GAN from Pseudo Data to Real Data

Inverse Problem for Detector Effects

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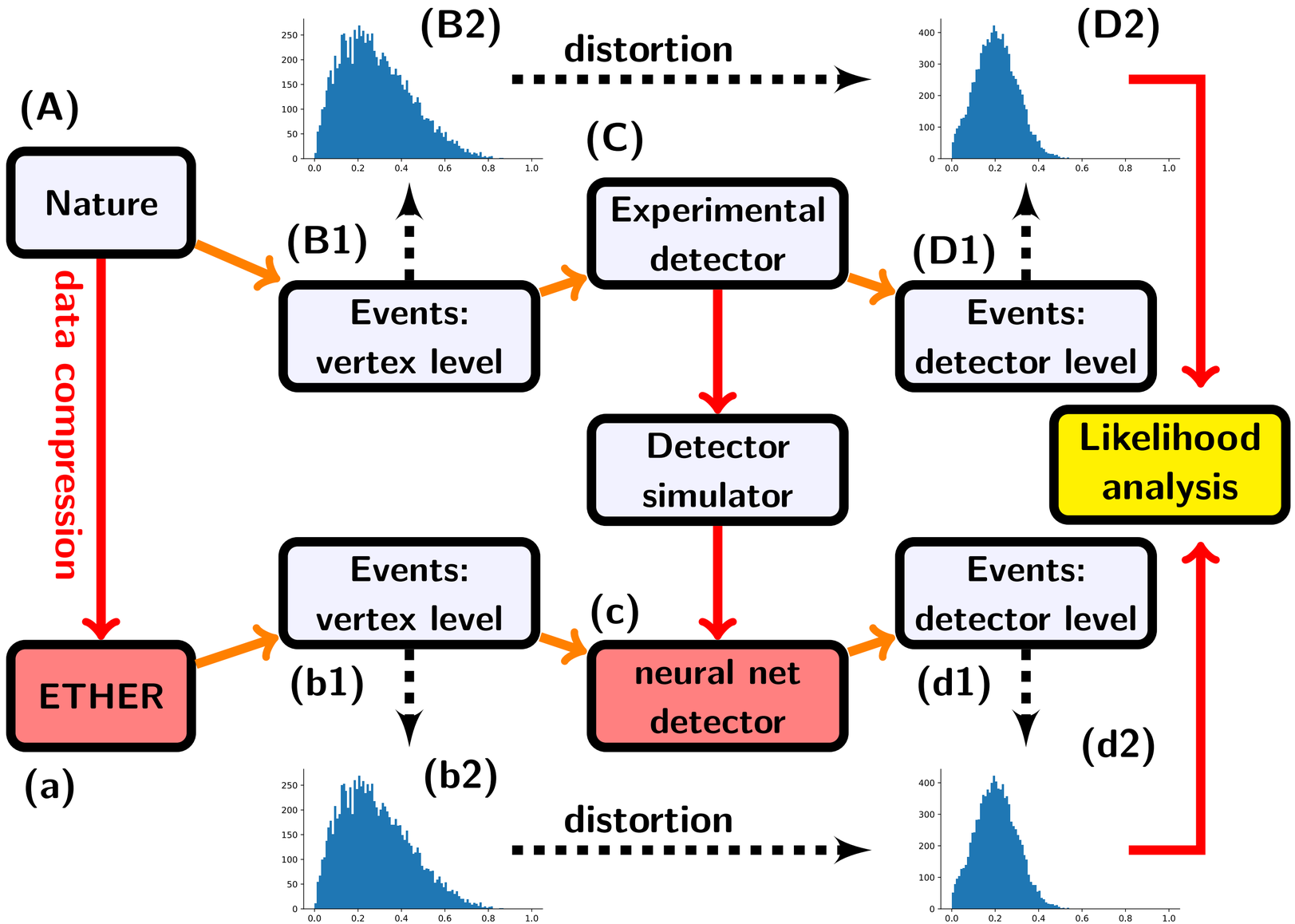
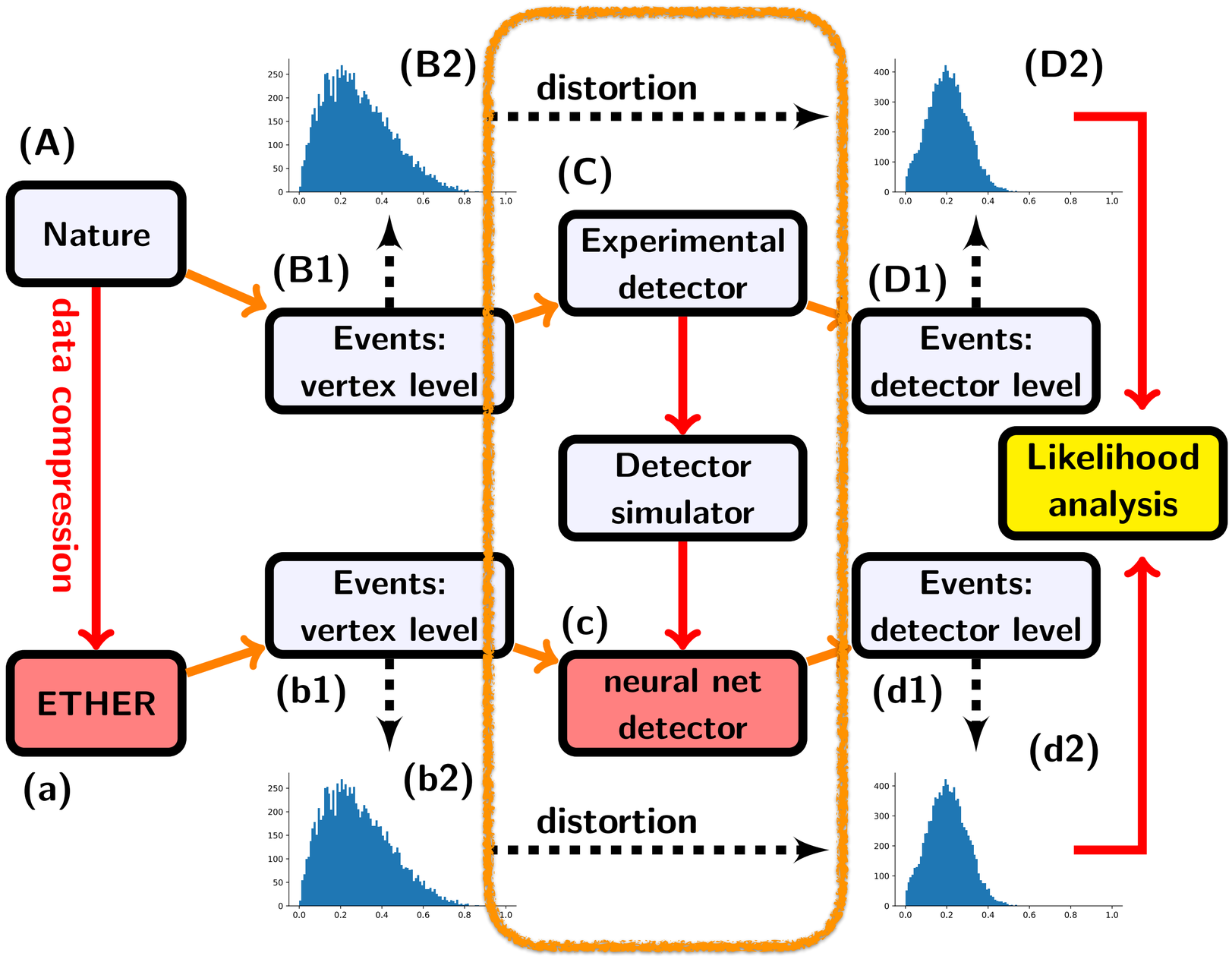
Workflow of UMCEG/ETHER



