Summary on the Nucler/Hadron Physics Session @ NP04

Tokai, Ibaraki, Japan August 2-4, 2004

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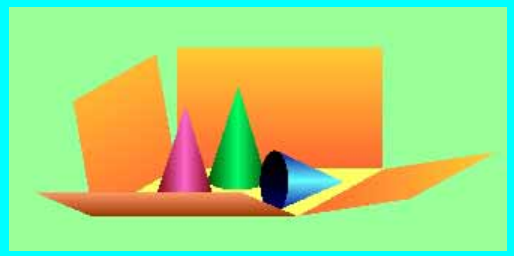
Approaches in Hadron Physics

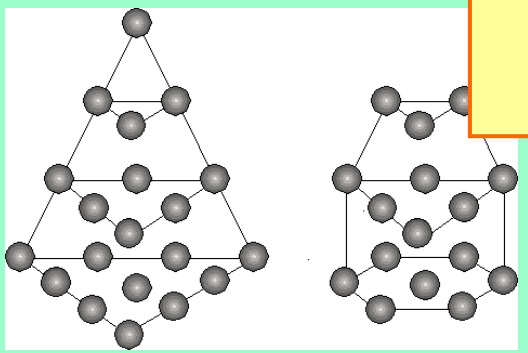


Studies of Structure and Properties of Hadron

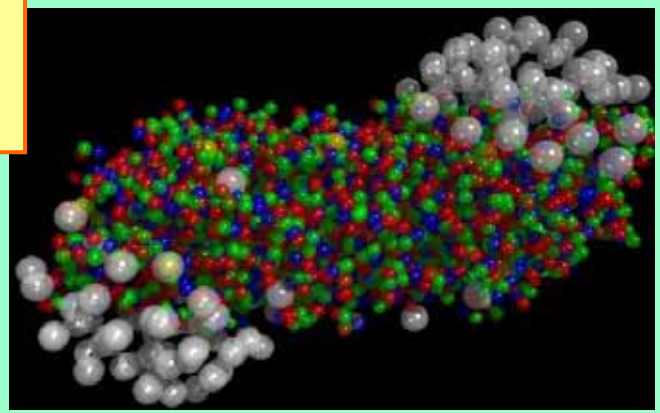
Variety of approaches ➔ variety of LoIs / Proposals

Physics of **Quark-Gluon** Multi-body System

Mystery of Confinment



Search for Exotic Particles



De-confinement

Hadron-related Letters of Intent

Table 1 Summary of Letters of Intent and requested beams

	Contact	Requested	Momentum	Phase-1						Phase-2	Future Possibilities								Suggested
	Person(s)	Beam	Range	K1.8	K1.1	K0.8	KL	Test	High	Neutrino	High-resol.	Several GeV	Heavy	Pol.	PRISM	PRISM-II	Fast	NuFact-J	Schedule
			(GeV/c)					Beam	Mom.		line	Separated	Ion	Proton			Extraction		
LOI-06	K. Imai	K-	0.8, 1.1, 1.8	○	○														Day-1
LOI-07	M. Ieiri	K-, π+	1.0-1.6	○	○														Phase-1
LOI-08	H. Noumi	π+/-	1.0-1.2								○								Phase-1
LOI-09	T. Fukuda	K-/π-	0.9/1.0		△						○								Phase-1
LOI-10	T. Nagae et al.	K-	0.9, 2-3		○							○							Day-1
LOI-21	S. Ajimura	K-/π+	0.8/1.0		○														Phase-1
LOI-01	V.V.Sumachev et al.	π+/-	0.6-2.1	△															Phase-1
LOI-03	A.D. Krisch	p	51						○					○					Phase2+
LOI-11	S. Yokkaichi	p	31, 51						○				○						Phase-1
LOI-13	H. Spinka, S. Sawada	π,K,p	< 6						○			○							Phase-1
		pol.-p/HI											○	○					
LOI-15	J.-C. Peng, S. Sawada	p, pol.p, HI							○				○	○					Phase-1
LOI-18	T. Murakami	p	30						○				○						Phase-1
		p,π-	4.0-14.0						○										
LOI-23	L. Nemenov	p	30(50)						○										Phase-1
LOI-04	T.K. Komatsubara	K+	0.6-0.8			○													Phase-1
LOI-05	T. Inagaki	KL	~2				○												Phase-1
LOI-16	C. Rangacharyulu	K+				○													Phase-1
LOI-19	Yu. Kudenko, J. Imazato	K+	0.6-0.7			○													Phase-1
LOI-20	S. Shimizu	K+	0.6-0.7			○													Phase-1
LOI-12	K. Nishikawa	neutrino	~0.8							○									
LOI-17	B.L. Roberts	_+															○		Phase2+
LOI-22	Y.K. Semertzidis et al.	_+														○			Phase2+
LOI-25	PRIME Group	_-													○				Phase2+
LOI-02	S. Komamiya	e,_,π,K,p	0.5-2, <10					○											Day-1
LOI-14	S. Sawada	π,K,p, primary	> 5						○			○	○	○					Phase-1
LOI-24	PRISM Group	μ													○	○			Phase2+
LOI-26	Y. Kuno, R.S. Hayano	anti-p, _, ..													△		○	△	N/A
LOI-27	Y. Kuno, Y. Mori	neutrino																○	N/A
LOI-28	V. Obraztsov, T. Tsuru	K-	~12									△							Phase2+
LOI-29	T. Kishimoto																		N/A
LOI-30	K. McDonald et al.	p	50														○		Phase2+

