Applied Statistics

Calibration

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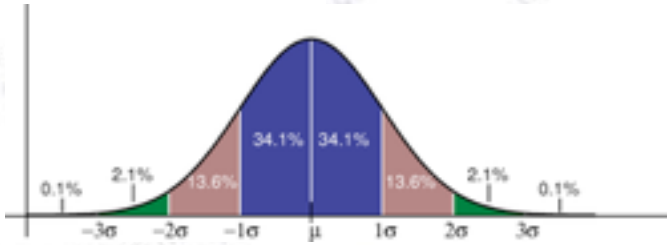


"Statistics is merely a quantisation of common sense"

Calibration definition

"Operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties (of the calibrated instrument or secondary standard) and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication."

[International Bureau of Weights and Measures]

Personally, I would shorten this to:

"Operation that, under specified conditions:

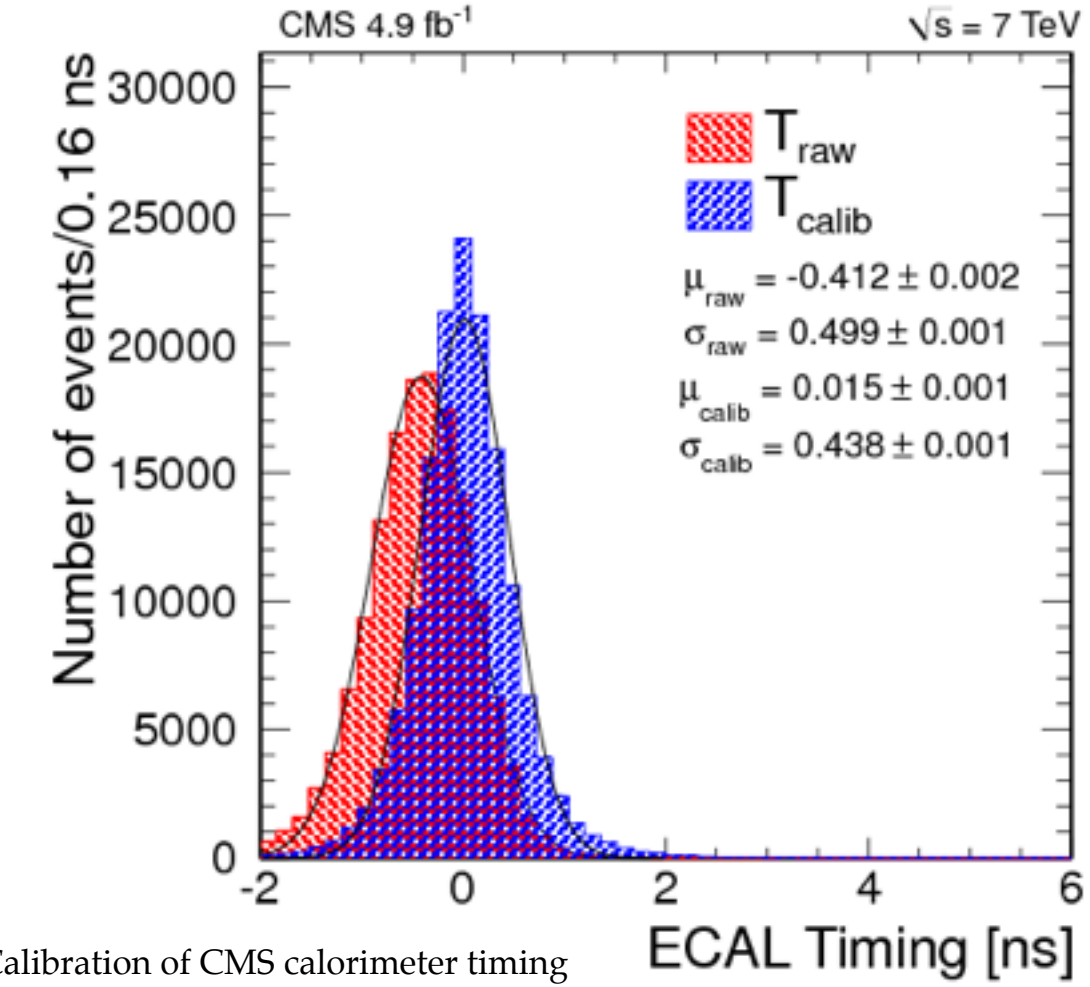
- Establishes a relation between the quantity of interest and associated information
- Uses this information to correct/improve the estimate of the quantity of interest."

