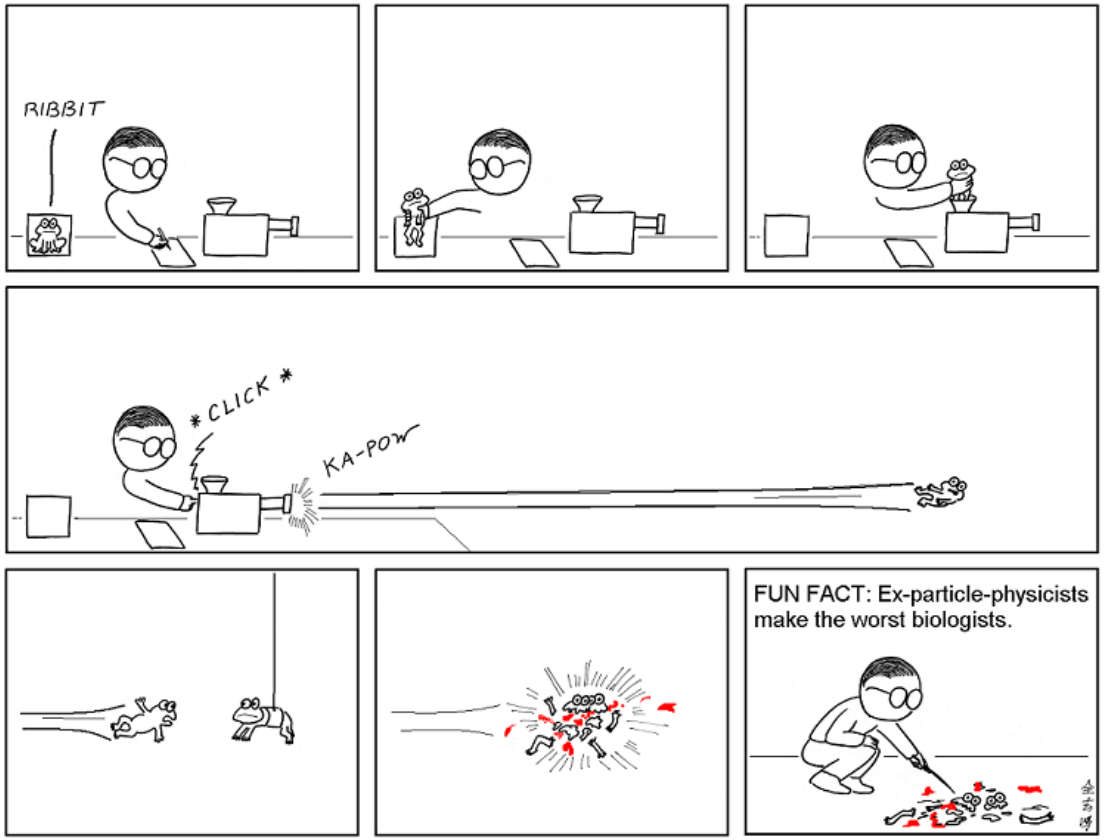
Measuring the Σ Polarisation Observable for Double π^0 Photoproduction

Simon Gardner

Erice School
22 September 2015

University of Glasgow

Outline



http://abstrusegoose.com/156

Motivation

Goal

Motivation

Thirst for knowledge nature

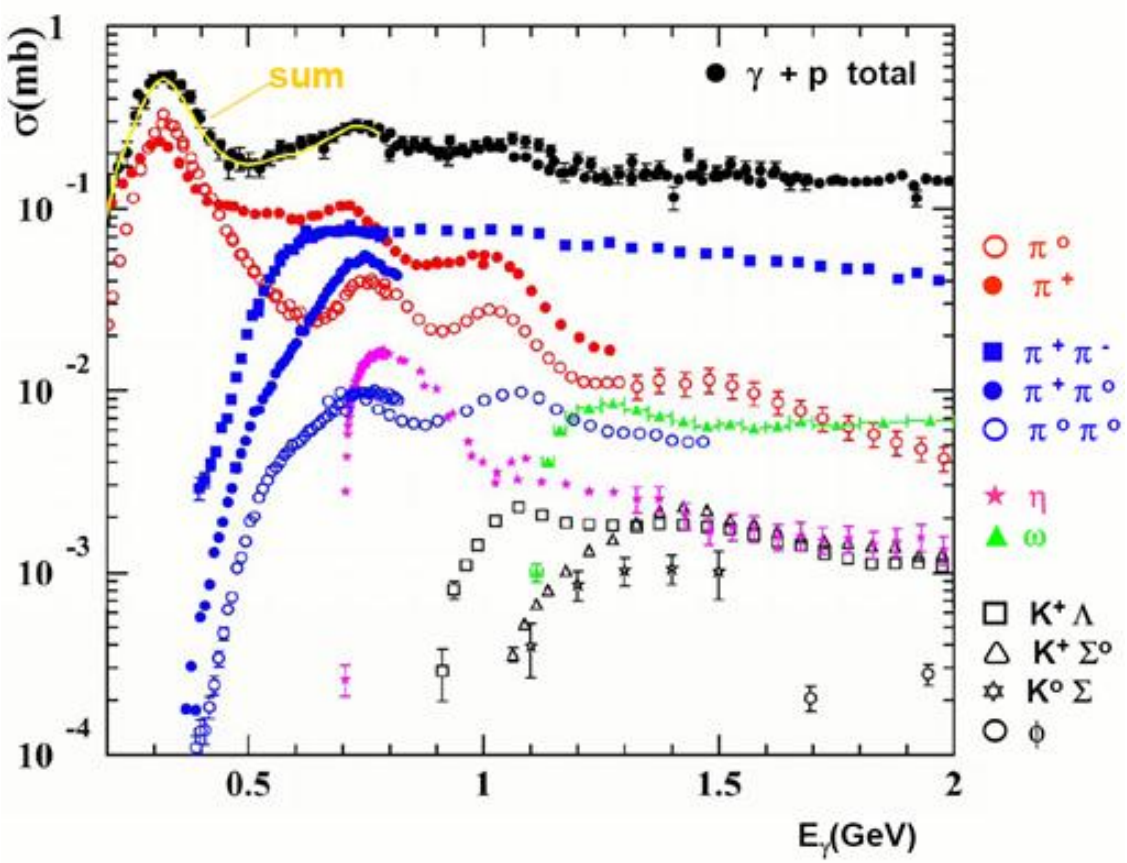
Motivation

Goal

Accumulating

Motivation

There is a lack of double π^0 polarisation observable data. Additional information helps theorists refine their nucleon models.



Motivation

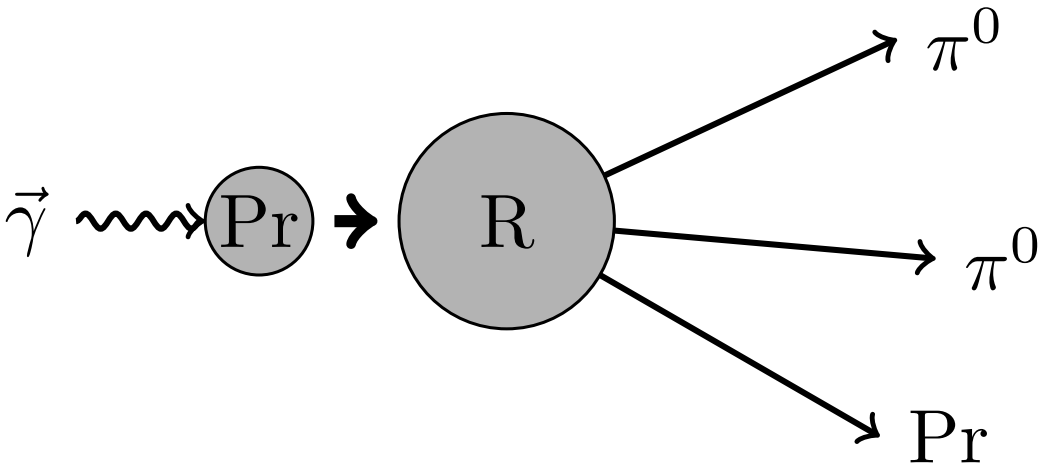
University of Glasgow

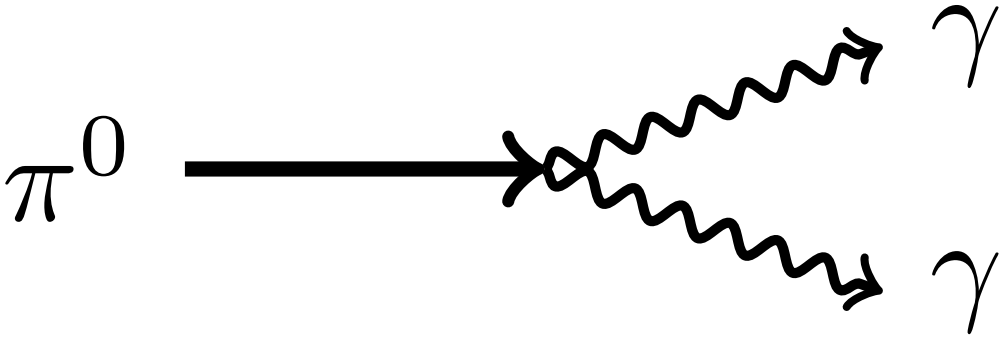
Goal

Measuring Σ polarisation observable in double π^0 photoproduction off the proton

Motivation

Outline

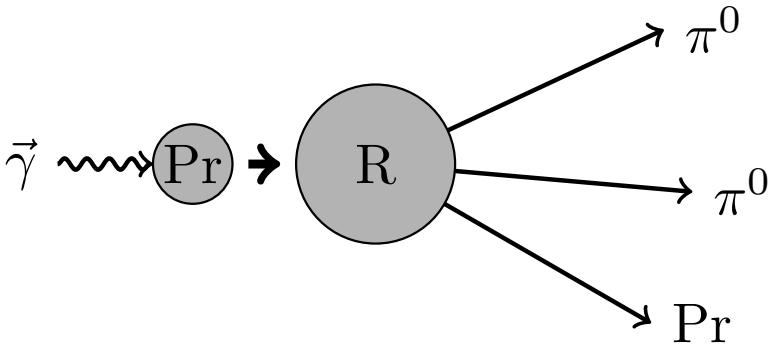


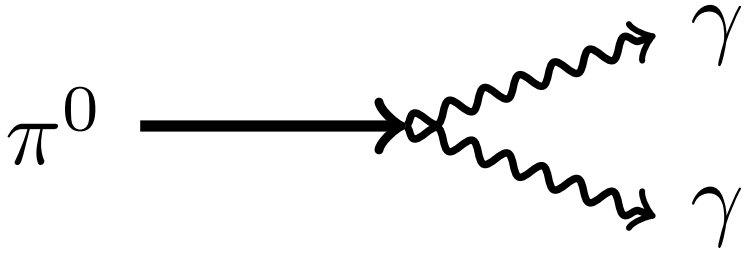


Basic Physics

Neutral Pion (π^0)

Lightest Meson
Mass = 135 MeV
Charge = 0
Quark Content = $\frac{u\bar{u}-d\bar{d}}{\sqrt{2}}$
Electromagnetic Decay
Decay = 2γ (99%)
Mean Lifetime = $8.4 \times 10^{-17} s$

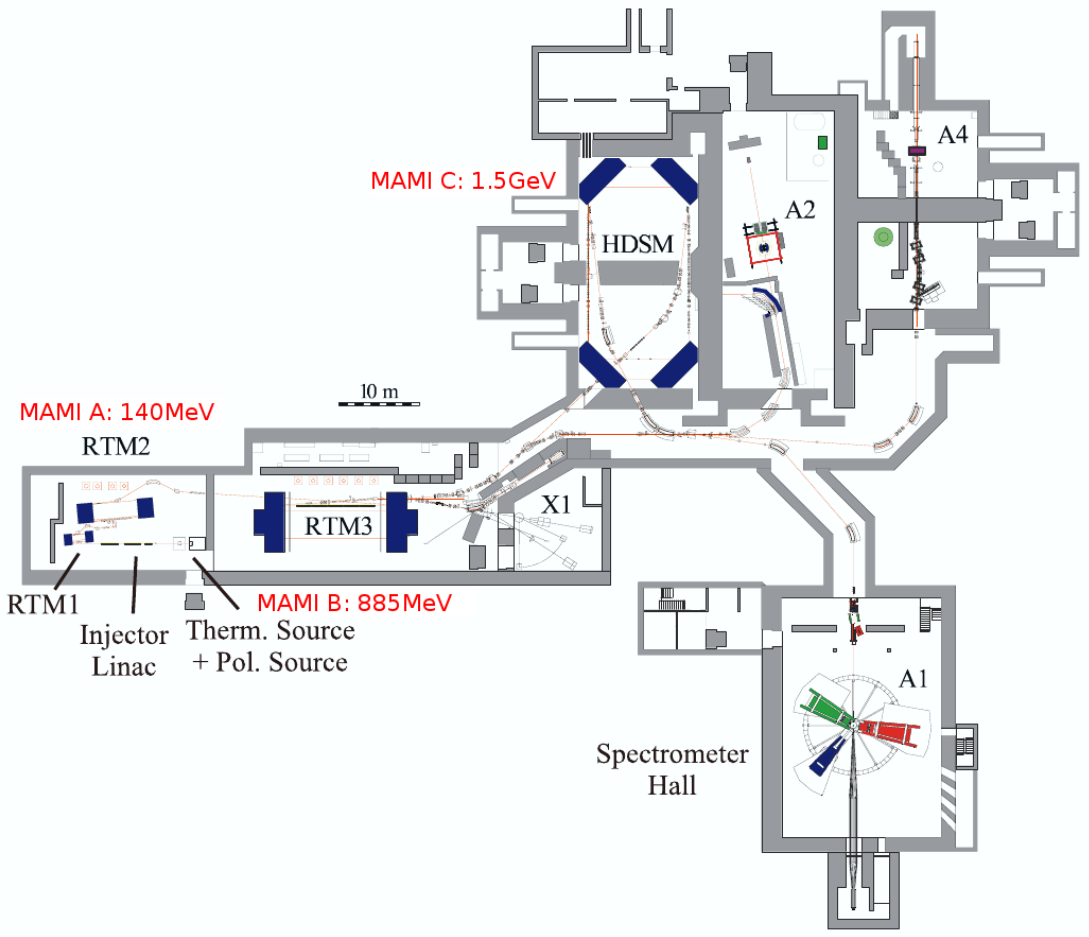




π^0 Detection

At the speed of light a π^0 would decay within 2.5 nm so impossible to detect directly.
Desired specialised photon detector.

