



Consultative Committee for Length (CCL)

Report to CGPM

President: Attilio Sacconi

Executive Secretary: Lennart Robertsson

20 October 2011



24 CCL members

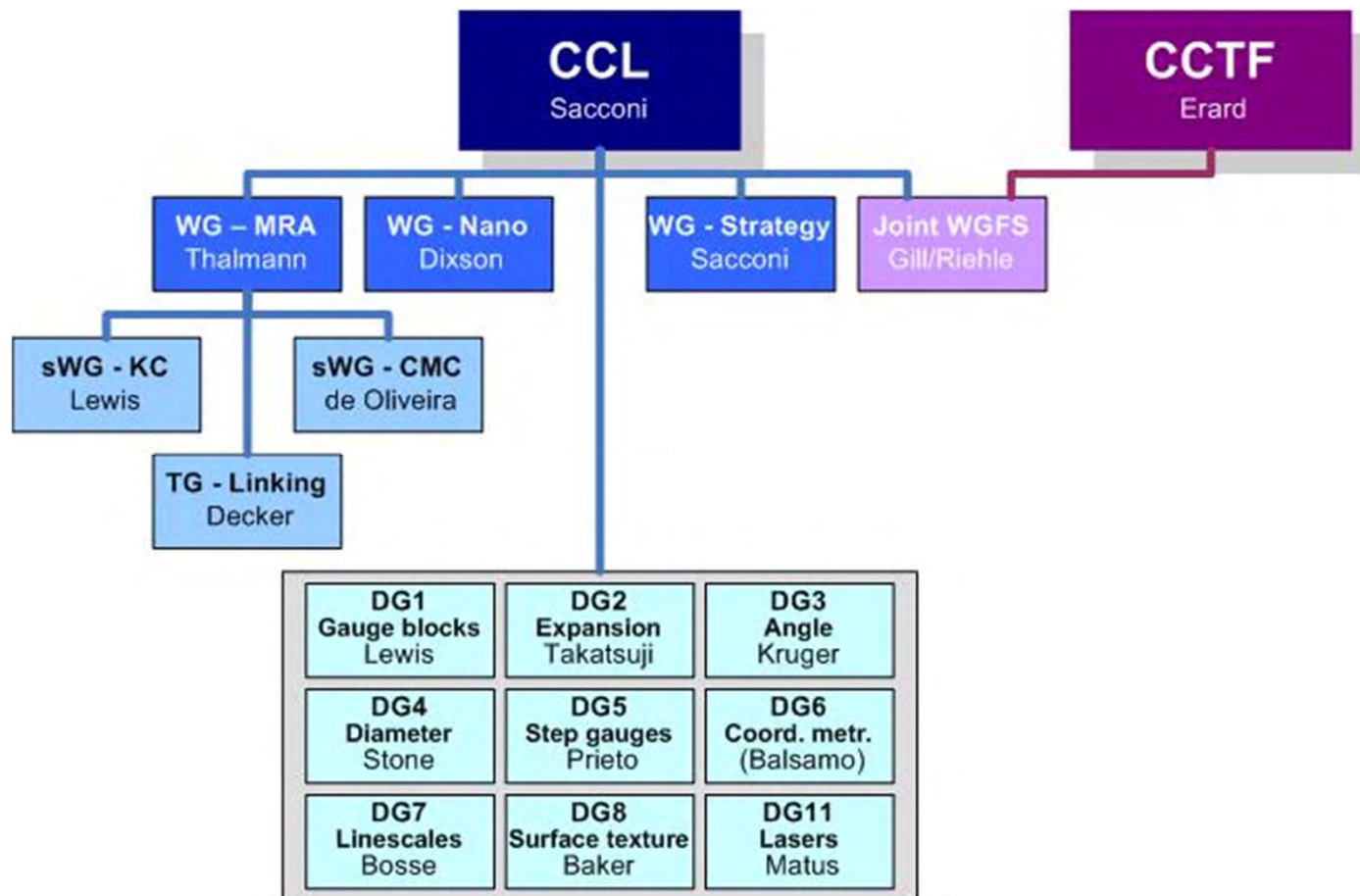
2 new members

- A*STAR, Singapore
- BEV, Austria
- CEM, Spain
- CENAM, Mexico
- CMI, Czech Republic
- LNE, France
- INMETRO, Brasil
- INRIM, Italy
- JILA, USA
- KRISS, Korea
- METAS, Switzerland
- MIKES, Finland
- NIST, USA
- NMIA, Australia
- NMIJ, Japan
- NMISA, South Africa
- NIM, China
- UME, Turkey
- NPL, United Kingdom
- NRC-INMS, Canada
- PTB, Germany
- SMU, Slovakia
- VSL, Netherlands
- VNIIM, Russia

New official observer: IPQ, Portugal.