[Shortening of the above]

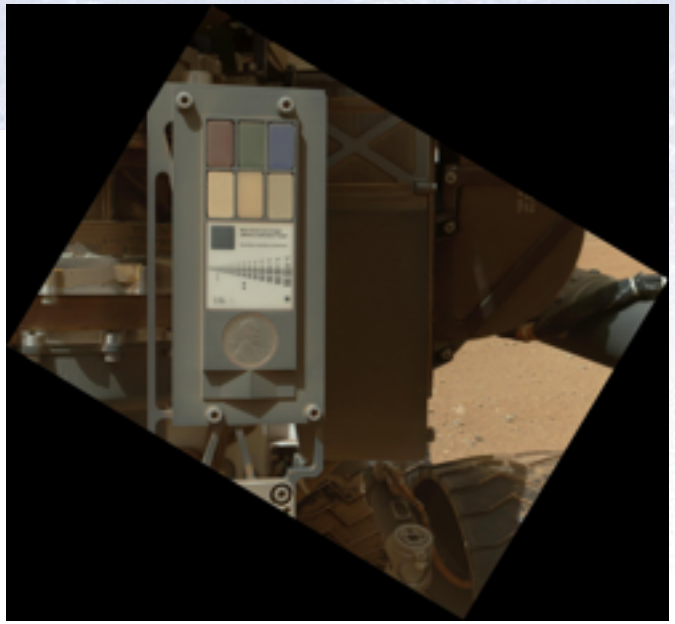
Let's have a few examples…

Calibration is many things!

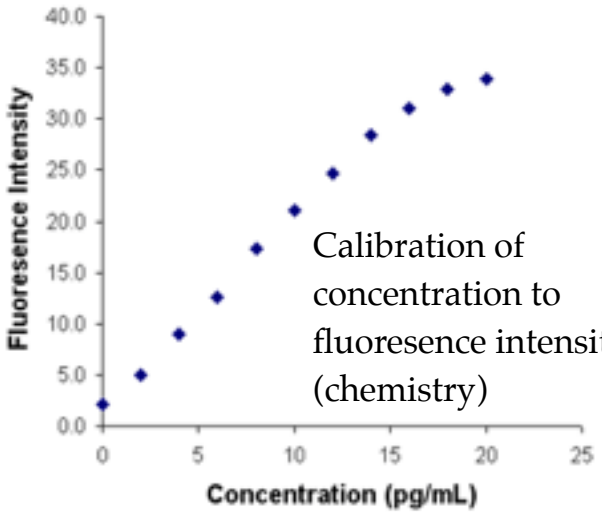
Every field of science involves calibration of some kind.



Calibration of CMS calorimeter timing



Calibration target of Mars rover "Curiosity"



Calibration of concentration to fluoresence intensity (chemistry)

General considerations

Though calibration spans widely, there are a few general considerations:

★ **Using control sample/group:**
- Purpose: To ensure that there is not some (inherent) bias.
- Aim: A good control sample is large and looks "exactly" like signal.
- Example: People without "signal" disease spanning same lifestyles.

