Search for the $\bar{K}NN$ state in photoproduction with LEPS2 spectrometer

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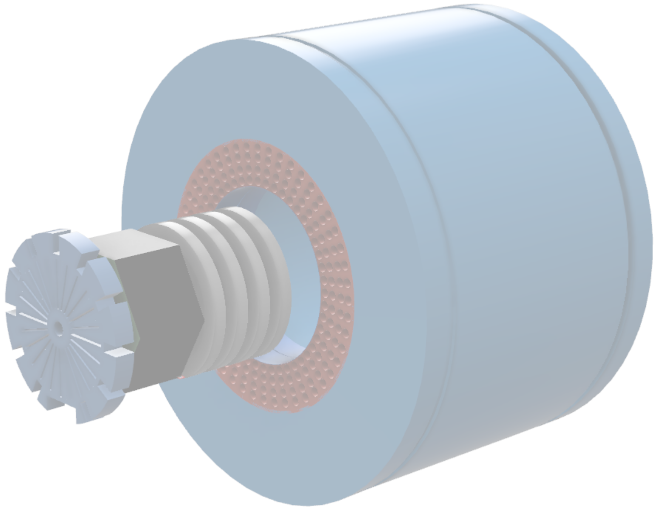
Contents

- **Physics motivation**
  - Physics interest with $\bar{K}NN$ state
  - Experimental Review on $\bar{K}NN$ search
  - A New Experiment with LEPS2 Solenoid Detectors
- **LEPS2 Experiment**
  - SPring-8 and LEPS2 Beam line
  - LEPS2 Solenoid detectors
  - Expected performance



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Kaonic nuclei

$\bar{\mathrm{K}}$N interaction

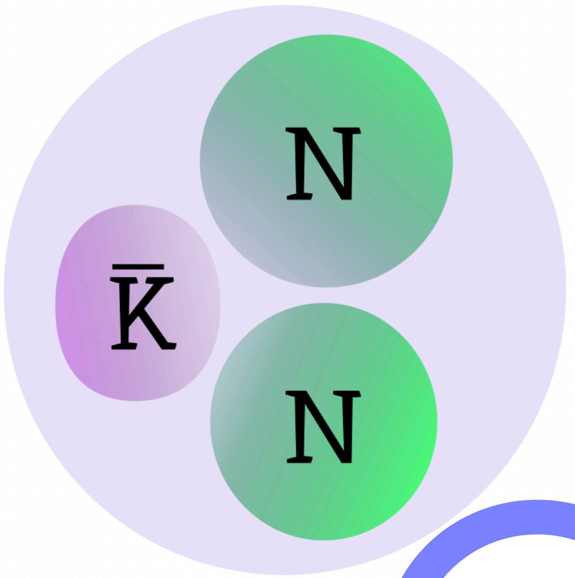
Known to be strongly attractive ($\bar{\mathbf{K}}\mathbf{N}(\mathbf{I}=\mathbf{0})$ channel)
from K-p atomic X-ray shift and low energy K- p scattering data

The simplest kaonic nuclei $\bar{\mathrm{K}}\mathrm{NN}(\mathbf{I}=1/2)$

$$|\bar{K}[NN]_{I=0}\rangle_{I=1/2} = -\frac{1}{2}|[\bar{K}N]_{I=0}N\rangle_{I=1/2} + \frac{\sqrt{3}}{2}|[\bar{K}N]_{I=1}N\rangle_{I=1/2}$$

$$|\bar{K}[NN]_{I=1}\rangle_{I=1/2} = \frac{\sqrt{3}}{2}|[\bar{K}N]_{I=0}N\rangle_{I=1/2} + \frac{1}{2}|[\bar{K}N]_{I=1}N\rangle_{I=1/2}$$

$$|\bar{K}[NN]_{I=1}\rangle_{I=3/2} = -|[\bar{K}N]_{I=1}N\rangle_{I=3/2}$$



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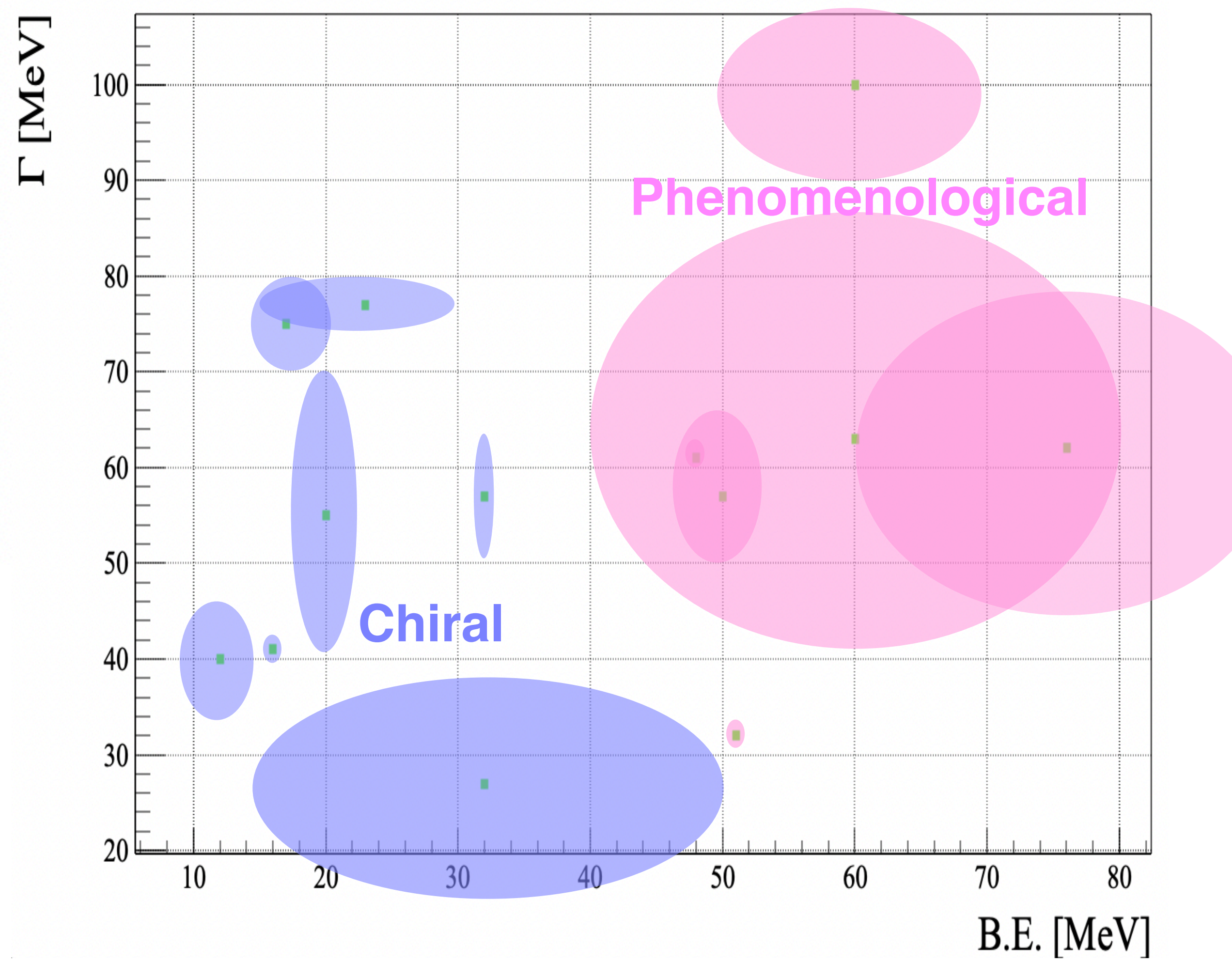
Theoretical prediction of $K^{-}pp$ state

Work	B [MeV]	Γ [MeV]	Method	Type of potential
Barnea et al. [106]	16	41	Variational	chiral
Dote et al. [107]	17-23	40-70	Variational	chiral
Dote et al. [108]	14-50	16-38	ccCSM	chiral
Ikeda et al. [109]	9-16	34-46	Faddeev	chiral
Bayar et al. [110]	15-30	75-80	Faddeev	chiral
Sekihara et al. [111]	15-20	70-80	Faddeev	chiral
Yamazaki et al. [112]	48	61	Variational	phenomenological
Shevchenko et al. [113]	50-70	90-110	Faddeev	phenomenological
Ikeda et al. [114]	60-95	45-80	Faddeev	phenomenological
Wycech et al. [115]	40-80	40-85	Variational	phenomenological
Dote et al. [116]	51	32	ccCSM	phenomenological
Revai et al. [117]	32/ 47-54	50-65	Faddeev	chiral/phenomenological

Laura Tolos and Laura Fabbietti, arXiv:2002.09223v1 (2020)



Theoretical prediction of B.E. and Γ

depend on the $\bar{K}N$ interaction and theoretical framework.

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Experimental results of K^-pp search

Positive

FINUDA@DAΦNE
PRL 94 (2005) 212303

DISTO@SATURNE
PRL104(2010) 132502

E27@J-PARC
PTEP(2015) 021D01

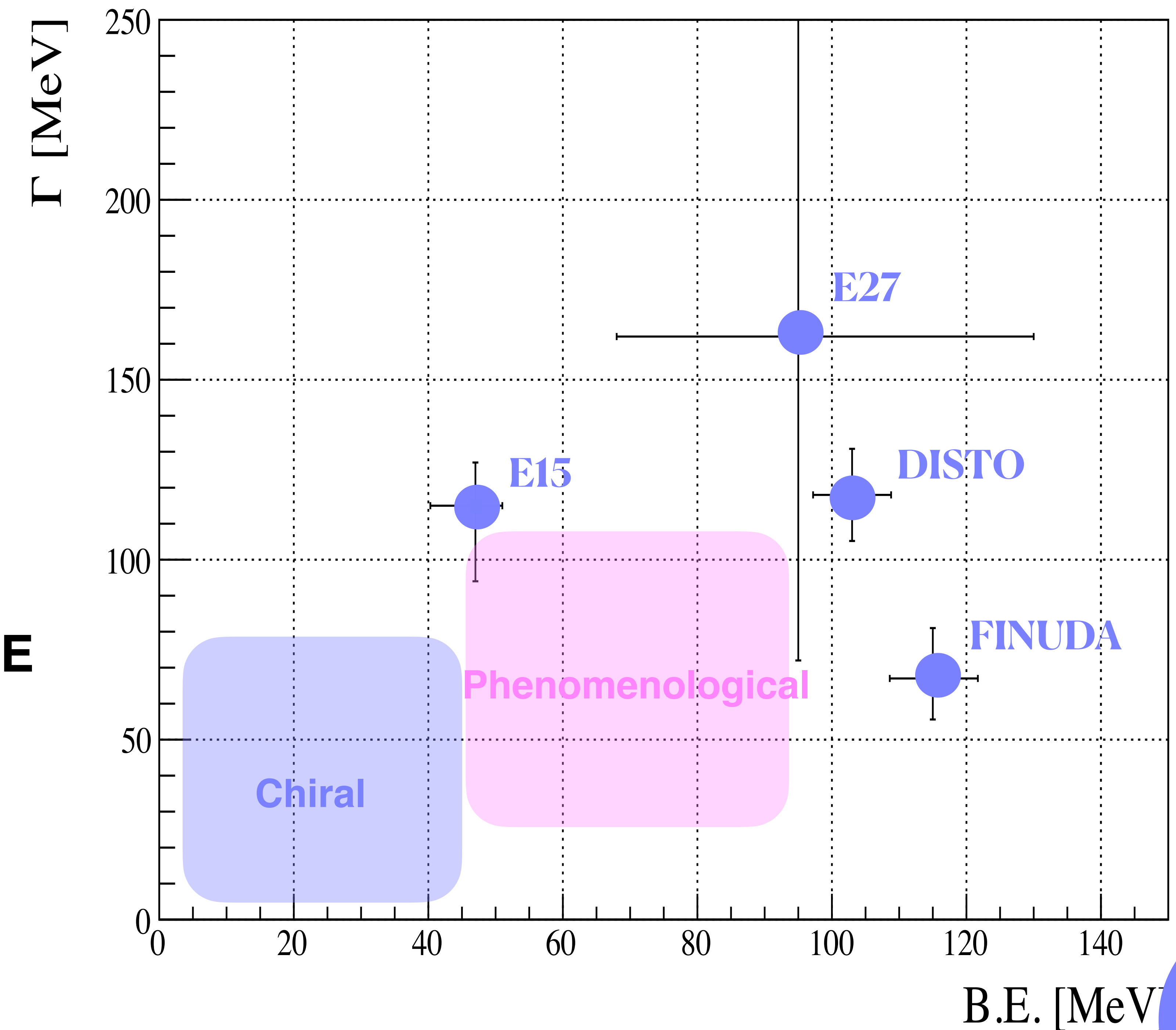
E15@J-PARC
PLB789 (2019) 620

Negative

AMADEUS@DAΦNE
arXiv:1809.07212

LEPS@SPring-8
PLB 728 (2014) 616

HADES@GSI
PLB742(2015) 242



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Study of K^-pp with various beams

J-PARC E15	J-PARC E27	LEPS
$^3He(K^-, \Lambda p)n$	$d(\pi^+, K^+)Yp$	$d(\gamma, K^+\pi^-)X$
$P_K = 1.0$ GeV/c	$P_\pi = 1.69$ GeV/c	$P_\gamma = 1.5 - 2.4$ GeV/c

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Study of K^-pp with various beams

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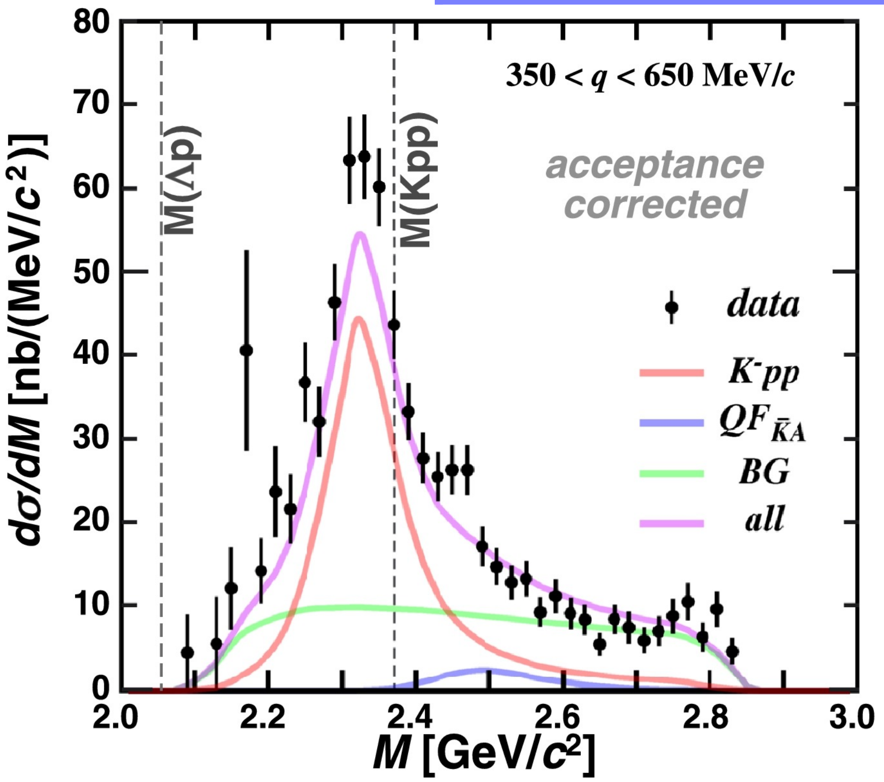
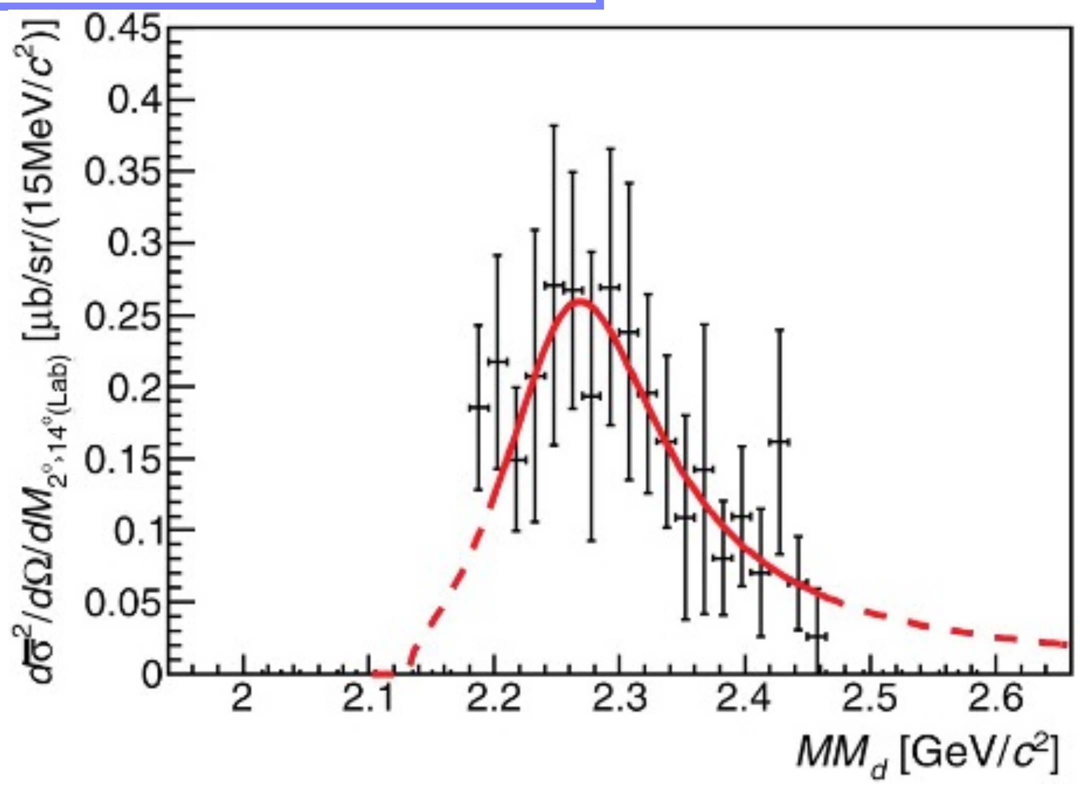


PLB789 (2019) 620



PTEP(2015) 021D01

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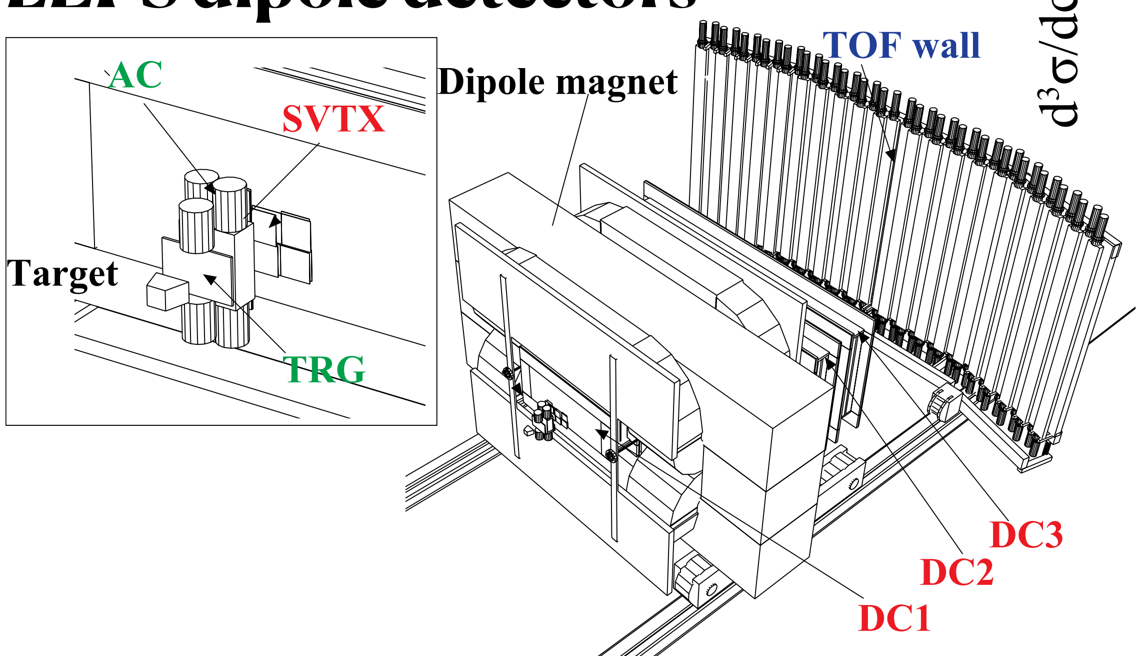
Study of K^-pp with various beams

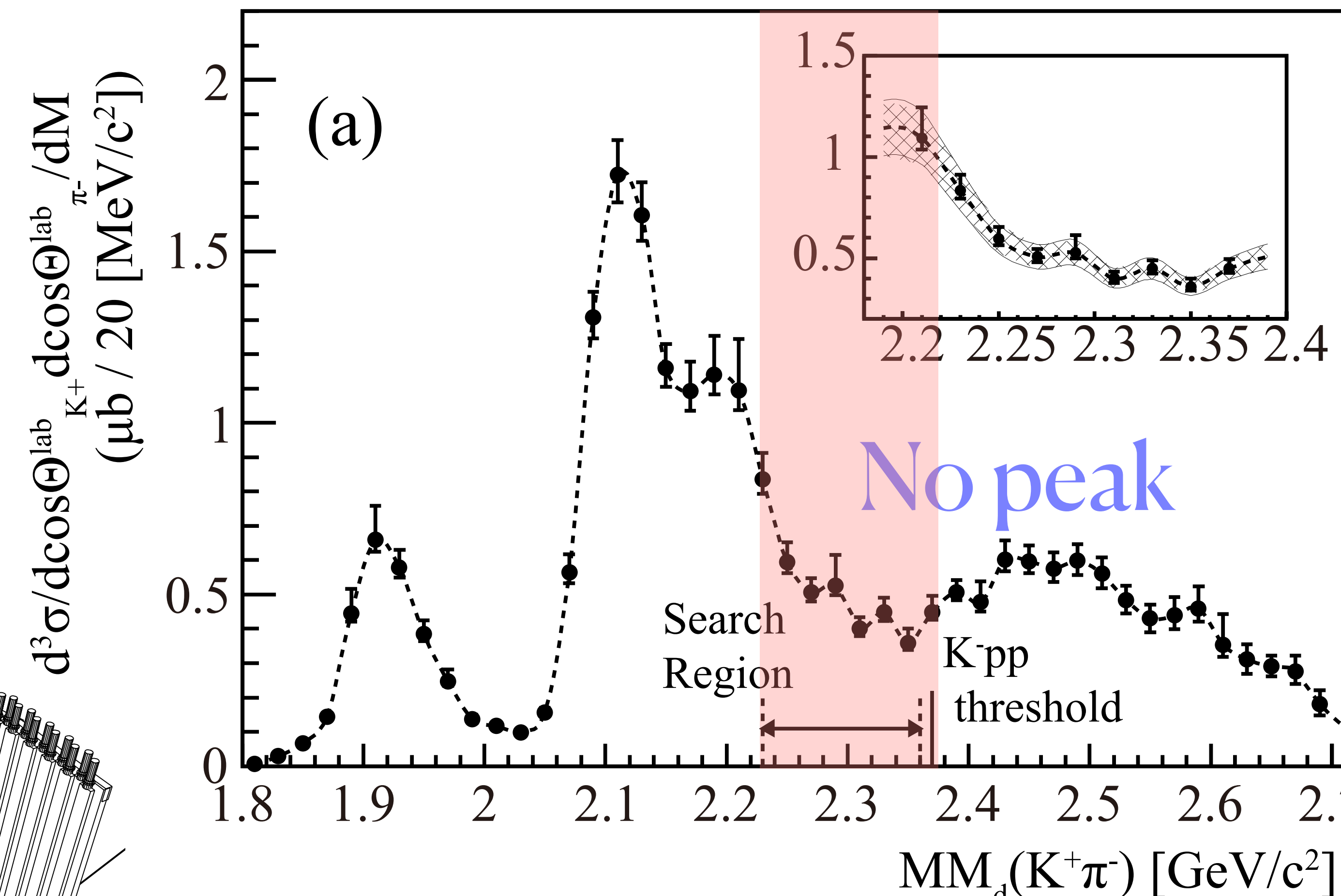
LEPS

$\mathbf{d(\gamma, K^+\pi^-)X}$
$P_\gamma = 1.5 - 2.4$ **GeV/c**

LEPS dipole detectors



Covered forward region



PLB 728 (2014) 616

The upper limit as 1 μb.

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Study of $\mathrm{K^-pp}$ with various beams

LEPS

$\mathbf{d(\gamma, K^+\pi^-)X}$

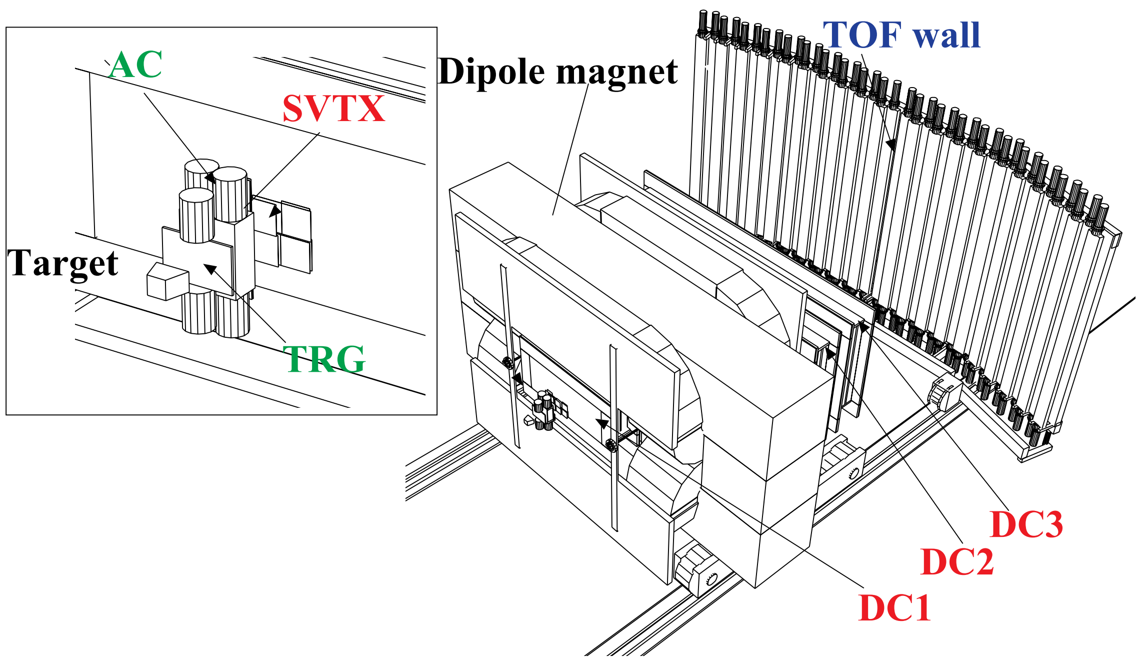
$P_\gamma = 1.5 - 2.4\ \mathbf{GeV}/c$

LEPS2

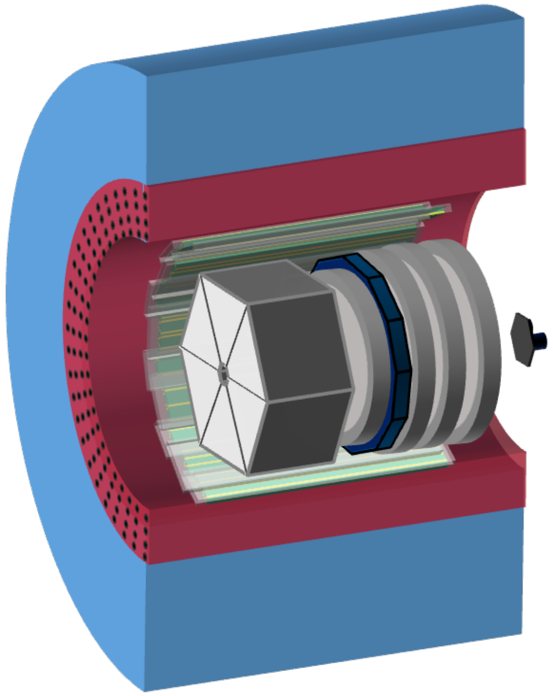
$\mathbf{d(\gamma, \Lambda p)K^0}$

$P_\gamma = 1.3 - 2.4\ \mathbf{GeV}/c$

LEPS dipole detectors



Exclusive measurement



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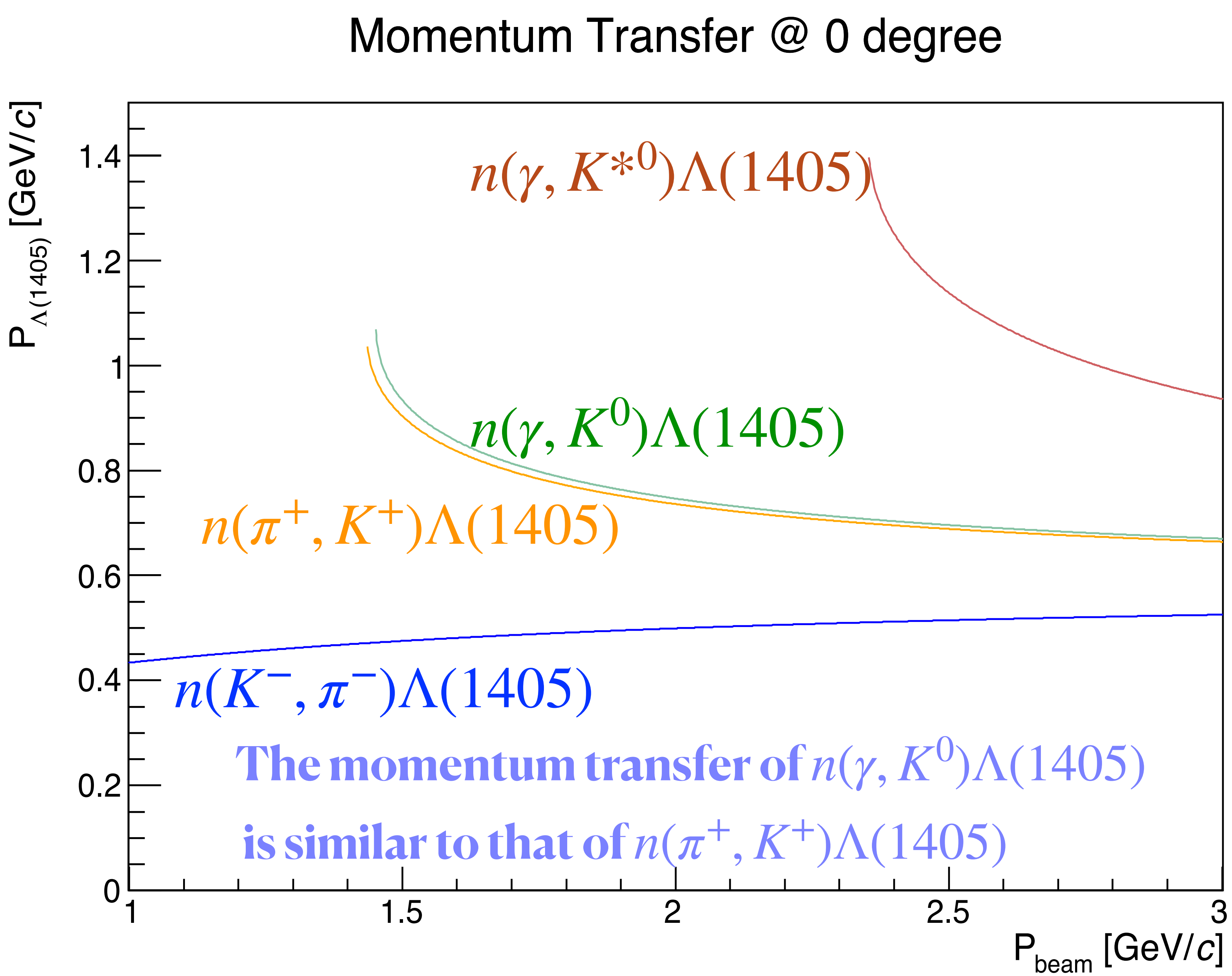
Study of K^-pp with various beams



