The mechanical structure for the new SDHCAL Prototype

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CALICE Meeting. 9 Sep 2015. MPP Munich

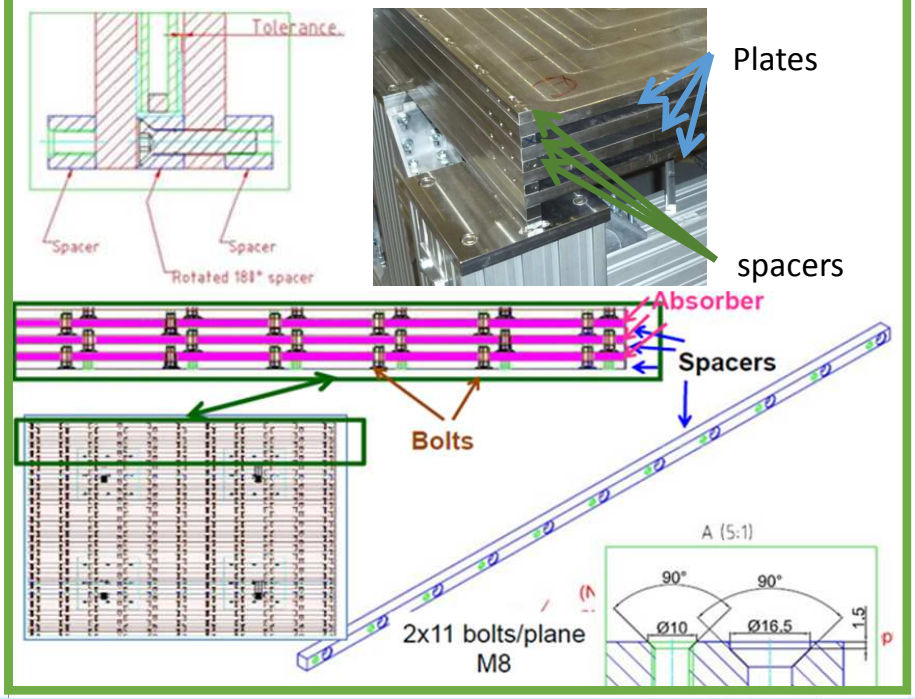
General overview

Final objective :

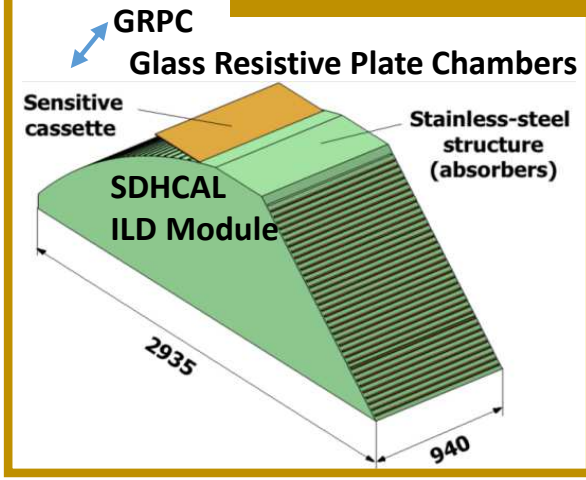
To design and build a mechanical absorber SHDCAL structure with ~4 long (3m) plates using beam welding capable to accommodate the largest ILD GRPC chambers .

1m3 prototype mechanics concept

~1m2 stainless still plates 15mm thick,
<0.5mm planarity
Assembled together with lateral spacers
fixed to the absorber **using staggered bolts**



ILD SDHCAL Barrel Module Design



Stainless still plates
up to ~3x1m2
15mm thick,
<1 mm planarity

Assembled together with lateral spacers by **welding**

Main Differences

1m3 prototype	New Prototype
~1x1m2 plates 51 plates Bolts	~3x1m2 plates 4 plates Welding

Welding vs screwed

Mechanical (absorber) structure of **sampling calorimeters** must be **robust** and **compact** with **as less as possible dead spaces** (lateral and longitudinally)

It can be built by assembling together **absorber plates and spacers** that guarantee the space needed to insert the GRPC detectors (GRPC thickness = 11mm).

The assembly of **absorber plates and spacers** can be done using:

➔ **Bolts**

Big bolts are needed to support the big weight of the structure

➔ biggest lateral size of the spacer

➔ **Increase lateral dead zones between prototype modules**

➔ **Welding**

➔ Allows to **decrease the lateral size of the spacer** ➔ **Less dead zone**

➔ Could introduce **deformations**

Different possible welding methods can be considered

The most precise

Electron beam welding:

The **best** but it **needs vacuum conditions** and not clear how affordable it is for big modules

