

# Status update of the ZAOT dichroics design & production for the VD-Module-0

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# 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	143 x 143 202 x 97.5 97 x 97	CIEMAT, IFIC (Spain) INFN-MiB(Italy)	PE ZAOT	
pTP coating		UniCAMP (Br)	UniCAMP	
SiPMs	2560	CIEMAT, (Spain), INFN,UniMiB (Italy)		
Flexes	128	UCSB,FNAL,INFN-MiB		

# Dichroics

- PE (Spain) LAr designed- Substrate: synthetic quartz
  - 143 x 143 mm → 16 per XA side
    - 64 → 4 Membrane
    - 128 → 4 Cathode units
    - Total of 192 glasses
- ZAOT (Italy) LAr designed. Substrate: optical glass BF33:
  - 202 x 97.5 mm → 18 per XA side
    - 36 → first 2 x Upstream Membrane units
    - 72 → first 2 x Upstream Cathode units
    - Total of 120 glasses
  - 143 x 143 mm → 16 per XA side
    - 32 → 2 x Top Downstream Membrane units
    - 64 → 2 x Downstream Cathode units
    - Total of 96 glasses

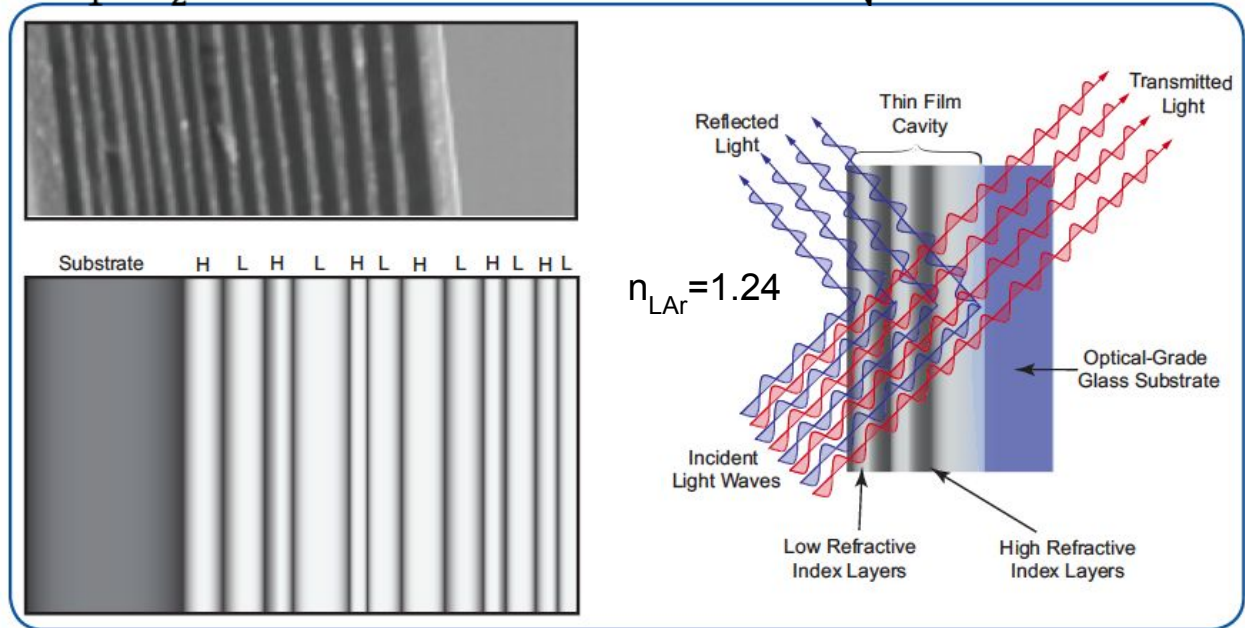
# The structure of a Dichroics filter based on MultiLayer structures

