E452

Hyperon-Nucleon Scattering Experiments

Kozi Nakai

Summary of the 30-years efforts for the $V_{\Sigma N}^{LS}$ determination since 1978.

Experimental Studies of Hyperon -Nucleon Interaction

- Hypernuclear experiments
  - High-resolution spectroscopy
  - Hyper-gammaray Spectroscopy
  - Good theoretical leadership

- Hyperon-nucleon scattering experiments
  - Triggerable tracking detector
  - Active target
  - 3D image reconstruction

Historical Background: Physics Motivation

1978 Heidelberg-Saclay Coll. at CERN

$$V_{\Lambda N}^{LS} \approx 0$$

Confirmed by KEK and BNL Experiments.

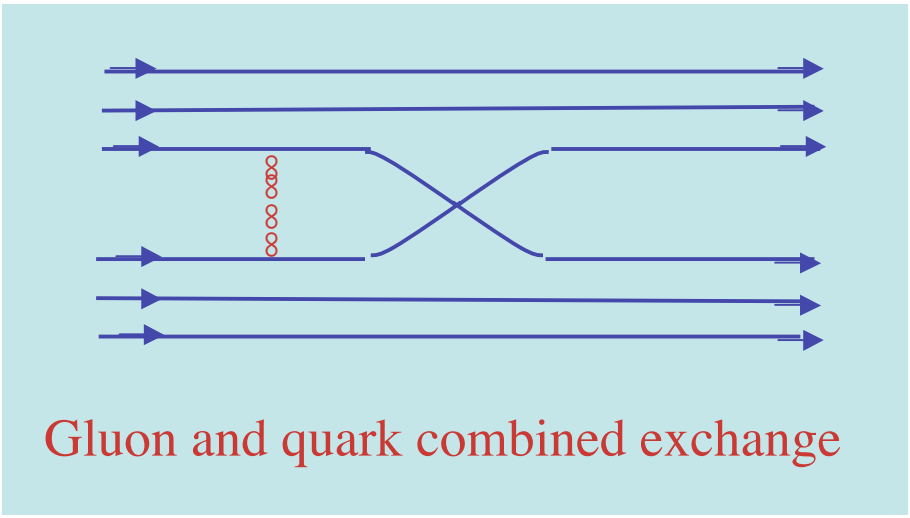
ΛN interaction

Hypernuclear Exp.

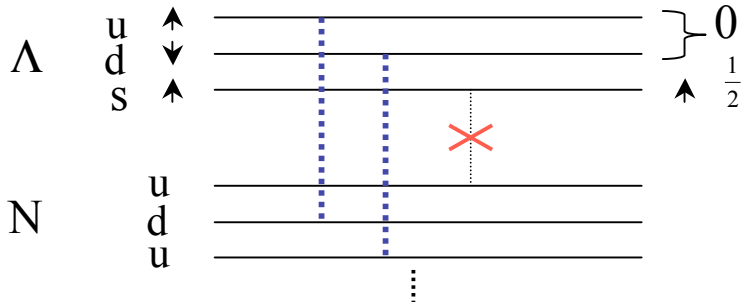
$$\begin{cases} V_{\Lambda N}^{Central} = \frac{2}{3} V_{NN}^{Central} & \text{(Central force)} \\ V_{\Lambda N}^{LS} \approx 0 & \text{(L-S force)} \end{cases}$$

1979 Pirner

1982 Pirner and Povh



Gluon and quark combined exchange



$$V_{\Sigma N}^{LS} \geq V_{NN}^{LS}$$

1988 Yazaki Quark cluster model

$$V_{NN}^{LS} < V_{\Sigma N}^{LS}$$

30 y

1978 at CERN Heidelberg-Saclay Coll.

Search for Σhypernuclei with in-flight method

1986 at KEK Heidelberg-Tokyo Coll.

B.Povh, Th.Walcher, S. Paul, ・・・・

T.Yamazaki, R.Hayano, K.Tanaka, ・・・・

Σhypernuclear experiment with the stopped-K method.

1998 at KEK Tokyo group

Σhypernuclei are produced only in a limited case

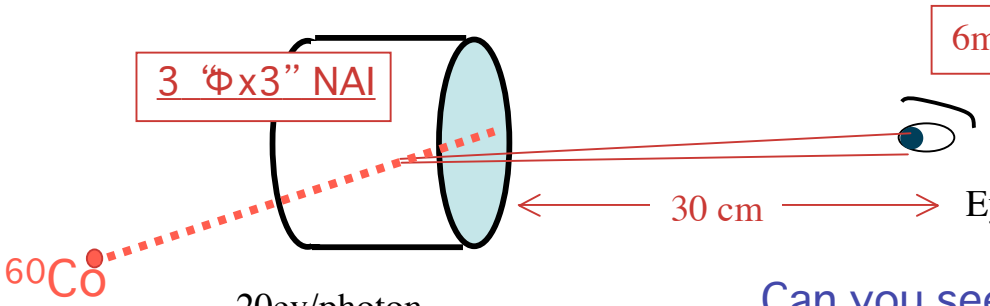
1998 at KEK TSU group

SCITIC development for the hyperon-scattering experiments

2002 Osaka PANIC

Large asymmetry in the Σ+P scattering experiments

2008 Final Report

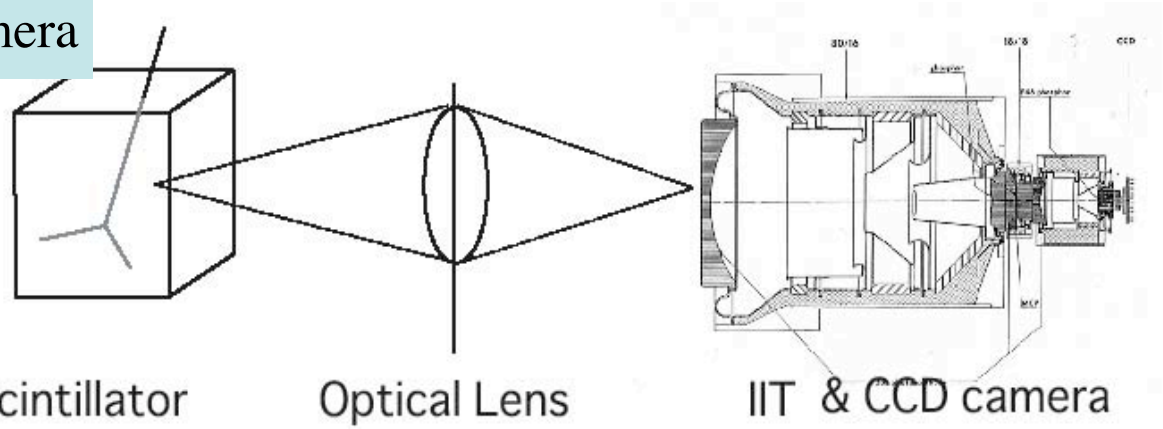


Can you see the scintillation light ?

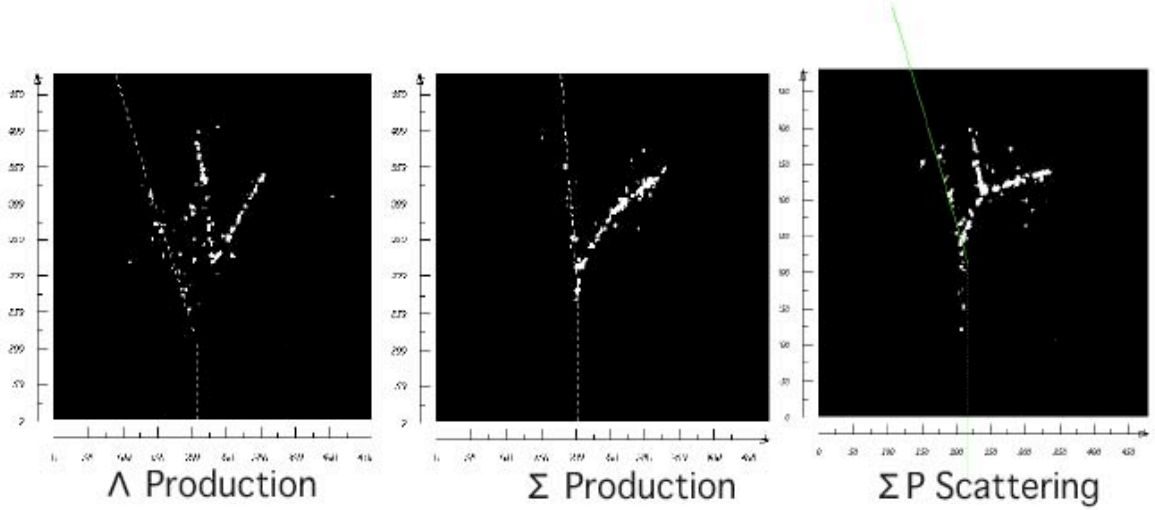
SCIntillation Track Image Camera

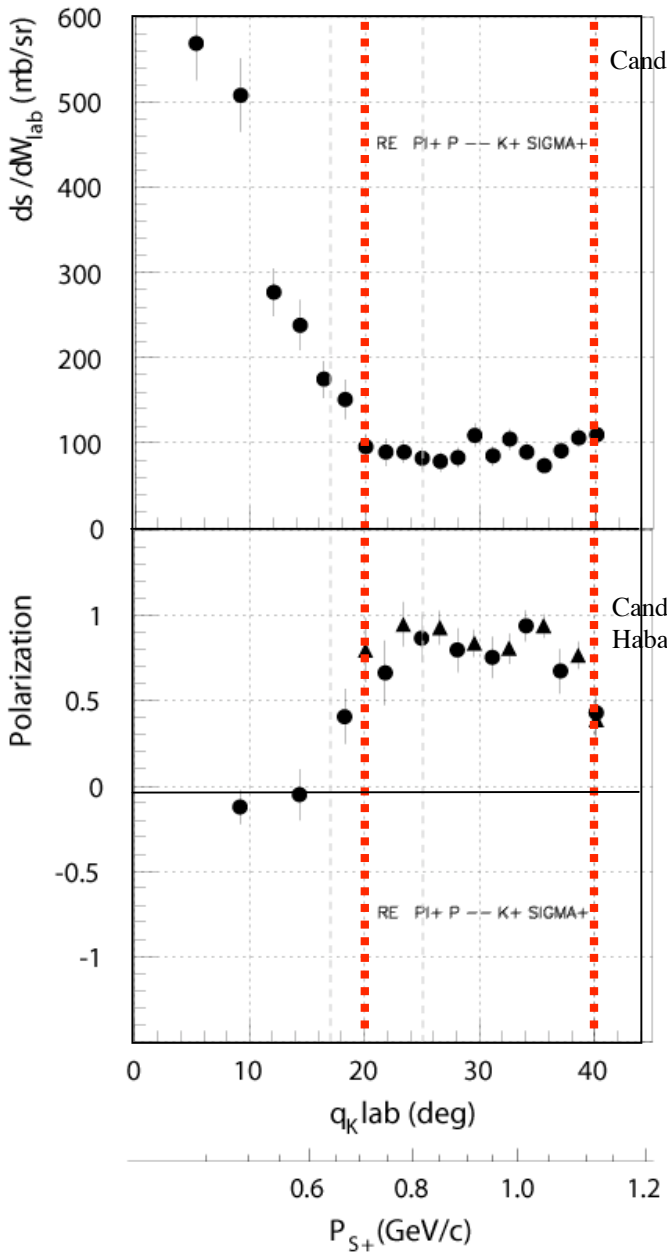
SCITIC

(a)



