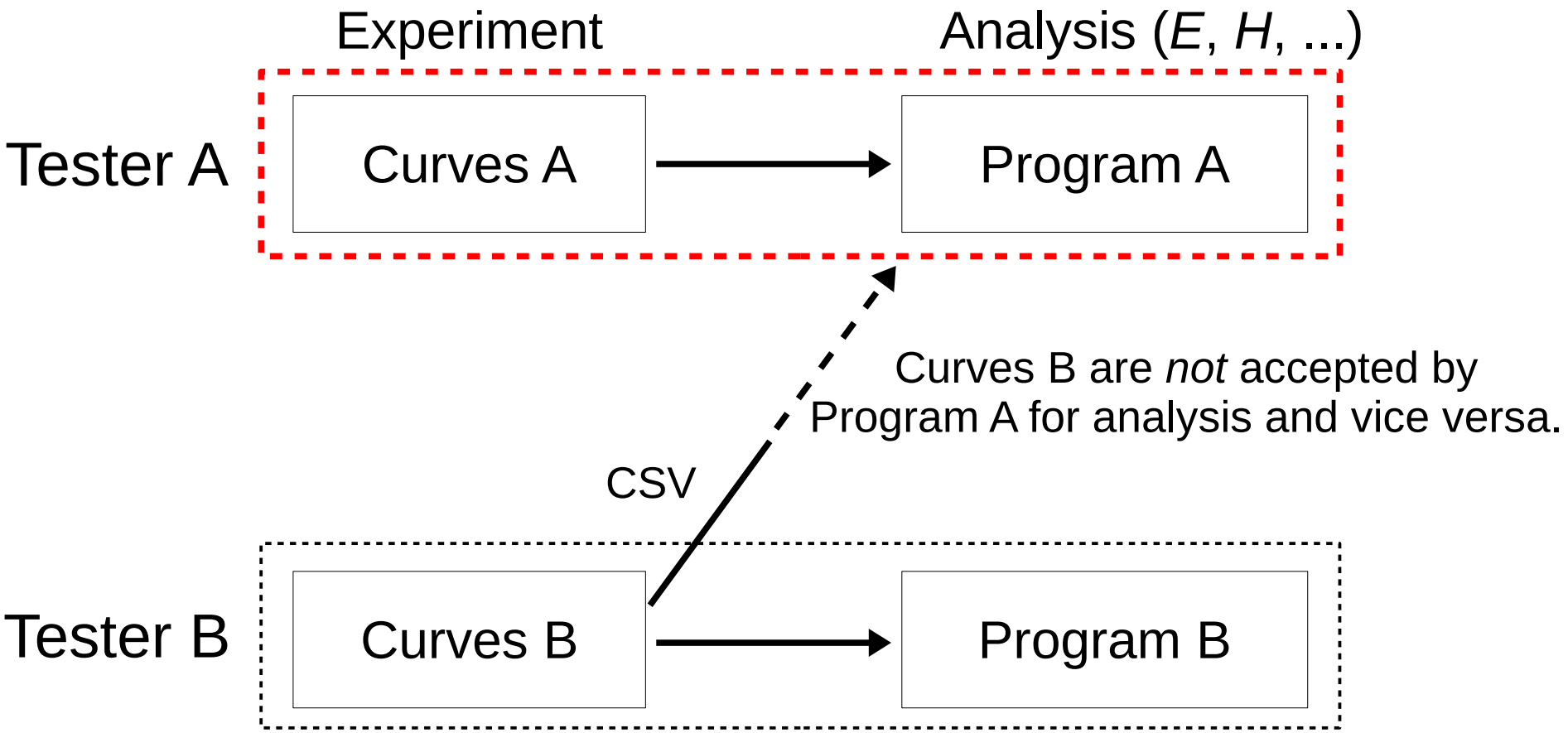
However, some IIT users have concerns:
"Output is sometimes *not good*"

Possible reasons:

- inappropriate use of testers
- poor experimental conditions
- etc.
- analysis process (often *underestimated*)

2. Data flow in IIT

The current data flow is *closed* in each tester.