LEPS2

$d(\gamma, \Lambda p)K^0$
$P_\gamma = 1.3 - 2.4$ **GeV/c**

Detected Λ and proton

J-PARC E27

$d(\pi^+, K^+)Yp$
$P_\pi = 1.69$ **GeV/c**

Tagged 2 protons

Compared directly with E27 results

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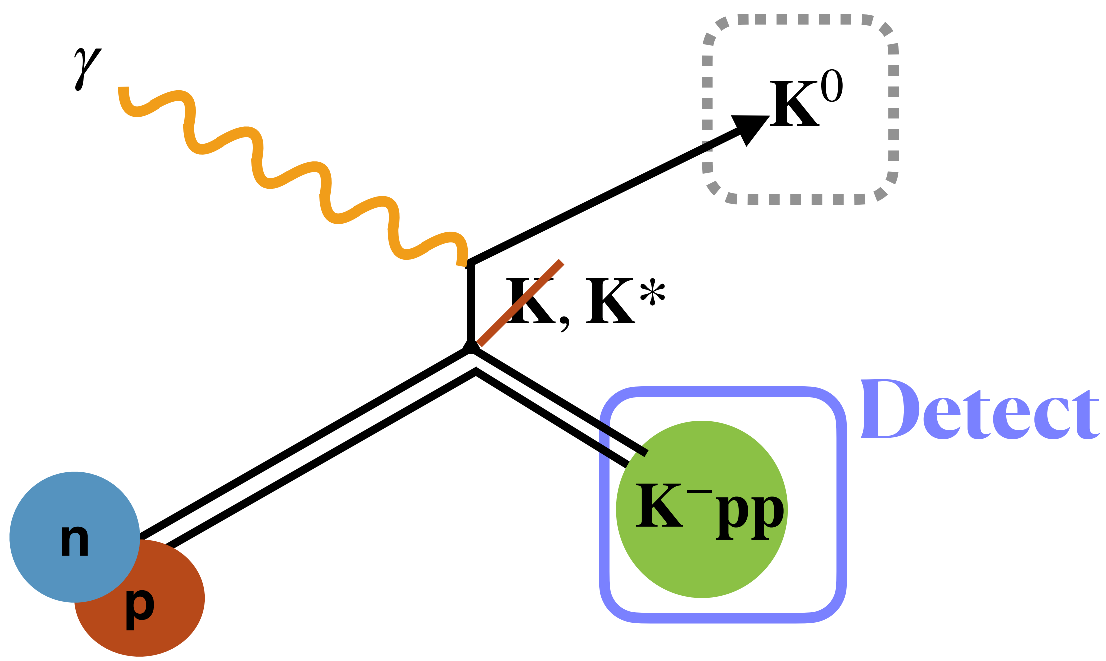
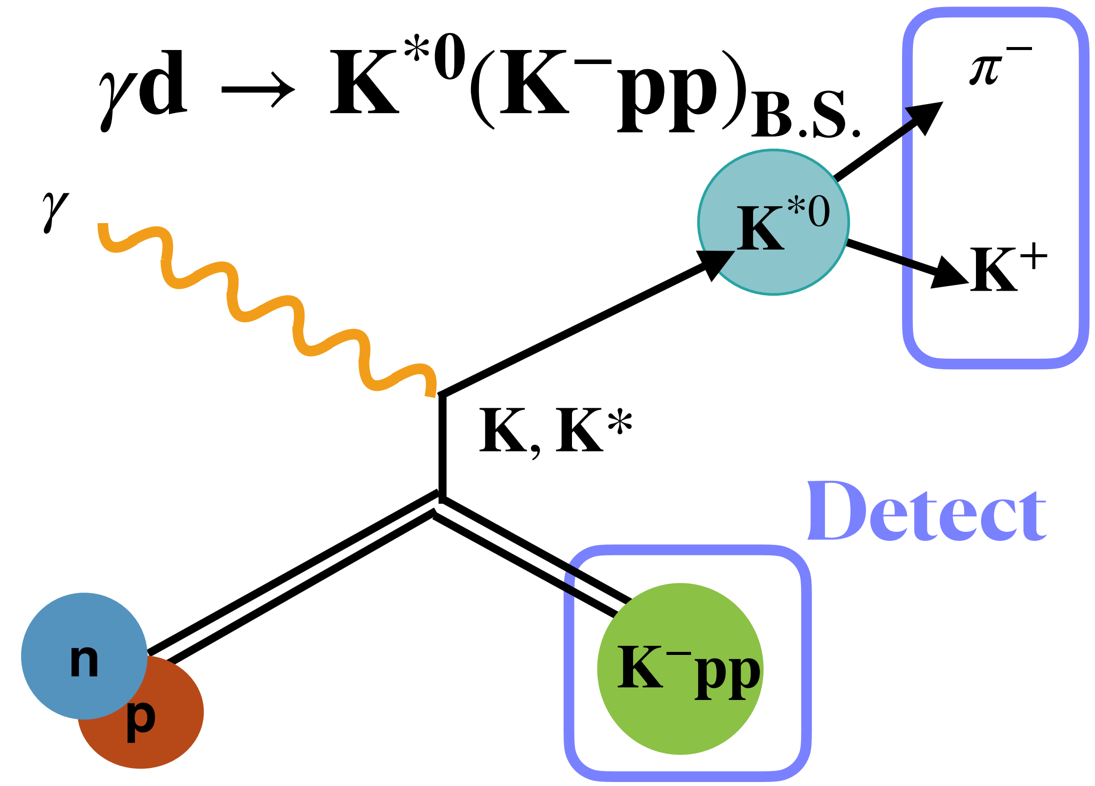
Search for K^-pp with LEPS2 spectrometer

The LEPS2 spectrometer has large acceptance.

$$\gamma d \rightarrow K^0 (K^- pp)_{B.S.}$$



$$\gamma d \rightarrow K^{*0} (K^- pp)_{B.S.}$$



- The simplest reaction.
- K^0_s(measurable) / K^0 ~ 50%

- Parity filter

$P\gamma \perp K\pi$: Unnatural parity exchange (**K**)

$P\gamma \parallel K\pi$: Natural parity exchange (**K***)

- High momentum transfer

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Search for K^-pp with LEPS2 spectrometer

Decay modes of K^-pp state

First step of LEPS2

- non-mesonic decay mode : Λp, $\Sigma^0 p$, $\Sigma^+ n$
- mesonic decay mode : $\Lambda\pi N$, $\Sigma\pi N$

Measurement of the Ratio of branching fractions

	E27	E15
$\Gamma(\Lambda p)/\Gamma(\Sigma^0 p)$	$0.92^{+0.16}_{-0.14}(stat.)^{+0.60}_{-0.42}(syst.)$	≈ 1.7

Y. Ichikawa et al, PTEP(2015) 021D01 T. Yamaga et al, Phys. Rev. C **102**, 044002

$\Gamma(\Lambda p)/\Gamma(\Sigma^0 p) \simeq 1.2$ **owing to the** $\Lambda(1405)$ **dominance doorway process**

T Sekihara et al, Phys. Rev. C **79**, 062201, Phys. Rev. C **86**, 065205

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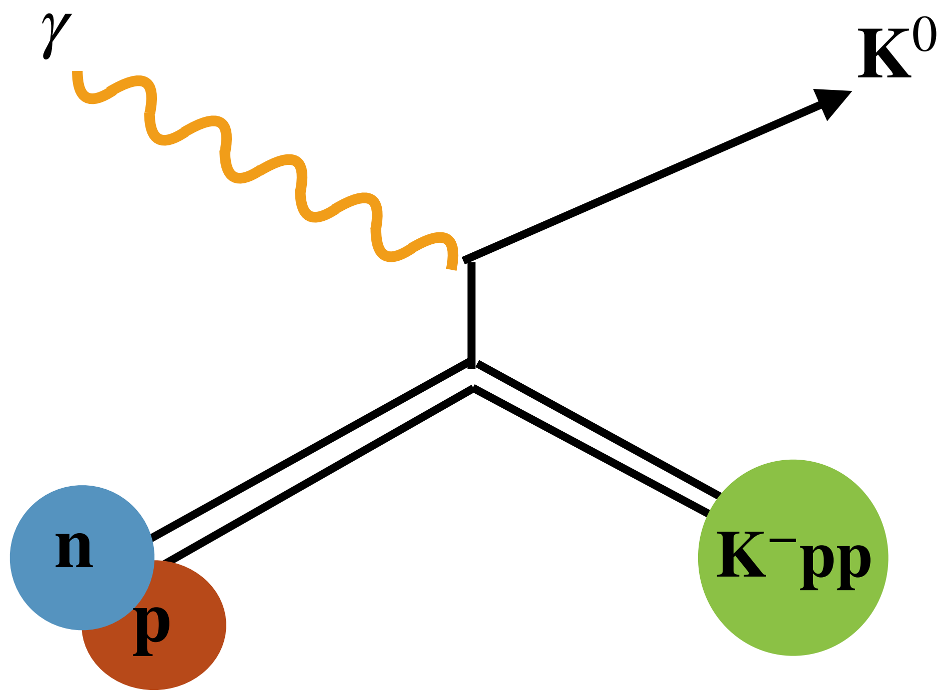
Search for K^-pn

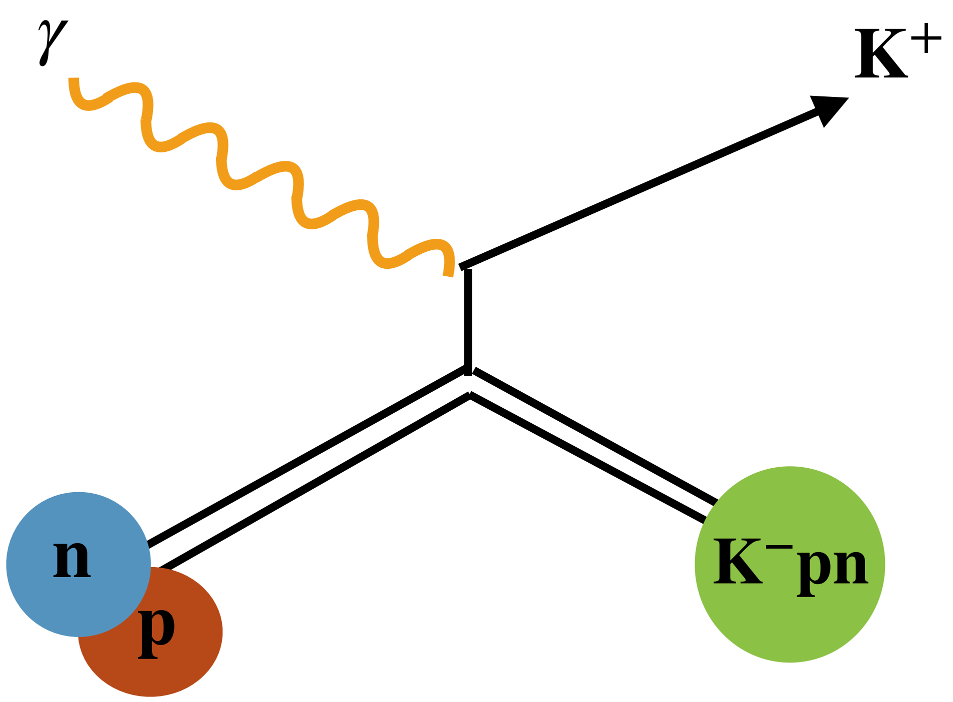
$$[\bar{K}N]_{I=0}N(I = 1/2)$$

Isospin partner

$[K^-p]p$ ⟺ $[K^-p]n$

Can be observed with same experimental setup





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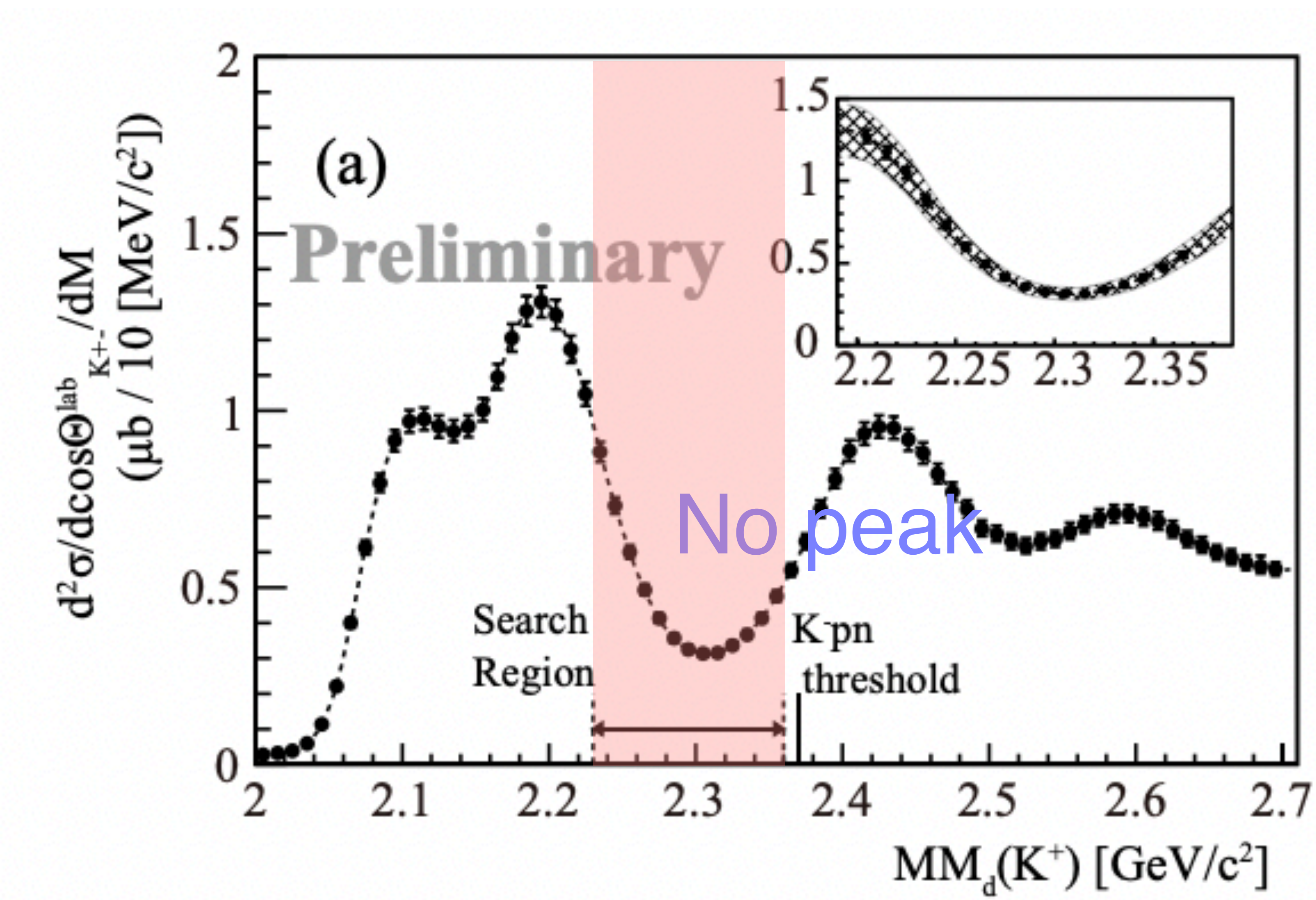
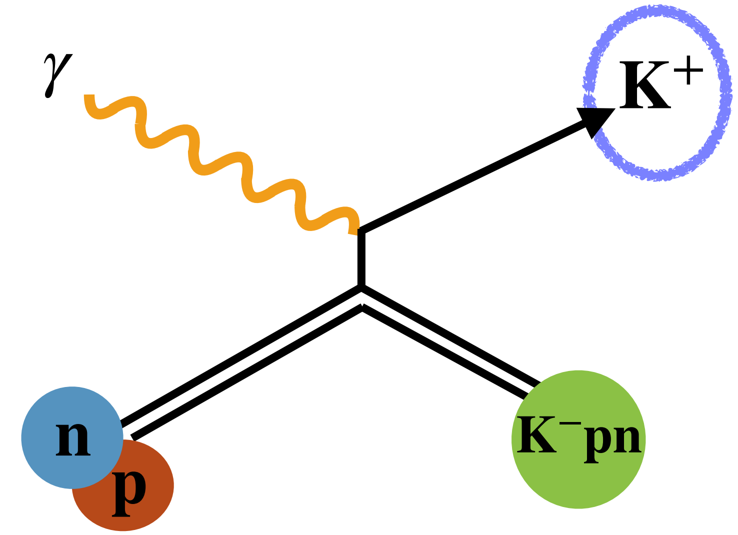
Search for K^-pn with LEPS

Previous Study @ LEPS





The upper limit as $0.1\ \mu\mathbf{b}$.

PoS Hadron2013 (2013) 180

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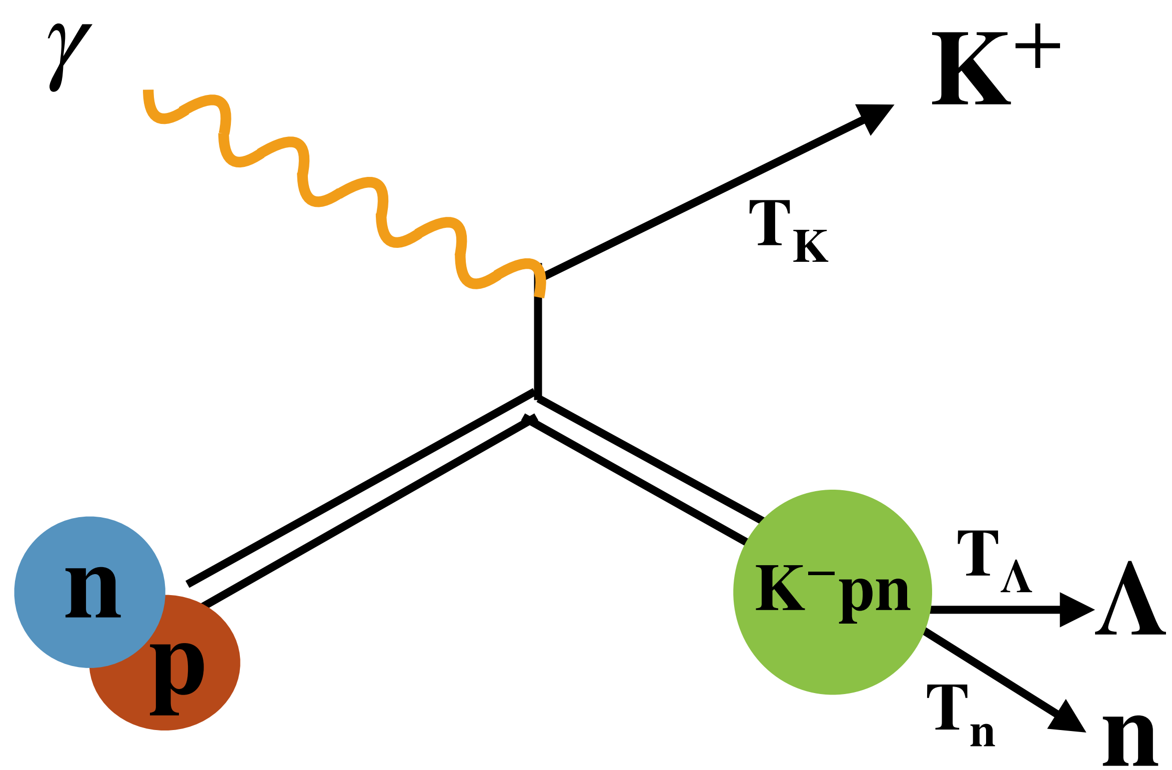
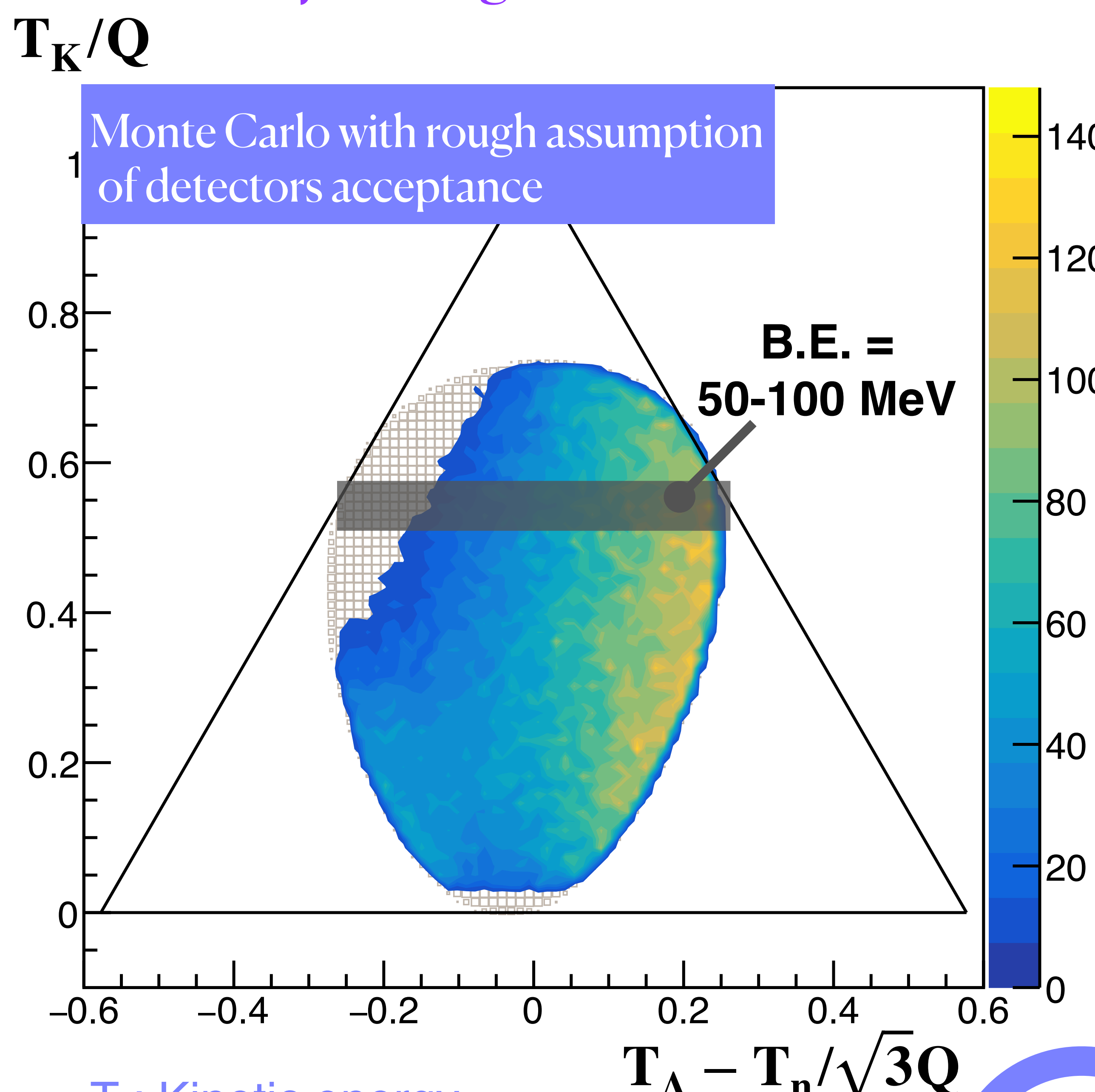
Search for K^-pn with LEPS2

Reconstructed by missing mass

$$\gamma d \rightarrow K^+(K^-pn)_{B.S.} \rightarrow K^+\Lambda\, n$$

detect





T : Kinetic energy
Q : Q-value of the reaction

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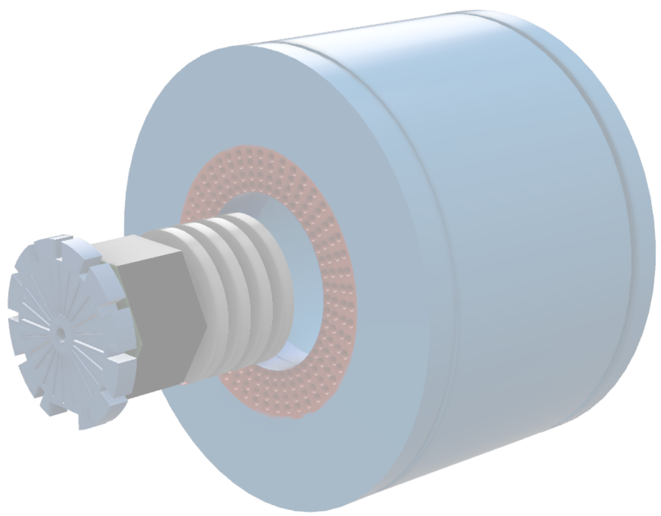

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What's LEPS2 Experiment ?