(b)



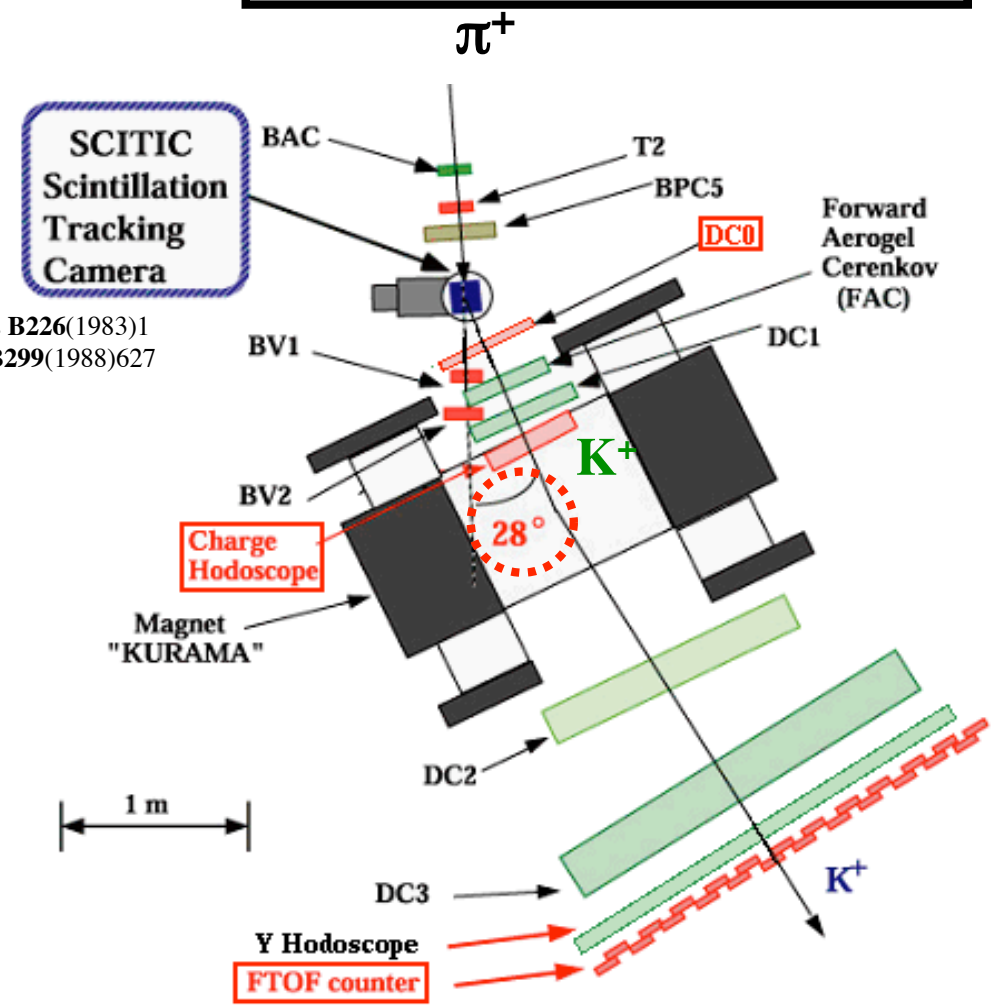


Candlin et al, Nucl. Phys **B226**(1983)1

Candlin et al, Nucl. Phys **B226**(1983)1
Haba et al, Nucl. Phys. **B299**(1988)627

$\pi^+ + p \rightarrow K^+ + \Sigma^+$ **(Production)**
$\Sigma^+ + p \rightarrow \Sigma^+ + p$ **(Scattering)**

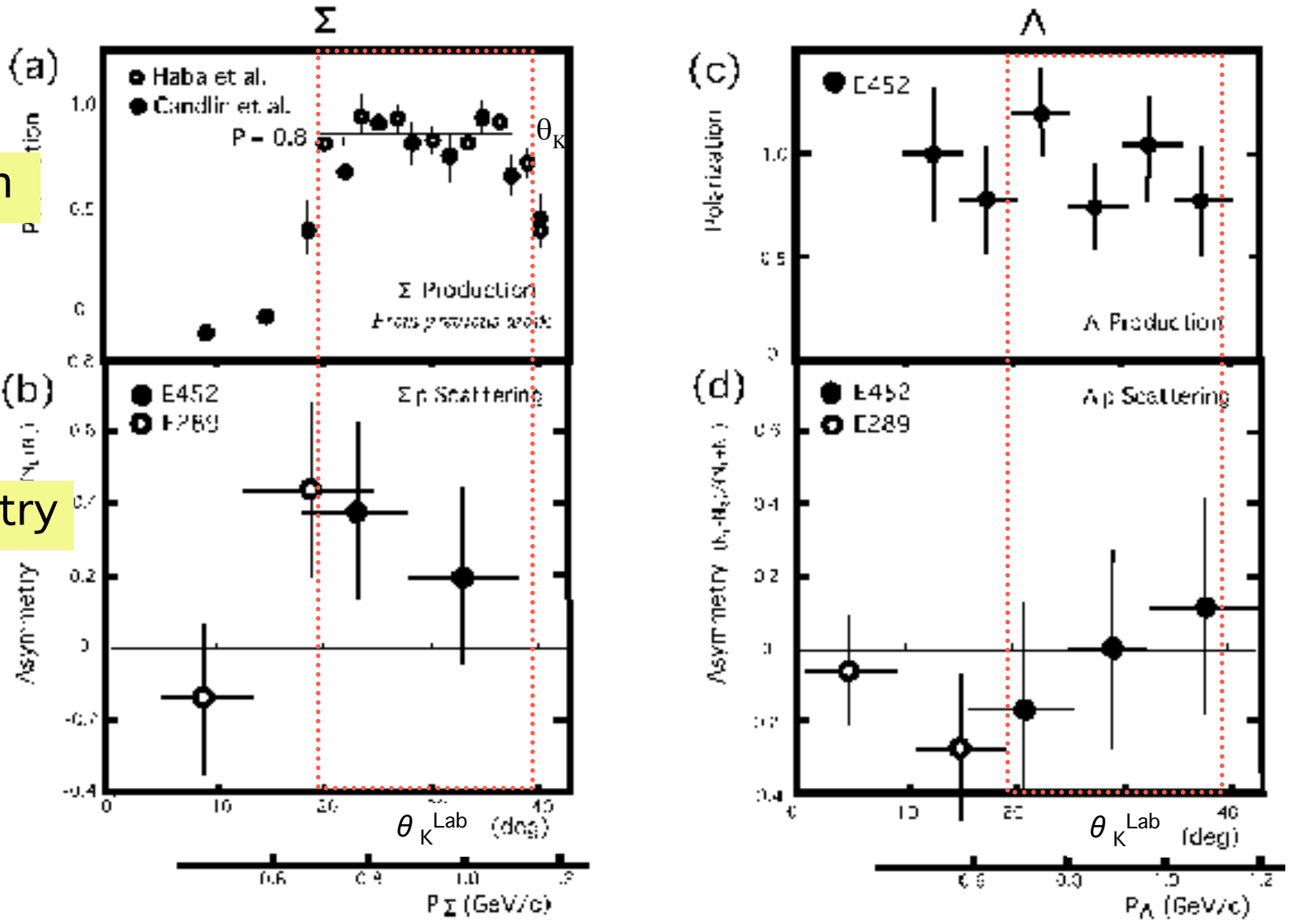
$\pi^+ + n \rightarrow K^+ + \Lambda$ **(Production)**
$\Lambda + p \rightarrow \Lambda + p$ **(Scattering)**