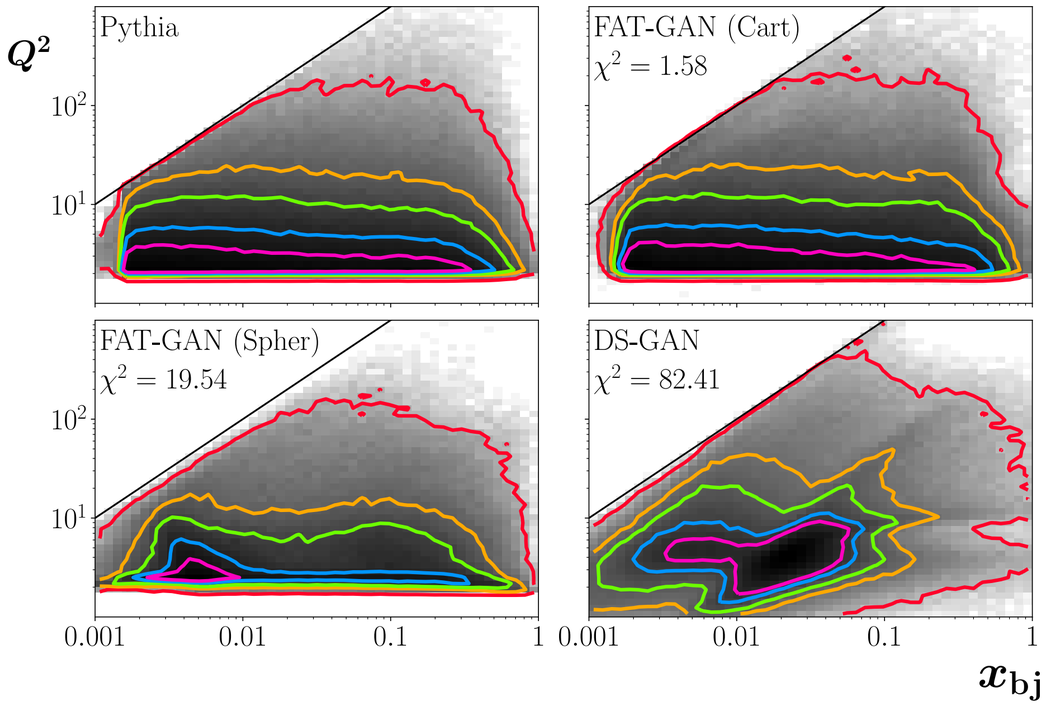
Workflow of UMCEG/ETHER



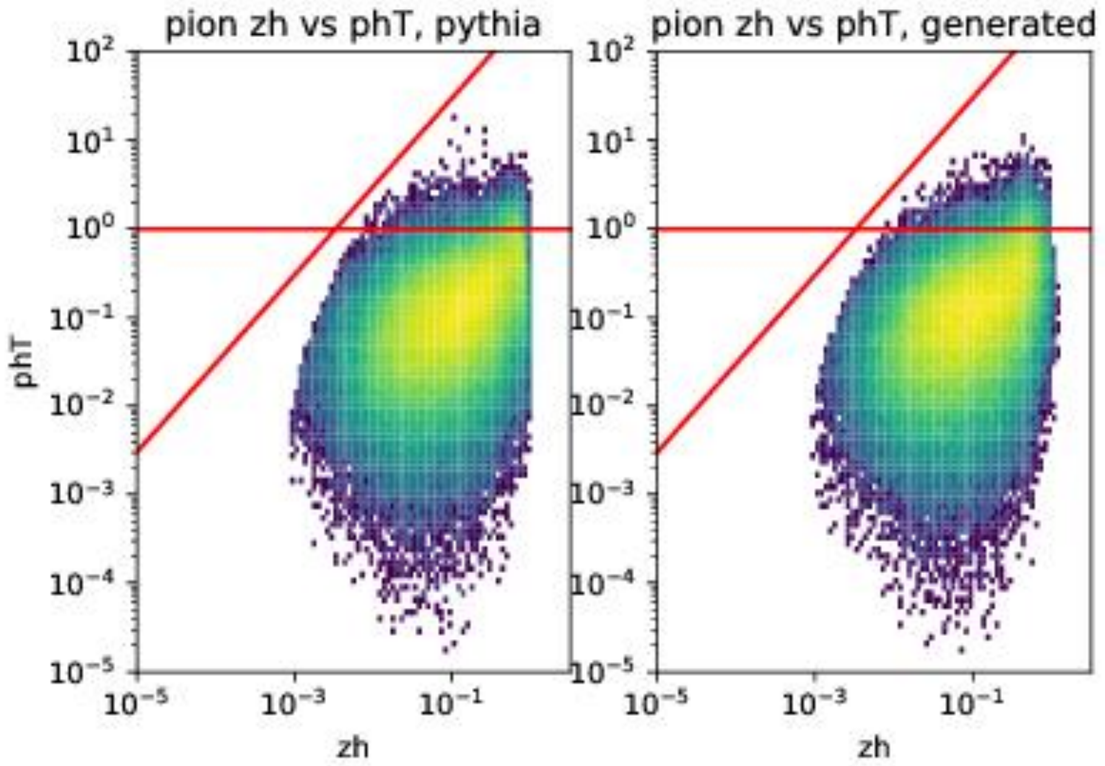
What We Have Achieved

A GAN trained with pseudo data generated by Pythia

Inclusive DIS (single particle GAN)



Semi-inclusive DIS (double particle GAN)

