Hadron physics with Simon Eidelman

Boris Shwartz,

Budker Institute of Nuclear Physics,
Novosibirsk State University

Our colleague and friend, Simon Eidelman, a leading researcher at the Budker Institute of Nuclear Physics in Novosibirsk and a professor of Novosibirsk State University, died on June 28, 2021.

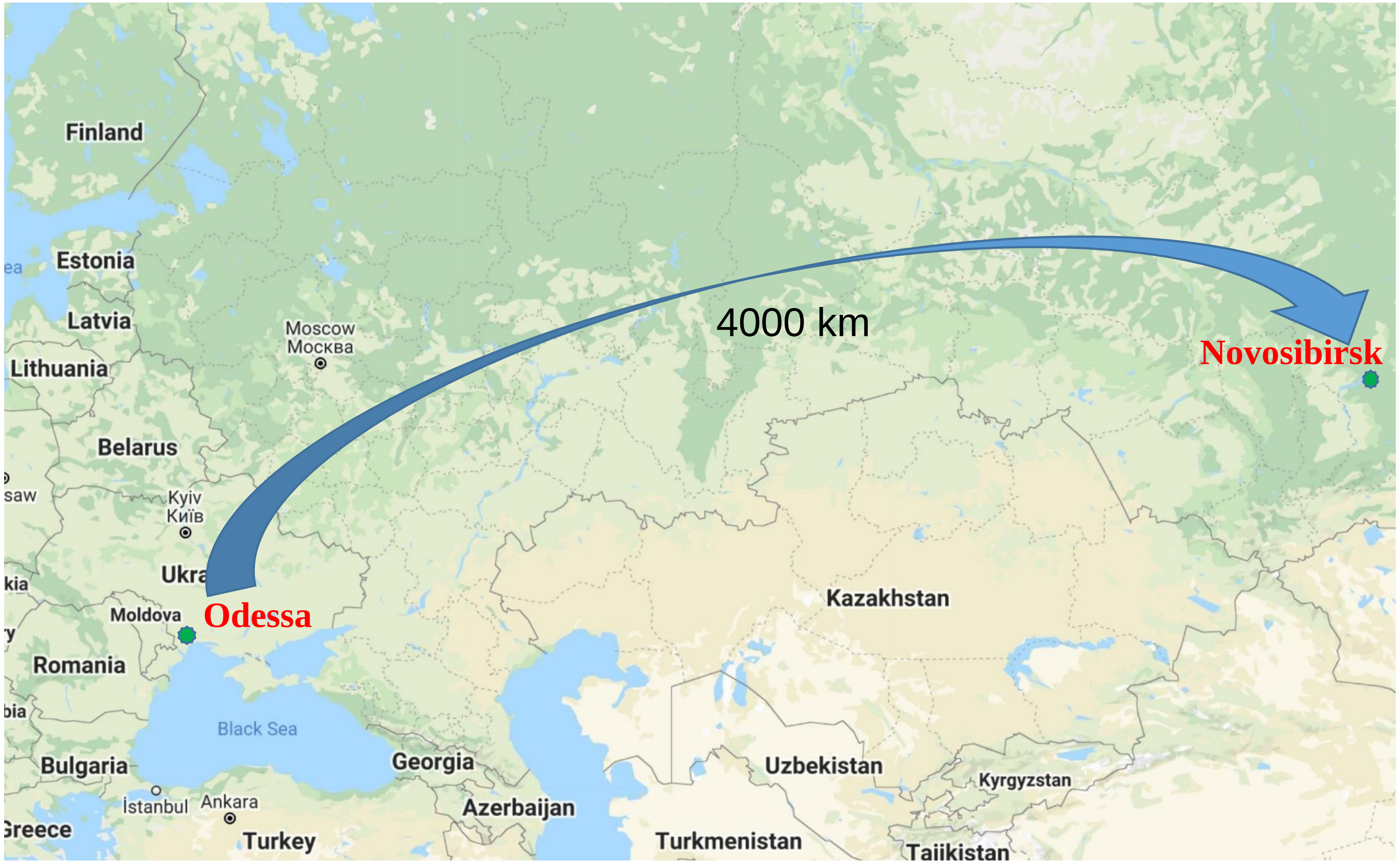
We received more than 100 responses with expressions of condolenses, from his colleagues over all the world and from collaborations which he belonged. Here I would like to quote only one of these messages, from Steve Olsen, that, I believe, expresses the common sentiments.

Date: Tue, 29 Jun 2021 08:05:49 +0900
From: Stephen Lars Olsen

Shocking news. Please pass on my condolences to Simon's family & his Budker Institute colleagues. In our long collaboration, Simon and I worked closely together on many of Belle's papers. For me this was a continuous learning project, with Simon gently but firmly correcting my physics and then politely explaining what I was getting wrong. But not only physics! Simon would often just as gently and just as firmly correct my English. He knew and understood all the grammar rules that I suppose I was taught in HS but that never registered (was I sleeping?). Like the physics, he was usually right. Amazing man. I will really really miss him.

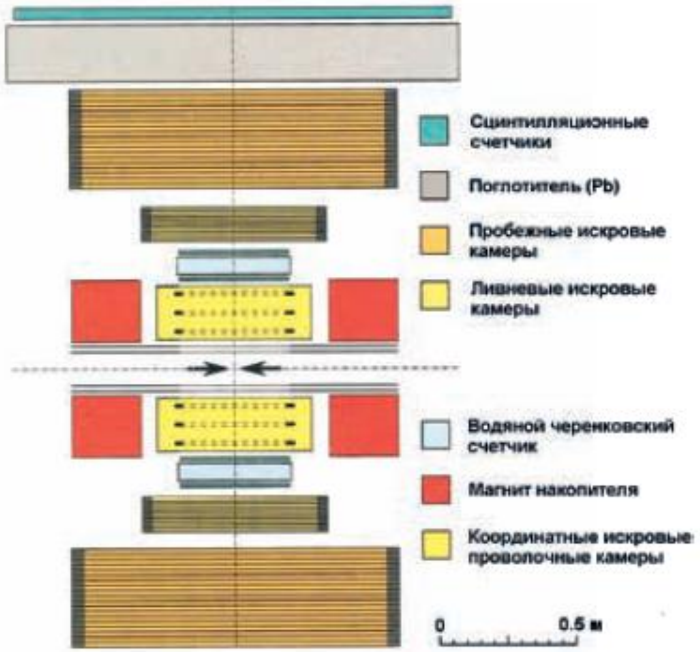
Steve

Simon (Semyon) Eidelman was born in Odessa in 1948. He went to Novosibirsk at age 15, to enter to a special high school for extraordinarily gifted students.



He then studied physics at Novosibirsk State University. Being undergraduate student, in 1968, Simon joined the Budker Institute of Nuclear physics and remained there his entire professional life. In parallel, for many years Simon was a faculty member at the Physics Department of Novosibirsk State University. He held the High Energy Physics Chair for ten years. Simon always cared for, helped and supported students and young colleagues.

Simon's scientific activity was mostly connected with experiments at electron-positron colliders. He started his career by participating in the discovery of multihadron events at VEPP-2, a pioneering e^+e^- collider.



Volume 42B, number 4 PHYSICS LETTERS 25 December 1972

OBSERVATION OF MULTIHADRONIC EVENTS IN e^+e^- COLLISIONS AT THE ENERGY OF 1.18–1.34 GeV

L.M. KURDADZE, A.P. ONUCHIN, S.I. SEREDNYAKOV, V.A. SIDOROV and S.I. EIDELMAN
Institute of Nuclear Physics, Novosibirsk, USSR

First e^+e^- collider VEPP-2, E_{CM} up to 1.4 GeV

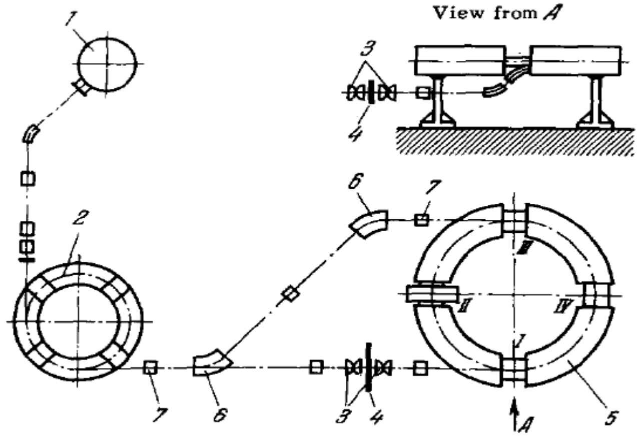


FIG. 4. General arrangement of the VÉPP-2 installation. 1 – Injector, 2 – B-3M synchrotron, 3 – parabolic lenses, 4 – converter, 5 – storage track, 6 – turning magnets, 7 – quadrupole lenses.

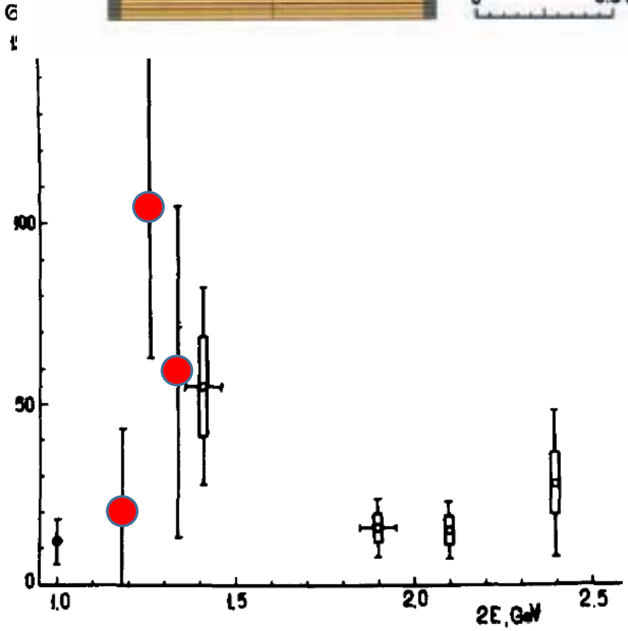
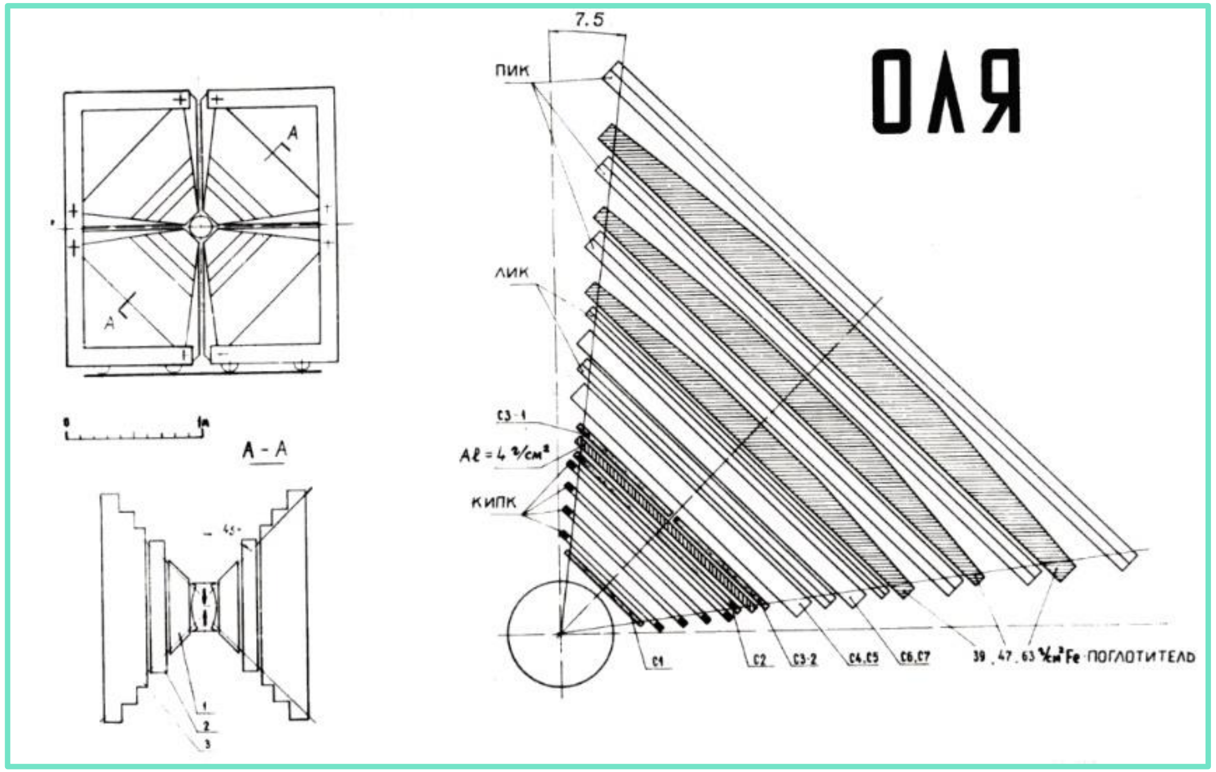


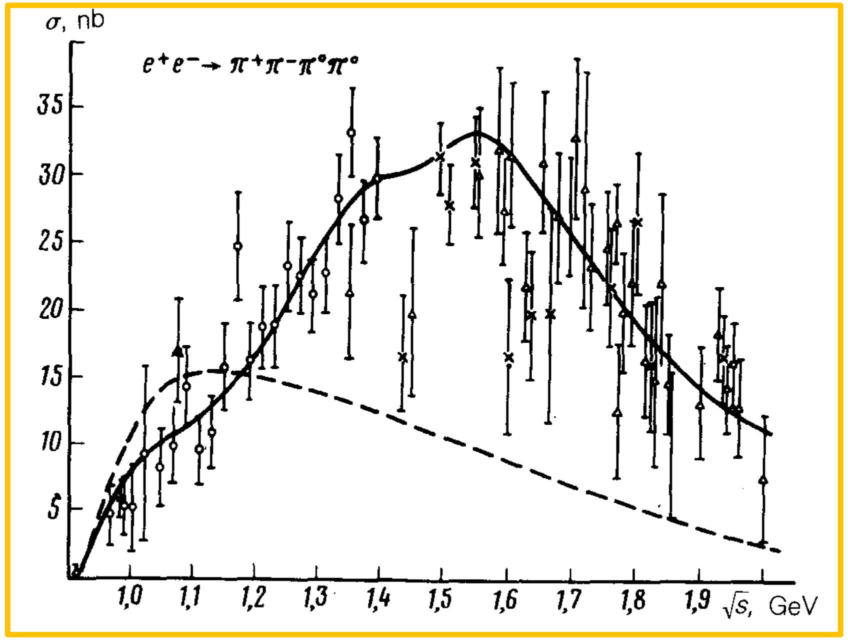
Fig. 3. The total cross-section of the multihadronic processes $e^+e^- \rightarrow$ more than 2 charged pions: ACO – [21], VEPP-2 – this paper, ADONE–$\gamma\gamma$ – [19].

Then, in 1974, Simon moved to experiments with the OLYA detector at the new collider VEPP-2M, where comprehensive study of electron-positron annihilation into hadrons was performed in the energy range up to 1.4 GeV.