SPring-8

@Hyogo, JAPAN

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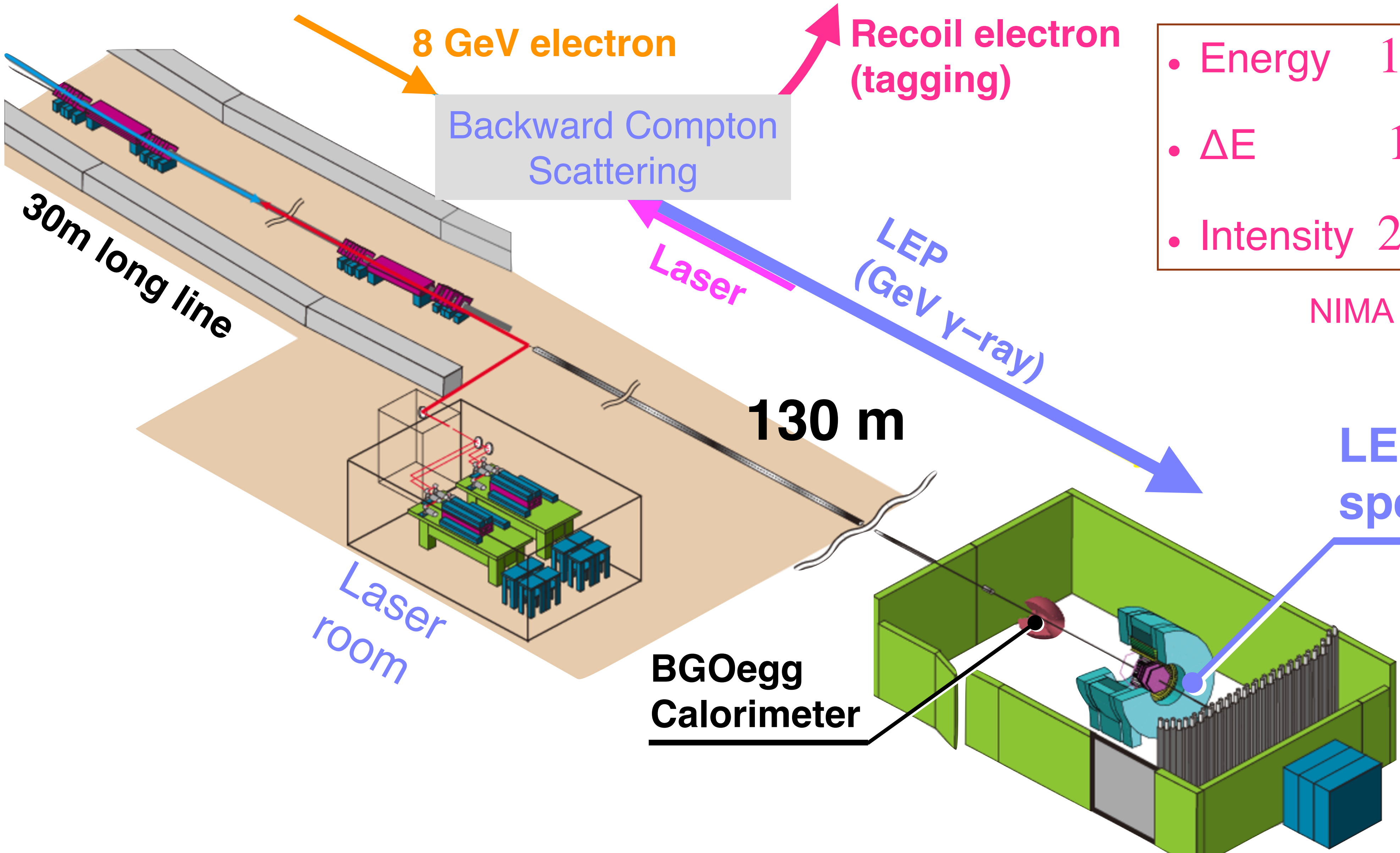
What's LEPS2 Experiment ?

2nd Laser Electron Photon beam line at SPring-8

Photon beam produced via the laser-induced Compton scattering



- Energy $1.3 - 2.4$ **GeV**
- ΔE 12 **MeV**
- Intensity 2.3×10^6 **cps**

NIMA 1033(2022) 166677

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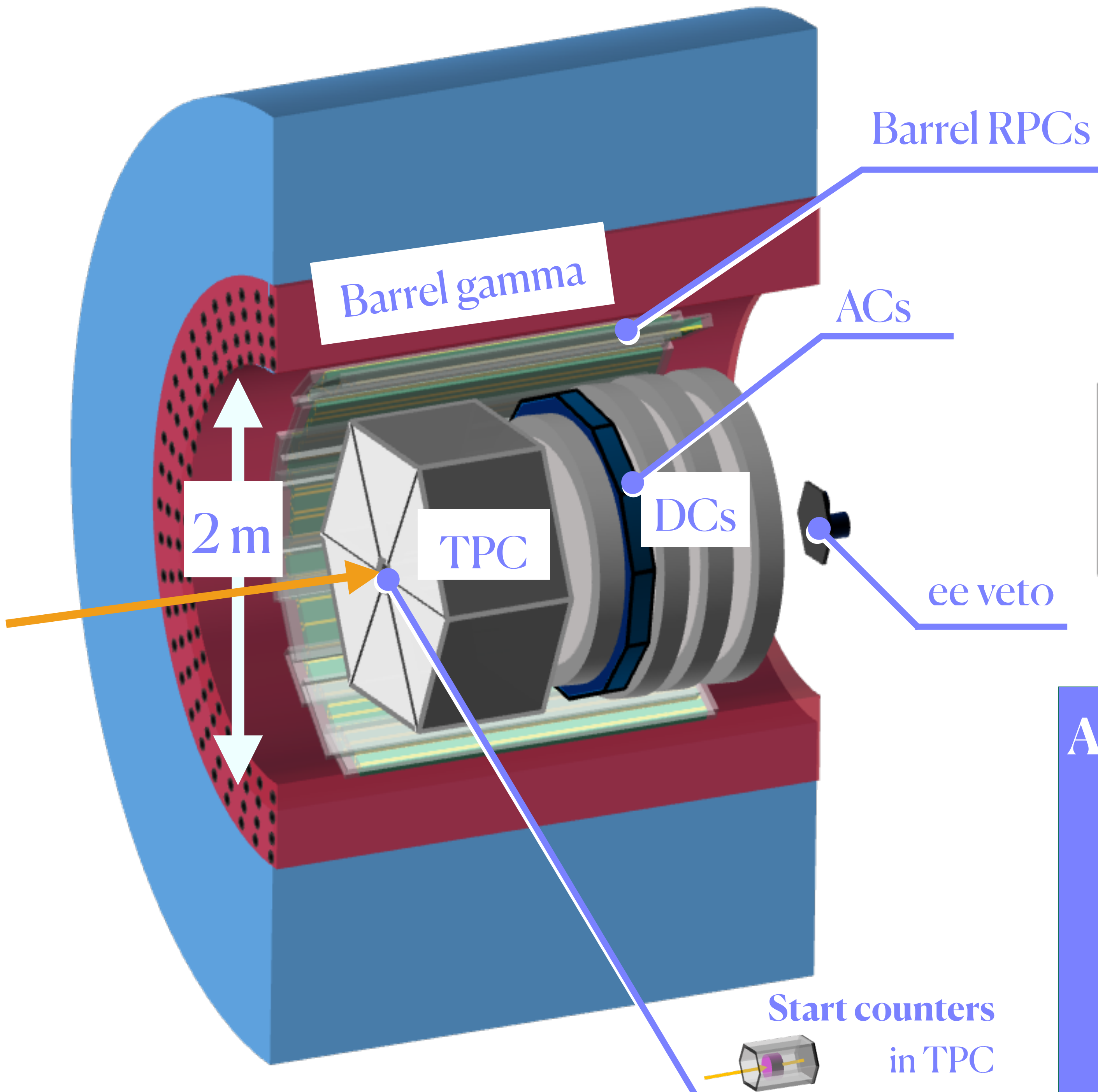
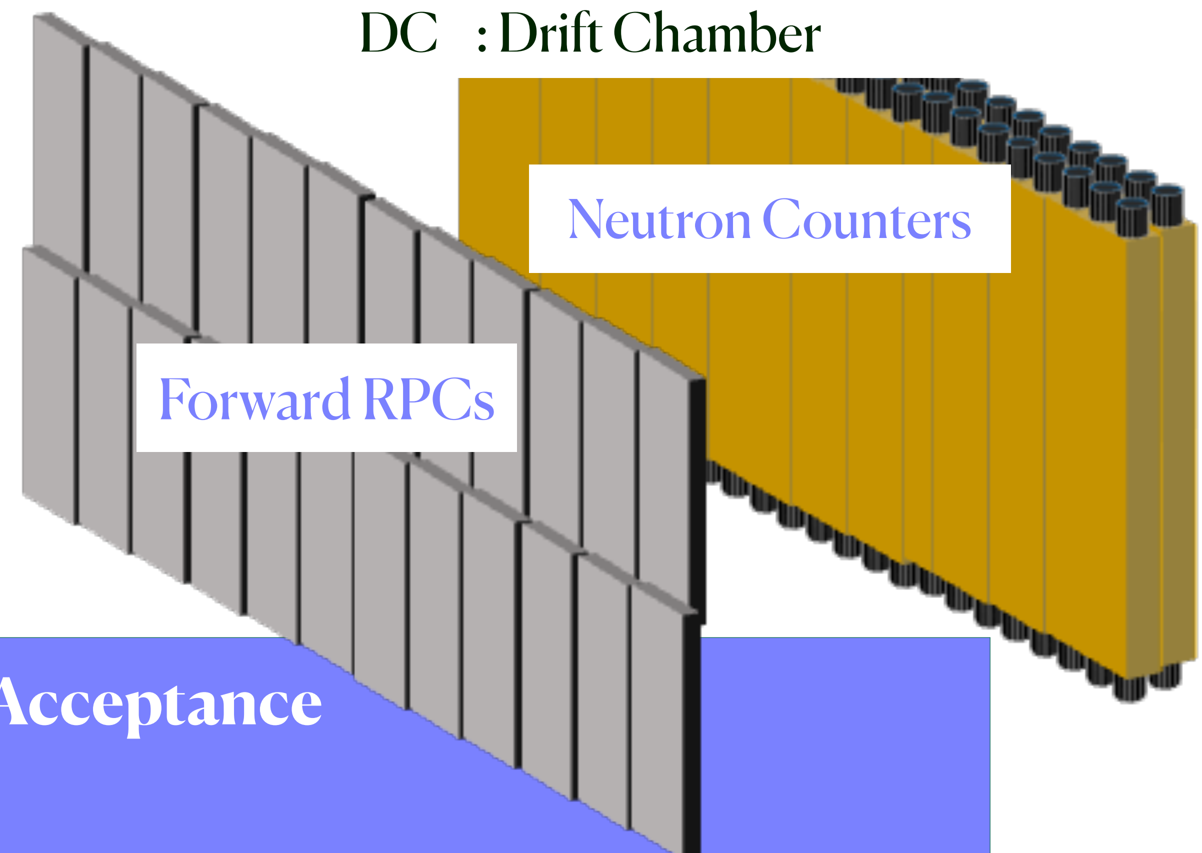
LEPS2 Solenoid Detectors



TPC : Time Projection Chamber
AC : Aerogel Cherenkov counter
RPC : Resistive Plate Chamber
DC : Drift Chamber



Acceptance

7° – 110° (Charged particles)
40° – 110° (γ-rays)
0° – 12° (neutrons)

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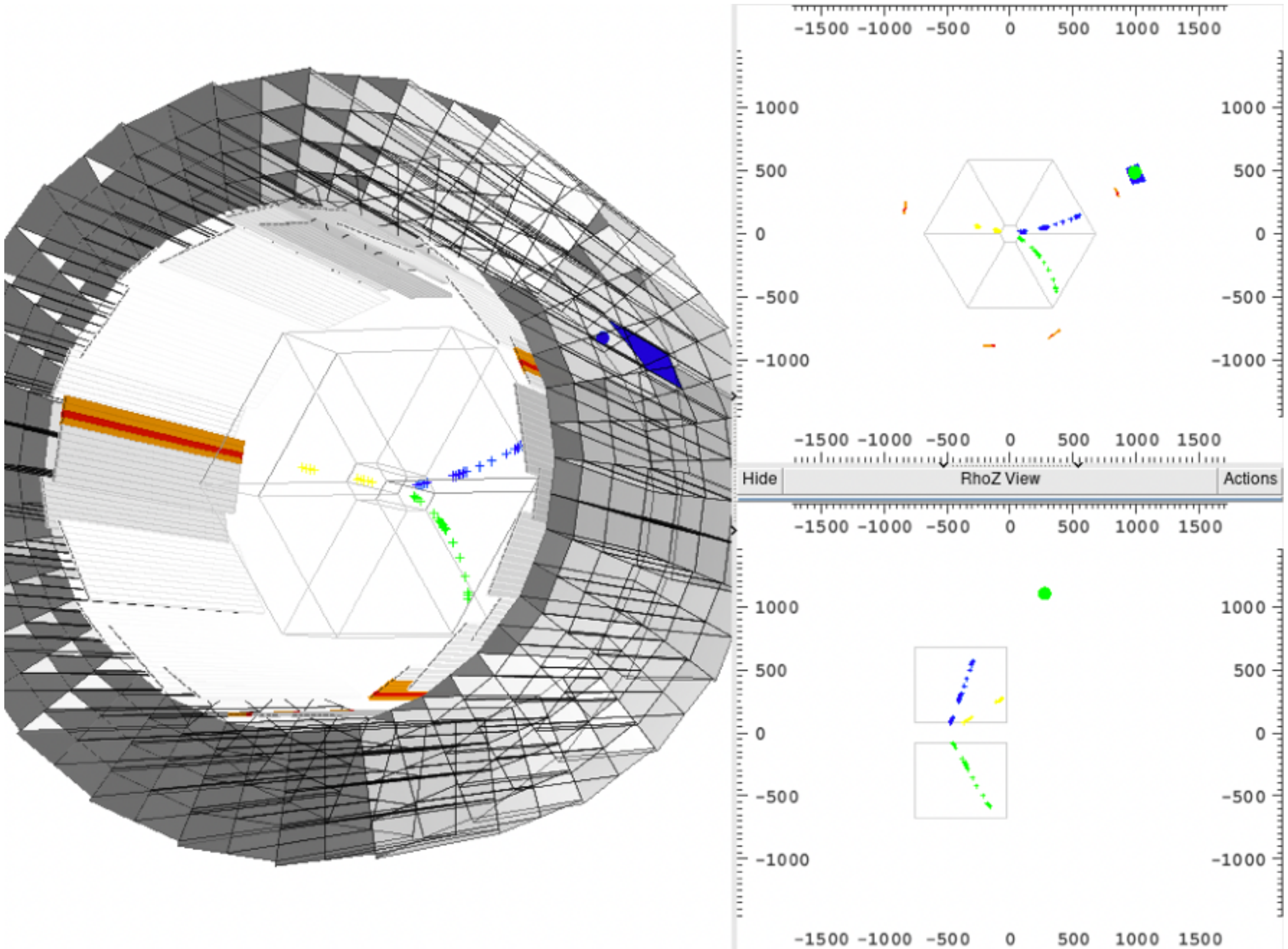
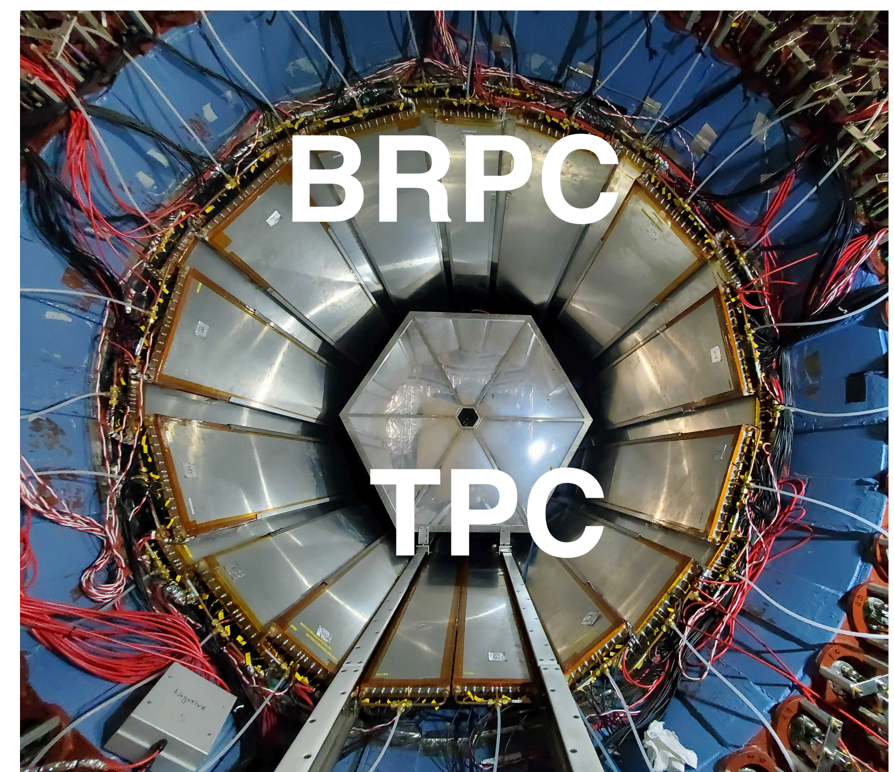
LEPS2 TPC & BRPC



Data taking in 2022 - 2023

LH_2 Data : 1.9 x 10^{12} photons

LD_2 Data : 5.7 x 10^{12} photons



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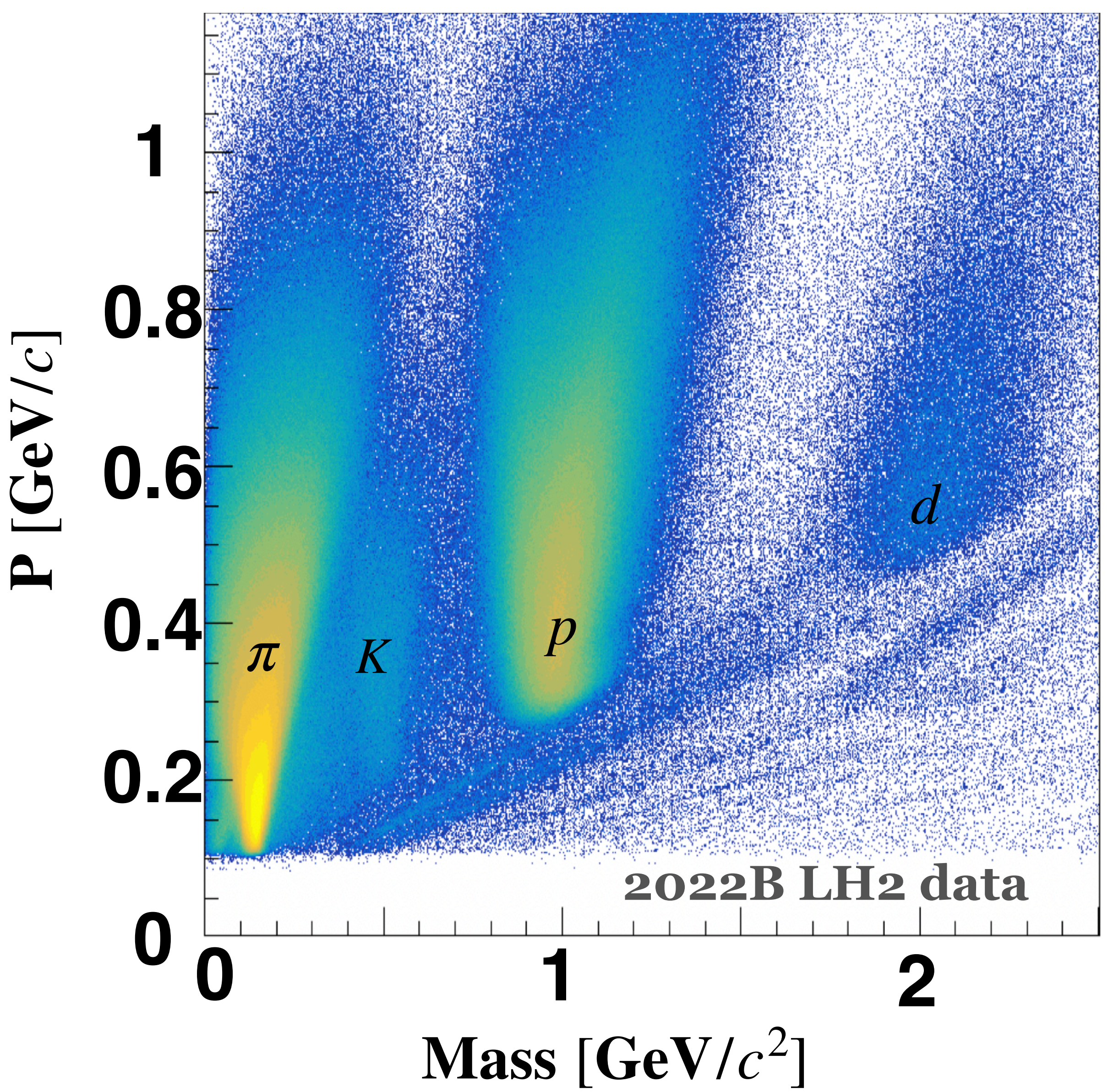
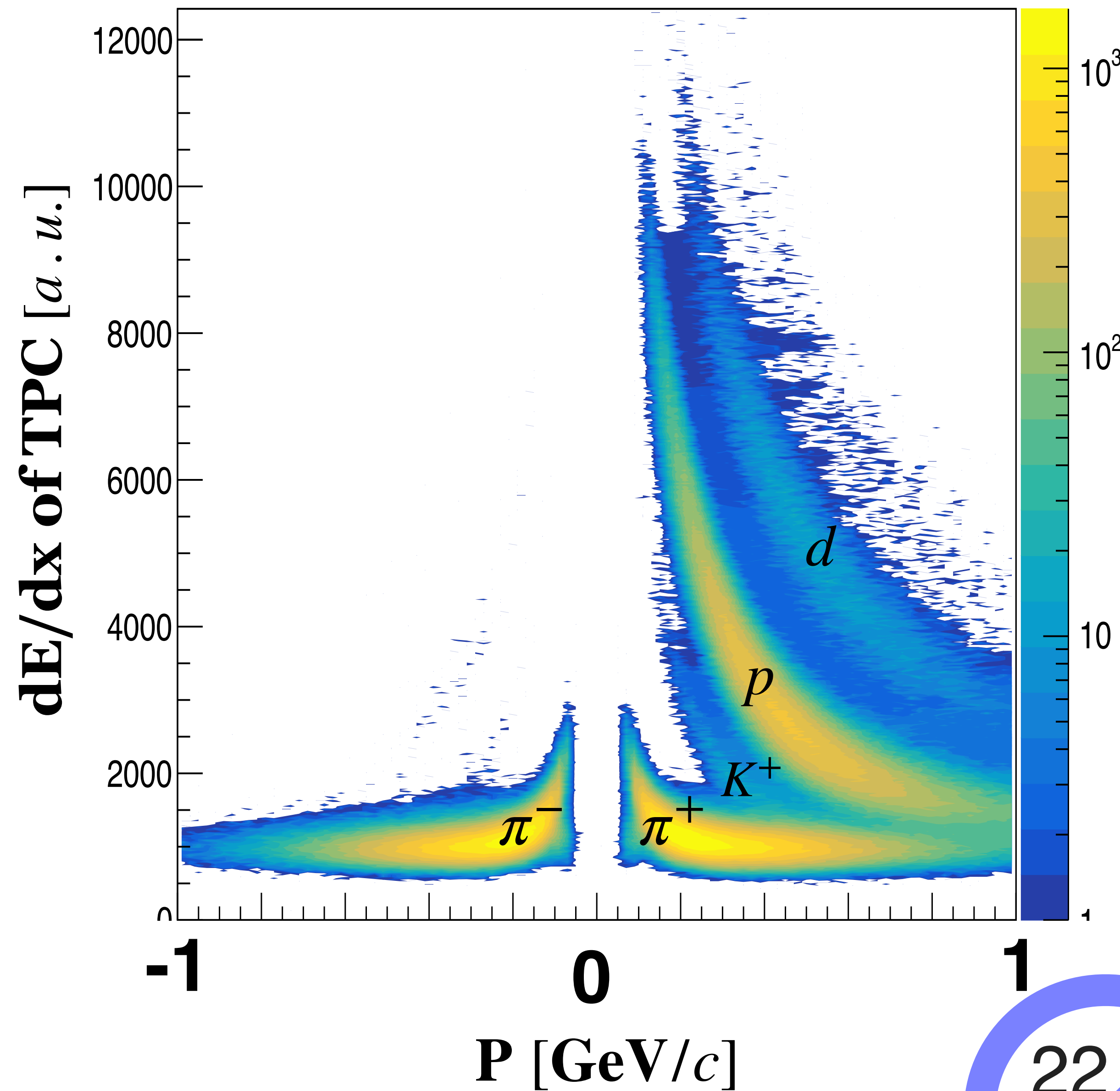
LEPS2 TPC & BRPC

Particle identification





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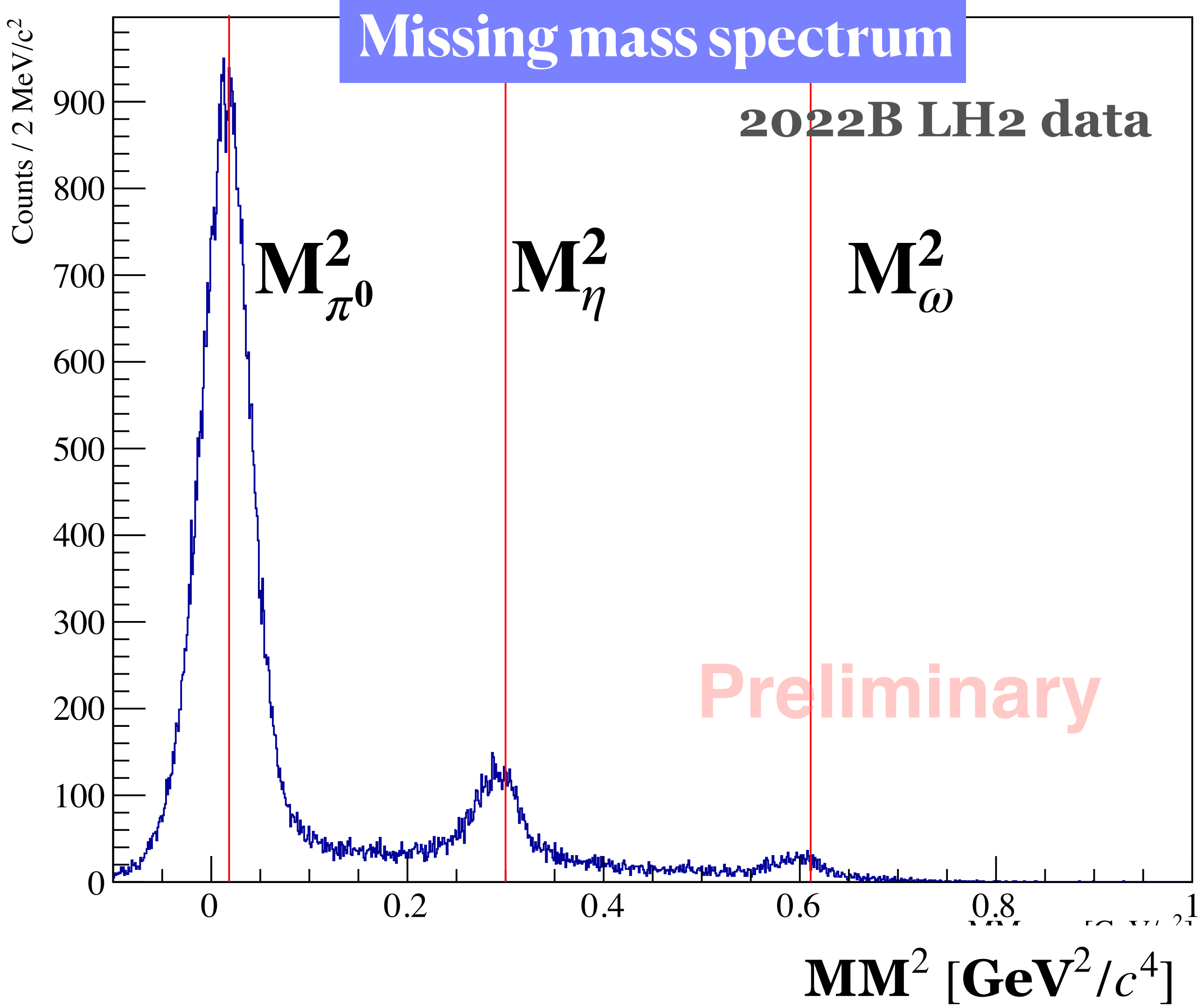
LH_2 Data Analysis