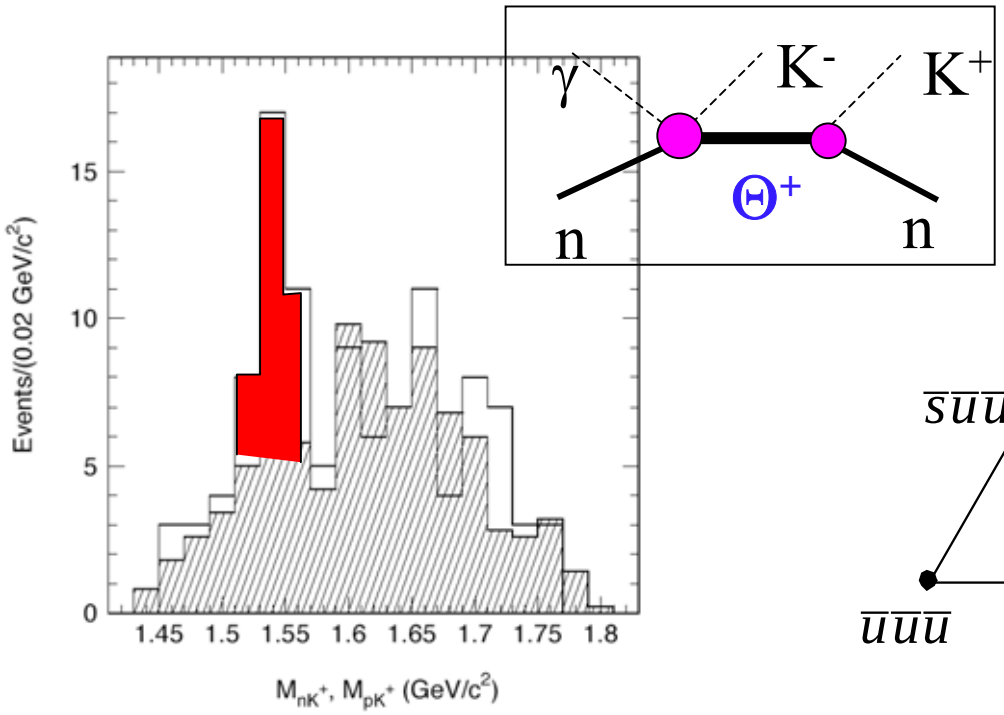
- L01, L11, L13, L14, L15, L18, L23 are assigned as Phase-1.
- In addition, LoI10: Study of Dense K-Nuclear System ($K^- + A \rightarrow N + {}_K A^{-1}$) was evaluated as Day 1.