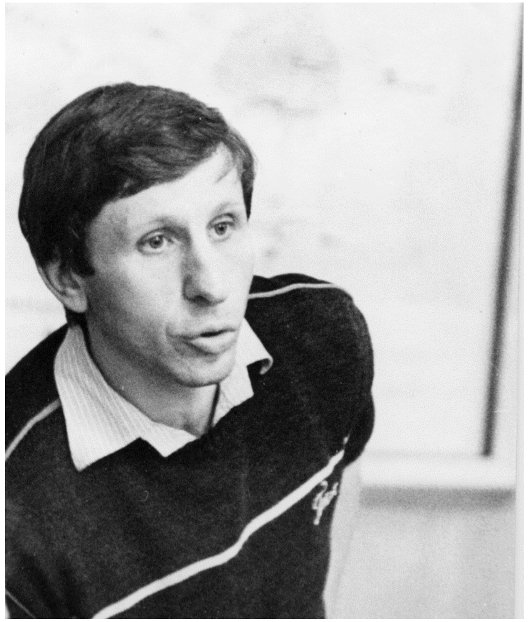


VEPP-2M – e^+e^- collider (1974-2000), max ECM 1.4 GeV, $L_{max} = 3\times10^{30}$ $cm^{-2}s^{-1}$

Simon's main tasks in the OLYA experiments: MC simulation, data processing, radiation corrections calculation, analysis of the four pion channels



Study of the Reaction $e^+e^- \to \pi^+\pi^-\pi^0\pi^0$ at 2E Up to 1.4 GeV,
L.M. Kurdadze, …, S.I.Eidelman, JETP Lett. 43 (1986) 643-645,
Pisma Zh.Eksp.Teor.Fiz. 43 (1986) 497-499
Study of e+e−→π+π−π+π− Reaction at 2E Up to 1.4 GeV,
L.M. Kurdadze, …, S.I.Eidelman, JETP Lett. 47 (1988) 512-515,
Pisma Zh.Eksp.Teor.Fiz. 47 (1988) 432-434



Theoretical works:

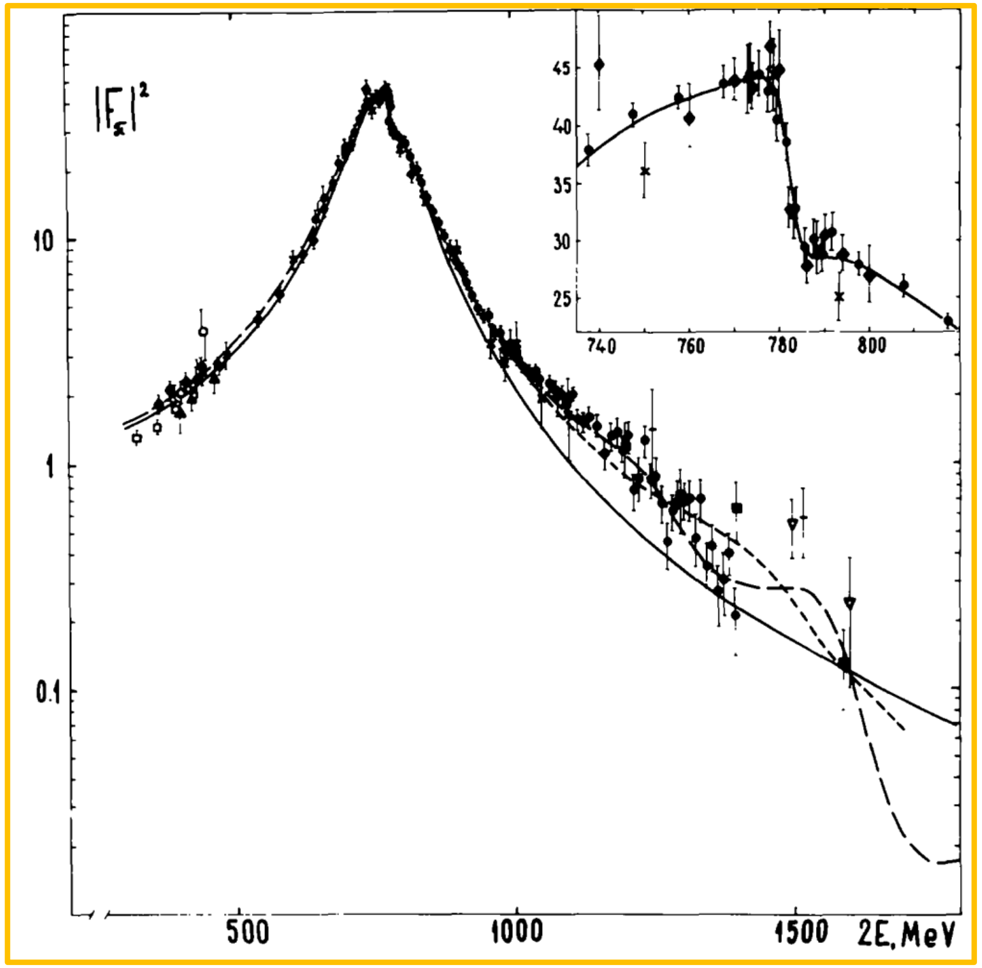
F Meson Contribution to Charge Asymmetry of π Mesons in the Reaction $e^+e^- \to \pi^+\pi^-$,
V.N. Novikov, S.I. Eidelman, Yad.Fiz. 21 (1975) 1029-1032

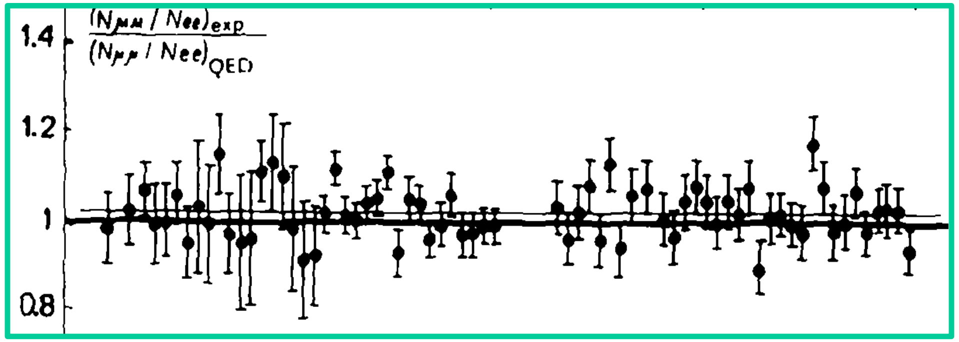
e^+e^- Annihilation Into Two and Three Photons at High-Energy
S.I. Eidelman, E.A. Kuraev, Nucl.Phys.B 143 (1978) 353-364

OLYA – pion form factor measurements

Combined results of OLYA and CMD detectors were published in:
Electromagnetic Pion Form-Factor in the Timelike Region
L.M. Barkov et al., Nucl.Phys.B 256 (1985) 365-384

$$a_H = (68.4 \pm 1.1) \times 10^{-9}$$





On the basis of the precise data on hadron cross sections Simon with co-authors (L.M.Kurdadze, A.I.Vainstein) performed the first comparison of the QCD sum rules with experiment.

e^+e^- Annihilation Into Hadrons Below 2-GeV. Test of QCD Predictions

S.I. Eidelman, L.M. Kurdadze, A.I. Vainshtein, Phys.Lett.B 82 (1979) 278-280

$$\int_{4m_\pi^2}^{\infty} e^{-s/M^2} R^{I=1}(s)\,ds = \frac{3}{2}M^2\left[1 + \frac{\alpha_s(M)}{\pi} + \frac{\pi^2}{3}\frac{\langle 0|(\alpha_s/\pi)G^a_{\mu\nu}G^a_{\mu\nu}|0\rangle}{M^4} - \frac{448\pi^3\alpha_s}{81}\frac{|\langle 0|\bar{q}q|0\rangle|^2}{M^6}\right],$$

$$R^{I=1} = \frac{\sigma(e^+e^- \to \text{hadrons}, I=1)}{\sigma(e^+e^- \to \mu^+\mu^-)}$$

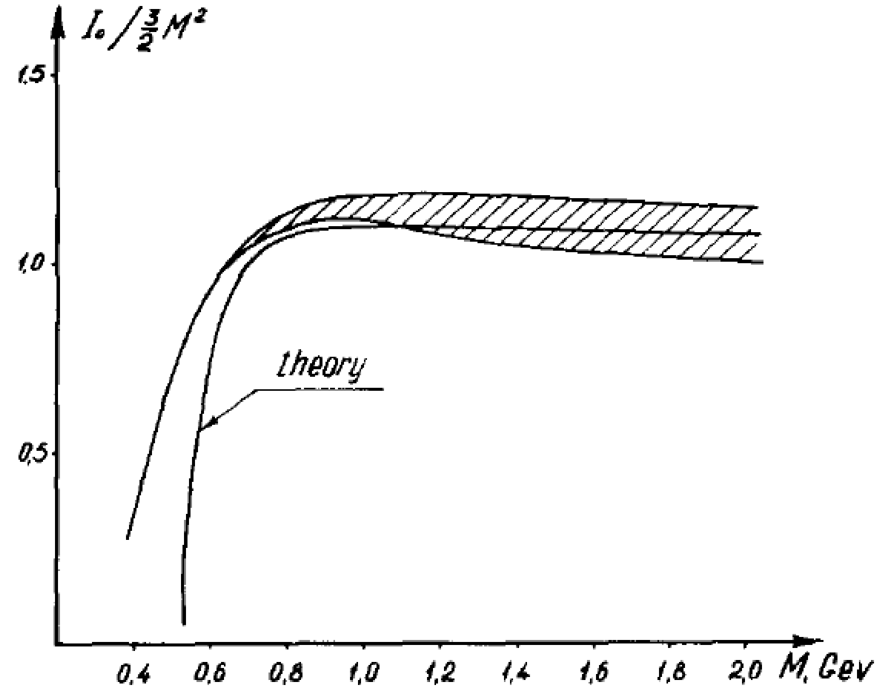


Fig. 2. Comparison of the first sum rule with experiment. $I_0 = \int_{4m_\pi^2}^{\infty} e^{-s/M^2} R^{I=1}(s)\,ds$.

At the end of 1979 the e+e− collider VEPP-4 at BINP came into operation. The first experiment at this collider was performed with the OLYA detector. During March – April 1980 a measurement of the J/Ψ and Ψ’ masses was performed using resonance depolarization method of the beam energy calibration. Simon actively participated in this work.

HIGH PRECISION MEASUREMENT OF THE PSI AND PSI-prime MESON MASSES
A.A.Zholents et al.,
Phys.Lett.B 96 (1980) 214-216.

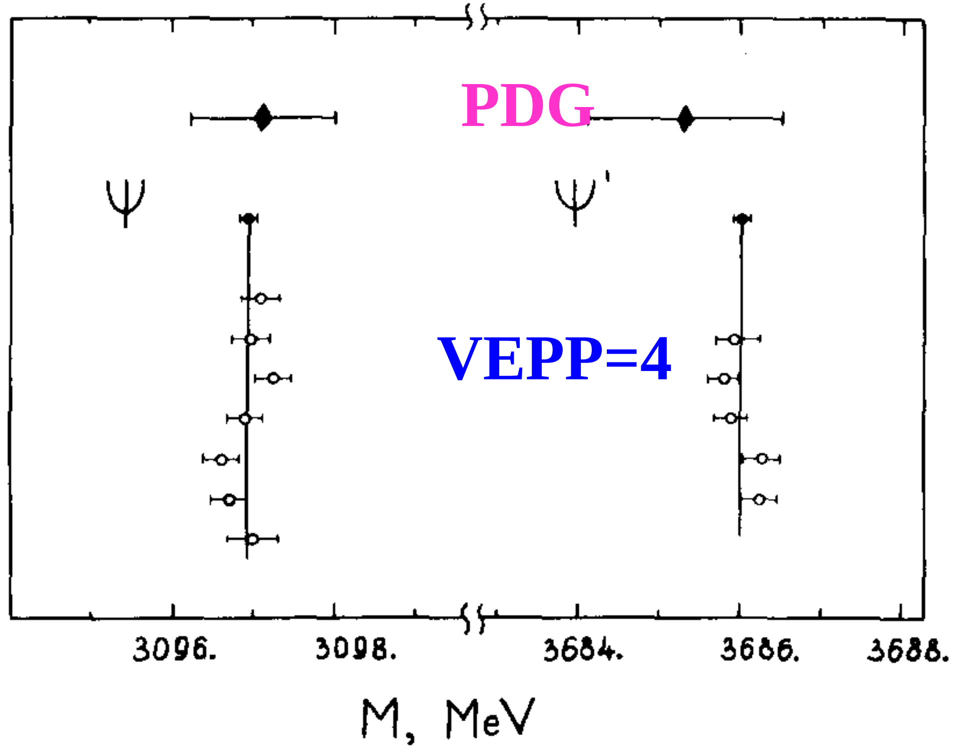


Fig. 2. Results of the Ψ- and Ψ′-meson mass measurements at VEPP-4. Open circles show the values obtained in separate cycles, dark circles are the weighted average. The diamonds correspond to the world averages.

CERN – ISR

In the beginning of eighties Simon visited CERN for several months and took part in the experiments with Axial Field Spectrometer at ISR

A comparison of direct photon, pi0, and eta production in p anti-p and pp interactions at the CERN ISR
Axial Field Spectrometer Collaboration
T. Akesson et al.,
Phys.Lett.B 158 (1985) 282-288

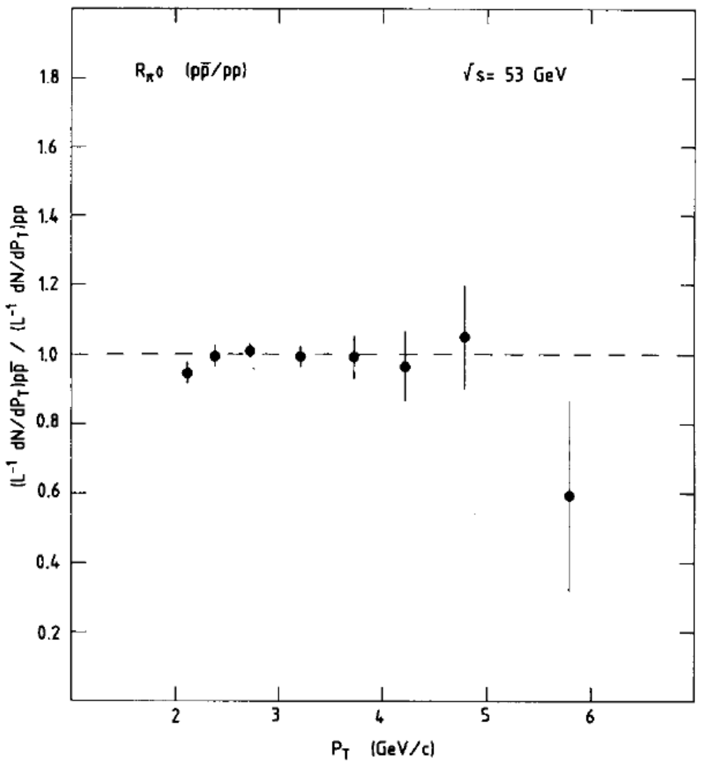


Fig. 3. Ratio of π^0 production obtained in $p\bar{p}$ collisions to that obtained in pp collisions.

