Measuring neutron polarisation in pn production using CLAS

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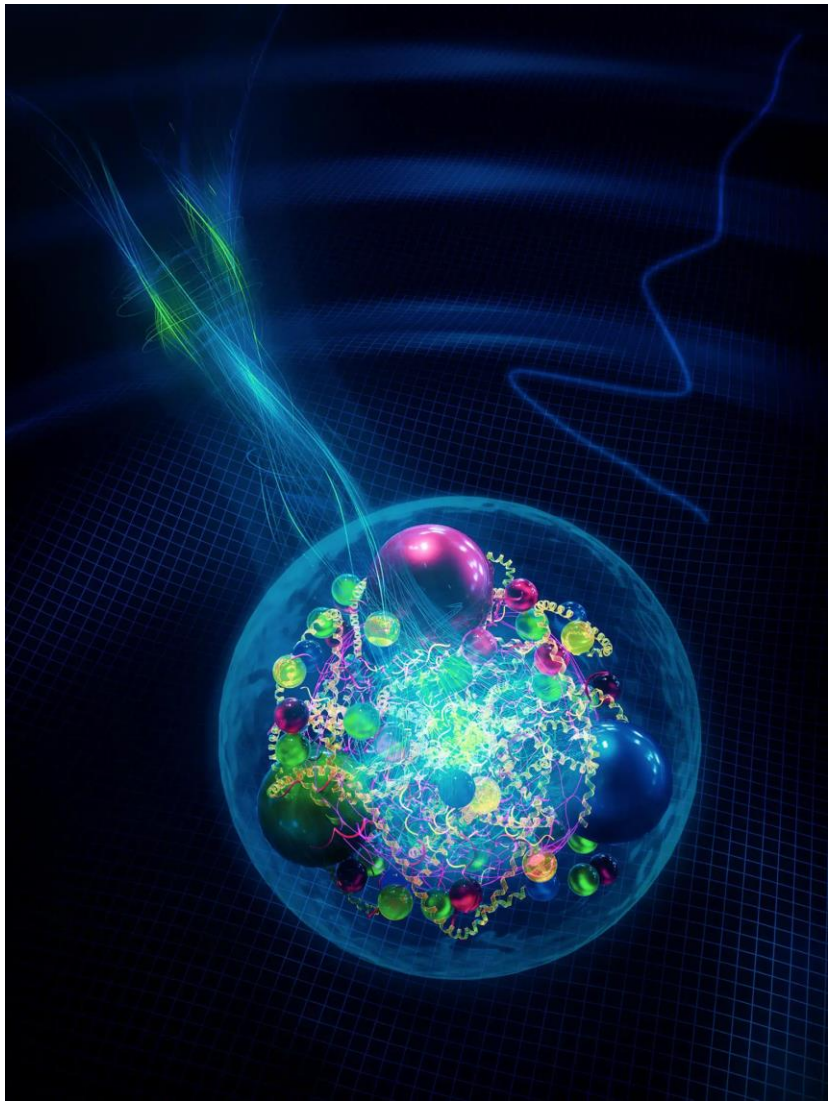
Motivation

Analysing Neutron polarisation

- Insight into neutron stars
- Studying SRCs (Short Range Correlations)
- The recently discovered dibaryon, d*(2380)

Building the world dataset

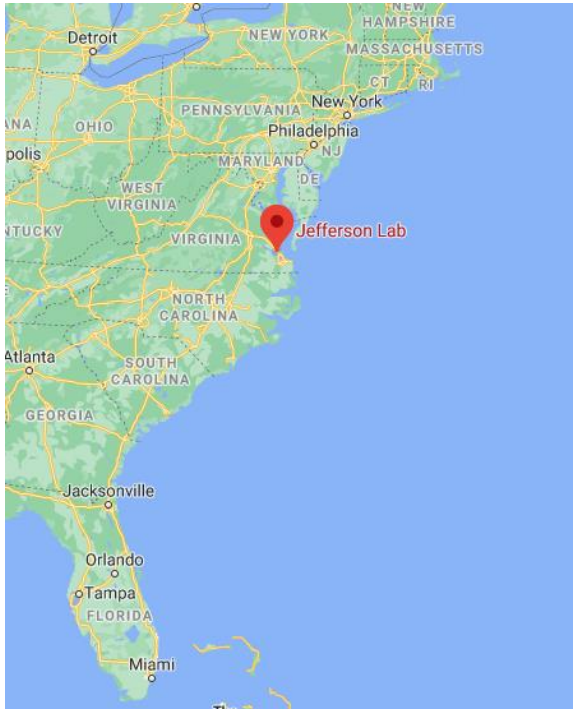
- Gaps in energy/angular coverage
- Utilizing existing data with a novel approach

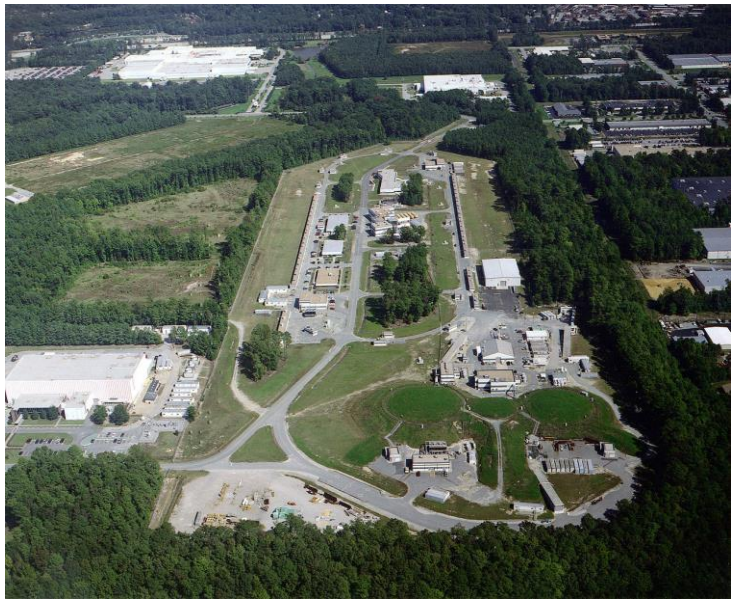


Artistic view of the neutron and its internal structure
CREDIT: ©: Professor Dr. Xiaorong Zhu, University for Science and Technology, China

Jefferson Lab

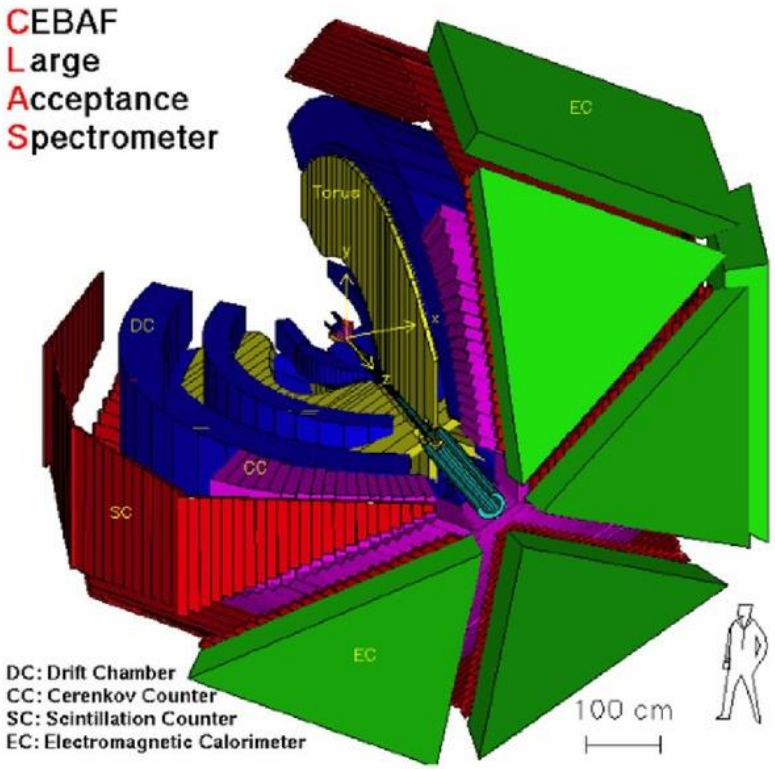
- International laboratory Est 1984
- US Department of Energy facility
- A world leading electron accelerator (CEBAF)
- Various experiments done across 4 halls (A-D)





