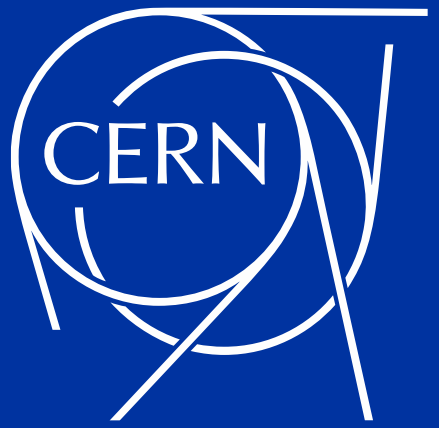
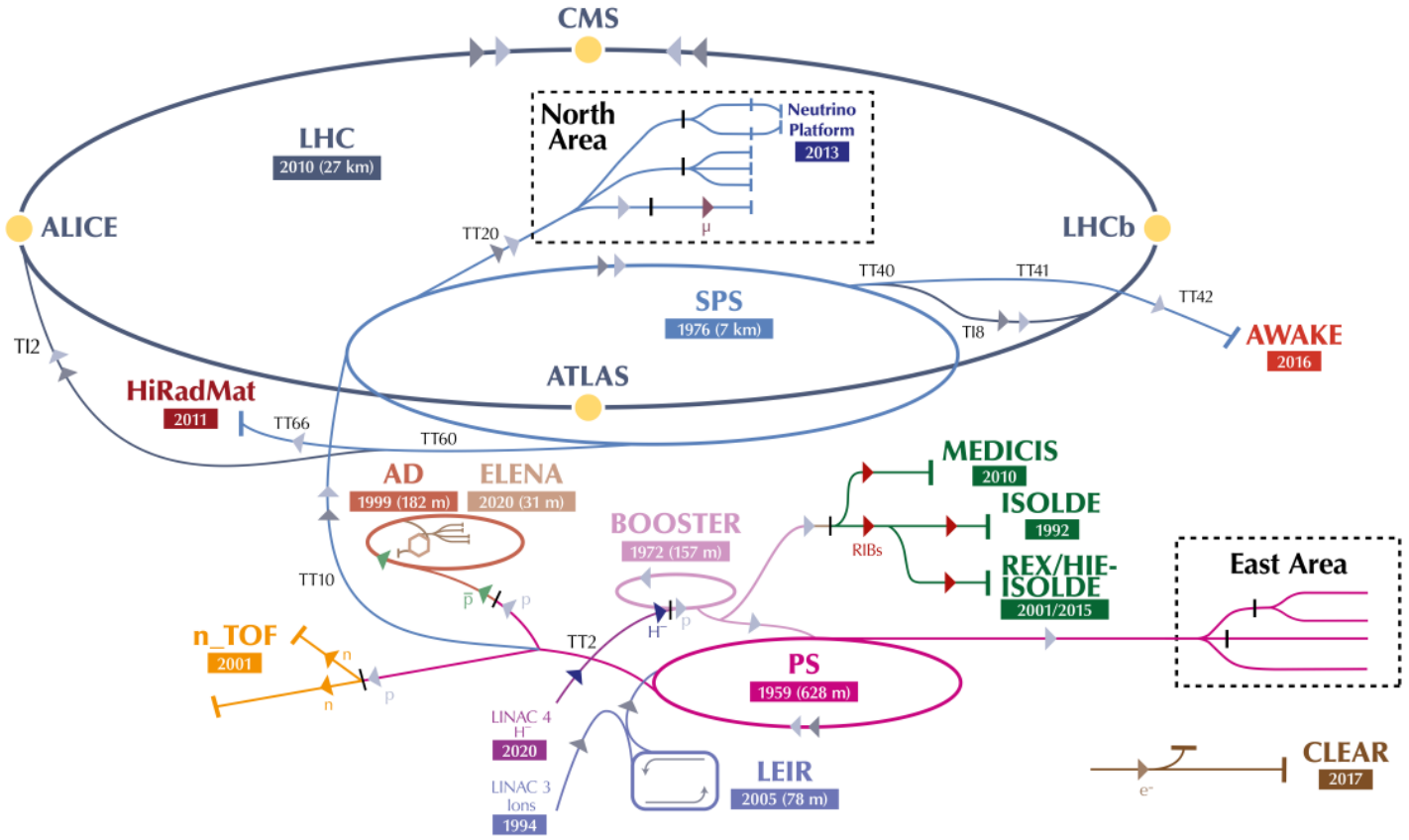


Vacuum and leak detection technologies at CERN

Jose A. Ferreira Somoza

6th October 2022

The CERN accelerator complex
Complexe des accélérateurs du CERN



H⁻ (hydrogen anions) · p (protons) · ions · RIBs (Radioactive Ion Beams) · n (neutrons) · p̄ (antiprotons) · e⁻ (electrons) · μ (muons)

LHC - Large Hadron Collider // SPS - Super Proton Synchrotron // PS - Proton Synchrotron // AD - Antiproton Decelerator // CLEAR - CERN Linear Electron Accelerator for Research // AWAKE - Advanced WAKefield Experiment // ISOLDE - Isotope Separator OnLine // REX/HIE-ISOLDE - Radioactive EXperiment/High Intensity and Energy ISOLDE // MEDICIS // LEIR - Low Energy Ion Ring // LINAC - LINear ACcelerator // n_TOF - Neutrons Time Of Flight // HiRadMat - High-Radiation to Materials // Neutrino Platform

