Detailed study of the NNbar threshold with CMD-3 at VEPP2000

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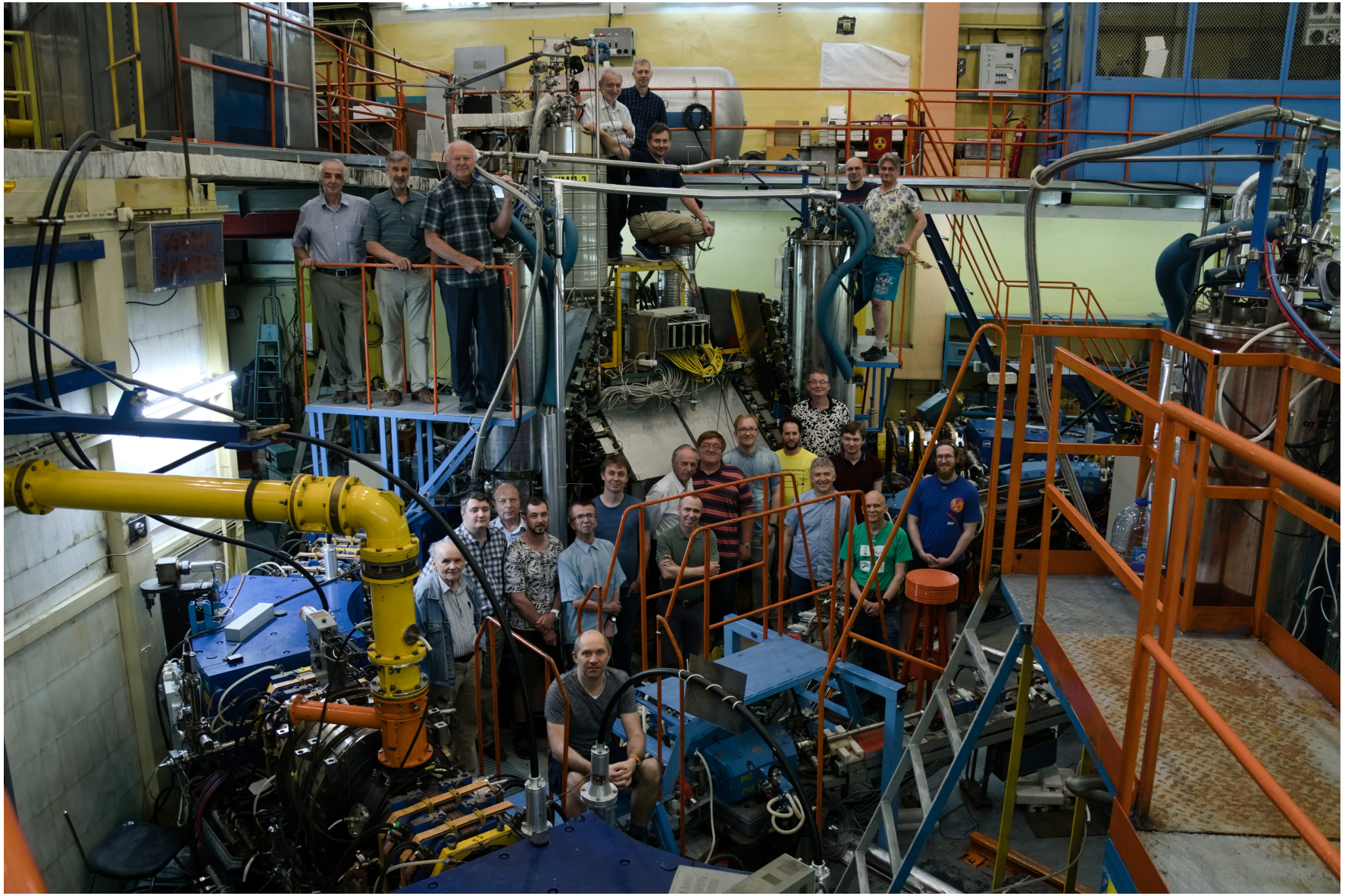
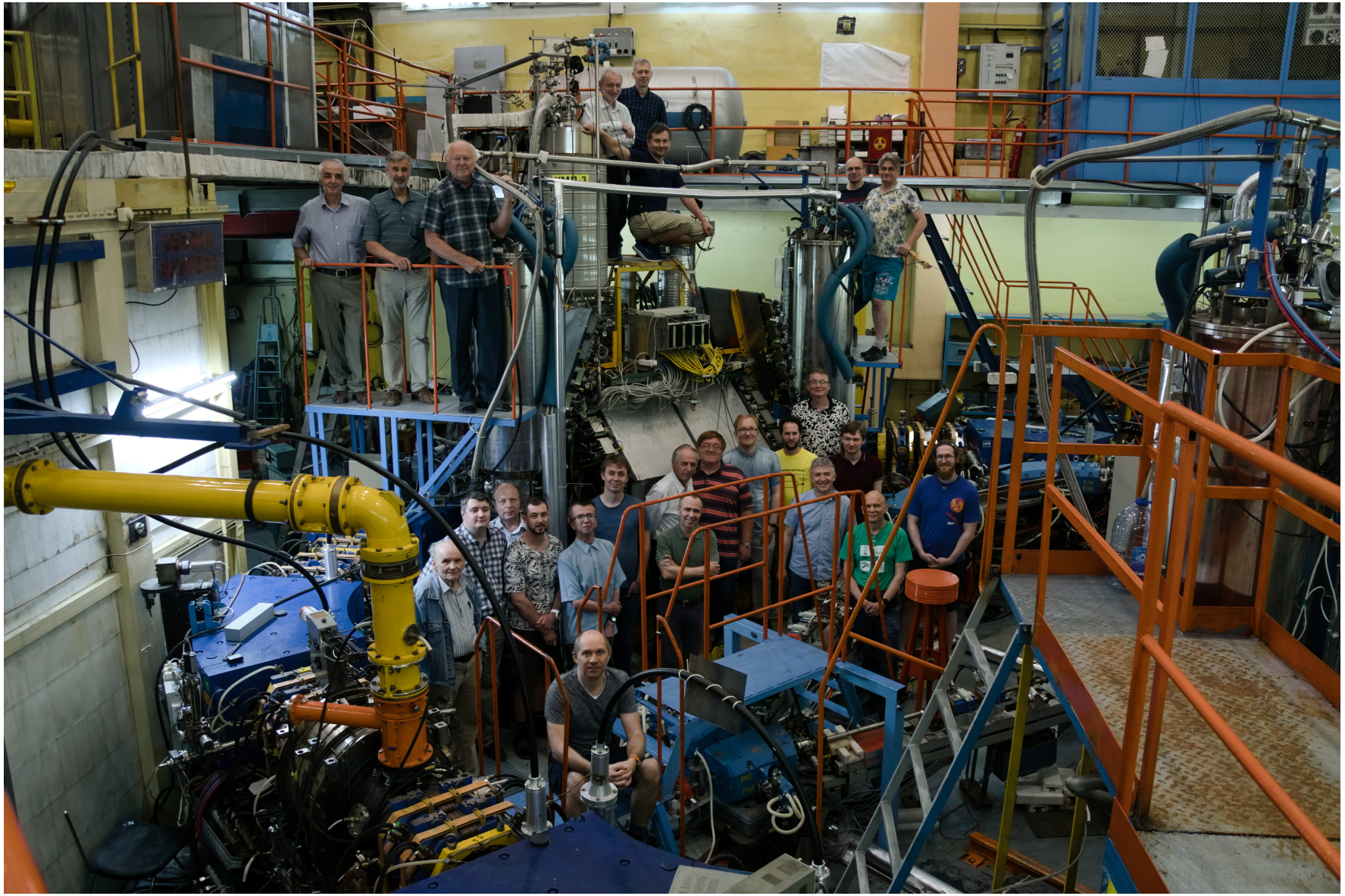
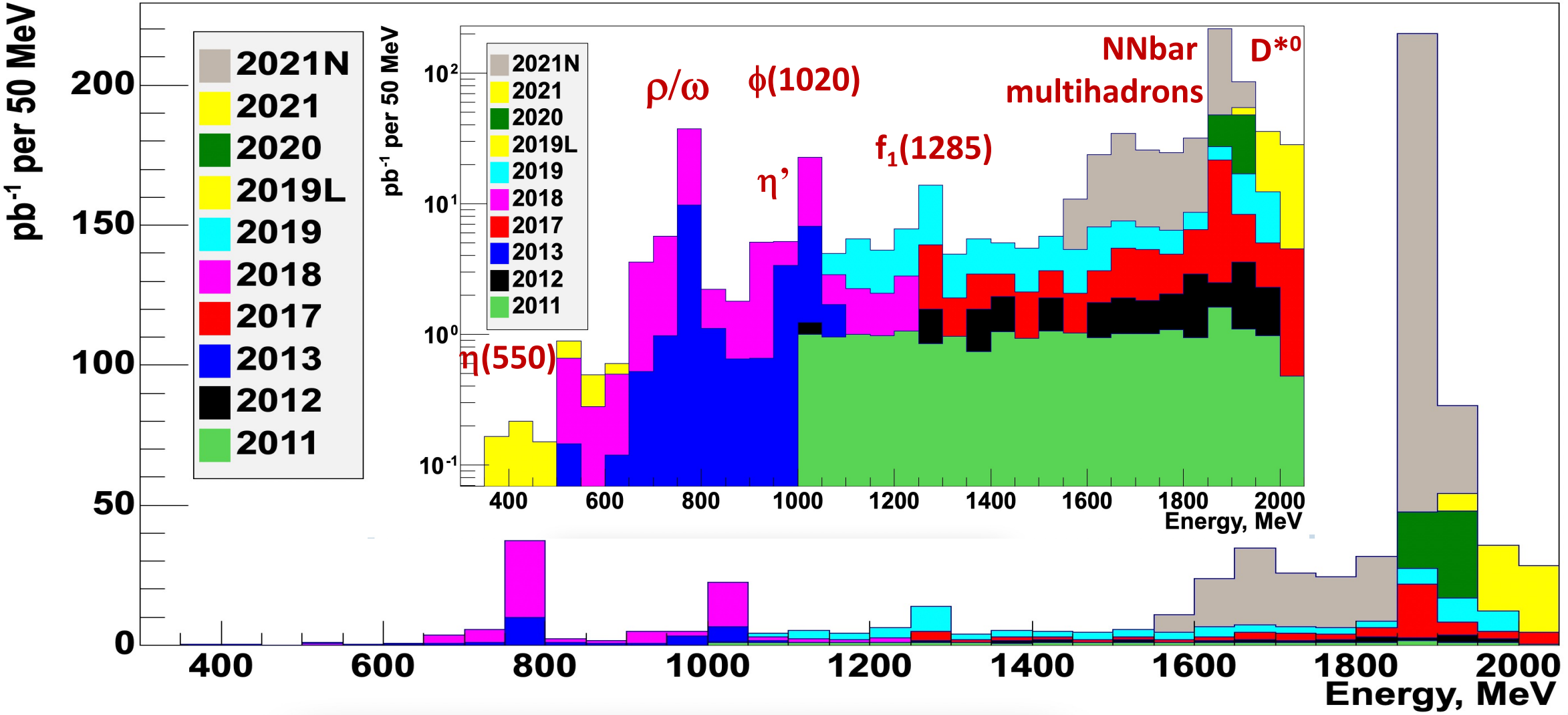
CMD-3 Collaboration at VEPP2000 collider



