Nuclear tracks analysis in passive Radon detector using scanner

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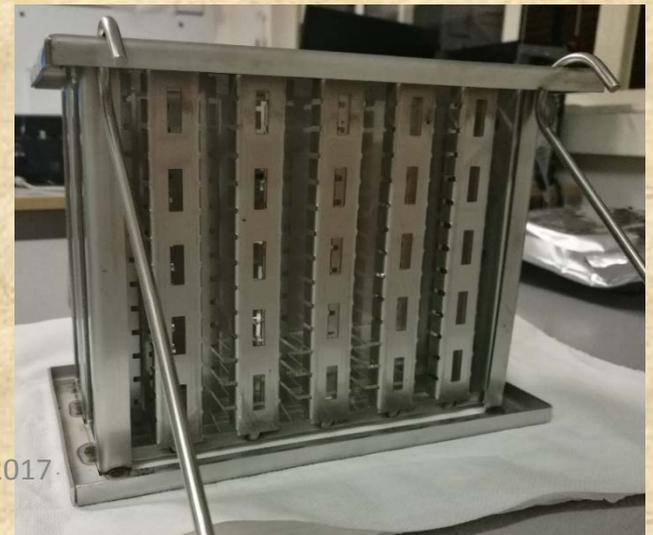Dipartimento di Matematica e Fisica

An alternative, fast and economic method of tracks analysis relesead by Radon in CR39 and LR115 detectors

Apparatus :
 A commercial scanner
A free software

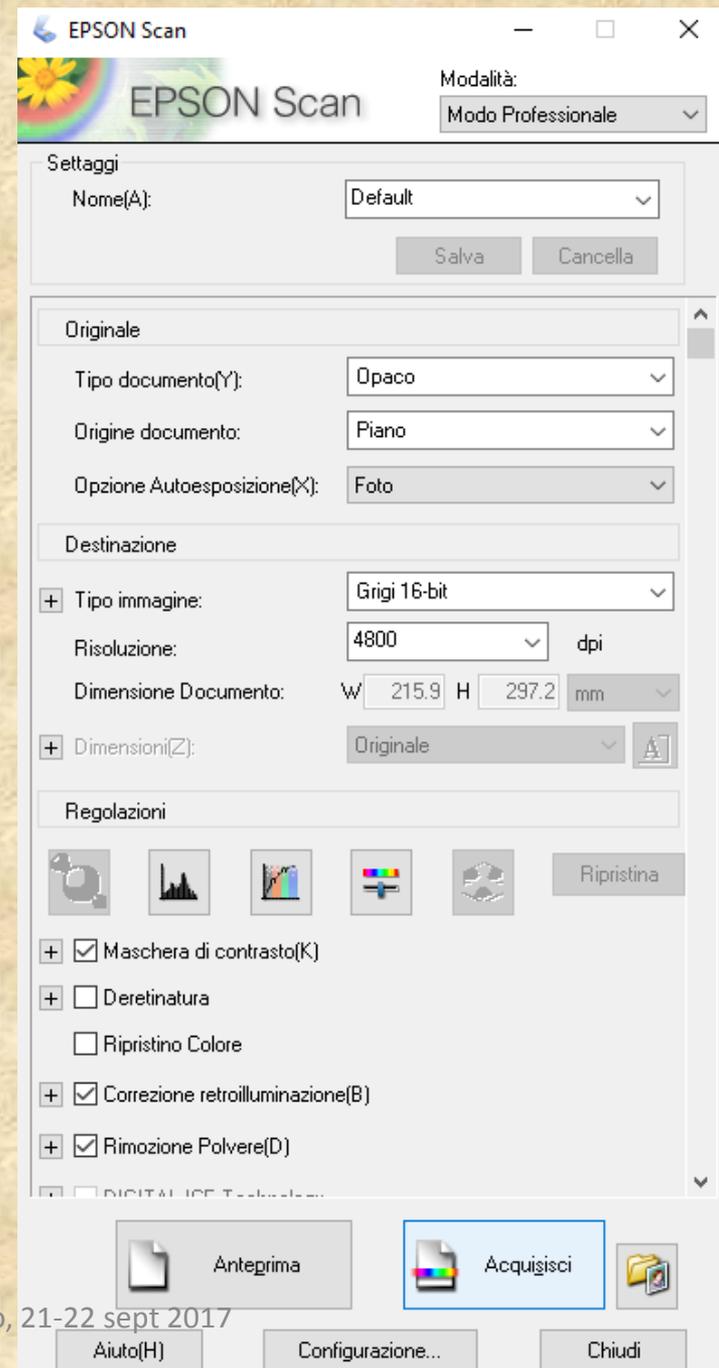# Apparatus used for chemical etching of CR39 detectors

Scanner: Epson Perfection V800 Photo

Grid for positioning CR39 detectors

EPSON Scan

Modalità: Modo Professionale

Settaggi

Nome(A): Default

Salva   Cancella

Originale

Tipo documento(Y): Opaco

Origine documento: Piano

Opzione Autoesposizione(X): Foto

Destinazione

Tipo immagine: Grigi 16-bit

Risoluzione: 4800 dpi

Dimensione Documento: W 215.9 H 297.2 mm

Dimensioni(Z): Originale

Regolazioni

Ripristina

☑ Maschera di contrasto(K)

