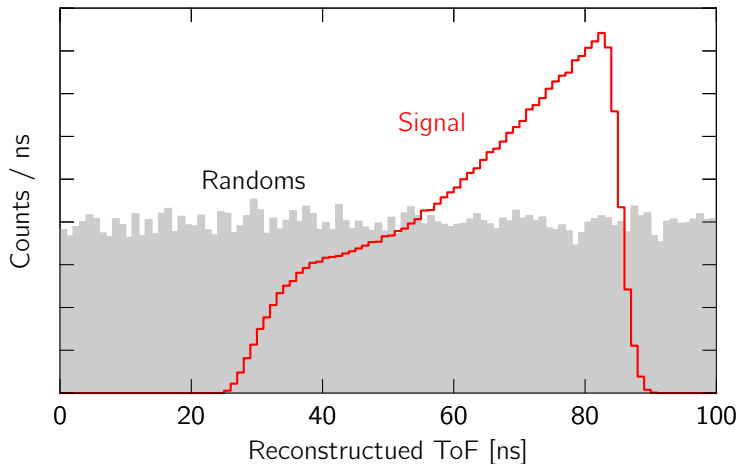# Simulating Signal and Background

Axel Schmidt

Answering ERR charge 4 (expected rates) and charge 7 (simulation status)

July 29, 2020

Random background will be the limit to the final LAD precision.

Simulated protons hitting middle LAD panel

Random background will be the limit
to the final LAD precision.

Statistical Uncertainty:
$$\delta S/S = \frac{\sqrt{S+B}}{S}$$

Random background will be the limit to the final LAD precision.

Statistical Uncertainty:

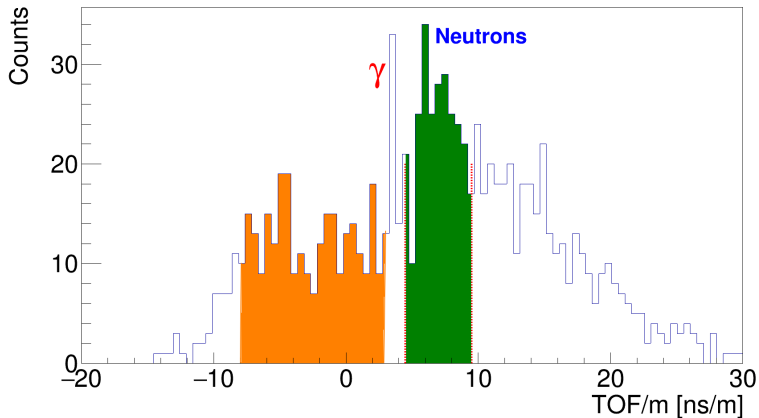$$\delta S/S = \frac{\sqrt{S+B}}{S}$$

Increase the luminosity by factor of F:

$$\delta S/S \longrightarrow \frac{\sqrt{FS + F^2B}}{FS} = \frac{\sqrt{S/F + B}}{S}$$

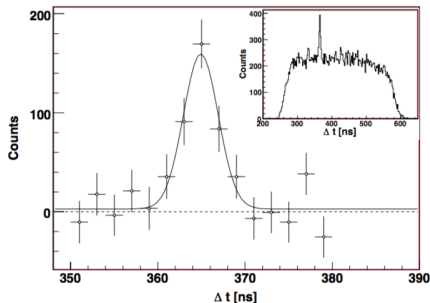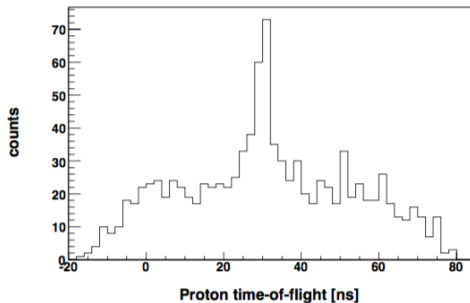Add systematic problems with subtracting large backgrounds!

Our group has experience with large background analyses.

I. Korover et al., (CLAS) with PRL

Our group has experience with large background analyses.

