



# Status of LS2 collimators production and prospect for LS3

I. Lamas Garcia EN-STI-TCD

*On behalf of the Collimation Team and with contributions from several CERN groups: EN-MME, EN-SMM, BE-ABP, BE-BI, BE-RF, TE-VSC, EN-ACE, EN-HE, ATS-DO and many others*



International Review of the HL-LHC Collimation System

CERN, Geneva

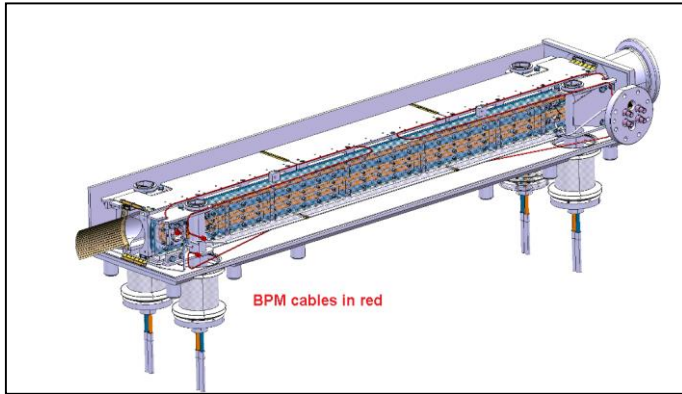
February 12<sup>th</sup>, 2019



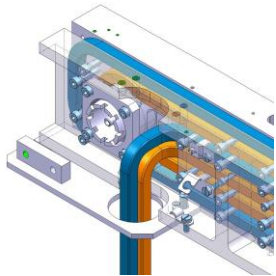
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# Collimation Production for LS1



BPM cables in red

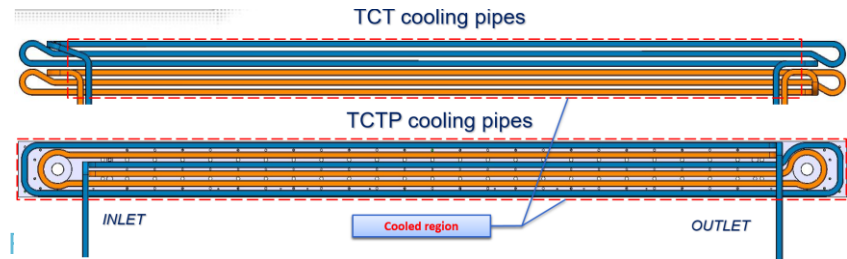


Many thanks to  
EN-MME

Collimator Types	Units	Absorbing material
TCTP	20	W alloy
TCPC	2	Si Crystal

## Options

Collimator Types	Units	Absorbing material
TCTW	4	W alloy
TCSP	2	CFC
TCPP	1	CFC



# Recap. of experience of LS1 production

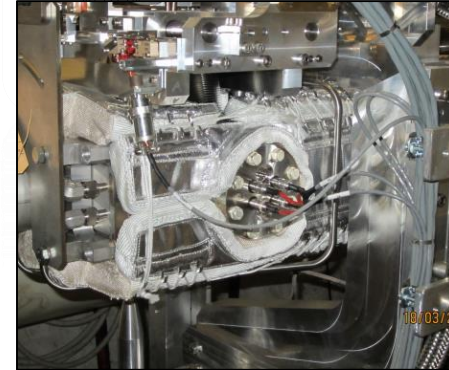
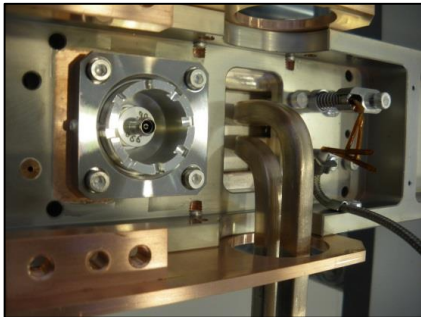
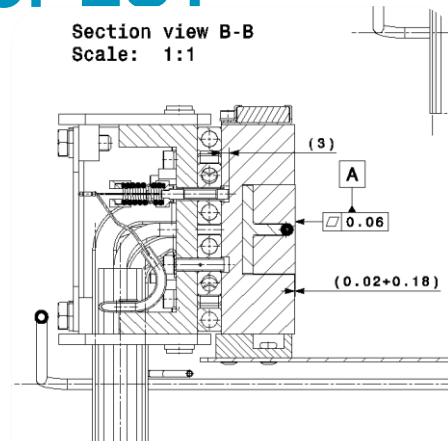
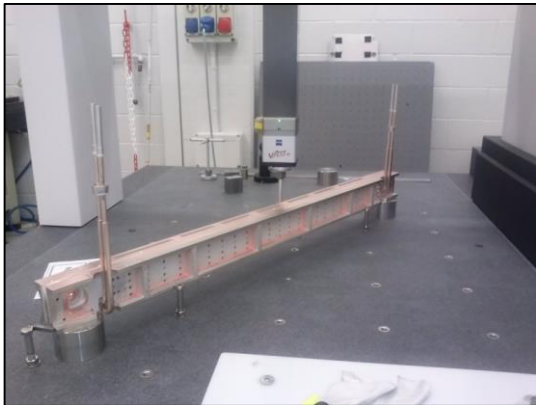
## Draw backs

- SDMS
  - Samples and qualification...but the contract was cancelled
- CECOM (mechanical tables)
  - Not quite precise machining
  - Drawing constraints review
  - Breathing-on-neck follow up campaign
- Ferrites and their TT
- W blocks as received
- Manifold welding
- BPM cables and flanges
- TCTW (wire brazing, very challenging)

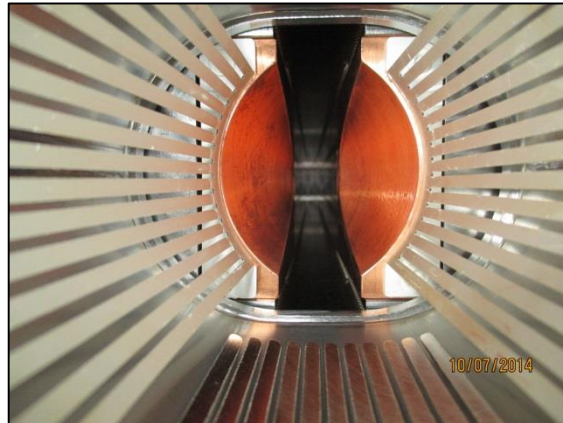
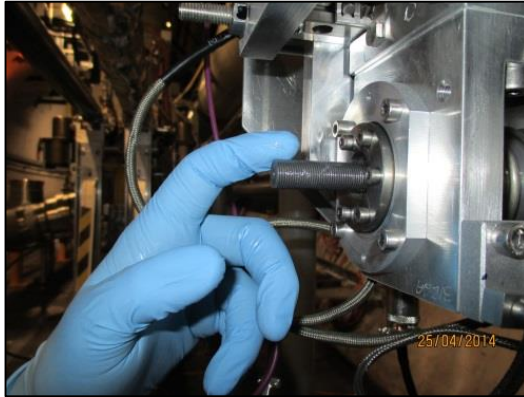
## Points in favor

