

Aladi Márk

HUN-REN Wigner Fizikai Kutatóközpont



Kedves Miklós csoportvezető,  
Hegedűs Gergő, Imene Benabdelghani, Inger Ádám

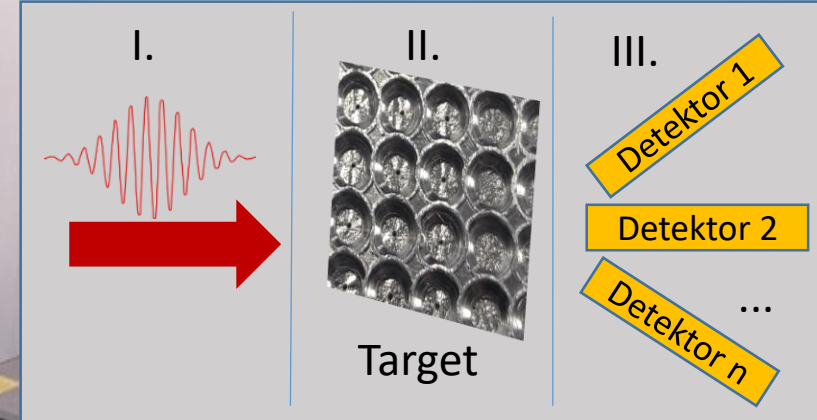
**NAPLIFE**  
Nanoplasmonic Laser Fusion



NAPLIFE szakmai vezető: Biró Tamás Sándor

# Nagyintenzitású lézerforrás a Wigner Fizikai Kutatóközpontban

Titán-zafír lézerrendszer

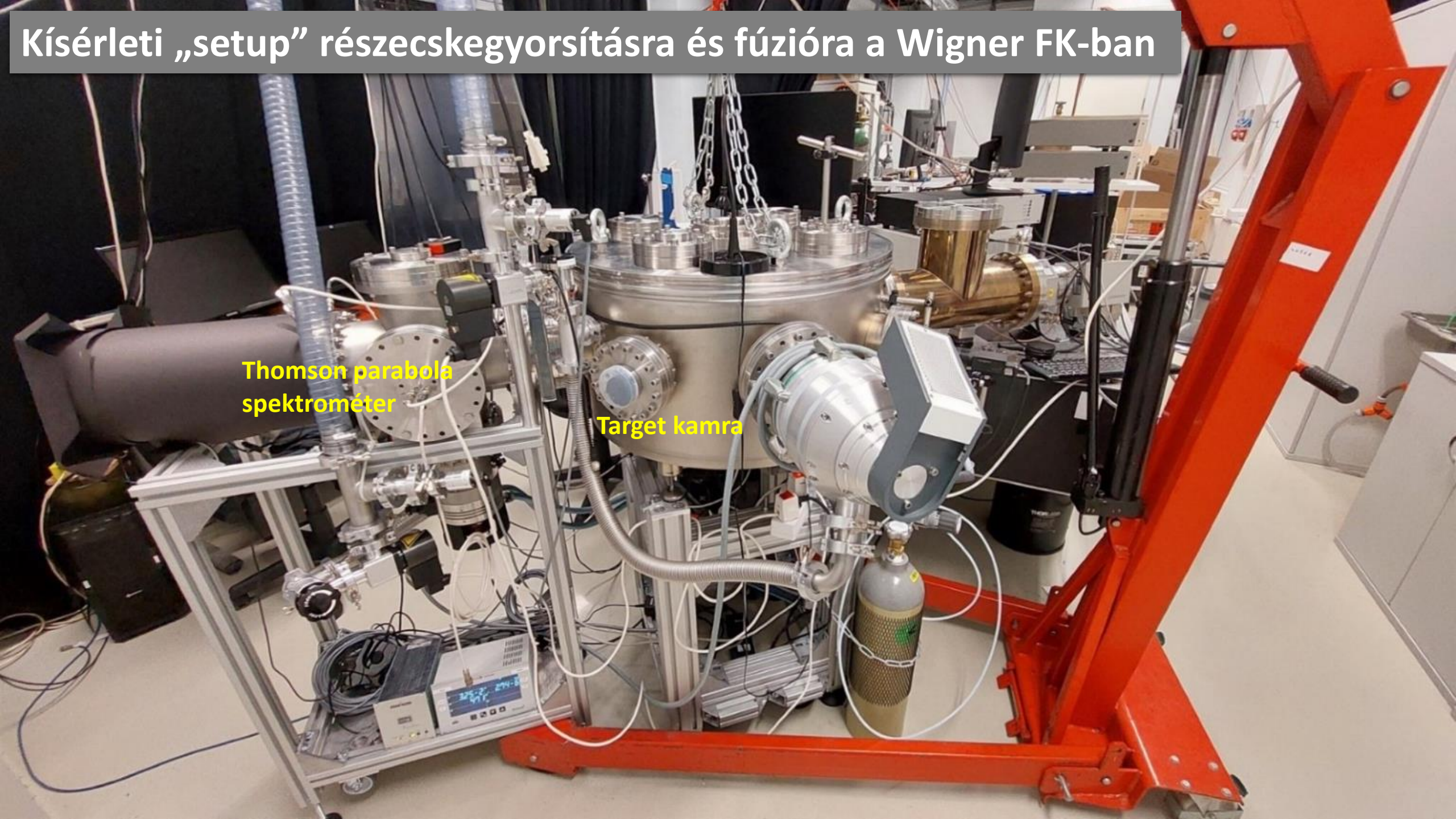


$\lambda_L = 800 \text{ nm}$  (központi hullámhossz)  
 $\tau_p = 40 \text{ fs}$  (impulzushossz, femto:  $10^{-15}$ )  
 $E_p = 30 \text{ mJ}$  (impulzusenergia)  
 $I_L \approx 10^{17} \text{ W/cm}^2$  (fókuszált intenzitás)

# Kísérleti „setup” részecskegyorsításra és fúzióra a Wigner FK-ban

Thomson parabola  
spektrométer

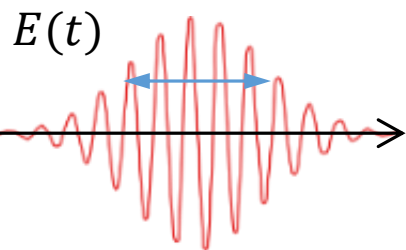
Target kamra



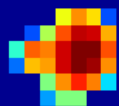
# Egy lézerimpulzus tulajdonságai

Egy lézerimpulzus pontos jellemzése..