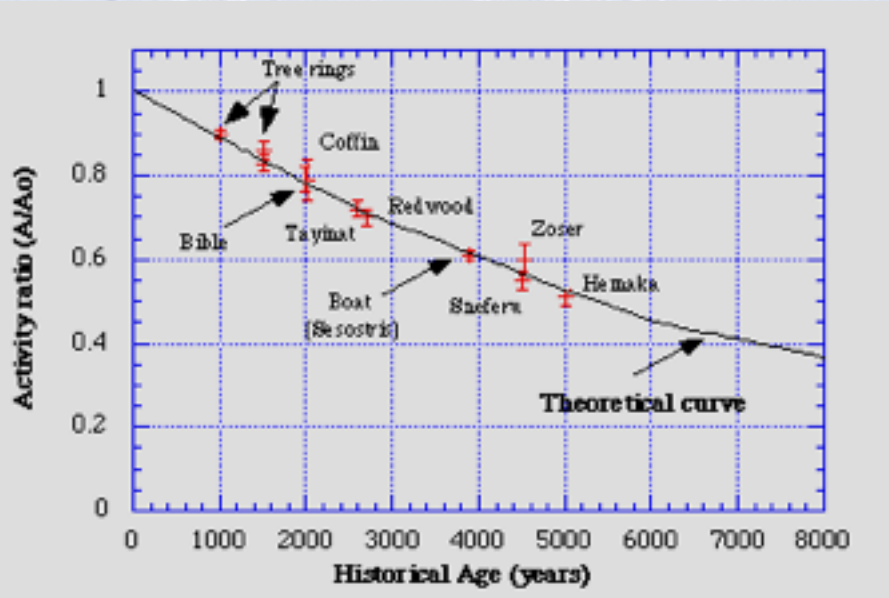
★ **Considering result for already well determined quantity:**
- Purpose: To ensure that there is not some (inherent) bias.
- Aim: A good control measurement is "easy" and well measured.
- Example: Unbiased momentum resolution using particle resonances (Z).

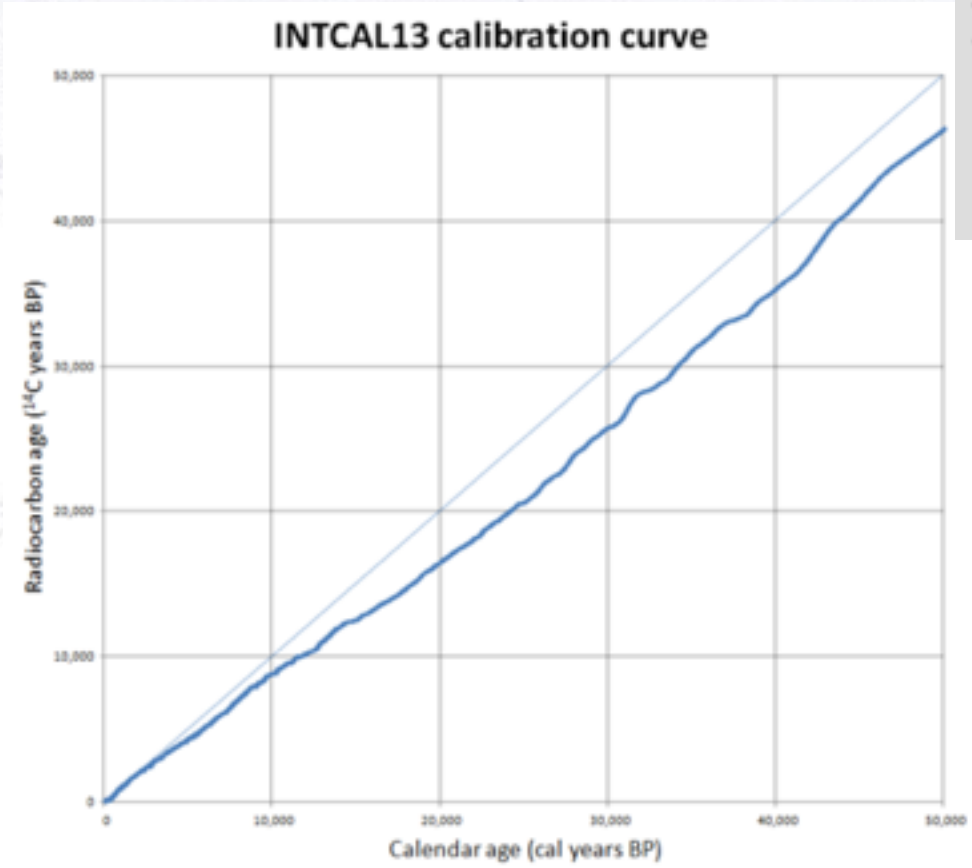
★ **Determining relation to well measurable quantity:**
- Purpose: Infer quantity in question from other sources/measurements.
- Aim: If one can't measure directly, perhaps it can be done indirectly.
- Example: Measuring flow of liquid in pipe using microphone (noise!).

