



**The CLAS12 large area RICH detector**

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**ABSTRACT**

A large area RICH detector is being designed for the CLAS12 spectrometer as part of the 12 GeV upgrade program of the Jefferson Lab Experimental Hall-B. This detector is intended to provide excellent hadron identification from 3 GeV/c up to momenta exceeding 8 GeV/c and to be able to work at the very high design luminosity up to  $10^{35} \text{ cm}^{-2} \text{ s}^{-1}$ . Detailed feasibility studies are presented for two types of radiators, aerogel and liquid  $\text{C}_6\text{F}_{14}$  freon, in conjunction with a highly segmented light detector in the visible wavelength range. The basic parameters of the RICH are outlined and the resulting performances, as defined by preliminary simulation studies, are reported.

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# RICH Test-Beam: aerogel performance

Important observables that will be extensively investigated are transverse Momentum Distribution functions (TMDs) describing intrinsic spin-orbit effects and Generalized Parton Distribution functions (GPDs), containing information about the spatial distribution of quarks and the relation (by a sum rule) to the elusive orbital momenta. Several experiments have been already performed by the JLab12 PAC to study kaon versus pion production in exclusive and semi-inclusive scattering, providing access to the decomposition of the two sets of non-perturbative functions.

Main features of CLAS12 include a high operational luminosity of  $10^{35} \text{ cm}^{-2} \text{ s}^{-1}$ , an order of magnitude higher than the current setup, and operation of highly polarized beam and target. The conceptual design of the CLAS12 detector is shown in Fig. 1. The central detector with the high-field (5 T) solenoid is used for particle tracking at large angles. The forward detector detects charged and neutral particles in the angular range between 5 and  $40^\circ$ . It employs a 2 T torus magnet detector symmetry of CLAS. In the base equipment,

and event reconstruction can be achieved in this momentum range by replacing the existing low-threshold Cherenkov counter (LTCC) with a RICH detector without any impact on the baseline design of CLAS12.

**2. The CLAS12 RICH**

To fit into the CLAS12 geometry, the RICH should have a projective geometry with six sectors that cover the space between the torus cryostats and covering scattering angles from  $5^\circ$  to  $40^\circ$ . Fig. 3. Being downstream to the torus magnet at a distance of 1.5 m from the interaction point, the RICH has to cover a solid angle of each sector spanning an area of the order of  $4 \text{ m}^2$ . Being placed between detectors which are already in the construction, the gap depth cannot exceed 1 m. The proposed solution is a focusing RICH.

A setup similar to the one adopted in Hall-B, using a  $\text{C}_5\text{F}_{12}$  or  $\text{C}_6\text{F}_{14}$  radiator and a CsI-deposited radiator chamber as a UV-photon detector, is being studied. The required pion rejection factor at momenta above 3 GeV/c.

The preliminary results on ongoing Monte Carlo studies, based on a GEANT3 toolkit with simplified geometry and optical surface

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 INFN - University of Ferrara

# Characterization of aerogel tiles

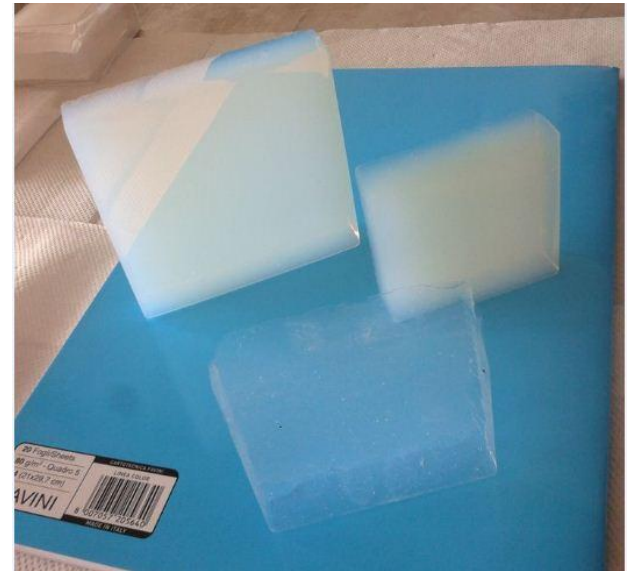
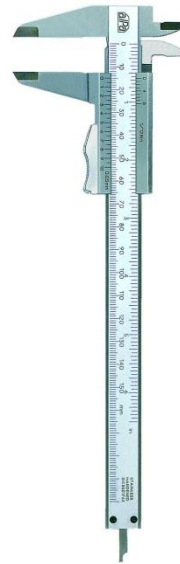
➤ Geometry (area, thickness) →

➤ refractive index

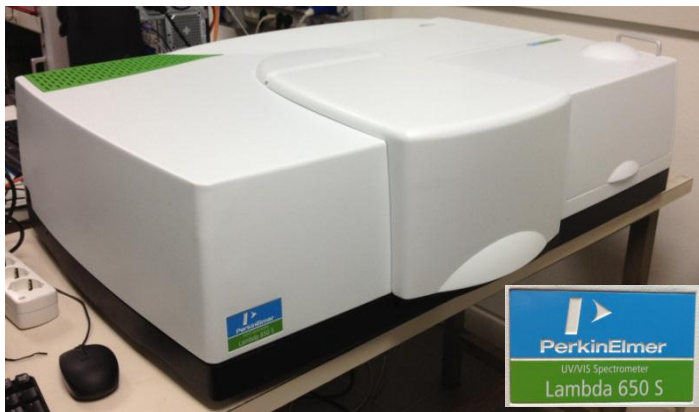
➤ Transmittance

➤ Absorption length

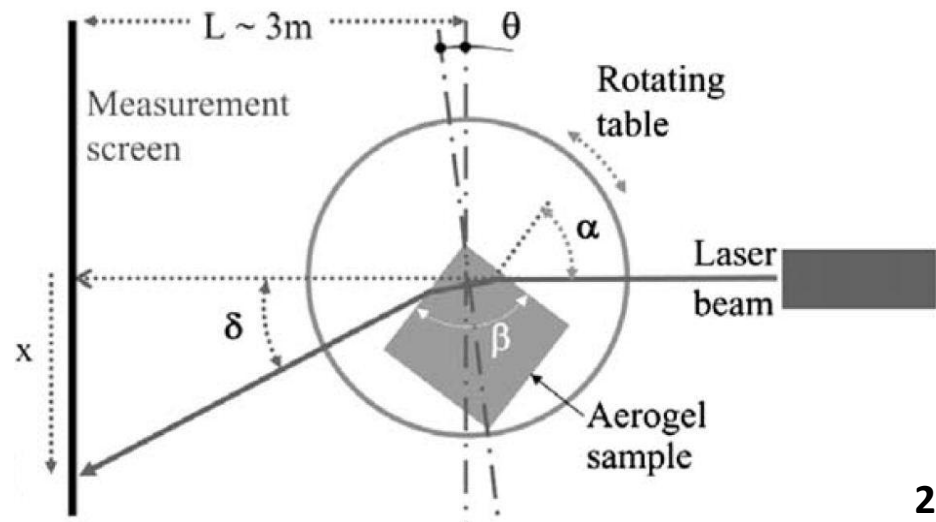
➤ Scattering length



spectrophotometer

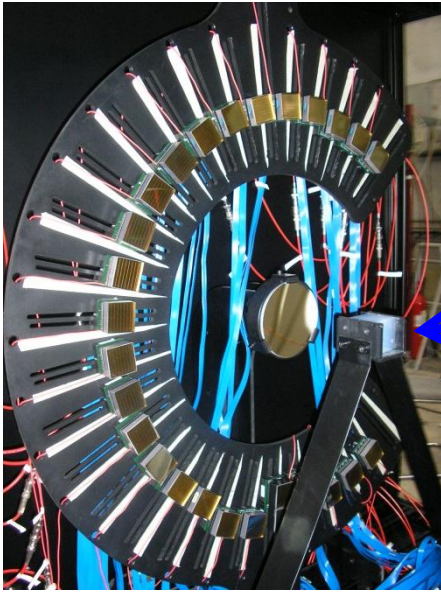


prism method

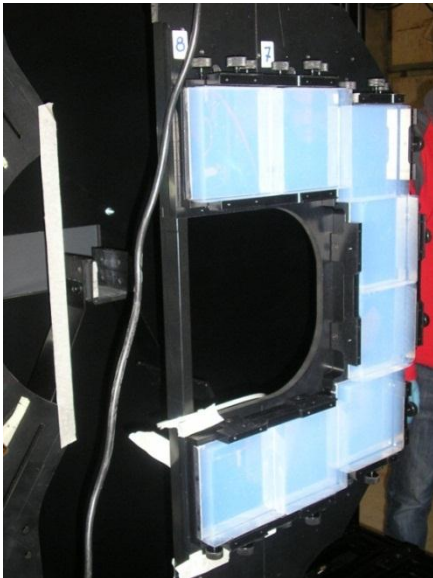


Part 1  
Measuring Transmittance,  
scattering and absorption length

## direct light



## reflected light

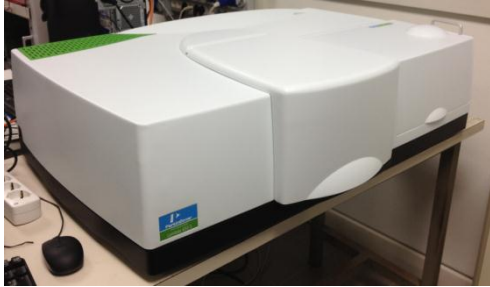


## Aerogel tiles used in August 2012 Test-beam

Name	n	thickness (cm)	area (cm × cm)
Nov 1.04 2cm tile1	1.04	2	6 × 6
Nov 1.05 2cm tile1	1.05	2	6 × 6
Nov 1.05 2cm tile2	1.05	2	6 × 6
Nov 1.06 2cm tile1	1.06	2	6 × 6
Nov 1.05 3cm tile1	1.05	3	6 × 6
Nov 1.05 3cm tile3	1.05	3	6 × 6
Nov 1.05 3cm tile4	1.05	3	6 × 6
Nov 1.06 3cm tile1	1.06	3	6 × 6
Nov 1.06 3cm tile2	1.06	3	6 × 6
Nov 1.05 2cm Sample1	1.05	2	10 × 10
Nov 1.05 2cm Sample2	1.05	2	10 × 10
Nov 1.05 2cm Sample3	1.05	2	10 × 10
Nov 1.05 2cm Sample4	1.05	2	10 × 10
Nov 1.05 2cm Sample5	1.05	2	10 × 10
Nov 1.05 2cm Sample6	1.05	2	10 × 10
Nov 1.05 2cm Sample7	1.05	2	10 × 10
Nov 1.05 2cm Sample8	1.05	2	10 × 10
Nov 1.05 3cm AMS1	1.05	3	10 × 10
Nov 1.05 3cm AMS2	1.05	3	10 × 10
Nov 1.05 3cm AMS3	1.05	3	10 × 10
Nov 1.05 3cm AMS4	1.05	3	10 × 10

- 3 refractive indices (1.04, 1.05, 1.06)
- 2 thicknesses (2cm, 3cm)
- 2 areas  $6 \times 6 \text{ cm}^2$ ,  $10 \times 10 \text{ cm}^2$ )

# Basic formalism and selected results



Transmittance

$$T(\lambda) = e^{-\frac{t}{\Lambda_{tot}}} = e^{-t\left(\frac{1}{\Lambda_A} + \frac{1}{\Lambda_S}\right)} = e^{-\frac{t}{\Lambda_A}} \cdot e^{-\frac{t}{\Lambda_S}} = A \cdot e^{-\frac{Ct}{\lambda^4}}$$

Hunt formula

$$A = TF = e^{-t/\Lambda_A} \Rightarrow \Lambda_A = -t/\ln A \quad \text{Absorp. length}$$

