Cascade Baryon Production with high-momentm beamline

M. Naruki (Kyoto Univ.)
J-PARC workshop, 2014/8/9, Tokai

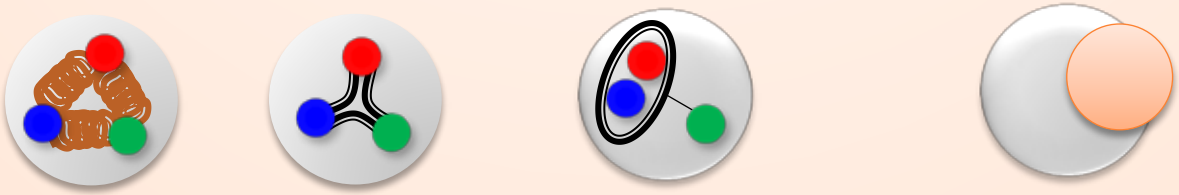
Contents

- Introduction
  - Current Experimental Situation
- Experimental Plan
  - Cascade Baryons

Baryon spectroscopy

- Baryon : building blocks of our world
- description based on QCD with spectroscopy
  - understand degree of freedom and interaction between them underlying the spectrum

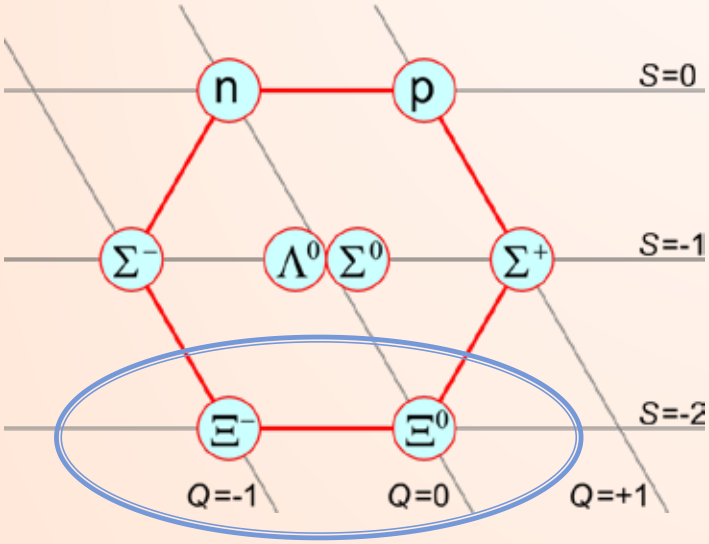
QM flux tube diquark meson-baryon

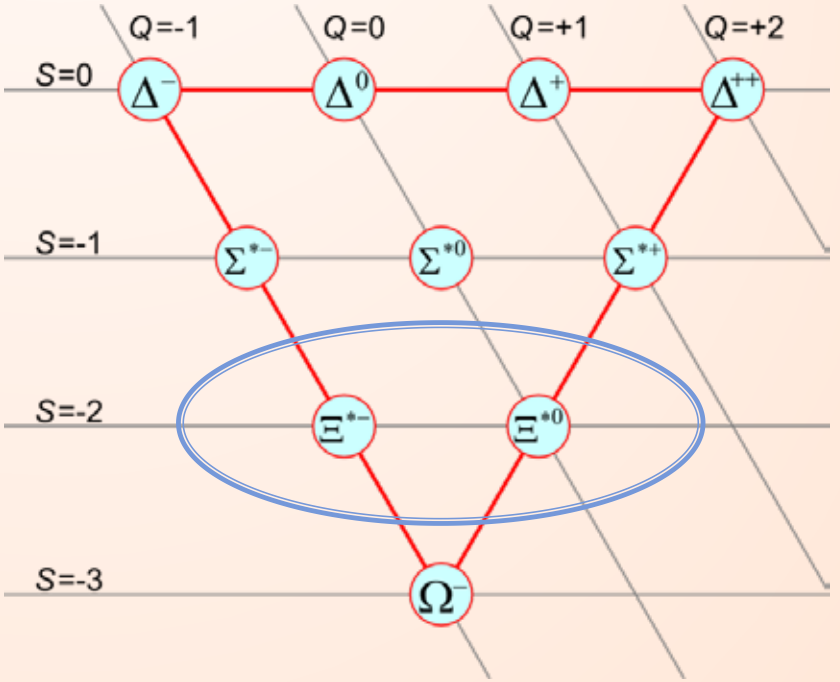


needs theoretical interpretation to connect experiments to QCD

Ξ Baryon

σ(KN)





100μb

10μb

1μb

Ξ(1321) ½+ (****)

Ξ(1530) 3/2+ (****)

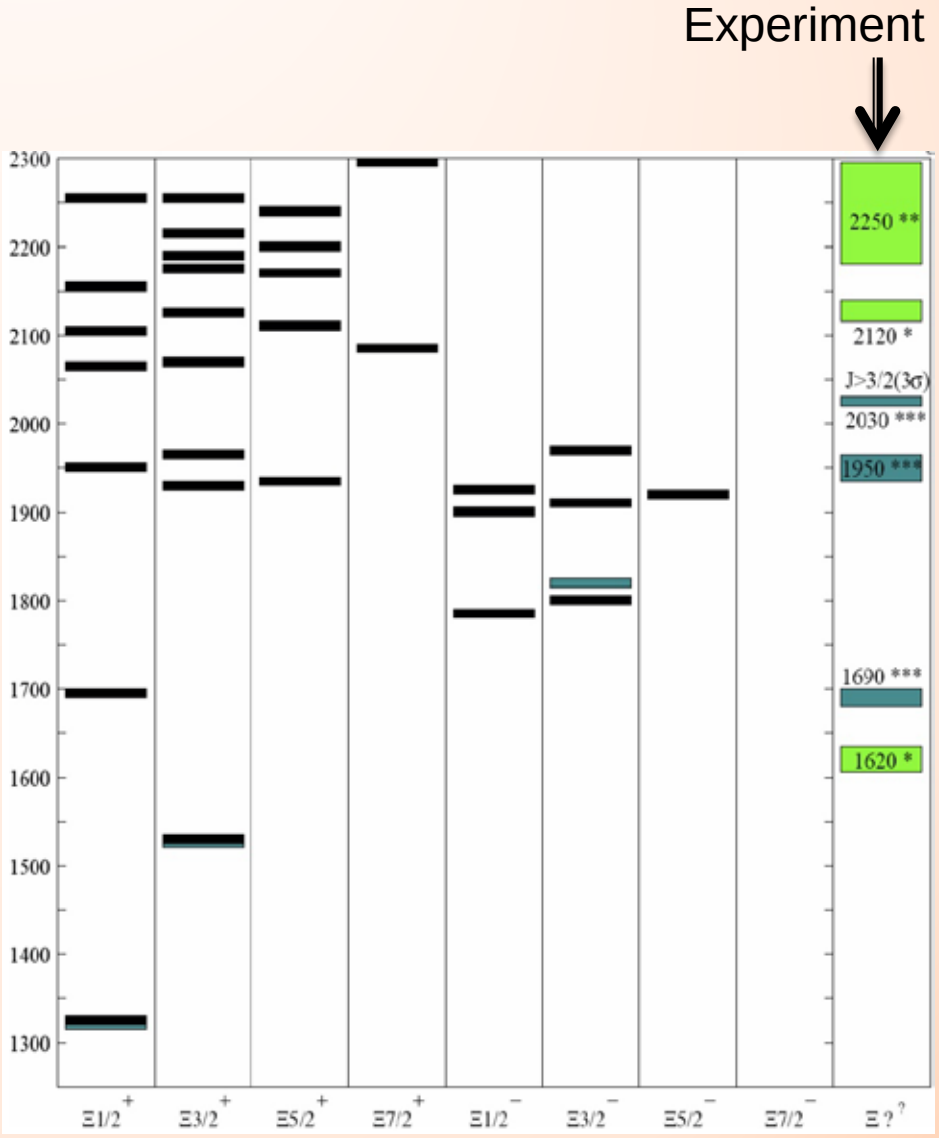
Only g.s. of each multiplet are rated as four-star states.
**** existence is certain, properties are well determined.

Quark Model Calculation

44 states were predicted up to 2.3 GeV

Only 11 states were reported.

- spin assignment is established : 3
- certain but need confirmation : 3
- evidence is fair : 2
- evidence is poor : 3



