Production of linear polarized Photons [*]

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- Kinematics and cross section of bremsstrahlung
- Modelling of bremsstrahlung
- Analytical description: ANB
- Monte Carlo description: MCB
- Results
- Asymmetry of the ^{4}He($\vec{\gamma}$,np) reaction
- Summary

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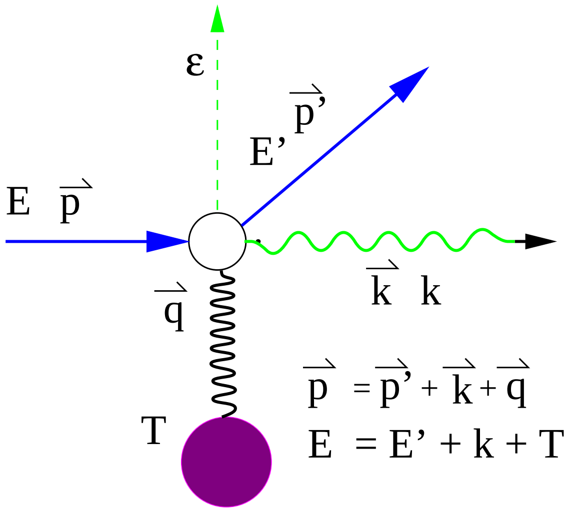
Bremsstrahlungs Process

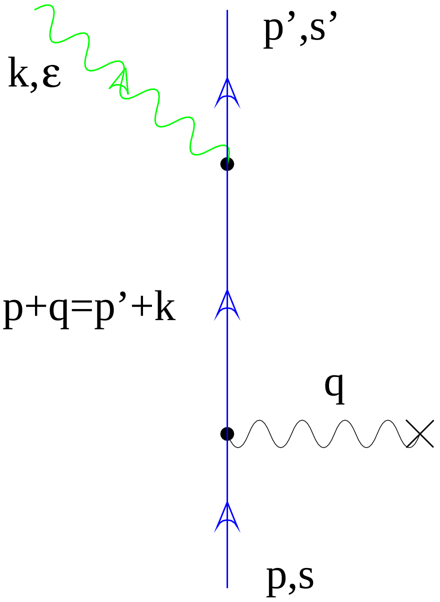


Kinematics:

momentum transfer:

$$\delta = q_l^{\min}(E_\gamma) < q < 2\delta$$

$$q_t/q_l \approx 10^3 \rightarrow \text{pancake}$$



Cross section:

$$\sigma \sim k\left(\frac{\epsilon p'}{kp'} - \frac{\epsilon p}{kp}\right)^2$$

$$\approx \frac{1}{k}\cos^2\phi$$

main contribution:

$\vec{E} \parallel \vec{\epsilon} \in (\vec{p}, \vec{q})$ plane

Intensity: $I = \frac{k}{\sigma}\frac{d\sigma}{dk}$

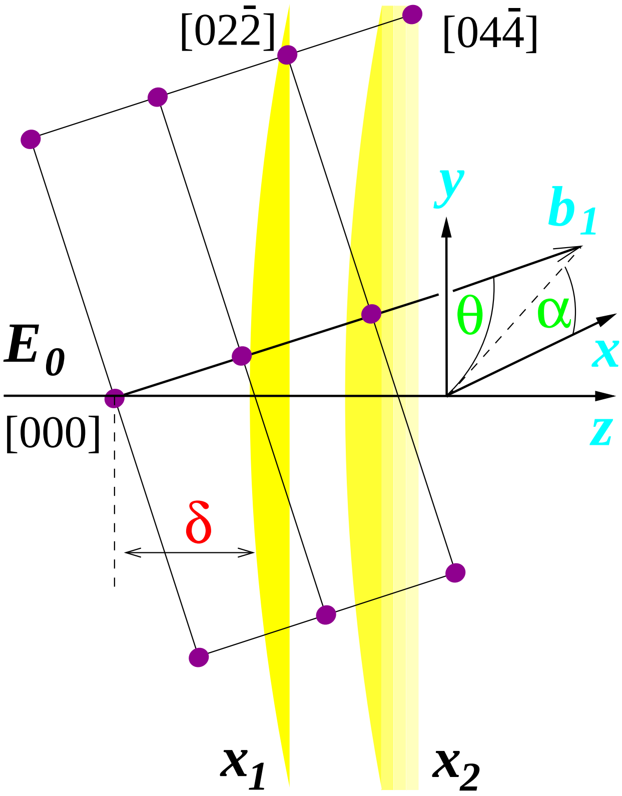
Bremsstrahlung off a Lattice

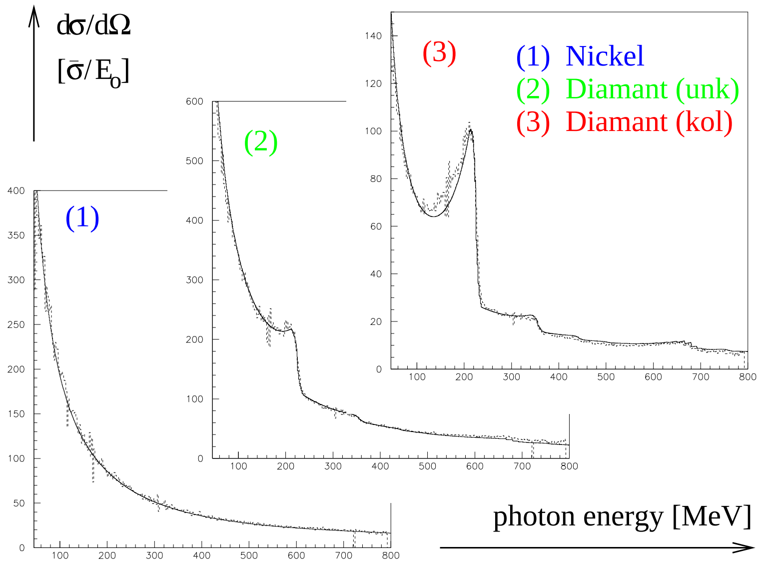
Pancake in a lattice

Bragg condition ($\vec{q} = \vec{g}$)
→ coherent Bremsstrahlung
→ fixes momentum transfer
→ polarized beam

$$\begin{aligned} I_{\text{tot}} &= \left[f_D \sum \delta(q-g) \right. \\ &\quad \left. +(1-f_D)\right] I_{\text{BH}} \\ &= \sum I_{\text{coh}}(g) + I_{\text{inc}} \\ P &= \left(I_\perp - I_{||}\right) / I_{\text{tot}} \end{aligned}$$

photon energy: $x = k / E_0$
I_{coh} depends on θ, α





Collimation:

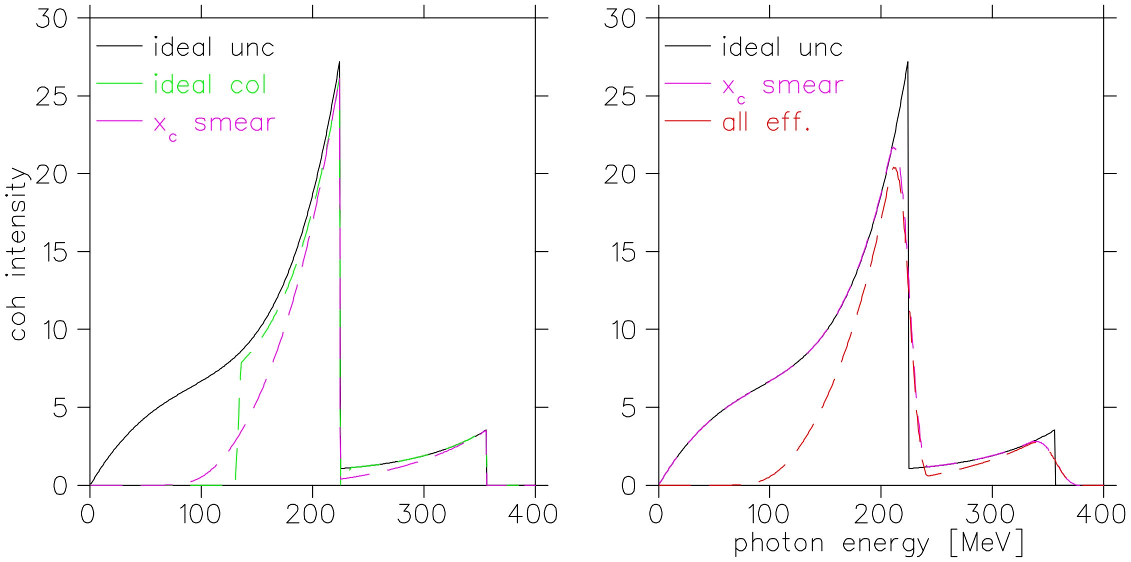
incoherent:
gets reduced

coherent:
not affected
in $x_c < x < x_d$
$x_d, x_c \leftarrow \vartheta_c, \vec{g}$

Non-ideal beam

source	→	effect	influence
temperature	→	Debye Waller factor	$I_{\text{coh}}/I_{\text{inc}}$
BS : beam spot size	→	"fuzzy" collimator	x_c
BD: beam divergence	→	+ variation of θ, α	x_d
MS : multiple scattering	→	increases BD	x_d

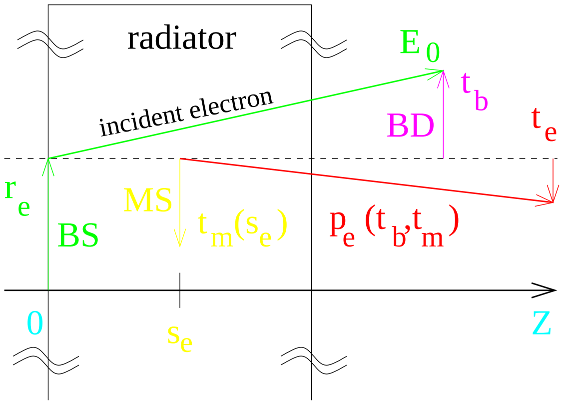
$$I_{\text{exp}} = \int_{MS} ds \int_{BD} d^2 t_b \; w(\vec{t}_b) \otimes w(\vec{t}_m(s)) \times \int_{BS} d^2 r_e \; w(\vec{r}_e) \; I_{\text{coh}}(\theta_0, \alpha_0, \vec{t}_e) \Big|_{r_c > |\vec{r}^{\,c}_{\gamma}|}$$



Monte Carlo Simulation (MCB)

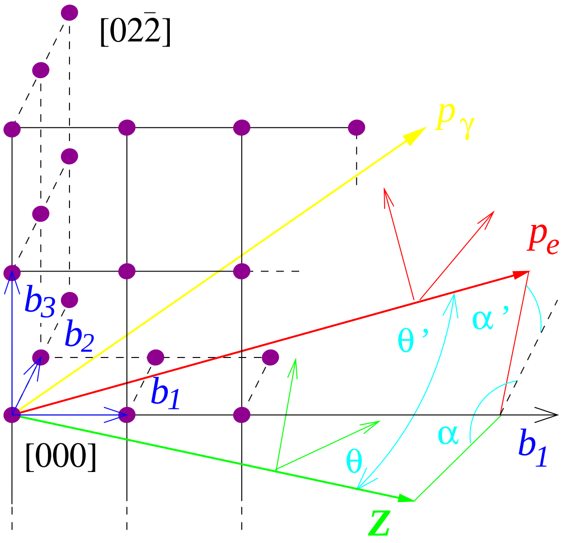
Parmeters:

- E_0 distribution
- *BS* distr. $\vec{r}_e$
- *BD* distr. $\vec{t}_b$
- *MS* distr. $\vec{t}_m(s)$ (radiator thickness)
- temperature, crystal angles, radiator Z, ρ



Brems process

- $\theta_0, \alpha_0 \xrightarrow{\vec{p}_e} \theta_e, \alpha_e$
- calc intensity I^{coh} in these variables
- photon ⟶ lab sys
- check collimation



Advantage: 'precise', evaluation of each event

Approximative Analytical Calculation (ANB)

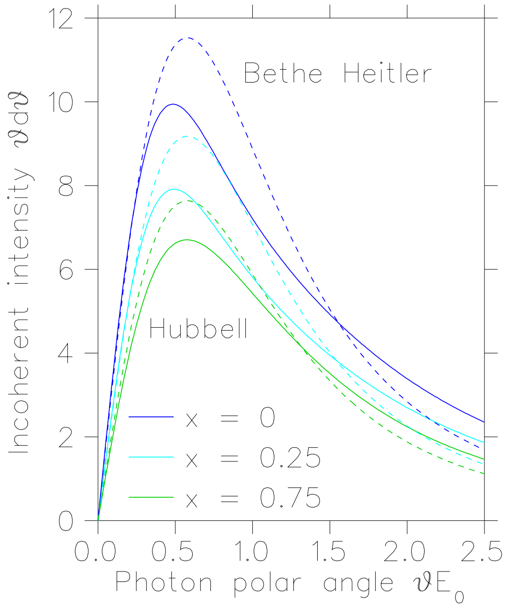
Approximations

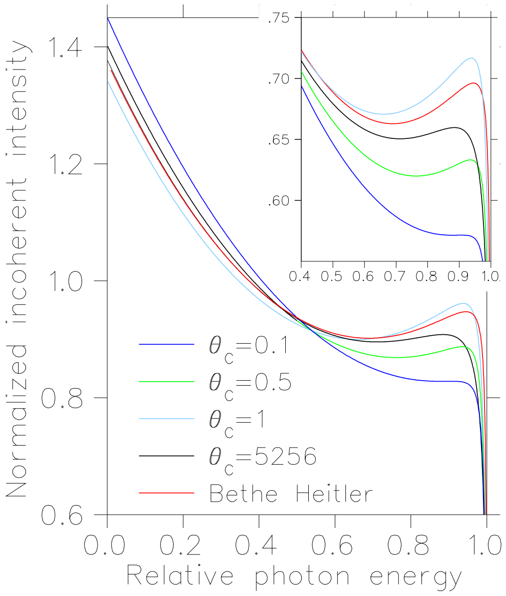
- 2d transversal distributions ⟶ spherical symmetrical
- mean multiple scattering distribution: $\bar{\sigma}_m$ (Moliére therory)
- ‘total’ electron divergence (ED): $\sigma^2_{ED} = \bar{\sigma}^2_m + \sigma^2_{BD}$

$$\Rightarrow \quad I^{\text{inc}/\text{coh}}_{\text{exp}} = \int_{\text{6 fold}} \longrightarrow \int_{\vartheta_c} w(\vartheta_C) I^{\text{inc}} \;/\; C_{ED}\bar{I}^{\text{coh}}$$

Improvements (ANB,MCB ↔ Göttingen)

- Hubbells xsec: better Z, x, ϑ_c dependence JAP 30/7(59)981
- e^- contrib. more exact: Z, x, E_B dependent Mathew, Owens NIM 111(73)157





