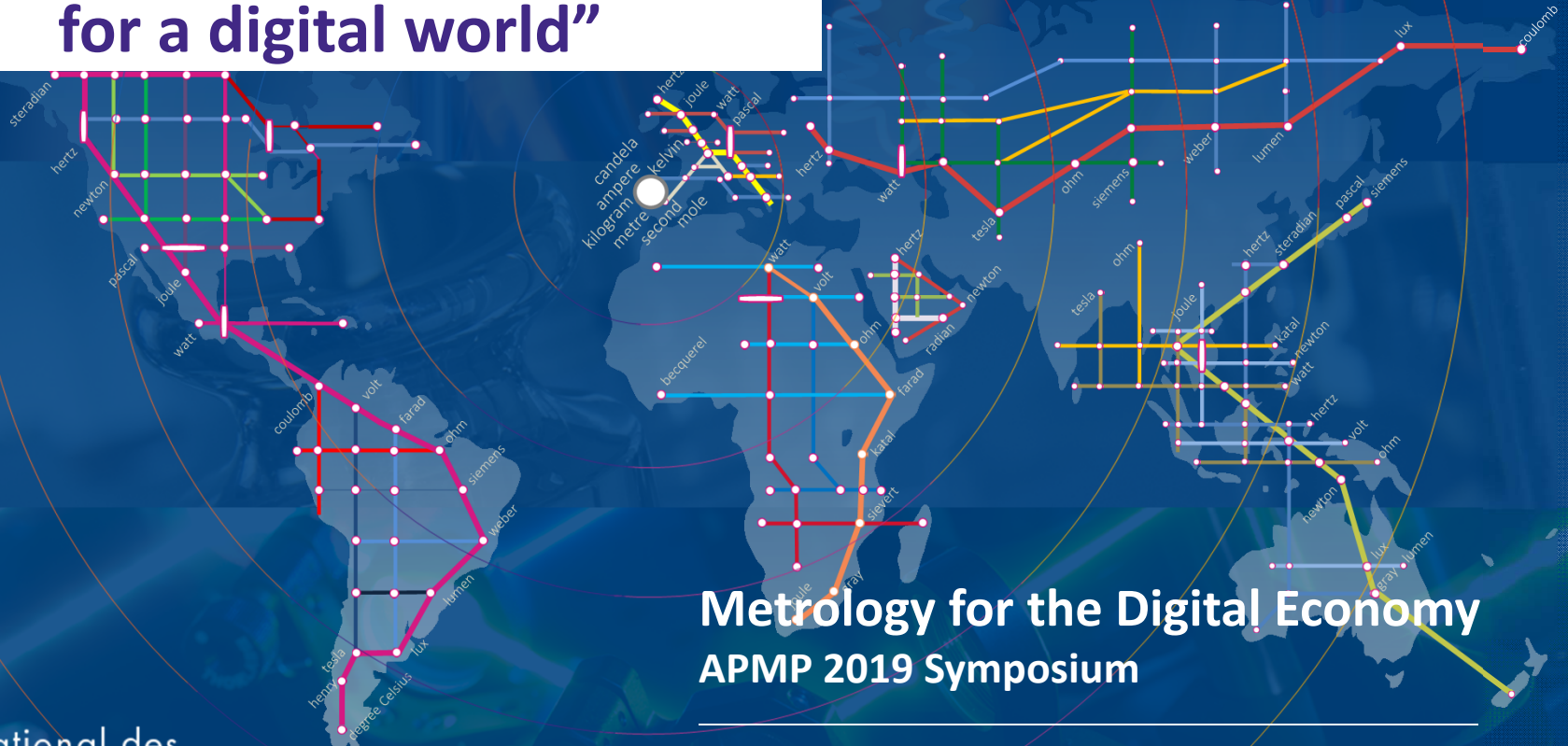


“Comparable measurements for a digital world”

Metrology for the Digital Economy APMP 2019 Symposium

Bureau
International des
Poids et
Mesures

Dr Martin Milton
BIPM Director
4 December 2019



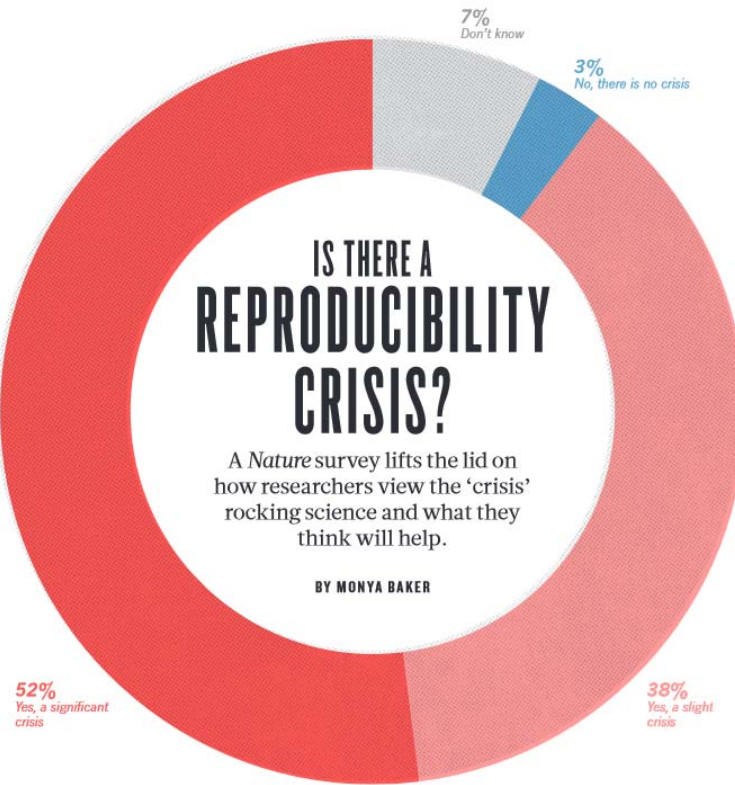
How can metrology support the digital economy?