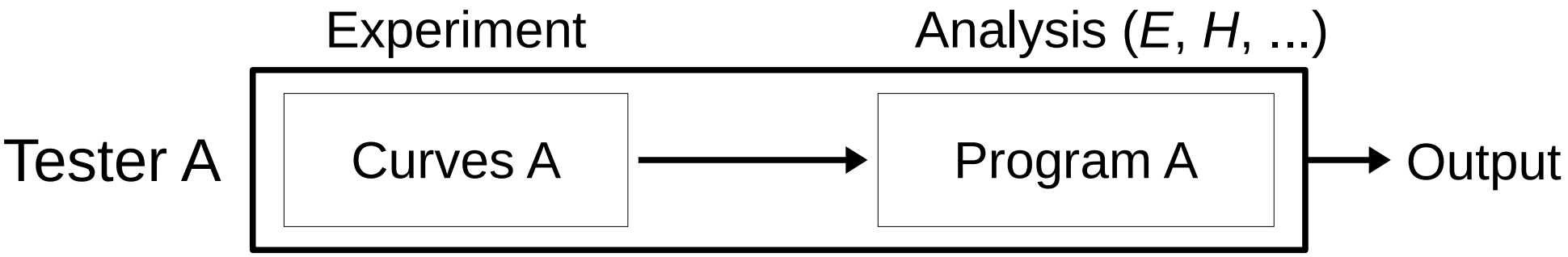


(a) Current data flow in IIT.

Fig. 1

2. Data flow in IIT

A closed data flow is like a black box.



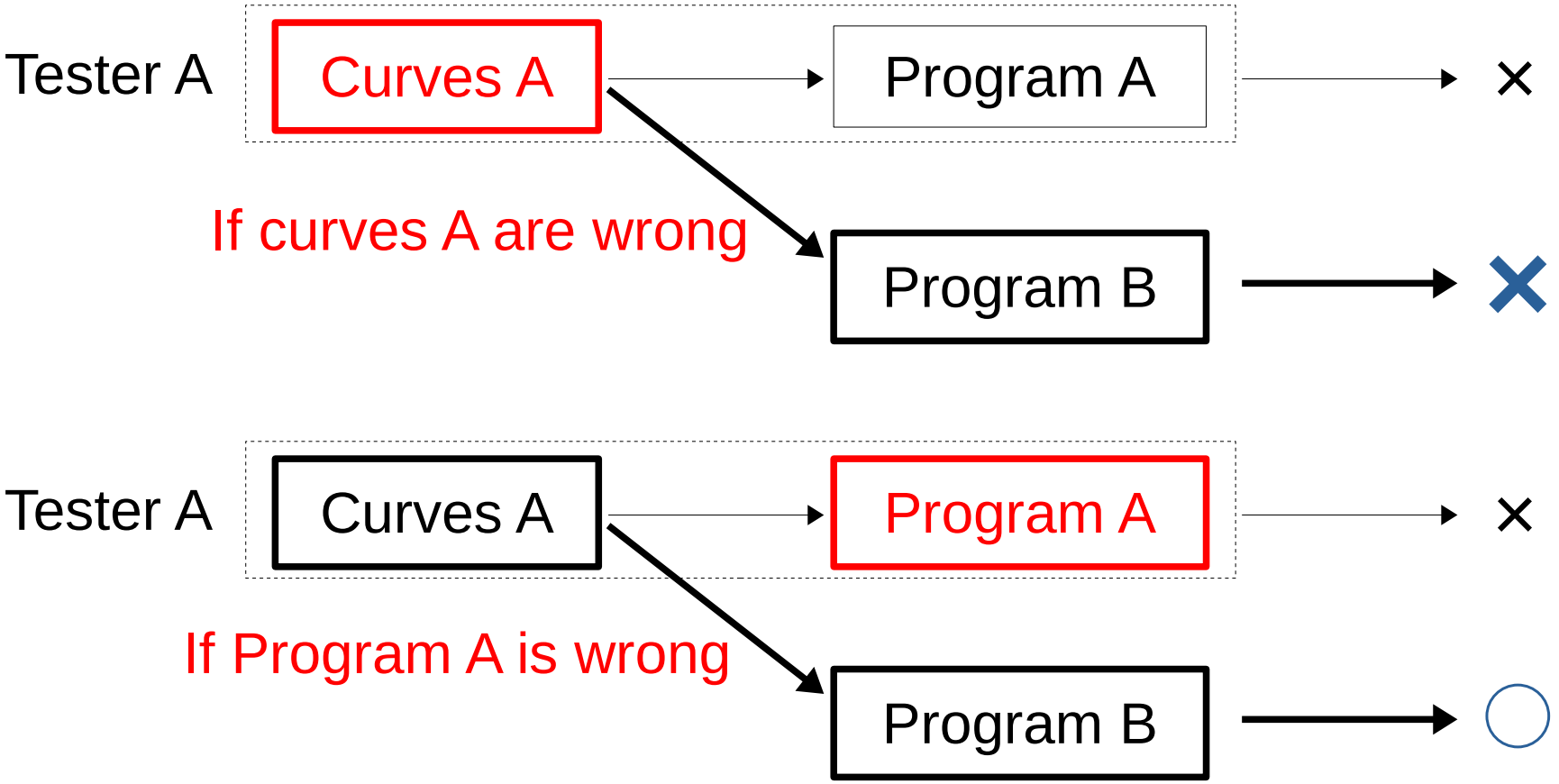
If the output is not good, It is difficult to tell which is wrong,

