

RD51 Mini-Week

BE-CEM-EPR Electronics Service

R. Berberat, S. Danzeca



**Controls
Electronics &
Mechatronics**



Introduction to the BE-CEM-EPR Electronics Service

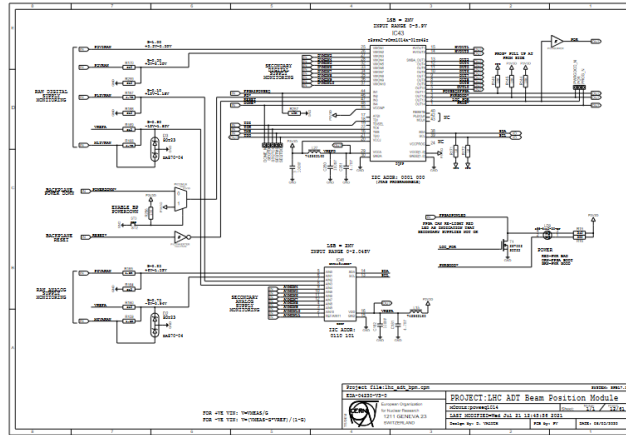
BE-CEM-EPR offers a support service to the CERN-wide electronics community in the domain of Printed Circuit Boards (PCB) and Electronic Module Assembly.

The main activities of the service are:

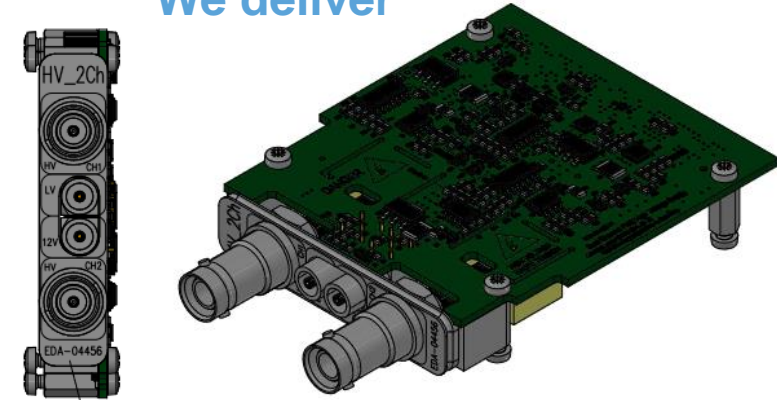
- CERN Altium & Cadence Libraries: creation and maintenance
- Layout design for electronics boards and crates
- Manufacturing of bare PCB at CERN or by subcontracting
- Mechanical parts production in collaboration with EN-MME
- Assembly and integration of electronic modules, internally or by subcontracting

Introduction to the BE-CEM-EPR Electronics Service

You develop



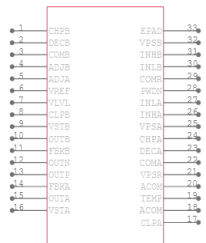
We deliver



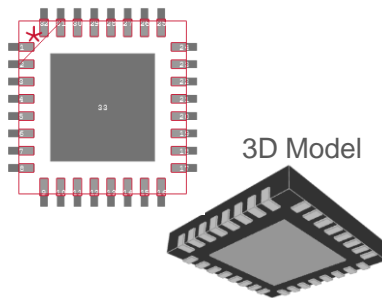
We can help

BE-CEM-EPR Electronics Service

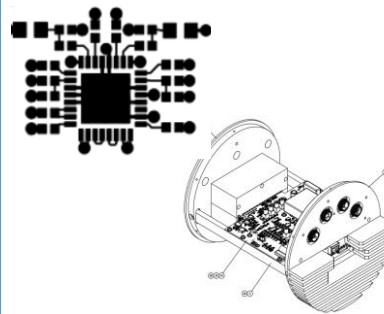
Schematic Libraries



PCB Libraries



Layout and integration



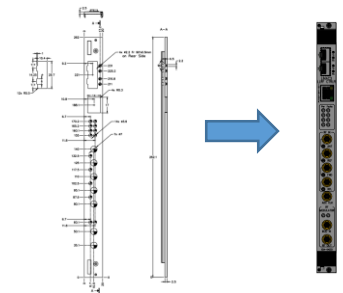
PCB and parts procurement



PCB assembly



Mechanical production in collaboration with EN-MME



Introduction to the BE-CEM-EPR Electronics Service

A team of 18 members coming from the industry and composed of 9 CERN employees and 12 FSU members (Field Support Unit team)

- 2 Engineers specialized in production processes, dedicated to design reviews for the jobs done in our Design Office, subcontractor validation and planning follow-up
- 3 Engineers & Technicians specialized in PCB assembly and special repair (hours invoiced)
- 2 ADMIN students, working on bare PCB ordering and cost invoicing
- 2 TTE, 1 completing the electronic assembly workshop team and 1 involved in assembly QA

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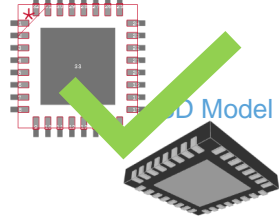
- 6 FSU technicians for the design of standard and special PCB layouts (hours invoiced)
- 1 FSU technicians specialized in CAD libraries (free of charge for all CERN users)
- 2 FSU technical assistants for ordering components and assembly, which is a real advantage for the users of the service (free of charge)

