Overview of collider projects at BINP

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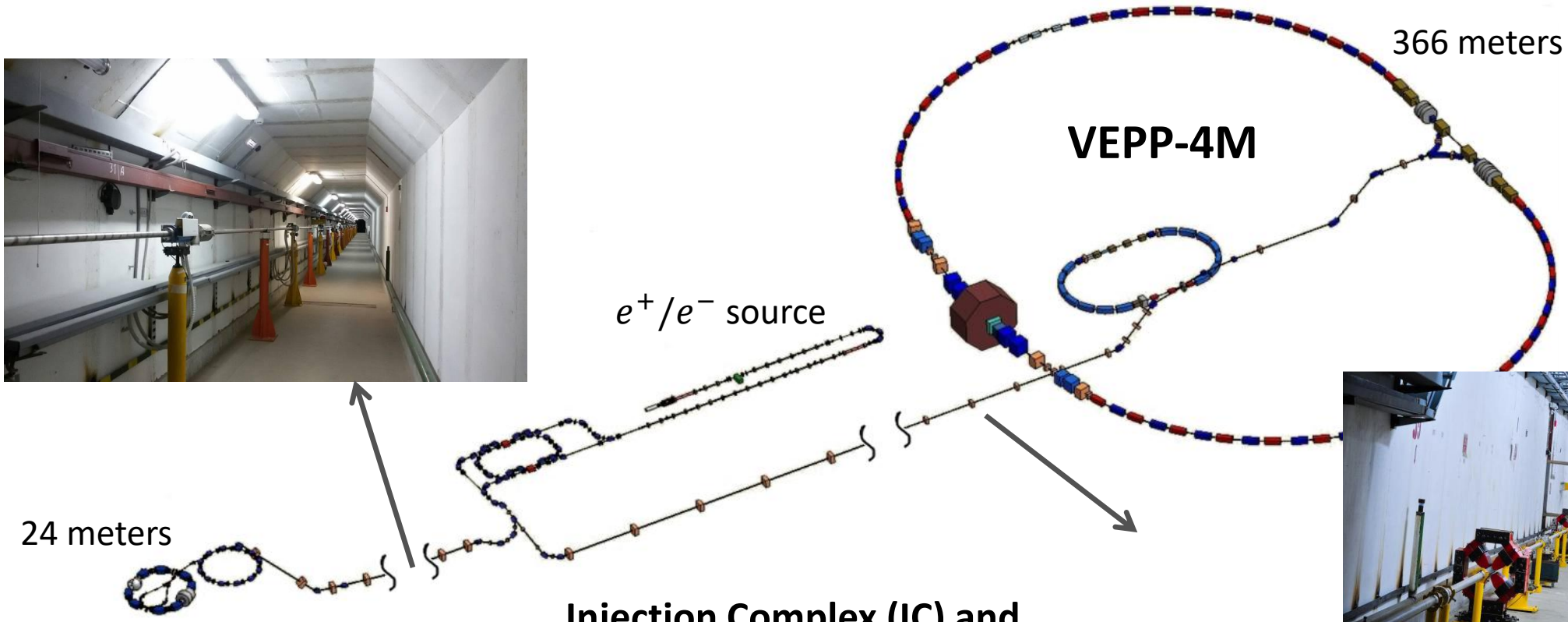
Outline

- Existing accelerator complex
- Upgrade of VEPP-2000
- VEPP-6
- VEPP-4C
- Synergy with STCF

BINP accelerator complex layout

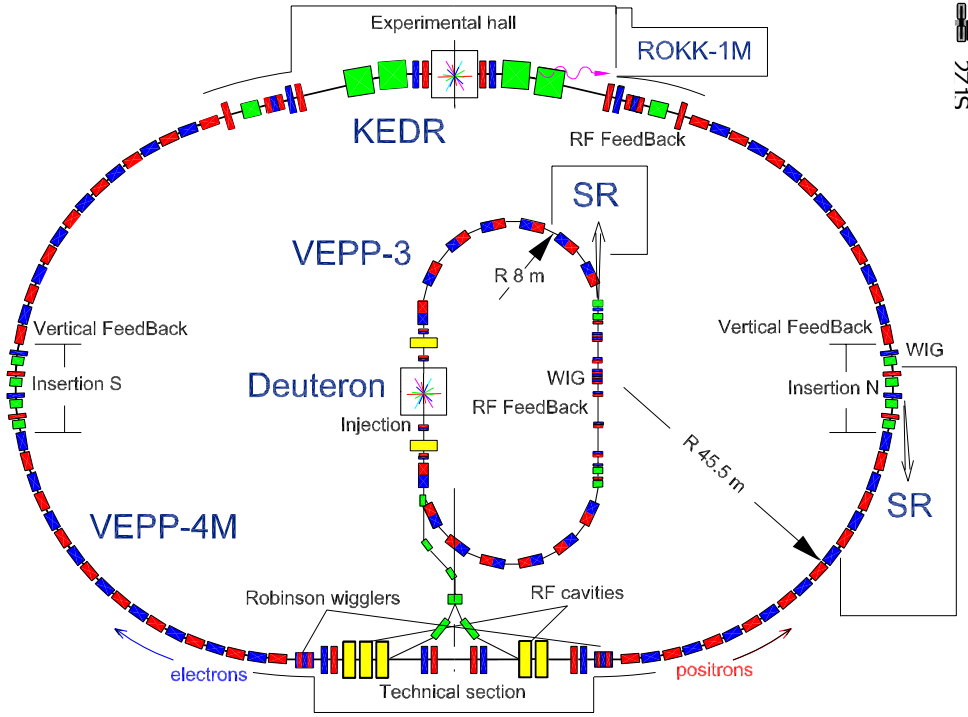


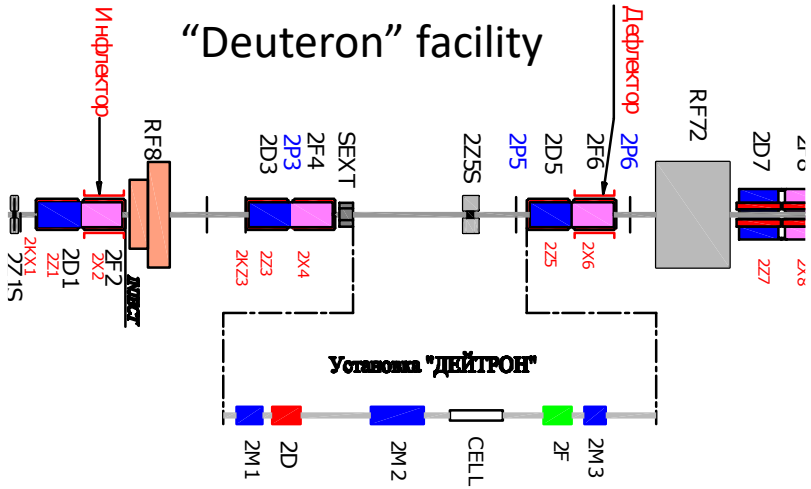
VEPP-4M and VEPP-3

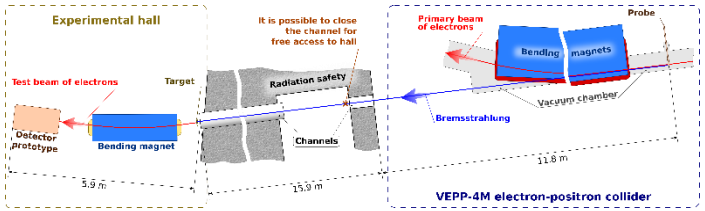
VEPP-4M

Beam energy range 0.925-4.7 GeV

Luminosity $\sim 4 \cdot 10^{31}\ cm^{-2}s^{-1}$





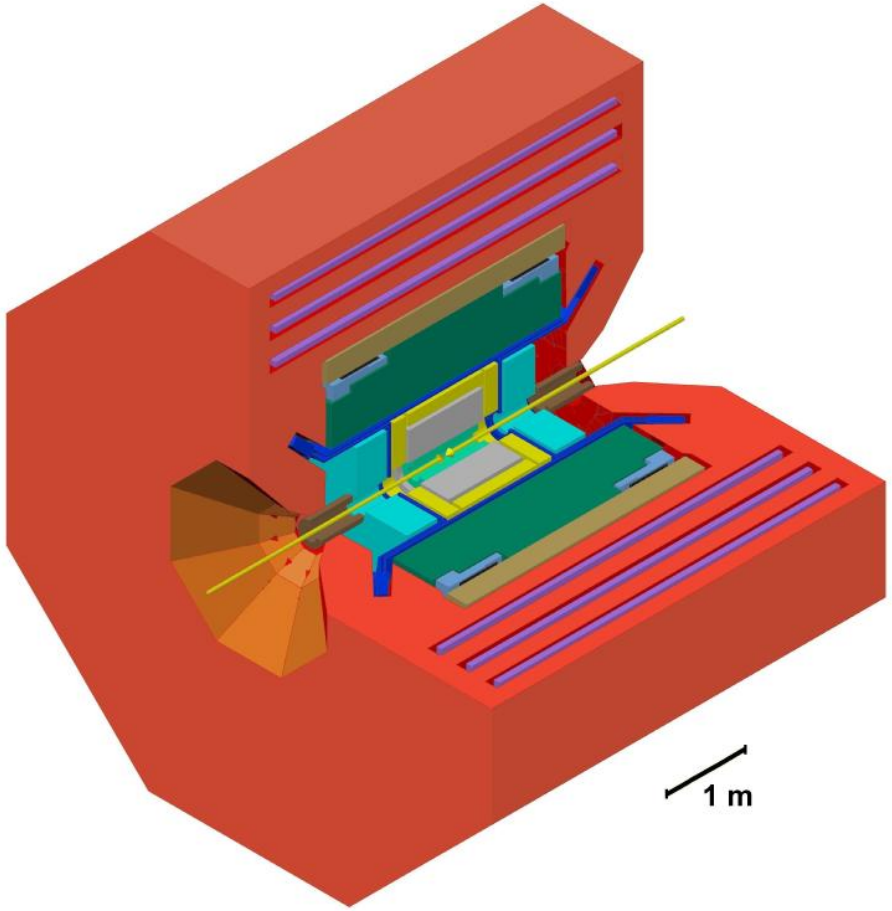


Test beam facility

Experimental program:

- e^+e^- HEP with KEDR detector
- SR at VEPP-3 (2 GeV)
- SR at VEPP-4M (2÷4 GeV)
- Nuclear physics at VEPP-3 with Deuteron facility
- Test Beam Facility at VEPP-4M

KEDR detector



- Straw tubes VD
- DC
- ASHIP PID
- LKr barrel calo
- CsI endcap calo
- TOF system
- Range system

Precise beam energy measurement

- Compton
- Resonance depolarization (Touschek, laser polarimeter)

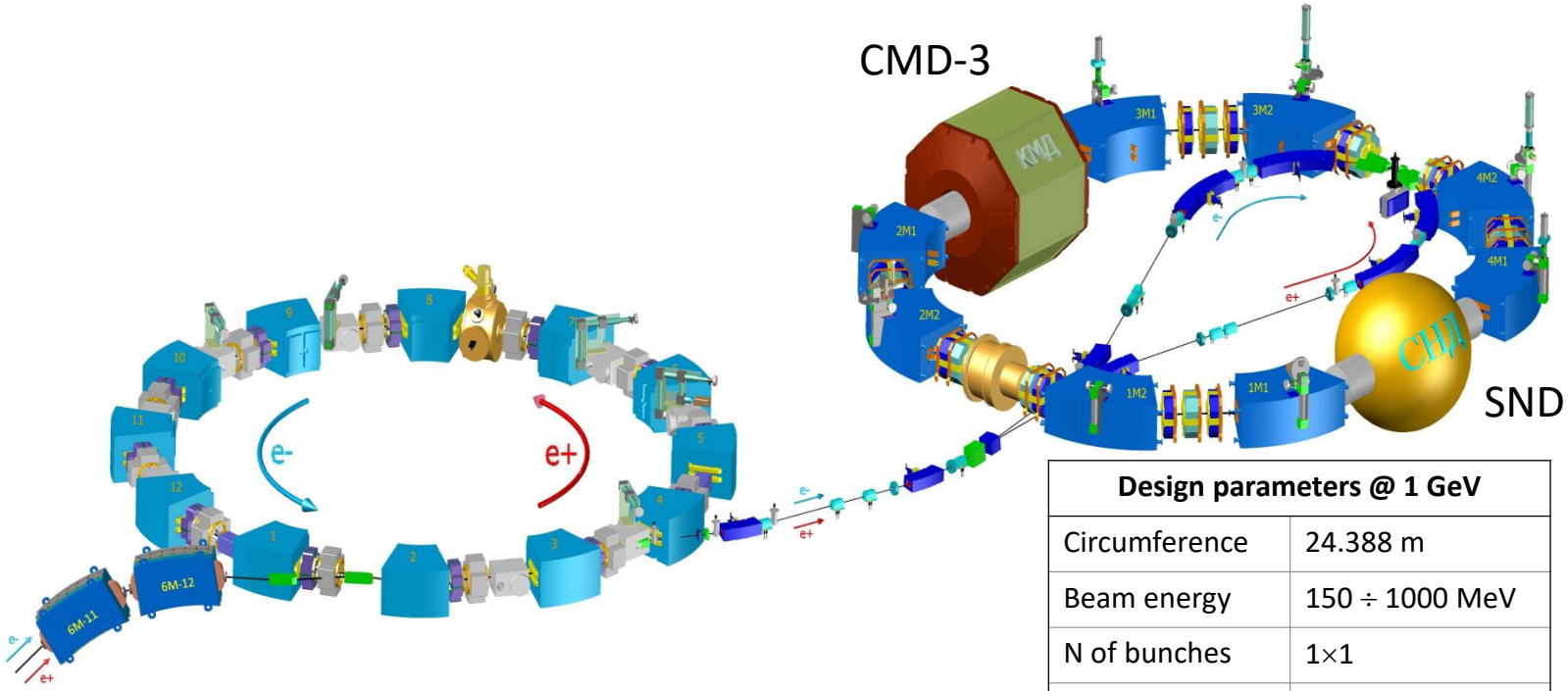
Key results:

- R ratio (1.84-3.72 GeV, 4.56-6.96 GeV in progress)
- J/ψ , $\psi(2S)$, τ, D masses
- J/ψ , $\psi(2S)$ widths (partial, leptonic,…)

1-2 more years of data taking:

- Υ(1S) mass and leptonic width
- $\sigma(\gamma^*\gamma^* \to hadrons)$

VEPP-2000



Design parameters @ 1 GeV	
Circumference	24.388 m
Beam energy	150 ÷ 1000 MeV
N of bunches	1×1
N of particles	1×10^{11}
Betatron tunes	4.14 / 2.14
Beta*	8.5 cm
Luminosity	1×10^{32} $cm^{-2}s^{-1}$

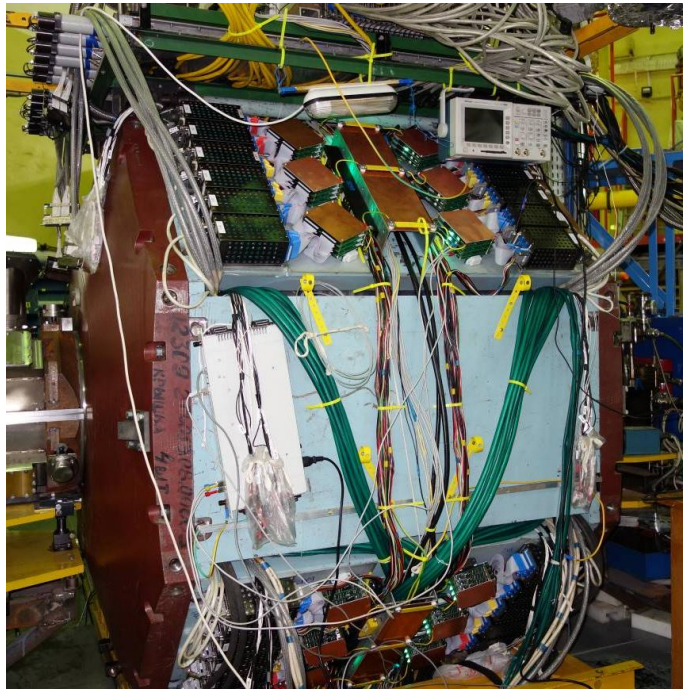
World-highest luminosity below 2 GeV (except at φ)

Experimental program:

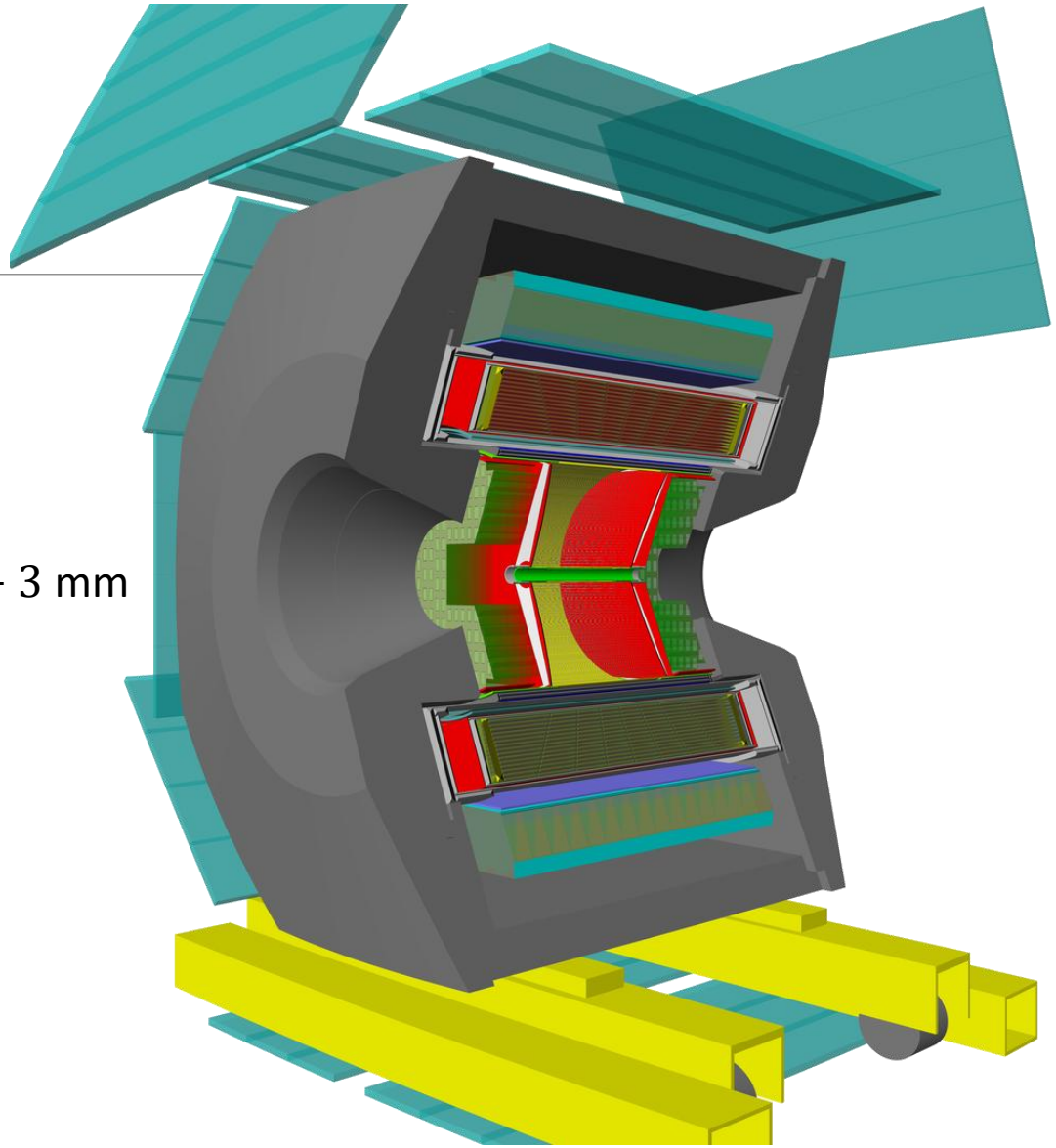
- Exclusive $e^+e^- \to hadrons$ at $\sqrt{s} \leq 2.007$ GeV (spectroscopy of uds hadrons, dynamics,…)
- Related to muon (g-2)
- $p\bar{p}$, $n\bar{n}$ threshold
- Other topics