- Providing trustworthy data
- Supporting open data
- Digital formats for Metrology
- Addressing the “reproducibility crisis”
- Adopting the FAIR principles
- New initiatives by the CIPM

IS THERE A REPRODUCIBILITY CRISIS?

A *Nature* survey lifts the lid on how researchers view the 'crisis' rocking science and what they think will help.

BY MONYA BAKER



1,576
RESEARCHERS SURVEYED

The New York Times

SCIENCE TIMES AT 40

Essay: The Experiments Are Fascinating. But Nobody Can Repeat Them.

Science is mired in a “replication” crisis. Fixing it will not be easy.

52%
Yes, a significant
crisis

3%
No, there is no crisis

38%
Yes, a slight
crisis

1,576
RESEARCHERS SURVEYED

The New York Times

7%

3%
No, there is no crisis

SCIENCE TIMES AT 40

Essay: The Experiments Are Fascinating. But Nobody Can Repeat Them

Science is mired in a “replication” crisis.
It’s not as easy as it used to be.

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Yes, a significant
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The
Economist

Topics ▾

Current edition

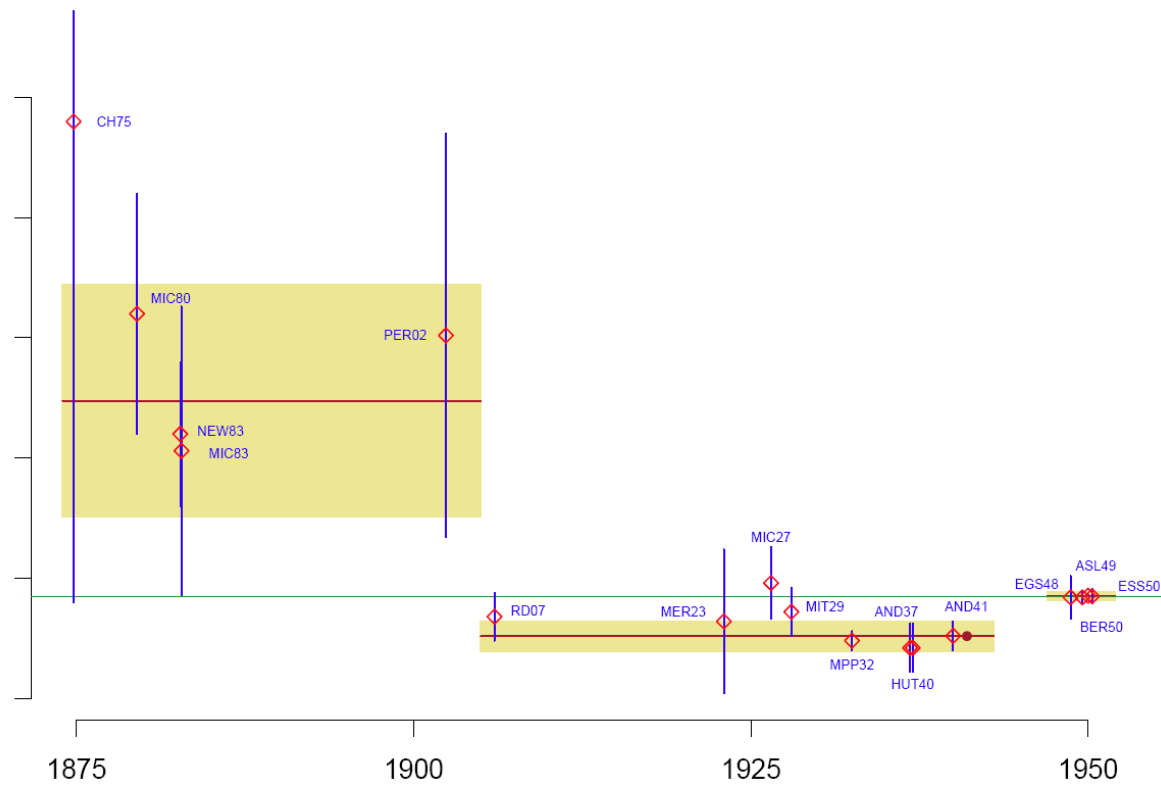
More ▾

Trouble at the lab

Scientists like to think of science as self-correcting. To an alarming degree, it is not