Experiment (Curves) or Analysis (Program)?

∵ We don't have a way to check their validity independently.

2. Data flow in IIT

If curves can be processed by other programs, we have more information.



This cross-checking is quite useful to spot a problem.

With a common data format, we can easily exchange curves between testers.

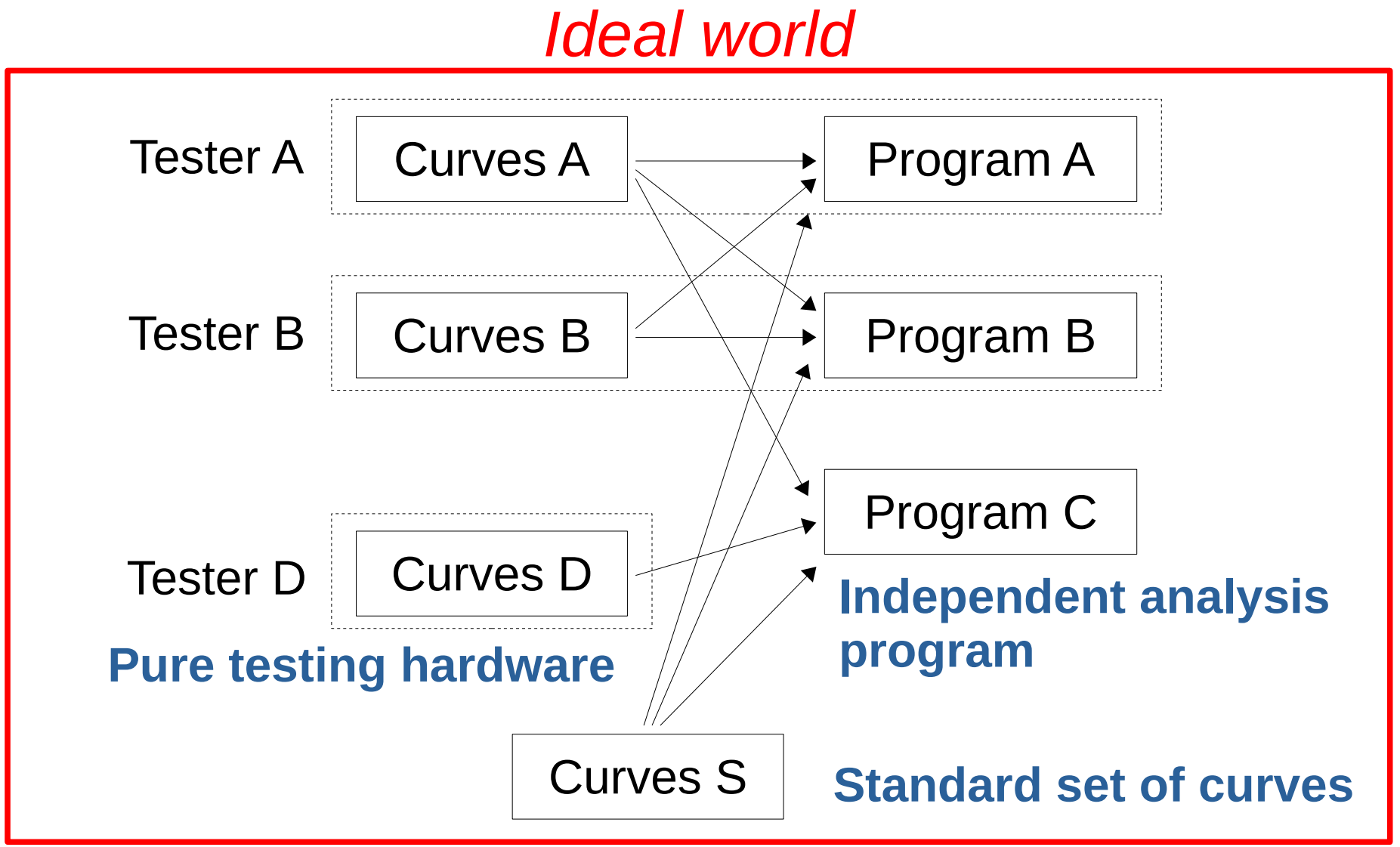


Fig. 1

Two steps for a common data format

1. Define a format

- column positions of depth (*h*) and force (*F*)
- unit
- various experimental conditions
- etc.

A more versatile format than CSV such as XML, is recommended.

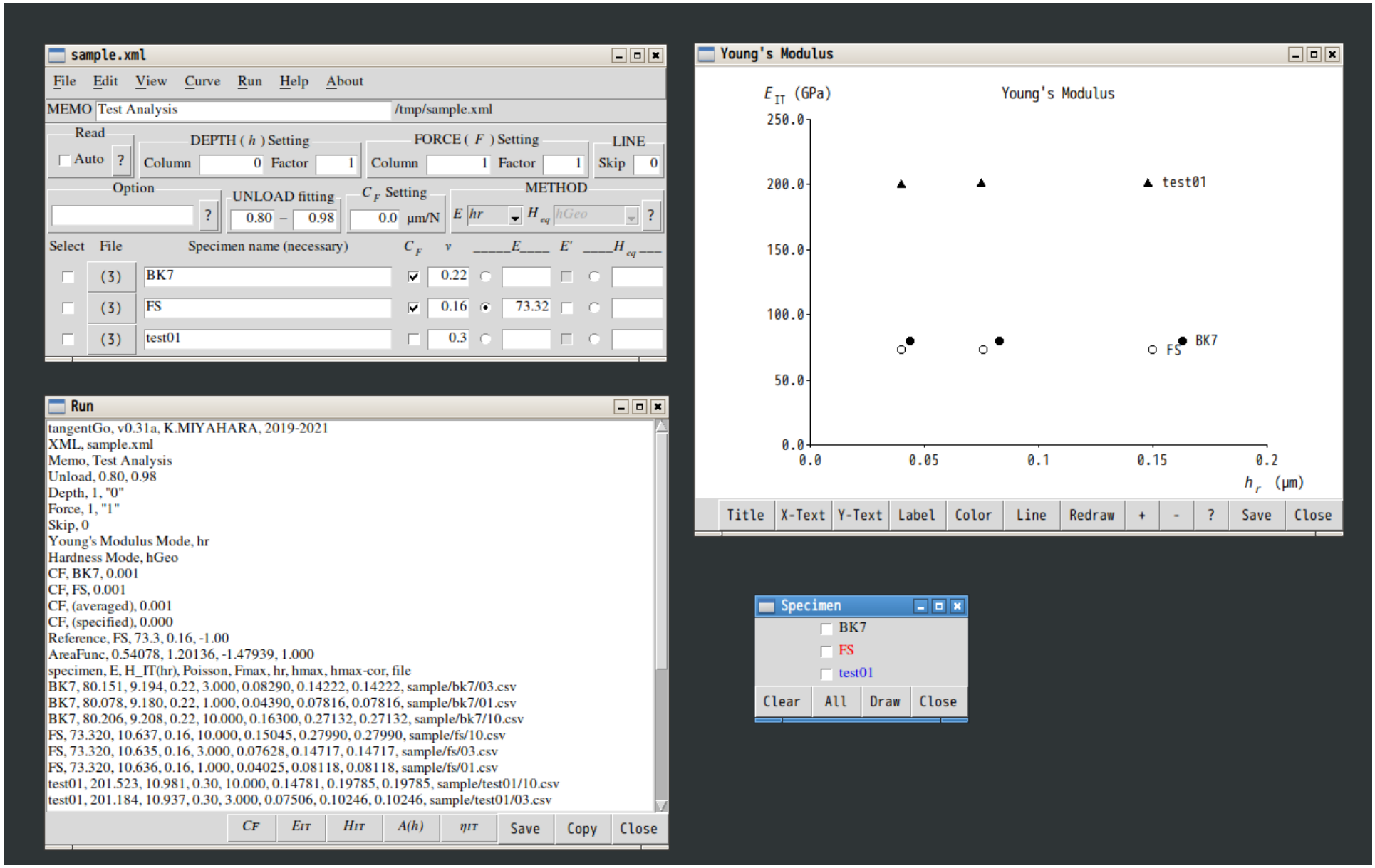
2. Each tester should support the format

