



Status of U70

Report WEXMH01

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on behalf of the U70 staff



XXVI Russian Particle Accelerator Conference
October 1-5, 2018, Protvino, Moscow region

Outlook

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

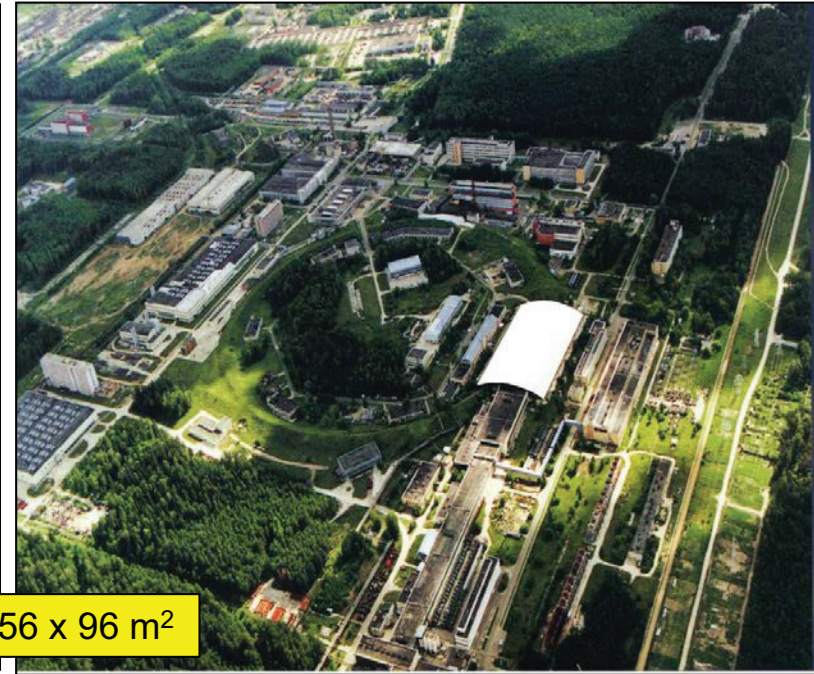
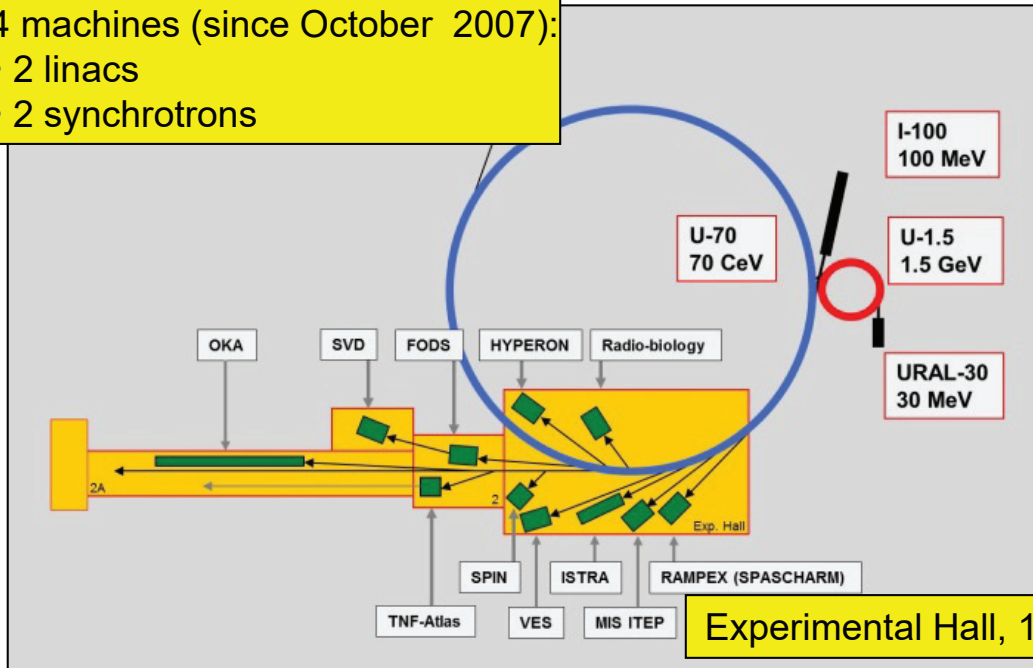
Accelerator Complex U-70 & synchrotron U-70 per se

“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

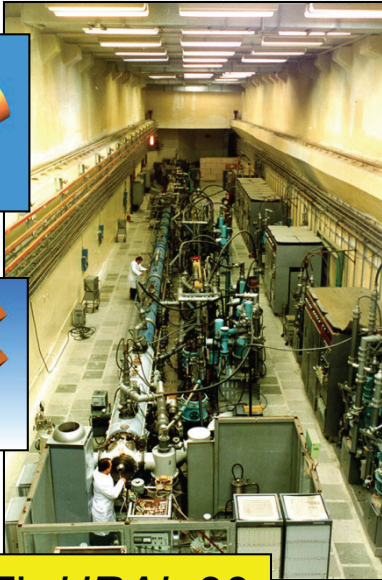
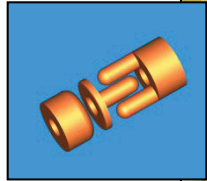
In the SIS-18, SIS-100 name convention:

- LIS-233 [T·m]
- LIS-6.9 [T·m]

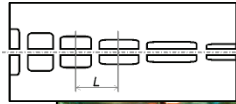
Light-ion (C nuclei):

- (very) high energy 24.1-34.1 GeV/u
- intermediate (though high) energy 453-455 MeV/u