BE-CEM-EPR Electronics Service

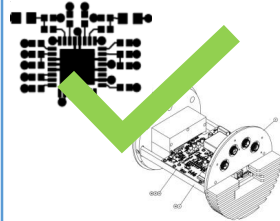
Schematic Libraries



PCB Libraries



Layout and integration



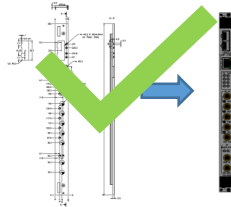
PCB procurement and some components



PCB assembly



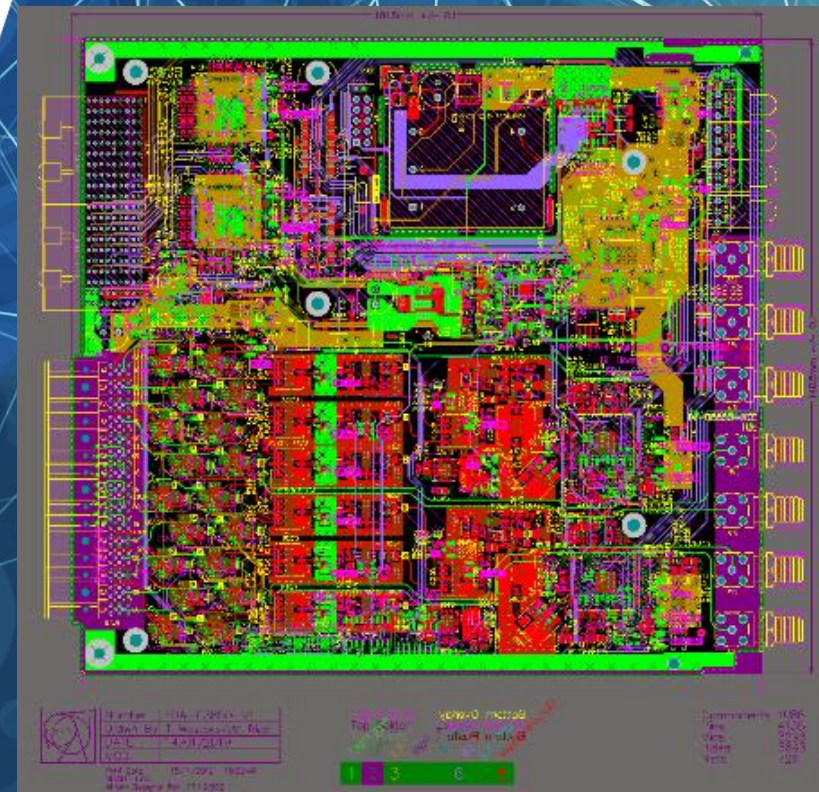
Mechanical production in collaboration with EN-MME



Layout design for electronics boards and crates



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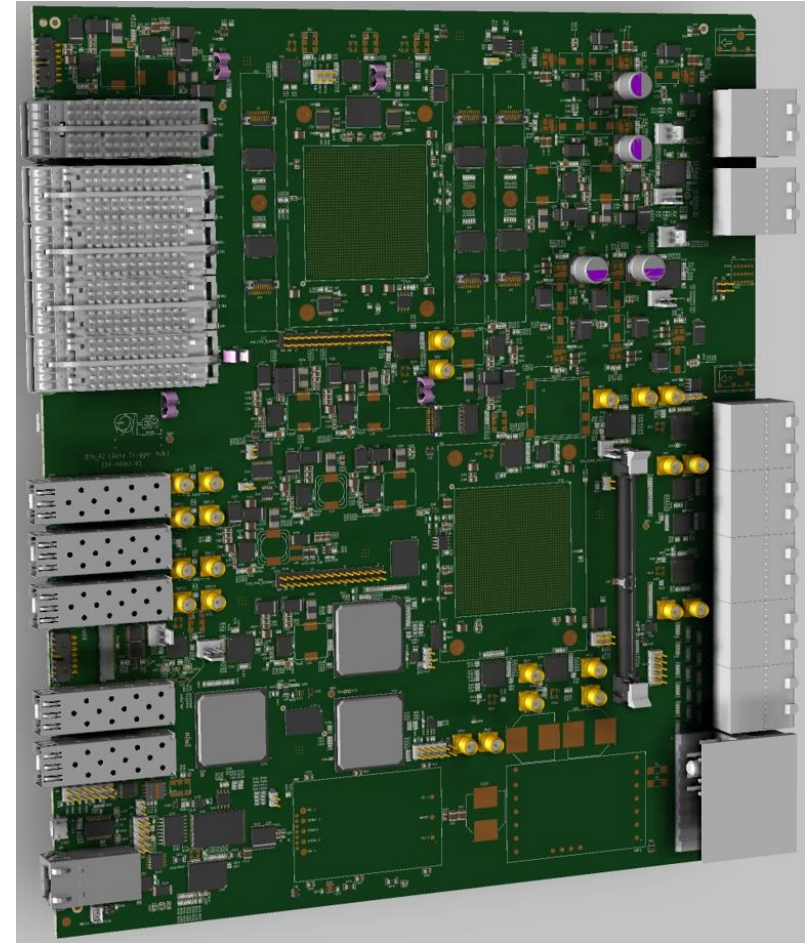
Layout design for electronics boards and crates

Example: Complex layout design managed by the design office for EP-CMD (CMS - DAQ & Trigger)

Some specifics of this design:

- 280mm x 322mm
- 22 layers
- 0.075mm minimum trackwidth
- 12'811 holes and via holes
- controlled impedance lines, filled & capped via holes

You may find more information about this board here: <https://cms-daq-dth-p2.web.cern.ch/>



DTH_P2 (Data Trigger Hub)

Layout design for electronics boards and crates, with production

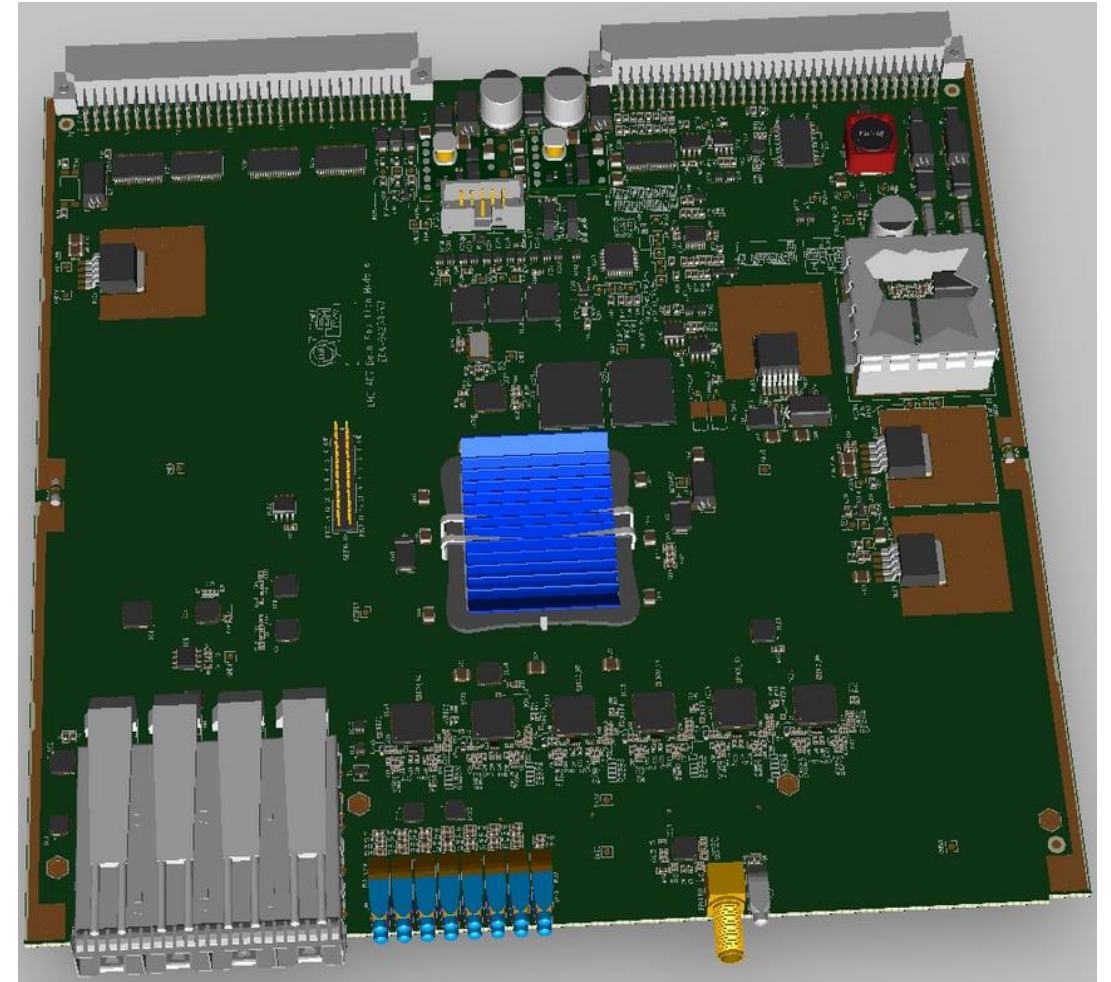
Example: Typical production we have managed in September 2022 for SY-RF

