Jefferson Lab

OLD DOMINION UNIVERSITY
IDEA FUSION

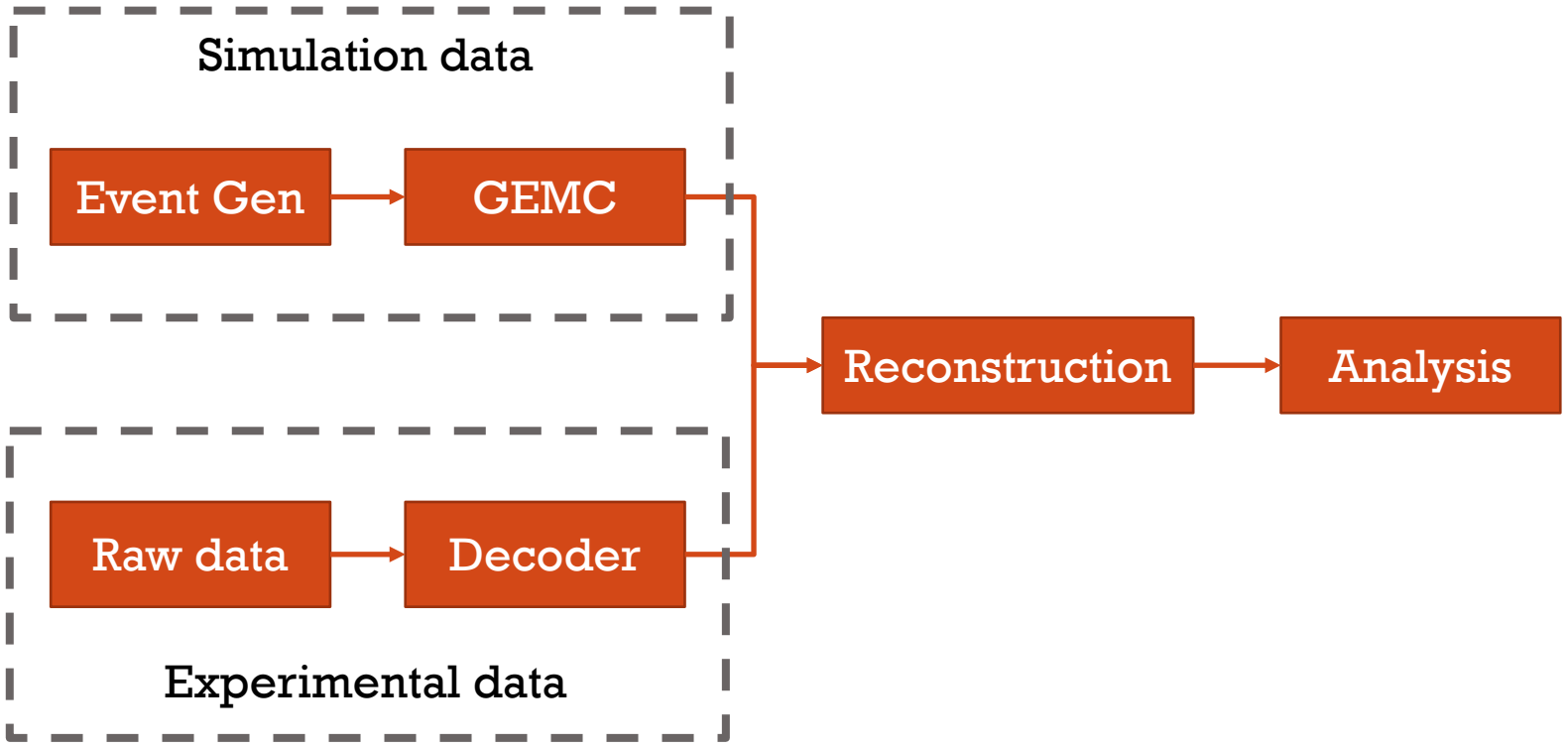
ANALYSIS OF INCLUSIVE DIS WITH RGA DATA

Nate Dzbenski

Nuclear Seminar

DATA ANALYSIS

THE PATH

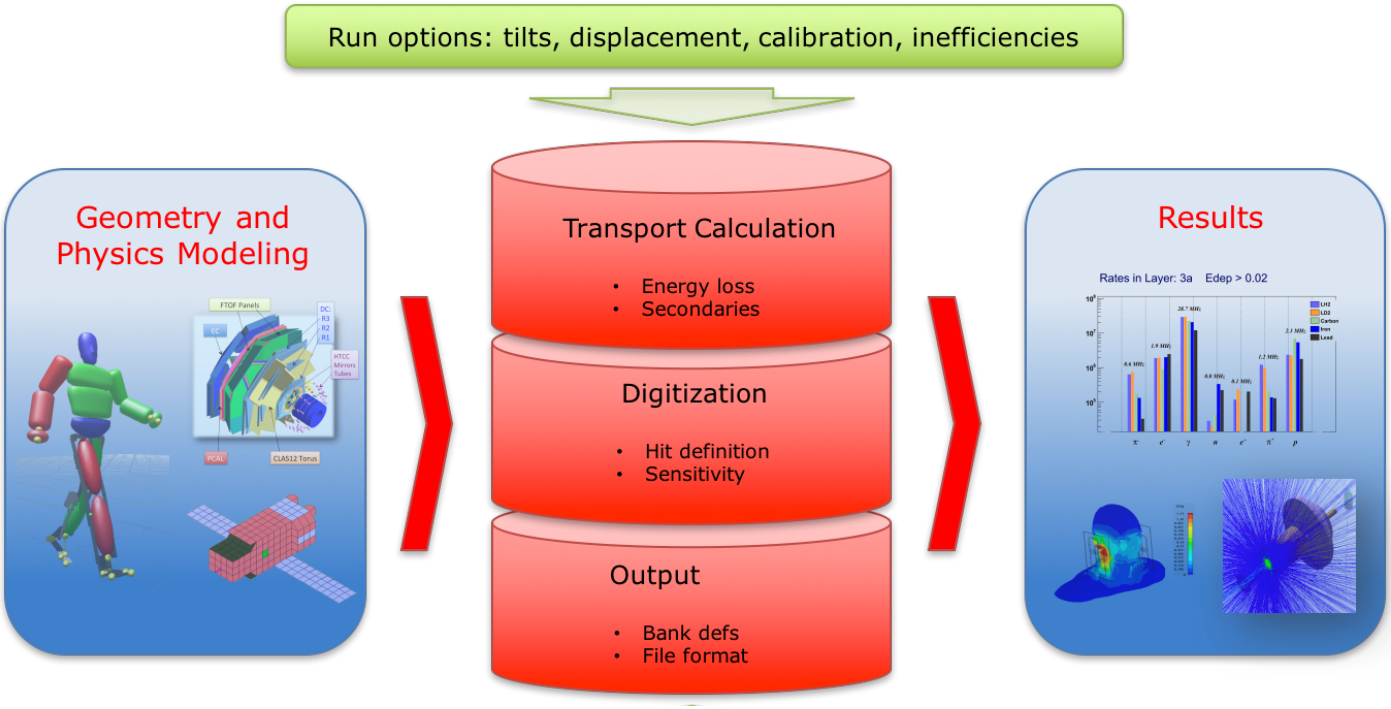


DATA ANALYSIS

GEANT4 MONTE-CARLO SIMULATIONS

GEMC is a Monte-Carlo based package of Geant4 used primarily for CLAS12.

Geant4 is a toolkit used to simulate particles passing through and interacting with matter.



DATA ANALYSIS

GEANT4 MONTE-CARLO SIMULATIONS

Use internal event generator or external EG in LUND format

LUND Header	
column	quantity
1	**Number of particles**
2	Mass number of the target (UD)
3	Atomic number oif the target (UD)
4	Target polarization (UD)
5	**Beam Polarization**
6	Beam type, electron=11, photon=22" (UD)
7	Beam energy (GeV) (UD)
8	Interacted nucleon ID (2212 or 2112) (UD)
9	Process ID (UD)
10	Event weight (UD)

LUND Particles	
column	quantity
1	**index**
2	Lifetime [nanoseconds] (UD)
3	**type (1 is active)**
4	**particle ID**
5	Index of the parent (UD)
6	Index of the first daughter (UD)
7	**momentum x [GeV]**
8	**momentum y [GeV]**
9	**momentum z [GeV]**
10	Energy of the particle [GeV] (UD)
11	Mass of the particle [GeV] (UD)
12	**vertex x [cm]**
13	**vertex y [cm]**
14	**vertex z [cm]**

1 DVCS events (ePπ0γ):

```
4   1   1    0.0   0.0 11   10.600   1       1      0.2373006E-02
1  -1.  1     11   0    0   -0.9830   0.0981  9.6502  9.7007  0.0005  0.0000 0.0000  -0.8072
2   1.  1   2212   0    0    0.7333   0.1126  0.6391  1.3560  0.9380  0.0000 0.0000  -0.8072
3   0.  1    111   0    0    0.2498  -0.2107  0.2808  0.4515  0.1349  0.0000 0.0000  -0.8072
4   0.  1     22   0    0   -0.0001  -0.0000  0.0299  0.0299  0.0000  0.0000 0.0000  -0.8072
```

DATA ANALYSIS

GEANT4 MONTE-CARLO SIMULATIONS

Define detector geometries, materials, banks, and hit-processes

```
# make drift volume from cathode to first GEM (30-70 mm)
sub make_drift_volume
{
    my $rmin  = $radius[2] + $thickness[2];
    my $rmax  = $gem_radius[0] - $gap;
    my $pspan = 360.;
    my $phistart = 0;
    my %detector = init_det();
    my $mate  = "BONuSGas";

