



**Big Science
Business
Forum
2022**

Overview of Opportunities in the area of Instrumentation at CERN

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5th October 2022 | Big Science Business Forum

Introduction

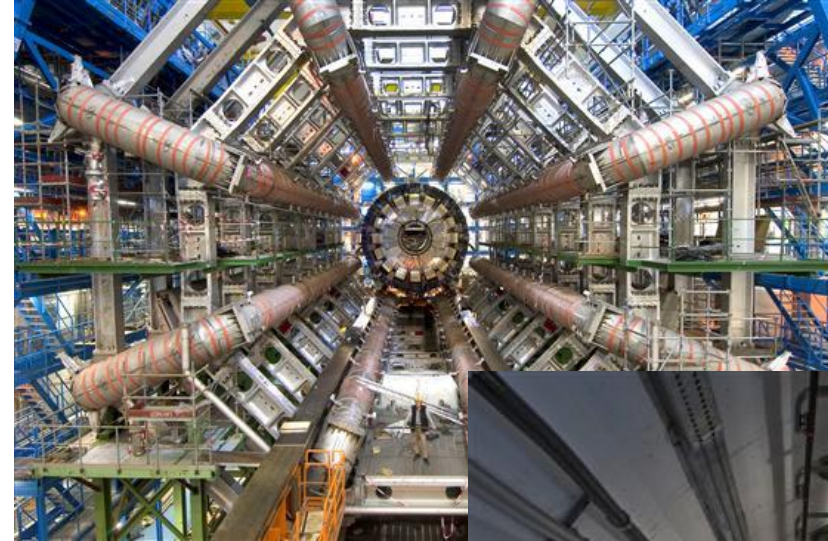
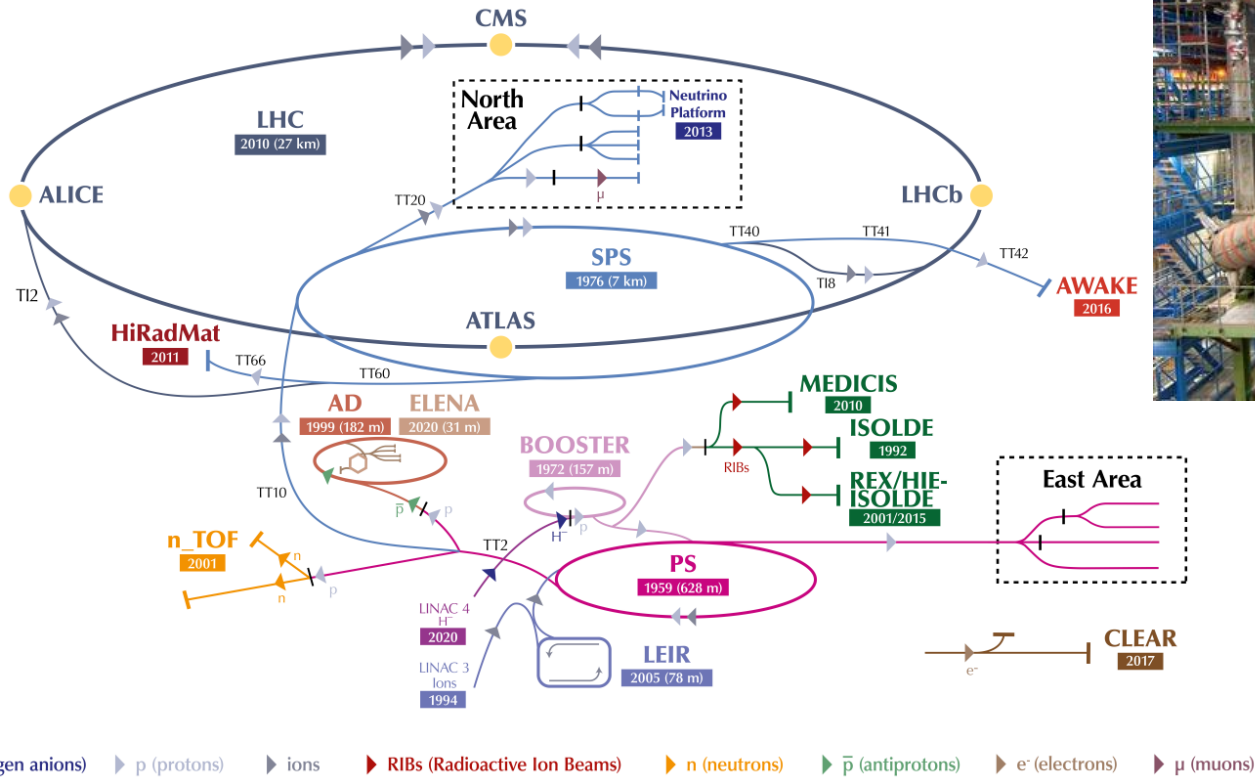
- **CERN is an engineering facility that produces physics**
- We design, build, operate and maintain by far the largest complex of particle accelerators in the world
- It is a 'mature' organization with a stable annual budget of ~ 1 B€
- **This means that past procurement is a good indicator of future needs.**
- We have spent an average of almost 20 M€ per year on instrumentation in the last 5 years
- **The main ongoing procurement projects are:**
- 'High-Luminosity LHC'* (HL-LHC), a major upgrade to both the LHC machine, with also major upgrades to the LHC experiments
- A long-term Consolidation project (CONS) to update and replace many of the older machine systems, in particular fixed-target beam experimental areas (NA-CONS, EA-CONS)
- **I will show statistics for all areas of CERN instrumentation procurement, but then focus on upcoming examples of procurement in beam diagnostics and optical fibres**

Link to recent HL-LHC technical meeting--
<https://indico.cern.ch/event/1161569/>



CERN accelerator complex

The CERN accelerator complex
Complexe des accélérateurs du CERN

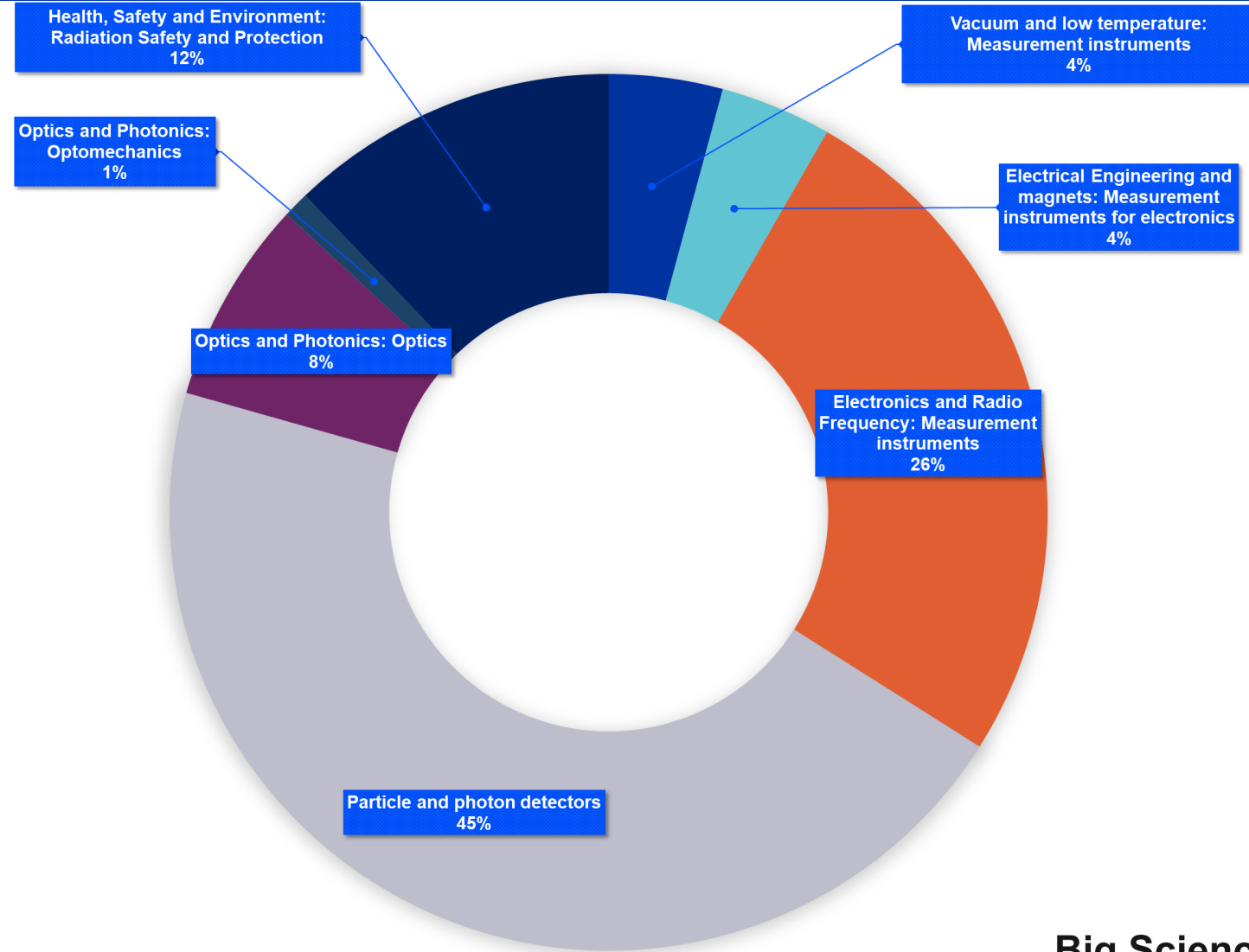


LHC - Large Hadron Collider // SPS - Super Proton Synchrotron // PS - Proton Synchrotron // AD - Antiproton Decelerator // CLEAR - CERN Linear Electron Accelerator for Research // AWAKE - Advanced WAKEfield Experiment // ISOLDE - Isotope Separator OnLine // REX/HIE-ISOLDE - Radioactive Experiment/High 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