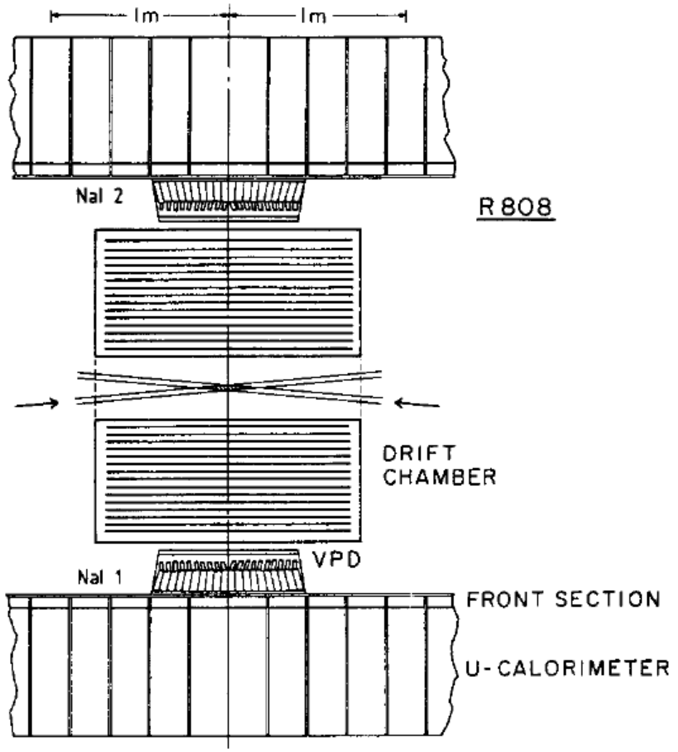
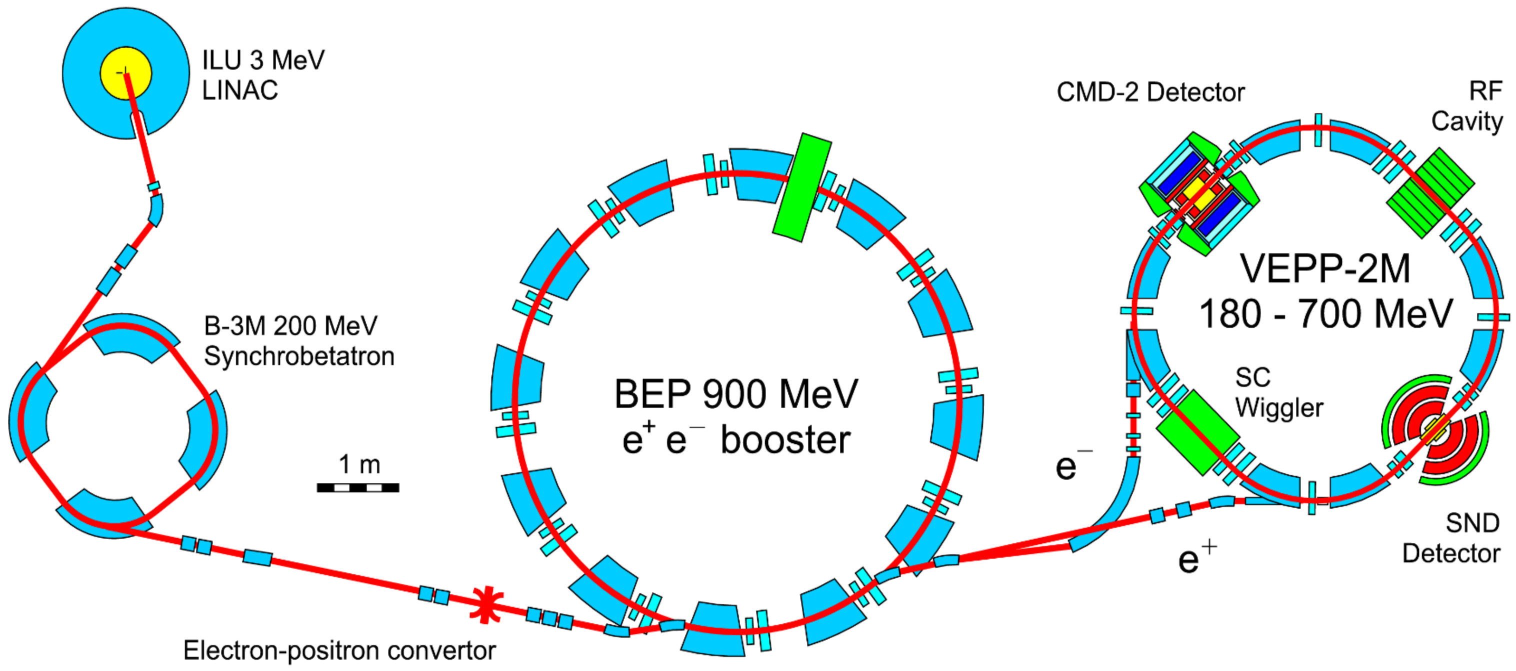


Fig. 1. Experimental set-up as seen from above.

Upgraded (1990) VEPP-2M collider at BINP



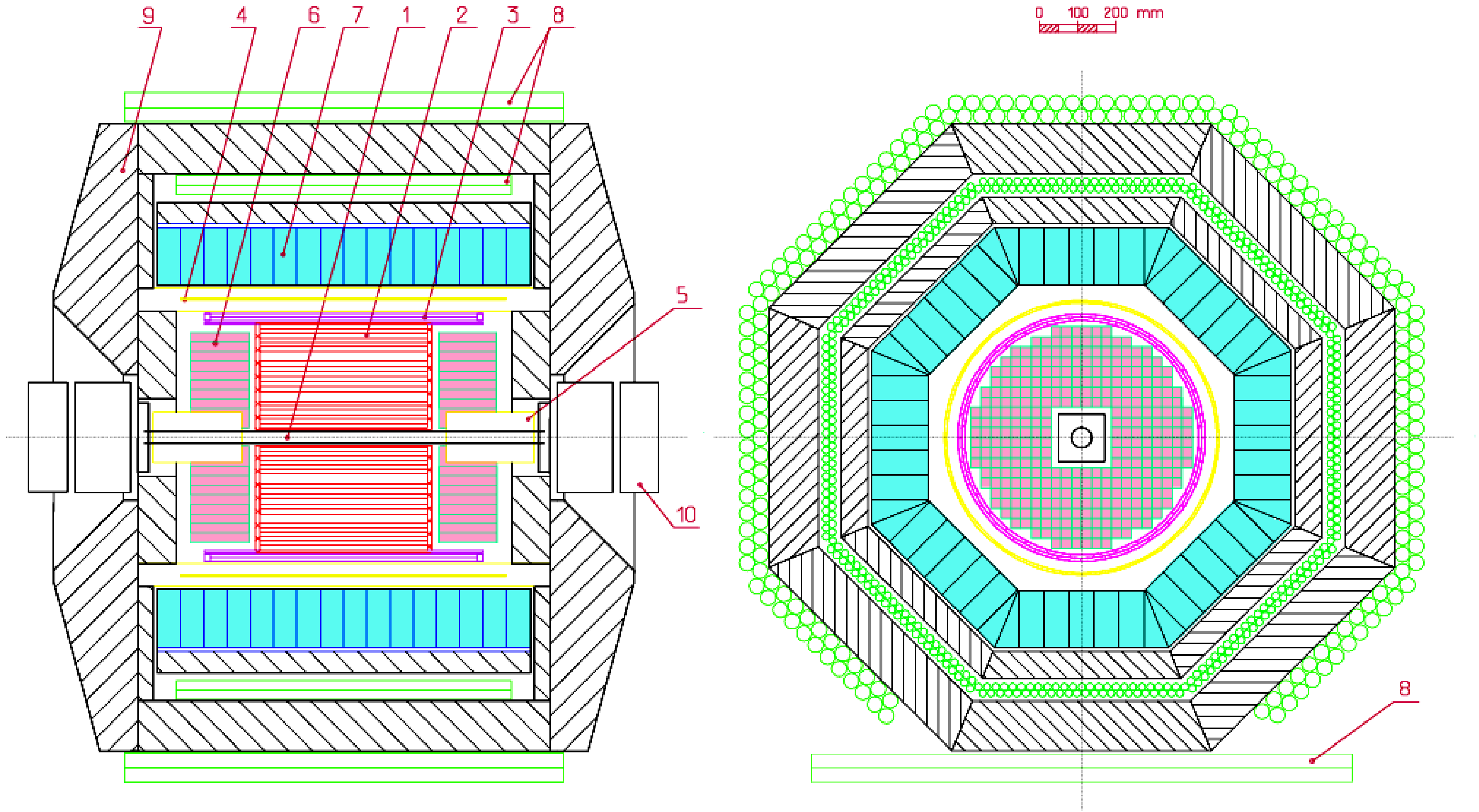
The VEPP-2M collider with the luminosity of $3{\cdot}10^{30}cm^{-2}s^{-1}$ was the main supplier of the precise data on the hadronic cross section in the energy range below up to 1.4 GeV for more than 25 years.

CMD-2 from 1992
SND from 1995

With L ≈ $3{\times}10^{30}$ $cm^{-2}s^{-1}$ VEPP-2M was pre- ϕ - factory from 1974 to 2000

$$\int Ldt \approx 70\, pb^{-1}$$

The Cryogenic Magnetic Detector (CMD-2)

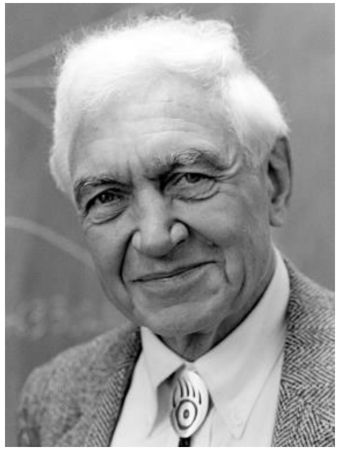


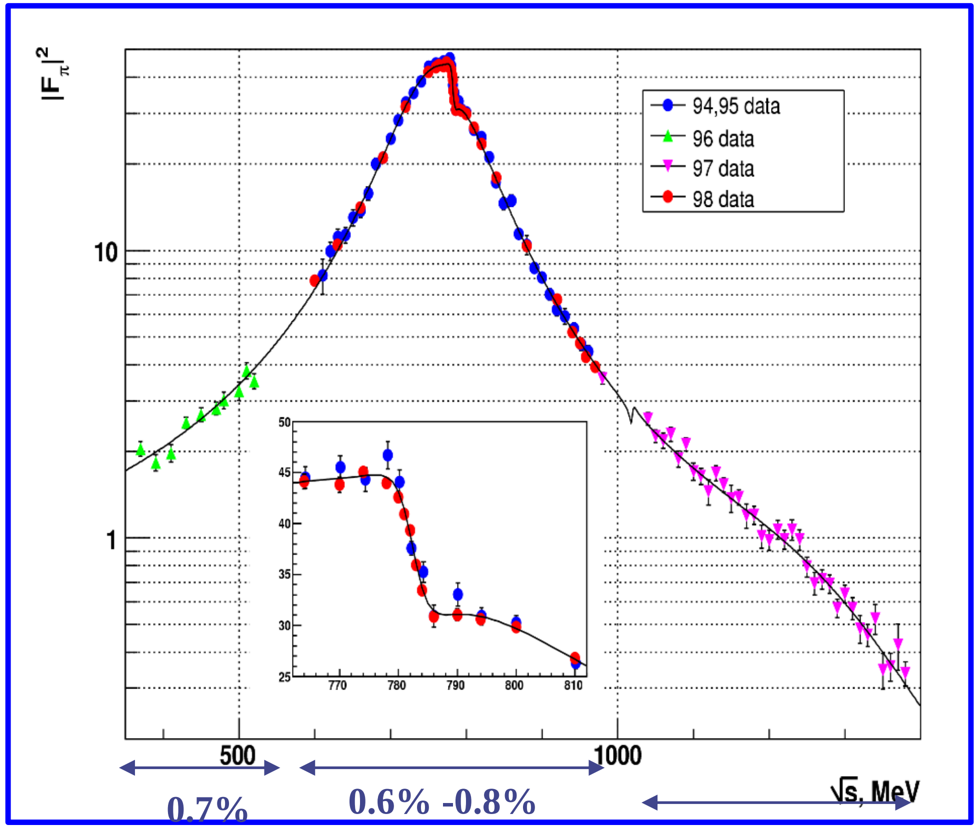
1 - vacuum pipe,
2 - drift chamber,
3 - Z-chamber,
4 - main solenoid,
5 - compensating solenoid,
6 - endcap BGO calorimeter,
7 - barrel calorimeter,
8 - range system,
9 - flux return yoke,
10 - storage ring lens.

The main goal of CMD-2 detector was a measurement of the hadron production cross section in e^+e^- annihilation as well as a study of rare decays of light mesons

Due to preparation of the E821 experiment at BNL Prof. Vernon Hughes came to BINP in the end of eighties to convince people to measure $R_{had} = \sigma_{had}/\sigma_{\mu\mu}$ with 1% accuracy.

That time this looks to be almost impossible.





1.2-4.2%

Systematic error

It took about 15 years to achieve this accuracy. Simon contributed a lot to this long work.

Calculaton of HVP to (g-2)

Thanks to his deep understanding of experimental and theoretical issues, Simon became one of the pioneers in utilizing very precise measurements of the hadron production cross section in e^+e^- for the evaluation of the hadronic contribution to the anomalous magnetic moment of the muon, (g-2).

Hadronic contributions to g-2 of the leptons and to the effective fine structure constant alpha (M(z)2)**
S.Eidelman, F. Jegerlehner, Z.Phys.C 67 (1995) 585-602

35 pages, 706 citations

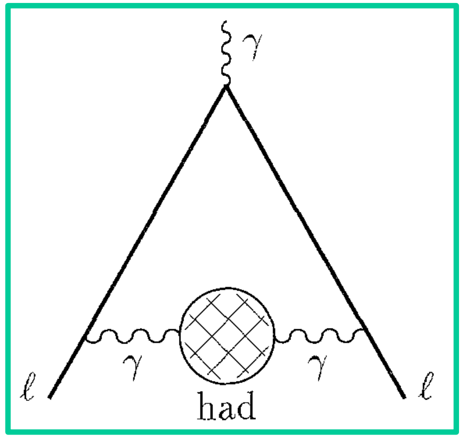


Table 1. Comparison of estimates of $a_\mu^{had} \times 10^{10}$ by different authors

$a_\mu^{had} \times 10^{10}$	Author	Year [Ref.]
663 ± 85	Barger et al.	1975 [16]
702 ± 80	Calmet et al., Narison	1978 [17]
684 ± 11	Barkov et al.	1985 [18]
$707 \pm 6 \pm 16$	Kinoshita et al.	1985 [19]
$710 \pm 10 \pm 5$	Casas et al.	1985 [20]
$705 \pm 6 \pm 5$	Martinovič, Dubnička	1990 [21]
$724 \pm 7 \pm 26$	Jegerlehner	1991 [22]
$699 \pm 4 \pm 2$	Dubničková et al.	1992 [23]
$702 \pm 6 \pm 14$	This work	
$725 \pm 6 \pm 15$	RG improved	

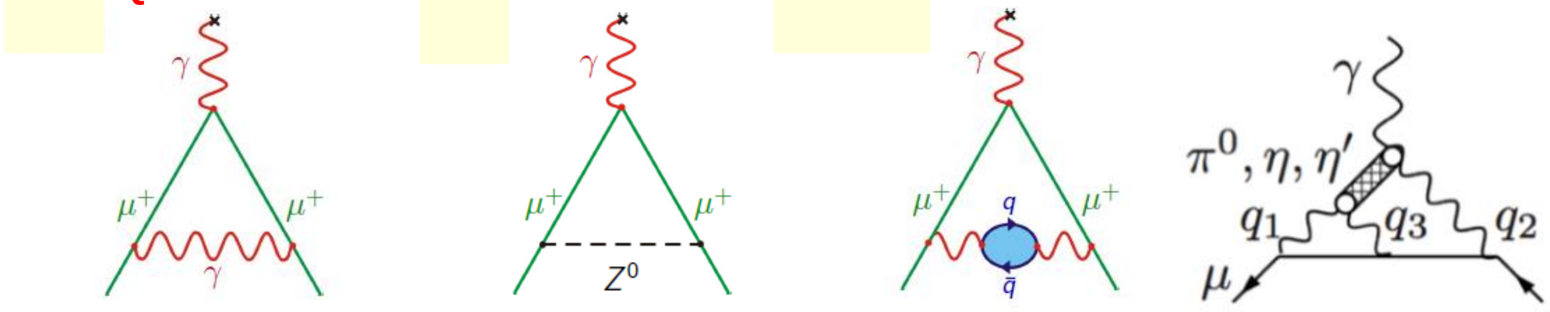
Table 2. Comparison of estimates of $\Delta\alpha_{had}^{(5)}(M_Z^2)$ by different authors