    $detector{"name"} = "sensitive_drift_volume";
    $detector{"mother"}      = "rtpc";
    $detector{"description"} = "Sensitive drift volume";
    $detector{"color"}       = "ff88994";
    $detector{"type"}        = "Tube";
    $detector{"dimensions"}  = "$rmin*mm $rmax*mm $z_half*mm $phistart*deg $pspan*deg";
    $detector{"material"}    = $mate;
    $detector{"style"}       = 1;
    $detector{"sensitivity"}  = "rtpc"; ## HitProcess definition
    $detector{"hit_type"}     = "rtpc"; ## HitProcess definition
    print_det(\%configuration, \%detector);
}
```

DATA ANALYSIS

GEANT4 MONTE-CARLO SIMULATIONS

Put all detectors, relevant G4 physics processes, magnetic fields, beam conditions OR LUND file input into the GEMC simulation with the .gcard

```
<gcard>
    <!-- target. Notice variation give the target type. Can be: lH2, lD2, ND3 -->
    <detector name="/u/home/nathand/gemc/devel/detectors/targets/cad/"   factory="CAD"/>
    <detector name="/u/home/nathand/gemc/devel/detectors/targets/target" factory="TEXT" variation="cad"/>

    <!-- central detectors  -->
    <detector name="/u/home/nathand/gemc/devel/detectors/bst/bst"                factory="TEXT" variation="java"/>
    <detector name="/u/home/nathand/gemc/devel/detectors/bstShield/bstShield"    factory="TEXT" variation="w51"/>
    <detector name="/u/home/nathand/gemc/devel/detectors/micromegas/micromegas" factory="TEXT" variation="michel"/>

    <!--ctof, cad  -->
    <detector name="/u/home/nathand/gemc/devel/detectors/ctof/ctof"      factory="TEXT" variation="cad"/>
    <detector name="/u/home/nathand/gemc/devel/detectors/ctof/javacad/"  factory="CAD"/>
    <detector name="/u/home/nathand/gemc/devel/detectors/cnd/cnd"        factory="TEXT" variation="original"/>

    <!--high threshold cherenkov -->
    <detector name="/u/home/nathand/gemc/devel/detectors/htcc/htcc"      factory="TEXT" variation="original"/>

    <!-- magnets -->
    <detector name="/u/home/nathand/gemc/devel/detectors/magnets/solenoid" factory="TEXT" variation="original"/>
    <detector name="/u/home/nathand/gemc/devel/detectors/magnets/cad/"     factory="CAD" />
```

