



Status of U70

Report MOB01

Vladimir Kalinin

on behalf of the U70 staff

Outlook

- Generalities
- Runs
- Upgrades
- Acceleration of light ions
- Conclusion

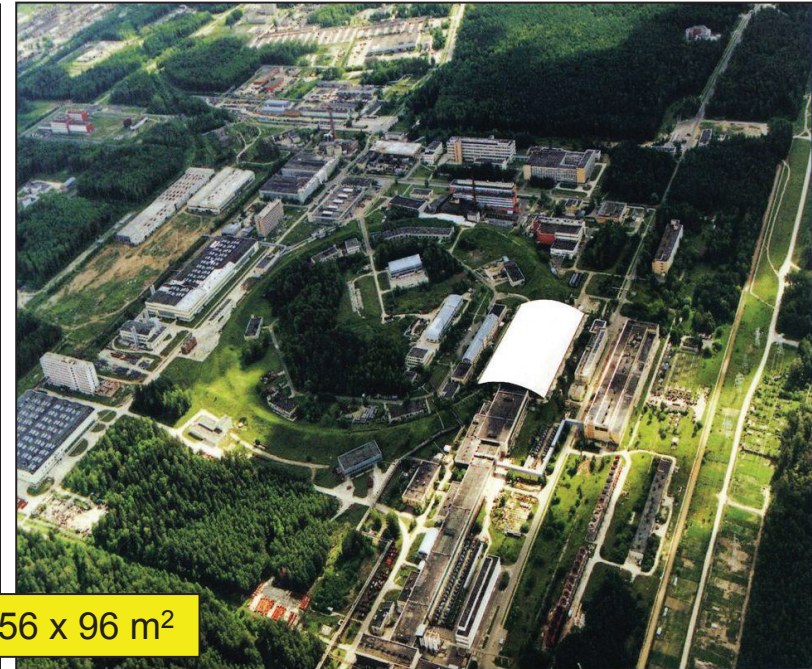
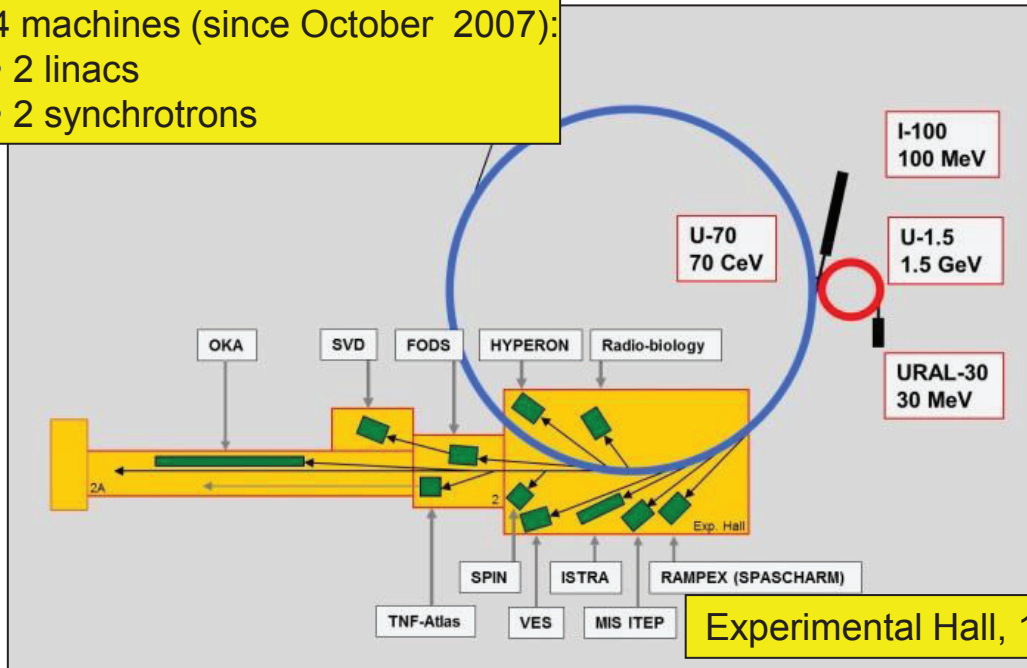
Accelerator Complex U-70 & synchrotron U-70 per se

“Register of unique nuclear physics facilities ...” approved by the RF Government order issued on December 30, 2009, No. 2125-p

Layout, AC U-70 vs the U-70 proper

4 machines (since October 2007):

- 2 linacs
- 2 synchrotrons



Modes:

- p (default, 50-70 GeV)
- light-ion (C, complementary)

URAL-30/U-1.5/U-70
I-100(2 of 3)/U-1.5/U-70

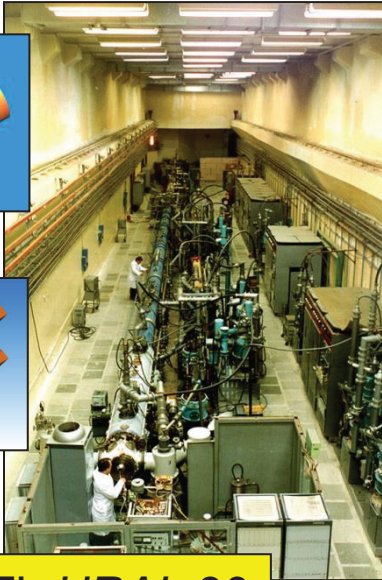
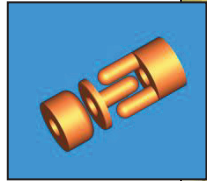
Light-ion (C nuclei):

- (very) high energy 24.1-34.1 GeV/u
- intermediate (though high) energy 180-455 MeV/u

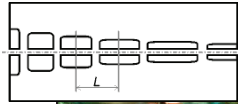
In the SIS-18, SIS-100 name convention:

- LIS-233 [T·m]
- LIS-6.9 [T·m]

