



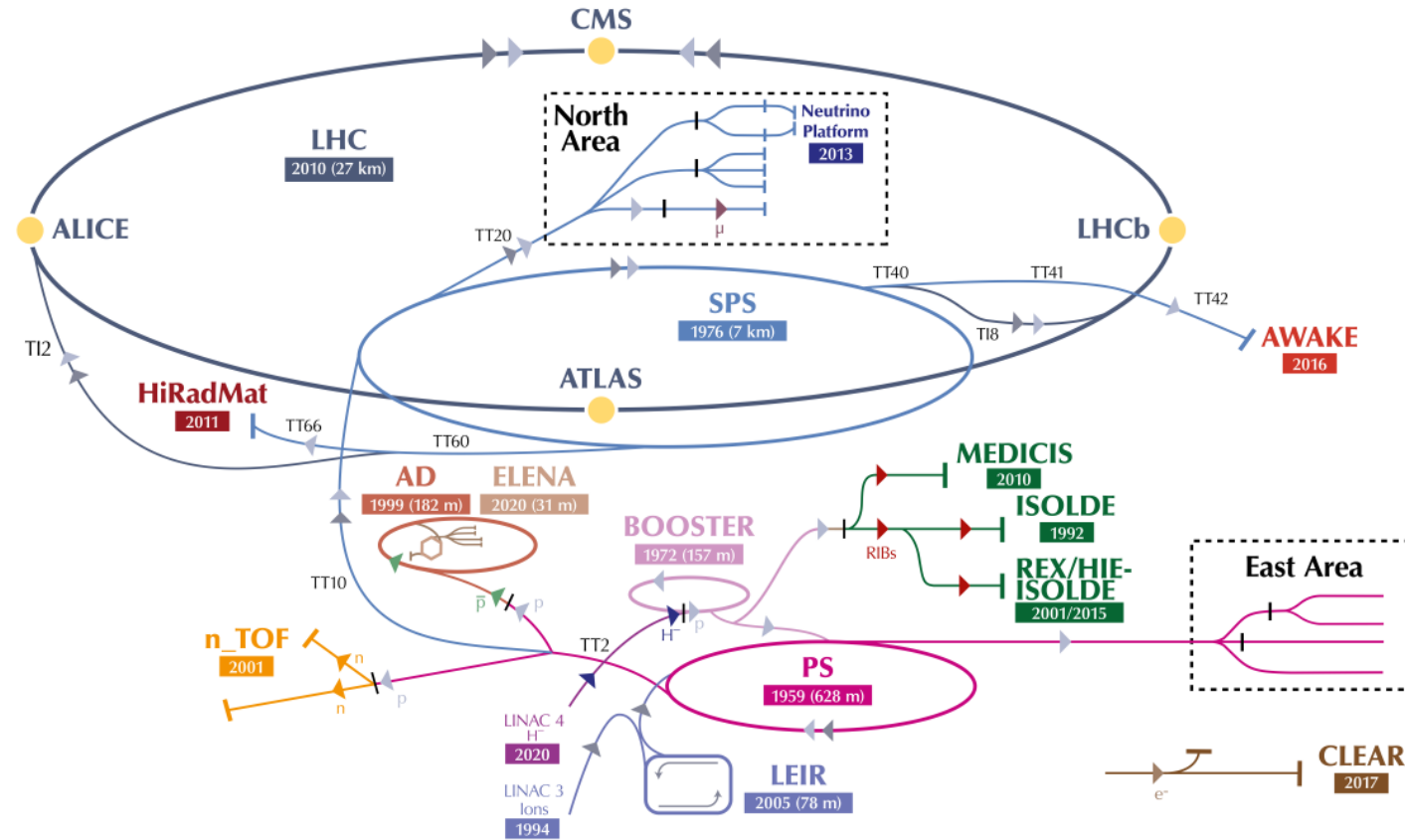
Vacuum and leak detection technologies at CERN