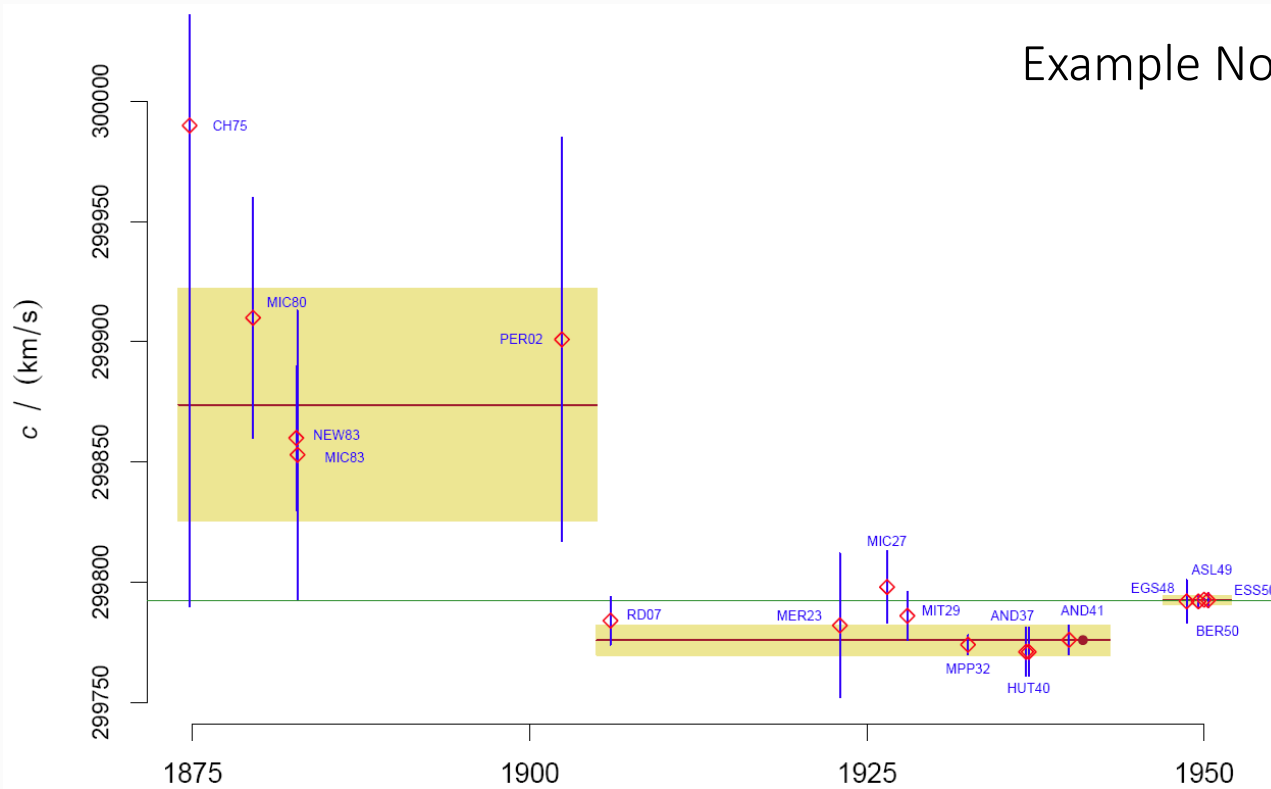


Trustworthy data ?

