Charmed Baryon Spectroscopy via the (π, D^{*-}) reactions

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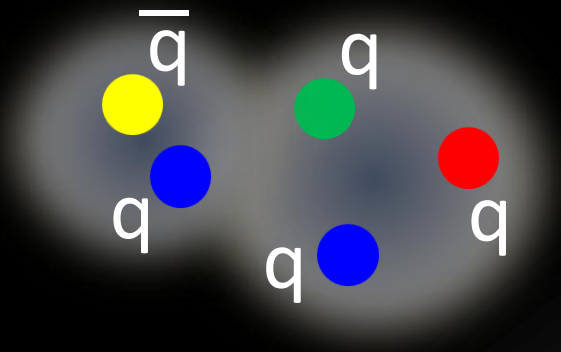
for the P50 collaboration

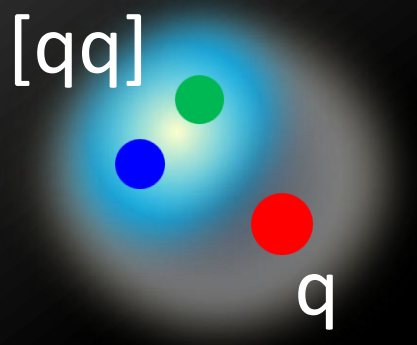
What are good building blocks of Hadrons?

Constituent Quark



hadron (colorless cluster)

Diquark?
(Colored cluster)



Diquarks

Color-Magnetic Interaction of two quarks

$V_{CMI} \sim [\alpha_s/(m_i m_j)]^*(\lambda_i,\lambda_j)(\sigma_i,\sigma_j)$

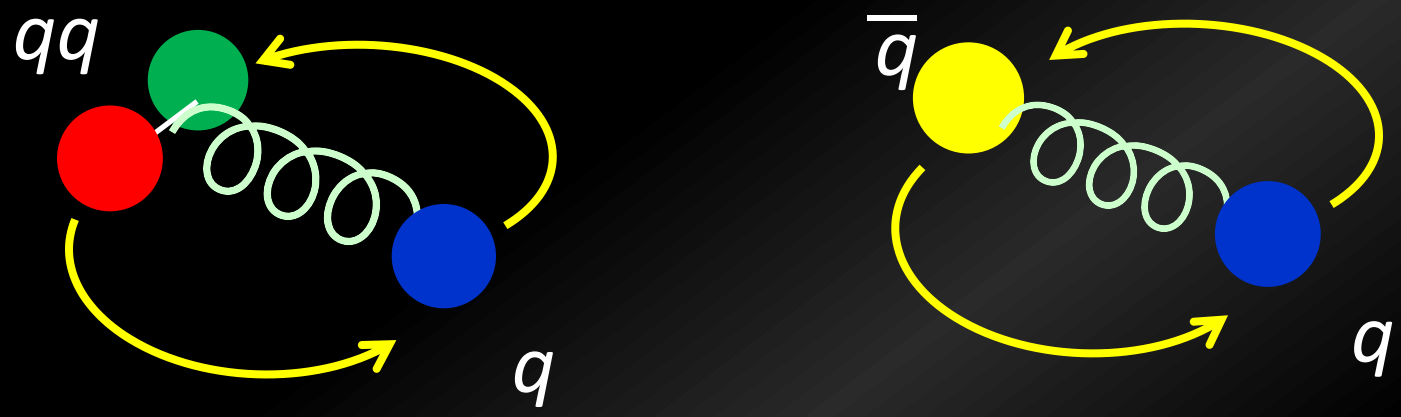
"Good Diquark": Strong Attraction

$V_{CMI}(^1S_0, \overline{3}_c) = 1/2^* V_{CMI}(^1S_0, 1_c)$

[qq] [$\overline{q}$q]

Emergent Diquarks

Baryons as well as Mesons seem to be well described by a Rotating String Configuration with a universal string tension.



$$M^2 \sim \Omega * L$$

A distance of [qq]-q/$\overline{q}$-q increases as L increases.

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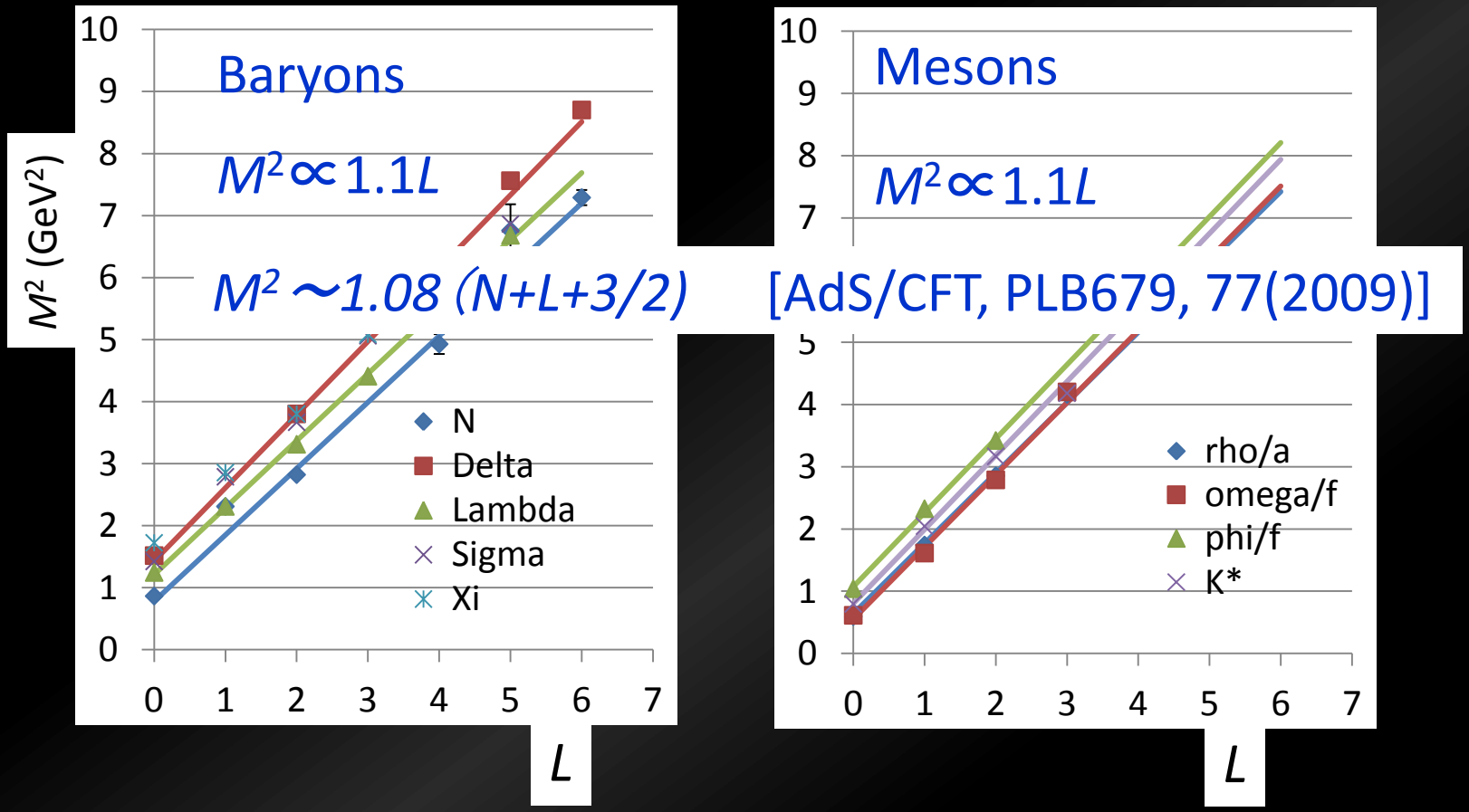

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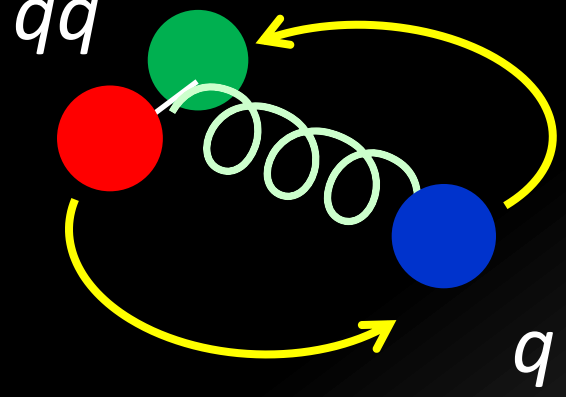
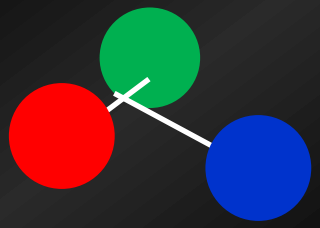
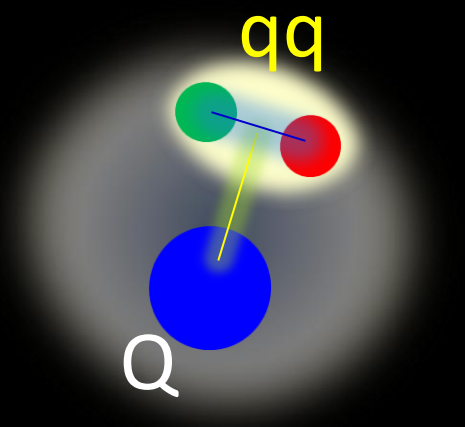


"diquark"
in low-lying modes



Charmed Baryon



$V_{CMI} \sim [\alpha_s/(m_i m_j)]^*(\lambda_i,\lambda_j)(\sigma_i,\sigma_j)$

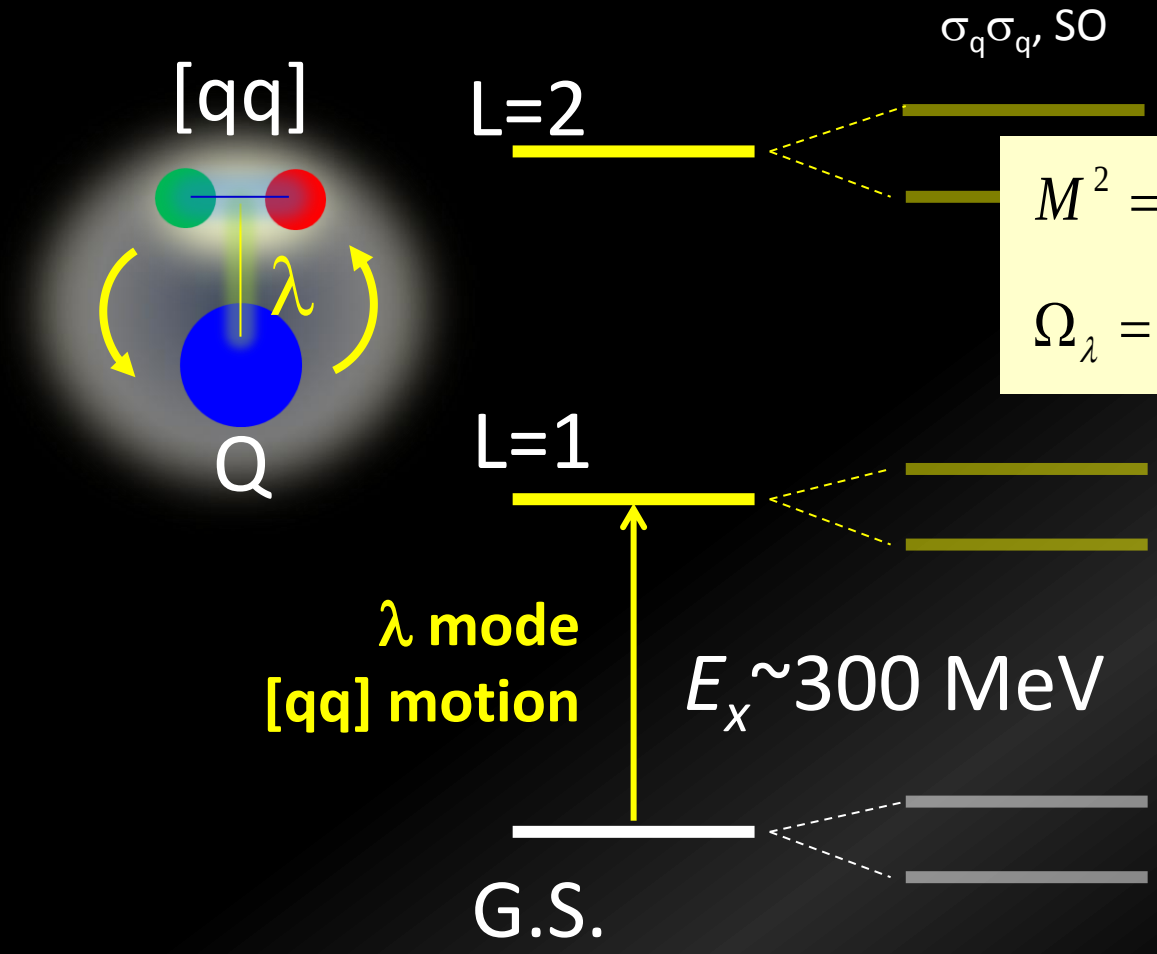
Weak CMI with a heavy Quark

- [qq] is well Isolated and developed

- Level structure of Y_c^* provides diquark properties
  - "diquark mass"

Precision measurement of collective [qq] orbital E_x gives a [qq] mass

Covariant Oscillator QM w/ Universal Spring [PTP 91, 775('94)]



$$M^2 = \Omega_\lambda L + \Omega_\rho L + M_0$$

$$\Omega_\lambda = 2K^{1/2}\sqrt{2(M_Q + m_{qq})^3/(M_Q m_{qq})}$$

Precision measurement of collective [qq] orbital E_x gives a [qq] mass

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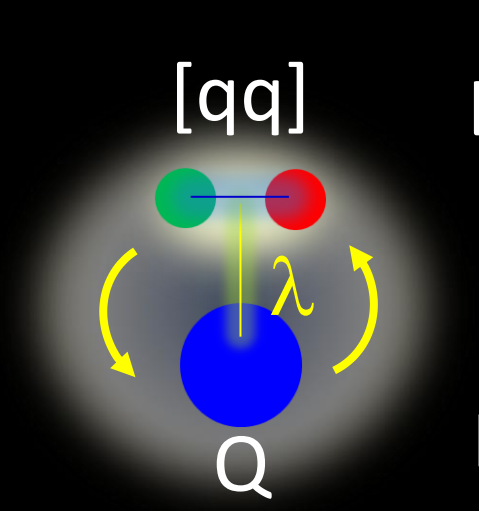


$\sigma_q\sigma_q$, SO

L=2

$$M^2 = \Omega_\lambda L + \Omega_\rho L + M_0$$

$$\Omega_\lambda = 2K^{1/2}\sqrt{2(M_Q + m_{qq})^3/(M_Q m_{qq})}$$

L=1

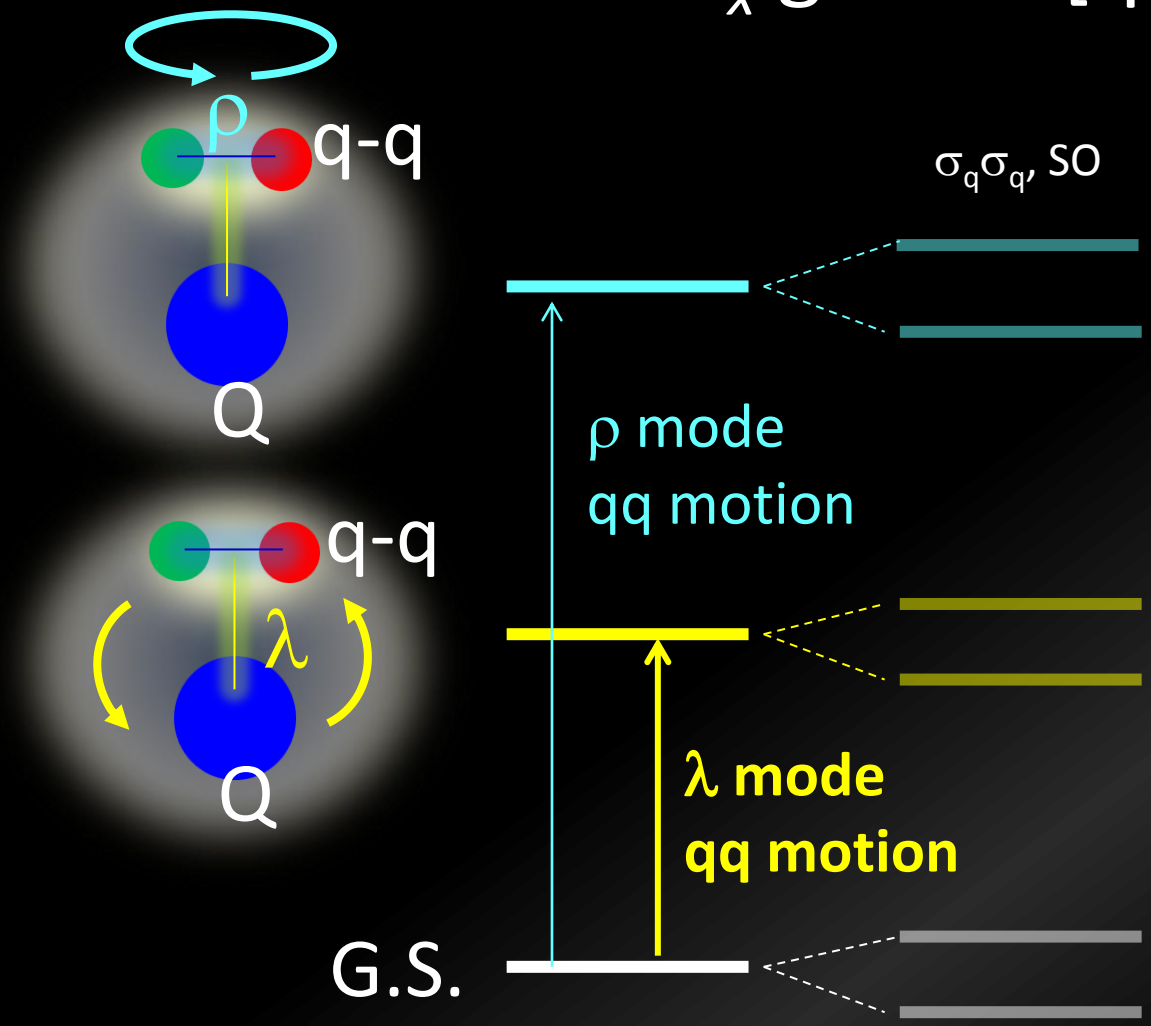
λ mode
[qq] motion

E_x~300 Me

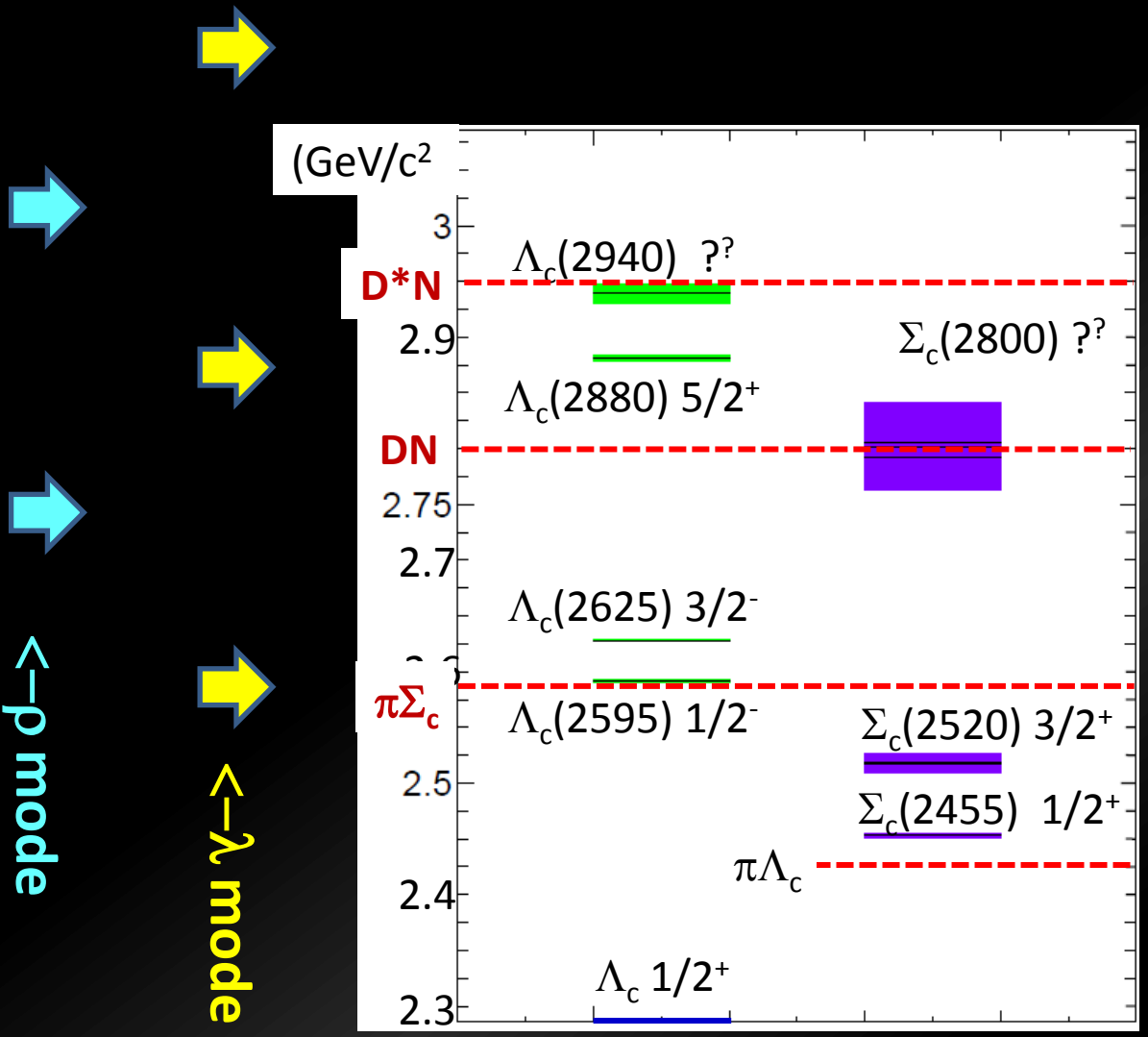
$$dE_x \sim dm_{qq}/30\,[\mathrm{MeV}]$$

G.S.

