NEAR-THRESHOLD CHARGED KAON PAIR PRODUCTION IN TWO PROTONS COLLISIONS

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OUTLINE

1. Physics motivation
2. COSY-11 detection system
3. $pp \rightarrow ppK^{+}K^{-}$ reaction analysis
4. Results and conclusions

1. PHYSICS MOTIVATION

Investigation of the K^+K^- and NK interactions

- structure of the scalar mesons $f_0(980)$ and $a_0(980)$ - $K\bar{K}$ molecules?

  M. Bargiotti, et al., Eur. Phys. J. C26, 371 (2003)

  N.N. Achasov and G.N. Shestakov, Phys. Rev. D58, 054011 (1998)

- nature of the $\Lambda(1405)$ hyperon - K^-p bound state?

  J.M.M. Hall et al., Phys. Rev. Lett. 114, 132002 (2015)

- properties of kaons inside dense baryonic matter

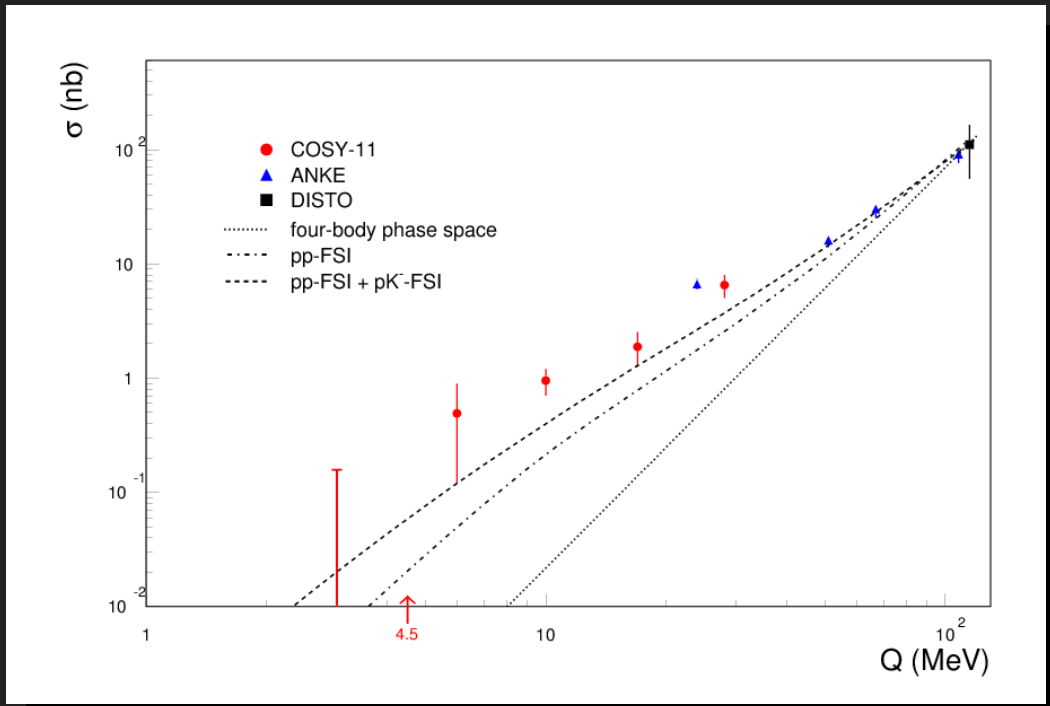
  P. Moskal et al., J. Phys. G 28, 1777 (2002)

- structure of the neutron stars

  Y. Lim et al., Phys. Rev. C 89, 055804 (2014)

$pp \to ppK^+K^-$ excitation function

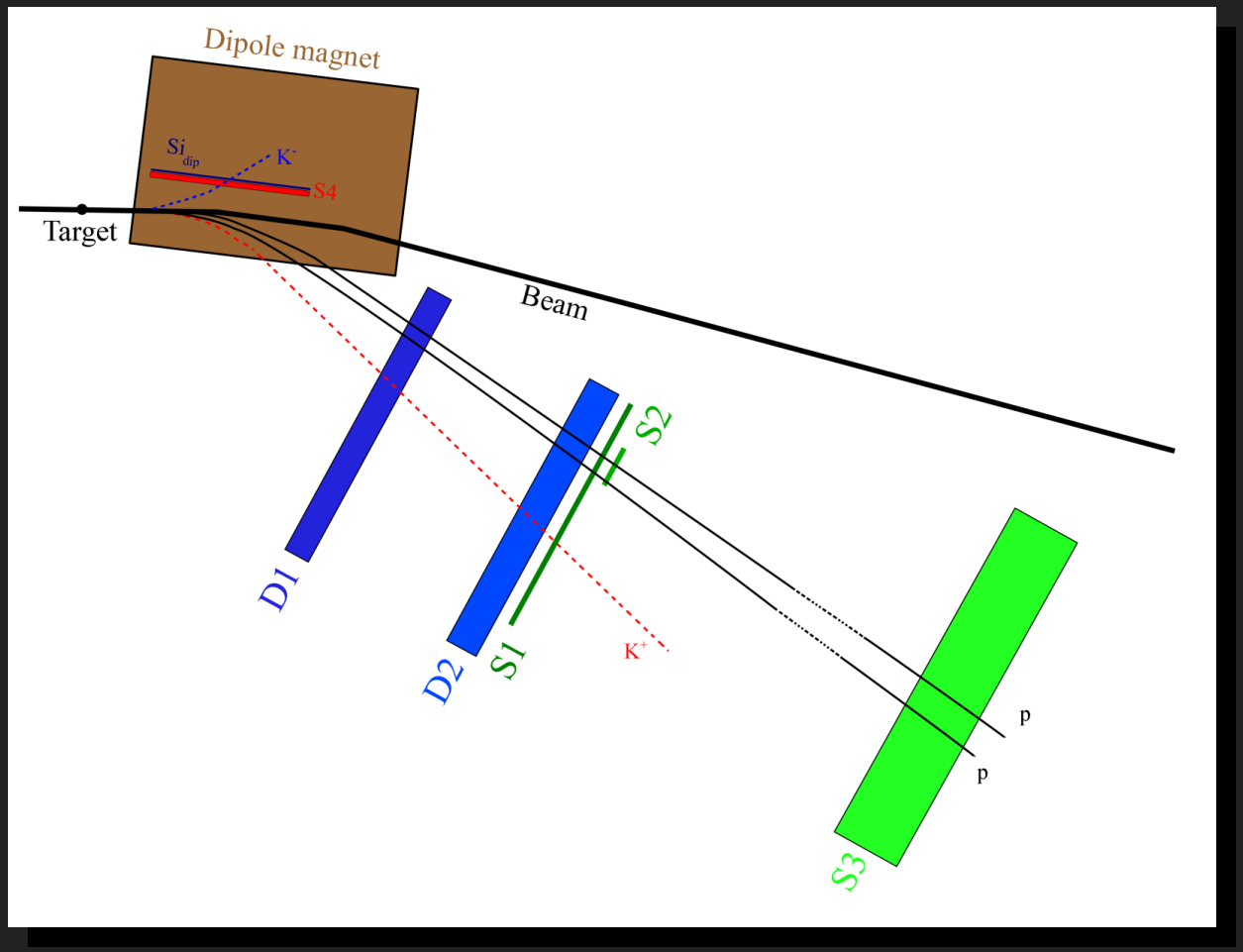
- phase space factor multiplied by pp-FSI factor underestimates the low energy data
- inclusion of K^-p-FSI is not sufficient to describe the excitation function
- new experiment at Q = 4.5 MeV



