Precise measurement of $\Lambda \rightarrow p\pi^-$ decay width of $^{5}_{\Lambda}$He

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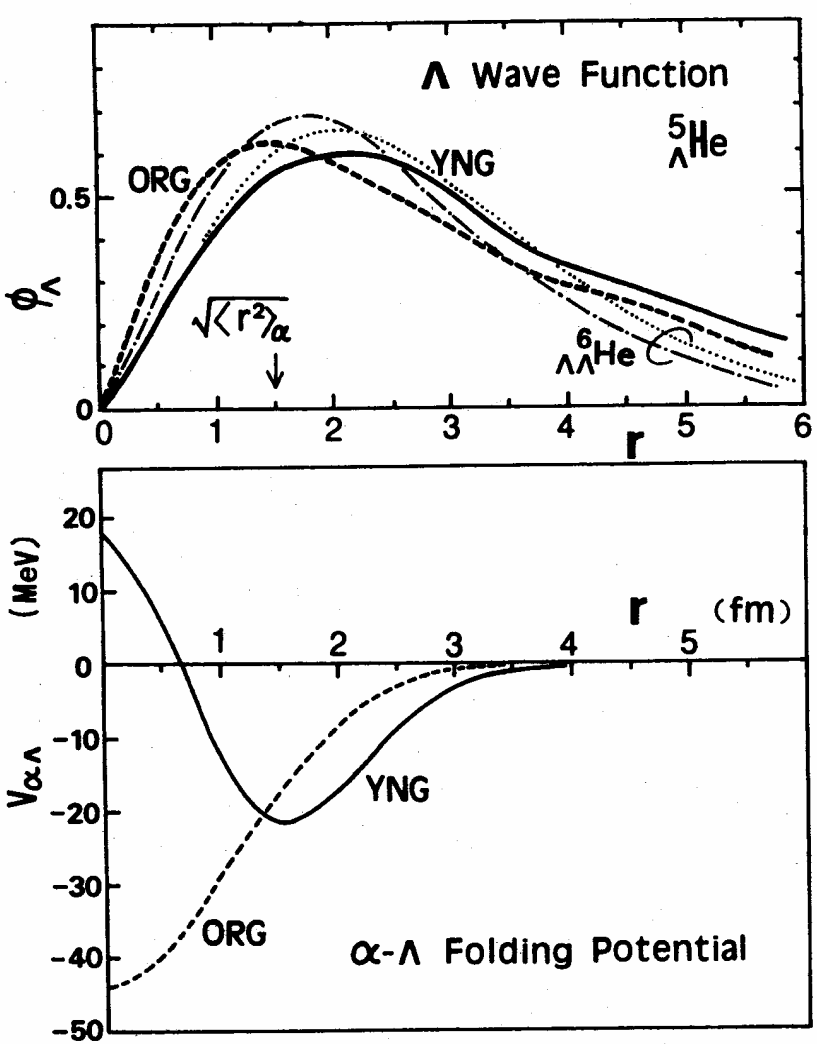
Why significant to measure “decay”?

Calculation for two different α-Λ potentials, ORG and YNG
(Motoba *et al.* NPA577)



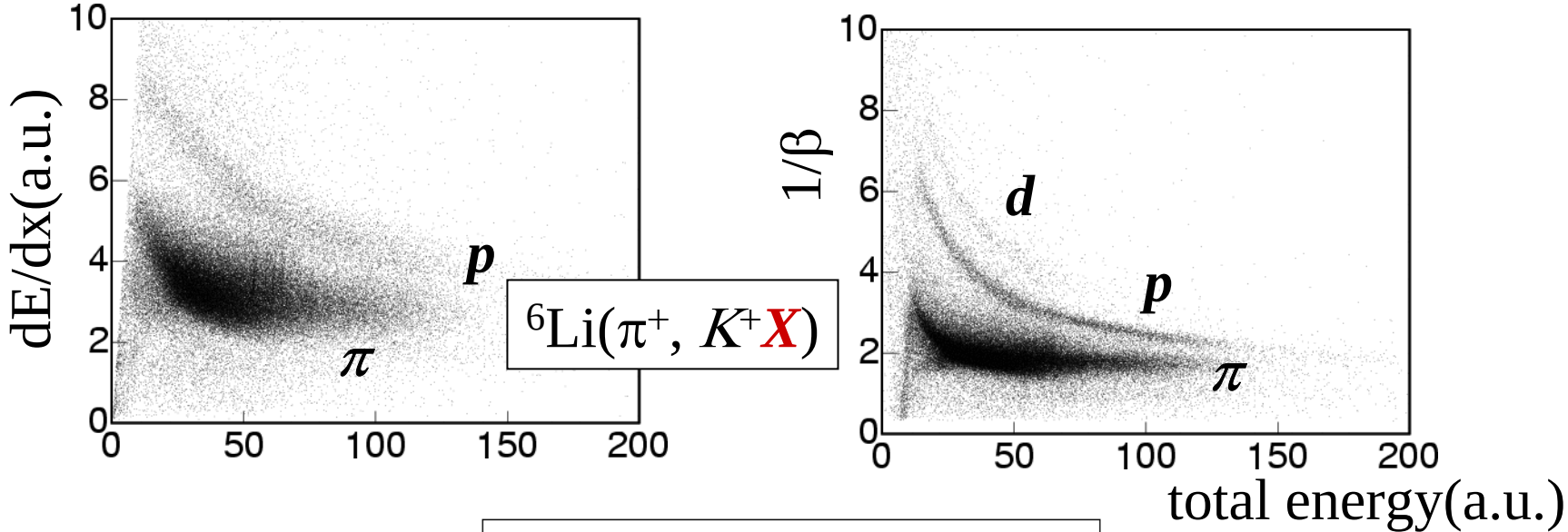
$\Gamma_{\pi^-} / \Gamma_\Lambda$		
Theory		Experiment (BNL, Szymanski *et al.*)
ORG	YNG	
0.321	0.393	0.44 ± 0.11

