Update on Progress of the NewKILO Joint Research Project

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Implementing the new realisation

To implement the redefinition there is a requirement to develop a practical means to link the realisation experiments to the SI and to allow maintenance and traceability of the mass scale following redefinition.

3 key aspects:

- Provide a means of accurately fixing the Planck (and Avogadro) constant with reference to the International Prototype Kilogram (IPK)
- Allow dissemination of the new realisation at the level of the NMIs should be achieved with uncertainty contributions smaller than the required (relative) uncertainty of the realisation (2 in 10^{-8})
- Provide a means of maintaining the standard between realisations (WB and Avogadro Key Comparison)

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Implementation - key areas of research

- Next generation mass standards (watt balance and vacuum compatible, optimised for stability)
- Procedures for air/vacuum transfer to optimise the repeatability of the process
- Characterisation of the surface of mass standards to understand dynamic sorption mechanisms and effects of cleaning and storage in various media
- Develop apparatus and optimise procedures for the storage, cleaning and transportation of primary mass standards

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Key areas of research - progress

- New mass standards and materials
  - Nickel-superalloy and (single crystal) tungsten have good properties and are being evaluated as new materials for weights

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Comparison of materials for new standards

Material	Advantages	Disadvantages
Platinum-iridium	Well characterised material Easy to machine	Expensive Relatively high magnetic permeability
Stainless steel	Well characterised material Used for the majority of current weights	High magnetic permeability Complex alloys - Surfaces difficult to analyse
Silicon	Excellent surface finish achievable Natural silicon readily available Very low magnetic permeability	Low density so must be weighed in vacuum Potential static issues
Gold alloy	Good magnetic properties Easy to machine Dense	Low relative hardness Samples analysed showed anomalous sorption characteristics
Iridium	Hard Good magnetic properties Dense	Difficult to machine Expensive
Nickel super alloy	Similar density to stainless steel Hard Good magnetic properties	Relatively expensive and difficult to obtain
Single crystal tungsten	Excellent magnetic properties Density similar to that of Pt-Ir	Difficult to manufacture artefacts High quality crystals of suitable size expensive and difficult to obtain
Plated copper	Excellent magnetic properties Easy to manufacture Similar density to stainless steel	Quality of artefacts relies on good coating process and material Au – soft, Rh – show inclusions form polishing

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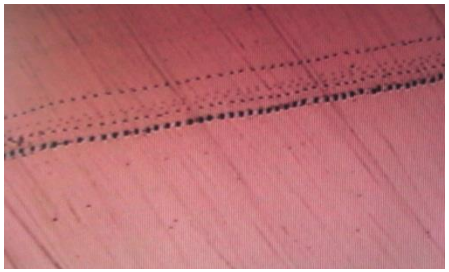
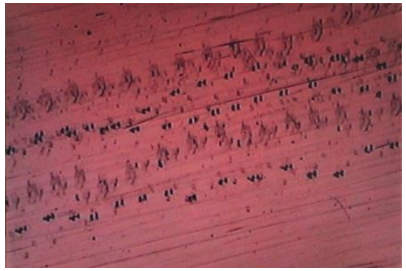
Materials for weight support and storage

- Titanium good multiple weight application (e.g. weighing pan)

