Mechanic developments for the ECAL-P of LUXE
(an update)

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Outline

Update since WIS meeting in September 2023

- new dX length of tungsten plates: 550mm $\rightarrow$ 555mm
- proposal to update/modify the T-frame geometry
- new mounting of CF and kaptons on T-Frames
- mounting of PCBs to the T-frames (in progress...)
- Faraday cage
- patch panel
- beam window
- light (in)transparency
- electrical grounding
- new position for geodesy pillars

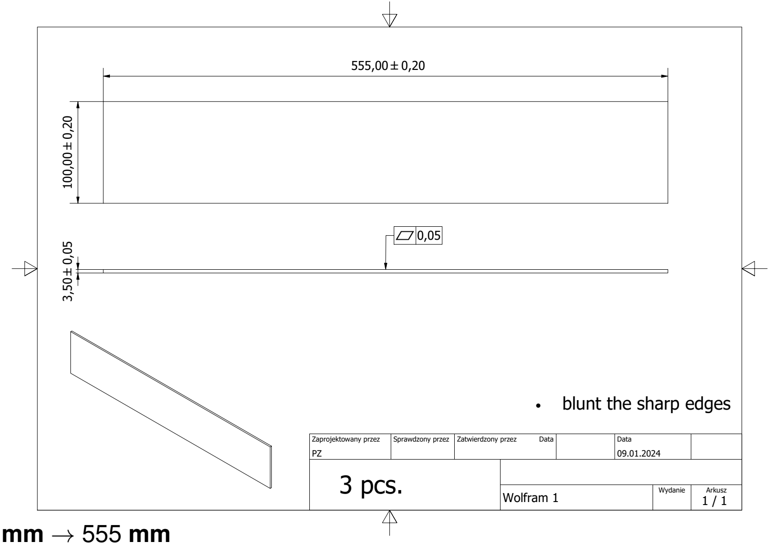
Design Assumptions

Baseline specification:

- ECAL-P is sampling calorimeter
- 21 $1X_0$ (3.5 mm thick) tungsten plates as absorber
- 1 mm gaps between tungsten plates
- 20 layers of CALICE silicon sensors (0.32 mm thick) as active medium
- open architecture (flexible choice of the number and thickness of the absorber plates)
- possible removal/insertion of single detector plane in case of repair/service
- fixture to facilitate gentle insertion/removal of detector planes
- mounting points (nests) of markers for geodesy laser tracker survey
- patch panel for readout cables
- auxiliary equipment for shielding, transportation and positioning “on beam”

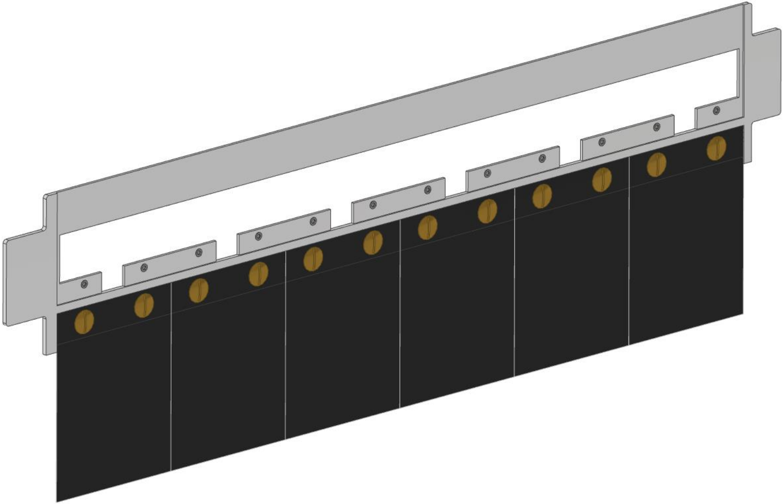
ECAL-P: New tungsten plates dX dimension

New tungsten plates dimensions (as for “pilot order”)



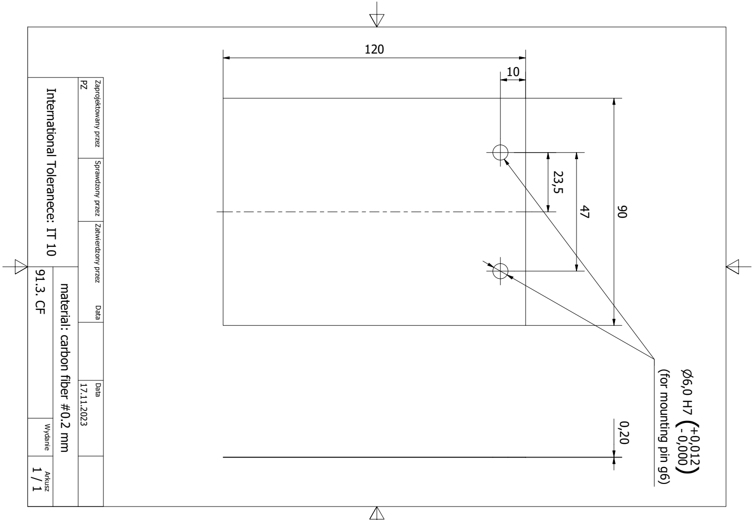
- **dX:** 550 **mm** → 555 **mm**
- to allow for sensor-sensor (flexible, tbd later) dX-gaps (6 CALICE sensors, max. 5 × 1 mm gaps)

OLD: T-frame with Carbon Fiber: support for Si sensors and kapton



- 0.2 mm thick Carbon Fiber (CF) structure to support the Si sensors
- modular structure: 6 CF pieces for each CALICE Si sensor, **no gaps between CF → non realistic !!**

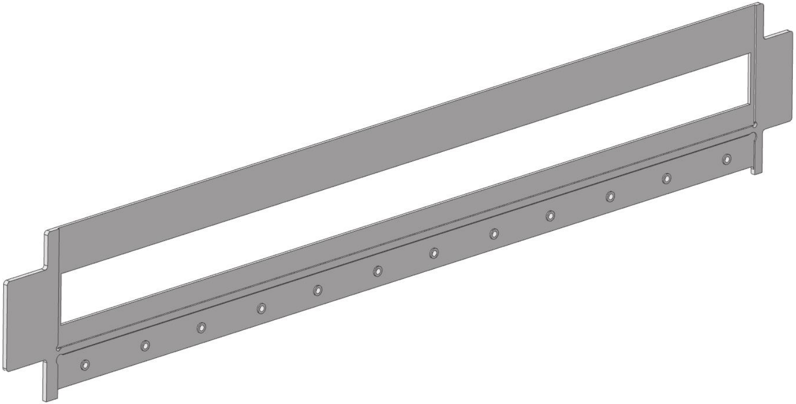
CF dimensions for pilot order: $90 \times 120\ \mathrm{mm}^2$



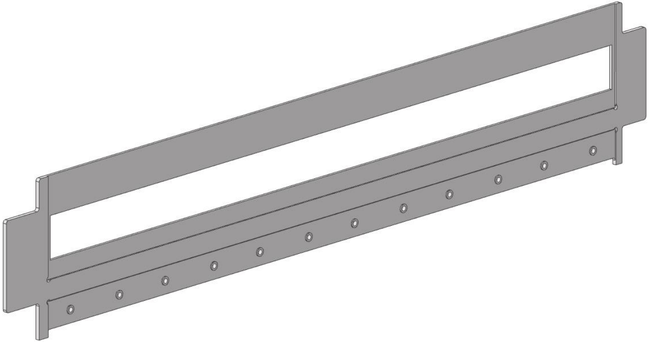
- **holes: positioning/alignment on T-frames and jigs during sensor gluing to kaptons**
- sensor-sensor gaps will depend on the CF and T-frame precision

ECAL-P: modified geometry of T-frame

OLD: T-frame: the dY width of the “back-bone” : 5 mm

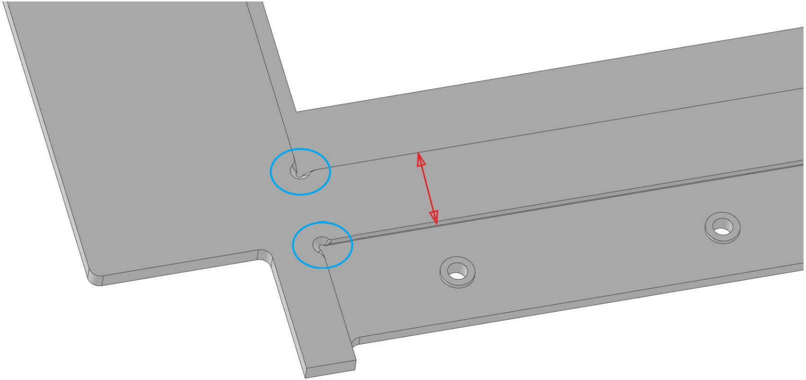


- OLD: T-frame: the dY width of the “back-bone” : 5 mm



- NEW: T-frame: the dY width of the “back-bone” : 15 mm
- to add more stiffness/rigidity along the T-Frame
- this requires 10 mm longer kaptons/tracers from Si sensor to the PCB connectors (38 mm $\rightarrow$ 48 mm)
- **Question: is it acceptable form the electrical point of view ?**
  What is this length (and experience) from the TB setup ?