CERN Spending on Instrumentation 2017-2022, CHF

Vacuum and low temperature: Measurement instruments	3,860,196
Electrical Engineering and magnets: Measurement instruments for electronics	3,776,732
Electronics and Radio Frequency: Measurement instruments	23,663,639
Particle and photon detectors	41,832,077
Optics and Photonics: Optics	6,906,798
Optics and Photonics: Optomechanics	882,280
Health, Safety and Environment: Radiation Safety and Protection	11,192,280
Total 2017-2022	92,114,002



Electronics and RF: Measurement Instruments

Total number of orders	2125
Total VAT excl.	23,665,599
Mean	11,136
Median	1,921

example:

1x Vector network analyzer 100 kHz to 44 GHz 2-port

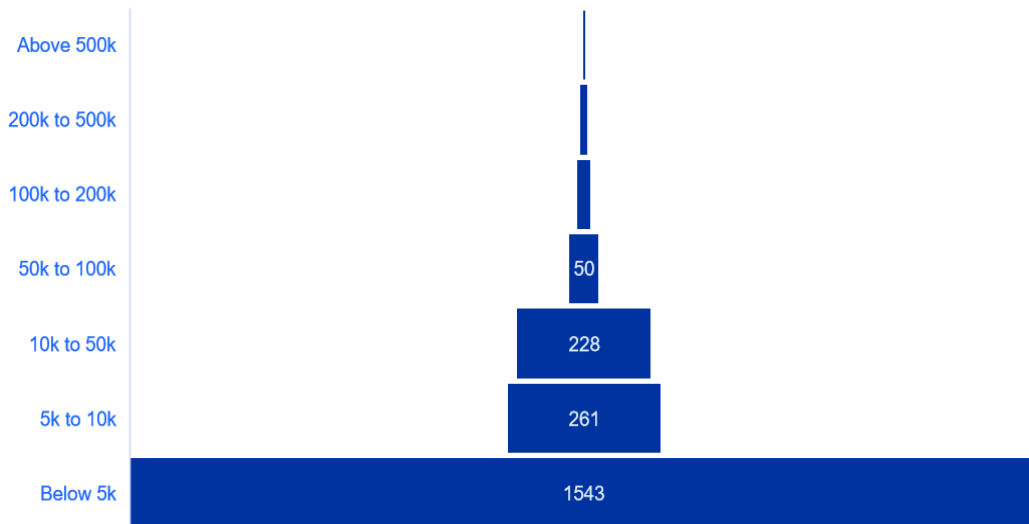
Project: Beam Instrumentation (General)

Total price: 79,456 CHF

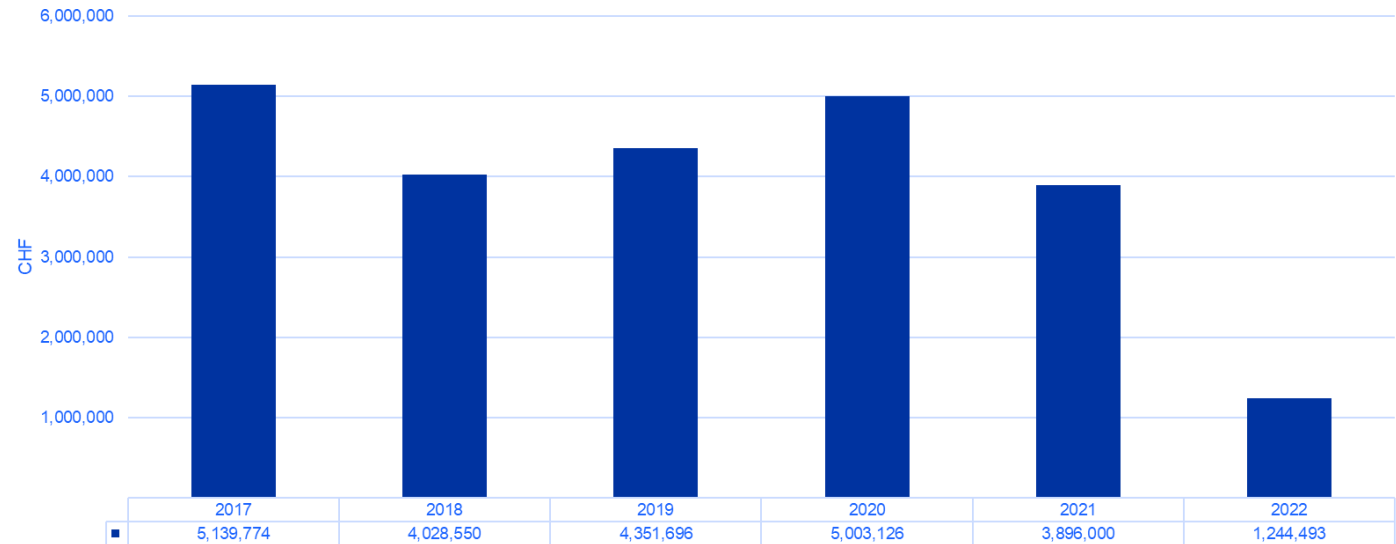
Country of origin: MY

Year: 2021

Orders Value



Electronics and RF: Measurement Instruments



Particle and photon detectors

Total number of orders	605
Total VAT excl.	41,832,077
Mean	69,143
Median	5,814

example:

12x Diamond Detectors

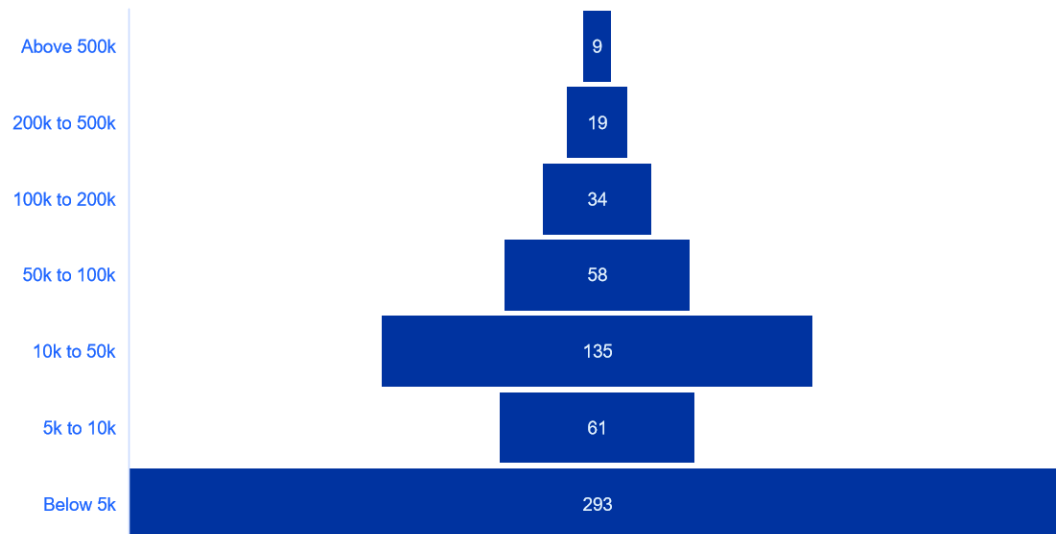
Project: BI Beam Loss Monitors LHC

Total price: 38,000 EUR

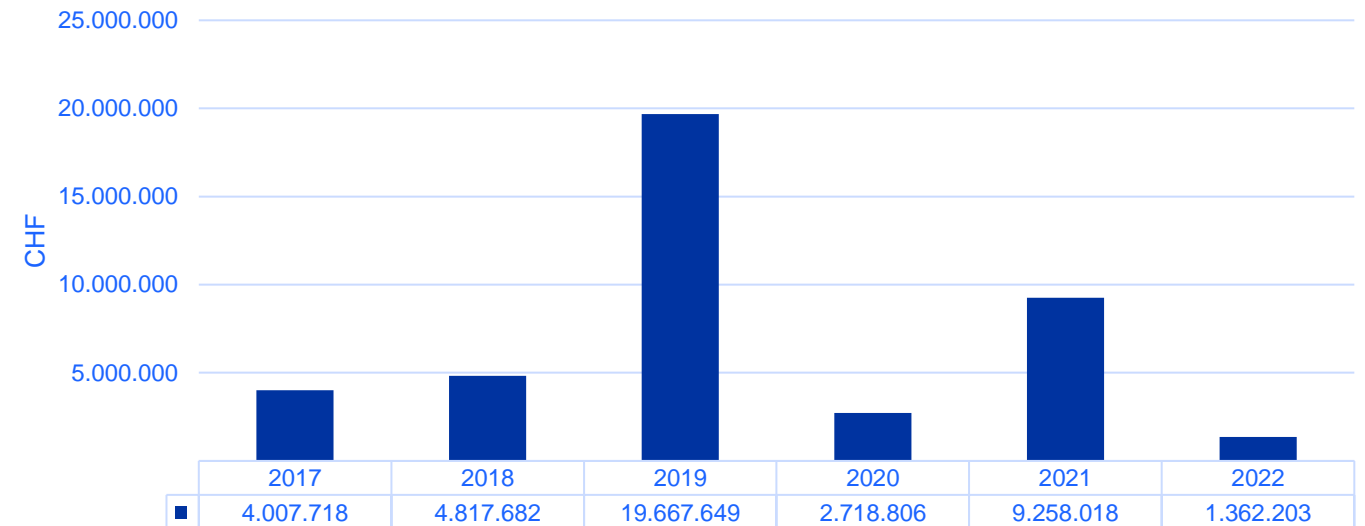
Country of origin: AT and UK

Year: 2019

Orders Value

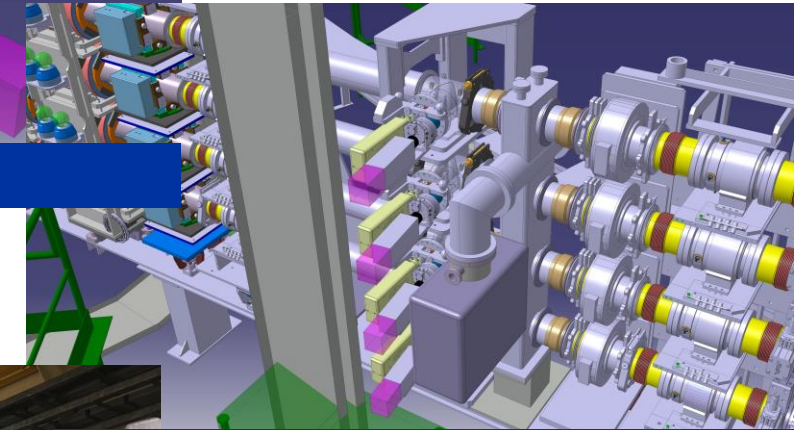
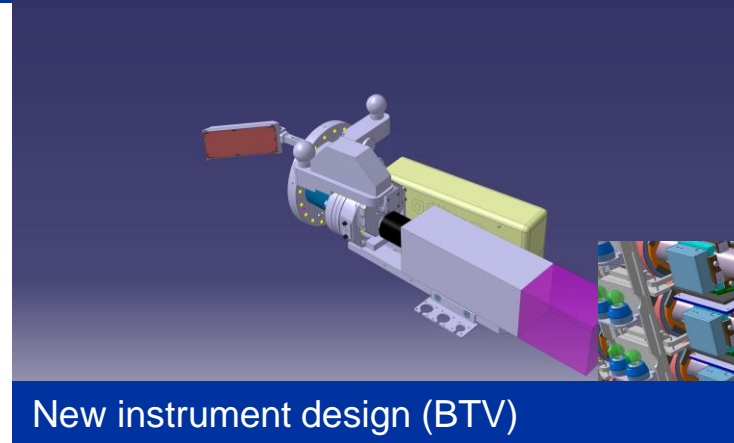


Particle and photon detectors



Example: Consolidation of beam observation screens

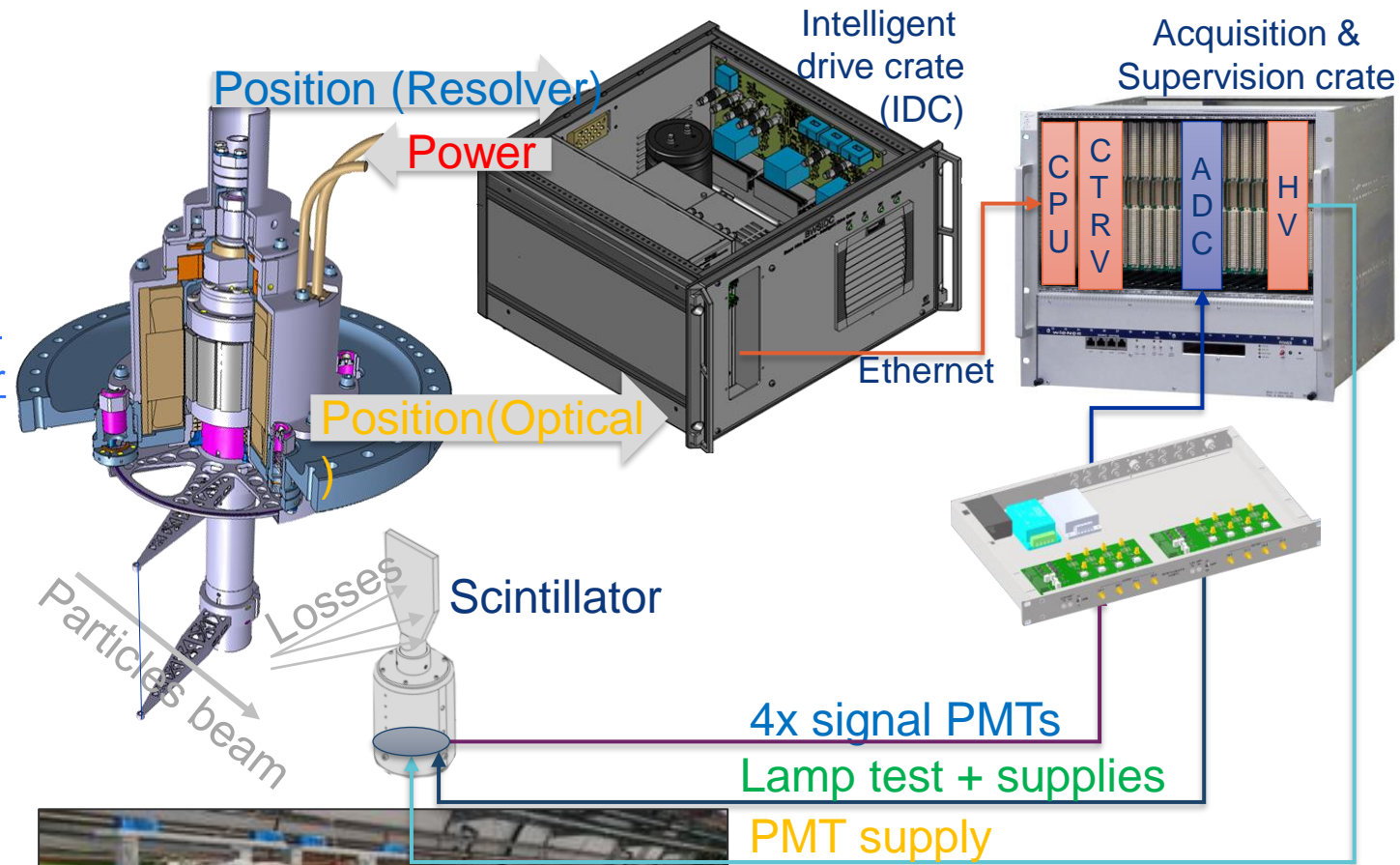
- **Simple, widely-used beam set-up device**
- Ceramic screen is moved into the beam with an in-out (magnetically coupled) actuator for the measurement
- Light emitted by the beam passing through the screen is observed by a radiation-hard digital camera
- Assembled onto a vacuum chamber with flange and glass viewport
- **Ongoing consolidation, replacing obsolete designs with state-of-the-art**
- Some 30 instruments replaced with a second phase planned for 2024-5
- All the components above will be procured
- **Generally CERN makes it's own designs, procuring commercial components and build-to-print mechanics**



instrumentation@CERN - Ray VENESS

Example: New beam profile measurement for the LHC

- **High precision, 'fast wire scanner'**
 - A [carbon \(nano-tube\) wire](#) is held in [metal additive machining forks](#)
 - This is rapidly passed across the beam by a [PMS motor](#)
 - Wire position is measured with [optical encoder](#) and [coil](#)
 - The whole assembly is mounted on a [vacuum chamber](#) with [viewports](#)
- **Dedicated acquisition and control**
 - Ex-vacuum [scintillator](#) and [photomultiplier](#) with [optical link](#) to a [commercial ADC](#) and [acquisition electronics](#)
 - Custom drive and control [electronics cards](#) with [power supplies](#) in a [crate](#)
- **New Design in progress**
 - Testing [magnetically coupled drive](#) with [linear motor](#) and [optical ruler](#) for wire position measurement
 - First series of 12 instruments needed for installation in 2026



