SigmaBar Lambda model

Walter Ikegami Andersson

Uppsala University
on behalf of the $\overline{\text{P}}$ANDA collaboration

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GSI

New decay models in pandaroot

Preparation of analysis tools for master thesis of Gabriela Perez

- Spin observables measurement
  $\overline{p}p \to \Sigma\Lambda$, $\Lambda \to p\pi$, $\Sigma \to \Lambda\gamma$
- New decay, transition form factor
  $\overline{p}p \to \Sigma\Lambda$, $\Lambda \to p\pi$, $\Sigma \to \Lambda e^+e^-$

Two new decay model in pandaroot

- $\overline{p}p \to \Sigma\Lambda$
  - Based on data parametrisation
- $\Sigma \to \Lambda e^+e^-$
  - Based on theoretical derivations

Previous measurement at LEAR

Differential cross section parametrized as

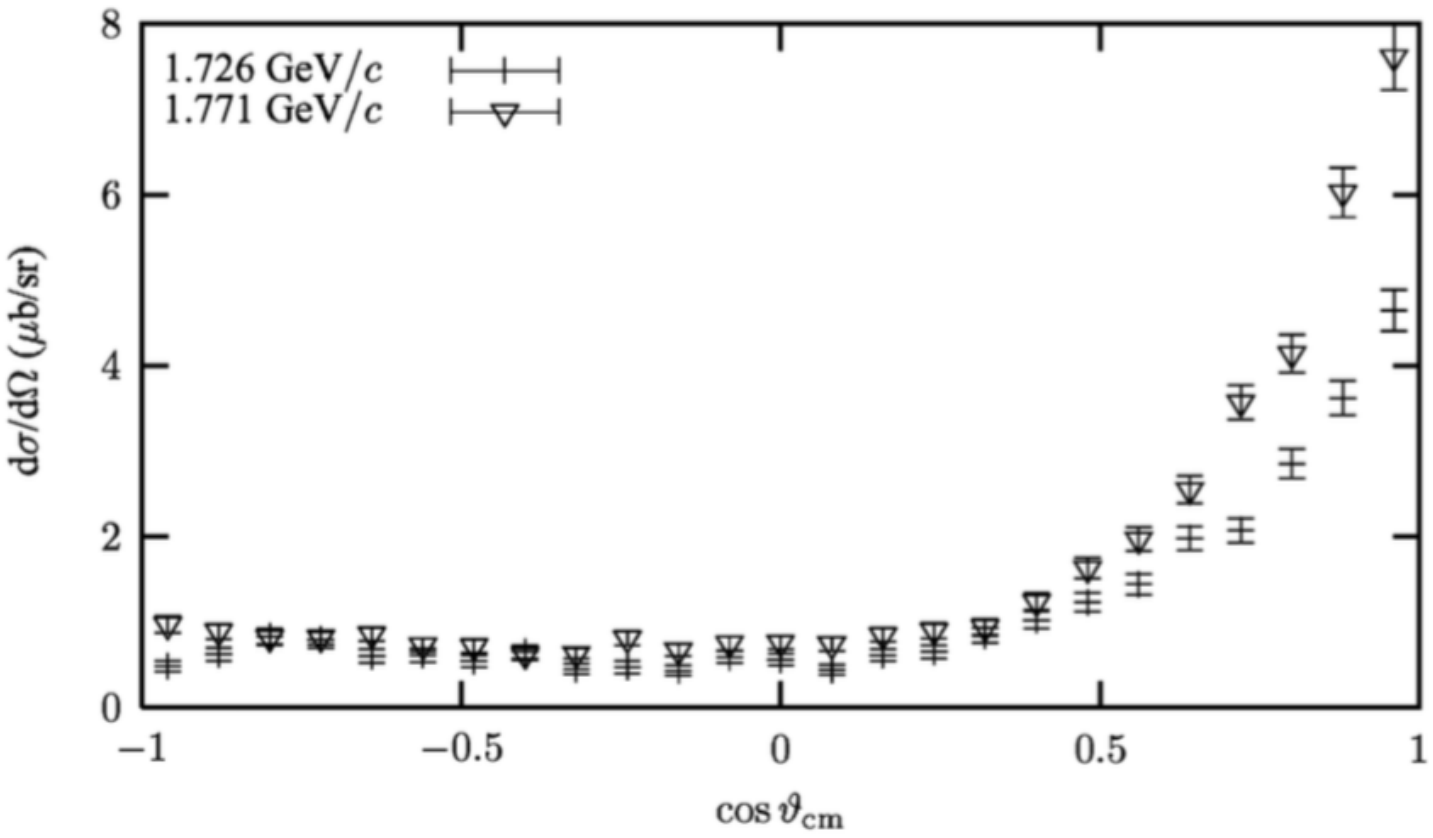
$$I \propto e^{-b|t|}$$

- t - momentum transfer squared
- b - slope parameter

Slope parameter measured by LEAR: $b \sim 11 - 14$ GeV^{-2}

E. Klempt et al. Physics Reports 368 (2002) 119–316

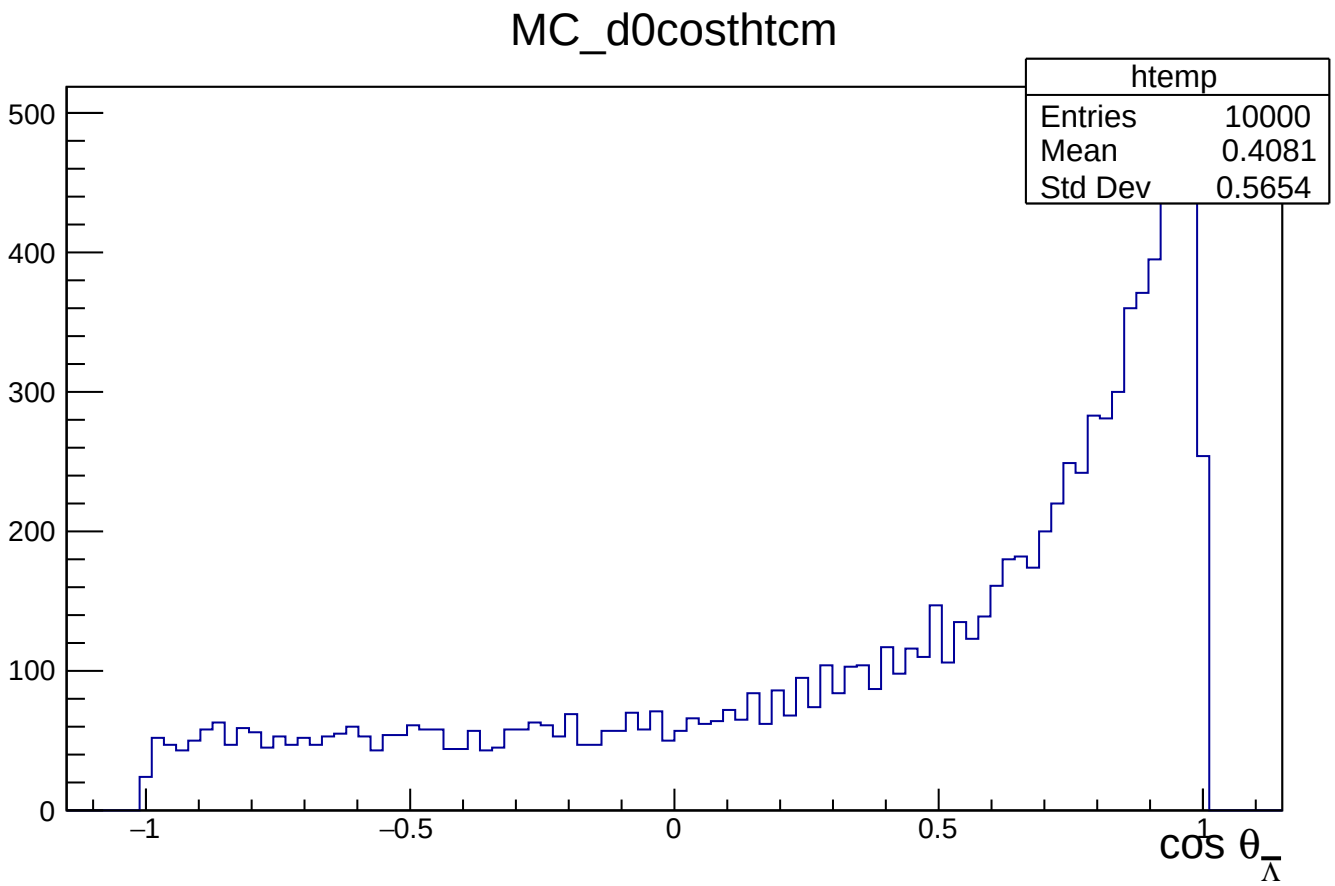
Previous measurement at LEAR