NEW: T-frame: the dY width of the “back-bone” : 15 mm (zoom)

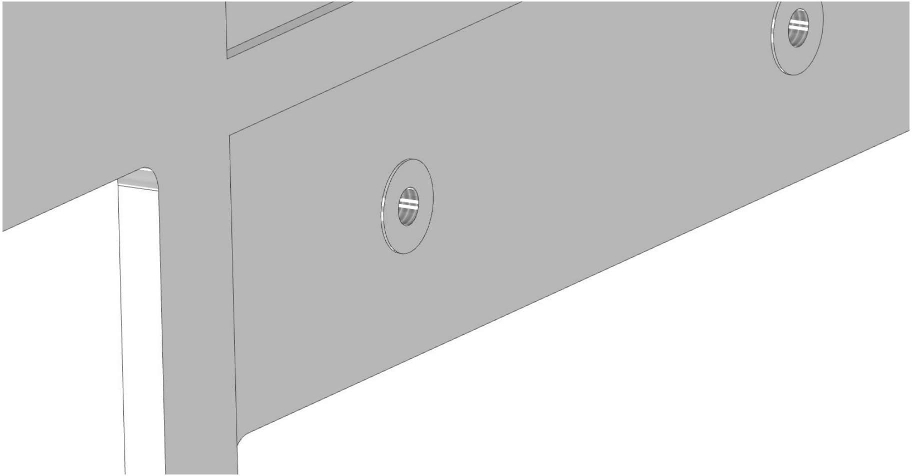


- NEW: T-frame: the dY width of the “back-bone” : 15 mm
- **T-frame prototyping: two approaches:**
- 1) directly from the 3 mm thick Al substrate plate
- 2) by (double sided) machining of 6 mm thick Al substrate plate (better flatness ?)

ECAL-P: New mounting of CF support and kaptons on the T-Frames

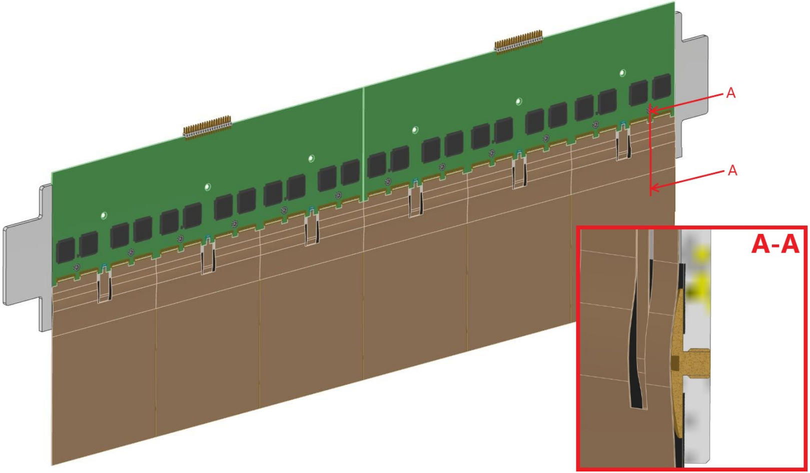
using pins and holes for positioning/alignment on T-frames and jigs during sensor gluing to kaptons

T-frame: Support for PCB and Carbon Fiber (zoom)



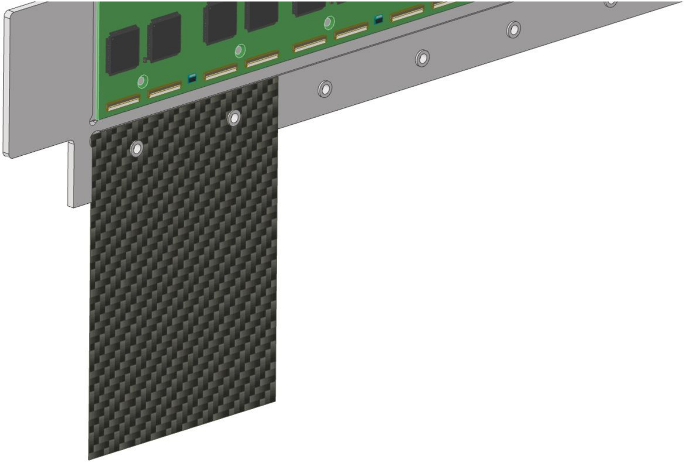
- zoom on the pin (positioning) with the hole (pin mounting ($\varnothing$ 6 mm), hole $\varnothing$ 3.5 mm, no screws)

OLD: T-frame with Carbon Fiber and PCB + kapton



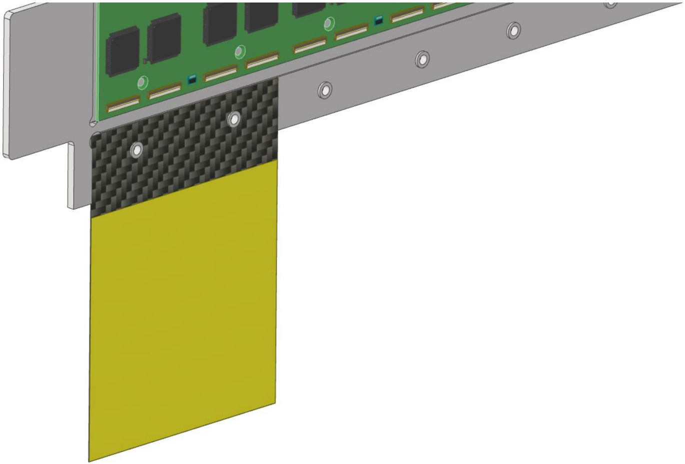
- some “wrinkles” on the signal kapton (ugly solution... → now redesigned !)
- Si sensors are wrapped between two kapton layers (HV and charge readout)
- screws extend 0.6 mm above the surface: not in collision, kapton flexible enough (?)

NEW: T-frame: CF + sensors instrumentation: step 1



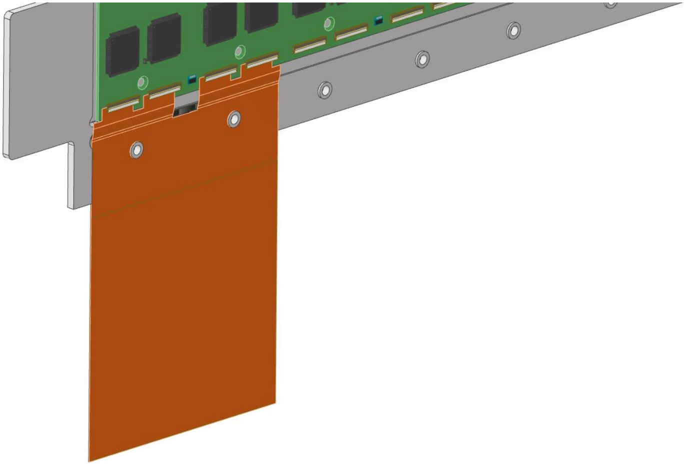
- T-frame with CF support (200 um) (120×90 mm^2)
- **NOTE: CF + Si sensors + kaptons will be mounted as one unit after gluing**
- here are presented “layer by layer” only for better visualization

NEW: T-frame: CF + sensors instrumentation: step 2

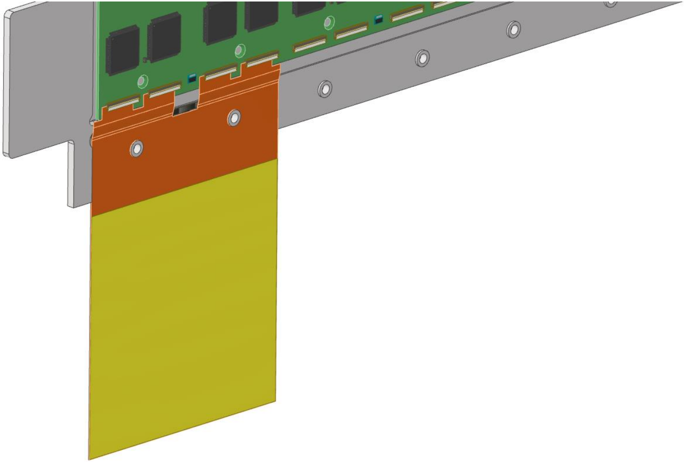


- T-frame with CF support (200 um) and gluing double-sided tape (50 um ?)
- **NOTE: CF + Si sensors + kaptons will be mounted as one unit after gluing**
- here are presented "layer by layer" only for better visualization

NEW: T-frame: CF + sensors instrumentation: step 3

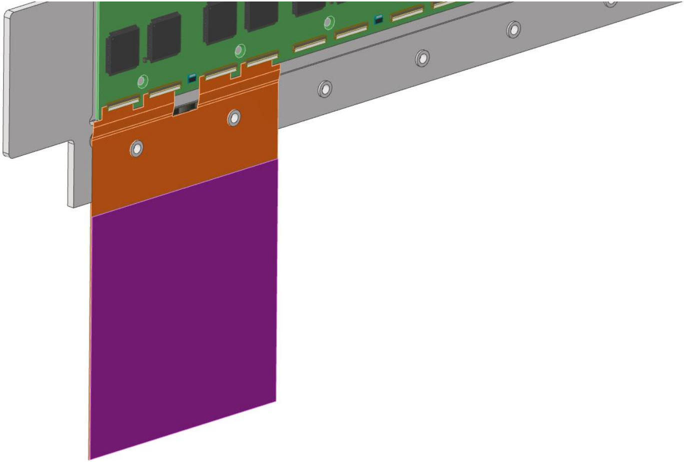


- T-frame with CF support (200 um) and ... readout kapton (120 um ?)
- **Question: are the holes OK for kapton tracers distribution ?**