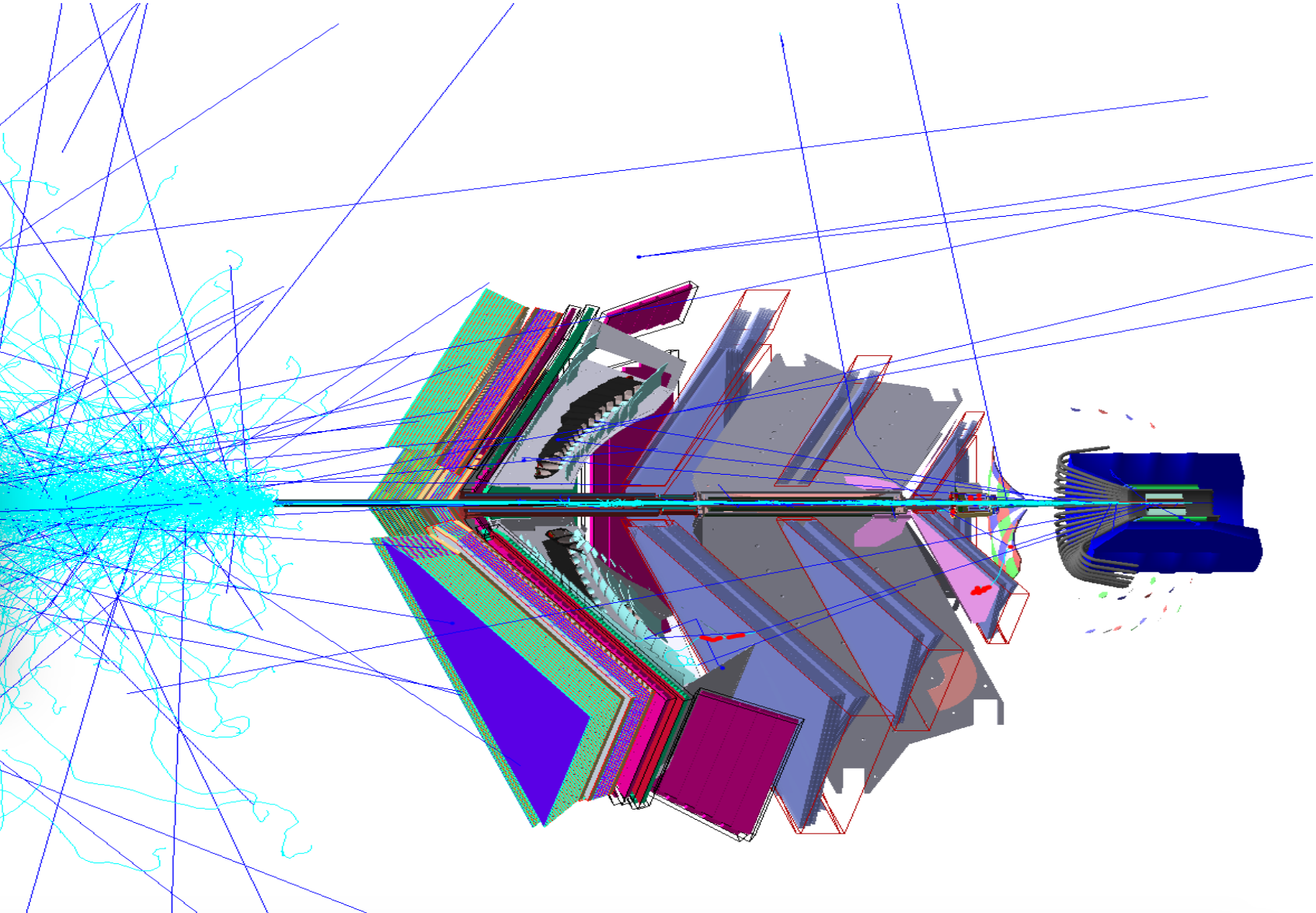
DATA ANALYSIS

GEANT4 MONTE-CARLO SIMULATIONS

```
    <!-- fields, precise mode -->
    <option name="FIELD_PROPERTIES" value="TorusSymmetric, 2*mm, G4ClassicalRK4, linear"/>
    <option name="FIELD_PROPERTIES" value="clas12-newSolenoid,  1*mm, G4ClassicalRK4, linear"/>

    <option name="PHYSICS" value="FTFP_BERT + STD + Optical"/>

    <option name="OUTPUT"   value="evio, gemc_5_40_04Mar2019.evio"/>

    <option name="INPUT_GEN_FILE" value="LUND, lund/ep_20.lund"/>
    <option name="NGENP" value="20"/>

    <!-- beam conditions -->
    <!-- <option name="BEAM_P"   value="e-, 10.6*GeV, 0.0*deg, 180.0*deg"/>
    <option name="BEAM_P"   value="proton, 90*MeV, 0.0*deg, 180.0*deg"/>
    <option name="SPREAD_P" value="10*MeV, 45*deg, 180.0*deg"/>
    <option name="BEAM_V"   value="(0, 0, 0)cm"/>
    <option name="SPREAD_V" value="(0.3, 18)cm"/> -->

    <!-- <option name="BEAM_P"   value="e-, 10.6*GeV, 0.0*deg, 180.0*deg"/>
    <option name="SPREAD_P" value="0*GeV, 0*deg, 180.0*deg"/>
    <option name="BEAM_V"   value="(0, 0, -20)cm"/>
    <option name="SPREAD_V" value="(0.3, 0)cm"/> -->

    <option name="USE_GUI" value="1"/>

    <!-- create a slice visualization -->
    <option name="EXEC_MACRO" value="slice.vis"/>

    <option name="N" value="0"/>

    <option name="RUNNO" value="11"/>
```

