

Compton Scattering at MAX-lab

Mattias Andersson

Department of Nuclear Physics
Lund University

on behalf of the
Compton@MAXlab Collaboration

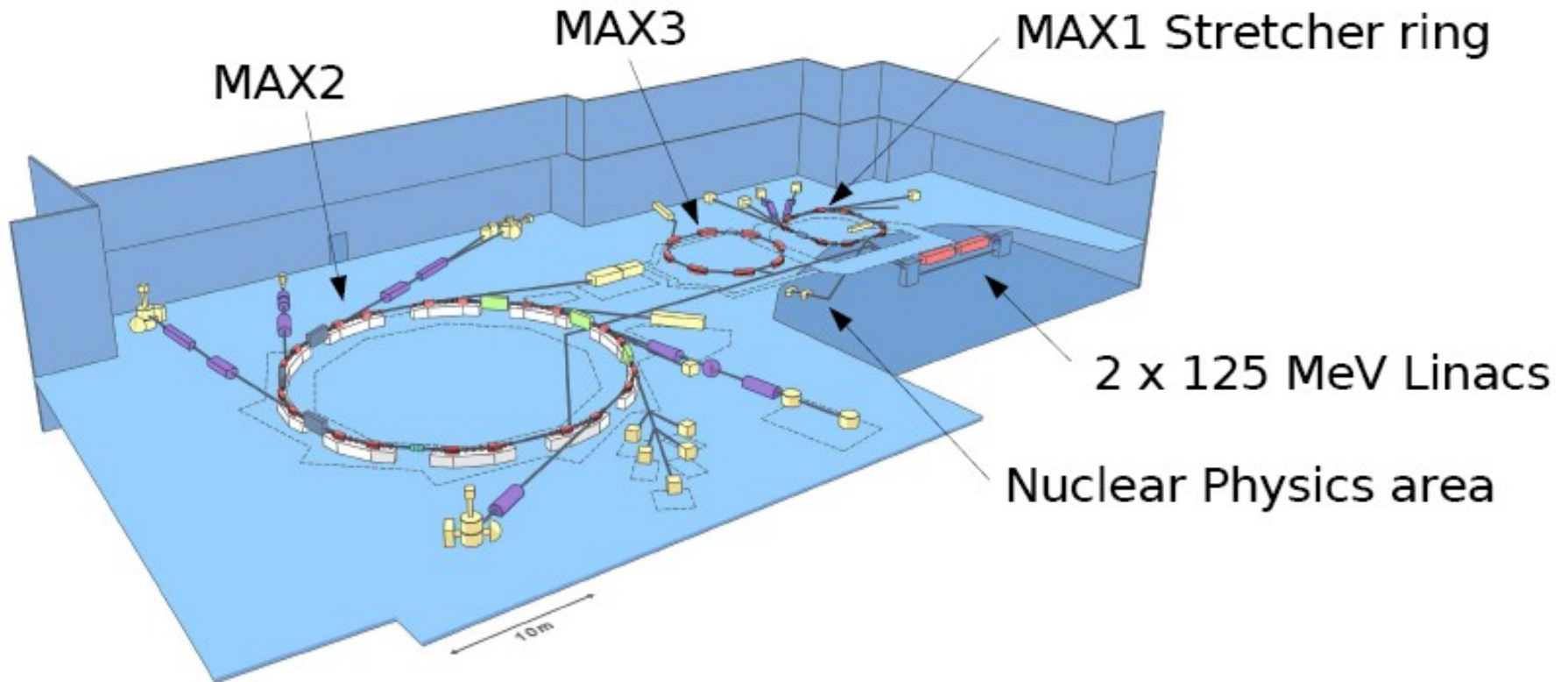


Compton Scattering at MAX-lab

Outline

- MAX-lab
- Compton and polarisabilities
- Experiment set-up
- Preliminary results