Some characteristics of this design:

- 233mm x 221mm
- 10 layers
- 0.1mm minimum trackwidth
- 3'291 holes and via holes
- Signal integrity / Controlled impedance lines
- Filled & Capped via holes
- Holes tolerances for press-fit connectors
- 92 different references of components

Quantity produced:

- A total of 18 units in fast production time



LHC ADT Beam Position Module

Layout design for electronics boards and crates, with production

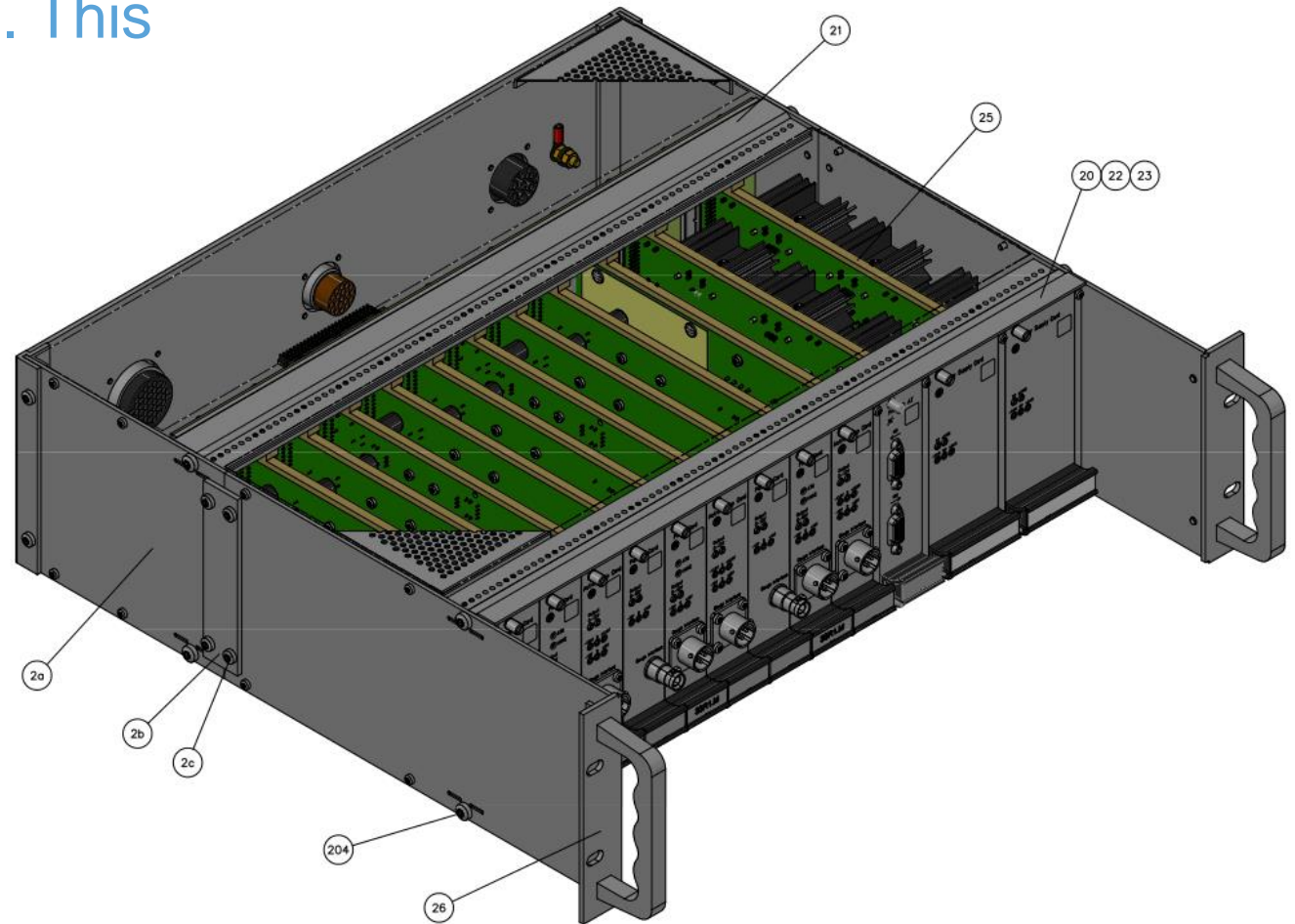
Example: Typical production of a crate. This production was done for TE-VSC

Crate including:

- 6 different types of populated PCB
- Internal cables
- Mechanical parts produced in collaboration with EN-MME

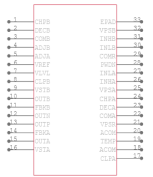
Quantity for production:

- A total of 186 units, delivered in November 2022

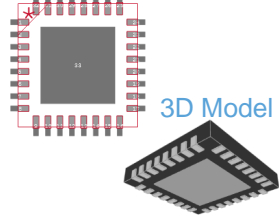


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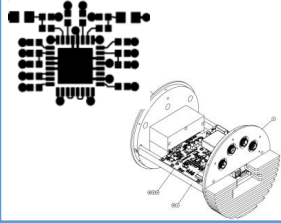
Schematic Libraries