C. Wilkin, AIP Conf. Proc. 950, 23 (2007)

2. COSY-11 DETECTION SYSTEM

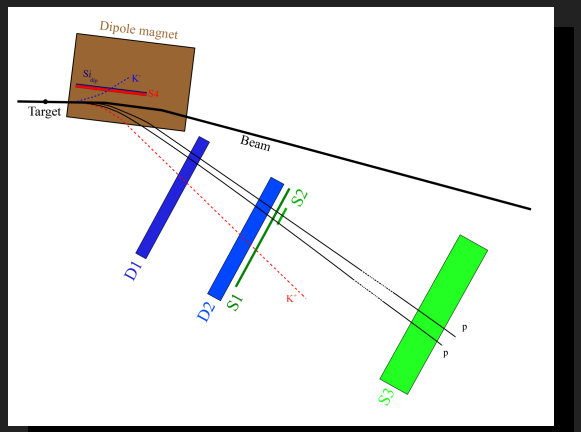
COSY-11 detection system



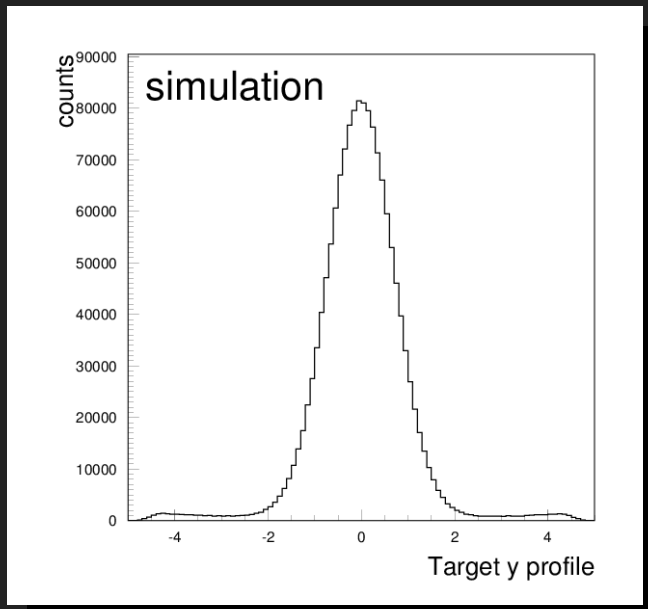
- internal H_2 cluster target
- COSY dipole magnet
- drift chambers D1 and D2
- scintillation hodoscopes S1, S2 and S3
- silicon pad detector inside the dipole gap

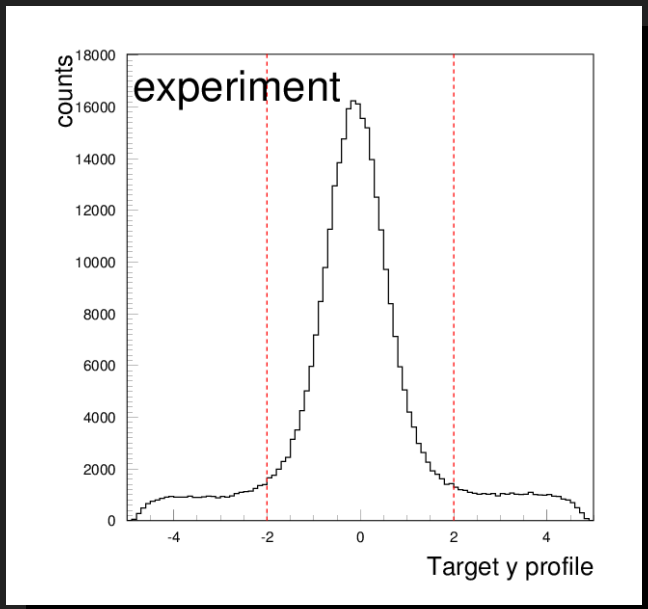
3. $pp \to pp K^+ K^-$ REACTION ANALYSIS

Positive charged particles momentum determination

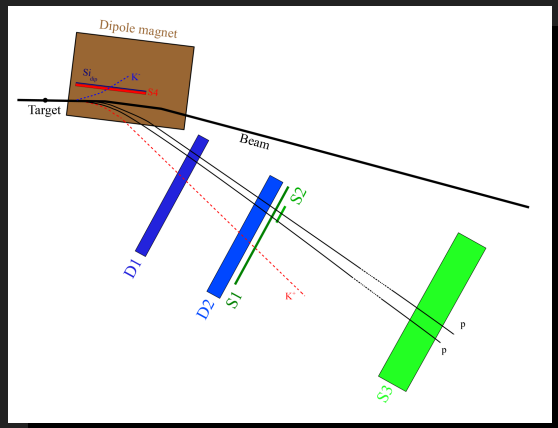


- in horizontal plane: D1 and D2 tracks are traced back in the magnetic field to the target point
- in vertical plane: target profile distribution is determined

