K^+ photo-production at LEPS

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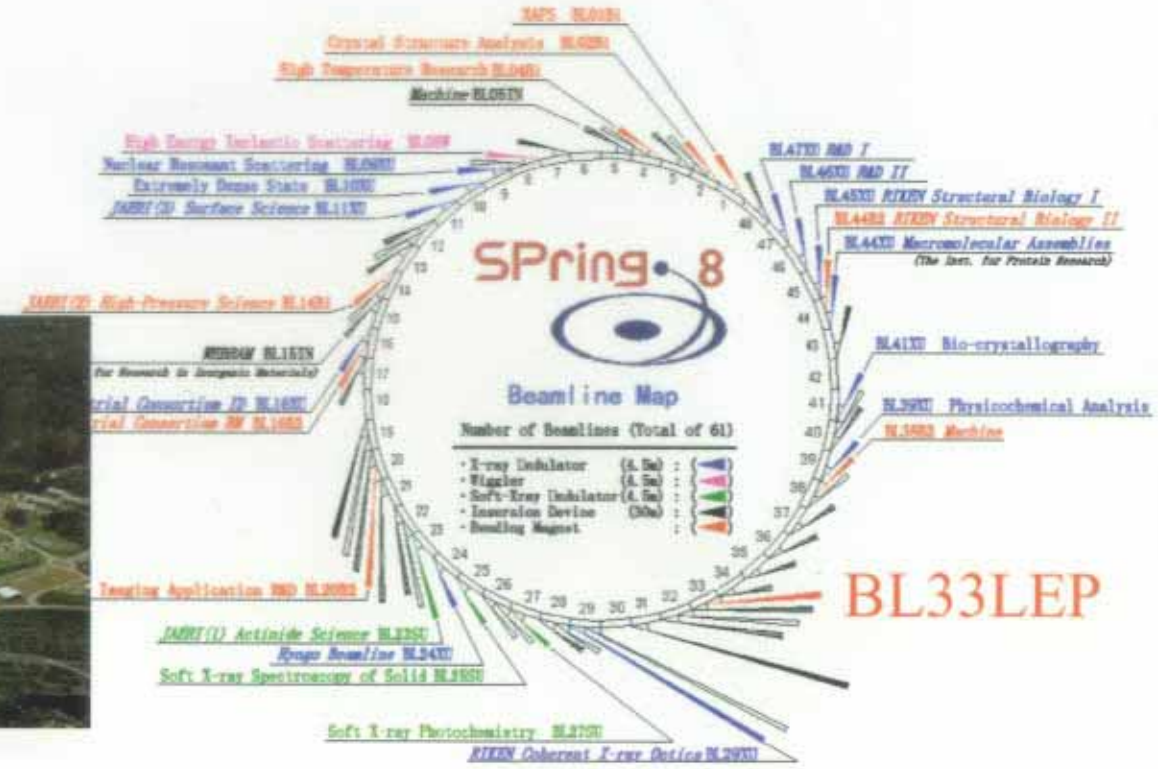
for the
LEPS collaboration

- Introduction
- Laser-Electron-Photon facility at SPring-8
- K^+ photo-production
  - Theoretical background
  - Experimental details
  - First results
- Conclusion/Outlook
- $\gamma + n \rightarrow K^+K^-$? $\rightarrow$ 'Z$^+$'
  - $\Lambda(1405)$
  - ϕ photoproduction
  - ω " "
  - η, η' " "

SPring-8

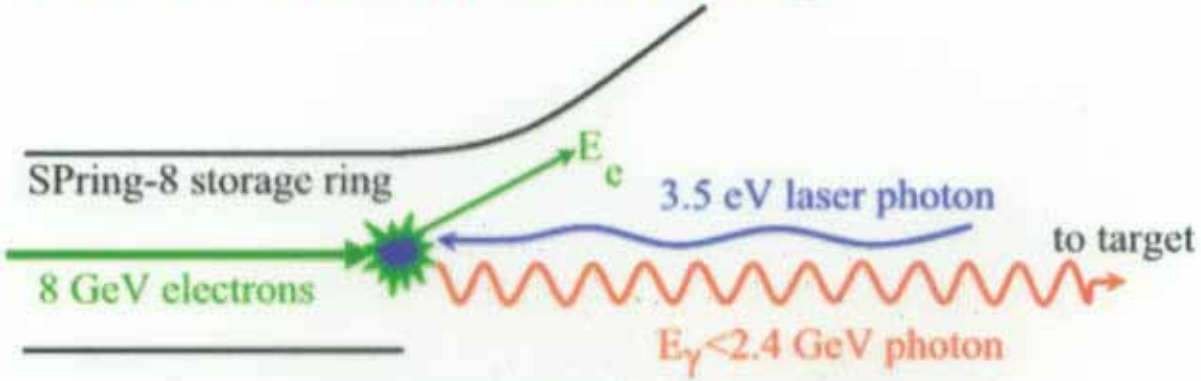
SPring-8
(Super Photon ring-8 GeV)

- Third-generation synchrotron radiation facility
- Circumference: 1436 m
- 8 GeV
- 100 mA
- 62 beamlines



