Hyperon Proton Scattering at 50 GeV

- Introduction & Interests
- $\Xi^- p \rightarrow \Lambda\Lambda$
- P_y & A_y^T of Λp, $\Sigma^+ p$

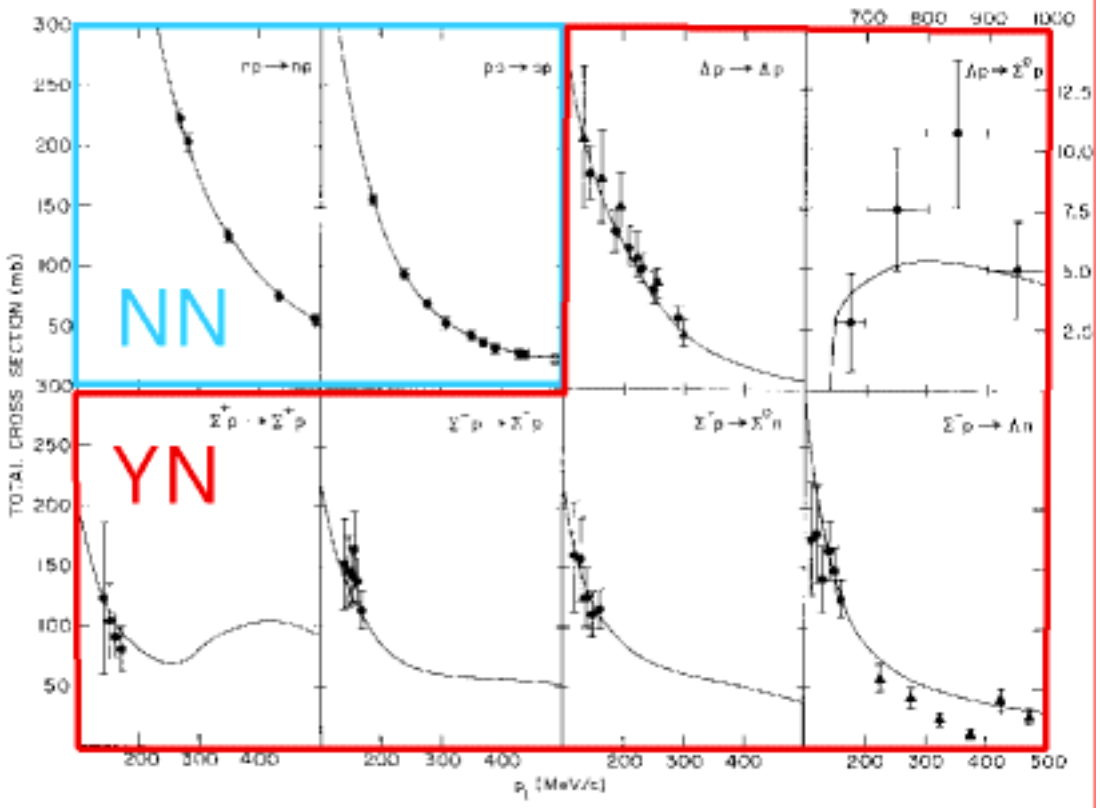
International Workshop
on
Nuclear and Particle Physics
at 50-GeV PS

Dec.10 - 12, 2001
KEK, Tsukuba, Japan

by

M. Ieiri	KEK
K. Imai	Kyoto University
B. Bassalleck	University of New Mexico

Present status of YN data



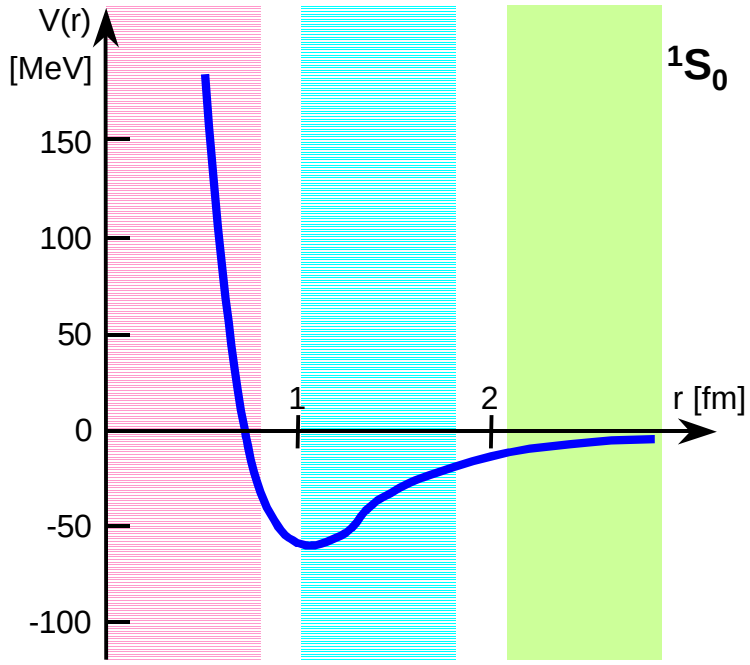
from Dover & Feshbach Ann.Phys.198(90)321

Numbers of data points in angular distributions

	pp	pn	YN
• dσ/dΩ	2080	3777	23(+39)
• P	1275	814	a few
• Other obs.	1444	304	0

from Arndt et al. PRD28(83)97

B-B potential pictures



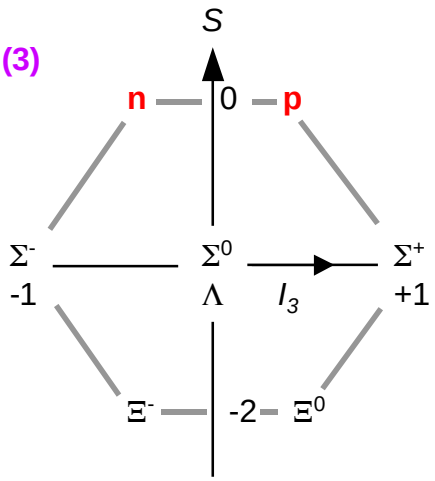
OBE **HC, ω** **ρ,σ, •••** **π**

- Paris — from pN interaction
- Nijmegen — meson : pseudoscaler- vector-nonet+σ
- Bonn-Julich — multi-meson exchange

QCM **(λ•λ)(σ•σ)** **Eff.Meson Exch. pot.**
Pauli

- Tokyo
- Kyoto
- Tubingen

••• **Flavor SU(3)**



Why

Baryon–Baryon strong interaction

short range part (core, H-particle,...)
l•s strength (ALS,...)
strong isospin dependence

incorporate mesons and quarks, ... how, ...

Then, ...
By getting reliable & accurate Y–N scattering data

→ get THE PICTURE inspired by (or, if possible, based on) QCD [SU(3)f]