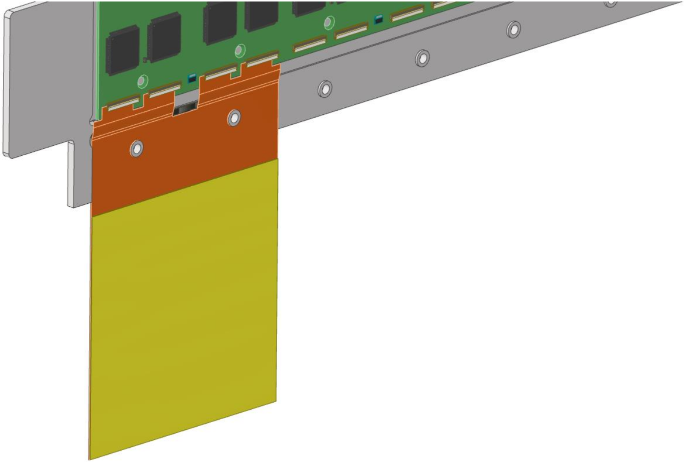
- T-frame with CF support (200 um) and ... readout kapton (120 um) and glue (50 um ?)
- **NOTE: CF + Si sensors + kaptons will be mounted as one unit after gluing**
- here are presented “layer by layer” only for better visualization

NEW: T-frame: CF + sensors instrumentation: step 5



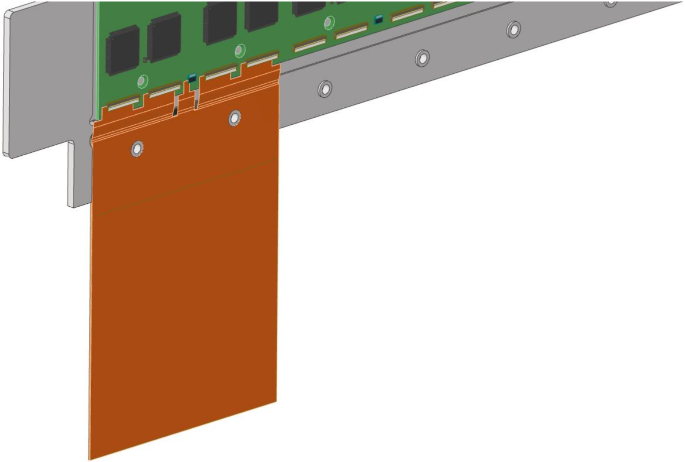
- T-frame with CF support (200 um) and ... Si sensor (320 um)
- **NOTE: CF + Si sensors + kaptons will be mounted as one unit after gluing**
- here are presented “layer by layer” only for better visualization

NEW: T-frame: CF + sensors instrumentation: step 6



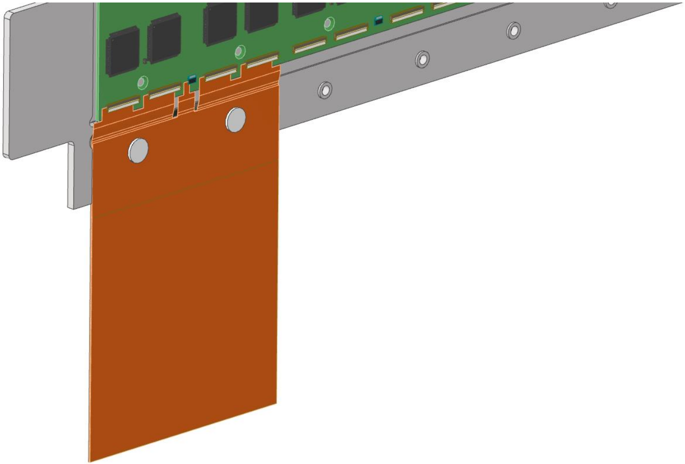
- T-frame with CF support (200 um) and ... Si sensor (320 um) + glue (50 um ?)
- **NOTE: CF + Si sensors + kaptons will be mounted as one unit after gluing**
- here are presented “layer by layer” only for better visualization

NEW: T-frame: CF + sensors instrumentation: step 7



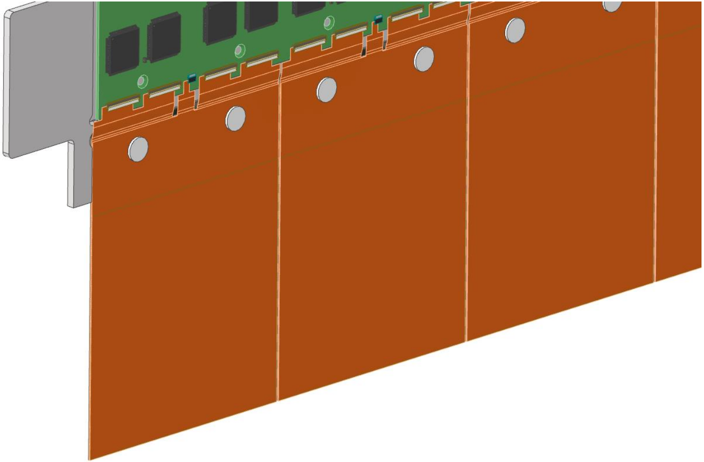
- T-frame with CF support (200 um) and ... HV kapton (70 um ?), as the last layer (mechanical shielding !)
- **Question: are the holes OK for kapton tracers distribution ?**

NEW: T-frame: CF + sensors instrumentation: step 8



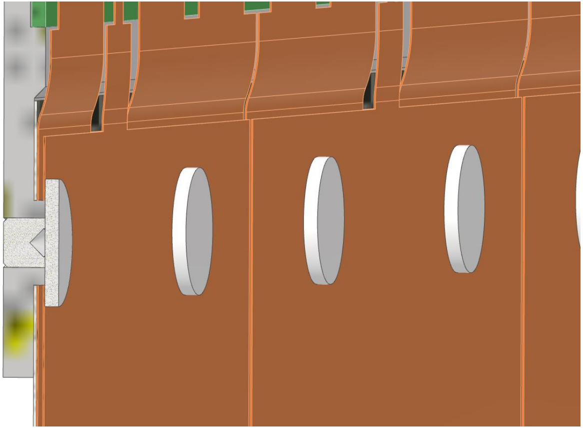
- T-frame with CF/sensor/kaptons fixed by plastic pin ⌀ 3.5 mm (head ⌀ 9 mm, 1 mm thick)
- **NOTE: CF + Si sensors + kaptons will be mounted as one unit after gluing**
- here are presented “layer by layer” only for better visualization

NEW: T-frame: CF + sensors instrumentation: step 9



- T-frame with CF support/sensor/kaptons more modules, current CF-CF gap: 1 mm
- **NOTE: CF + Si sensors + kaptons will be mounted as one unit after gluing**
- here are presented “layer by layer” only for better visualization

NEW: T-frame: CF + sensors instrumentation: step 10

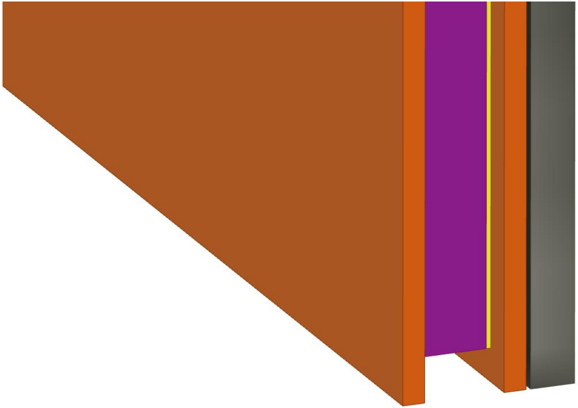


- details of the pin mounting (easy to dismantle !)
- T-frame with CF/sensor/kaptons fixed by plastic pin ⌀ 3.5 mm (head ⌀ 9 mm, 1 mm thick)
- plastic pins will be manufactured by gluing the two parts (cone-like space for glue)
- or by 3D printing (some R&D needed what will be the best plastic)

NEW: T-frame: CF + sensors instrumentation

- T-frame with CF/sensor/kaptons fixed by plastic pin ⌀ 3.5 mm (head ⌀ 9 mm, 1 mm thick)
- **Question: is the pin-to-PCB distance (**$\sim 2-3$ **cm) sufficient to handle the connectors ?**

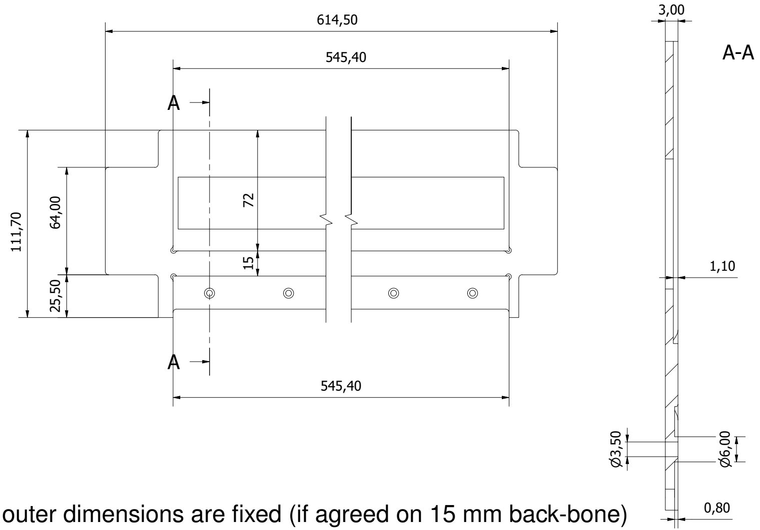
NEW: T-frame: CF + sensors + kaptons: dZ clearance



- Dimensions: CF: 200um, Si: 320um, kaptons: 190um (120+70um), 3$\times$glue: 150um ? (spare 140um)
- CF margin to physical edge of Si sensors: 150um $\rightarrow$ **Question: is it enough ? too much ?**
- **Question: should the kaptons shape match the CF shape ? Should be a bit smaller ?**