CMD-3, Collaboration, VEPP2000 collider



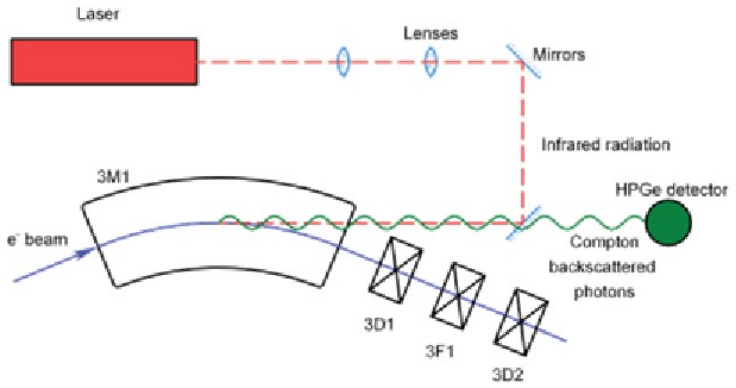
CMD-3 integral 669.4 1/pb



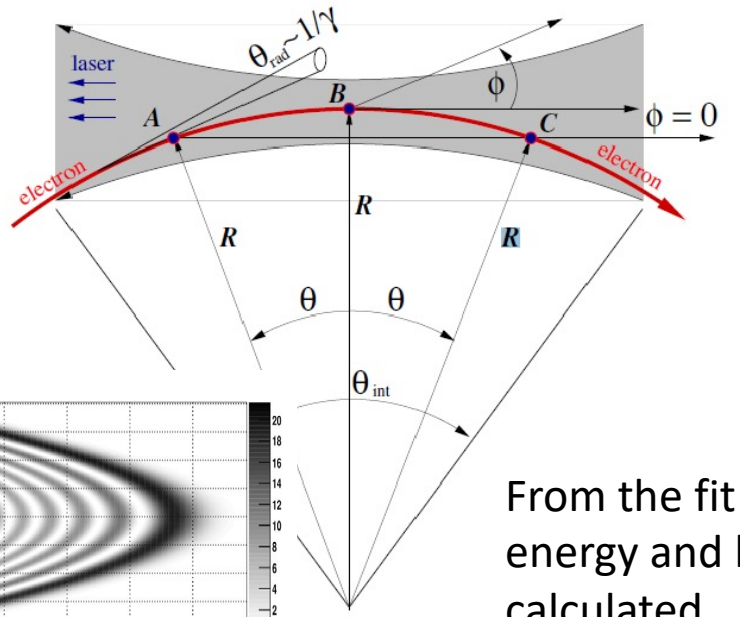
About 10 papers are published. More than 20 exclusive e+e- -> hadrons cross sections are under study.

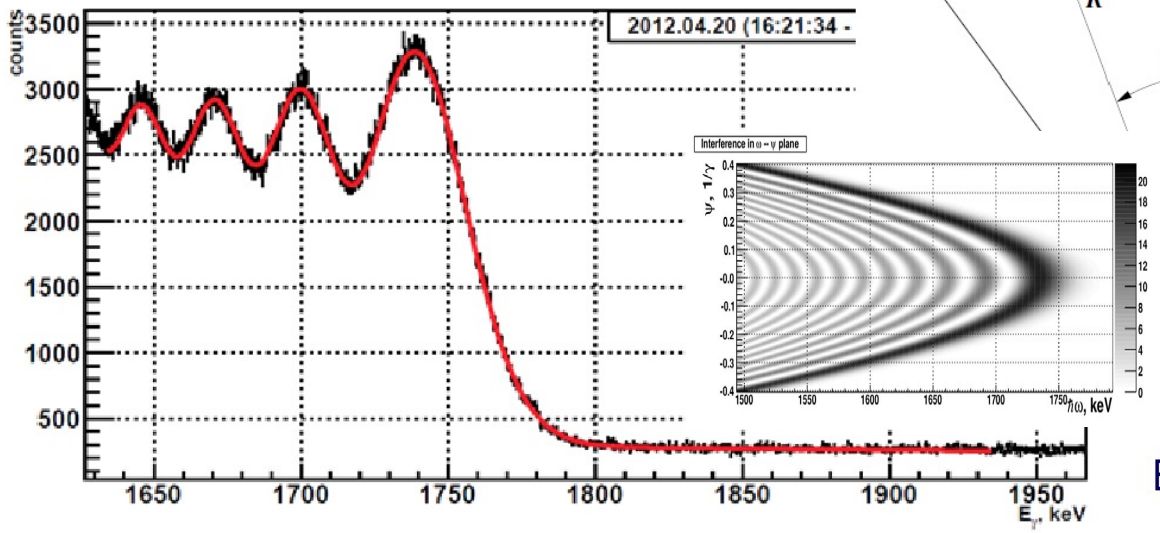
Energy measurement

Starting from 2012, energy is monitored continuously using Compton backscattering



Light from A and B interferes





From the fit parameters, the beam energy and beam energy spread are calculated.