Detected by TPC

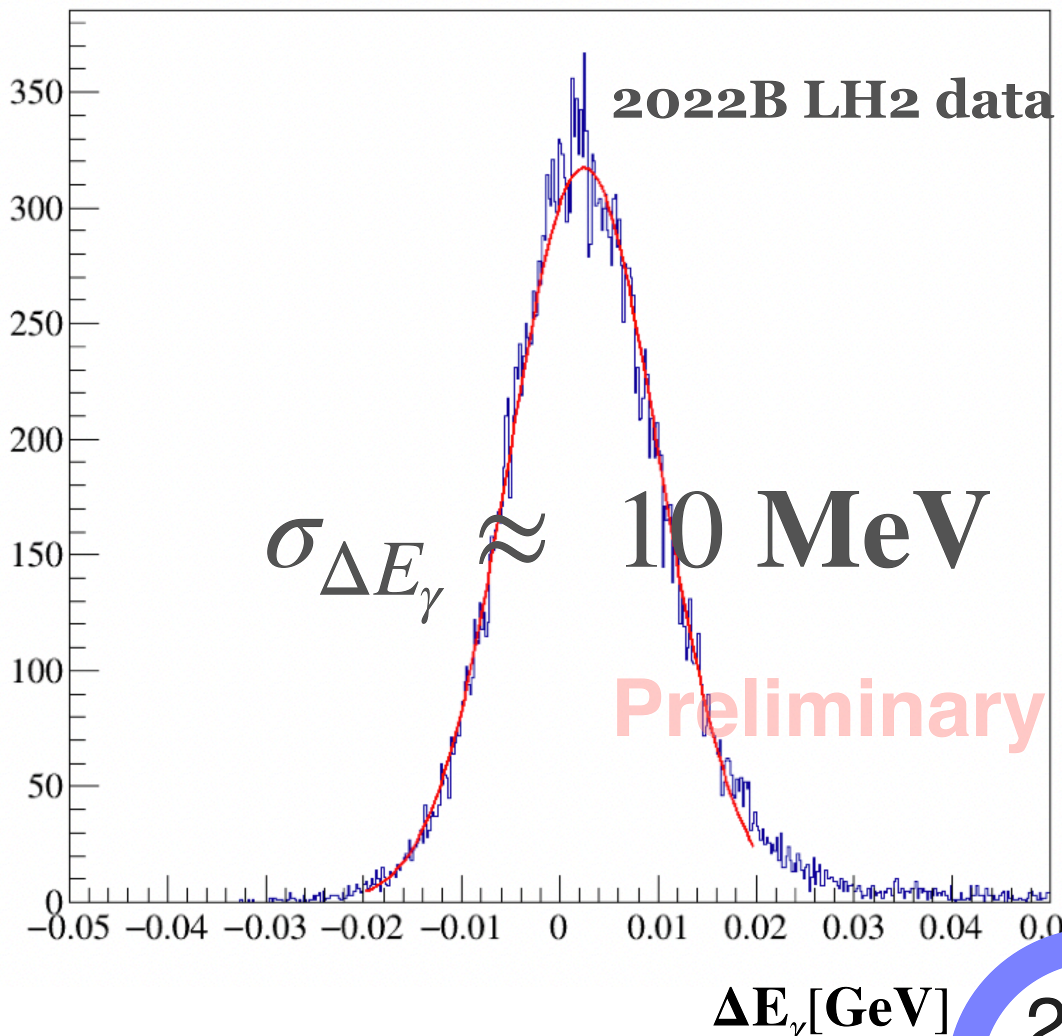
$$\gamma p \rightarrow \boxed{p}\, X$$

Missing mass spectrum



Photon Beam Energy Resolution

$$\Delta E_\gamma = E_{\gamma\ measured} - E_{\gamma\ expected(\pi^0)}$$



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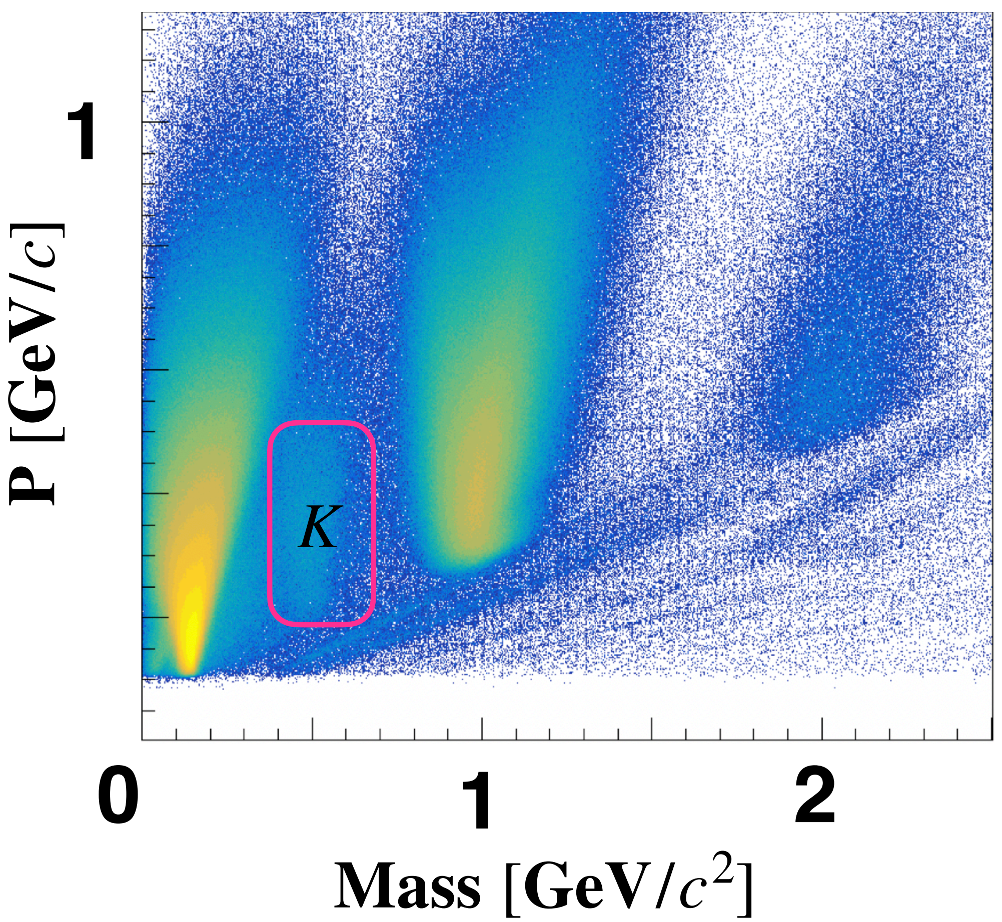
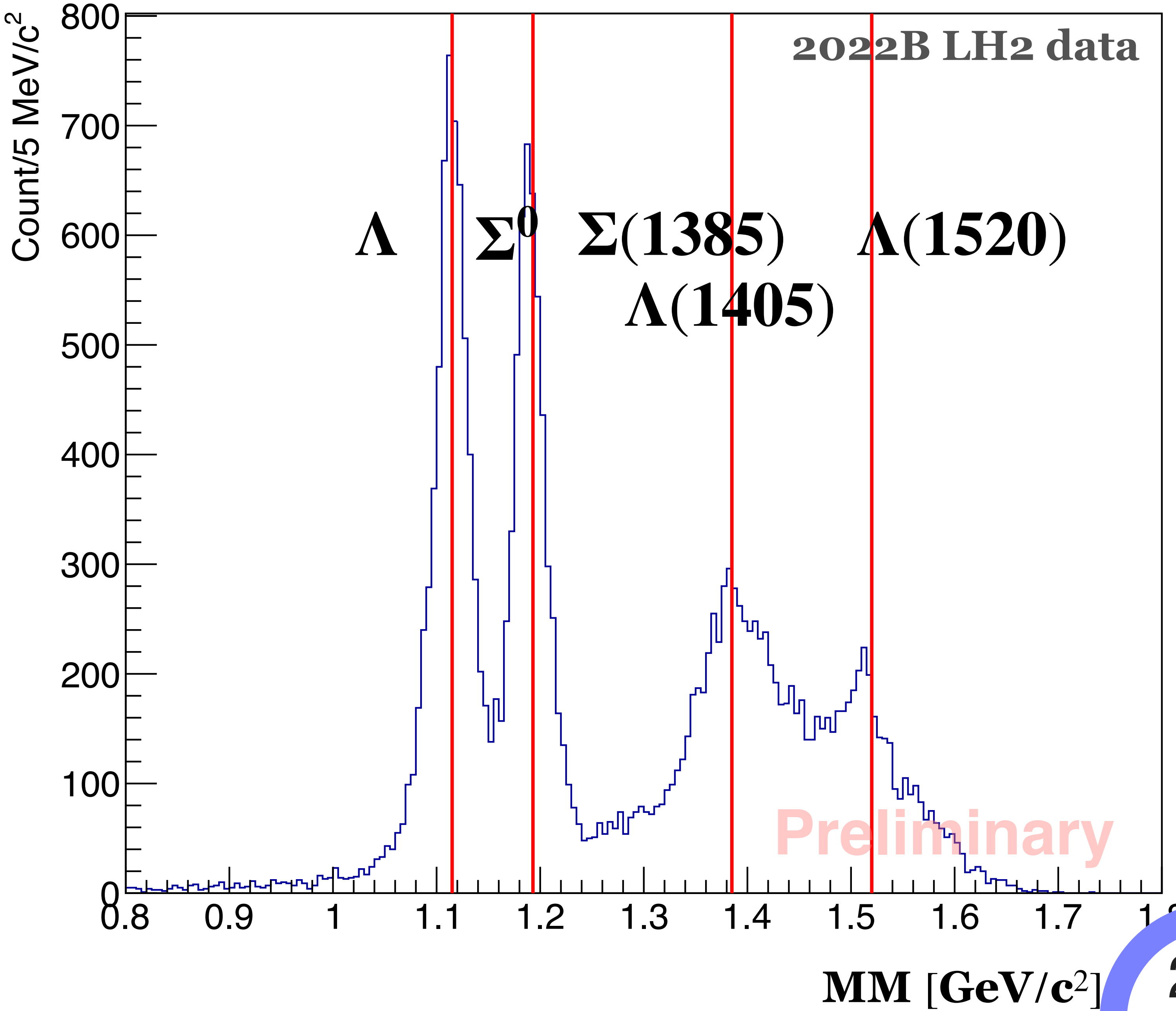
LH_2 Data Analysis

Detected by TPC & BRPC

$$\gamma p \rightarrow \boxed{K^+} \, X$$





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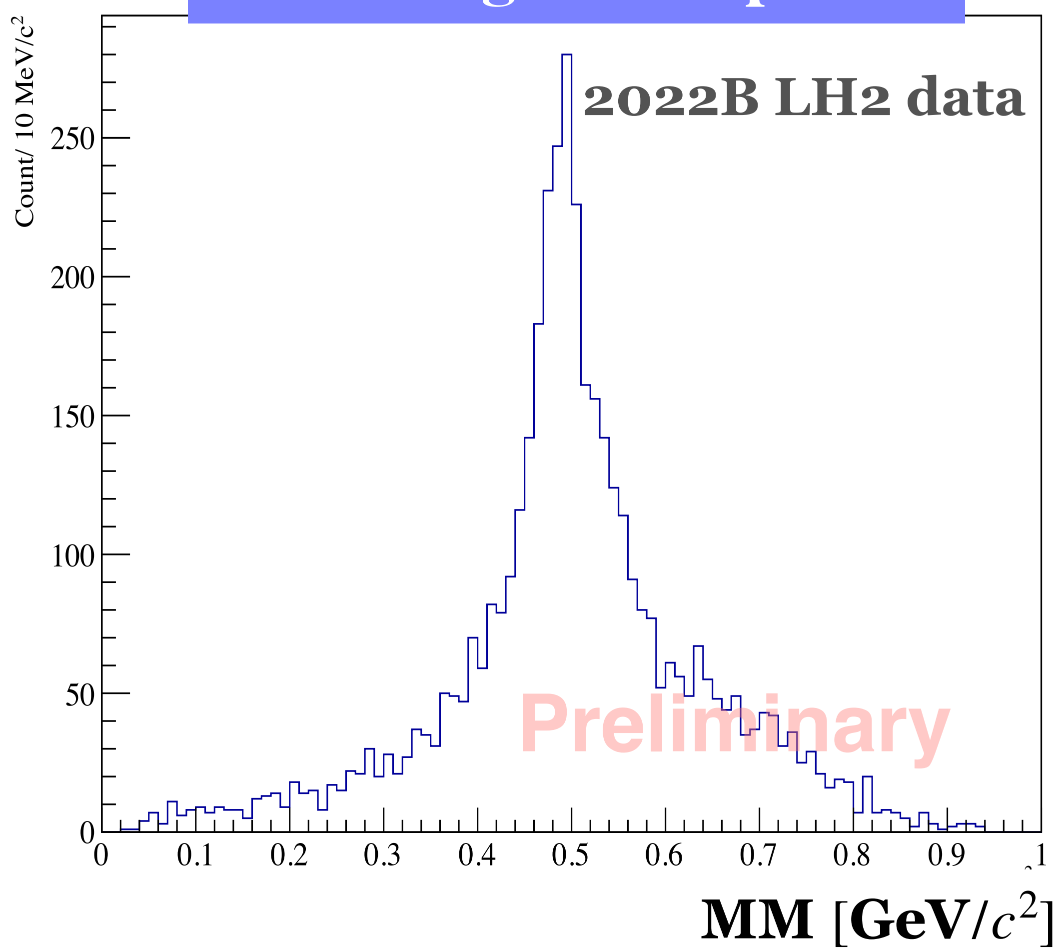
LH_2 Data Analysis

$$\gamma \mathrm{p} \rightarrow \mathrm{K}^{+} \Lambda$$

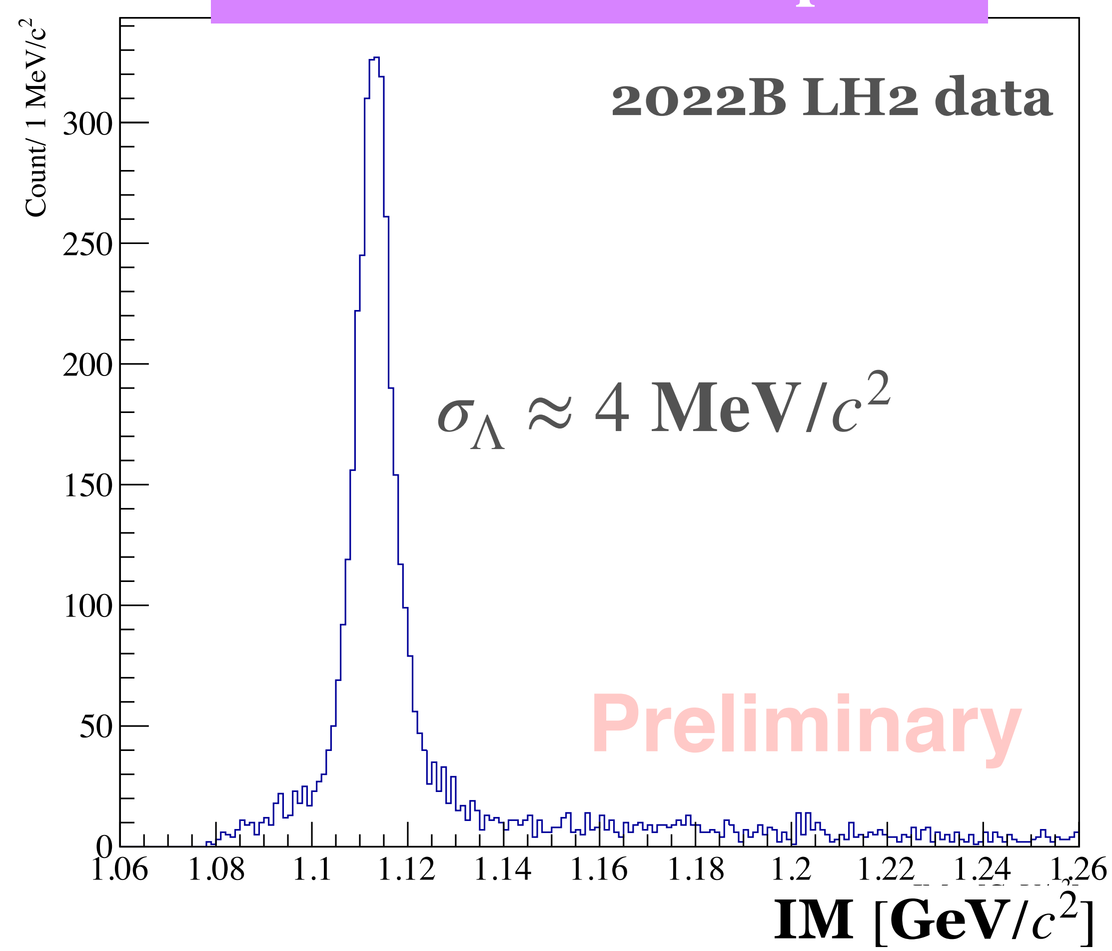
I. Select the events that has two tracks ($\mathbf{p}$, π^-)

II. Apply some cuts

Missing mass of pπ^-



Invariant mass of pπ^-



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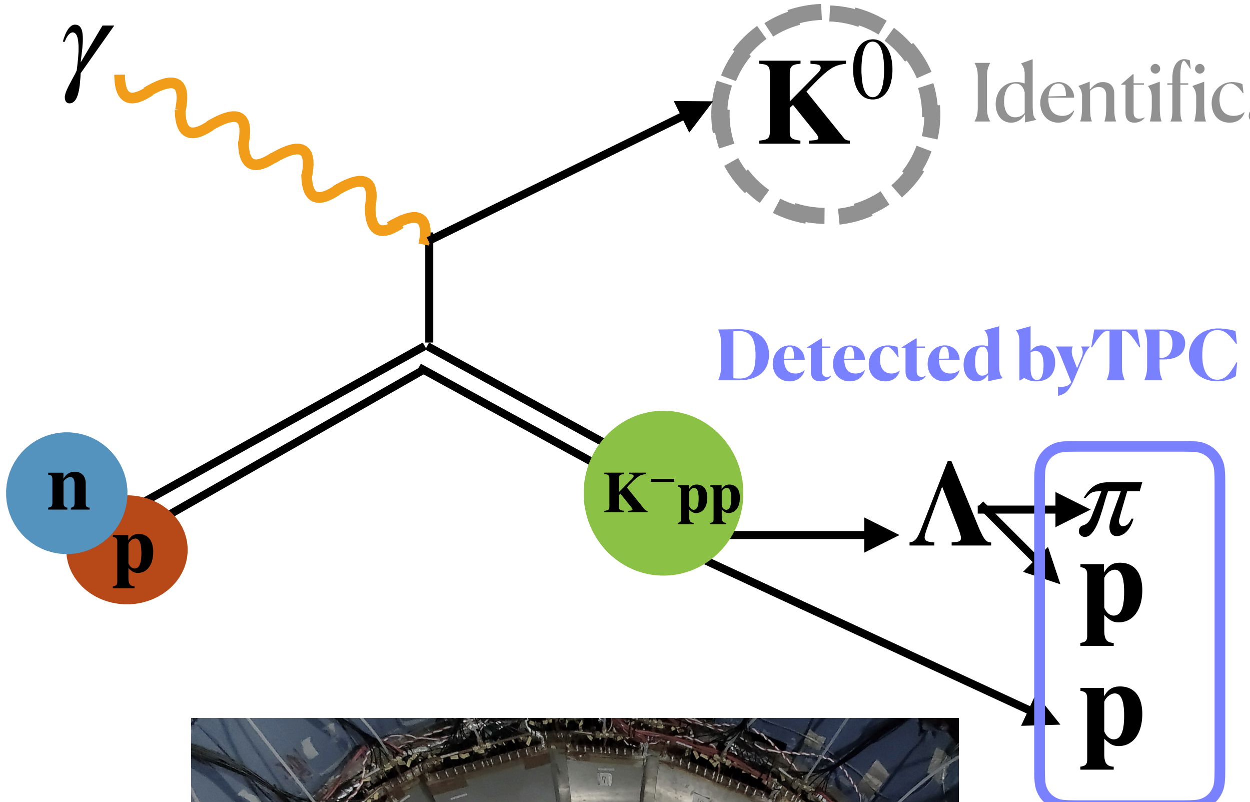
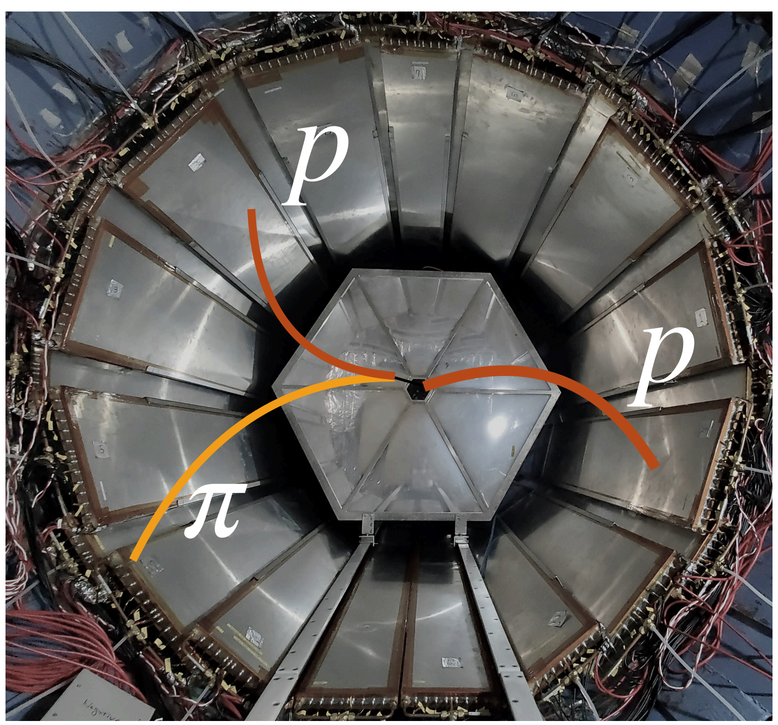
Estimation of the K^-pp yield



Identification by missing mass



$Y(\mathbf{K^-pp \to \Lambda p\ mode})$

$=$ **#photons** $(8.6 \times 10^{12}$: **1 M Hz, 100 days**)

$\times$ **#deuterons** $(6.7 \times 10^{23}$: **14 cm LD2**)

$\times\ \sigma_{\mathbf{Kpp \to \Lambda p}}$: $(7.5 - 75\ \mathbf{nb})$

$\sigma_{\gamma n \to K^0 \Lambda(1405)}$: $(0.1 - 1\ \mu \mathbf{b})$ Ref.E27

$\times$ **the Probability of $\Lambda^* p \to (\mathrm{Kpp}) \to \Lambda p$**(7 . 5%)

100000 **events**/100 **days**(*if* $\sigma = 15$ **nb**)

$\times$ **Acceptance** ($\approx 5\%$)

$\approx$ 5000 **events**/100 **days**

Already collected the 70-day data

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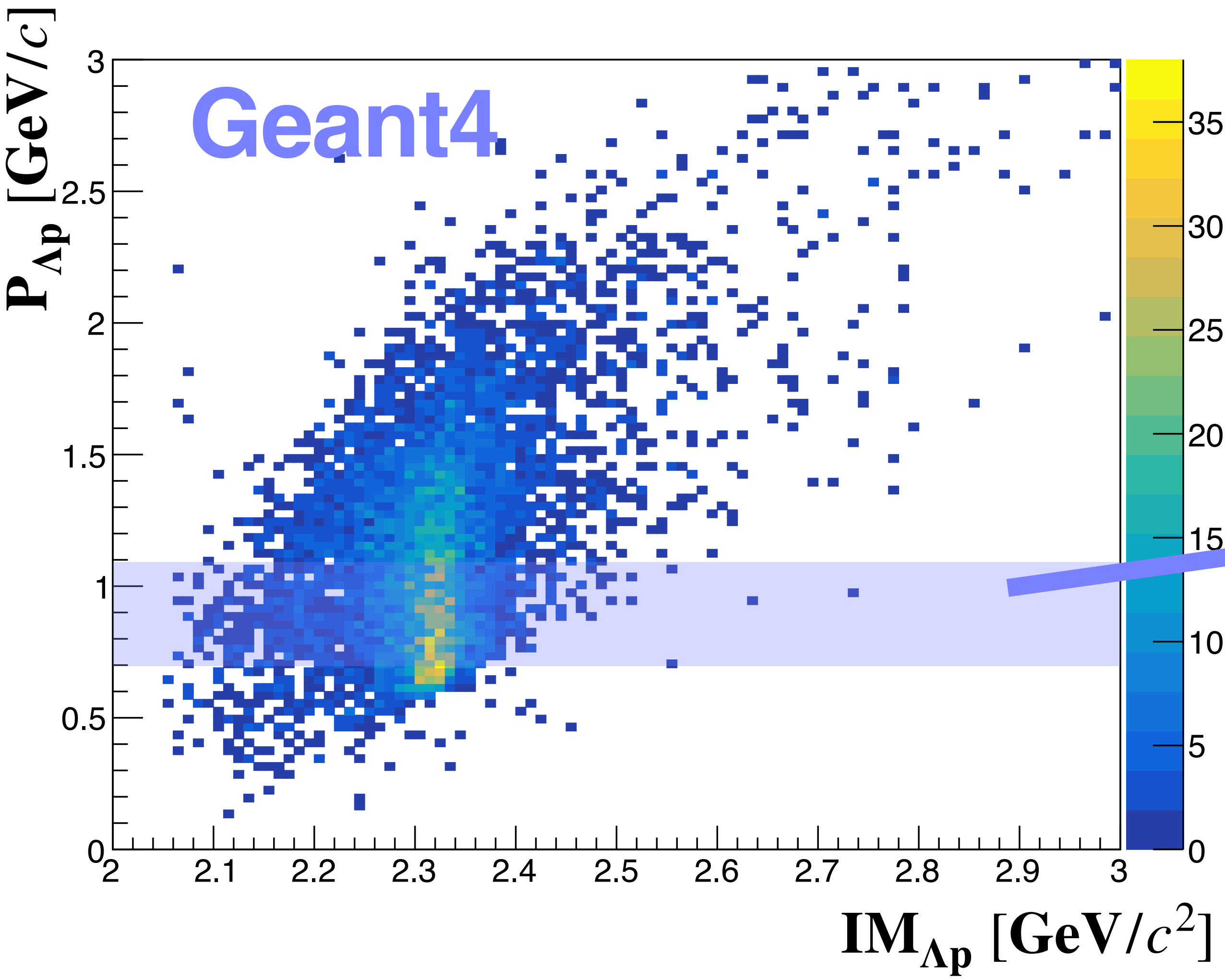
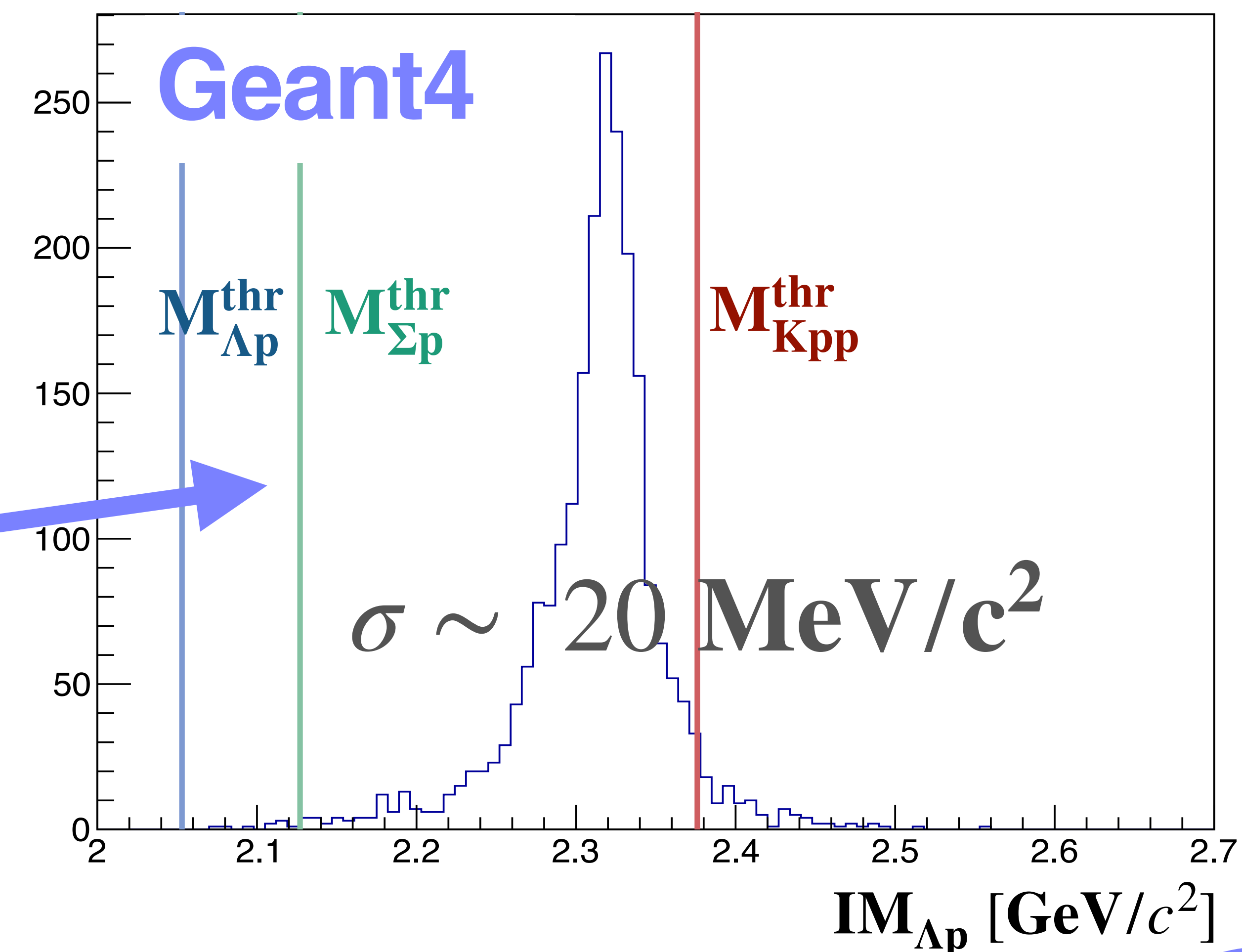
Expected results for K^-pp search

$$\gamma d \rightarrow K^0(\bar{K}NN)_{BS} \rightarrow K^0 \Lambda p$$

Mass : **2 . 324** GeV/c^2
(B.E = **50** MeV)
Width : **0** GeV/c²





We will show the results of real data as soon as possible !

