KLF: K_L production and transport

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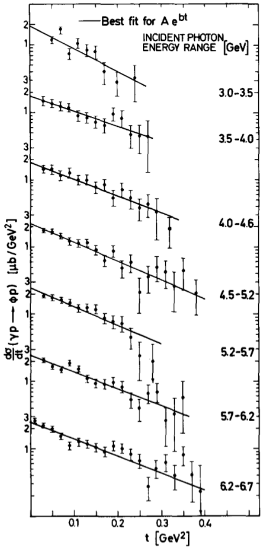
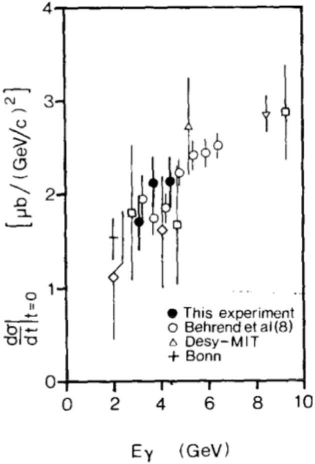
Outline

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

Behren, NP B144 (1978)



Barber, PLB 79 (1978)



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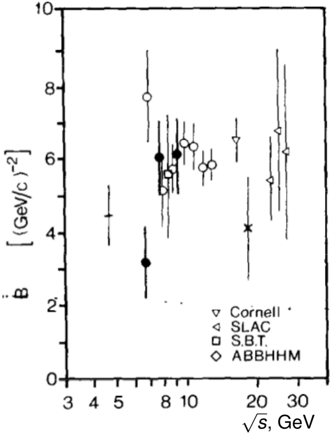


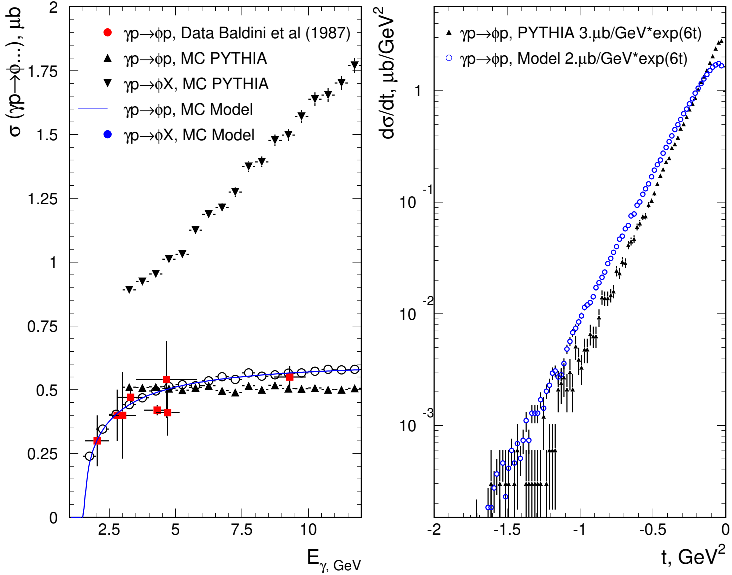
Parametrization

$d\sigma/dt = A(s) \cdot \exp(B(s)t)$

$\sigma_{tot}(s) \approx A/B$

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

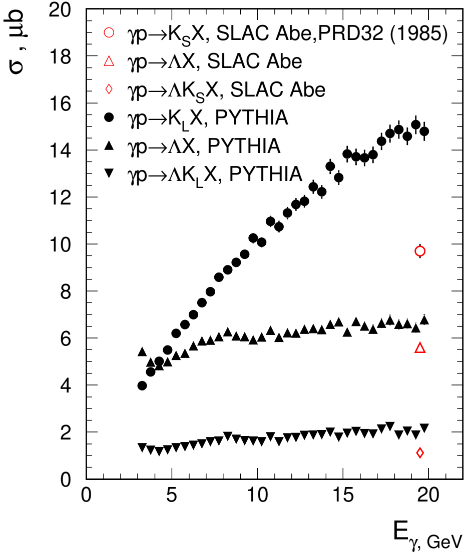
$\gamma p \to \phi(1020)p$ reaction and its modelling



- Model: fit to the data $d\sigma/dt = A(s) \cdot \exp(6t)$ $1.6 < E_\gamma < 12$ GeV
- PYTHIA applicable at $E_\gamma > 3$ GeV, used in $3 < E_\gamma < 12$ GeV
- PYTHIA for $\gamma p \to \phi p$ - close to the model and the data
- PYTHIA for $\gamma p \to \phi X$ 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