- Oliver Aberle
- CINEL
  - Samples and qualification campaign
  - Prototype jaws
  - Brazing quality reached
- Thermal Contact Conductance Test Bench
- Quality control management

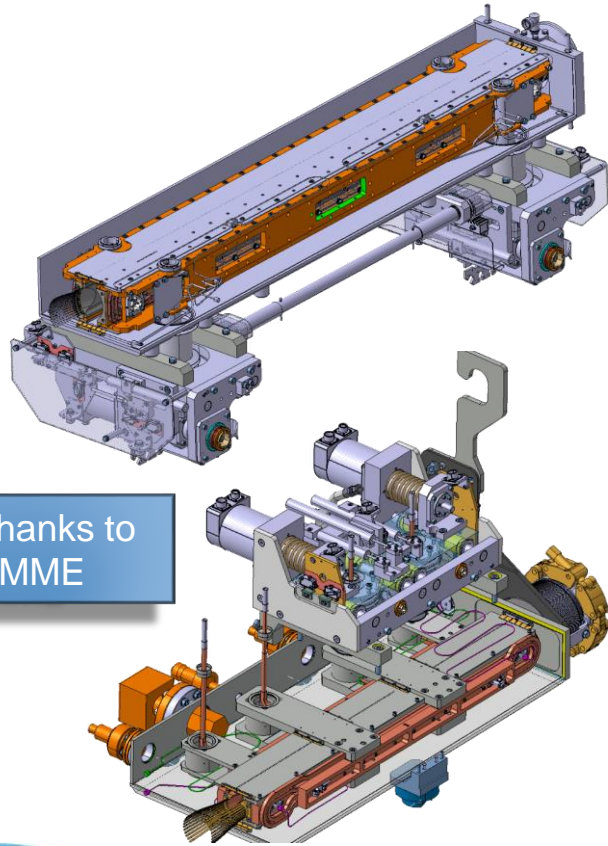
# Collimation Production for LS1



# Collimation Production for LS1



# Collimation Production for LS2



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EN-MME

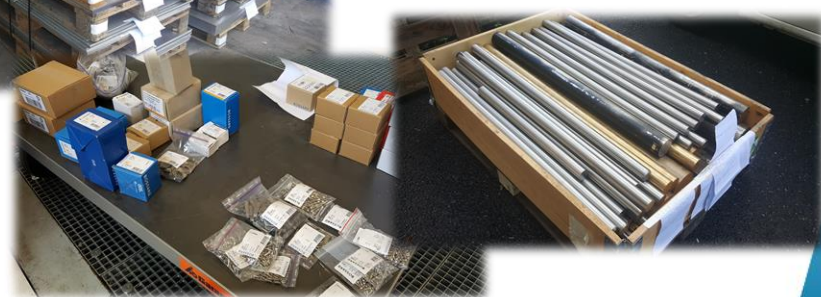
Collimator Types	Units	Absorbing material
TCSPM	10	Mo-MoGr
TCPM (Cons)	5	MoGr
TCLD	5	W alloy

## Options

Collimator Types	Units	Absorbing material
TCTPM	4	CuCD
TCLD	2	W alloy

# 2017 recap.

- TCSPM Prototype Manufacturing
- TCLD Prototype Manufacturing
- LS2 Collimators Production
  - Market Survey (MS-4272)
  - Invitation to Tender (IT-4272)
  - Finance Committee (12/2017)
  - **Contract award (01/2018)**
  - Material Procurement
    - Raw material
    - Commercial components





