High Resolution Search for Θ^{++}, Θ^{+} Pentaquark in Hall C at JLab

- Introduction
- A high resolution, high statistics search
  - –High resolution magnetic spectrometers
- Summary

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Experiments	Results Mass (MeV)	Width (Mev)	Significance (σ)
LEPS	$1540 \pm 10 \pm 5$	$\Gamma < 25$	4.6 ± 1
DIANA	$1539 \pm 2 \pm$ "few"	$\Gamma < 8$	4.4
CLAS	$1542 \pm 2 \pm 5$	FWhM < 21	5.3 ± 0.5
SAPHIR	$1540 \pm 4 \pm 2$	$\Gamma < 25$	4.8
ITEP (ν's)	1533 ± 5	$\Gamma < 29$	6.7
HERMES	$1526 \pm 2 \pm 2.5$	$\Gamma < 20$	5.6
World Average	1535 ± 2.5		
Prediction	1530 $\Gamma < 15$	I=0 S=+1	$J^P = \frac{1}{2}^+$

W. Lorenzon, Jlab Nov. 2003

1555 MeV from CLAS proton data,
Two Θ^+ (1526) and Θ^+(1571) peaks?
Battaglieri et al. PR04-021

ZEUS results: 1527 MeV
Width=10 MeV

What are the issues?

√ • Mass
  - 1526 MeV - 1555 MeV for Ξ^+ (experiments)
  - Two Ξ^+ peaks? (M. Battaglieri et al.)

√ • Width
  - < (9 - 28) MeV (limited by experimental resolutions)
  - < 15 MeV (30 MeV, Jaffe hep-ph/0401187)
  - < 1 MeV (PWA of K^+p, K^+d data by Arndt et al.)

• Spin & Parity
  - $1/2^+$, chiral soliton model
  - $1/2^+$, $3/2^+$, correlated diquark model
  - $1/2^-$, Lattice, QCD sum rule, uncorrelated quark models

√ Isospin

- Iso-singlet
  - So far no experimental evidence for Θ^{++}
  - Diakonov et al., Chiral soliton model
- Iso-vector
  - Walliser & Kopeliovich, topological soliton model Θ^{*++} particle of mass 1.65 to 1.69 GeV
  - Wu & Ma, chiral soliton model, Θ^{*++} mass of 1.61 GeV
  - Bijker et al predict mass of exotic baryons 1.66 & 1.78 GeV using flavor-spin SU(6) representation
- Iso-tensor
  - Capstick, Page, Roberts
  - Gerasyuta & Kochkin predicts Θ^{**++} 1575 MeV

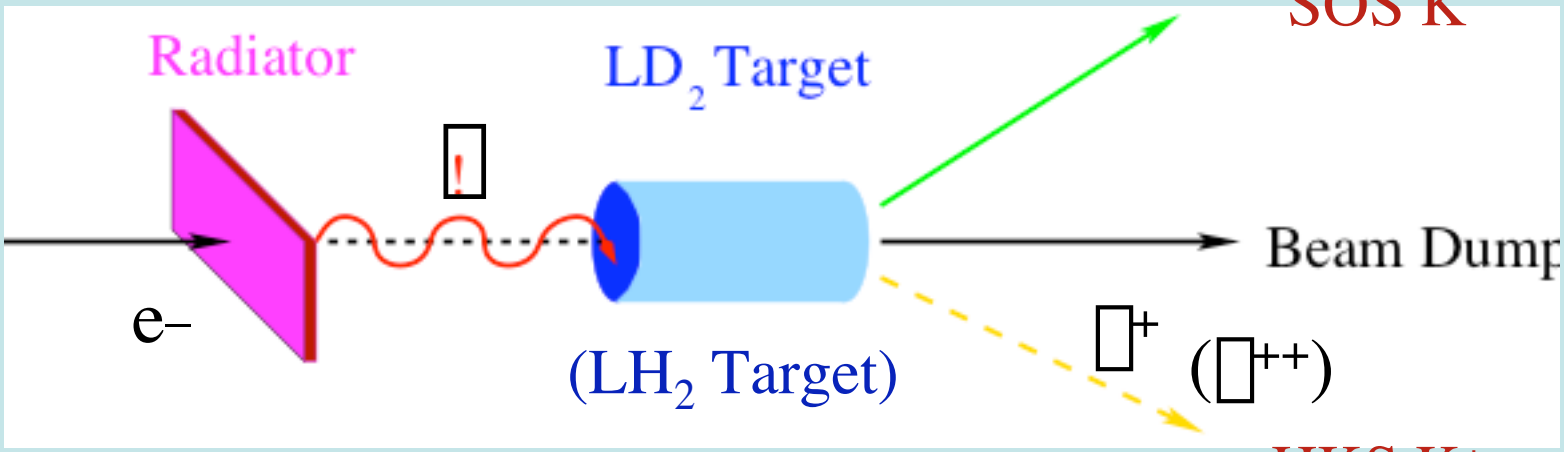
(1761 MeV) for J=1/2 (3/2) for positive parity

Experiment

- Photoproduction processes:

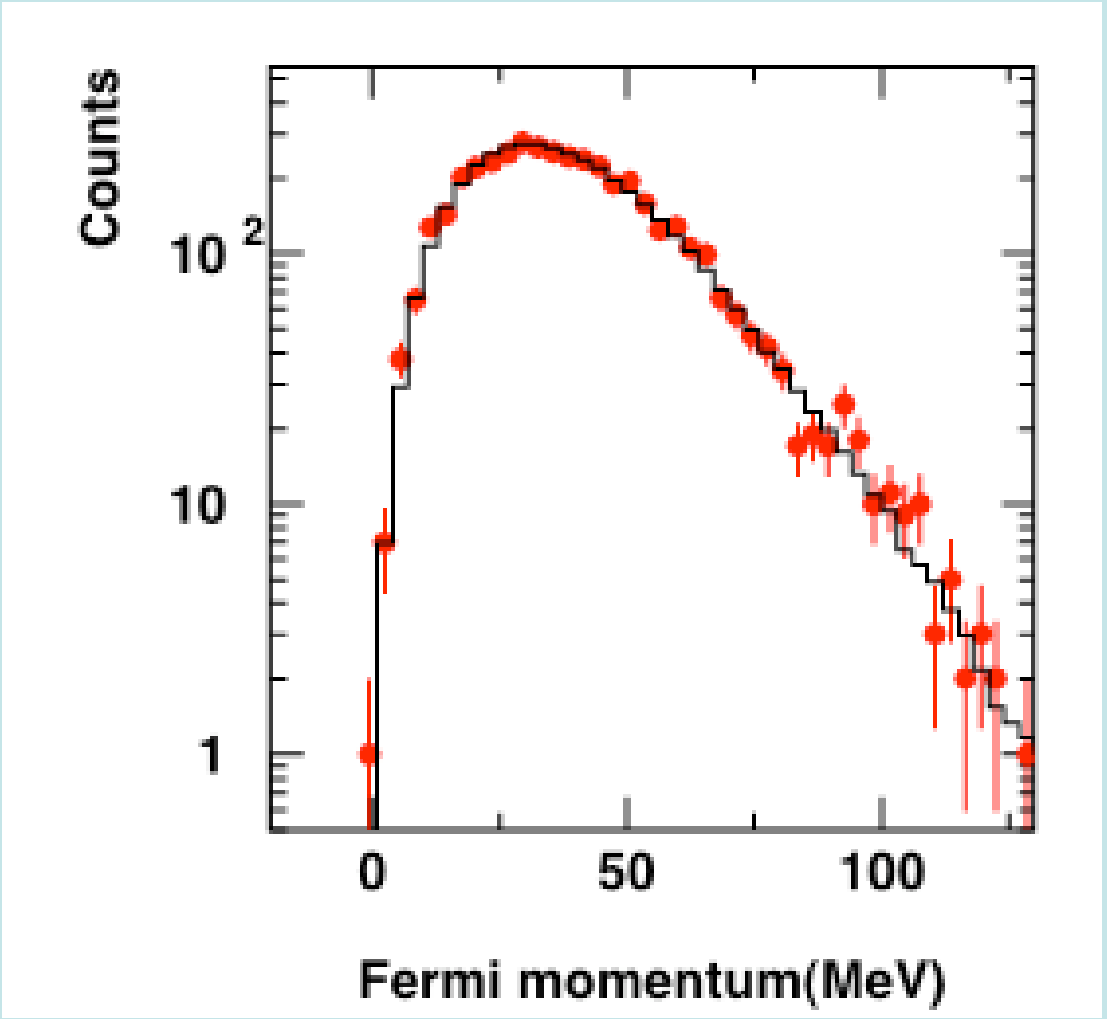
$\gamma + p \rightarrow \Sigma^{++} K^{-} \rightarrow (pK^{+}) K^{-}$ $(K^{+}K^{-})$ √

$\gamma + n \rightarrow \Sigma^{+} K^{-} \rightarrow (nK^{+}) K^{-}$ $(K^{+}K^{-}n)$ √



