

Remarks on RGA inclusive data, older data sets, and models

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-=online=-

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Introduction

Disclaimer: This is just GN's \$0.02 worth...

- Many people contributed (directly or indirectly) to this talk (and they will hopefully be acknowledged as appropriate).
- ...and they all have done their level best! thanks!
- Therefore, all **inaccuracies, miss-statements, controversial, or just plain wrong statements** are mine alone!
- That said, we press onward...

As I'm sure many of you are aware...

- CLAS12 continues to be a vibrant, active collaboration
- ...with new (and excellent!) leadership, both at the Hall and User levels
- in 2025 C12 has published a plethora of papers, including this one (no room here, see next page!):

Phys. Rev.C 112 (2025) 2, 025201, Jan 2025

Phys. Rev. C

Inclusive Electron Scattering in the Resonance Region off a Hydrogen Target with CLAS12

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NOTE: As my name appears among those not-quite-in-alphabetic order, I must have contributed (a tiny bit) to this effort.

Introduction (III)



RGA (e, e') was quite an effort/achievement:

- besides statistics (and lots of MC), corrections, dead channels, etc...
- sector-to-sector systematics
- deconvolution (as opposed to bin-by-bin acceptance correction)
- iterations (of the model used to generate MC input)
- ...blueprint on extracting cross-sections out of CLAS12 data.
- so many thanks to the heavy lifters in this project: **V.K., K.J., V.M.**
- the nominal physics goal: map out nucleon electroexcitation amplitudes up to Q^2 of 10 GeV^2 (and W up to 2.5 GeV)
- However, what I want to touch upon today is this: how do these results stack up compared w/ world data?
- luckily, **we** (as a field), have accumulated 50+ years-worth of (e, e') data!

But why? CLAS12 is great!



Motivation:

- There are some (reported) **tensions** between the published RGA inclusive xsect results and the **world data** a/o leading (e, e') models.
- it would be beneficial to characterize these **tensions** and (if needed)
- identify (or attempt to, anyway) the root of these
- ...esp. as some of the **world data** results stem from the same lab (!)

“THE” REAL Rationale:

- ✚ The PhD student graduated, moved on...
- ✚ Hall & Lab Leadership interested in this.
- ✚ could have (ahem!) done a (slightly) better comparison job...
- ✚ I am deeply invested in this type of physics
- ✚ I, (GN), am old enough and foolish enough...

How should we proceed?



Strategy:

- keep RGA data as much as possible **as is** ((W, Q^2) - grid). set [1]
- we shall **compare** this data with:
 - Eric Christy's model (Bosted-Christy (BC), resonances, transition to DIS, higher Z targets)
 - CJ model (pdf-based, not expected to have resonances)
 - **world data** set either from primary sources: papers, PhD theses or, in the case of most SLAC data, the early 1990's re-analysis (Whitlow). set [2]
- we shall **NOT compare** this data (for now!) with:
 - not (yet!) published inclusive results (E12-10-002, Marathon?)
 - AI-based models (coming soon!)

To move forward w/ this...



We shall need:

- ✓ get a recent (and working!) version of the CJ code (includes pdf $\rightarrow$ xsect capabilities)
- ✓ *ditto* for the Bosted–Christy model (includes model for R

$$R = \frac{\sigma_L}{\sigma_T} \quad \dots \text{namely } R1998)$$

- ✓ select subset of world data that is in the RGA range*
- ✓ select only (4 now!) the data for which cross-sections were originally published (so no F_2 only points). set [2]
- ✓ evaluate CJ & BC models for both sets [1] and [2]
- ✓ evaluate the Jacobian needed to get from

$$\frac{d^2\sigma}{dE d\Omega} \rightarrow \frac{d^2\sigma}{dW dQ^2}$$

(once the above are on hand we can talk about) **Tactics:**

We could (apologies for the text-. Lots of pictures follow!):