The CERN accelerator complex
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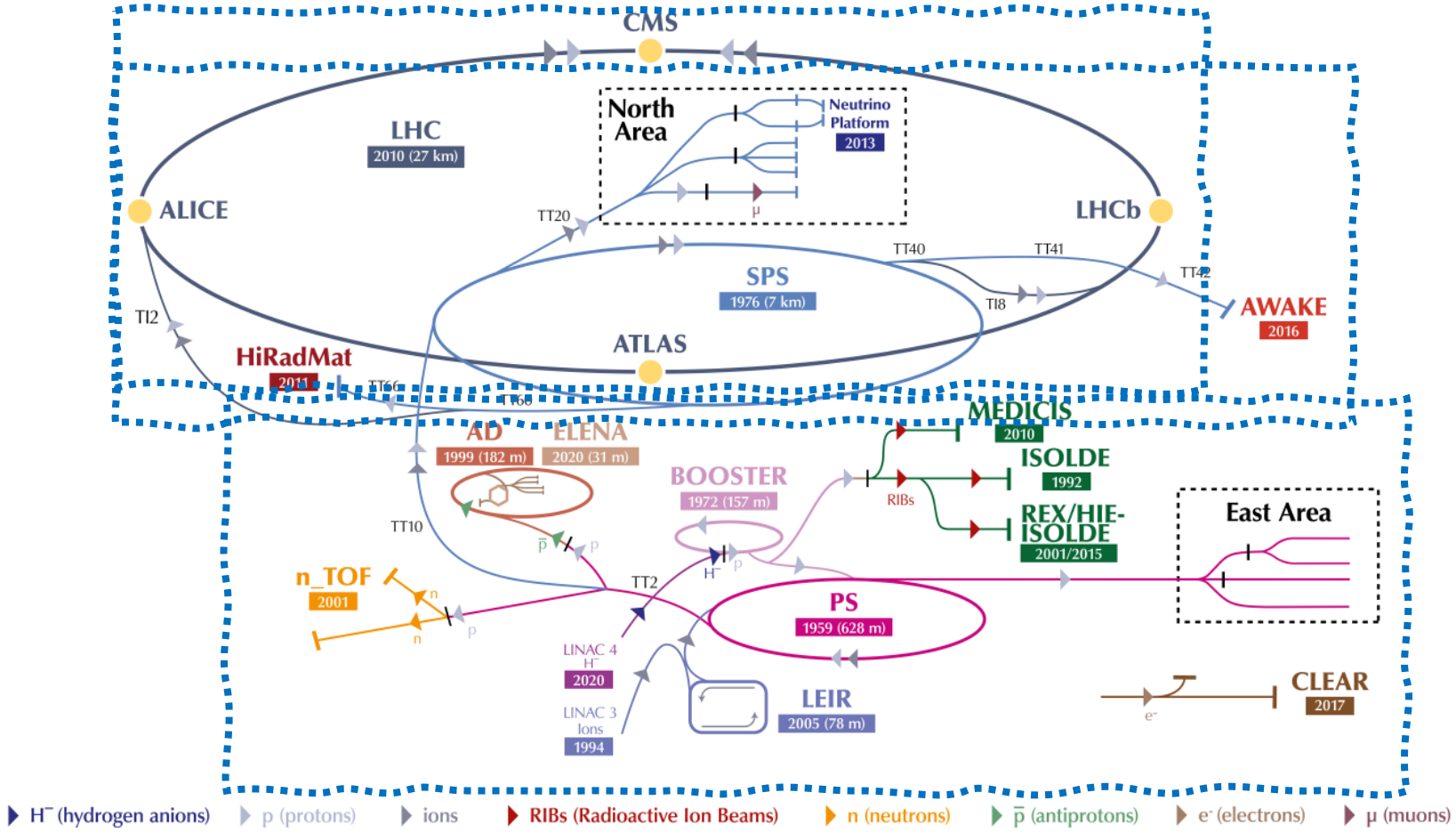

