

PhCollector plans and schedule for pDUNE-VD

C. M. Cattadori on behalf of the PhCollector WG

XA Components

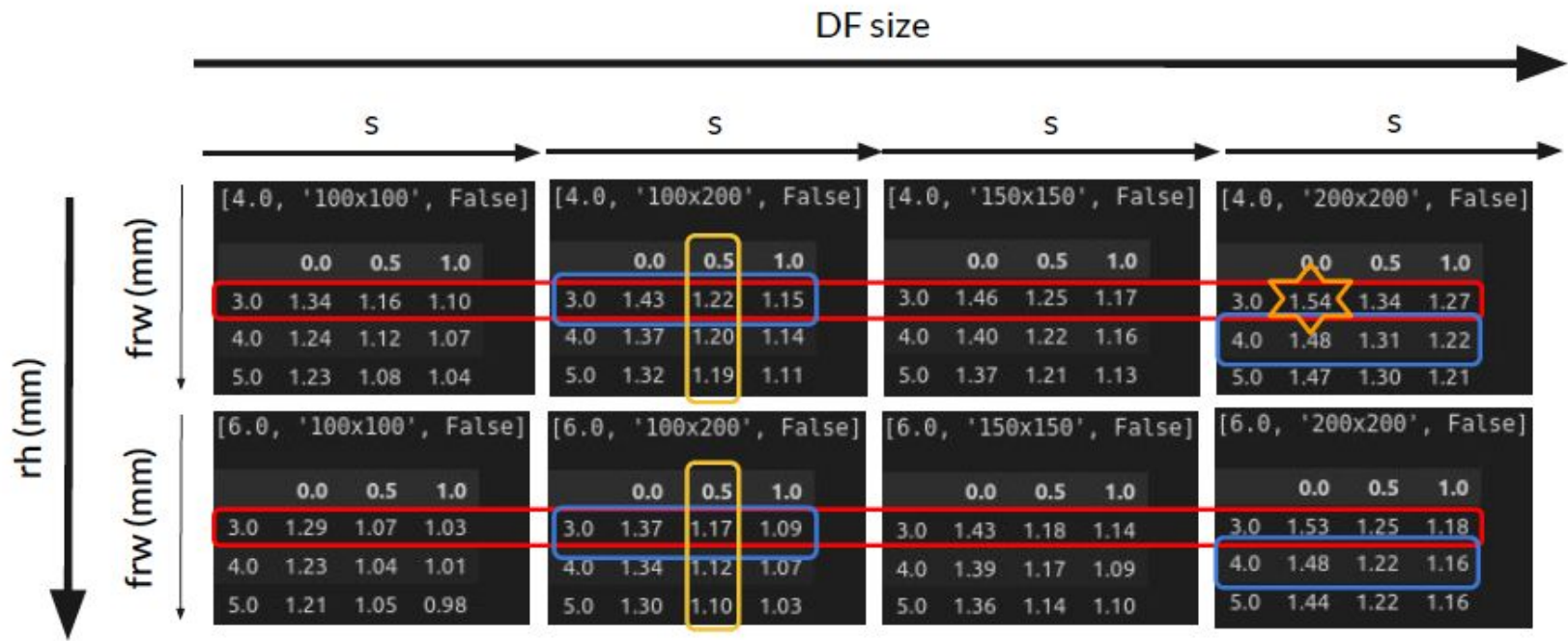
Component	Size/Number	Groups involved	Manufacturer	
Mechanics	660 x 660 16 units	CSU,IOWA,NIU (US)		
WLS Lightguides	625 x 625 max 16 units	INFN-MiB,UniMiB (Italy)	G2P (Italy) LC (Italy)	
Dichroics	200 x 100 150 x 150 97 x 97	CIEMAT, IFIC (Spain) INFN-MiB(Italy)	ZAOT	
pTP coating		UniCAMP (Br)	UniCAMP	
SiPMs	2560	CIEMAT, (Spain), INFN,UniMiB (Italy)		
Flexes	128	UCSB,FNAL,INFN-MiB		

Mechanics (inside the PDU)

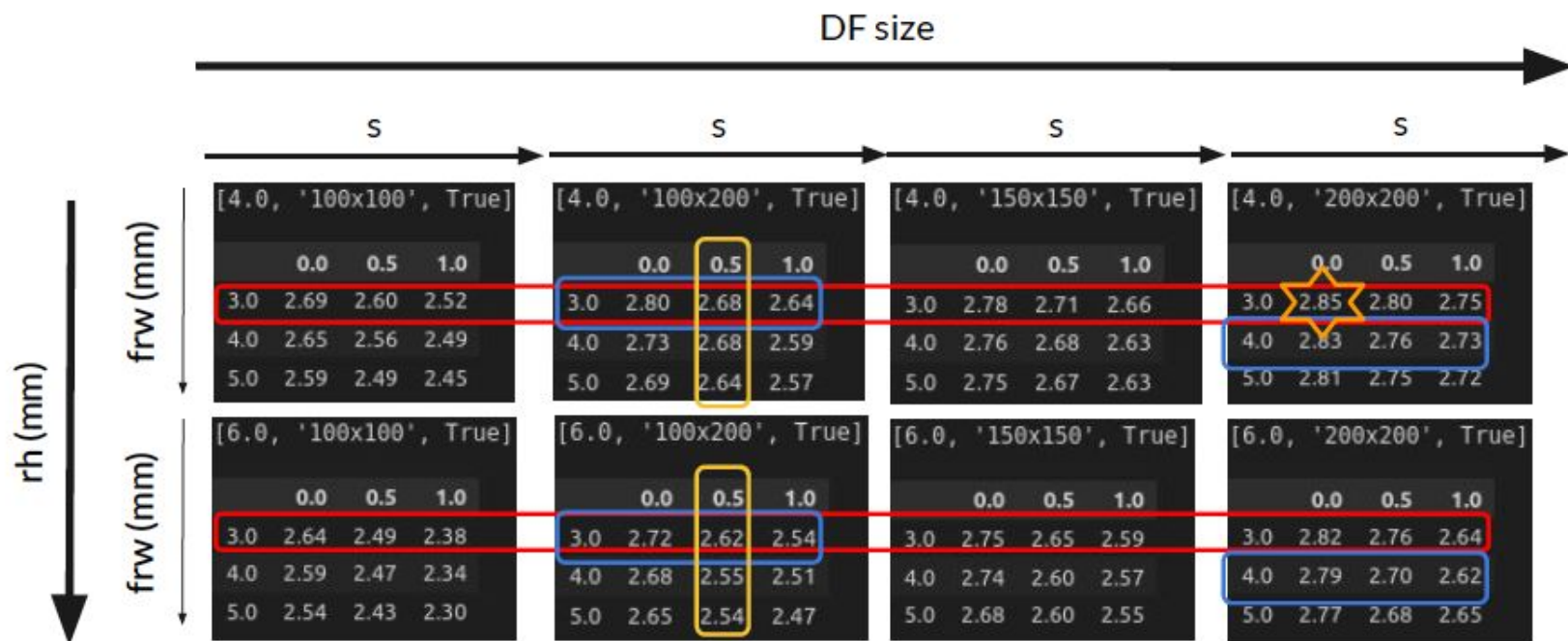
- Two design for v4 & v5 under are being refined to test details
 - electrical and light shield
 - spring system
 - clips for glasses
 - cable routing
- Deployment of v4 & v5 in CB
 - 17-24 october
- Merge the two design for Module-0
- Optimization of the mechanics relevant dimensions ongoing by MC sym
 - frame ribs width
 - frame ribs height
 - reflective vs non reflective/diffusive frame