Chao, Isgur & Karl

Ξ baryon spectroscopy

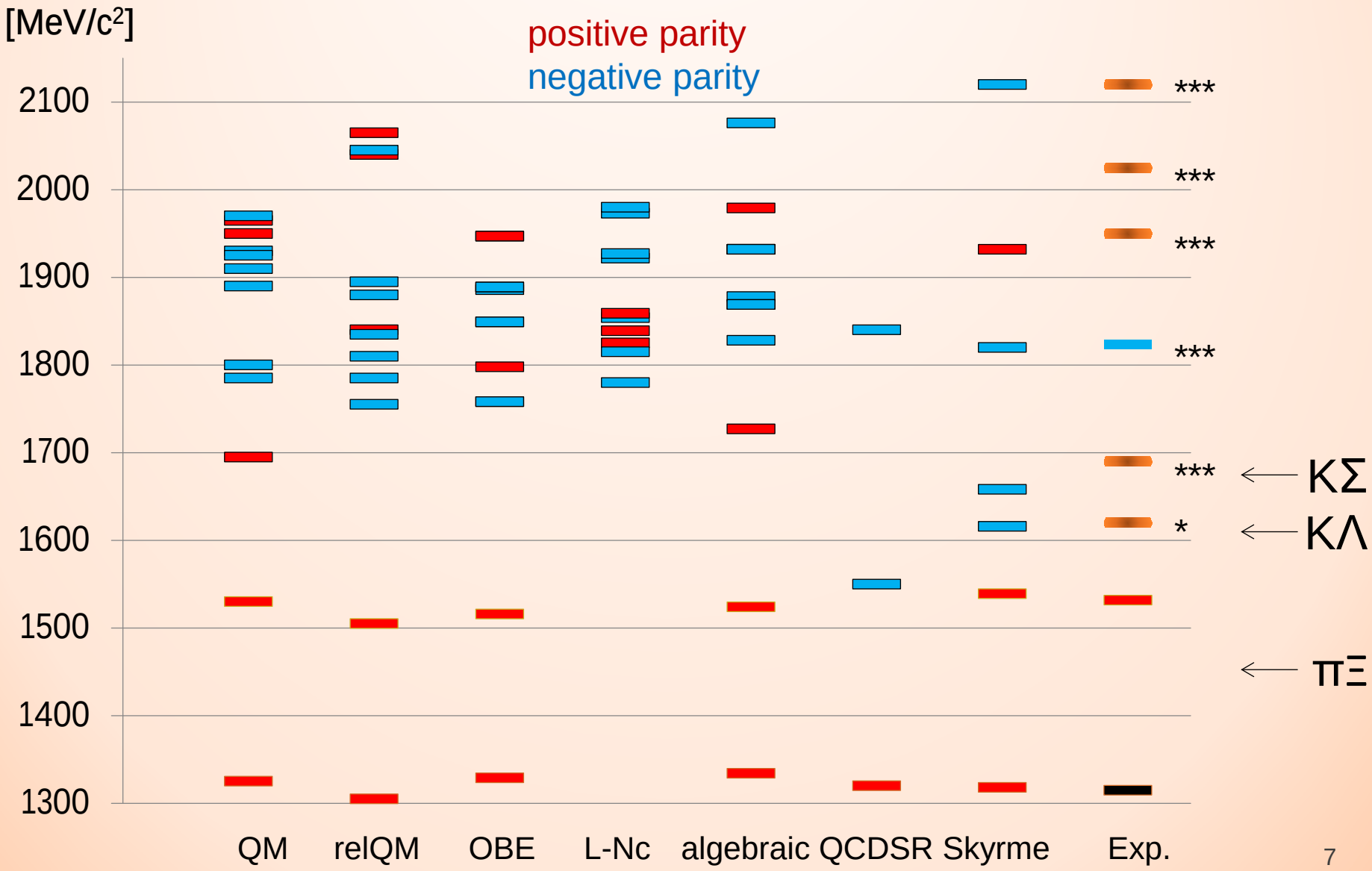
- Experimental Advantages
  - narrow width ~ 10MeV
    - clearly separated on the spectrum
  - multi-vertex condition
    - Ξ* à Ξπ
      à Λπ
      à pπ
  - Unique S=-2 / Isospin simplicity ½

- Experimental information is largely lacking, due to lack of intense kaon beam. (mostly from bubble chamber exp. in '60-'70s.)
  à K^-p reactions at J-PARC

Particle	J^P	Overall status
Ξ(1318)	1/2+	****
Ξ(1530)	3/2+	****
Ξ(1620)		*
Ξ(1690)		***
Ξ(1820)	3/2−	***
Ξ(1950)		***
Ξ(2030)		***
Ξ(2120)		*
Ξ(2250)		**
Ξ(2370)		**
Ξ(2500)		*

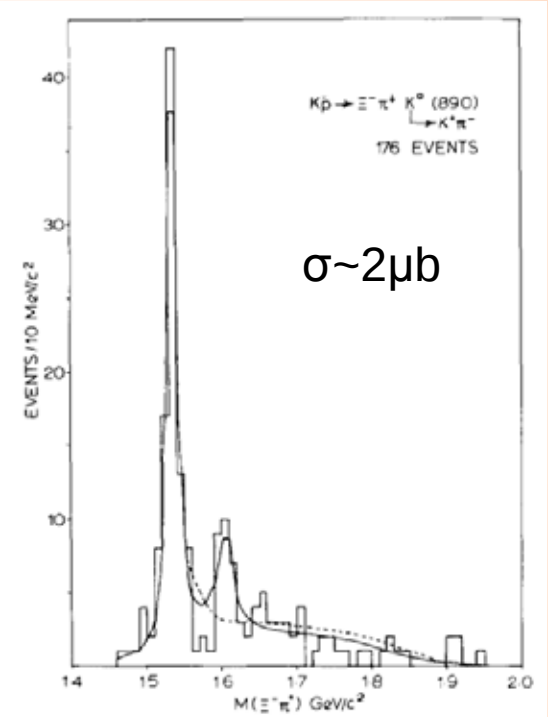
PDG (2012)

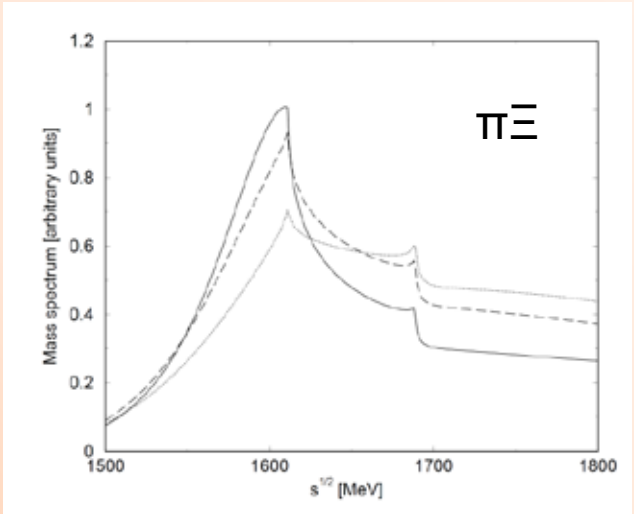
Ξ* - Theoretical Predictions



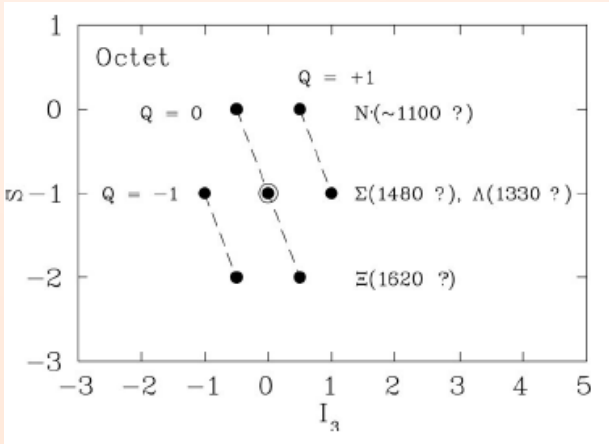
Ξ(1620)*

- first excited state, if exist.
  - Is this a Roper-like state?
- dynamically generated resonance
- candidate for exotic baryon; 5q