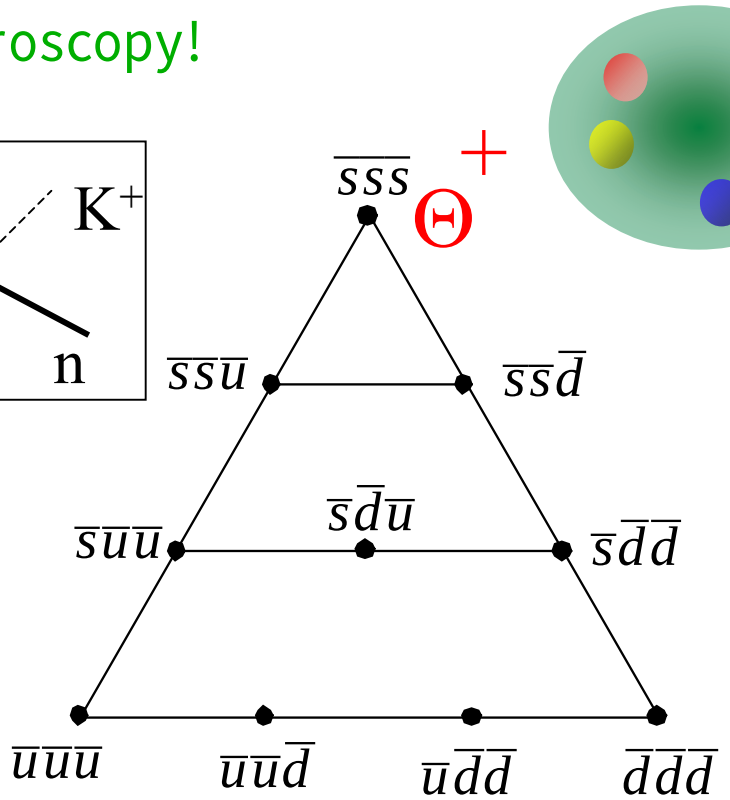
Topics of Hadron Physics @ NP04

- Letters of Intent
  - Dimuon (Flavor asymmetry at Large x_{Bj}, etc.)
    - Peng/S.Sawada
  - Spin Structure of Nucleon or on Nucleon Reaction
    - Miyachi, Krisch
  - Hadron Spectroscopy
    - Sumachev
  - Meson Property in Nuclear Medium
    - Yokkaichi
  - Basic Property in Low Energy QCD (pi-pi, pi-K scatt. Length)
    - Nemonov
- Recent Development
  - Multiquark (or Meson-Baryon) States
    - Hosaka, Imai, Miwa, Lanskoy, Iwasaki, Kishimoto, Doering
  - Δs via Neutrino Scattering
    - Miyachi, Saito
- Beamline
  - High Momentum Beamline
    - Sawada

Pentaquark (Hosaka, Imai, Miwa, Kishimoto)

- Θ^+ discovery at LEPS/Spring-8
  - Mass around 1540 MeV
  - New Era for Hadron Spectroscopy!

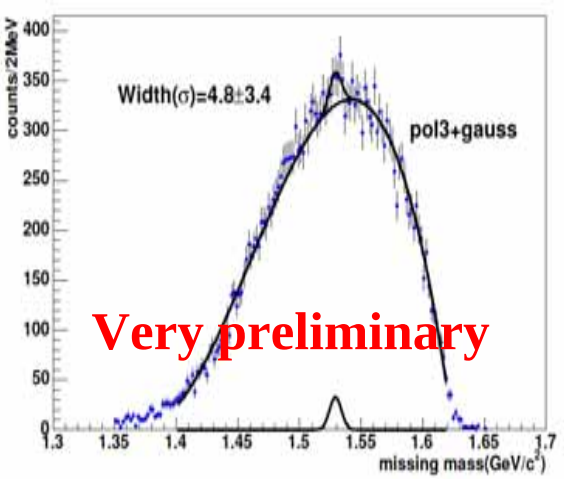




Pentaquark (Hosaka, Imai, Miwa, Kishimoto)

- Width, parity, spin are unknown.
- Null results have been reported from high energy machines.

- Θ^+ production by hadron beams
  - Preliminary result from KEK-PS
    - E522: Θ^+ search via (π^-,K^-) reaction
      - Hint on Θ^+?
      - Two kinds of upper limit estimation of cross sesion: around 2 μb
    - Can be continued at J-PARC

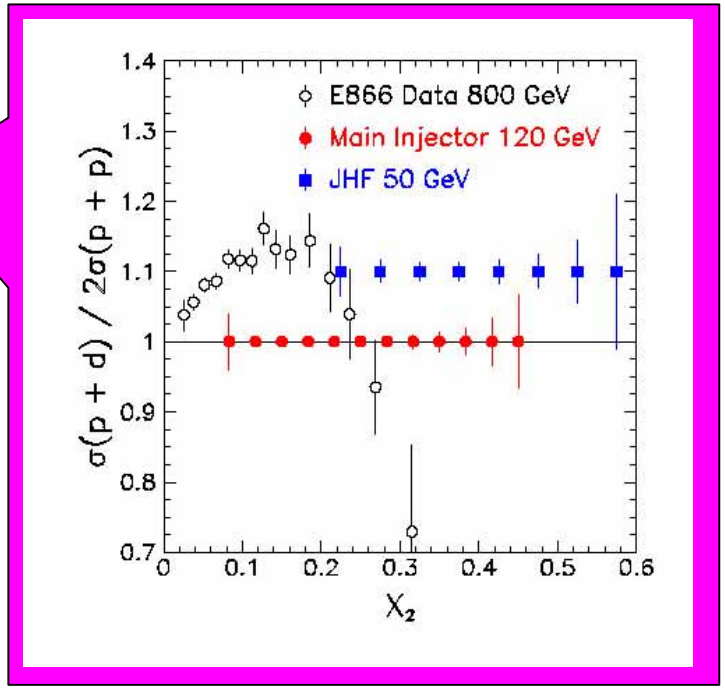


Pentaquark (Hosaka, Imai, Miwa, Kishimoto)