Photo album of the machines



RFQ DTL *URAL-30*



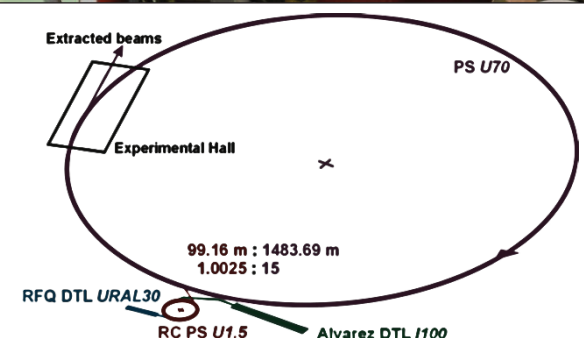
Alvarez DTL *I-100*



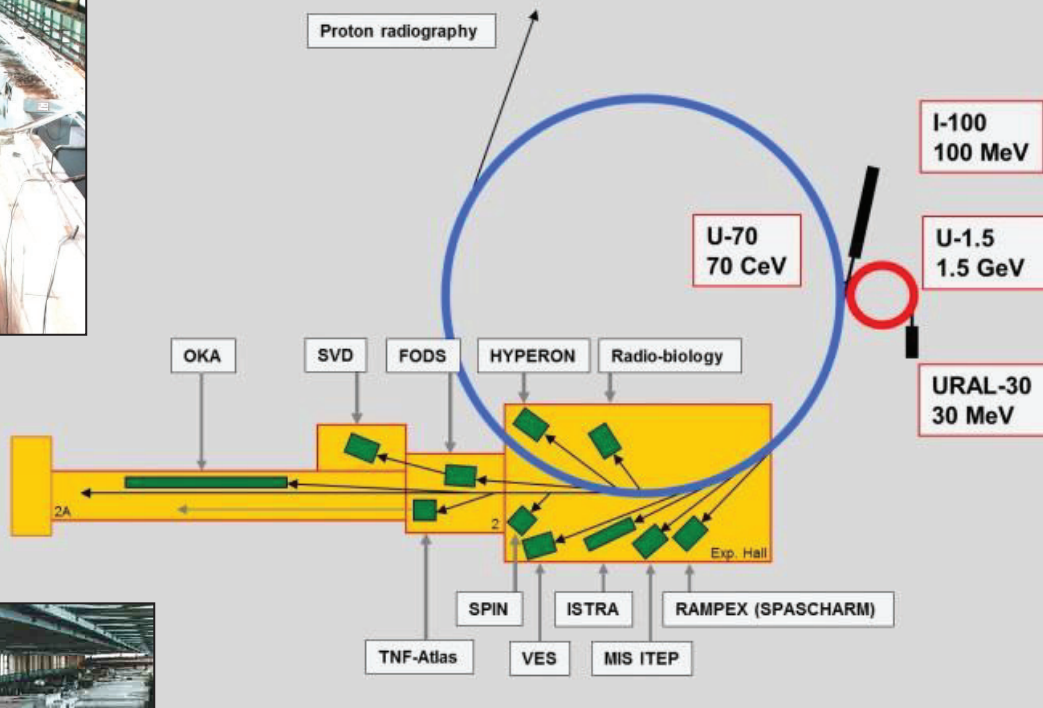
Main PS *U-70*



RC PS *U-1.5*



Fixed-target physics and BTL network



Beams of
 p , π , K , e , ν , C

Fields of HEP research:

- h spectroscopy
- spin physics
- rare K -decays
- h - A interactions
- nuclear physics
- [ν physics]

Applied research:

- p radiography
- C radiobiology
- ...

Collaborators:

IHEP, ITEP, JINR,
INR, St.-Pb NPI, BINP,
SINP MSU, NRNU
MEPHI, CERN, ...
VNIIEF, MRRC NMRRRC
ITEB, IMBP, FMBC...

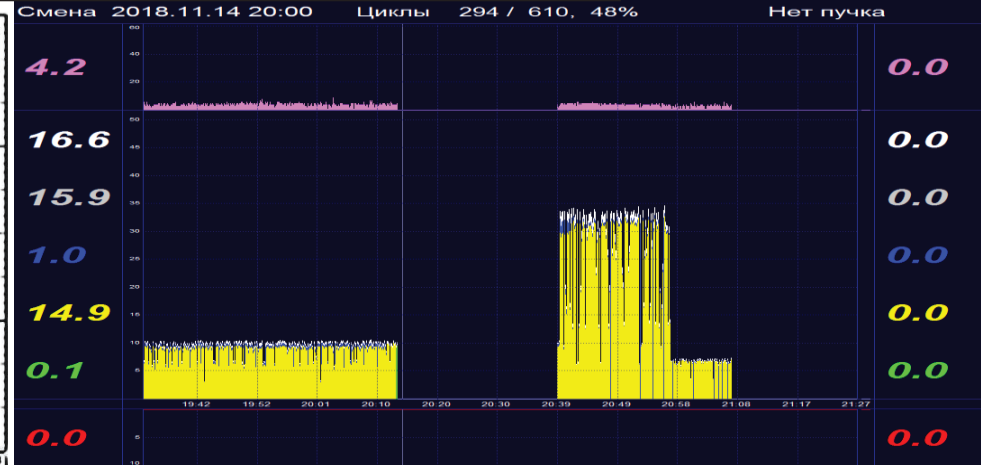
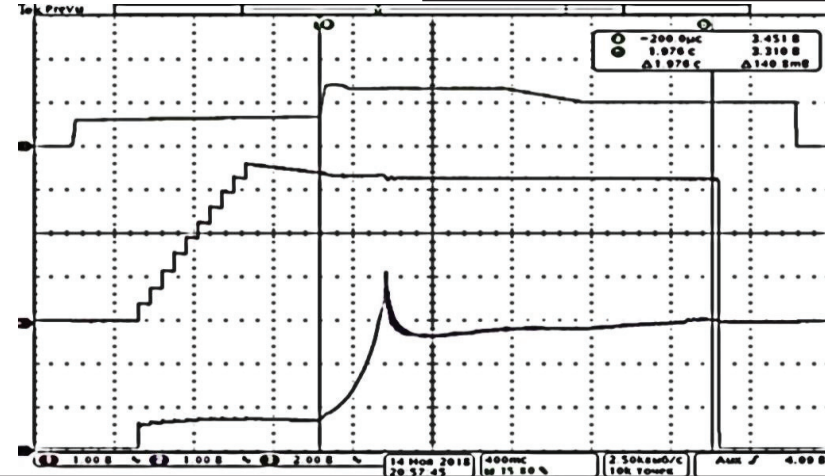
Up to 10 HEP experiments (= No of setups) per a run,
Up to 7 beam users per a cycle

RUNS

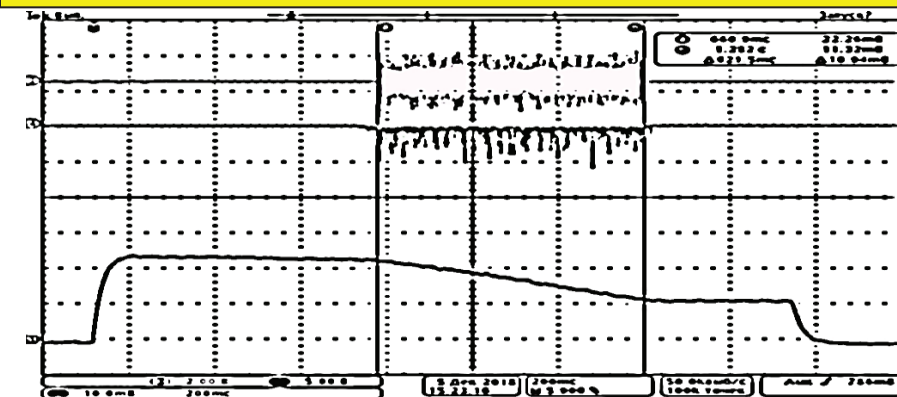
	Run	2018-2	2019-1	2019-2	2020-1	2021-1
Launching linac URAL30, booster U1.5 and U70 sequentially (I100 in parallel with a delay)		October, 01	September, 16	October, 19	October, 19	February, 24
Beam in the U70 ring since		November, 06	October, 07	November, 24	November, 21	March, 24
Fixed-target physics program with extracted top-energy beams (either of protons or of carbon nuclei)		November, 12 –20, 9 days	-	November, 25-December, 2, 8 days	November, 26-December, 15, 20 days	March, 29 – April, 12, 15 day
No. of multiple beam users (of which the 1st priority ones)		4 (4)	4(4)	11(6)	12(8)	10(4)
MD sessions and R&D on beam and accelerator physics, days		19	13	6	18	12
Light-ion acceleration program, intermediate energy only		November, 21 – December, 12, 17½ days	October, 07–27, 20½ days	December, 03–12, 9½ days	December, 16–30, 14½ days	April, 13–30, 17½ day

