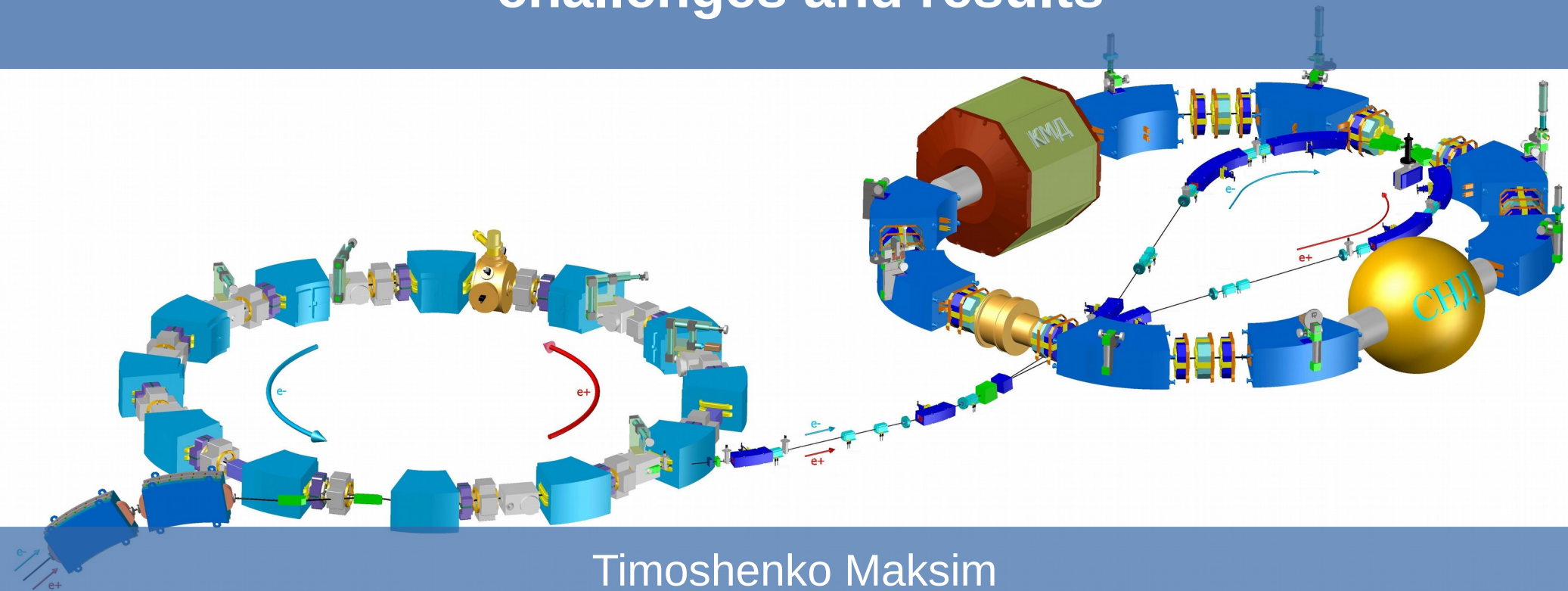


VEPP-2000 collider operation in 2019-2021 runs: challenges and results



Timoshenko Maksim
on behalf of VEPP-2000 team

RuPAC21

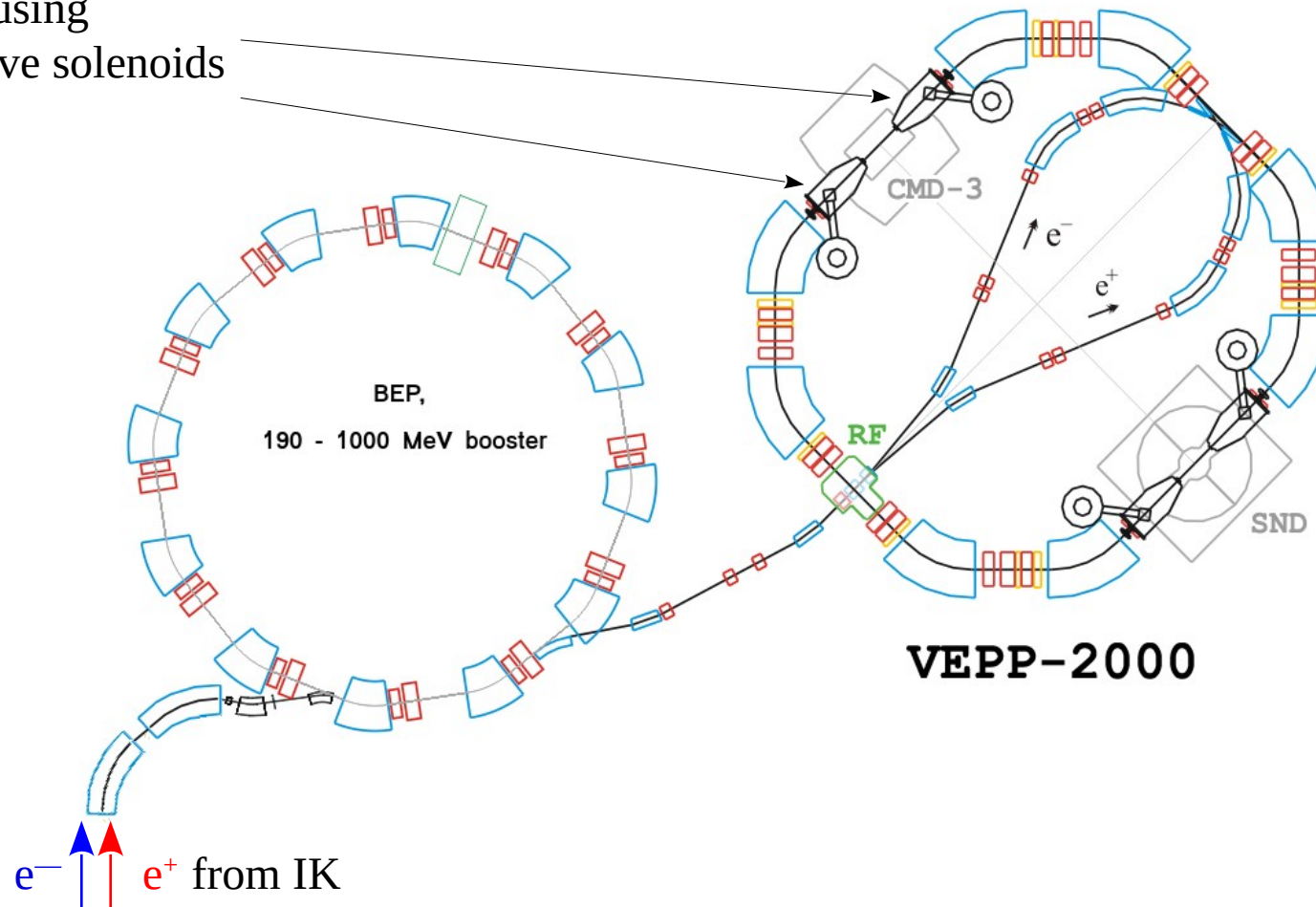
26 Sep — 2 Oct 2021r. Alushta, Crimea

Contents

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

VEPP-2000 layout & parameters

13 T final focusing
superconductive solenoids
x4



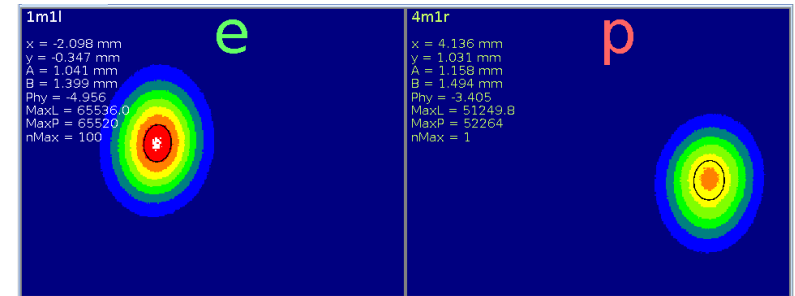
Main parameters @ 1GeV

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	$1.0 \times 10^{32} \text{ cm}^{-2}\text{s}^{-1}$

Round beams concept

Luminosity increase scenario:

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



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

- ✓ 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!