PCE with non-reflective frame



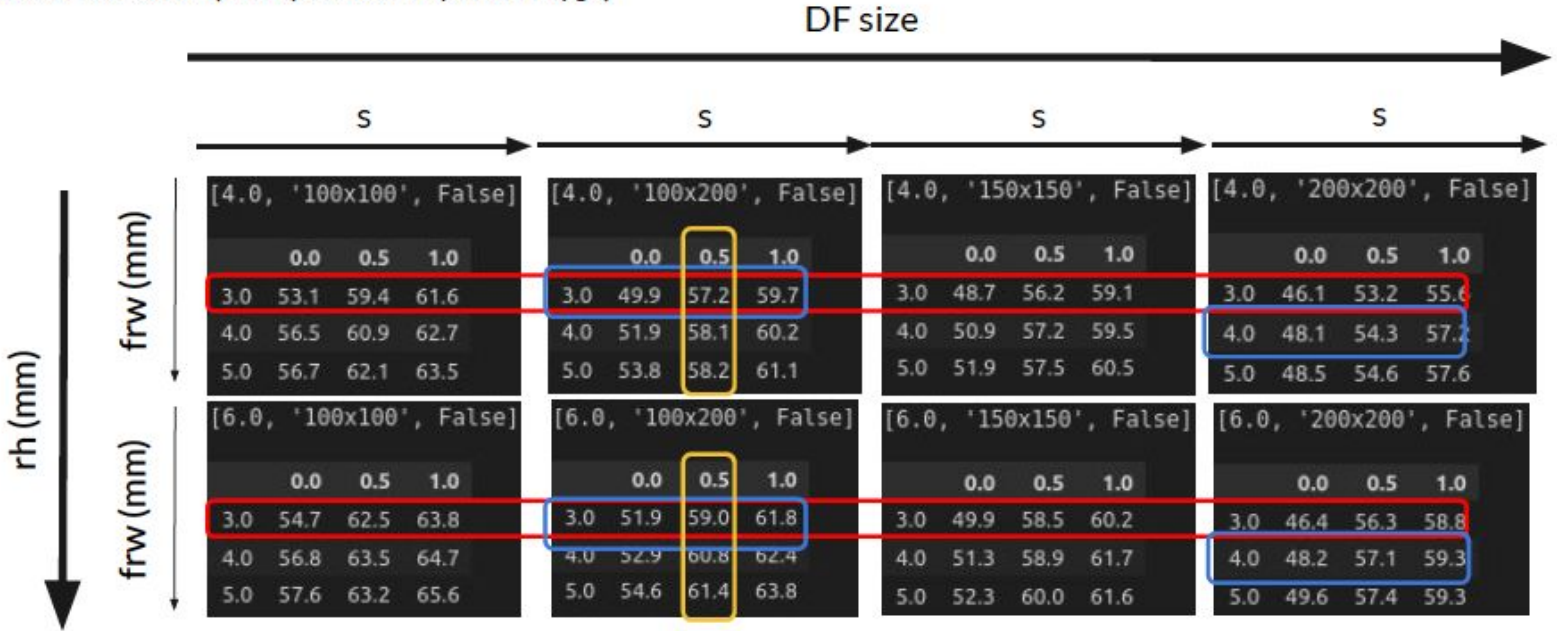
Mechanics optimization w.r.t. PCE

PCE with reflective framediffusive frame = -7% PCE
w.r.t. reflective

Results Mechanics optimization w.r.t. PCE

Percent PCE loss wrt best-case scenario with non-reflective frame

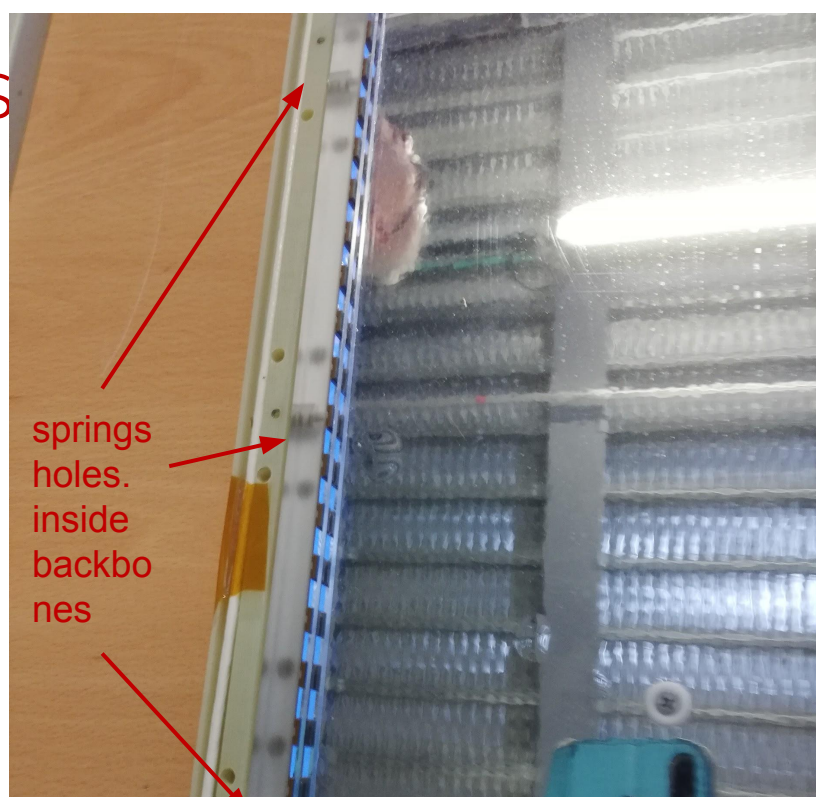
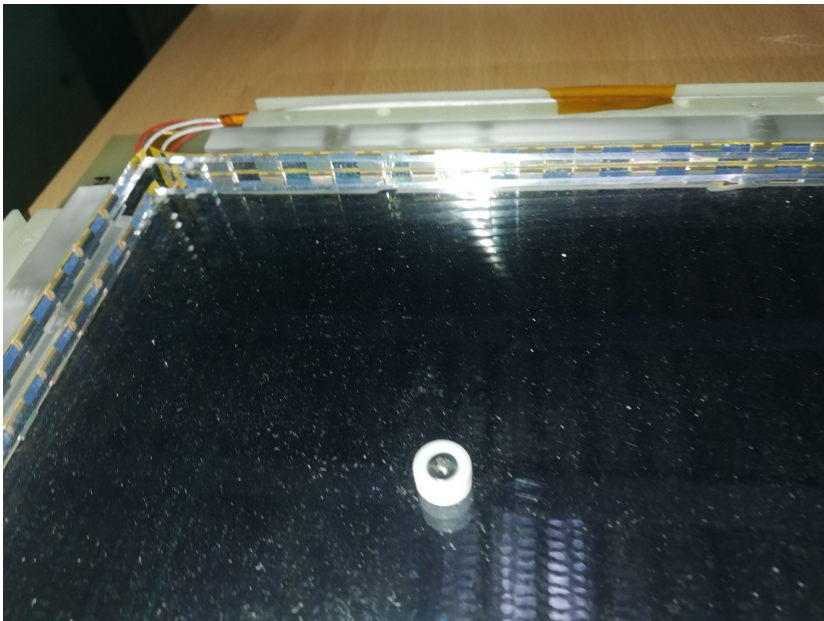
**overall best-case scenario (non-reflective and reflective configs.)*