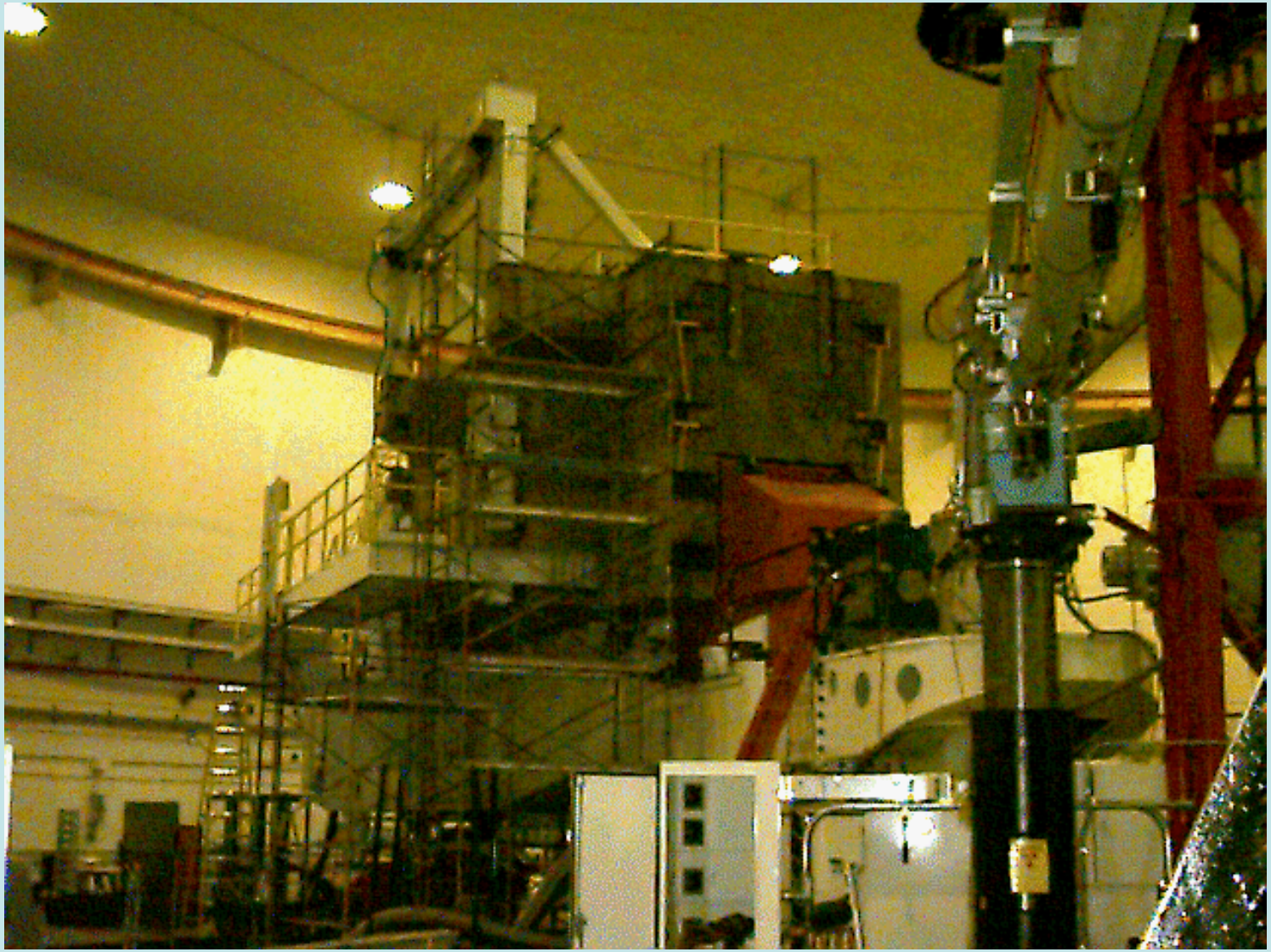
$\vec{e}+n \rightarrow e'+p$

L.Y. Zhu et al, PRL91, 022003 (2003)