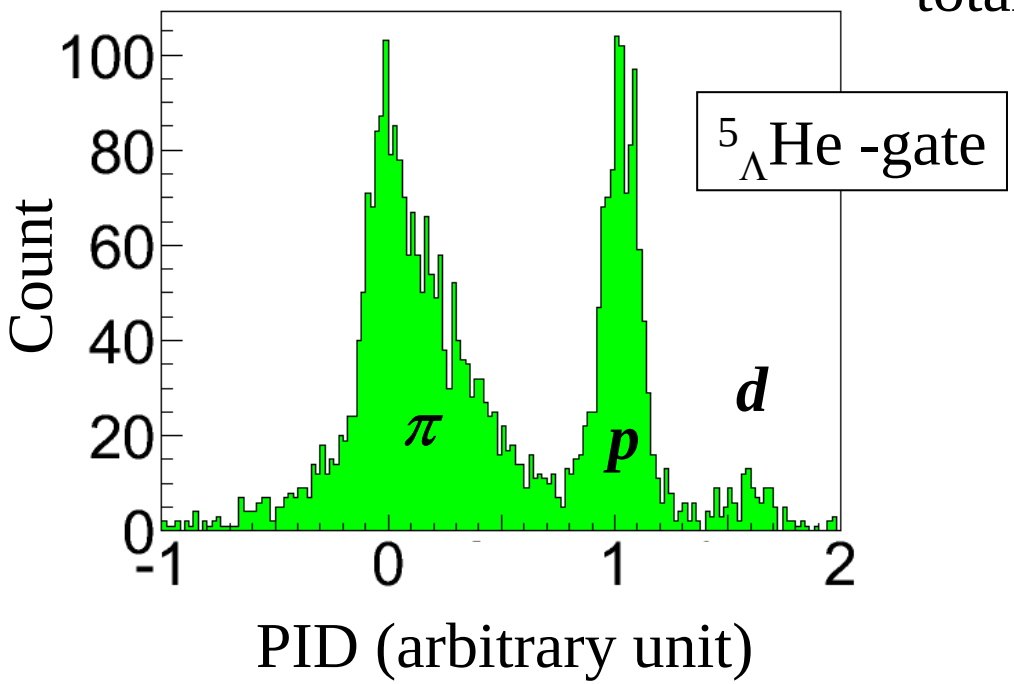
Mesonic decay width is sensitive to α–Λ potential shape.

