Absorber R&D

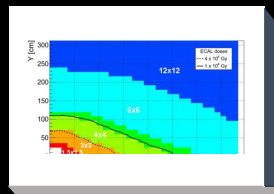
2022 overview and outlook 2023

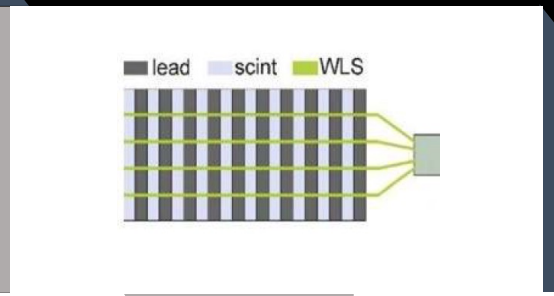
H. Gerwig on behalf of all people in Industry and Institutes working on the absorbers either in tungsten or lead

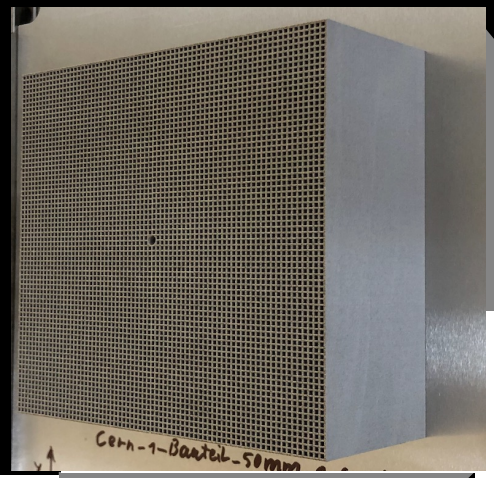
LHCb ECAL Upgrade II Workshop, IJCLab Orsay 12/Dec/2022

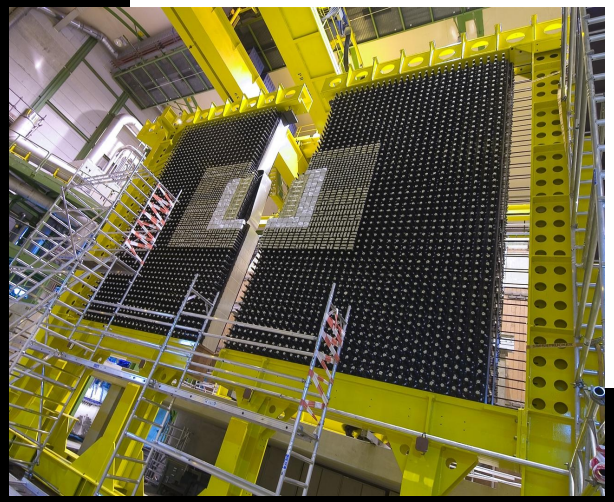
Content

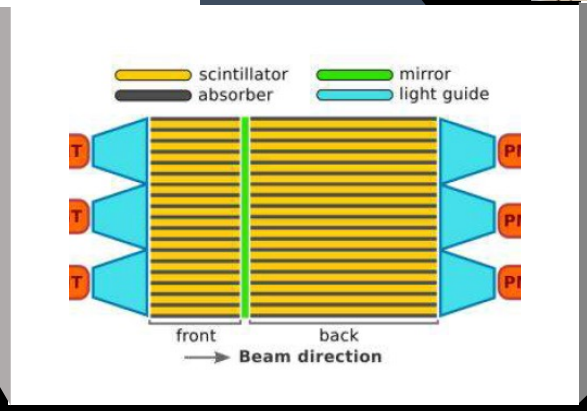
- Motivation for ECAL upgrade and some consequences in a nutshell
- Dimensions, numbers, characteristics of lead and tungsten absorbers
- Tungsten absorber 3D printing achievements
- Lead absorber knowledge transfer and near future plans
- Integration issues, rotation of modules, effects on beam plug

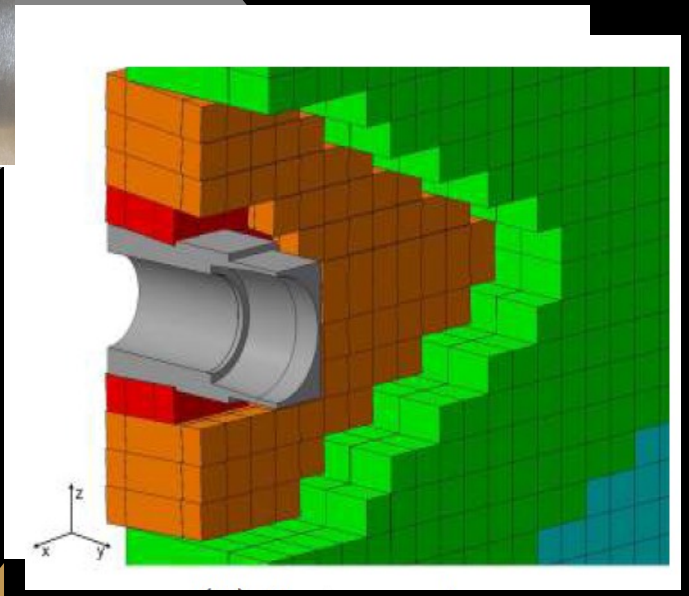












Motivation and consequences in a nutshell

Characteristics for lead and tungsten moduls

(from Frederik dall 'Omo/ D. Karpenkov)

Lead (needed #144)

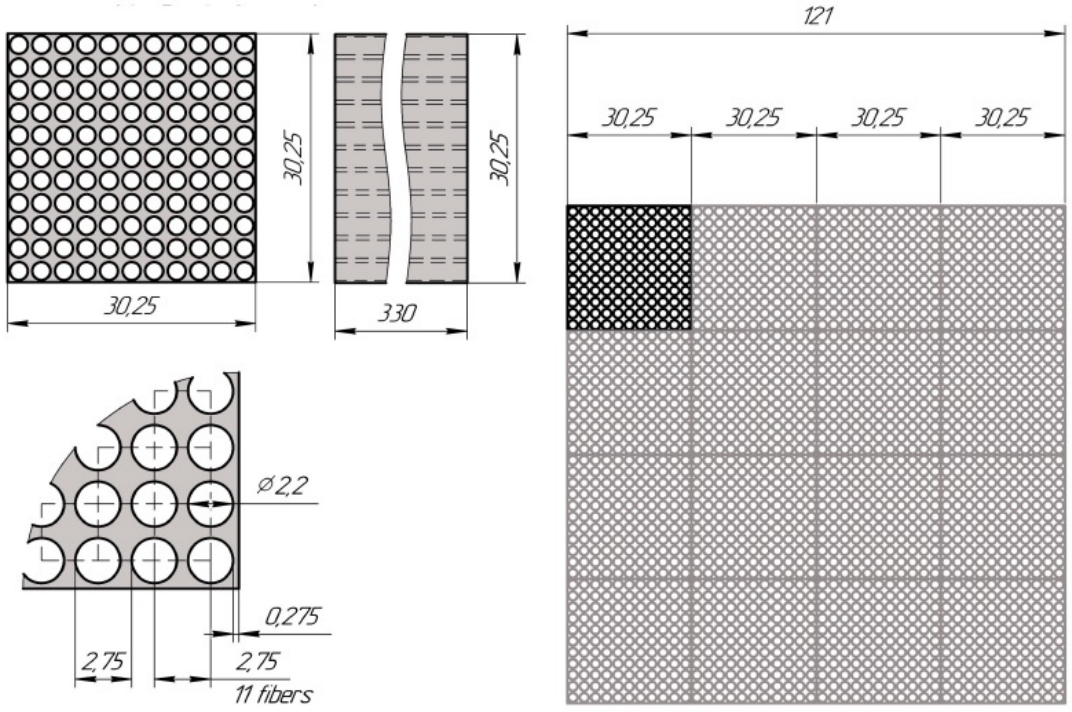


Figure 1: SPACAL cast lead-based absorber structure.

