HYPERNUCLEAR SPECTROSCOPY IN THE WIDE MASS RANGE USING THE (e,e'K^+) REACTION

Analysis status of E01-011 and
Preparation status of E05-115

HallC Meeting, JLab
(10th August 2007)
S N Nakamura, Tohoku Univ.
Hall C – HKS/HES Collaboration

The (e,e'K^+) reaction vs. γ spectroscpy at J-Parc

JLab (e,e'K^+) J-Parc (K,$\pi\gamma$)

$p \rightarrow \Lambda$ ***Mirror Hypernuclei*** $n \rightarrow \Lambda$

Good resolution for absolute BE incl. nucleon unbound

Excellent resolution for level differences of bound states

Thin enriched targets

Complementary techniques to study hypernuclei

Challenge of (e,e'K) HY Study

- Large e' Background due to Bremsstrahlung and Møller scattering

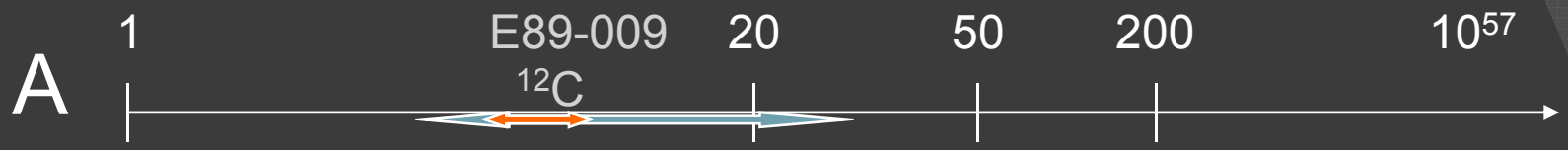
  Signal/Noise, Detector

High Quality Electron Beam is Essential !

- Small Hypernuclear Cross Section
- Coincidence Measurement (e', K^+)

  Limited Statistics

Hypernuclei in wide mass range



Elementary Process

^{7}Li ^{12}C E01-011 ^{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

Neutron/Hyperon star,
Strangeness matter

Hyperonization →

Softening of EOS ?

Superfluidity

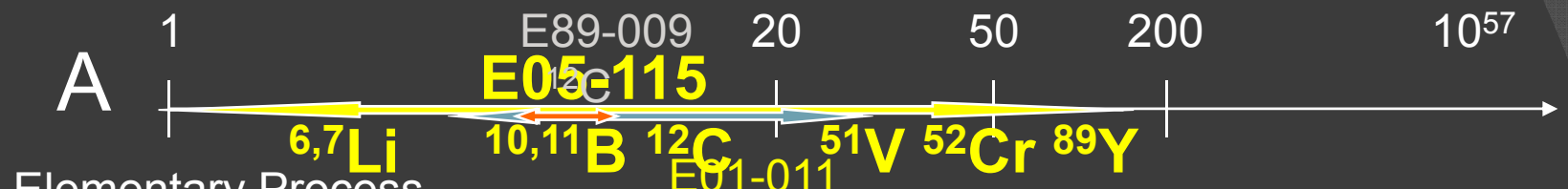
Medium - Heavy hypernuclei

Single-particle potential

Distinguishability of a Λ hyperon

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

Hypernuclei in wide mass range



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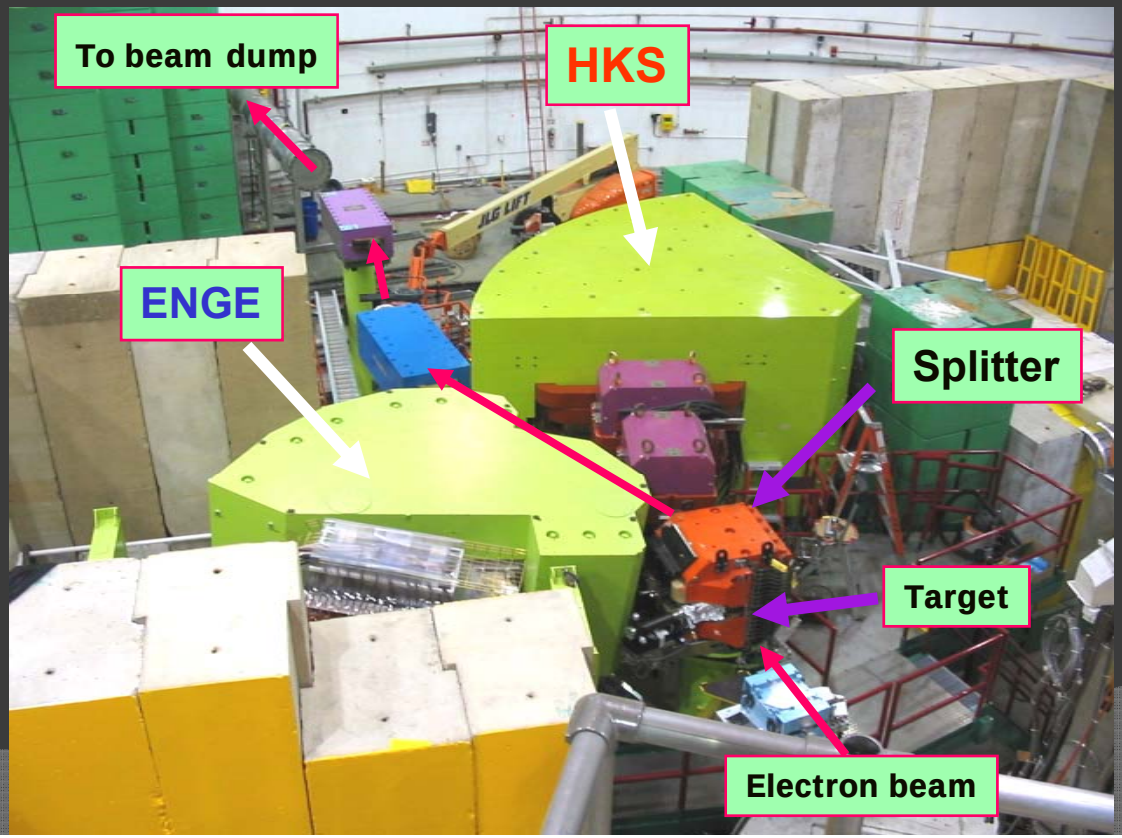
3rd Generation Experiment

Second Generation Exp. at JLab

2005 E01-011 (Hall C)

First step to midium heavy hypernuclei (^{28}Si, ^{12}C, ^{7}Li)



Two Major Improvements

New HKS

Tilt Method

Beam: 30 μA , 1.8GeV
HKS: $\Delta p/p$=2 x 10 $^{-4}$ [FWHM]
Solid angle 16msr(w/ splitter)

Analysis Strategy

- Obtain reliable transfer matrices
  - HKS is brand-new
  - Tilt ENGE is unknown
  - Heavily saturated SPL magnet
- Check MM scale
  - Absolute MM scale
  - Differential linearity
  - Integral linearity
- Estimate Cross sections
  - Detailed simulation incl. survey info.

