NIM, *Today and in Future*

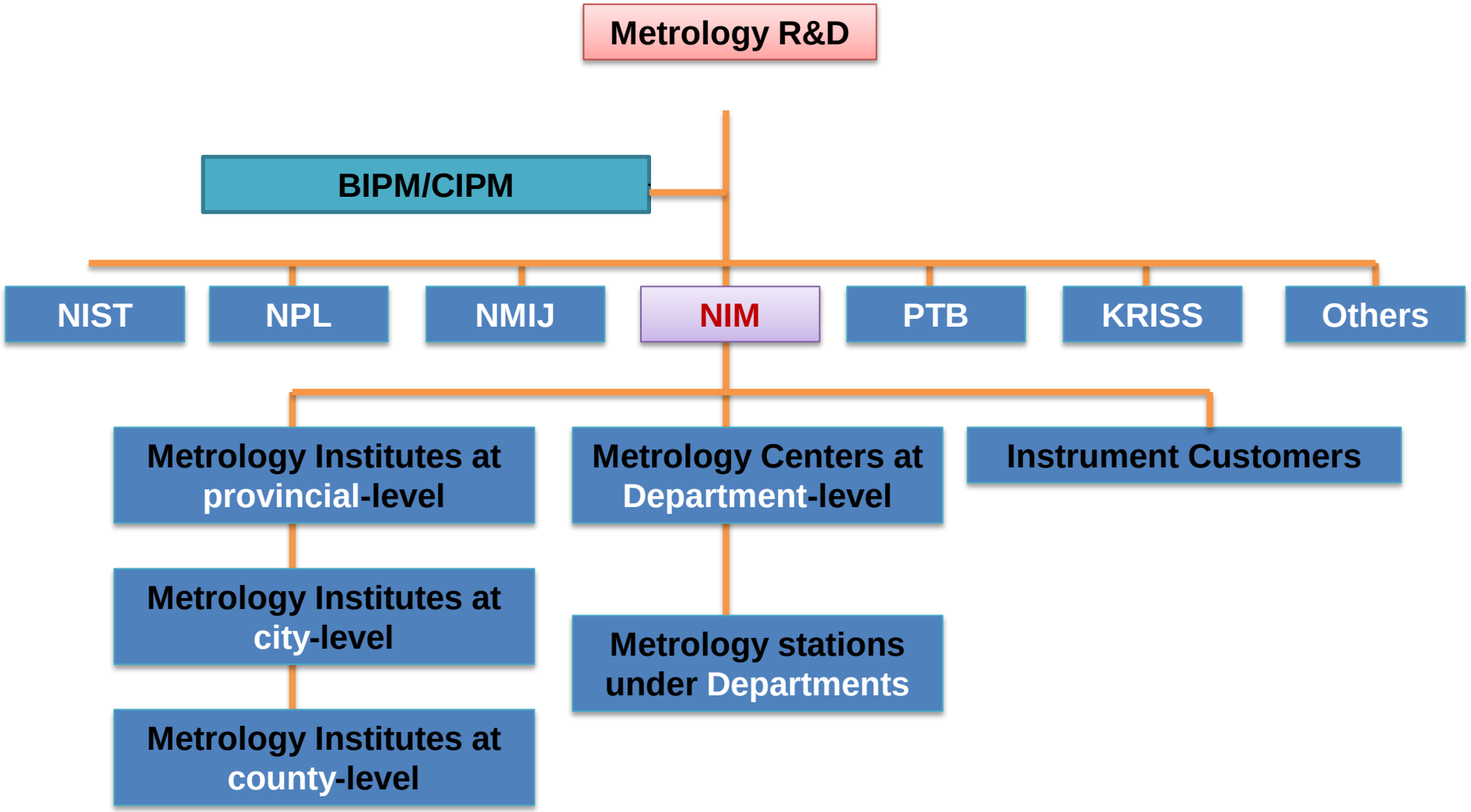
WU FANGDI **Deputy Director of NIM**

AUG 9,2016 GUANGZHOU

中国计量科学研究院
National Institute of Metrology,China

Content

NIM's role in the traceability Chain



1. Role and Tasks

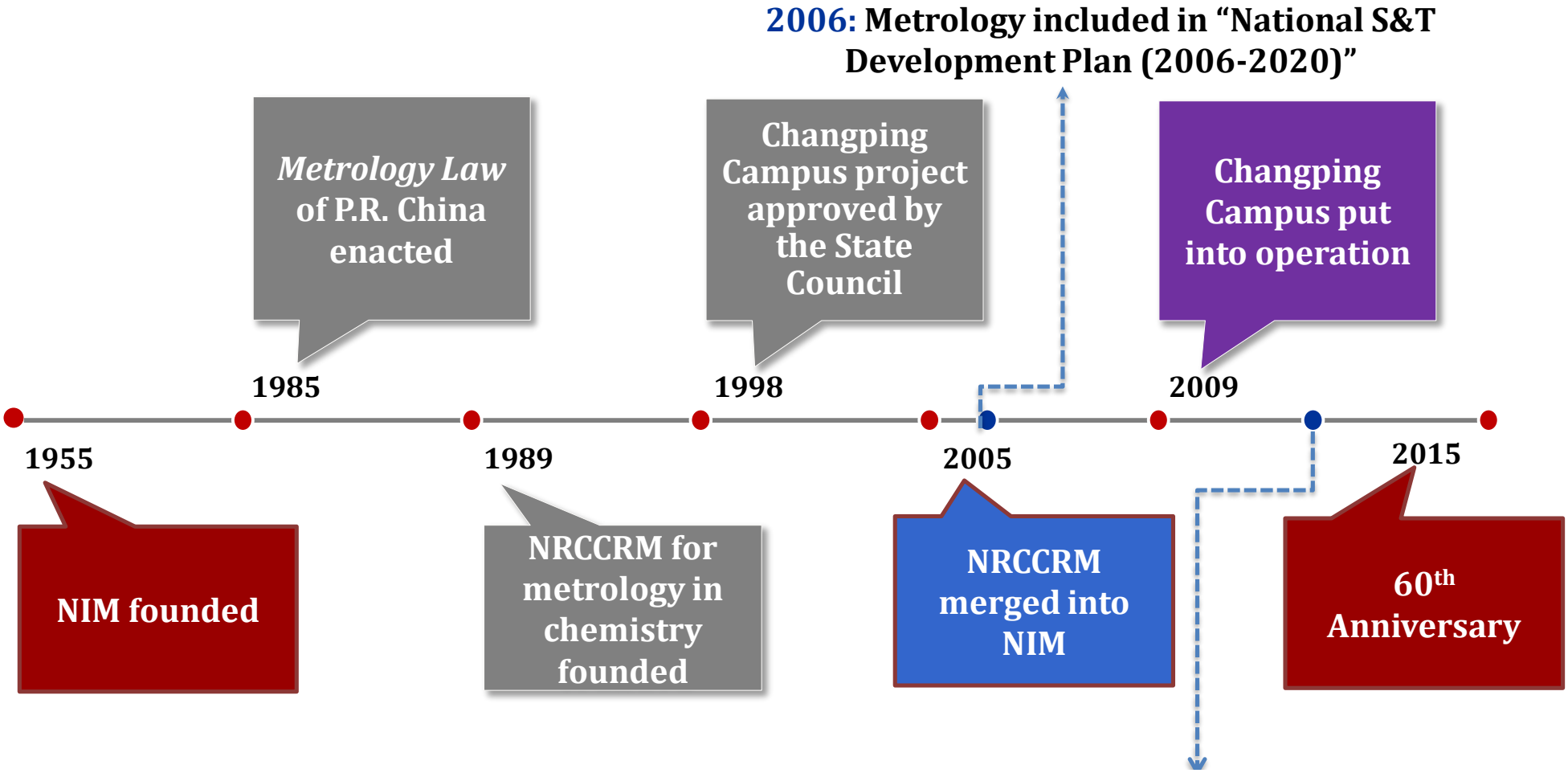
What is NIM

1. Founded in 1955, a non-profit research organization under AQSIQ
2. the National Metrology Institute (NMI) and the state-level technical body for legal metrology
3. China's signatory to the CIPM MRA a member of APMP
4. At the heart of Chinese metrology system