$$\Gamma_{\pi^-} = b_{\pi^-} / \tau$$

Experimental observables

Charged particle identification

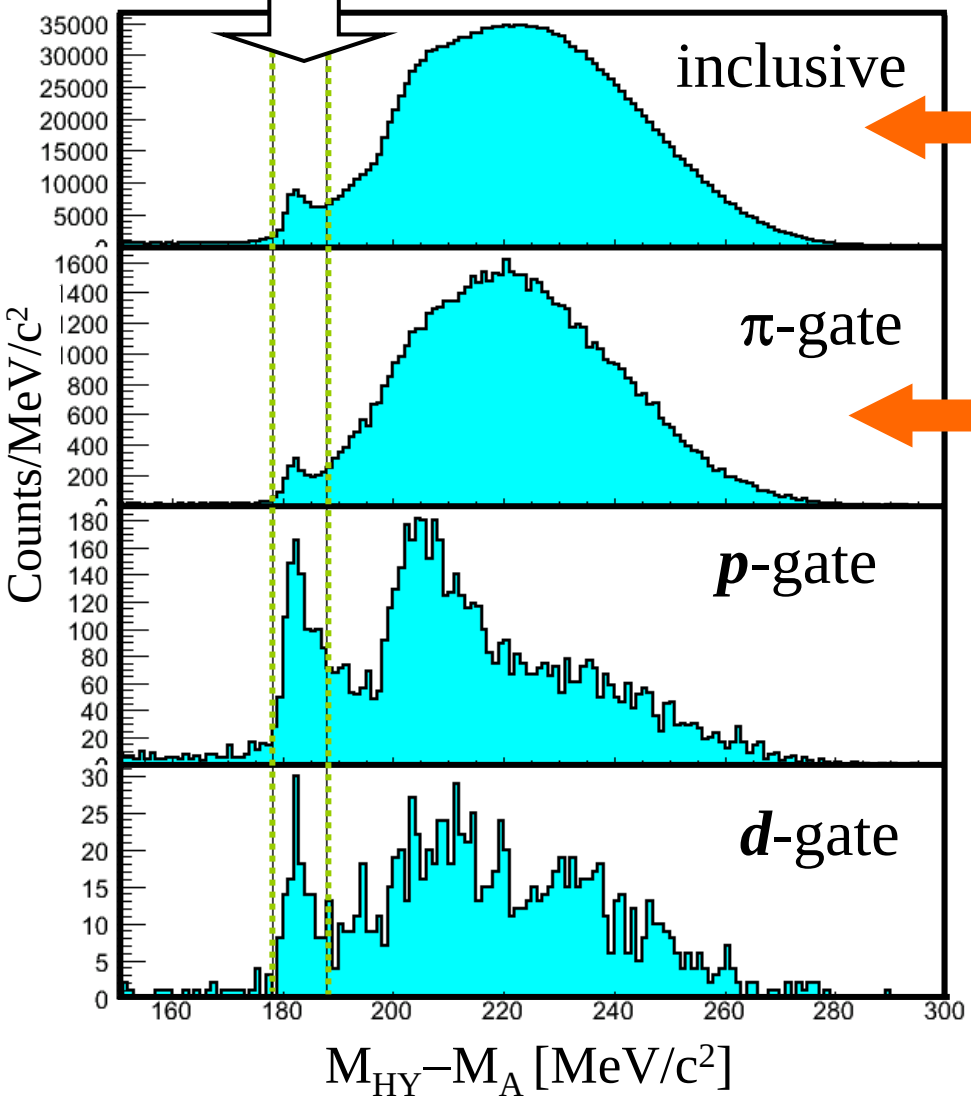


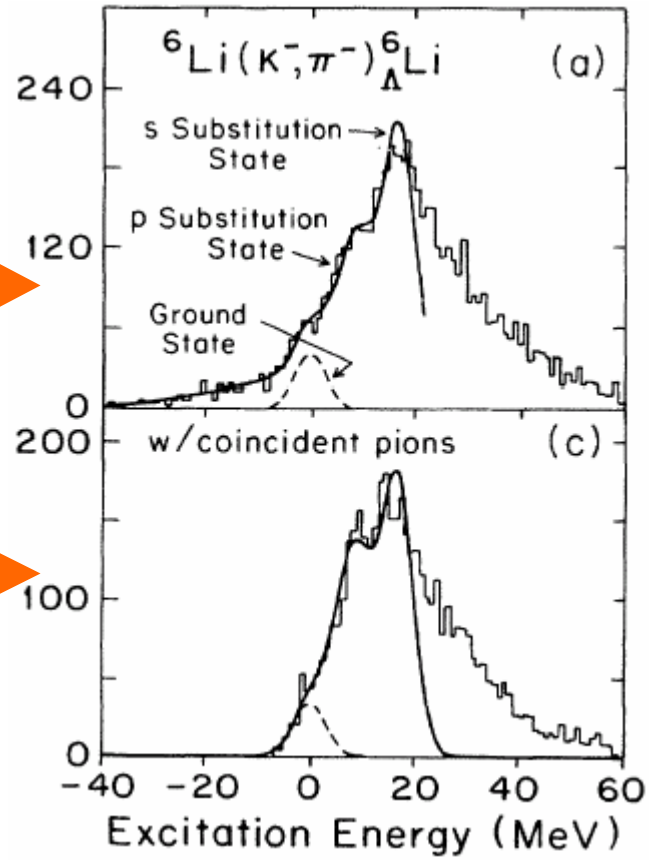


Hypernuclear mass spectra

^{6}Li(π^+, K^+p)$^{5}_{\Lambda}$He

- Good S/N (~ 10)
- Good resolution





Previous experiment at BNL

Szymanski *et al*. PRC43, 849(1991)

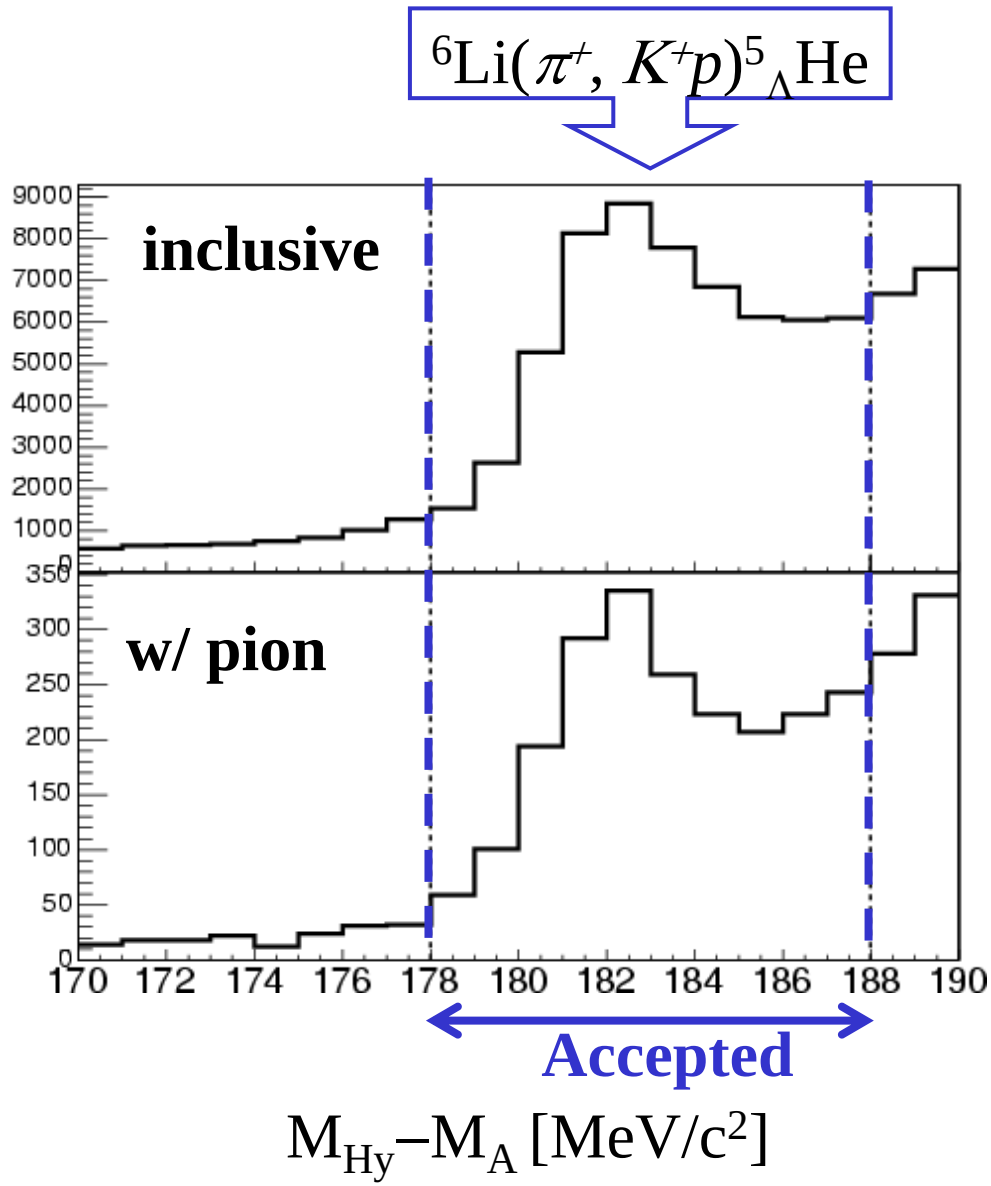
Branching ratio of $\Lambda \rightarrow p\pi^-$ decay