The CLAS detector (1998-2012)

- CEBAF Large Acceptance Spectrometer
- Housed in Hall B of JLab
- A many component detector system
- Accepting beam energies up to 6GeV



The Start Counter

- A set of 3mm thick plastic scintillators surrounding the target, parallel to the beam line
- Used to determine start time of particle events

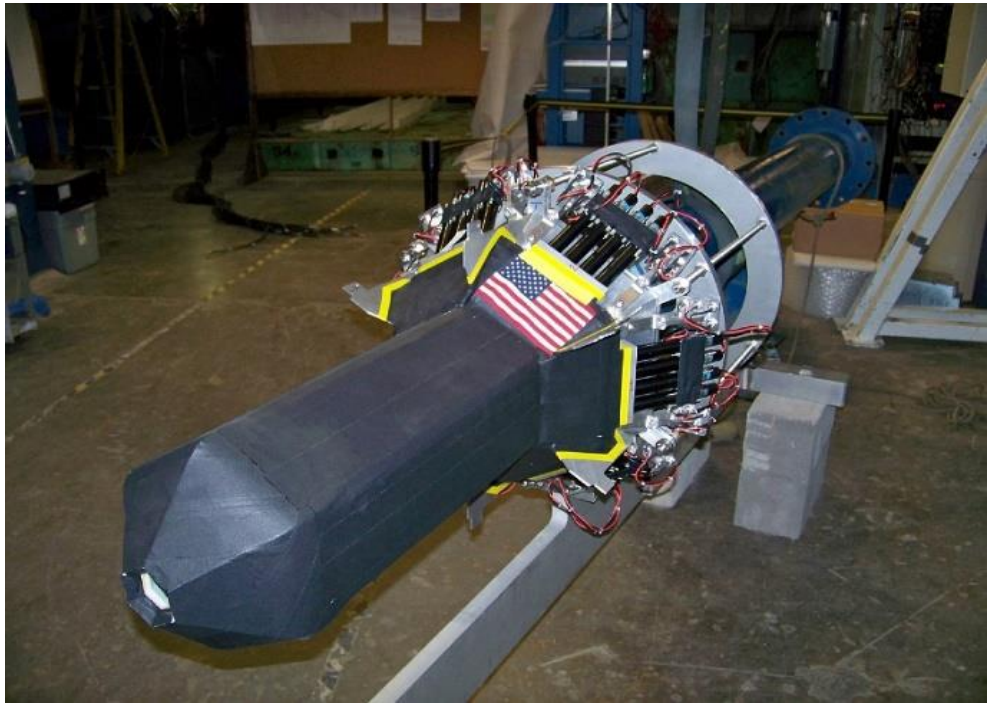
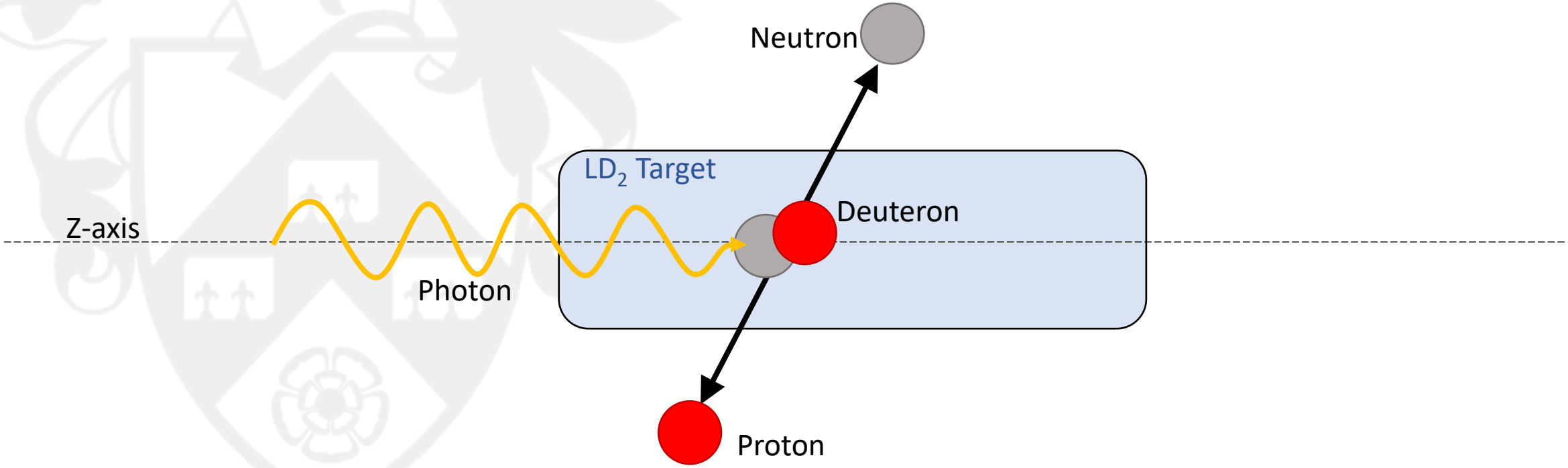


Photo of the start counter during CLAS's construction.
https://www.jlab.org/Hall-B/album/index.html

Experiment g13 (2006-2007)

$\gamma d \rightarrow pn$

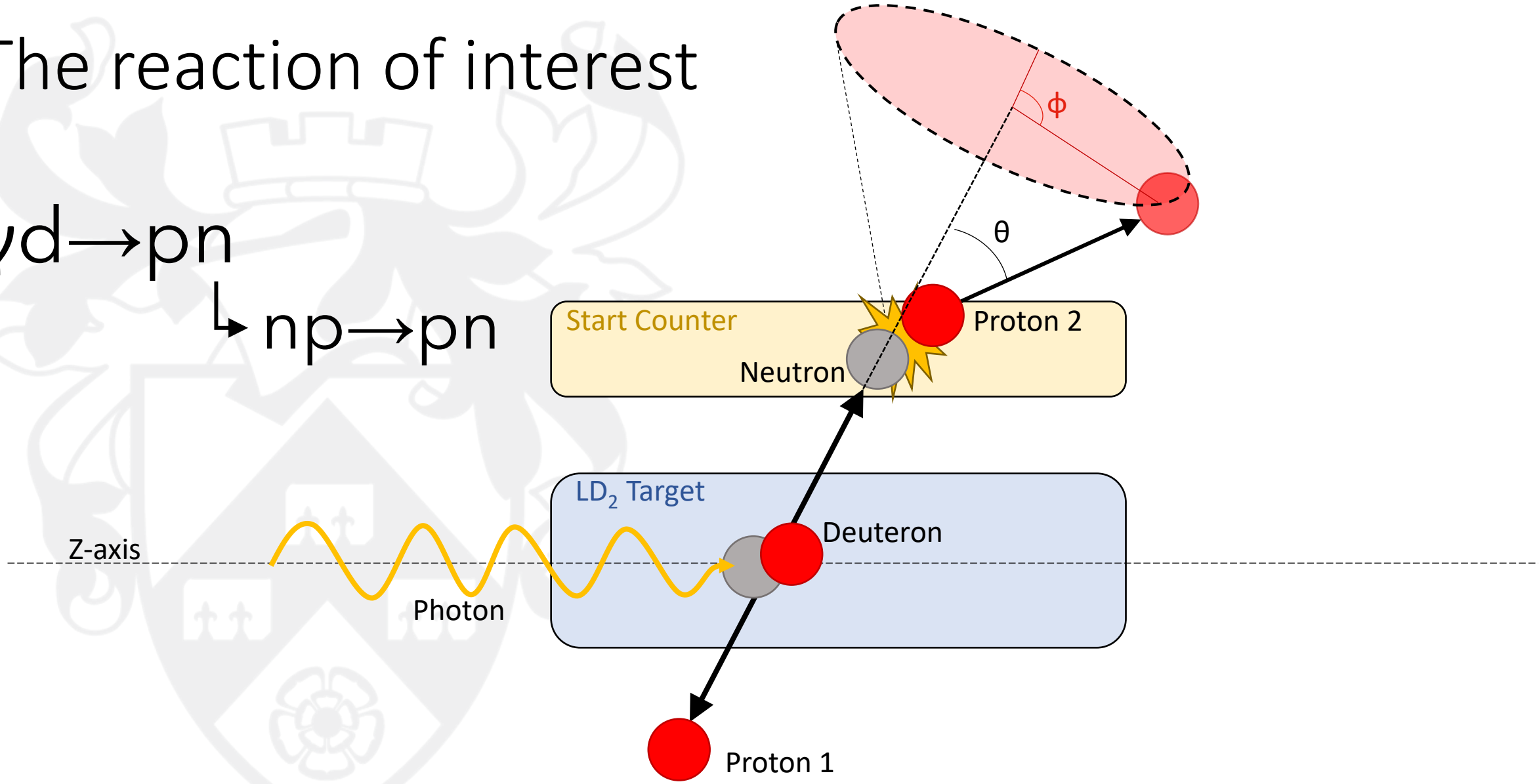
- Polarised photon beam
- Liquid Deuterium target (LD_2)
- Proposed to study Kaon production and search for baryon resonances