RUN 2018-2

Radiographic facility, p (50 GeV), 108 hours
fast-extraction,
1-10 equal bunches $3\text{--}4.5 \cdot 10^{11}$ ppb

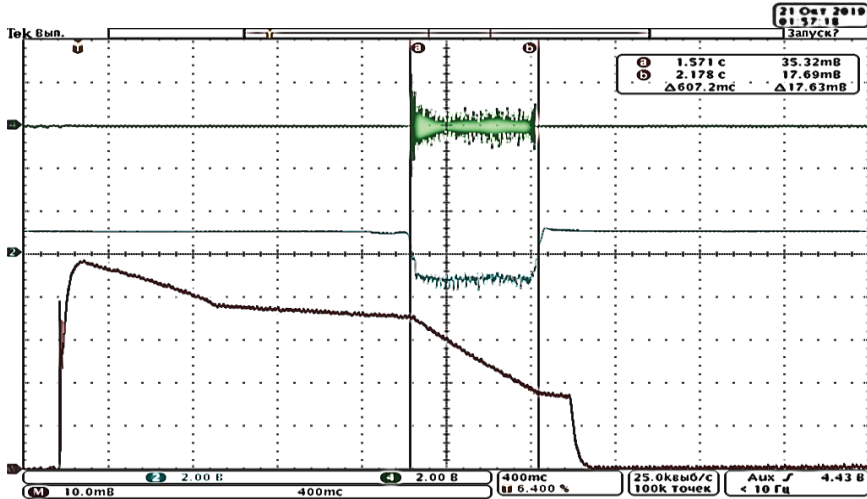
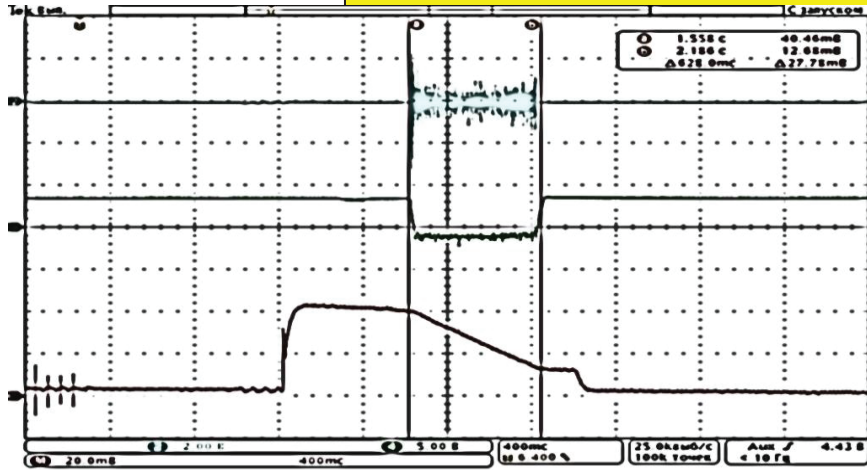


Radiobiological and biophysical research,
C (455 MeV/u) $4.0 \cdot 10^9$ ipp

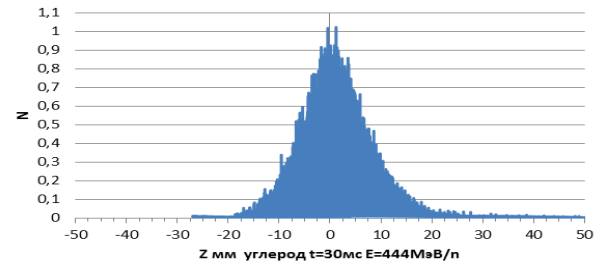
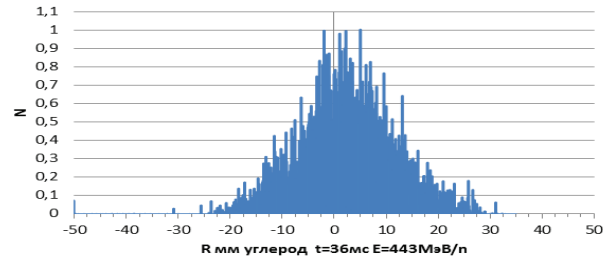
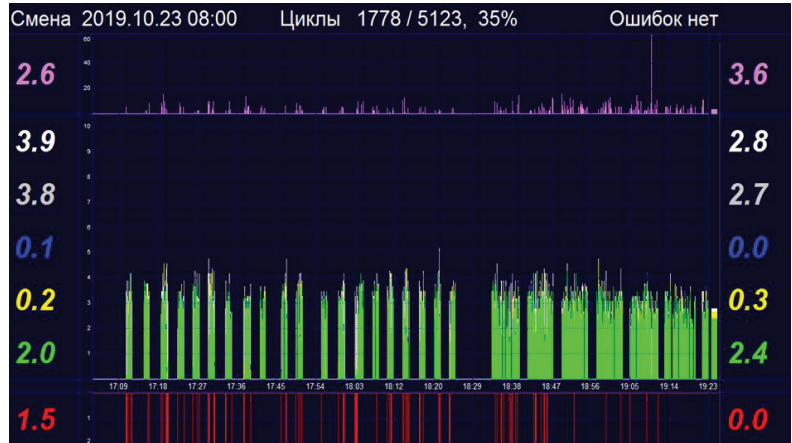


RUN 2019-1

Radiobiological and biophysical research,
C (455 MeV/u, 300 MeV/u) $4.6 \cdot 10^9$ ipp

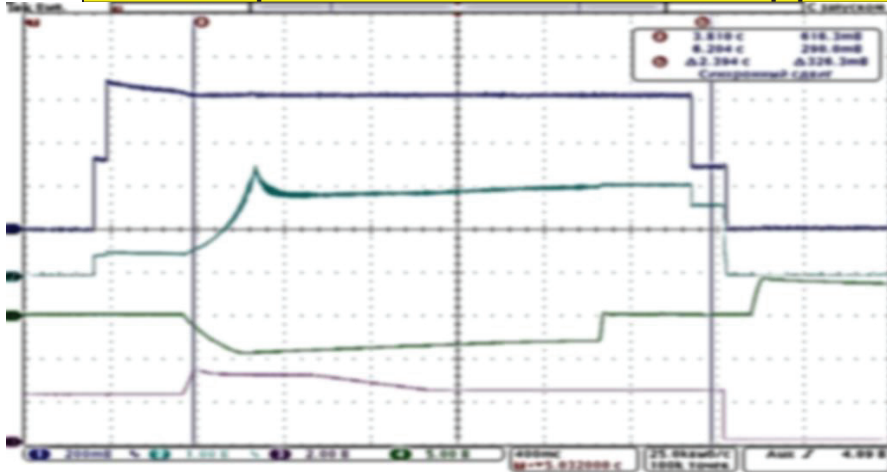


26 Окт 2019
13:34:59

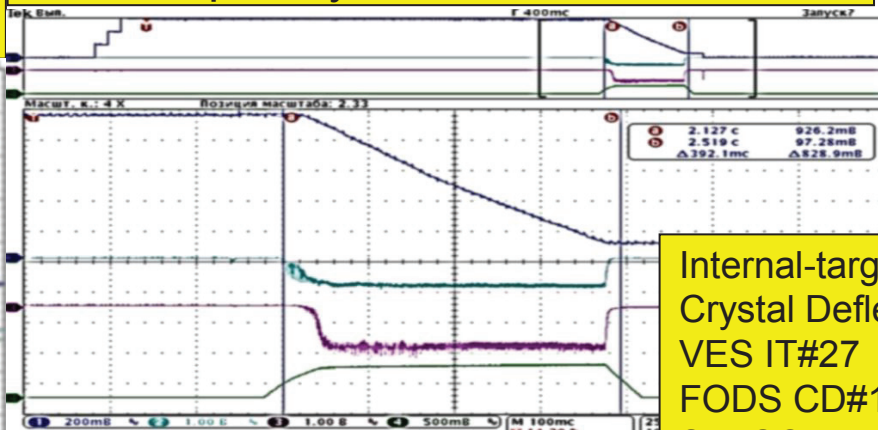


RUN 2019-2

Radiographic facility, NEUTRON,
 p (50 GeV), fast-extraction,
 1-15 equal bunches $3-4.2 \cdot 10^{11}$ ppb

