Status of the Nuclotron

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for the Nuclotron team

VBLHEP, JINR

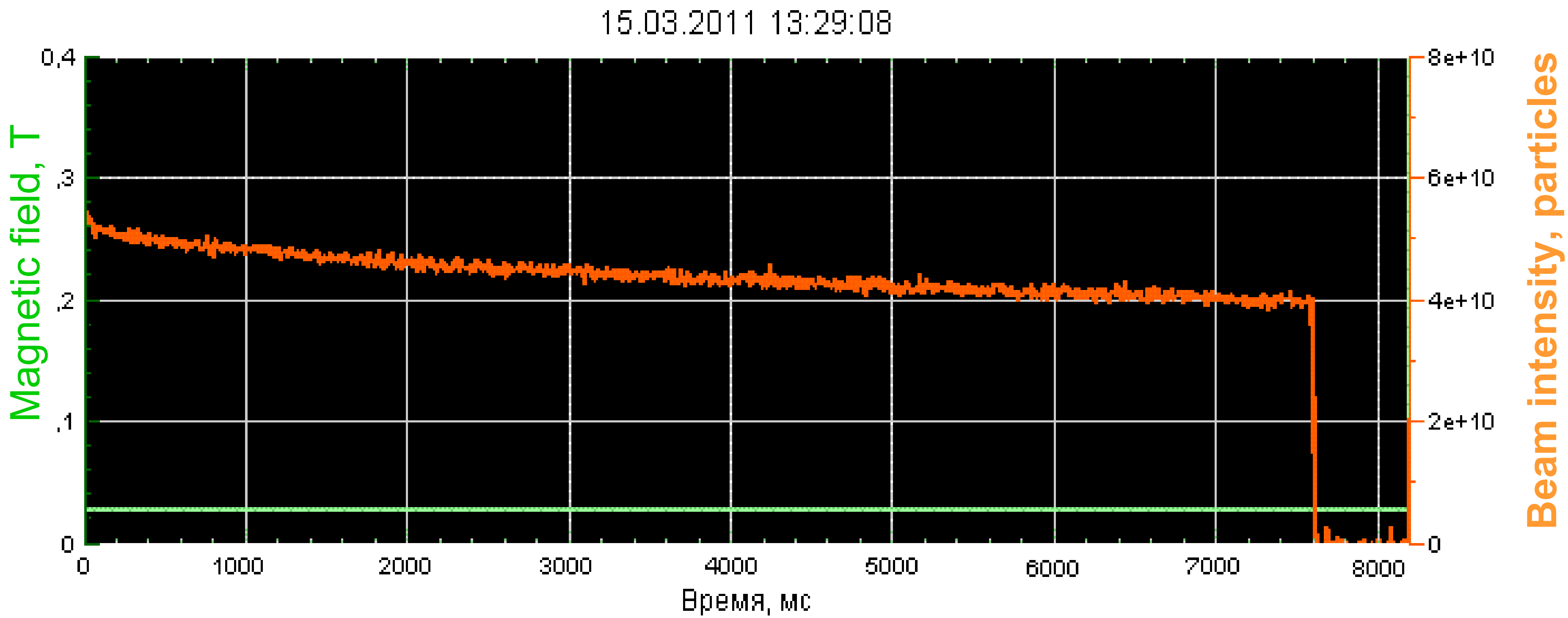
Status of the Nuclotron

Contents

1.Results of the Nuclotron upgrade
2.Machine development
-Increase of the beam energy
-Optimization of the beam dynamics
-Development of power supply system
-Development of the diagnostics
-Development of ion sources, fore-injector modernization
3. Nuclotron as a basic test facility for NICA
-Long plateau of the magnetic field
-Preparation for stochastic cooling

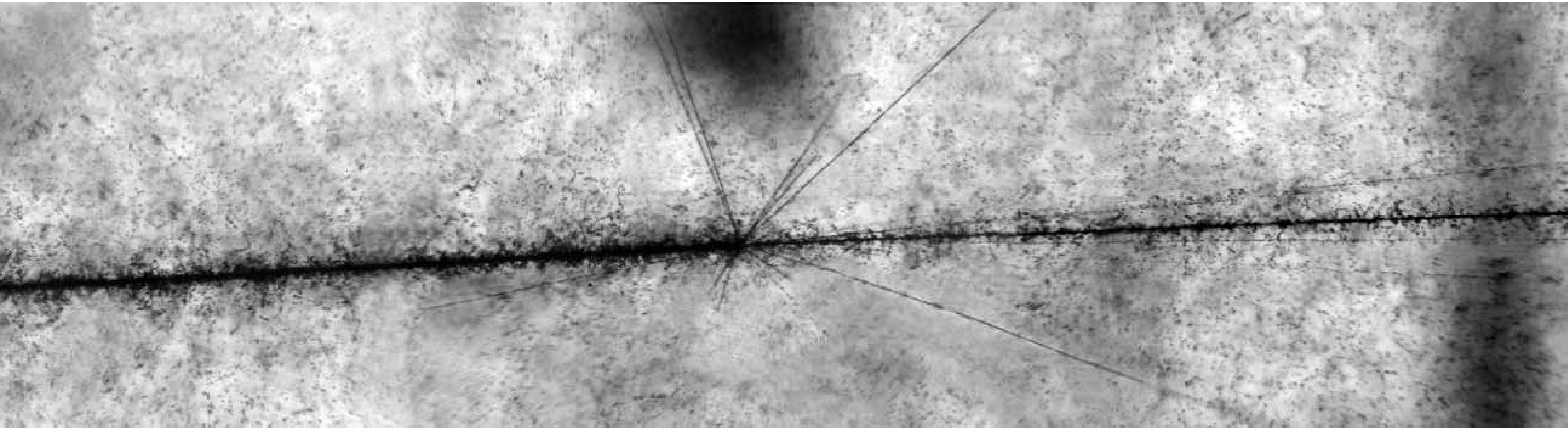
Nuclotron-M Results

Estimation of the average vaccum in the Nuclotron ring measuring circulating deutron beam lifetime at E=5 MeV/u corresponds to the vacuum pressure not worse than 4*10^{-10} Torr.