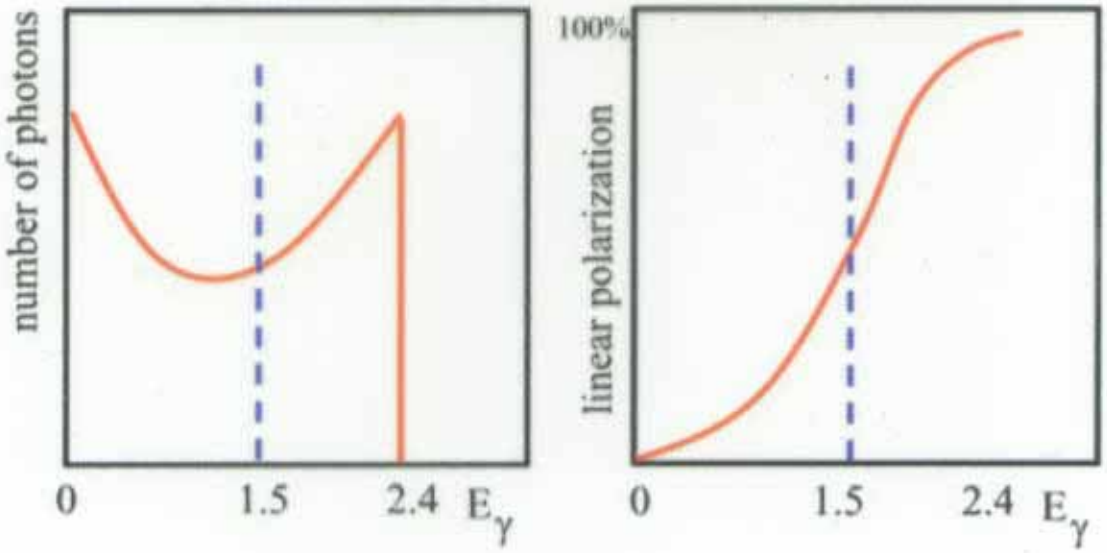
Producing GeV photons

Backward Compton Scattering



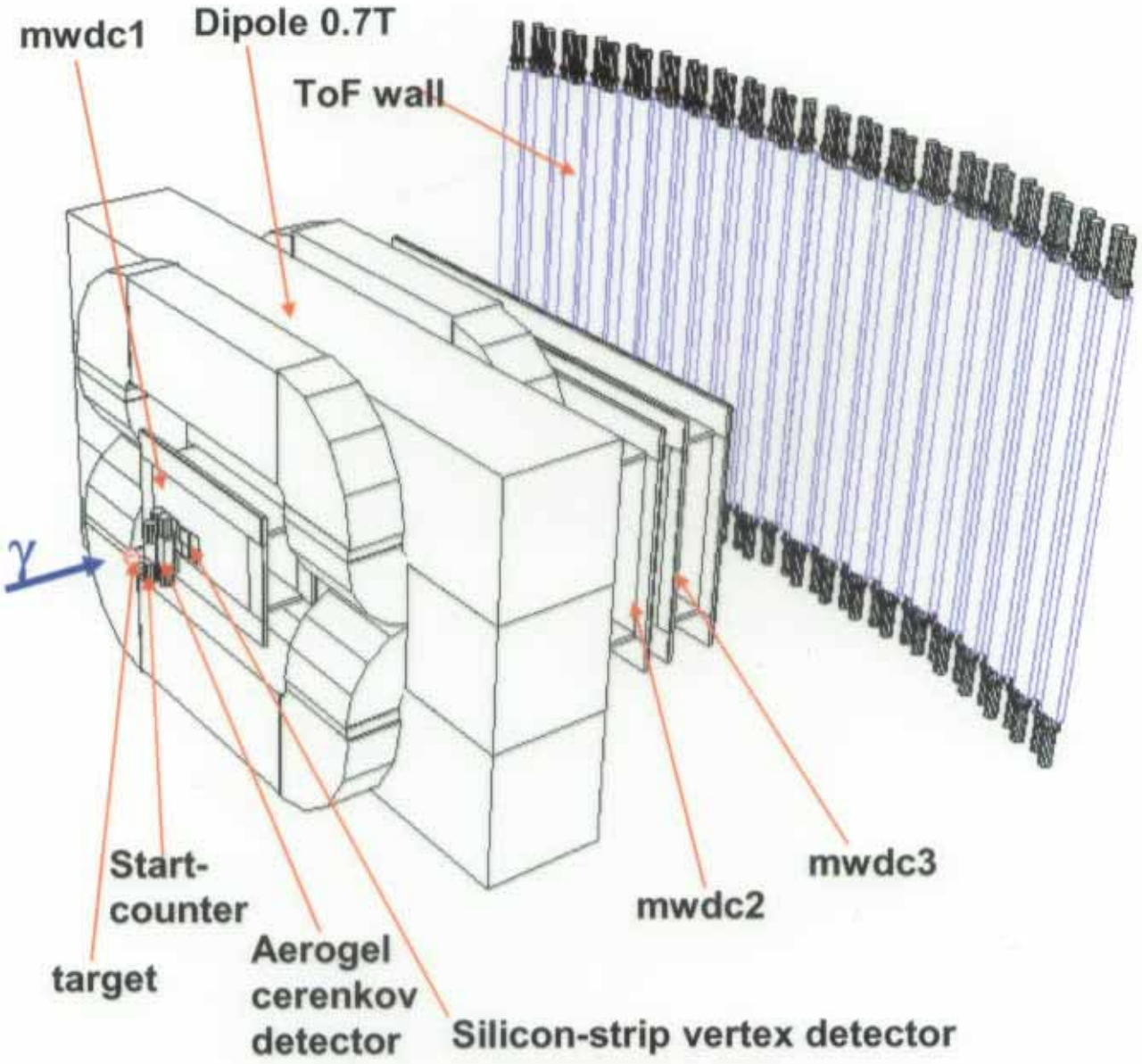
E_e(after BCS)=8 GeV-E_γ

→ measured, so E_γ known (E_γ>1.5 GeV)!



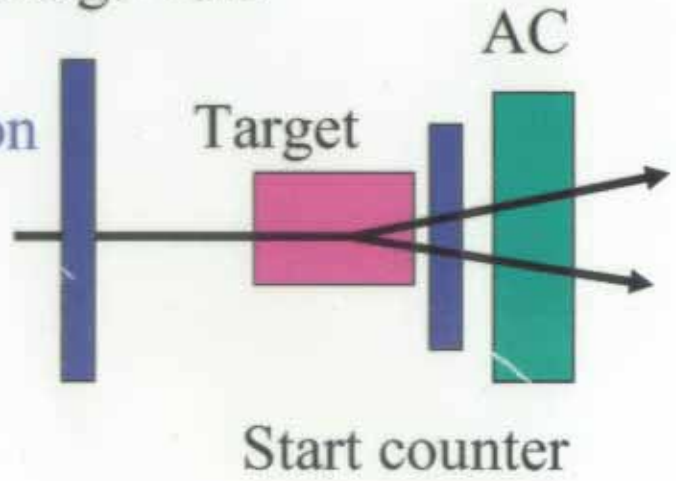
$$E_\gamma = \frac{4E_{laser}E_e^2}{m_e^2 + 4E_{laser}E_e}$$

The LEPS detector

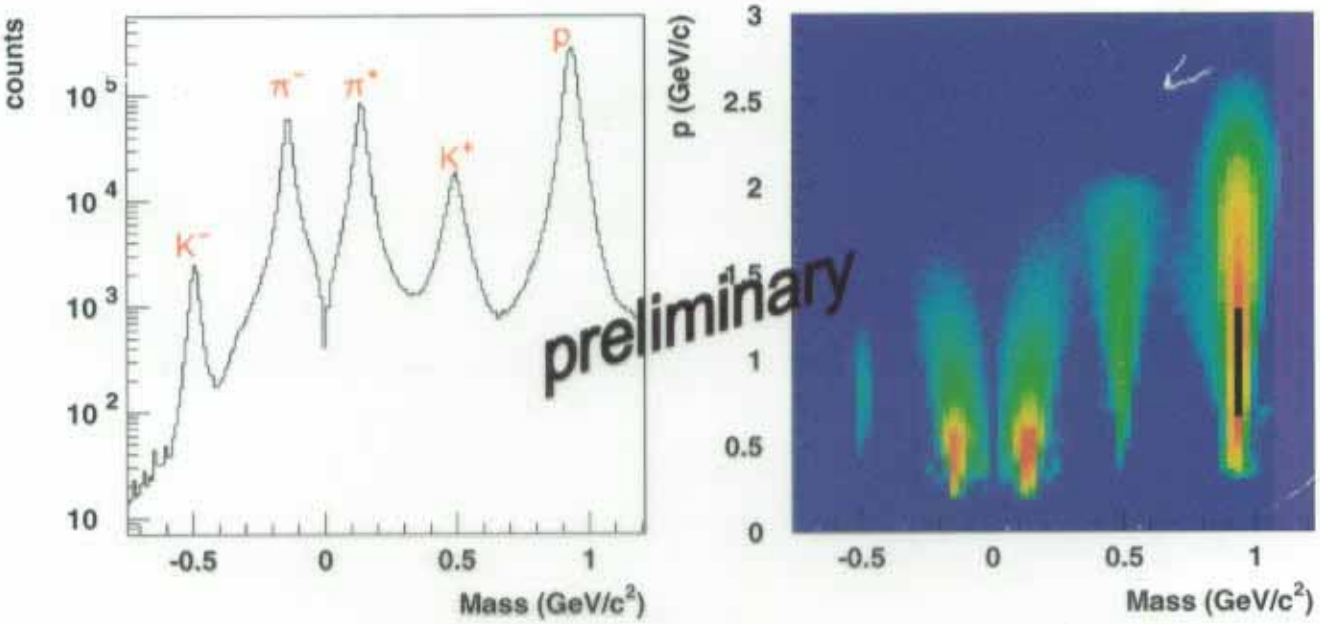


Trigger

- Photon requirement — about 30 Hz for 800 kHz@tagger
  - Tagger hit
  - No signal in charge veto
- Charged particle production
  - Start counter
  - TOF hit
- e^+ e^- veto
  - AC (n = 1.03)
    - $p_\pi < 0.6$ GeV/c