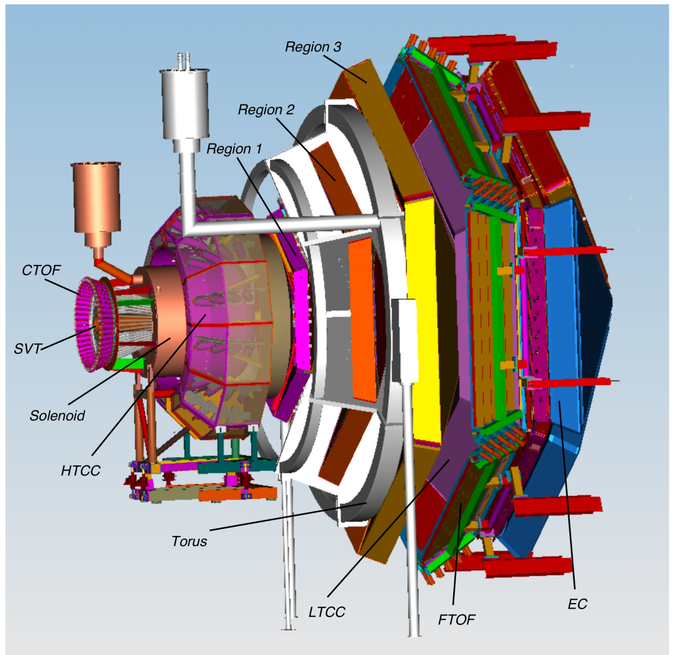


See following talks by Luisa Valesco, Yaohang Li, Yasir Alanazi

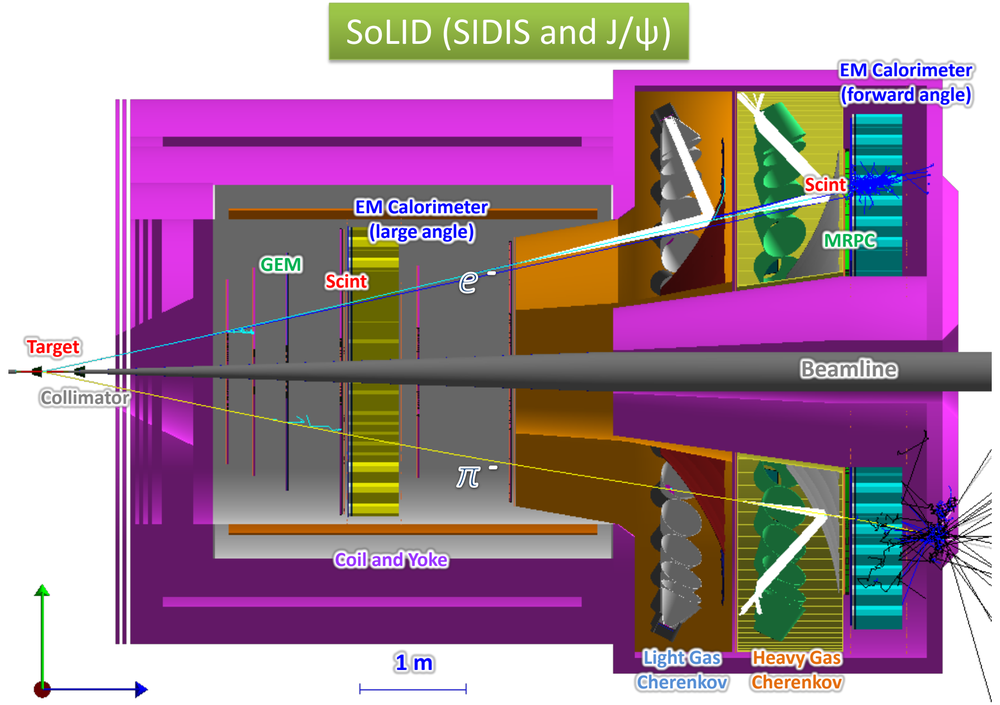
How the Real World is Measured

We “see” the real world with detectors.
However …

- We cannot “see” everything: only long-lived particles within the acceptance of our “eyes”
- What we “see” may not from the vertex: multiple scatterings, beam halo, cosmic rays, …
- What we “see” is not the same as at the vertex: information changes on the path
- What we “see” always comes with uncertainties: resolution
- What we “see” may not be what enters our “eyes”: false track, mis-PID, …



[Figure from CLAS12 website]



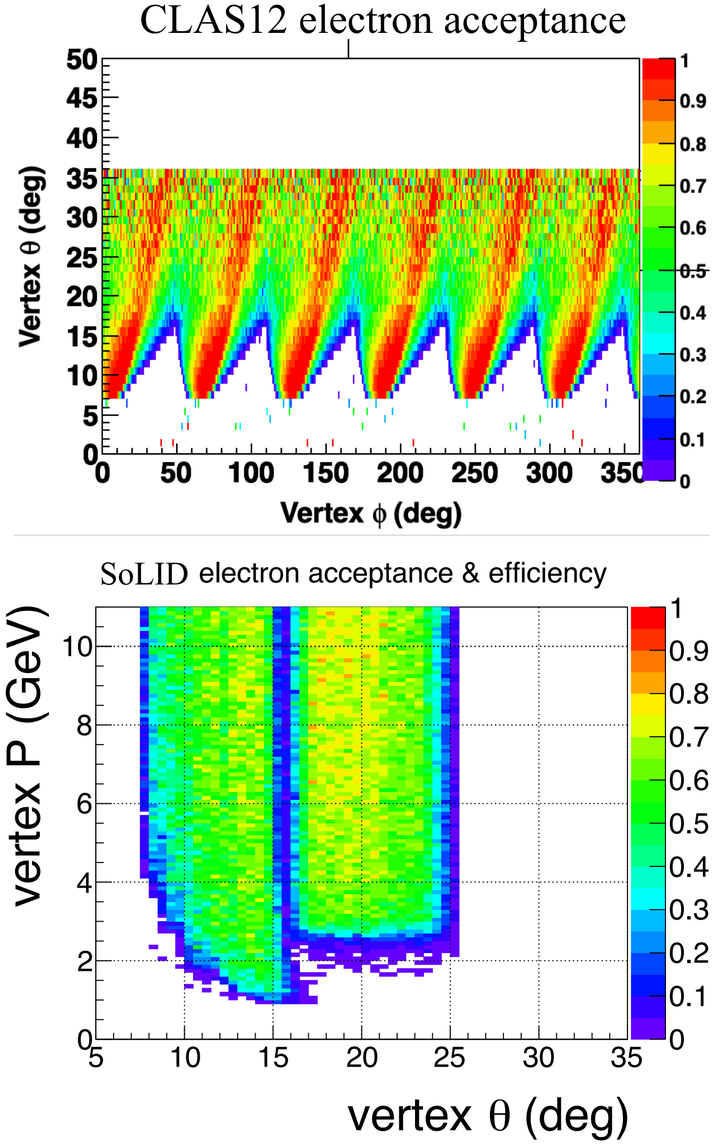
[Figure from SoLID preCDR]