The reaction of interest

$\gamma d \rightarrow pn$

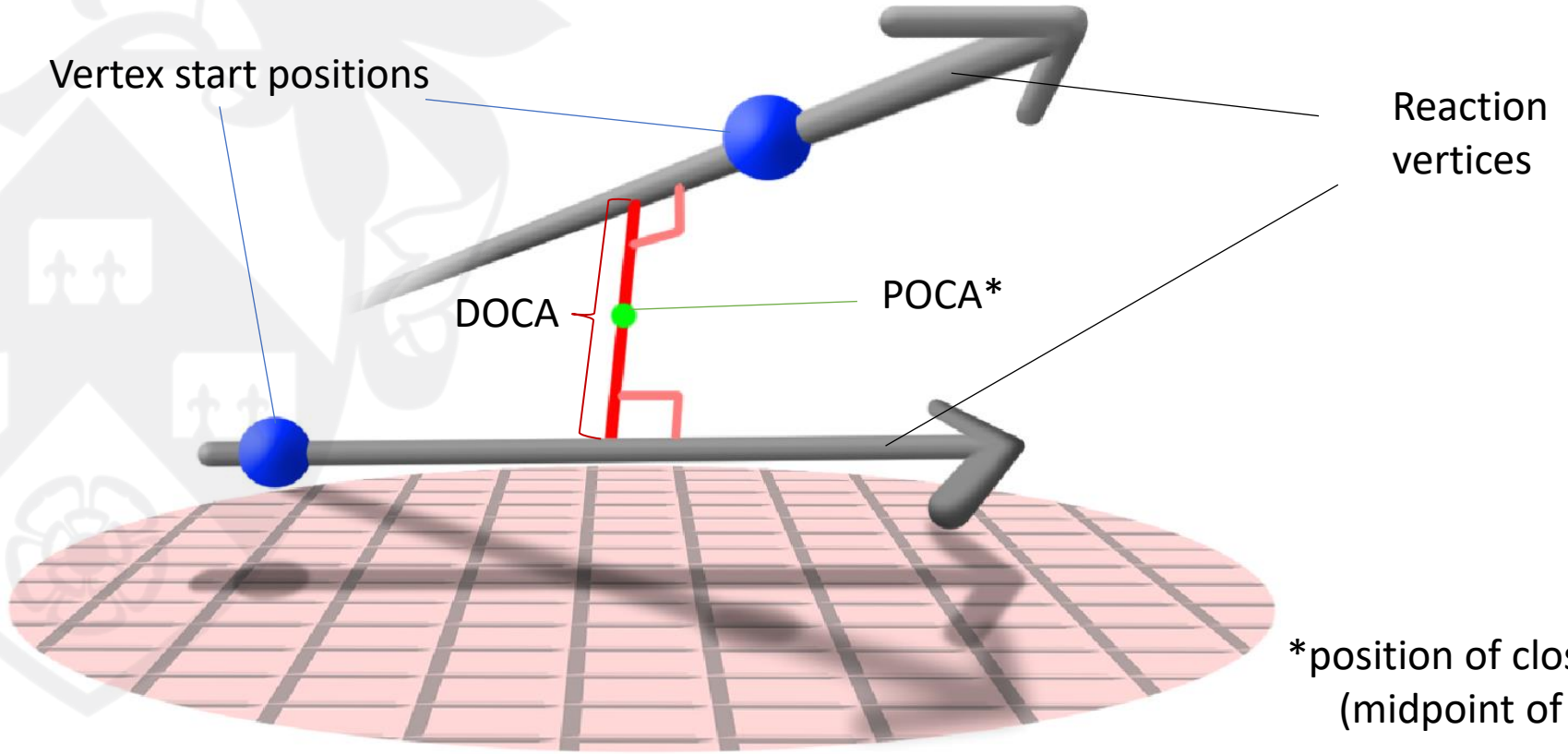
↳ $np \rightarrow pn$



$$I(\theta_{sc}, \phi_{sc}) = I_0(\theta_{sc})[1 + A(\theta_{sc})(P_y \cos\phi_{sc} - C_{x'} P_\gamma^{\odot} \sin\phi_{sc})]$$

Differentiating the protons

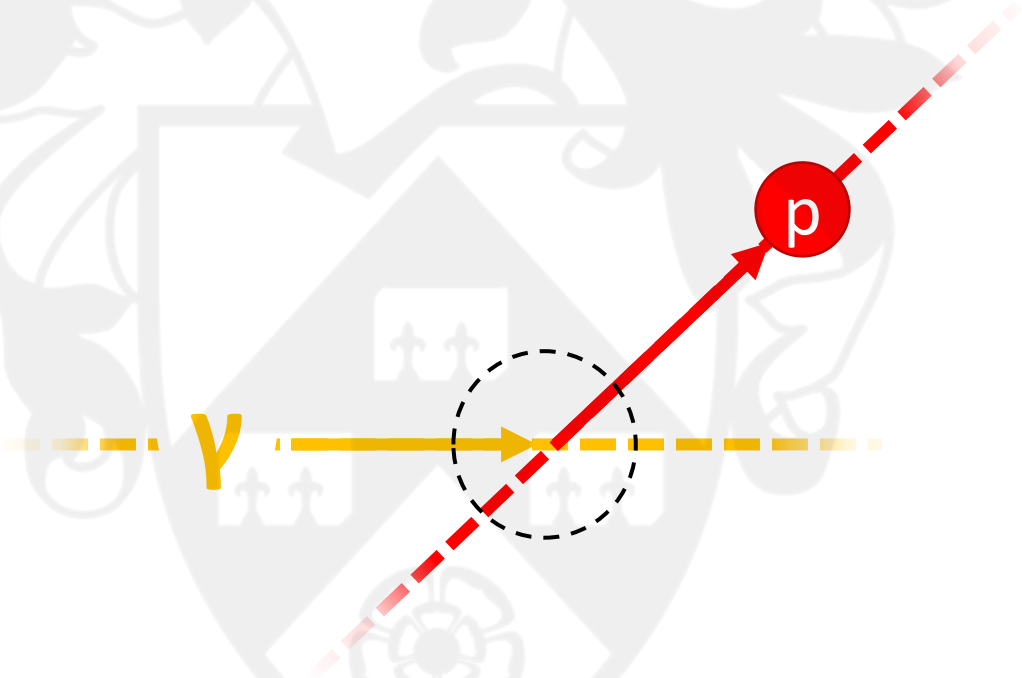
- DOCA (Distance Of Closest Approach)
- The closest distance between two vertices