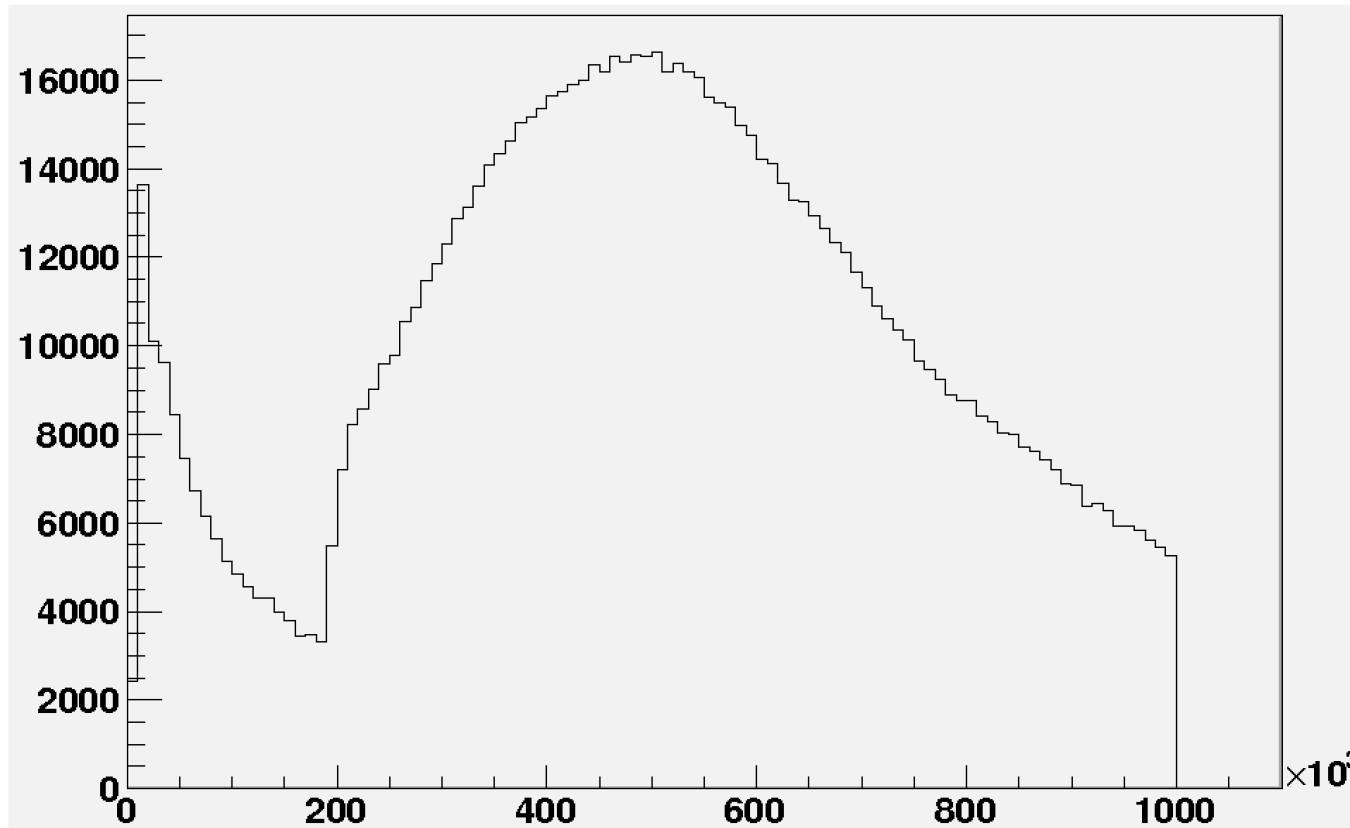
MAX-lab



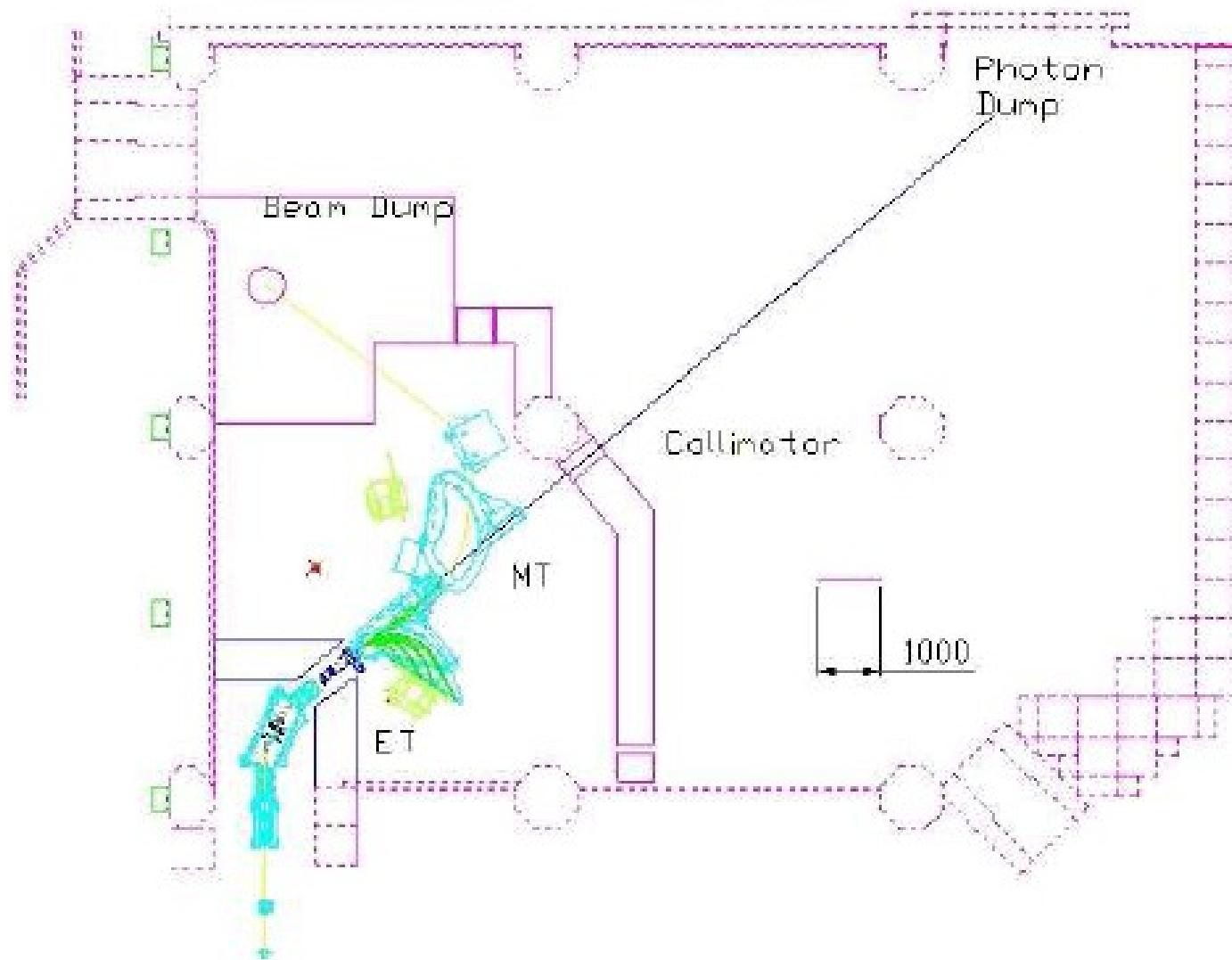
Nuclear physics: 18 weeks of the beam time at MAX1.

