Search for the K^-pp bound state in LEPS/LEPS2

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SPring-8

Super Photon ring 8GeV

★large 3rd -generation synchrotron radiation facility.

★ 8 GeV electron storage ring

★ Current: 100 mA

LEPS facility

Laser-Electron-Photon facility at SPring-8

→Hadron Physics
using photon beam (1.5 GeV – 3 GeV)
← backward Compton scattering method

Ex.
- Penta quark Search
- meson properties in medium (ϕ A-dep)
- K^-pp bound state search ← Today's talk

etc

Contents

- What is the K-pp bound state?
- Experiment at LEPS
- Results
- Future work: search in LEPS2 experiment
- Conclusion

☆This presentation is based on **Phys.Lett. B728 (2014) 616-621**

What is the K^-pp bound state?

- $\bar{K}$ - nuclei interaction
- K^-pp bound state
- Search experiment using a photon beam

$\overline{K}$-nuclei interaction

Systematic study on Kaonic atoms

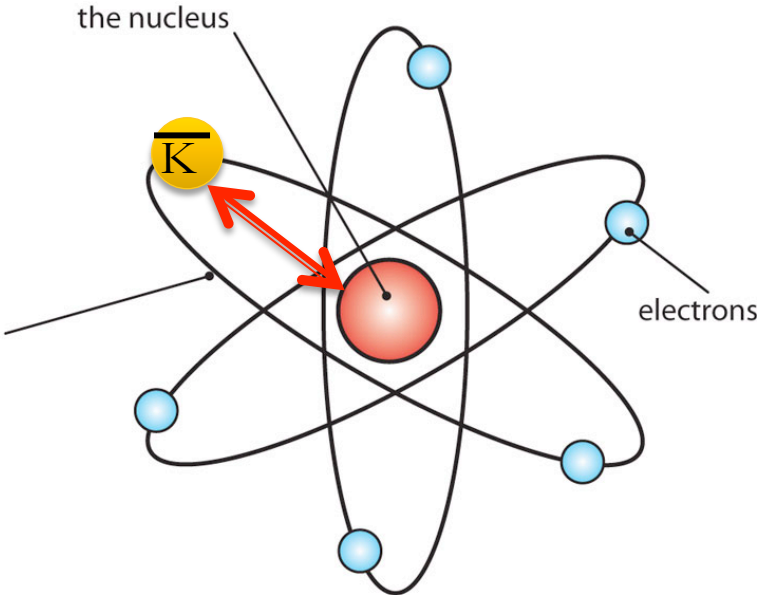
$\overline{K}$ potential is as deep as ~ 200 MeV !

Kaon condensation in Neutron Star

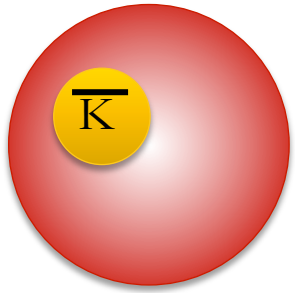
D. B. Kaplan and A. E. Nelson, Phys. Lett., B175 (1986) 57