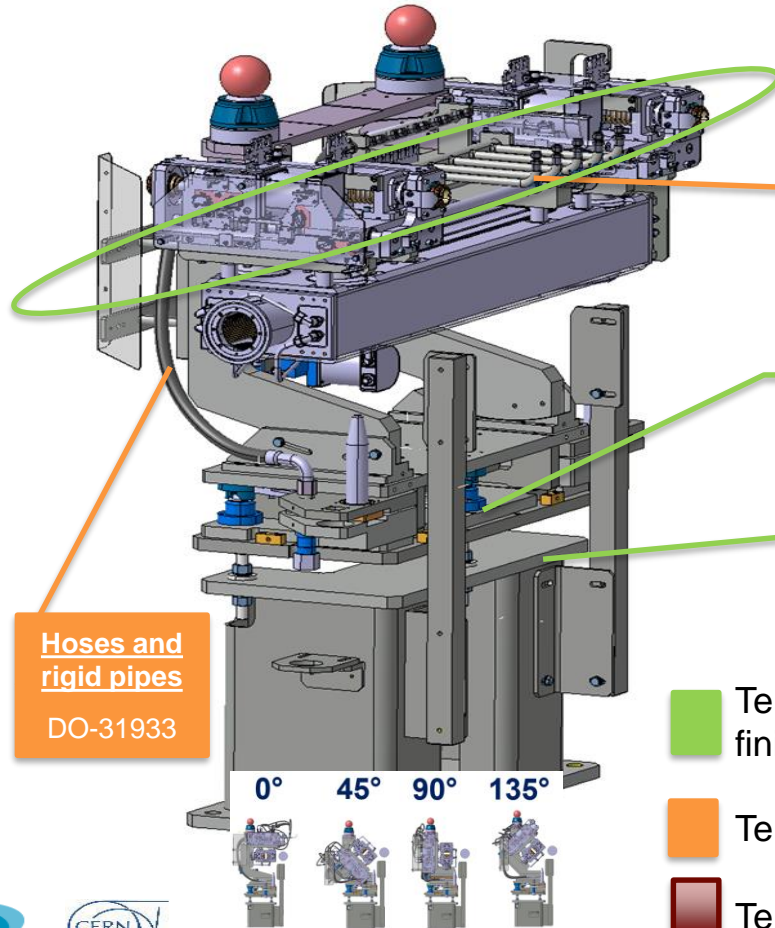
# Make or Buy plan LS2 Collimators

Many thanks to  
ATS-DO

Item	Cost Range (CHF)	Remarks
MoGr Absorber Blocks	c>750k	TCSPM/TCPMP absorber blocks Tungsten Heavy Alloy for TCLD (c<50k)
LS2 Collimators Production	c>750k	Production of LS2 Collimators. All hardware/components/materials provided by CERN Materials (304, 316L, 316LN, Alu., etc) – CERN Stores
Glidcop	200k<c<750k	Non-competitive Tender (No MS Firm)
Connectors for hydraulic circuits	50k<c<200k	Single Source by Design Requirements
Guiding Shaft and linear bearings	50k<c<200k	Single Source by Design Requirements
Bellows	50k<c<200k	Tender for mechanical bellows
Roller Screws	50k<c<200k	Single Source by Design Requirements
BPM Internal Semi-rigid vacuum cables	50k<c<200k	Non-competitive Tender (No MS Firm). Also tender for external RF Semi-rigid cables. LS2 & LS3
BPM components - Connector Flange Assembly	50k<c<200k	Tender for connector flange assembly. LS2 & LS3
BPM - Pick-up buttons	50k<c<200k	Tender for pick-up buttons (new development). LS2 & LS3
BPM - Blind Mate connector	50k<c<200k	Tender for pick-up buttons (new development). LS2 & LS3
Bake-out Jackets	50k<c<200k	Tender for bake-out jackets
Supports for collimators	50k<c<200k	Tender for metallic supports for LS2 Collimators
Jacks for TCLD	50k<c<200k	Tender for the TCLD jacks
Manifolds	50k<c<200k	Tender for LS2 Collimators manifolds
Switches	50k<c<200k	Rad-hard mechanical switches. Tender for LS2 only.
Motors	c>750k	Blanked Contract for HL-LHC Collimators. LS2 & LS3
LVDTs	c>750k	Blanked Contract for HL-LHC Collimators. LS2 & LS3

# HL-LHC collimators procurement

Many thanks to  
ATS-DO



LS2 Collimators Production  
(5 TCPPM, 10 TCSPM & 5 TCLD)  
DR-6490686 - IT-4272

Manifolds  
DR-7427660 – DO-31931

Plug-in system (Connectors)  
DR-6854219 – Single Tender

Fixed Supports  
DR-6854220 – DO-31249

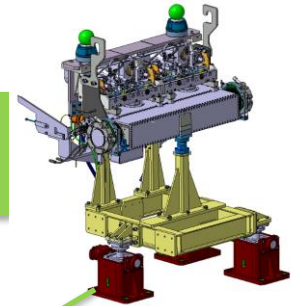
Hoses and rigid pipes  
DO-31933

Jacks for TCLD collimators and cryostats  
DR-7158169 - DO-31326

■ Tendering finished

■ Tendering on-going

■ Tendering not started



# HL-LHC collimators procurement

Many thanks to  
ATS-DO

## Jaw Absorber Blocks

- MoGr (TCPPM, TCSPM)  
DR-6272020 - IT-4201
- CFC (TCSPM) back-up for TCSPM  
DR-7039188 – Single Tender
- Tungsten Heavy alloy (c<50k, No DR)

Glidcop for back stiffener and housing blocks  
DR-6850041 - Single Tender

Bake-out jackets  
DR-6891552 – DO-30880

316LN Connector Flanges  
DR-6849315 - DO-31067

Vacuum Si<sub>2</sub>O Cables  
DR-6843955 – Single Tender

Stainless Steel 304L, 316L & 316LN  
c<50k (Central Stores)

Roller Screws  
DR-6854217 – Single Tender

LVDT  
DR-6734749 – IT-3425

Guiding Shaft & Bearings  
DR-6854216 – Single Tender

Hard-Rad Mech. Switches

DR-7478086  
DO-31829

Welded Bellows  
DR-6854215 – DO-30814

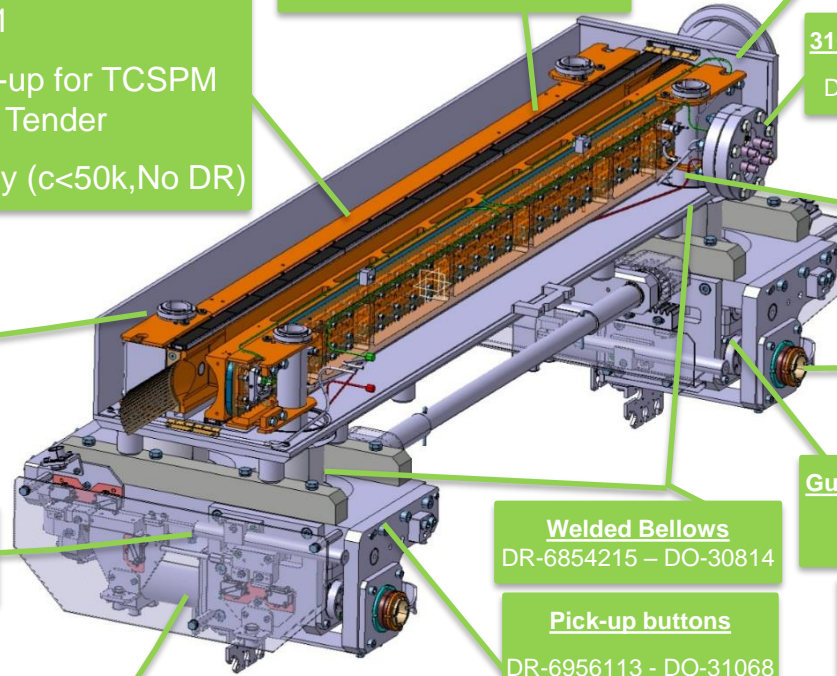
Pick-up buttons  
DR-6956113 - DO-31068  
DO-31045

External Cable assemblies

DR-6849313 +  
DR-6956223  
Tendering ongoing  
(MS-4441)