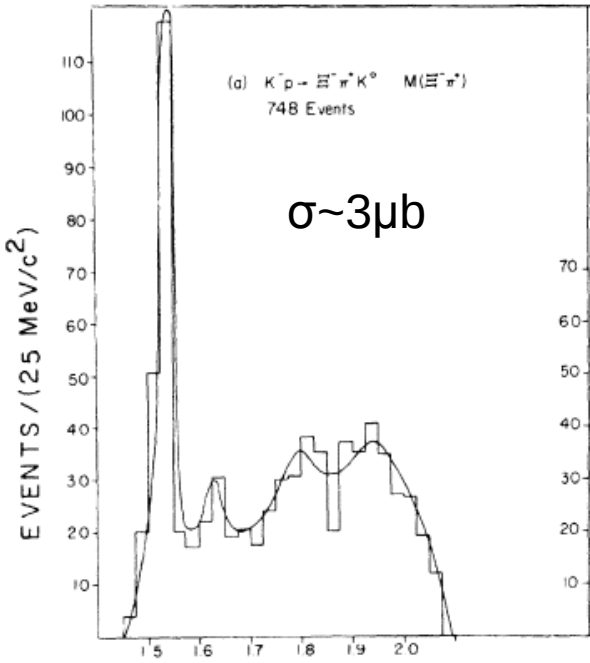




Ramos, PRL89 (‘02) 252001

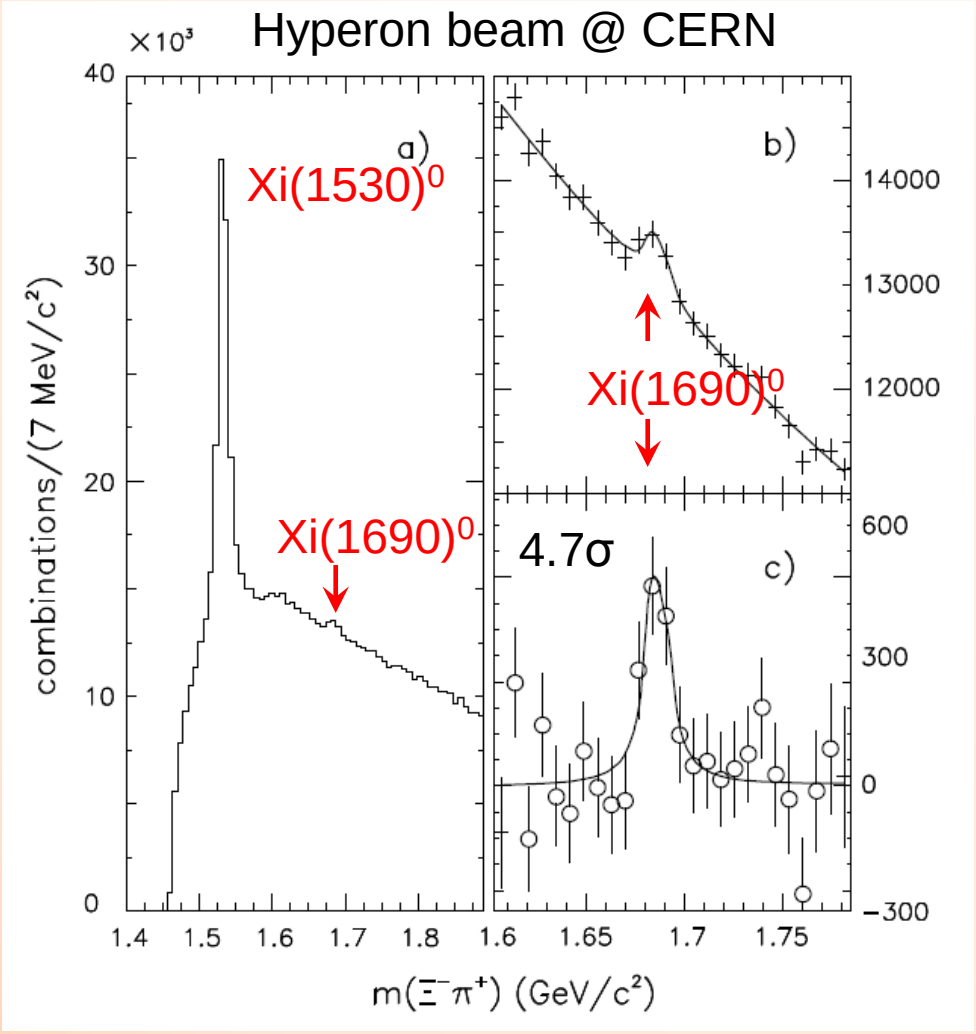


Azimov, PRC68(03)045204



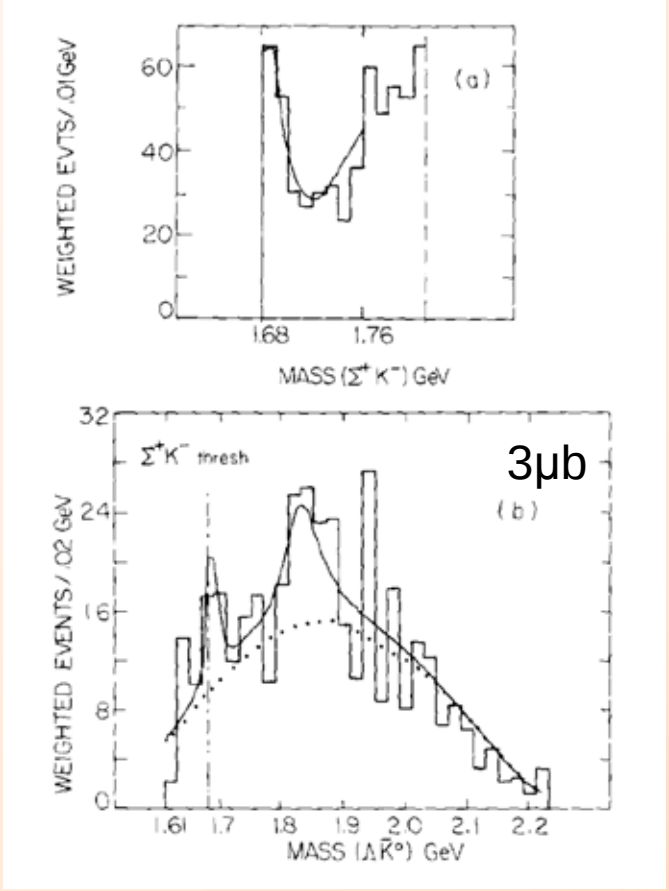
Ξ(1690) ***

Hyperon beam @ CERN



Adamovich et al., EPJ,C5('98)621

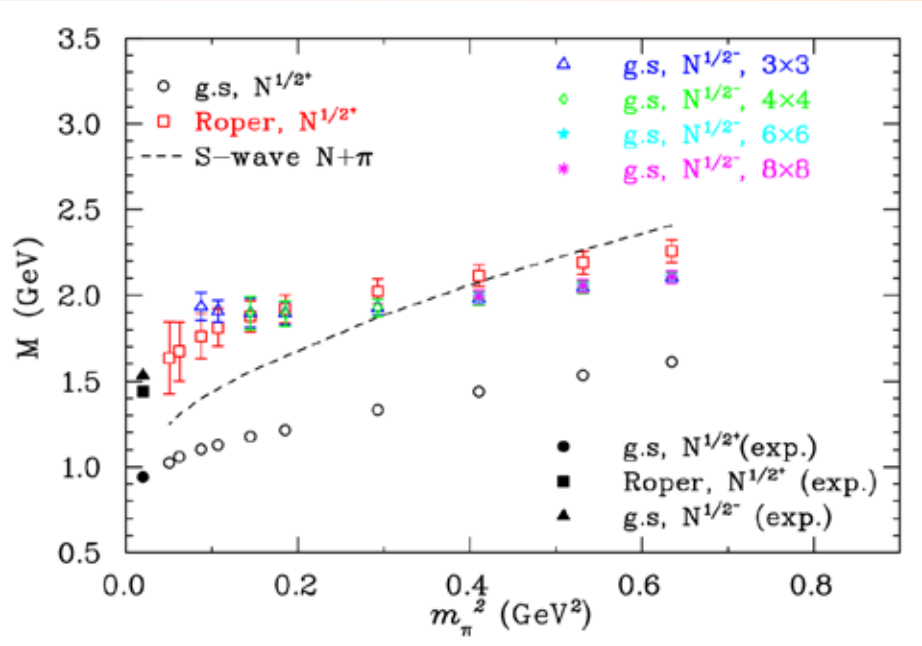
4.2GeV/c K^-p à YKKπ



Dionisi et al., PL,80B,('78)145

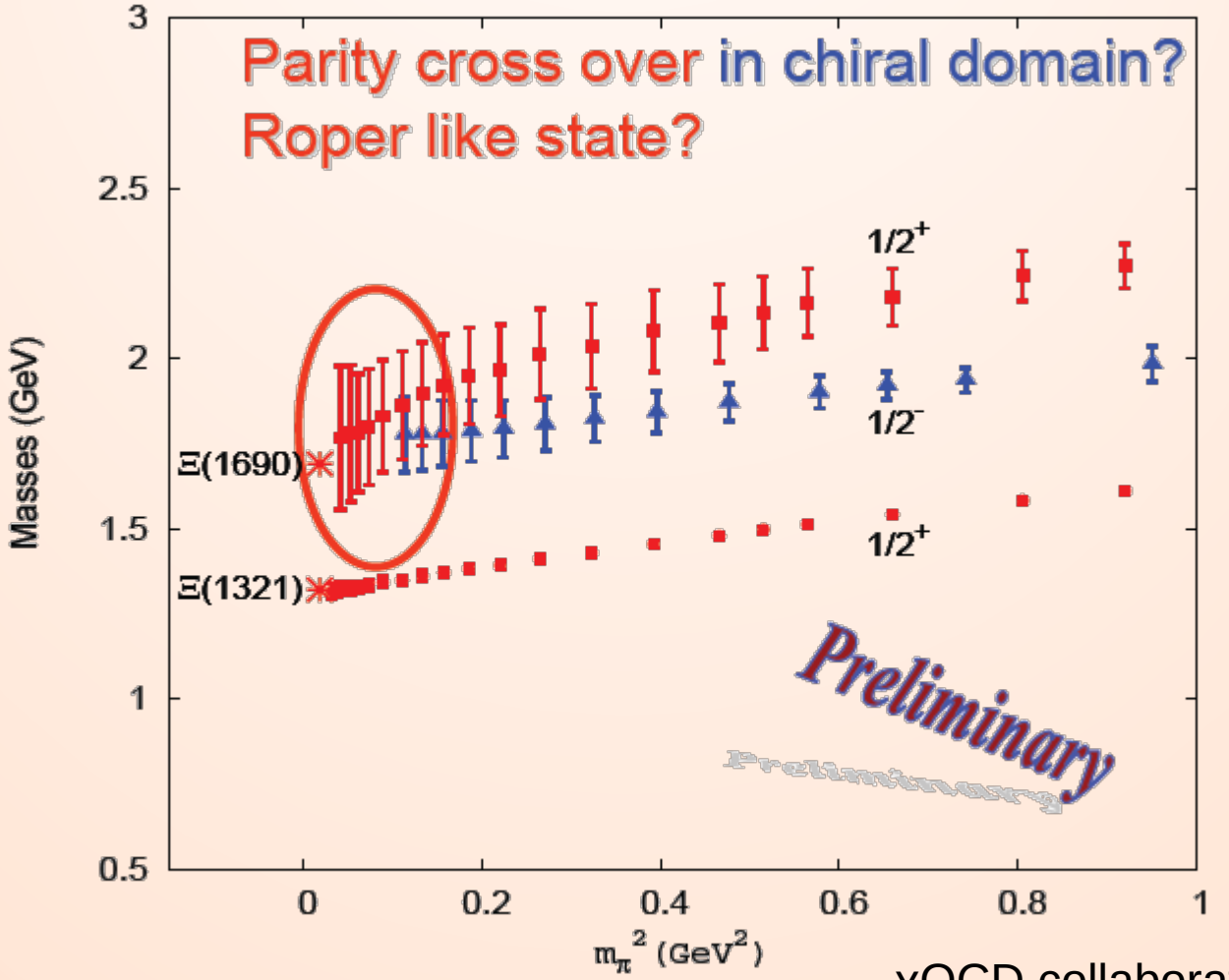
Roper resonance

- too light to think of it as ½+ N*.
  - OBE
  - Skyrme
  - qqqG (M>1.8GeV)
  - not qqq
    - meson-baryon coupled channel approach
  - 5q content ~ 25%
  - π could model



Mahbub et al., PLB693(2010)351

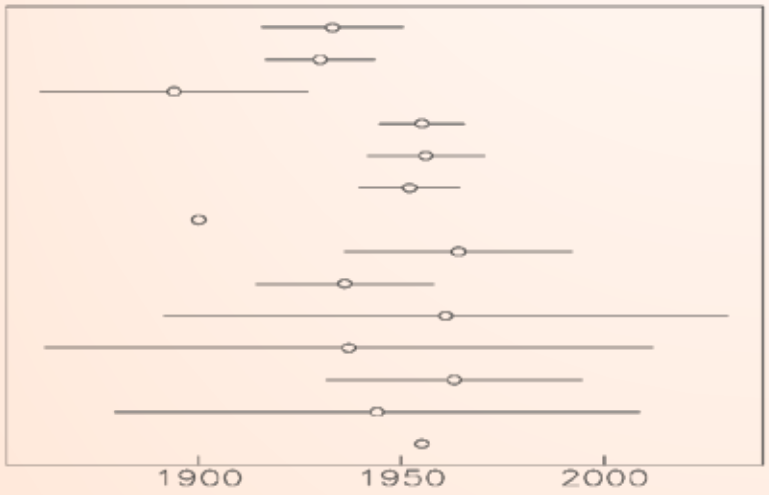
Octet baryons from LQCD



χQCD collaboration

Ξ(1950)***

- is this a same state?