Tasks

1. Develop national measurement standards and ensure their international equivalence by participating in international comparisons;
2. Maintain competitive measurement capabilities and disseminate quantity values to ensure accuracy and consistency of quantity values throughout China;
3. Conduct basic and applied research to meet national needs

2. Milestones



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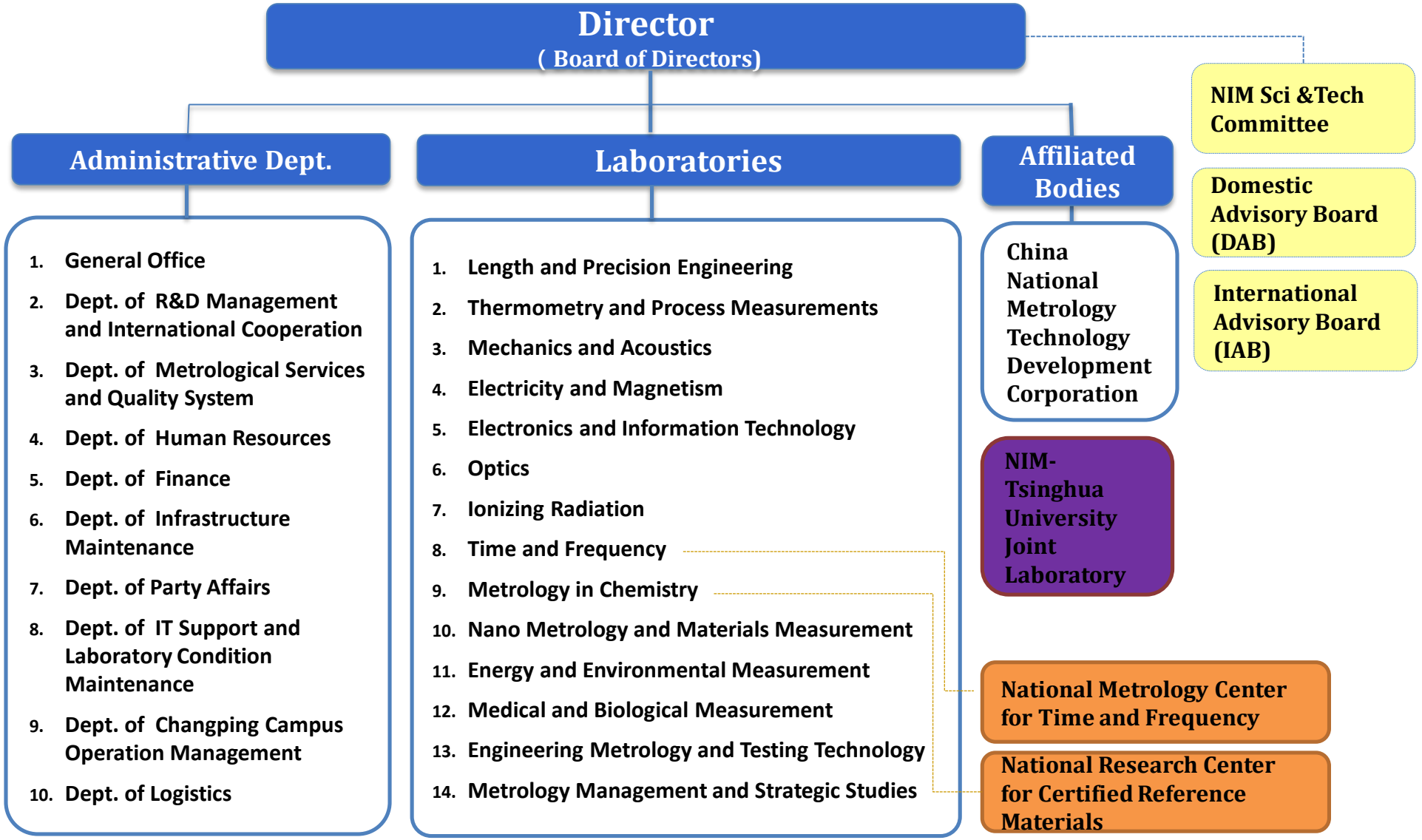
3. Organization



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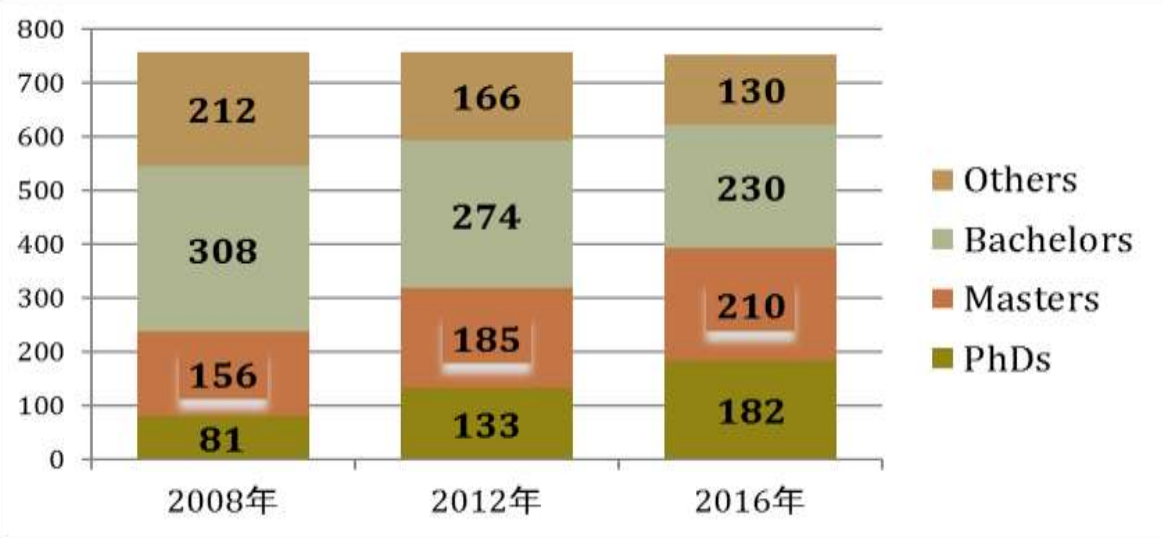
Staff & Budget

Staff: approx. 1000

•750 full-time employees, 150 contract employees, 100 students (26 post-doctors)



Budget: $123 million (800 mil YUAN) annually

•70% government appropriations

•30% service income

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Technical capabilities

Measurement Standards

•**441 national standards** , ***increase by 18% from the year of 2010***
•**1356 types of CRMs**, ***increase by 42% from the year of 2010***

