Hypernuclear Experiment with High-resolution Electron Spectrometer (E05-115)

Hall C User Meeting

(26 Jan 2007)

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Hypernuclei in wide mass range

A

1 — E89-009 — 20 — 50 — 200 — 10^{57}

^{12}C

E01-011

Elementary Process

^{7}Li ^{12}C ^{28}Si

Strangeness electro-production

Light Hypernuclei (s,p shell)

Fine structure

Baryon-baryon interaction in SU(3)

$\Lambda\Sigma$ coupling in large isospin hypernuclei

Cluster structure

Medium - Heavy hypernuclei

Single-particle potential

Distinguishability of a Λ hyperon

$U_0(r)$, $m_\Lambda^*(r)$, $V_{\Lambda NN}$, …

Neutron/Hyperon star,
Strangeness matter

Hyperonization →

Softening of EOS ?

Superfluidity

Hypernuclei in wide mass range

A: 1 — 20 — 50 — 200 — 10^{57}

E05-115: ^{6,7}Li, ^{10,11}B, ^{12}C, ^{51}V, ^{52}Cr, ^{89}Y

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3rd Generation Experiment

How can we improve the experiment?

- Signal to Noise Ratio
  - ~~Trivial way : Reduce beam current~~
  - Improve VP tagging efficiency
  - Reduce Physics Background (Brems, Mϕller
- Energy Resolution
  - Better Understanding of Spectrometer Optics
- Hypernuclear Yield
  - Larger Acceptance of Spectometers
  - Good VP tagging effciency

Except for optics tune data

Better Matching Between HKS and HES

HES

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Higher primary beam energy keeping VP energy ($E\gamma$=1.5GeV)

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  - Better Understanding of Spectrometer Optics
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HES