Photo album of the machines



RFQ DTL *URAL-30*



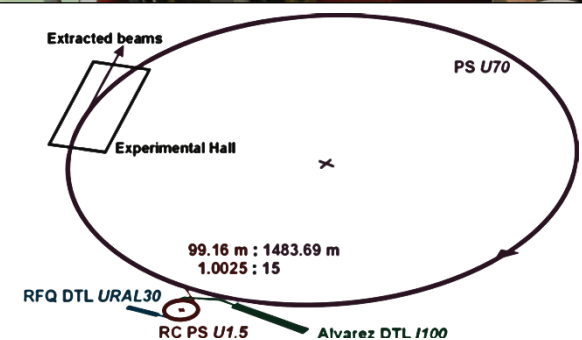
Alvarez DTL *I-100*



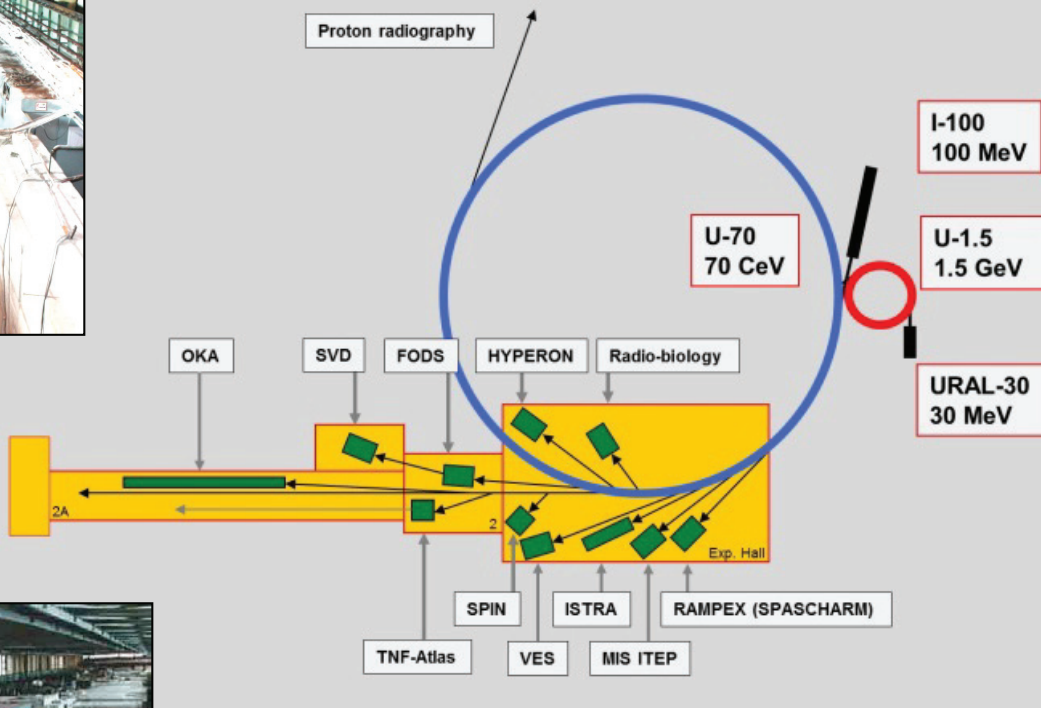
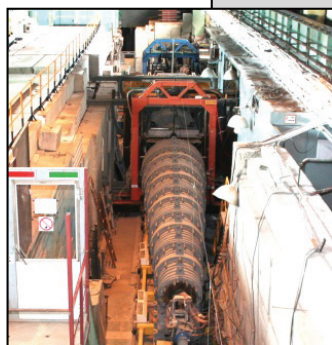
Main PS *U-70*