Precision measurement of Collective [qq] orbital E_x gives a [qq] mass



Limited # of Charmed Baryons have yet been observed.



What we will measure…

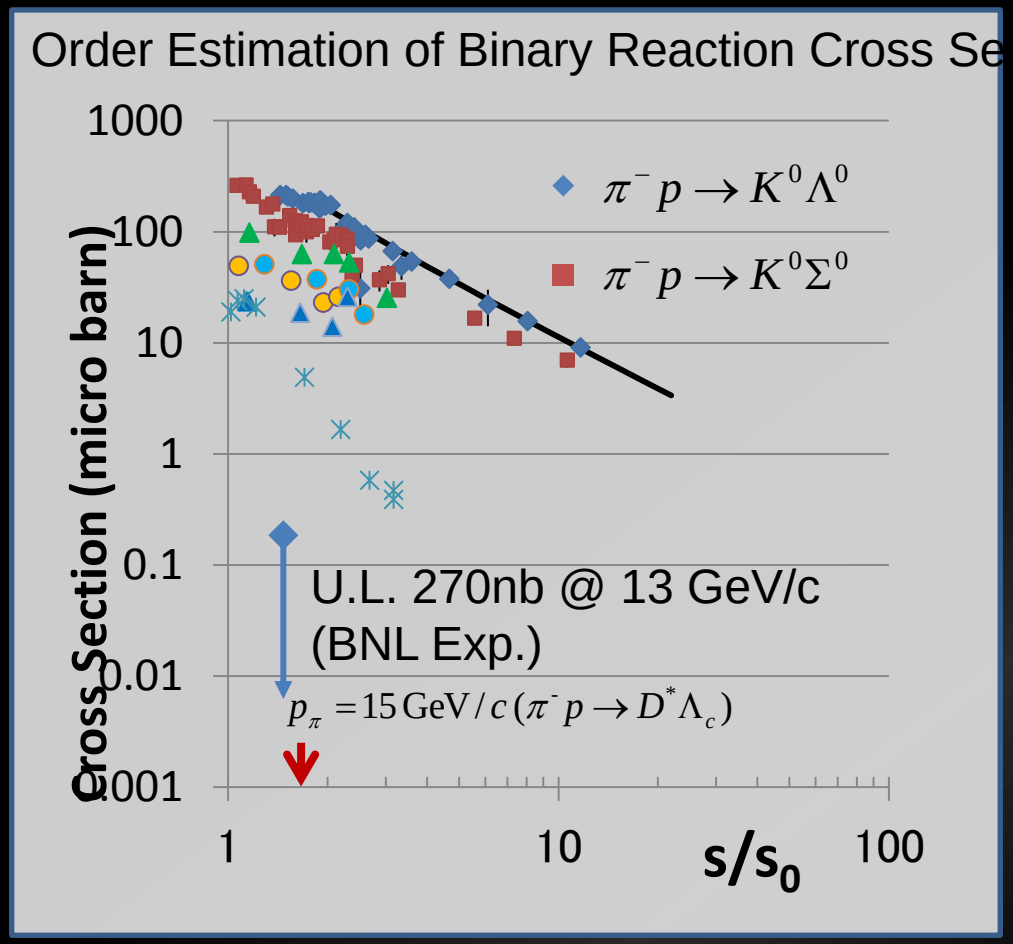
Missing mass spectroscopy via the (π,D*-) reactions.

- Excitation Energies and widths of charmed baryons
  - From the G.S. to highly E.S. of E_x>1 GeV w/ ~5.5 MeV res.
  - Independent of decay final states
- Decay properties of the populated states
  - Strong BG suppressions for the parent states
  - Decay branching ratios (Partial widths)
  - Possible assignment of spins

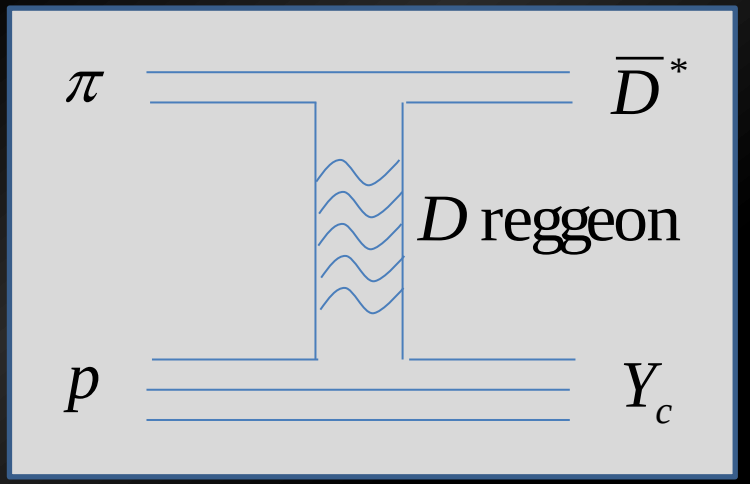
Production Cross Section

No exp. data : σ<270nb@13 GeV/c (PRL55, 154(1985))

Estimation: $10^{-4\sim-5}$ of $\sigma(\pi^- p \to K\Lambda, K\Sigma) \sim 1$ nb



Binary Reaction at High E is well described as quark planar diagram.



A.B. Kaidalov, ZPC12, 63(1982)

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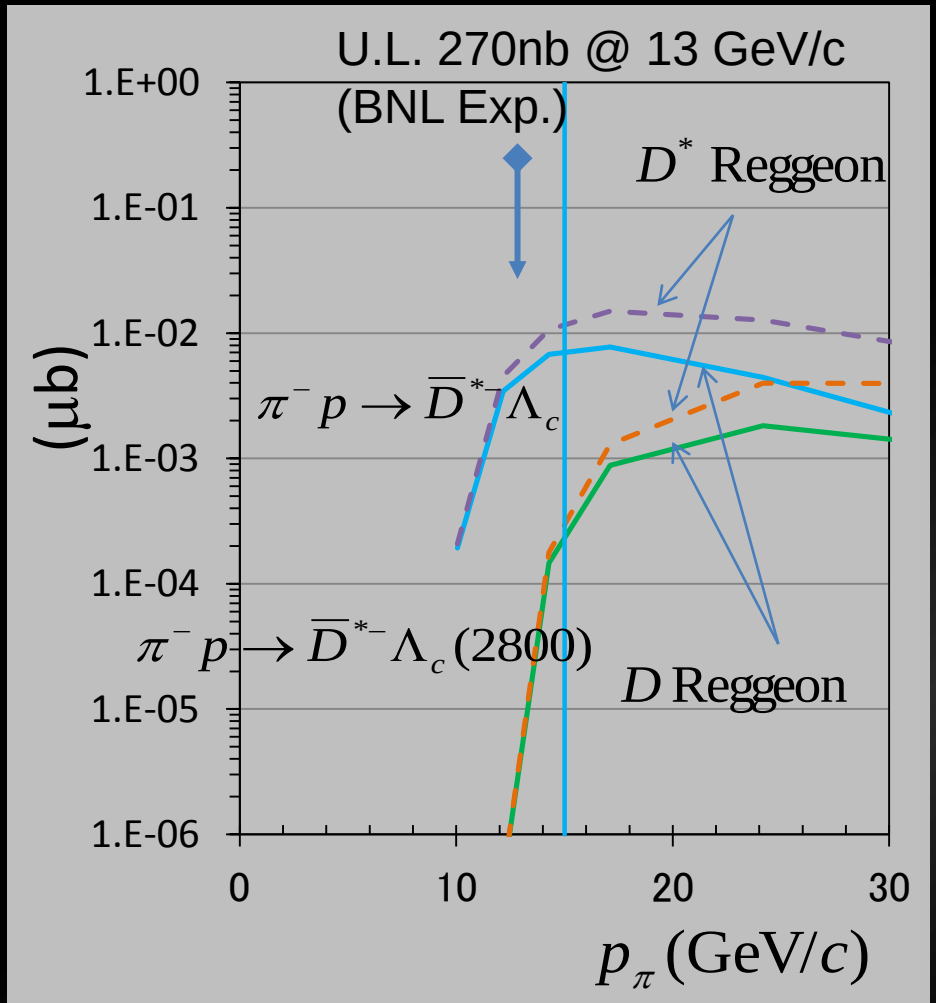

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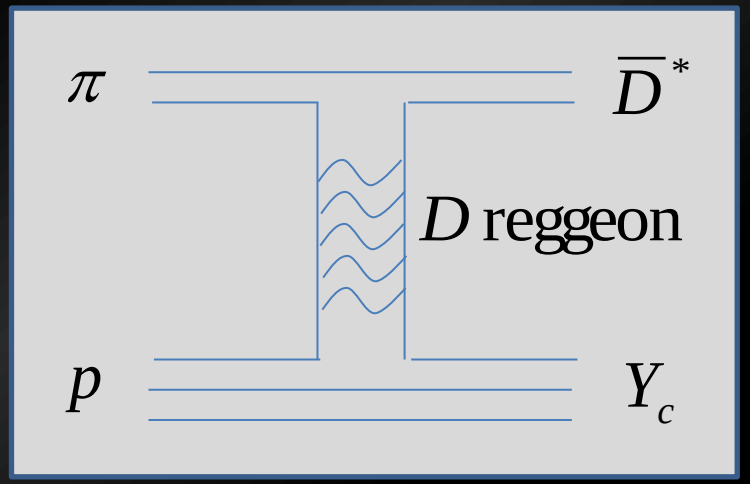
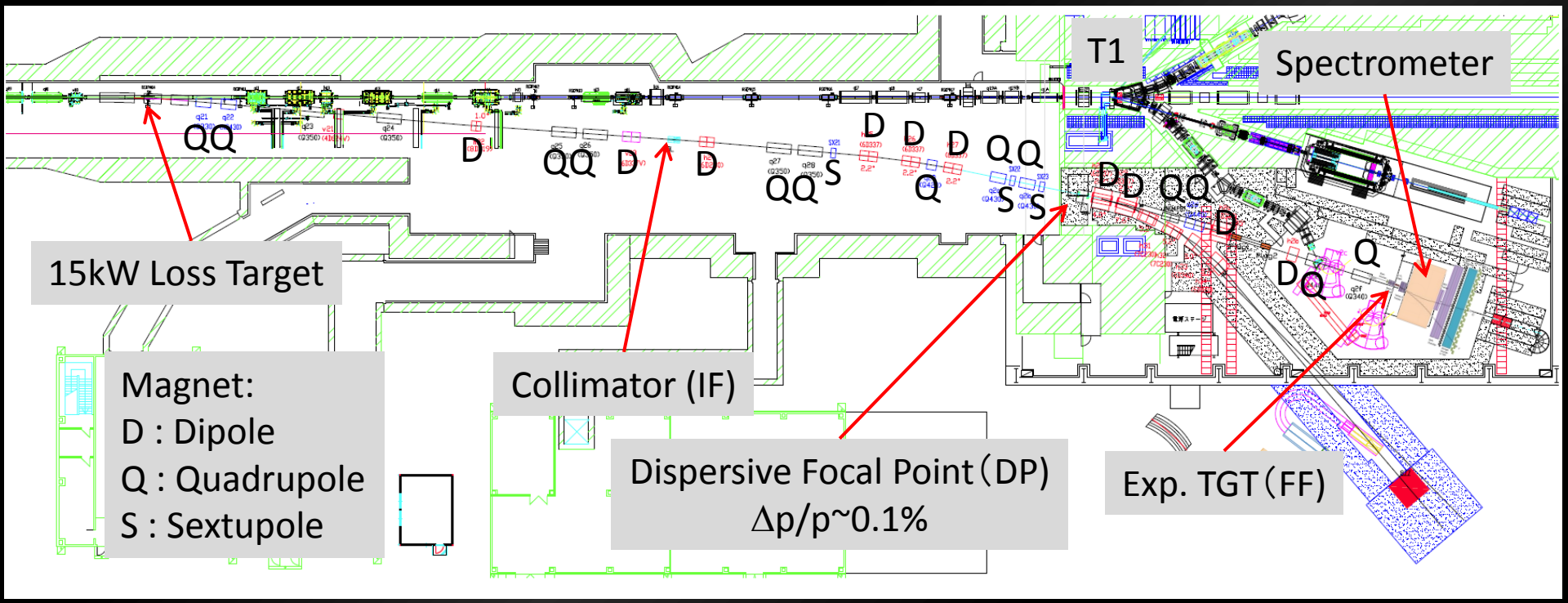


A.B. Kaidalov, ZPC12, 63(1982)

High-res., High-mom. Pion Beam

- High-intensity secondary Pion beam can be delivered.
  - 2 msr・%、1.0 x 10^7 Hz @ 15GeV/c π
- High-resolution beam: $\Delta p/p$~0.1%
  - Momentum dispersion and eliminate 2nd order aberrations



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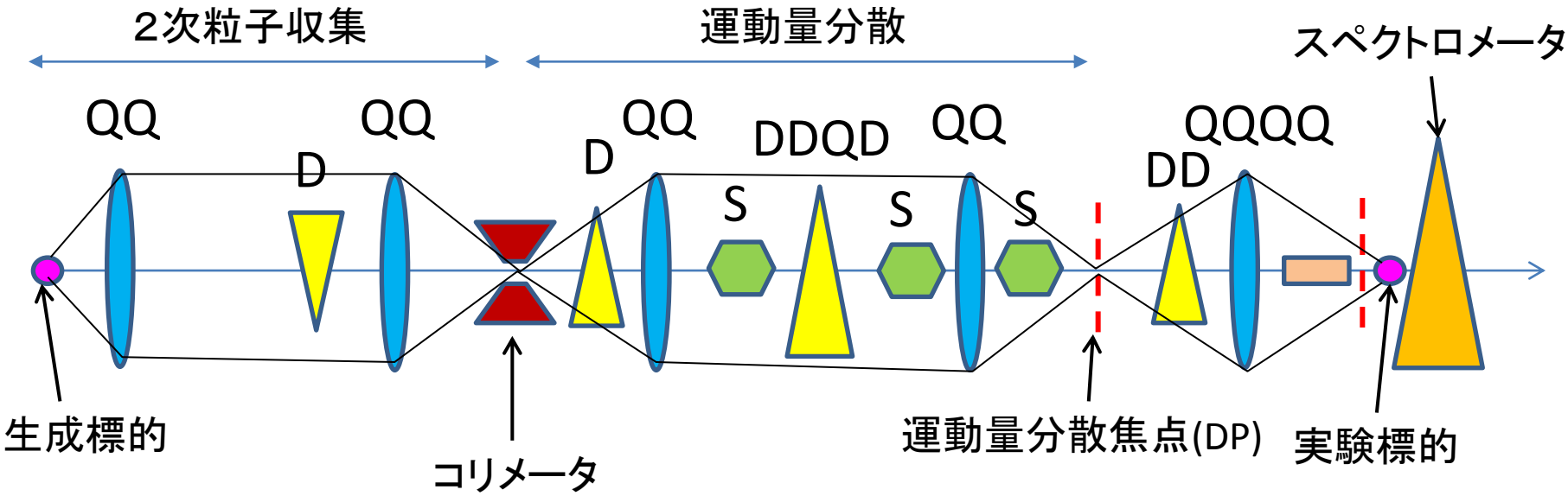
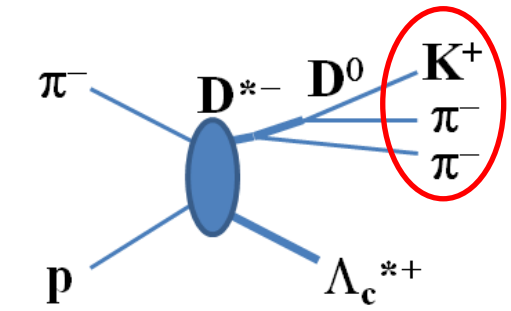
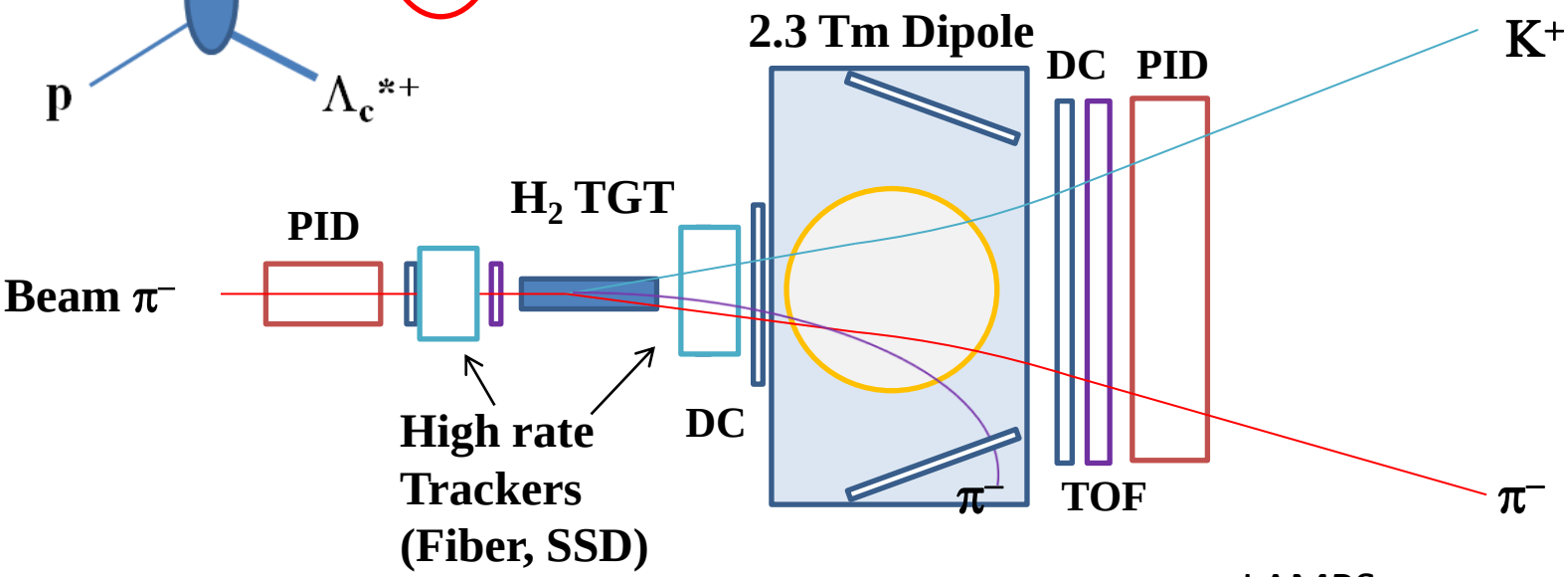
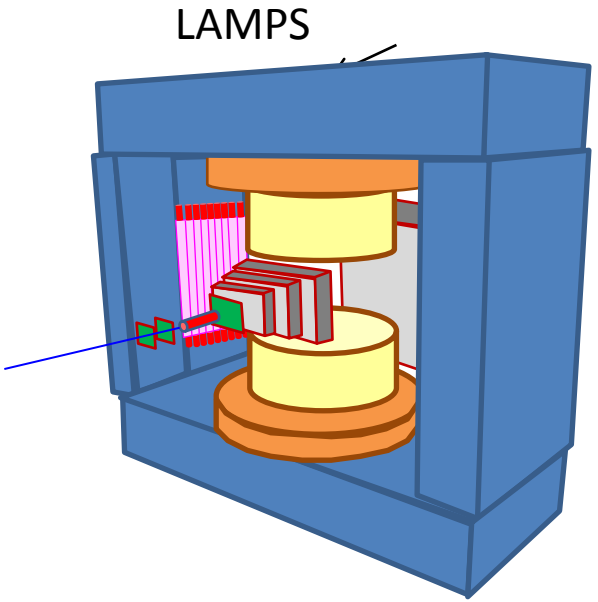


