Status of e+e- data from energy scan

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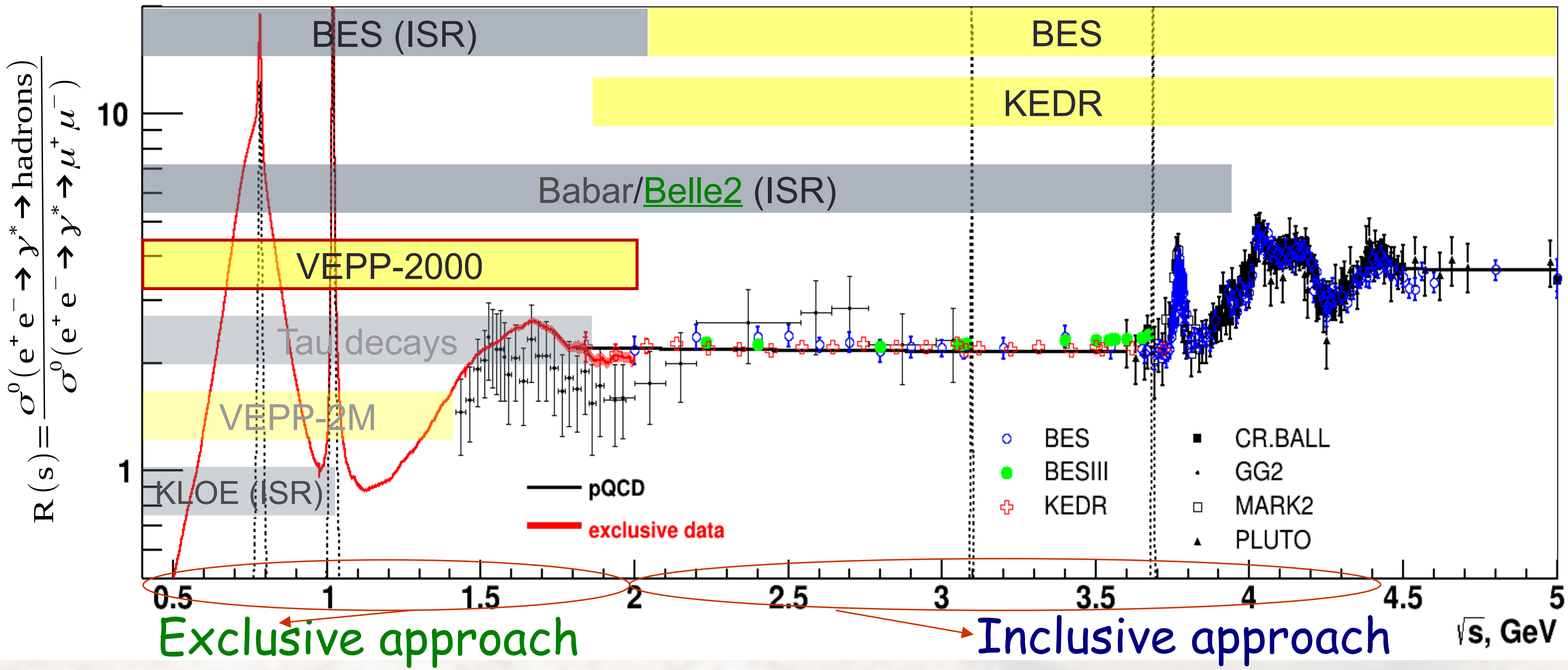
Muon Precision Physics Workshop

Liverpool, UK

R measurements

Two techniques: ISR vs Energy scan



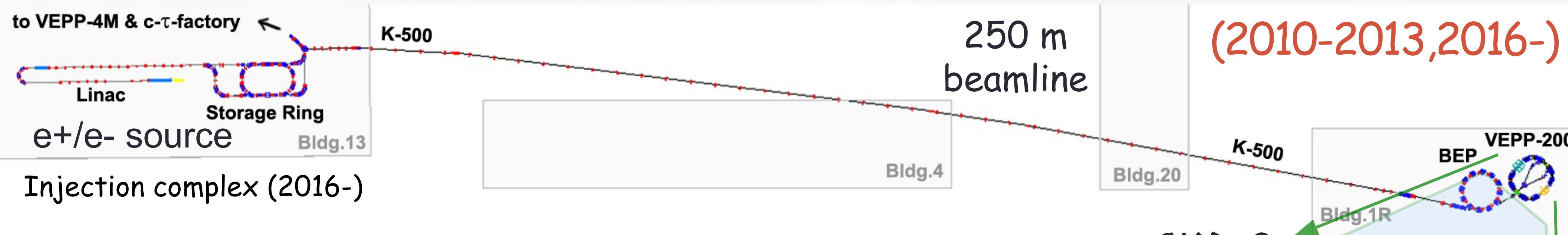
VEPP-2000: direct exclusive measurement of σ (e+e- → hadrons)

Only one working these days on scanning below <2 GeV

World-best luminosity below 2 GeV (except 1 GeV – where KLOE outperfomed everybody)

BESIII, KEDR – inclusive measurement of R(s) from 2 GeV to 5 GeV

VEPP-2000 e+e- collider



(2010-2013,2016-)

Injection complex (2016-)

<u>VEPP-2000: direct exclusive measurement of σ (e+e- → hadrons)</u>

Only one working this days on scanning 2E = 0.32-2 GeV

Unique optics, "round beams" to reach higher L

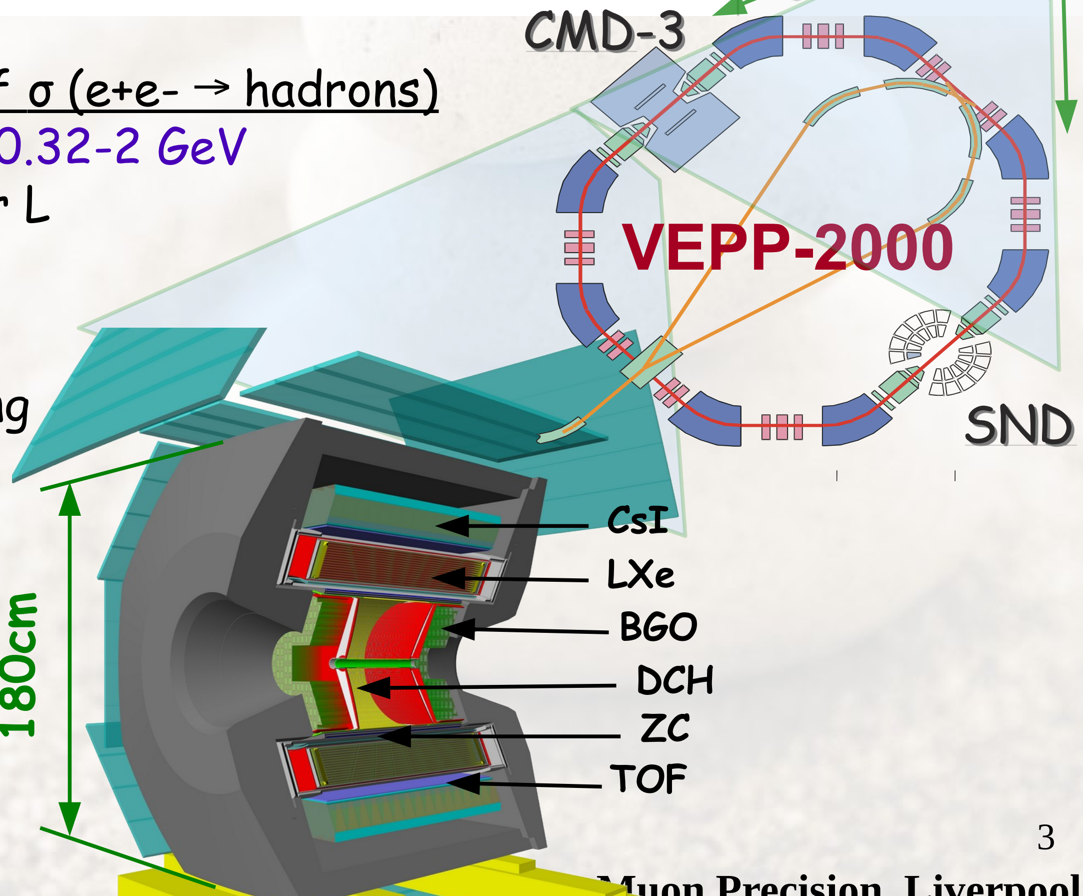
$L = 0.8\times10^{32}\ cm^{-2}s^{-1}$ at 2E= 2 GeV

Energy monitoring by Compton backscattering

$\sigma_{\sqrt{s}} \approx 0.1$ MeV

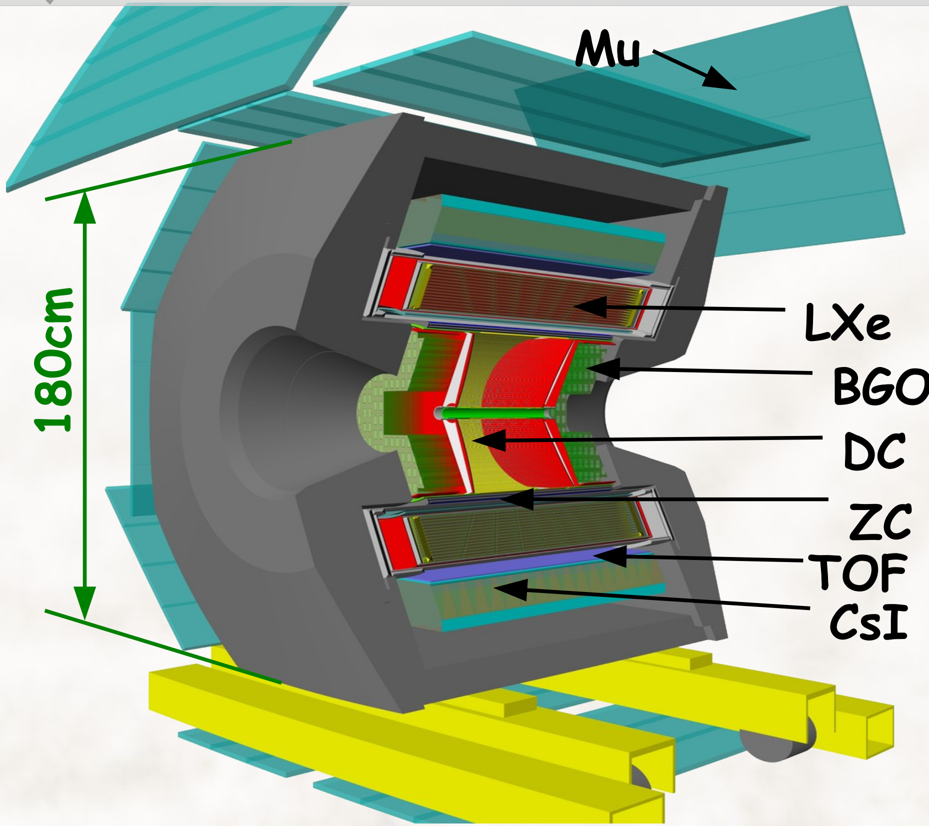
<u>Two detectors: CMD-3 and SND</u>

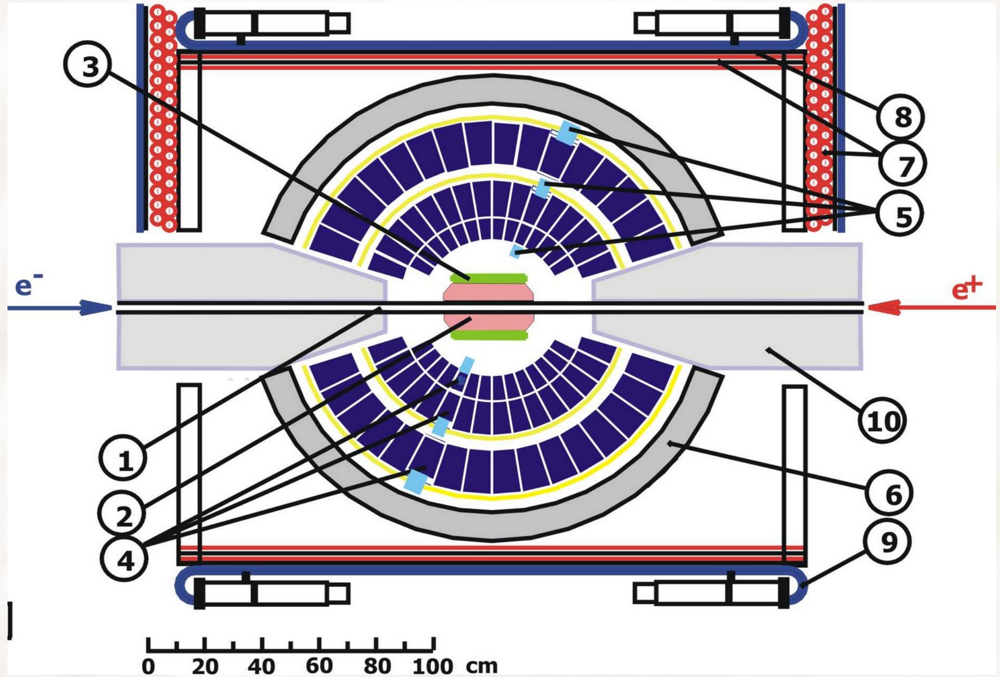
started by the end of 2010




VEPP-2000
collider ring
SND
CMD-3
6.65 m

CMD-3 and SND





1.3 T magnetic field

Tracking: $\sigma_{R\varphi}$ ~ 100 μm, σ_Z ~ 2mm

Combined EM calorimeter (LXe,CsI, BGO):

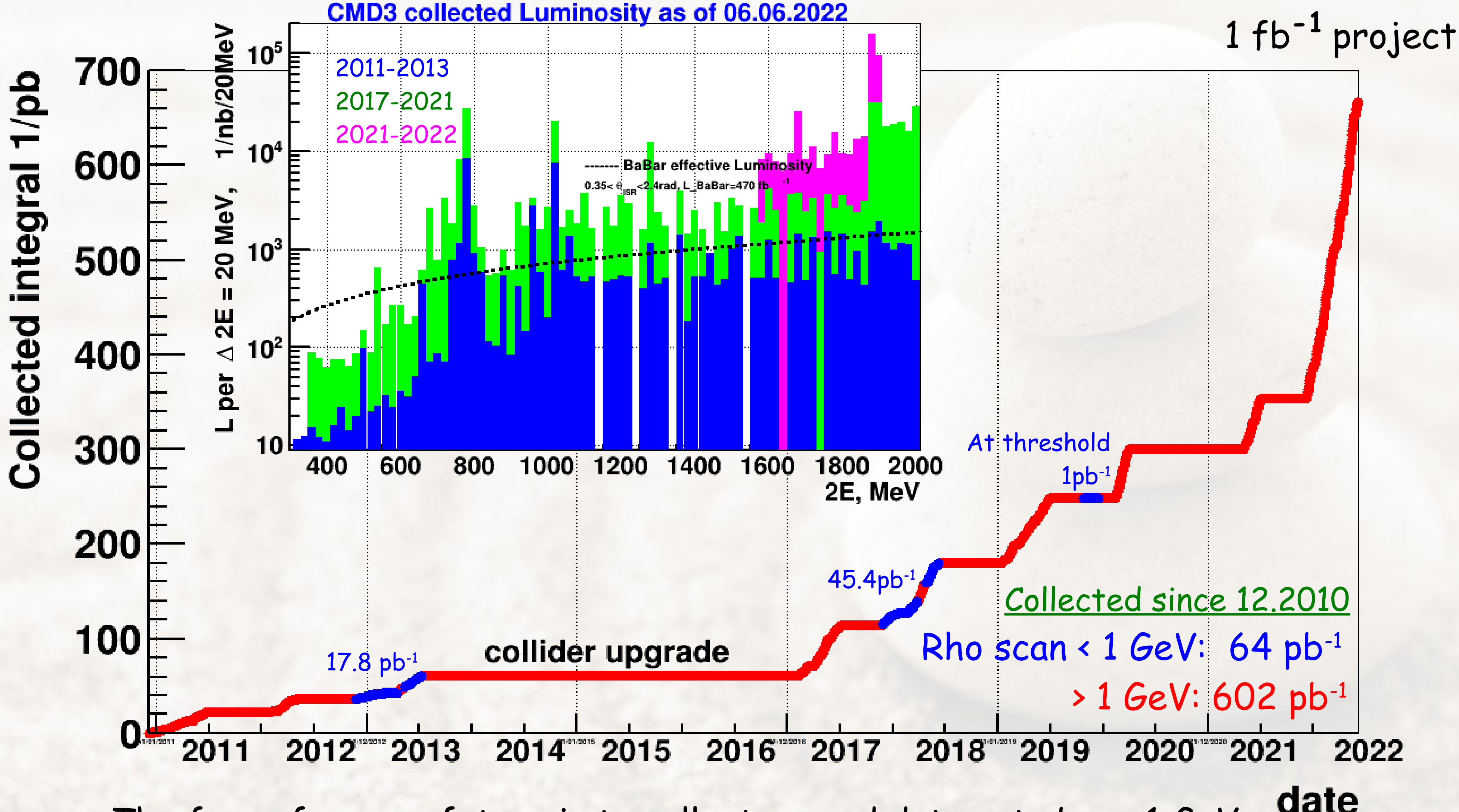
σ_E ~ 3-8%,Tracking in LXe calorimeter

~2mm measurement of conversion point

1 – beam pipe, 2 – tracking system, 3 – aerogel Cherenkov counter , 4 – NaI(Tl) crystals, 5 – phototriodes, 6 – iron muon absorber, 7–9 – muon detector

In 1996-2000 SND collected data at VEPP-2M

Overview of CMD-3 data taking runs



The focus for near future is to collect record data set above 1 GeV

SM prediction for muon g-2

White Paper 2020 (e-Print: 2006.04822)