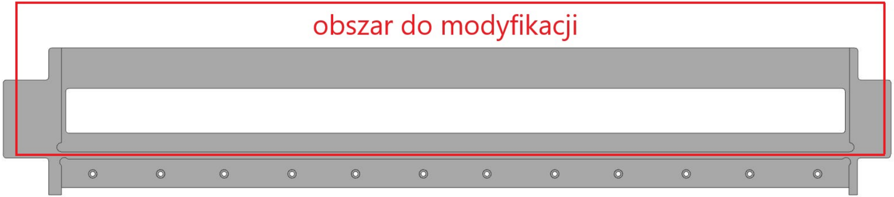
T-frame: mounting of PCB

NEW: T-frame: outer dimensions (for 555 mm tungsten, 15 mm back-bone)



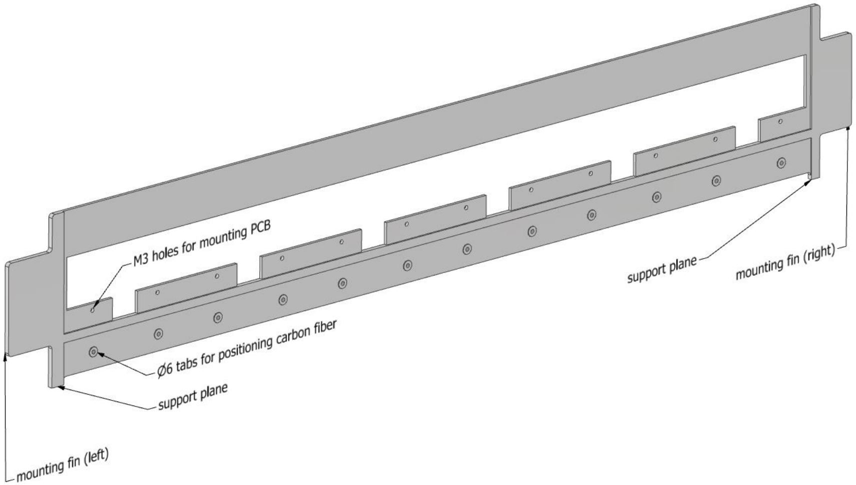
- The outer dimensions are fixed (if agreed on 15 mm back-bone)
- thickness of PCBs (1 mm + 0.1mm insulating kapton) ? width of the upper crossbar ?

T-frame: details still to be defined



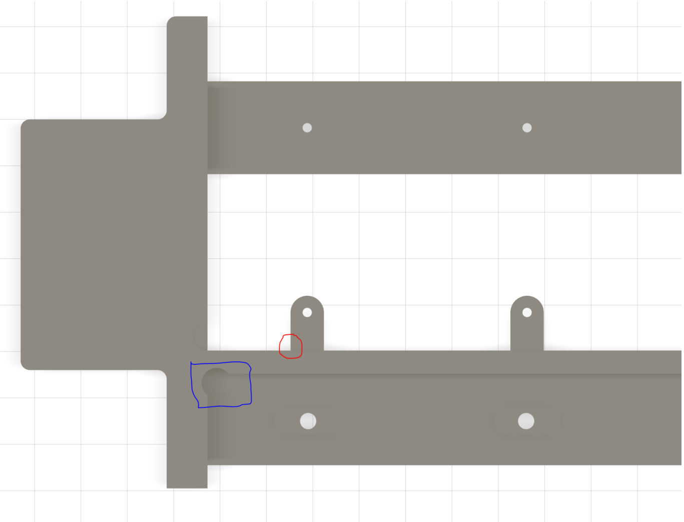
- The outer dimensions and shape if fixed
- details of PCBs mounting (easy to dismantle !) still TBD (red rectangle area)

OLD: T-frame: Support for PCB and Carbon Fiber (old proposal, tbd.)



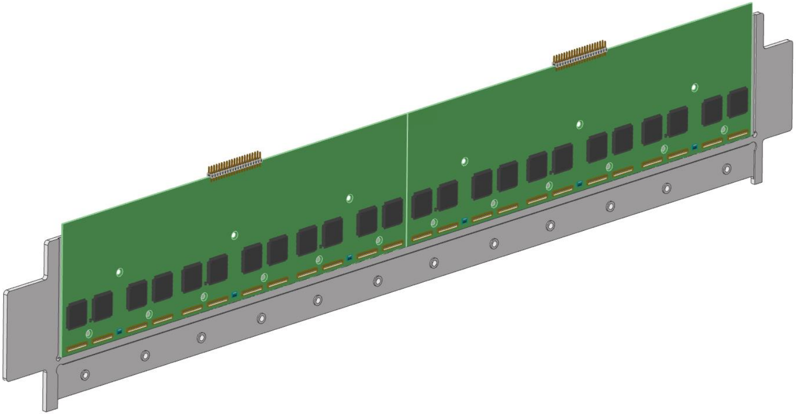
- pins for mounting the carbon fiber
- **Question: holes/screws for PCBs (is it optimal solution ?)**

NEW: T-frame: Support for PCB, proposal from Kuba



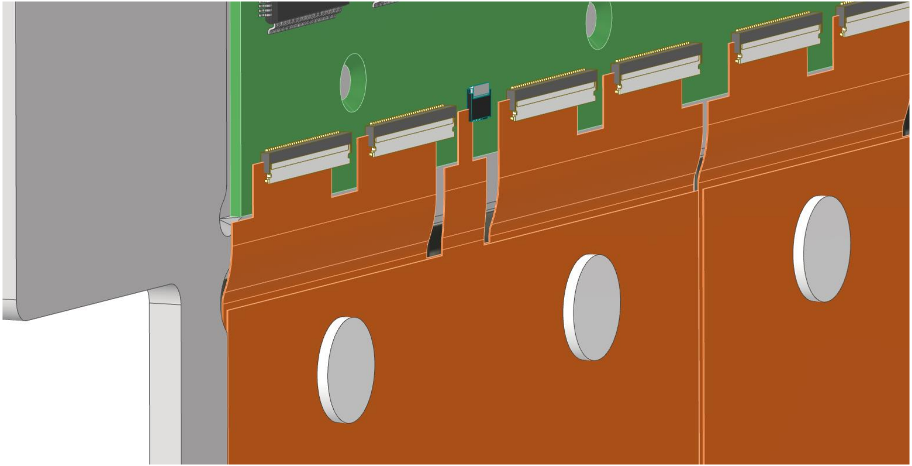
- new proposal for discussion (Kuba), “tabs” and thiner upper cross-bar (1.9 mm $\rightarrow$ 1.7 mm ?)
- more space for ASIC chipsset

T-frame: OLD PCB on T-frame (assuming 555mm tungsten)



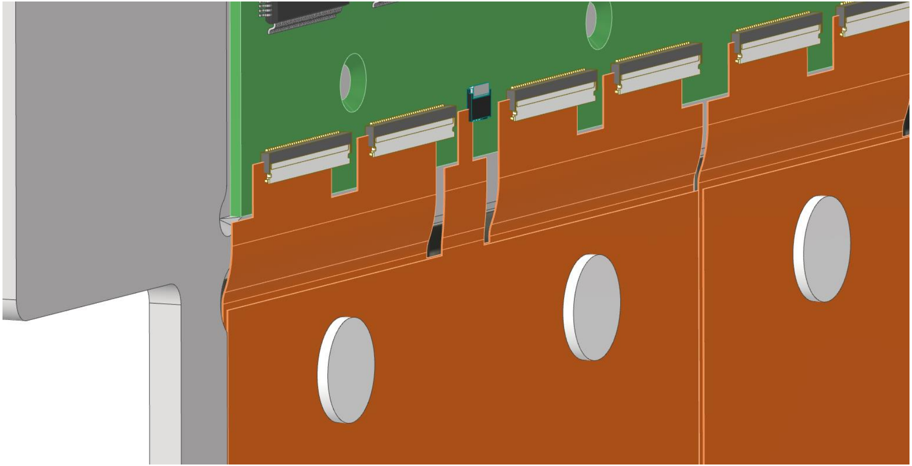
- The outer dimensions and shape if fixed
- details of PCBs mounting (easy to dismantle !) still TBD

T-frame: OLD PCB on T-frame (assuming 555mm tungsten and 1 mm CF-CF gap)



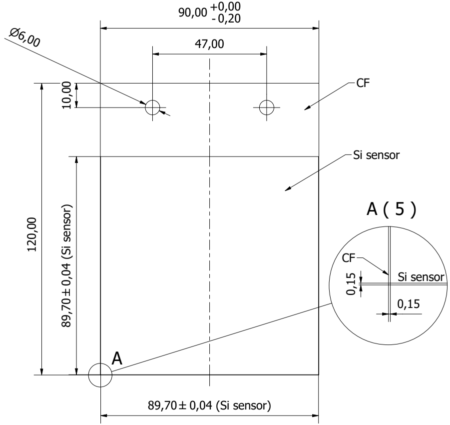
- visible kaptons-PCB-connectors mismatch
- **Problem: this depends on the CF-CF gap and has too be specified sooner then originally assumed...**
- **What about the PCB-PCB gap ?** Can we keep equidistant kapton connectors over whole T-frame ?

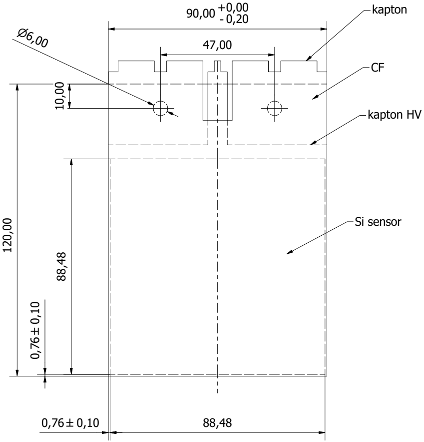
T-frame: OLD PCB on T-frame (assuming 555mm tungsten and 1 mm CF-CF gap)



- high precision is required (gluing, T-frame machining, PCB connectors mounting, kapton connectors, ...)
- **Question: what are the (transverse pitch) tolerances on PCB-kapton connectors (and tracers) ?**
- PCB connectors defines the routing of kapton tracers or vice-versa ? (who comes first ?)