Spectrometer Concept

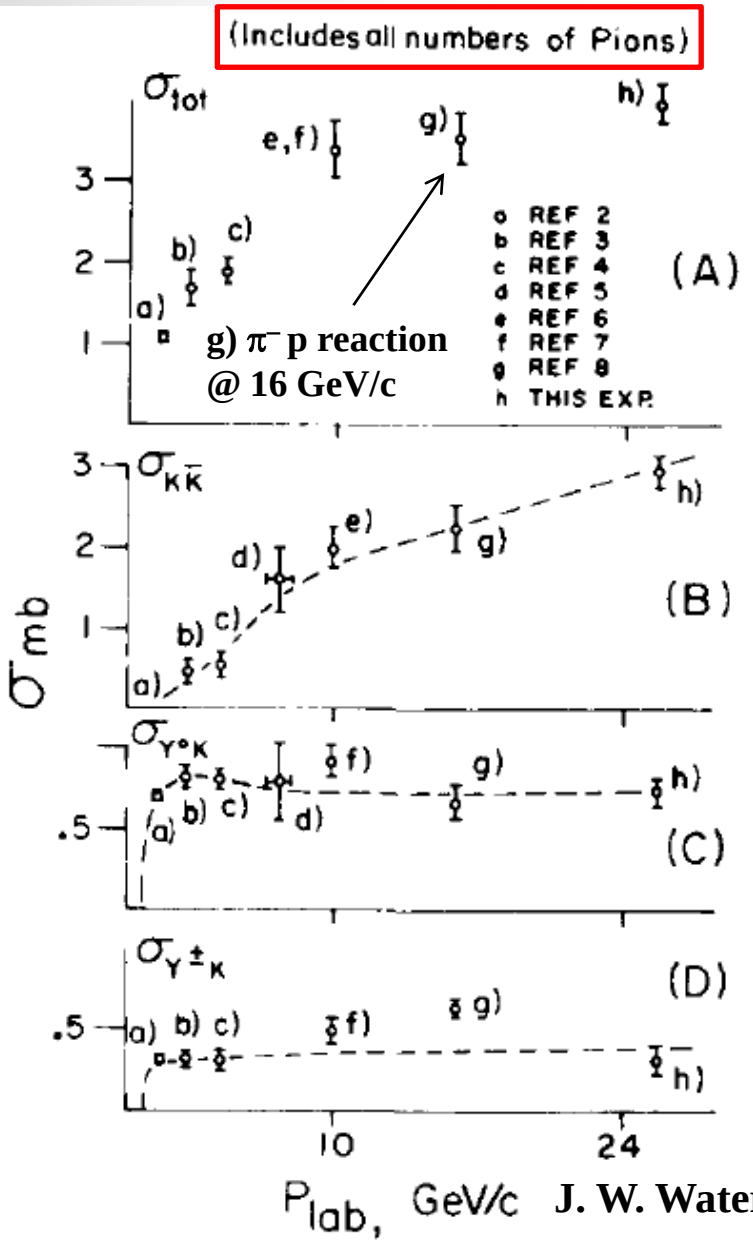




- Large Acceptance, Multi-Particle
  - *K*, π from D^0 decays
  - Soft π from D^{*-} decays
  - (Decay products from Y_c^*)
- High Resolution
- High Rate
  - SFT/SSD op. >10M/spill at K1.8



Background Reduction



(A) Any s-production: 3.4(4) mb

(B) K-pair production: 2.1(3) mb

- $K^+ K^-$, $K_1^0 K_2^0$, $K_2^0 K_2^0$

(C) Y^0 production: 0.7(2) mb

- ΛK^0, ΛK^+, $\Sigma^0 K^0$, $\Sigma^0 K^+$

(C) $Y^\pm$ production: 0.6(1) mb

- $\Sigma^+ K^0$, $\Sigma^+ K^+$, $\Sigma^- K^0$, $\Sigma^- K^+$

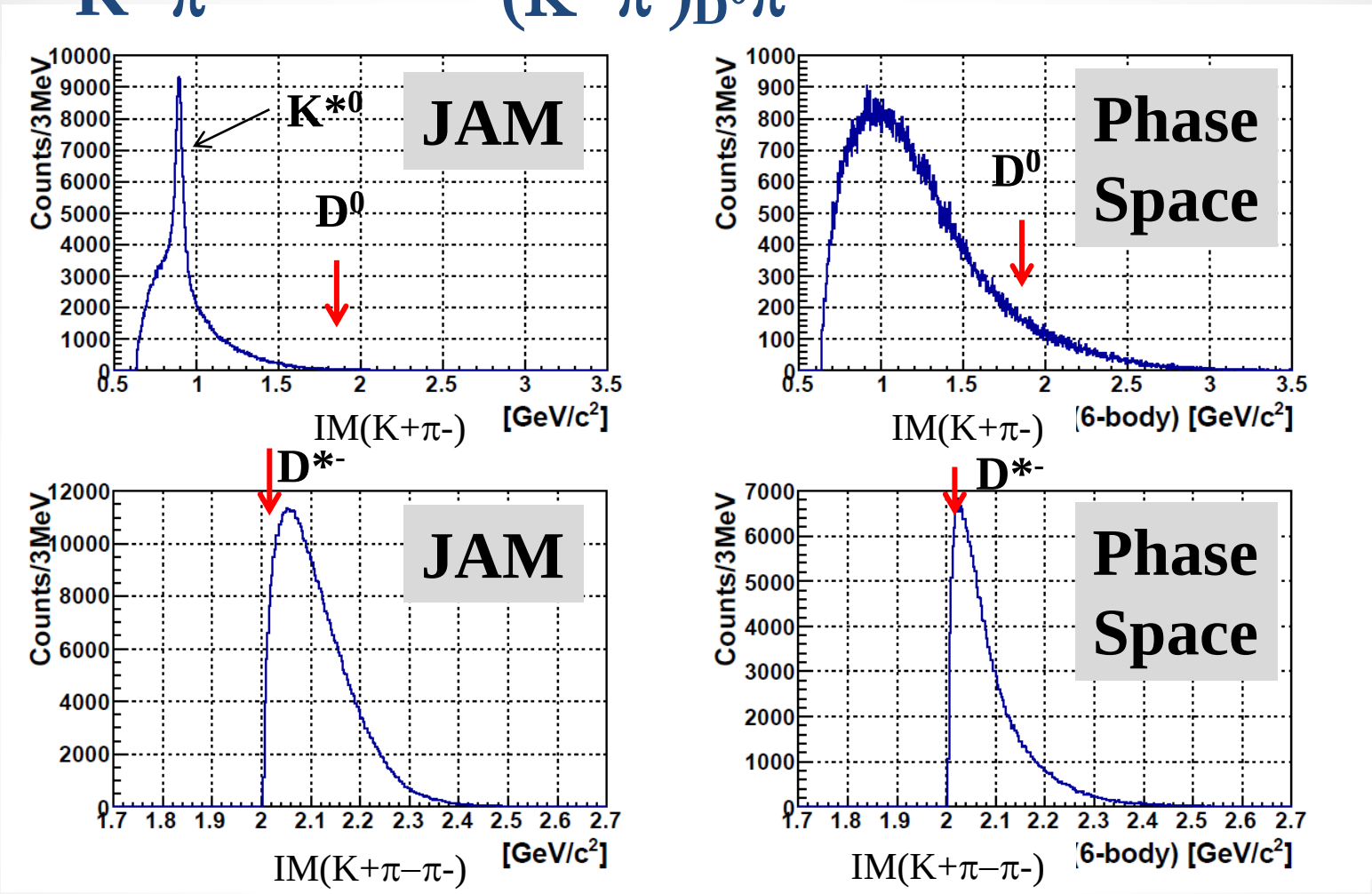
- $\sigma(K_1^0 X) = 1.15 \pm 0.12$ mb

σ_{BG}=3.4mb at most (A)

Mission:
Pick up ~nb signals out of ~mb BG

J. W. Waters et al, NPB17 (1970) 445

$IM_{K^+\pi^-}$ & $IM_{(K^+\pi^-)_{D^0}\pi^-}$ reconstruction



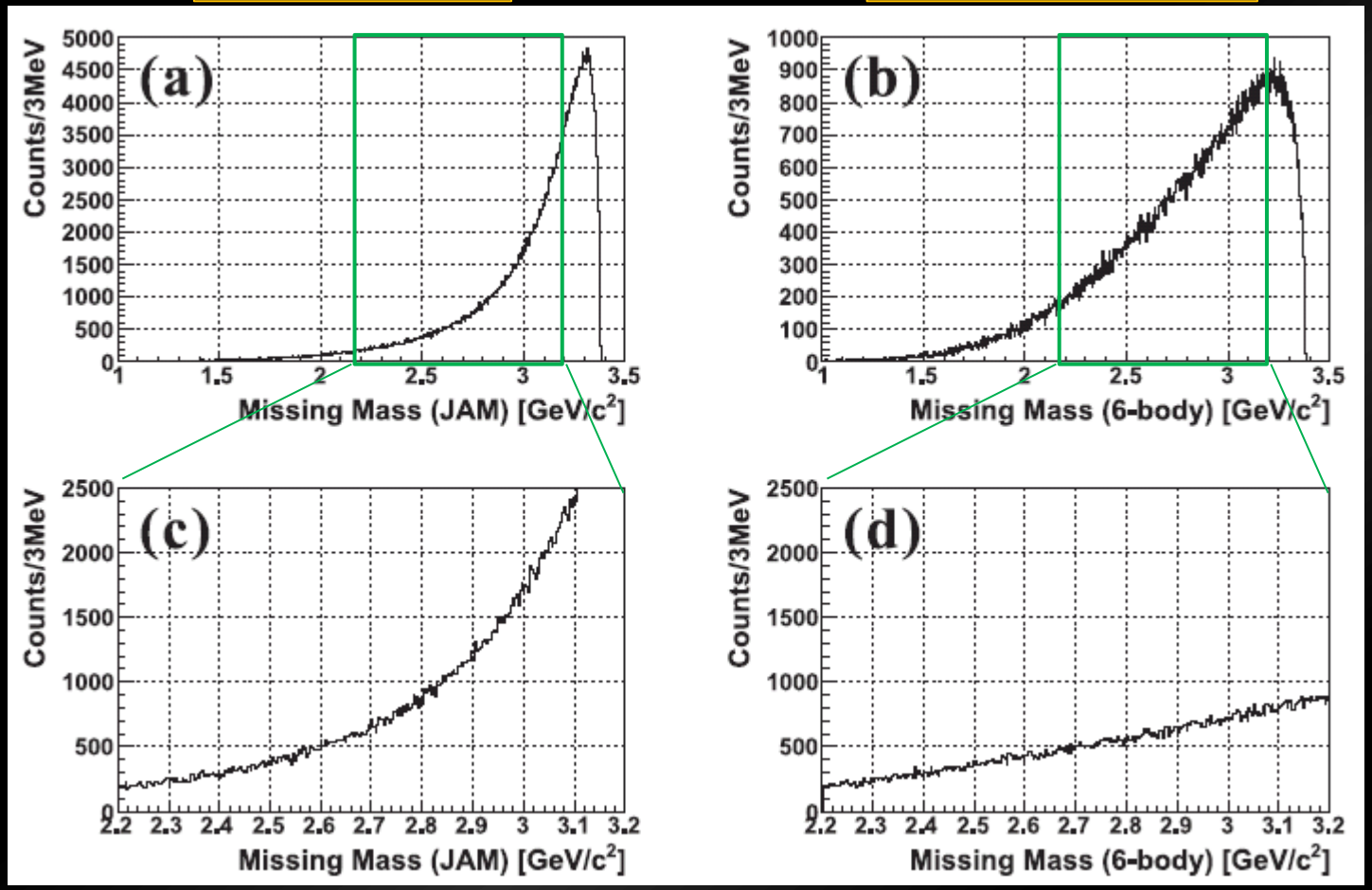
JAM: Simulation Code for ultra-rel. Nucl. Collision

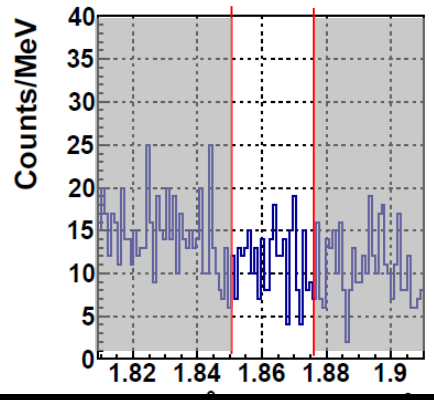
Phase Space: Isotropic distribution in multi-body P.S.

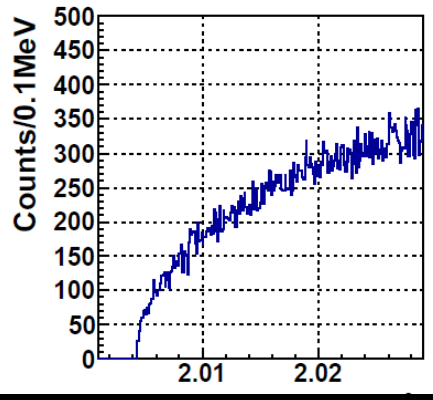
Background Shapes in $MM_{\pi^- p \to D^{*-} X}$

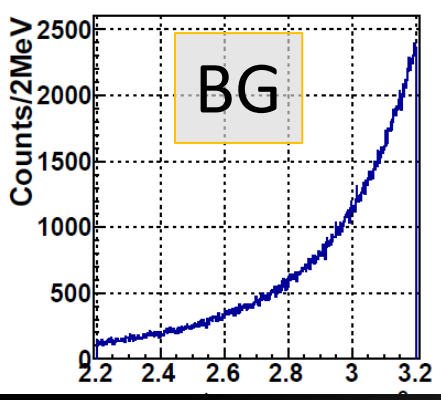
JAM code

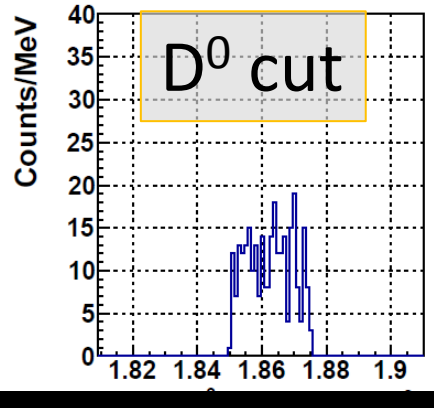
Phase space

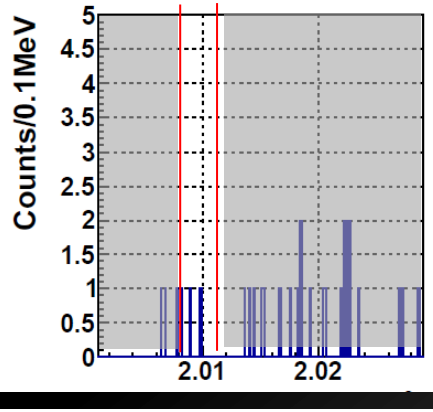


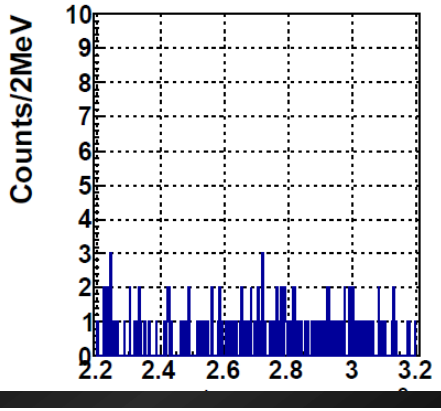


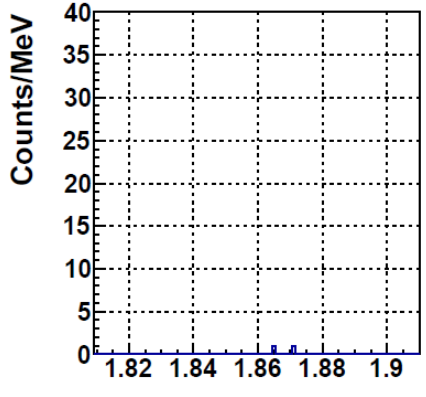




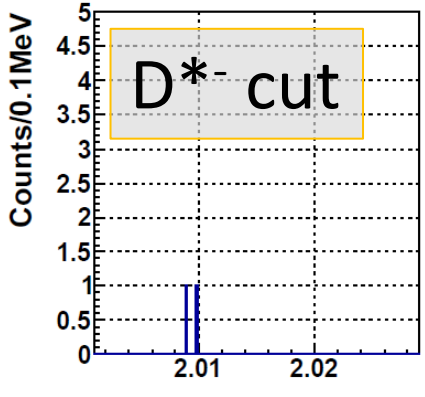








IM($K^-\pi^+$) [GeV/c^2]