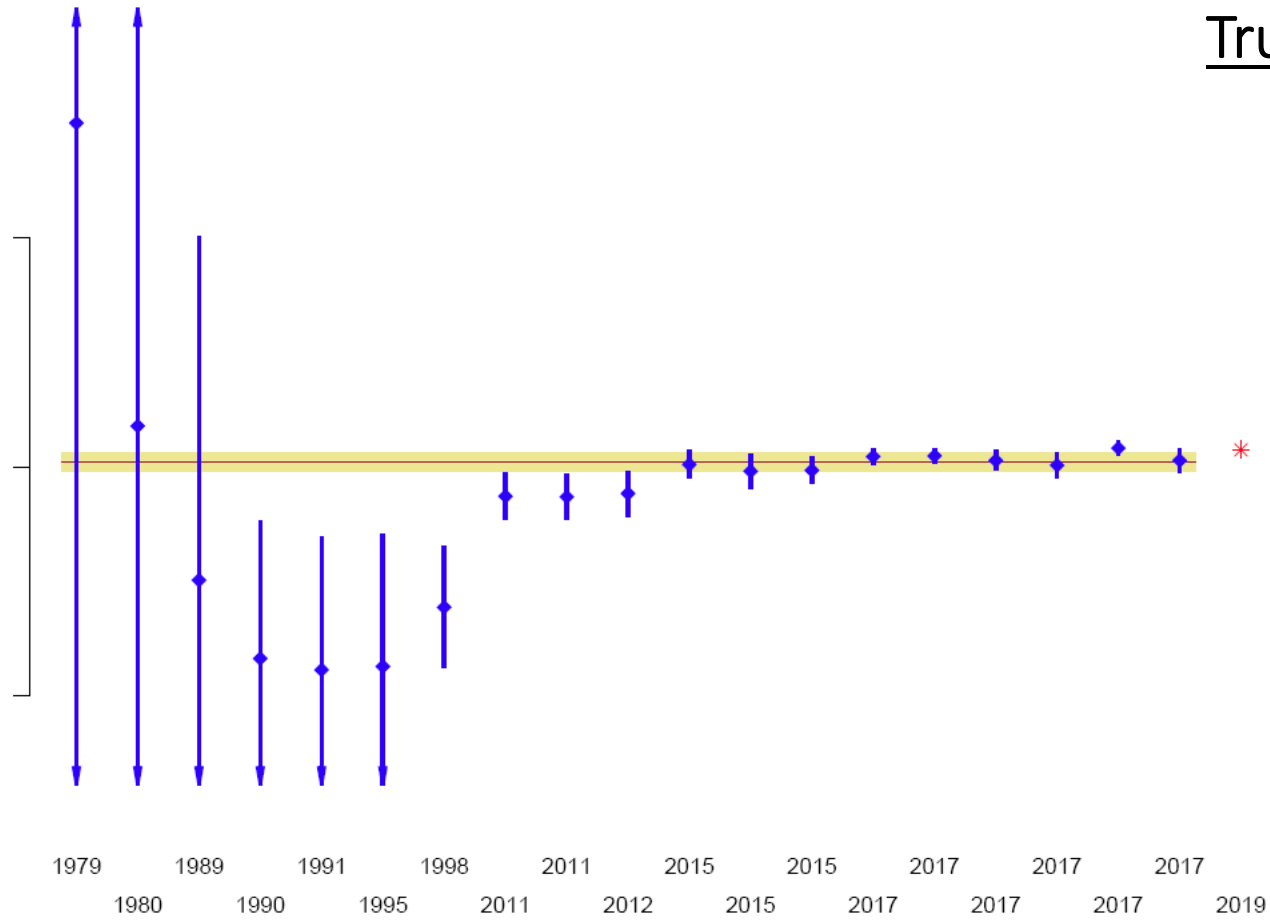


Trustworthy data ?

Example No 1 - The speed of light , c

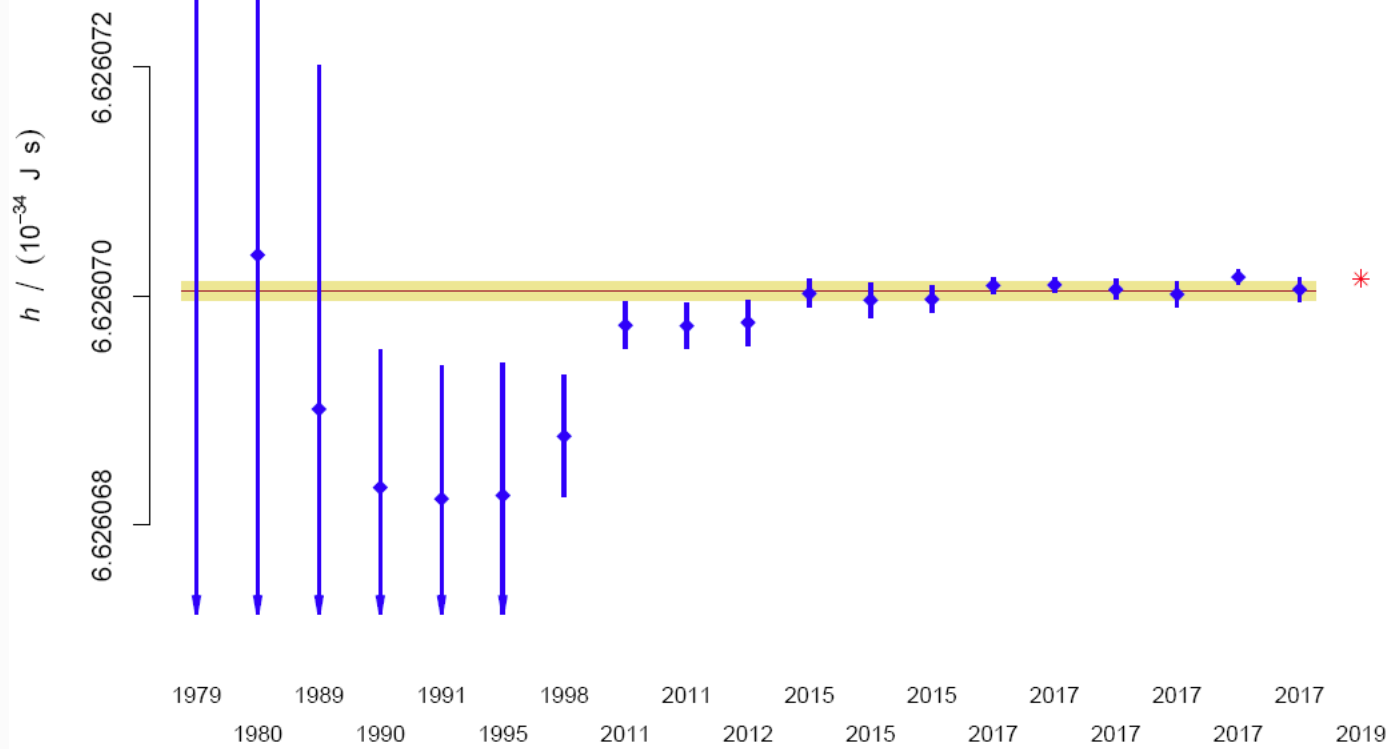


Trustworthy data ?

