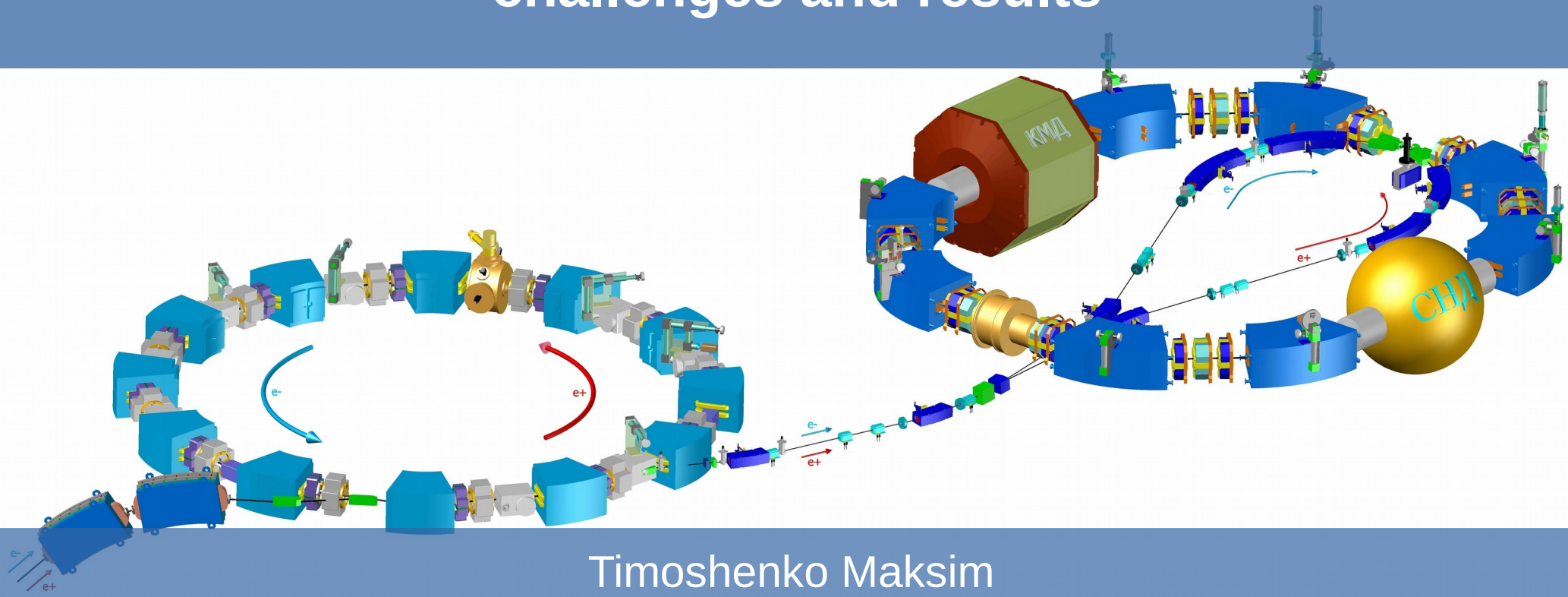
VEPP-2000 collider operation in 2019-2021 runs: challenges and results



Timoshenko Maksim
on behalf of VEPP-2000 team

RuPAC21
26 Sep — 2 Oct 2021г. Alushta, Crimea

XXVII RuPAC
Alushta 2021

ВЭПП
2000

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- VEPP-2000 layout & parameters
- Work crhonology
- Analysis of dead time
- Future plans
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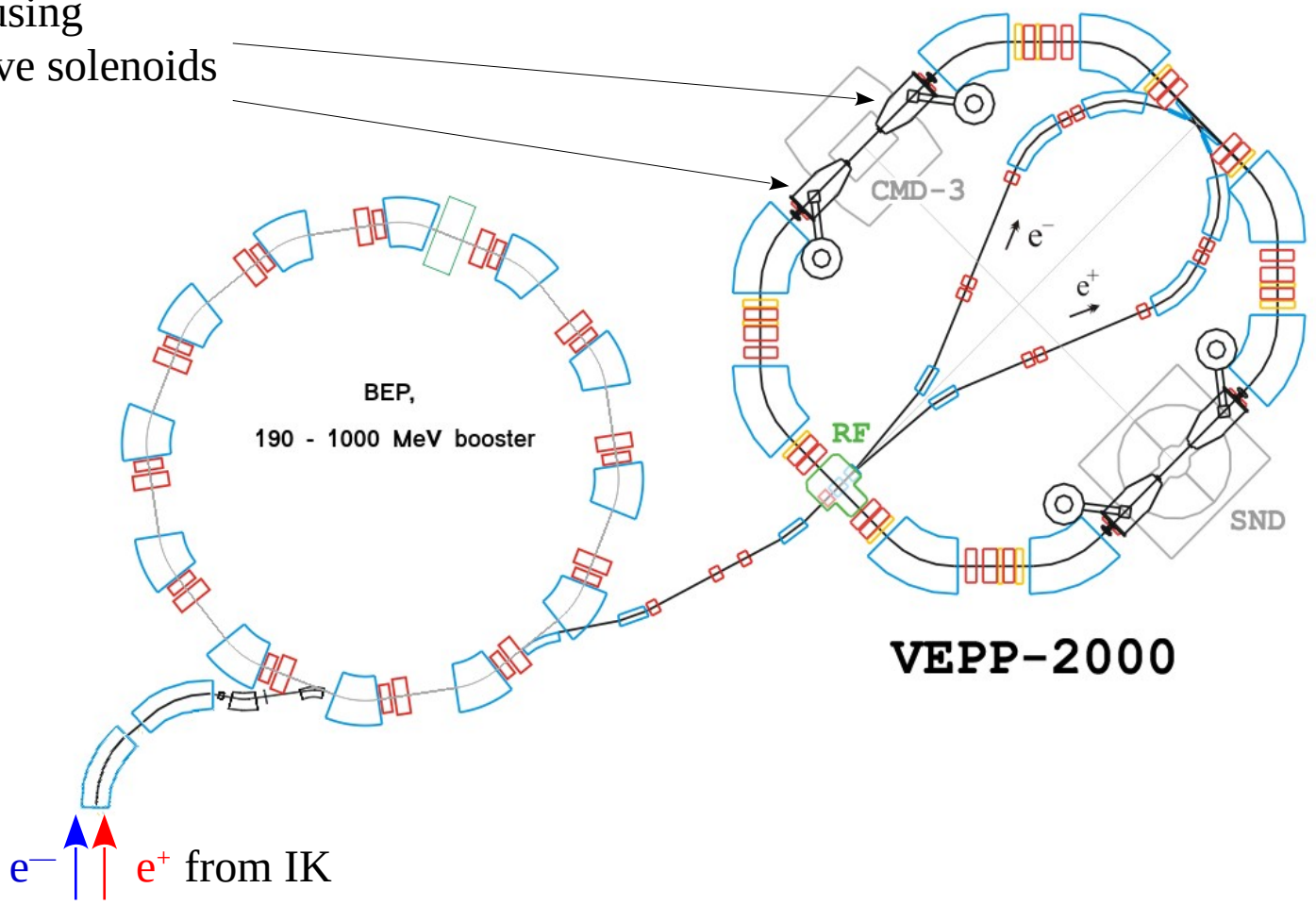
VEPP-2000 layout & parameters

13 T final focusing superconductive solenoids x4

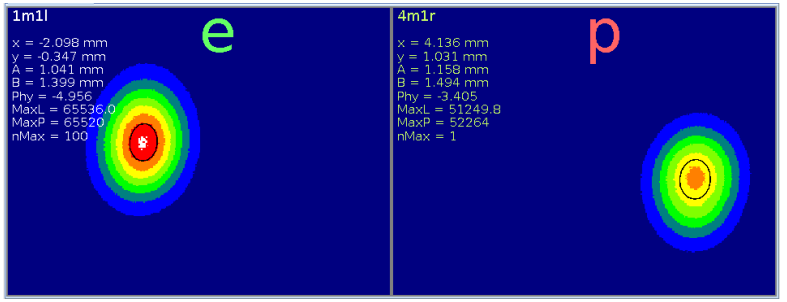


Main parameters @ 1GeV			
Circumference	24.388 m	Energy	160 ÷ 1000 MeV
Number of bunches	1×1	Number of particles	1.0×10^{11}
Betatron tunes	4.1/2.1	Beta-functions @ IP	8.5 cm
Beam-beam param.	0.1	Luminosity	1.0×10^{32} $cm^{-2}s^{-1}$

Round beams concept

Luminosity increase scenario:

- ✓ Number of bunches (i.e. collision frequency)
- ✓ **Bunch-by-bunch luminosity**



$$L = \frac{\pi\gamma^2\xi_x\xi_y\varepsilon_x f}{r_e^2\beta_y^*}\left(1+\frac{\sigma_y}{\sigma_x}\right)^2 \quad \Rightarrow \quad L = \frac{4\pi\gamma^2\xi^2\varepsilon f}{r_e^2\beta^*}$$

- ✓ Geometric factor: $\left(1+\sigma_y/\sigma_x\right)^2 = 4$
- ✓ Beam-beam limit enhancement: $\xi = \frac{N r_e \beta^*}{4\pi\gamma\sigma_0^2} \geq 0.1$
- ✓ IBS for low energy? Better life time!