Mass spectra



- Decreasing mass resolution with momentum
- For K^+ analysis: 3σ cut is used

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Data set

- **Dec. 2000-Jun. 2001**
  50mm LH_2
- **May-Jun 2002**
  150 mm LH_2
- **~50% horizontal polarization**
  ~50% vertical polarization
- **γ flux ~$8 \cdot 10^5$ Hz**
  Trigger Rate ~30 Hz

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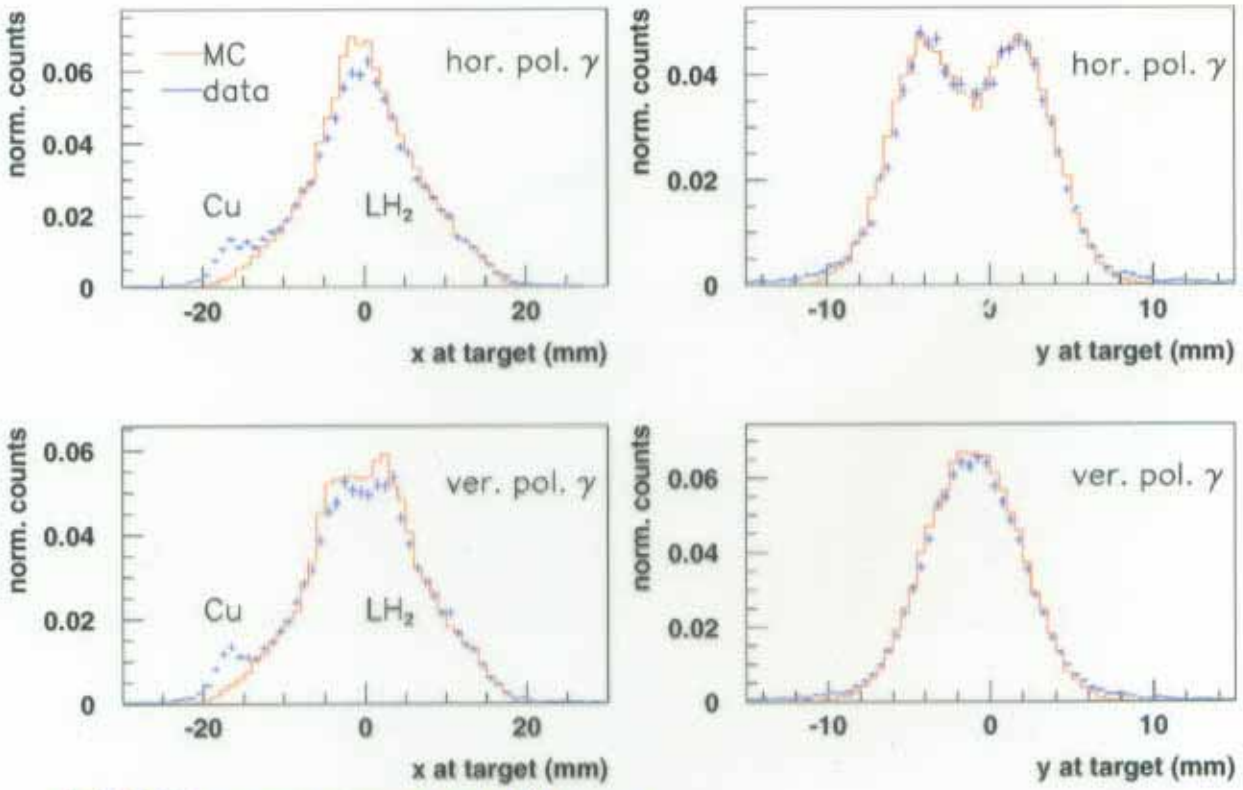
Vertex distributions (x,y)



- **BCS cross section:**

$$\frac{d\sigma}{d\Omega} = \Sigma_0 \left[1 + tS_{lin} Q_1 \cos(2\phi) + P_y S_{circ} Q_2 \sin(\phi) \right]$$

$$S_{circ}^2 + S_{lin}^2 = 1, \cos(\theta) = \frac{E_e - E_\gamma \left(1 + 1/k_i \right)}{E_e - E_\gamma}$$

- **e-beam has large horizontal divergence**

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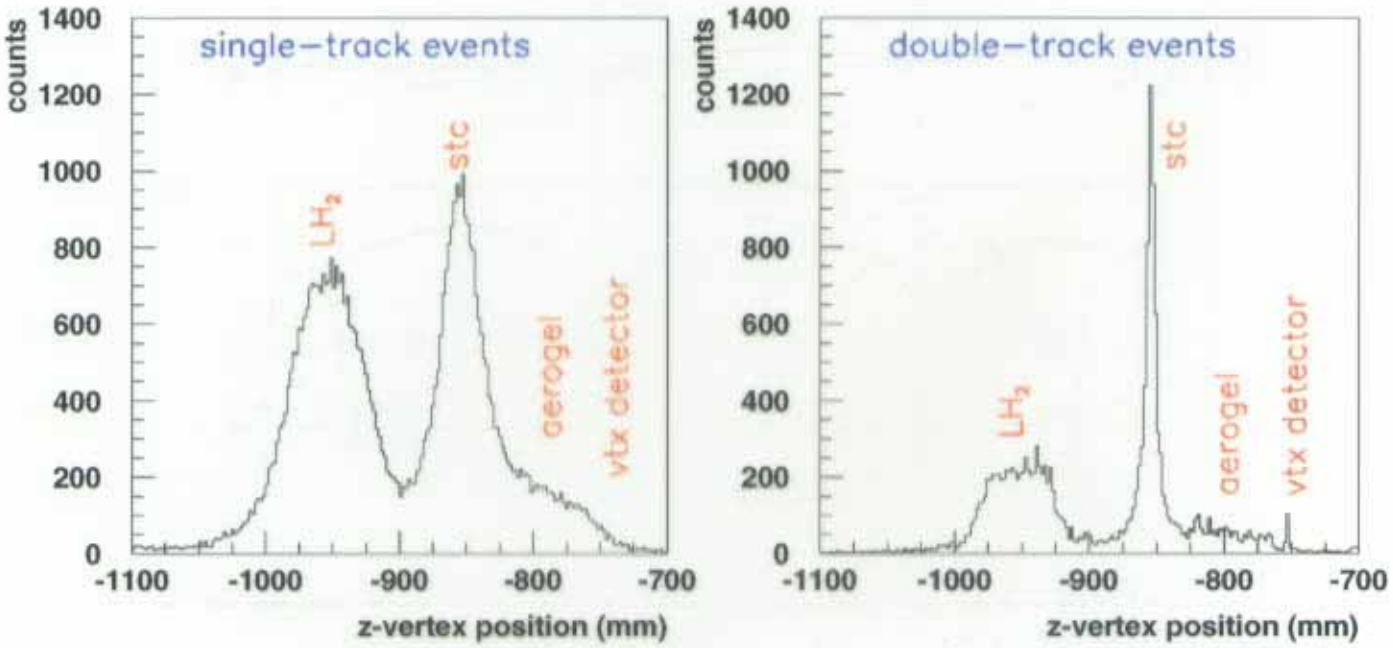
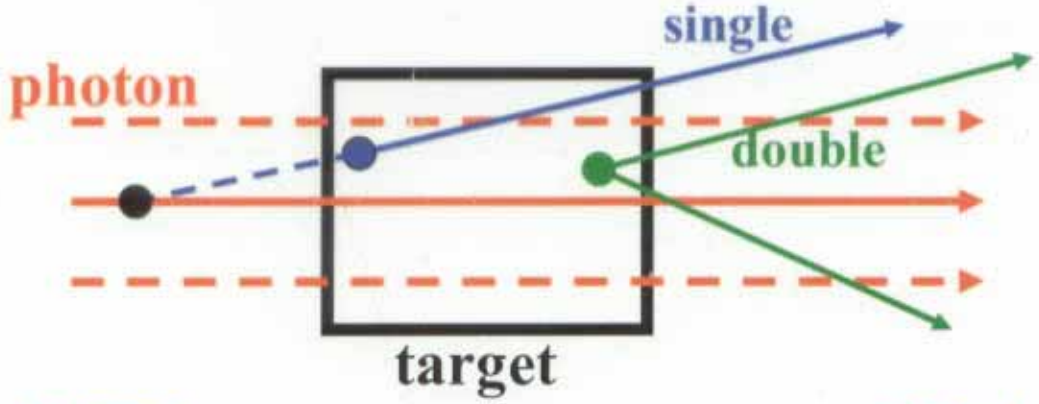
Vertex distribution (z)