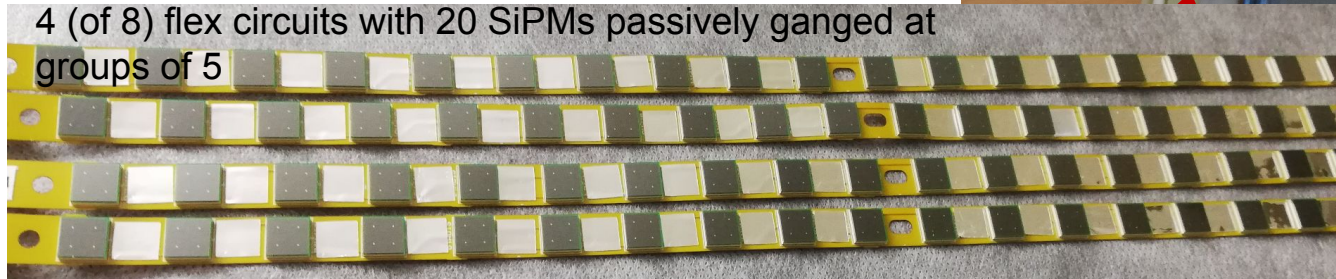
WLS plates for Module-0

- **Max Size: 625 x 625 x 4 mm³**
- Purchase Order for 20 laser cut plates is being issued by INFN-MiB to G2P company (funds available since yesterday)
- Production plans:
 - October: refurbishment and commissioning of the reactor for pDUNE_VD production
 - November: Production of 20 (16 + 4) units (spares and for tests at other institutions)
 - edge laser cut at an external Company (v1-to-v5) showed very good results
- **Expected Delivery: By end of November (w. edge dimples)**

V1: spring loaded SiPM-WLS

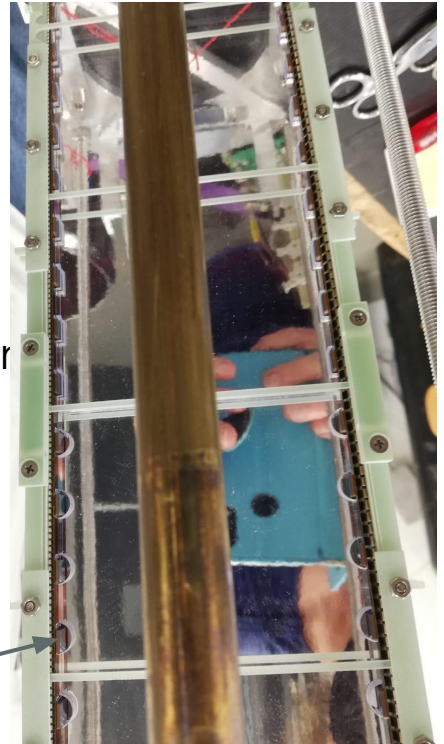


4 (of 8) flex circuits with 20 SiPMs passively ganged at groups of 5

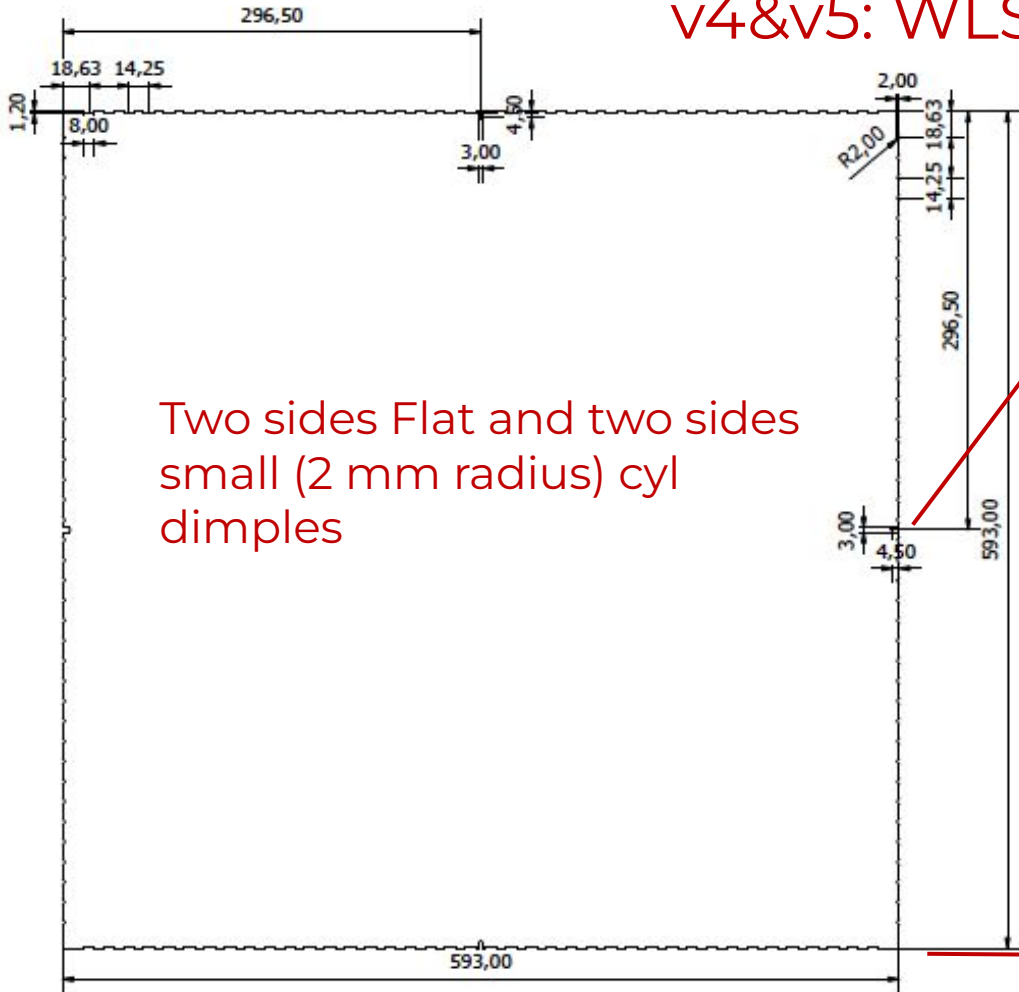


WLS plates for pDUNE: Edge dimples

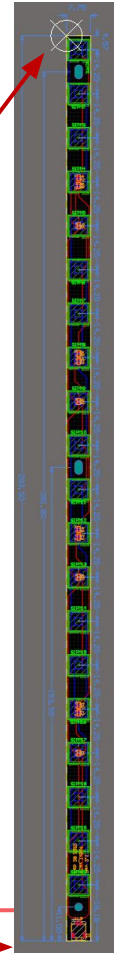
- Edge Dimples:
 - to improve the light extraction.
 - several shapes have been proposed/tested
 - sym & meas. prefer WLS with Viquity and small dimples
 - No conclusive exp. results yet available (neither from the CB program nor from test stands at home institutions)
- Measurements at MiB will resume hopefully on 11 October 2022 on a HD-SC with dimpled WLS
- **Decision on Dimple size and shape needed by mid of November.**
- Available and tested the SiPMS coupling to WLS with
 - flat edges (v1 and v2) laser cut
 - flat dimples v3 (2 sides glued, 2 sides spring loaded)
 - parabola dimples & flat (v4)
 - cyl dimples (HD-WLS plates)