D. Shwartz et al., "Round colliding beams at vepp-2000with extreme tuneshifts". In Proc. eeFACT2018, Hong Kong, China

Lattice requirements

Axial symmetry of counter beam force together with x-y symmetry of transfer matrix should provide additional integral of motion (angular momentum $M_z = x'y - xy'$).
Particle dynamics remains nonlinear, but becomes 1D.

Lattice requirements:

- Head-on collisions
- Small and equal β-functions at IP: $\beta_x = \beta_y$
- Equal beam emittances: $\varepsilon_x = \varepsilon_y$
- Equal fractional parts of betatron tunes: $\nu_x = \nu_y$

Round beam
$M_x = M_y$

V.V.Danilov et al., EPAC'96, Barcelona, p.1149, (1996)

5

Scientific program

SND:

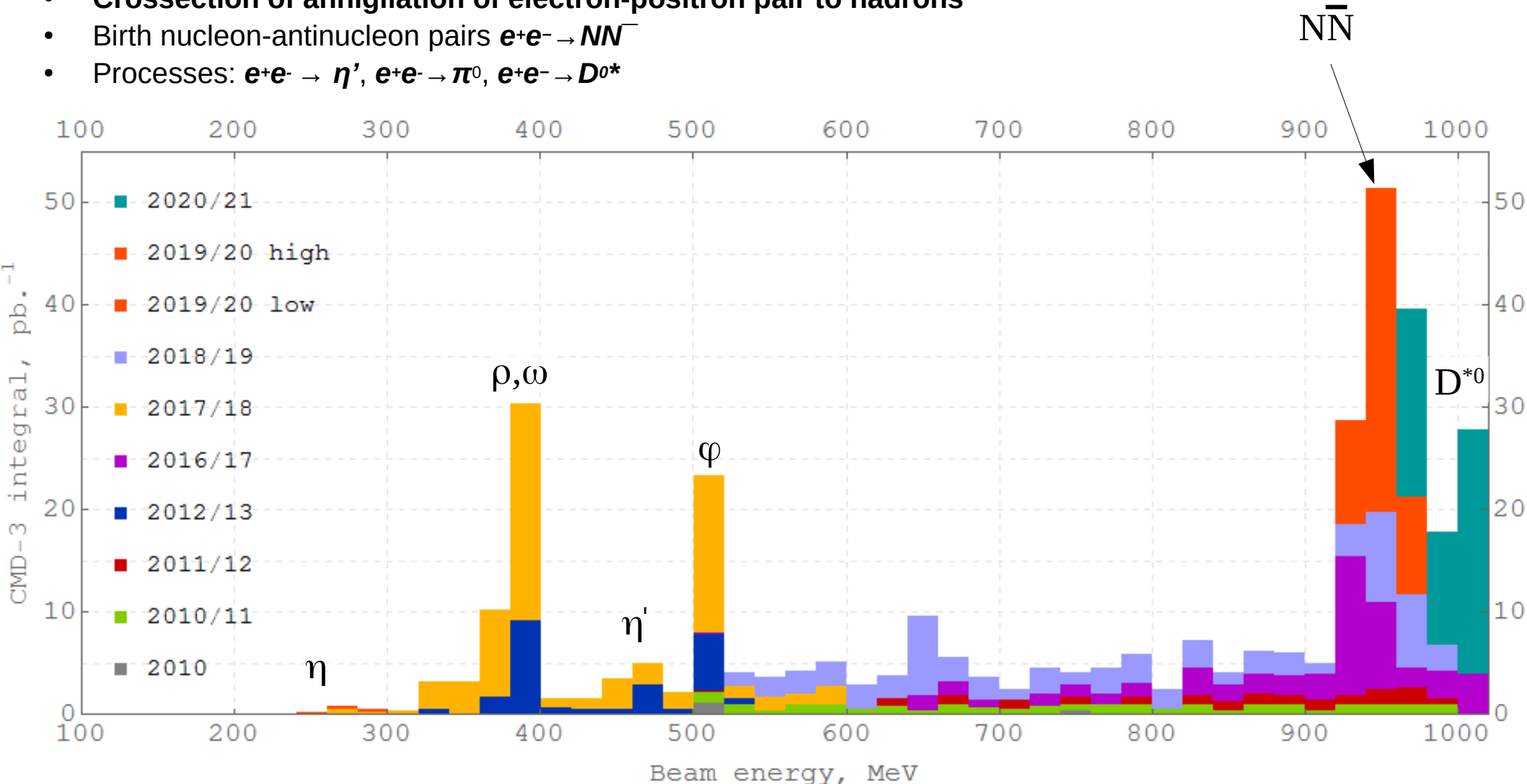
- **Crossection of annigilation of electron-positron pair to hadrons**
- Measurements of ***ω, ρ*** and ***φ*** (782, 770 and 1020 MeV)
- Looking for $e^+e^- \rightarrow \eta$ (547.853 ± 0.024 MeV)

V. Druzhinin et al., "Study of e+e− annihilation into hadrons with the SND detector at the VEPP-2000 collider", Proceedings of Science, 2020

CMD-3:

- **Crossection of annigilation of electron-positron pair to hadrons**
- Birth nucleon-antinucleon pairs $e^+e^- \rightarrow N\bar{N}$
- Processes: $e^+e^- \rightarrow \eta'$, $e^+e^- \rightarrow \pi^0$, $e^+e^- \rightarrow D^{0*}$

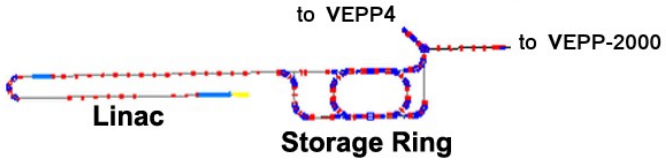
A E Ryzhenenkov et al., "Overview of the CMD-3 recent results", Journal of Physics: Conference Series, 2020



2019-2020 run

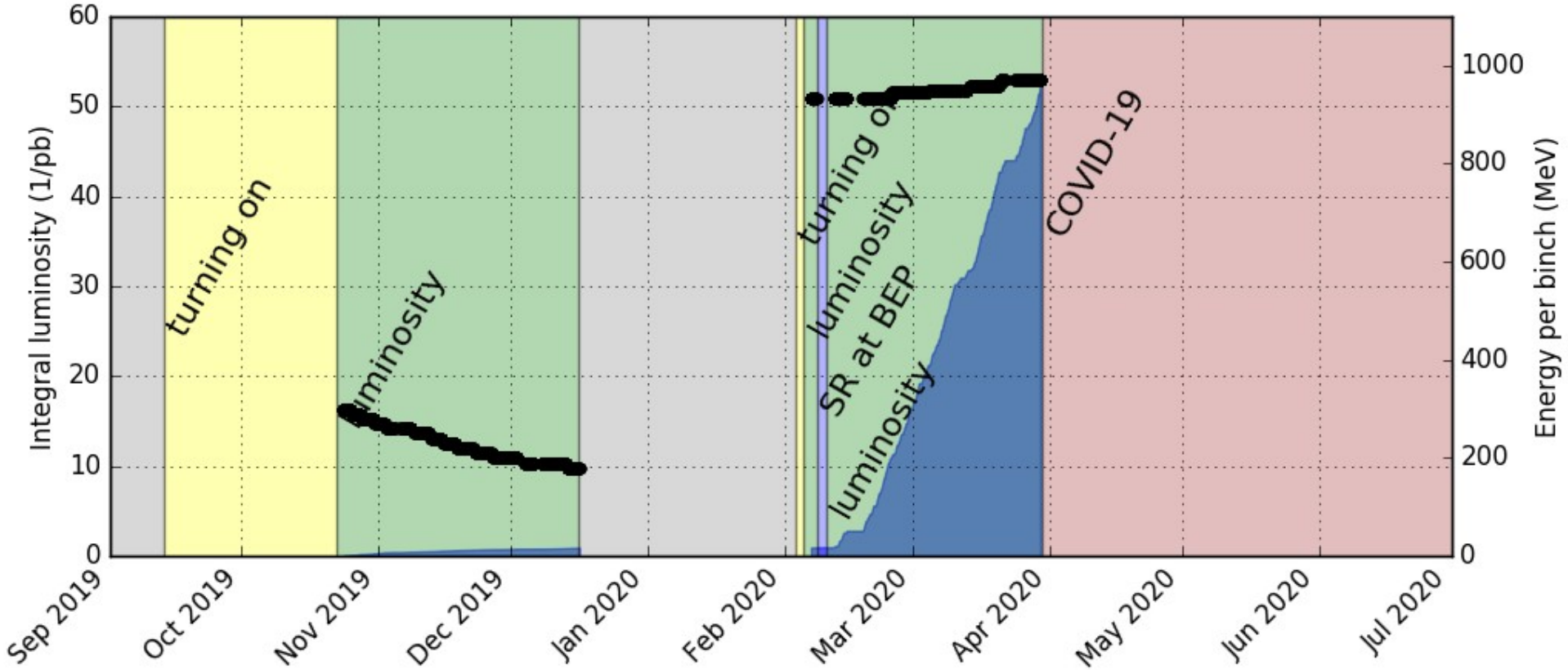
Turning on:

- Tuning power, control and diagnostic systems
- Soft debugging and upgrade
- Stabilization of cooperative regime *VEPP-2000* — *IK* — *VEPP-4*
- Detectors calibration



Luminosity — luminosyti time integral aquisition

SR at BEP —A. Krasnov et al., ”Synchrotron Radiation Beamline Installed at BINP to Study the High Luminosity LHC vacuum system”, in Proc. RuPAC2016



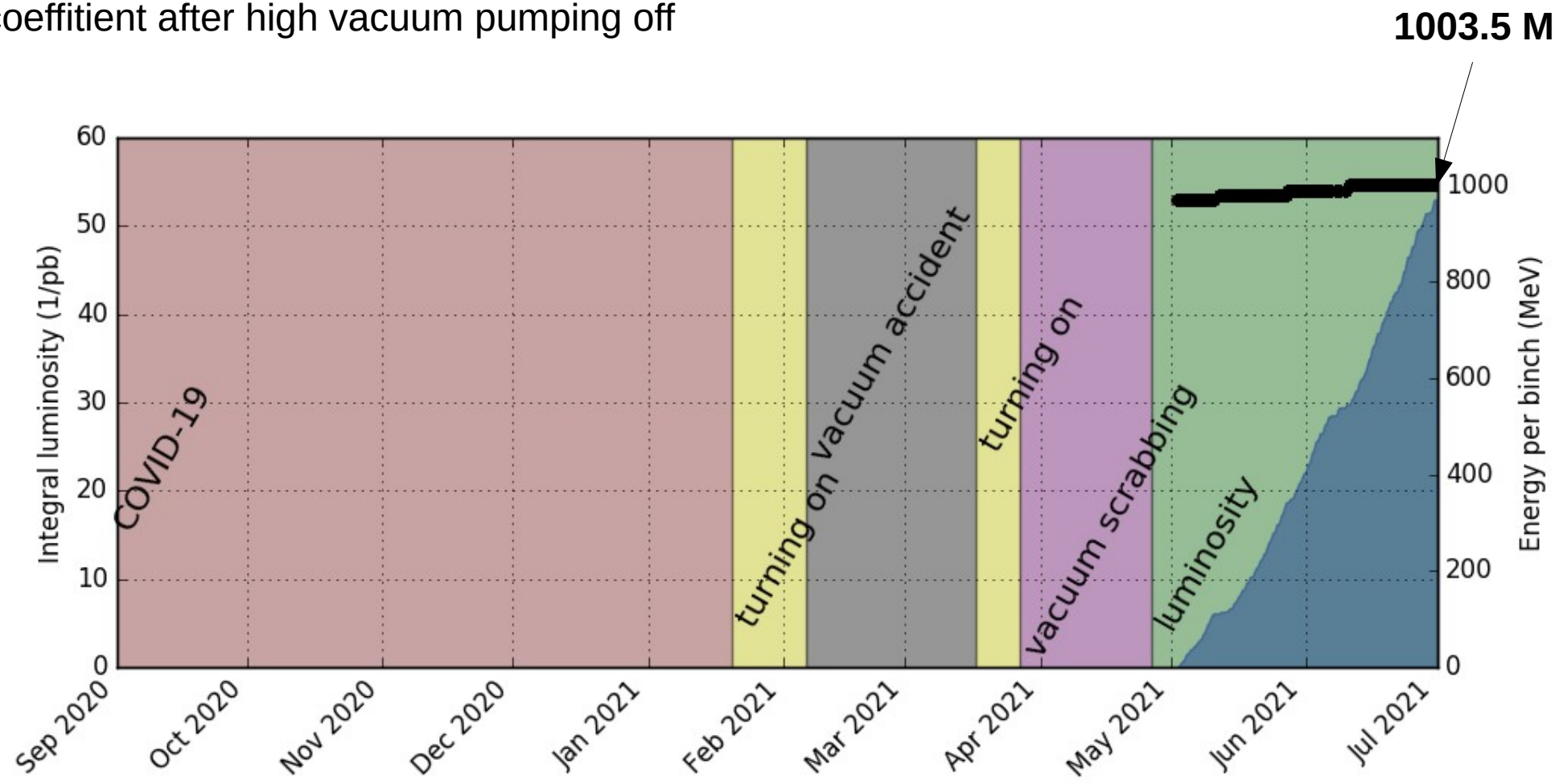
2020-2021 run

Vacuum accident:

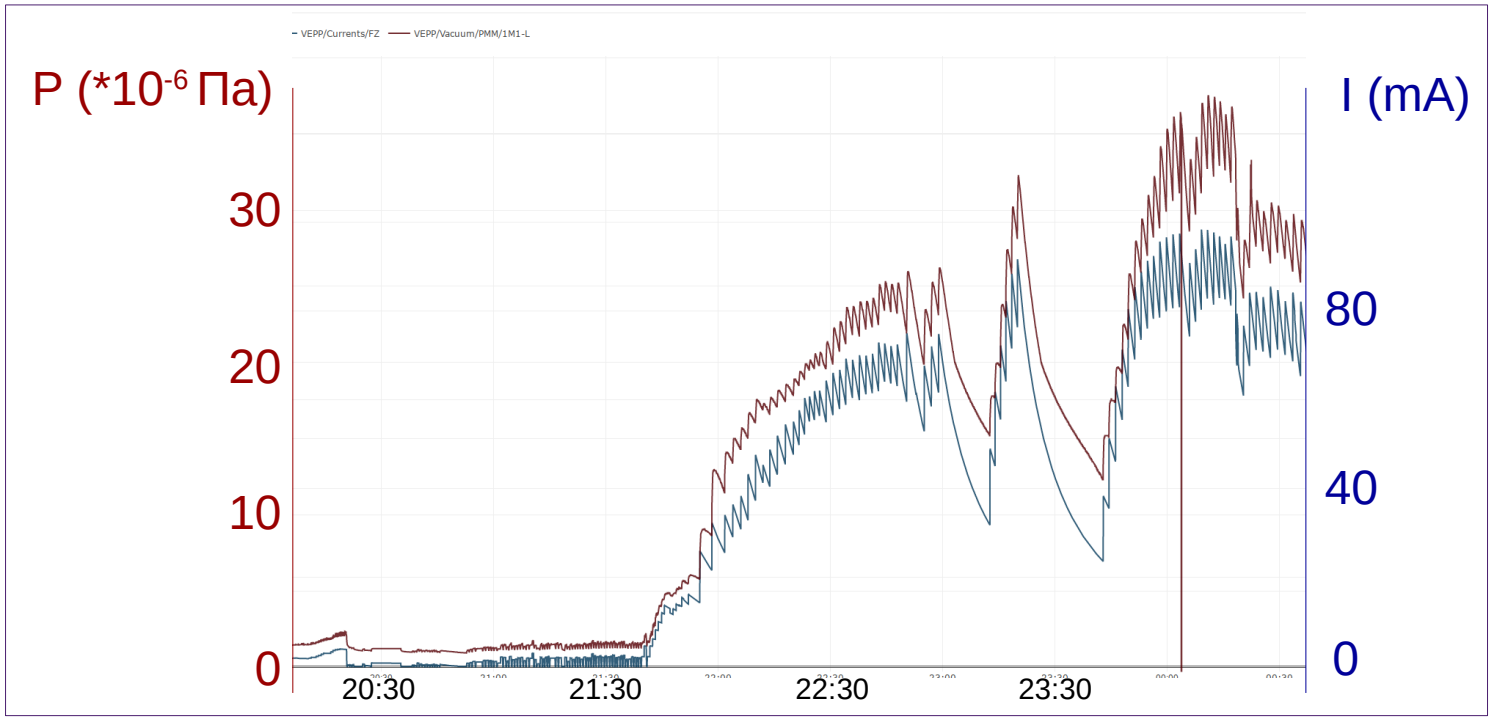
Burning hole in the vacuum chamber inside pre-injection magnet transfer line