General working plan & protocol

Working plan

Ongoing

I. **Optimization** of **assembly procedures using electron beam welding** with **smaller structures**

II. **Design** of the **final structure** and associated **handling tools**

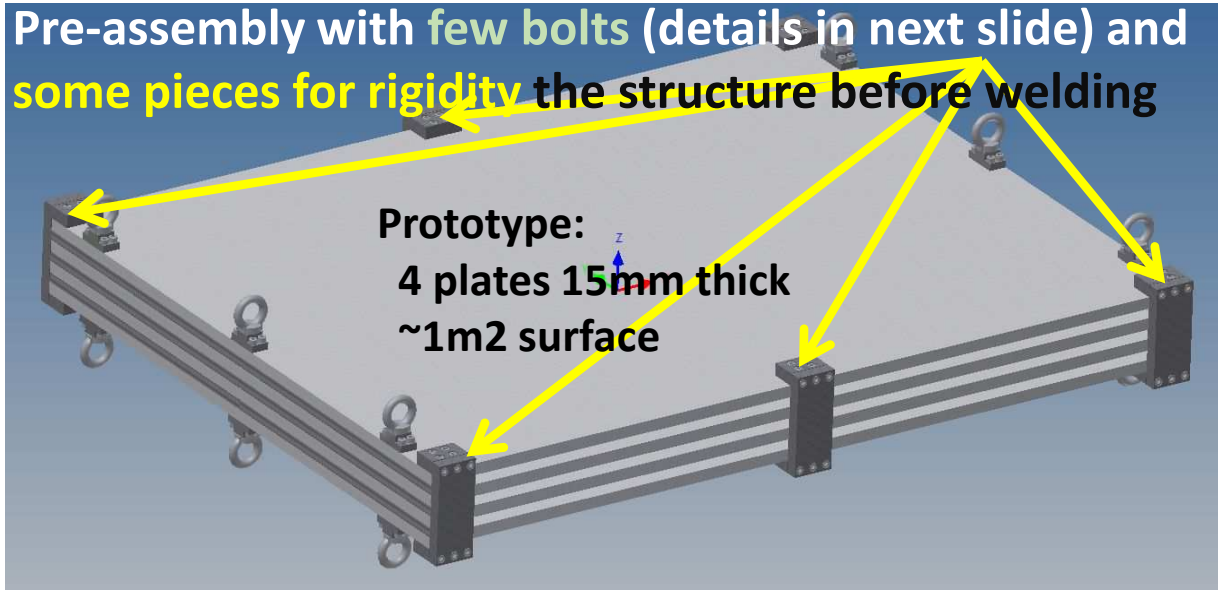
III. **Construction** of the **handling tools**

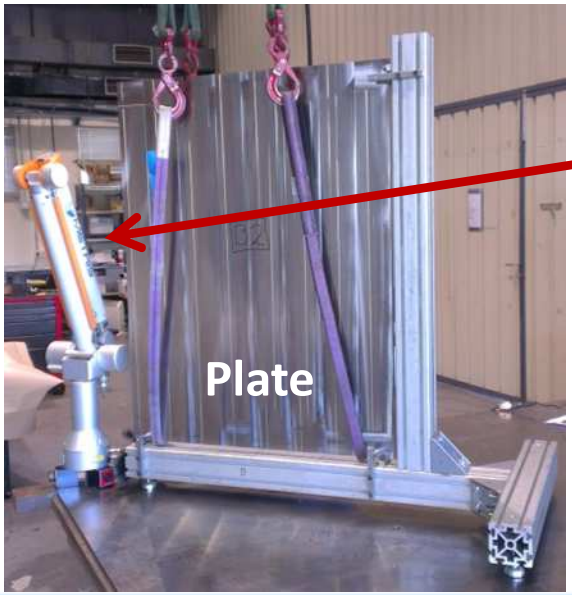
IV. **Assembly** of the **final structure** and **Verification**

Assembly protocol

1.- **Plates production** and **verification of dimensions**
2.- The structure is **pre-assembled at CIEMAT** using smaller bolts (to fix the position of the plates) and some pieces for ridigity the structure before welding for transport and manipulation
3.- **Verification** of the **dimensions** of the structure
4 .- **Electron beam welding at CERN**
5.- **Verification** of the **dimensions** of the structure **at CIEMAT** to check the **deformations**