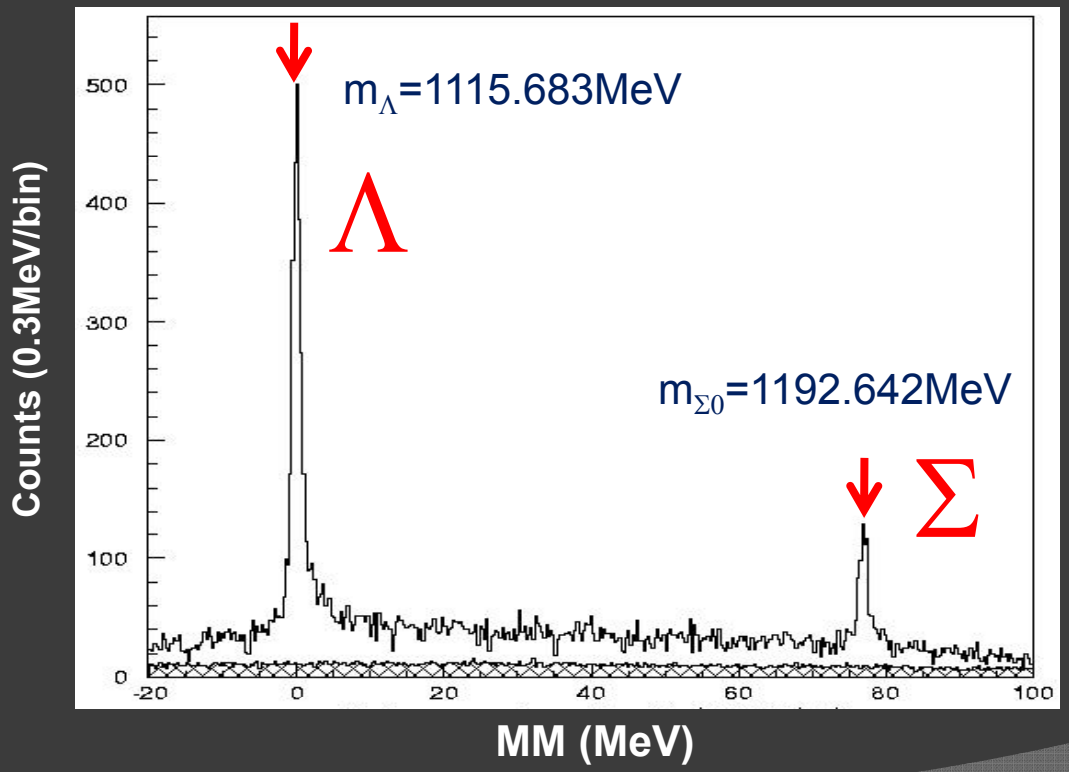
Transfer matrices tune

Λ,Σ^0 peak position : abs. MM scale

kinematics info

E_{beam}

$P_{e'}$, P_K, $\theta_{e'}$,θ_K

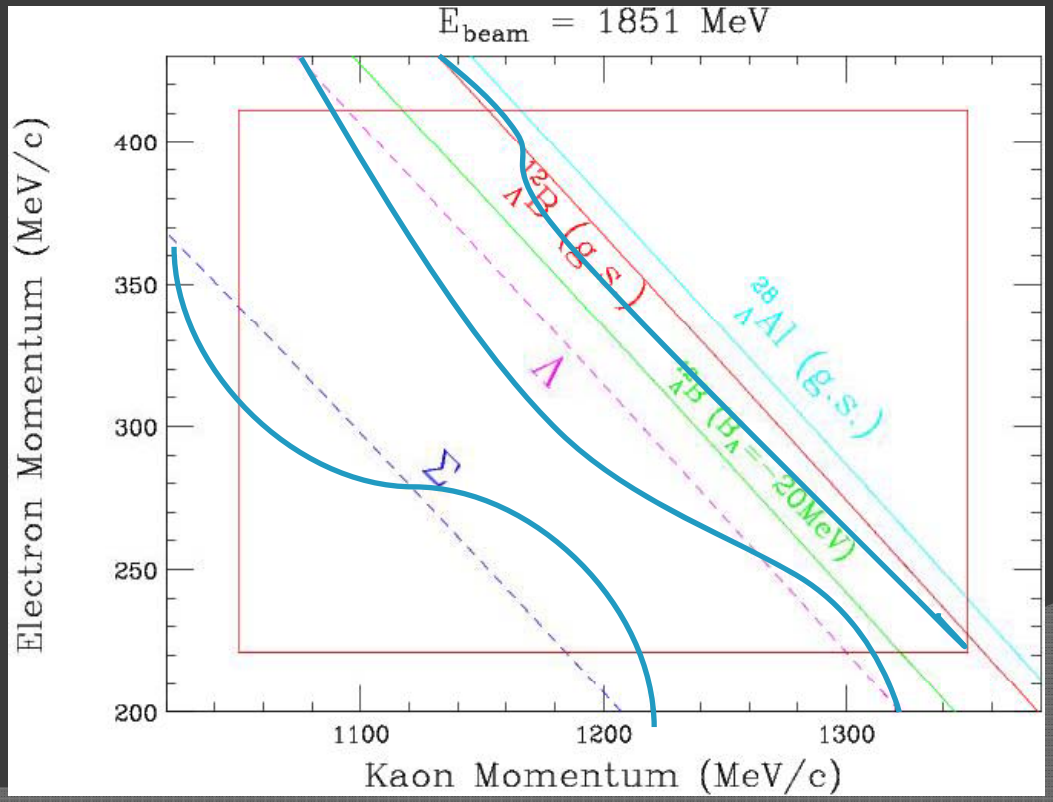


Thanks to wide mom. acceptance of HKS

Transfer matrices tune

Λ, Σ^0 and other peak widths :

Optics info.