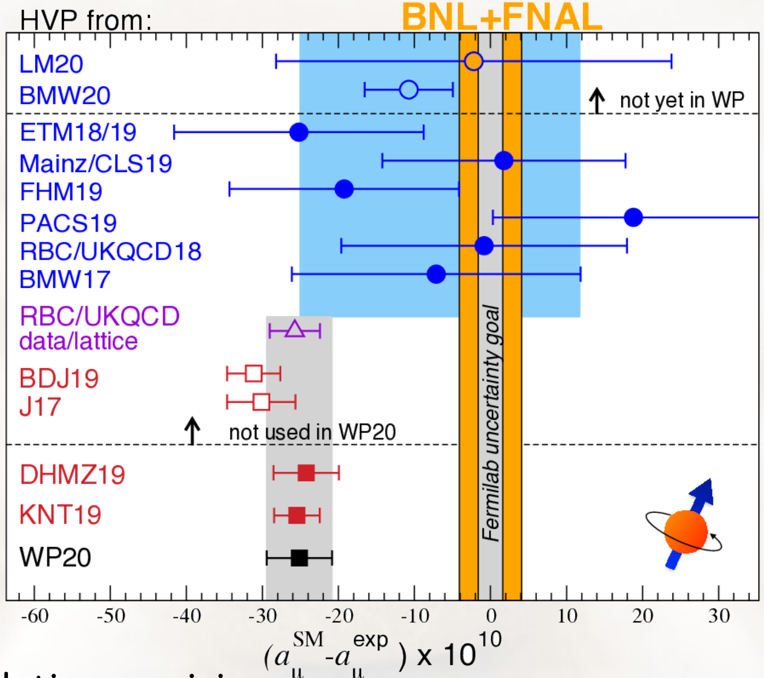
Experimental world average (E821+E989)

a_μ = 11 659 206.1 ± **4.1** x 10^{-10}

Theoretical prediction data driven

a_μ = 11 659 181.0 ± **4.3** x 10^{-10} **(WP20)**

Δa_μ = 25.1 ± **5.9** x 10^{-10}



e-Print: 2203.15810

Hadronic part from measured cross-section

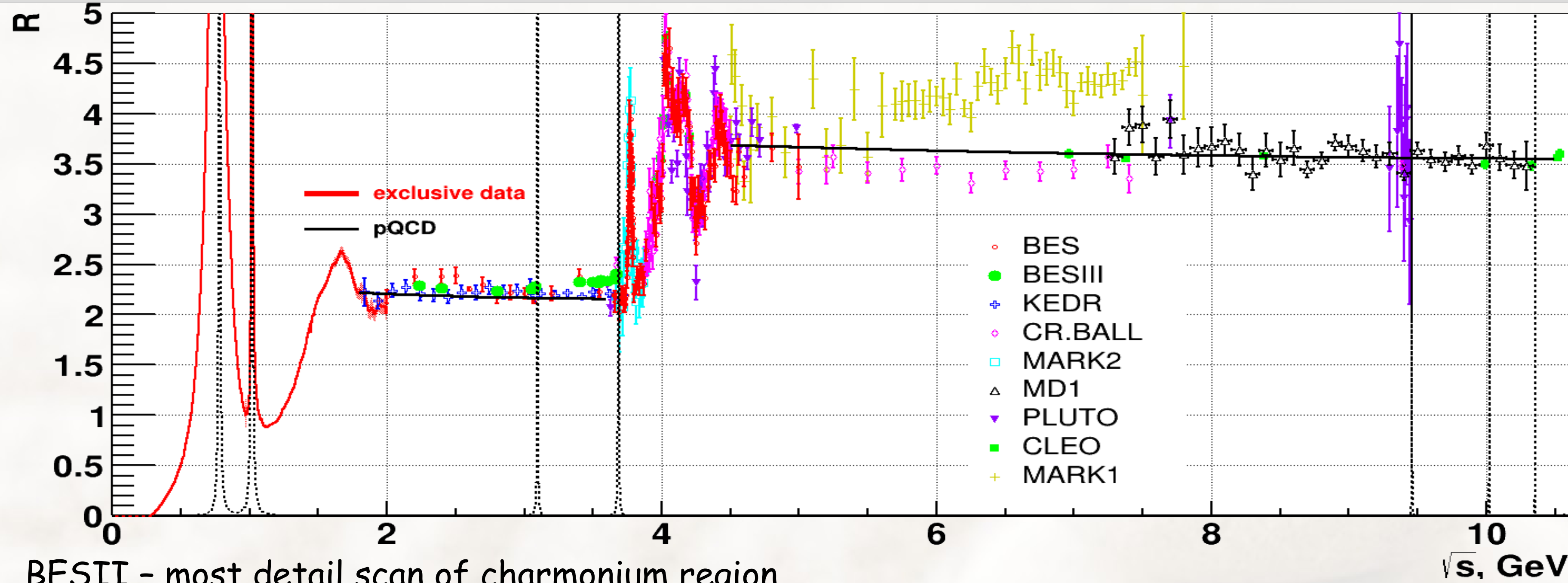
LO hadronic 693.1 ± **4.0** x 10^{-10}

		Relative precision
$\pi^+\pi^-$	506.0 ± 1.9 ± 2.8 (KLOE/BABAR difference)	0.7%
$\pi^+\pi^-\pi^0$	46.4 ± 1.5 (mostly from omega region)	3.2%
$\pi^+\pi^-\pi^0\pi^0$	18.1 ± 0.7	3.9%
Inclusive($\sqrt{s}$>1.8-3.7 GeV)	34.0 ± 0.7 ± 0.7 (DV+QCD)	2.9%

……………….

Light-by-light 9.2 ± 1.9

Inclusive R(s) at √s > 2 GeV



BESII – most detail scan of charmonium region

KEDR, BESIII – systematic precision 2-3% at √s < 3.7 GeV

√s =	1.84 – 3.05 GeV	3.1 – 3.72 GeV
R_{KEDR} =	2.23 ± 0.05	2.20 ± 0.03
R_{BES} =	2.26 ± 0.05	2.34 ± 0.07
R_{pQCD} =	2.18 ± 0.02	2.16 ± 0.01

Phys.Lett. B770 (2017) 174-181
Phys.Lett. B788 (2019) 42-51
Phys.Rev.Lett. 128 (2022) 6, 062004

a_μ (Inclusive(√s>1.8-3.7 GeV)) = 34.0 ± 0.7 ± 0.7 × 10^{-10} (±2.9%)

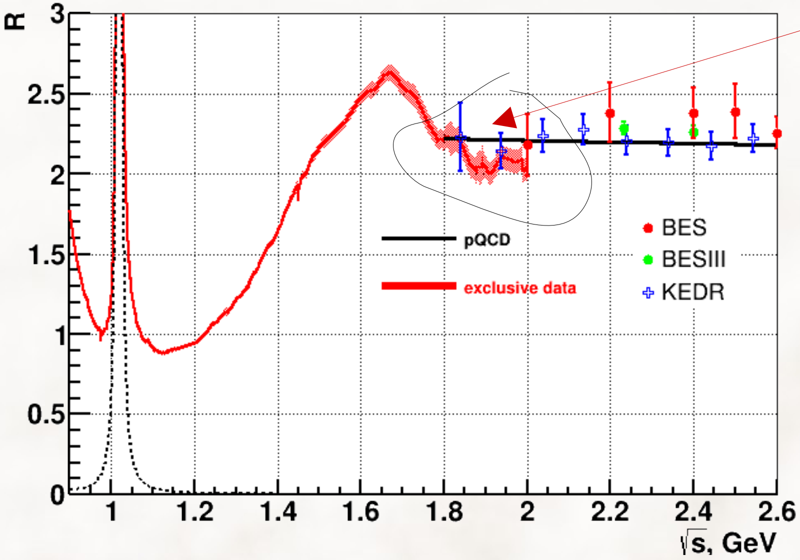
DV+QCD

Expected in future:

BESIII – have another 114 points (just 14 was published) at 2. < √s < 4.6 GeV

KEDR – did 2 scans of 2E=4.5 - 7 GeV (+ up @10 GeV), analysis ongoing

Inclusive vs Exclusive connection



✗ Sum of exclusive channels is ~10% smaller as compared to pQCD at 2E=1.85-2 GeV assigned as quark-hadron duality violation systematic

<u>All channels of e+e- → hadrons should be mesuared</u>

>30 channels contribute at $\sqrt{s}$ = 2 GeV

In past isospin relations were used,

for example 2K2π to (g-2)μ:

was by isospin relations in HLMNT11

$3.31 \pm 0.58 \times 10^{-10}$

after BaBar all modes measurements:

$2.41 \pm 0.11 \times 10^{-10}$ (at $\sqrt{s} < 2.0$ GeV)

a_μ (Inclusive($\sqrt{s}$>1.8-3.7 GeV)) = $34.0 \pm 0.7 \pm 0.7 \times 10^{-10}$ (±2.9%)

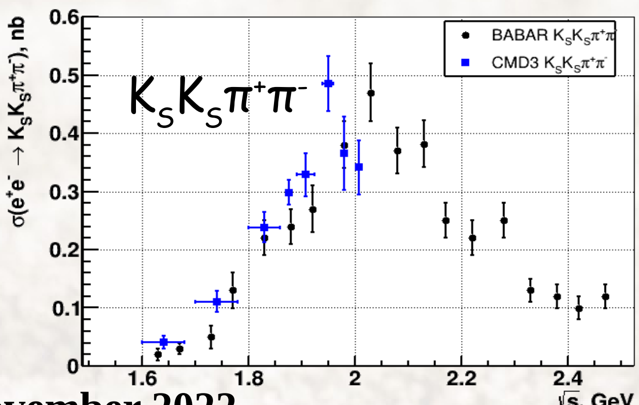
DV+QCD

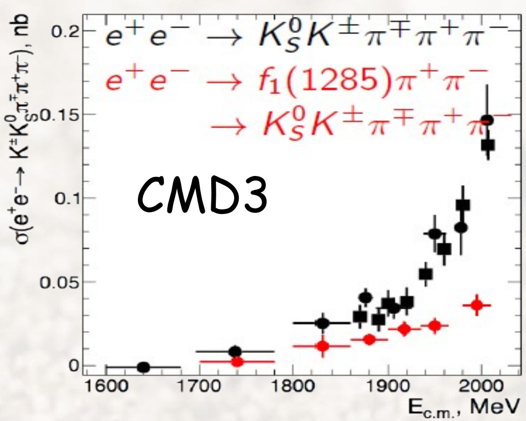
All parts of e+e- → hadrons cataloguing effort is ongoing.

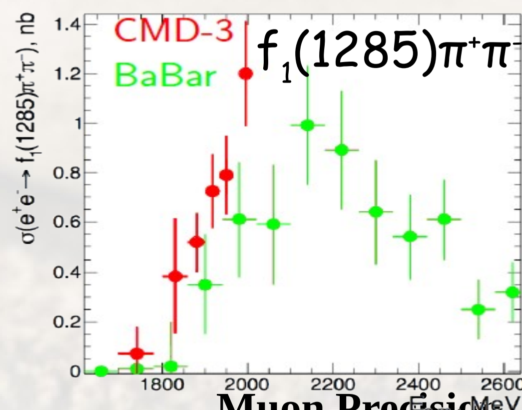
It will strengthen R(s) at 1-2 GeV

Phys.Lett.B 804 (2020) 135380

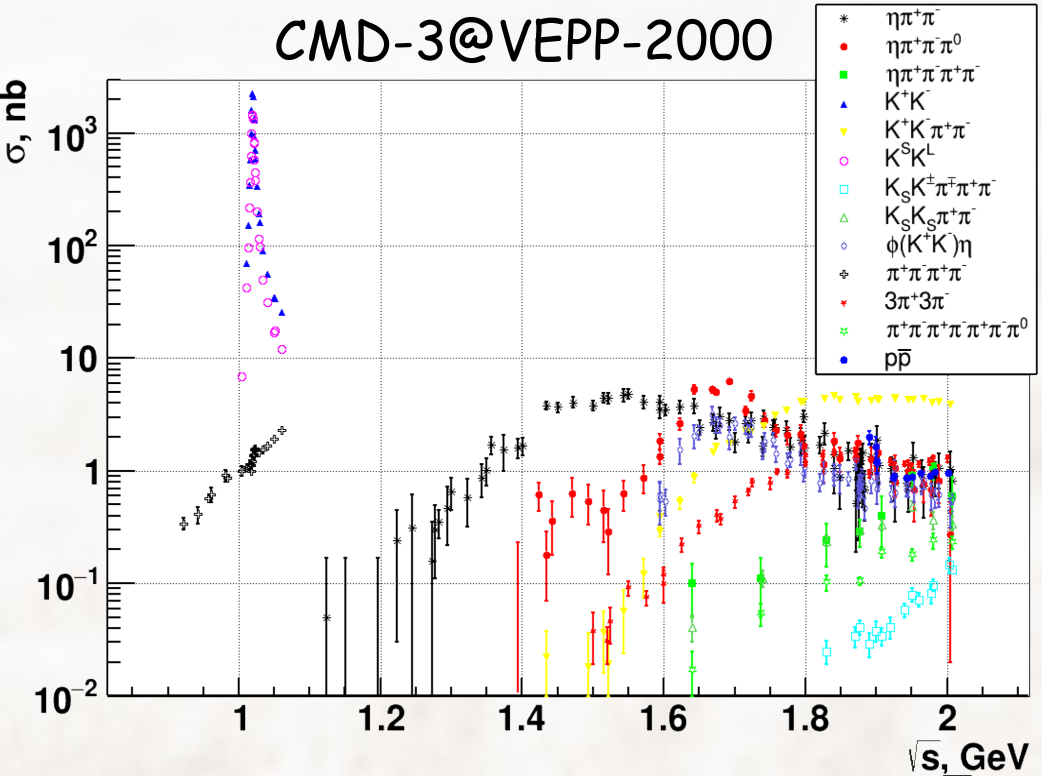
2207.04615 [hep-ex]

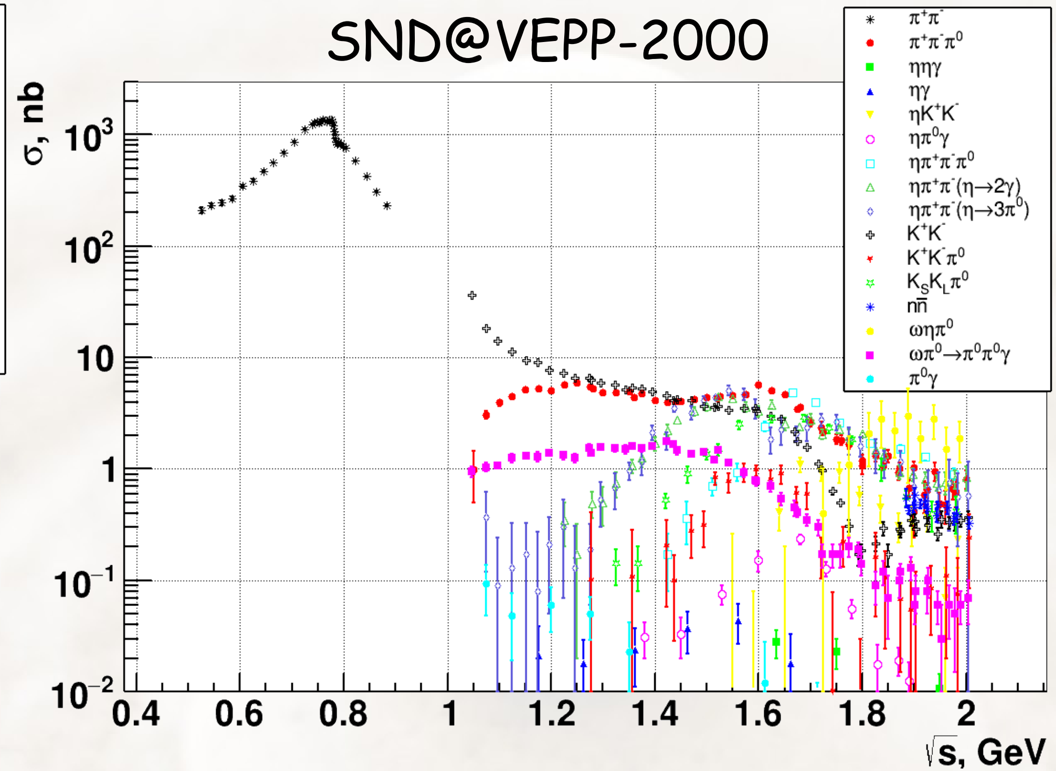






CMD-3 & SND published

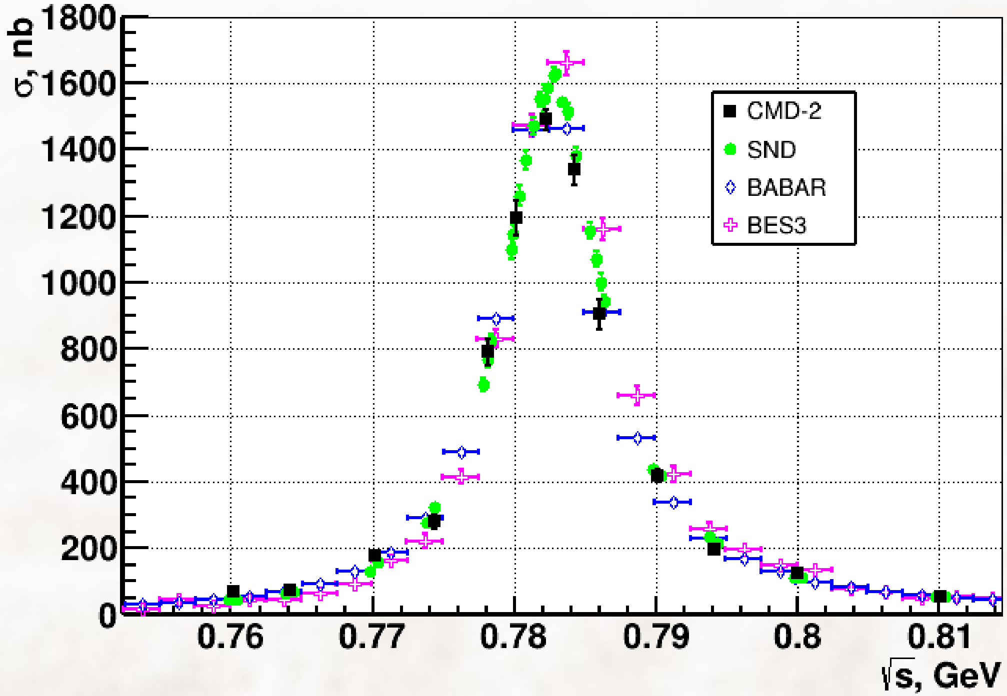




- CMD-3@VEPP-2000: $e^+e^- \to$ η', $p\bar{p}$, $2(\pi^+\pi^-)$, $3(\pi^+\pi^-)$, $3(\pi^+\pi^-)\pi^0$, $\eta\pi^+\pi^-$, $\eta\pi^+\pi^-\pi^0$, $\eta\pi^+\pi^-\pi^+\pi^-$, K^+K^-, K_SK_L, $K^+K^-\pi^+\pi^-$, $K_SK_S\pi^+\pi^-$, $K_SK^\pm3\pi$, $K^+K^-\eta$
- SND@VEPP-2000: $e^+e^- \to$ η, η', f1, $n\bar{n}$, $\pi^0\gamma$, $\eta\gamma$, $\eta\eta\gamma$, $\eta\pi^+\pi^-$, $\eta\pi^+\pi^-\pi^0$,
  - $\pi^+\pi^-$, $\pi^+\pi^-\pi^0$, $\pi^0\pi^0\gamma$, $\omega\eta\pi^0$, K^+K^-, $K^+K^-\pi^0$, $K_SK_L\pi^0$, $K^+K^-\eta$