1936 Holes (for PS), **26 kg for a 290mm** Modul

Tungsten (needed #32)

	Front Section	Back Section
Length, mm	45	105
Volume, cm^3	324.99	758.31
Density, g/cm^3	19.3	
Mass, g	6272.4	14635.6
Outer Dimension, mm	121.2×121.2	
Square Hole Dimension, mm	1.2	
# Square Holes	5041	
Pitch between holes, mm	1.67	
Absorber Wall Thickness, mm	0.47	
Central Hole Diameter, mm	3.2	

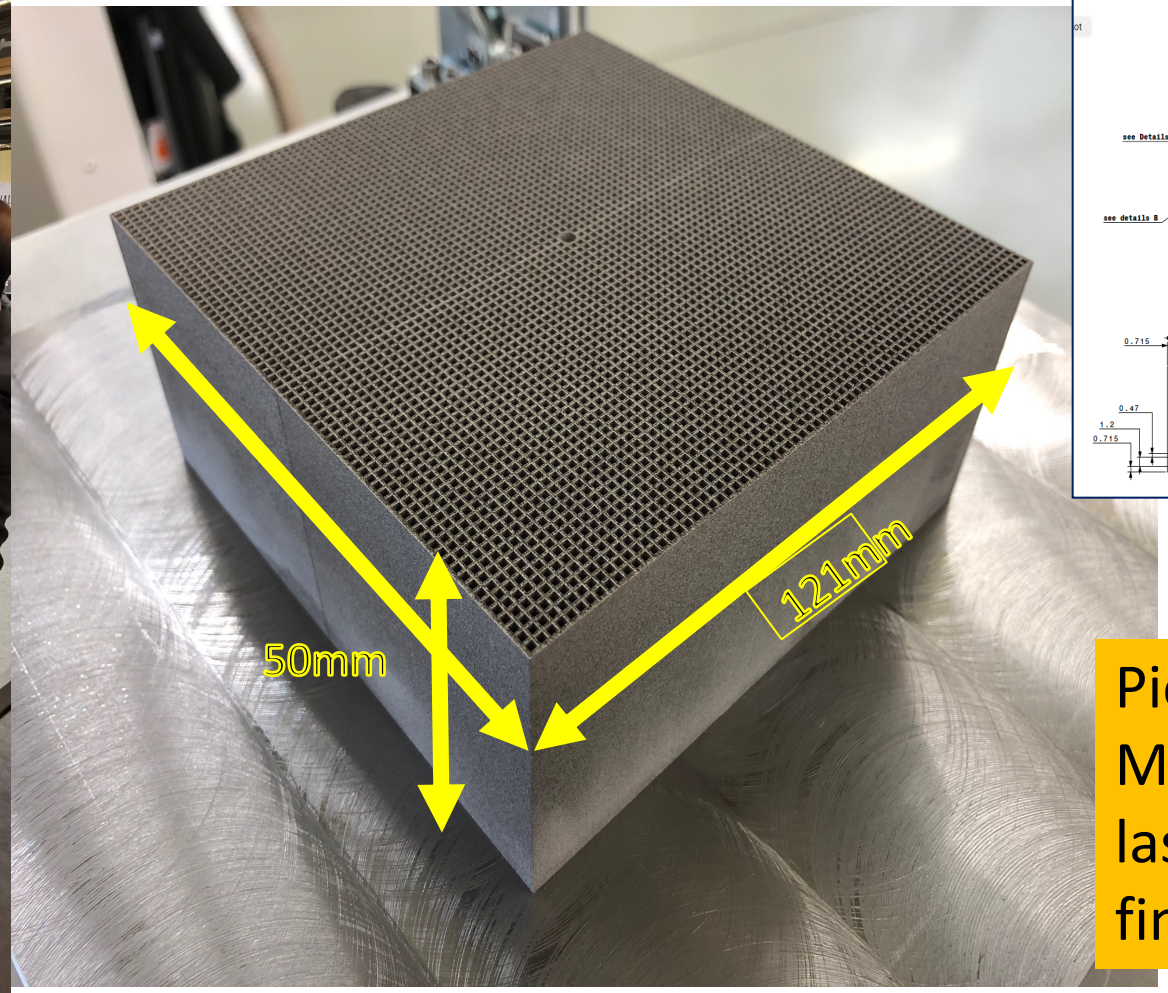
Table 3.2: Main parameters of the SPACAL W absorber front and back section [49]

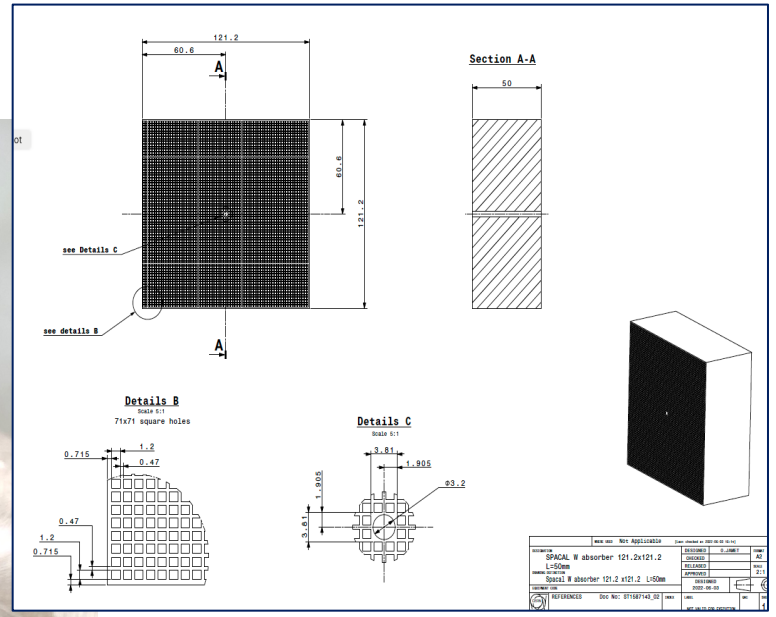
5041 Holes (for GAGG/PS), **20,9 kg for a 150 mm** Modul

