NPL National Physical Laboratory | Centre for Carbon Measurement

Introduction to metrology

Emma Woolliams

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esa

fiducial reference measurements for satellite ocean colour

CEOS

Metrology for Earth Observation and Climate

http://www.emceoc.org

EMRP

European Metrology Research Programme

Programme of EURAMET

The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union

EURAMET

European Association of National Metrology Institutes

About NPL …

- Founded in **1900**
- World leading **National Metrology Institute**
- ~750 staff; 550+ specialists in Measurement Science plus 200 visiting researchers pa
- State-of-the-art laboratory facilities
- 388 Laboratories (35,746 sq. metres)
- The heart of the UK's **National Measurement System** to support business and society
- Experts in **Knowledge Transfer**

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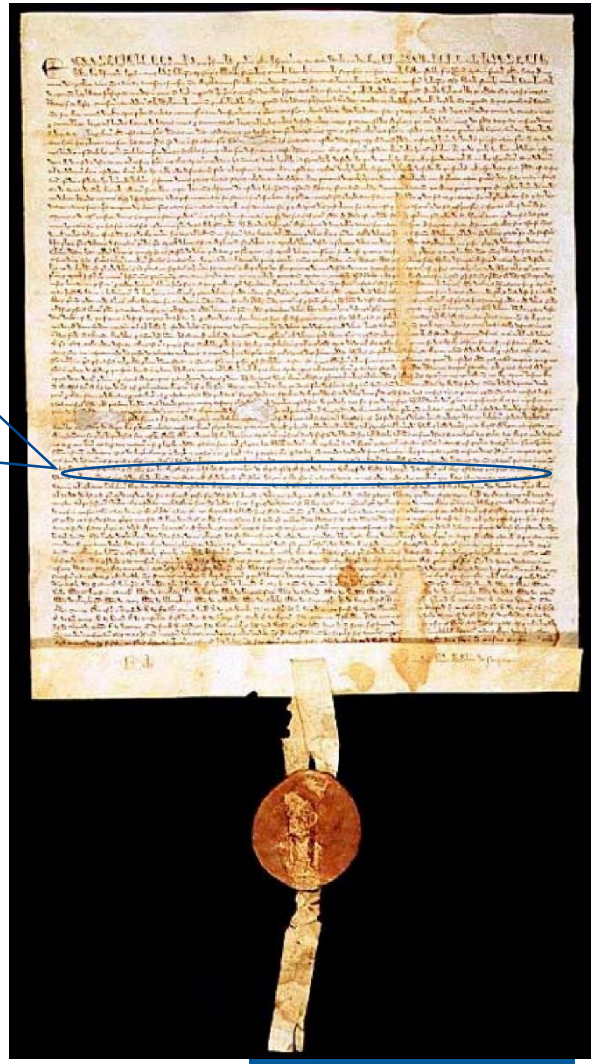
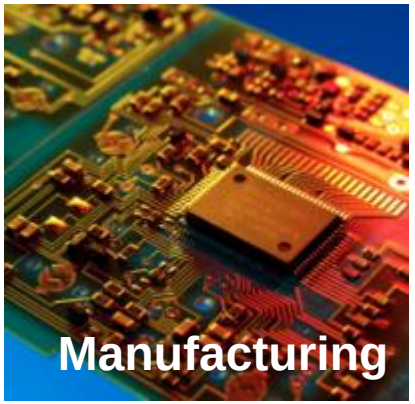
For trade …

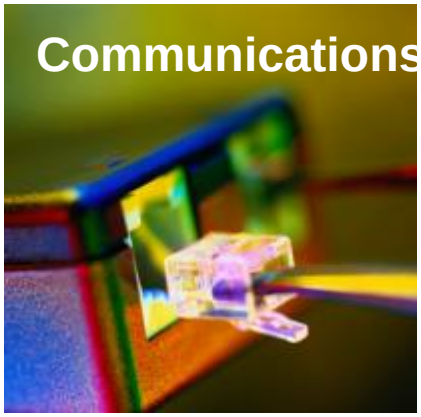
Magna Carta, 1215

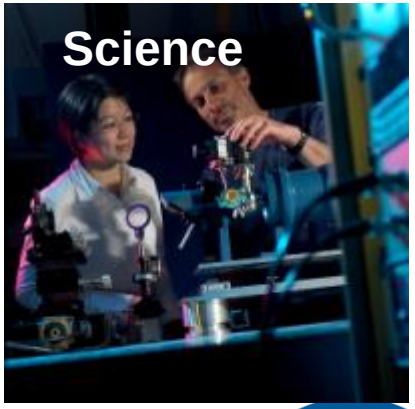
There shall be standard measures of wine, ale, and corn (the London quarter), throughout the kingdom. There shall also be a standard width of dyed cloth, russett, and haberject, namely two ells within the selvedges. Weights are to be standardised similarly.