$$b_{\pi^-} = \frac{N_{\pi^-}}{N_{\mathrm{inc}} \times \Omega}$$

$$= \frac{1954}{53946 \times 0.0971}$$

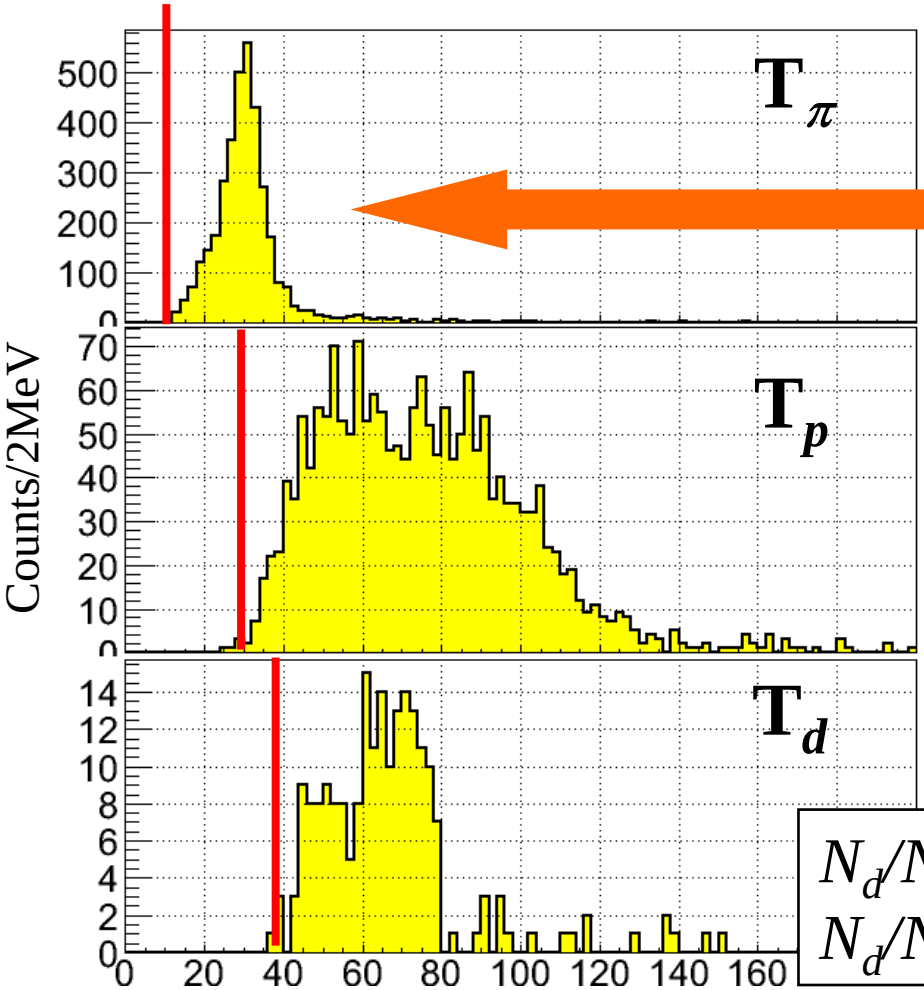
$$= 0.371 \pm 0.009$$

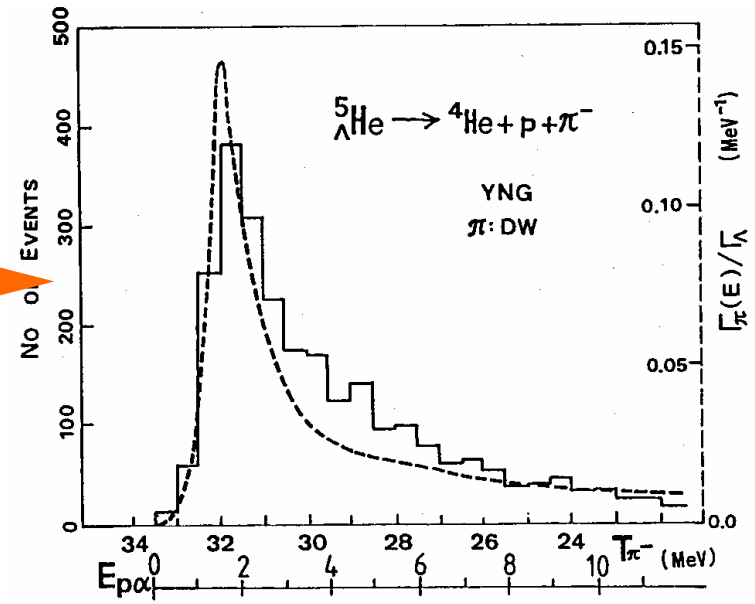
(statistical error only)



Energy spectra of $\pi/p/d$

Detection threshold

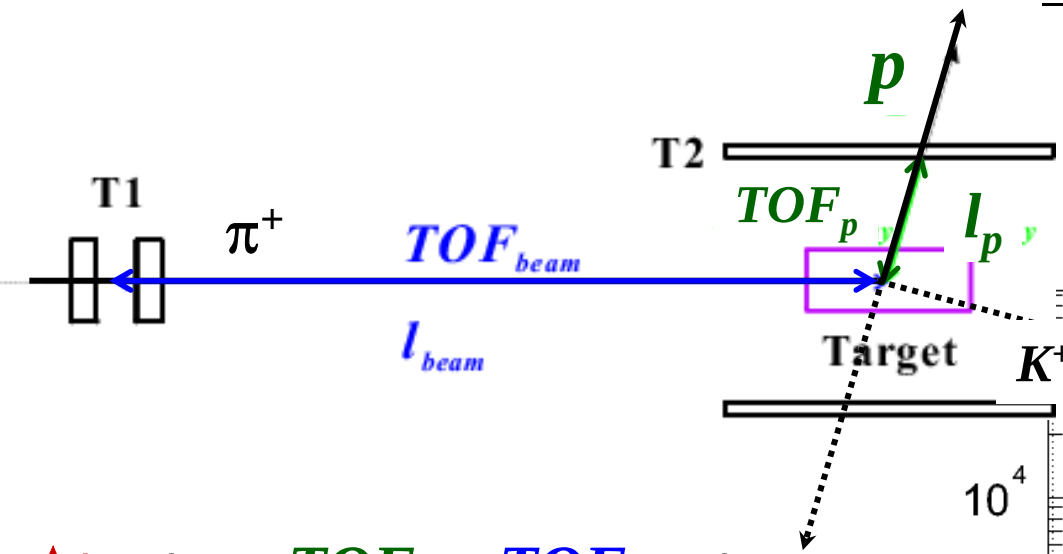




High resolution data by emulsion experiment
(Motoba *et al.* NPA577)