J^P	Mass	Width
5/2- octet	1950	137
5/2+ octet	1965	38
1/2- decuplet	1900	69
have different decay pattern (Valderrama)		

Ξ+Be

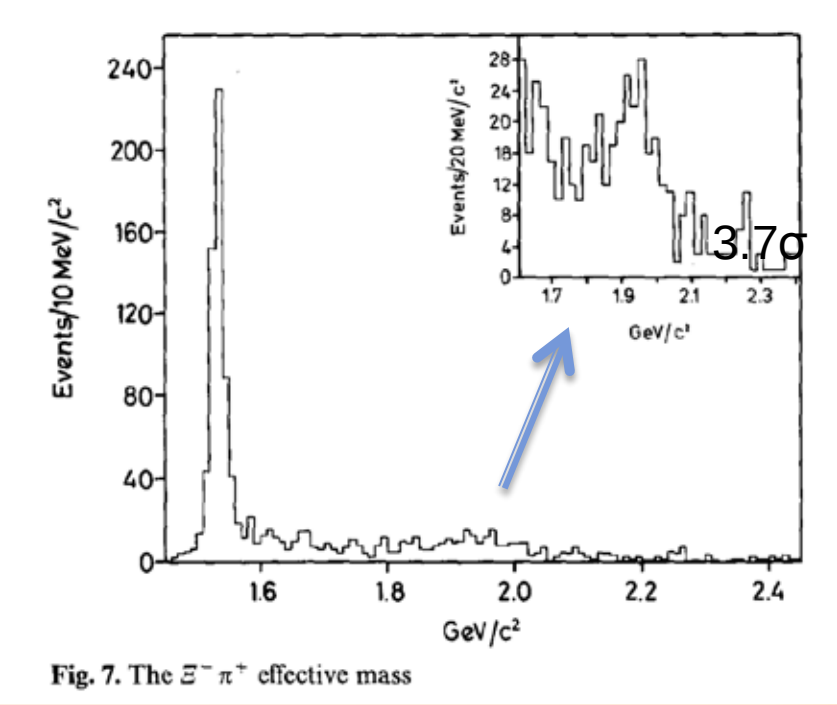


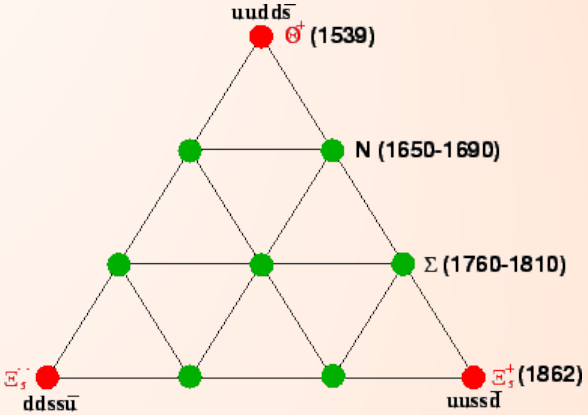
Fig. 7. The $\Xi^- \pi^+$ effective mass

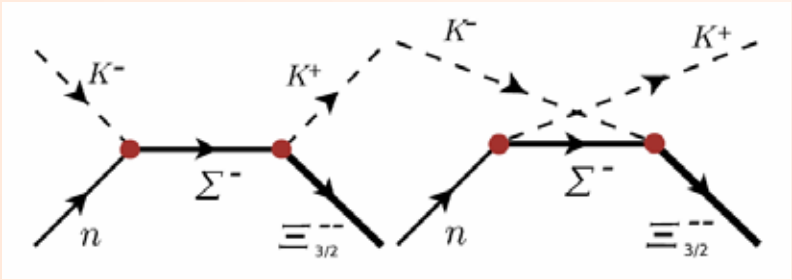
Biagi et al., ZPC,34('87)15

→ (relative) amplitude of each resonances

Ξ(1860)--

- member of $\overline{10}$, S=-2,I=2/3,Q=-2
- only NA49 reported positive evidence in Ξ-π-/Ξ-π+
- combinatorial background is much suppressed in K-p reaction

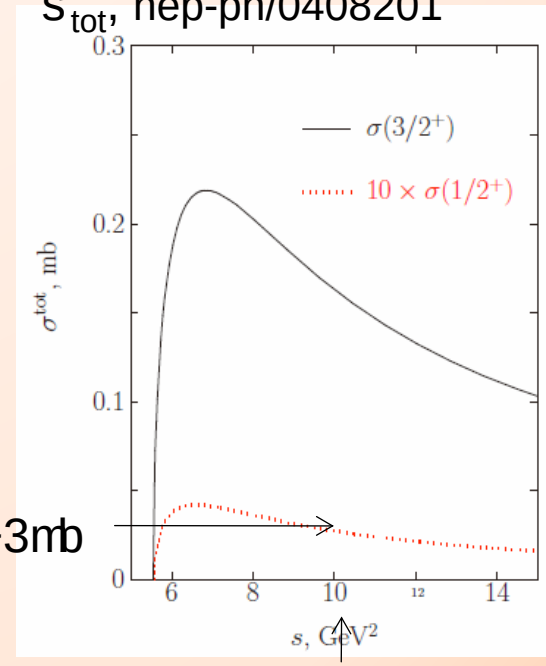




theoretical calc.