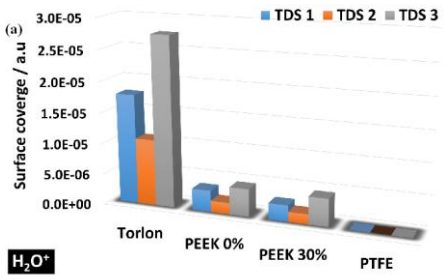

PTFE

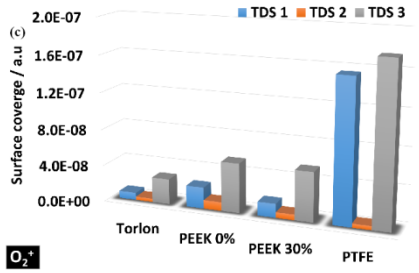

PEEK

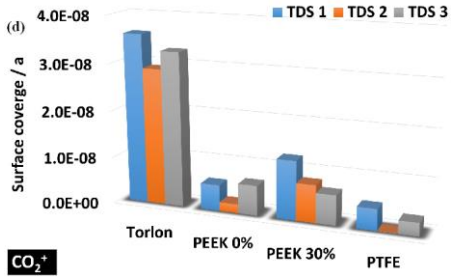

Aluminium

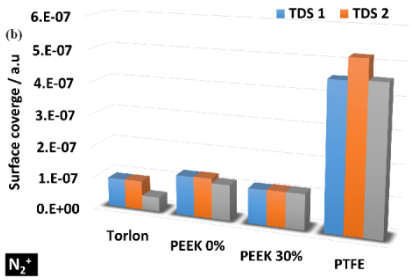

Titanium

- PEEK most suitable for mass support in storage containers









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  - No mass change below a vacuum pressure of 0.1 Pa

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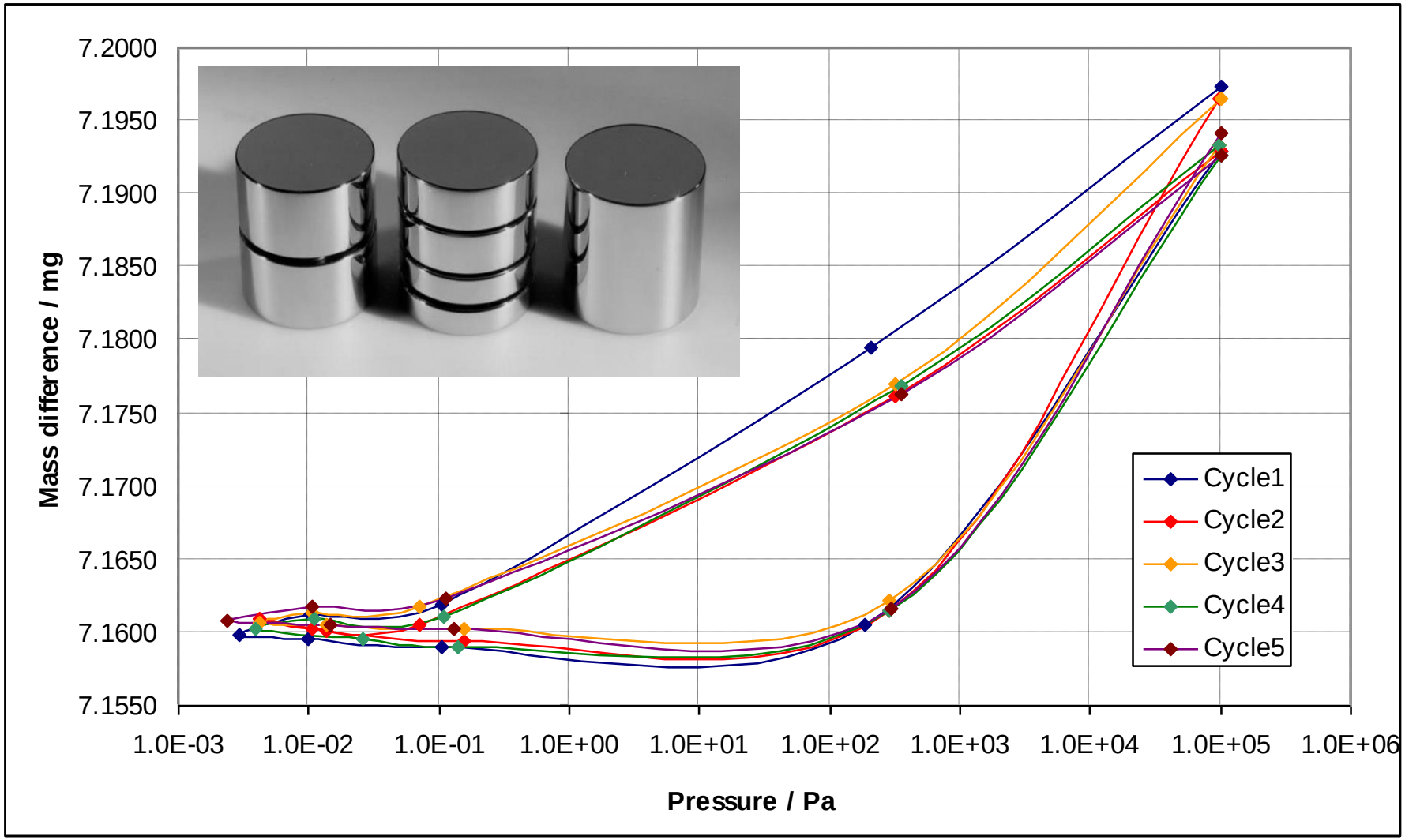
Sorption/Pressure correlation