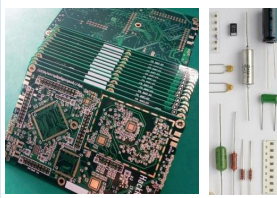
PCB Libraries



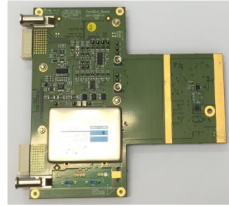
Layout and integration



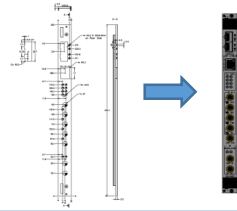
PCB procurement and some components



PCB assembly



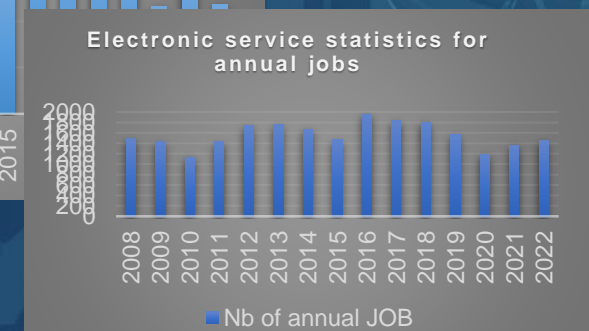
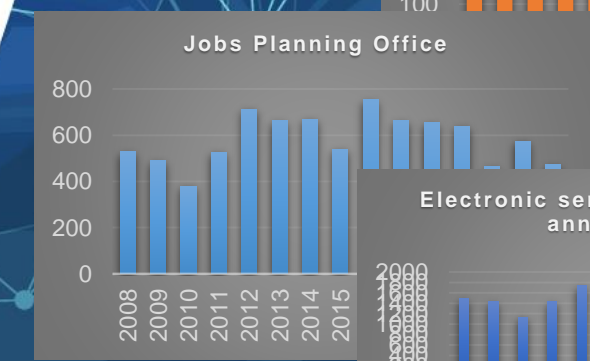
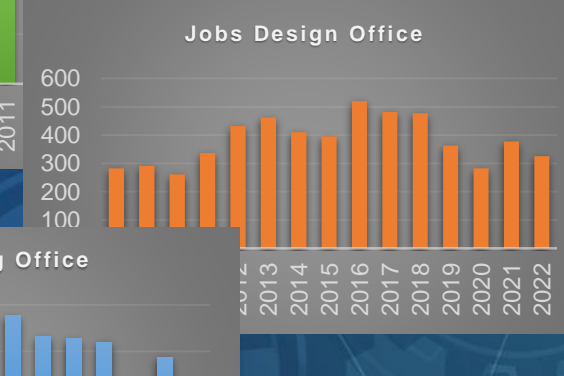
Mechanical production in collaboration with EN-MME



Some numbers regarding BE-CEM-EPR Electronics Service



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Some numbers regarding BE-CEM-EPR Electronics Service

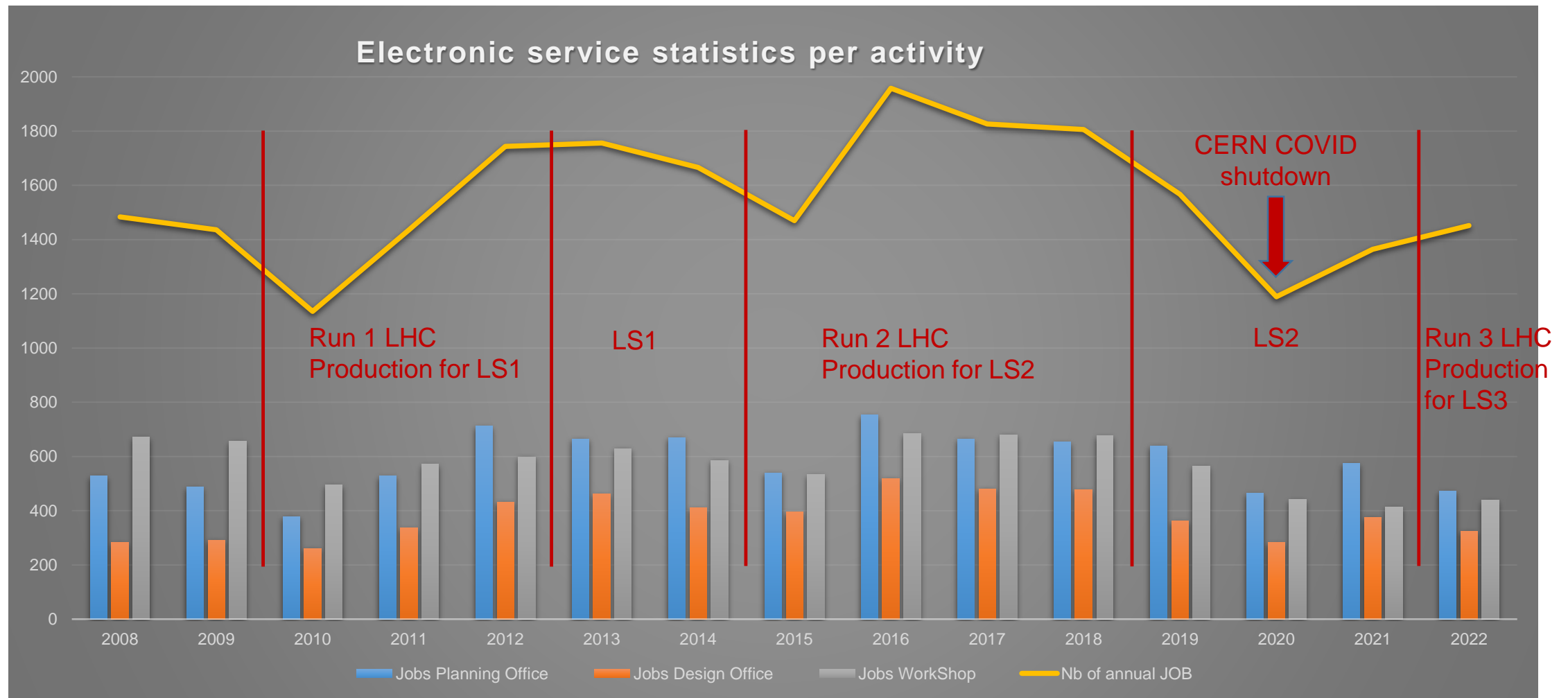
From the 1st of January to the 21th of December 2022, the Electronic Service managed a total of 1'450 projects

- 325 of them included a layout design
- 470 of them included subcontracting activities
- 439 included assembly done in our Electronic Assembly Workshop in building 107
- 6'075 bare PCB were produced, in approx. 400 different types
- 10'217 Electronic Modules were assembled, in approx. 400 different types

The CERN Altium library contains a total amount of more than 14'600 components to maintain and we introduced 874 new components in 2022

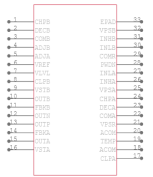
The CERN Cadence library contains more than 20'000 components created during the last 25-30 years