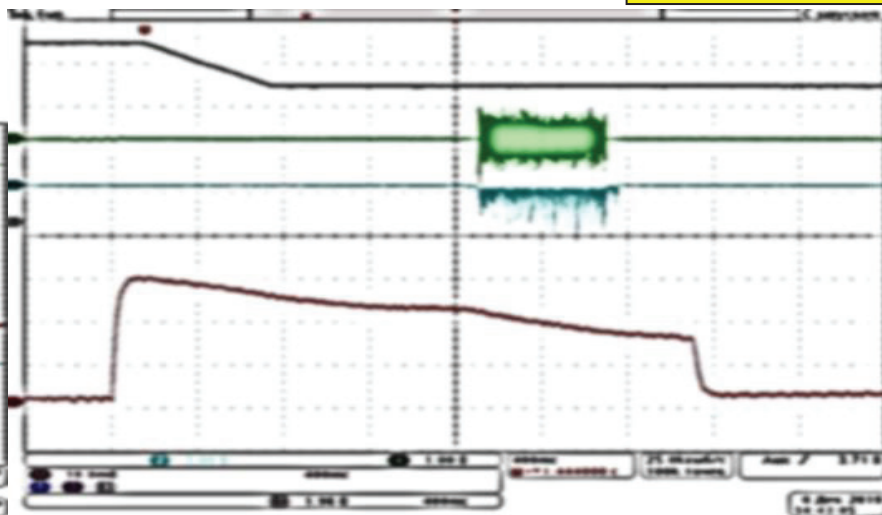
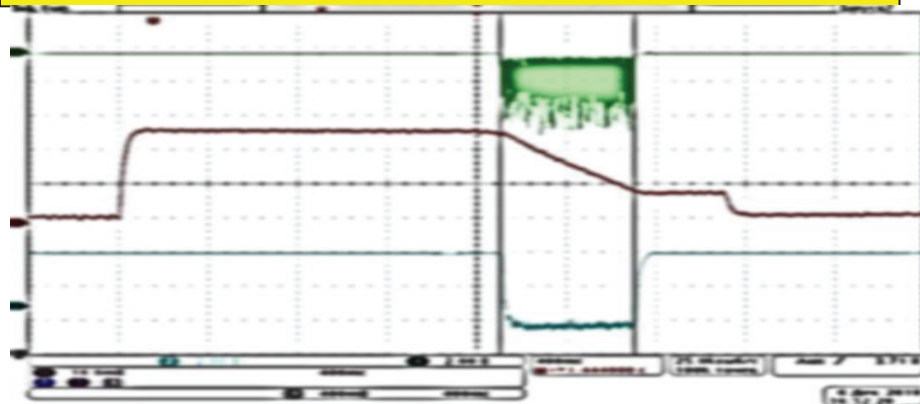


Fundamental physics, p (50 GeV)
 lowered priority



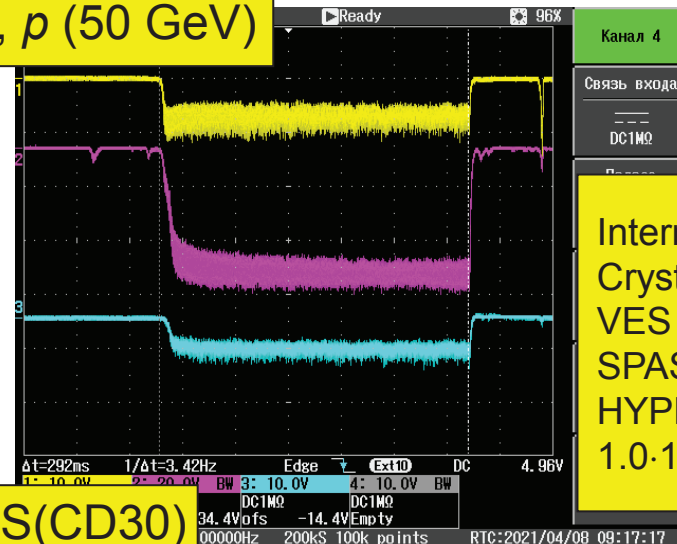
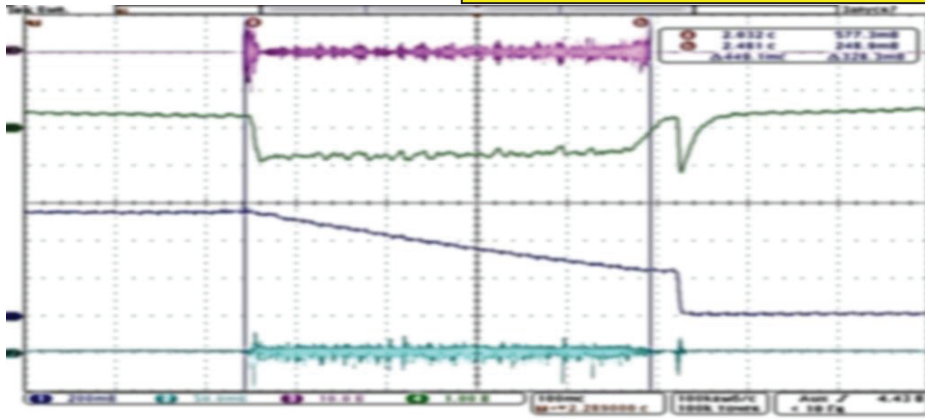
Internal-targets(IT)
 Crystal Deflector(CD)
 VES IT#27
 FODS CD#19
 SPASCHARM IT#24
 SVD CD#19
 $1.0 \cdot 10^{12}$ ppp

Radiobiological and biophysical research,
 C (455 MeV/u, 300 MeV/u) $2-4.6 \cdot 10^9$ ipp