Tungsten 3D printing, the choices of lengths

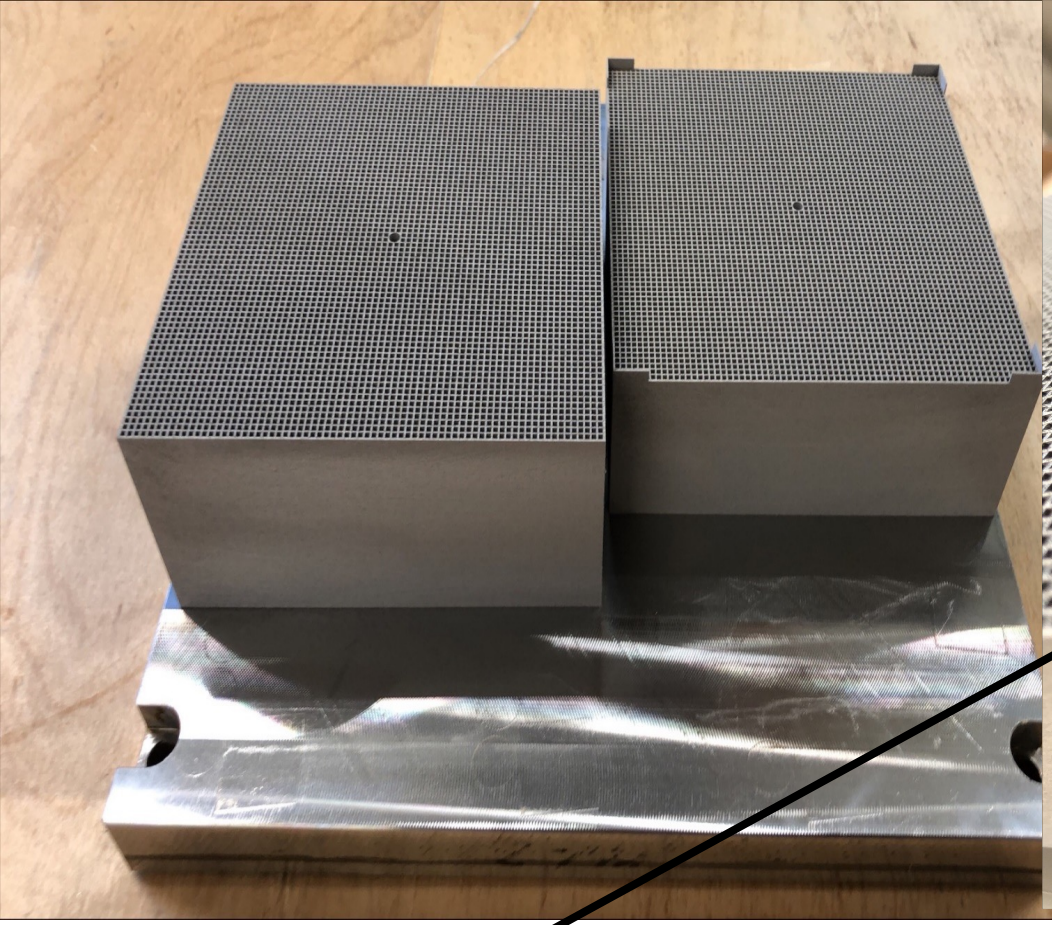
- First trials in 2020 haven't been satisfactory in terms of roughness quality (R_a 15µ, R_t 140µ)
- Much better results with actual company (EOS, R_a<5, R_t <50), limitation in height (85 mm)
- After single cell (15x15 mm), 9 cell (45x45 mm) now move to modul size 121x121 mm
- Lengths chosen: 50+50+50+40 mm (for different testbeam purposes):
    - For LS3 cell siz =2cm, modul length 190mm (for PS), single side read out (W/PS)
    - For LS4 cell size=15mm, modul length 150 mm for GAGG, double sided readout, mirror @50 mm from front

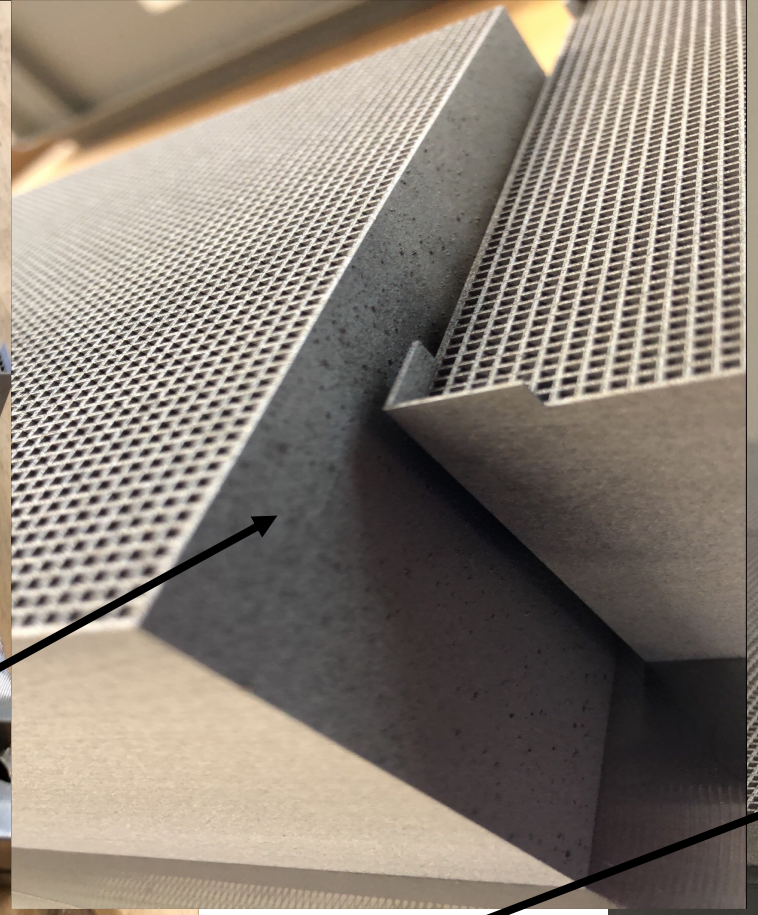
Scale 1:1 Tungsten absorber

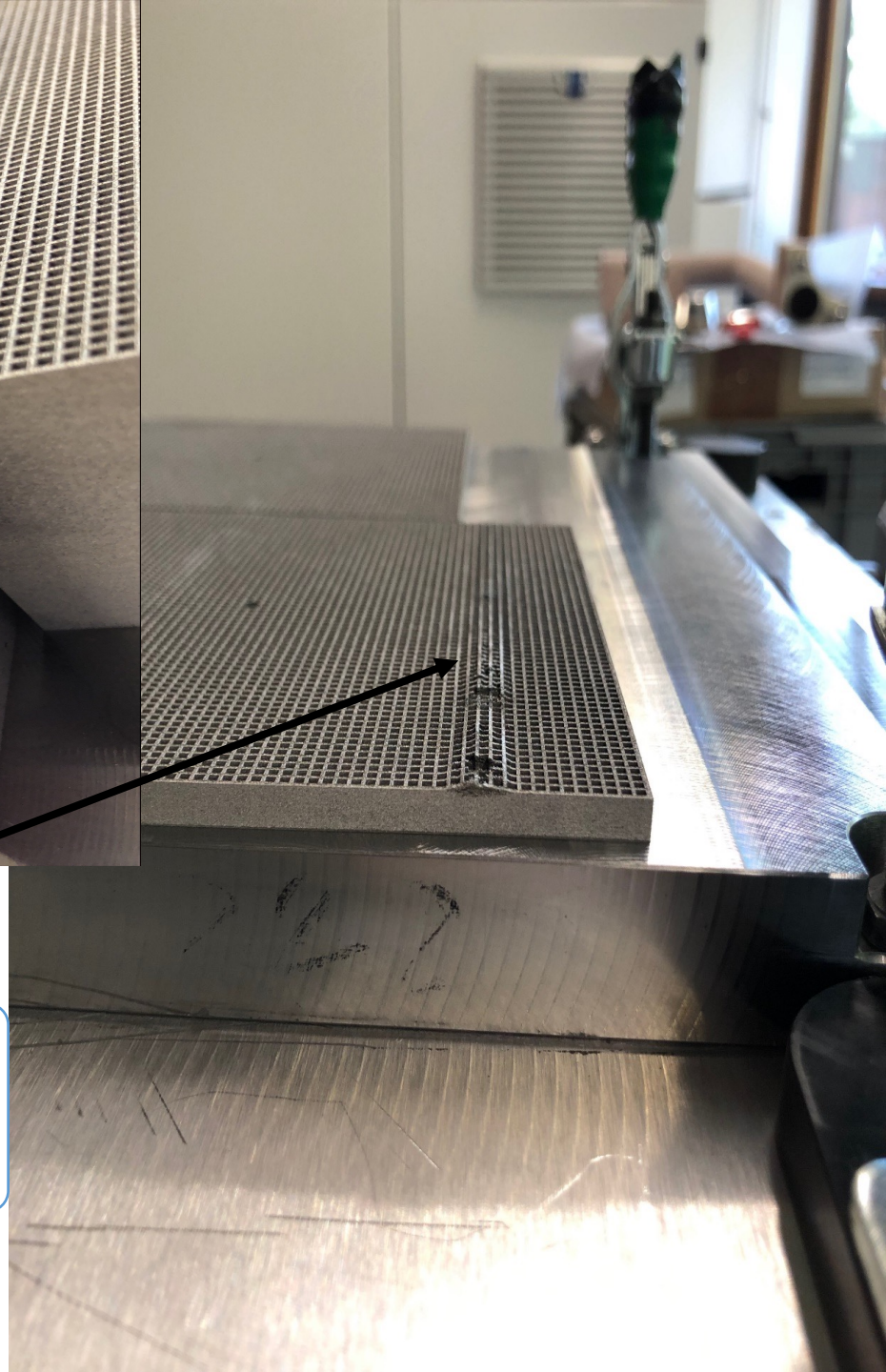




Piece achieved with EOS Munich, last week, dual laser, 4 days printing job, fine detail resolution.