- export curves (out)
- accept curves for analysis program (in)

With a common data format, we can discuss analysis process more easily and intensively.

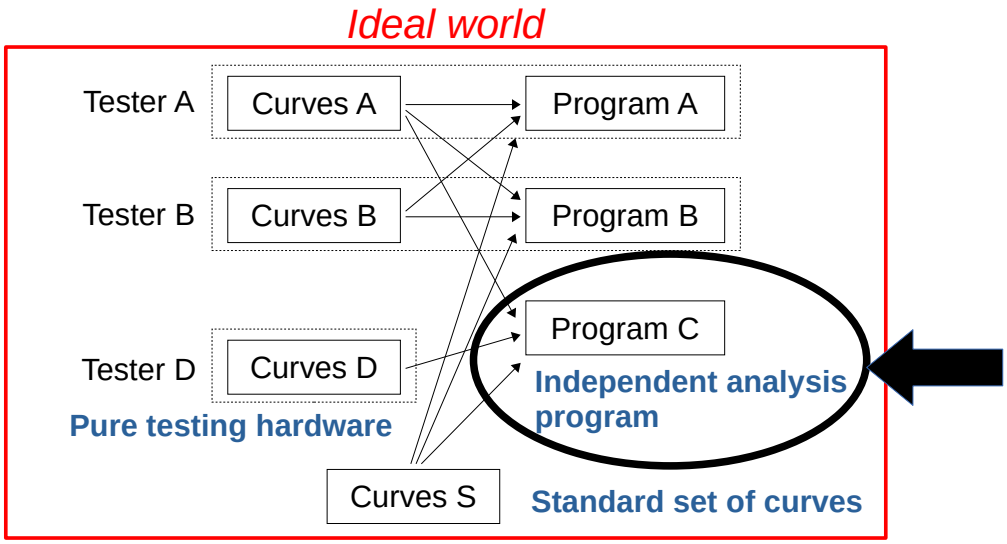
3. Analysis

tangentGo, analysis program (by Miyahara)