$\overline{K}$ bound state in nuclei → Kaonic nuclei

Y. Akaishi and T. Yamazaki, Phys. Re ., C65 (2002) 044005



Kaonic atom

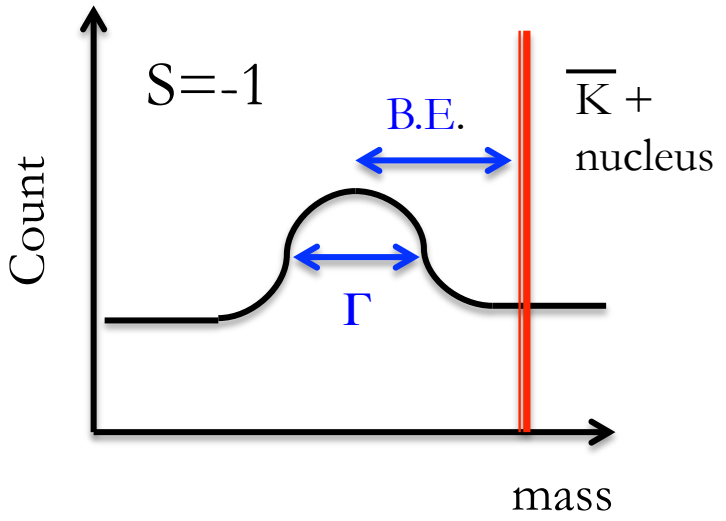


Kaonic nuclei

K^-pp bound state

Q. Does Kaonic nuclei exist really?

A. *theory* :
shoud exist!
experiment :
The existence has
not been established.

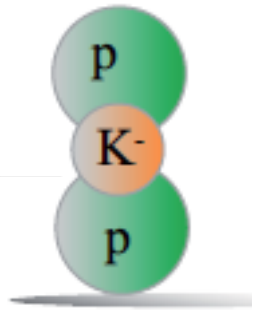


A large = absorption effect large = hard to observe

→ K^-pp bound state : the simplest kaonic nuclei

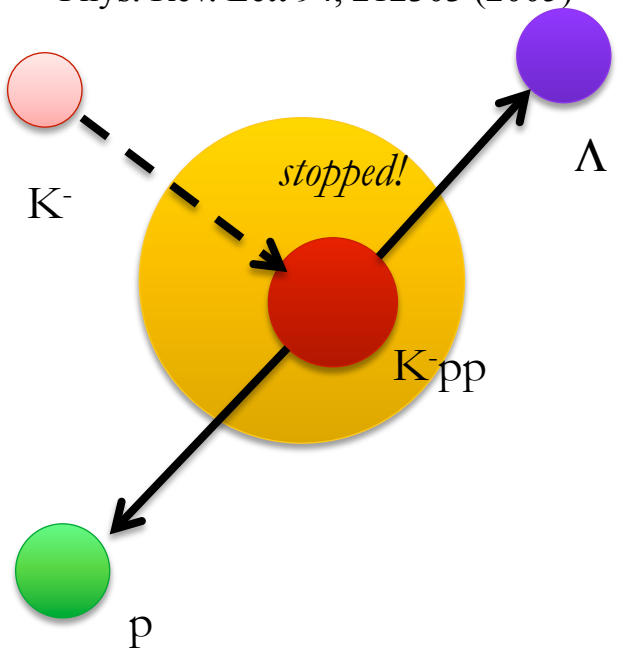
Theoretical prediction
B.E. = 10 – 100 MeV
Γ = 10 – 100 MeV