Vacuum scrabbing:

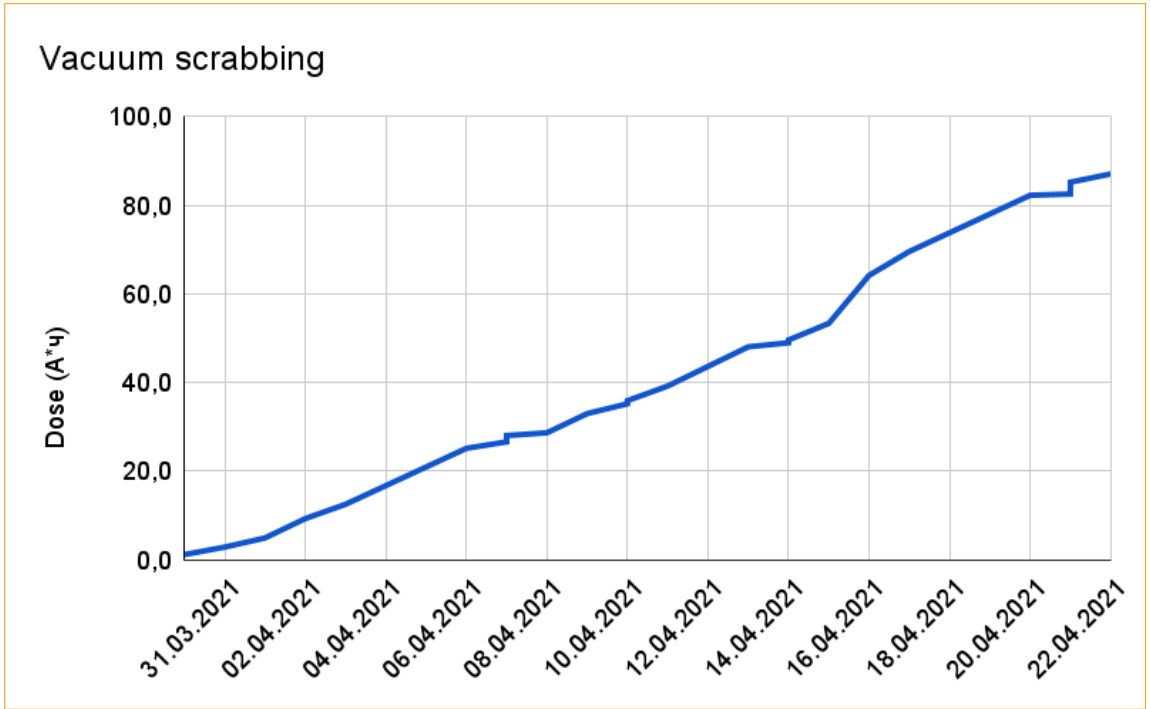
Decreasing of the photodesorption coeffitient after high vacuum pumping off