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6th October 2022

The CERN accelerator complex

Complexe des accélérateurs du CERN

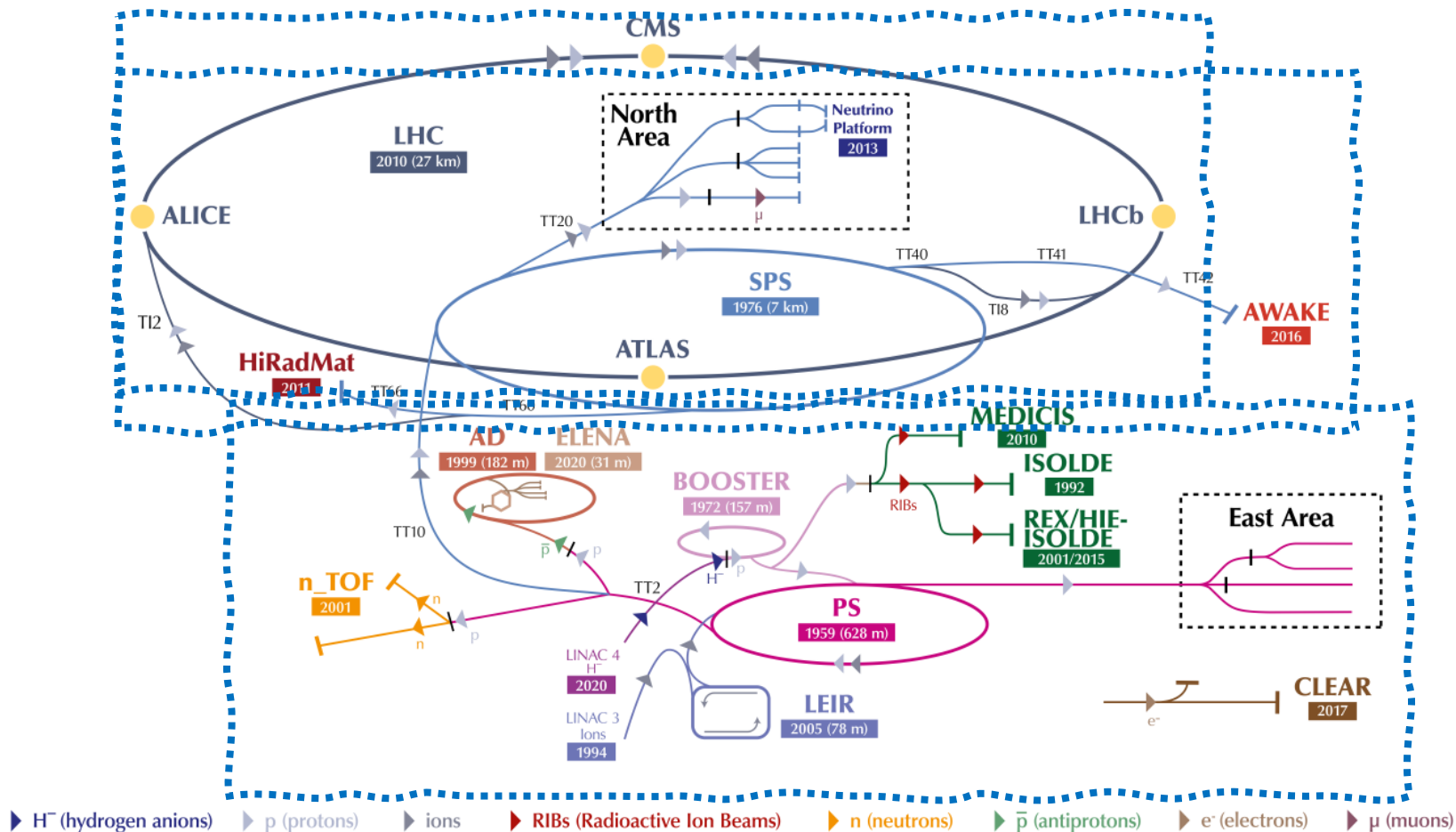


▶ H^- (hydrogen anions) ▶ p (protons) ▶ ions ▶ RIBs (Radioactive Ion Beams) ▶ n (neutrons) ▶ \bar{p} (antiprotons) ▶ e^- (electrons) ▶ μ (muons)

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

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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

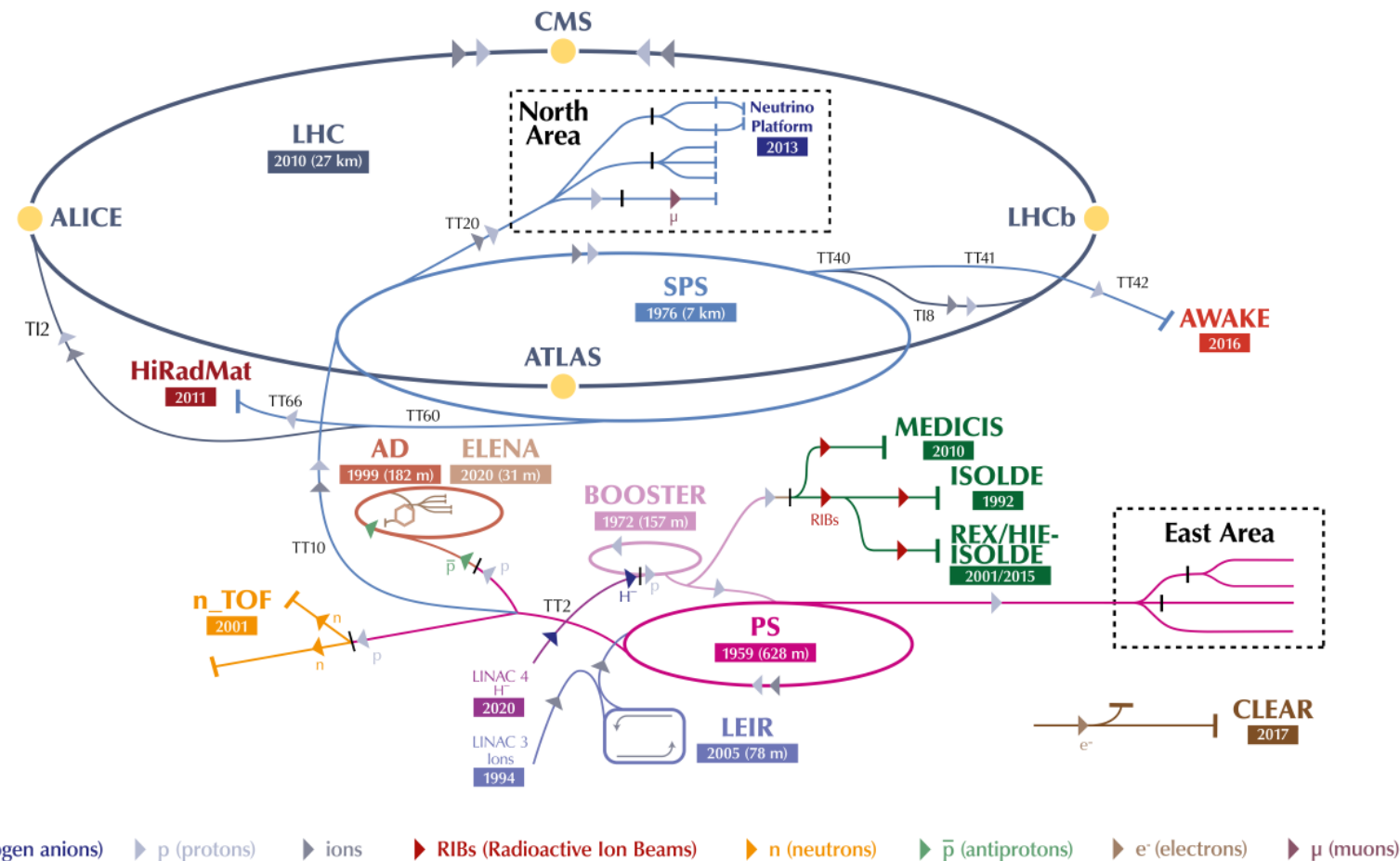
LHC:

- ❑ 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



- 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**

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NEW TECHNOLOGIES FOR THE HIGH-LUMINOSITY LHC



2

CIVIL ENGINEERING

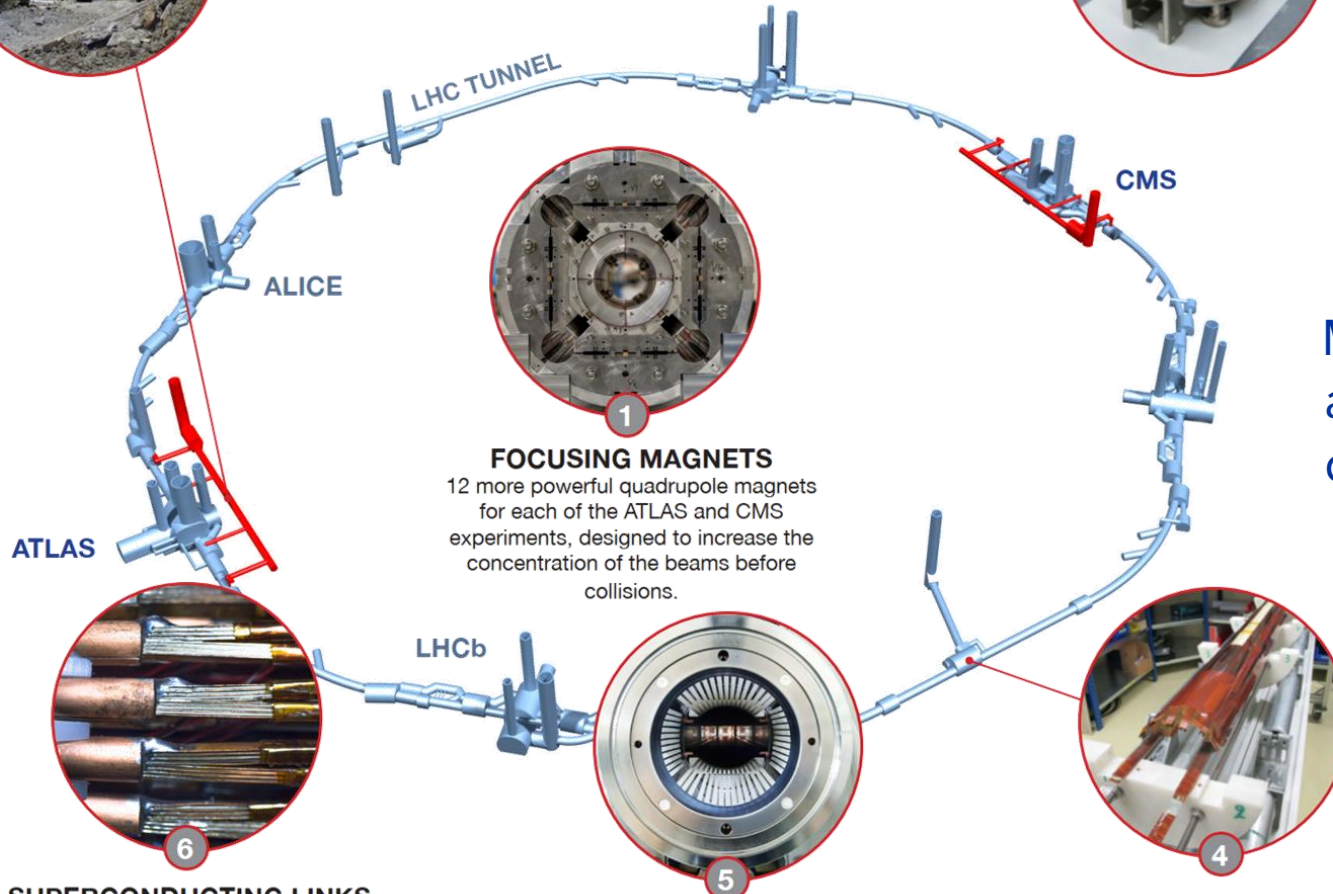
2 new 300-metre service tunnels and
2 shafts near to ATLAS and CMS.



3

“CRAB” CAVITIES

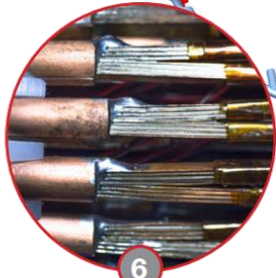
16 superconducting „crab“
cavities for each of the ATLAS
and CMS experiments to tilt the
beams before collisions.



1

FOCUSING MAGNETS

12 more powerful quadrupole magnets
for each of the ATLAS and CMS
experiments, designed to increase the
concentration of the beams before
collisions.



6

SUPERCONDUCTING LINKS

Electrical transmission lines based on a
high-temperature superconductor to carry
current to the magnets from the new service
tunnels near ATLAS and CMS.