- $g_{KSX} = g_{KNQ}$,
- form factor : K photoproduction

s_{tot}, hep-ph/0408201



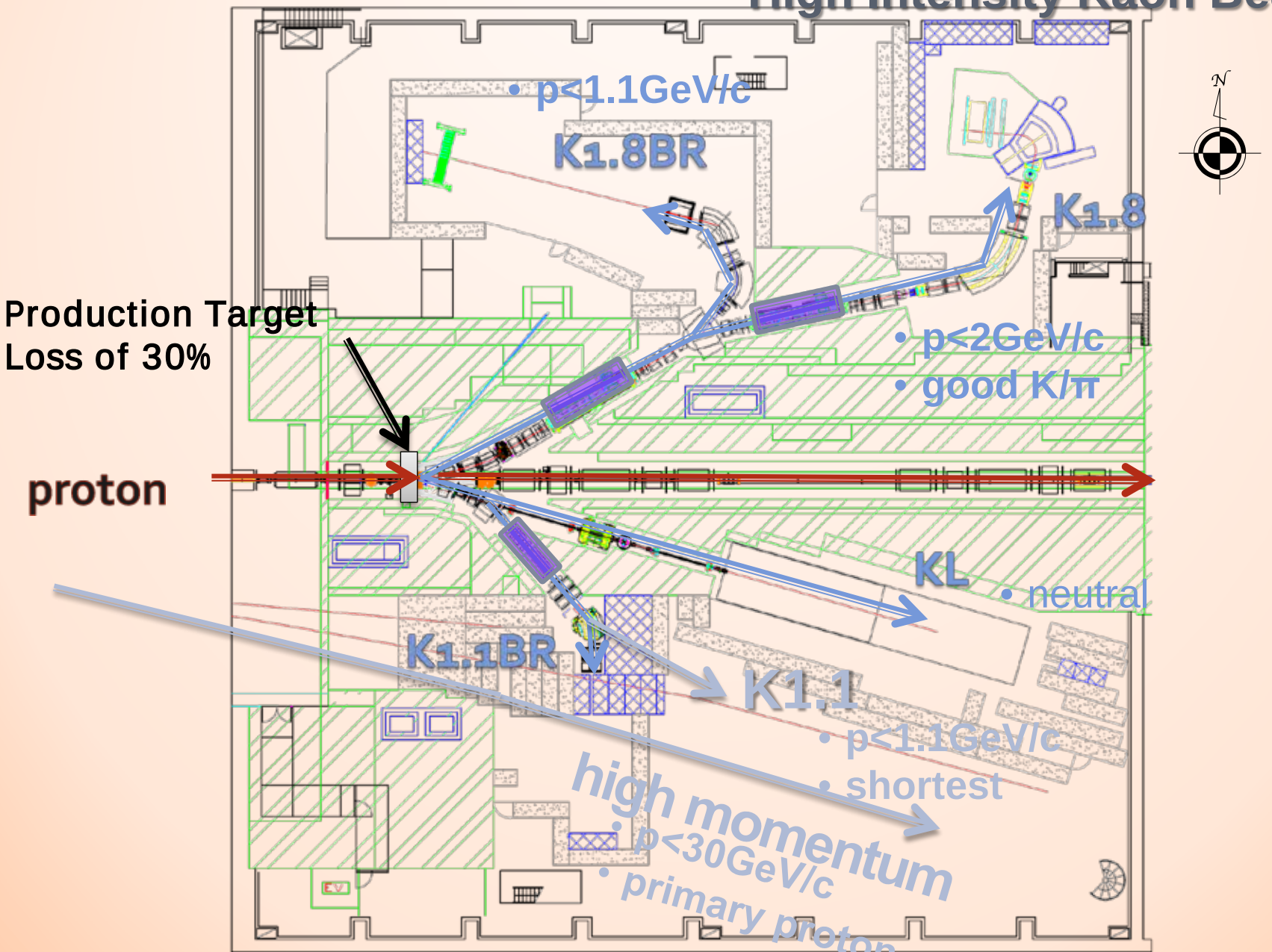
~3mb

- I_{K^-}=6x104 ppp, target: deuteron ~1%, 40days, acceptance~10% à ~500 counts

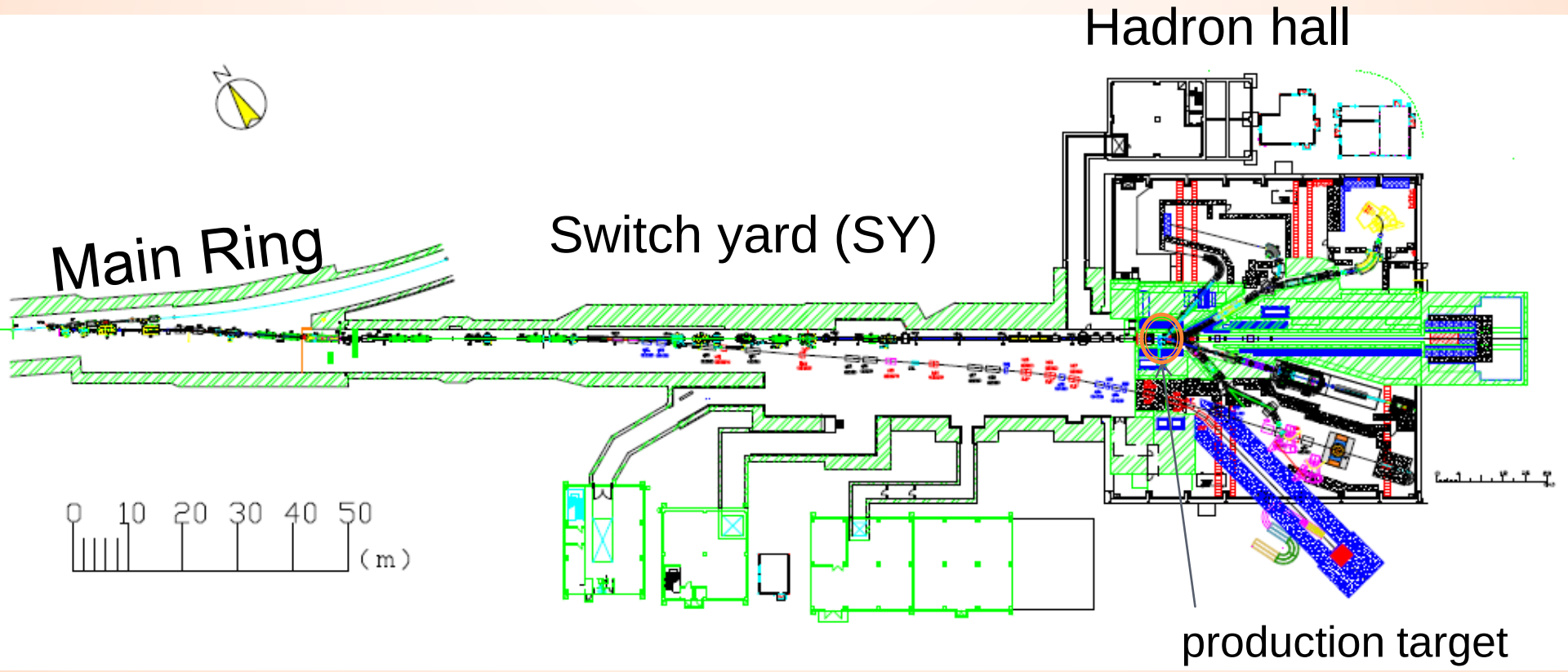
p_{lab}=5GeV/c

Hadron Experimental Facility

High Intensity Kaon Beams



High momentum beamline



at SM1 high-p beam branches off from the primary line

- 30 GeV primary proton (10^{10}/s, 10^{12}/s)
- unseparated secondary particles (< 20 GeV/c)

expected secondary beam intensity

	p (GeV/c)	Yield 5 °	Yield 0 °
p+	5	8.2E7	1.3E8
p+	10	1.9E7	2.8E8
p-	5	6.0E7	7.8E7
p-	10	1.2E7	1.3E8
K+	5	5.4E5	5.6E5
K+	10	7.6E5	6.8E6
K-	5	2.3E5	3.6E5
K-	10	1.7E5	2.1E6
p bar	5	1.1E6	1.2E6
p bar	10	1.5E5	1.2E6

30 GeV proton

15 kW loss target

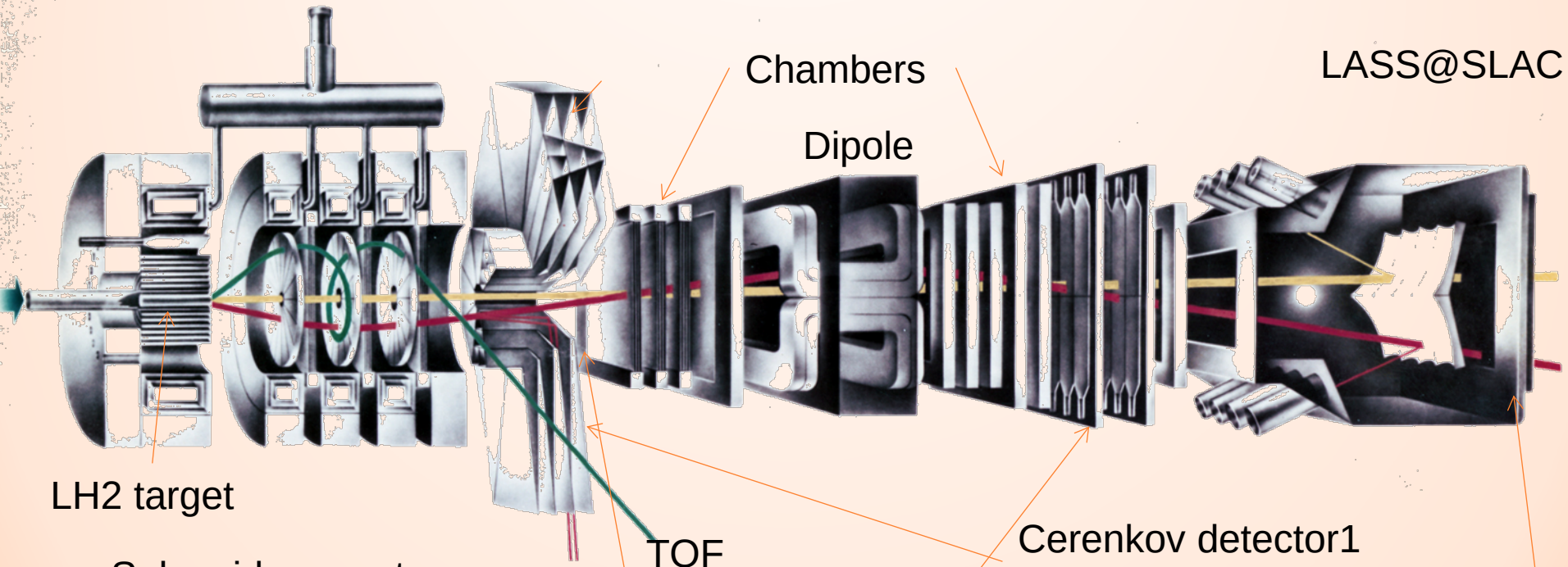
(Dp/p)DW:
0.16 msr%

beam line length :
120 m

Sanford-Wang
formula

LASS Spectrometer

11 GeV/c K^- p

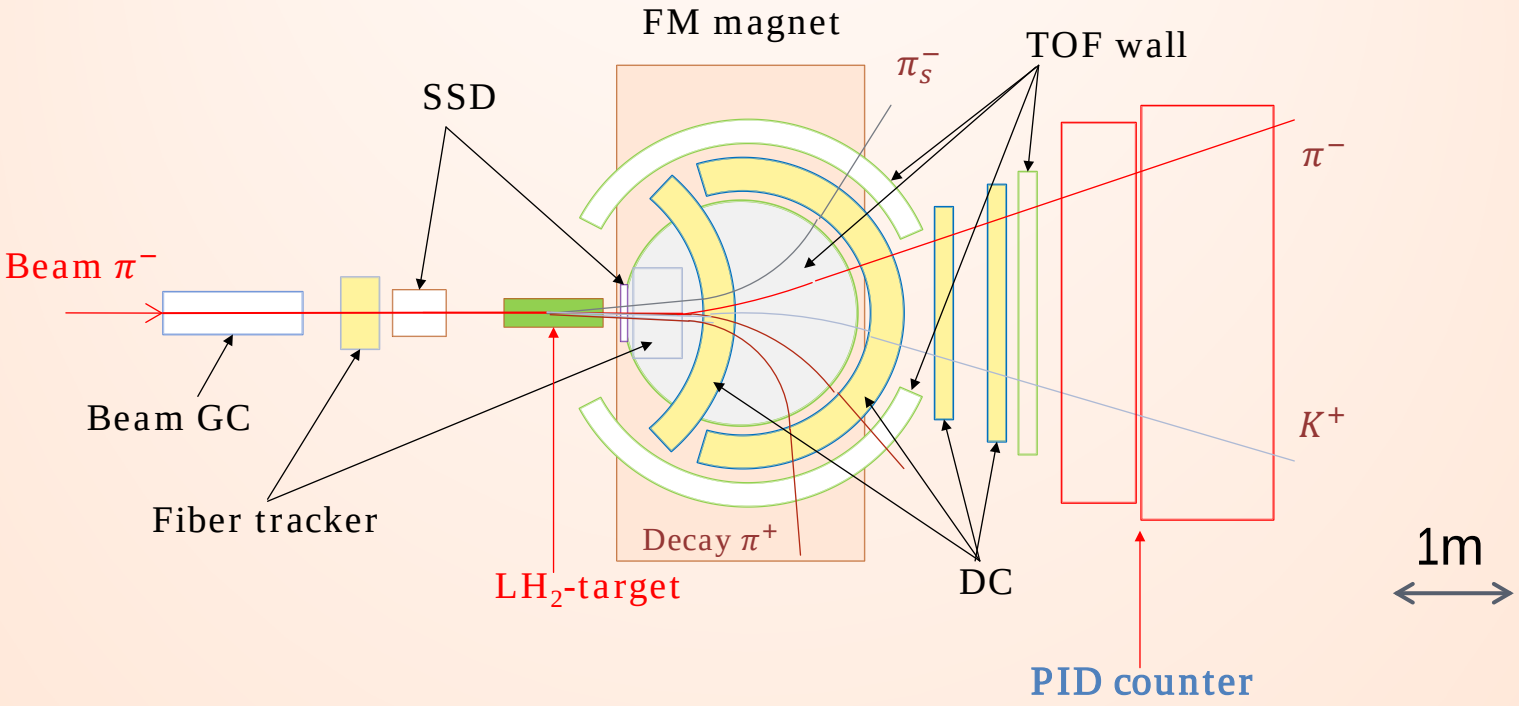


Solenoid magnet

momentum analysis
dE/dx : π/p <0.7GeV/c

"Electronic Bubble Chamber"