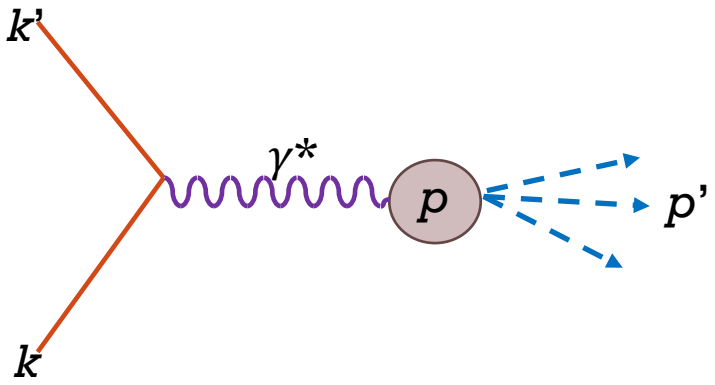
DATA ANALYSIS

GEANT4 MONTE-CARLO SIMULATIONS



INCLUSIVE DEEP INELASTIC SCATTERING

KINEMATIC VARIABLES



Final hadronic state
Total invariant mass (W)

$$W = k + p$$

4-momentum transfer

$$q = k - k'$$

$$Q^2 = -q^2 = 4EE' \sin^2\left(\frac{\theta}{2}\right)$$

Fraction of total momentum of a particular parton (Bjorken-*x*)