☐ Deretinatura

☐ Ripristino Colore

☑ Correzione retroilluminazione(B)

☑ Rimozione Polvere(D)

Anteprima   Acquisisci

Aiuto(H)   Configurazione...   Chiudi
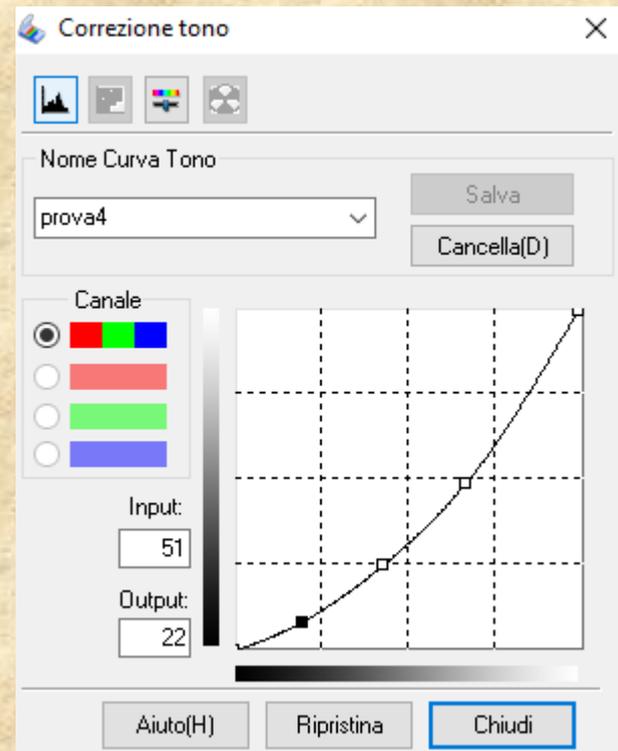
Acquisition parameters

Grey 16 bit
4800 dpi
Area: 14mm x 14mm
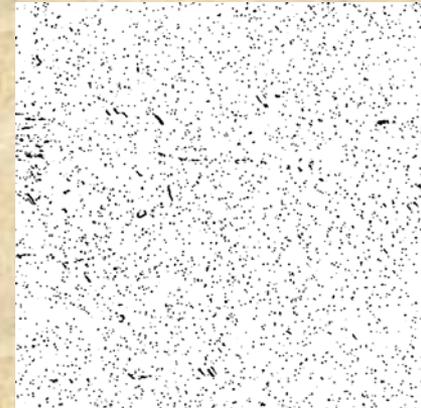Contrast mask
Dust removal
Backlight correction
Tone correction

Procedure with the ImageJ

Application of
 Filter *"Accurate Gaussian Blur"*
Bandpass Filter
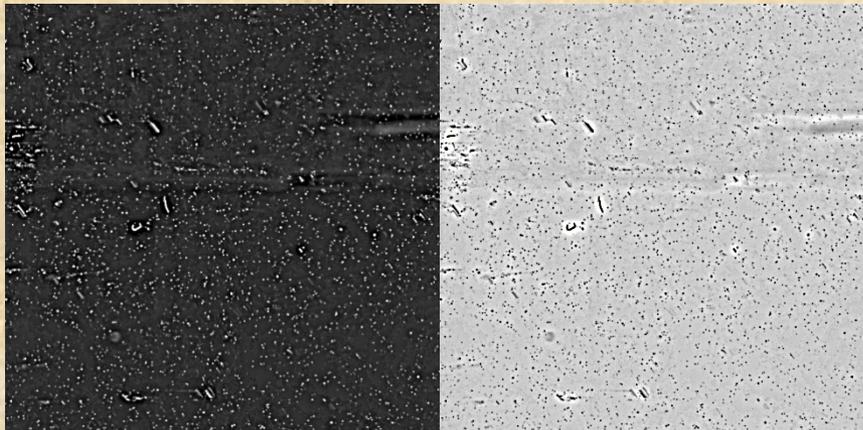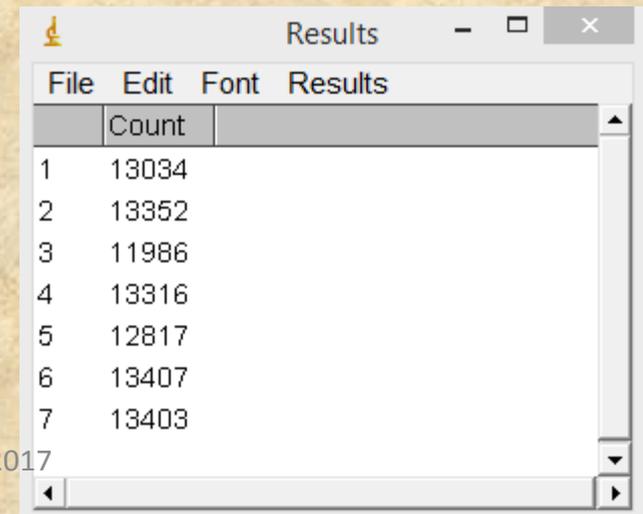Inversion of image color
Find Stack Maxima plugin

Binary image

Image of an Cr-39 after the application of the
"Bandpass Filter…" **(left), inverted image (right)**