Electron beam

Pulse stretcher: 100 ns linac pulse \Rightarrow 100 ms extracted pulse



Nuclear Physics Cave



Tagged photons at MAX-lab

- Choice of:
 - Electron energy 115 – 201 MeV
 - Tagger MT or ET
 - Tagger setting
$$\Rightarrow \begin{array}{l} E_{\gamma} : 25 - 185 \text{ MeV} \\ \Delta E_{\gamma} : 0.2 - 1.0 \text{ MeV} \end{array}$$
- Intensity (typical)
 - 20 nA
 - ~ 40 % tagg. eff.
$$\Rightarrow 0.5 \text{ MHz/MeV tagged photons}$$

Compton@MAXlab Collaboration

Duke University

University of Edinburgh

University of Glasgow

University of Göttingen

University of Illinois

University of Kentucky

Kharkov Institute of Physics and Technology

Lund University

The Mount Allison University

University of Saskatchewan

The George Washington University

Compton Scattering Programme

- $D(\gamma, \gamma)$
Test recent calculations
Extract neutron polarisabilities
- ${}^4\text{He}(\gamma, \gamma)$ and ${}^{12}\text{C}(\gamma, \gamma)$
Extract polarisabilities

Nucleon Polarisabilities

- The electric and magnetic polarisabilities measure the extent of which an external electric or magnetic field can induce an electric or magnetic dipole moment in a nucleon.
- The polarisabilities constitute fundamental structure constants.

α_n and β_n from $D(\gamma, \gamma)$

$D(\gamma, \gamma)$:

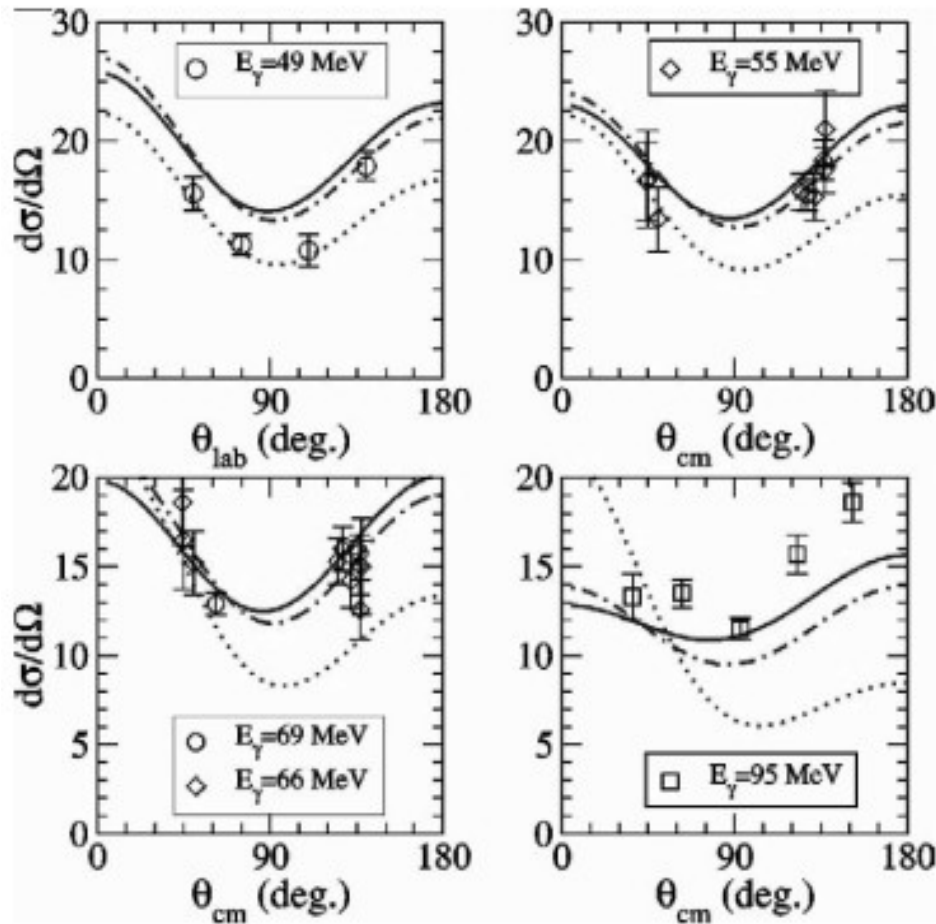
$\frac{d\sigma}{d\Omega}$ sensitive to α_N and β_N in the backward direction

$$\alpha_N = \frac{\alpha_p + \alpha_n}{2} \quad \beta_N = \frac{\beta_p + \beta_n}{2}$$