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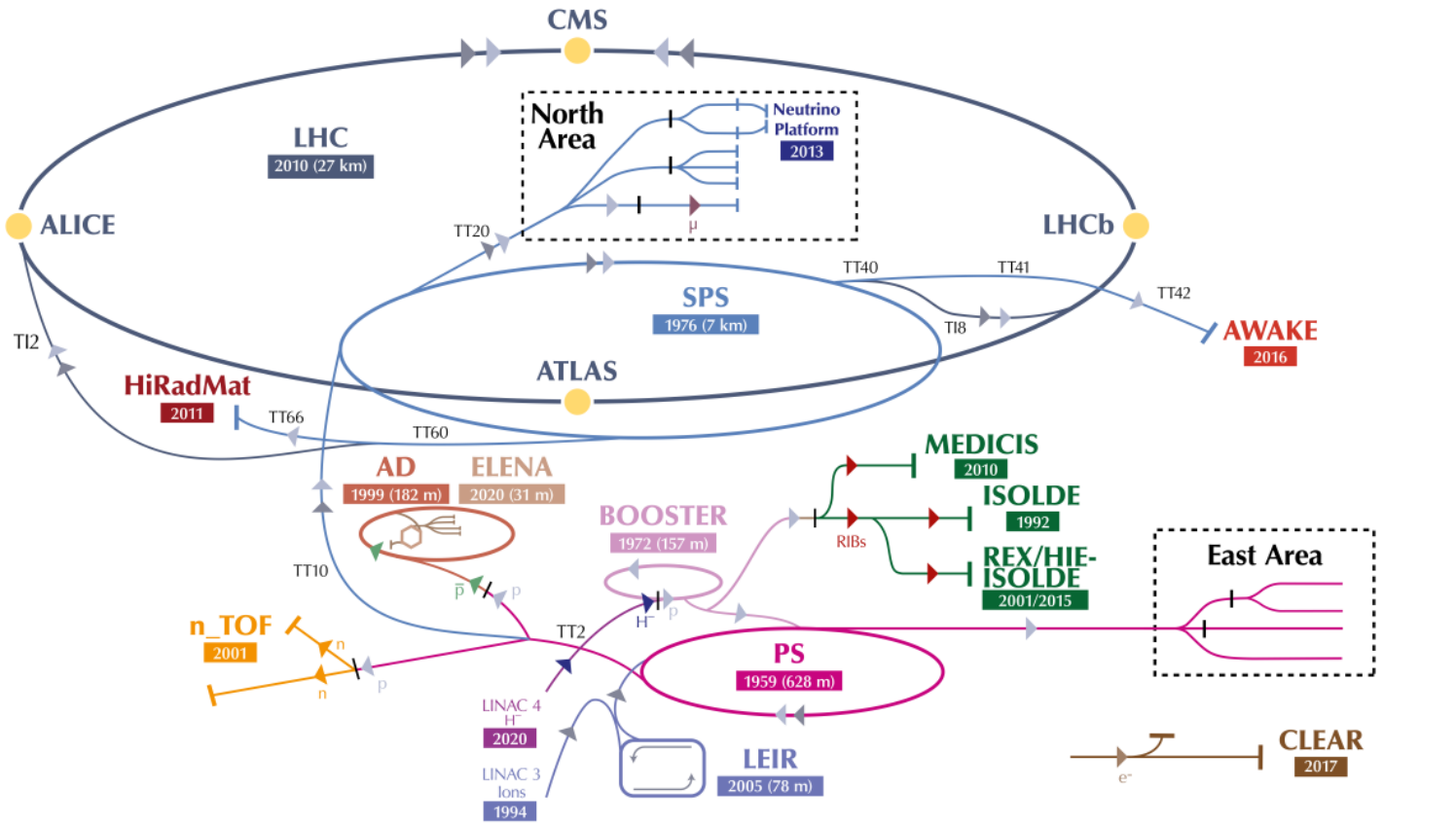
PS complex:
- ❑ LINAC4, LINAC3, PSB, PS, LEIR, AD, ELENA, nTOF, ISOLDE, REX/HIE-ISOLDE, MEDICIS, East Area and CLEAR
- ❑ Approx. 3 km beam lines

SPS complex:
- ❑ SPS ring and HiRadMat, AWAKE, Noth Area, TI2 and TI8
- ❑ Approx. 15 km of beam lines

LHC:
- ❑ Insulation vacuum and QRL 50 km
- ❑ Arcs: 50 km
- ❑ LSS and dump lines: 9 km

TOTAL 127 km of vacuum lines (not including cryogenic system)

