SPECTROSCOPY OF MULTI-STRANGE HYPERNUCLEI

Darmstadt, June 8, 1998

J. Pochodzalla

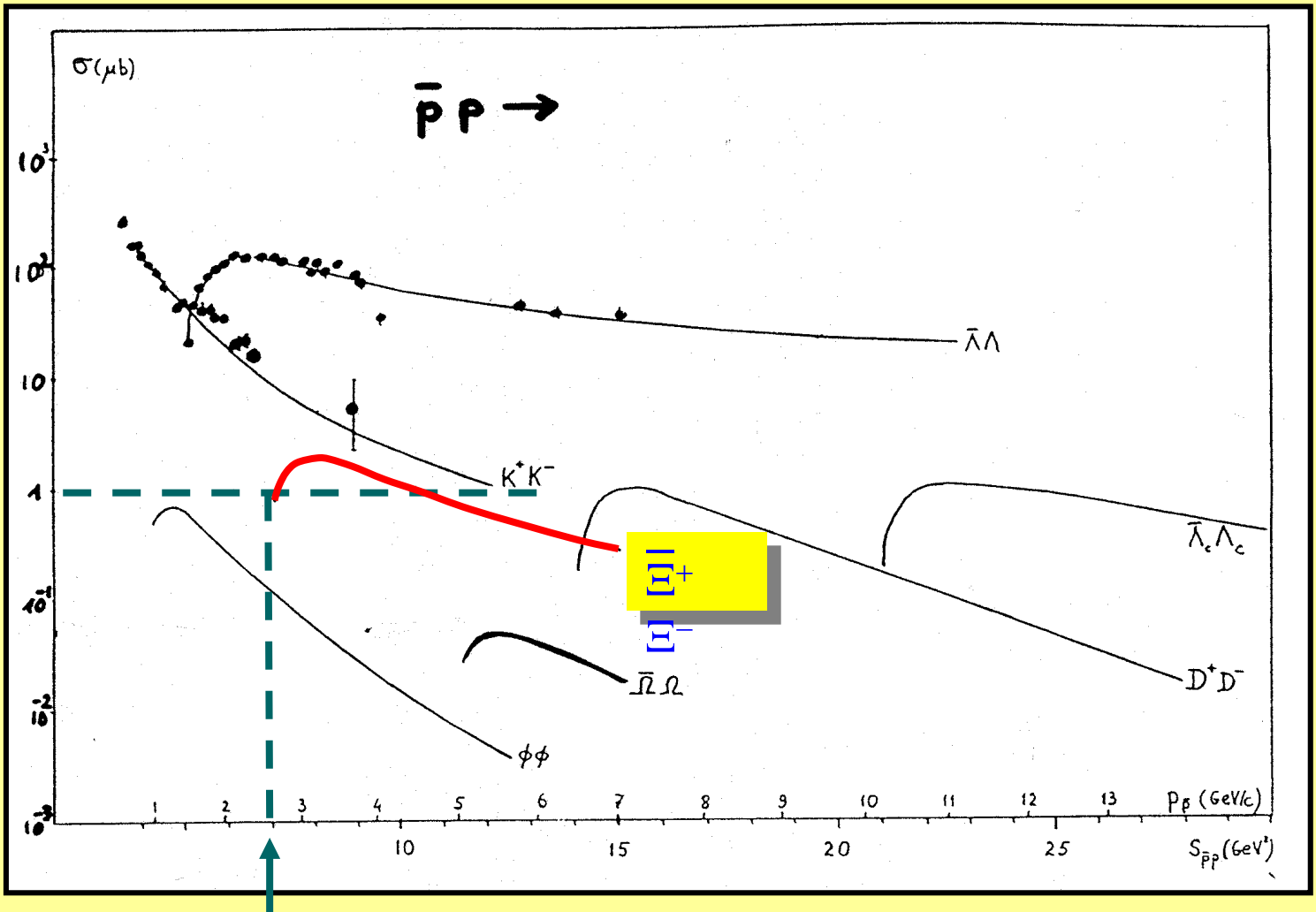
M. Bleicher, L. Gerland, B. Kopeliovich, U.Lynen, L. Neise, B.Povh, H.W. Siebert, S. Soff, H. Stöcker

Hadron-Antihadron Production in $\bar{p}p$ Collisions

J. Pochodzalla
MPI -HD

Kaidalov & Volkovitsky

quark-gluon string model



2.6 GeV/c

8 with L =10^{32} $cm^{-2}s^{-1}$ à 100 s^{-1}

Present Status of Multi-Strange Hypernuclei

J. Pochodzalla
MPI -HD

Only 6 candidates for multi-hypernuclei are observed

1963: Danysz *et al*. $^{10}_{\Lambda\Lambda}$Be

1966: Prowse $^{6}_{\Lambda\Lambda}$He

1991: Aoki *et al*. $^{10}_{\Lambda\Lambda}$Be or $^{11}_{\Lambda\Lambda}$Be

1991: Aoki *et al.* 3 non-mesonic decays

but...

1989: Dalitz *et al*.