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Summary

- LEPS2 is searching for the $\bar{K}NN$ state in photoproduction.
- Large-acceptance LEPS2 solenoid spectrometer is best suited for the $\bar{K}NN$ search with detection of all decay particles, such as Λp.
- We have already collected the data for the expected K^-pp yield of few thousand events.
- The analysis of the first dataset is now underway.

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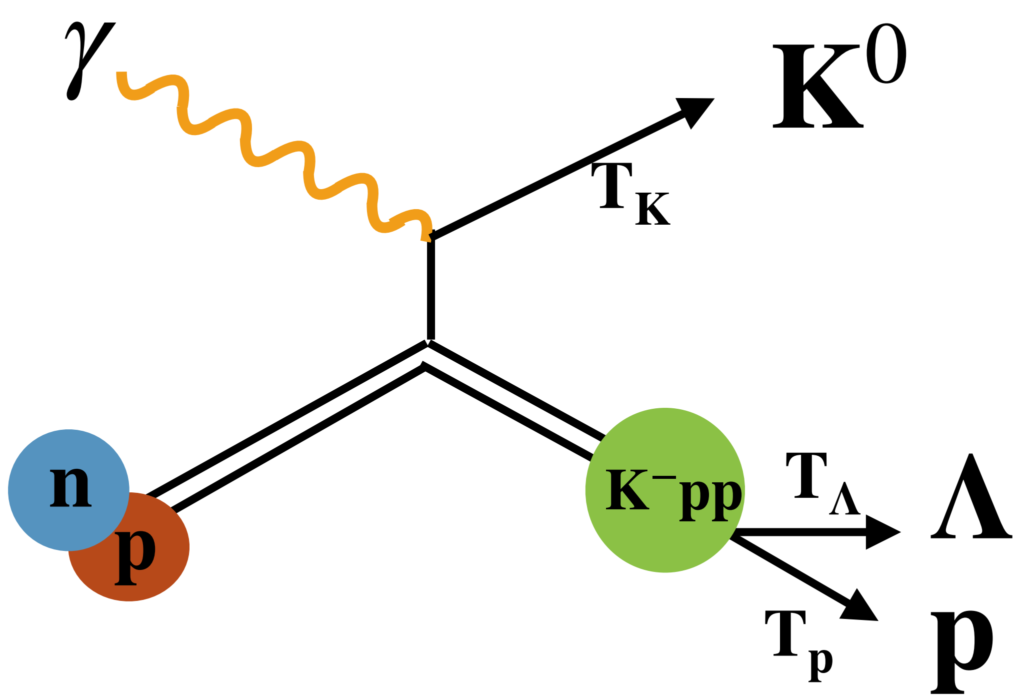
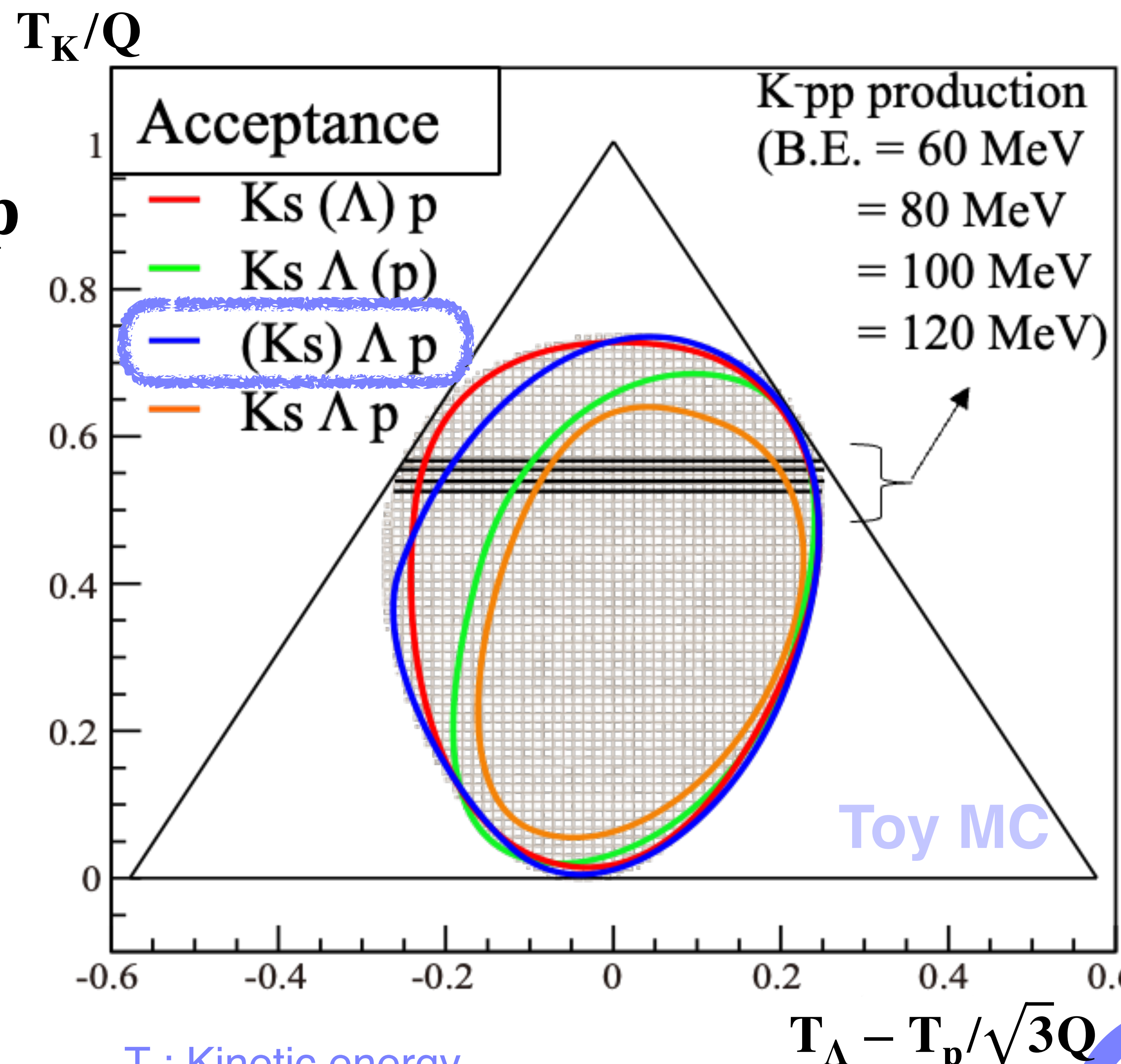
Back up

Search for K^-pp with LEPS2 spectrometer

$$\gamma d \rightarrow K^0(K^-pp)_{B.S.} \rightarrow K^0 \Lambda p$$





T : Kinetic energy
Q : Q-value of the reaction

PHYSICAL REVIEW C **79**, 062201(R) (2009)

Λ(1405)-induced nonmesonic decay in kaonic nuclei

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(Received 18 April 2009; published 29 June 2009; publisher error corrected 30 June 2009)

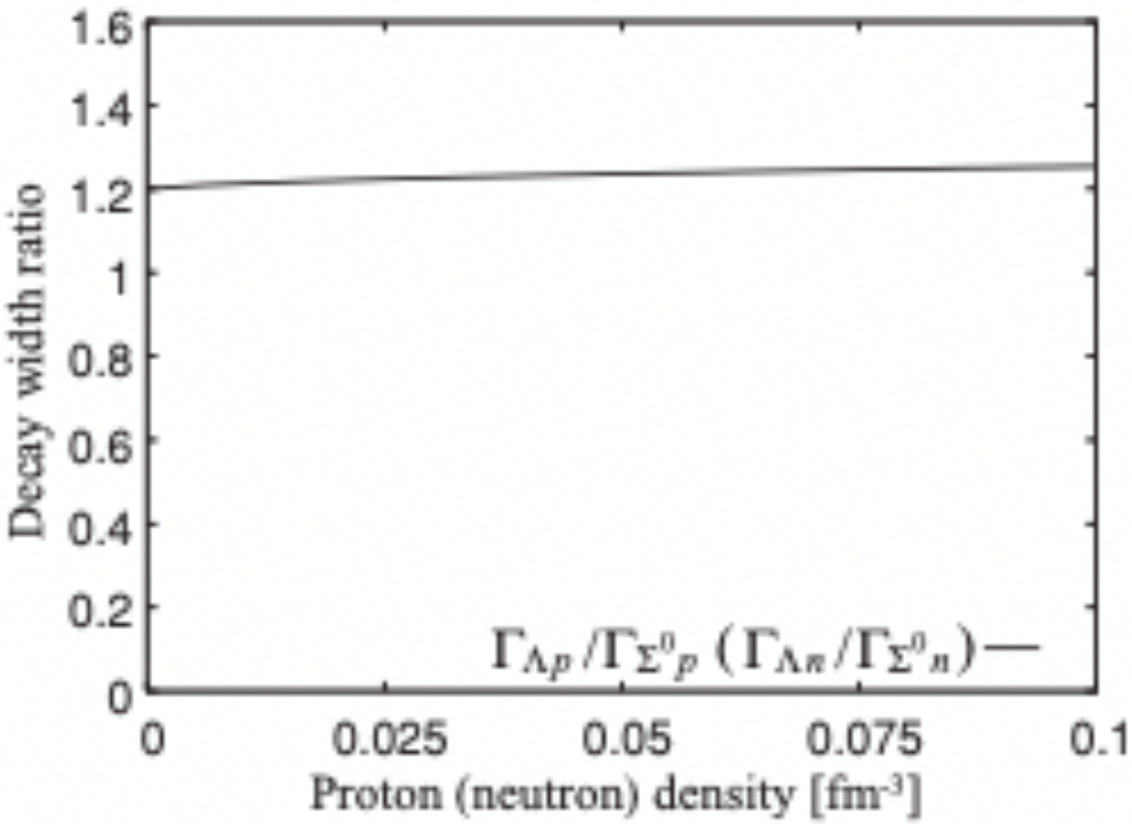

FIG. 3. Nonmesonic decay width ratio of kaonic nuclei.

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Branching ratios of mesonic and nonmesonic antikaon absorptions in the nuclear medium

PHYSICAL REVIEW C **86**, 065205 (2012)

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(Received 18 April 2012; revised manuscript received 8 July 2012; published 13 December 2012)

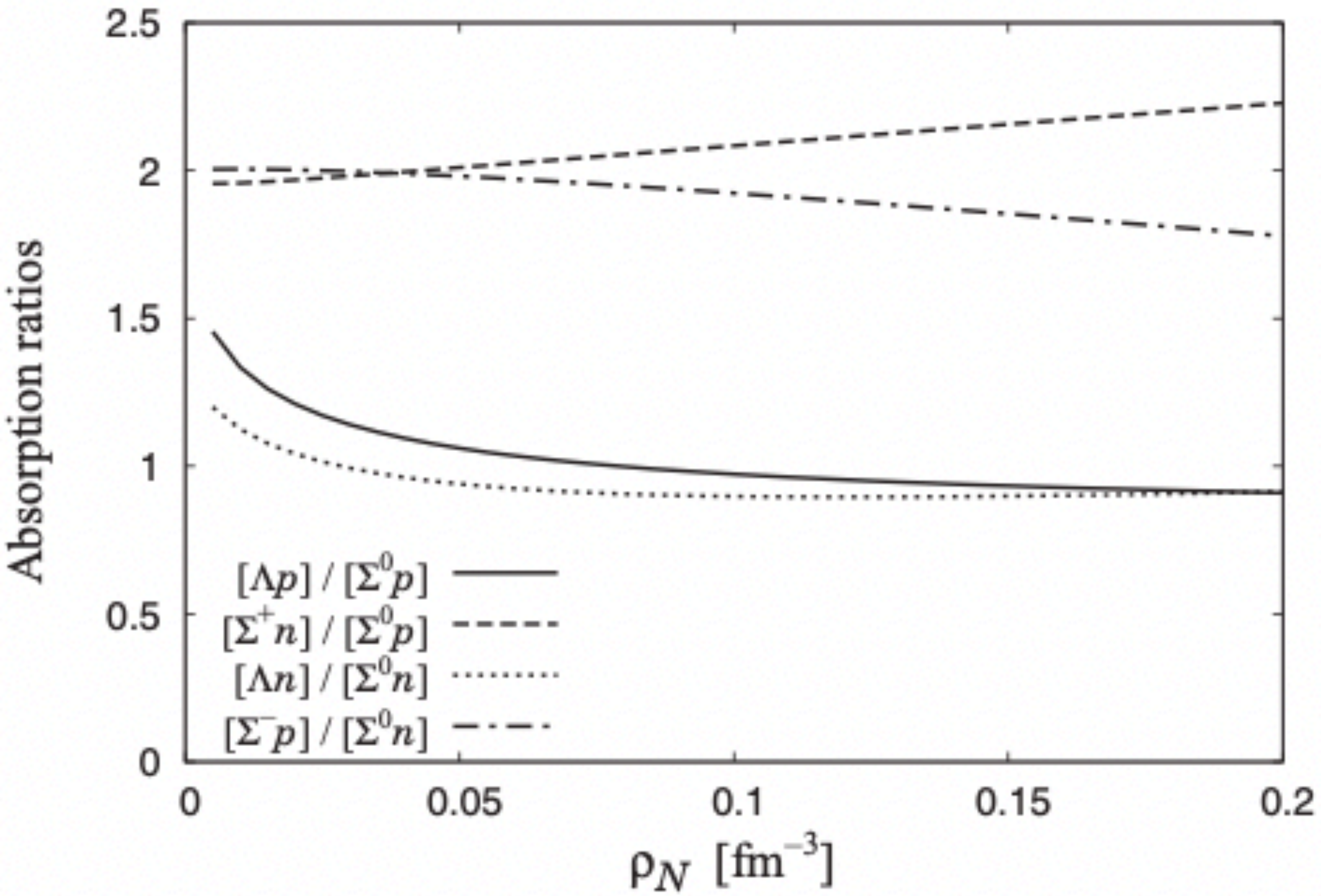
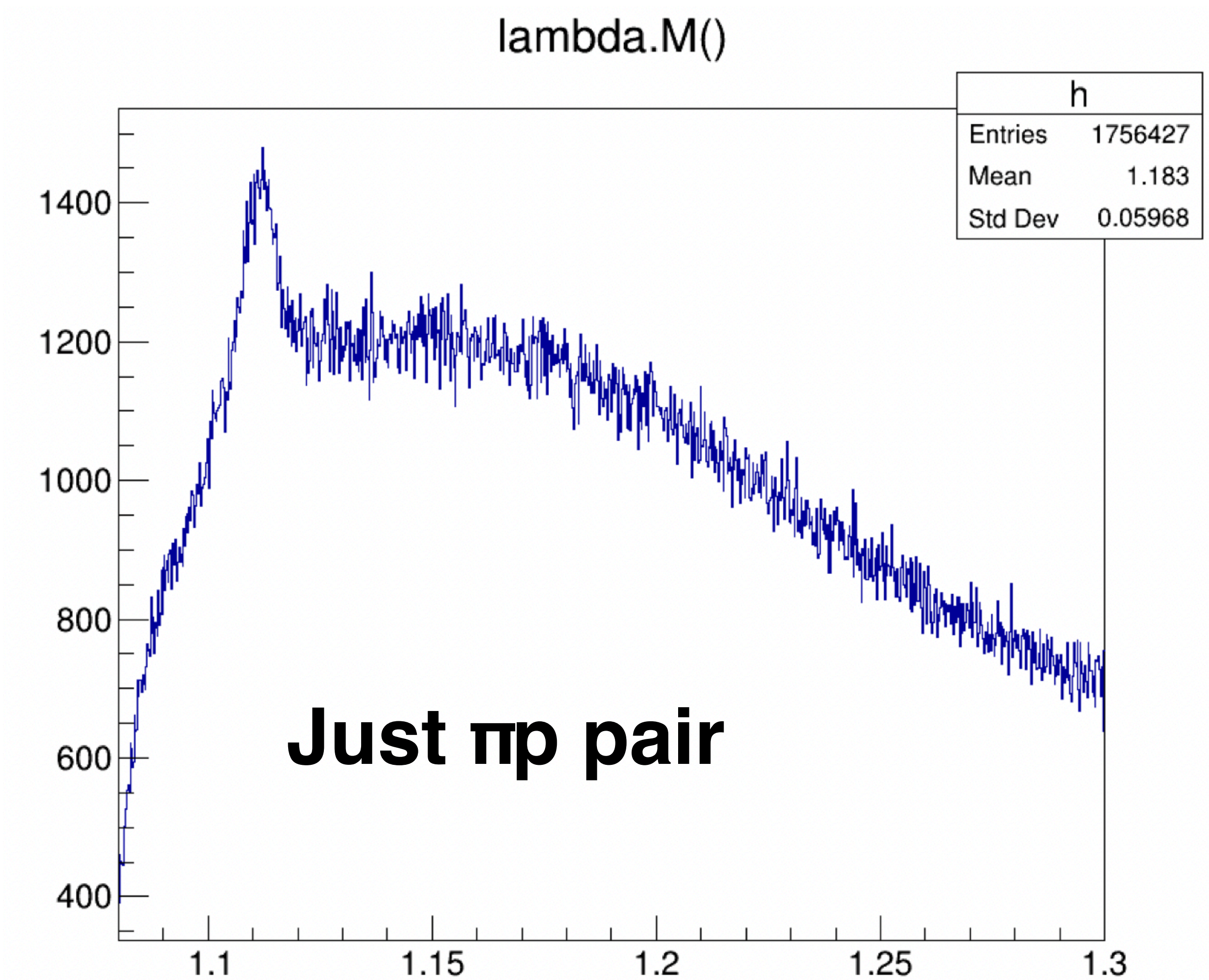


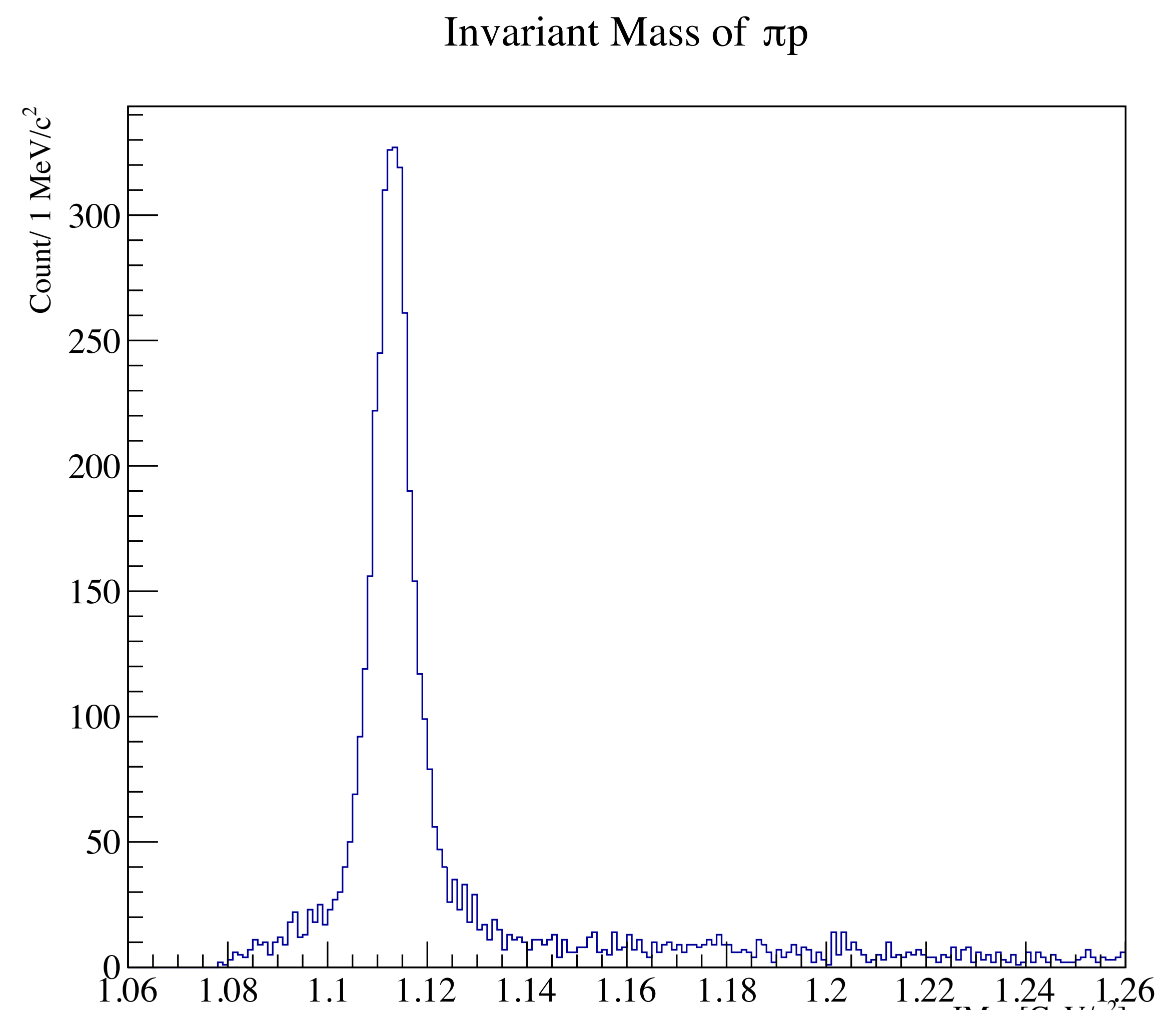
FIG. 12. Ratios of nonmesonic absorption potentials for $[\Lambda p]/[\Sigma^0 p]$, $[\Sigma^+ n]/[\Sigma^0 p]$, $[\Lambda n]/[\Sigma^0 n]$, and $[\Sigma^- p]/[\Sigma^0 n]$ as functions of nuclear density.

$\gamma p \rightarrow K^{+} \Lambda$

W/ EnergyLoss Corr.

Apply some cuts






```
auto cut1 = TCut(" dis < 10 &&v_pos1.z() < -400 &&v_pos1.z() > -570");
auto cut2 = TCut("oAngle*180/3.141592 > 20 && oAngle*180/3.141592 < 80");
auto cut3 = TCut("v_pos1.Perp() > 15 && mRatio > 1 ");
auto cut4 = TCut("mis.M() > 0.4 && mis.M() <0.6");
auto cut5 = TCut("lam.M() > 1.11 && lam.M() < 1.13");
```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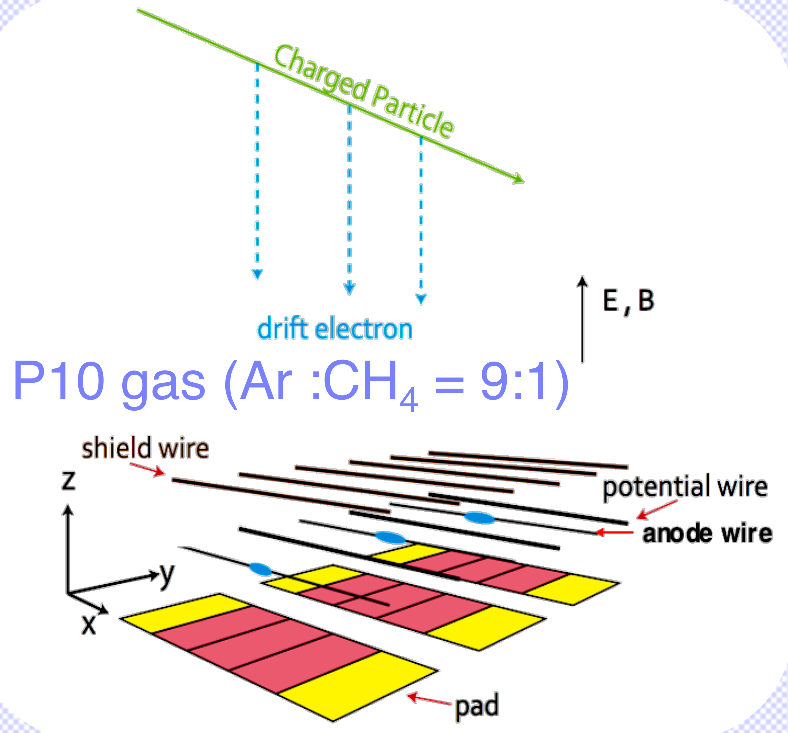
LEPS2TPC

