

KLF: K_L production and transport

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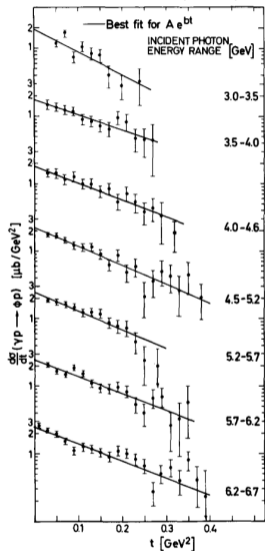
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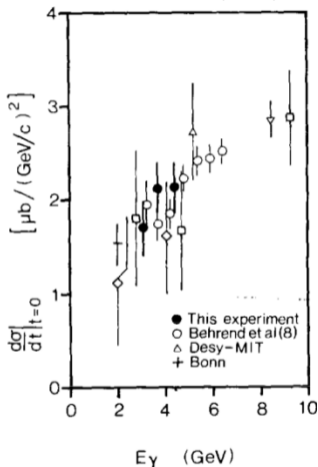
- 1 $\gamma + p \rightarrow \phi + p, \phi \rightarrow K_L K_S$ production model
- 2 Inclusive $\gamma + p \rightarrow K_L + X$ production in PYTHIA
- 3 K_L transport and rates at the cryo target

$\gamma p \rightarrow \phi(1020)p$ reaction and its modelling

Behren, NP B144 (1978)

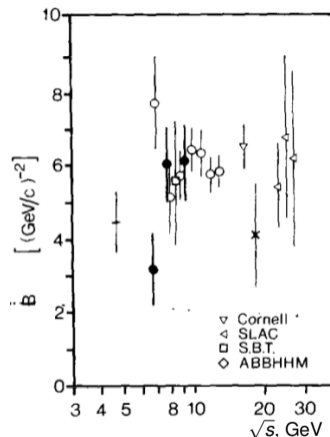


Barber, PLB 79 (1978)



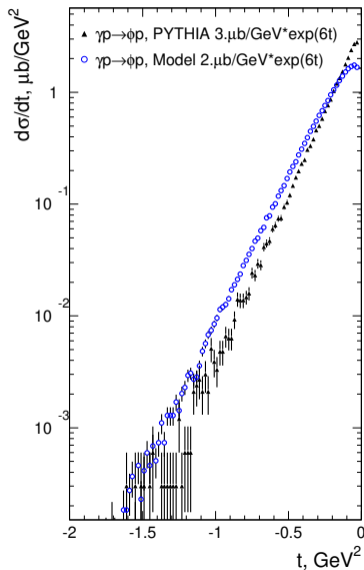
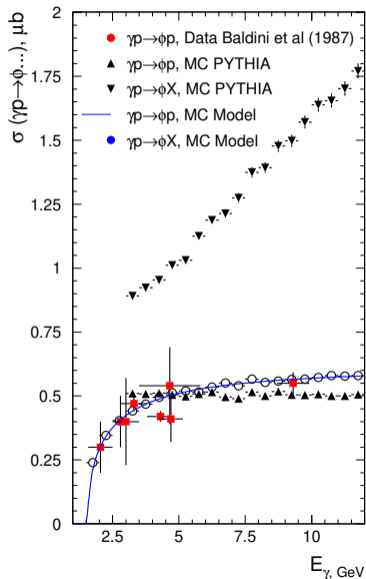
Parametrization
 $d\sigma/dt = A(s) \cdot \exp(B(s)t)$
 $\sigma_{tot}(s) \approx A/B$

Barber, PLB 79 (1978)



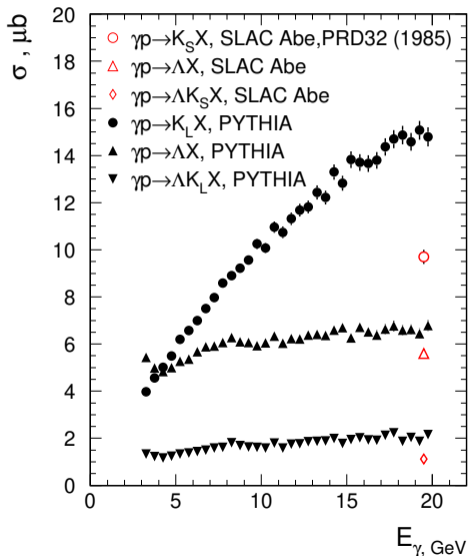
- $B(s) \approx 5-6 \text{ GeV}^{-2}$ const
- $A(s)$ a weak dependence