? Danysz event o.k. but double mesonic decay surprising

? Prowse event questionable

1991: Dover *et al.*

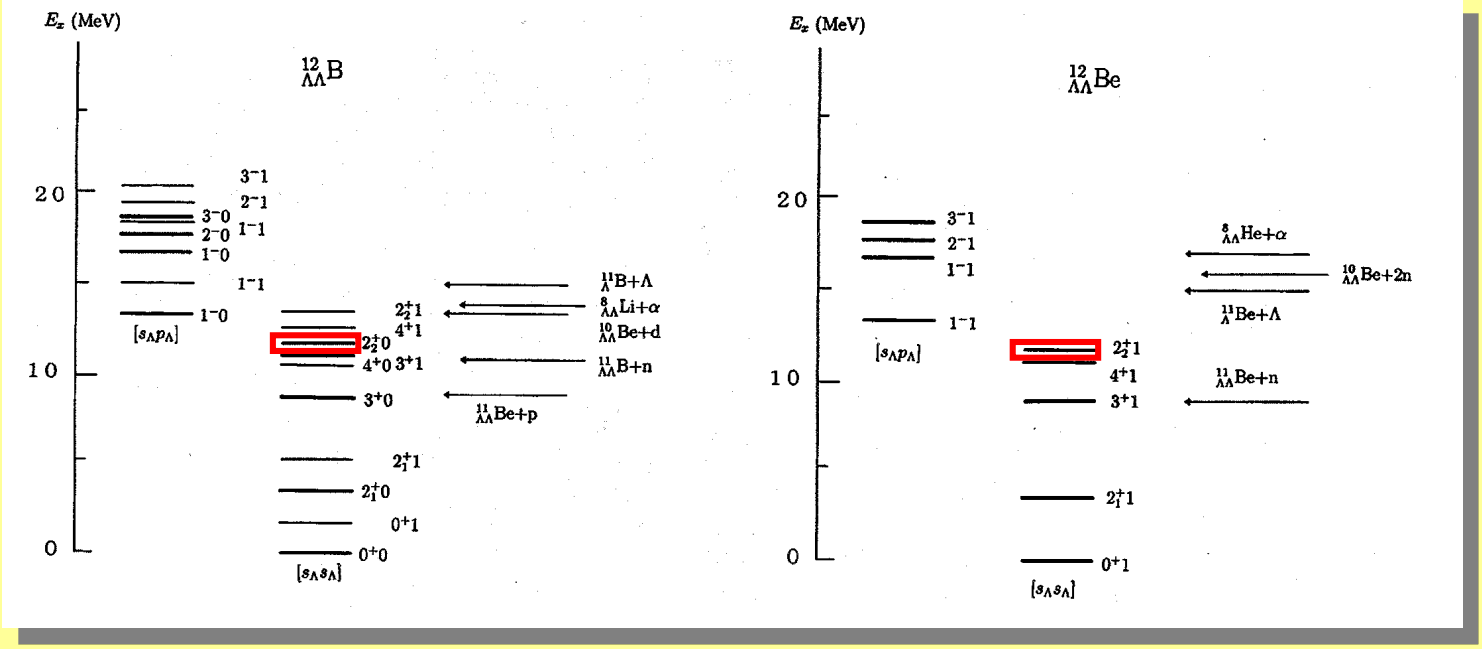
? Aoki event possibly $^{13}_{\Lambda\Lambda}$B

Ξ^-(dss)**p**(uud) Þ Λ(uds)Λ(uds)

- "cool" production: energy release ΔE= 28 MeV
- Ξ^-+^{12}C: T. Yamada and K. Ikeda, PRC **56**, 3216 (1997)

TABLE VIII. Calculated production rates per Ξ (R/Ξ) averaged over the absorption rates in the case of $V_{0\Xi}=16$ MeV.

Channel	R/Ξ (%)
$^{12}_{\Lambda\Lambda}$B+n	1.48
$^{12}_{\Lambda\Lambda}$Be+p	0.99
$^{11}_{\Lambda\Lambda}$Be+d	1.81
$^{10}_{\Lambda\Lambda}$Be+t	0.02
$^{9}_{\Lambda\Lambda}$Li+α	0.02
$^{6}_{\Lambda\Lambda}$He+^{7}Li	0.23
$^{5}_{\Lambda\Lambda}$H+^{8}Be	0.20
$^{9}_{\Lambda}$Be+$^{4}_{\Lambda}$H	0.07
$^{8}_{\Lambda}$Li+$^{5}_{\Lambda}$He	0.04
$^{12}_{\Lambda}$B+Λ	1.08