*position of closest approach (midpoint of the DOCA)

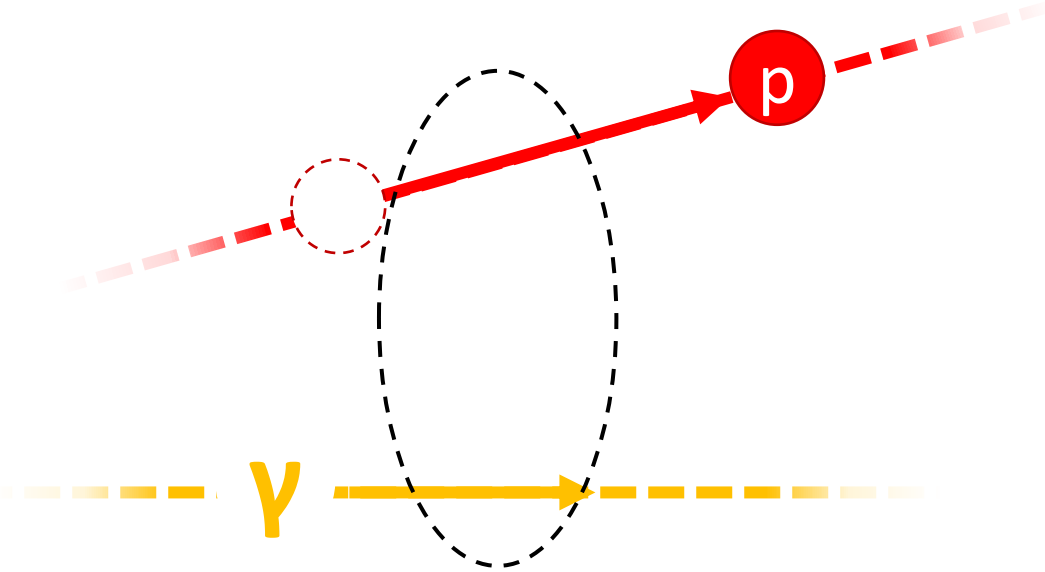
Differentiating the protons

p1 and γ



- Smaller DOCA

p2 and γ

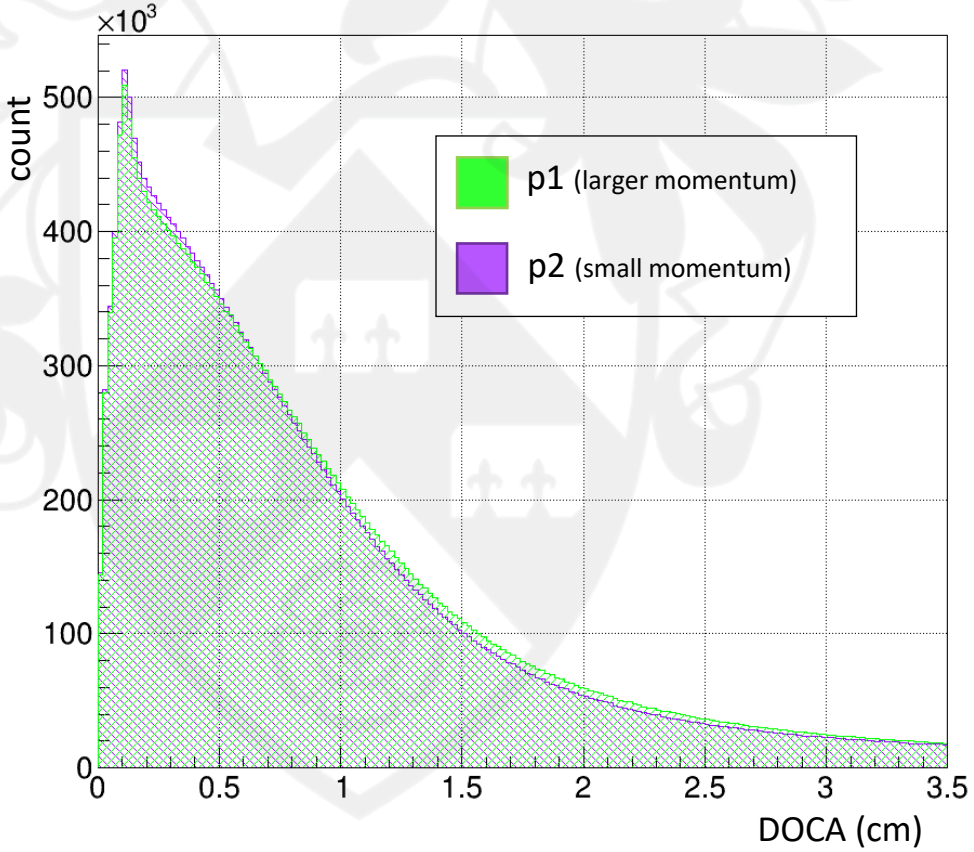


- Larger DOCA

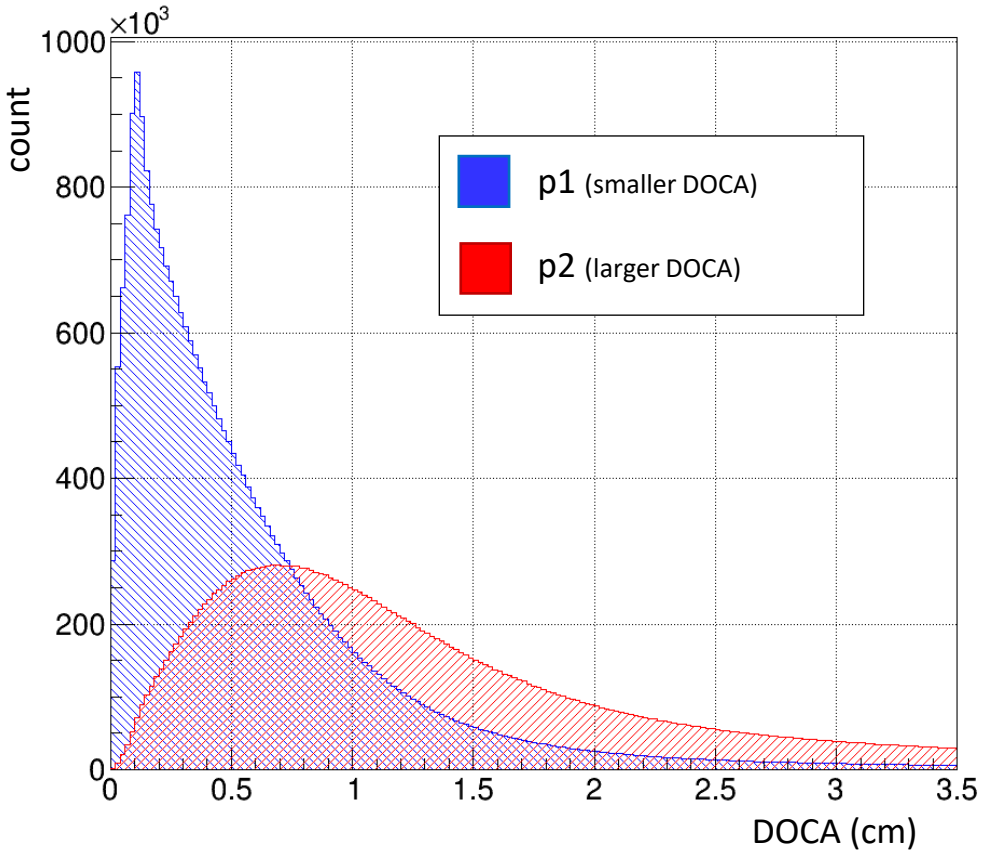
Differentiating the protons