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

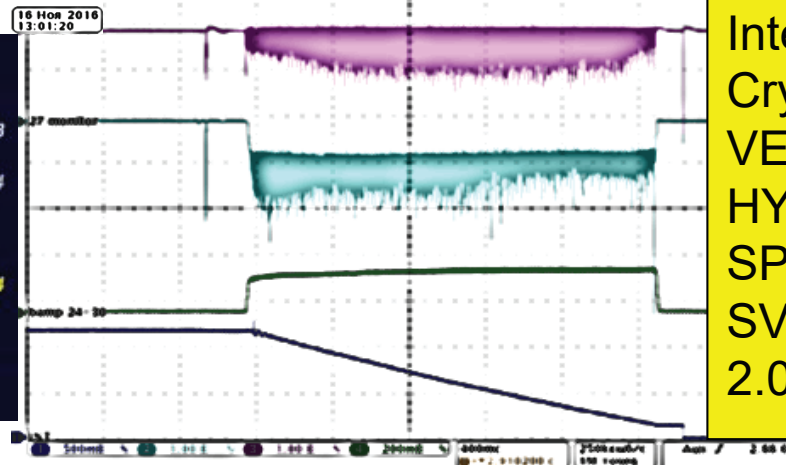
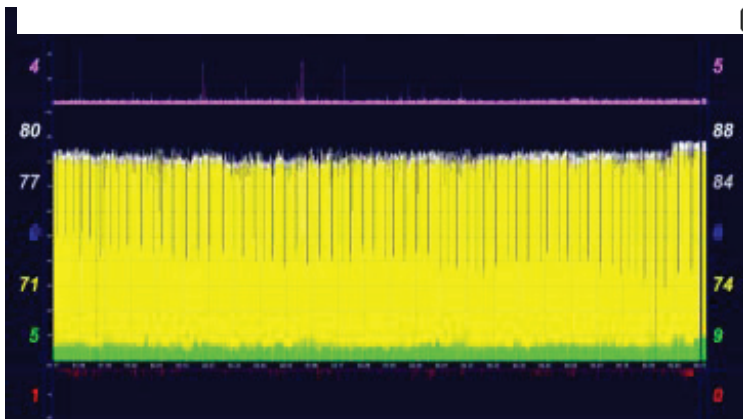
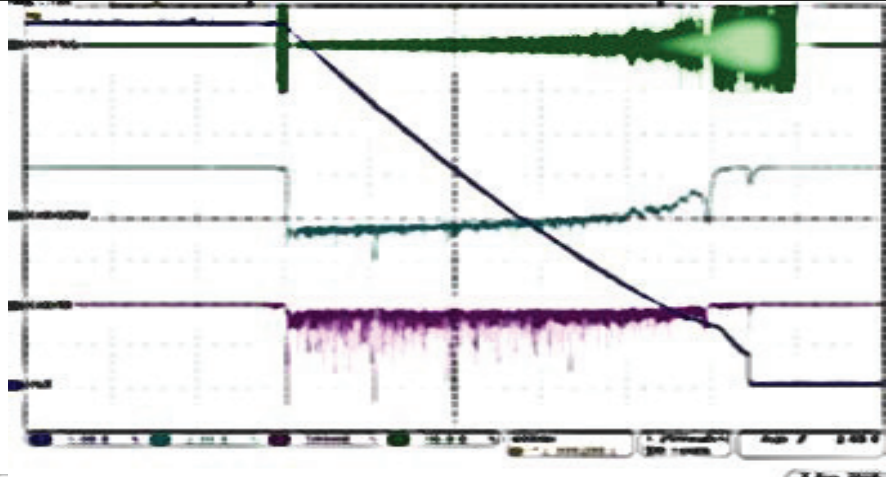
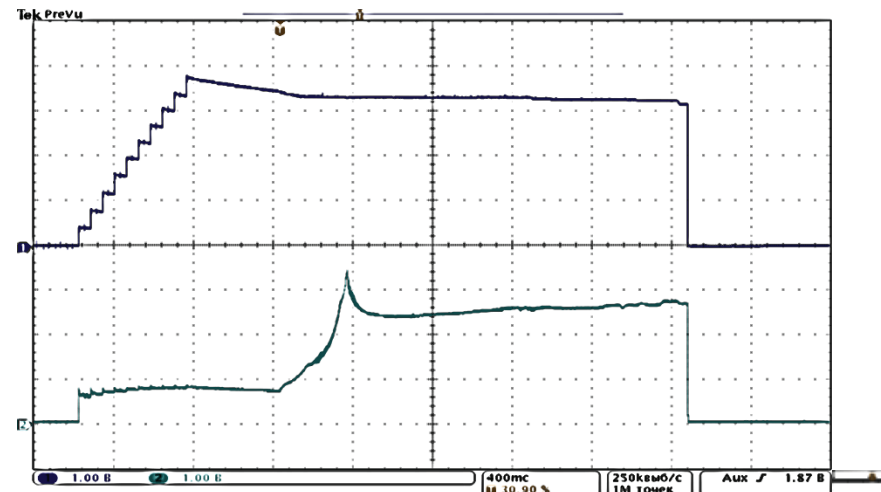
	Run	2016-2	2017-1	2017-2	2018-1
Launching linac URAL30, booster U1.5 and U70 sequentially (I100 in parallel with a delay)		October, 03	February, 27	October, 30	February, 05
Beam in the U70 ring since		November, 03	March, 27	November, 27	March, 06
Fixed-target physics program with extracted top-energy beams (either of protons or of carbon nuclei)		November, 07 – December, 19, 42 days	April, 14 –29, 15½ days	December, 04 – 18, 14 days	March, 12 – April, 26, 45 day
No. of multiple beam users (of which the 1st priority ones)		8 (7)	5 (3)	3(1)	10(9)
MD sessions and R&D on beam and accelerator physics, days		12	17	25	7
Light-ion acceleration program, intermediate energy only		December, 19–27, 8½ days	March, 27–April 09, 13½ days	December, 18–29, 11½ days	April, 26–27, 1 day

RUN 2016-2

Radiographic facility, 192 hours,
 p (50 GeV), fast-extraction,
 $3-4 \cdot 10^{11}$ ppb

Fundamental physics, 672 hours, p (50 GeV)