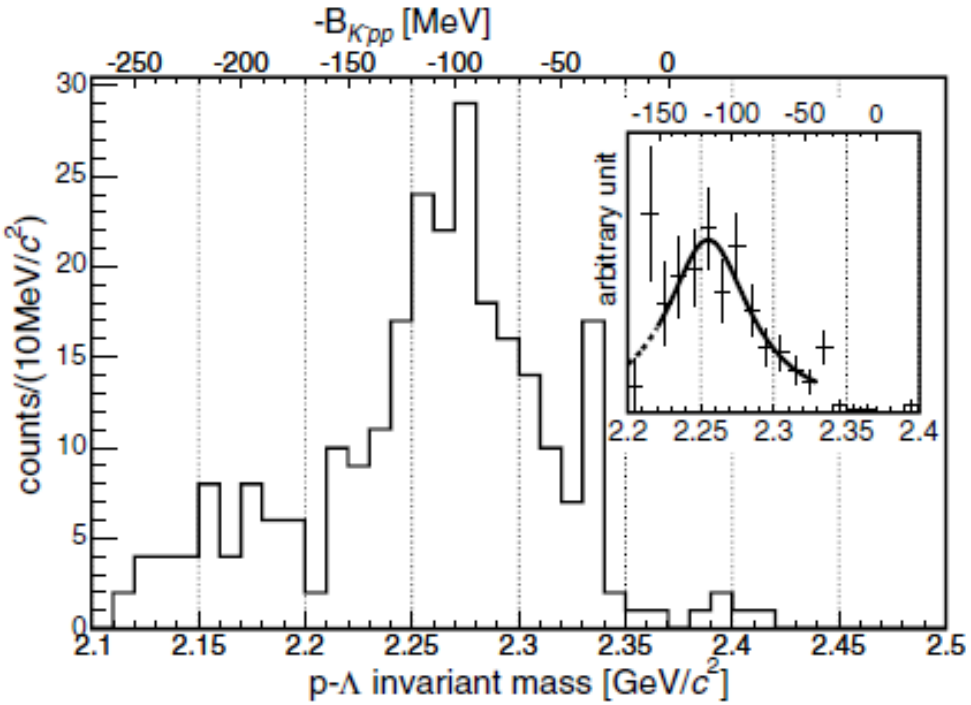
still controversial



FINUDA experiment

Phys. Rev. Lett 94, 212303 (2005)





stopped K^- on nuclei → K^-pp → Λp

$$\text{B.E.} = 115^{+6}_{-5}(stat)^{+3}_{-4}(syst)\ \text{MeV}$$
$$\Gamma = 67^{+14}_{-11}(stat)^{+2}_{-3}(syst)\ \text{MeV}$$

- inconsistent with theoretical predictions.