<u>Many channels is under active analysis</u>

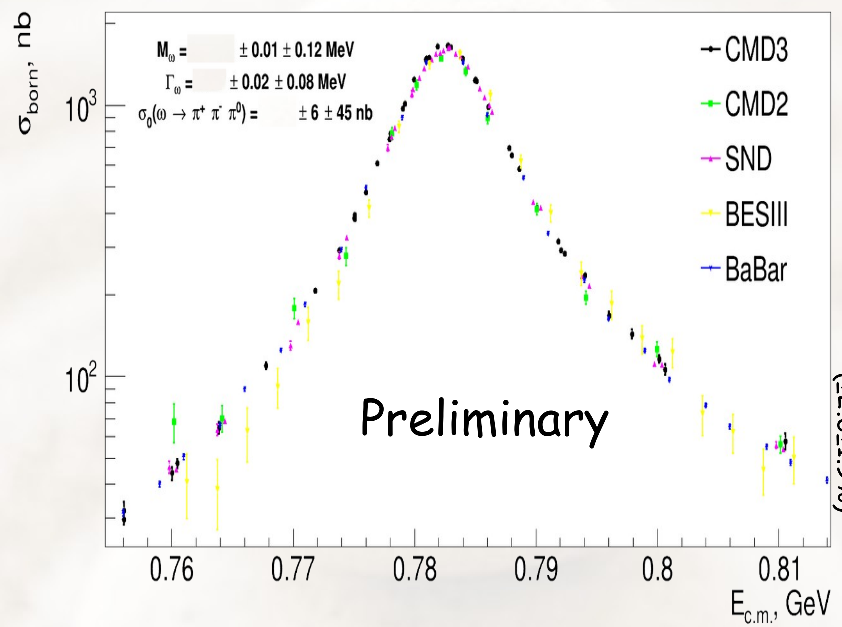
e+ e− → π+ π−π0



CMD2/SND@VEPP-2M disagree at 8%

BES3/BABAR systematic ~ 1.3-1.5% at ω
1912.11208 [hep-ex]/2110.00520 [hep-ex]
It should bring δa_μ to <0.6×10^{-10}

CMD-3 analysis is ongoing



2013, 2018 data, 2.6×10^6 3π events,
L ~54 1/pb
Results are systematics-limited
Expected ~ 2-3%

$a_\mu(\pi^+\pi^-\pi^0) = 46.4 \pm 1.5 \times 10^{-10}$ (±3.2%)
$\pm1.2\pm0.9$(correlated) $\times10^{-10}$ (±2.6±1.9%)

3π channel was also measured as part of 2π analysis at CMD-3
in collinear events acceptance: result in backup slide

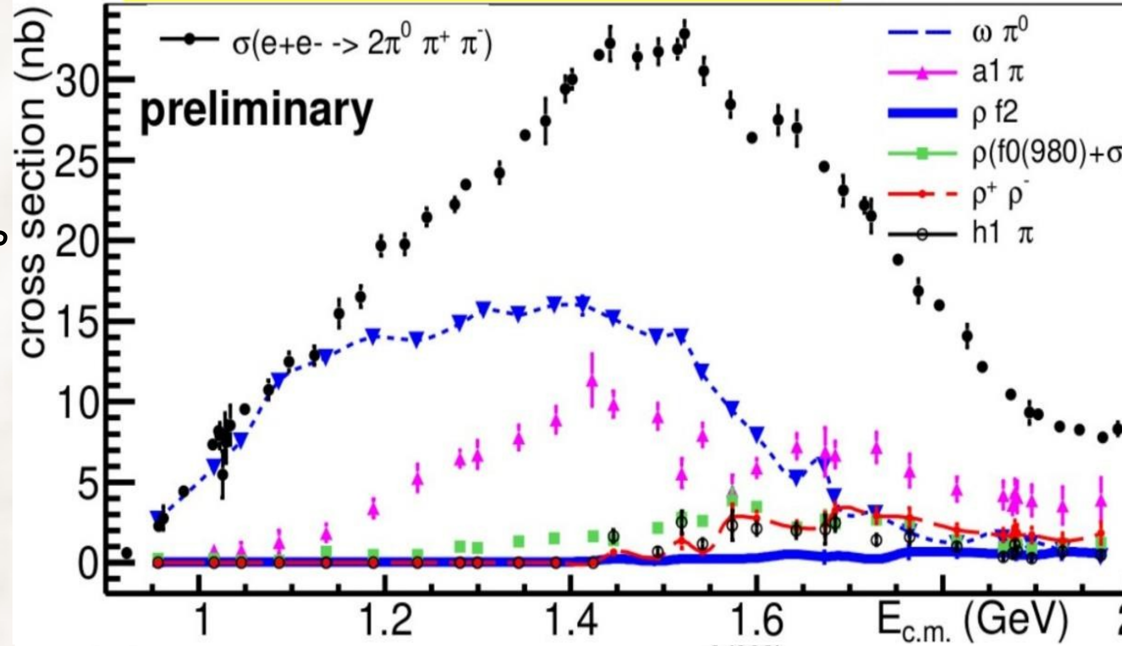
Dynamics in 4π with CMD-3

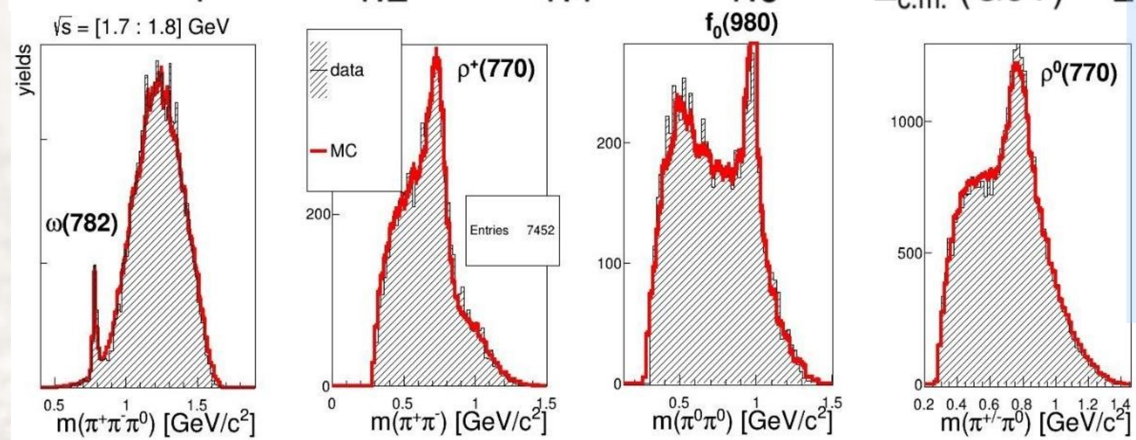
In order to measure hadronic cross section, you have to understand the dynamics of the process.
High statistics is crucial!
CMD-2/SND@VEPP-2M systematic dominated by model uncertainty ~3-5%

Simultaneous amplitude analysis of 150k $\pi^+\pi^-\pi^0\pi^0$ and 250k $\pi^+\pi^-\pi^+\pi^-$ events.
Many intermediate states is observed:

- $\omega[1^{--}]\pi^0[0^{-+}]$
- $a1(1200)[1^{+}]\pi[0^{-}]$
- $\rho[1^{--}]f_0/\sigma[0^{++}]$
- $\rho f_2(1270)[2^{++}]$
- $\rho^+\rho^-$
- $a_2(1320)[2^{++}]\pi$
- $h_1(1170)[1^{+-}]\pi^0$
- $\pi'(1300)(0^{-+})\pi$

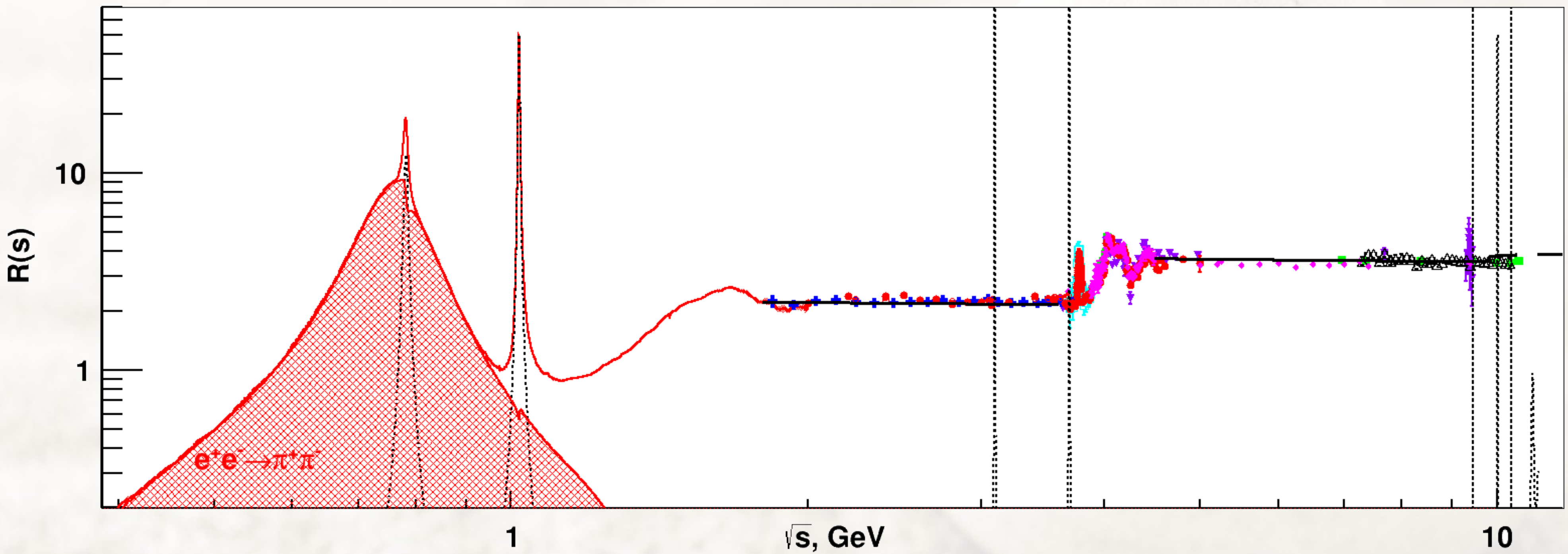
$$R_i(s) = \frac{\int |V_i \cdot \mathbf{H}_{i\perp}(\Omega)|^2 d\Phi}{\int |\sum_\beta V_\beta \mathbf{H}_{\beta\perp}(\Omega)|^2 d\Phi} \cdot \sigma_{2\pi^0\pi^+\pi^-}(s)$$





$a_\mu(\pi^+\pi^-\pi^0\pi^0) = 18.1 \pm 0.7 \times 10^{-10}$ (±3.9%)

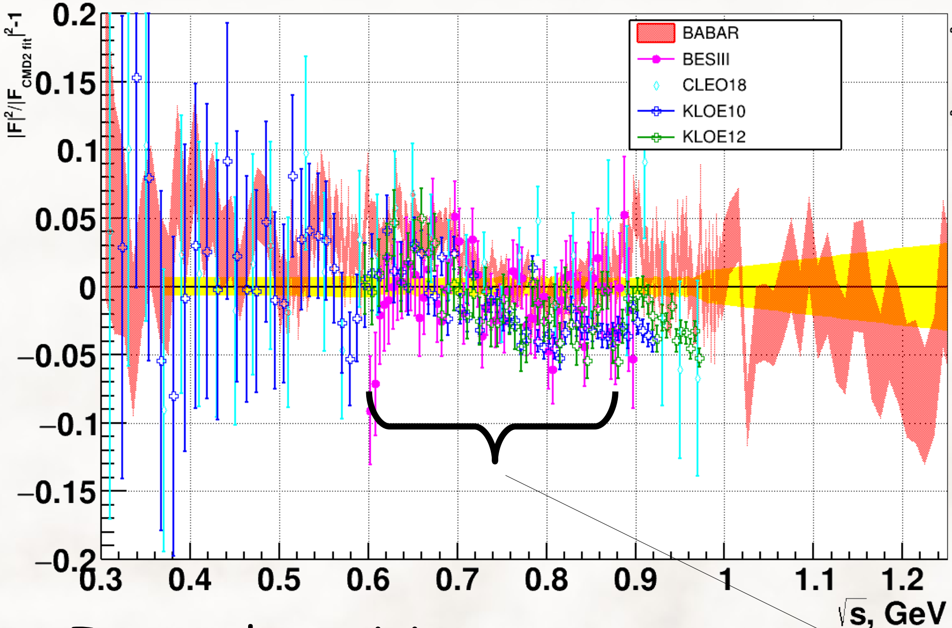
$e^+e^- \to \pi^+\pi^-$

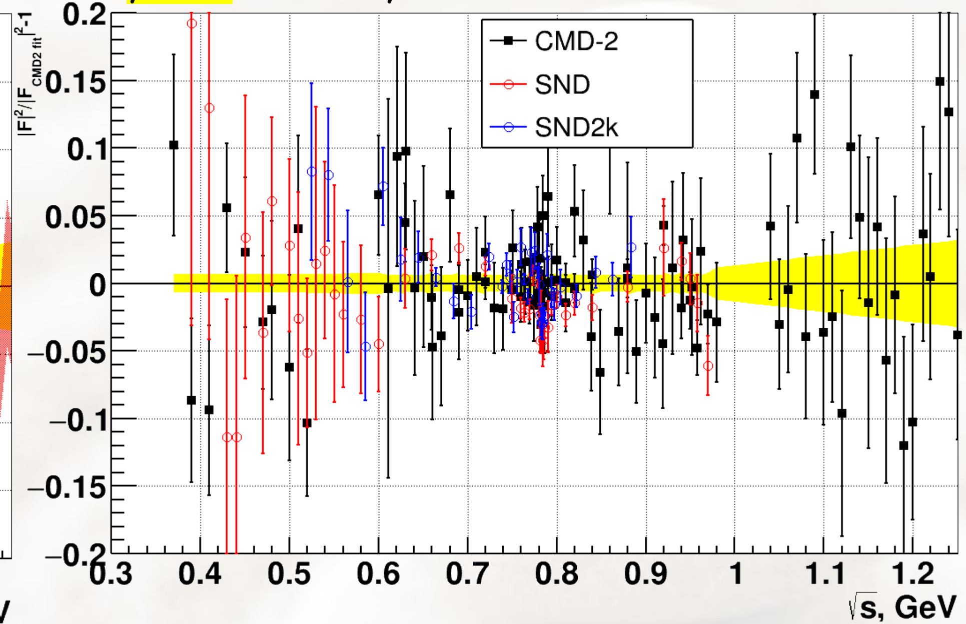


Gives main contribution to R(s) at √s < 1 GeV

The $\pi+\ \pi-$ contribution to a_μ^{had}

Relative to CMD-2 fit, yellow band – systematic value





$a_\mu(\pi^+\pi^-) = 506.0 \pm 1.9 \pm 2.8 \times 10^{-10}$ (±0.7%)

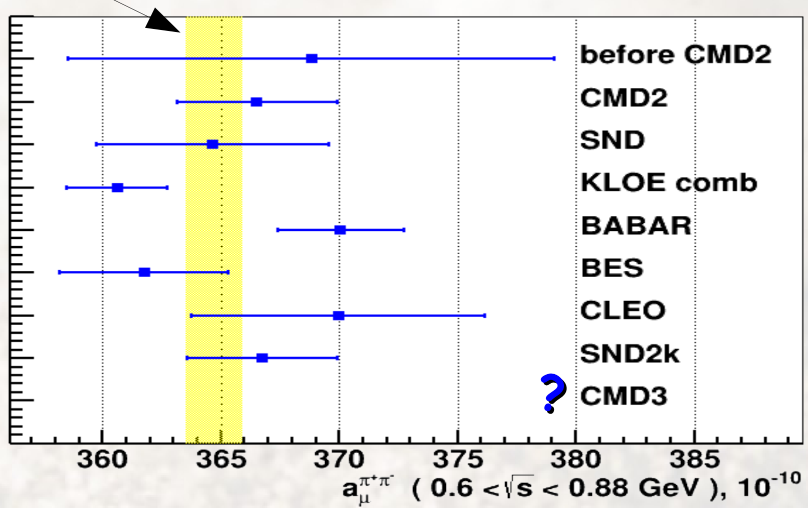
KLOE/BABAR difference

Integral precision is limited by systematics

Seen 2.9σ tension KLOE vs BaBar

local inconsistencies larger than claimed systematic errors

→ additional scale factor



Systematic Error (ρ-region)

CMD2: 0.6-0.8%

SND: 1.5%

KLOE: 0.8%

BABAR: 0.5%

BES: 0.9%

CLEO: 1.5%

SND2k : 0.8%

CMD3:

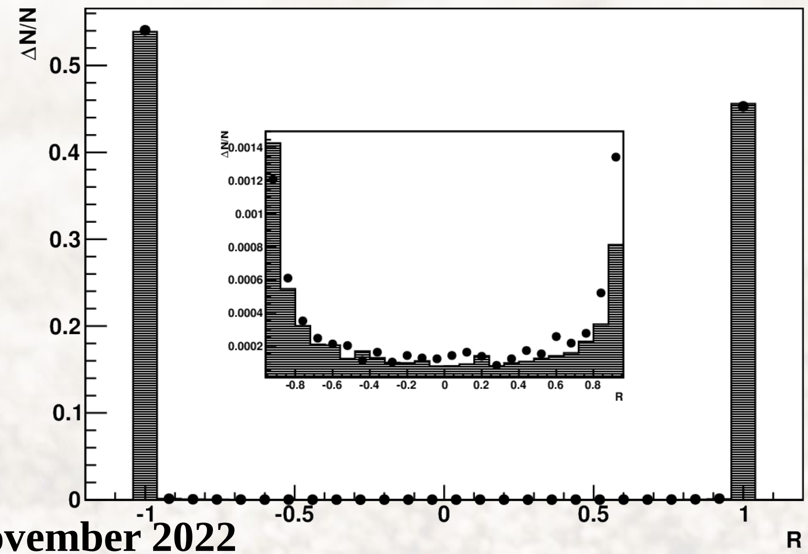
e+e- → π+π- @ SND

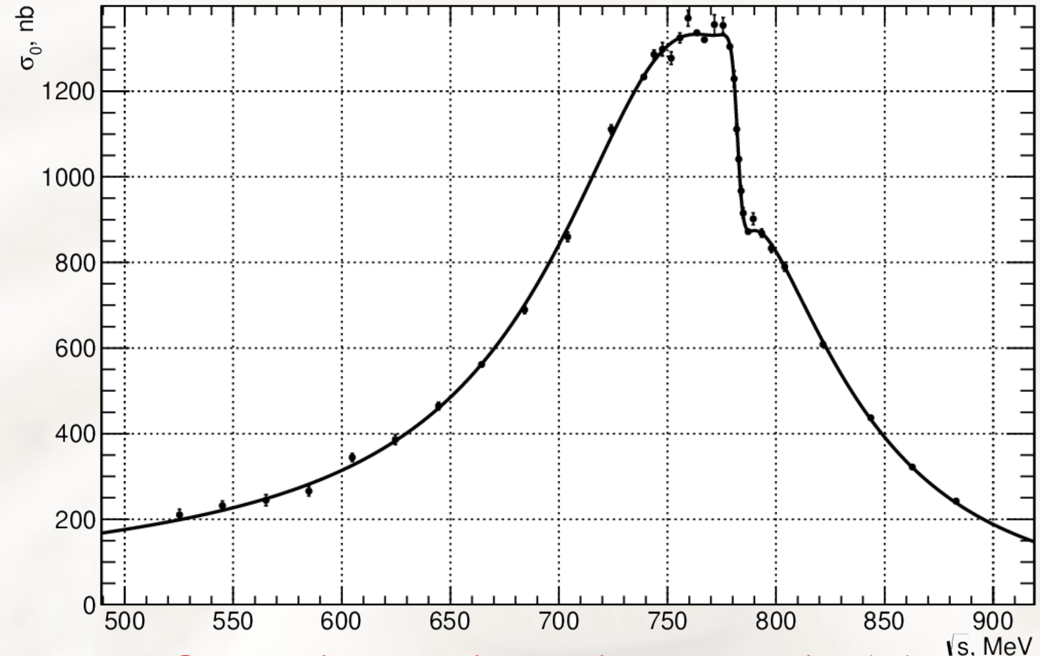
First measurement of $e^+e^- \to \pi^+\pi^-$ at VEPP-2000

The analysis is based on
4.7 pb^{-1} data recorded in 2013
~ 10^6 $\pi^+\pi^-$, $\mu^+\mu^-$, 1.3×10^6 e^+e^-
(~1/10 full SND data set)

π/e separation by ML (BDT)
using information on shower profile
from 3-layers of calorimeter

M.N. Achasov et al, JHEP 01 (2021) 113





Systematic uncertainty on the cross section (%)

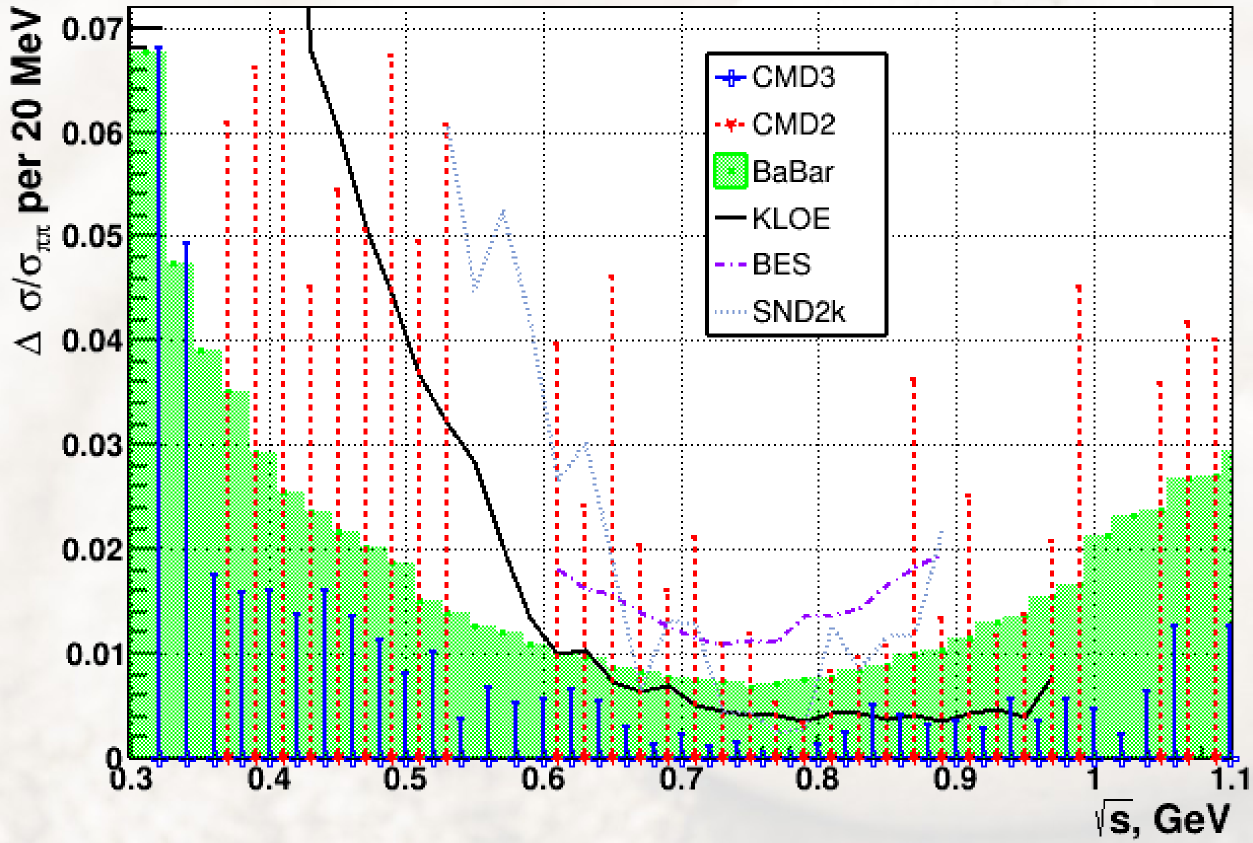
Source	< 0.6 GeV	0.6 - 0.9 GeV
Trigger	0.5	0.5
Selection criteria	0.6	0.6
e/π separation	0.5	0.1
Nucl. interaction	0.2	0.2
Theory	0.2	0.2
Total	**0.9**	**0.8**

e+e- → π+π- by CMD-3

Statistical precision of cross section measurement for seasons at <1 GeV (2013+2018+2020)
a few times better than any other experiments

Full statistic up to date with ρ scans

RHO2013
RHO2018
LOW2020

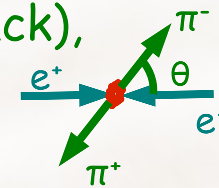


Analysis based on L = 61.8 pb^{-1} at √s < 1 GeV (+23.1 pb^{-1}, 1.0-1.1 GeV)

34×10^6 $\pi^+\pi^-$, 3.7×10^6 $\mu^+\mu^-$, 44×10^6 e^+e^-
events selected at √s < 1 GeV

e+e- → π+π- by CMD3

Very simple topology (just 2 track back to back),
but the most challenging channel
due to high precision requirement.



Analysis was performed trying to reach systematic ~0.35-0.5%

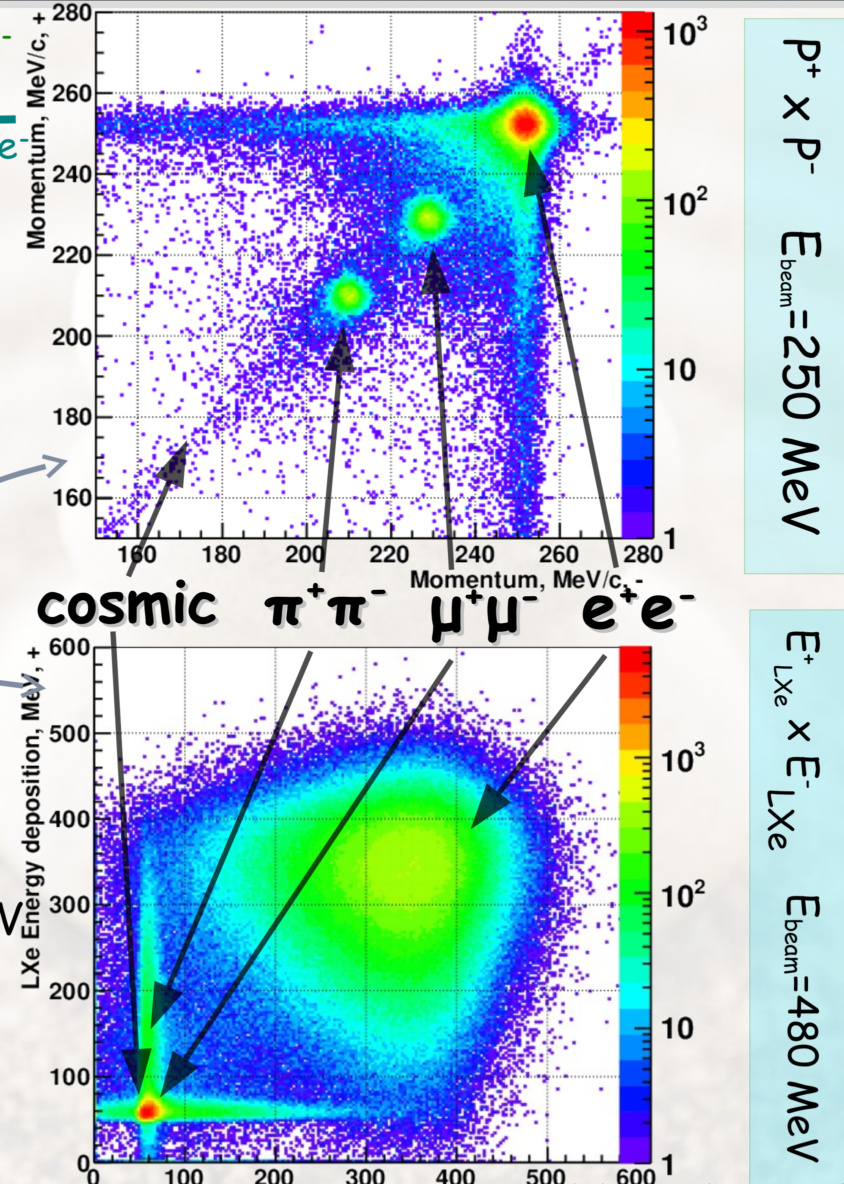
Crucial pieces of analysis:

- ✗ e/μ/π separation
- ✗ radiative corrections
- ✗ precise fiducial volume
- ✗ ...

events separation either
1) by momentum
2) or by energy deposition

3) additional cross-check
by angle distribution

4) using shower profile at >1GeV

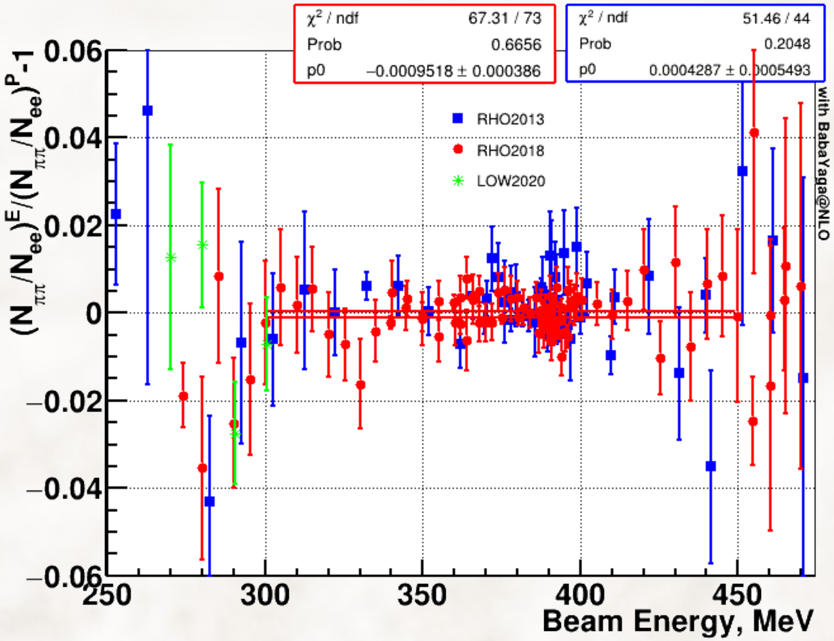


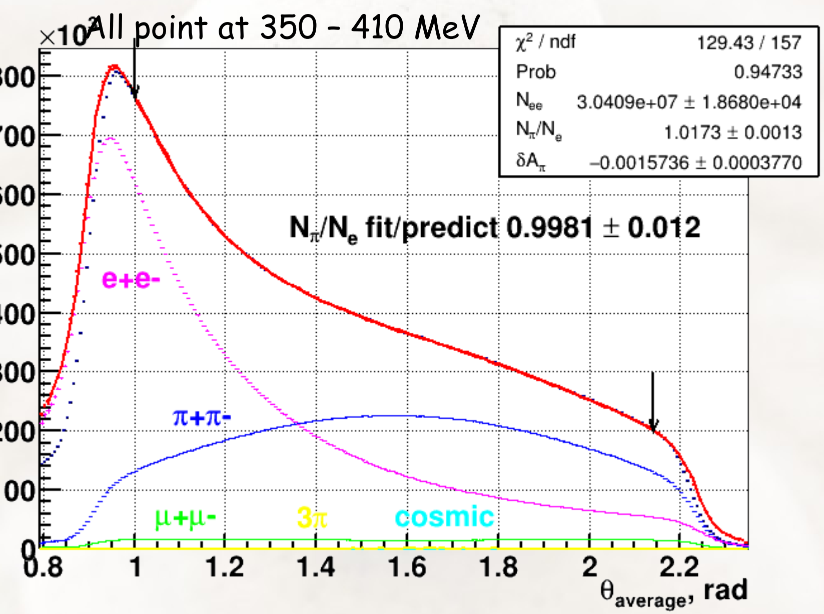
e/μ/π separation

3 methods for $N_{\pi\pi}$ /N_{ee} determination based on independent informations:

1) Momentum from DCH **2)** Energy deposition in LXe **3)** angles in DCH

E vs P separations





Fit by θ distribution

For sum of 350-410 MeV points

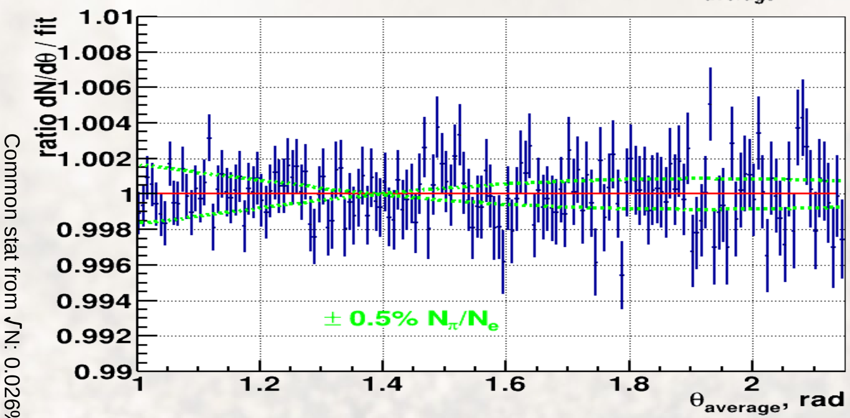
by momentums in DCH: $N_{\pi\pi}$ /N_{ee} = 1.0192 +- 0.00028

by energies in LXe Δ $N_{\pi\pi}$ /N_{ee} = -0.08 +- 0.023%

from theta with free δA: = -0.19 +- 0.12%

with fixed δA=0: = +0.22 +- 0.07%

Common stat from √N: 0.026%



consistency at ~ 0.2%

Fiducial volume

Polar angles are measured by DCH with help of charge division method.

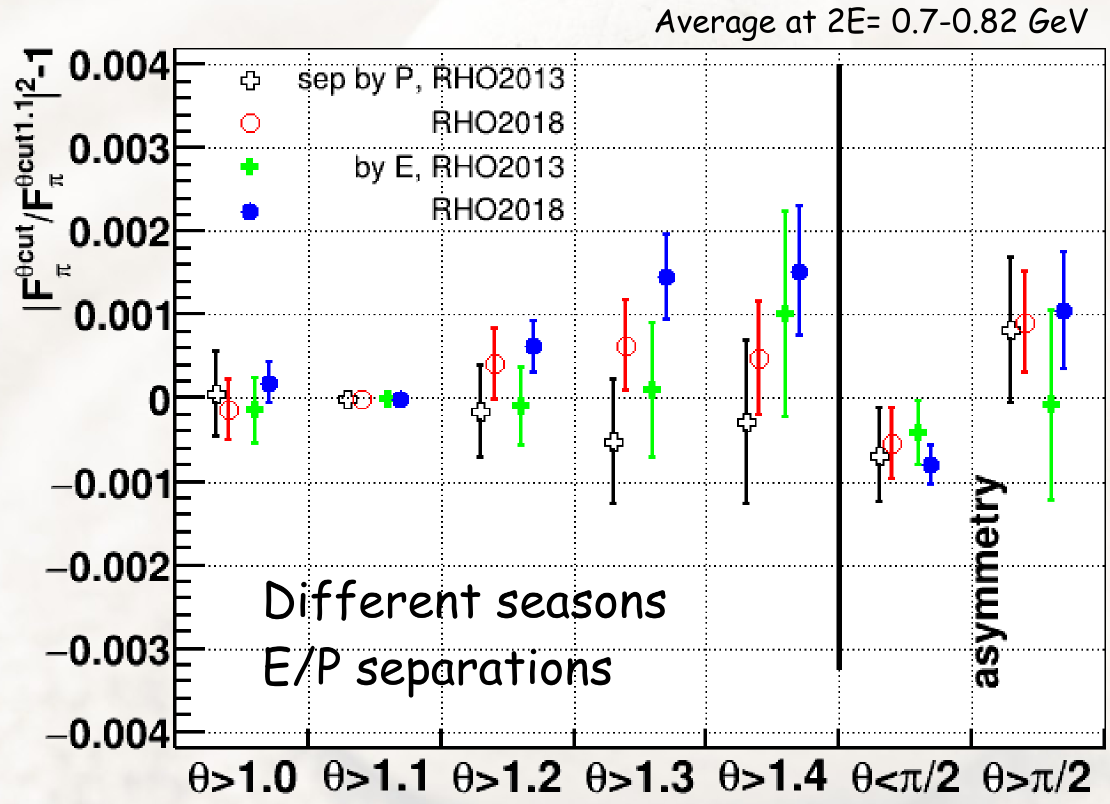
External system with strip readout is used for calibration:

- LXe calorimeter
  strip size 10-15 mm, $\sigma_z \sim 2$ mm
- ZC multiwire chamber until 2017
  strip size 6 mm, $\sigma_z \sim 0.7$ mm