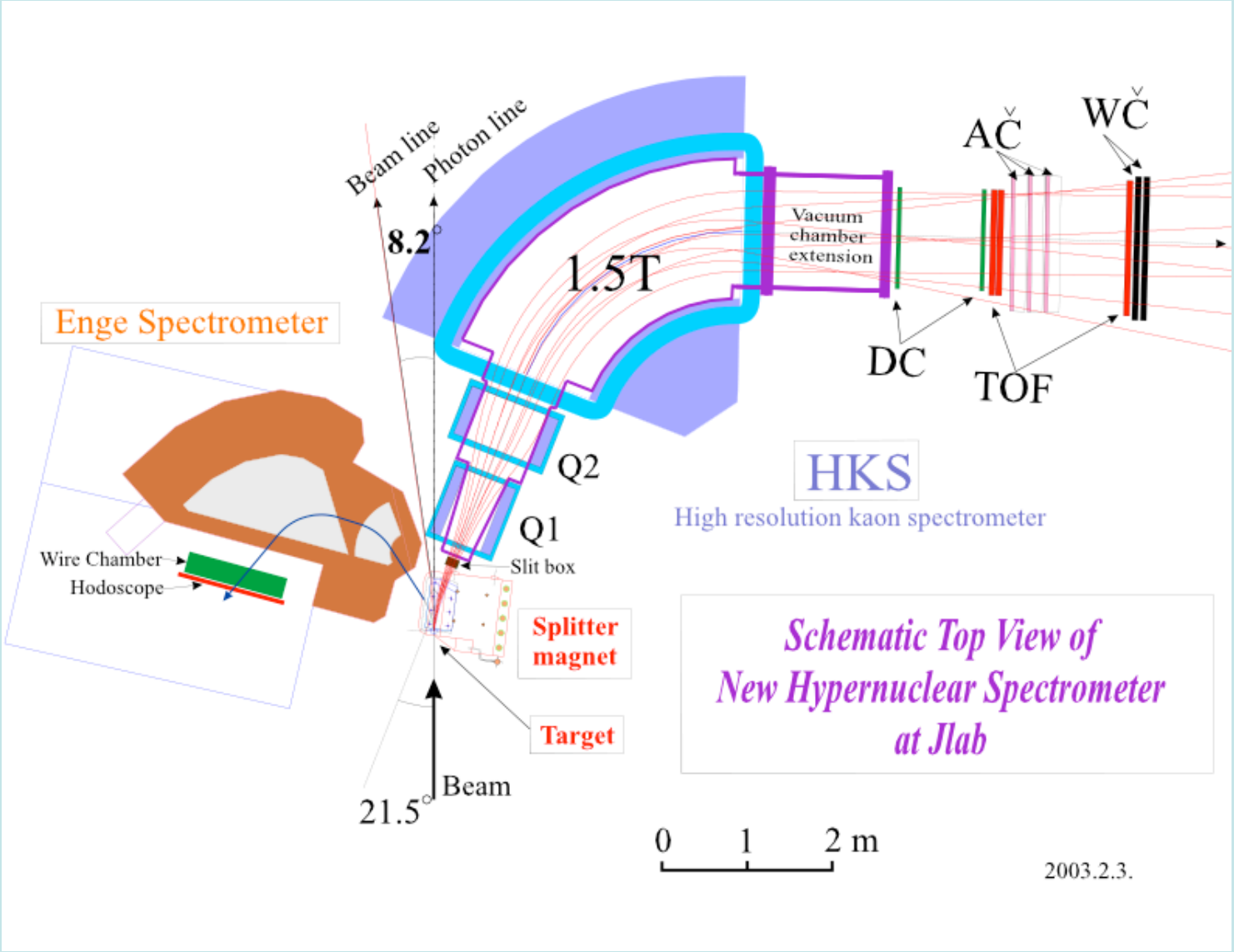


L.Y. Zhu, Ph.D. Thesis, Feb 2004, MIT

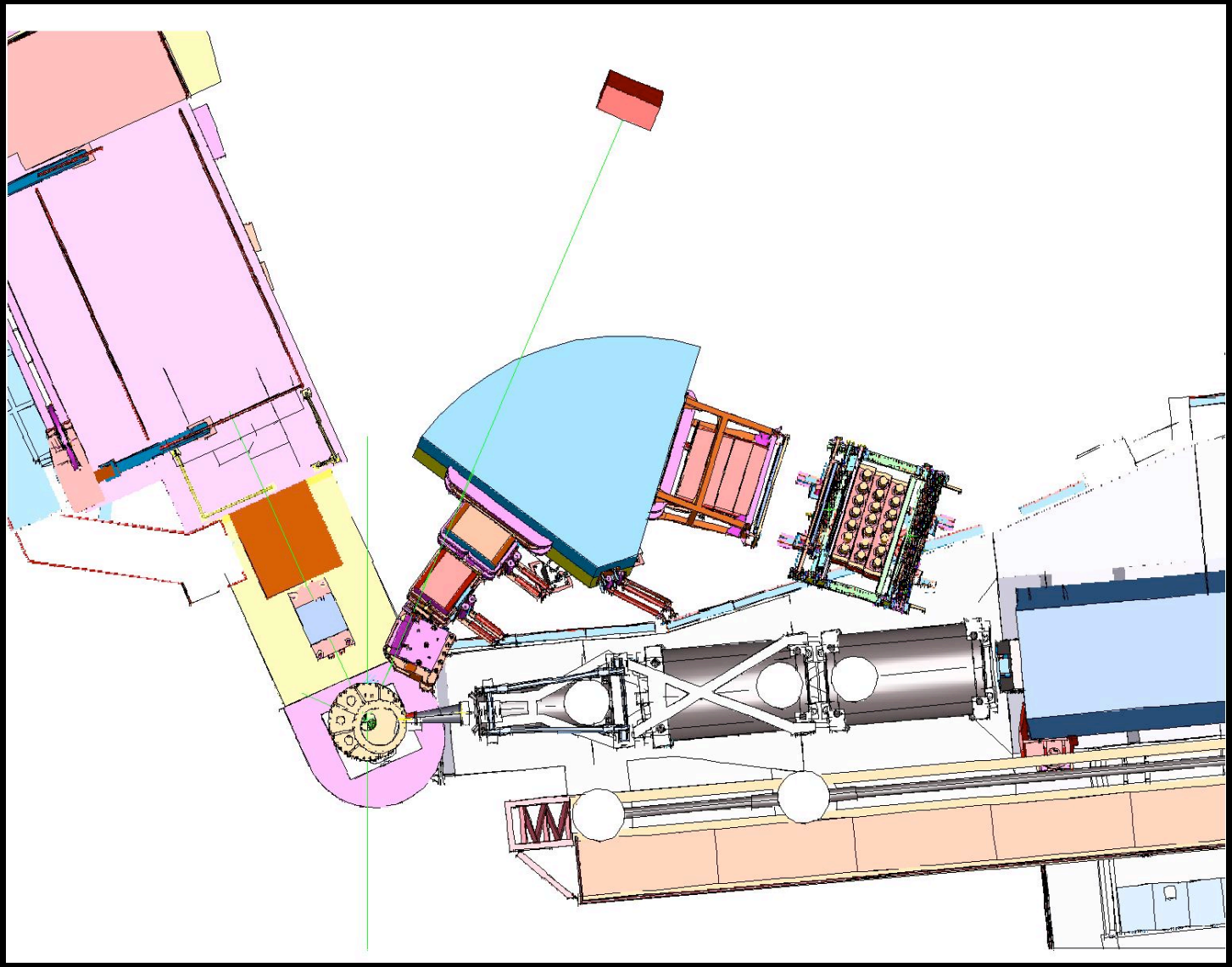