Metrological Services

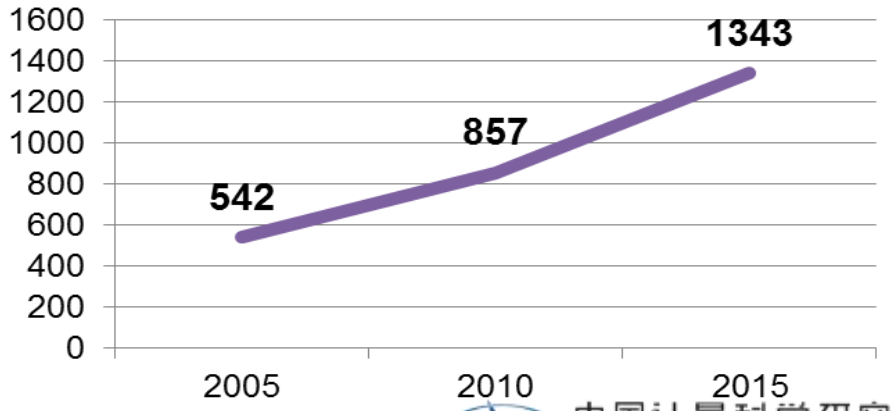
•**Providing 587 AQSIQ-authorized verifications, 568 CNAS-accredited calibrations and 335 testing services to customers**

International Comparisons

•**~700 BIPM/CIPM/APMP comparisons**
•**More as piloting lab**
•**participation rate in international and regional comparisons exceeding 60%.**

CMCs

•**1343 CMCs in BIPM KCDB, *increase by 41% from 2010, from 9th to 4th***



Awards & Honors

80 state-level science awards
Nearly 400 ministry-level science awards

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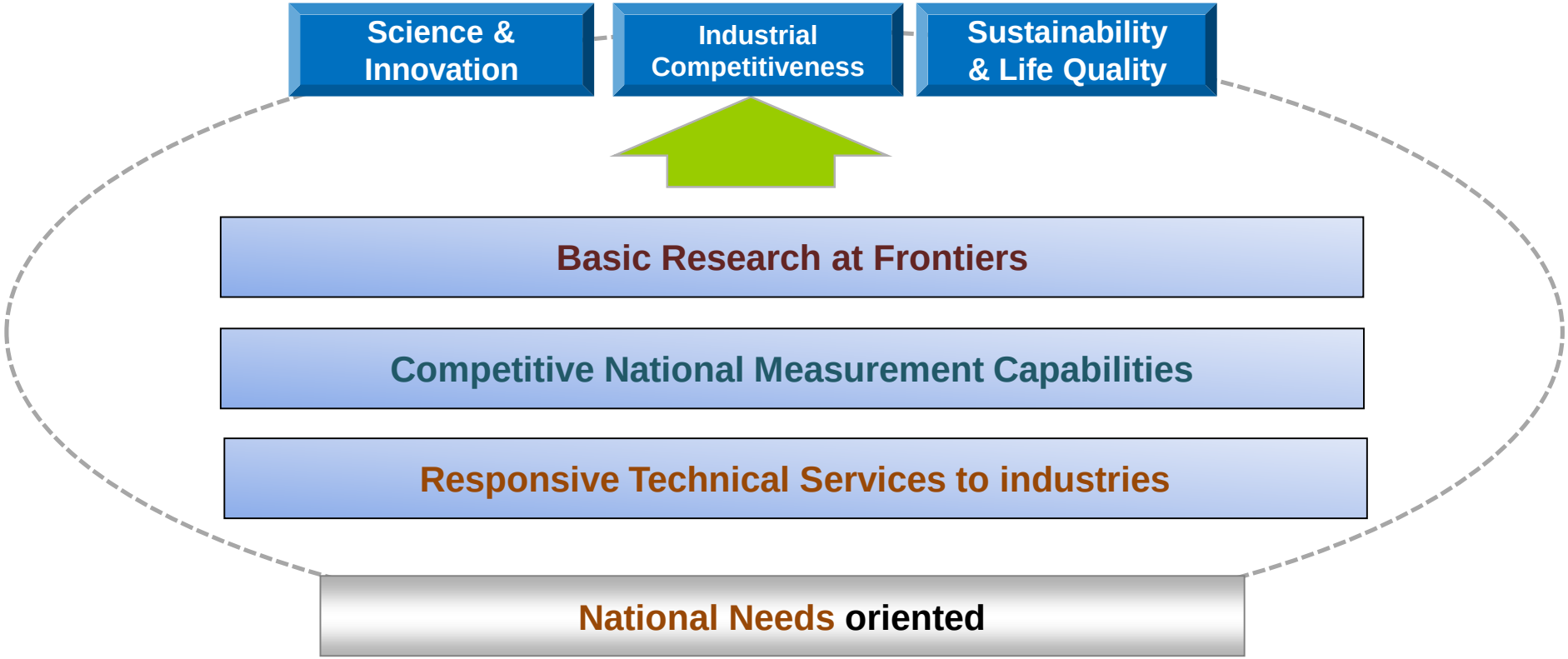
Content

Mission

MISSION

To support China's economic growth and social progress with world-advanced science, standards and measurement capabilities.



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1. Fundamental research

SI - Determination of fundamental physical constants and development of advanced quantum measurement standards

Funded by the National Key-Tech Research Program of MoST

- Determination of k_B
- Measurement of molar mass of ^{28}Si crystal for determination of N_A
- Joule Balance (h)
- Calculable capacitor and determination of fine-structure constant
- Cesium Atomic Fountain clock
- ^{87}Sr optical lattice clock
- Programmable Josephson junction array voltage standard
- Primary method of isotopic abundance measurement

1.1 Determination of k_B

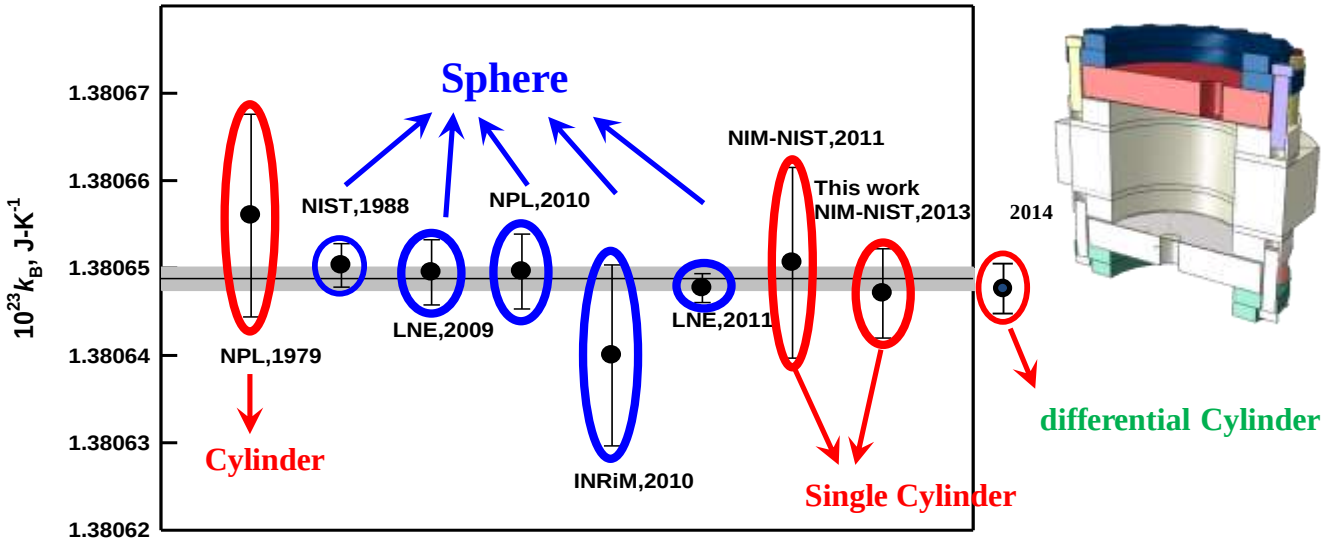
Determination by a single cylindrical resonator has reached uncertainty of 3.7×10^{-6}, contributing weight to the adjusted value published on CODATA. With the noise thermometry, it has reached uncertainty of 3×10^{-6}.