$1\ \mathrm{fb}^{-1}$ collected per detector

CMD-3

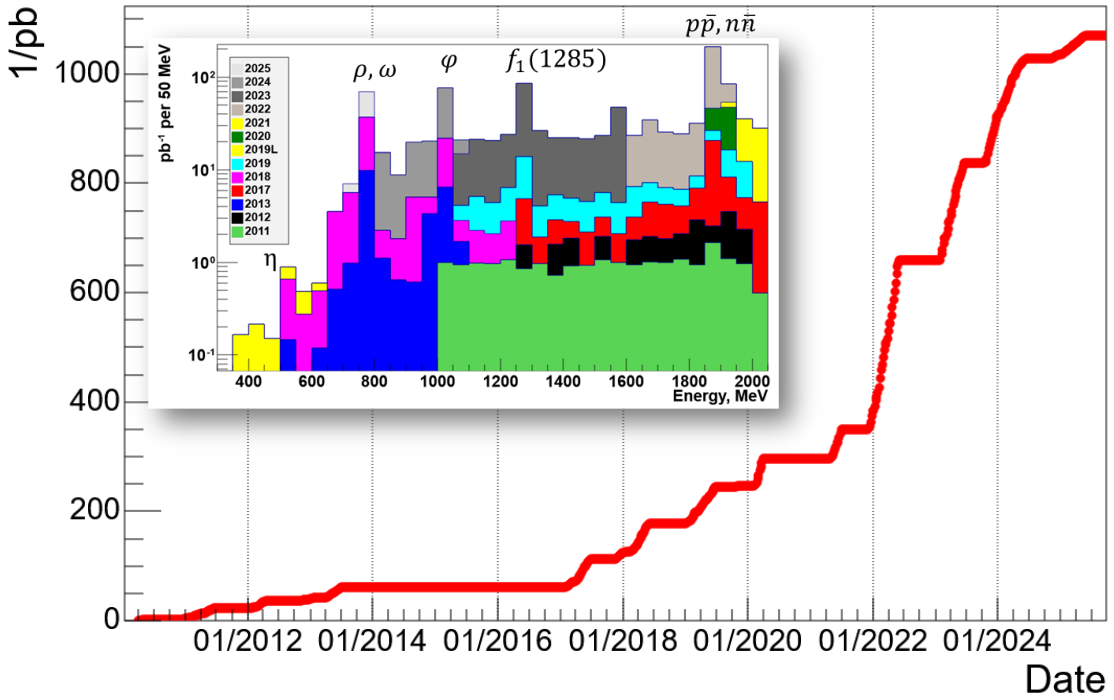


- B field 1.0-1.3 T
- DC resolution
  - $\sigma_{R\varphi} \sim 100\ \mu, \sigma_z \sim 2-3$ mm
- Combined calorimeter (LXE, CsI, BGO), 13.5 X_0
  - $\sigma_E/E \sim 3\% - 10\%$
  - $\sigma_\Theta \sim 5$ mrad



VEPP-2000

Collected integral (per detector)

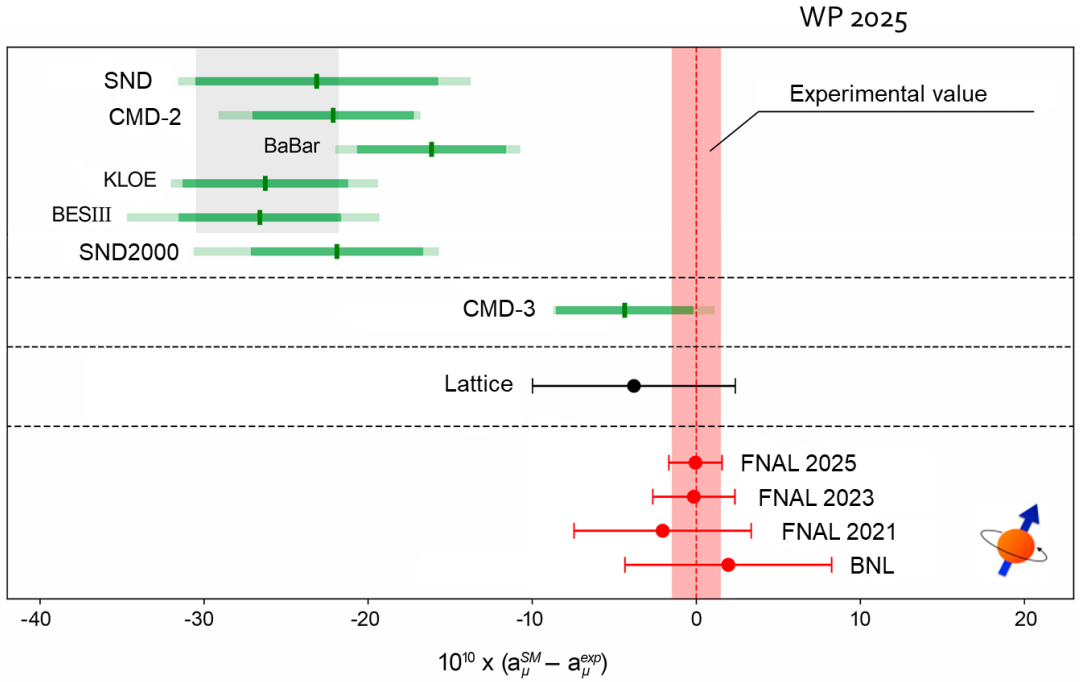


Exclusive final states under analysis

Signature	Final states (preliminary, published)
2 charged	$\pi^+\pi^-, K^+K^-, K_SK_L, p\bar{p}$
2 charged + γ's	$\pi^+\pi^-\gamma, \pi^+\pi^-\pi^0, \pi^+\pi^-\eta, K^+K^-\pi^0, K^+K^-\eta, K_SK_L\pi^0, K_SK_L\eta, \pi^+\pi^-\pi^0\eta, \pi^+\pi^-2\pi^0, \pi^+\pi^-3\pi^0, \pi^+\pi^-4\pi^0$
4 charged	$\pi^+\pi^-\pi^+\pi^-, K^+K^-\pi^+\pi^-, K_SK^\pm\pi^\mp$
4 charged + γ's	$\pi^+\pi^-\pi^+\pi^-\pi^0, \pi^+\pi^-\eta, \pi^+\pi^-\omega, \pi^+\pi^-\pi^+\pi^-\pi^0\pi^0, K^+K^-\eta, K^+K^-\omega$
6 charged	$\pi^+\pi^-\pi^+\pi^-\pi^+\pi^-, K_SK^\pm\pi^\mp\pi^+\pi^-, K_SK_S\pi^+\pi^-$
6 charged + γ's	$3(\pi^+\pi^-)\pi^0$
Neutral	$\pi^0\gamma, \eta\gamma, \pi^0\pi^0\gamma, \pi^0\eta\gamma, \pi^0\pi^0\pi^0\gamma, \pi^0\pi^0\eta\gamma$
Other	$n\bar{n}, \pi^0e^+e^-, \eta e^+e^-$
Rare decays	$\eta', D^*(2007)^0$

Next round of experiments at VEPP-2000

Anomalous magnetic moment of muon



SM estimation of a_μ based on $\sigma(e^+e^- \to hadrons)$ is ~3 times less precise than experimental value

VEPP-2000 energy range is still interesting:

- Need $\sigma(e^+e^- \to \pi^+\pi^-)$ with <0.2% precision (as well as other exclusive final states)
- Dynamics of $e^+e^- \to hadrons$ (amplitude analysis)
- Rare processes

