JINR Photocathode Research: Status and Plans

M.A. Nozdrin, N.I. Balalykin, V.F. Minashkin, G.D. Shirkov (JINR)
E.I. Gacheva, A.K. Potemkin, V.V. Zelenogorskii (IAP RAS)
J. Huran (JINR / IEE SAS)

nozdrin@jinr.ru

Abstract

Photocathode research in the frame of the "transmission" photocathode conception (backside illuminated cathode based on a quartz/sapphire plate or a metal mesh which is a substrate for thin film made of a photomaterial) is being conducted in the Veksler and Baldin Laboratory of High Energy physics (LHEP) of the Joint Institute for Nuclear Research (JINR). Status of the 30-keV DC Photogun test bench and recent results of the extremely thin carbon film based cathodes research are described. Progress in the full-scale photoinjector prototype (max electron energy of 400 keV) is given. Startup of the photoinjector was performed, 70 keV electrons were extracted (650 pC).

Motivation

Creation of the effective backside irradiated photocathode

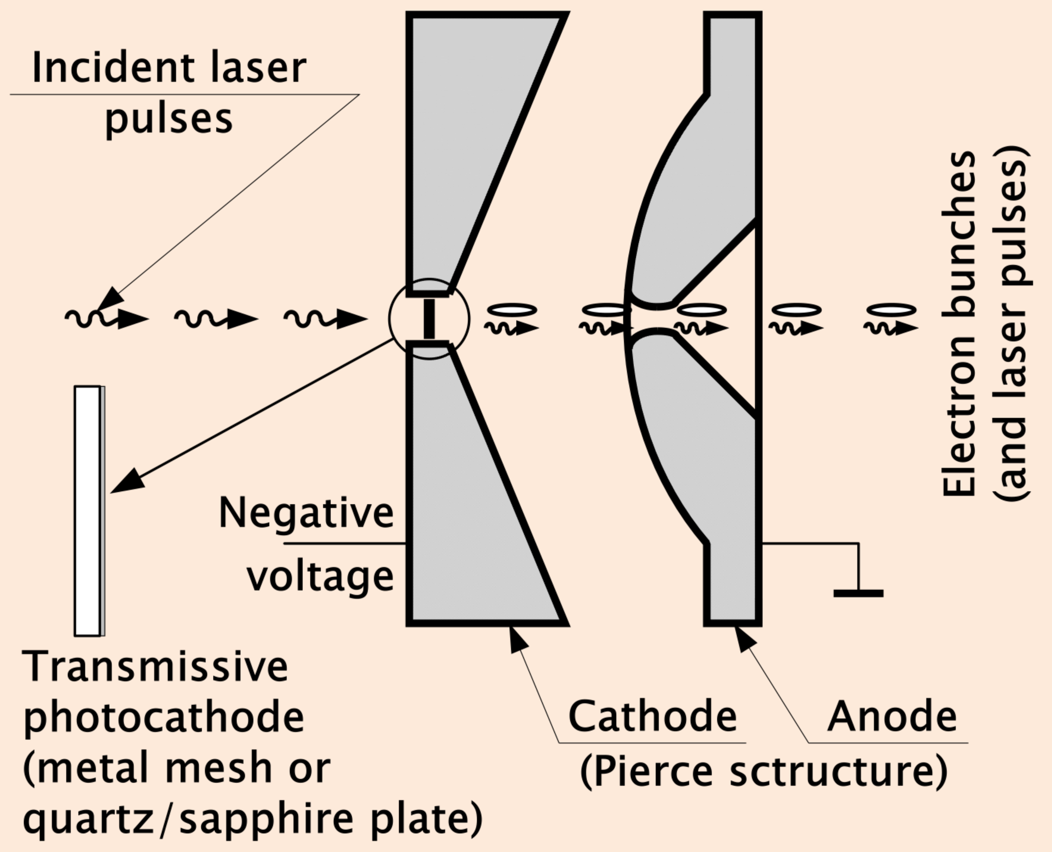
Advantages:

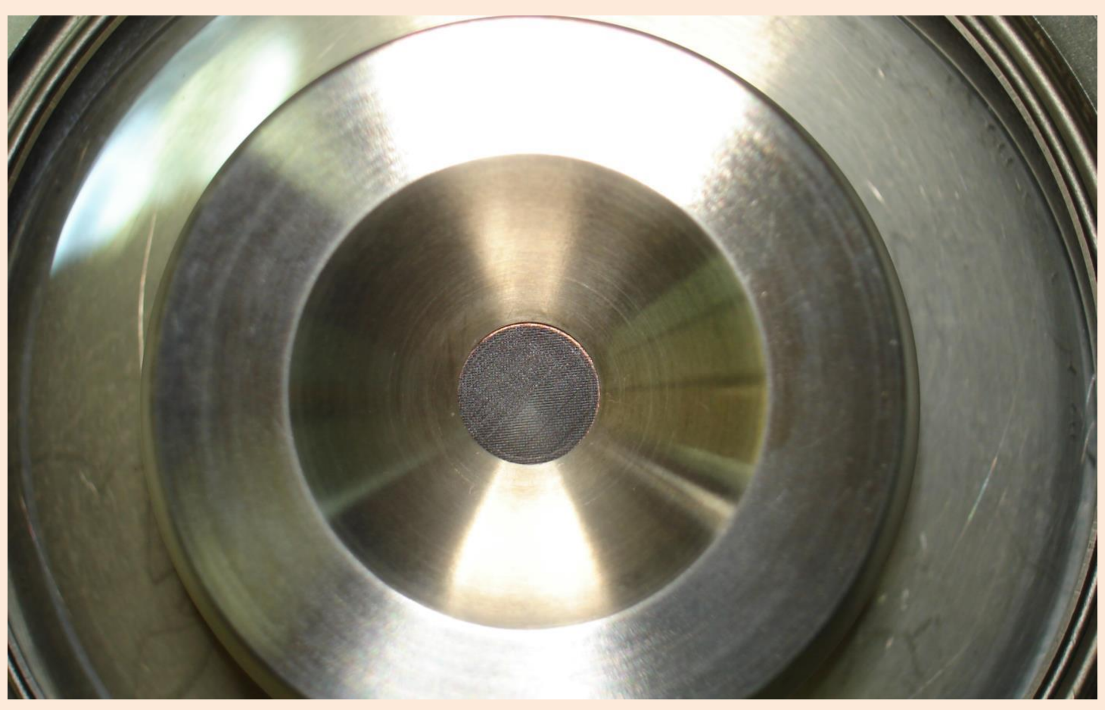
- considerable simplification of the laser beamline
- QE rising due to the vectorial photoeffect
- accelerator equipment alignment possibility
- lower emittance

The most promising material are various carbon-based films:

- low vacuum required
- high radiation resistance
- reasonable QE (especially for $\lambda \leq 190$ nm)