Some numbers regarding BE-CEM-EPR Electronics Service

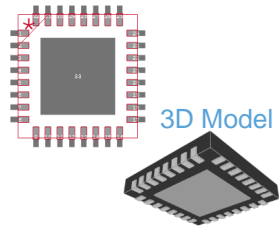


BE-CEM-EPR Electronics Service

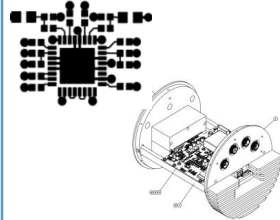
Schematic Libraries



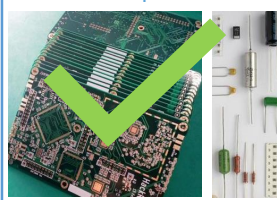
PCB Libraries



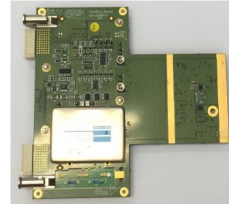
Layout and integration



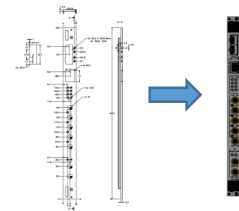
PCB procurement and some components



PCB assembly



Mechanical production in collaboration with EN-MME



Manufacturing of bare PCB by subcontracting or at CERN with EP-DT-EF



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Printed Circuit Boards (PCB) specifics

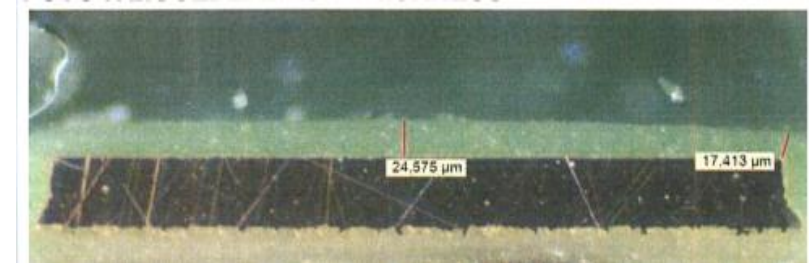
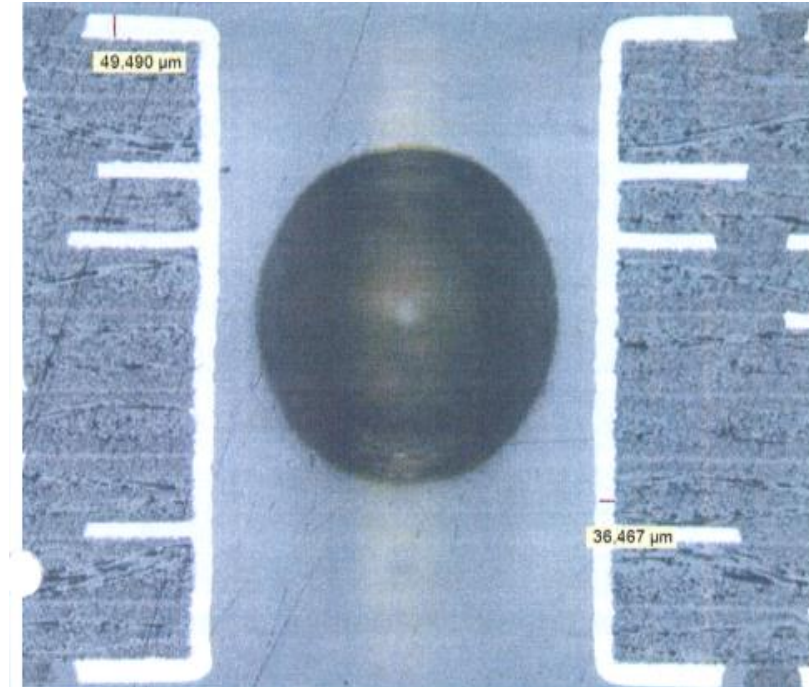
- One of the most expensive single parts of an assembly
- A defective PCB may result in the complete loss of components
- Defects in PCB may be hidden and introduce reliability problems during operation and/or for safety critical equipment
- The PCB must withstand the assembly process (RoHS, High Tg) and CERN safety rules (halogen-free base material)
- As compared to “off the shelf “ components, each PCB is a new product made in limited quantity and each production may be impacted by technical issues during the complex manufacturing processes



Selection of PCB supplier is critical

PCB Supplier Requirements

- ✓ ISO 9001:2015 certified company in a CERN member state
- ✓ Halogen-free base materials (CERN Standard IS41)
- ✓ All process steps shall be done in-house, no subcontracting allowed
- ✓ Manufacturing according to relevant IPC standards
- ✓ Acceptance of PCB shall be compliant with IPC-A-600 class 3
- ✓ Controlled impedances shall be measured by the PCB manufacturer
- ✓ Blind and buried via holes according to IPC-DR-572
- ✓ Cold room for material storage and laboratory for measuring process chemistries on a daily basis
- ✓ Test coupons and micro-section report is an important part of the deliverables for each order with >2 copper layers



PCB procurement strategy

In parallel with the external subcontractors, some productions are given to EP-DT-EF:

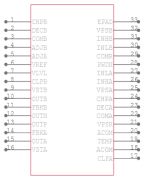
- Low volume or prototypes
- Fast Track production
- Specific designs, too risky to subcontract
- Process validation



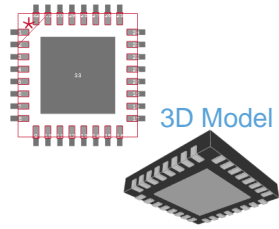
Chemical processes must be maintained operational by EP-DT-EF and in perfect conditions for manufacturing of physics detectors. Our PCB production requests help to maintain the minimum workload and the machines/chemicals “operational”

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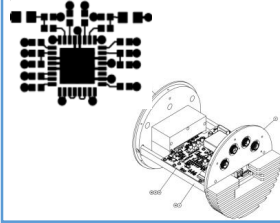
Schematic Libraries