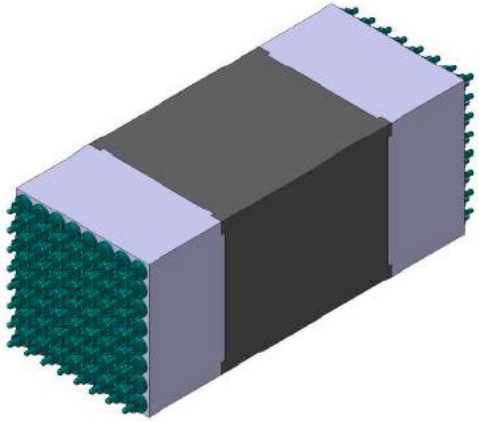


Good looking not always means being fine and according to spec (pimples and spots in and outside)

Scaling up from a cell (15x15mm), to 9 cells (45x45) went without problems

Moving then from 45x45 mm to 121x121 new problems with recoating

Problems are solved in the meantime



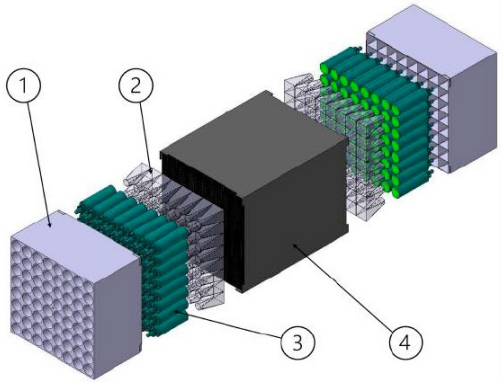
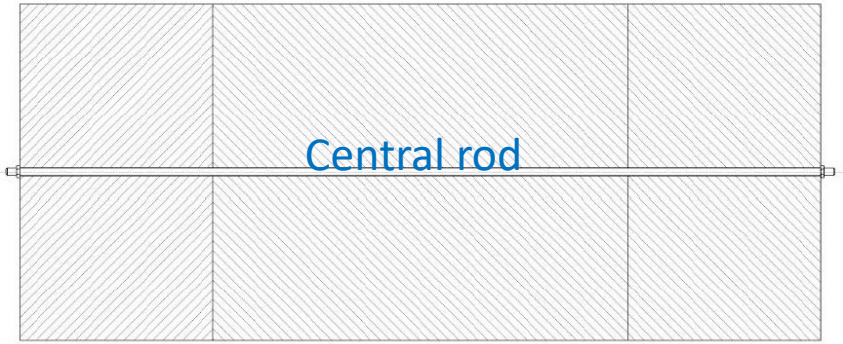
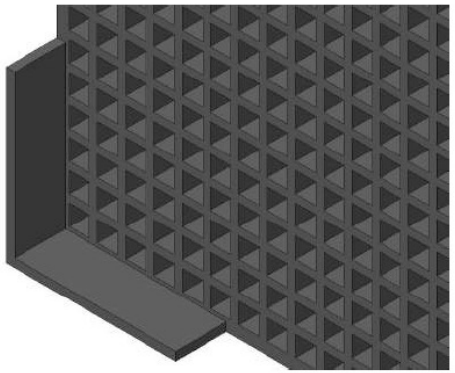
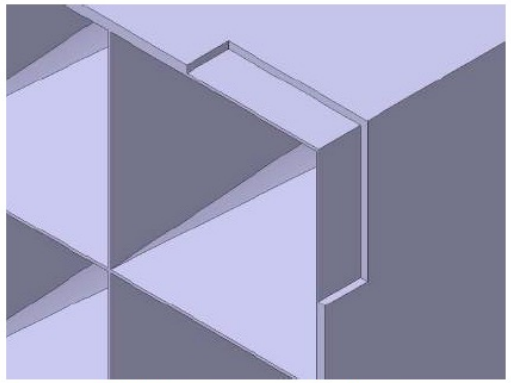


Figure 3.5: Exploded view of SPACAL W module showing the housing (1), LG (2), PMT (3) and absorber (4) (Source: own representation)





(a) L-shaped step in absorber



(b) Counterpart in the housing

Design features of SPACAL tungsten module

- The module consisting of the absorber and a housing for th LG and PMT is held together by a central rod with M3
- Special corner elements assure the correct fitting of housing w.r.t absorber

First 3d printed single cell tungsten protos from Tsinghua University Beijing

15x15x50mm

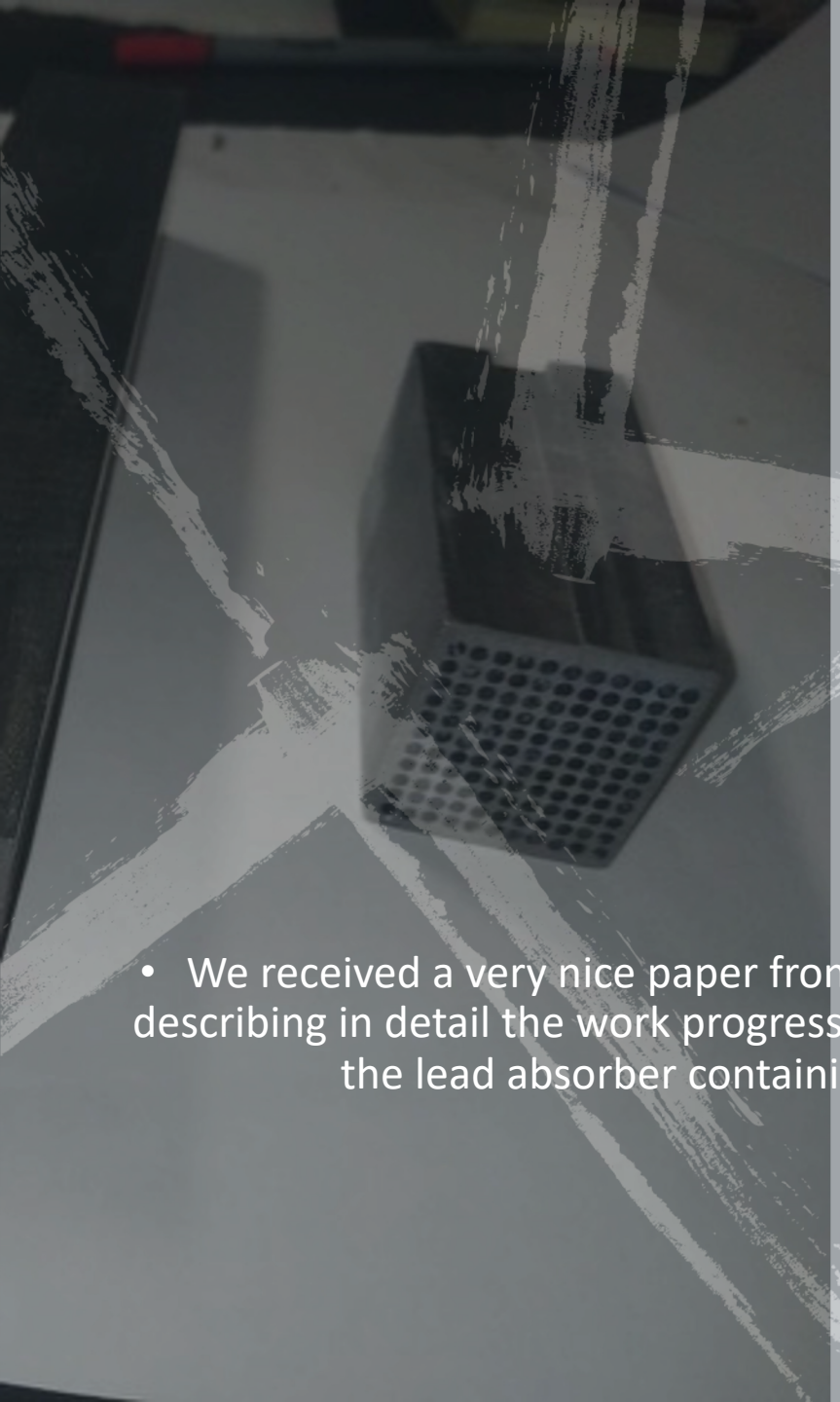
Up to 130mm height can be produced with this machine