$\alpha_p - \beta_p$ is well known from ${}^1\text{H}(\gamma, \gamma)$ and the Baldin sum rule provide numbers for $\alpha_p + \beta_p$ and $\alpha_n + \beta_n$
 $\Rightarrow \alpha_n$ and β_n can be extracted from the cross section

Recent $D(\gamma,\gamma)$ χ PT calculations

Beane *et al.*, Nucl. Phys. A747 (2005) 311



49 and 69 MeV
Lucas *et al.*, Illinois

55 and 66 MeV
Lundin *et al.*, Lund

95 MeV
Hornidge *et al.*, SAL

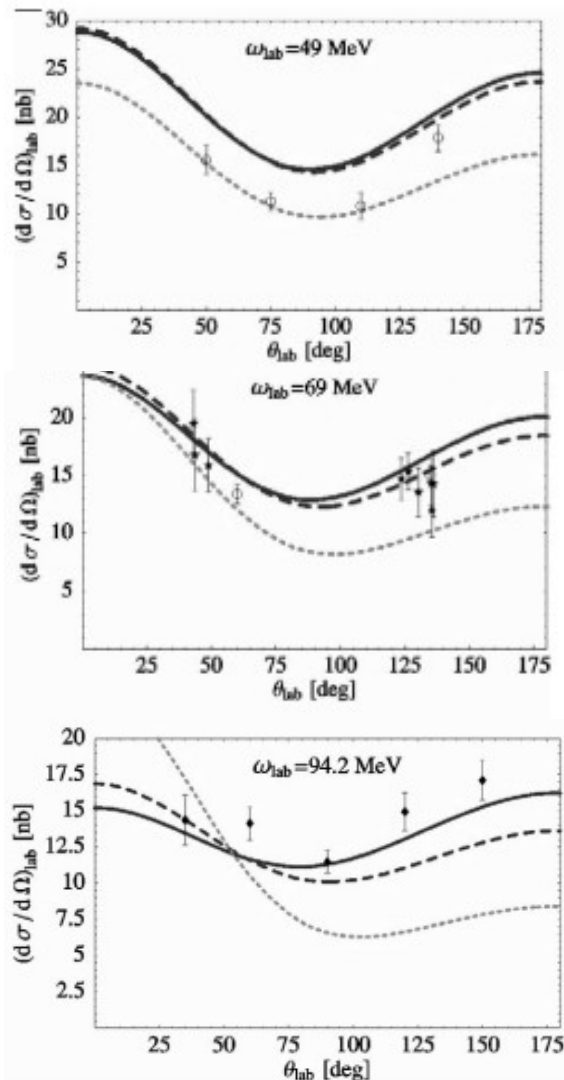
..... $O(Q^2)$

· - · - · $O(Q^3)$

— $O(Q^4)$

Recent $D(\gamma,\gamma)$ χ PT calculations

Hildebrandt *et al.*, Nucl. Phys. A748 (2005) 573



49 and 69 MeV
Lucas *et al.*, Illinois

55 and 66 MeV
Lundin *et al.*, Lund

95 MeV
Hornidge *et al.*, SAL

..... $O(Q^2)$

- - - $O(Q^3)$ HB χ PT

— $O(\epsilon^3)$ SSE

Goal of present $D(\gamma,\gamma)$ experiment

Significantly increase the world $D(\gamma,\gamma)$ data set.

- 40 – 110 MeV
- 30° – 150°
- Statistical errors $< 5\%$

Experiment set-up

Liquid deuterium target

Three of the largest NaI-detectors worldwide:

CATS (Mainz)

BUNI (Boston)

DIANA (Kentucky)