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- Storage and transfer of standards
  - Storage in argon shows improved stability over storage in air

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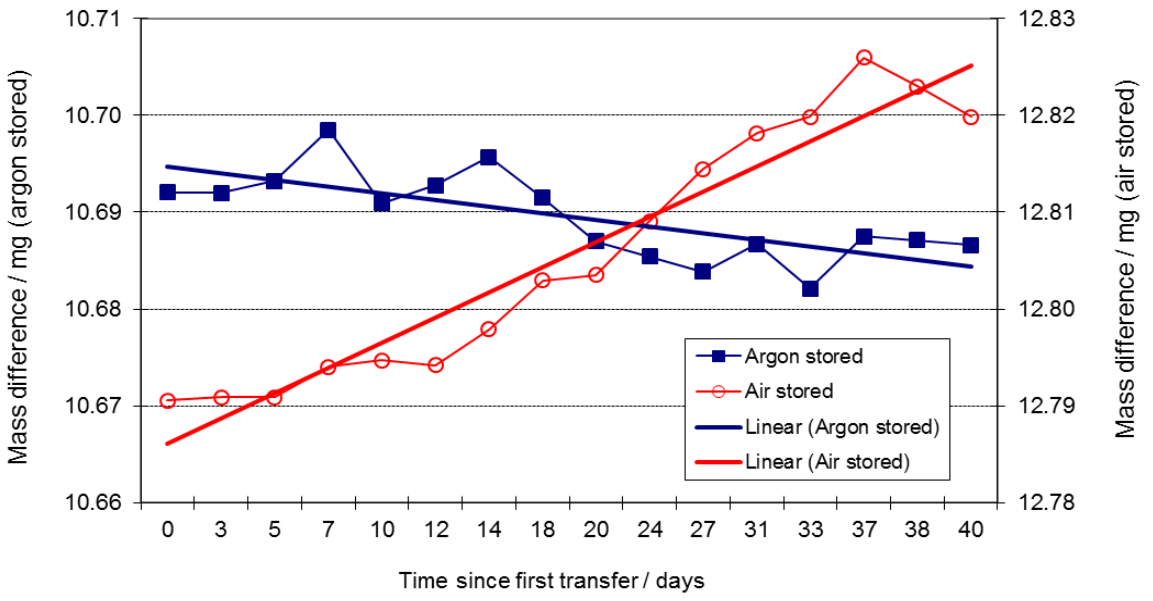
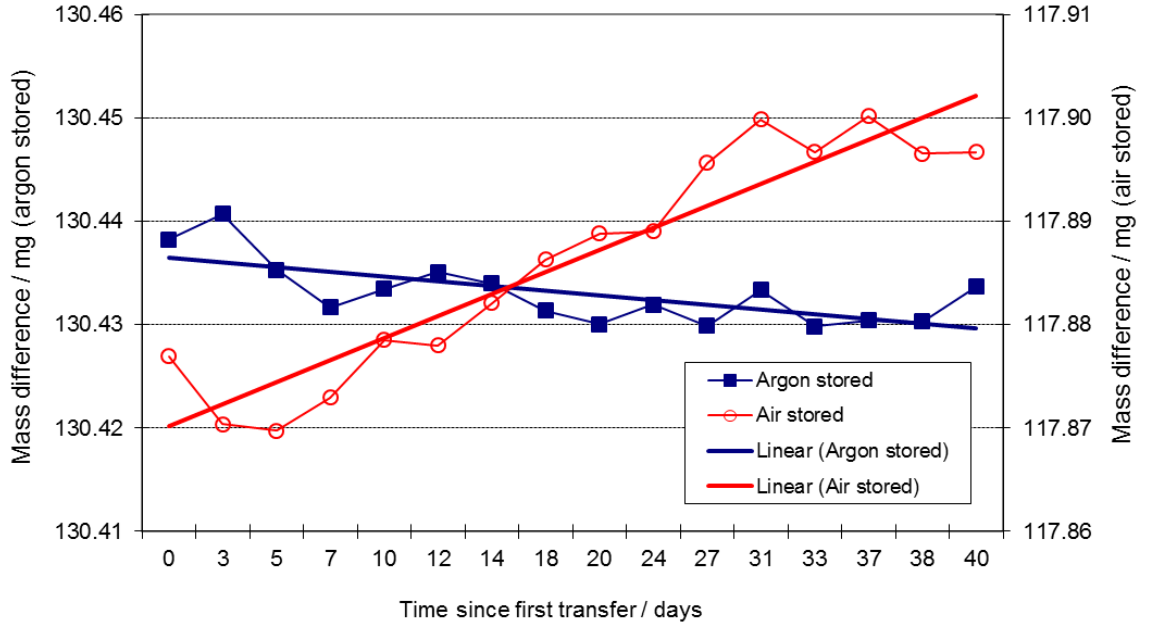
NewKILO Mass storage