- Due to 'wide' photon-beam spotsize, single-track vertex resolution is degraded



K^+ photoproduction

- Track/event selection
  - **K^+ mass cut (3σ)**
  - **$P(\chi^2)_{track}>0.02$**
  - **z-vertex cut (-1100.<z<-900)**
  - **xy-vertex cut (remove Cu)**
  - **decay-in-flight track cuts**

    $c\tau$=3.713 m
  - **tagger background cut**
  - **e^+e^- cut ($\Theta_{K+}>0.02$)**
- Missing mass cuts
  - **$\Lambda(1116),\Sigma^0(1192)$: 2σ**

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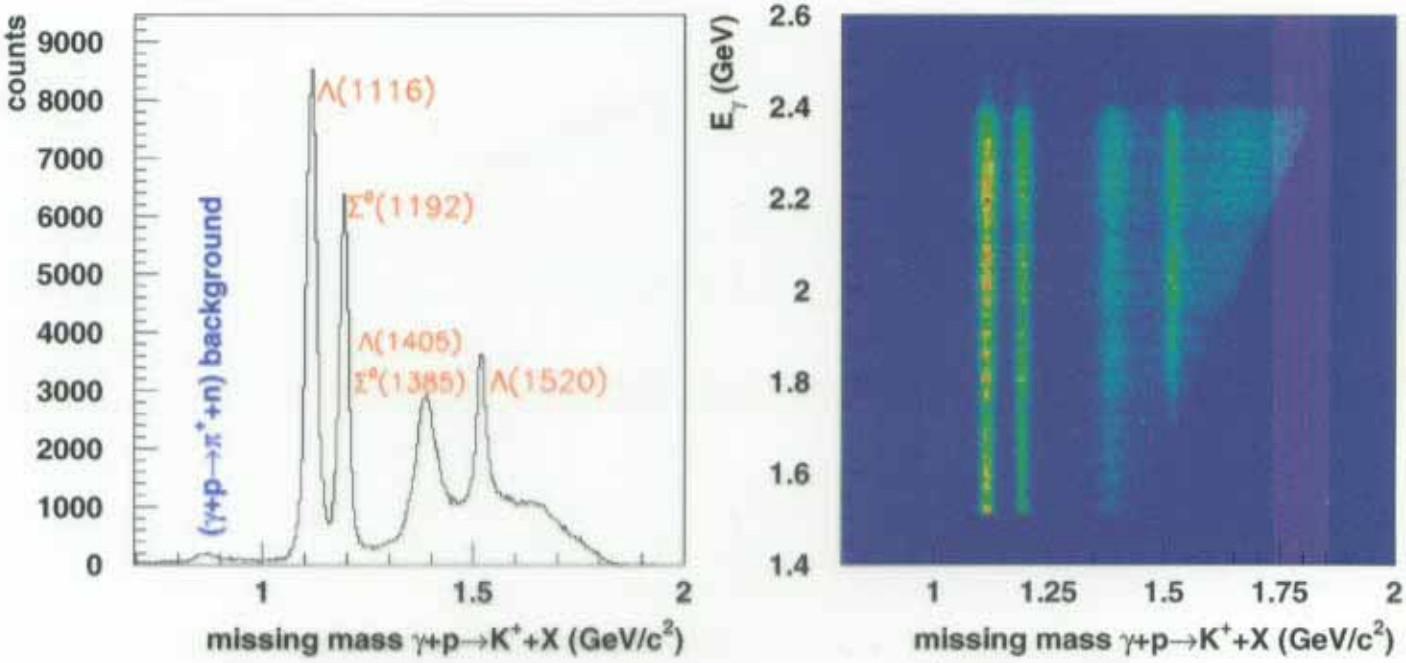
K^+ missing mass

preliminary



- Missing mass resolution ~14 MeV
- Center-of-momentum range 1.9<W<2.3
- t range t_{max}<t<-0.6
- Current analysis 2σ cut for Λ, Σ^0
- ~60% of total data is used for current results (50mm target)