OKA, SPIN Slow stochastic extraction, $8.0 \cdot 10^{12}$ ppp



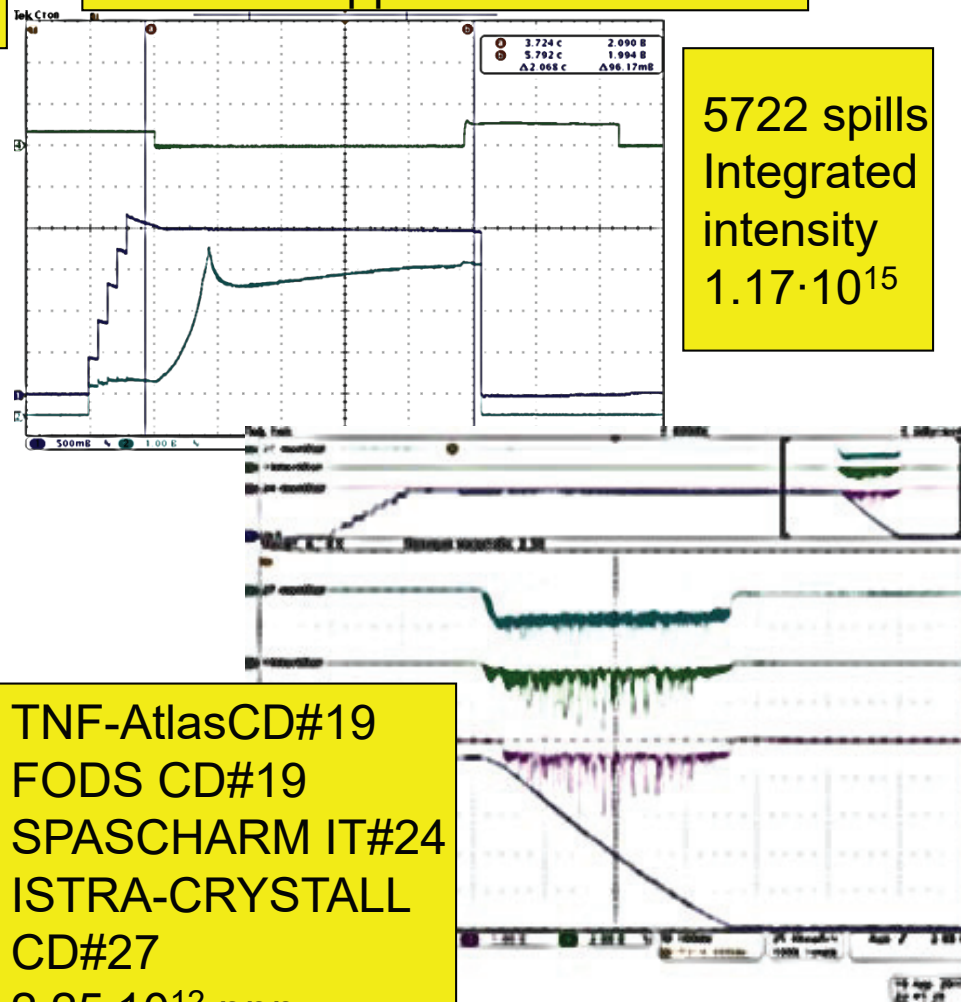
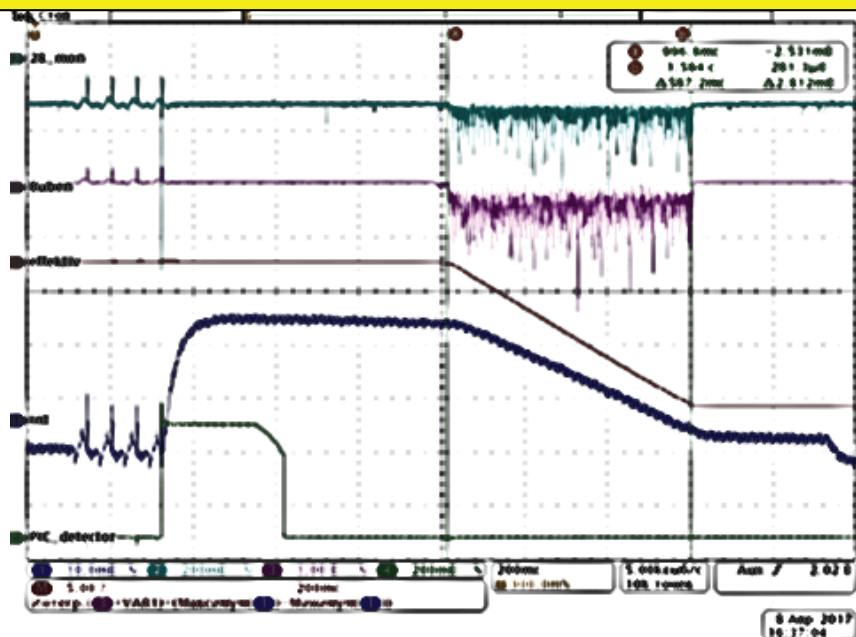
Internal-targets(IT)
Crystal Deflector(CD)
VES IT#27
HYPERON IT#35
SPASCHARM IT#24
SVD CD#19
 $2.0 \cdot 10^{12}$ ppp

RUN 2017-1

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

Radiographic facility, 192 hours,
 p (30, 50 GeV), fast-extraction,
 $3-4.5 \cdot 10^{11}$ ppb

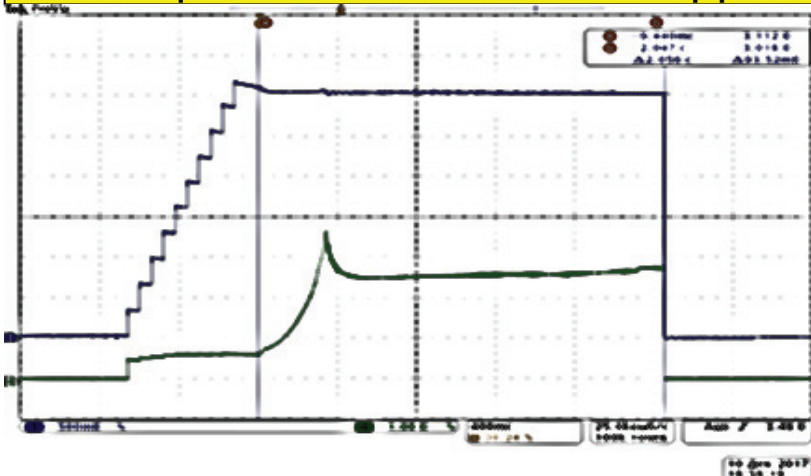
5722 spills
Integrated
intensity
 $1.17 \cdot 10^{15}$



TNF-AtlasCD#19
FODS CD#19
SPASCHARM IT#24
ISTRA-CRYSTALL
CD#27
 $2.25 \cdot 10^{12}$ ppp