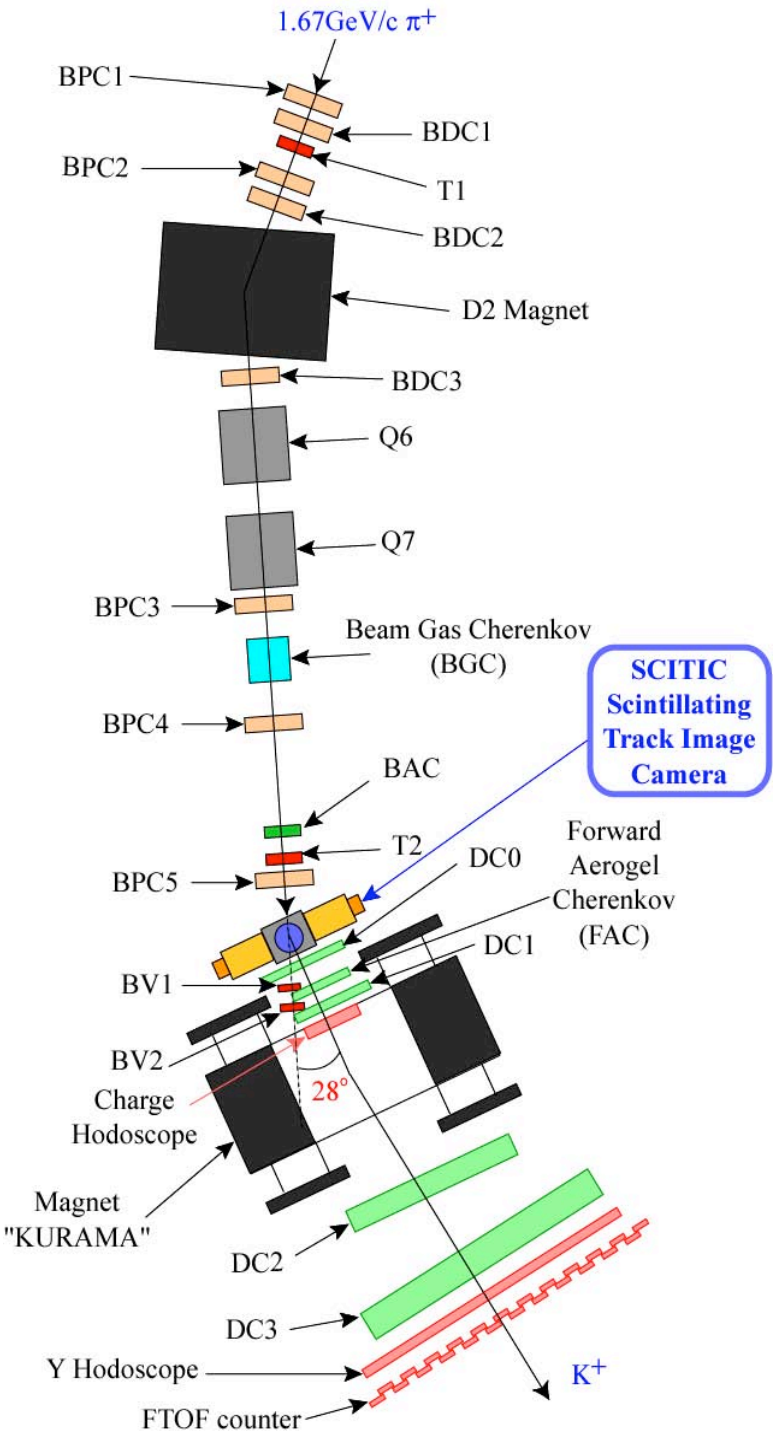


PANIC 2002

Polarization

R/LAsymmetry



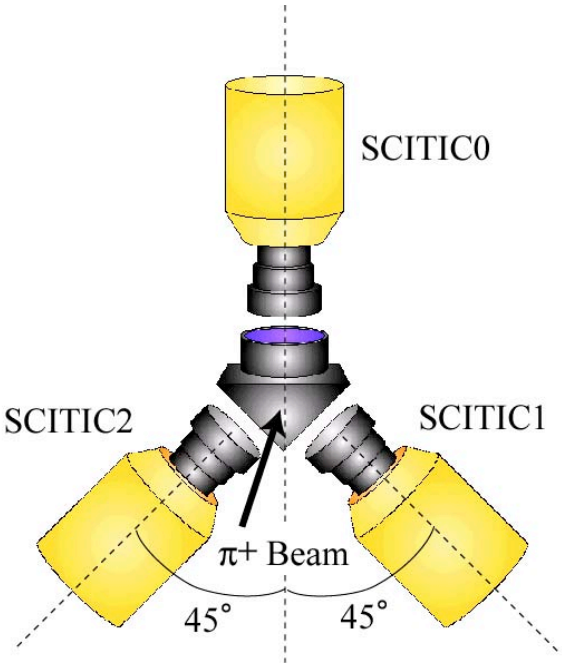


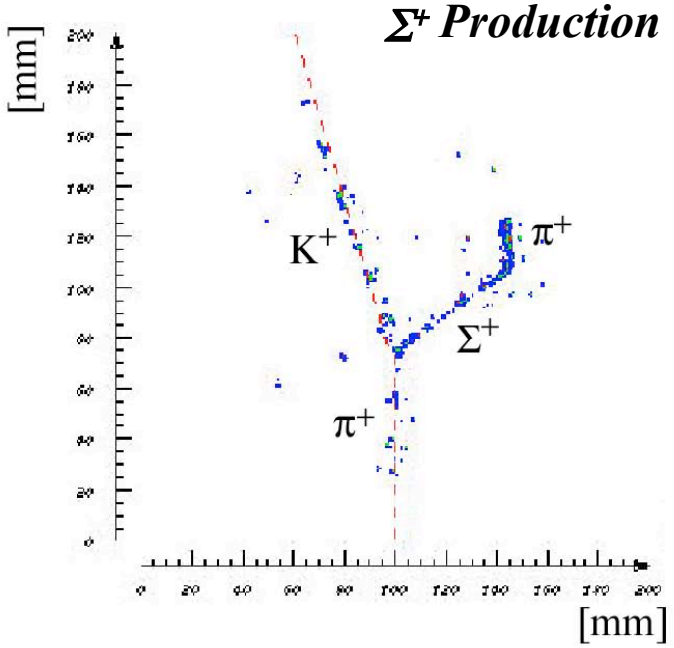
$\pi^+ + p \rightarrow K^+ + \Sigma^+$ **(Production)**

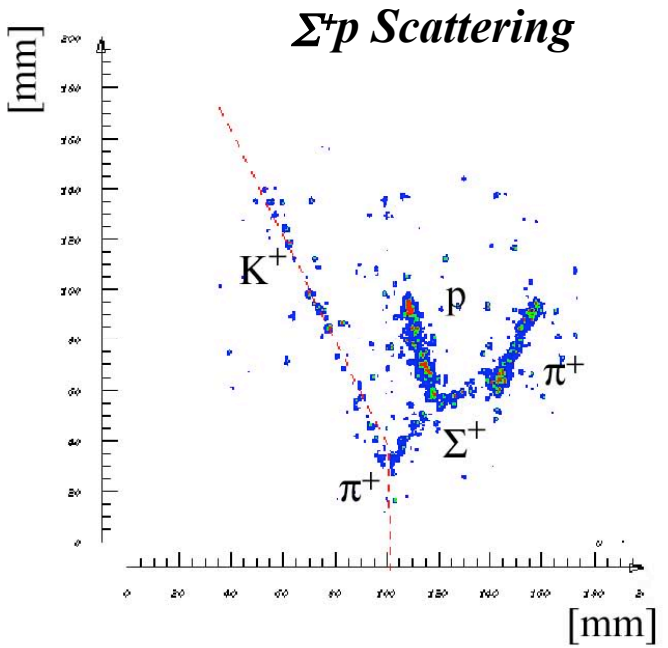
$\Sigma^+ + p \rightarrow \Sigma^+ + p$ **(Scattering)**

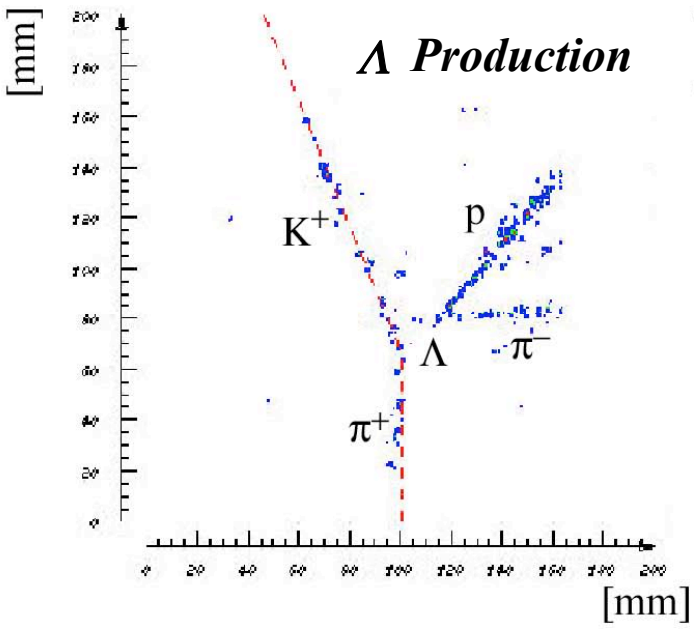
$\pi^+ + n \rightarrow K^+ + \Lambda$ **(Production)**

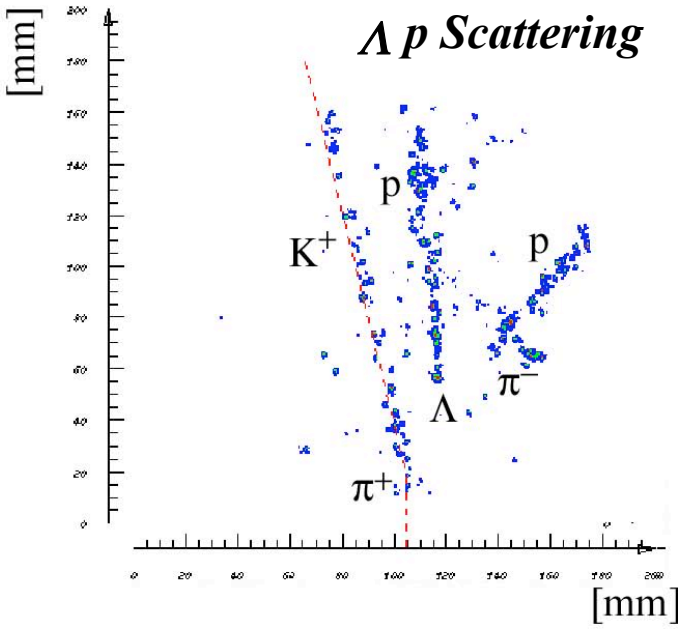
$\Lambda + p \rightarrow \Lambda + p$ **(Scattering)**




Σ+ Production
[mm]
K+
π+
Σ+
π+
[mm]


Σ+p Scattering
[mm]
K+
p
π+
Σ+
π+
[mm]


Λ Production
[mm]
K+
p
Λ
π−
π+
[mm]


Λ p Scattering
[mm]
p
K+
p
π−
Λ
π+
[mm]

E452 Data Analysis

(On-line Mass Trigger)

Raw Data — 1,700,000

Computer

(Spectrometer analysis)