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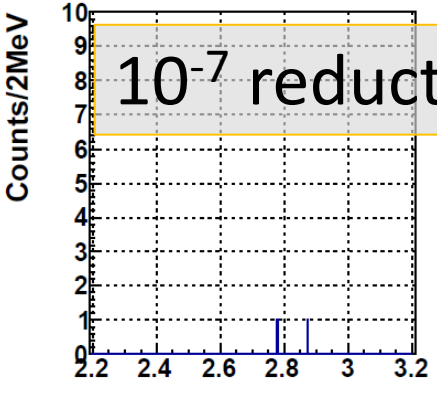
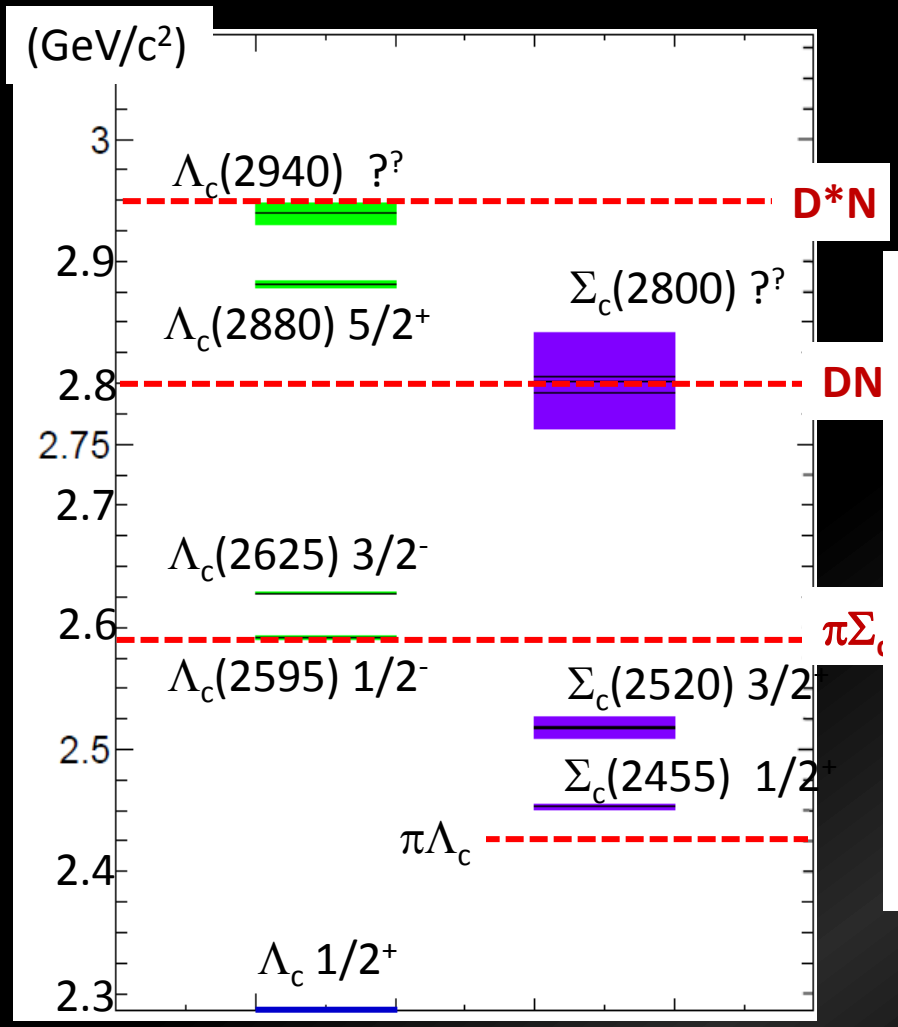
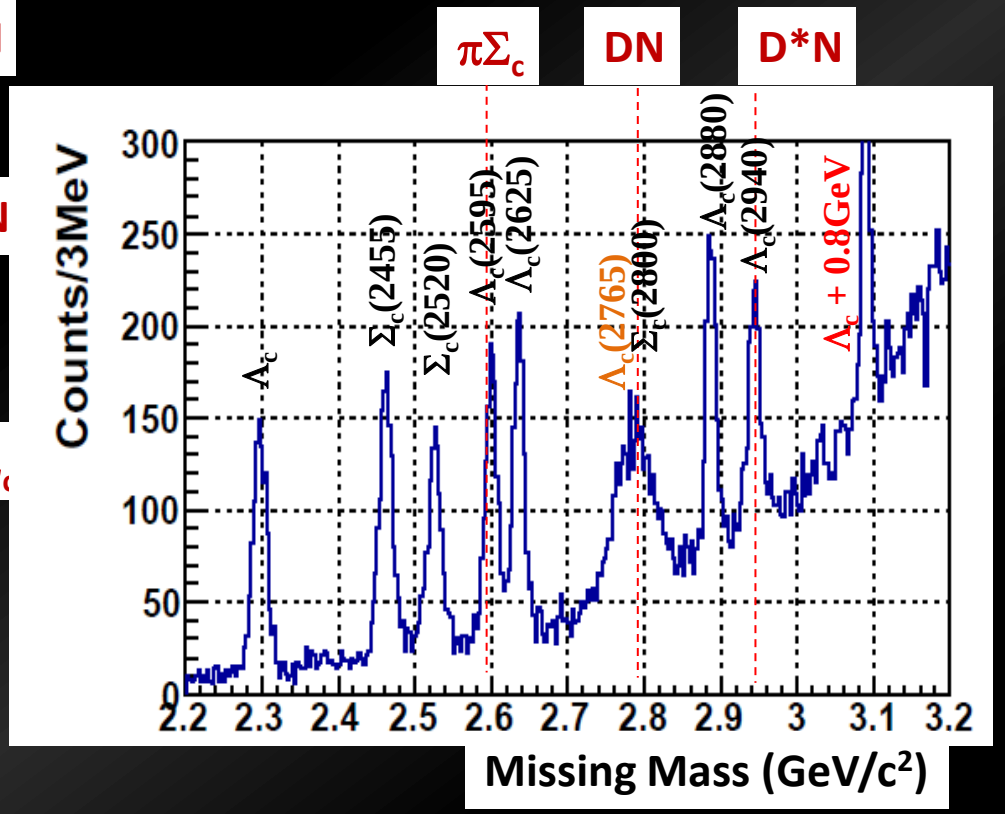


MM((π^-,D*-)) [GeV/c^2]

Expected Spectrum in the (π,D*$^-$) reaction

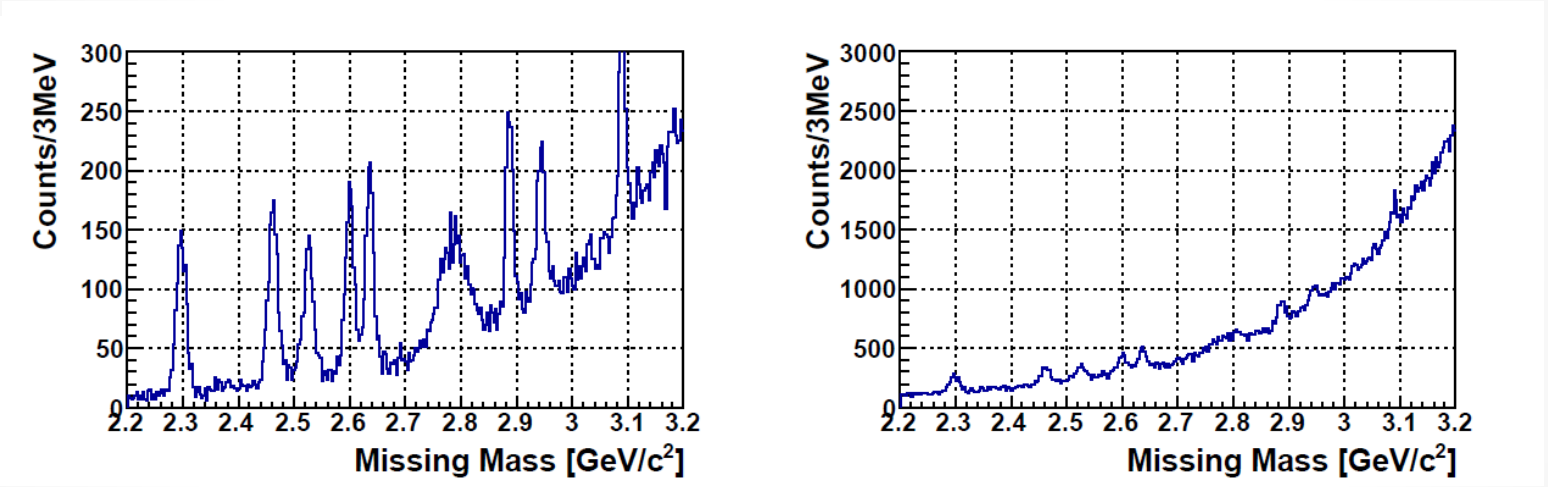


Signal: 1 nb/Yc* :~1000 events
BG: 1.8 mb (JAM)



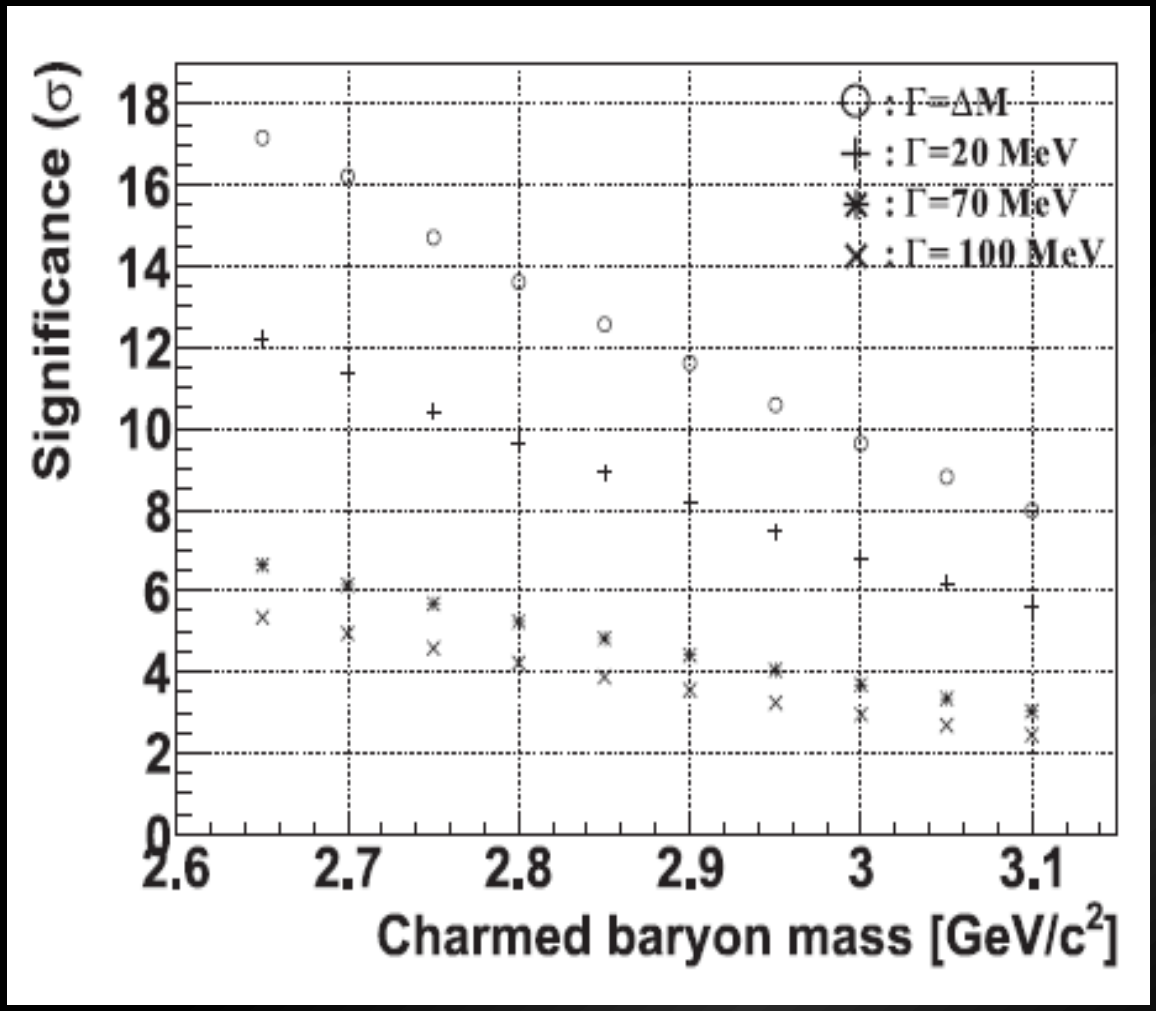
Missing mass spectra w/ Y_c*

10^{-7} BG eduction → **10 times more BG**



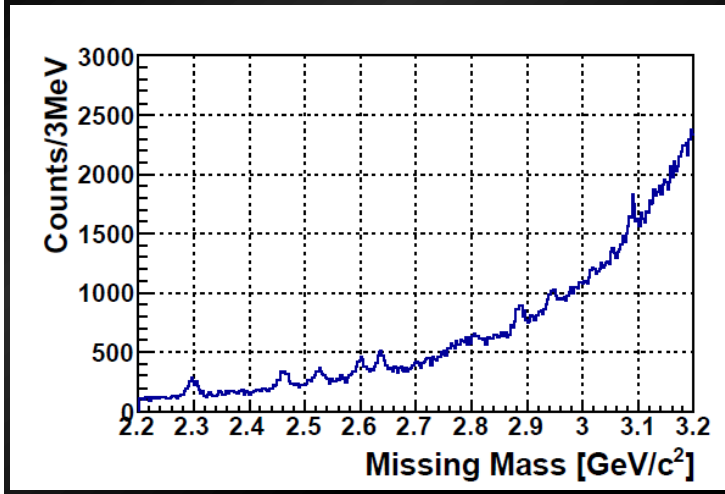
- Assuming 10^{-7} and 10^{-6} BG reduction, generated by using the JAM code
  - BG: σ_{tot} = 1.8 mb
- For each Y_c*, production cross section of 1 nb, mass and width from PDG
  - ~1000 counts for each Y_c*

Signal Sensitivity



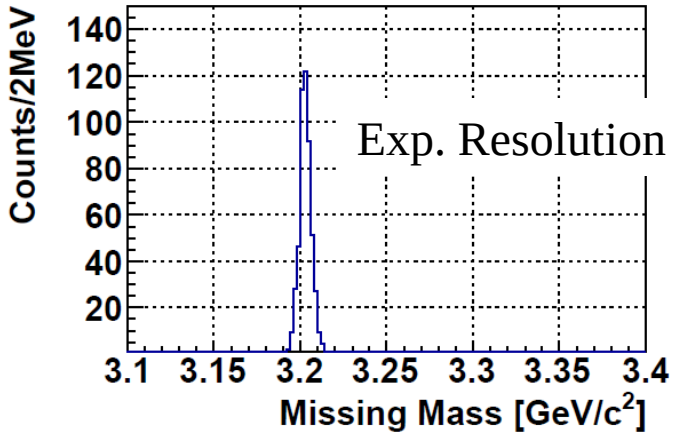
Signal: 1000 events

BG: 10^{-6} reduction

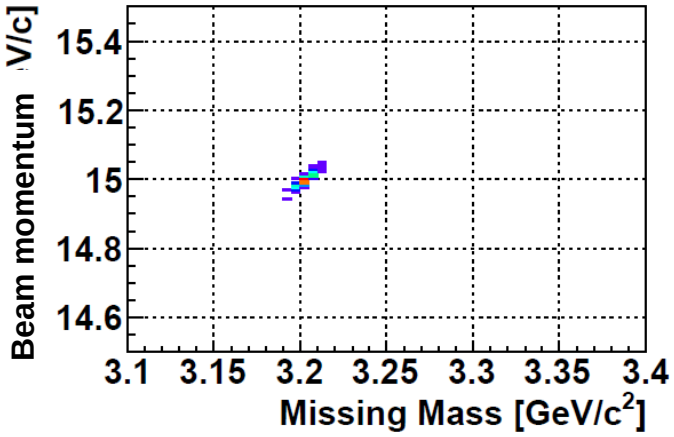


Reflection: $\pi^- p \rightarrow (D^{*-} D^{*+})_X n$

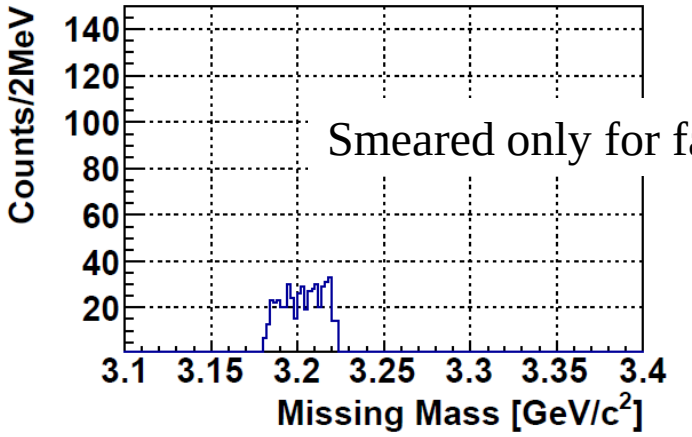
Mono-chromatic beam



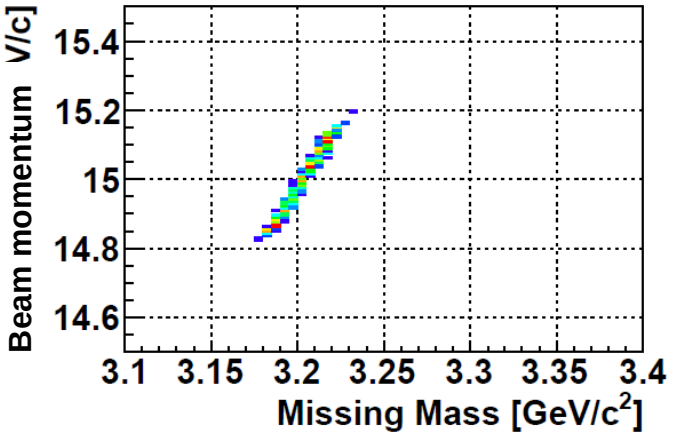
Exp. Resolution



Dispersive beam

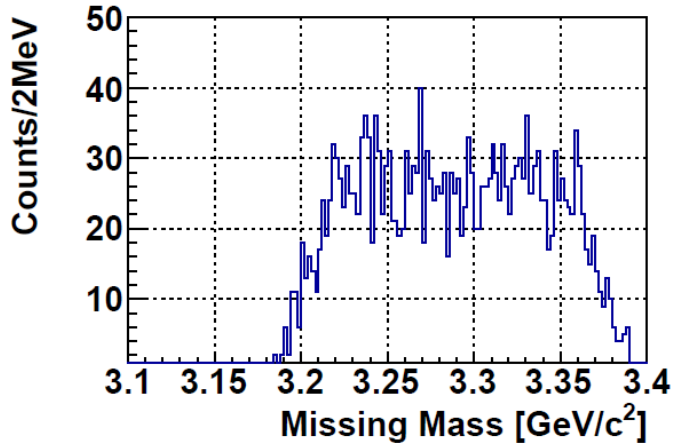


Smeared only for fake

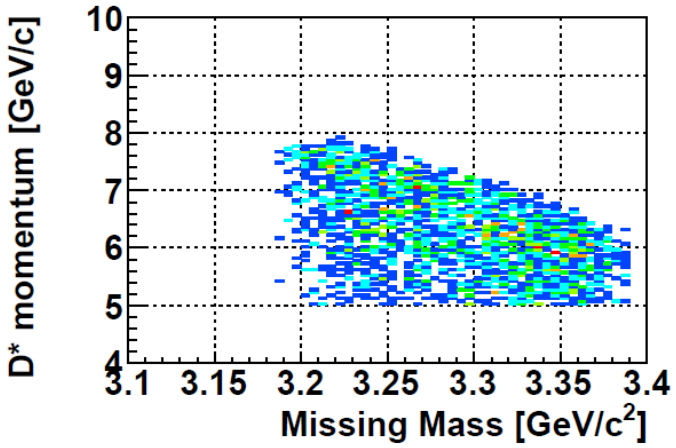


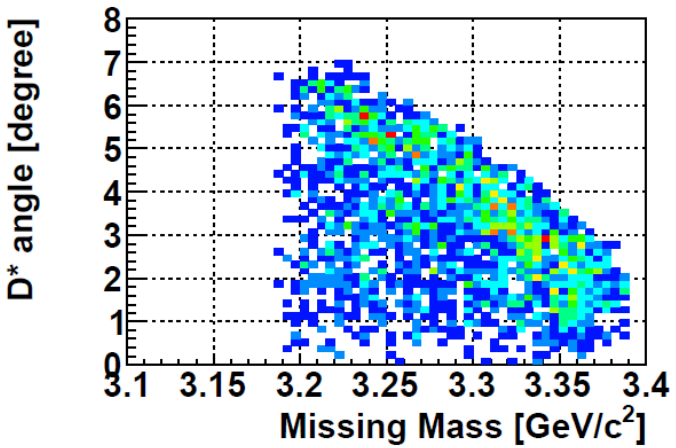
D*- scattering angle fixed ($\theta = 0^\circ$, $\phi = 0^\circ$)

Reflection: $\pi^- p \rightarrow (D^{*-} D^{*+})_X n$



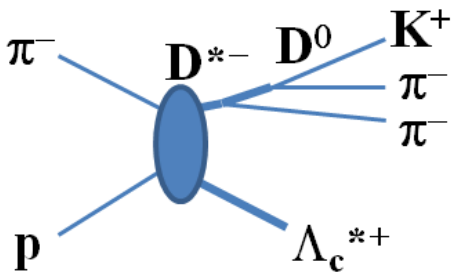
Isotropic angular distribution:
Smeared ~150 MeV in the MM spectrum