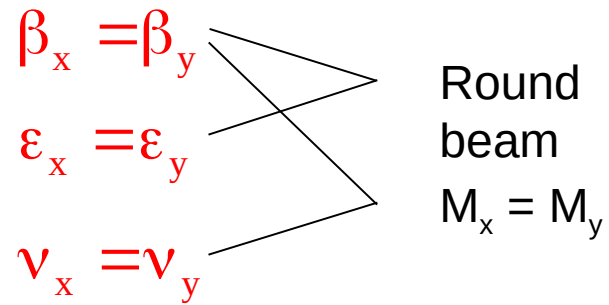
*D. Schwartz et al., "Round colliding beams at vepp-2000 with extreme tunes shifts".
In Proc. eeFACT2018, Hong Kong, China*

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:
- Equal beam emittances:
- Equal fractional parts of betatron tunes:



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

Scientific program

SND:

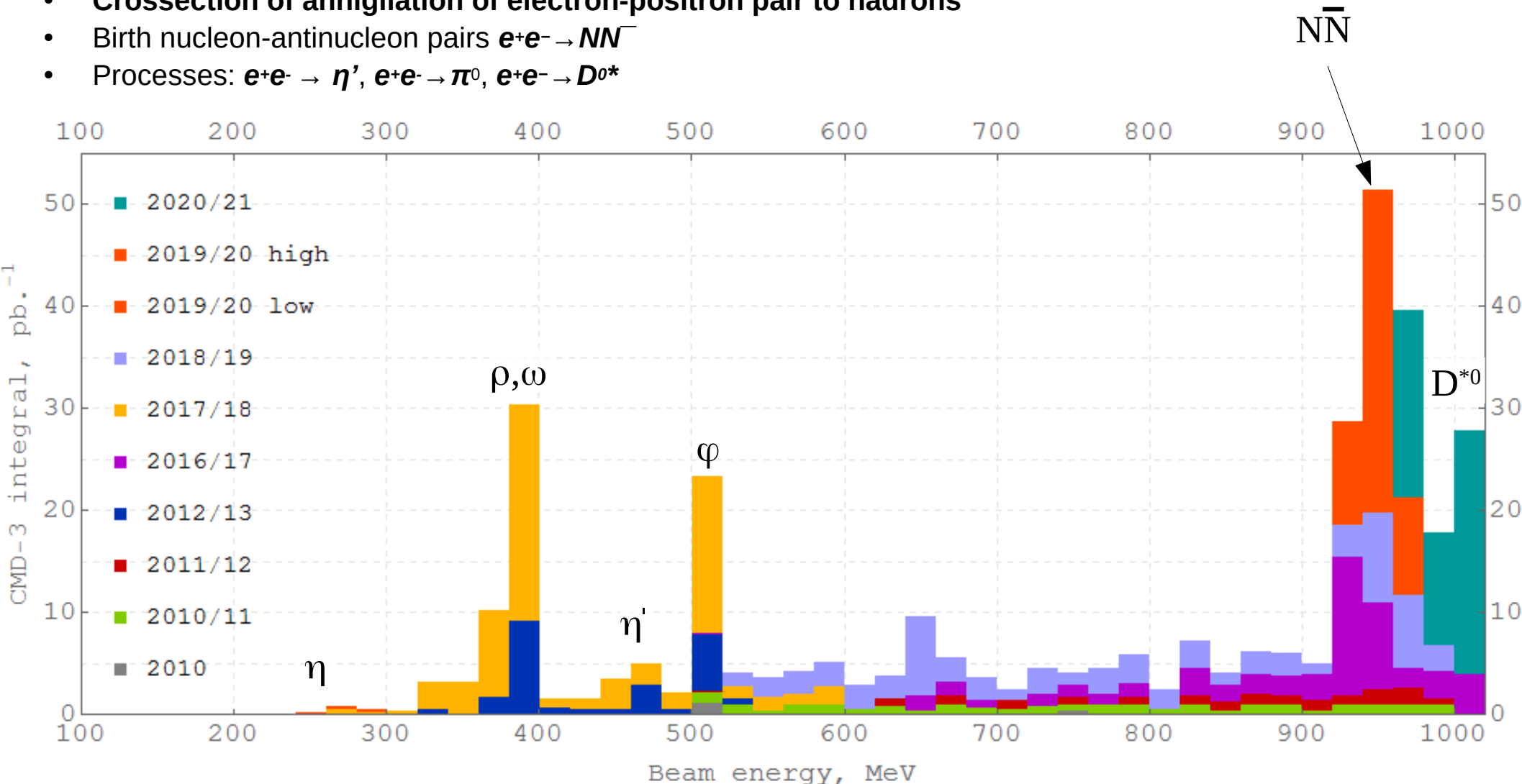
- **Cross-section of annihilation of electron-positron pair to hadrons**
- Measurements of ω , ρ and ϕ (782, 770 and 1020 MeV)
- Looking for $e^+e^- \rightarrow \eta$ (547.853 ± 0.024 MeV)

CMD-3:

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

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

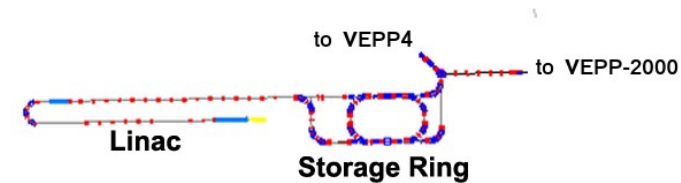
A E Ryzhenenkov et al., "Overview of the CMD-3 recent results", *Journal of Physics: Conference Series*, 2020



2019-2020 run

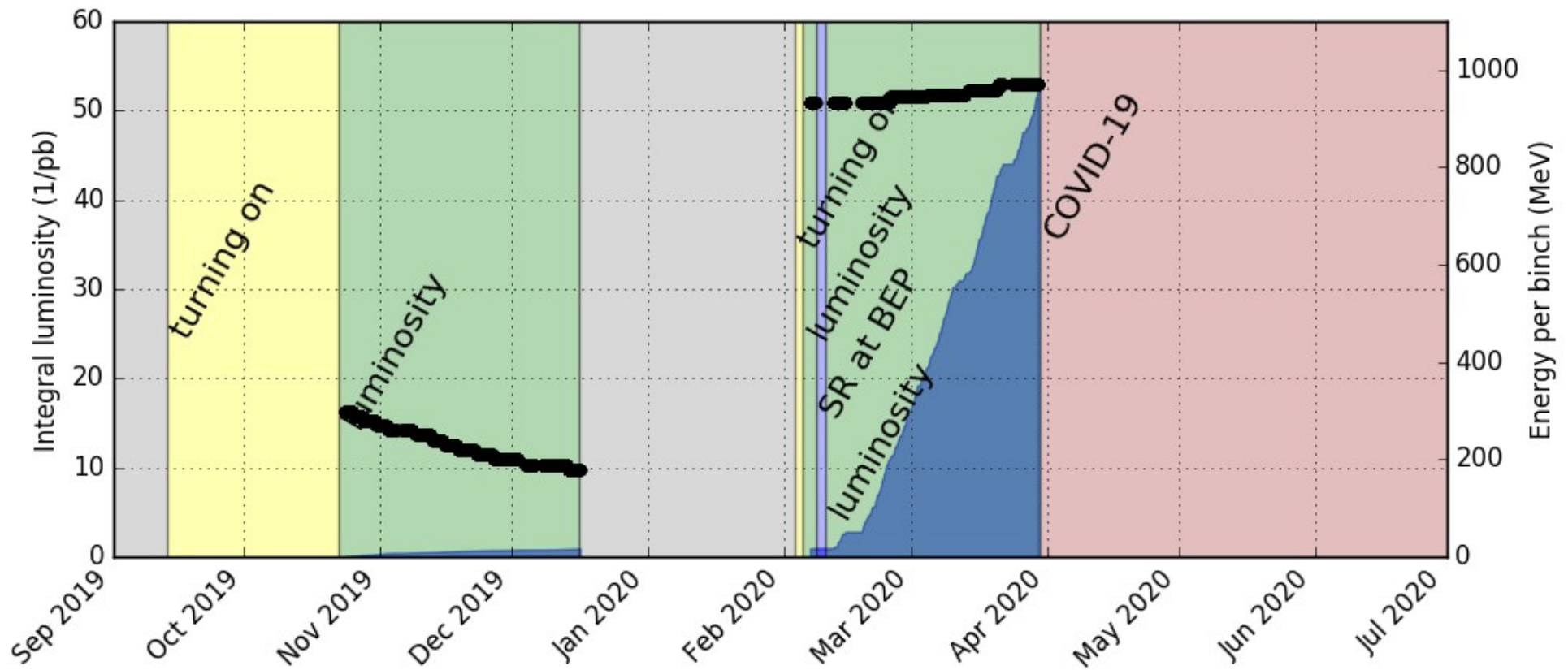
Turning on:

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



Luminosity — luminosity time integral acquisition

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



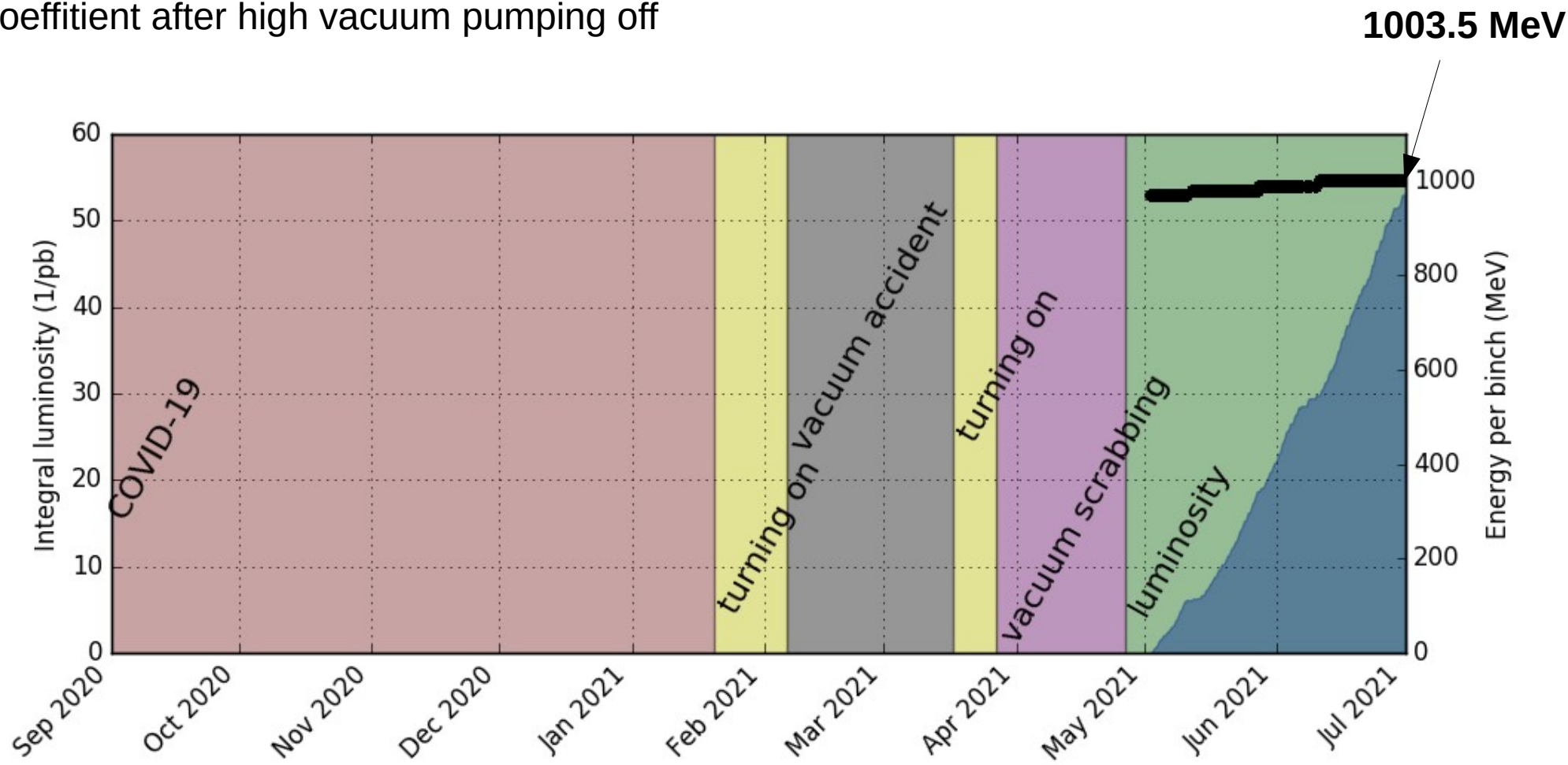
2020-2021 run

Vacuum accident:

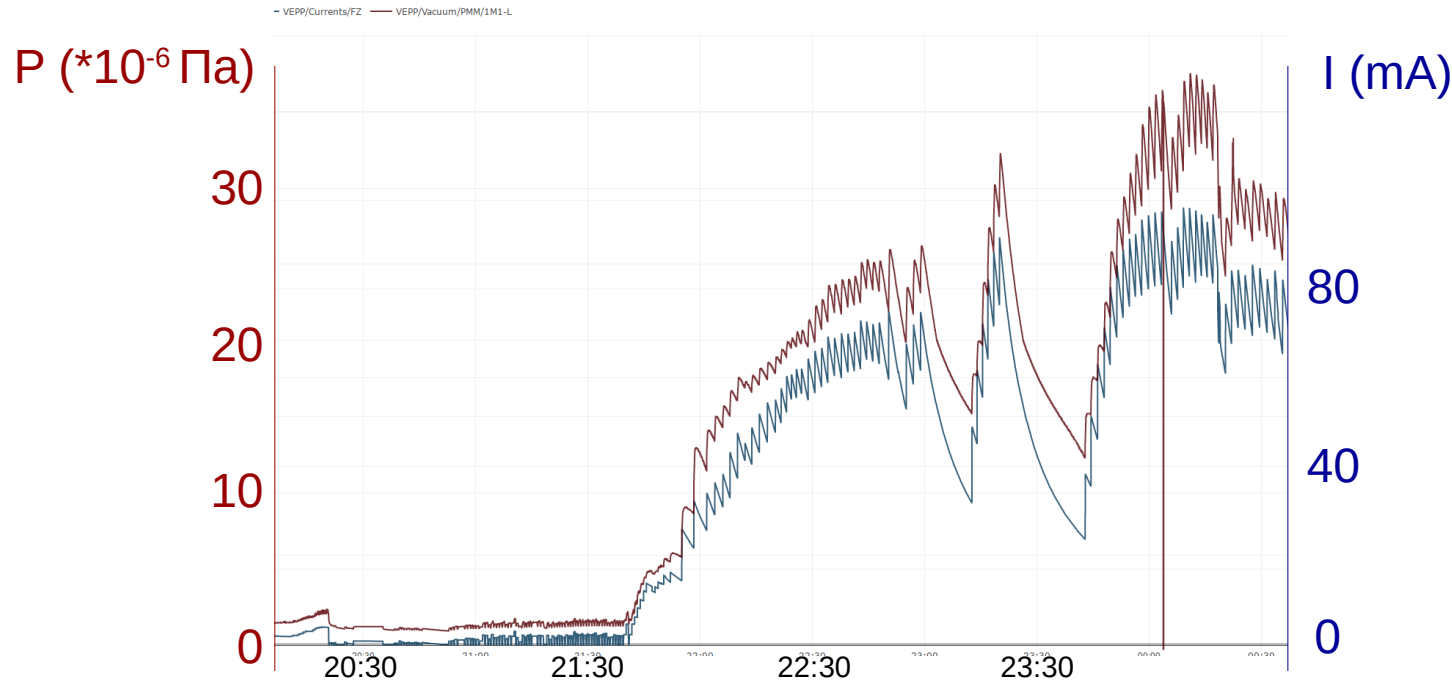
Burning hole in the vacuum chamber
inside pre-injection magnet transfer line