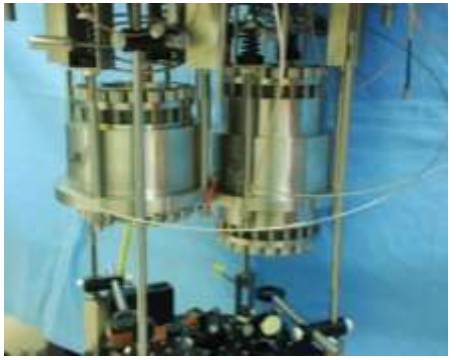
Now only NIST and NIM have got consistent k_B constant measurement results with two different methods.

Acoustic thermometry
NIST、NPL、LNE、NIM、INRIM
Uncertainty~ $(2\sim2.5)\times10^{-6}$

k_B

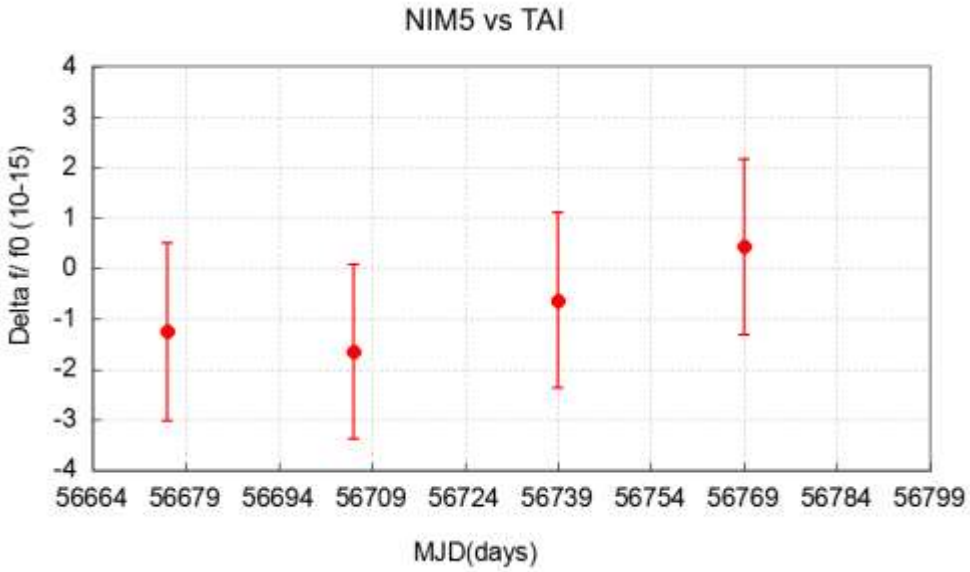
Noise thermometry
NIST、NIM
Uncertainty~ 3×10^{-6}





1.2 Cs Fountain Clock

2014: NIM5 evaluations has been accepted by BIPM and published on Circular T



NIM5 data vs TAI from Circular T 319

In progress: Development of NIM6 clock :

- NIM5+ NIM6 contribute to UTC

- steer TA(NIM)

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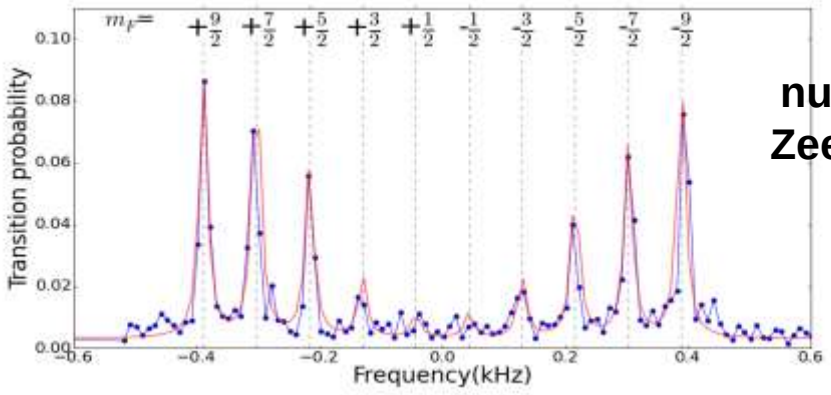
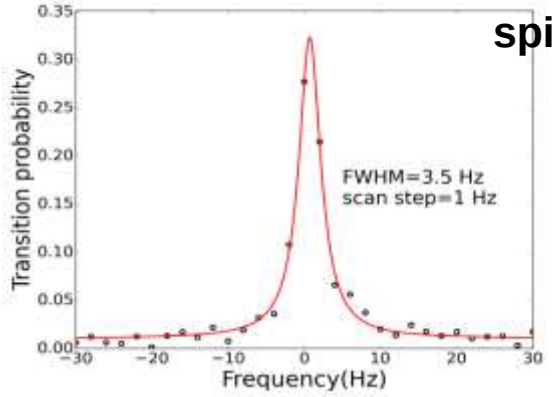
1.3 Strontium Optical Lattice Clock

Narrow clock transition linewidth: 3.5 Hz (2015)

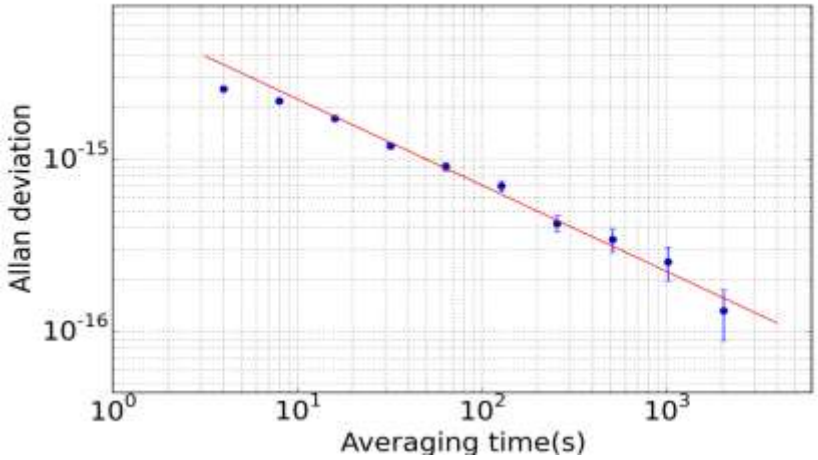


nuclear spin Zeeman state



spin polarized

self-comparison stability 1.3e-16 @ 2000s (2015)



Target of 2015:

- Evaluation uncertainty <5e-16

- Calibration uncertainty <5e-15

Report data to CCTF in 2015。

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1.4 Measurement of molar mass of ^{28}Si crystal

PTB, NIST, NRC, NMIJ and NIM have all determined the molar mass of ^{28}Si crystal using MC-ICP-MS. NIM's results got in China and at PTB have both shown good agreement with PTB's results.

Besides, NIM has used a different method, a high resolution inductively coupled plasma mass spectrometer (HR-ICP-MS) (Element 2) combined with the (IDMS).