$N_d/N_p \sim 0.15$
$N_d/NMWD \sim 0.064$

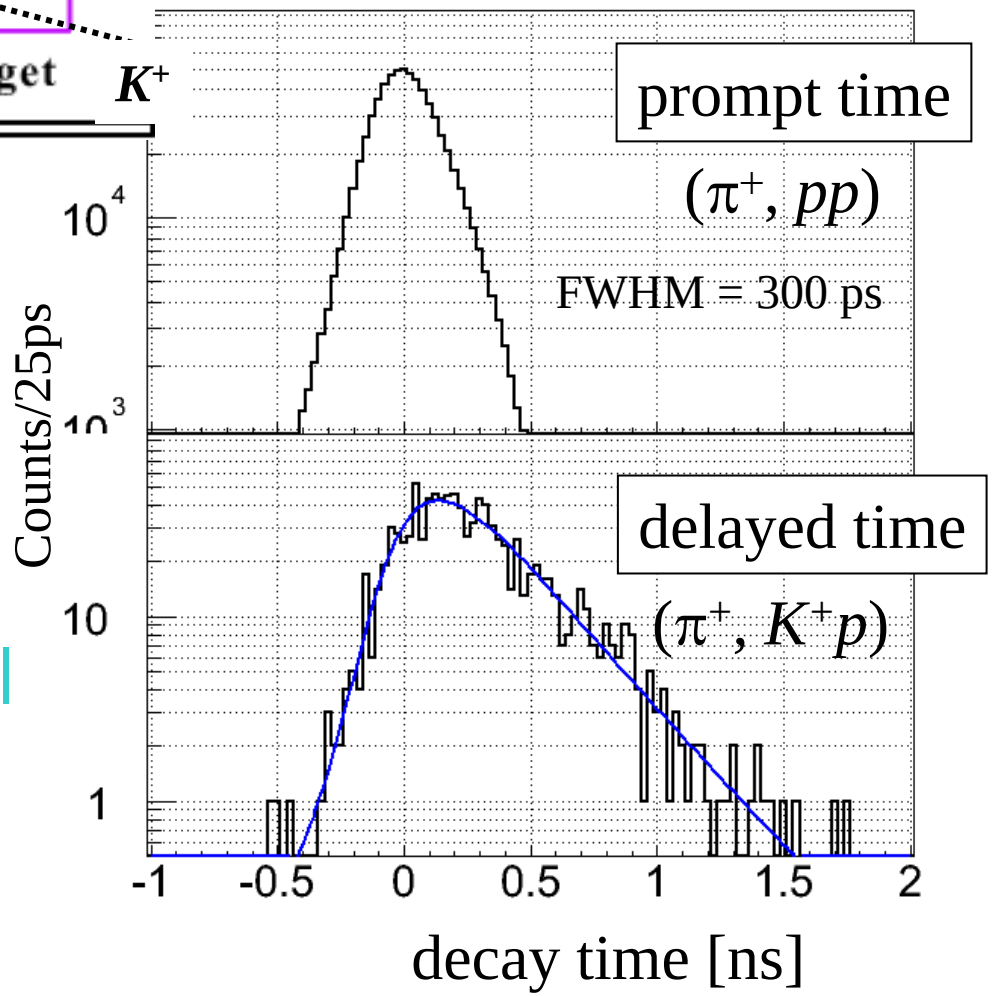
Lifetime measurement of $^{5}_{\Lambda}$He



$$\Delta t = t_{T2} - TOF_p - TOF_\pi - t_{T1}$$
$$= t_{T2} - l_p/(\beta_p c) - l_\pi/(\beta_\pi c) - t_{T1}$$