Short-Orbit Spectrometer

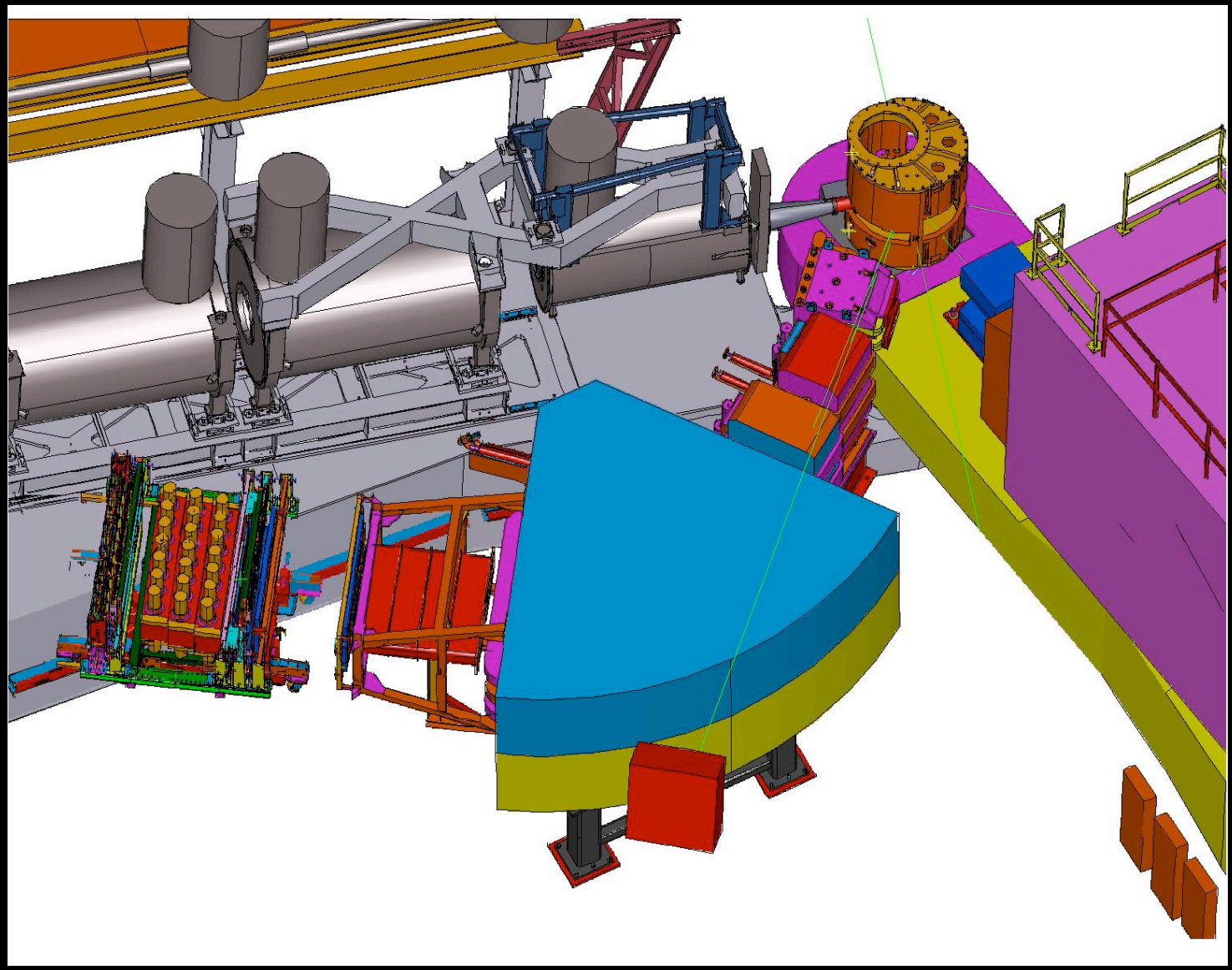


High Resolution Kaon Spectrometer (Tohoku University)