v4&v5: WLS

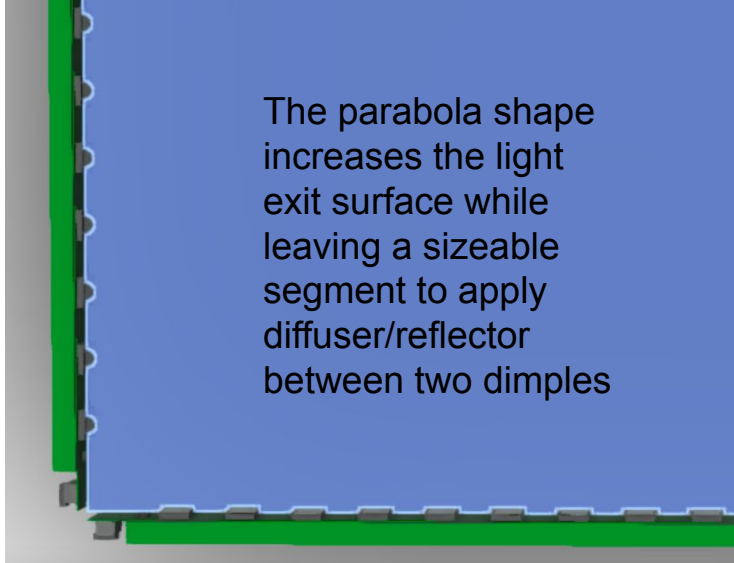


Two sides Flat and two sides small (2 mm radius) cyl dimples

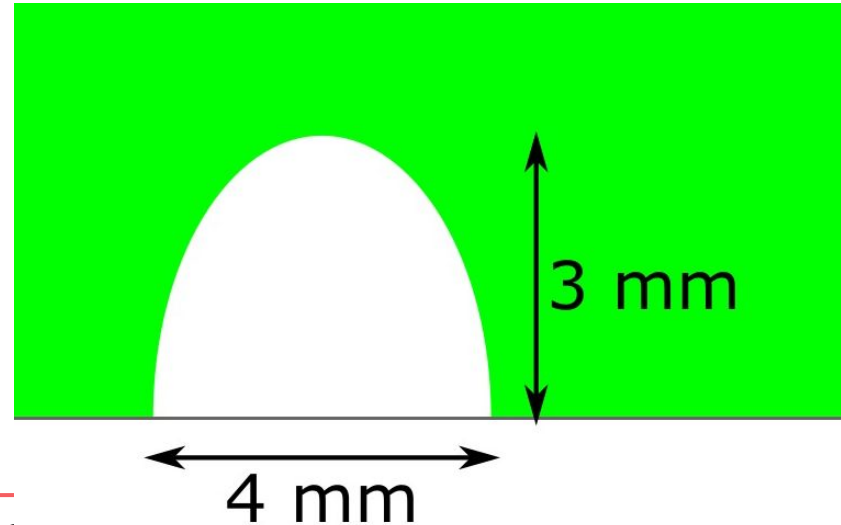


WLS plate for v4 and v5

- The 4th (of 5) plate produced in 2021 is being cut tomorrow
 - 2 sides flat
 - 2 side parabolic shaped dimples
 - plate size after laser cut 593 x 593 mm



The parabola shape increases the light exit surface while leaving a sizeable segment to apply diffuser/reflector between two dimples



Summary of P1, P2,P3,P4 deployed in 2022

	v1	v2	v3	v4
date	2021→ 2022	July 2022	August 2022	?
n. sides	1	2	1	?
WLS size	599 x 599	593 x 593	593 x 593	593 x 593
WLS edges	flat	flat	flat dimp 8 x 1.4	flat¶ dimpl
WLS-SiPMs	springs	vert. & horiz. spring	horiz. springs	?
SiPMs gluing	-	-	yes on flat dimpl	-
SiPms	Hamamatsu S14160			
Dichroics	Campinas/CSU 97 x 97 mm	Campinas/CSU 97 x 97 mm	Valencia/Photonex port 97 x 97 mm	MiB/ZAOT 202 x 97 mm

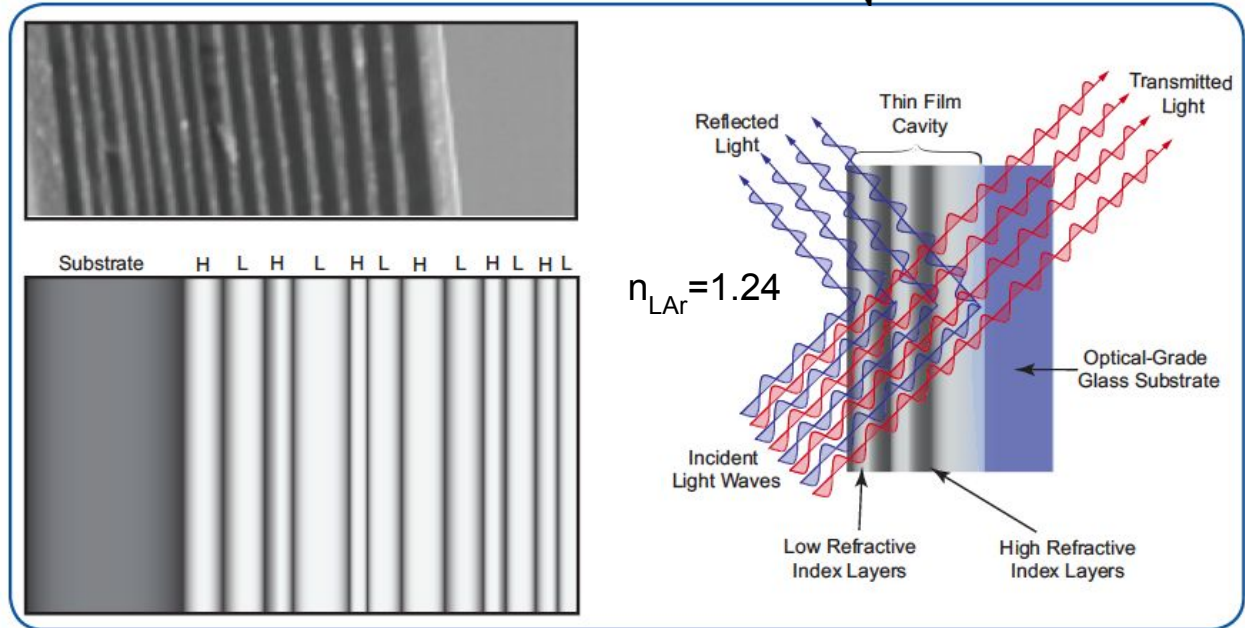
Dichroics

- Manufacturers:
 - **Photonexport** (Spain): 2 pilot production 97 x 97 size
 - **ZAOT** (Italy): 2 pilot production, 97 x 97, 100 x 95 (HD), 200 x 100 sizes
 - some differences in the ML number and adopted ML materials
 - PE: 30 layers; SiO₂ & ZrO₂
 - ZAOT: 36 layers; SiO₂ & HfO₂
- **Design defined so far in air:**
 - cutoff at 400 nm → 50% T_{max} @ λ 400 nm
 - Pass from T > 90% to T < 2% in 30 nm
 - T < 5% up to 500 nm and as low as possible for 420- 470 nm
 - AOI in air 40 to 60 deg