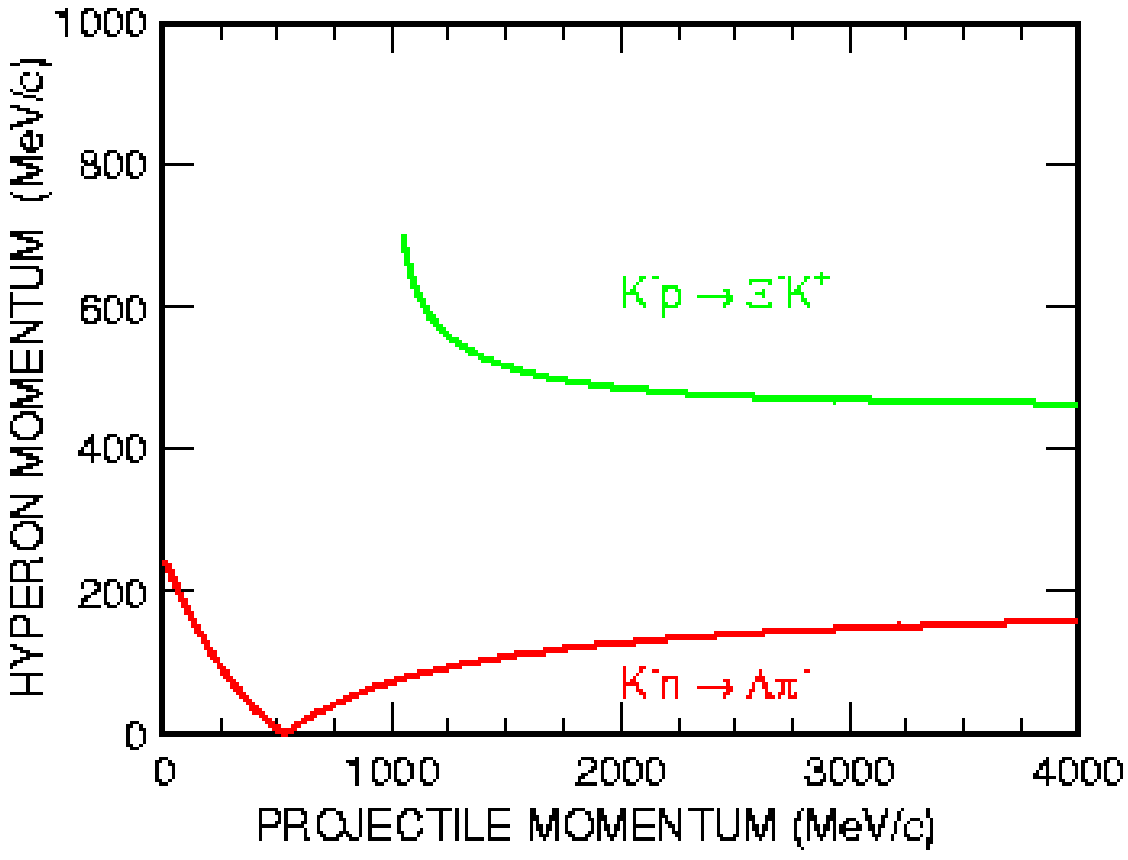
8 total probability $p_{\Lambda\Lambda} \approx 0.05$

individual states a factor of ≈10 lower

Hyperon Production

J. Pochodzalla
MPI -HD

- strangeness exchange



typical Ξ recoil momentum > 460 MeV/c

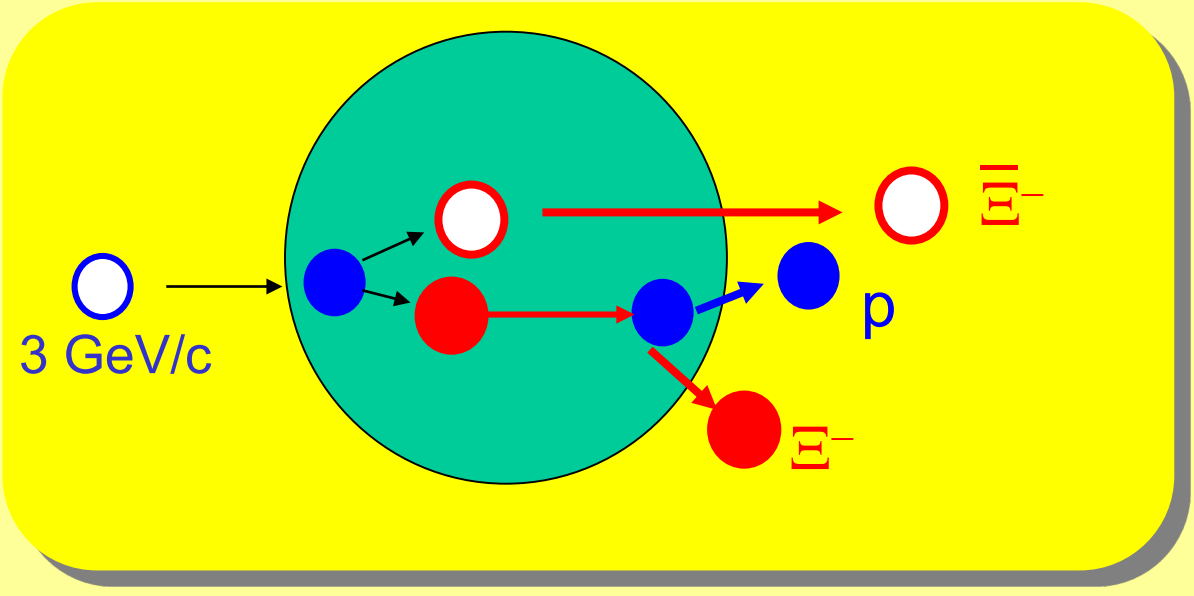
storage of K^- not possible ($c\tau$ = 3.7 m)

KEK-E176:	80 stopped Ξ
ß E373:	1000 stopped Ξ
AGS-E885:	9000 stopped Ξ

Production of low-momentum Ξ^-

J. Pochodzalla
MPI -HD

- $\Xi^- \bar{\Xi}^+$ production close to threshold (p_{TH} = 2.62 GeV/c)
- de-accelerate Ξ^- by Ξ^- p elastic scattering