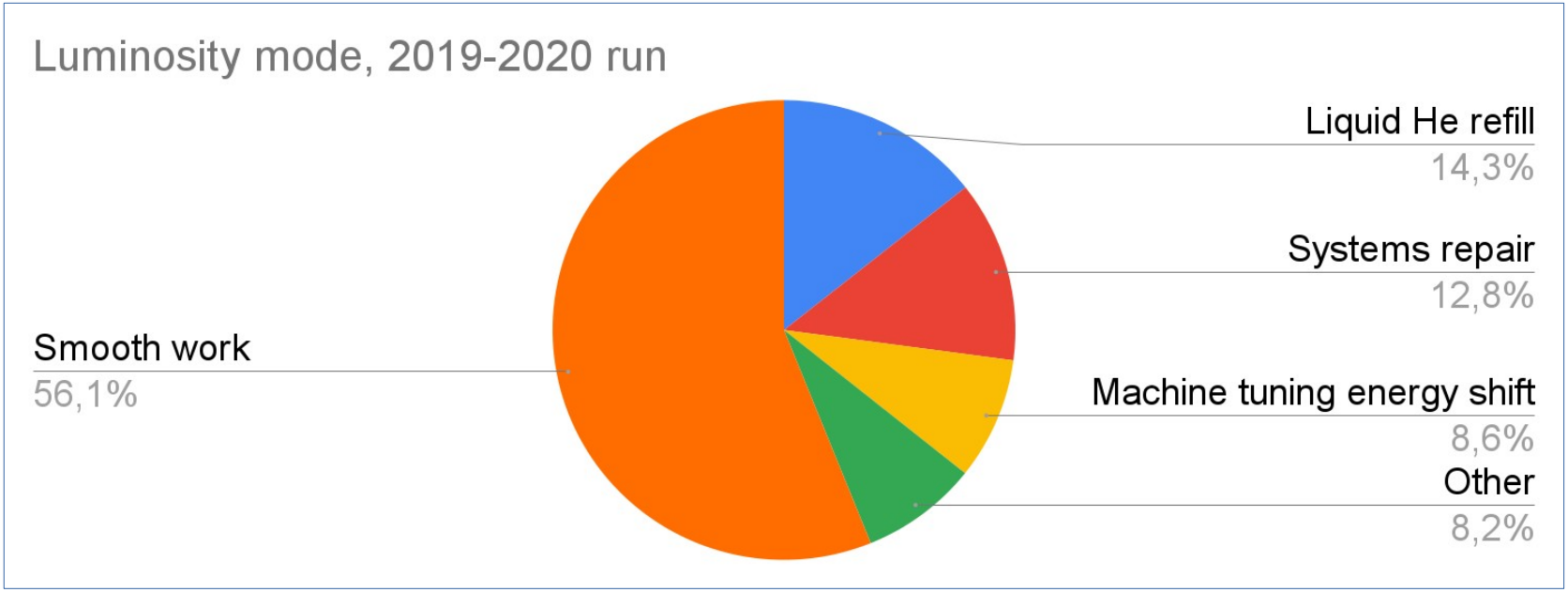
Vacuum accident

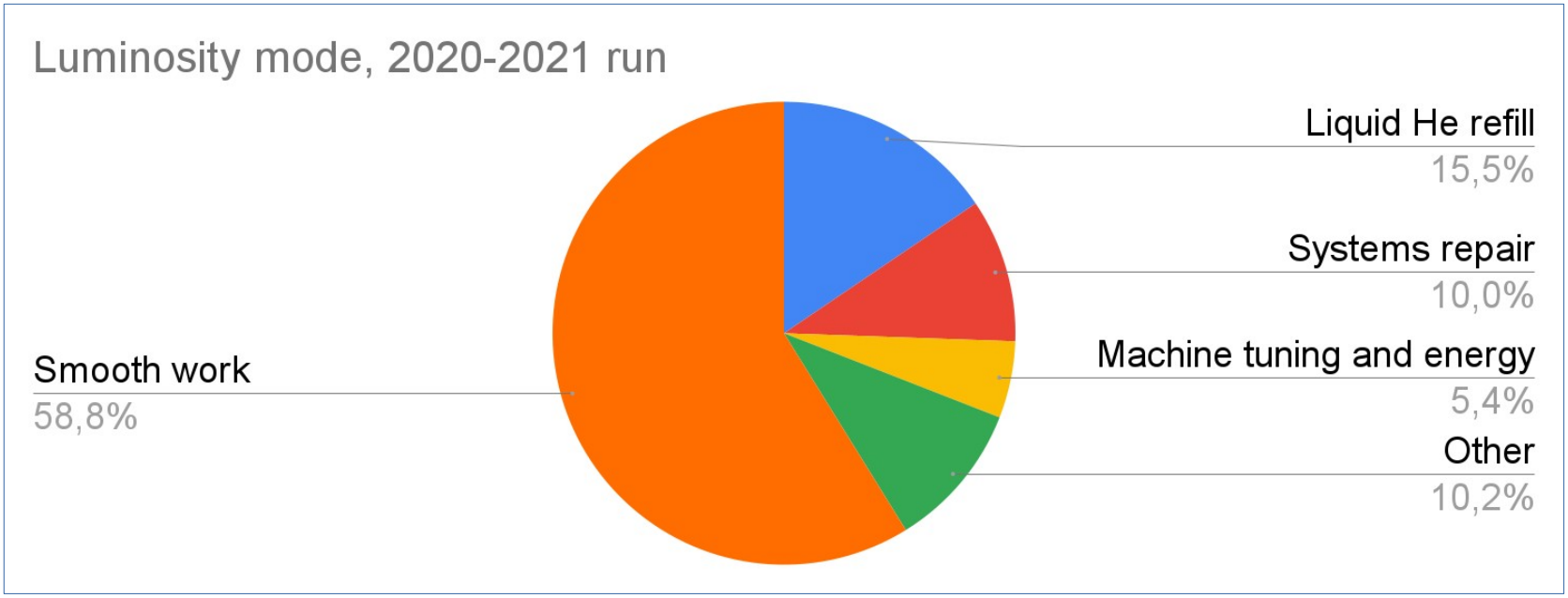


$$P = P_0 + a_{desorption} * I$$



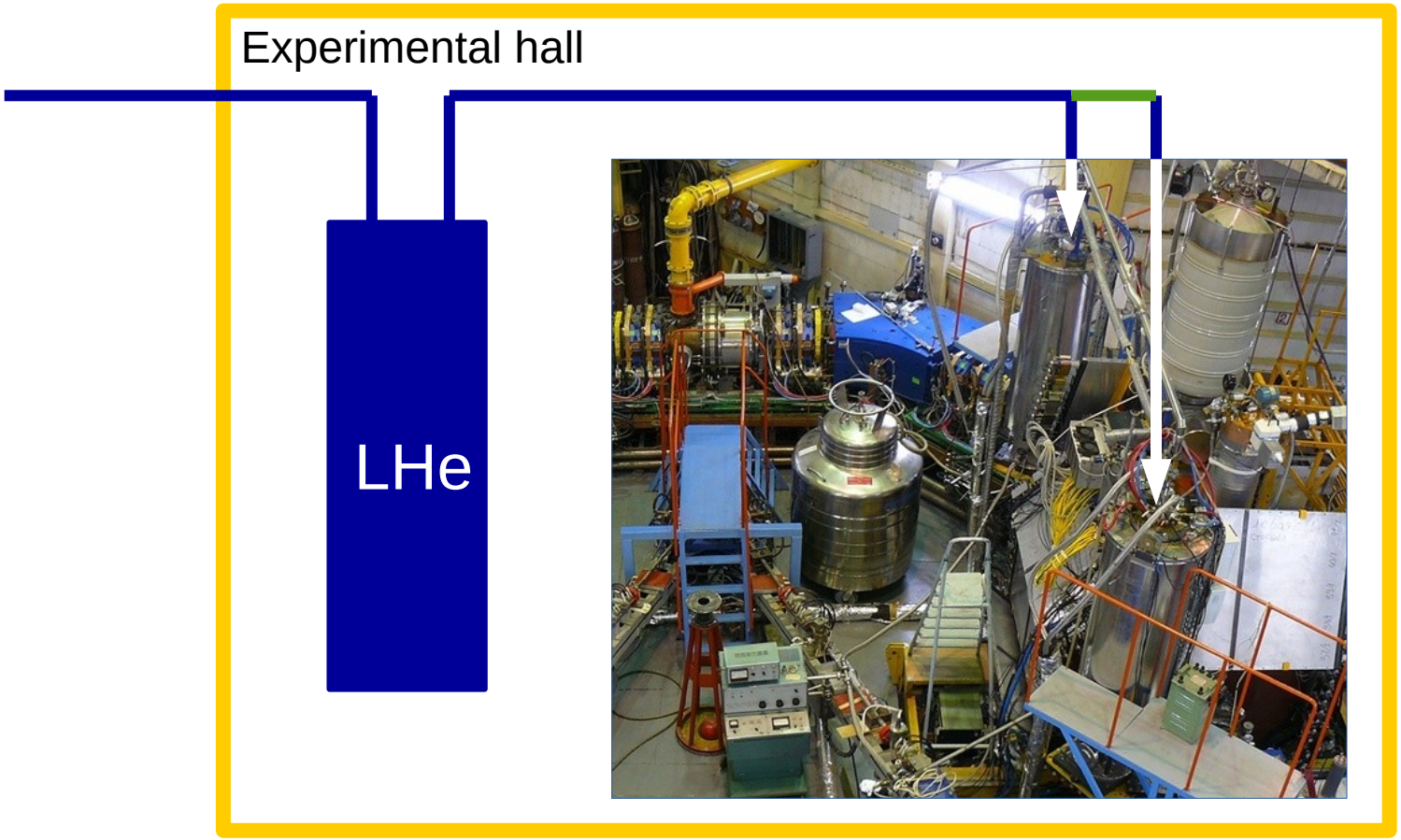
Luminosity mode efficiency





Other: IK tuning, Water station interruption, Power interruption

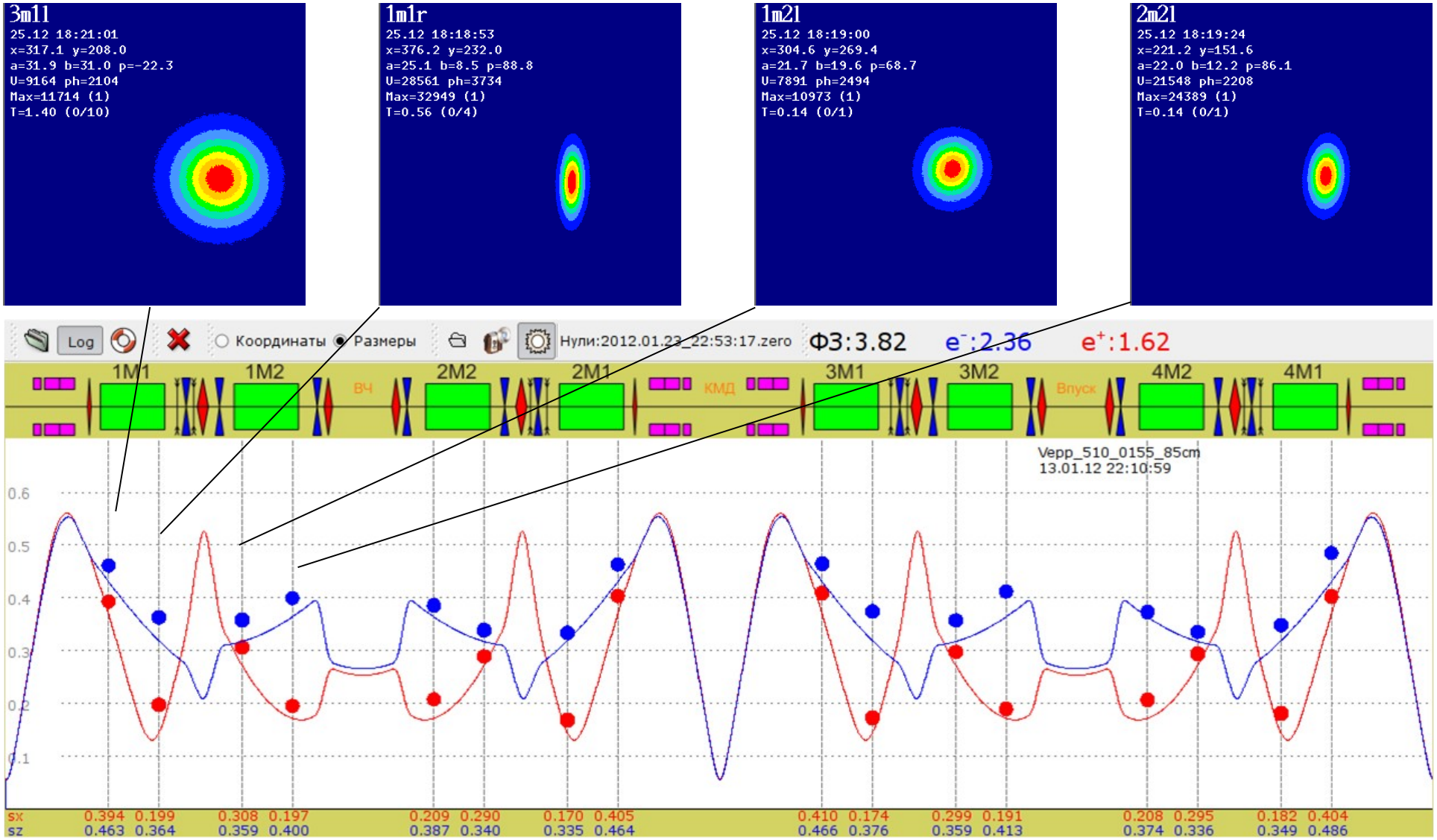
Future project “Helium outside”



Power supplies renewal

- **Quadrupole magnets**
- **Pulse magnets**
- **...**

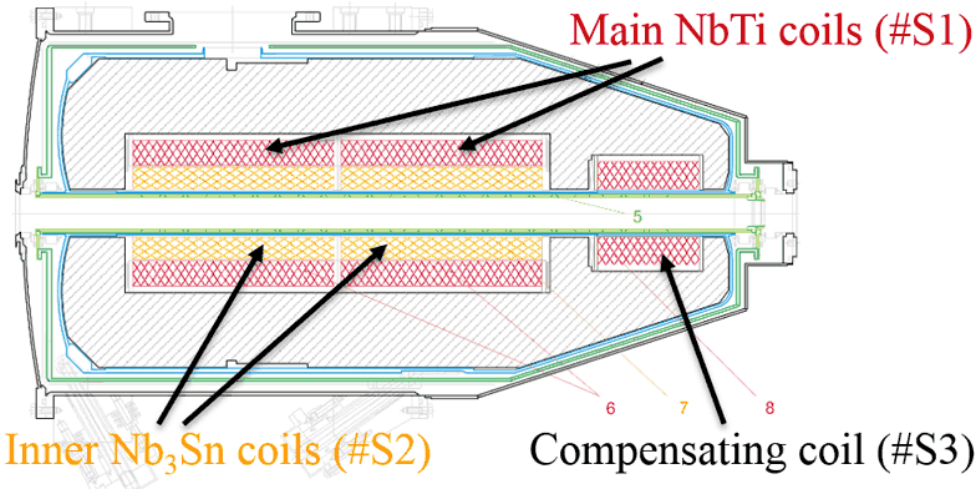
Lattice correction



"Round Beam Lattice Correction using Response Matrix at VEPP-2000",
in Proc. IPAC'10, Kyoto, Japan, 2010, pp. 4542-4544.