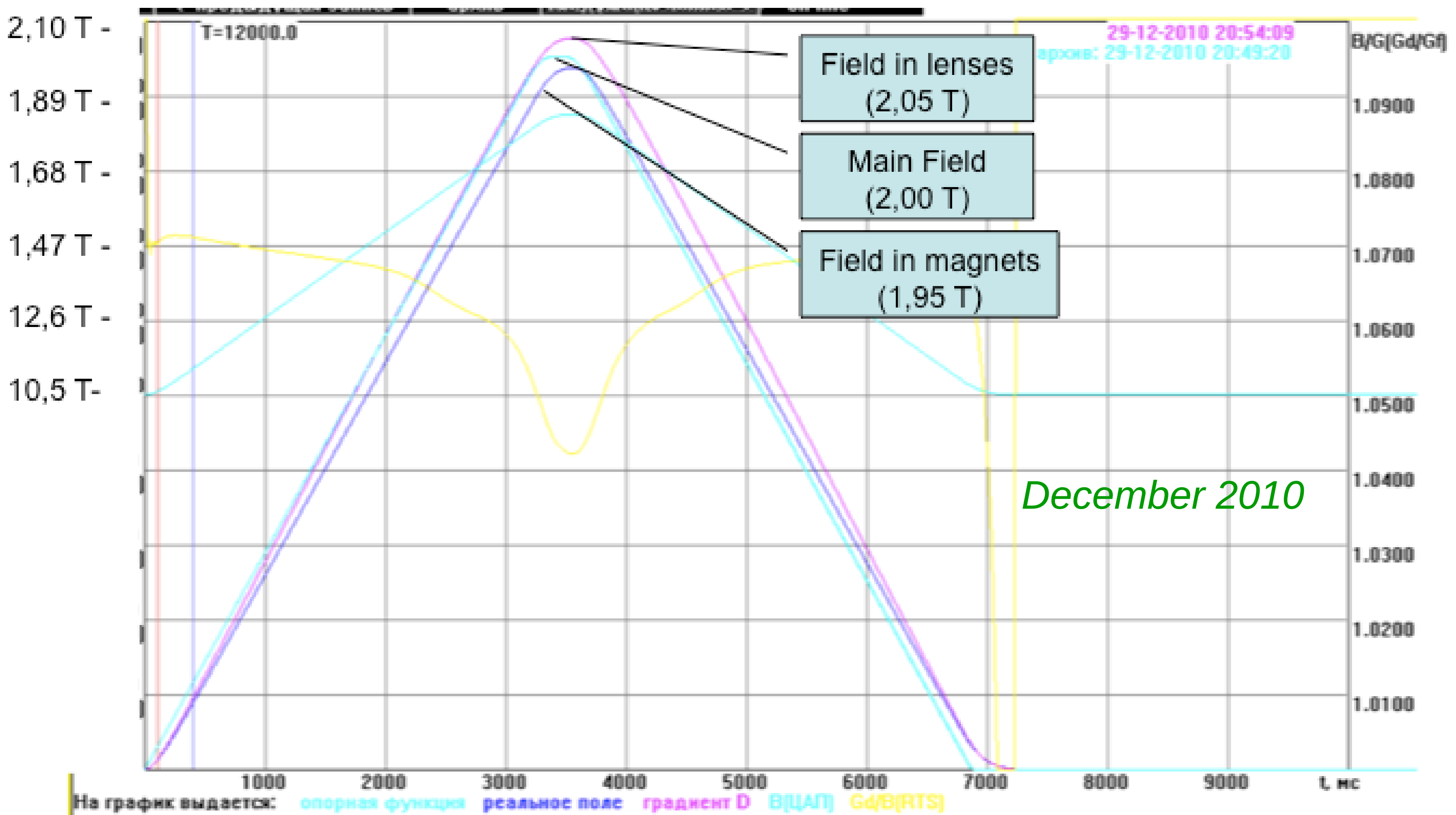
Nuclotron-M Results

March 2010:



Xe (1 Gev/n) trace on photoemulsion
(experiment "Becquerel")

Nuclotron-M Results



	t,мс	Гс - Bo	B	Gd	Gf	Gd-B	Gd-kB	мВ - Ub	Ug	Ib	Ig	Bo	B	G	kB	kB'	k
инж.	113.2	677.5	289.0	309.4	249.7	20.4	20.4	1332.3	14.3	63.0	1.0	258.7	112.2	9730.3	8425.5	6899.8	1.00000
	400.0	2423.6	1850.2	1981.7	0.0	131.5	131.5	1824.0	14.6	405.6	0.0	927.7	707.4	9700.0	8409.6	6905.5	1.00000
	6517.0	2165.3	2681.6	2867.0	0.0	185.4	185.4	-1615.3	10.4	578.0	1.7	808.0	1003.9	9712.7	8422.2	6898.2	1.00000

Nuclotron-M Results

-Full scale modernization of the cryogenic system was carried out.
As result the cooling power at 4,5 K was increased up to 4 kW,
the reliable work at maximum magnetic field
and at prolonged magnetic cycle duration was provided.
The operation term was sufficiently increased;
today the new equipment can be used for the NICA/MPD purposes already.

-The vacuum system was modernized.
It permitted to decrease the residual gas pressure in the Nuclotron beam pipe by two orders of magnitude and to provide a possibility of heavy ion acceleration.
The obtained result allows solving general task of the Nuclotron as a part of the heavy ion collider injection chain – to provide acceleration of heavy nuclei from 0,6 GeV/u (injection energy from the booster) up to 4,5 GeV/u without losses.

Nuclotron-M Results

-Modernization of control system, diagnostic and radio frequency accelerating systems was performed.

As result new cycle control equipment, digital generator providing relation between accelerating voltage frequency and magnetic field value,
new power supply system for corrector magnets,
digital orbit measurement system and others were put into exploitation.

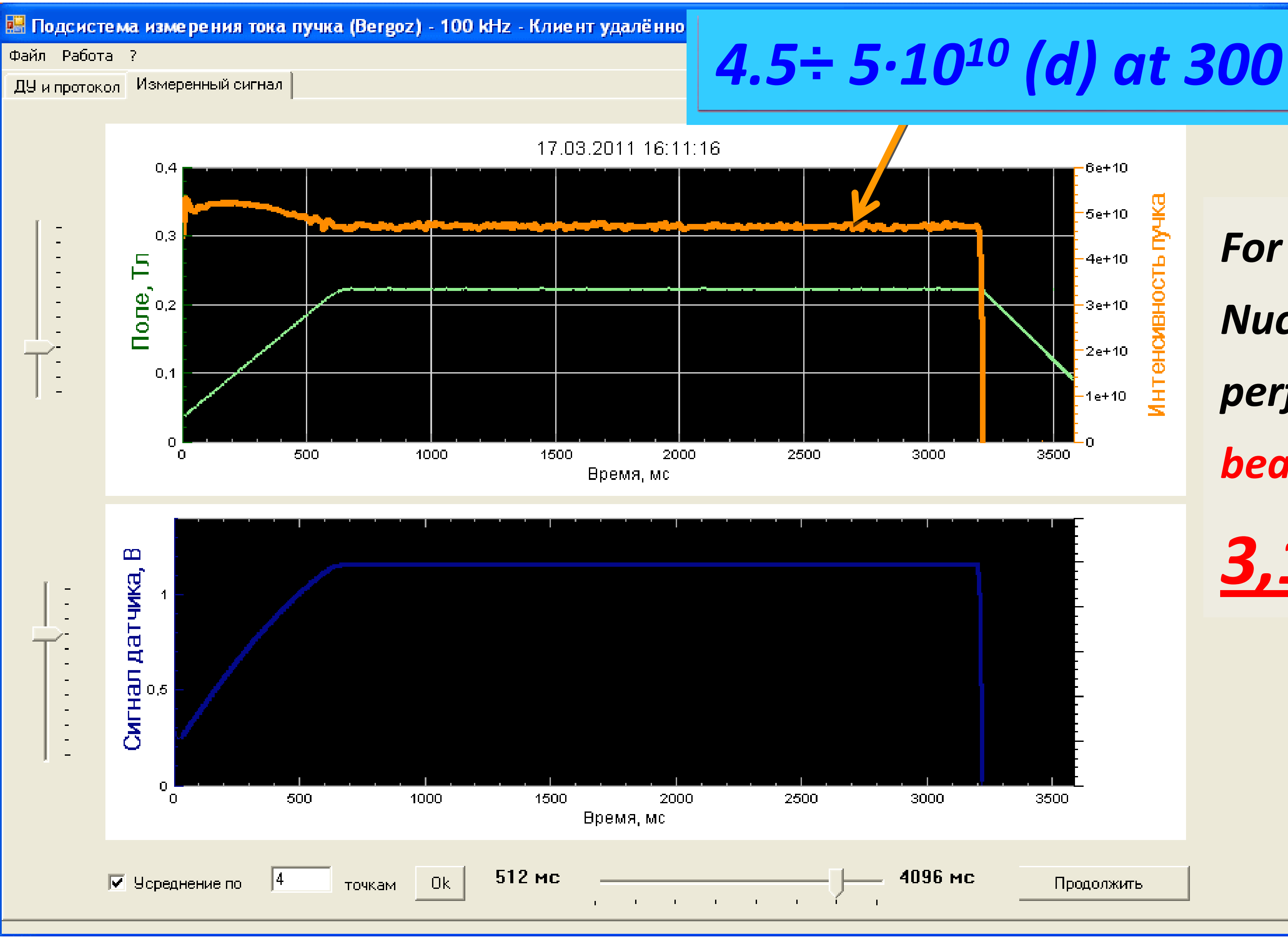
-New power supply and quench protection system

based on consequent connection of the Nuclotron structural magnets, all supply units and energy evacuation switches was created. Practical realization of this scheme required modernization of existing supply units, development and construction of two new units for current variation in focusing and defocusing lenses, disassembly of old cable lines and assembly of a few kilometers of new ones.