Optimization using electron beam welding with small structures - First prototype





Quality control measurements

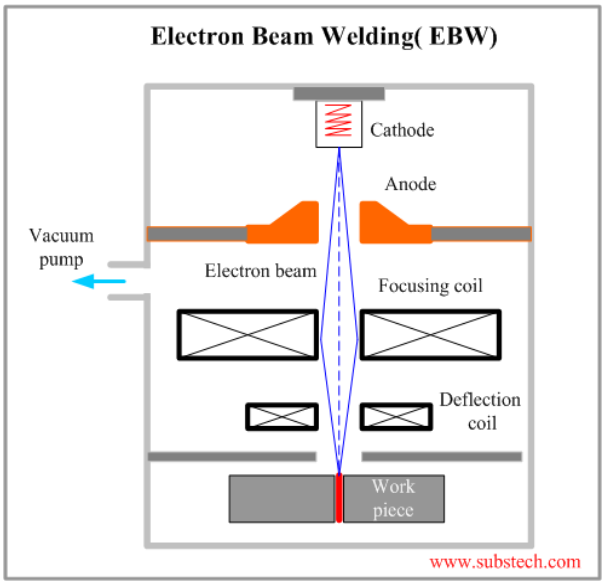
Electron beam welding machine @ CERN

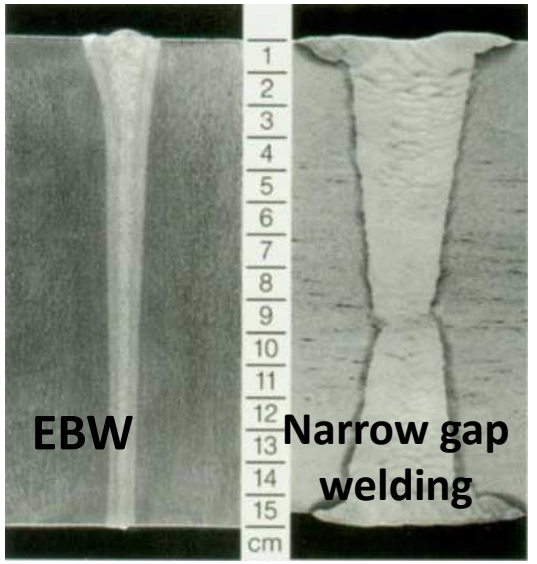
Collimate electron beam

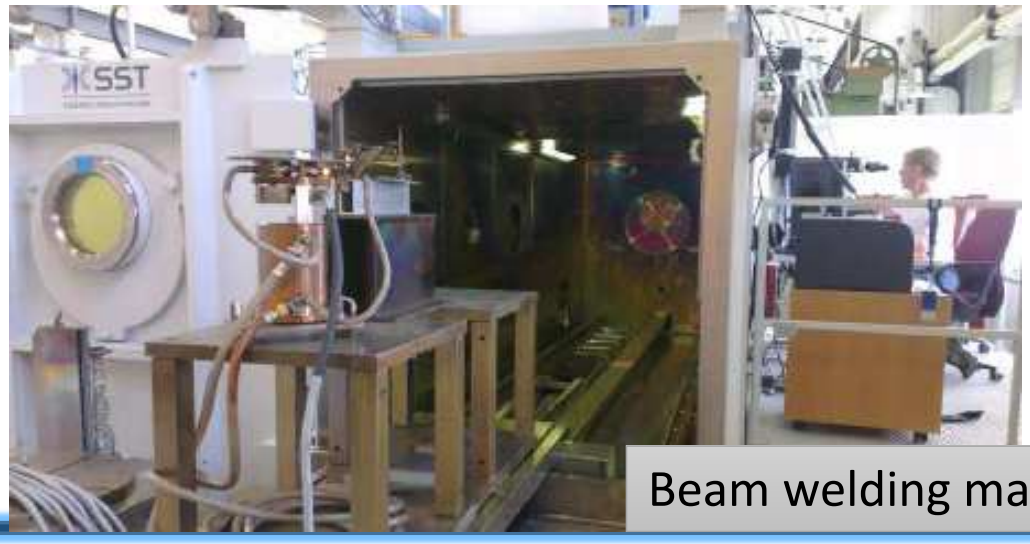
➔ Very **narrow welding**

➔ **Less deformations**

Vacuum conditions needed







Beam welding machine @ CERN

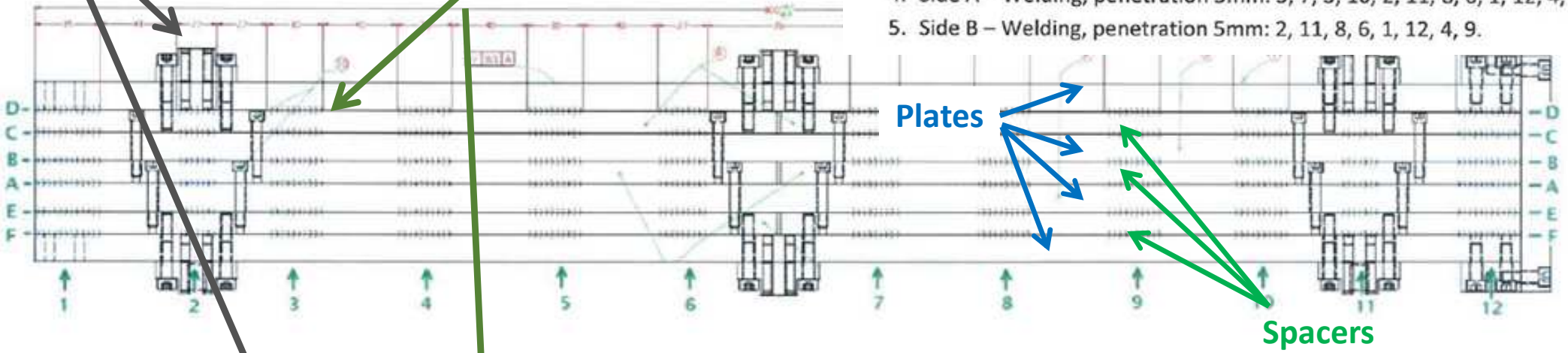
4(1m2) plates prototype welding @ CERN

The welding sequence has been the following:

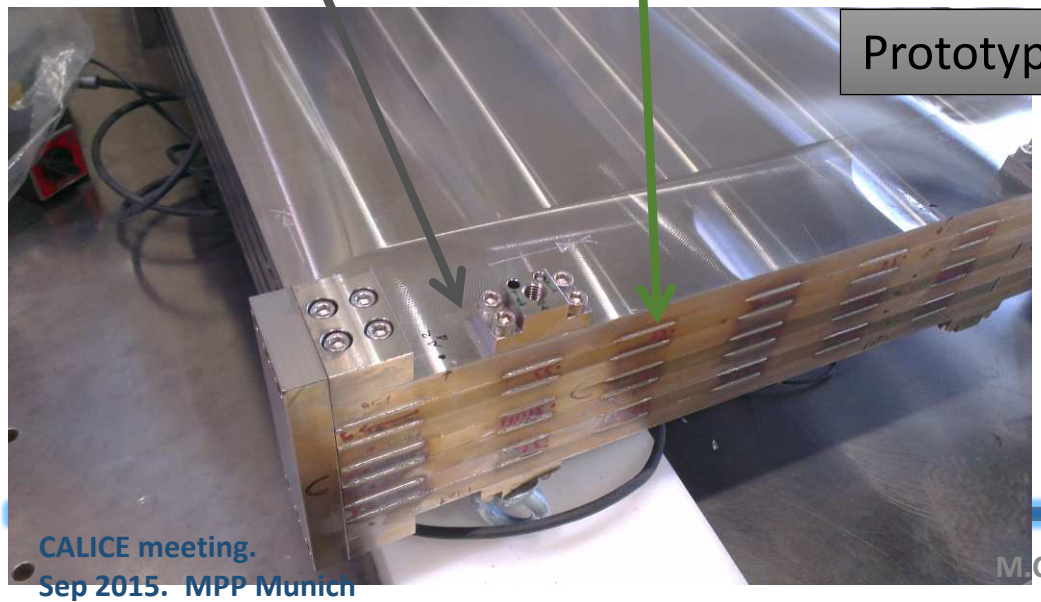
1. Side A – Tack welding, penetration 2mm: 6, 1, 12, 4, 9.
2. Side B – Tack welding, penetration 2mm: 6, 1, 12, 4, 9.
3. Side B – Welding, penetration 5mm: 5, 7, 3, 10.
4. Side A – Welding, penetration 5mm: 5, 7, 3, 10, 2, 11, 8, 6, 1, 12, 4, 9.
5. Side B – Welding, penetration 5mm: 2, 11, 8, 6, 1, 12, 4, 9.

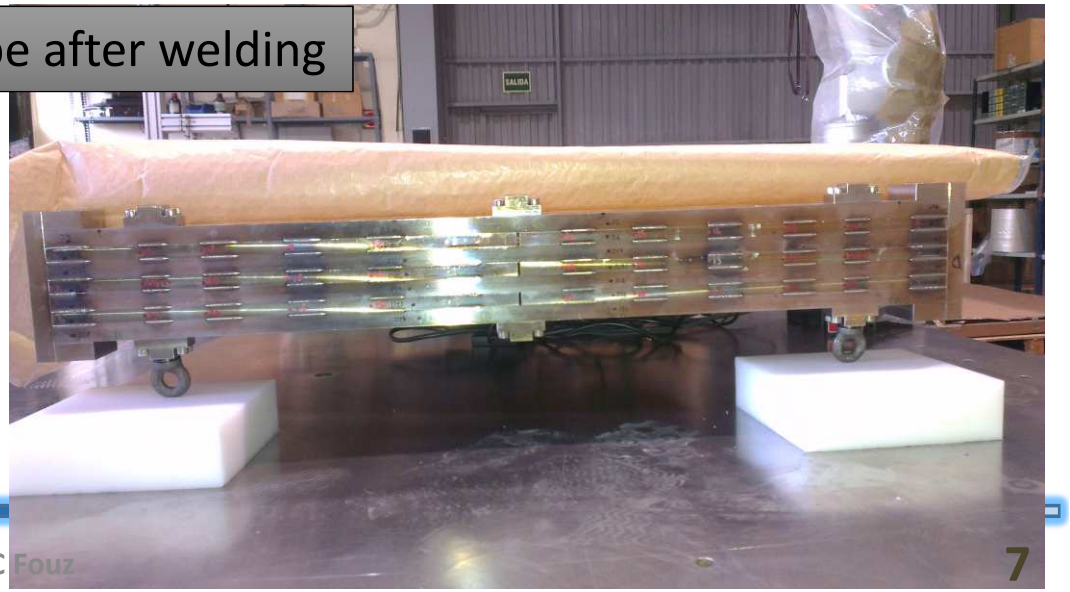
Bolts to fix the plates and spacers for further welding

