DIRAC note 2010-05

New Nickel Target

Valery Brekhovskikh, Jan Smolík, Tomáš Vrba,
Marin Marius Gugiu

September 10, 2010

Abstract

Physical and geometrical specifications of the new Ni target installed in the DIRAC experiment in 2009 are described in this note.

1 Introduction

In the DIRAC experiment thin foil targets are used for productions of pions and kaons [1]. A set of targets were used for this purpose during data taking in 1999-2009: Pt (28 μm thick), Ni (94 and 98 μm thick), Ti (250 μm thick). Main target was the Ni one. In 2009 it was decided to install new one Ni target with higher purity of the composition. Among others the previous one was used during few years and taking into account rather high proton flux of the DIRAC experiment it composition was changed due to nuclear-proton interactions. For this reason Nickel foils of thickness 0.1 μm was ordered from Alfa Aesar Company [2] and installed before the start of the 2009 run into the DIRAC target station.

2 Properties of the new Ni target

As mentioned before two 50x50 mm Puratronic® Nickel foils of thickness 0.1*mm* was ordered from Alfa Aesar Company. The declared purity of the foil is 99.994% (metals

basis). The copy of certificate of analysis is presented below. We did not provide independent analysis.

Certificate of Analysis

PURATRONIC®

HIGH PURITY RESEARCH
CHEMICALS & MATERIALS

Nickel **foil, 0.1 mm (0.004in) thick, Puratronic®, 99.994% (metals basis)**

Stock Number: 12046

Lot Number: I20S002

Analysis

Ag	< 0.05	Al	0.015	As	< 0.01	Au	< 0.05
B	< 0.001	Ba	< 0.001	Be	< 0.001	Bi	< 0.005
Br	< 0.01	C	19	Ca	< 0.05	Cd	< 0.01
Ce	< 0.001	CI	< 0.05	Co	0.055	Cr	0.02
Cs	< 0.001	Cu	0.06	F	< 0.01	Fe	9.2
Ga	< 0.01	Ge	< 0.05	H	1	Hf	< 0.005
Hg	< 0.05	I	< 0.005	In	< 0.005	Ir	< 0.01
K	< 0.05	La	< 0.001	Li	< 0.001	Mg	< 0.005
Mn	0.025	Mo	0.02	N	1	Na	< 0.001
Nb	< 0.01	Nd	< 0.001	O	4	Os	< 0.01
P	< 0.005	Pb	< 0.005	Pd	< 0.05	Pt	< 0.05
Rb	< 0.001	Re	< 0.01	Rh	< 0.01	Ru	< 0.01
S	< 1	Sb	0.01	Sc	< 0.001	Se	< 0.01
Si	0.05	Sn	< 0.01	Sr	< 0.01	Ta	< 1
Te	< 0.005	Th	< 0.0001	Ti	1.235	Tl	< 0.01
U	< 0.0001	V	< 0.001	W	0.02	Y	< 0.001
Zh	< 0.01	Zr	< 0.005				

Values given in ppm unless otherwise noted Carbon,
hydrogen, nitrogen, oxygen and sulfur determined by LECO
All other elements determined by GDMS

Certified bv:

Quality ('ontrol

Alfa Aesar®

A Johnson Matthey Company

30 Bond Street • Ward Hill, MA 01835-8099 USA • Telephone: (978) 521-6300 • Fax:(978) 521-6350 Toll-free
Catalog Sales: (800) 343-0660 • Technical Services: (800) 343-7276 • Specialty/Bulk Sales: (888) 343-8025
www.alfa.com • email: info@alfa.com

The most important parameter in our case is the thickness of the foil as 1% ambiguity in thickness leads to 1.5% in systematic error for life-time. We made several types of measurements to define it precisely.

At the **first** we determined average thickness by measuring weight and area of foils. For weighing classical analytical balance with accuracy of 0.5 *mg* was used. The area was determined by graphical program from scanned picture of the foil.

We estimated upper limit of the error for this method as 1%. The results are draw up in Table 1.

Table 1: Determination of average thickness. Ni density ρ = 8.908*g/cm*3 [3].

Foil	weight [g]	area [cm^2]	thickness [μm]
I	2.5018 ± 0.0005	26, 388 ± 0.264 26, 059 ± 0.260	106.4 ± 1.1 107,8 ± 1.0
II	2.3986 ± 0.0005	25. 297 ± 0.253	106.4 ± 1.1

At the **second** one we measured thickness on several points using micrometer caliper with accuracy of 1 μm and precise electronic micrometer with accuracy 0.1 μm. The result for Foil I is shown in Figure 1 and for Foil II in Figure 2. The measurements were done for sixteen points with 1 μm accuracy – black numbers in both Figures. With electronic micrometer nine points in the center of each foil were measured – white numbers in Figures 1,2.