How

...basically, "double scattering" technique

hyperon production reaction

hyperon scattering

, and hyperon decay

- Vertex detector

  Scintillating Fiber at KEK since 1990

  KEK-PS E251 for Σ^+P

  E289 for Σ^+p, Σ^-p, Λp

  Liquid Scintillator

  KEK-PS E452

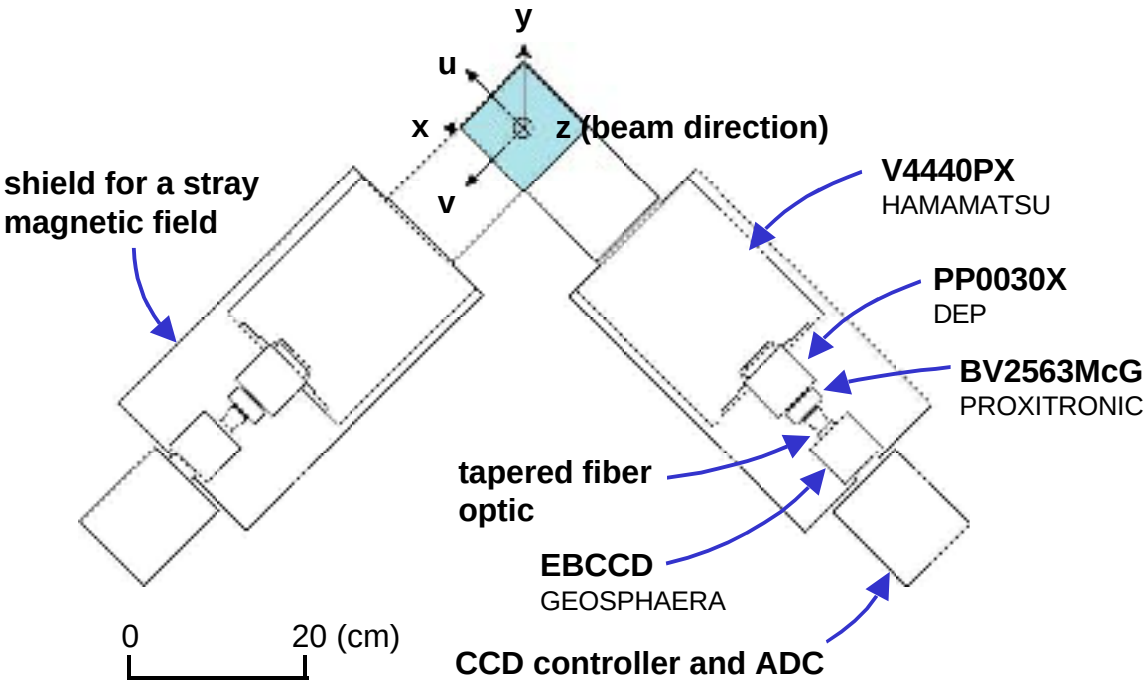
- Liq. H2 + Cylindrical Drift Chamber 

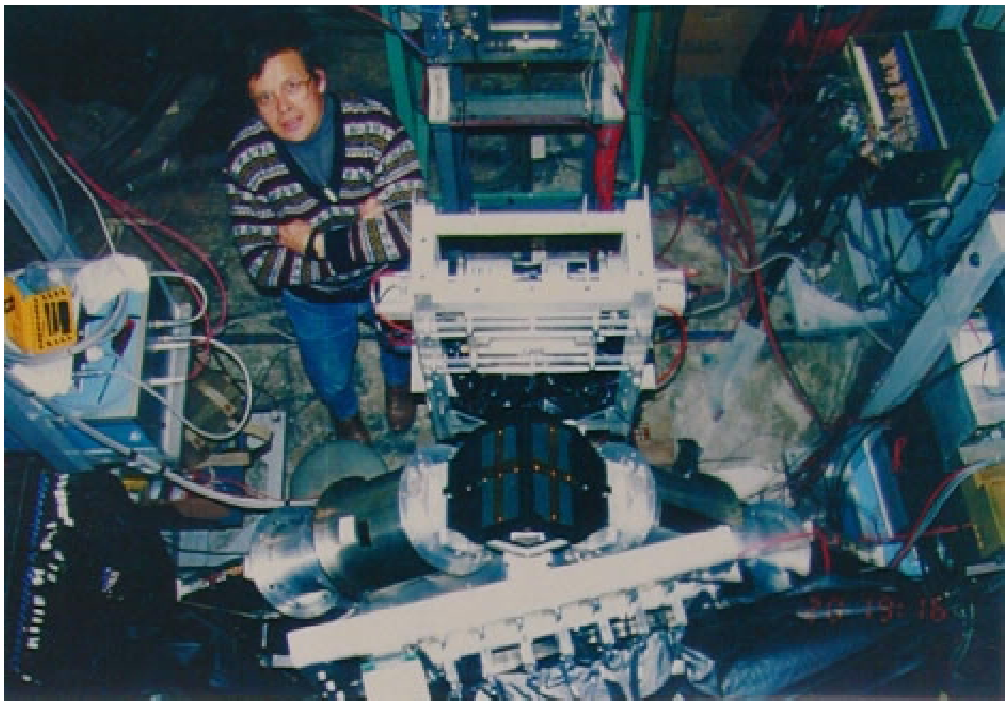
  BNL P928

  LOI @ 50 GeV

  for Ξ^-p $\rightarrow$ Ξ^-p, $\Lambda\Lambda$

SciFi block & II chain

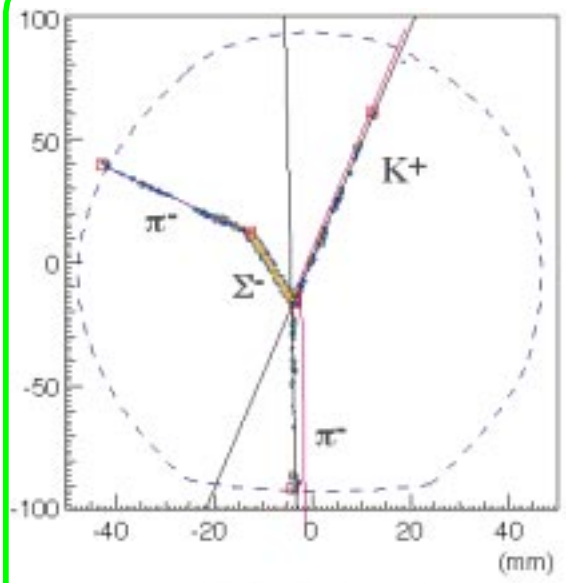




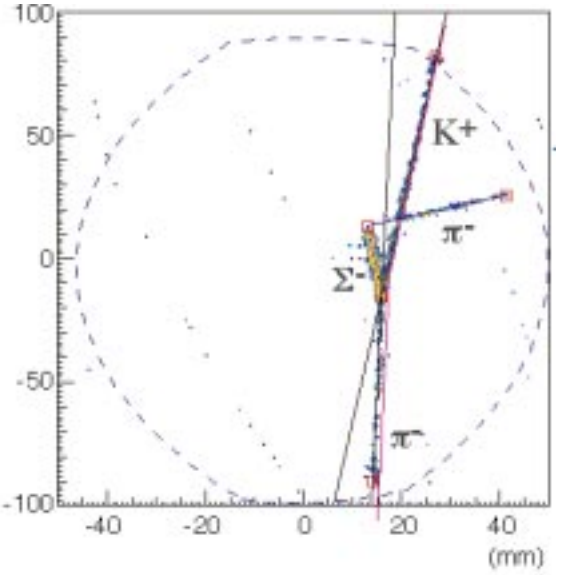
Typical events

Candidates of ...

Σ^- production (Σ^- beam)

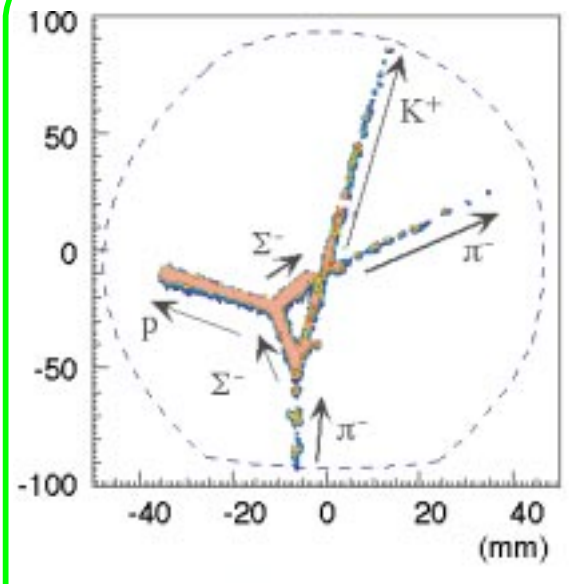


U-Z view (EBCCD-L)

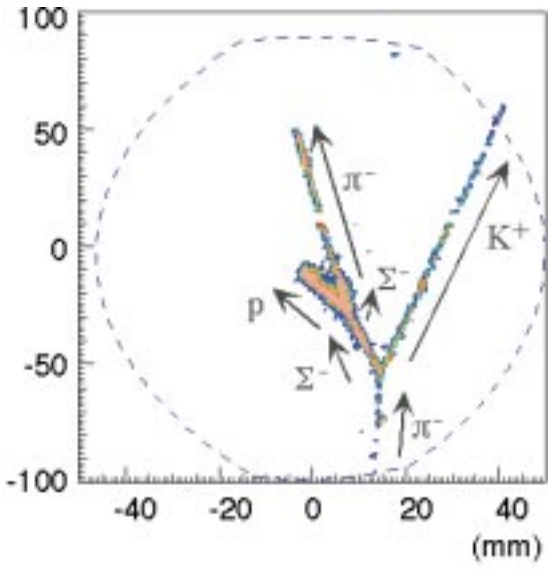


V-Z view (EBCCD-R)

Σ^- scattering



U-Z view (EBCCD-L)



V-Z view (EBCCD-R)

AGS PROPOSAL

TITLE: **Ξ^-p scattering experiment**

FROM: M. Ieiri – KEK
K. Imai, H. Kanda, Y. Kondo, K. Yamamoto,
several students – Kyoto Univ.
T. Fukuda, J. Nakano – INS, Univ. of Tokyo
R. Chrien – BNL

SPOKESMAN: M. Ieiri
KEK, Oho 1-1, Tsukuba, Ibaraki 305, Japan
E-Mail: kekpsa::ieiri or ieiri@kekpsa.kek.ac.jp
and
K. Imai
Dept. of Physics, Kyoto Univ., Sakyo-ku, Kyoto 606-01, Japan
E-Mail: kytvax::imai

BEAM: **1.8 GeV/c K^-**

REACTION: (K^-, K^+)