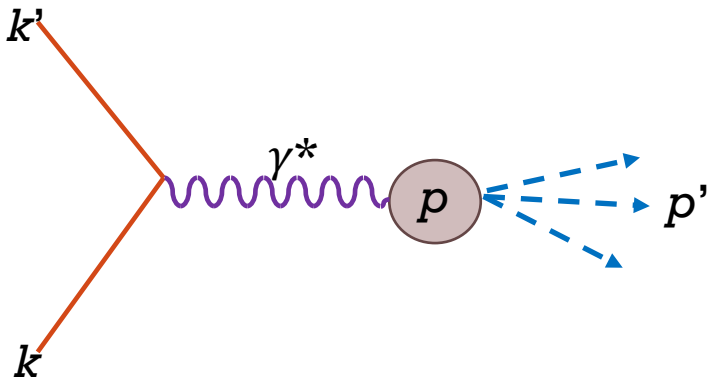
$$x_B = \frac{Q^2}{2M_P \nu}$$

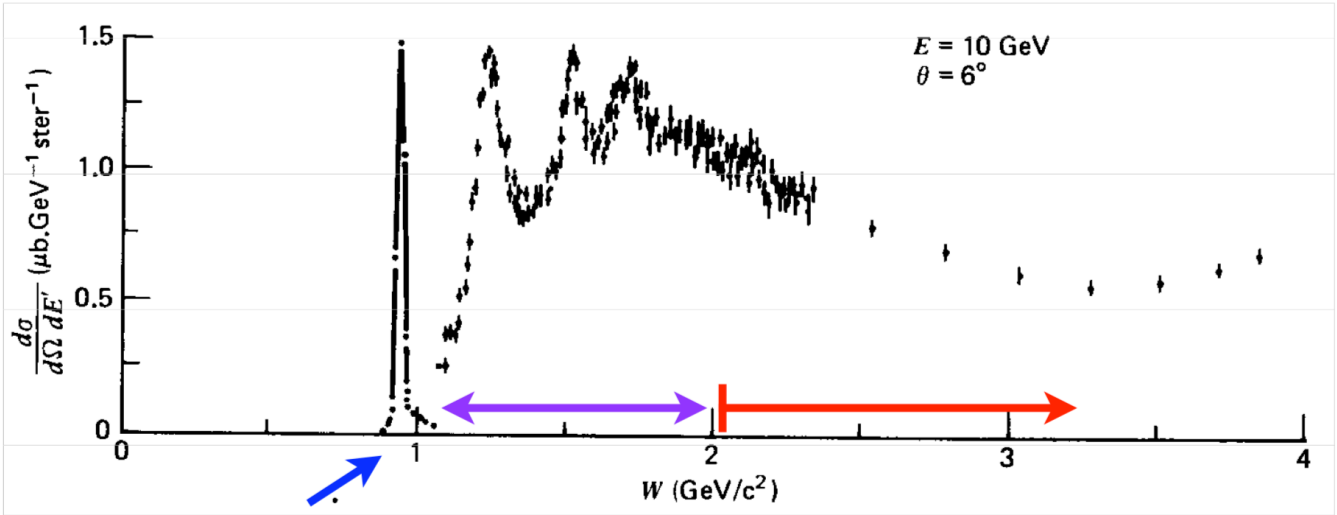
Energy of virtual photon

$$\nu = E - E'$$

SCATTERING REGIMES

CROSS-SECTION VS. W



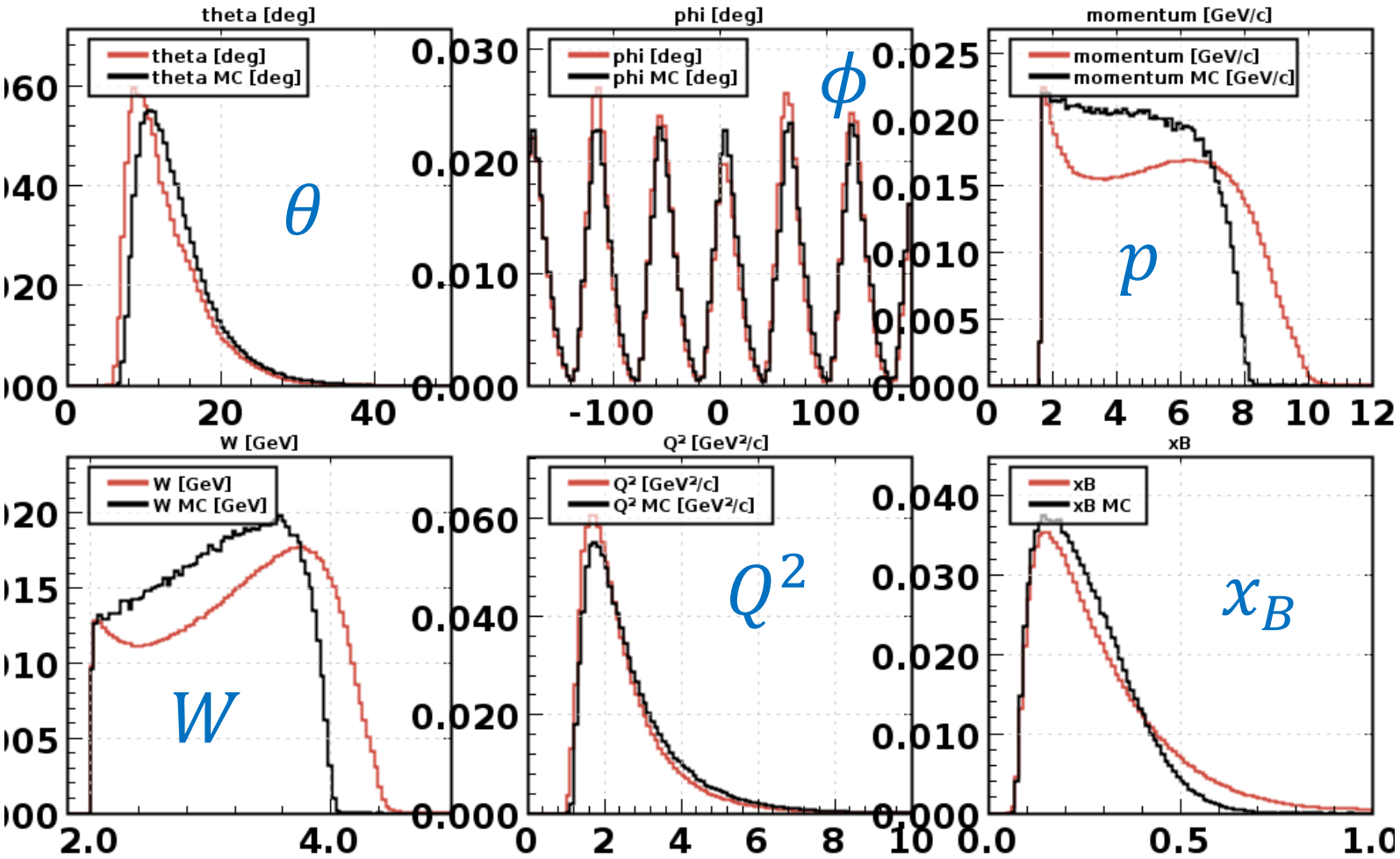


elastic scattering
ep → ep

resonance region
ep → eΔ, eN*, ...

DIS regime: W > 2 GeV
ep → e(X = many hadrons)