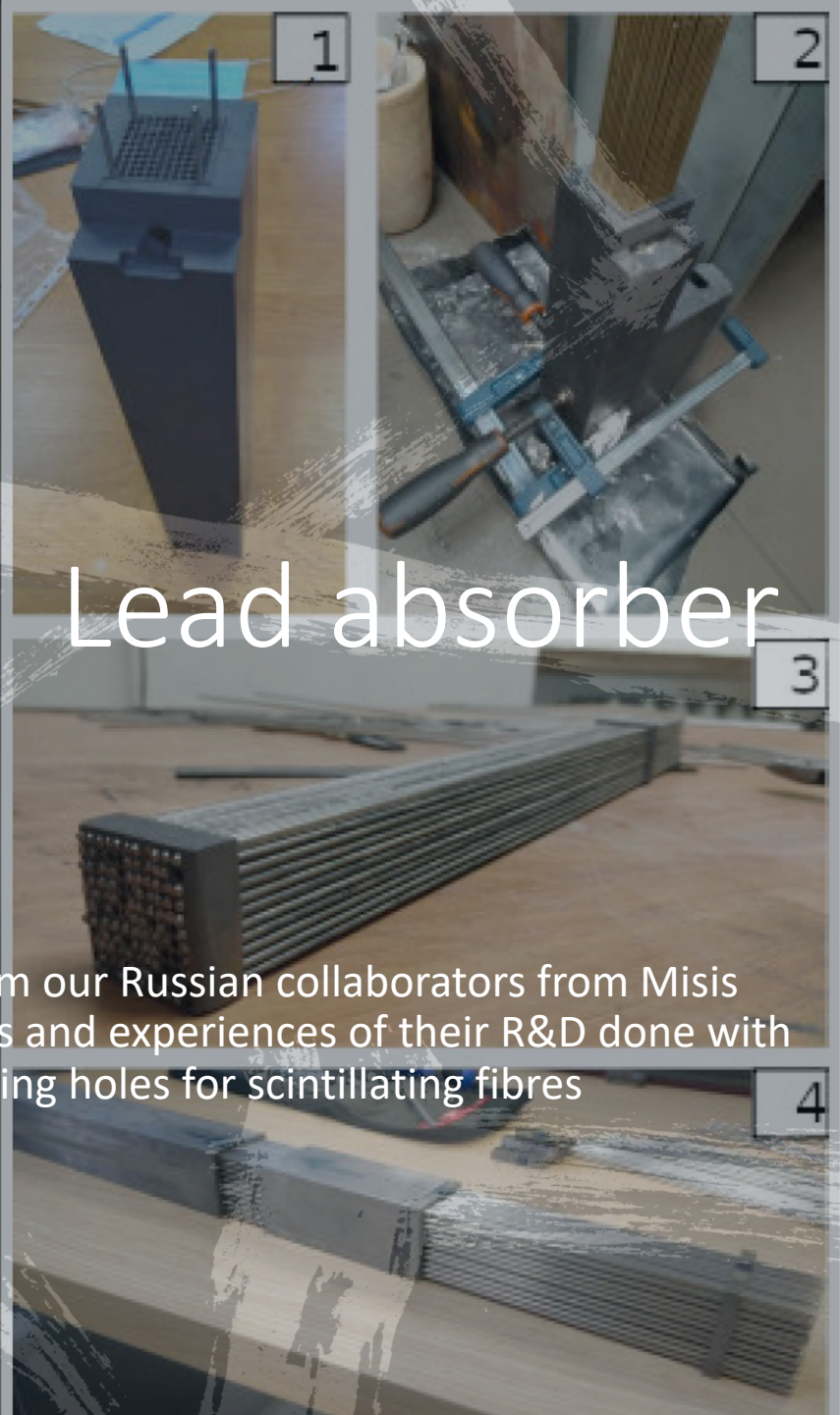
Summary of test results

	#1 – Batch 1			#2 – Batch 1			#3 – Batch 2			#4 – Batch 2		
Ra	3.968	4.716	4.604	3.841	4.005	3.992	4.218	4.122	3.626	3.858	4.220	4.895
Rt	32.492	60.180	48.075	31.171	32.617	30.299	35.228	37.405	35.815	32.339	34.566	39.864

- Measurement was done with Mitutoyo SJ-411.
- For each prototype, 3 measurements were made on 2 surfaces.

Now remeasured at CERN metrology and values confirmed





Lead absorber

- We received a very nice paper from our Russian collaborators from Misis describing in detail the work progress and experiences of their R&D done with the lead absorber containing holes for scintillating fibres

SPACAL single cell prototype description

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S. Mishurov, V. Rykalin, E. Shmanin and D. Strekalina

April 2022

Introduction

The LHCb ECAL Upgrade phase 2 implies usage of modules with di granularity and technologies. One of the technology suitable for the inne in terms of radiation hardness, energy and time resolutions is the spaghett calorimeter (SPACAL) modules. The significant part of the inner modules be produced with lead-based absorber and scintillating fibres made of polystyrene. This document describes the present status and perspecti the cast technology for Lead-based SPACAL. The chosen fibre dimensio step between nearest holes are the results of optimization performed wi GEANT4 simulation.

The Lead/Polysterene SPACAL module is a block of high lead based m with external dimension $121 \times 121 \times 330$ mm^3, subdivided onto 16 cells (of 4×4 with 30.25×30.25 mm^2 transverse size each). Each cell cont matrix of 11×11 holes suitable for $\varnothing 2$ mm scintillating fibres. The mo schematically shown in Figure 1.