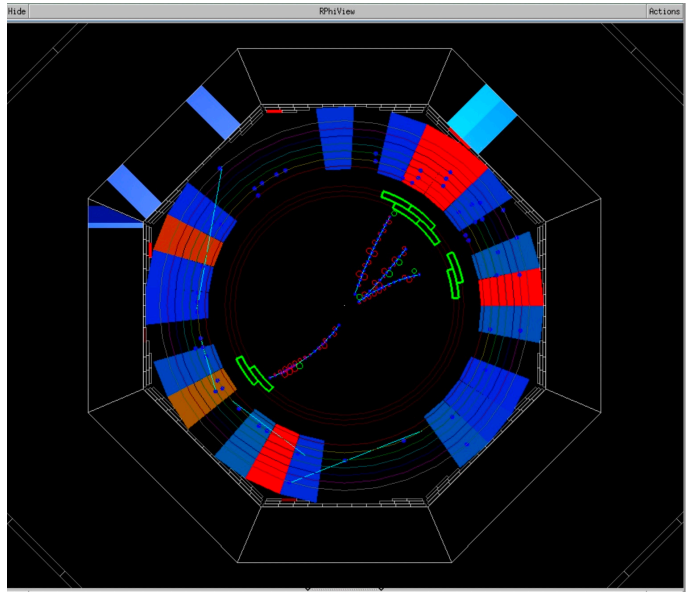
E = 993.662 ± 0.016 МэВ

MeV

M.N. Achasov et al. arXiv:1211.0103v1 [physics.acc-ph] 1 Nov 2012

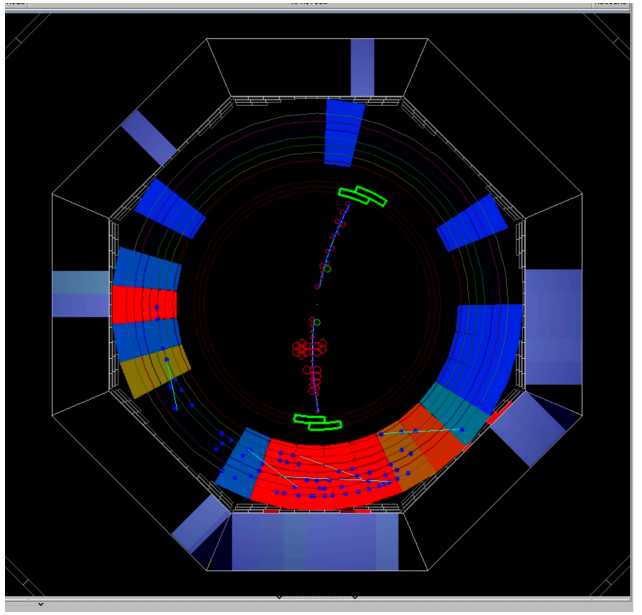
NNbar threshold scan - 2017 data

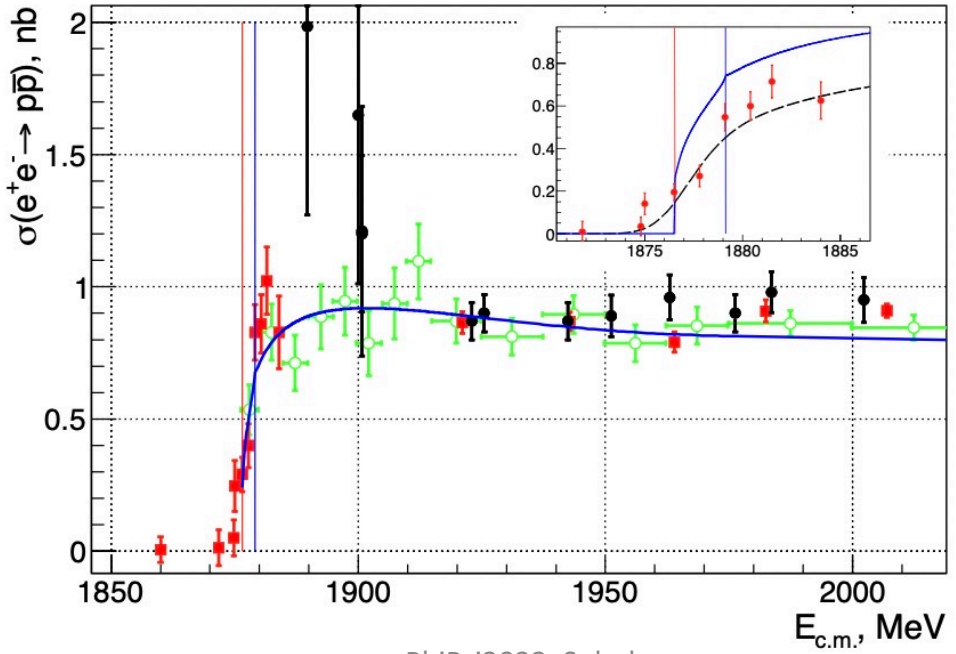
20+50 pb $^{-1}$ ~2 pb^{-1}/point



Anti-protons close to the production threshold are seen as an annihilation star at the vacuum beam pipe (or in the DC inner wall)+ large energy deposition in the calorimeters.

Above 1900 we see collinear PPbar tracks in DC





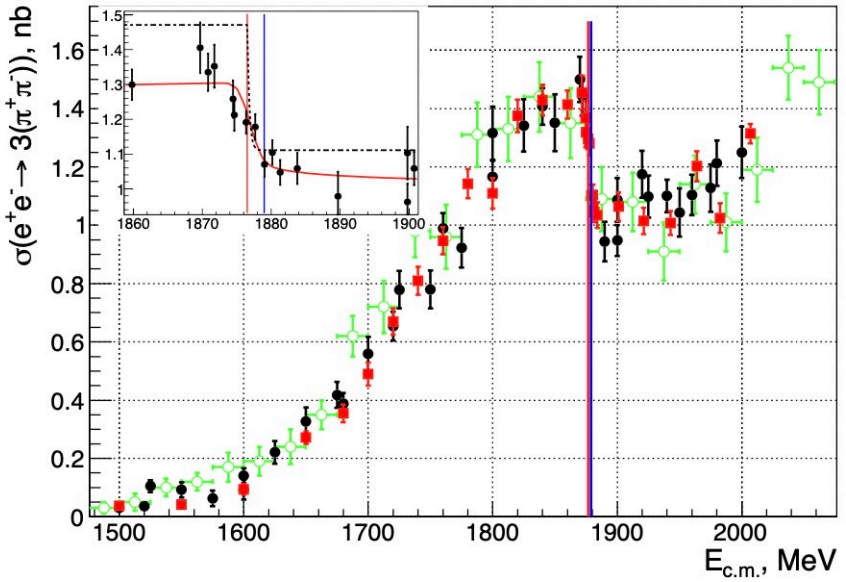
Geen points – BaBar data

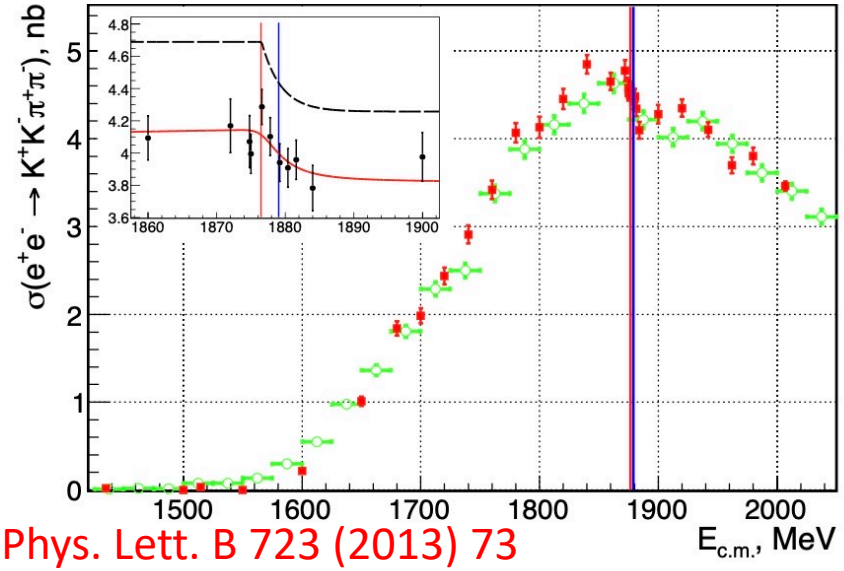
Phys. Lett. B 723 (2013) 73

Phys. Lett. B 794 (2019) 64–68

Theory:
A.I. Milstein, S.G. Salnikov,
Nucl. Phys. A 977 (2018) 60.