PCB Libraries



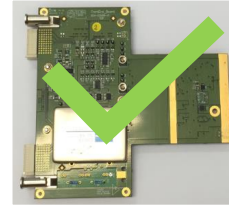
Layout and integration



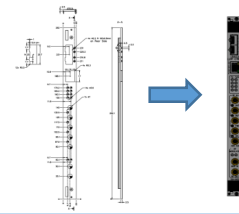
PCB procurement and some components



PCB assembly



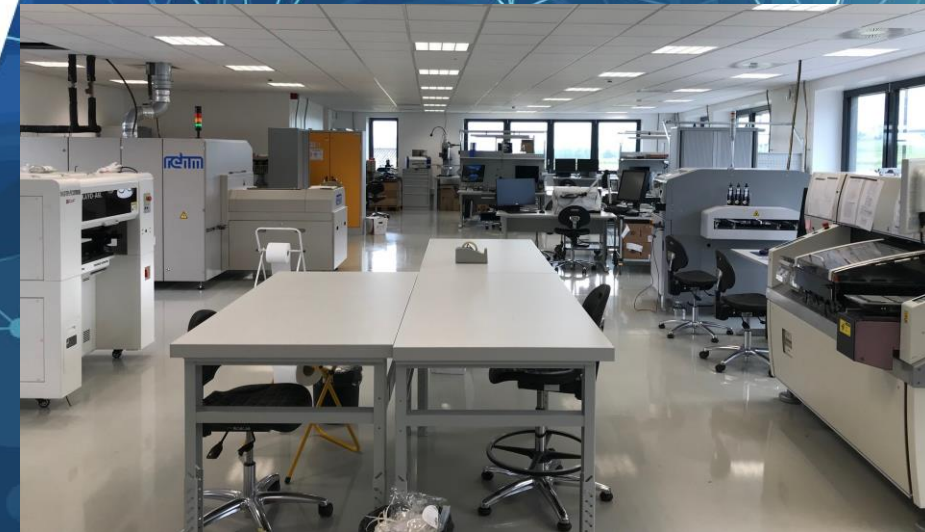
Mechanical production in collaboration with EN-MME



Assembly and integration of electronic modules, by subcontracting or internally



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Electronic assembly procurement strategy

- 3 categories of assemblies
 - Simple: through hole components, low density
 - Intermediate: Through hole and simple SMD components
 - Complex: BGA, QFN, LGA packages
- Each category has its assembly requirements, leading to specific processes and dedicated equipment
- A firm equipped for the assembly of complex boards will not be competitive for simple ones
- Urgent projects often require proximity to the firm
- For assembly, a price model is not easy to establish and may generate too expensive costs for simple productions

Electronic Assembly Supplier Requirements

- ✓ ISO 9001:2015 certified company
- ✓ In a CERN Member State
- ✓ All process steps shall be done in-house, no subcontracting allowed
- ✓ Assembly processes according to J-STD-001
- ✓ Acceptance of electronic assemblies in compliance with IPC-A-610, class 3

Class 1 -- General Electronic Products

Includes products suitable for applications where the major requirement is function of the completed assembly.

Class 2 -- Dedicated Service Electronic Products

Includes products where continued performance and extended life is required, and for which uninterrupted service is desired but not critical. Typically the end-use environment would not cause failures.

Class 3 -- High Performance Electronic Products

Includes products where continued high performance or performance-on-demand is critical, equipment downtime cannot be tolerated, end-use environment may be uncommonly harsh, and the equipment must function when required, such as life support or other critical systems.

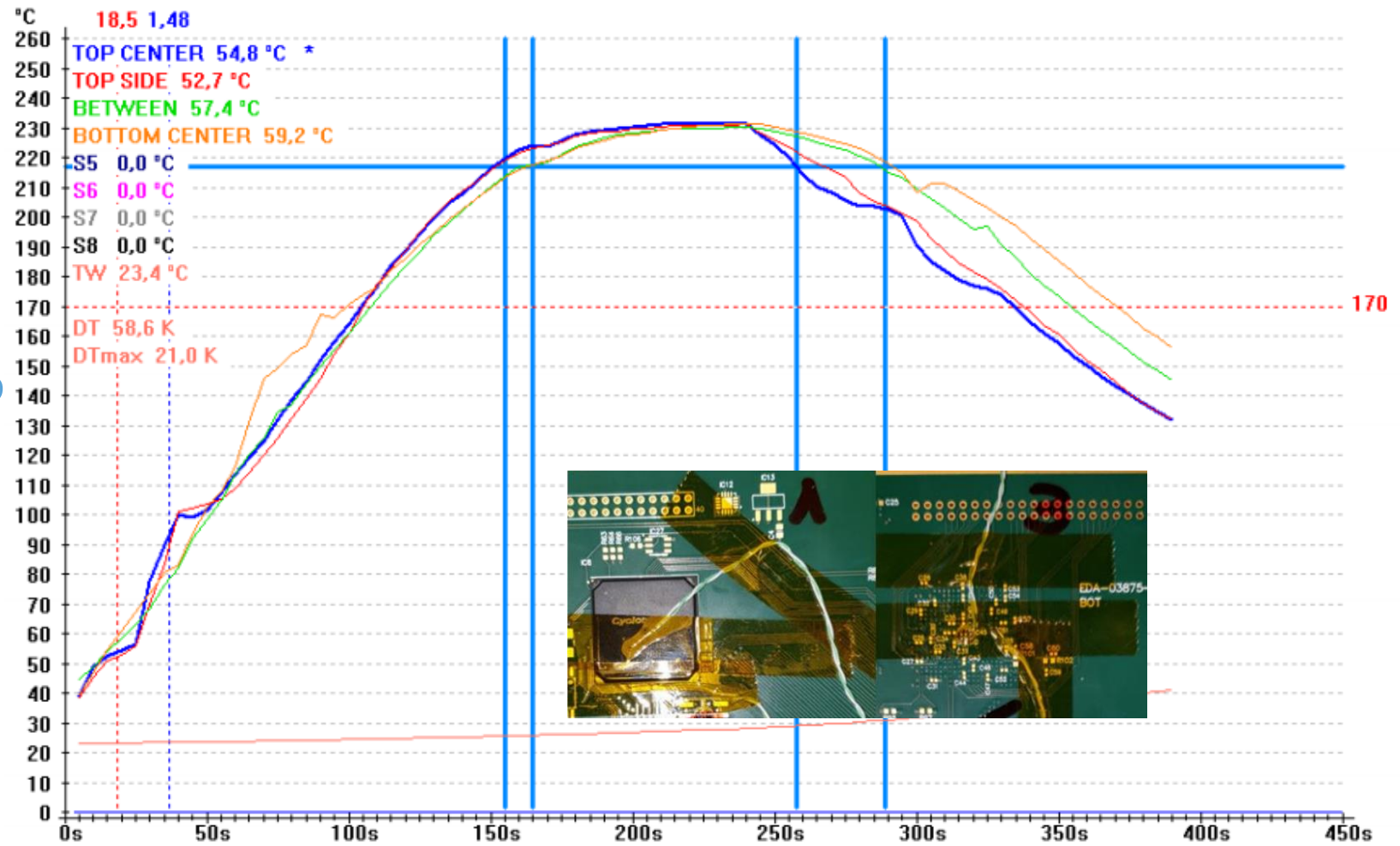
- ✓ Industrial cleaning process in-house is mandatory
 - ✓ Vapour phase oven is a real advantage
-