Stepped Motors  
DR-6723429 – IT-3385

Control Systems  
Framework contract



# Collimators production

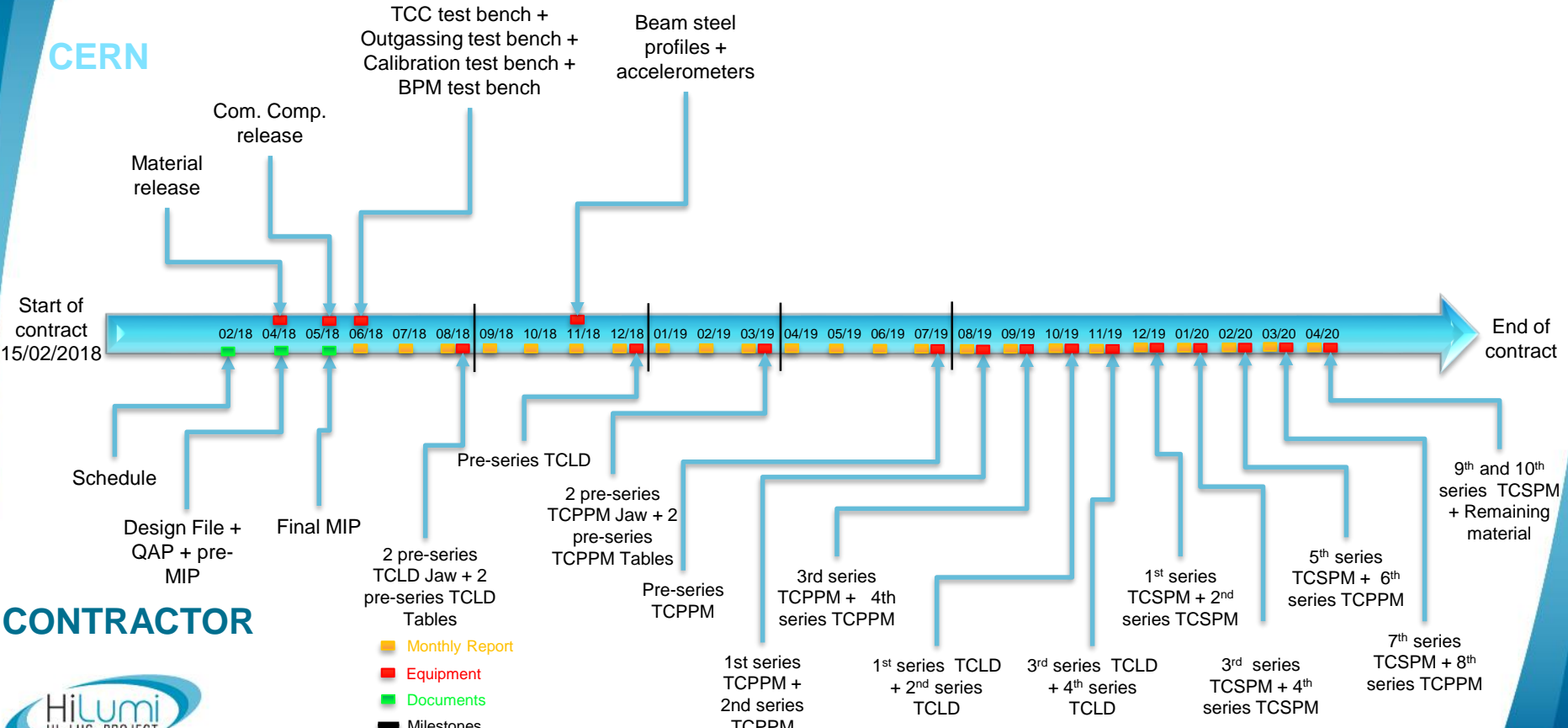
## Company: CINEL

- Based in Padua
- Specialized in:
  - Precision Machining
  - Welding and cleaning
  - Vacuum brazing
  - 3D measurements
  - Precise assembly
- Contract award 01/2018
- Kick of meeting 02/2018



# Collimators production - Deliverables time-line

CERN



CONTRACTOR



# Collimators production follow up

## Follow up - EDMS/MTF Documentation traceability

- Tests and reports
- Design modifications/proposals
- Procedures
- Quality Assurance Plan (QAP)
- Manufacturing Inspection Plan (MIP)

**Equipment Identifier:** HCTCLDA001-CZ00001  
**Other Identifier:** None  
**Description:** HL-LHC Auxiliary Collimators in DS Area - Model A [TCLDA]

Step ID	IR/E	Other name	Description	Status	Last Repeated
1	0		Traceability of materials - CERN and External Company (*)	In Progress	
5	0		3D measurements - External company	Done	OK
10	0		BPM Test, Without Vacuum - External company	Done	OK
15	0		Vacuum & Bake-out - External company	Done	OK
17	0		Electronic Test before Vacuum	Done	OK
20	0		Electronic Test Under Vacuum - External company	Done	OK
25	0		BPM Test, Under Vacuum - External company	Done	OK
30	0		Agreement for Shipment - External company	Done	OK
35	0		Agreement for Shipment - CERN	Done	OK
40	0		Reception of Final Documentation - CERN	In Progress	OK
45	0		Arrival - CERN	Done	OK
50	0		Reception CERN - Electronic Test	Pending	
55	0		BPM Test	Pending	
60	0		LVDT Calibration & Motors	Pending	
65	0		Data for operation	Pending	
70	0		SU Targets Alignment - CERN	Pending	

# Collimators production milestones

## CERN deliveries to CINEL

- Raw material (03/2018)
- Commercial components for TCLD pre-series (06/2018)
- Thermal Contact Conductance (TCC) test bench (08/2018)
- BPM and torque-meter Test benches (08/2018)
- Outgassing test bench (02/2019)

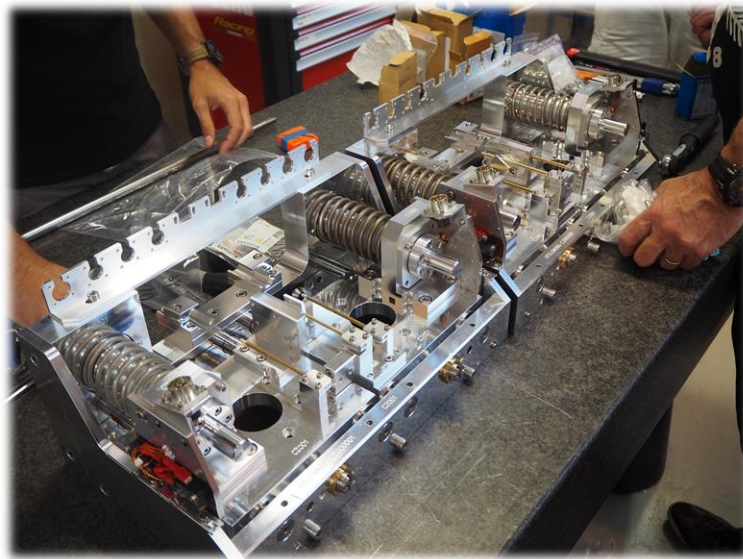
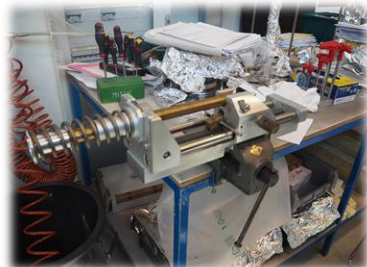
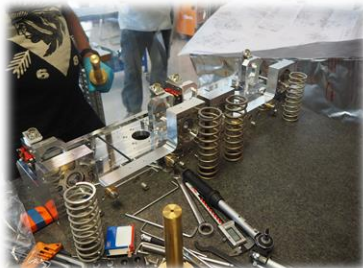
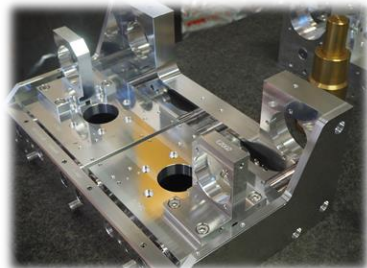