NNbar threshold in hadronic reactions





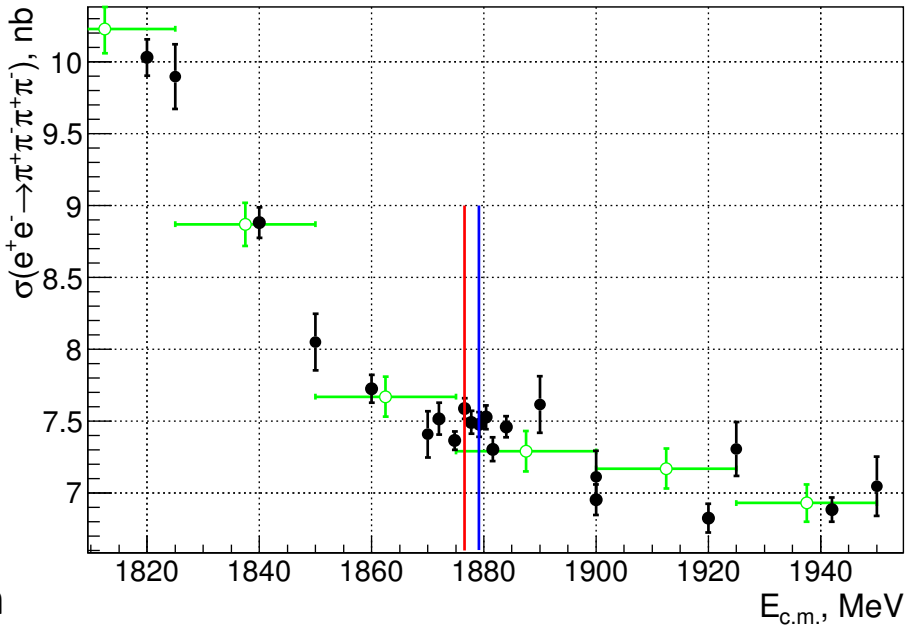
Phys. Lett. B 723 (2013) 73
Phys. Lett. B 794 (2019) 64–68

Energy spread ~ 1 MeV

Simultanious fit with PPbar by exponentialy rising (drop) functions gives:

σ^{thr} = 0.18±0.27 MeV

Consistent with zero within uncertainty in energy due to beam spread and radiative corrections.



No signal for the e^+e^- -> $\pi^+\pi^-\pi^+\pi^-$ reaction

The idea, that signal in the hadronic cross section is propotional to the annihilation rate of NNbar to this final state does not work!

Are there any indications for other hadronic cross sections?

New scans

- Scan 2019 – from 1.4 to 2.0 GeV c.m. 28 points with ~2 pb^{-1}/point — 40.462 pb^{-1}
- Scan 2020 – from 1.870 to 1.935 GeV – 5 points with 10 pb^{-1}/point — 46.870 pb^{-1}
- Scan 2021 – from 1.935 to 2007 GeV – 4 points with 10pb^{-1}/point (24 pb^{-1} at 2007) — 48.400 pb^{-1}
- Scan 2021-2022 at NN threshold and below: — 282.844 pb^{-1}

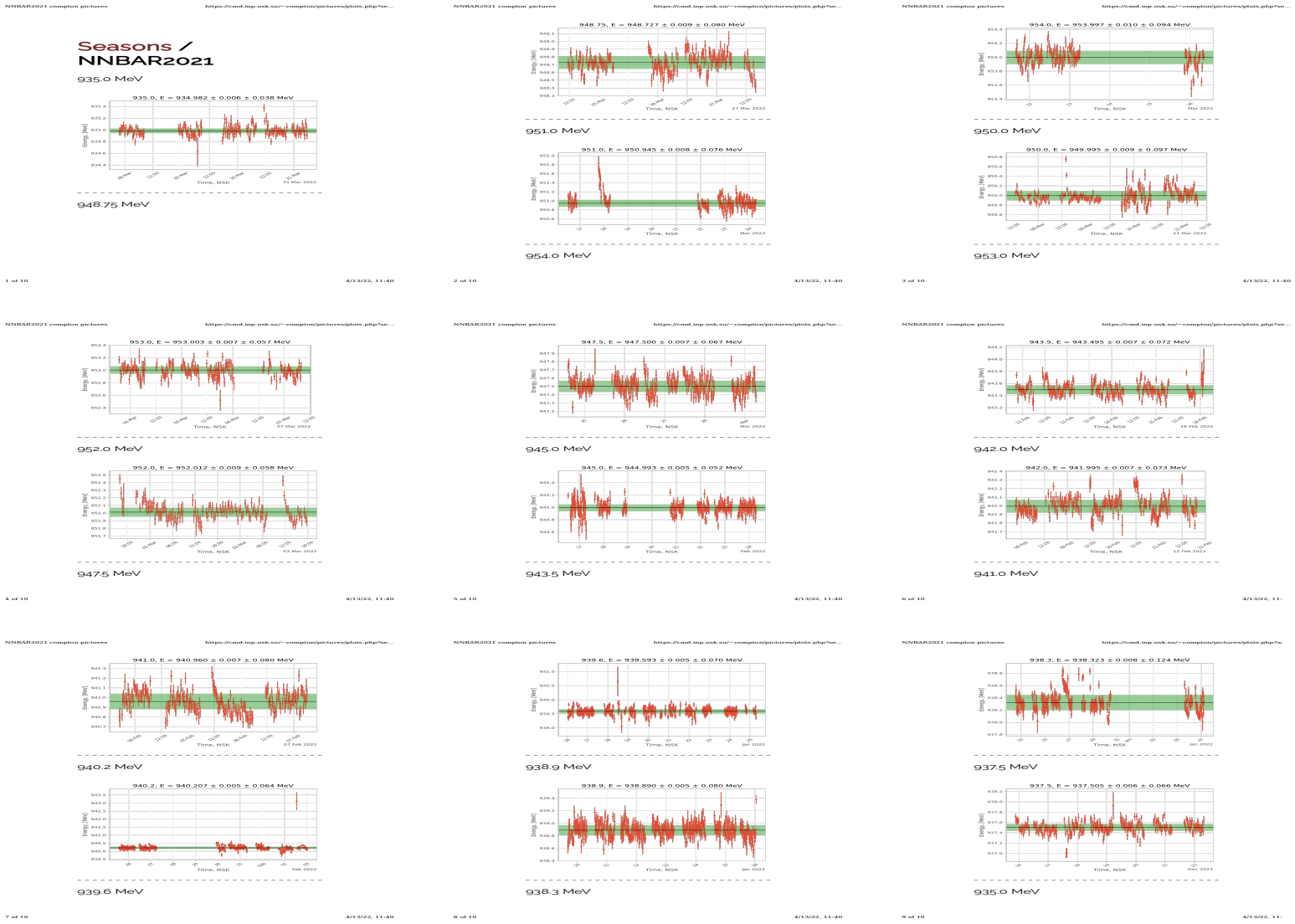
  18 point at the threshold with ~1 MeV step – 10 pb^{-1}/point (x5 to 2017 scan)

  13 points below threshold with 10 MeV step – 5-10 pb^{-1}/point

418.5 pb^{-1}

We plan to study energy behavior of many hadronic reactions at the NNbar threshold

Energy control during data taking at each point

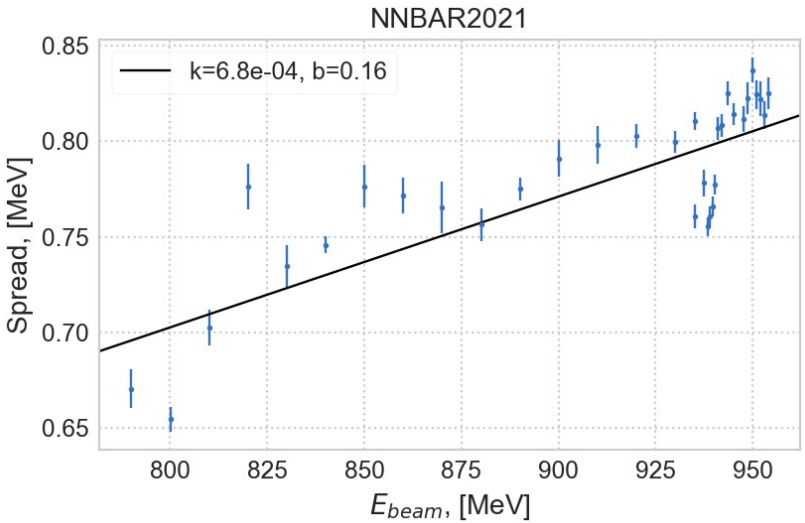


Energy measurement each 20 minutes

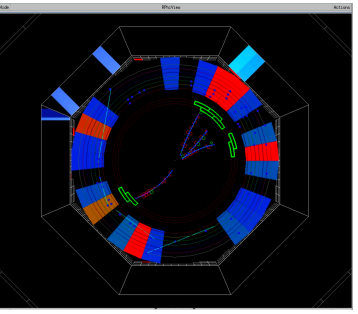
Green bands – are the estimated uncertainty in the energy ~50-60 keV