$\Delta\alpha_{had}^{(5)}(M_Z^2)$	Author	Year [Ref.]
0.0285 ± 0.0007	Jegerlehner	1986 [25]
0.0283 ± 0.0012	Lynn et al.	1987 [26]
0.0287 ± 0.0009	Burkhardt et al.	1989 [27]
0.0282 ± 0.0009	Jegerlehner	1991 [28]
0.02666 ± 0.00075	Swartz	1994 [29]
0.02732 ± 0.00042	Martin and Zeppenfeld	1994 [30]
0.0280 ± 0.0007	This work	

a_μ- SM calculations and experiment

Muon anomaly, $a_m = (g-2)_m/2$

$$a_\mu^{theory(SM)} = a_\mu^{QED} + a_\mu^{weak} + a_\mu^{had}$$



Source	Value (10^{-10})	Uncertainty (10^{-10})
QED	11 658 471.895	0. 008
Weak	15.4	0.2
Hadronic $+ LbL$	693.0	4.9
BNL E821	11 659 208.9	6.4
BNL – SM Theory	28.7	8.0

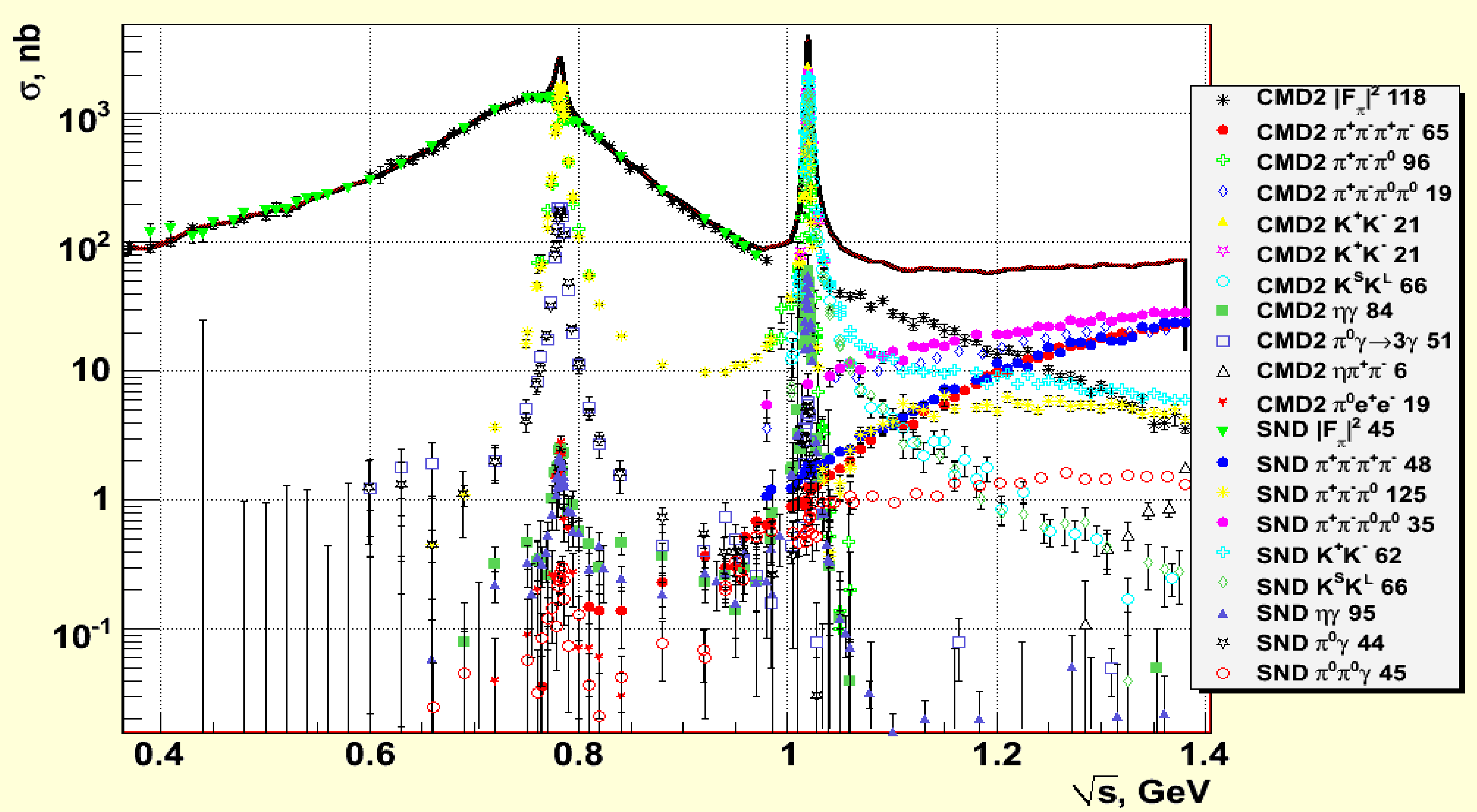
$$a_\mu^{had} = \frac{\alpha^2}{3 \cdot \pi^2} \int_{4m_\pi^2}^{\infty} ds \frac{K(s)}{s} R(s)$$

$$R(s) = \frac{\sigma(e^+e^- \to \gamma^* \to hadrons)}{e^+e^- \to \mu^+\mu^-}$$

$a_\mu^{exp} - a_\mu^{SM} = 3.6\sigma$ (M. Davier et al., EPJC71(2011)1515)

With L ≈ 10^{30} $cm^{-2}s^{-1}$ VEPP-2M was pre- ϕ - factory from 1974 to 2000

$$\int L dt \approx 70\, pb^{-1}$$



Systematic error:	~0.6-0.7%	1.0%	0.6%	1.5%	1.5 -- 3.5 %	Error of R(s)
Total error:	~ 6 -- 1%	1.5%	1--2%	2.0%	2.5 -- 3.5 %	

A consideration of the possibility of the studies using ISR at B-factories.

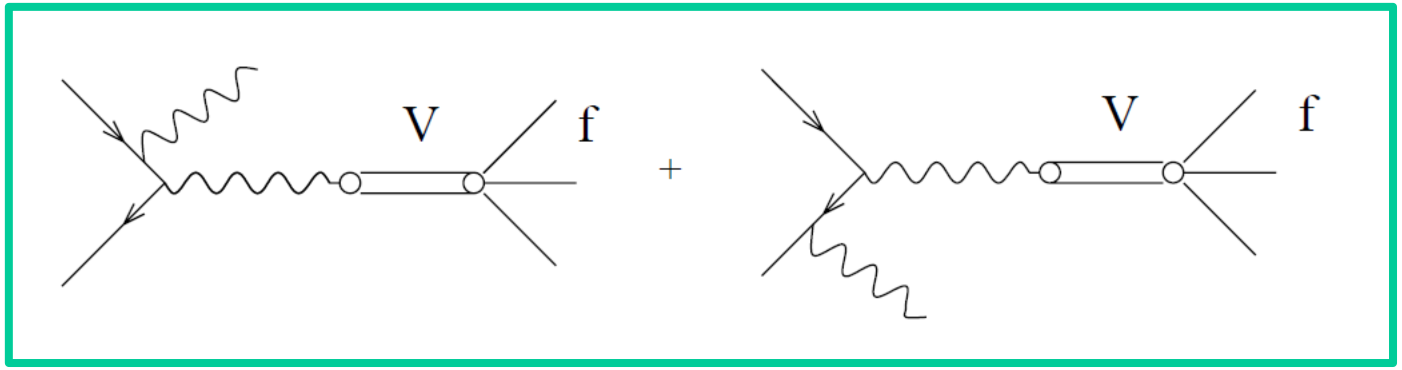
Spectroscopy at B factories using hard photon emission

Maurice Benayoun, S.I. Eidelman, V.N. Ivanchenko, Z.K. Silagadze,

Mod.Phys.Lett.A 14 (1999) 2605-2614, Frascati Phys.Ser. 15 (1999)

Contribution to: Workshop on Hadron Spectroscopy (WHS 99)

171 citations



First calculations: V.N. Baier, V.A.Khoze, Sov. Phys. JETP 21, 1145 (1965)

Tau-lepton decays and e^+e^- annihilation to hadrons via CVC

e^+e^- annihilation into hadrons and exclusive tau decays
S.I. Eidelman, V.N. Ivanchenko, Phys.Lett.B 257 (1991) 437-440

101 citations

$$B(\tau^- \to h^- \nu_\tau) = B(\tau^- \to e^- \bar{\nu}_e \nu_\tau) \frac{3\cos^2\vartheta_C}{2\pi\alpha^2 m_\tau^8} I ,$$

$$I = \int_0^{m_\tau^2} \sigma_h(s) g(s) \mathrm{d}s ,$$

$$g(s) = s(m_\tau^2 - s)^2 (m_\tau^2 + 2s) ,$$

Table 2
τ-lepton branching ratios.

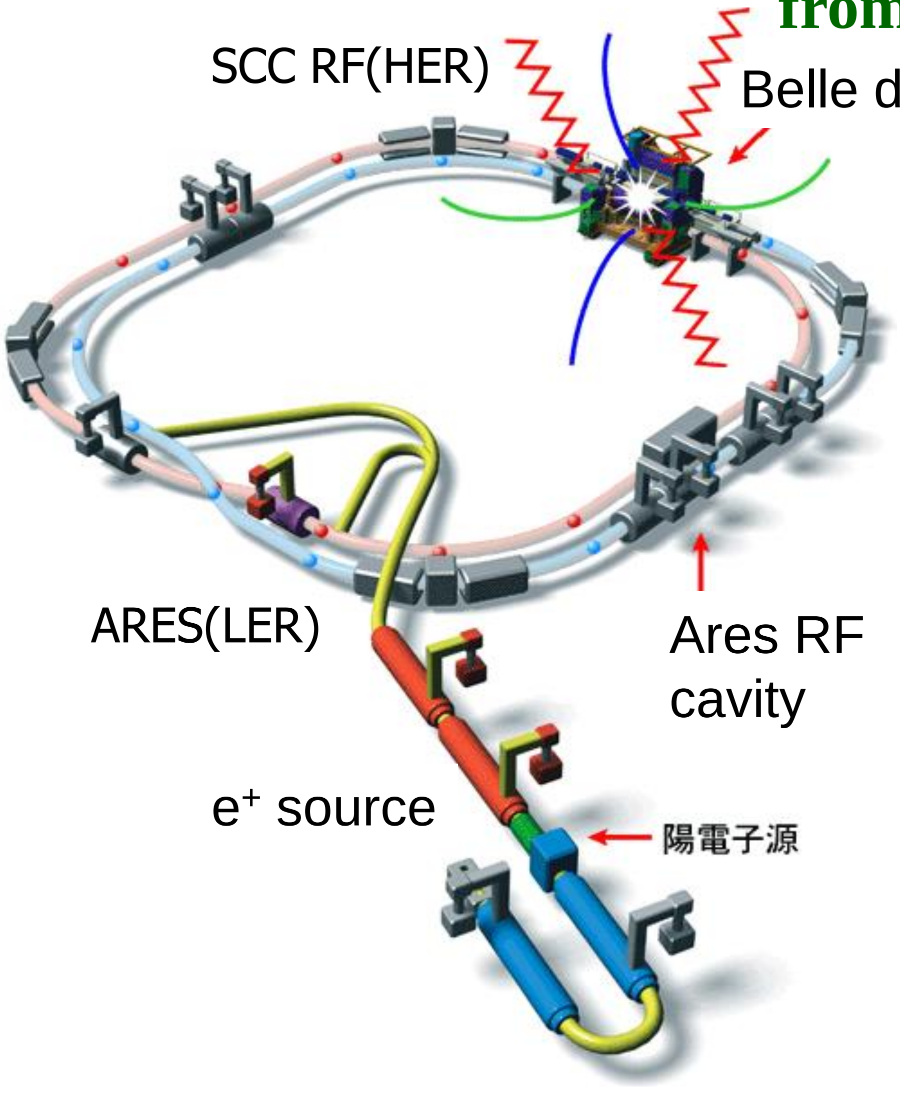
Decay	Branching ratio [%]		
	this work	PDG [a]	other works
$\tau^- \to \pi^- \pi^0 \nu_\tau$	23.4 ±0.8	22.7±0.8	21.8 [b]
			23.4±0.9 [c]
$\tau^- \to \omega\pi^- \nu_\tau$	2.2 ±0.3	1.6±0.5	
$\tau^- \to \pi^+\pi^-\pi^-\pi^0 \nu_\tau$	4.3 ±0.3	4.4±1.6	4.9 [b]
$\tau^- \to \pi^-\pi^0\pi^0\pi^0 \nu_\tau$	1.07±0.06	3.0±2.7	1 [b]
$\tau^- \to \eta\pi^-\pi^0 \nu_\tau$	0.13±0.02	<1.1	0.15 [d]
$\tau^- \to K^- K^0 \nu_\tau$	0.11±0.03	<0.26	0.5 [b]
$\tau^- \to (6\pi)^- \nu_\tau$	0.19±0.14		<0.42 [b]
$\tau^- \to \phi\pi^- \nu_\tau$	<0.09		
	0.02 [e]		

[a] Ref. [1]. [b] Ref. [3]. [c] Ref. [9]. [d] Ref. [4].
[e] The prediction using the model from ref. [28].

The KEKB Collider

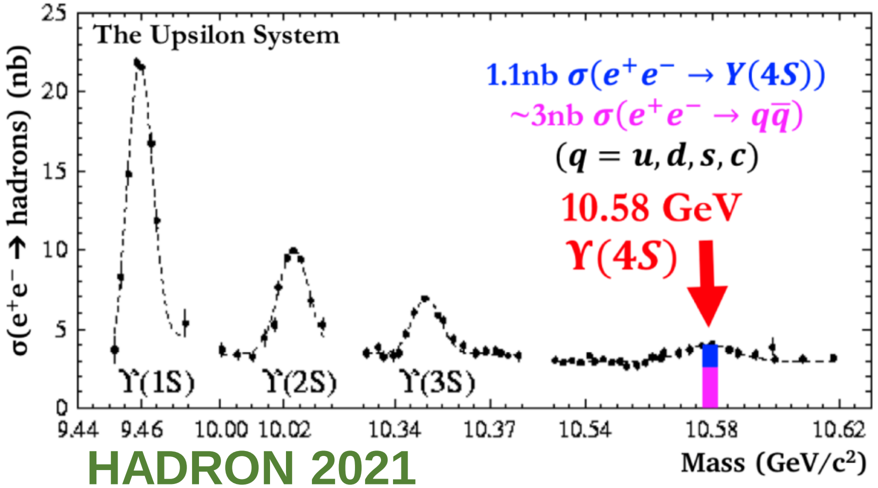
World record: *L = 2 x 10^34/cm^2/sec*

from 1999 to 2010

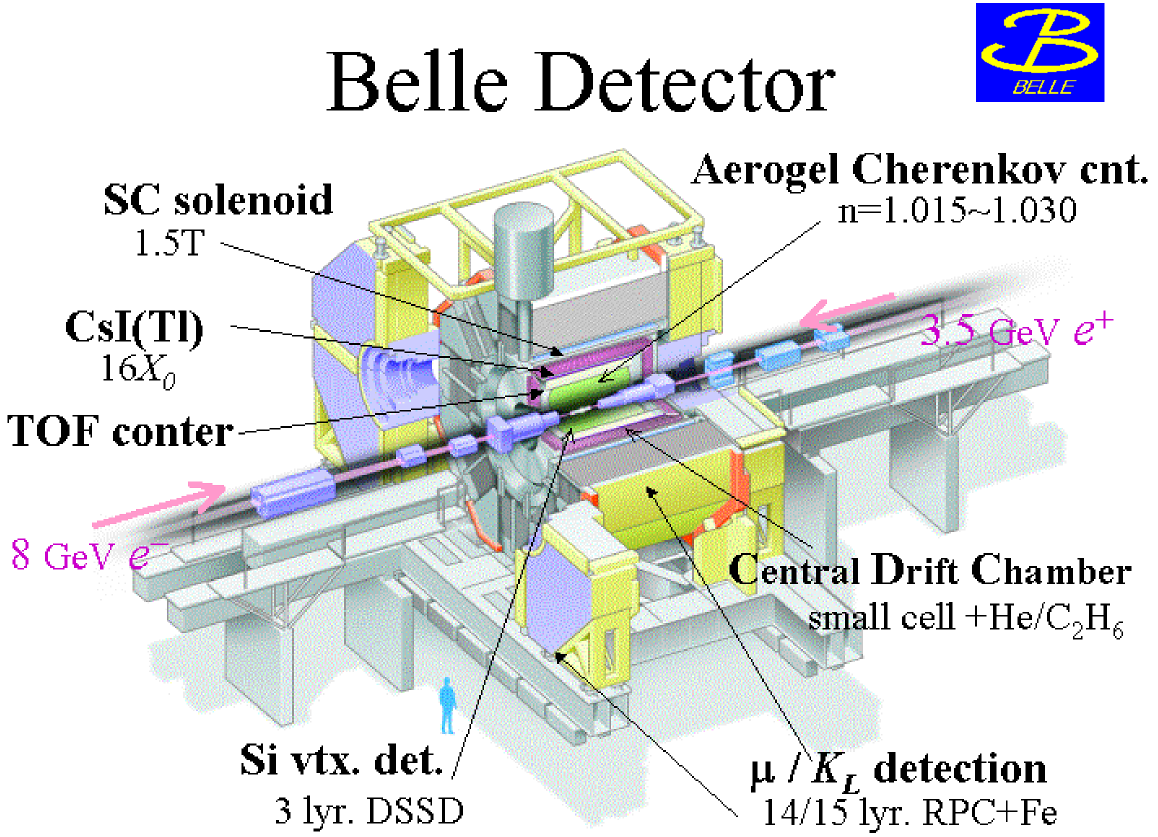


8 x 3.5 GeV
22 mrad
crossing angle

e+e−



Belle Detector



The primary goal of the Belle and BaBar experiments was to discover the CP violation in B mesons and to measure the parameters of CPV. This was achieved by both experiments in 2001