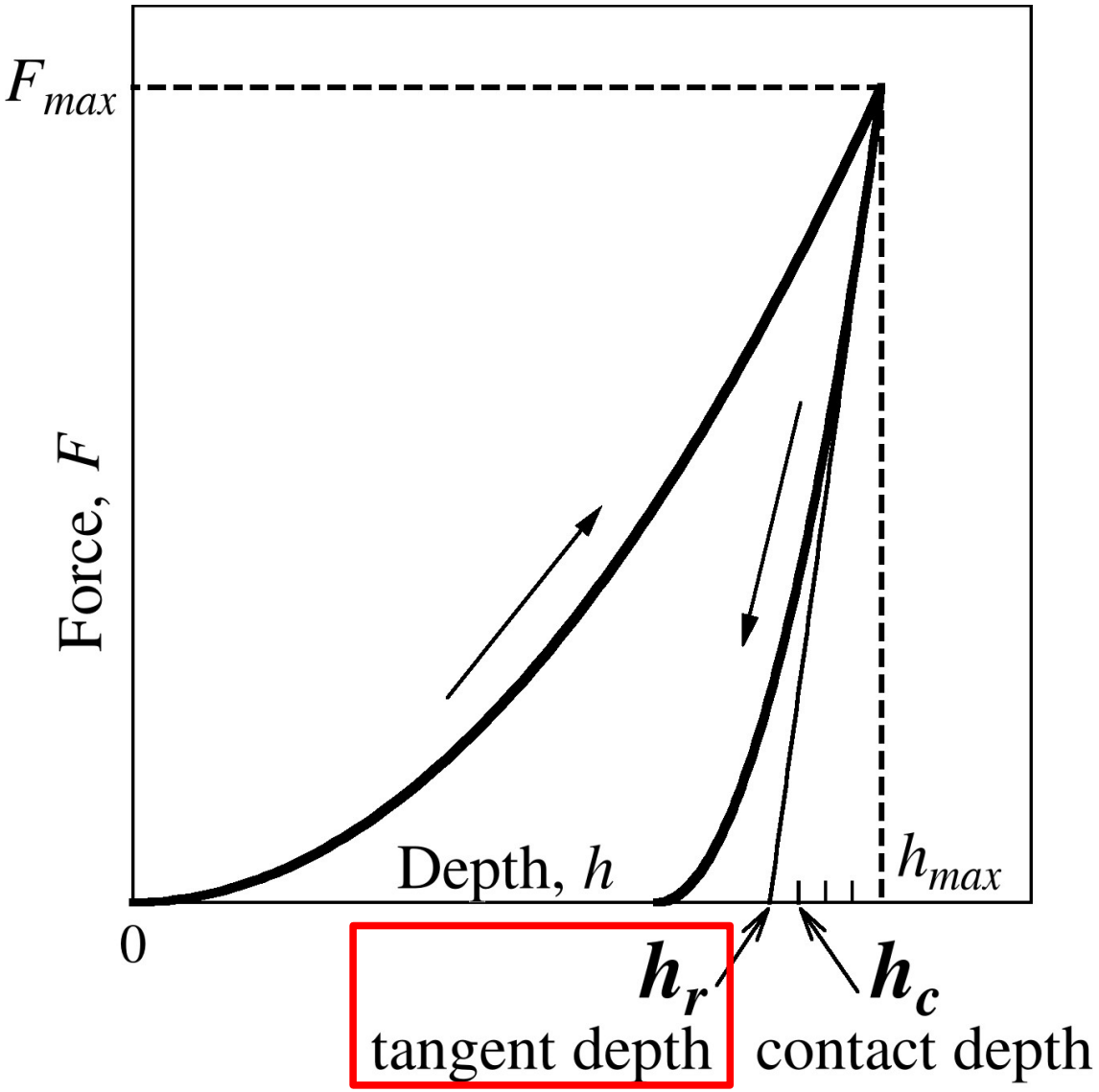
Introduction of tangentGo

- Independent analysis program for IIT



- Calculate Young's modulus and hardness from curves
- Several testers supported [needs common data format]
- GUI supported
- Windows/macOS/Linux
- Free to download and use
- Official website: https://3zip.net/t/en.html