After completion of the Nuclotron upgrade 3 runs (#43 - #45) were performed:
Total duration 2900 hours , 1400 hours – experimental program

Machine development run #43

$4.5 \div 5 \cdot 10^{10}$ (d) at 300 MeV/u



For the first time at Nuclotron had been performed

beam slow extraction

3,1 GeV/u

Increase of the beam energy

Run # 43

Slow extraction at 3.1 GeV/u

Run #44

7.12.2011 $^{+6}$C 3.42 GeV/u,
slow extraction and transport to BM@N area

18.12.2011 d 4 GeV/u (1.47 Тл)

Run #45

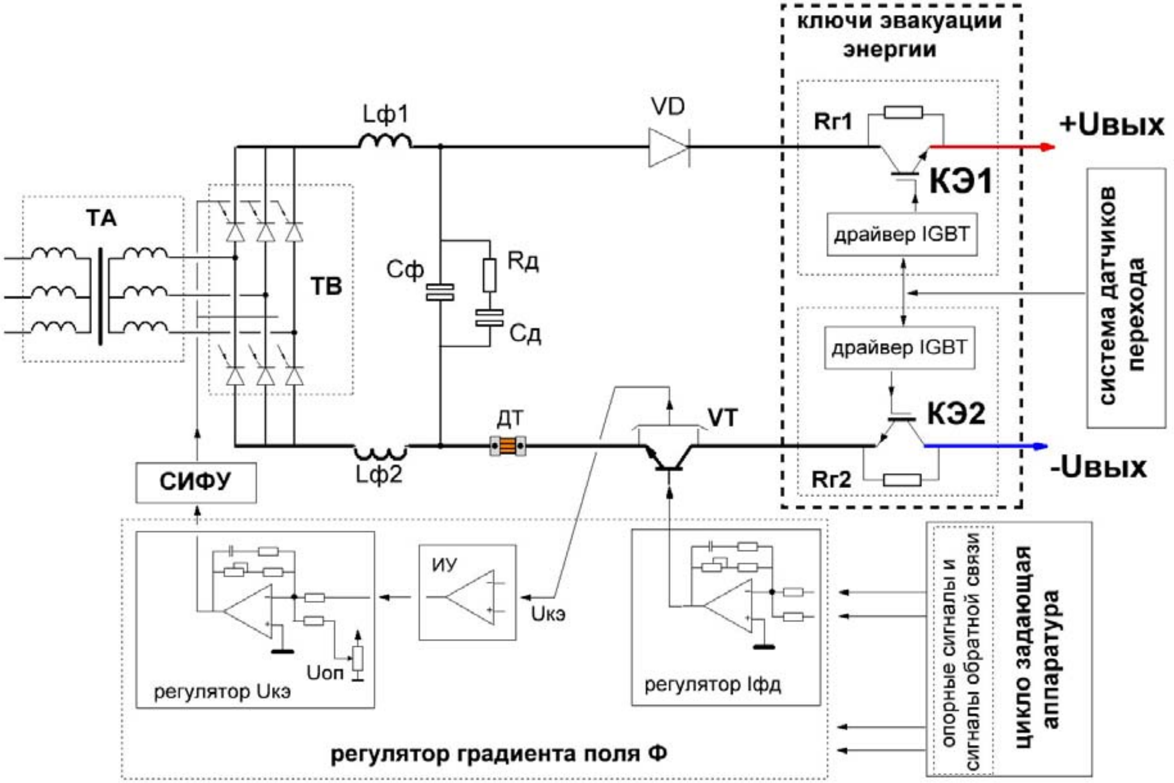
Routine operation d 4 GeV/u (Energy&Transmutation)

At the end of the run – slow extraction d 4.5 GeV/u

Development of power supply system

Run #44 – passive filter
+ thyristor rectifier 37TB

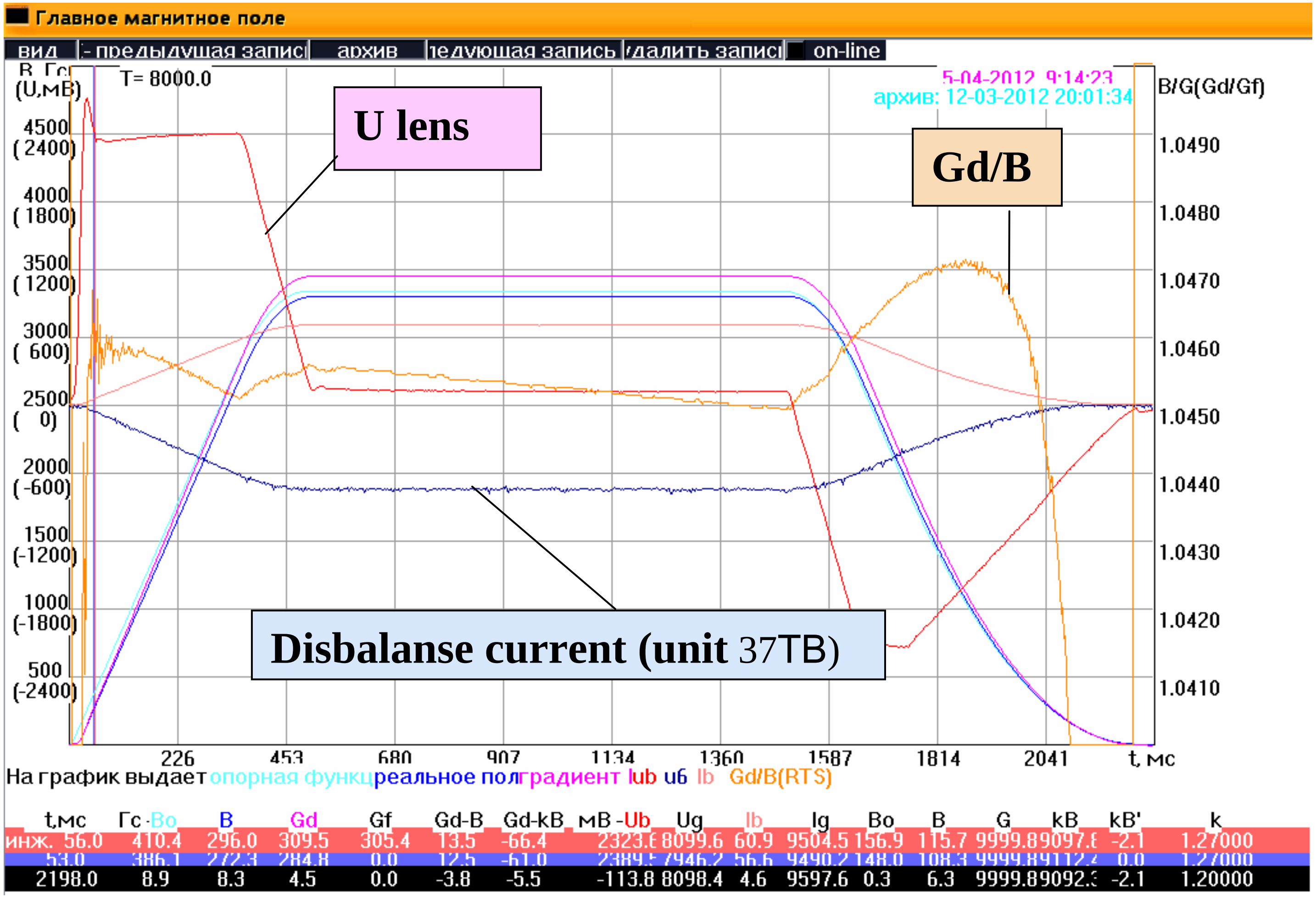
Run #45 «fast» disbalance unit:



Development of power supply system

<u>Run 45:</u> <u>SC magnets PS</u> has been optimized to operate at

dB/dt = 0.8 T/s (sufficient for NICA!)



Beam dynamics optimization

RF system:
- Max phase misalignment decreased up to < 2^0 (passive devices), max phase misalignment < $\pm 10^0$;
- New phase detector commissioned ;
- Remote control has been put in operation.

Digital RF control generator:
- tuning/control of the RF on flattop has been commissioned (essential for slow extraction and measurement of the dispersion and critical energy).

Power supply:
- Stablilization of the working point has been achieved.

The result: no losses during acceleration!