The growing demand for better measurements







2% of GDP dependent on a robust measurement system

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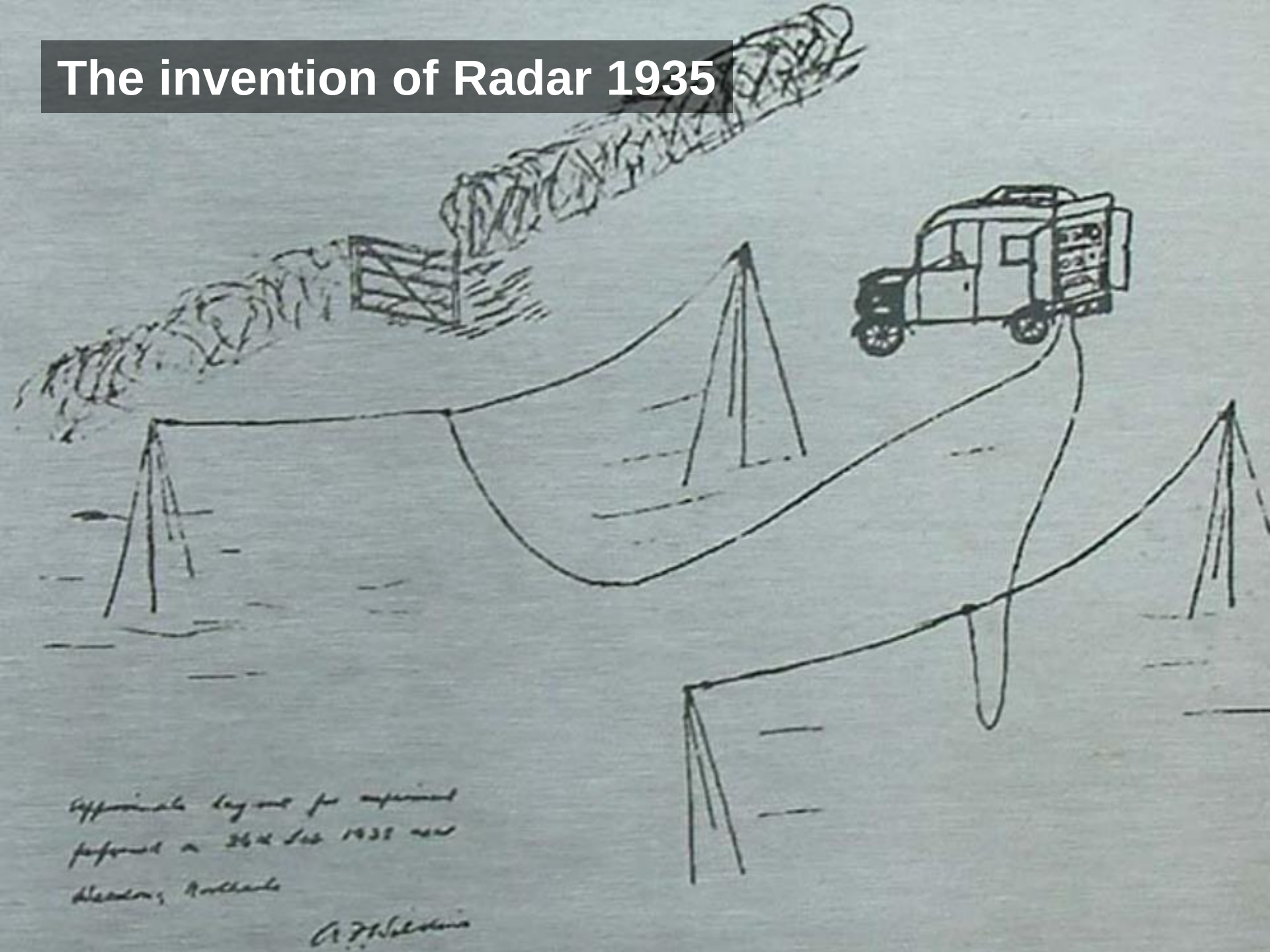
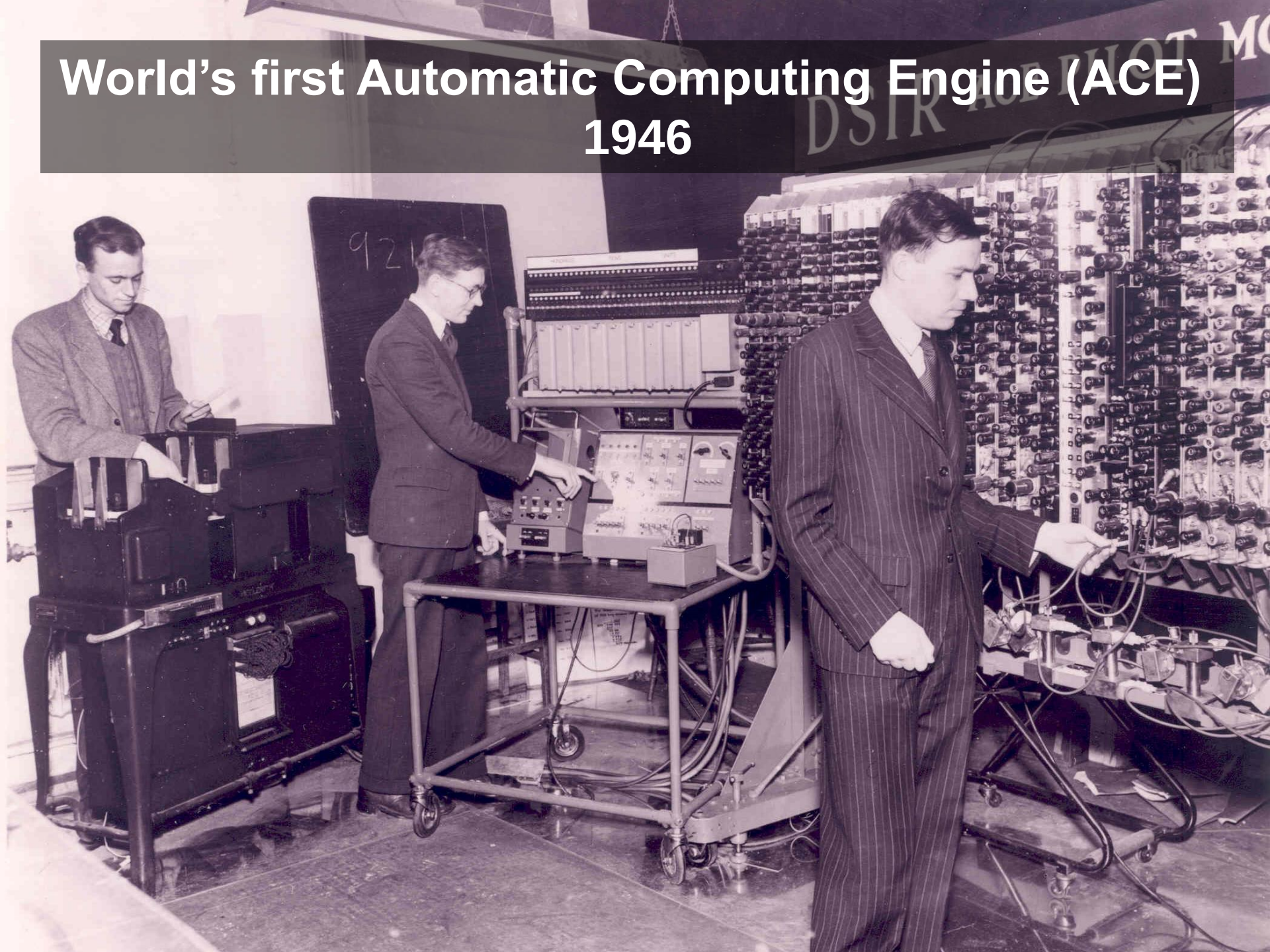
The invention of Radar 1935



World's first Automatic Computing Engine (ACE) 1946




World’s first Caesium Atomic Clock 1955

Packet-switching developed at NPL 1966


Weighing Concorde 1980
DANGER


Testing Mobile Phones 1999

Emissions 2012

DOCUMENTS DIPLOMATIQUES

DE

LA CONFÉRENCE DU MÈTRE.

PARIS.

IMPRIMERIE NATIONALE.

1875.

CONVENTION DU MÈTRE.

ARTICLE PREMIER.

Les Hautes Parties contractantes s'engagent à fonder et entretenir, à frais communs, un *Bureau international des Poids et Mesures*, scientifique et permanent, dont le siège est à Paris.

ART. 2.

Le Gouvernement français prendra les dispositions nécessaires pour faciliter l'acquisition ou, s'il y a lieu, la construction d'un bâtiment spécialement affecté à cette destination, dans les conditions déterminées par le Règlement annexé à la présente Convention.

ART. 3.

Le Bureau international fonctionnera sous la direction et sous la surveillance exclusive d'un *Comité international des Poids et Mesures*, placé lui-même sous l'autorité d'une *Conférence générale des Poids et Mesures* formée de délégués de tous les Gouvernements contractants.

ART. 4.

La présidence de la Conférence générale des Poids et Mesures est attribuée au président en exercice de l'Académie des Sciences de Paris.