The structure of a Dichroics filter based on DML

- **Reflectivity:** $\rho^2 = \left| \frac{n_1 - n_2}{n_1 + n_2} \right|^2$ • *Cutoff dependency from refraction index*

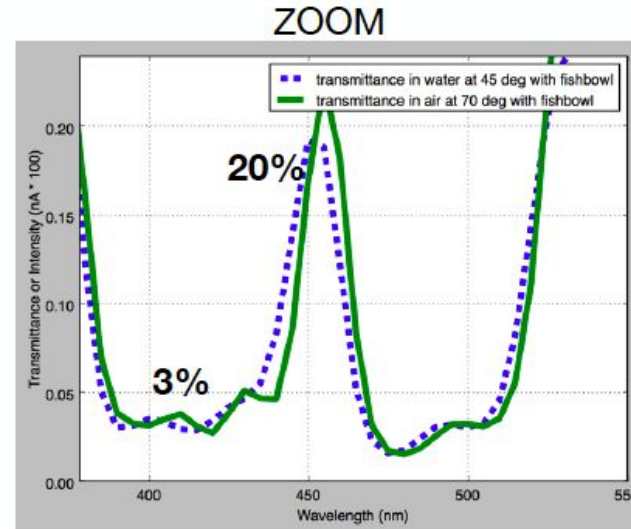
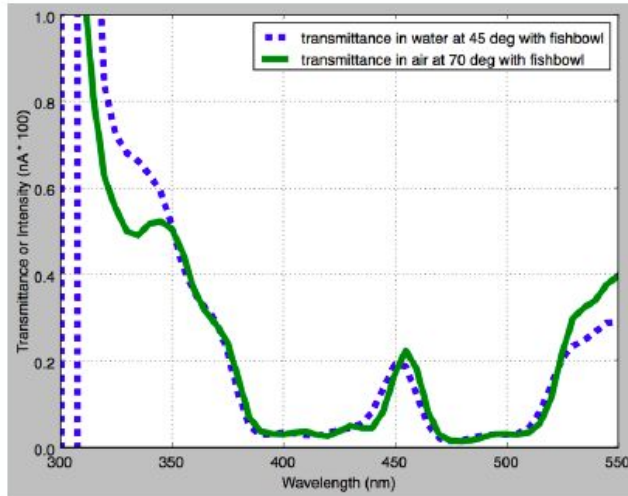
$$\lambda = \lambda_0 \sqrt{1 - \frac{n_1^2}{n_2^2} \sin^2 \theta^2}$$



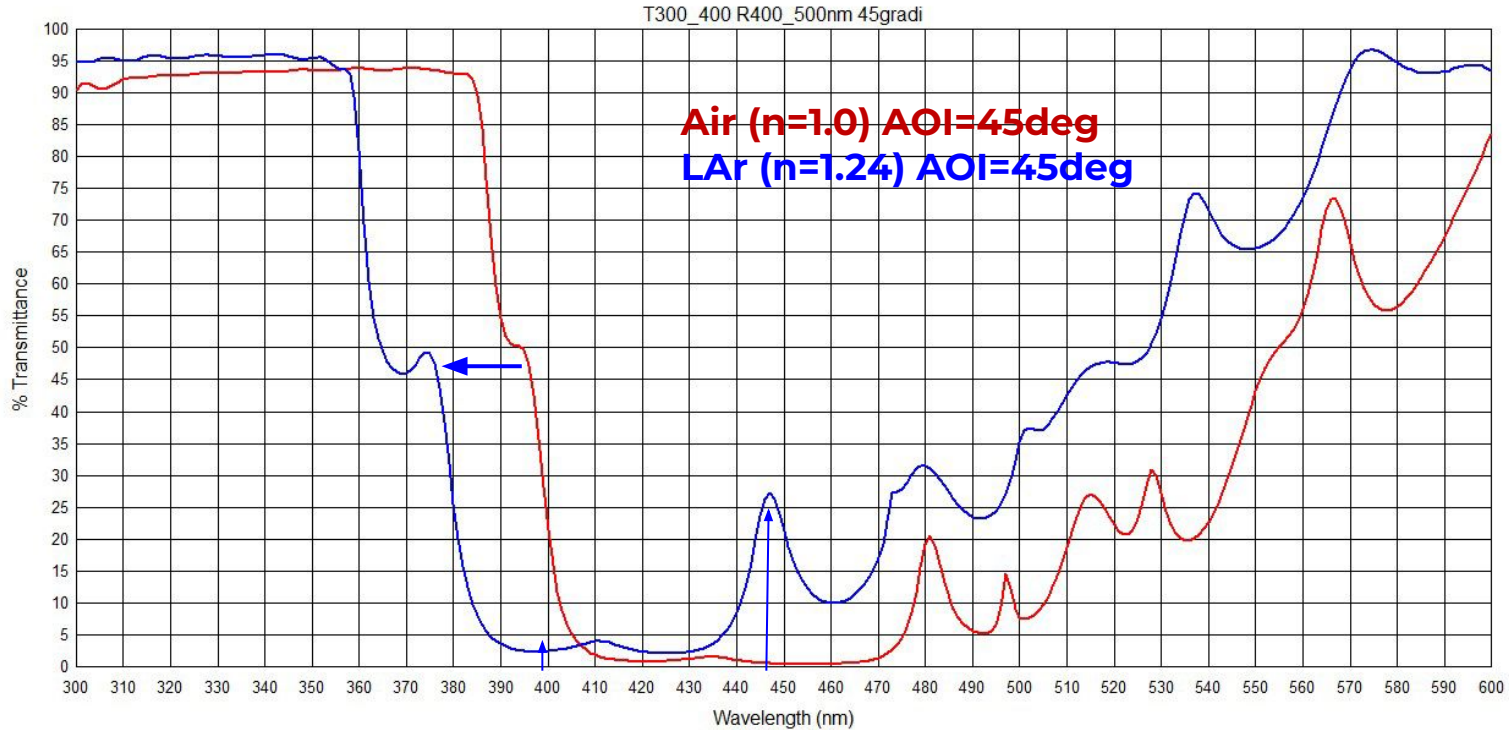
2. Reflexion loss at equivalent AOR

- We have done tests in water
- From Snell's law 70° in air corresponds to 45° water
- Similar behaviour above cutoff