5

COLLIMATORS

15 to 20 new collimators and 60 replacement
collimators to reinforce machine protection.

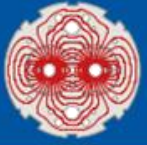


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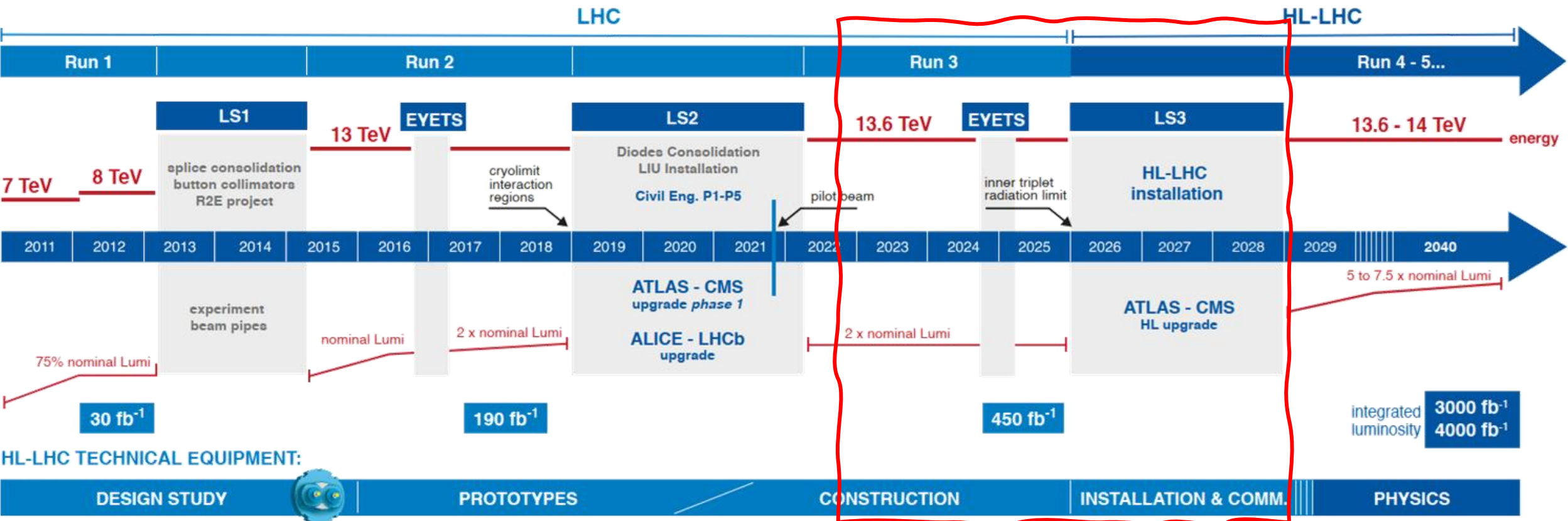
BENDING MAGNETS

4 pairs of shorter and more
powerful dipole bending magnets
to free up space for the new
collimators.