The metre: 1791 - 1799

Pierre-Françoise-André Méchain

Jean-Baptiste-Joseph Delambre

The Measure of all Things - Ken Alder

The metre

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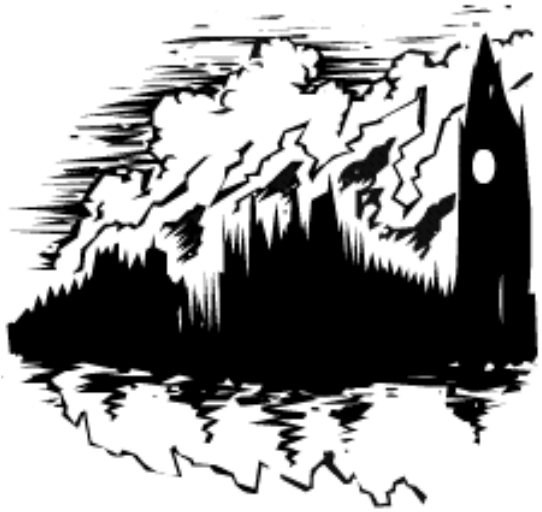

Today

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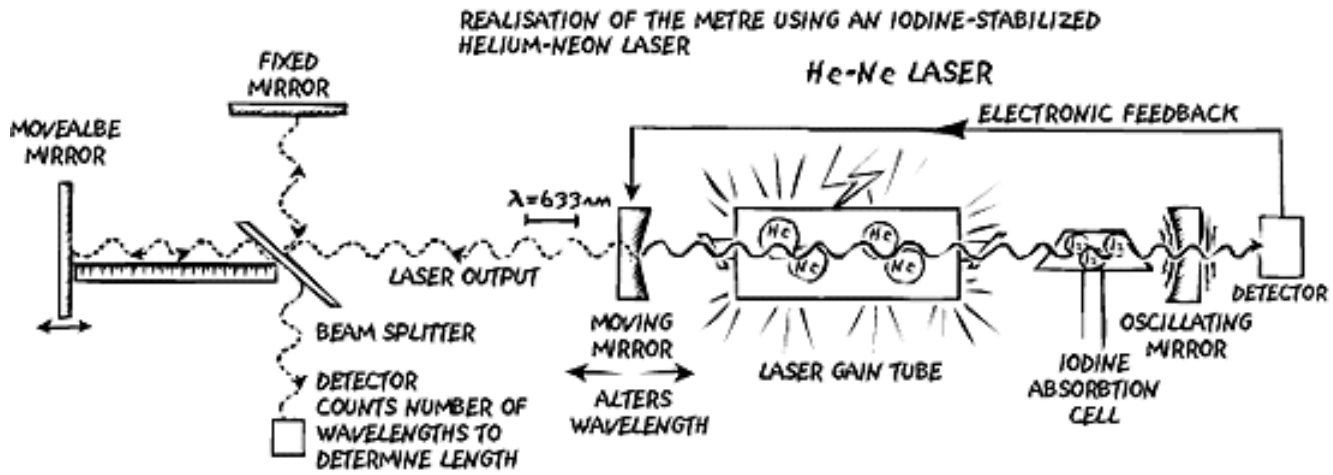
The metre is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second



SI Units

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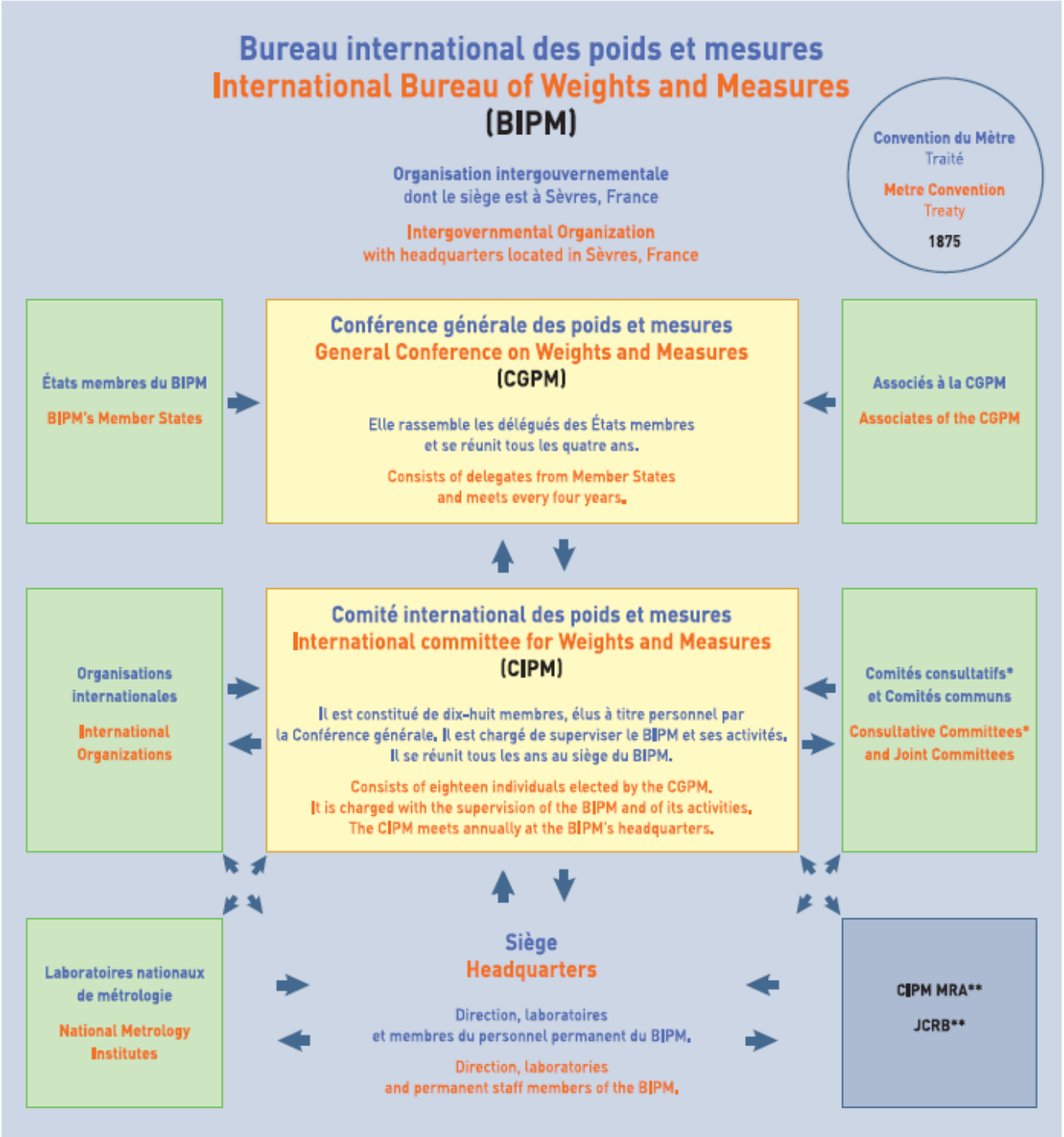
	kilogram	Mass
	metre	Length
	second	Time
	ampere	Electric Current
	kelvin	Temperature
	candela	Luminous Intensity
	mole	Amount of Substance