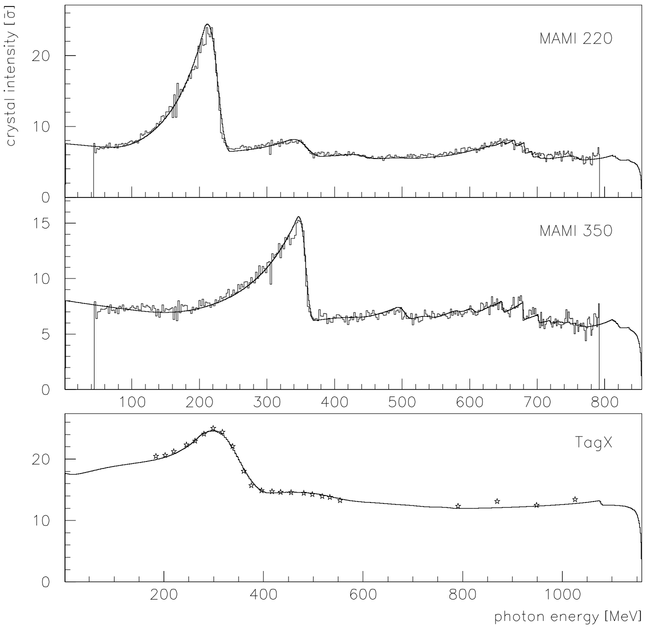
Results

^{4}He($\vec{\gamma}$,2N) @ MAMI:

Diamond-yield compared to total crystal intensity for $k_d = 220, 350$ MeV

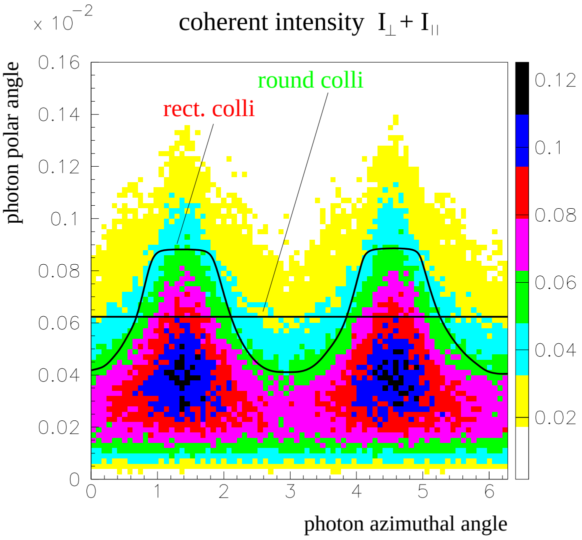
TagX @ Tokio:

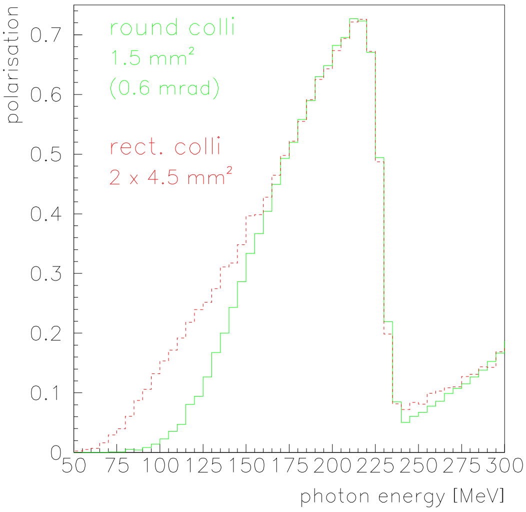
1.2 GeV, $k_d = 350$ MeV



Rectangular collimator

same total collimated cross section (tagging efficiency)