- other interpretation.

→ check using other reactions are necessary

Other Search experiments

- Other experiments
  - J-PARC : K^-, π^+ beam
  - DAΦNE : low energy K^- beam
  - GSI : proton beam
- New experiment at LEPS using γ beam

1.5 – 2.4 GeV

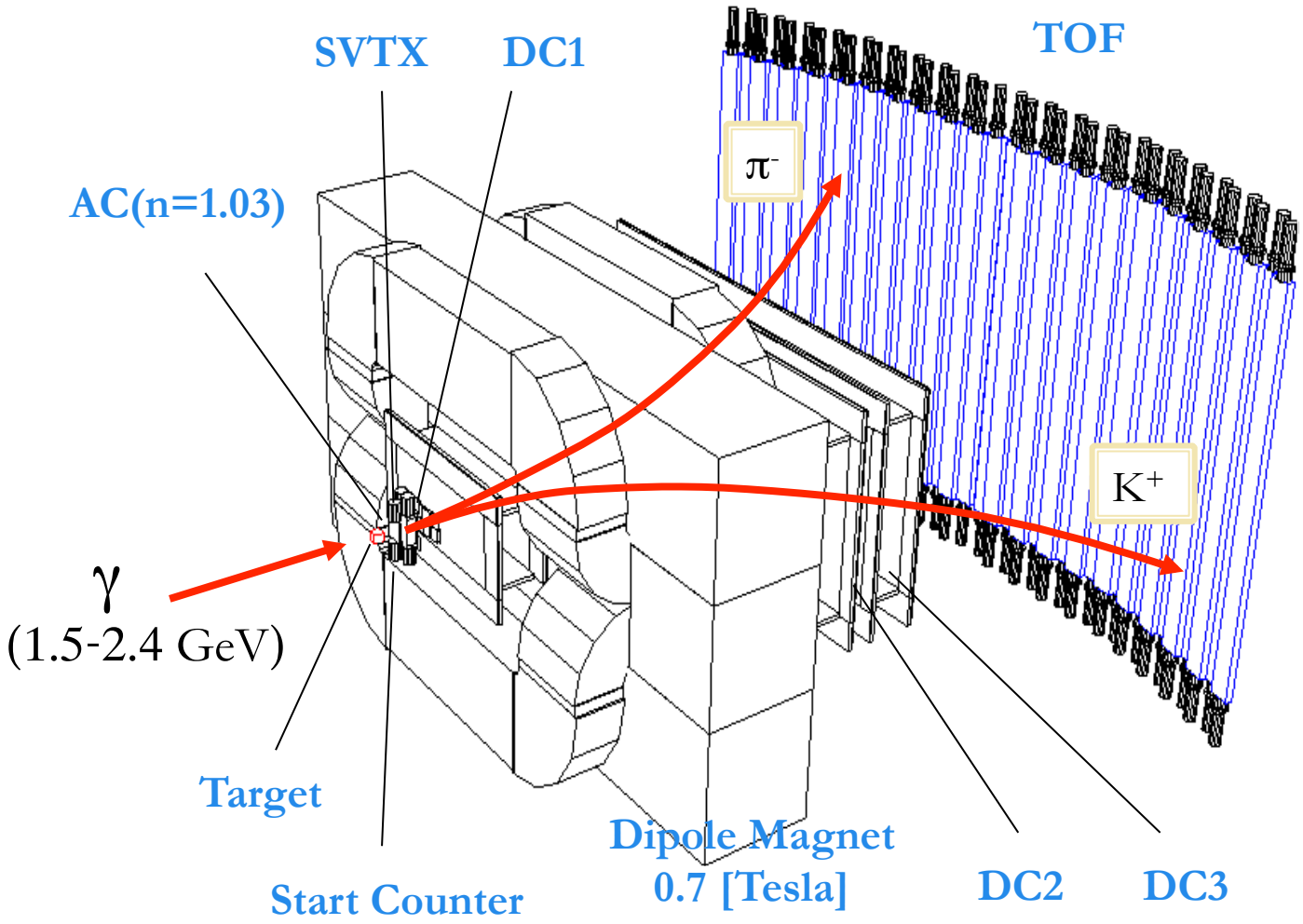
$$\gamma + d \rightarrow K^+ + \pi^- + X$$