	Count
1	13034
2	13352
3	11986
4	13316
5	12817
6	13407
7	13403

Analysis of the intrinsic background of detectors

Average Number of tracks   2170
Standard Deviation   257

Tracks Density (cm-2)   1107
Standard Deviation (cm-2)   131
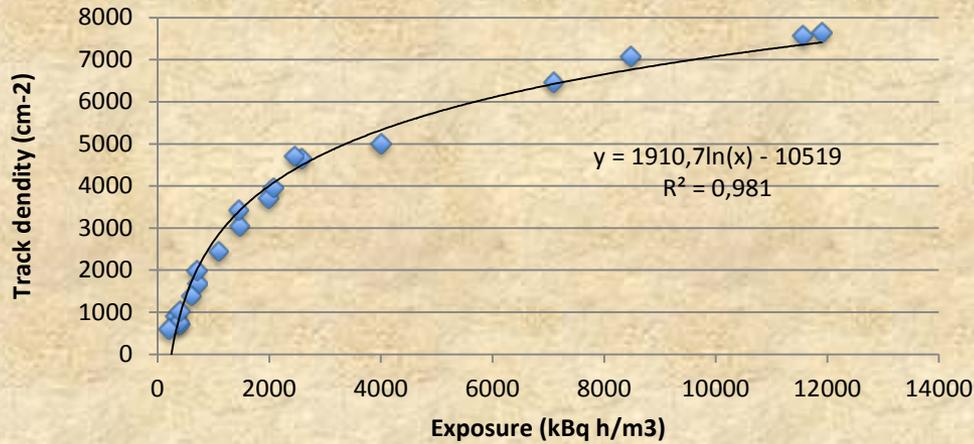
Calibration of the scanner method

To carried out a calibration curve data coming from
intercomparison campaigns of BfS 2014, BfS2015, Lurisia,
mi.am reference detectors,
INMRi-ENEA laboratory ,
LARA laboratory of Napoli
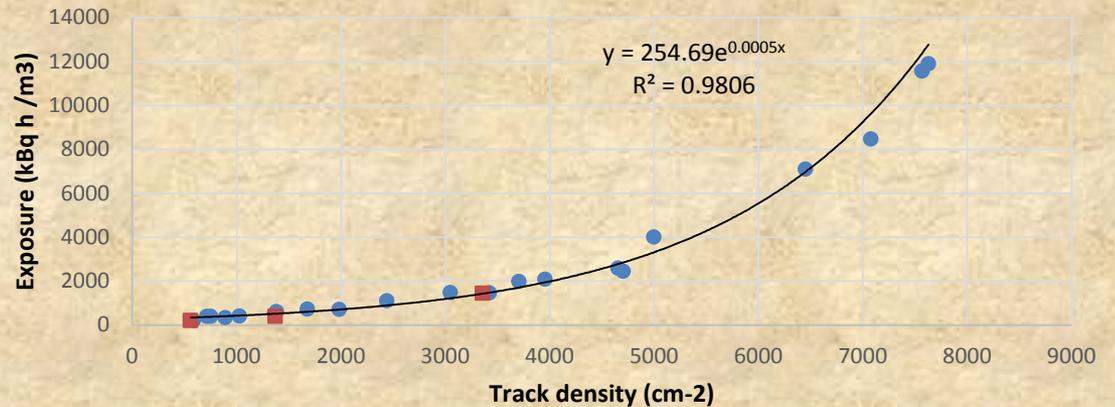were used.

Range of exposure used
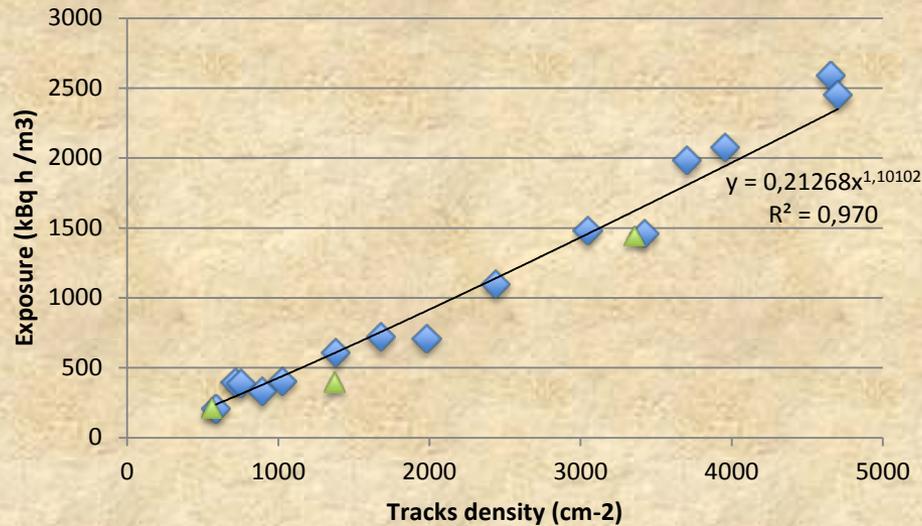200 – 12000 kBq h /m3
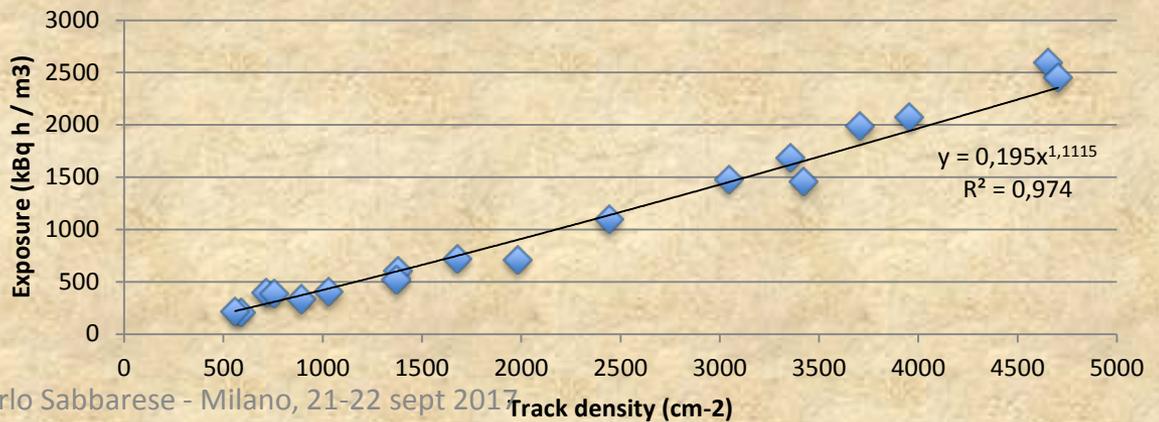
Calibration curve