Carbon Fiber + Si sensor + kaptons : dimensions (dead space between sensors)

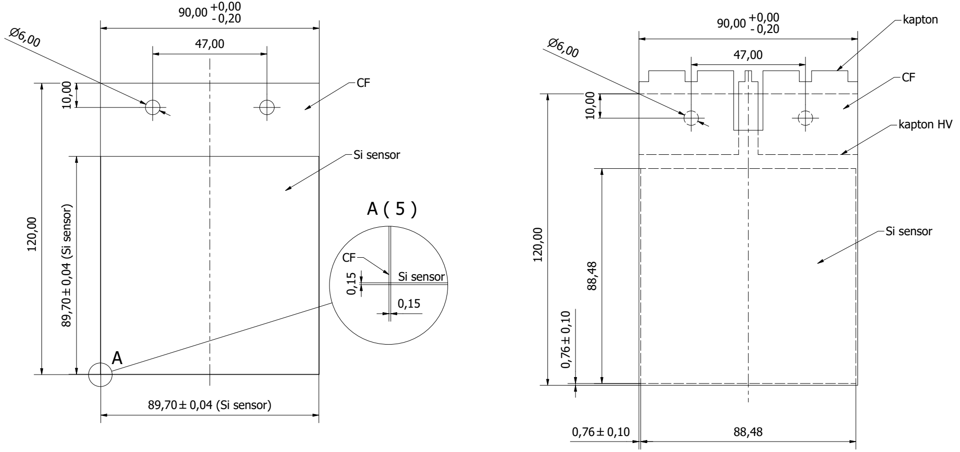




- physical Si sensor size
- CF + Si

- active Si sensor area
- CF + Si + 2 kaptons

Carbon Fiber + Si sensor + kaptons : dimensions : dX clearance



- assuming dX = 90 mm CF width (0.15 mm margin to physical Si edge) and no gaps between the CF:
- the distance between Si active area is already (if no CF-CF gap): $1.22 + 0.3 = 1.52$ mm
- **Question: is** 2.02 **mm still acceptable ?** (i.e.: 0.5 mm CF-CF gap → fixing the PCB kapton connectors)

ECAL-P: electrical grounding

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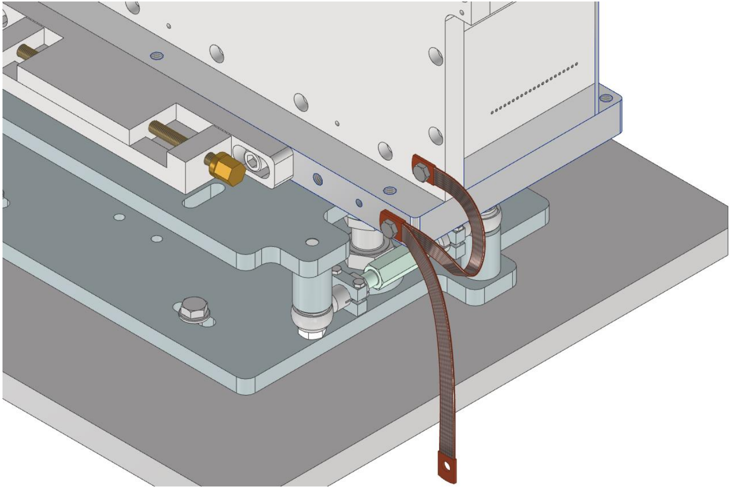


- one point at the outer rear corner to avoid current loops
- attached to the ECAL-P main body and to the transportation plate

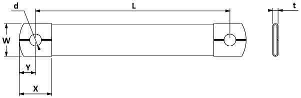
Earthing braids: bare or tinned copper

EARTHING BRAIDS

ERR	ERT	ETT

Single wire Cu-ETP UNI EN 13602 - Ø 0,20 mm (special wire on demand)
Bare or Tinned copper braid
Terminals in bare or tinned copper
Standard cross section from 6 mm² up to 75 mm²
Customized solutions on demand
Current loads following IEC 439

Build your own earthing braid following the drawing here below and the examples in the table



Type	Cross-Sect.	Wire	L	W	X	Y	d Ø	t	Ordering Code
	mm²	Ø mm	dimensions in mm						
ERR	16	0,20	150	17	23	13	9	2,5	ERR 16-17/150-9
ERT	25	0,20	300	23	23	13,5	9	3,2	ERT 25-23/300-9
ETT	50	0,20	550	30	30	15	11	4,5	ETT 50-30/550-11
BUILD YOUR EARTHING BRAID									

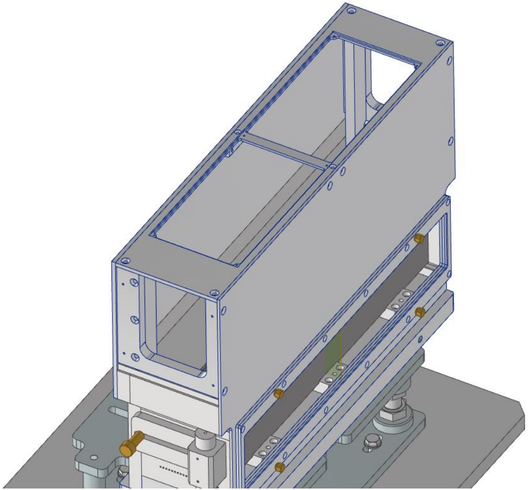
EARTHING BRAIDS - standard

Code	Cross-Sect.	Single wire	L	W	X	Y	d Ø	t	Current load
	mm²	Ø mm	dimension in mm						ΔT 50°C
ERR									
ERR 6-11/ L- 7	6	0,2	75-100-150	11	13	7	7	2	90 A
ERR 10-17/ L- 9	10	0,2	100-150-200-250-300	17	23	13	9	2	130 A
ERR 16-17/ L - 9	16	0,2	100-150-200-250-300	17	23	13	9	2,5	160 A
ERR 25-23/ L - 9	25	0,2	100-150-200-250-300	23	23	13,5	9	3,2	220 A
ERR 35-23/ L - 9	35	0,2	100-150-200-250-300	23	23	13,5	9	3,4	260 A
ERR 50-30/ L - 11	50	0,2	100-150-200-250-300	30	30	15	11	4,5	340 A
ERR 75-30/ L - 11	75	0,2	100-150-200-250-300	30	30	15	11	5	420 A
ERT									
ERT 6-11/ L- 7	6	0,2	75-100-150	11	13	7	7	2	90 A
ERT 10-17/ L- 9	10	0,2	100-150-200-250-300	17	23	13	9	2	130 A
ERT 16-17/ L – 9	16	0,2	100-150-200-250-300	17	23	13	9	2,5	160 A
ERT 25-23/ L – 9	25	0,2	100-150-200-250-300	23	23	13,5	9	3,2	220 A
ERT 35-23/ L – 9	35	0,2	100-150-200-250-300	23	23	13,5	9	3,4	260 A
ERT 50-30/ L – 11	50	0,2	100-150-200-250-300	30	30	15	11	4,5	340 A
ERT 75-30/ L – 11	75	0,2	100-150-200-250-300	30	30	15	11	5	420 A
ETT									
ETT 6-11/ L- 7	6	0,2	75-100-150	11	13	7	7	2	90 A
ETT 10-17/ L- 9	10	0,2	100-150-200-250-300	17	23	13	9	2	130 A
ETT 16-17/ L – 9	16	0,2	100-150-200-250-300	17	23	13	9	2,5	160 A
ETT 25-23/ L – 9	25	0,2	100-150-200-250-300	23	23	13,5	9	3,2	220 A
ETT 35-23/ L – 9	35	0,2	100-150-200-250-300	23	23	13,5	9	3,4	260 A
ETT 50-30/ L – 11	50	0,2	100-150-200-250-300	30	30	15	11	4,5	340 A
ETT 75-30/ L – 11	75	0,2	100-150-200-250-300	30	30	15	11	5	420 A

- differs by cross-section and current load

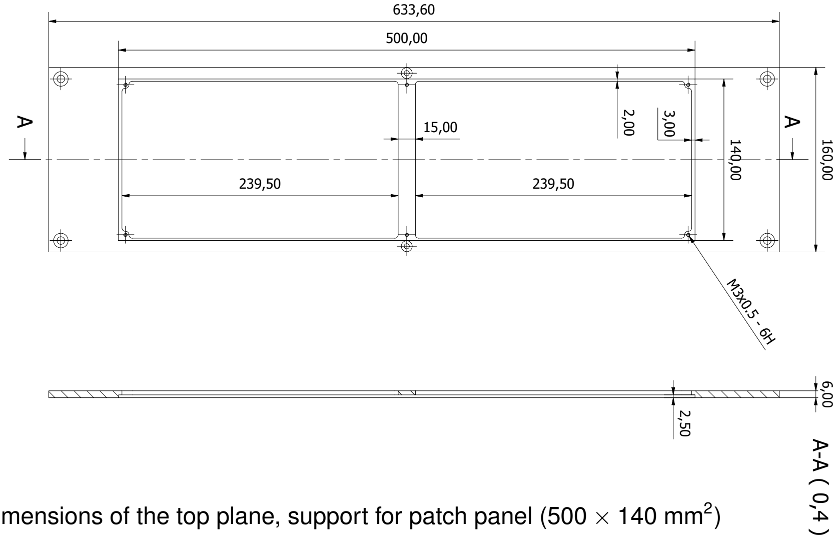
ECAL-P: Faraday cage

ECAL-P: Faraday cage: overview



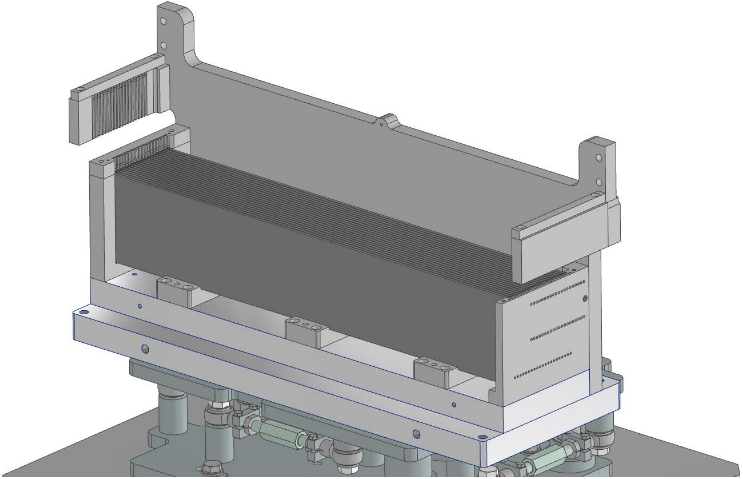
- modular structure: mounting points for patch panel and beam window