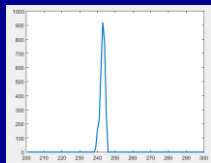
- Ismétlési frekvencia
- Impulzushossz
- Impulzusenergia
- Csörp
- Polarizáció
- Fókuszolt eloszlás
- Kontraszt
- Nyalábméret
- Spektrum
- Transzverzális eloszlás



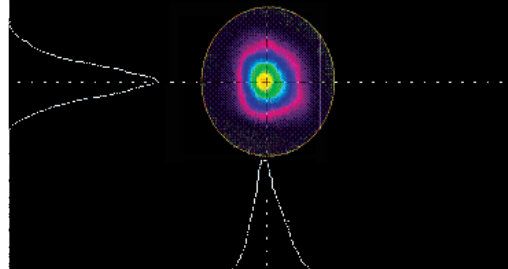
Fókuszált nyaláb átmérője



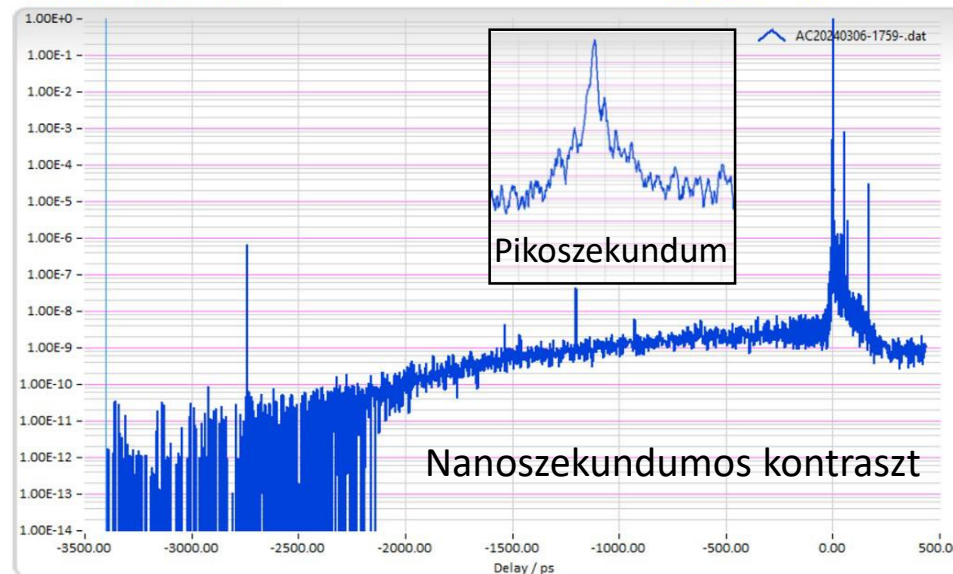
$$I_L \approx 10^{17} \text{ W/cm}^2$$



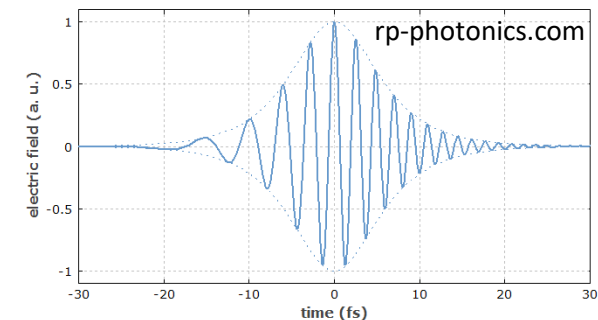
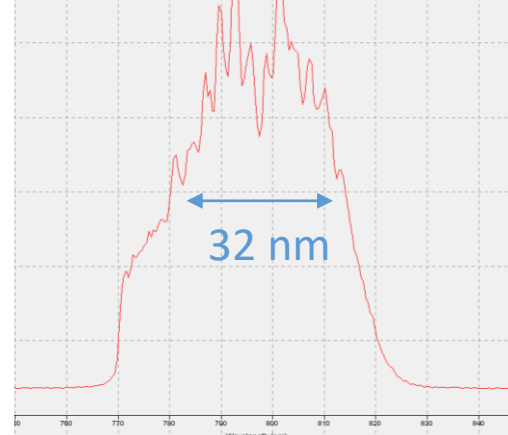
Nyalábméret és transzverzális eloszlás



Autocorrelation Traces



Spektrum and központi hullámhossz



## Generation and characterization of the highest laser intensities ( $10^{22}$ W/cm<sup>2</sup>)

S.-W. Bahk, P. Rousseau, T. A. Planchon, V. Chvykov, G. Kalintchenko, A. Maksimchuk,  
G. A. Mourou, and V. Yanovsky

FOCUS Center and Center for Ultrafast Optical Science, University of Michigan, Ann Arbor, Michigan 48109-2099

Received June 21, 2004

We generated a record peak intensity of  $0.7 \times 10^{22}$  W/cm<sup>2</sup> by focusing a 45-TW laser beam with an  $f/0.6$  off-axis paraboloid. The aberrations of the paraboloid and the low-energy reference laser beam were measured and corrected, and a focal spot size of  $0.8 \mu\text{m}$  was achieved. It is shown that the peak intensity can be increased to  $1.0 \times 10^{22}$  W/cm<sup>2</sup> by correction of the wave front of a 45-TW beam relative to the reference beam. The phase and amplitude measurement provides for an efficient full characterization of the focal field. © 2004 Optical Society of America

OCIS codes: 010.1080, 140.3590, 320.7090.

## Realization of laser intensity over $10^{23}$ W/cm<sup>2</sup>

JIN WOO YOON,<sup>1,2,1</sup> YEONG GYU KIM,<sup>1,3,1</sup> IL WOO CHOI,<sup>1,2</sup> JAE HEE SUNG,<sup>1,2</sup>  
HWANG WOON LEE,<sup>1</sup> SEONG KU LEE,<sup>1,2,4</sup> AND CHANG HEE NAM<sup>1,3,5</sup>

<sup>1</sup>Center for Relativistic Laser Science, Institute for Basic Science, 123 Cheomdangwagi-ro, Buk-gu, Gwangju 61005, Republic of Korea

<sup>2</sup>Advanced Photonics Research Institute, Gwangju Institute of Science and Technology, 123 Cheomdangwagi-ro, Buk-gu, Gwangju 61005, Republic of Korea

<sup>3</sup>Department of Physics and Photon Science, Gwangju Institute of Science and Technology, 123 Cheomdangwagi-ro, Buk-gu, Gwangju 61005, Republic of Korea

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<sup>5</sup>e-mail: chnam@gist.ac.kr

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High-intensity lasers are critical for the exploration of strong field quantum electrodynamics. We report here a demonstration of laser intensity exceeding  $10^{23}$  W/cm<sup>2</sup> with the CoReLS petawatt (PW) laser. After wavefront correction and tight focusing with a two-stage adaptive optical system and an  $f/1.1$  ( $f = 300$  mm) off-axis parabolic mirror, we obtained near diffraction-limited focusing with a spot size of  $1.1 \mu\text{m}$  (FWHM). From the measurement of 80 consecutive laser shots at 0.1 Hz, we achieved a peak intensity of  $(1.1 \pm 0.2) \times 10^{23}$  W/cm<sup>2</sup>, verifying the applicability of the ultrahigh intensity PW laser for ultrahigh intensity laser-matter interactions. From the statistical analysis of the PW laser shots, we identified that the intensity fluctuation originated from air turbulence in the laser beam path and beam pointing. Our achievement could accelerate the study of strong field quantum electrodynamics by enabling exploration of nonlinear Compton scattering and Breit-Wheeler pair production. © 2021 Optical Society of America under the terms of the OSA Open Access Publishing Agreement

### Óriási térerősségek:

$$E_{\text{max}} \left[ \left( \frac{V}{\text{cm}} \right) \right] \cong 2.75 \times 10^9 \left( \frac{I_L}{10^{16} \text{ W/cm}^2} \right)^{1/2}$$

$$B_{\text{max}} [\text{Gauss}] \cong 9.2 \times 10^6 \left( \frac{I_L}{10^{16} \text{ W/cm}^2} \right)^{1/2} .$$

### Óriási fénynyomás:

$$P_L = \frac{I_L}{c} (1 + R) \approx 3.3 \text{ Mbar} \left( \frac{I_L}{10^{16} \text{ W/cm}^2} \right) (1 + R)$$

$$I_L = 3 \times 10^{18} \frac{\text{W}}{\text{cm}^2} \Rightarrow 1 \text{ Gbar}$$

1 GeV-es elektronok gyorsulása lézerplazmában:  $5 \times 10^{20}$  g.

Három naptömegű, 10 km sugarú neutroncsillag felszínén a gyorsulás  $4 \times 10^{11}$  g.