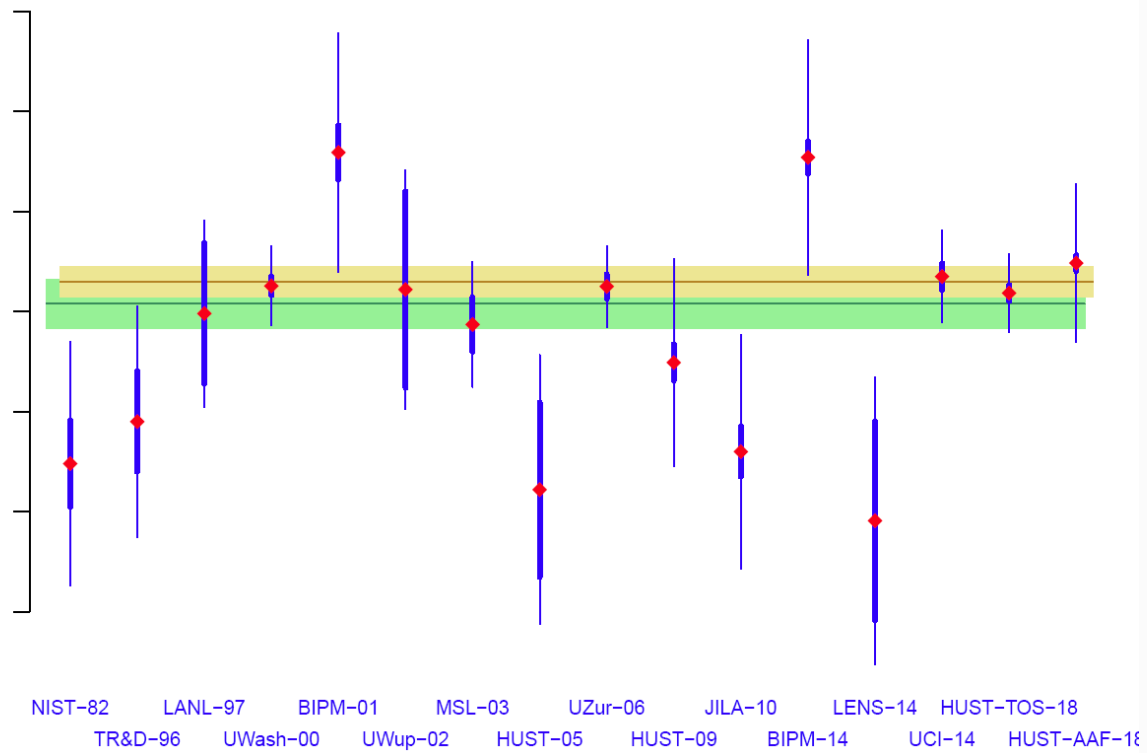


Trustworthy data ?

Example No 2 - The Planck constant , h

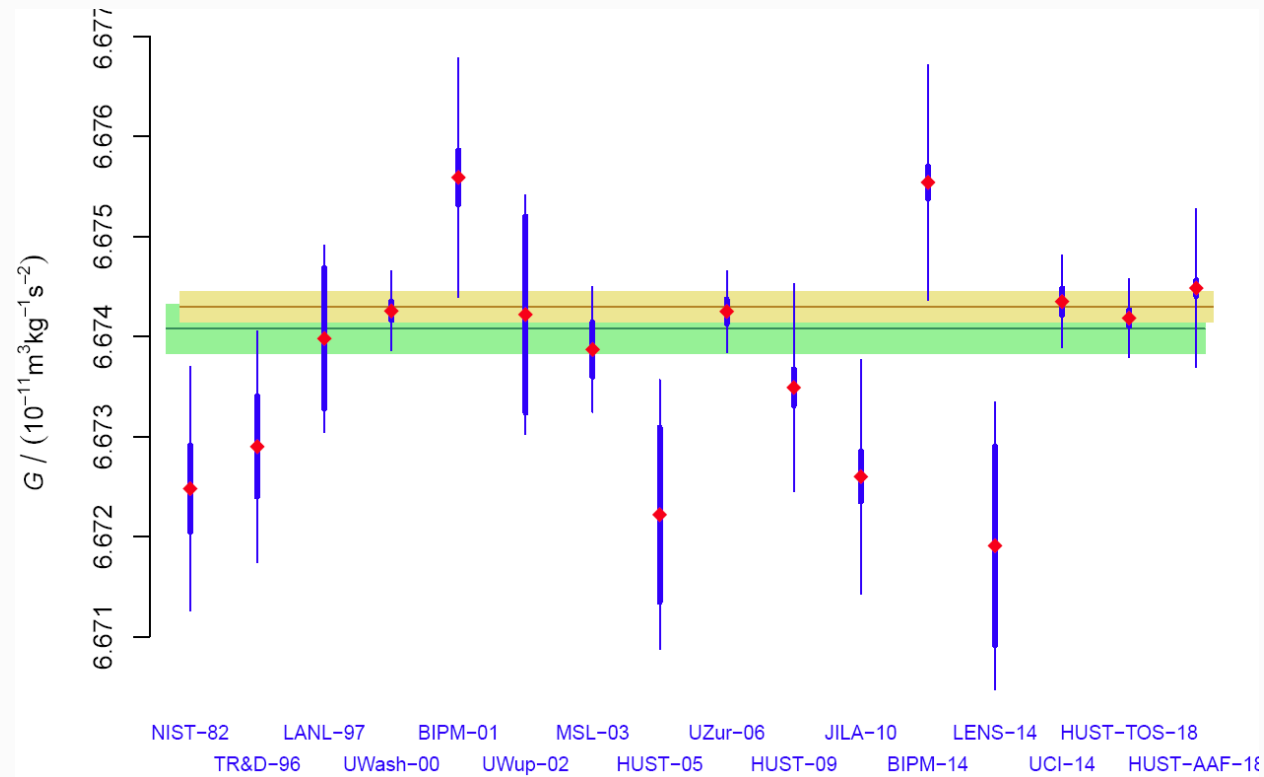


Trustworthy data ?