Electronic Assembly Supplier Requirements

Measurement of thermal profile for reflow process

- Mandatory for “complex” assemblies
- When BGA, LGA and specific components are on the board to be assembled
- Defined in our documentation
- Measured using real PCB & dummy components

➔ **Critical for high quality assemblies**

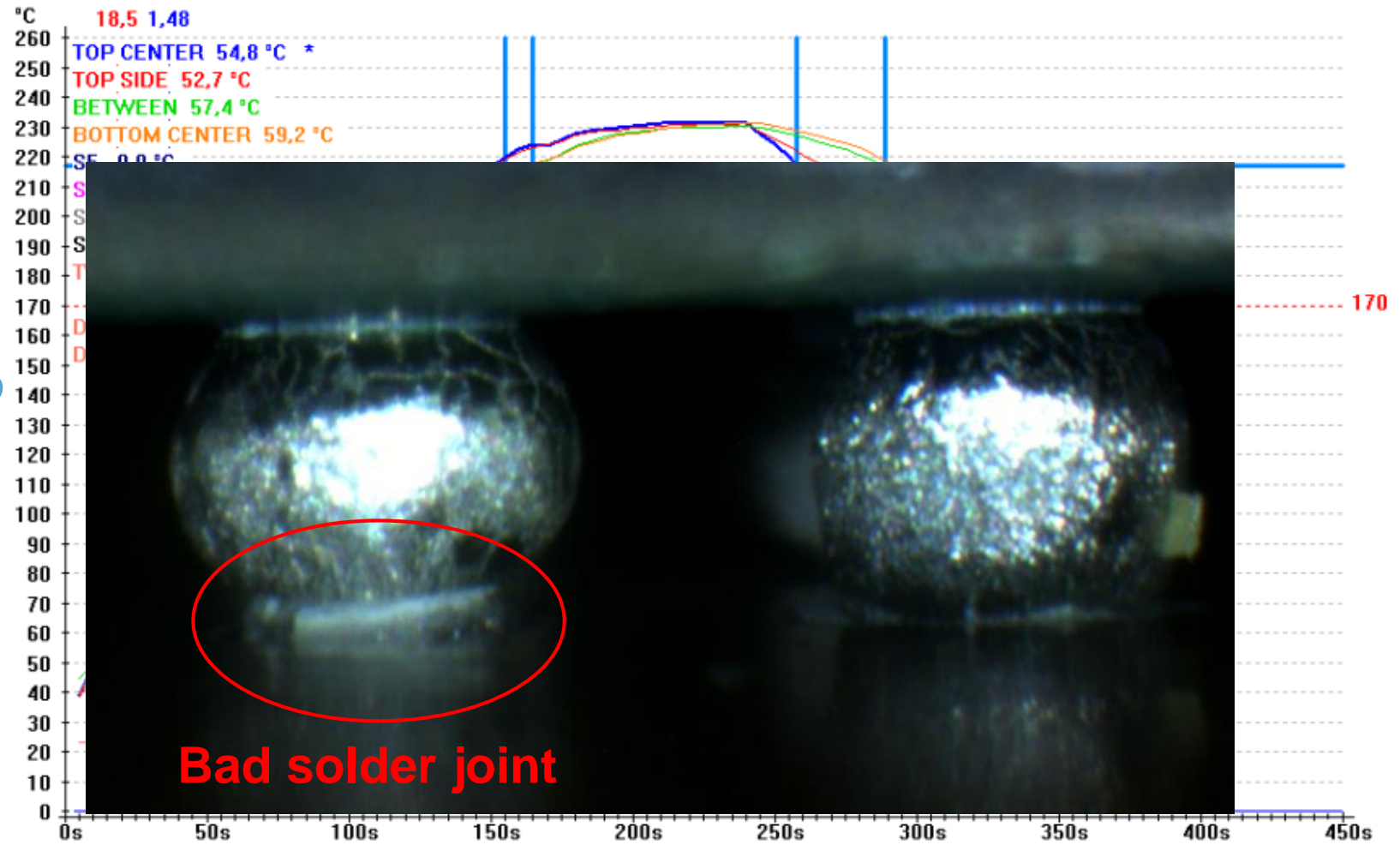


Electronic Assembly Supplier Requirements

Measurement of thermal profile for reflow process

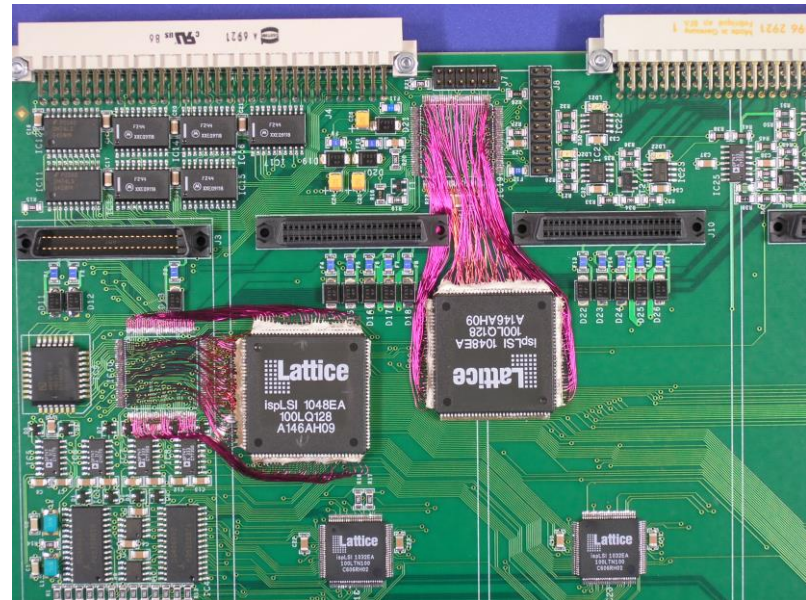
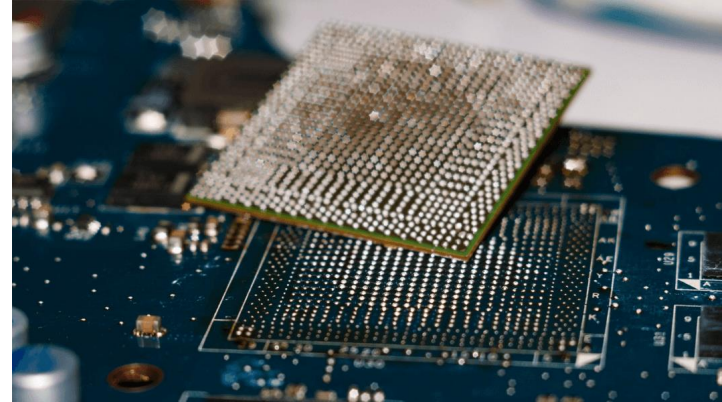
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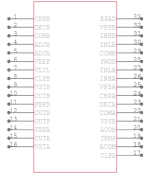
Internal Electronics Assembly Workshop