Vacuum scrubbing:

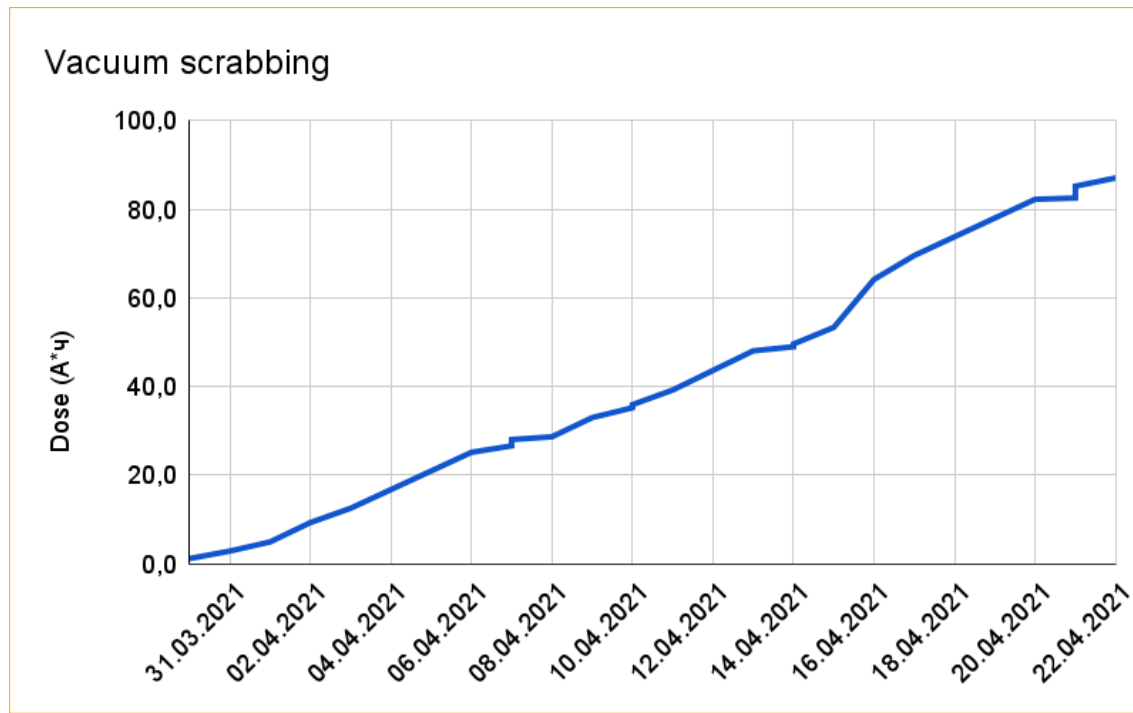
Decreasing of the photodesorption
coefficient after high vacuum pumping off