E. Klempt et al. Physics Reports 368 (2002) 119–316

Simulation test: MC truth

- Describe as flat distribution with exponential part
- Use one input variable: beam momentum



Dalitz decay $\Sigma \to \Lambda e^+ e^-$

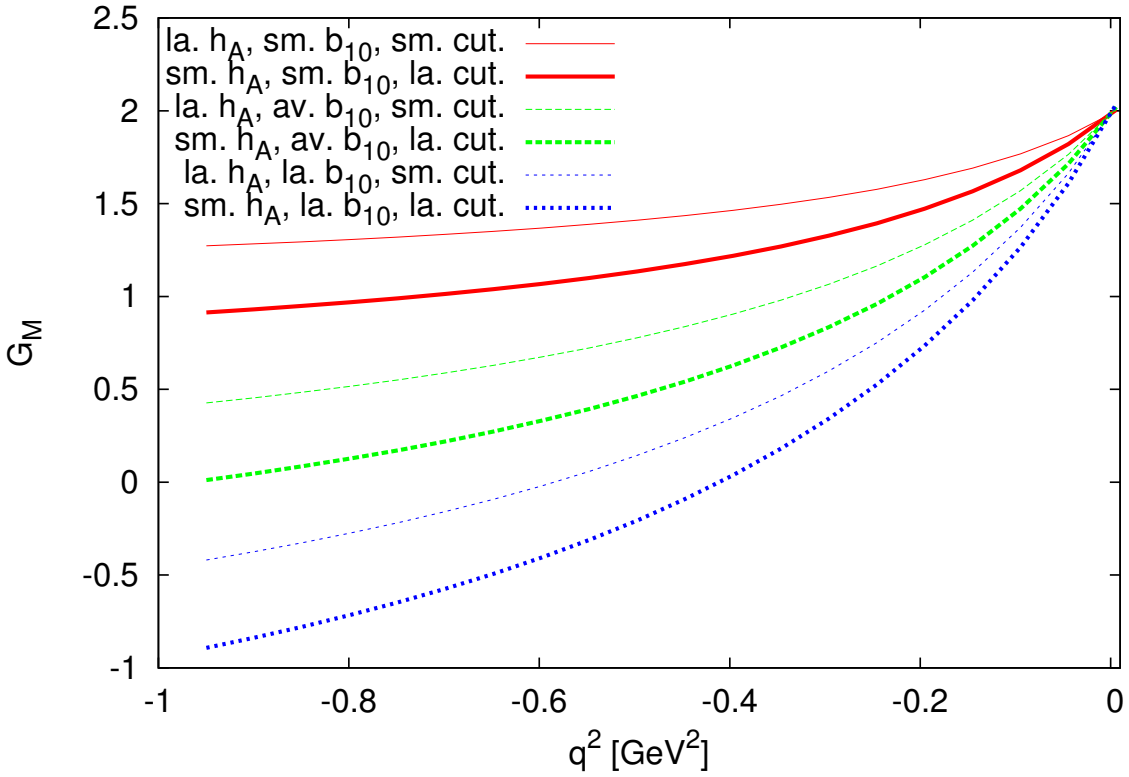
Motivation for styding decay

- $\Sigma \to \Lambda e^+ e^-$ never measured
- QED prediction: BR $\sim 10^{-3}$
- Transition form factors of hyperon
  $\to$ ingredient of understanding sturcture of hadrons
- Measuring G_M in time-like region
  $\to$ predictive power in space-like region