Excelent ! machine stability

The energy spread is also measured for each energy point

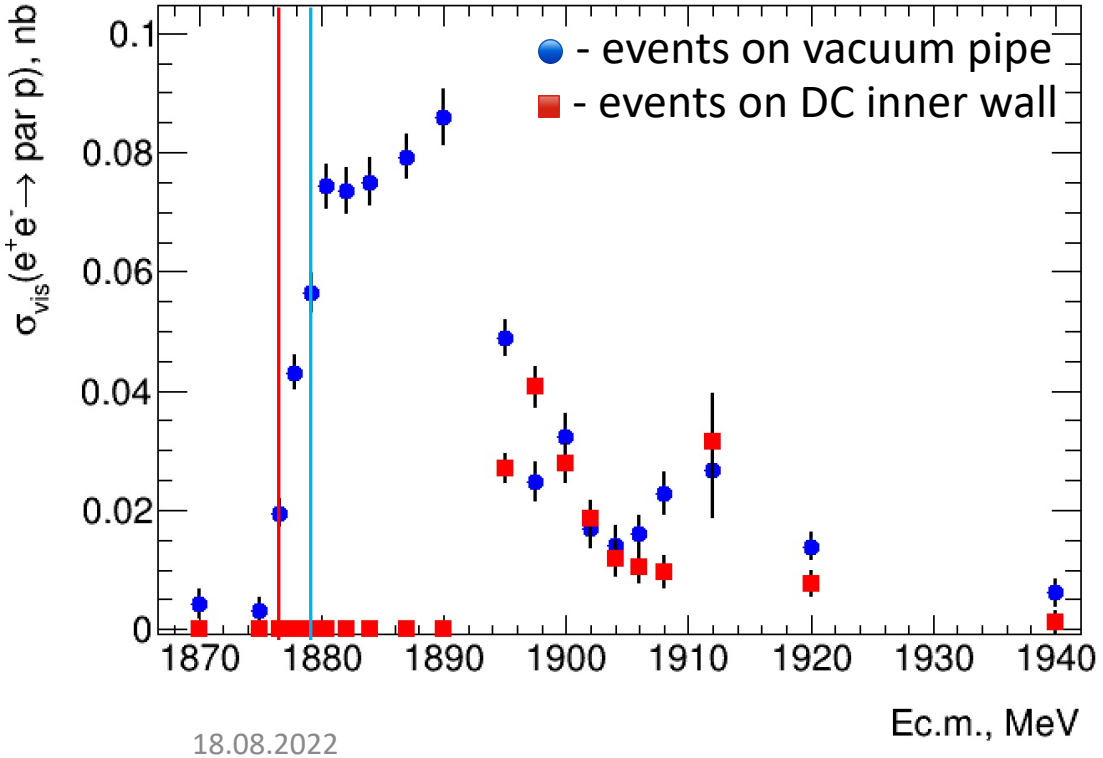


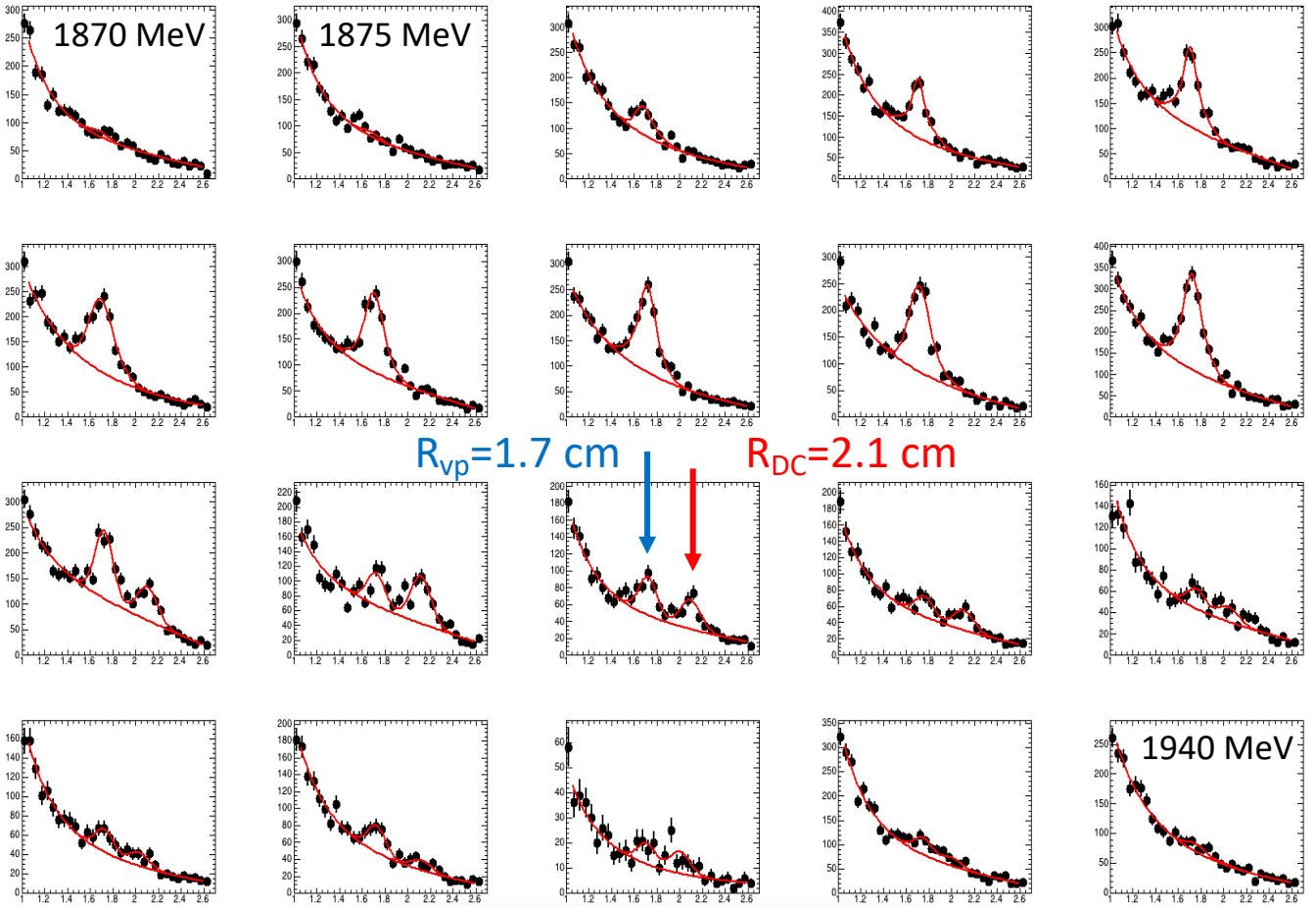
New ppbar detailed threshold scan



Anti-protons close to the production threshold are seen as an annihilation star at the vacuum beam pipe (or in the DC inner wall)+ large energy deposition in the calorimeters.