Track density - Exposure

$y = 1910{,}7\ln(x) - 10519$
$R^2 = 0{,}981$

Track dendity (cm-2) / Exposure (kBq h/m3)

Esp vs Tracks/cm2

$y = 254.69e^{0.0005x}$
$R^2 = 0.9806$

Exposure (kBq h /m3) / Track density (cm-2)

Range useful for indoor and workplaces

$y = 0,21268x^{1,10102}$
$R^2 = 0,970$

Best fit using AIRP2017 Intercomparison data

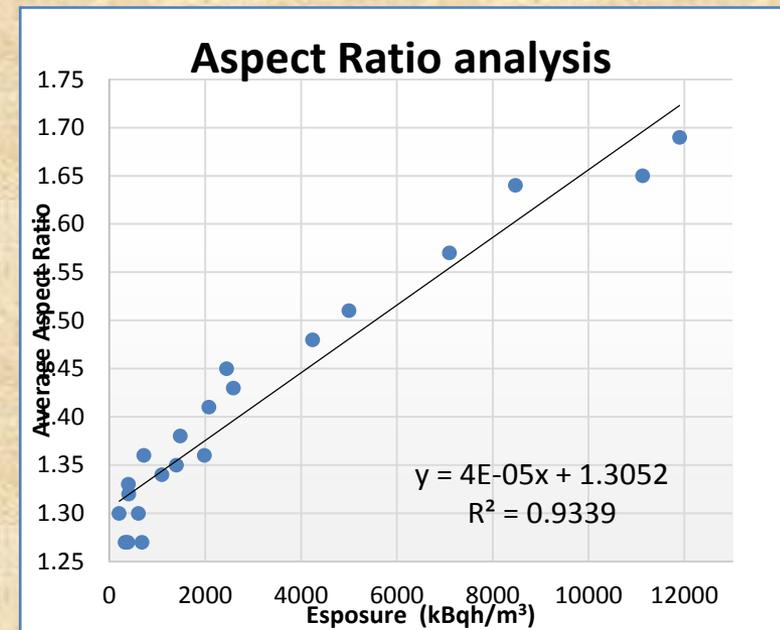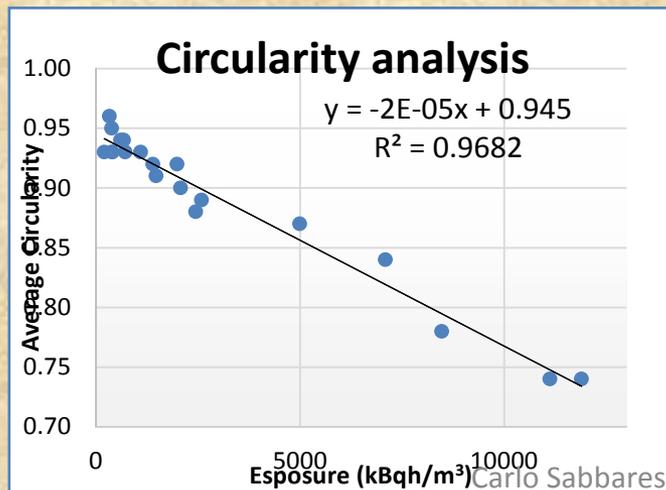$y = 0,195x^{1,1115}$
$R^2 = 0,974$