- **Reflectivity:**  $\rho^2 = \left| \frac{n_1 - n_2}{n_1 + n_2} \right|^2$

Dichroic ML operate as a Fabry-Perot interferometer

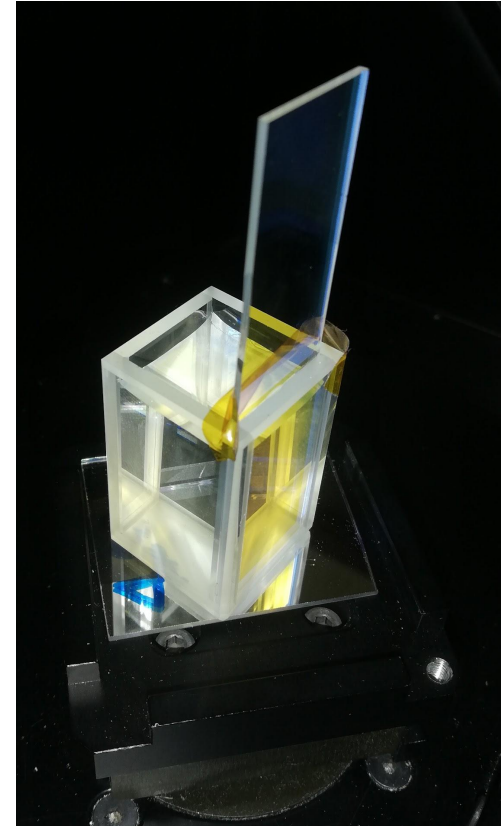
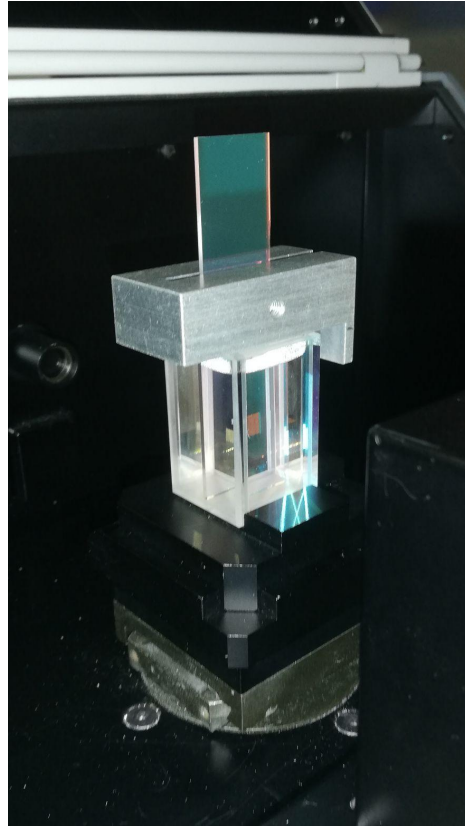
- *Cutoff dependency from refraction index*

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



# Measurements on ZAOT Dichroics ML coatings

- A slice of dichroic coated glass is located at the center of a 2 cm side vial (optical glass) filled with demi H<sub>2</sub>O
- The AOI of the glass w.r.t. the beam is changed by mean of a goniometer
- Measurements performed in a spectrofotometer