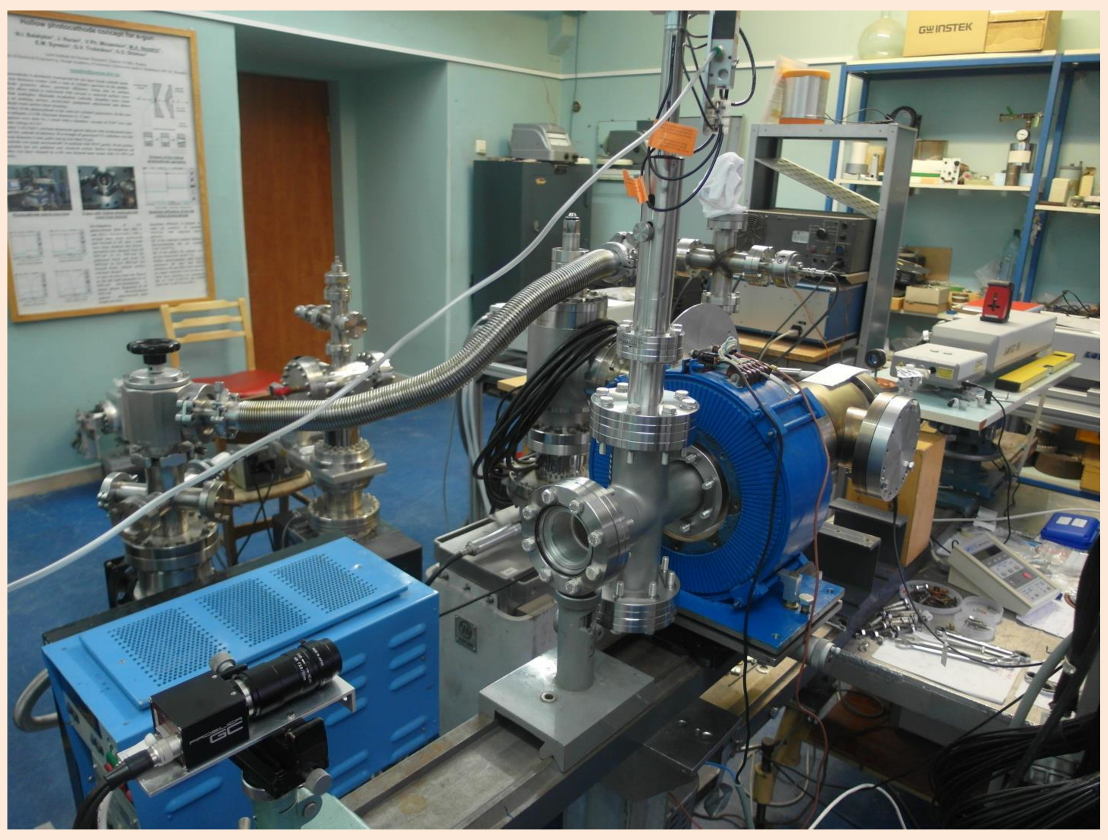
Conception





Photogun Bench

- Main research instrument so far
- DC gun, voltage 10-30 keV
- Industrial single-pulse UV lasers
- Focusing magnet with correction windings
- Diagnostics (Faraday cup / CCD camera)



