Optical Components - WLS bars, filters and coatings

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DUNE SP-PDS 60% review

06/18/2020

UNICAMP

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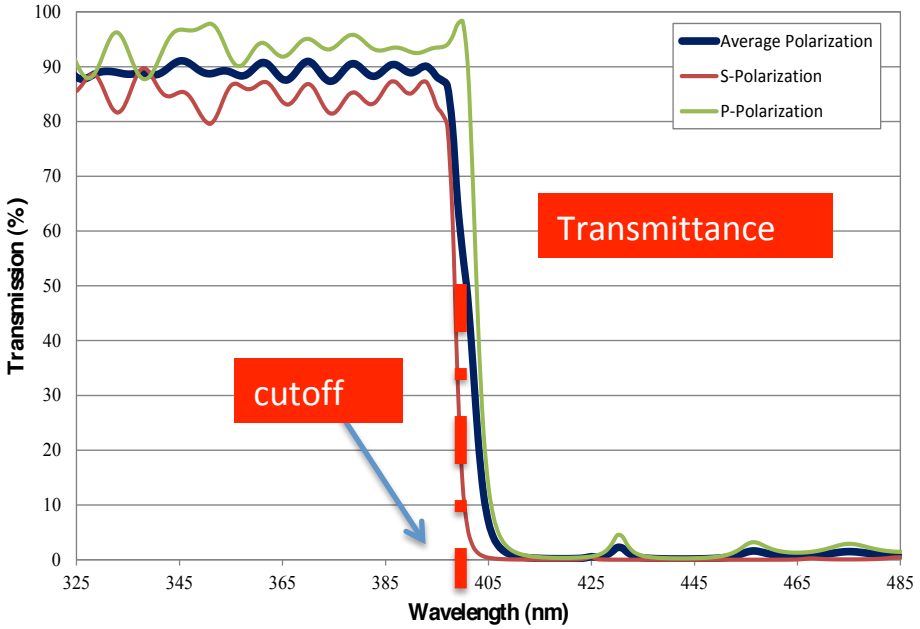
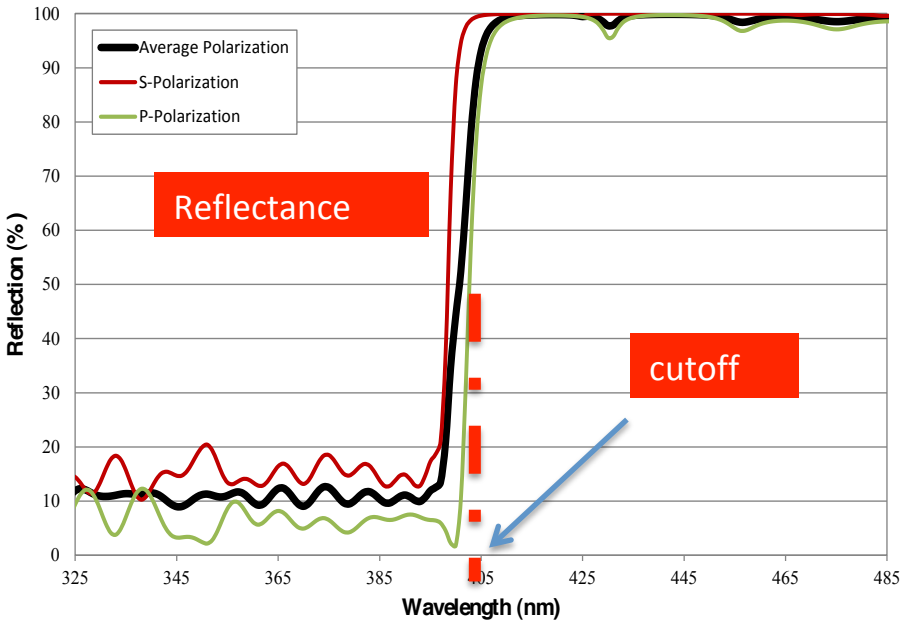
- Optical Filters
  - Substrate choice
  - Production
  - Tests
- WLS bars
  - Tests of different matrixes
- Internal reflector – 3M VIKUITI –
- Coatings
  - Productions

Optical Filters

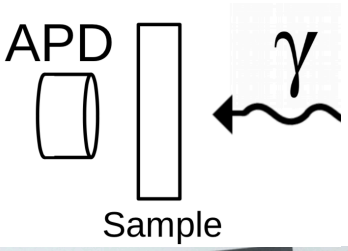
The optical filters needs to have the following characteristics:

- Transparent to wavelengths bellow the filter cutoff
- Reflective for wavelengths above the filter cutoff
- Designed for Angle Of Incidence of 45 degrees

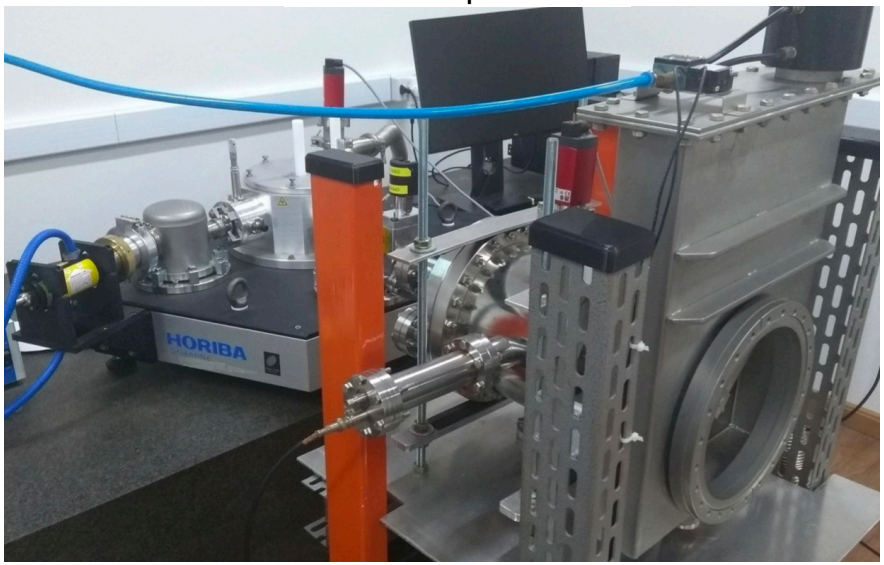




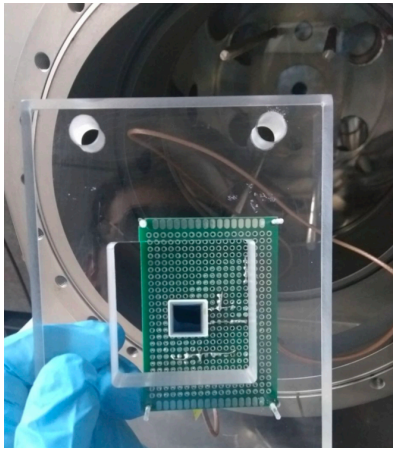
Substrate analysis

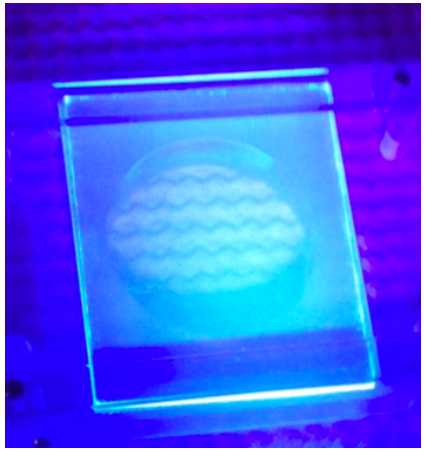


- A test setup designed to perform comparative measurements of different filter substrates produced by Opto Electronics company.