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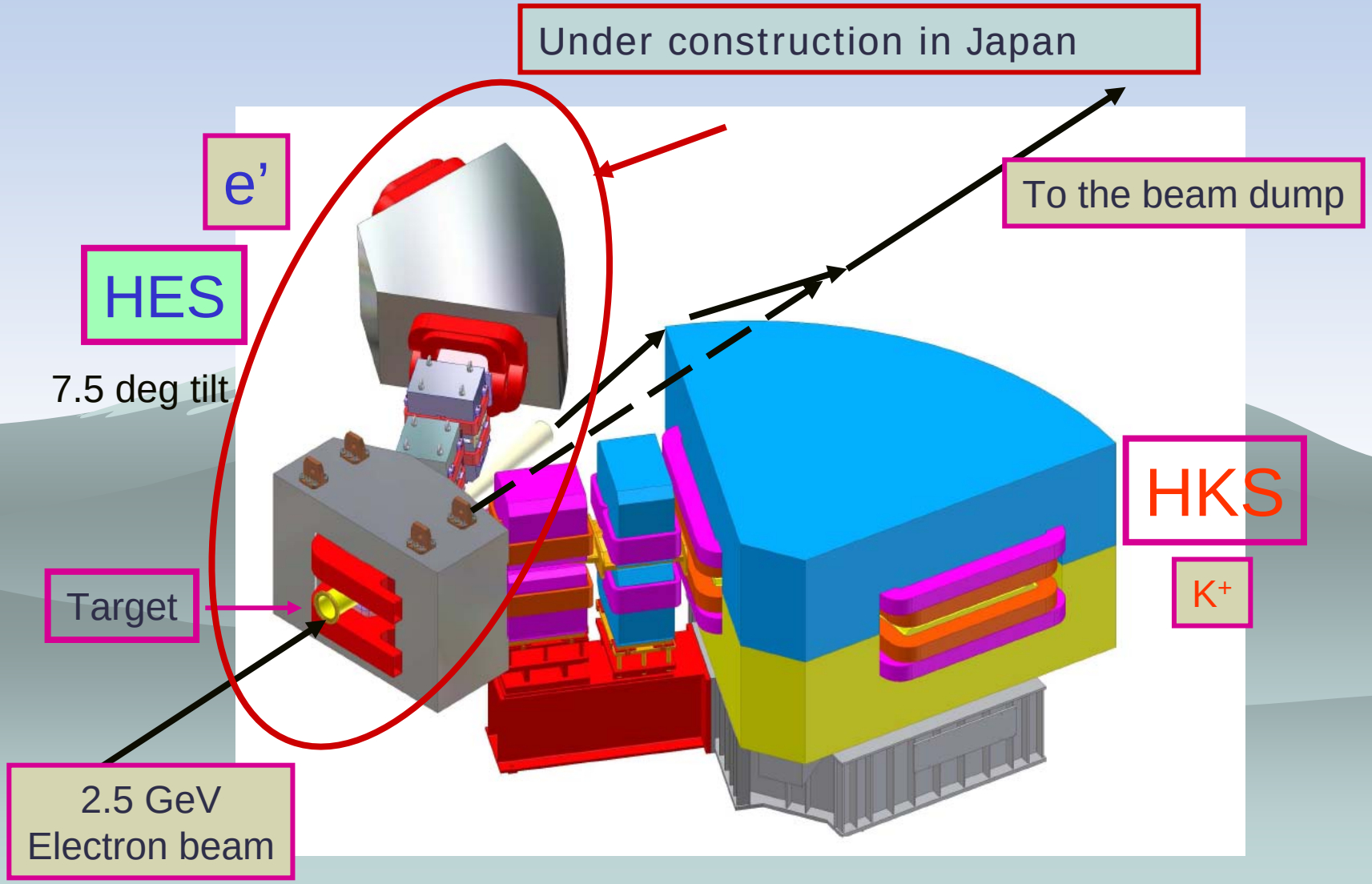
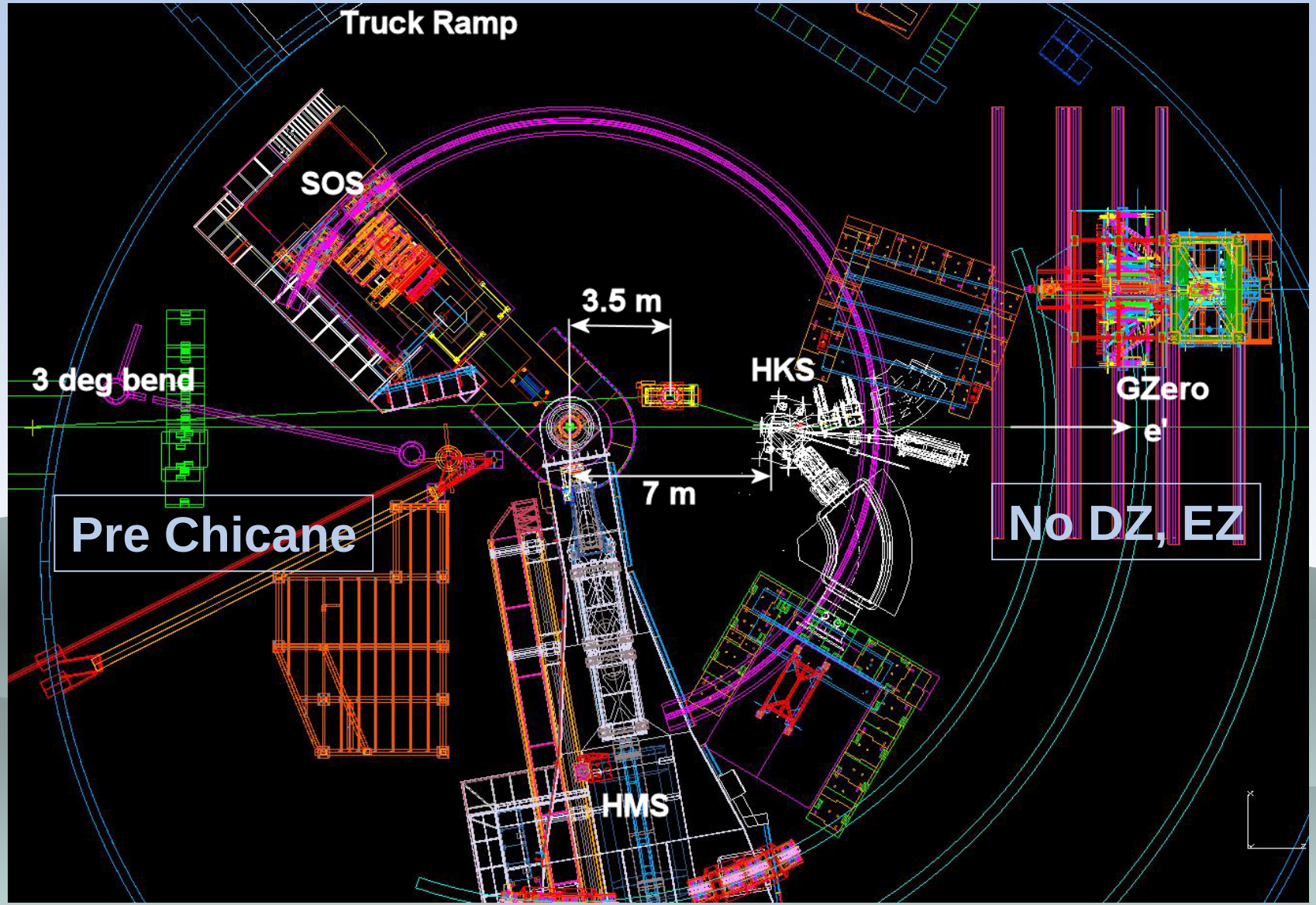
Higher primary beam ene[illegible]y keeping VP energy (Eγ=1.[illegible]eV)