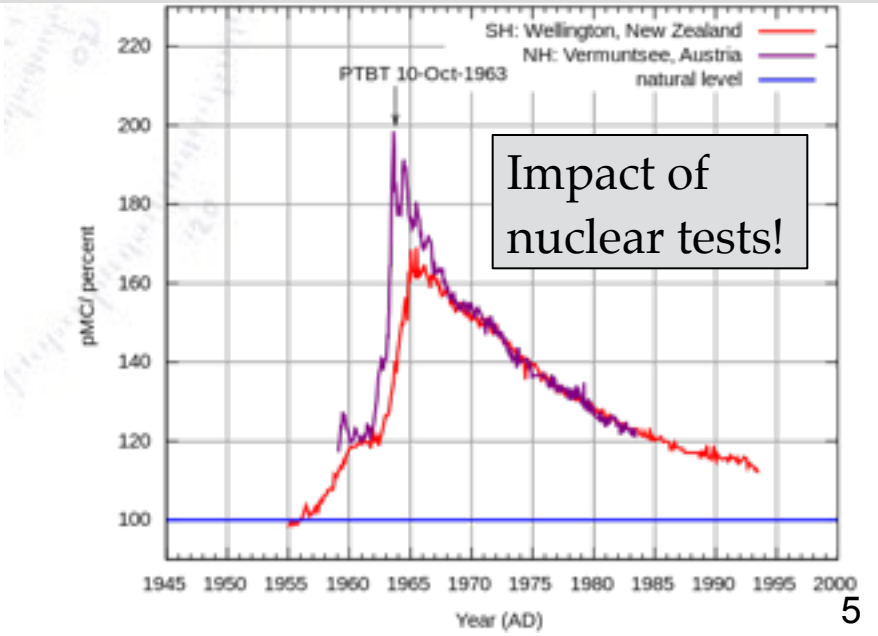
Each field of science have their own "tricks of the trade", and sometimes breakthroughs are made through calibration.

Example: Carbon 14 dating

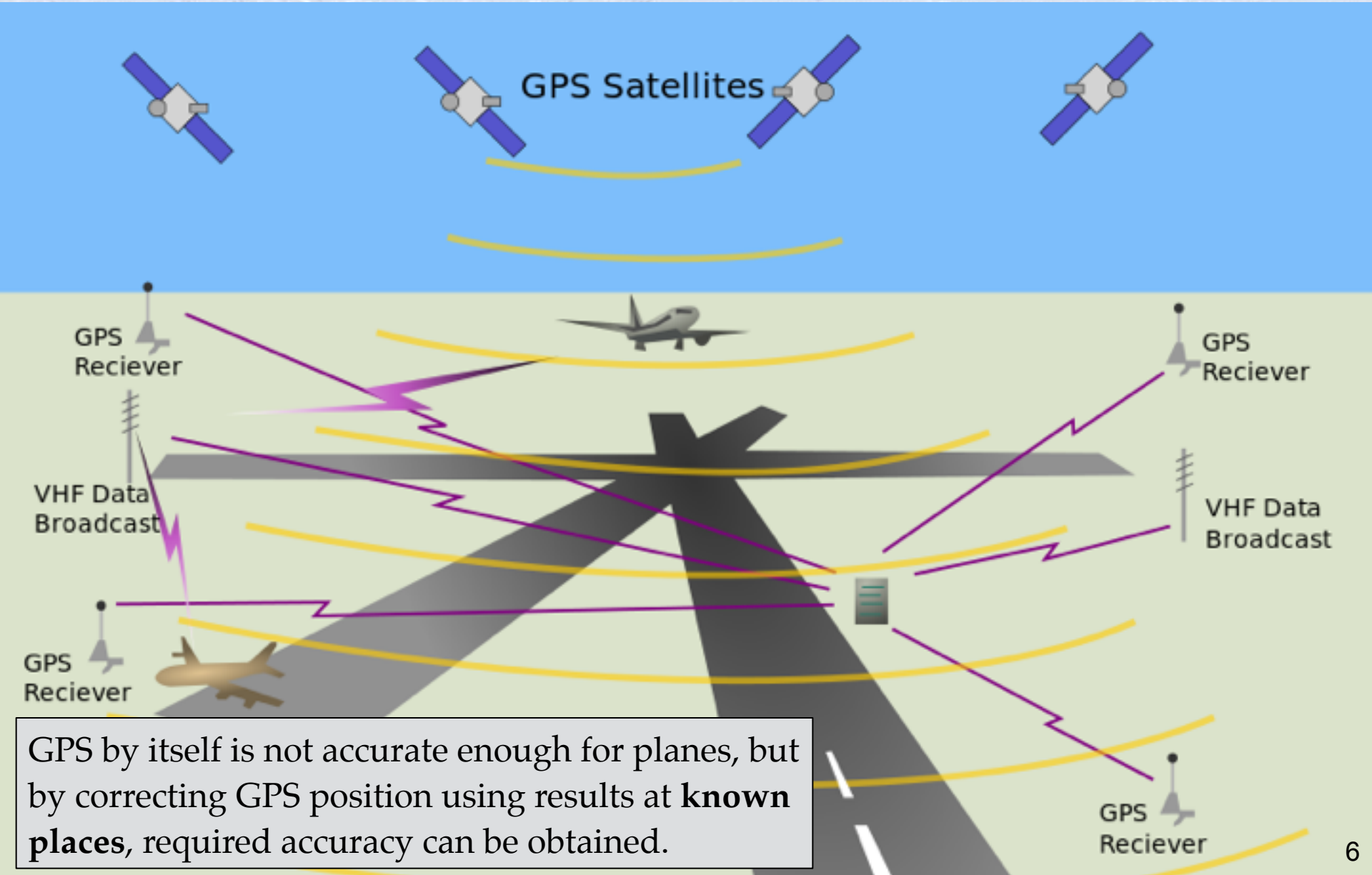
Carbon 14 dating used (and uses) samples of known age (from historical sources) to calibrate the scale and uncertainties.
Tree rings have played a central role!