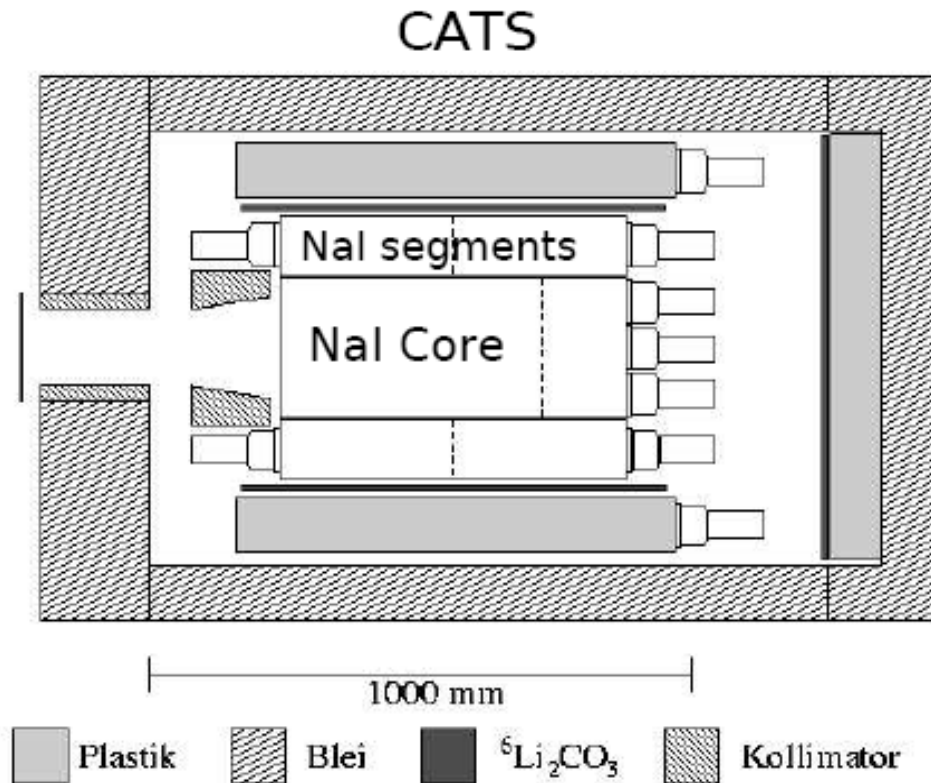


CATS

Standard electronics

Trigger: single particle detected in one of the NaI-detectors

Nal detectors



Nal Core: \varnothing 27 cm \times 64 cm

Six Nal segments

Nal total: \varnothing 48 cm \times 64 cm

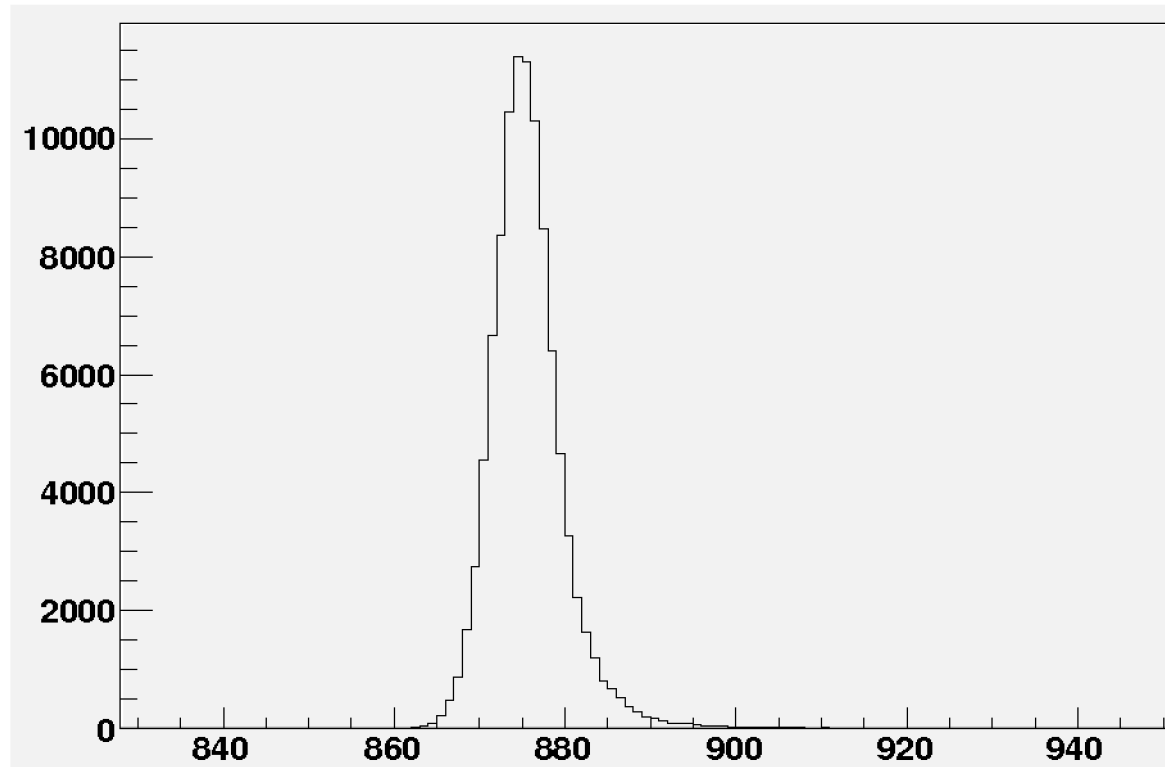
Figure from O. Jahn, Diplomarbeit, Mainz

Run summary

- Nov 2006 (3 weeks)
 - Tests with liquid D target
 - $D(\gamma,\gamma)$ data collection
- Feb 2007 (4 weeks)
 - $D(\gamma,\gamma)$ data collection
- Nov 2007 (4 weeks)
 - $D(\gamma,\gamma)$ data collection