measure E and p → calculate X mass by the missing mass method

★ Search for peak structures
in the region from 2.22 to 2.36 GeV/c^2 (B.E. 10 – 150 MeV)

Experiment at LEPS

LEPS spectrometer



position

SSD
(SVTX)
Drift Chamber
(DC 1~3)

time

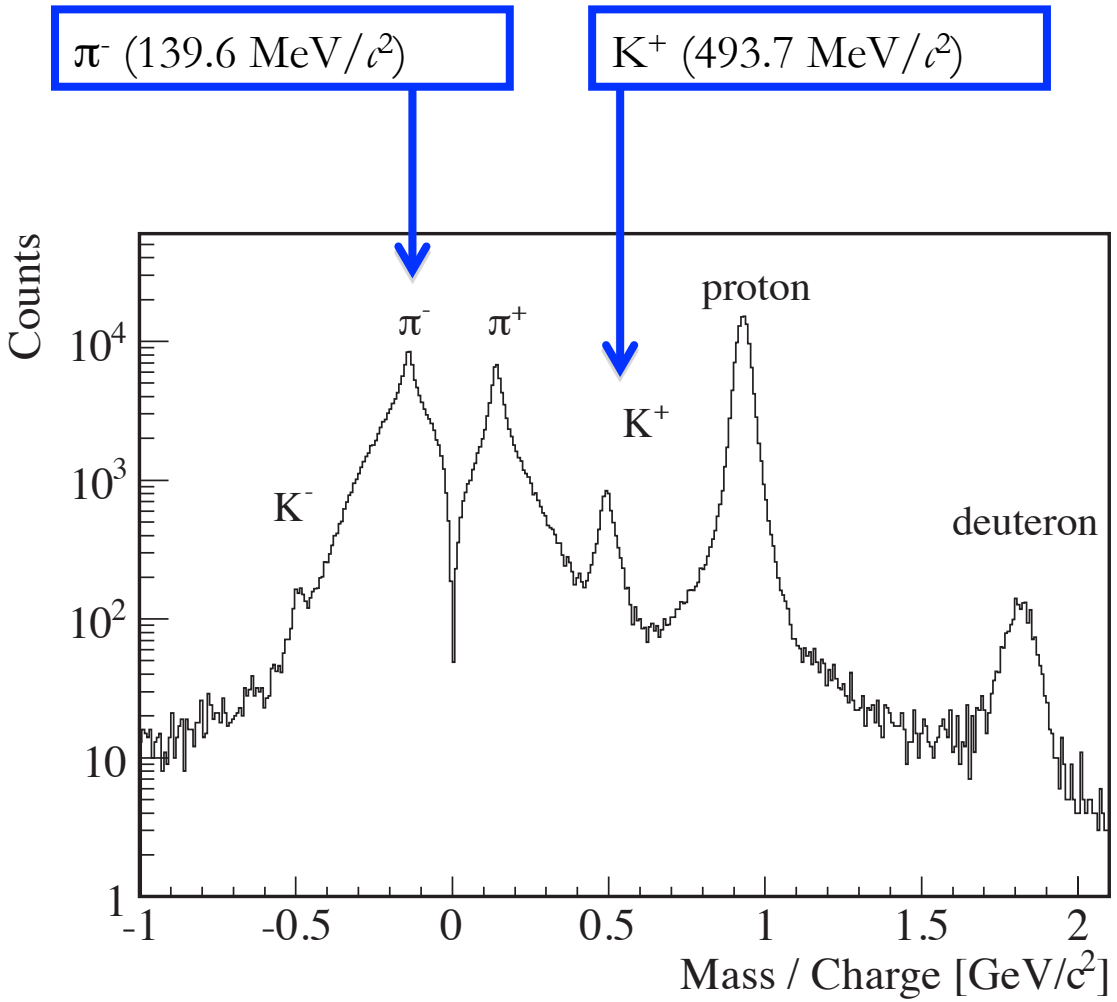
Start Counter
(SC)
Time of flight wall
(TOF)

trigger

Aerogel Cherencov
counter
(AC)
Start Counter (SC)

K^+ and π^- are detected at very forward angle(< 15 degree)

Particle Identification



TOF (Time of flight)