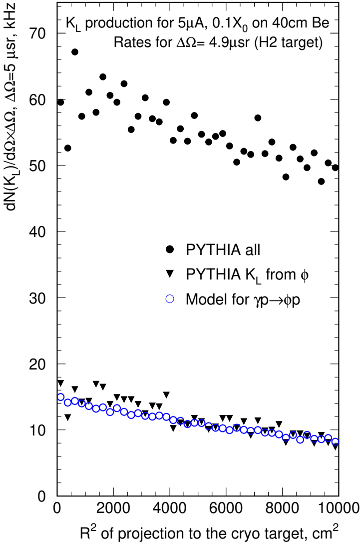


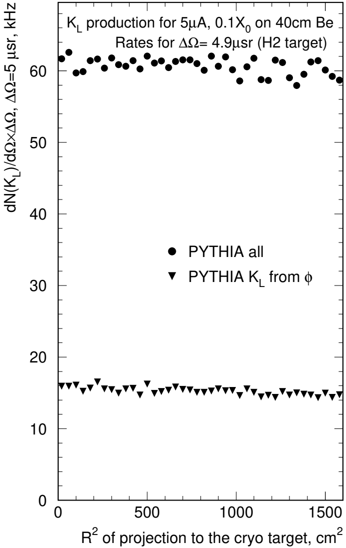
- Only one measurement on inclusive K_L photoproduction at $E_\gamma \leq 20$ GeV: SLAC at 20 GeV (*Abe et al PRD 32, 2869 (1985)*)
- PYTHIA at 20 GeV compared to the SLAC measurement
  K_L and K_S are produced at the same rate
  - $\Lambda + X$ close to experiment
  - $K_L + X$ (or $K_S + X$) 40% higher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

Reaction	E_γ GeV	σ, μb 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 μA 12 GeV beam, $0.1X_0$ radiator, 70 m distance to a ⌀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 $5 \cdot 10^{-6}/1.6 \cdot 10^{-19} \cdot 0.1 \cdot \ln\frac{12}{3} = 4.3 \cdot 10^{12}$ Hz (no collimation)
  - Used: $3.0 \cdot 10^{12}$ Hz, spectrum from *cohbrems*
- Be target: 40 cm (74 g/cm^2), ⌀6 cm
- Cryo target ⌀6 cm at 24 m from the Be target
- Projection of the K direction to the cryo target: uniform density for $R < 50$ cm

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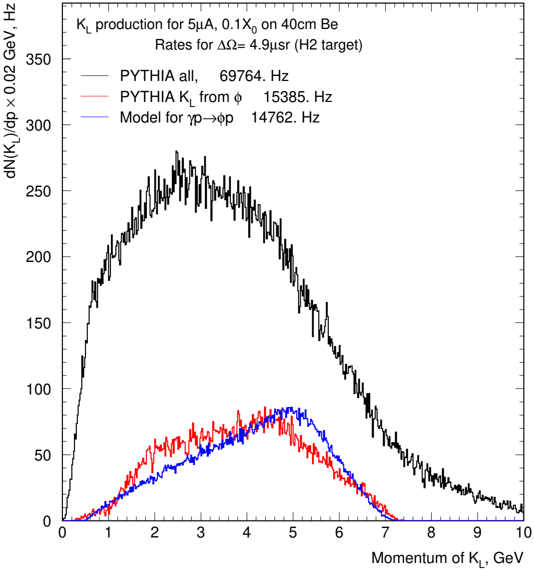
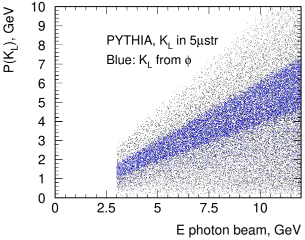
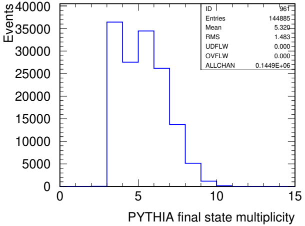
K_L projection to the cryo target







- Hyperons in ≈ 35% of events

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K_L flux at the cryo target

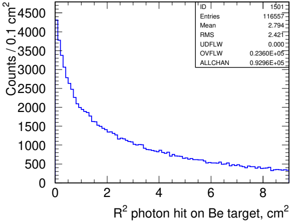
Photon angular distribution is dominated by multiple scattering of the beam in the radiator.
Model: uniformly distributed radiation point

Photon rates for $E_\gamma > 3.0$ GeV, $r_\gamma(Be) < R$
#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

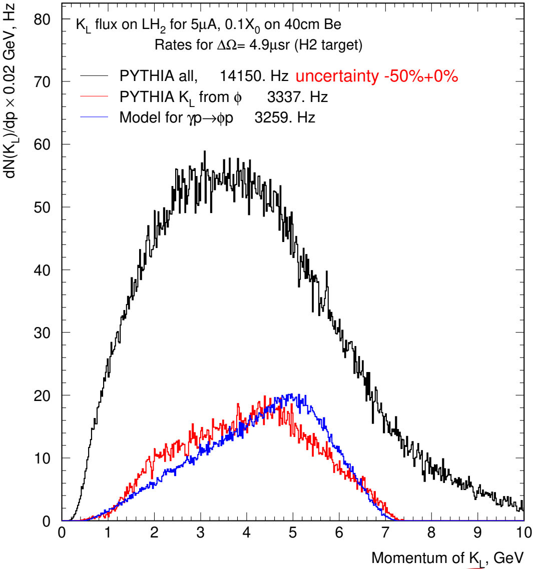
- Cryo target is seen as a fixed solid angle from any point in the Be target
- The elliptical aperture does not obstruct kaons
- Decays: assigned weight $\exp(-(24\mathrm{m}/15\mathrm{m}) \cdot m_K/p_K)$
- 27% K_L go through W plug



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

- 10 cm W at 2 GeV: 0.23 $\Rightarrow \ell_{abs}$=6.8 cm
- 16 cm Cu at 2 GeV: 0.27 $\Rightarrow \ell_{abs}$=12.2 cm
- For 90/10% W/Cu 16.5 g/cm^3 ℓ_{abs}=7.8 cm

Absorption: further studies 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.