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

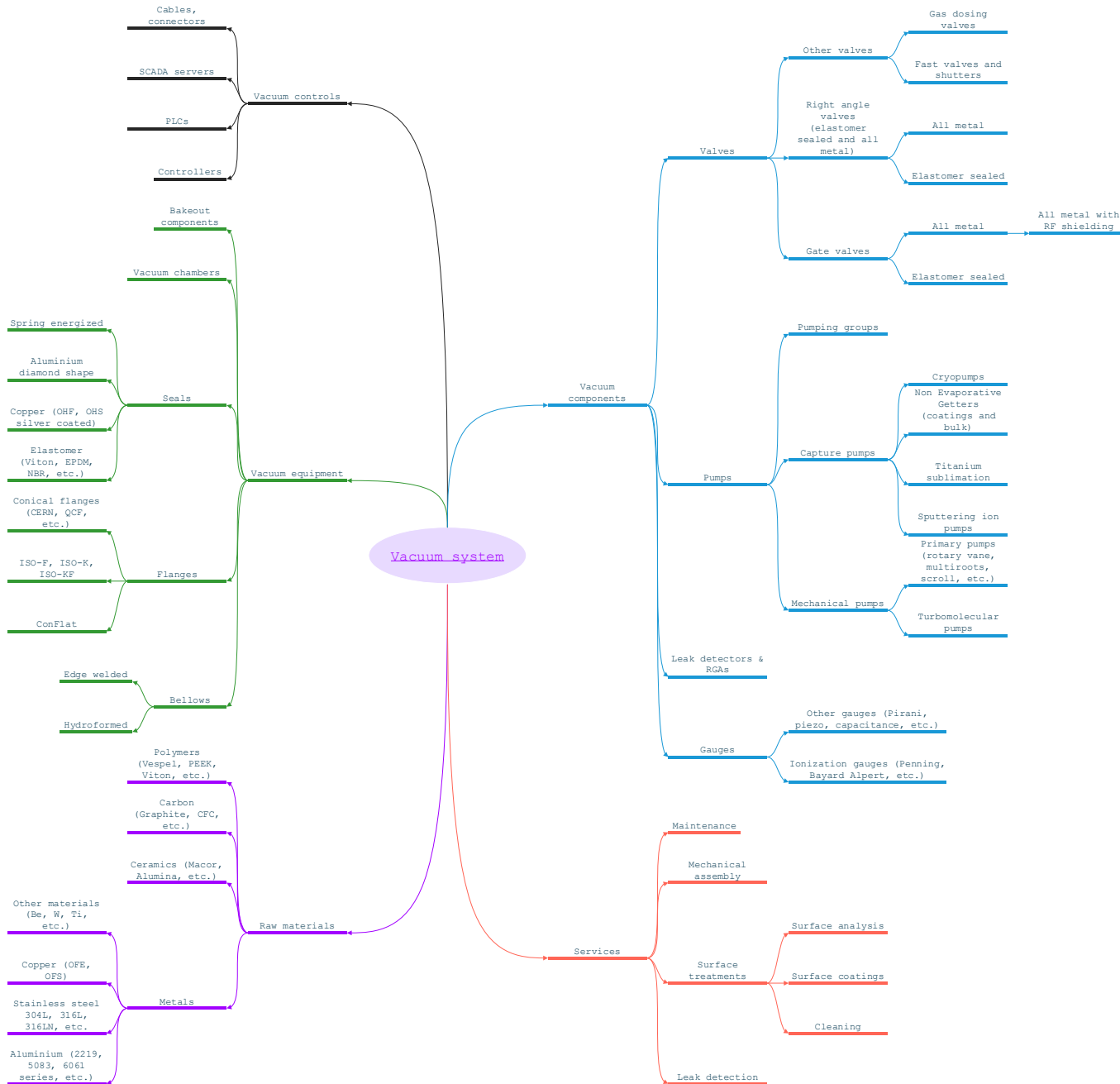


LHC / HL-LHC Plan



HL-LHC CIVIL ENGINEERING:

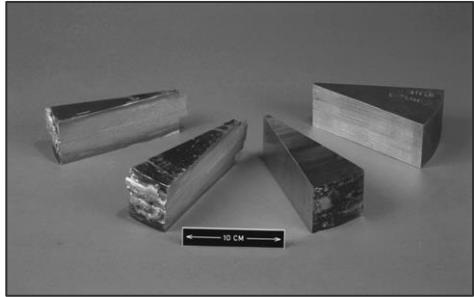




Any vacuum system requires specific materials, equipment and services

- 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.)

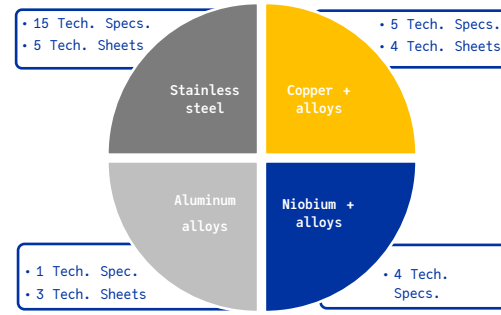
Ceramics (Macor,
Alumina, etc.)

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

Copper (OFE,
OFS)

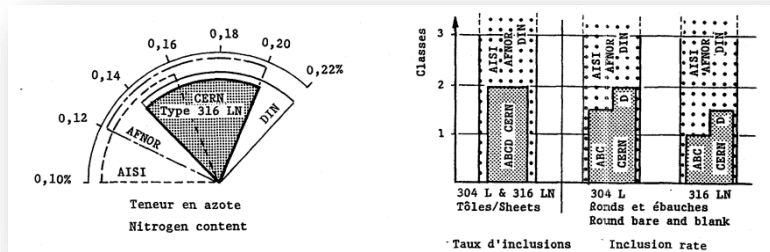
Stainless steel
304L, 316L,
316LN, etc.

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



Raw materials

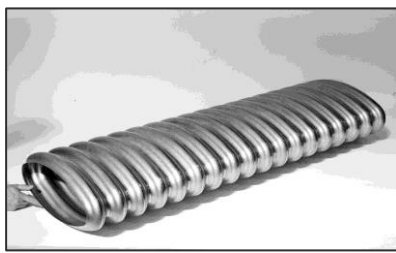
Metals



Raw Materials:

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





Spring energized

Aluminium
diamond shape

Copper (OHF, OHS
silver coated)

Elastomer
(Viton, EPDM,
NBR, etc.)

Conical flanges
(CERN, QCF,
etc.)