Solenoids misalignment

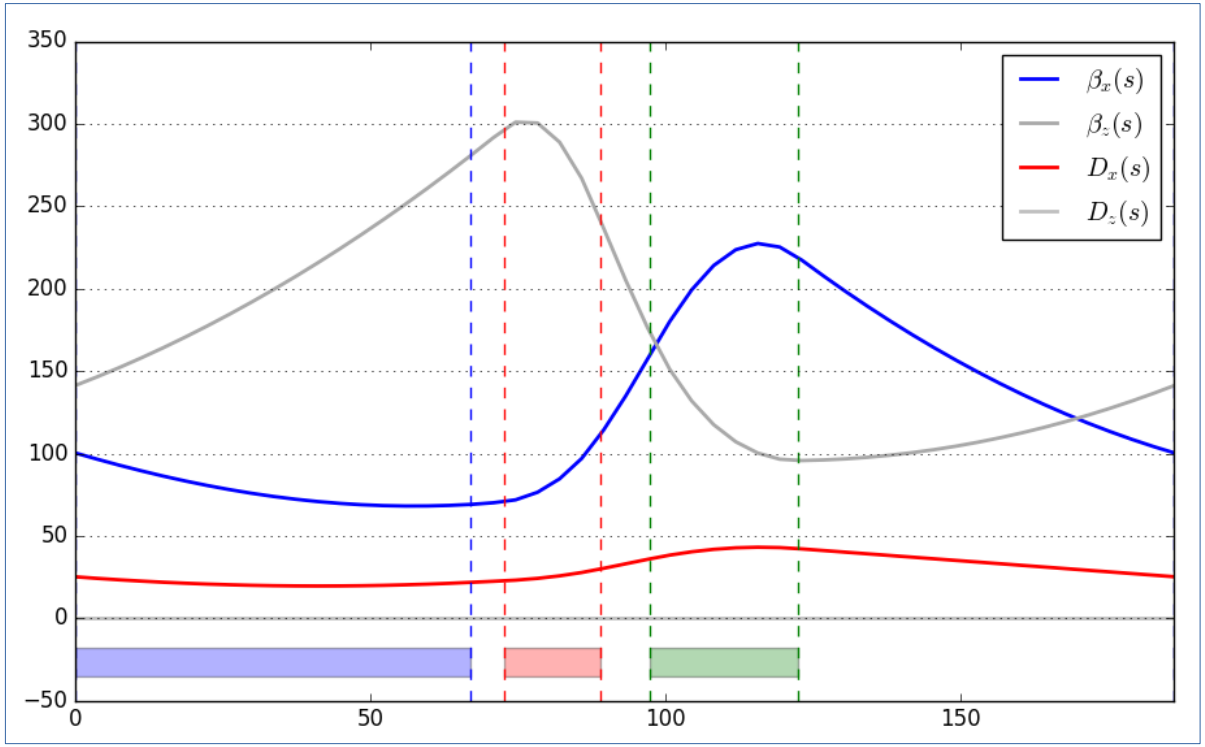
D. Shwartz, «Final Focusing Solenoids Beam-based Positioning Test», in Proc. IPAC2021, Campinas, SP, Brazil



	dx, mm	dx', mrad	dy, mm	dy', mrad
1S1	**+0.98** ± 0.30	**+0.17** ± 0.18	**+1.21** ± 0.40	**-2.33** ± 0.36
1S2	**+0.89** ± 0.25	**+1.26** ± 0.15	**+0.93** ± 0.38	**-0.40** ± 0.30
1S3	**+2.66** ± 0.40	**-2.20** ± 0.23	**+1.45** ± 0.42	**+0.94** ± 0.56

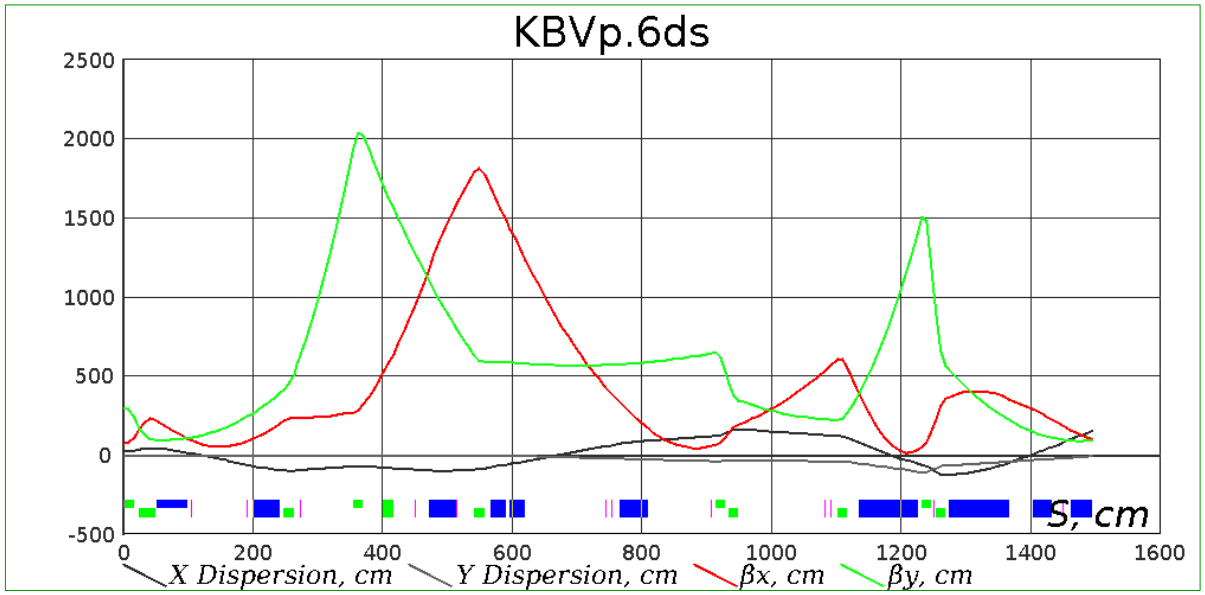
BEP and KBV lattice

BEP:



× ***12***

BEP to VEPP transfer line (KBV):