See presentation by Stefan Leupold at PANDA CM 17/1 March 6-10
See paper https://arxiv.org/pdf/1701.09130.pdf

C. Granados, S. Leupold, E. Perotti

Magnetic transition form factor Σ-Λ



- large uncertainty

↪ directly related to uncertainty in NLO low-energy constant b_{10}

↪ can be determined from measuring $G_M(0)$, $\left.\frac{dG_M}{dq^2}\right|_{q^2=0}$

$\Sigma \to \Lambda e^+ e^-$ Full differential distribution

Double differential decay width $\Sigma^0 \to \Lambda\, e^+ e^-$:

$$\frac{d^2\Gamma}{ds\, dz} = \frac{1}{(2\pi)^3\, 64 m_\Sigma^3}\, \lambda^{1/2}(m_\Sigma^2, s, m_\Lambda^2)\, \left(1 - \frac{4m_e^2}{s}\right)^{1/2} \overline{|\mathcal{M}|^2}$$

$$\begin{aligned}
\overline{|\mathcal{M}|^2} \quad = \quad & \frac{e^4}{s^2}\, 2((m_\Sigma - m_\Lambda)^2 - s) \\
& \Big\{ |G_E(s)|^2\, (m_\Lambda + m_\Sigma)^2\, \left(1 - \left(1 - \frac{4m_e^2}{s}\right) z^2\right) \\
& \quad + |G_M(s)|^2\, (s\,(1 + z^2) + 4m_e^2\,(1 - z^2))\Big\}\,.
\end{aligned}$$

Slide by Stefan Leupold

$\Sigma \to \Lambda e^+ e^-$ Full differential distribution, cont.

Independent kinematical variables:
$s := (p_{e^+} + p_{e^-})^2 = q^2$
z is cos of angle between e^- and Λ in rest frame of dilepton