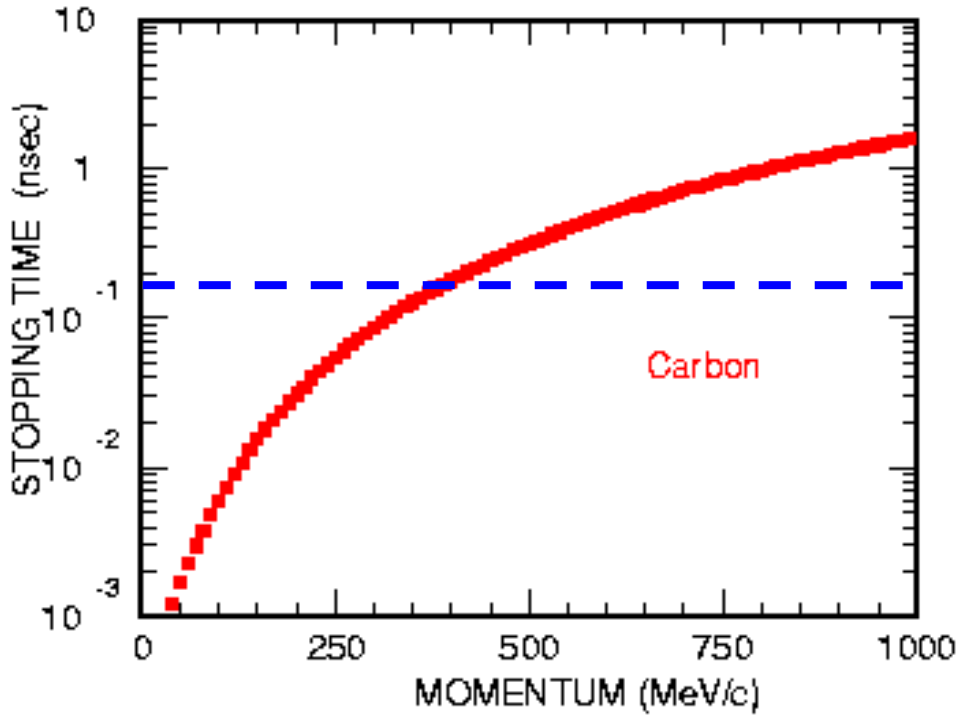
signature:

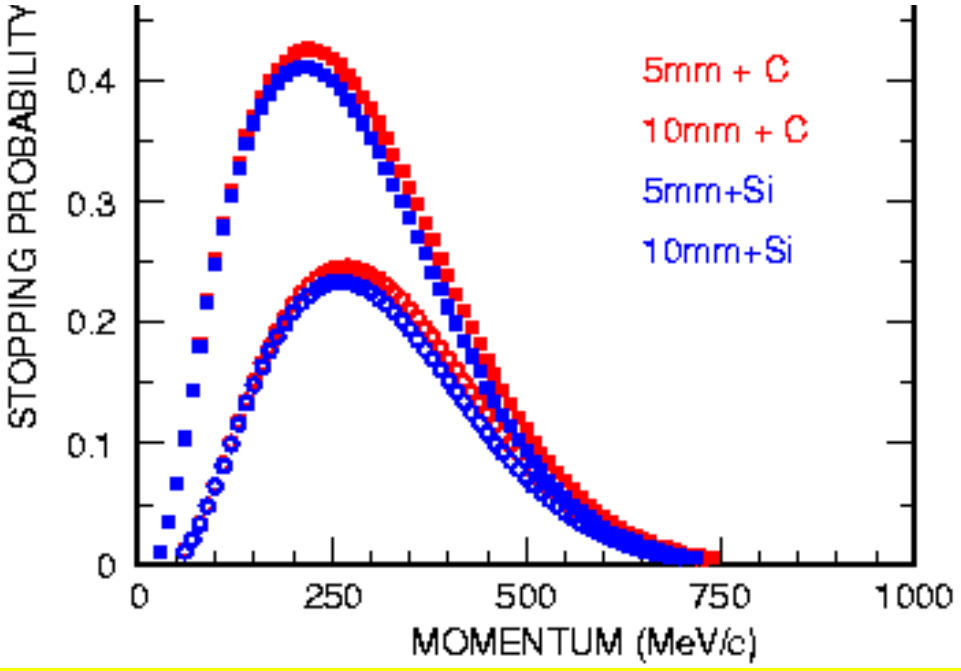
- $\bar{\Xi}^-$ with large momentum
- Ξ^- capture and secondary decay

Ξ^- Properties

J. Pochodzalla
MPI -HD

- Ξ^- mean life 0.164 nsec





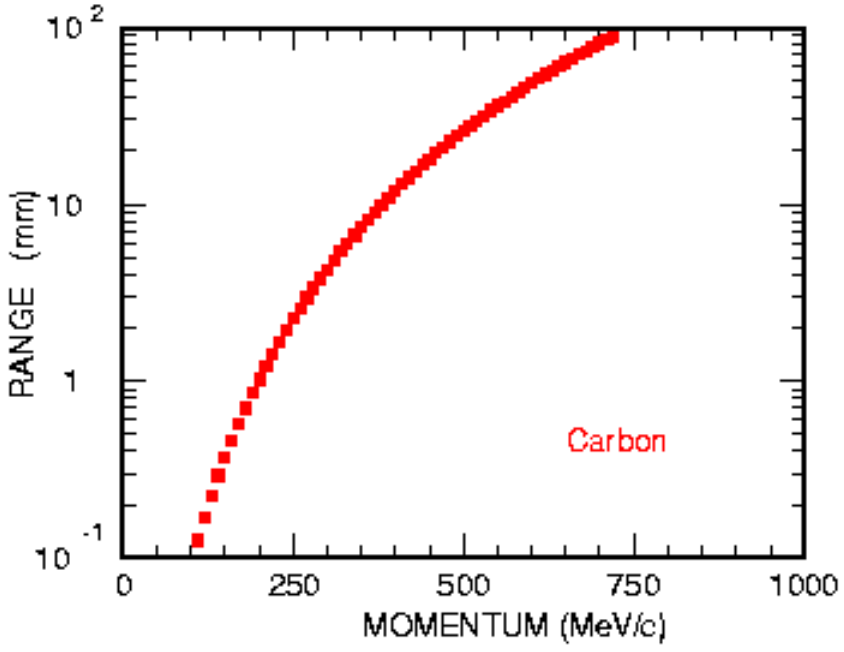
8 minimize distance *production à capture*