- **Fused Silica** and an **Optical Glass (B270)** were tested using a Deuterium light source monochromator (emission 120 - 400nm) and a Si APD S8664-1010 (sensitive between 320nm -/ 1000nm)

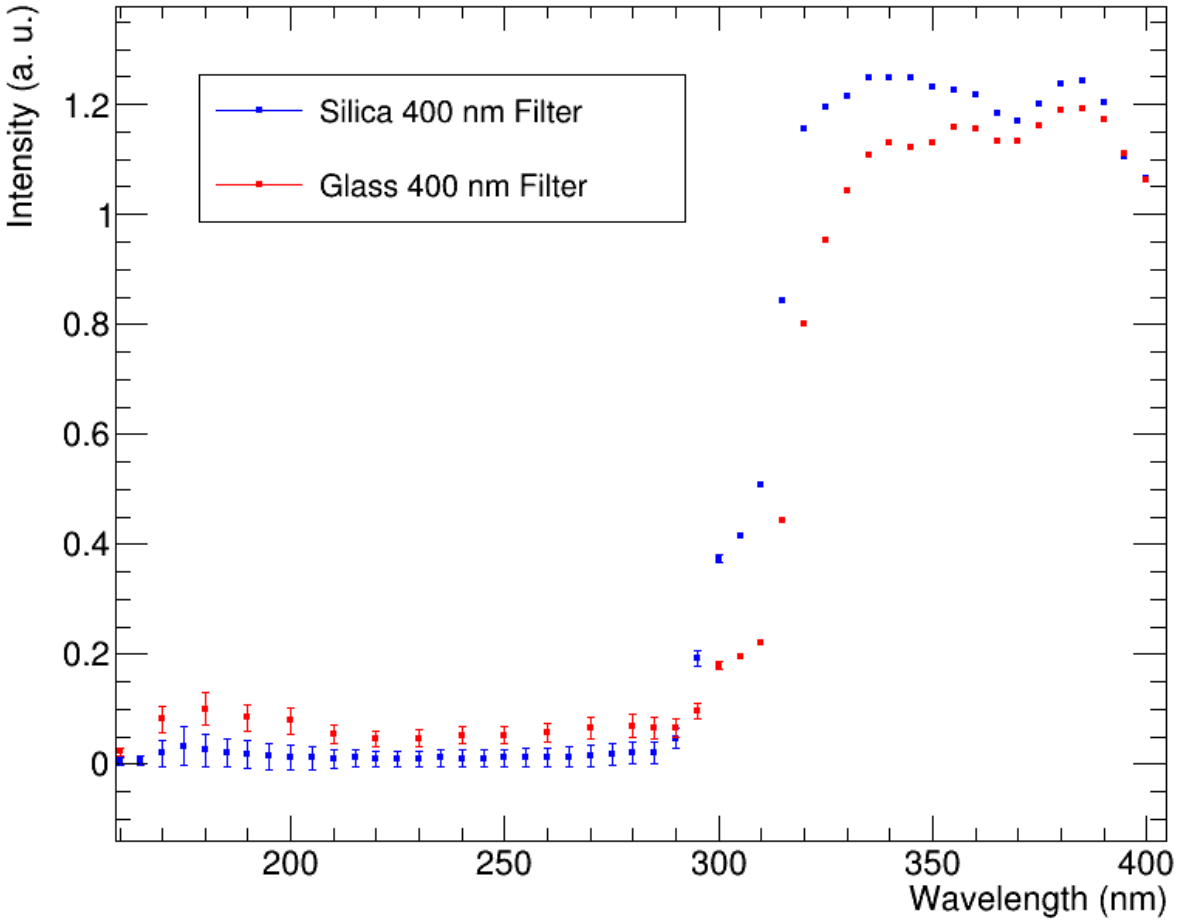




- Cutoff 300nm
- Calibration: direct light to APD

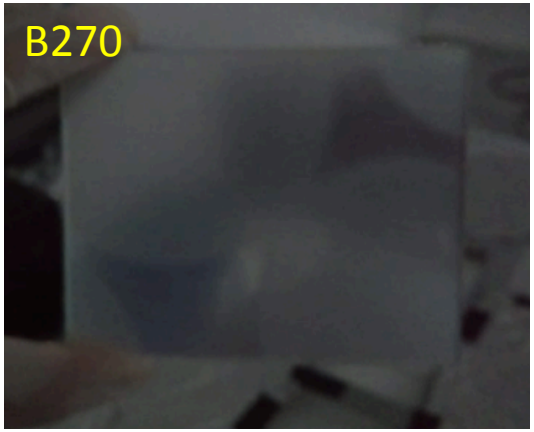
Results

- Above 350nm the transmittance spectrum of the two samples is similar.
- The **adhesion of pTP** on both substrates, and robustness of the film in LN_2 investigated. No differences were identified.
- B270 selected as baseline since it is much **cheaper** than fused silica and shows **the same level of performance** in the relevant wavelength range



Opto Filters - First Batch

- The first samples of filters were made of B270 (optical glass) and fused silica
- After the cleaning process and the evaporation with p-TP a circular structure appeared on both samples:

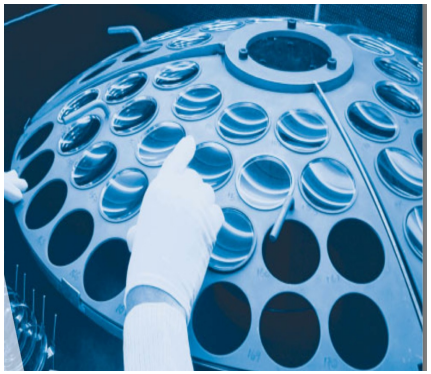


Several tests was done at CTI:

(Chemical hood, muffle, wettability and adhesion tests)

- The problem was not due to the cleaning procedure or pTP evaporation.