ZC vs LXe compatibility is used to control systematics

+ LXe vs DCH, DCH at inner radius effects

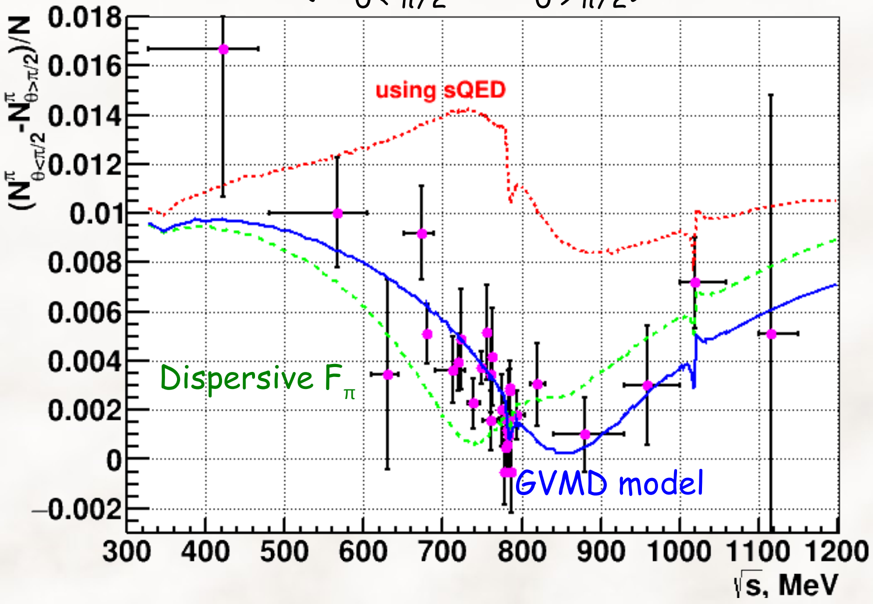
Dependence on theta cut $\theta_{cut} < \theta^{event} < \pi - \theta_{cut}$



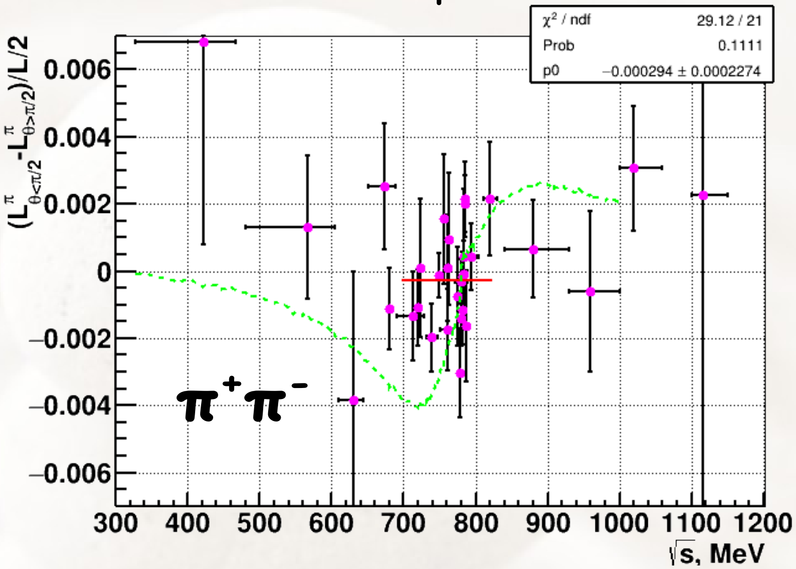
$|F_\pi|^2$ stable at <0.05% level

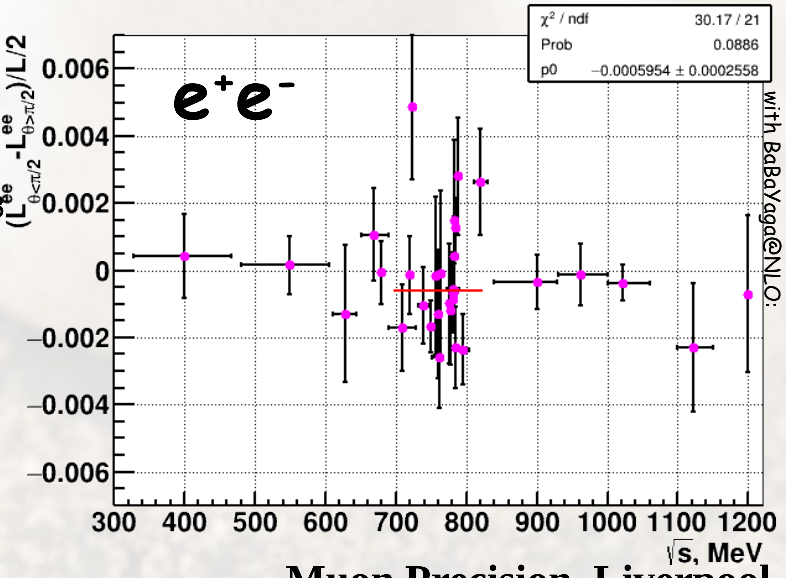
Charge asymmetry in e+e- -> π+π-

$A = (N_{\theta < \pi/2} - N_{\theta > \pi/2})/N$



Relative to prediction





Conventional sQED approach gives ~ 1% inconsistency

The theoretical model within GVMD was introduced,

describes well the CMD-3 data R.Lee et al., Phys.Lett.B 833 (2022) 137283

was confirmed by calculation in dispersive formalism

M.Hoferichter et al., JHEP 08 (2022) 295

Average at $\sqrt{s}$ = 0.7-0.82 GeV:

$\pi^+\pi^-$: <δA> = -0.029 ± 0.023 %

e^+e^-: <δA> = -0.060 ± 0.026 %

Ensure our θ angle systematic estimation for $|F_\pi|^2$

Radiative corrections

Measurement of $e^+e^- \to \pi^+\pi^-$ requires high precision calculation of radiative corrections.

Two high precision MC generators is used
MCGPJ(0.2%, e+e-,μ+μ-,π+π-) vs BabaYaga@NLO (0.1%, e+e-,μ+μ-)

e+e- → e+e-(γ) : great consistency <0.1% in the total cross section
e+e- → μ+μ-(γ) : It is missed mass term in FSR term in most of generators
(effect 0.4% at $\sqrt{s}$=0.32 GeV)
e+e- → π+π-(γ) : only MCGPJ available with 0.2% precision
(for energy scan experiments)

Achieved precision in current analysis is sensitive
for differential cross sections predictions
e/π separation by momentum requires
$d\sigma/dP^+dP^-$ spectras as initial input
Asymmetry study requires $d\sigma/d\theta$ spectras

Radiative corrections

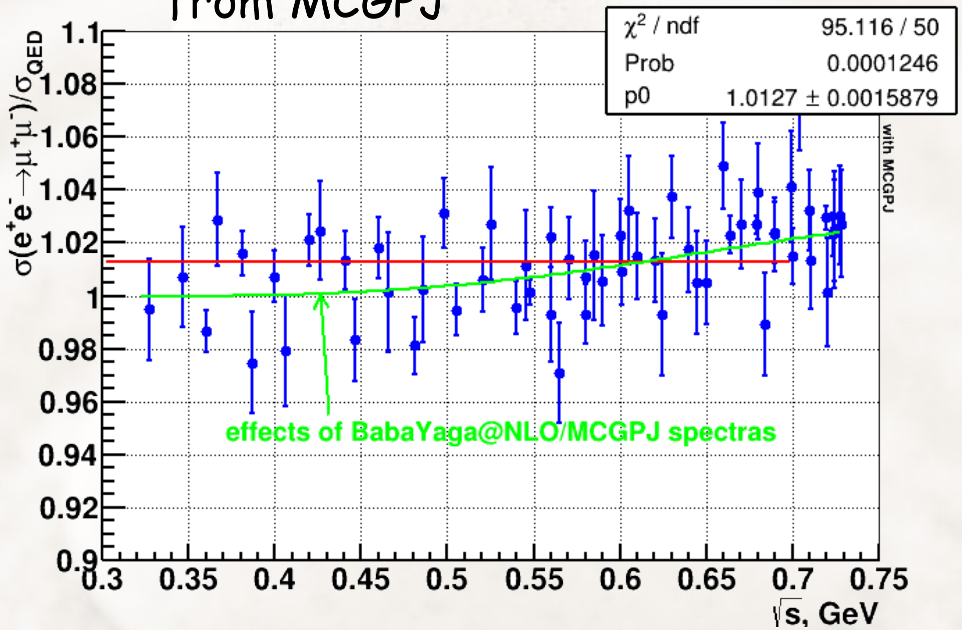
Measurement of $e^+e^- \to \pi^+\pi^-$ requires high precision calculation of radiative corrections.

BaBaYaga@NLO shows better agreement with the data:

1) Momentum spectras better describe data:
gives consistent results in $N_{\mu\mu}$/QED
(effect on $|F_\pi|^2$ ~0.2% at $\sqrt{s}$=0.78 GeV,
and rising to 1.5% at 0.9 GeV when using P-separation)

2) Experimental asymmetry in e+e- data
relative to BabaYaga@NLO:
δA = -0.060 ± 0.026 %
relative to MCGPJ
δA = -0.140 ± 0.026 %
BabaYaga@NLO consistent with NNLO MCMule
δA = +0.006 ± 0.003 % at $\sqrt{s}$=0.76 GeV

effect on $N_{\mu\mu}$/QED
with input $d\sigma/dP^+dP^-$ spectras
from MCGPJ



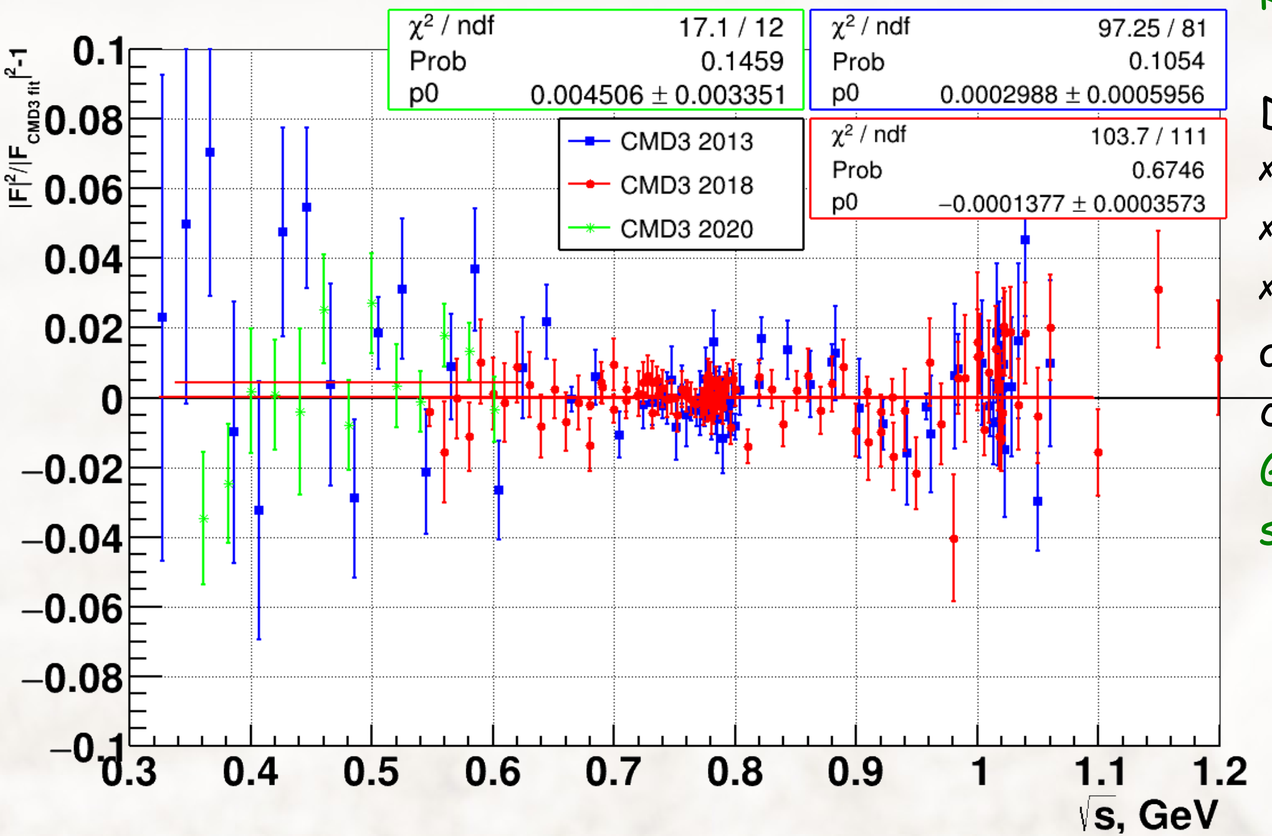
We adopted generators usage in this way:

e+e- : BabaYaga@NLO
μ+μ- : BabaYaga@NLO (differential cross section)
MCGPJ (integral)
π+π- : MCGPJ

MCGPJ/BabaYaga@NLO difference gives systematics

Better NNLO generators are needed for higher precision

Consistency checks



Result consistent between seasons within < 0.1%

DCH was in very different conditions:

- correlated noise
- 4 middle layers off (HV-related) in 2013
- etc….

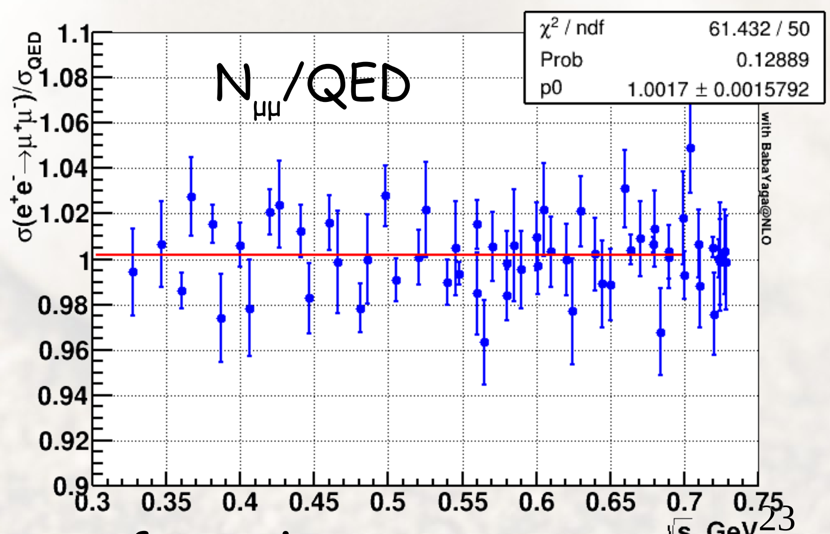
as result it gives ~x2 difference in some corrections

Good check of angle/tracking related systematics

$|F_\pi|^2$ RHO2018/RHO2013 Δ = -0.04 ± 0.07 %

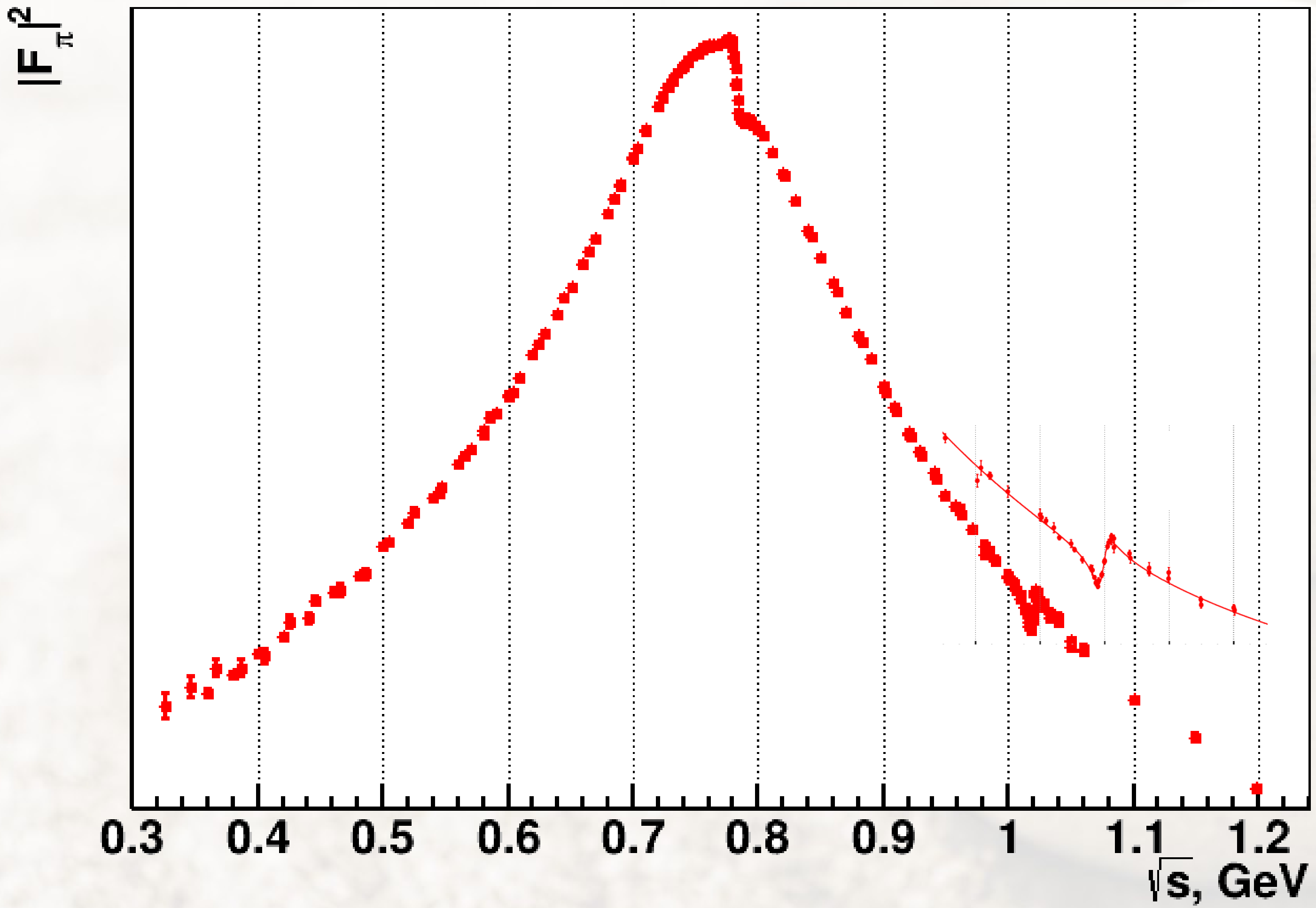
LOW2020/RHO2013 Δ = -0.5 ± 0.6 %

$N_{\mu\mu}$/QED Δ = +0.17 ± 0.16 %



Many others consistency checks were performed

Coming soon



The publication is in preparation. As soon as it will be ready, we'll announce results.