Transfer matrices tune

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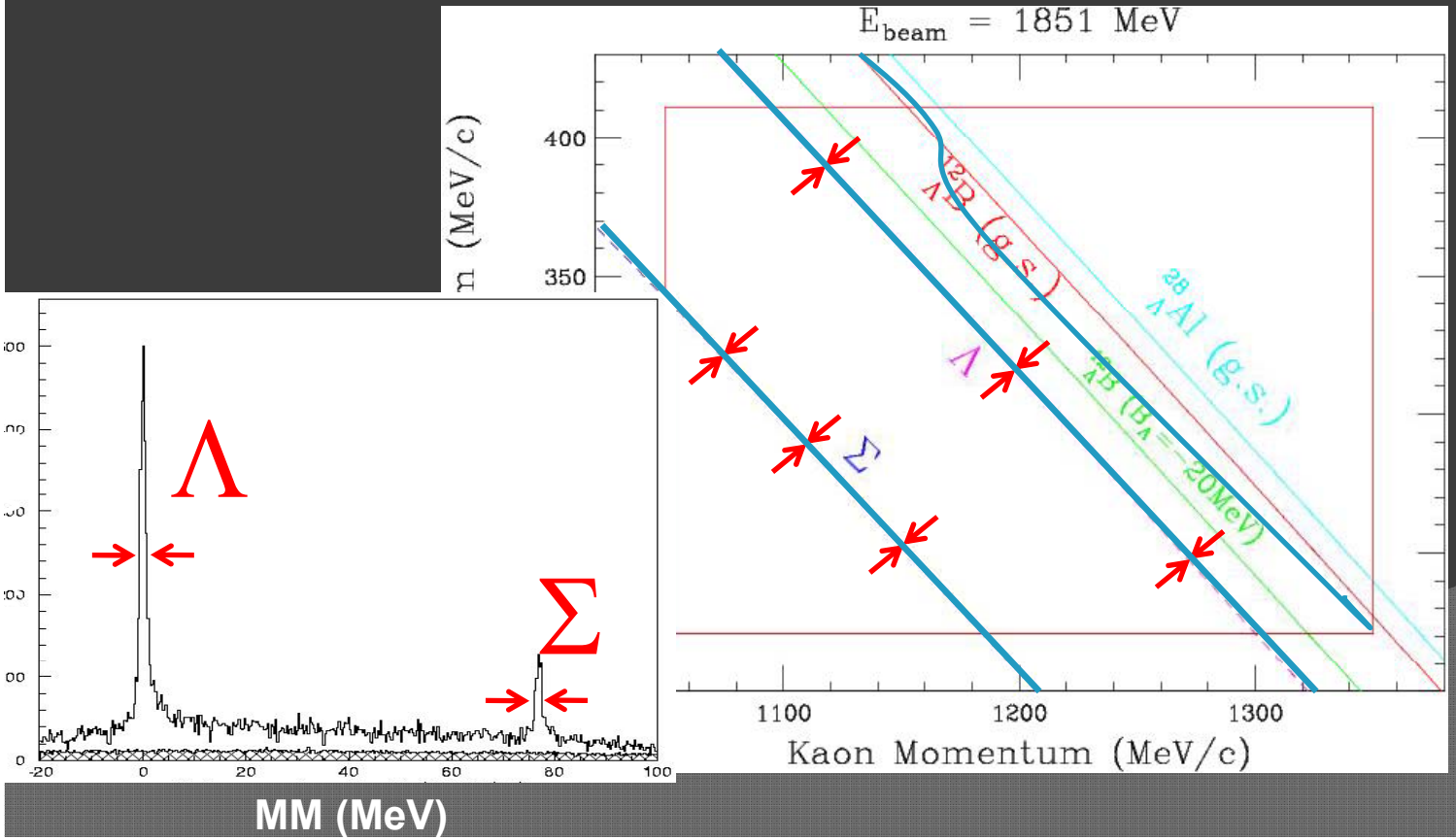

Transfer matrices tune

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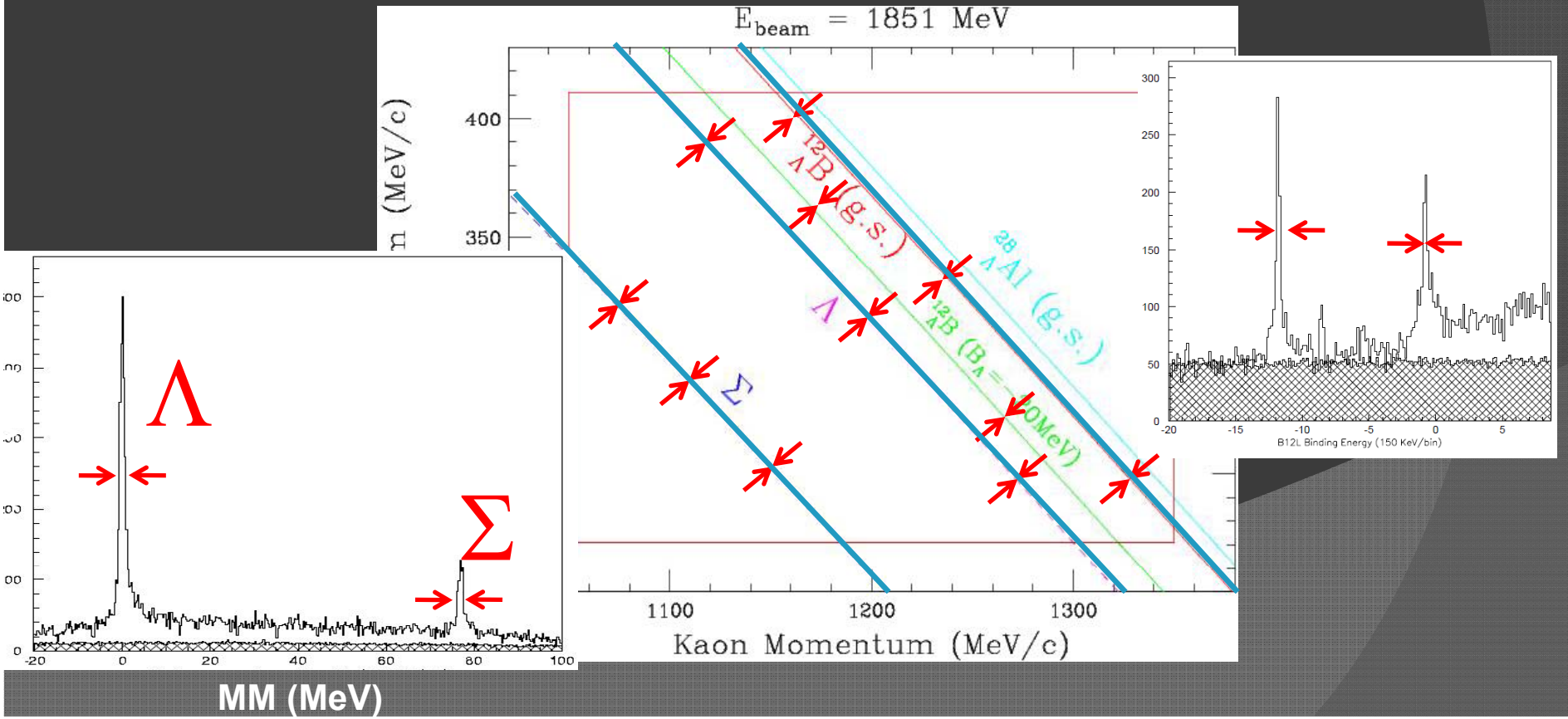
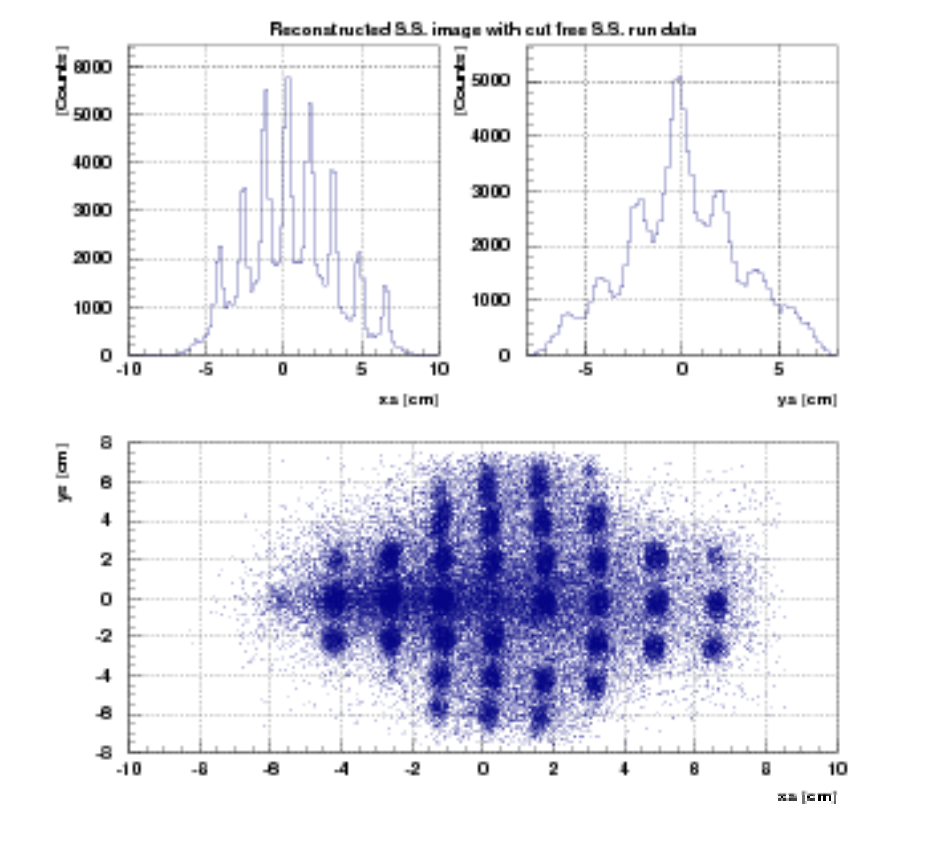


Transfer matrices tune

Sieve Slit Pattern: Angle info.