- Silicon and SS weights stored in air or inert gas. Mass measurements made in vacuum.
- Artefacts stored in air show increase in mass due to surface contamination.
- Artefacts in argon show slight decrease in mass.
- Care with handling and transfer of artefacts (to balance) is critical in maintaining stability.





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- Air/vacuum transfer procedures
  - No mass change below a vacuum pressure of 0.1 Pa
- Storage and transfer of standards
  - Storage in argon shows improved stability over storage in air
- Cleaning
  - UV/Ozone and Plasma techniques are viable alternatives to nettoyage-lavage
  - Exposure to vacuum following cleaning shows increased contamination compared with air or nitrogen

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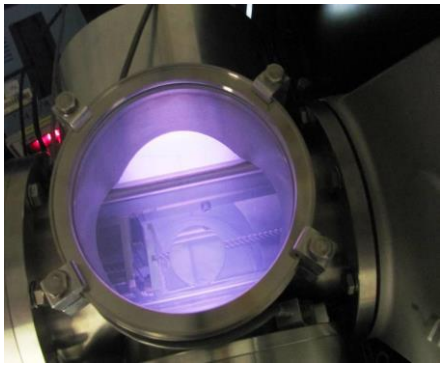
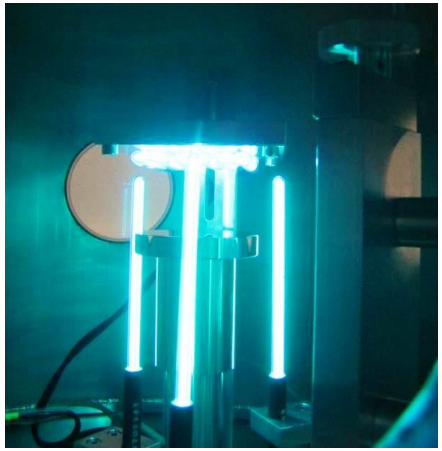
New cleaning techniques for mass standards

- Traditional cleaning is generally by nettoyage-lavage at the BIPM or solvent (manual or ultrasonic) at NMIs
- New techniques using UV activated ozone and low pressure (H_2 and O_2) plasma have been developed
- These techniques are non-contact therefore less user dependent and more controllable than manual methods
- Parallel evaluation of 3 cleaning techniques – UV/Ozone, Hydrogen plasma and BIPM method has been undertaken (gravimetrically and using surface analysis)
- Subsequent storage conditions (air, vacuum and nitrogen, 10 days) have been evaluated to characterise recontamination