Kinematical Cut (Spectrometer)
z-vertex
invariant mass

Human

(Image analysis)

(Image Correction (Distortion))
Scanning
Categorize image (Σ, Σp, Λ, Λp)
Pointing
Vector of each track

(Σp events)

26,485

13,817

7,621

Computer

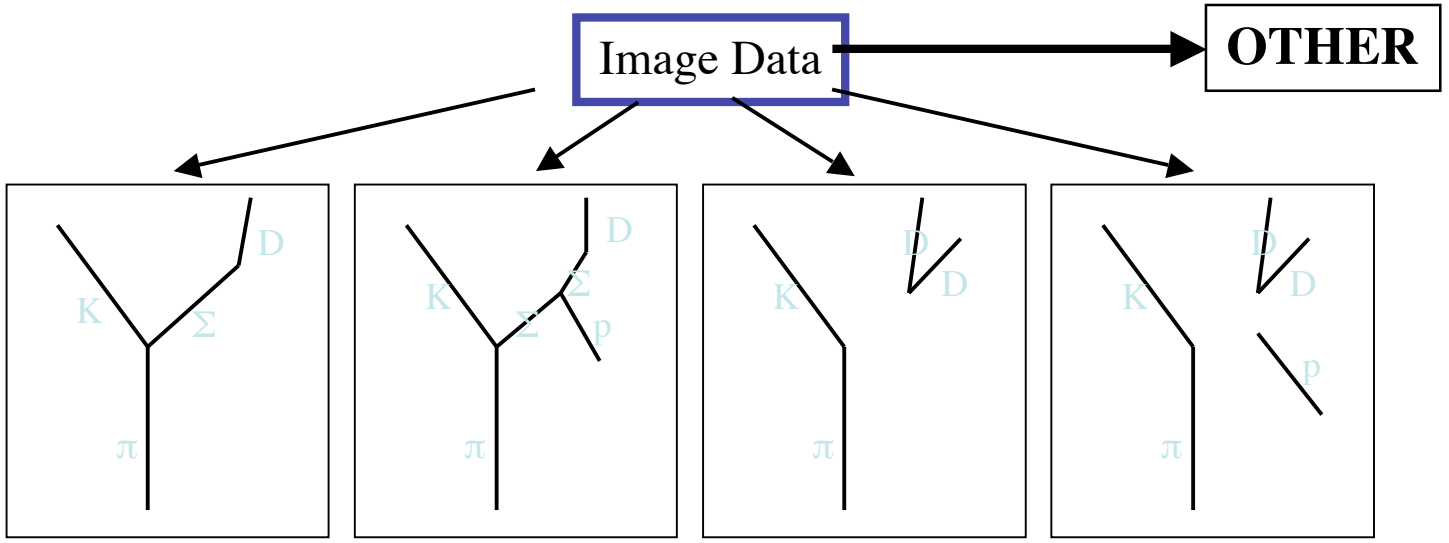
(Image analysis)

Kinematical Cut Free (H)
Quasi Free (C)
Geometrical cut (Ambiguity of 3-D image)

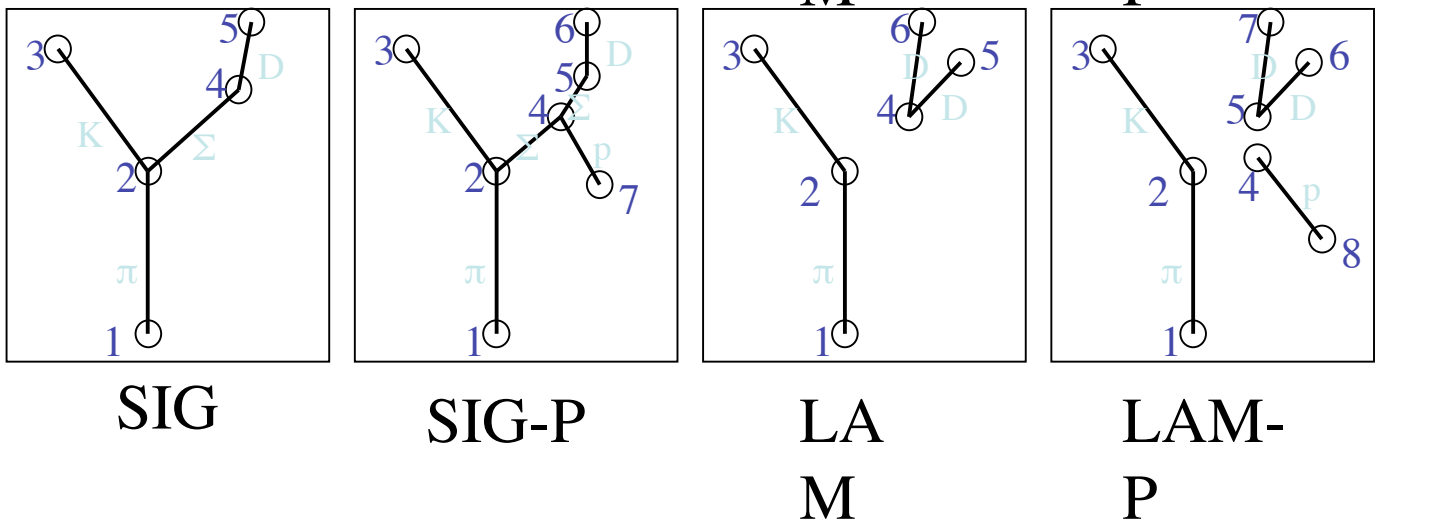
Polarization
Left-Right Asymmetry

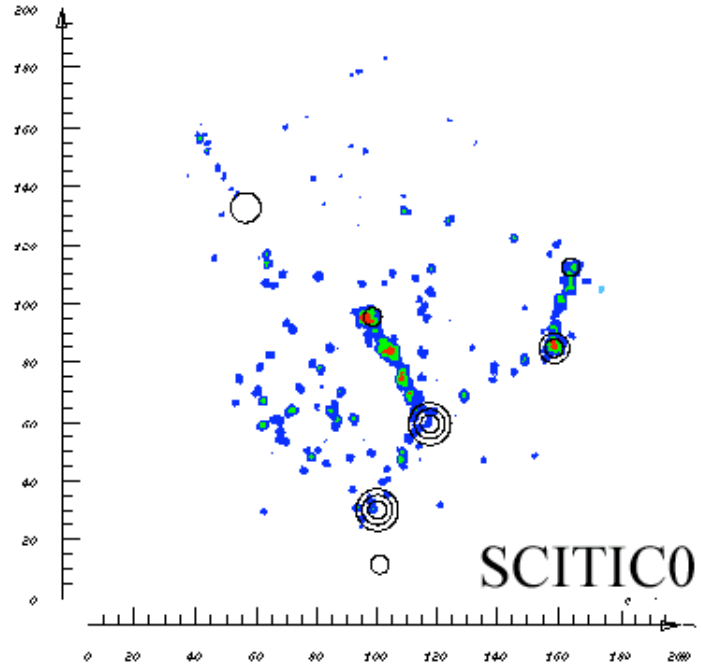
81

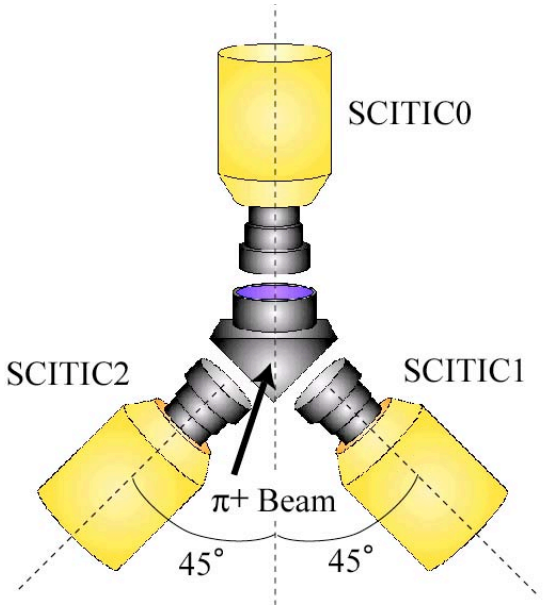
Scanning (Event categorization)

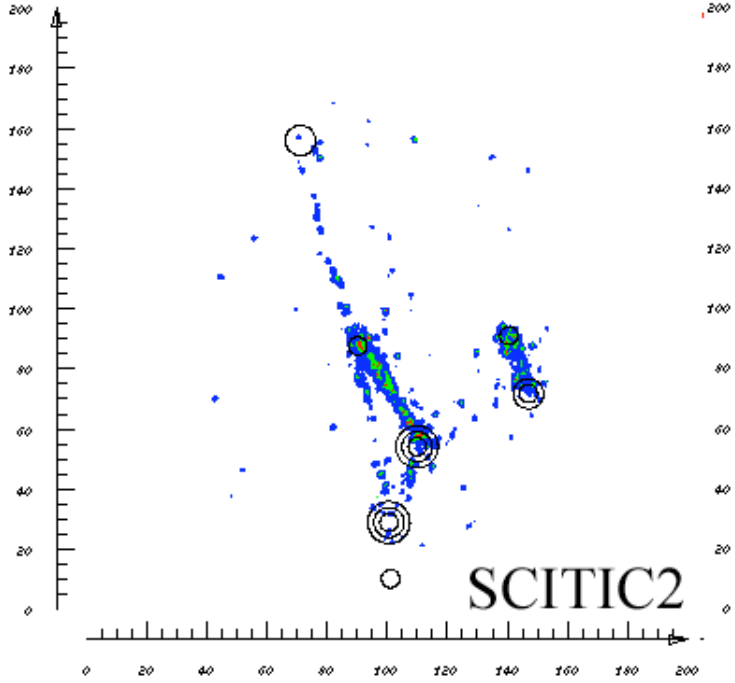


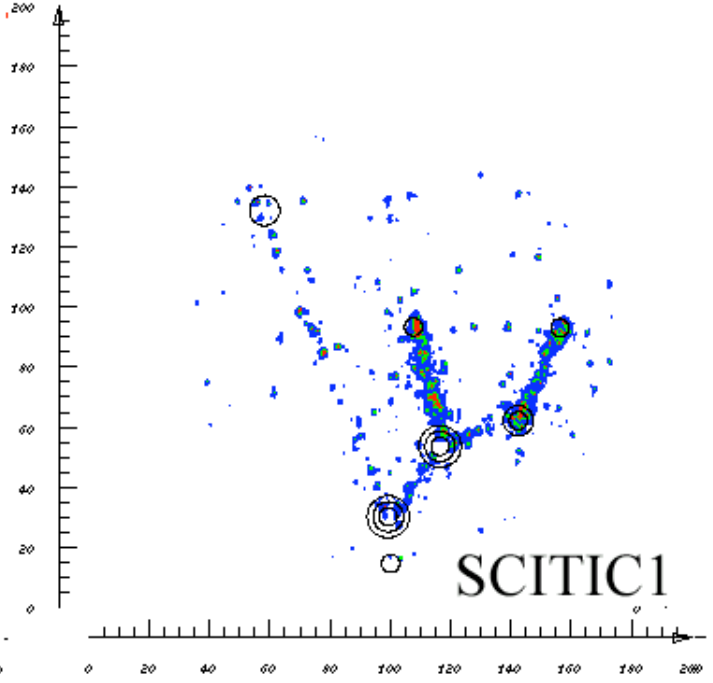
Pointing (Vector of each track)