TARGET: **A liquid hydrogen**

BEAM LINE: **D6**

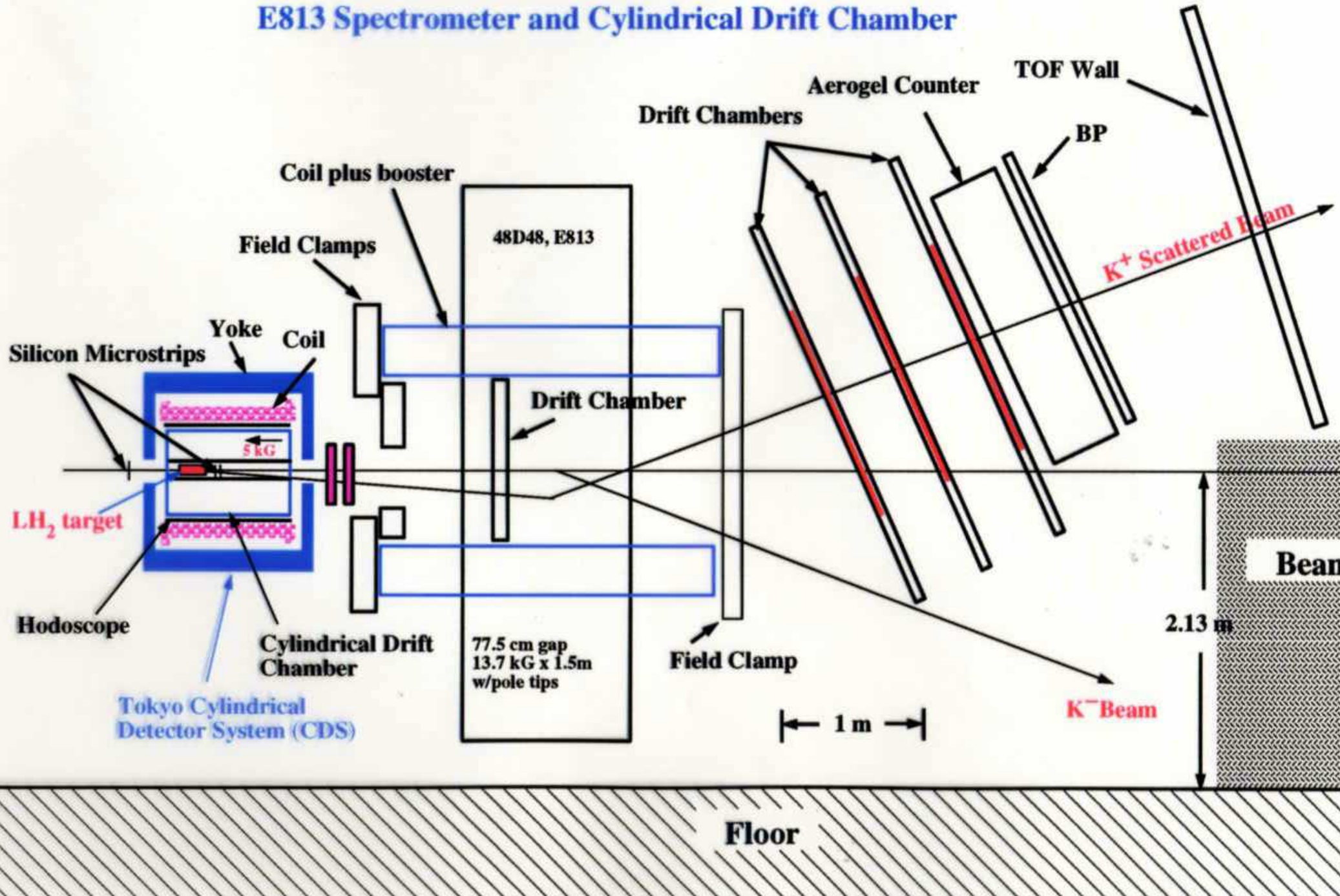
DETECTORS: **The 48D48 spectrometer & the CDS detector**

TIME REQUESTED: (assuming **2×10^6 K^-/spill** with **3.6 sec. repetition rate**)

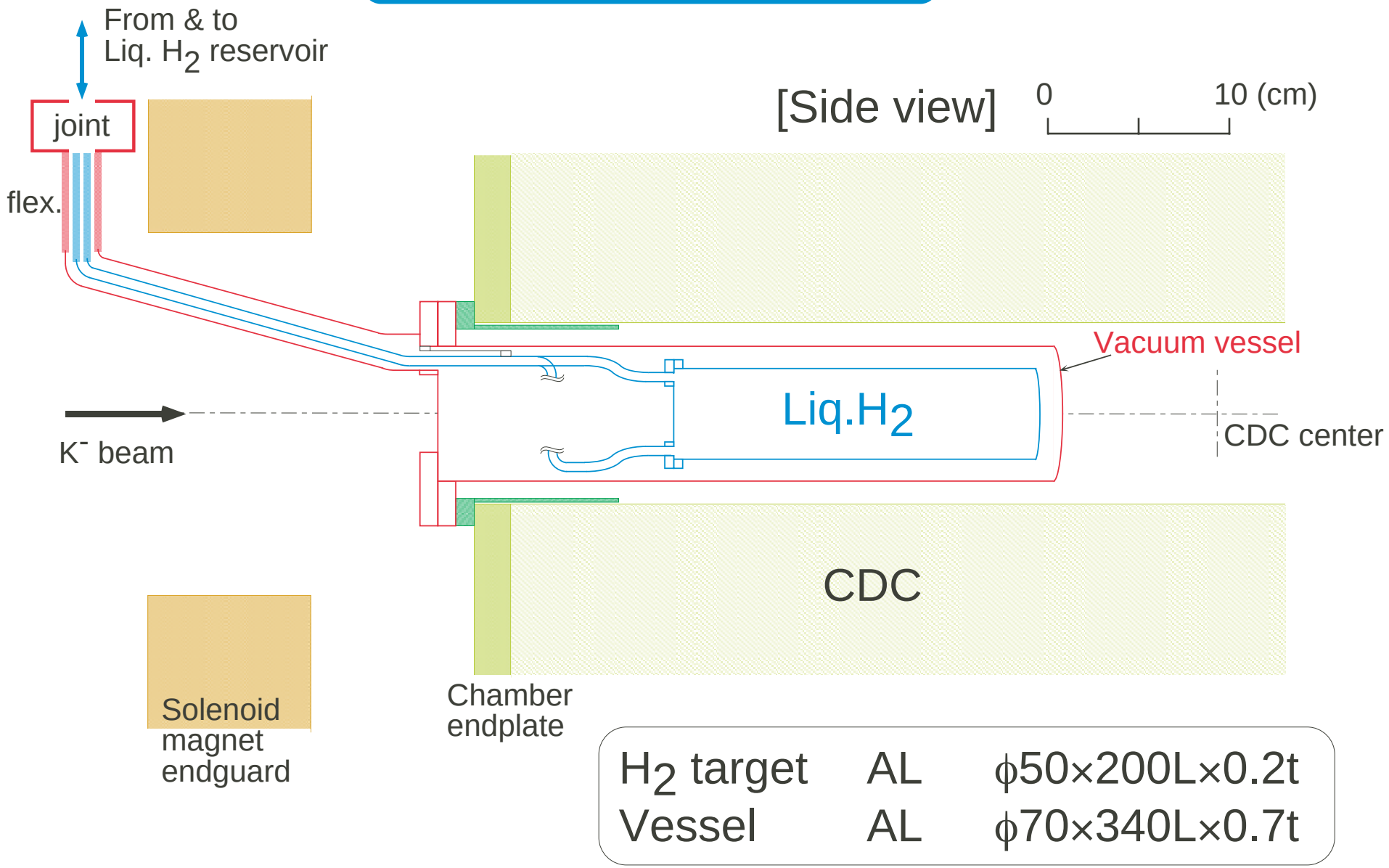
1000	hours	– Data taking
200	hours	– Engineering & Setup
Total 1200	**hours**	

P928, $\Xi^- p$ Scattering (= E906 + Liq. H_2 & MSD)