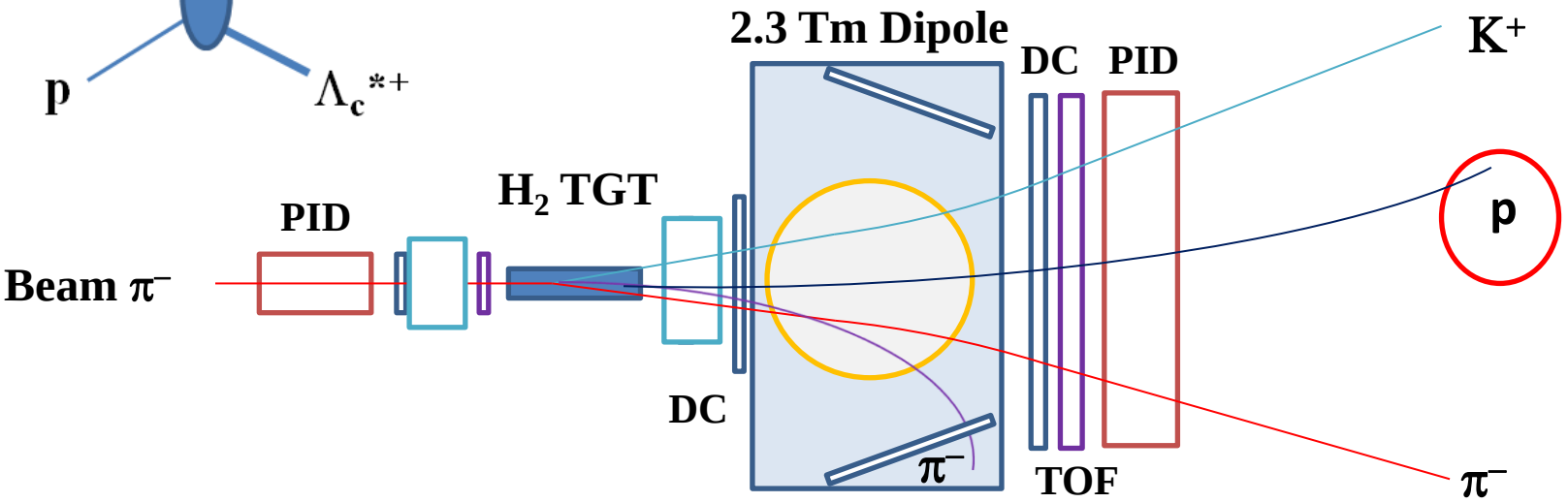




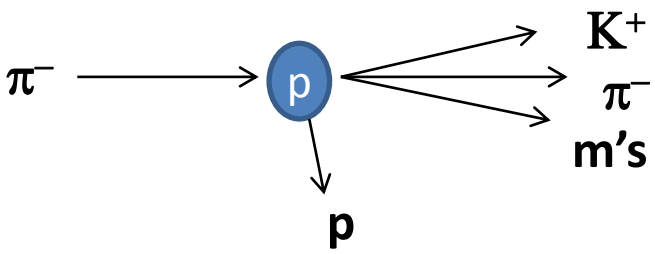
- **MM has Correlation w/ Momentum transfer (angular correlation)**
- **Bump position changes as an incident momentum.**

Spectrometer Concept

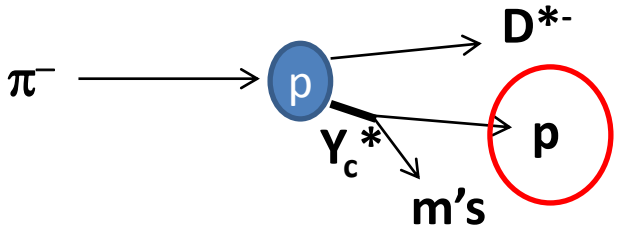




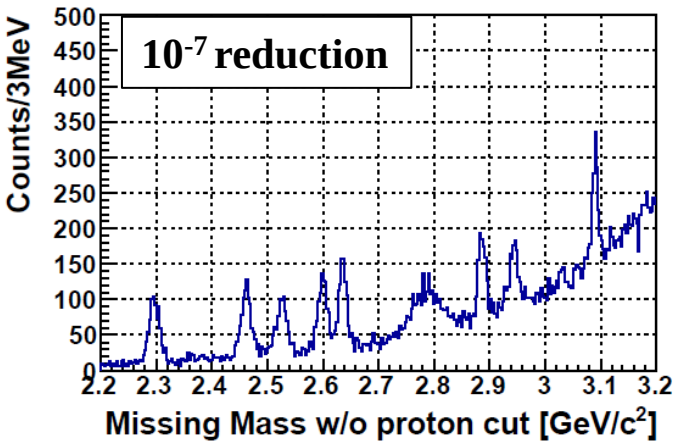
Multi-meson productions (BG)

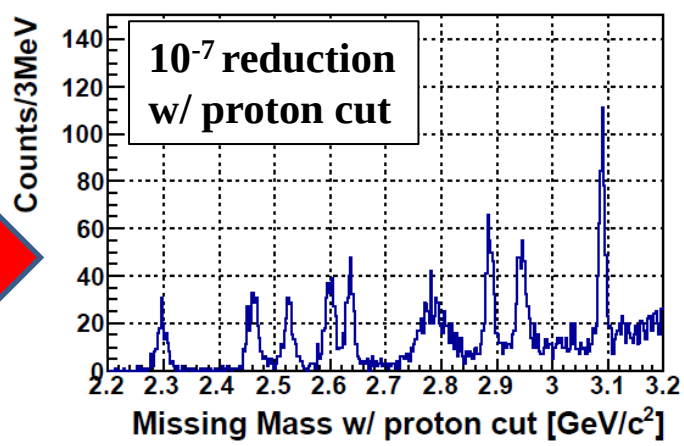


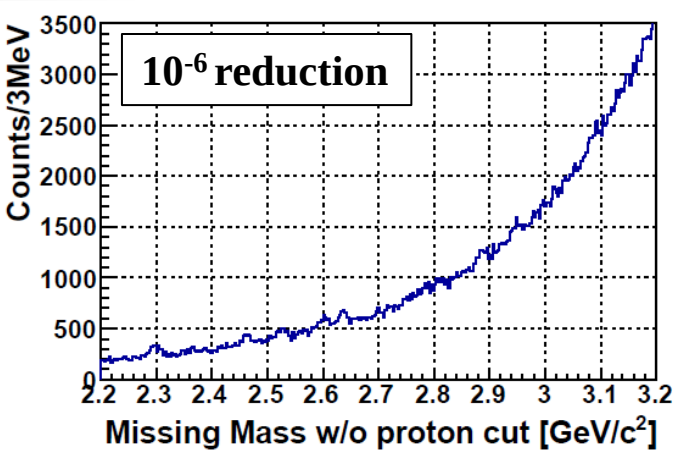
Y_c* production (Signal)

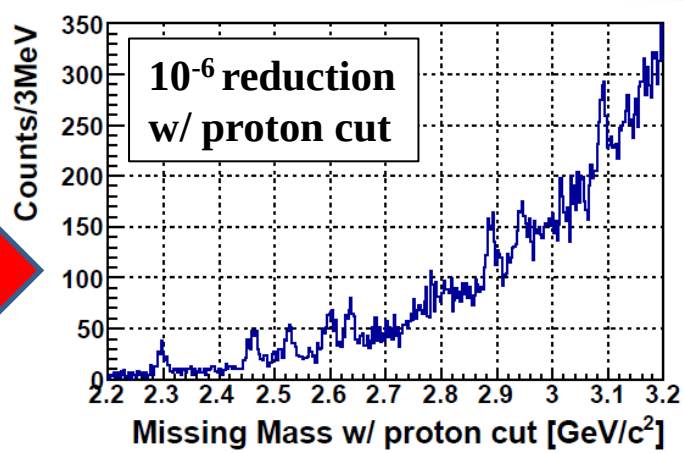


Forward proton detection



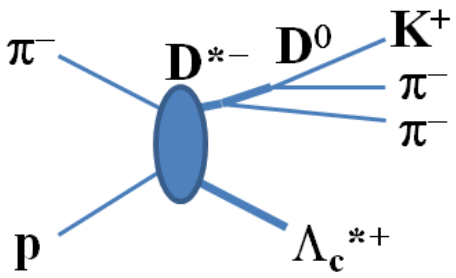


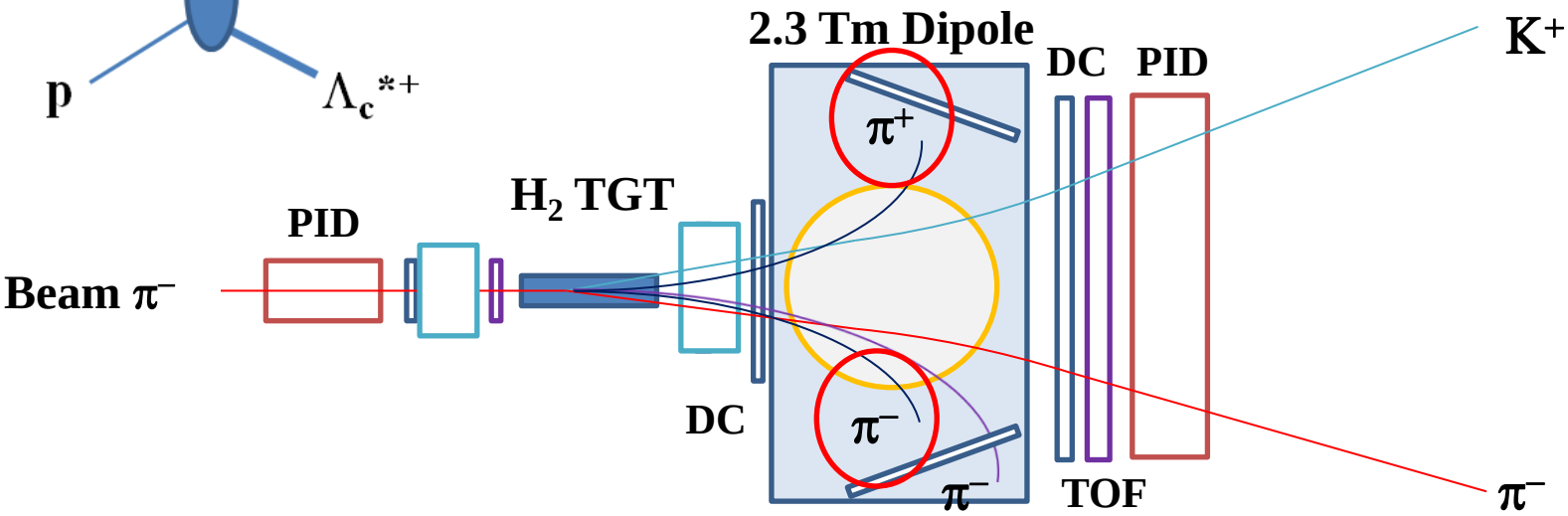




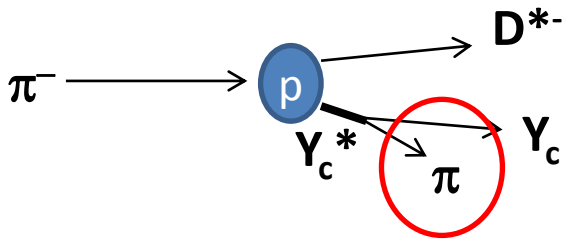
- **Further BG reduction (significance ⇒ × 1.5)**
  - **Yied for Y_c* is reduced to be 1/4**
  - **S/N is improved from 1:15 ⇒ 1:6 @ $\Lambda_c(2880)$**

Spectrometer Concept

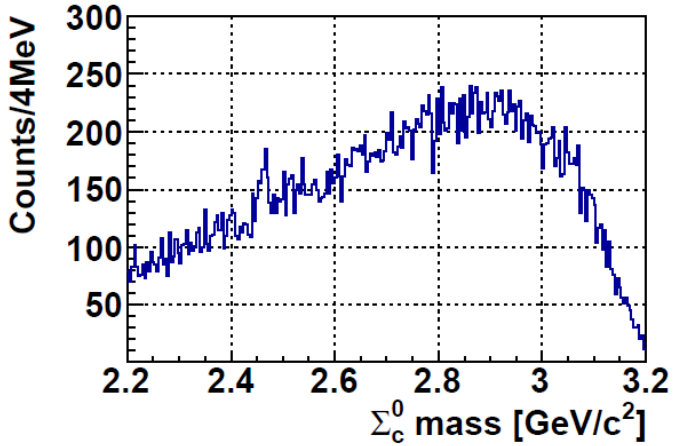


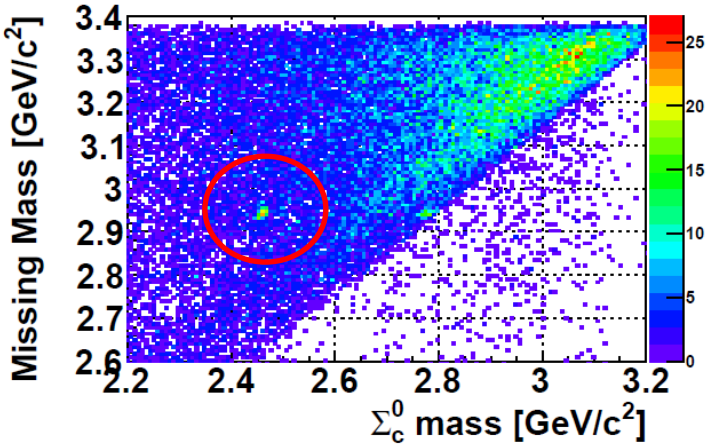


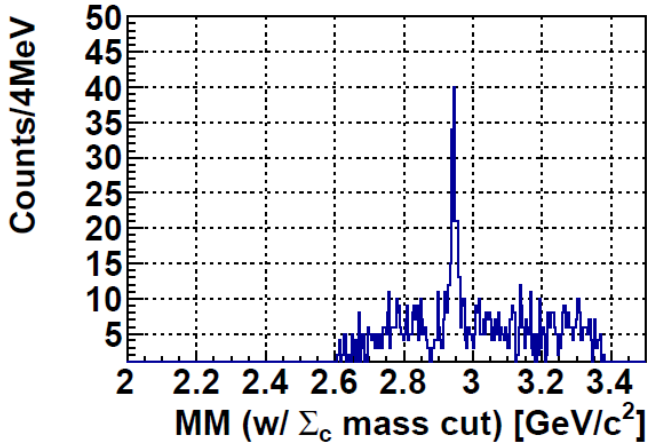
Y_c^*->Y_c+π decay process

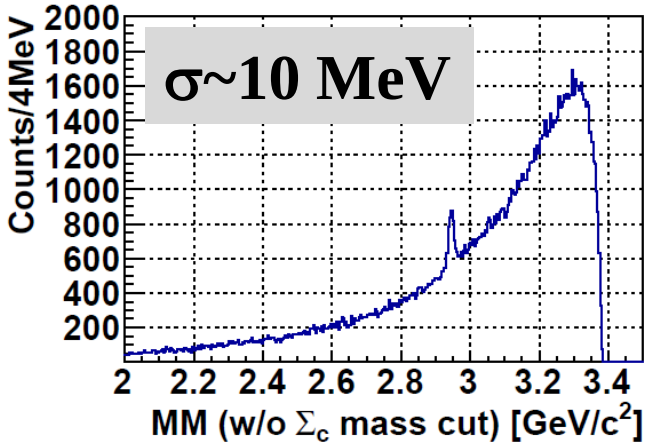


$\Lambda_c(2940)$->$\Sigma_c(2455)^0+\pi^+$ decay



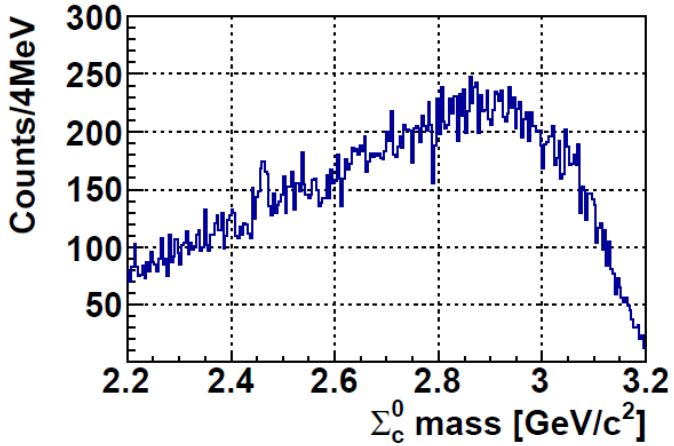


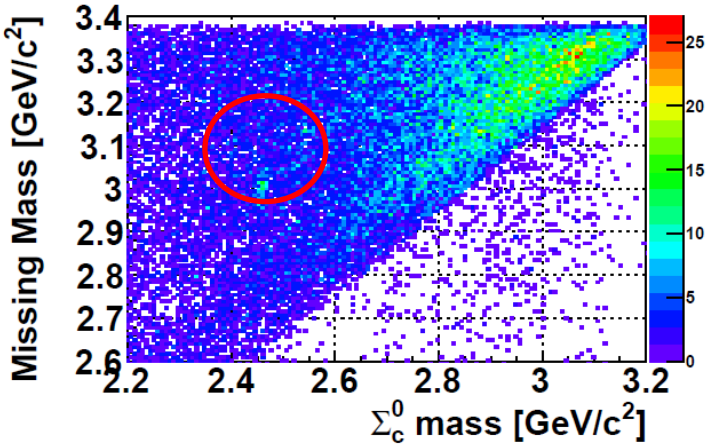


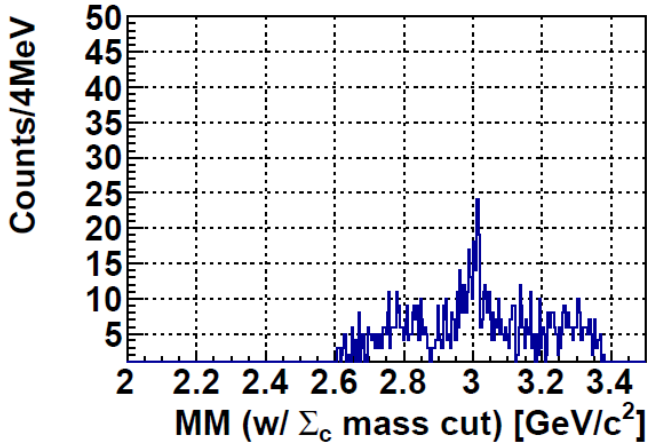


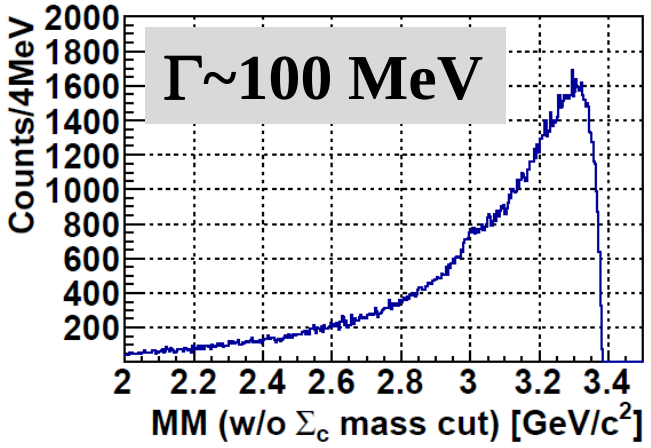
Further Reduction of BG in coin. w/ a decay pion

$\Lambda_c(3000)$->$\Sigma_c(2455)^0+\pi^+$ decay









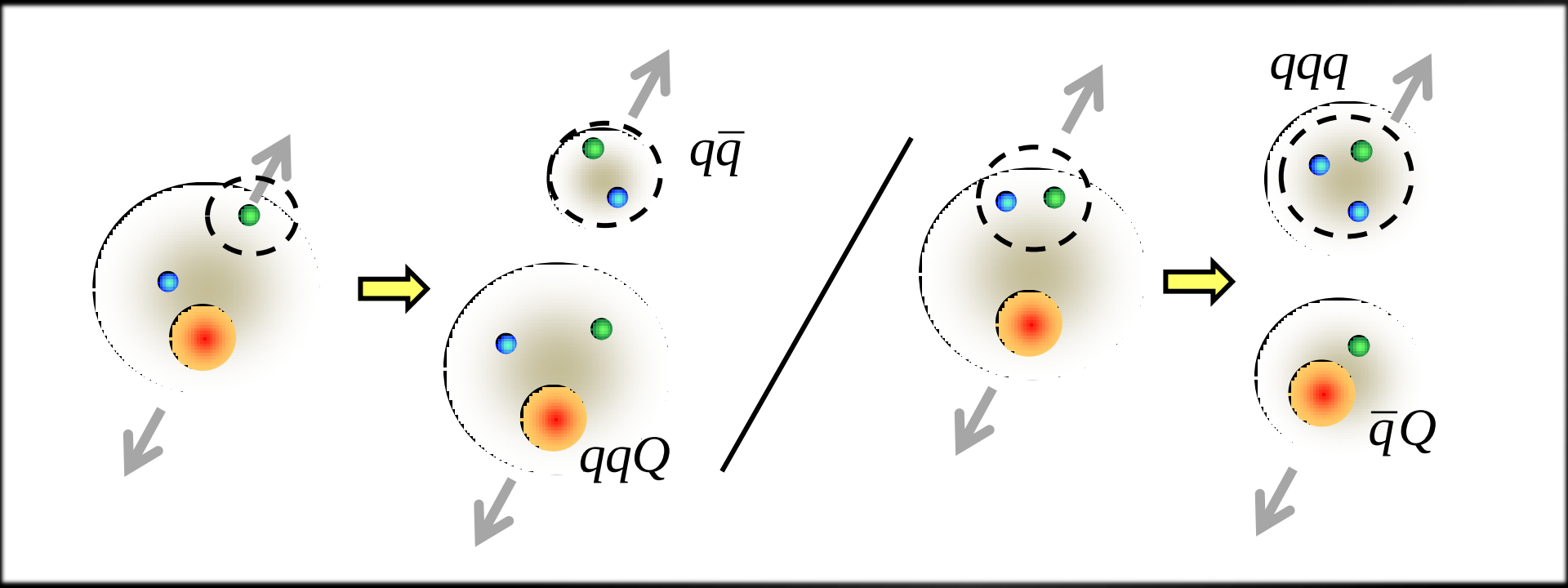
Further Reduction of BG in coin. w/ a decay pion

What we will measure…

Missing mass spectroscopy via the (π,D*-) reactions.