“tangent depth analysis” in tangentGo



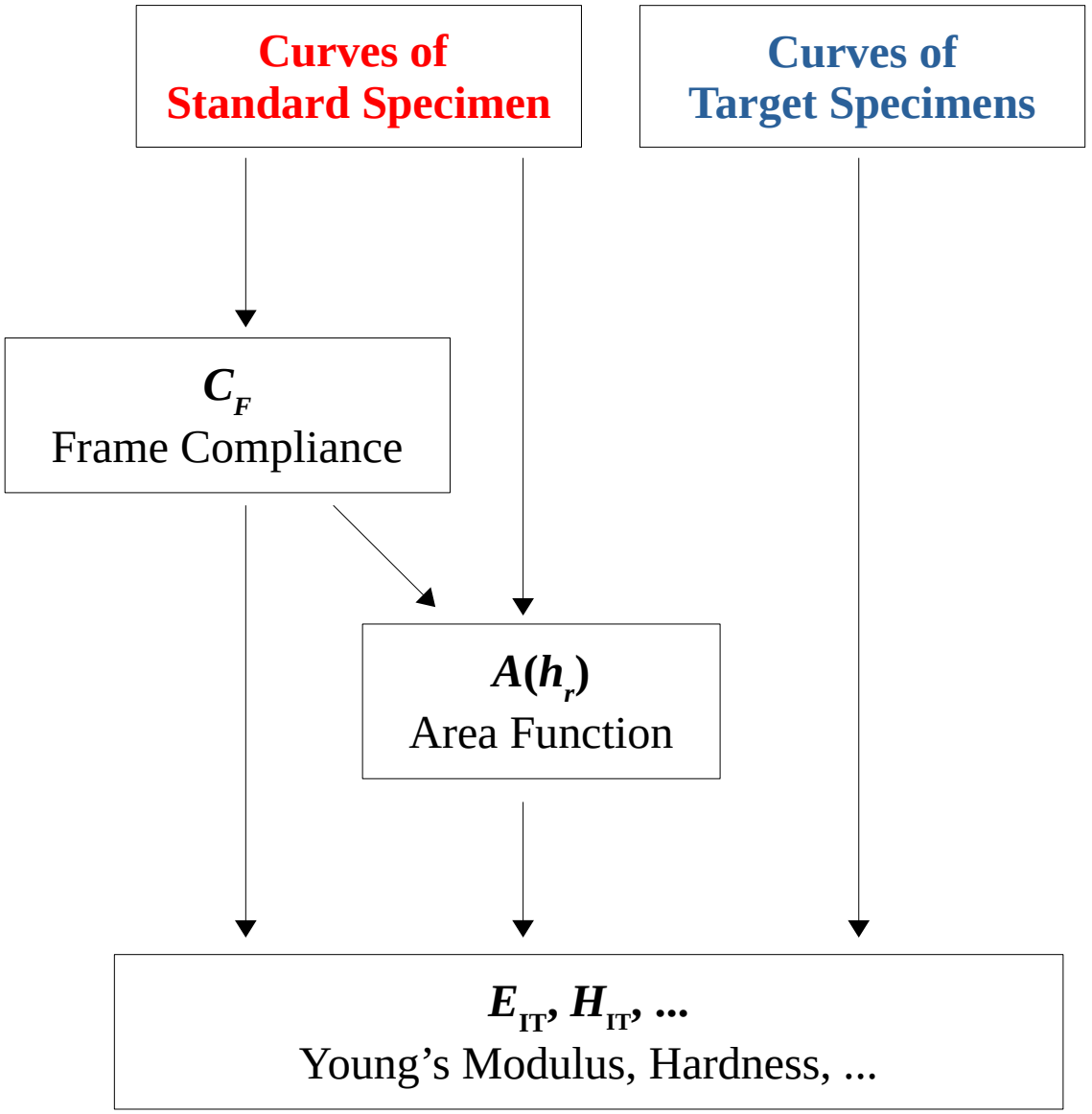
$$h_c = h_{max} - 0.75\,(h_{max} - h_r)$$

- Proposed by Ishibashi et al.
- Analysis engine of tangentGo
- Output: *E*, *H*, etc.
- Uses a fundamental equation

$$E_r = \frac{\sqrt{\pi}}{2} \cdot \frac{S}{\sqrt{A}}$$

- The tangent depth h_r, is used instead of the contact depth h_c.
- It is confirmed that appropriate Young's moduli of 12 specimens are obtained with two different IIT testers [4-6].

tangent depth analysis (simplified flow)