Analysis of some characteristics of tracks using ImageJ software
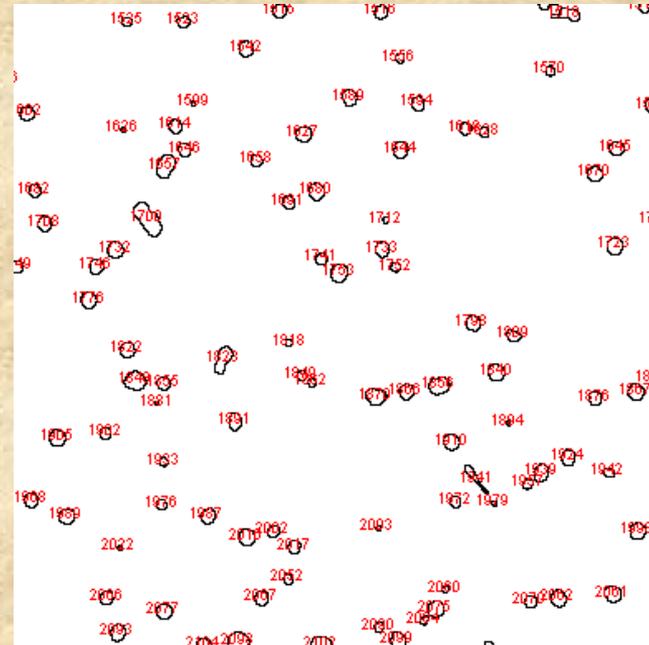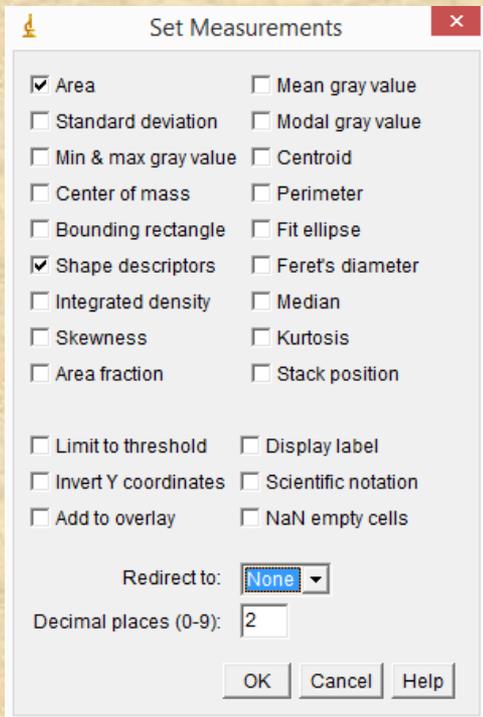
Zoom of part of a detector

Tracks area analysis

Average track area (μm2) vs Exposure (kBqh/m3)

$$y = 23017e^{6E-05x}$$
$$R^2 = 0{,}70$$

Tracks Area

Circolarity = 4π Area / (Perimeter)^2

Circularity analysis

Average Circularity vs Esposure (kBqh/m³)

$$y = -2E-05x + 0.945$$
$$R^2 = 0.9682$$

Aspect Ratio analysis

Average Aspect Ratio vs Esposure (kBqh/m³)

$$y = 4E-05x + 1.3052$$
$$R^2 = 0.9339$$
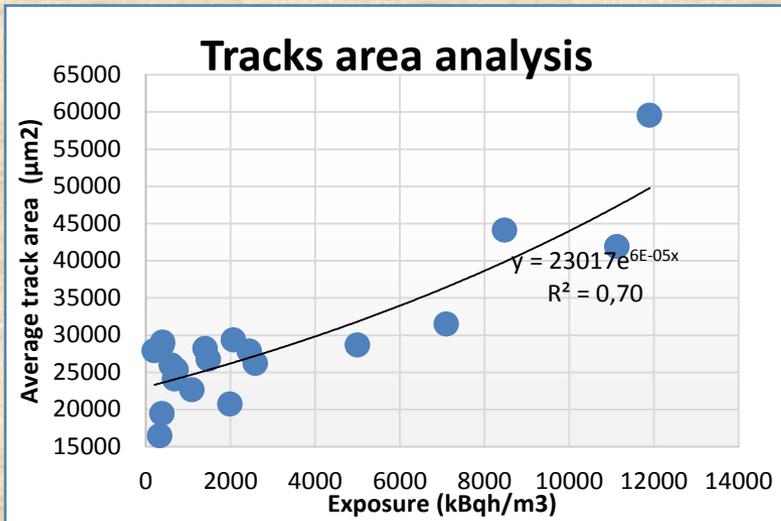
Aspect Ratio = Majior asix/ Minor axis

Tracks diameter distributions

400 kBq h/m3

2000 kBq h/m3

5000 kBq h/m3

12000 kBq h/m3

Tracks Diameter analysis

$y = 0{,}9142\ln(x) - 4{,}5971$

$R^2 = 0{,}94$

Average Diameter (µm)