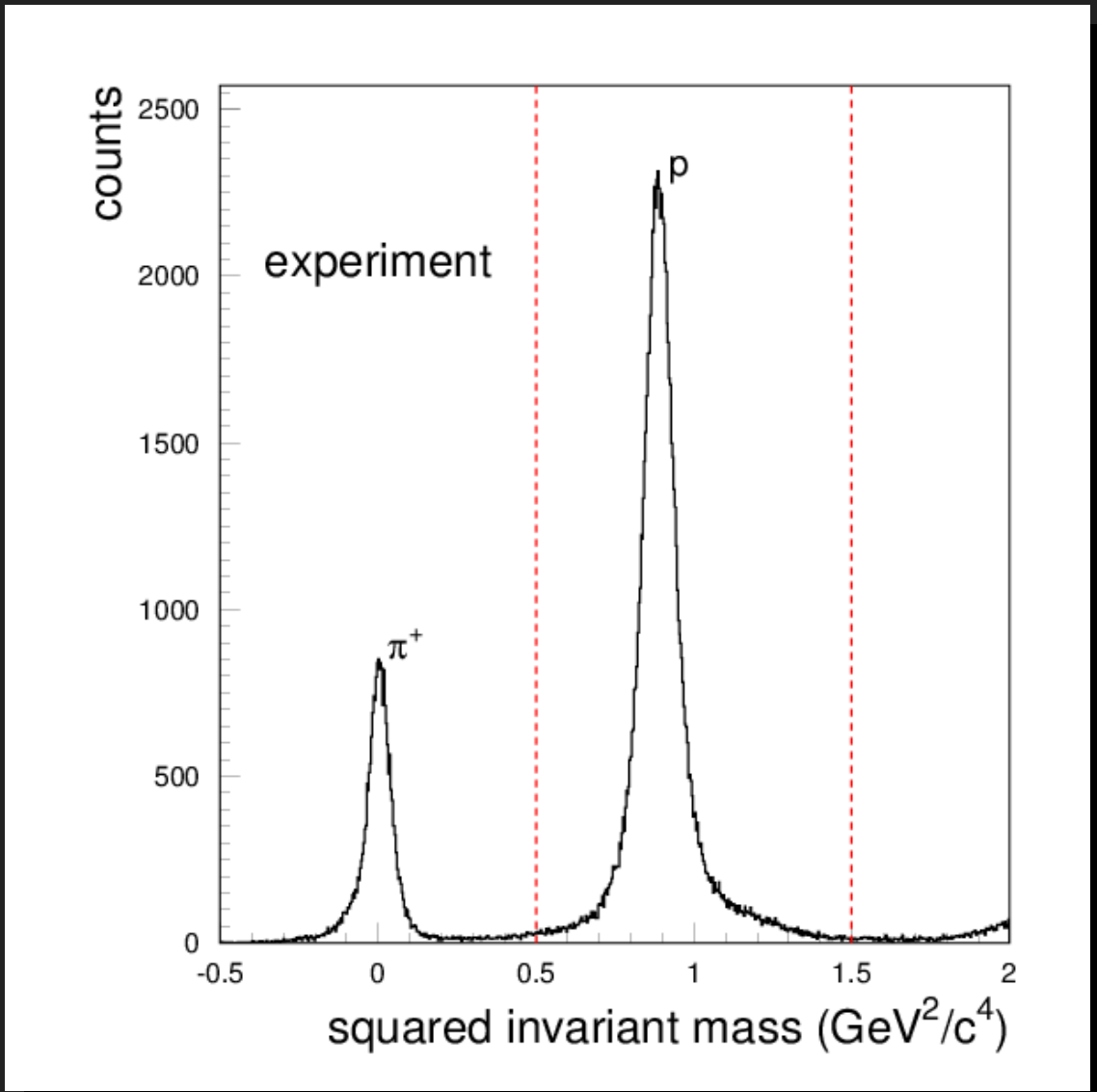




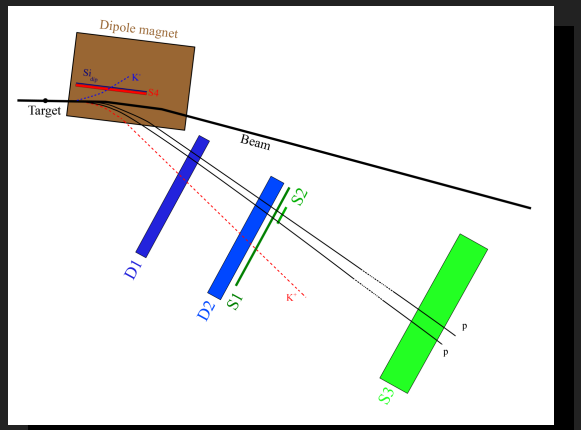
pp identification



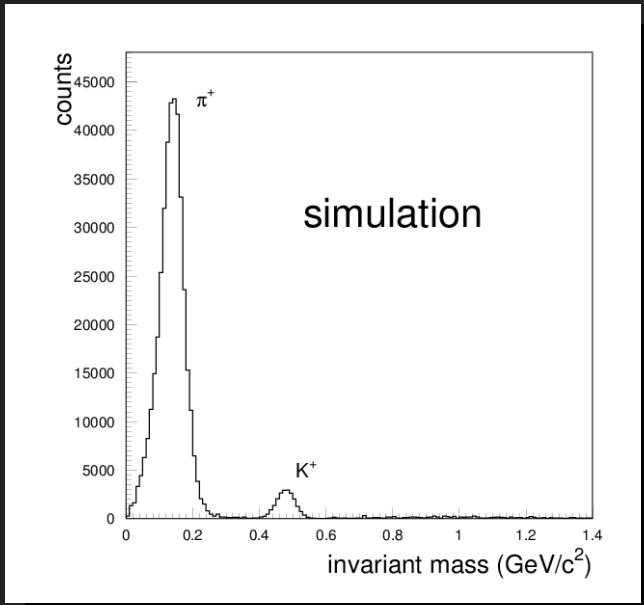
- known momentum
- velocity calculation from time-of-flight between S1 (or S2) and S3
- S2 helps to separate two protons hitting one S1 segment

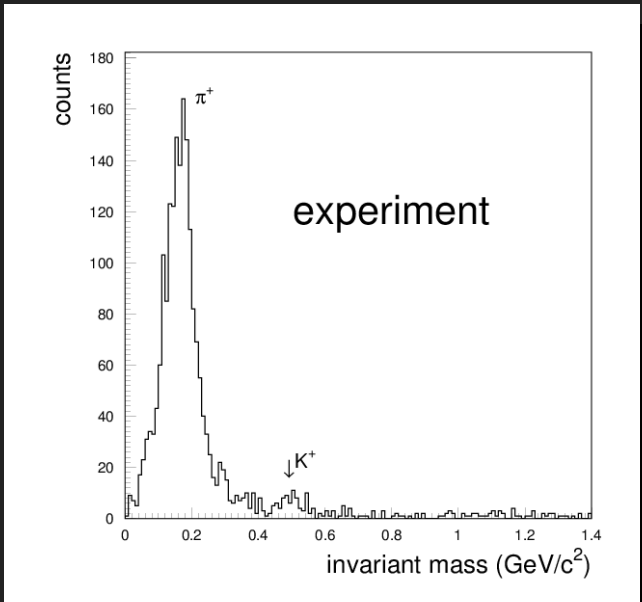


K^+ identification

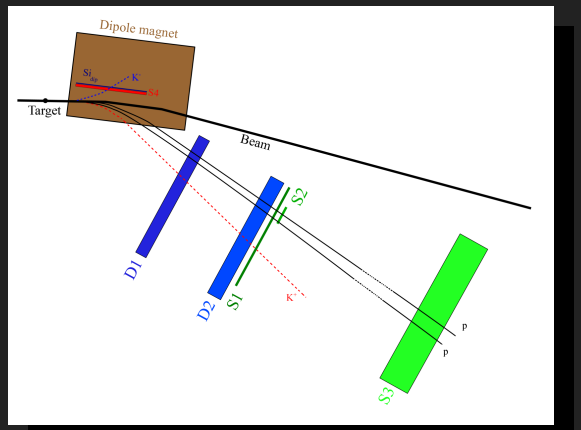


- K^+ is not measured in S3
- K^+ identification is based on time-of-flight between target and S1