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Political

Scientific

Technical / Scientific

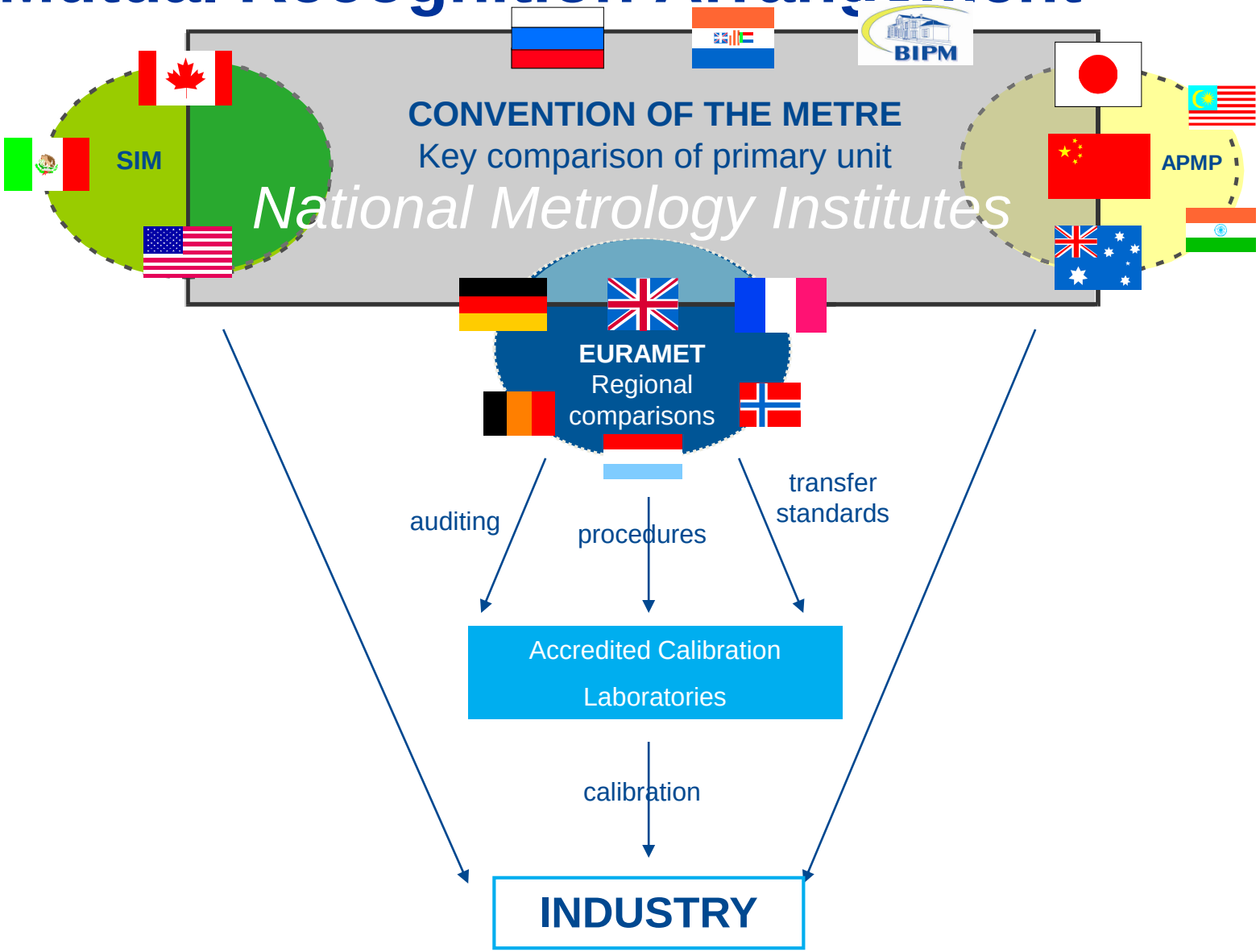
The GUM

The Guide to the expression of Uncertainty in Measurement (GUM)

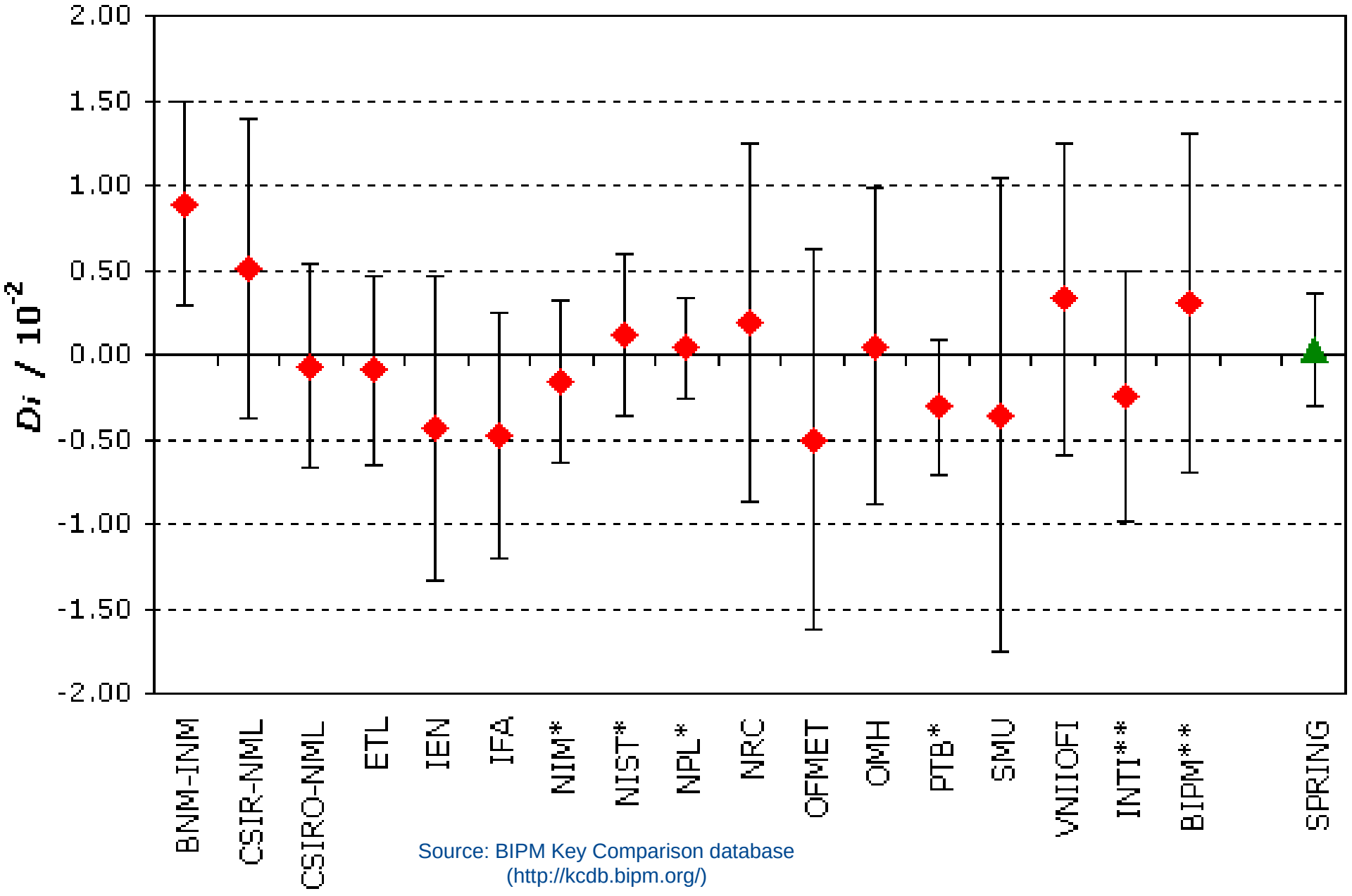
- The foremost authority and guide to the expression and calculation of uncertainty in measurement science
- Written by the JCGM and BIPM
- Covers a wide number of applications
- Technical with formal mathematics

http://www.bipm.org/en/publications/guides/gum.html

SI traceability
Mutual Recognition Arrangement



KC: Luminous intensity



Source: BIPM Key Comparison database
(http://kcdb.bipm.org/)