$$m^2 = p^2(1/\beta^2 - 1)$$

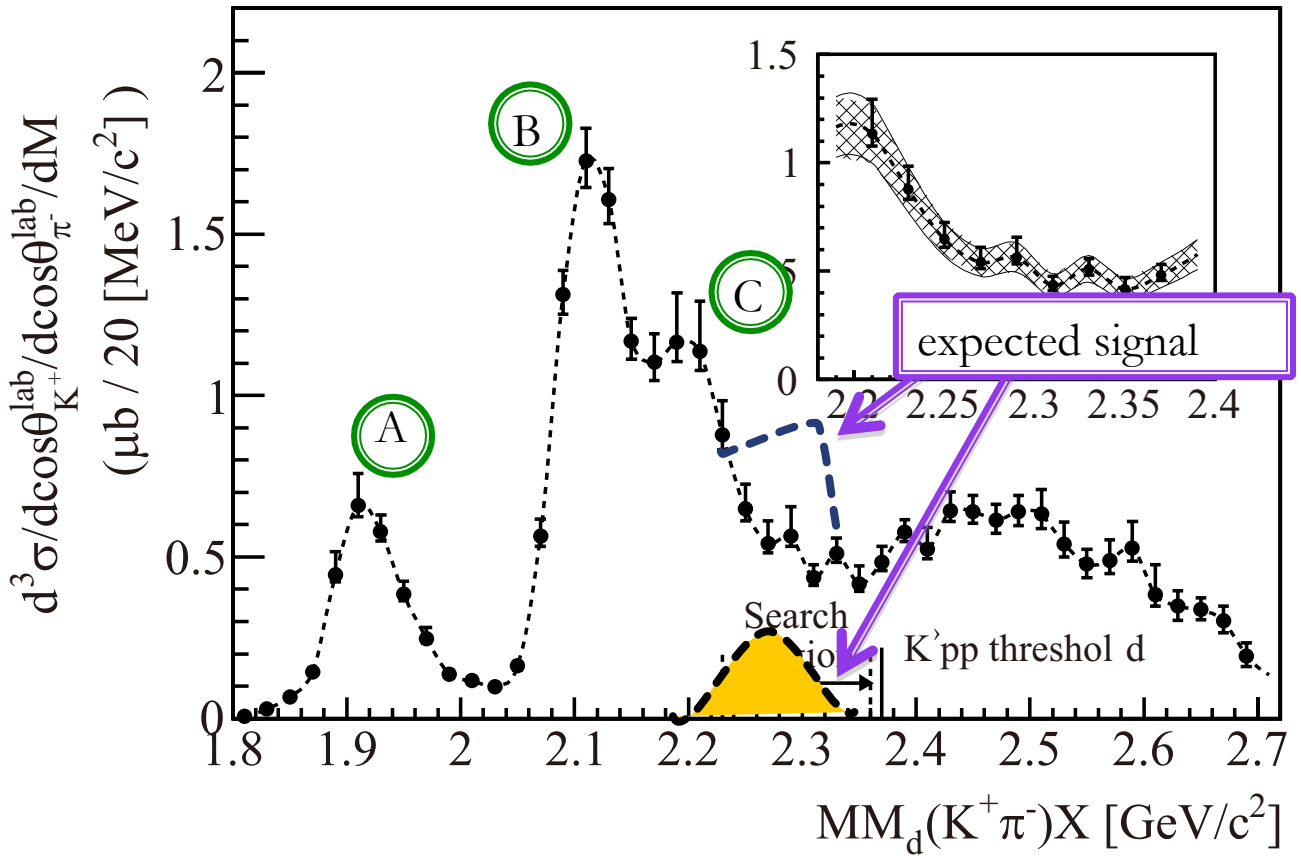
Track reconstruction
+ Runge-Kutta method.

$\Delta p \sim 6$ MeV/c
@ 1 GeV/c

$\Delta M \sim 10$ MeV/c^2
(2.22 - 2.36 GeV/c^2)
in $MM_d(K^+\pi^-)$

Results

missing mass spectrum



cut condition
$-\cos\theta^{lab}_{K+}>0.95$
$-\cos\theta^{lab}_{\pi-}>0.95$
$-0.25<p_{K+}<2.5$
$-0.25<p_{\pi-}<0.6$

A:
$\gamma\, n \rightarrow \Sigma^- K^+$
$\Sigma^- \rightarrow n\, \pi^-$
B:
$\gamma\ p \rightarrow \Lambda\, K^+\, \pi^-$
C:
$\gamma\, p/n \rightarrow \Sigma^{-/0}\, K^+\, \pi^-$