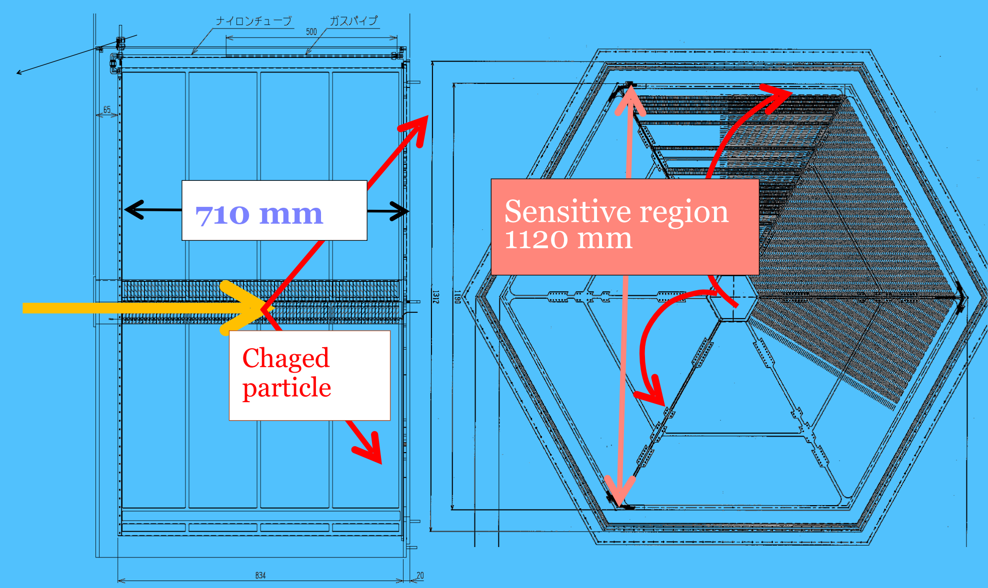


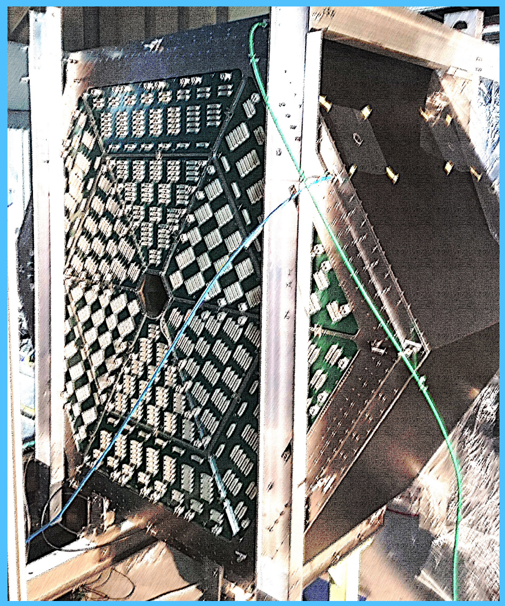
x position

the center of the charge in pads

y position

the center of layer



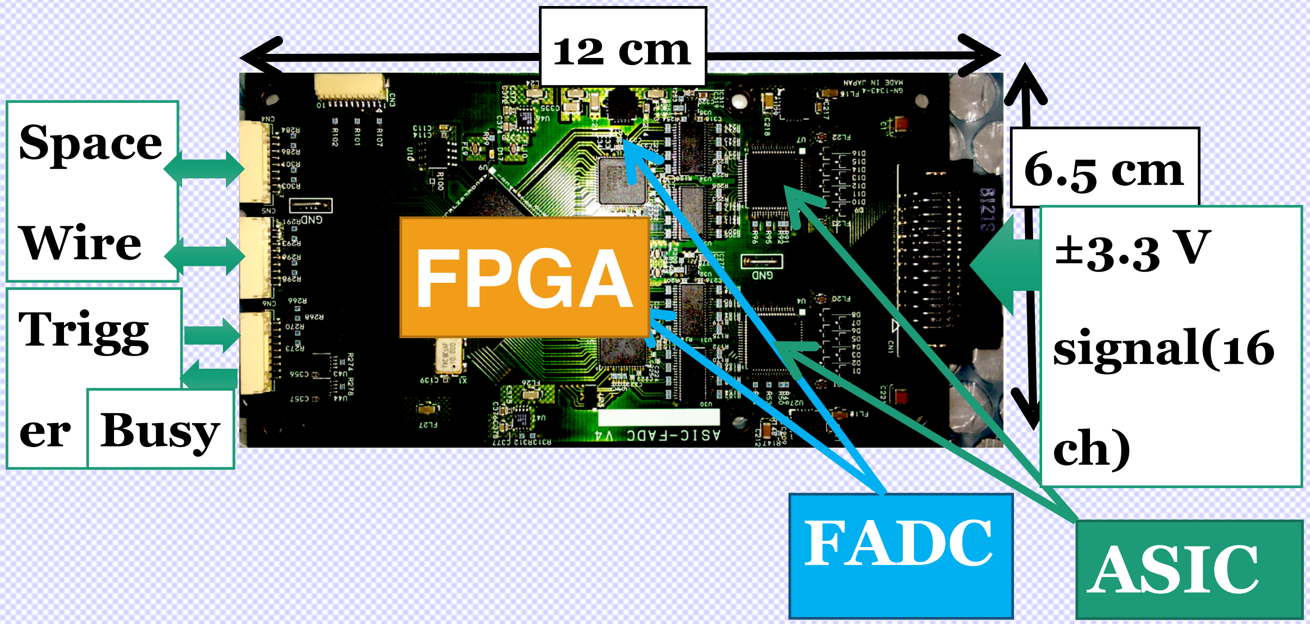


Pad size
x:4.6 mm
y:10 mm

Pad layer
24 layers

Pad number
10830 pads

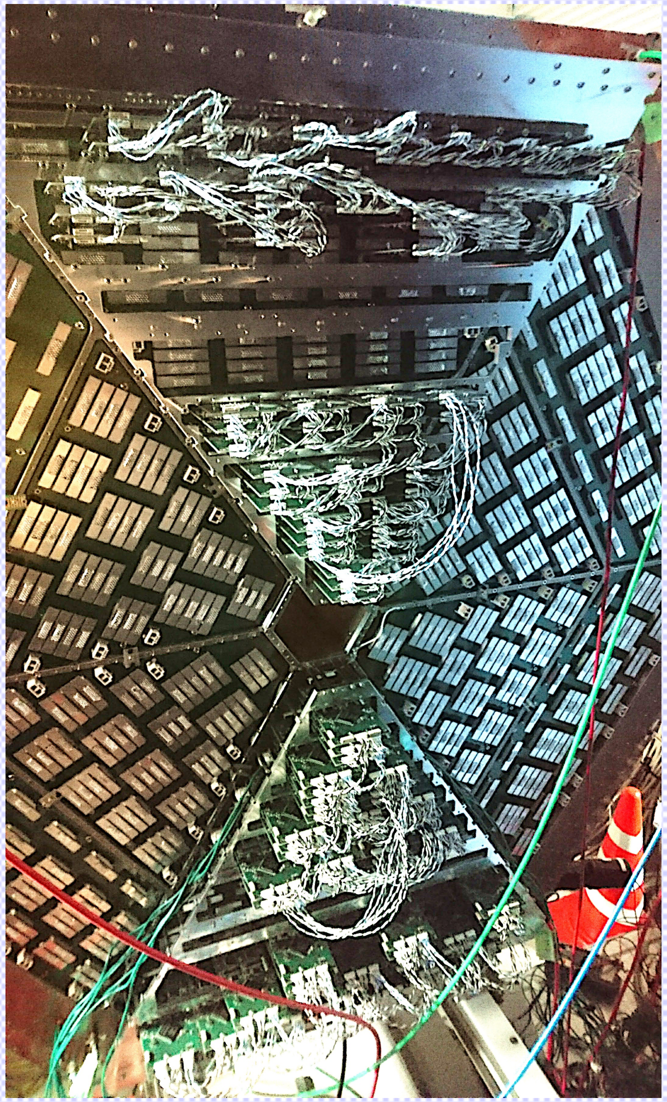
FADC board



- ASIC: Shaping amplifier(8 ch/chip)
  Gain 1 V/pC
  Signal width 200~400 ns

- FADC: AD9257(8 ch/chip)
  Accuracy 14 bit
  Input voltage range 2 V
  Sampling frequency 40 MSPS

- Power consumption ~230 mW/ch



Plug directly into TPC

The results of Cosmic-ray data

Performance evaluation of LEPS2TPC

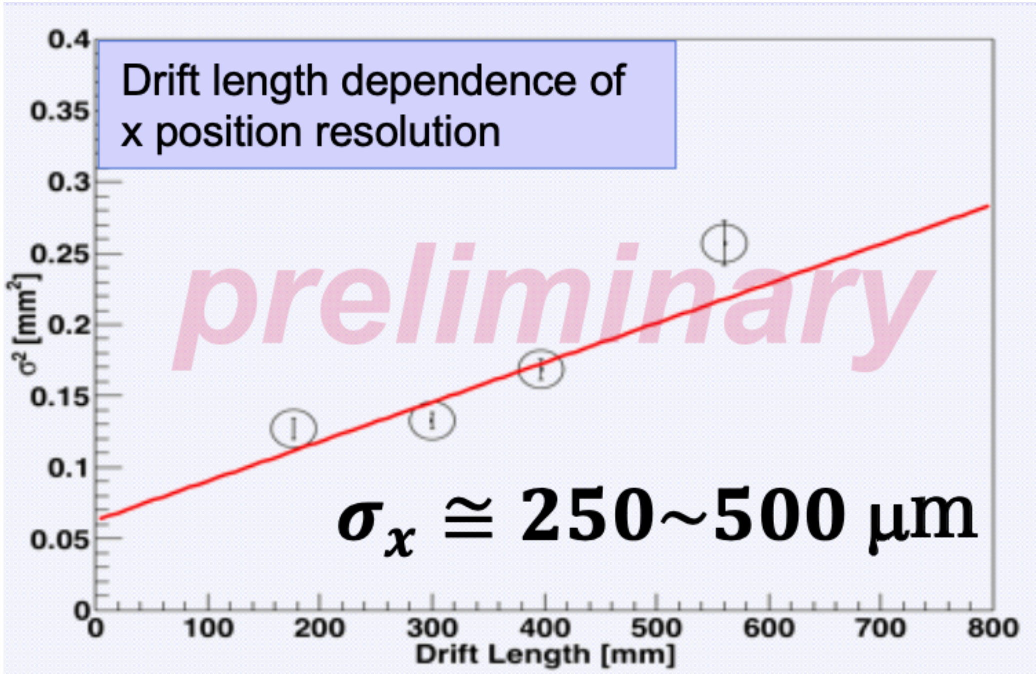
	$\sigma_{x,0}$	σ_D^2	$\sigma_{P,W}^2$
Experimental Result	138^{+13}_{-15} ∝m	0.77±0.03 ∝m	4.01±0.4 m m²
	150 ∝m	1.16±0.01 ∝m	1.34±0.01 m m²
	$\sigma_{z,0}$	$\sigma_{z,D}^2$	σ_{dip}^2
Experimental Result	654^{+40}_{-43} ∝m	0.40±0.1 ∝m	2.70±0.3 m m²
	700 ∝m	0.40±0.01 ∝m	2.38±0.01 m m²

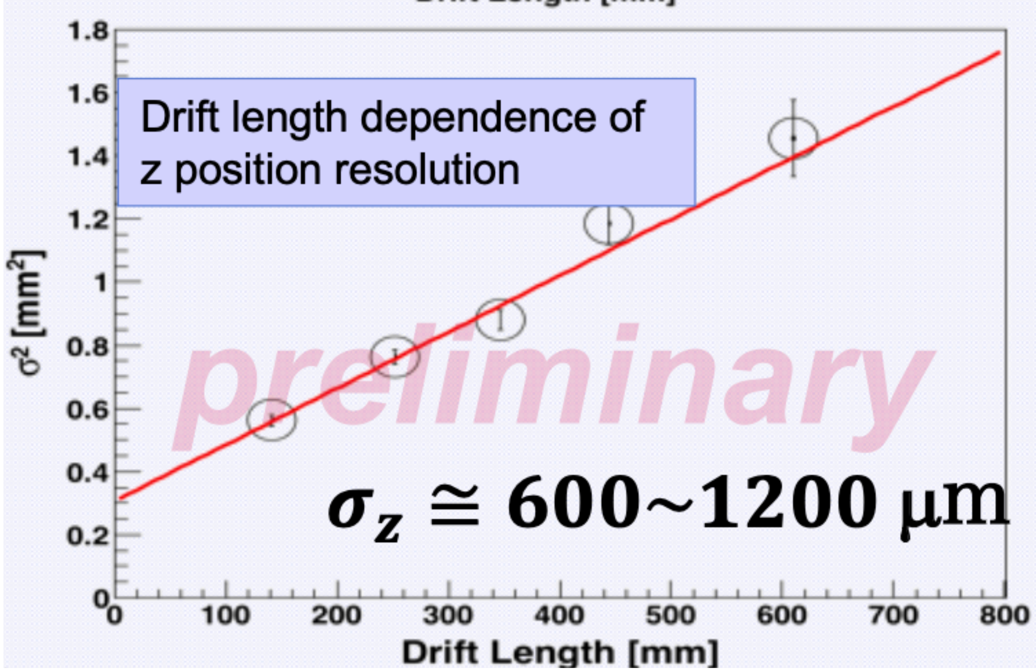
3 times larger than previous study

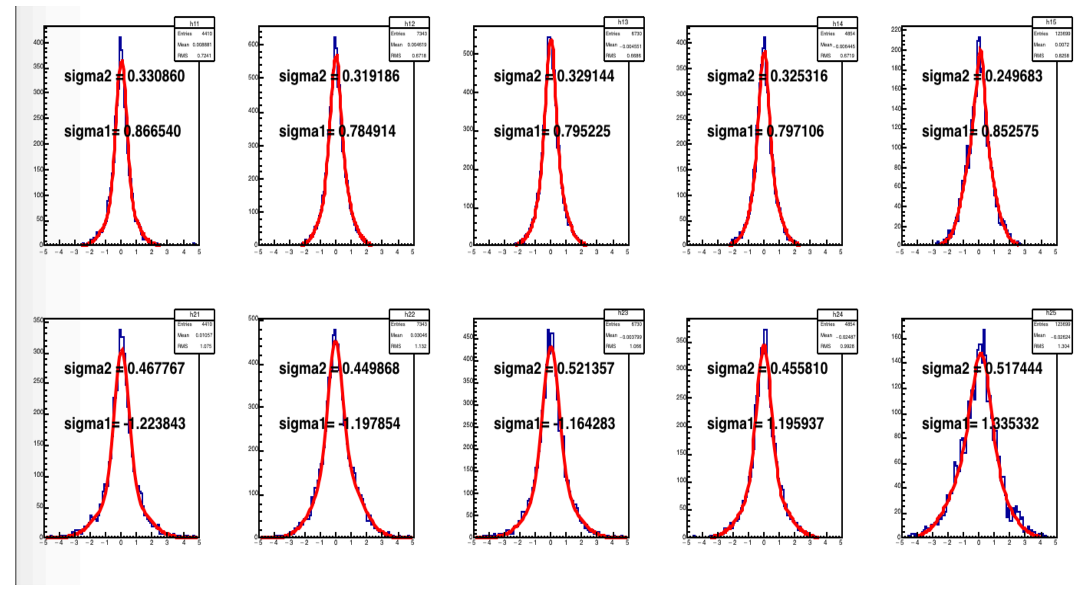
The value of previous study

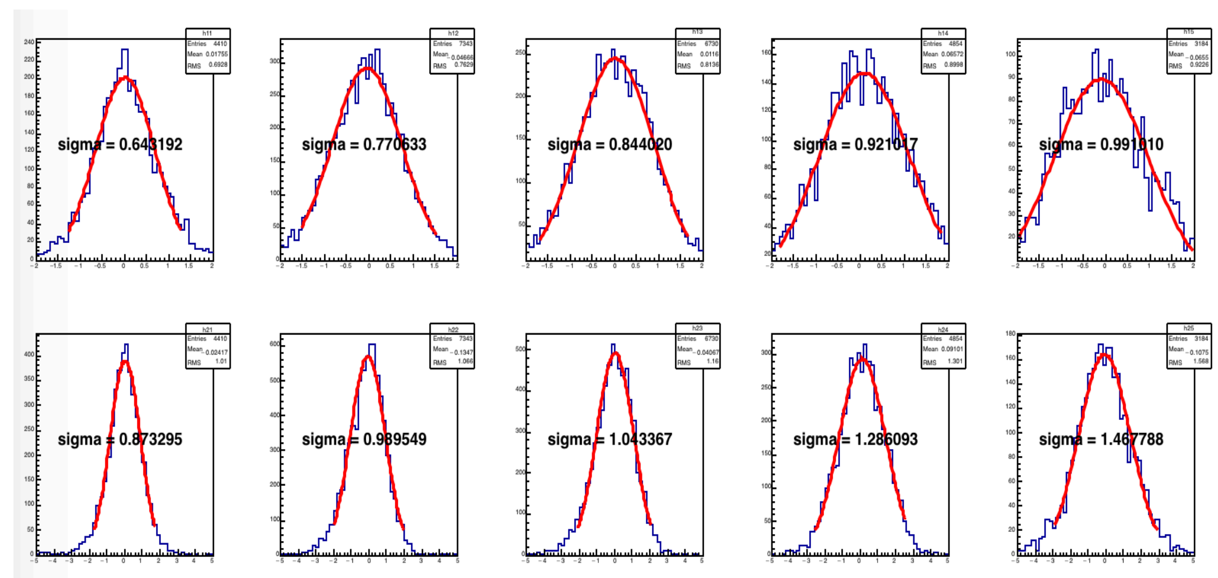
Required performance of position resolution

The Performance of LEPS2TPC









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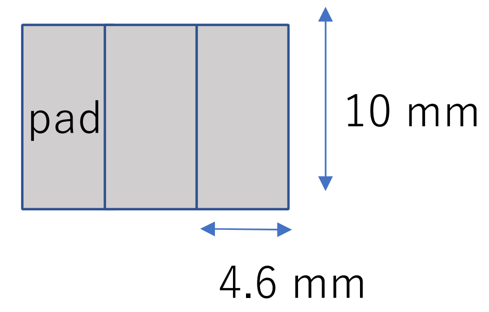
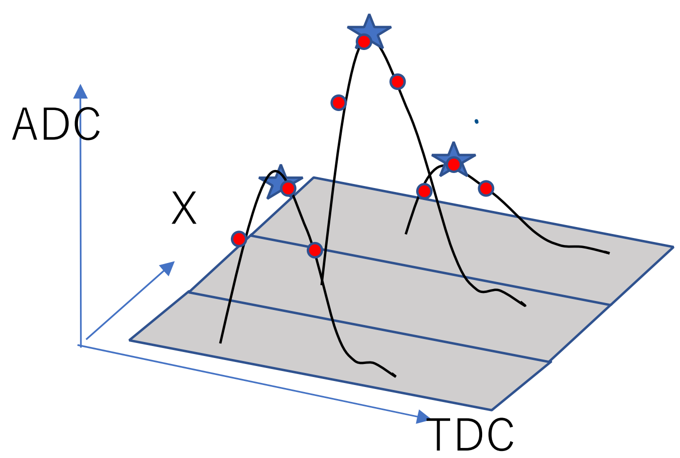
The method of Clustering

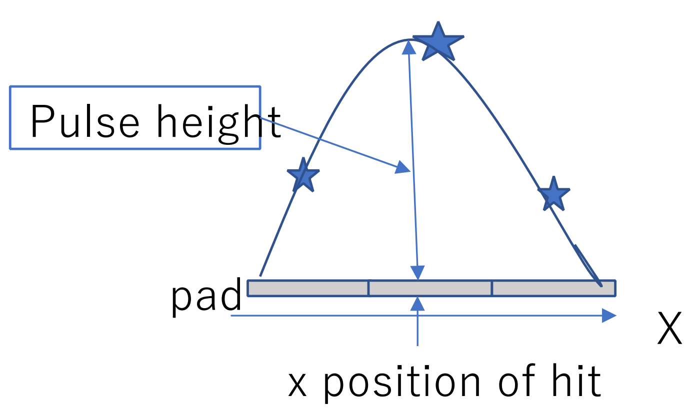


Using 3 Pads Data



1. Solve the Gaussian function using 3 points(●)

Get adc and tdc at peak of each pads.

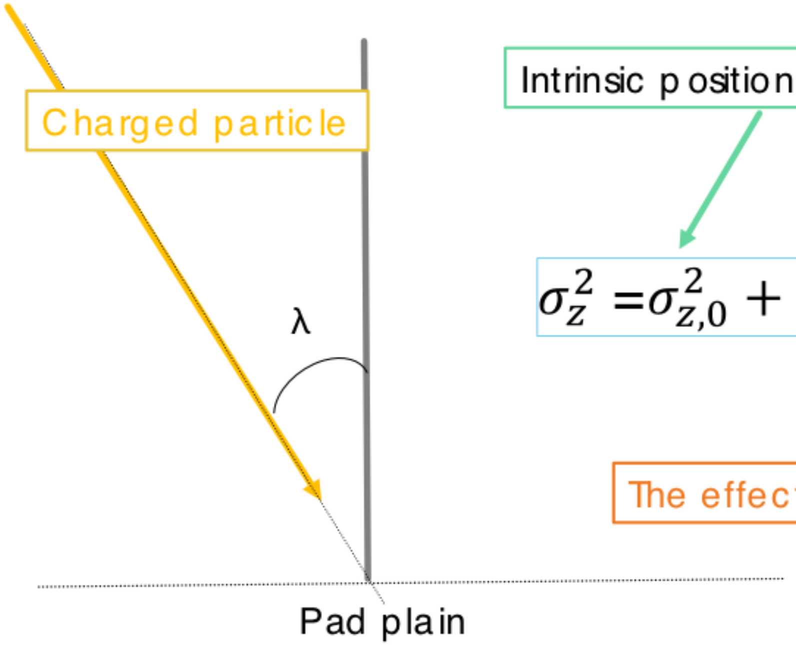


2. Solve the Gaussian function using 3 peaks(★)

Get x position of hit and pulse height.

Drift time is the mean of 3 pads tdc at peak

Position resolution of TPC



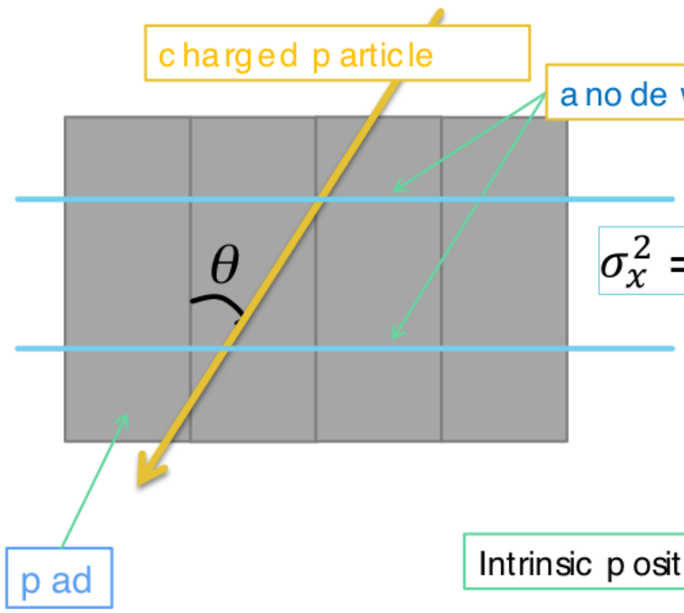
Intrinsic position resolution

The Effect of angle λ

$$\sigma_z^2 = \sigma_{z,0}^2 + \sigma_{z,D}^2 \cdot L_D + \sigma_{dip}^2 \cdot tan^2 \lambda$$

The effect of diffusion of drift electoron

Position resolution of TPC



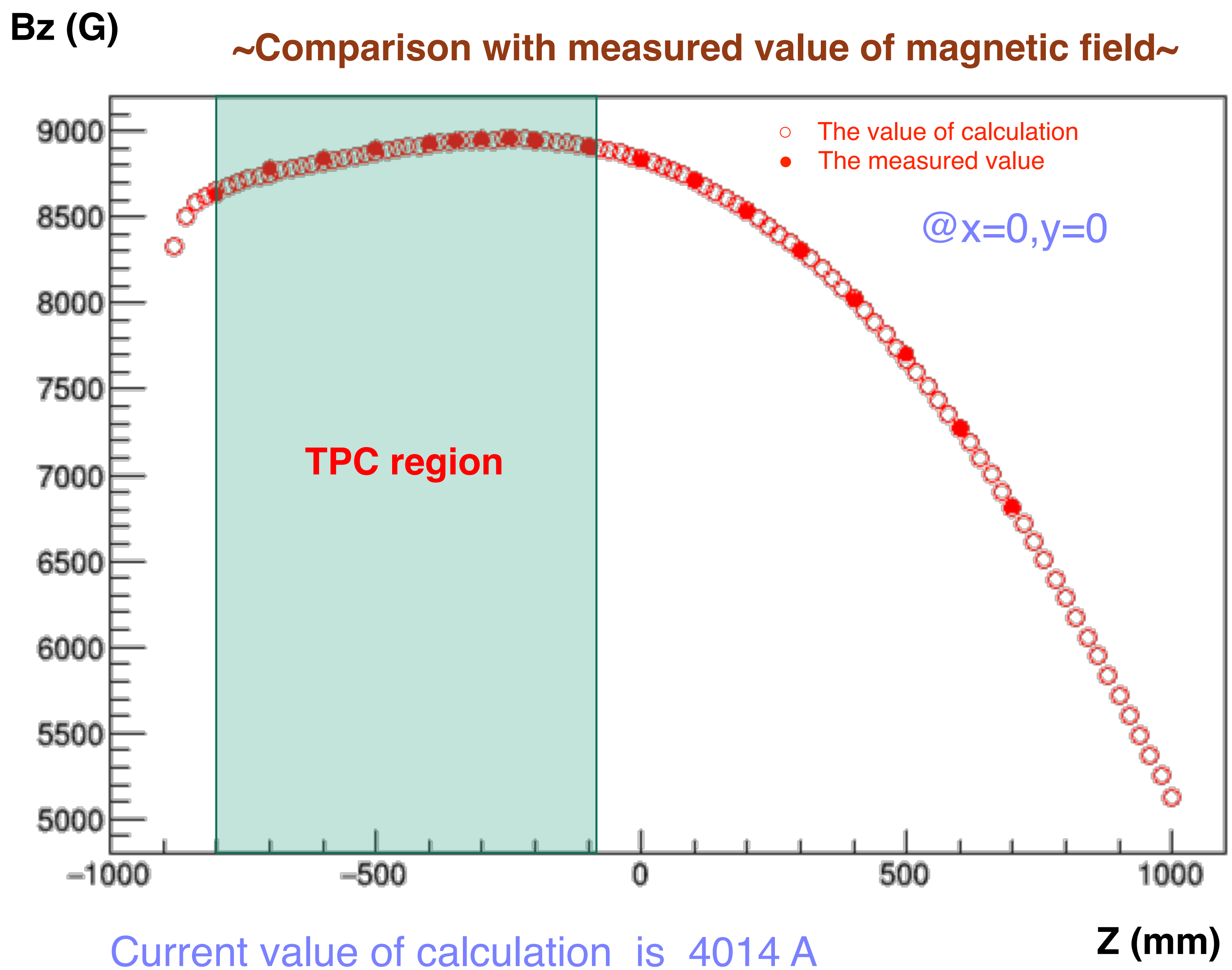
The Effect of angle θ

$$\sigma_x^2 = \sigma_{x,0}^2 + \sigma_D^2 \cdot L_D + \sigma_{P,W}^2 \cdot tan^2\theta$$

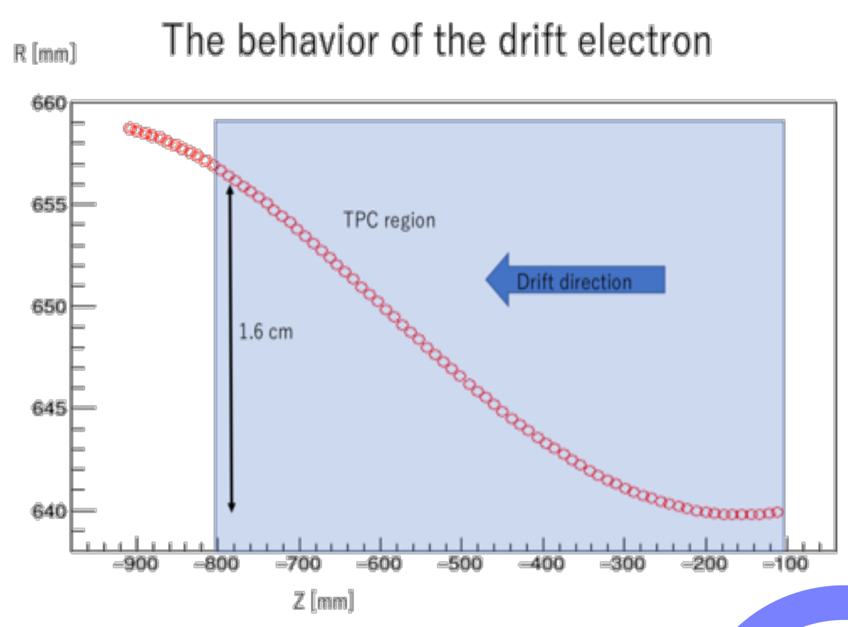
The effect of diffusion of drift electoron

Intrinsic position resolution

magnetic field calculation



Current value of calculation is 4014 A



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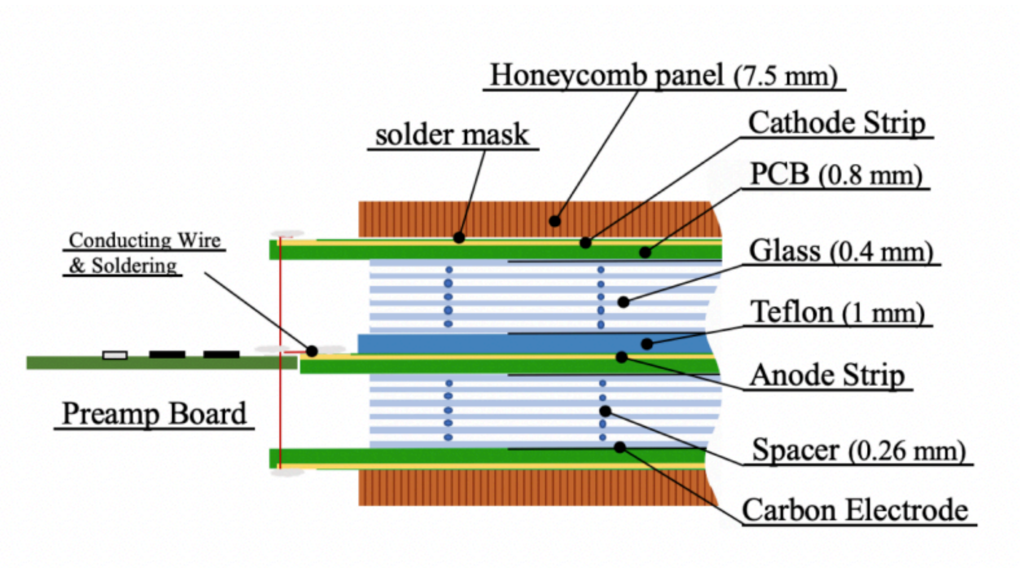
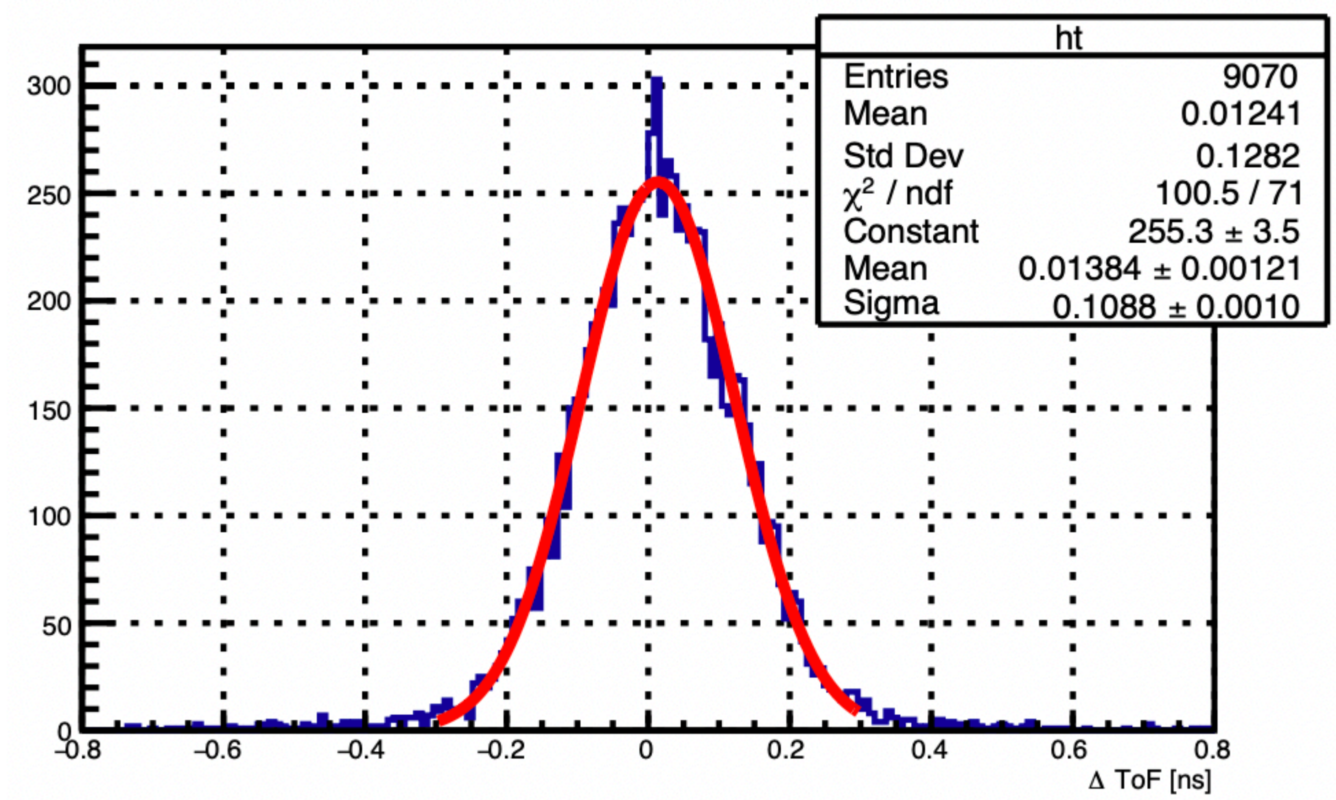
The Performance of BRPC



$$\Delta TOF = TOF_{measure} - TOF_{expected(\pi)}$$



$$\sigma_{\Delta TOF} = \ 110\ \mathbf{ps}$$

Inclusive the TPC resolution

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Background processes

☆ Physics background (two step process.)