Transflectance

$$\Lambda_S = \frac{\lambda^4}{Ct} t \quad \text{Scarrering length}$$

# Basic formalism and selected results

Transmittance

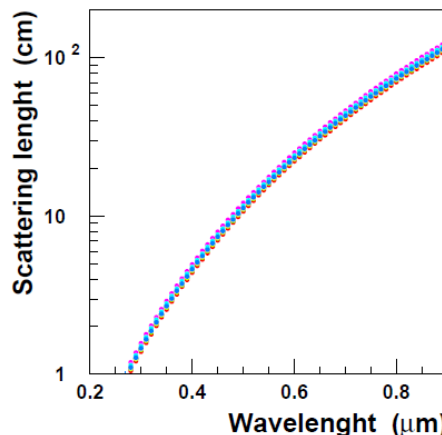
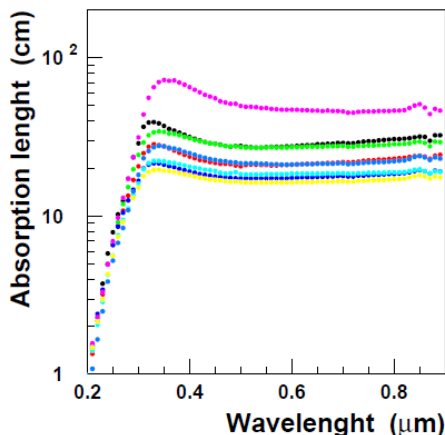
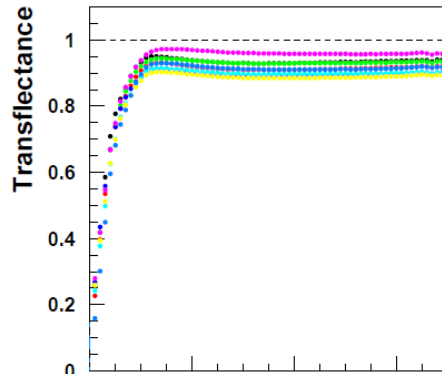
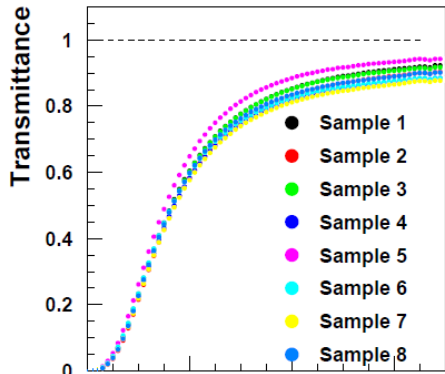
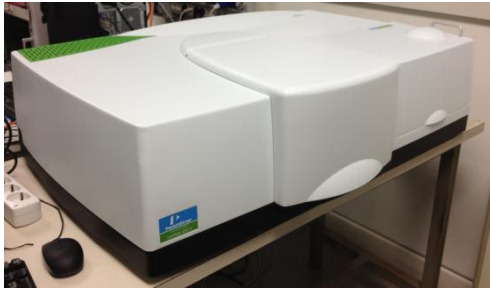
$$T(\lambda) = e^{-\frac{t}{\Lambda_{tot}}} = e^{-t\left(\frac{1}{\Lambda_A} + \frac{1}{\Lambda_S}\right)} = e^{-\frac{t}{\Lambda_A}} \cdot e^{-\frac{t}{\Lambda_S}} = A \cdot e^{-\frac{Ct}{\lambda^4}}$$

Hunt formula

$$A = TF = e^{-t/\Lambda_A} \Rightarrow \Lambda_A = -t/\ln A \quad \text{Absorp. length}$$

$$\Lambda_S = \frac{\lambda^4}{Ct} \quad \text{Scarrering length}$$

Transflectance

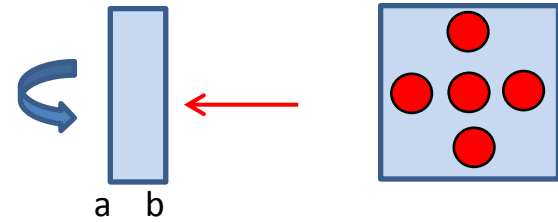
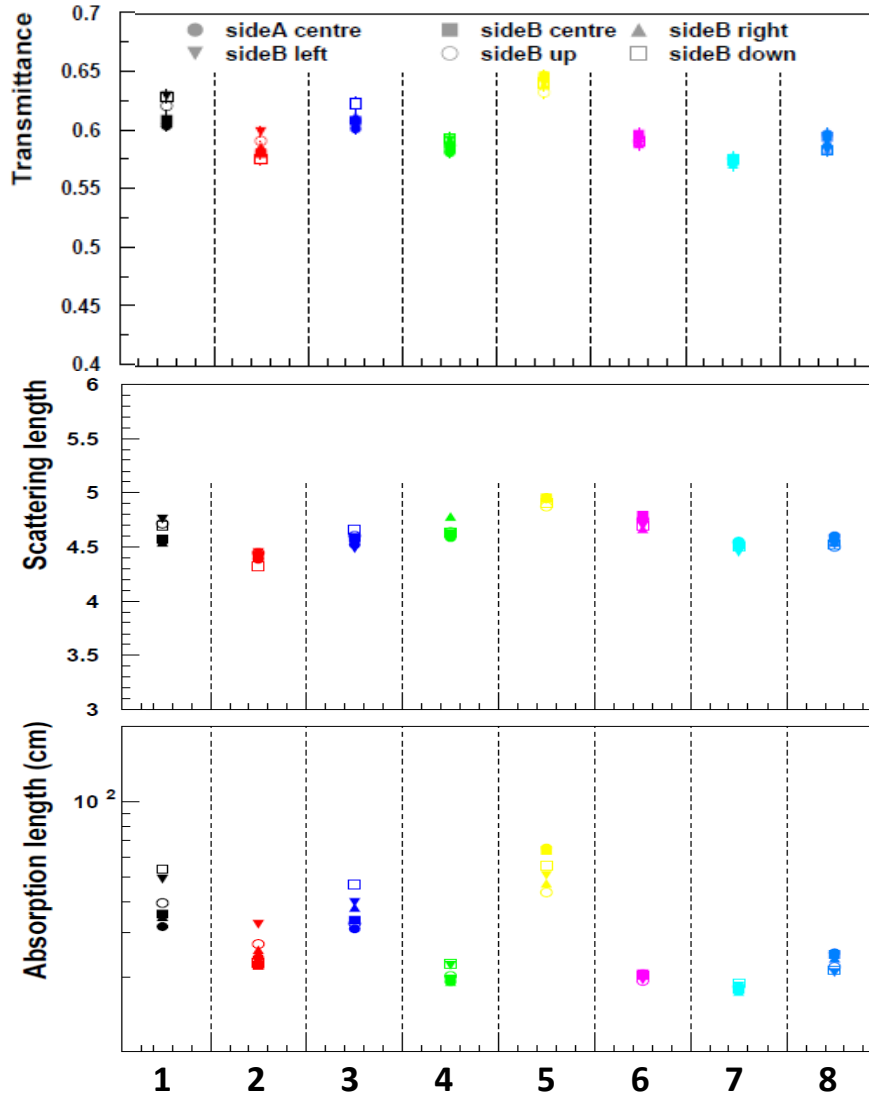


Aerogel tiles used in August 2012 Test-beam

Name	n	thickness (cm)	area (cm × cm)
Nov 1.04 2cm tile1	1.04	2	6 × 6
Nov 1.05 2cm tile1	1.05	2	6 × 6
Nov 1.05 2cm tile2	1.05	2	6 × 6
Nov 1.06 2cm tile1	1.06	2	6 × 6
Nov 1.05 3cm tile1	1.05	3	6 × 6
Nov 1.05 3cm tile3	1.05	3	6 × 6
Nov 1.05 3cm tile4	1.05	3	6 × 6
Nov 1.06 3cm tile1	1.06	3	6 × 6
Nov 1.06 3cm tile2	1.06	3	6 × 6
Nov 1.05 2cm Sample1	1.05	2	10 × 10
Nov 1.05 2cm Sample2	1.05	2	10 × 10
Nov 1.05 2cm Sample3	1.05	2	10 × 10
Nov 1.05 2cm Sample4	1.05	2	10 × 10
Nov 1.05 2cm Sample5	1.05	2	10 × 10
Nov 1.05 2cm Sample6	1.05	2	10 × 10
Nov 1.05 2cm Sample7	1.05	2	10 × 10
Nov 1.05 2cm Sample8	1.05	2	10 × 10
Nov 1.05 3cm AMS1	1.05	3	10 × 10
Nov 1.05 3cm AMS2	1.05	3	10 × 10
Nov 1.05 3cm AMS3	1.05	3	10 × 10
Nov 1.05 3cm AMS4	1.05	3	10 × 10

# Measurements at 400nm

For each tile, the measurements were repeated by “illuminating” 6 different positions

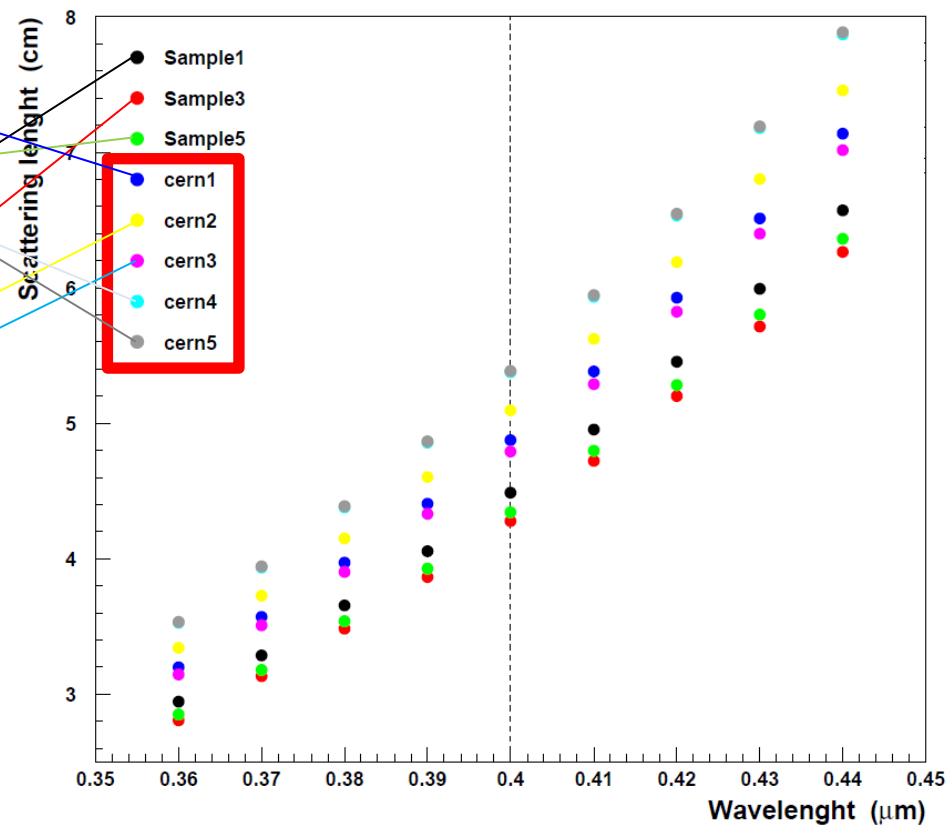
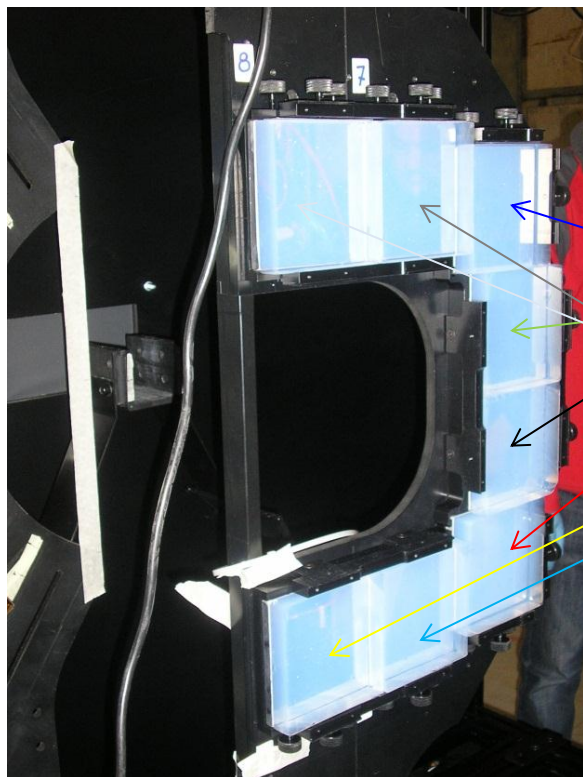


Name	T	$\Lambda_A$ (cm)	$\Lambda_S$ (cm)
Sample 1	0.617	40.7	4.6
Sample 2	0.587	26.6	4.4
Sample 3	0.610	36.9	4.6
Sample 4	0.589	20.4	4.6
Sample 5	0.642	54.5	4.9
Sample 6	0.593	20.1	4.7
Sample 7	0.575	18.1	4.5
Sample 8	0.590	22.9	4.5
<b>Average</b>	<b>0.600</b>	<b>31.4</b>	<b>4.6</b>