Hall A BigBite + HAND

- Shneor et al., **PRL** 99 072501 (2007)
- Subedi et al., **Science** 320 p. 1476 (2008)
- Korover et al., **PRL** 113, 022501 (2014)

Useful kinematic variables:

- W': Hadronic mass given spectator momentum
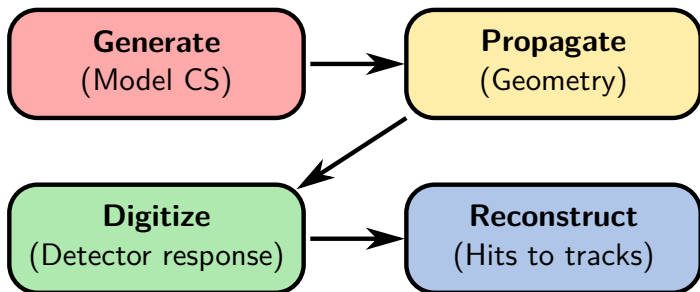
$$W'^2 = (q^\mu + p_d^\mu - p_s^\mu)^2$$

- x': Bjorken-x given spectator momentum

$$x' = \frac{Q^2}{2q_\mu(p_d^\mu - p_s^\mu)}$$

- α_s: Light cone momentum of spectator (a measure of virtuality)
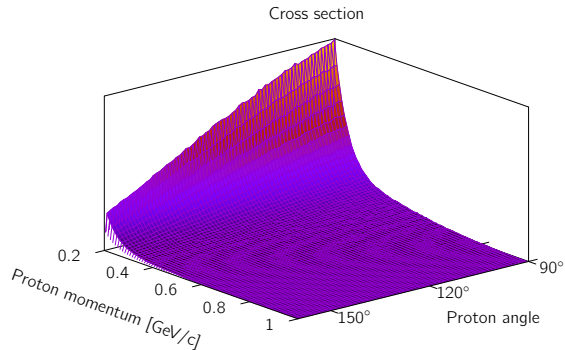
$$\alpha_s = \frac{E_s - \hat{q} \cdot \vec{p}_s}{m}$$

We developed a Fast MC for quickly testing and improving our design.
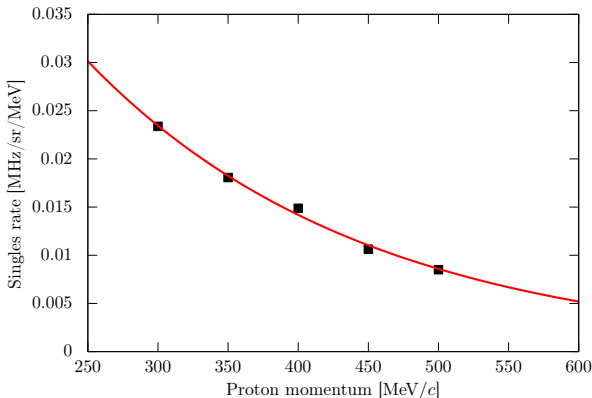
Generator

- Cross section calculations by Wim Cosyn, Misak Sargsian
    - Tagged-DIS cross section (signal)
    - Inclusive e^- generator (background singles)
- Same as in proposal
- TFoam class for importance sampling

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Generator continued . . .

Proton singles estimated from E01-015 (BigBite at $100°$).

- 16.7 MHz/sr at a luminosity of 3.8×10^{37} cm^{-2}s$^{-1}A^{-}1$ for protons > 0.25 GeV/c
- We plan 1.2×10^{37} cm^{-2}s$^{-1}A^{-1}$
- $= 5.3$ MHz/sr $\longrightarrow$ assume isotropic 6 MHz/sr

Generator continued . . .

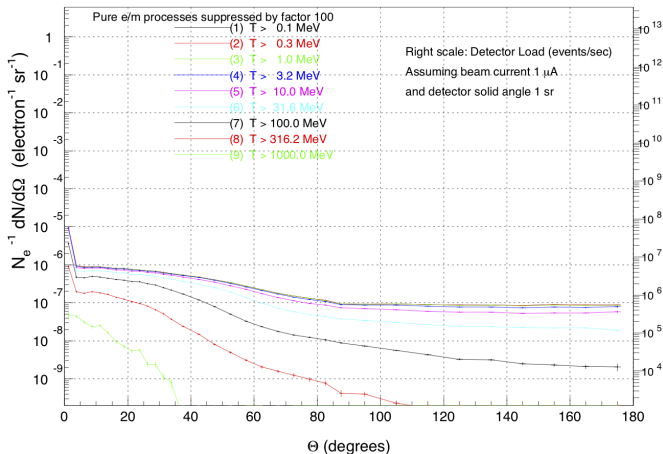Proton singles estimated from E01-015 (BigBite at $100°$).