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Error

is **NOT** *the same as*

Uncertainty

Uncertainty – Error – Correction

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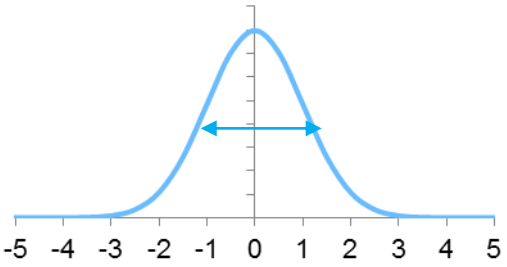
Uncertainty



Describes the spread

Drawn from a probability distribution described by uncertainty

Error

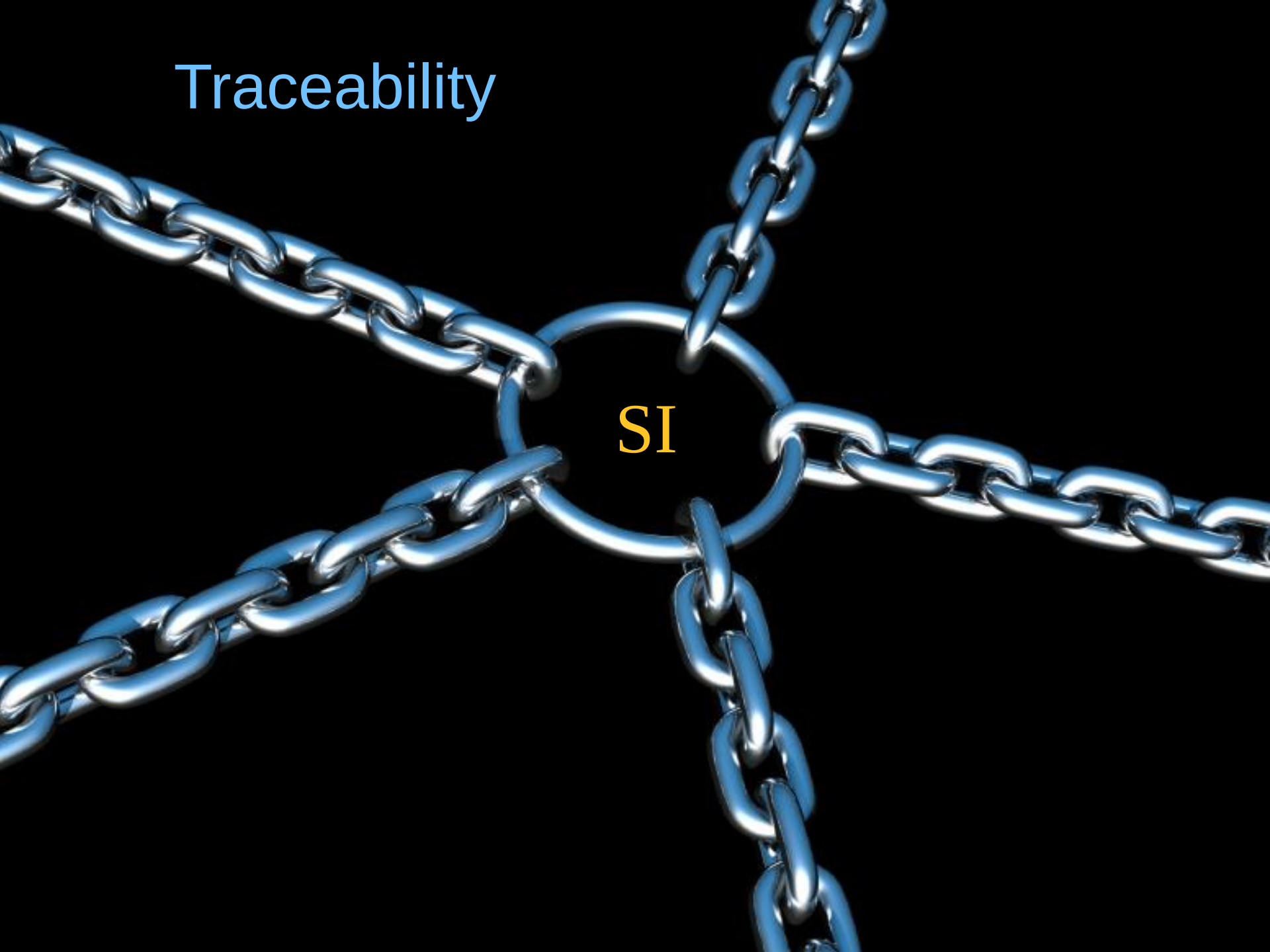
Difference to the (unknowable) true value