Commercial sputtering deposition system with sample holder with circular patterns



opto
OPTO ELETRÔNICA SÃO CARLOS S/A

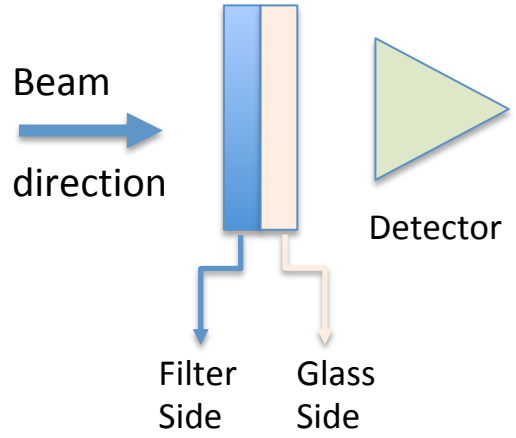
- Opto company changed this disc
- New filters are perfect !!!

Production

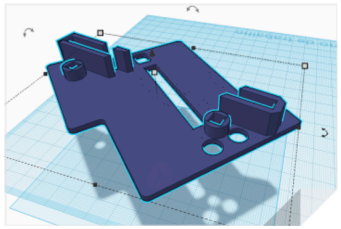
Date	#	Coated	Visual Inspection	
09/16/2019	23	09/18	Circular halo	
10/25/2019	12	10/29	Visibly perfect after coating	2 Lab Leptons 2 Milan 4 CERN 4 Syracuse
11/07/2019	30	11/08	10 coated - ok	18 FNAL 2 Milan
		11/11	11 coated - ok	
11/19/2019	130	----	---	---
12/03/2019	40	----	---	1 UV-VIS tests

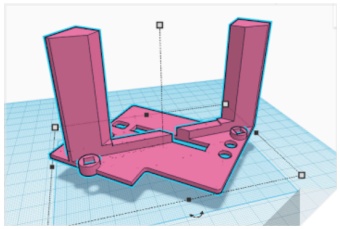
Tests @ UNICAMP

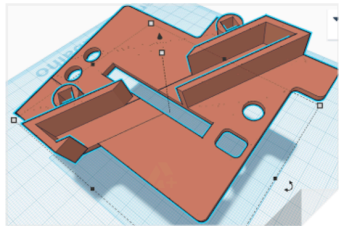
UV-VIS spectrometer Perkin-Elmer



- Reflectivity (8 angle from incidence beam)
- Transmittance (different angles) : 3D print support





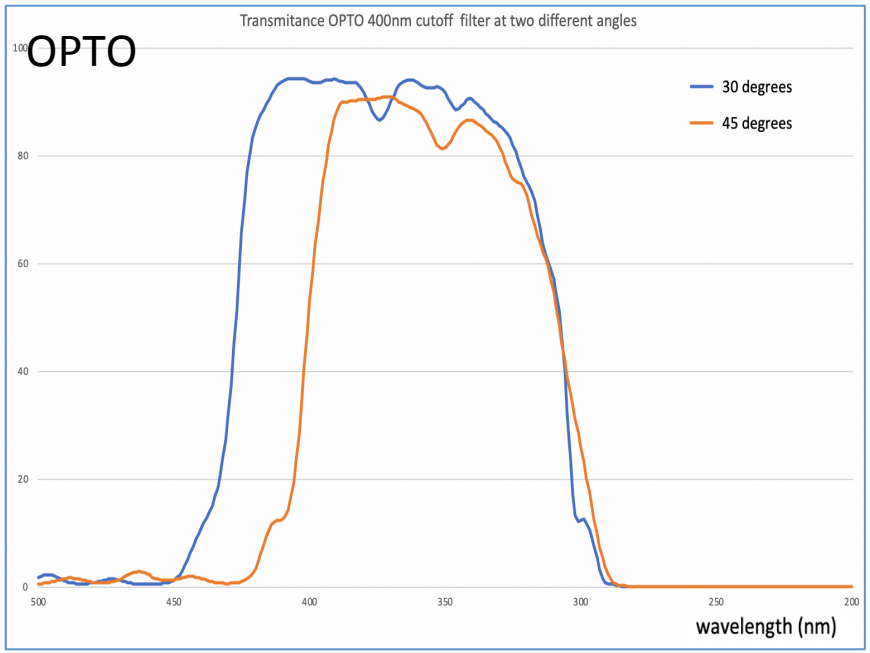


Courtesy of Frederico DeMolin

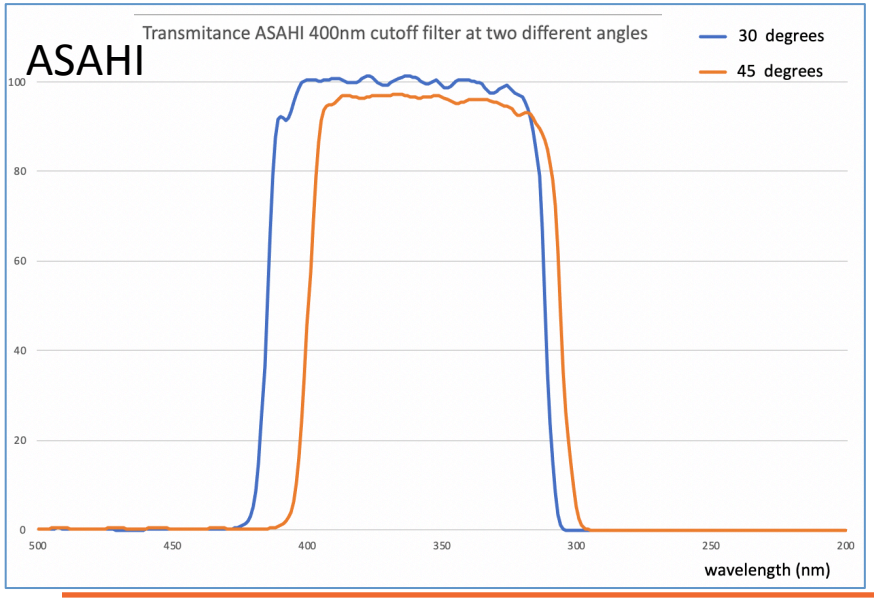
- Humidity and Temperature controlled
- Samples:
- Filters from OPTO, OMEGA and ASAHI