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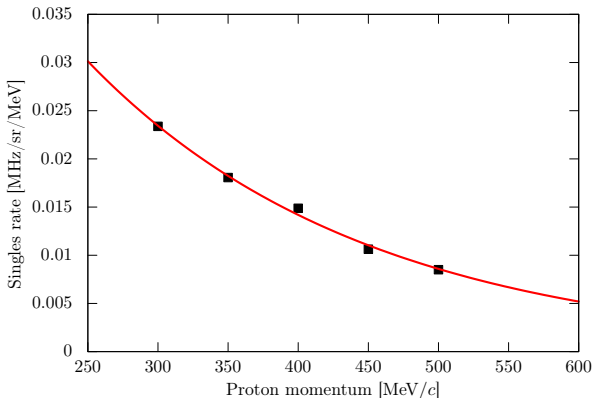
This is more than 50% higher background rate than Geant4 results from P. Degtiarenko.
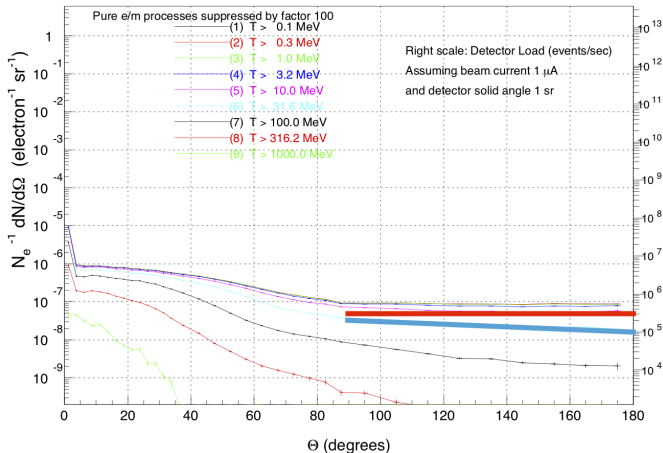
We assume 6 MHz/sr isotropic.
Pavel found 4 MHz/sr at 90°.

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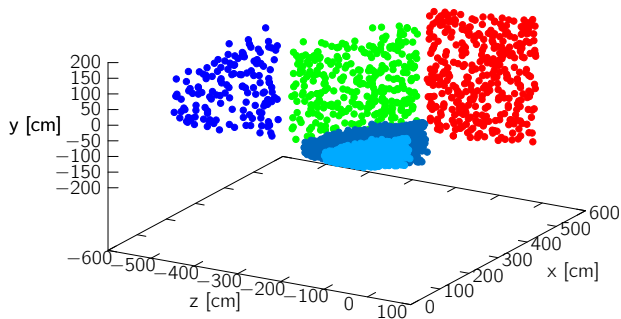
We assume 6 MHz/sr isotropic.
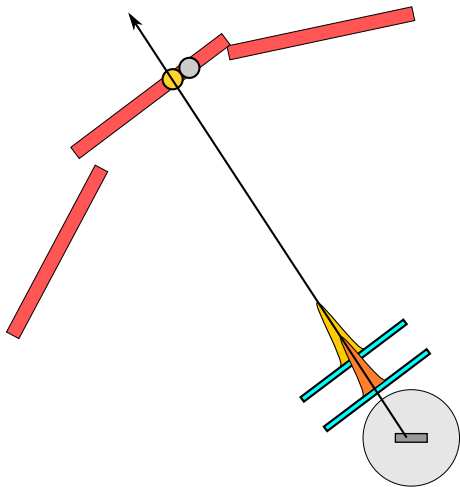Pavel found 4 MHz/sr at 90°.

Propagation

- Window apertures
- Detector acceptances
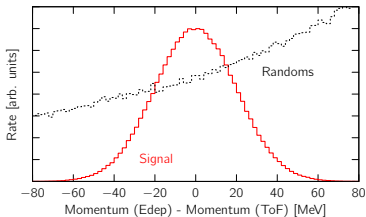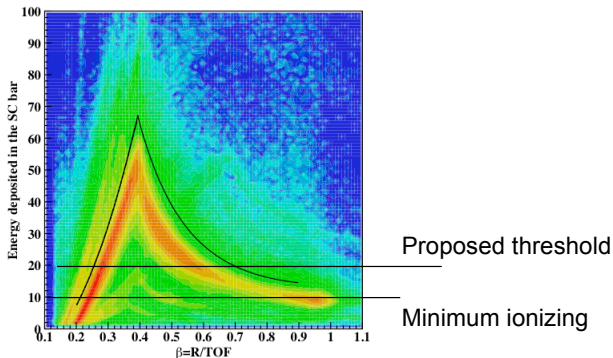- Multiple scattering from windows, GEMs, other material