Residual, uncorrectable, unknown error

Correction

Known offset from true value

Traceability

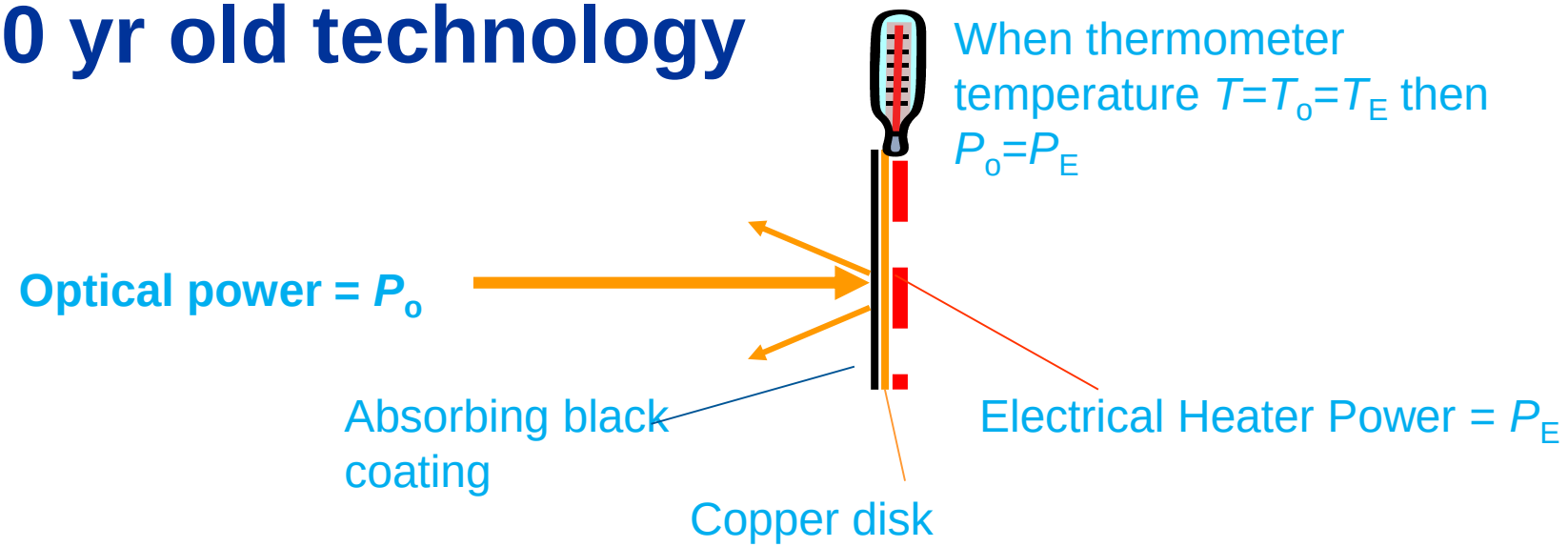


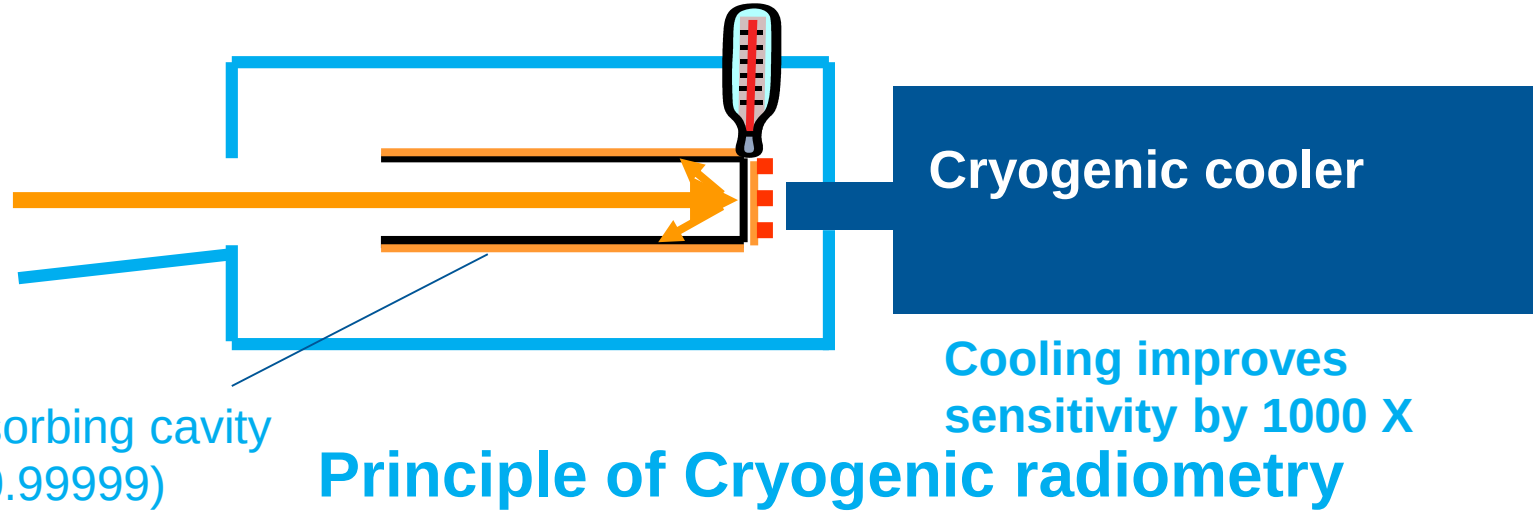
Traceability

"Property of a measurement result relating the result to a stated metrological reference (free definition and not necessarily SI) through an unbroken chain of calibrations of a measuring system or comparisons, each contributing to the stated measurement uncertainty"

Committee on Earth Observation Satellites (CEOS)

Electrical Substitution Radiometry – a 100 yr old technology





Principle of Cryogenic radiometry

30 years of cryogenic

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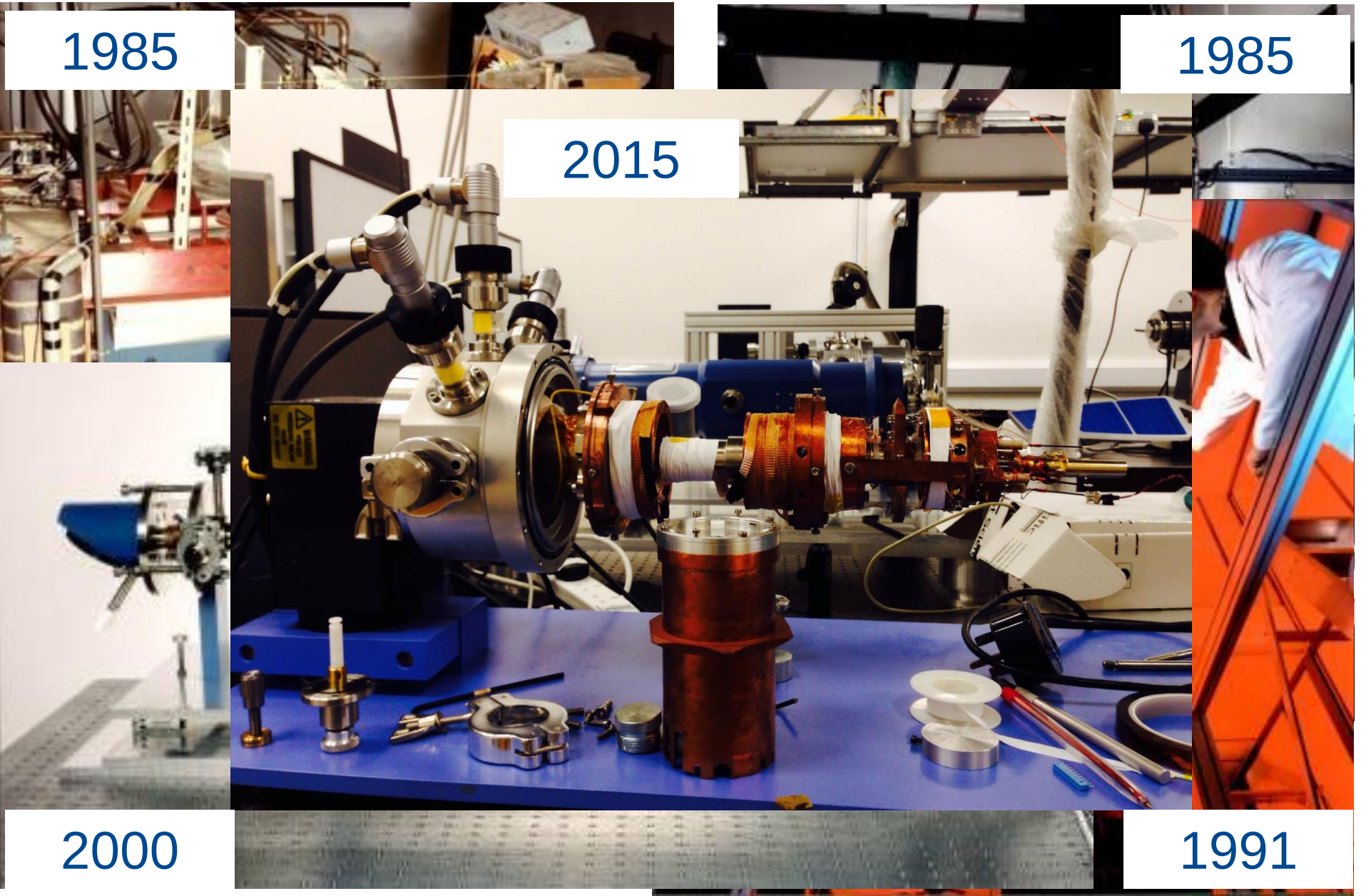