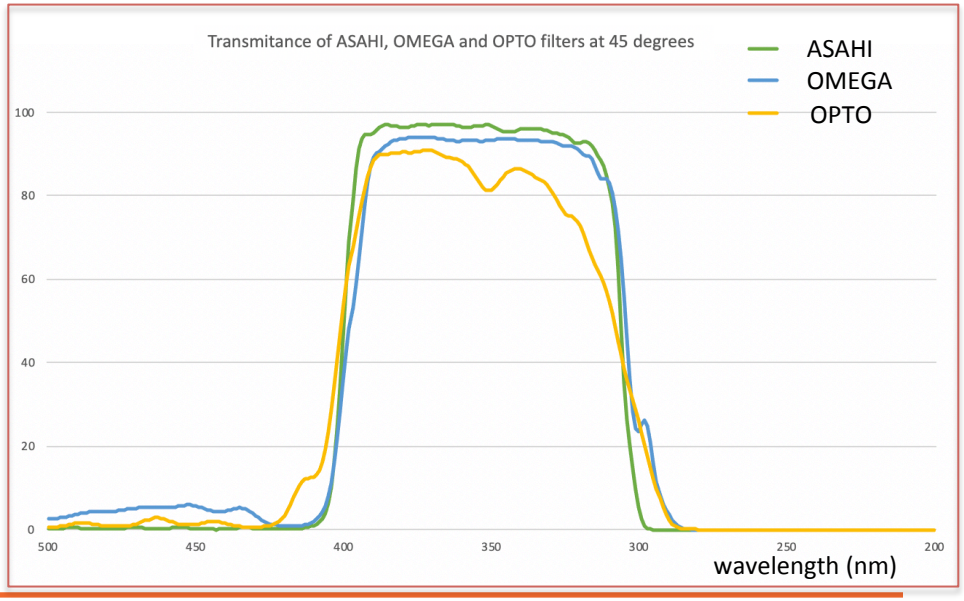
  400nm cutoff

Transmittance



- The design of OPTO filters is inspired to the ASAHI and OMEGA ones.
- OPTO will increase the number of layers in order to reach the optical performance as ASAHI and OMEGA
- OPTO was chosen due to ease of communication between industry and university, and the very competitive cost.