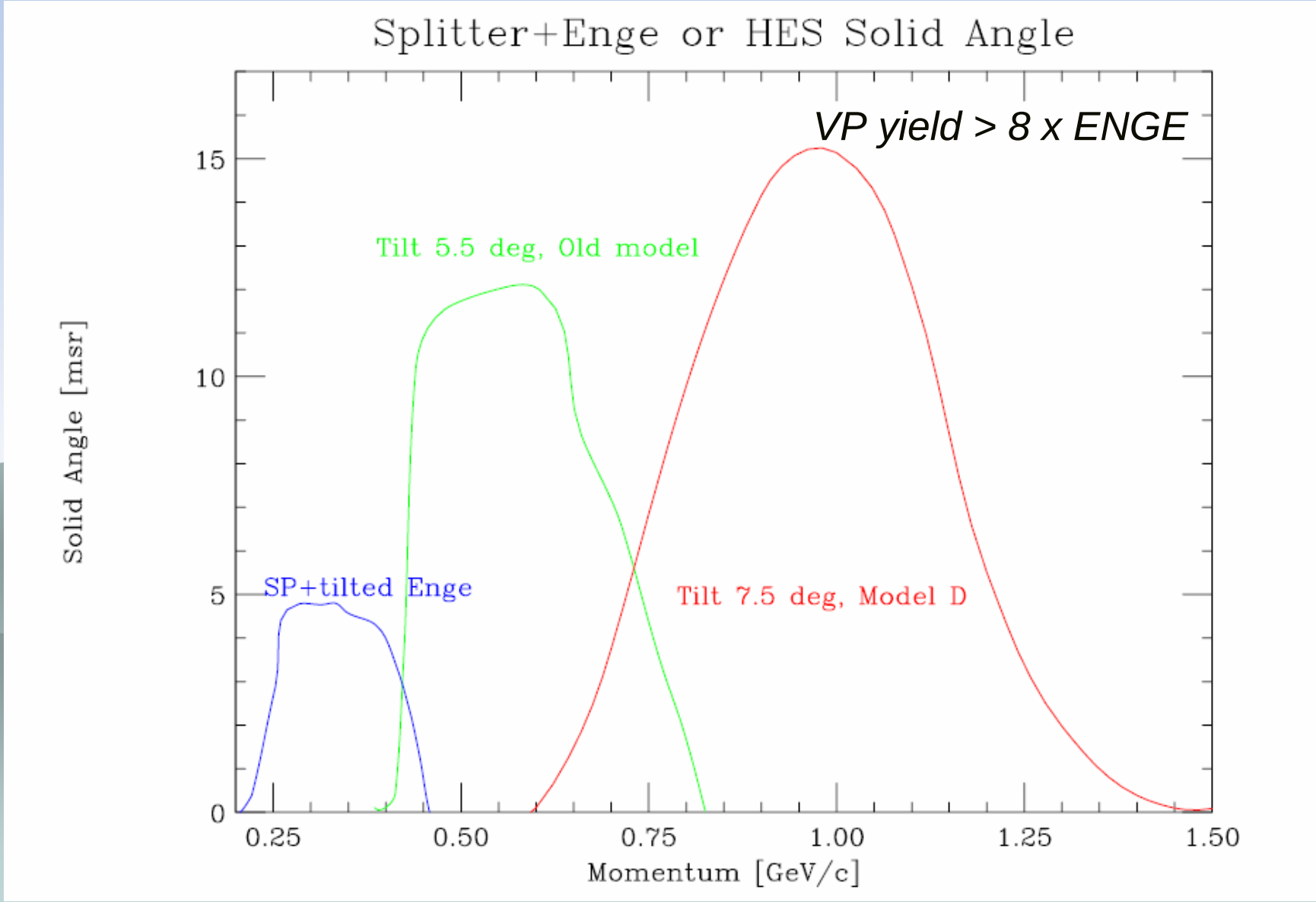
HES

HKS+HES+New SPL




Truck Ramp
SOS
3.5 m
HKS
3 deg bend
GZero
e'
7 m
Pre Chicane
No DZ, EZ
HMS

HES Solid Angle



Evolution of (e,e'K$^+$) HY spectroscopy

2000

	E89-009			
Configuration	**SOS+ENGE +Splitter**			
Beam intensity (μA) on ^{12}C	0.66			
thickness (mg/cm^2)	22			
Hypernuclear yield ($^{12}_{\Lambda}B_{gr}$: /hr)	0.5-0.9			
Resolution (keV)	**750**			
Beam energy (GeV)	1.7-1.8			
p_K (central : GeV)	1.2			
p_e (central: GeV)	0.3			
θ_K (degree)	0-7			
θ_e (degree)	0			