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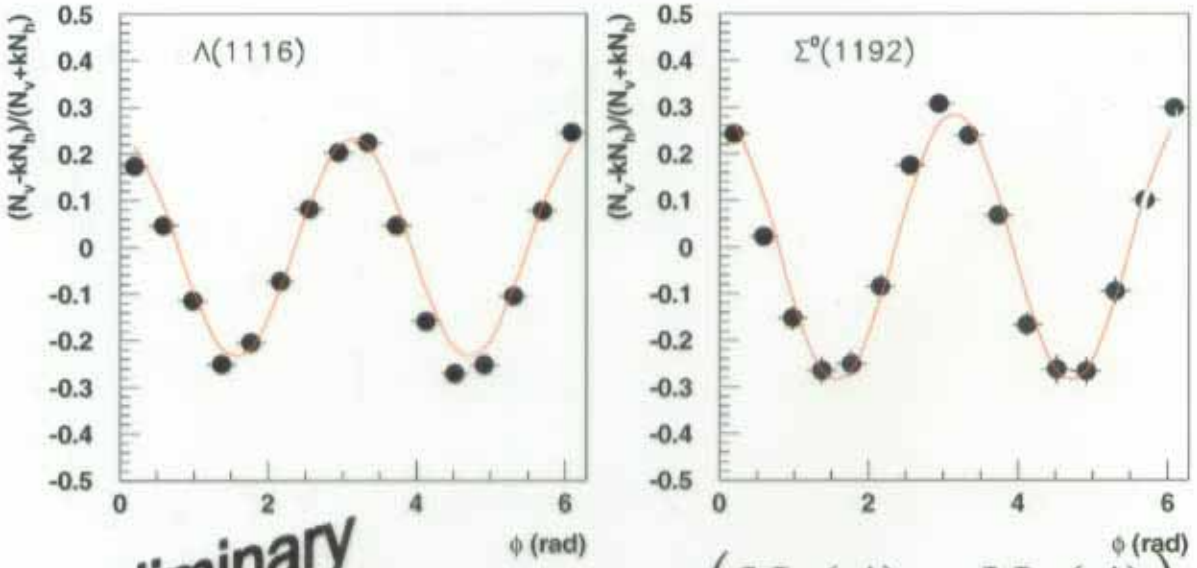
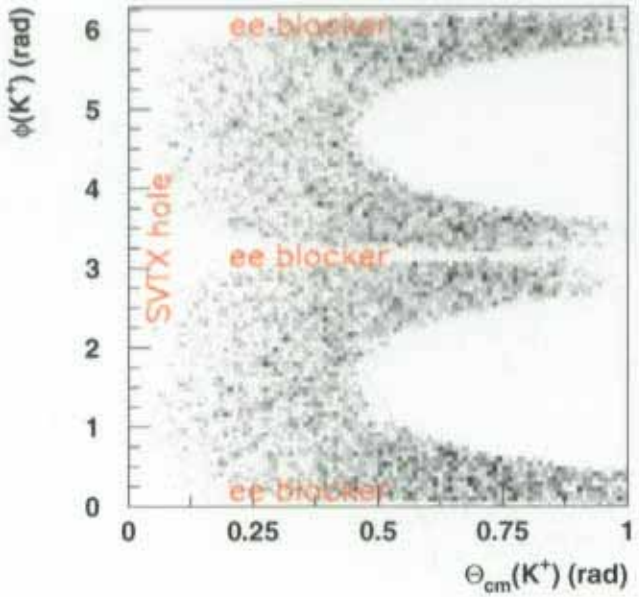
Beam asymmetry measurement



preliminary

$$\Sigma(\phi)P = \frac{\left(N_v(\phi) - N_h(\phi)\right)}{\cos(2\phi)\left(N_v(\phi) + N_h(\phi)\right)}$$



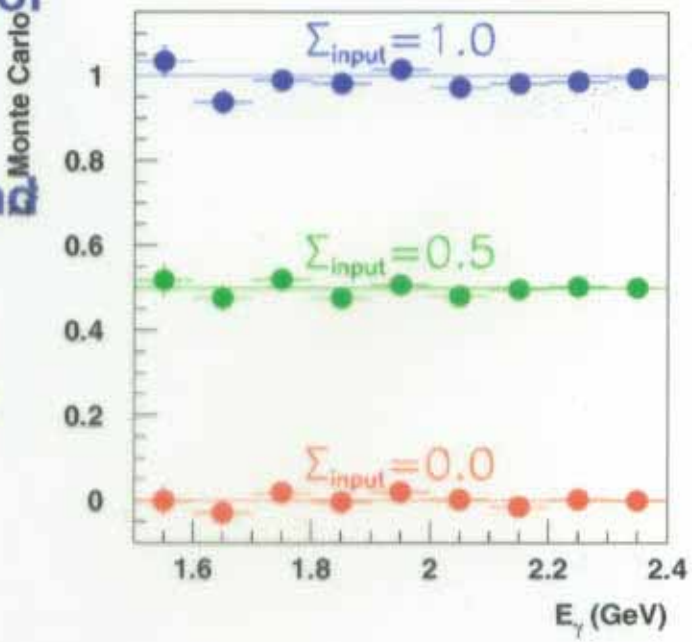
Systematic errors II

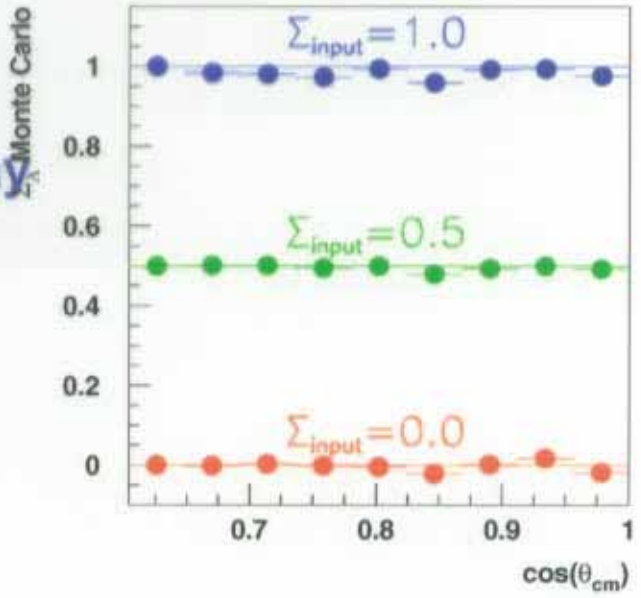
preliminary

- **Finite resolution of angle measurement**
- **decay-in-flight and other effects**
- **Polarization-dependent beam profiles**

use MC simulation

- **detector resolutions**
- **energy-loss, decay in flight, multiple scattering taken into account**
- **More detailed simulations underway**