Transfer matrices tune

Kinematic Tune
(Λ,Σ^0 peak position)

Sieve Slit
Hole pattern

Other peaks
shapes

Optics Tune
(Λ,Σ^0 , $^{12}_{\Lambda}$B peak widths)

Check MM scale

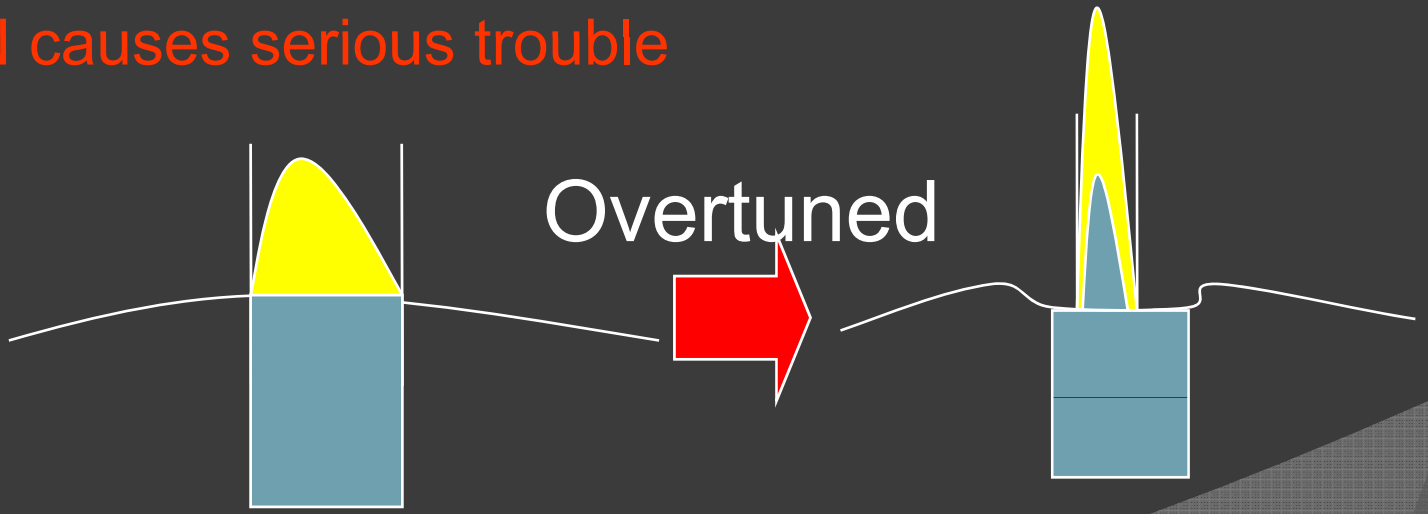
- NLF tune is strong enough to Deform MM scale.
  - Diff./Int. Linearity Check
  - Blind analysis w/Sim. data
    - (Reliable Sim. is necessary to have cross section)

MM scale calibration

Λ, Σ, gs

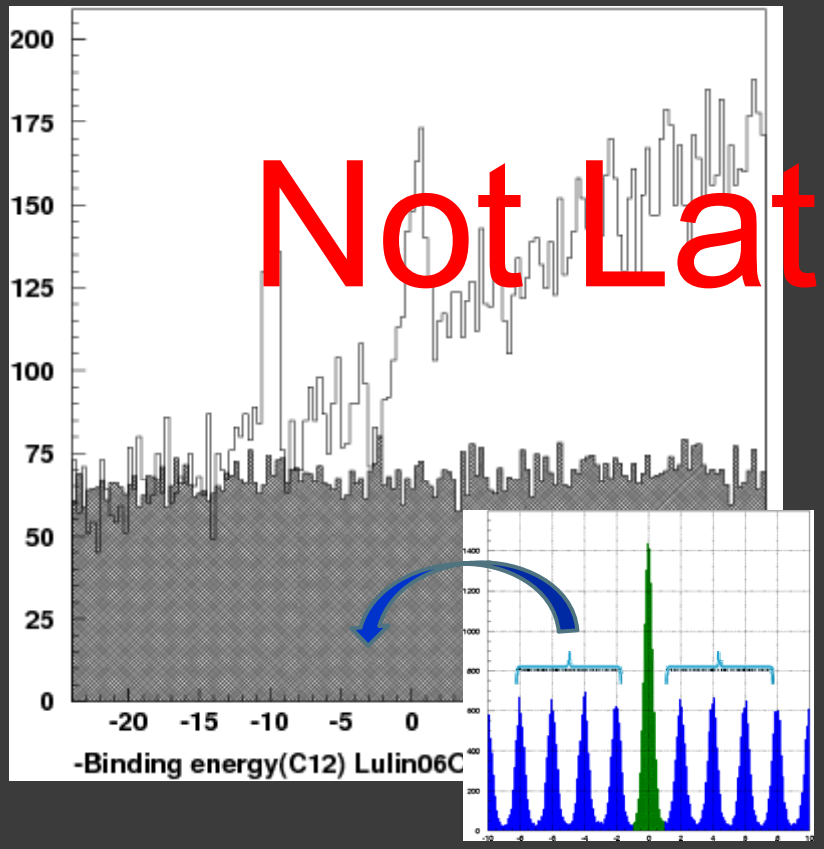
- physical peaks can serve to
  calibrate absolute mass scale, linearity