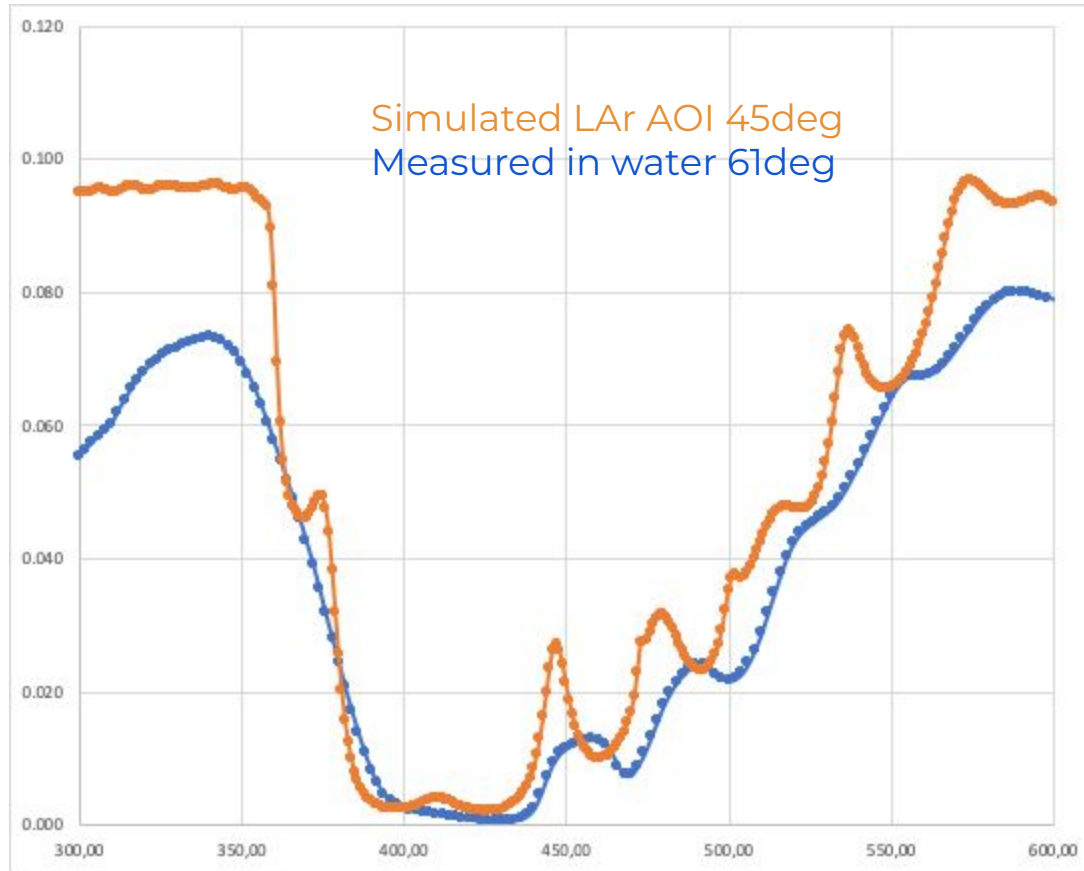
Measurements in H₂O (proxy of LAr)
 $n_{\text{H}_2\text{O}}=1.33$; $n_{\text{LAr}}=1.24$



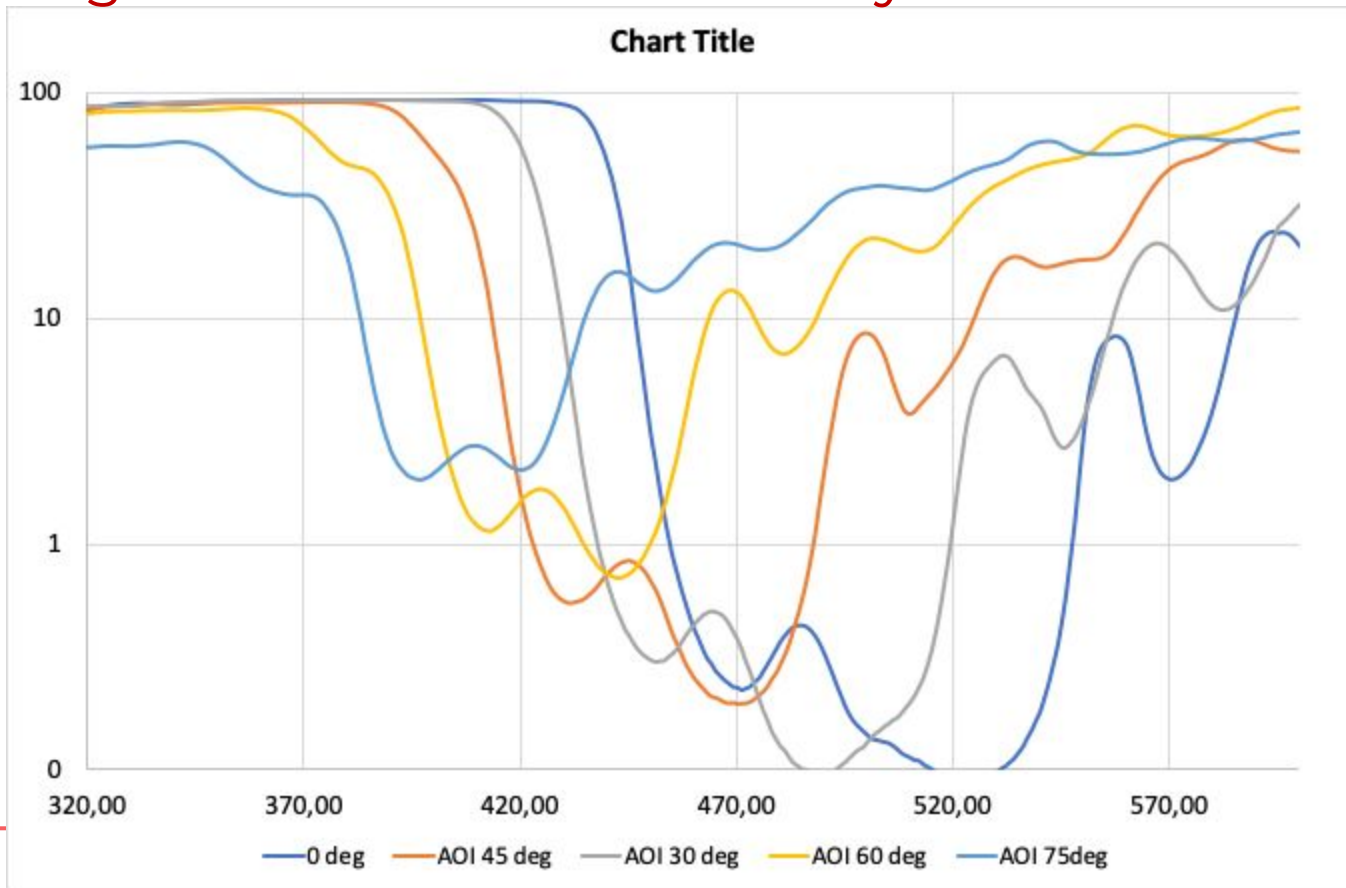
Impact of LAr vs Air design: ZAOT simulated T curves