- Excitation Energies and widths of charmed baryons
  - From the G.S. to highly E.S. of E_x>1 GeV w/ ~5.5 MeV res.
  - Independent of decay final states
- Decay properties of the populated states
  - Strong BG suppressions for the parent states
  - Decay branching ratios (Partial widths)
  - Possible assignment of spins

Structure and Decay Partial Width



Excited (qq) Good [qq]

- $\Lambda(1520)$ -> NK (D wave!)>$\pi\Sigma$, similarly $\Lambda(1820)$, $\Lambda(2100)$
- Possible explanation of narrow widths of Charmed Baryons

Yield Estimation/Beam Time Request

- I_{beam}=10^7 π/s, n_{TGT}=4 g/cm^2, $\Delta\Omega/\Omega$~14%

  br($D^{*-} \rightarrow \pi^- D^0$, $D^0 \rightarrow K^+\pi^-$)=0.67*0.039

  ε(DAQ,Tracking,PID)=0.9*0.7*0.9

  → 4.5 events/day/nb

- Missing Mass Resolution σ_{MM}~ 5.5 MeV

  If a Peak Res. $\delta\sigma_{MM}$ <5 MeV for dm_{qq}~100 MeV,

  Keep sensitivity for excited states w/ Γ~100 MeV

  → >1000 events, >200 days

Summary

- Charmed Baryon Spectroscopy via the (π,D*-) reactions
  - Shed light on "diquark": colored object in hadrons
  - Clarify a Level Structure of the charmed baryons
    - From the ground state to highly excited states of E_x~1 GeV
    - Independent of decay final states
  - Decay Branching Ratios (Partial Widths)
    - Suppressions of $[qq^{bar}]$-[qqQ] decays if "Good diquark" in Y_c*
    - Possible assignment of spins
- A New Project of Hadron Physics at J-PARC, High-p BL
  - High-res., High-intensity 2ndary Beam
  - Large Acceptance, Multi-Particle Spectrometer

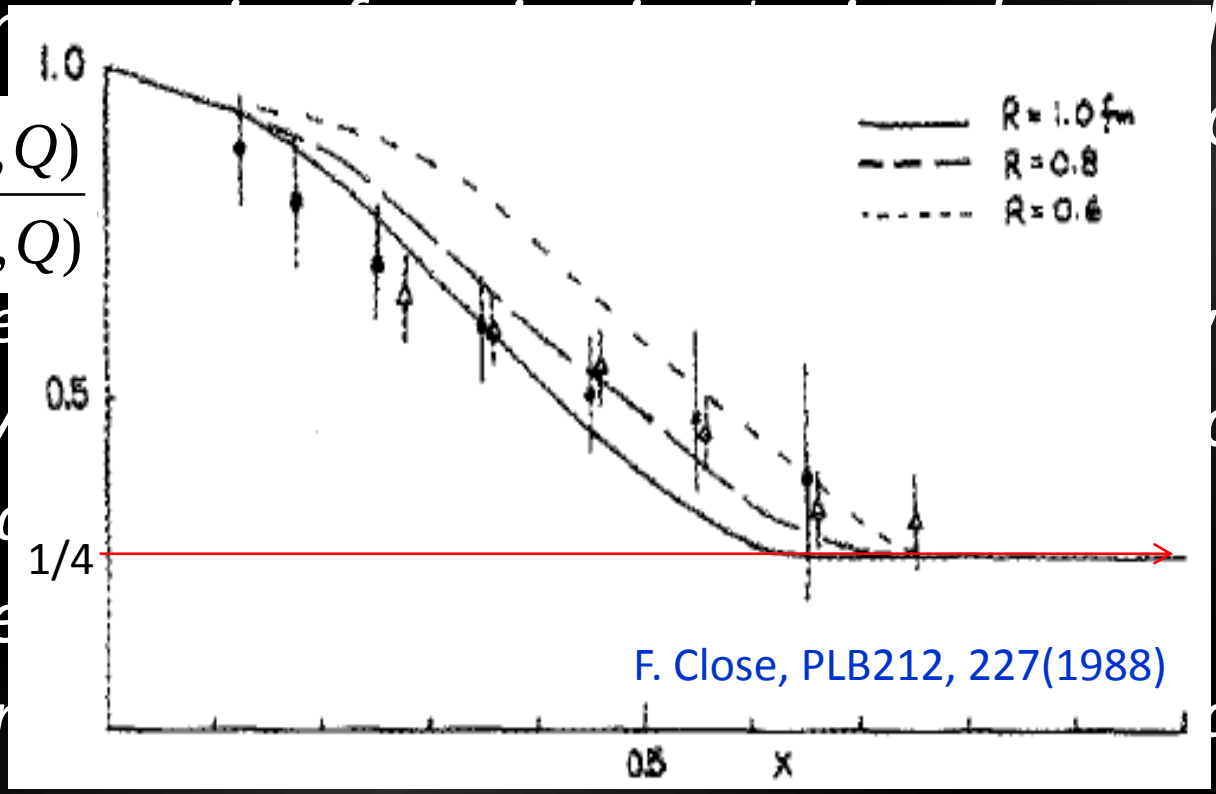
Backup

Indications of Diquarks

- Λ - Σ (80 MeV), Λ_c - Σ_c (215 MeV) mass difference
  - Energy difference of Good "[ud]" to Bad "(qq)"
- Λ Fragmentation function in e^+e^- is enhanced.
  - $\Lambda:\Sigma = 0.08:0.023$, $\Lambda_c:\Sigma_c = 0.074:0.014$ [$s^{1/2}$=10 GeV]
- EM FF Ratio at x=1 in DIS on n/p
  - Converging into 1/4 ($=e_d^2/e_u^2$), where [ud] tightly bound
- $|\Delta I|=1/2$ in non-lept'c decay of strange hadrons
  - "ud" antisymmetric pair is favored.
- Possible explanation of Hadron spectra
  - missing 20plet, Light Scalar Meson Nonet: $\{[qq][qq]^{bar}\}_{GS,}$ …

Indications of Diquarks

- Λ - Σ (80 MeV), Λ_c - Σ_c (215 MeV) mass difference
  - Energy difference of Good "[ud]" to Bad "(qq)"
- Λ Fragr… …d.
  - … …GeV]
- EM…
  - Conve… …bound
- $|\Delta I|=1/$… …ons
  - "ud" …
- Possible…
  - missi… …$qq]^{bar}\}_{GS,}$
    …



Covariant Oscillator Quark Model

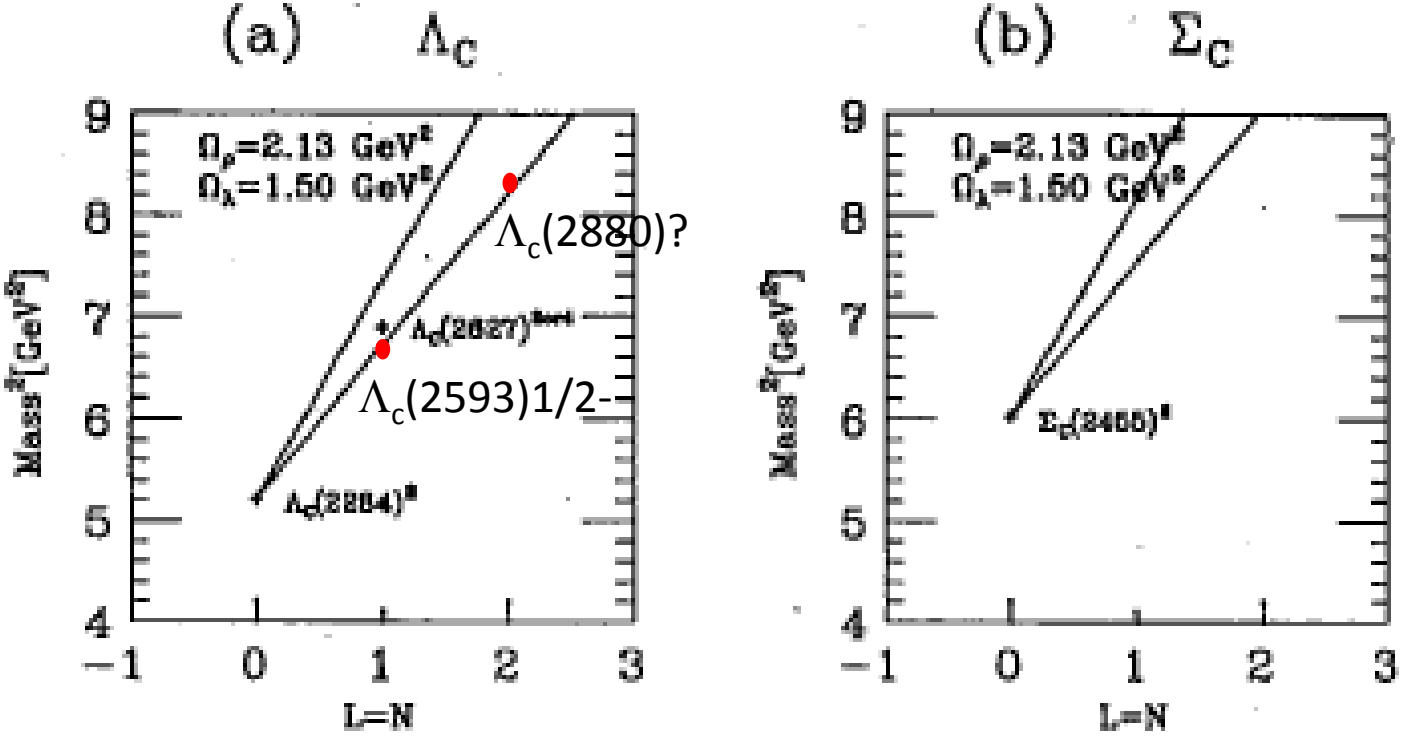
S. Ishida et al, PTP91, 775(1994)

Mesons : $M^2 = \Omega L + M_0^2$,

$$\Omega_\rho = 2(2m + M)\left(\frac{3K_3}{m}\right)^{1/2},$$

Baryons : $M^2 = \Omega_\rho L_\rho + \Omega_\lambda L_\lambda + M_0^2$.

$$\Omega_\lambda = 2(2m + M)\left(\frac{K_3}{m} + \frac{2K_3}{M}\right)^{1/2}.$$



Diquarks in Lattice QCD

Diquark correlation function

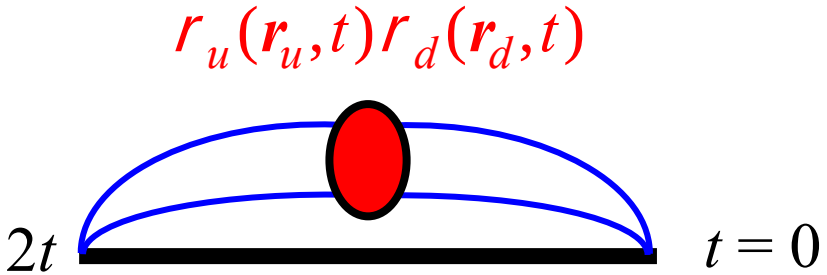
$$C(\boldsymbol{r}_u,\boldsymbol{r}_d;t)=\langle 0|J_{\mathrm{G}}(0,2t)\,r_u(\boldsymbol{r}_u,t)\,r_d(\boldsymbol{r}_d,t)\,J_{\mathrm{G}}^{\dagger}(0,0)|0\rangle$$

$$r(\boldsymbol{r},t)=\bar{q}_f g_0 q_f,\quad f=u,d$$

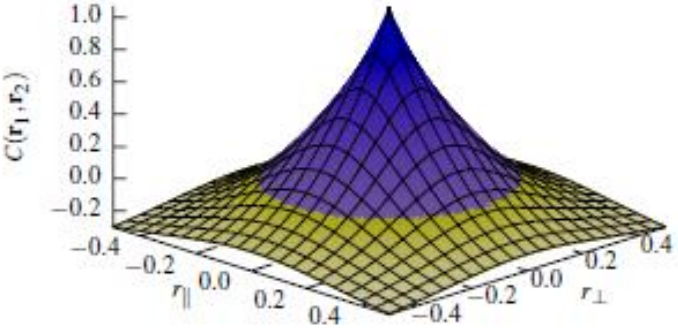
$$J_{\mathrm{G}}(x)=\epsilon^{abc}[u_a^T(x)C\Gamma_{\mathrm{G}}d_b(x)\pm d_a^T(x)C\Gamma_{\mathrm{G}}u_b(x)]s_c(x)$$

ud-diquark

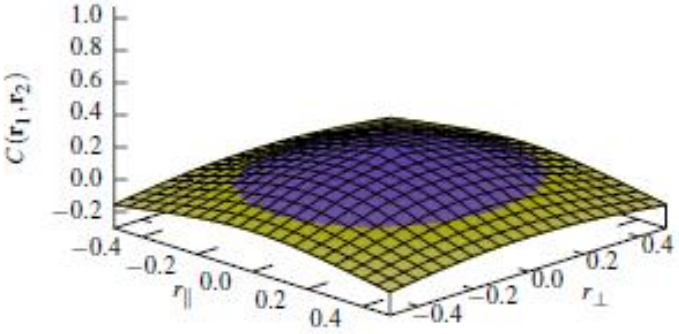
"Static" quark (heavy quark)