Esposure (kBqh/m³)
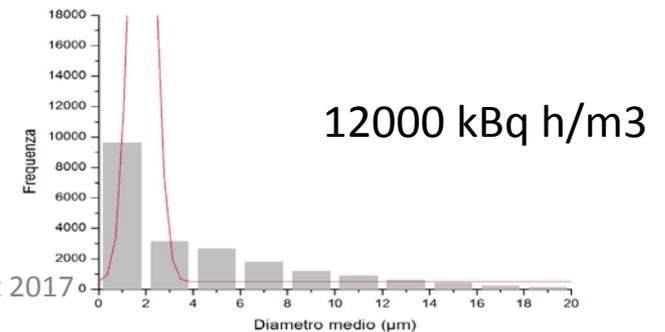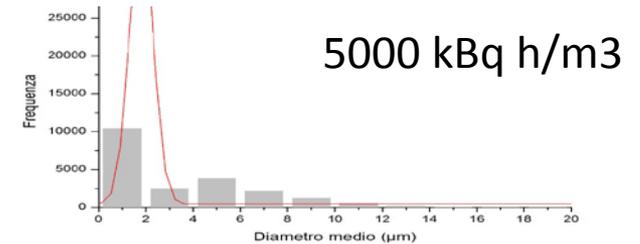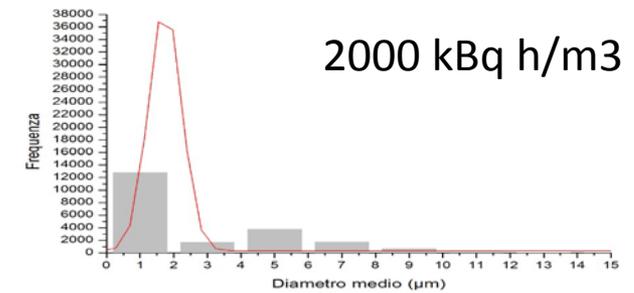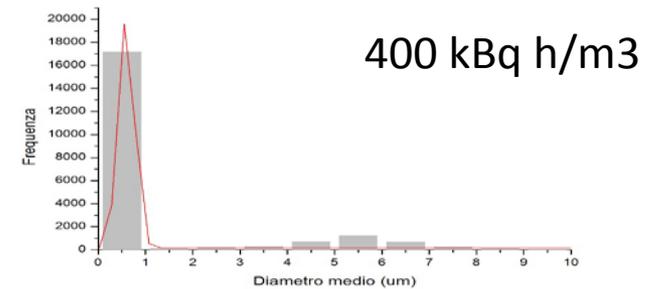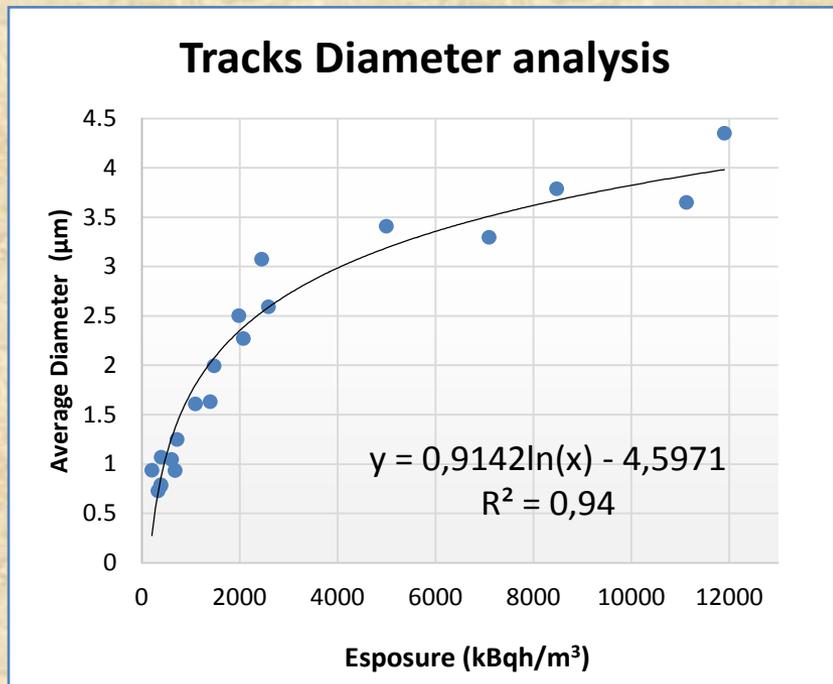
Conclusions – CR39 detectors

The method developed works very well

Up to 3000 kBq h/m3   (Radon indoor)

Calibration curve almost linear can be well used

The average area and diameter are independent of the exposure values

The Aspect Ratio and circolarity values indicate that tracks are almost circular

Then, no overlaped tracks or very negligible effect

Over 3000 kBq h/m3

Calibration curve is not linear

The average area and diameter values increase vs exposure values

The Aspect Ratio and circolarity values indicate that tracks are not circular

Then, overlaped tracks is not negligible effect

LR-115 detectors

Thickness measurement

To determine the residual film thickness, the scanned image was processed using the option 'create background', which measures the level of transparency of the film.