ISO-F, ISO-K,
ISO-KF

ConFlat

Edge welded

Hydroformed

Bakeout
components

Vacuum chambers

Seals

Vacuum equipment

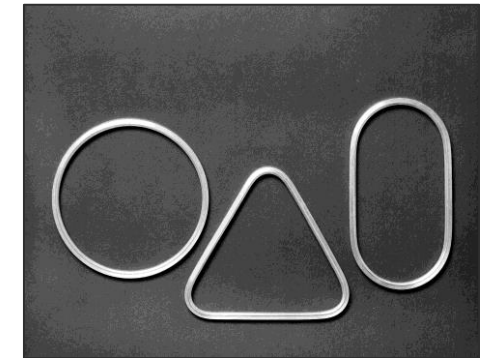
Flanges

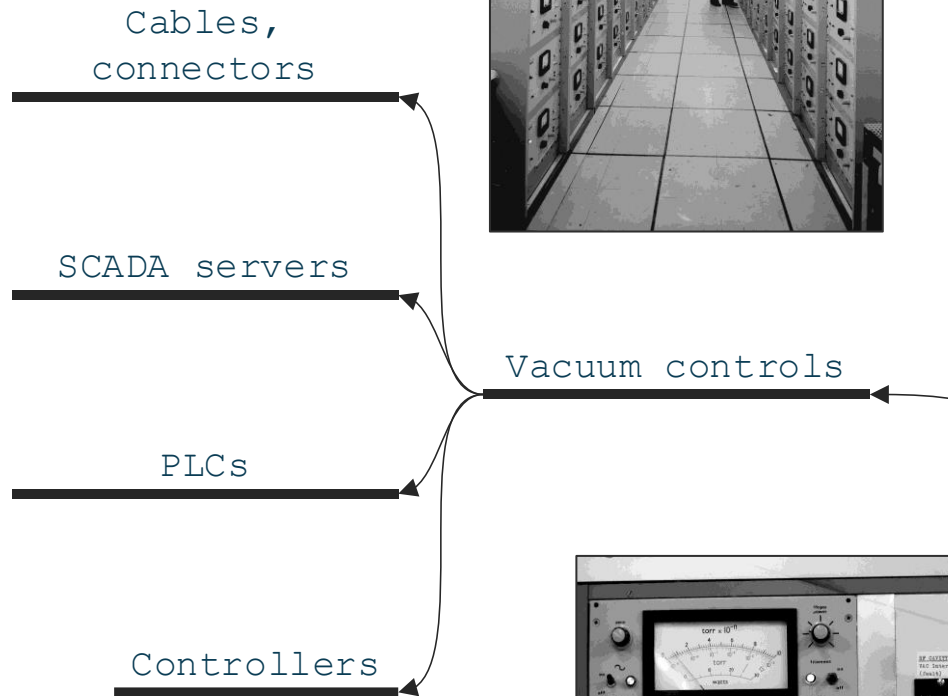
Bellows



Vacuum equipment:

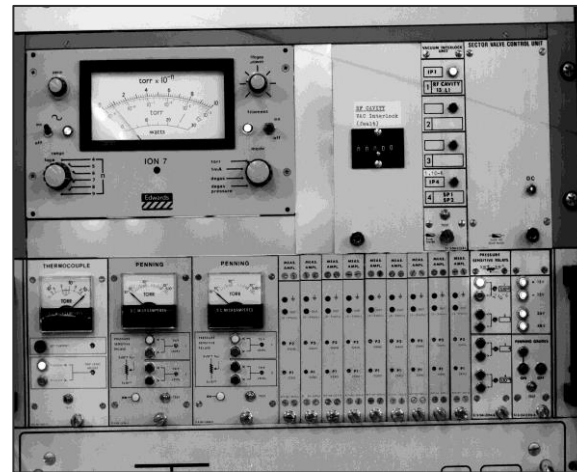
- Seals and CF flanges through CERN central stores (contracts with specs well defined)
- Vacuum chambers are designed at CERN and production is often subcontracted
- Few hydroformed bellow suppliers from member states (material provided by CERN).
- Vacuum chambers >750kCHF <5 MCHF
- Seals >200 kCHF 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





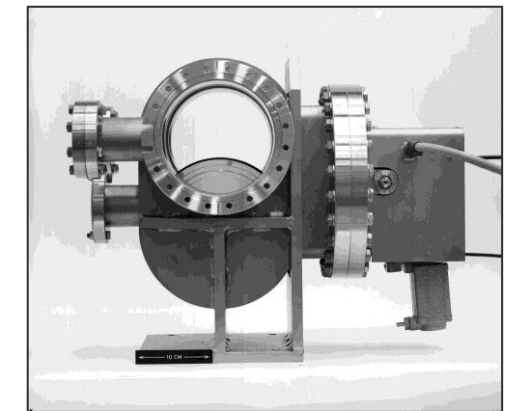
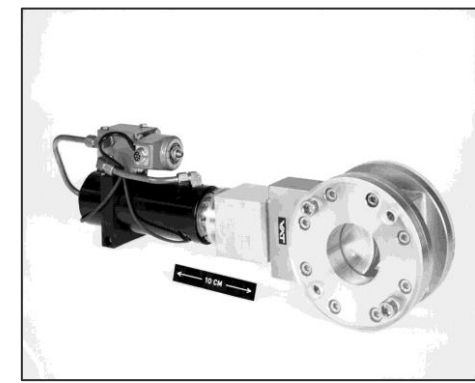
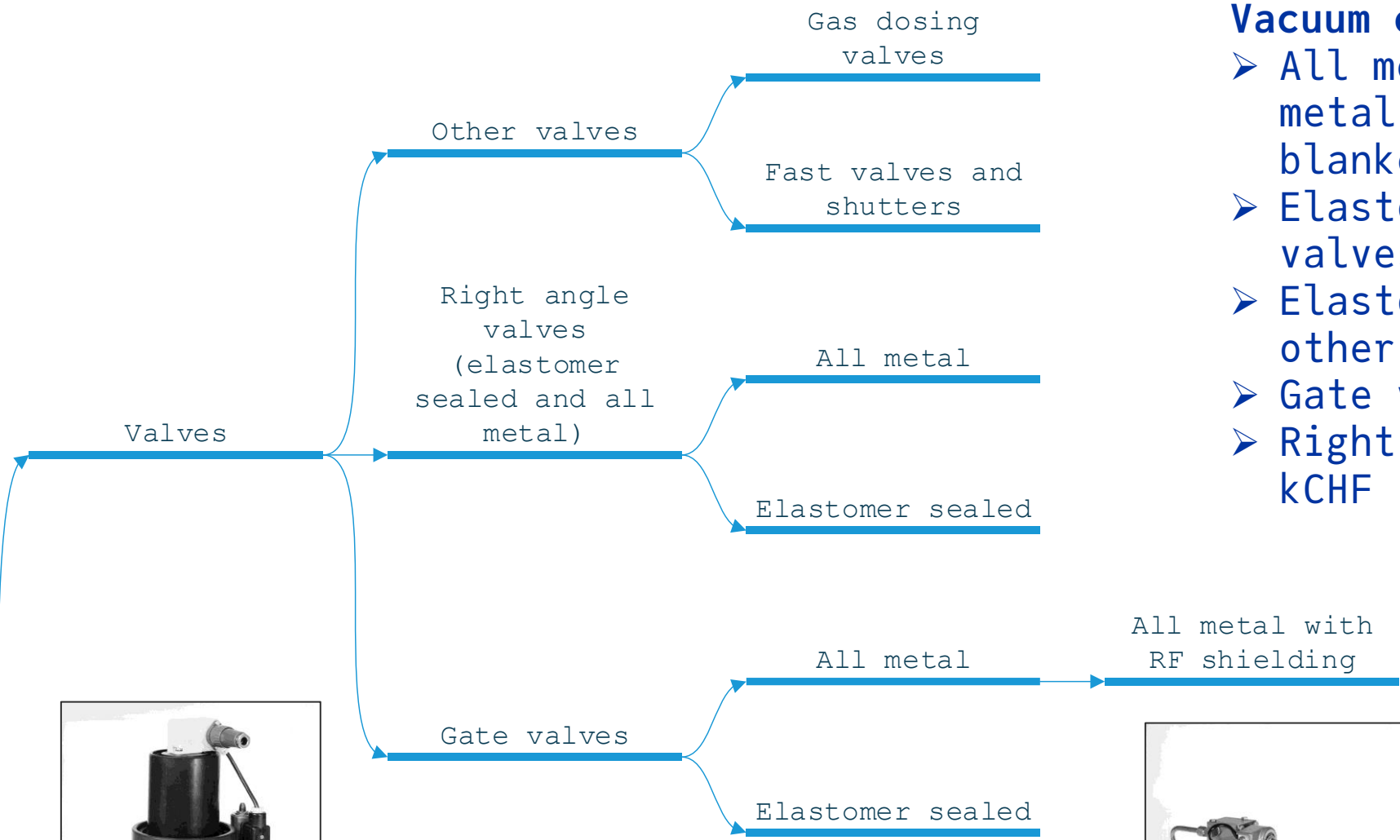
Vacuum controls:

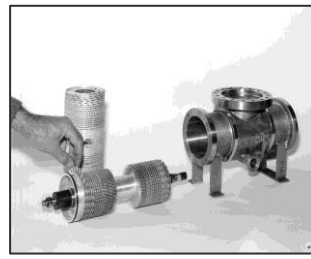
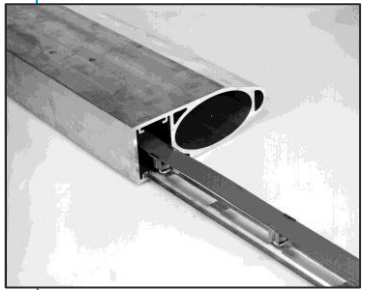
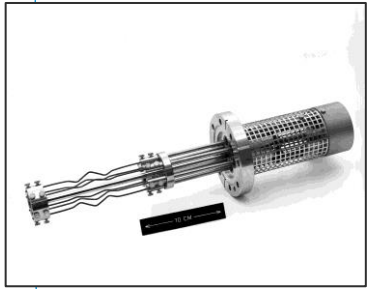
- PLC and ion pump controllers through blanket contracts
- Cables centralised by EN-EL (blanket contracts and procurement through central stores)
- Other controllers, very often procured with the equipment, i.e. turbopumps, or from CERN stores, i.e. TPG300
- PLCs <200 kCHF
- Ion pump controllers >200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





Pumping groups

Cryopumps

Non Evaporative
Getters
(coatings and
bulk)

Titanium
sublimation

Sputtering ion
pumps

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

Turbomolecular
pumps

Capture pumps

Mechanical pumps

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



Leak detectors &
RGAs

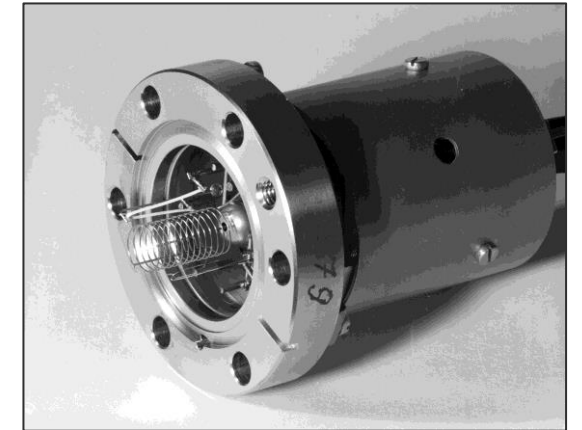
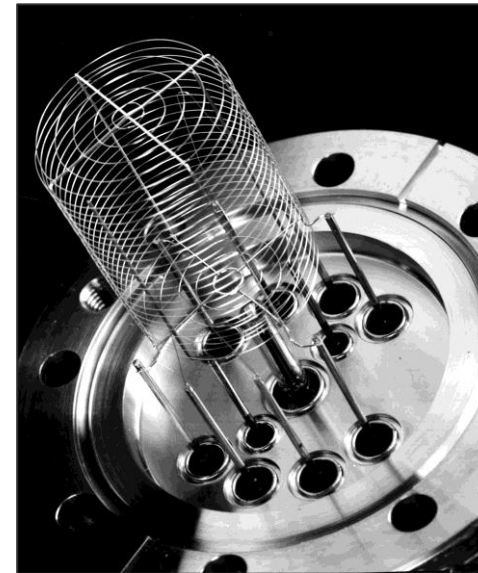
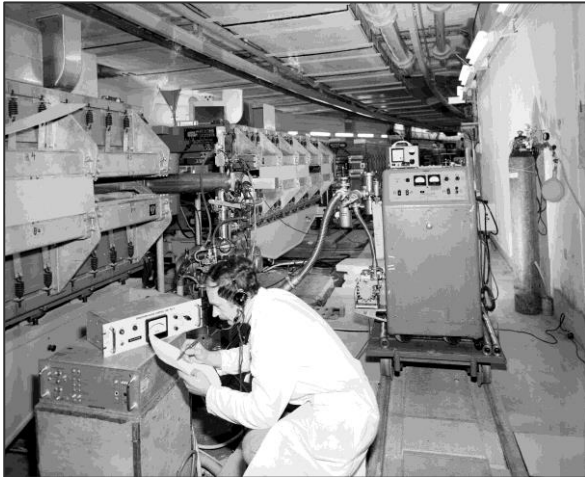
Gauges