E813 Spectrometer and Cylindrical Drift Chamber

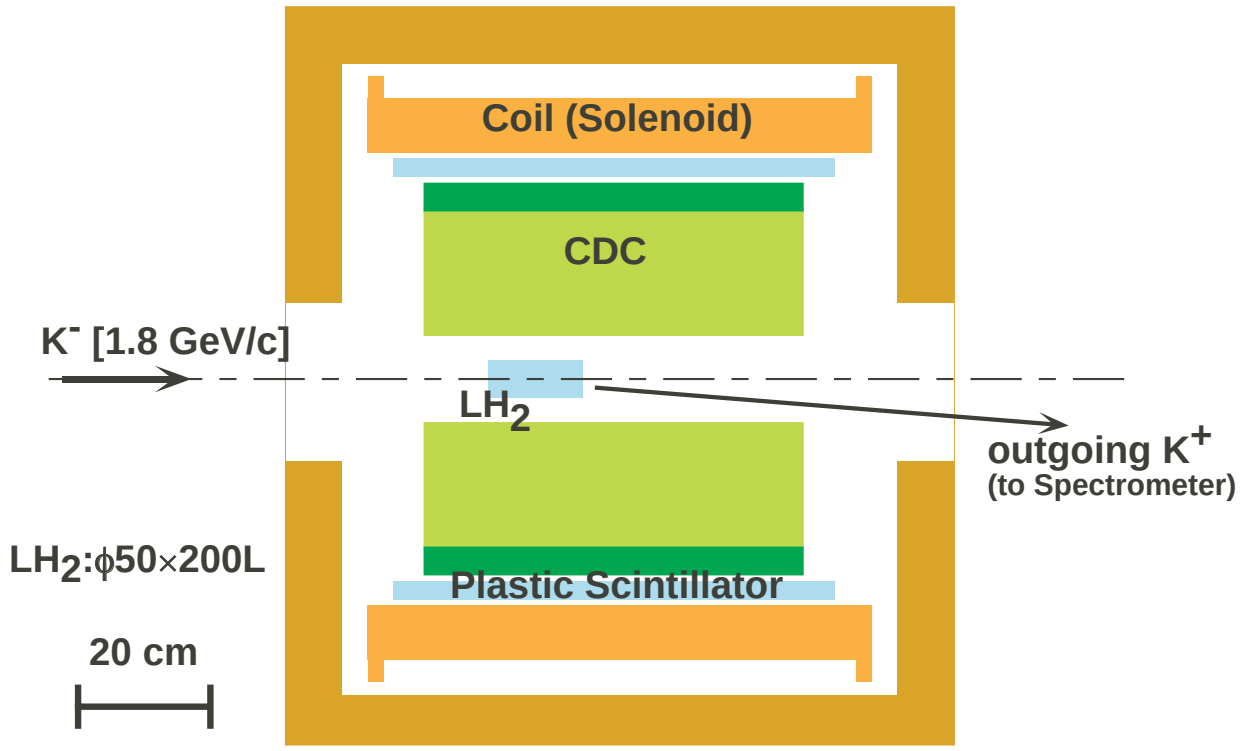


Liquid hydrogen target

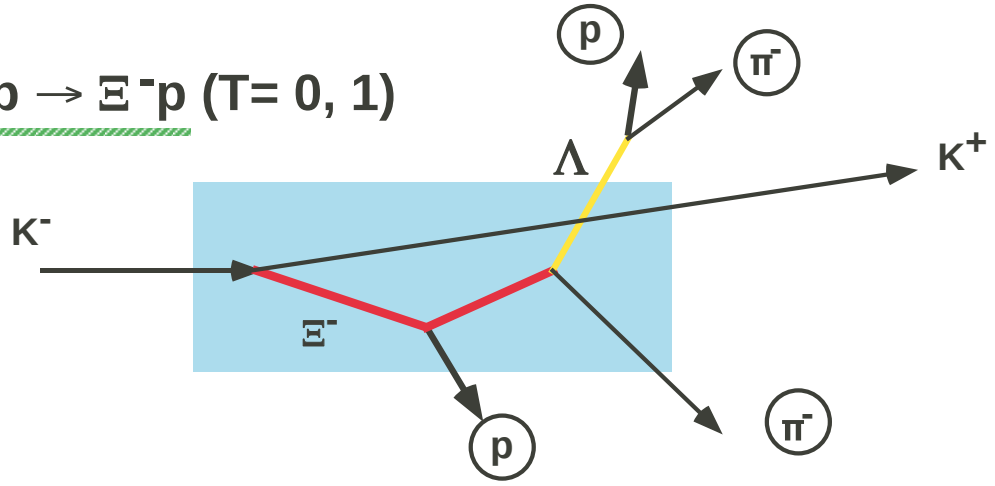


H_2 target	AL	ϕ50×200L×0.2t
Vessel	AL	ϕ70×340L×0.7t

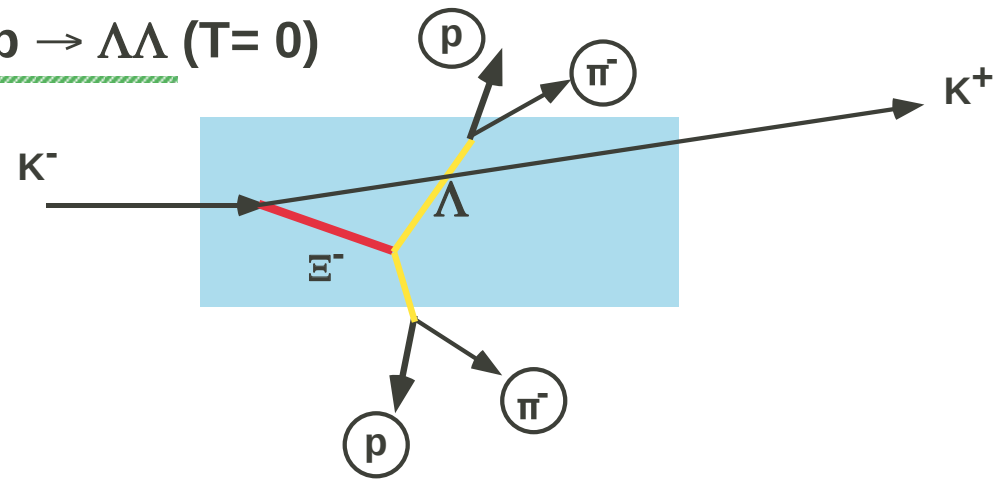
Ξ^-p scattering



• $\Xi^-p \rightarrow \Xi^-p$ (T= 0, 1)



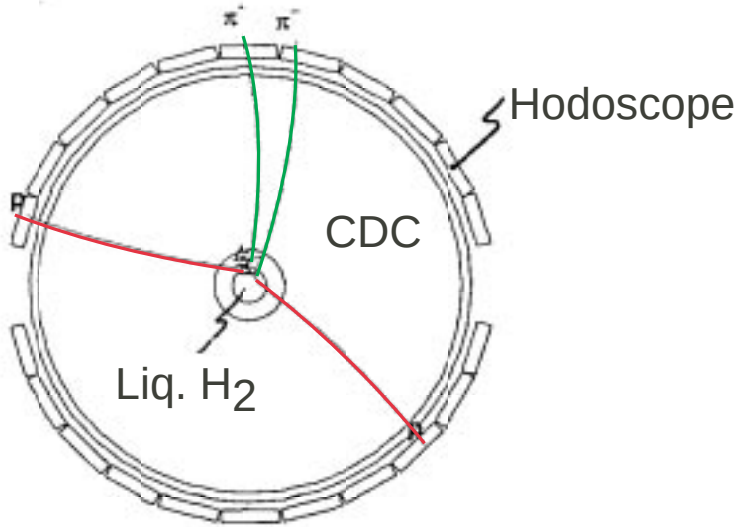
• $\Xi^-p \rightarrow \Lambda\Lambda$ (T= 0)



$\Xi^- p \rightarrow \Xi^- p$ (T=0,1)

$\hookrightarrow \Lambda\pi^-$

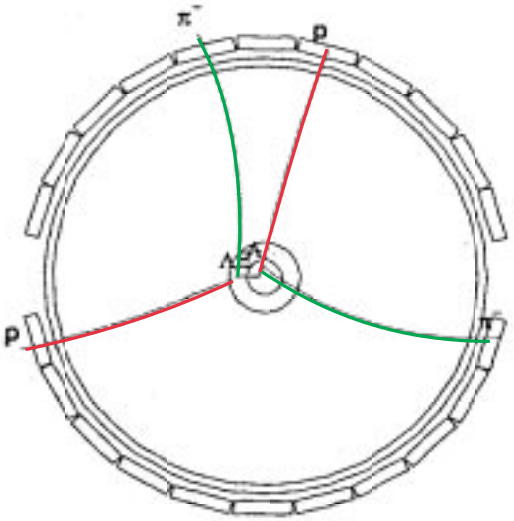
$\hookrightarrow p\pi^-$

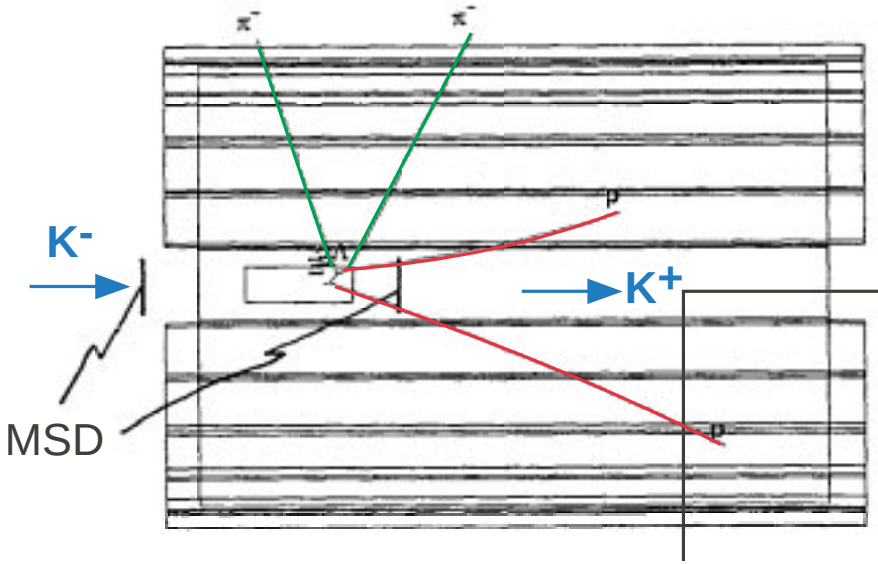


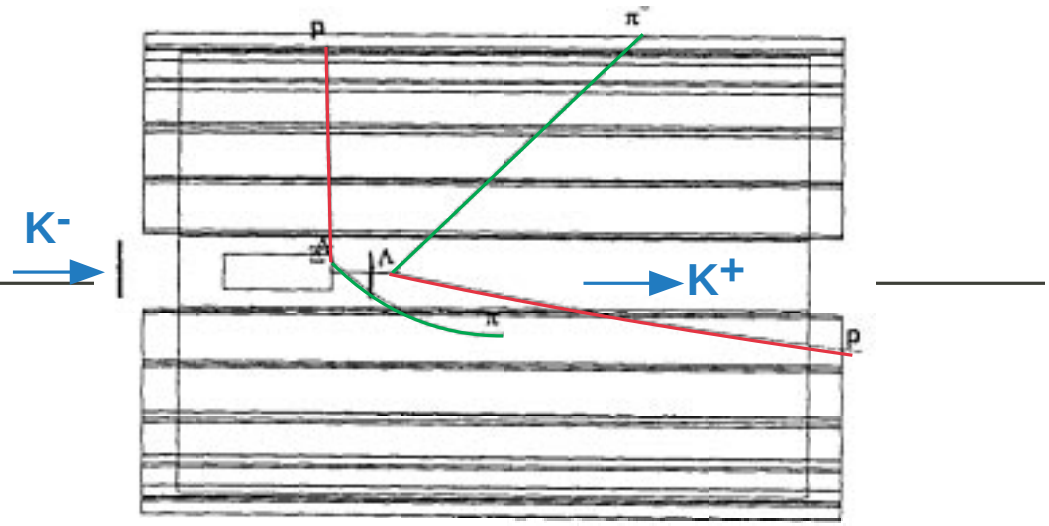
$\Xi^- p \rightarrow \Lambda\Lambda$ (T=0)