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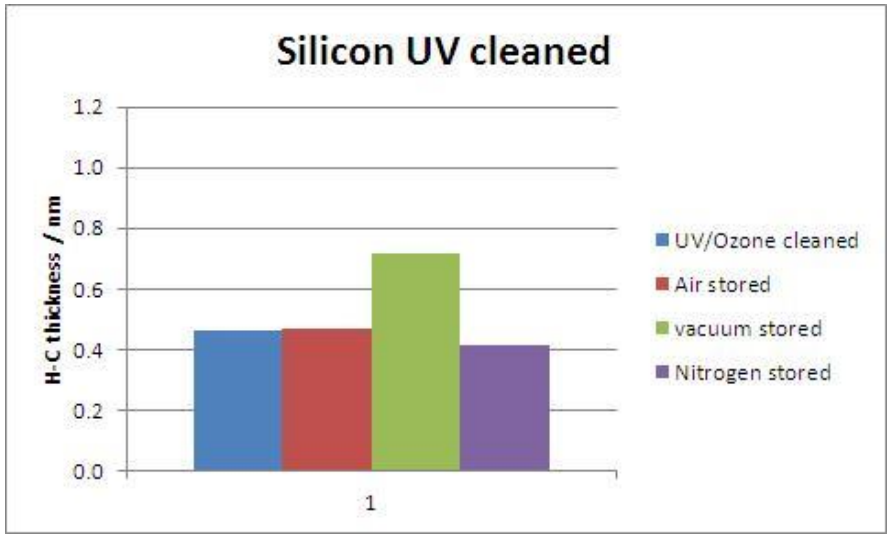
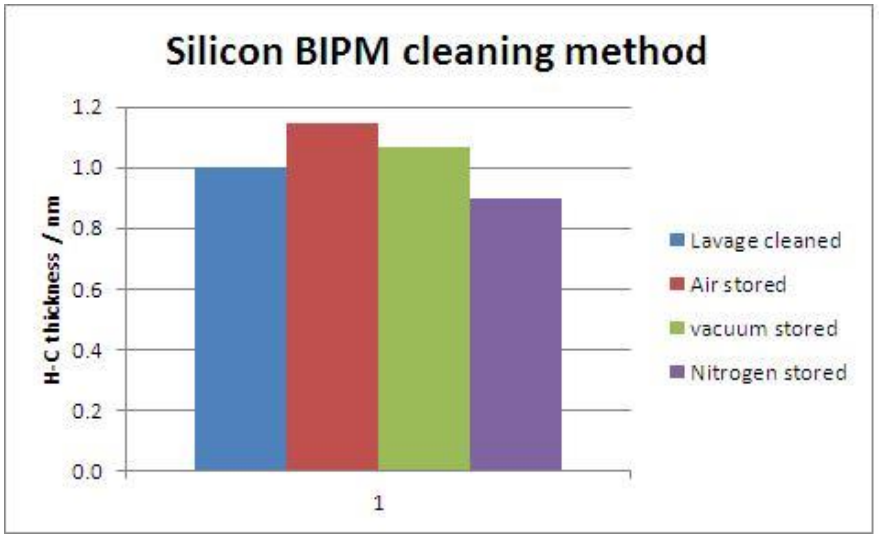
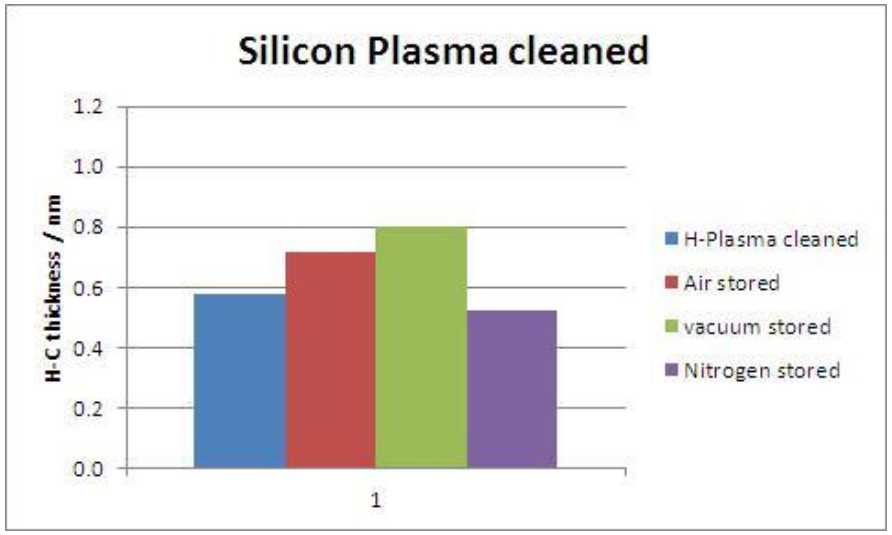
Cleaning and storage – Silicon