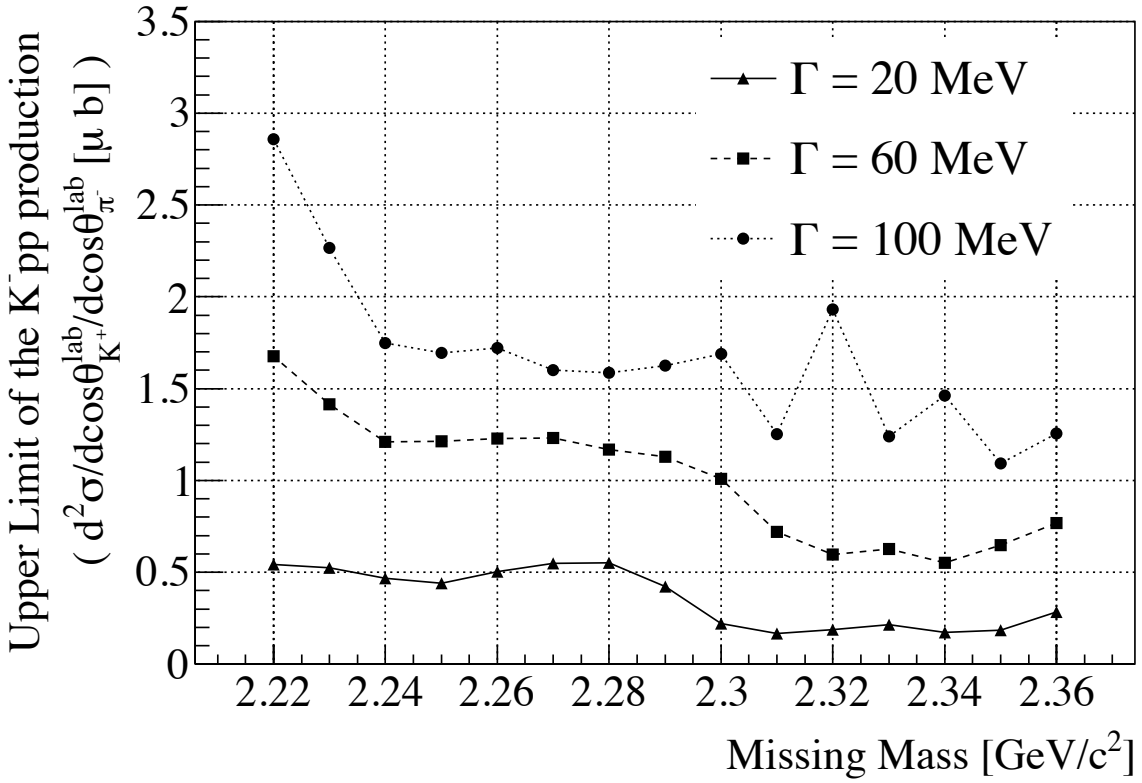
B+ C : ~11 μb

Peak structure was searched in 2.22 - 2.36 GeV/c^2.

→No peak structure was observed!

upper limit of cross section

B.E. →15 points (10-150 MeV)
Γ →3 points (20, 60 and 100MeV)