- p1 and p2 defined by DOCA between photon and proton

Before

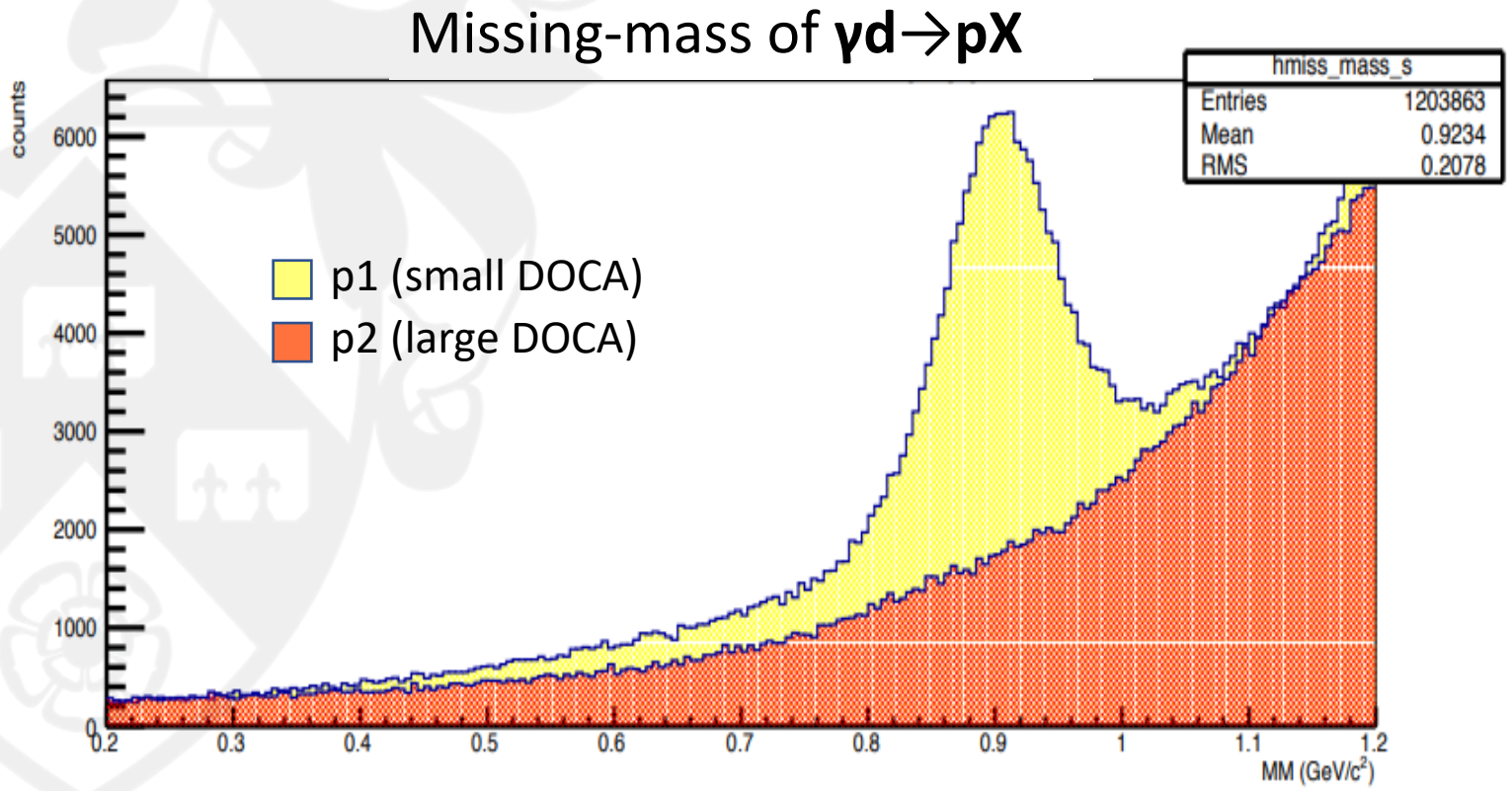


After



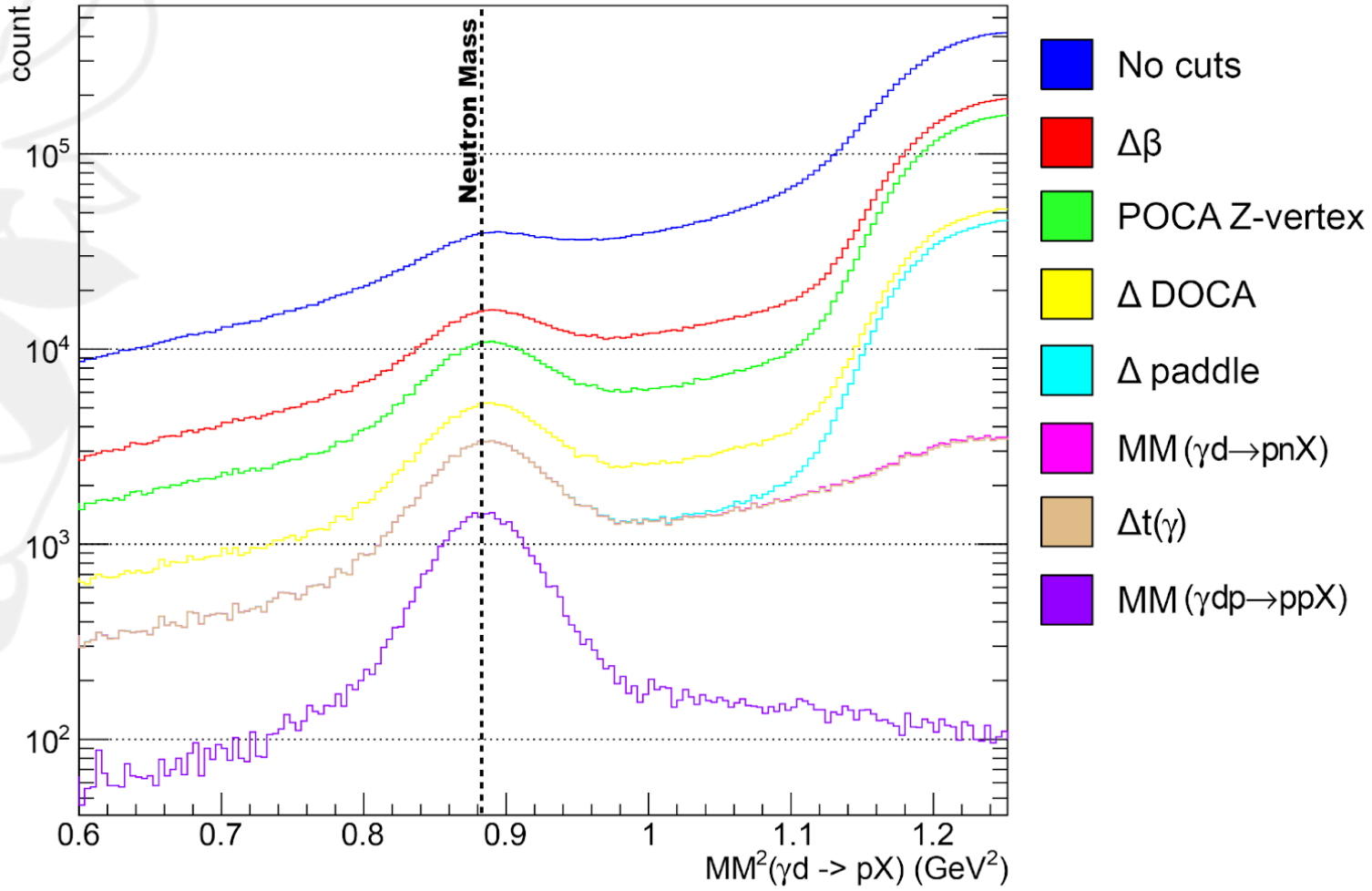
Missing mass of protons

- The distinction between p1 and p2 using DOCA is also clear in missing neutron mass