$\hookrightarrow p\pi^-$

$\hookrightarrow p\pi^-$



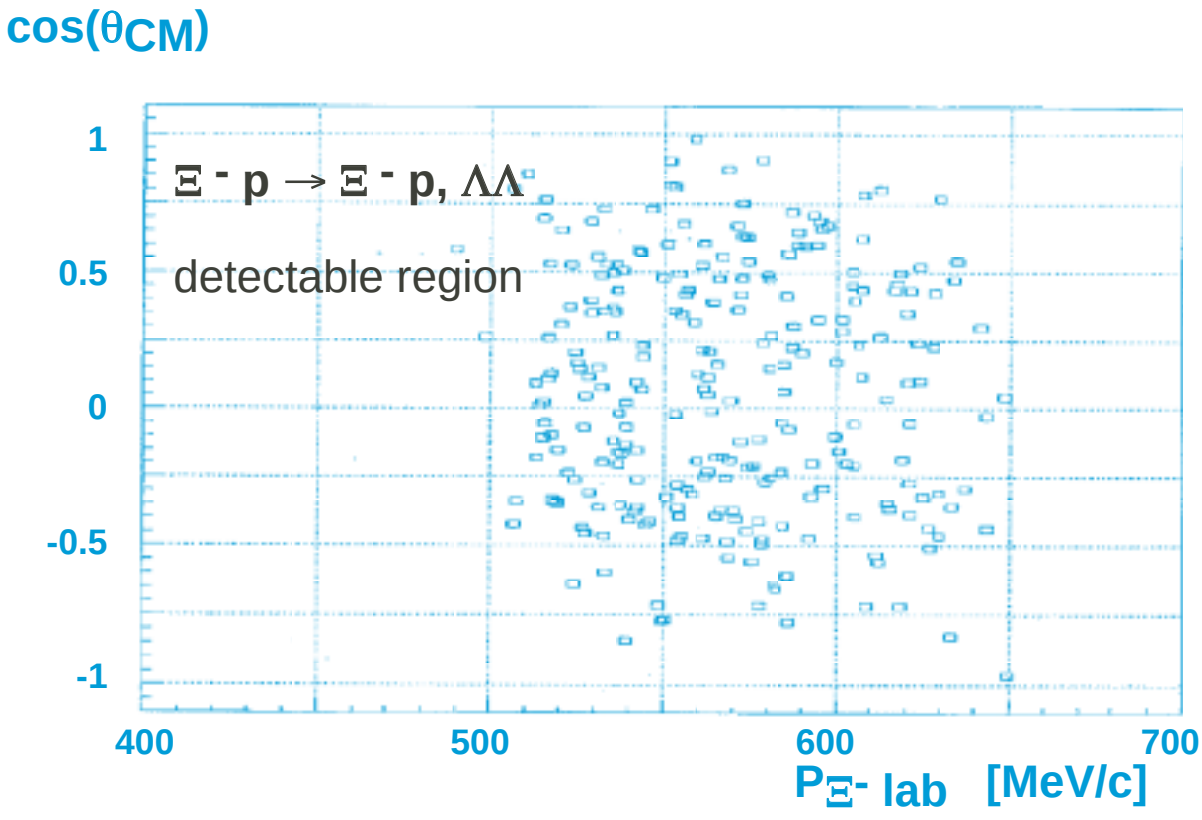




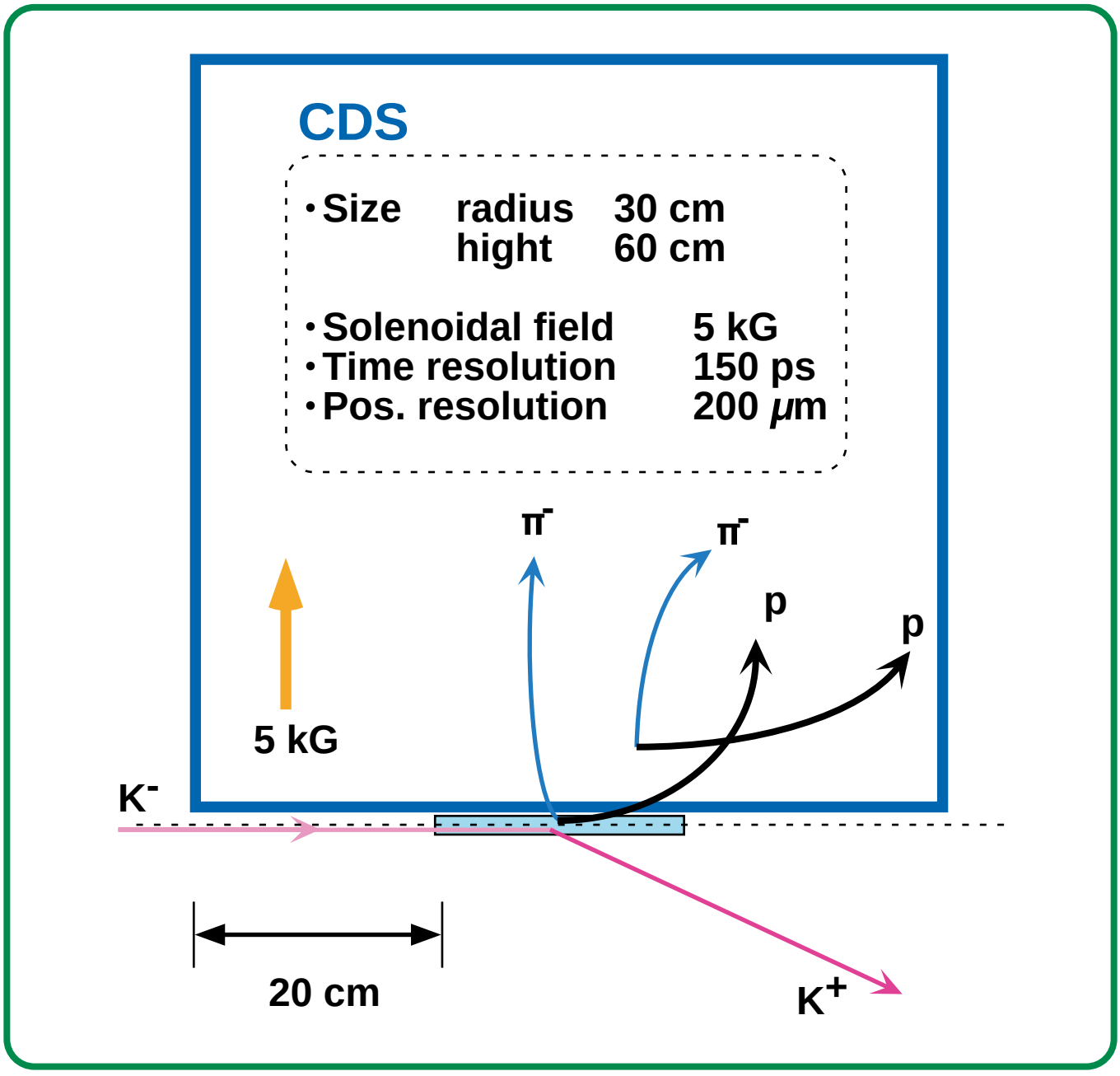
Expected yields of Ξ⁻ p scattering

• Spectrometer	0° – 13°	
• Spectrometer TOF	8	m
• K^- intensity	2×10^6	/spill
• Number of Hydrogen	8.5×10^{23}	/cm^2
• Ξ⁻ production rate	1.2	/spill
• Momentum range of Ξ⁻	500 - 650	MeV/c