# Refraction of light generated in PMMA in LAr & Dichroics

Angle inc. at  
PMMA surf

$n=1.49$

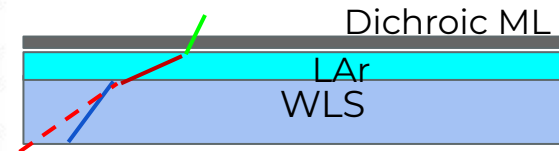
$n=1$

$n=1.24$

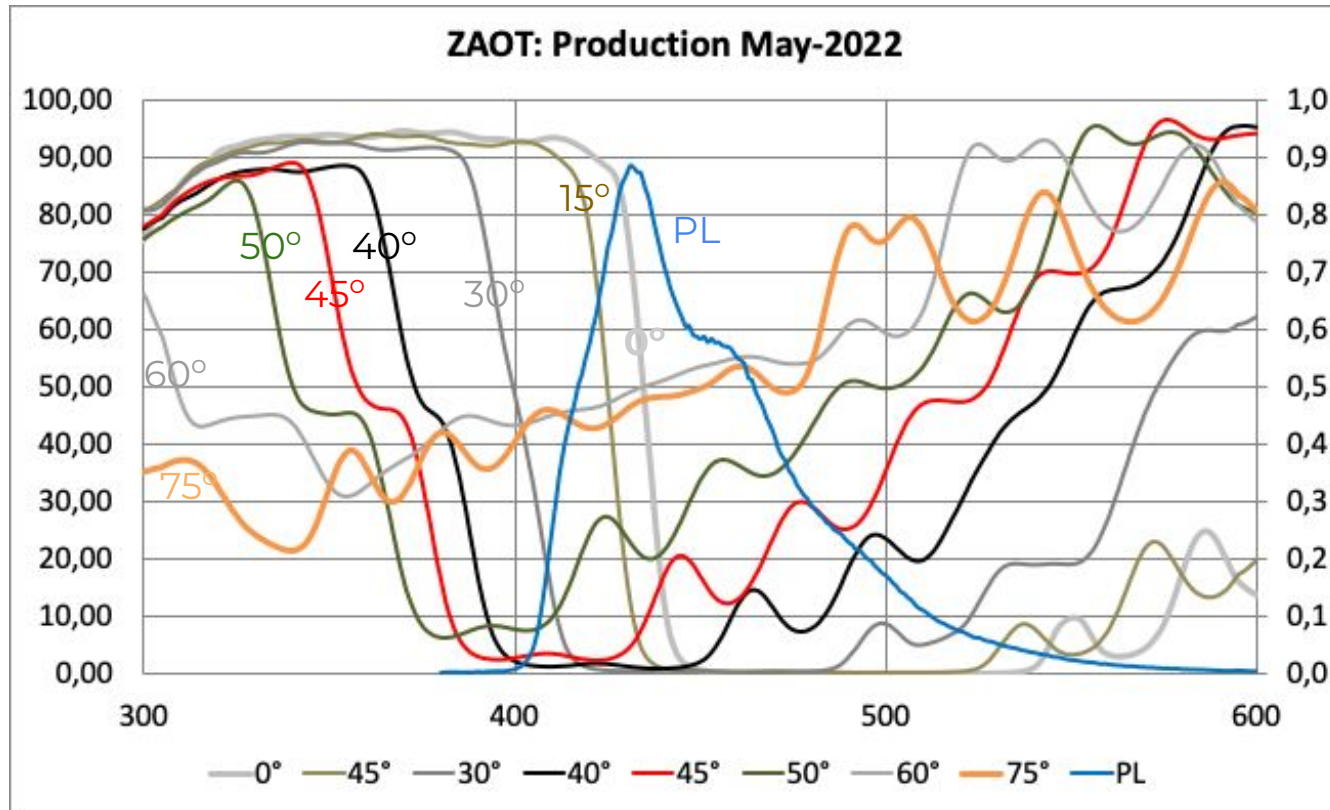
$n\sim 1.69$

Theta inc at	Refracted ang. in Air	Refracted ang. in LAr	Refracted ang. in Dichroic
0.00	0.00	0.00	0.00
5.00	7.46	6.01	4.41
10.00	15.00	12.04	8.81
15.00	22.68	18.12	13.19
20.00	30.64	24.27	17.55
25.00	39.03	30.52	21.88
30.00	48.16	36.93	26.16
35.00	58.72	43.57	30.38
40.00	73.29	50.57	34.52
42.15	89.19	53.74	36.27
45.00		58.18	38.57
50.00		67.00	42.48
55.00		79.83	46.24
56.00		84.99	46.96
56.33		89.61	47.20

- below  $\theta_{crit}$  → refraction
- above  $\theta_{crit}$  → TIR
- $\theta_{crit}(\text{PMMA-LAr}) = 56.3^\circ$
- $\theta_{crit}(\text{PMMA-air}) = 42.2^\circ$
- → PMMA lightguide is less tight in LAr than in Air
- more light exit in the LAr and should be reflected back by dichroic ML