Conclusion

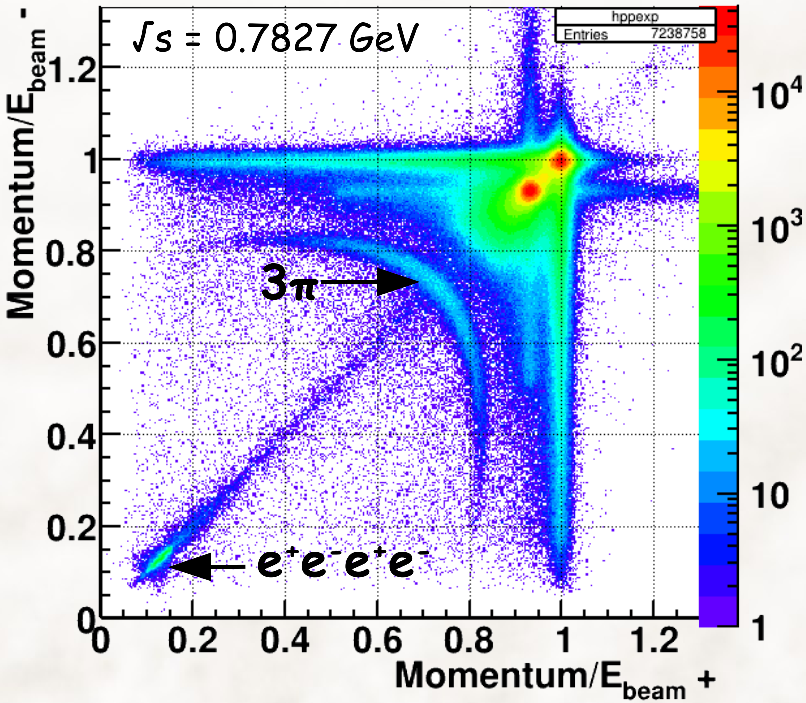
- VEPP-2000 collider is only one working this days on direct scanning below <2 GeV for measurement of exclusive σ ($e+e- \rightarrow$ hadrons)
- Collider performance is constantly improving, with already collected ~0.67fb^{-1}

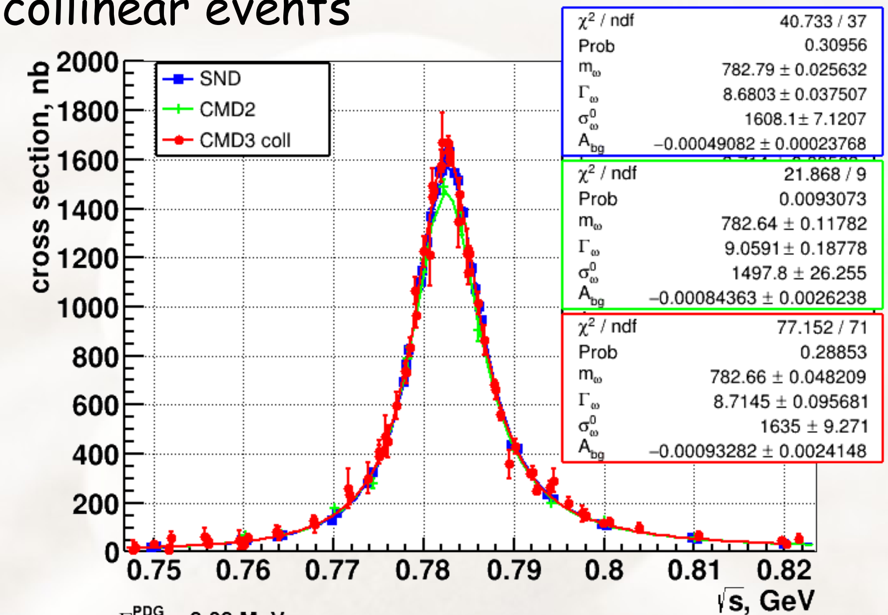
- Data analysis are in progress, many result were published
- First pion formfactor data at VEPP-2000 was published in 2021 by SND using ~10% of total available data set
- CMD-3 pion formfactor publication is under preparation, it will be based on full data set at $\sqrt{s} < 1$ GeV

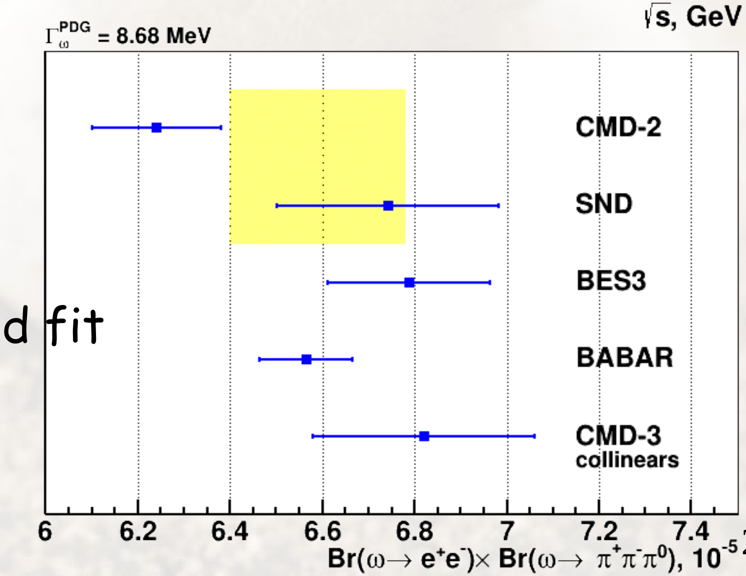
backups

$\sigma(e^+e^- \to \pi^+\pi^-\pi^0)$ within collinear events

Collinear events selection for 2π analysis







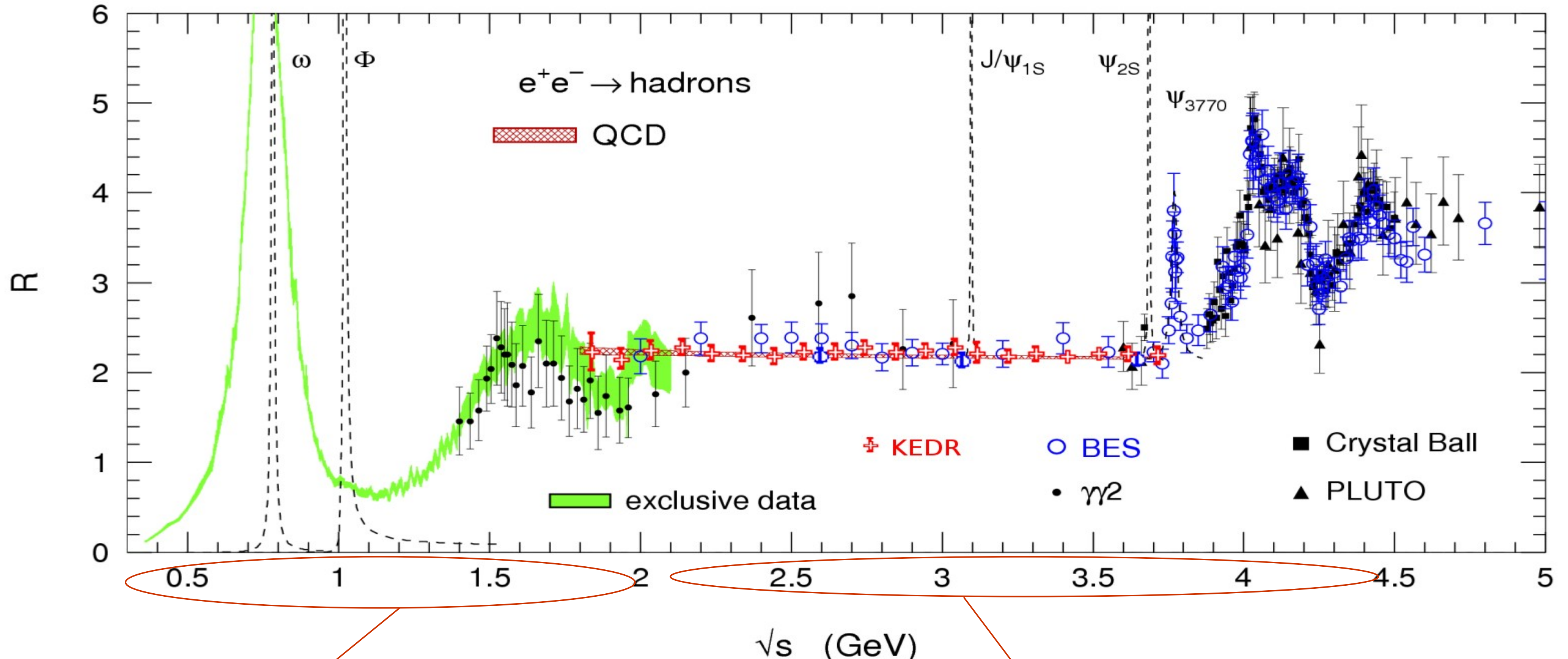
$e^+e^- \to \pi^+\pi^-\pi^0$ is background for $\pi^+\pi^-$ analysis (0.8% at ω)

Number of 3π events is additional parameter in likelihood fit

$$B(\omega\to e^+e^-)B(\omega\to\pi^+\pi^-\pi^0) = (6.82 \pm 0.04 \pm 0.24)\times 10^{-5}$$

confirm SND@VEPP-2M result

Inclusive vs exclusive measurements



Exclusive approach:

- ✗ measure each final state separately and calculate the sum
  VEPP-2M, VEPP-2000, Babar, KLOE
- ✗ gives better precision

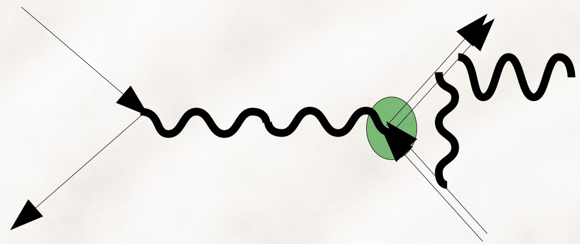
Inclusive approach:

- ✗ select events with any hadron(s) in the final state
  BES, KEDR, etc
- ✗ possible because of many modes and high track multiplicity

sQED assumptions

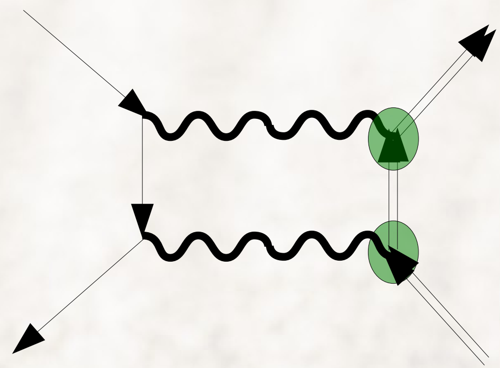
The radiative correction calculations is commonly done in the sQED approach,
It's mean that the calculations are performed without form factor,
then final Amplitude is scaled by $F(q^2)$

It works well for such amplitudes:



A = sQED*F(s)

But it is too naive for loop diagrams:



sQED: $|M^2| \sim |F(s)|^2$

Two pion vertex gives:
$|M^2| \sim F(s)*F((q_0-q)^2)*F(q^2)$

two cases of changes:

1) when 2 photon hard
$\sim F^2(s/4)/F(s)$ non IR term x10
2) 1 soft photon, one vertex go off-peak
$\sim F(s-2E\omega)/F(s)$ part of IR by 1./2

Strong modification of loop integral parts

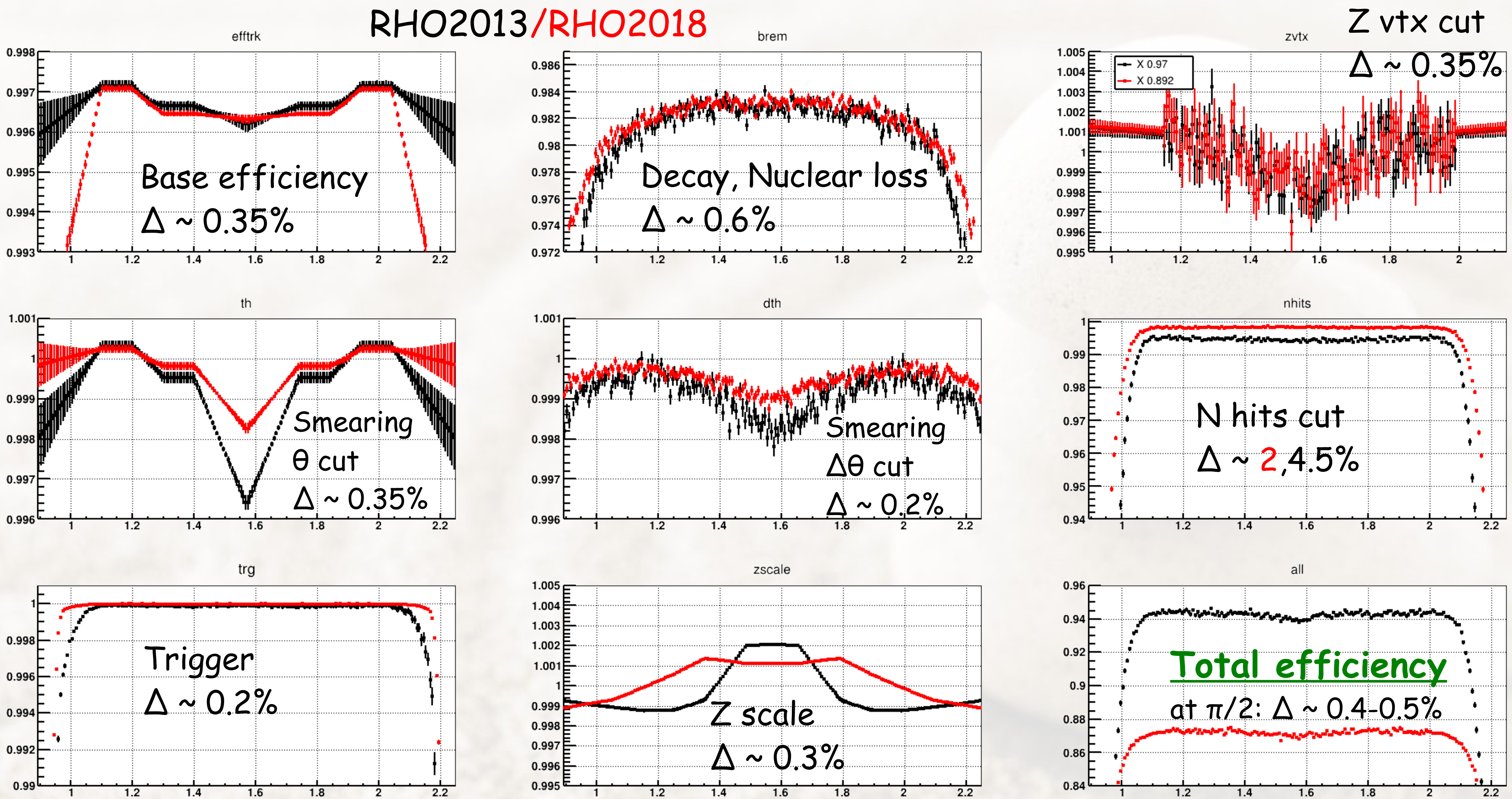
with $|F(M_\rho^2)|^2 \sim 45$

Proper way will be to put $F(q^2)$ to each vertex

Thanks to Roman Lee, this calculations was done with above sQED

π+π- эффективность от θ угла

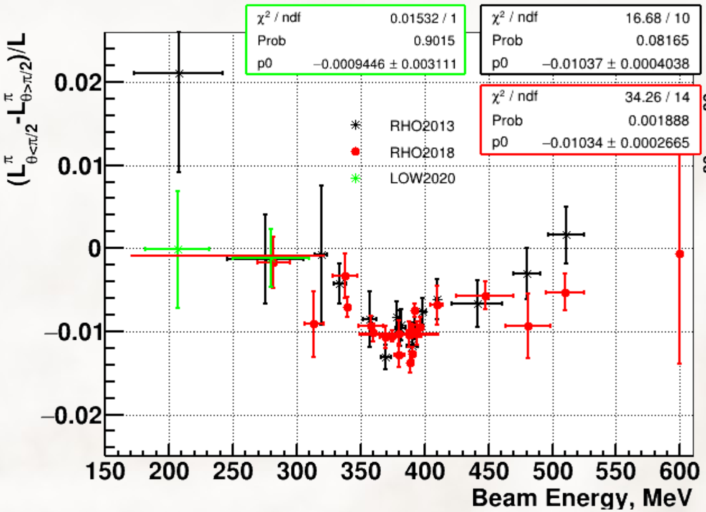
RHO2013/RHO2018



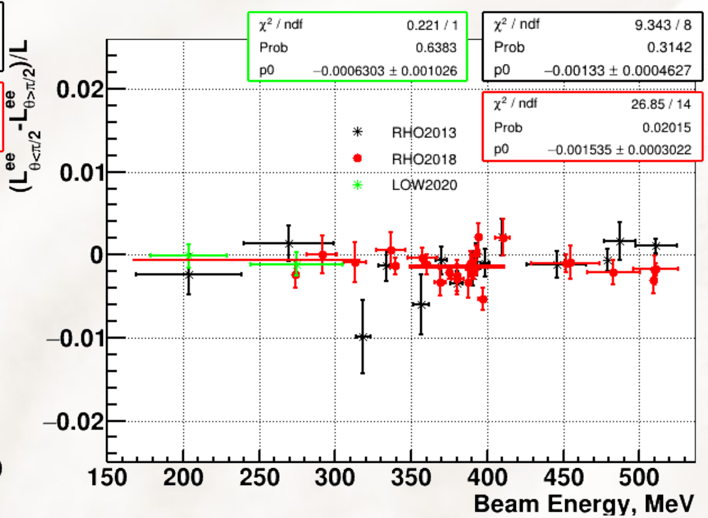
Сумма по всем точкам 350-410 МэВ

Asymmetry relative to generator prediction

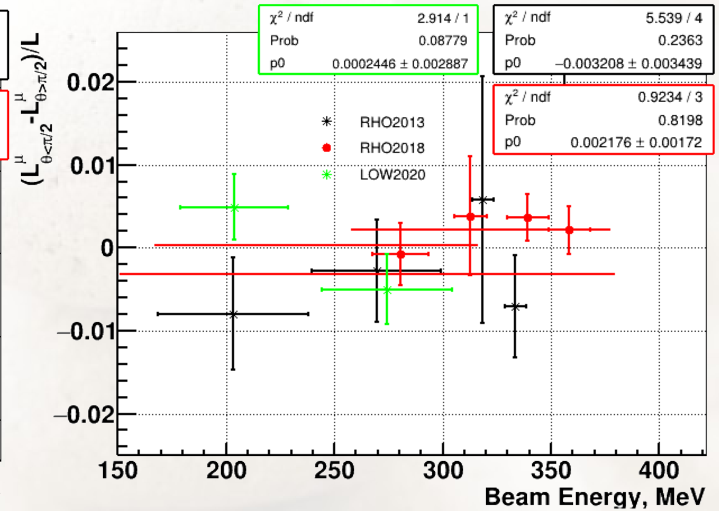
δA (π+π-)