Measurements at ScMat UniMiB

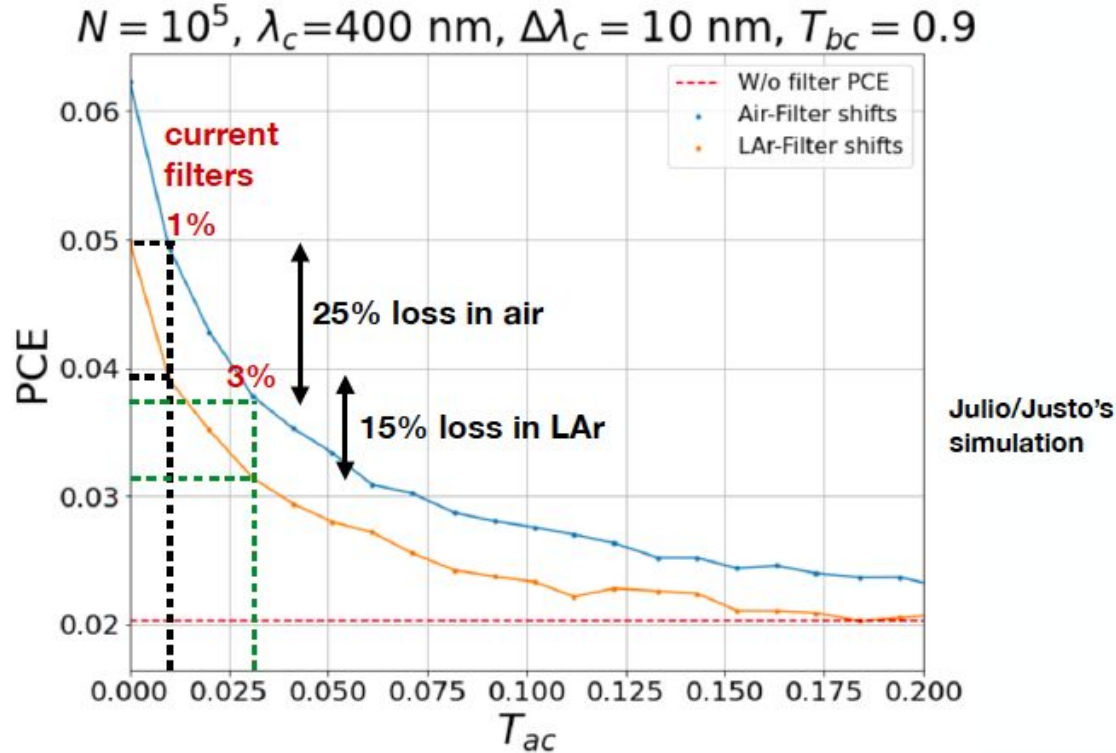


T vs wavelength for large size (202 x 97.5 mm) ZAOT dichroics glasses: measurements by ZAOT



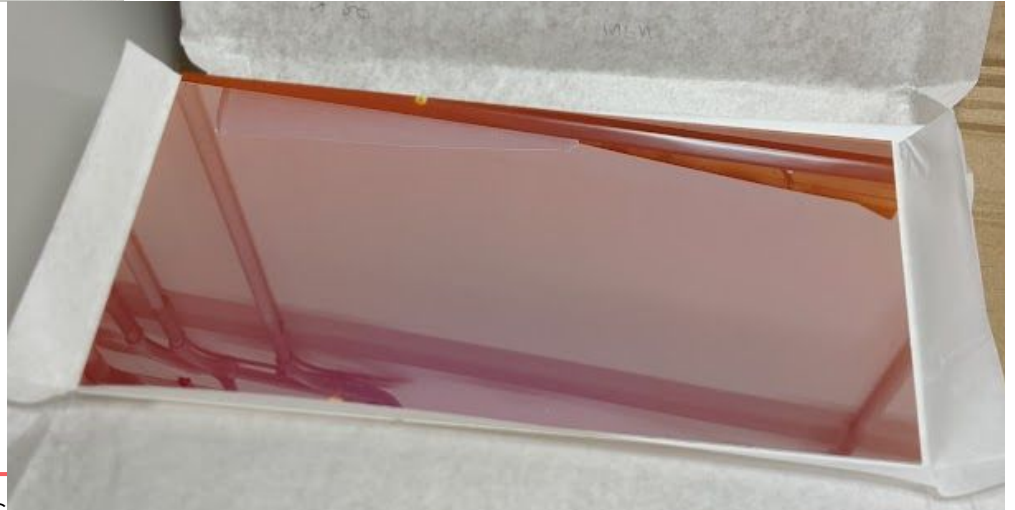
Impact of Transmission above cutoff: LAr vs Air design

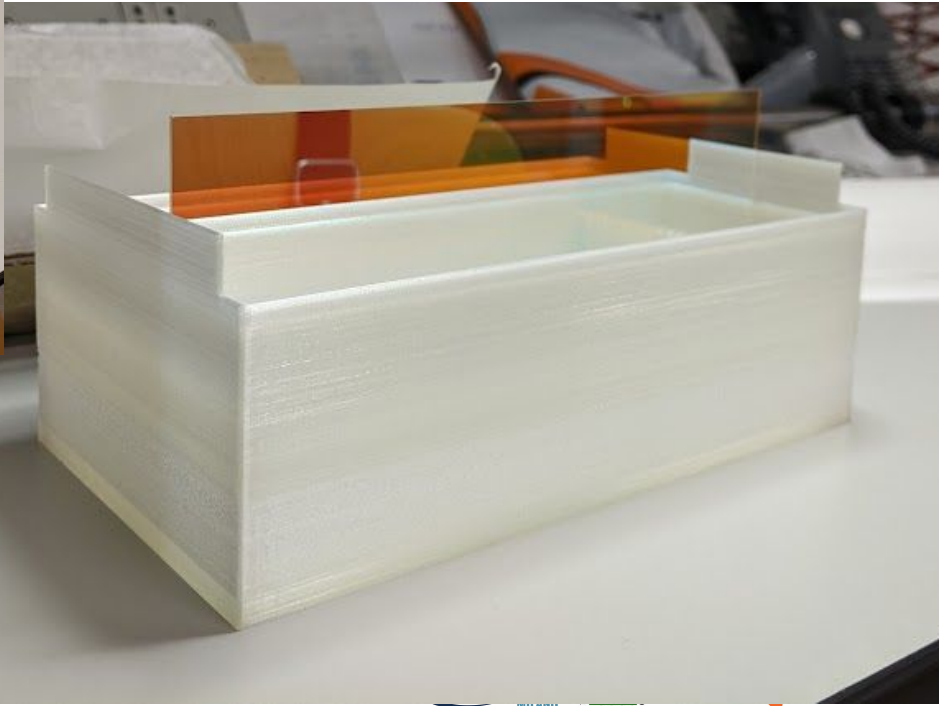
- 25% efficiency loss in air when going from 1% to 3% transmission
- 15% in LAr (for simplified trans. curves)