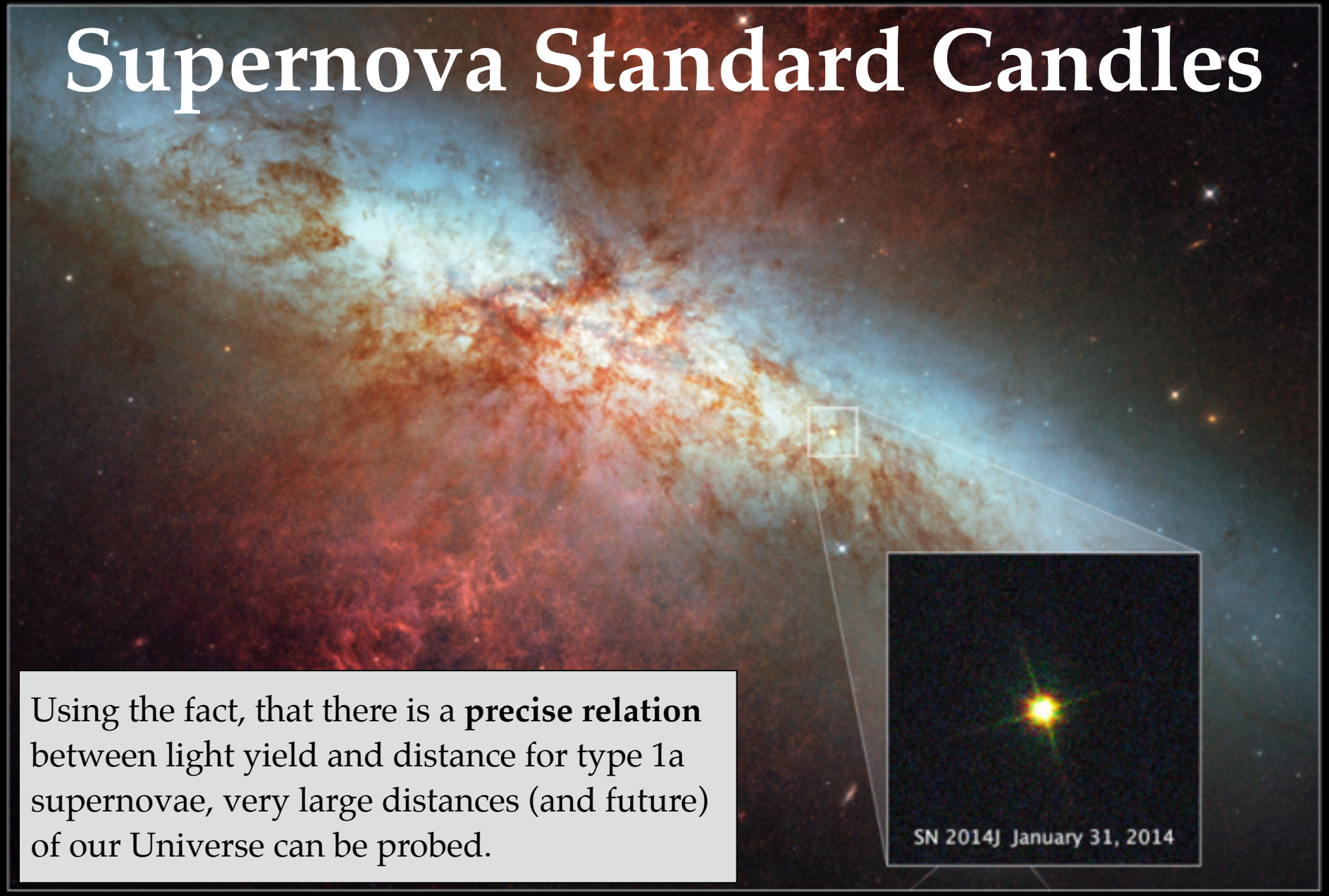




Example: Differential GPS



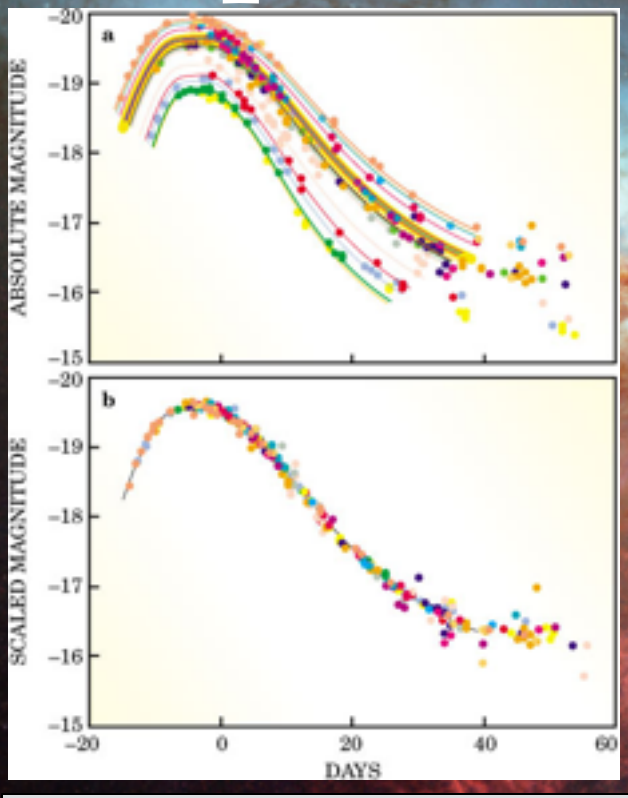
GPS by itself is not accurate enough for planes, but by correcting GPS position using results at **known places**, required accuracy can be obtained.



Supernova Standard Candles

Using the fact, that there is a **precise relation** between light yield and distance for type 1a supernovae, very large distances (and future) of our Universe can be probed.

Supernova Standard Candles



But in order to get best precision, further calibration is needed!

Using the fact, that there is a **precise relation** between light yield and distance for type 1a supernovae, very large distances (and future) of our Universe can be probed.

Conclusions

Calibration is usually a central part of analysing data in order to:

- Ensure that measurements are correct and correct them if they are biased.
- Establish/calibrate the uncertainty on measurements.

But it requires foresight and good planning of an experiment to be able to calibrate precisely. Being able to do so, distinguishes the **good experimenter**.