The CERN accelerator complex
Complexe des accélérateurs du CERN



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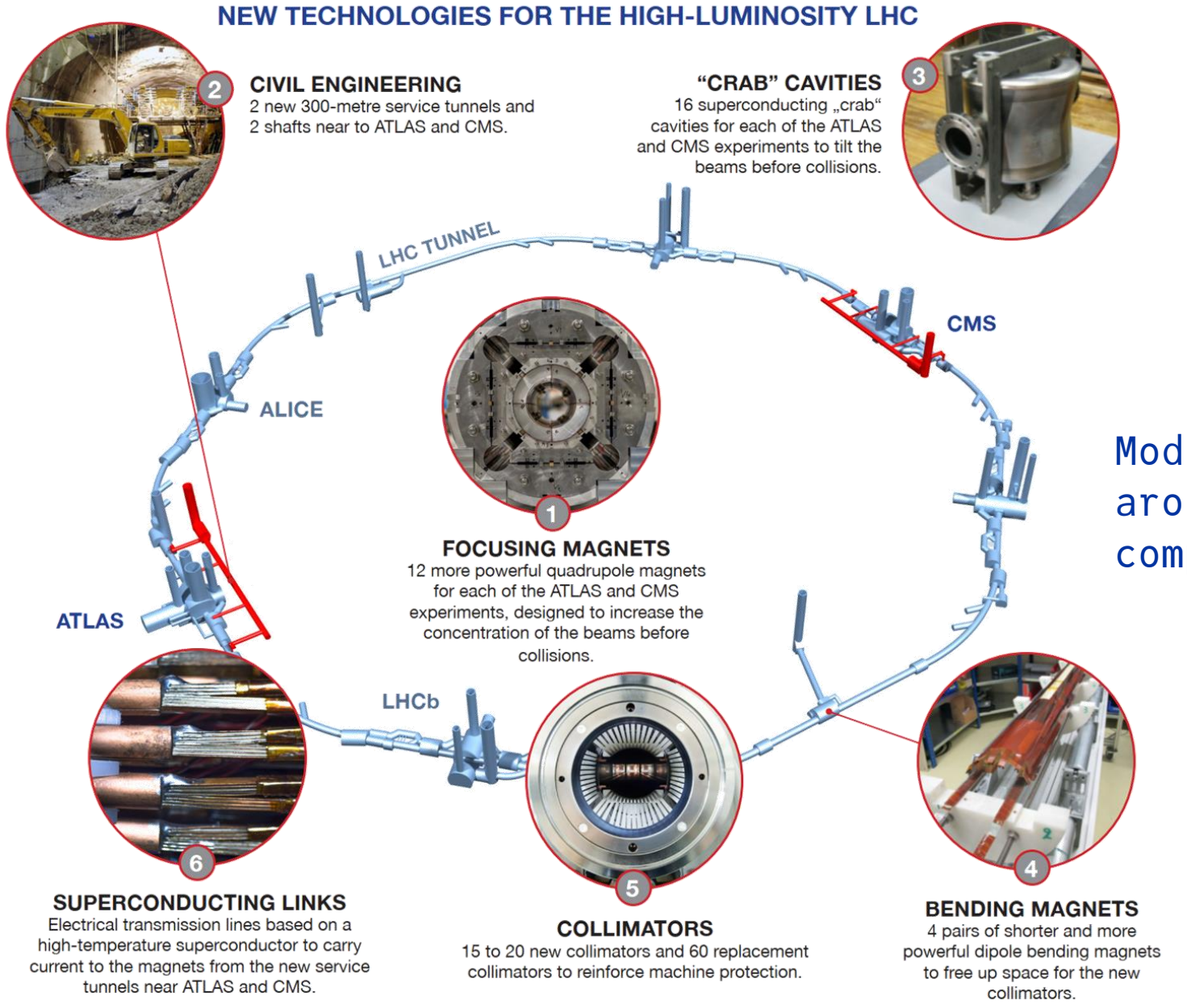
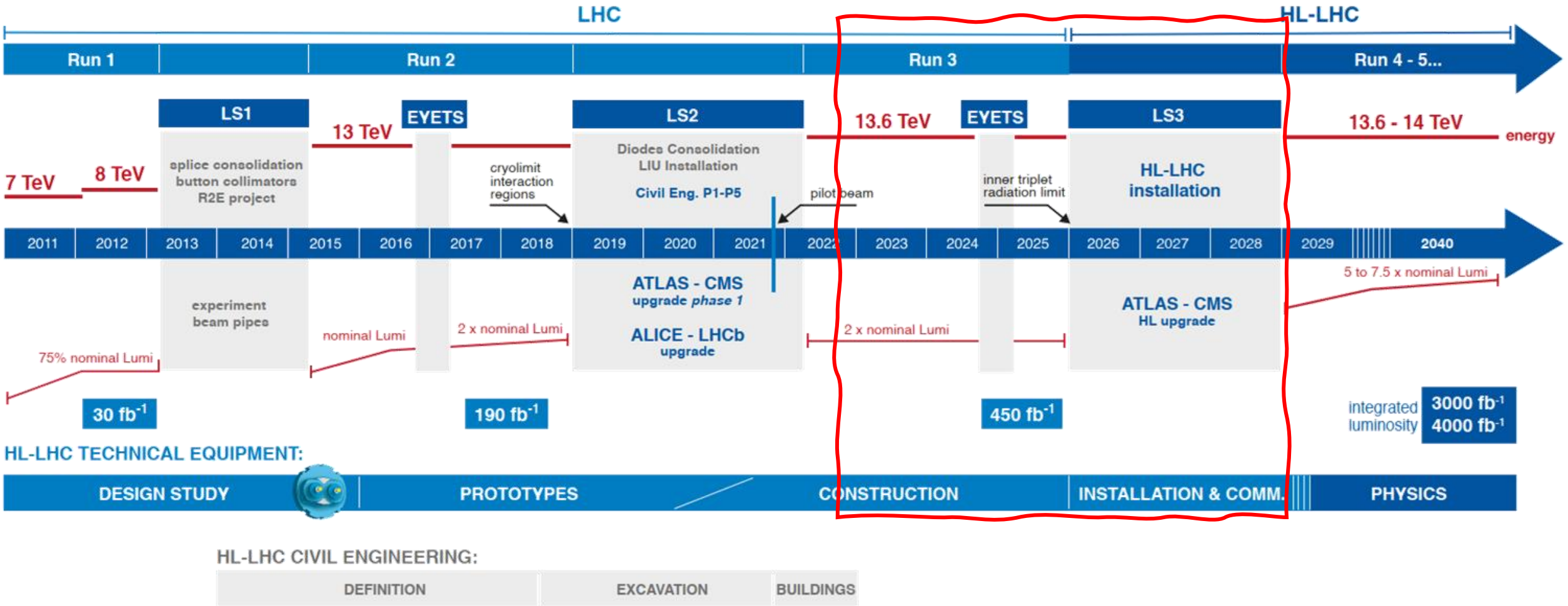
- CERN hosts very old facilities (>40 years) that require consolidation ➔ continuous work requiring new and refurbished vacuum components
- Wide pressure range from XHV (<10^{-12} mbar) up to atmospheric ➔ Wide range of requirements and equipment
- The accelerator complex continues growing with new projects:
  - PUMA (ELENA/ISOLDE)
  - AWAKE Run 2b/c
  - **High Luminosity LHC**

HiLumi HL-LHC PROJECT



Modifications of the layout around ATLAS and CMS require a complete new vacuum layout

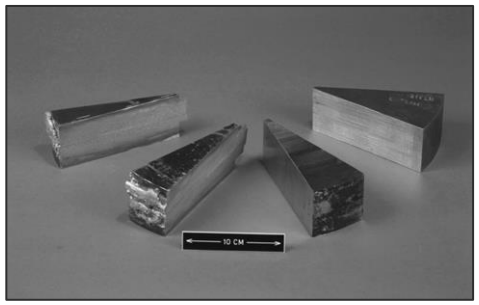
LHC / HL-LHC Plan



Any vacuum system requires specific materials, equipment and services

- How CERN is procuring them?
- What are the needs for the next 5 years?

  - ❑ Blanket contracts
  - ❑ CERN central stores
  - ❑ Standard procurement



Polymers (Vespel, PEEK, Viton, etc.)