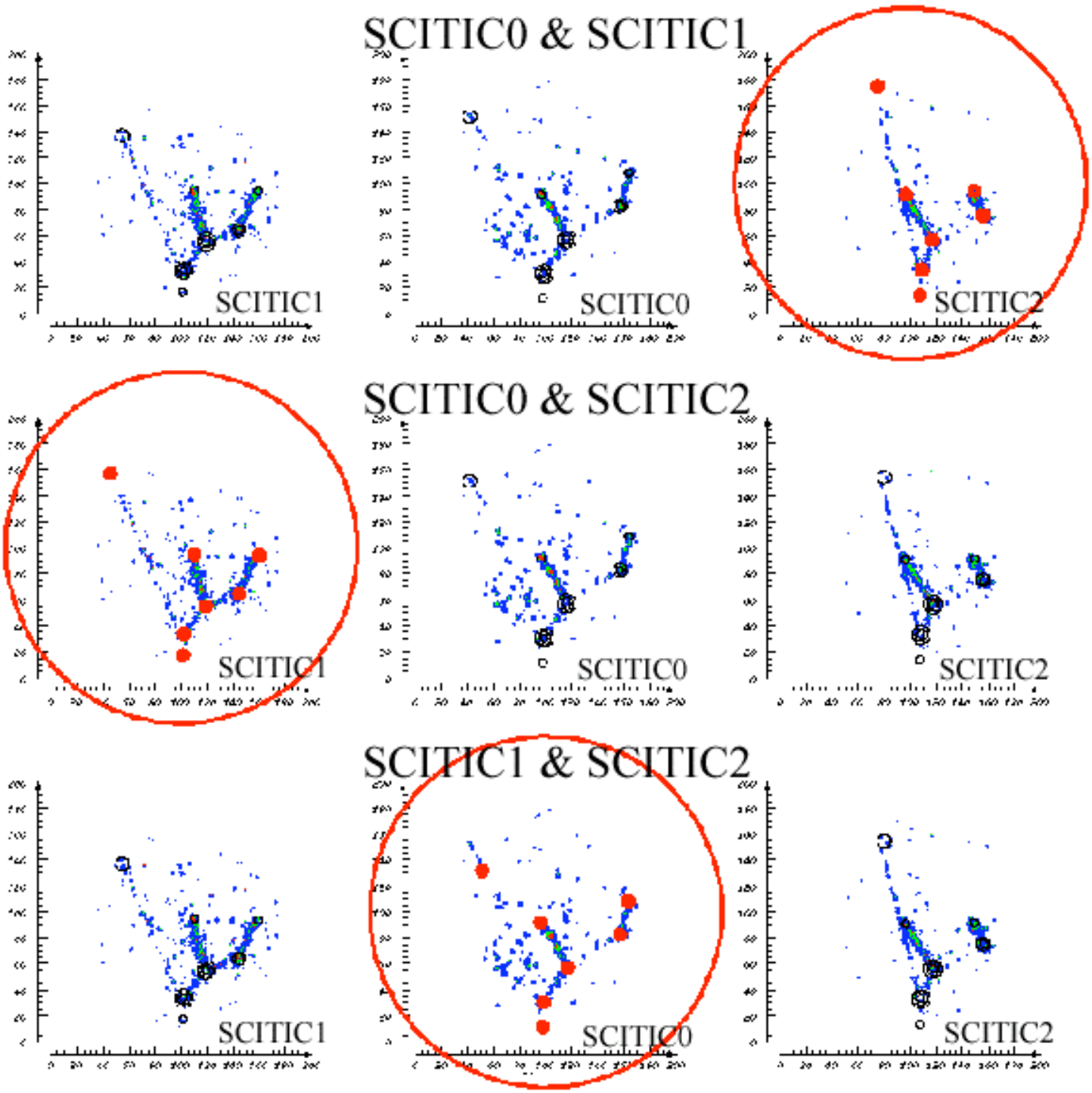


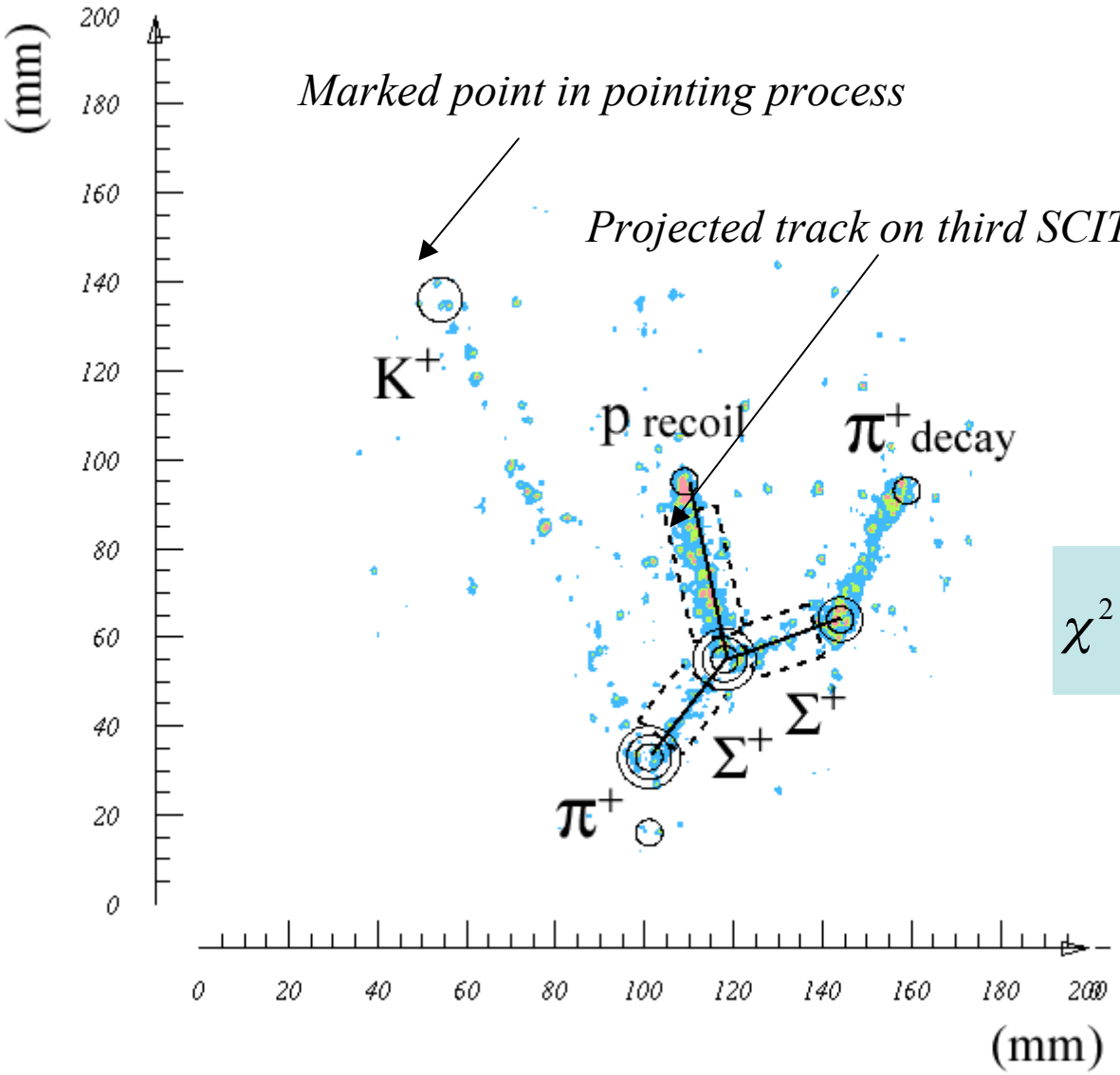

SCITIC0


SCITIC0
SCITIC2
SCITIC1
π+ Beam
45°
45°


SCITIC2


SCITIC1


SCITIC0 & SCITIC1
SCITIC1
SCITIC0
SCITIC2
SCITIC0 & SCITIC2
SCITIC1
SCITIC0
SCITIC2
SCITIC1 & SCITIC2
SCITIC1
SCITIC0
SCITIC2