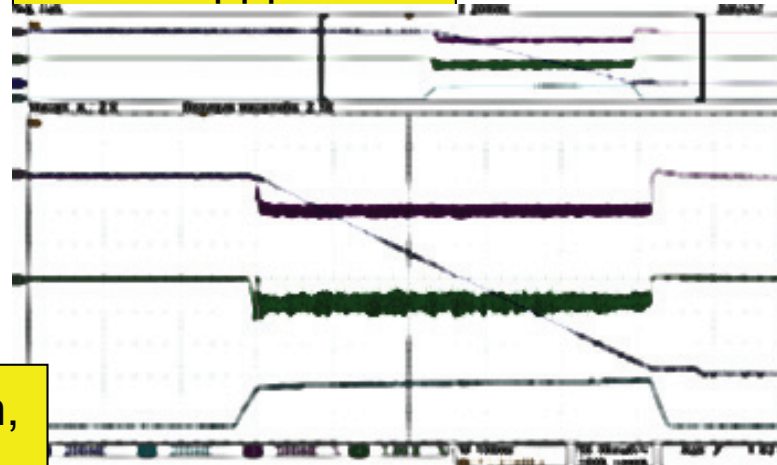
RUN 2017-2

Radiographic facility, p (50-60 GeV),
fast-extraction,
1-10 equal bunches $3\text{--}4.5 \cdot 10^{11}$ ppb

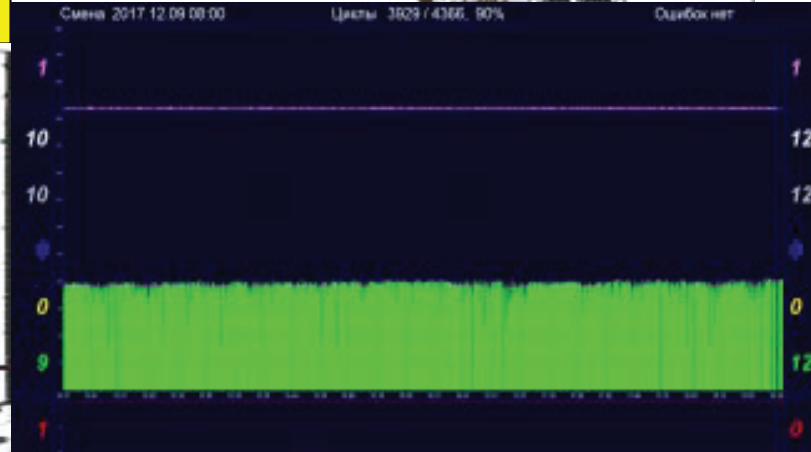
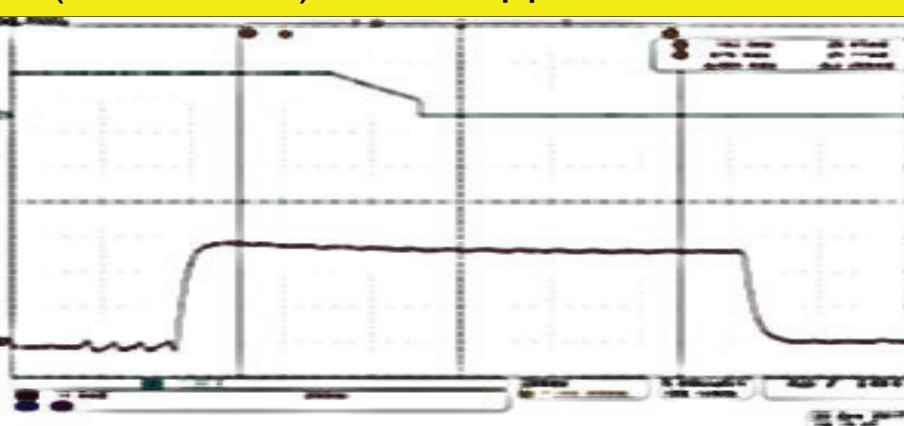


Fundamental physics, p (50 GeV)
lowered priority

HYPERON
ISTRA-CRYSTALL
 $1.2 \cdot 10^{12}$ ppp

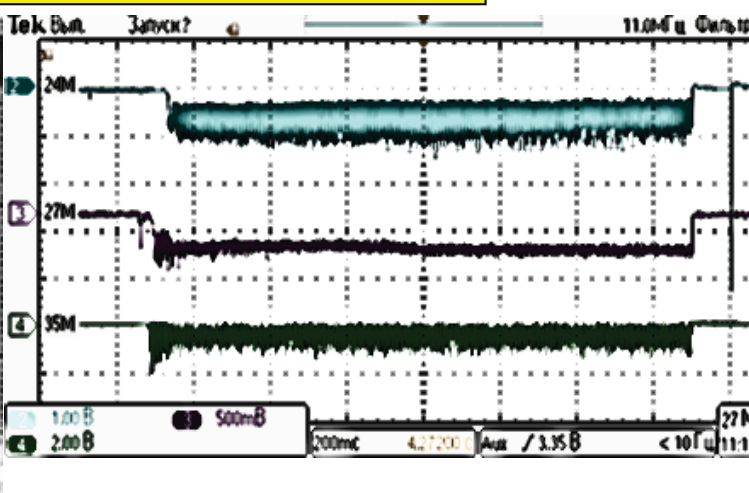
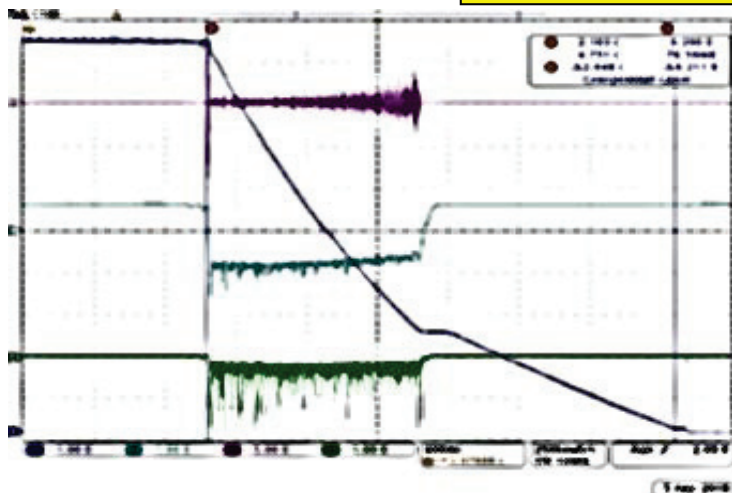