$$\int_{1999}^{2010} L dt = 1\, ab^{-1}$$

Peak lumi record at KEKB: L=2.1 x 10^{34}/cm2/sec with crab cavities

$E^+ = 8$ GeV, $E^- = 3.5$ GeV, $\sqrt{s}=10.58$ GeV, $\beta\gamma=0.42$

F/B asymmetric detector

High vertex resolution, magnetic spectrometry, excellent calorimetry and sophisticated particle ID ability

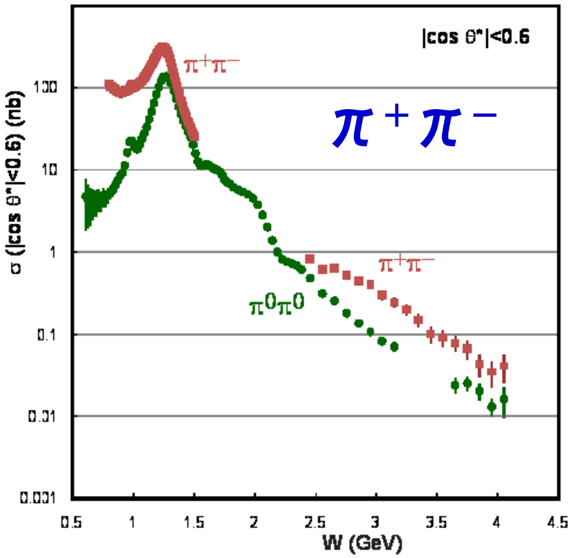
Beside of the main task, lot of other important results were obtained

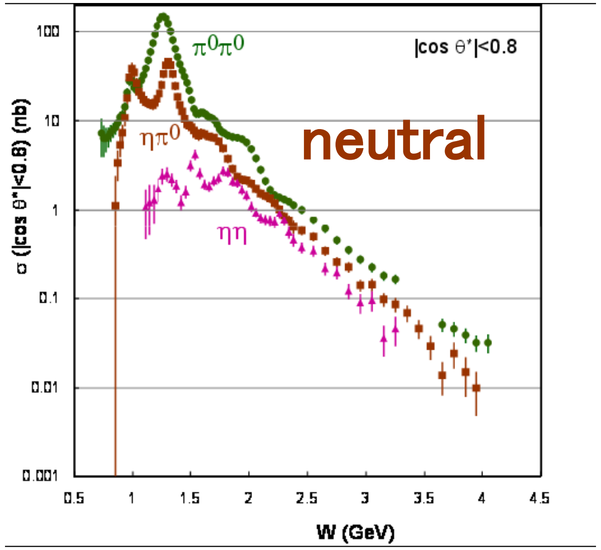
- Observation of direct CP violation in B decays
- Measurements of the CPV parameters in different modes (ϕK^0, $\eta' K^0$, $K_S K_S K_S$, …)
- Measurements of rare decay modes (e.g., $B \to \tau\nu$, $D\tau\nu$)
- Observation of new charmonium-like and bottomonium-like hadronic states
- $b \to s$ transitions: probe for new sources of CPV and constraints from the $b \to s\gamma$ branching fraction
- Forward-backward asymmetry (A_{FB}) in $b \to s l^+ l^-$ has become a powerfull tool to search for physics beyond SM.
- Observation of D mixing
- Search for lepton flavour violation in τ decays
- Study of the hadronic τ decays
- Precise measurement of the hadronic cross sections in $\gamma\gamma$ and $e^+e^-(\gamma_{ISR})$ processes

So wide researches area become possible because of clean event environment and well defined initial state in the e^+e^- experiments as well as high luminosity and general purpose detectors

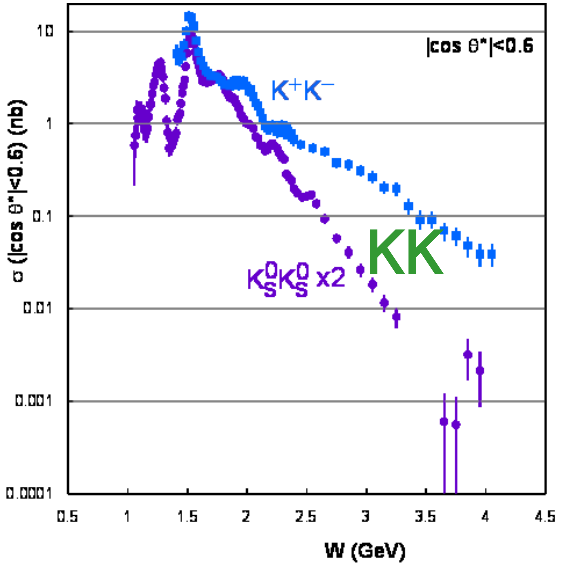
Two-Photon Measurements at Belle

	GeV	|cost*|	fb-1	Ref.	year
γ J/ψ	3.2 - 3.8		32.6	PLB540, 33	2002
π+π-	2.4 - 4.1	0.6	88	PLB15, 39	2005
	0.8 -1.5	0.6	86	PRD75, 051101	2007
				JPhySocJpn76, 074102 2007	
K+K-	1.4 - 2.4	0.6	67	EPJC32, 323	2003
	2.4 - 4.1	0.6	88	PLB15, 39	2005
ppbar	2.0 - 4.0	0.6	89	PLB621, 41	2005
4 mesons	2.75 - 3.75		395	EPJC53, 1	2006
KsKs	2.4 - 4.0	0.6	398	PLB651, 15	2007
	1.05 - 4.0	0.8	972	PTEP2013, 123C01	2013
π0π0	0.6 - 4.0	0.8	95	PRD78, 052004	2008
	0.6 - 4.1	0.8	223	PRD79, 052009	2009
ηπ0	0.84 - 4.0	0.8	223	PRD80, 032001	2009
ηη	1.096 - 3.8	1.0	393	PRD82, 114031	2010
ω J/ψ	3.9 - 4.2		694	PRL104, 092001	2010
ϕ J/ψ	4.2 - 5.0		825	PRL104, 112004	2010
$\omega\omega$,$\omega\phi$,$\phi\phi$	thr - 4.0		870	PRL108, 232001	2012
η'π+π-	1.4 - 3.4		673	PRD86, 052002	2012
π0	$Q^2 \varepsilon [4,40] GeV^2$		759	PRD86, 092007	2012
π0π0	$Q^2 < 30 GeV^2$		759	PRD93, 032003	2016
ppbarK+K-	3.2 - 5.6		980	PRD93, 112017	2016

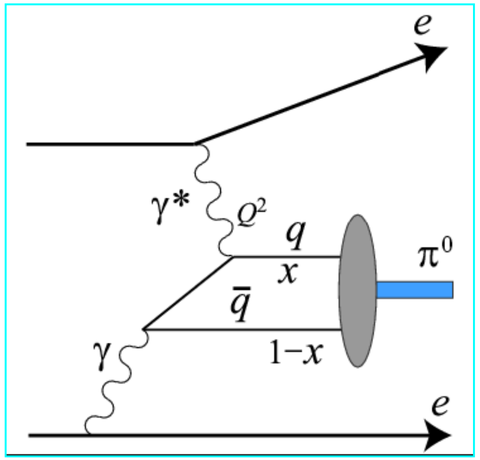




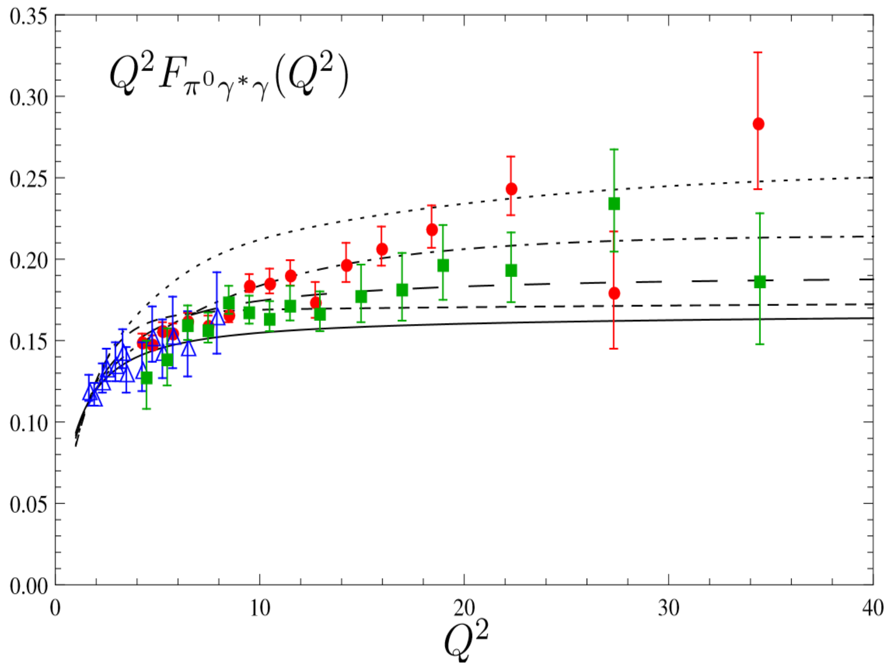
Two-meson γγ cross sections



π^0 Transition Form Factor

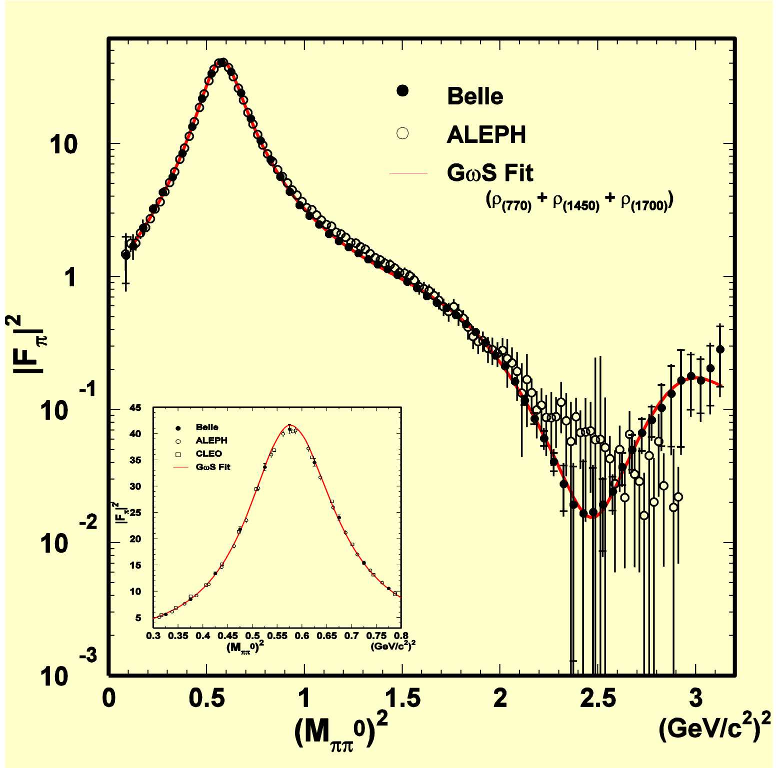


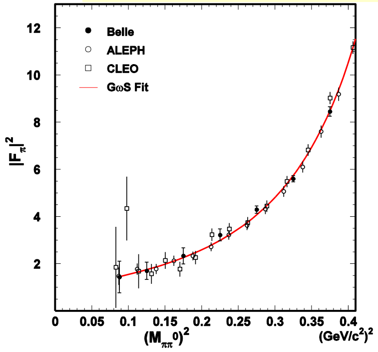
The pion transition form factor for the "asymptotic" (solid line) and different models



High-statistics study of the $\tau^- \to \pi^- \pi^0 \nu_\tau$ decay

Phys. Rev. D 78, 072006





5.6x 10^6 $\tau^- \to \pi^- \pi^0 \nu_\tau$ decays (72.2/fb).