$\gamma p \rightarrow \phi(1020)p$ reaction and its modelling



- Model: fit to the data
 $d\sigma/dt = A(s) \cdot \exp(6t)$
 $1.6 < E_\gamma < 12 \text{ GeV}$
- PYTHIA applicable at $E_\gamma > 3 \text{ GeV}$, used in $3 < E_\gamma < 12 \text{ GeV}$
- PYTHIA for $\gamma p \rightarrow \phi p$ - close to the model and the data
- PYTHIA for $\gamma p \rightarrow \phi X$ inclusive - larger, but contributes little at small K angles
- PYTHIA: ϕ decay is simulated isotropically (not helicity-based). No significant effect on the K angular distribution is observed.

K_L inclusive production in PYTHIA

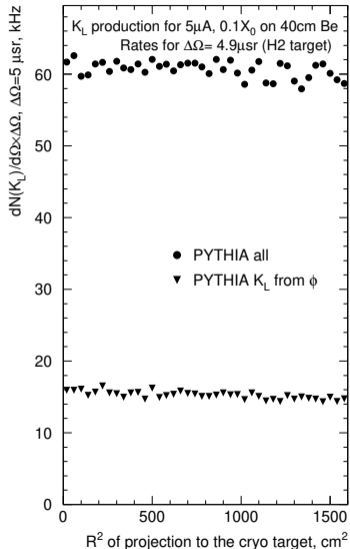
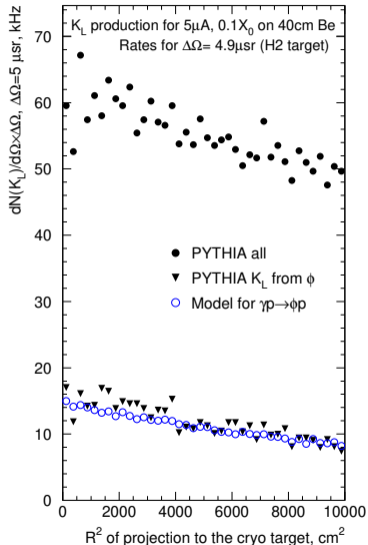


- Only one measurement on inclusive K_L photoproduction at $E_\gamma \leq 20$ GeV: SLAC at 20 GeV (Abe et al PRD 32, 2869 (1985))
- PYTHIA at 20 GeV compared to the SLAC measurement K_L and K_S are produced at the same rate
 - $\Lambda + X$ close to experiment
 - $K_L + X$ (or $K_S + X$) 40% higher than experiment
 - $\Lambda K_S + X$ twice higher than experiment

Reaction	E_γ GeV	$\sigma, \mu\text{b}$	
		Experiment	PYTHIA
$\gamma + p \rightarrow K_L + X$	20	9.7 ± 0.3	15.0
$\gamma + p \rightarrow \Lambda + X$	20	5.6 ± 0.2	6.3
$\gamma + p \rightarrow \Lambda K_S + X$	20	1.13 ± 0.06	2.0

PYTHIA may overestimate K_L production by a factor 1.5 -2

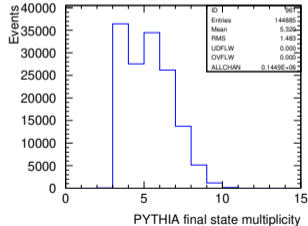
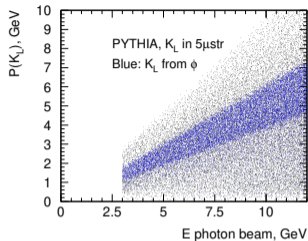
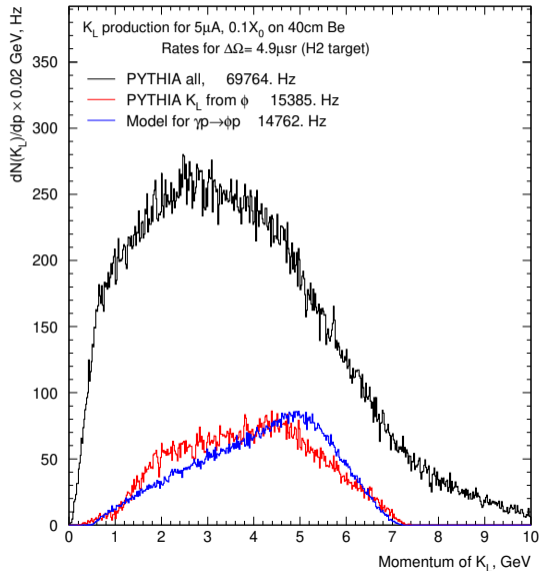
K_L production and its angular dependence