# Improvements in production techniques (Novosibirsk)

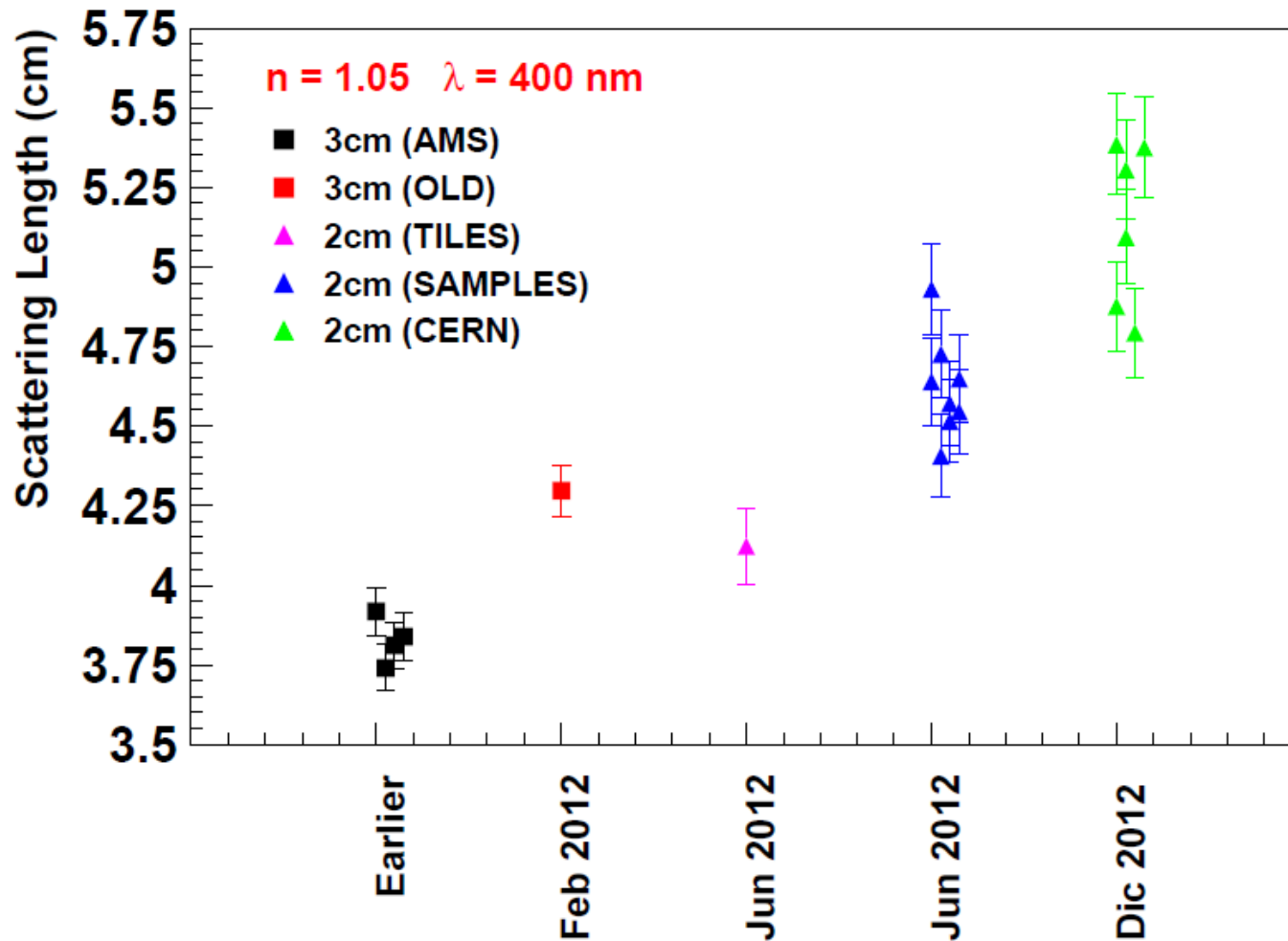
December 2012 test-beam

Name	n	thickness (cm)	area (cm × cm)
Nov 1.05 2cm <b>cern1</b>	1.05	2	10 × 10
Nov 1.05 2cm <b>cern2</b>	1.05	2	10 × 10
Nov 1.05 2cm <b>cern3</b>	1.05	2	10 × 10
Nov 1.05 2cm <b>cern4</b>	1.05	2	10 × 10
Nov 1.05 2cm <b>cern5</b>	1.05	2	10 × 10





# Improvements in production techniques (Novosibirsk)

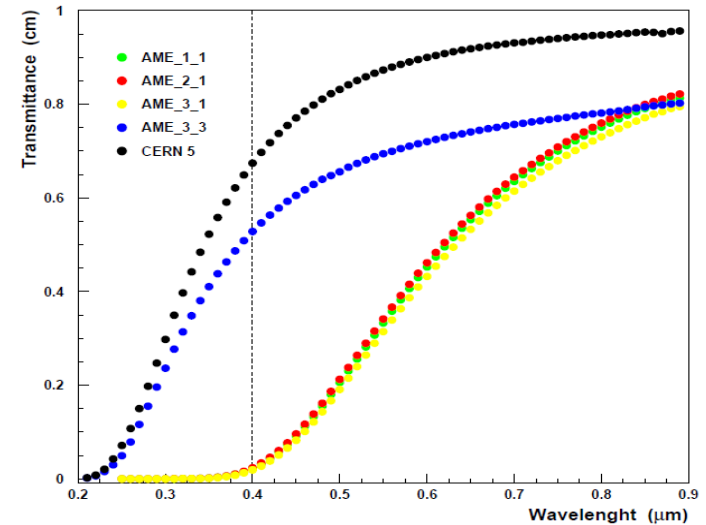


There is a clear trend showing that the production technique and the resulting quality of the aerogel is significantly improving in time.

# Optical properties of APEN aerogel

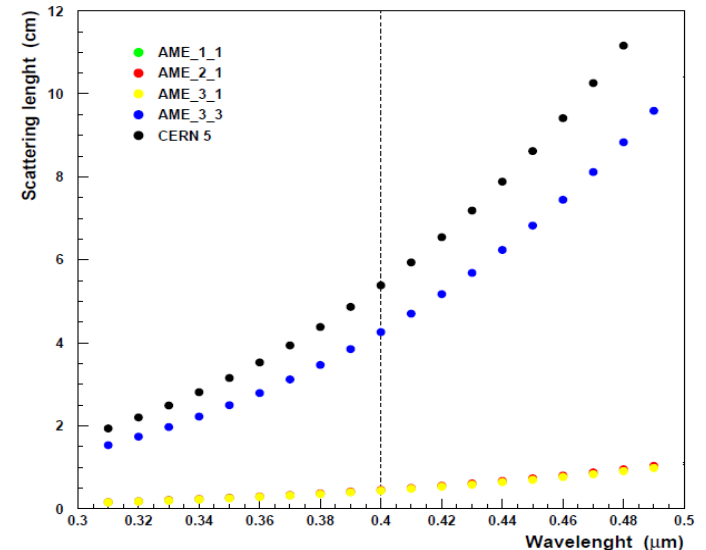


- 10 tiles
- 3 formats: large, medium, small
- 2 thickness: 1.7 cm, 0.95 cm
- 2 refractive indices:  $n = 1.05$  (9 tiles) and  $n = 1.01$  (1 tile)



@ 400 nm

Name	n	Area (cm <sup>2</sup> )	Thick (cm)	T	$\Lambda_A$ (cm)	$\Lambda_S$ (cm)
AME_1_1	1.05	9.5x9.5	1.7	2.2 %	26.4	0.4
AME_2_1	1.05	9.5x9.5	1.7	2.4 %	29.7	0.5
AME_3_1_A	1.05	9.5x9.5	1.7	1.9 %	17.9	0.4
AME_3_3	1.01	6.5x6.5	1.7	52.8 %	7.1	4.3
CERN5	1.05	10x10	2.0	67.4 %	85.0	5.4



The only one with reasonable performances has  $n = 1.01$

Part 2  
Monitoring the aerogel  
transparency during test beams

# Monitoring the transparency

The Novosibirsk aerogel is **hydrophilic**, i.e. tends to absorb humidity from the air, resulting in a worsening of the optical performances  $\Rightarrow$  need to periodically monitor the transparency

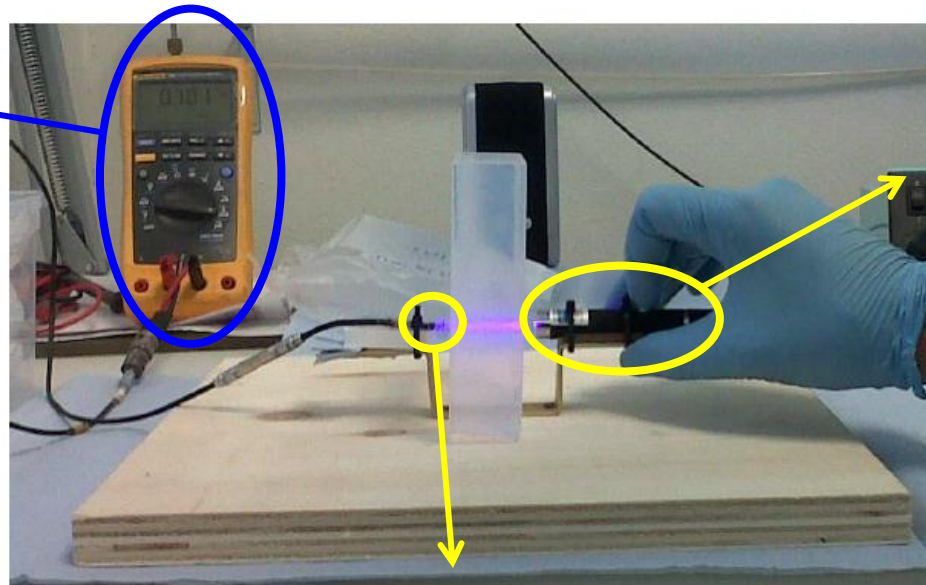
Fast measurements were performed with a very simple set-up:

Multimeter:  
reads current

$$T_i = \frac{I_{\text{aerogel}}}{I_0}$$



$$\langle T \rangle = \frac{1}{10} \sum_{i=1,10} T_i$$



Laser:  
blue light (405 nm)

photodiode output in mA

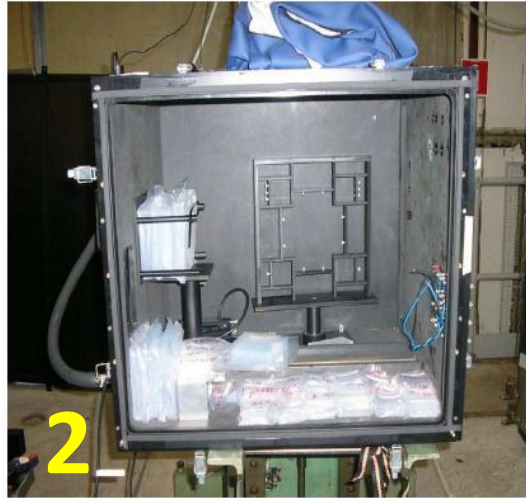
The method is fast (few minutes for each set of 10 measurements) but introduces several **systematic effects** (laser-photodiode distance, aerogel local non-homogeneities, laser instabilities) that result in a broadening of the measured transparencies.

The RMS of each set of measurements was assigned as a global systematic uncertainty  $\Delta T$

# Restoring/preserving the transparency

Several methods were tested to preserve/restore the transparency after exposure to air

1. Storing tiles in a dry cabinet (Ferrara)
2. Storing tiles in a box fluxed with nitrogen (August tet-beam)
3. Baking tiles at few hundreds (celsius) degrees for a few hours



We experienced that the transparency is approximately preserved if the tile is sealed within a small plastic bag.