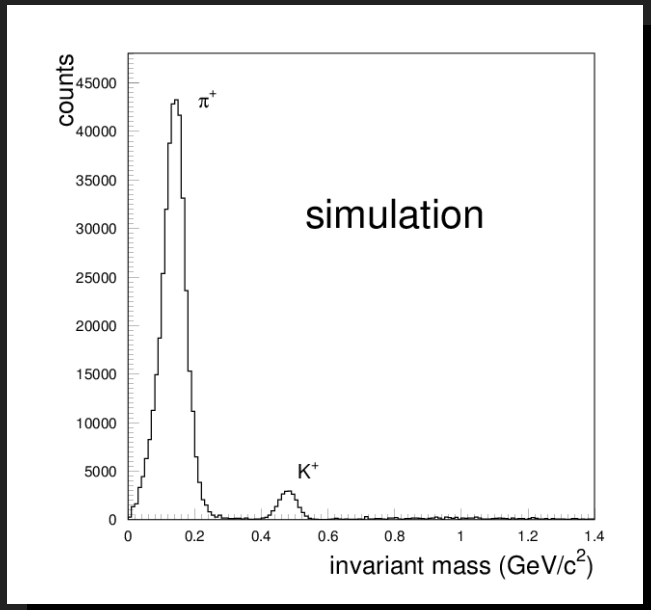


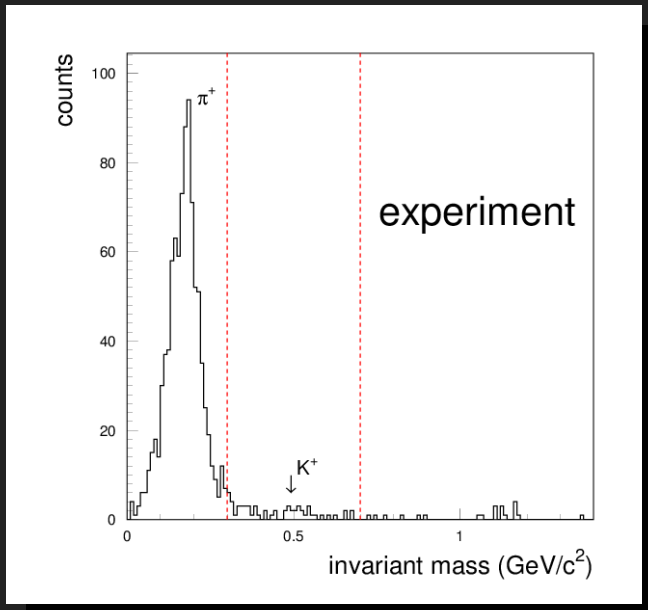


K^+ identification

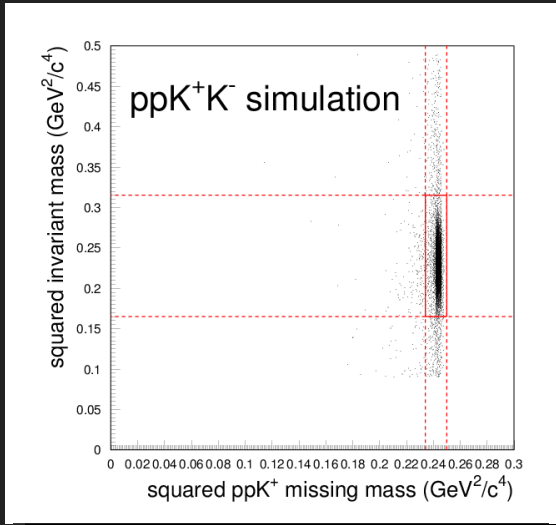


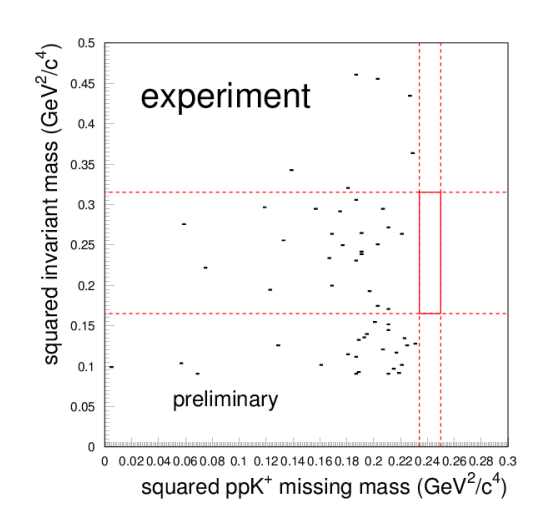
- K^+ is not measured in S3
- K^+ identification is based on time-of-flight between target and S1
- Monte Carlo: K^+ is registered in S1 segment from 9 to 12