Carbon (Graphite, CFC, etc.)

Ceramics (Macor, Alumina, etc.)

Other materials (Be, W, Ti, etc.)

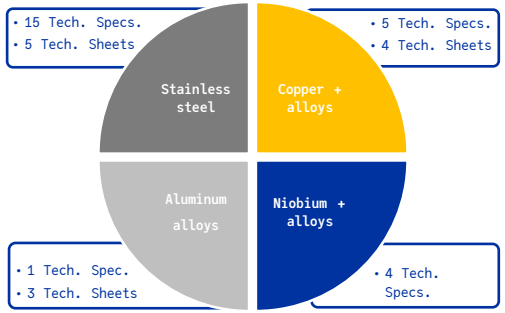
Copper (OFE, OFS)

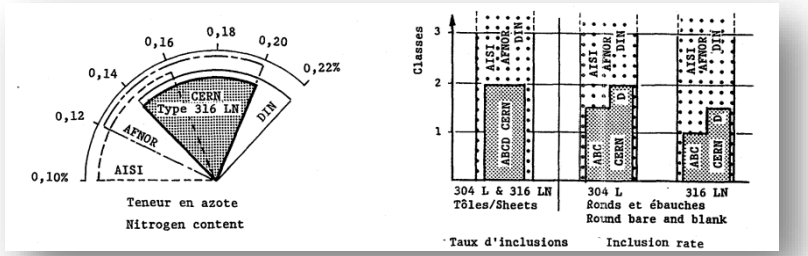
Stainless steel 304L, 316L, 316LN, etc.

Aluminium (2219, 5083, 6061 series, etc.)

Raw materials

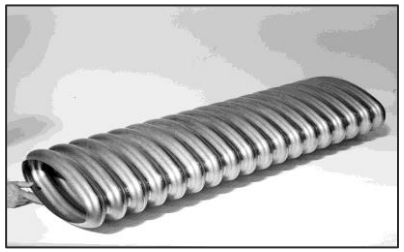
Metals





Raw Materials:

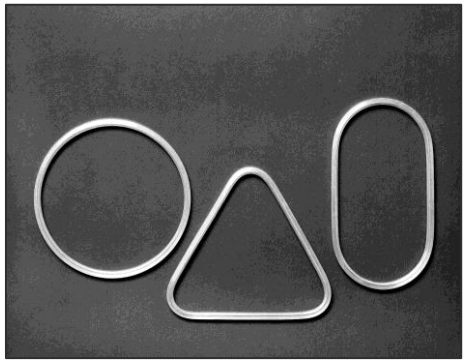
- Most common materials ➔ particular technical specification for vacuum applications
- Provided mainly through CERN central stores
- Metals >750kCHF <5 MCHF



- Vacuum equipment
  - Bakeout components
  - Vacuum chambers
  - Seals
    - Spring energized
    - Aluminium diamond shape
    - Copper (OHF, OHS silver coated)
    - Elastomer (Viton, EPDM, NBR, etc.)
  - Flanges
    - Conical flanges (CERN, QCF, etc.)
    - ISO-F, ISO-K, ISO-KF
    - ConFlat
  - Bellows
    - Edge welded
    - Hydroformed

Vacuum equipment:

- Seals and CF flanges through CERN central stores (contracts with specs well defined)
- Vacuum chambers are designed at CERN and production is often subcontracted
- Few hydroformed bellow suppliers from member states (material provided by CERN).
- Vacuum chambers >750kCHF <5 MCHF
- Seals >200 kCHF < 750 kCHF
- Flanges <200 kCHF
- Bakeout equipment >200 kCHF < 750 kCHF



