BTL mechanical design

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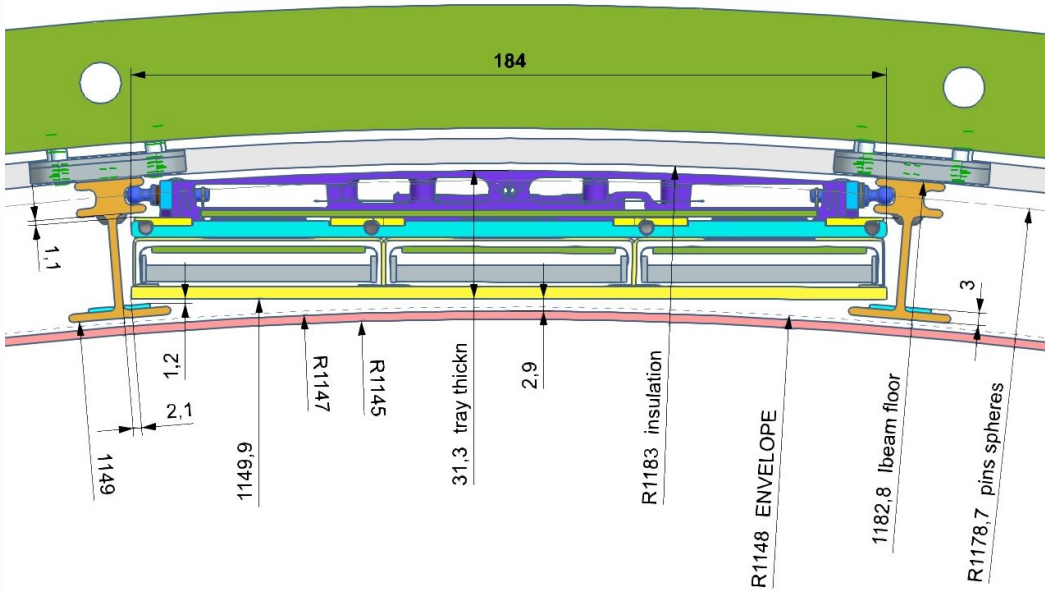
September 19, 2023

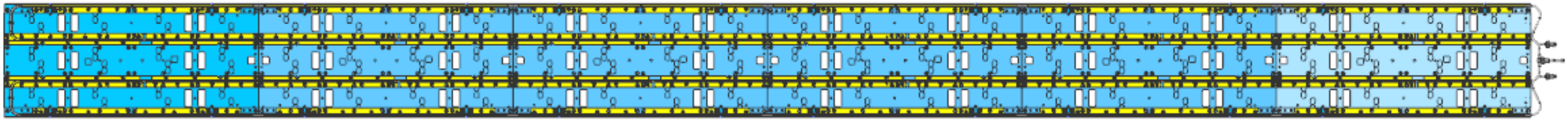
Tray scheme

"TOM" Design : Tubes On Middle Cooling Loop clamped with clamping laminas to Cooling Plates

The 6 Cooling plates constitute the structural backbone placed between Detectors Modules and electronic boards

Choice of split cooling plate for compliance to rails shape





BTL trays dimensions and envelope

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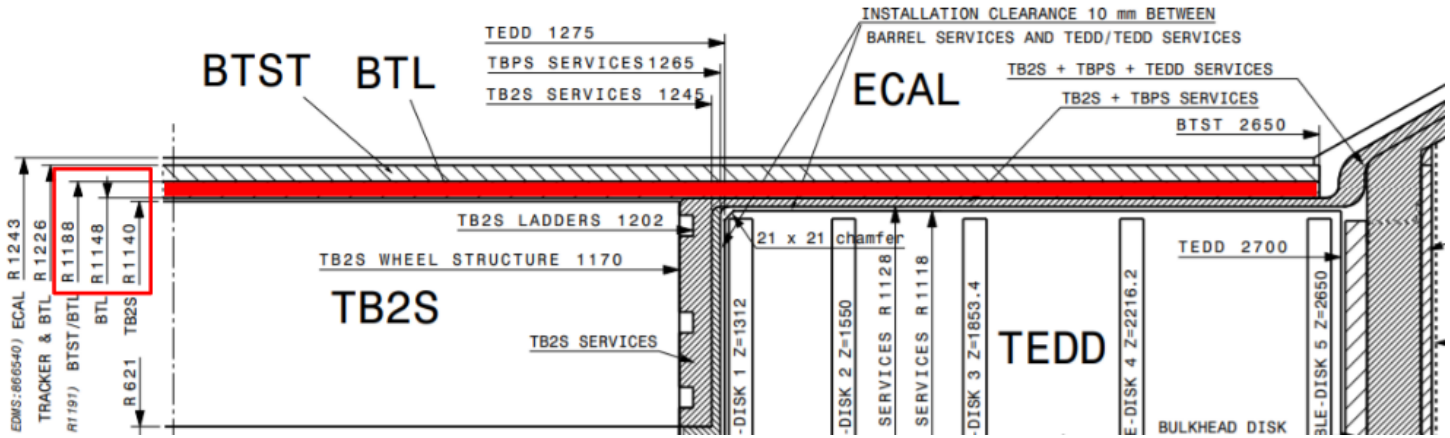
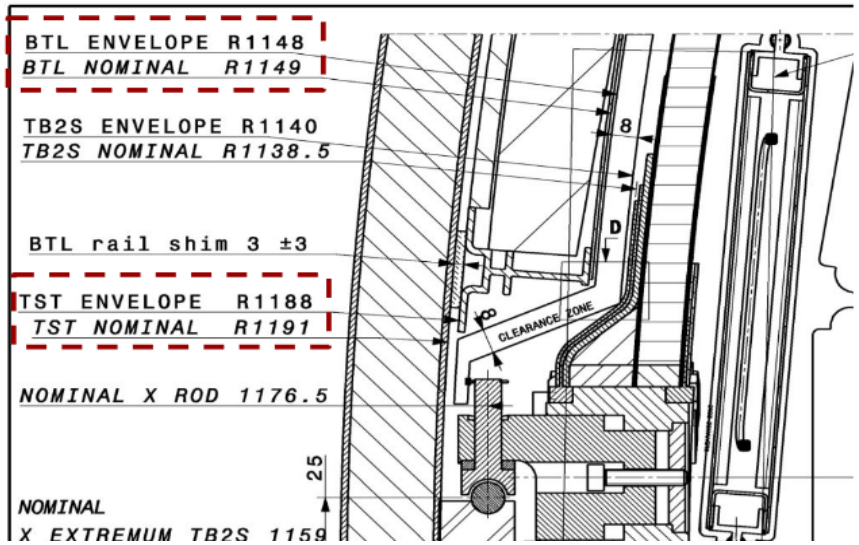
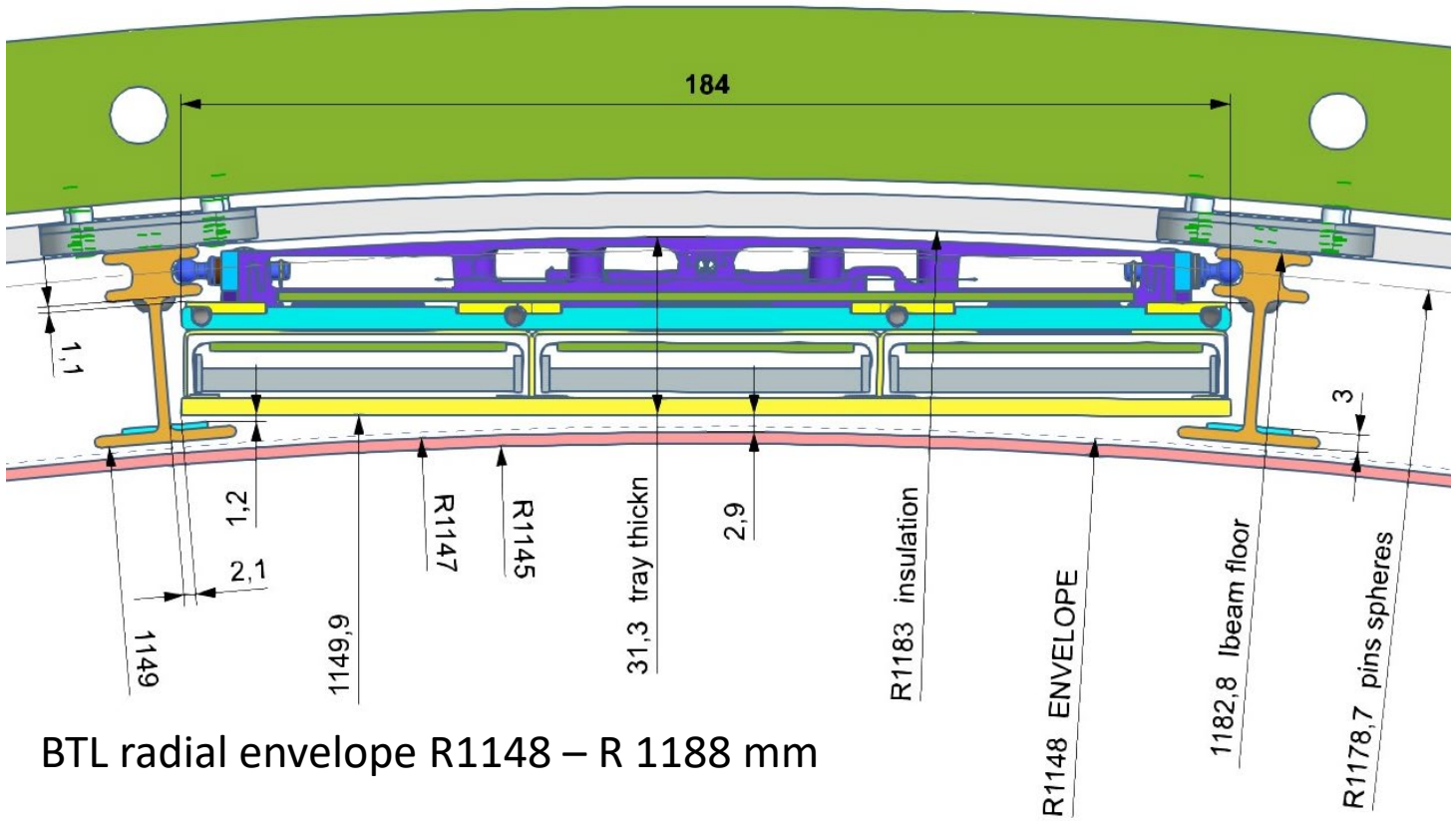
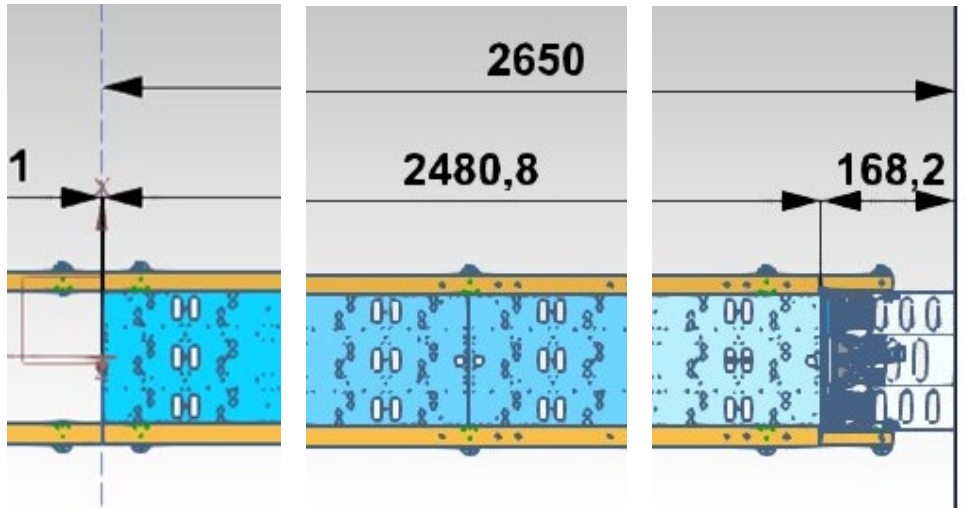






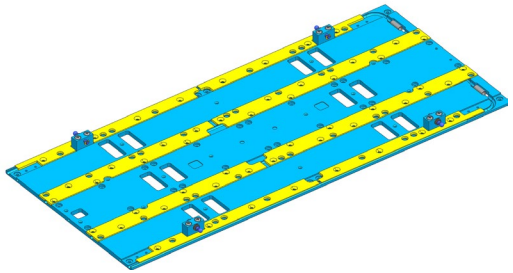
BTL radial envelope R1148 – R 1188 mm

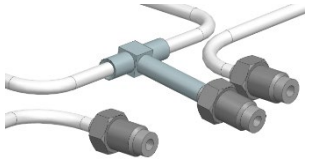


Cold Tray from Z +/- 1 mm to Z +/- 2481.8 mm

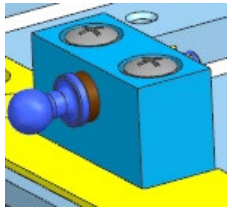
Tray components and jigs (only “mechanics” considered)

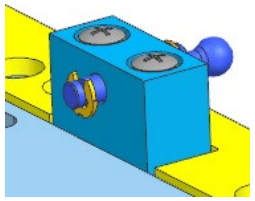
Cold tray (CT)
- 6 Cold Plates (CP) /tray
- 48 Laminas /tray
- 1 Cooling loop (CL) including
  - Tee
  - Fittings (Swagelock VCR glands)



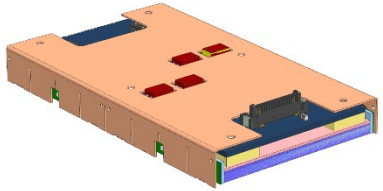


Tray to rails interfaces
- Roller pins
- Rollers blocks
- Screws, pins

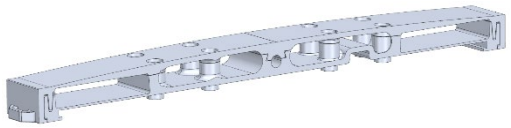




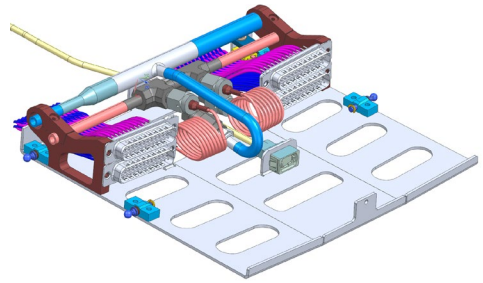
Detector modules mechanics
- Copper cases (DMs)
- DMs to CPs Thermal interfaces



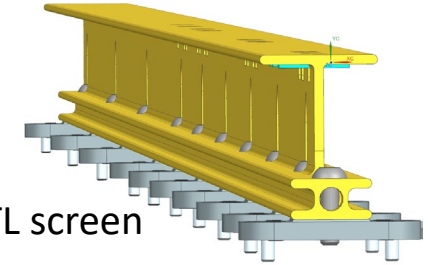
Other tray components
- Cables brackets
- Tray «bottom» insulation



Service tray
- Manifold
- Fittings and capillaries
- Service support tray and rollers

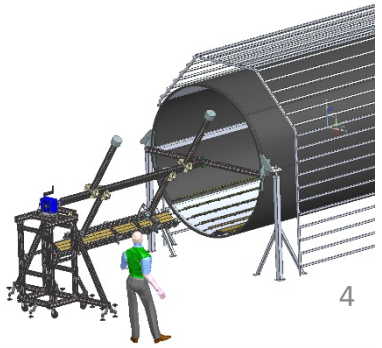


Interface to BTST and TRK services
- I-beams (rails)
- I-beams feet
- BTST insulation
- Insert on I-beams to fix ribs and TRK/BTL screen



Main Jigs for trays assembly
- Pipes assembly and transport cradles
- Tray assembly and transport cradles
- Tray assembly «skewer holder»

Main Jigs for installation
- I-beams installation jig
- Dummy tray for go/no go check
- Tray installation jig



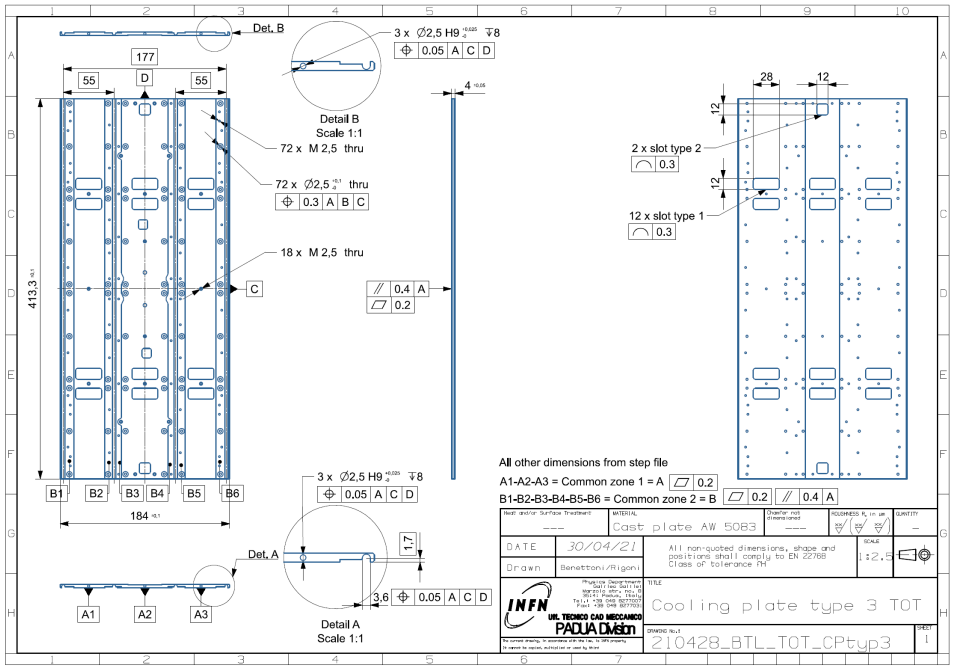
Cold Plates and laminas

n. 6 Cold Plates per tray, 450 overall
Aluminum alloy AW6082
Pipes embedded in the grooves machined in the plates
Tapped and through holes to fix clamping laminas, DMs, rollers and boards (CC)
Through slots for DMs to CC connectors
Features / holes for
Handling, cables fixing
tray hooking for Insertion