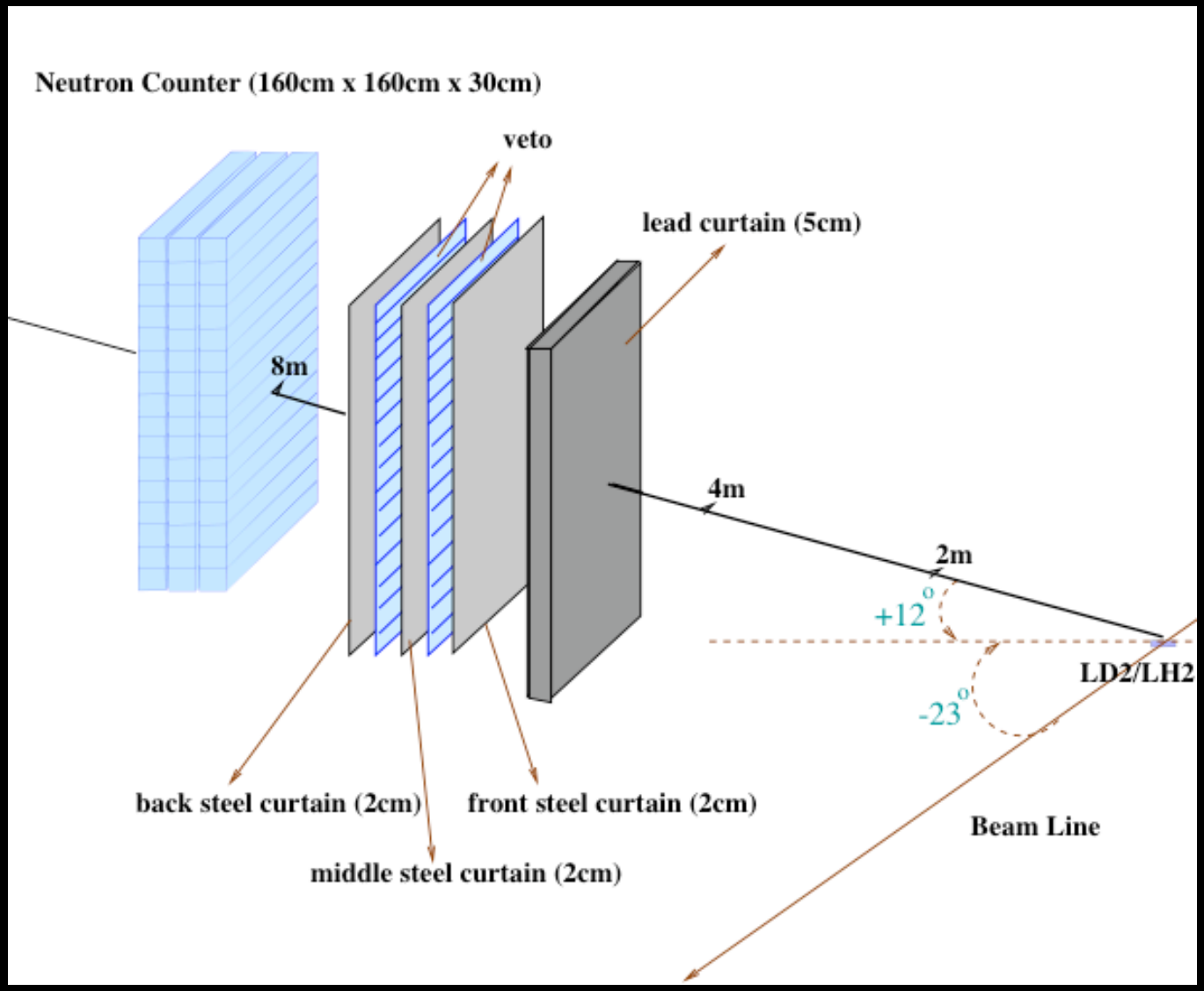


Experimental Setup





The neutron detector

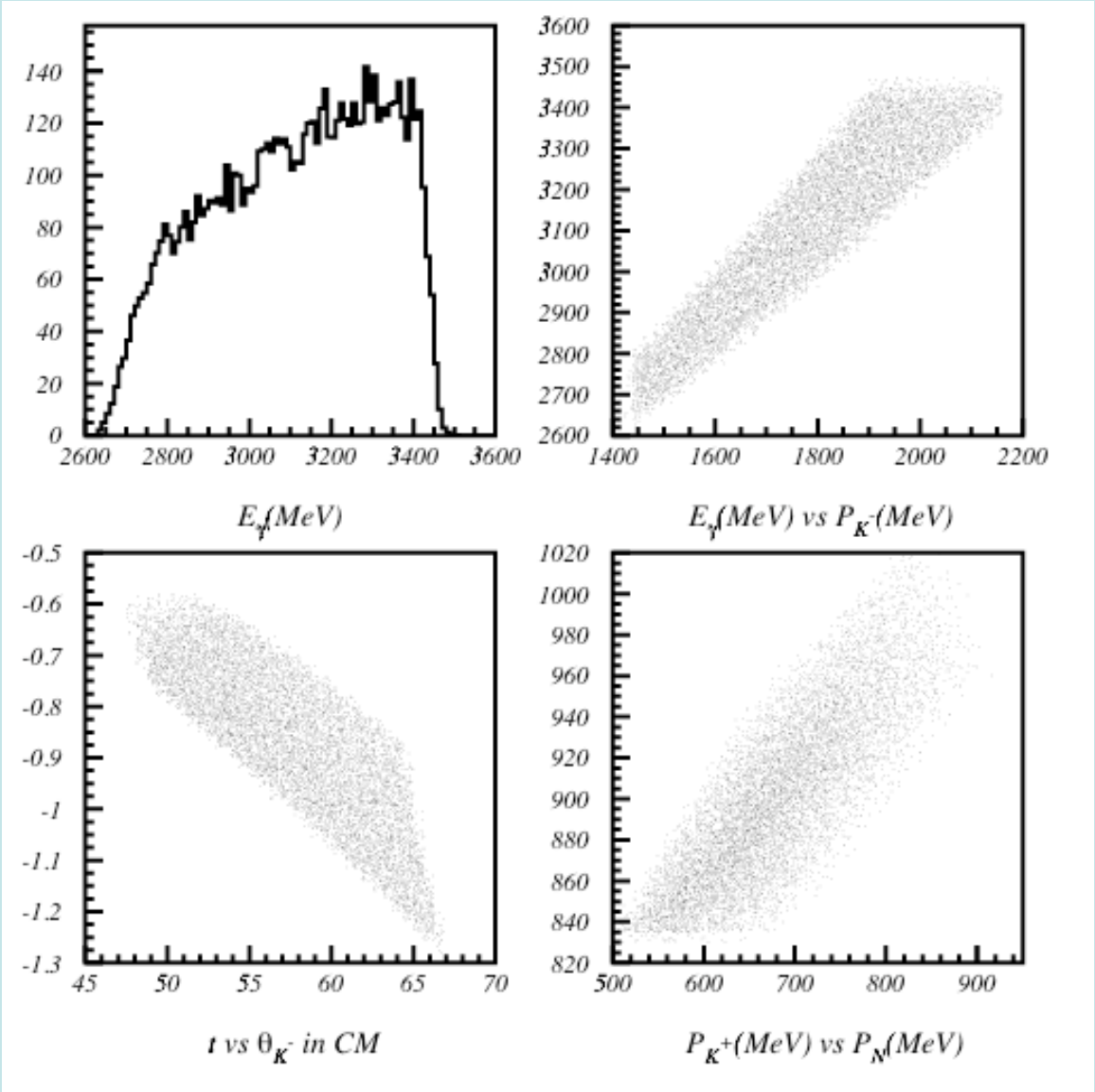


Kinematics

	E_e (GeV)	θ_{sos} (degree)	P_{sos} (GeV/c)	$(\theta/\theta)_{HKS}$ (degree)	P_{HKS} (GeV/c)	$(\theta/\theta)_n$ (degree)
θ^+	3.525 (LD_2)	20.0	1.709	-23.0/ -9.0	0.964	-23.0/ +12.0
	3.525 (H,1.54)	20.0	1.709	-23.0/ -9.0	0.964	
θ^{++}	3.525 (H,1.66)	20.0	1.625	-23.0/ -9.0	1.170	
	3.150 (H,1.75)	20.0	1.350	-23.0/ -9.0	1.200	

The physical angle of HKS is 32 degree!

Kinematic coverage (mass=1540 MeV setting)