Calibration of detectors

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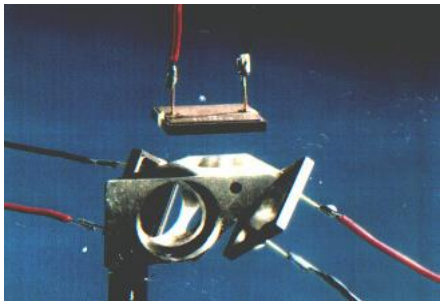
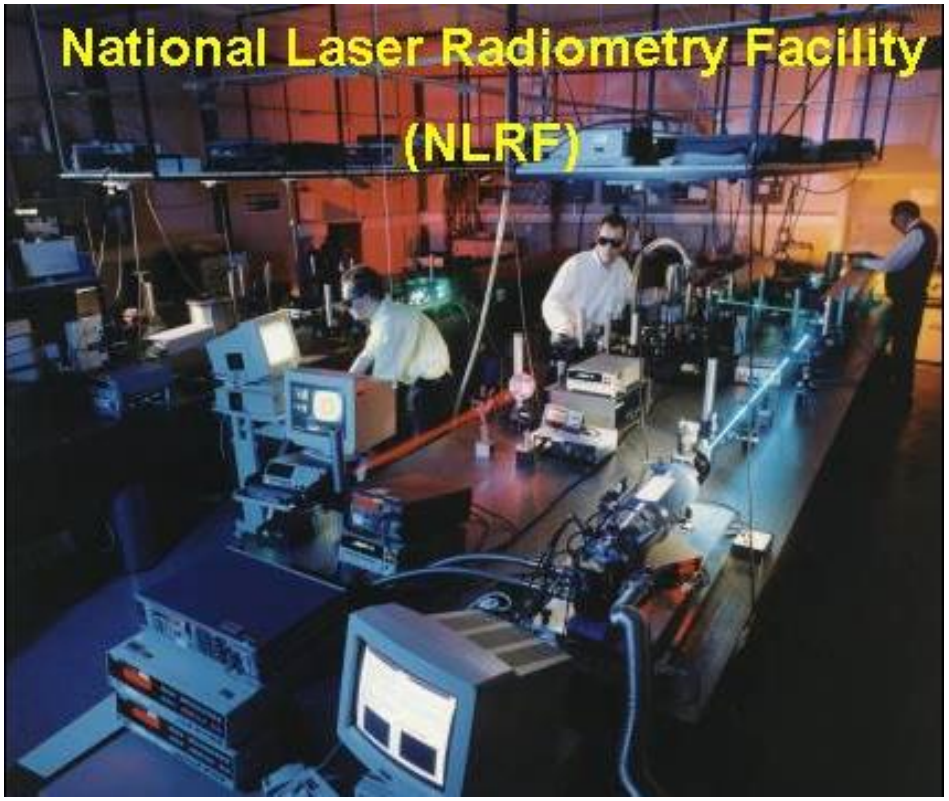
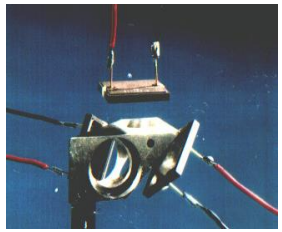
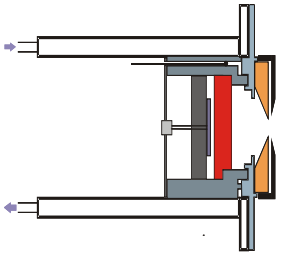
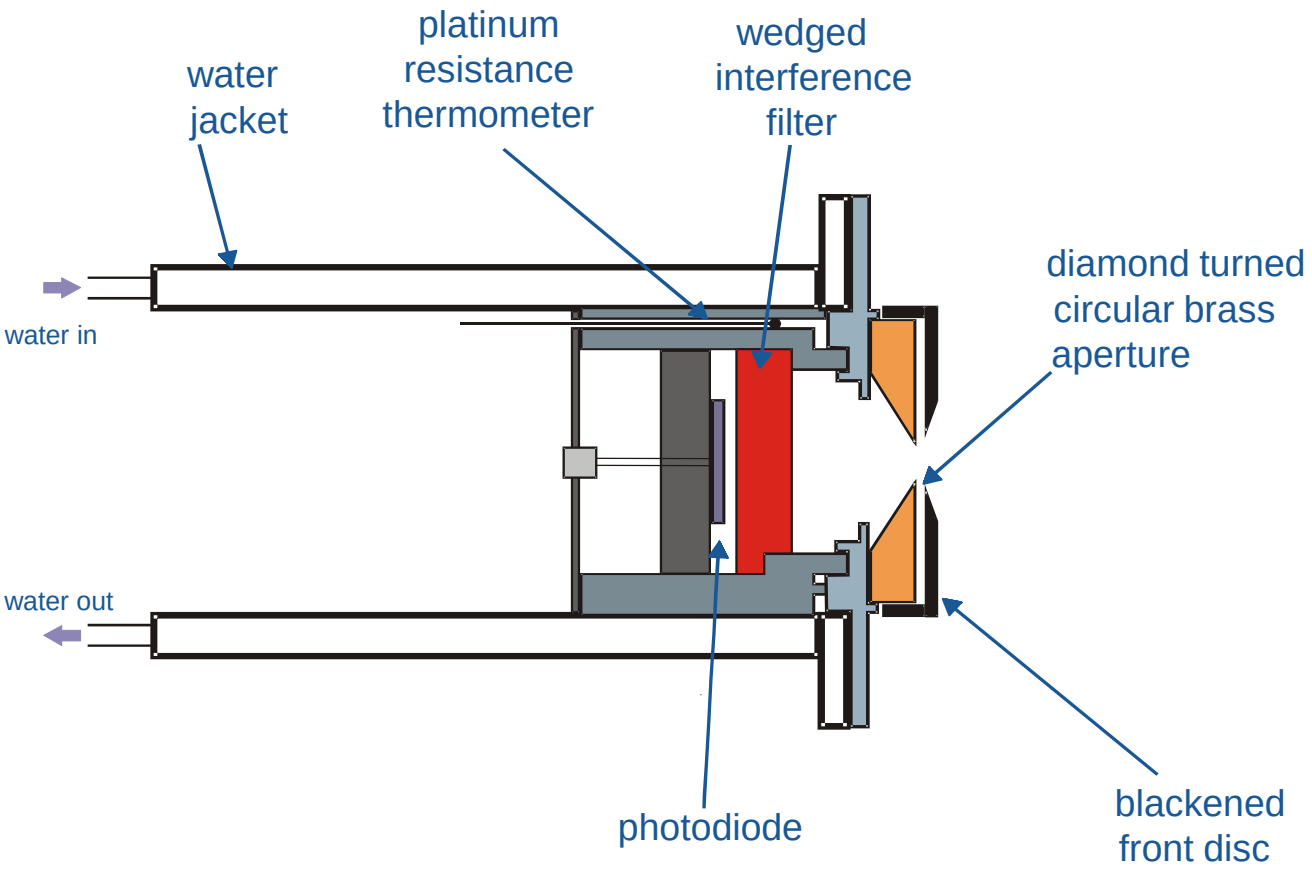




Filter radiometry







Blackbody Temperature

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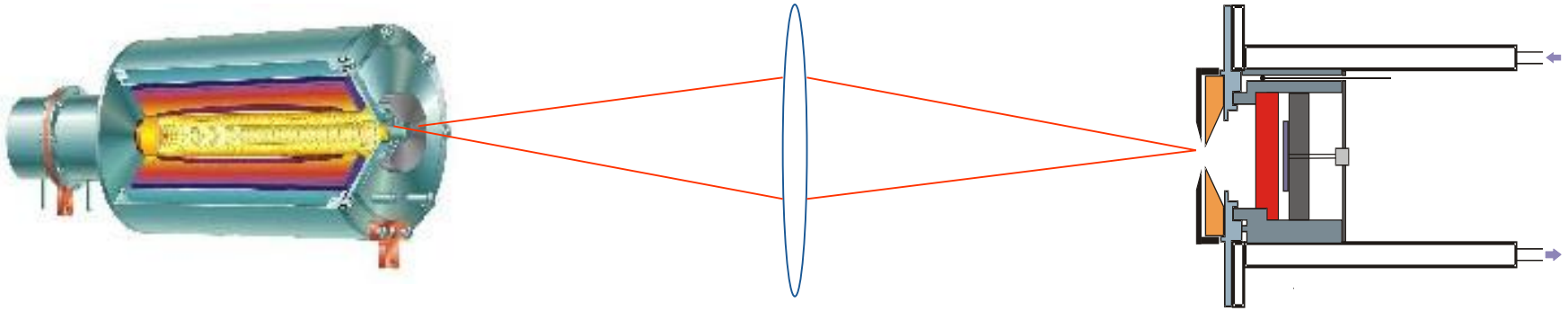