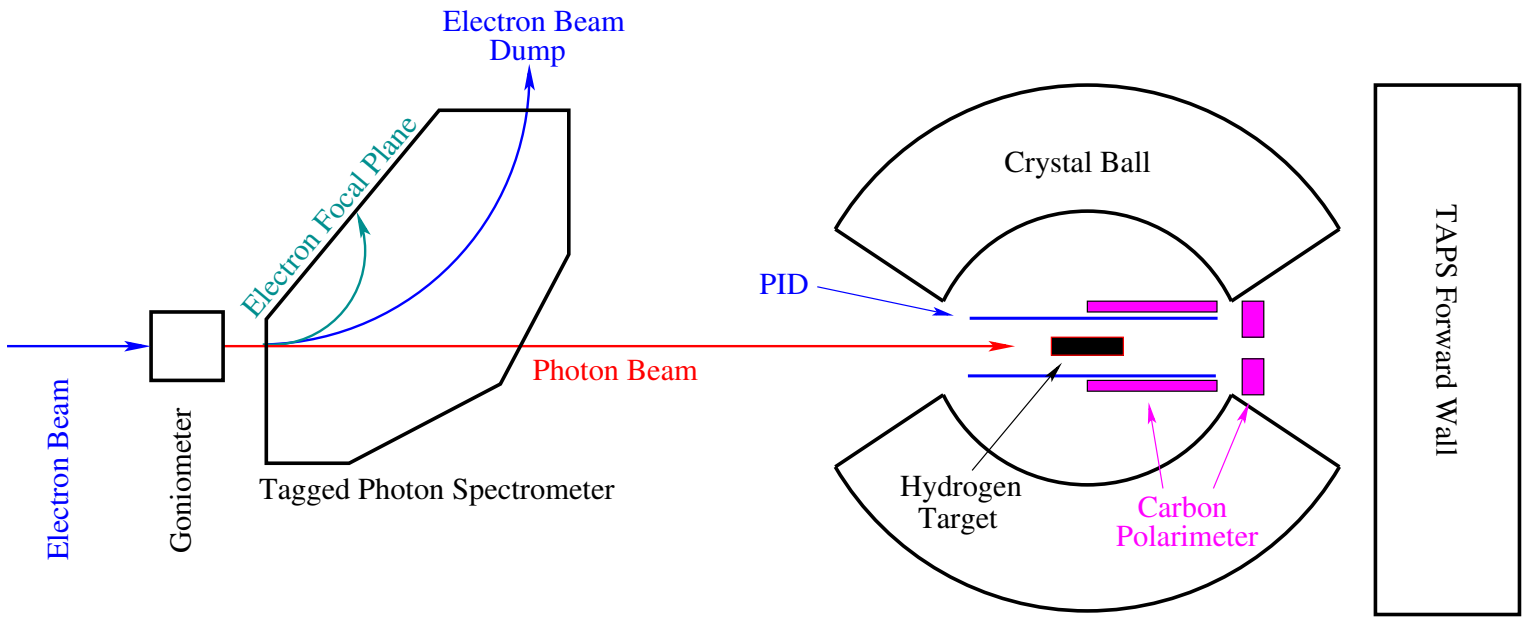
Outline



MAMI - A2

Experimental Hall

High precision tagged photon experiments
Fed by continuous beam of electrons with energy up to 1.6 GeV



MAMI - A2

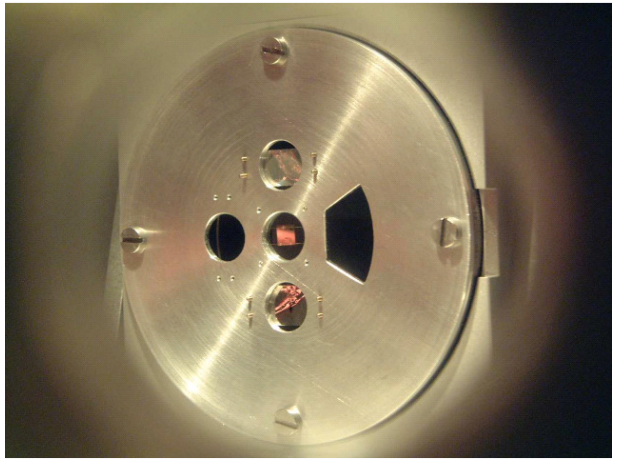
Experimental Hall

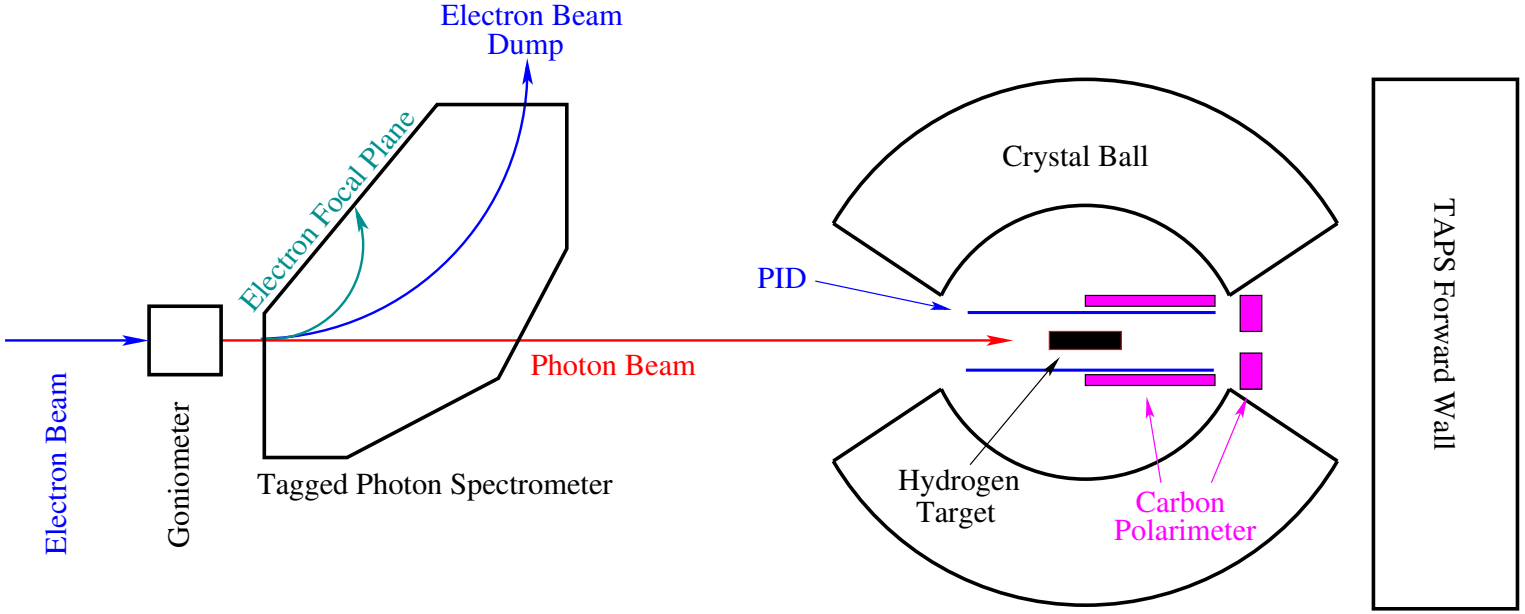
Goniometer, radiators

Bremsstrahlung radiation

Coherent scattering (Bragg)

Linear polarisation





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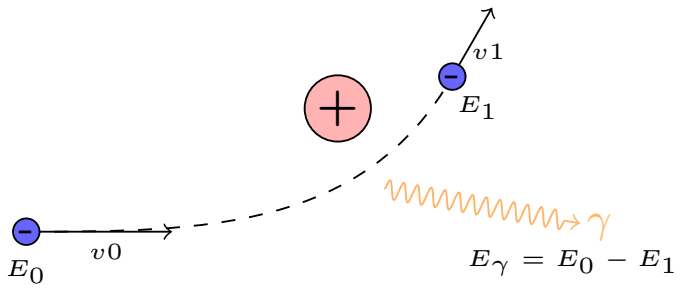
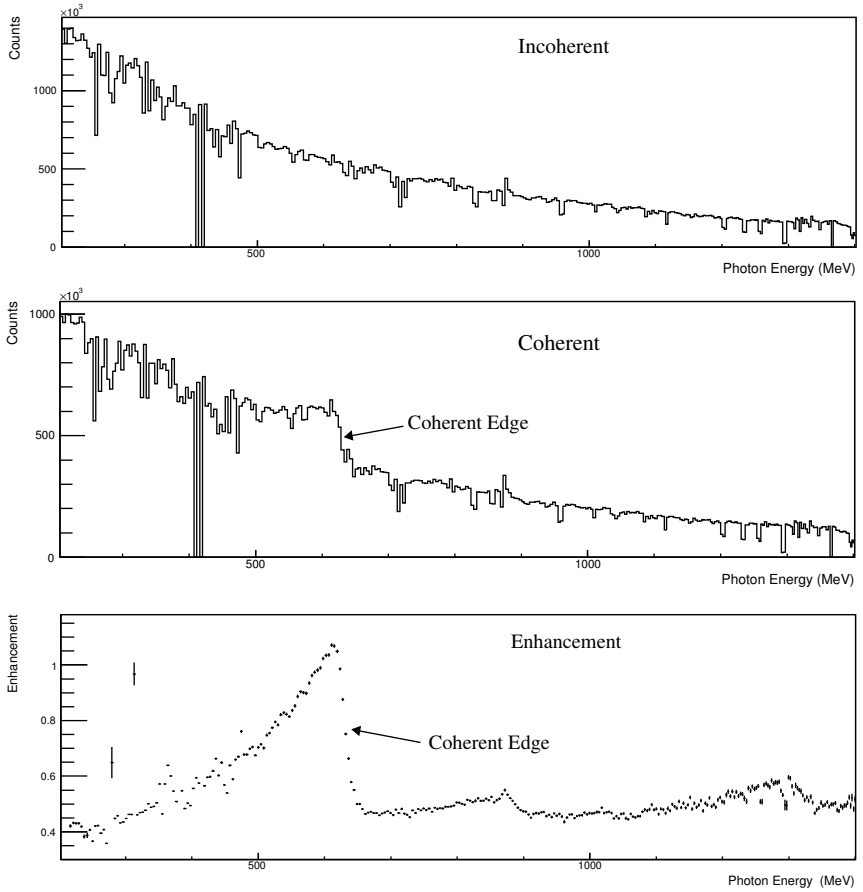