δA (e+e-)



δA (μ+μ-)



Average at 2E=350-410 MeV

<δA> = -1.04 ± 0.02 %

ρ - like behaviour

with MCGPJ:

<δA> = -0.15 ± 0.03 %

with BaBaYaga@NLO:

-0.07 ± 0.03 %

Fixed order NNLO ~ -0.06

No trends for e+e-

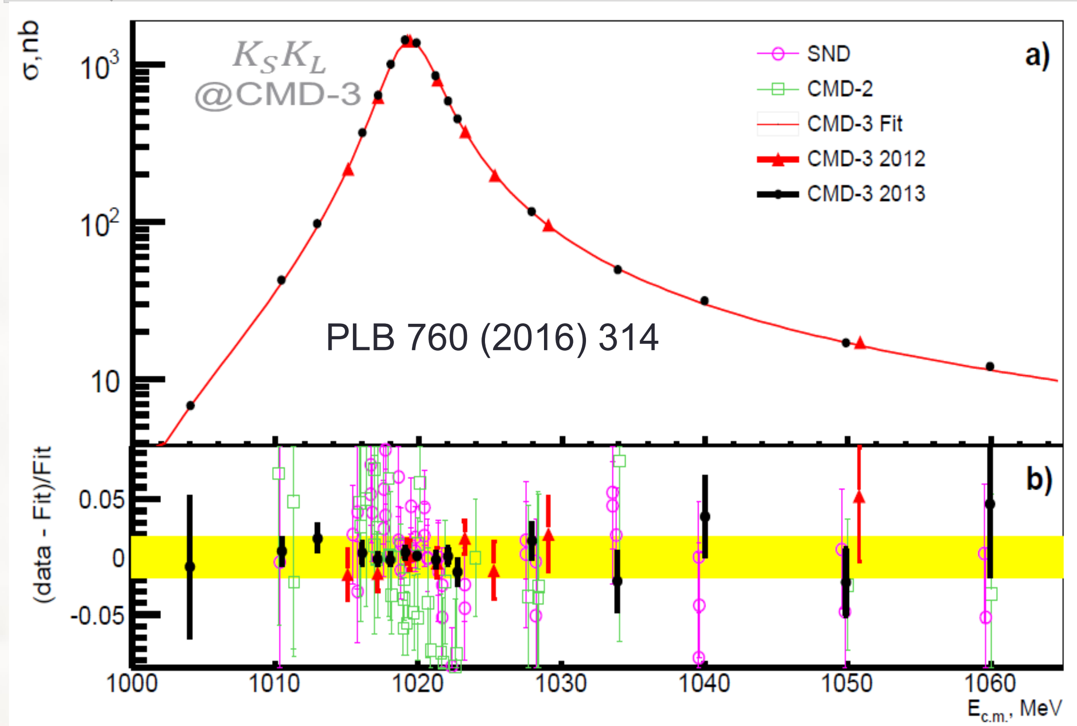
BabaYaga/MCGPJ difference gives ~ 0.08%

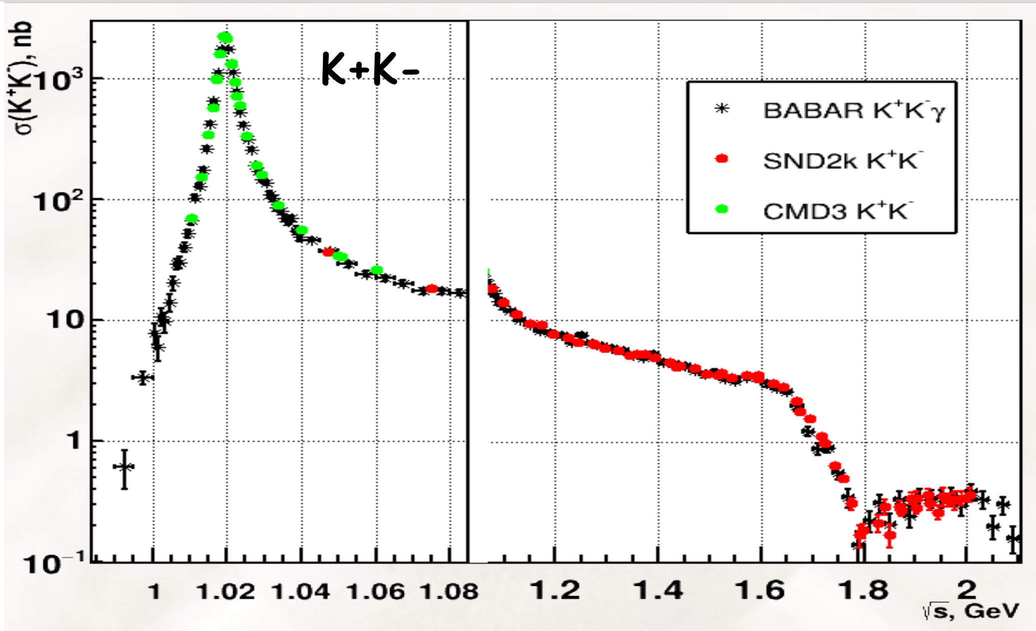
Detector systematic ~ 0.1%

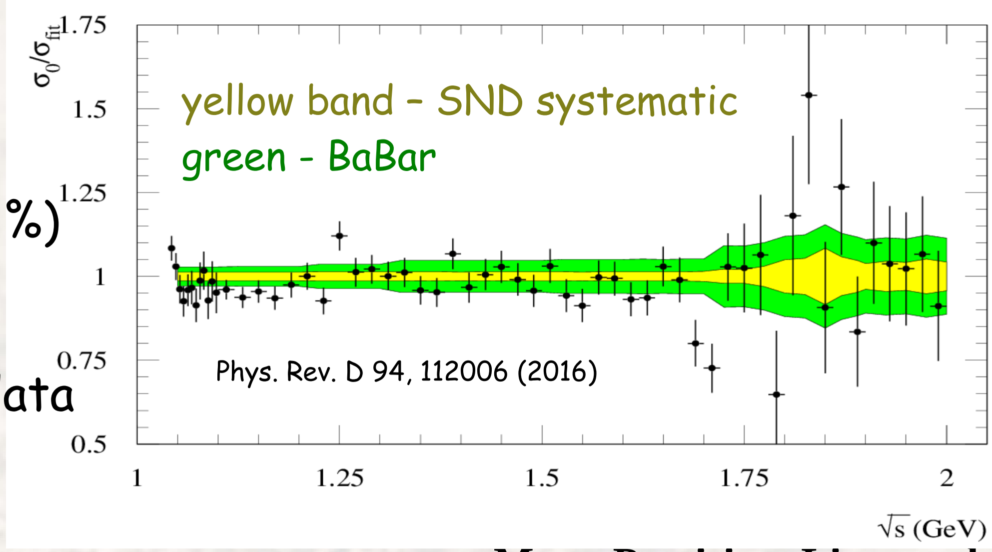
<δA> = 0.10 ± 0.14 %

Nμμ can be extracted only at lowest energies

e+e- -> K$\bar{K}$



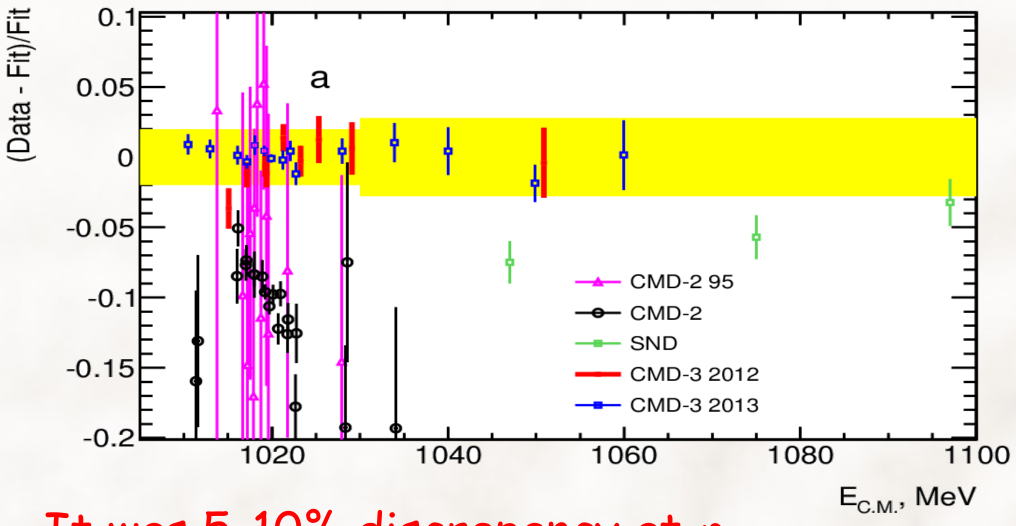


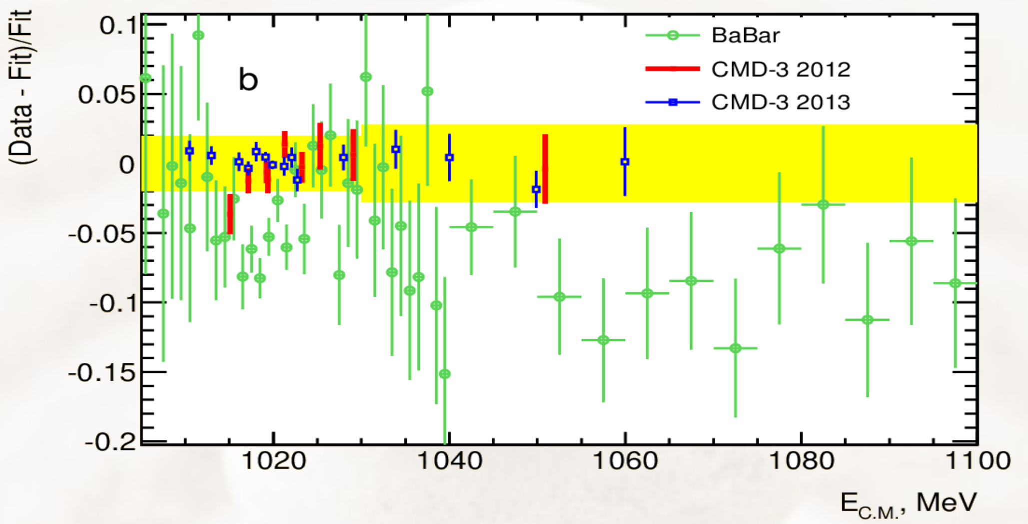


CMD-3: KsKl at φ - Best systematic precision (1.8%)
CMD-3: K+K- is under internal review (syst 2%)

The SND measurement agrees with the BABAR data and has comparable or better accuracy.

φ → K+K- comparison between experiments





It was 5-10% discrepancy at φ

Between CMD-2 (2.2% systematic) CMD2 underestimated trigger inefficiency for slow K+K-

SND at VEPP-2M (7.1%)

with BaBar data (0.72%)

New CMD-3 cross-section is above CMD-2 and BaBar,

but it is in consistency with isospin symmetry:

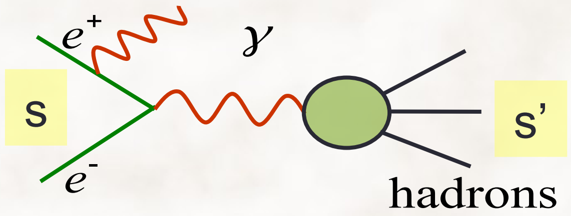
$$R = \frac{g_{\phi K^+K^-}}{g_{\phi K_S K_L}\sqrt{Z(m_\phi)}} = 0.990 \pm 0.017$$

- $R_{SND} = 0.92 \pm 0.03 (2.6\sigma)$
- $R_{CMD-2} = 0.943 \pm 0.013 (4.4\sigma)$
- $R_{BaBar} = 0.972 \pm 0.017 (1.5\sigma)$

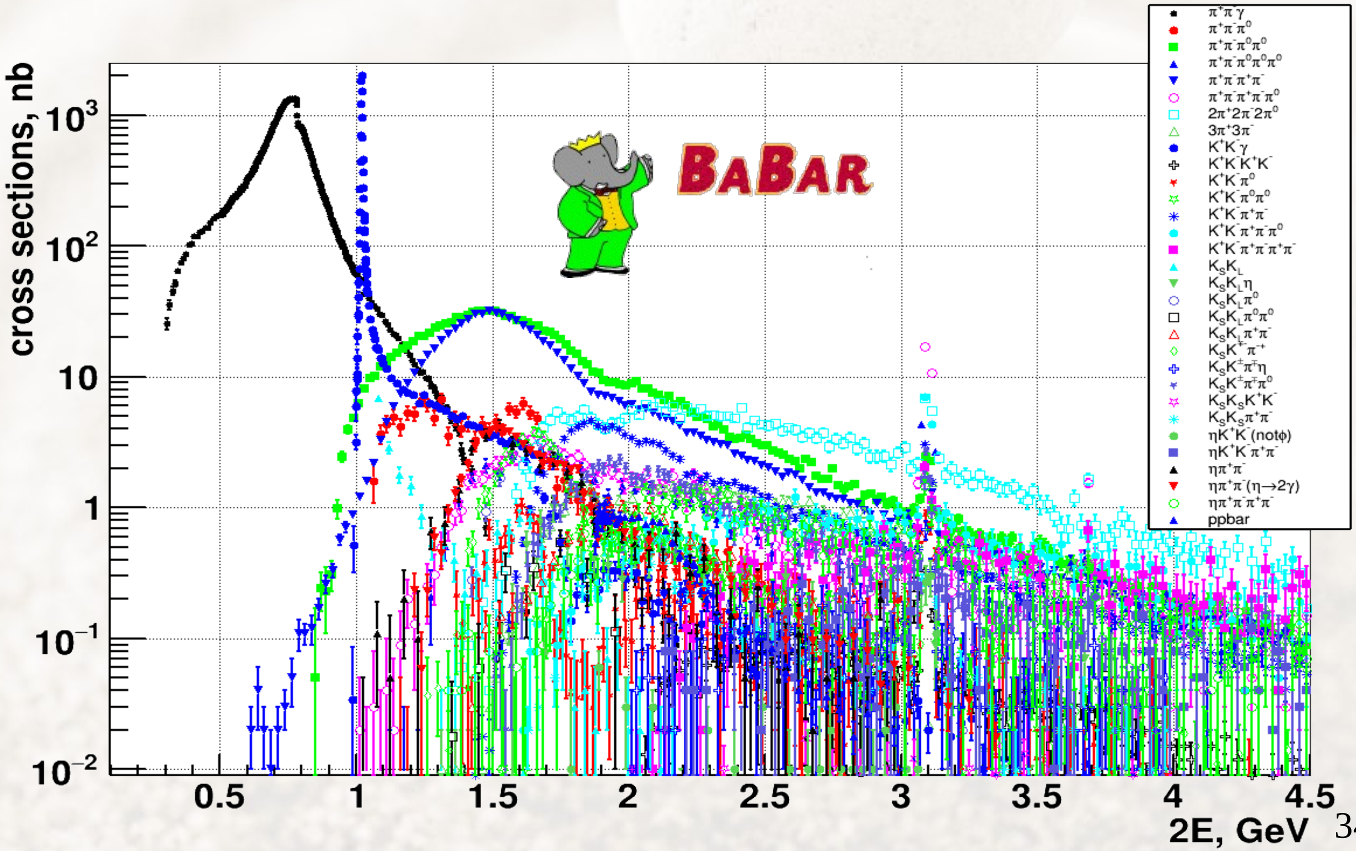
ISR approach

Additional approach to measurement of the hadronic cross-sections was fully developed over last decades: ISR (Initial State Radiation), advanced by BaBar and KLOE.

$$d\sigma(\, e^+e^- \rightarrow \text{hadrons} + \gamma\,) = H(Q^2,\theta_\gamma\,) \times d\sigma(\, e^+e^- \rightarrow \text{hadrons})$$

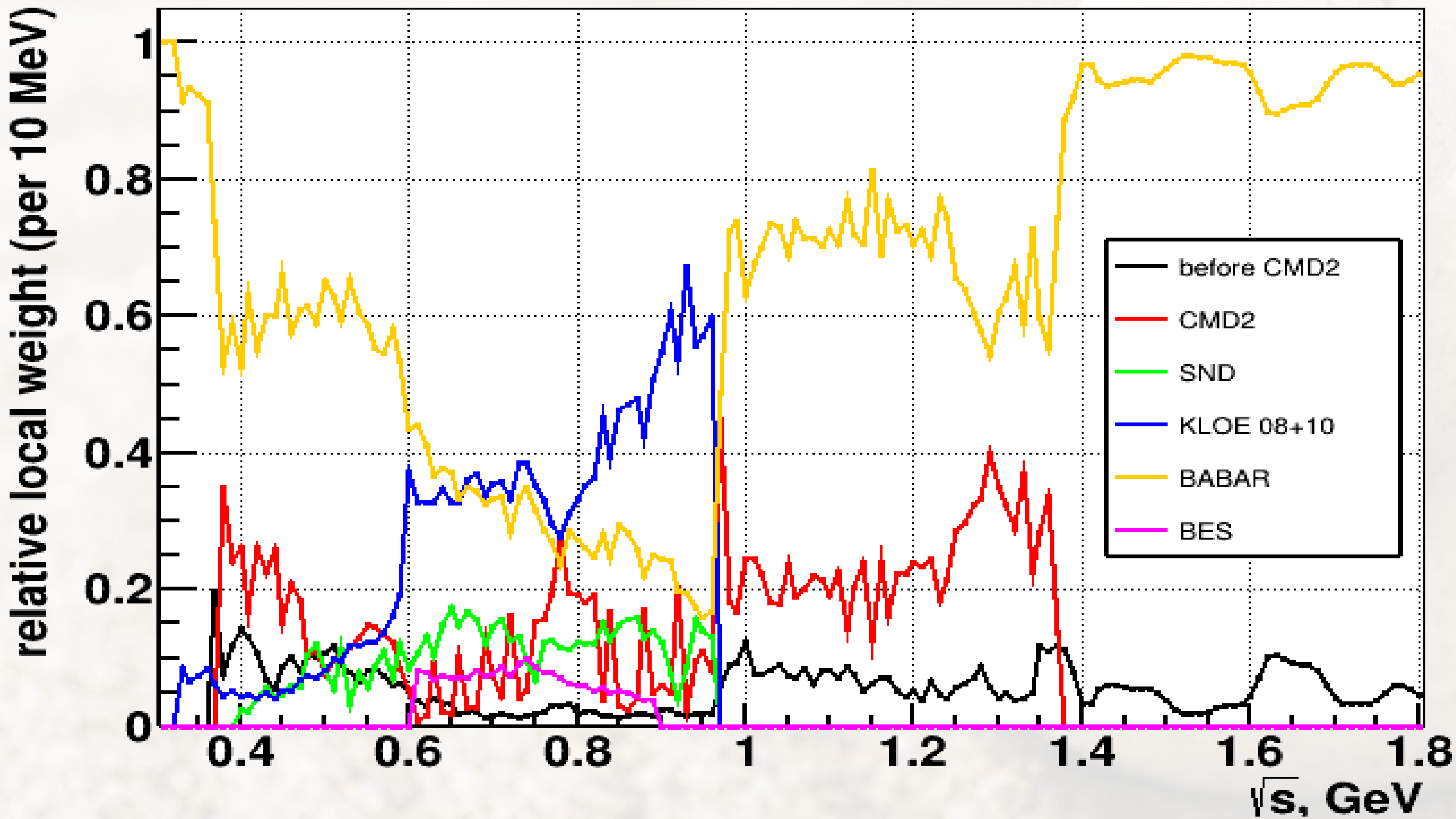


Main idea: cross-section is measured in the wide energy range, using events with hard photon, emitted by initial particles.