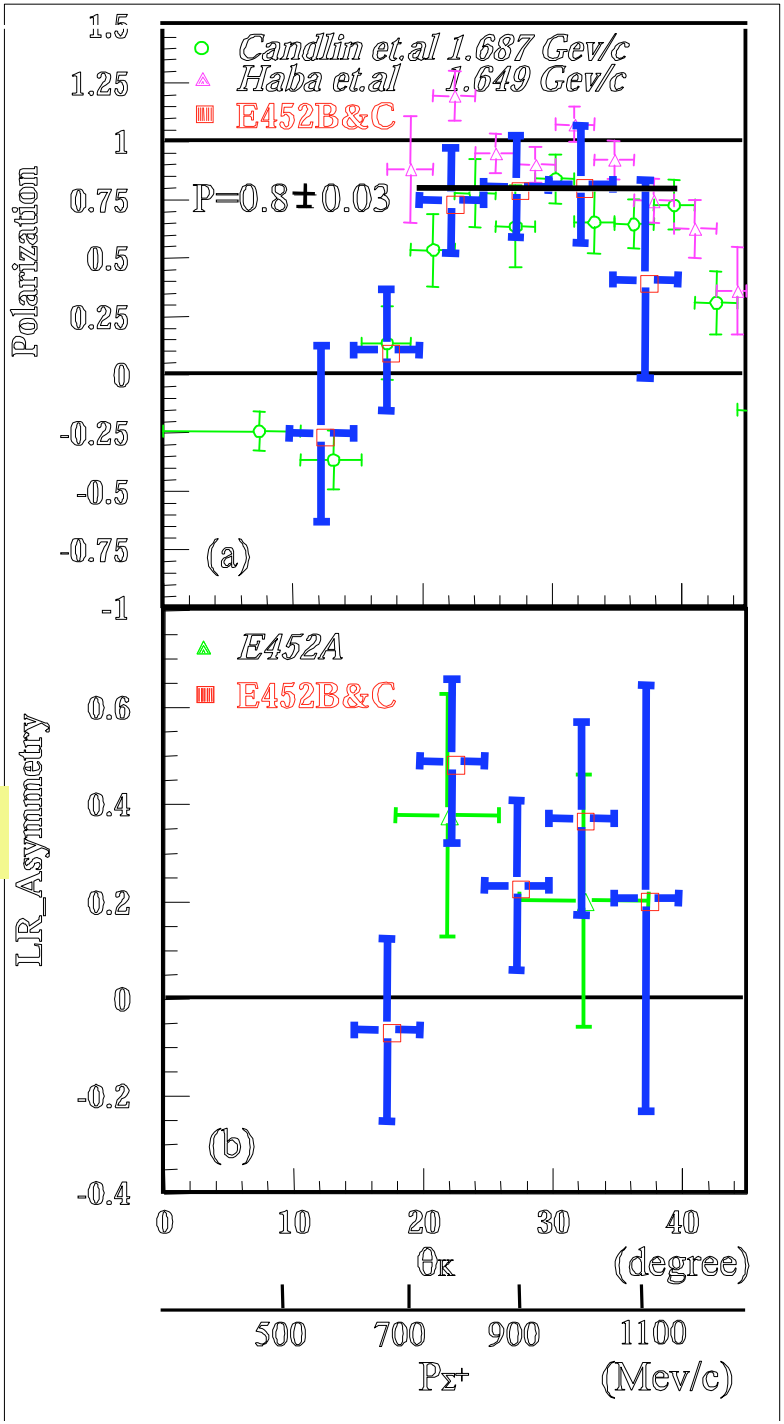
$$\chi^2 = \frac{\chi^2_{\Sigma_pro.} + \chi^2_{\Sigma_sct.} + \chi^2_{P_rec.}}{3}$$

chi Select 3D pattern having minimum square $\chi^2 < 10$

Results

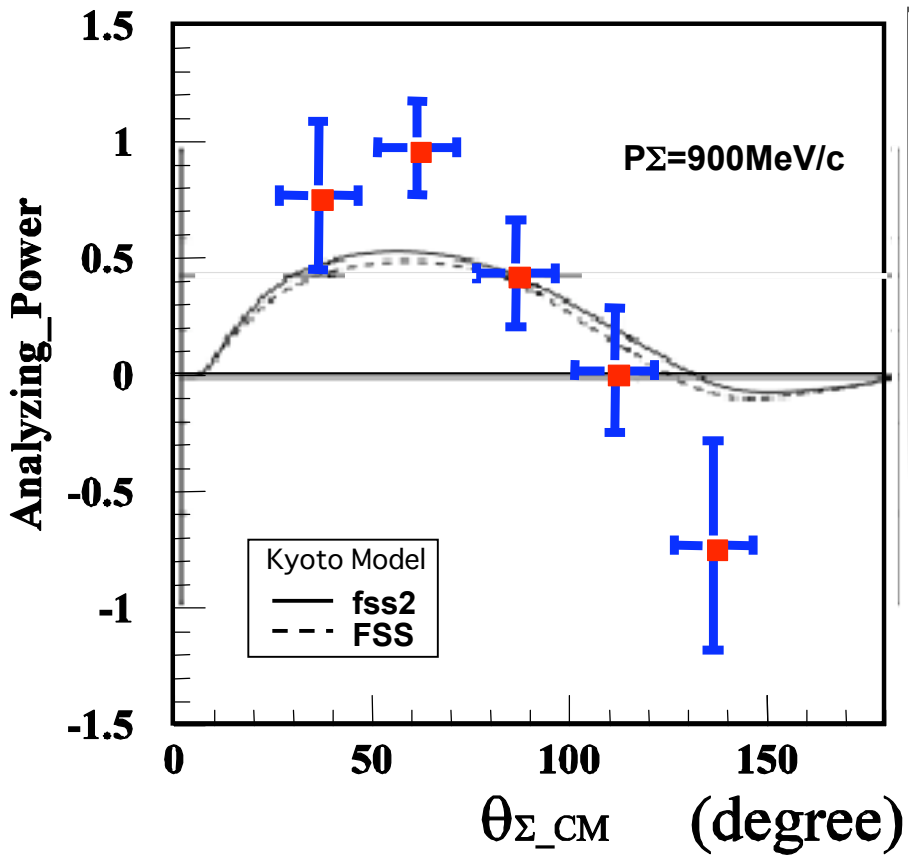
Σ^+ Polarization

Σ^+p LR Asymmetry



Analyzing Power

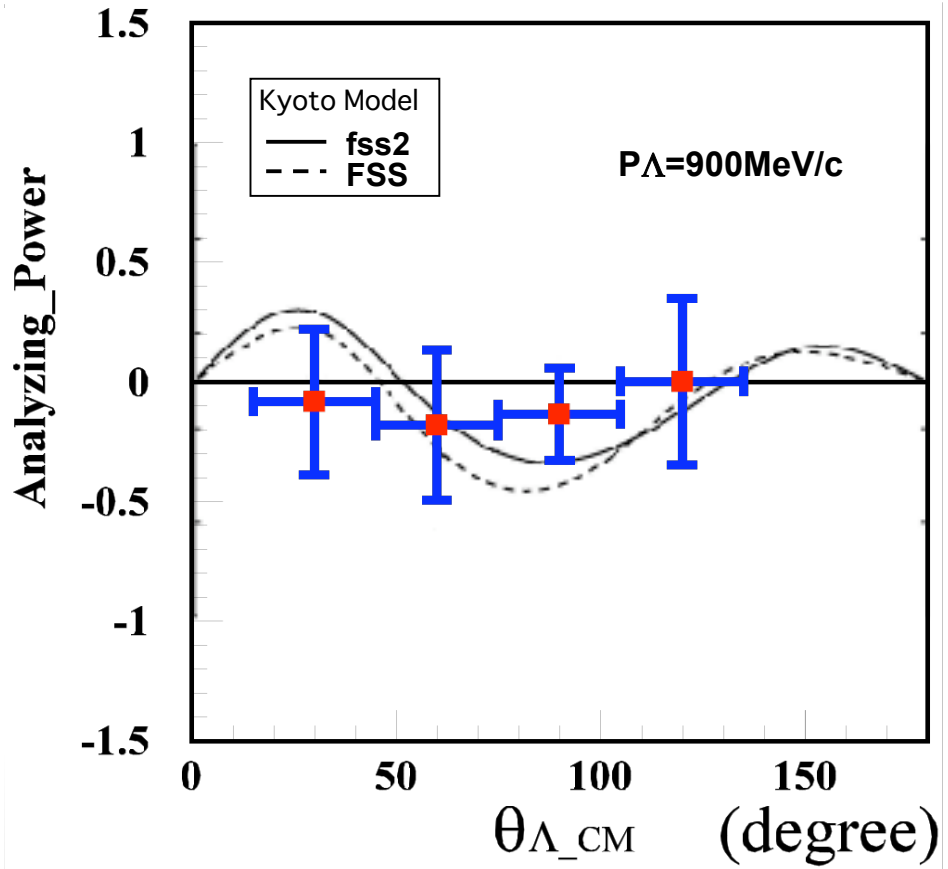
Σ^+p Scattering



θΣCM (degree)	Analyzing Power
25 – 50	0.75±0.32
50 – 75	0.96±0.20
75 – 100	0.42±0.23
100 – 125	0.00±0.27
125 - 150	-0.75±0.45