Beam dynamics optimization

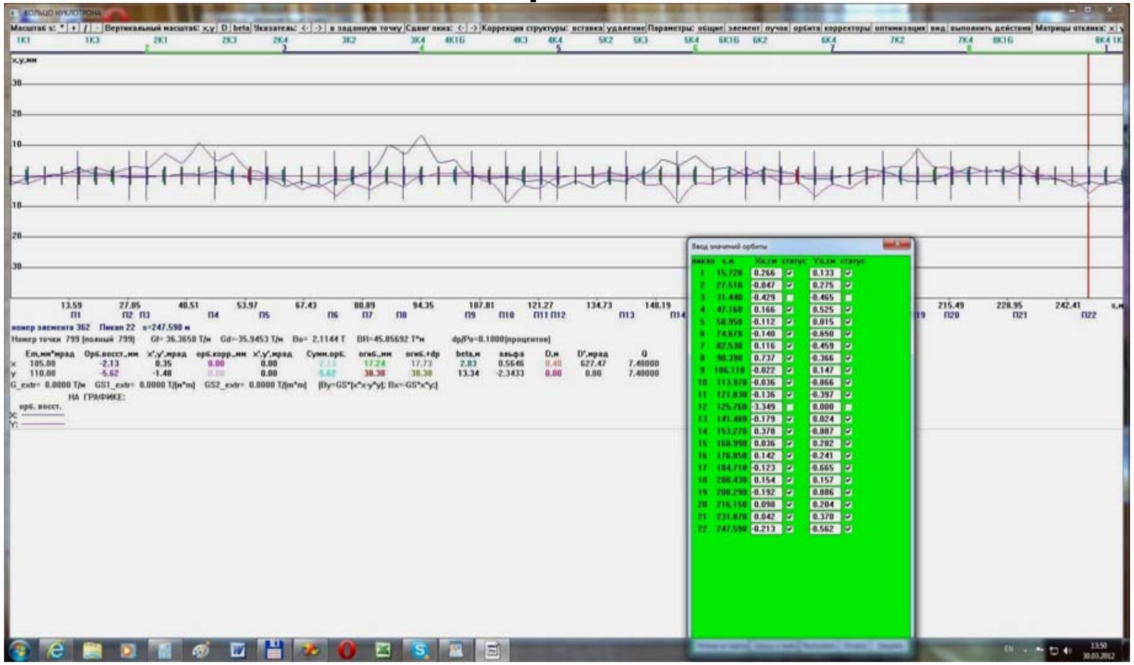
Cupture optimization

-Orbit correction at injection,

-Cycle of the correcting magnets,

-Working point optimization,

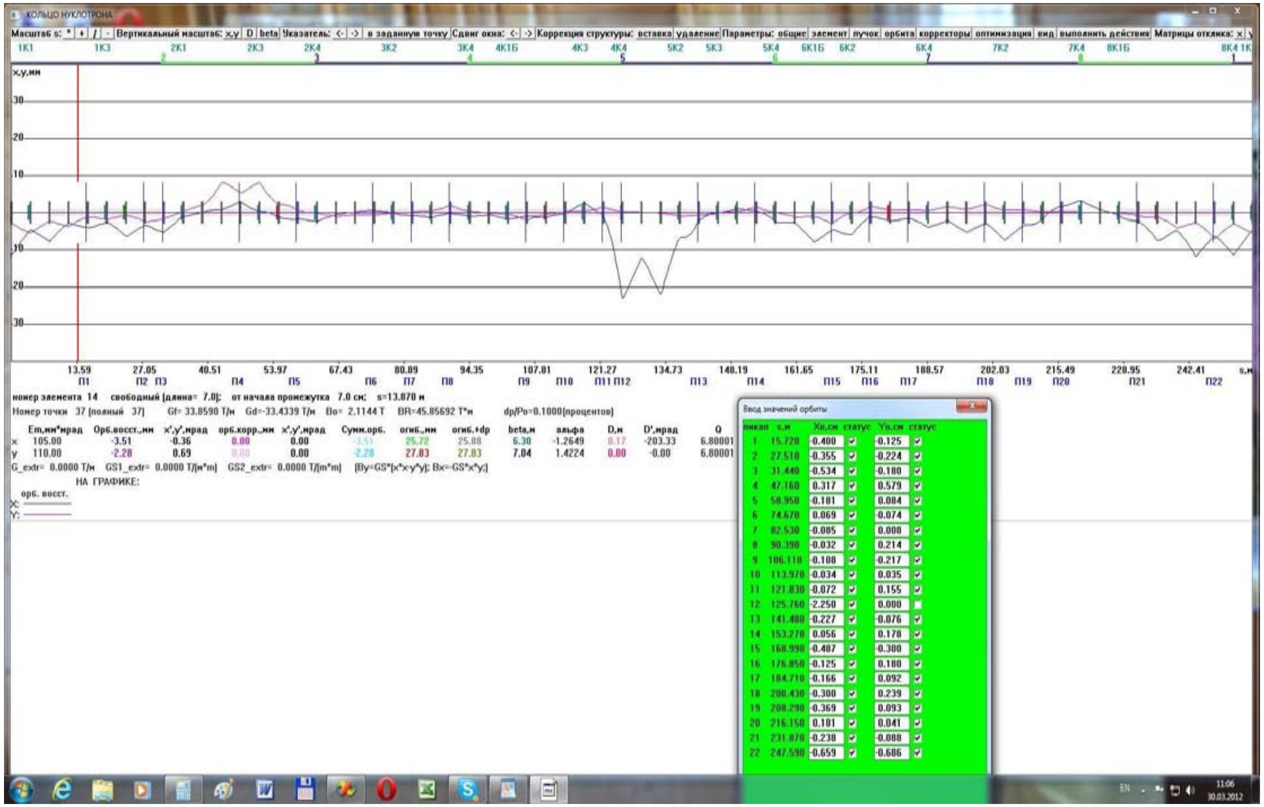
-Adiabatic RF capture.



Run #45 (Q ≈ 7,2), $x_{pp} \approx z_{pp} \approx$ 18mm.

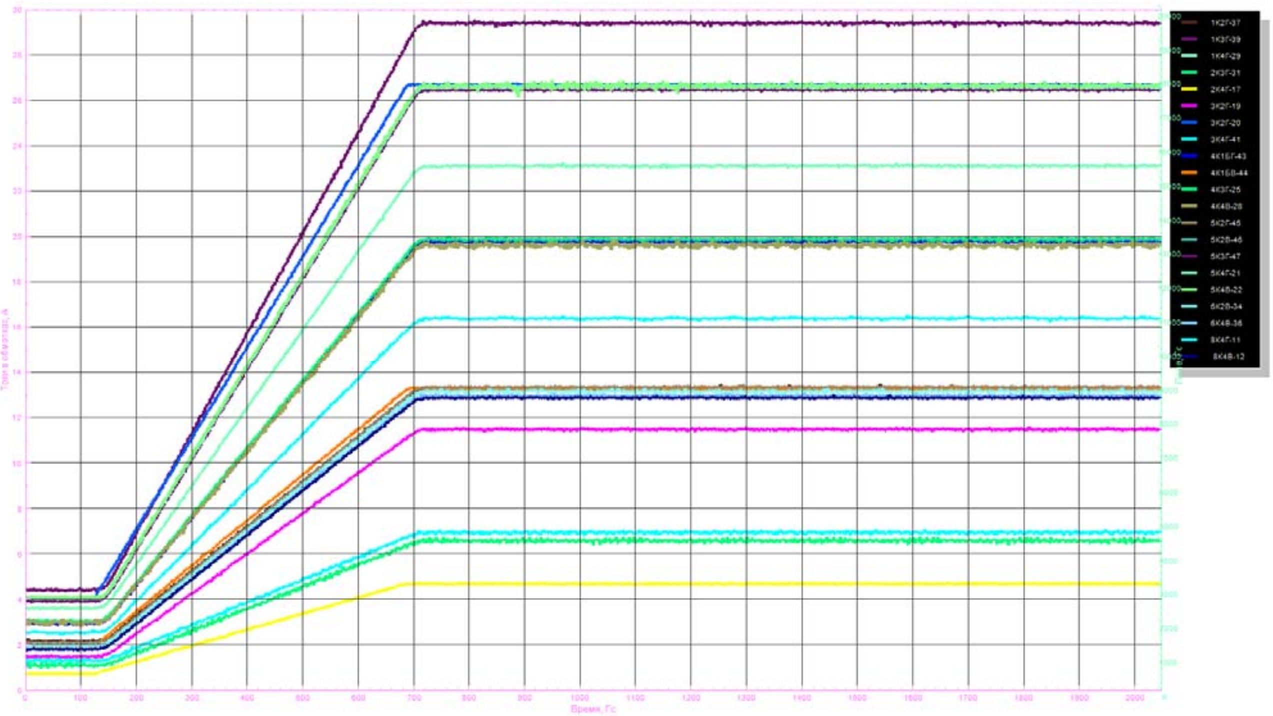
Beam dynamics optimization

Orbit bump in the slow extraction region
in the design working point (Q ≈ 6,8), Run #45