Example: Beam Loss Monitoring System Upgrades

- **Beam loss monitors are safety-critical, broadly distributed instruments**
- Ionisation chamber detector with 4 layers of acquisition and processing electronics
- **Major upgrade and expansion programme for HL-LHC and CONS**
- As the accelerators produce more intense beams, better control on losses needed
- Large new production of ionization chambers (~2000 over the next decade)
- Updated acquisition electronics cards, plus planned replacement of ageing systems

LS4 (2032):

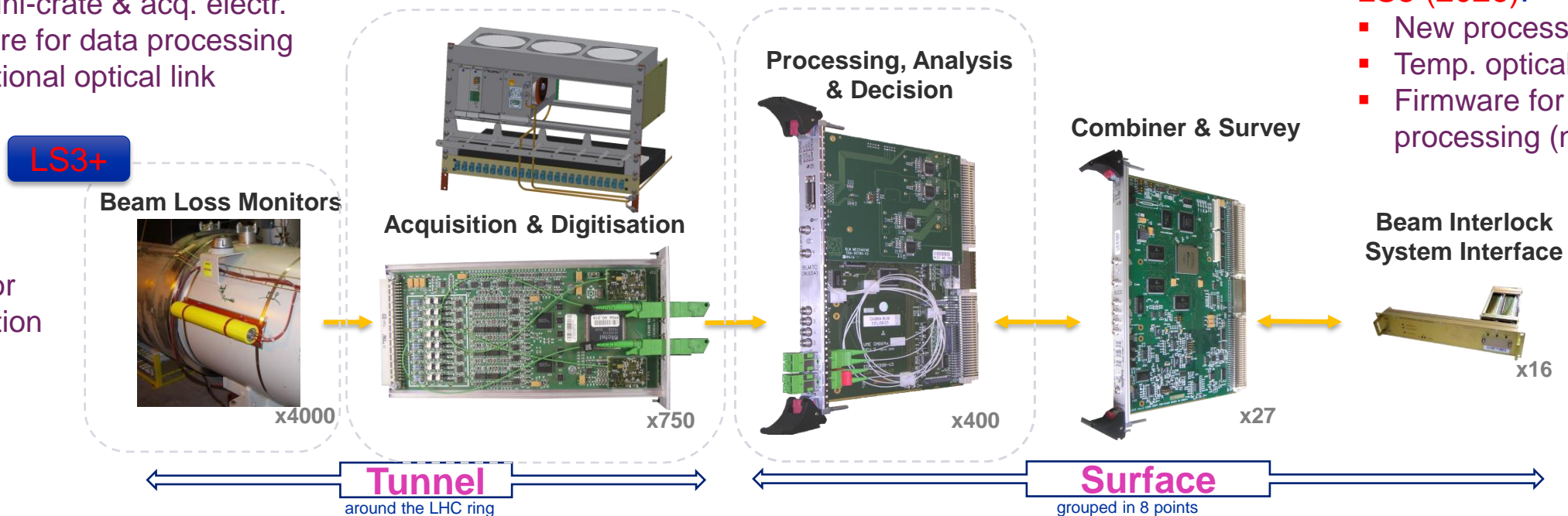
- New mini-crate & acq. electr.
- Firmware for data processing
- Bidirectional optical link

LS3 (2026):

- New processing electronics
- Temp. optical receivers
- Firmware for data processing (new FPGA)

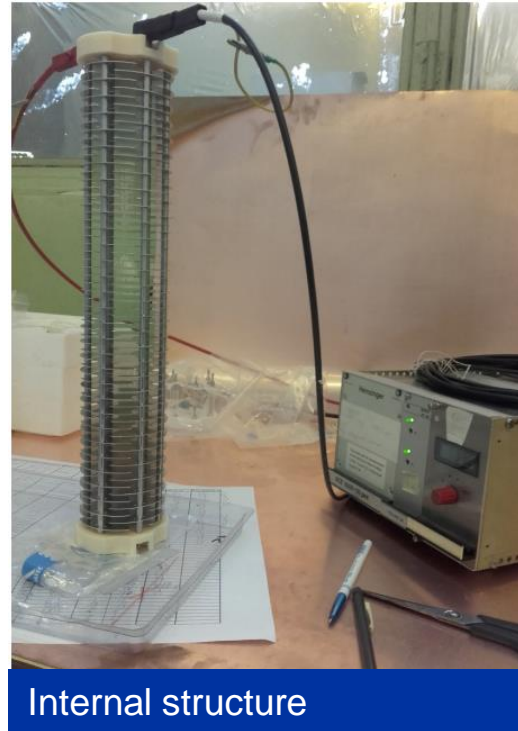
LS3+:

- Detector production



Beam loss monitor ionization chamber production

- **CERN is planning a new production of ionization chambers**
- This consists of precise aluminium discs mounted on ceramic supports for ~ 10 keV electrical operation, inside a chamber with partial gas pressure
- **Production tooling for large series**
- As some '000s of chambers are needed, a series production tooling will be procured with vacuum, heating and gas injection



Internal structure



Ionisation chambers in the LHC tunnel

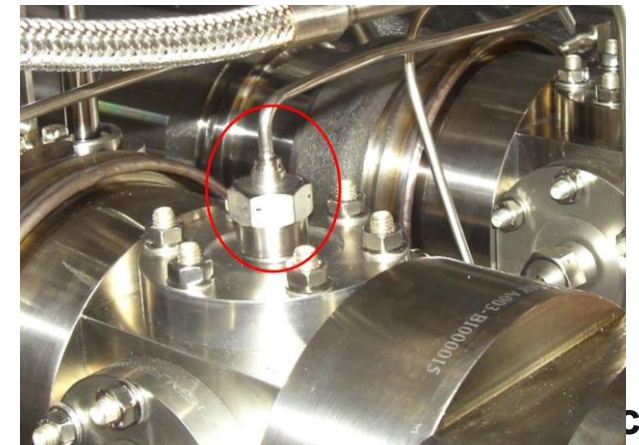
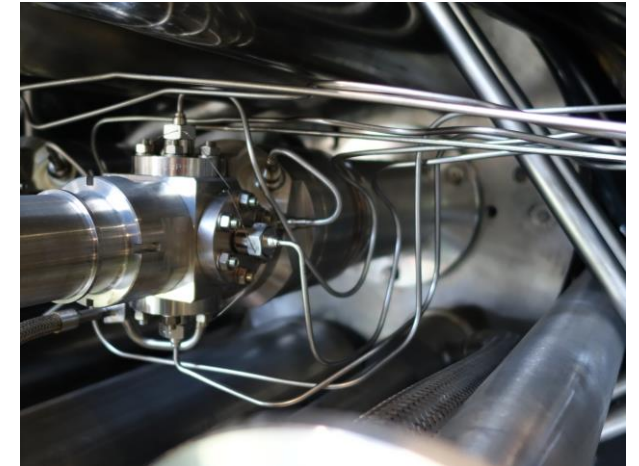


Production tooling

Upcoming industrial opportunities for SiO₂ coaxial cables

Contract description	Comments	Market Survey	Invitation to Tender	Estimated volume
Supply of 600 SiO ₂ coaxial RF cable assemblies	Specialty product	Q4 2022	Q1 2023	600 cables

- **600 SiO₂ coaxial RF connectorized cable assemblies needed for Beam Instrumentation and Collimation activities within the High-Luminosity LHC (HL-LHC) Project**
 - 4 different variants (length: 1.25–2.5 m; connectors: SMA or N type)
 - CERN specific requirements: ionizing radiation tolerance, compatibility with both cryogenic and high temperatures, compatibility with Ultra-High Vacuum (UHV), excellent RF performance, and mechanical robustness
- **Looking for an experienced supplier who can rapidly provide two off-the-shelf cables for CERN qualification purposes**
- **Estimated cost range: 200 – 750 kCHF**



Contact: michal.krupa@cern.ch

Example: Optical fibre supply, duct & cable blowing

■ In general:

- **Blanket** contracts for the supply of equipment
- **Service** contracts for installation and maintenance
- **Contact volume** of approx. 1.2 m€ per year in this field

■ Supply contracts (blanket purchase)

- Supply of optical fibre cables, pre-terminated cables, terminal hardware, etc...