Acceptance and Efficiency

Detectors only cover part of the phase space
Particles generated at the vertex may not be detected

- the angle is out of the detector coverage
- momentum/energy is below the threshold
- decay before arriving the detector
- scatter with materials on the path
- …

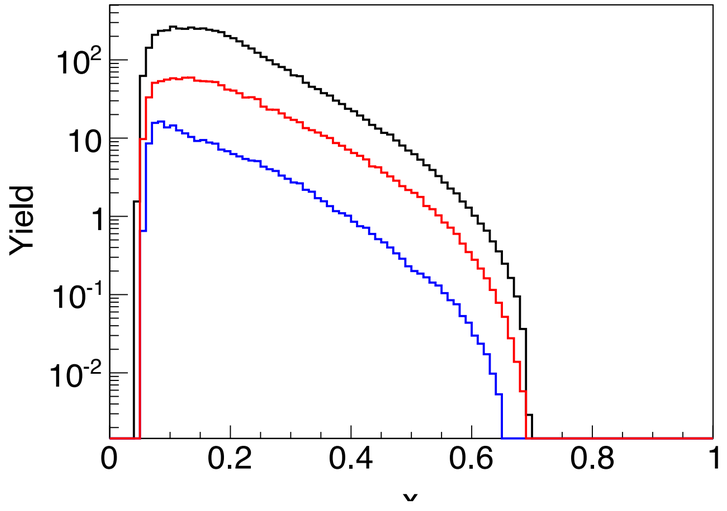
The yield of events are reduced.
The shape of the distribution may also change.

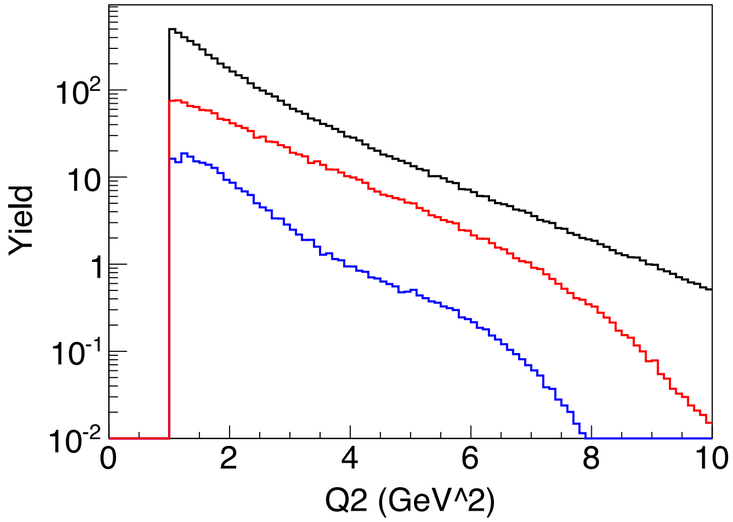


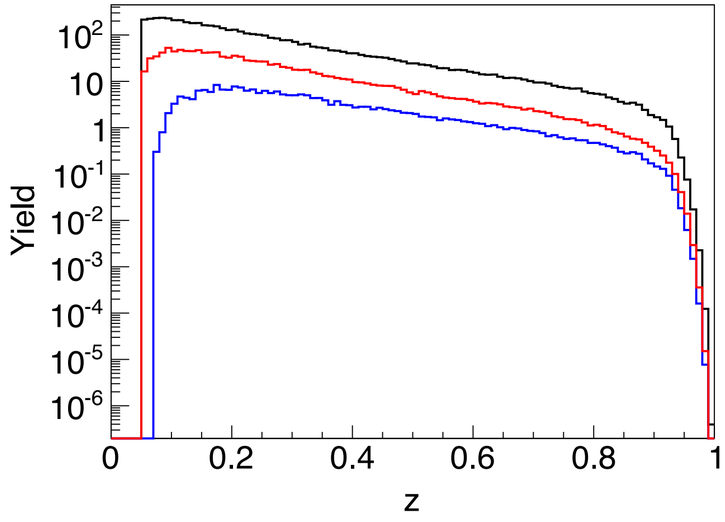
[Acceptance files by Z.W. Zhao]