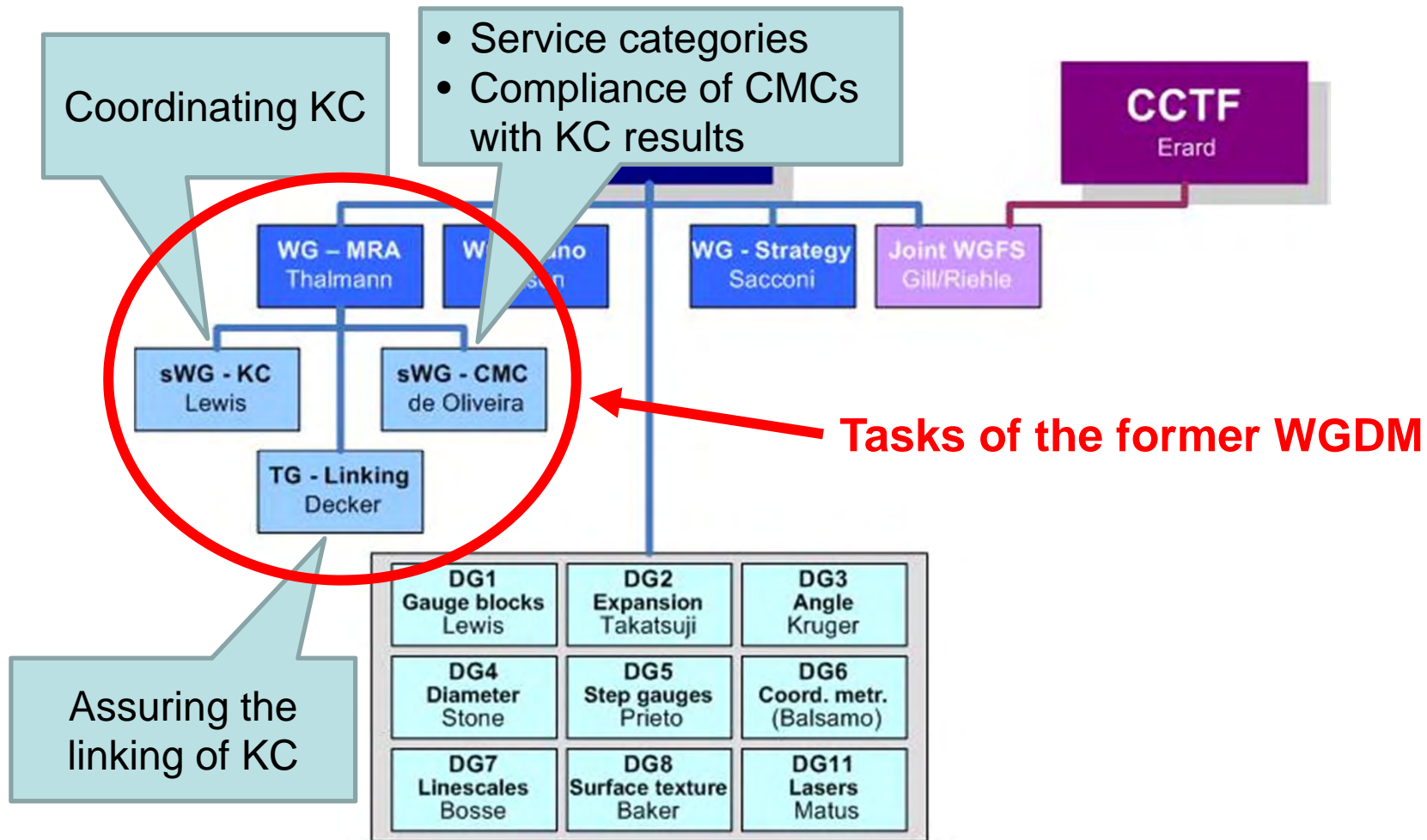
CCL working group structure

Following the recommendation of CIPM, CCL adopted in 2009 a new working group structure:



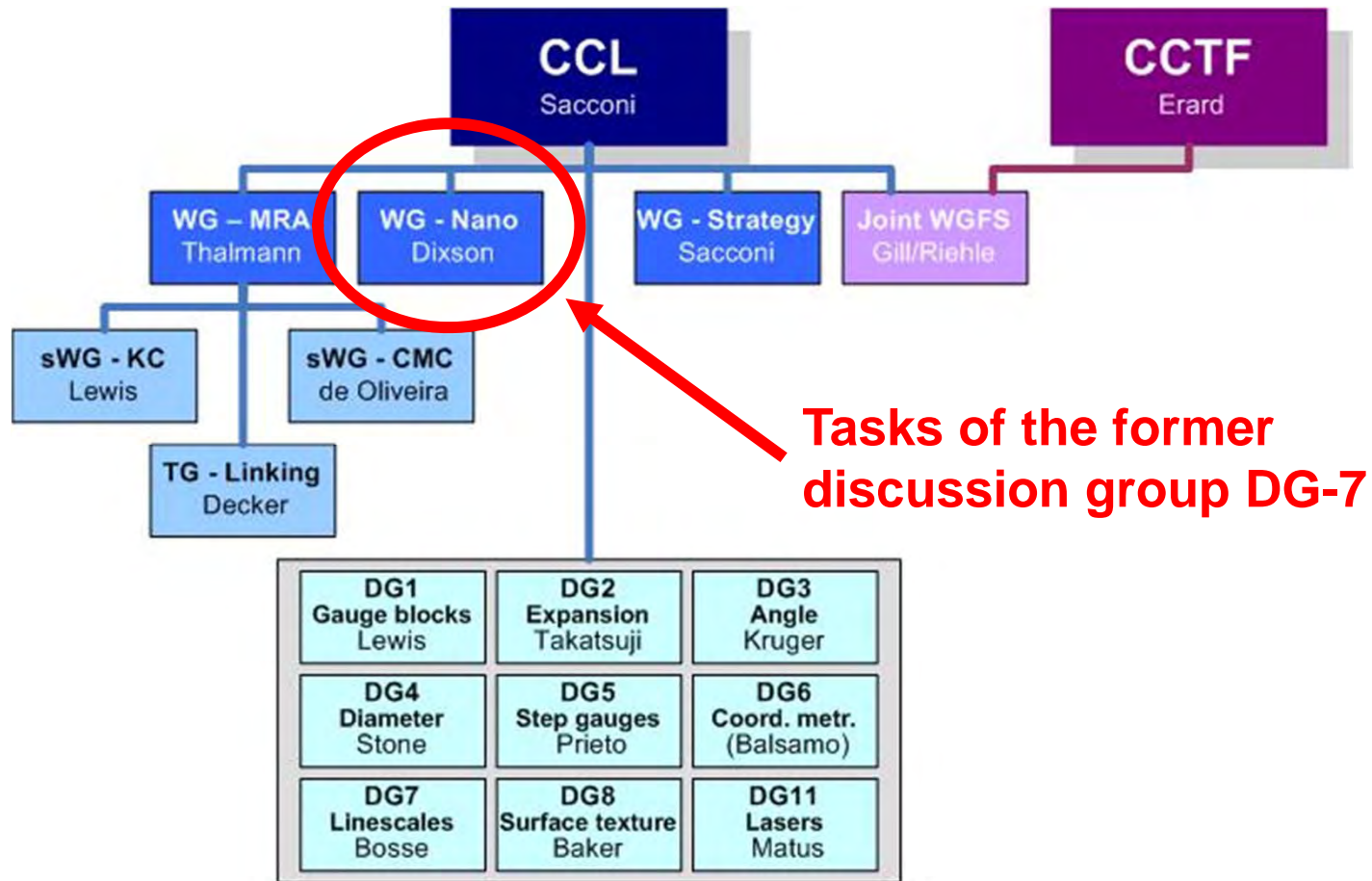
CCL working group structure

WG-MRA, including sub working groups and task group



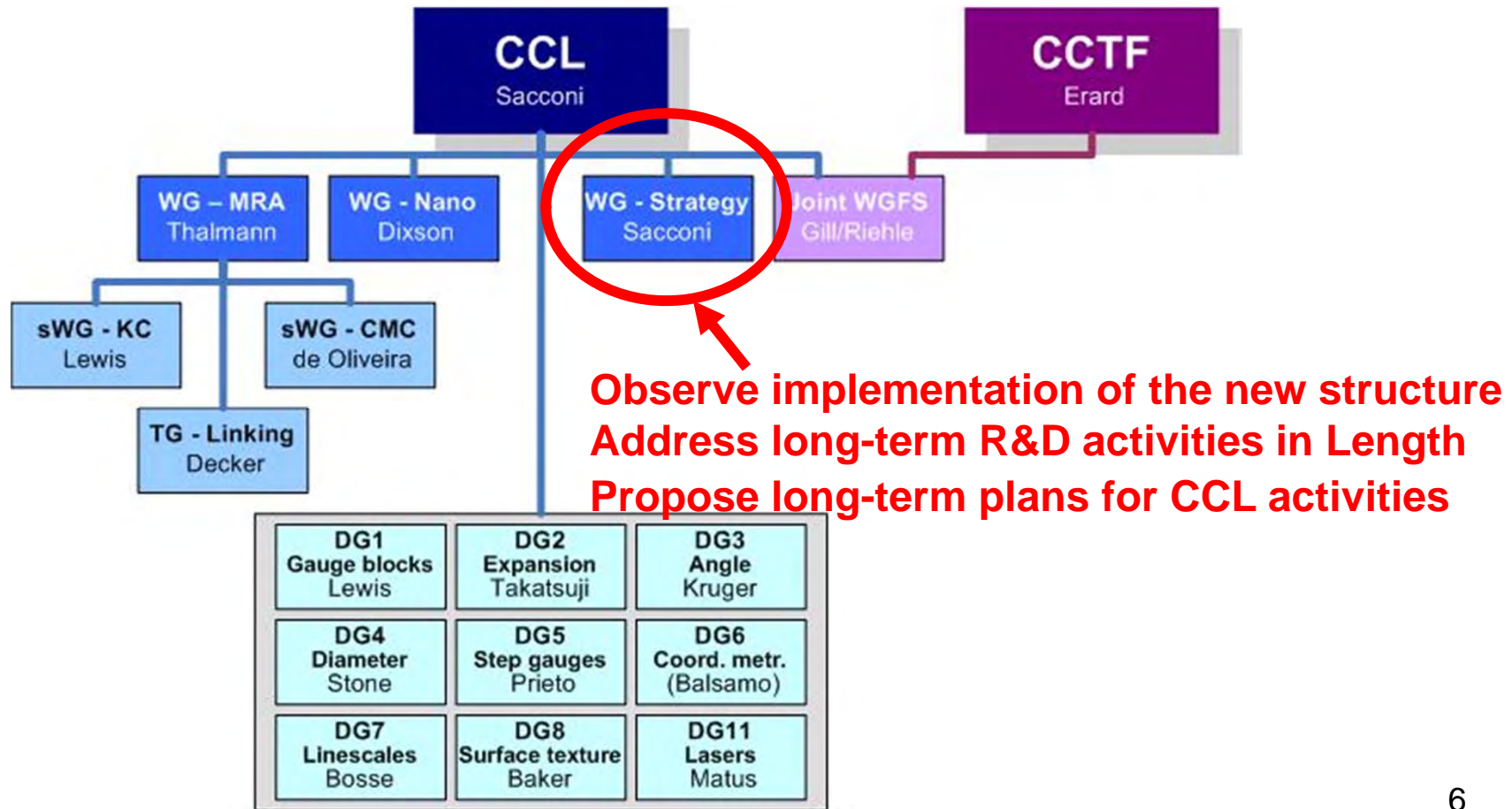
CCL working group structure

WG-N Dimensional nanometrology



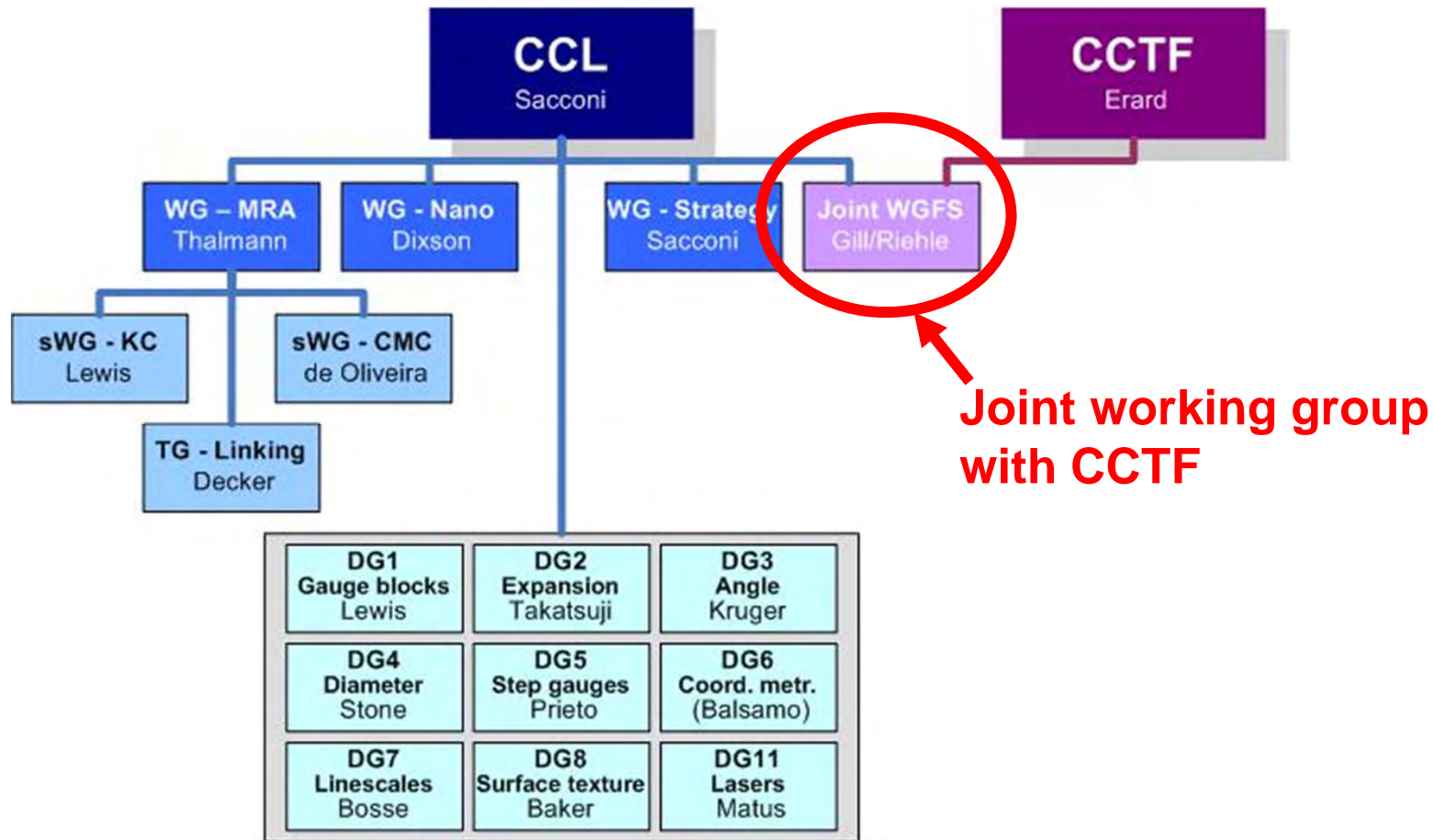
CCL working group structure

WG-S Strategic planning



CCL working group structure

WGFS Frequency standards





Meetings since last CGPM 2007

- WGDM 24 – 25 September 2008, INRIM, Torino
- FSWG (joint WG of CCTF and CCL), Sèvres, 2 June 2009
- WGDM 8 – 9 June 2009, BIPM
- **CCL 10 – 11 June 2009 (14th CCL meeting)**
- WG-S 9 June 2010, A*STAR, Singapore
- WG-MRA 10 – 11 June 2010, A*STAR, Singapore