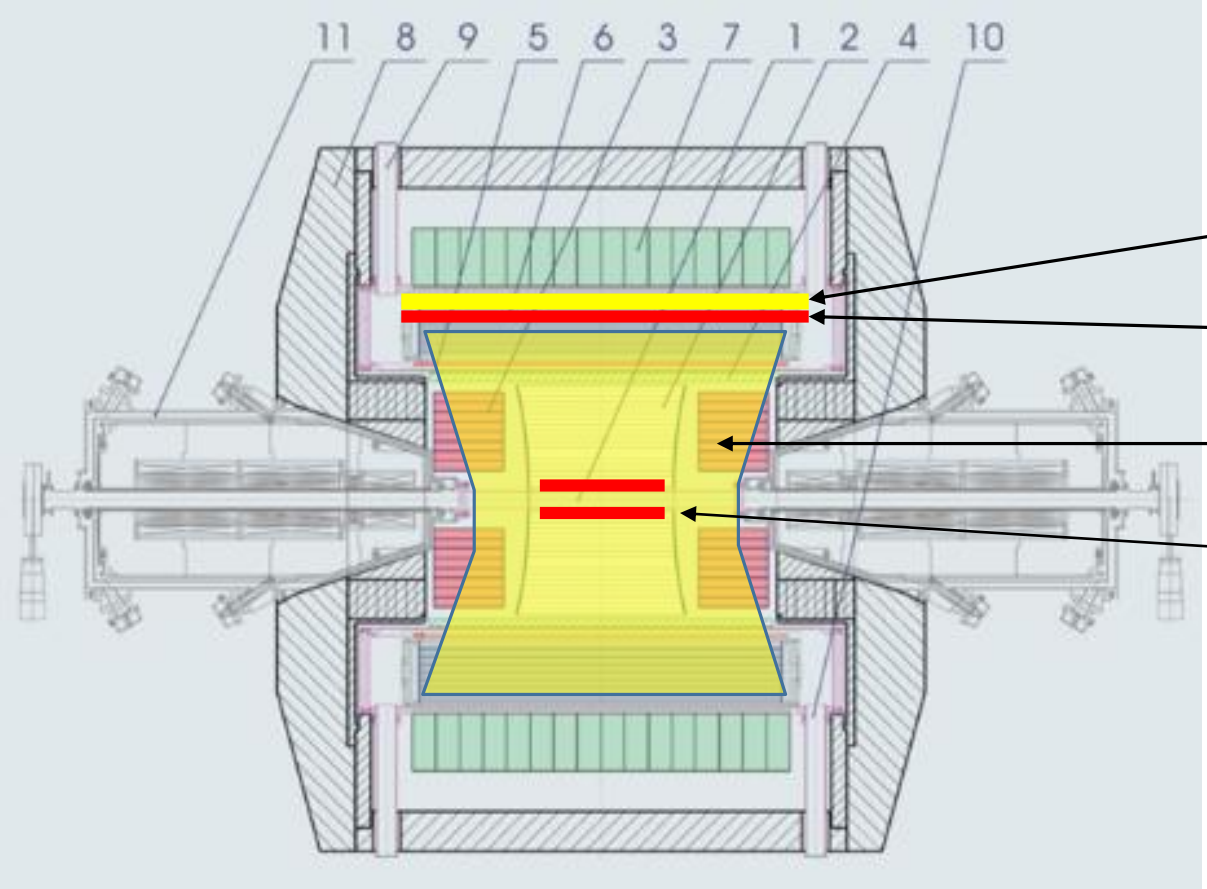
VEPP-2000 luminosity is still the highest in the world in its energy range. The precision is limited by detectors.

2026-2027(?) – continue data taking with existing detectors; work on detectors upgrades

2027(?)-2029 – shutdown for upgrades

~2030 – start data taking with upgraded detectors

CMD-3 upgrades

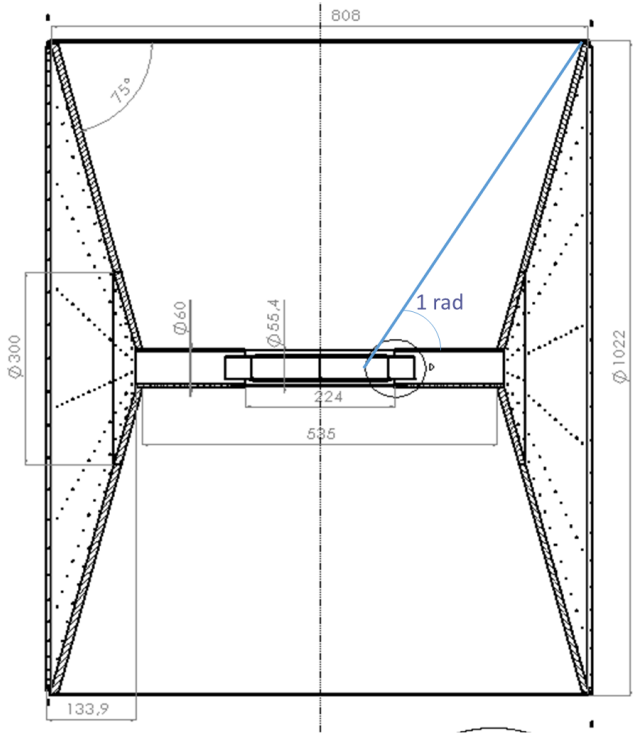


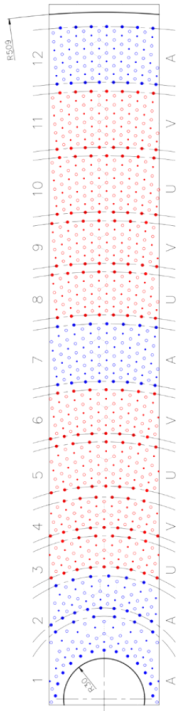
CMD-3 upgrades:

- New SC magnet
- New Z-chamber
- New drift chamber
- New silicon vertex detector
- New electronics

CMD-3 upgrades

New drift chamber



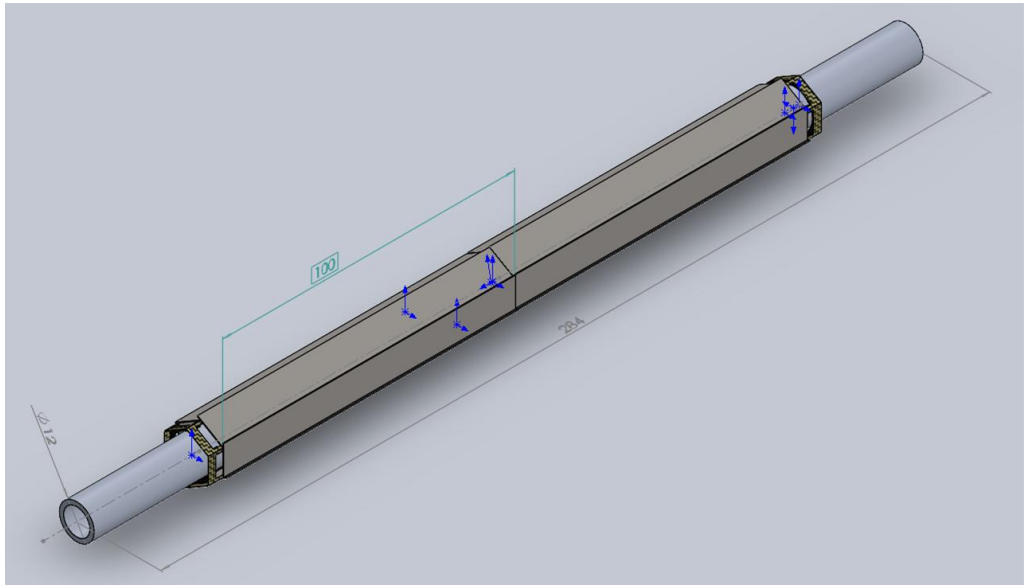


The CMD-3 new drift chamber geometry

INNER DIAMETER, mm	60
OUTER DIAMETER, mm	1018
WIRE LENGTH, mm	535 ... 792
ENDPLATE THICKNESS, mm	
NUMBER OF WIRES:	20 350
• SIGNAL ⌀25 um	5 672
● FIELD ⌀100 um	3 334
○ FIELD ⌀125 um	11 344
TOTAL TENSION LOAD, kg	1 595
ON THE INNER CYLINDER	129
ON THE OUTER CYLINDER	1 466
ENDPLATE FLEXURE (MAX)*, mm	

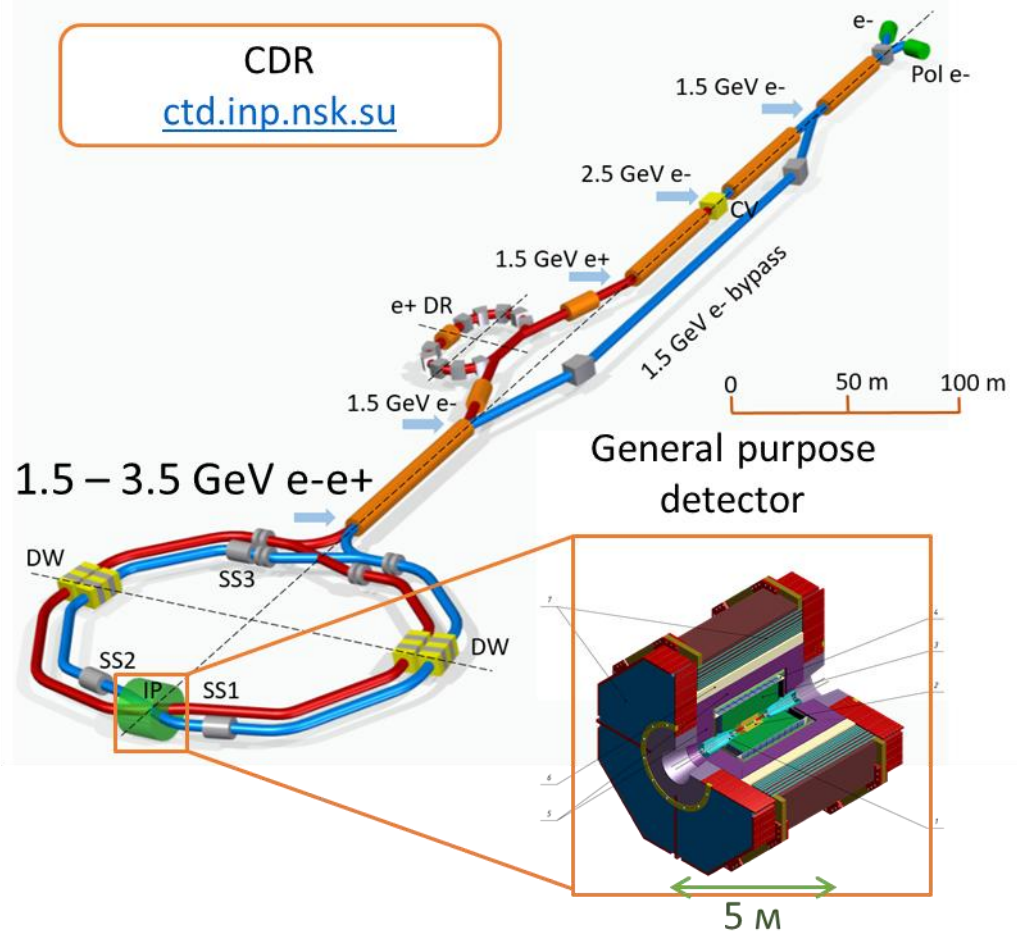
* ENDPLATE MATERIAL:
Aluminum alloy V95 GOST 4784-2019 (ENAW-7075, ISO AlZn6MgCu)