$$\tau = 278\ ^{+11}_{-10}\ \text{ps}$$

cf. Szymanski *et al.*(1991)
$\tau = 256 \pm 20$ ps

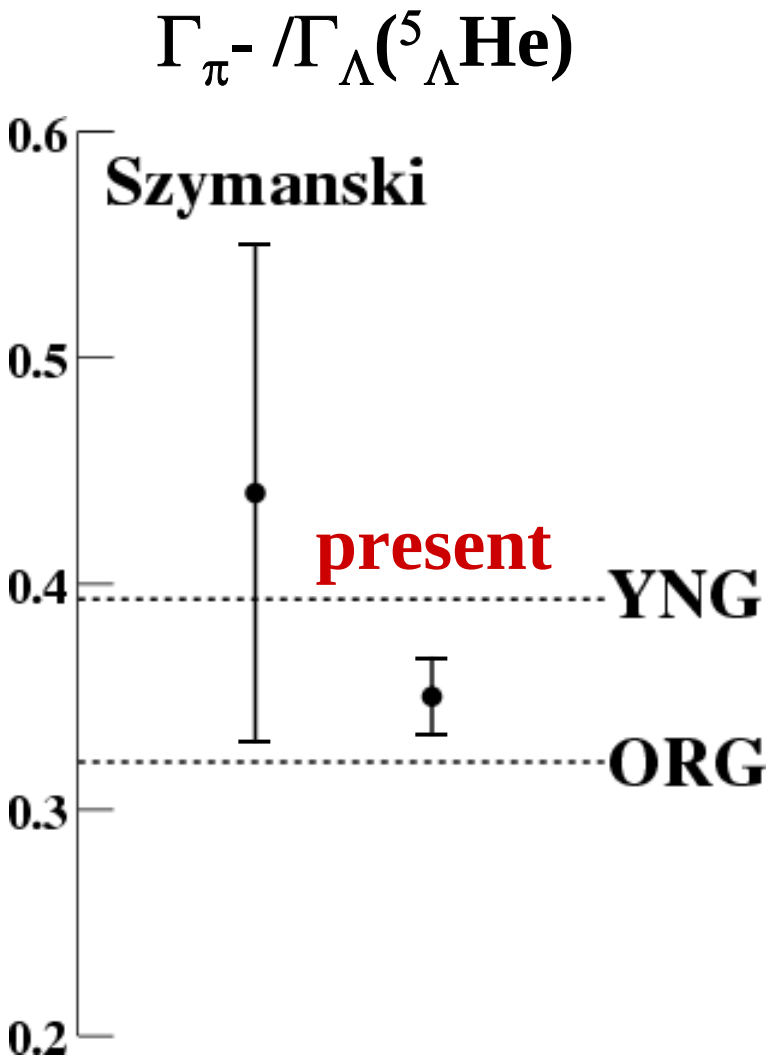


Results

	Experiment		Theory	
	Present	J.J.Szymanski *et al*	ORG	YNG
$\Gamma_{tot}/\Gamma_{\Lambda}$	**0.947 ± 0.037**	1.03 ± 0.08	–	–
$\Gamma_{\pi^-}/\Gamma_{\Lambda}$	**0.351 ± 0.017**	0.44 ± 0.11	0.321	0.393

- statistical error only

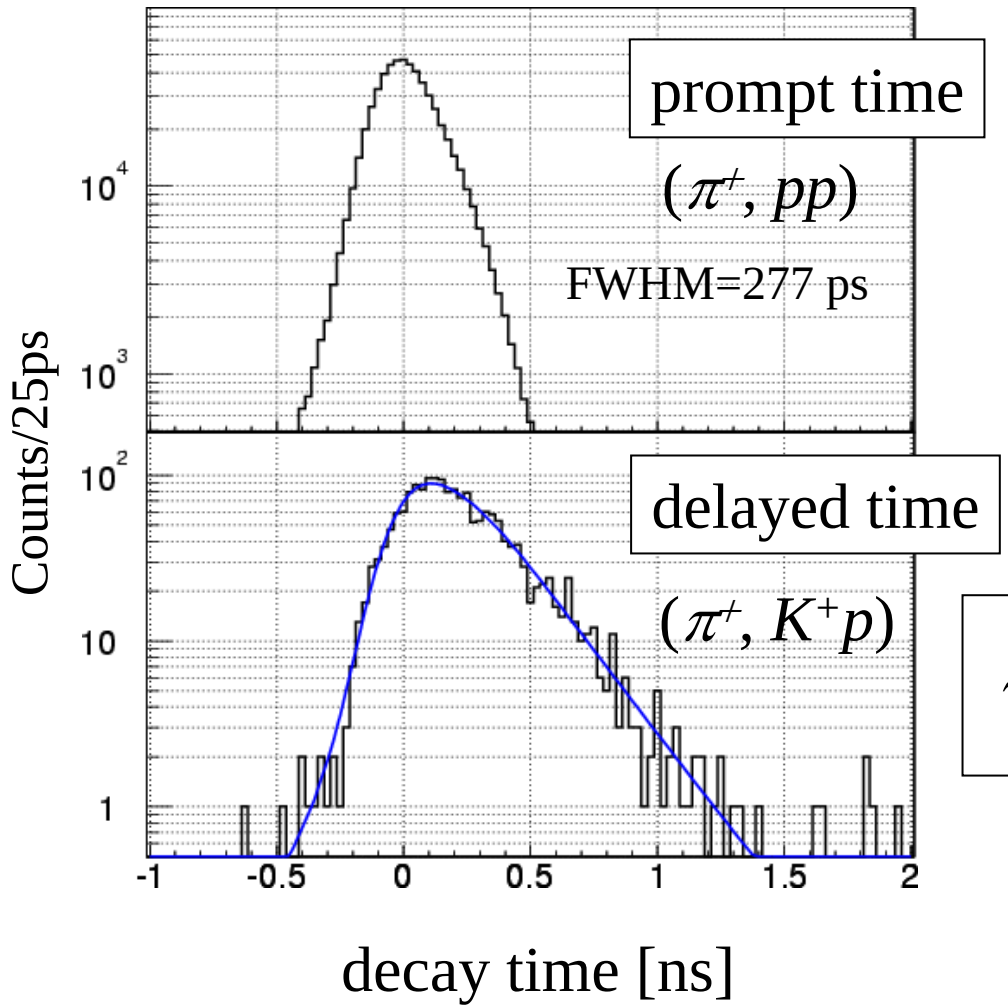
Comparison with theoretical predictions



Significantly larger α-Λ overlap than YNG potential is indicated.

New potential is required.