-Γ= 20 MeV
0.17 - 0.55 μb

-Γ = 60 MeV
0.55 - 1.7 μb

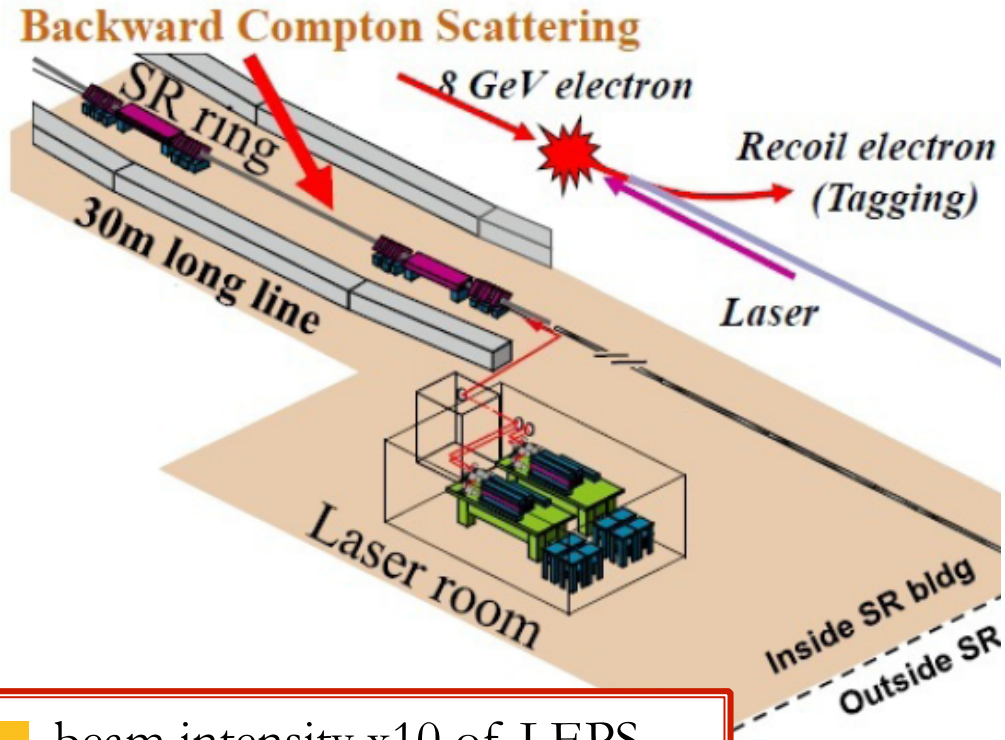
-Γ =100 MeV
1.1 – 2.9 μb

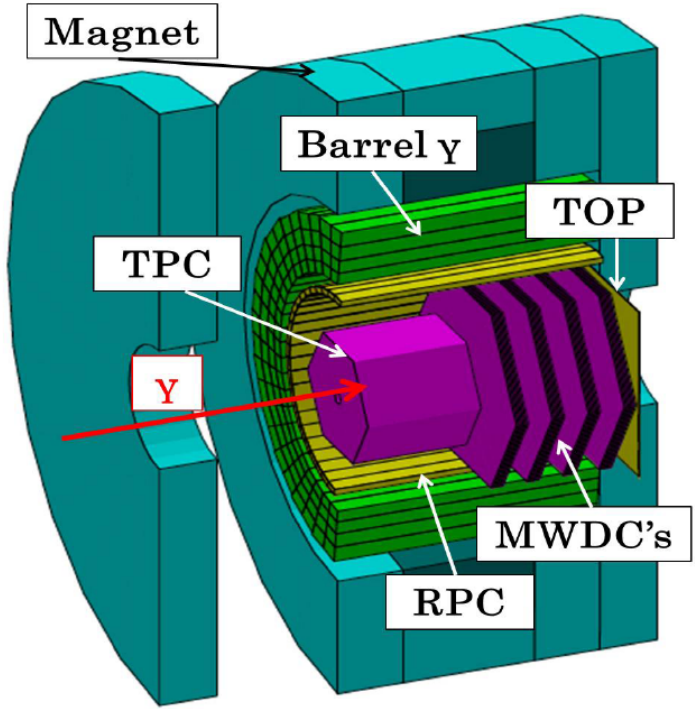
1.5 - 26 % of $YK^+\pi^-$ production cross section.

K^-pp production cross section is small. → exclusive experiment
→ LEPS2

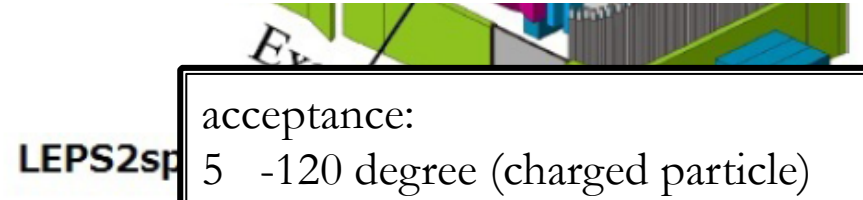
Search in LEPS-2 experiment

LEP2 facility





- beam intensity x10 of LEPS (10^7 cps)
- 4 π detector
- under construction for the 1st experiment



acceptance:
5 -120 degree (charged particle)
30 - 100 degree (γ)
p/Δp ~ 1%

Conclusion

Conclusion

- *K*$^{-}$*pp* bound state was searched for via the γ d $\rightarrow$ K^{+} π^{-} X reaction at LEPS/SPring-8.
- Significant peak structures were not found in $MM_d(K^{+}\pi^{-})$ spectrum, and the upper limits of the production cross section were determined.
- LEPS2 has potential for more sensitive search experiments.

Collaborators

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Thank you for your attention!