Silicon vertex detector



Dmitrii Kyshtymov. Status of drift chambers development at BINP. Tue, 10:55
Vyachaslav Ivanov. Simulation of SCTF drift chamber. Tue, 11:20

From SCTF to VEPP-6



For many years, Super Charm-Tau Factory (SCTF) was a flagship collider project at BINP

CDR: sct.inp.nsk.su
Physics program: Achasov et al., Phys.Usp. 67 (2024) 55-70

At the moment there is no clear path and/or timeline for SCTF approval for construction. Financial support for R&D finished at 2025.

We are now focused on development of VEPP-6 collider.

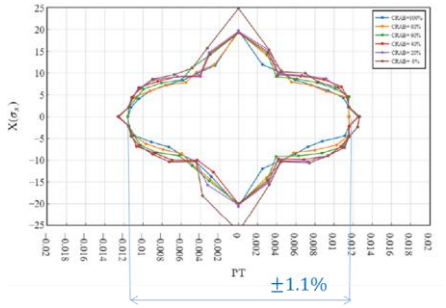
CDR is expected in 2026

There is a lot in common between VEPP-6 and SCTF

SCTF R&D and synergy with other projects

SCTF R&Ds

VEPP-4C
VEPP-6



Collider simulations

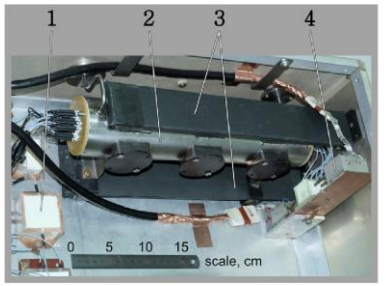
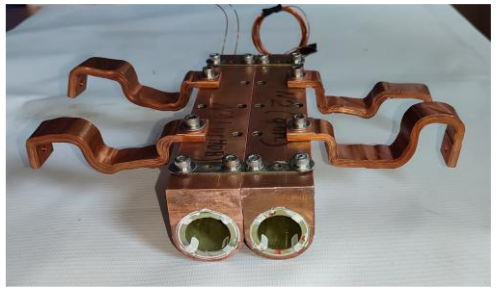


Photo of the small prototype. *The numbers indicate: 1 — high-voltage low-pass filter, 2 — small prototype, 3 — scintillators, 4 — preamplifiers.*

Drift chamber

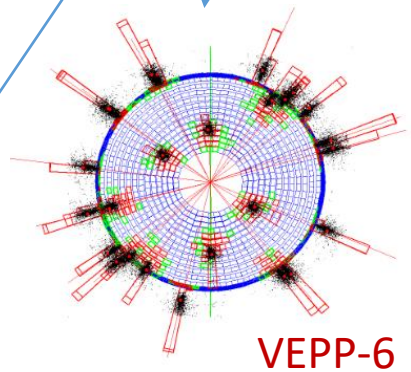
CMD-3
VEPP-6



FF design

VEPP-4C
VEPP-6

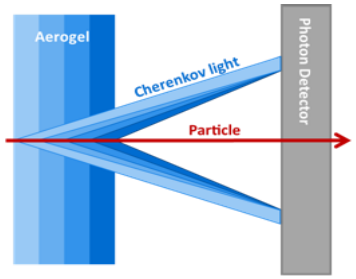
…



VEPP-6

Detector Simulations

Daniil Zhadan. Status of BINP SCT software. Tue, 9:00



FARICH-based PID

SPD (JINR)

pCSI Calorimeter

VEPP-6

From A.Bogomyagkov

- e^+e^- collider - J/ψ factory and beyond
  - Beam energy from <0.5 to 1.6 GeV (J/ψ) (2.1 GeV)
  - Luminosity $\mathcal{L} \approx 10^{34}\ cm^{-2}c^{-1}$ @ 1.6 GeV
  - Located at BINP (Novosibirsk)
- General purpose detector
- Physics
  - J/ψ decays, physics of light hadrons

  $5 \times 10^{11}\ J/\psi$: $5 \times 10^8\ \eta$, $3 \times 10^9\ \eta'$, $10^{10}\ a_2/f_2$, $10^9\ \Lambda\bar{\Lambda}$,…
  - Baryon thresholds
  - Measurement of $e^+e^- \to hadrons$, direct/ISR

E, MeV	500	1000	1550	2100
Π, m	388			
2θ, mrad	50			
β_x^*/β_y^*, mm	150/3			
I_{tot}, A	0.4	0.78	1.5	1.5
ε_x, nm	66	34	31	31
$\varepsilon_y/\varepsilon_x$	0.006			
ξ_x/ξ_y	0.005/0.03	0.008/0.05	0.01/0.1	0.01/0.1
$T_{Touschek}$, s	900	900	1100	2000
$\mathcal{L}$, $10^{32}cm^{-2}s^{-1}$	**3** DAΦNE: 2-4	**26** VEPP-2000: 0.9	**140** BEPCII: 3.1	**200** BEPCII: 10

Anton Bogomyagkov. Parameters optimization of e+e- crab waist colliders at low energy. Mon, 14:30
Mikhail Skamarokha. Emittance optimization in CW colliders for Touschek lifetime enhancement. Tue, 9:25

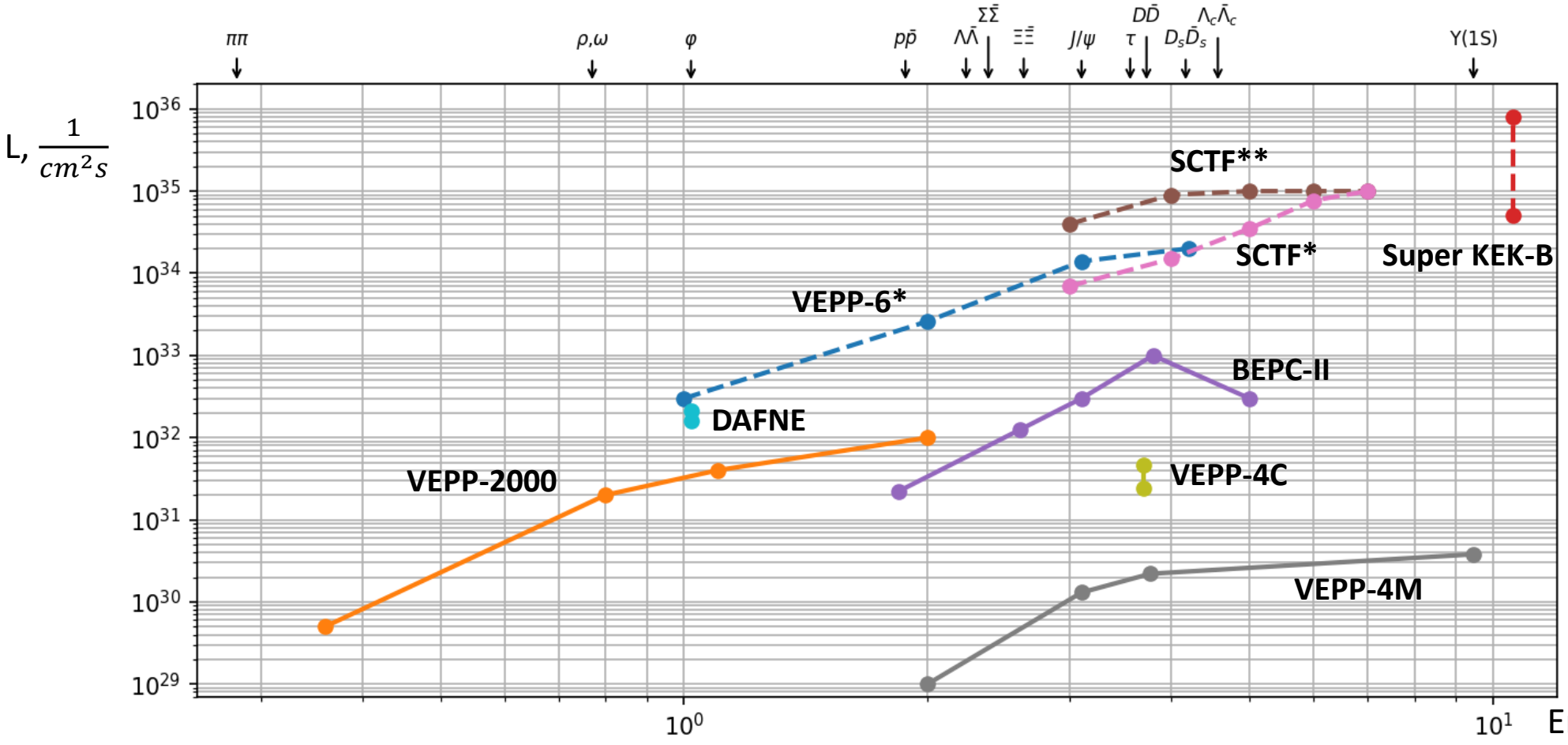
VEPP-6 physics: selected topics

- **Near threshold anomalies (strong interactions of light hadrons)**
  - Since the first observation of the X(3872) near the DD* threshold extensive search for similar effects have been performed in virtually all HEP experiments, mainly systems with heavy flavors. Many XYZ particles observed.
  - Observations with light hadrons:
    - Energy dependence of $e^+e^- \to$ *light hadrons* cross section at the NN-bar threshold (CMD-3, BABAR)
    - Possible non-conventional state ϕ(2170) in strange sector has been observed by BESII and BaBar.
  - VEPP-6: a detailed and systematic study of such anomalies at low energies, including analysis of the internal dynamics (and isospin structure) via the amplitude analysis.
- **Nucleon and hyperons form factors**
- **Physics of light mesons in charmonium decays** (radiative decays, gluon enriched environment,…)
- **Rare and forbidden processes** ($e^+e^- \to D^{*0}$, weak decays,…)