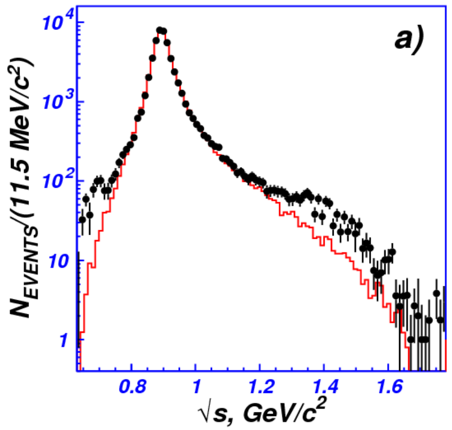
Parameter	Fit result (fixed $\|F(0)\|^2$)	Fit result (all free)
M_ρ, MeV/c^2	$774.6 \pm 0.2 \pm 0.5$	$774.9 \pm 0.3 \pm 0.5$
Γ_ρ, MeV	$148.1 \pm 0.4 \pm 1.7$	$148.6 \pm 0.5 \pm 1.7$
$M_{\rho'}$, MeV/c^2	$1446 \pm 7 \pm 28$	$1428 \pm 15 \pm 26$
$\Gamma_{\rho'}$, MeV	$434 \pm 16 \pm 60$	$413 \pm 12 \pm 57$
$\|\beta\|$	$0.15 \pm 0.05^{+0.15}_{-0.04}$	$0.13 \pm 0.01^{+0.16}_{-0.04}$
ϕ_β, degree	$202 \pm 4^{+41}_{-8}$	$197 \pm 9^{+50}_{-5}$
$M_{\rho''}$, MeV/c^2	$1728 \pm 17 \pm 89$	$1694 \pm 41 \pm 89$
$\Gamma_{\rho''}$, MeV	$164 \pm 21^{+89}_{-26}$	$135 \pm 36^{+50}_{-26}$
$\|\gamma\|$	$0.037 \pm 0.006^{+0.065}_{-0.009}$	$0.028 \pm 0.020^{+0.059}_{-0.009}$
ϕ_γ, degree	$24 \pm 9^{+118}_{-28}$	$-3 \pm 13^{+136}_{-29}$
$\|F(0)\|^2$	[1.0]	$1.02 \pm 0.01 \pm 0.04$
χ^2/NDF	80/52	65/51
$\rho''(1700)$ signif., σ	6.5	7.0

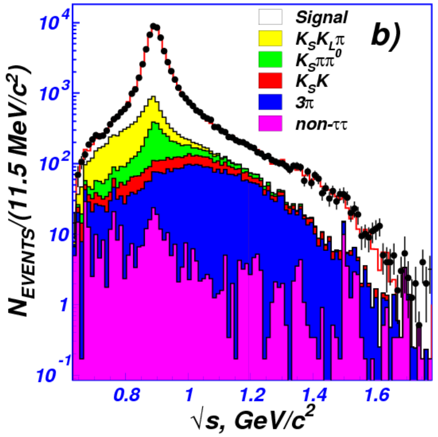
$$Br(\tau^- \to \pi^- \pi^0 \nu_\tau) = (25.17 \pm 0.04 \pm 0.40)\%$$

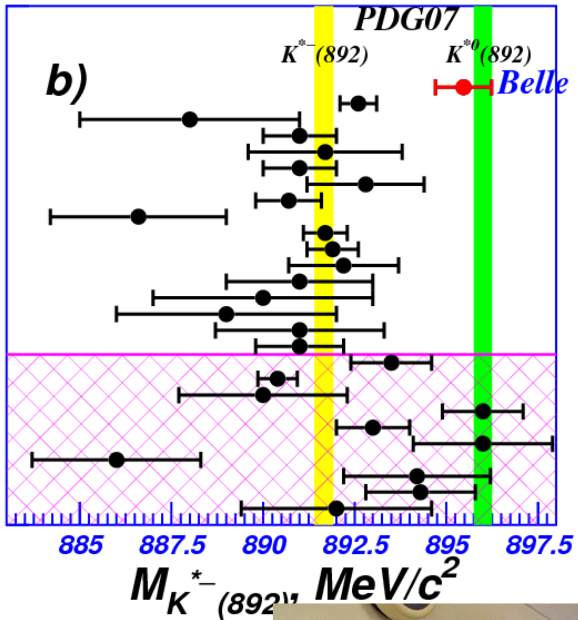
Study of $\tau^- \to K_S \pi^- \nu_\tau$ decay at Belle

PLB 654, 65 (2007)

351 fb^{-1}







	$K_0^*(800) + K^*(892) + K_0^*(1430)$	
	Solution 1	Solution 2
$M_{K^*(892)^-}$, MeV/c^2	895.42 ± 0.19	895.50 ± 0.22
$\Gamma_{K^*(892)^-}$, MeV	46.14 ± 0.55	46.20 ± 0.69
$\lvert\gamma\rvert$	0.954 ± 0.081	1.92 ± 0.20
$\arg(\gamma)$	0.62 ± 0.34	4.03 ± 0.09
$\varkappa$	1.27 ± 0.22	2.28 ± 0.47
χ^2/n.d.f.	86.5/84	95.1/84
$P(\chi^2)$, %	41	19

$M(K^*(892)^-)$ = (895.47 ± 0.20(stat.) ± 0.44(syst.) ± 0.59(mod.)) MeV

$\Gamma(K^*(892)^-)$ = (46.2±0.6(stat.)± 1.0(syst.) ± 0.7(mod.))MeV

B($\tau^- \to K_S \pi^- \nu_\tau$) = 0.404±0.002(stat.) ±0.013(syst.)%.

Measurements of branching fractions of τ lepton decays with one or more K_S^0

Mode	Branching Fraction	Ref.
$K_S^0 X^- \nu_\tau$	$(9.15 \pm 0.01 \pm 0.15) \times 10^{-3}$	This exp.
$\pi^- K_S^0 \nu_\tau$	$(4.16 \pm 0.01 \pm 0.08) \times 10^{-3}$	This exp.
$K^- K_S^0 \nu_\tau$	$(7.40 \pm 0.07 \pm 0.27) \times 10^{-4}$	This exp.
$\pi^- K_S^0 \pi^0 \nu_\tau$	$(1.93 \pm 0.02 \pm 0.07) \times 10^{-3}$	This exp.
$K^- K_S^0 \pi^0 \nu_\tau$	$(7.48 \pm 0.10 \pm 0.37) \times 10^{-4}$	This exp.
$\pi^- K_S^0 K_S^0 \nu_\tau$	$(2.33 \pm 0.03 \pm 0.09) \times 10^{-4}$	This exp.
$\pi^- K_S^0 K_S^0 \pi^0 \nu_\tau$	$(2.00 \pm 0.22 \pm 0.20) \times 10^{-5}$	This exp.
$\pi^- K_S^0 K_L^0 \nu_\tau$	$(1.01 \pm 0.23 \pm 0.13) \times 10^{-3}$	ALEPH [34]
$\pi^- K_S^0 \pi^0 \pi^0 \nu_\tau$	$(0.13 \pm 0.12 \pm 0.00) \times 10^{-3}$	ALEPH [8]
$\pi^- K_S^0 \eta \nu_\tau$	$(0.44 \pm 0.07 \pm 0.03) \times 10^{-3}$	Belle [16]
$\pi^- K_S^0 K_L^0 \pi^0 \nu_\tau$	$(0.31 \pm 0.11 \pm 0.05) \times 10^{-3}$	ALEPH [8]
$K_S^0 h^- h^+ h^- \nu_\tau$	$(0.115 \pm 0.095 \pm 0.04) \times 10^{-3}$	ALEPH [34]

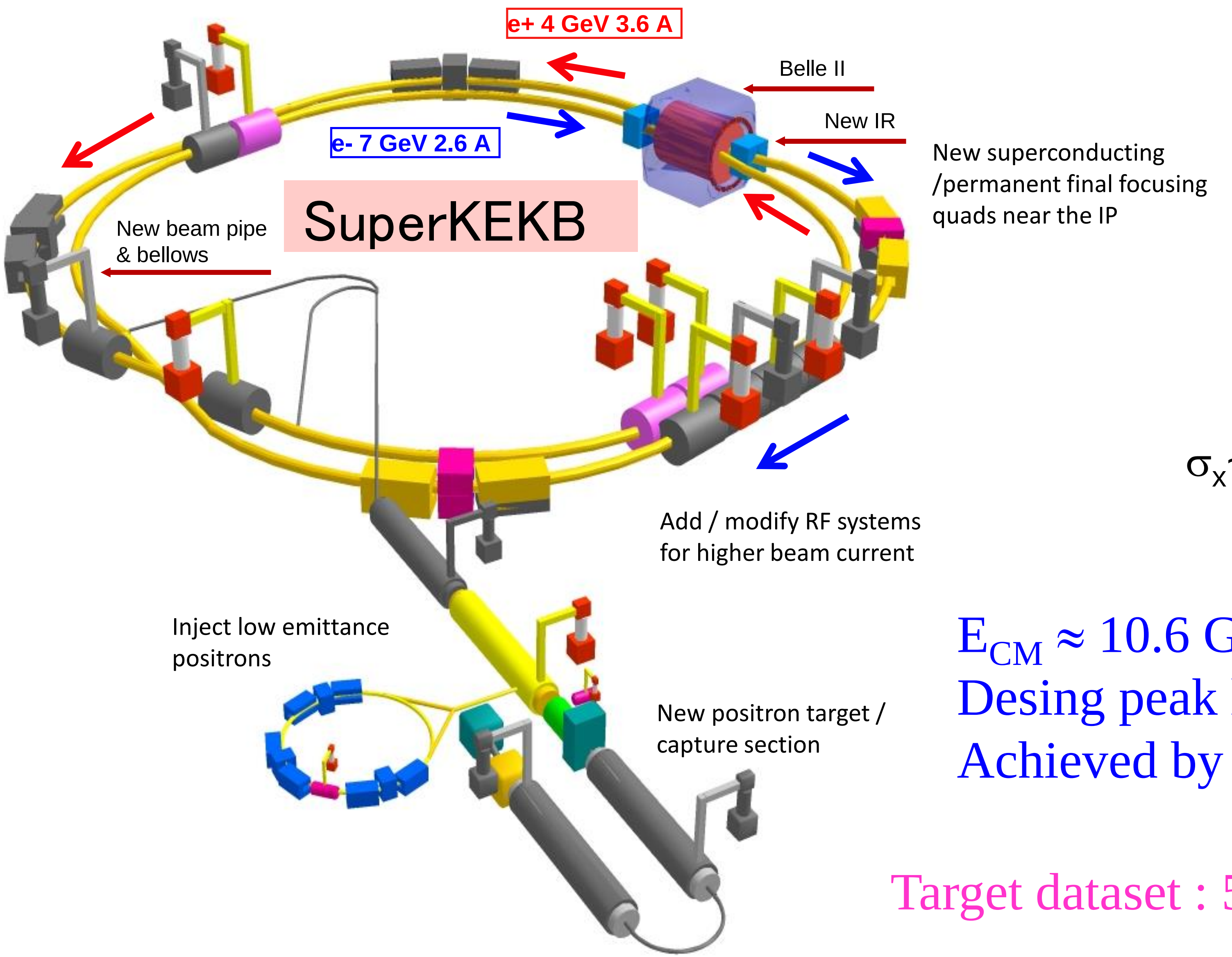
669 fb^{-1}

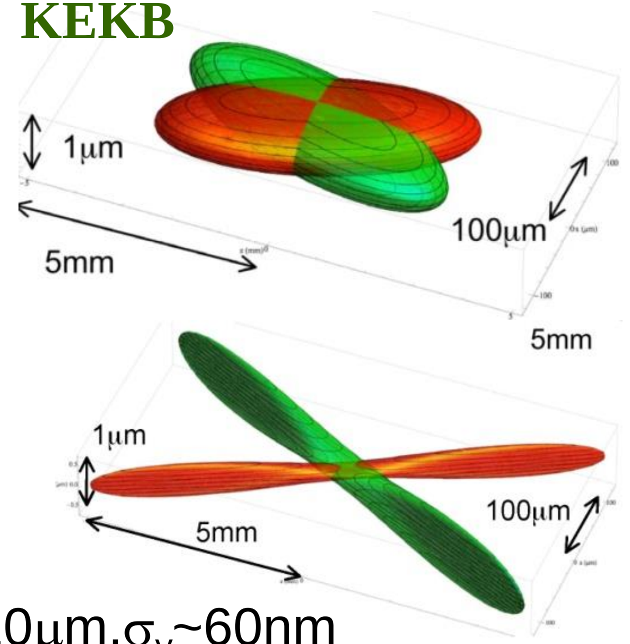
$B(f_1(1285)\pi^-\nu) \cdot B(f_1(1285) \to K^0_S K^0_S \pi^0) = (0.74 \pm 0.12 \pm 0{:}08) \cdot 10^{-5};$

$B(f_1(1420)\pi^-\nu) \cdot B(f_1(1420) \to K^0_S K^0_S \pi^0) = (0\ 20 \pm 0{:}09 \pm 0{:}02) \cdot 10^{-5};$

$B(K^{*-} K^0_S \pi^0) \cdot B(K^{*-} \to K^0_S \pi^-) = (1.06 \pm 0.15 \pm 0.11) \cdot 10\text{-}5:$

SuperKEKB/Belle II





σ_x~10μm,σ_y~60nm

Nano-Beam SuperKEKB

$E_{CM} \approx 10.6$ GeV

Desing peak luminosity $6.0\times10^{35}cm^{-2}s^{-1}$

Achieved by now - $3.0\times10^{34}cm^{-2}s^{-1}$

Target dataset : 50 ab^{-1}(50×Belle)

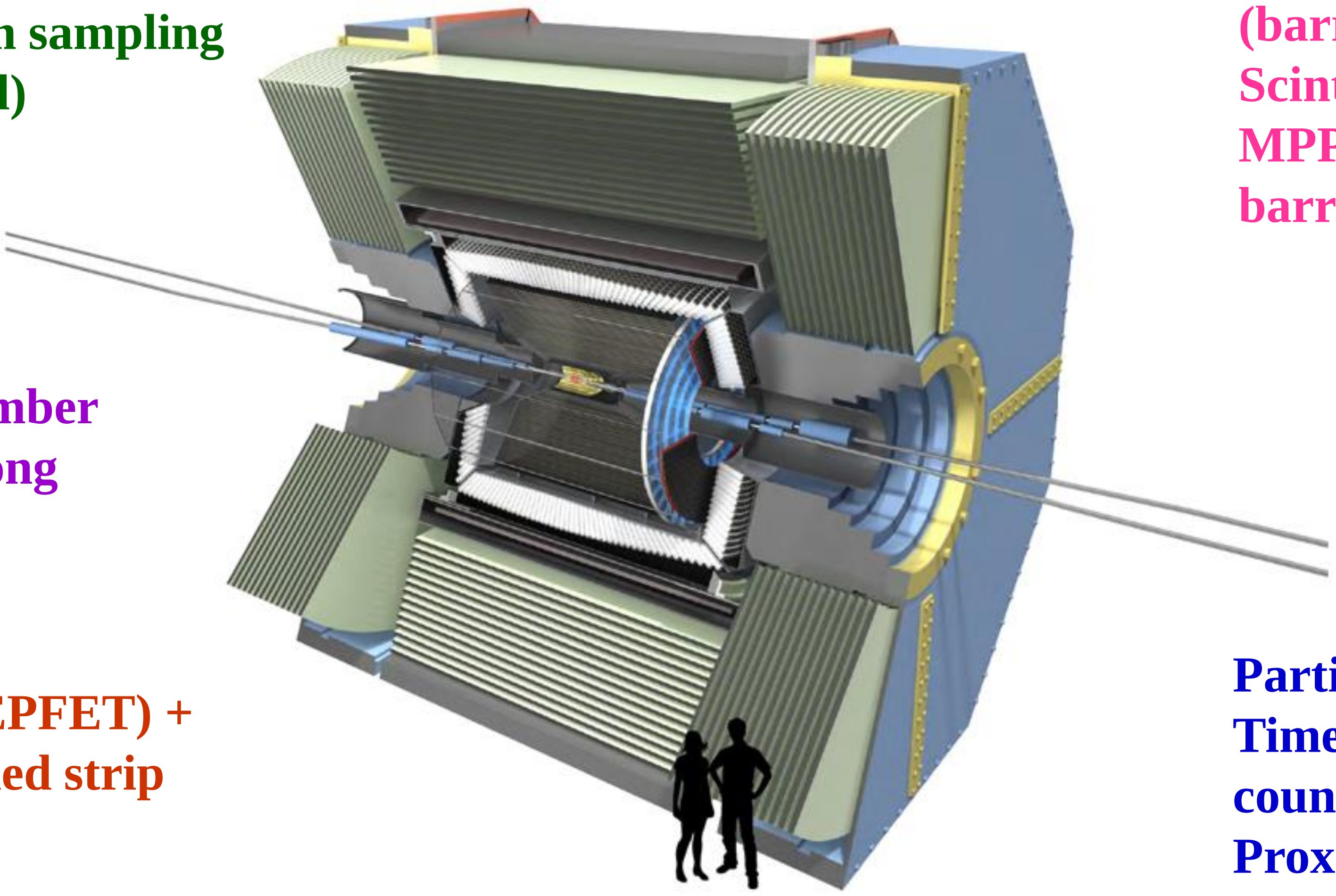
Belle II Detector

EM Calorimeter:
CsI(Tl), waveform sampling electronics (barrel)

electrons (7GeV)