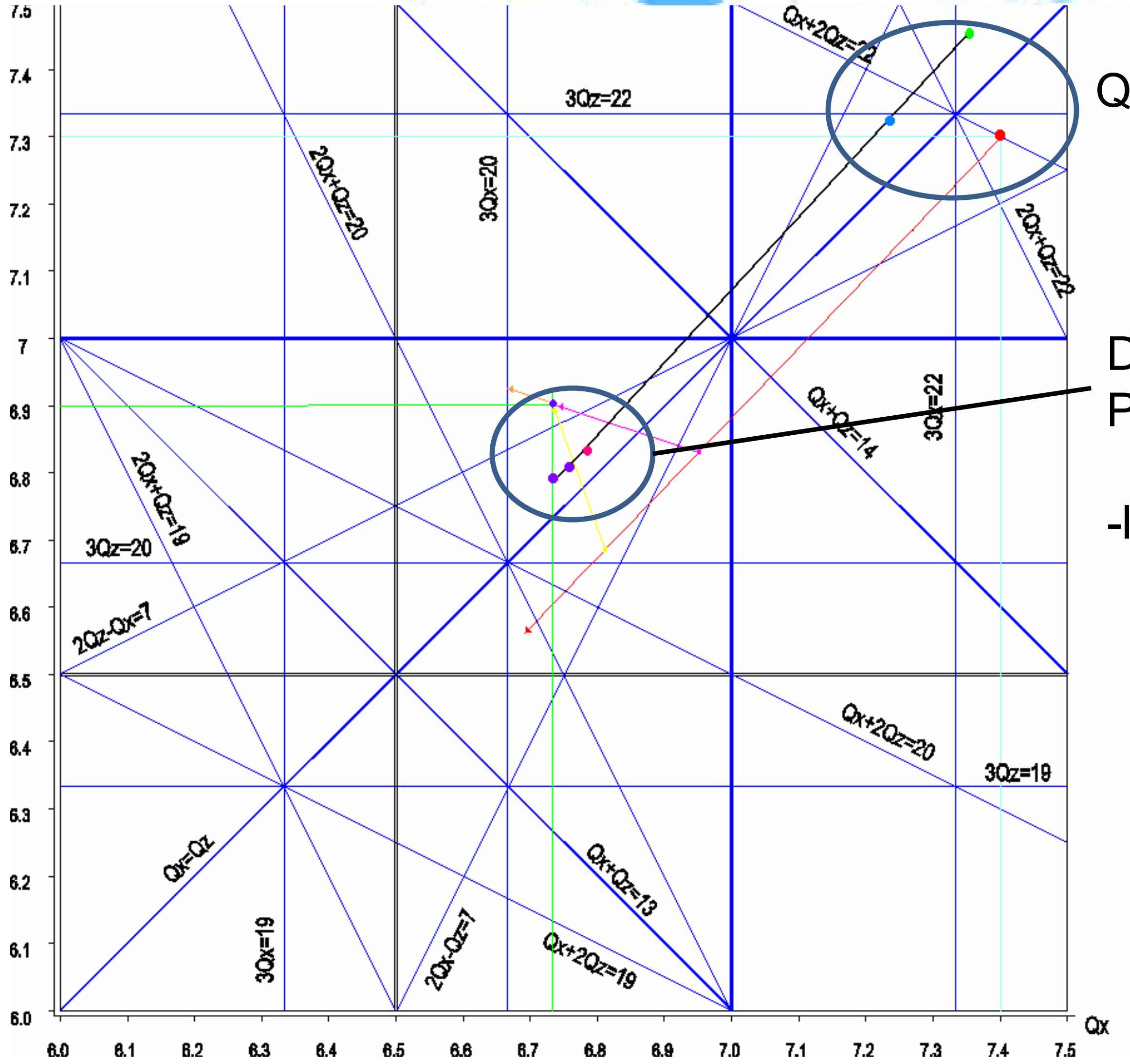


Beam dynamics optimization

Run #45, Cycle of the correctors ($I = I_{inj.}/B_{inj.} \times B$)



Beam dynamics optimization



Q ~ 7.3

Design
Position Q ~ 6.8

-low dispersion.

Working point optimization

Diagnostics development

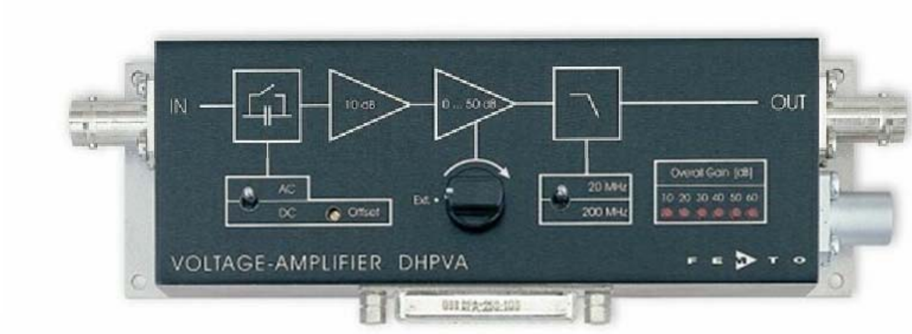
Thermometry:

Experimental fragment of new system was tested during runs #44, #45

Diagnostics development

Fast current transformer (BERGOZ FCT)