Many thanks to  
EN-SMM, BE-BI & TE-VSC

# Collimators production milestones

## TCLD pre-series Mechanical tables

- Assembled at CINEL on 07/2018
- Received, tested and approved at CERN on 08/18

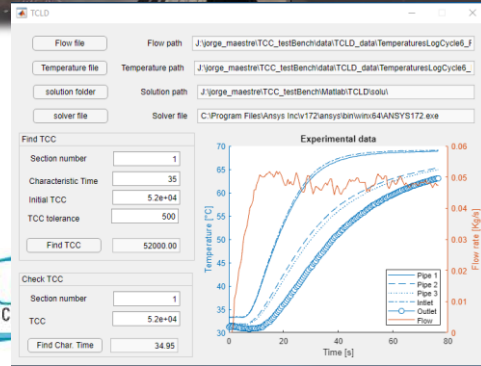
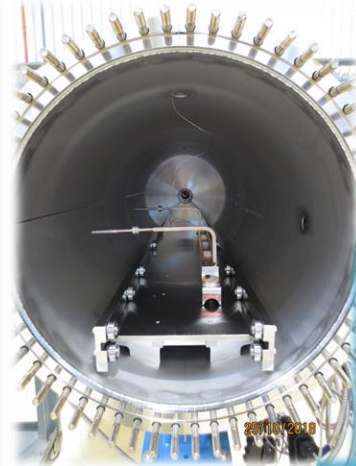
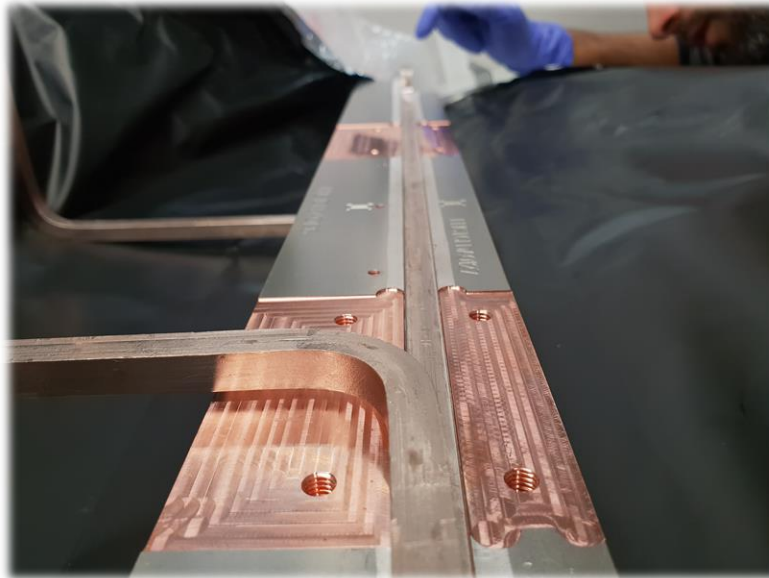
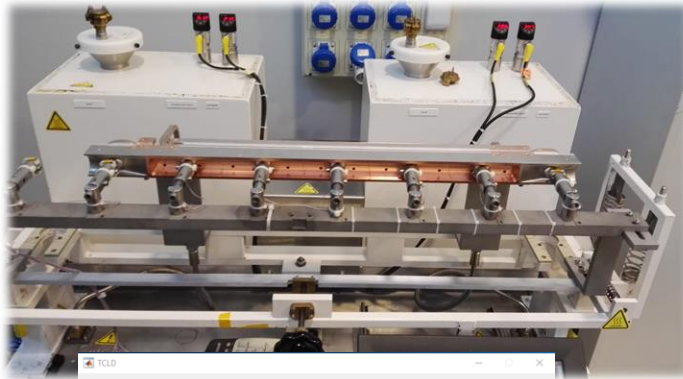




# Collimators production milestones

## TCLD pre-series Jaws

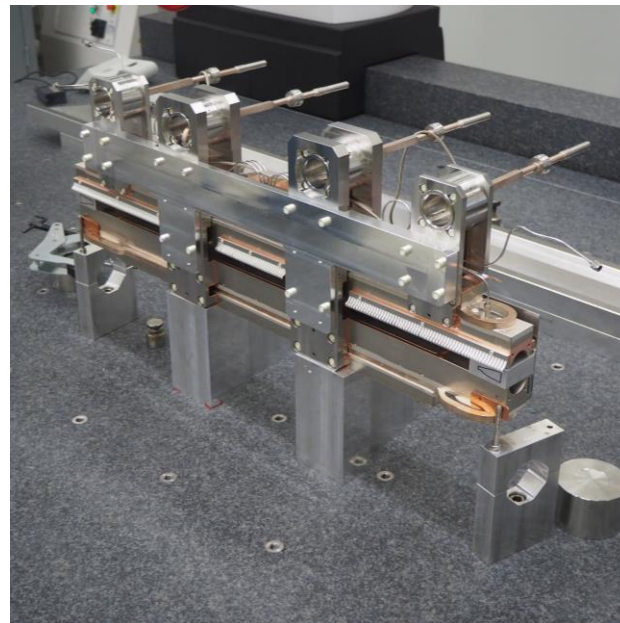
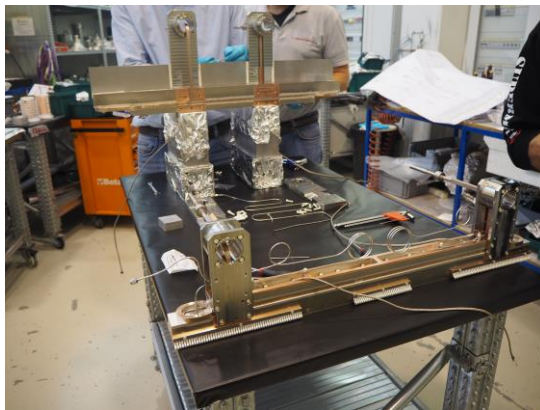
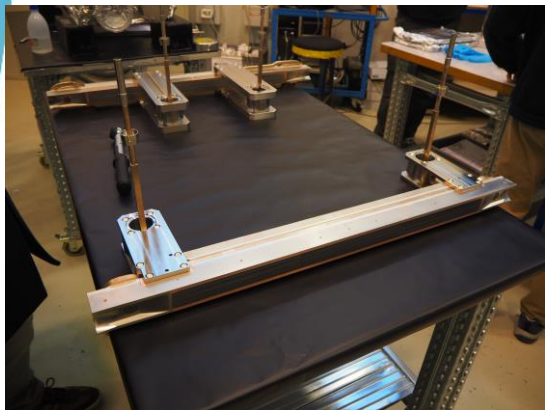
- Brazed at CINEL on 09/2018
- Received, tested and approved at CERN on 10/18