200 x 100 size
production at ZAOT
July 2022

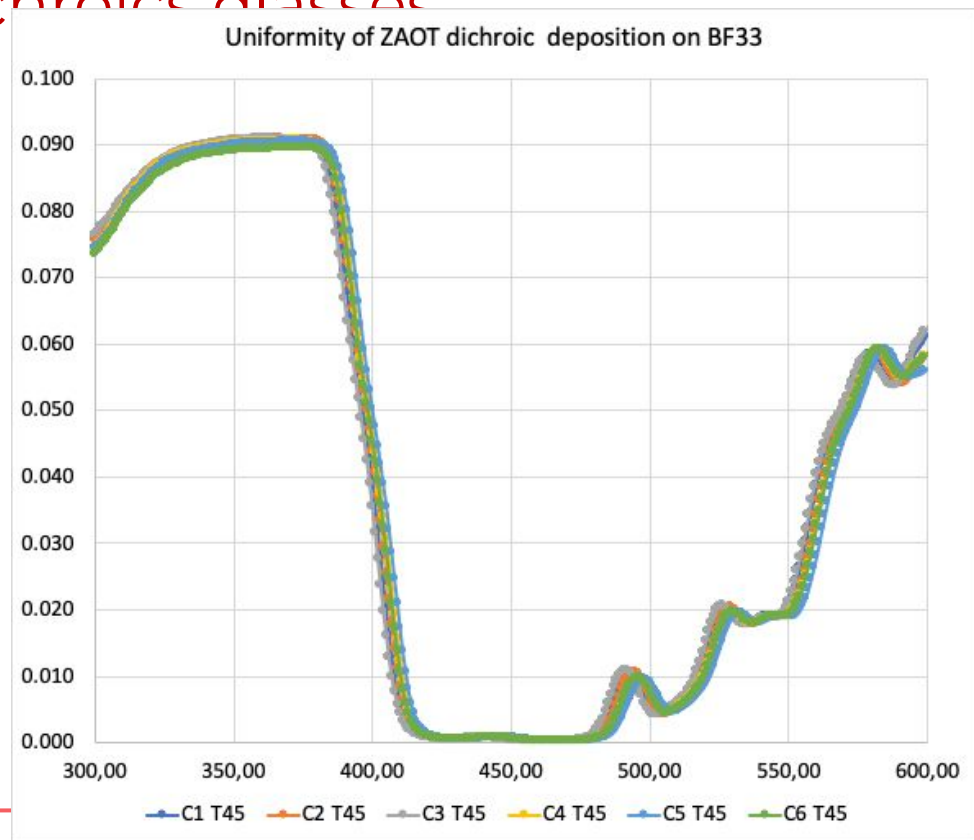
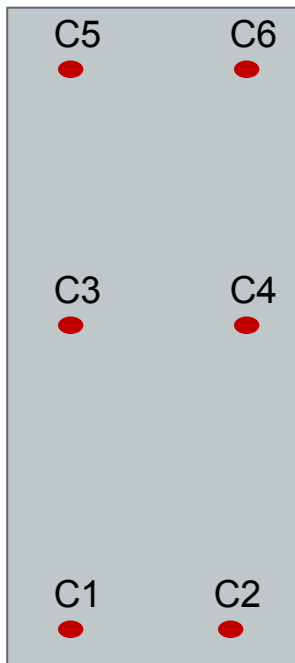




30/09/2022

C.M. Ca

Uniformity of T vs wavelength at 45 deg for large size (202 x 97.5 mm) ZAOT dichroic glasses



C.M. Cattadori

pTP evaporation capabilities @ Campinas

(agreed with Ana Machado)

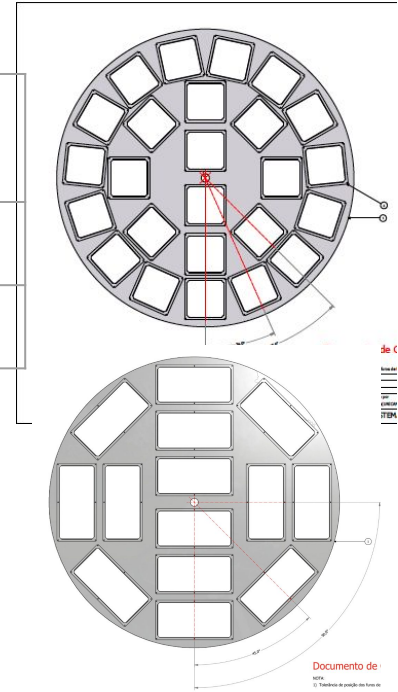
Size	glass/batch	n.batch/day	glasses/week	equivalent 2 sides XA-VD/week
97 x 97	25	2	250	3.5
202 x 97.5	14	3	210	5.8

Coating thicknesses:

- 430u/cm² central ring
- 340u/cm² middle ring
- 240u/cm² external ring

Coating periods:

- Nov29 to Dec19 2022
- Jan09 to Jan20 2023



Dichroics (Italy and Spain)

- ZAOT and PE company ready for Module-0 production with the suboptimal air design
 - half/full 430/860 production by mid November (4-5 weeks lead time)
- pTP deposition on critical path
 - Campinas facility is available
 - Manpower must be provided by us

v2 design optimization & production at PE and ZAOT

- Ongoing
- New design further optimized for LAr is expect by the end of next week
 - then must be tested and characterized by us
- Mass production should start in one week
 - Delivery by 15 November
 - → mismatch with the Module-0 schedule

A possible proposal for Module 0

- Re-use the existing dichroics from CBs plus extraproduction at ZAOT and PE
- Spain:
 - +14 glasses 97 x 97 mm²
- MiB:
 - 20 glasses 200 x 100
 - 48 glasses 97 x 97
- Re-use all the filters (144) of CBs v1->v3
- Total:
 - 144 + 14 + 48 = 198 glasses 97 x 97 mm² size
 - 20 glasses 200 x 100 mm² size
- Enough for all the 6 x (97 x 97) + 1 x (200 x 100) single side Membrane Modules
- New production w. new design of dichroics optimized in LAr for the 8 Cathode XA

XA Components

Component	Size/Number	Groups involved	Manufacturer	Criticality
Mechanics	660 x 660 16 units	CSU,IOWA,NIU (US)		Medium
WLS Lightguides	625 x 625 max 16 units	INFN-MiB,UniMiB (Italy)	G2P (Italy)	Low
Dichroics	200 x 100 150 x 150 97 x 97	CIEMAT, IFIC, UGR (Spain) INFN-MiB(Italy)	ZAOT	High
pTP coating		UniCAMP (Br)	UniCAMP	High
SiPMs	2560	CIEMAT, UGR,IFIC (Spain) INFN,UniMiB (Italy)	FBK,HPK	Medium
Flexes	128	UCSB,FNAL,INFN- MiB	??, SCEN	Medium

Conclusions: items on the critical path

- Dichroics still suboptimal design for LAr
 - Mass production may start in one week from now based on the present design and some optimization
 - 200 x 100 size seems to be the best option: optimize the mechanics, the pTP coating and both assembly time and procedures. Uniformity demonstrated, pTP evaporation disk available
 - two pTP evaporation time windows identified in Dec22 and Jan23
- Mechanics under optimization and downselection to minimize
 - electrical shield
 - light shield
 - passive vs active/reflective/diffusive surfaces
 - still in the downselection phase
 - two more prototypes will be deployed on 17-24 Oct22

Conclusions:

- Mechanics
 - design still under downselection
- WLS
 - downselect the dimple shape and size
- Question:
 - can we reuse dichroics from CBs prototypes without spoiling the CB program?