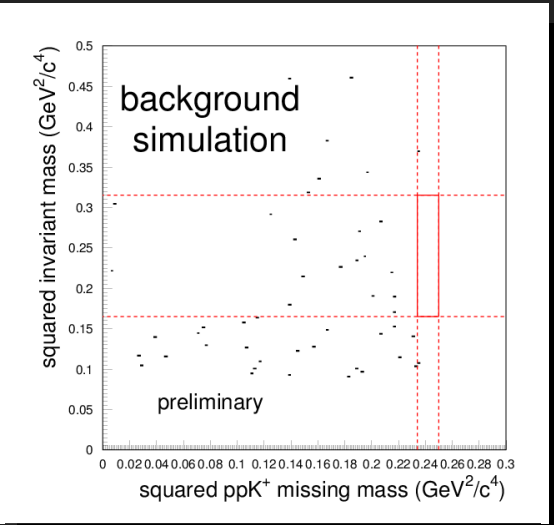




K^- identification





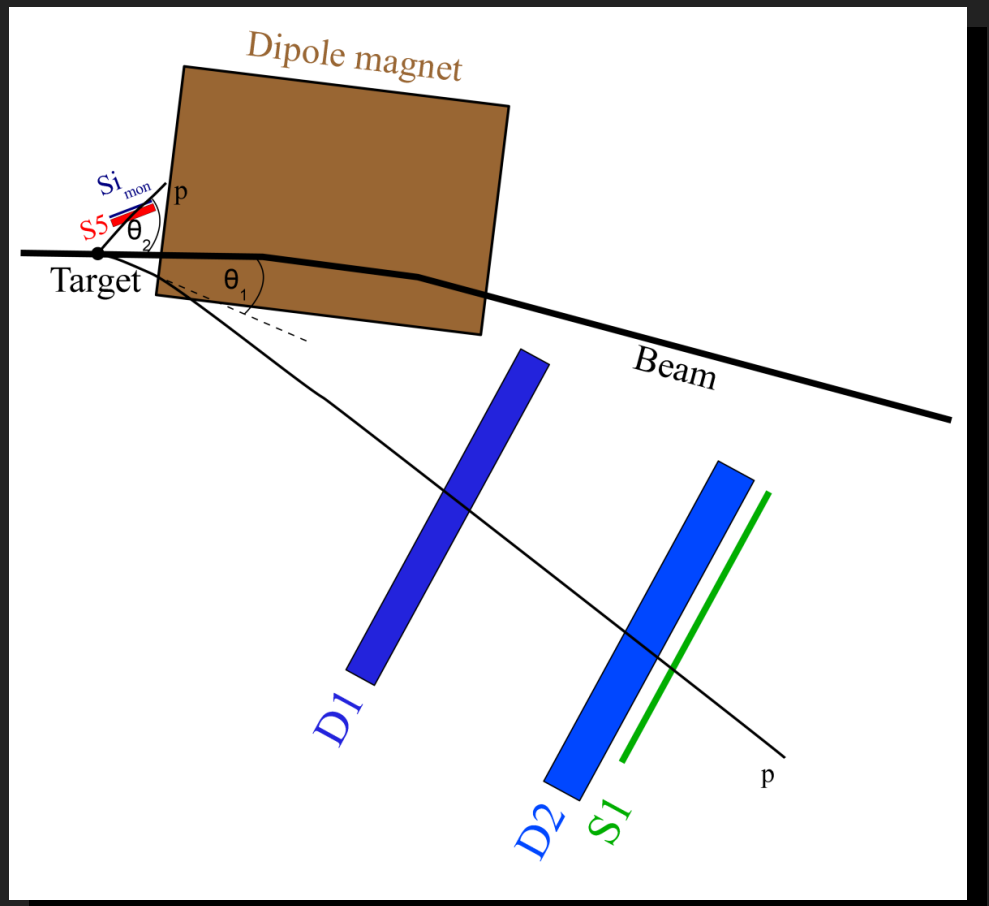


- the ppK^+K^- events signature: invariant mass value equals to the K^+ mass and missing mass value equals to the K^- mass
- **no signal inside 3σ region**
- experimental background from other reactions

Reaction	Events
$pp \to pp\pi^+\pi^-$	2
$pp \to pp\pi^0\pi^+\pi^-$	6
$pp \to pp2\pi^+2\pi^-$	10
$pp \to pp2\pi^0\pi^+\pi^-$	1
$pp \to pK^+\Lambda$	0
$pp \to pp3\pi^0\pi^+\pi^-$	4
$pp \to pp\pi^0 2\pi^+2\pi^-$	10
$pp \to pK^+\Sigma^0$	0

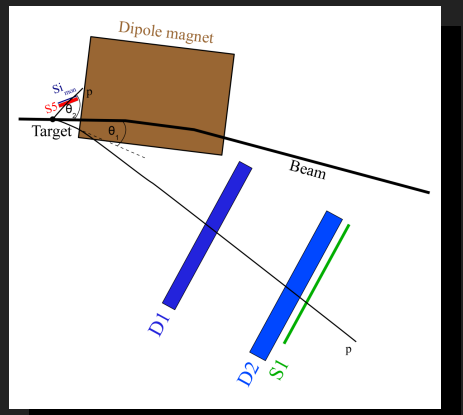
Luminosity determination

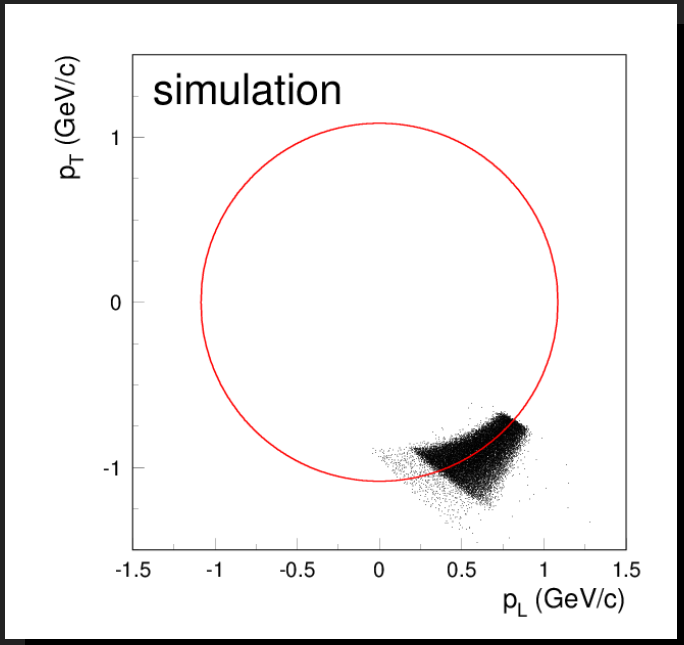
- proton scattered in the forward direction: bent in the magnetic field and registered in D1, D2 and S1
- recoil proton: detected in the position sensitive silicon pad detector Si_{mon}

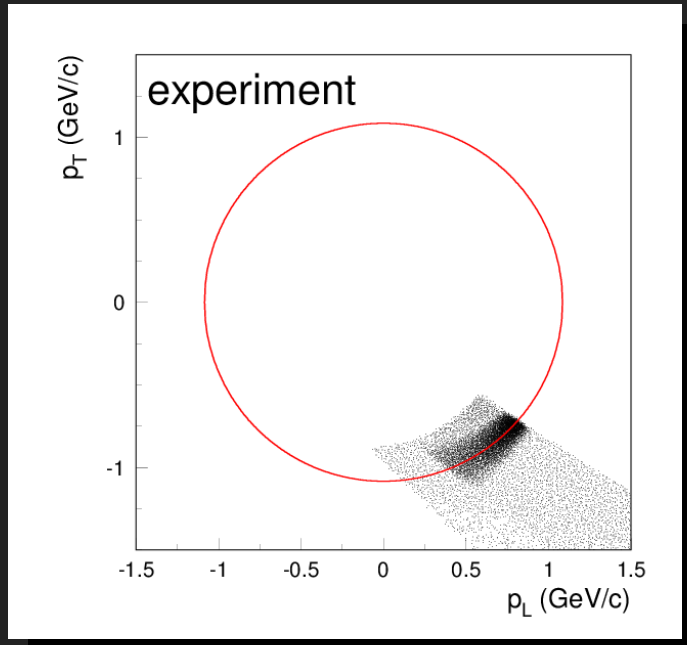


Proton scattered in the forward direction

- reconstruction of the momentum at the target
- from kinematics: parallel (p_L) and perpendicular (p_T) momentum vector components form an ellipse
- 4σ cut on the distance to the theoretical ellipse helps to remove the background events