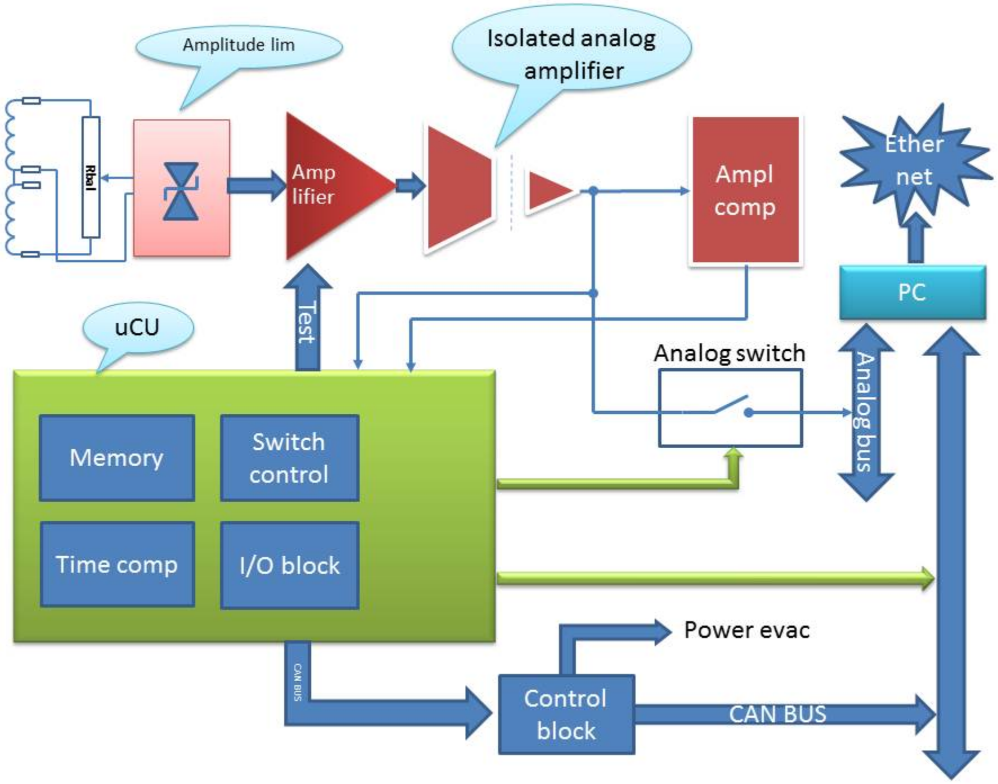
FEMTO DHPVA-200 Amplifier



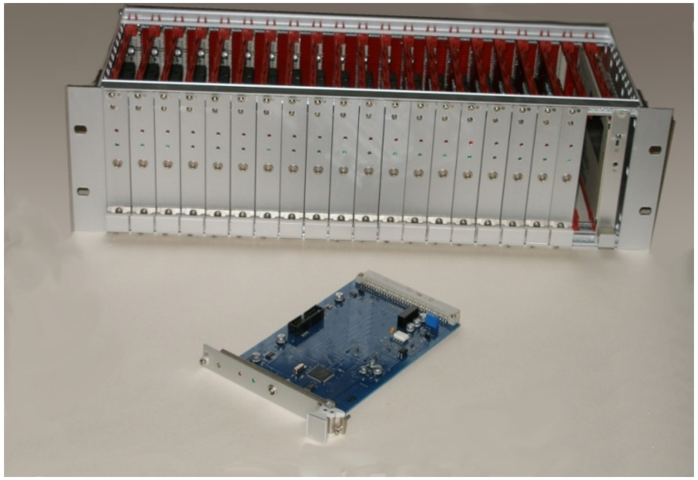
Maximum sensitivity

FCT + DHPVA-200 → 5 V/mA

New quench detectors

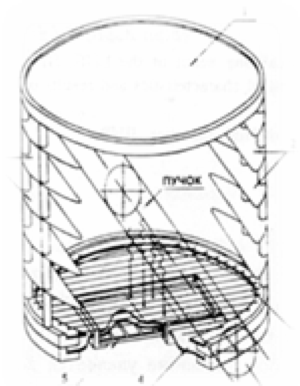


A.Sidorin, WEPPD024

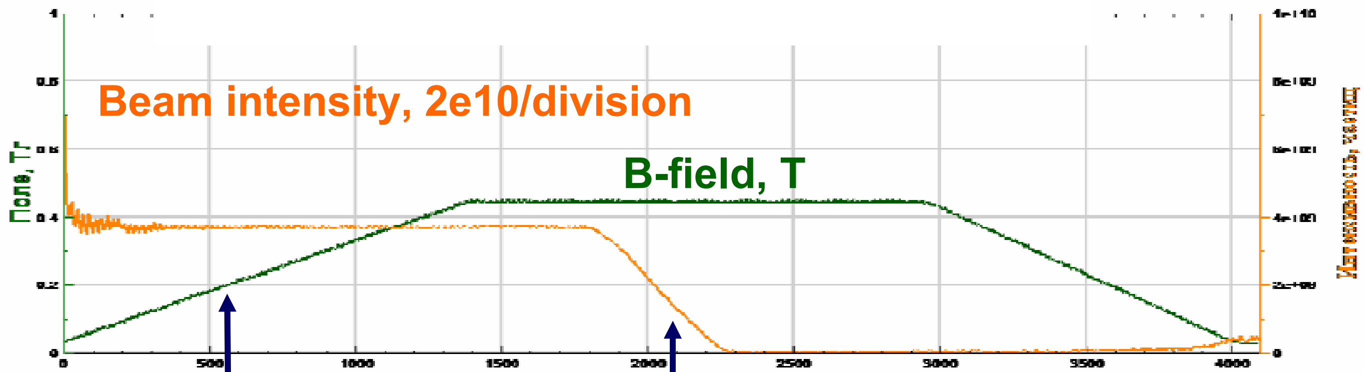


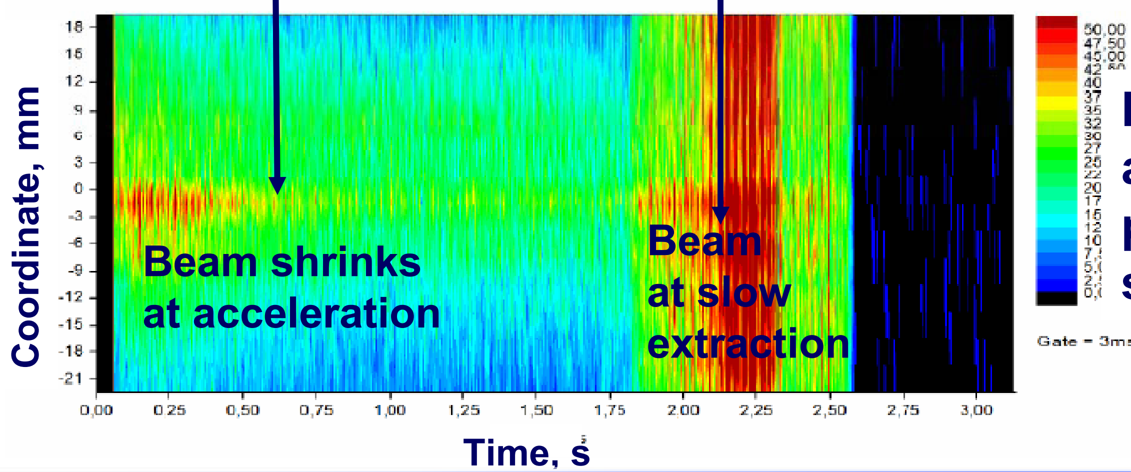
Diagnostics development

Ionization profilometer



Control of the horizontal beam position





Beam position according to profilometer signal

Development of ion sources

Heavy Ion Source KRION-6T

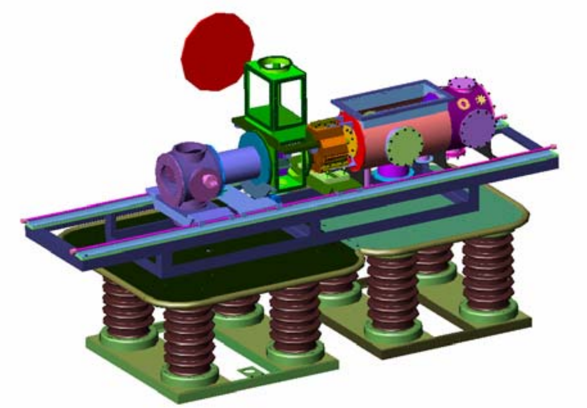
Assembled cryostat and vacuum vessels

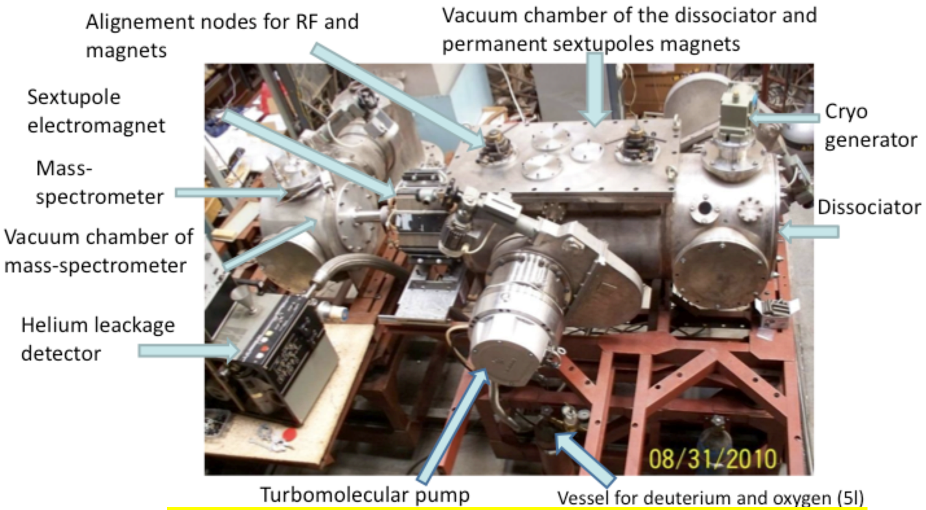
E.Donets, oral presentation

New laser source:

Nd-YAG laser
Pulse energy 2.75 кJ,
Pulse duration 10-12 ns

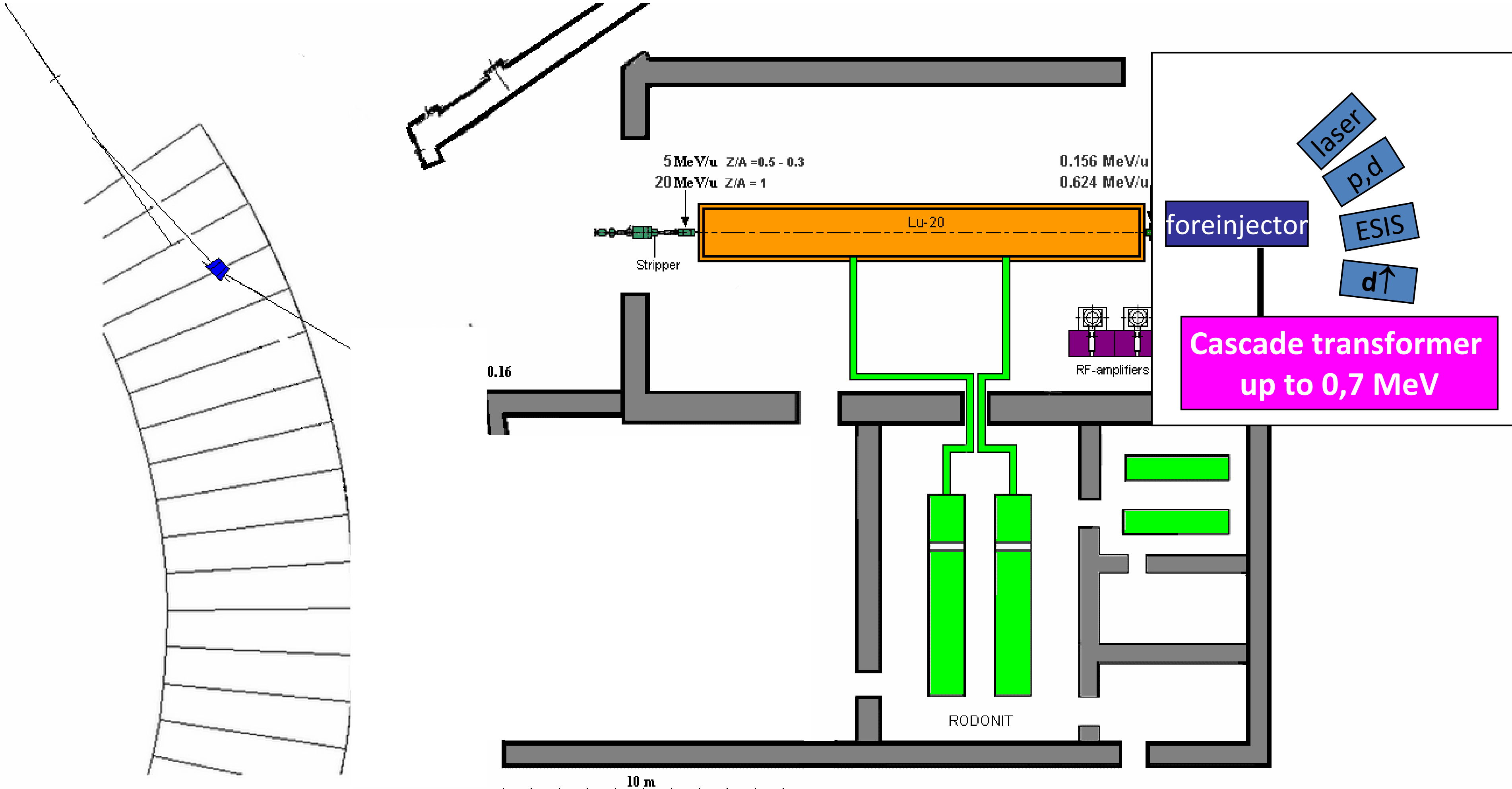
Source of polarized particles (p, d, H)
JINR+INR RAS





We plan to assemble and TEST SPP at Nuclotron with d in the end of 2012

Fore-injector upgrade



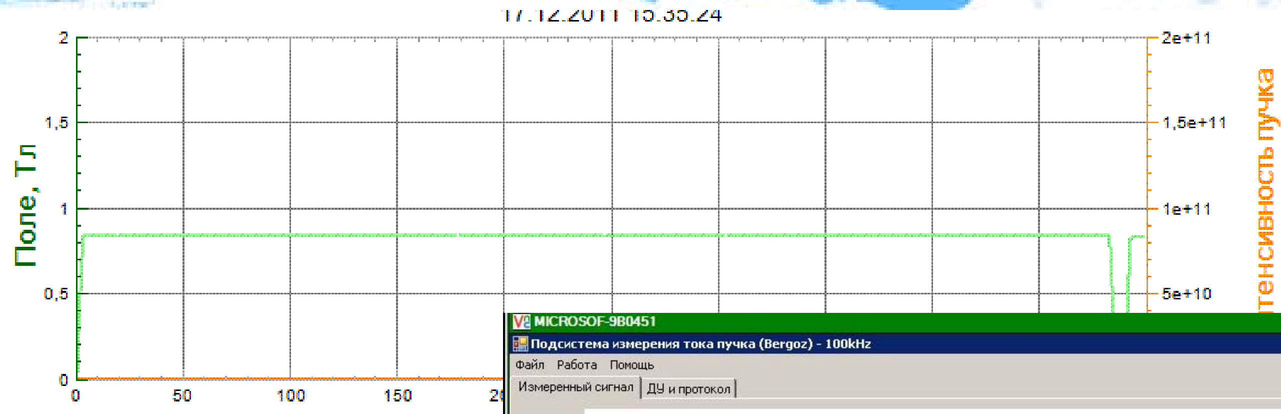
Long plateau of the magnetic field

- Insulating amplifier for shunt,
- Cycle control system,
- data registration

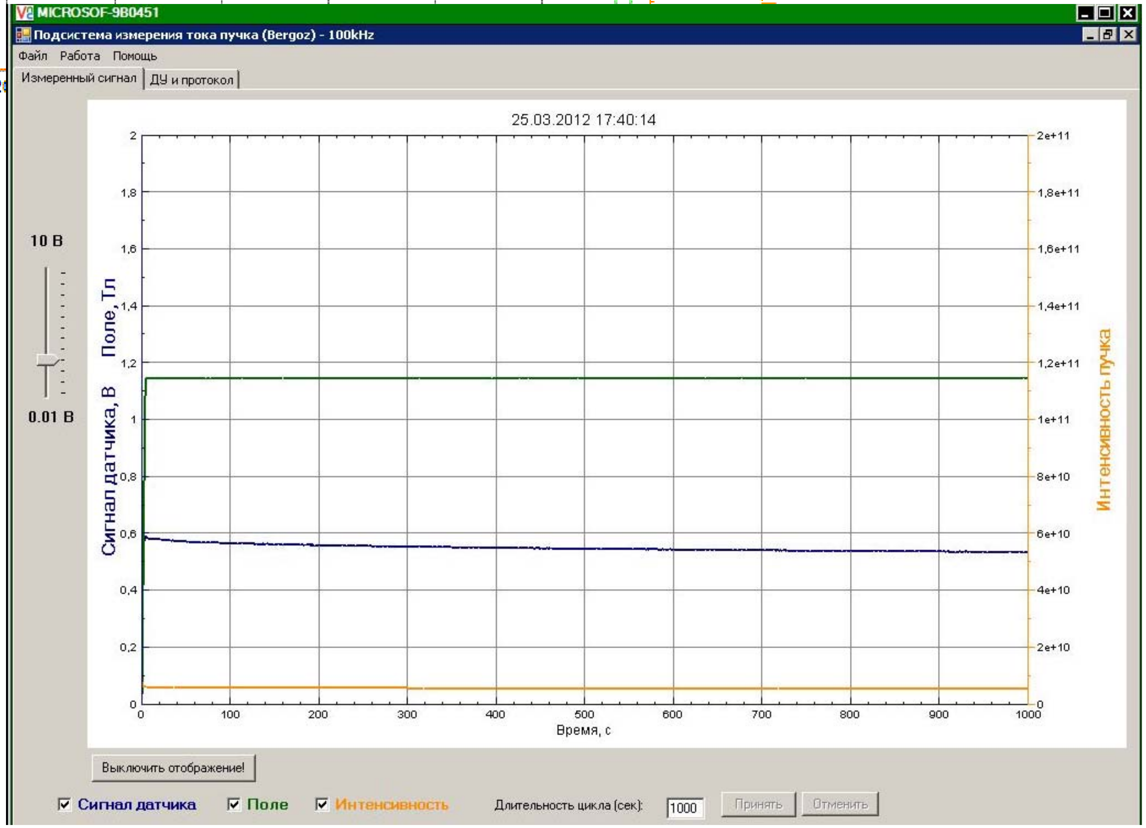
(on the basis of equipment and software of parametric current transformer BERGOZ).