Gyenge ekvivalenciaelv kísérleti ellenőrzésének lehetősége!

L. Á. Gergely and T. Harko, AIP Conf. Proc. 1462, 9–12 (2012)

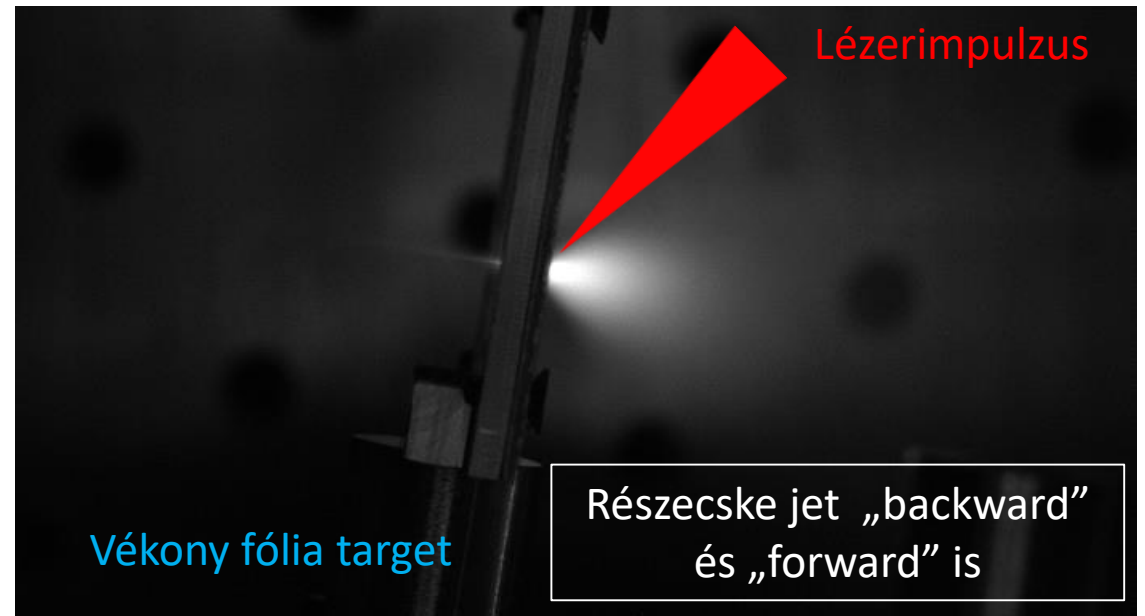
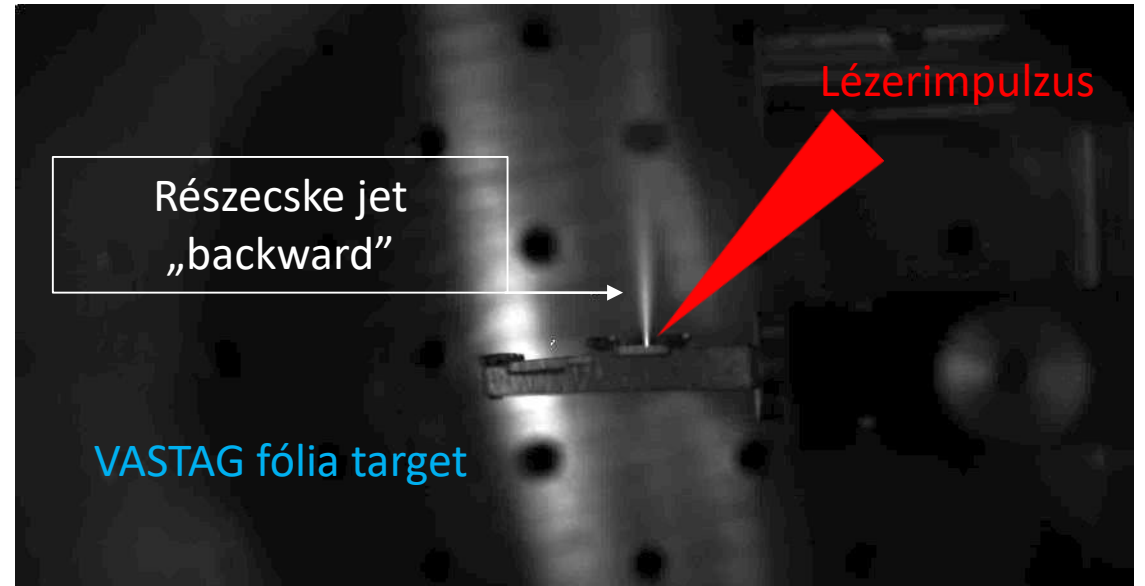
W. P. LEEMANS et al. Nature Phys 2, 696–699 (2006).