Lifetime measurement of $^{12}_{\Lambda}C$



$$\tau = 212\ ^{+7}_{-6}\ \text{ps}$$

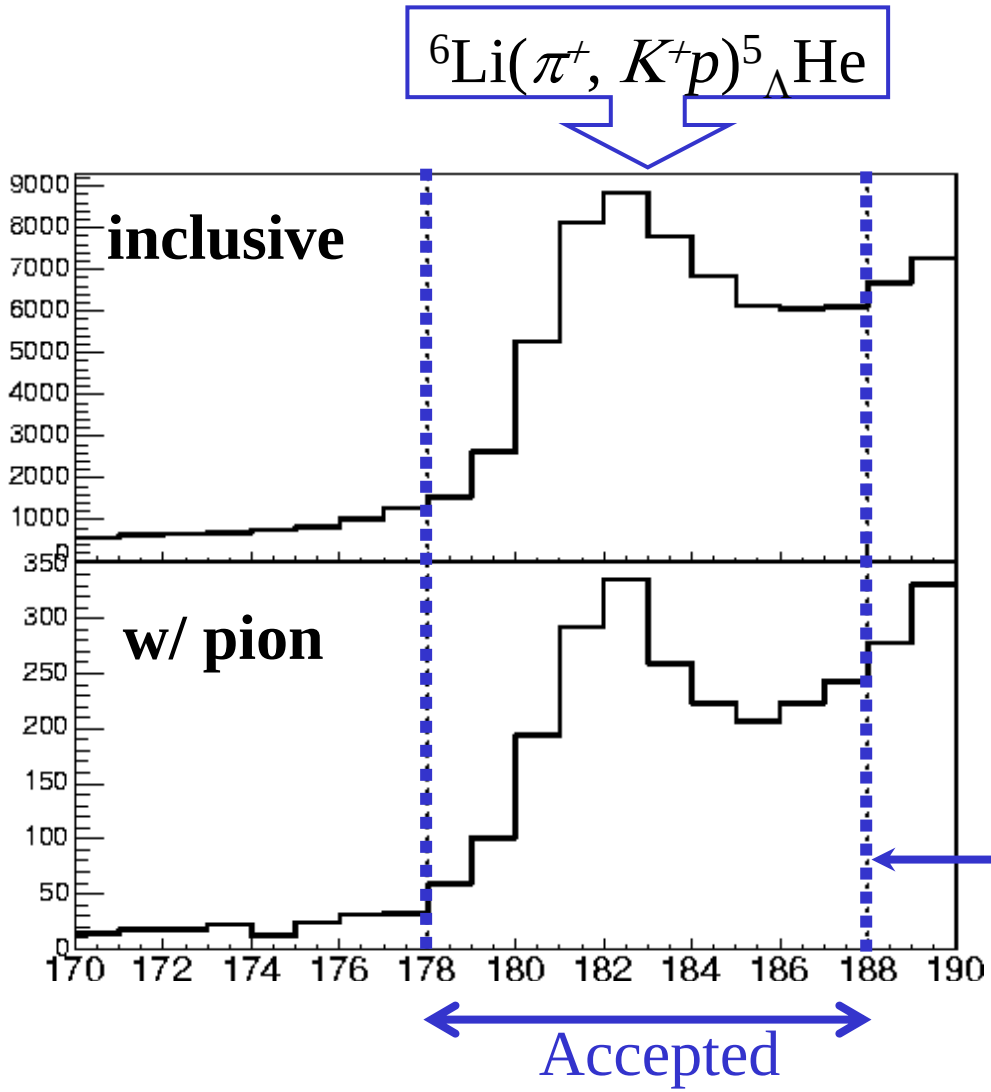
cf. Park *et al.*
$\tau = 230 \pm 15$ ps

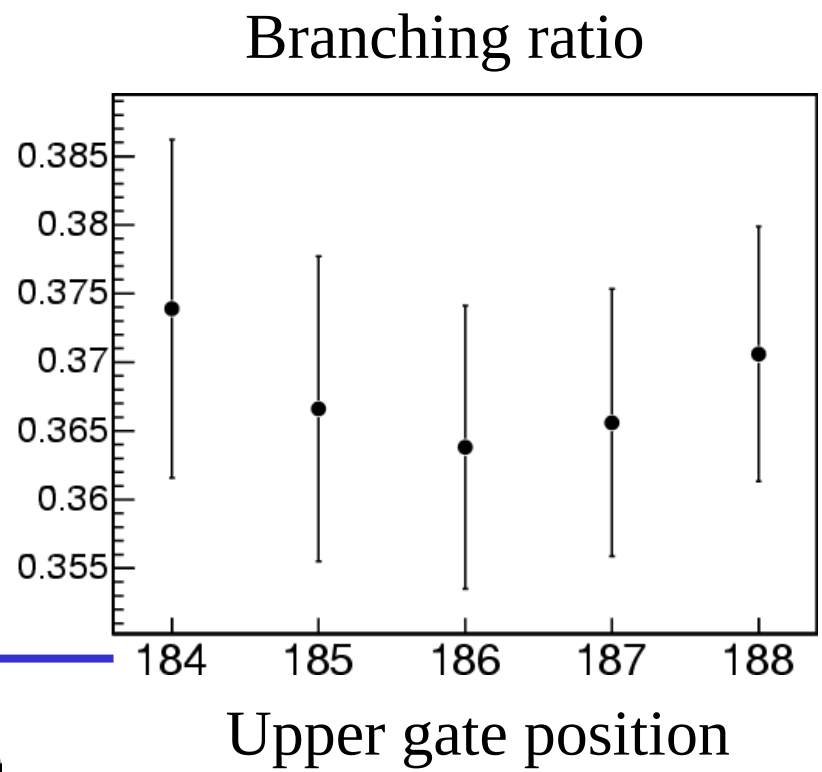
Summary

- The total decay width and π^- decay width of ${}^{5}_{\Lambda}\mathrm{He}$ were precisely measured.
- $\Gamma_{tot} / \Gamma_{\Lambda}({}^{5}_{\Lambda}\mathrm{He}) = 0.947 \pm 0.037$.
- $\Gamma_{\pi^-} / \Gamma_{\Lambda}({}^{5}_{\Lambda}\mathrm{He}) = 0.351 \pm 0.017$.
- New α-Λ potential need be developed.

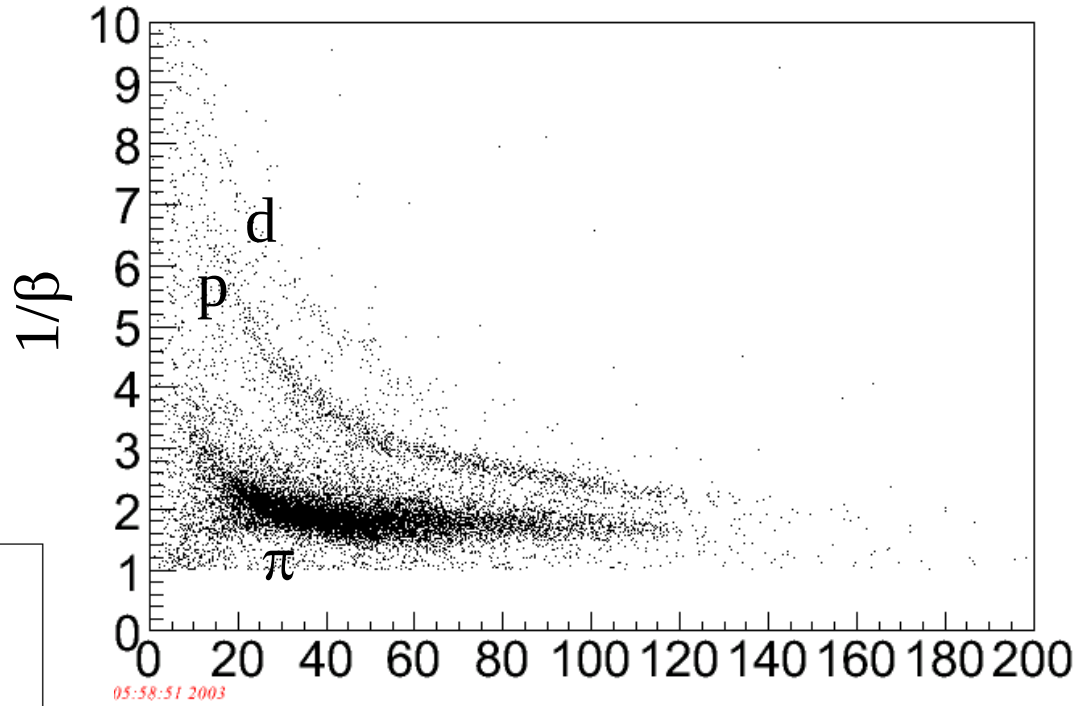
- Lifetime of ${}^{5}_{\Lambda}\mathrm{He}$ and ${}^{12}_{\Lambda}\mathrm{C}$ were determined with twice higher accuracy than previous measurement.