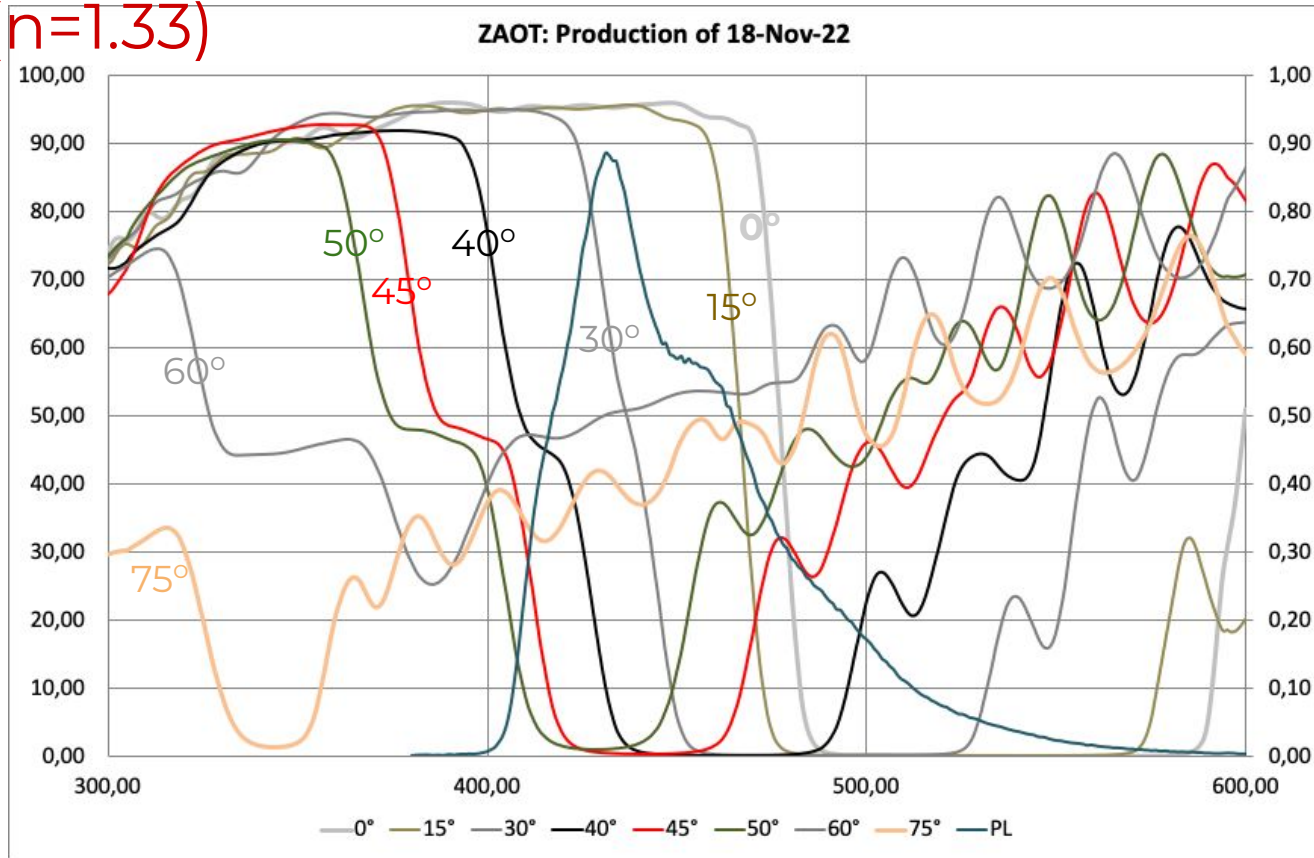


# Production May-22, measurements in H2O (n=1.33)



- Designed for AOI= 45° in air, as OPTO
- Good “closure” for small AOI:15°-40°
- Bad closure for AOI>50°
- Mounted on Cold Box v4&v5
- Mounted and measured on the PDE MiB setup (see C. Brizzolari talk)

# Production 18-Nov-2022 - Measurements in water (n=1.33)

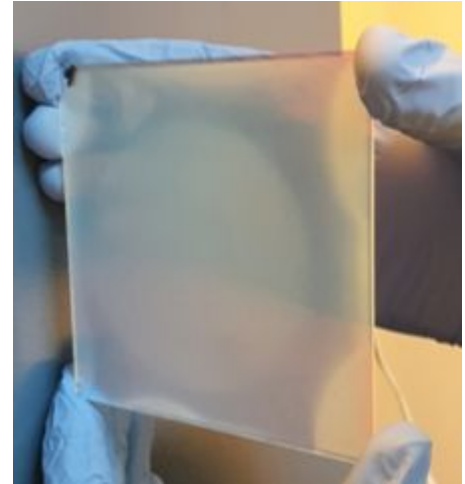


- Designed for AOI= 45° in LAr
- Good “closure” for intermediate AOI: 40°-50°
- Bad closure for AOI>50°
- LAr design → narrower reflectivity dip → the PL spectrum is barely fully contained



# Problems of parasitic ML coating reported by Campinas

- The Campinas group reported the appearance of an halo after pTP evaporation: this for all the three sizes (202 x 97.5, 100 x 77, 97 x 97) produced by ZAOT.
- This has to be attributed to parasitic ML deposition on the top face of the glass
- The ZAOT has improved the sealing of the evaporation mask
- The pilot production showed no parasitic coating
- Problem seems solved
- The glasses will be ultrasound cleaned after dichroics deposition, hence will arrive in Campinas ready for pTP evaporation
- Serendipity finding: the parasitic deposition makes the pTP layer very well attached to the glass



# Dichroics

- PE (Spain) LAr designed:
  - 143 x 143 mm → 16 per XA side
  - delivery by 12/12/2022 of 160 units for 4 Membrane + 4 Cathode
- ZAOT (Italy) LAr designed:
  - 202 x 97.5 mm
    - 36 → first 2 x Upstream Membrane units delivery by 25/11/22
    - 72 → first 2 x Upstream Cathode units delivery by 29/11/22
    - Total of 120 glasses
  - 143 x 143 mm
    - 36 → 2 x Top Downstream Membrane units delivery by 20/12/22
    - 72 → 2 x Downstream Cathode units delivery by 20/11/22
- ZAOT will produce a set of 100 x 77 mm dichroics for PDE measurements of the new production with our PDE setup
- Proposal: ask PE/IFIC to produce a batch of at least 3 x (100x 77 mm) glasses