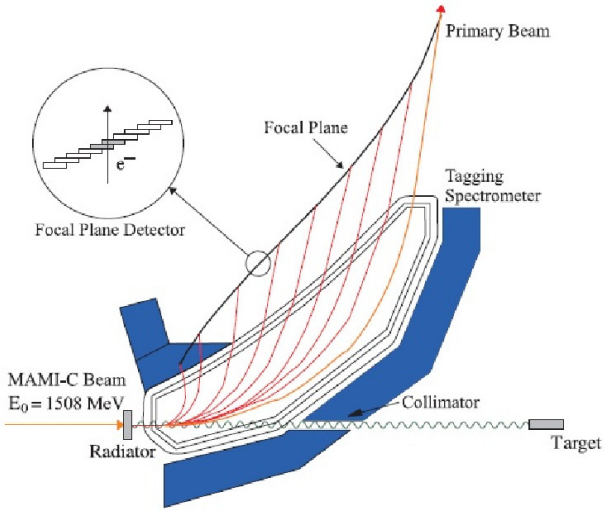
MAMI - A2

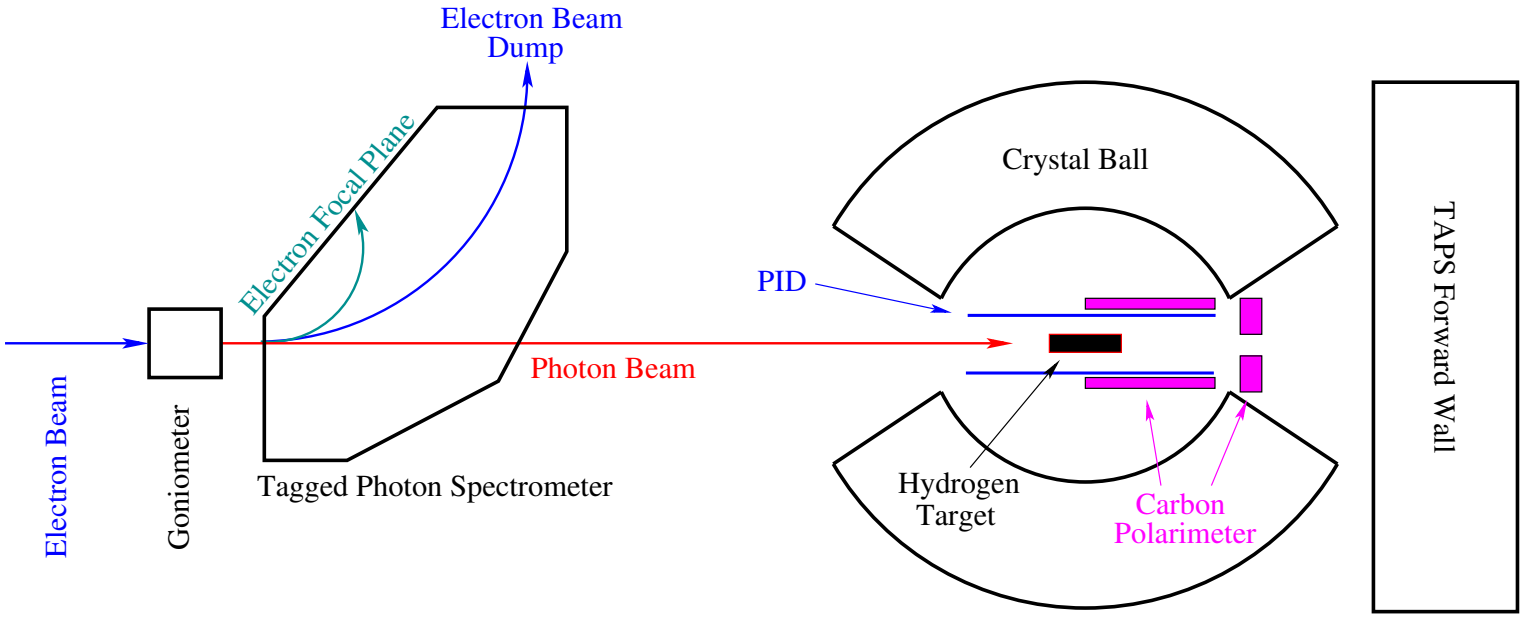
Experimental Hall

Glasgow Photon Tagger

Indirect photon energy

352 Channels





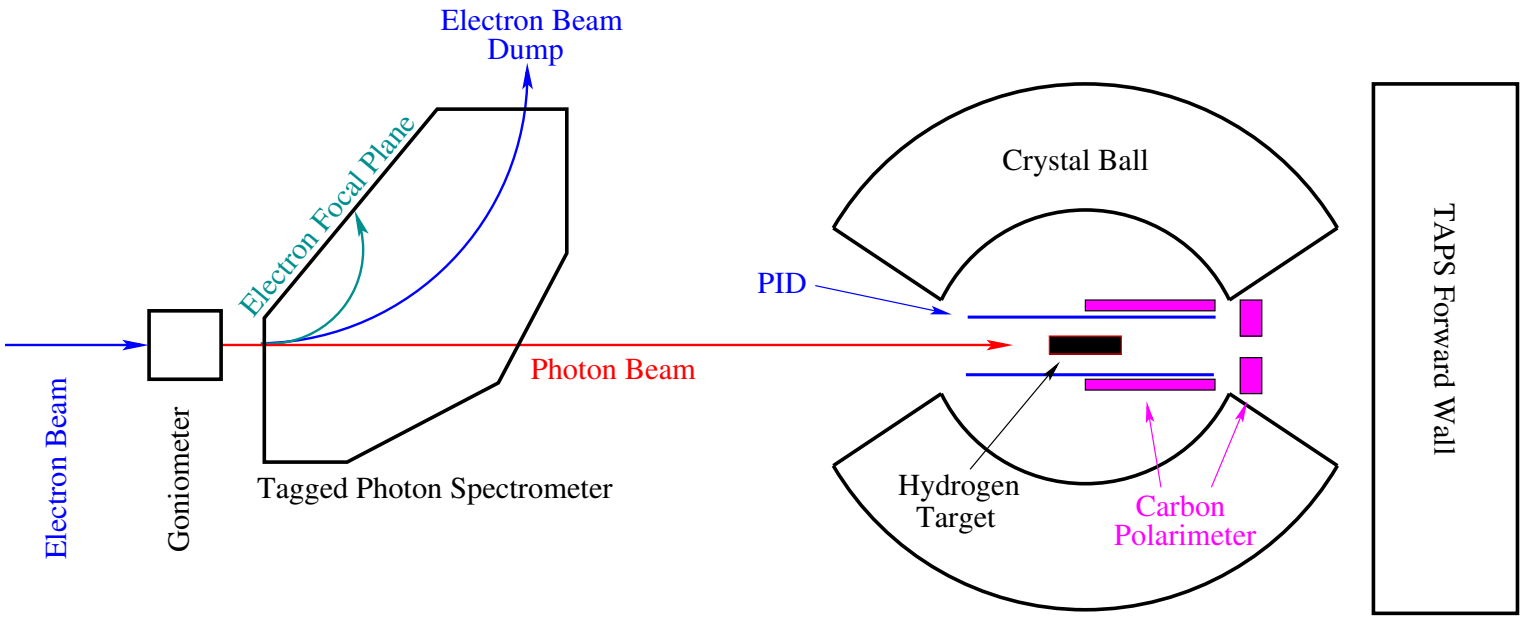
MAMI - A2

Experimental Hall

Liquid hydrogen target

Centre of detector system

20.5 K at 1080 mBar



MAMI - A2

Experimental Hall

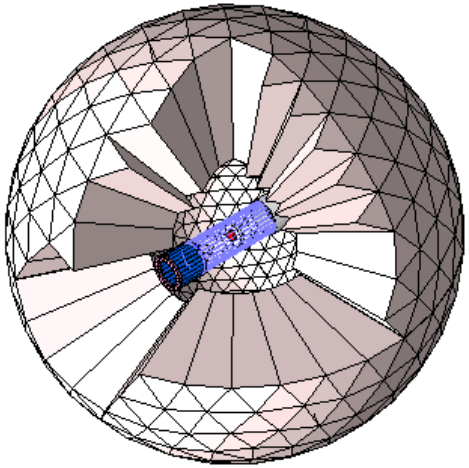
Crystal Ball

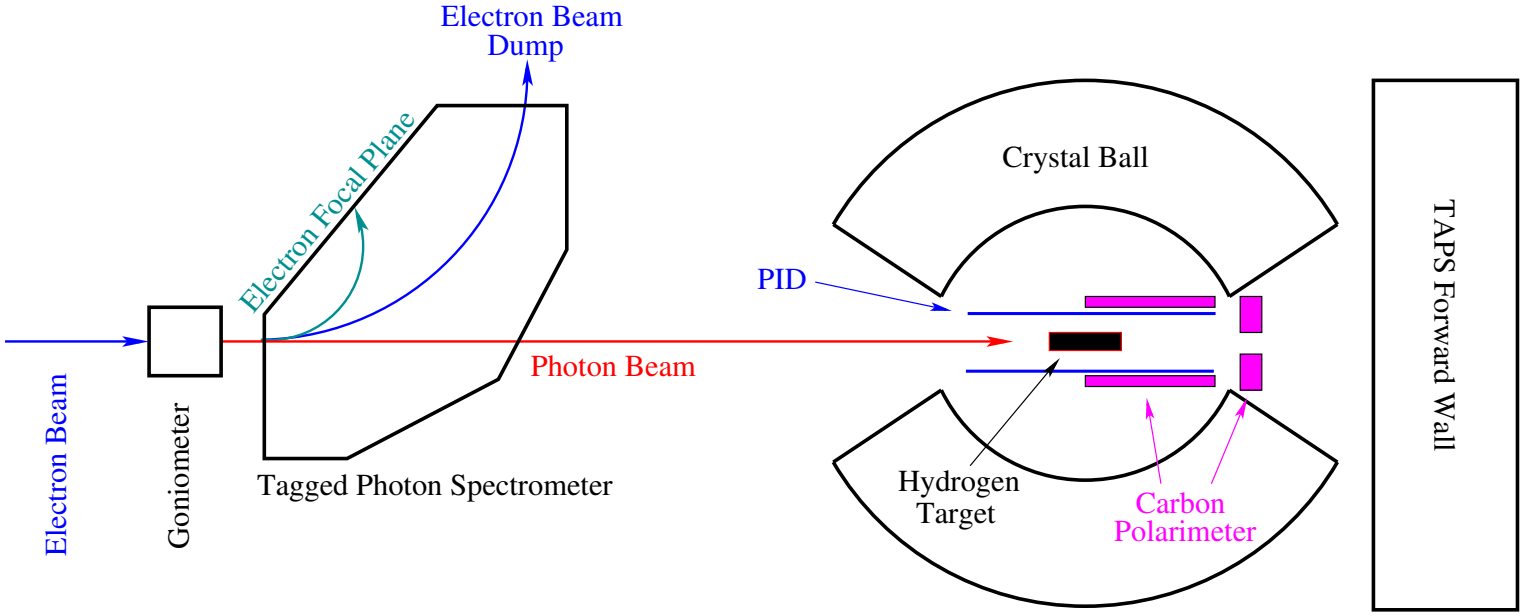
672 NaI Crystals

$\sim 4\pi$ photon detector

Energy resolution 2-4 MeV

Particle ID systems





MAMI - A2

University of Glasgow

Experimental Hall

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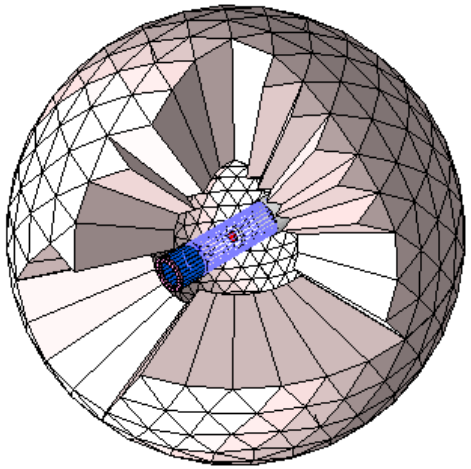
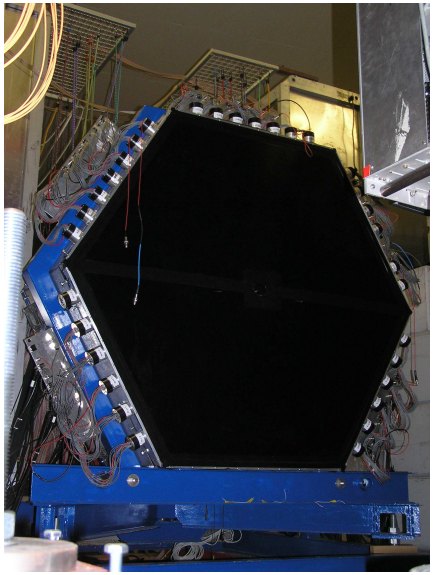




TAPS

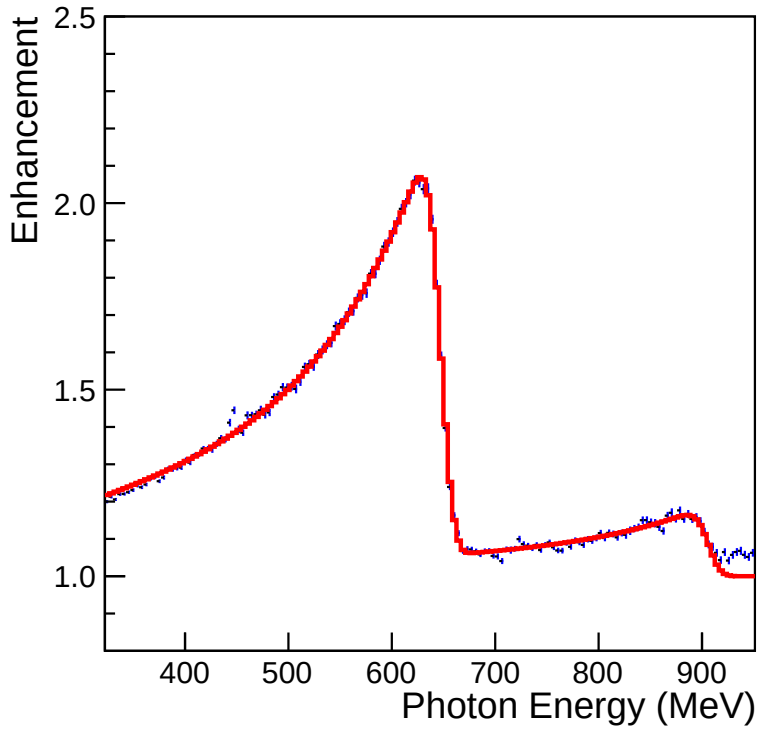
Two Armed Photon Spectrometer

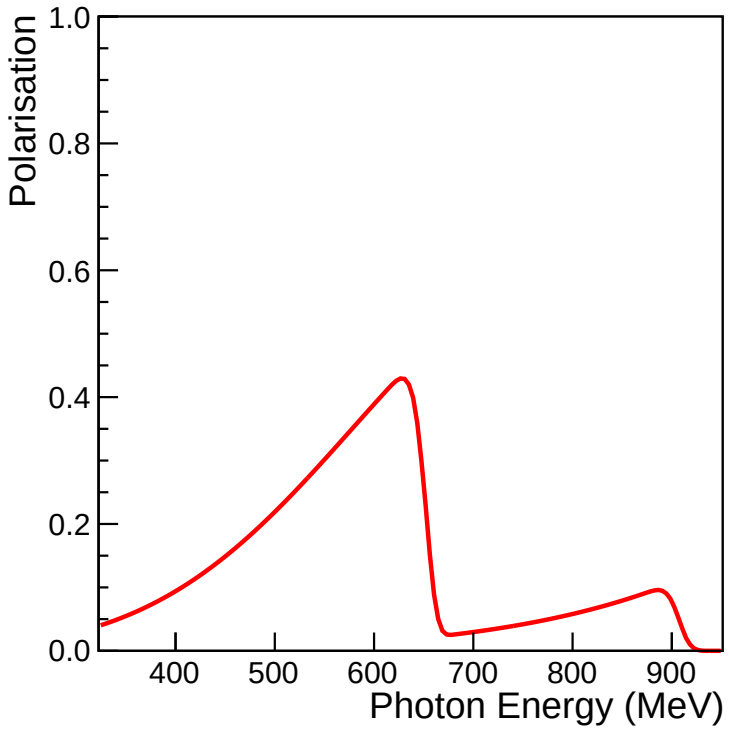
Covers forward angles $0^\circ < \theta < 20^\circ$