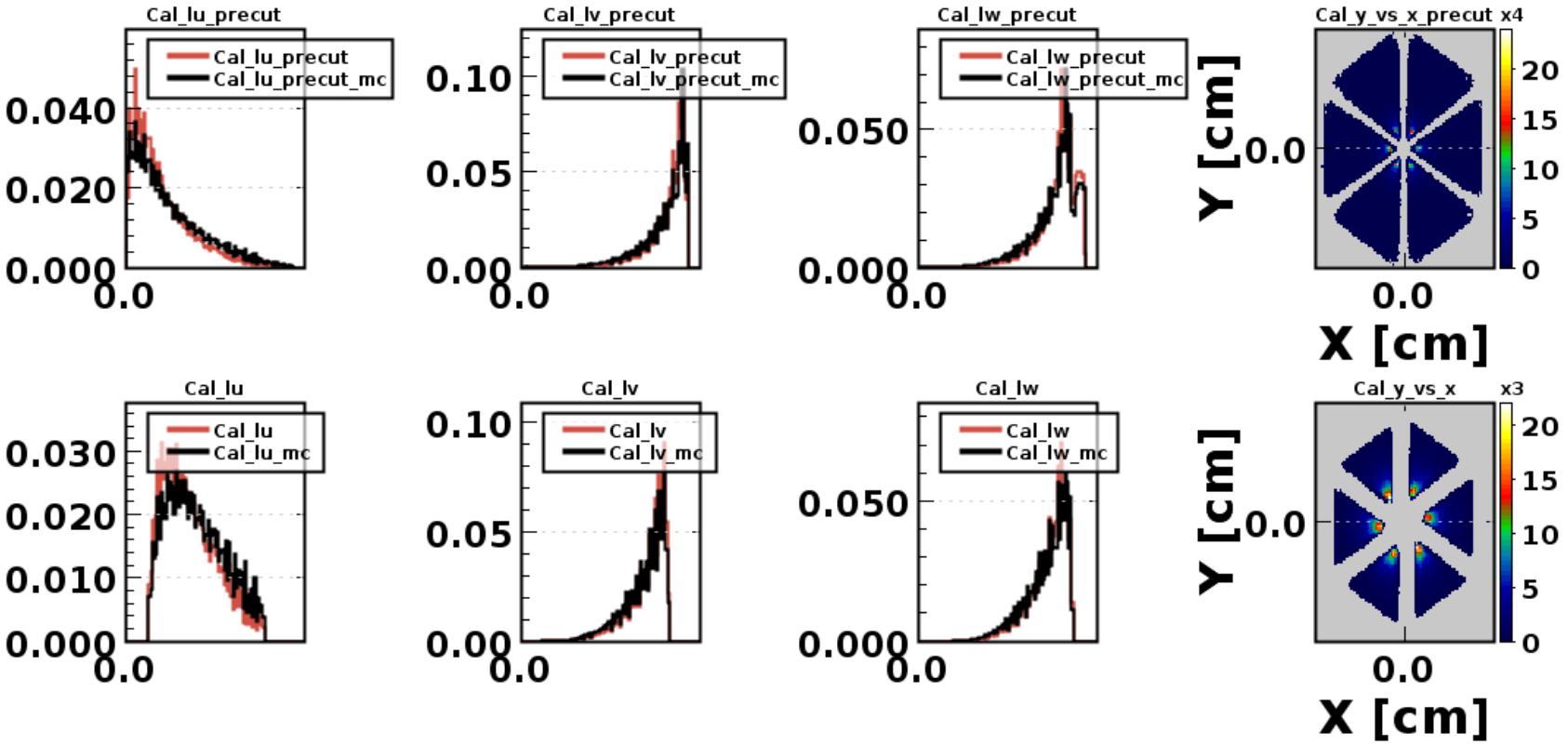
DATA ANALYSIS – RUN GROUP A



Cuts: q < 0, 5° < θ < 40°, W > 2 GeV/c², Q² > 1 GeV²/c², nphe > 2

DATA ANALYSIS – RUN GROUP A

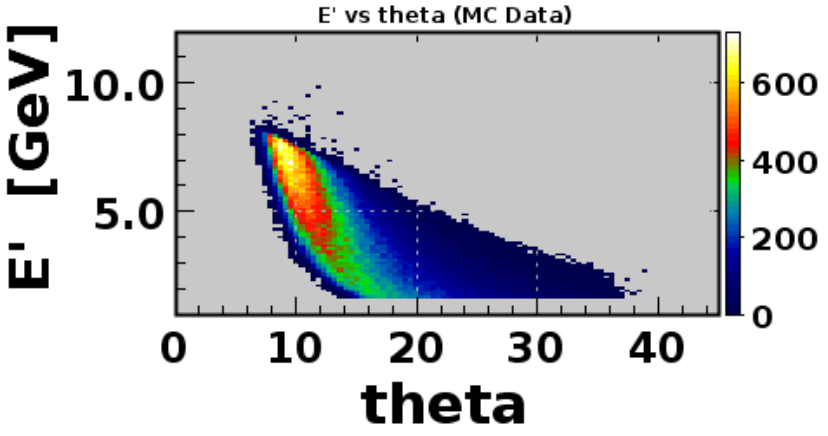
RGA data

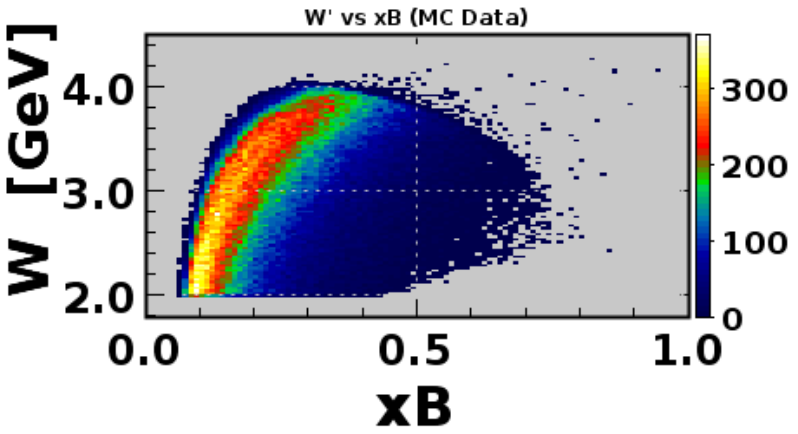


Cuts: 60 cm < lu < 350 cm, lv < 370 cm, lw < 390 cm

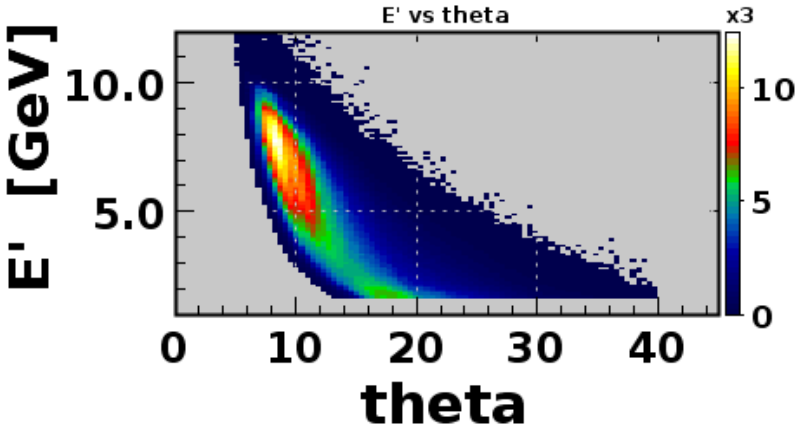
DATA ANALYSIS – RUN GROUP A