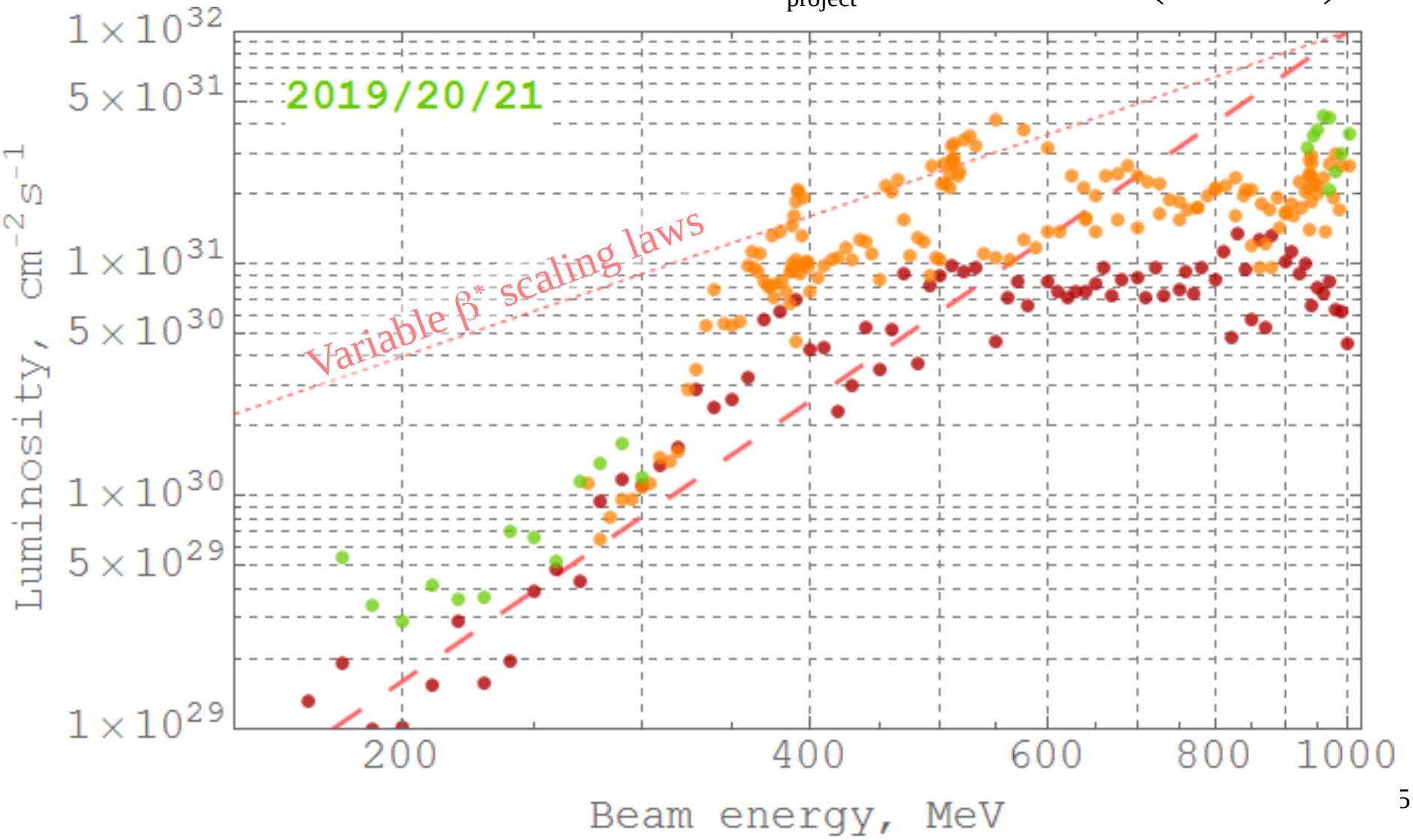


Lumonosity achieved

Highest luminosity achieved

$L_{peak} = 5\times10^{31}\ cm^{-2}s^{-1}$ (at 550 MeV)

$L_{project} = 1\times10^{32}\ cm^{-2}s^{-1}$ (at 1 GeV)