Digitization and Reconstruction

- **Detector Resolution**
  - GEM resolution: 100 μm
  - LAD resolution: 300 ps
- **Reconstruction**
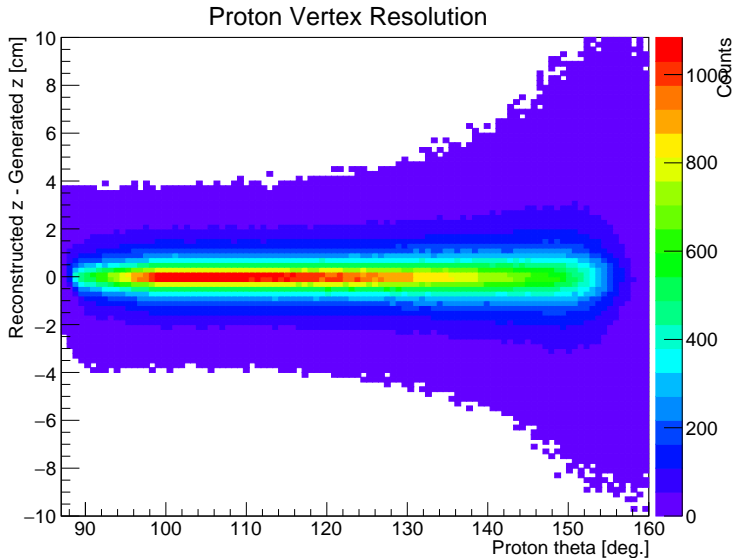 - Momentum from velocity
  - Path-length
  - Time-of-flight

Background reduction: Momentum vs. dE/dx

Proposed threshold

Minimum ionizing

Randoms

Signal

■ ≈ 20 MeV/c resolution
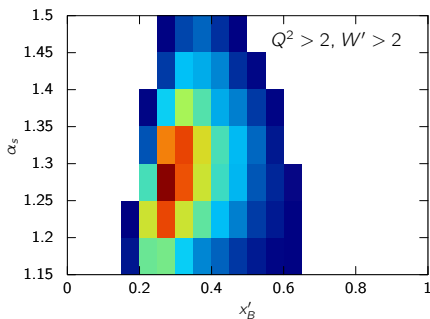
Background reduction: GEM vertexing

Proton Vertex Resolution

Event Selection

- e^- in spec. + proton at LAD
- $Q^2 > 2$ GeV$^2/c^2$
- $W' > 2$ Gev

- $\theta_{qs} > 110°$
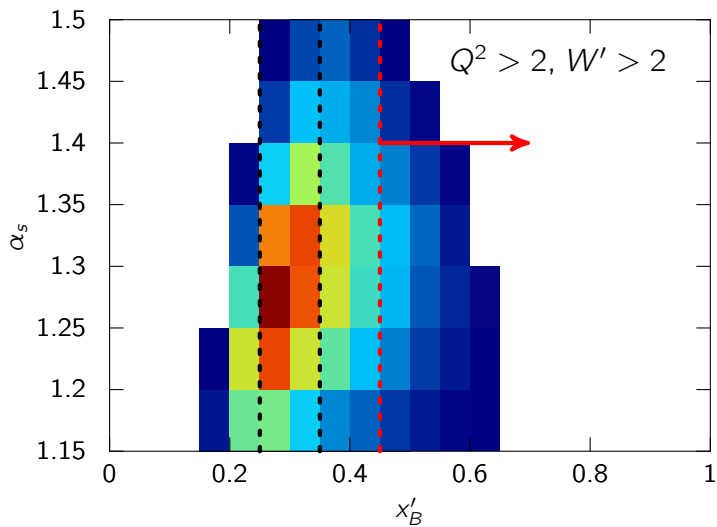- $p_s > 275$ MeV
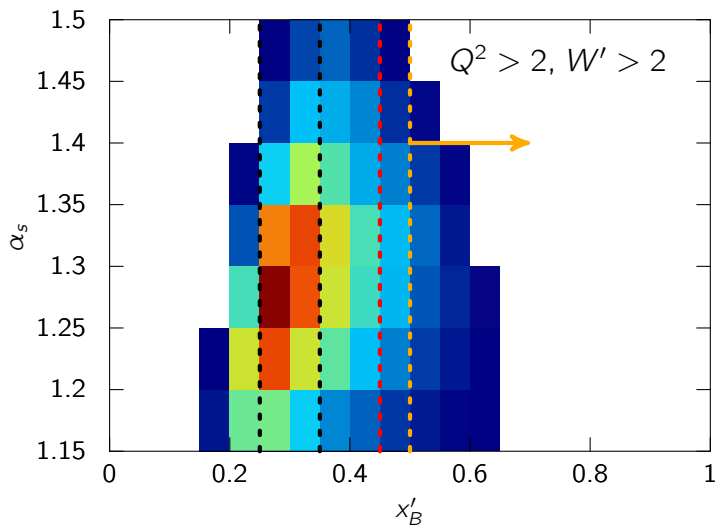- 2σ cuts on E_{dep}, vertex