(December test-beam)



# Some results

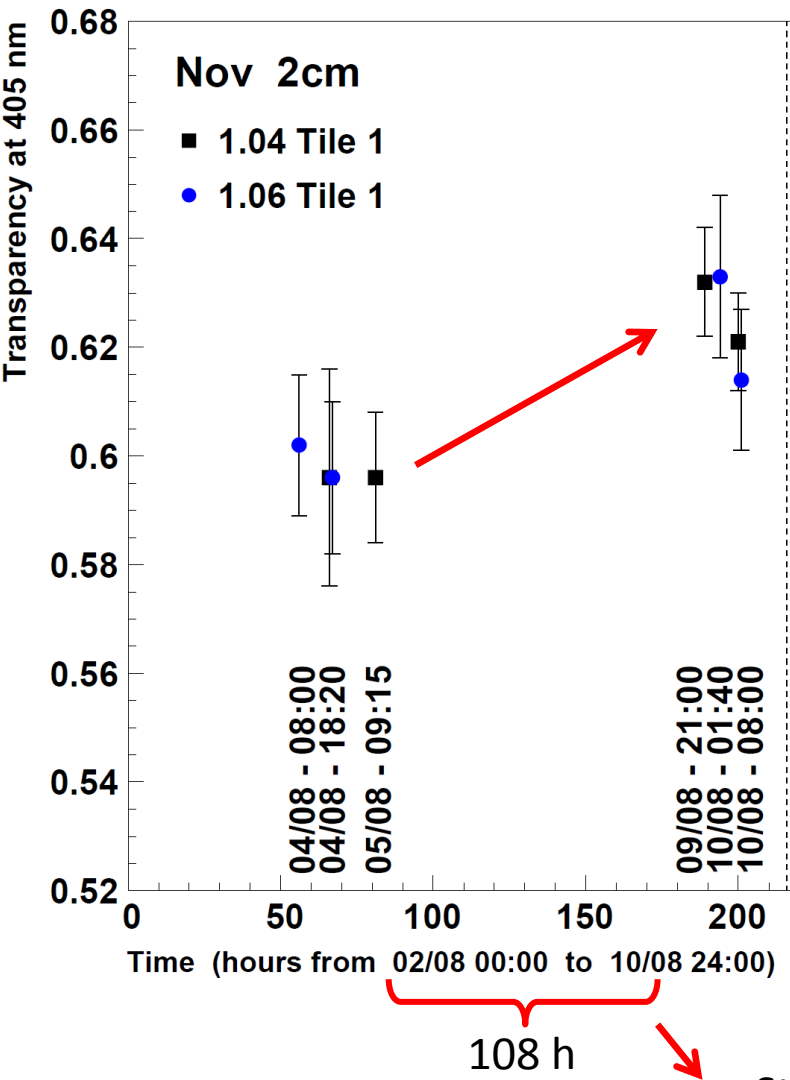


Table 2: Nov. 1.04 2cm tile1

Date/time of meas.	$T_{min}$	$T_{max}$	$T_{average}$	$\Delta T$	notes
04/08/2012 18:20	0.570	0.638	0.596	0.020	meas. before SiMP run 390
05/08/2012 09:15	0.580	0.611	0.596	0.012	meas. after SiMP run 390
09/08/2012 21:00	0.614	0.648	0.632	0.010	meas. before SiMP run 432
10/08/2012 08:00	0.608	0.637	0.621	0.009	meas. before final packing

Table 3: Nov. 1.06 2cm tile1

Date/time of meas.	$T_{min}$	$T_{max}$	$T_{average}$	$\Delta T$	notes
04/08/2012 08:00	0.584	0.619	0.602	0.013	meas. before SiMP run 383
04/08/2012 18:20	0.575	0.622	0.596	0.014	meas. after SiMP run 389
10/08/2012 01:40	0.615	0.657	0.633	0.015	meas. before SiMP run 439
10/08/2012 08:00	0.597	0.639	0.614	0.013	meas. before final packing

Storage in box with nitrogen

# Some results

Spectrophotometer measurements are found to be systematically smaller

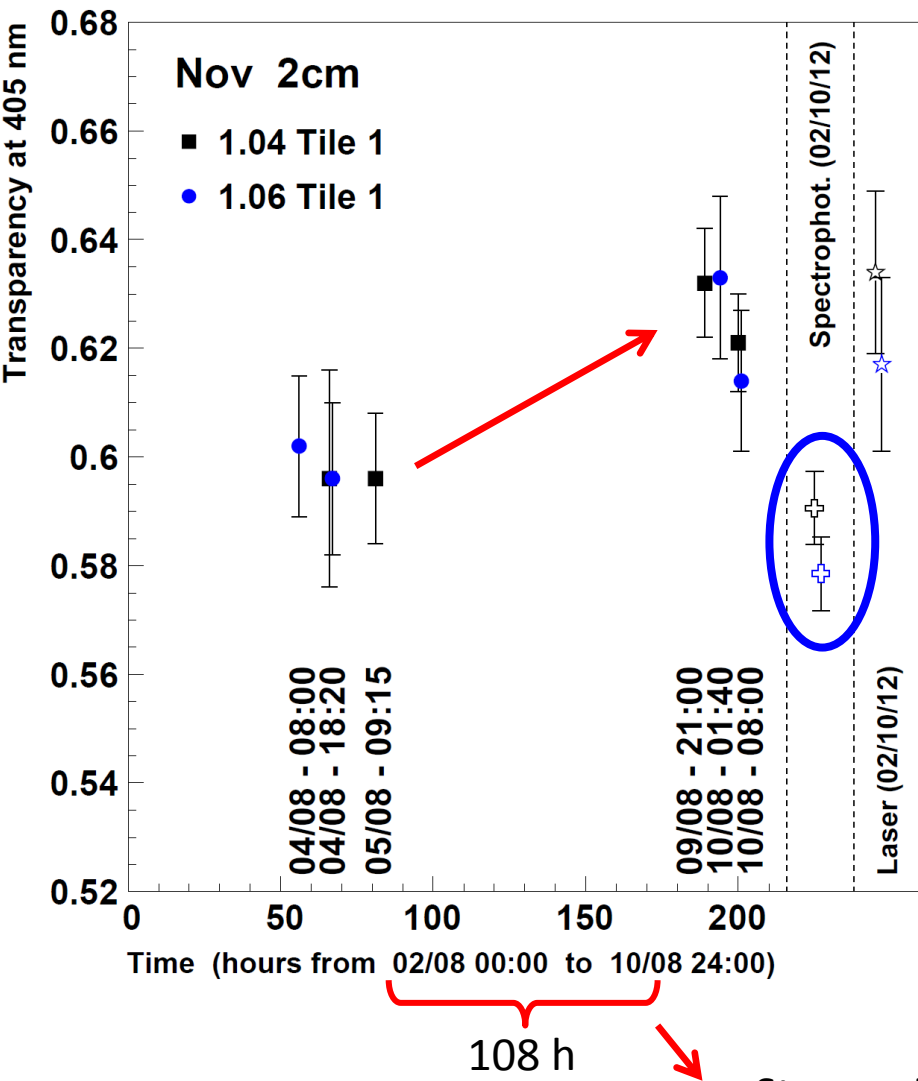


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09/08/2012 21:00	0.614	0.648	0.632	0.010	meas. before SiMP run 432
10/08/2012 08:00	0.608	0.637	0.621	0.009	meas. before final packing
02/10/2012	0.608	0.654	0.634	0.015	meas. in Ferrara (laser)
02/10/2012			0.591	0.007	meas. in Ferrara (spectrophot.)

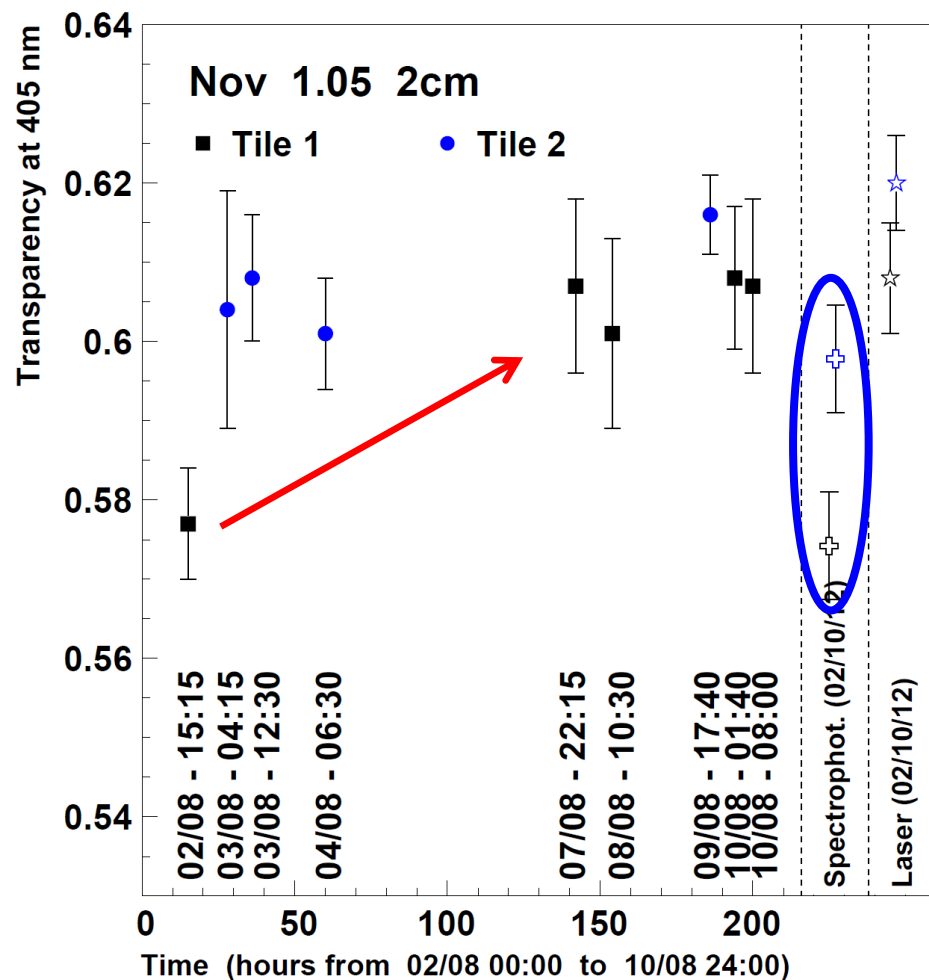
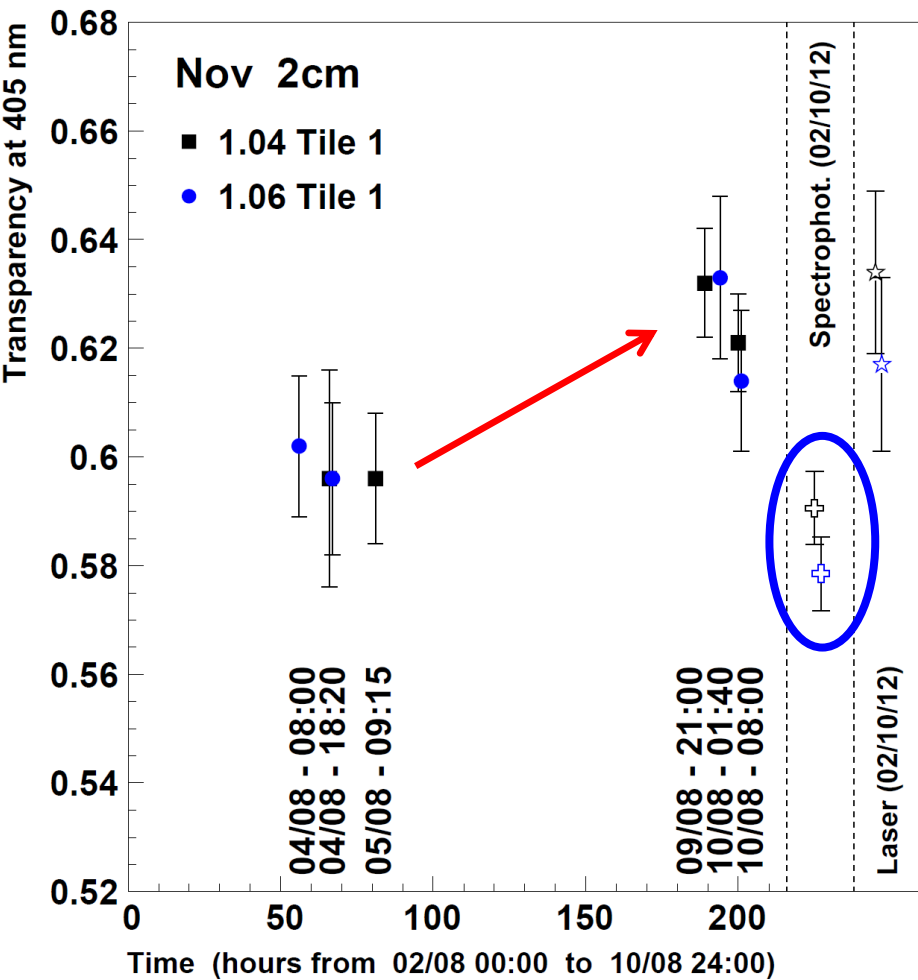
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04/08/2012 18:20	0.575	0.622	0.596	0.014	meas. after SiMP run 389
10/08/2012 01:40	0.615	0.657	0.633	0.015	meas. before SiMP run 439
10/08/2012 08:00	0.597	0.639	0.614	0.013	meas. before final packing
02/10/2012	0.590	0.639	0.617	0.016	meas. in Ferrara (laser)
02/10/2012			0.578	0.007	meas. in Ferrara (spectrophot.)