Vacuum accident

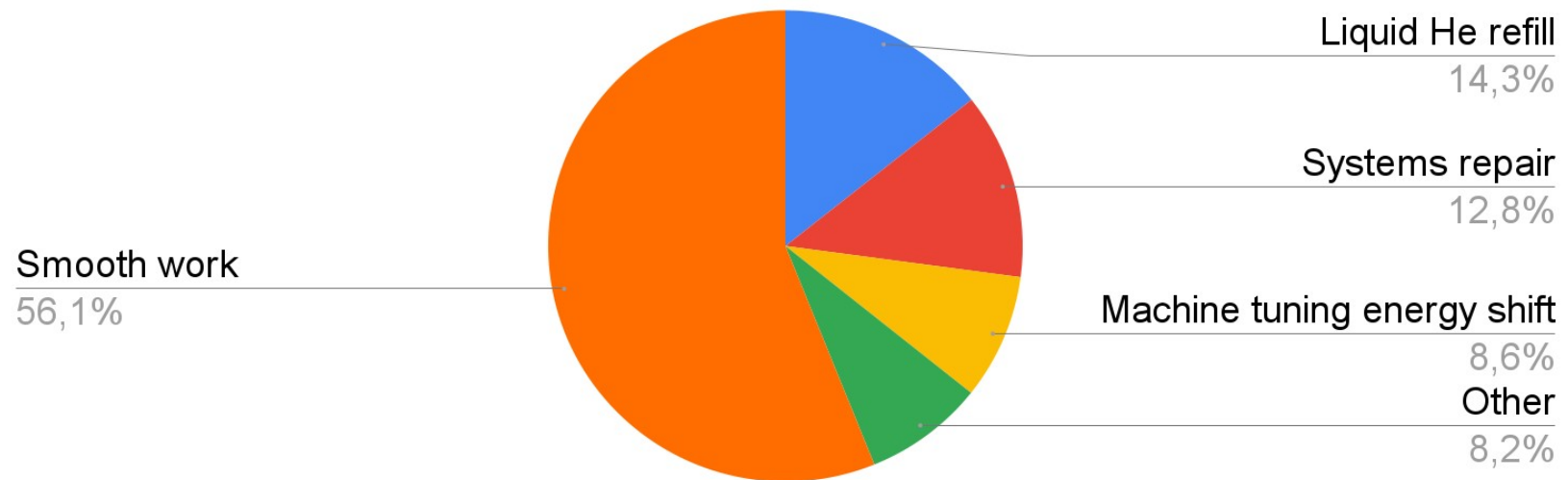


$$P = P_0 + a_{\text{desorption}} * I$$

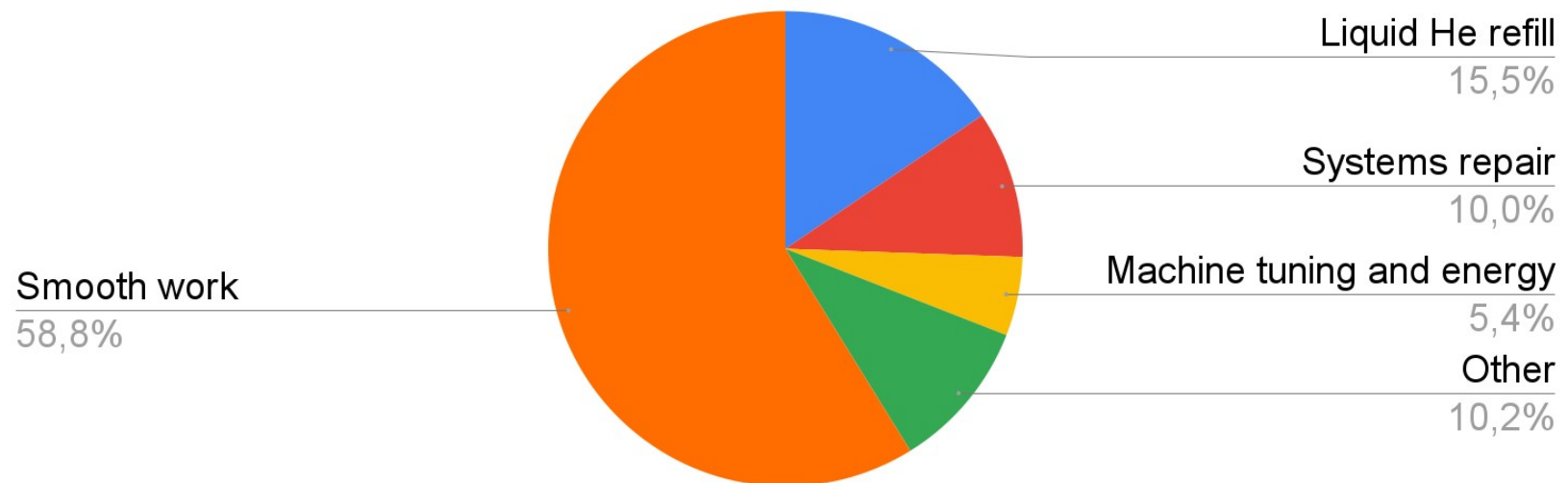


Luminosity mode efficiency

Luminosity mode, 2019-2020 run

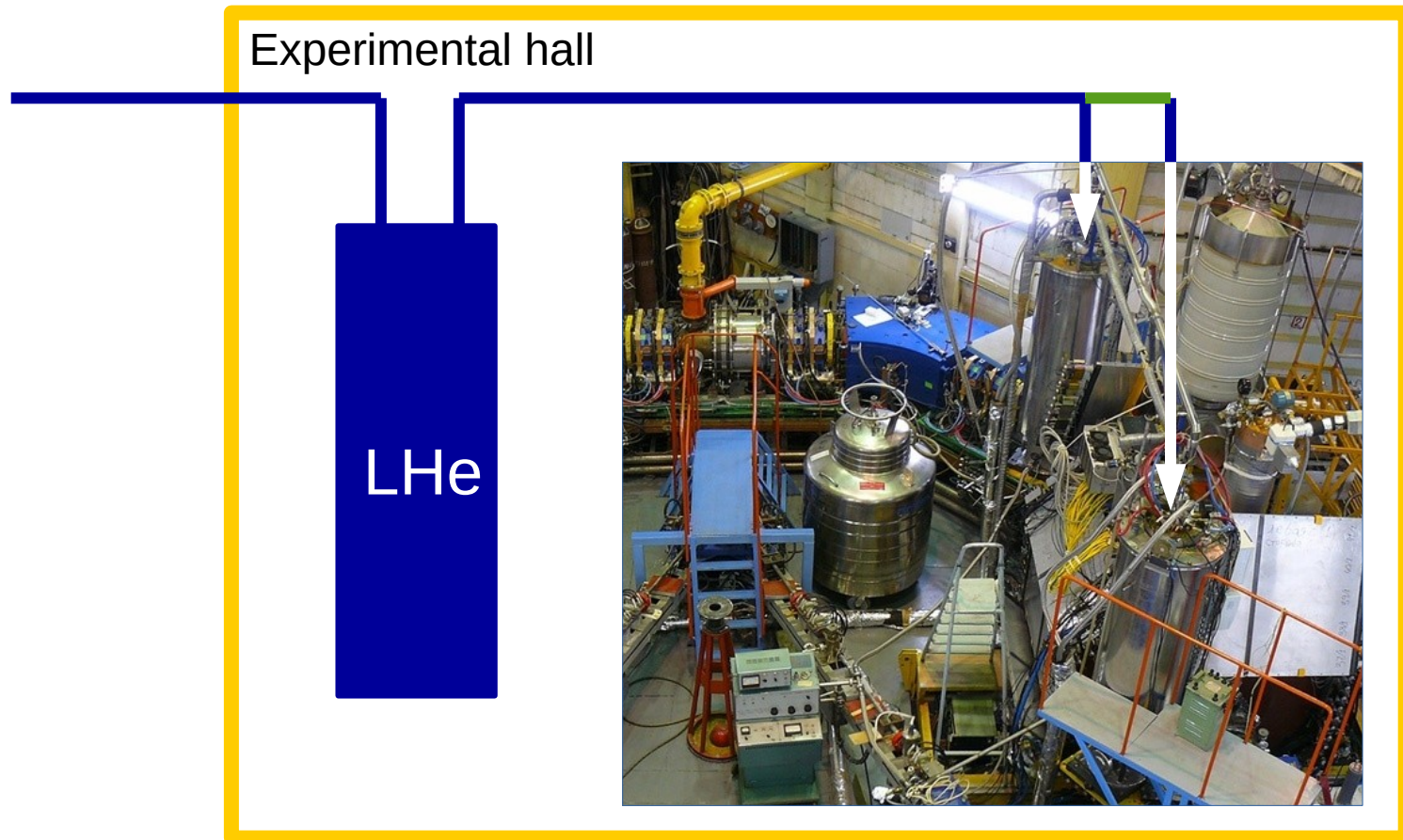


Luminosity mode, 2020-2021 run



Other: IK tuning, Water station interruption, Power interruption

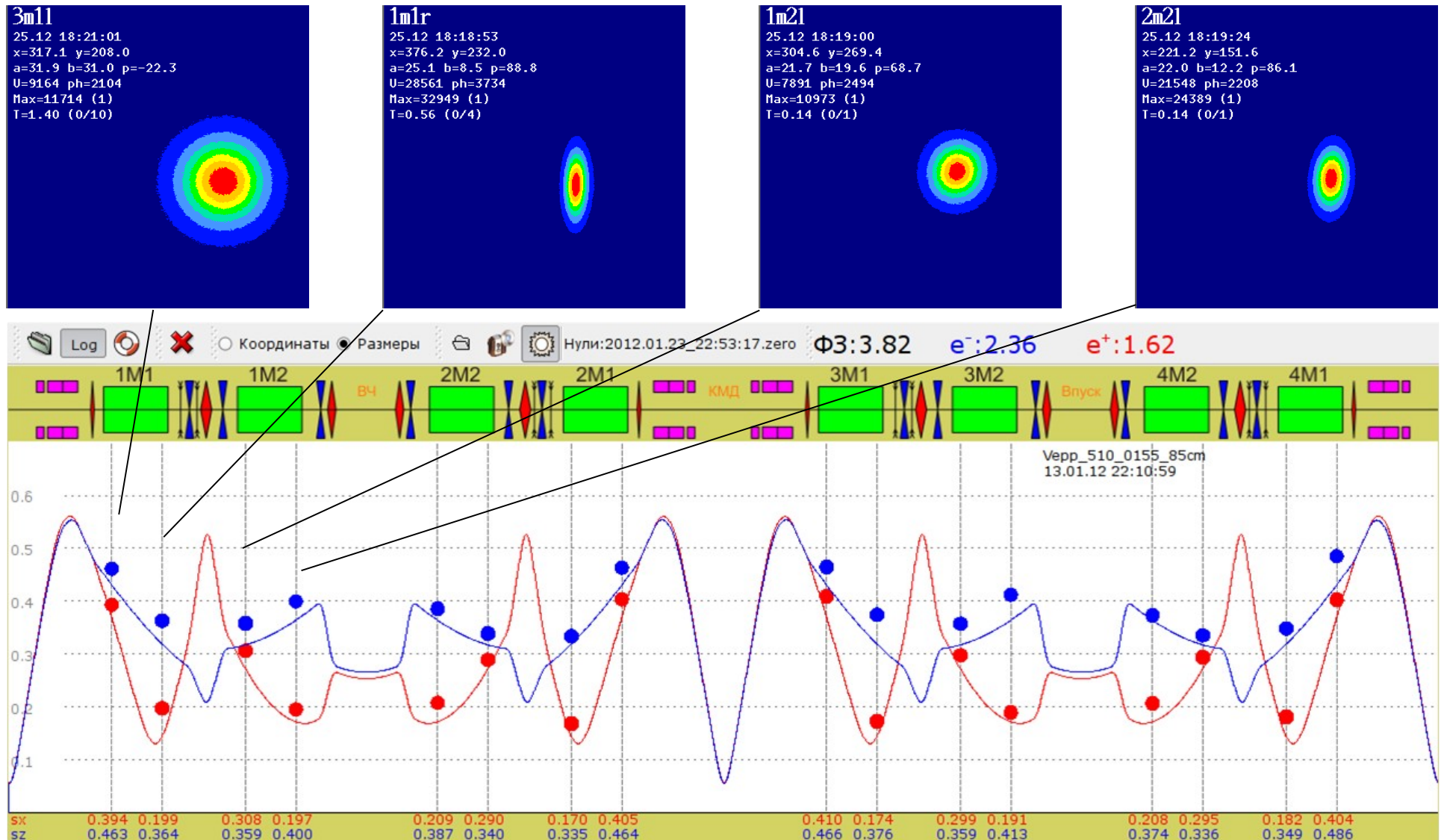
Future project “Helium outside”



Power supplies renewal

- Quadrupole magnets
- Pulse magnets
- ...