initial momentum 100-500 MeV/c

Tracking of Ξ^-

J. Pochodzalla
MPI -HD

- range a few mm

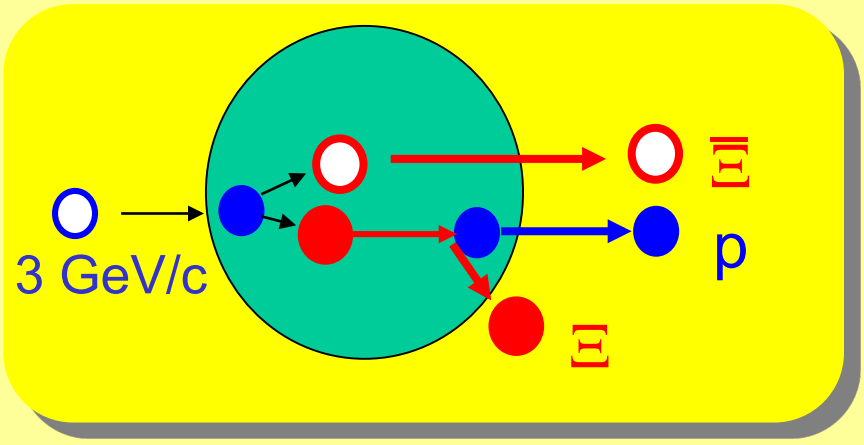


- several closely spaced layers of small micro-strip tracking detectors (diamond, Si) close (5mm) to the primary target resp. beam
- Ξ decay during cascading ($\sim 10^{-12}$s) small (Batty 95)

8 tracking and capture probability of $p_{CAP} \approx 0.15$ feasible

Production Probability for low-momentum Ξ⁻

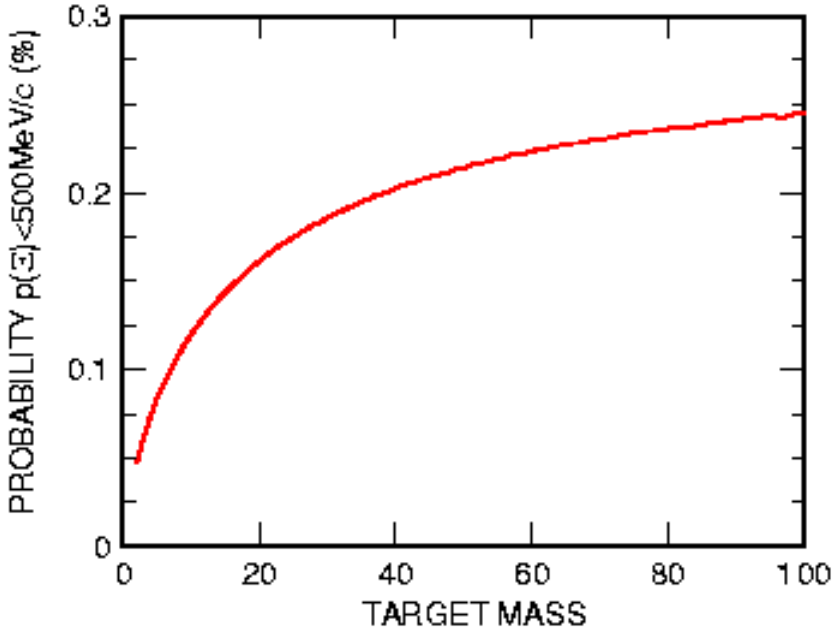
J. Pochodzalla
MPI -HD



- $\Xi\,\bar{\Xi}$ cross section ~ $A^{2/3}$
- $\bar{\Xi}$ absorption $\sigma = 0.8 \cdot \sigma_{ABS}(\bar{p}p)$
- elastic scattering σ_{EL}=10mb

$\sigma(\Xi^- p \Rightarrow \Xi^- p)$ = 13±6mb, Dover & Gal; $\sigma(\bar{p}p \Rightarrow \bar{p}p)$=22mb