( ) expected * select one angle

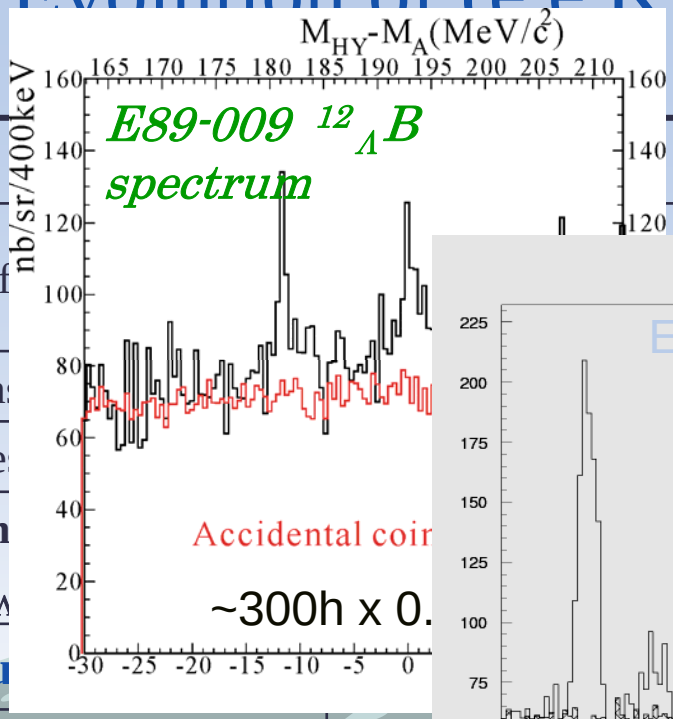
Evolution of (e,e'K$^+$) HY spectroscopy

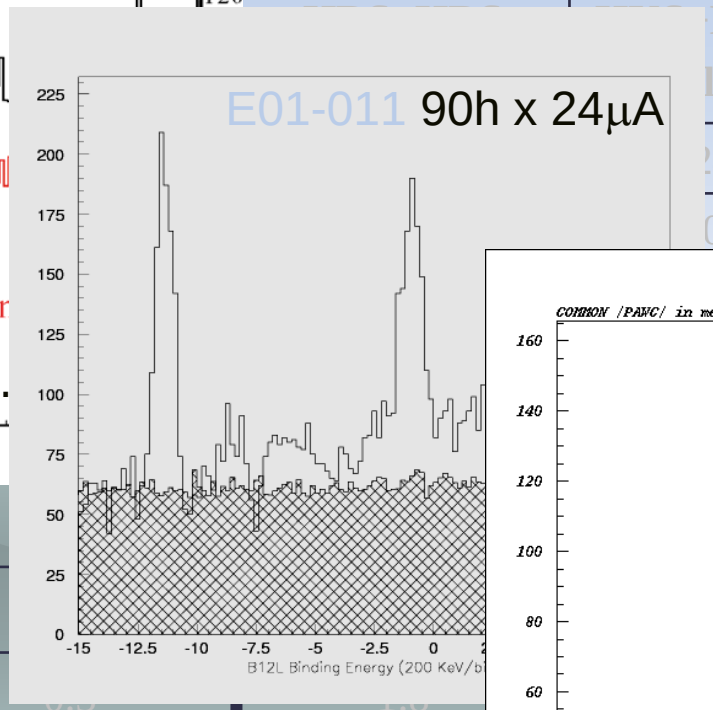
	2000	2004-2005	2005	
	E89-009	E94-107 (HallA)	E01-011	
Configuration	**SOS+ENGE +Splitter**	**HRS+HRS +Septum**	**HKS+ENGE +Splitter**	
Beam intensity (μA) on ^{12}C	0.66	100	24	
thickness (mg/cm^2)	22	100	100	
Hypernuclear yield ($^{12}_{\Lambda}B_{gr}$: /hr)	0.5-0.9	**2-4**	**8~10**	
Resolution (keV)	**750**	**650**	**<750**	
Beam energy (GeV)	1.7-1.8	4	1.8	
p_K (central : GeV)	1.2	2.0	1.2	
p_e (central: GeV)	0.3	1.8	0.3	
θ_K (degree)	0-7	6	1-13	
θ_e (degree)	0	6	4.5	