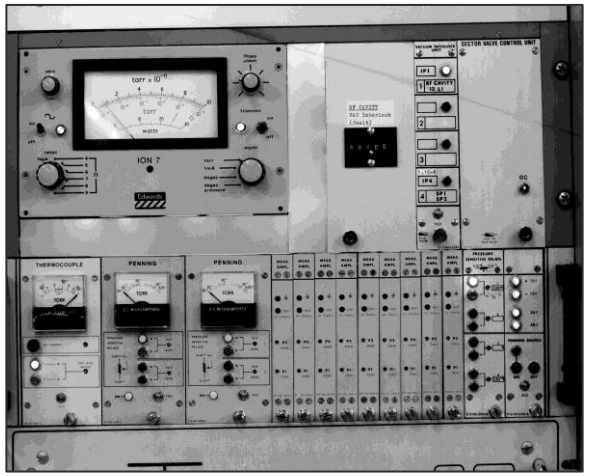
Cables, connectors

SCADA servers

Vacuum controls

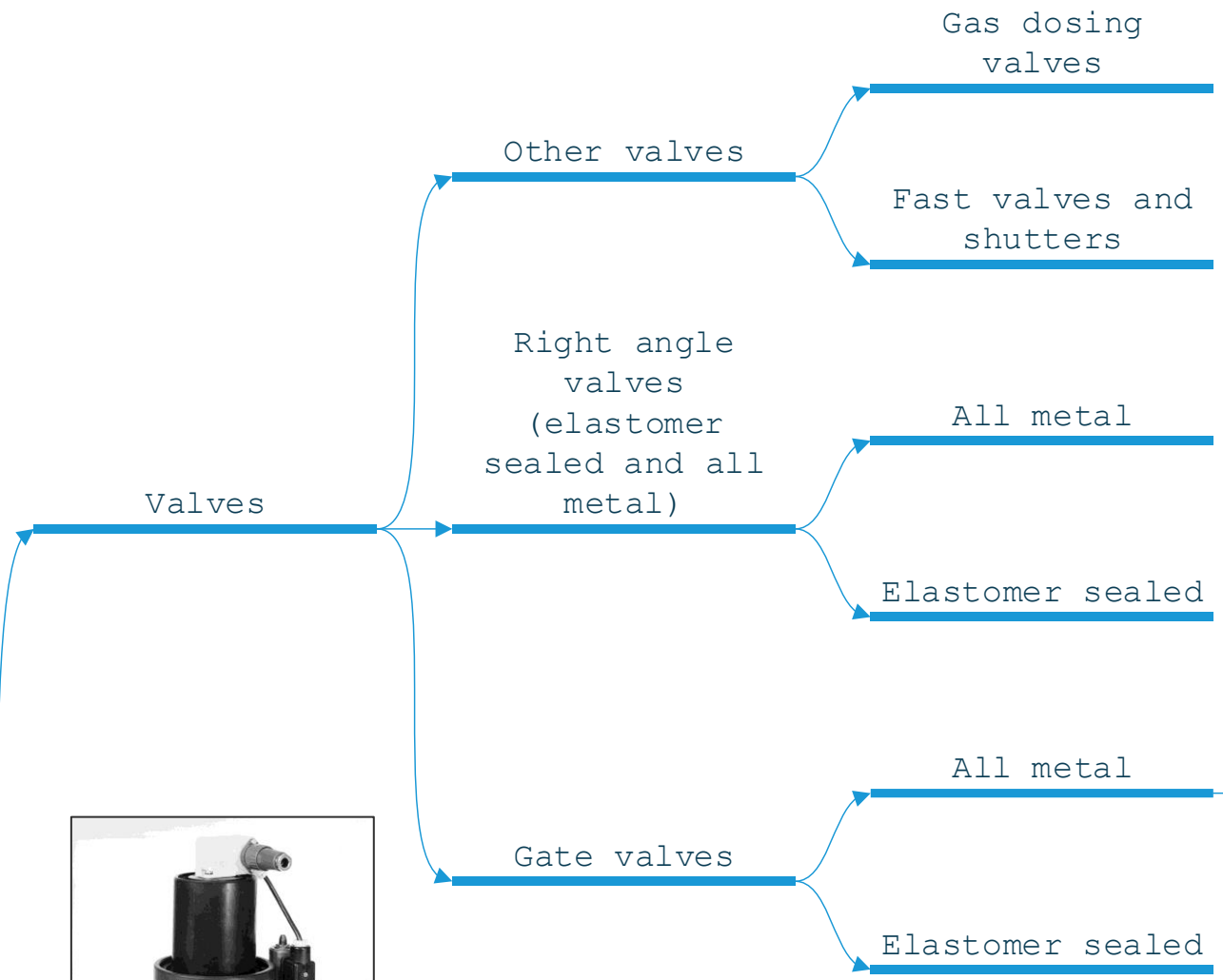
PLCs

Controllers



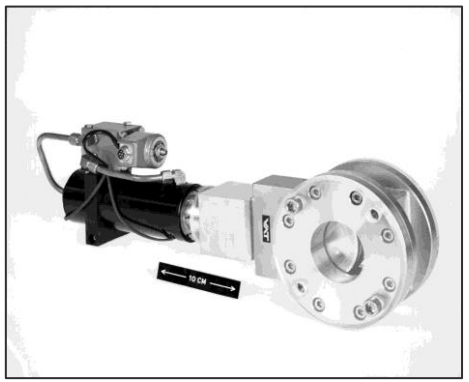
Vacuum controls:

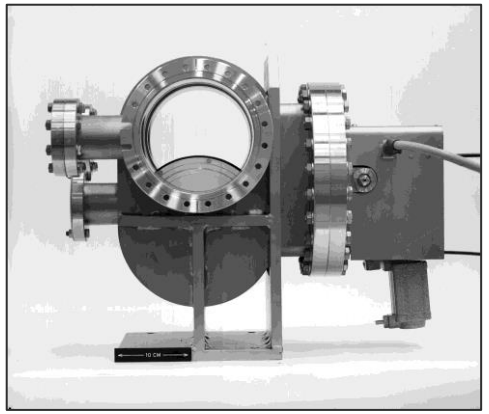
- PLC and ion pump controllers through blanket contracts
- Cables centralised by EN-EL (blanket contracts and procurement through central stores)
- Other controllers, very often procured with the equipment, i.e. turbopumps, or from CERN stores, i.e. TPG300
- PLCs <200 kCHF
- Ion pump controllers >200 kCHF < 750 kCHF

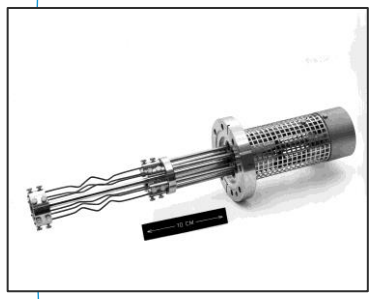


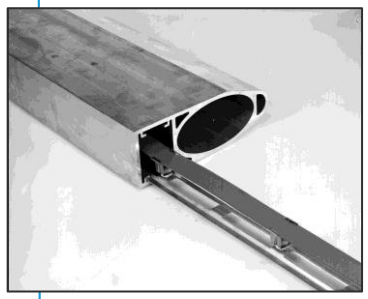
Vacuum components/valves:

- All metal gate valves and all metal right angle valves through blanket contract
- Elastomer sealed electropneumatic valves through CERN central stores
- Elastomer sealed gate valves or other valves → Open procurement
- Gate valves >750kCHF <5 MCHF
- Right angle valves >200 kCHF < 750 kCHF