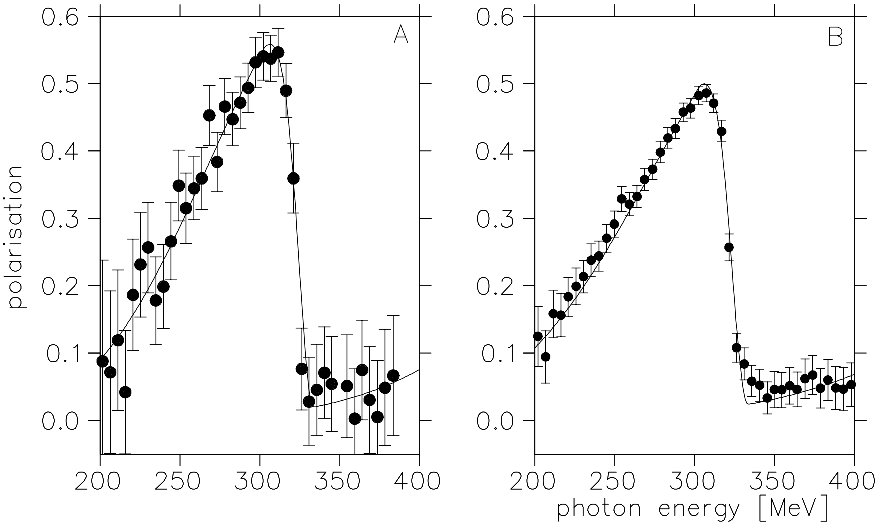
Polarisation and Asymmetry on ^{4}He

^{4}He(γ,π^0)

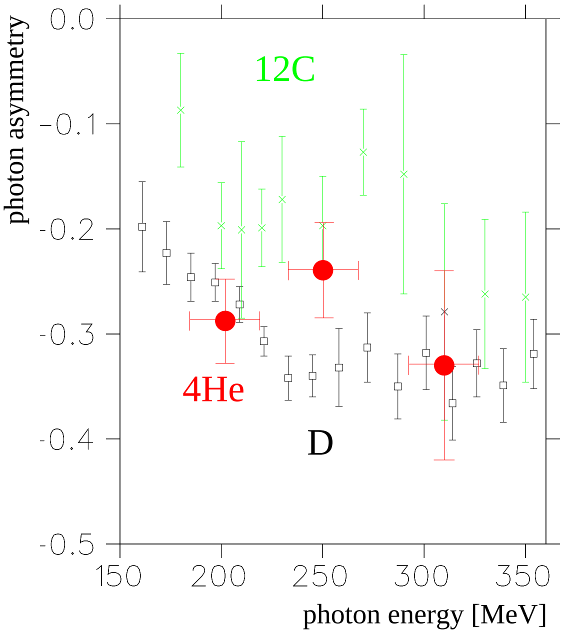
@ MAMI w. TAPS

P_γ completely transferred to azimuthal asym. of π^0 mesons:

$P_\gamma \propto \mathcal{A}^{\pi^0}(\epsilon_{\|,\perp})$



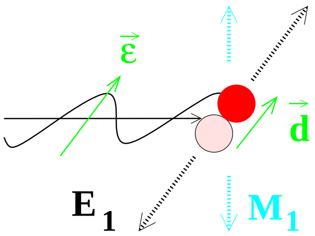
$\longrightarrow$ ANB calc. for 2 colli angles: $\vartheta_c^{A,B} = 0.5, 0.7$ mrad



^{4}He(γ,np)

@ MAMI with PiPTOF

Low E_γ :
E1 dominant $\rightarrow \Sigma$ pos



$E_\gamma > \pi$ threshold : (Δ exc.)
M1 dominant $\rightarrow \Sigma$ neg

$\longrightarrow$ ^{4}He $\sim$ D ? (only subset of data ! calibration not yet finished)

preliminary !!

Summary

- improved bremsstrahl description
  for different radiators and collimators due to the use of Hubbells cross section and a more exact calculation of the electron contribution.

- two codes:
  ANB approximative but fast
  MCB slow but ‘exact’
  → $|P_{\text{MCB}} - P_{\text{ANB}}| \lesssim 2\%$, ANB ≈ 200 faster

- reliable prediction of the polarisation over a wide photon energy range, with systematic error less than 3%

→ small contribution from photon polarisation to systematic error of asymmetries