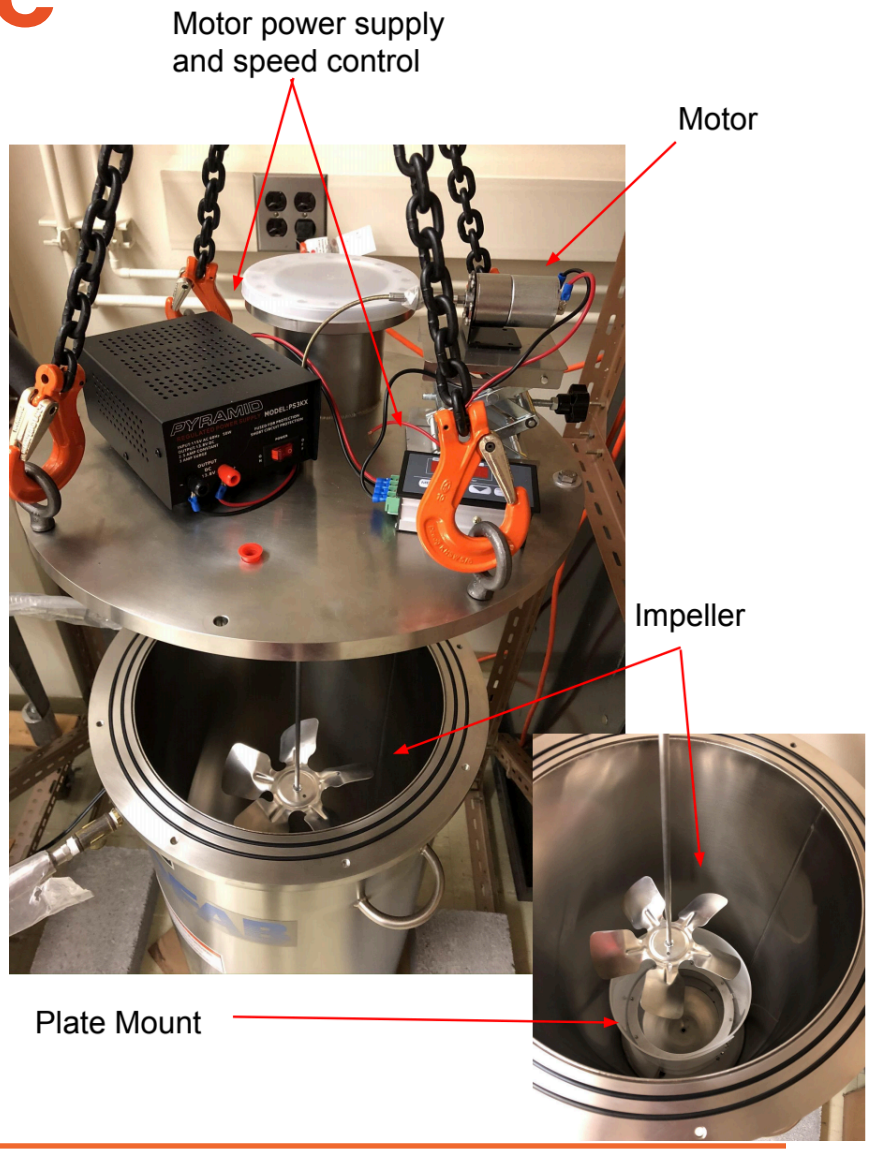




Tests @ Syracuse

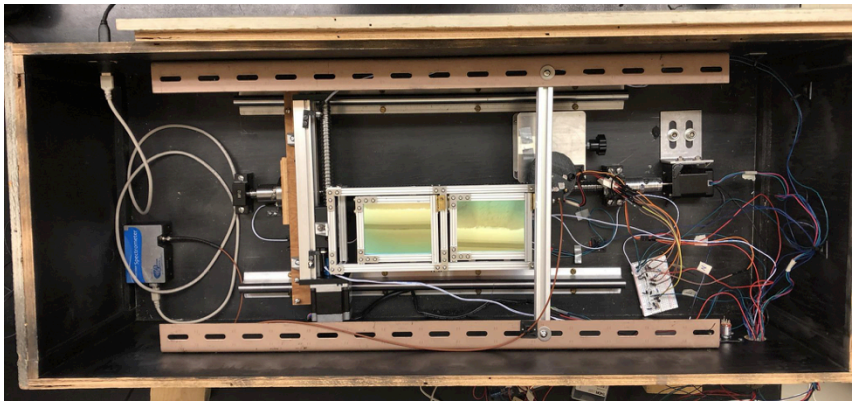
By Denver Whittington & Kyle Spurgeon

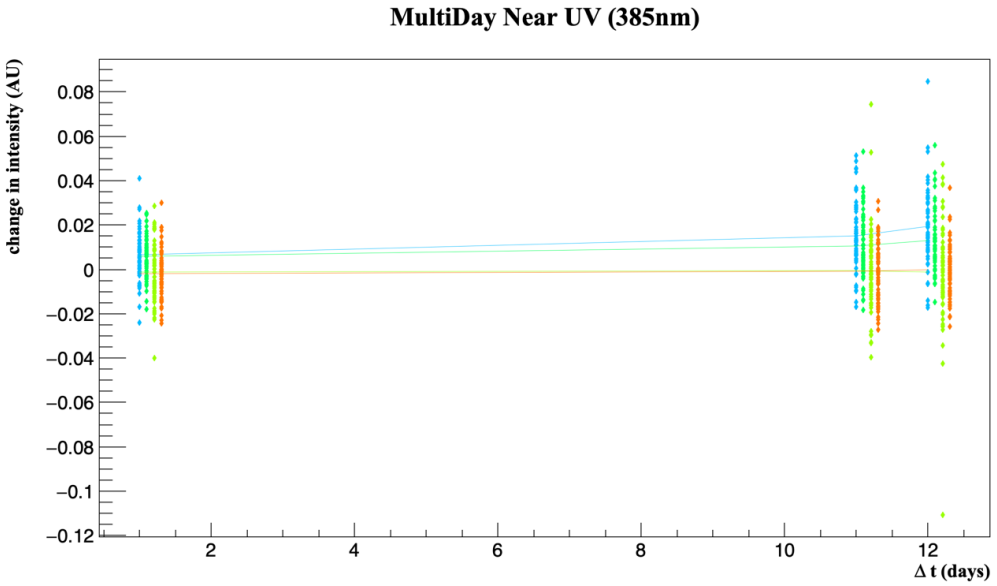
- Goal is to analyze the resiliency of pTP filter coating in flowing argon
- Test Setup - 74L LAr cryostat with a frame suspending the coated filters
- Periodically inspected for degradation in their opacity, transparecy and WS response
- ~10X the flow of the far detector to simulate stress over a long period
- DarkBox with a visible light (near UV) for scanning.
- Will submerge in Ar for 1 week as soon as COVID-19 shutdown ends (July)

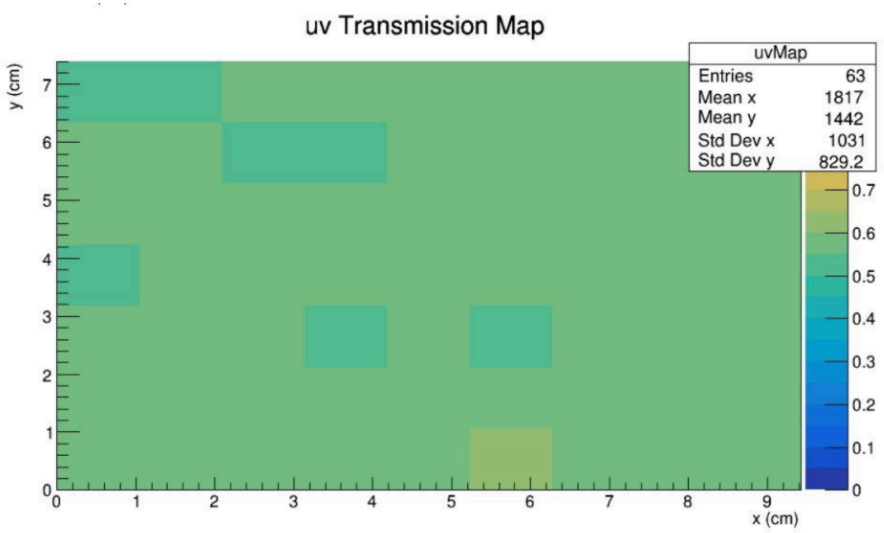


Dark Box test and results

- Three LEDs have been setup to illuminate a single spot on the plate at 0° (385nm, 430nm, 610nm)
- Spectrometer to detect the outgoing light.
- 63 point scanning procedure





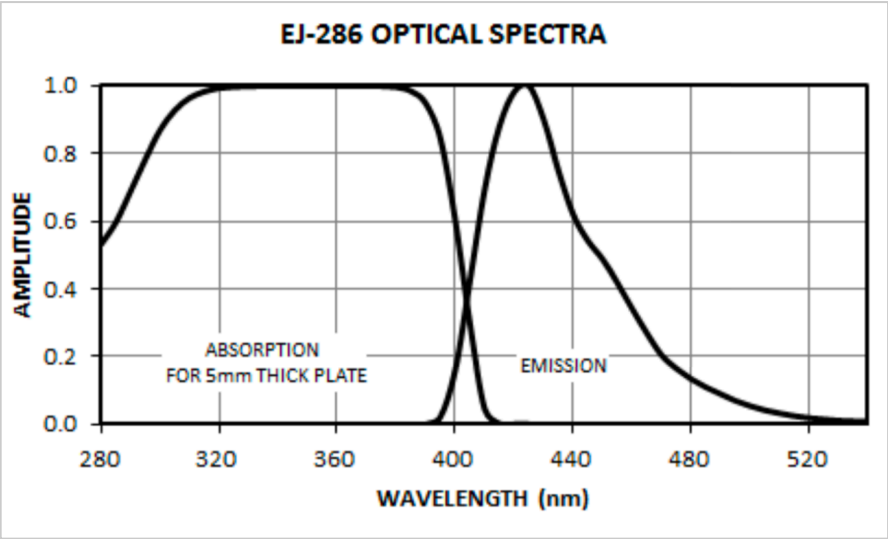


WLS bars

Tests ELJEN light bars

- LN2 immersion
  - PVT substrate
- Annealing @ FNAL
- LN2 controlled immersion
  - PVT and Polystyrene substrate

Baseline for DUNE
- ELJEN (EJ286) comercial Blue emmiting WLS plate
- Peak wavelength 425nm
- Matrix **polystyrene**



LN2 immersion test

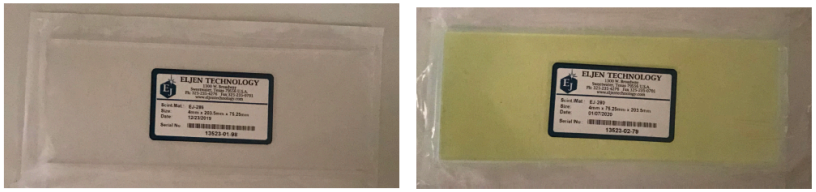


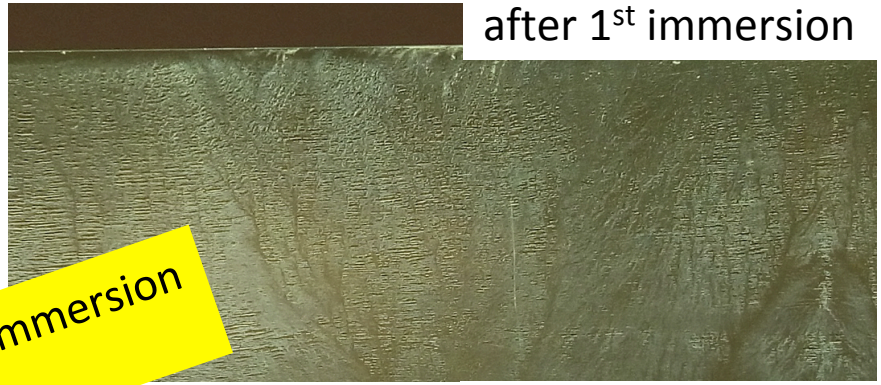
Fig. 1 – EJ286 (left) and EJ280 (right).