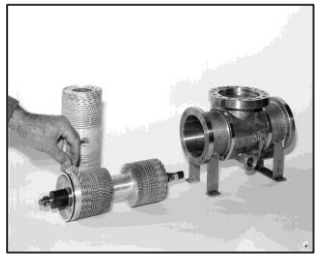






Pumps

Pumping groups



Capture pumps

Cryopumps

Non Evaporative Getters (coatings and bulk)

Titanium sublimation

Sputtering ion pumps

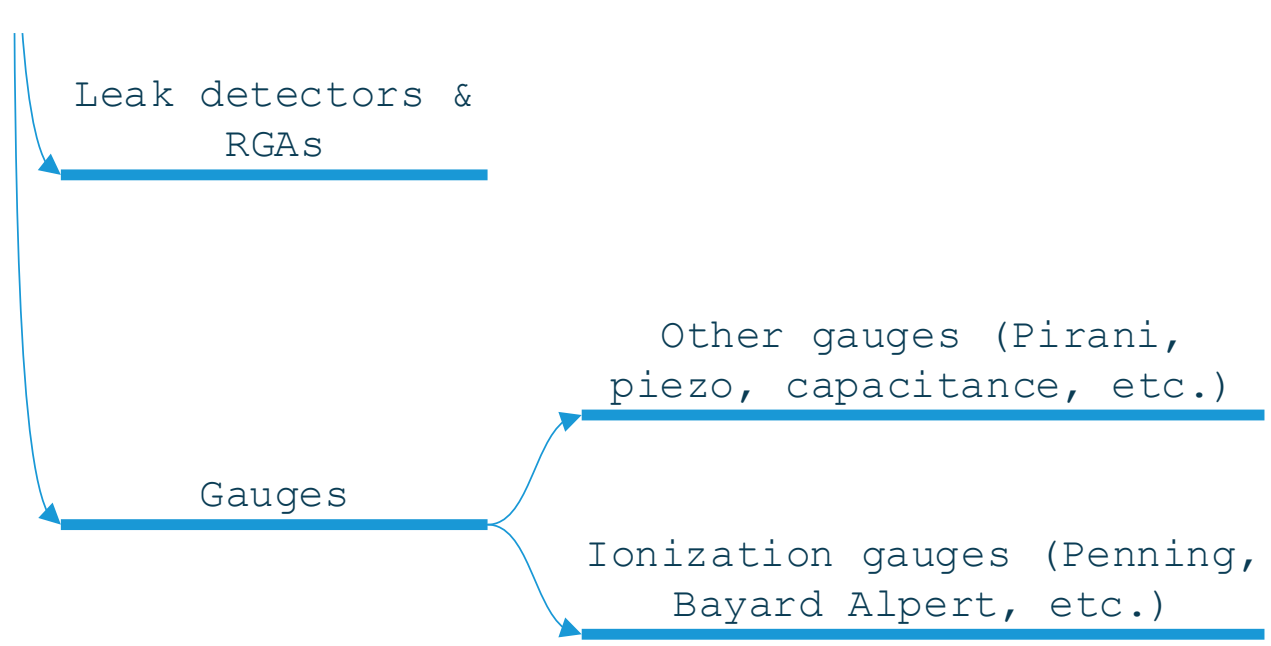
Mechanical pumps

Primary pumps (rotary vane, multiroots, scroll, etc.)

Turbomolecular pumps

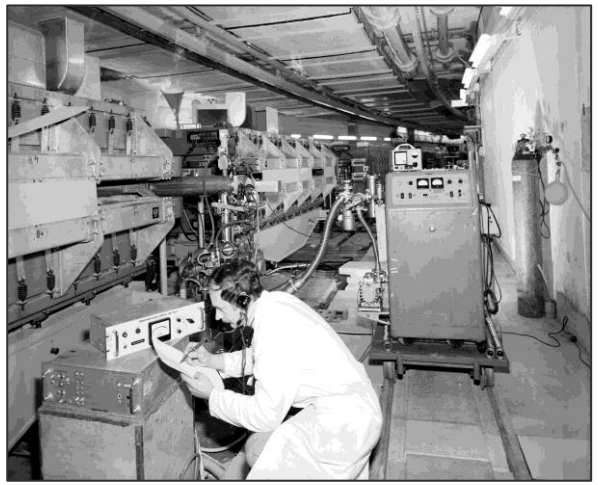
Vacuum components/pumps:

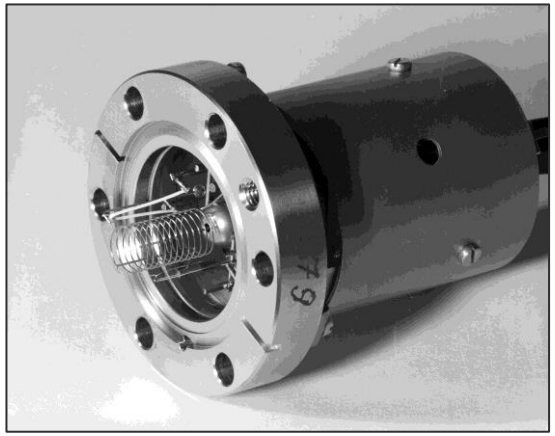
- Ion pumps, turbopumps, NEG cartridges and dry primary pumps through blanket contracts
- Some rotary vane pumps through CERN stores
- NEG coating produced internally
- Other components through open procurement
- New contract in market survey for the supply of approx. 120 dry pumps MS-4778/TE 200k-750k CHF
- Turbopumps >200 kCHF < 750 kCHF
- Ion pumps >200 kCHF < 750 kCHF
- NEG cartridges >200 kCHF < 750 kCHF