- BIPM cleaning method either leaves more contamination on the surface or contamination forms rapidly on the surface after cleaning (before measurement)
- Vacuum stored samples gained most contamination after cleaning

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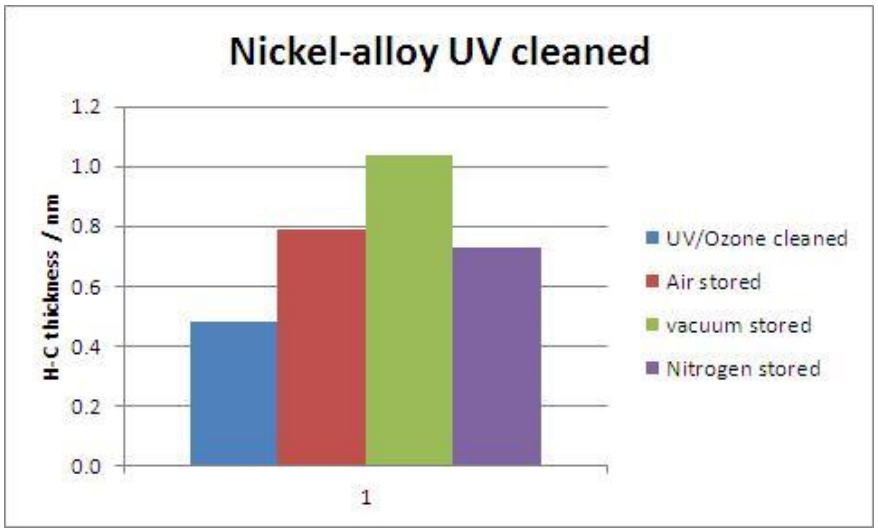
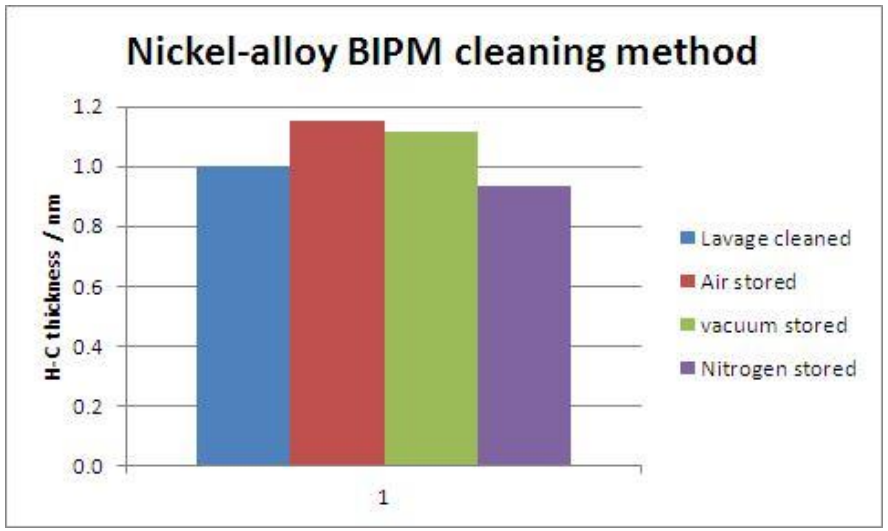
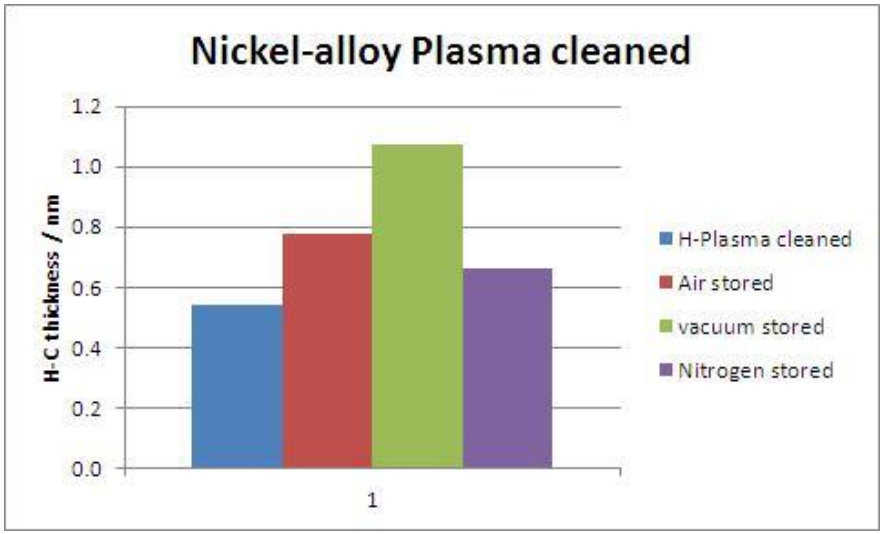
Cleaning and storage – Ni Alloy