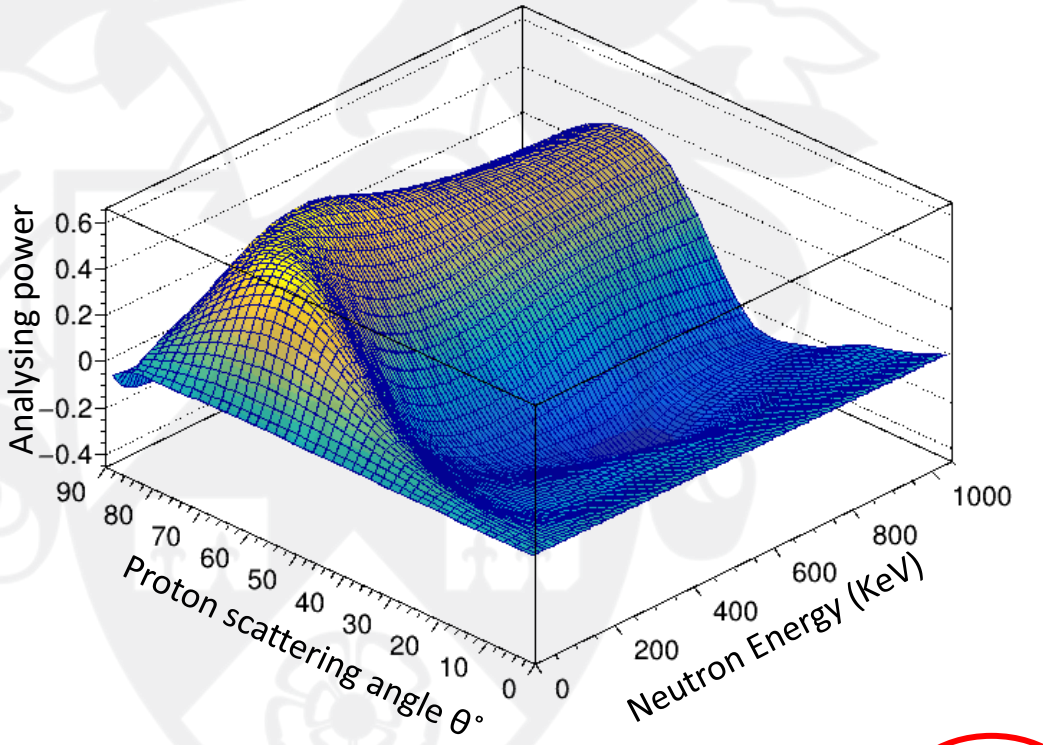
Filtering the data

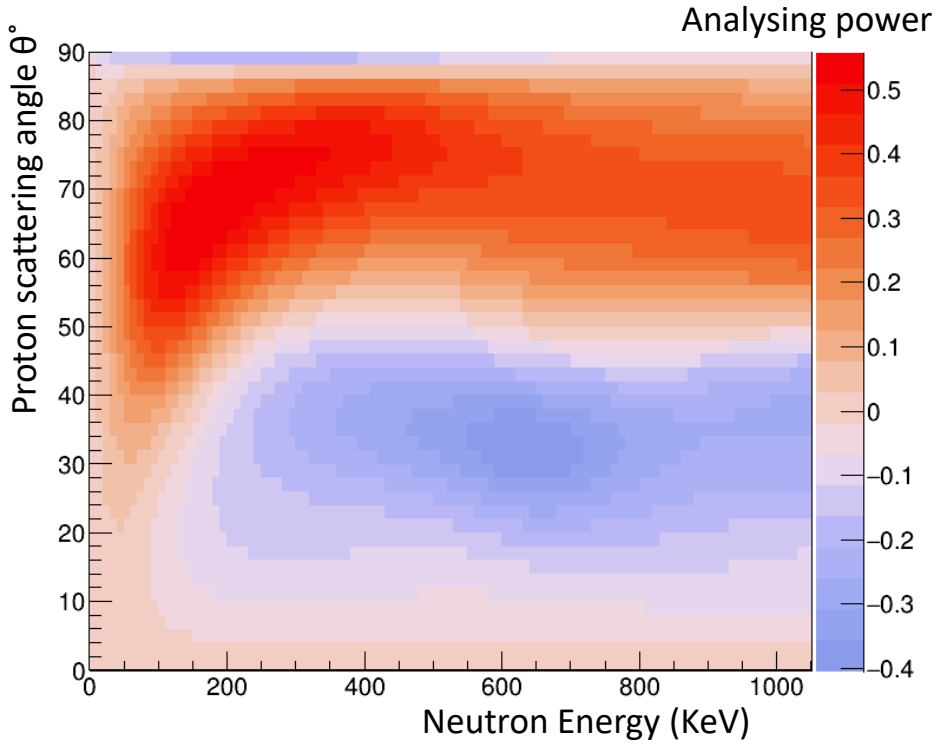
Goal: Isolate the events of interest as much as possible



SAID model

- Relates analysing power to P scattering angle and N energy





$$I(\theta_{sc}, \phi_{sc}) = I_0(\theta_{sc})[1 + A(\theta_{sc})(P_y \cos\phi_{sc} - C_{x'} P_\gamma^{\odot} \sin\phi_{sc})]$$

Maximum Likelihood technique

- Most mathematically likely values of Cx extracted using a “maximum” (minimum) likelihood technique
- Cx parameterised with a many parameter function of photon energy and reconstructed Neutron θ (Legendre functions)

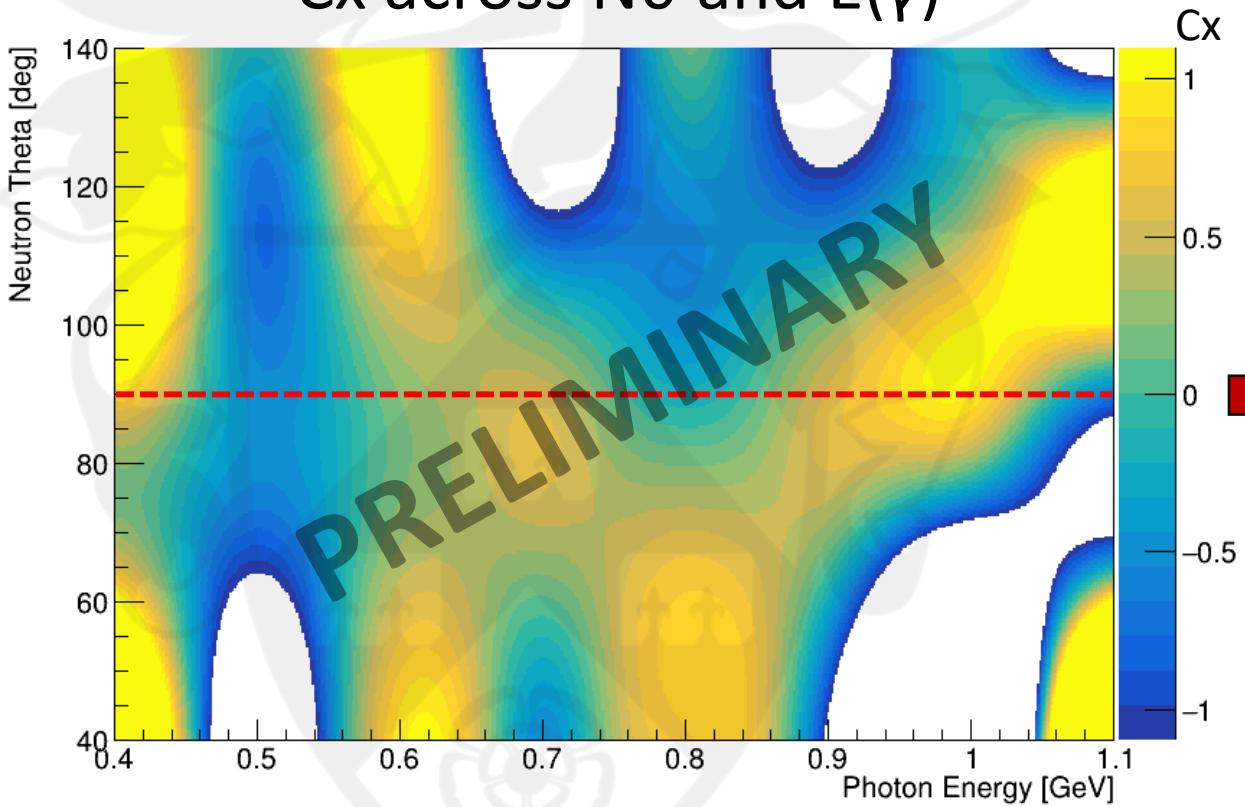
$$\text{Minimize: } \sum -2\log[\,1 + \alpha\left(P_y \cos(\varphi) - \boldsymbol{C_x} P_\gamma^{\odot} \sin(\varphi)\right)]$$