It is evident from Figures 1 and 2 that flatness of foils is not very good. Moreover the measured thickness is mostly higher than average values from Table 1. Due too good consistence between values obtained by manual and electronic micrometer we can exclude, with high probability, the absolute shift in these measurements.

The possible reason of incompatibility between the results of those two methods lies in bad smoothness and waviness of the foils. The study of foils under Atomic Force and Electron microscopes shows existence of both these effects.

The Figures 3 shows the general 3D view of some part of the Foil #1 obtained by Atomic Force microscope. The value of flatness distortion is about 0.07 μm, this is much less than difference between two methods. But looking at Figure 4 we see a lot of small pimples on the surface of foil. The influence of them cannot be determined on the base of measurement were done, but as the diameter of micrometer caliper probe is about 5 mm it may cause the shift of measured value on the height of this pimples or foil unevenness.

The confirmation of understate value of the density 8.81 we get if take the value 109 for thickness compare with table value 8.90.

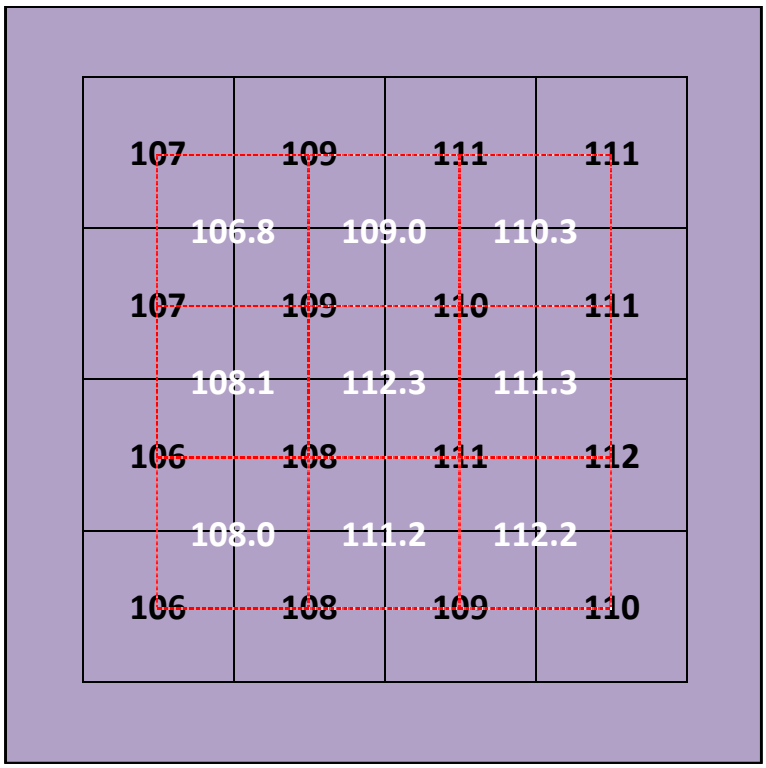


Figure 1. Results of measurement with two types of micrometers for Foil #1.