- $\sigma(\Xi^- p \Rightarrow \Xi^- p) \propto exp(B \cdot t)$; B=5GeV^{-2}



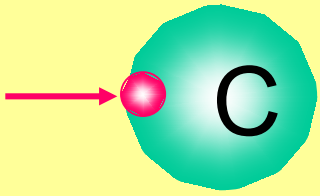
8

event probability p_{500} = 0.002

but: multiple scattering neglected

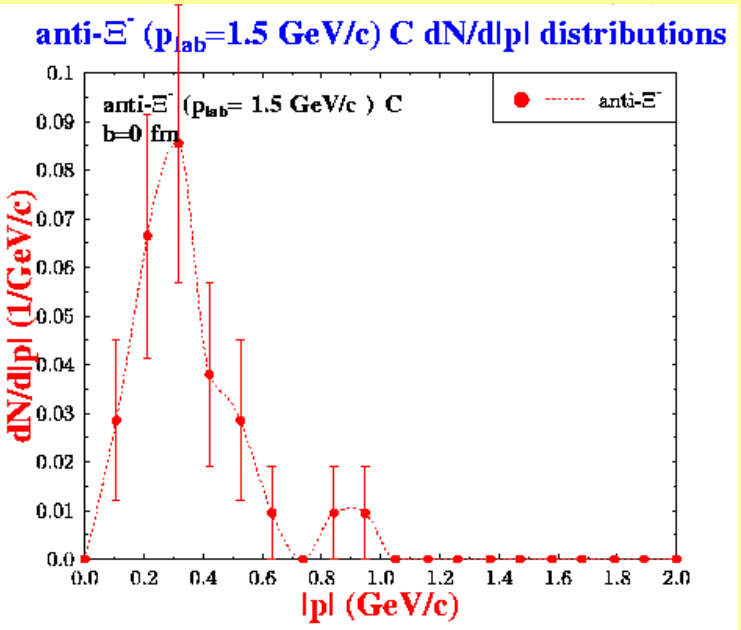
UrQMD

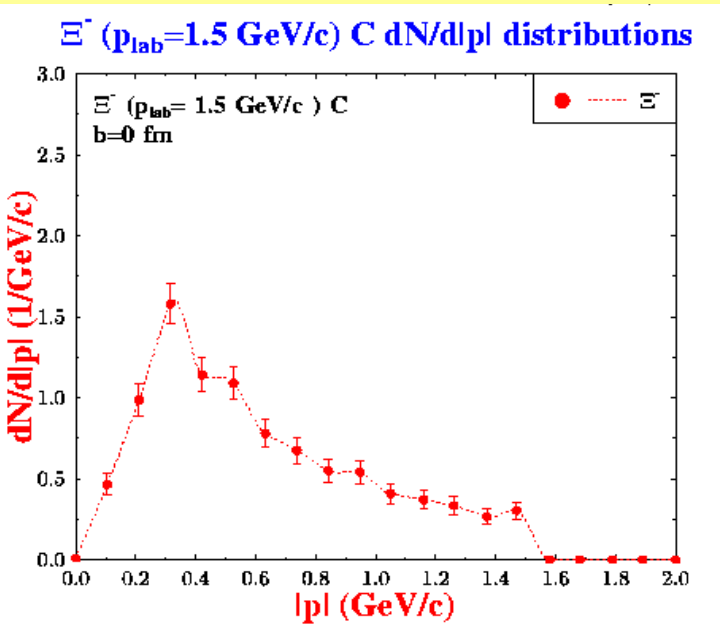
J. Pochodzalla
MPI -HD

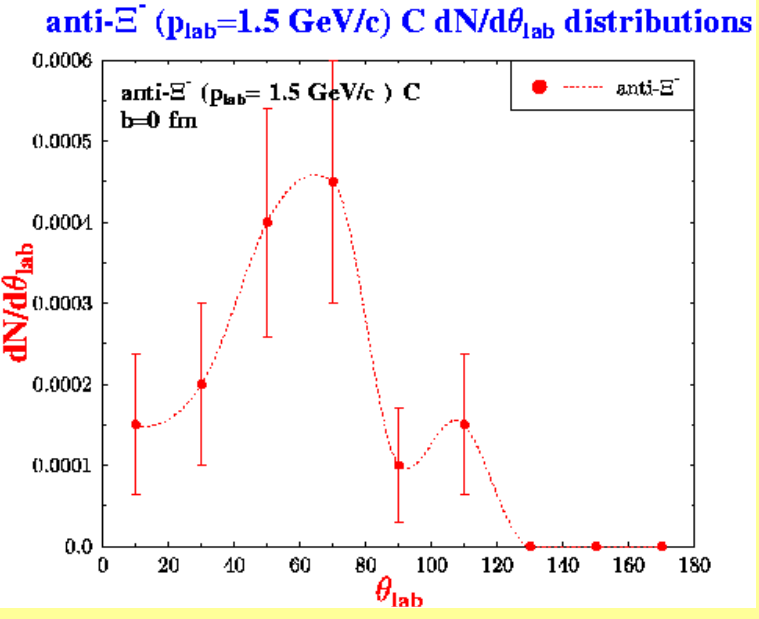


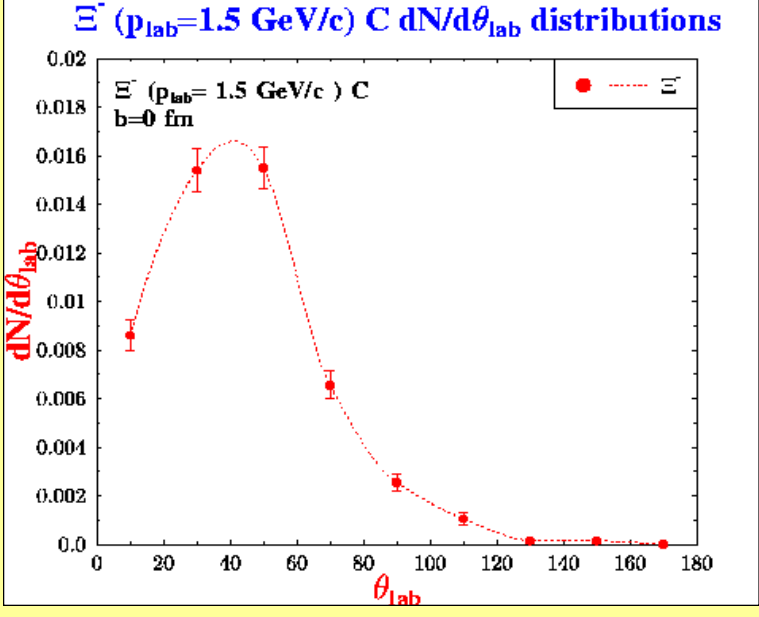
Sven Soff *et al.* (Frankfurt)