In-beam measurement

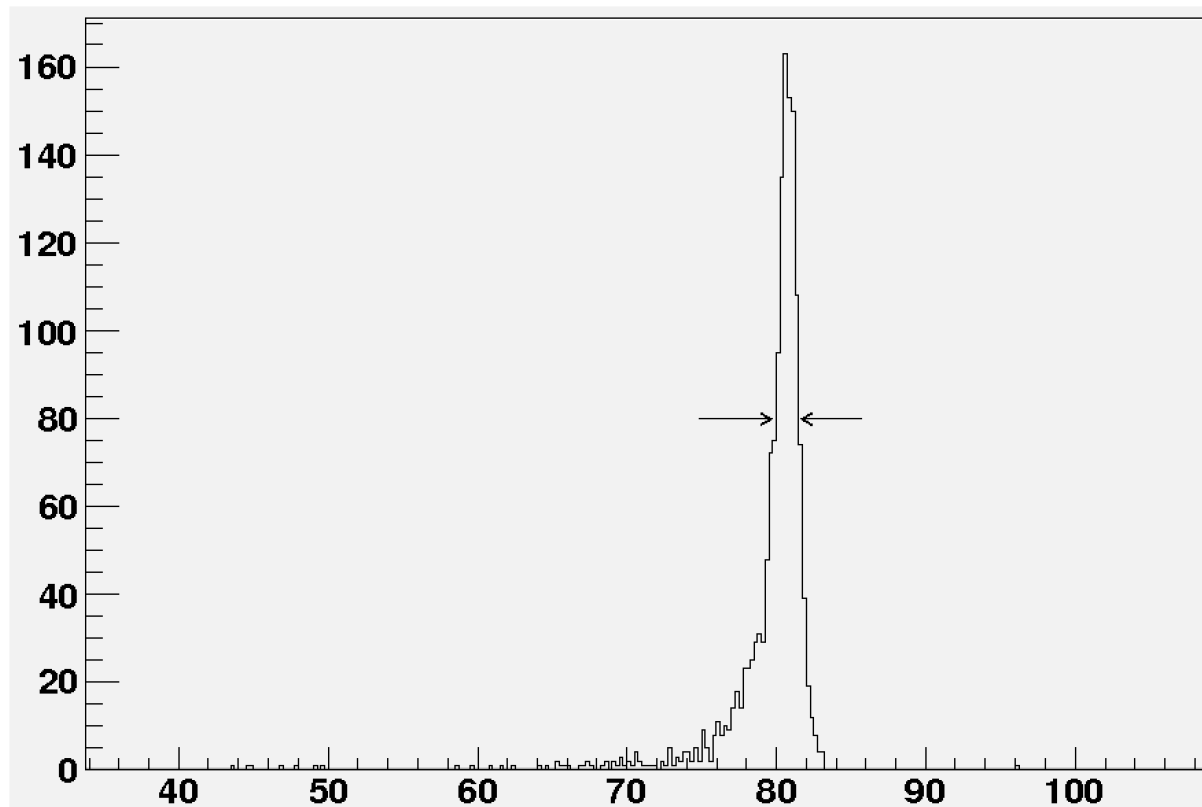
Focal plane coincidence TDC peak



Time resolution: ~ 2 ns FWHM

In-beam measurement

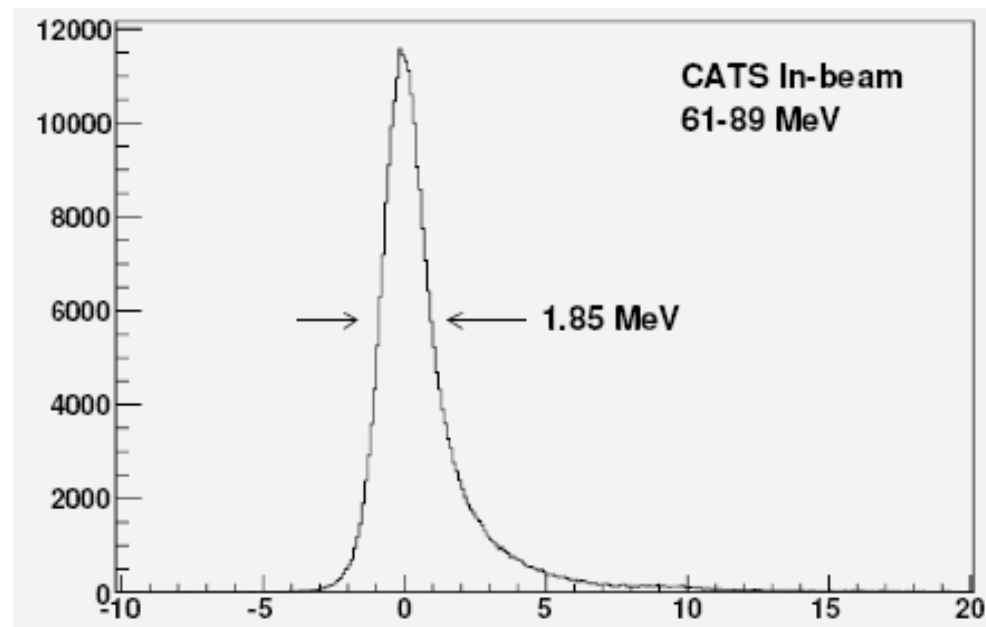
Energy deposited in the core (CATS) with a cut on a single FP channel.