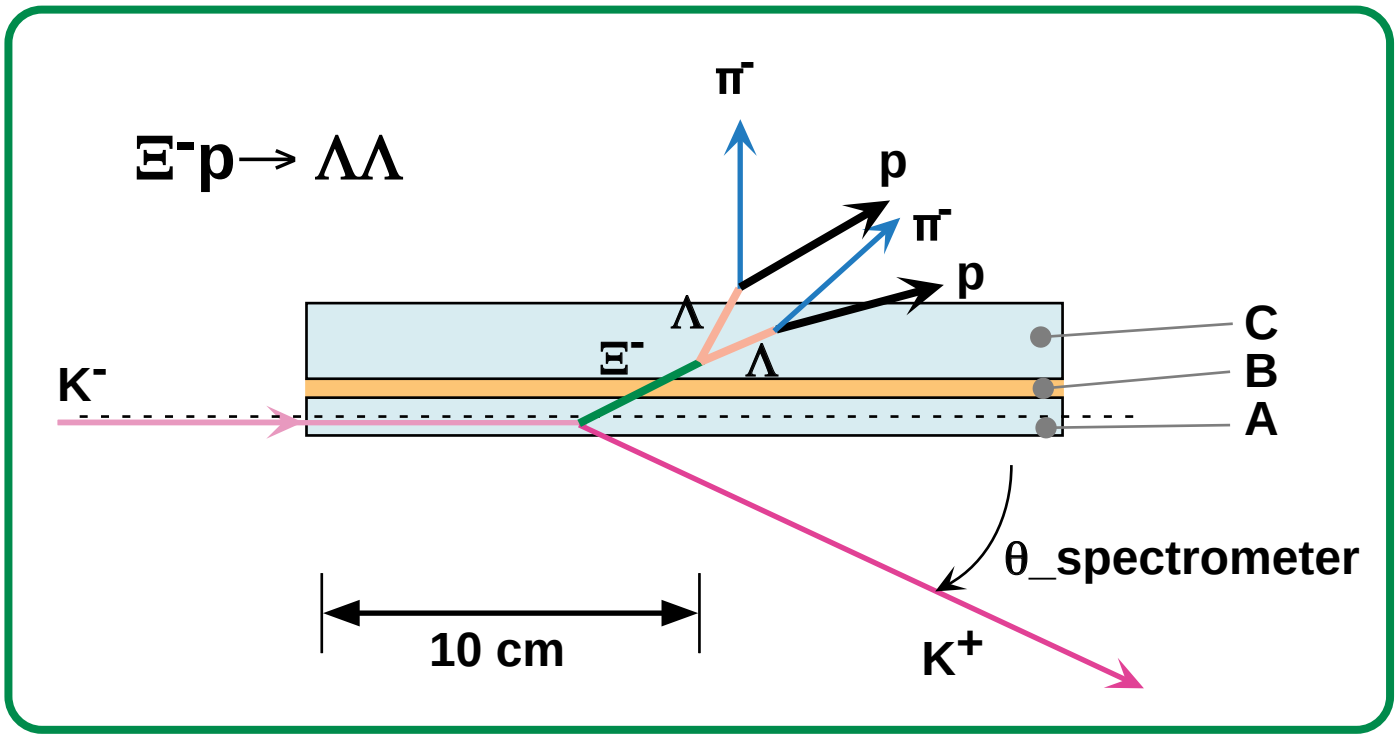
	Ξ⁻p → Ξ⁻p	Ξ⁻p → ΛΛ
• in 1000 hours	2800	1900
• Final number	140	60



CDS


CDS
• Size radius 30 cm
hight 60 cm
• Solenoidal field 5 kG
• Time resolution 150 ps
• Pos. resolution 200 μm
π-
π-
p
p
5 kG
K-
20 cm
K+

Target region

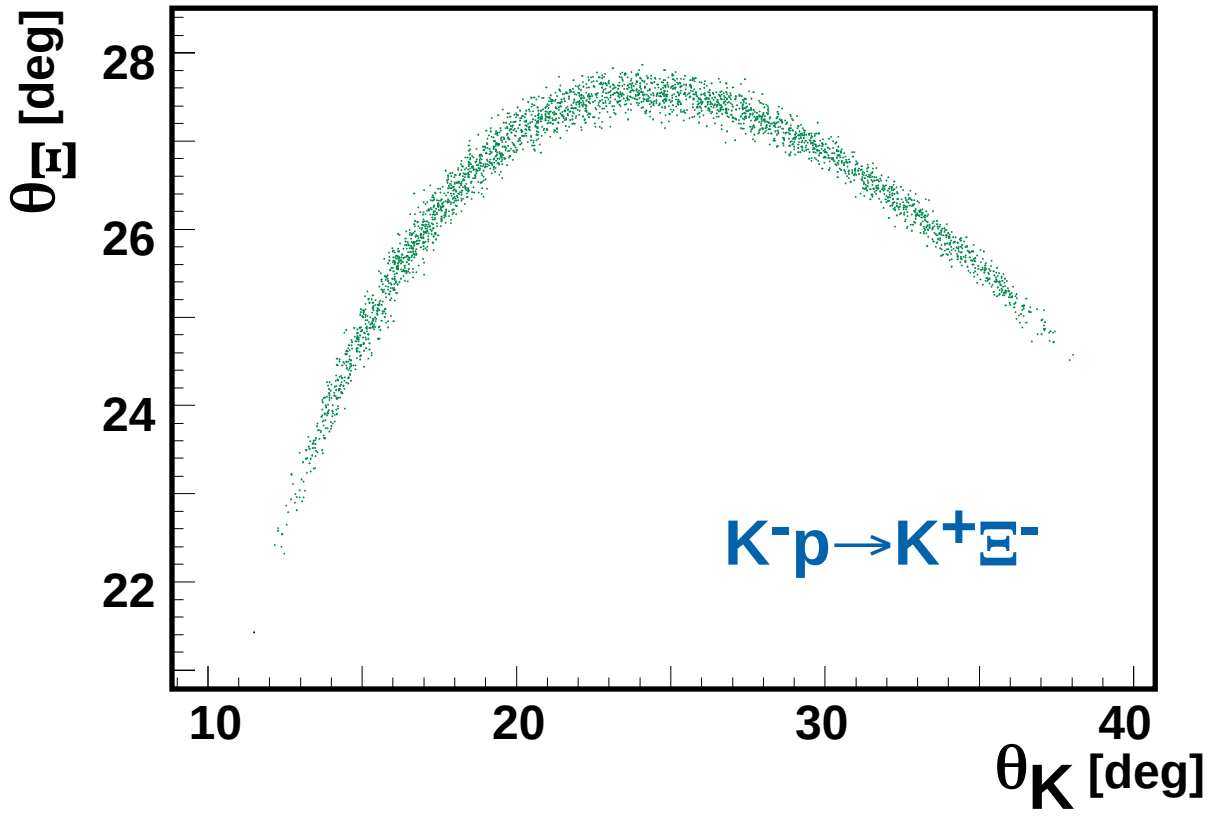


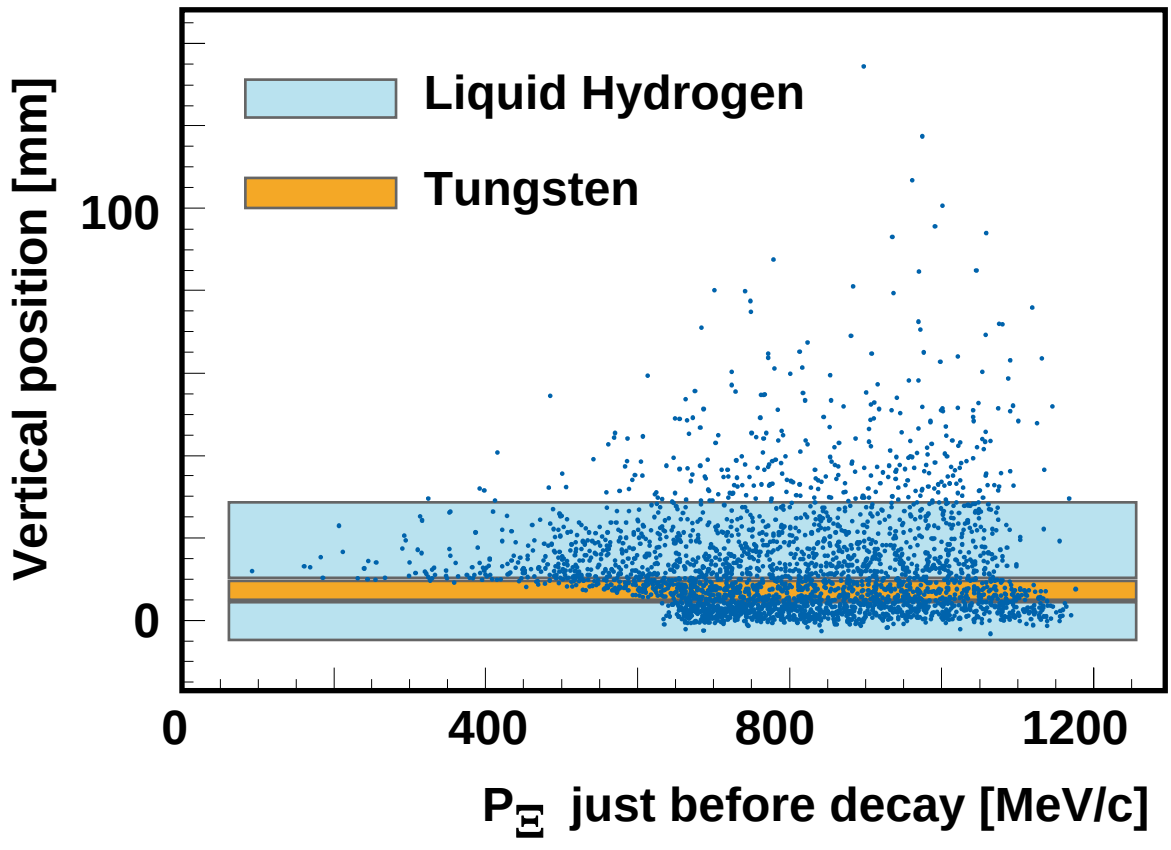
- K^- Beam
  - Intensity 10^7 K^-/sec
  - Momentum 1.7 GeV/c
  - Size σ_horizontal 15 mm
    σ_vertical 1 mm