- Future possibilities
  - KEK-PS E559: K+ p ->π+ Θ+ reaction with SKS spectrometer
  - KEK-PS E548: Search for X (=Kπ bound state)
    - Θ^+=KπN bound state? The key is Kπ interation.
  - K^+n phase shift?
  - At J-PARC?
    - Spin/Parity might be measured before J-PARC.
    - K^+n phase shift: p$\sim$500MeV/c
    - Θ^+ nuclei (hyponuclei): (K+, π+) spectroscopy at $p_K\sim$1GeV/c
    - Other pentaquarks (N*, Σ*, Ξ*): need higher momentum beamlines (p<2.5GeV/c?)
    - Charmed pentaquarks with 5GeV/c neutrino beams

Physics with dimuon @ 50 GeV (Peng)

- Direct investigation of qurak-gluon multibody system
- dbar/ubar (flavor asymmetry) at large x ➔ closely related with spin structure
- Anti quark PDF in A
- Quark energy loss in A
- PDF in large x
- Drell-Yan and J/ψ with polarized beam



More Parton Distributions (Miyachi, Saito)

- Polarized parton distribution (Miyachi)

$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + L_q + \Delta G + L_G$$

$$\Delta\Sigma = \Delta u + \Delta d + \Delta s + \Delta\bar{u} + \Delta\bar{d} + \Delta\bar{s}$$

  - ΔG: measured at SMC, COMPASS, HERMES, RHIC-Spin
  - $\Delta\Sigma$: Δu and Δd have been relatively well masured.
  - Flavor SU(3) symmetry? ➔ Δs and Δsbar should be measured by neutrino scattering at J-PARC!

- Δs (Saito)

→ Improve Knowledge on Spin Flavor Structure of the Proton

- Beyond Flavor SU(3) assumption

$$d_n = \eta^E(\Delta u d_u^E + \Delta d d_d^E + \Delta s d_s^E)$$
$$\propto m_u \Delta u + m_d \Delta d + m_s \Delta s$$

→ Neutron EDM

- n-EDM predicted using q-EDM and Δq

→ Dark Matter

- Better determination of Dark-Matter reaction

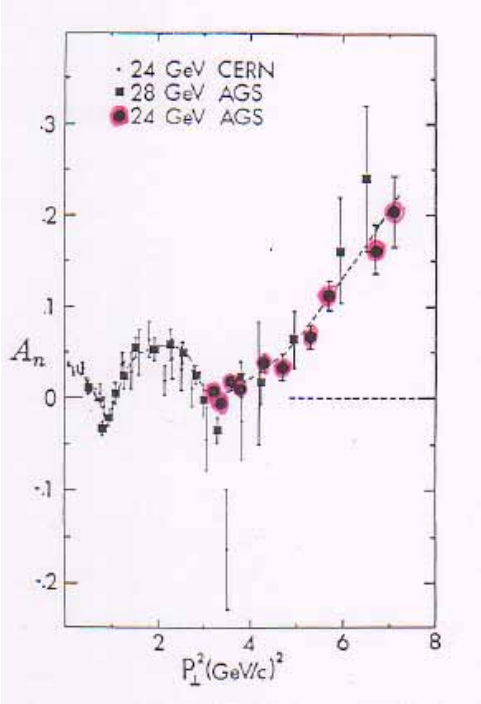
$$\sigma(\chi p \to \chi p) \propto \frac{4}{9}\Delta u + \frac{1}{9}(\Delta d + \Delta s) \text{ (photino) or}$$
$$\propto \frac{17}{36}\Delta u + \frac{5}{36}(\Delta d + \Delta s) \text{ (pure } U(1) \text{ gaugino)}$$