(including TG-Linking and discussion groups)
- WG-N 10 June 2010, A*STAR, Singapore
- WG-MRA 6 – 7 October 2011, METAS, Wabern.

CCL Key comparisons

The first round of CCL key comparisons is completed:

- | | |
|----------------------------------|-------------------|
| • K1 Short gauge blocks | Results on KCDB |
| • K2 Long gauge blocks | Results on KCDB |
| • K3 Angle | Results on KCDB |
| • K4 Cylindrical diam. standards | Results on KCDB |
| • K5 Step gauge | Results on KCDB |
| • K6 Ball plate | Results on KCDB |
| • K7 Line scales | Results on KCDB* |
| • K8 Surface texture standards | Results on KCDB* |
| • K11 MeP lasers | Results on KCDB** |

* Conducted as CCL-RMO comparisons, still partly running

** On-going KC (former BIPM comparison).

CCL Key comparisons

The first round of CCL key comparisons is completed:

- K1 Short gauge blocks } Shall be combined to CCL-K1
- K2 Long gauge blocks }
- K3 Angle Results on KCDB
- K4 Cylindrical diam. standards Results on KCDB
- K5 Step gauge Shall be abandoned; DG6 is investigating new ways to validate the coordinate metrology CMCs
- K6 Ball plate
- K7 Line scales
- K8 Surface texture standards Results on KCDB*
- K11 MeP lasers Results on KCDB**



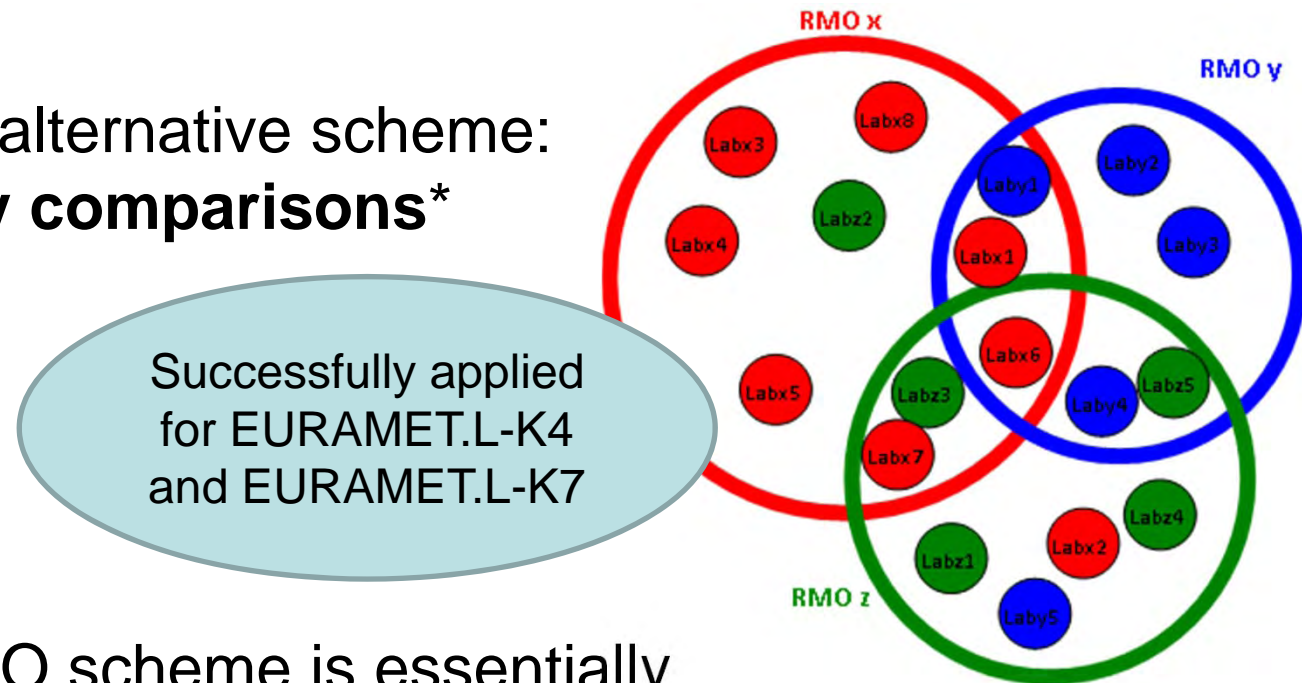
RMO Key comparisons

The first round of RMO key comparisons is completed:

- | | |
|----------------------------------|------------------|
| • K1 Short gauge blocks | Results on KCDB |
| • K2 Long gauge blocks | Results on KCDB |
| • K3 Angle | Results on KCDB |
| • K4 Cylindrical diam. standards | Results on KCDB |
| • K5 Step gauge | Results on KCDB |
| • K6 Ball plate | Results on KCDB |
| • K7 Line scales | Results on KCDB* |
| • K8 Surface texture standards | Results on KCDB* |

CCL-RMO key comparison

If appropriate, alternative scheme:
CCL-RMO key comparisons*



- The CCL-RMO scheme is essentially equivalent to the „classical“ scheme: From the commonly participating labs, a „**virtual CCL-KC**“ may be formed
- CCL-RMO comparisons are linked

* *The CCL-RMO comparison scheme, CCL/WGDM/09-22*



2nd round of key comparisons

Currently, CCL is running the 2nd round of key comparisons:

- CCL-K1.2011, Gauge blocks running
- EURAMET.L-K3, Angle running as CCL-RMO-KC.



Problems with key comparisons

- Finding pilot laboratories for 2nd round
- Finding comparison standards (cost!)
- Delayed reports
- Monitoring the progress of KC
- Monitoring CMC claims versus KC results
- Monitoring corrective actions

The problems are addressed!

- Finding pilot laboratories for 2nd round
- Finding comparison standards (cost!)

No solution!

- Delayed reports
- Monitoring the progress of KC
- Monitoring CMC claims versus KC results
- Monitoring corrective actions

WG-MRA developed new tool for monitoring the progress

- Executive reports
- Guidance document*
- sWG-CMC

* CCL WG-MRA-GD1, Running of MRA comparisons in length metrology and monitoring their impact on CMCs

WG-N Dimensional nano metrology



Pilot Study	Artefacts	Status
Nano1	linewidth (CD mask)	in progress
Nano2	step heights	completed
Nano3	linescales	completed
Nano4	1D gratings	completed
Nano5	2D gratings	completed
Nano6	linewidth (Single Crystal CD)	in progress

- 6 pilot studies successfully operated
- Results published in KCDB as CCL supplementary comparisons

Establishing traceability in nano metrology

Future possibilities:

- Atomic scale step heights
- Sub-nanometer surface roughness
- Nanoparticle measurements
- Deep sub-micrometer pitch.