384 BaF_2 Crystals

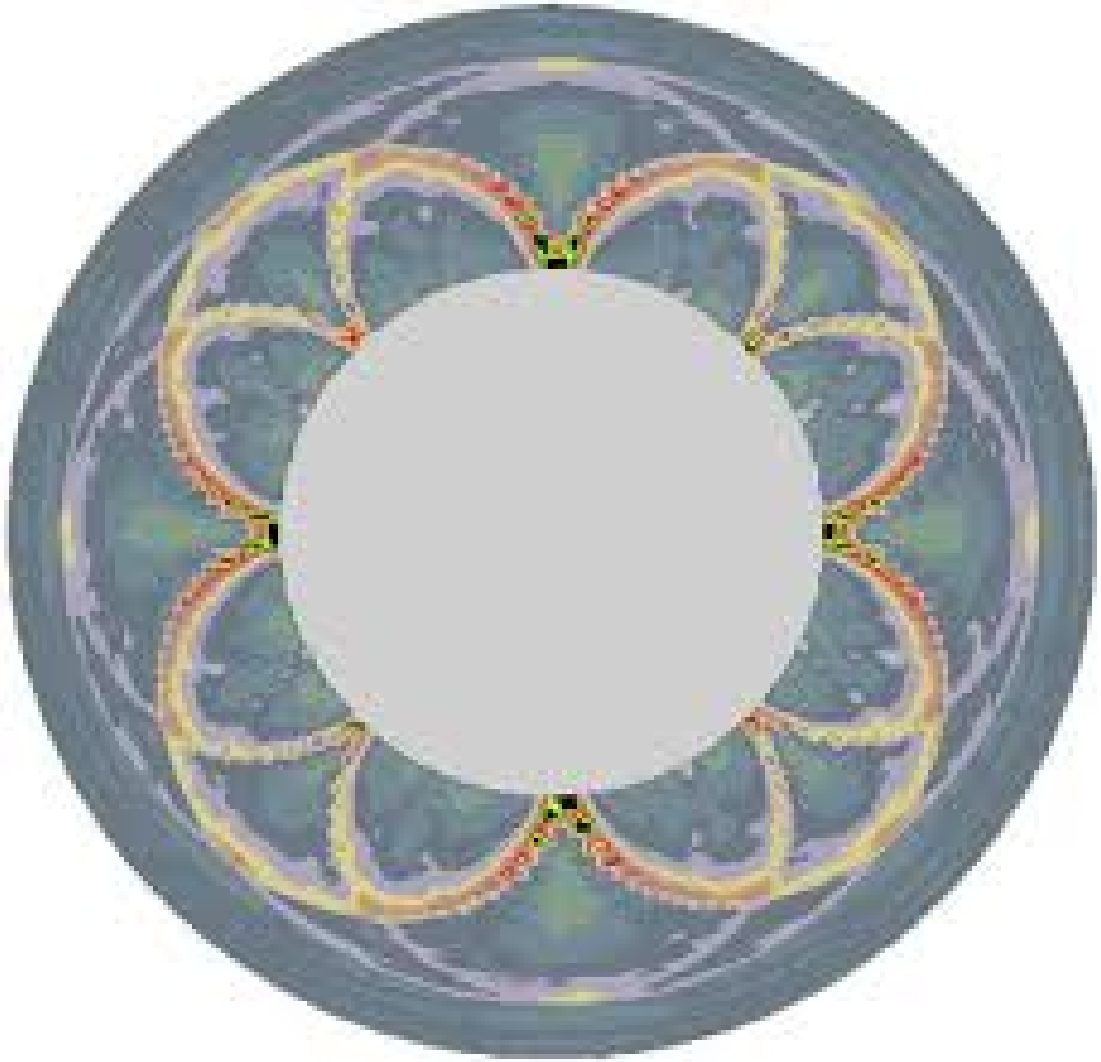
Experimental Run

Beam 1.5 GeV
Coherent range 450-650 MeV
Linear polarisation up to 43%





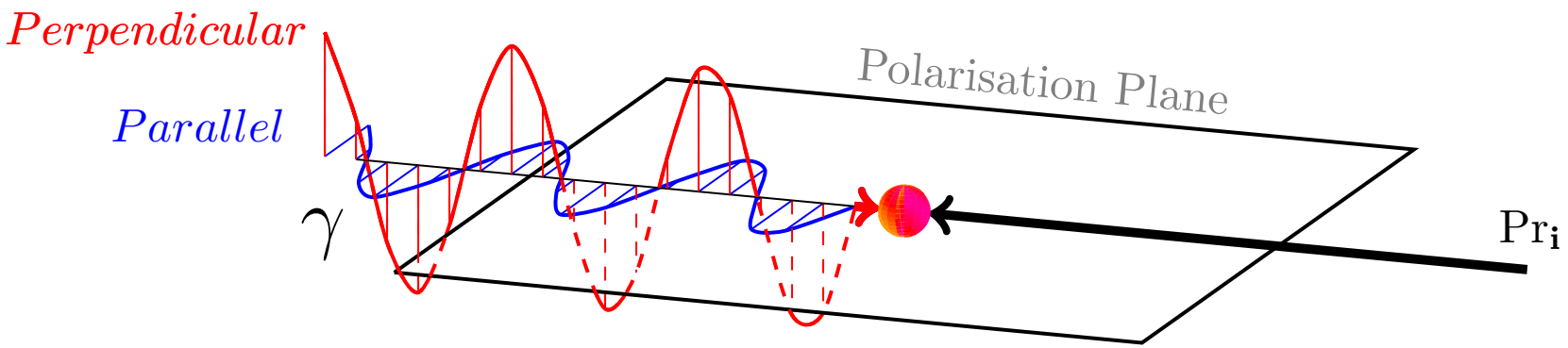
Outline



http://arxiv.org/abs/0809.1739

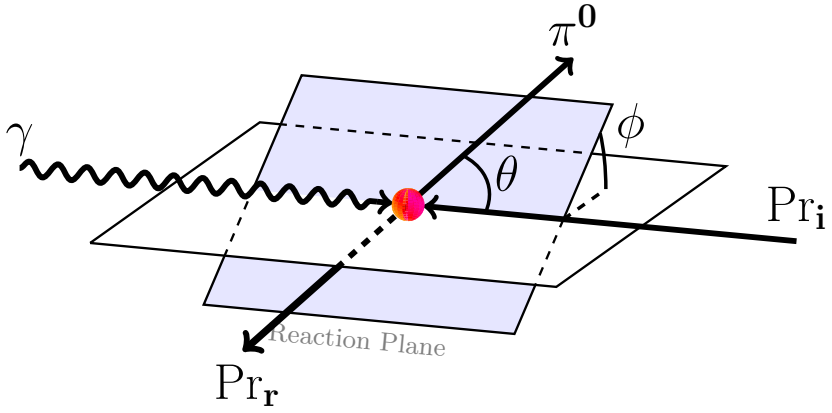
Photon Asymmetries

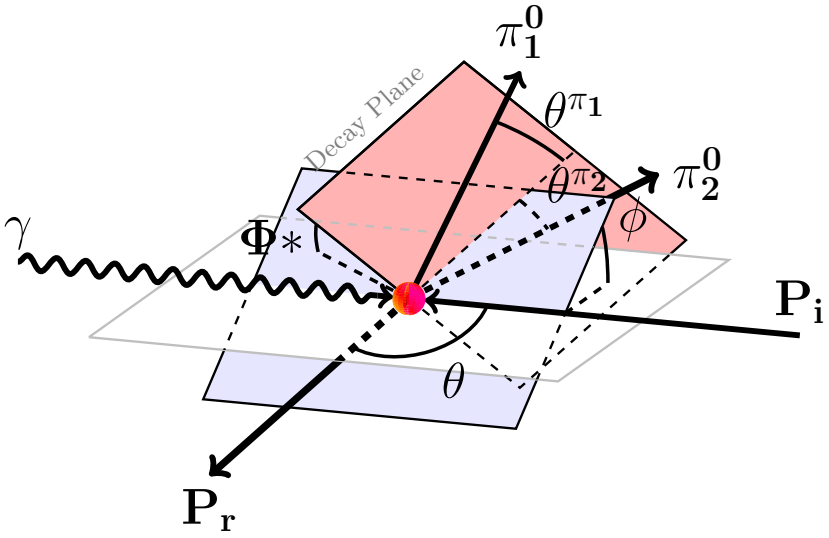
Measurements are taken at two perpendicular photon polarisations



Photon Asymmetries

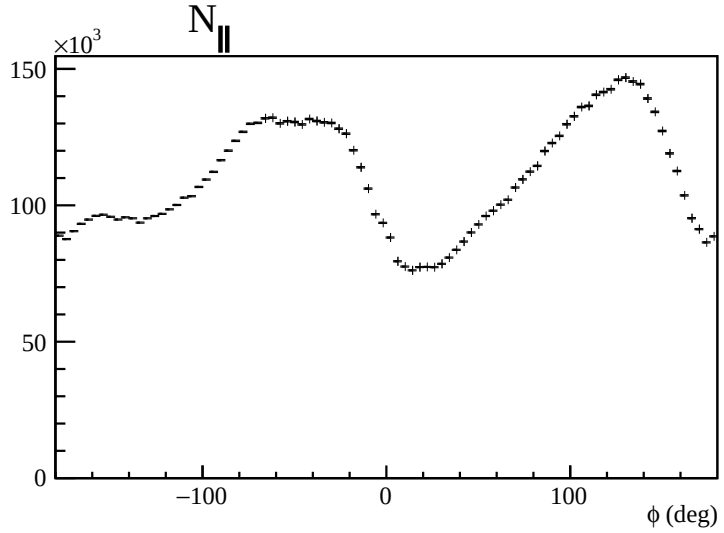
Measurements are taken at two perpendicular photon polarisations
Azimuthal phi from polarisation plane (White)

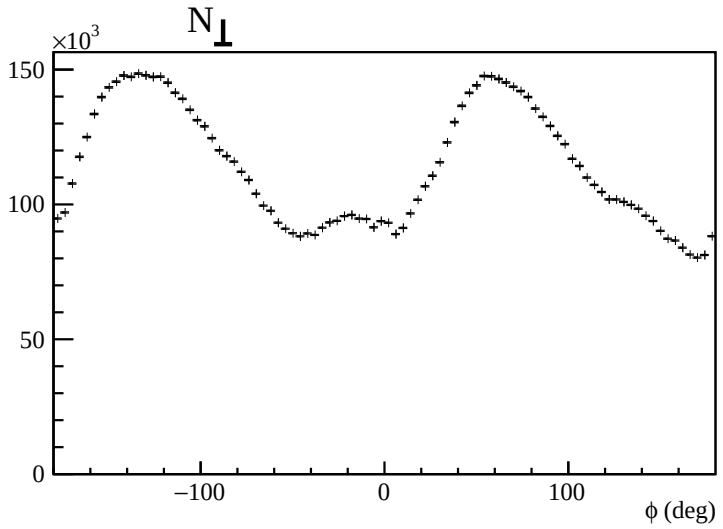




Photon Asymmetries

Measurements are taken at two perpendicular photon polarisations
Photon angular distributions are affected by detector acceptance





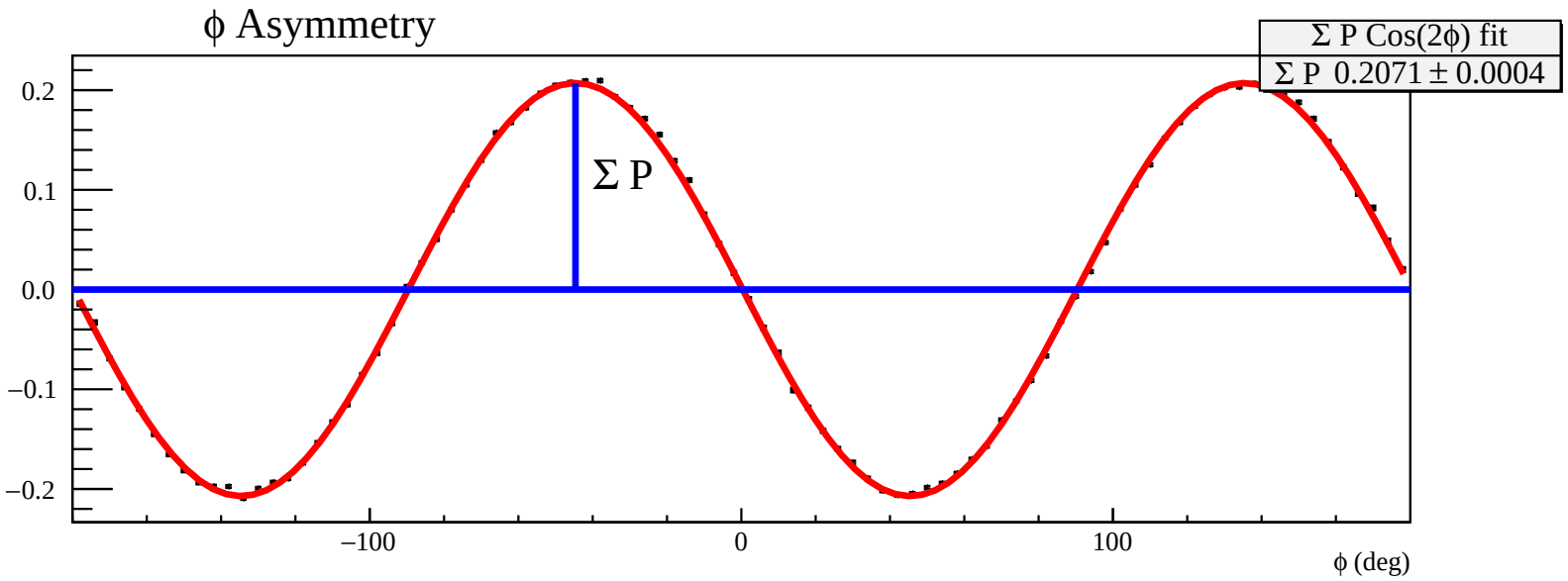
$$Asymmetry = \frac{N_{\perp} - N_{\parallel}}{N_{\perp} + N_{\parallel}} \tag{1}$$

Photon Asymmetries

Measurements are taken at two perpendicular photon polarisations

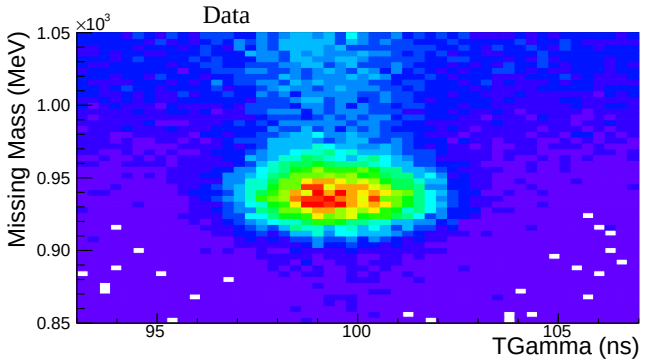
Photon angular distributions are affected by detector acceptance

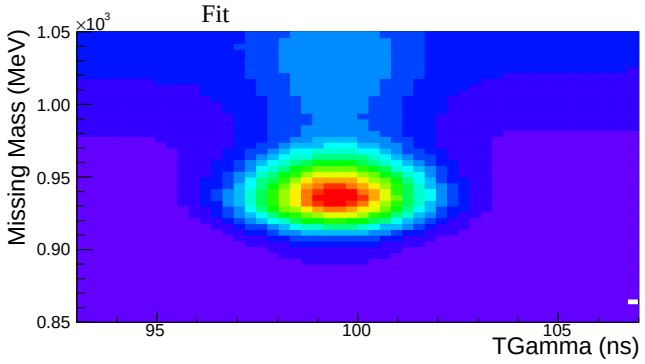
Photon asymmetries are unaffected by detector acceptance

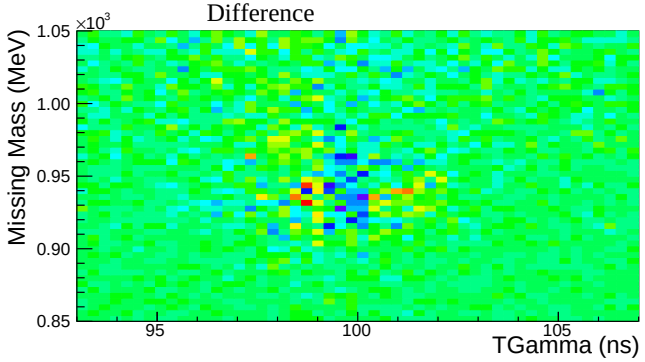


$$Asymmetry = \frac{N_{\perp} - N_{\parallel}}{N_{\perp} + N_{\parallel}} = \Sigma \cdot P^{lin} \cdot \cos(2\phi) \qquad (1)$$