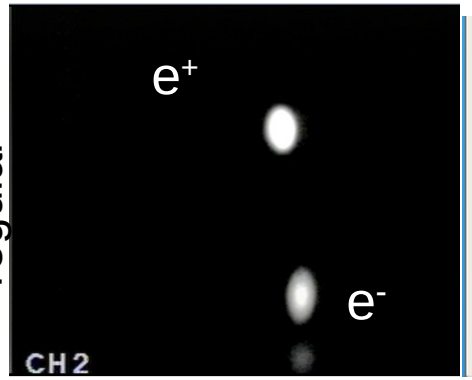


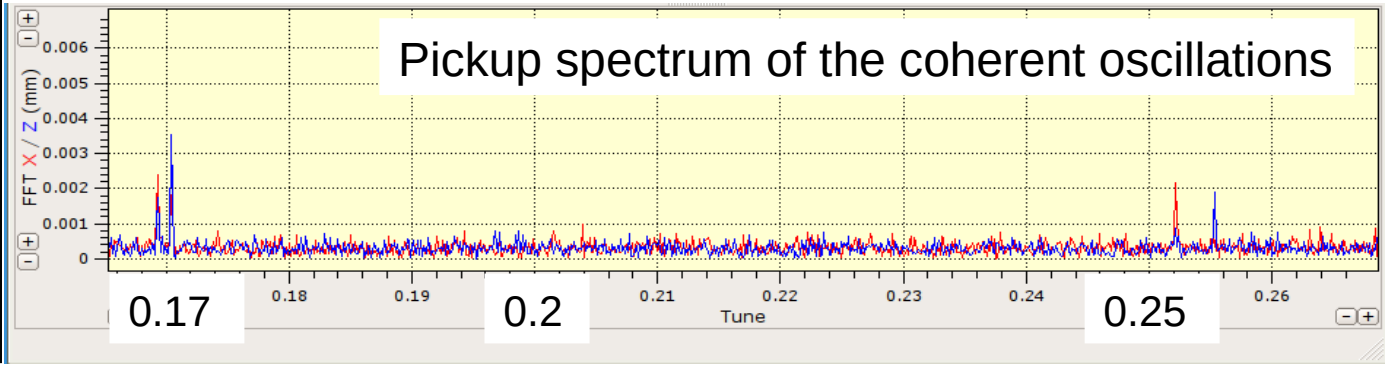
Flip-flop effect

TV

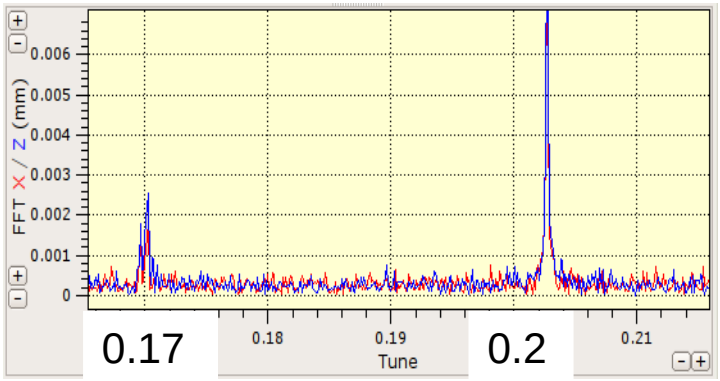
σ π

regular

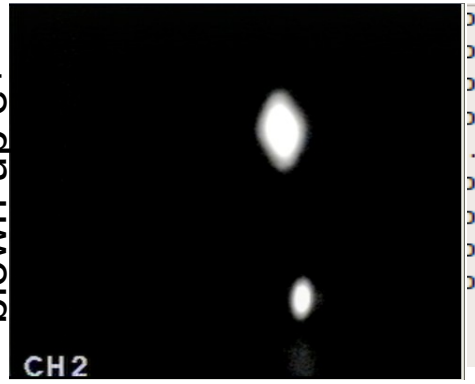


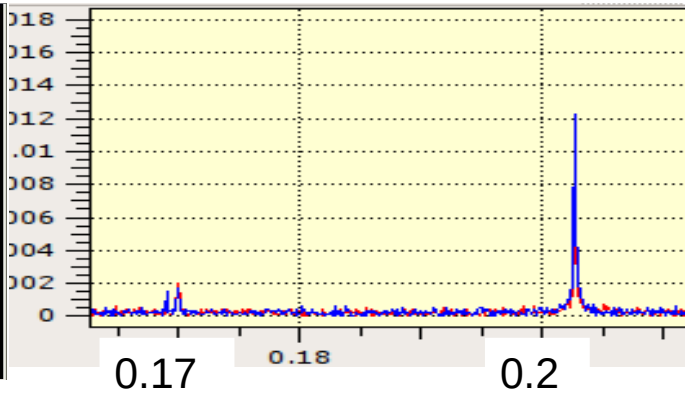


blown-up e-



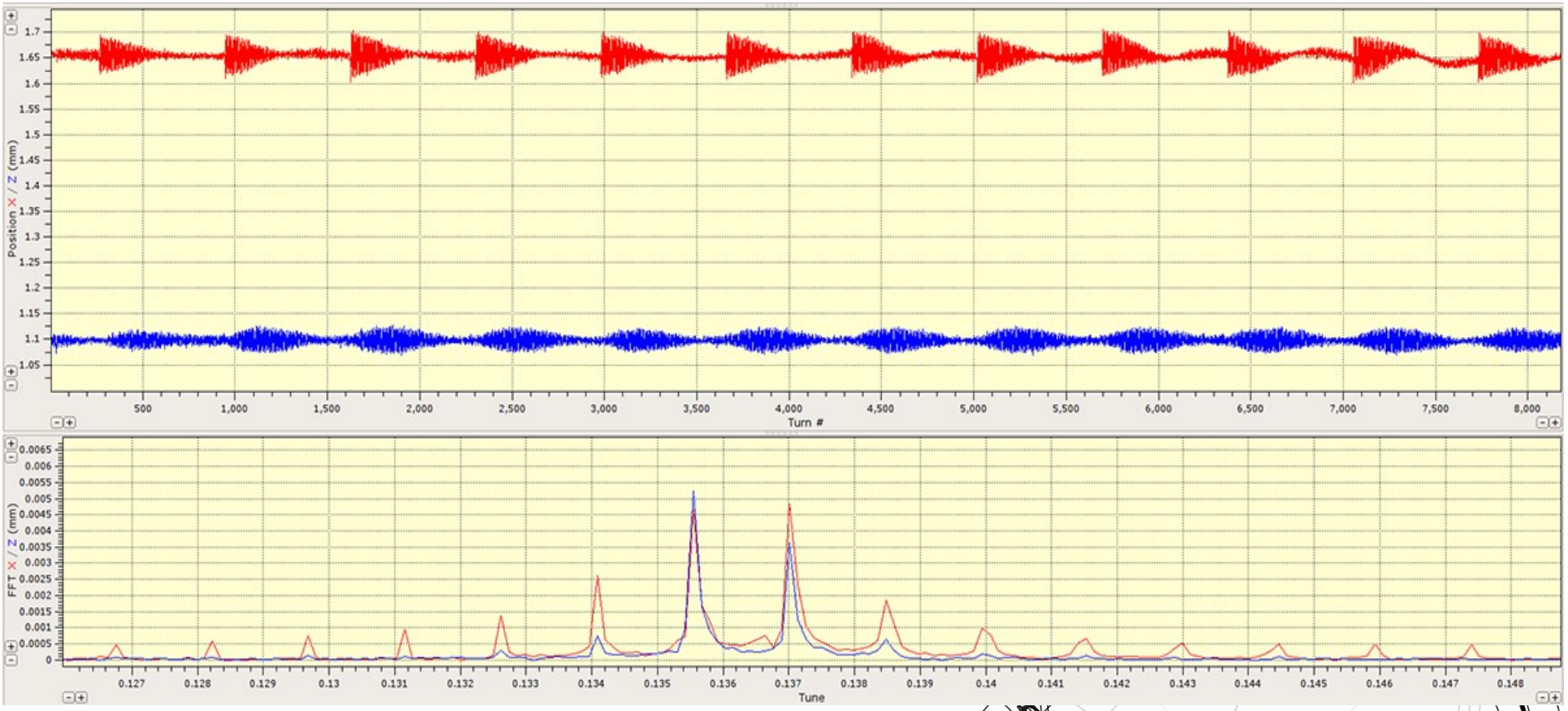
blown-up e+





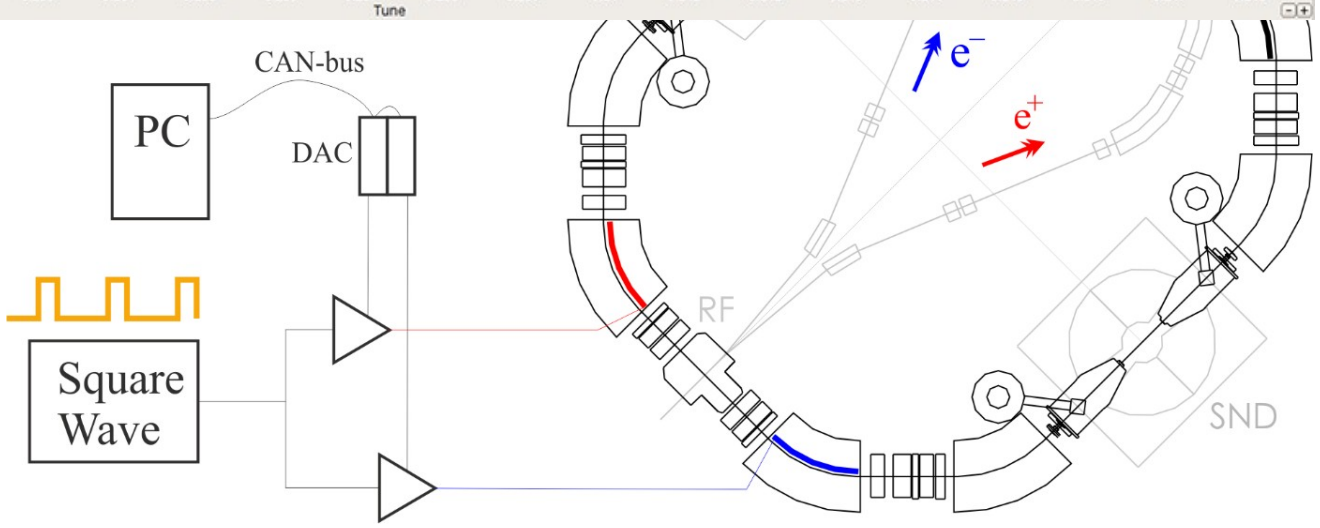
E = 240 MeV,
I_{beam} ~ 5×5 mA

Beam shaker

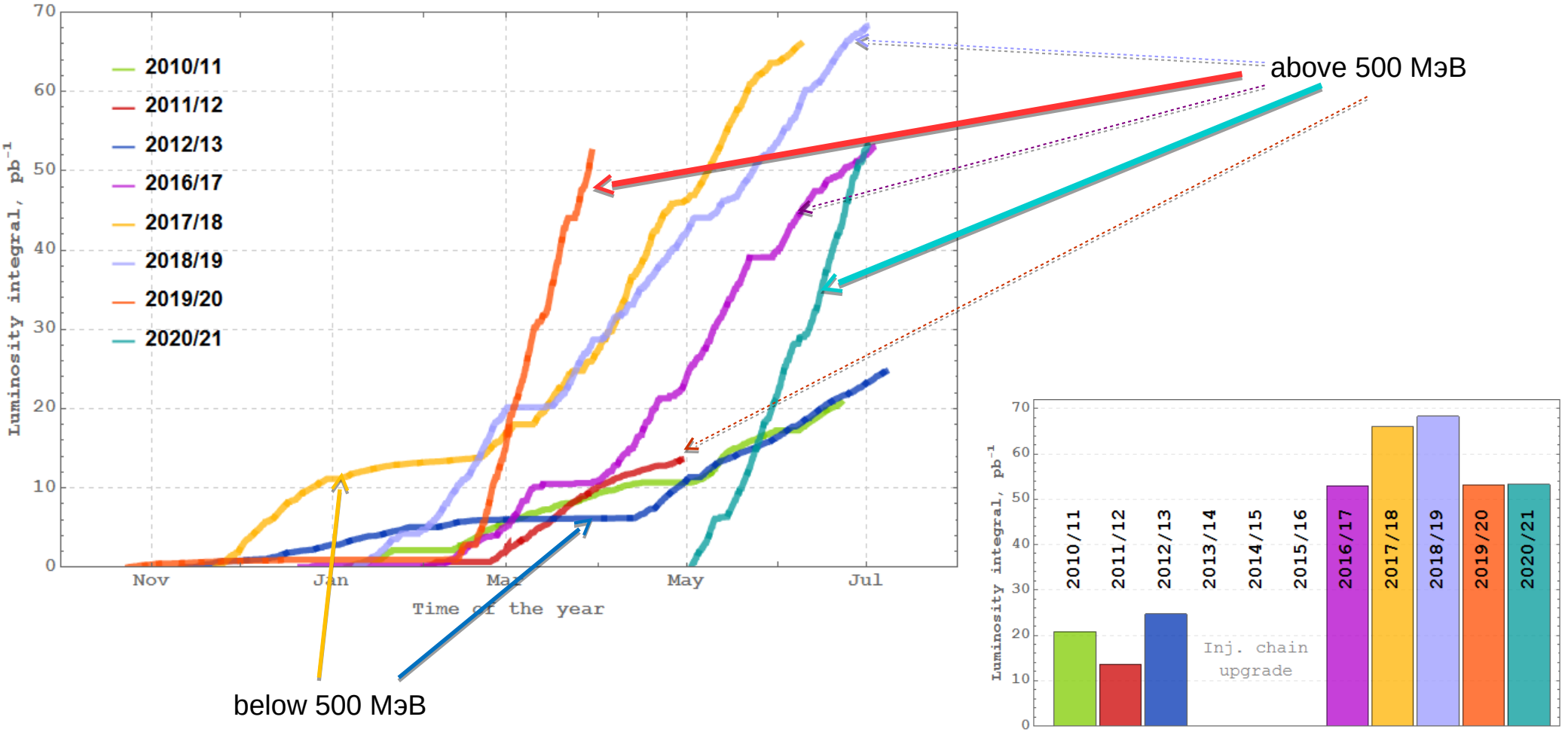


Typical values:
50-100 V, 300 ns, 50 μs

(T_{rev} = 81.4 ns)



Results



Plans summary

- Booster and transfer channel lattice investigation
- Power supplies systems renewal
- * ”Liquide helium outside” project realization
- **Luminosity integral up to 1 fb-1 (now 350 pb^{-1})**

Thanks for your attention