Track counting

For the track counting, the image was treated with some filtration processes in order to reduce the 'optical noise'. Analysis is performed on the three main colour components (red, green and blue): the tracks are better distinct and clear in the green and blue components.
In fact, systematic tests showed that the analysis of the green component provides the better sensitivity.
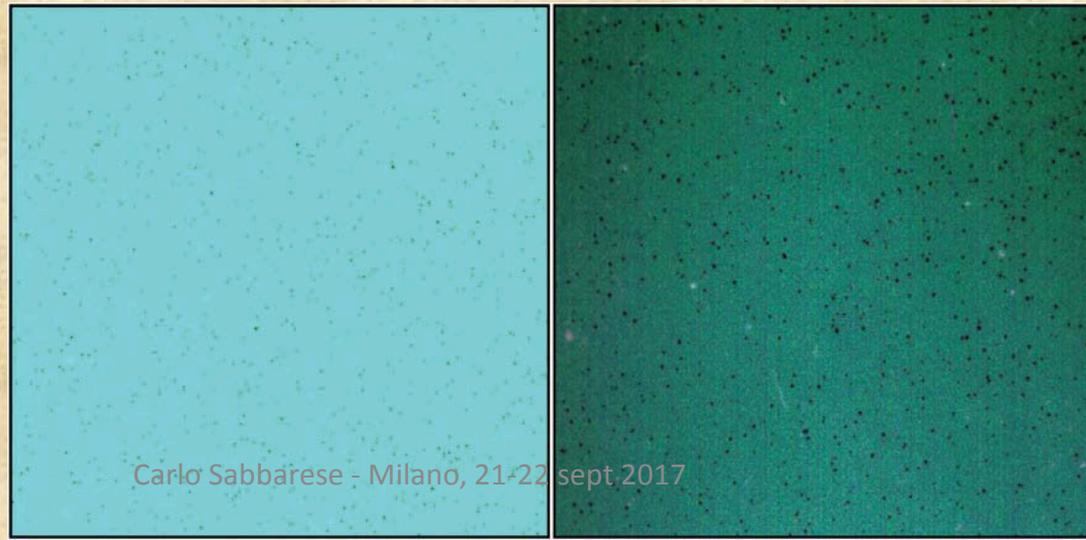
Fit curves of thickness versus LI and OD.
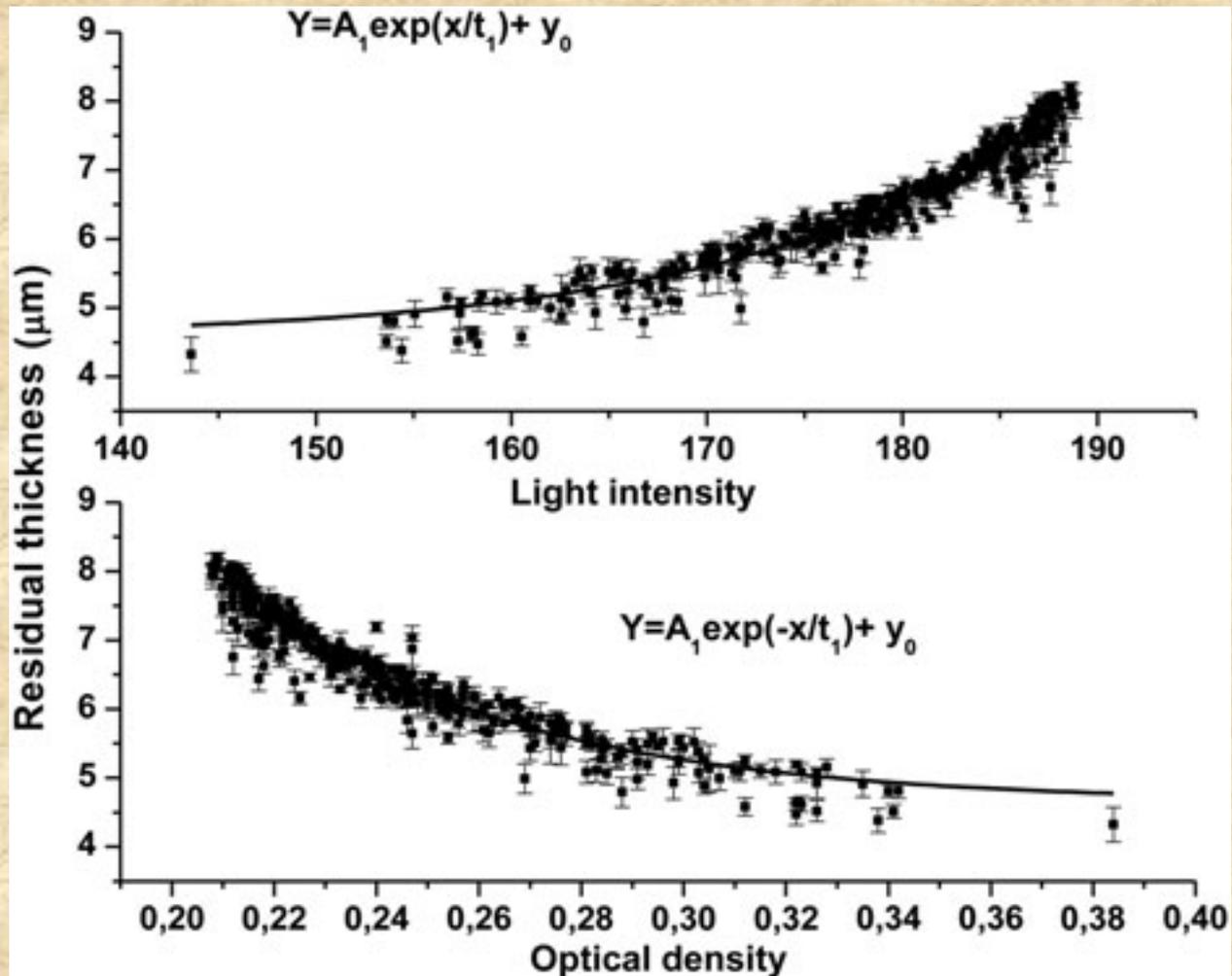
Detector calibration

The calculation of radon specific activity through the
use of LR-115 passive detectors requires the following:
– background correction,
– thickness correction and
– calibration factor

Study of the background

For the study of the background, 60 non-exposed films were developed in order to calculate the parameters for the required correction through a linear regression between track density and residual thickness.