① Elastic scattering process

γ + n → K^0 Λ, Λ + p → Λ + p

② inelastic scattering process

γ N → K^0 Y* , Y* + N → Λ + p

Other BG source?

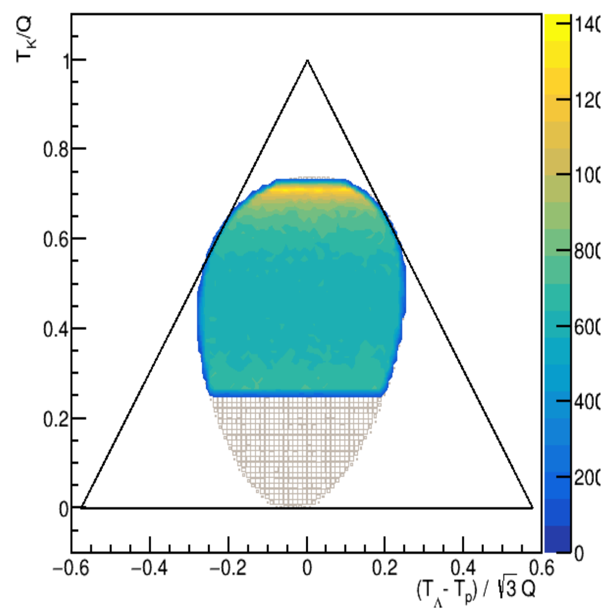
☆ Unphysical background

* p/π mis-identification,
* wrong p/π pair
* missing particle.

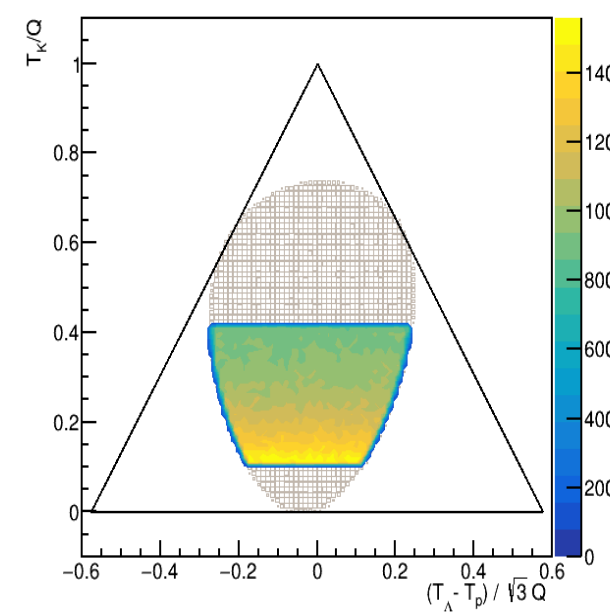
etc…

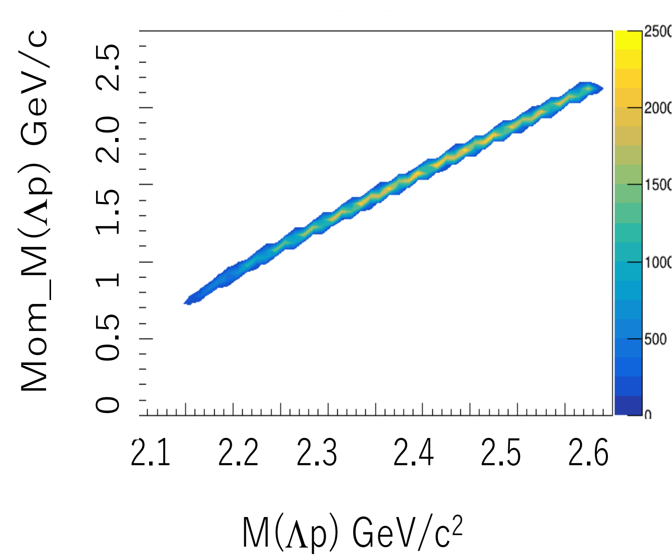
→ Evaluation with the data of LH_2 (Next FY)

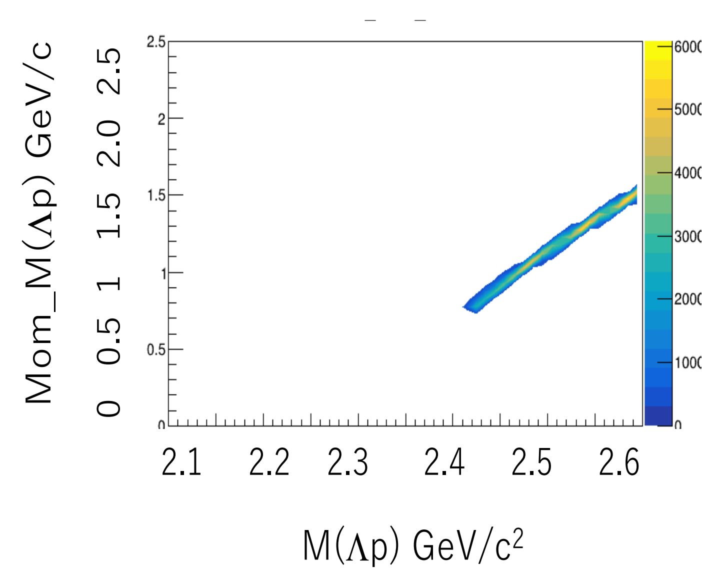
① Elastic Scattering (isotropic, w.o. FM)



② inelastic Scattering (Y* = Λ(1405) width=0 MeV, w.o. FM)







BG candidate

$$\gamma d \rightarrow K^0 \Lambda p$$

$$\gamma d \rightarrow K^0 \Sigma^0 p \rightarrow K^0 \Lambda \gamma p$$

$$\gamma d \rightarrow K^0 (Kpp)_B \rightarrow K^0 \Lambda p \pi^0$$

$$\gamma d \rightarrow K^0 (Kpp)_B \rightarrow K^0 \Sigma^0 p$$

Two-step processes

such as secondary scattering of generated Λ and p also become BG.

Role of a triangle singularity in the $\gamma p \to K^+\Lambda(1405)$ reaction

PHYSICAL REVIEW C **95**, 015205 (2017)

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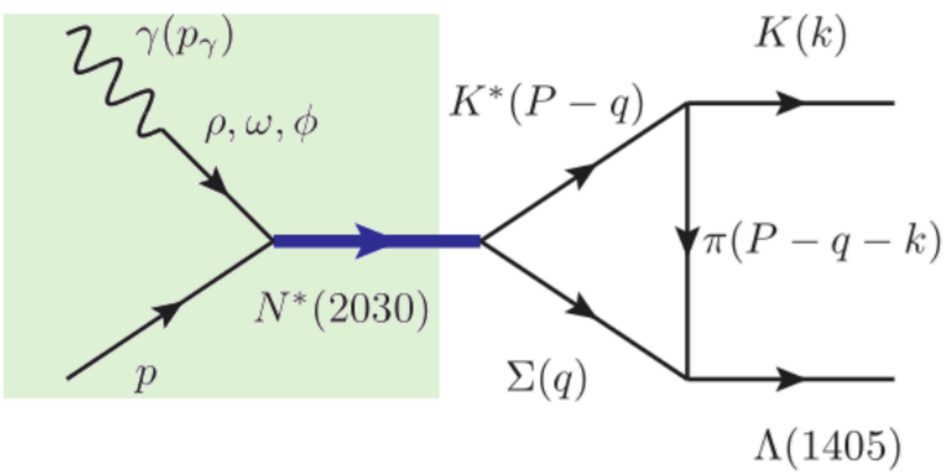
and Departamento de Física Teórica and IFIC, Centro Mixto Universidad de Valencia-CSIC Institutos de Investigación de Paterna, Apartado 22085, 46071 Valencia, Spain

N^* process



$$-i\tilde{t} = i\frac{e}{g}\mathcal{C}_{\gamma V}\epsilon_l(\gamma) \qquad \mathcal{C}_{\gamma V} \equiv \begin{cases} \frac{1}{\sqrt{2}} & \rho^0 \\ \frac{1}{3\sqrt{2}} & \omega \\ -\frac{1}{3} & \phi \end{cases}$$

$$[\gamma \to V \ (V = \rho^0, \omega, \phi)]$$

$$g_{N^*N\rho} = -0.3 - 0.5i, \quad g_{N^*N\omega} = -1.1 - 0.4i,$$

$$g_{N^*N\phi} = 1.5 + 0.6i, \quad g_{N^*K^*\Sigma} = 3.9 + 0.2i.$$

(*NV*: isospin basis)

$$g_{\gamma N, N^*} = \sum_{V=\rho^0,\omega,\phi} \mathcal{C}_{\gamma V} g_{N^*NV}$$

$$= \frac{1}{\sqrt{2}}\left(\frac{\mp 1}{\sqrt{3}} g_{N^*N\rho}\right) + \frac{1}{3\sqrt{2}} g_{N^*N\omega} - \frac{1}{3} g_{N^*N\phi}$$

($-$: proton, $+$: neutron)

$$\frac{|g_{\gamma n, n^*}|^2}{|g_{\gamma p, p^*}|^2} \sim 2.5$$

Eur. Phys. J. A **44**, 445–454 (2010)

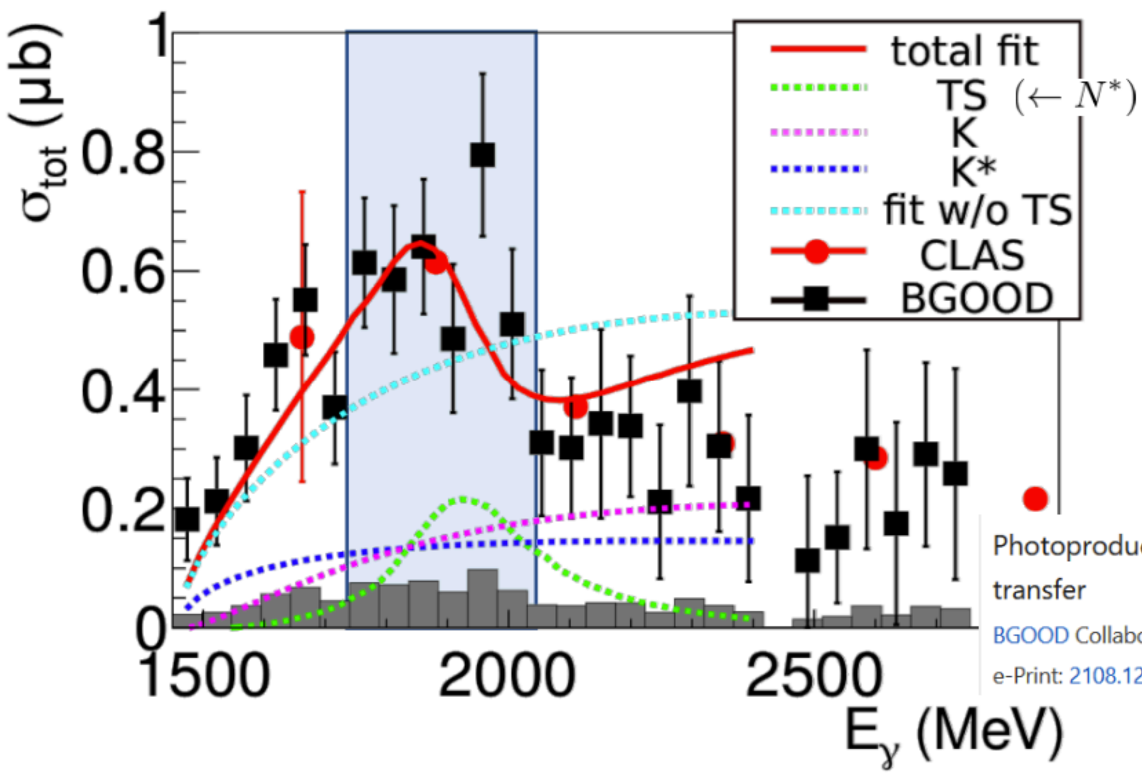
Dynamically generated resonances from the vector octet-baryon octet interaction

E. Oset[1] and A. Ramos[2,a]

$$|\rho N\rangle^{I_z=+1/2}_{I=1/2} = -\sqrt{\frac{2}{3}}|\rho^+ n\rangle - \sqrt{\frac{1}{3}}|\rho^0 p\rangle$$

$$|\rho N\rangle^{I_z=-1/2}_{I=1/2} = +\sqrt{\frac{1}{3}}|\rho^0 n\rangle - \sqrt{\frac{2}{3}}|\rho^- p\rangle$$

$$[|\rho^+\rangle = -|I=1, I_z=+1\rangle]$$



Photoproduction of $K^+\Lambda(1405) \to K^+\pi^0\Sigma^0$ extending to forward angles and low momentum transfer

BGOOD Collaboration • G. Scheluchin (Bonn U.) et al. (Aug 27, 2021)

e-Print: 2108.12235 [nucl-ex]

- Estimation (incoherent sum)

$$(2.5 \times 0.2)_{N^*} + (2.5 \times 0.15)_{K^*} + (0 \times 0.15)_K + (? \times 0.05)_{K\bar{K}N}$$

$$\sim 0.9 \text{ μb} \; + \; ?_{K\bar{K}N}$$

$$[E_\gamma \sim 1.9 \text{ GeV}]$$

$$\sigma_{\gamma n \to K^0 \Lambda(1405)} \sim 0.9 \text{ μb?}$$

$$(\sigma_{\gamma n \to n^* \to K^0 \Lambda(1405)} \sim 0.5 \text{ μb})$$

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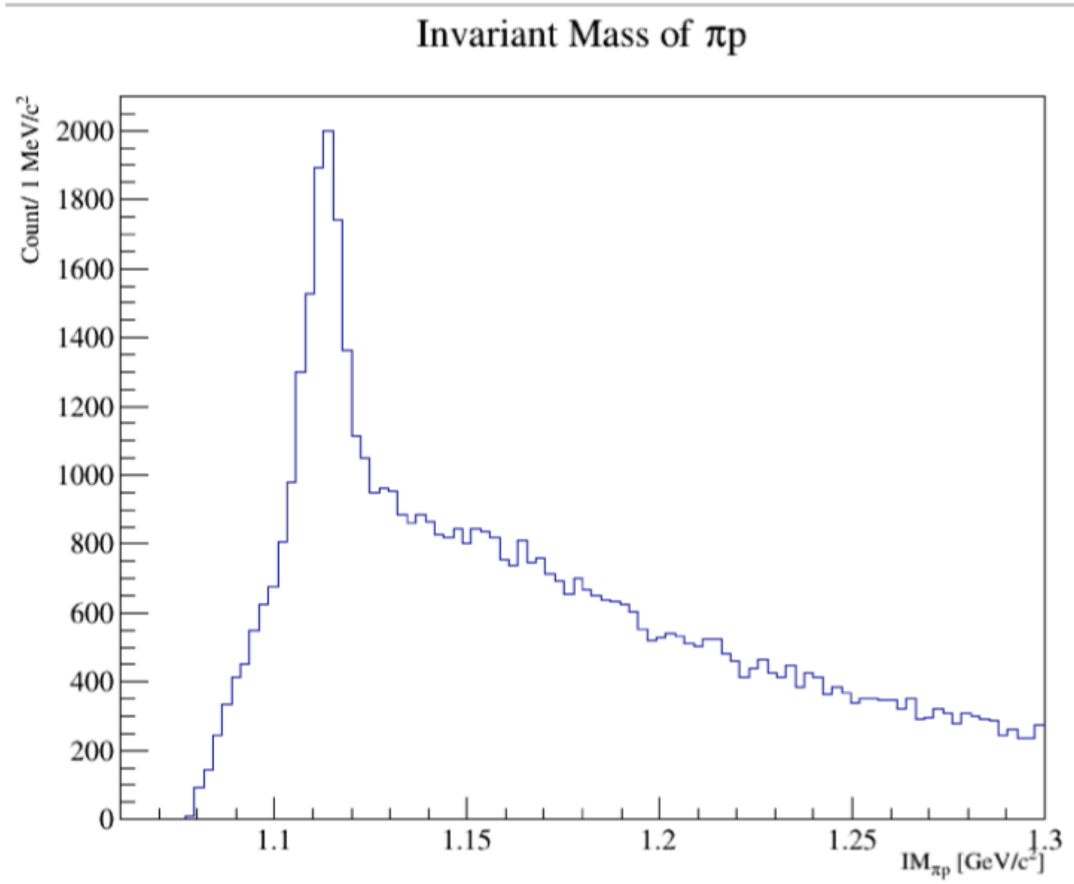
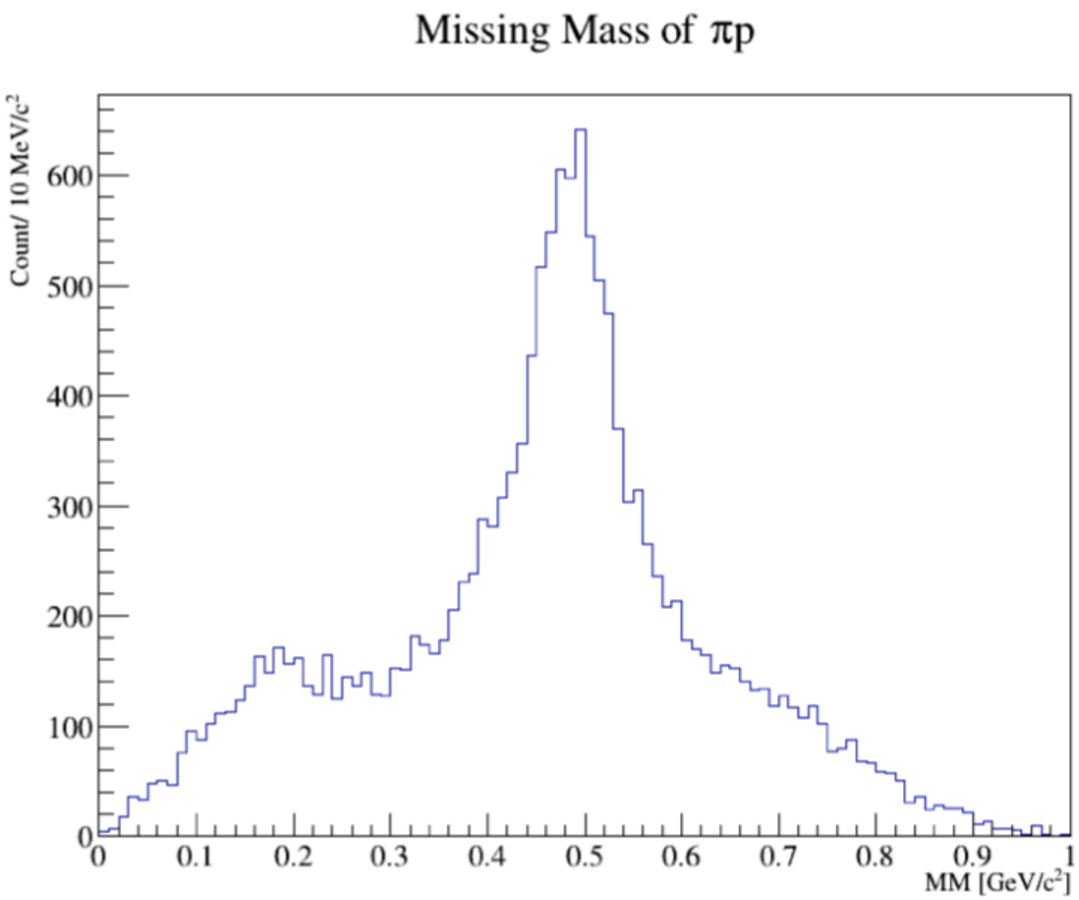
LH2 Data

$\gamma p \to K^+ \Lambda$ **Perp() > 0 mm**





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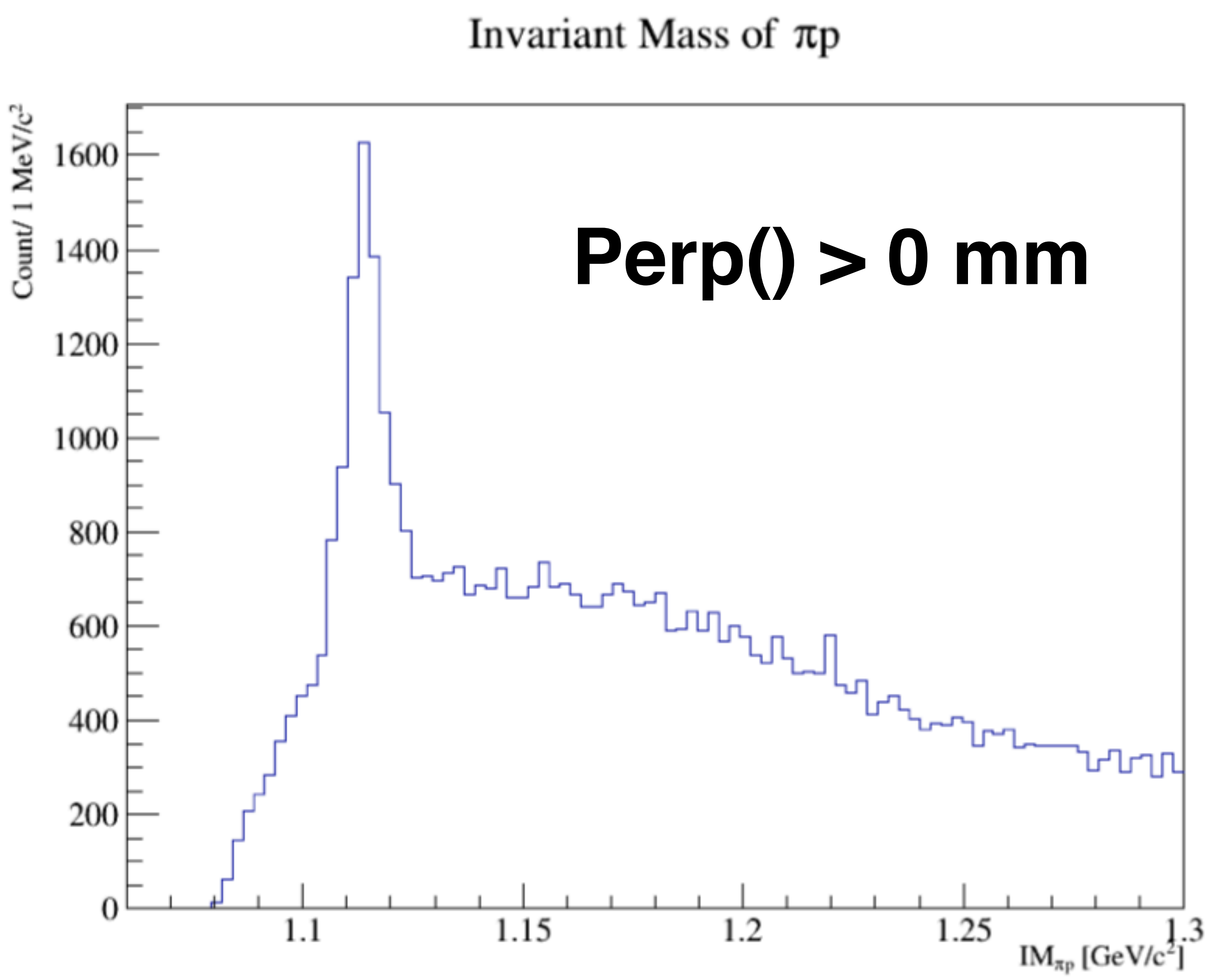
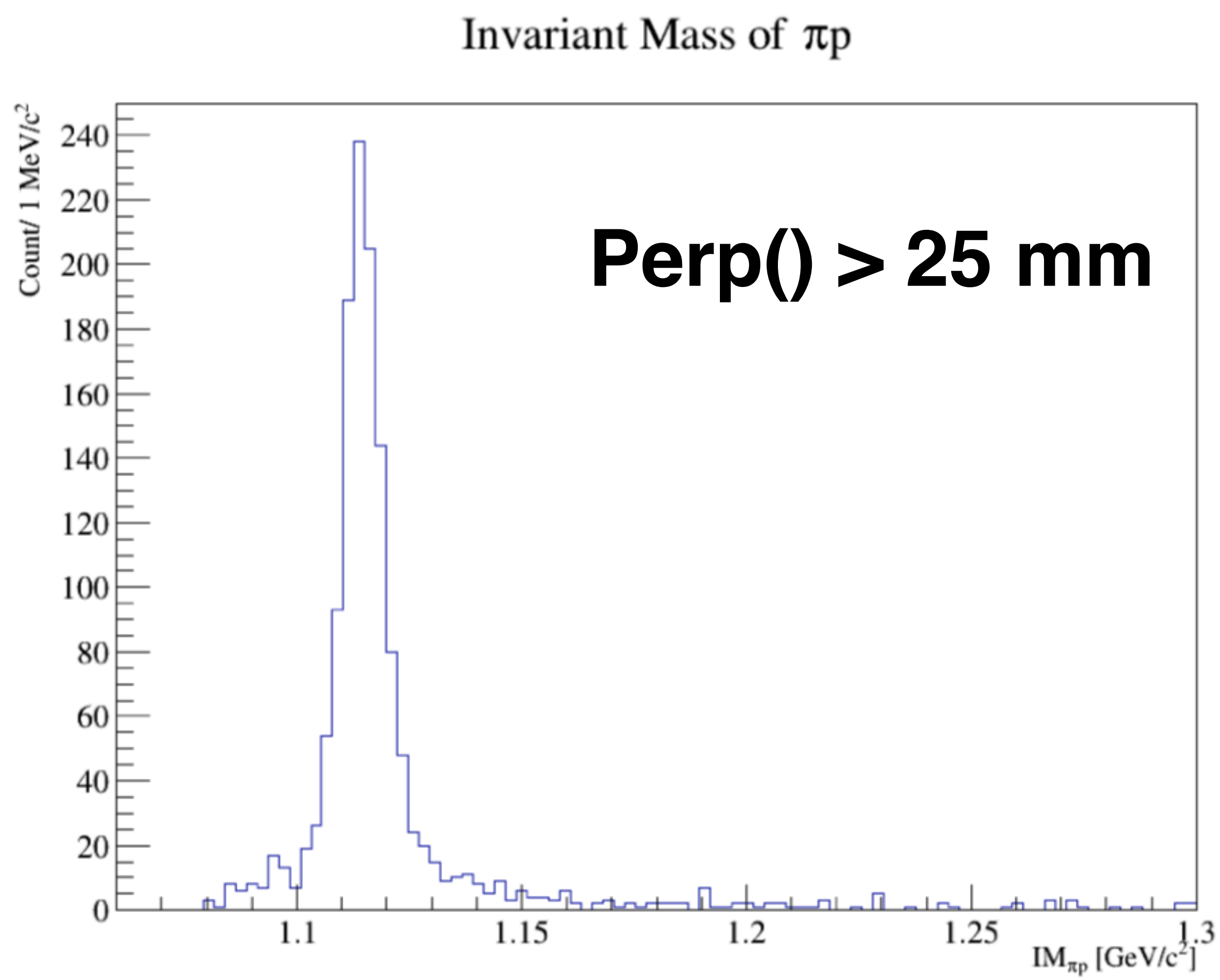
LD2 Data