ECAL-P: Faraday cage: dimensions of the top plane

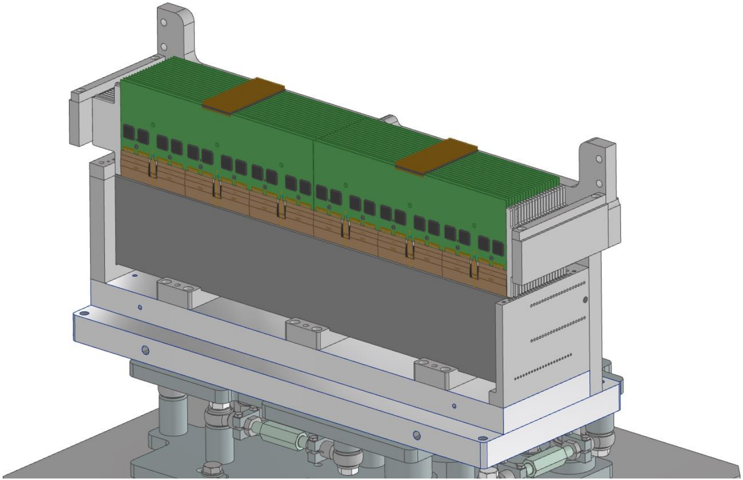


- dimensions of the top plane, support for patch panel (500 $\times$ 140 mm^2)
- patch panel: connectors to external world, clock distribution, ...

ECAL-P: Faraday cage: modification of the back plane

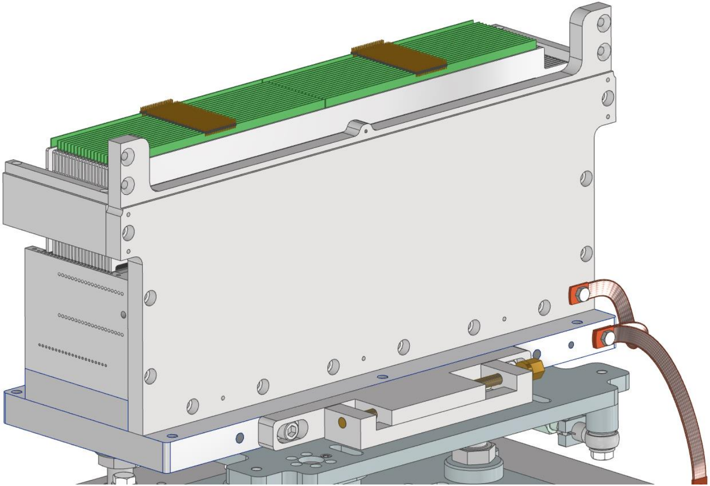


- minimal modification of the back plane: support for other modules
- (combs structure unchanged)



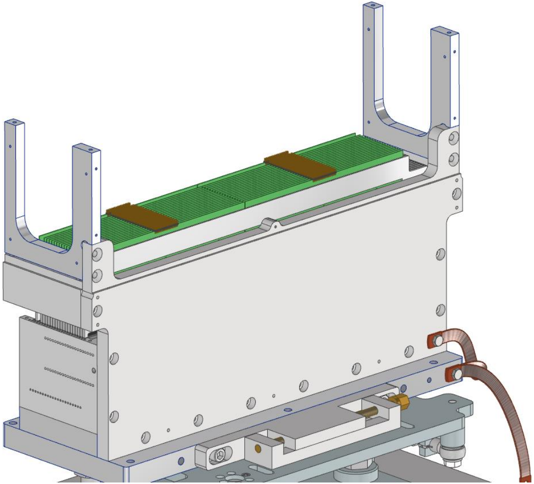
- minimal modification of the back plane: support for other modules
- (combs structure unchanged)

ECAL-P: Faraday cage: modification of the back plane



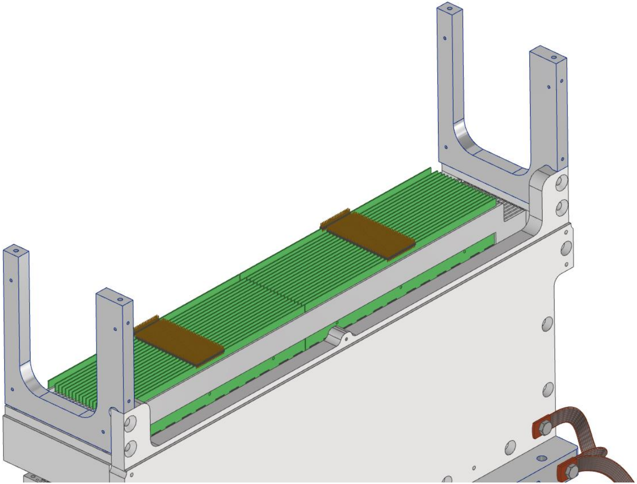
- minimal modification of the back plane: support for other modules
- (combs structure unchanged)

ECAL-P: Faraday cage: mounting points for upper structure



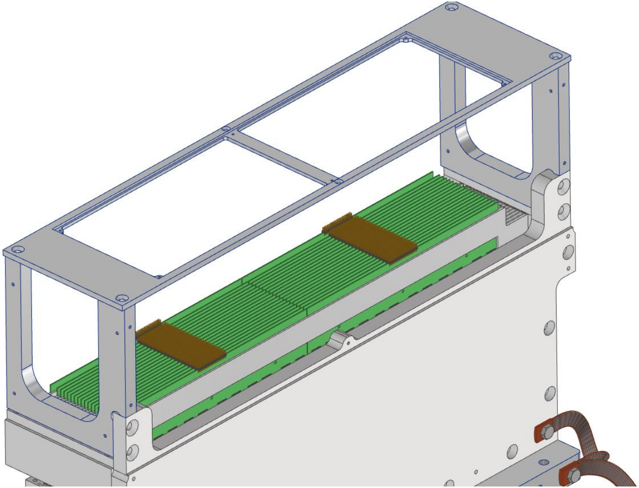
- U-shaped mounting fixture for upper structure

ECAL-P: Faraday cage: step by step: stage 1



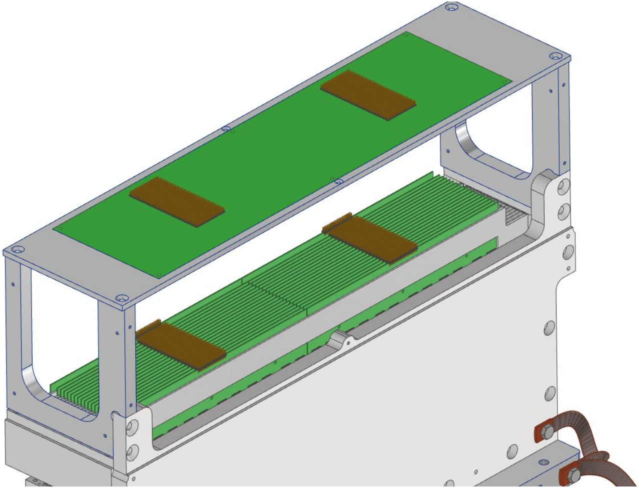
- U-shaped mounting fixture for upper structure

ECAL-P: Faraday cage: step by step: stage 2



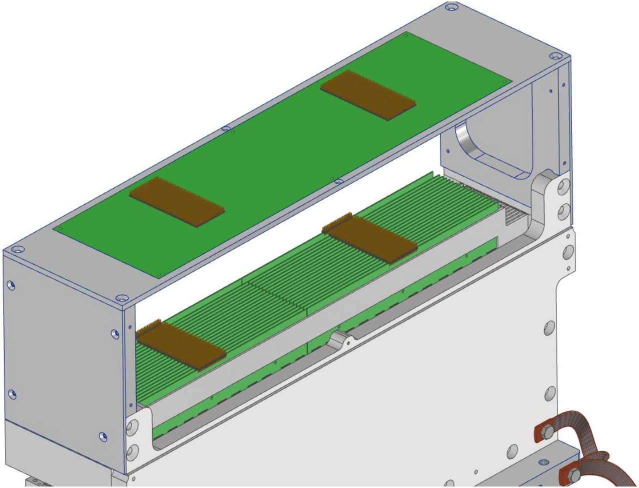
- top support for patch panel (the same length of all inner cables: $\sim$ 15 cm)

ECAL-P: Faraday cage: step by step: stage 3

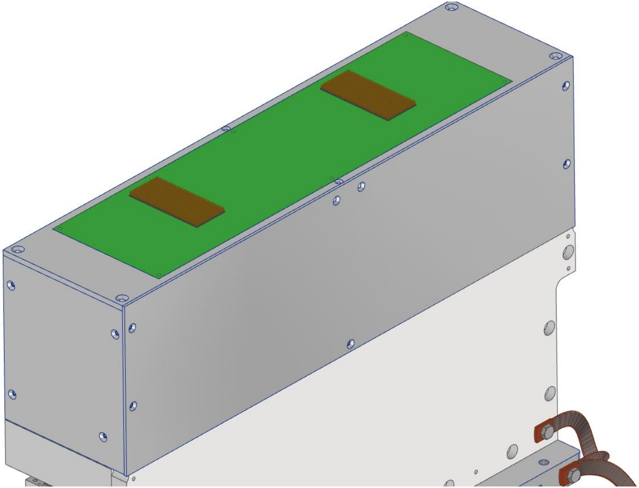


- patch panel: 500 $\times$ 140 mm^2, access from all sides for connecting cables
- top support for patch panel: inner and outer connectors, clock distribution, etc...