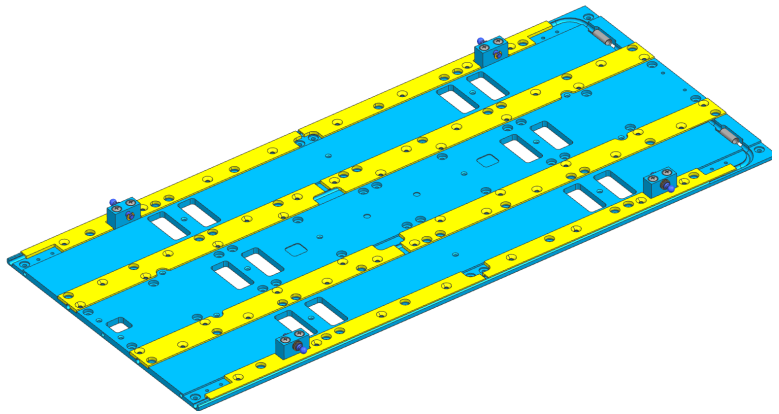
Laminas to clamp pipes to CPs in order to minimize CP-to-CL thermal resistance
Shaped to avoid conflict wrt electronics, rollers, screws, brackets for assembly
Preserved distance of CC bottom components to laminas: > 2 mm
n.8 laminas/CP , 48 laminas/tray
3.5k pieces individually machined

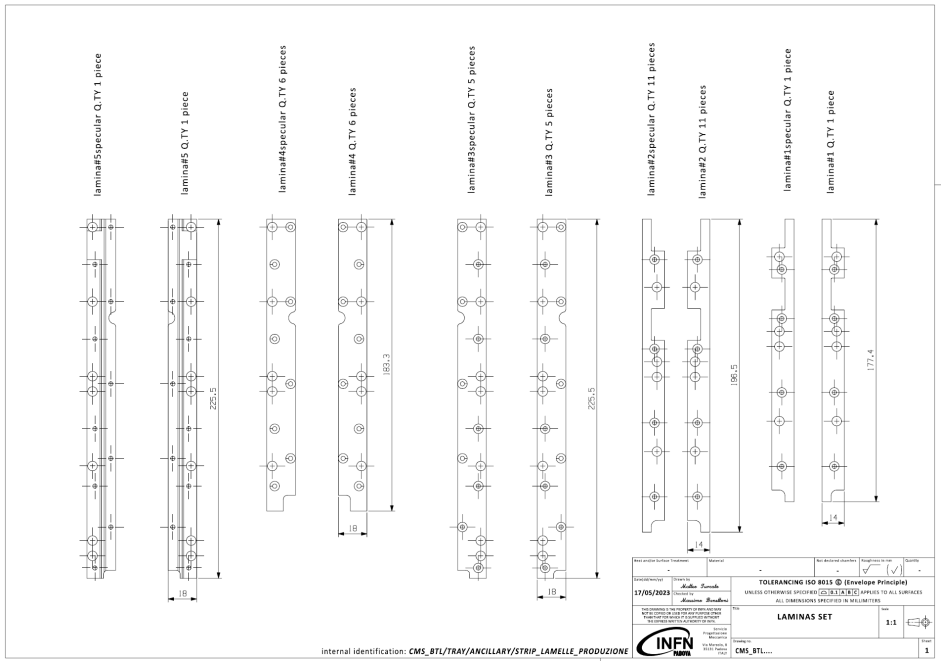
Surtec 650 coating

7 sets of full CT produced up to now
No major issues



Final check of CAD models before launch production:
interferences
required holes and features



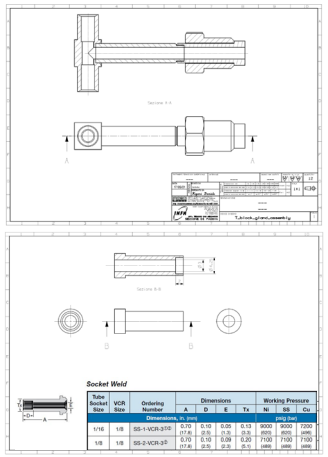


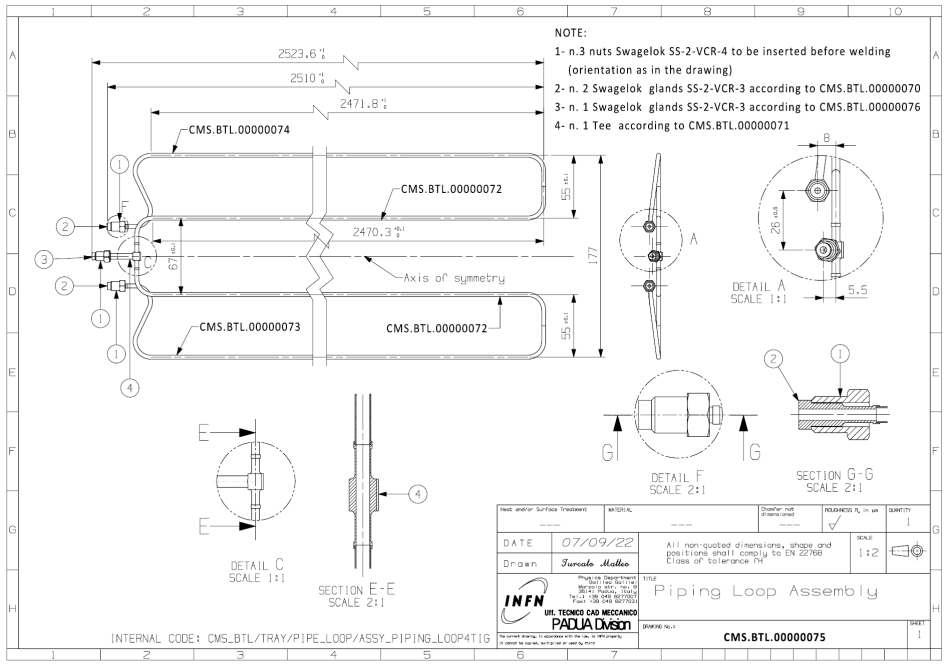
Cooling loops prototyping and qualification

Pipe loops prototypes produced up to now:

- 1x EB brazed prototype
  - piping bending, Tee and glands @ INFN Padova
  - vacuum EB brazing @ CERN
- 2 x TIG welded prototypes

All made of 3.5 mm O.D., 3 mm I.D. Aisi 316L pipes, tee and Swagelok glands
Both types passed qualification process …



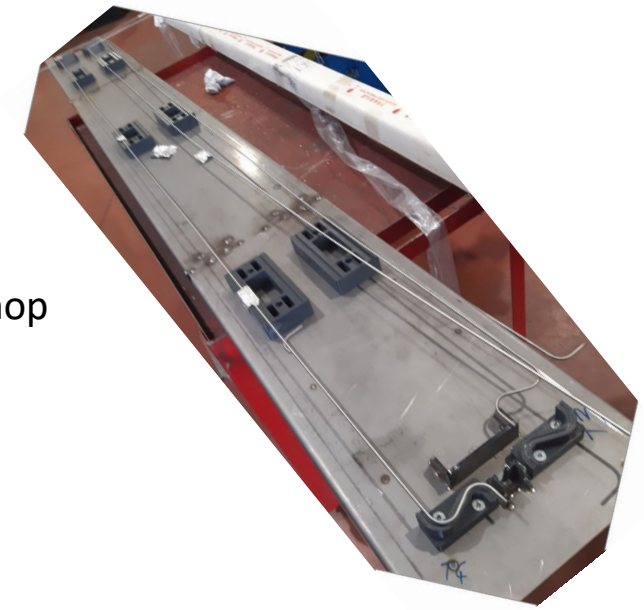


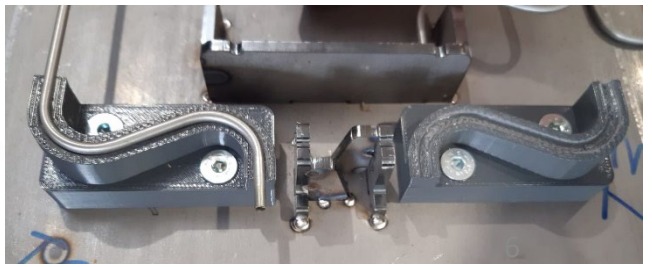
Prototyping of TIG welded Cooling loop @ supplier workshop

- CNC bending
- on full size jig for bending shape and length check
- Tuning of welding parameters on samples
- X-ray check to verify welding tuning on samples and on CLs

- Tee and glands produced/machined by INFN Padova workshop
- 100% X-ray check of all (7/loop) TIG weldings

- got offer for full production … ready for order
- bare pipes production ~ 10 weeks lead time





Cooling Loops qualification

X-ray:
CL prototypes brazing and welding X-ray scanned
Brazed prototype tomography:
https://edms.cern.ch/ui/#!master/navigator/document?D:100941045:100941045:subDocs
TIG welded prototypes X-ray report provided by the supplier.

Pressure and leak test according https://edms.cern.ch/document/2631824

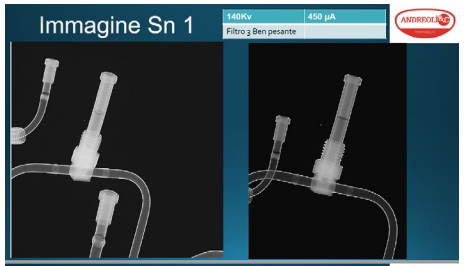
Pressure test at CERN @ 125/S-03 HSE-OHS
All CL prototypes passed 186 bars pressure test

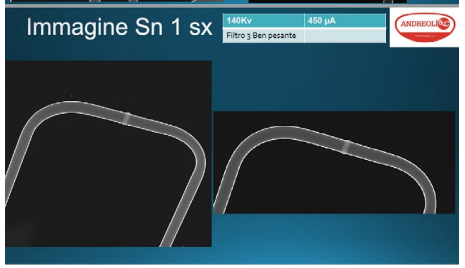
https://edms.cern.ch/ui/#!master/navigator/document?D:101335700:101335700:approvalAndComments
https://edms.cern.ch/ui/#!master/navigator/document?D:101335701:101335701:approvalAndComments

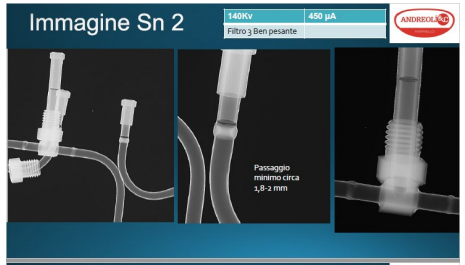
Leak test at CERN @ PH-DT lab 168/R-F05
TIG welded CLs passed He leak test , leak rate < 4 E-10 mbar l/s

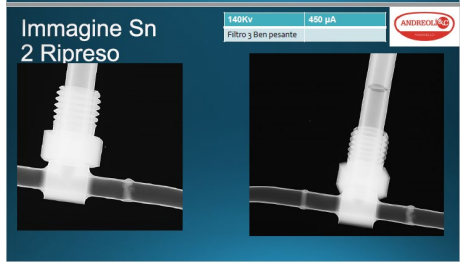
One re-welded joint damaged btw disconnection of leak detector and connection CO2 bottle

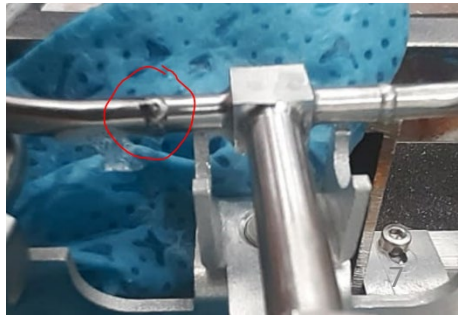
Provisional clamping/stiffening to put in place to avoid stresses during plugging/unplugging
QA / QC will be performed at CERN (likely @ PH-DT lab 168/R-F05) by BTL Group
Foreseen 0.5h / CL => one week overall





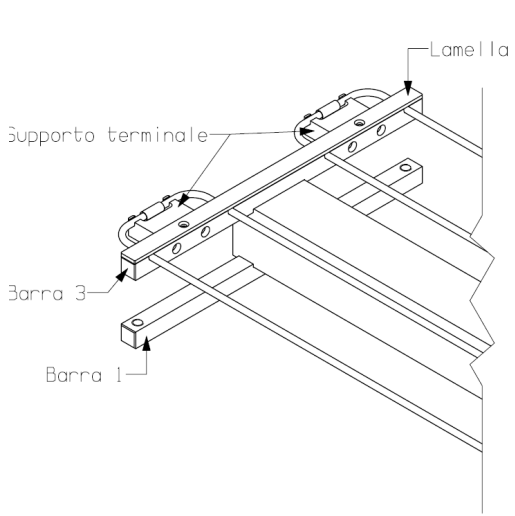


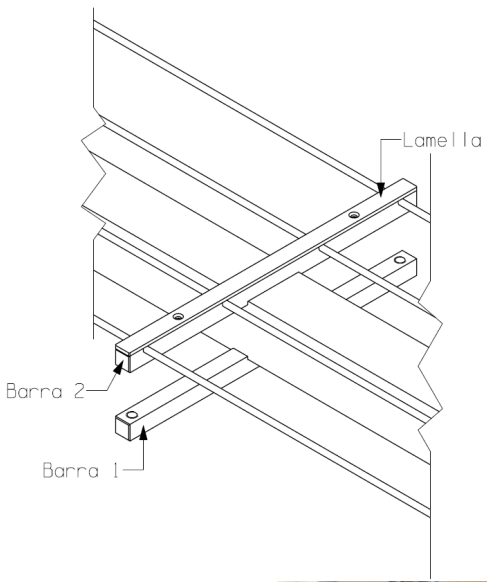


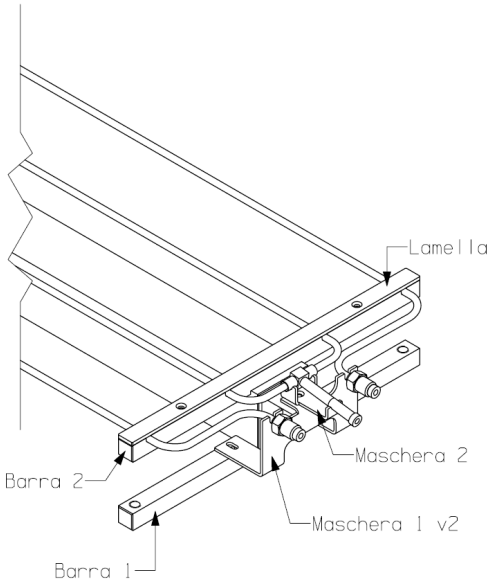


Pipe loop assembly frame

2.5 m long frame …. for loops shipping and storing.
Will be updated to lodge a few superposed loops

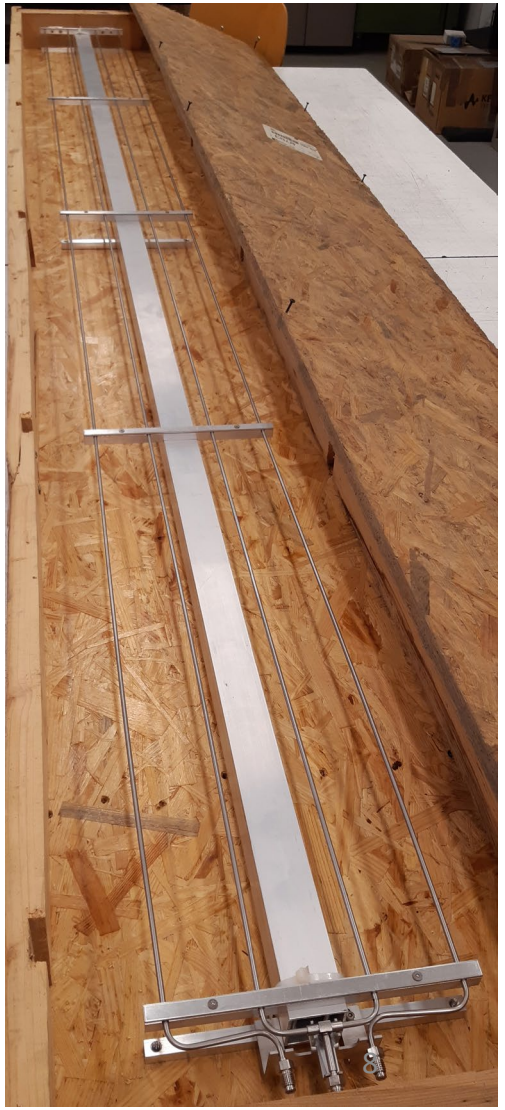






E.g. prototypes
Two loops overlapped on same frame

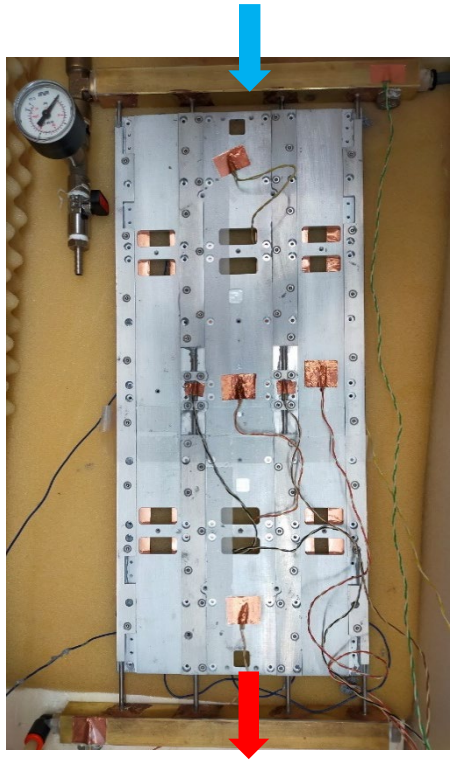
Pitch among CLs to be increased for better access to the connections