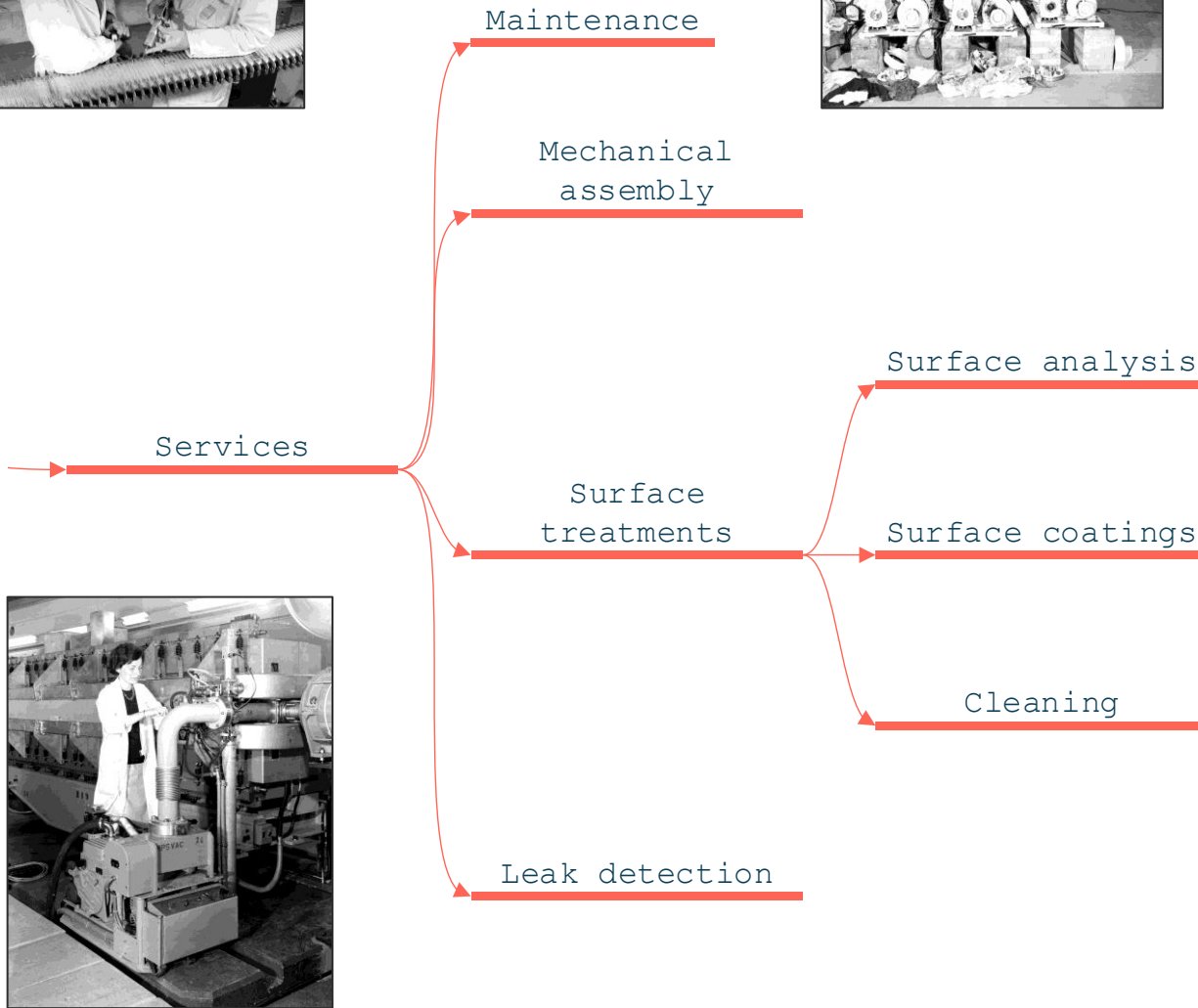
Other gauges (Pirani,
piezo, capacitance, etc.)

Ionization gauges (Penning,
Bayard Alpert, etc.)

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

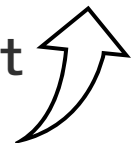
Summary

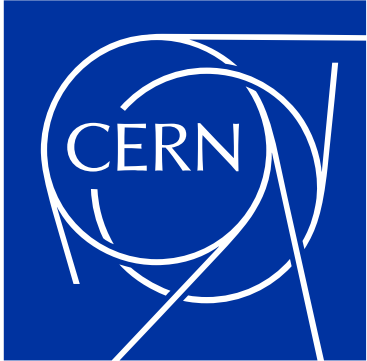
- ❑ The renovation of old equipment in the accelerator chain (consolidation) and HL-LHC are two big projects for the next 5 years.
- ❑ A big amount of vacuum equipment has to be procured and replaced/installed
- ❑ Difficulties to find several suppliers for certain components (bellows, aluminium seals,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

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