ECAL-P: Faraday cage: step by step: stage 4

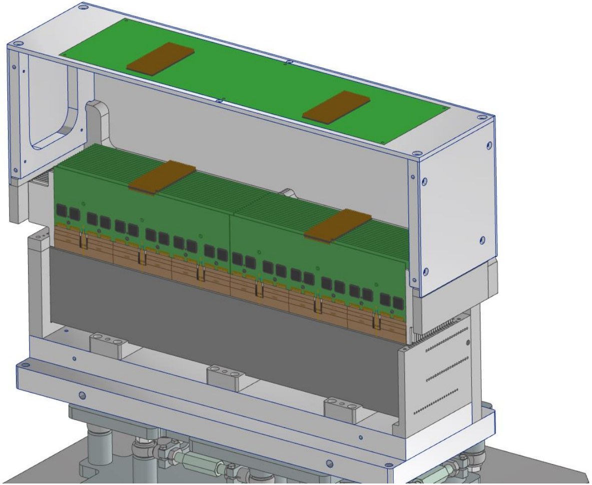


- Faraday cage: side walls mounted



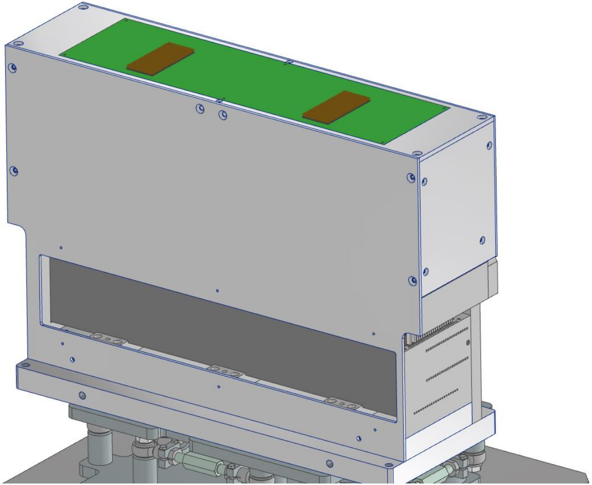
- Faraday cage: rear wall mounted

ECAL-P: Faraday cage: step by step: stage 6



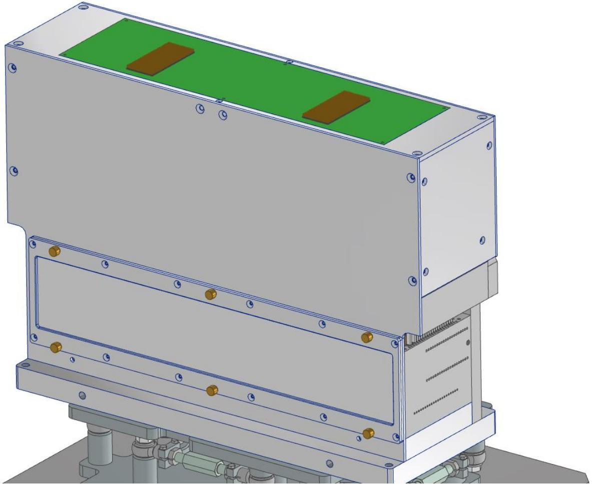
- Faraday cage: open front view
- **Question: do we need** $\sim$ 15 **cm for the cables connecting PCBs with patch-panel ?**

ECAL-P: Faraday cage: step by step: stage 7



- Faraday cage: front wall mounted, open beam window

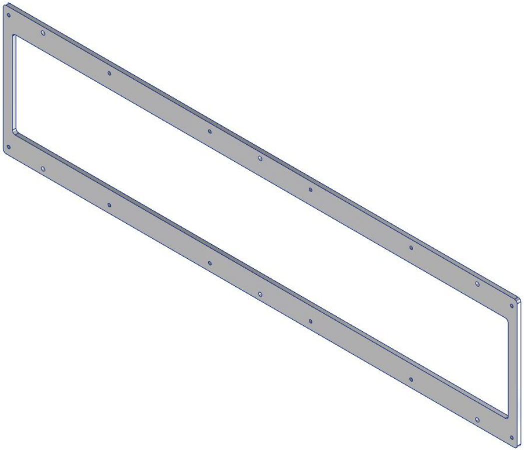
ECAL-P: Faraday cage: step by step: stage 8



- Faraday cage: front wall mounted, beam window closed

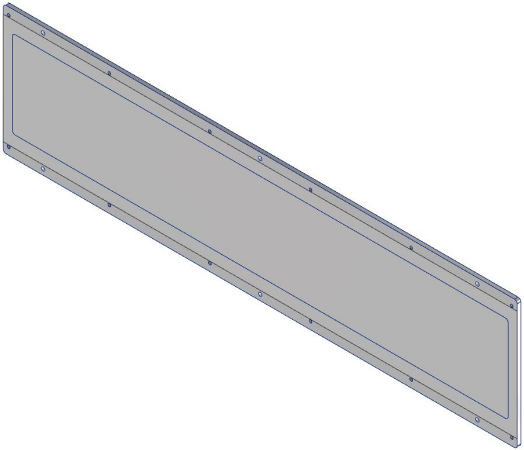
ECAL-P: beam window
(as separate module, easy to install)

ECAL-P: Faraday cage: beam window



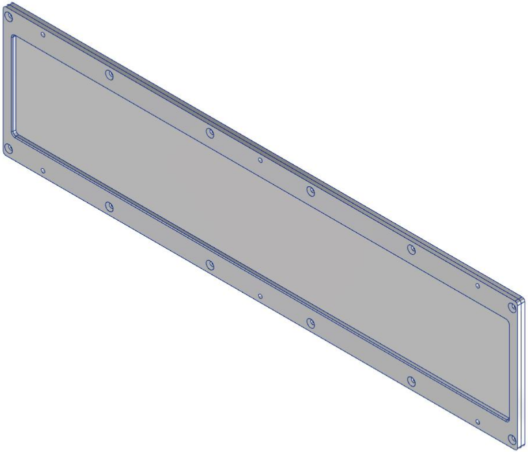
- beam window: frame

ECAL-P: Faraday cage: beam window



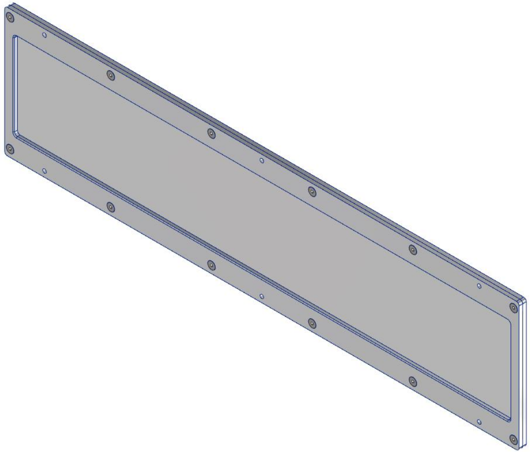
- beam window: frame with aluminum foil (copper ?)
- **Question: what is the optimal thickness of the foil ?**

ECAL-P: Faraday cage: beam window



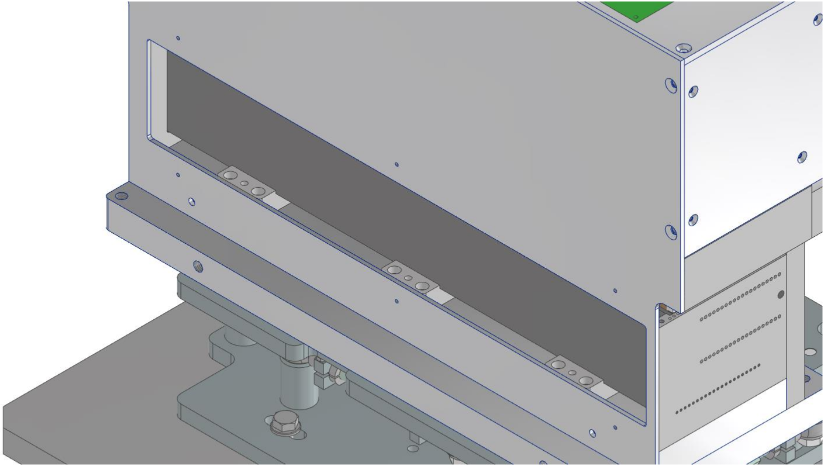
- beam window: frame with aluminum foil and cover frame