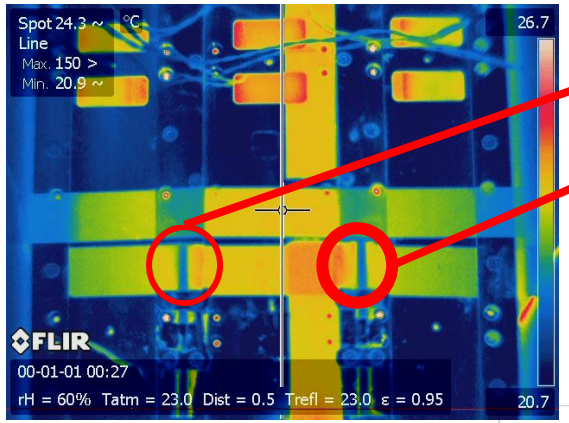
Tray design thermal qualification

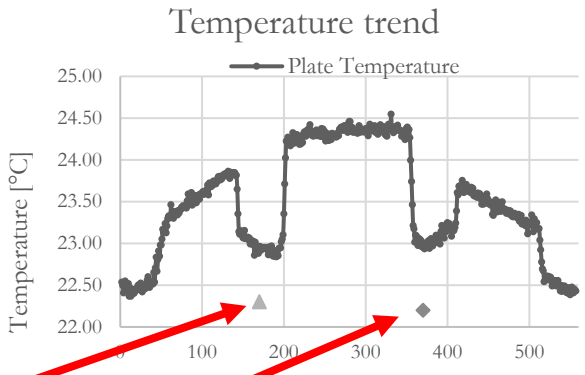
Various test performed by varying:
- CP design
- thermal compound (TIM)
- different filling of grooves

~ 100W/CP distributed along 4 «belts» under pipes to simulate DMs heat distribution
Temperature drop between CP and pipes minimized to ~ 2.1 °C



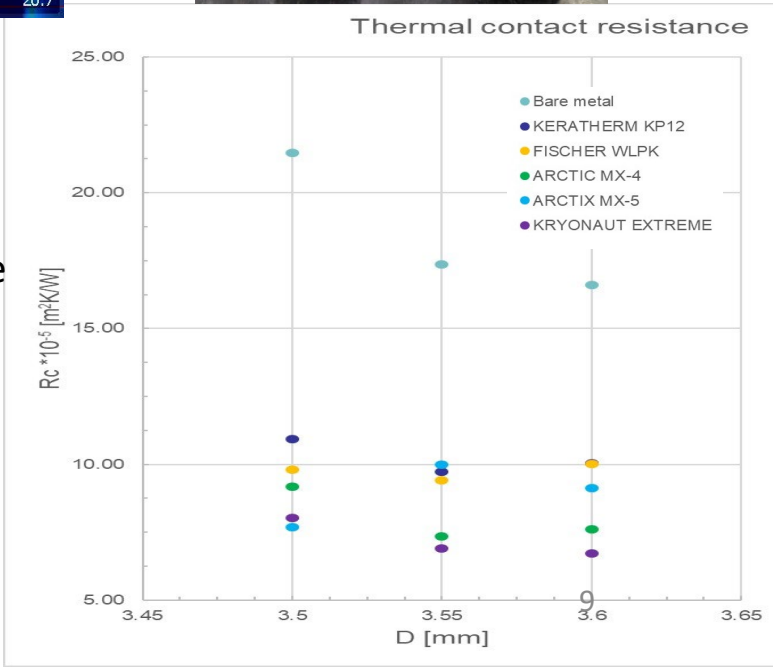
	T CP max [°C]	T pipes [°C]	ΔT max [°C]
λ TIM = 10 W/mK	25.6	23.3	**2.3**
λ TIM = 5 W/mK	26.1	23.3	**2.8**
NO TIM	36.6	23.9	**12.7**
λ TIM = 5 W/mK Grooves fully filled	25.8	23.1	**2.7**





Thermal compounds qualification

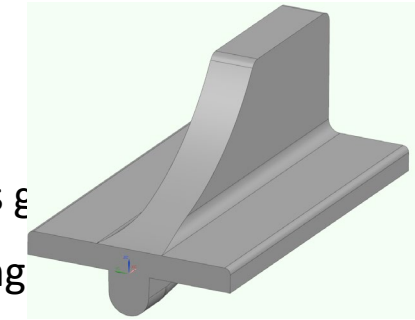
Samples to test thermal coupling efficiency of different compounds
Simulating short portion of tray groove geometry, different groove width 3.5, 3.55, 3.6 mm
Measuring temperature at pipe to alu block interface wrt steady heat flow and pipes temperature
Comparison of different compounds: Kerafol KP12, Fischer WLPK, Arctic MX-4 (8.5 – 10 W/mK)
Radiation resistance qualification in progress as other items
Arctic MX-4 better one at reasonable cost, easy to spread
Kryonaut Extreme, seems much higher cost
To consider other candidates e.g. already qualified
Parameters : thermal performance, workability/spreadability, radiation resistance …

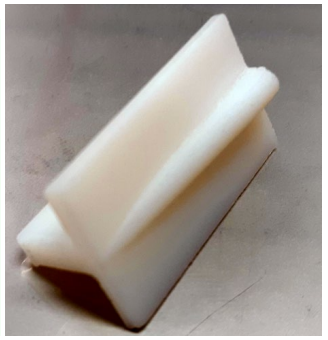


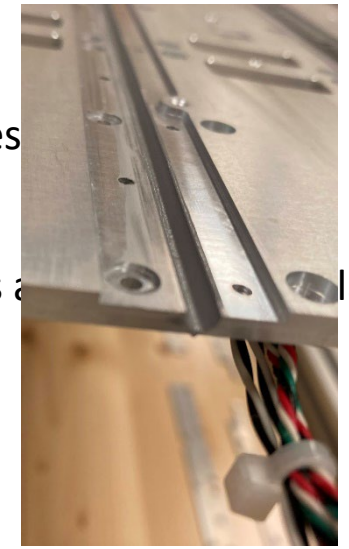
Cold Tray assembly procedure

- Align plates with Φ2.5 mm pins and 0.2 mm shims
  - Verify overall lenght, CP alignment and pipes g
  - Dry test pipe loop insertion and laminas fixing
  - Clean
- Spread compound with shaped tool and remove excess
- Spread compound in the laminas groove with shape tool and remove exces
- Insert pipes loop in the tray grooves
- Realize a uniform thickness , order of ~ 0.1 mm, before inserting the pipes a la

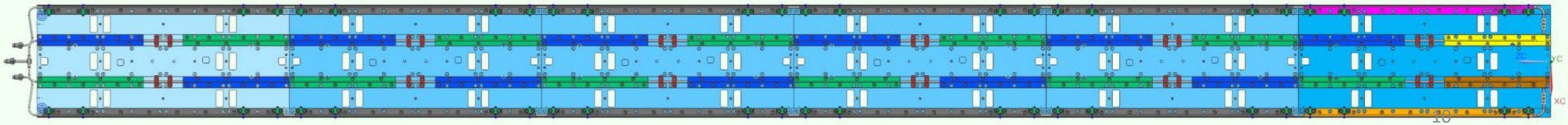
  further test coming to better define tool, procedure and QA/QC
- Place laminas from U end to front, and screws (torque t.b.c.)
- Laminas screwed using M2.5 x 4 mm countersunk head screws.
- 52 screws/CP, overall 312 screws/tray.





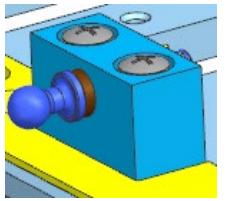
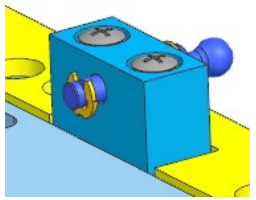


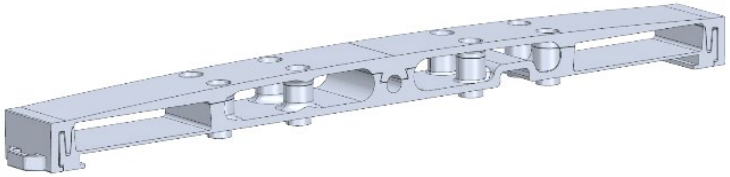
Lam1
Lam1speculare
Lam2
Lam3
Lam4
Lam5
Lam6
Lam7



Rollers, rollers blocks, cable fastners, insulations

- Various prototypes produced and used for mock-up, test, TIF ….
- Rollers Ti or SS offers available
- Block, GF (CF) Peek? G10-11? … Got offer for GF-Nylon, to refine
- Belleville washers (spring washers) on upper side rollers (pitch compliance)
- Cable fastners, 3D printed

- Insulation: thickness avalability, rad hardness, «dustyness»
- Got samples of:
- Rohacell IG51, IG-F 51 , Airex T92, T10, TegraCore
- Rohacell rigid, dusty
- Airex T92/T10/TegraCore (PET) not much rigid, clean, rad hardness?
- Airex R82 (PEI) as baseline, can be cleaned to avoid dusty appearance

- Tray protection covers if needed
  - Trays well protected by BTST and TRK/BTL cover plate
  - If needed Mylar foils to prevent protruding elements from getting caught

Load test for tray design structural qualification

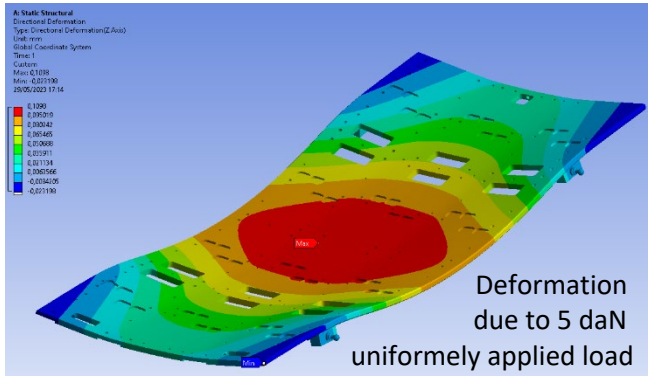
Load (at CP center) perpendicular to CP plane:
- deformation at mid points btw rollers: ~ 0.09 mm/daN
- FEA: ~ 0.02 mm /daN, (~ 0.07 mm/daN in the CP center)

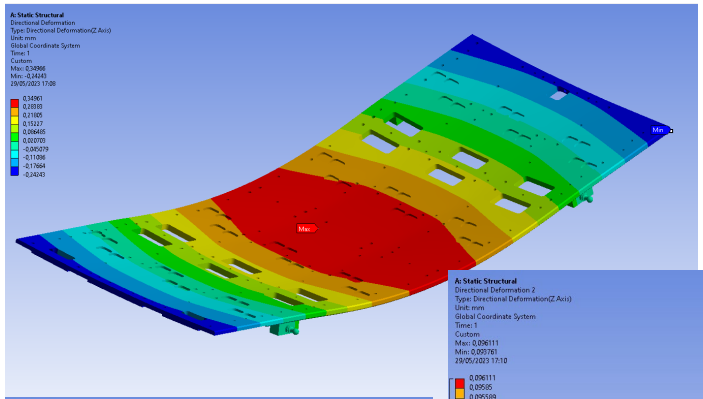
Refined prototype with zero clearance btw blocks and roller pins:
- deformation at mid points btw rollers: ~ 0.06 mm/daN
(tighter coupling tolerances, cost, rollers may not roll/slide…)

Load parallel to CP plane:
- deformation of top CP edge: 0.01 mm/daN
- FEA: 2 um/daN

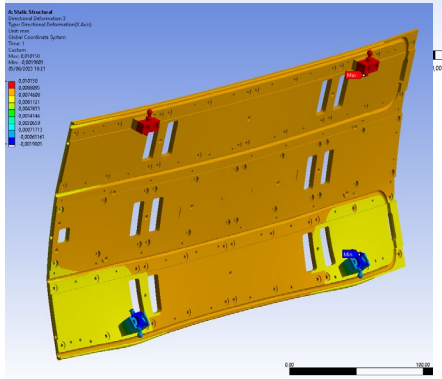
Roller blocks by GF or CF peek
Roller pins with no clearance w.r.t. roller block hole

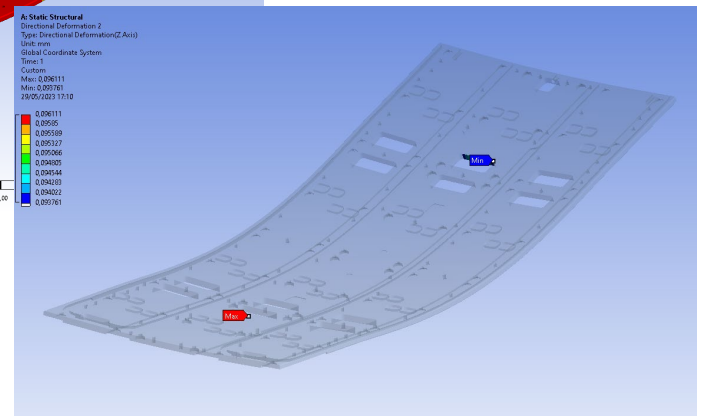
Worst expected sag
(polar positions)
mostly due
to rollers sag
up to ~ 0.25 mm
(vs ~ 0.1 mm FEA)

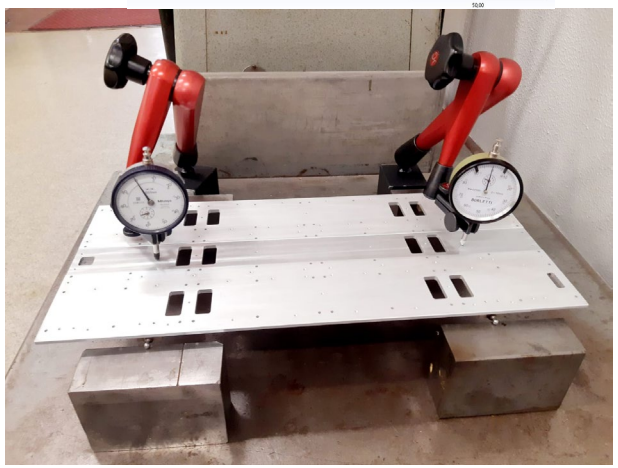

Deformation
due to 5 daN
uniformely applied load

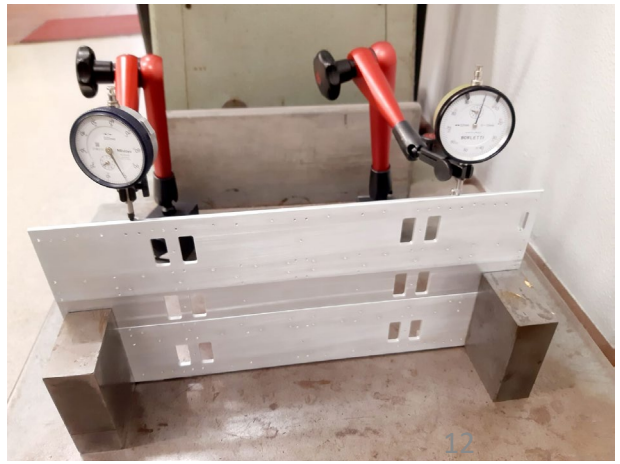


Simulation of test setup with single force at CP center, 5daN





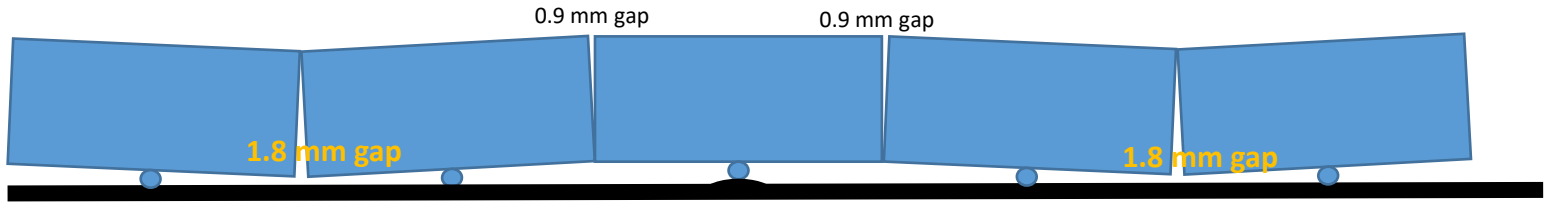




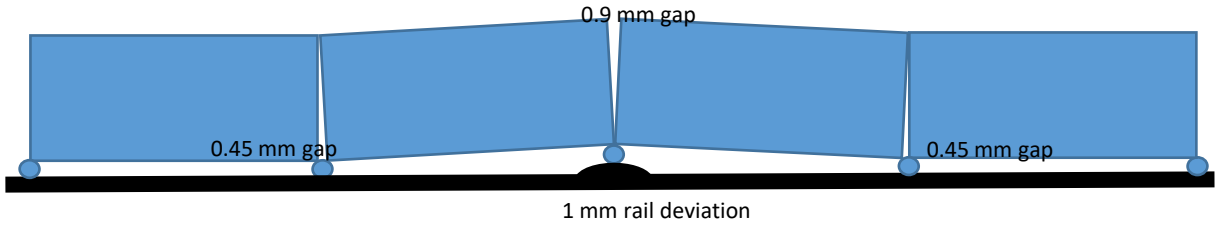
Rollers position on the CP

To minimize effect of rails deviation, rollers shall be as near as possible to CP corners