# Targetek

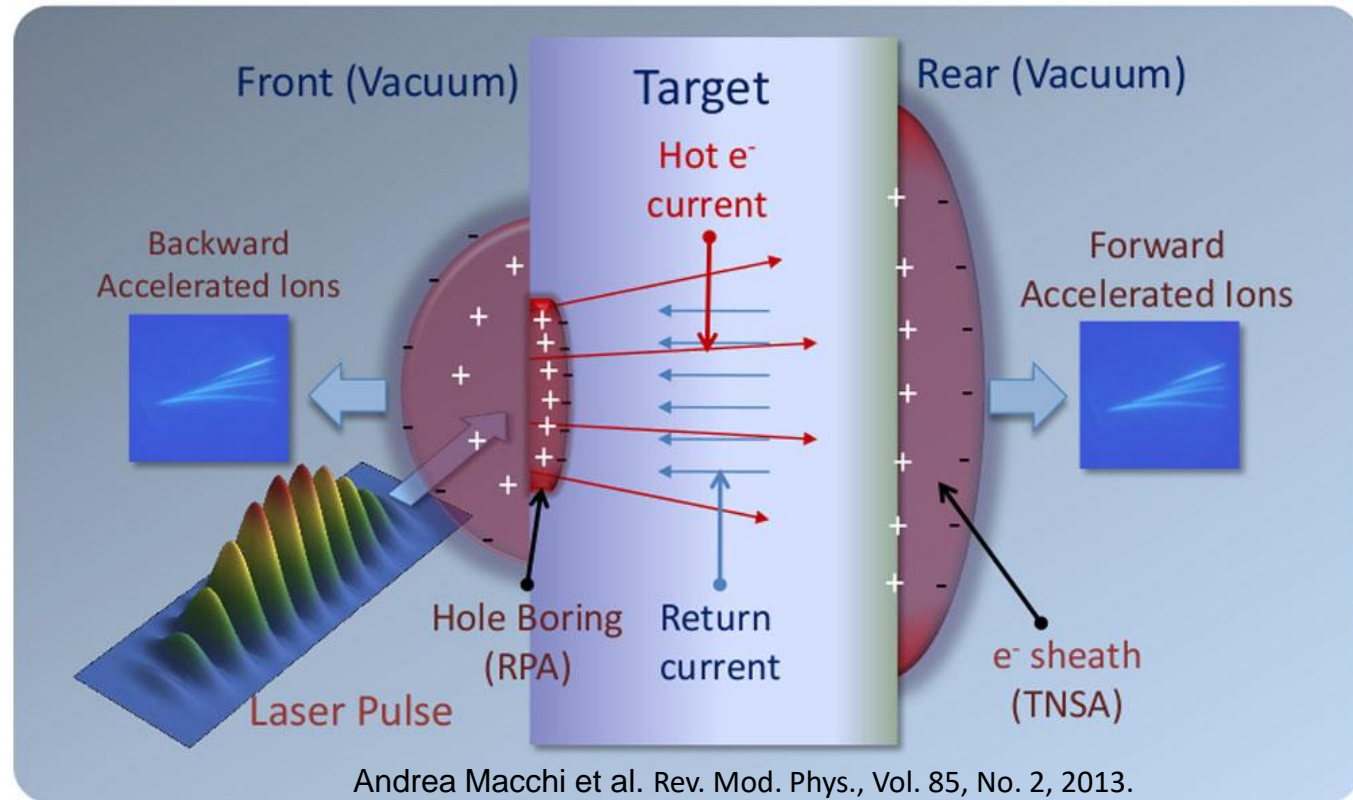
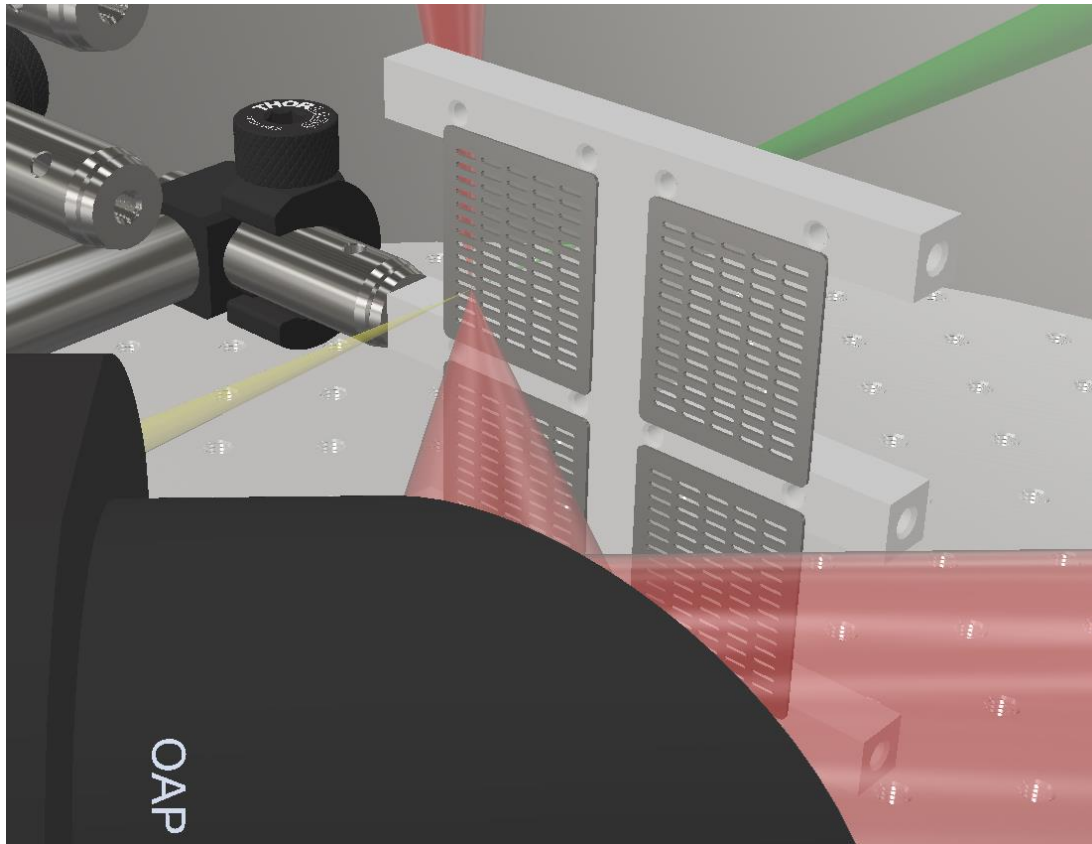
## Gáz/folyadék target



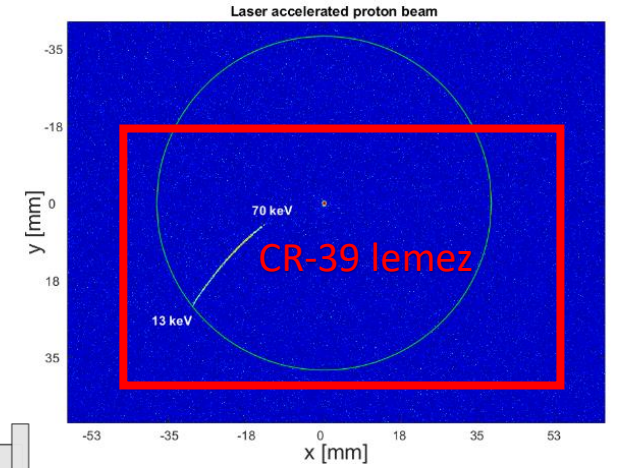
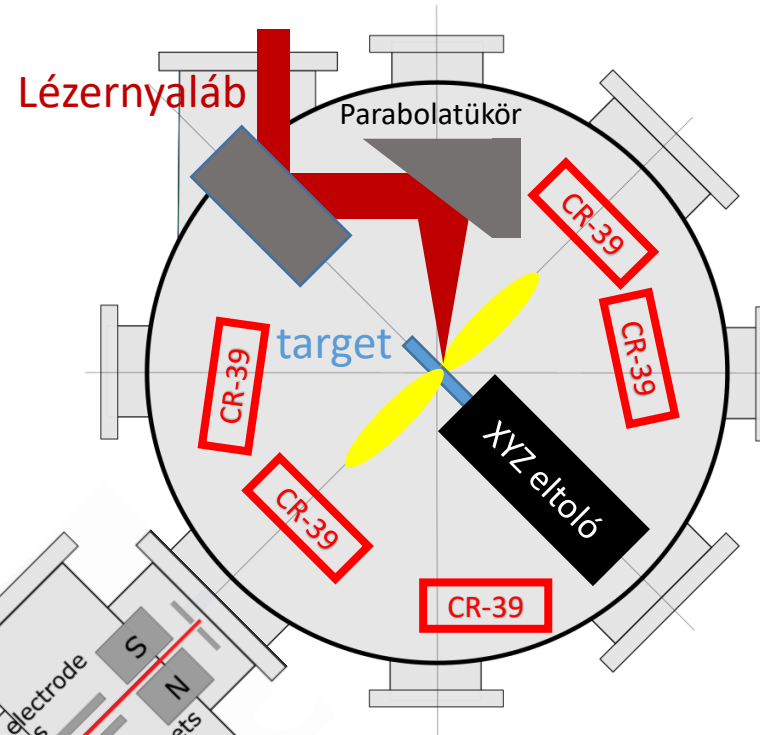
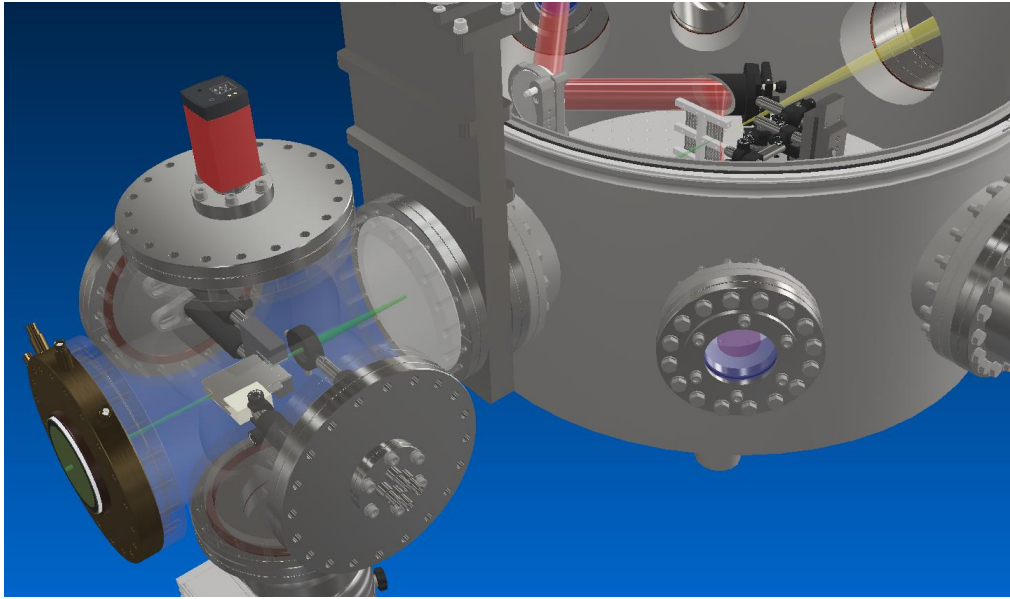
## Szilárd target