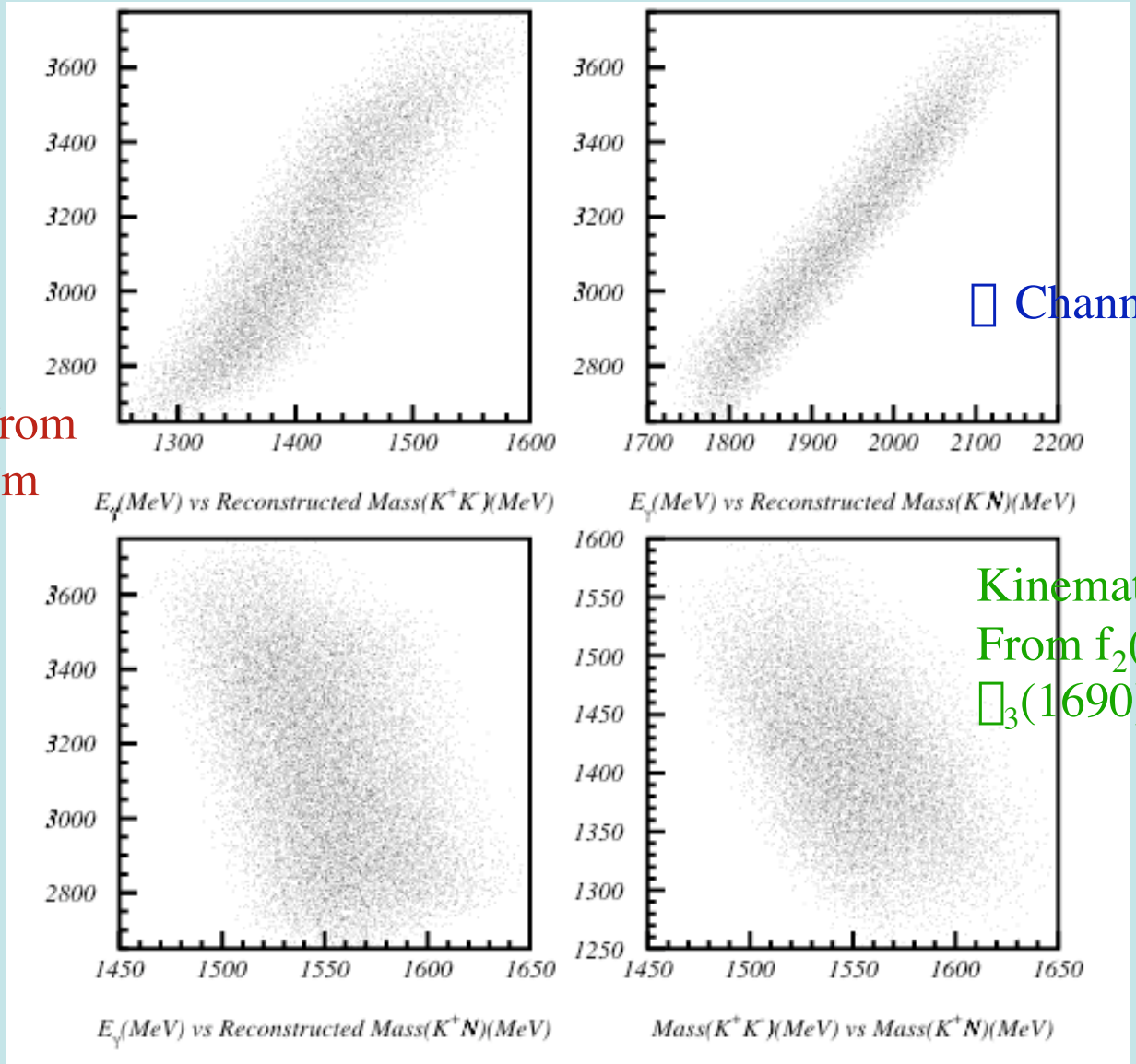


$(\mathrm{GeV/c})^2$

Backgrounds

- □ photoproduction
- □ photoproduction
- K^+K^- photoproduction
- Kinematic reflections due to production of higher mass mesons which decay into K^+K^-
  - $f_2(1275)$
  - $a_2(1320)$
  - □$_3(1690)$