- Prototypes -> in general 10 PCB or 10 panels
- Same rules as when outsourced
- Impossible-to-subcontract assemblies
 - beware of the lead-time due to limited resources
- Repair/rework of almost any component type
- Board/assembly modification
- On-demand PCBA cleaning

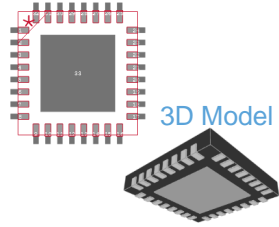


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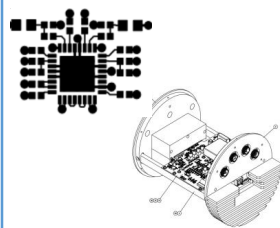
Schematic Libraries



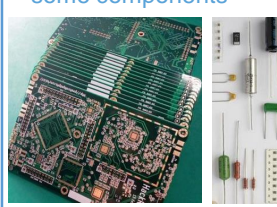
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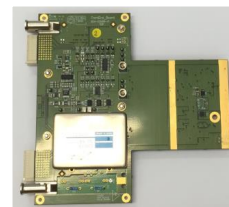
Layout and integration



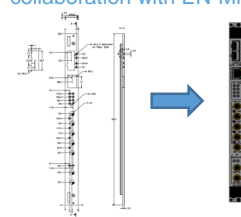
PCB procurement and some components



PCB assembly



Mechanical production in collaboration with EN-MME



How to submit a new design and/or production request



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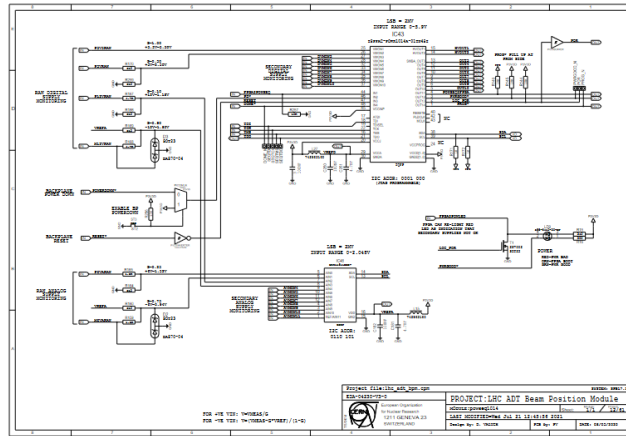
How to contact the Electronic Service and what we need

You should contact us via our generic email address (service-electronics-design@cern.ch) with all the necessary information, according to our **New Design Introduction** form available here: [NDI_form.xlsx](#)

- Type of work (PCB design, mechanics, finalization study,..)
- Files to provide (Altium project, Cadence project, PDF or paper documents,..)
- Links to project files (public file in your Home directory, cdsusers folder for Cadence or any other folder (accessible for reading))
- Characteristics/specifics of your project (impedance values, voltage, high frequencies and all important parameters)
- Production information, as for total of bare PCB quantity, mounted or not mounted, mechanical parts and all relevant information. No limit in quantities but be aware the production time will be longer than for small/medium quantities.
- The desired lead-time, knowing that a standard production time is for small/medium quantities is 3 to 8 weeks.
 - Attention: for huge productions, you should contact us as soon as possible in order to anticipate to the maximum as production time or component shortages may increase significantly the overall lead-time
- A budget code which will be used for ordering bare PCB, components and assembly subcontracting activities

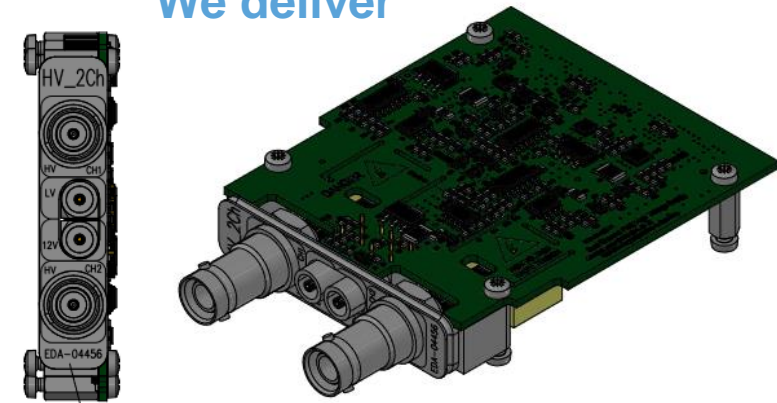
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You develop



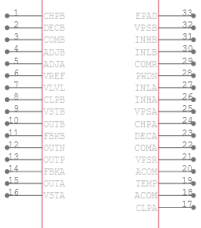
Please, feel free to contact us and we will evaluate together how we can help you with your Electronics Projects

We deliver

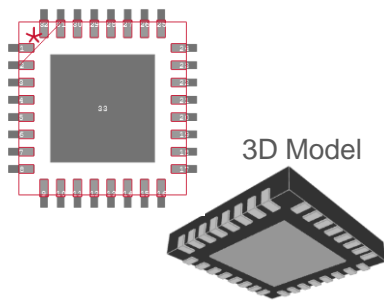


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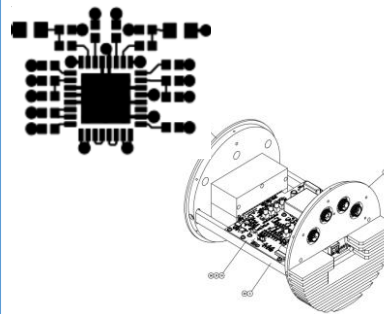
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PCB Libraries



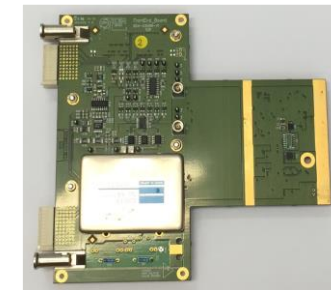
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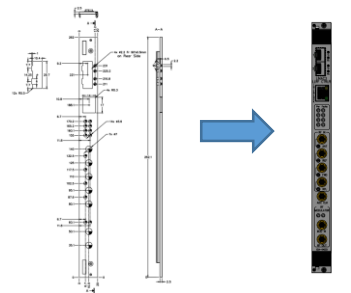
PCB and parts procurement



PCB assembly



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Thank you for your
attention!



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