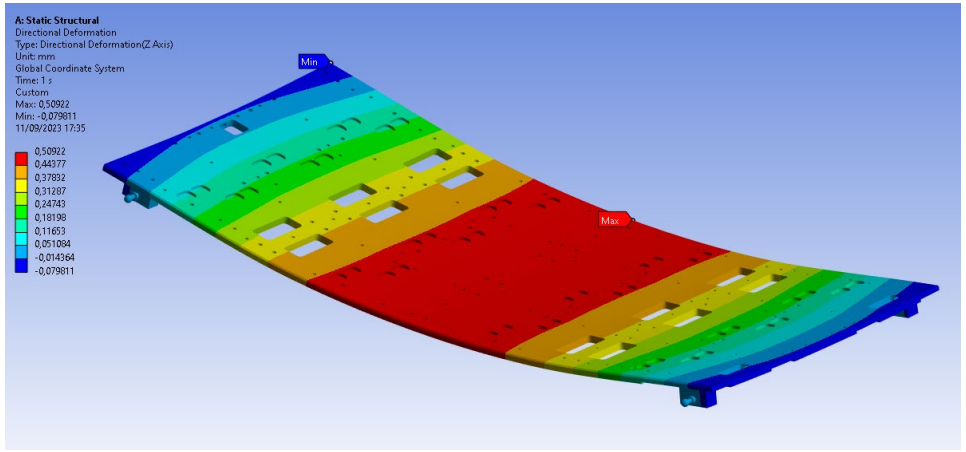
RUs rotation propagate to all the RUs and to all tray



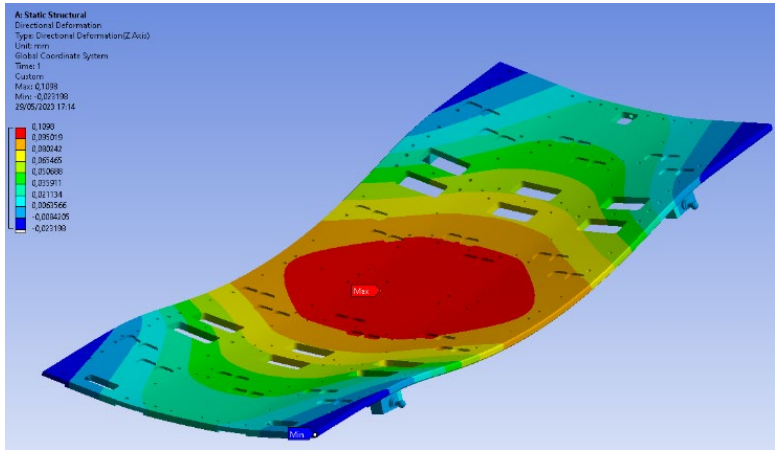
RUs rotation is smaller and does not propagate, limited to only two RUs



Rollers at CP corners maximize sag perpendicular to tray plane (tray at and near polar positions)

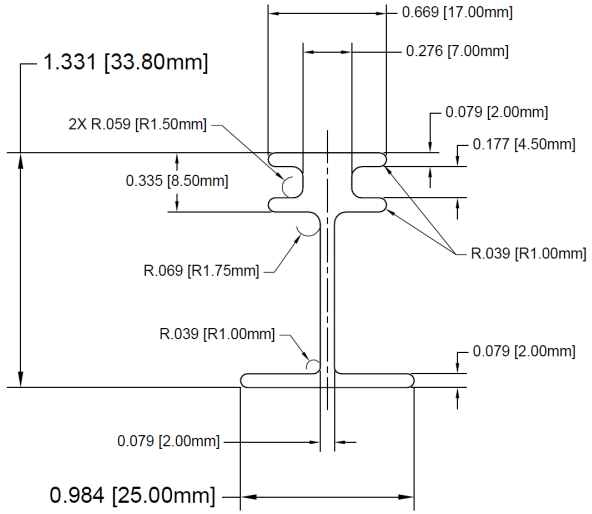


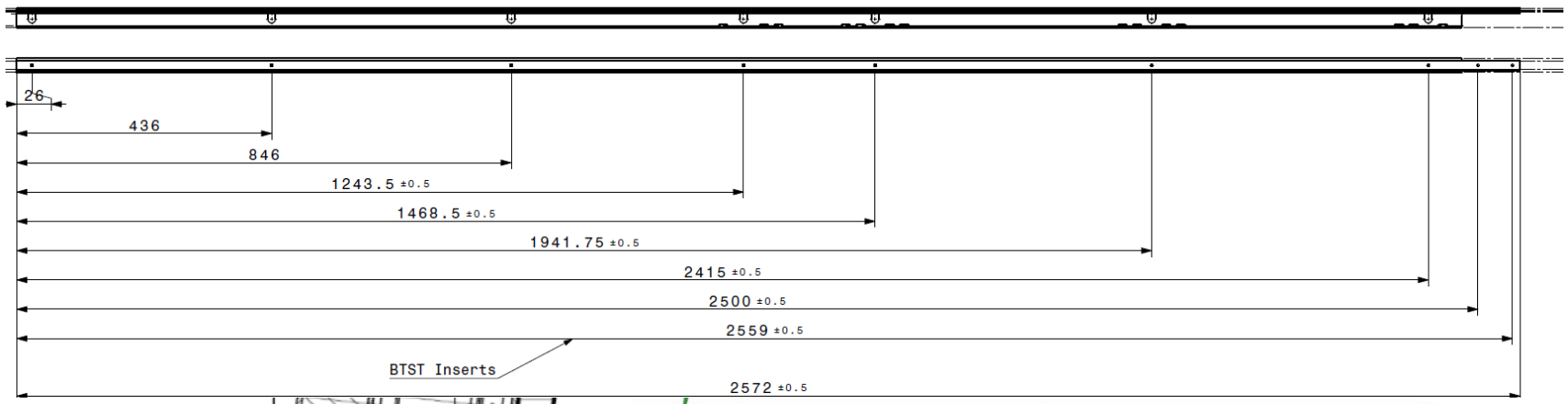
Rollers position as trade off between the two requirements

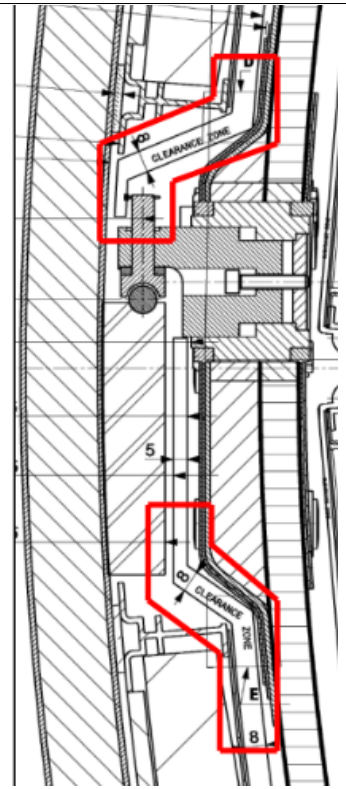


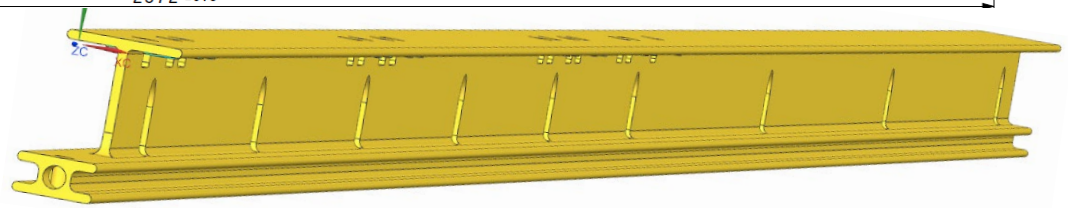
I-beams

As presented at BTST EDR
https://indico.cern.ch/event/1097318/contributions/4616812/attachments/2355293/4022573/EDR_20211201.pdf



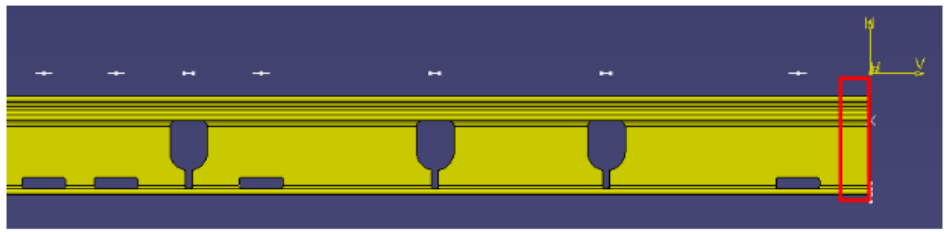




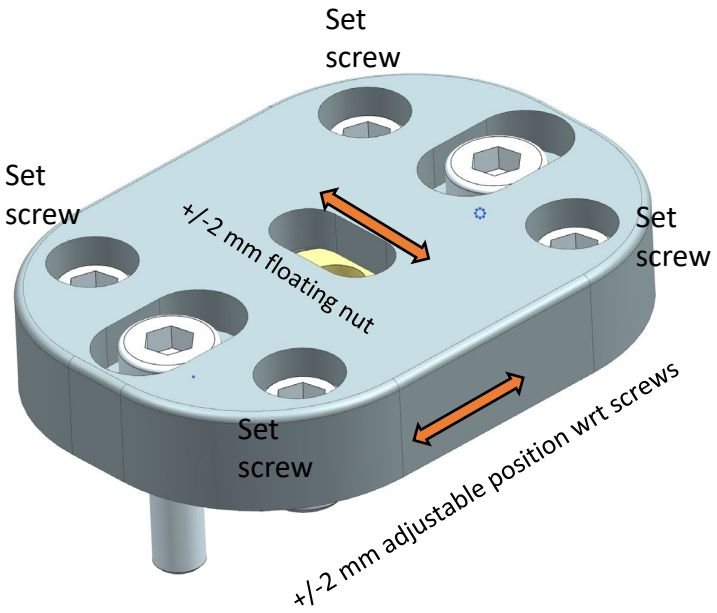


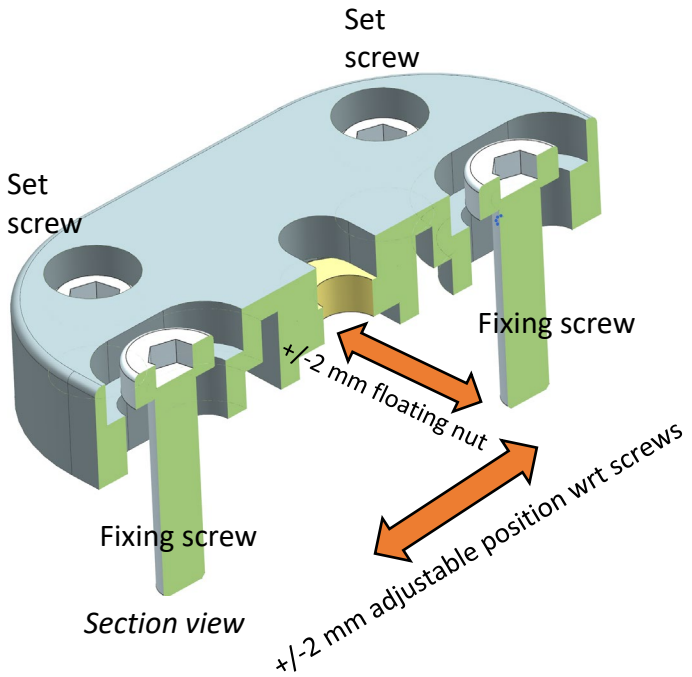
- Pultruded Glas Fiber,
- Feet position ~ in correspondence of TRK service ribs, doubled at service ends, plus other positions
- Larger pitch < 500 mm
- “Special” (half “wing”) I-beams near TRK rails (2 specular types)
- “Special” longer I-beams every 6 trays (supertray)

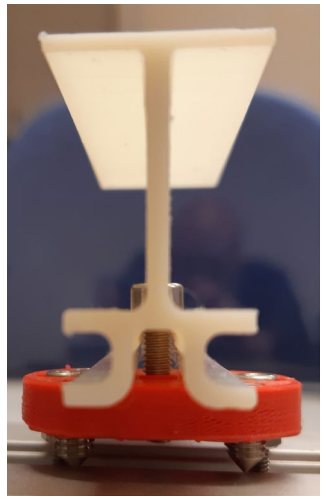
Overall 4 I-beams types from same pultrusion



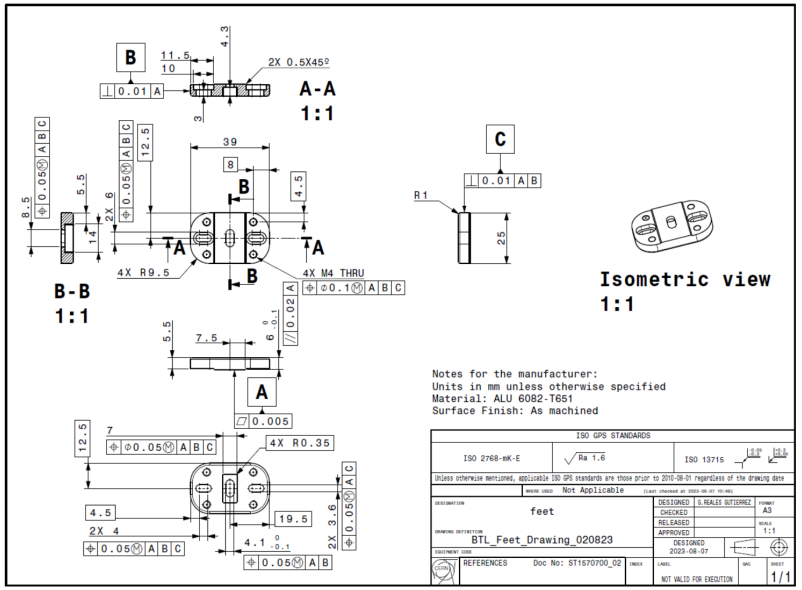
I-beam to BTST fixing brackets (feet) design







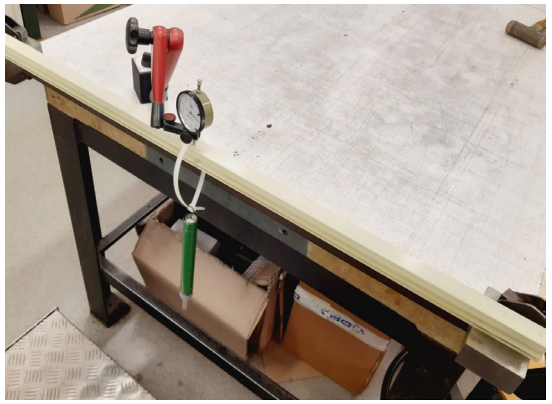
- **allows adjustment in phi, r, z**
- 2xM3 screws fixing bracket to M3 riveted inserts, +/- 2 mm adjustment to compensate rivets ϕ tolerance
- set screws to adjust radial position and tilting in all directions
- 1 embedded M4 nut, +/- 2 mm floating in Z
- pre-mounted on BTST, aligned and positioned on jig , still adjustable with I-beam on it.

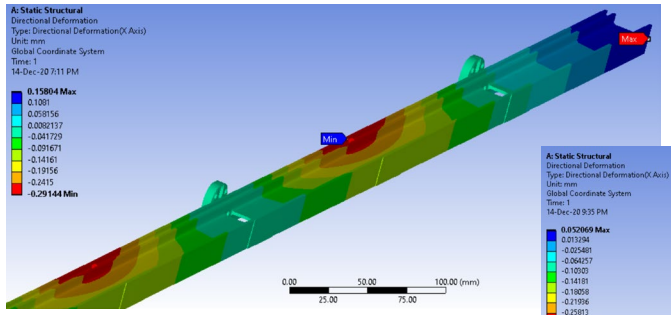


- Pre-production ready soon

I-beam elastic properties qualification and I-beams deformation esteem

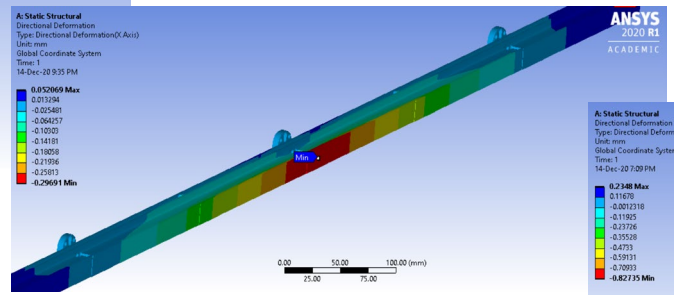
Load test to esteem GF I-beam elastic properties, assumed as unidirectional orthotropic:
E_z ~ 40 GPa, $E_{x,y}$ ~ 4 Gpa (corresponding to ~ 60% of GF … depending on fibers modulus)

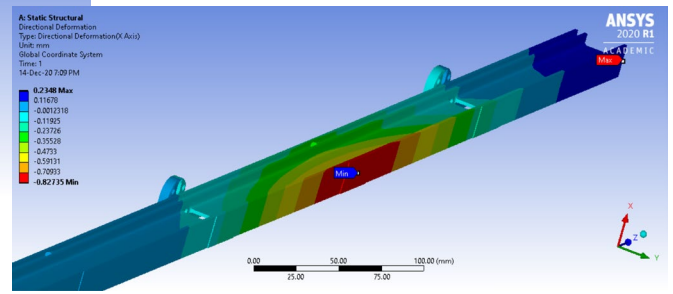




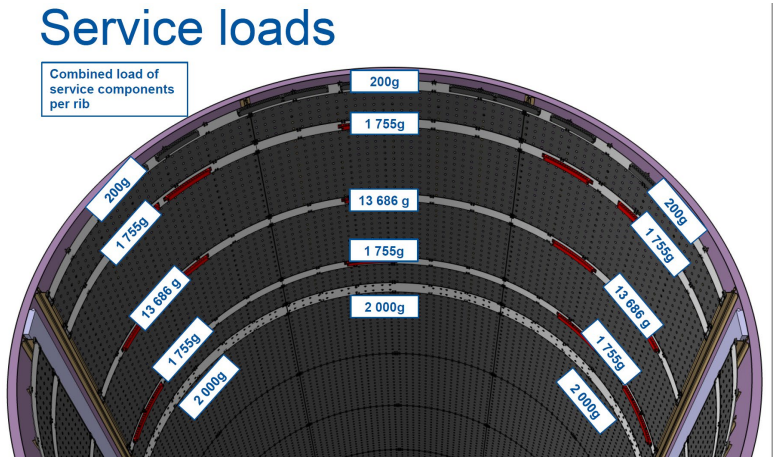
UltraPul 821049 - 82% fiberglass reinforced aromatic polyurethane