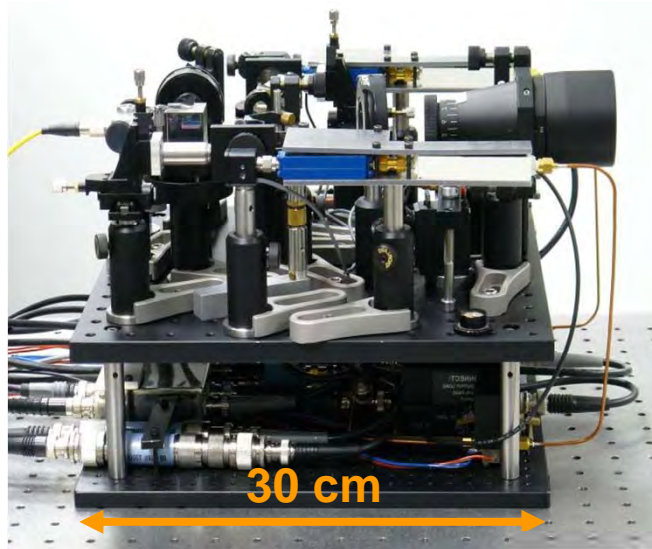
Challenges in Length Metrology

From kilometres to nanometres

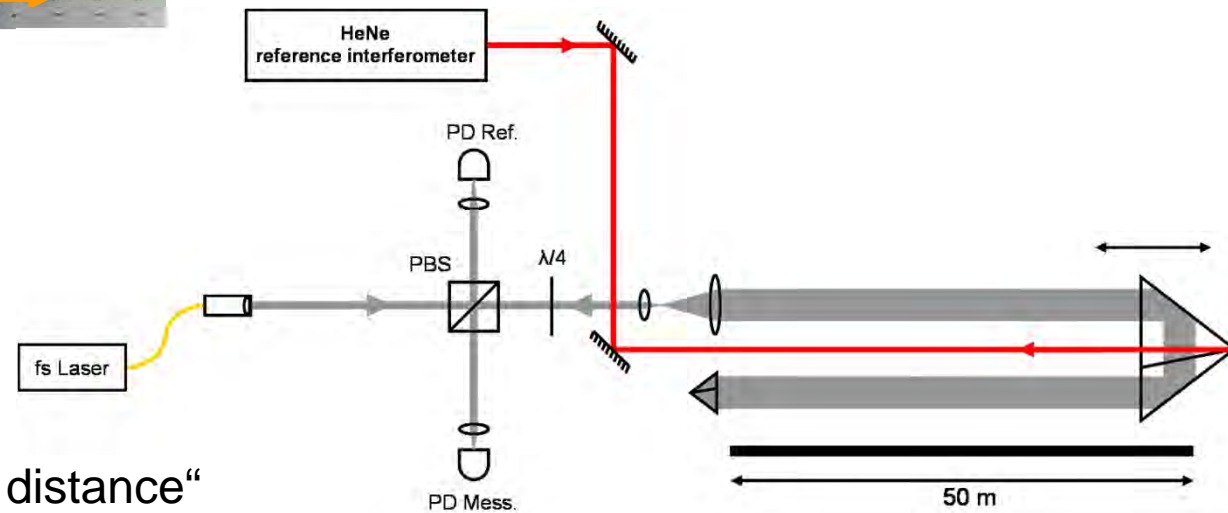


- Long distance interferometry and range finding (including fs frequency comb applications)
- Metrology of large structures in production engineering
- Multi-sensor (tactile, optical) coordinate metrology
- Micro x-ray computed tomography
- Micro coordinate metrology for micro parts
- Metrology of functional structured surfaces (including areal surface texture)
- 3D metrology at the nano scale
- Metrology of nano particles
- High resolution interferometry at sub nanometre accuracy.

Long distance interferometry using fs frequency combs



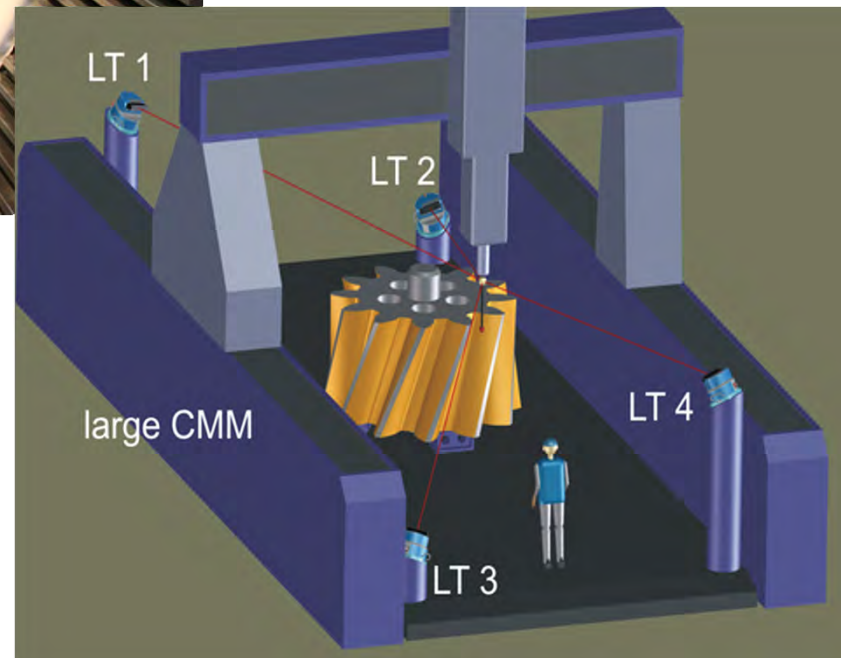
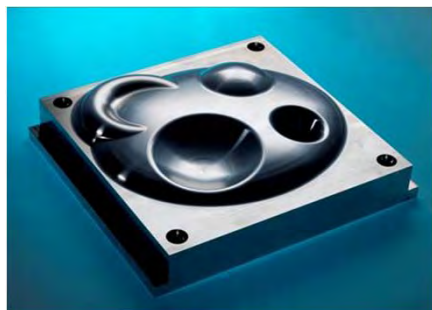
Time of flight distance measurement based on fs laser