Track : 13 hits or more

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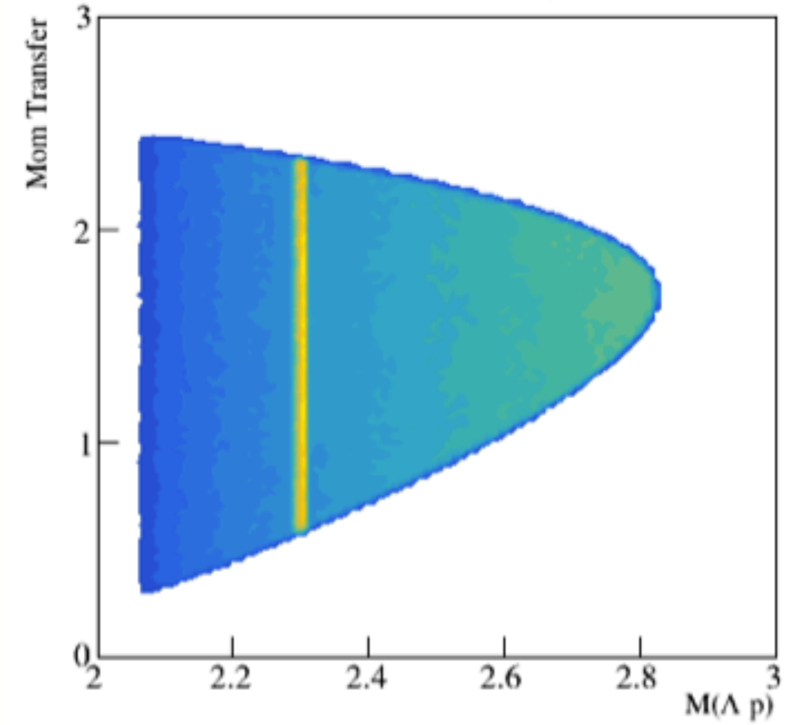
Toy MC Results(Eg = 2 GeV)

Kpp探索実験(シミュレーション)

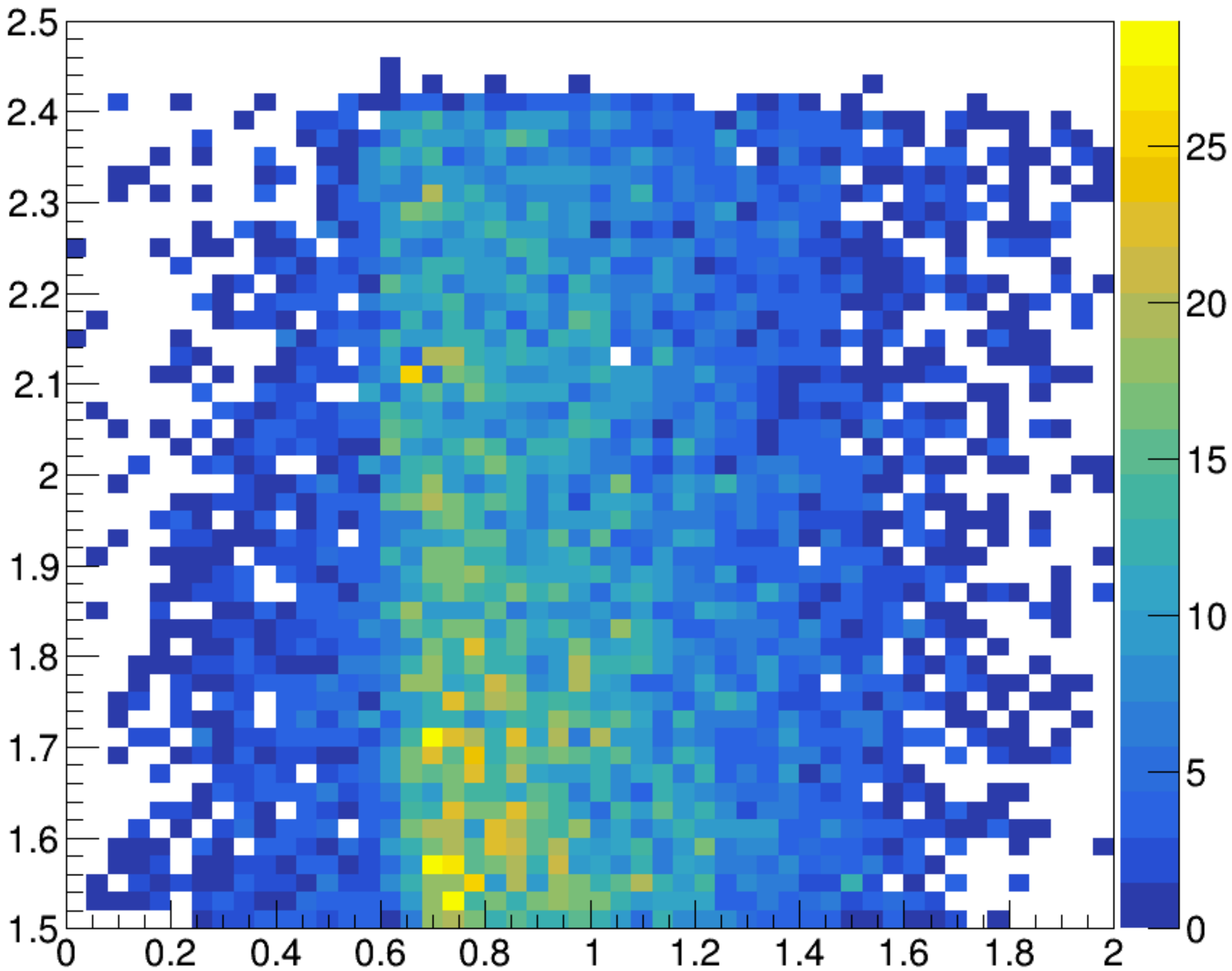
（Kpp : NonReso = 1 : 50）

$$\gamma d \to K^0 Kpp \to K^0 \Lambda p \to \pi^+ \pi^- \pi^- pp$$

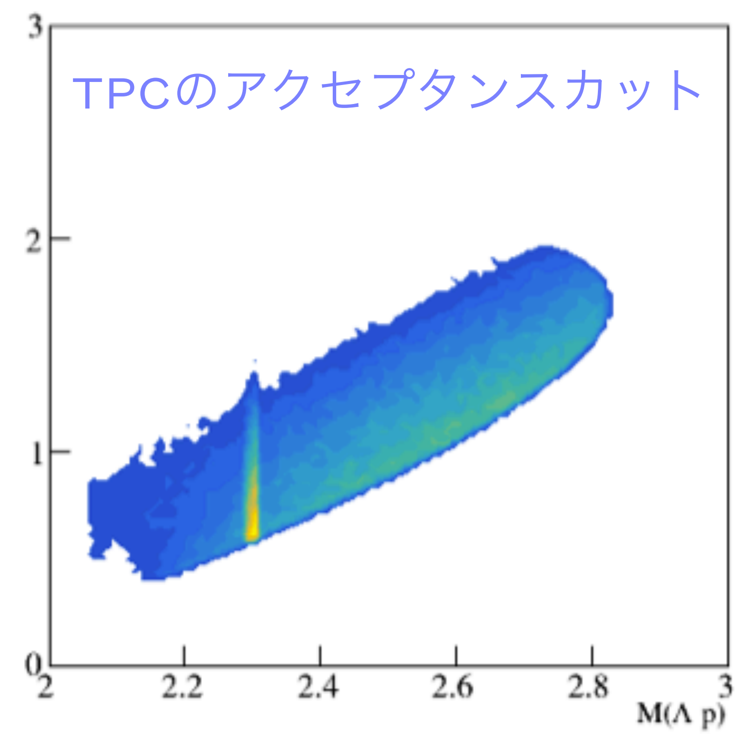
運動学の制限のみ



Eγ[GeV]

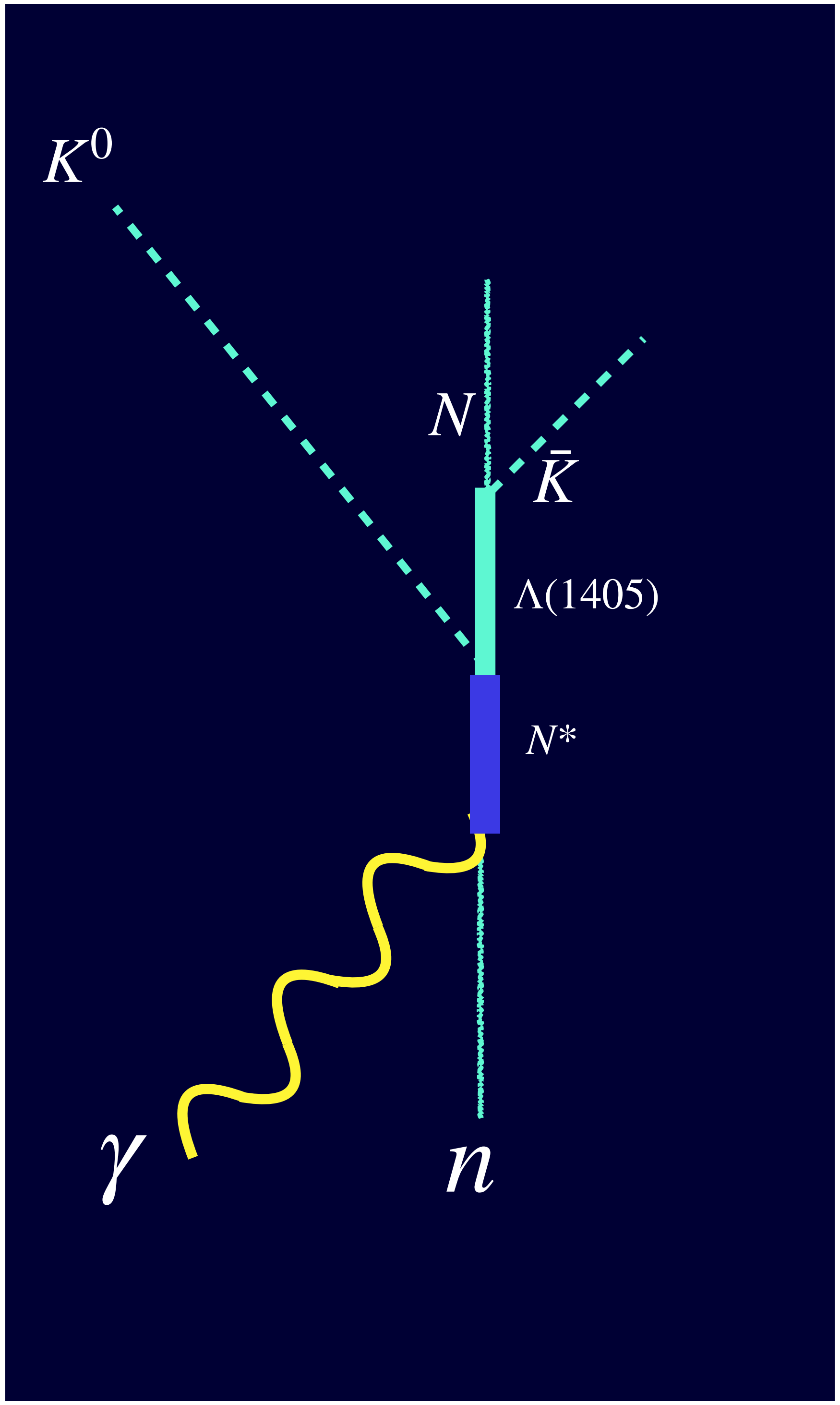


ΔMom [GeV/c]



Momentum Transferは、0.6 - 1.2 GeV

$\gamma n \to \Lambda(1405)K^0$ の見積もり

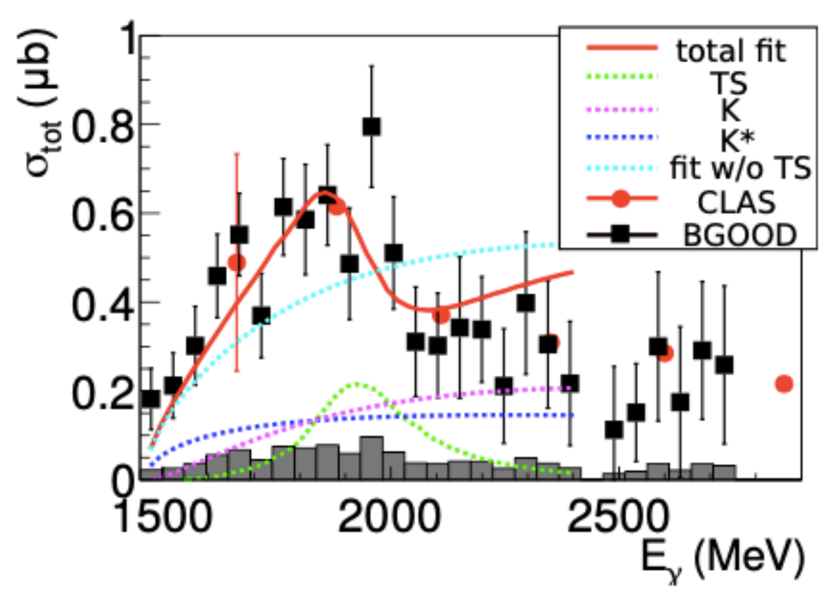


$\gamma NN^*Coupling$の強さの比（保坂さんノート、酒井さんノート参照）と

$\gamma p \to \Lambda(1405)K^+$から求める。

Photoproduction of $K^+\Lambda(1405) \to K^+\pi^0\Sigma^0$ extending to forward angles and low momentum transfer

G. Scheluchin,[1,*] S. Alef,[1] P. Bauer,[1] R. Beck,[2] A. Braghieri,[3] P. Cole,[4] R. D. Salvo,[5] D. Elsner,[1] A. Fantini,[5,6] O. Freyermuth,[1] F. Ghio,[7,8] A. Gridnev,[9] D. Hammann,[1,†] J. Hannappel,[1] T. Jude,[1] K. Kohl,[1] N. Kozlenko,[9] A. Lapik,[10] P. L. Sandri,[11] V. Lisin,[10] G. Mandaglio,[12,13] R. Messi,[6,7,†] D. Moricciani,[6] A. Mushkarenkov,[10] V. Nedorezov,[10] D. Novinsky,[9] P. Pedroni,[3] A. Polonski,[10] B.-E. Reitz,[1,†] M. Romaniuk,[6,14] H. Schmieden,[1] V. Sumachev,[9,‡] and V. Tarakanov[9]
(BGOOD Collaboration)



$\gamma n \to \Lambda(1405)K^0$の断面積

N*寄与

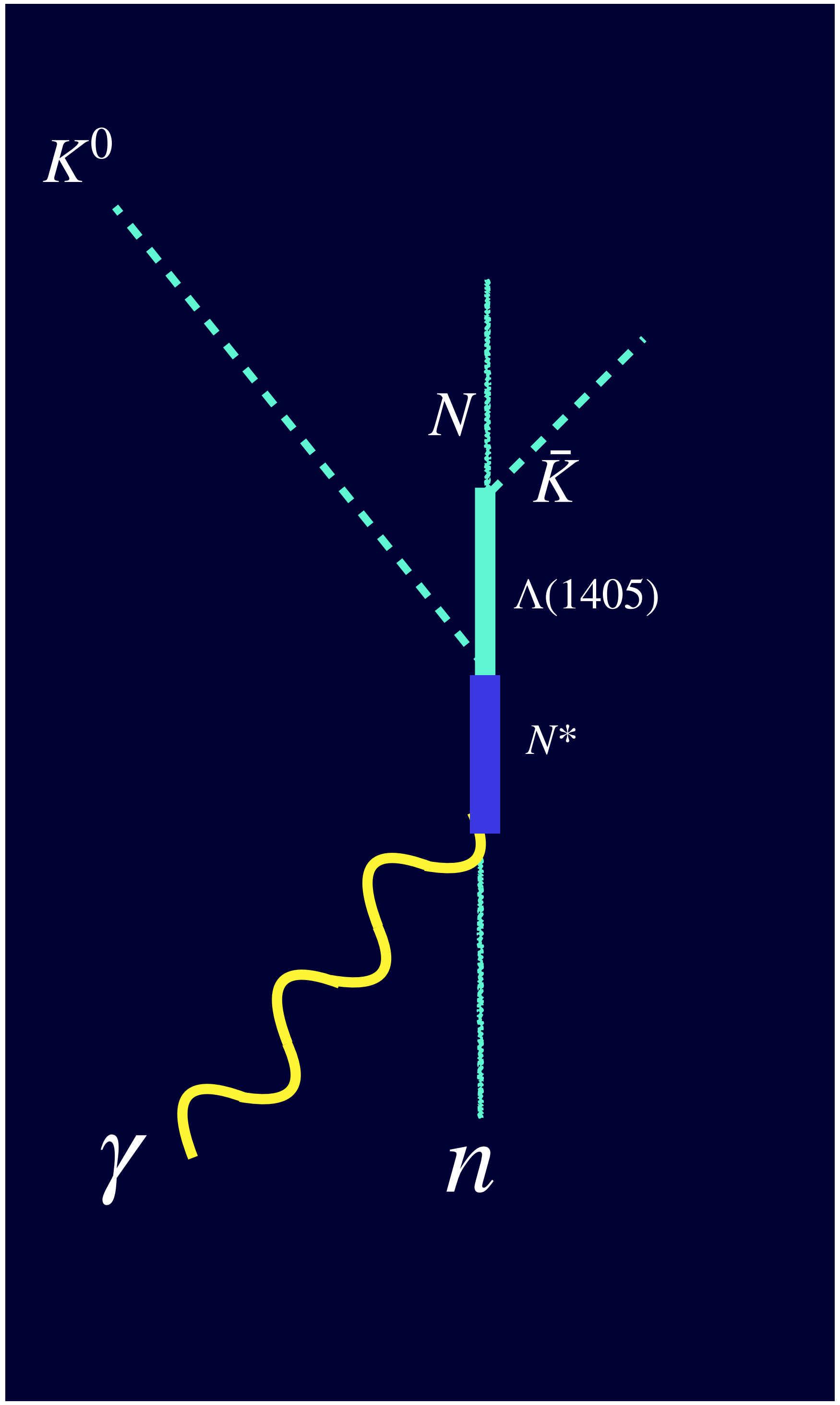
~ 0.5 ub

K*寄与

~ 0.4 ub

N*の寄与やK*の寄与はモデルによって、かなり違う。

$\gamma n \to \Lambda(1405)K^0$ の見積もり



$\gamma NN^* Coupling$の強さの比（保坂さんノート、酒井さんノート参照）と

$\gamma p \to \Lambda(1405)K^+$から求める。

Photoproduction of Λ^* and Σ^* resonances with $J^P = 1/2^-$ off the proton

Sang-Ho Kim,[1,*] K. P. Khemchandani,[2,†] A. Martínez Torres,[3,‡] Seung-il Nam,[1,4,§] and Atsushi Hosaka[5,6,¶]

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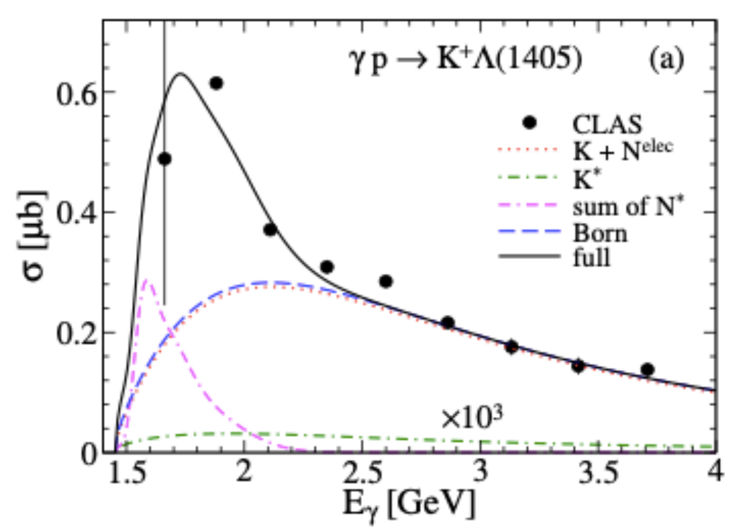
[2] *Universidade Federal de São Paulo, C.P. 01302-907, São Paulo, Brazil.*
[3] *Universidade de Sao Paulo, Instituto de Fisica, C.P. 05389-970, Sao Paulo, Brazil.*
[4] *Asia Pacific Center for Theoretical Physics (APCTP), Pohang 37673, Korea*
[5] *Research Center for Nuclear Physics (RCNP), Osaka University, Ibaraki, Osaka, 567-0047, Japan*
[6] *Advanced Science Research Center, Japan Atomic Energy Agency (JAEA), Tokai 319-1195, Japan*

(Dated: January 22, 2021)



$\gamma n \to \Lambda(1405)K^0$の断面積

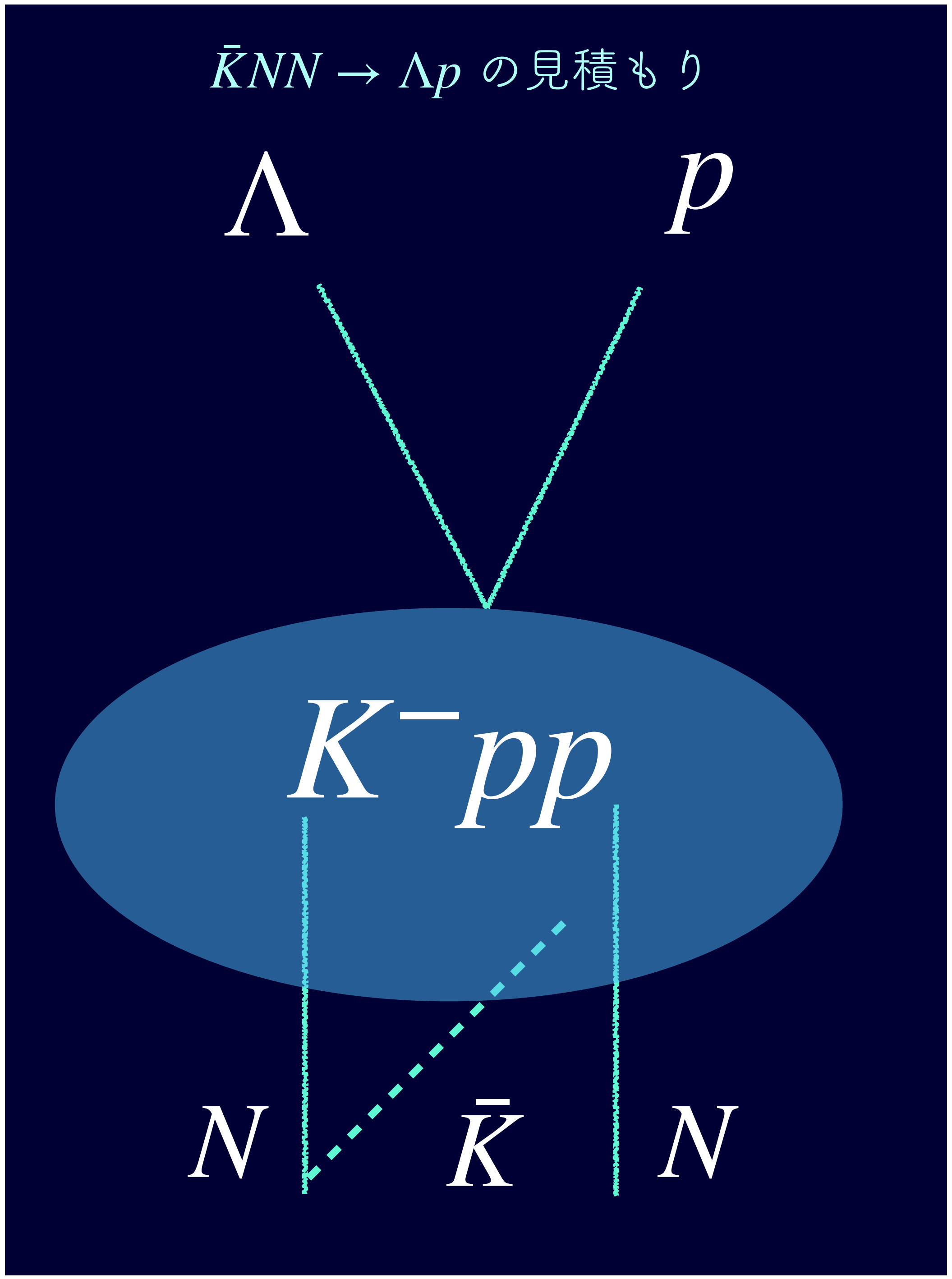
N*寄与

~ 0.03 ub

K*寄与

~ 0 ub

見積もる上での課題

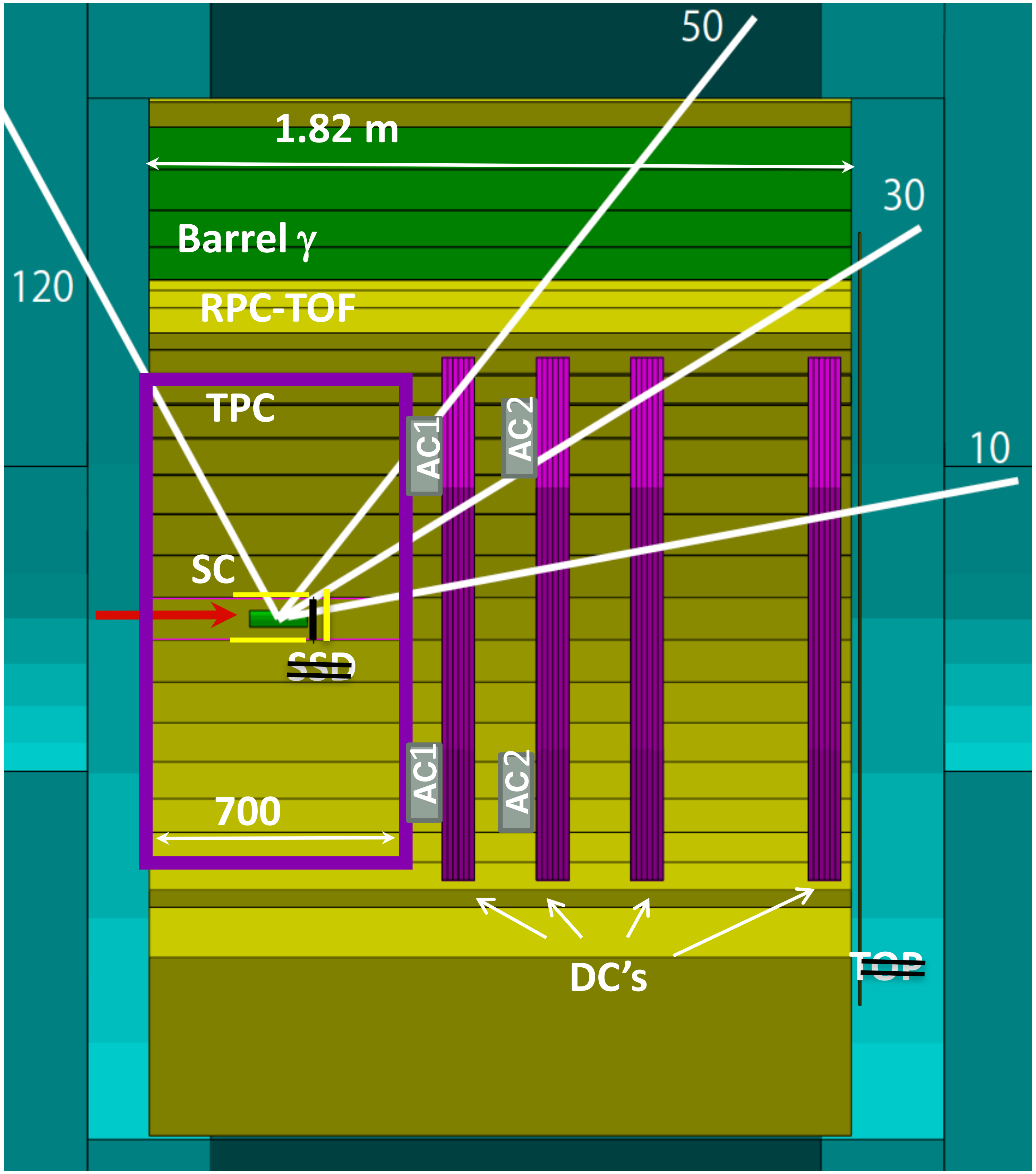


最初の入射する$\bar{K}$が大きな運動量を持っている

知りたいこと

★Λ(1405)生成から何%がKpp経由Λpになるのか

★崩壊後のΛpの角度分布



Tracking system

DC

σ : ∼150 μm

x,x',u,u',v,v'

TPC

σ : ∼400 μm

∼20 layer

PID system

RPC

Δt : ∼50 ps

AC

n=1.03 (30° ∼ 40°)

n=1.05 (40° ∼ 50°)