Study of the beta parameter

The beta parameter was evaluated for six different
exposures ranging from 290 to 8534 kBq m23
h. The values of beta are consistent in each
counting and versus exposure is constant.

Study of the calibration factor

The study of the calibration factor was performed
using several exposures carried out at certified laboratories,
I.N.M.R.I. at ENEA-Casaccia in Rome
and the BfS in Berlin, and at the Radioactivity
Laboratory of the University 'Federico II' of Naples (LARA)

Calibration curves
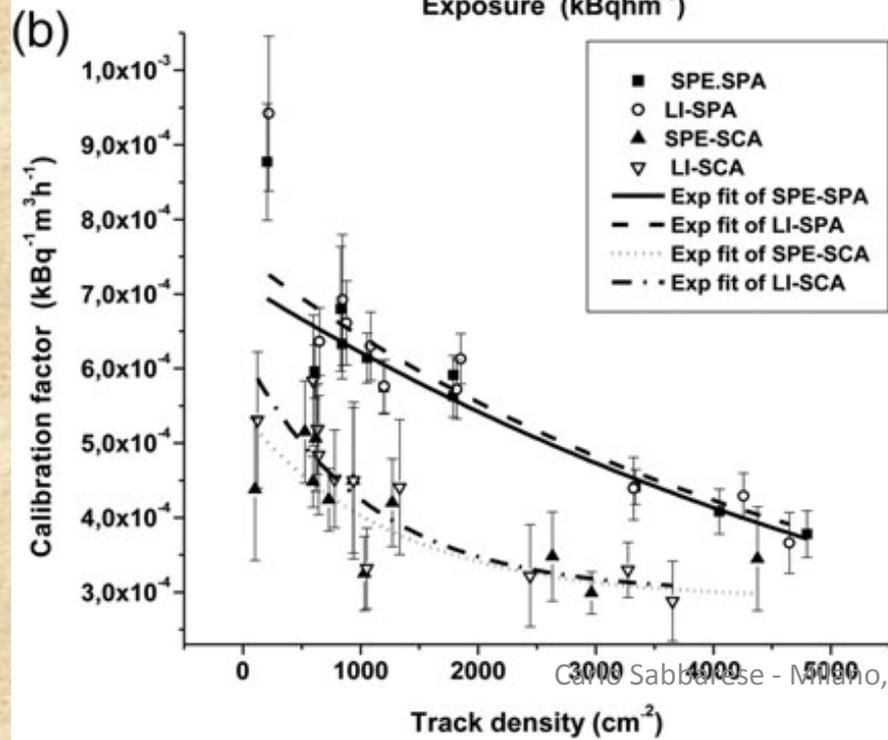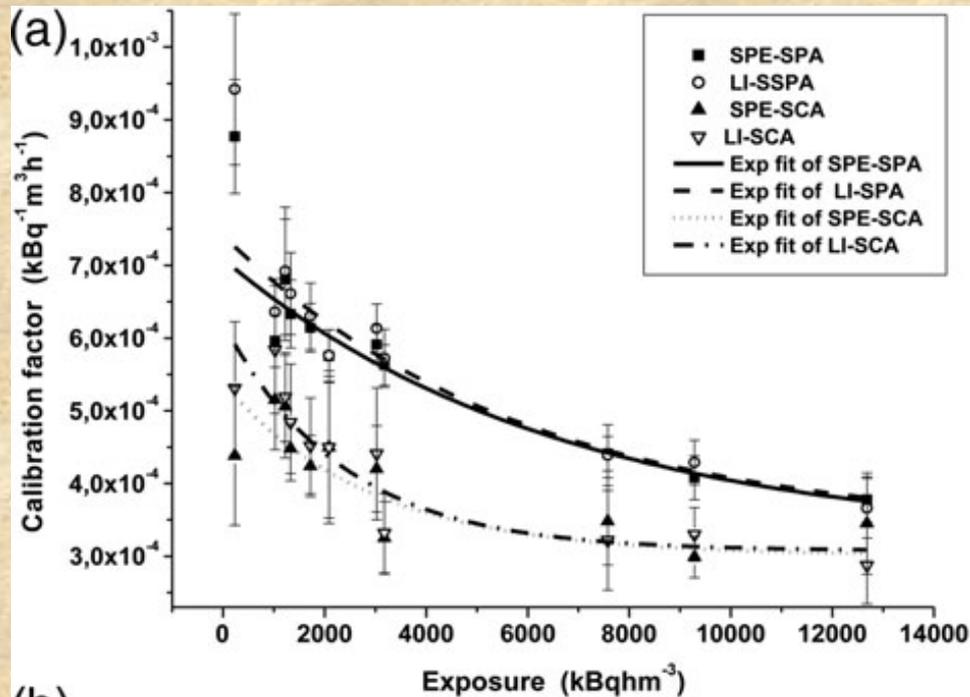
Conclusions – LR115 detectors

The method developed works very well
and was normally used for 4 years at our laboratory.

Also for these detectors the effect of tracks
overlapping is highlighted by the calibration curve.

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Thank you for attention

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