Work is underway to develop a comprehensive program

Kirill Chilikin. High-statistics amplitude analyses of charmonium decays. Tue, 14:50
Alexander Bobrov. Measurement of the $e^+e^- \to p\bar{p}$ cross section near threshold with a high energy resolution. Wed, 9:50

Colliders at a glance



SCTF/VEPP-6:

*τ_T ≥900 sec

**τ_T ≥300 sec

Road to VEPP-6

Development of VEPP-6 is a long journey

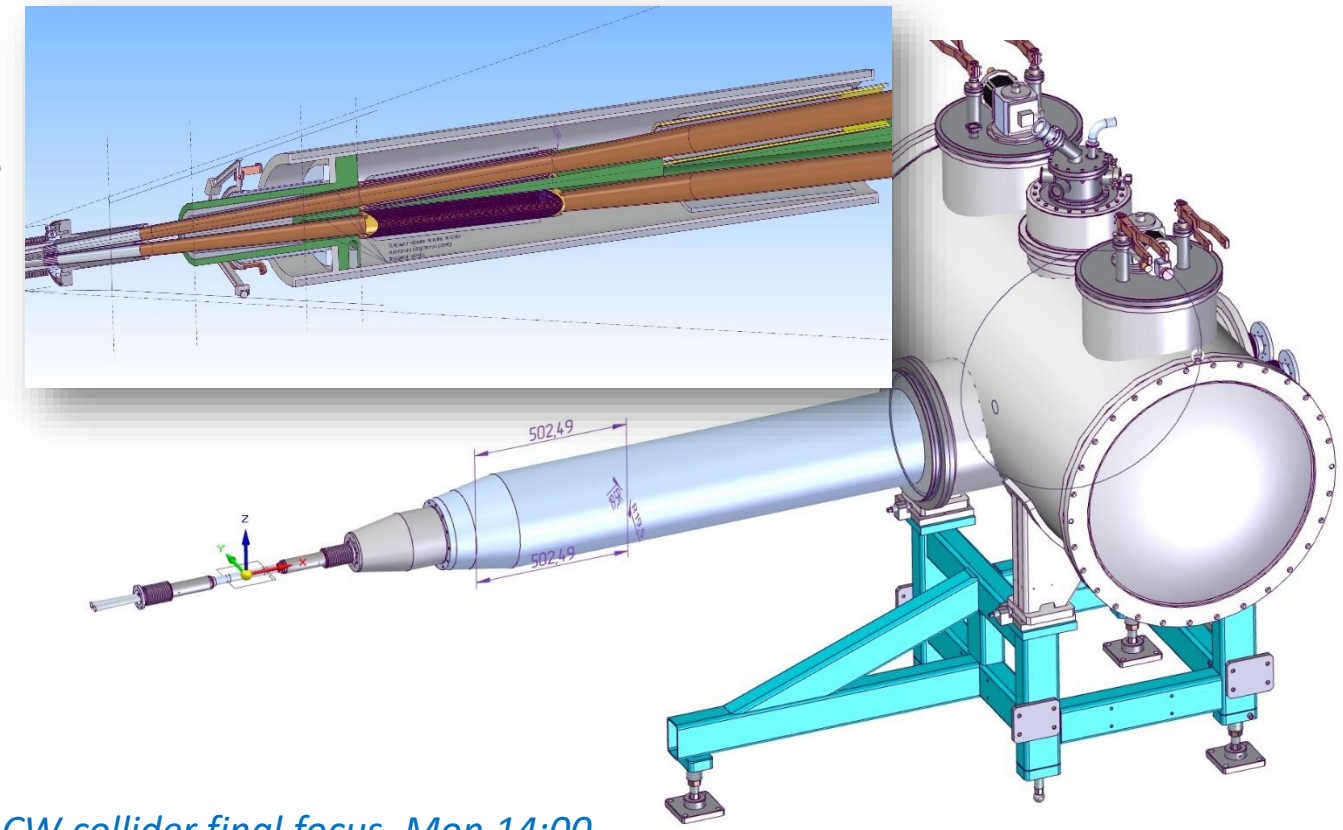
- In 2025 VEPP-6 project was included to the draft of Russian federal program, developed by Russian Academy of Science.
- There are groups, working on development of detailed CDR for physics program, accelerator and detector
- Many results obtained within SCTF R&D program are relevant for VEPP-6
- Independent of the obtaining government support for the whole project, we plan to perform two critical R&D studies
  - Full-scale test of the final focus
  - VEPP-4C: test of the crab-waist at VEPP-4M

Full-scale test of the final focus

- Done: test of CCT lenses for FF
- Under development: technical design of the full FF installation
- Plan to build the full installation and to perform complete set of tests

Designed for VEPP-6, beneficial for STCF and other CW-based projects.

Topic for discussion: to implement FF test as joint project of VEPP-6 and STCF teams



Alexander Krasnov. Preliminary design of the BINP CW collider final focus. Mon,14:00
Nikolay Meznetsev. Development of the Canted Cosine Theta magnets for the CW final focus. Tue, 14:25

VEPP-4C: CW test at VEPP-4M

- Idea: use existing VEPP-4M facility and FF installation to perform comprehensive study of crab-waist technique (VEPP-4C)

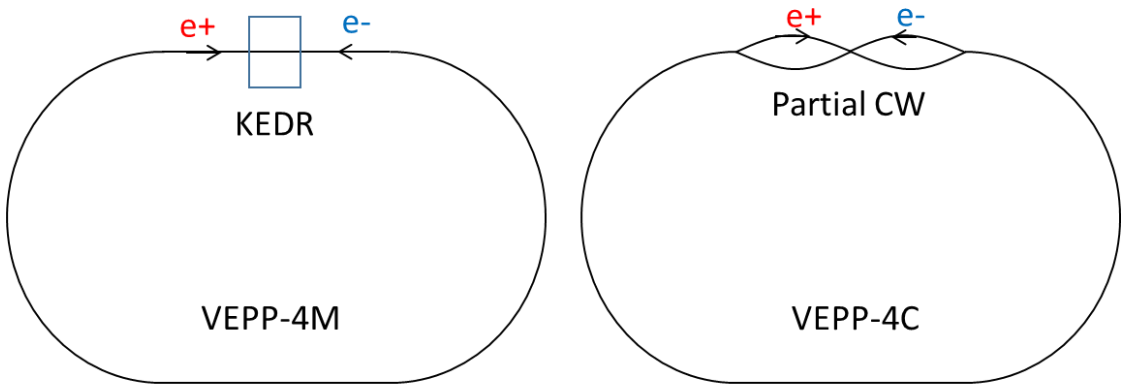
  VEPP-4M straight section is modified.
  Electrostatic separation of colliding beams.