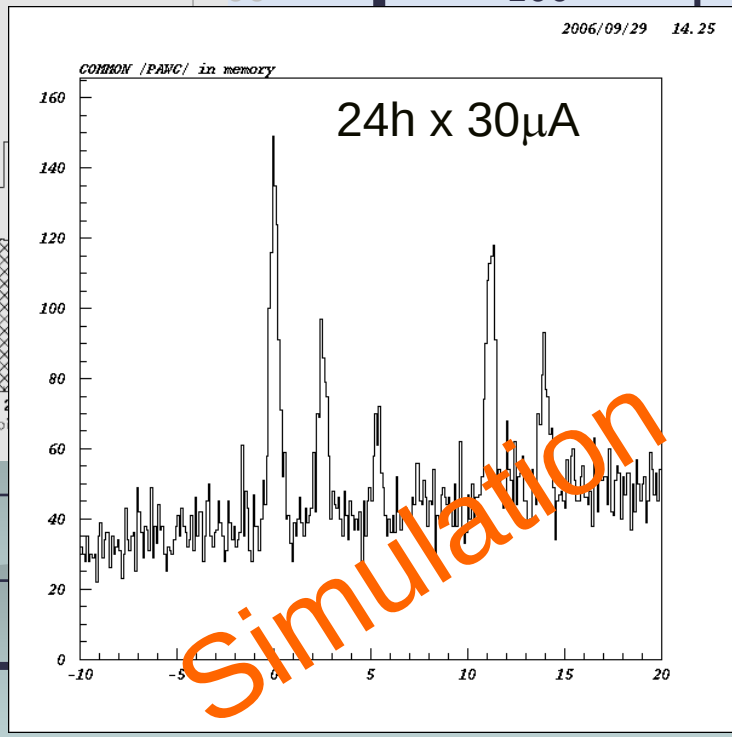
( ) expected * select one angle RICH HKS+Tilt

Evolution of (e,e'K$^+$) HY spectroscopy

		2004-2005	2005	(2008)
		E94-107 (HallA)	E01-011	E05-115
Conf			ENGE litter	HKS+HES +New splitter
Beam inten			24	30-100
thickne			00	100
Hypern (12$_\Lambda$				
Resolu				
Beam energy (GeV)				
p_K (central : GeV)				
p_e (central: GeV)				
θ_K (degree)	0-7	6		
θ_e (degree)	0	6		







( ) expected * select one angle RICH HKS+Tilt HKS+Tilt+HES

Necessary Detectors

- HES Magnets
  - Machining & Coil winding will start soon
- HKS Upgrade
  - New TOF counter or Lucite Cherenkov
  - Upgrade Water Cherenkov
  - Magnetic Field Proof Aerogel Cherenkov
- HES Detectors
  - EDC will be used again
  - Additional Drift Chamber
  - New Hodoscopes

Other Developments

- GEANT4 Simulation
  - HKS and HES
  - K arm and e’ arm simultaneous simulation
- Tilt Angle and Offset Optimization
- Design of Pre-Post-Chicane

(e,e'K) Current Status and Future

1st Generation (E89-009) — 750 keV (FWHM)

^{12}C Target — 0.6 $^{12}{}_{\Lambda}$B /hour

HKS Tilt Method

2nd Generation (E01-011)

^{7}Li, ^{12}C, ^{28}Si, Targets

(e, p), (e, π), (e, K), (e,e'p), (e,e'π), (e,e'K)

Further Analysis Necessary
Resolution
MM scale
Cross section

HES

3rd Generation (E05-115) — ~ 400 keV (FWHM)

^{6,7}Li,^{10,11}B, ^{12}C,^{51}V,^{52}Cr,^{89}Y Targets — 30-100 $^{12}{}_{\Lambda}$B /hour

Cross section angle dependence

Time-line of Hall C Hyp.Nucl. program

2000 E89-009 beamtime
2001 PAC19 E01-011 Proposal approved ^{12}C, ^{28}Si
2002 HKS&Detectors R&D started
2003 KEK test beamtime/HKS field mapping
HKS shipped to JLab
2004 HKS Preassembly@JLab test lab.
HES basic design started (HES approved by JP. Gov.)
2005 Jan Installation @ Hall C started
June Beam tune started
PAC25 E05-115 Proposal accepted
July Physics run started $^{6,7}Li$, $^{10,11}B$, ^{51}V, ^{52}Cr, ^{89}Y
Oct Beamtime finished

2006-2007 HES Design & Fabrication
2007 end HES shipping to JLab
200X E05-115 Beamtime

We are here!