# pTP evaporation capabilities @ Campinas (agreed with Ana Machado)

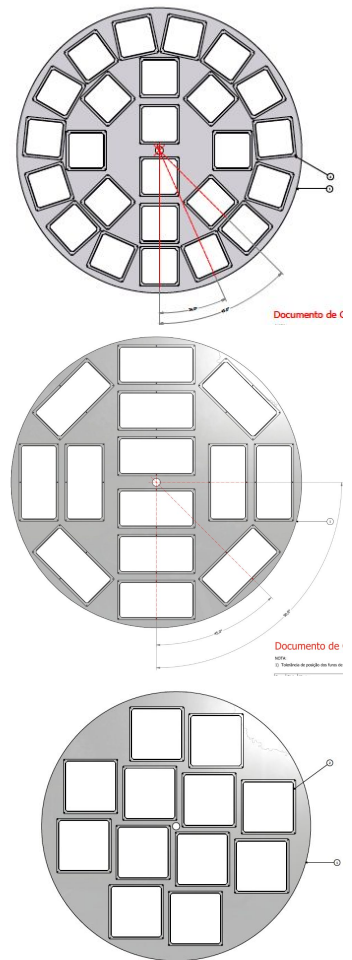
Size mm x mm	glass/batch #	n.batch/day #	glasses/week #	equivalent 2 sides XA-VD/week
97 x 97	25	2	250	3.5
202 x 97.5	14	3	210	5.8
150 x 150	12	3	180	5.6

## Coating periods:

- Nov29 to Dec19 2022
- Jan09 to Jan20 2023

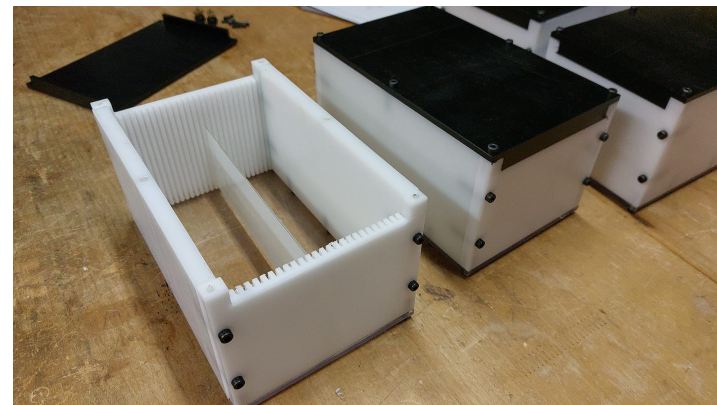
## Coating thicknesses:

- 430u/cm<sup>2</sup> central ring
- 340u/cm<sup>2</sup> middle ring
- 240u/cm<sup>2</sup> external ring



# Conclusions

1. The production of ~120 LAr designed ML dichroics deposition on 202 x 97.5 mm glasses is ongoing at ZAOT. Parasitic dichroic deposition solved. US Cleaning
2. delivery in two batches by the end of November: after the QC they will be immediately shipped in transport boxes to Campinas for pTP evaporation
3. Campinas will ship back the pTP filters to CERN
4. PE will deliver the filters in one batch by 12 December 2022: they will be immediately hand-carried to Campinas for the pTP evaporation. They will be hand-carried back from Campinas to CERN
5. The LAr design at ZAOT produced improvements in the range 40-50 deg, good optical density, but much narrower reflectance dip.
6. Curves are available for syms
7. The december production can be further optimized (new design)/go back to May 2022 production



# Tentative Plan Little Contingency (Carla)

To be checked with ZAOT if they can produce 170 filters in November

	Oct 22	November 22				December 22				January 23			
	4	1	2	3	4	1	2	3	4	1	2	3	4
ZAOT:													
design	█			█	█								
production		(32+128)x(143.8x143.8)				????							
QC & delivery			█					█					
shipping					█				█				
pTP coating						█					█	█	█
delivery at CERN							█					█	█
PE: 150 x150													
design		█	█										
production					64 x (150 x 150)				128				
QC & delivery						█							
shipping							█			█			
pTP coating							█				█	█	
delivery at CERN												█	█