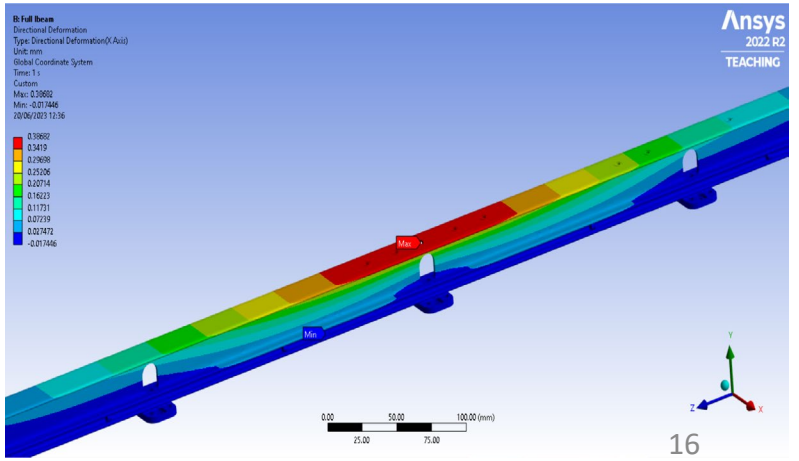
Varius check of I-beam deformation vs load position and feet pitch





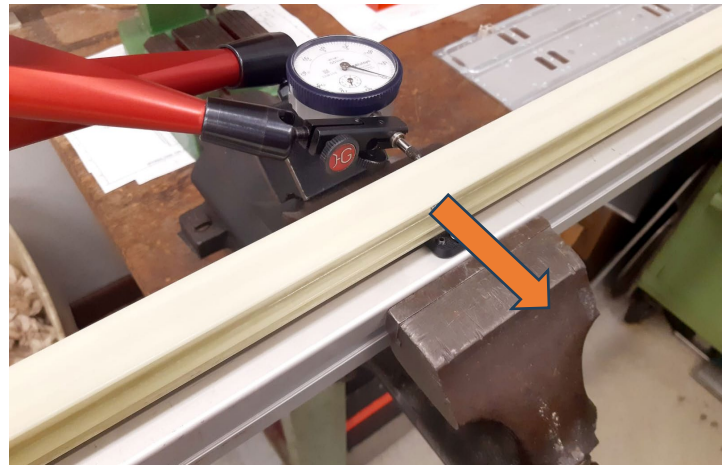
Measurement of I-beam-on-feet deformation w.r.t. esteemed load in BTST



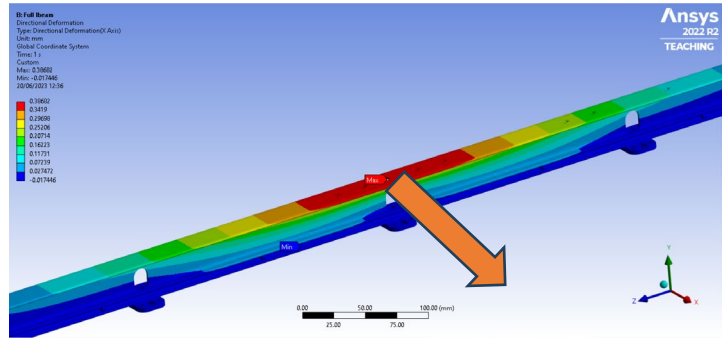


Design qualification: I-beam + feet deformation

Worst case tracker service load ~ 137N/sector
Assuming load distributed on ….3 I-beams?
transversal/tangential load on I beam «wing»: ~ 45 N/I-beam
(worst case scenario, sectors near equator)
Test of different types of material for feet vs
FEA: ~ 0.38 mm (@50N load, GF resin) ~ 0.08 mm/daN



ABS 3d printed feet
~ 1.1 mm (@50N load on top wing border) ~ 0.22 mm/daN
Factor ~ 3 discrepancy (local deformation due to nut & screws)



PA12 30% GF 3d laser printed feet: ~ 0.14 mm/daN

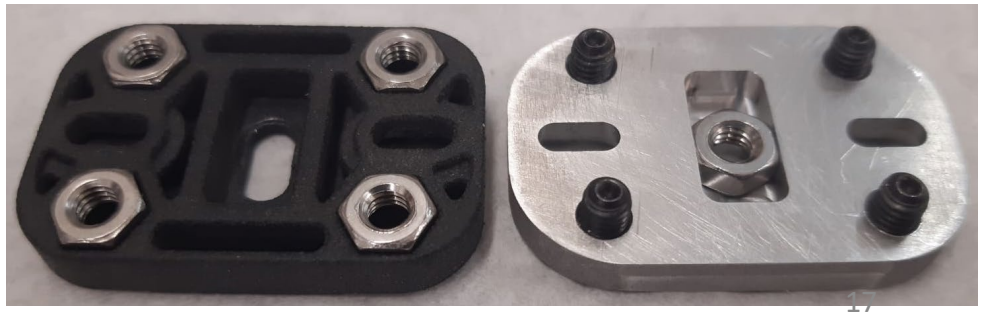
Sample from TIF/Guillermo, bulk: ~ 0.14 mm/daN
Aluminum feet, bulk: ~ 0.06 mm/daN

Peak deformations on wings => affecting services, effect on trays negligible

G11 and Aluminum feet pre-production in progress for final test and material choice

Actual deformation w*ill depend on*

- actual load per each I-beam,
- stifness of ribs … vs rotation of I-beam wing
- stiffness of BTST surface where the 4 set screws sit (coupling to BTST)
- …….

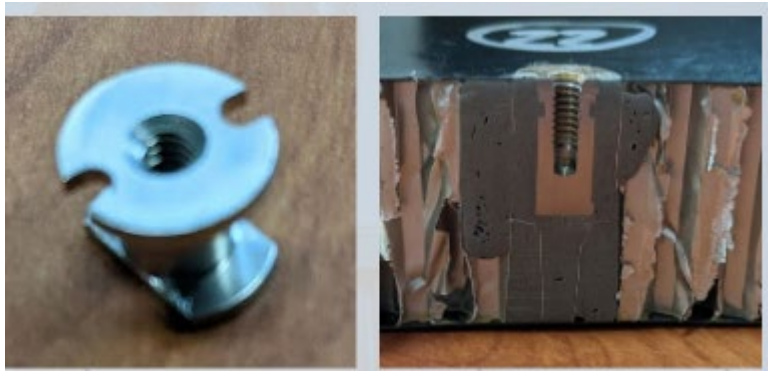


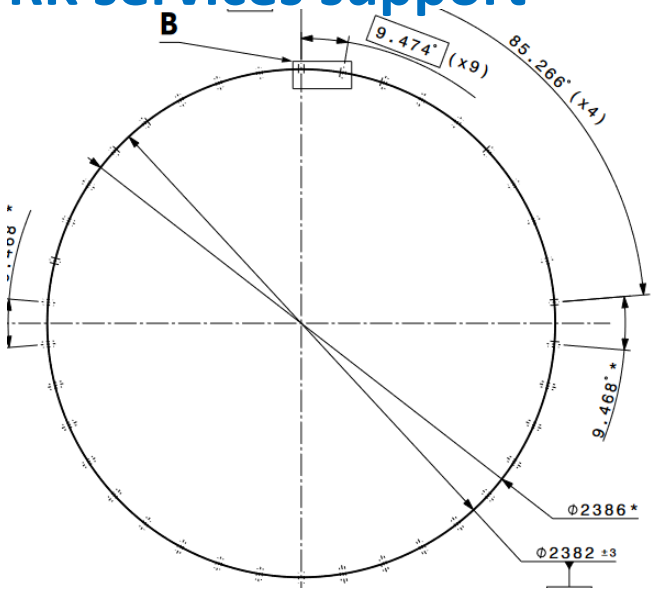
I-beams Coupling to BTST and TRK services support