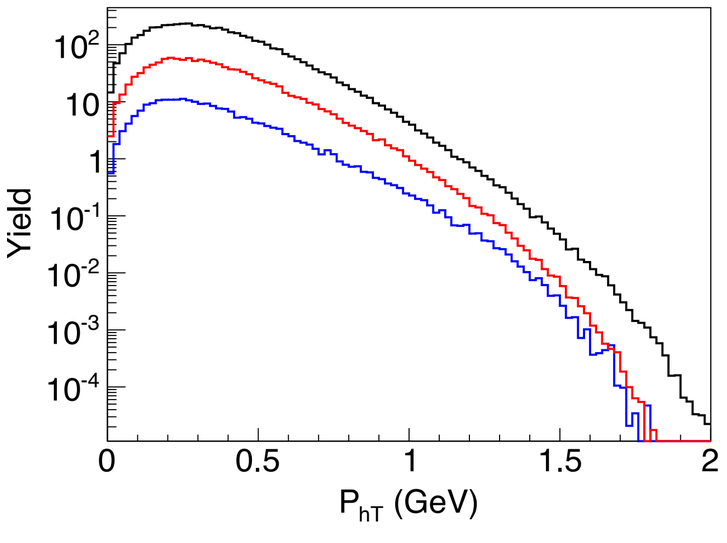
Acceptance and Efficiency

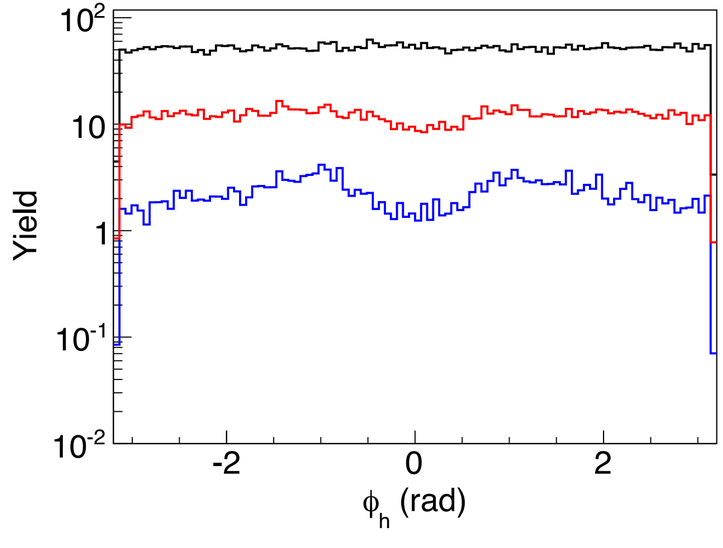
Example: (SIDIS)











Black: events at vertex

Red: apply CLAS12 acceptance

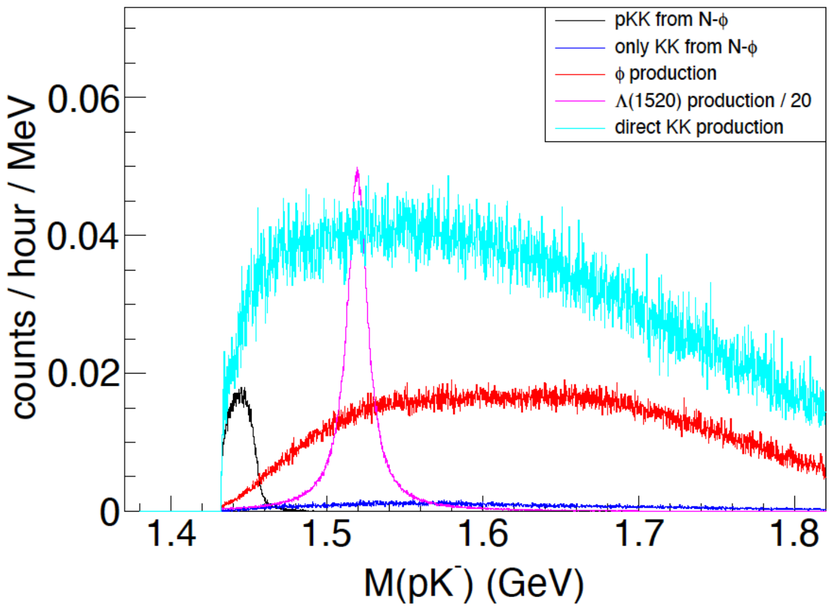
Blue: apply SoLID acceptance

Resolution

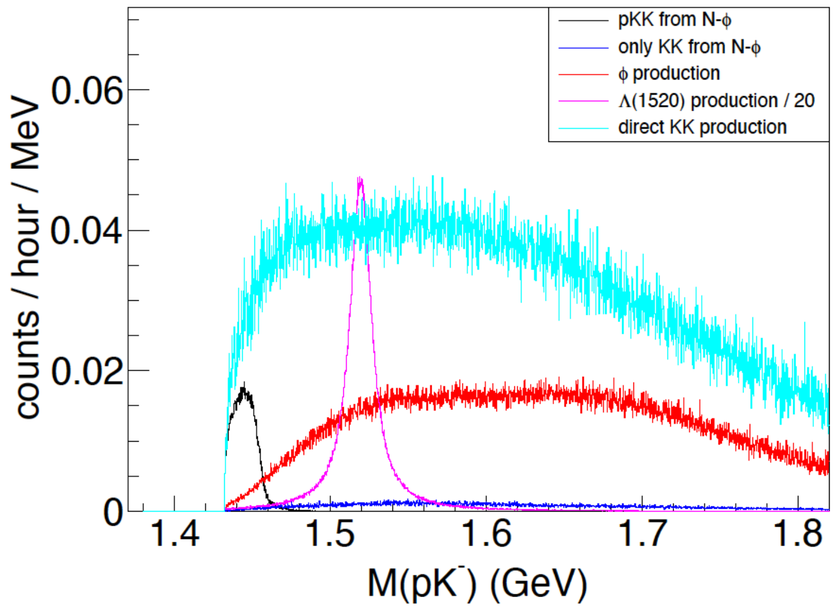
The momenta and angles of particles recorded by the detectors have uncertainties.