Radiobiological and biophysical research,
C (455 MeV/u) $4.6 \cdot 10^9$ ipp



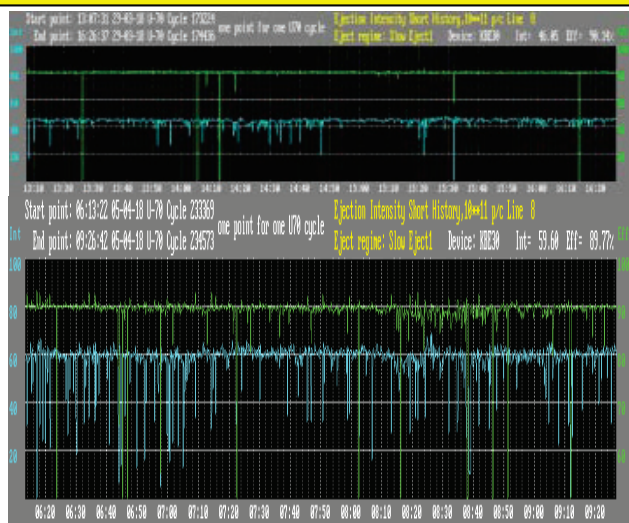
RUN 2018-1

Fundamental physics, p (50 GeV)

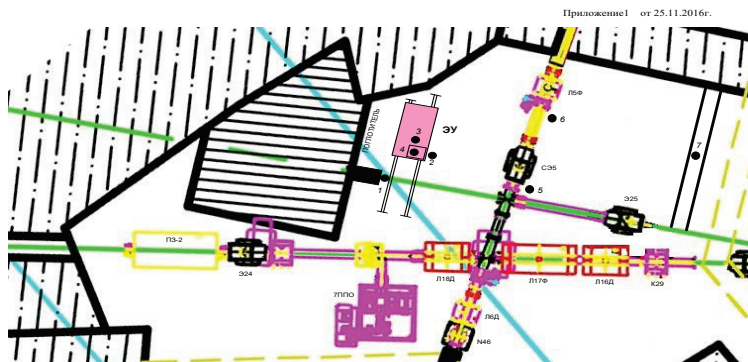


Internal-targets
Crystal deflector
TNF-Atlas
Istra
FODS
VES
SVD
HYPERON
SPASCHARM
 $2.0 \cdot 10^{12}$ ppp

OKA, SPIN Slow stochastic extraction, up to $7.0 \cdot 10^{12}$ ppp



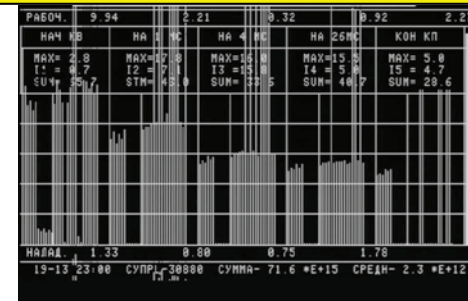
U1.5 irradiation center



RUN 2017-1 2017-2 2018-1
Irradiate electronics and scintillators
in frames of the upgrade activity for the
TileCal calorimeter of the CERN LHC
ATLAS experiment.

2017-1 5.15×10^{17} protons
2017-2 2.2×10^{16} protons
2018-1 3.6×10^{16} protons

RUN 2016-2
fiberglass PCBs with microchip's on it
organic scintillators and activation detectors
Up to 5.285×10^{17} protons



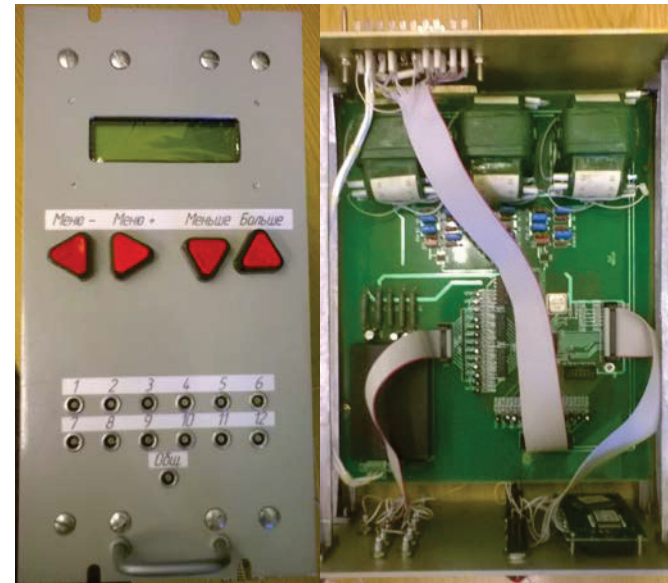
UPGRADES

U1.5 power supply system upgrade.