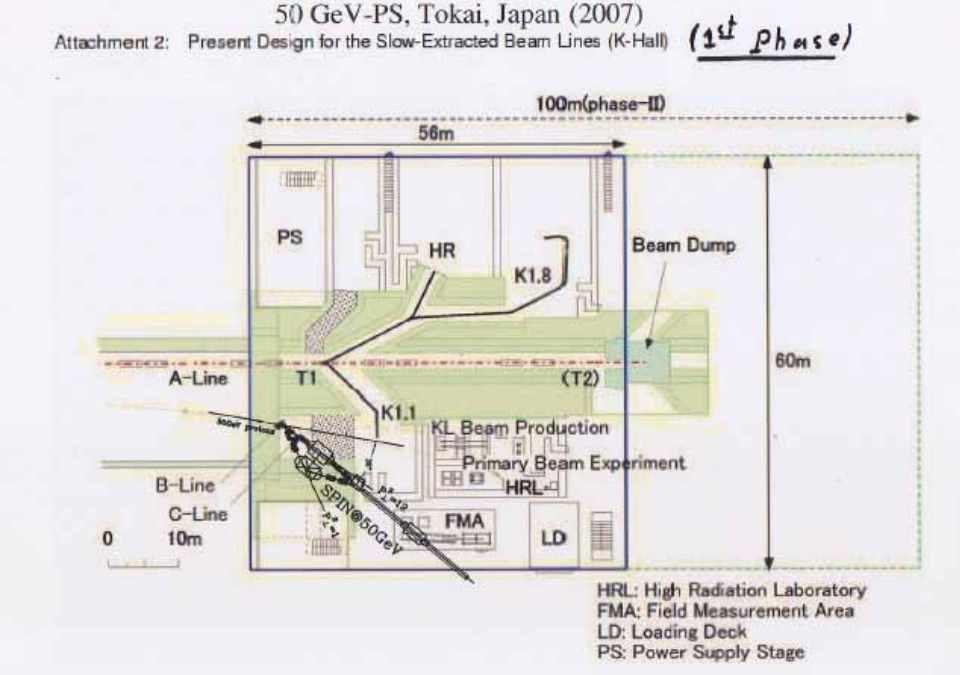
More Parton Distributions (Miyachi, Saito)

- Experiment
  - νN and νbarN elastic scattering
    - Cross section can be written using form factors, one of which equals to Δs.
  - BNL E734
    - Liq. Scintillator + drift tube (170t), 0.5E19 POT for νN, 2.5E19 POT for νbar, Q2>0.4GeV^2
  - '@J-PARC
    - On-axis at near detector hall for T2K
    - Liq. Scintillators with different H/C mixture
    - 1E21 POT possible in one year (130 days)
      - 30 times more than BNL E734
        - E734: Δs = -0.10+-0.08
        - J-PARC: Δs = -0.10 +-0.03, systematics significantly improved
    - Lower Q^2 cutoff

SPIN@J-PARC (Krisch)

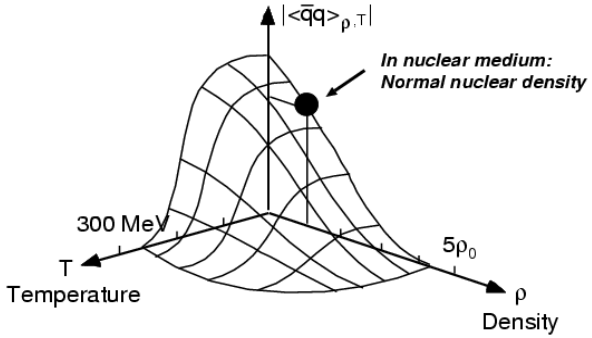
- An beyond BNL-AGS
- 10^{11}pps proton beam on pol. H_2 target
  - Unpolarized proton beam at the beginning, while polarized proton beam in the future.
- Pol. target ready, spectrometers exist.

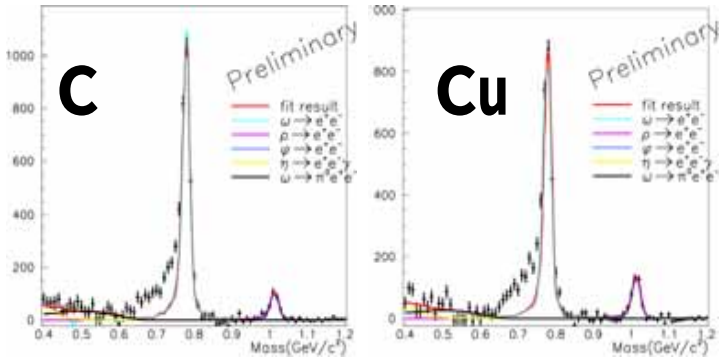


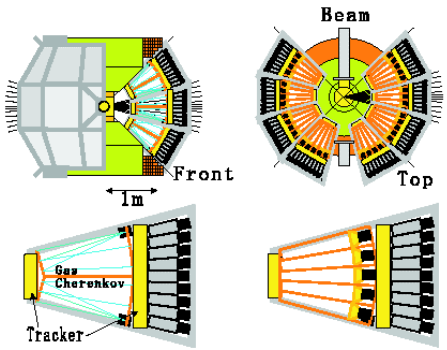


Chiral Symmetry in Dense Matter (Yokkaichi)