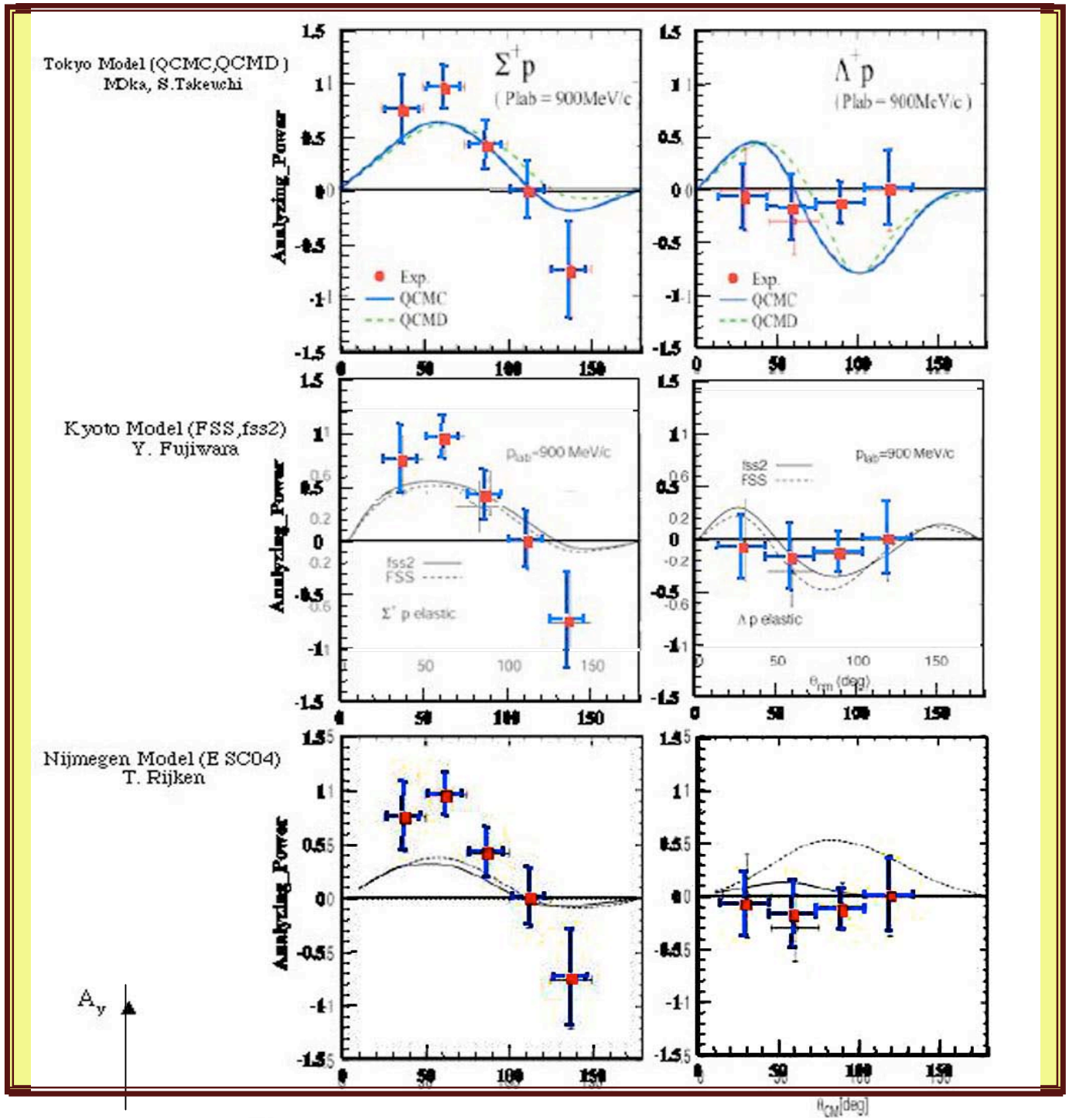
81evnets

Λp Scattering



θΛCM (degree)	Analyzing Power
15 – 45	-0.08±0.30
45 – 75	-0.18±0.31
75 – 105	-0.14±0.19
105 – 135	0.00±0.35

67evnets

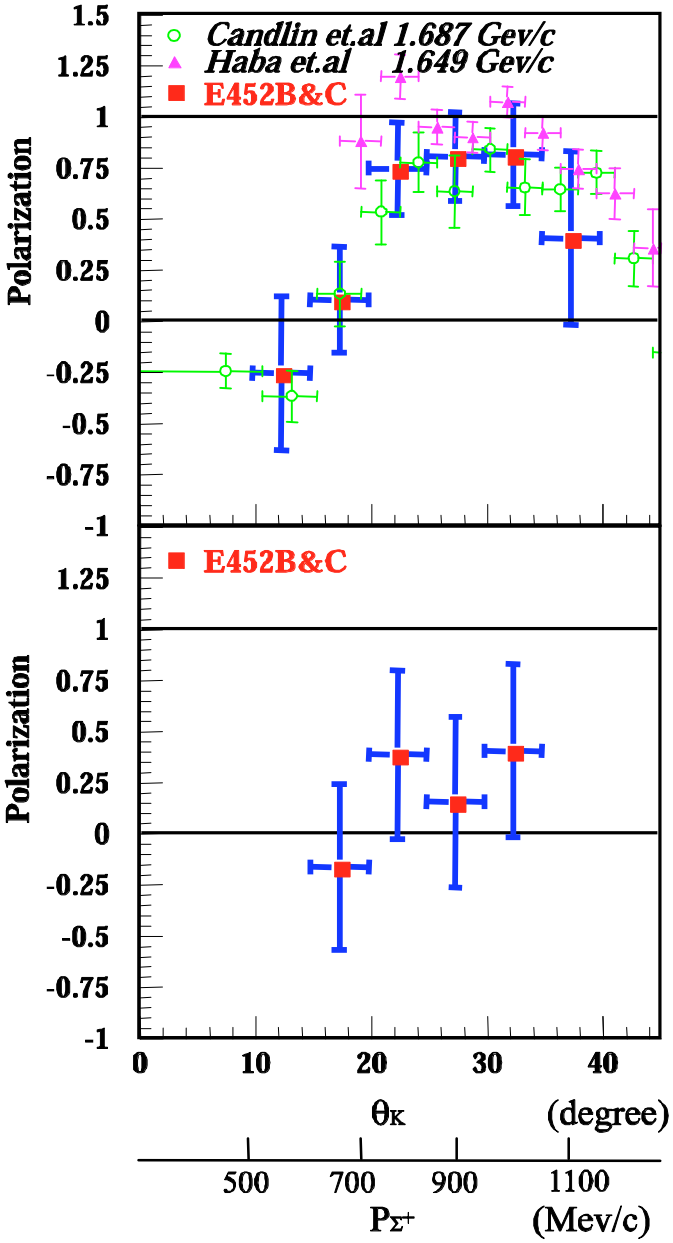

Tokyo Model (QCMC,QCMD)
MOka, S.Takeuchi
Kyoto Model (FSS,fss2)
Y. Fujiwara
Nijmegen Model (E SC04)
T. Rijken
Σ+p
(Plab = 900MeV/c)
Λ+p
(Plab = 900MeV/c)
Exp.
QCMC
QCMD
Analyzing_Power
Plab=900 MeV/c
fss2
FSS
Σ+ p elastic
Λ p elastic
θcm (deg)
Ay
θCM[deg]

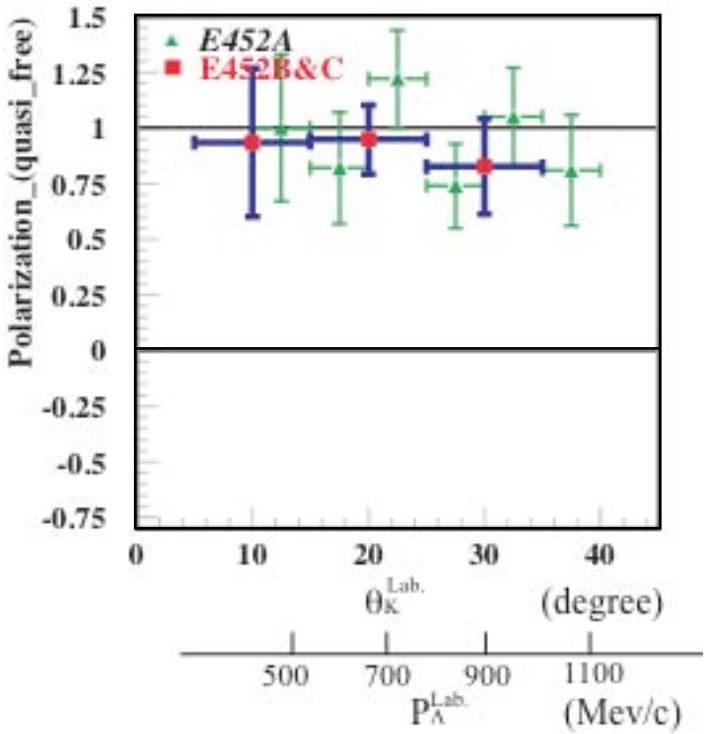
Σ

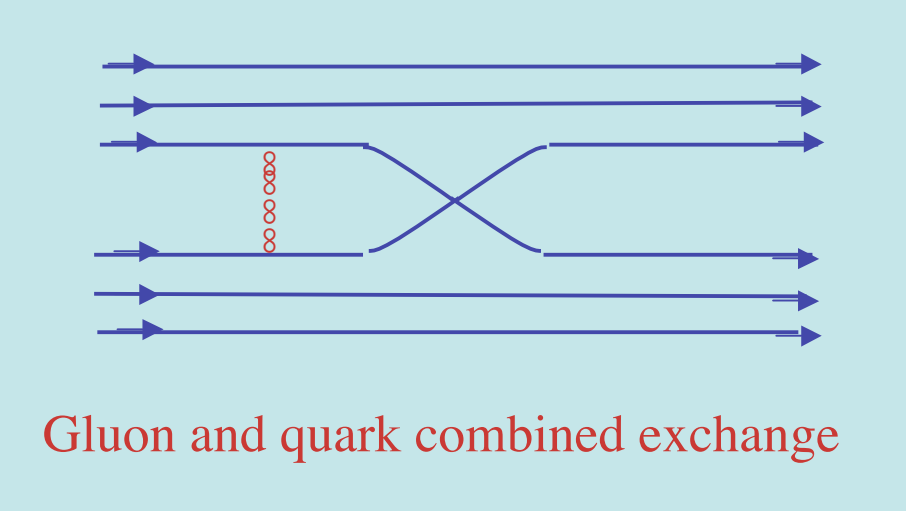
Λ

F

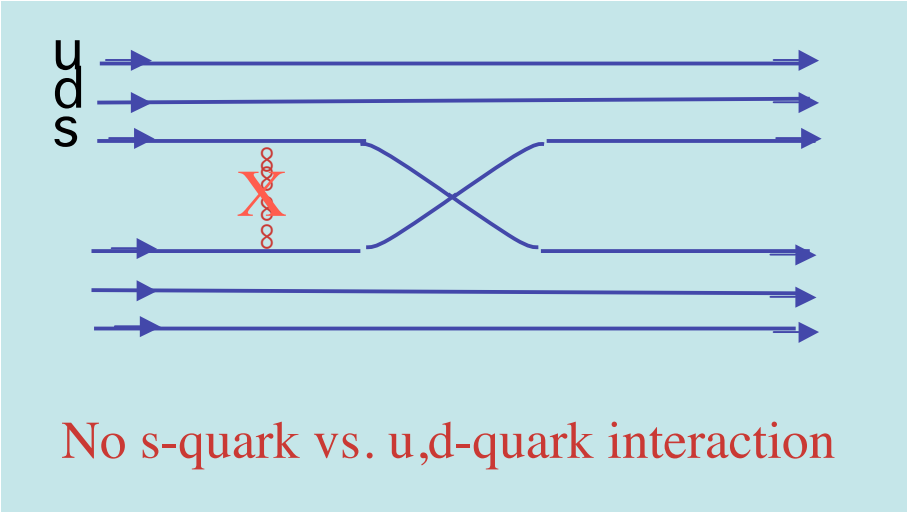
QF


Candlin et.al 1.687 Gev/c
Haba et.al 1.649 Gev/c
E452B&C
E452B&C
Polarization
Polarization
θK (degree)
PΣ+ (Mev/c)