$$z := \frac{\Delta m^2}{(\Delta m^2)_{\max}}$$

with $\Delta m^2 := (p_{e^+} + p_\Lambda)^2 - (p_{e^-} + p_\Lambda)^2$ and

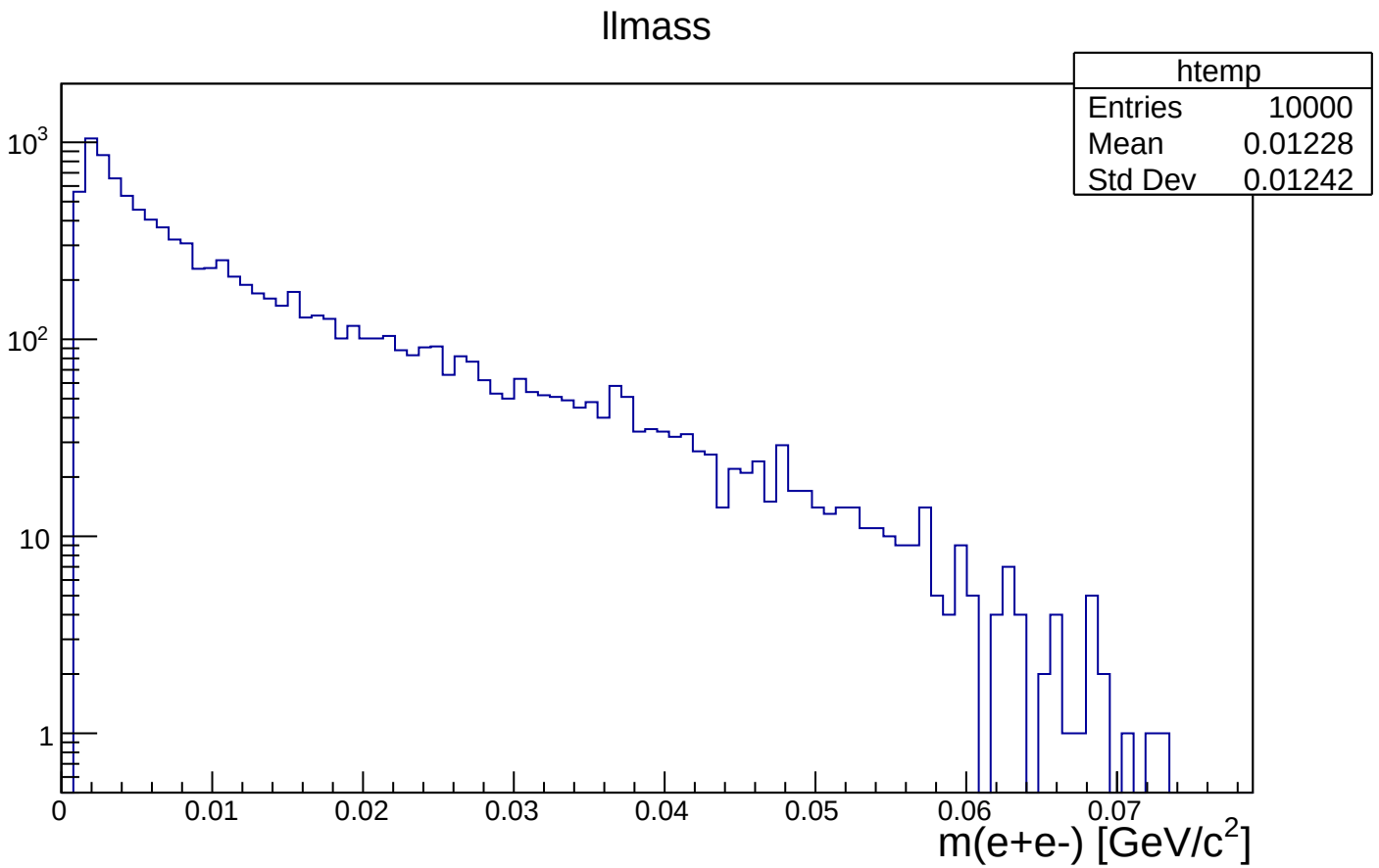
$$(\Delta m^2)_{\max} := \lambda^{1/2}(m_\Sigma^2, s, m_\Lambda^2)\sqrt{1 - \frac{4m_e^2}{s}}\,.$$

kinematical variables cover the ranges
$z \in [-1, 1]$ and $4m_e^2 \leq s \leq (m_\Sigma - m_\Lambda)^2$

Källén function $\lambda(a, b, c) := a^2 + b^2 + c^2 - 2(ab + bc + ac)$

$\Sigma \to \Lambda e^+ e^-$ Full differential distribution, cont.

- q^2 region small $\to$ expect fluctuation in $\mathcal{O}(1\%)$
- Assume $G_M(q^2) = a + bq^2$, $a = 1.98$ from χPT
- Assume $G_E(q^2) = a + bq^2$, $a = 0$
- Slopes of G_E and G_M are input parameters



Usage in Decay File

- LambdaSigmaBar input: beam momentum
- SigmaDalitz input: slope of G_E, G_M

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noPhotos

Decay pbarpSystem
1.0 anti-Sigma0 Lambda0          LambdaSigmaBar 1.771;
Enddecay

Decay anti-Sigma0
   1.0  anti-Lambda0 e+ e-       SigmaDalitz 0. 3.597;
Enddecay

Decay anti-Lambda0
   1.0  anti-p- pi+              PHSP;
Enddecay

Decay Lambda0
   1.0  p+ pi-                   PHSP;
Enddecay

End
```

Usage in Decay File, charge conjugate

Charge conjugate also possible. Anti-particle always forward-boosted.

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noPhotos

Decay pbarpSystem
0.5 anti-Sigma0 Lambda0          LambdaSigmaBar 1.771;
0.5 anti-Lambda0 Sigma0          LambdaSigmaBar 1.771;
Enddecay

Decay anti-Sigma0
   1.0  anti-Lambda0 gamma       PHSP;
Enddecay

Decay Sigma0
   1.0 Lambda0 gamma             PHSP;
Enddecay

Decay anti-Lambda0
   1.0  anti-p- pi+              PHSP;
Enddecay

Decay Lambda0
   1.0  p+ pi-                   PHSP;
Enddecay

End
```

The End

Thank you for your attention!

Backup