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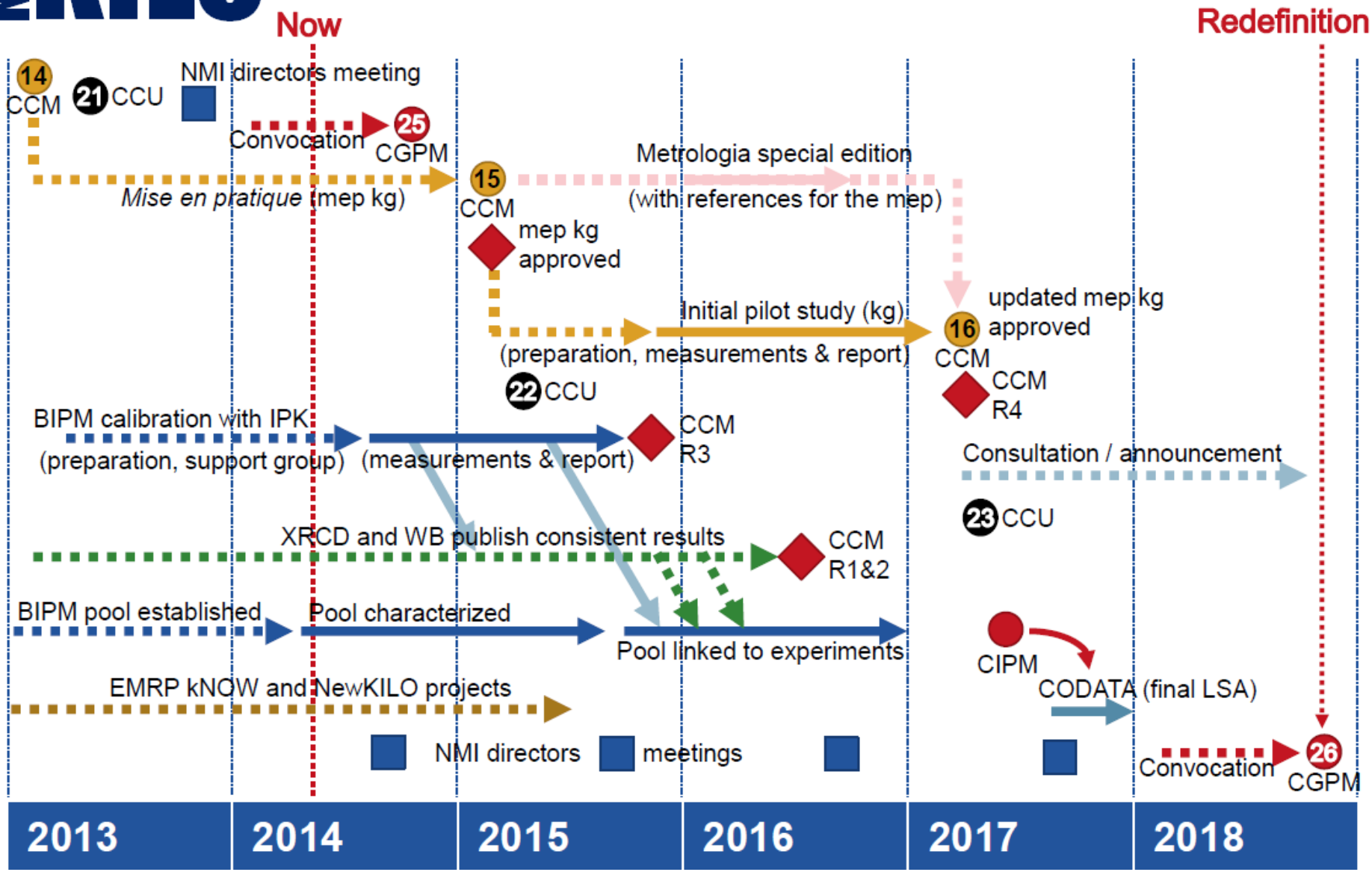
Timescale – CCM roadmap to redefinition