Samples: Blue (EJ286) and Green (EJ280) WLS emitters from ELJEN.

The matrix substrate is a polymer base: Polyvinyl Toluene (**PVT**) - same used in few R&D setups: ICEBERG , Xe Test at CERN and single cell X-ARAPUCA at UNICAMP

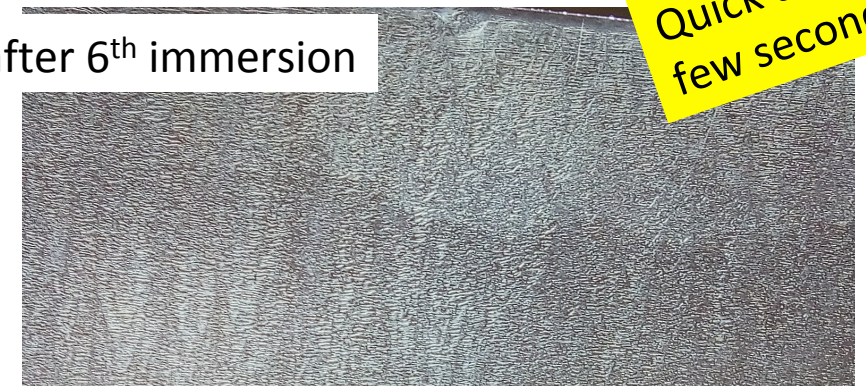
after 1st immersion

after 1st immersion

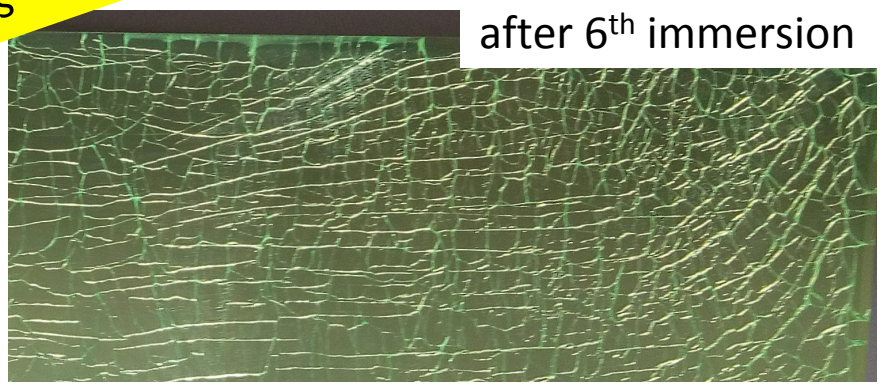


Quick dunk immersion few seconds

after 6th immersion

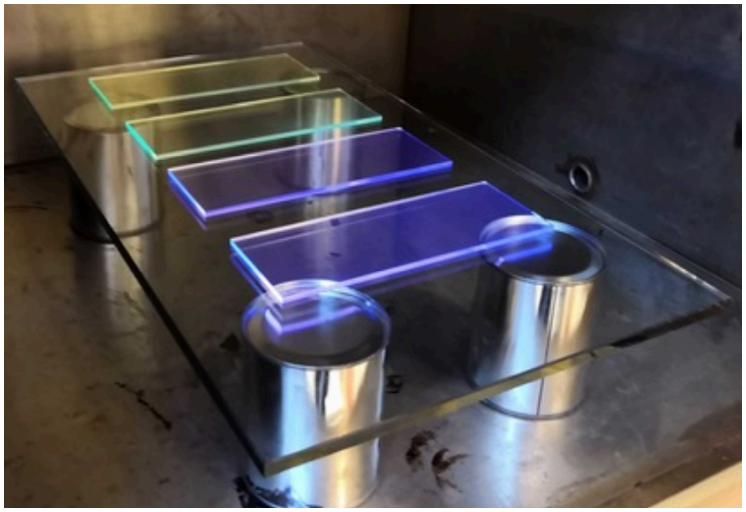


after 6th immersion



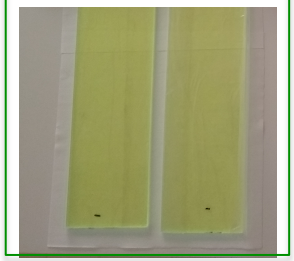
Annealing

- Develop thermal treatments (annealing) to prevent cracking.
- Anneled 2 blue and 2 green light guides in an oven at FNAL at 80°C.



LN2 controlled immersion test

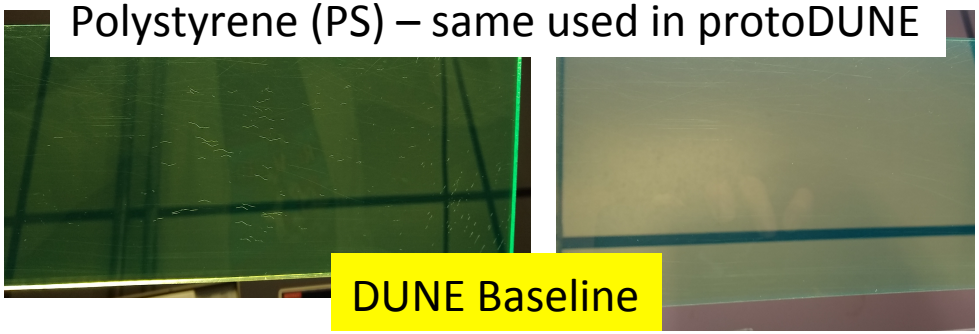
Polystyrene (PS)
NOT annealed



PVT

EJ286 EJ280

Polystyrene (PS) – same used in protoDUNE



DUNE Baseline

Tests consisted in:

- **Immersion "speed" of 2cm/min**
- bars/plates immersion in an Arapuca frame

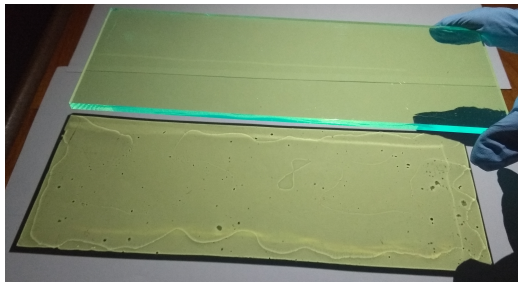
Before and After LN_2 immersions were taken:

- Optical Microscope images
- Transmittance
- Fluorescence (emission and excitation spectras)