ECAL-P: Faraday cage: beam window



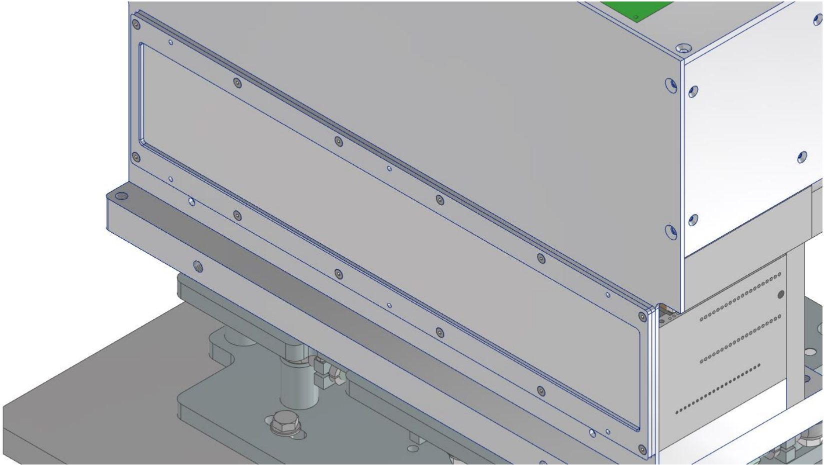
- beam window: frame with aluminum foil and cover frame plus screws

ECAL-P: Faraday cage: beam window



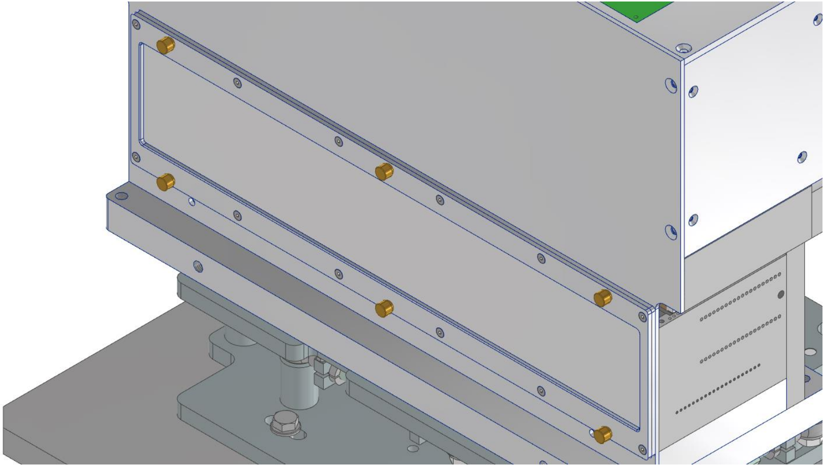
- beam window: ECAL-P beam hole

ECAL-P: Faraday cage: beam window



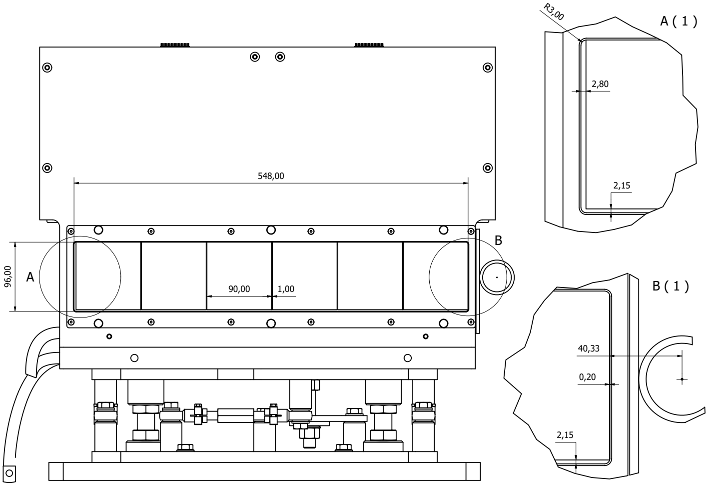
- beam window: ECAL-P beam hole covered

ECAL-P: Faraday cage: beam window



- beam window fixed
- easy to replace in case of Al foil damage

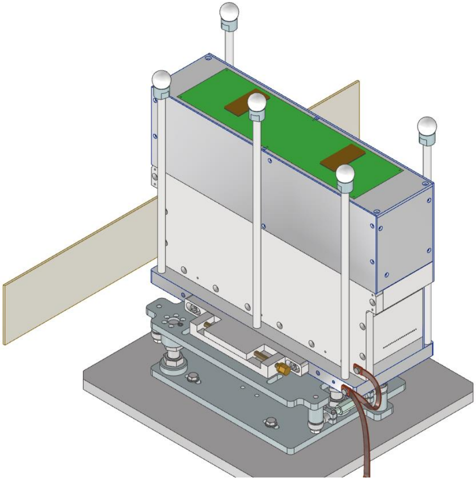
ECAL-P: Faraday cage: beam window dimensions



- possible showers starting in the beam window frame, if e^+ very close to the beam-pipe

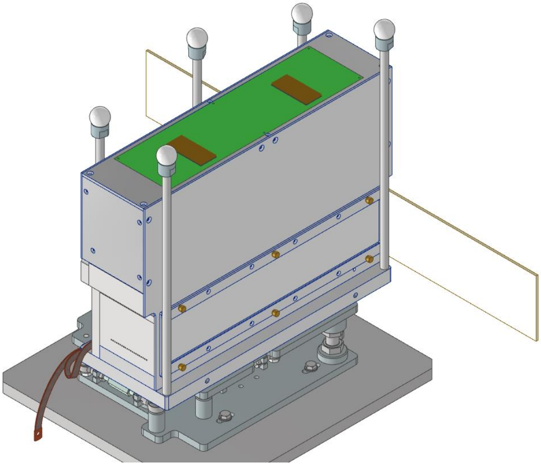
ECAL-P: pillars for geodesy markers

ECAL-P: Pillars for geodesy markers, rear view



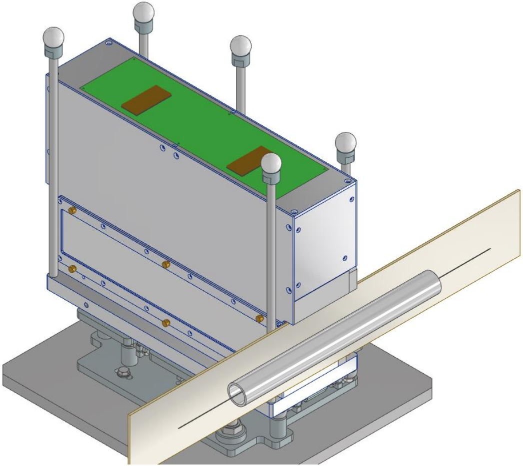
- new positions for pillars, now mounted to the transportation plate

ECAL-P: Pillars for geodesy markers, outer front view



- new positions for pillars, now mounted to the transportation plate

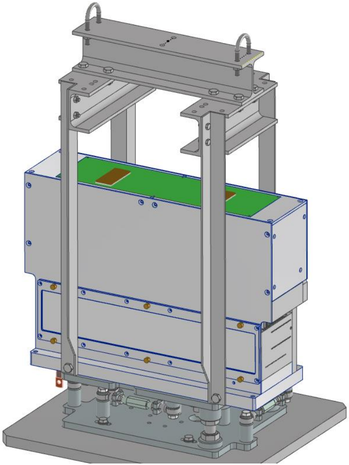
ECAL-P: Pillars for geodesy markers, inner front view



- new positions for pillars, now mounted to the transportation plate
- exact heights to be adjusted...

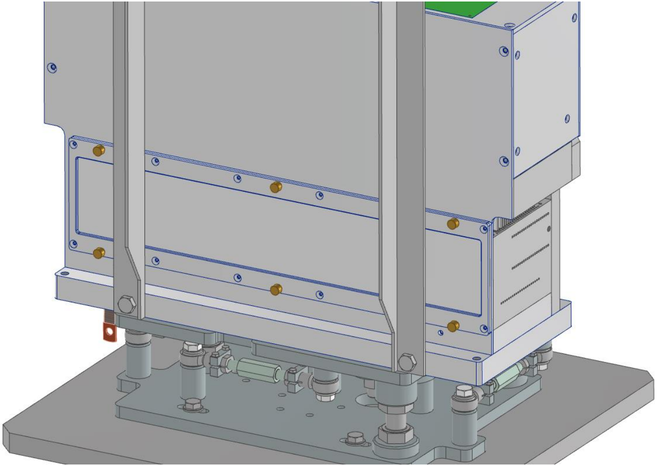
ECAL-P: spider in action with Faraday cage

ECAL-P: Spider

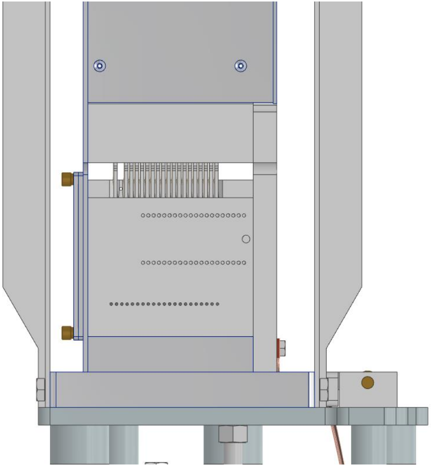


- spider not in conflict with new modules

ECAL-P: Spider (zoom)



- spider not in conflict with new modules



- spider not in conflict with new modules

Conclusions/Plans

- technical note: to be updated (new modules, Faraday cage, etc,...)
- funding for the prototype: $\sim$ 8 kEuro
- construction soon, ordering of materials for:
- main body
- combs
- T-frames
- lowering/lifting mechanism
- 3 tungsten plates

Thank you for the Attention !