- position and energy resolution of the caliometer
- knowledge of the magnetic field
- track reconstruction
- radiative energy loss
- scattering with materials on the path
- …

Example: eA → epKKX [H. Gao *et al.*, Phys. Rev. C 95, 055202 (2017)]



smeared with CLAS12 and ALERT resolution

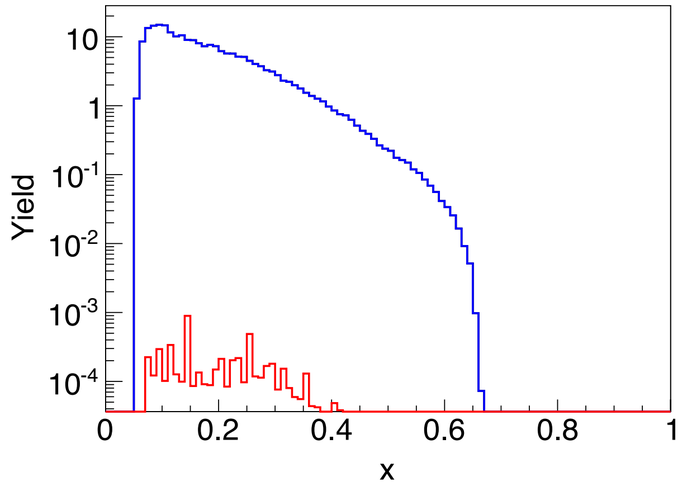


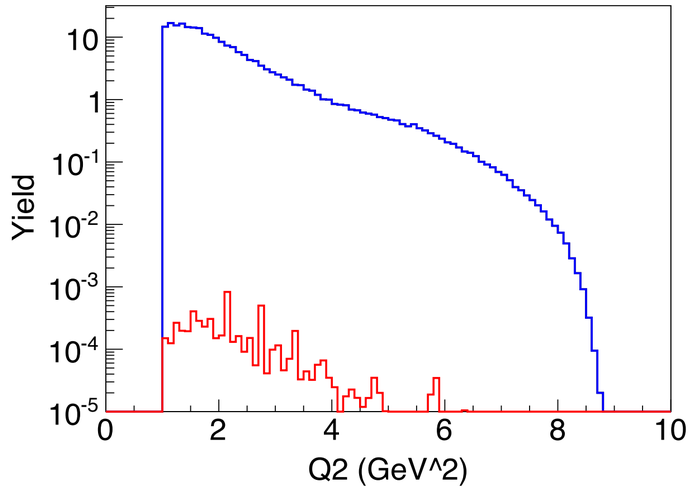
Time Resolution

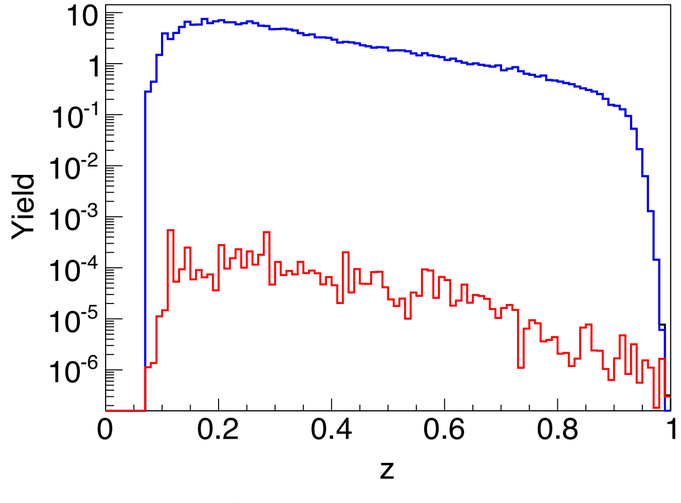
When identifying multiple particles in the final state
- particles from different events may be counted as from a single event
- “coincidence” is understood within the time resolution