J-PARC E50 Spectrometer



High resolution & Large acceptance spectrometer

- Larget acceptance (60% for D*)
- Detector configuration for high-resolution (dp/p=0.2%)
  - Possible decay mode measurement: $Y_c^* \rightarrow Y_c + p$...
- Multi-particle detection in the high rate environment

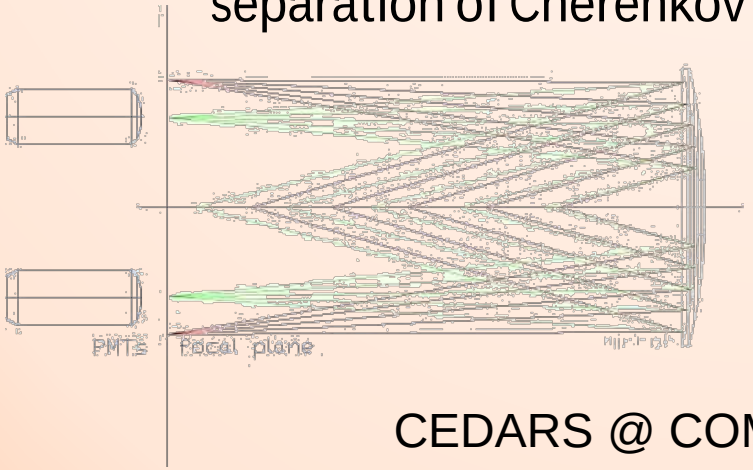
LOI – Ξ Spectroscopy at high-p

5 GeV/c K^-p à $K^{(*)+}\Xi^{*-}$ w/ E50 spectrometer

- Missing & Invariant Mass
- Issues
  - Beam Kaon Tagging : $K/\pi \sim 10^{-2}$
  - Background Suppression : vertex cut / double strangeness