- Target 5 cm wide × 20 cm long
  - A: production 1 cm Liq. Hydrogen
  - B: degrader 0.5 cm Tungsten
  - C: scattrering 2 cm Liq. Hydrogen

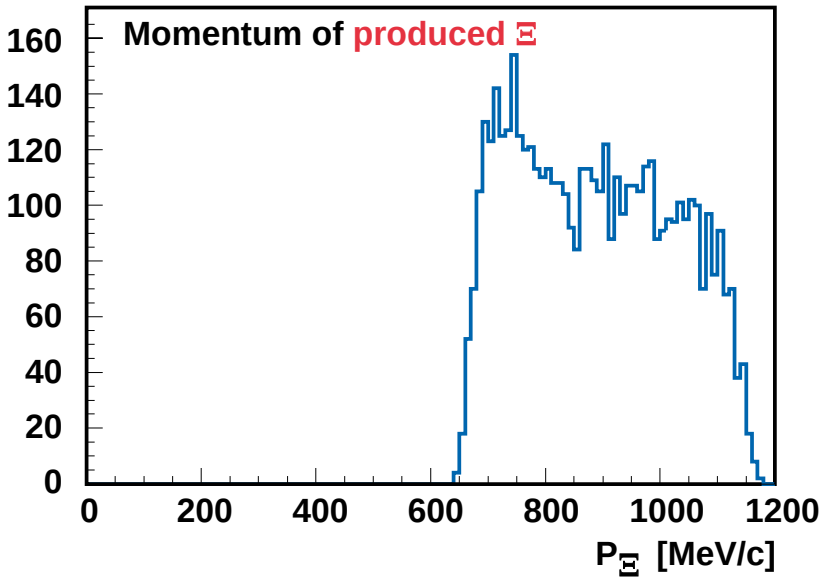
- K^+ spectrometer θ_spectrometer ~ 25° at center

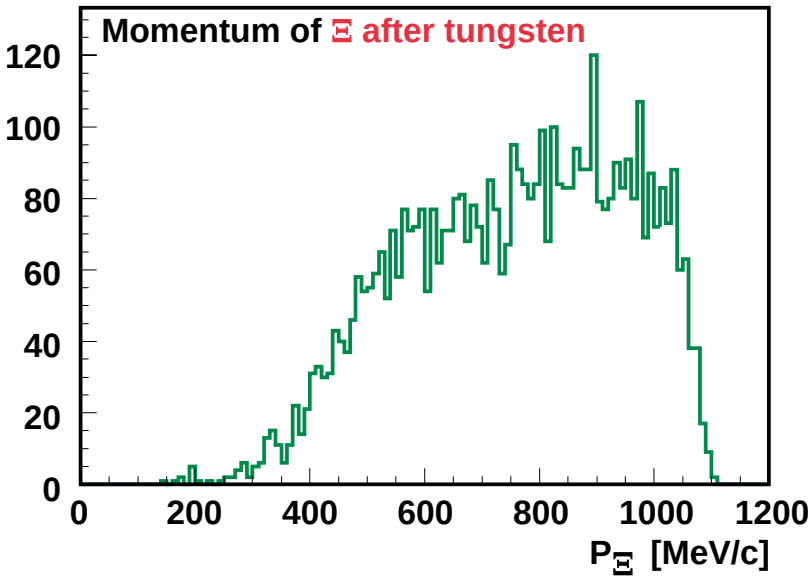
Ξ^- production

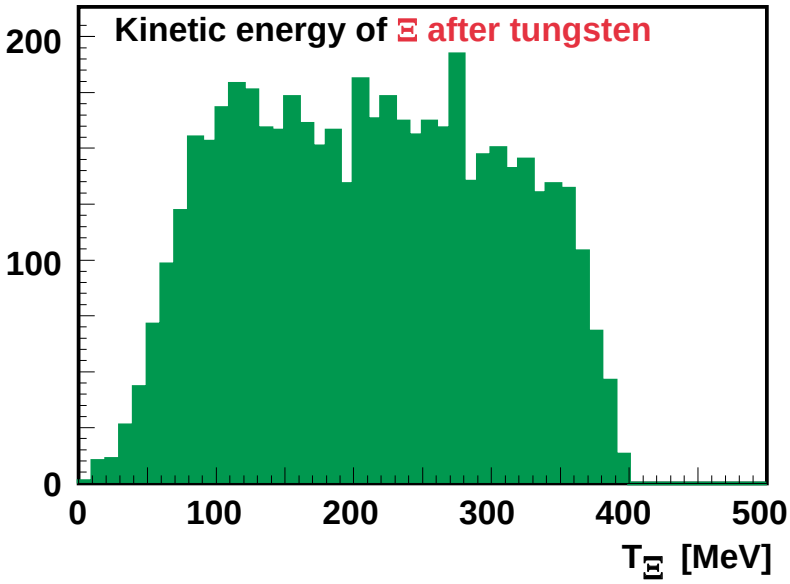




Momentum & Kinetic Energy of Ξ^-

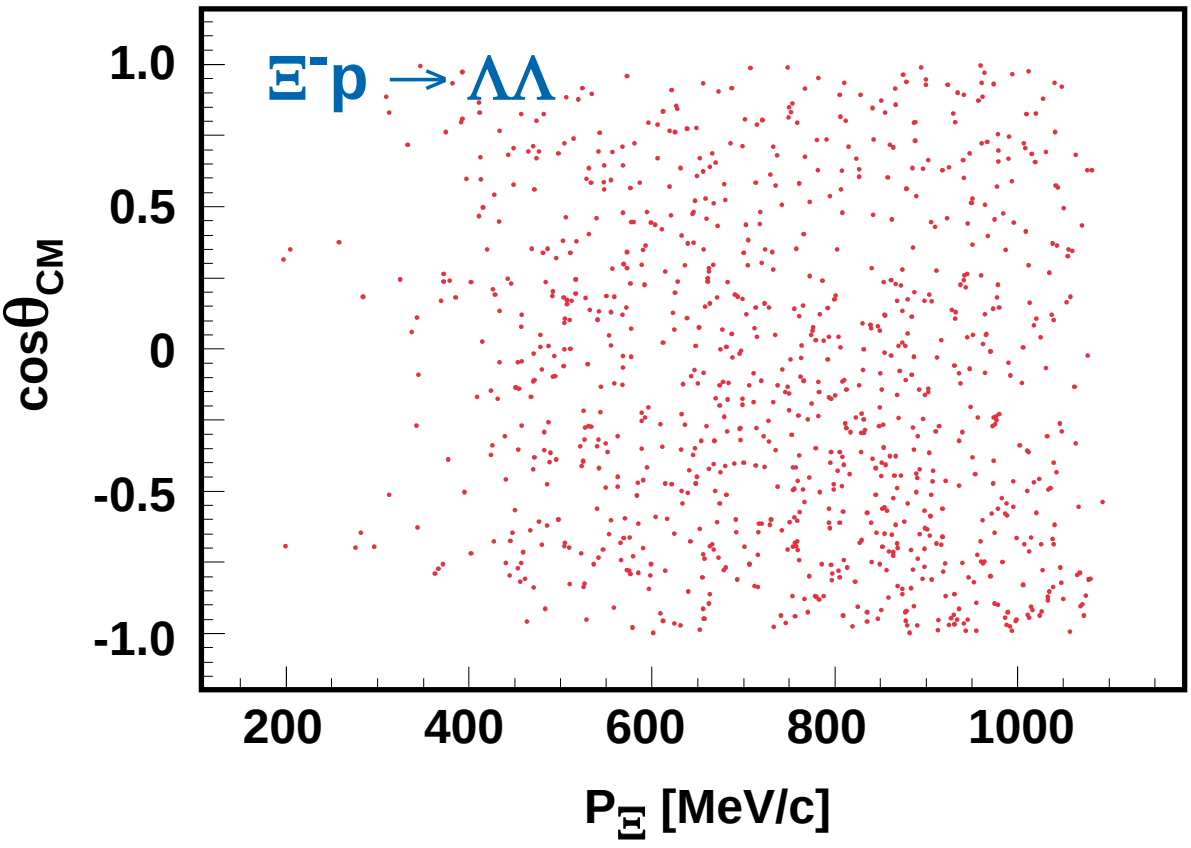






$\Xi^- p \rightarrow \Lambda\Lambda$ reaction Yields

• Spectrometer	[deg]	25	
• Spectrometer TOF	[m]	5	
• K^- intensity	[s^{-1}]	10^7	
• Number of Hydrogen	[/cm^2]	8.5×10^{23}	
• Trigger rate (K^+)	[s^{-1}]	11	
• Momentum of Ξ^-	[MeV/c]	300 - 1100	
• reaction rate	[s^{-1}]	0.0043	(0.009 elastic)
• 100 days measurement		37000	(78000 elastic)
• Detectable number		550	(2300 elastic)