E452A
E452B&C
Polarization_(quasi_free)
θK Lab. (degree)
PΛ Lab. (Mev/c)



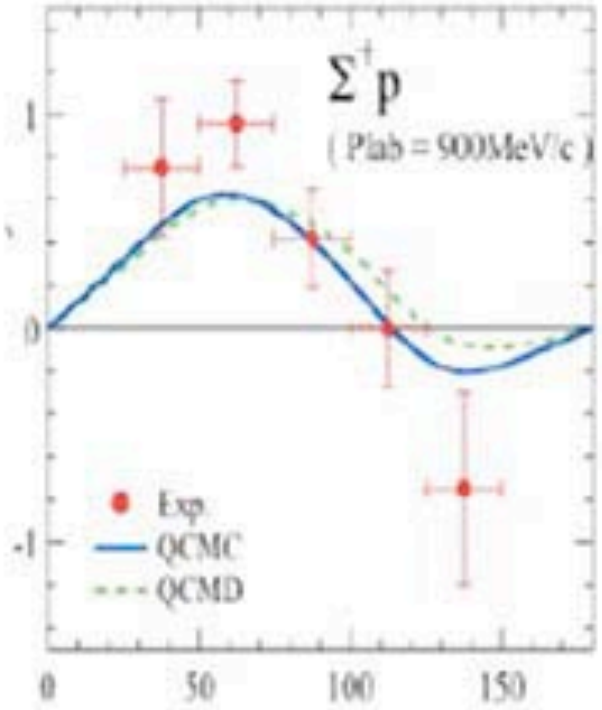
Gluon and quark combined exchange

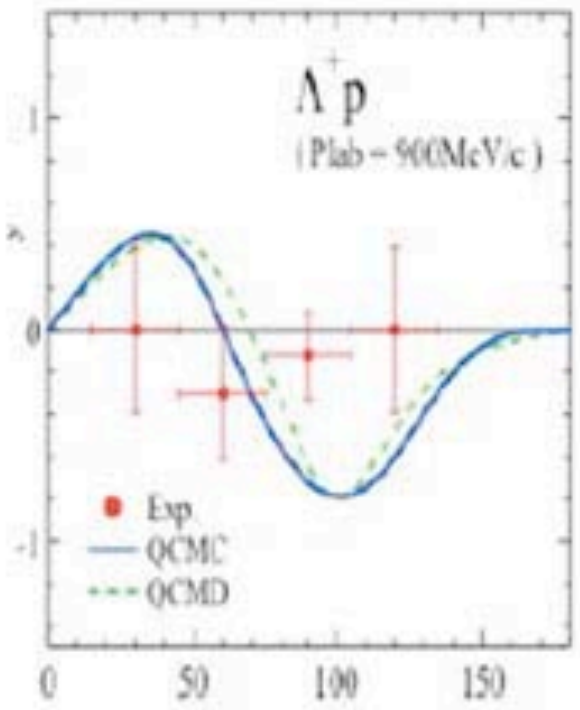


No s-quark vs. u,d-quark interaction

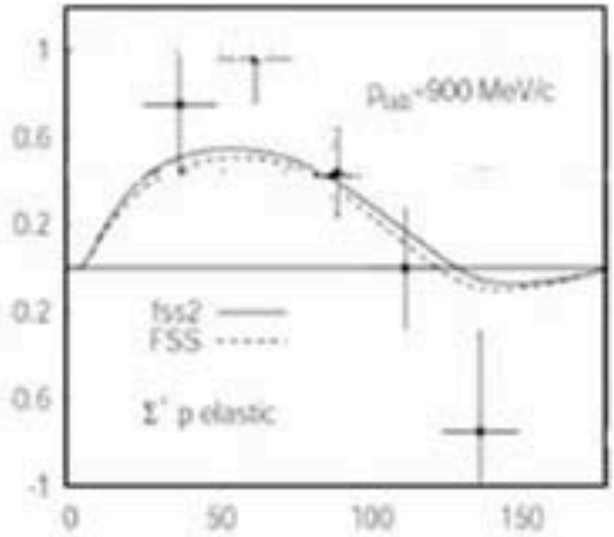
Λ-spin behaves like a spectator

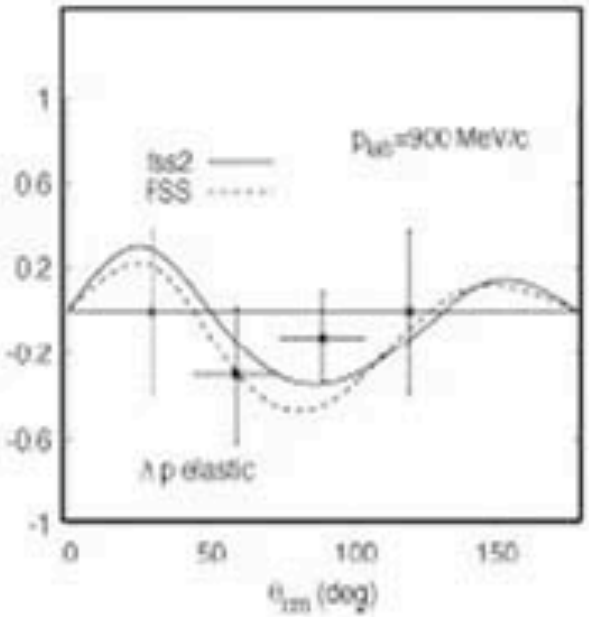
Tokyo Model (QCMC,QCMD)
MOka, S.Takeuchi

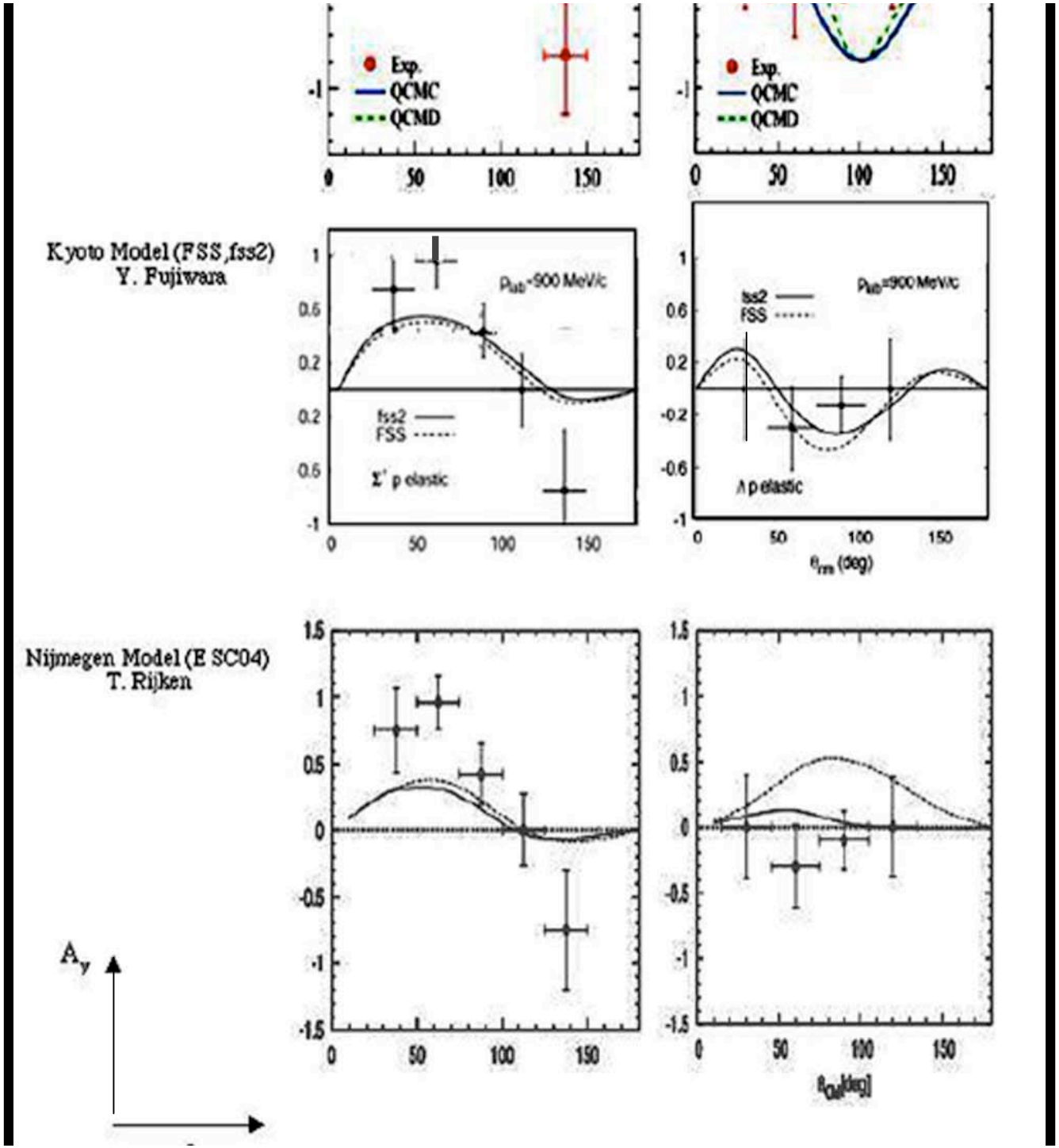




Kyoto Model (FSS,fss2)
Y. Fujiwara






Exp.
QCMC
QCMD
Exp.
QCMC
QCMD
Kyoto Model (FSS, fss2)
Y. Fujiwara
P_{lab}=900 MeV/c
fss2
FSS
Σ' p elastic
P_{lab}=900 MeV/c
fss2
FSS
Λ p elastic
θ_{cm} (deg)
Nijmegen Model (E SC04)
T. Rijken
A_y
θ_{Cal}[deg]