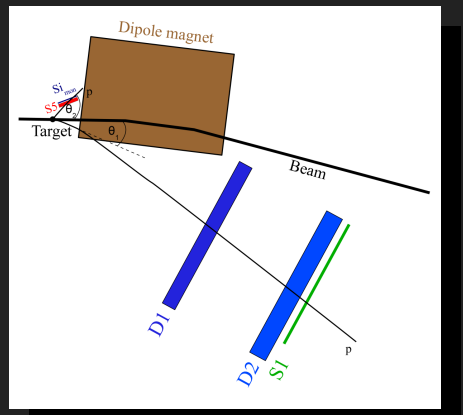


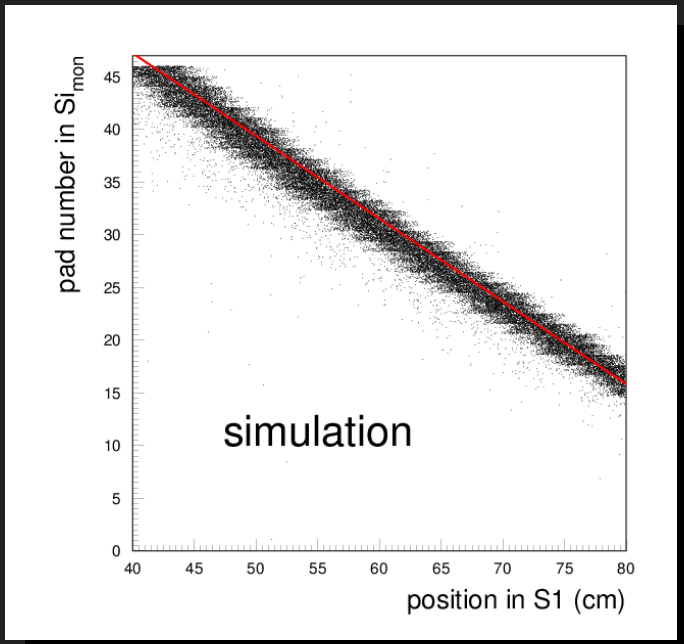


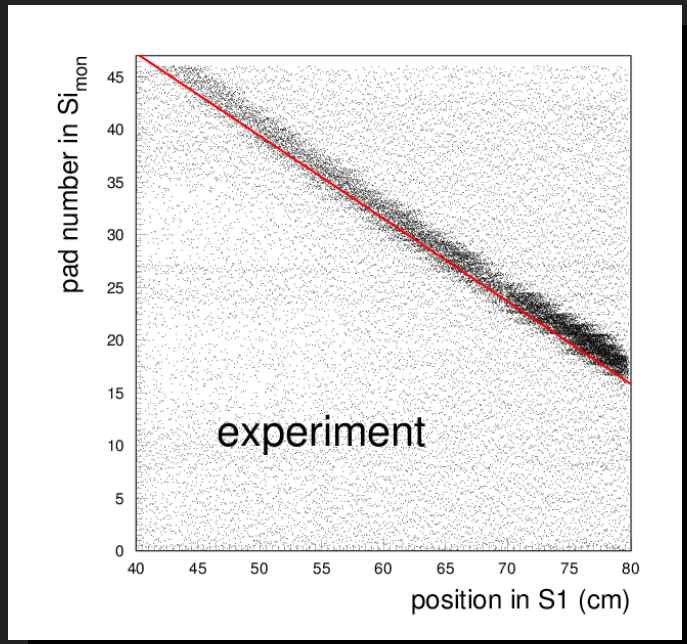


Elastic scattered protons correlation

- both protons scattering angles are kinematically connected
- angular range covered by the S1 detector is divided into nine 2° intervals
- projection of the data along the correlation line is determined for each interval separately

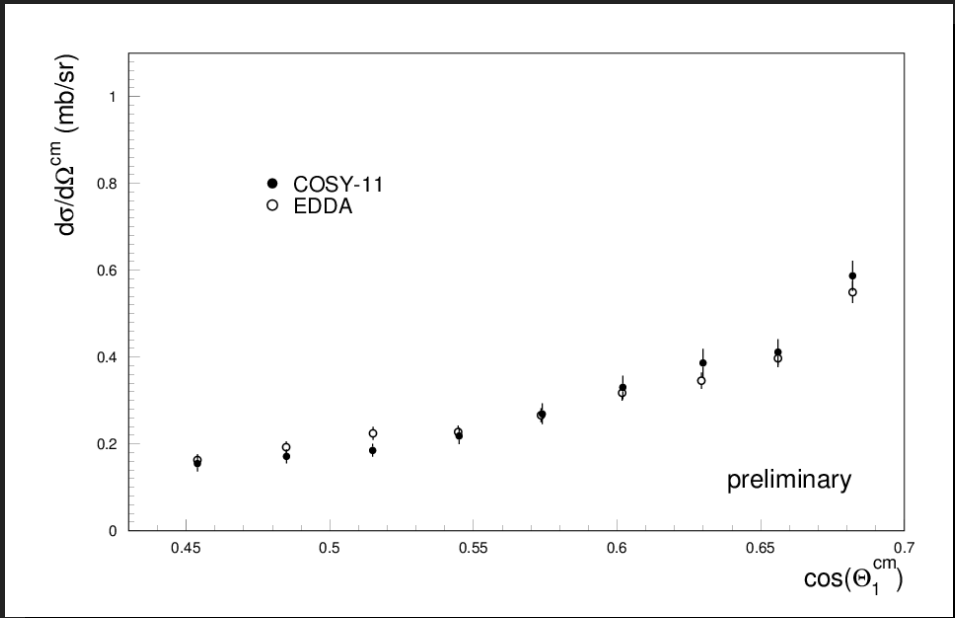






Integrated luminosity

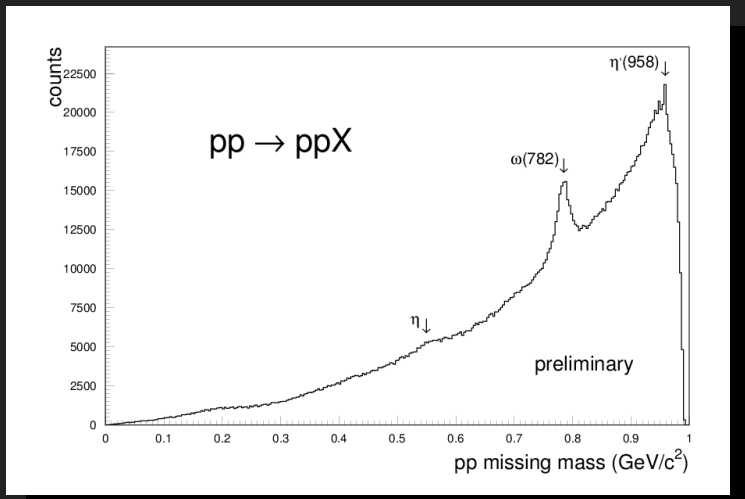
- elastic cross sections from measurements performed by the EDDA collaboration
- integrated luminosity equals to $1.52 \pm 0.03_{stat} \pm 0.07_{syst}$ pb^{-1}