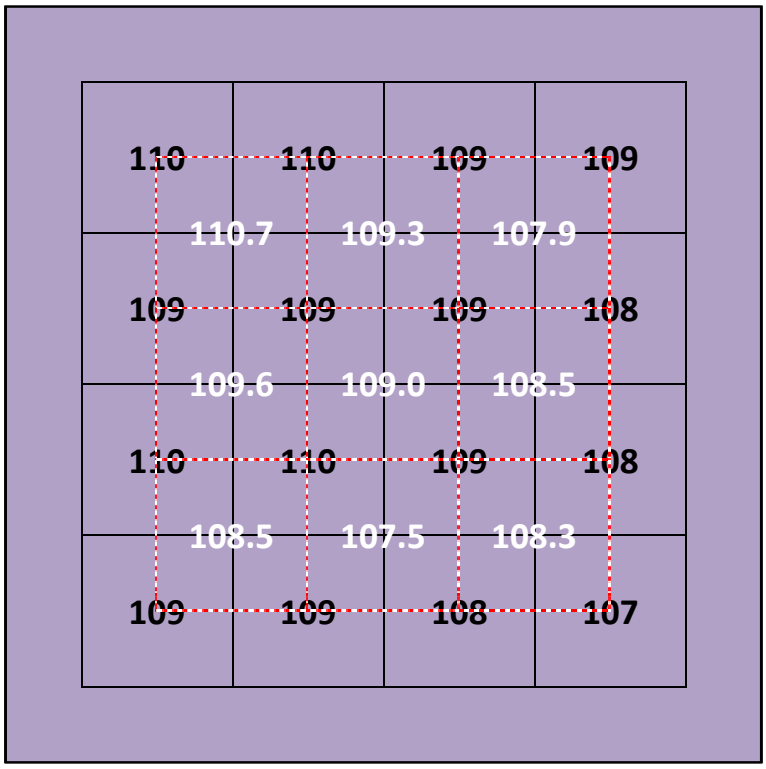


Figure 2. Results of measurement with two types of micrometers for Foil #2.

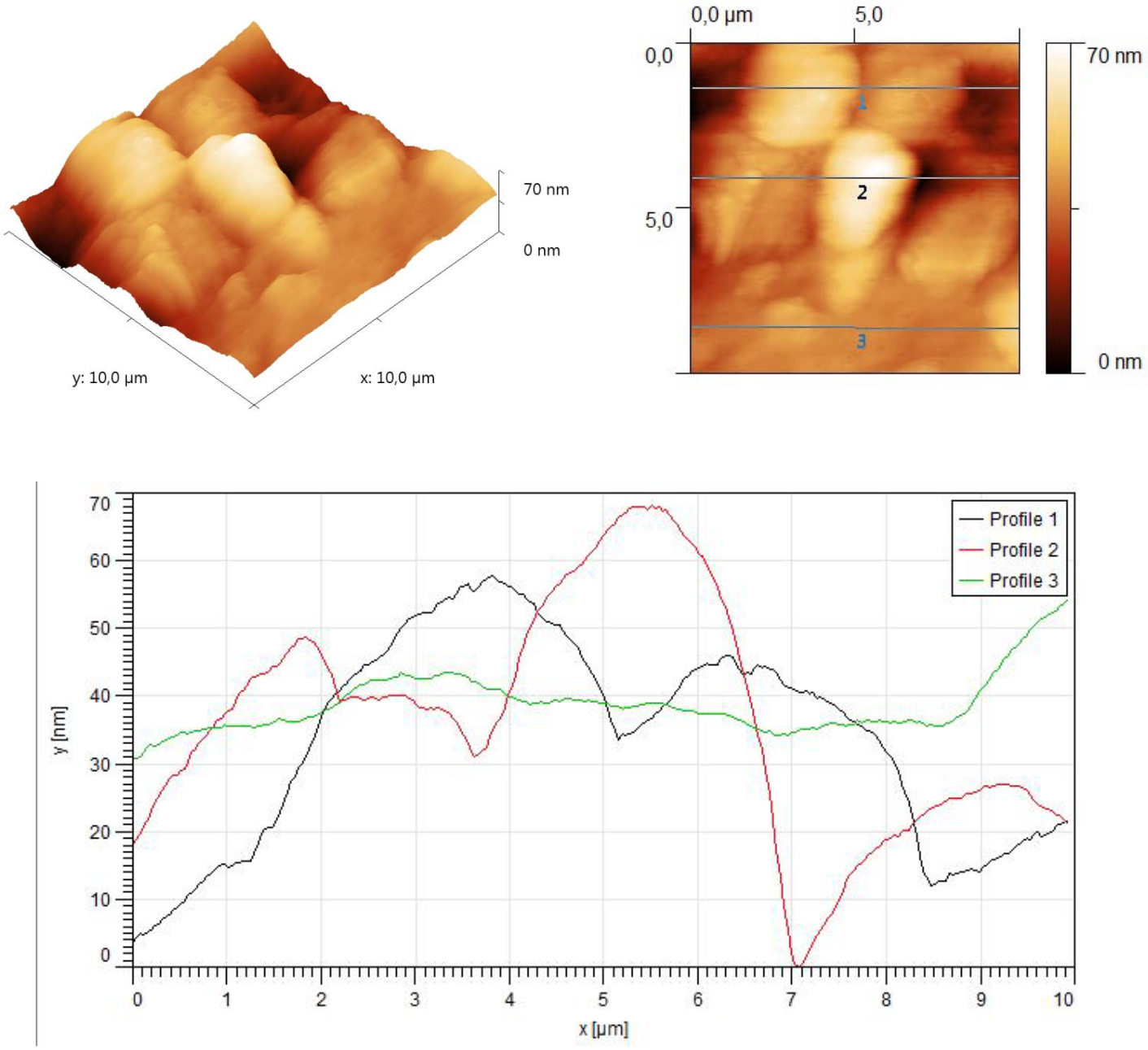
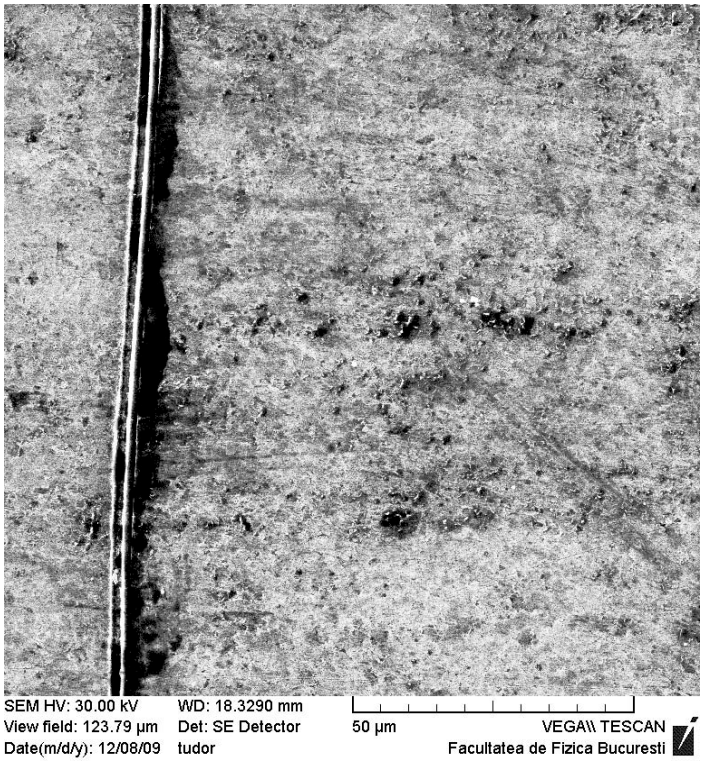