- Chiral symmetry in nuclear matter
- Results from KEK-PS E325
  - Have found a hint of the meson mass modification
- Experiment @ J-PARC: electron spectrometer
  - R&D being continued: HBD etc.
  - 30-50GeV protons, 10^9pps
  - Much more statistics than KEK-PS







Spin Rotation Parameters in $\vec{\pi}\vec{p}$ Elastic Scattering (Sumachev)

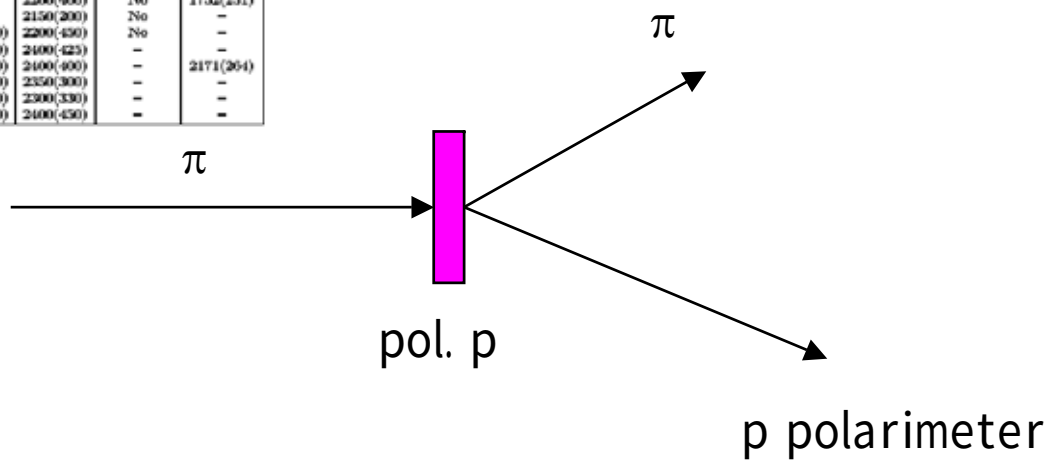
- Hadron Spectroscopy with pol. H_2 target and π beams.
  - Study ambiguous N*, Delta* states.
- Pol. target exists.
- π beams: 0.6 < p < 2.1 GeV/c, 10^7 particles/sec.
- 2 - 3 weeks per one energy, several energies in total.

Table 1. Parameters of the N^* - resonances.

Name	L2J	Status	KA84	CMB80	SM95	KSU92
N(1440)	P11	****	1410(135)	1440(340)	1467(440)	1462(391)
N(1520)	D13	****	1519(114)	1525(120)	1515(106)	1524(124)
N(1535)	S11	****	1526(120)	1550(240)	1535(66)	1534(151)
N(1650)	S11	****	1670(180)	1650(150)	1667(90)	1659(173)
	S11		No	No	1712(174)	No
N(1675)	D15	****	1679(120)	1675(160)	1673(154)	1676(159)
N(1680)	F15	****	1684(128)	1680(120)	1678(126)	1684(139)
N(1700)	D13	***	1731(110)	1675(90)	No	1737(250)
N(1710)	P11	***	1723(120)	1700(90)	[1770-1889]	1717(478)
N(1720)	P13	****	1710(190)	1700(125)	1820(354)	1717(383)
N(1900)	P13	**	No	No	No	1879(498)
N(1990)	F17	**	2003(350)	1970(350)	No	2086(535)
N(2000)	F15	**	1882(93)	No	1814(176)	1903(494)
N(2080)	D13	**	2081(265)	1880(180)	No	1804(450)
	D13		No	2060(300)	No	No
N(2090)	S11	*	1880(95)	2180(350)	No	1928(414)
N(2100)	P11	*	2050(200)	2125(250)	No	1885(113)
N(2190)	G17	****	2140(380)	2200(500)	2131(478)	2127(547)
N(2200)	D15	**	2228(310)	2180(400)	No	–
N(2220)	H19	****	2205(365)	2230(500)	2258(334)	–
N(2250)	G19	****	2268(300)	2250(480)	2291(772)	–