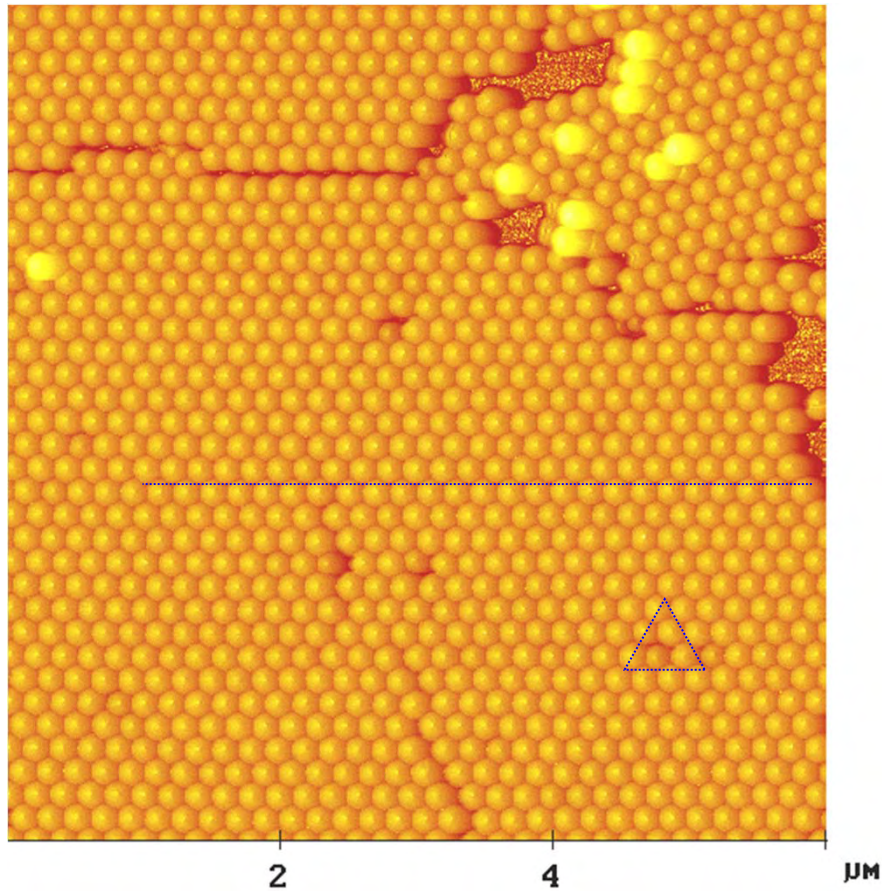
Metrology of large structures



Laser tracer assisted coordinate metrology



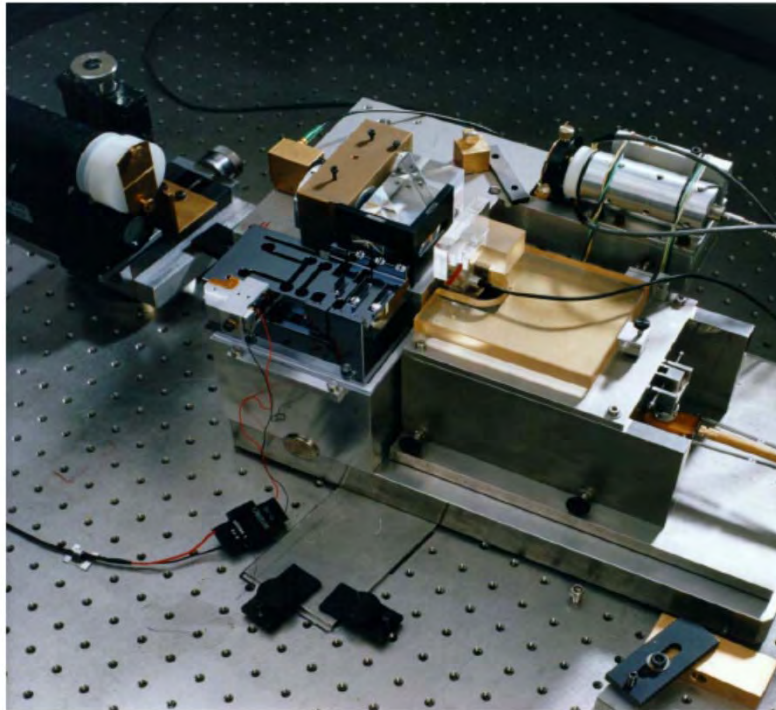
Metrology of nano particles



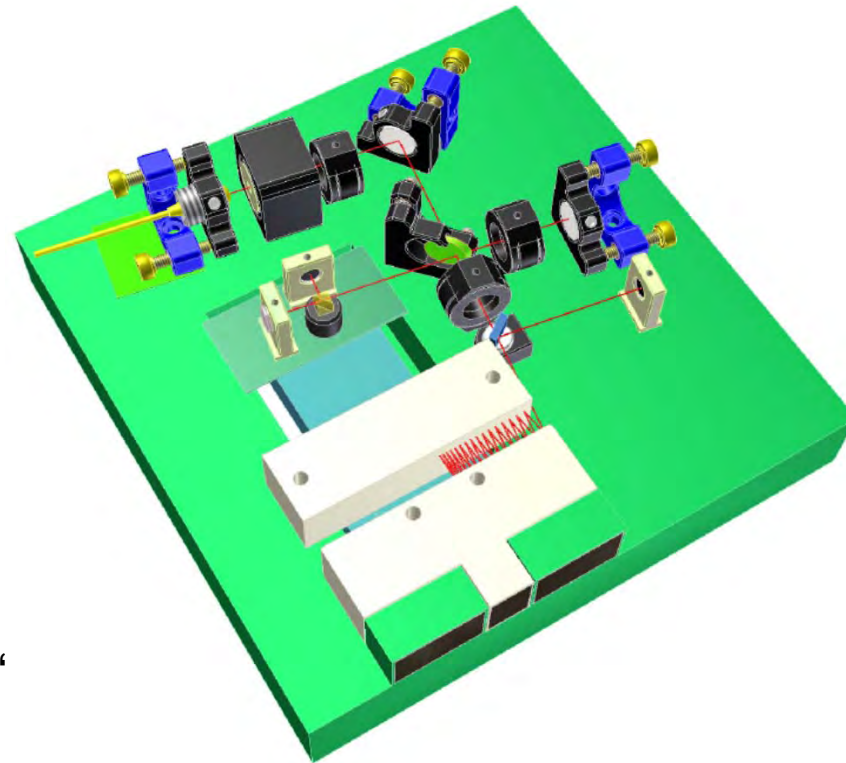
Nano particles measured with metrology AFM



High resolution interferometry at sub nanometre accuracy



COXI (x-ray interferometer) and high accuracy transfer standard for interferometer comparison at pm resolution.



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Thank you for your attention!