Bad S/N causes serious trouble

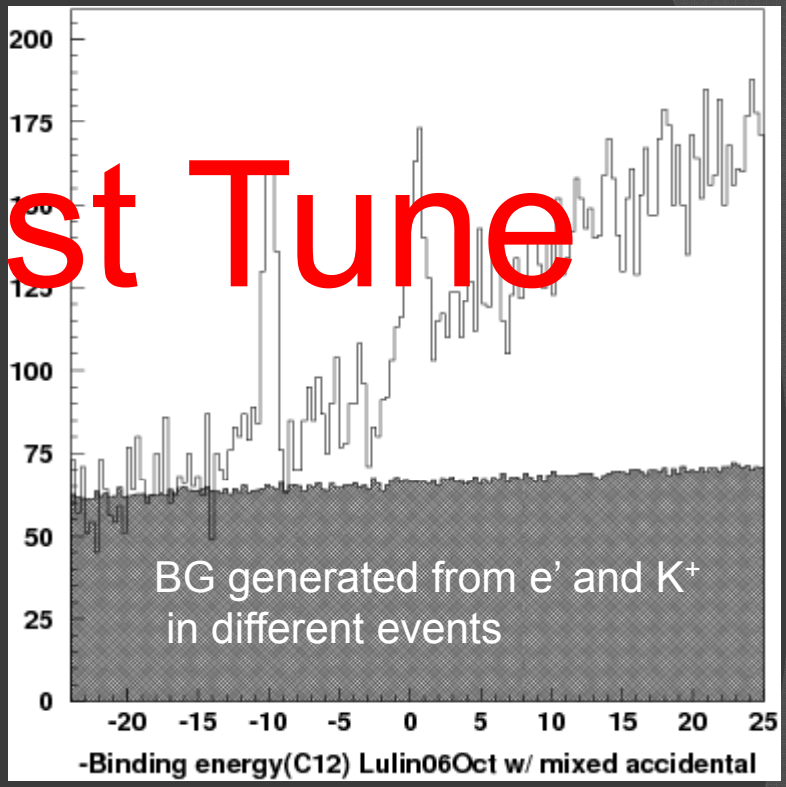


BG shape gives info. about diff. linearity

Mixed event for $^{12}_{\Lambda}$B



Not Latest Tune



Normal accidental
(Off-time gate)

Mixed accidental

BG statistics : increase as much as we want

Latest Tune

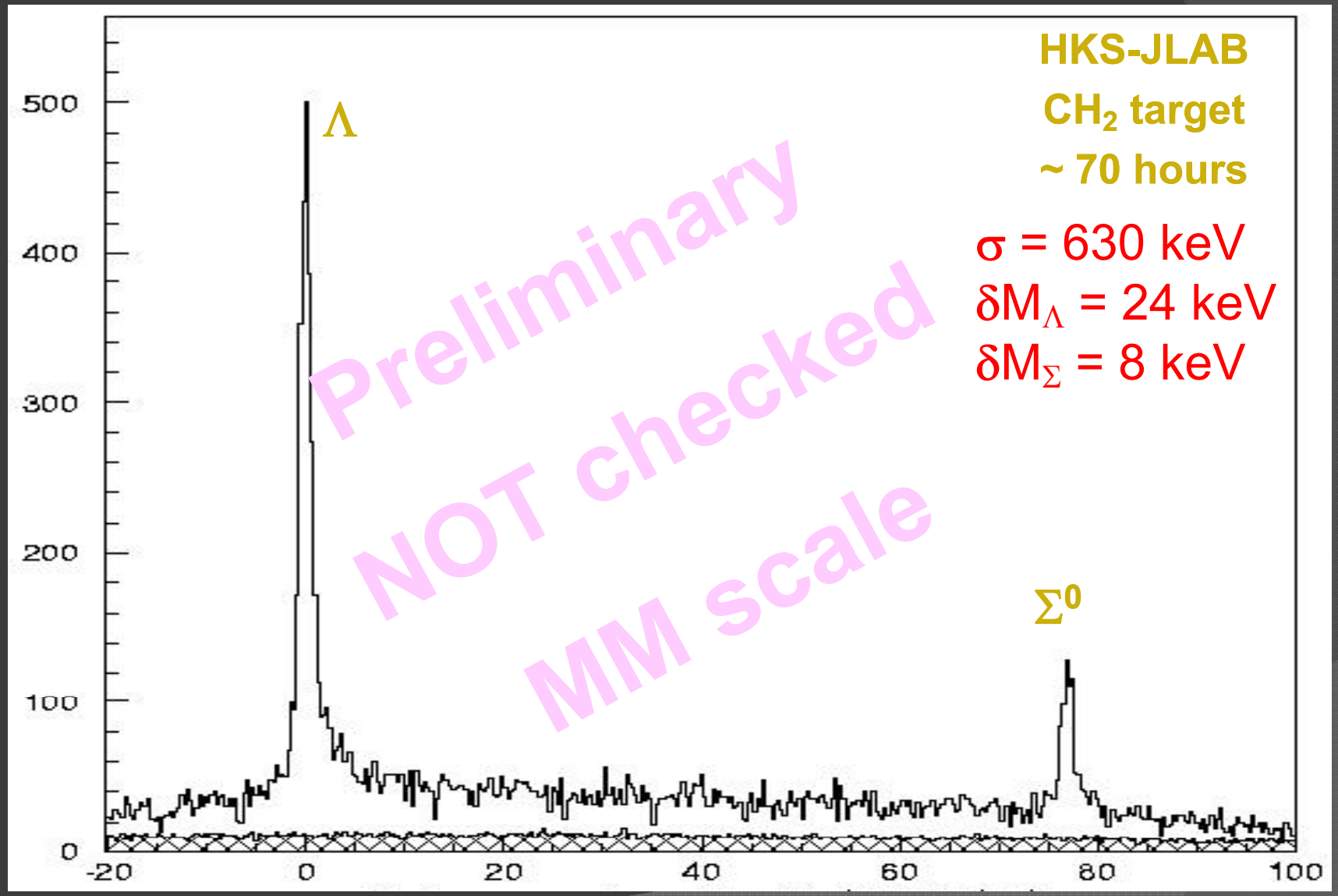
MM scale check was not applied.

- Spectra might be affected by differential/ integral NON-linearity.

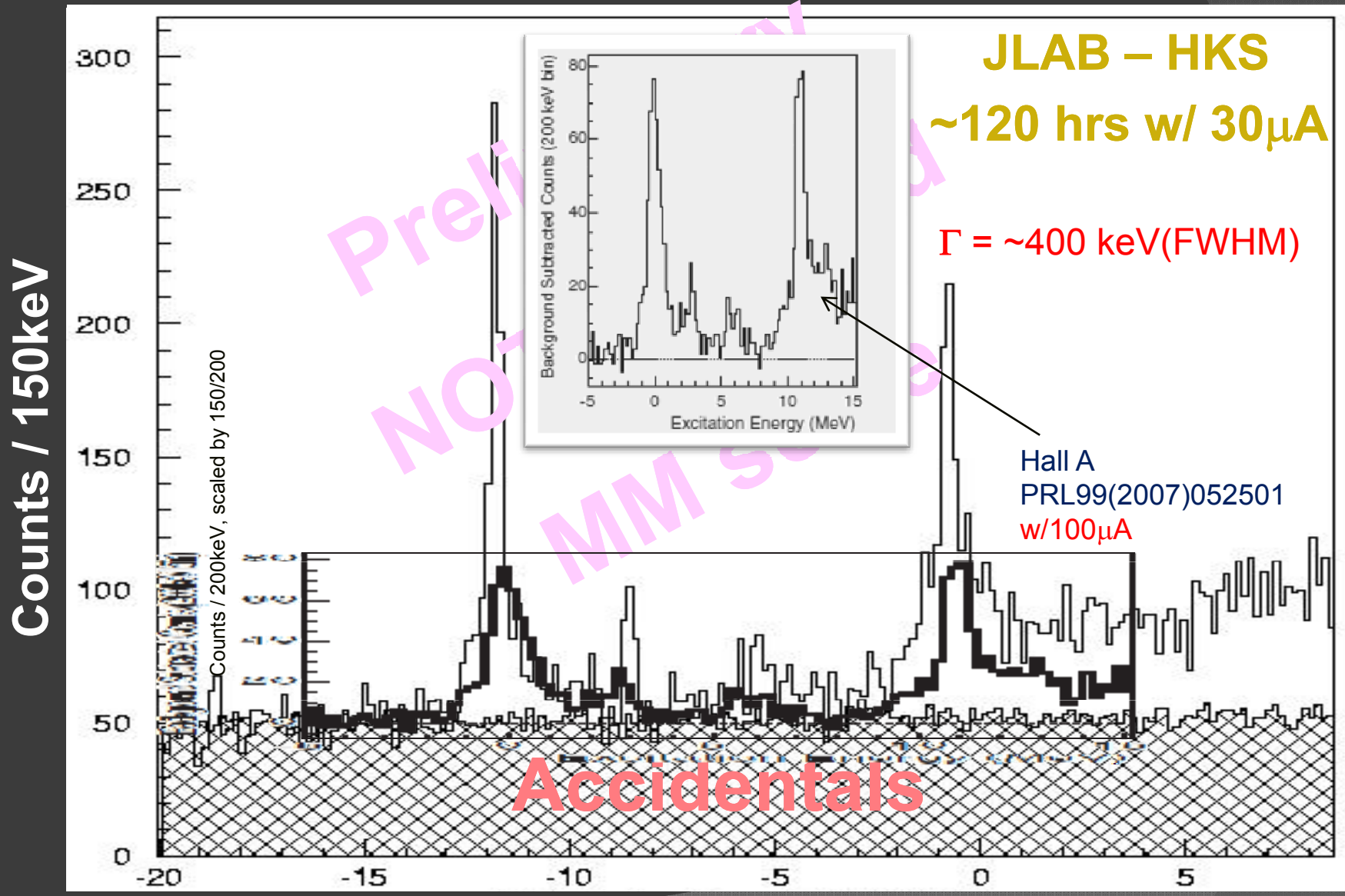
- Absolute MM scale might be changed by further analysis.