Welding points



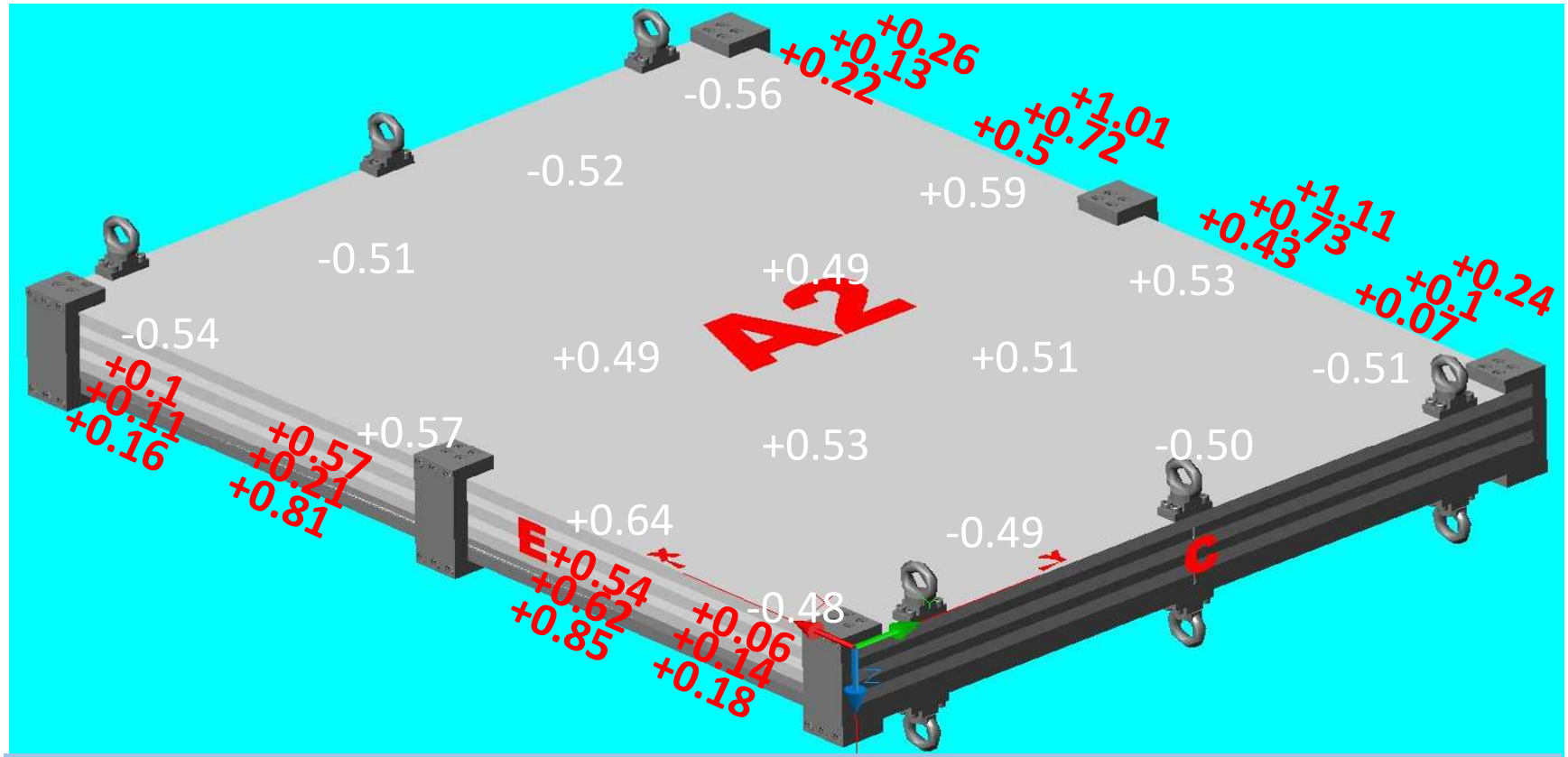
Prototype after welding





Example of deformations measured

Measurements have been done AFTER REMOVING the PIECES FOR RIDIGITY (the picture includes them)



Differences with respect to the initial status of the plate in Z.

Differences with respect to the initial status of the distance between plates

Deformations found (~1mm) bigger than expected in X-axis. O.K in Y-axis

➔ Probably due to the welding sequence used

Welding optimization with new small prototypes

After discussing latest results from the EBW process with the CERN people, (distortions of the module were bigger (~1mm) than expected) we conclude **that it will be necessary more tests to optimize the method for minimizing deformations.**

Three new smaller prototypes ~1000x400 cm2 to be built and welded to optimize the procedure before assembly the final one

First small prototype:

Repeat the same process to verify the results

Second small prototype

Optimize the process by:

1.- Using a more symmetric welding sequence (ABFDEC instead of ABCDEF)

2.- Changing parameters to weld with a more focalized beam

Third small prototype

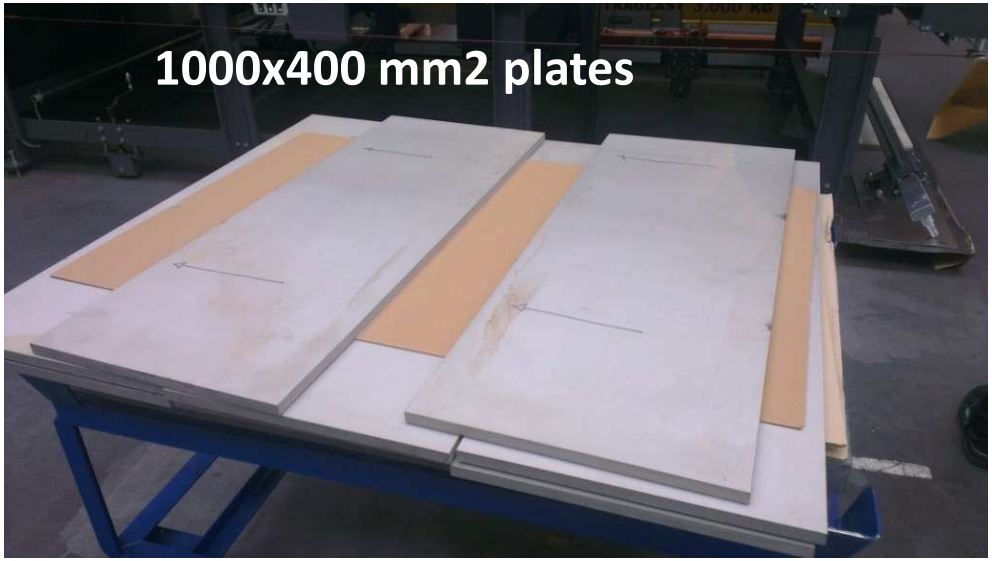
Repeat the same processes of the second prototype to confirm the method