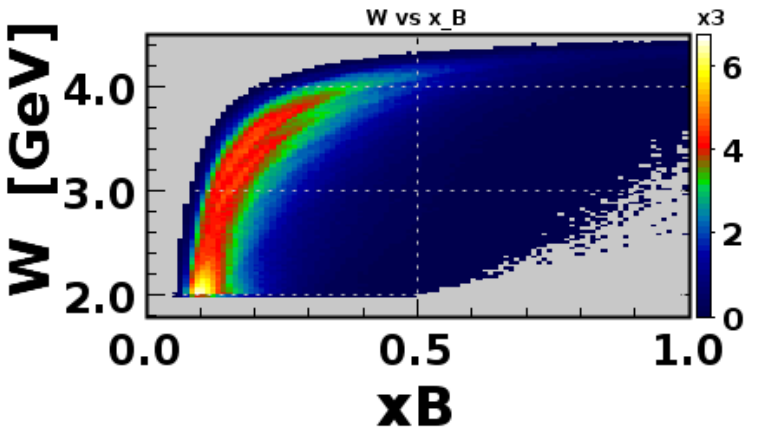
MC data





RGA data





Cuts: $q < 0, 5° < \theta < 40°, W > 2$ GeV/c^2, $Q^2 > 1$ GeV^2/c^2, nphe > 2

DATA ANALYSIS – RUN GROUP A

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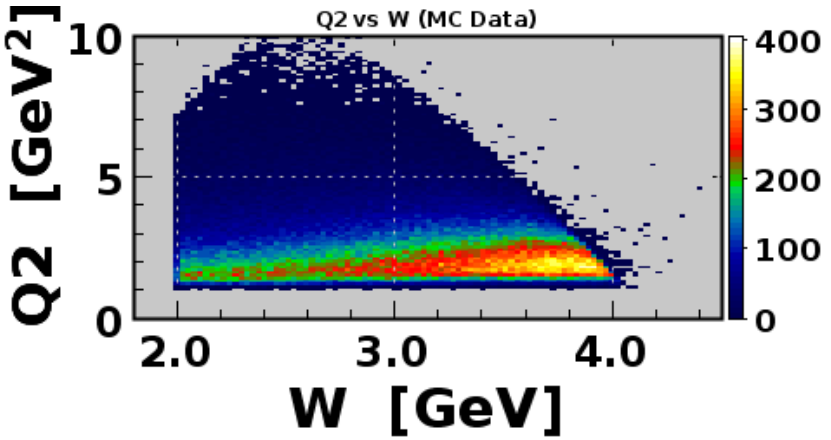
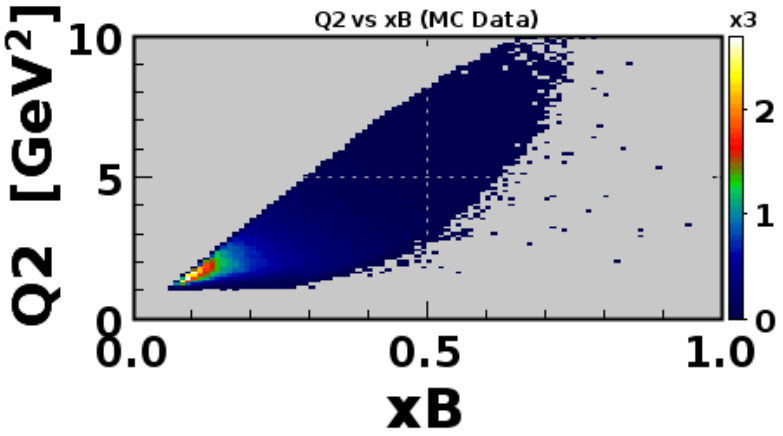
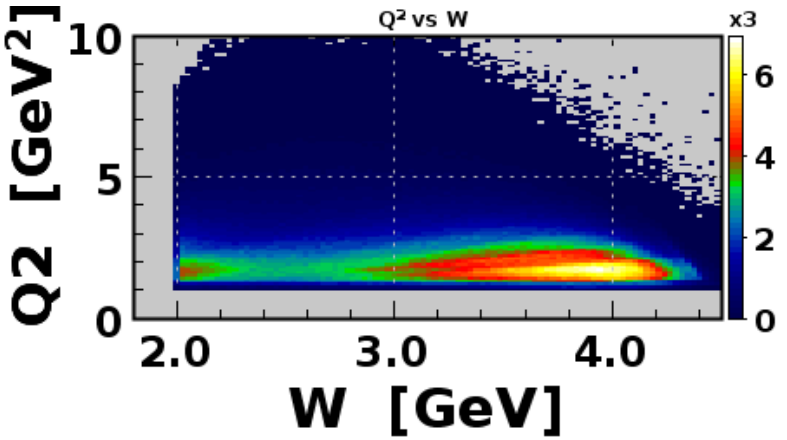
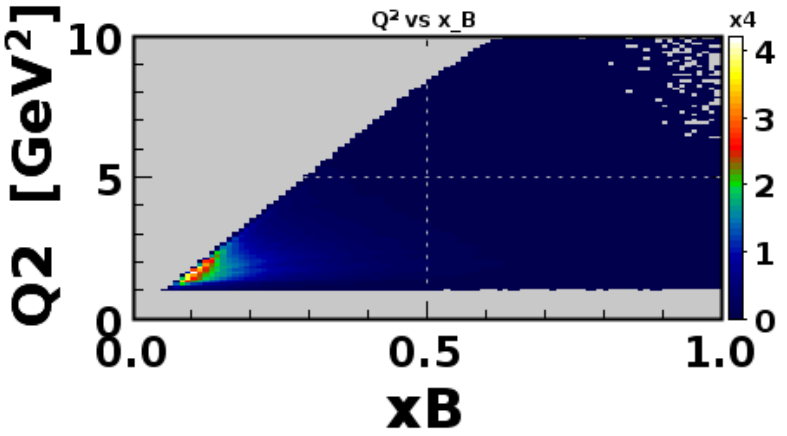