Summary

- (e,e'K+) reaction is a new and promissing way of study hypernuclei
- Only (so far) JLab CEBAF $\rightarrow$ e^- beam for (e,e'K)
- 1st generation experiment (E89-009) proved potential of (e,e'K) hypernuclear spectroscopy
- 2nd generation experiments (E01-011) explored p-shell, beyond p-shell hypernuclei with advanced experimental techniques (HKS, Tilt Method)
- 3rd generation experiment (E05-115) with HES in preparation aims to study wide mass range

HES will be shipped to JLab by the end of 2007.

HES Parameters

(HES is basically smaller version of the HKS)

- Splitter (27 tons)

Magnetic field	1.8 T
Full gap	17 cm (including vacuum chamber thiclness)
Length (beam direction)	1.2 m
Splitter-Q1	0.8 m

- Q1 (2.7 tons)

Field gradient	7.8 T/m
Length	0.6 m
Bore diameter	0.2 m (Effective full width 0.4 m)
Q1-Q2	0.3 cm

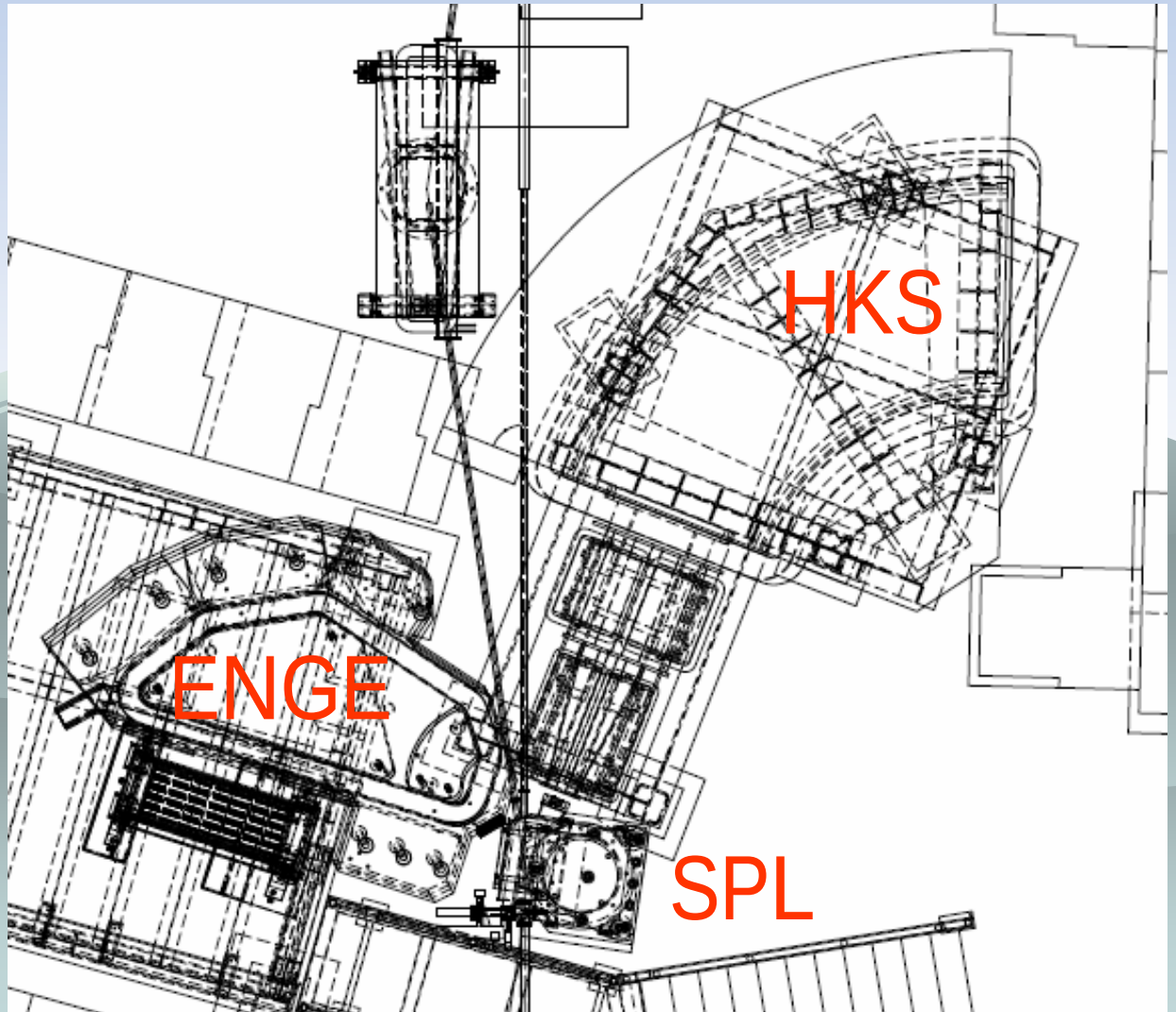
- Q2 (3.05 tons)