Figure 3. Scan of Foil #1 with Atomic Force Microscopy.



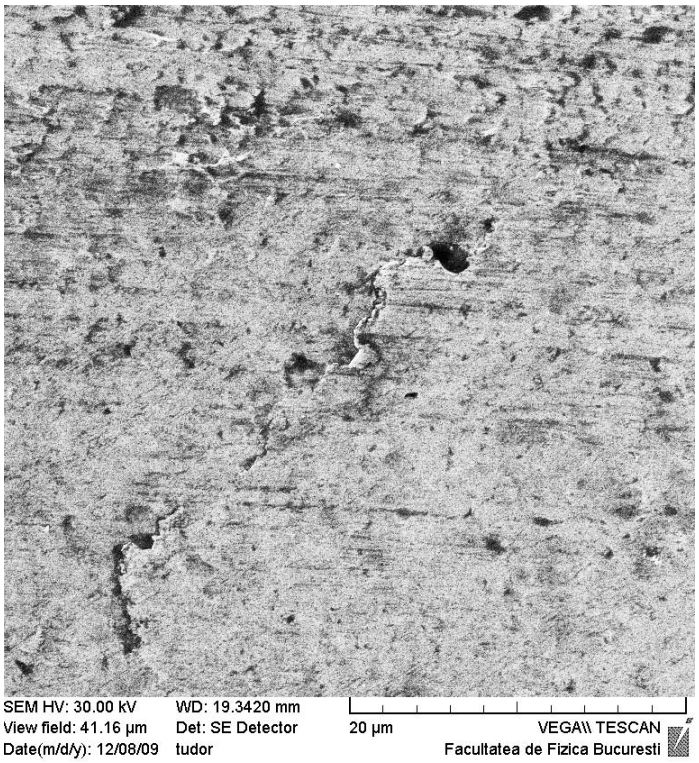


Figure 4. Scan of Foil #1 with Electron Microscopy.

3 Conclusions

Due to better flatness as a target was installed Foil II.

The thickness in the place where beam spot cross the target is:

- ✓ 109.0±0.5μm. – on the base of measurements with micrometer;
- ✓ 106.4 ± 1.1 (107,8 ± 1.0) – on the base of measurements weight and area.

Taking into account all above propose to take as thickness of the target the value

108 ± 1 μm

and for density to use table value:

8.9 $g/cm3$

4 References

[1] Detection of π+π− atoms with the DIRAC spectrometer at CERN
B Adeva et al 2004 J. Phys. G: Nucl. Part. Phys. 30 1929-1946

[2] http://www.alfa.com/en/gh100w.pgm

[3] http://en.wikipedia.org/wiki/Nickel