# Collimators production milestones

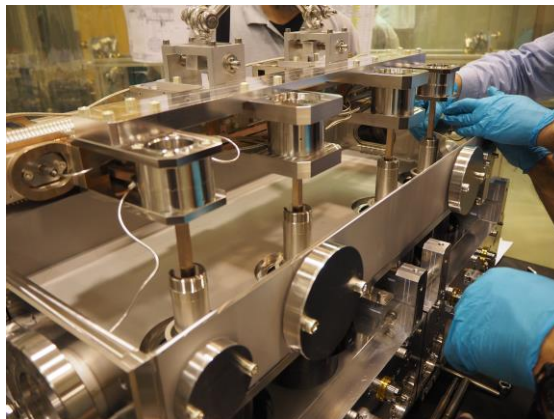
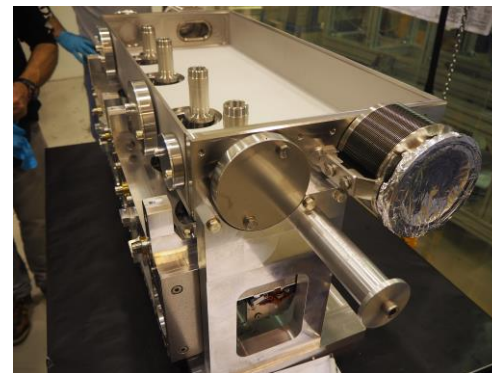
## TCLD pre-series Jaws

- TCLD jaws to be final assembled at CINEL (11/2018)



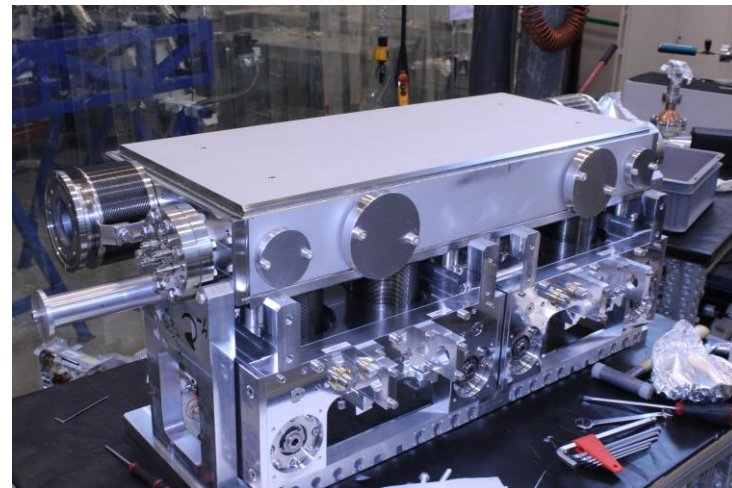
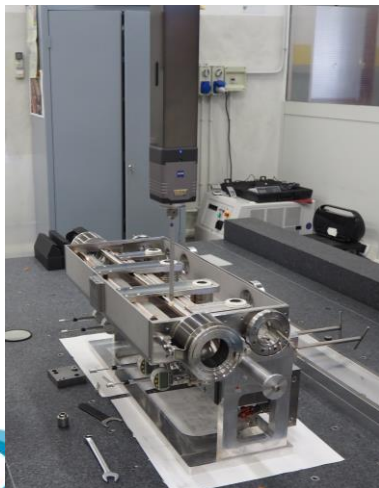
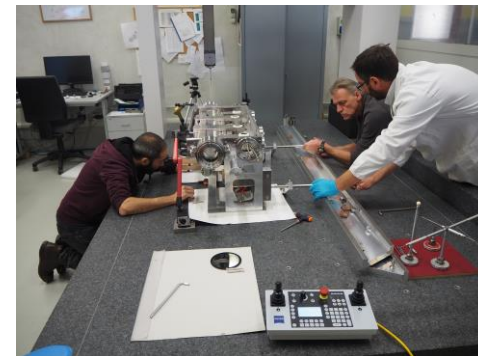
# Collimators production milestones

- TCLD pre-series Collimator:
  - TCLD pre-series collimator assembly (11/2018)
  - TCLD pre-series 3D metrology + tests + fine adjustments (12/2018)
  - TCLD pre-series cover EBW (12/2018)
  - TCLD pre-series final tests and bake-out (01/2019)
  - TCLD pre-series shipment to CERN collimator reception milestone (01/2019)



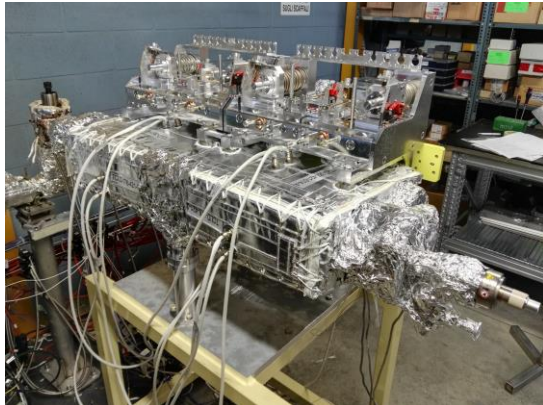
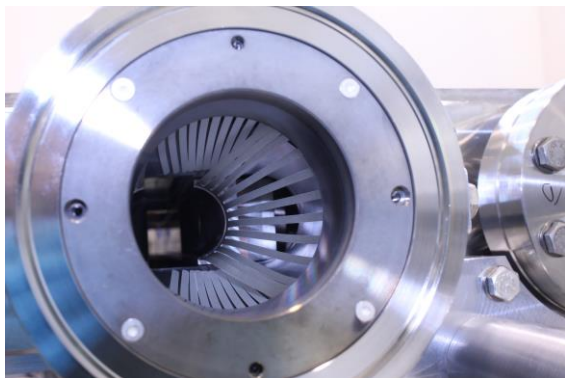
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# Collimators production milestones