- 3 currently in place

- Supply of optical fibre ducts and microducts for cable blowing

- 1 to tender ongoing

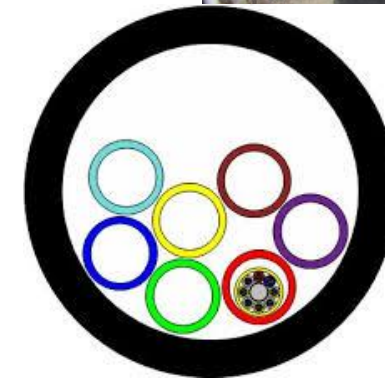
- Supply of specialty fibres for telecom and sensing

- 1 to tender foreseen in 2023 for radiation resistant fibres

■ Service contract

- Installation (by both air-blowing and conventional cable pulling)

- 1 currently in place



Contact: Daniel.ricci@cern.ch



Upcoming industrial opportunities for optical fibres

Supply contracts (blanket purchase contracts up to 5 years)

Contract description	Comments	Market Survey	Invitation to Tender	Estimated volume
Supply of optical fibre ducts and microducts	New contract	Q3 2022	Q4 2022	200 km
Supply of radiation resistant single mode optical fibres (Specialty)	New contract	2023-24		1500 km

Concerning Specialty Fibres, we are also keen to explore opportunities/partnerships with experienced manufacturers for:

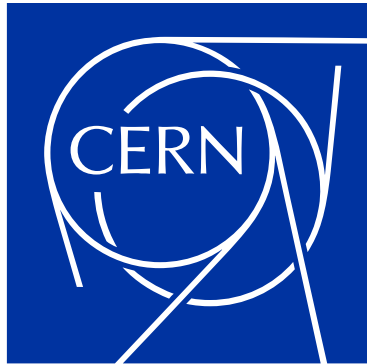
- **radiation-sensors** (e.g. with Phosphorous-doped fibres or radio-luminescent fibres)
- **polarization maintaining fibres**

Contact: Daniel.ricci@cern.ch



Summary

- **CERN spends ~20 M€ per year on instrumentation**
- Broad range of applications from particle physics to safety
- Broad range of technology including mechanics, optics, sensors and electronics as well as 'off-the-shelf' instruments such as network analysers
- Significant needs in infrastructure for instrumentation (e.g. cables, fibres) in addition to this instrumentation budget
- **Several major projects in active procurement**
- HL-LHC, NA-CONS, LHC experimental upgrades
- CERN aims to profile costs within the annual budget. However, there are also many 'in-kind' and 'collaboration' procurements not directly passing through our budgets
- **Beam instrumentation (my area)**
- 150+ new in-vacuum instruments to design and manufacture in next 5 years for HL-LHC and NA-CONS, plus major beam-loss monitor project



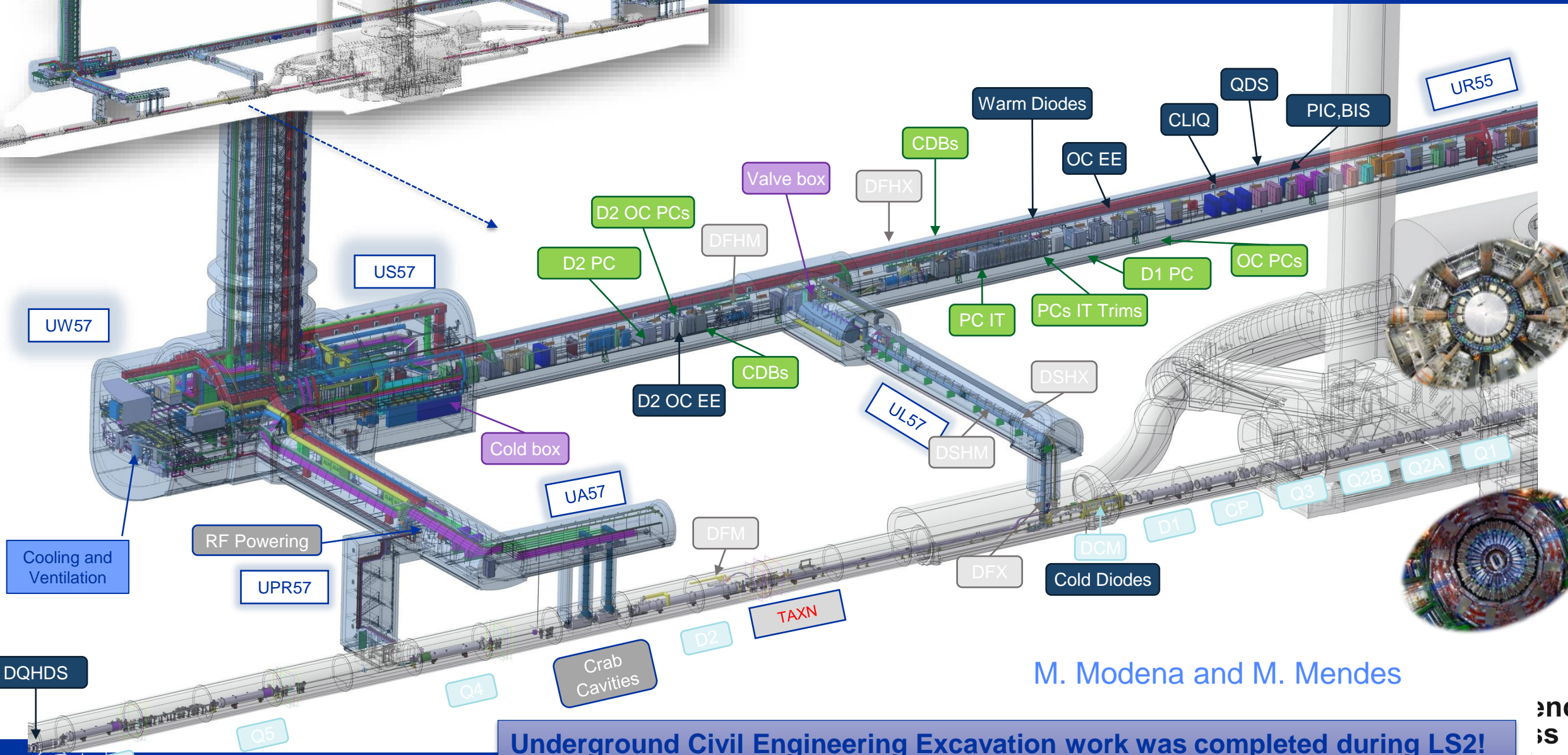
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Thanks to: Dmitry Gudkov, Daniel Ricci, Christos Zamantzas,
James Storey, Ben Moser

Backup slides



HL-LHC Scope in 1R and 5R



M. Modena and M. Mendes

Underground Civil Engineering Excavation work was completed during LS2!

Vacuum and low temperature: Measurement instruments

Total number of orders	296
Total VAT excl.	3,860,196
Mean	13,041
Median	2,267

example:

500x 1.7 – 300 K temperature sensors

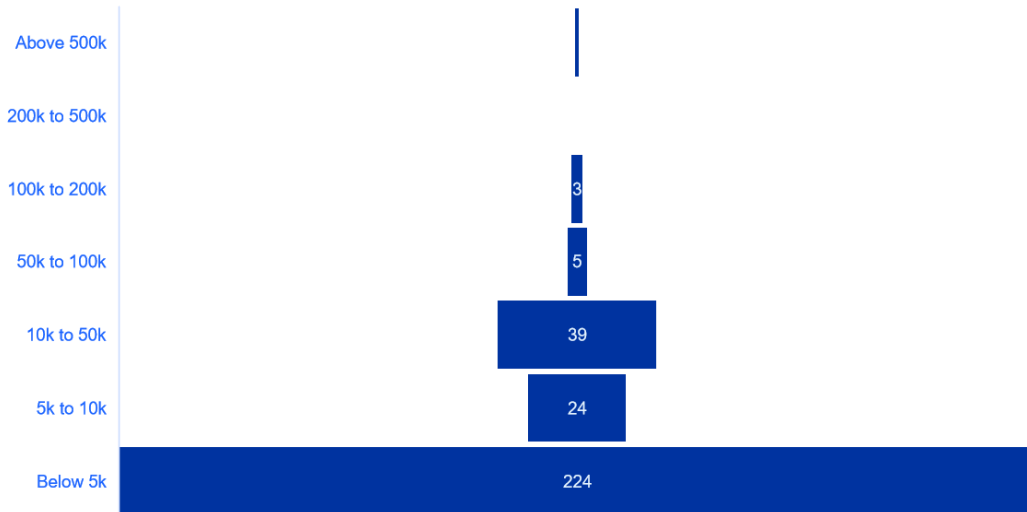
Project: HL-LHC project WP09 (Controls and Instrumentation – P1/P5)