RUN 2020-1

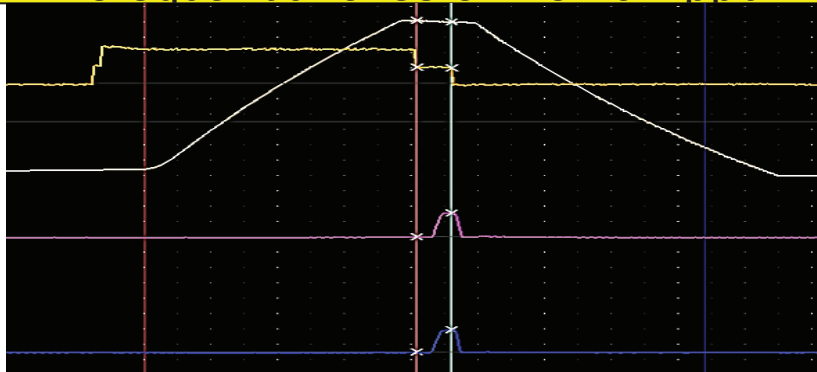
Fundamental physics, p (50 GeV)



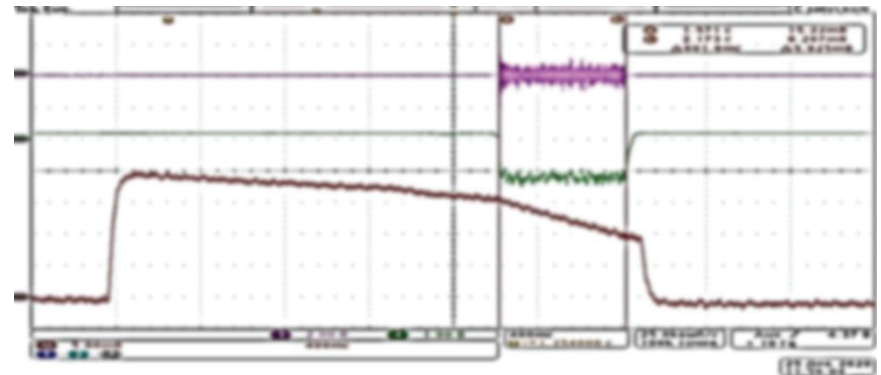
Internal-targets(IT)
Crystal Deflector(CD)
VES IT#27
SPASCHARM IT#24
HYPERON IT#35
 $1.0 \cdot 10^{12}$ ppp

OKA,SPIN Slow stochastic extraction,FODS(CD30)
, up to $3.5 \cdot 10^{11}$ ppp

Radiographic facility, NEUTRON,
 p (50 GeV), fast-extraction,
1-15 equal bunches $3-4.5 \cdot 10^{11}$ ppp



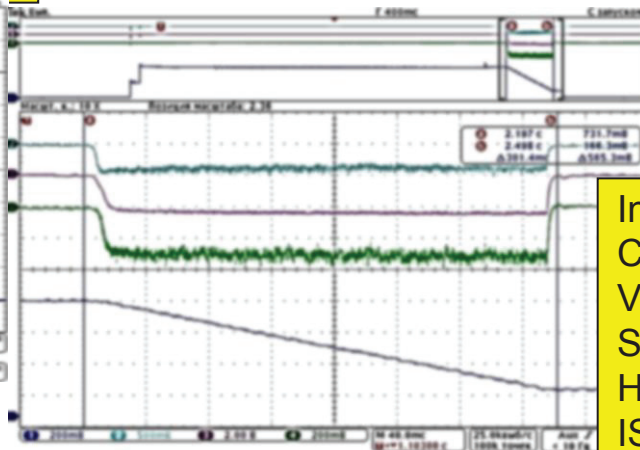
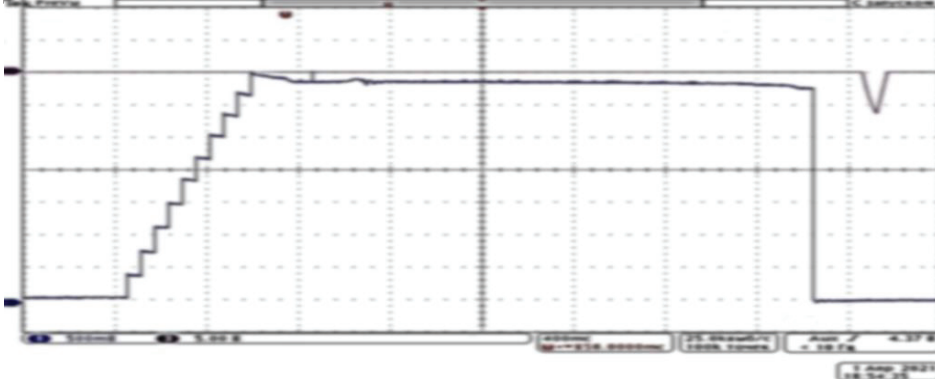
Radiobiological and biophysical research,
C (455 MeV/u, 300 MeV/u) Slow extraction



RUN 2021-1

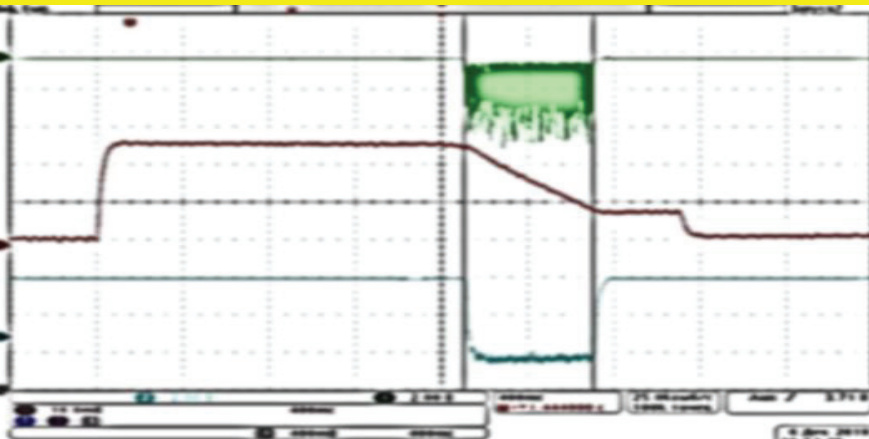
Radiographic facility, NEUTRON, SPIN
 p (50 GeV), fast-extraction,
 1-15 equal bunches $3\text{--}4.5 \cdot 10^{11}$ ppb