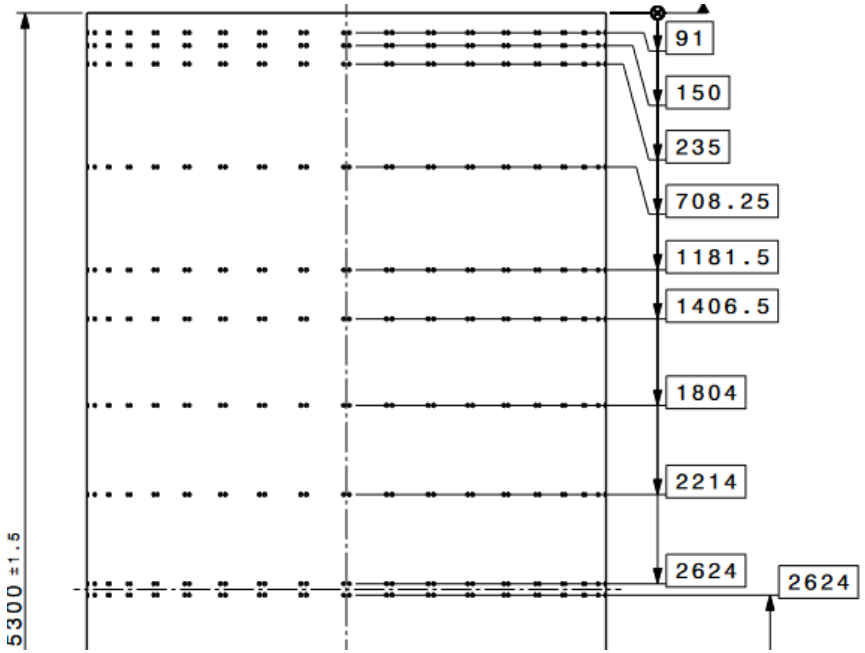
Inserts in BTST to fix Ibeams feet

See BTST EDR

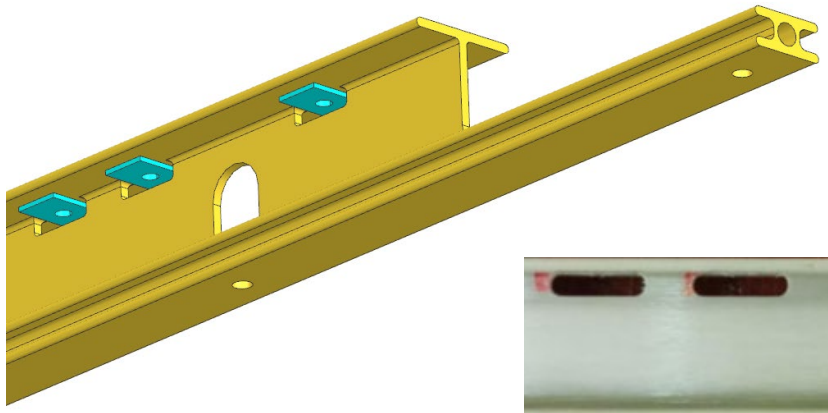
https://indico.cern.ch/event/1097318/

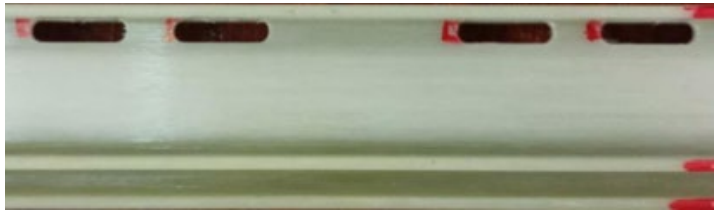


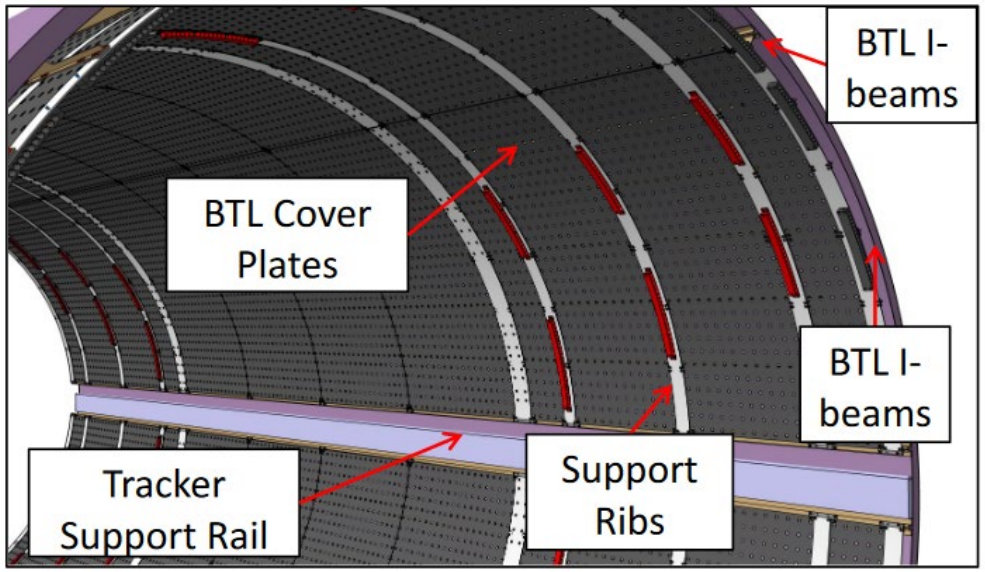




Ibeam inserts for TRK ribs fixing and BTL cover plates

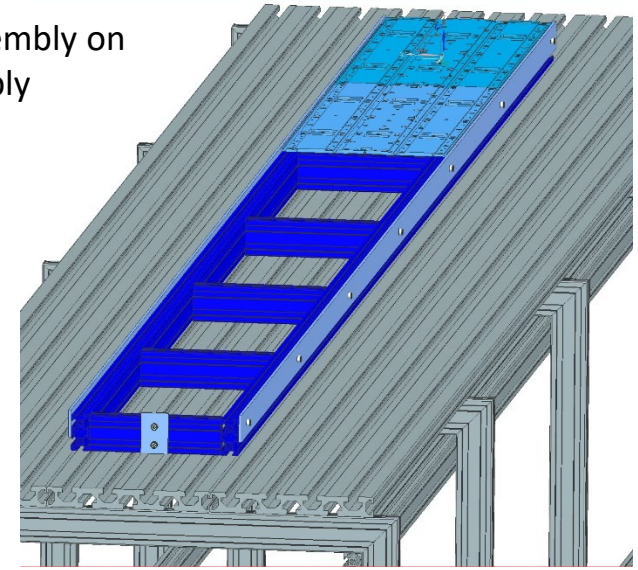




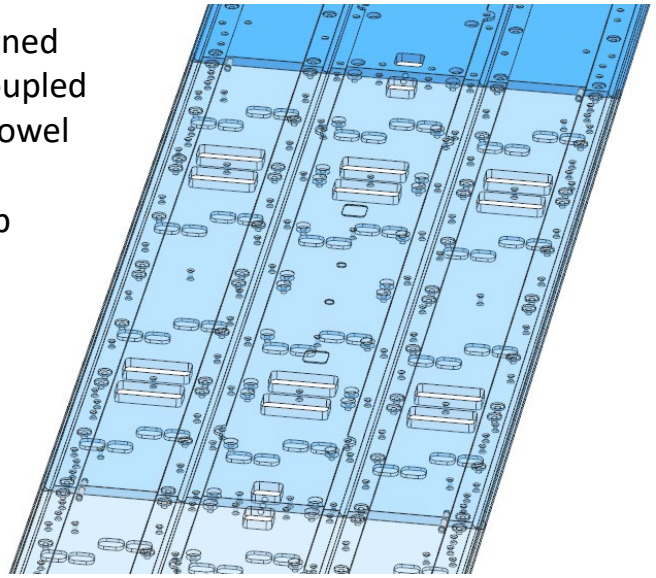


Tray assembly jigs and sequence

CT assembly on assembly frame

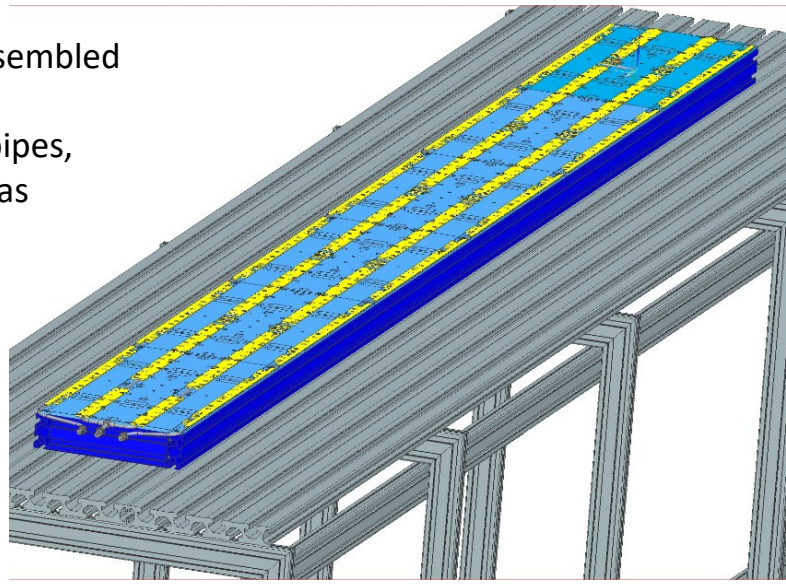


CP aligned and coupled with dowel pins, 0.2 gap in btw

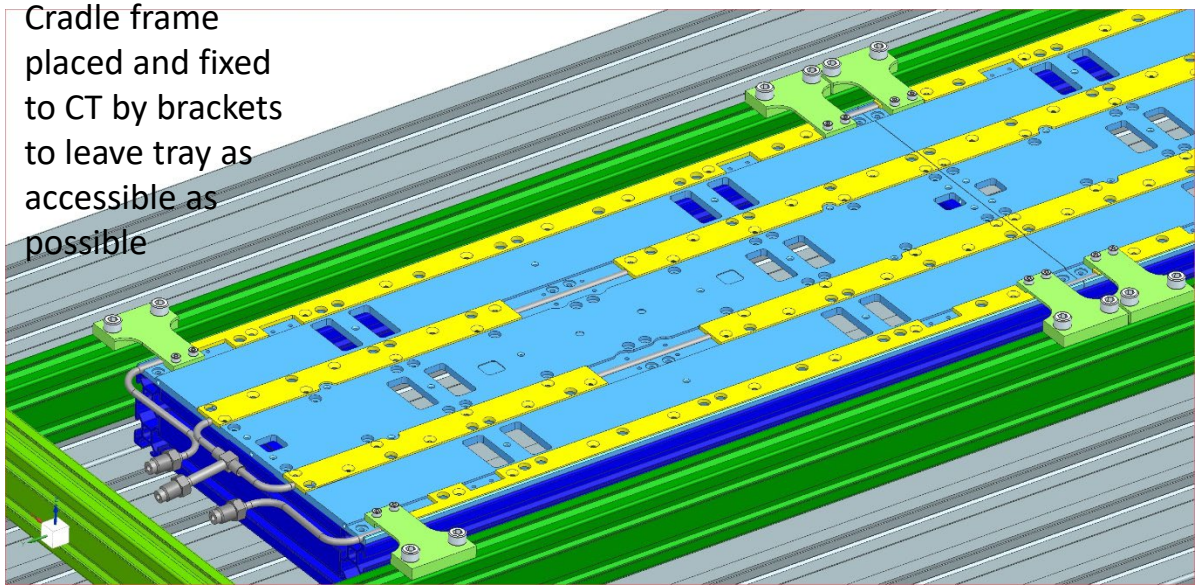


CT assembled

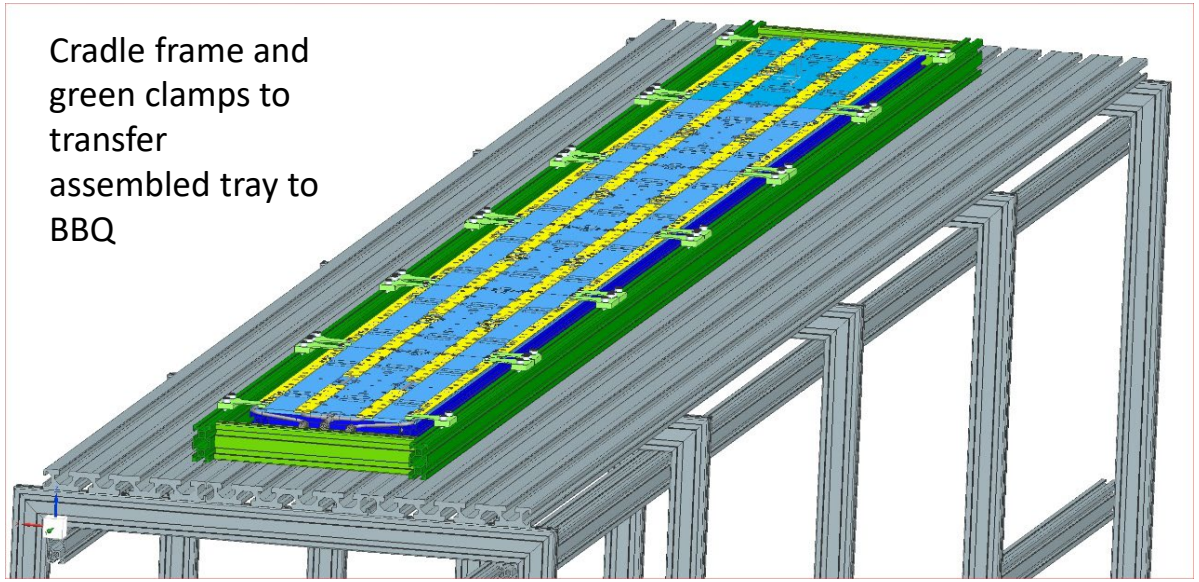
CPs, pipes, laminas



Cradle frame placed and fixed to CT by brackets to leave tray as accessible as possible

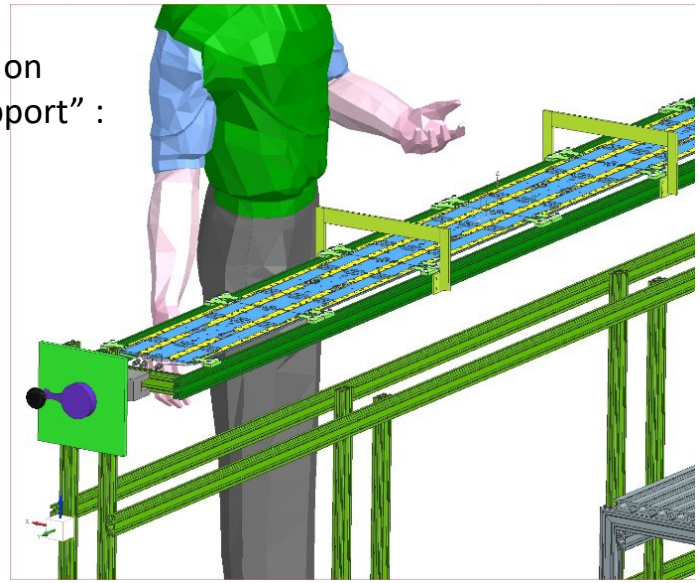


Cradle frame and green clamps to transfer assembled tray to BBQ

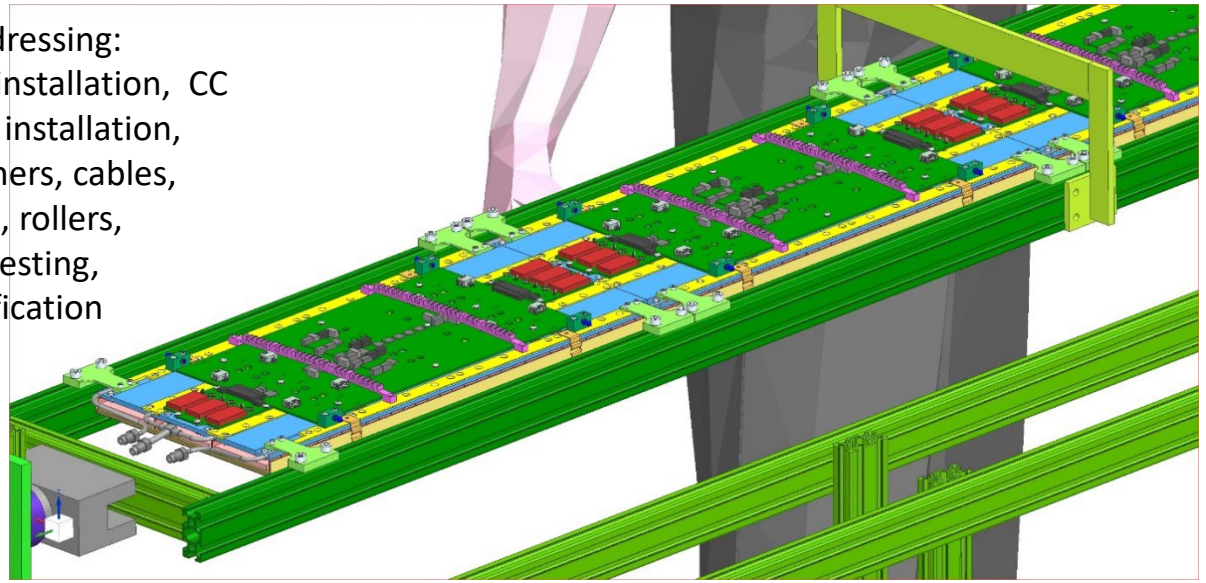


Tray assembly tools and sequence (@ Assembly Centers)

Tray moved on “skewer support” : both faces accessible

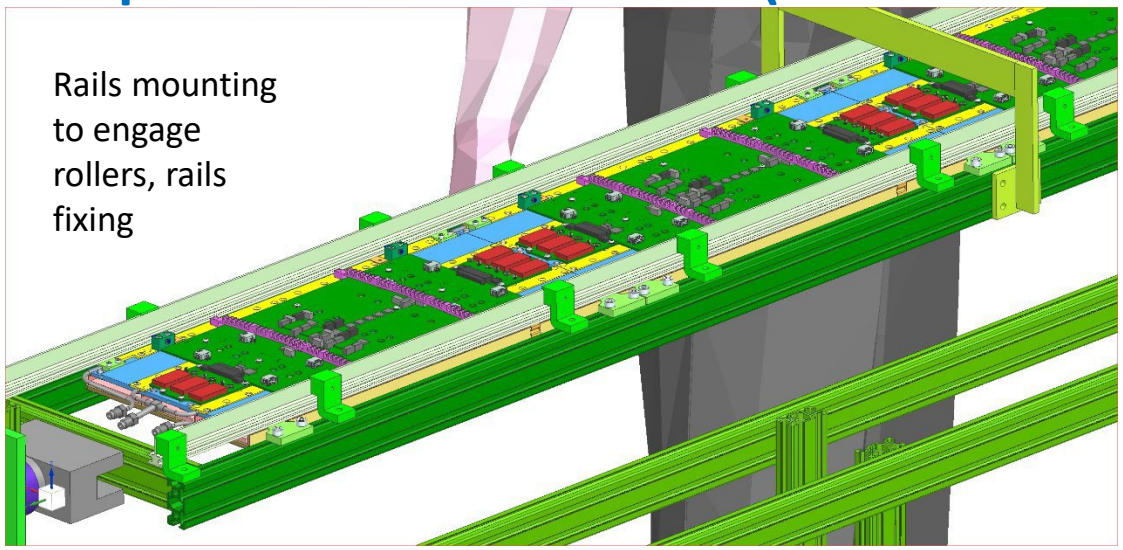


Tray dressing:
DMs installation, CC cards installation, fasteners, cables, fibers, rollers,
Tray testing, qualification

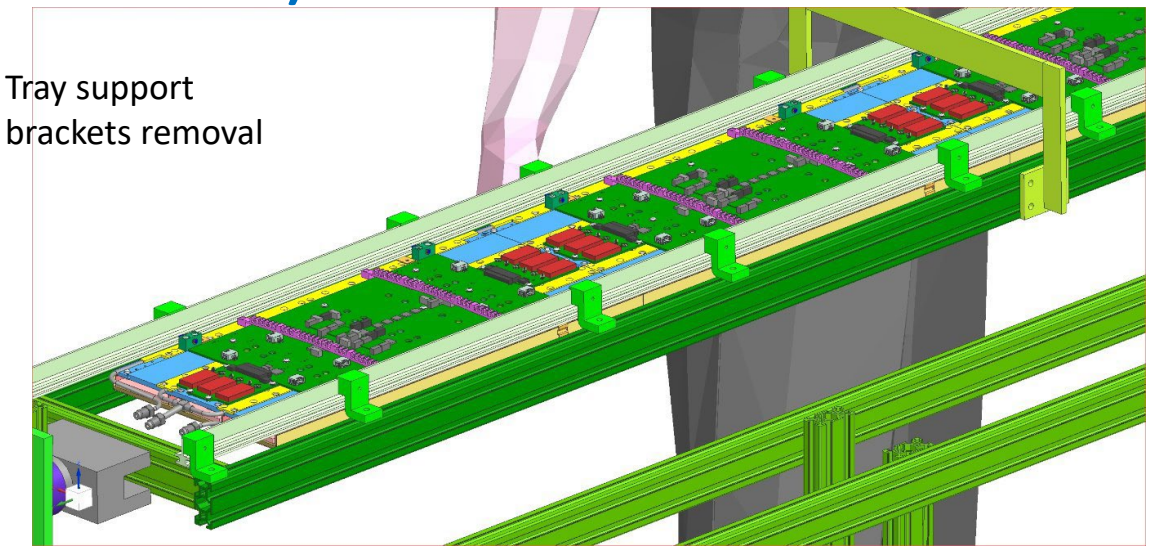


Preparation for installation (mechanics only considered)

Rails mounting to engage rollers, rails fixing

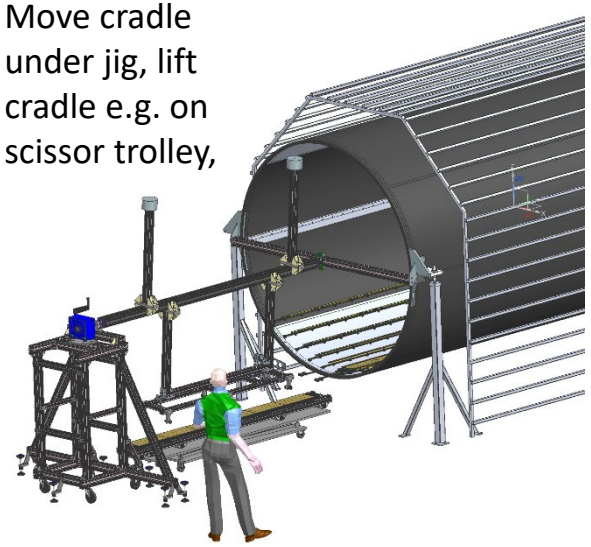


Tray support brackets removal



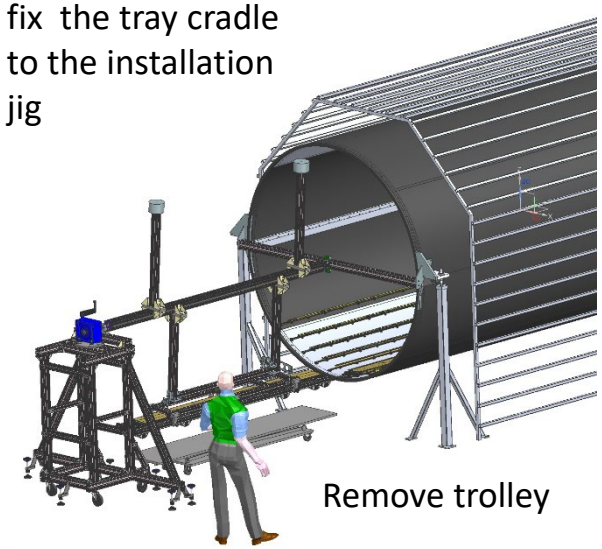
Tray installation jig concept and installation sequence

Move cradle under jig, lift cradle e.g. on scissor trolley,

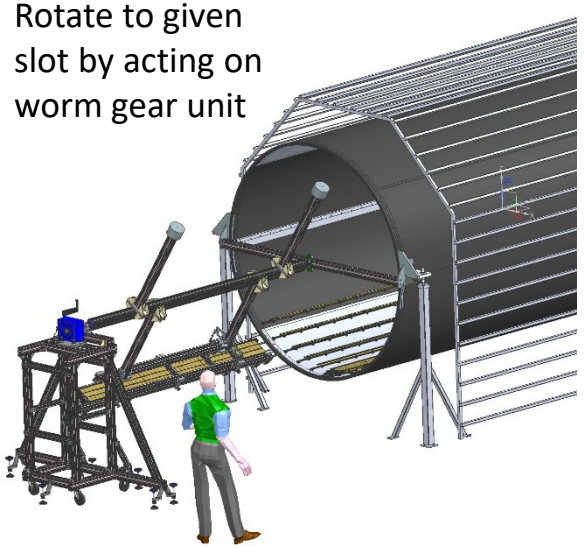


fix the tray cradle to the installation jig

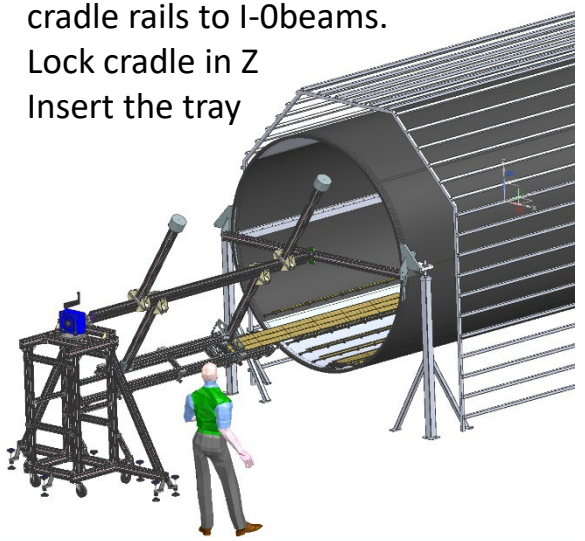
Remove trolley



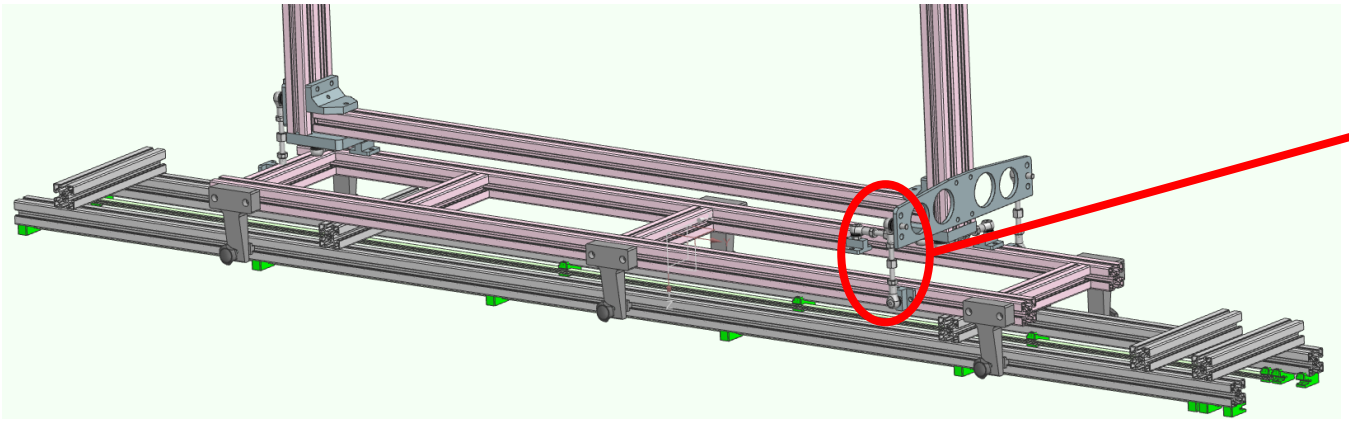
Rotate to given slot by acting on worm gear unit