Storage in box with nitrogen

# Some results

Spectrophotometer measurements are found to be systematically smaller



Storage in box with nitrogen



# Looking for a general trend

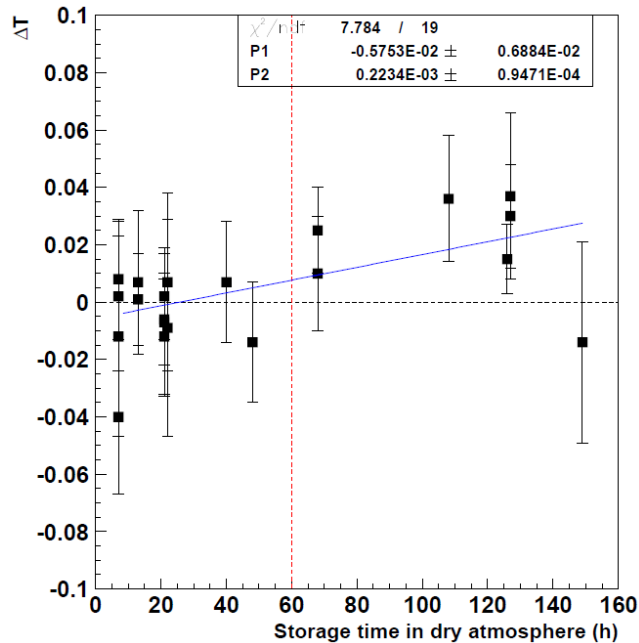
After storage in dry atmosphere (box fluxed with nitrogen)

Aerogel tile	storage time (h)	$T_{before}$	$T_{after}$	$\Delta T$
Nov. 1.05 3cm tile4	149	$0.391 \pm 0.018$	$0.377 \pm 0.017$	$-0.014 \pm 0.035$
Nov. 1.06 2cm tile1	127	$0.596 \pm 0.014$	$0.633 \pm 0.015$	$+0.037 \pm 0.029$
Nov. 1.05 2cm tile1	127	$0.577 \pm 0.007$	$0.607 \pm 0.011$	$+0.030 \pm 0.018$
Nov. 1.05 2cm tile2	126	$0.601 \pm 0.007$	$0.616 \pm 0.005$	$+0.015 \pm 0.012$
Nov. 1.04 2cm tile1	108	$0.596 \pm 0.012$	$0.632 \pm 0.010$	$+0.036 \pm 0.022$
Nov. 1.06 3cm tile1	68	$0.455 \pm 0.007$	$0.465 \pm 0.013$	$+0.010 \pm 0.020$
Nov. 1.06 3cm tile2	68	$0.455 \pm 0.007$	$0.480 \pm 0.008$	$+0.025 \pm 0.015$
Nov. 1.05 3cm tile3	48	$0.392 \pm 0.009$	$0.378 \pm 0.012$	$-0.014 \pm 0.021$
Nov. 1.05 2cm tile1	40	$0.601 \pm 0.012$	$0.608 \pm 0.009$	$+0.007 \pm 0.021$
Nov. 1.05 3cm tile1	22	$0.386 \pm 0.023$	$0.377 \pm 0.015$	$-0.009 \pm 0.038$
Nov. 1.05 3cm tile3	22	$0.363 \pm 0.015$	$0.370 \pm 0.016$	$+0.007 \pm 0.031$
Nov. 1.05 3cm AMS1	21	$0.459 \pm 0.009$	$0.461 \pm 0.006$	$+0.002 \pm 0.015$
Nov. 1.05 3cm AMS2	21	$0.471 \pm 0.009$	$0.465 \pm 0.007$	$-0.006 \pm 0.016$
Nov. 1.05 3cm AMS3	21	$0.459 \pm 0.013$	$0.452 \pm 0.013$	$-0.007 \pm 0.026$
Nov. 1.05 3cm AMS4	21	$0.463 \pm 0.007$	$0.451 \pm 0.013$	$-0.012 \pm 0.020$
Nov. 1.06 3cm tile1	13	$0.458 \pm 0.012$	$0.465 \pm 0.013$	$+0.007 \pm 0.025$
Nov. 1.06 3cm tile2	13	$0.475 \pm 0.007$	$0.476 \pm 0.009$	$+0.001 \pm 0.016$
Nov. 1.05 2cm sample1	7	$0.641 \pm 0.007$	$0.649 \pm 0.014$	$+0.008 \pm 0.021$
Nov. 1.05 2cm sample3	7	$0.638 \pm 0.011$	$0.626 \pm 0.024$	$-0.012 \pm 0.035$
Nov. 1.05 2cm sample4	7	$0.620 \pm 0.008$	$0.580 \pm 0.019$	$-0.040 \pm 0.027$
Nov. 1.05 2cm sample5	7	$0.656 \pm 0.015$	$0.658 \pm 0.011$	$+0.002 \pm 0.026$

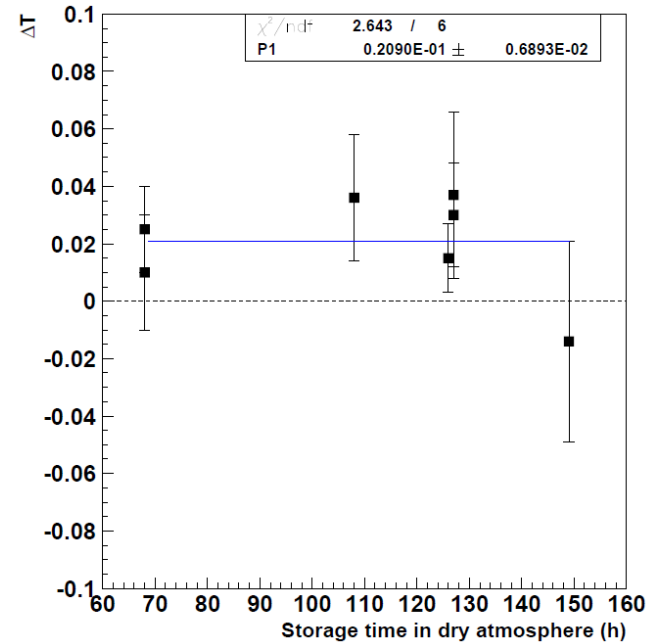
} > 60 h

} < 60 h

# Looking for a general trend



1<sup>st</sup> order polynomial fit:  
hint of a slop (but low significance)

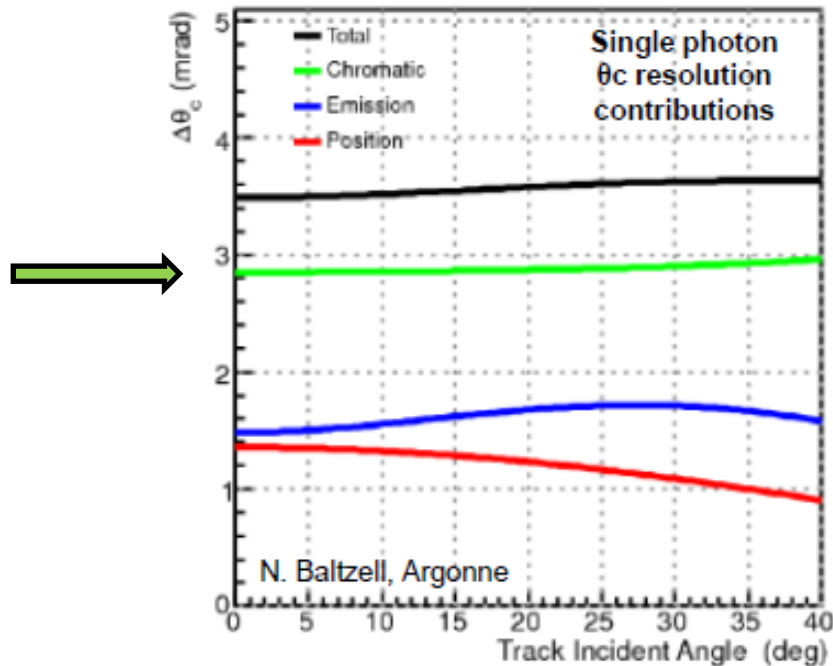


0<sup>th</sup> order polynomial fit (constant):  
 $const \approx 0.021 \pm 0.007 \rightarrow 3\sigma$

- There is an evidence of partial transparency restoration after at least 60 hours of storage in dry (nitrogen) atmosphere
- Storage periods shorter than 60 hours do not result in appreciable improvements
- Periods in which the aeogel was exposed to air (i.e. To humidity) were too short (< 60h) to produce any appreciable effect on the transparency


# Part 3

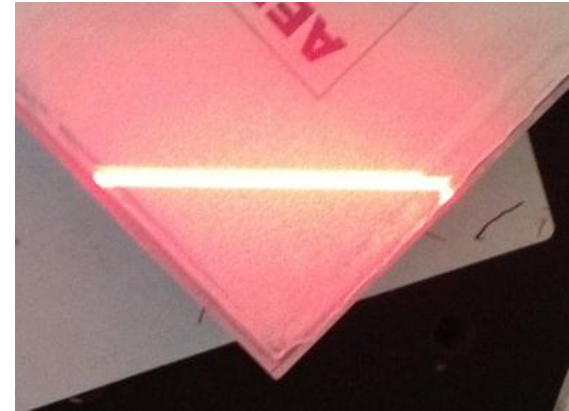
## Measures of refracting index and dispersion law



**Main motivation:** From Nathan simulations the chromatic error is expected to be the largest contribution to the final uncertainty on the Cherenkov angle.

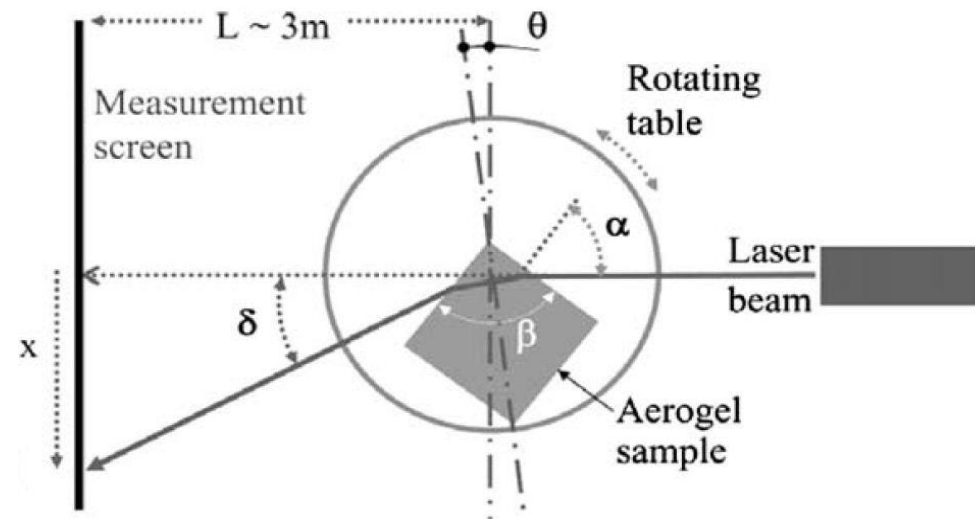
# The "standard prism" method

- The adjacent sides of the aerogel tile form a prism
- One measures the deviation of a laser beam passing through the aerogel tile edges (prism) 
- The position of the laser beam spot is measured on a screen placed downstream



- The aerogel **refractive index**  $n$  can be determined by fitting the angular distribution of the spots of the refracted beam with the **Snell-Descartes law**:

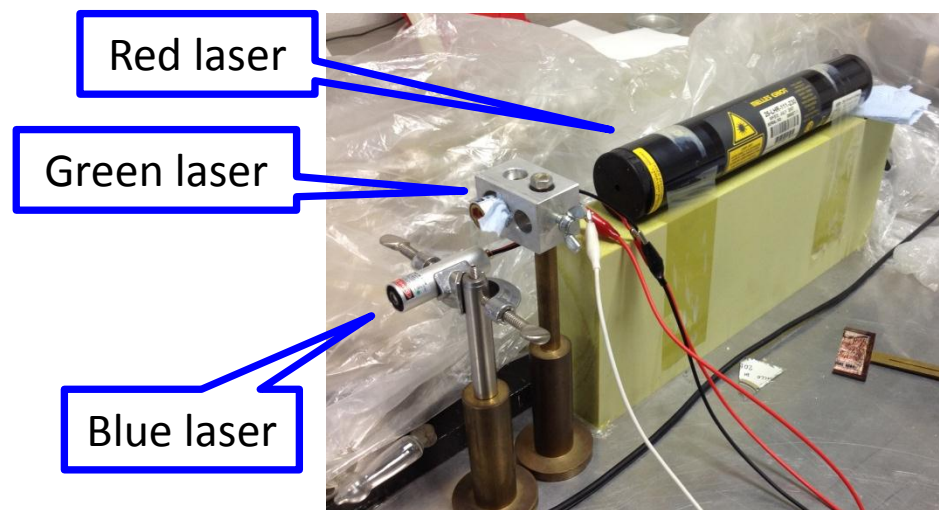
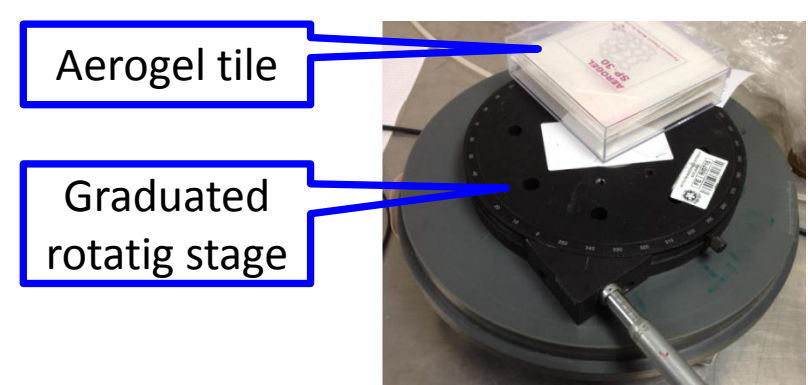
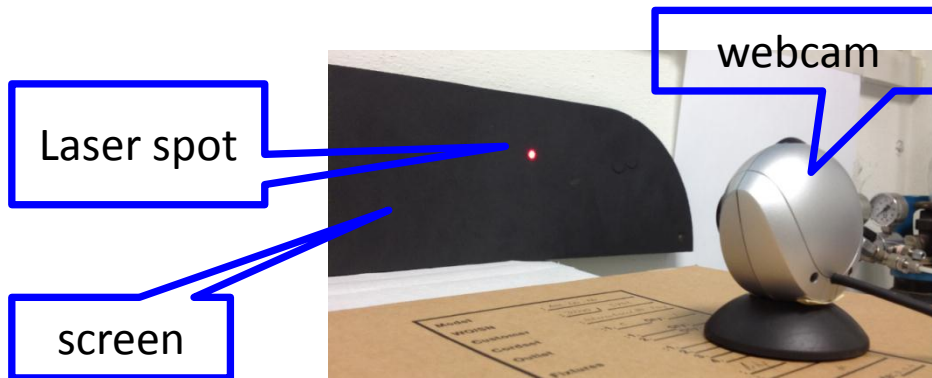
$$\delta = \alpha - \beta + \arcsin \left\{ n \cdot \sin \left[ \beta - \arcsin \left( \frac{\sin \alpha}{n} \right) \right] \right\}$$



NIM A 614 (2010)

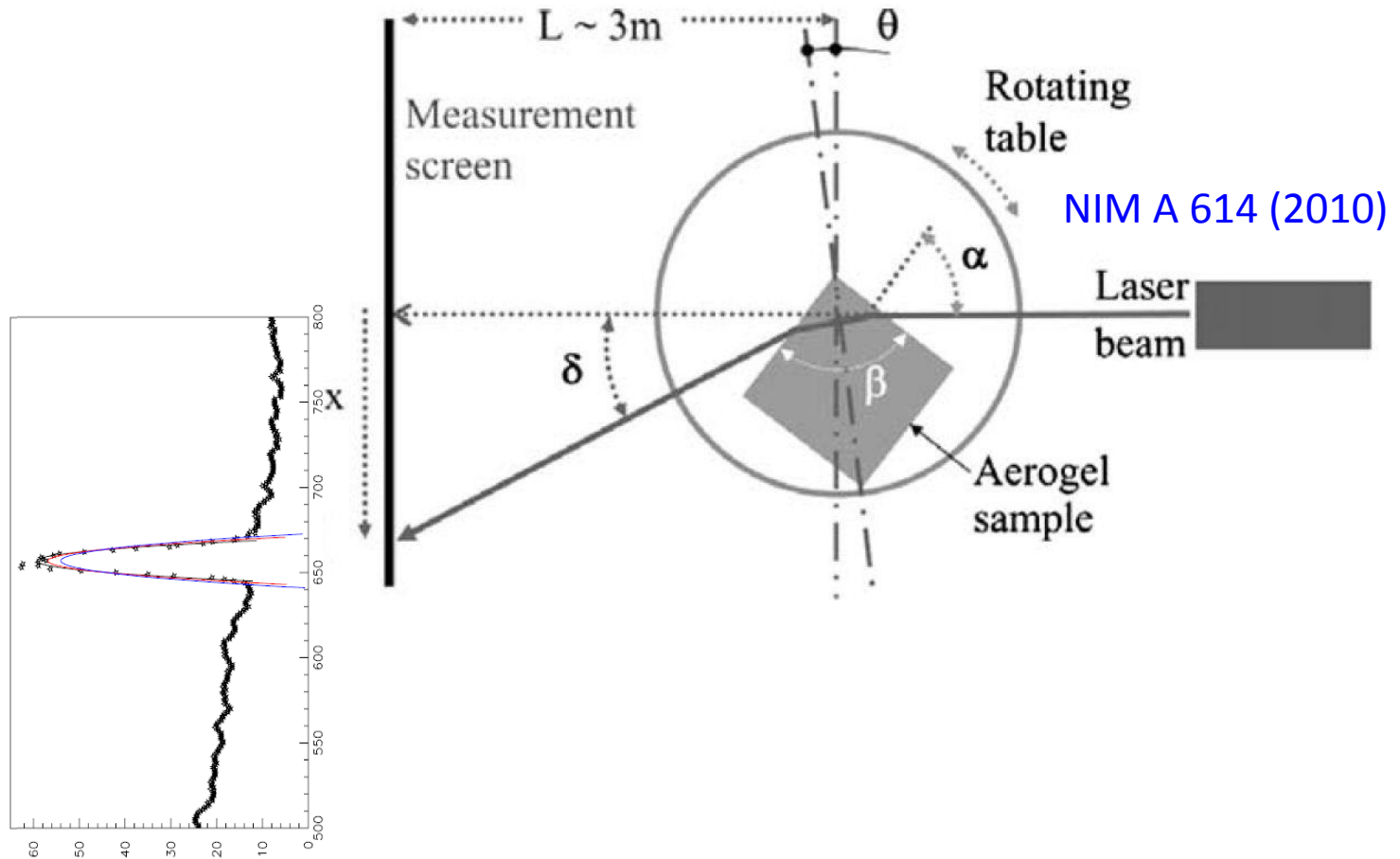
# The Ferrara set-up

- The aerogel tile is positioned upon a graduated rotating stage
- Three lasers were used: **red ( $\lambda=632.8$  nm)**, **green ( $\lambda=532$  nm)**, **blue ( $\lambda=405$  nm)**
- The beam spots on the screen are recorded by a digital photcamera
- The screen was placed at a distance  $L=3016$ mm
- The “zero” position was obtained using the direct beam (i.e. without the aerogel tile)



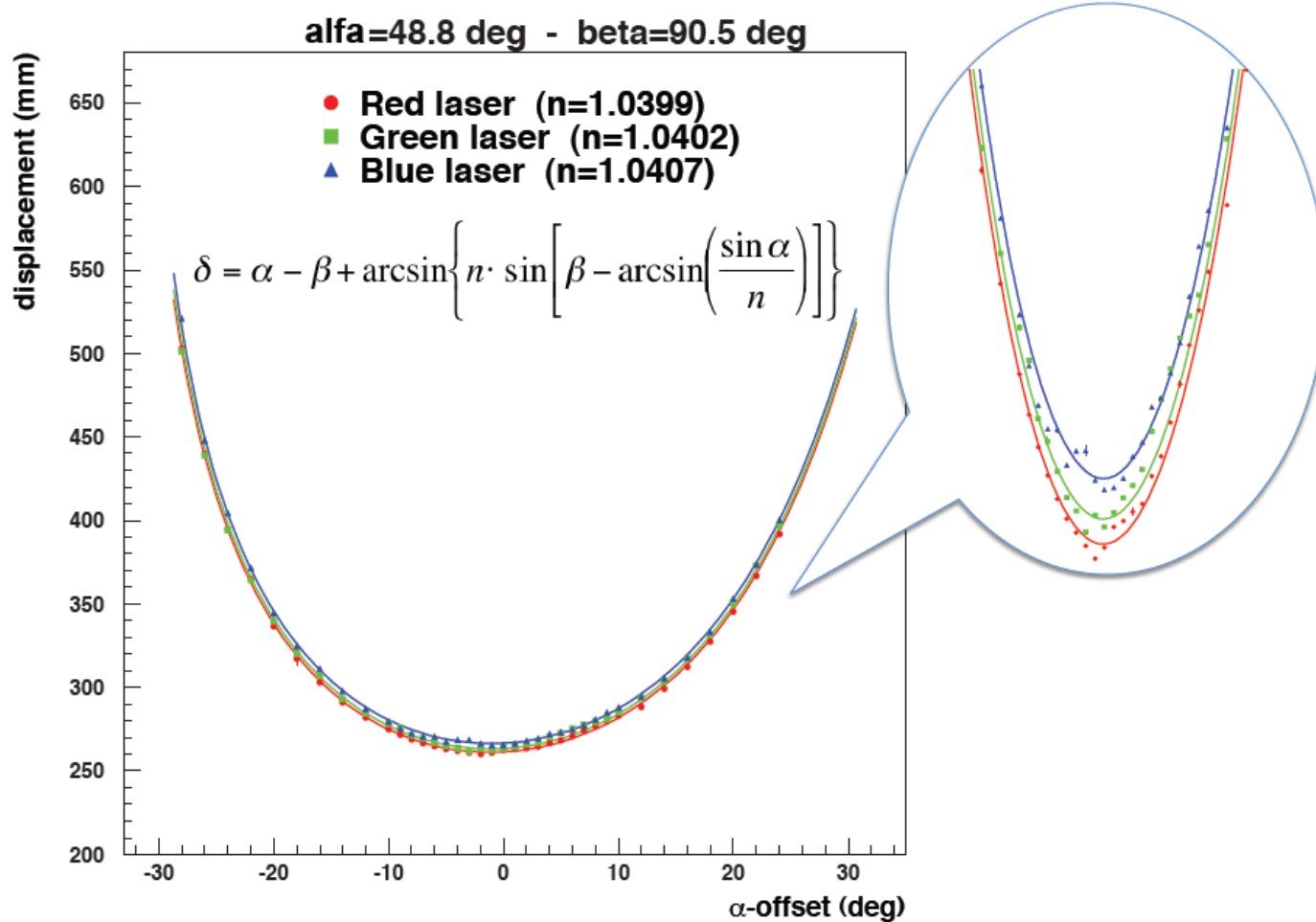
# The procedure

1. The intensity spectra are extracted from the analysis of the spot images
2. The peaks are fitted with a parabola to obtain the position of the maxima



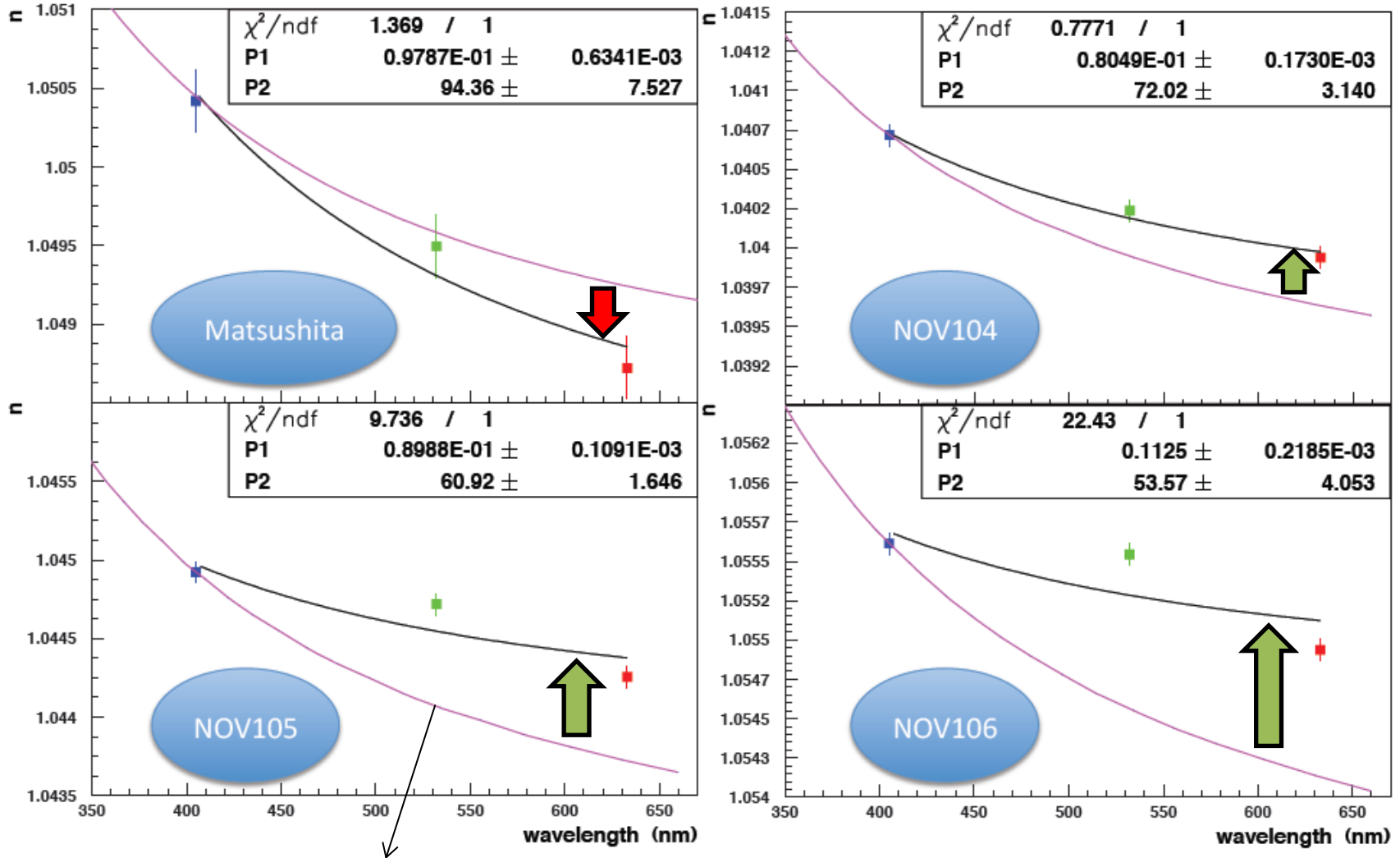
3. The positions of the maxima are plotted vs.  $\alpha$  and fitted with the **Snell-Descarted law**

# Extracting the refractive index



The dispersion law:  $n^2(\lambda) - 1 = \frac{a_0 \lambda^2}{\lambda^2 - \lambda_0^2} \quad \longrightarrow \quad n(\lambda) = \sqrt{1 + \frac{P_1 \lambda^2}{\lambda^2 - P_2^2}}$

# Extracting the refractive index



Expected trend: phenomenological estimate based on “old generation” aerogel measurements

- Preliminary data show a chromatic dispersion smaller than expectations for Novosibirsk
- More precise measurements are in order.