Energy resolution: 1.4 MeV FWHM

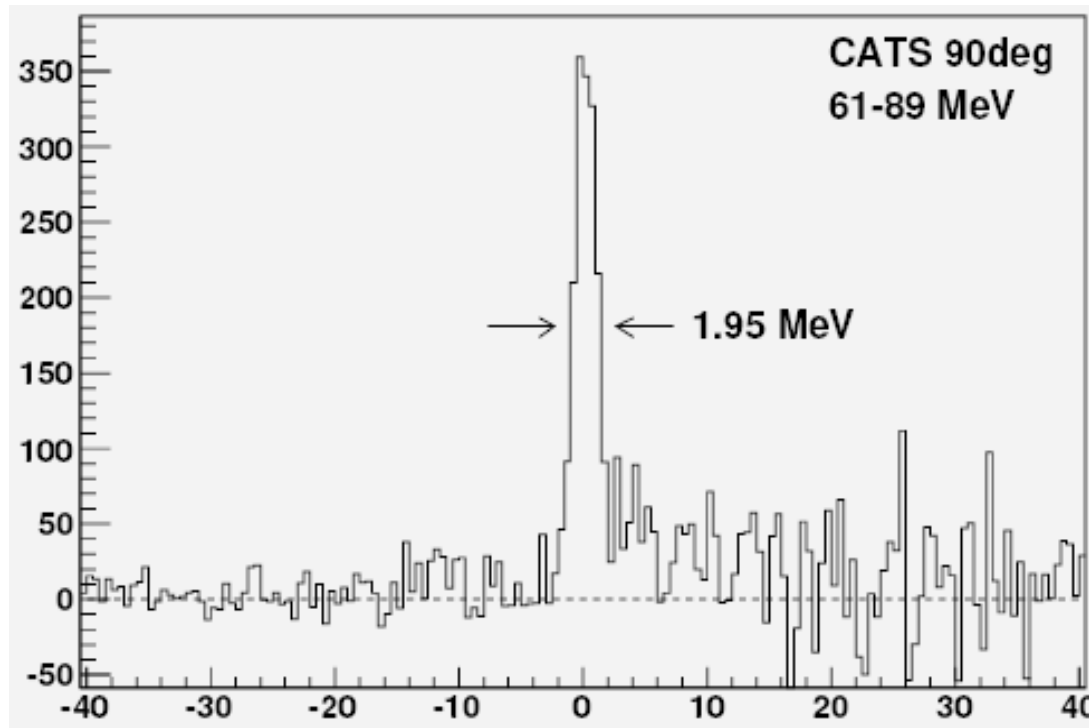
In-beam measurement

Missing energy = Incoming photon energy (Tagger) –
Detected energy (core + segments)