Production of plates

Till now (1m3 and small prototypes) the required plate flatness has been obtained by machining the plates but this process is very time consuming and expensive for the final production.
Roller leveling could be the solution (already used by the HCAL for ~2m long plates)

Last week we (E.Calvo & MC Fouz) have performed some tests at **ARKU at Baden-Baden (Germany)** ***www.arku.de/*** for several plates:

8 small plates (~1000x400 mm2) for 2 small prototypes (4 plates each)
5 plates (~2900 x 1010 mm2) for the final prototype (4 plates + 1 spare)



Roller level machine – FlatMaster 120

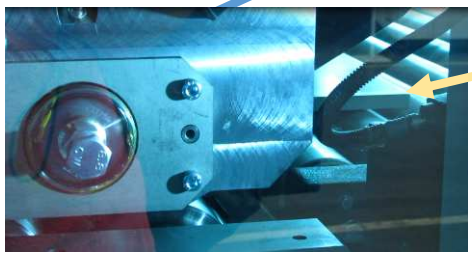
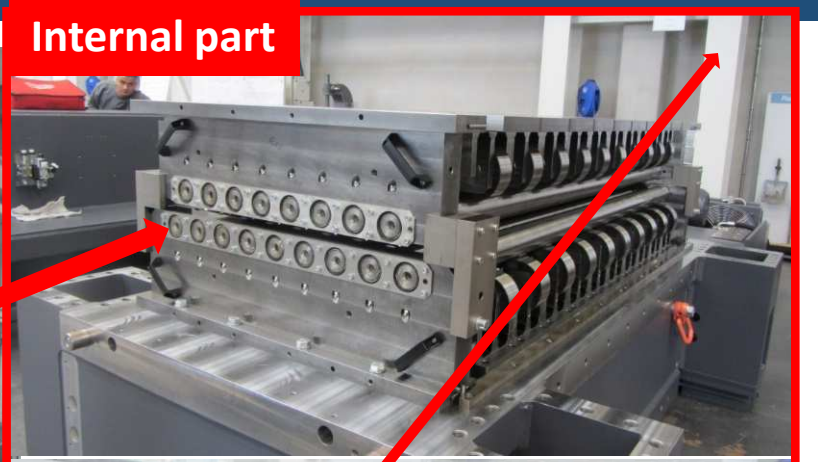


Plate going out

Internal part

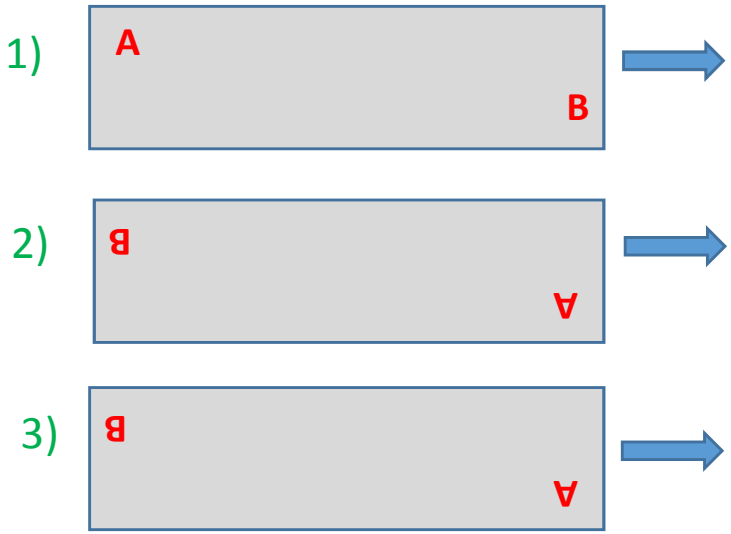


ARKU

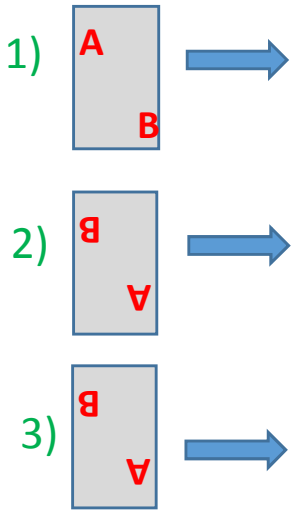
Leveling Procedure

The plate enters 3 times in the machine in two different orientations

3x1m2 plates



0.4x1m2 plates



Steps 1 & 2: mainly for stress relief
Step 3: mainly for final flatness

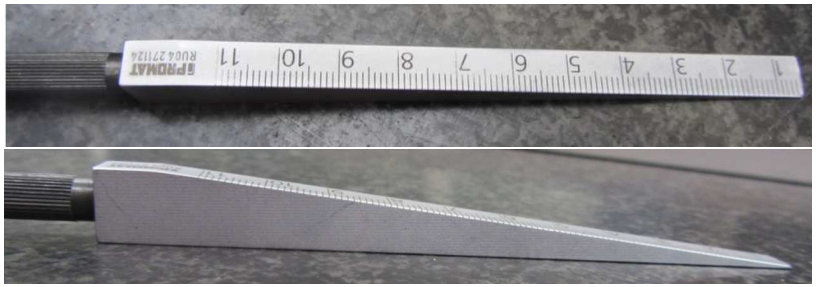
Stress relief helps on decreasing deformations during the welding