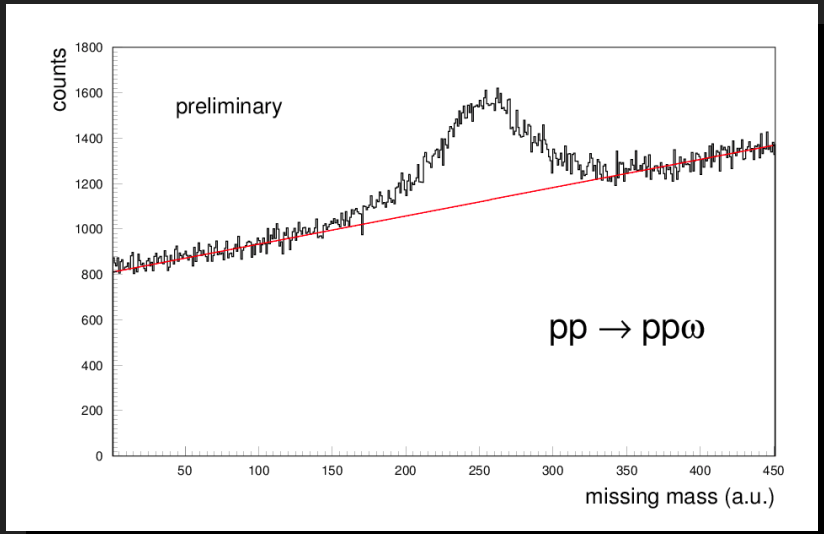


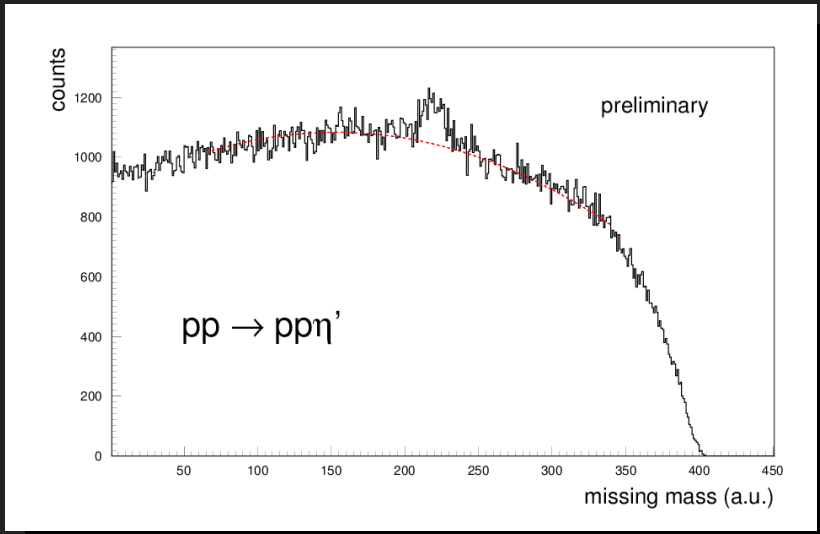
D. Albers et al., A precision measurement of pp elastic scattering cross-sections at intermediate energies, Eur. Phys. J. A22 (2004) 125-148

Luminosity verification

- pp → ppω and pp → ppη' events above background

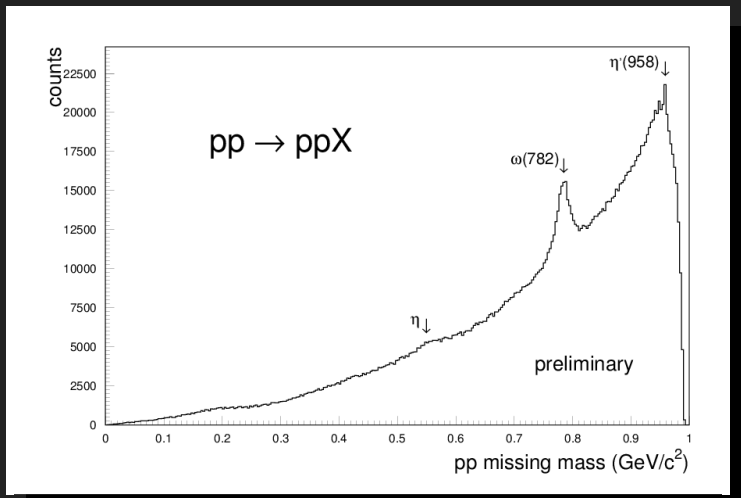


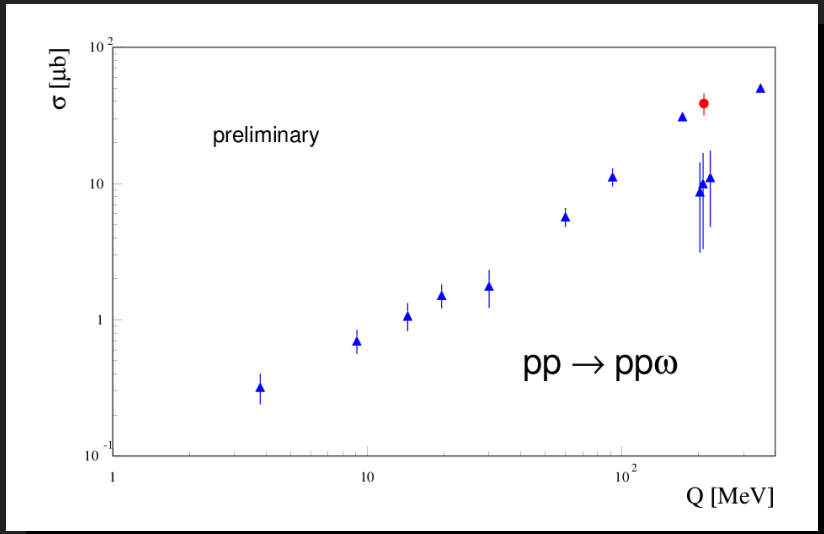


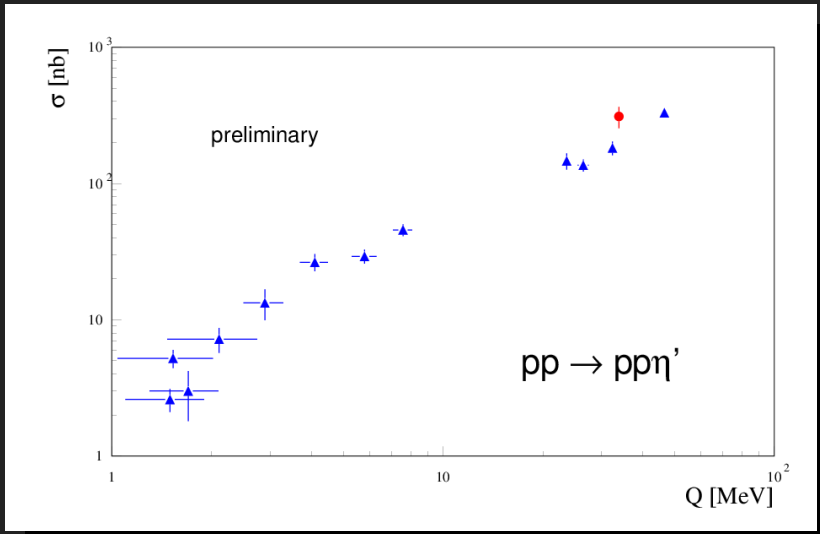


Luminosity verification

- pp → ppω and pp → ppη' events above background
- detection efficiency:
  pp → ppω = 0.06%
  pp → ppη' = 0.76%
- total cross sections:
  σ_{tot}(ppω) = 38.51 μb at Q = 210 MeV
  σ_{tot}(ppη') = 308.86 nb at Q = 34 MeV