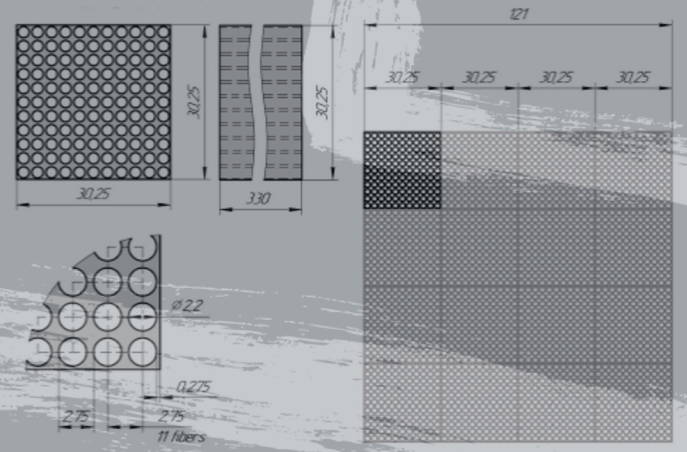
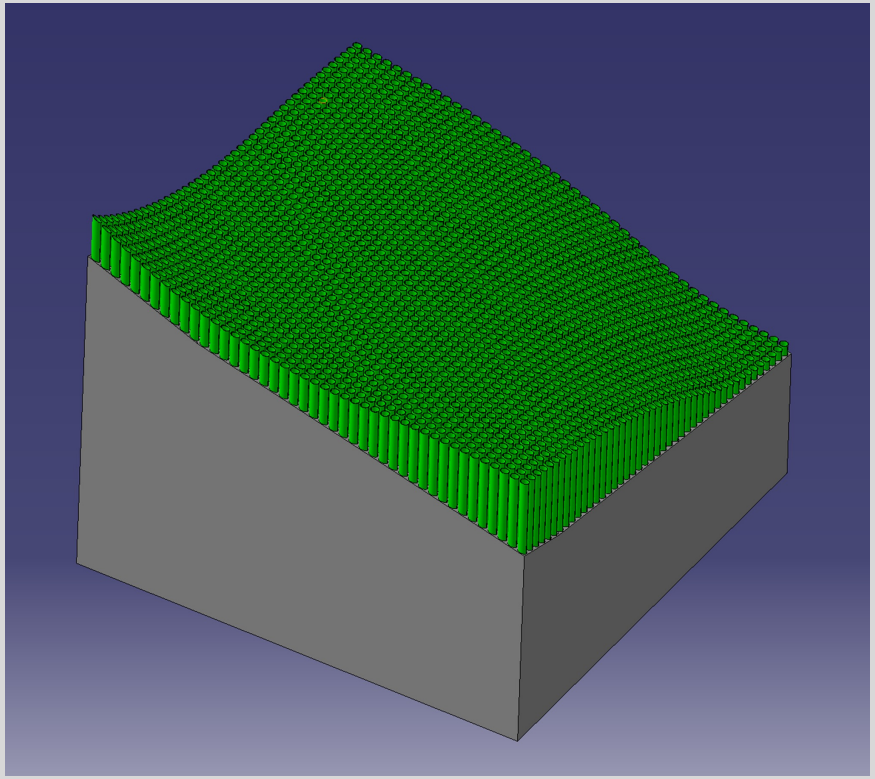
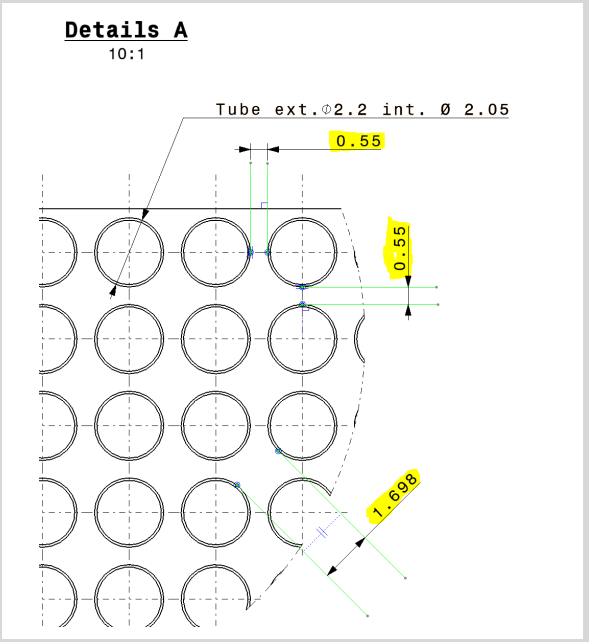


Figure 1: SPACAL cast lead-based absorber structure.

Lead absorber

- This idea with capillary tubes is the most promising
- We want to transfer this to industry now.
- Process is a low-pressure casting with feed in from bottom
- A company and a research center have been identified
- An informal price inquiry is requested





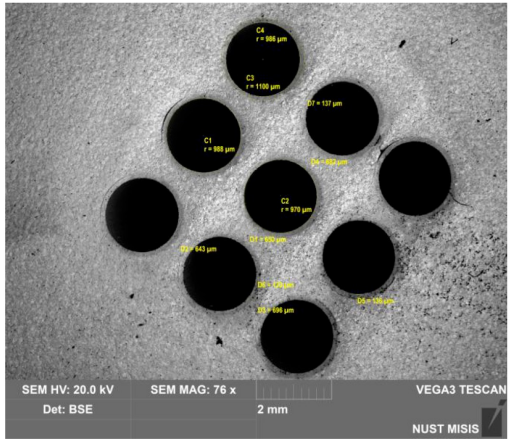
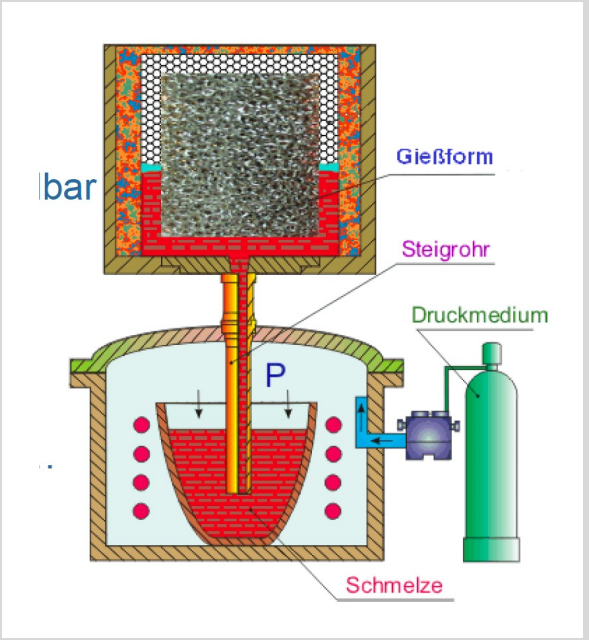
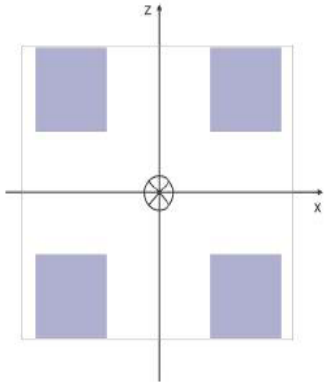


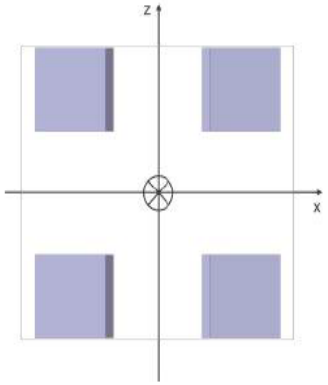
Figure 16: Insufficient adhesion of lead to the surface of the tubes



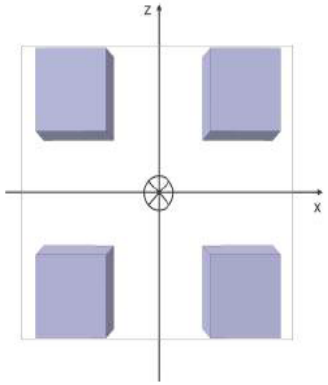
Integration issues 1: rotation of modules of the order of 3º