Differential Cherenkov detector

- separation of Cherenkov ring



CEDARS @ COMPASS

rejection power ~10^{-2}

Yield Estimation

$I_K=10^5$/spill

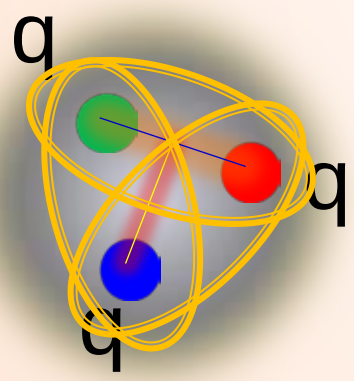
σ=1μb

$d\Omega/4\pi$ = 50%

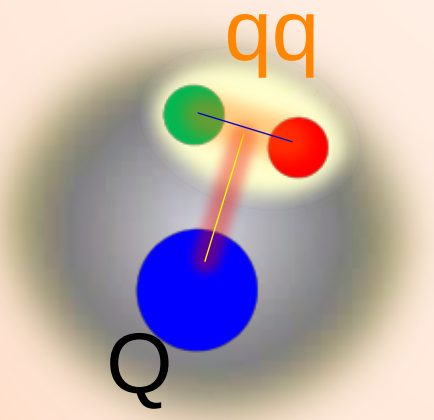
4g/cm^2 LH2 target

à Y = ~10^4/1month

Baryon with Heavy Quark



Most fundamental question
Interaction btwn quarks
Diquark correlations



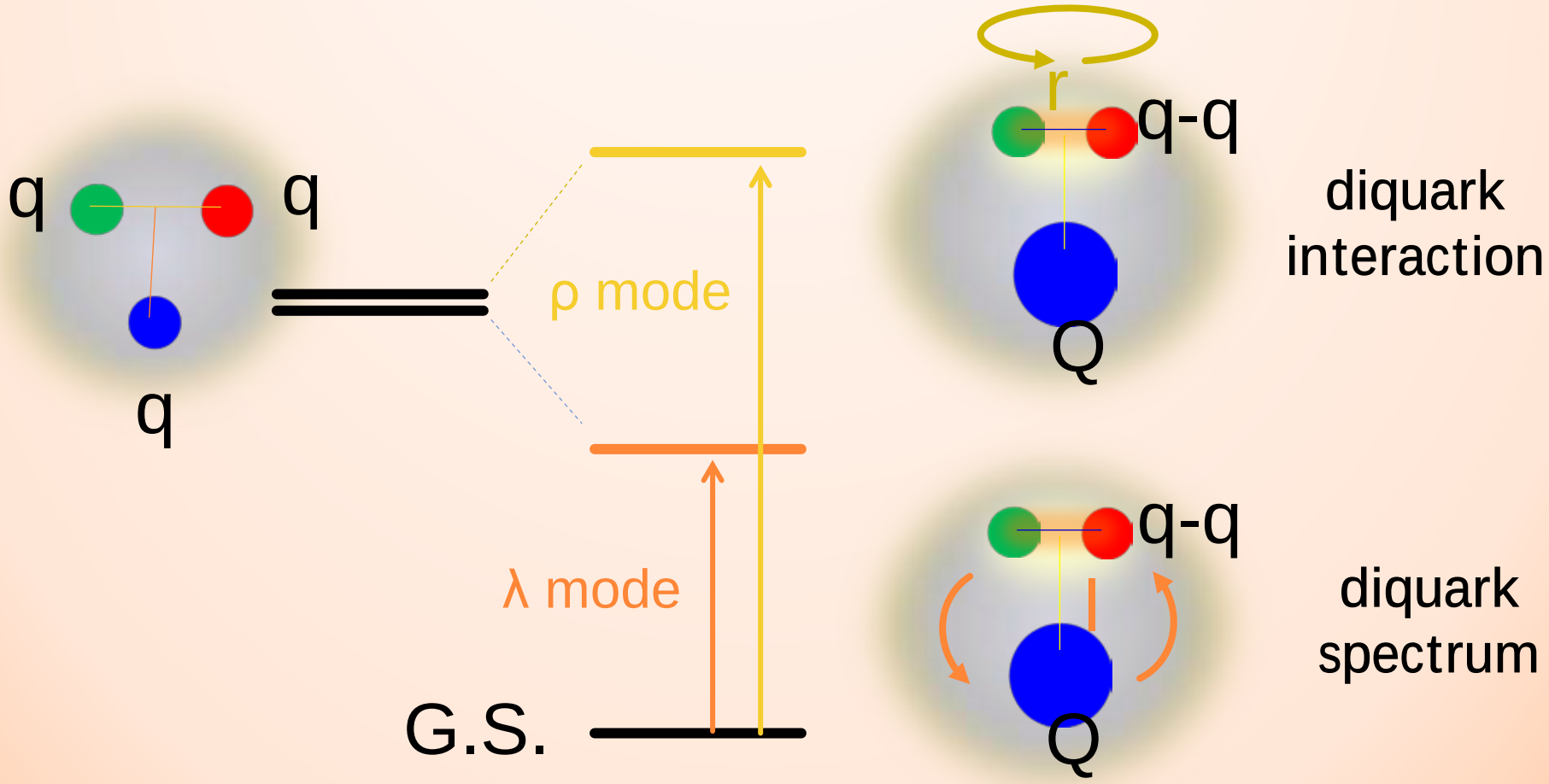
→ Charmed baryon

to close up diquark correlations

- Weak Color Magnetic Interaction with a heavy Quark

Heavy Baryon – strange to charm

- λ and ρ motions split in heavy baryons



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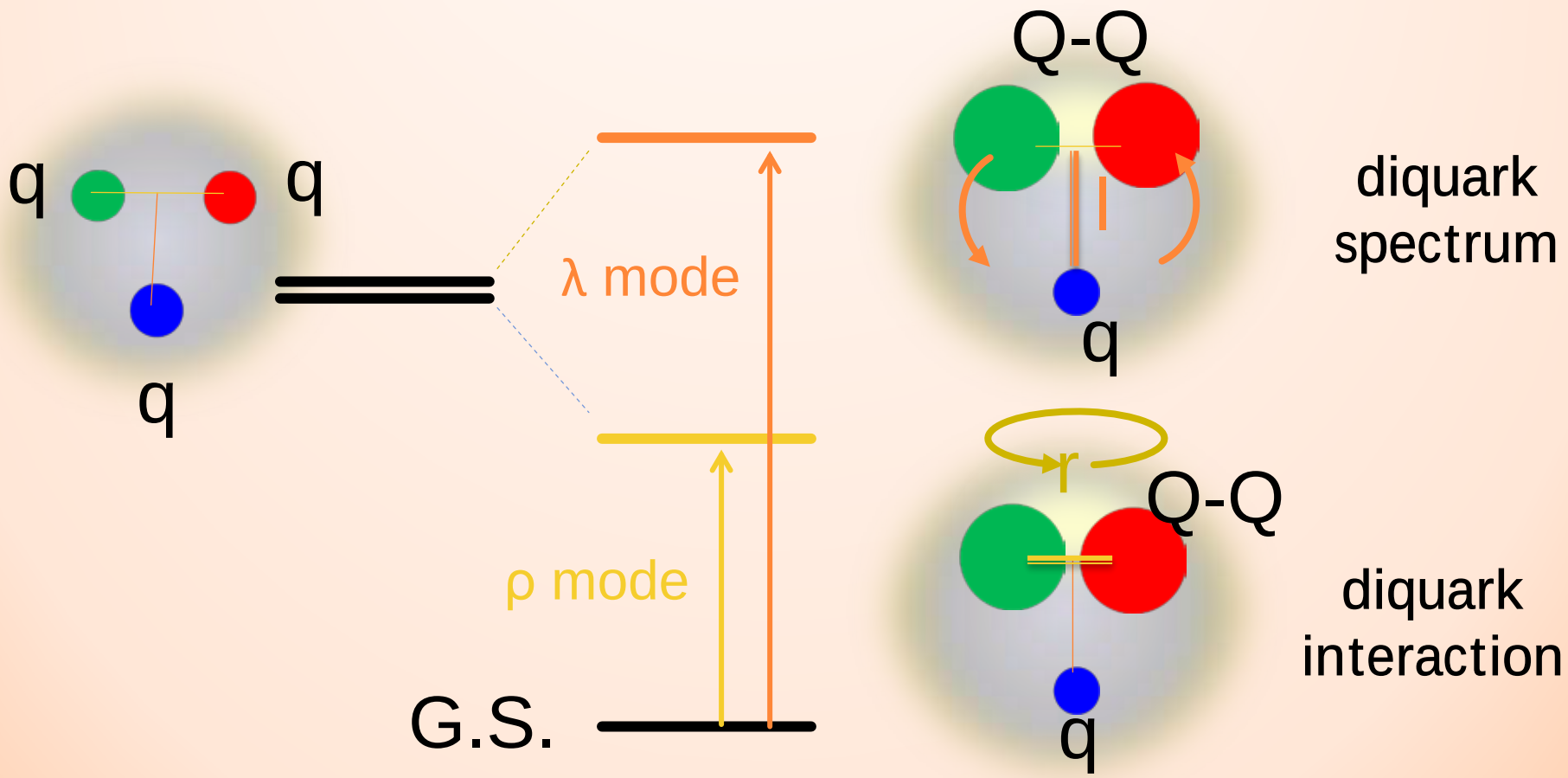
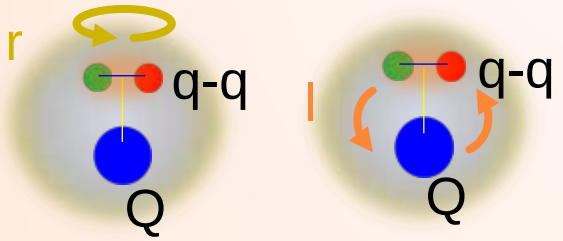
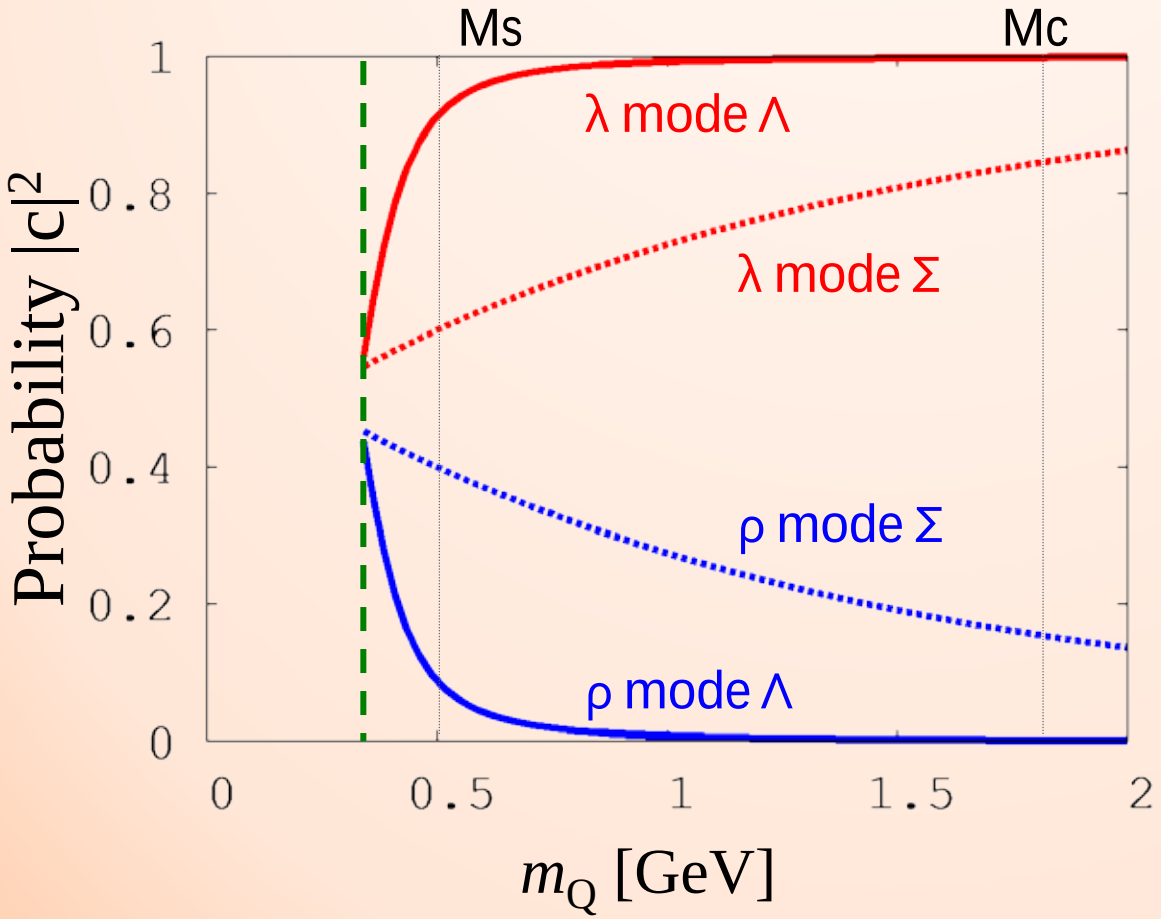


Negative-parity Baryon



QM calculation by
Yoshida, Sadato, Oka, Hosaka



Λ_c is pure λ mode

Λ_s is almost λ mode

Ξ will be almost ρ mode

Ξ_{cc} will be pure ρ mode

平成30年度（2018年度）に着手

ハドロンホールの拡張

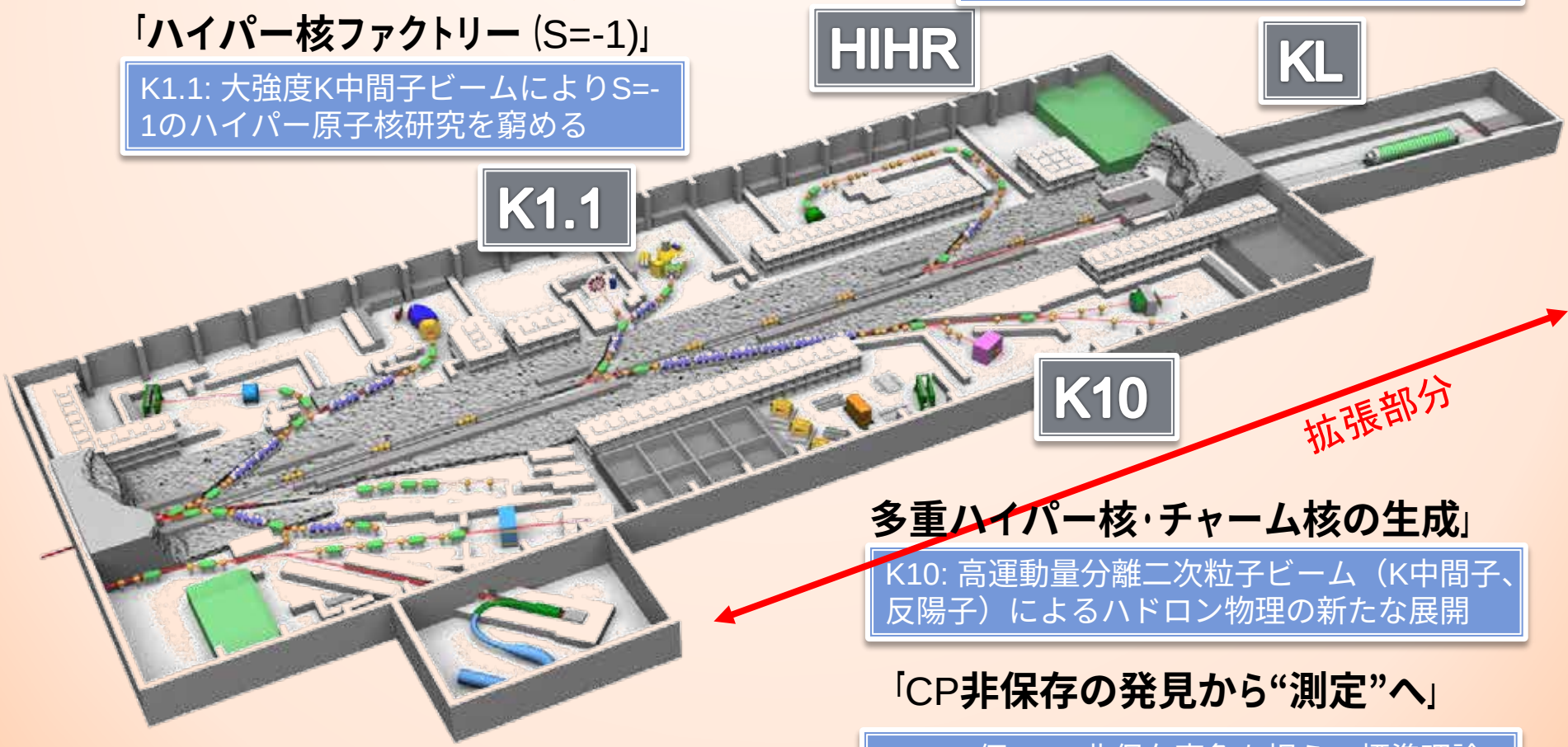
狭矮な1期ハドロンホールを拡張し、ユーザーの希望にこたえる。内容についてコミュニティをベースに検討中。ハドロンホールユーザー会（HUA）の承認の下、設計グループを結成。核物理委員会では、本拡張計画を「新1次陽子ビームライン建設」の次に実現すべき、100億円超規模では最優先の課題と決議。