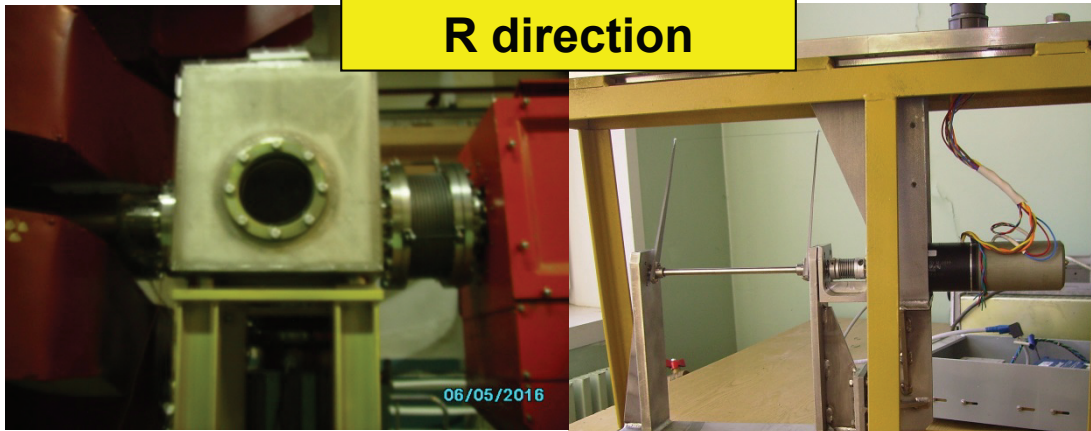
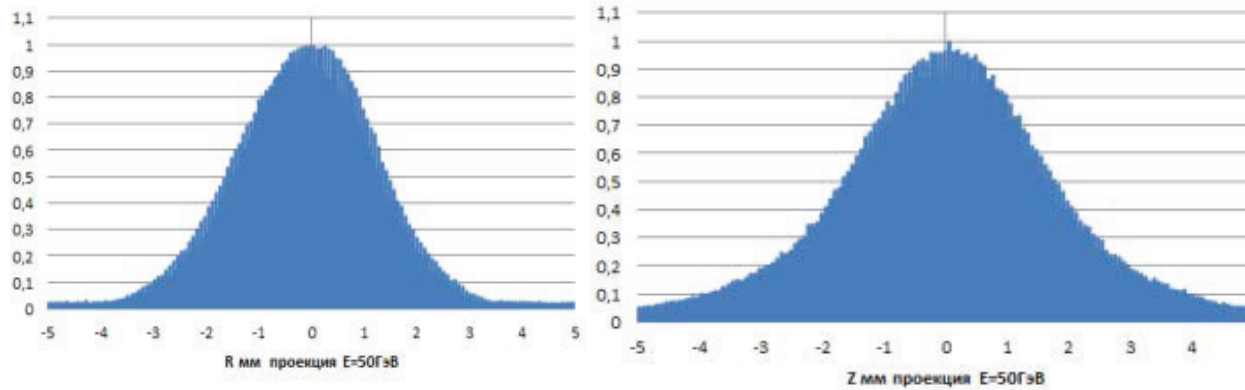
U70 power supply system upgrade.

One of useful developments was to derive reference to synchronize the PSP trigger from the stepped-down 220/0.1 kV parent voltage directly via home-made electronics.



UPGRADES

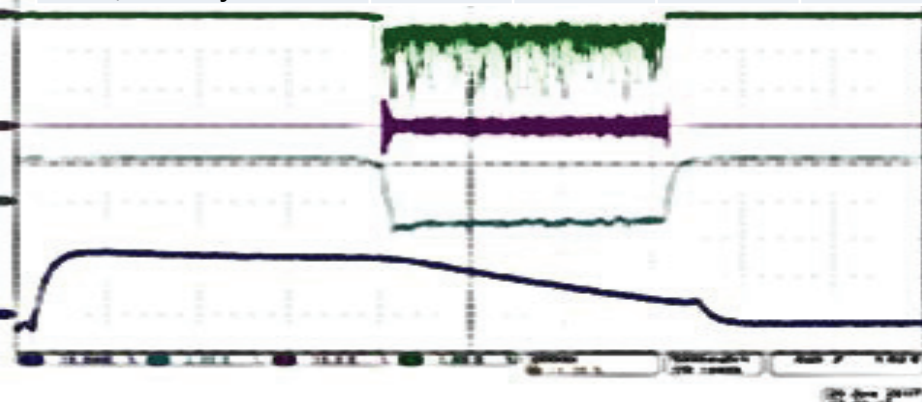
U70 Diagnostic system New flying-wire beam profilometer (transverse)



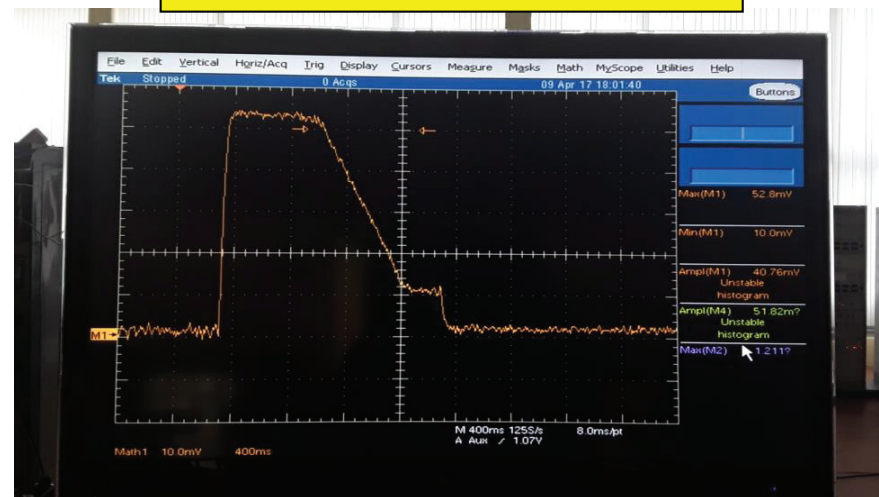
Acceleration of light ions

C (455 MeV/u), 3 RUNS,
224 hours MD sessions and R&D on beam
and accelerator physics
224 hours radiobiological and
biophysical research