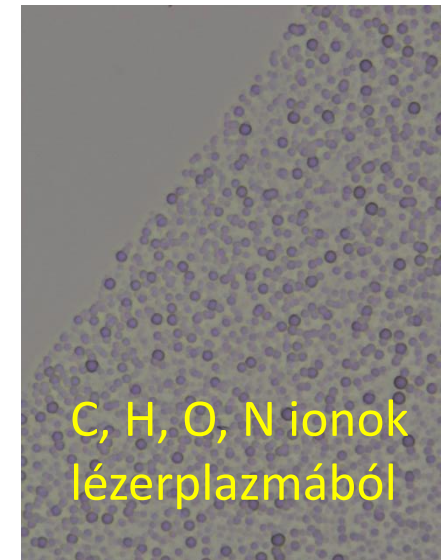
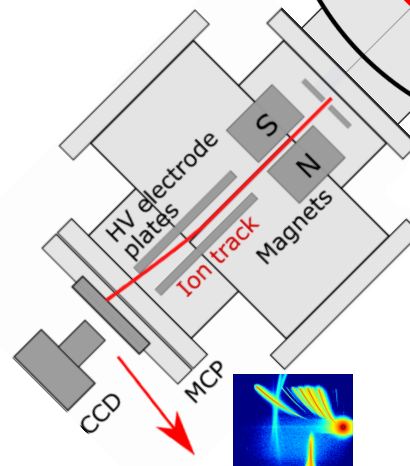
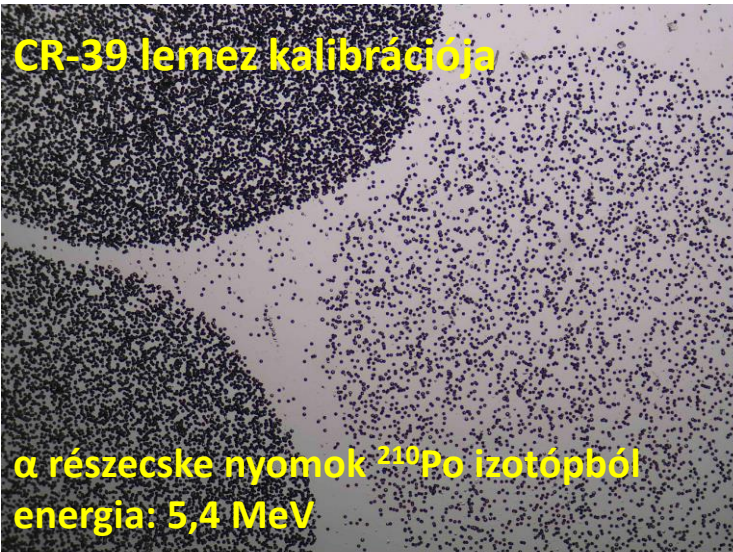
# A gyorsítási mechanizmus