- compare at the **cross-section** level...
 - + keeps RGA result exactly **as is**
 - very little world xsect data that **exactly** matches RGA kinematics
 - expanding matching criteria leads to unavoidable model dependencies
 - excludes a lot (100x??) of the world data (including CLAS results!)
 - was already done in the paper; deemed insufficient!
(otherwise we would not be having this discussion!)
- compare at the **structure function (F_2)** level (**IN suggestion!**)
 - requires extracting F_2 from the RGA data (which I've done ☒)
 - introduces model dependency at least via R
(possibly also through the evolution strategy if grid matching)
 - + allows for the widest possible comparison w/ models/published results.
 - + including CLAS6 data!
 - + Substantially easier to carry out ([1]: ~250 data points vs [2]: 4000+)

We'll try to show a little of both!

Cross-section level comparison

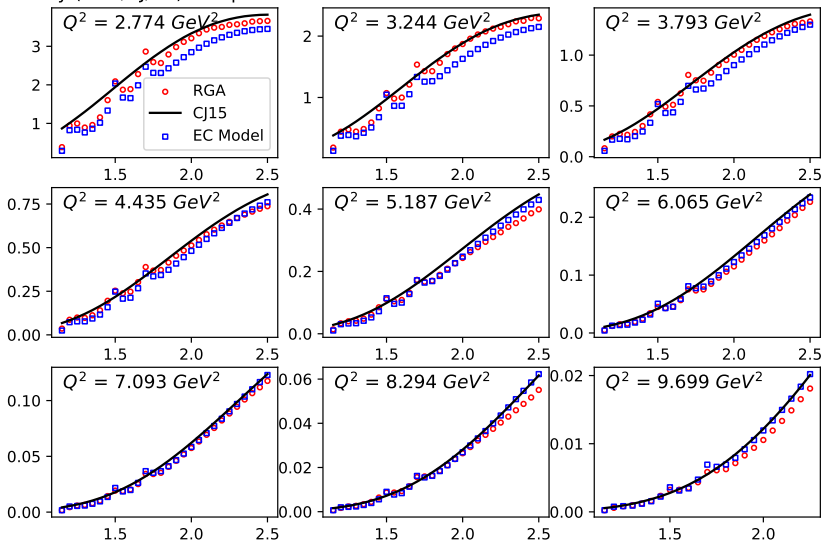


First steps (compare w/ leading models):

- evaluate CJ and BC (aka EC) models for all the [1] kin. points. ✓
- **NOTE 1:** CJ not expected to work at low Q^2 a/o W^2 below 3-ish! Except, possibly, in a q-h Duality way. ✓
- **NOTE 2:** upper Q^2 limit for BC validity not well-defined. ✓
- ✓ ✓ ✓ So let's see how it goes...

Cross-section comparison

3-way (RGA/CJ/EC) Comparison...



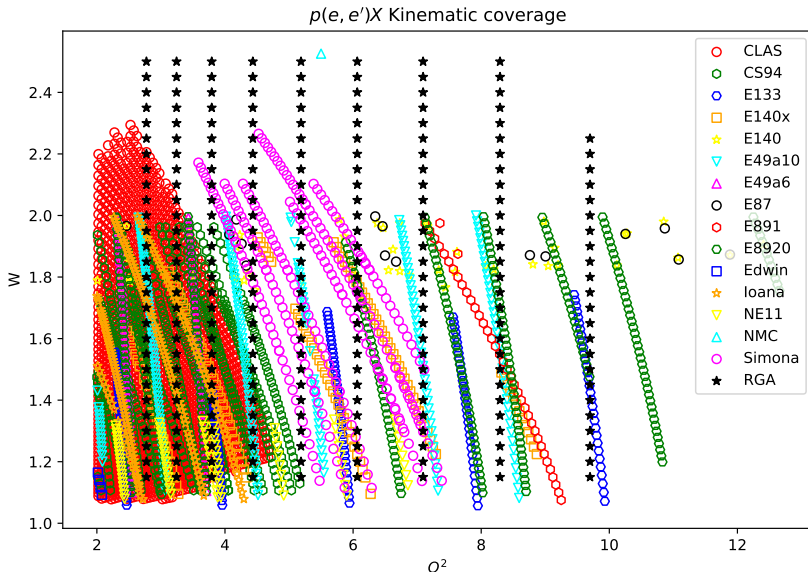
Cross-section level comparison (II)