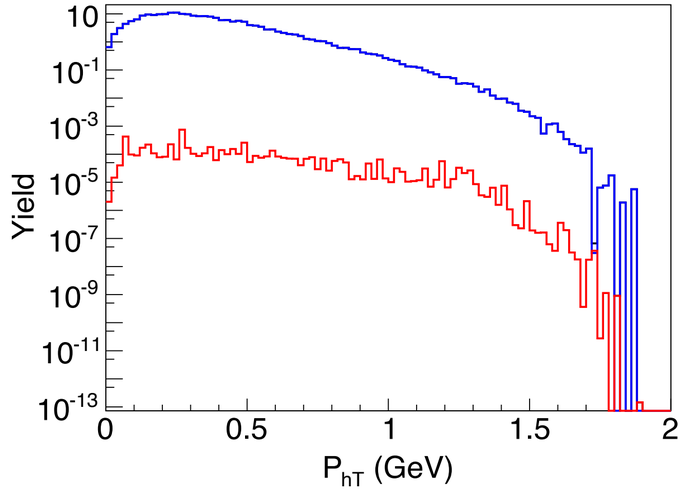
Example: SIDIS

Blue: real coincidence eπ
Red: random coincidence eπ





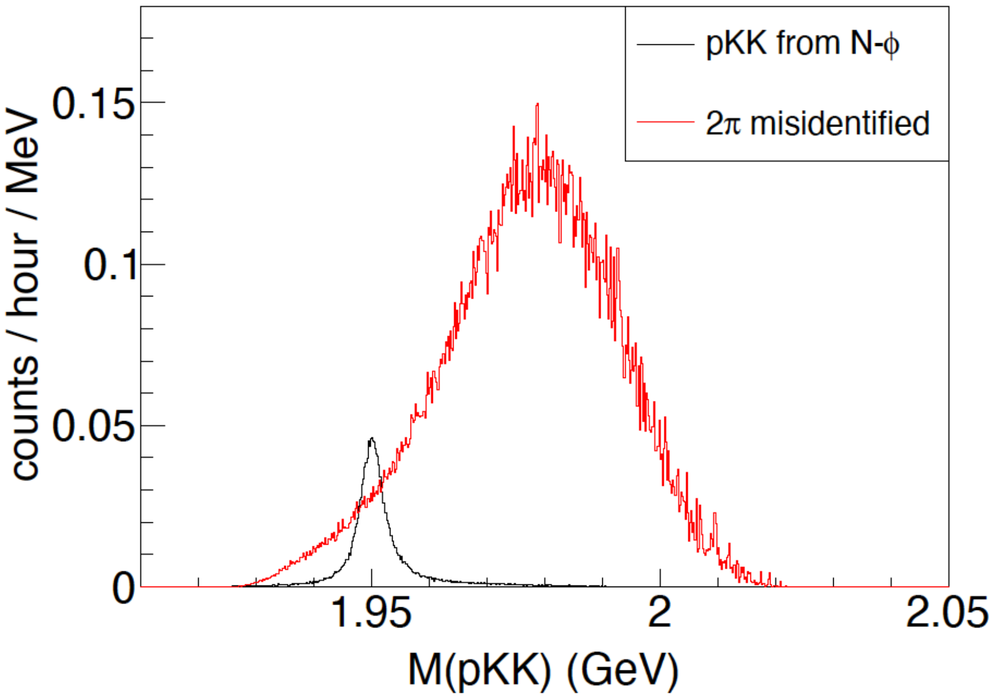




Particle Identification

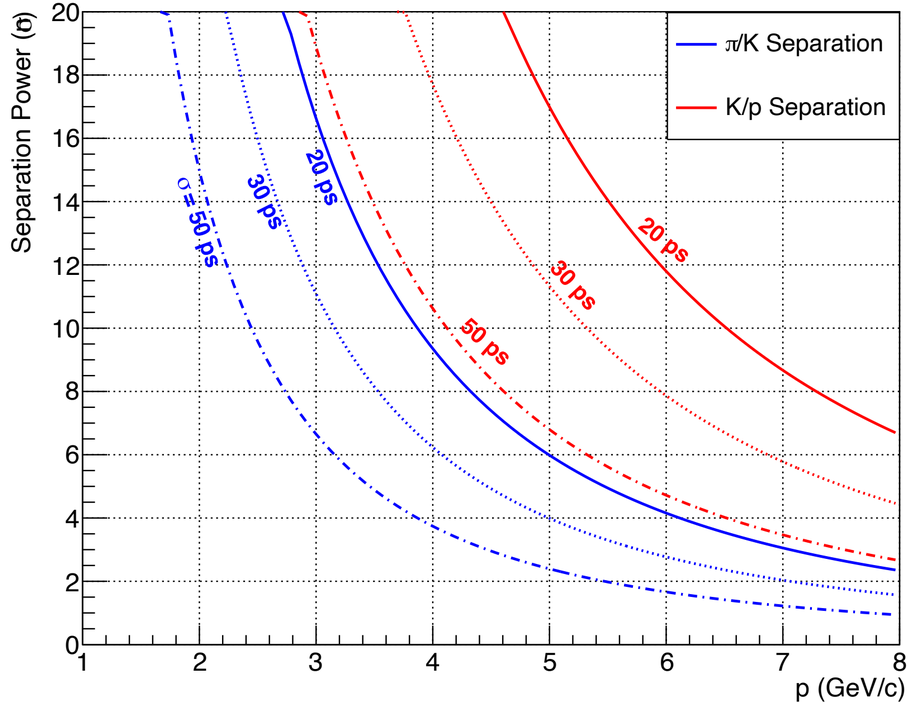
The particle type may be misidentified
- statistically known, not event by event

Example: eA → epKKX



assume 2% pion are misidentified as kaon

Example: separation with TOF



[From proposal E12-10-006D/E12-11-108B]

More Other Effects

- Cosmic rays
- Scattering from the residue gas
- Scattering from materials on the path, *e.g.* target cell, tracking detectors, …
- False track
- Radiative energy loss
- …

Summary

- Goal: training with real data, distorted by detector effects, to develop a GAN to generator events at the vertex.

- Challenge: some information is missing; recorded information is distorted and could be wrong.

- Method: algorithms for inverse problems with multiple solutions; combine data from different experiments; a NN-based detector simulation.

Thank you!