- Photon flux simulated for $5\mu\text{A}$ 12 GeV beam, $0.1X_0$ radiator, 70 m distance to a $\varnothing 6$ cm Be target. For $3 < E_\gamma < 12$:
 - Richard's code: $3.0 \cdot 10^{12}$ Hz for 0.014 cm radiator, $4.0 \cdot 10^{12}$ Hz for no collimation
 - Simple check

$$5 \cdot 10^{-6} / 1.6 \cdot 10^{-19} \cdot 0.1 \cdot \ln \frac{12}{3} = 4.3 \cdot 10^{12} \text{ Hz (no collimation)}$$
 - Used: $3.0 \cdot 10^{12}$ Hz, spectrum from *cohbrem*
- Be target: 40 cm (74 g/cm^2), $\varnothing 6$ cm
- Cryo target $\varnothing 6$ cm at 24 m from the Be target
- Projection of the K direction to the cryo target: uniform density for $R < 50$ cm

K_L projection to the cryo target



• Hyperons in $\approx 35\%$ of events

K_L flux at the cryo target

Photon angular distribution is dominated by multiple scattering of the beam in the radiator.

Model: uniformly distributed radiation point

Photon rates for $E_\gamma > 3.0$ GeV,

$r_\gamma(\text{Be}) < R$

#1 - Richard's calculator

#2 - Used model

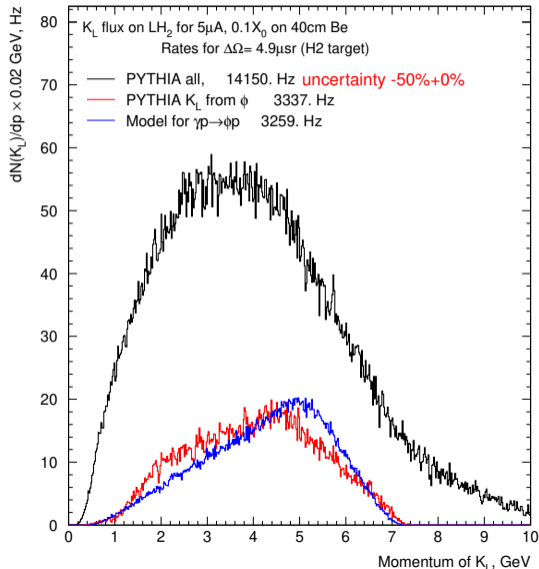
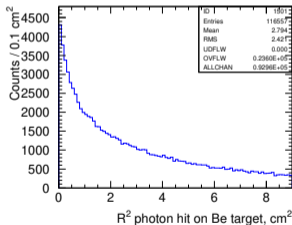
R, cm	Rate #1	Rate #2
100	4.0 THz	4.0 THz
3.0	75%	80%
2.0	50%	57%
1.5	35%	42%
1.0	21%	25%

Transport

- Cryo target is seen as a fixed solid angle from any point in the Be target
- The elliptical aperture does not obstruct kaons
- Decays: assigned weight $\exp(-24\text{m}/15\text{m}) \cdot m_K/p_K$
- 27% K_L go through W plug

Eberhard et al, NIMA, 350 (1994), calculations for 0.35-2.6 GeV:

- 10 cm W at 2 GeV: 0.23 $\Rightarrow \ell_{\text{abs}}=7.0$ cm Absorption:
- 16 cm Cu at 2 GeV: 0.27 $\Rightarrow \ell_{\text{abs}}=12.0$ cm further studies
- For 80/20% W/Cu 16.5 g/cm³ $\ell_{\text{abs}}=7.8$ cm needed



Summary

- K_L production simulated using:
 - A data-based model for $\gamma p \rightarrow \phi p$
 - PYTHIA ($E_\gamma > 3$ GeV) for inclusive $\gamma p \rightarrow K_L X$
PYTHIA may overestimate the inclusive production by a factor 1.5 - 2
- K_L flux on the cryo target was evaluated taking into account absorption in the W plug and decays:
 - 3.3 kHz from $\gamma p \rightarrow \phi p$
 - 14 kHz from PYTHIA $\gamma p \rightarrow K_L X$
7 - 10 kHz considering the PYTHIA's uncertainty
Inclusive production also populates low K_L momentum range more than ϕ production
 - Other uncertainties: the absorption model. Further studies needed.