Central Drift Chamber
Smaller cell size, long lever arm

Vertex Detector
2 layers Si Pixels (DEPFET) +
4 layers Si double sided strip DSSD



KL and muon detector:
Resistive Plate Counter (barrel outer layers)
Scintillator + WLSF + MPPC (end-caps , inner 2 barrel layers)

positrons (4GeV)

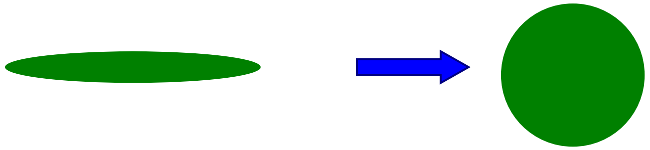
Particle Identification
Time-of-Propagation counters (barrel)
Prox. focusing Aerogel RICH (forward)

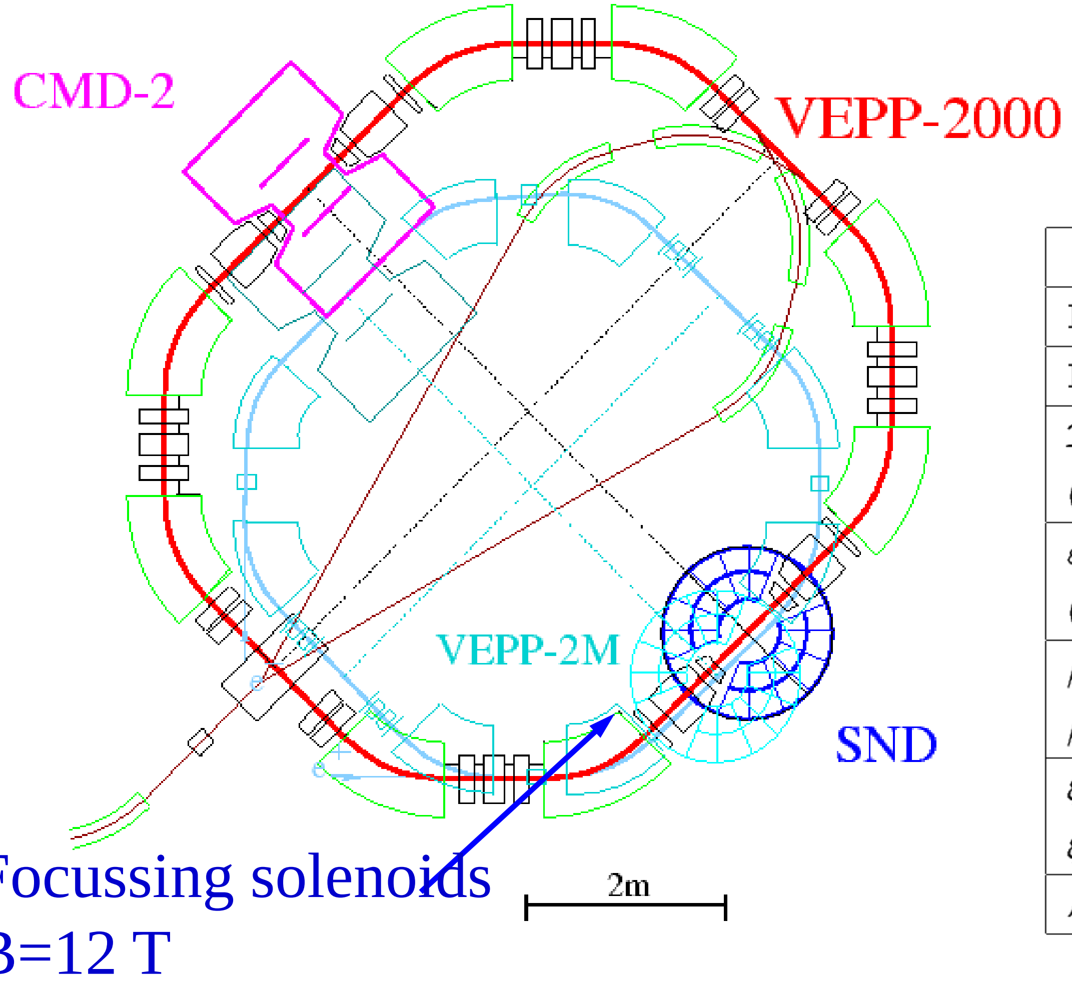
Physics runs started in 2019

New collider VEPP-2000 at BINP (from 2010)

The main idea – round beams!

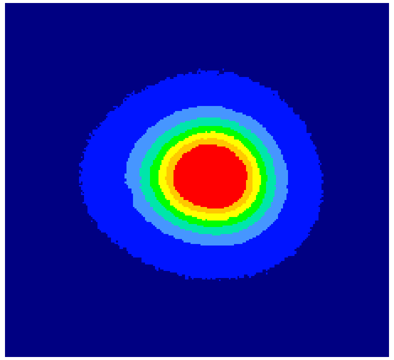
2Emax: 1.4 GeV $\rightarrow$ 2 GeV





VEPP-2M & VEPP-2000 parameters

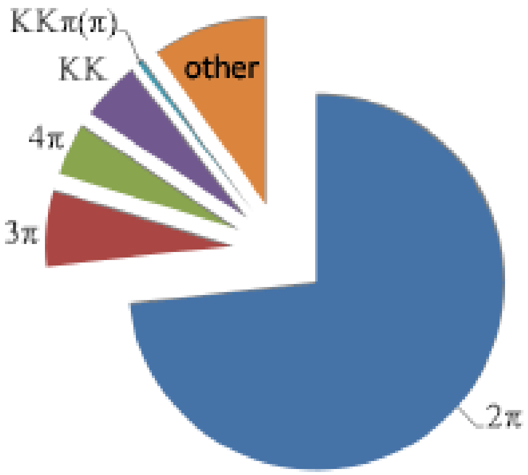
	VEPP-2M	VEPP-2000	
E (MeV)	510	510	900
Π (cm)	1788	2235	2235
$\mathcal{I}^+,\mathcal{I}^-$ (mA)	40	34	200
$\varepsilon \cdot 10^5$ (cm · rad)	3	0.5	1.6
β_x (cm)	40	6.3	6.3
β_z (cm)	5	6.3	6.3
ξ_x	0.016	0.075	0.075
ξ_z	0.050	0.075	0.075
$\mathcal{L}(cm^{-2}s^{-1})$	$3 \cdot 10^{30}$	$1 \cdot 10^{31}$	$1 \cdot 10^{32}$



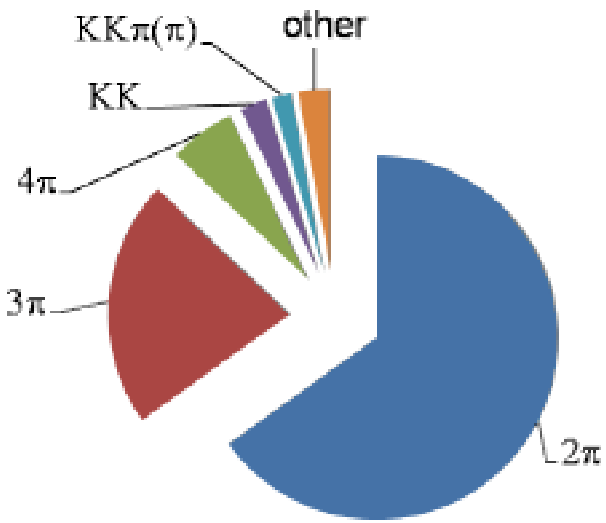
CMD-3 at VEPP- 2000

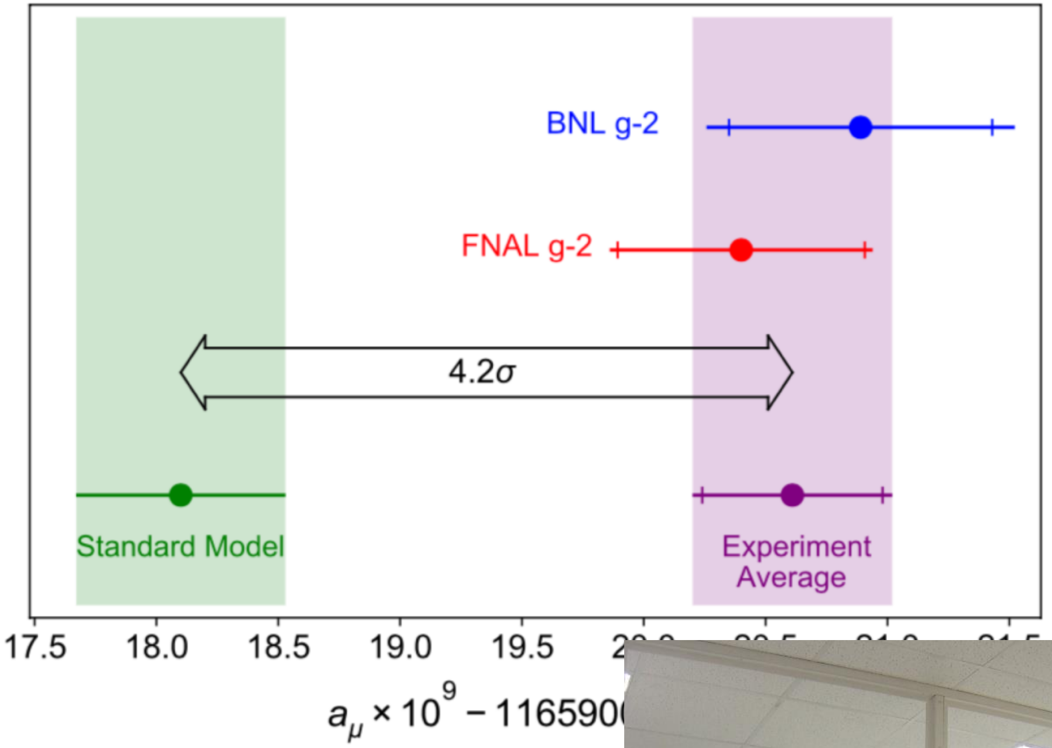
Since new experiments at FNAL and JPARC expect to improve the accuracy of muon (g-2) by factor 3, we need in a precision of the hadronic cross section at the level of 0.3%

$a_\mu^{had,LO\text{-}VP}$



$a_\mu^{had,LO\text{-}VP}$ error squared

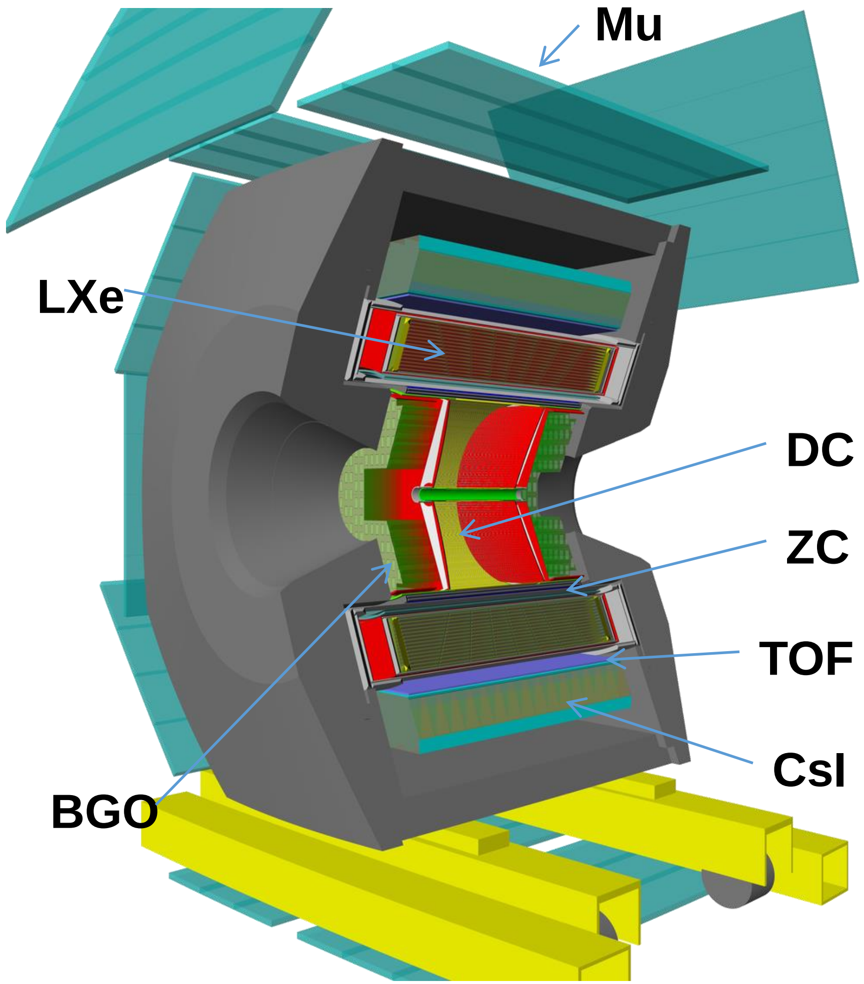




VEPP-2000 - detectors

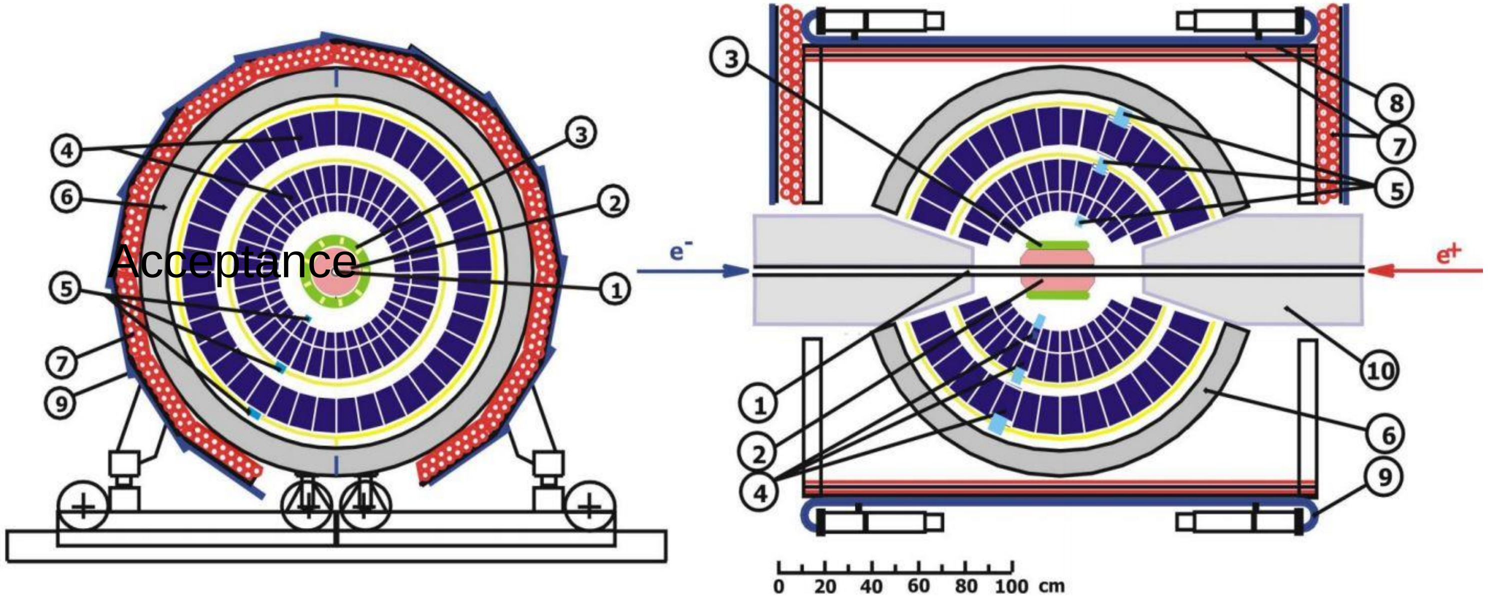
CMD-3

Compact multipurpose detector comprising magnetic spectrometry with high resolution calorimetry