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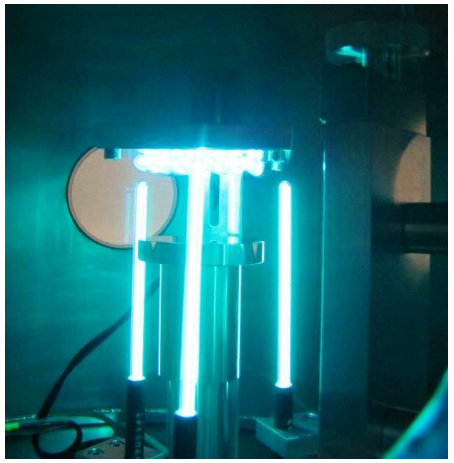
Impact of the kilogram redefinition

- Realisation can be via watt balance or Avogadro experiments thus the unit of mass can theoretically be established by any NMI
- Initially the best uncertainty of realisation will be 2 in 10^8 (compared with zero currently)
- Procedures must be in place initially to link the realisation experiments with IPK and subsequently to disseminate the unit to end users
- Additional uncertainty in this dissemination (from vacuum to air) needs to be small to minimise the increase in CMCs available to users - currently 15 µg for 1 kg (k = 1)
- **Result – minimal impact for end users**



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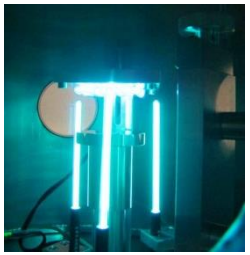
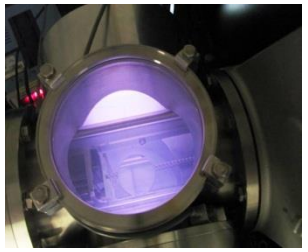
A collaboration research project between 11 EURAMET NMIs

- NPL, CMI, CNAM, DFM, EJPD, LNE, MGRT, MIKES, PTB, SMU, TUBITAK
- INRIM, NRC
- BIPM, KRISS, Häfner, Mettler-Toledo, Sartorius
- TU-Ilmenau, IPQ, IMBiH

www.newkilo.sk

Thank you for your attention

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