LOTIS TII UV Lasers

LS-2134

t = 15 ns, E = 15 μJ

LS-2132UTF

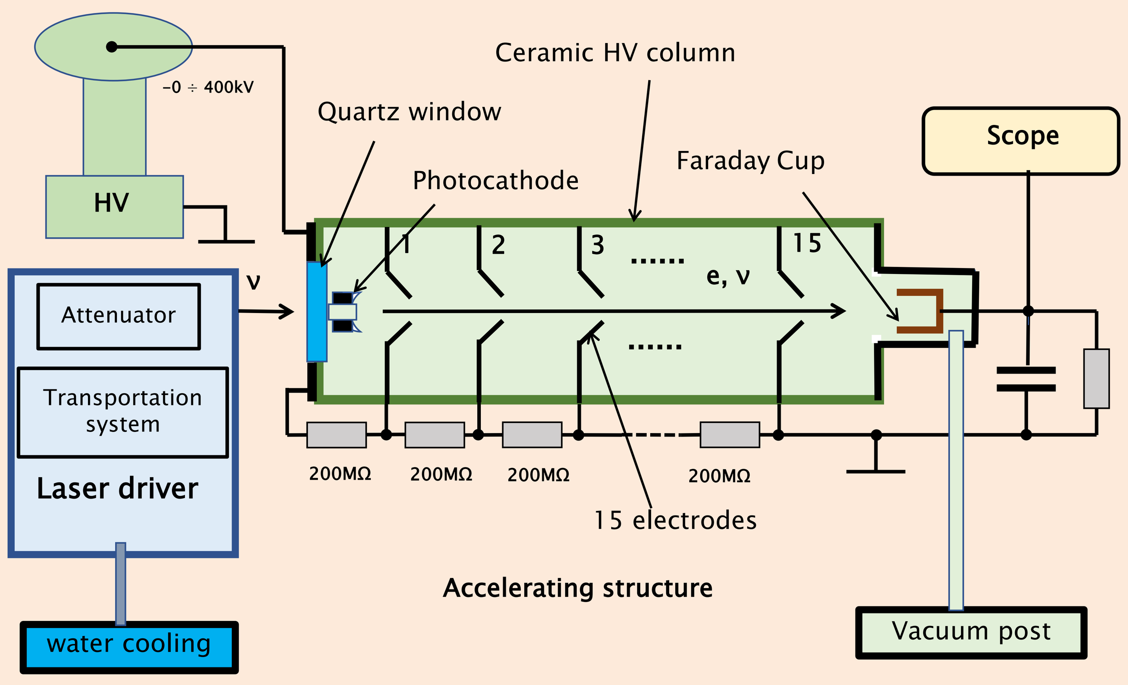
t = 8 ns, E = 45 μJ

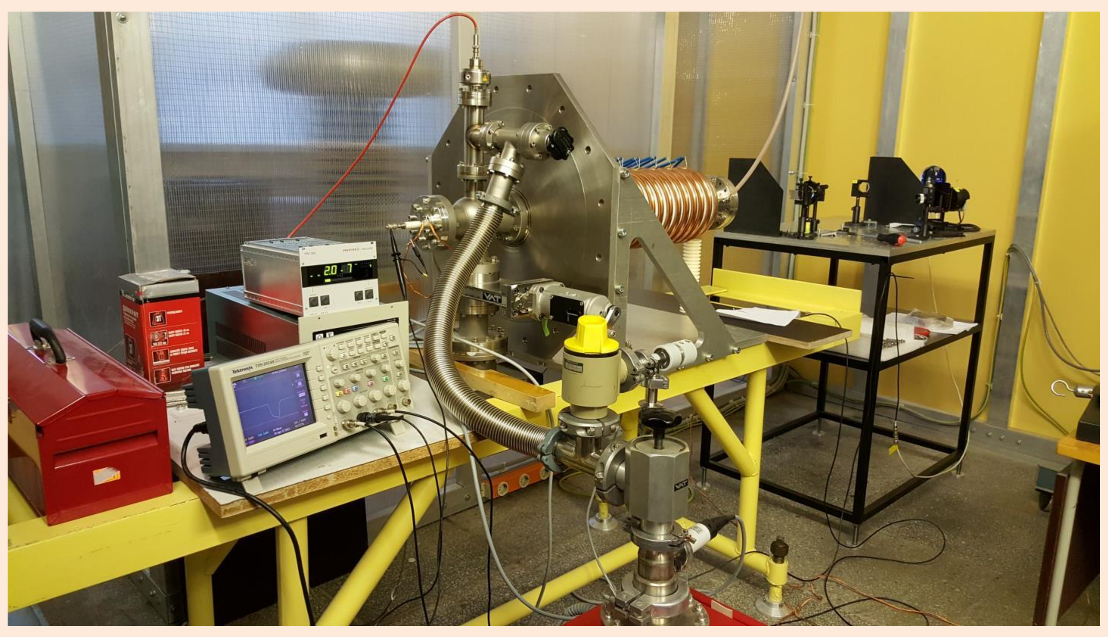
213 nm setup

LS-2132UTF with external 5th harmonic assembly

Photoinjector Bench

- Future research instrument
- Triode DC gun, max electron energy 400 keV
- Unique laser driver by IAP RAS
- Extended diagnostics (slit mask emittance measurement)





N-doped carbon based extremely thin films

- Substrate: double side polished quartz glass
- Method: Reactive Magnetron Sputtering (RMS)
- Conditions: pressure of 0.7 Pa, input RF power of 150 W at 13.56 MHz, substrate temperature of 900 °C.
- Inert gas: argon, flow rate 25 sccm
- Reactive gas: mixture of nitrogen (6 sccm) and hydrogen or deuterium in var. concentrations:

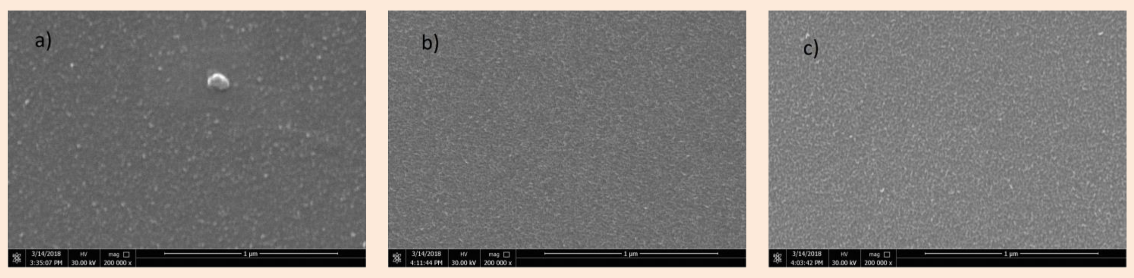
QT1	QT2	QT3	QT4	QT5
none	1 (H)	3 (H)	6 (H)	3 (D)

- Film thickness: 18-25 nm.