Trustworthy data ?

Example No 3 - The gravitational constant , G

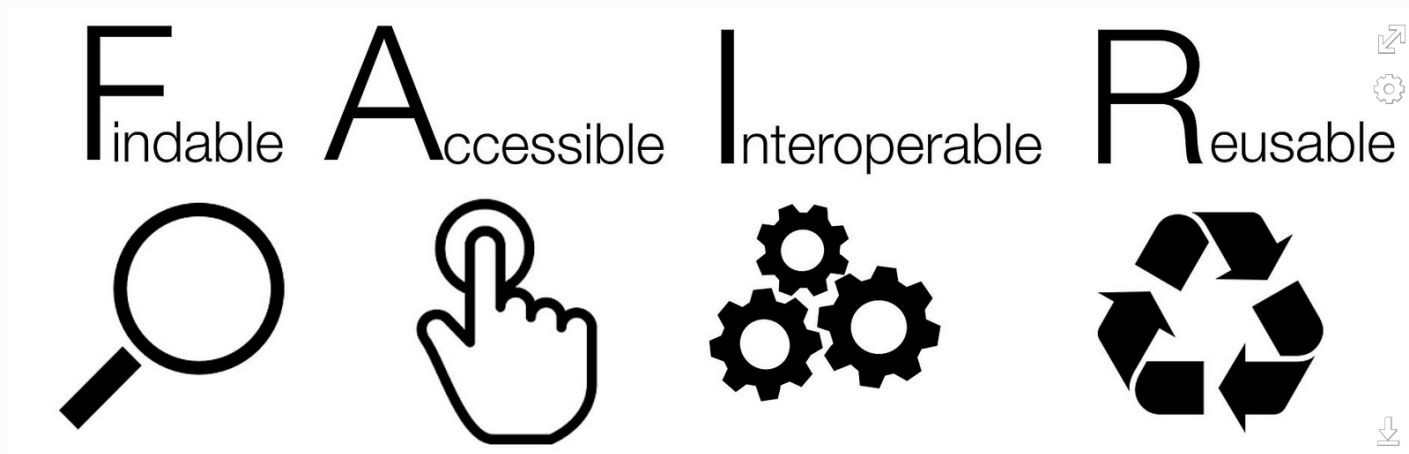


When can we be confident in data?

- We can only be confident ...if we can fully trust it as the product of the independent, rigorous application of multiple, essentially different methods.
- Measurement data with these qualities are **trustworthy** and are a cornerstone of scientific consensus that enables advances in all areas of science and technology.
- The organized practice of measurement science includes principles and practices that — if widely adopted — should ensure that data are trustworthy.
- “Lack of reproducibility is not necessarily bad news; it may herald new discoveries and signal scientific progress”.

Reproducible research and decision making is underpinned by trustworthy data

data management and stewardship



Statement from the [G20 leaders at the 2016 summit in Hangzhou](#)

Data management and stewardship



Data and supplementary materials have sufficiently rich metadata and a unique and persistent identifier.

FINDABLE



Metadata and data are understandable to humans and machines. Data is deposited in a trusted repository.

ACCESSIBLE



Metadata use a formal, accessible, shared, and broadly applicable language for knowledge representation.

INTEROPERABLE



Data and collections have a clear usage licenses and provide accurate information on provenance.

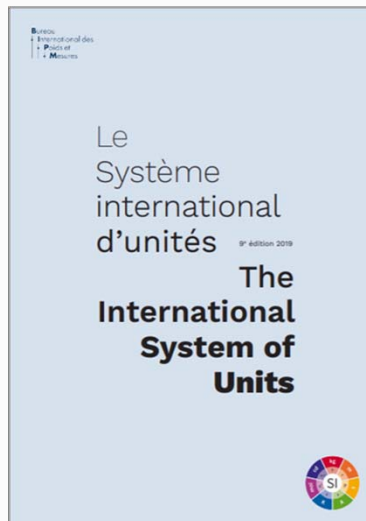
REUSABLE

Applying the FAIR principles?

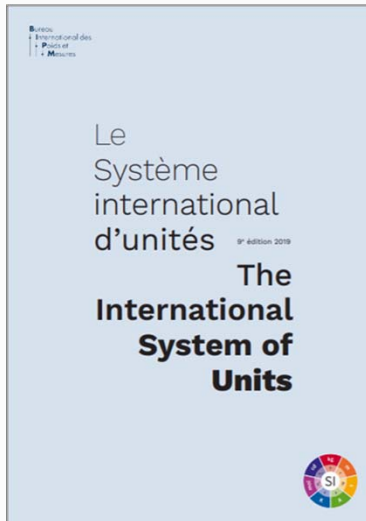


The (Digital) International System of Units (SI)