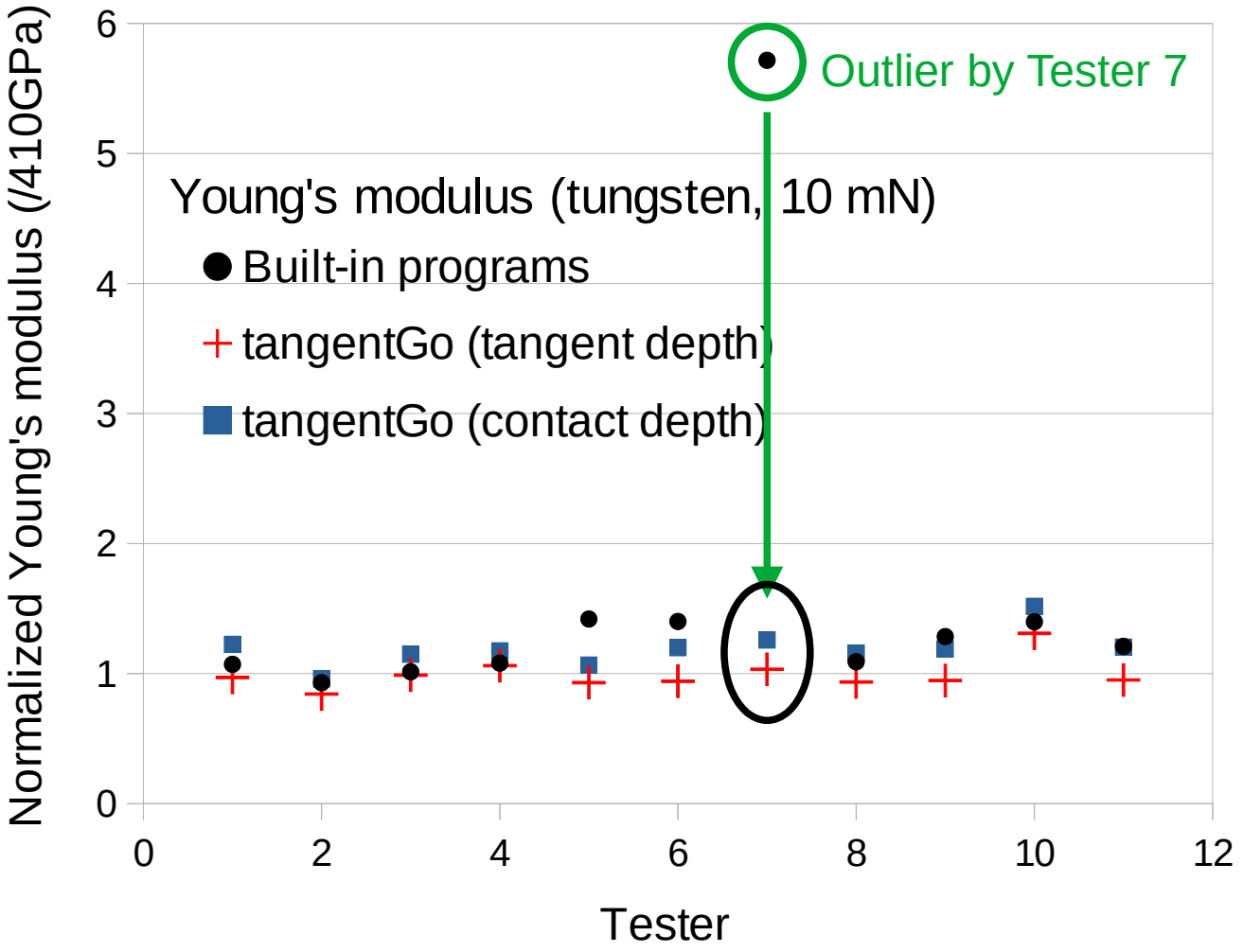


- No recursive loop
- Please refer original papers [4-6] for details
- Summary available in tangentGo website

[4] T. Ishibashi et al., *J. Mater. Test. Res.* Vol. 61, No. 2, pp. 60-67, 2016.
[5] T. Ishibashi et al., *J. Mater. Test. Res.* Vol. 62, No. 2, pp. 68-77, 2017.
[6] T. Ishibashi et al., *J. Mater. Test. Res.* Vol. 62, No. 3, pp. 164-172, 2017.

Example of tangentGo and tangent depth analysis

- Tested with 11 different IIT testers
- the *same* experimental curves are analyzed by each built-in program and tangentGo (tangent depth and contact depth)



- No outlier by tangentGo (Curves are OK)
- Variation is smaller by tangentGo.
- tangentGo (tangent depth) is better.
- Analysis programs can significantly affect the results.

Conclusions

1. The necessity of a common data format is discussed with data flow in IIT.

2. An independent analysis program developed by the author is briefly introduced.

tangentGo

3. In the examples, it is shown that analysis programs can significantly affect the output results.

4. A common data format is necessary to discuss analysis process in IIT.