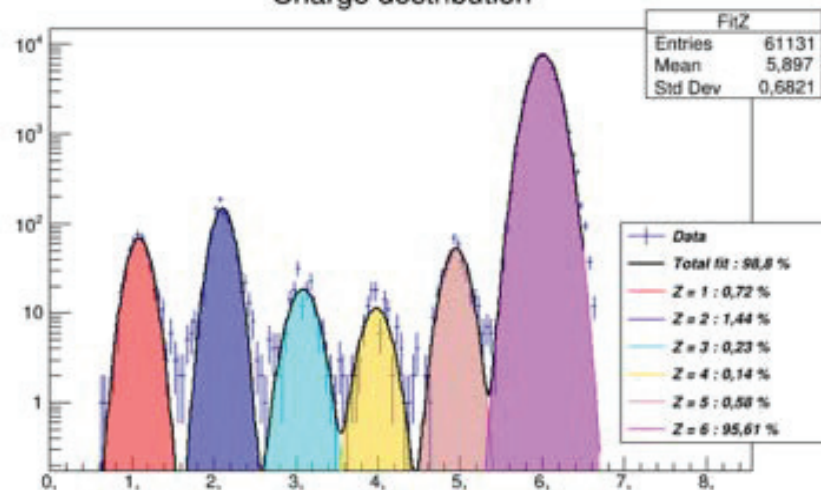
Institution	2016-2	2017-1	2107-2	2018-1
MRRC of NMRCR, http://mrrc.nmicr.ru	+	+		
ITEB of RAS, web.iteb.psn.ru	+	+		
IBMP of RAS, www.imbp.ru		+	+	
FMBC of FMBA, fmbafmbc.ru		+		
JINR, www.jinr.ru	+	+		



C (455 MeV/u) $8.5 \cdot 10^9$ ipp



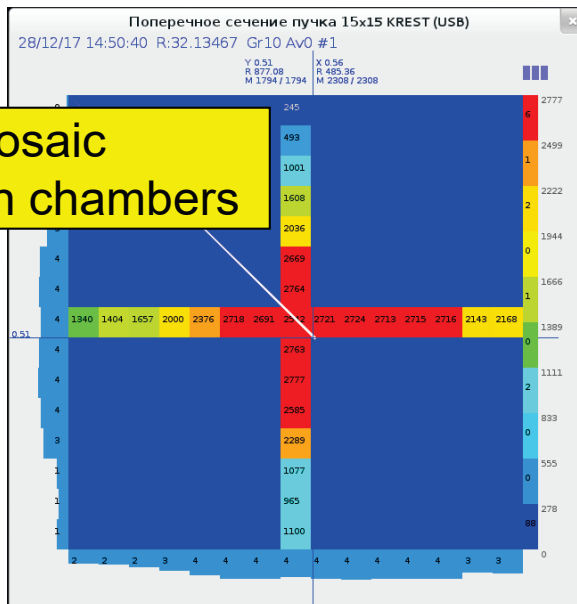
Charge distribution



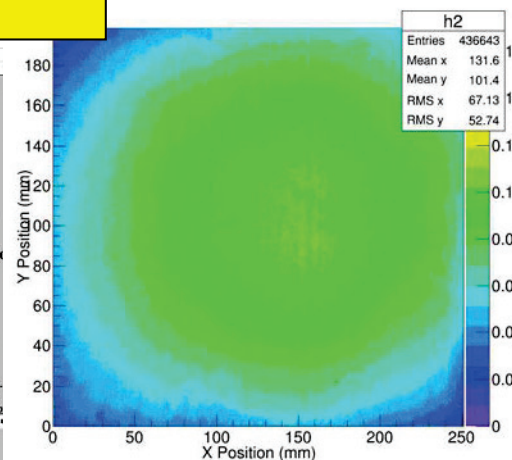
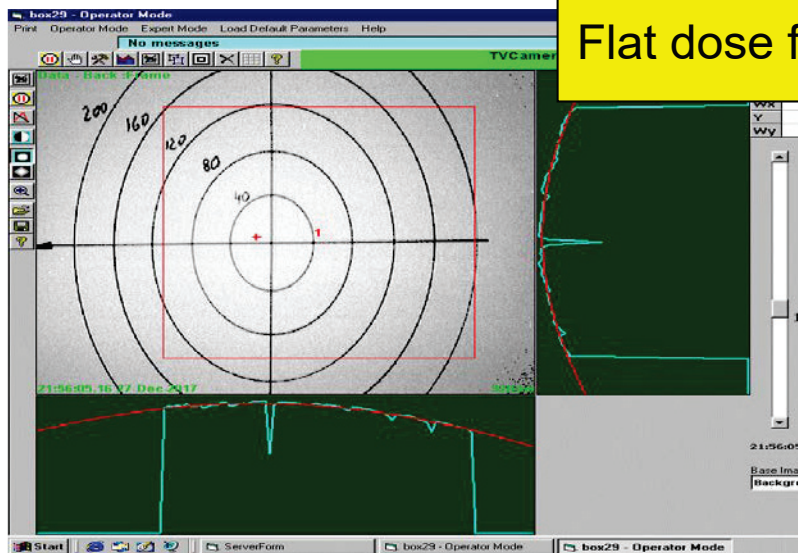
Acceleration of light ions

IBMP RAS, experiments

4-way mosaic
ionization chambers



Flat dose field



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 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