Structural properties

- Techniques:
  - Rutherford backscattering spectrometry (for elemental composition)
  - Elastic recoil detection (for elemental composition
  - Raman spectroscopy (for I(D)/I(G) ratio)
  - Scanning electron microscopy (for structural morphology)

Sample	C, %	N, %	H, %	D, %	O, %	I(D)/I(G)
QT1	83	13	2	0	2	1.14
QT2	83	12	4	0	1	1.39
QT3	82	12	5	0	1	1.29
QT4	82	12	5	0	1	1.34
QT5	83	12	2	2	1	1.17

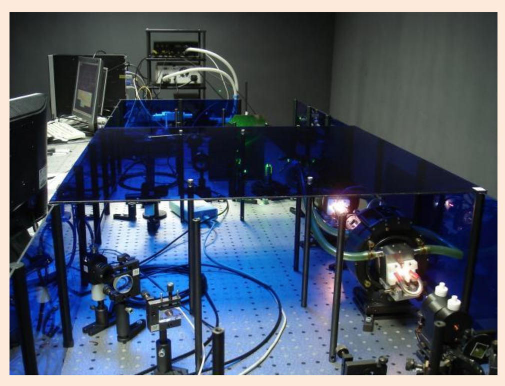


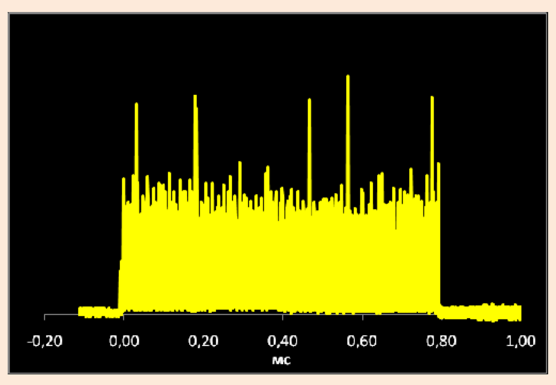
Photoemission properties

Sample	Q, pC	QE (%) x 10^{-4}	I(D)/I(G)
QT1	930	4.9	1.14
QT2	1140	6.1	1.39
QT3	1590	8.4	1.29
QT4	840	4.5	1.34
QT5	1470	7.8	1.17

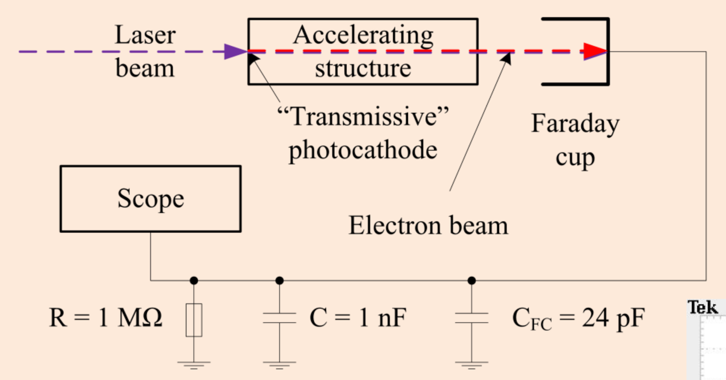
Laser Driver

Wavelength	262 nm
Bunch train repetition rate	10 Hz
Bunch train duration	800 μs
Bunches in the train	8000
Bunch duration	10 ps
Bunch energy	1,5 μJ





Bench Startup



Copper mesh photocathode, cell 40×40 μm, Ø30 μm

U = −70 kV

Q = 650 pC (in the bunch train)

Current:

- bunch: 8 mA
- bunch train: 0.8 μA
- average (f = 10 Hz): 6,5 nA