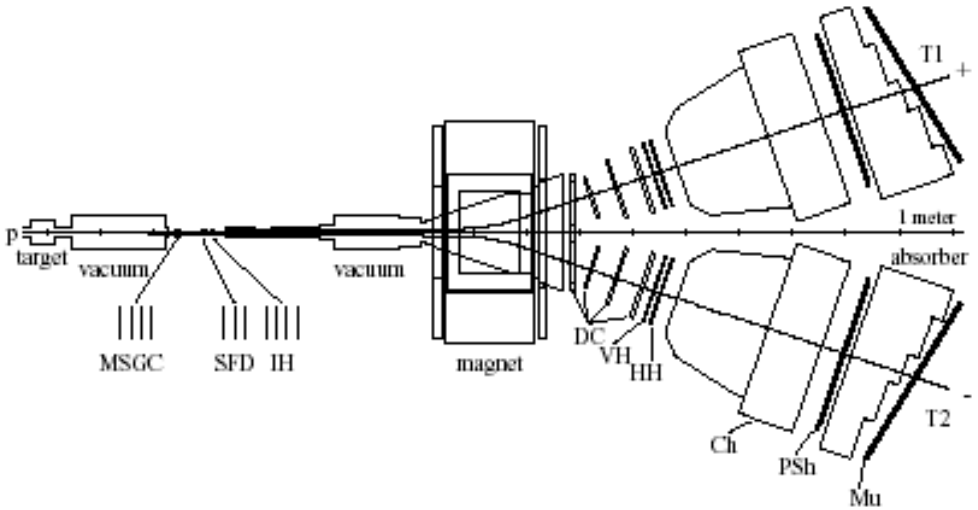
Table 2. Parameters of the Δ - resonances.

Name	L3,2J	Status	KA84	CMB80	SM95	KSU92 [7]
Δ(1232)	P33	****	1233(116)	1232(120)	1233(114)	1231(118)
Δ(1600)	P33	***	1522(222)	1600(300)	[1675-2193]	1706(430)
Δ(1620)	S31	****	1610(139)	1620(140)	1617(108)	1672(154)
Δ(1700)	D33	****	1680(230)	1710(280)	1680(272)	1762(600)
Δ(1750)	P31	*	No	No	No	1744(300)
Δ(1900)	S31	***	1908(140)	1890(170)	No	1920(263)
Δ(1905)	F35	****	1905(260)	1910(400)	1850(294)	1881(327)
Δ(1910)	P31	****	1888(280)	1910(225)	2152(760)	1882(239)
Δ(1920)	P33	***	1868(220)	1920(300)	No	2014(152)
Δ(1930)	D35	***	1901(195)	1940(320)	2056(590)	1956(526)
Δ(1940)	D33	*	No	1940(200)	No	2057(460)
Δ(1950)	F37	****	1923(224)	1950(340)	1921(232)	1945(300)
Δ(2000)	F35	**	No	2200(400)	No	1752(251)
Δ(2150)	S31	*	No	2150(200)	No	–
Δ(2200)	G37	*	2215(400)	2200(450)	No	–
Δ(2300)	H39	**	2217(300)	2400(425)	–	–
Δ(2350)	D35	*	2305(300)	2400(400)	–	2171(264)
Δ(2390)	F37	*	2425(300)	2350(300)	–	–
Δ(2400)	G39	**	2468(480)	2300(330)	–	–
Δ(2420)	H3,11	****	2416(340)	2400(450)	–	–



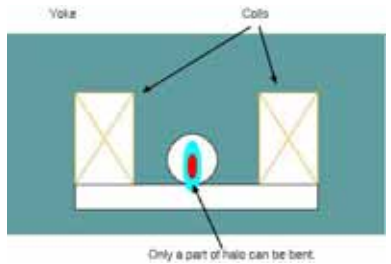
Life time measurement of $\pi\pi$ and πK atoms (Nemenov)