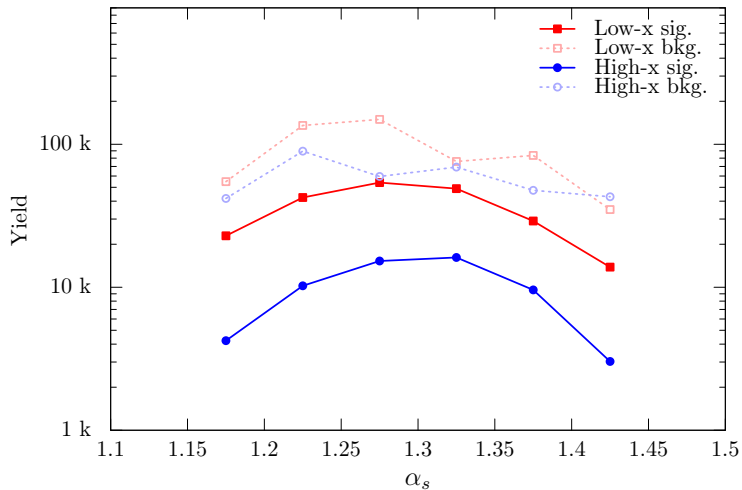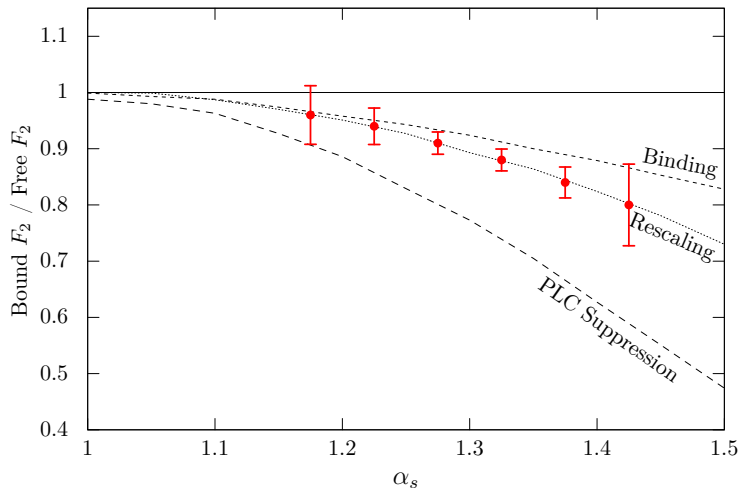

Signal

Background
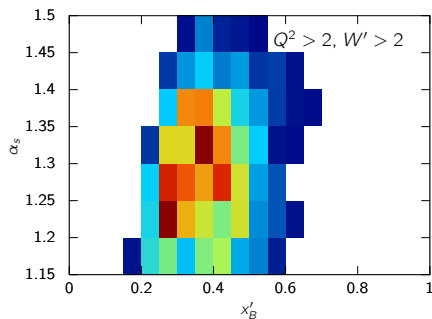
Event Selection

Event Selection

Expected yields

Expected reach

Summary

- Fast MC developed for rapid optimization

- Background reduction from
  - Energy deposition
  - Vertexing

- Expected 250k low-x' events, 70k high-x' events at 1.2×10^{37} cm^{-2}s$^{-1}A^{-1}$.

- Accidental background rate is 4–8x signal

ERR Charges

Charge 4: What are the expected data rates for the experiment (both physics data rate and background rates)?

Configuration	Physics (counts/hr)	Background (counts/hr)
LAD + HMS 13.5°	578	2,730
LAD + SHMS 13.5°	889	3,730
LAD + HMS 17°	96.9	899
LAD + SHMS 17°	114	811

Charge 7: What is the simulation ... status for the experiment?...
We have developed a fast MC for rapidly evaluating different configurations.