# Conclusions and outlook

Ferrara is developing skills and tools for the characterization of the optical properties of aerogel tiles for the CLAS12 RICH

- A PerkinElmer spectrophotometer is being employed for the optical characterization of aerogel tiles (transmittance, absorption length and scattering length)
- Measurements show that the new generation aerogel from Novosibirsk have higher performances (higher transparency, longer scattering length)
- Studies on transparency deterioration (due to humidity absorption) have been carried out during the CERN test-beams using a simple set-up.  
Several procedures to recover/preserve transparency were tested and are being used.
- Measurements of refractive index and dispersion law were performed with the prisms method using blue, red and green lasers. Preliminary data show a chromatic dispersion smaller than current expectations.

Back-up slides

# The aerogel tiles from US

The refractive index at 400 nm, not provided by the manufacturer, was estimated through rough measurements of density using the [empirical relation](#):

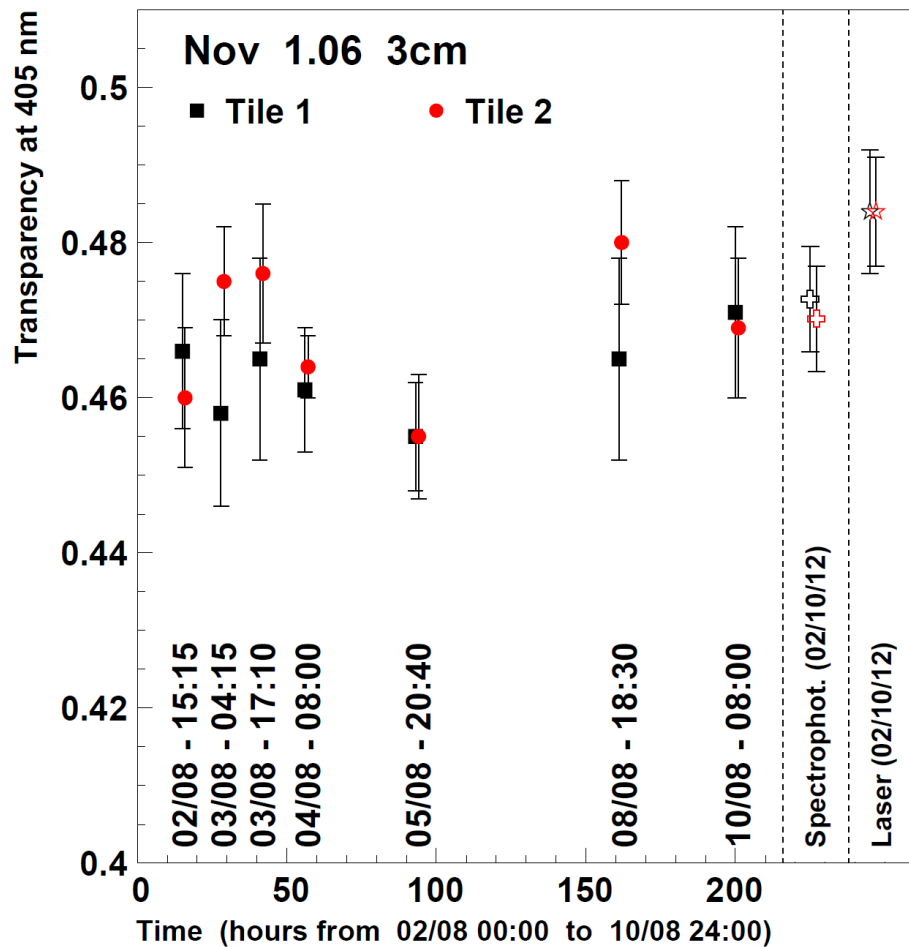
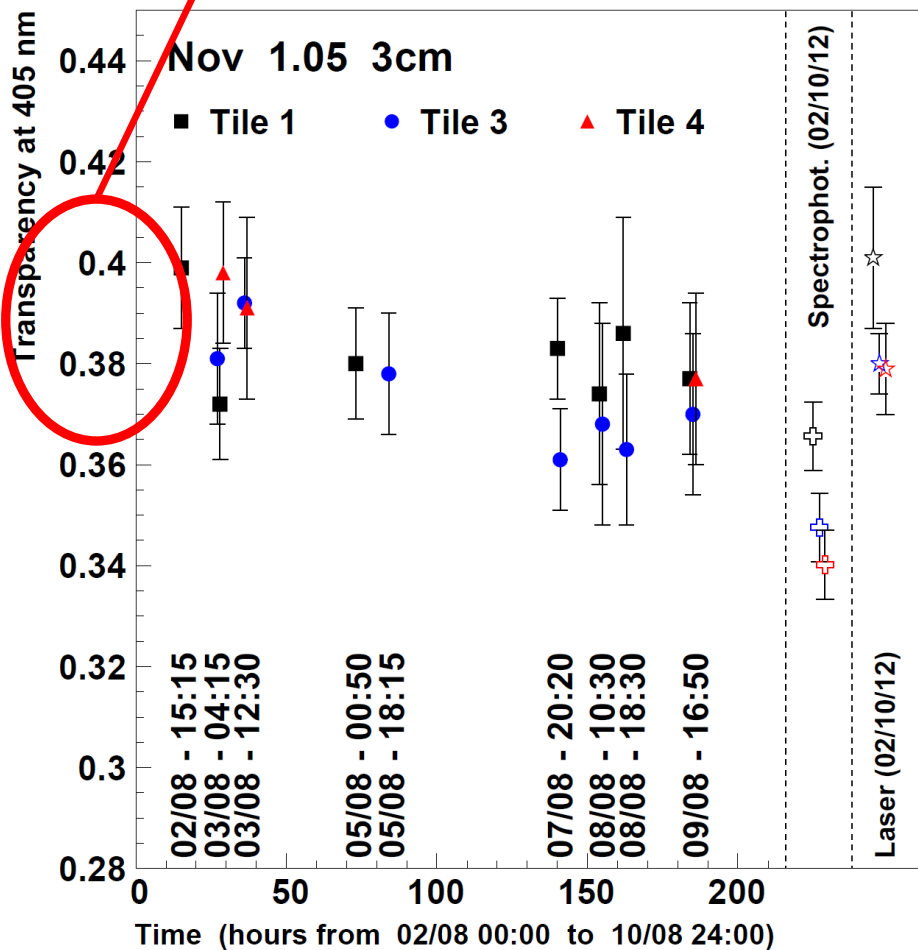
$$n^2(400 \text{ nm}) = 1 + 0.438 \cdot \rho$$

[A.F.Danilyuk et.al., Recent results on aerogel development for use in Cherenkov counters, NIM A494 (2002) 491]

Name	Size [ $cm^3$ ]	$\rho$ [ $g/cm^3$ ]	n (400 nm)
AME_1_1	$9.5 \times 9.5 \times 1.7$	0.218	1.047
AME_1_2	$9.5 \times 9.5 \times 1.7$	0.223	1.048
AME_1_3	$9.5 \times 9.5 \times 1.7$	0.225	1.048
AME_2_1	$9.5 \times 9.5 \times 1.7$	0.219	1.047
AME_2_2	$9.5 \times 9.5 \times 1.7$	0.226	1.048
AME_3_1_A	$6.5 \times 6.5 \times 1.7$	0.217	1.046
AME_3_1_B	$6.5 \times 6.5 \times 1.7$	0.217	1.046
AME_3_2_A	$6.5 \times 6.5 \times 0.95$	0.246	1.052
AME_3_2_B	$6.5 \times 6.5 \times 0.95$	0.231	1.049
AME_3_3	$7.2 \times 7.2 \times 1.7$	0.070	1.015