Fundamental physics, p (50 GeV),
 180 hours lowered priority



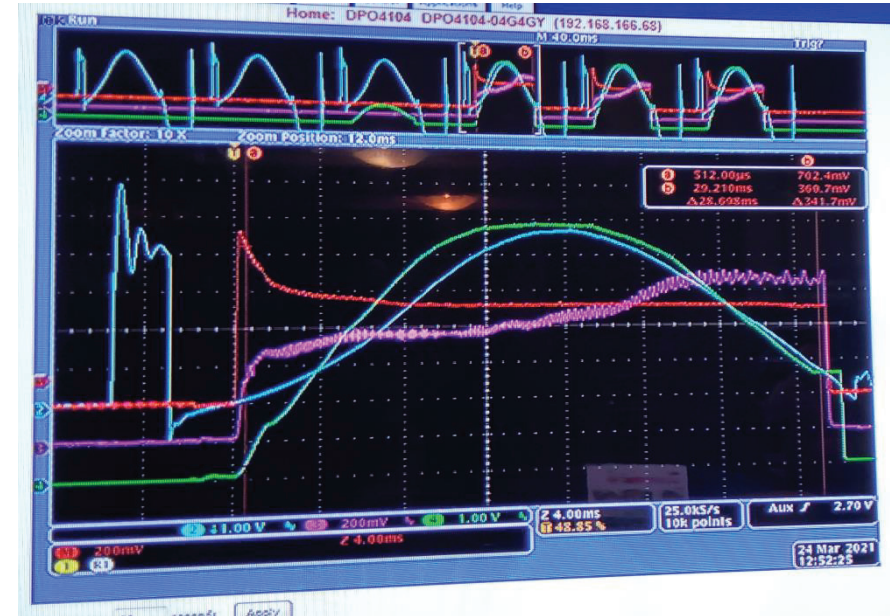
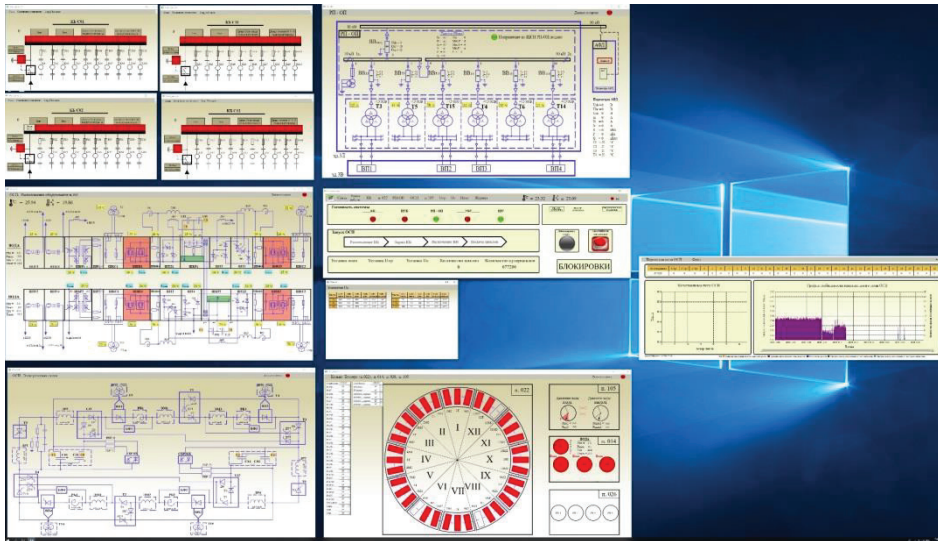
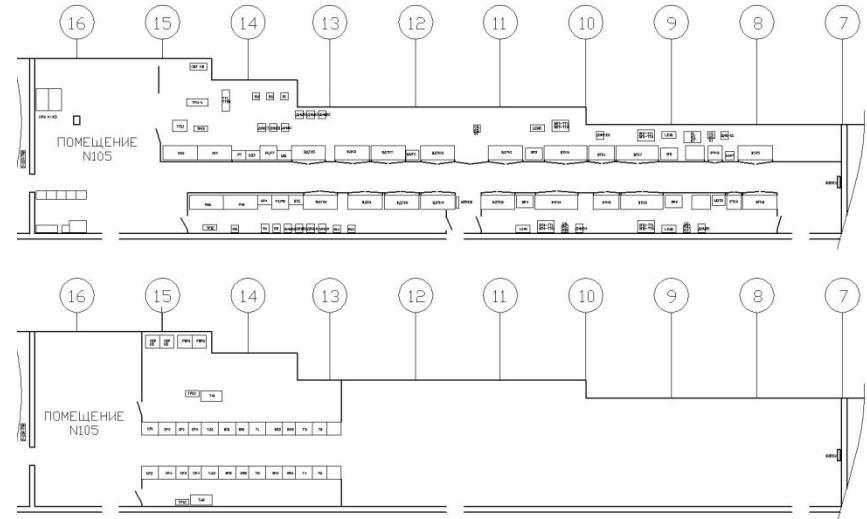
Internal-targets(IT)
 Crystal Deflector(CD)
 VES IT#27
 SPASCHARM IT#24
 HYPERON IT#35
 ISTR CD#27
 $1.0 \cdot 10^{12}$ ppp

Radiobiological and biophysical research,
 C (180-455 MeV/u) $2\text{--}2.5 \cdot 10^9$ ipp



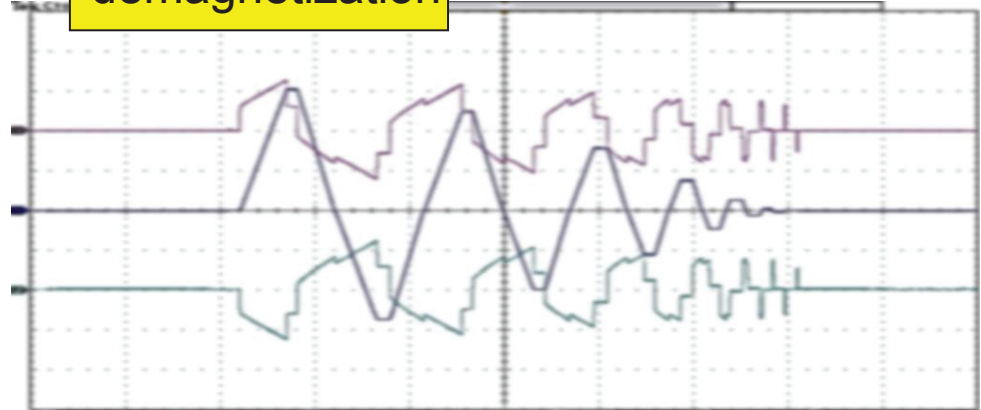
UPGRADES

U1.5 power supply system upgrade.



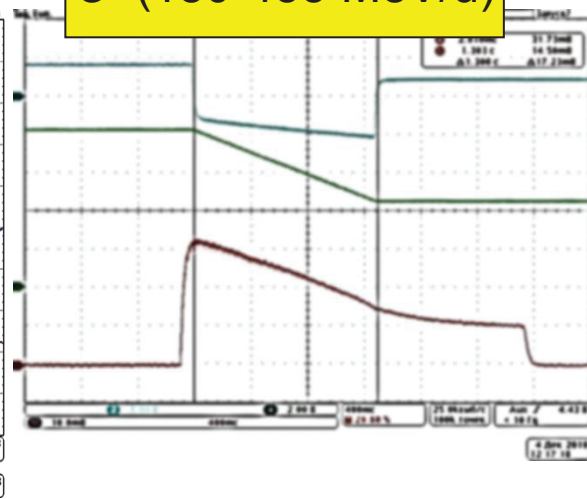
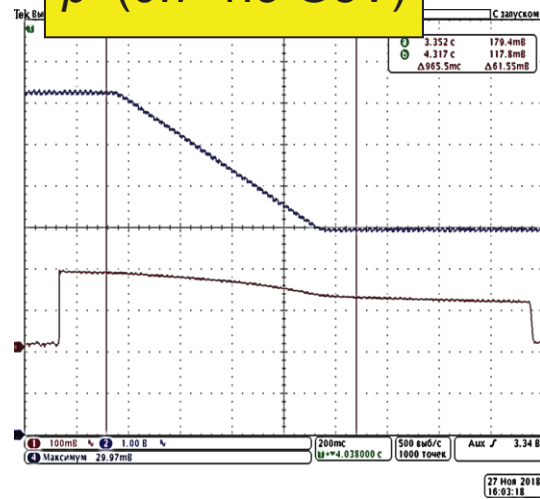
UPGRADES