Outline







Analysis Overview

University of Glasgow

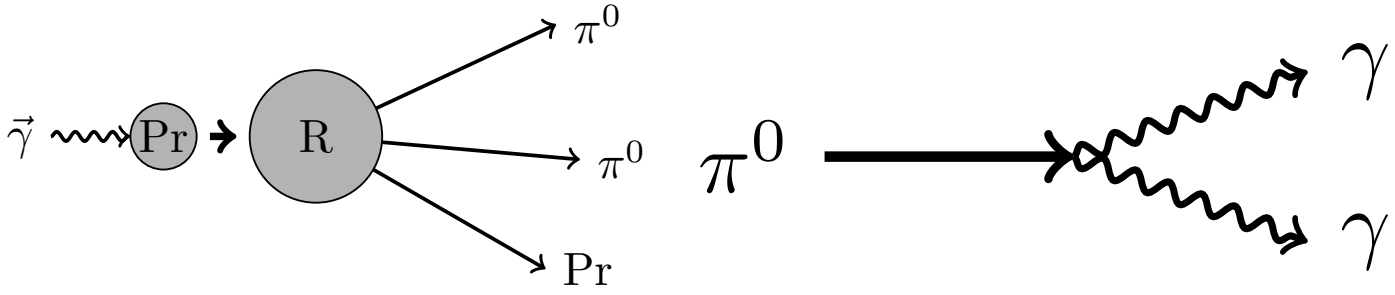
Steps

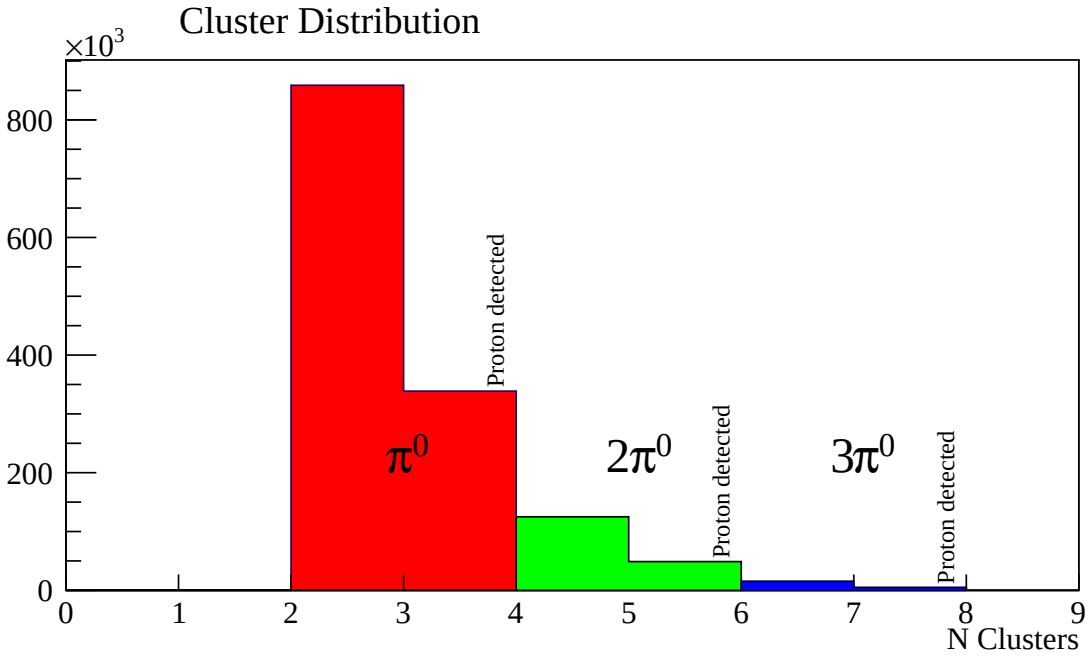
Develop technique on single π^0 photoproduction

- Particle ID
- Reaction ID
- Extract signal from data using weighted fits to data
- Calculate asymmetry from ϕ distribution

Repeat process for double π^0 photoproduction

Reaction ID

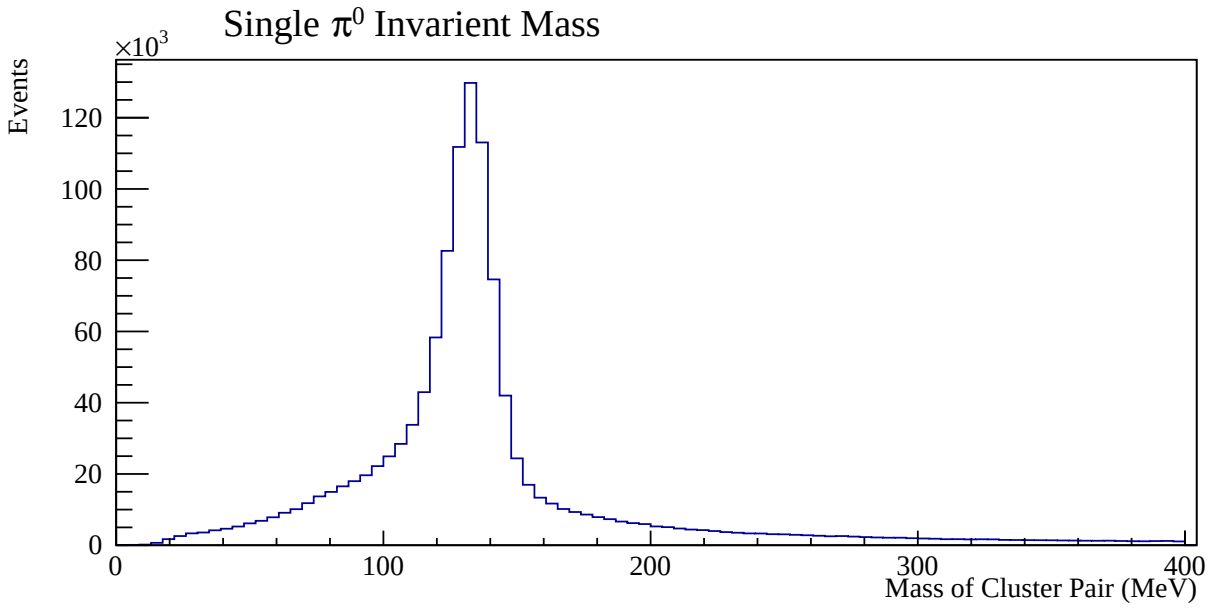




Events with N or N+1 clusters taken to be an $N\pi^0$ reaction.

Reaction ID

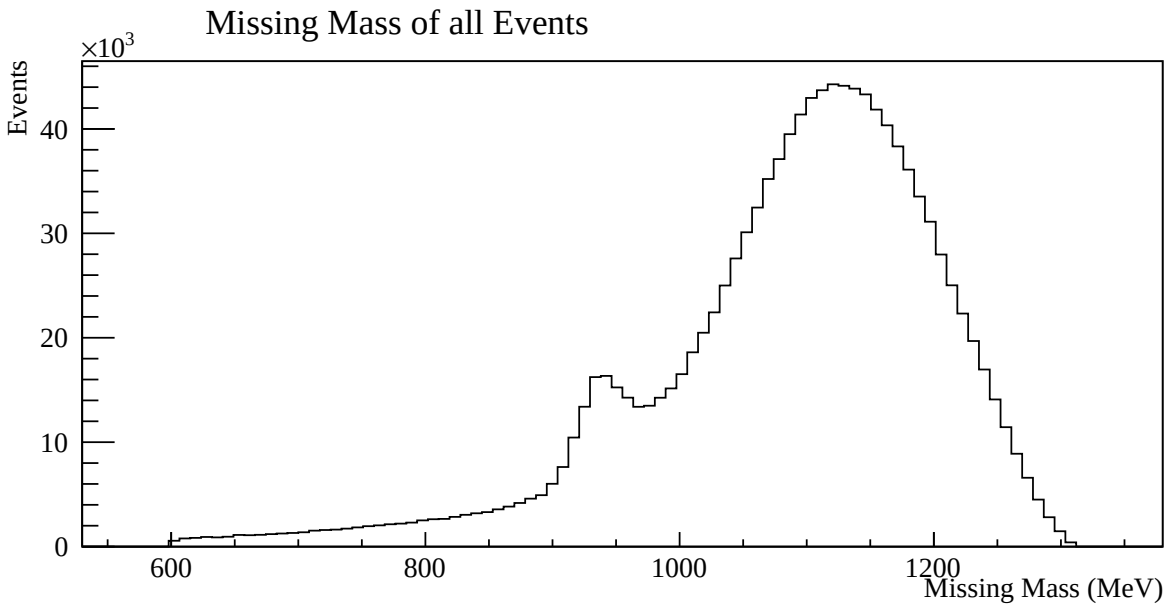
Loop over pairs of clusters adding 4-Vectors
χ^2 test is performed on the differences from the π^0 mass
Smallest χ^2 identifies reaction π^0s



Identified vectors set to have the π^0 mass
Remaining cluster assumed to be Proton; now ignored

Reaction ID

$$\vec{Pr}_{recoil} = \vec{Pr}_{target} + \vec{\gamma}_{tagged} - N\vec{\pi^0} \quad (2)$$



Distribution of the recoil vector "Missing Mass" is made of signal and background components.

$_s$*Plot* - Weighted Fitting

Details

sPlot: a statistical tool to unfold data distributions (2005)
http://arxiv.org/abs/physics/0402083
Developed for BABAR at SLAC
Events designated weights from fitting PDFs to data

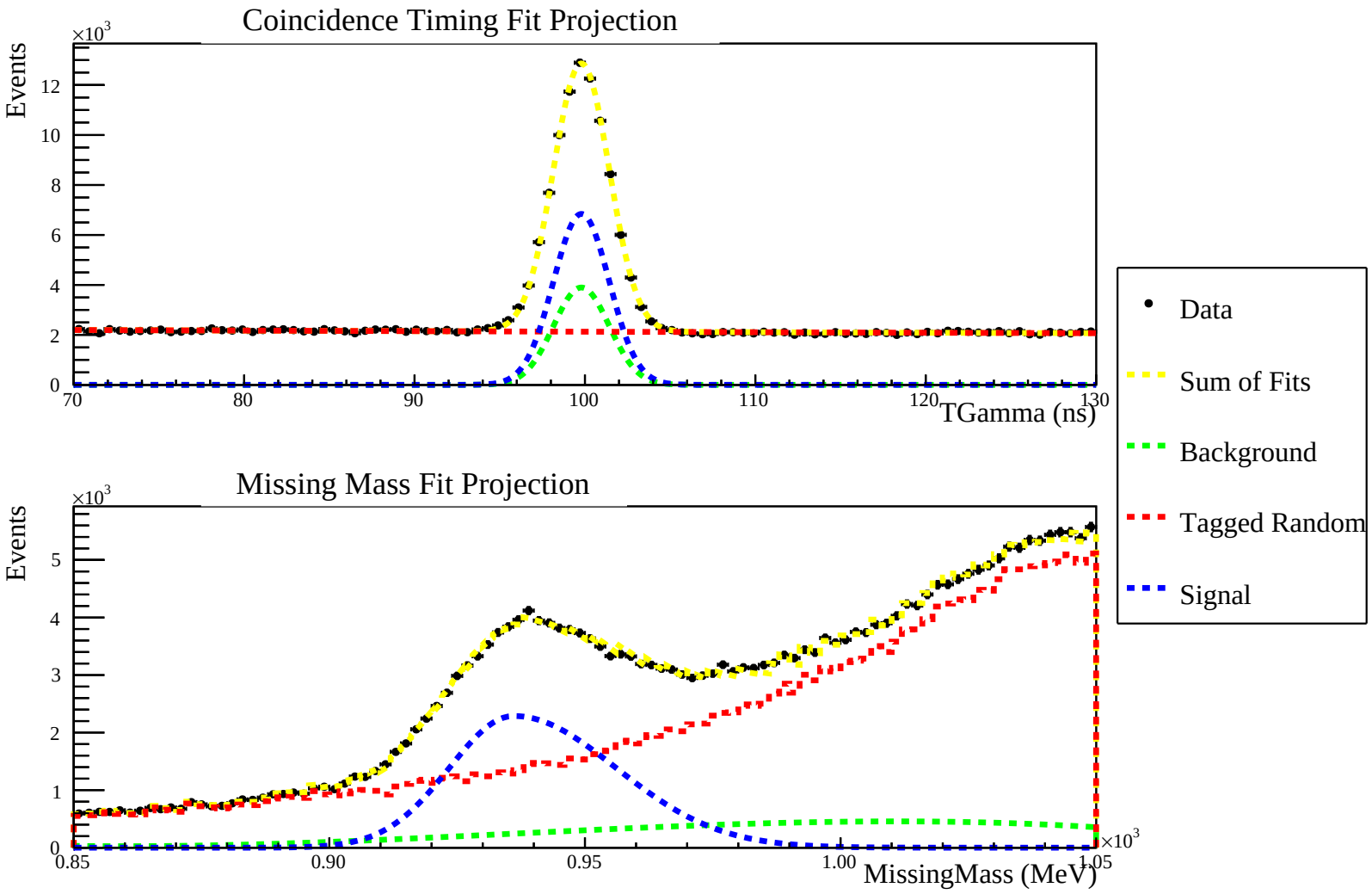
Advantages

Handles multiple event types simultaneously
No hard cuts are made
Eliminates background dilution by disentangling signal