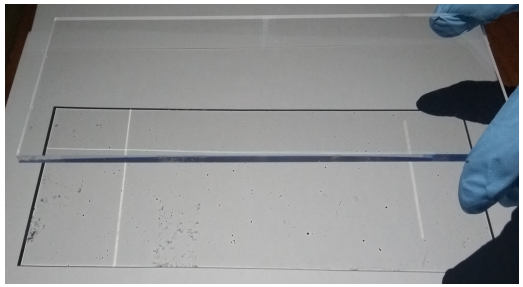
Before

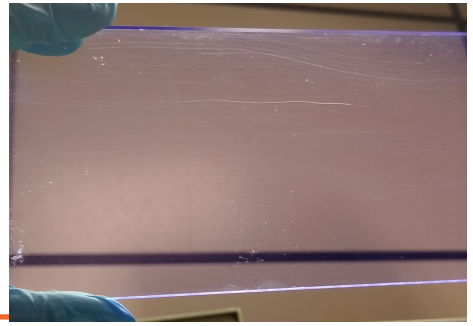
After 3rd immersion

EJ280 annealed



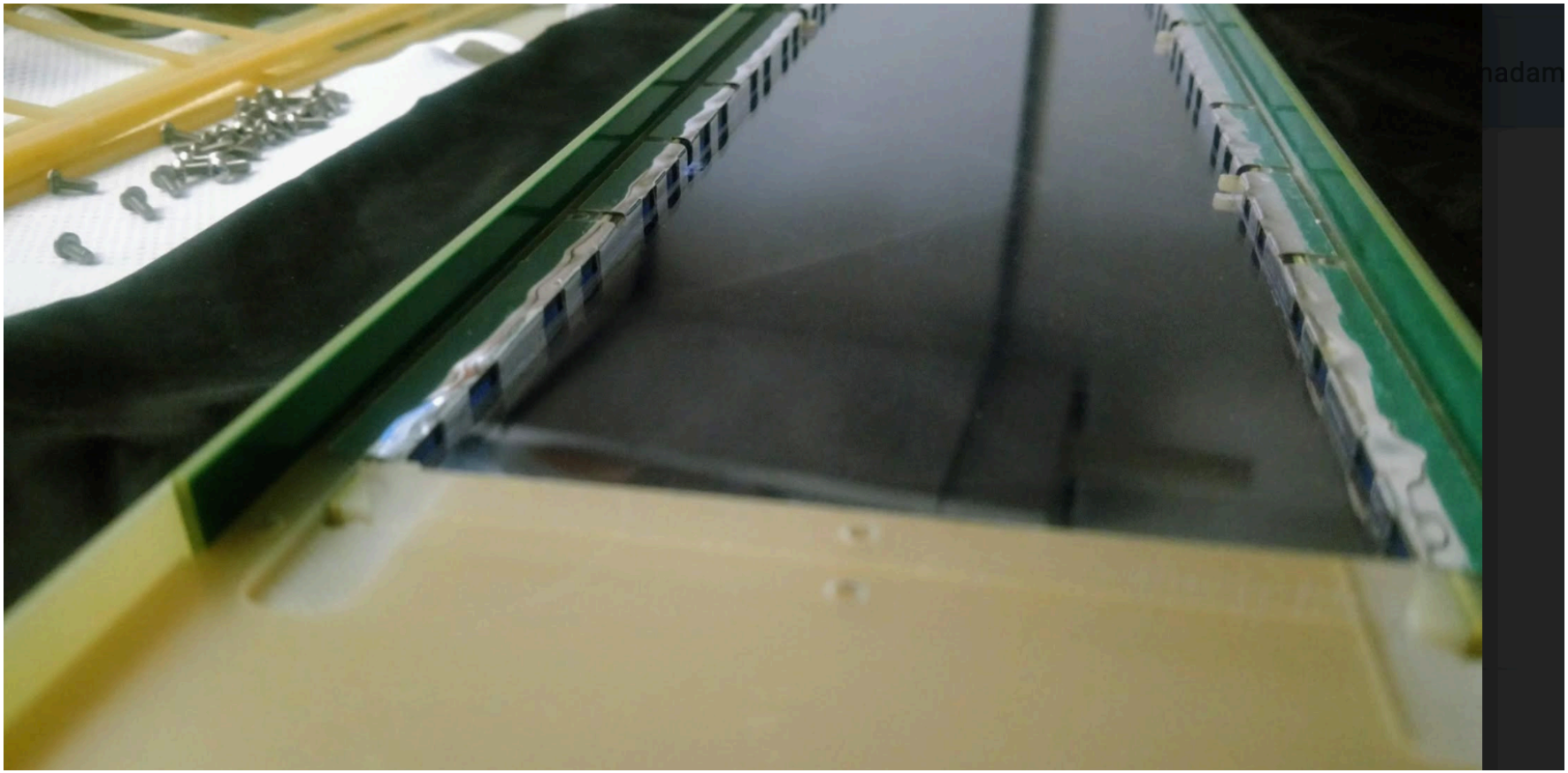
EJ286 annealed





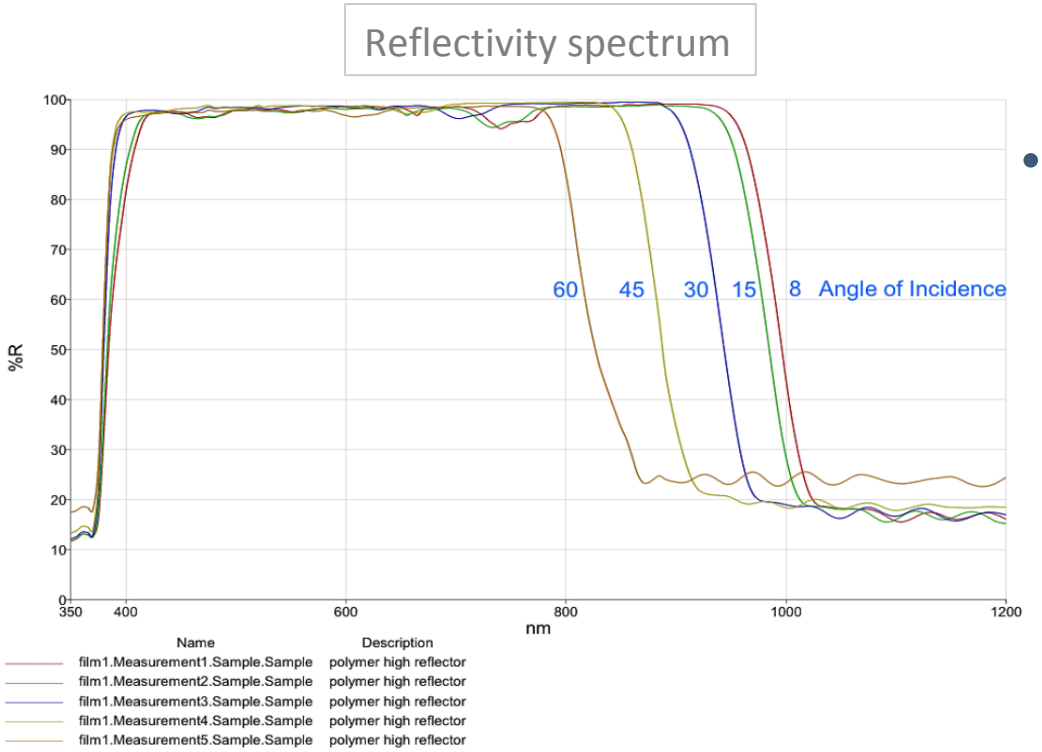
- EJ286 PVT Substrate after ICEBERG test – several thermal cycles