Field gradient	5.0 T/m
Length	0.5 m
Bore diameter	0.25 m (Effective full width 0.5 m)
Q2 – D	0.8 m

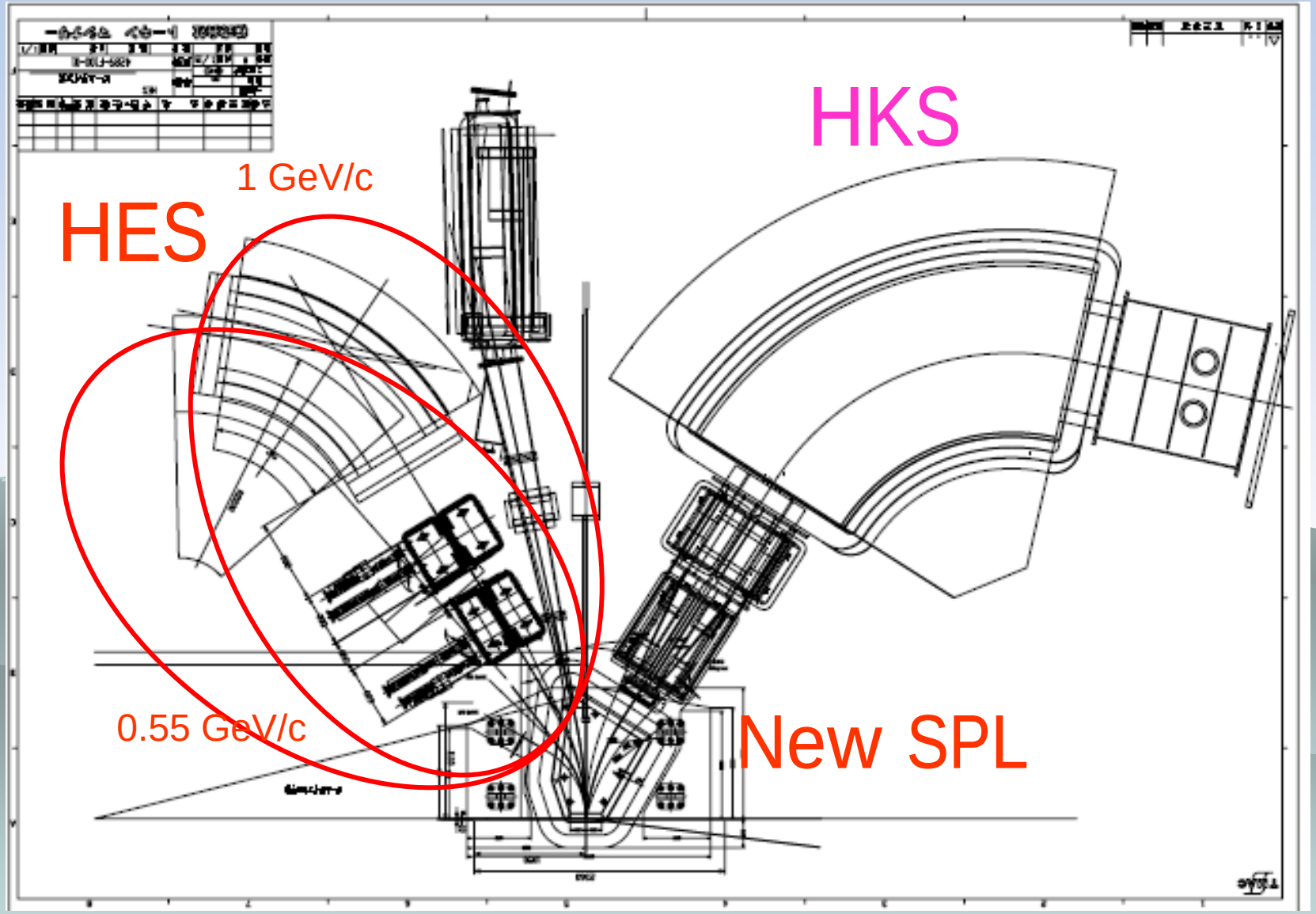
- Dipole (36 tons)