➔ Another advantage vs plate machining

Quality control measurements of plates

A fast quality control has been performed during the tests at ARKU
➔ More precise tests will be done at CIEMAT (setup still to be prepared)

The measurements have been done using **feeler gauges**



The larger plates were tested over the leveling machine (1mm planarity) and the smaller plates over a precision table (too small for the big plates)

1 Data sheet per plate - Example

ARKU Maschinenbau GmbH, Siemensstraße 11, D-76532 Baden-Baden

Leveling Protocol

Ident.-Nr.: FL1506-4 | Rev.-Grad: 05 | Page 1 of 1 | Date: 04.09.2015

Customer name: Ciemat | Customer tester :

Responsible at ARKU: Mr. Enke | ARKU tester : Mr. Baumer

Machine type: FlatMaster 120 | Machine No.: 650120 | Number of rollers: 13 | Roller diameter [mm]: 120 | Machine width [mm]: 2000 | Leveling speed [m/min]: 6

Part No.: 1d | Material designation: 304L | Material category: stainless steel | Yield point [N/mm²]: 308 | Tensile strength [N/mm²]: 623 | Hardness:

- Punched part
- Laser part
- Flame-cut part
- [x] Sheet blank
- Plasma-cut part
- Water-jet-cut part
- Part
- [x] Blank
- Disc
- Coil segment
- Perforated plate
- warm rolled
- cold rolled
- scaled
- sandblasted
- [x] blank
- grounded
- galvanized
- foil-coated

Thickness min: 15,2 mm | Thickness max: 15,3 mm | Length: 2960 mm | Width: 1050 mm | Ø outer: mm | Ø inner: mm

Notch: ☐ Yes ☒ No

Initial State: Longitudinal curvature: 1 mm | Across curvature: 1,8 mm | Findings

measuring position: ☐ Vertical ☒ Horizontal ☐ On both sides

Required flatness: 0,2 mm / 1000 mm | mm / part

measuring position: ☐ Vertical ☒ Horizontal ☐ On both sides

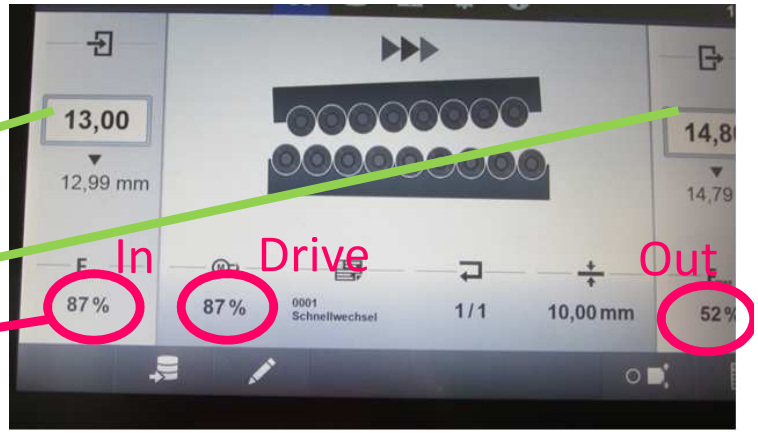
No. X_X	Leveler adjustment Entry		Part orientation				Findings
1_0	13,00	14,80	☐	☒	☒	☐	
1_1	13,00	14,80	☐	☒	☒	☐	
1_2	13,70	15,00	☐	☒	☒	☐	

Number of leveled parts: 1 pcs.

Remark: Initial state measured the complete part (3000mm), after 1_0 turned the part front to rear, leveling result measured complete part (3000mm) = 1,2mm/3000mm