SND

Main advantage: high resolution calorimeter with $0.95 \times 4\pi$ uniform acceptance



1 – vacuum chamber, 2 – tracking DC, 3 – aerogel n=1.13, 1.05 4 – NaI(Tl) crystals, 5 – phototriodes, 6 – absorber, 7–9 – muon detector, 10 – SC solenoids

CMD-3 results and analyses ongoing

Published

$K_S K_L$	PLB 760 (2017) 314
K^+K^-	PLB 760 (2017) 314
pp	PLB 759 (2016) 634
$3(\pi^+\pi^-)$	PLB 723 (2013) 82
$\pi^+\pi^-\ \pi^+\pi^-$	PLB 768 (2017) 345
$\pi^+\pi^-\ \pi^0\eta$	PLB 773 (2017) 150
$K^+K^-\pi^+\pi^-$	PLB 756 (2016) 153

Detail discussion will be done in the next talk by Evgeniy Kozyrev

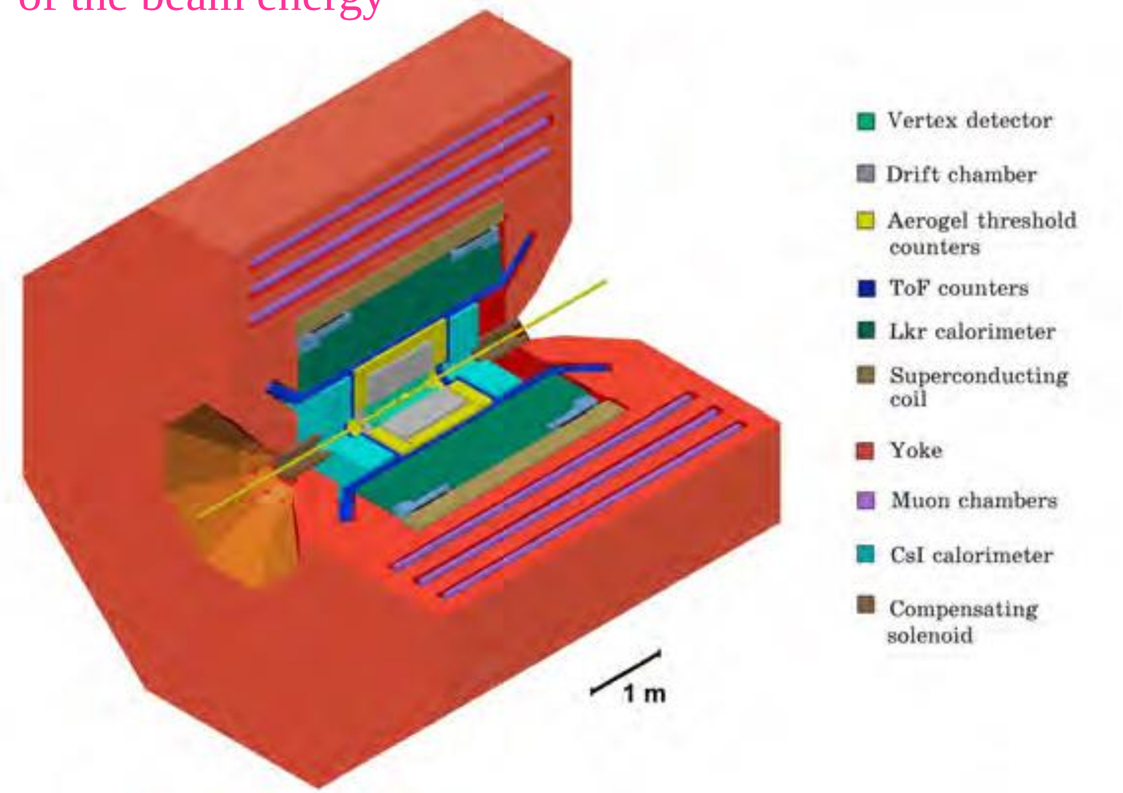
Analyses ongoing

$\pi^+\pi^-\ \omega$
$\pi^+\pi^-\ \eta(3\pi)$
$\pi^+\pi^-\ \eta(2\gamma)$
$K^+K^-\ \omega$
$K^+K^-\ \eta$
$K^+K^-\ \pi^0$
$K_S K_L$
$2(\pi^+\pi^-)$
$3(\pi^+\pi^-)\ \pi^0$
$\omega \to \pi^0\ e^+e^-$

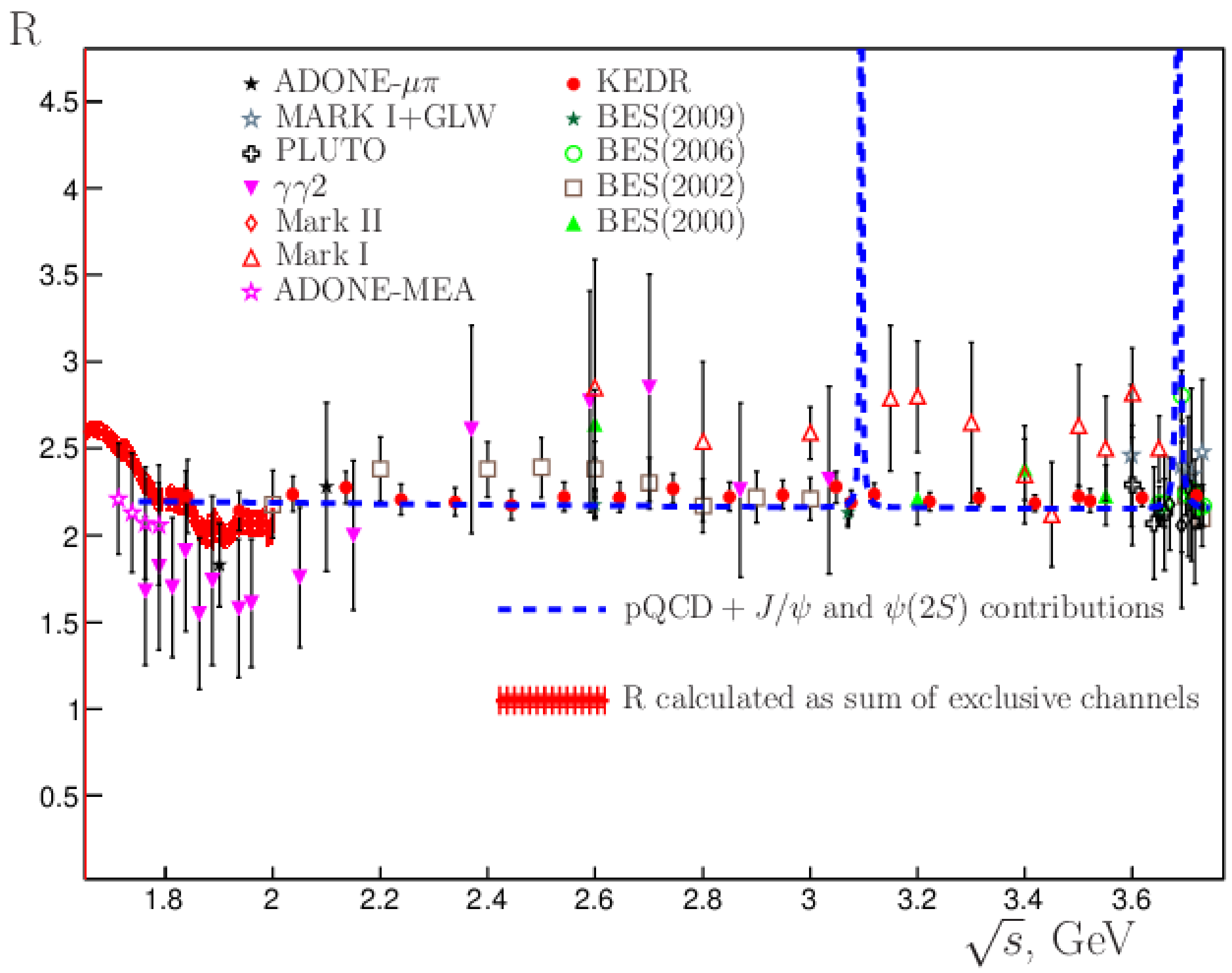
KEDR at VEPP-4, R measurement

VEPP-4 E_{CM} from 1.8 to 10 GeV
Luminosity - 2×10^{30} @ E_{CM} = 3 GeV
2×10^{30} @ ECM = 10 GeV

Features: wide energy range and precise measurement of the beam energy



Total hadronic cross section: inclusive vs sum of exclusive cross sections

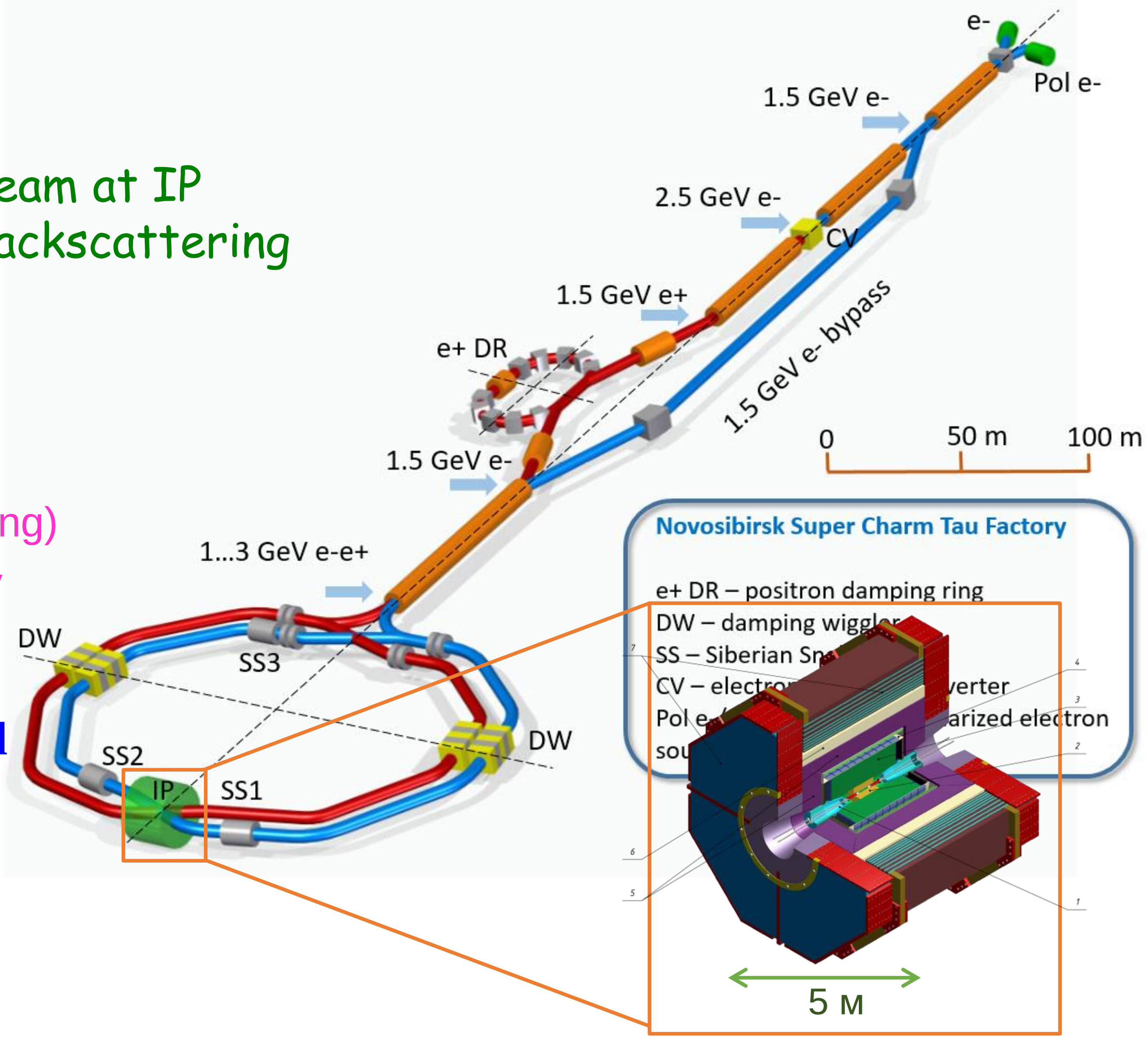


C-tau factory project

- Beam energy from 1.0 to 3.5 GeV
- Luminosity 10^{35} $cm^{-2}s^{-1}$ at E_{CM}=2 GeV
- Longitudinal polarization of electron beam at IP
- Beam energy calibration by Compton backscattering

- The work on this project started in 2010
- From 2017 – IAC was formed, regular international meetings are organizing
- 2018 – CDR was renewed (development is continuing)
- the decision of Russian government is expected by the end of 2021

Simon Edelman was enthusiast of this project and very actively participated in the development of physics program and organization of international and national meeting as well as connection with experts over the world.



BINP Super c/τ factory project

- Beam energy from 1.0 to 2.5 GeV (3 GeV)
- Peak luminosity is 10^{35} $cm^{-2}s^{-1}$ at 2 GeV
- Electrons can be polarized longitudinally at IP
- On-line energy monitoring ($\sim 5 \div 10 \cdot 10^{-5}$)

Charmonia

Spectroscopy, BR`s of J/ψ decays to light mesons, detail study of higher cc and XYZ states;

Weak decays of J/ψ, the total branching ratio of $c \to s$ transition is $(2–4)\times 10^{-8}$

Charm mesons and Charm baryons

Spectroscopy, BR's, cross sections, Mixing, Search for $\mathcal{CP}$ violation

τ lepton

Michel parameters, Spectral functions, search for $\mathcal{CP}$ violation, Lepton flavour violation, Lepton universality

Two-photon processes

Search and study of the normal and exotic C-even states, measurement of the $\sigma(\gamma\gamma \to$ hadrons), TFF measurements

e+e- -> hadrons: total cross section by scan and ISR

PDG from 1990

Simon has been a key author in the international Particle Data Group (PDG) for thirty years. Since 2006 he led the PDG subgroup responsible for meson resonances, analyzing and incorporating many results into the Review of Particle Physics with uncanny precision. For many years he was responsible for scanning the whole particle physics literature for results of interest to PDG. He co-authored many PDG review articles and served as a member of the PDG Representative Board. In recognition of his great contributions to PDG, he was chosen to be the first author of the 2004 edition of the Review of Particle Physics. His extensive knowledge and kind words of wisdom are sorely missed in the Particle Data Group.

Conferences-schools

Thanks to his deep knowledge and wide scientific horizons, combined with a wonderful sense of humor, along with a kind and friendly nature, Simon possessed a unique ability to galvanize colleagues into joint projects within many international collaborations and meetings, as well as into informal scientific groups.

Simon was also a superb scientific editor. He had a rare gift of formulating scientific problems and results clearly and concisely. This provided an invaluable contribution to a very large number of papers which he authored, co-authored and refereed.

Conclusion

In spite of many subjects discussed in this talk, the list is quite incomplete. I did not mention in my talk his participation in LHCB and (g-2)/EDM (J-PARC) collaborations as well as, probably many other Simon's activities. Everybody who knew and was working with him will always remember him as an invaluable colleague.

IAC of HADRON conference seria

establishes a prize honoring the memory of Simon to be awarded in future editions of the conference, starting from the next one, in 2023.

Its purpose will be to acknowledge an outstanding young research in hadron physics, fostering her/his career. This prize is also intended to remind some of the many virtues Simon had, and encourage the younger generations to pursue these values, like scientific honesty or international orientation. It will then -as Simon would have surely done- show this young scientist the way to follow: correct firmly though kindly when needed, take into account everyone's views with equity and inclusiveness, discuss politely only based on physics, never inflate one's work and appreciate others'.