Disadvantages

Requires knowledge of the shape of signal and background events

$_s$*Plot* - Weighted Fitting - Single π^0



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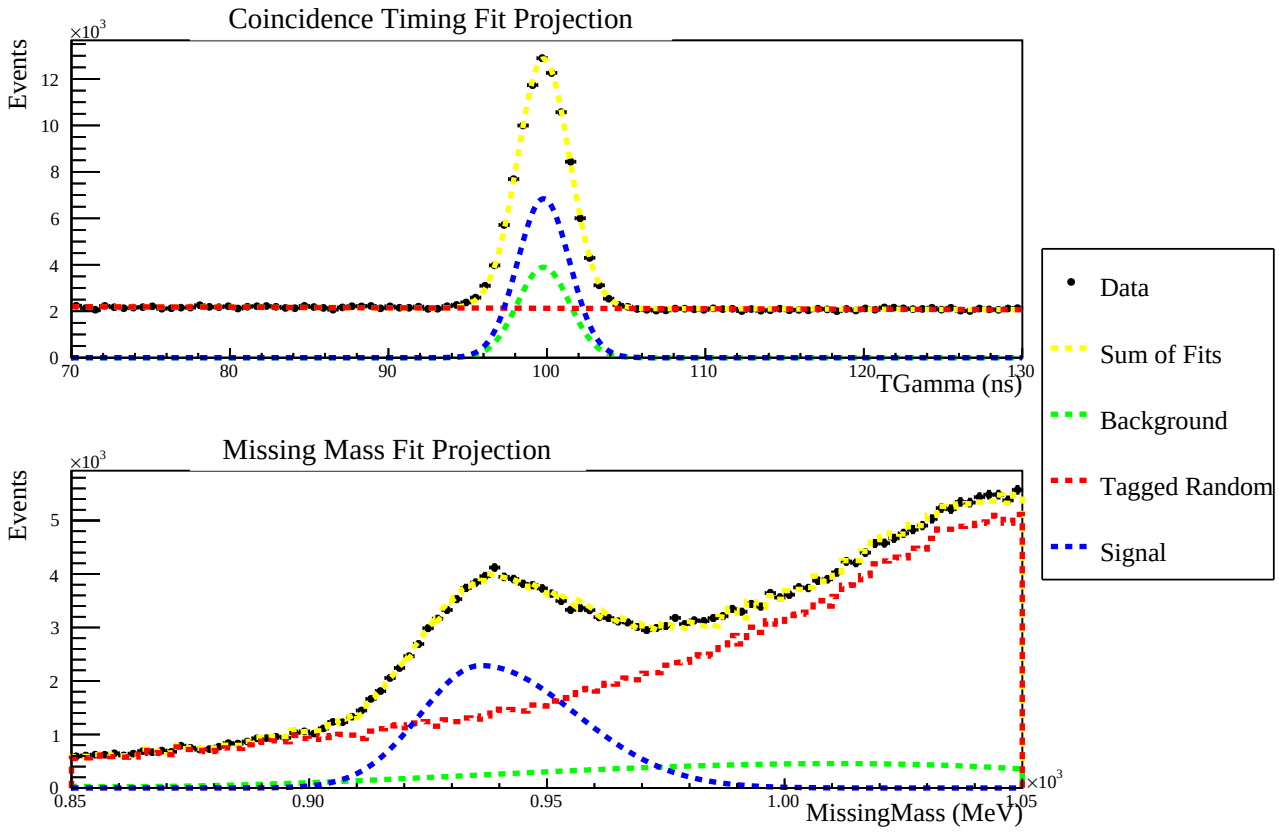
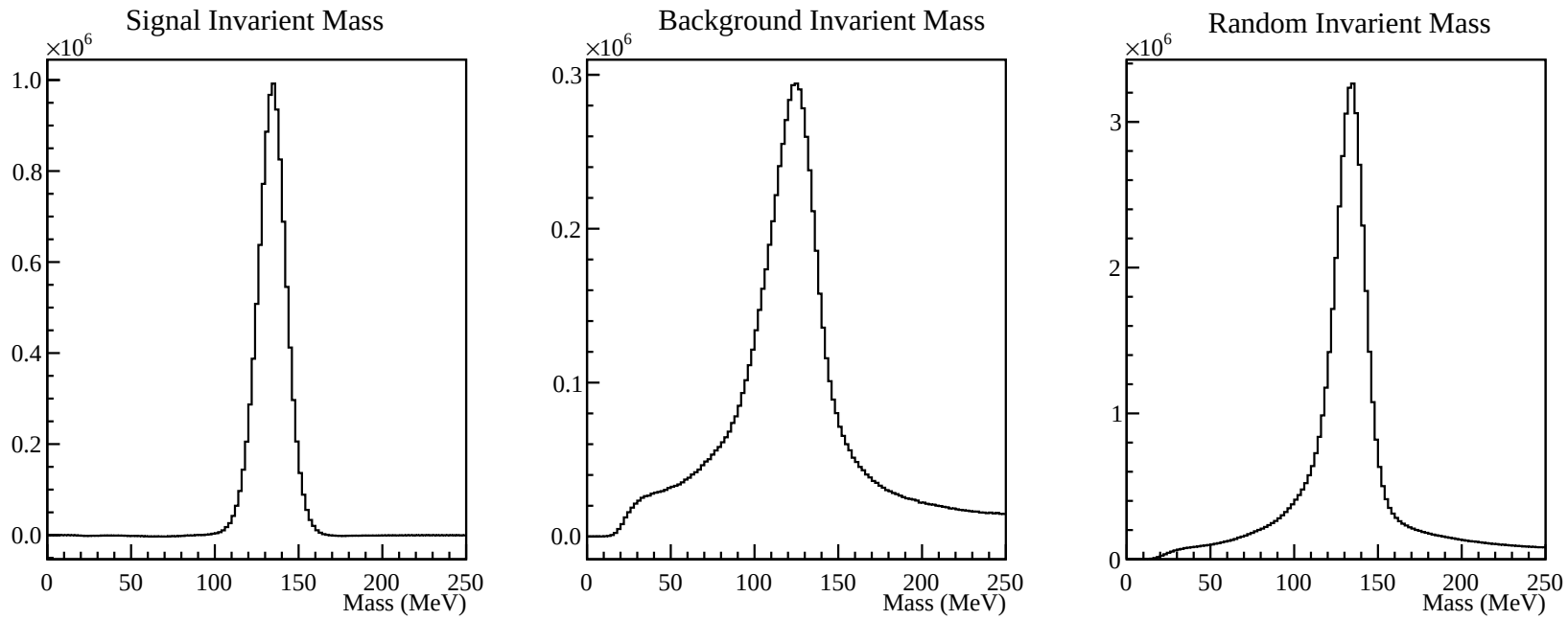


	Missing Mass	Timing
Signal	Bifurcated Gaussian	Gaussian
Background	Cubic	Gaussian
Tagged Random	Sideband histogram	Line

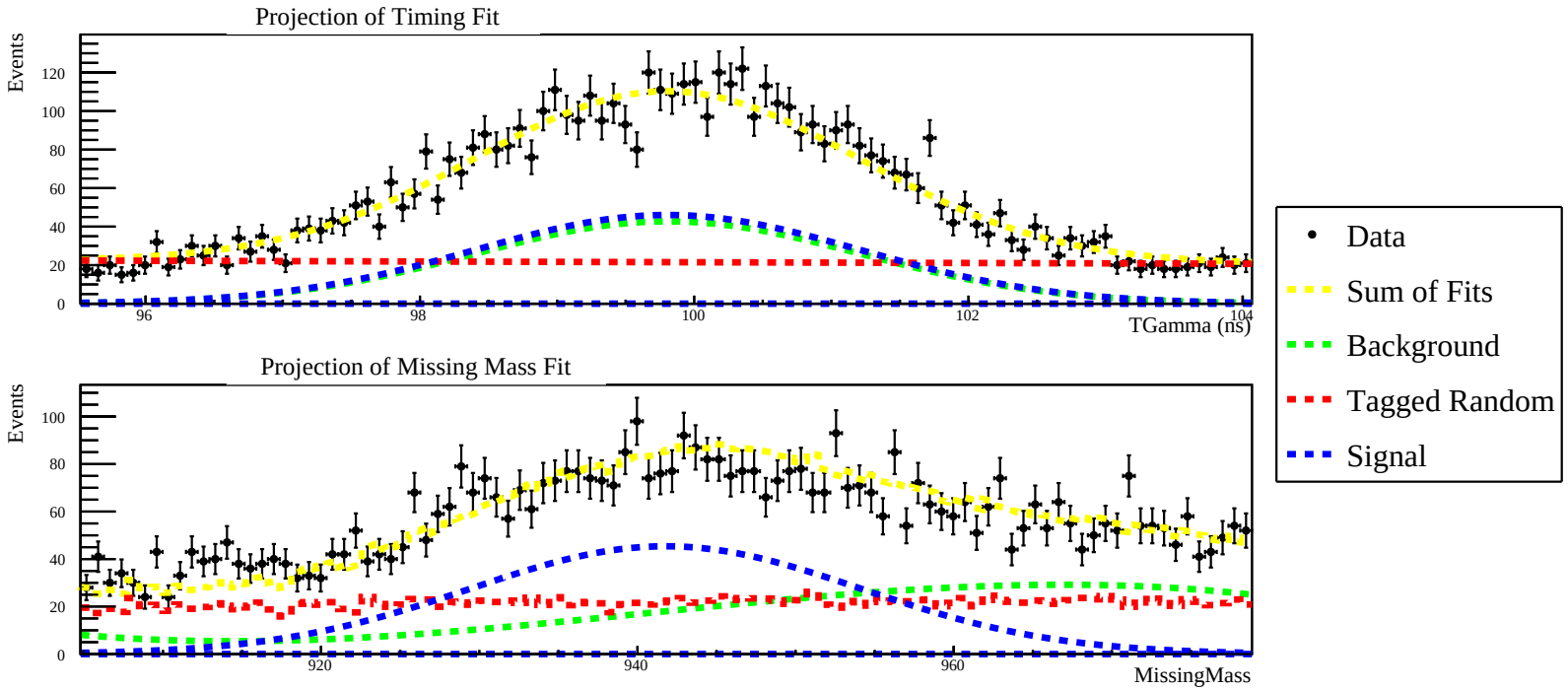
$_s$*Plot* - Weighted Fitting - Single π^0

Each event is given 3 weights from the fit



Signal invarient mass is cleaned up with narrow peak at π^0 invariant mass.

$_sPlot$ - Weighted Fitting - Double π^0



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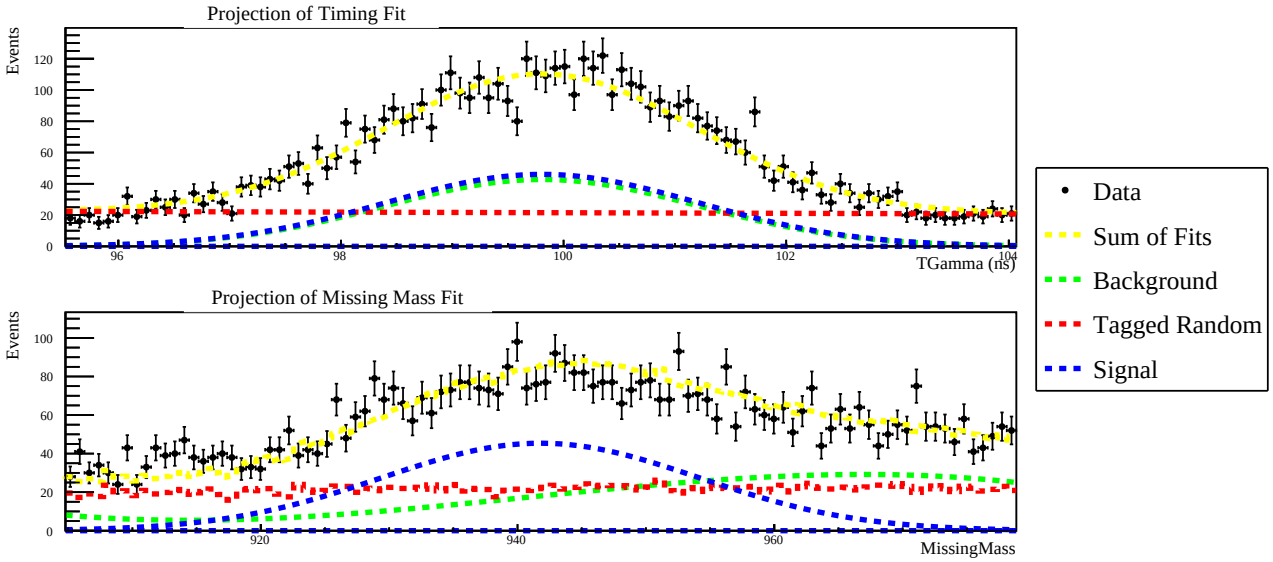

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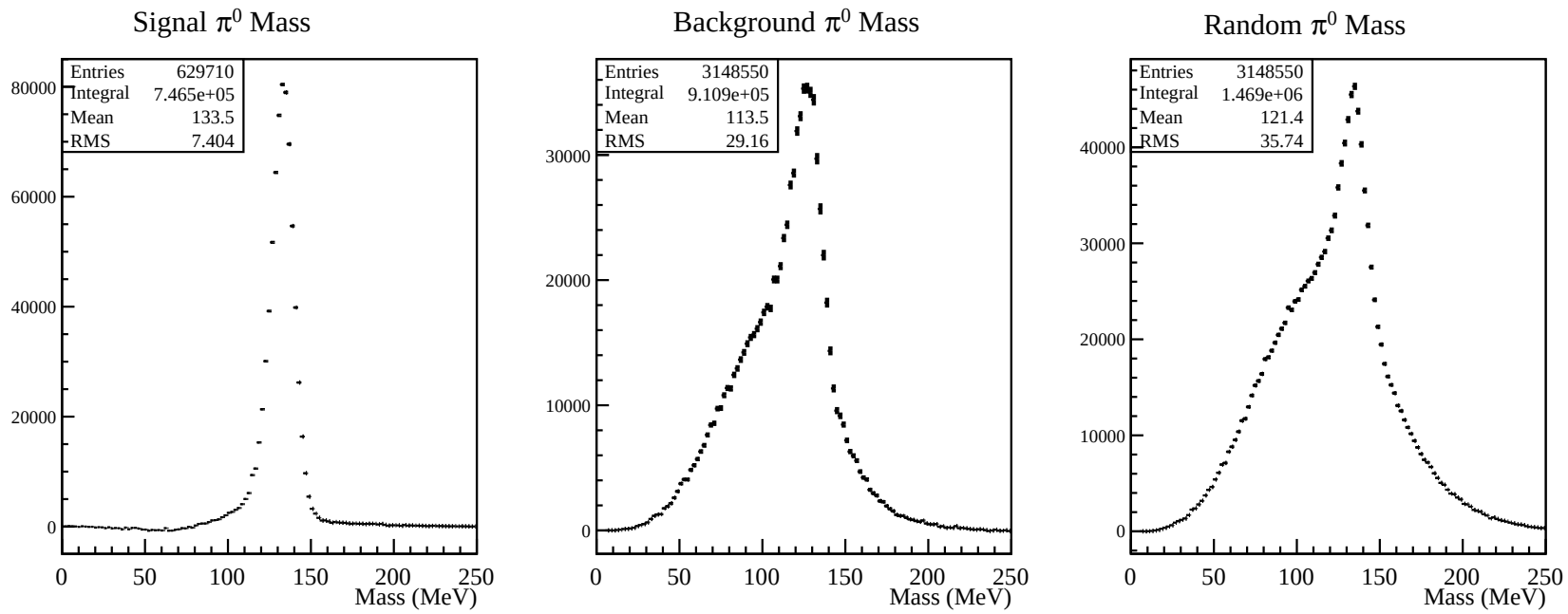