RGA data





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DATA ANALYSIS – RUN GROUP A

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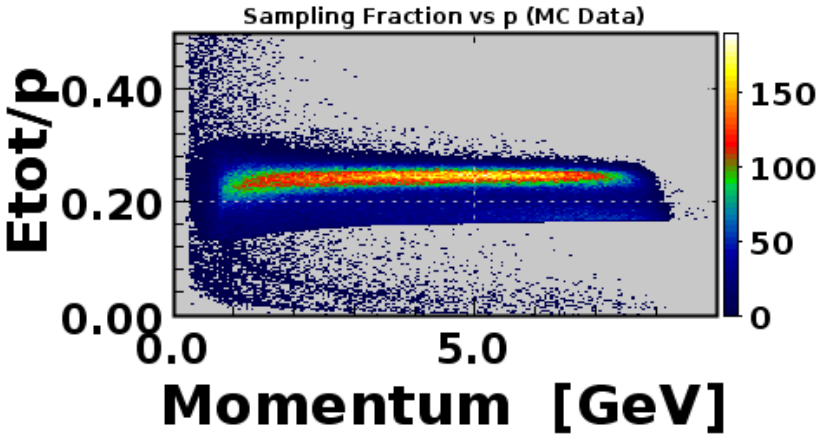
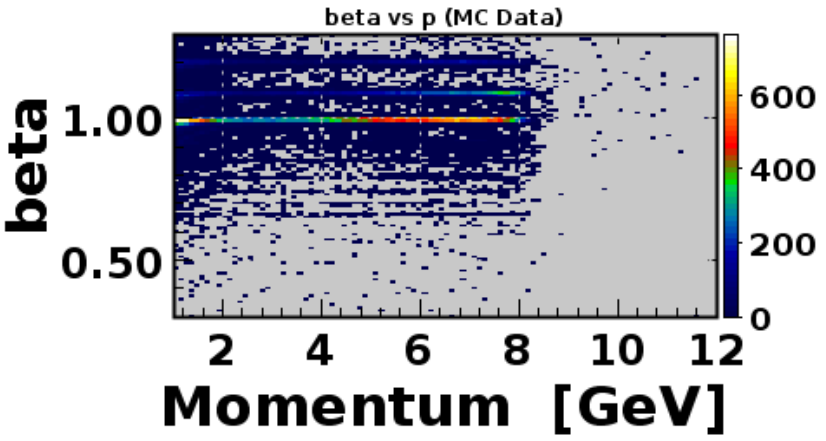
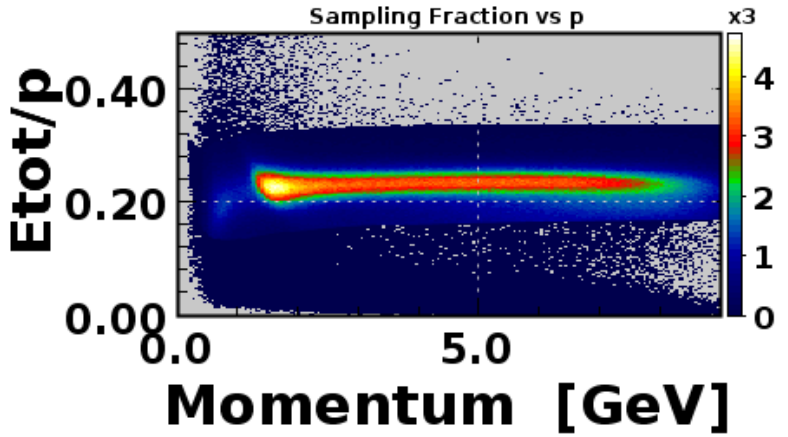
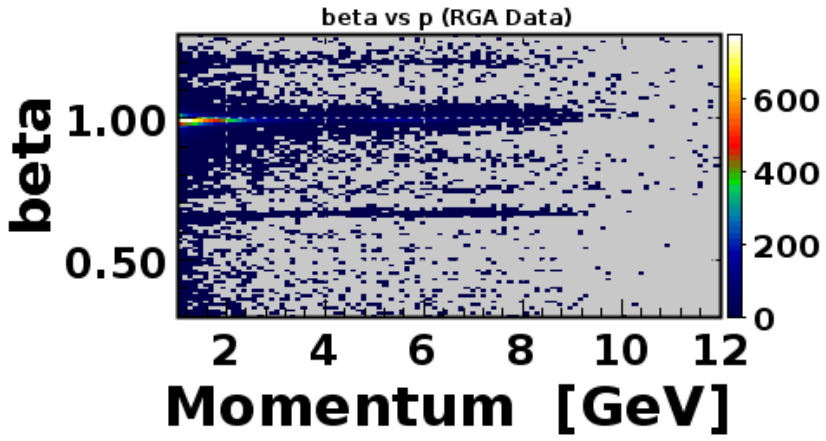




RGA data





Cuts: $q < 0, 5° < \theta < 40°, W > 2\ GeV/c^2, Q^2 > 1\ GeV^2/c^2$, nphe > 2

FUTURE WORK

- Generate new LUND file with energies up to 10.6 GeV and create new data set from MC
- Identify sources of deltas between MC and RGA data
- Identify electron:
  - ✓ Kinematic cuts for DIS
  - ✓ Fiducial cuts on ECAL
  - ✓ At least 2 phe in HTCC
  - ❑ 60 MeV deposited in PCAL
  - ❑ Implement 5σ cut on sampling fraction
  - ❑ Cut on β vs. p
- Extract cross section from MC and RGA data
- Compare ‘em