Relative local weight of different experiments in π+π-

Nowadays the π+π- data is statistically dominated by ISR(KLOE, BaBar)



Locally precision is limited by statistic

50 years of hadron production at colliders

Volume 25B, number 6 PHYSICS LETTERS 2 October 1967

INVESTIGATION OF THE ρ-MESON RESONANCE WITH ELECTRON-POSITRON COLLIDING BEAMS

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Institute of Nuclear Physics, Siberian Branch of the USSR Academy of Sciences, Novosibirsk, USSR

Received 1 September 1967

Preliminary results on the determination of the position and shape of the ρ-meson resonance with electron-positron colliding beams are presented.

When experiments with electron-positron colliding beams were planned [1, 2] investigation of the process

$$e^- + e^+ \rightarrow \pi^- + \pi^+$$

$$e^- + e^+ \rightarrow K^- + K^+$$

1 September 1967

Start of e+e- → hadrons measurements

Phys.Lett. 25B (1967) no.6, 433-435

VEPP-2, Novosibirsk

Detector was made from different layers of Spark chambers,
readouts by photo camera

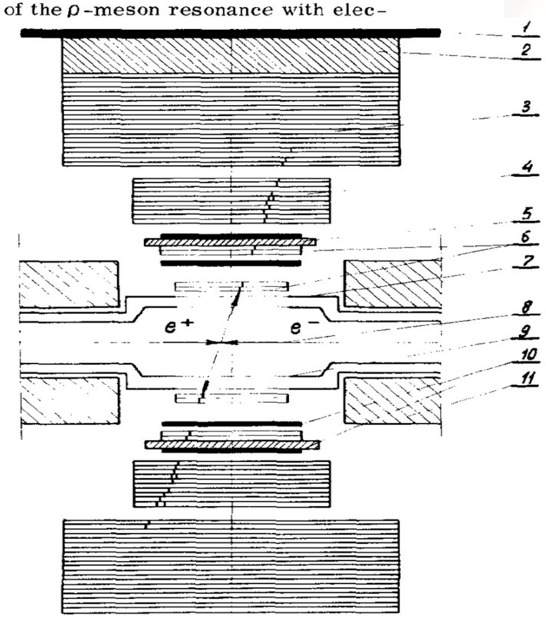


Fig. 1. Spark chambers system:
1) Anticoincidence scintillation counter
2) Lead absorber 20 cm thick
3) "Range" spark chamber
4) "Shower" spark chamber
5) Duraluminium absorber 2 cm thick
6) Thin-plate spark chambers

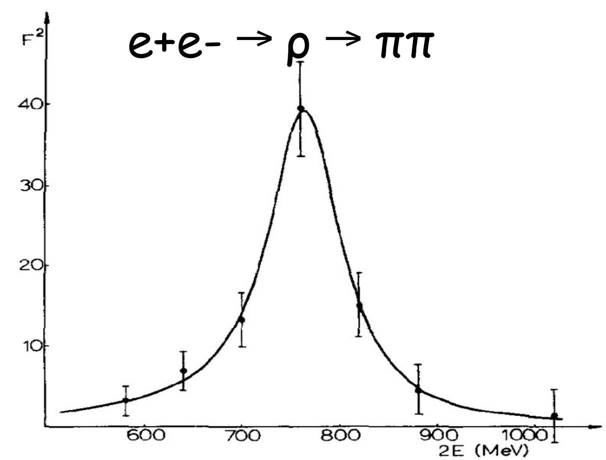
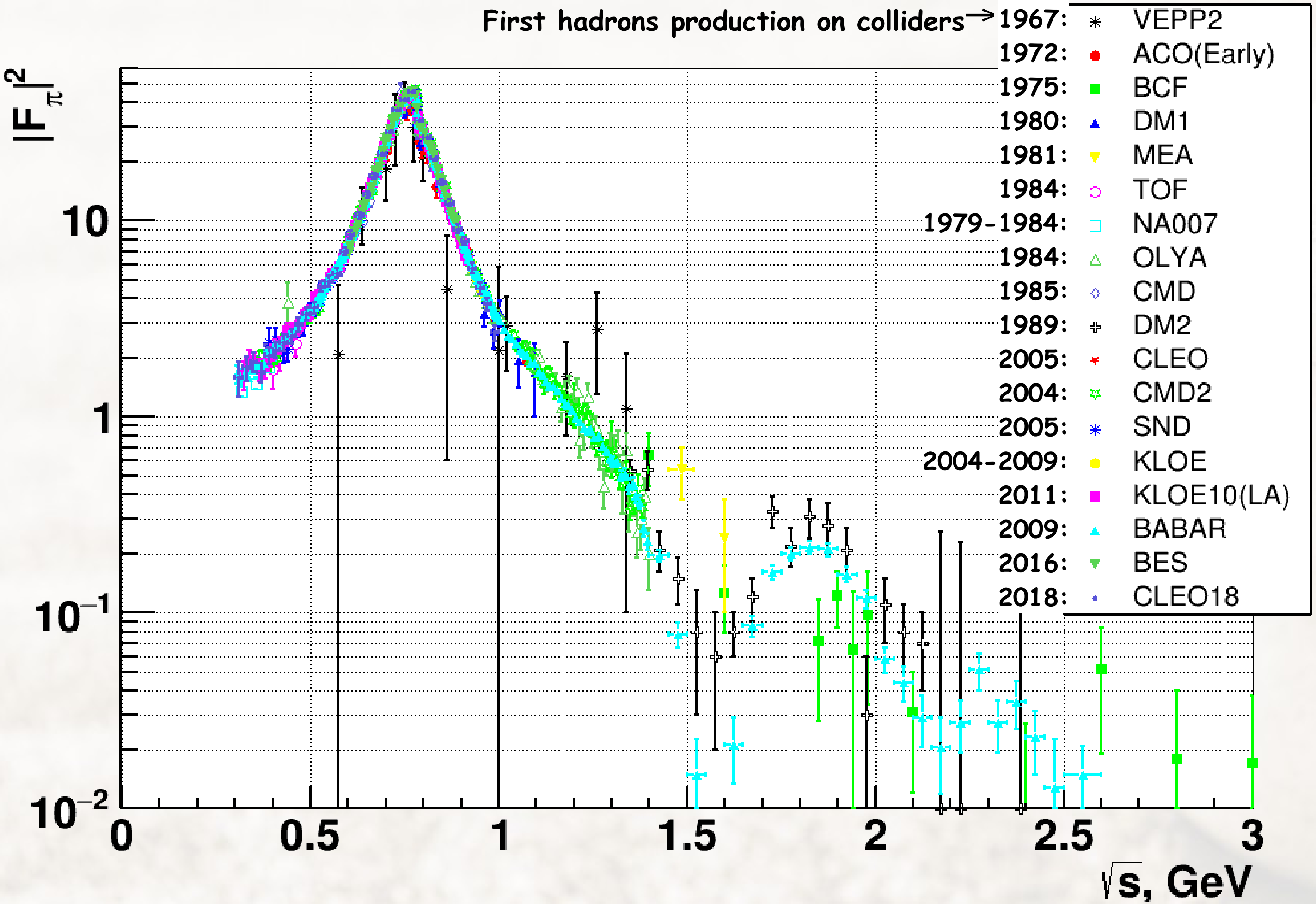


Fig. 2. Experimental values of F^2 (E) approximated by the Breit-Wigner formula.

ment geometry and F- modulus of the form factor for pion pair production [1]. In the case of QED with no other forces F=1. If the particles are produced at the angle 90° with respect to the beam axis then a=18. Integration over the solid angle gives a=20.4.

e+ e− → π+ π− today



New g-2 experiments and future e+e- as ILC, FCC-ee require average precision ~0.2%

Before 1985

Low statistical precision

Systematic >10%

NA7 A few points with >1-5%

1985 - VEPP-2M

with more detailed scan

OLYA systematic 4%

CMD 2%

2004 with CMD2 at VEPP-2M

was boost to systematic: 0.6%

(near same total statistic)

The uncertainty in a_μ(had) was improved by factor 3 as the result of VEPP-2M measurements

New ISR method

e+e- → γ + hadrons

(limited only by systematic):

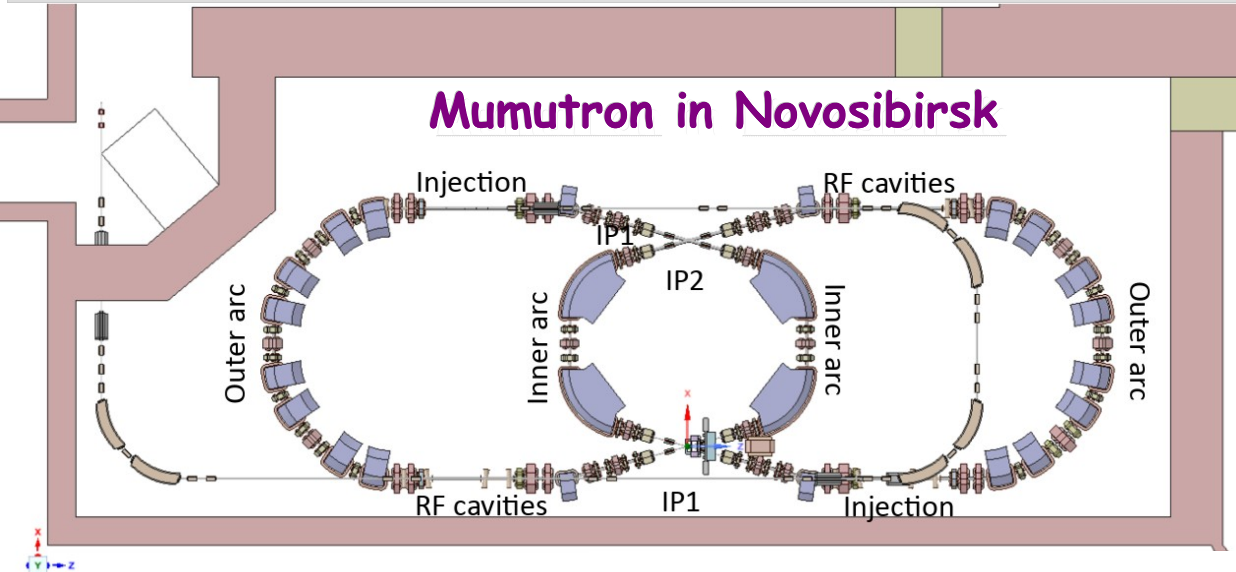
KLOE: 0.8%

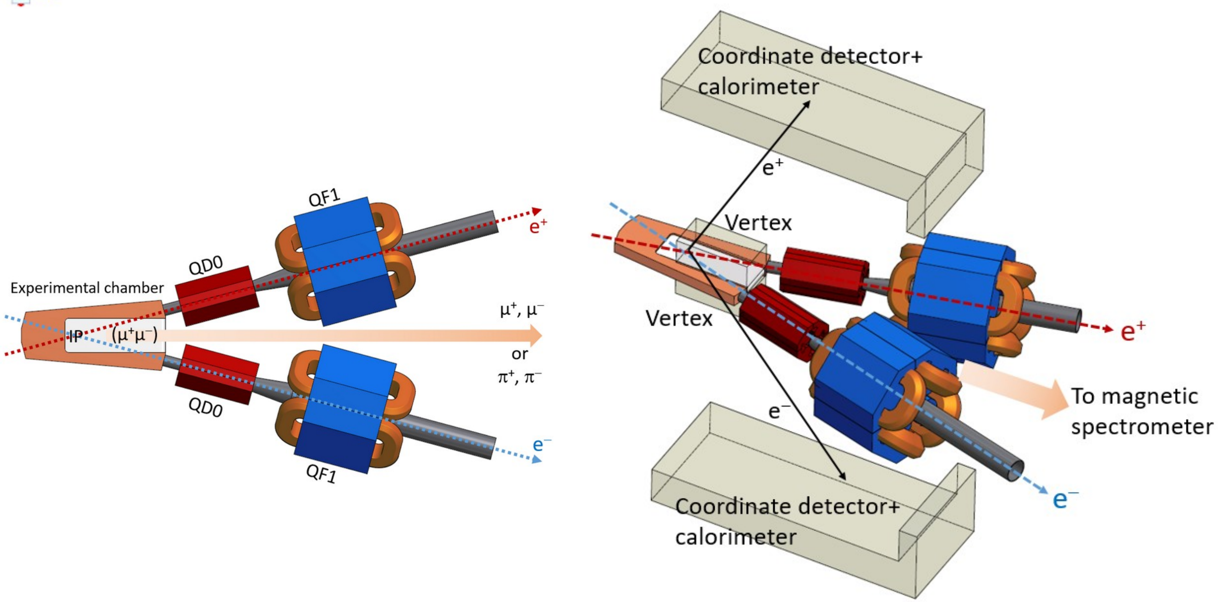
BaBar: 0.5%

BES: 0.9%

CLEO: 1.5%

Future low energy e+e- machines(mumutron)





project is under consideration

Can be as an accelerator technology testbench for SCTauF

1[st] stage :

Observation & study of dimuonium - μμ bound state

$\sqrt{s}$ = 212 MeV

L ~ 8×10^{31} $1/cm^2s$

2[nd] stage with reversed beams and dedicated detector:

Rho-factory

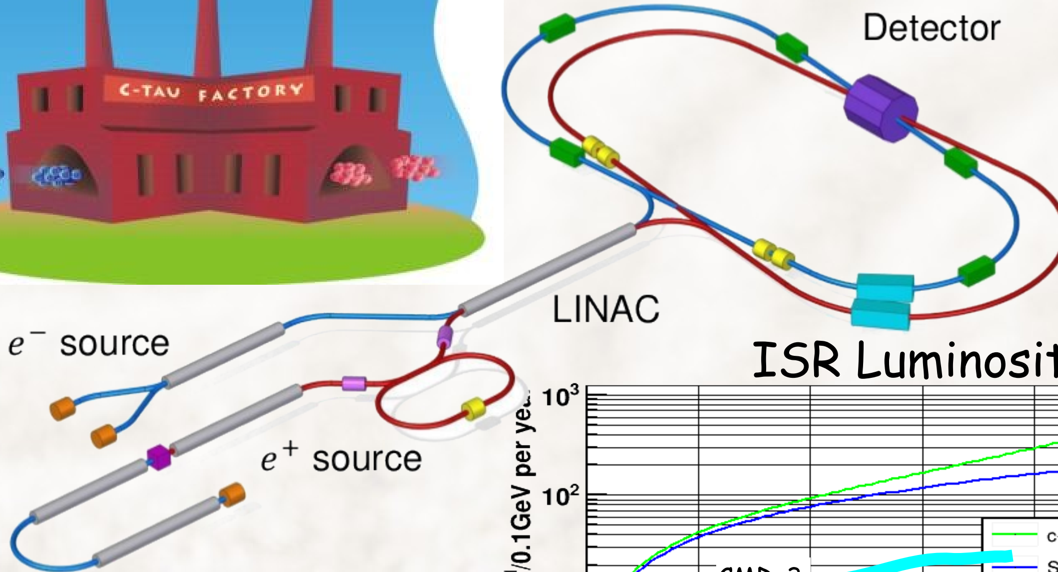
- 15° crossing angle
- $\sqrt{s}$ = 0.55-0.96 GeV
- L ~ 0.6-1. × 10^{33} $1/cm^2s$

Future low energy e+e- machines(super c-tau factories)

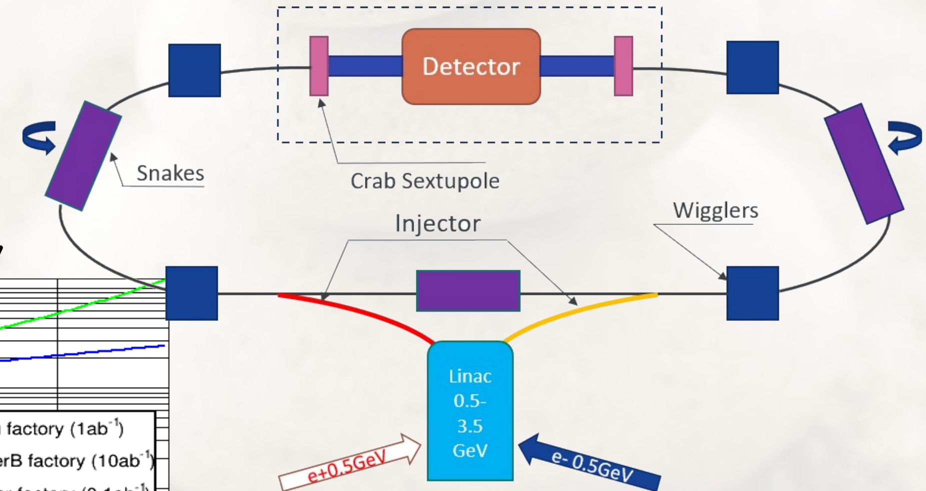
Two projects is under consideration

- e+e− collider, 2E = 2 ÷ 7 GeV
- Study of charmed hadrons and τ
- 10^{35} 1/cm^{2}s luminosity with Crab-waist collisions
- Polarized e- beam

SCTF in Novosibirsk



STCF in China



ISR Luminosity