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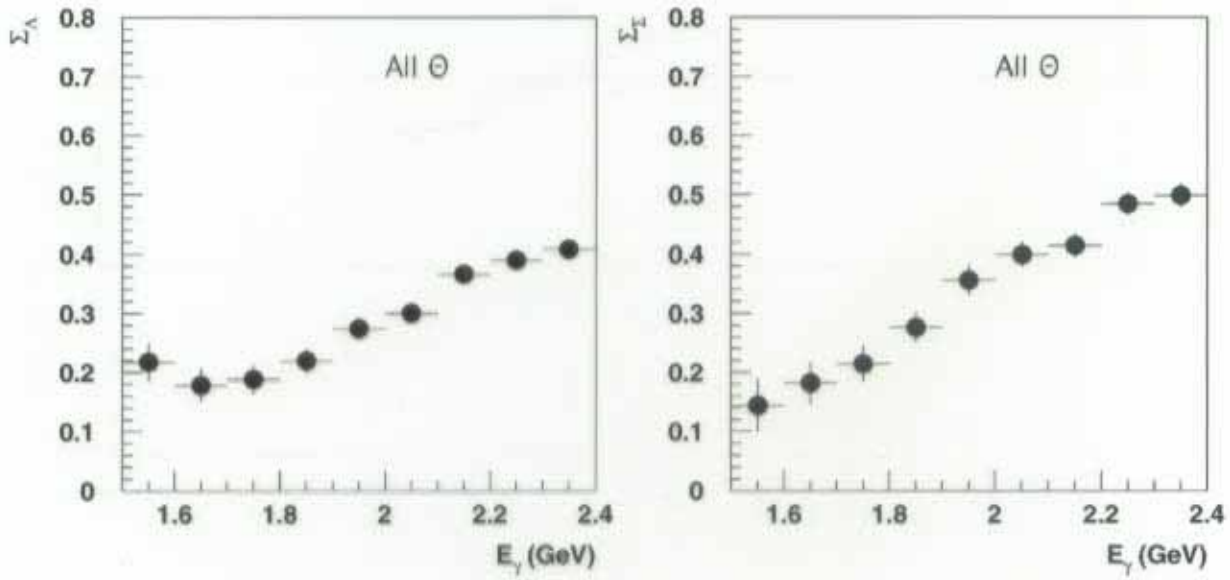
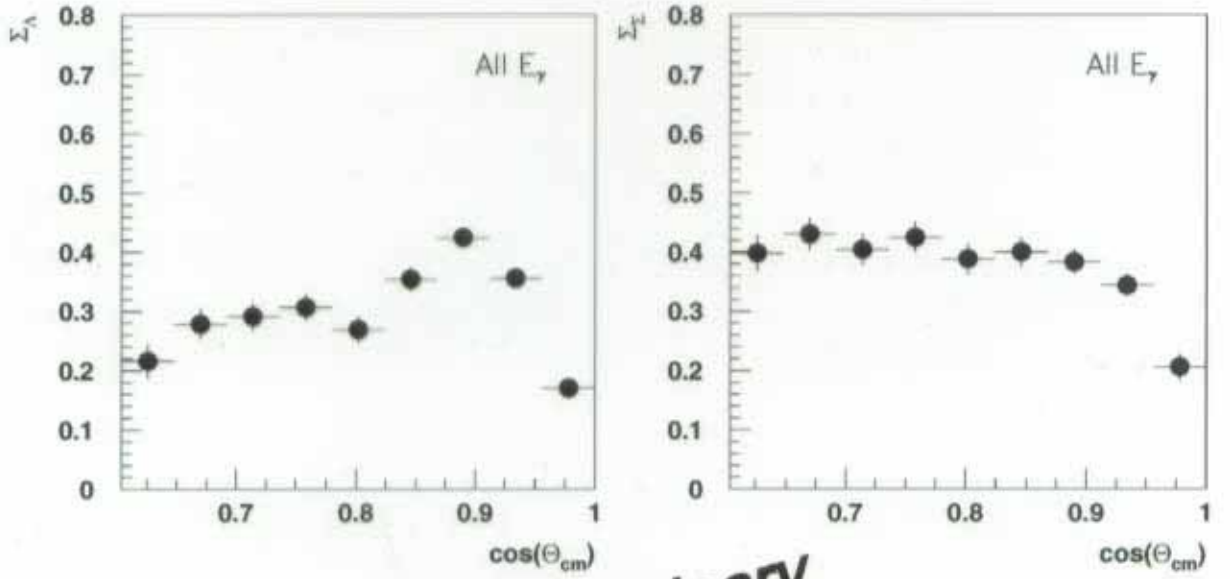
Beam Asymmetry

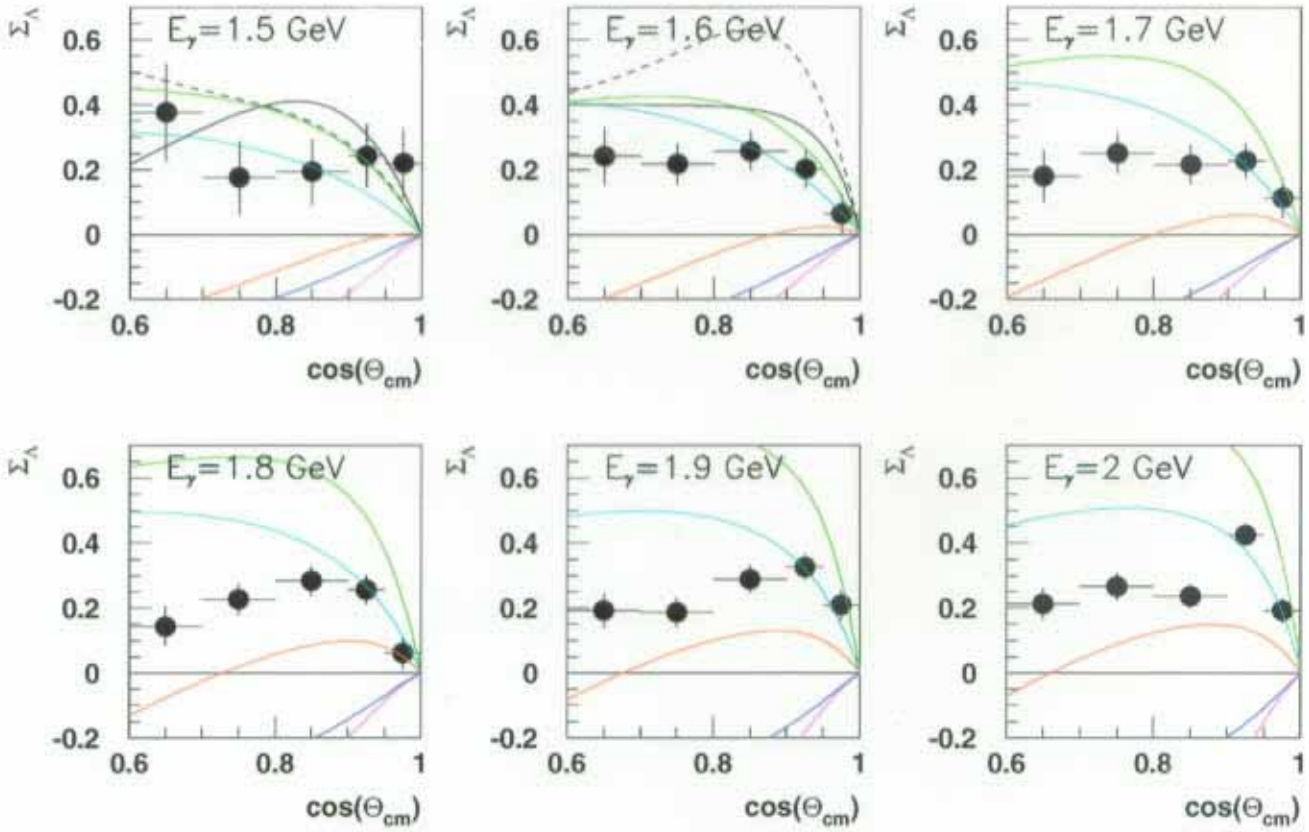




preliminary

Beam asymmetry Λ

preliminary



Mart & Bennhold: Born terms, $K^*(891)$,$K_1(1270)$, $S_{11}(1650)$, $P_{11}(1710)$,$P_{13}(1720)$; Haberzettl FF

- - - - - **Without 'missing' $D_{13}(1900)$**

——— **With 'missing' $D_{13}(1900)$**

Janssen et al.: Born terms, $K^*(891)$,$K_1(1270)$, $S_{11}(1650)$, $P_{11}(1710)$,$P_{13}(1720)$,$D_{13}(1895)$