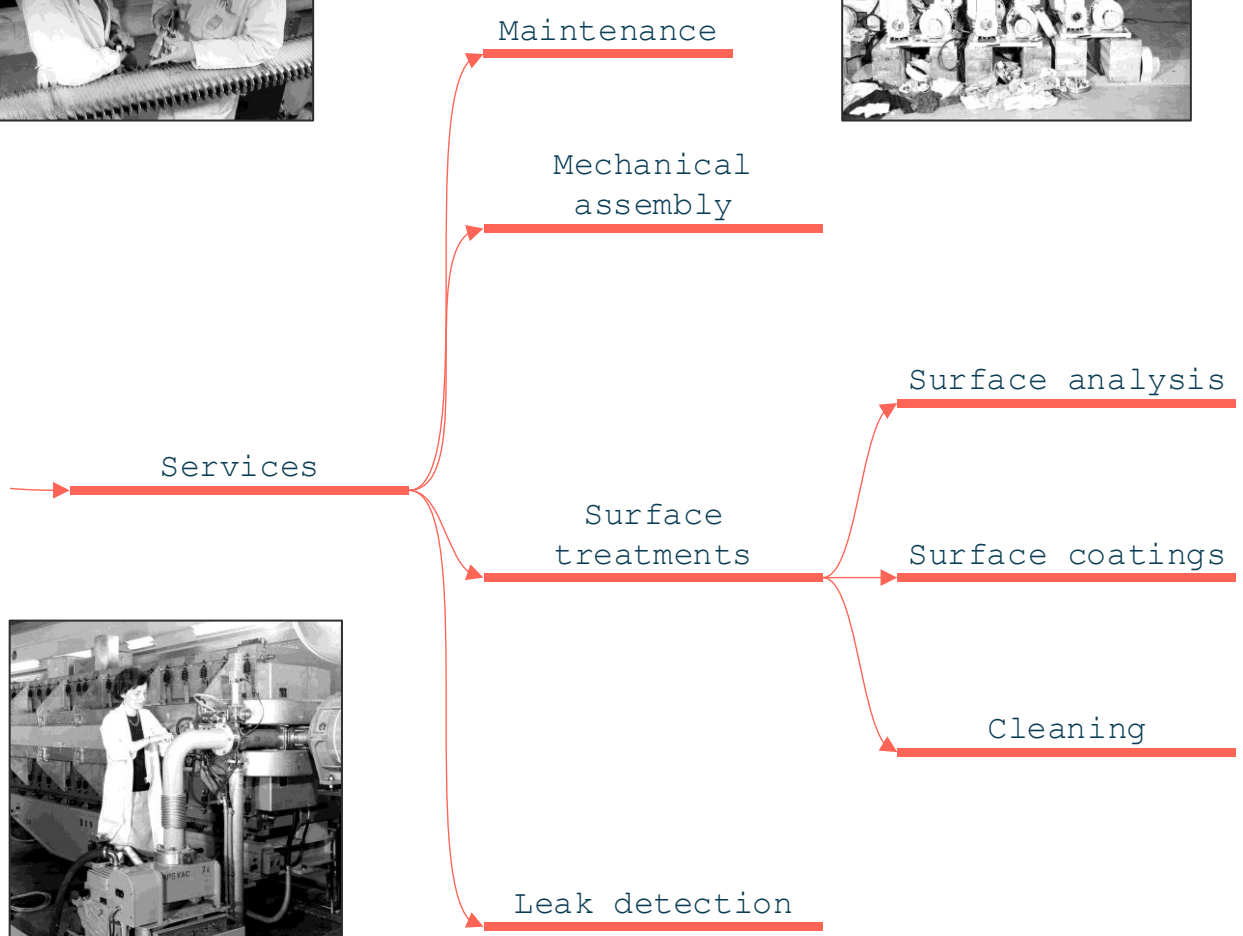


Vacuum components/instrumentation:

- Penning and Pirani from CERN central stores
- RGAs and leak detectors through blanket contracts
- Other components through open procurement
- Leak detectors <200 kCHF
- Gauges <200 kCHF
- RGA >200 kCHF < 750 kCHF







Vacuum service:

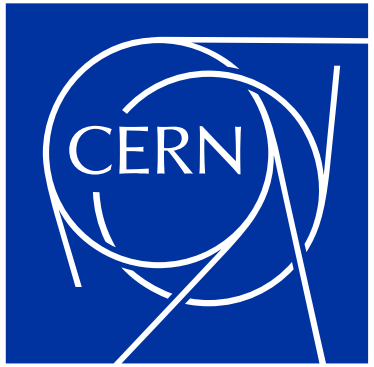
- One contract for external vacuum service (maintenance, leak detection and mechanical assembly)
- New contract in market survey MS-4778/TE 5M-10M CHF
- Surface treatments (cleaning, firing, coating, etc.) mostly done by CERN. Some outsourcing for big tasks

Summary

- The renovation of old equipment in the accelerator chain (consolidation) and HL-LHC are two big projects for the next 5 years.
- A big amount of vacuum equipment has to be procured and replaced/installed
- Difficulties to find several suppliers for certain components (bellows, aluminium seals, spring energized seals, etc.)
- Procurement processes are long. The delivery delays shall be respected.
- https://procurement.web.cern.ch/ → Guidelines for CERN procurement
- https://forthcoming-ms.app.cern.ch/ → Forthcoming Tendering

Contact us!

My contact details



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