Material & dimensions of plates

Machine display



Machine Parameters

Forces

The three steps

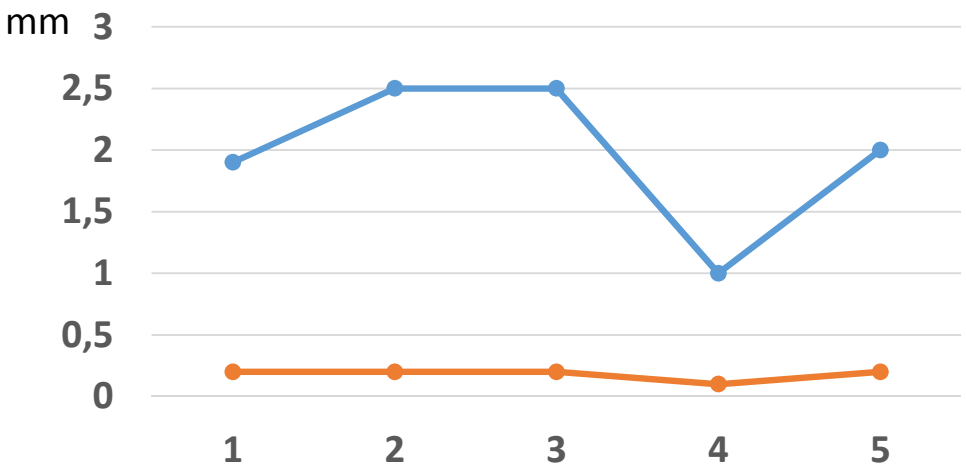
Initial flatness

Flatness after the three steps

Results for all plates

Larger plates

L1 ~ 2.9 m

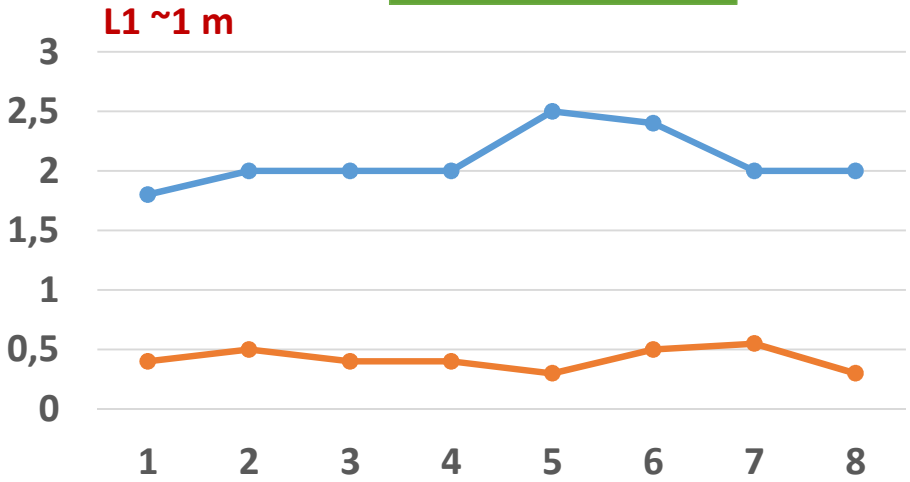


Before

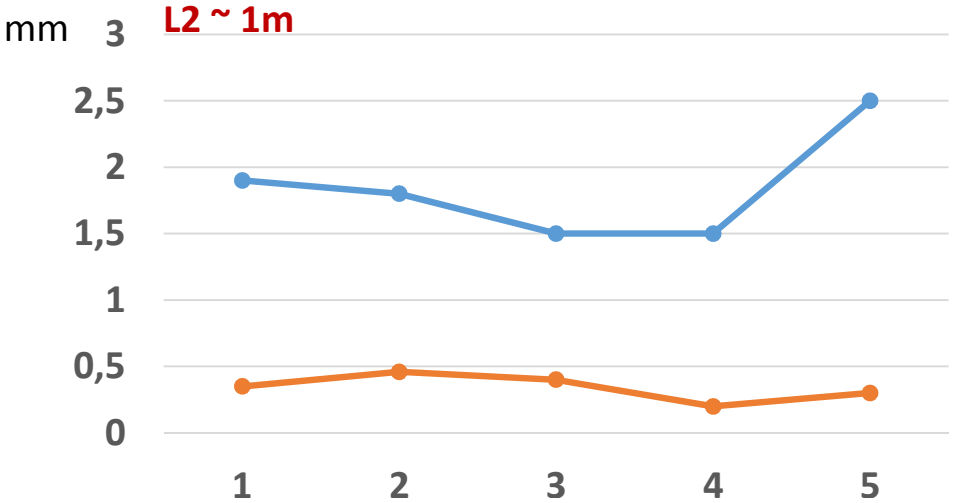
After

Smaller plates

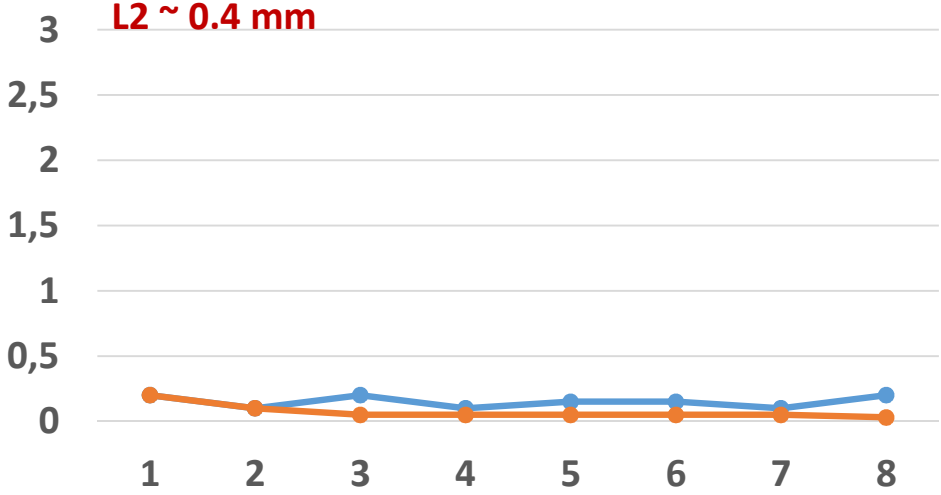
L1 ~1 m



L2 ~ 1m



L2 ~ 0.4 mm



Conclusions

The electron beam welding test shows reasonable results but more tests and optimization is needed

The first measurements of the plate flatness seems well bellow the 1mm but precise measurements of the flatness are still pending

Many thanks to ***ARKU***. In particular to **Alexander Enke, Stefan Ruoff and their technicians** for their help and collaboration for the roller leveling tests