A) Small cut off mass

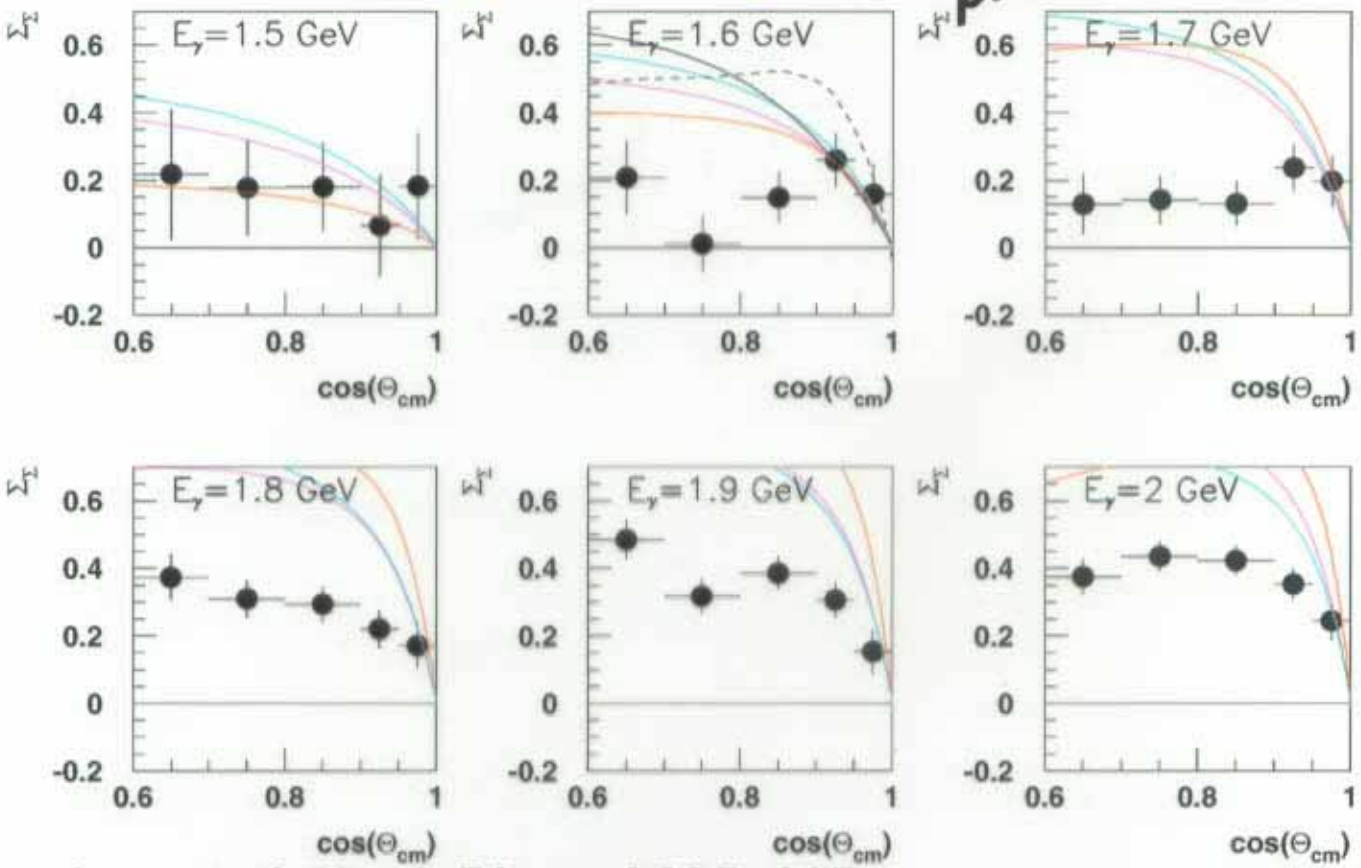
B) $\Lambda^*(1800,1810)$ u-chan

C) no restrictions on g

D&W HAB. FORMFACTOR

Beam Asymmetry Σ^0

preliminary



Lee et al. Nucl. Phys. A695, 237

– – – – – Born terms, $K^*(891)$,$S_{11}(1650)$, $P_{11}(1710)$, $\Delta(1900)$,$\Delta(1910)$, Single hadronic FF

——— + $K_1(1720)$, Haberzettl FF

Janssen et al. Born terms, $K^*(891)$, $S_{11}(1650)$, $P_{11}(1710)$,$P_{13}(1720)$, $\Delta^*(1900)$, $\Delta^*(1910)$, ($D_{13}(1895)$)

——— A) Small cut off mass

——— B) $\Lambda^*(1800,1810)$ u-chan

——— C) no restrictions on g

D&W FORMFACTOR

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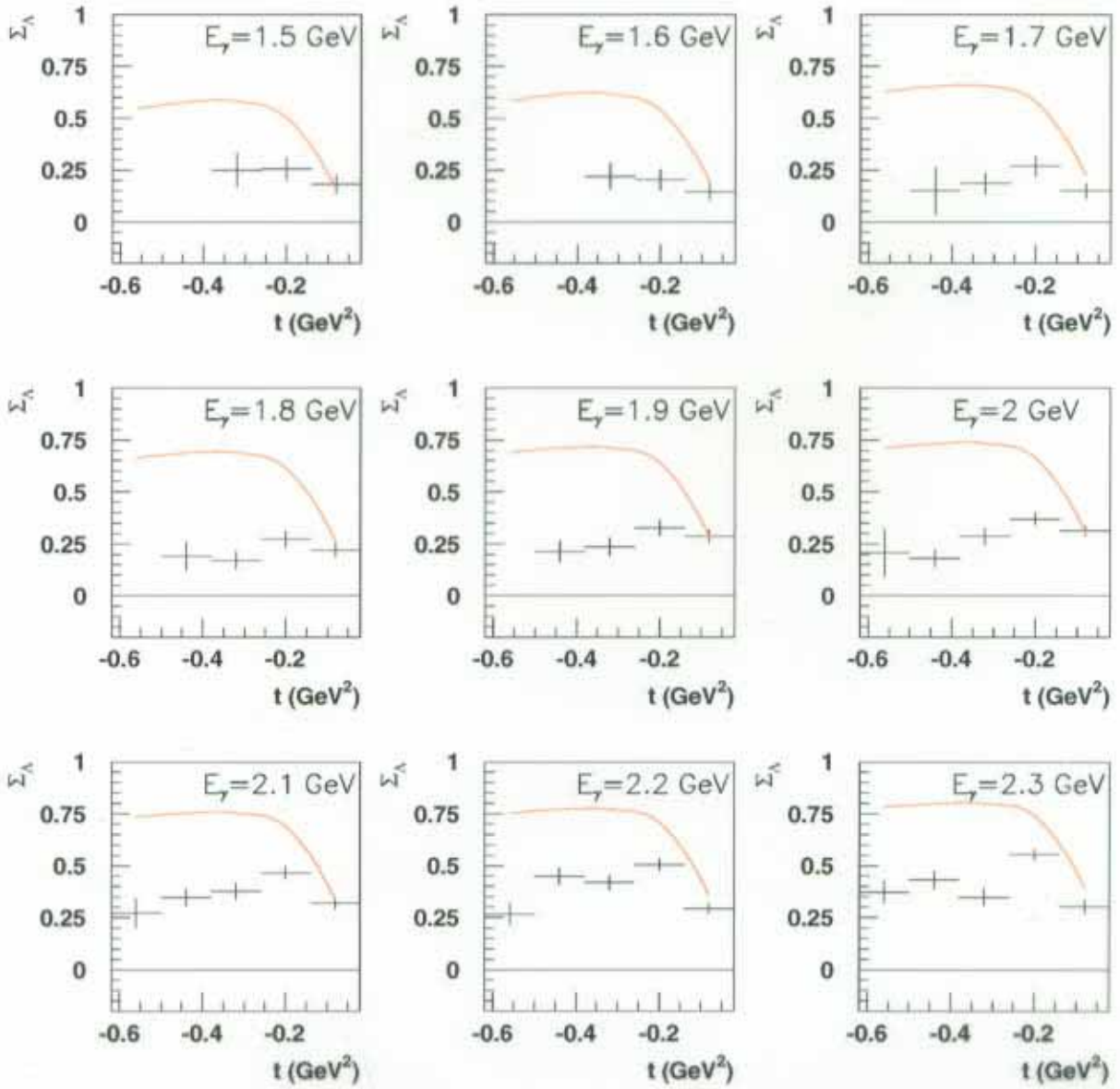
Comparison with Regge model (K^+,Λ)