Spectral Radiance and Irradiance

SI Units

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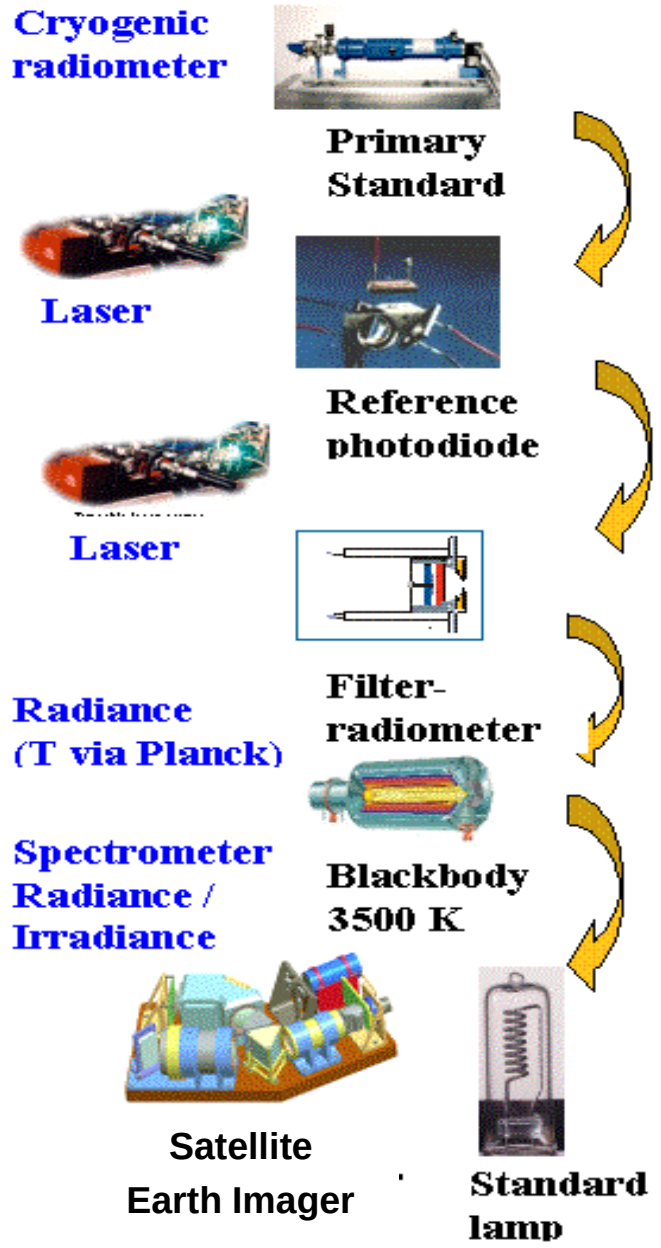
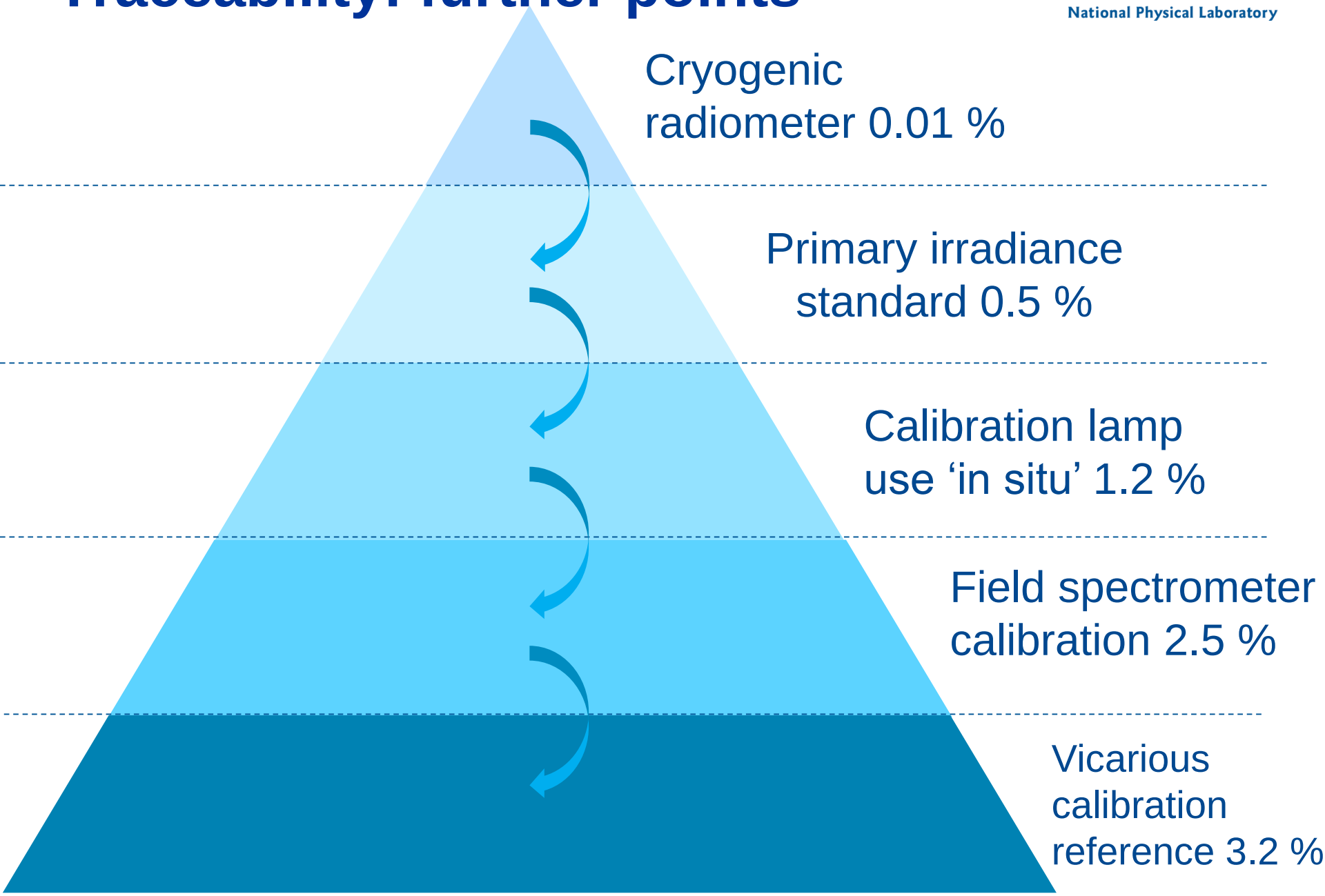


Traceability: further points



Conclusions

Because the whole history of physics proves that a new discovery is quite likely to be found lurking in the next decimal place.

F. K. Richtmeyer, 1932