Further steps:

- to compare w/ **world data** we need to either...
 - find points that very closely match one of our Q^2 - W grid points (which was done in the paper - **very few points** have this!)
 - do **matching**: using a model prediction to **evolve** a point from one kin. setting to a different (but close-ish!) kinematic setting
- Here is our approach for the latter:
 - for each point in [1] match Q^2 [2] to within some fraction of [1] (say **20%**)
 - match W between [1] and [2] to within some value (say **10 MeV**)
 - **#**'s can be varied for a looser/tighter match
 - **Note**: a point in [1] might have more (several!) world data point matches.
 - use the ratio of BC (or CJ!) model values in [1] and [2] to **extrapolate/evolve/move** the [2] point to the [1] grid.
 - (if needed) apply [1] jacobian to the extrapolated point
 - keep only world data that comes within some fraction (say **50%**) of the RGA result for plotting/comparison.

Let's see how this goes!

Starting point. Q^2 - W coverage



Cross-section comparison: RGA-world data

Pushing the comparison further

As seen on the previous slides...

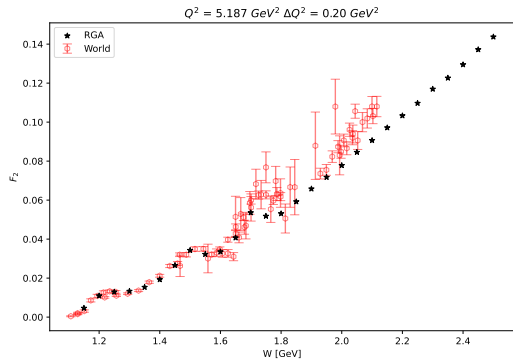
- very tight kin. matching yields very few world data points to compare to.
- a more productive approach would be to go for F_2 -level comparison.
- the only **ingredient** needed to turn RGA cross-section data into F_2 is the aforementioned R (R1998)*
- **IN:** to **minimize** model dependency, match only Q^2 s, leave W **as is**
- **IN:** yes, the W s would not match, but one gets complete* scans!
- ... therefore is straightfwd to extract and compare (by eye 2day, numerical if need be) the two **pdfs**. **Note:** Here **p** in pdf: **probability**, not **parton**!!
- ... completely removes model dependency, leaves only reliance on R .

Let's see how this goes!

F_2 comparison: RGA–world data

F_2 comparison: RGA–world data (II)

Observations



Distributions seen on the previous slides...

- no scaling. Just matching within the quoted Q^2 ranges.
- **RGA** results compare well/match the **WD** in the resonance region
- **RGA** error bars ($\sim 7\%$) are comparable w/ the **WD** uncertainties
- there is a possibility that **RGA** & **WD** slightly diverge toward higher W
- So let's apply **scaling** (Q^2 only) and see where we stand.

F_2 comparison: RGA–world data (V-ish?)

F_2 comparison: scaling function check



Quo Vadis?

In summary:

- RGA (e, e') result adds ~ 250 points to the **WD** data set, extending coverage to $Q^2 = 10 \text{ GeV}^2$.
- we carried out a meaningful, in-depth comparison of RGA results w/ models & prev. data



I hope I convinced you that:

- cross-section comparison: CJ15 seems to favor RGA data over BC model* at lower Q^2 , switches at higher values...
- F_2 comp.: RGA compares **well** to **WD** at all Q^2 s ($1-3 \sigma$)
- plans underway to use RGA xsect results to update CJ pdfs!
- higher W trend is worth further investigation (as a couple of 1-3% effects will make a substantial difference).
- **THANK YOU!**