good $m_\pi = 293$ MeV

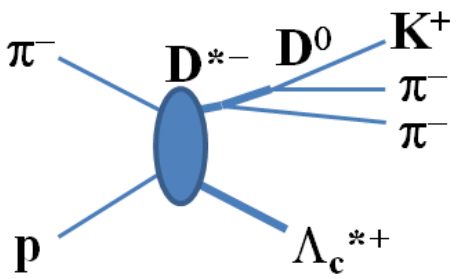


bad $m_\pi = 293$ MeV

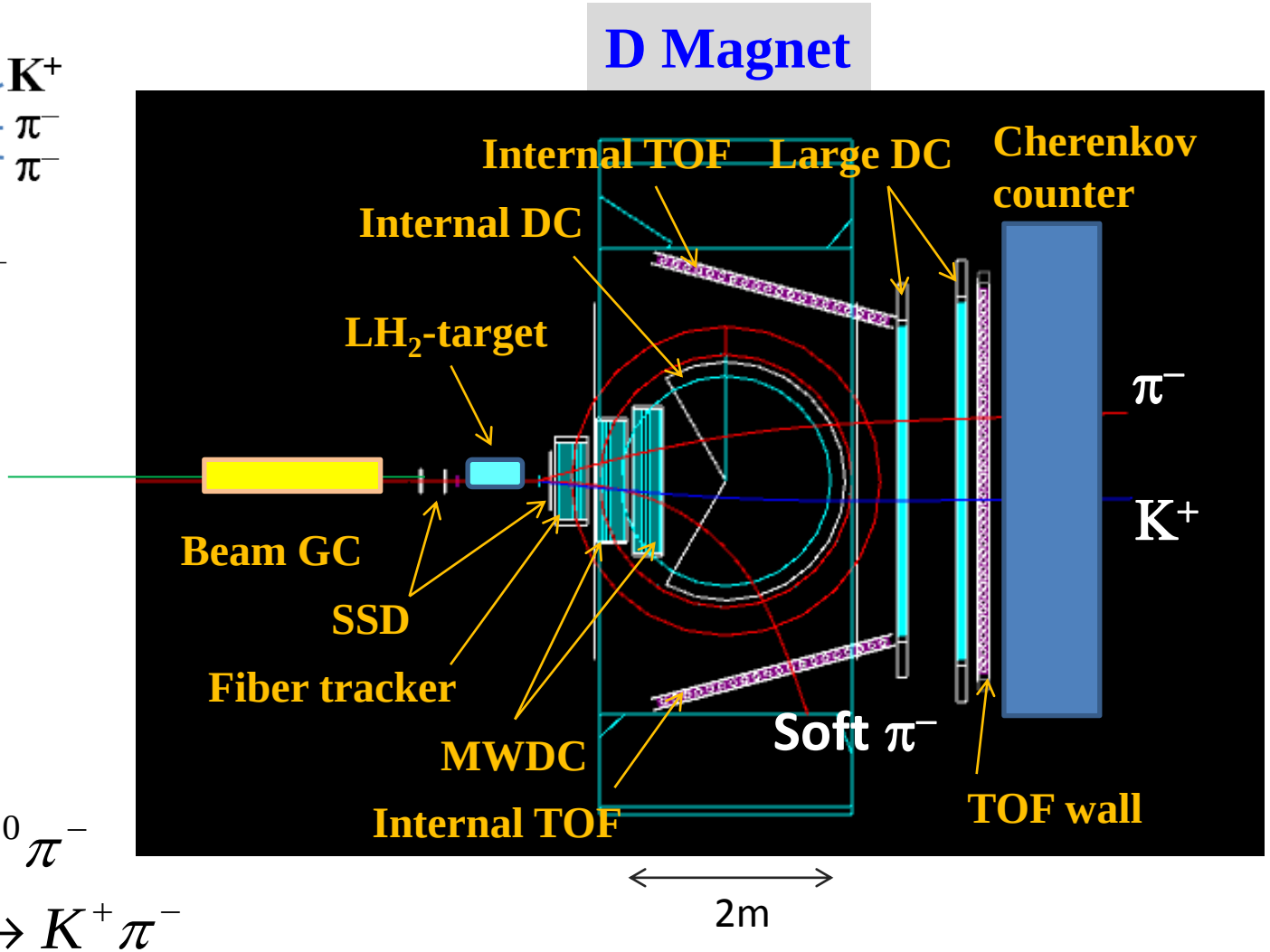


J. Green, M. Engelhardt, J. Negele, and P. Varilly, AIP Conf. Proc. 1441, 172(2012)

Simulation



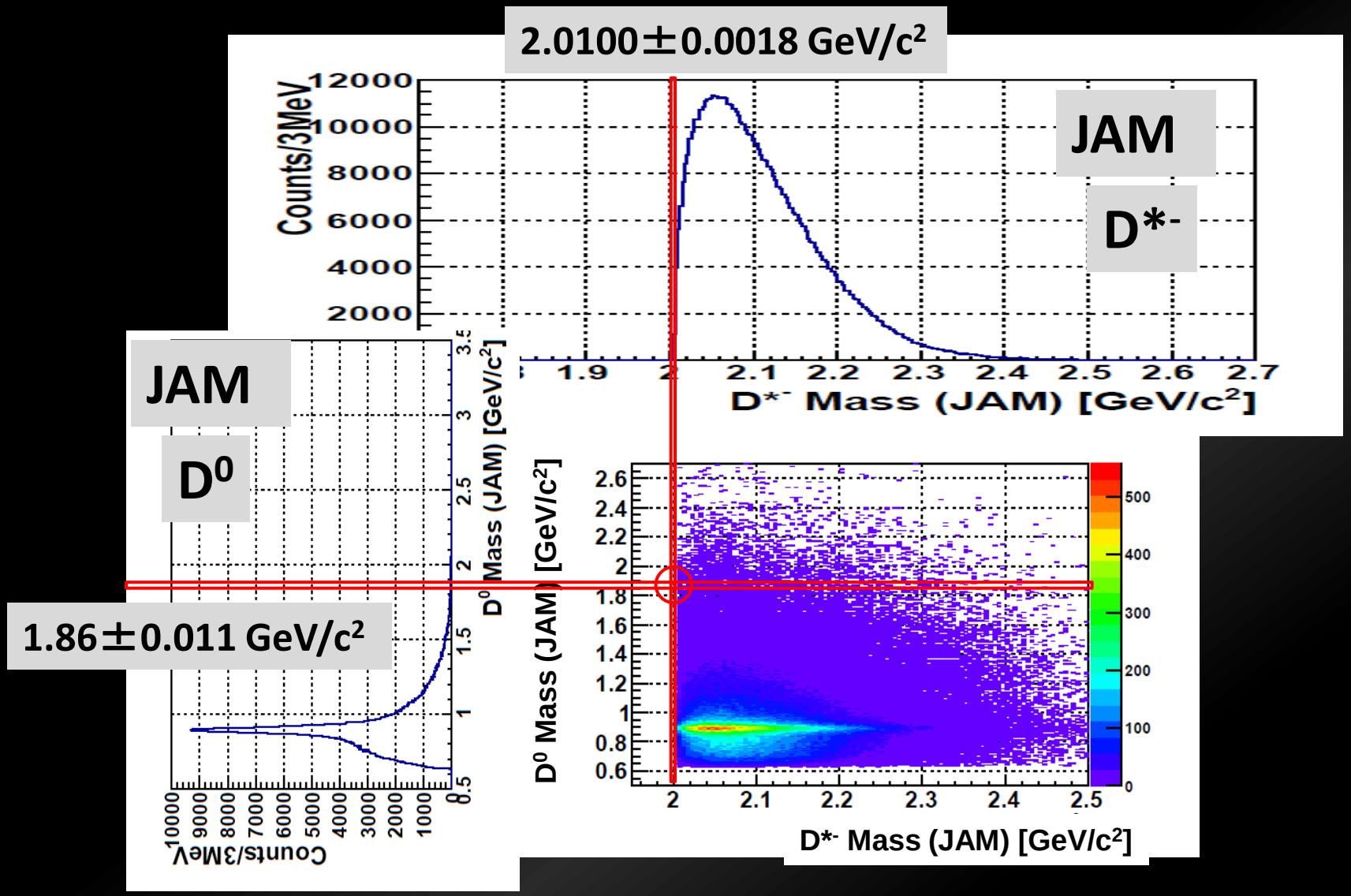
6x10^7 π/pulse
@15 GeV/c



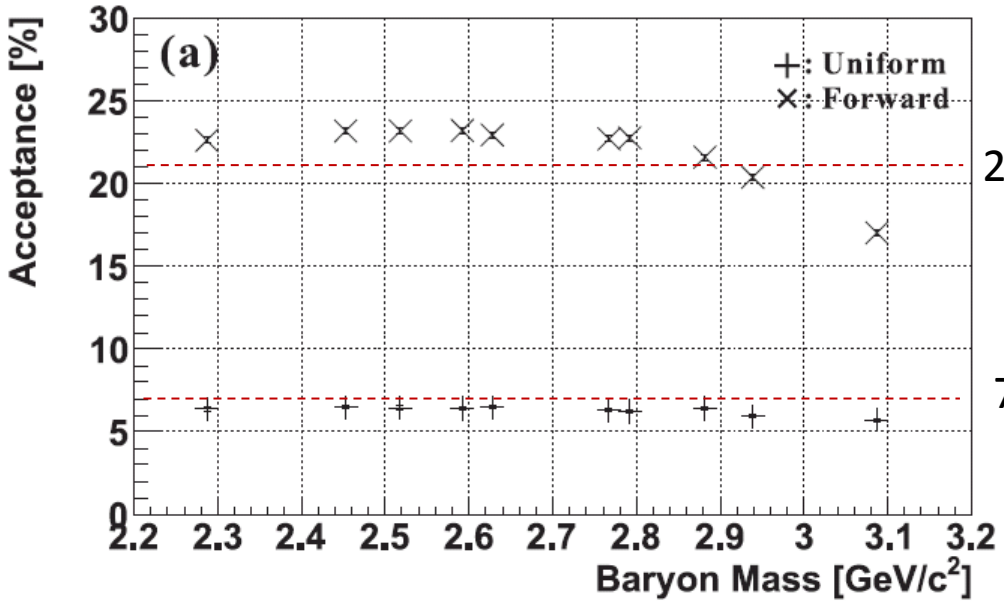
$$\pi^- p \to \overline{D}^{*0} Y_c$$
$$\mapsto \overline{D}^0 \pi^-$$
$$\mapsto K^+ \pi^-$$

Expected Resolution: ΔE_{MM}=5~6 MeV/c^2

BG reduction by D^{*-} and D^0 mass cuts

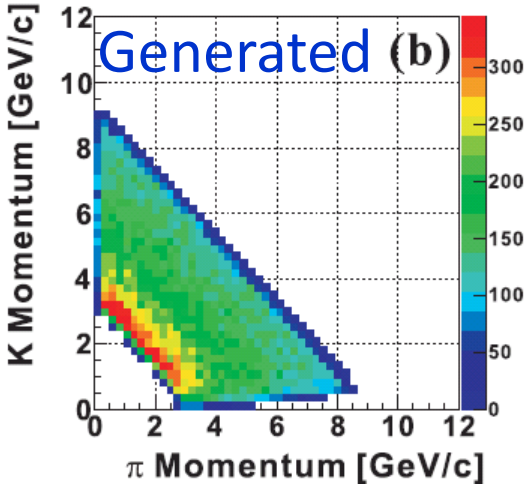


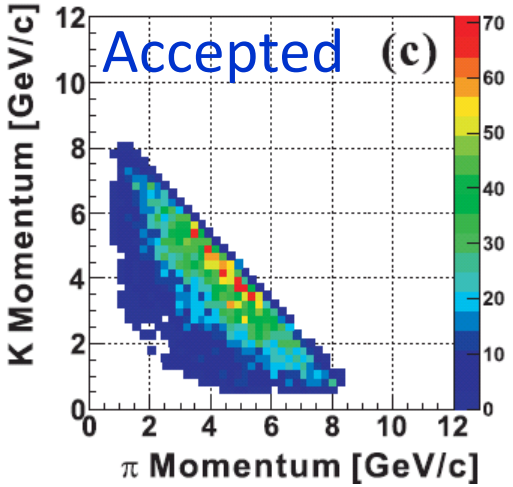
D^{*-} Acceptance



21% (t-channel scat.)

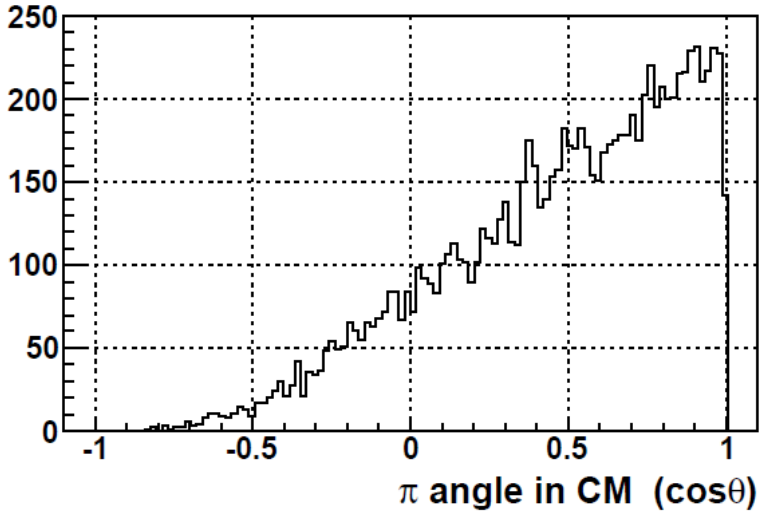
7% (isotropic scat.)

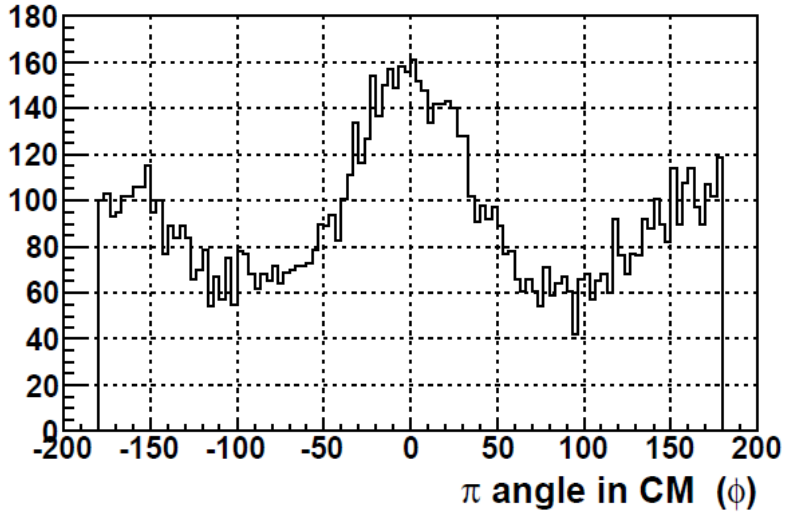




Acceptance for a Decay Pion

Default entrance detector size





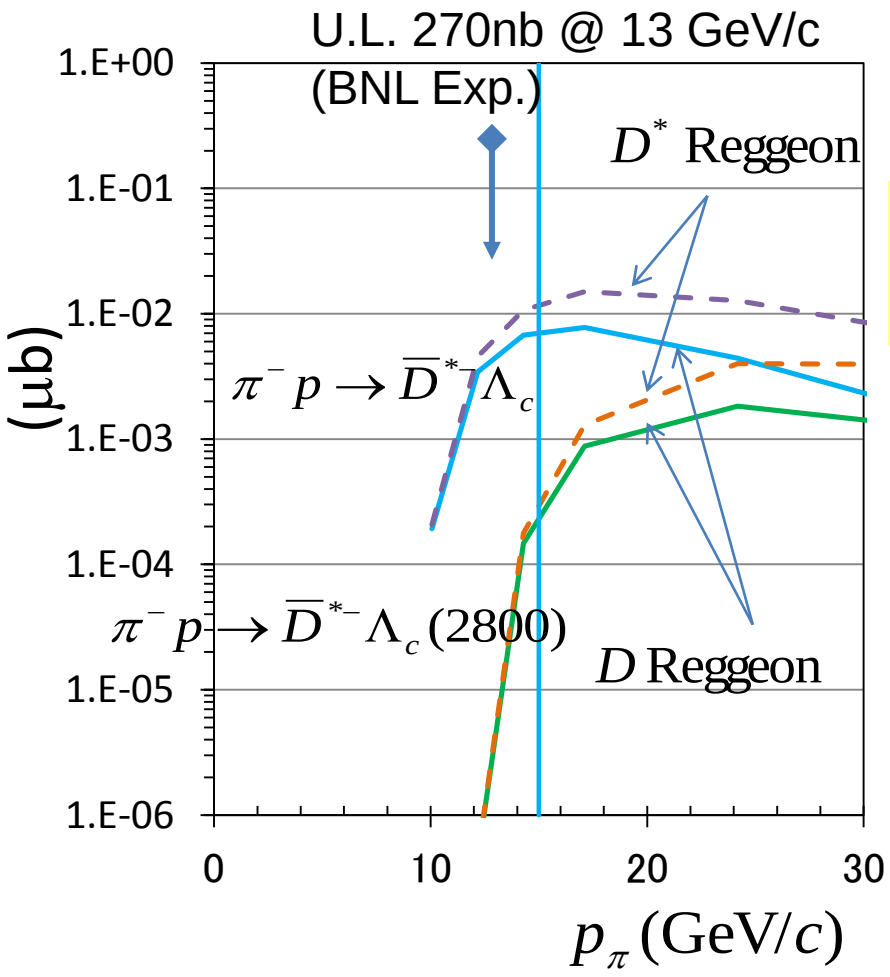
Large entrance detector size

- **$Y_c^* \rightarrow \Sigma_c(2455) + \pi$**

  G-J frame of Y_c^*

  θ: polar angle

  ϕ: azimuthal angle
- ~50% acceptance



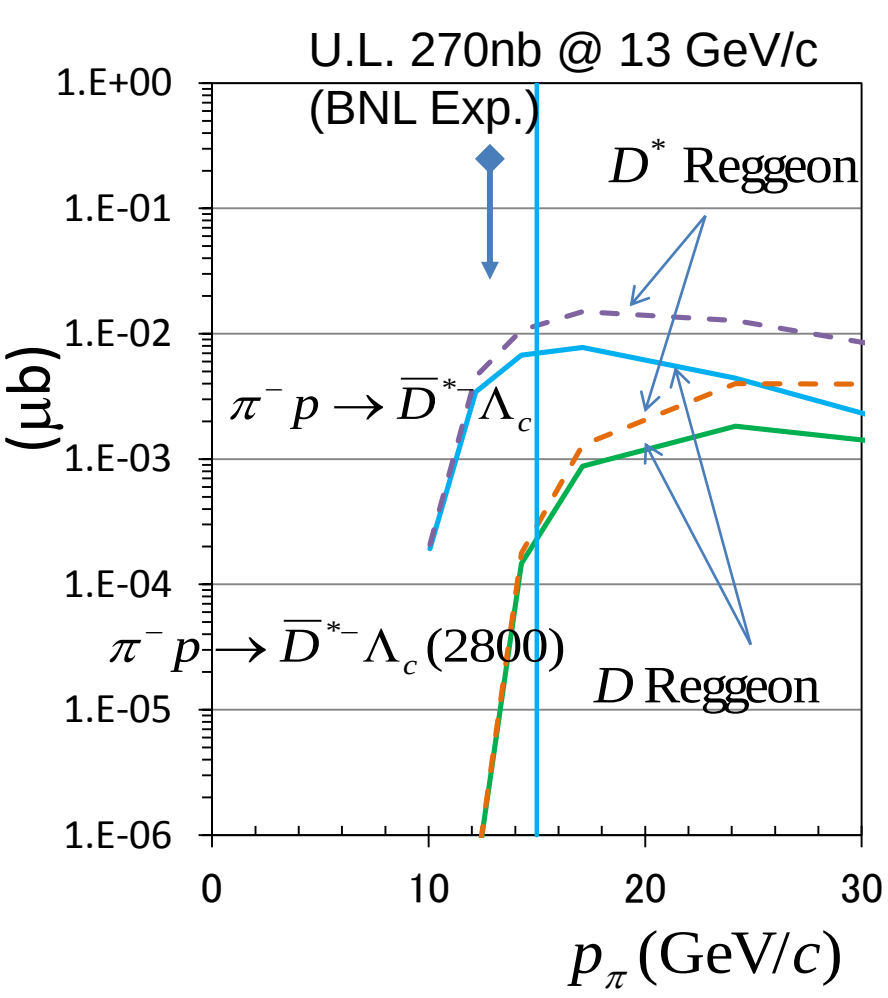
$$\sigma(s) = C\int_{t_0}^{t_1} dt \left[\frac{1}{64\pi s (p_m^{cm})^2} g_1^2 g_2^2 \, |F(t)|^2 |s/s_0|^{2\alpha(t)} \right]$$

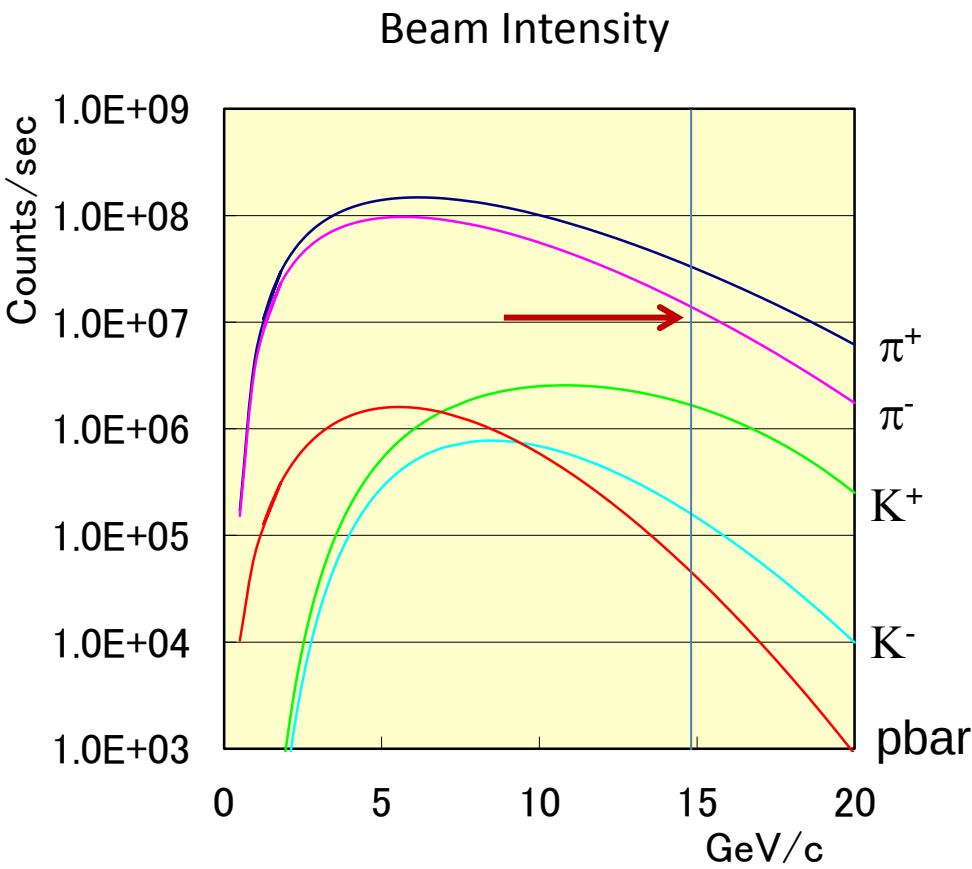
$$|F(t)|^2 = \exp(2R^2 t), \quad R^2 : \text{slope parameter}$$

$$\alpha(t) : \text{Regge Trajectory}$$

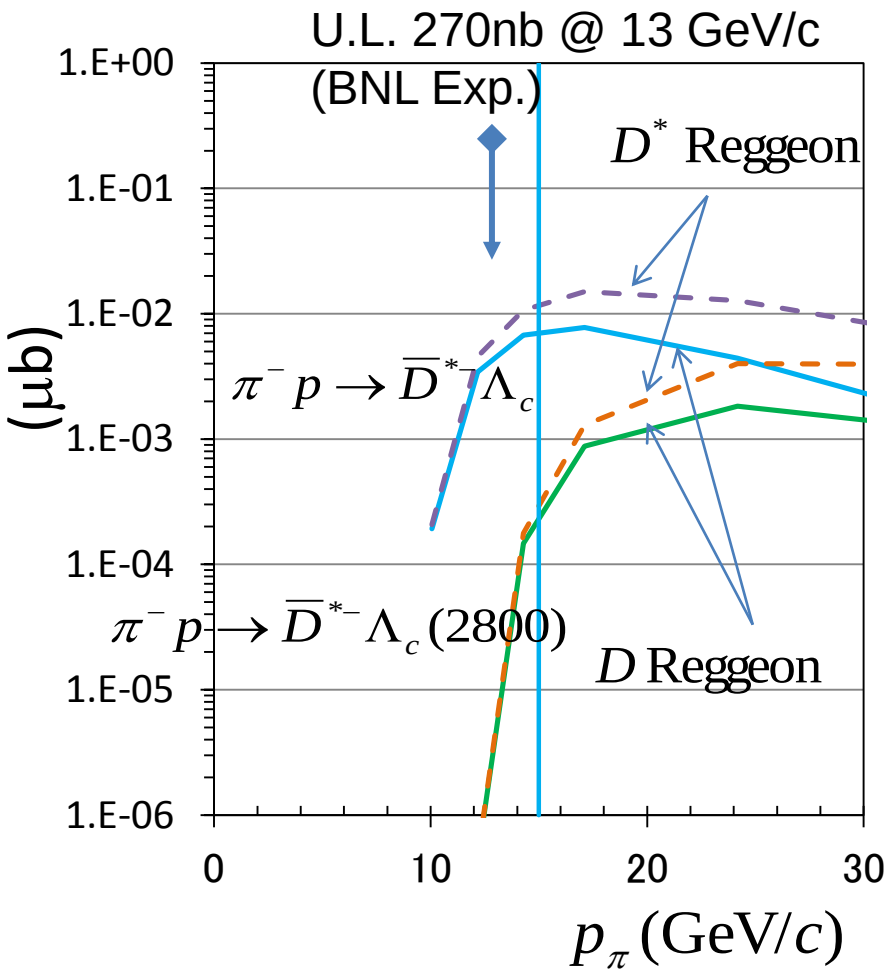
$$s_0 = (m_M + m_B)^2 : \text{scale parameter}$$