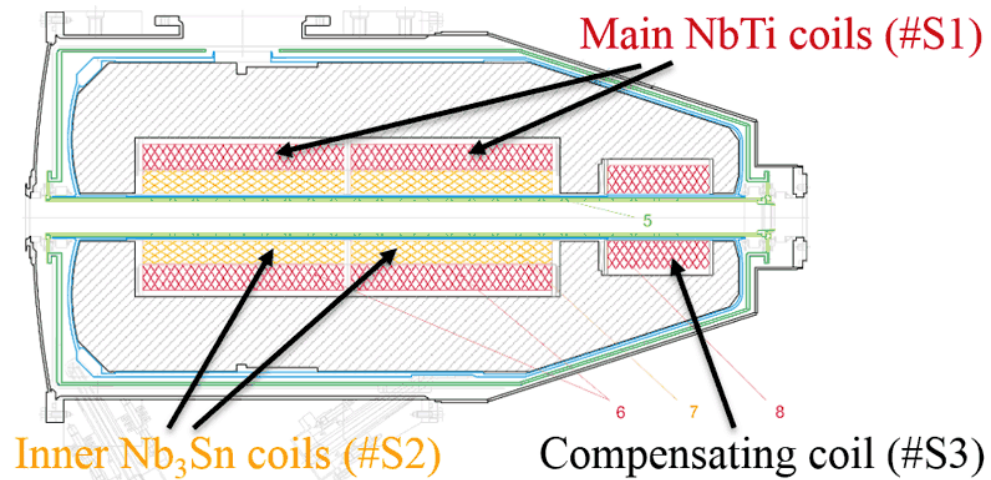
Lattice correction



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

Solenoids misalignment

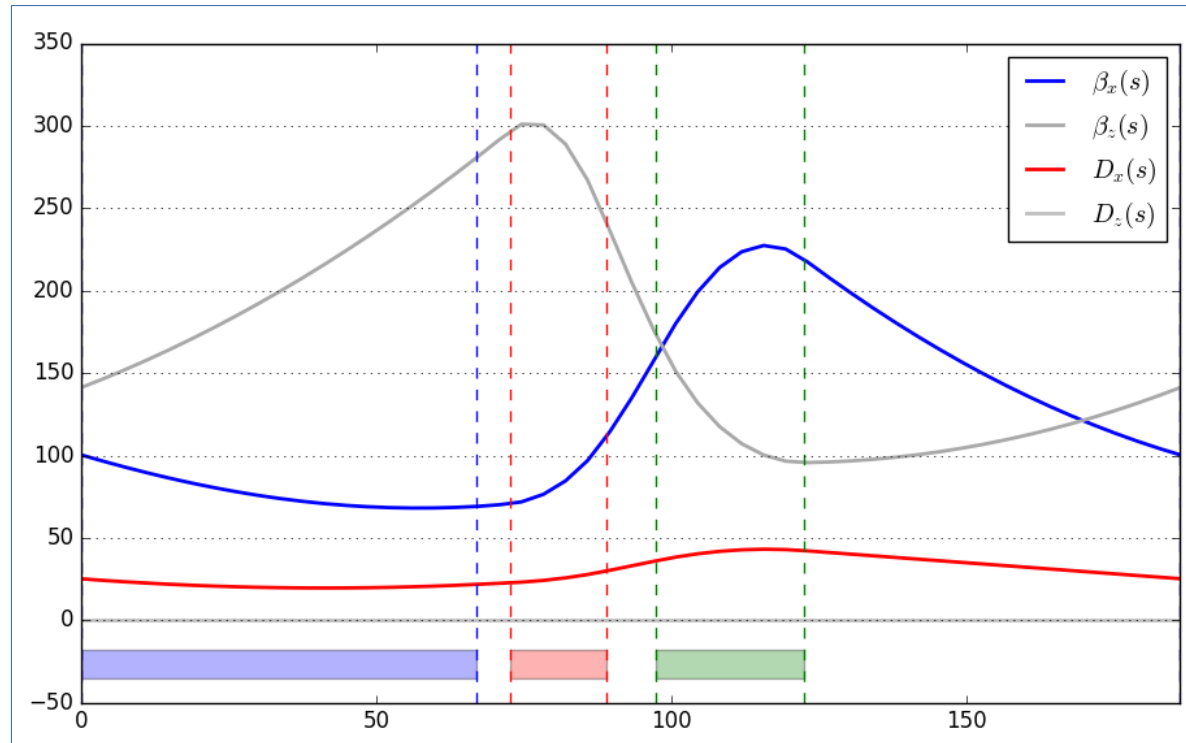
D. Shwartz, «Final Focusing Solenoids Beam-based Positioning Test»,
in Proc. IPAC2021, Campinas, SP, Brazil



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

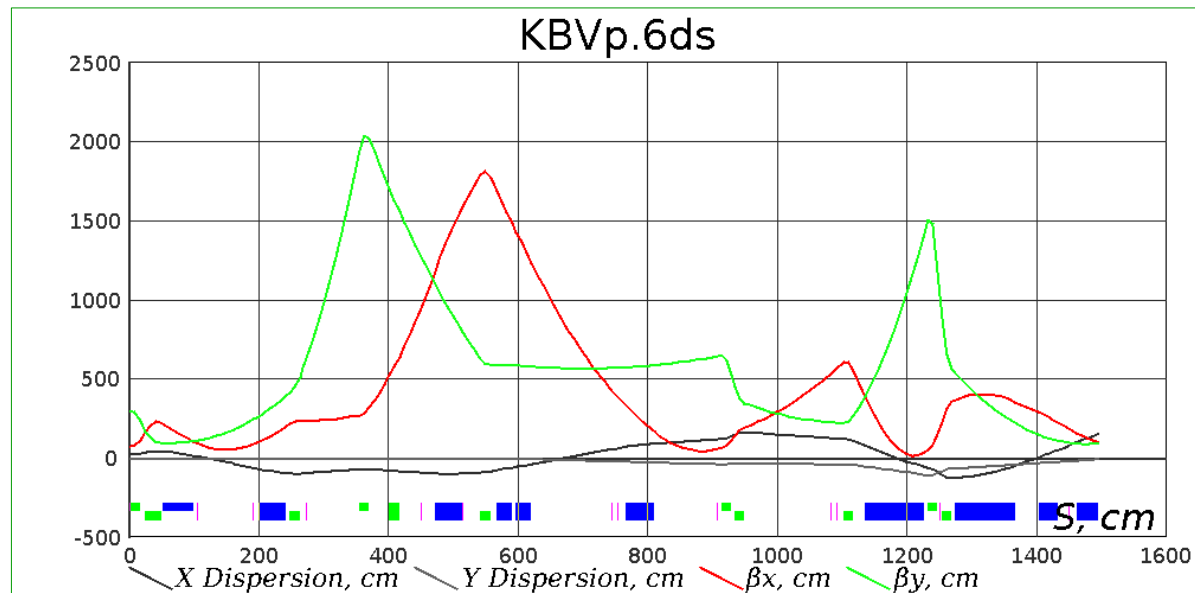
BEP and KBV lattice

BEP:



$\times 12$

BEP to VEPP transfer line
(KBV):