- Accidental BG will be subtracted by mixed event.

p(e,e'K$^+$)Λ&Σ^0 for kin/opt calib.



$^{12}C(e,e'K^+)^{12}_{\Lambda}B$ for kin./opt. calibration



Second Generation Exp. at JLab

2005 E01-011 (Hall C)

First step to midium heavy hypernuclei (^{28}Si, ^{12}C, ^{7}Li)

Newly introduced HKS

Introduction of Tilt ENGE
e' rate surpression

Open door to the heavier hypernuclear study with (e,e'K) reaction

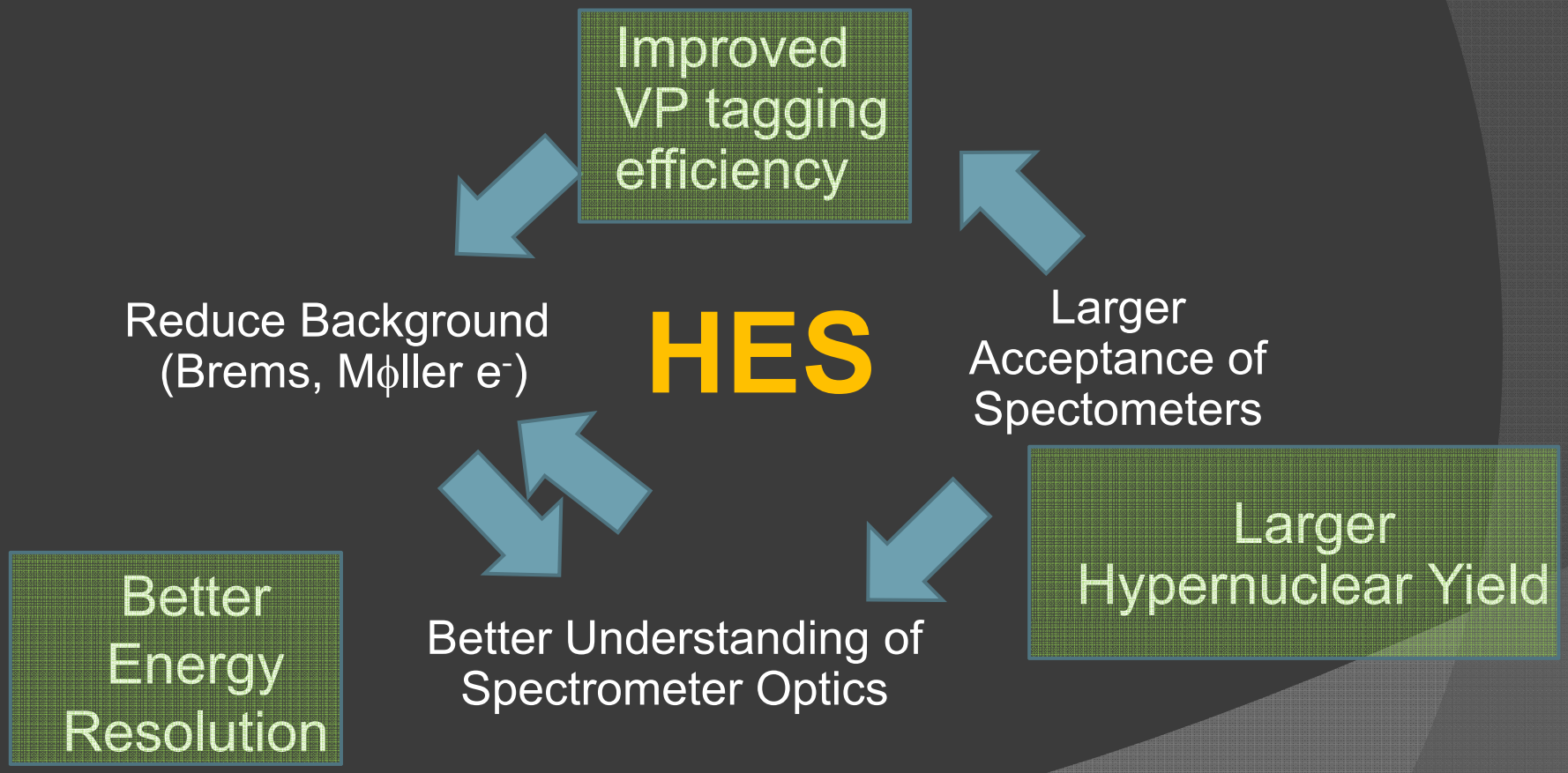
Third Generation : E05-115 experiment

- $^{51}V(e,e'K^+)^{51}{}_{\Lambda}Ti$, $^{52}Cr(e,e'K^+)^{52}{}_{\Lambda}V$ reactions
  - Λ binding energies for s,p,d orbits
  - Λ hypernuclear structure
  - *ls* splitting in l=2,3 orbits if the splitting is sizable