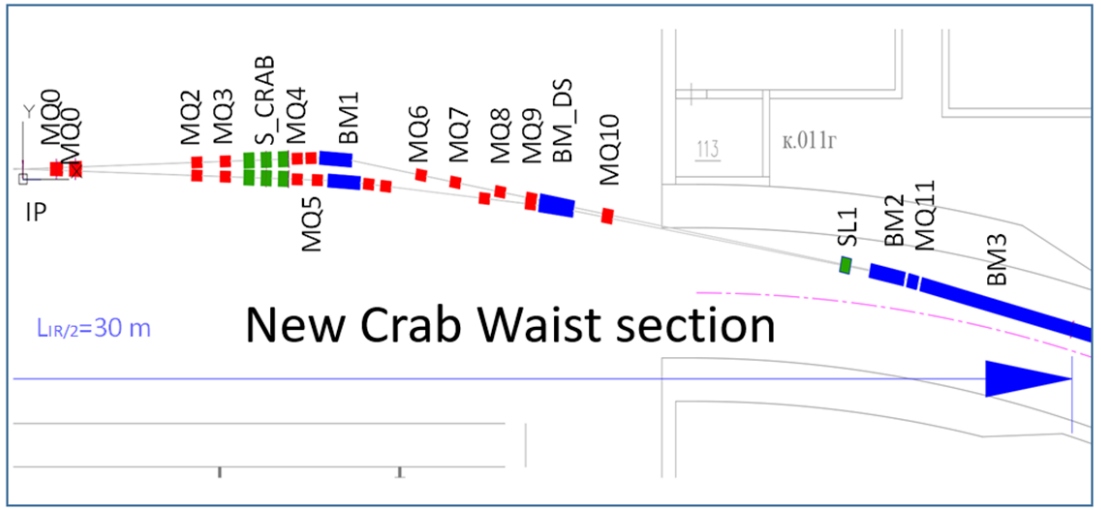
  20-50x luminosity of VEPP-4M

- What can be tested

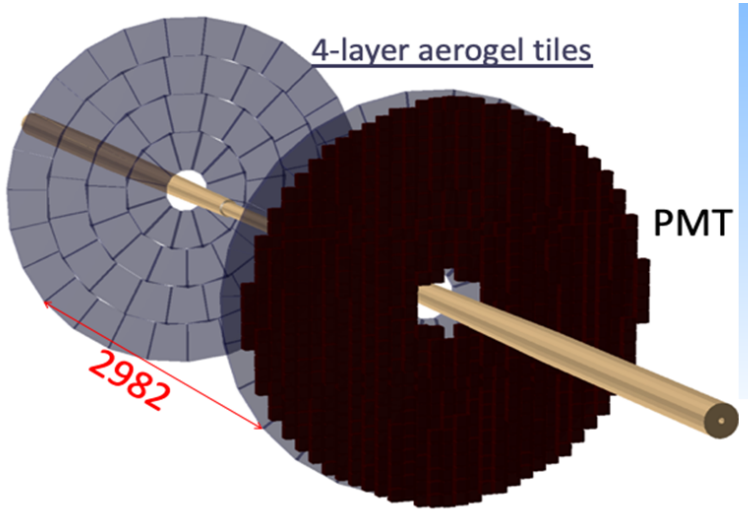
  final focus elements, nonlinear beam dynamics, beam-beam effects, backgrounds,…

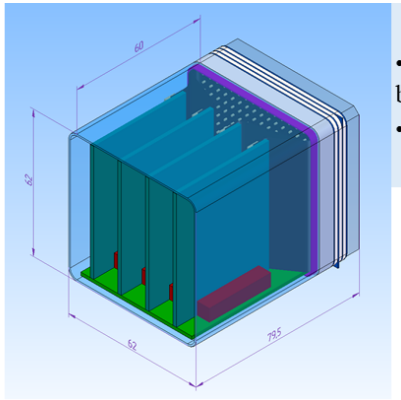
- Beneficial for all future collider projects, including STCF – topic for collaboration





Other R&D efforts: FARICH





Rectangular MCP PMT with active area 50x50mm

- Construction and design are under development in Novosibirsk by BINP and Ekran FEP in close cooperation
- All details and components will be produced in Russia

Goal parameters:

- 62× 62 mm^2 total area
- 50× 50 mm^2 sensitive area
- 16× 16 pixels with 3×3 mm size
- Multi-alkali or Bi-alkali PCs extended in blue region
- Fused silica entrance window
- Gain ≥5·10^5

SPD – FARICH system concept

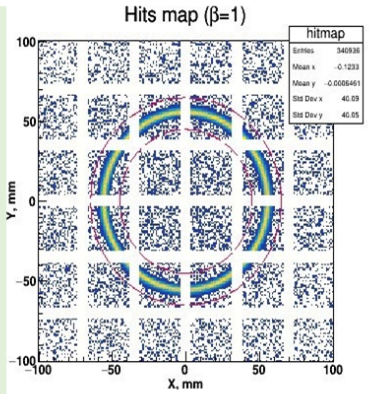
Aerogel:

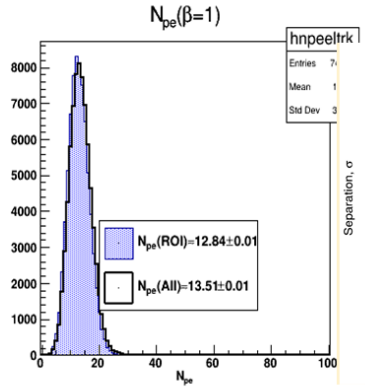
- 2 end-caps × 74 tiles (4 form-factors)
- 4-layer focusing aerogel:
  - n_{max}≤1.05 (to be optimized soon)
  - Total thickness 35÷40 (to be optimized)
  - Focus distance ~20 cm

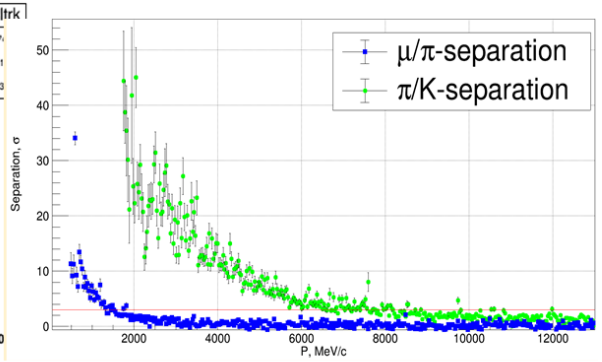
Position-sensitive MCP-PMT:

- 2 × 2200 PMTs ~33×33 mm^2 (pixel 3×3 mm^2) from Ekran FEP (soon)
- 2 × 550 PMTs ~60×60 mm^2 (pixel 3×3 mm^2) from BINP & Ekran FEP's R&D

Expected system parameters (obtained in G4 simulation)



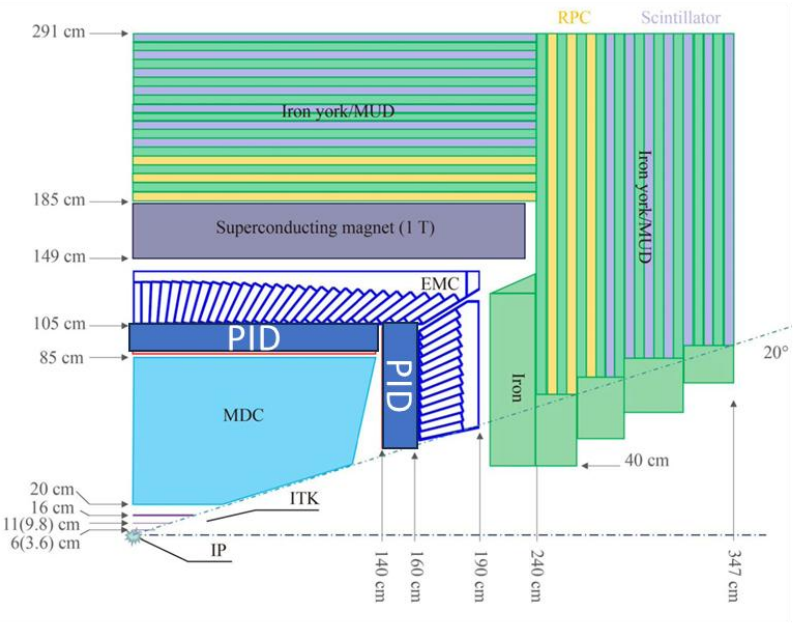


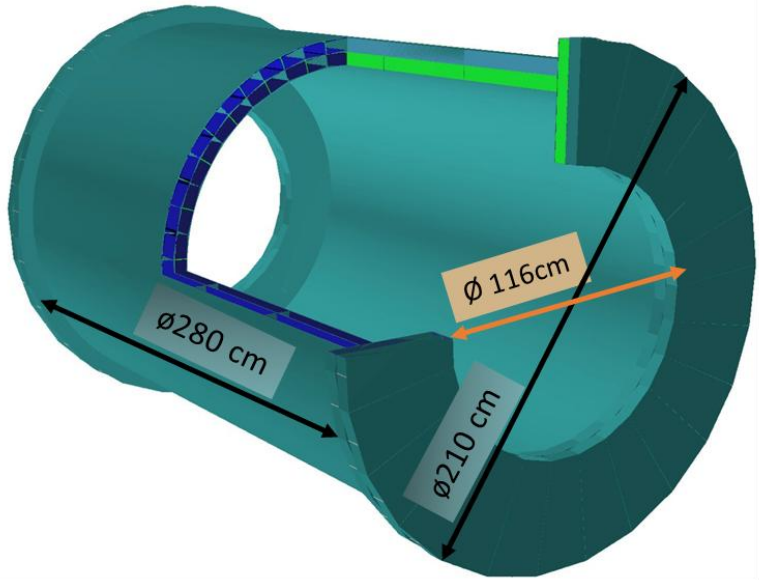


- FARICH is the key option for PID at SCTF
- We are working now on FARICH-based endcap PID for SPD detector (JINR)

Alexander Barnyakov Prospects of aerogel R&Ds at the BINP. Wed,9:20

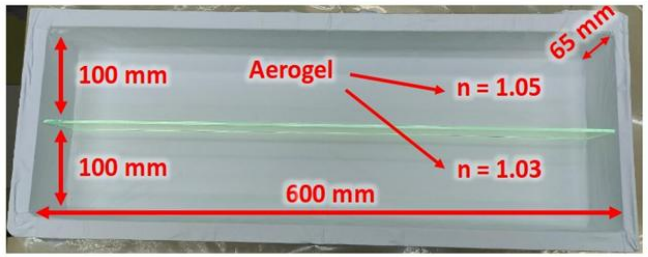
Other R&D efforts: ASHIPH PID for STCF





- ASHIPH based PID system was proposed for STCF in 2024
- There is collaborative R&D on this option between FDU, USTC and BINP