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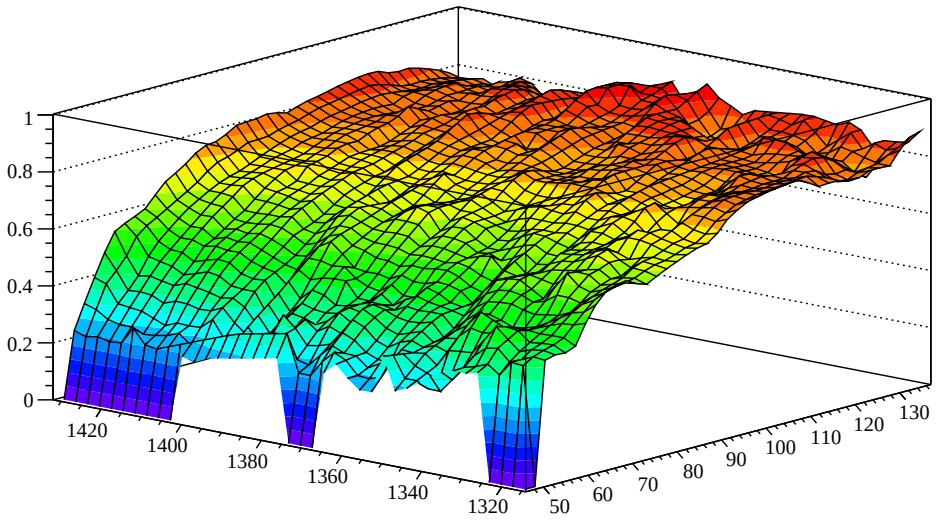
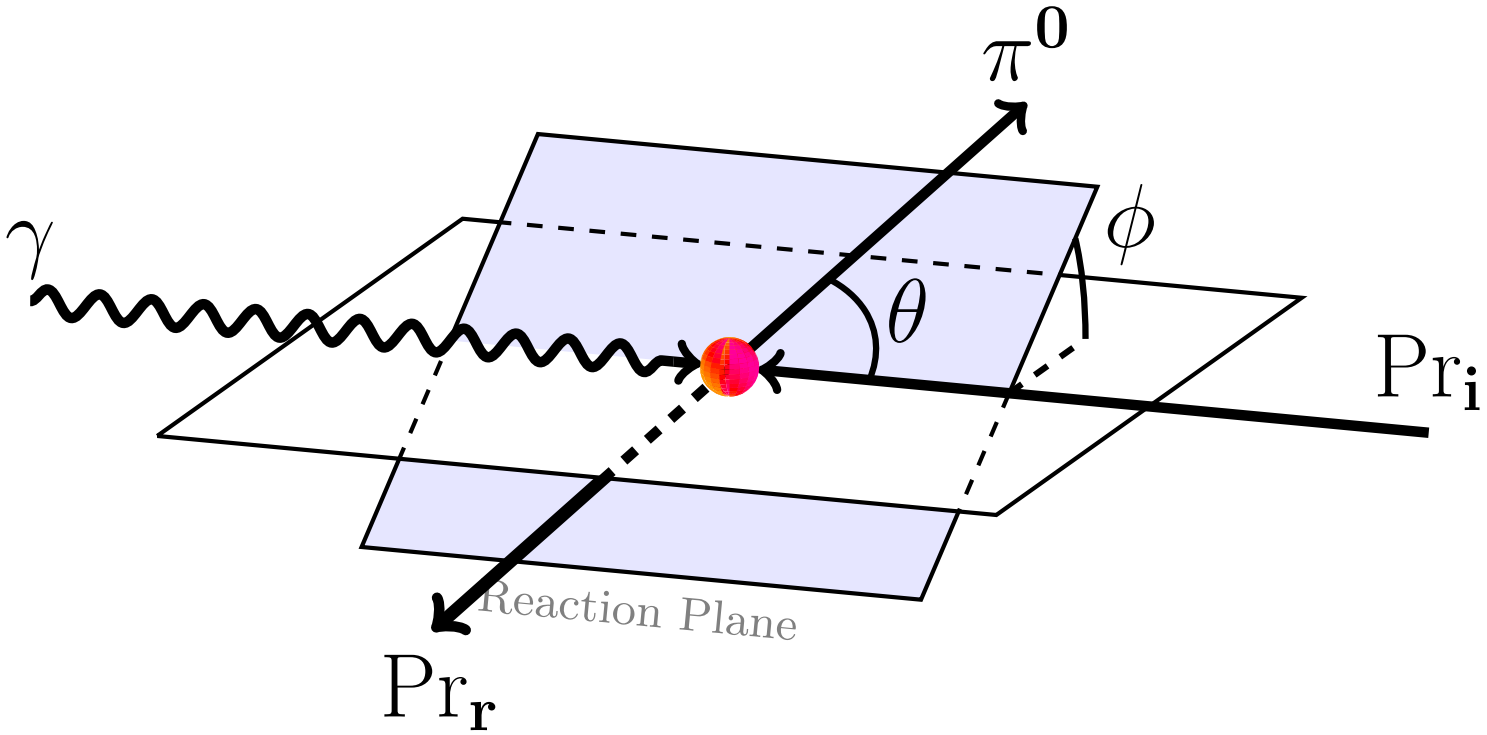
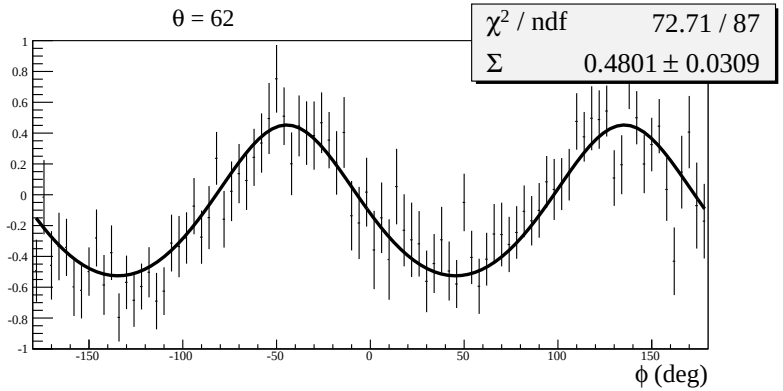
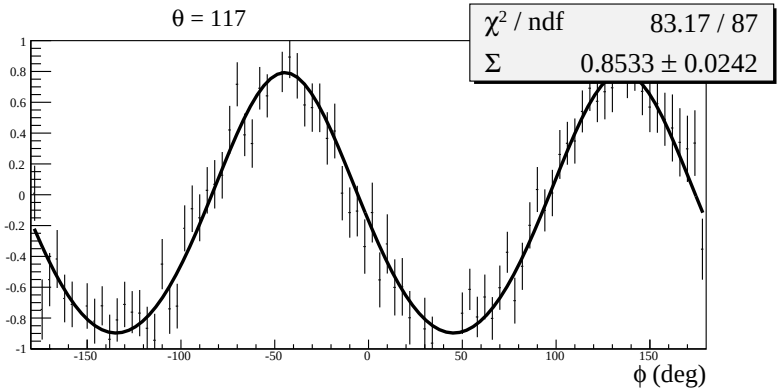


Single π^0 Sigma







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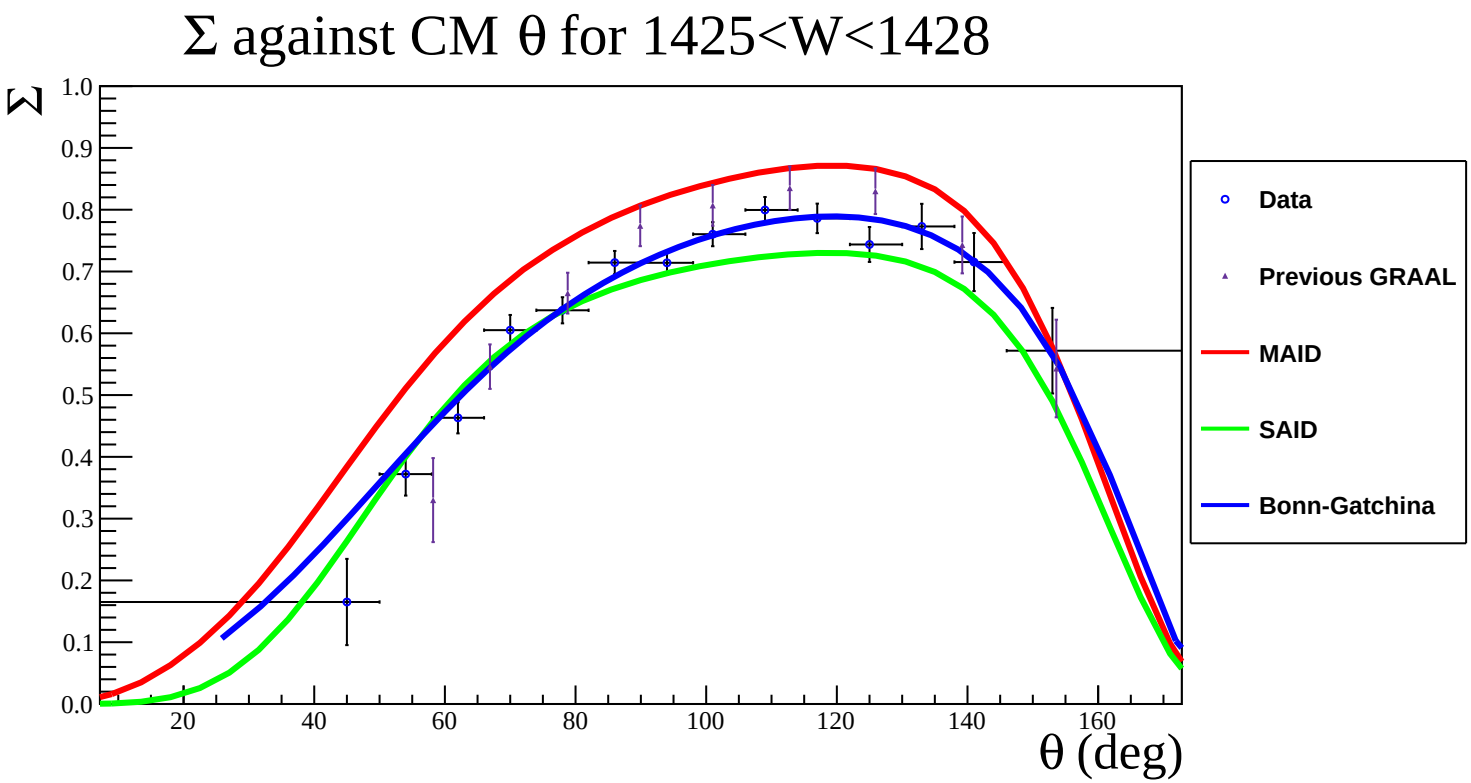
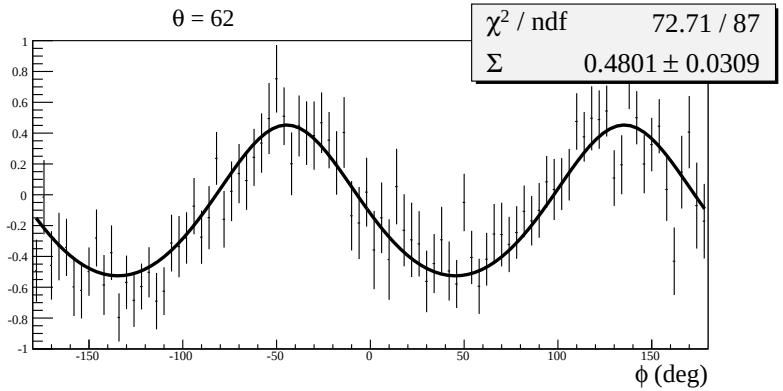
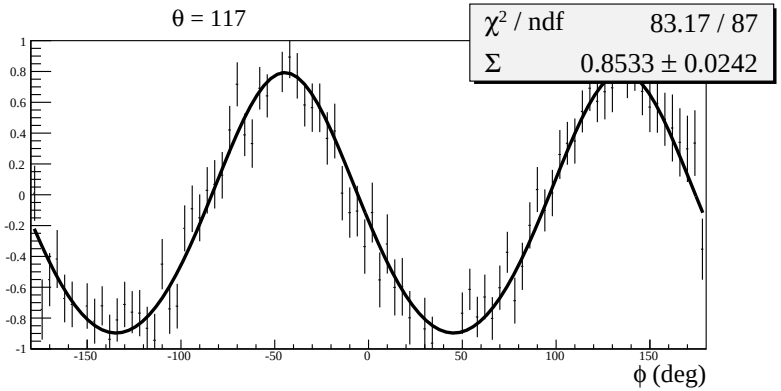
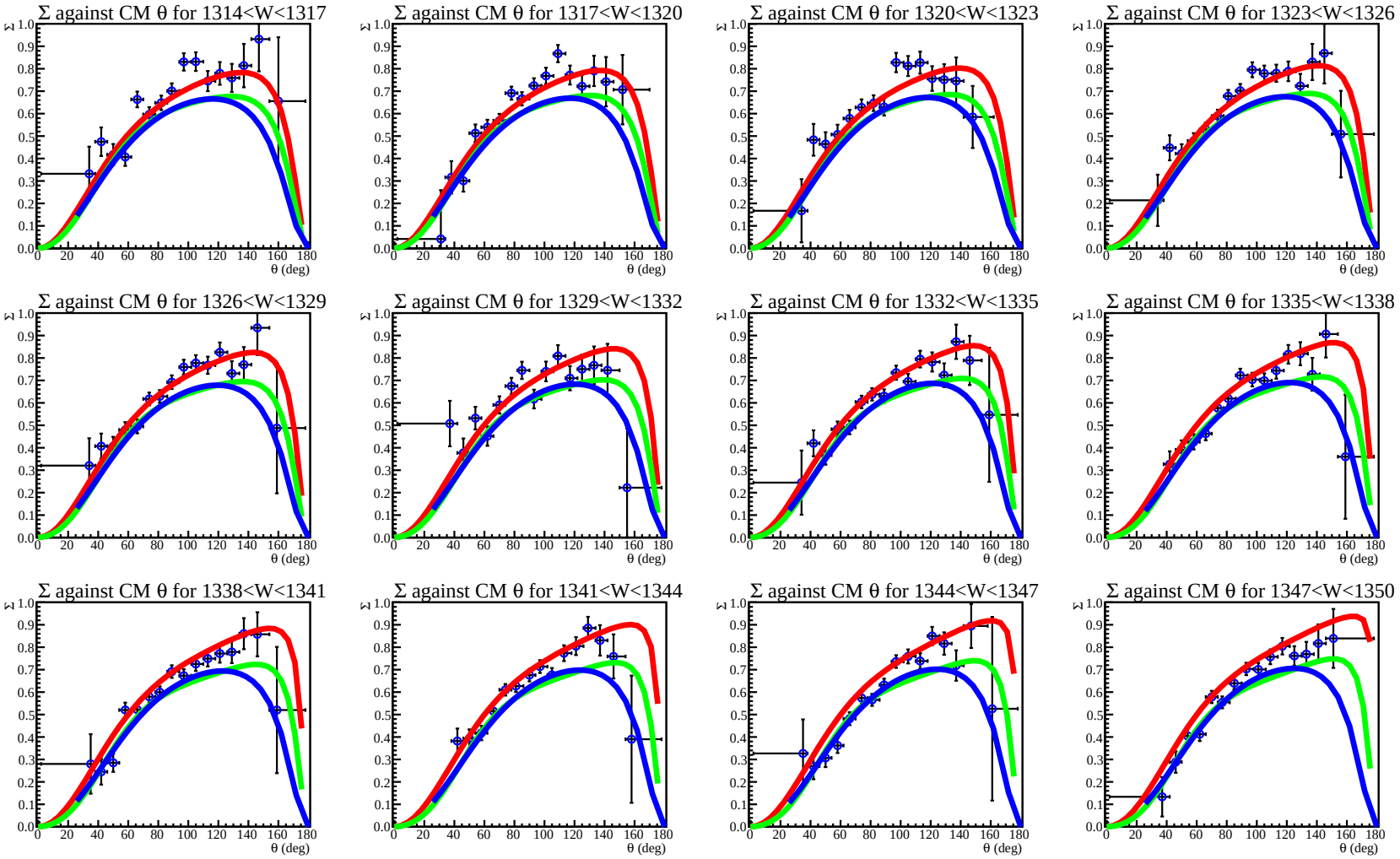