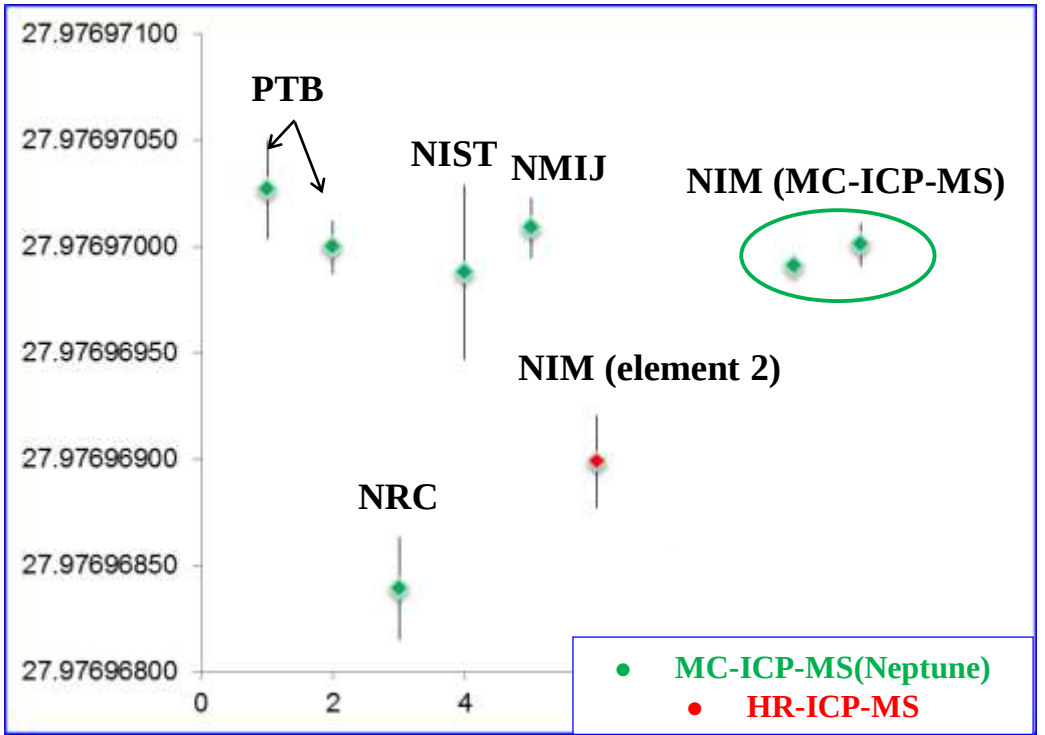
NIM will participate in the CCQM-P126 for Si isotopes measurement piloted by PTB.

Neptune
MC-ICP-MS

PTB,NIST,NRC,NMIJ, NIM

Element 2
HR-ICP-MS

NIM



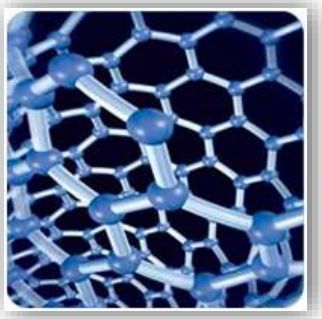
2. New metrology areas

New metrology areas in support of new-tech, emerging industries and social sustainability…

(National Key Technologies R&D Program, Ministry of S&T)

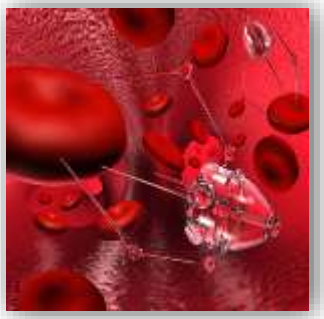
Energy

Environment

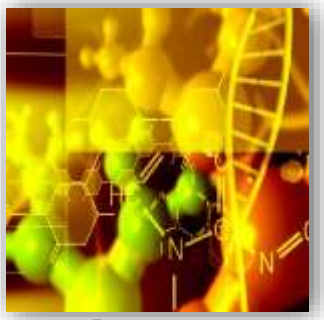


Nanotech &new materials

Information Technology



Biology



Chemistry

Medical equipment

3. Scientific Instrumentation

Development of torque and velocity measuring instruments for high-end motive power devices

Torque measurement

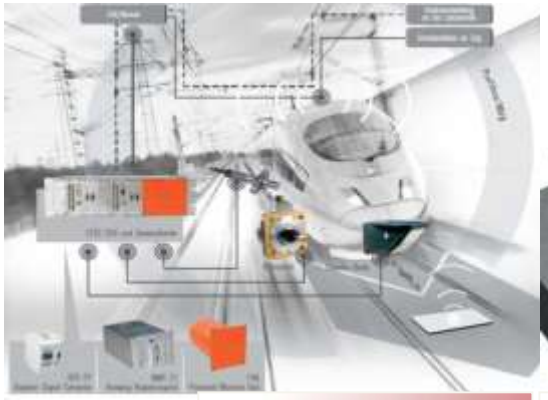
•R&D of high-precision air bearing technology and 20 kNm standard torque machine

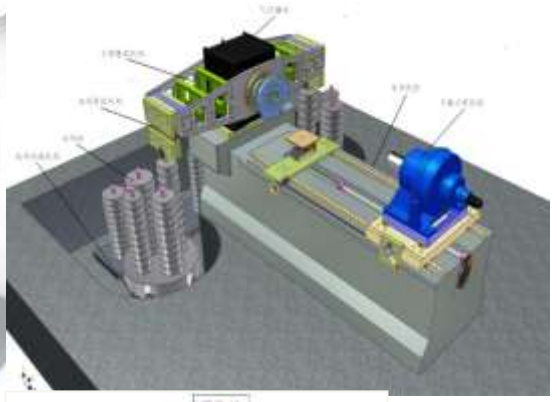
Velocity measurement

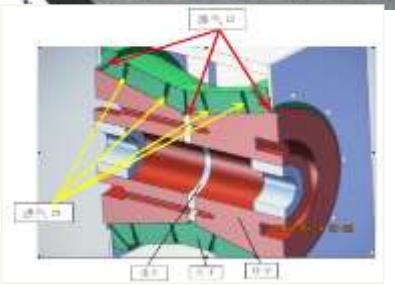
• R&D of Doppler Radar technology and high-precision instrument

Acceleration measurement

• R&D of calibration system for air-bag accelerometers







Mechanic power depends on torque and velocity

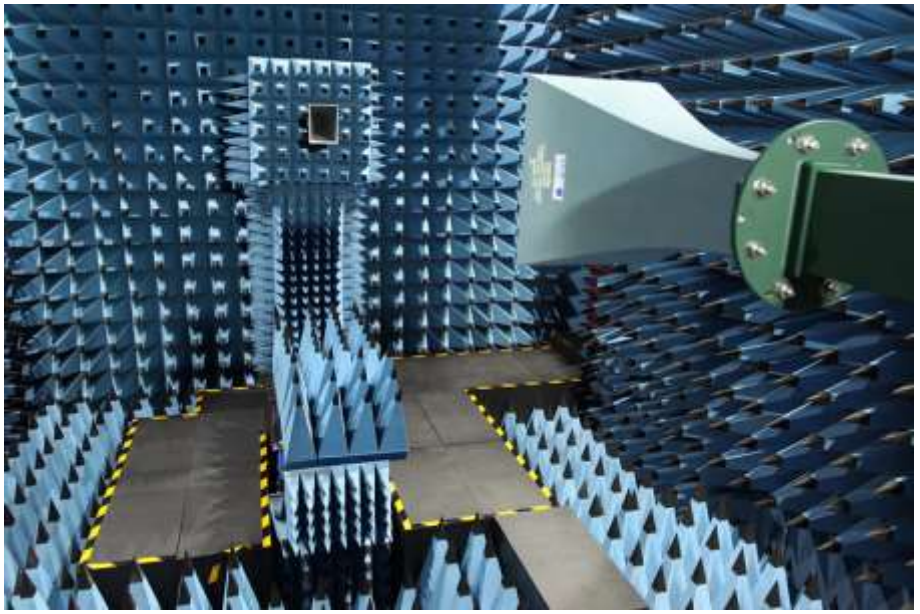
•The safety of high-end motive power devices is closely related with reliable measurement of torque, velocity and acceleration.