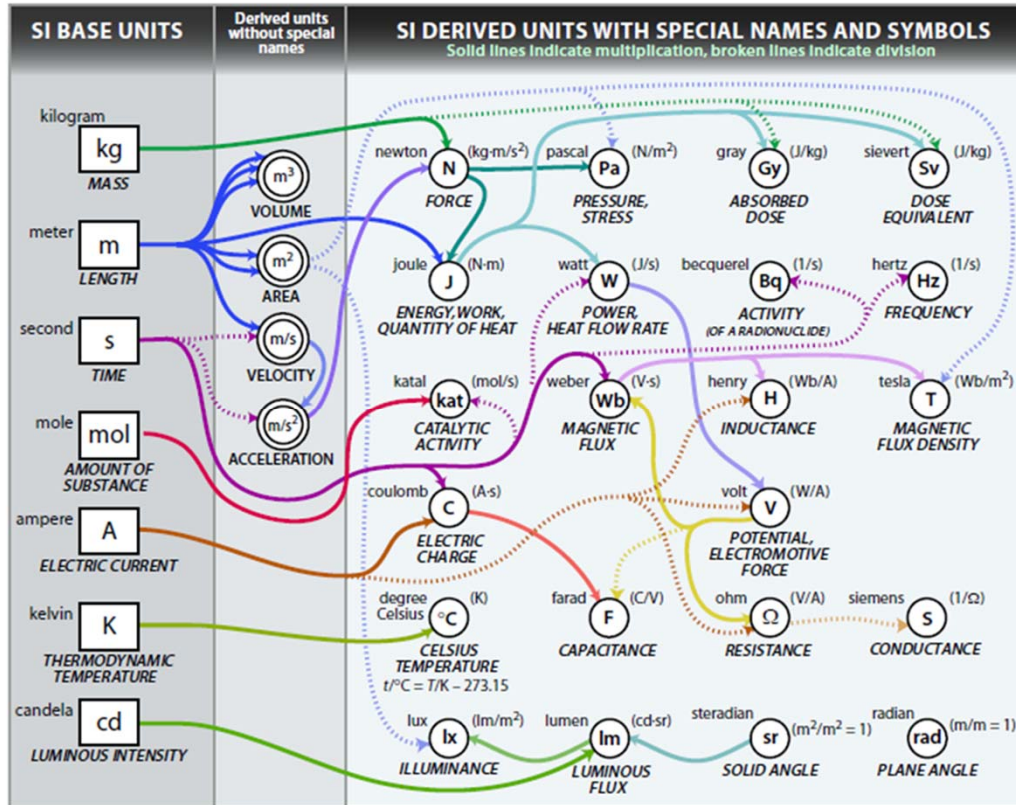
The (Digital) International System of Units (SI)



The (Digital) International System of Units (SI)



www.bipm.org



From NIST -<http://physics.nist.gov/cuu/Units/Sidiagram.html>

Prefixes

FACTOR	NAME	SYMBOL	MULTIPLYING FACTOR
10^{24}	yotta	Y	1 000 000 000 000 000 000 000 000
10^{21}	zetta	Z	1 000 000 000 000 000 000 000
10^{18}	exa	E	1 000 000 000 000 000 000
10^{15}	peta	P	1 000 000 000 000 000
10^{12}	tera	T	1 000 000 000 000
10^9	giga	G	1 000 000 000
10^6	mega	M	1 000 000
10^3	kilo	k	1 000
10^2	hecto	h	100
10^1	deca	da	10
10^0	deci	d	0.1
10^{-1}	centi	c	0.01
10^{-2}	milli	m	0.001
10^{-3}	micro	μ	0.000 001
10^{-6}	nano	n	0.000 000 001
10^{-9}	pico	p	0.000 000 000 001
10^{-12}	femto	f	0.000 000 000 000 001
10^{-15}	atto	a	0.000 000 000 000 000 001
10^{-18}	zepto	z	0.000 000 000 000 000 000 001
10^{-21}	yocto	y	0.000 000 000 000 000 000 000 001

CIPM initiatives to provide Digital Formats for Metrology

The CIPM has launched a **Task Group on the “Digital SI”**

- To enable SI-based digital communication in industry
- To support the digital science and open-science paradigms
- To get metrological services ready for artificial intelligence

Summit meeting on **“Digital communication in the SI”**
BIPM, 22nd and 23rd June 2020

Collaborations with ... other IOs ... experts nominated by NMIs.

“Comparable measurements for a digital world”

The BIPM – an international organization



CGPM – Conférence générale des poids et mesures

Official representatives of Member States.

CIPM – Comité international des poids et mesures

Eighteen individuals of different nationalities elected by the CGPM.

- Ten Consultative Committees
- Three Joint Committees with other International Organisations
- Sub-committees on Strategy, Finance, Pension etc

Scientific and technical secretariat (in Sèvres)

- International coordination and liaison
- Scientific collaboration– laboratories
- Capacity building and knowledge transfer