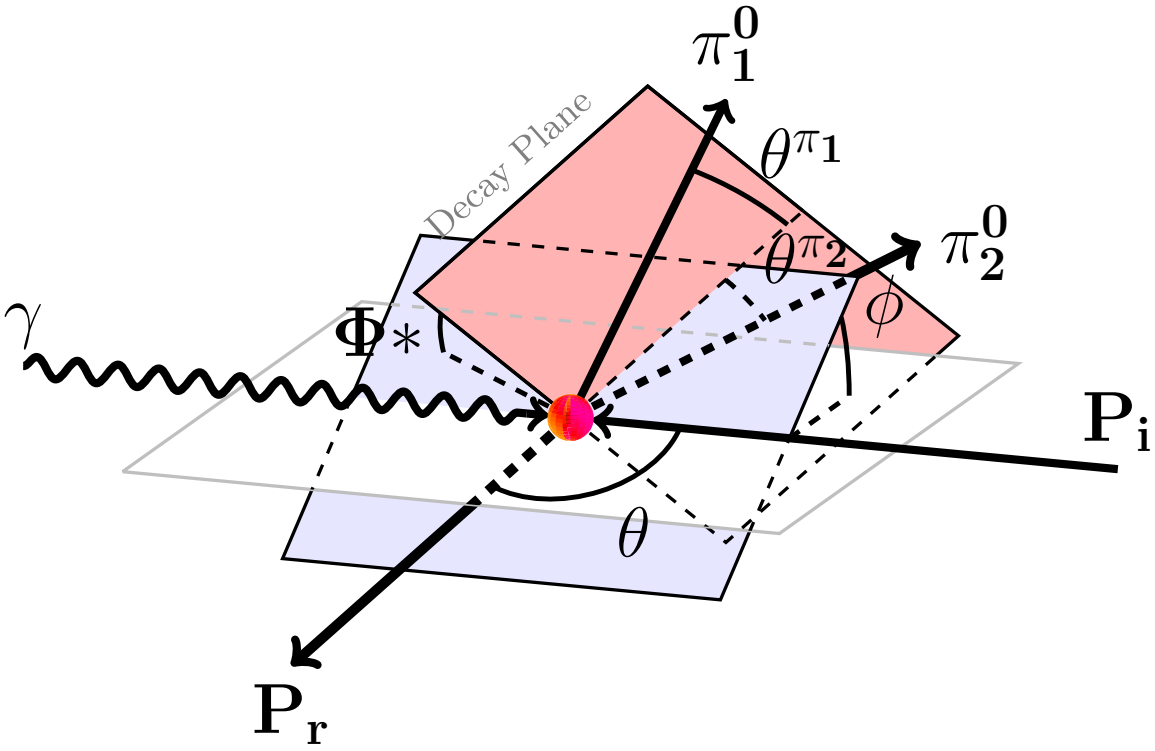


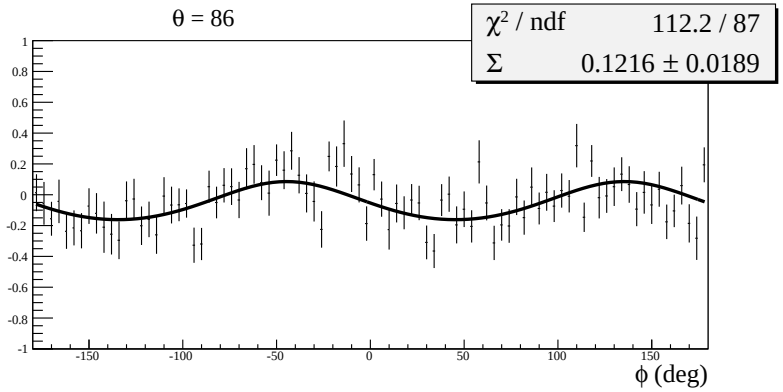


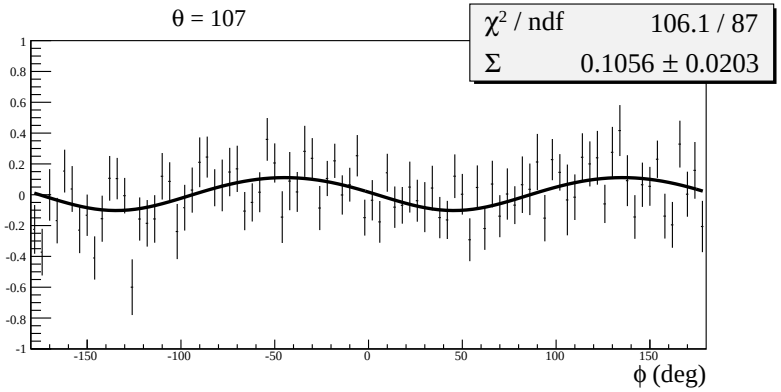
Single π^0 Sigma



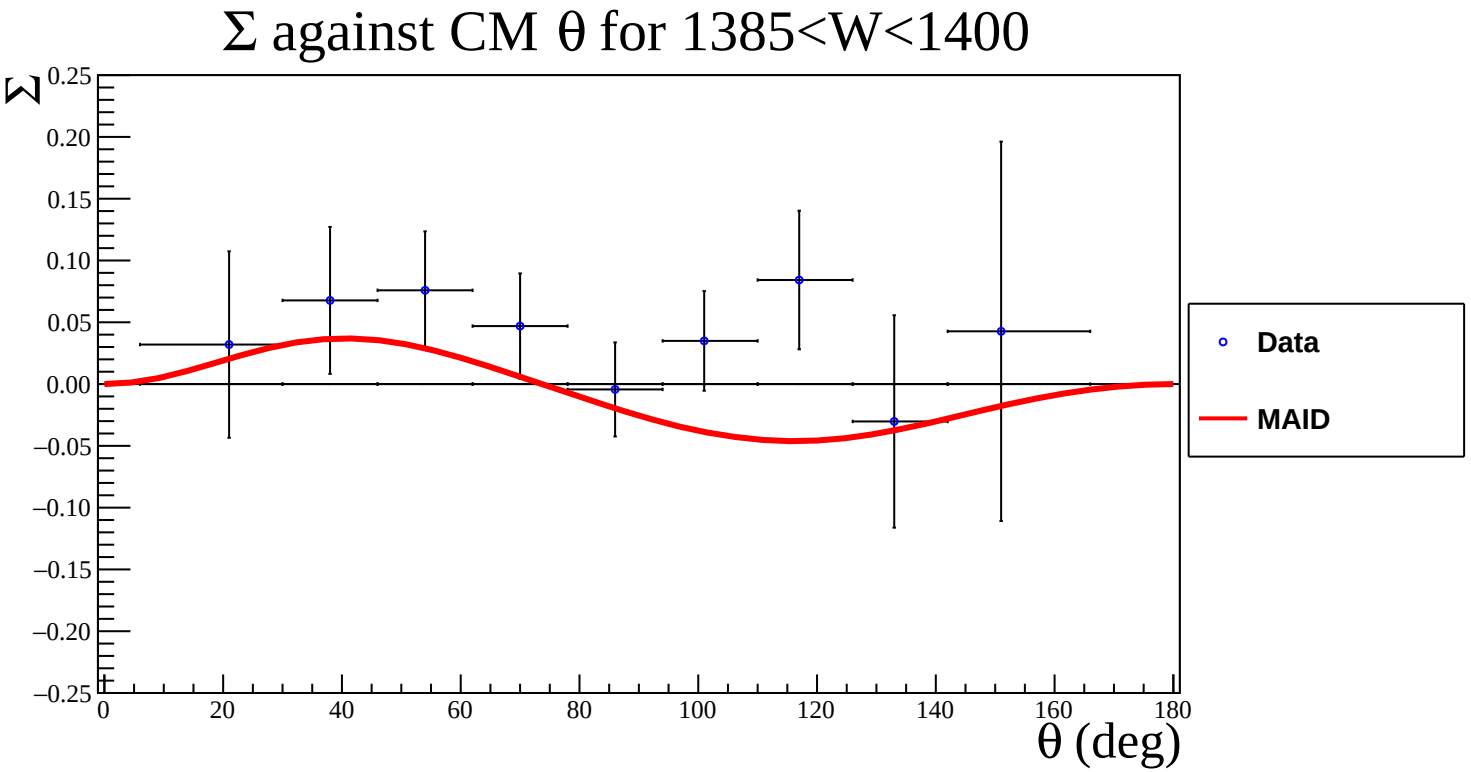
Double π^0 Sigma

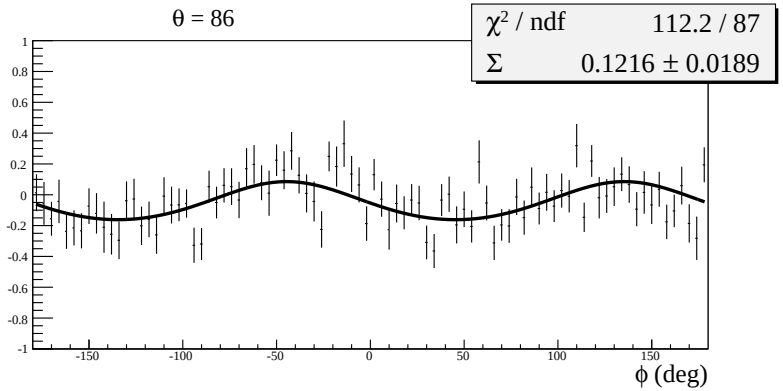


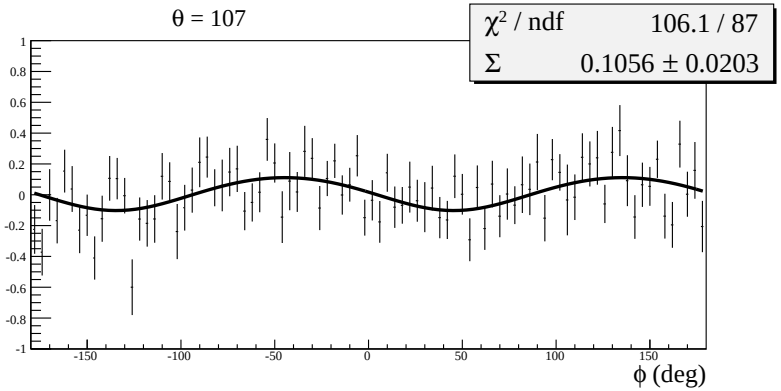




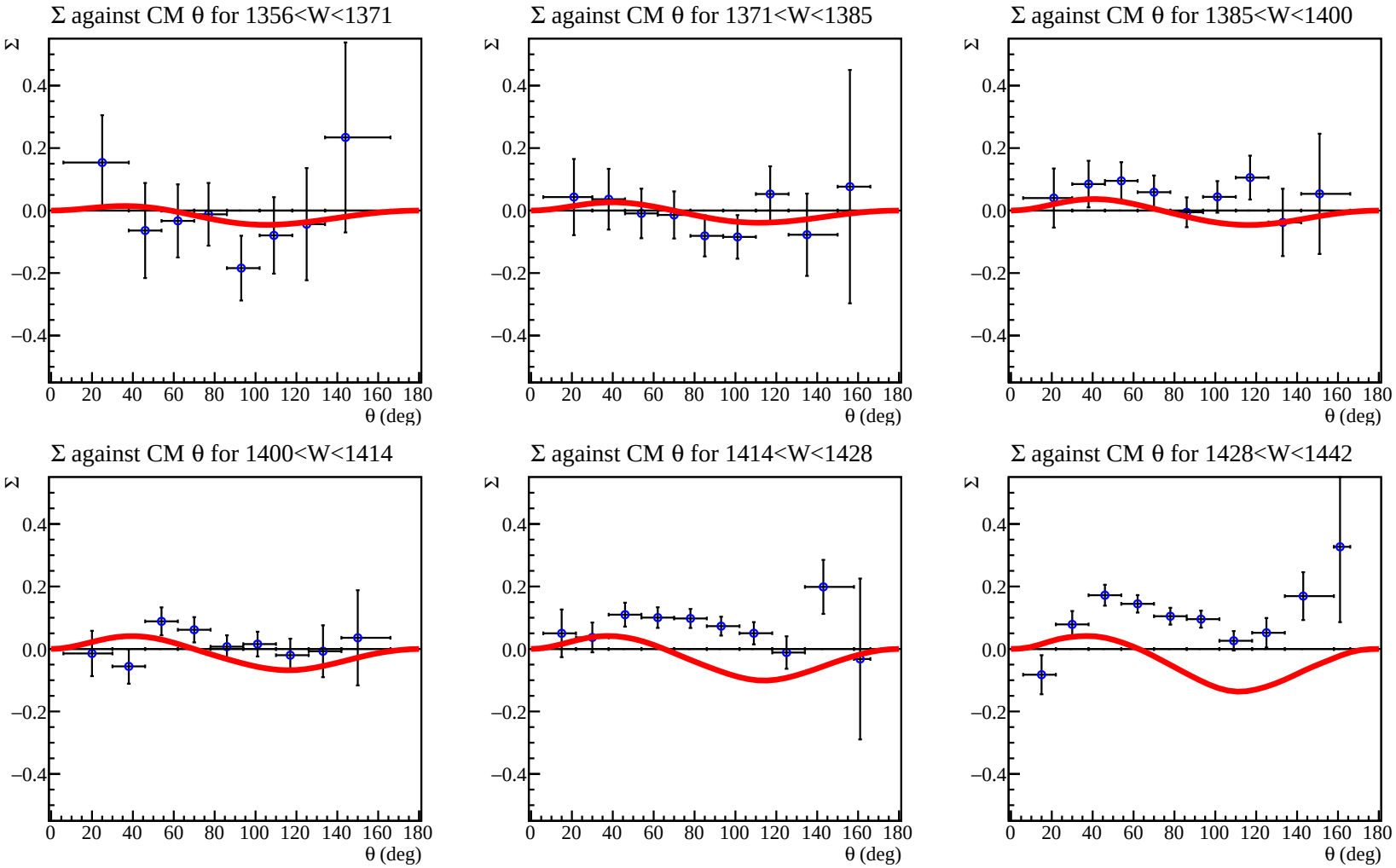
Double π^0 Sigma







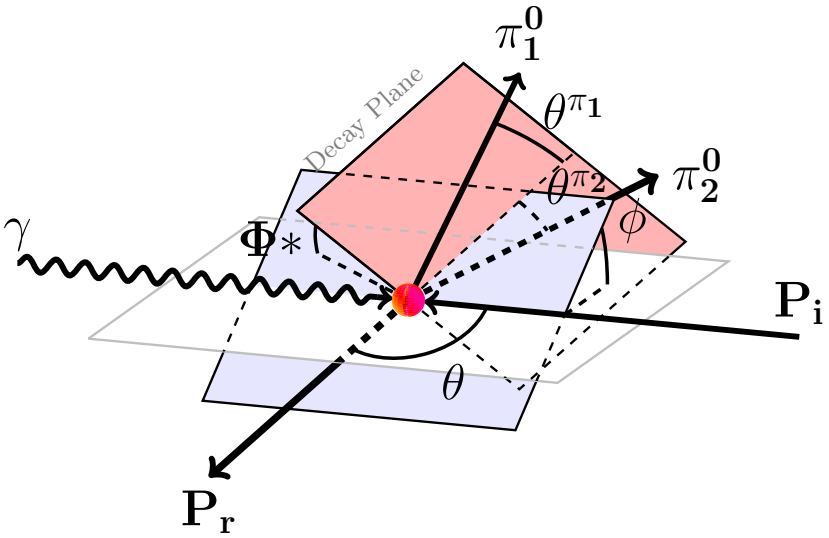
Double π^0 Sigma



Outline

Summary

- Single π^0, Σ observable analysis finished.
- Double π^0, Σ almost complete - Final checks.
- Observables I^s and I^c will also be extracted from this analysis.
- All observables have counterparts for $p\pi^0$ decay angle.



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