(a) Initial situation: non rotated



(b) First rotation arround the z-axis



(c) Second rotation arround the x-axis

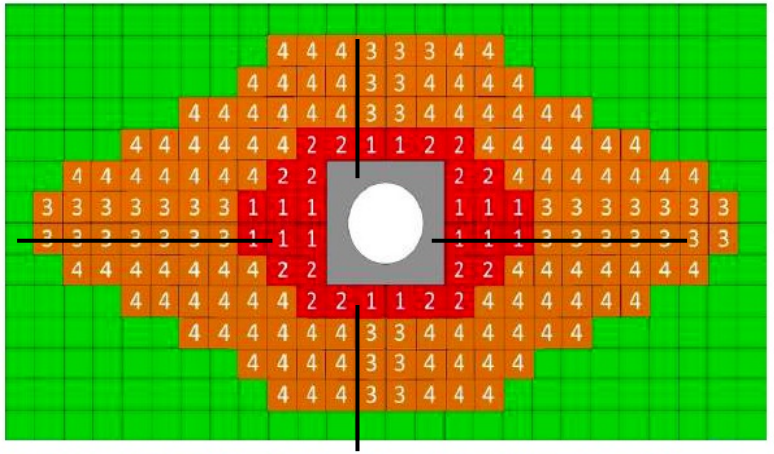
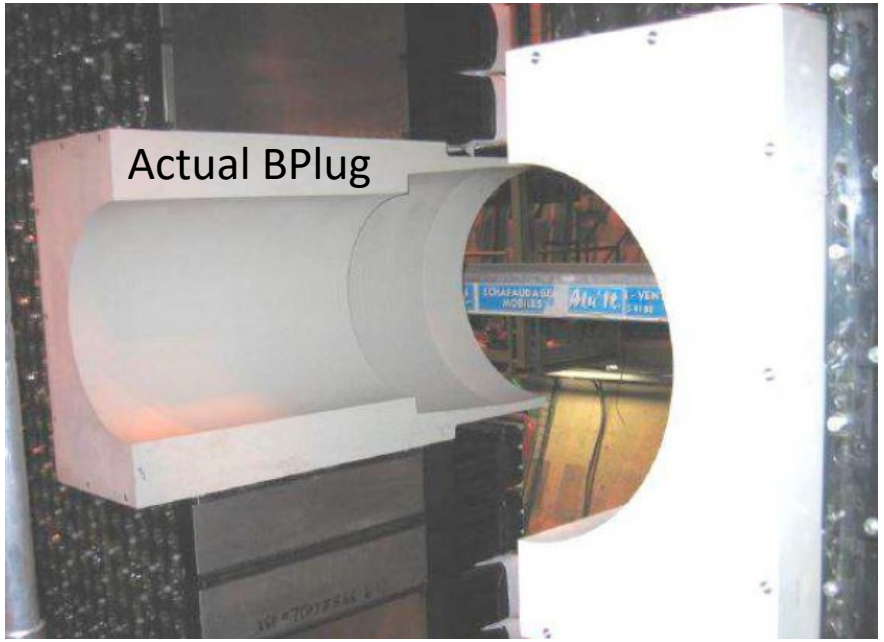
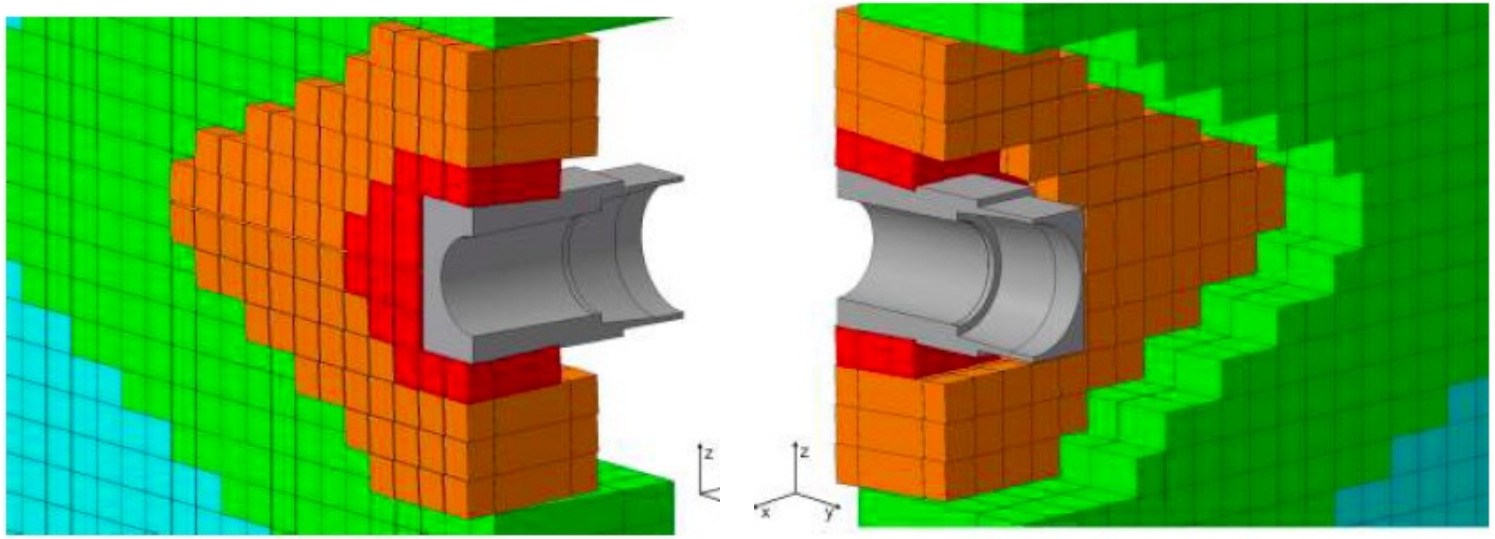


Figure 3.17: Map showing the zones for different module configurations; SPACAL W (red), SPACAL Pb (orange), SHASHLIK (green), BP (gray) (Source: own representation)

	Absorber	Modification
1	W	yes
2	W	no
3	Pb	yes
4	Pb	no

Table 3.3: Different module configurations in Figure 3.17





(a) Downstream view (b) Upstream view

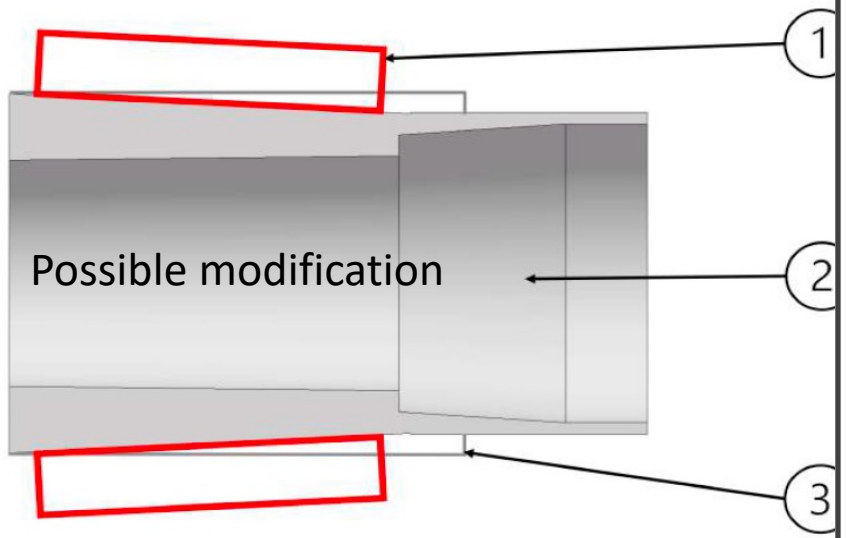
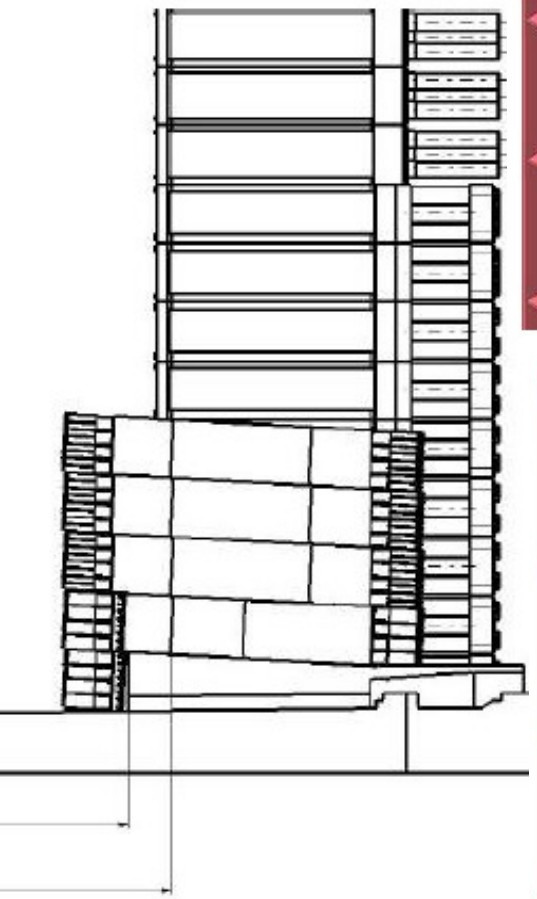
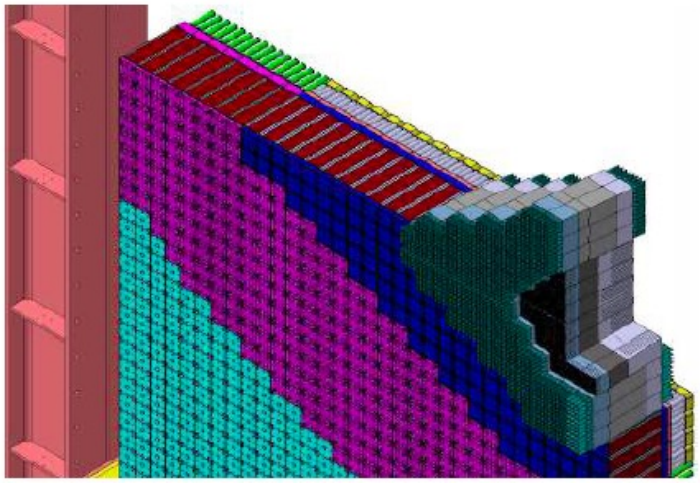