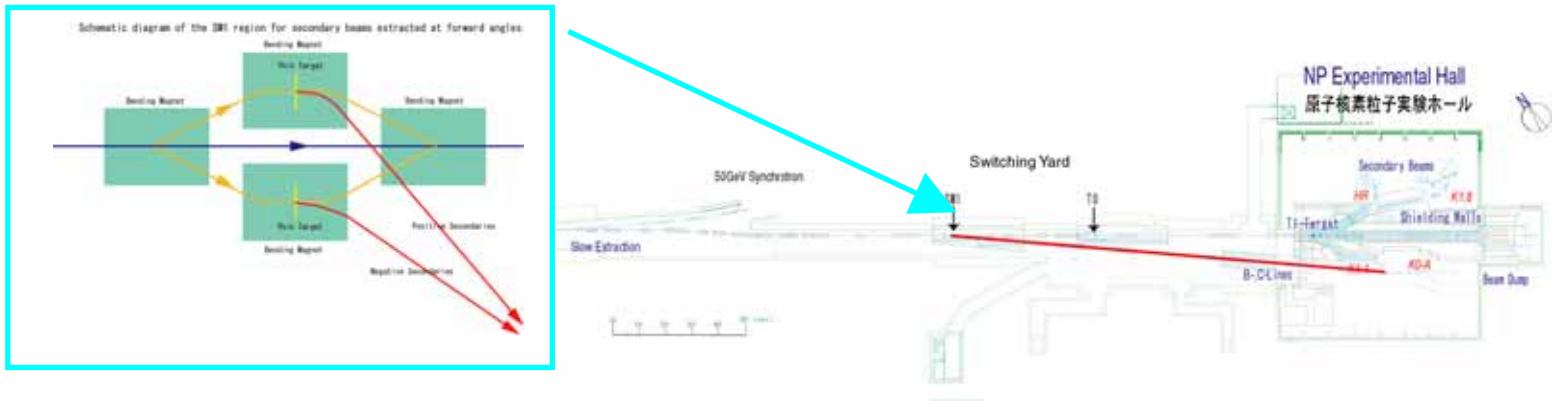
- Precise measurement of $\pi\pi$ and πK atoms ➔ scattering length a_0, a_2, $a_0 - a_2$
- Proton beams: 26GeV/c@CERN, 30-50GeV/c@J-PARC, Intensity$\sim 10^{11}$/sec
- Target: Ni 100μm
- Higher duty factor @ J-PARC than DIRAC@CERN is attractive.



High Momentum Beamline (Sawada)

- 10^9 – 10^{12} pps primary beams
  - Special device to separate a fraction of the main primary beam
    - Beam stealer, ES septum, bent crystal
- Secondary Beams:
  - Use a thin (2% = 15kW loss) target at SM1
  - Collect them at forward angles
  - Transfer them for ~120m





High Momentum Beamline (Sawada)

- Yield estimation for 30GeV(left) and 50GeV(right)

	Momentum (GeV/c)	dσ/dpdΩ (mb/sr/GeV/c)	Yield at SM1 (per 10^{14} protons)	Yield at 120m (per 10^{14} protons)
π^+	5	1400	3.7E7	2.4E7
π^+	10	210	1.1E7	8.9E6
π^-	5	1000	2.6E7	1.7E7
π^-	10	130	6.7E6	5.4E6
K^+	5	130	3.3E6	1.3E5
K^+	10	28	1.4E6	2.8E5
K^-	5	61	1.6E6	6.4E4
K^-	10	7.0	3.6E5	7.2E4
pbar	5	11	2.8E5	2.8E5
pbar	10	1.1	5.7E4	5.7E4

	Momentum (GeV/c)	dσ/dpdΩ (mb/sr/GeV/c)	Yield at SM1 (per 10^{14} protons)	Yield at 120m (per 10^{14} protons)
π^+	5	3700	9.5E7	6.2E7
π^+	10	930	4.7E7	3.8E7
π^-	5	3700	9.5E7	6.2E7
π^-	10	700	3.6E7	2.9E7
K^+	5	440	1.1E7	4.4E5
K^+	10	120	6.2E6	1.2E6
K^-	5	220	5.7E6	2.3E5
K^-	10	56	2.9E6	5.8E5
pbar	5	53	1.4E6	1.4E6
pbar	10	16	8.4E5	8.4E5

Summary

- Classification with beams
  - Pions: 0.6<p<2.1GeV/c, 10^7pps
    - Sumachev: Spin Rotation Parameter
  - Kaons: ~500MeV/c, 1GeV/c, <2.5GeV/c
    - Imai: Pentaquark states
  - Protons: 30GeV/c<p, 10^9pps
    - Yokkaichi: Meson Modification
  - Protons: 30GeV/c<p, 10^{11}pps
    - Nemenov: pi-pi and pi-K scattering length
    - Krisch: SPIN@J-PARC
  - Protons: 30GeV/c,<p 10^{12}pps
    - Peng: Dimuon
  - Neutrinos:
    - Imai: charmed pentaquark
    - Saito: Δs
- Many of the experiments need the high momentum beamline.