We plot radius of the vertex with >2 tracks and energy deposition > 500 MeV





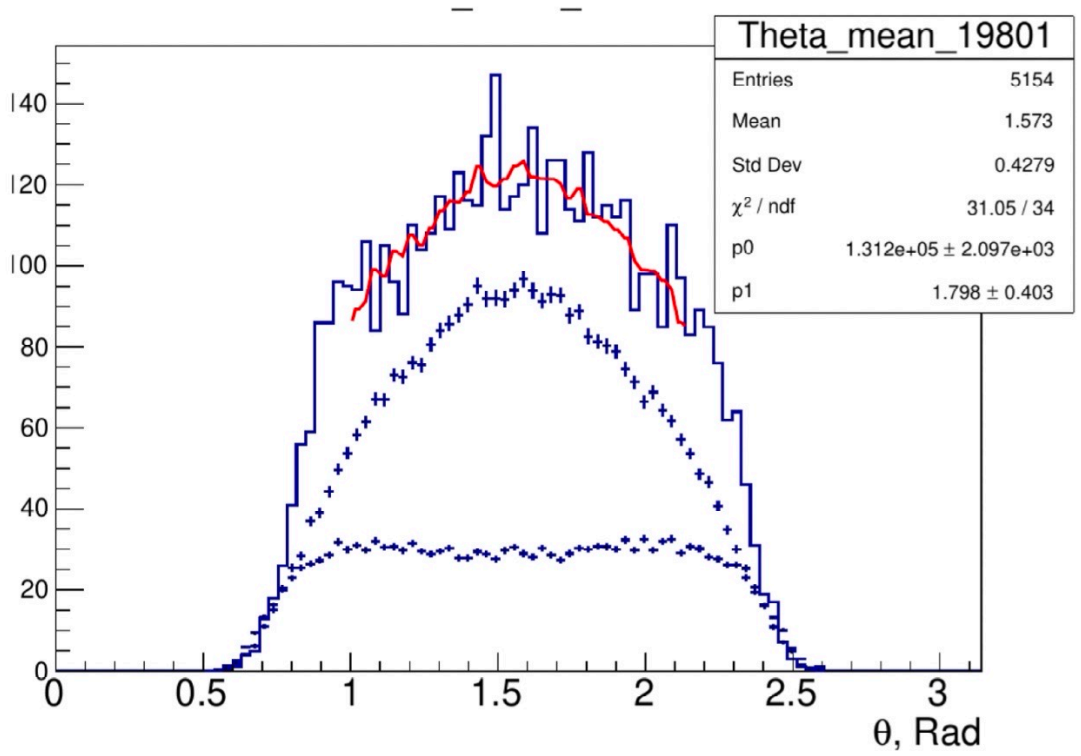
First peak – radius of the aluminum vacuum pipe R_{vp} = 1.7 cm, (0.5 mm)
Second peak – inner wall of the DC carbon fiber R_{DC} = 2.1 cm (0.25mm)

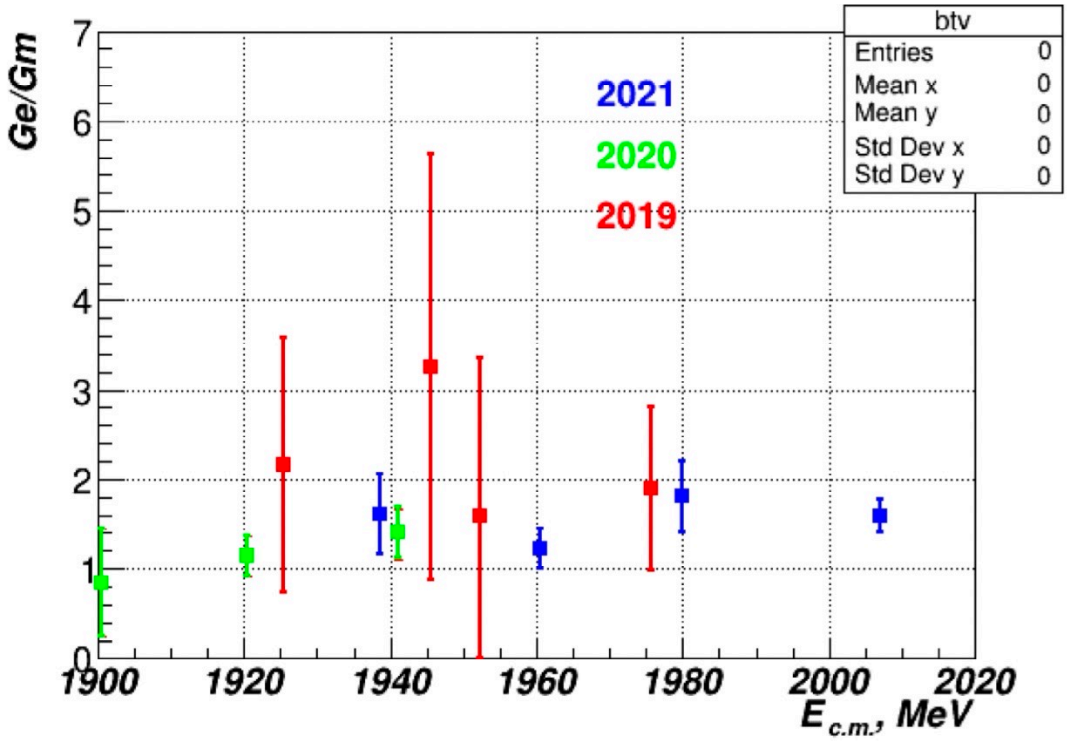
Just a monitor – not a measurement yet

GE/GM measurement

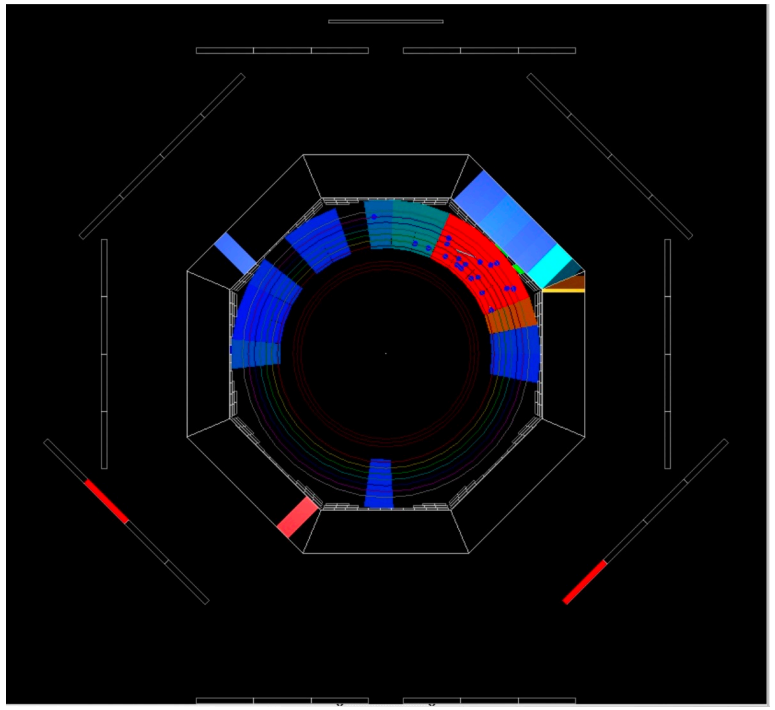
ppbar events polar angle distribution for Ec.m. = 1980 MeV,
and fit with sum of expected distributions with GE=0 and GM=0