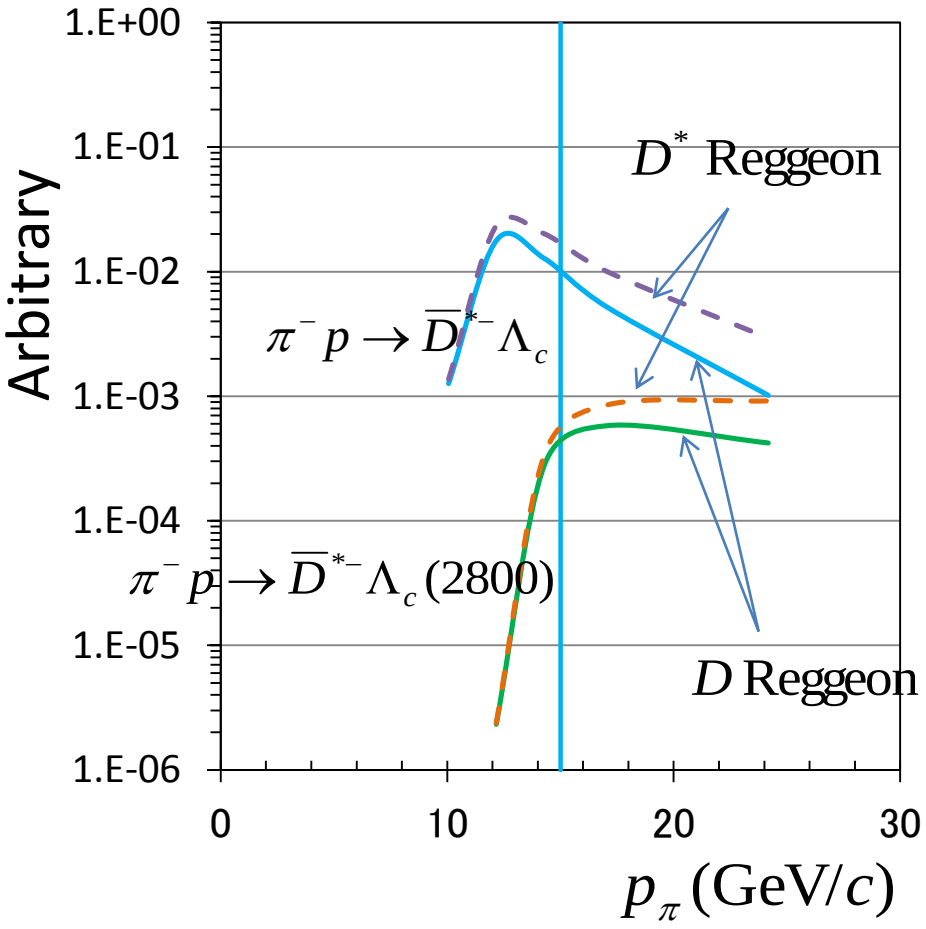
$$R^2 = 2.13\,\text{GeV}^{-2}$$





Sanford-Wang formula
15 kW loss Pt TGT,
Acceptance: 2 msr%
BL Length: 132 m,


U.L. 270nb @ 13 GeV/c
(BNL Exp.)
D^* Reggeon
$\pi^- p \to \bar{D}^{*-} \Lambda_c$
$\pi^- p \to \bar{D}^{*-} \Lambda_c(2800)$
D Reggeon
(μb)
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
0
10
20
30
p_π (GeV/c)


Arbitrary
D^* Reggeon
$\pi^- p \to \bar{D}^{*-} \Lambda_c$
$\pi^- p \to \bar{D}^{*-} \Lambda_c(2800)$
D Reggeon
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
0
10
20
30
p_π (GeV/c)

Background cross section

TABLE II. Neutral strange particles, inclusive cross sections in μb for $\pi^- p \to K_S^0 + X$, $\Lambda + X$, $\bar{\Lambda} + X$, $K_S^0 K_S^0 + X$, $K_S^0 \Lambda + X$, $\Lambda\bar{\Lambda} + X$, and $K_S^0 \bar{\Lambda} + X$.

π^- p reaction @ 16 GeV/c

No. of charged secondaries	K_S^0	Λ	$\bar{\Lambda}$	$K_S^0 K_S^0$	$K_S^0 \Lambda$	$\Lambda\bar{\Lambda}$	$K_S^0 \bar{\Lambda}$
0	122.5 ± 22.4	92.5 ± 16.8	6.6 ± 2.5	17.0 ± 6.0	38.9 ± 11.7	5.3 ± 2.9	1.1 ± 1.1
2	713.6 ± 43.7	465.9 ± 30.0	23.9 ± 3.6	74.5 ± 9.6	117.8 ± 13.8	7.9 ± 2.6	3.1 ± 1.8
4	787.2 ± 48.8	479.7 ± 31.3	15.8 ± 3.0	52.5 ± 7.9	76.7 ± 10.4	5.3 ± 2.4	···
6	266.3 ± 29.1	199.5 ± 22.6	1.2 ± 0.8	6.6 ± 2.8	22.7 ± 5.8	1.1 ± 1.1	···
8	45.2 ± 15.7	26.6 ± 10.1	0.8 ± 0.8	4.2 ± 4.2	···	···	···
10	2.4 ± 1.6	1.8 ± 1.5	···	···	···	···	···
Total inclusive	1937.2 ± 76.7	1266.0 ± 52.7	48.3 ± 5.4	154.8 ± 15.0	256.1 ± 21.6	19.6 ± 4.7	4.2 ± 2.2

F. Barreiro et al, PRD 17(1978)669

R. Honecker et al, NPB 13(1969)571

π^- p reaction @ 16 GeV/c

n_{ch}	Final state a)	σ(mb)	n_{ch}	Final state	σ(μb)
2	$p\pi^-$	4.36 ± 0.15	8	$p\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^-$	94 ± 23
	$p\pi^-\pi^0$	0.30 ± 0.10		$p\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^0$	126 ± 24
	$n\pi^+\pi^-$	0.27 ± 0.10		$n\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^-$	114 ± 25
	$p\pi^-Z^0$	1.58 ± 0.09		$p\pi^+\pi^+\pi^-\pi^-\pi^-\pi^-Z^0$	523 ± 63
	$\pi^+\pi^-Z^0$	2.49 ± 0.15		$\pi^+\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^-Z^0$	393 ± 51
4	$p\pi^+\pi^-\pi^-$	0.99 ± 0.05	10	$p\pi^+\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^-\pi^-$	9 ± 6
	$p\pi^+\pi^-\pi^-\pi^0$	0.70 ± 0.04		$p\pi^+\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^-\pi^-\pi^0$	65 ± 17
	$n\pi^+\pi^+\pi^-\pi^-$	0.29 ± 0.05		$n\pi^+\pi^+\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^-\pi^-$	26 ± 12
	$p\pi^+\pi^-\pi^-Z^0$	2.94 ± 0.16		$p\pi^+\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^-Z^0$	75 ± 22
	$\pi^+\pi^+\pi^-\pi^-Z^0$	2.81 ± 0.16		$\pi^+\pi^+\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^-\pi^-Z^0$	65 ± 20
6	$p\pi^+\pi^+\pi^-\pi^-\pi^-$	0.25 ± 0.02	12	$p\pi^+\pi^+\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^-\pi^-\pi^-$	<6
	$p\pi^+\pi^+\pi^-\pi^-\pi^-\pi^0$	0.55 ± 0.03		$p\pi^+\pi^+\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^-\pi^-\pi^0$	3 ± 3
	$n\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-$	0.19 ± 0.05		$n\pi^+\pi^+\pi^+\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^-\pi^-\pi^-$	8 ± 5
	$p\pi^+\pi^+\pi^-\pi^-\pi^-Z^0$	2.00 ± 0.11		$p\pi^+\pi^+\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^-\pi^-Z^0$	8 ± 6
	$\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-Z^0$	1.18 ± 0.07		$\pi^+\pi^+\pi^+\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^-\pi^-\pi^-Z^0$	5 ± 4

a) Z^0 represents a system of two or more neutral particles.

Strangeness production data

- $K^0_s \to K^+$とする
- 4 track以上が$K^+ \pi^- \pi^-$を含む

⇒~1.1 mb

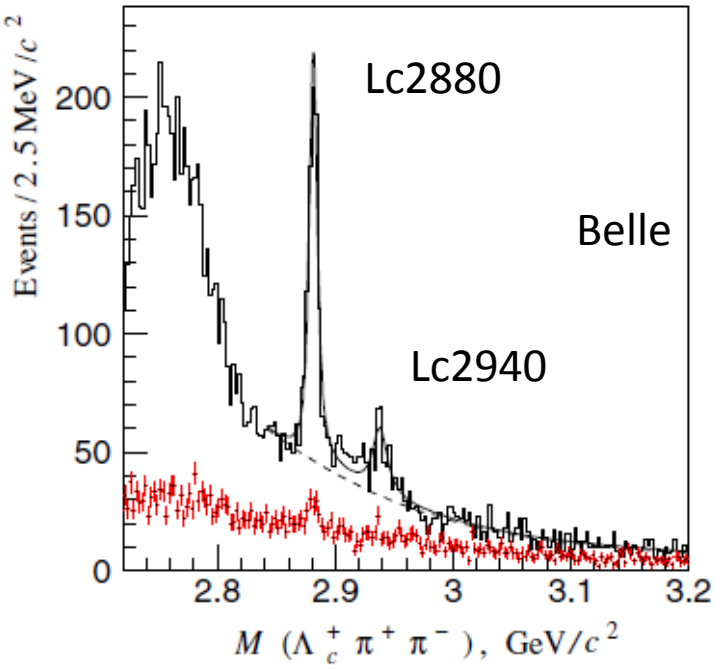
π production data

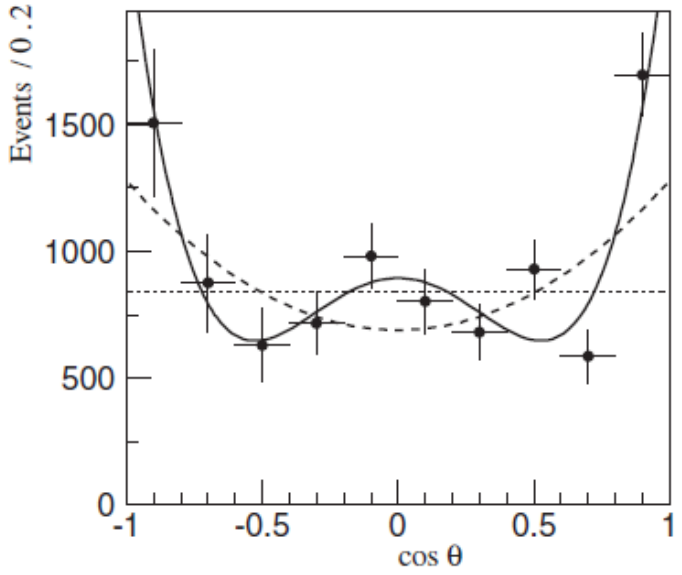
- 終状態に$\pi^- \pi^0(K^+) \pi^- \pi^-$等を含む
- Strangeness生成は1/10程度と仮定

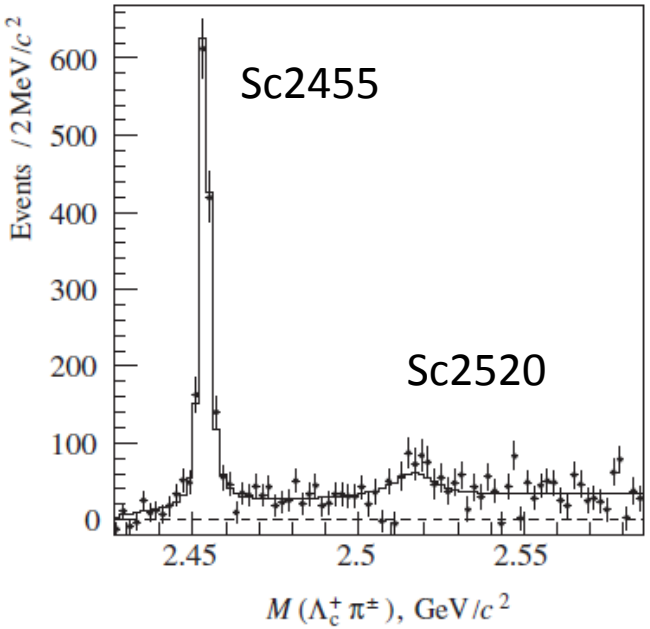
⇒~0.5 mb

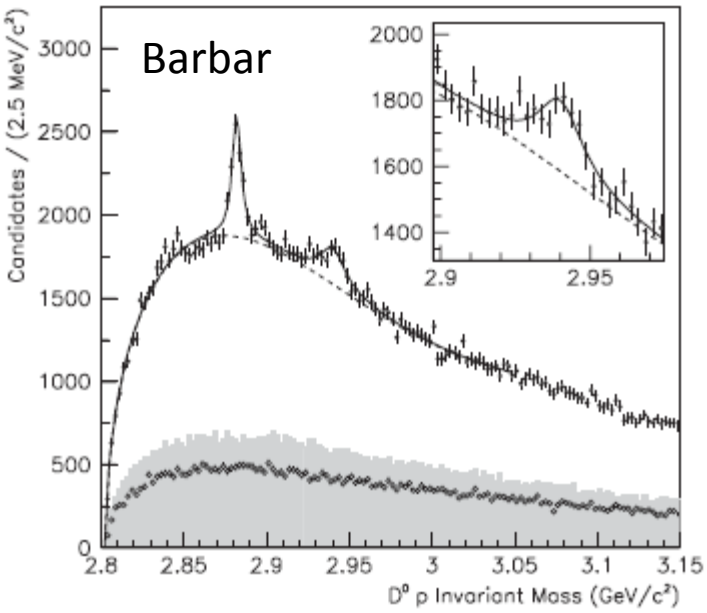
＊ $K^+ \pi^- \pi^-$になるものは0.5~1 mb程度か?

Shirotori's Slide

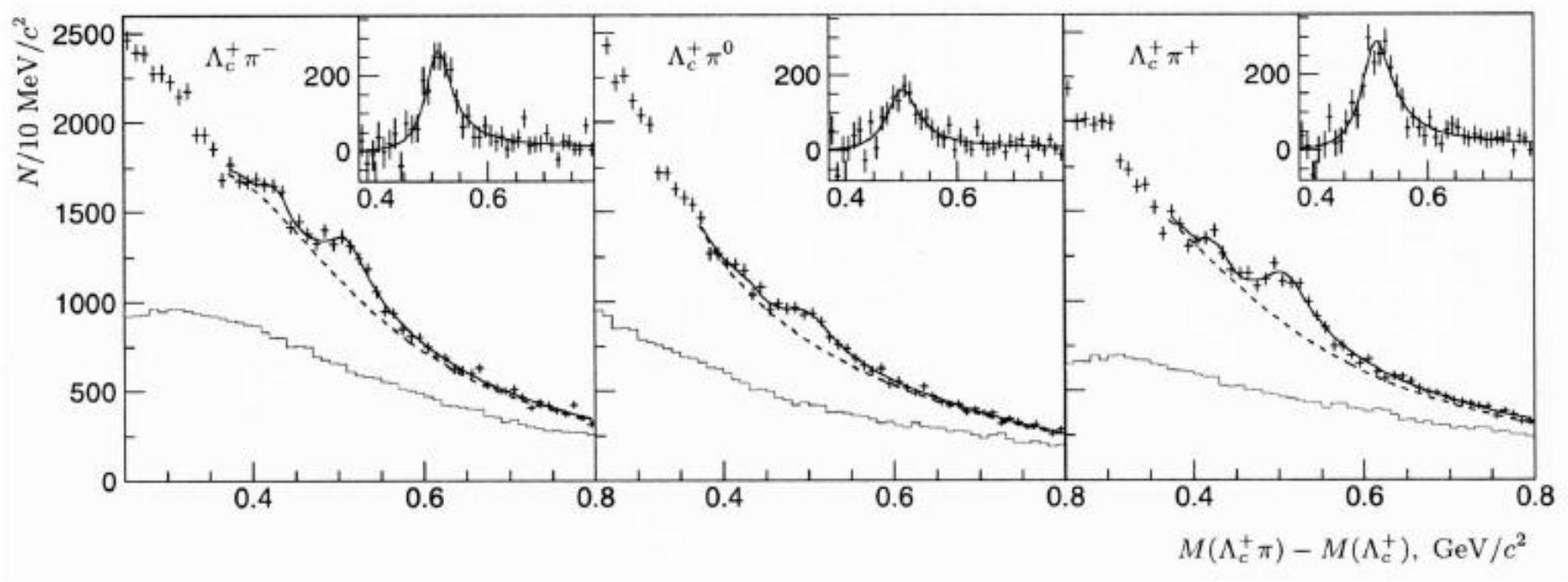

Lc2880
Belle
Lc2940
Events / 2.5 MeV/c²
M (Λc+ π+ π−), GeV/c²


Events / 0.2
cos θ


Sc2455
Sc2520
Events / 2 MeV/c²
M (Λc+ π±), GeV/c²


Barbar
Candidates / (2.5 MeV/c²)
D⁰ p Invariant Mass (GeV/c²)

Belle


$N/10\ \mathrm{MeV}/c^2$
2500
2000
1500
1000
500
0
$\Lambda_c^+\pi^-$
$\Lambda_c^+\pi^0$
$\Lambda_c^+\pi^+$
200
0
0.4
0.6
0.8
$M(\Lambda_c^+\pi) - M(\Lambda_c^+),\ \mathrm{GeV}/c^2$

A new research project in High-res., High-p Beam Line at J-PARC

- Proposed by RCNP, Osaka U. under the MOU on research cooperation among RCNP, IPNS/KEK, and the J-PARC Center
- Role of RCNP
  - Collect research ideas and collaborators
  - Introduce new methods/techniques
    - High-resolution, high-p Secondary Beam Line
    - Large Acceptance, Multi-Particle Spectrometer
      → Multi-Purpose System for Hadron/Nuclear Physics
  - Conduct hadron/nuclear physics with a leader ship of RCNP
    a platform for a research collaboration in Hadron Physics
- Charmed Baryon Spectroscopy at the High-p BL
  - RCNP-PPAC Project Review on 9/Nov/2012
  - Proposal submitted to the J-PARC PAC

Extension of Research Collaboration in Hadron Physics

LHC

Euro

Asia

BES III

U.S.

CLAS12

Hadron Physics Research Collaboration

photon beams

hadron beams

Belle/Belle II

e^+e^- collider

Schedule

Fiscal Year	2012	2013	2014	2015	2016	2017	2018
Accelerator	10kW	50kW	Toward 100kW			100kW	
Beam Line		Manufacturing		Install			
E16							
Magnet	Construction						
Detector		1/3 ready		Full install			
Beam Time					Experiment		
Charmed Baryon							
High Res. Beam	Design	Manufacturing		Install			
Detector	Design	R&D		Production		Install	
Beam Time							Exp.

GSI/FAIR	Construction	Install	Start