# Detektorok: Thomson parabola spektrométer és CR-39 nyomdetektor



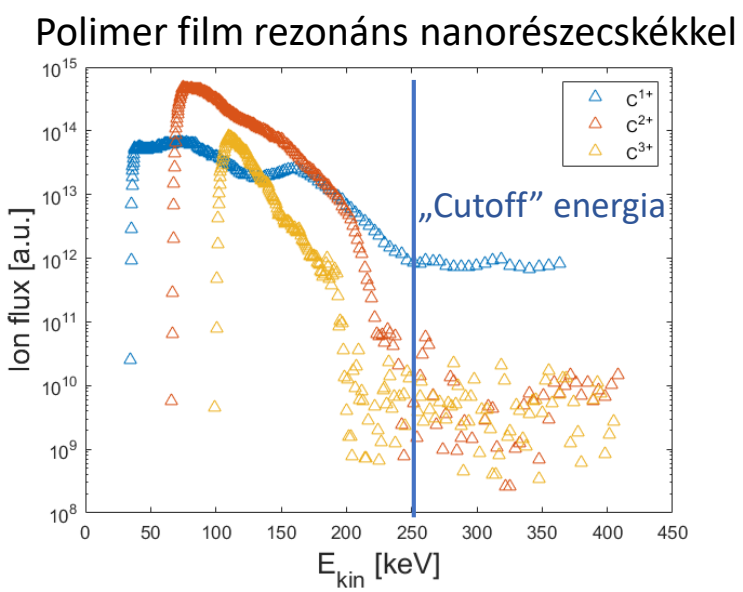
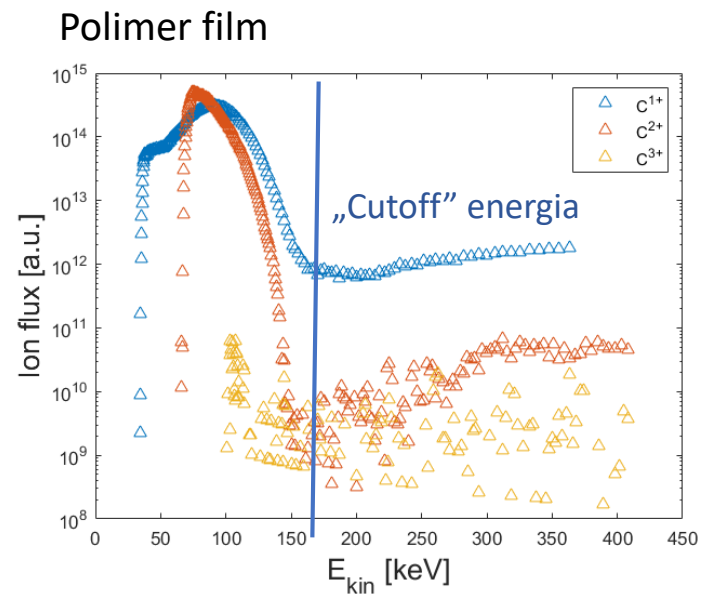
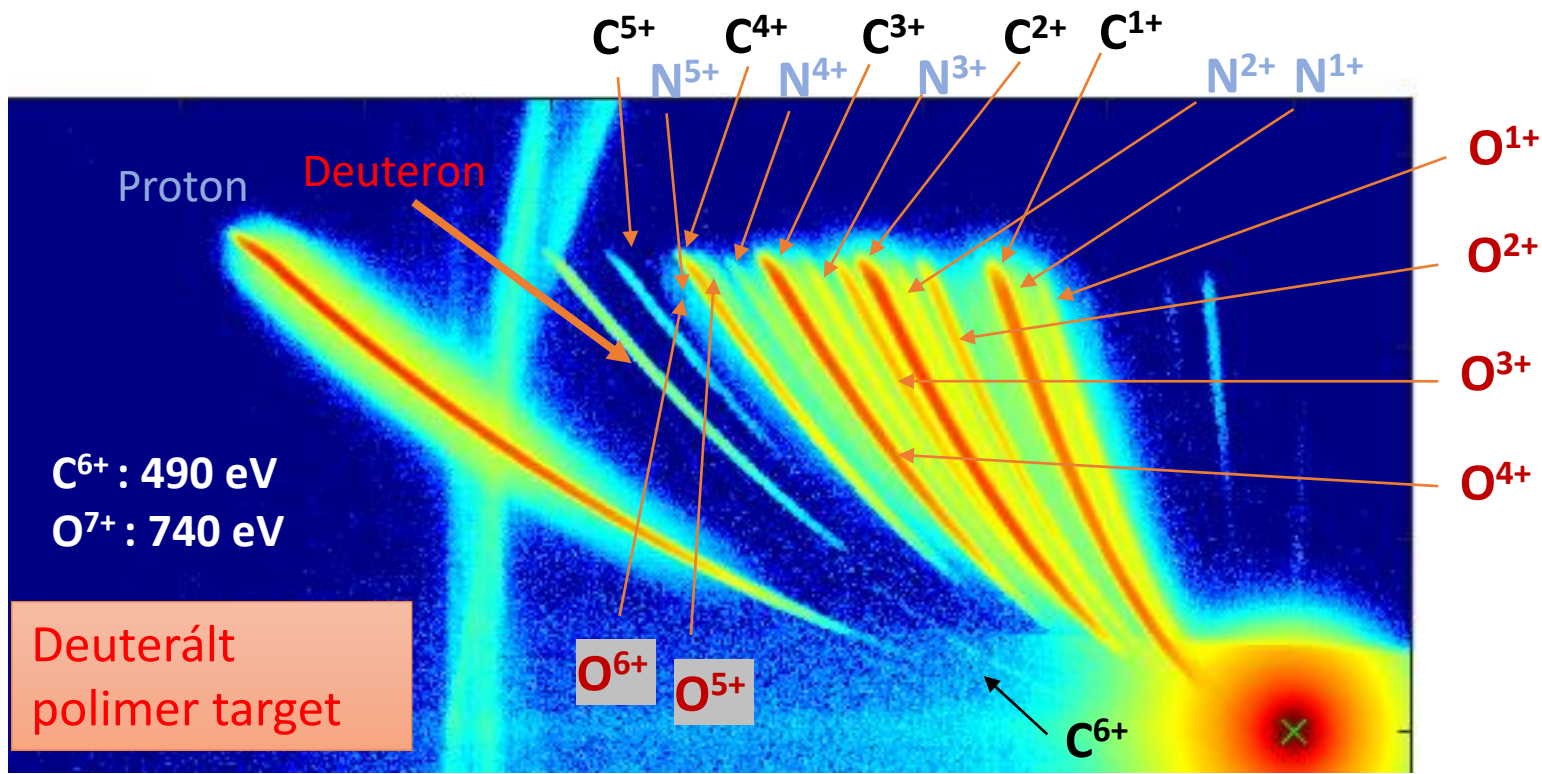
↑ Kalibráció



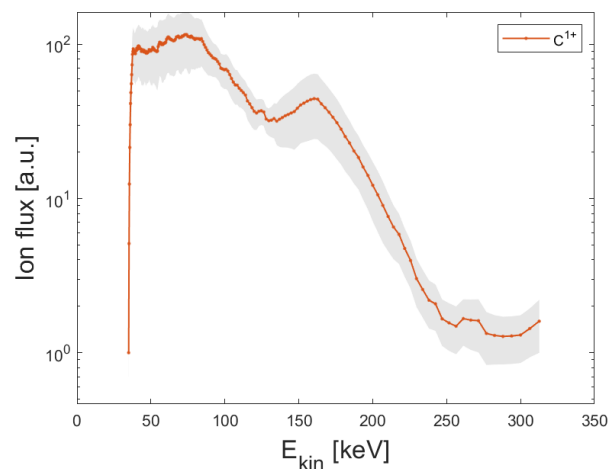
2 μm-es Al fólia blokkolja az alacsonyenergiás (< 1 MeV) plazmaionokat



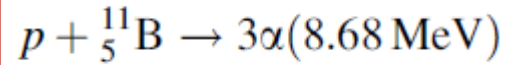
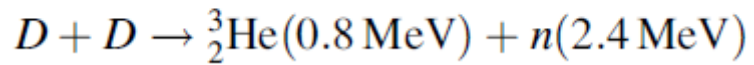
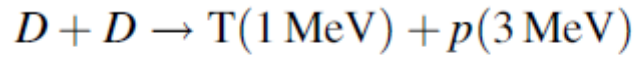
# Nemzeti Lézeres Transzmutációs Laboratóriummal közös kísérletek az ELI-ALPS-ban



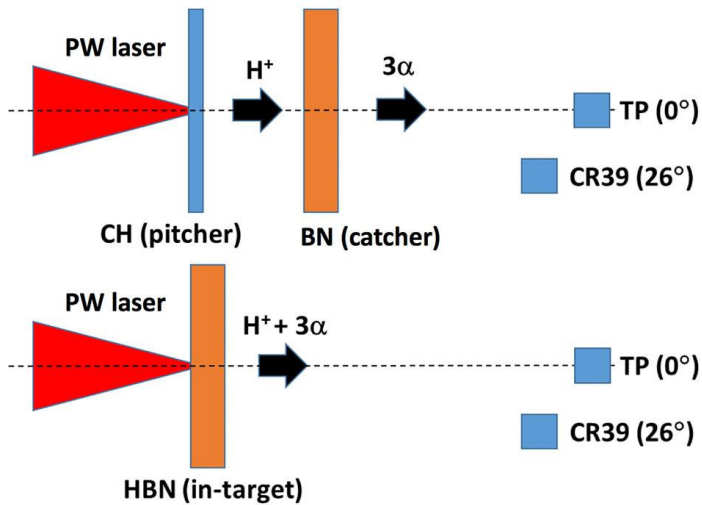
Az ionjelek fluktuációja:



# DD és pB reakció

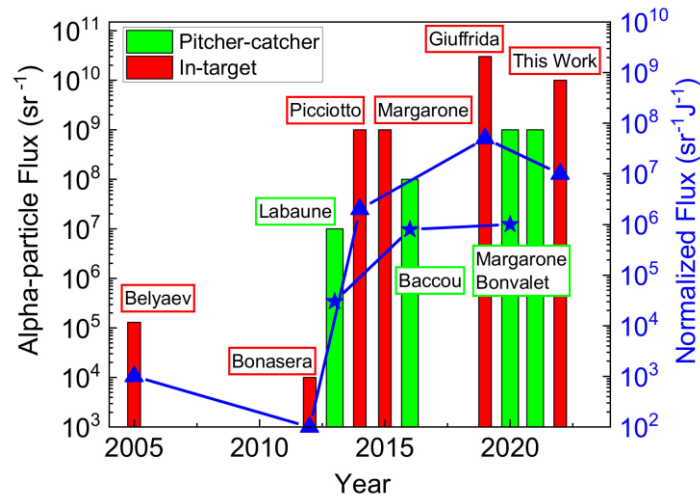


Két fő geometriai elrendezés:

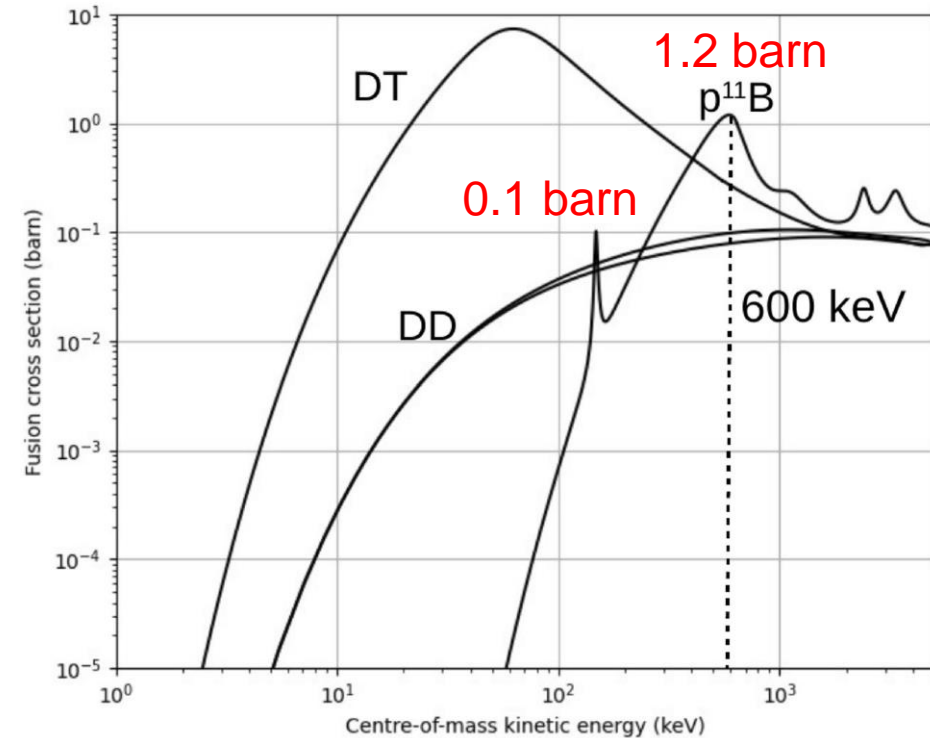


D. Margarone et al. Front. Phys. 8:343 (2020).

A pB fúziós kísérletek fejlődése:

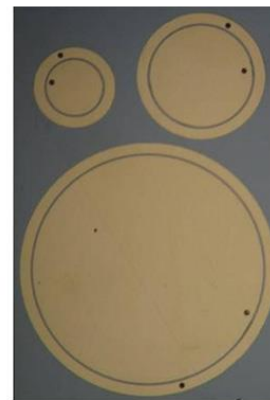
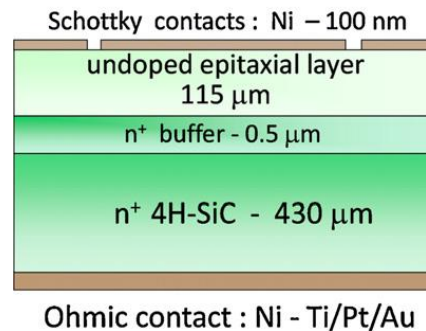
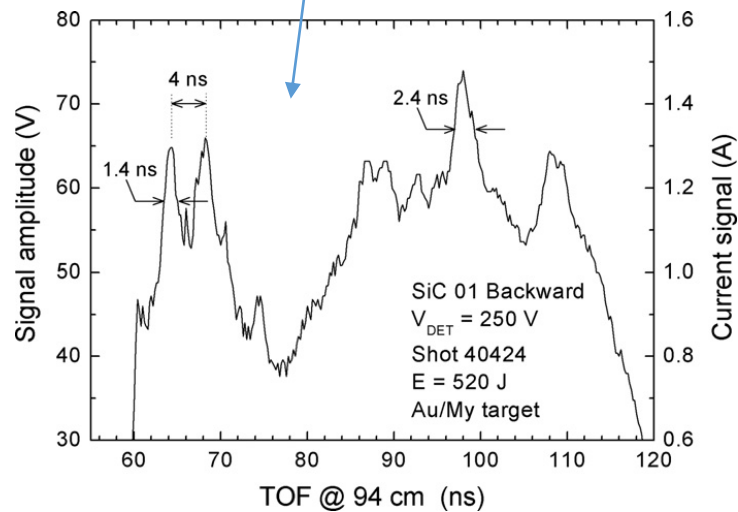
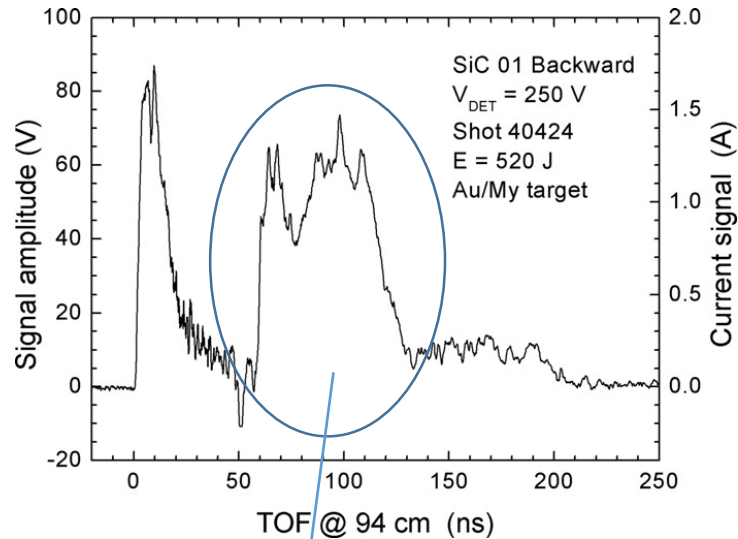