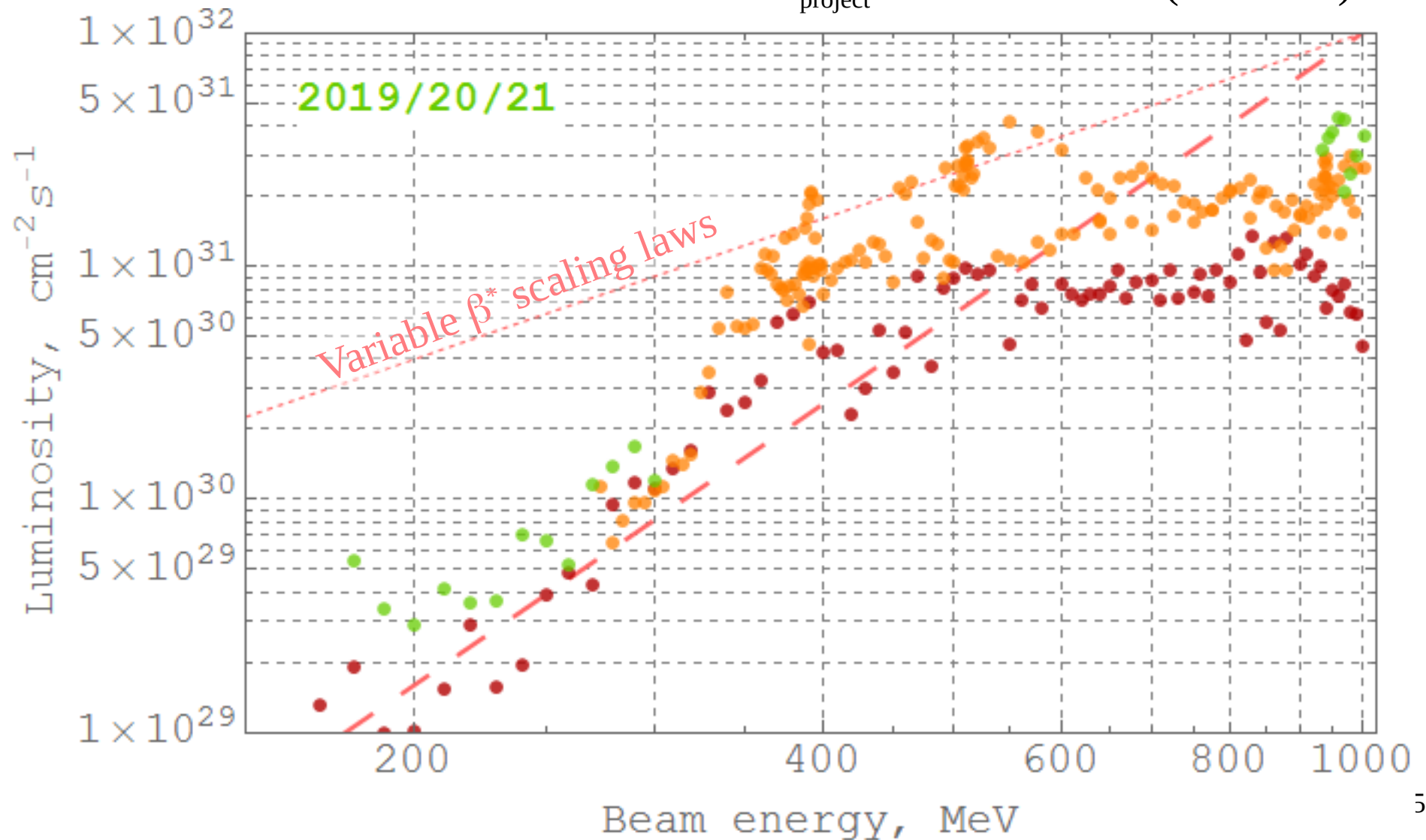


Luminosity achieved

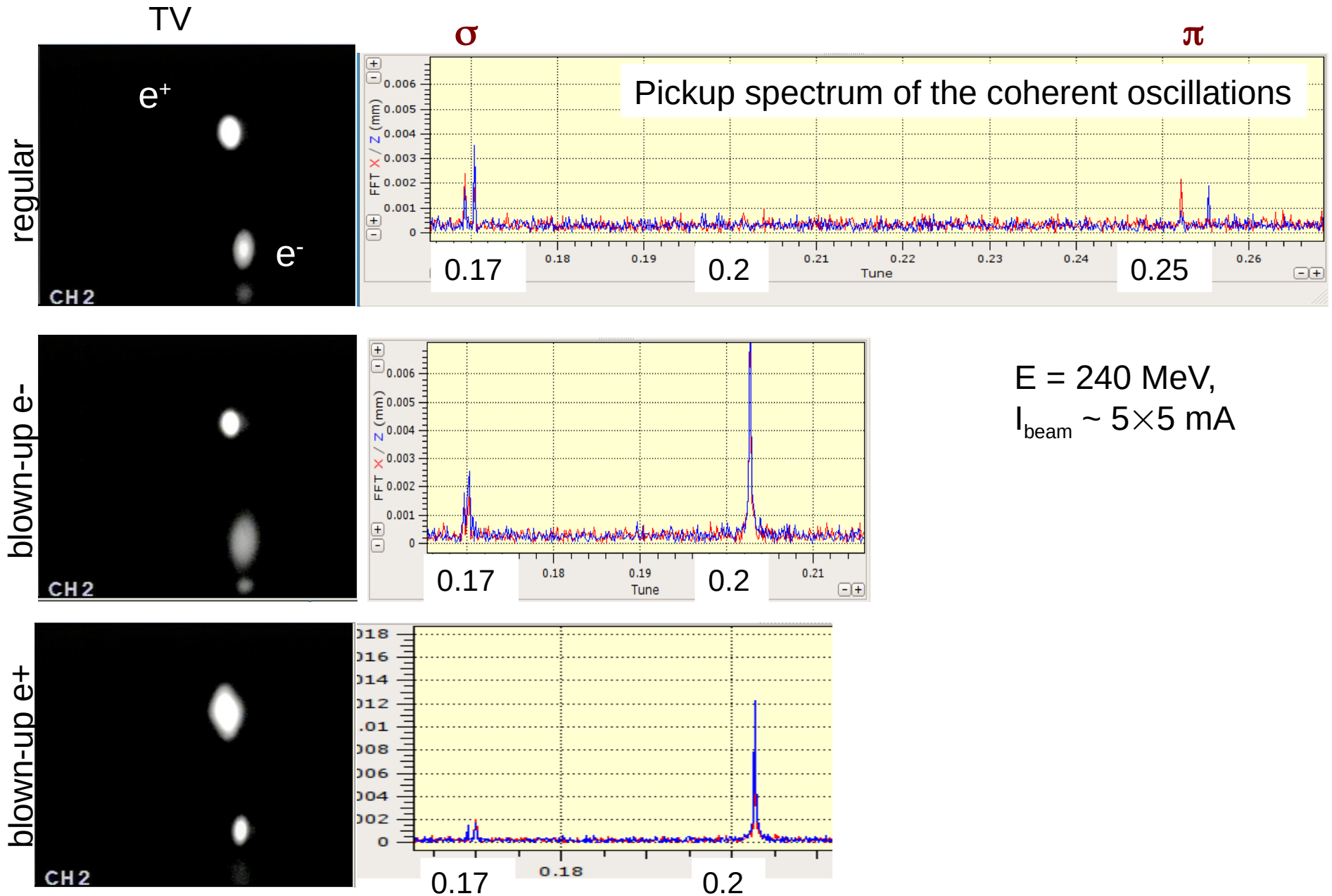
Highest luminosity achieved

$$L_{\text{peak}} = 5 \times 10^{31} \text{ cm}^{-2} \text{ s}^{-1} \text{ (at 550 MeV)}$$