The Metre Convention was signed in Paris by 17 nations on **20 May 1875**



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IN 1875

17 MEMBER STATES

14 CIPM MEMBERS

DIRECTOR

+ 2 ASSISTANTS



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In 2019

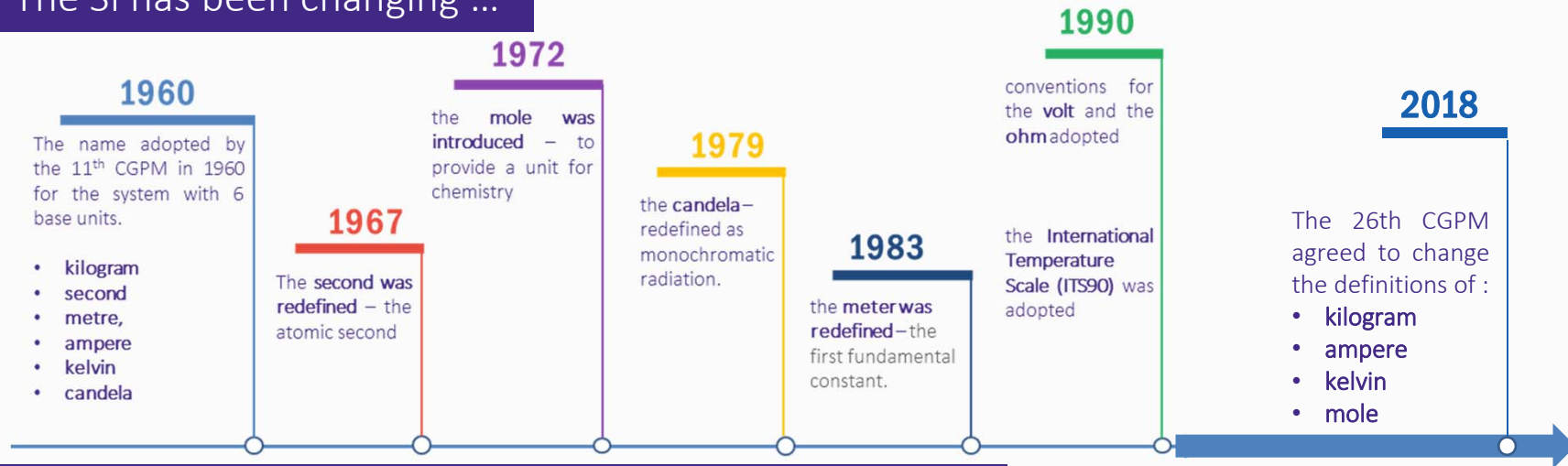
61 Member States

41 Associate States/Economies

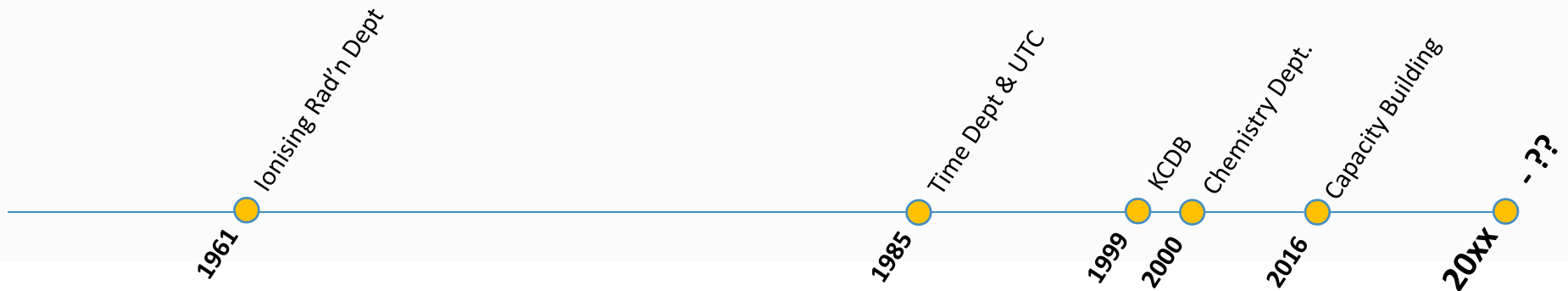
18 CIPM Members

Director and 70 staff

The SI has been changing ...

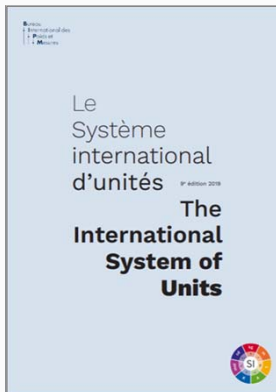


and the BIPM Work Programme has been changing ...



How can metrology support the digital economy?

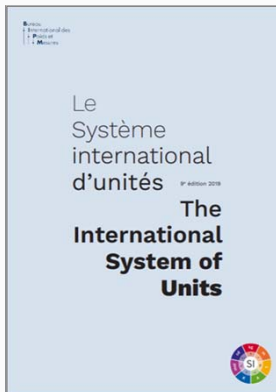
- By providing the basis for trustworthy data
- By supporting open data practices
- By developing digital formats for metrology



How can metrology support the digital economy?

- By providing the basis for trustworthy data
- By supporting open data practices
- By developing digital formats for metrology
- *By .. applying distributed ledger technology (blockchain) ...?*

cryptology?





Thank you

Bureau
 International des
 Poids et
 Mesures

Four 'Grand Challenges' that will profoundly transform society in the future:

- **AI and data** – putting transformative artificial intelligence, machine learning and other dataset-based technologies to the best possible use to achieve both economic and social goals.
- **Ageing society** – as the number of elderly citizens grows in the UK (and throughout the developed world), emerging technologies are being harnessed to maintain this group's quality of life.
- **Clean growth** –the transition to low-carbon technologies.
- **Future of mobility** – How people, goods and services are being moved around within cities, nations and, ultimately, the world is being rapidly re-imagined. Autonomous vehicles are already gaining traction.