4. Laboratories and Facilities

Open area test site (OATS)

- Measurement range: 30MHz – 2GHz
- The largest in the world:
  60 m (length) × 40 m (width)
- Best flatness: Center 25m * 25m ± 4mm
  Overall 60m * 40m ± 6mm
- Weathering steel welding (10 mm thick)
- Non-reflection within 40m

HF antenna metrology laboratory



- Measurement range: **250MHz-110GHz**
- Anechoic chamber inner size:
  15m [L] ×7.5m [W] × 7.7 m [H]
- reflectivity level: lower than 80dB.
- Indoor rail:10m, straightness ±0.06mm
- measurement uncertainty: ±0.04dB

4. Laboratories and Facilities

Gravity laboratory

A new gravity lab for hosting the ICAG-2017 is under construction

Size: 320 m^2. A concrete pier of 22.0 m×5.0 m which can provide very quiet site will enable10 instruments to operate together. Temperature control: 21°C ± 0.5°C

Absolute gravimeters

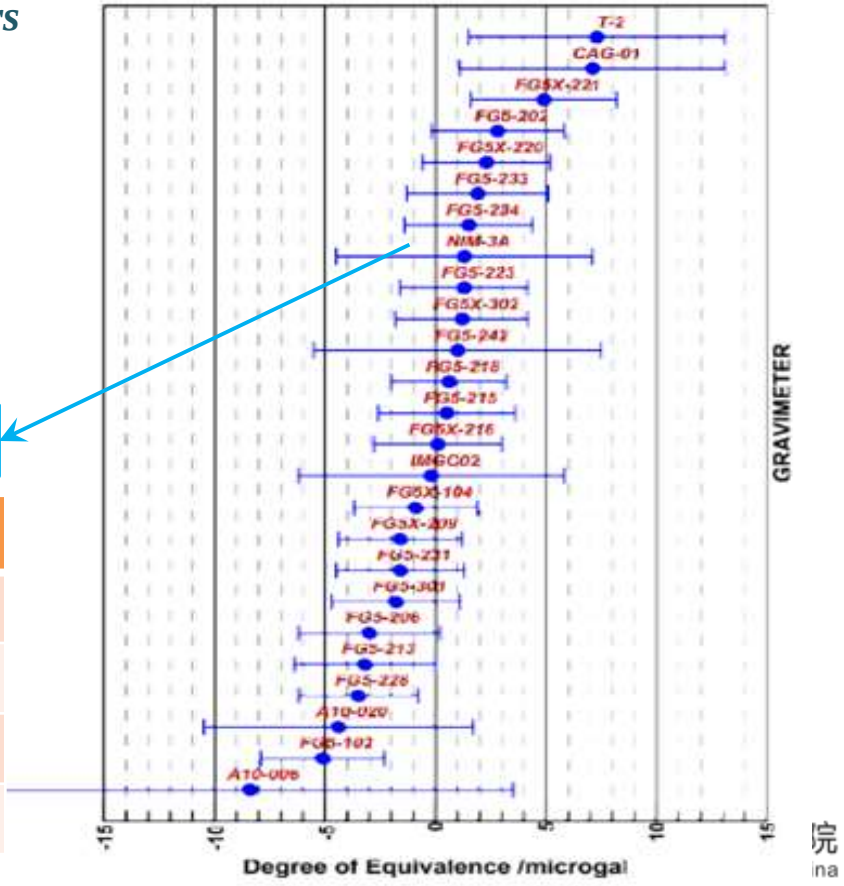
FG5-X

NIM-3

NIM-3A

Gravimeters	*Uncertainty*
FG5-X	*2μgal*
NIM-3A	*6μgal*
NIM-3	*50μgal*
Atom Gravimeter	*Under development*

Result of ICAG-2013 Draft A



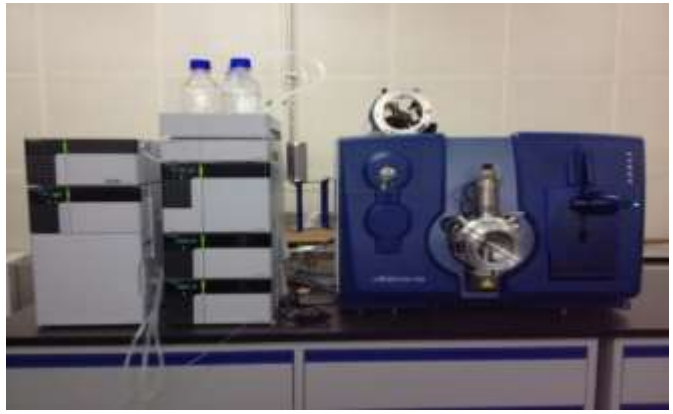
4. Laboratories and Facilities

Chemical Metrology Lab at Changping

Thermo MAT253稳定同位素质谱仪

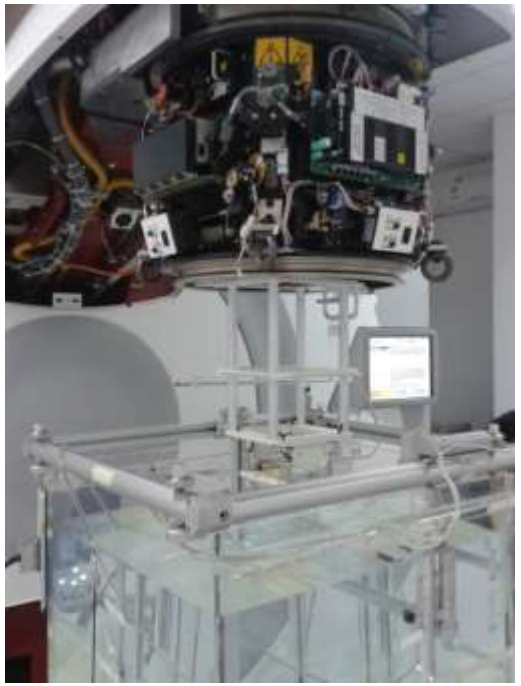
Waters Synapt G2 HDMS
离子淌度质谱仪

ABI-5500型Qtrap线性离子阱质谱



4. Laboratories and Facilities

CLINICAL LINAC Laboratory



- Photons : (4, 6, 8, 10, 15, 18, 25) MV
- Electrons : (4, 6, 8, 10, 12, 15, 18, 20, 22) MeV
- Radiation field size: 0.5 cm x 0.5 cm to 40 cm x 40 cm
- Dose rates: 0.5 Gy/min to 5 Gy/min

A cooperation project with NRC:

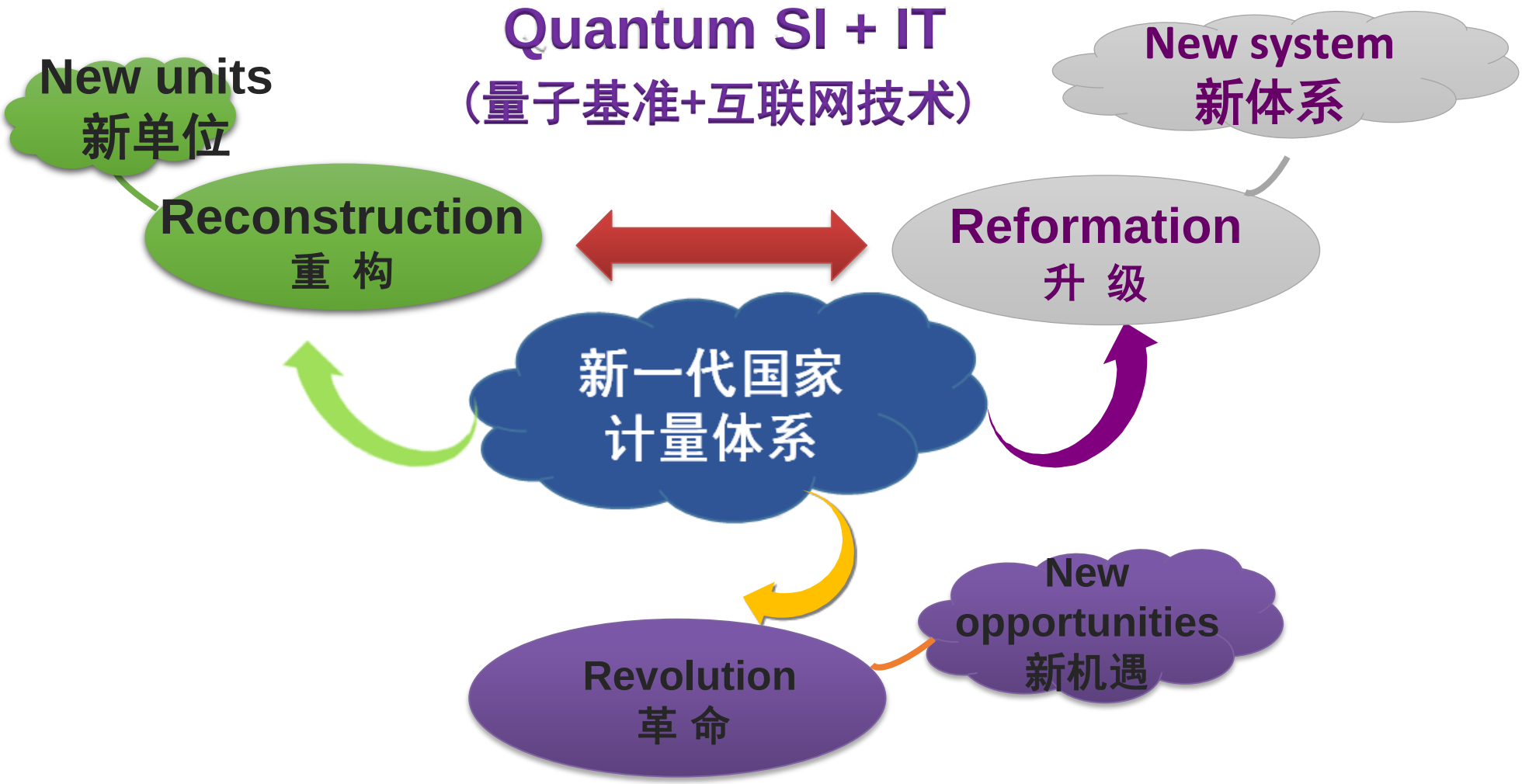
- Absorbed dose to water measured by water calorimeter for photon of 10 MV with the uncertainty of 0.35% (*k*=1). NIM plans to do the BIPM.RI(I)-K6 comparison in 2016.