D. Margarone et al. Appl. Sci. 2022, 12, 1444.

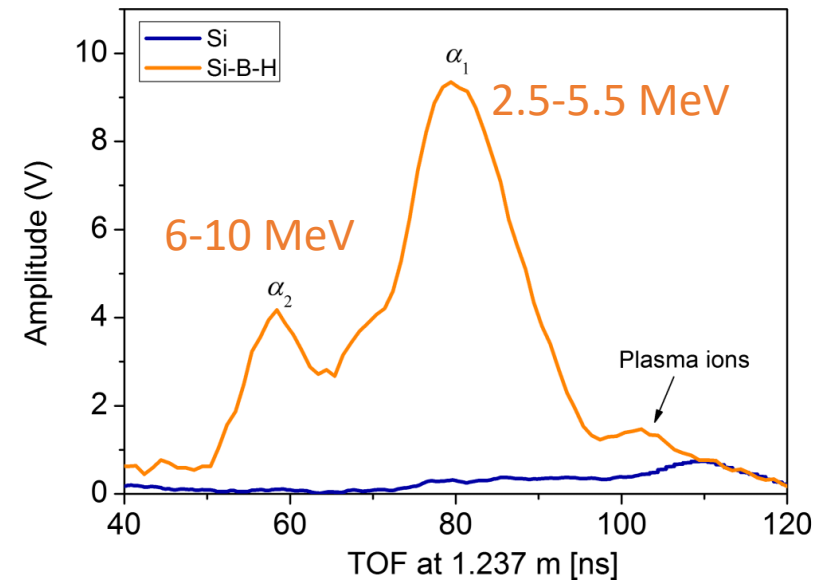


X. Ribeyre et al. Scientific Reports 12:4665 (2022).

# Proton-bór fúzióra jellemző alfa-részecske spektrum



Szilícium-karbid detektor

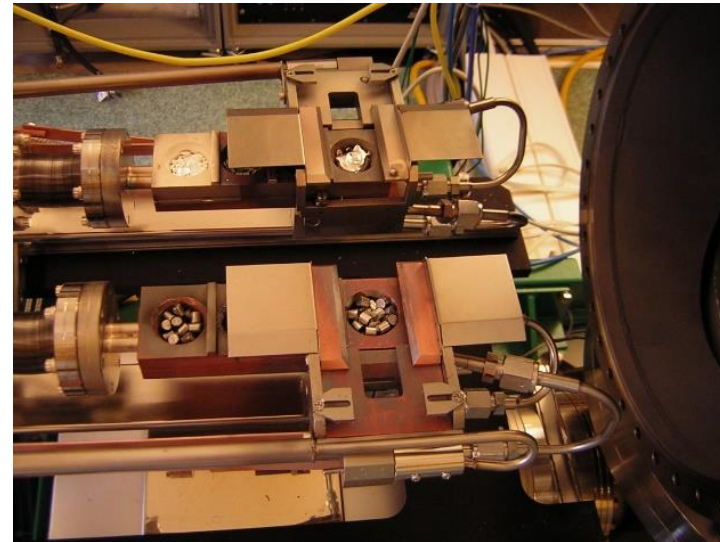
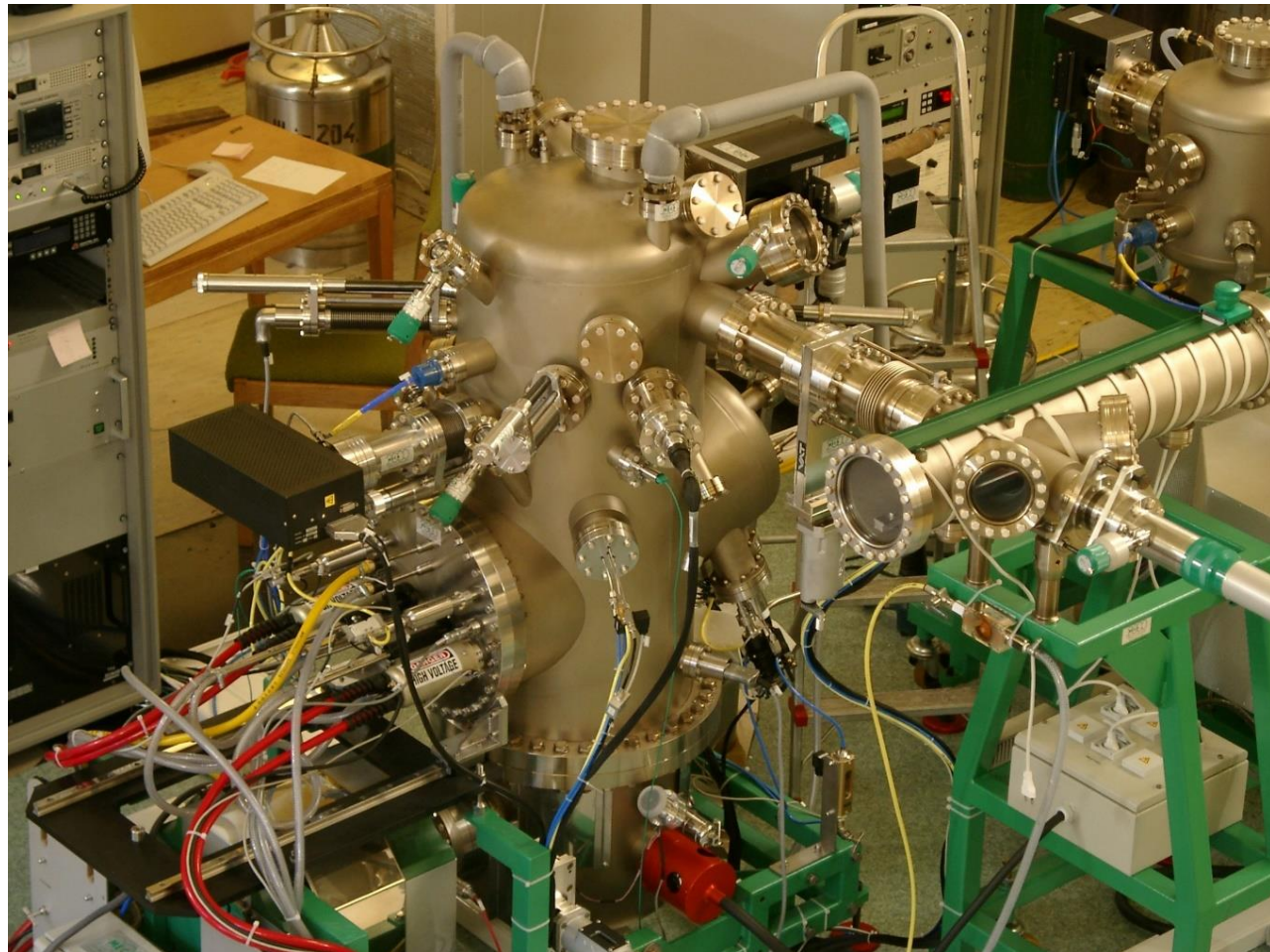


Repülési idő spektrum ionokra Si és Si-H-B target esetén. Alfa-részecske csúcsok és plazmaionok

A. Picciotto et al. PHYSICAL REVIEW X 4, 031030 (2014).

# Fém vékonyrétegek molekulanyaláb-epitaxiával

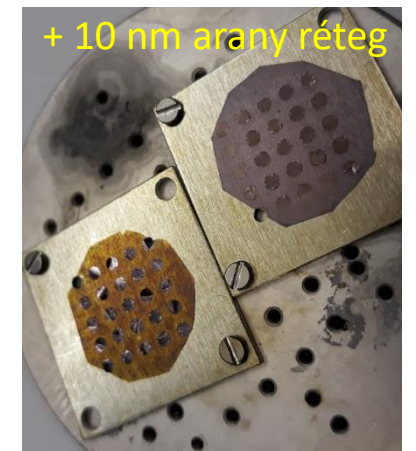
By Hegedűs Gergő, Merkel Dániel



Szénnanocsó fólia

By Gergely Németh

+ 10 nm arany réteg



- Bór réteg párologtatása polimer fóliára
- Bór-polimer multirétegek



B  
CH  
B

Cél: < 100 nm rétegvastagság

**Köszönöm a figyelmet!**