M. Guidal et al. NPA 627, 645(1997)

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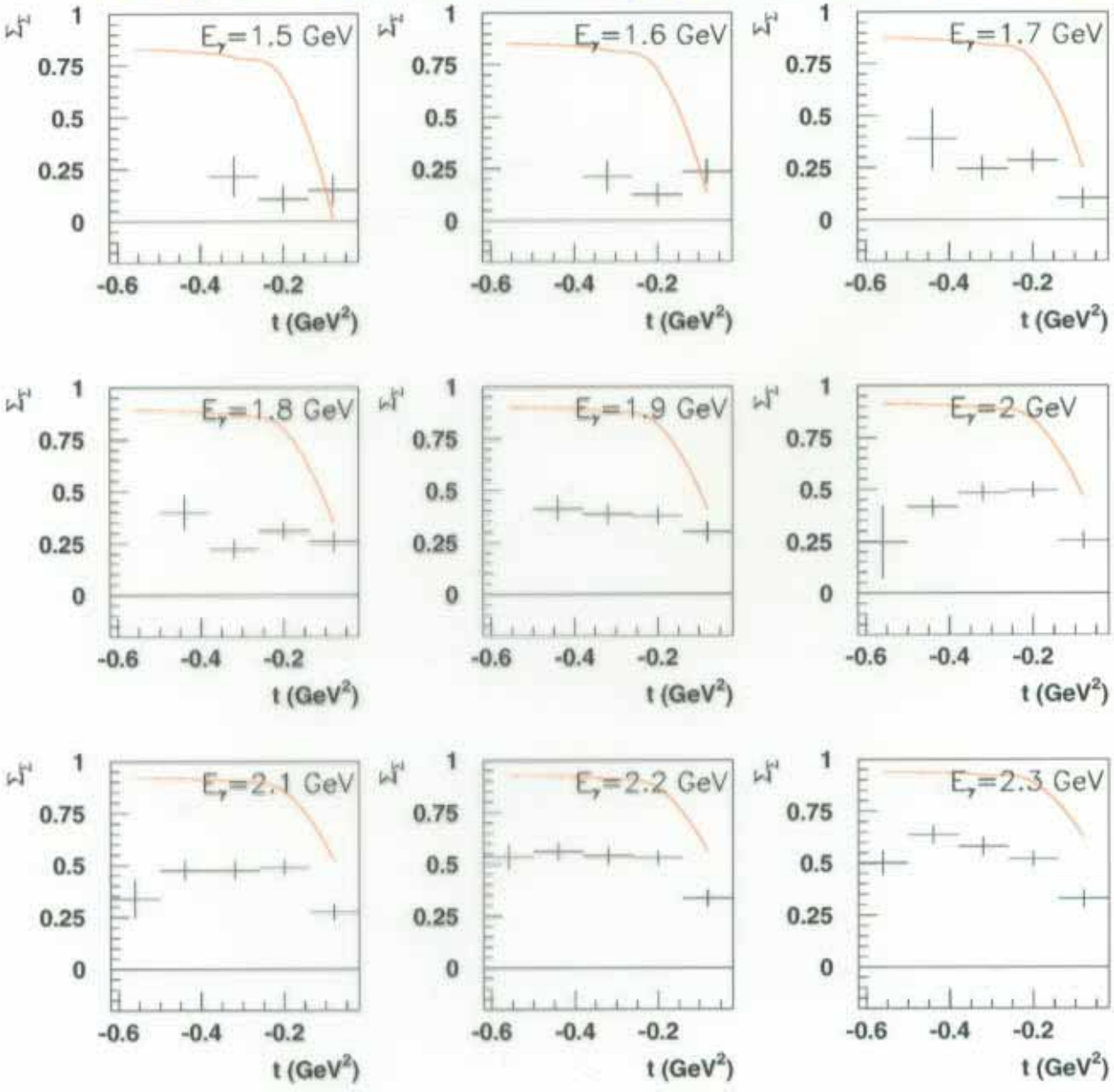
Comparison with Regge model (K^+,Σ^0)



M. Guidal et al. NPA 627, 645(1997)

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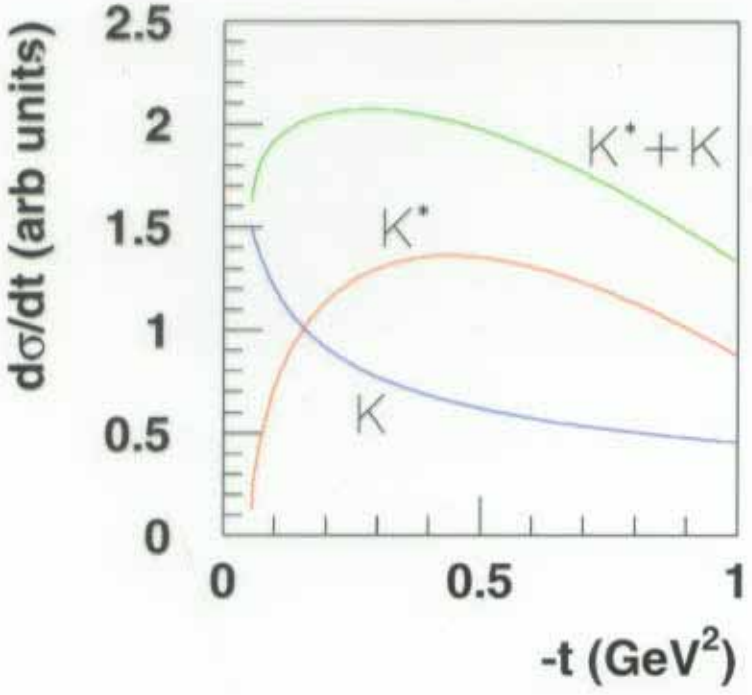
In progress…

- **Cross sections:**
  - **interference between K and K* diagrams can be studied at forward angles; LEPS can provide accurate measurement.**
  - **Important for total cross sections (GRAAL, CLAS, SAPHIR…)**
- **Recoil polarizations**
- **Beam-recoil (double) polarizations**

Require acceptance corrections via MC



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Conclusion & outlook

- **Currently, there is too little data to fix theoretical models and draw conclusions on the presence of missing resonances… Measurements of additional observables is needed**
- **At LEPS beam asymmetries are measured for**

  E_γ=1.5-2.4 GeV, $\cos(\Theta_{cm}(K^+))>0.6$

  ($1.9<W<2.3$, $t_{max}<t<-0.6$)
- **~60% of data has been analyzed for beam asymmetry that strongly add to the world data set on $K^+,\Lambda\Sigma^0$ photoproduction**
- **inclusion of all data and cross section determination in progress**
- **Study of recoil polarization and beam-recoil polarizations in progress**