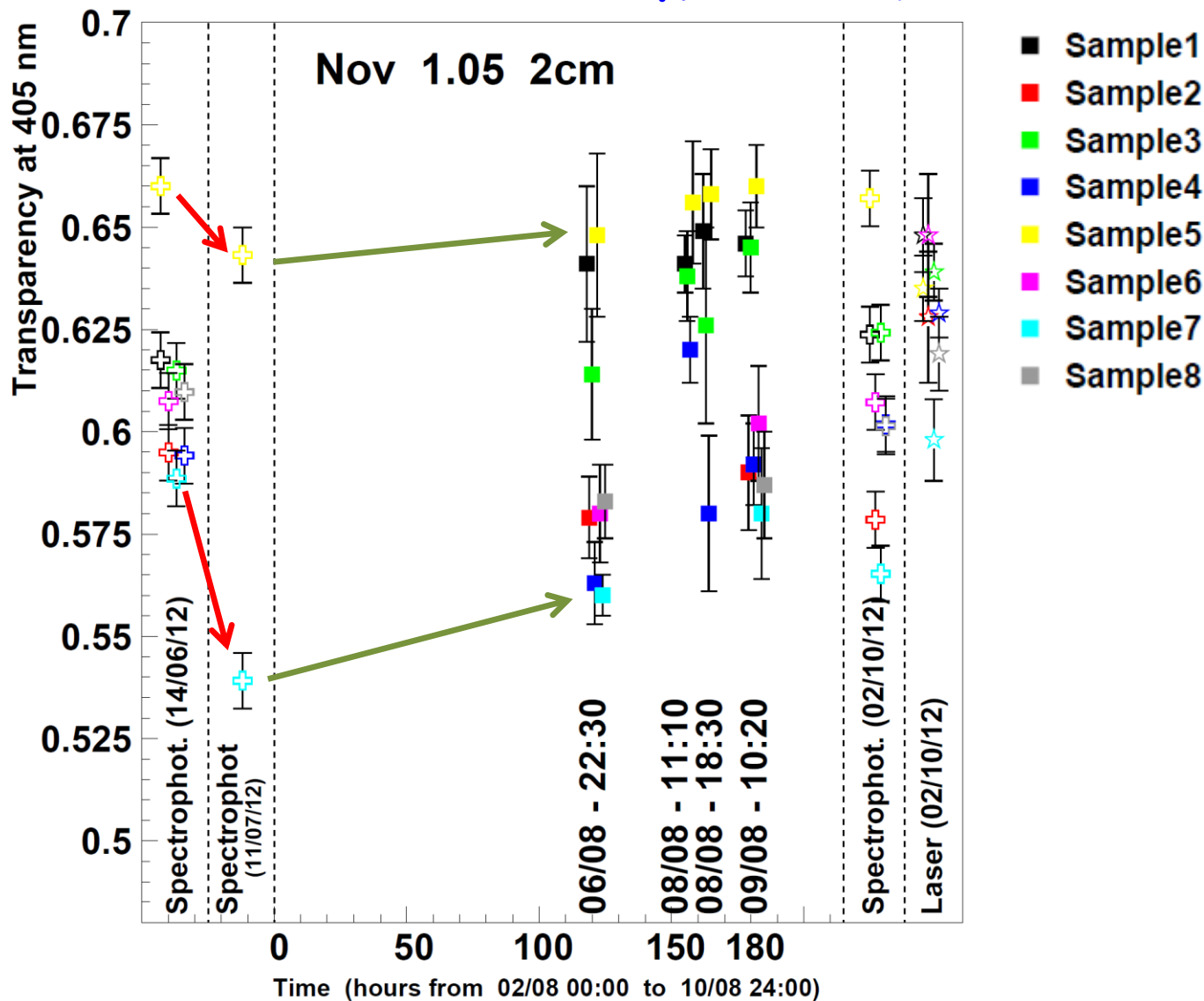
# Results

Very poor performances



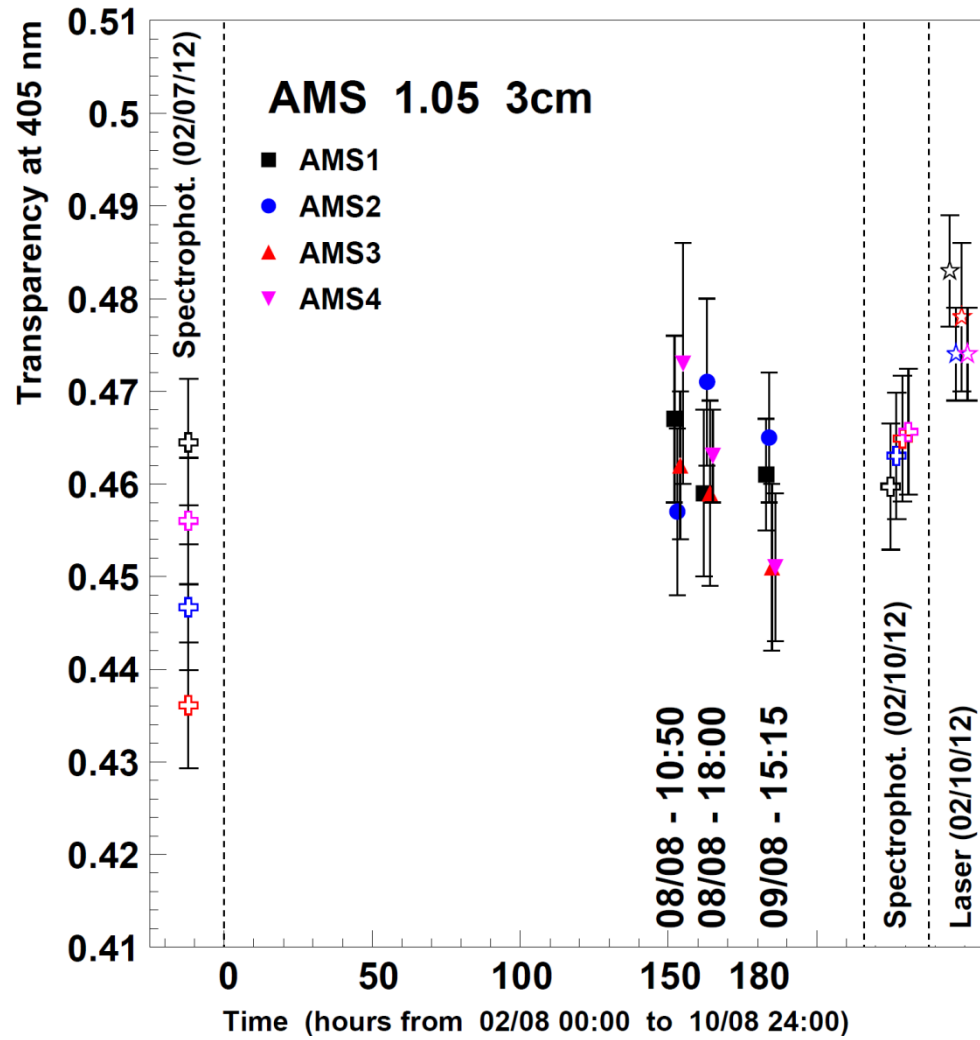
Results are relatively stable

# Some results



After storage in dry cabinet

# Results

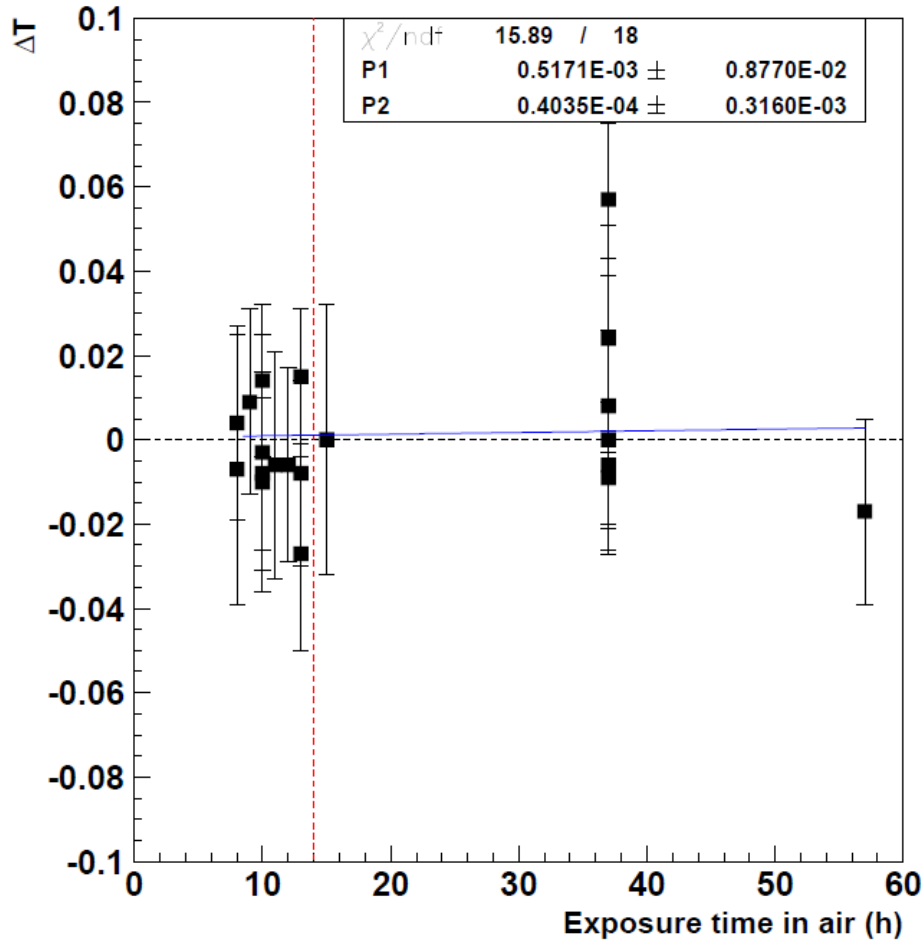


# Looking for a general trend

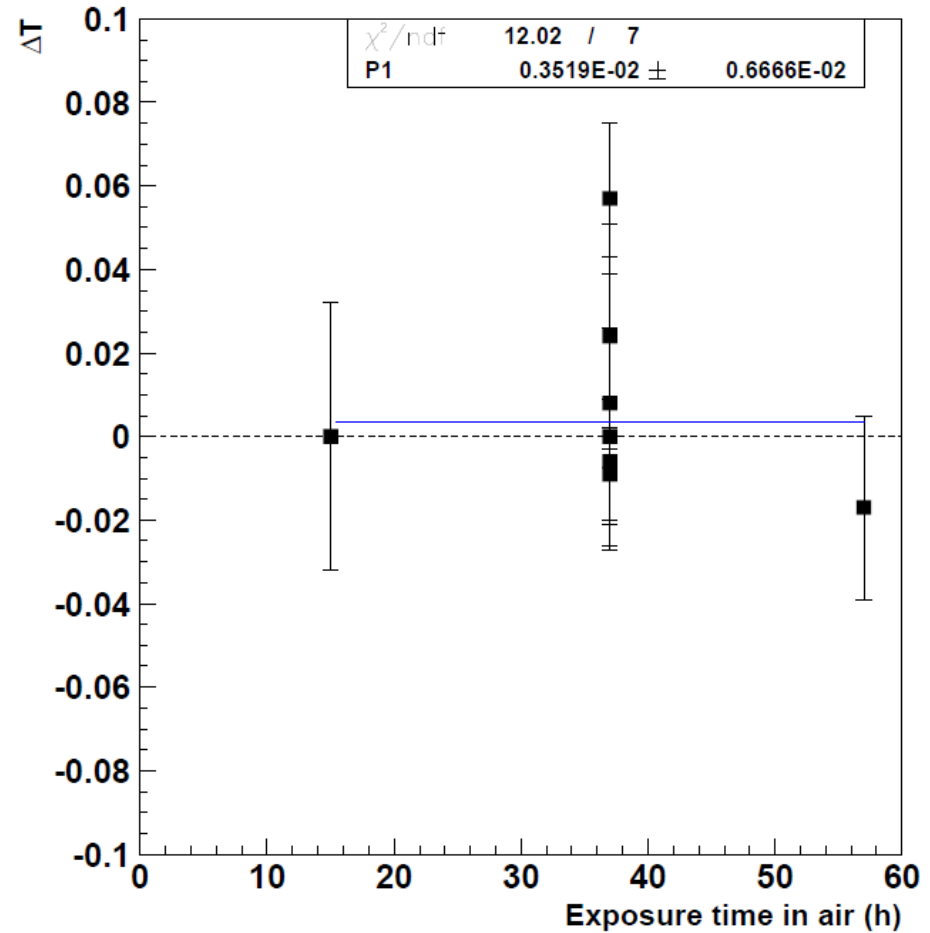
## After exposure to air

Tile	exposure time (h)	$T_{before}$	$T_{after}$	$\Delta T$
Nov. 1.05 3cm tile3	57	$0.378 \pm 0.012$	$0.361 \pm 0.010$	$-0.017 \pm 0.022$
Nov. 1.06 3cm tile1	37	$0.461 \pm 0.008$	$0.455 \pm 0.007$	$-0.006 \pm 0.015$
Nov. 1.06 3cm tile2	37	$0.464 \pm 0.004$	$0.455 \pm 0.007$	$-0.009 \pm 0.011$
Nov. 1.05 2cm sample1	37	$0.641 \pm 0.019$	$0.641 \pm 0.007$	$0.000 \pm 0.026$
Nov. 1.05 2cm sample3	37	$0.614 \pm 0.016$	$0.638 \pm 0.011$	$+0.024 \pm 0.027$
Nov. 1.05 2cm sample4	37	$0.563 \pm 0.010$	$0.620 \pm 0.008$	$+0.057 \pm 0.018$
Nov. 1.05 2cm sample5	37	$0.648 \pm 0.020$	$0.656 \pm 0.015$	$+0.008 \pm 0.035$
Nov. 1.04 2cm tile1	15	$0.596 \pm 0.020$	$0.596 \pm 0.012$	$0.000 \pm 0.032$
Nov. 1.05 3cm tile1	13	$0.399 \pm 0.012$	$0.372 \pm 0.011$	$-0.027 \pm 0.023$
Nov. 1.06 3cm tile1	13	$0.466 \pm 0.010$	$0.458 \pm 0.012$	$-0.008 \pm 0.022$
Nov. 1.06 3cm tile2	13	$0.460 \pm 0.009$	$0.475 \pm 0.007$	$+0.015 \pm 0.016$
Nov. 1.05 2cm tile1	12	$0.607 \pm 0.011$	$0.601 \pm 0.012$	$-0.006 \pm 0.023$
Nov. 1.06 2cm tile1	11	$0.602 \pm 0.013$	$0.596 \pm 0.014$	$-0.006 \pm 0.027$
Nov. 1.05 3cm AMS1	10	$0.467 \pm 0.009$	$0.459 \pm 0.009$	$-0.008 \pm 0.018$
Nov. 1.05 3cm AMS2	10	$0.457 \pm 0.009$	$0.471 \pm 0.009$	$+0.014 \pm 0.018$
Nov. 1.05 3cm AMS3	10	$0.462 \pm 0.015$	$0.459 \pm 0.013$	$-0.003 \pm 0.028$
Nov. 1.05 3cm AMS4	10	$0.473 \pm 0.019$	$0.463 \pm 0.007$	$-0.010 \pm 0.026$
Nov. 1.05 3cm tile3	9	$0.381 \pm 0.013$	$0.392 \pm 0.009$	$+0.009 \pm 0.022$
Nov. 1.05 2cm tile2	8	$0.604 \pm 0.015$	$0.608 \pm 0.008$	$+0.004 \pm 0.023$
Nov. 1.05 3cm tile4	8	$0.398 \pm 0.014$	$0.391 \pm 0.018$	$-0.007 \pm 0.032$

# Looking for a general trend



1<sup>st</sup> order polynomial fit:  
No significance (too short exposure times)



0<sup>th</sup> order polynomial fit (constant):  
No significance (too short exposure times)