Systematic error check of π^- decay branching ratio

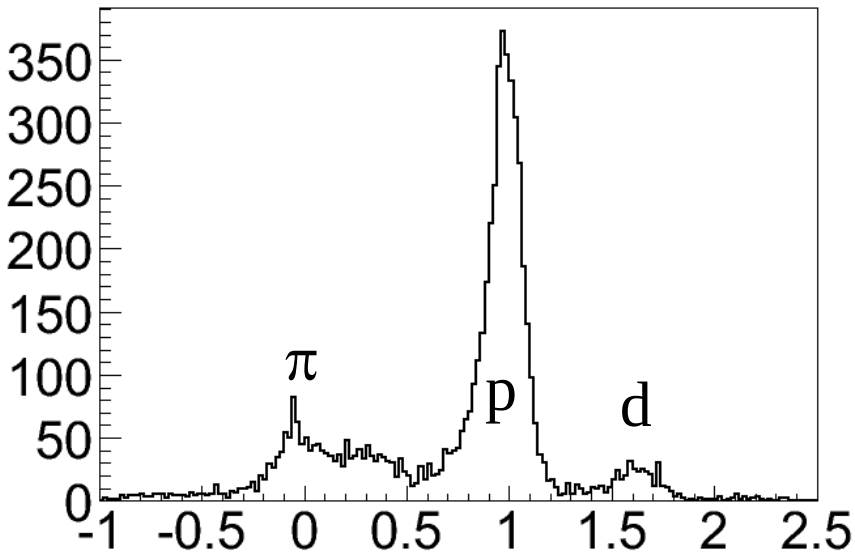




Charged particle from the decay of $^{12}_{\Lambda}C$

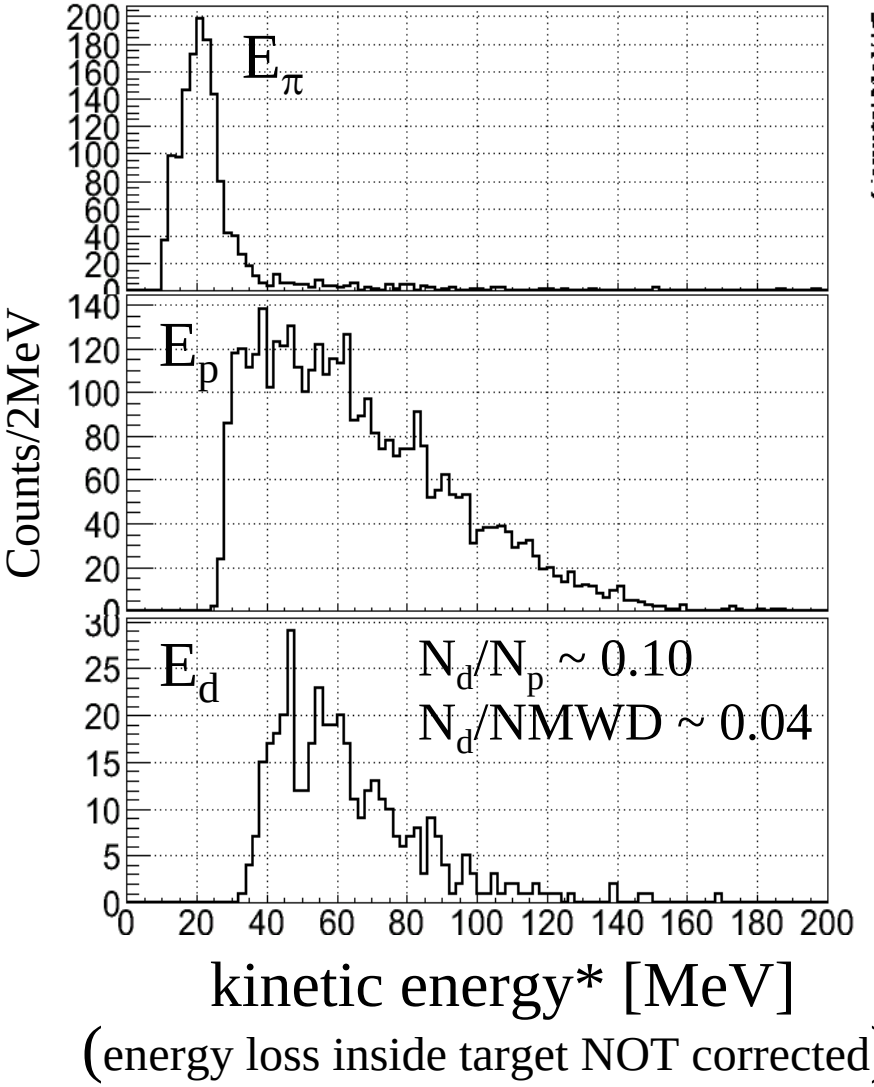


total energy (arbitrary unit)



PID (arbitrary unit)

Energy spectra of π/p/d from the decay of $^{12}_{\Lambda}C$



$^{12}C(\pi,K)$ excitation spectrum