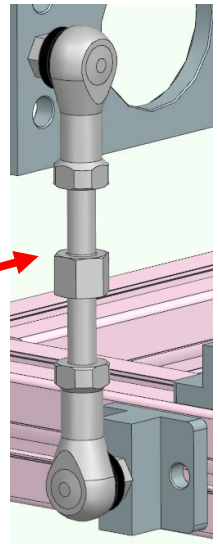


Fine tuning af rails alignment
Slide cradle in Z to couple the cradle rails to I-0beams.
Lock cradle in Z
Insert the tray

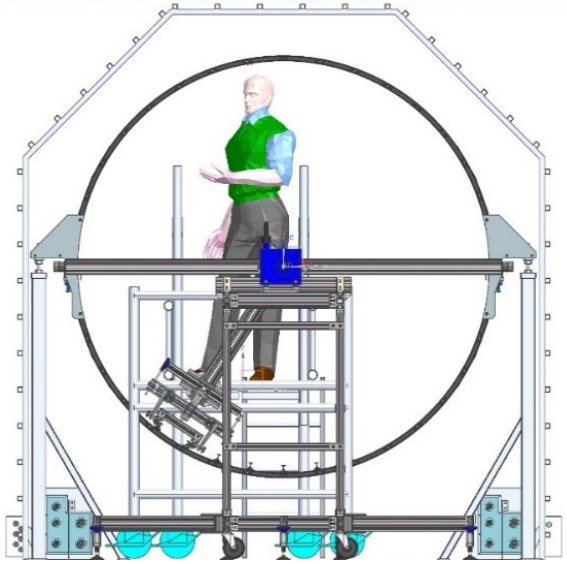


Tray Cradle fixed to kinetic mount, fully adjustable for fine alignment with the rails inside BTST (6 adjustable connections on ball hinges)





Jig and scaffolding inside BTST to be compatible each other… in progress



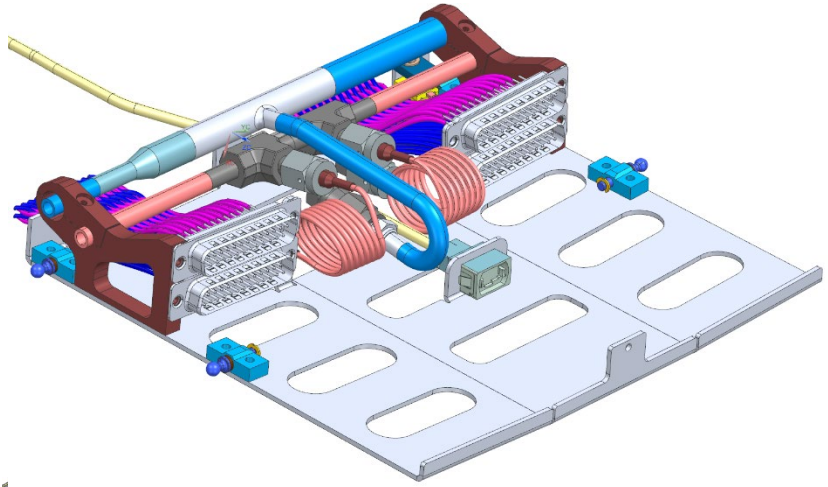
Tray installation jig assembly, functional test and 50% overload test

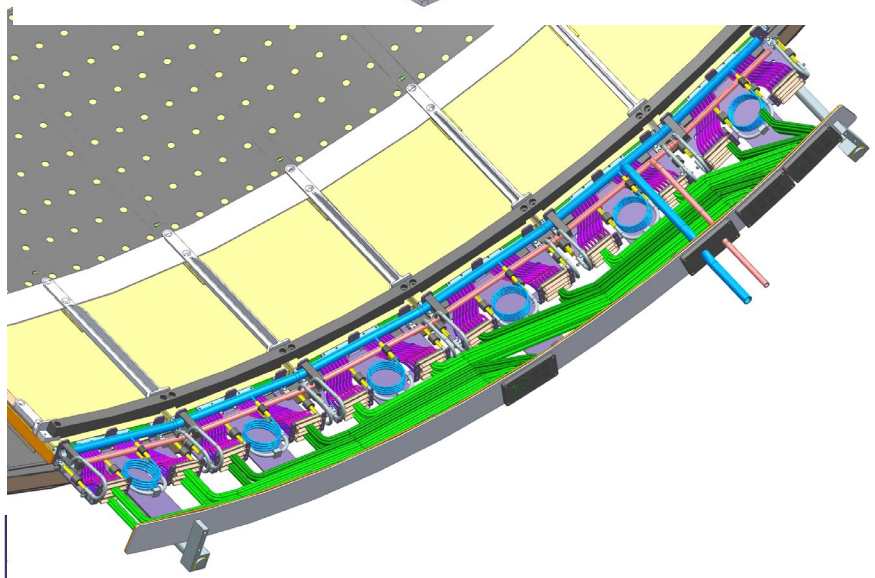
Ballast counterweights applied to reduce torque and stick slip effect on worm gear
Jig tested with up to 40 daN of dummy load (> 1.5 x nominal tray weight)
Will move asap to TIF for test and refinement

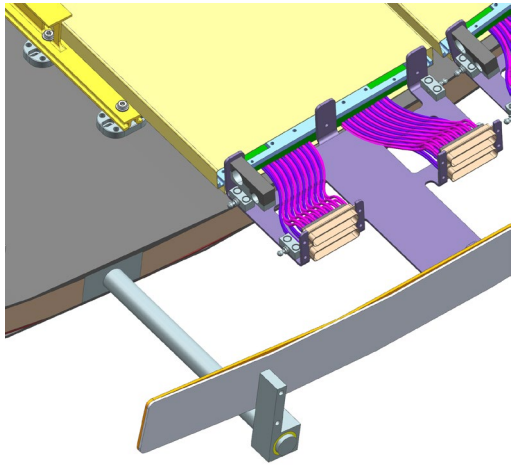
Service tray and connection procedure

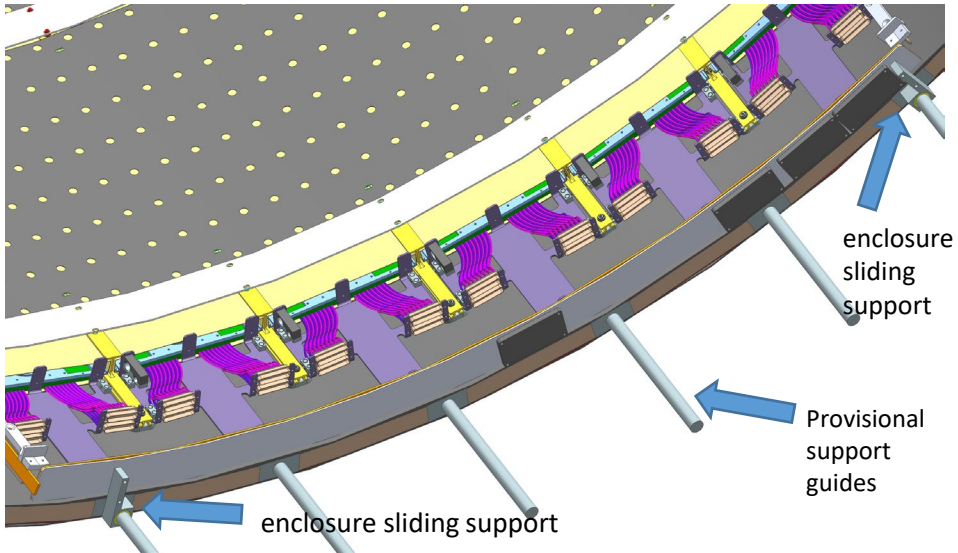
Supertray concept: tray services collected in group of 6 trays
Trays connected to common sector of BTST enclosure

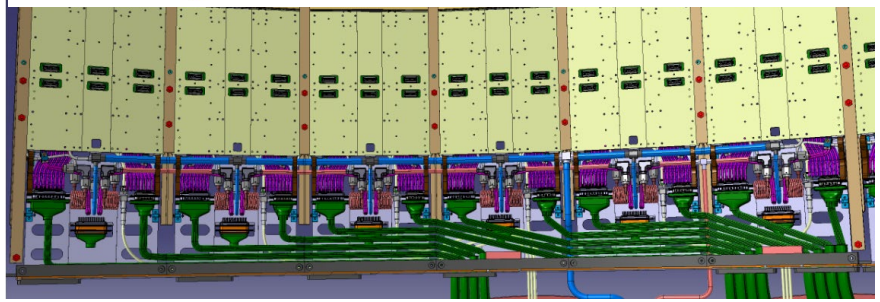
To gain access to service:e trays provisional support guides fixed to the BTST
Provisional support on sliding brackets mounted on the guides
Trays fixed to the enclosure or provisional blade, acting as Z tray constraint
Allows to extract the trays by ~ 20 cm to allow access to both sides











Thank you !

Backup

Status of the pre-orders and orders for mechanics,

CPs and laminas:

Prototypes from various supplier

Order procedure in progress to qualified supplier (officinacannarozzi.it)

Final CP design after EDR completion

Delivery schedule: pre-production (2 trays) end October, first batch (>20%) end December – mid January, delivered at CERN by end January . Latest batch delivery by end April 2024

Cooling loop:

prototypes (3 loops) produced

Baseline:

Order complete TIG welded circuits: pipes procurement, bending, welding, 10% sample basis X-ray

Delivery schedule: pre-production (2 loops) end December - January, first batch (>20%) end January-February, latest delivery April 2024

Backup: bending by supplier, EB brazing at Cern (as 1st prototype) more expensive

Status of the pre-orders and orders for mechanics

- Swagelok glands procurement: got offer, to order, 1st batch ~ November
- Swagelok glands machining: got offer, to order, 1st batch ~ December
- Tees production: got offer, to order, 1st batch ~ December

- roller-pins, roller block: got offer, to update for GF or CF peek
- I-beams: prototyped, qualified, to be machined

- thermal paste tbd
- Screws washers nuts … Ready for orders

Frames / boxes for loops to produce

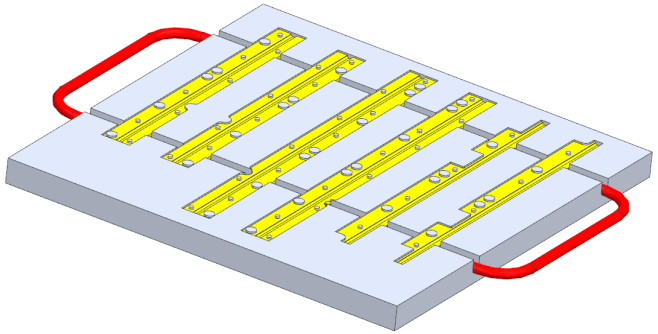
Cradle for trays BAC

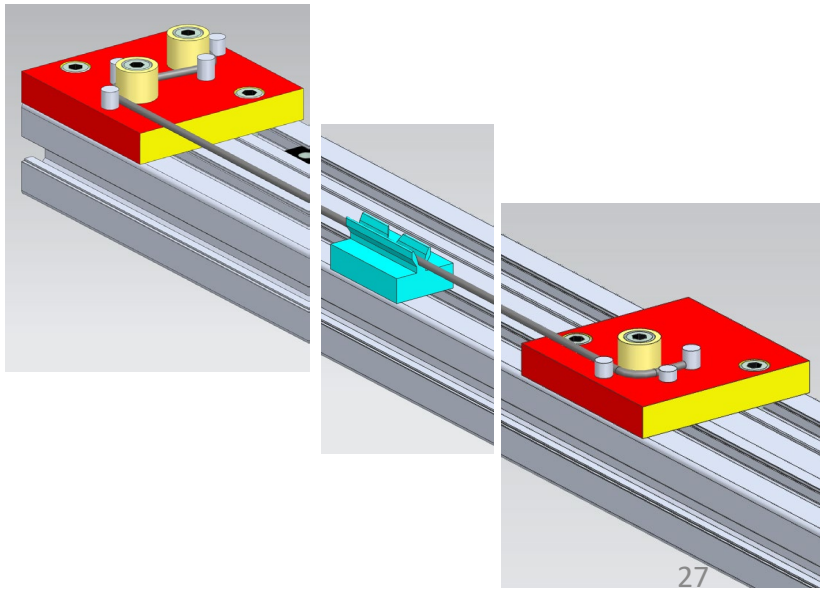
Tools - jigs for parts acceptance check

Design in progress of jigs/masks in order to check produced parts as qualification process :

CPs: overall dimensions, holes presence and position, grooves width and depth
Laminas: overall dimensions, holes presence and position

Bent pipes before welding





Checks and controls to be performed at suppliers, INFN Padova, CERN

Estimated cost Mechanics cost book, up to date as possible:

https://docs.google.com/spreadsheets/d/1r-tzdiBCrDjZQsFyFK1sXQLv7r0cD3JUW_pdU9ogSSU/edit?usp=sharing

Item	Item name	Nominal quantity	unit	Cost/unit, EUR	Overall cost KEUR	Comments
	OVERALL BTL TRAYs COST	**72**	**tray**		**261**	
	Cold plates including laminas	432	set		**130**	updated (prototypes supplier)
	Copper cases	5184	pc		**30**	updated 230207 Andrea B.
	OVERALL PIPING				**overall**	**58**
	bare pipes	720	m	32	**10**	updated 2209 from Resonetics
	Swagelok glands and nuts	216	set	20	**10**	3set/CP_loop, NOT including manifold, updated 2305
	tee, sleeve, connection elements	72	set		**4**	updated (external workshop)
	pipes cut and bending				**10**	updated (Adani/Andreoli esteem, including tool)
	loops welding including 10% X-ray test	72	set		**18**	updated 2307 Adani / Andreoli
	jigs for pipeworks handling and brazing	?			**6**	guess
	thermal paste	72	dose	50	**4**	guess
	thermal pads	72	set	50	**4**	guess
	Rollers and roller blocks	1872	set	12	**22**	updated (external workshop) excl material
	cables supports	432	pc	6	**3**	guess
	cables fastners				**1**	guess
	Tray Bottom insulation	72	set	50	**4**	guess
	Tray top cover	72	set	40	**3**	guess
	Tray bottom cover	72	set	40	**3**	guess
	Manifold	72	set		**???**	
	OVERALL BTST add-on and rails	74			**56**	
	rails	74	set		**30**	from Tommaso t.b.c.
	Ibeams fixing posts	666		24	**16**	updated (external workshop) excl material, or 5k by injection..
	BTST insulation + skin/cover	72	set		**10**	guess
	OVERALL TOOL and JIGS				**30**	
	insertion jig	1	tool		**15**	guess
	tray cradles	20		500	**10**	guess, cradles for tray handling/transport
	trolley	1			**2**	guess
	ancillaries ...				**3**	guess

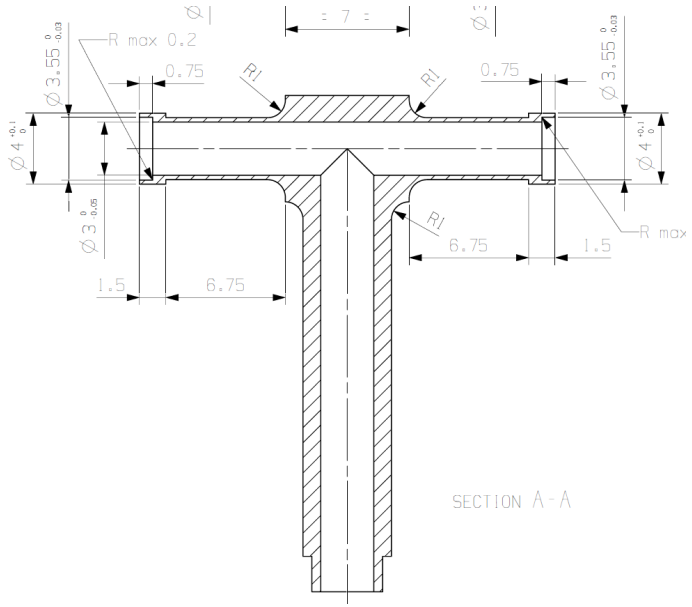
Cooling loop design for orbital welding

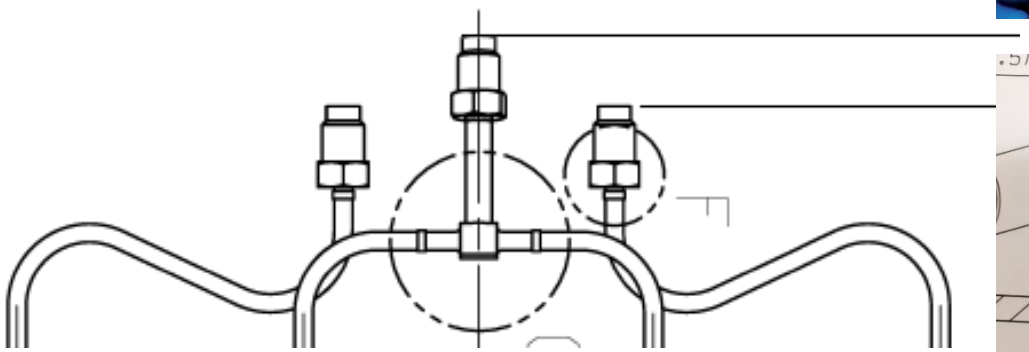
Adapting cooling loop «joints details design» for Orbital welding
Cheap, fast, repeatable industrial process

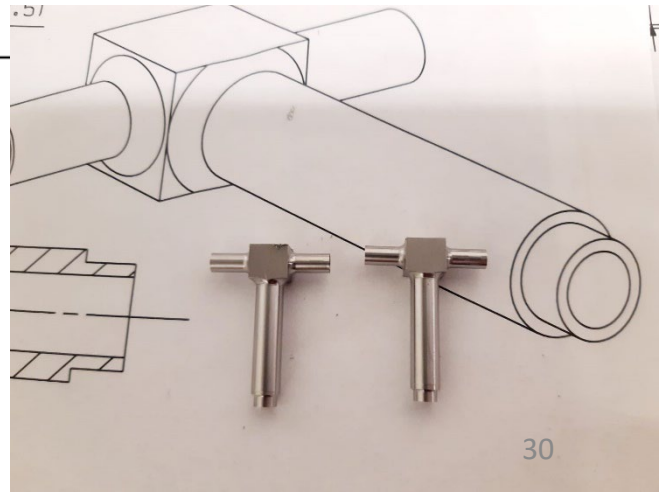
Requirements:
- Same diameter of the the two «items extremities» to weld
- Clear lenght (at constant and identical diameter) of > 6 mm on both sides

Company can perform X-ray in house, as needed for qualification and production
(10% sample basis of full production … t.b.c.)