PRELIMINARY

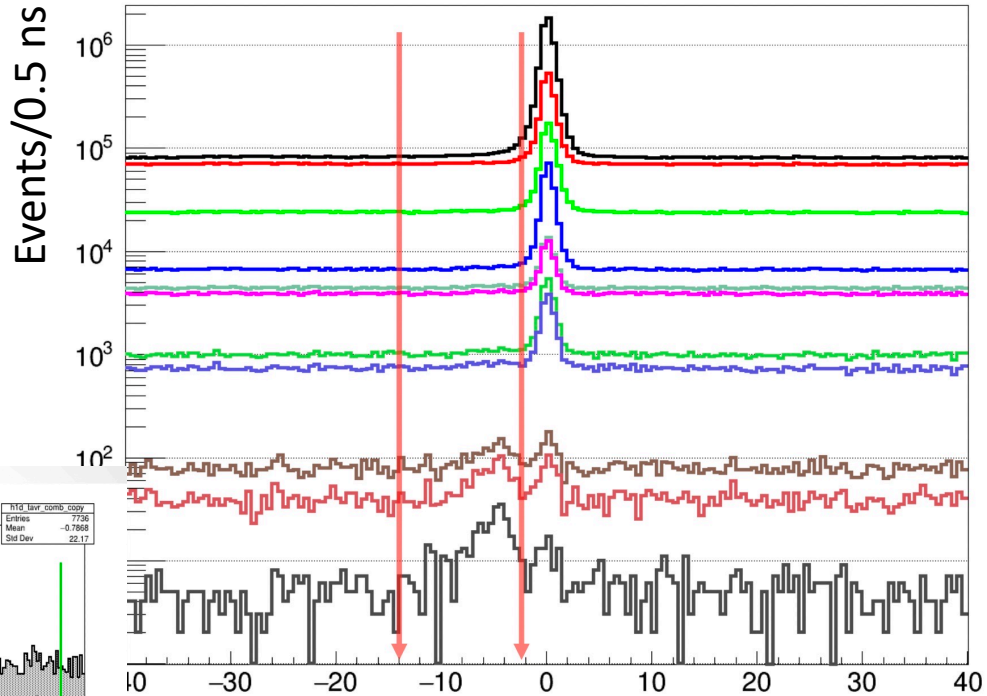




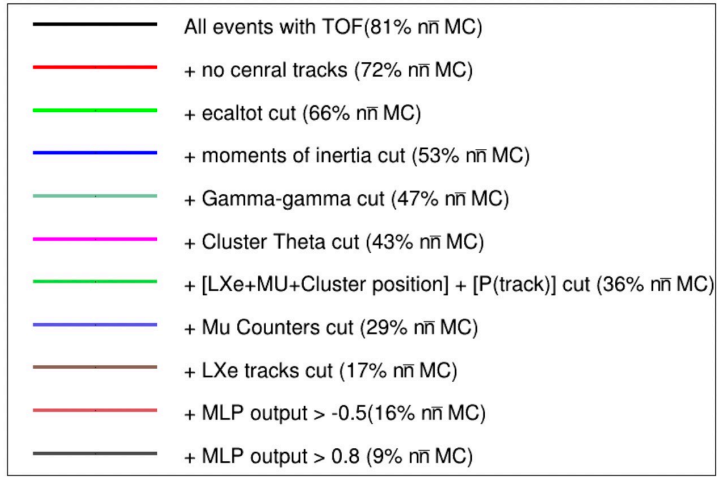
nnbar production

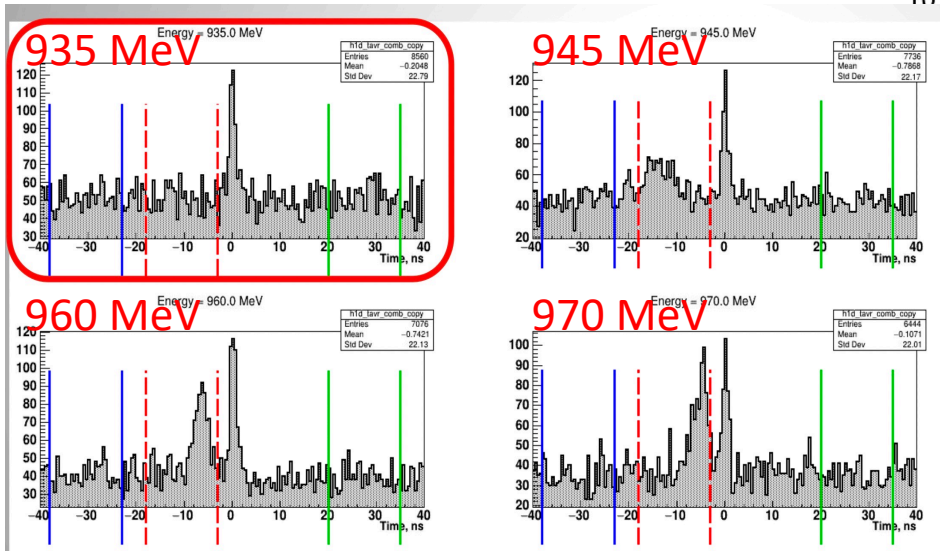


nnbar events are detected as a large energy single cluster in the calorimeters with delay timing in the TOF system, relative to the beam crossing.
Cross section is small and selections should suppress 5 orders of magnitude of backgrounds, mainly from the cosmic events.