- 1000 $\bar{\Xi}$ or Ξ at b=0 with p=1.5 GeV/c









emission probability of $\bar{\Xi}$ at forward angles (Û large momenta) ~ 0.2%

probability for low momentum Ξ ~ 40%

total probability $p_{500} = 0.002 \cdot 0.4 \cdot A^{2/3} \sim 0.004$

Schematic Setup

J. Pochodzalla
MPI -HD

beam: 3 GeV/c, Ø £ 1mm

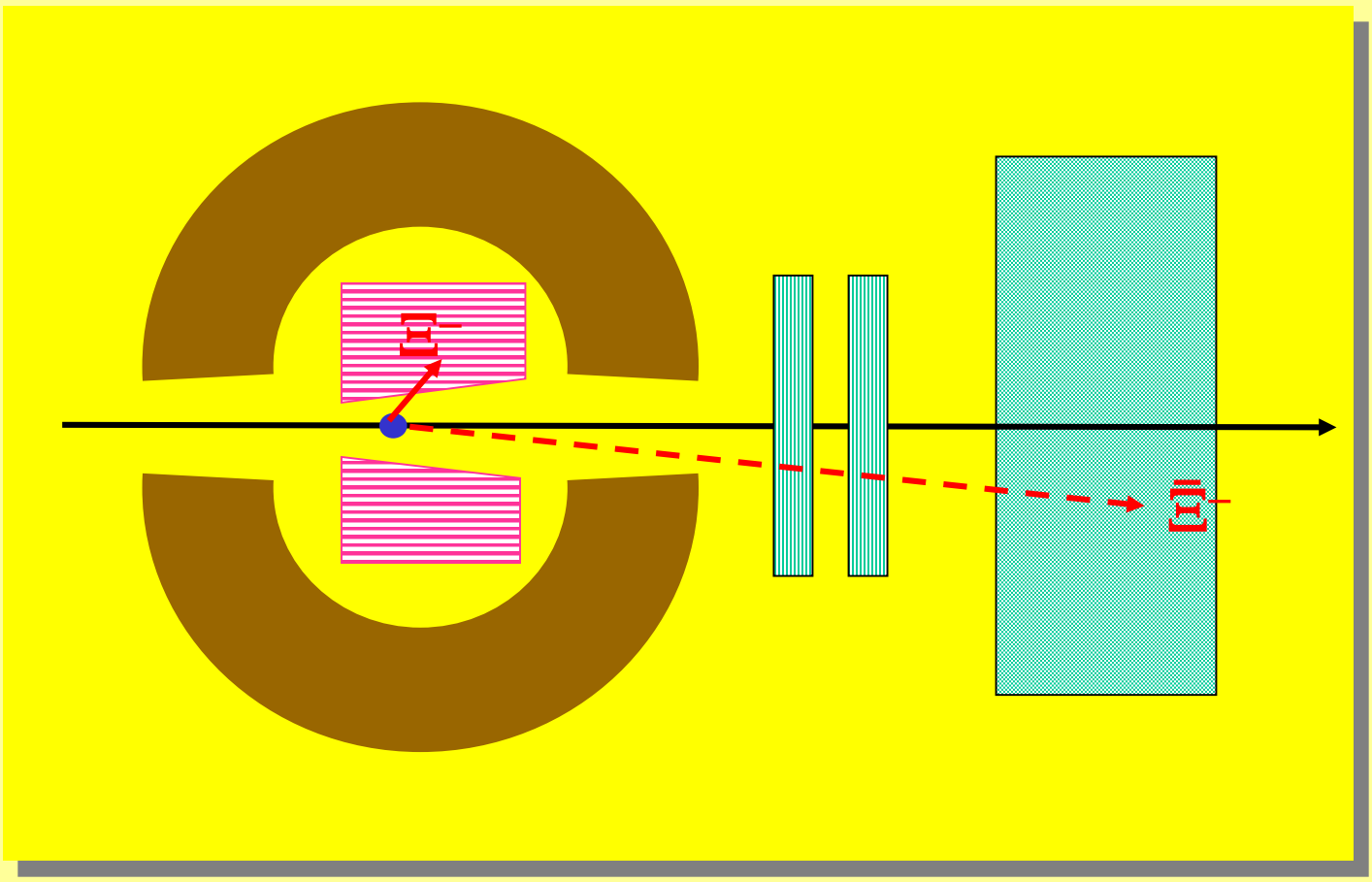
internal target (gas-jet e.g. Ne) width 1mm

diamond strip detector block: 26 mm thick; $\theta_{LAB} > 20^{o}$

forward tracking detectors: θ_{LAB} £ 20^{o}

(e.g. GEM, szintillators for stopped anti-protons with 1GeV/c)