Bend	50 degrees
ρ	2.2 m
Full gap	15 cm : (Effective > 12cm)
Inner full width	0.8 m

HKS + ENGE system (E01-011)



Drawing of the HES + HKS



Tilt Method will be applied to HES

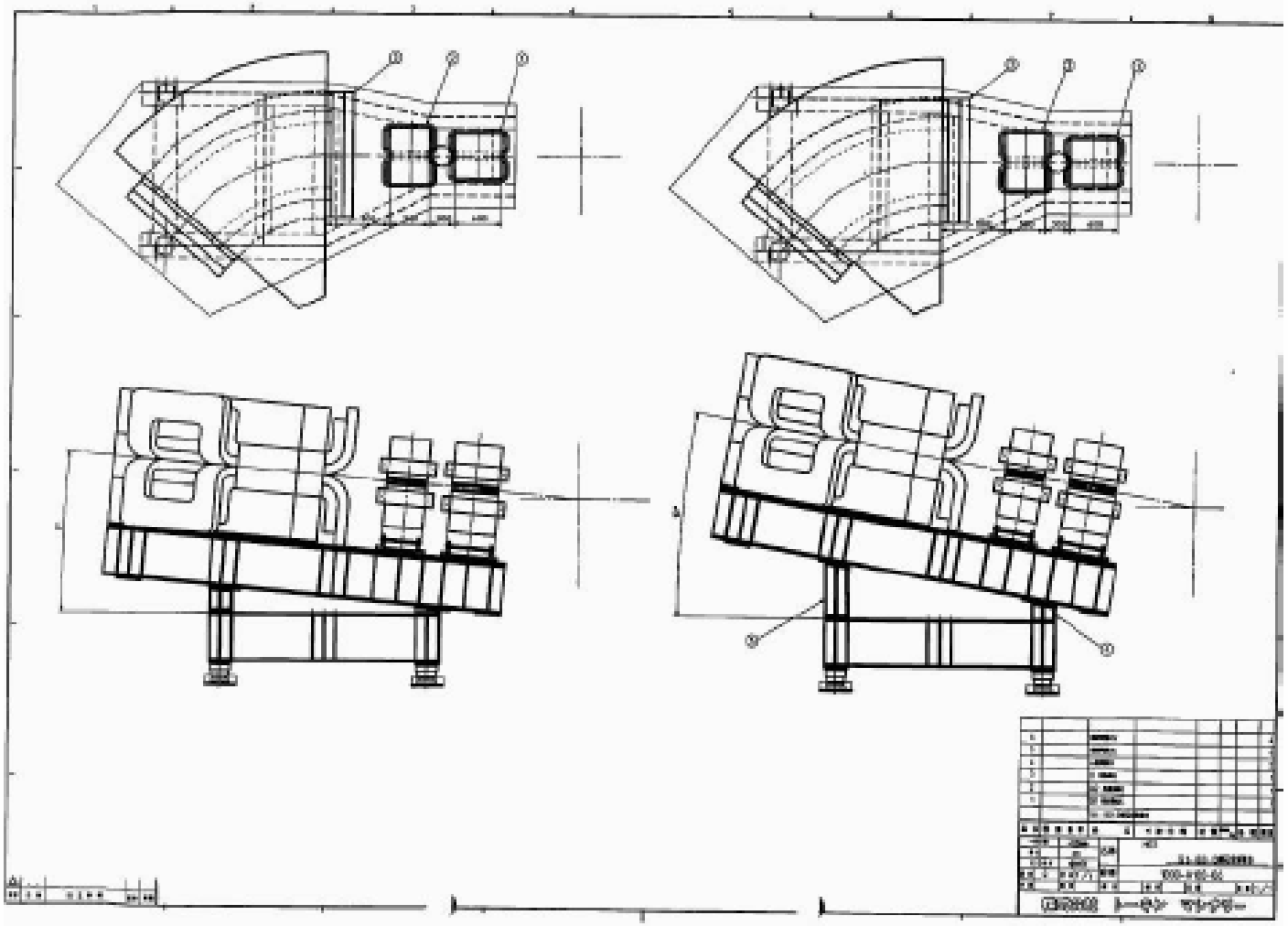


Figure 25: The "tilt method" will be also applied to the HES. The tilt angle will be optimized to the central momentum. It can be realized by changing the shim under the HES.

The New Splitter