Energy resolution: 1.85 MeV FWHM

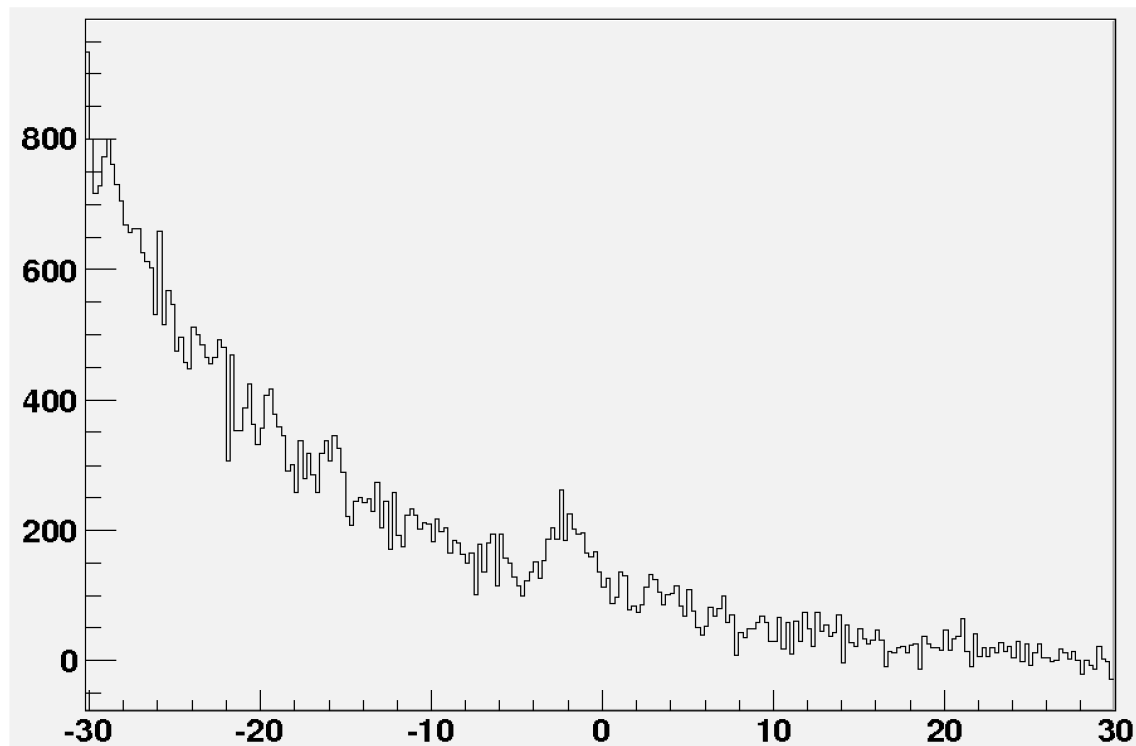
Carbon tests



Early analysis $\frac{d\sigma}{d\Omega} = 367 \pm 19 \text{ nb/sr}$

Preliminary $D(\gamma,\gamma)$ results

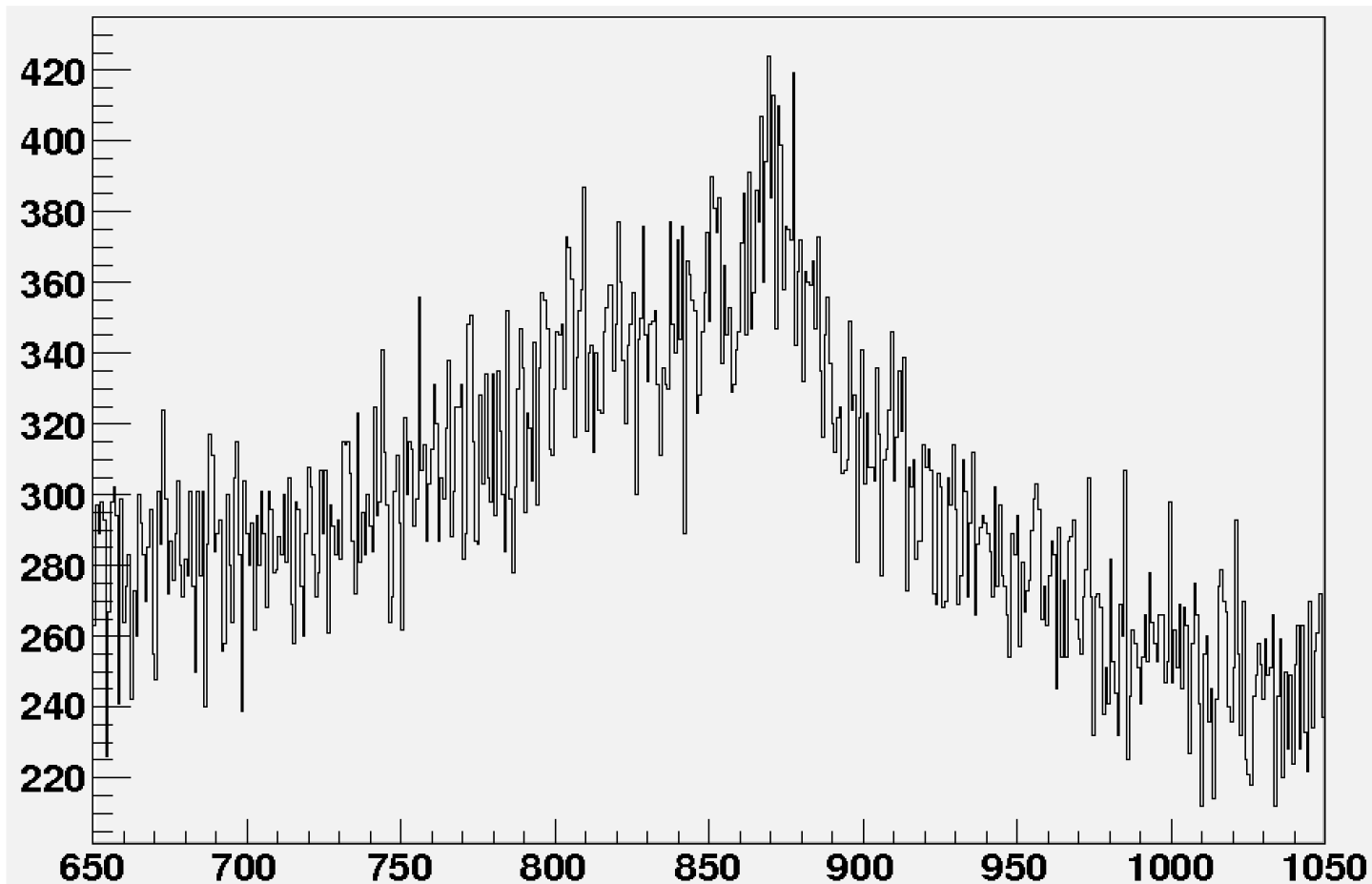
CATS at 150°
Missing energy
No background subtraction



We see a peak!
So far we may have ~ 800 events.

Preliminary $D(\gamma, \gamma)$ results

CATS at 150°
FP coincidence TDC peak
Missing energy cut



Summary

- Upgraded tagged photon beam at MAX-lab is operational and experiments are running.
- The three very large NaI detectors show the expected good energy resolution.
- $D(\gamma,\gamma)$ data has been taken and early results look promising.

Next step: Collect more $D(\gamma,\gamma)$ data to improve statistics.