fixed P_y

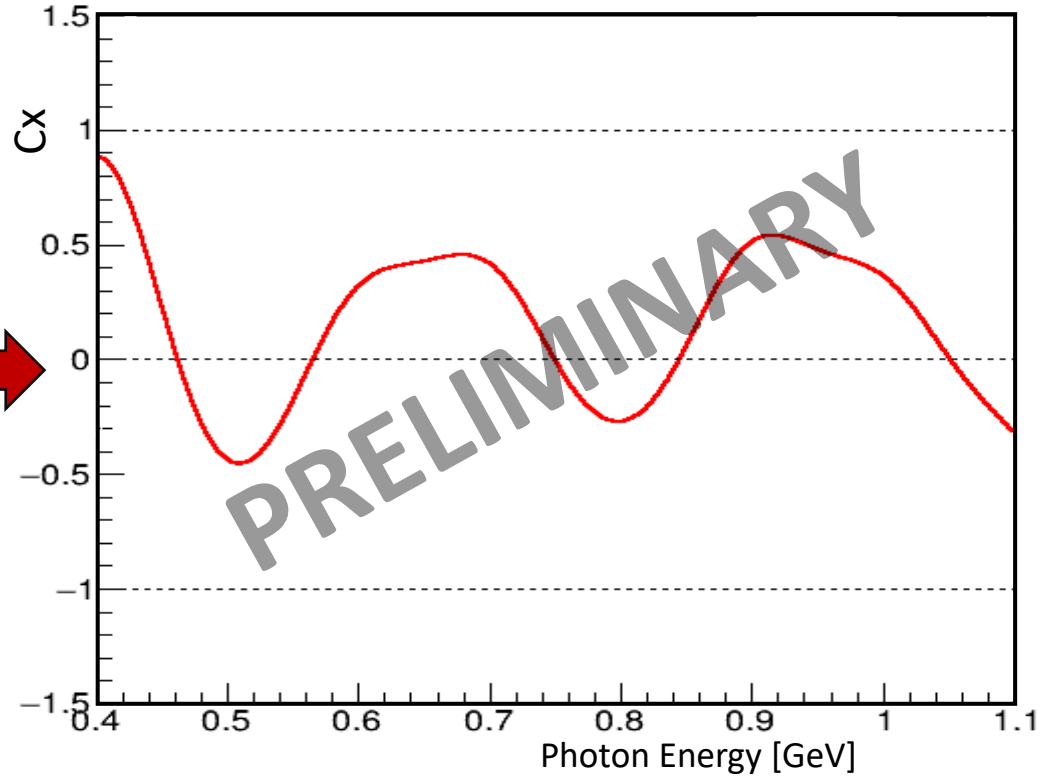
$$\boldsymbol{C_x} = f(\,E_\gamma, \theta_N, P0 \;\ldots P32\,)$$

Extracted Cx distribution

Cx across Nθ and E(γ)

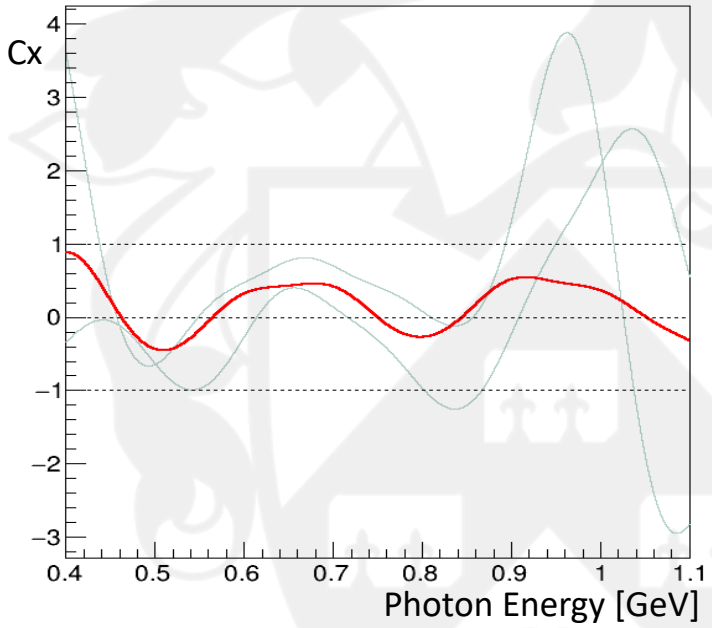


Cx vs E(γ) at Nθ=90˚

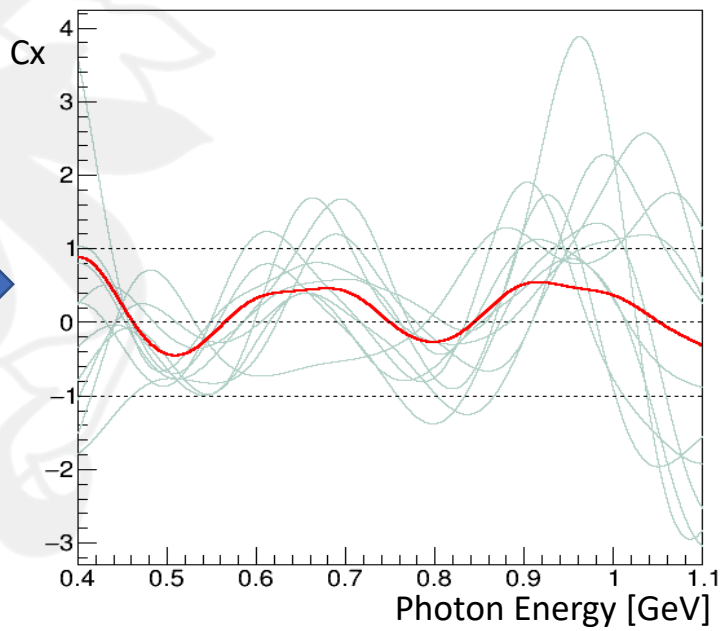


Bootstrap technique

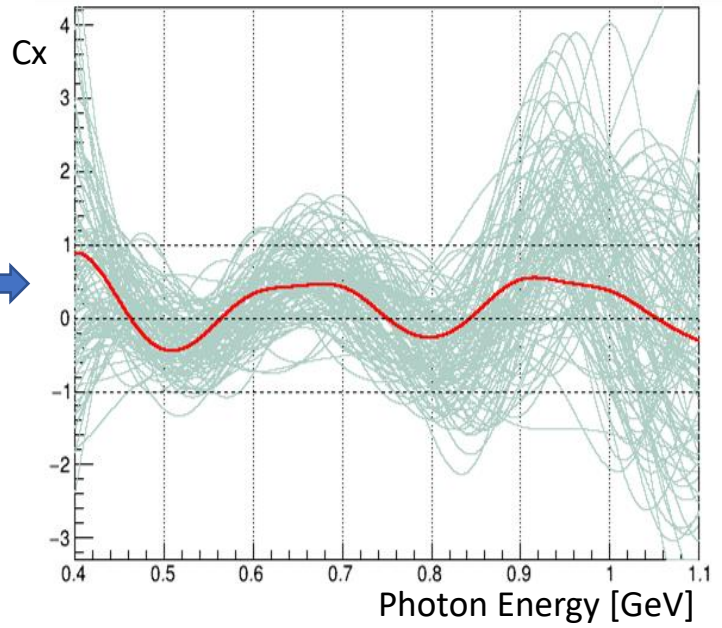
- New functions extracted after randomising original dataset
- Spread of new functions indicates the level of confidence