Spin Scattering Matrix

[N.Hoshizaki]

$$M = a + c(\sigma_n^1 + \sigma_n^2) + b(\sigma_n^1 - \sigma_n^2) + m\sigma_n^1\sigma_n^2 + g(\sigma_P^1\sigma_P^2 + \sigma_K^1\sigma_K^2) + h(\sigma_P^1\sigma_P^2 - \sigma_K^1\sigma_K^2)$$

$M(p_f, p_i) = 2\pi/ik \bullet \langle\theta_f\phi_f|S-1|\theta_i\phi_i\rangle \quad (\sim \langle\beta|T|\alpha\rangle \sim \langle\beta\chi_\beta^-, Vu_\alpha\rangle)$

I_0	$= 1/4\ \mathrm{Tr}(MM^\dagger)$	$1 + 2 \rightarrow 1 + 2$
I_0P_y	$= 1/4\ \mathrm{Tr}(MM^\dagger\sigma_n^1)$	$1 + 2 \rightarrow \vec{1} + 2$
I_0A_y	$= 1/4\ \mathrm{Tr}(M\sigma_n^1M^\dagger)$	$\vec{1} + 2 \rightarrow 1 + 2$
I_0D	$= 1/4\ \mathrm{Tr}(M\sigma_n^1M^\dagger\sigma_n^1)$	$\vec{1} + 2 \rightarrow \vec{1} + 2$
$I_0A_y^T$	$= 1/4\ \mathrm{Tr}(M\sigma_n^2M^\dagger)$	$1 + \vec{2} \rightarrow 1 + 2$
I_0D^T	$= 1/4\ \mathrm{Tr}(M\sigma_n^2M^\dagger\sigma_n^1)$	$1 + \vec{2} \rightarrow \vec{1} + 2$
I_0A_{nn}	$= 1/4\ \mathrm{Tr}(M\sigma_n^1\sigma_n^2M^\dagger)$	$\vec{1} + \vec{2} \rightarrow 1 + 2$
$I_0A_{nn}^n$	$= 1/4\ \mathrm{Tr}(M\sigma_n^1\sigma_n^2M^\dagger\sigma_n^1)$	$\vec{1} + \vec{2} \rightarrow \vec{1} + 2$

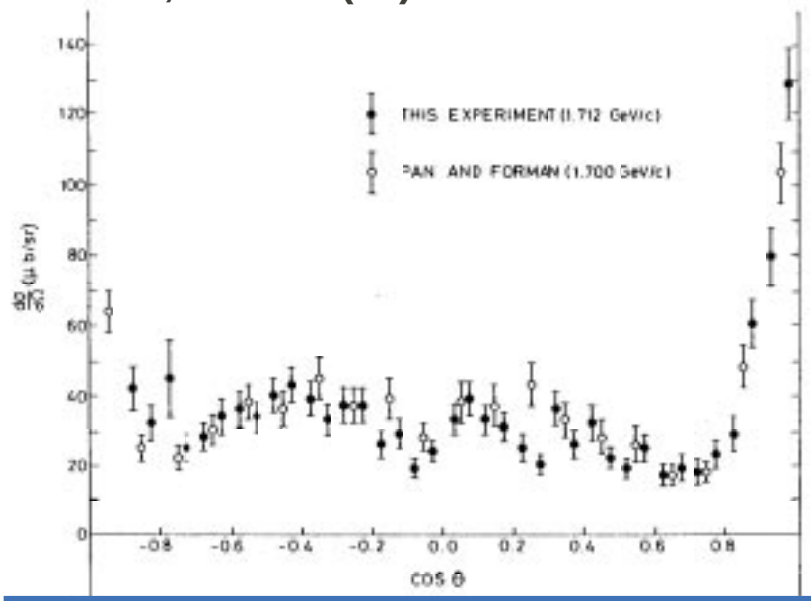
I_0	$= \lvert a\rvert^2 + 2\lvert c\rvert^2 + 2\lvert b\rvert^2 + \lvert m\rvert^2 + 2\lvert g\rvert^2 + 2\lvert h\rvert^2$	
I_0P_y	$= 2\ \mathrm{Re}[(a+m)c^* + (a-m)b^*]$	$= I_0A_y$
I_0D	$= \lvert a\rvert^2 + 2\lvert c\rvert^2 + 2\lvert b\rvert^2 + \lvert m\rvert^2 - 2\lvert g\rvert^2 - 2\lvert h\rvert^2$	
$I_0A_y^T$	$= 2\ \mathrm{Re}[(a+m)c^* - (a-m)b^*]$	$= I_0P_y^T$
I_0D^T	$= 2\ \mathrm{Re}(am^*) + 2\lvert c\rvert^2 - 2\lvert b\rvert^2 + 2\lvert g\rvert^2 - 2\lvert h\rvert^2$	
I_0A_{nn}	$= 2\ \mathrm{Re}(am^*) + 2\lvert c\rvert^2 - 2\lvert b\rvert^2 - 2\lvert g\rvert^2 + 2\lvert h\rvert^2$	
$I_0A_{nn}^n$	$= I_0A_y^T$	

Polarized hyperon beam

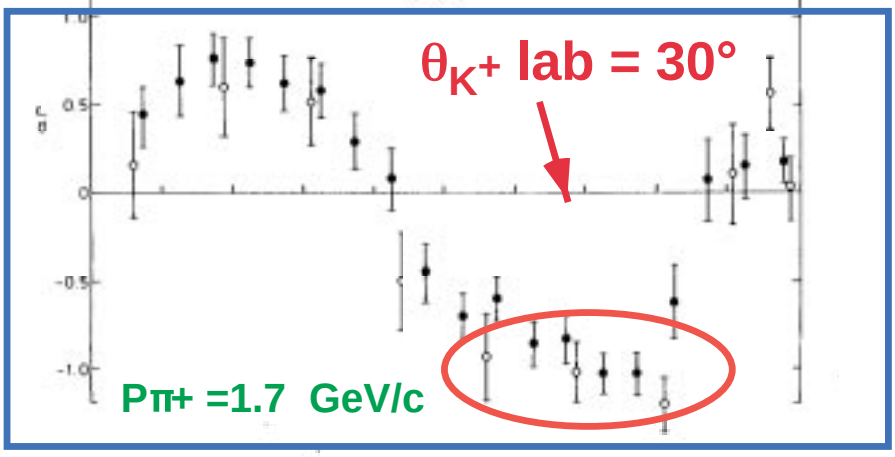
$\cdot\vec{\Sigma}^+$ $\pi^+ p \to K^+ \vec{\Sigma}^+$

Candlin et al., NPB226(83)1

$\frac{d\sigma}{d\Omega}$



αP



Haba et al., NPB299(88)627 @KEK

$\alpha P \approx -1$ ($1.5 < P_{\pi^+} < 2$ GeV/c, $20° < \theta_{K^+}$ lab $< 38°$)

$\cdot\vec{\Lambda}$ $\pi^- p \to K^0 \vec{\Lambda}$ $[\pi^+ n \to K^+ \vec{\Lambda}]$

Rutherford Lab. NPB141(78)29, NPB162(80)522

$P \approx 1$ ($1 < P_{\pi^-} < 1.8$ GeV/c, $5° < \theta_{K^0}$ lab $< 25°$)

Channels & Observables

[Summary of What]

	Channels	T	Category	Observables
p,n	pp → pp	1	27s	dσ/dΩ, P_y, D, ..
	pn → pn	1	27s	dσ/dΩ, P_y, D, ..
		0	10a	
Λ	Λp → Λp	1/2	27s, $\overline{10}$a, 8s, 8a	dσ/dΩ, P_y, A_y^T, D
Σ+	$\Sigma^+p \to \Sigma^+p$	3/2	27s, 10a	dσ/dΩ, P_y, A_y^T, D
Σ−	$\Sigma^-p \to \Sigma^-p$	3/2	27s, 10a	dσ/dΩ, A_y
		1/2	27s, $\overline{10}$a, 8s, 8a	
	$\Sigma^-p \to \Lambda n$	1/2	27s, $\overline{10}$a, 8s, 8a	dσ/dΩ, P_y, P_y^T
Ξ−	$\Xi^-p \to \Xi^-p$	1	27s, $\overline{10}$a, 10a, 8s, 8a	dσ/dΩ, P_y, A_y^T (, D)
		0	27s, 8s, 8a, 1s	
	$\Xi^-p \to \Lambda\Lambda$	0	27s, 8s, 8a, 1s	dσ/dΩ, P_y, A_y^T (, D)

— for ALS

— for channel dependence

— for H-particle

Summary

- **Several channels, observables and momentum range ...**

  One has to optimize between physics interest and technical feasibility.

- **High intensity ...**

  One needs new idea and/or R&D.

- **Future ... outcomes at JHF**

  ALS

  H

  Channel dep.

  THE PICTURE of BB strong interaction