New power supply (20 kW) for magnet U70 synchrotron



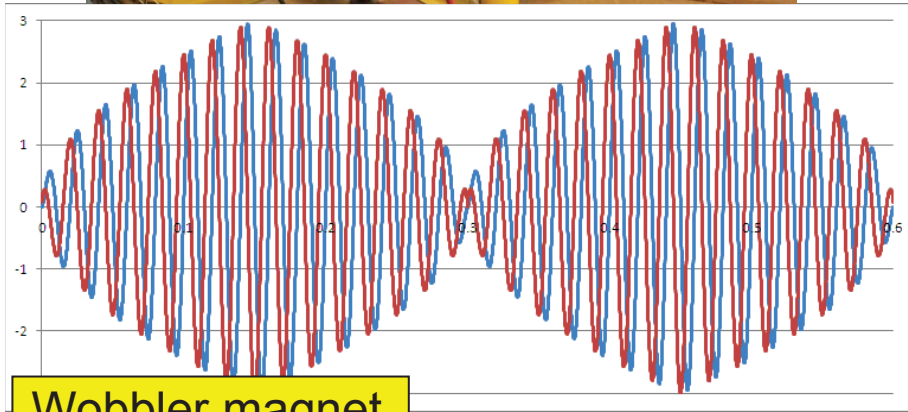
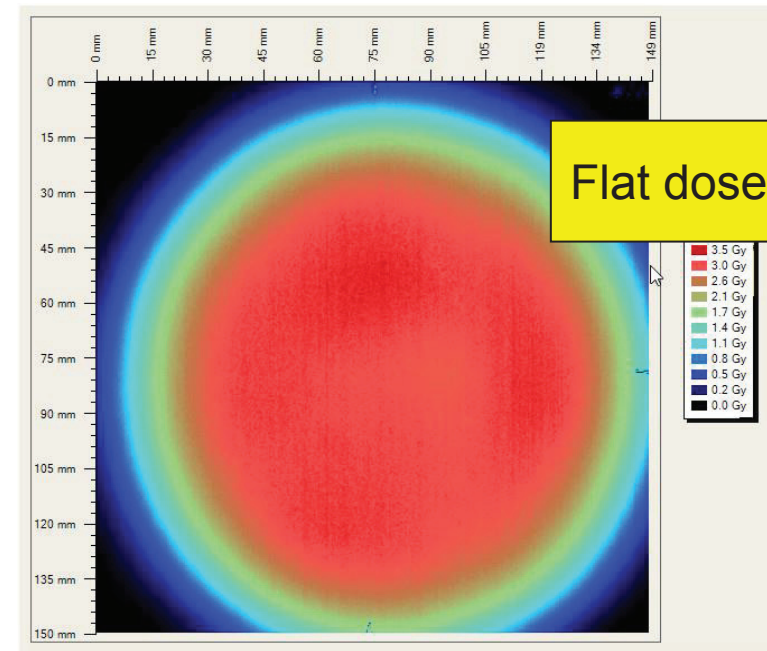
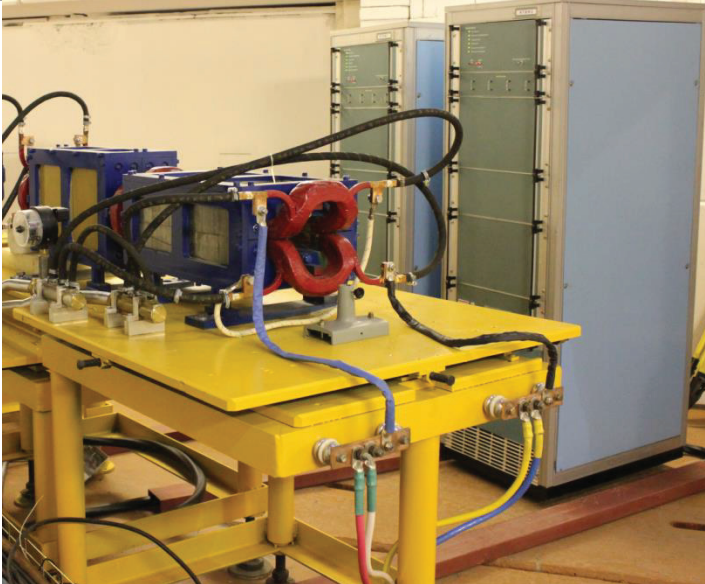
p (0.7-1.3 GeV)

C (180-455 MeV/u)

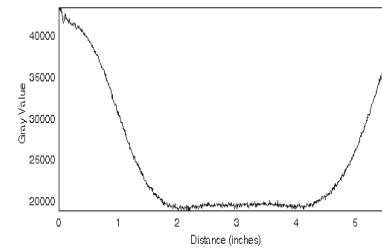


UPGRADES

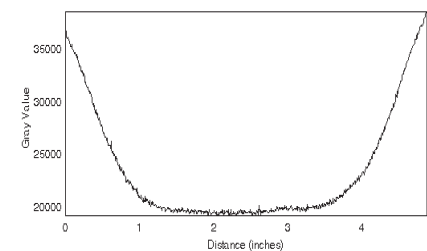
New irradiation field-forming system



Wobbler magnet current



X direction



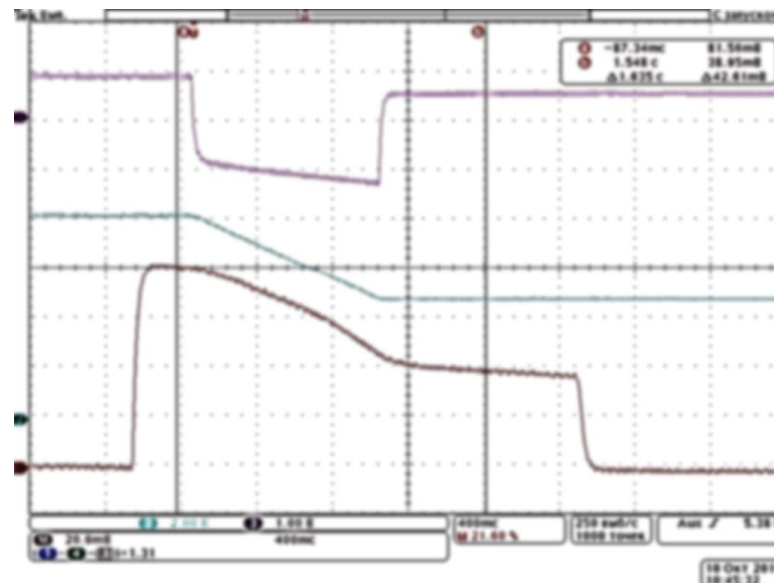
Y direction

Acceleration of light ions

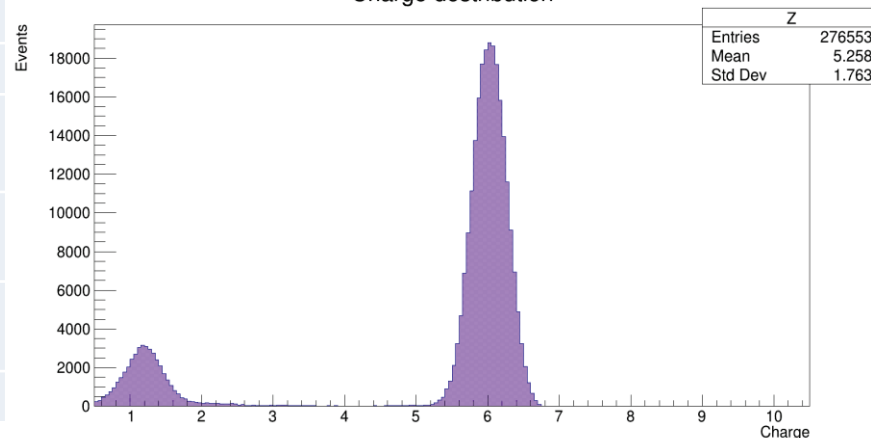
C (180÷455 MeV/u), 5 RUNS,
504 hours MD sessions and R&D on beam
and accelerator physics
372 hours radiobiological and
biophysical research