- shunt up to 6 kA

Long plateau of the magnetic field

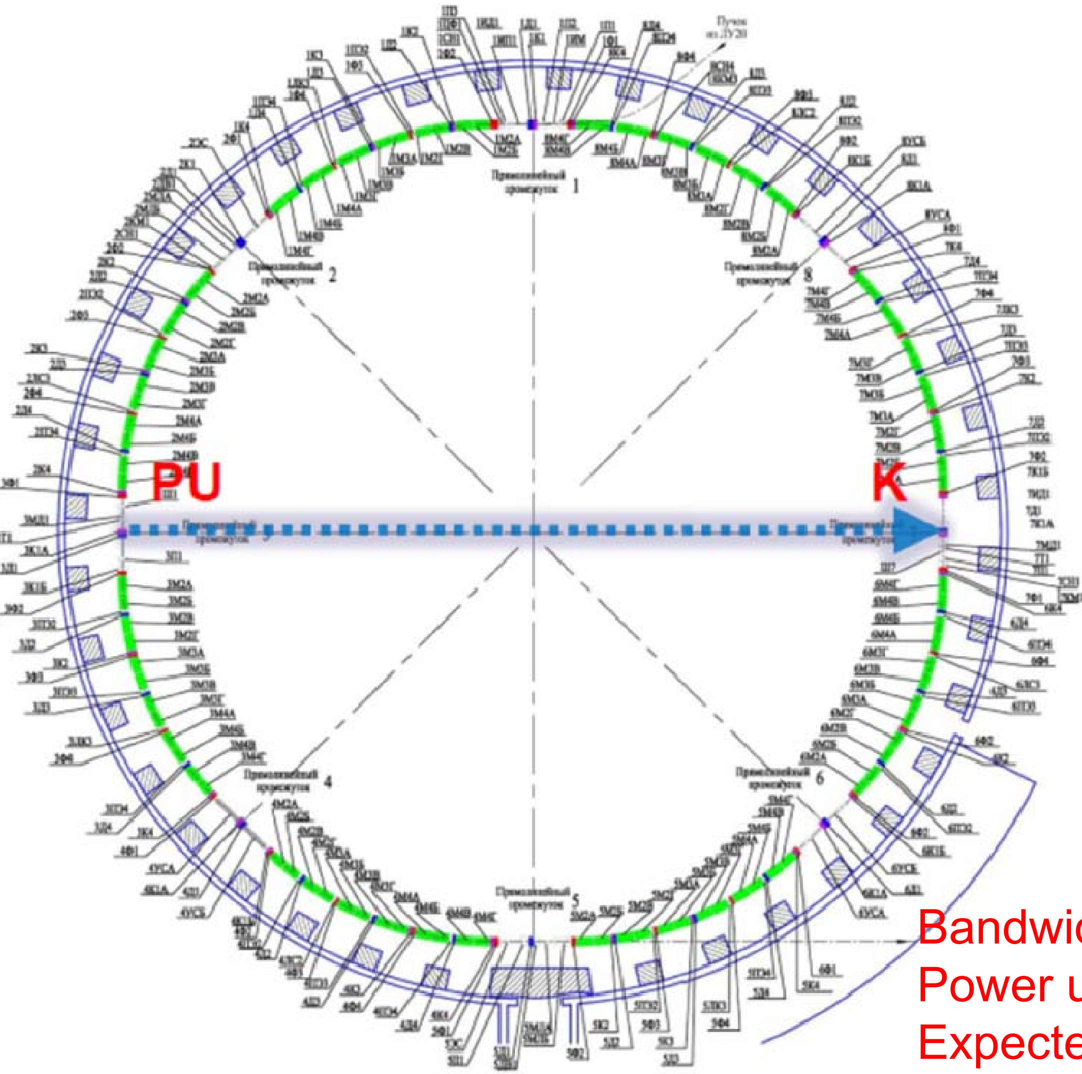


Run #44
Cycle duration 500 s
8 кG



Run #45
1000 s
1.2 T
d 5·10⁹

Stochastic cooling test at Nuclotron



N.Shurkhno, TUPPB004

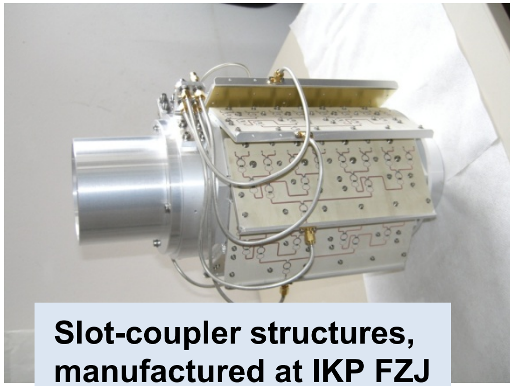
One plans to test consequently
for cooling
of coasting and bunched beams:

-longitudinal degree of freedom
Notch filter,
Palmer ,
Time of flight methods.

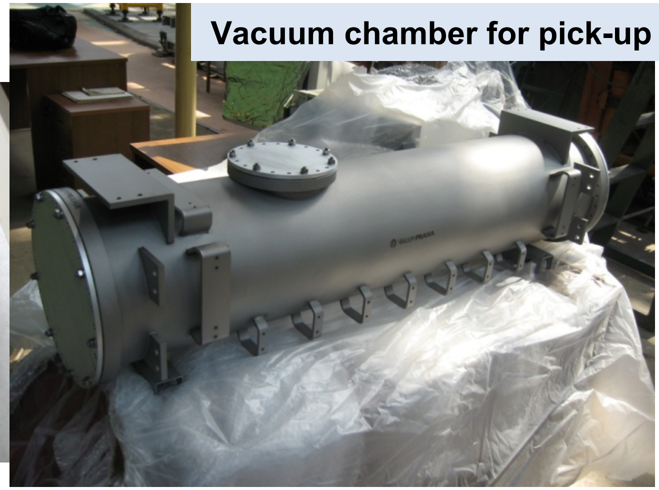
- Transverse cooling

Bandwidth 2-4 GHz,
Power up to 60 W,
Expected cooling time (coasting beam)10 s

Stochastic cooling test at Nuclotron

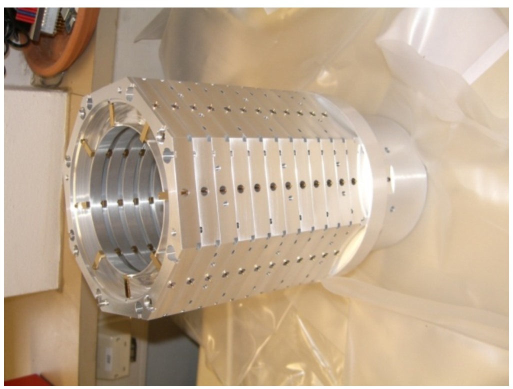


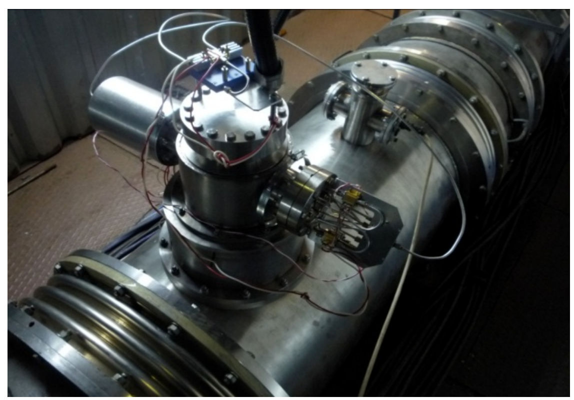
Slot-coupler structures, manufactured at IKP FZJ

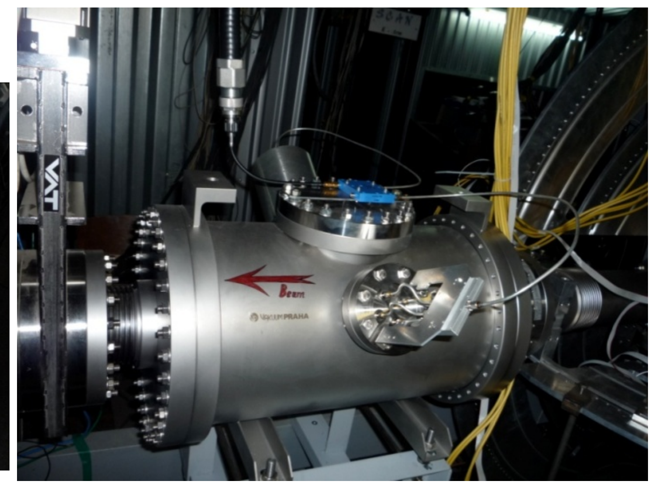


Vacuum chamber for pick-up

Vacuum chamber for kicker







Thank you for your attention