Unit price: 884 EUR / Total price: 442,000 EUR

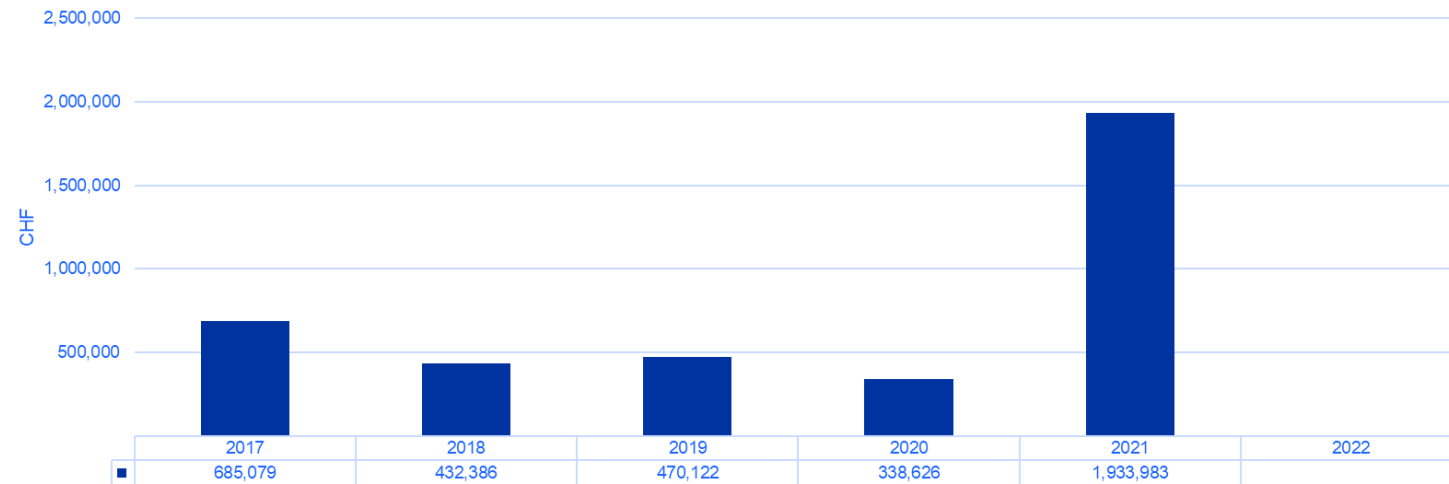
Country of origin: USA

Year: 2021

Orders Value



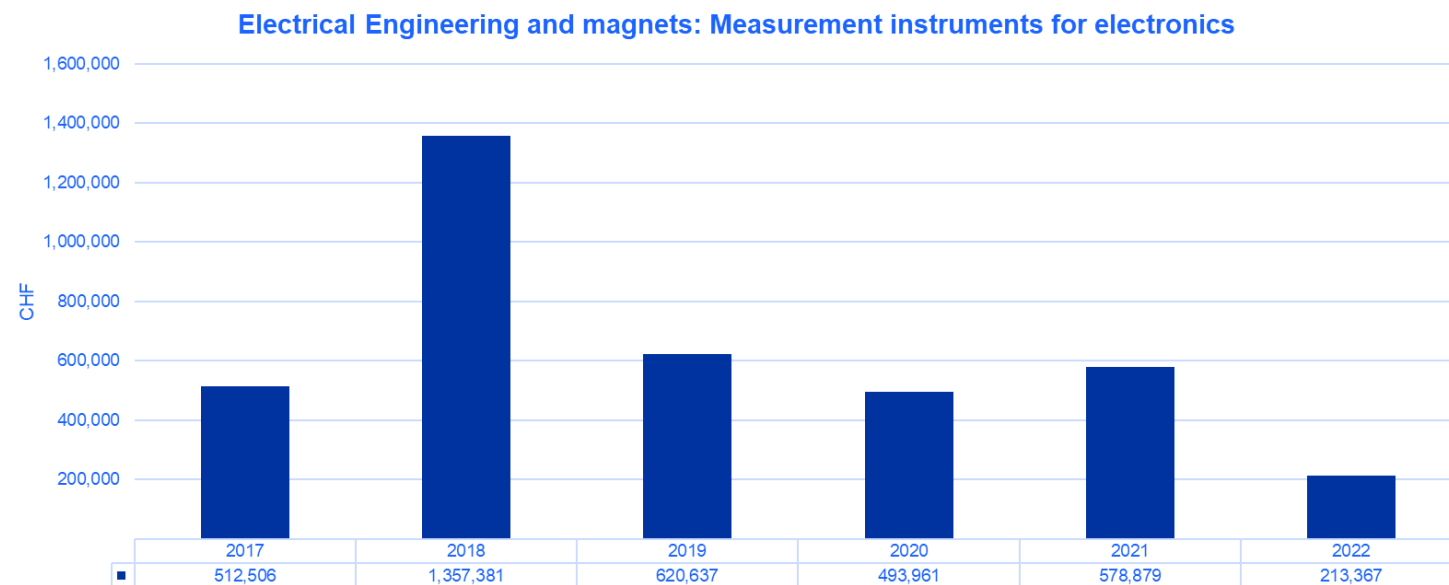
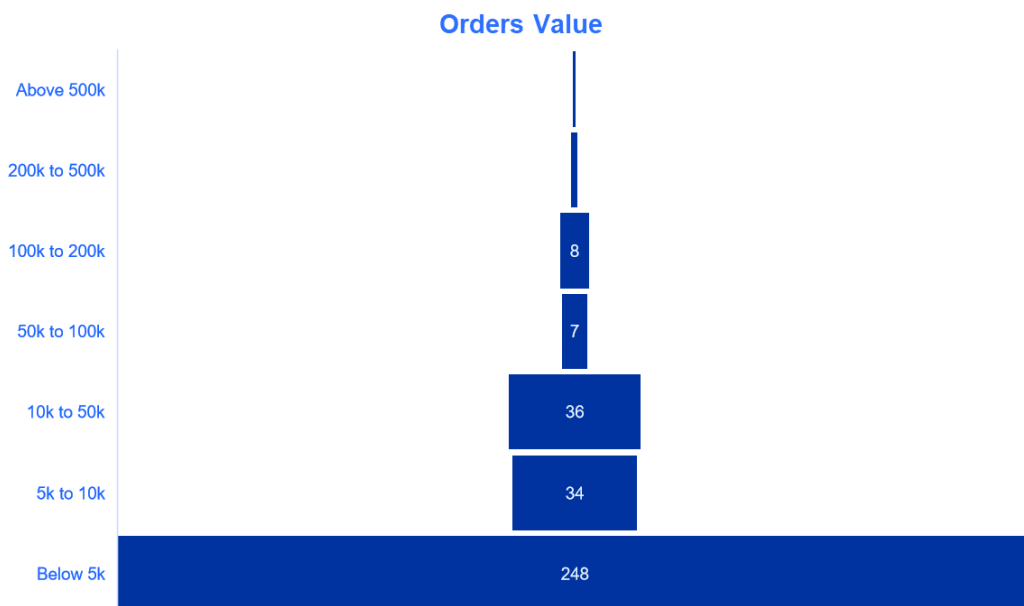
Vacuum and low temperature: Measurement Instruments



Electrical Engineering and magnets: Measurement instruments for electronics

Total number of orders	336
Total VAT excl.	3,776,731
Mean	11,240
Median	1,867

No example found!



Optics and Photonics: Optics

Total number of orders	1157
Total VAT excl.	6,909,585
Mean	5,972
Median	1,114

example:

1x Image Intensifier Unit + relay lenses

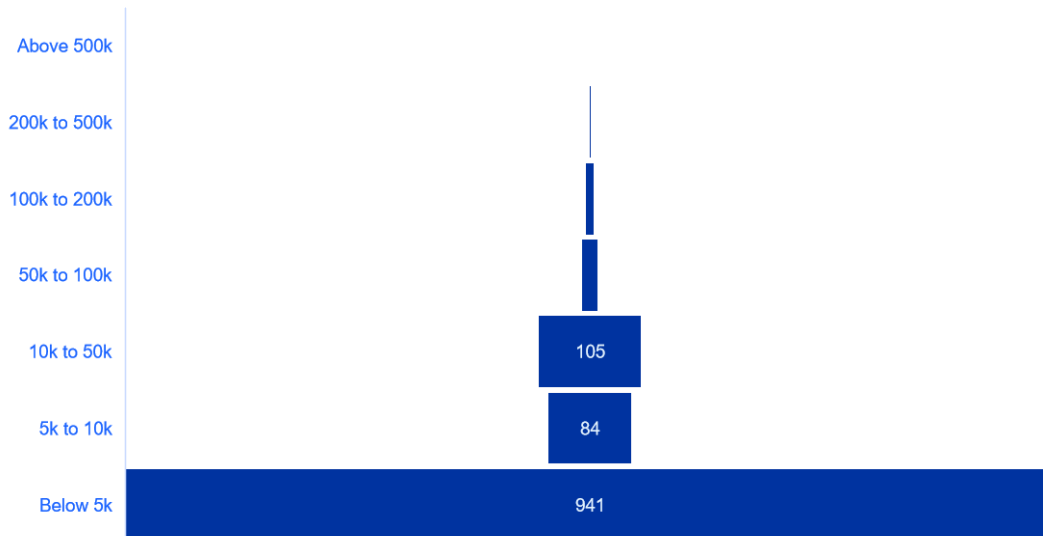
Project: AWAKE - Beam Instrumentation

Total price: 52,612 CHF

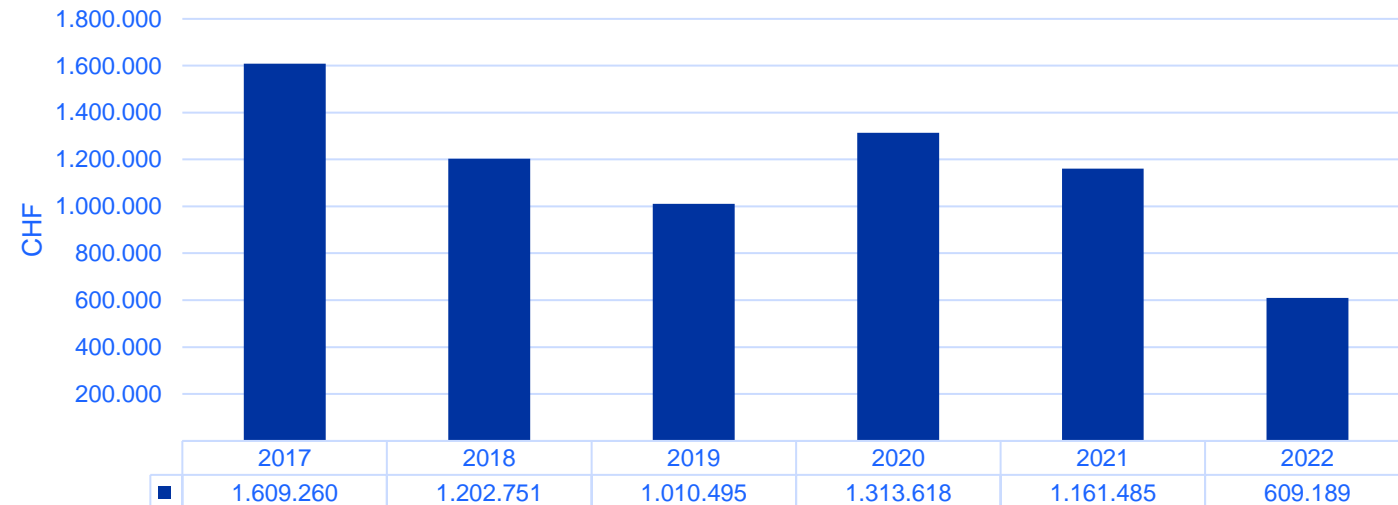
Country of origin: JP

Year: 2018

Orders Value



Spent by year



Optics and Photonics: Optomechanics

Total number of orders	397
Total VAT excl.	882,280
Mean	2,222
Median	894

example:

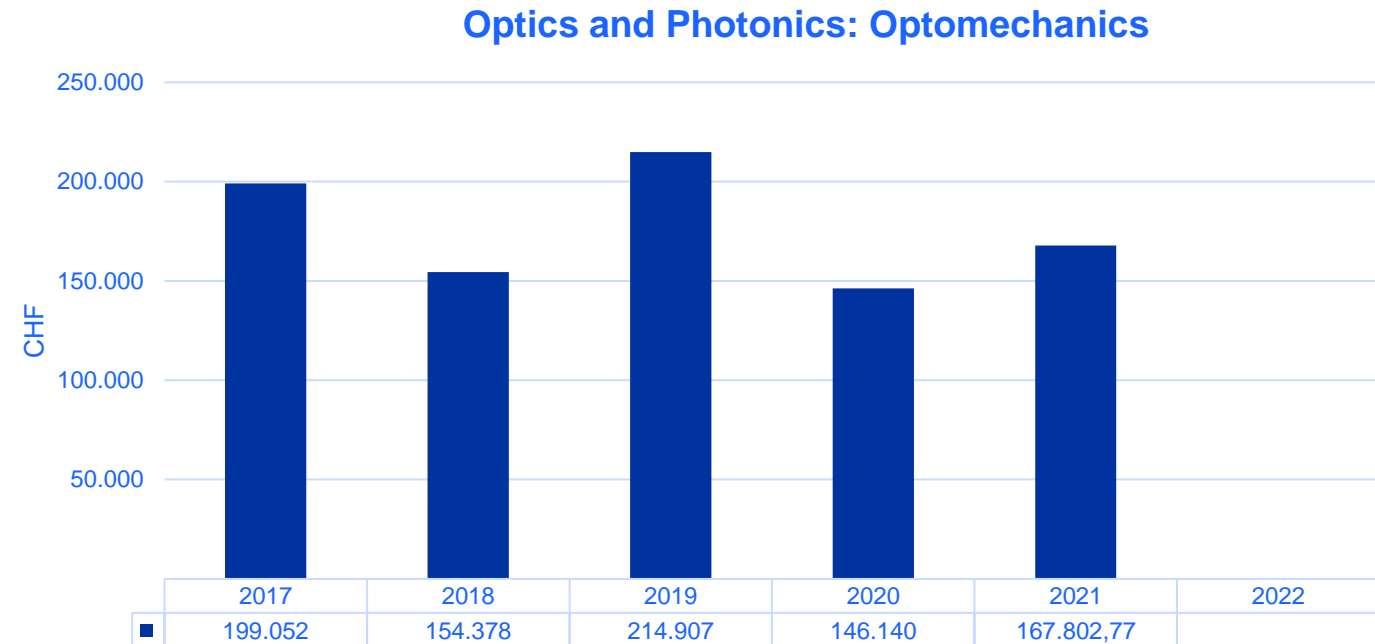
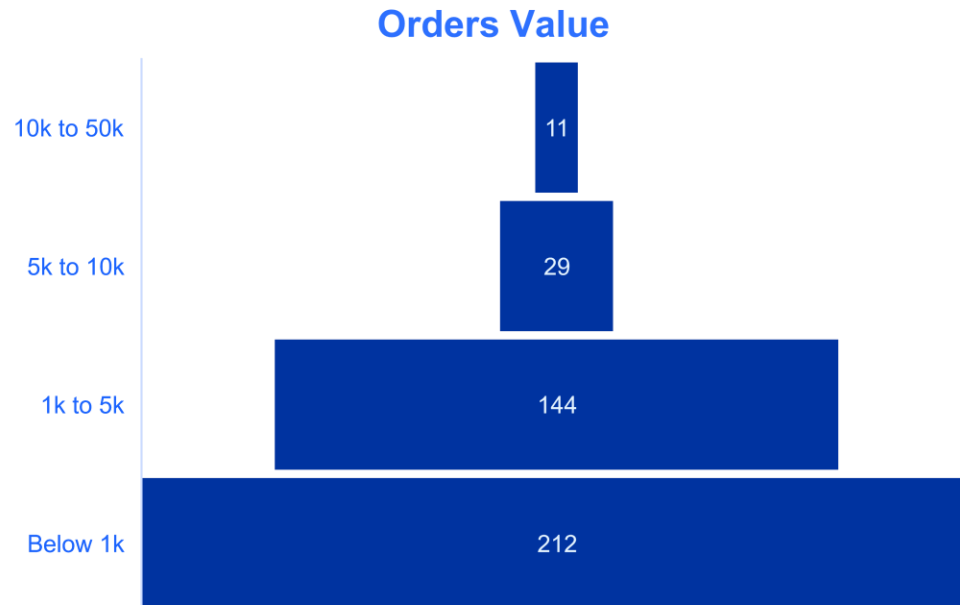
18x **special optical feedthrough**

Project: HL-LHC project WP4 (Cryomodule Development and Fabrication)