Background Studies

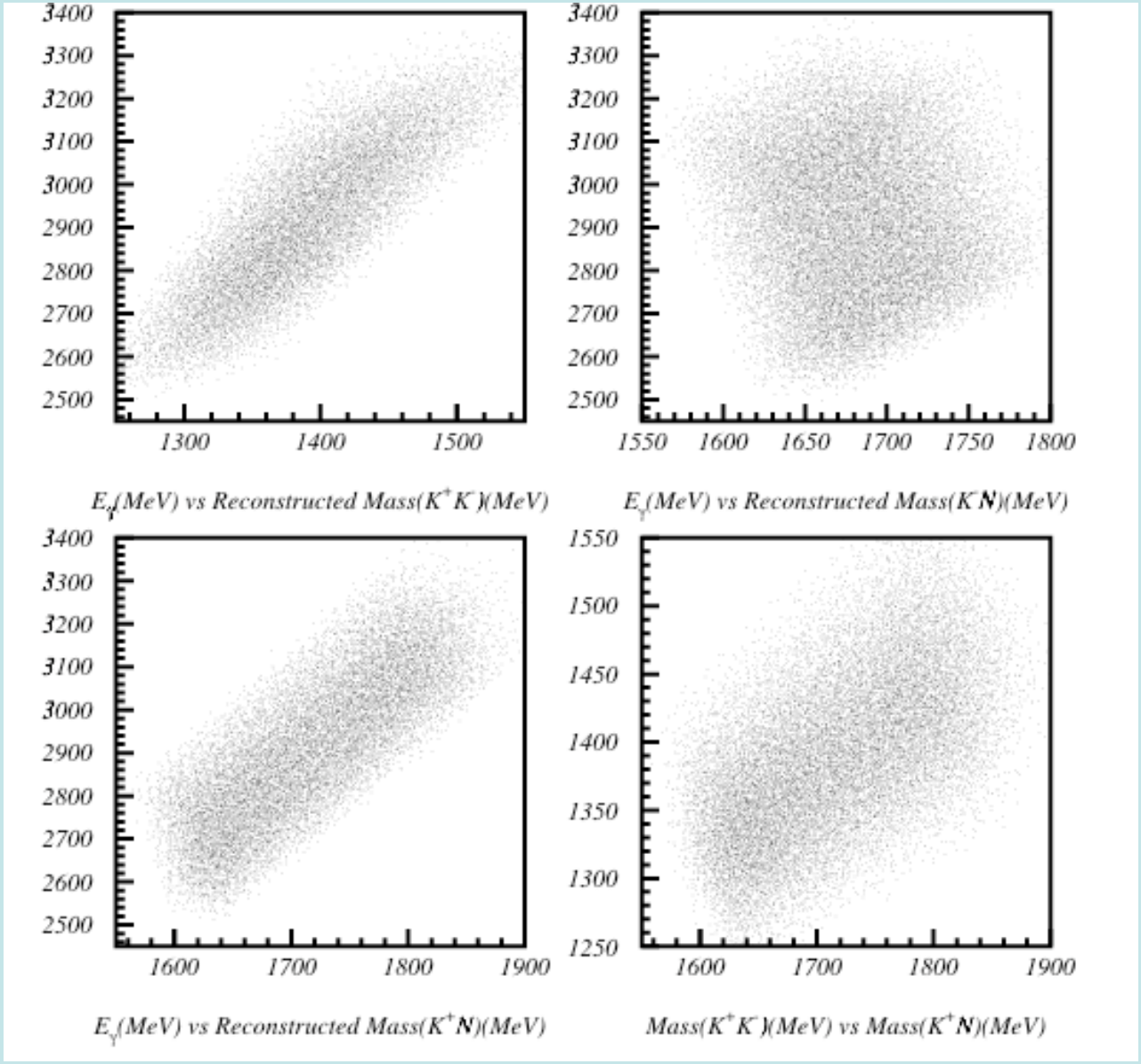


Background from
 not a problem

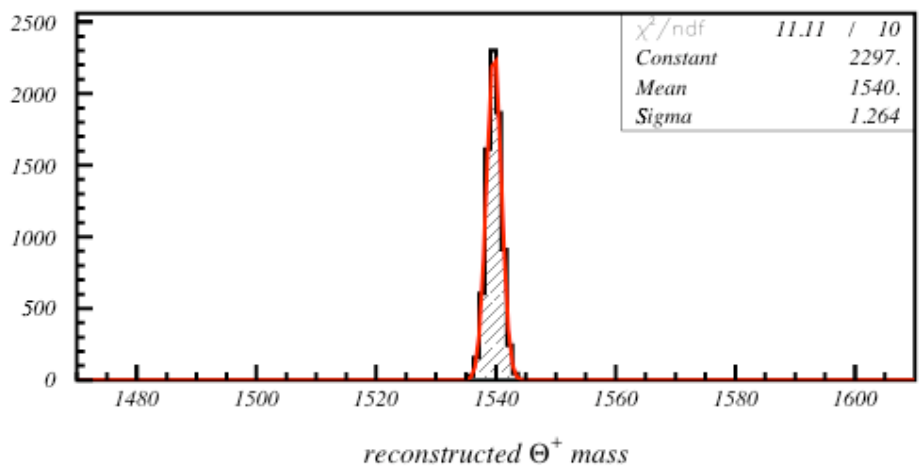
 Channel not a problem

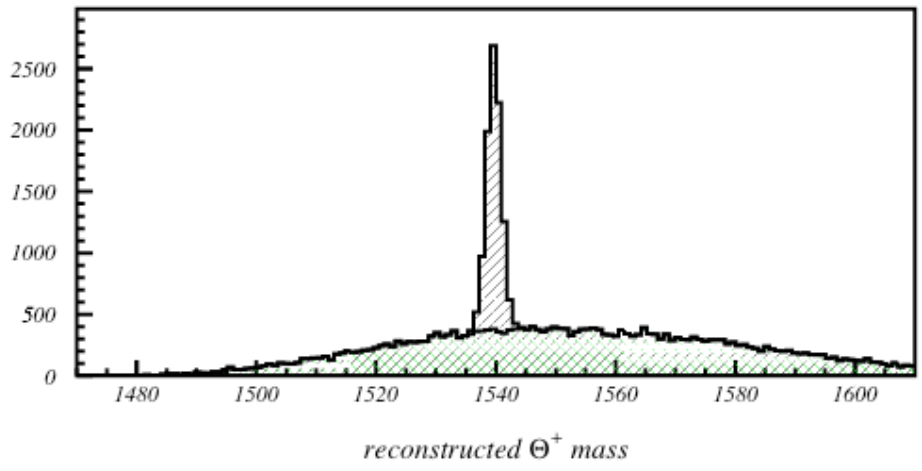
Kinematic reflections
From $f_2(1275)$, $a_2(1320)$,
$_3(1690)$, no problem

Background study for Θ++(1750) kinematics



Projection for Θ^+





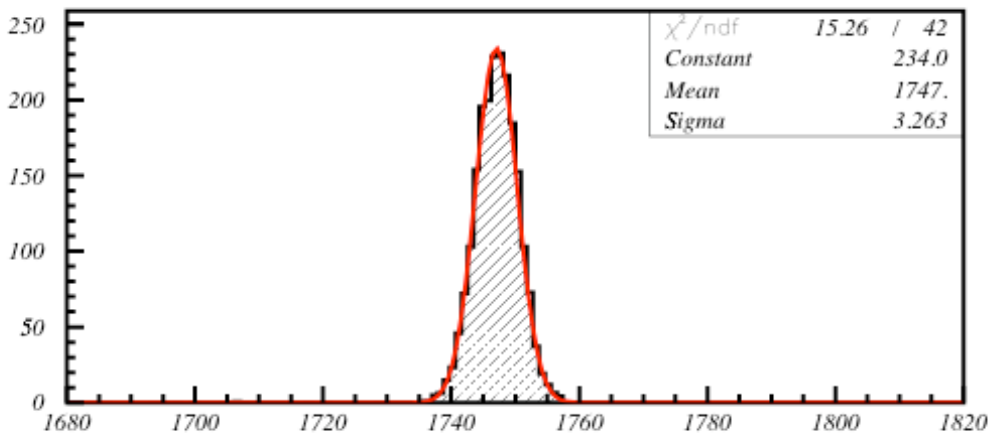
150 hours
Total expected events:
8755 (1428 with E_{Θ} cut)

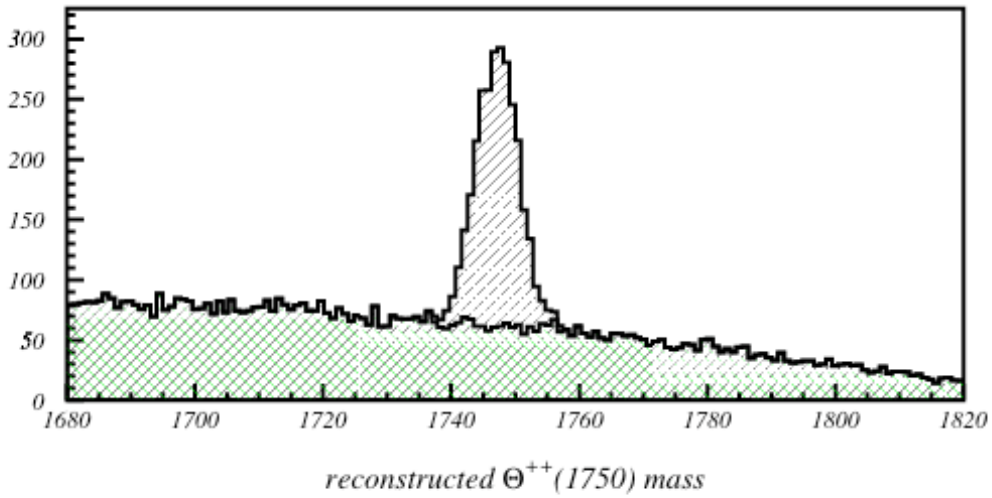
Sensitivity to Θ^+: 70 pb/sr
at 3σ level

E_e-100 MeV <E_{Θ}<E_e-25 MeV

Θ^+ mass range from acceptance is 1500 to 1600 MeV
Important for checking two peaks!

Θ^{++} search (sample spectrum for mass of 1750 MeV)





50 hours
Total expected events:
2095 (930 with E_{Θ} cut)

Sensitivity to Θ^{++}: 245 pb/sr
at 3Θ level for 1750 MeV
149 pb/sr for 1540 MeV,
and 134 pb/sr for 1660 MeV

Summary

- Confirm with high statistics the existence of Ξ^+ (8755), provide high statistics check to see whether there are two peaks or not
- Significantly improve the mass and width determination of Ξ^+ particle
  - Mass determination better than 1 MeV
  - Width determination 1.3 MeV (Γ)
- Provide high statistics search for Ξ^{++} in the mass region of 1500 to 1800 MeV