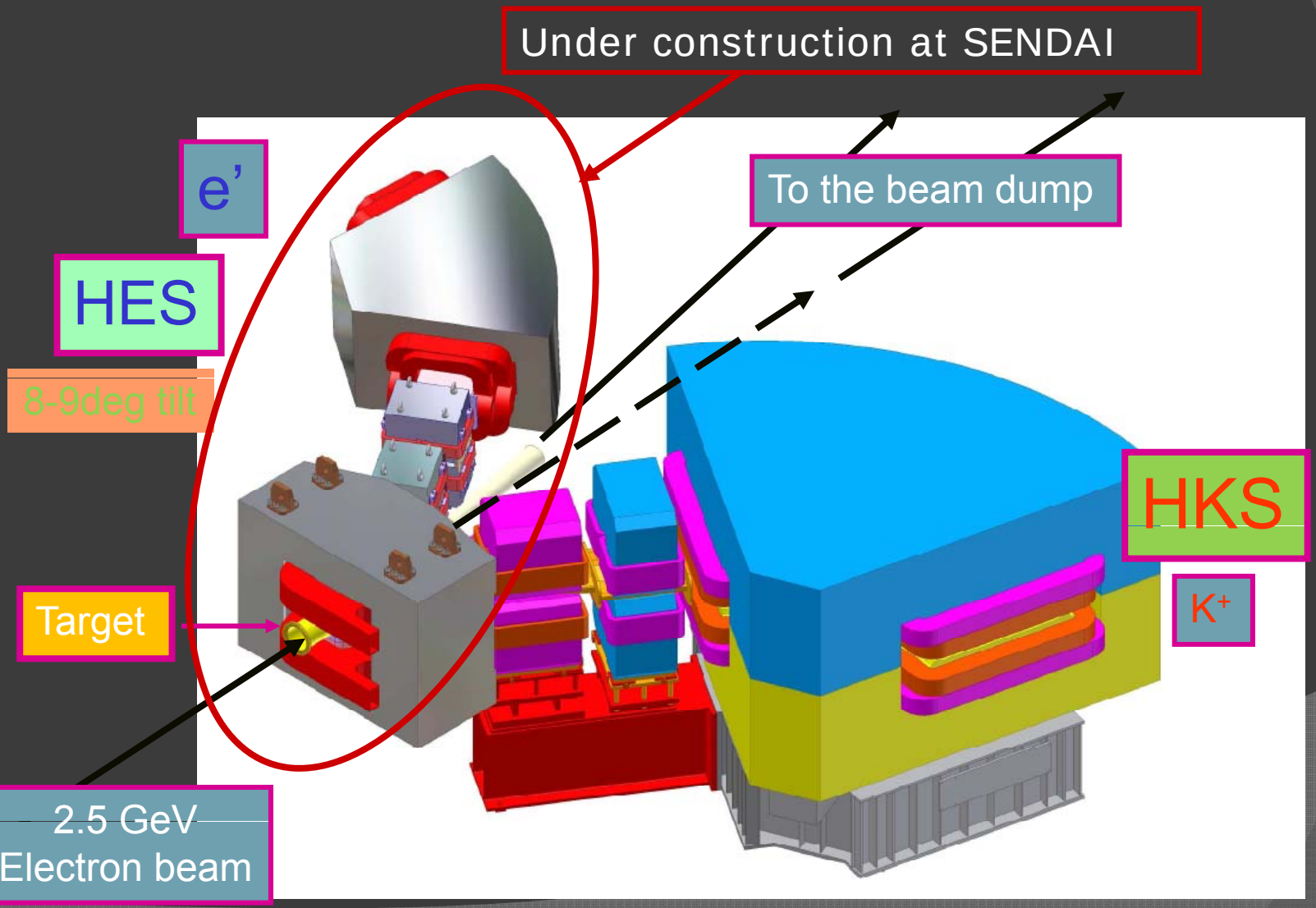
    or information about the configuration mixing of core nucleus
- $^{89}Y(e,e'K^+)^{89}{}_{\Lambda}Sr$ reaction
  - feasibility of (e,e'K+) spectroscopy in heavier hypernuclei
- $^{6,7}Li(e,e'K^+)^{6,7}{}_{\Lambda}He$ and $^{10,11}B(e,e'K^+)^{10,11}{}_{\Lambda}Be$
  - Precision hypernuclear structure in neutron-rich Λ hypernuclei
  - $\Lambda\Sigma$ coupling effect changing isospins with neutron number

Introduction of a new electron spectrometer (HES)

Improve the Experiment



HKS+HES+New SPL



To be developed

- HES magnets (EQ1, EQ2, ED and SPL)
- Electron hodoscope

- Electron Drift Chamber
  - EDC used for E01-011 + HDC (spare chamber)
- HKS detectors upgrade
  - Water Cerenkov, new Lucite C, TOF counters, AC magnetic shield

- Target (CH_2 target, Water cell, enriched Cr)

HES magnets status

- EQ1,EQ2, ED, SPL will be ready in Sep.