Picture made by C.Escobar 06/12/2020



VIKUITI

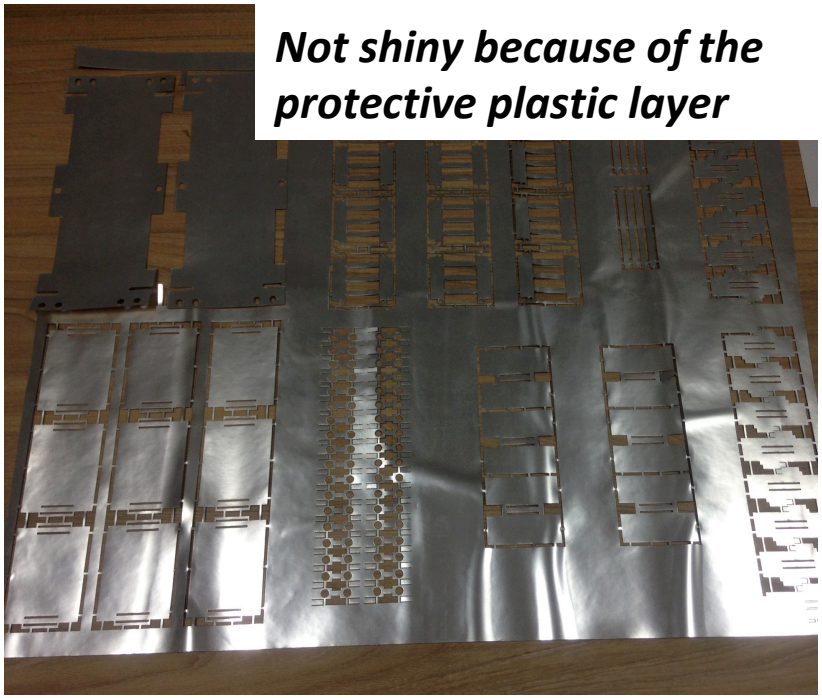
- 3M Vikuiti is a highly reflective film which is used to line the internal surface of the X-ARAPUCA cavity.



- It has high specular reflectivity above 400nm and **matches** very well the emmission **spectrum of the light guides**
- **Specular reflector favoured** with respect to diffuse reflector by **MC results**

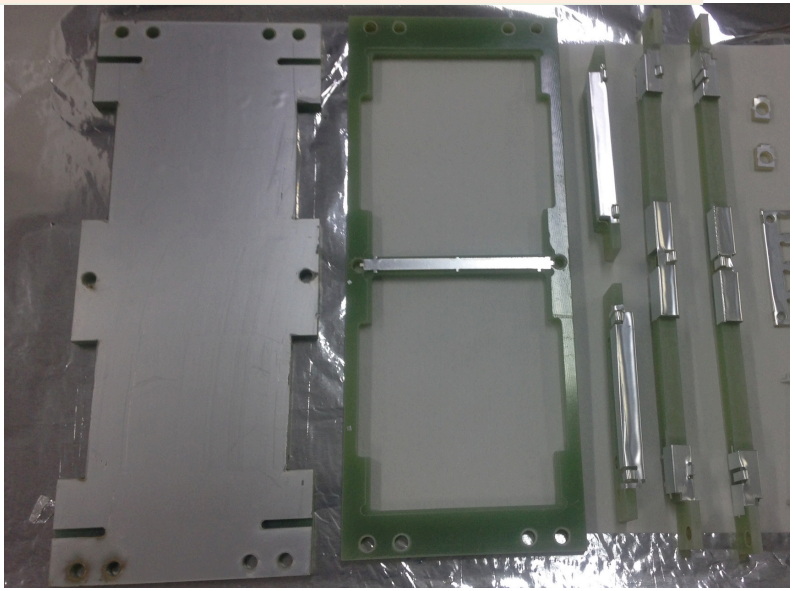
VIKUITI

- Vikuiti laser cut foil, with protective film



Not shiny because of the protective plastic layer

Gluing the VIKUITI at SBND modules



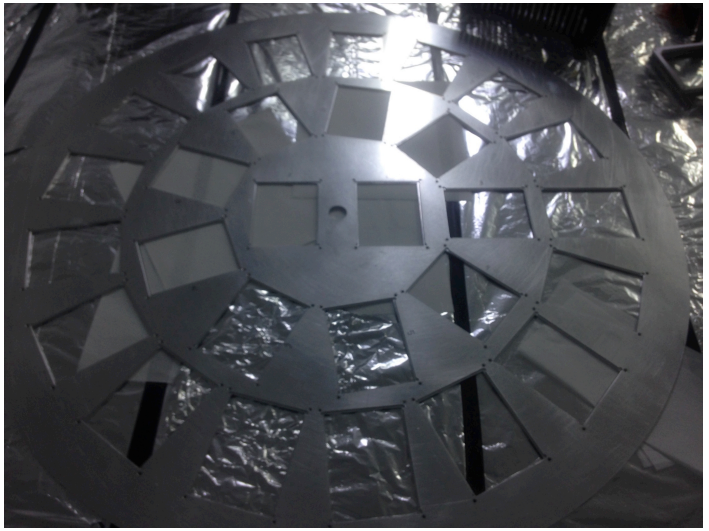
Coatings

- Specific procedure of filters' cleaning developed in collaboration with FNAL to maximize adhesion of the film on the glass

- pTP films produced by vacuum evaporation (pressure ~ 10^{-5}mbar) with a custom evaporator.

- Evaporator can host **28 filters**

- Each evaporation takes ~ 2 hours including pumping down



Protocols

Protocol		
Cleaning	Filters	done
	Frames	done
	Bolts and Nuts	done
Cryogenic tests	Filters	done
	WLS bars	done
Annealing	WLS bars	In progress
Coating	Filters	done
Assembly	X-ARAPUCA	In progress

Summary

- First batch of **OPTO dichroic filters performed well**. With current level of performance X-ARAPUCA prototypes meet requirements. **Next batch will have enhanced performances**

- **Long term test of p-TP** coatings will start as soon as the experimental activities @ Syracuse will restart

- Light-guide plates tested extensively through several thermal cycles with different immersion speeds. **Baseline design matrix behaved well**.

- Production of p-TP films on dichroic filters is **well mastered**

Thank you