「ハイパー核ファクトリー（S=-1）」

K1.1: 大強度K中間子ビームによりS=-1のハイパー原子核研究を窮める

「ハイパー核顕微鏡」

HIHR: 高分解能大強度二次粒子ビームによりハイパー原子核の精密測定へ



多重ハイパー核･チャーム核の生成」

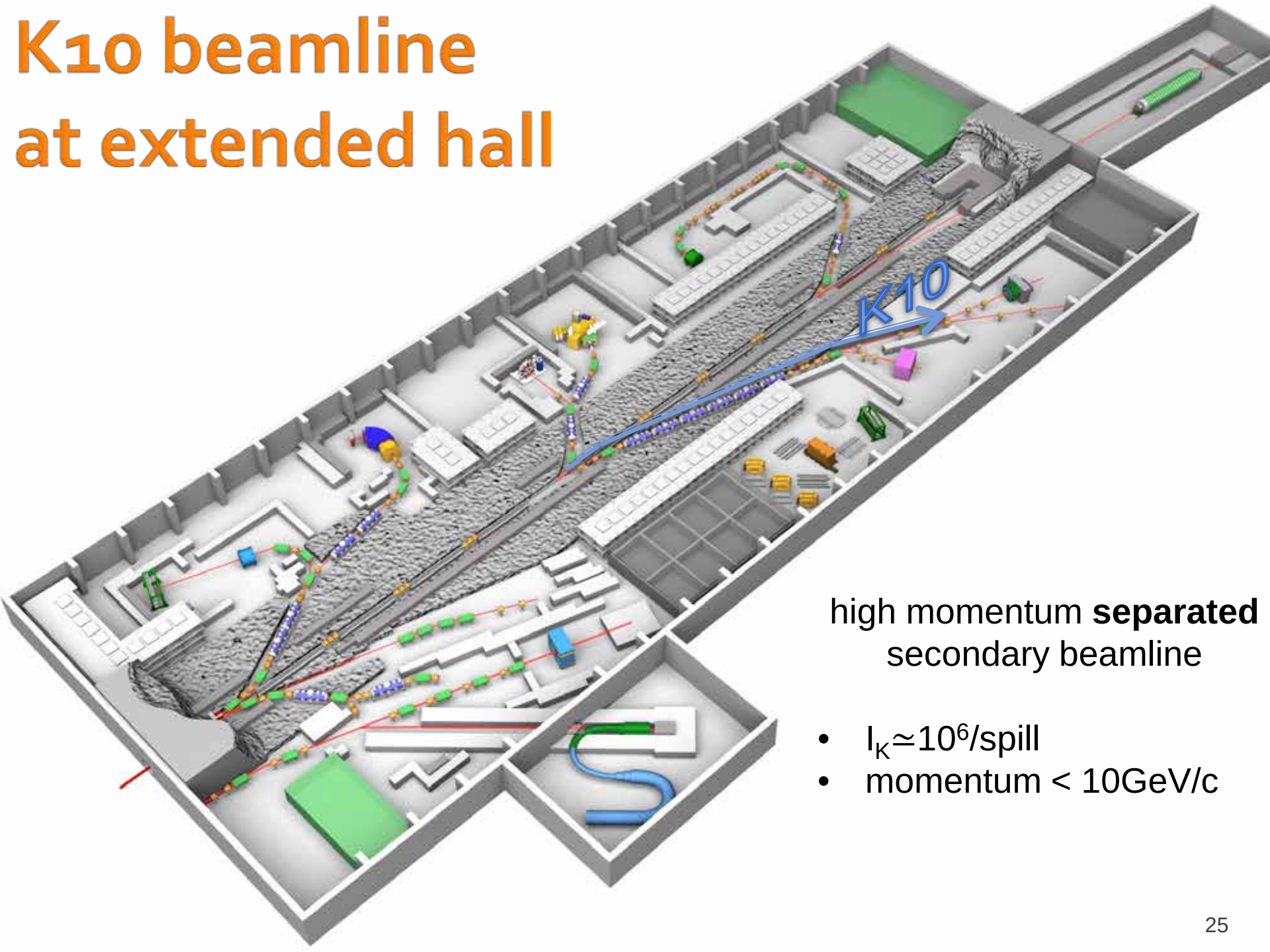
K10: 高運動量分離二次粒子ビーム（K中間子、反陽子）によるハドロン物理の新たな展開

「CP非保存の発見から“測定”へ」

KL:100個のCP非保存事象を捉え、標準理論を超えて物質優勢宇宙の謎に迫る

Slide by Hadron group

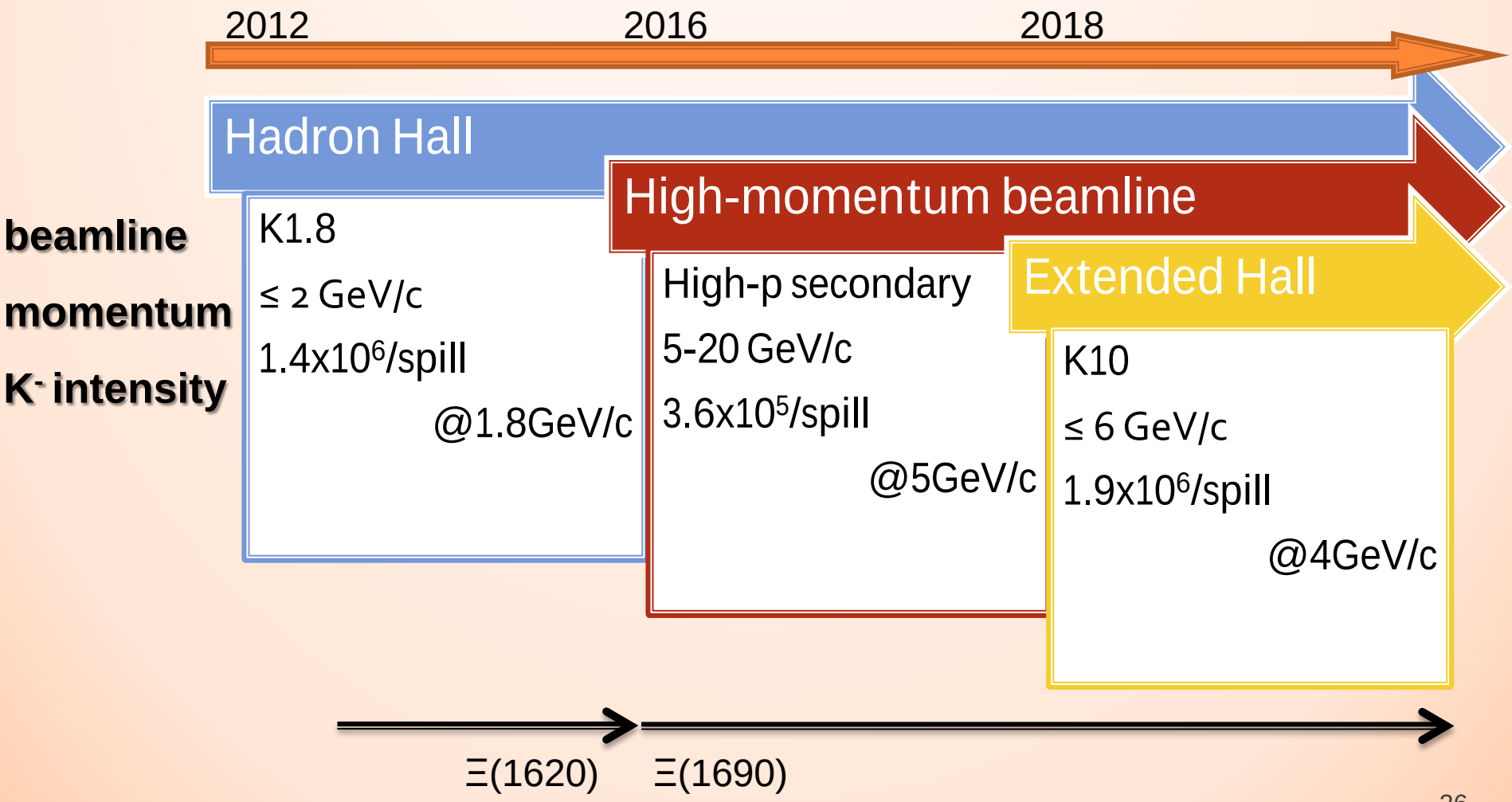
K10 beamline at extended hall



high momentum **separated** secondary beamline

- $I_K \simeq 10^6$/spill
- momentum < 10GeV/c

high momentum secondary beam



Summary

- We do not know much about Ξ.
- Systematic study is possible at J-PARC.
  - cross section/relative amplitude of each states
  - possibilities to explain light excited states.
  - Can diquark correlation be seen in Ξ baryons?