SPL yoke

SPL coil

HES magnets status

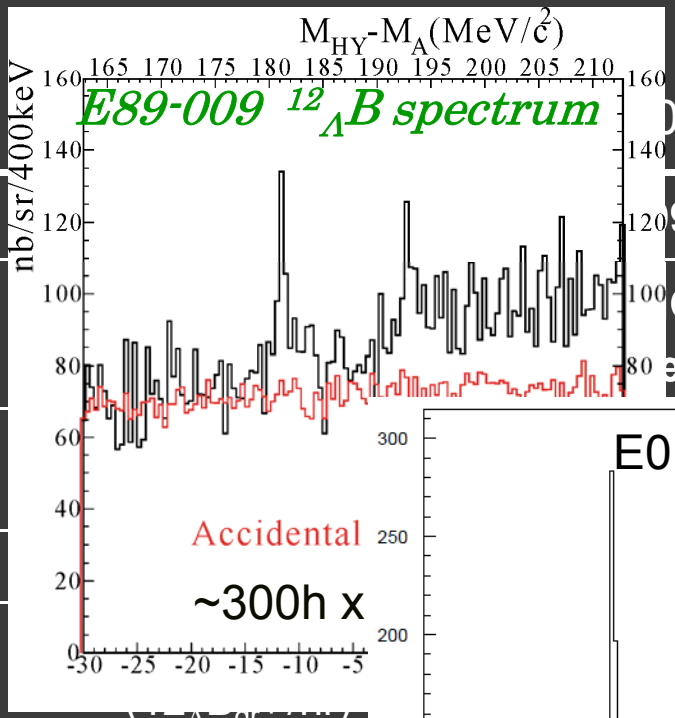
EQ1
painted

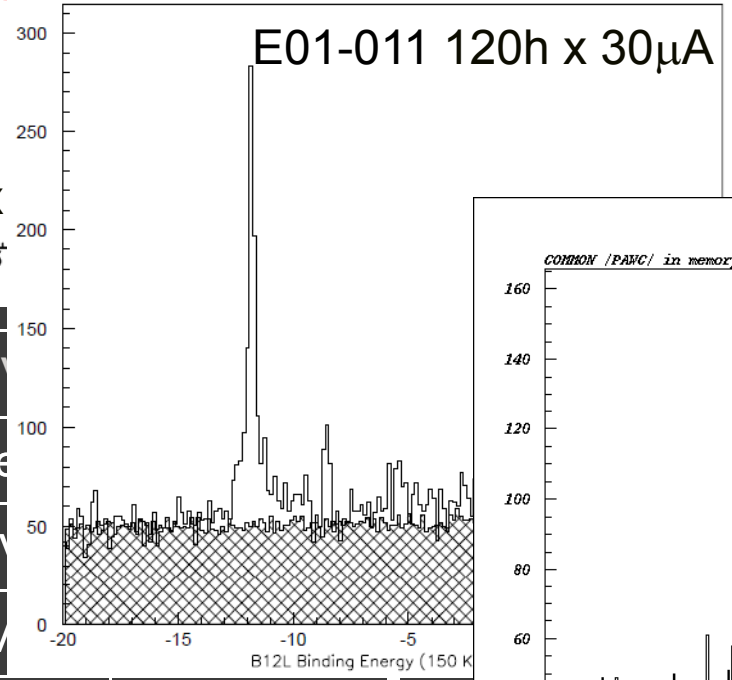
EQ2

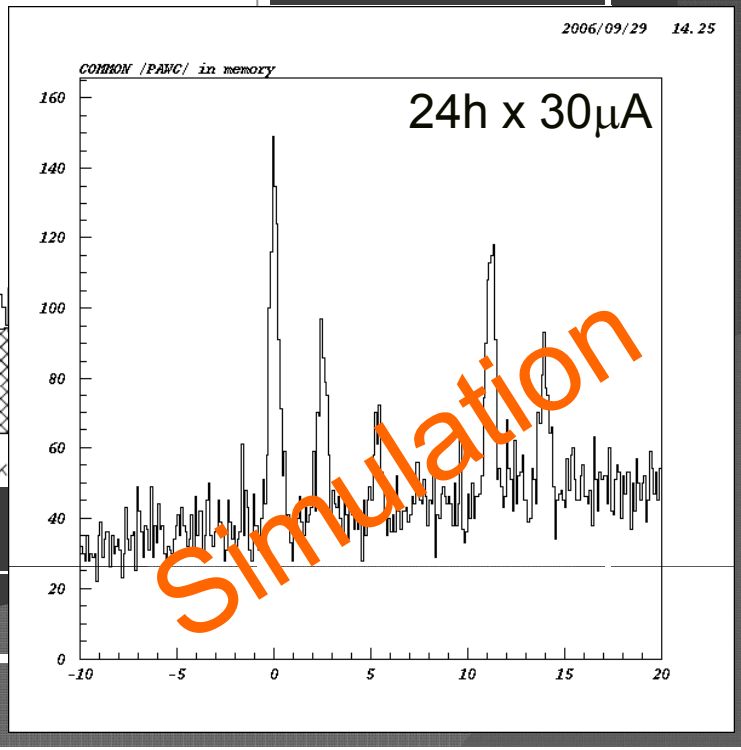
HES magnets status

ED

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







	2005	(2009)
9	E01-011	E05-115
GE er	HKS+ENGE +Splitter	HKS+HES +New splitter
Resolution (keV)		30-100
Beam energy (GeV)		100
p_K (central : GeV		
p_e (central: GeV		
θ_K (degree)	0-7	
θ_e (degree)	0	

( ) expected * select one angle

To make E05-115 analysis easy

- Good Calibration Data
  - Good p(e,e'K+)Λ,Σ^0 data :
    Water cell / water cooled CH2 target
    Good S/N, high statistics, w/o raster
  - High statistics, good S/N Carbon data should be periodically taken.
  - During calibration, beam condition should be stable.
- Good design of sieve slits
- Better understanding of new SPL, HKS, HES before the experiment

HES schedule

- EQ1,EQ2, ED, SPL will be ready in Sep.
- In 2007 summer-autumn,
  excitation test, field map in Japan
- Winter 2007, ship HES to JLab

By the end of 2008,
the collaboration will be ready for beam.

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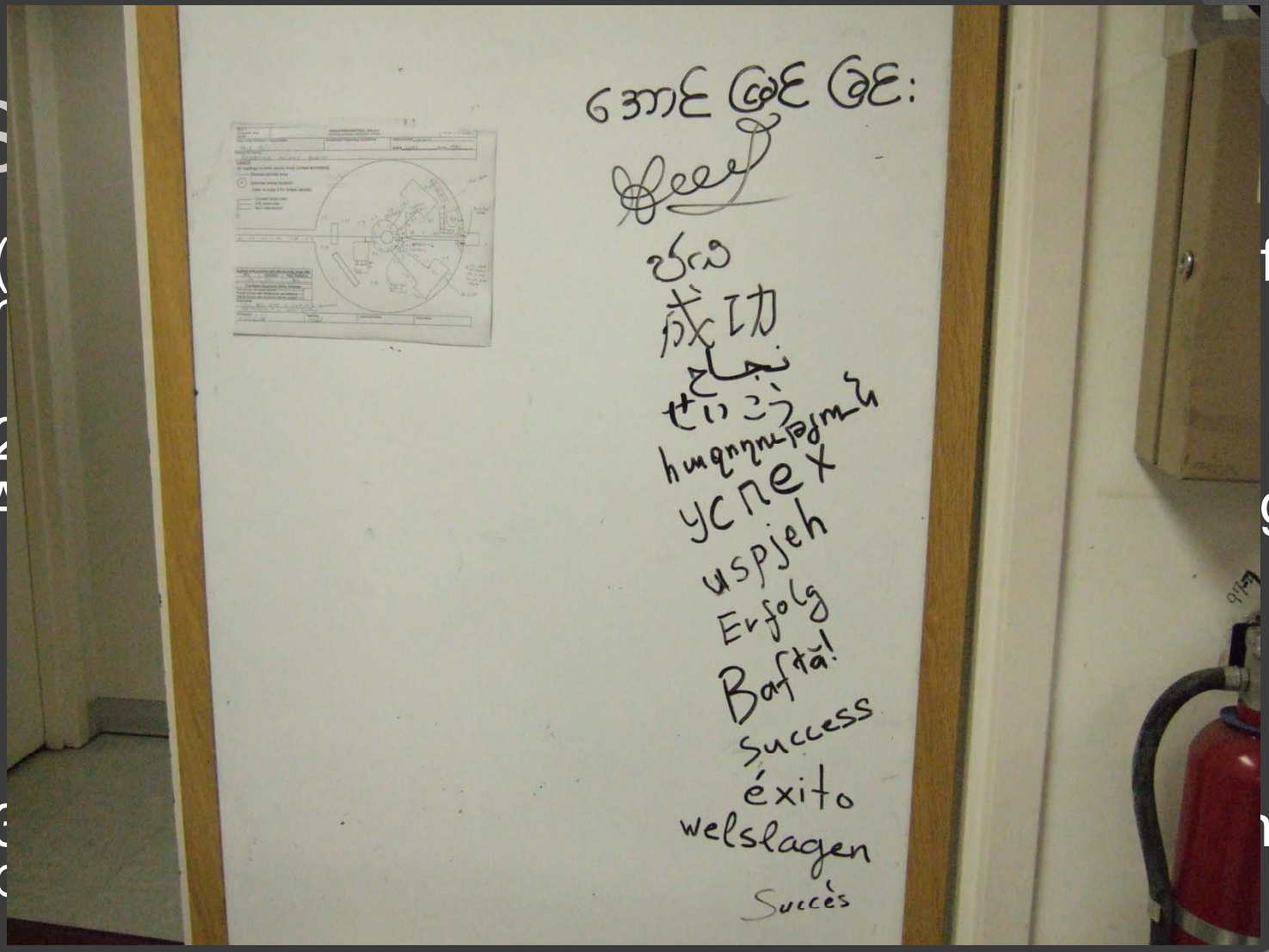

f study

g.

- Preparation in progress
  - HES will be shipped to JLab by the end of JFY2007.
  - Expect HKS installation at JLab Hall-C in JFY2008 (early 2009).