4. RESULTS AND CONCLUSIONS

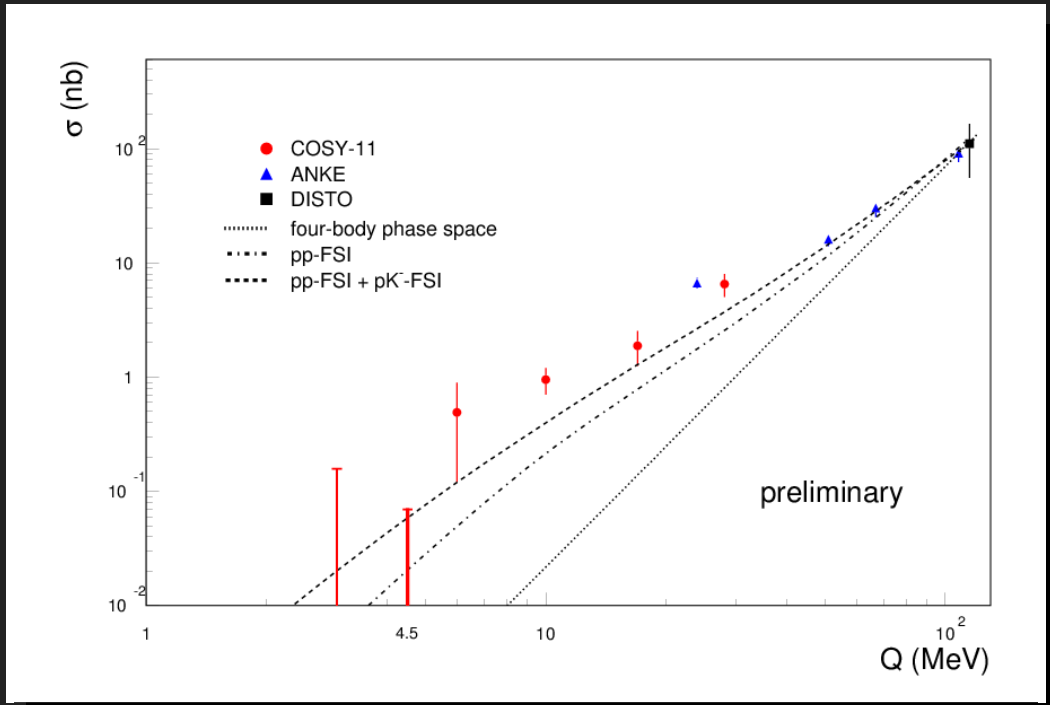
Results (preliminary)

- no events from $pp \to ppK^+K^-$ reaction was observed
- upper limit for confidence level 95% equals to 3 events
- efficiency from the Monte Carlo simulation equals to 2.83%
- luminosity from the elastic scattering equals to 1.52 pb^{-1}

↳ upper limit for $\sigma_{tot}(pp \to ppK^+K^-)$ at Q = 4.5 MeV equals to **0.070 nb**

Conclusions

- calculations based on pp-FSI and pK^--FSI with $a_{pK} = (-0.65 + 0.78i)$ fm underestimate the experimental results
(Y. Yan, arXiv:0905.4818)



C. Wilkin, AIP Conf. Proc. 950, 23 (2007)

Conclusions

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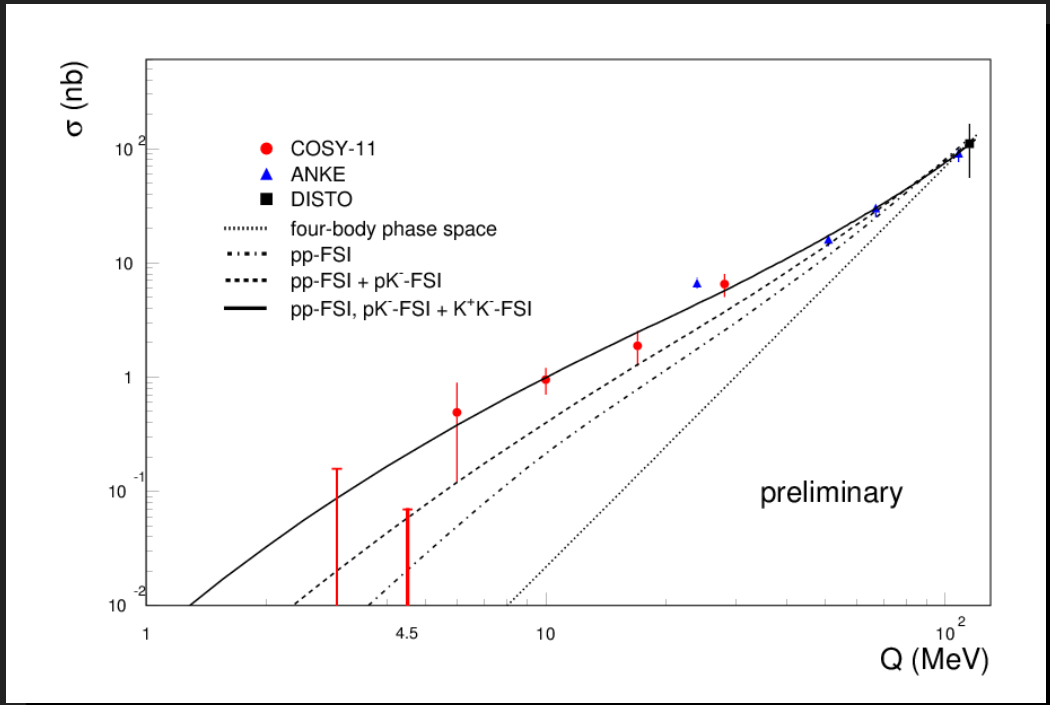
- adding K^+K^--FSI parameterized with the effective range approximation with $a_{KK} = 8.0$ fm and $b_{KK} = (-0.1 + 1.2i)$ fm overestimates the new upper limit
  (M. Silarski et al., Phys. Rev. C88, 025205 (2013))



C. Wilkin, AIP Conf. Proc. 950, 23 (2007)

Thank you for your attention