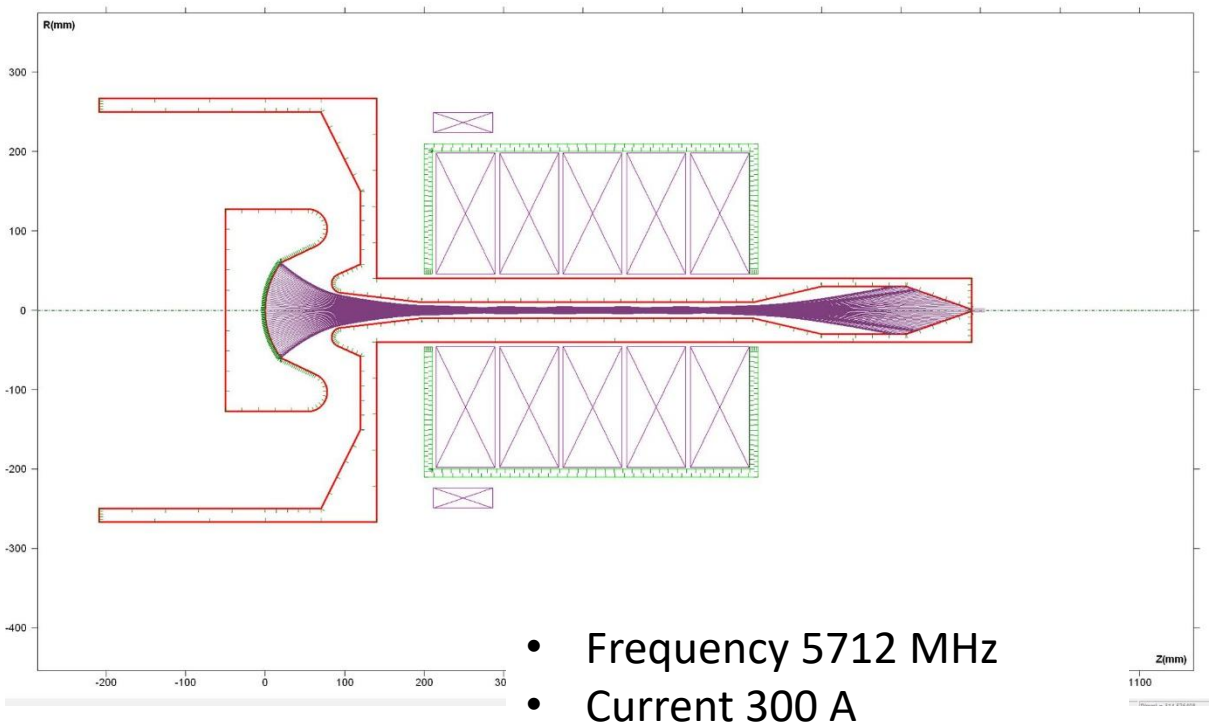
Kirill Petrukhin. R&D on ASHIPH system for the STCF. Wed, 9:00



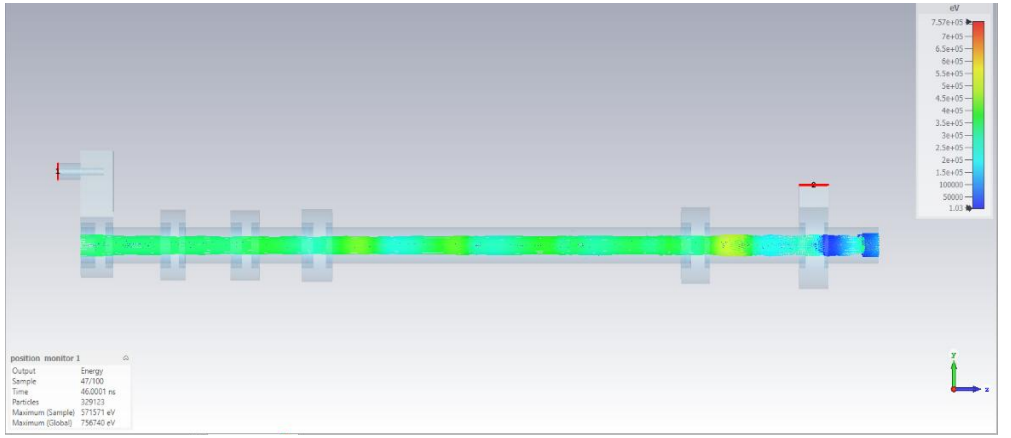
• The first ASHIPH-SiPM prototype was assembled in China in 2025 due to close cooperation FDU, USTC and BINP teams!
• The ASHIPH-SiPM prortotype was tested with mixed hadron beams at the CERN beam test facilities for the first time in October 2025!!

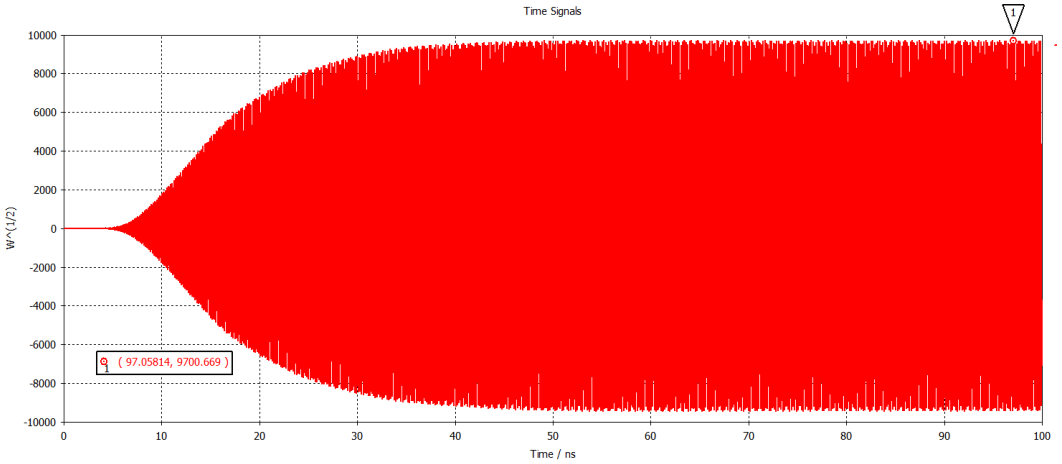
Very important experimental results are coming soon!!!

Other R&D efforts: 6 GHz linac/klystron

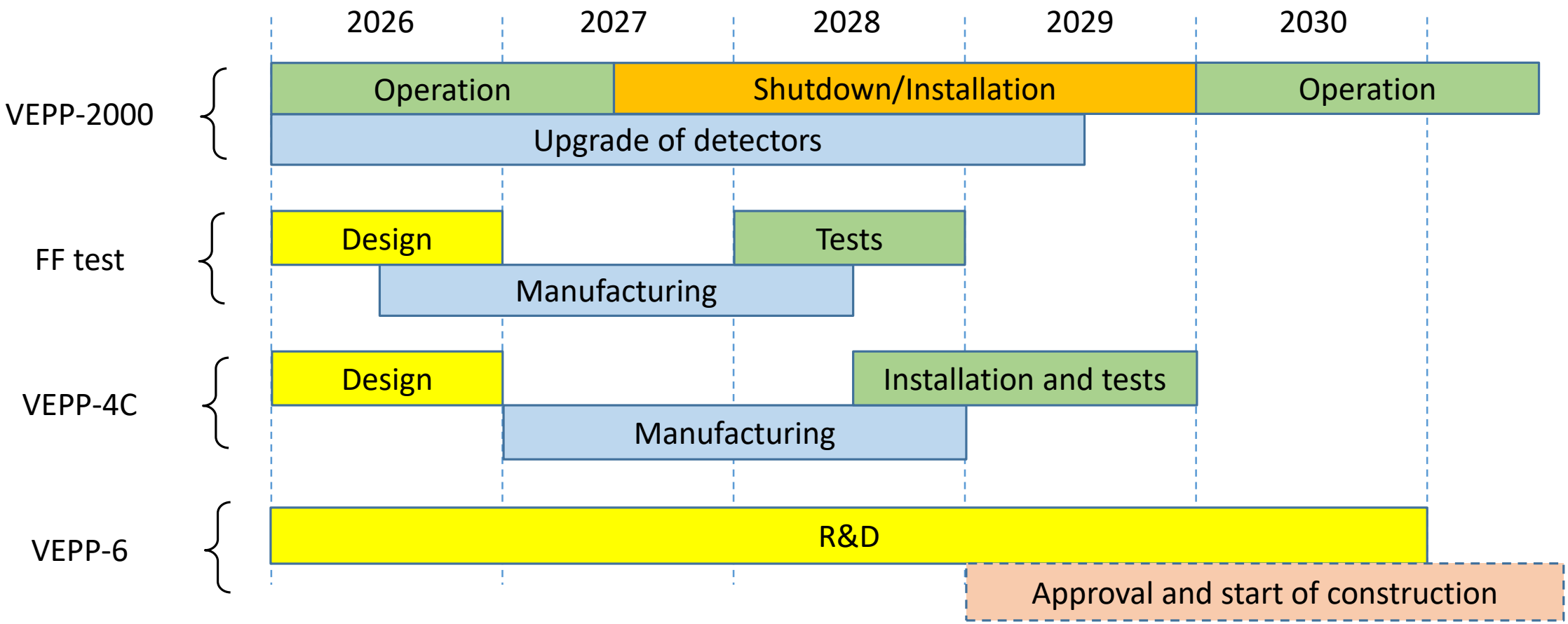


- Frequency 5712 MHz
- Current 300 A
- Voltage 400 kV
- RF power 50 MW





Optimistic timeline for the next 5 years



Conclusion

There is diverse HEP/colliders program at BINP, which fully utilizes the existing infrastructure

1. VEPP-2000 is the highest luminosity collider in the world at energies below 2 GeV. The new round of experiments is planed after upgrade of detectors, now in progress.
2. The full-scale test of final focus design is an important step toward the development of all future crab-waist-based colliders
3. VEPP-4C allows to perform comprehensive study of crab-waist technique using existing infrastructure of VEPP-4M collider
4. VEPP-6 is the flagship collider at BINP aimed at detailed study of strong interactions of light hadrons and search of new phenomena. Physics program of VEPP-6 is complementary to STCF physics program.

Many of these projects can be implemented as collaborative effort of BINP and STCF teams