"4π" Germanium ball



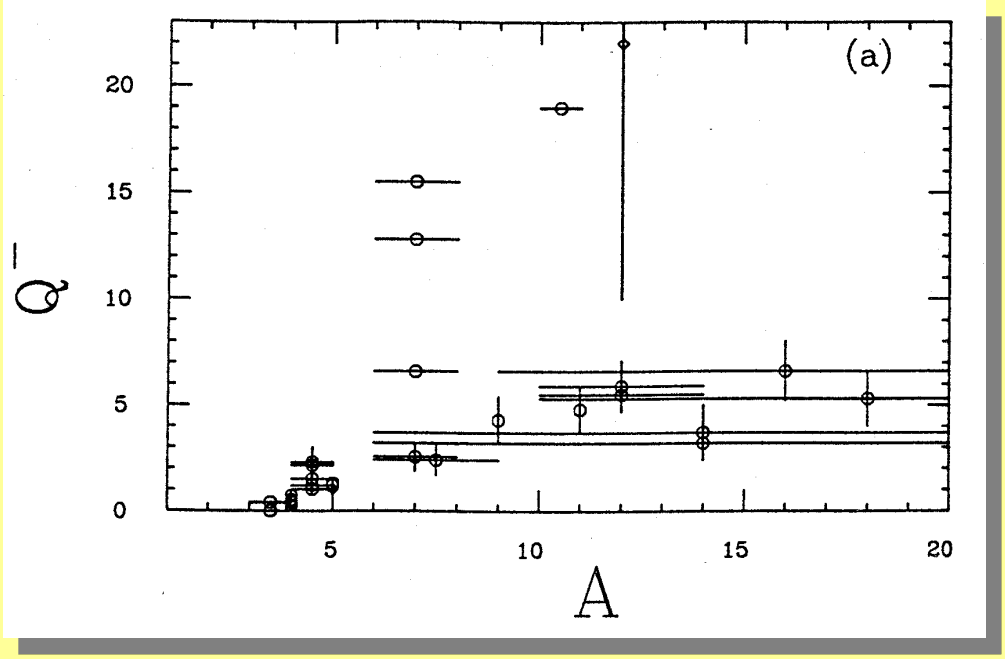
...additional tracking detectors for secondary decay products

Decay Properties

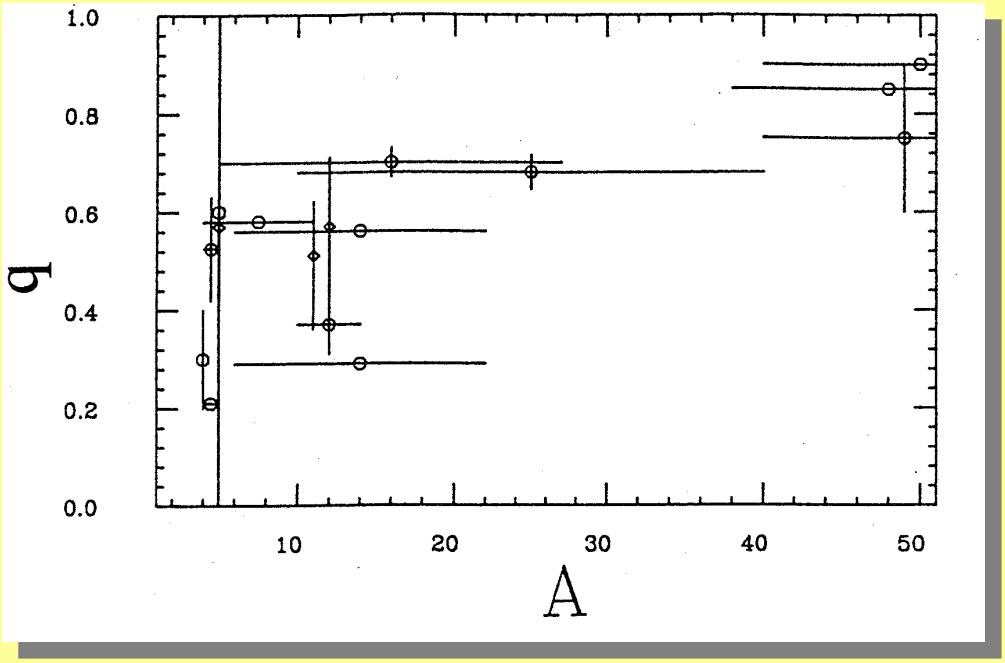
J. Pochodzalla
MPI -HD

- for heavy nuclei non-mesonic decay dominates

  non-mesonic: mesonic ≈ 5



- ΛN Þ NN ΔQ= 176 MeV: energetic nucleon
- (Λn Þ nn) : (ΛN Þ NN) ≈ 0.5



8 non-mesonic Ù decay with energetic proton has large probability in carbon $p_{NM} \approx 0.4$

Expected Count Rate

J. Pochodzalla
MPI -HD

- luminosity $10^{32}\,cm^{-2}s^{-1}$
- $\bar{\Xi}^{+}\Xi^{-}$ cross section 1μb for $\bar{p}p$ Þ 100 Hz
- p(100-500 MeV/c) $p_{500} \approx 0.003 \cdot 0.6 = 0.002$
- stopping and capture probability $p_{CAP} \approx 0.15$
- total ΛΛ conversion probability $p_{\Lambda\Lambda} \approx 0.05$

8 total ΛΛ hyper nucleus production 5 / hour

- gamma emission/event, $p_{\gamma} \approx 0.5$
- γ-ray peak efficiency $p_{GE} \approx 0.15$

8 total γ–rate ≈ 0.4/ hour

8 30 days beam time:

77000 stopped Ξ^{-} (KEK-E176: 80 ß E373: 1000)

3800 ΛΛ - hyper nuclei produced

~400 pionic decays

300 γ-transitions detected

Things To Do

J. Pochodzalla
MPI -HD

- complete microscopic calculation for anti-Ξ trigger
- detector studies (efficiencies...)
- background
- γ-spectrum
- …

8 spectroscopy of double-strange hypernuclei may be feasible !

- ξξξ