- TCLD pre-series Collimator:
  - TCLD pre-series collimator assembly (11/2018)
  - TCLD pre-series 3D metrology + tests + fine adjustments (12/2018)
  - TCLD pre-series cover EBW (12/2018)
  - TCLD pre-series final tests and bake-out (01/2019)
  - TCLD pre-series shipment to CERN collimator reception milestone (01/2019)



# Documentation status

## Contractor deliverables

- Schedule [EDMS 1887254](#)
- Detailed Design File
  - Modifications of CERN design
  - Modifications of CINEL
- TCLD summary modifications  
[EDMS 2061573](#)
- TCSPM/TCPPM summary  
modifications [EDMS 1887258](#)

- QAP
  - Organigram and Roles [EDMS 1887252](#)
  - Quality Manual [EDMS 1887261](#)
  - ISO 9001:2015 [EDMS 2066392](#)
- MIP [EDMS 1887262](#)
  - Quality control reports
  - Procedures
    - Cleaning [1887265](#)
    - Jaw Surface preparation [1887267](#)
    - Vacuum brazing [1887269](#)
    - UHV leak test [1887270](#)
    - Labelling and identification [1887271](#)
    - Cutting fluid [2061772](#)
  - Traceability sheet [EDMS 2082342](#)
- TCLD pre-series
  - MTF traceability tree MTF
  - All quality reports in EDMS/MTF

LS2 Collimators (TCLD, TCSPM) - Manufacturing  
Documentation Review 

# Current status and forecast (2019)

## TCSPM/TCPPM

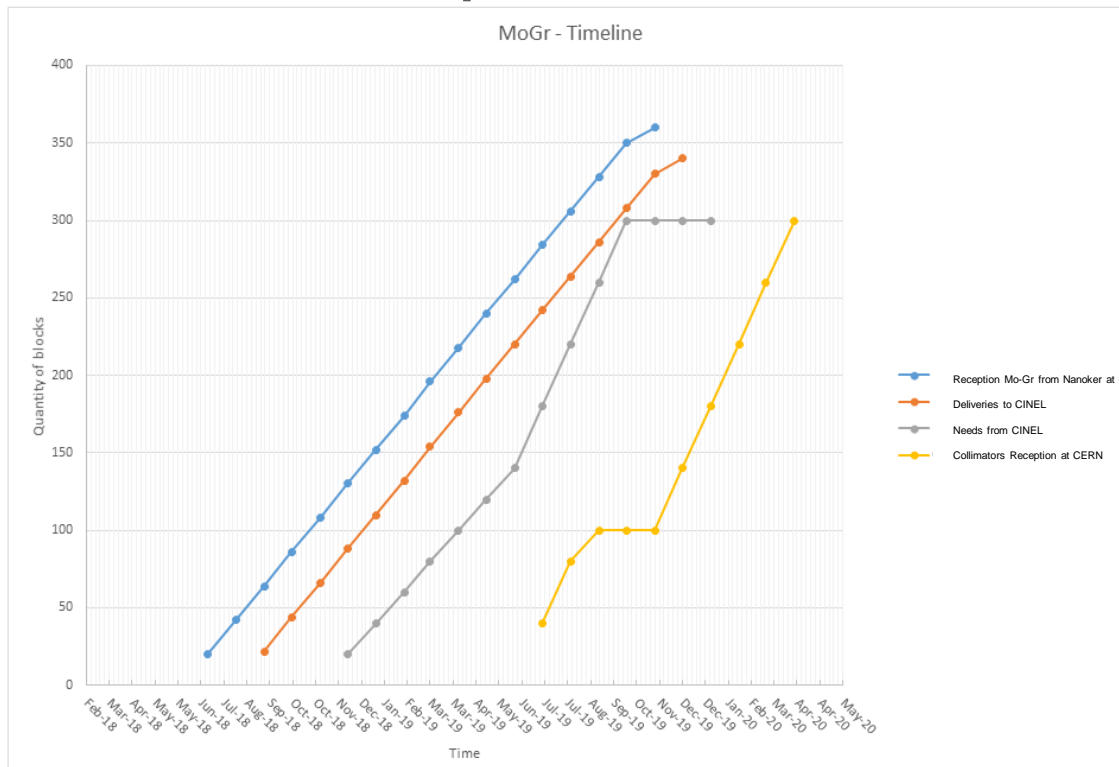
- Foreseen reception at CERN
  - TCPPM Pre-series Mechanical Tables (03/2019)
  - TCPPM Pre-series Jaws (03/2019)
  - Collimators Supports/Cradles (04/2019)
  - TCPPM Pre-series Collimator (07/2019)
  - 2 TCPPM series Collimators (08/2019)
  - 2 TCPPM series Collimators (09/2019)

## Collimators Surface Activities (b.272)

- Control Reception
- Ready for installation activities
  - Tuning/adjusting activities
  - 272 layout preparation and cradles assembly
  - Mechanical tests
  - Electronic measurements and tests
  - Alignment activities
  - Impedance measurements
  - Vacuum activities + bake out

# Collimators production milestones

## TCSPM/TCPPM Mo-Gr reception and deliveries timeline



Many thanks to  
EN-MME



# Deliverables along 2019

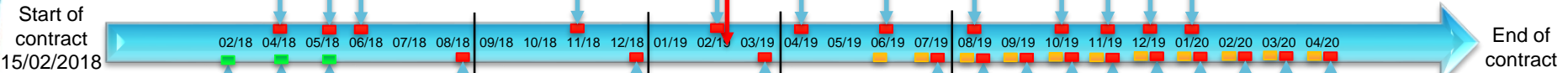
CERN

- Material release
- Com. Comp. release

- TCC test bench + Outgassing test bench + Calibration test bench + BPM test bench
- Accelerometers