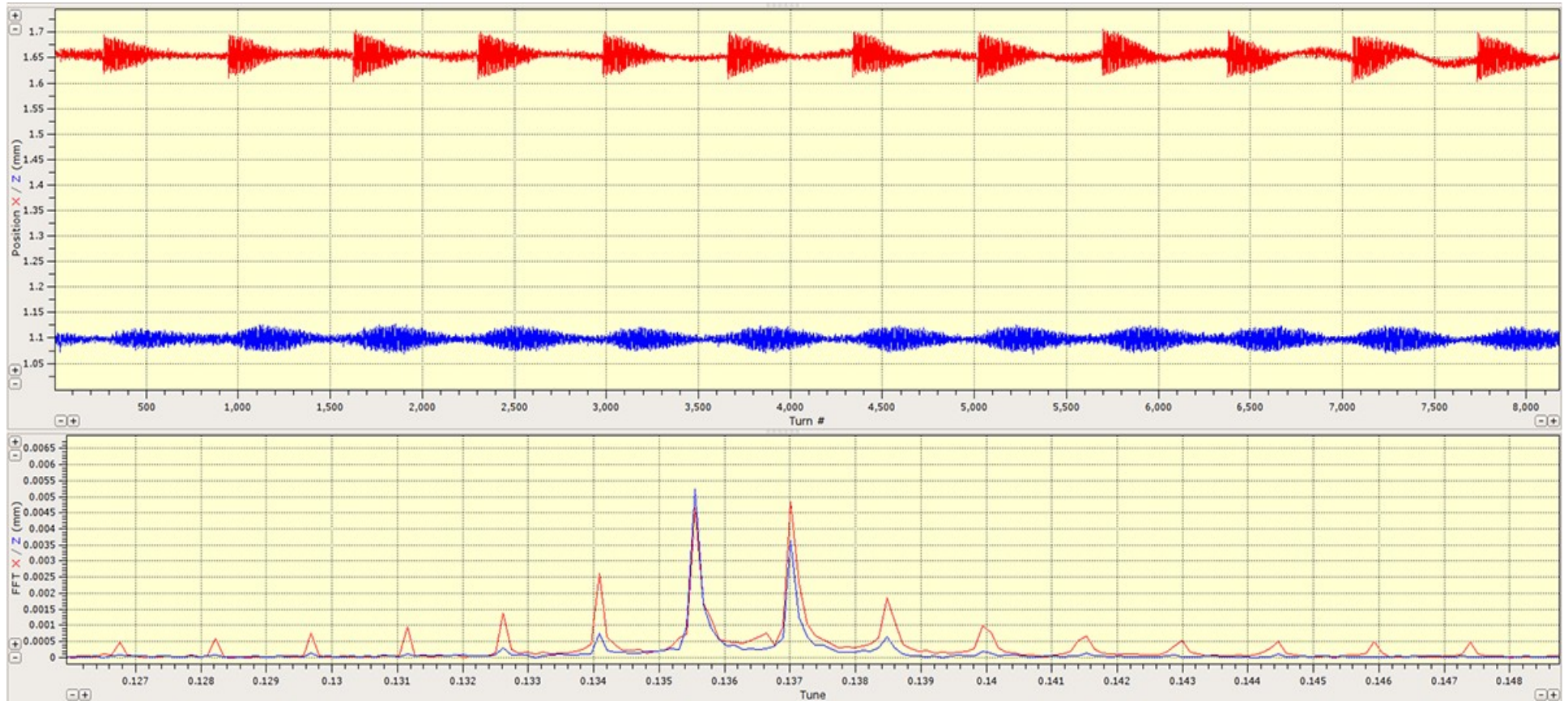
$$L_{\text{project}} = 1 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1} \text{ (at 1 GeV)}$$



Flip-flop effect

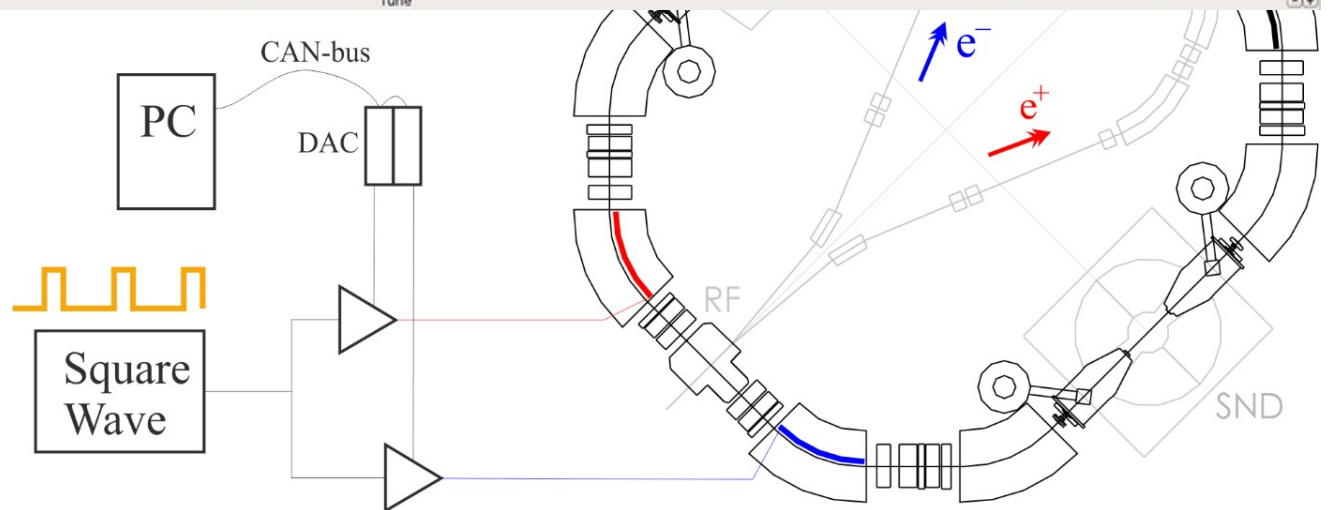


Beam shaker

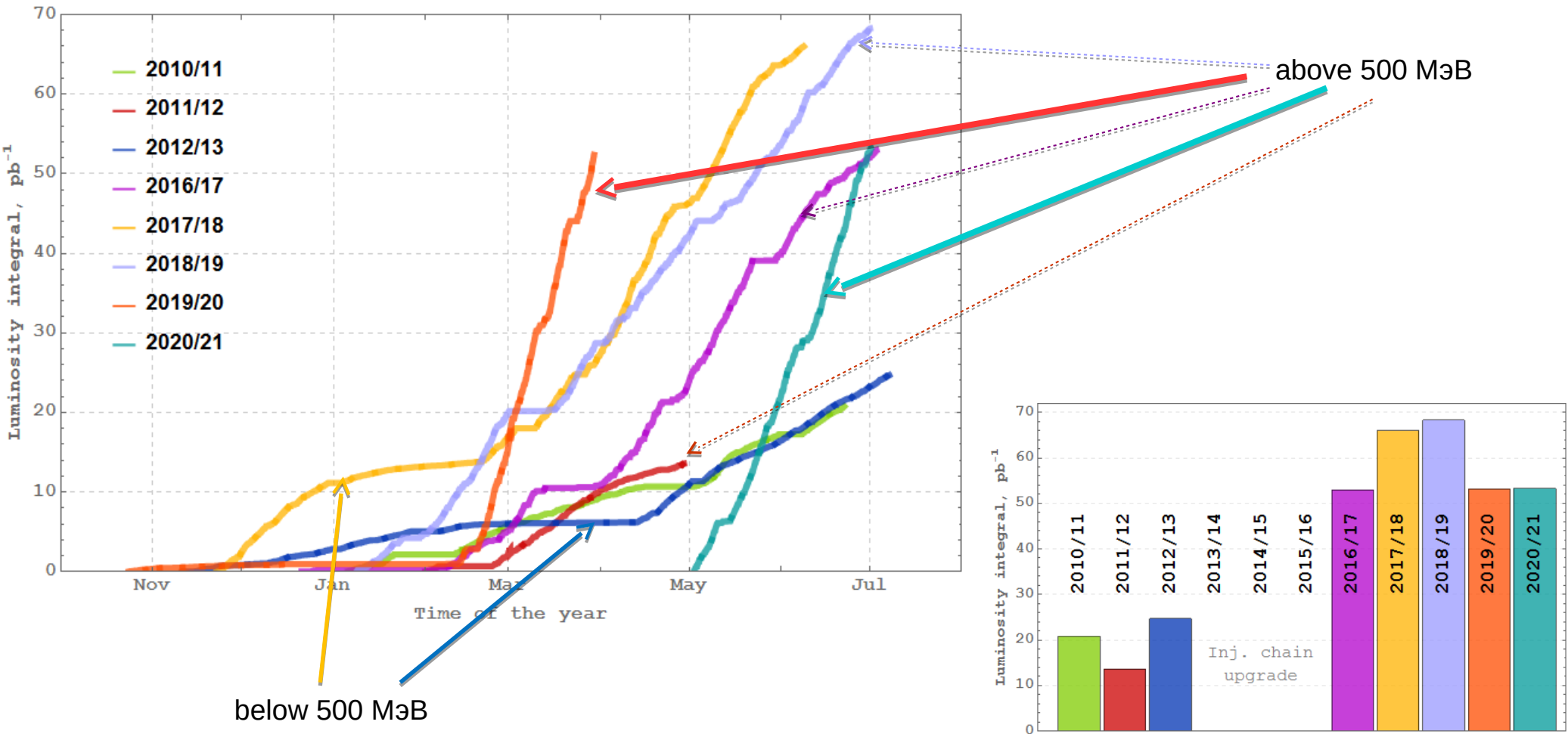


Typical values:
50-100 V, 300 ns, 50 μ s

($T_{\text{rev}} = 81.4$ 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