Peak at 0 is from Bhabha events

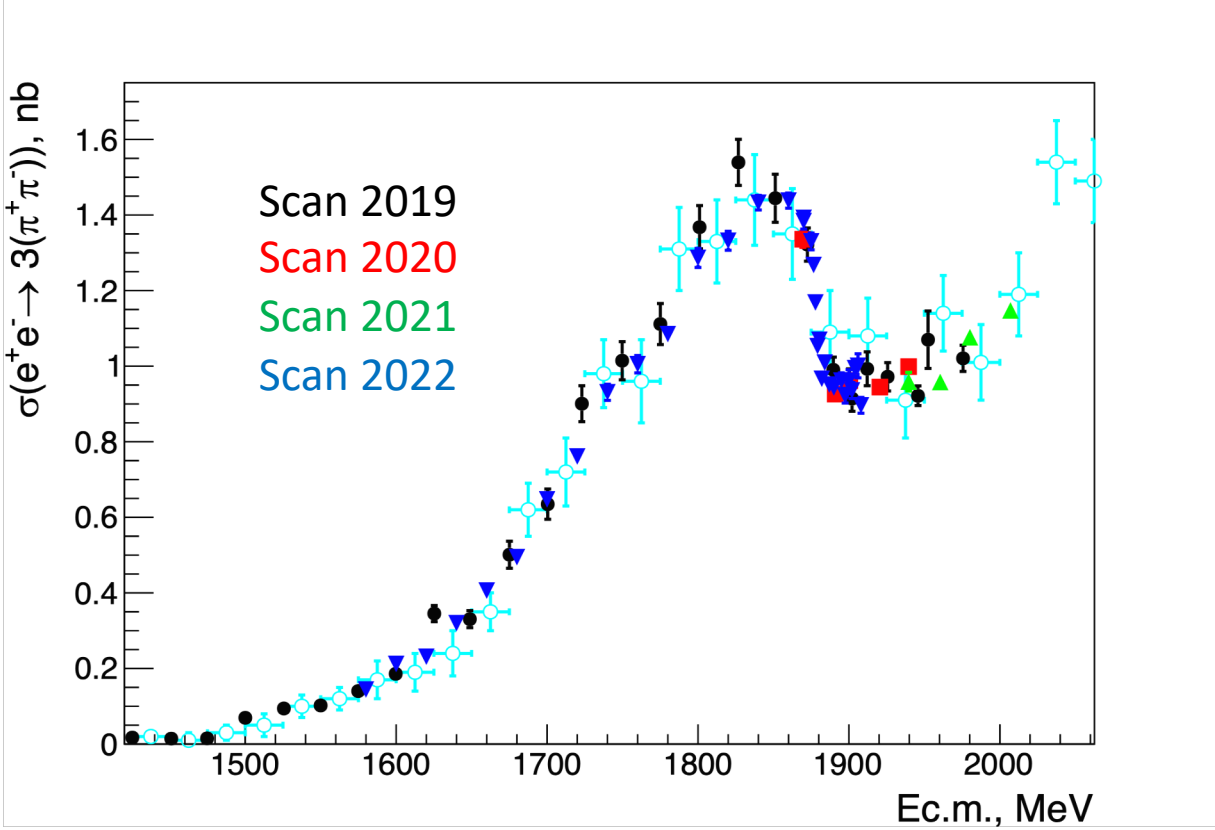


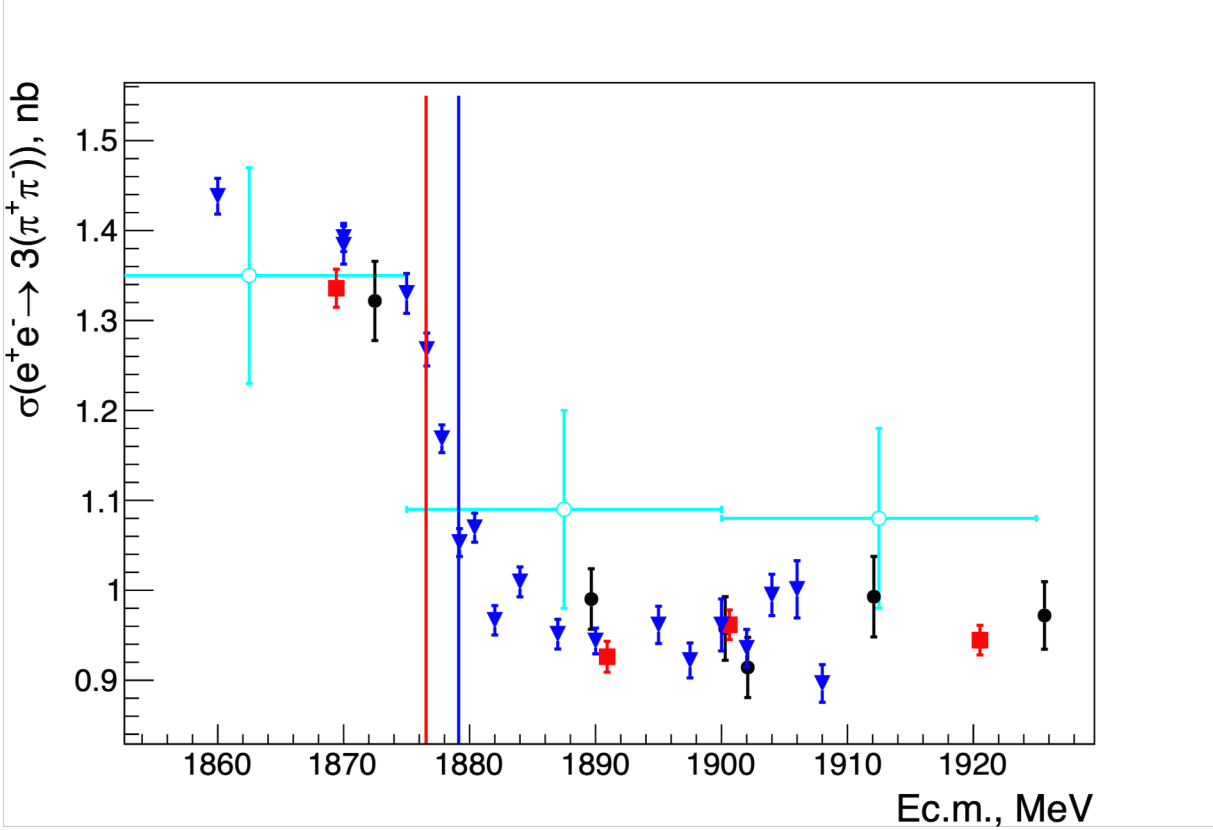


Analysis is in progress. Major problem comes from the efficiency calculation

First look to e^+e^- -> $3(\pi^+\pi^-)$ reaction

VERY PRELIMINARY



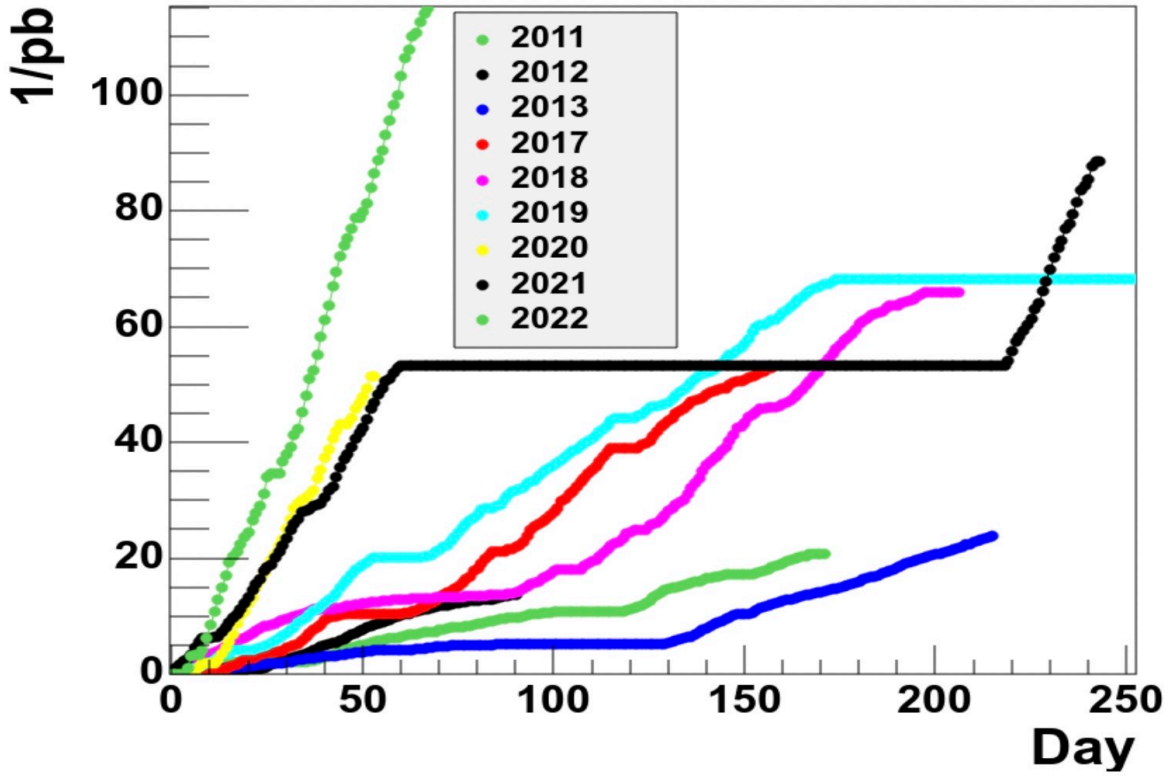


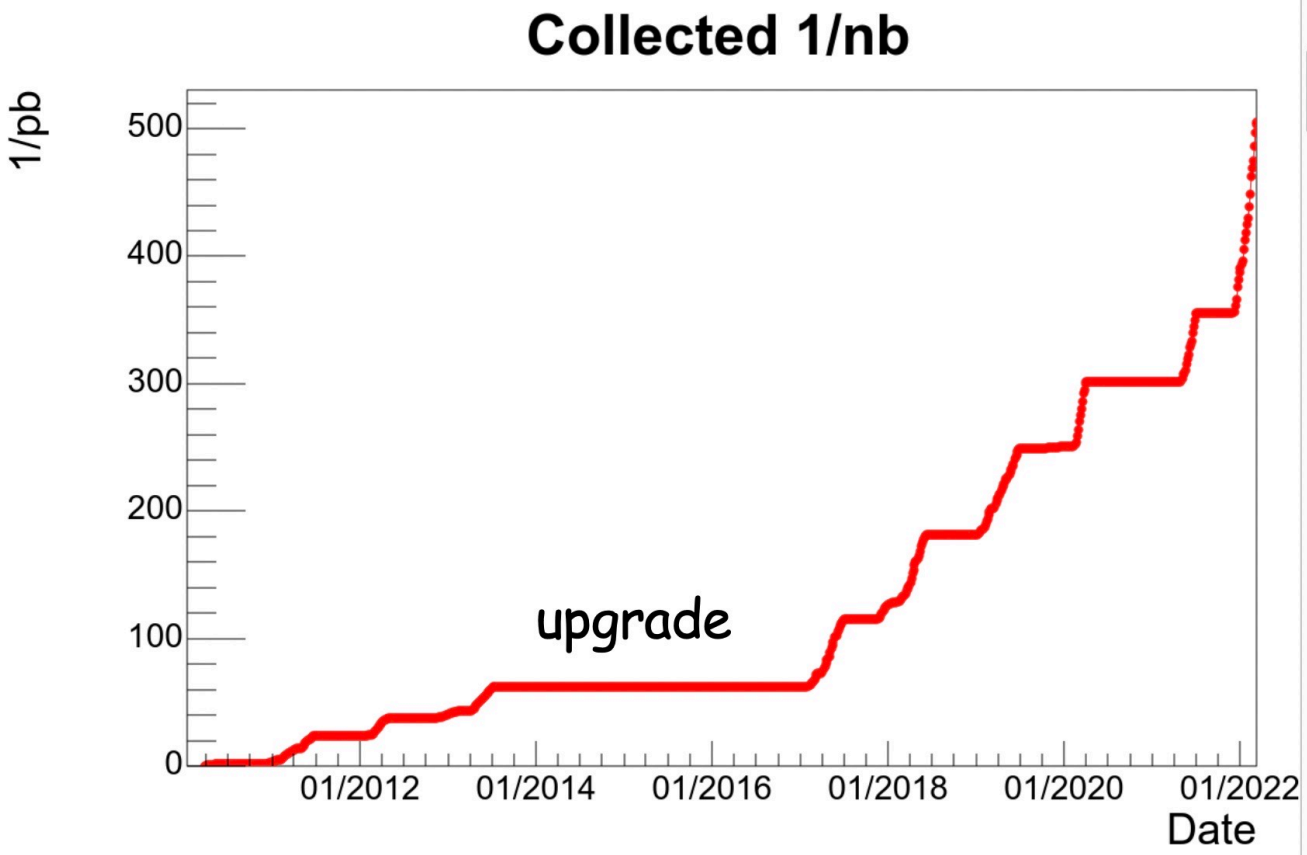
CONCLUSION

- Sharp cross section behaviors are observed at the NNbar threshold in the e^+e^- collisions in some of the hadronic reactions.
- New small-step energy scans have been performed at VEPP2000 e^+e^- collider with significantly increased (x5) integrated luminosity.
- First preliminary results from CMD-3 confirms a fast cross section changing in the e^+e^- ->ppbar and e^+e^- -> $3(\pi^+\pi^-)$ reactions.
- We plan to search for this effect, study cross section and production dynamic in other hadronic reaction.

THANK YOU

CMD-3 data taking history





A goal - 1 fb^{-1}