No. of bootstrap functions: **2**



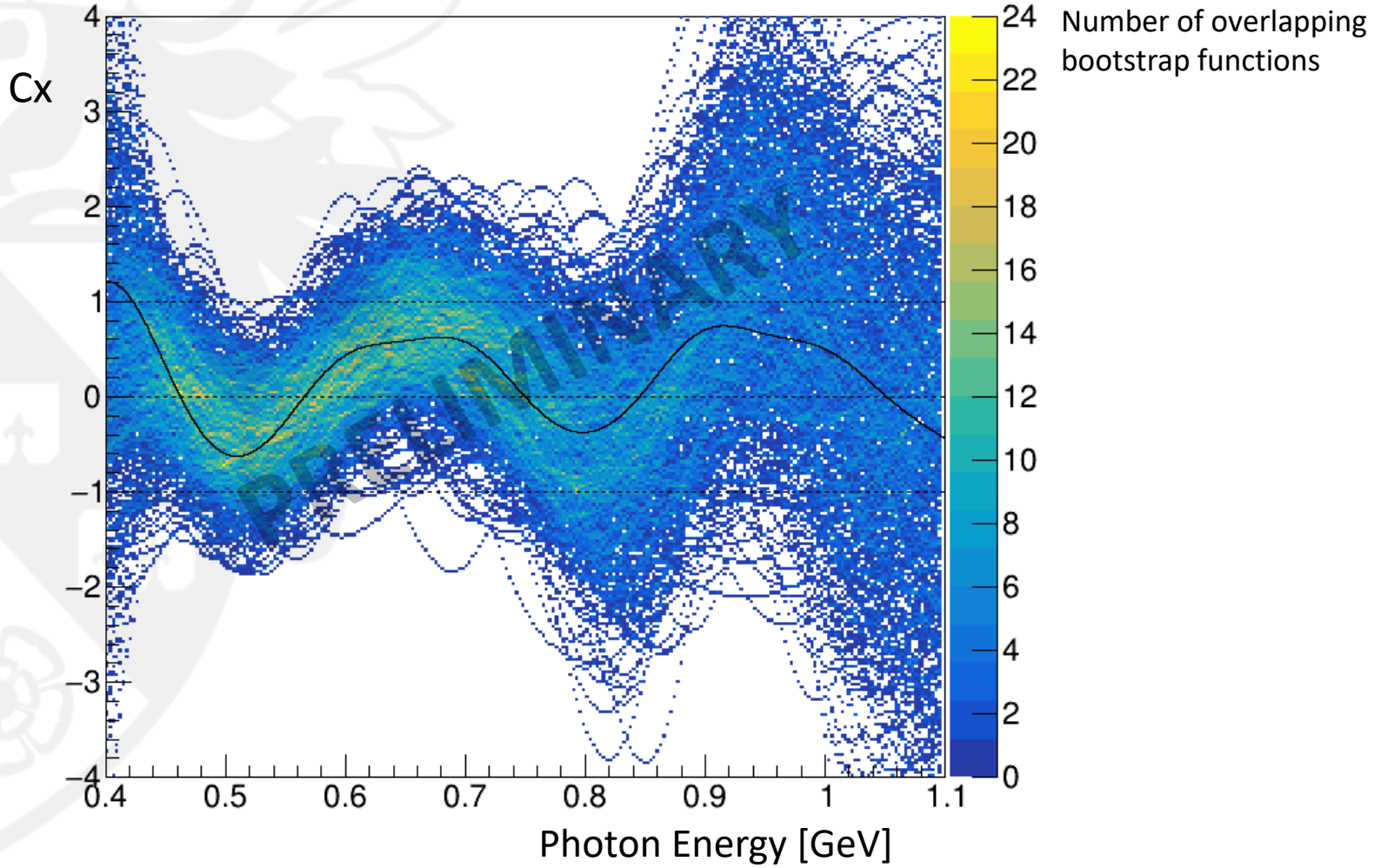
No. of bootstrap functions: **10**



No. of bootstrap functions: **100**

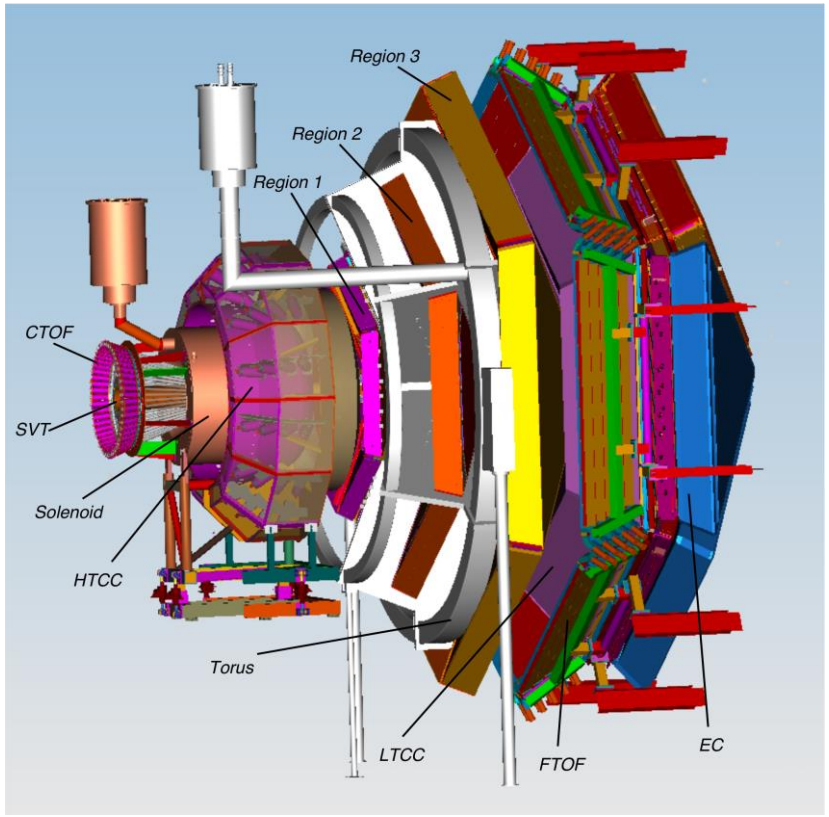
Bootstrap technique

- Overlaying functions shows where the fit is most confident

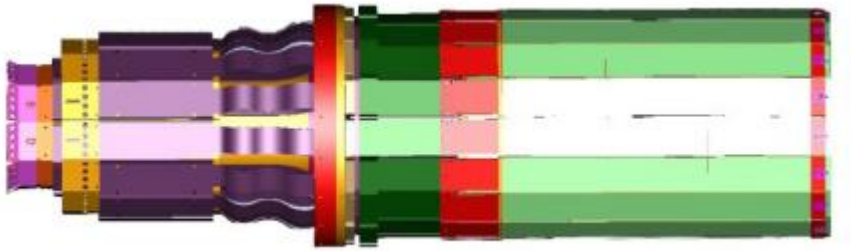


Extending to CLAS12

- The upgraded CLAS capable of 12GeV
- Run Group M
  - nuclear target experiments
  - Insight into SRCs
- This novel approach can be applied to CLAS12 and the SVT



CLAS12 render



The Silicon Vertex Tracker (SVT), component of CLAS12

Summary

- g13 study to be finalised
  - Filtering process refined
  - Background subtraction implemented
  - Comparisons made to simulated/published data
- Extend analysis to CLAS12 data with RGM
  - Provide first polarisation measurements of SRCs utilising the SVT

Thank you!

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