C (455 MeV/u) $1.35 \cdot 10^{10}$ ipp

Institution	2018-2	2019-1	2019-2	2020-1	2021-1
MRRC of NMRCR, http://mrrc.nmicr.ru	+	+	+	+	+
ITEB of RAS, web.iteb.psn.ru	+	+	+	+	+
IBMP of RAS, www.imbp.ru	+	+	+	+	
FMBC of FMBA, fmbafmbc.ru		+	+		
JINR, www.jinr.ru		+			+
VNIIFTRI, www.vniiftri.ru		+	+		
MEPHI, https://mephi.ru/				+	
IMB of BAS, www.bio21.bas.bg	+				

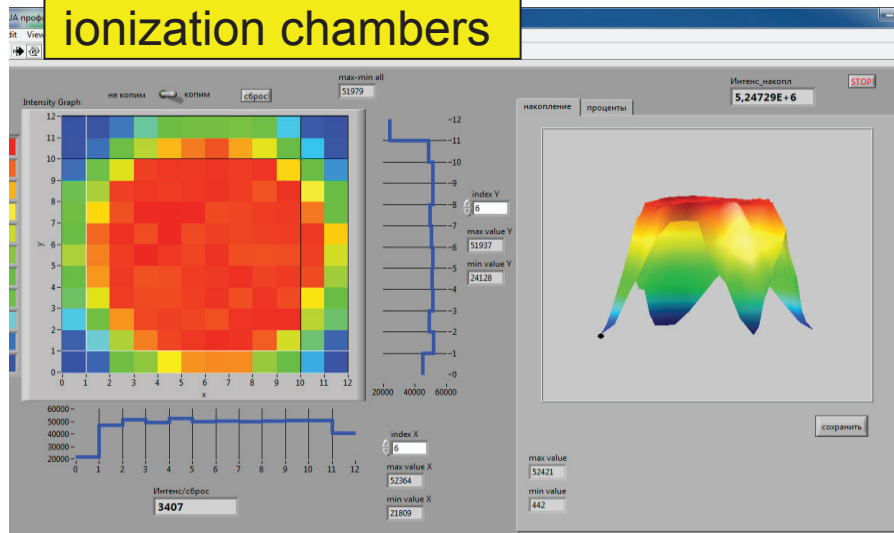


Charge distribution



Acceleration of light ions

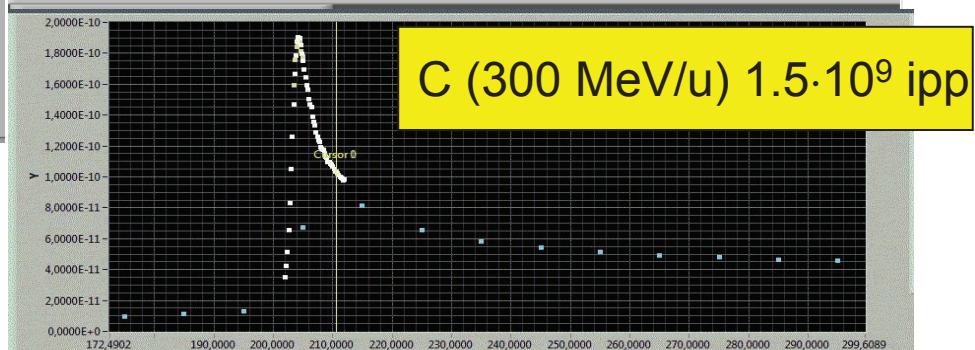
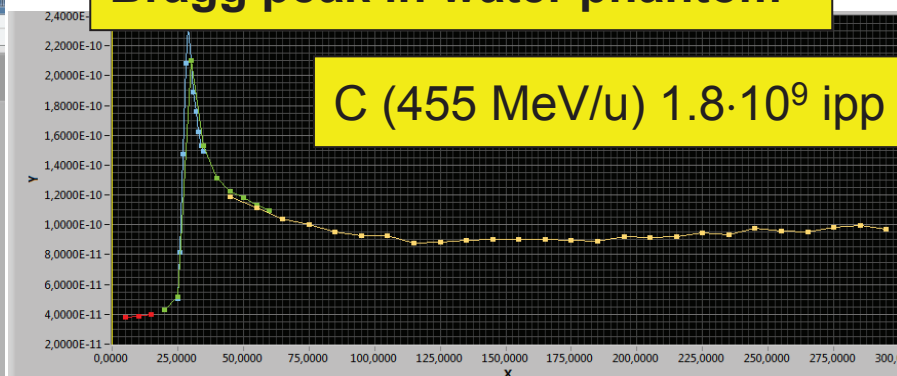
144-channel mosaic
ionization chambers



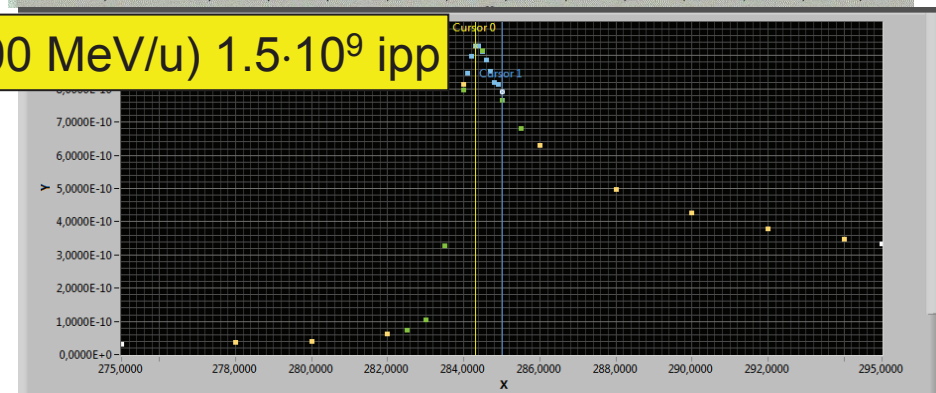
ITEB of RAS, experiments



Bragg peak in water phantom



C (200 MeV/u) $1.5 \cdot 10^9$ ipp



Conclusion

Accelerator Complex *U-70* of NRC “Kurchatov Institute” – IHEP (Protvino):

- comprises 4 machines (*URAL-30*, *I-100*, *U-1.5*, and *U-70* itself),
- readily ensures running the fixed-target physics program
- is subject to ongoing upgrade program
- has noticeably improved quality of proton beam recently
- now has slow extraction of 200, 250, 300, 350, 400, 455 MeV per nucleon of $^{12}\text{C}^{6+}$ beam for radiobiology and future prior-to-therapy studies
- *U-1.5* and *U-70* now belong to PS and (L)IS categories
- is open for a few promising options for future development

Thank you very much