TODAY

- Mo-Gr blocks TCSPM #6 and TCSPM #7
- Mo-Gr blocks TCSPM #4 and TCSPM #5
- Mo-Gr blocks TCSPM #2 and TCSPM #3
- Mo-Gr blocks TCSPM #8 and TCSPM #9
- Mo-Gr blocks TCSPM #10



- Schedule
- Design File + QAP + pre-MIP
- Final MIP

- Pre-series TCLD
- 2 pre-series TCPPM Jaw + 2 pre-series TCPPM Tables
- Pre-series TCPPM
- 3rd series TCPPM + 4th series TCPPM
- 1st series TCPPM + 2nd series TCPPM
- 1st series TCLD + 2nd series TCLD
- 3rd series TCLD + 4th series TCLD
- 3rd series TCSPM + 4th series TCSPM
- 7th series TCSPM + 8th series TCPPM
- 5th series TCSPM + 6th series TCPPM
- 9th series TCSPM + 10th series TCSPM + Remaining material

- Monthly Report
- Equipment
- Documents
- Milestones

CONTRACTOR



# LS2 collimators ready for installation schedule

Equipment	Location	Ready to install
TCSPM.6L7.B2	LSS7L	01-Jul-20
TCSPM.E5L7.B2	LSS7L	01-Jul-20
TCSPM.D4L7.B2	LSS7L	02-Jun-20
TCSPM.B4L7.B1	LSS7L	02-Jun-20
TCSPM.B4R7.B2	LSS7R	28-Feb-20
TCSPM.D4R7.B2	LSS7R	28-Feb-20
TCSPM.E5R7.B1	LSS7R	04-May-20
TCSPM.6R7.B2	LSS7R	04-May-20
Equipment	Location	Ready to install
TCLD.10L2.B1	C11L2	05-Feb-20
TCLD.10R2.B1	C11R2	05-Feb-20
TCLD.8L7.B1	C8L7	05-Mar-20
TCLD.8R7.B1	C8R7	05-Mar-20
Equipment	Location	Ready to install
TCPP.D6L7.B1	LSS7L	03-Feb-20
TCPP.C6L7.B1	LSS7L	03-Feb-20
TCPP.D6R7.B2	LSS7R	20-Dec-19
TCPP.C6R7.B2	LSS7R	20-Dec-19

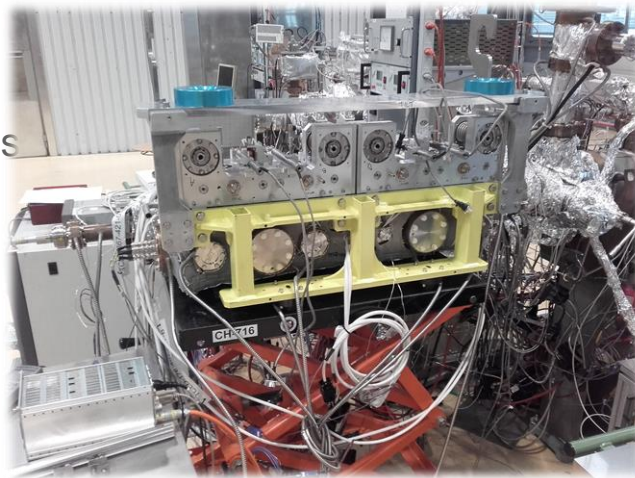
Many thanks to  
EN-ACE

# TCLD prototype validation activities

## Activities along the year

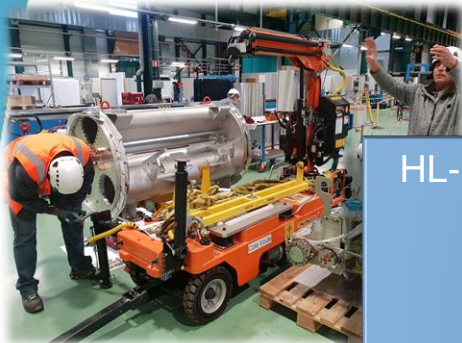
- Mechanical tables torque tests
- BPM flanges and cables installation and validation
- Heating jackets installation and design validation
- Outgassing test performed and compliant
- Patch panel + electrical connections
- Survey/Alignment validation
- Impedance validation

Many thanks to  
EN-HE, EN-SMM,  
BE-BI and TE-VSC



# TCLD prototype validation activities

## TCLD + Cryostat installation test

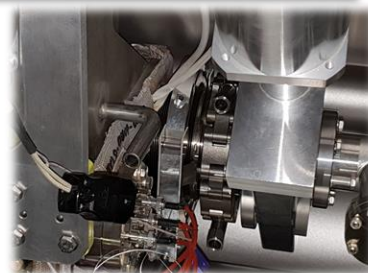
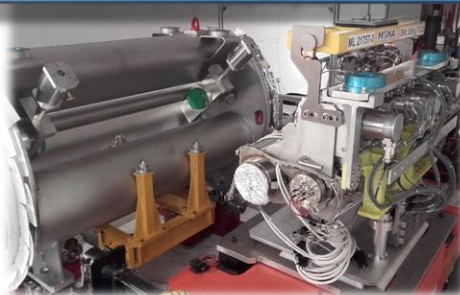


HL-LHC INTEGRATION REPORT FOR INSTALLATION APPROVAL - WP5: TCLD Integration Study

TCLD (WP5) Installation Procedure

TCLD (WP5) Safety Assessment Form

TCLD (WP5) Specific Risk Assessment



Many thanks to EN-HE, EN-SMM, TE-MS, EN-VSC and ATS-DO

# Plans for future productions: what can we expect for LS3

Improvement LS3 collimation upgrades (*from S. Redaelli's talk*)

- 10+2 low-impedance collimators (TCSPM)
- 12+2 tertiary collimators (TCTPM) [possibly +1 proto depending on design]
- 8+2 physics debris collimators (TCLP)
- 12+3 fixed masks (TCLM)
- Note: new design in common beam pipe regions of 'X' of IR1/5
- Final number of spares depends on numbers of designs
- ~50 new BIDs (and some new designs) and only one company fully qualified so far!

# Comments on the prospect for in-kind contributions

- Imperative to qualify any company through:
  - Samples qualification campaign (assessment on all technologies and capabilities necessary to produce a collimator)
    - Pre-series subassemblies
    - Mechanical tables
    - Complete Jaw assemblies
  - Pre-series collimator (as milestone and blocking point)
- Process gets shifted in time -> around 2 years for a first pre-series collimator
- Production from cradle to grave very demanding on human resources
- Parallel productions to be carefully assessed



***Thank you for your attention***