Unit price: 2140 EUR / Total price: 38520 EUR

Country of origin: DE

Year: 2017

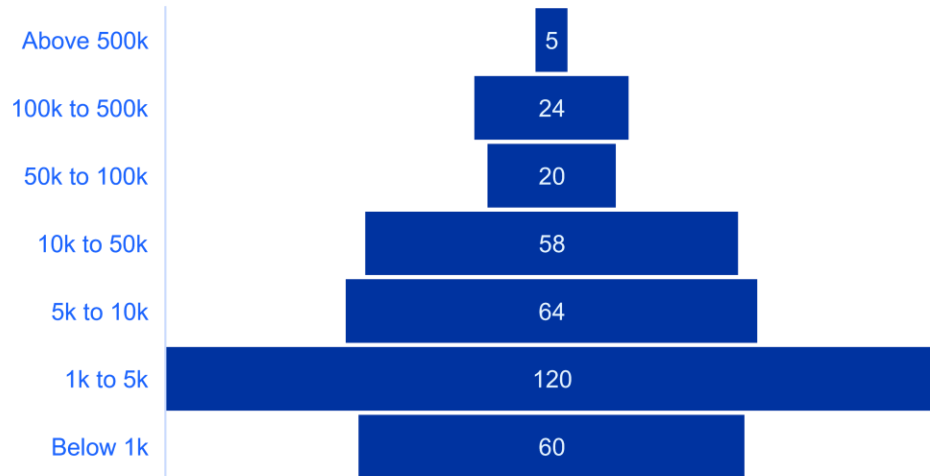


HSE: Radiation Safety and Protection

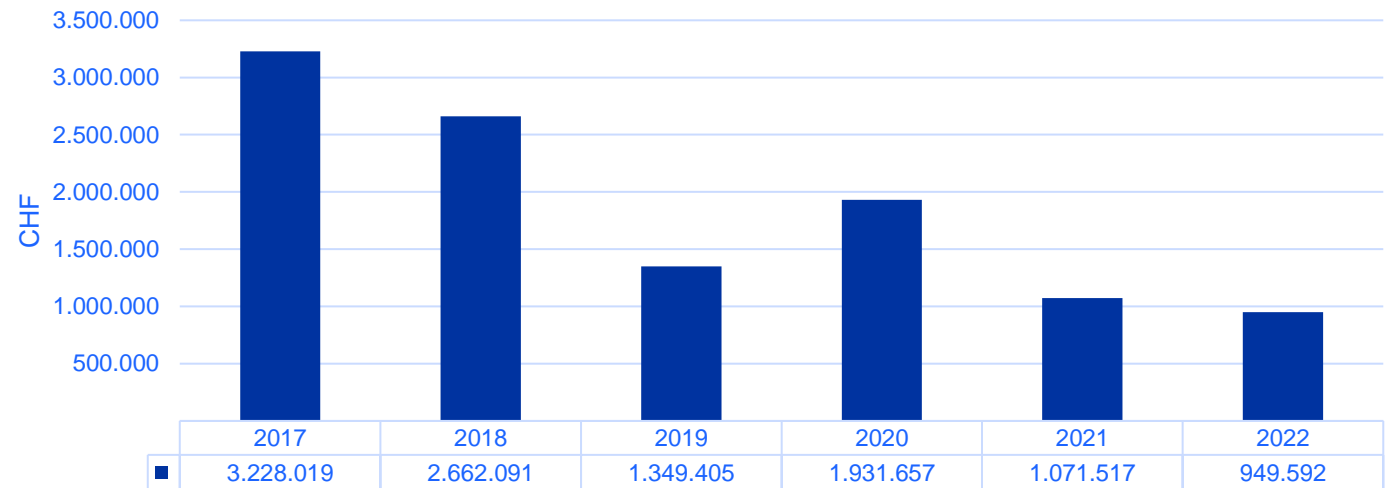
Total number of orders	351
Total VAT excl.	11,192,280
Mean	31,887
Median	4,738

example:
Shielding Walls and Doors + transfer system
 Project: MEDICIS
 Total price: 121,400 EUR
 Country of origin: FR
 Year: 2017

Orders Value

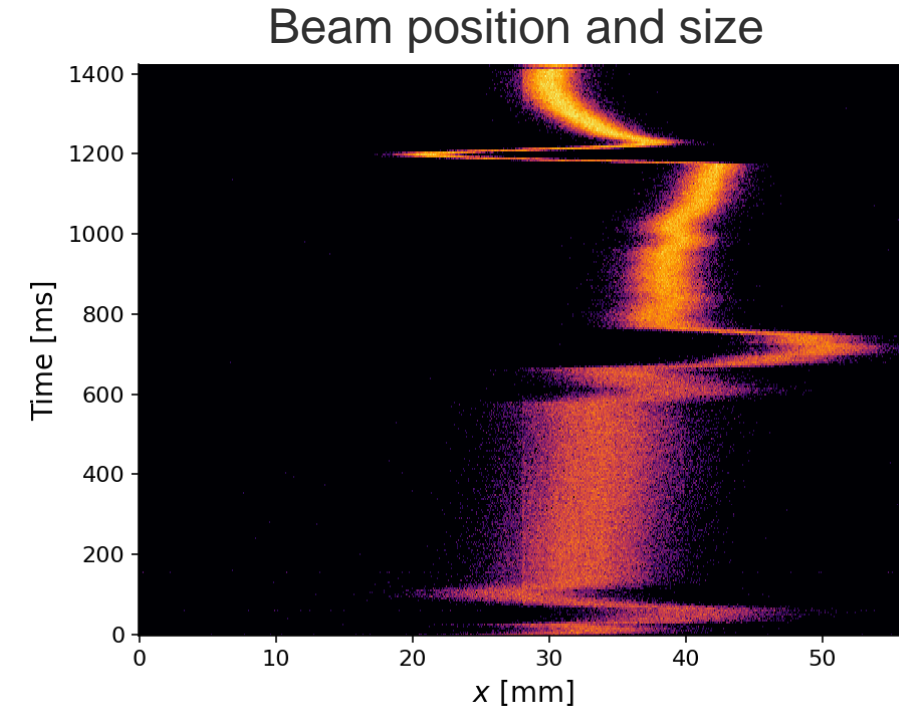
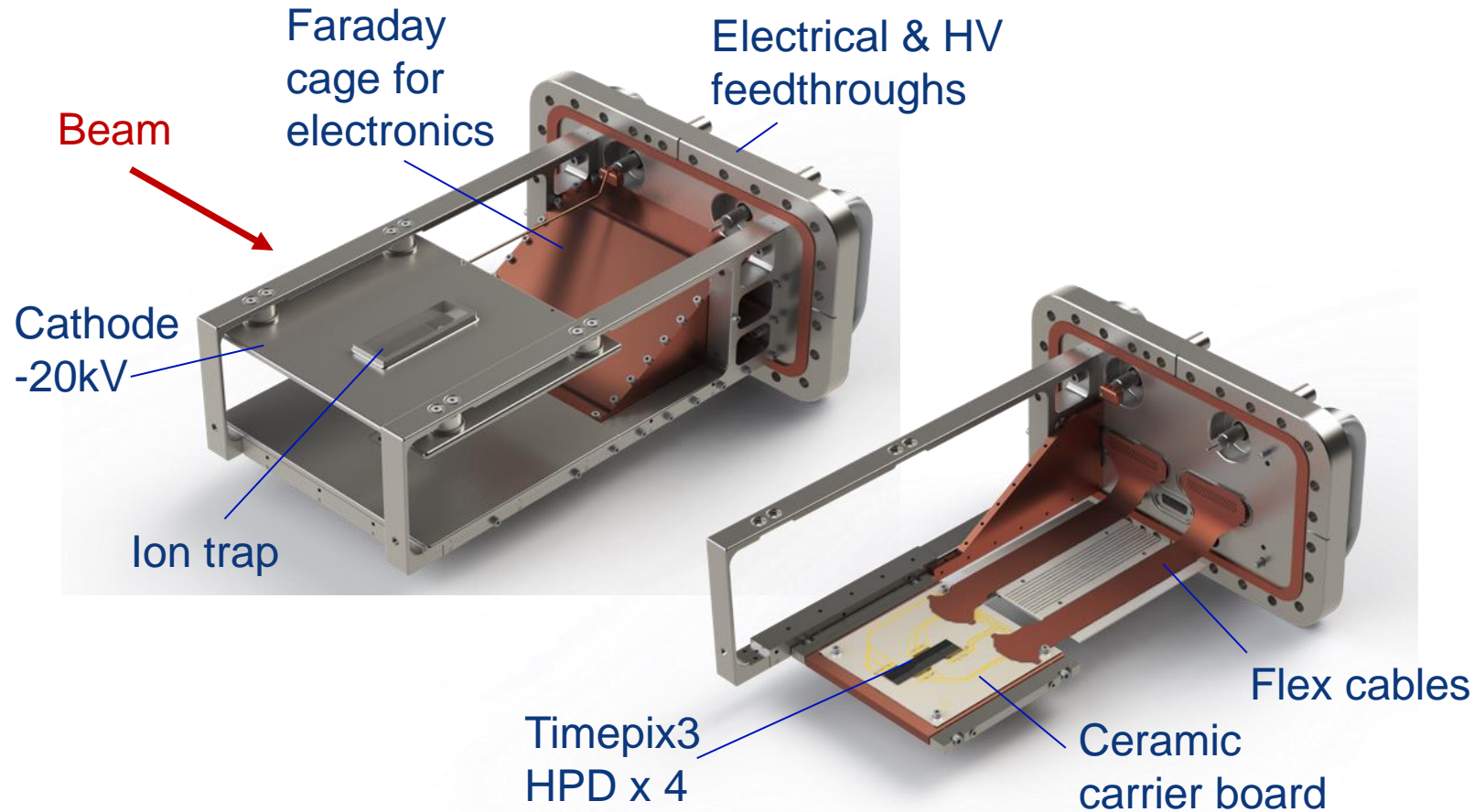


HSE: Radiation Safety and Protection



PS Beam Gas Ionisation Monitor

- Low impedance design and high vacuum compatibility



Measured through the PS cycle in May 2021