4. Laboratories and Facilities

Nano-scale Metrology Lab

Content

1. Opportunities & challenges



Reconstruction 重构

不受时空限制
Do not vary with time/space

独立计量体系
Independent reproduction

突破测量极限
New limit of accuracy

Reconstruction
重 构

New units
新单位

新领域和新单位
New areas and New units

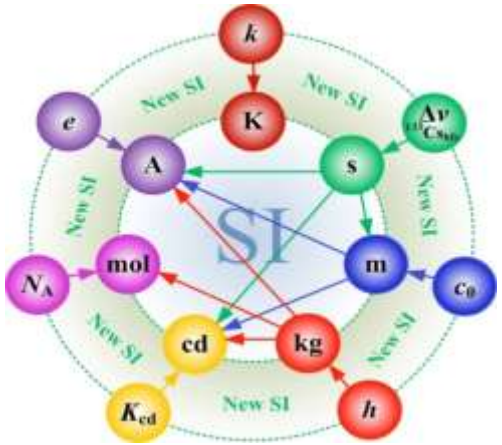
量子计量
Quantum Metrology

支撑SI重新定义的
基本物理常数测量
Determination of
Fundamental physical constant

高准确度
High accuracy

高稳定性
High stability

量子化
Quantum physics based



新一代量子计量基准
Next-generation Primary Measurement Standards

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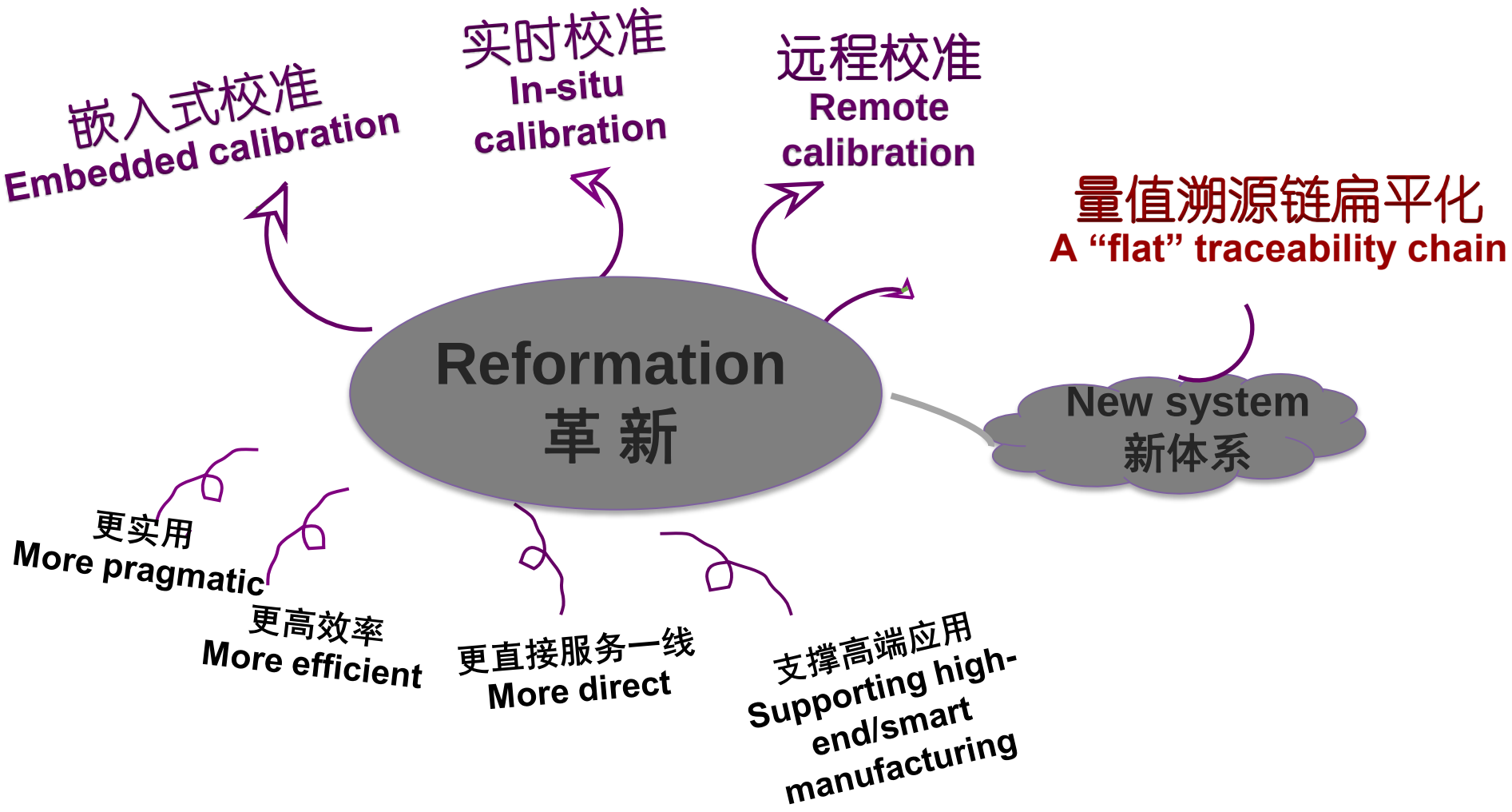
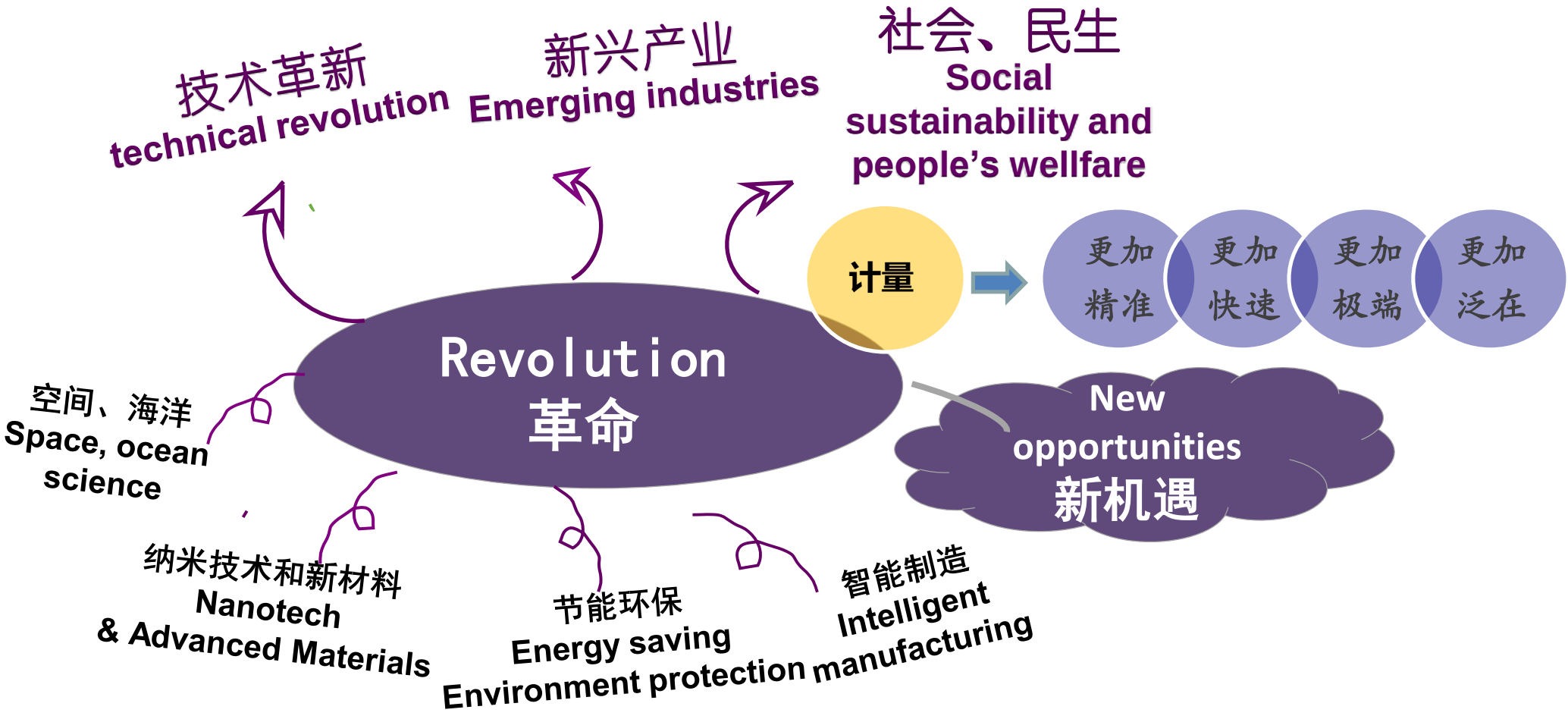
Reformation 升级



Revolution 革命



2. National strategies

“Innovation-driven Development” Strategy

10 industrial sectors of the 'Made in China 2025' strategy

Energy-saving & Environmental Protection

Metrology

“One Belt, One Road” Initiative

New Silk Road Economic Belt
the 21st Century Maritime Silk Road

Industrial Upgrading
(7 Strategic Emerging Industries)

- New Energy
- Environment
- Advanced materials
- Biology
- New IT
- New-energy Vehicle
- High-end Instrumentation

3. What to do?

1. Promote metrology to be at national strategic level

NIM strategy

National Metrology Development Plan (2013-2020)
National S&T Plan for the 13th Five-Year Period
AQSIQ 13th Five-Year Period Plan
13th Five-Year Plan for various sectors…

2. Stable government funding : propose a "Metrology R&D Program"

China's new-round of R&D Budget Management Reform (2014-2017)

To classify Central R&D Budget into **5 categories**:

1. **Natural science foundation** for basic research
2. **National Key Sci&Tech Project s**, e.g. aerospace, large aircraft;
3. **Key area R&D Funding:** e.g. environment, materials, **metrology??...**
4. **Enterprise Innovation Funding**
5. **Personnel and Infrastructure Development Funding**

3. Raise Metrology's legal status

4. Strategy for 2025

NIM Strategic Plan (2015-2025)

使命：

通过建立国际先进的计量基标准，提供一流的量值溯源服务和测量能力，支撑国家工业竞争力的提升和经济社会的发展。

Vision:

To promote industrial competitiveness and underpin the economic and social development of the country with world-advanced science, standards and measurement capabilities.

To be released by the end of 2015

6. Metrology R&D Program

1. **Fundamental research at frontiers - a quantum physics and IT based national measurement standard system;**
   - The development of new-generation quantum measurement standards, e.g. *optical clock*
   - The determination of fundamental physical constants for the SI base unit redefinition, e.g. K_b, N_A, *e, Joule Balance*
   - Chemical metrology, biological metrology.

2. **New fields of metrology - underpin industrial upgrading, social sustainability**
   - ***Priority new fields of NIM:*** Energy, environment, nano-metrology &advanced materials, medicine, biology, quantum devices, ocean, IT..

3. **Competitive measurement and calibration capabilities - a modern traceability chain conducive to industrial needs**
   - Embedded, in-situ calibration, remote calibration methods and tools,
   - Traceability system for micro/super large, dynamic quantities and measurements under extreme conditions…

7. Phase-II construction of Changping Campus

100,000 m^2
Budget: € 500 mil (3.4 B Yuan)
Time scope: 2016 - 2020

For: 1) Precision measurement laboratories
2) special-purpose laboratories (Large space / chemistry/ biology)
3) National Time & Frequency Metrology Center

Vision: 1) a few laboratories to be world-leading
2) a sharable research base
3) A center for innovation, HR development, world-wide collaboration

The “Culture” of Metrology

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Quantity defines the world, precision shapes the future

量值定义世界，精准改变未来

Thank You for Your Attention

谢谢大家