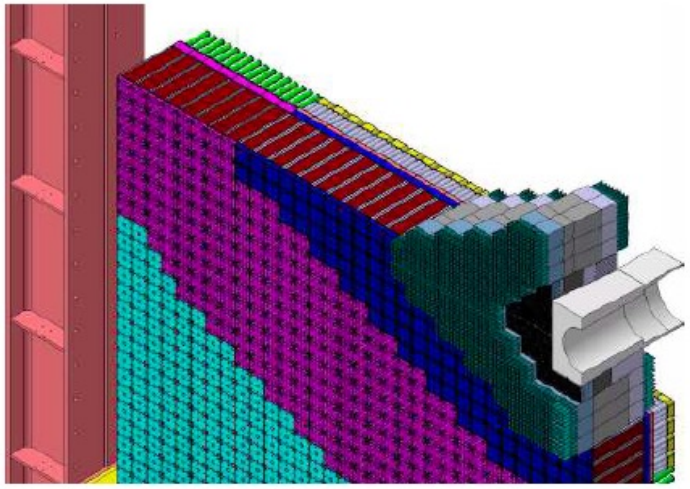
Figure 4.1: Side view downstream (left to right) of possible future BP design show
SPACAL W module (1), the BP (2) and current BP design (3) (Source: own represe

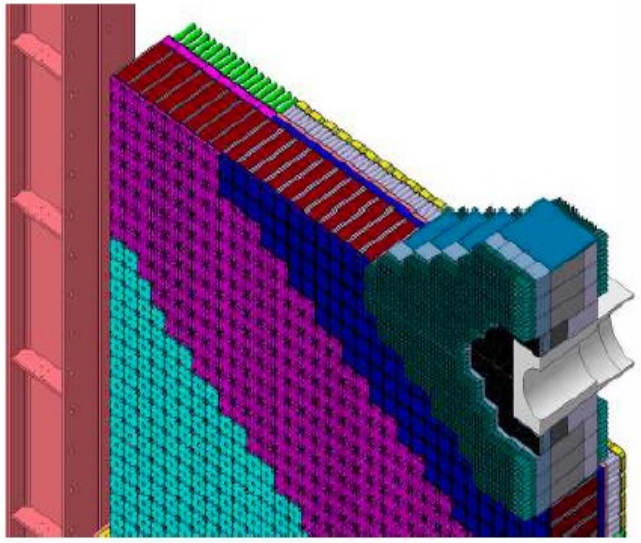
Integration issues 2: beam plug

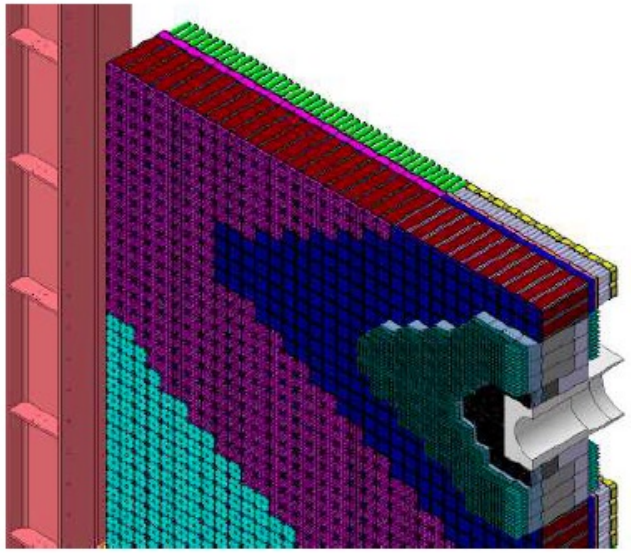
Integration issues 2:
The assembly principle of ‘the wall’ remains valid also with shims at certain locations

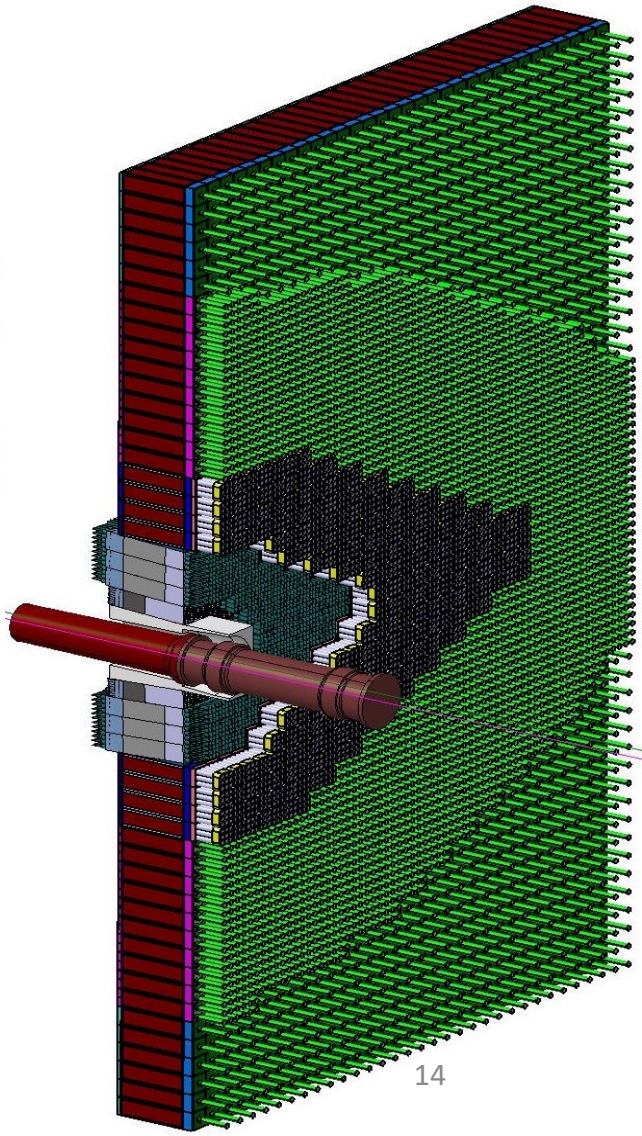












Summary and outlook ’23

- Successful **Proof of Feasibility** of a tungsten 3d printed 1:1 scale proto
- First tungsten protos of single cells from China (Tsinghua Univ.) look very promising
- Initially conisdered the diifcult part - the tungsten is now in advance wrt to the lead!
- Lead - the Misis report will help to transfer ideas and gained experience to industry
- Goal is to produce a lead absorber with capillary tubes until ca. Easter ’23
- All set, all solved? ------ Not at all!
- There is still a lot to do in integration, designing the modul, looking in detail at the assembly etc. etc.
- New collaborators welcome !!!