Welding may require to reduce hole diameter inside Tee and gland to increase thickness to a «safe value» for machining: now ID 3mm, may be ID 2.5 mm … assuming acceptable ?







Tray in plane deformability

4 CPs put on granite interposing rollers to minimize friction
Sides clamped at ~ 1250 mm pitch,
Force up to 20N applied in the middle, displacement measured
Deformability depend on

- Number of clamping elements on pipes
- Which pipes are clamped/locked, which can slide freely
- Gap between CPs (0.2 and 0.4 mm considered)

Plastic behavior, likely pipes slides above certain force

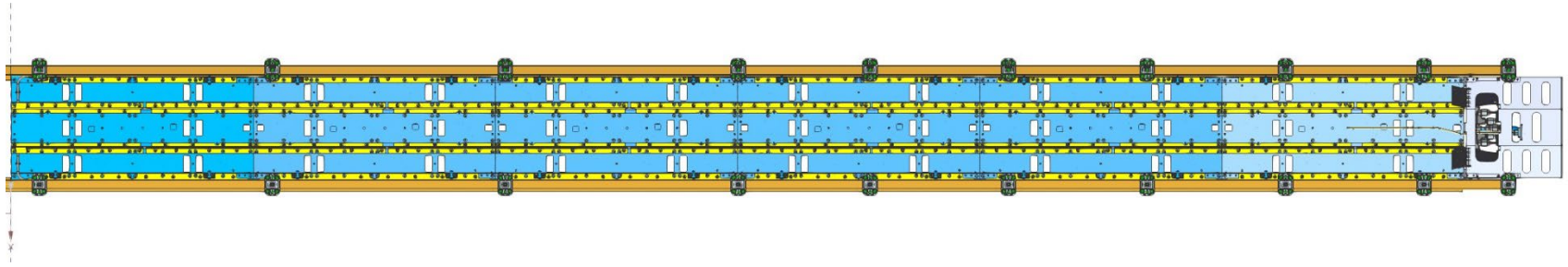
- Stiffer results ~ 0.25 mm/daN, more deformable ones ~ 0.8mm / daN
- To be compared to expected rails deviation, but compliance to reasonable rail shape shall be ok

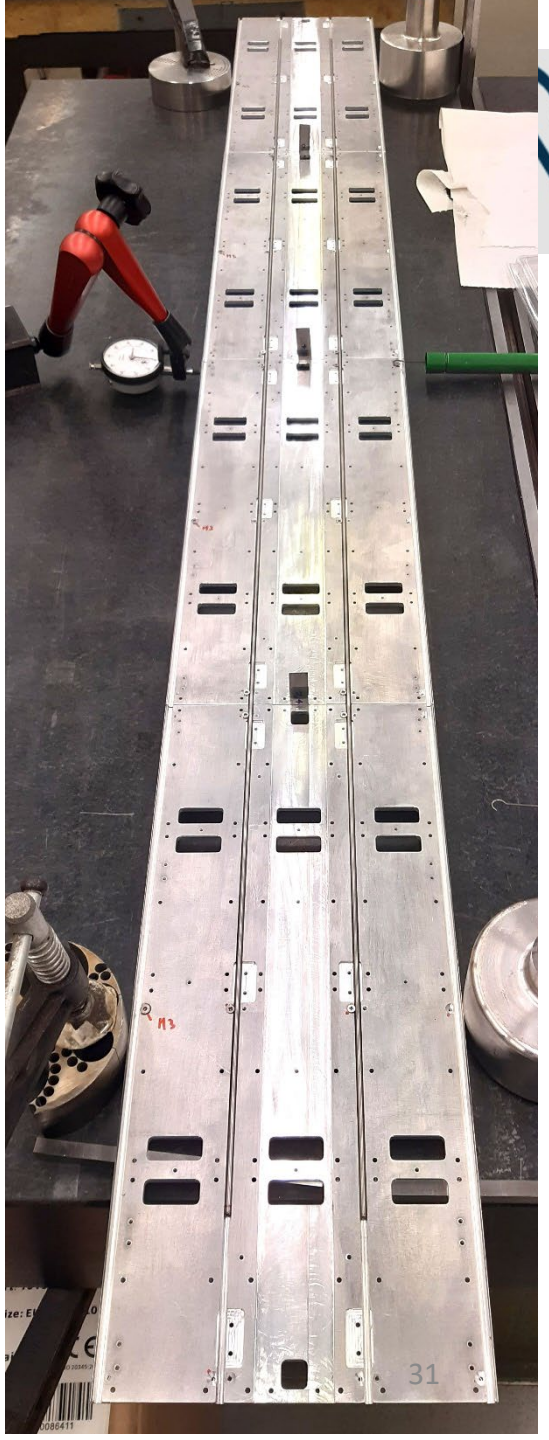
Gap between aluminium plates: 0,2 mm			
All the screws of the plate tightened, both in central and end positions			
	DISPLACEMENT [mm]		
FORCE [N]	1 st test	2 nd test	3 rd test
10 N	0,26	0,24	0,28
20 N	0,81	0,80	0,78

Gap between aluminium plates: 0,4 mm			
All the screws of the plate tightened, both in central and end positions			
	DISPLACEMENT [mm]		
FORCE [N]	1 st test	2 nd test	3 rd test
10 N	0,36	0,38	0,38
20 N	0,88	0,86	0,90

Gap between aluminium plates: 0,2 mm			
Only central screws tightened			
	DISPLACEMENT [mm]		
FORCE [N]	1 st test	2 nd test	3 rd test
10 N	0,48	0,55	0,48
20 N	0,90	0,89	0,87

Gap between aluminium plates: 0,4 mm			
Only central screws tightened			
	DISPLACEMENT [mm]		
FORCE [N]	1 st test	2 nd test	3 rd test
10 N	0,80	0,60	0,78
20 N	1,40	1,42	1,47





Tray production procedure (mechanics only): parts delivery and acceptance

- Copper housing (6k pcs)
  - E.g. masks to check housing main dimensions, holes position

- Cold plates and laminas (450 + 3.6k pcs)
  - E.g. masks to check CP dimensions and holes position
- Pipe sectors/bars … any check? (300 pcs)
- Bent pipes (300 pcs)
  - E.g. masks to check pipes overall shape and compliance to CPs grooves
  - Cleanliness?
- Small parts for cooling ciruits: Tees, machined fittings (~ 450 pcs)
  - E.g. go-no-go «gauges» to check relevant dimensions e.g. holes diameter and depth

2° priority ?
- Thermal pads interfaces
- Roller pins and roller blocks (2k + 2k)
- Cooling manifold capillaries (150)
- Manifold support trolley, manifold other mechanics, rollers, preheaters ..
- Tray covers

To be defined the acceptance procedures, what to check, if on sample basis or full production …

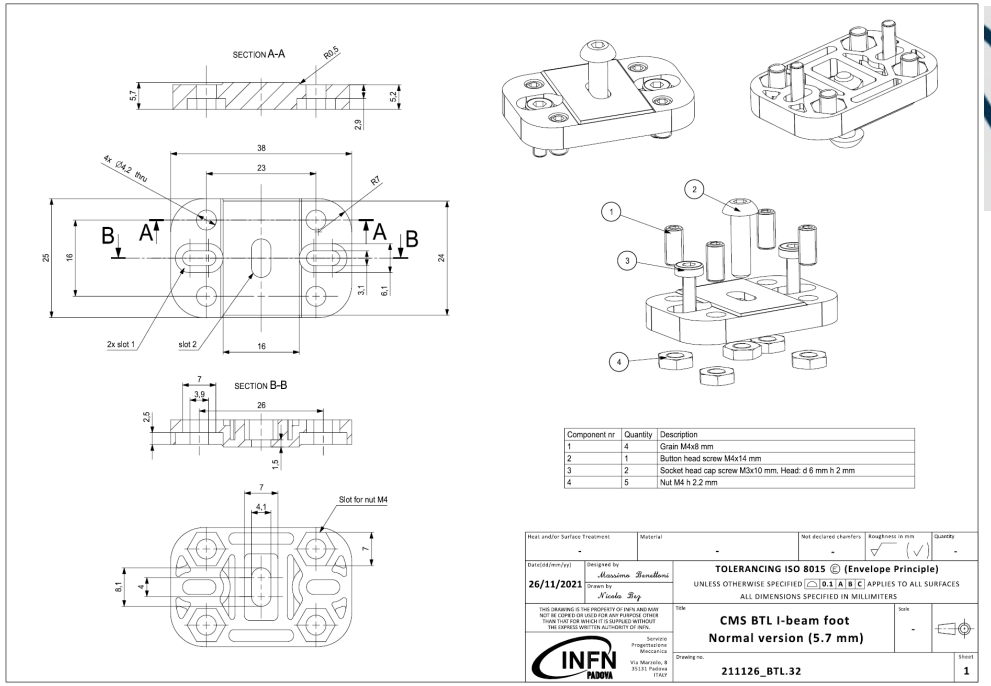
I-beams feet / fixing posts

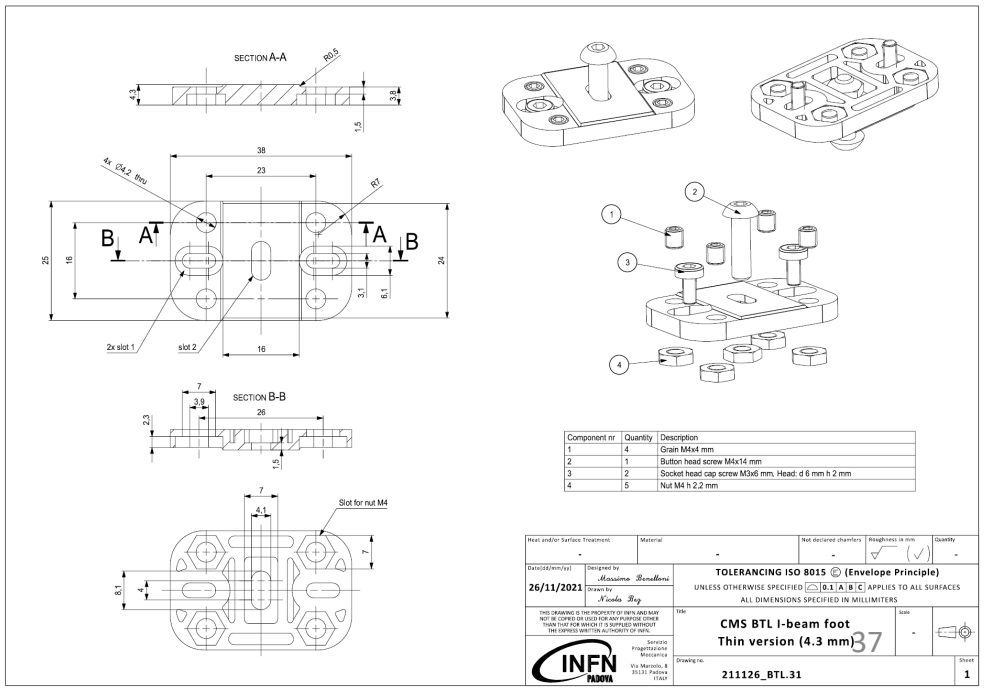
Two version foreseen:

- standard one 5.7mm thick
- thin one to compensate BTST deviation 4.3 mm thick

Prototypes can be made by 3D printing or machining
Full production: GF reinforced polymer (Peek or others)

To check production cost in case of machining, molding, 3D printing, quantity 1.4k not easy to “match”





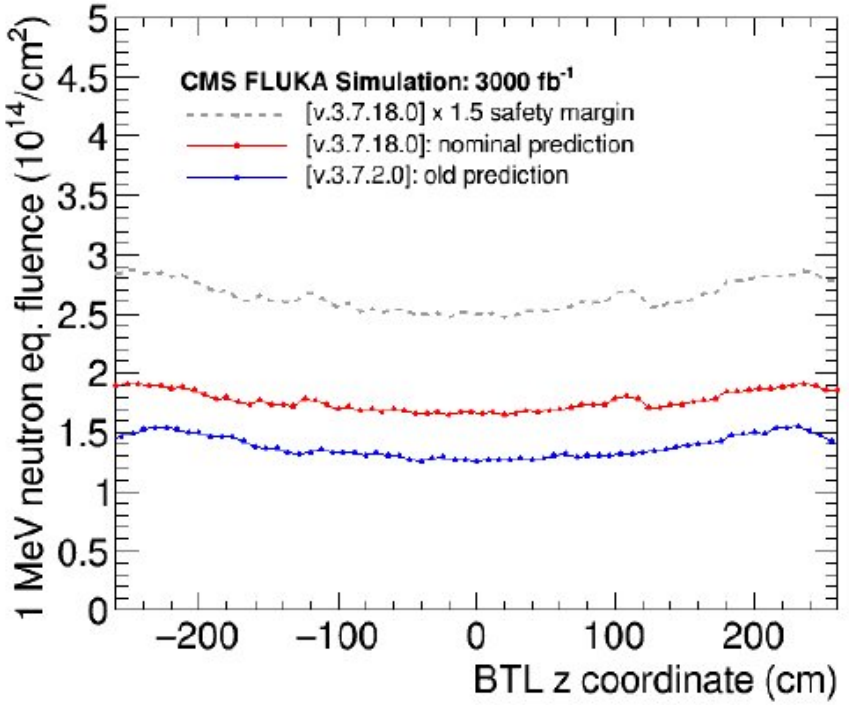
About thermal compound radiation resistance

- Alice SPD detector: AOS 52029 (discontinued)
- https://iopscience.iop.org/article/10.1088/1742-6596/41/1/039
- tested up to 27MeV protons up to a fluence of 5 x 10^{12} proton/cm2. This irradiation is equivalent to the dose of about 500 kRad

- Atlas Micro-strip detector: Dow Corning 340, Fischer Elektronik WLPG
- http://cdsweb.cern.ch/record/1238166/files/ATL-UPGRADE-PUB-2010
- equivalent fluence of 1.10^{14} 1Mev neq/cm2

- http://cds.cern.ch/record/686031
- ATL-INDET-97-177 ; ATL-I-PN-177: Radiation Hardness of thermal compound

No significant difference was observed after the irradiation of the thermal compound DC340 at a fluence between 2.3·10^{14} and 3.0·10^{14}, p/cm^2 . This measure confirms earlier results(PPE94).



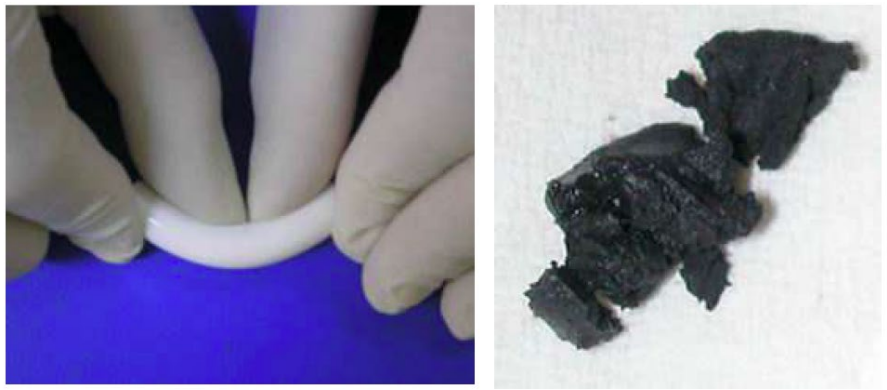


Figure 13: Samples out of the Plexiglas container after irradiation at a fluence of 1.5x10^{15} 24 GeV protons. Left: DC340. Right: WLPG.

Concerning the first observation, the DC340 which was originally pasty polymerized into a single and elastic block similar to a silicon rubber (see Figure 13). A change of the consistency had also been reported earlier[11] after an exposure to 1x10^{15} p/cm^2. The Fischer WLPG carbon loaded grease could be partly extracted and its consistency was dry and pasty as part of the oil was lost during the irradiation and storage time (see Figure 6). Depending of its use, the mechanical properties of the DC340 may be unsatisfactory. The mechanical characteristics of

The thermal grease study dedicated for the upgrade module program is essential for the selection of a thermal compound that will provide a satisfactory sliding join before and after irradiations of an equivalent fluence of 1.10^{14} 1Mev n_{eq}/cm^2. So far the silicon based gel and the organic oil based compounds are not satisfactory. Several other non-silicon based compounds are being considered. The mechanical and thermal ageing properties as well as the radiation hardness will have to be proven satisfactory for the ATLAS strip tracker upgrade operation.

Tray assembly tools and sequence