Cross-Section Tables with Sar*t*re

Status update towards Sar*t*re 1.3

Tobias Toll

Shiv Nadar University

Ongoing work together with

Thomas Ullrich, Mark, Liang

Incoherent Scattering

Good, Walker:

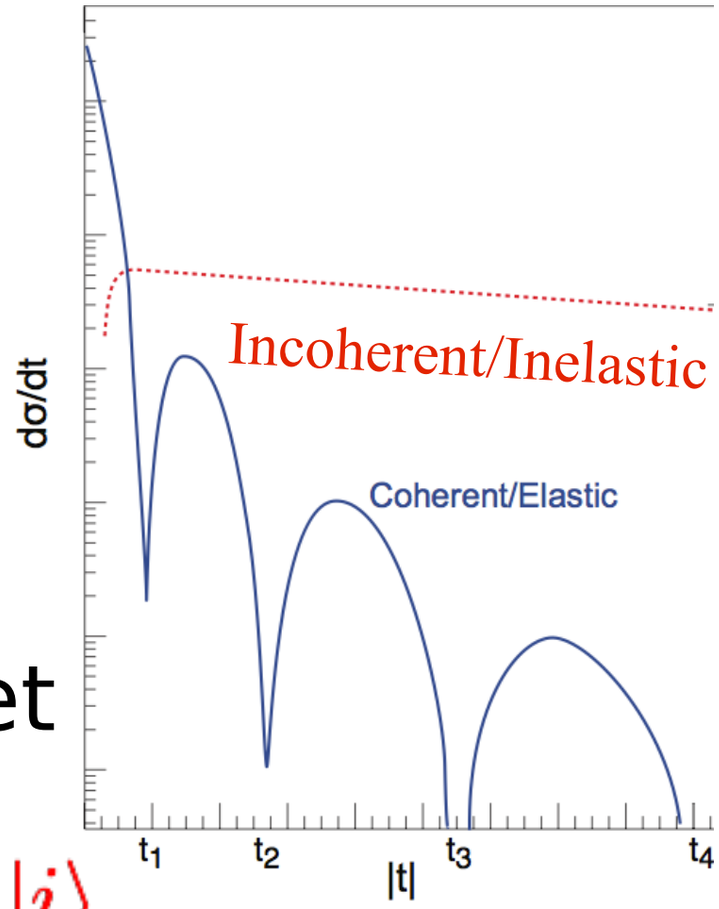
nucleus dissociates ($f \neq i$):

$$\sigma_{\text{incoherent}} \propto \sum_{f \neq i} \langle i|\mathcal{A}|f\rangle^\dagger \langle f|\mathcal{A}|i\rangle$$

complete set

$$= \sum_f \langle i|\mathcal{A}|f\rangle^\dagger \langle f|\mathcal{A}|i\rangle - \langle i|\mathcal{A}|i\rangle^\dagger \langle i|\mathcal{A}|i\rangle$$

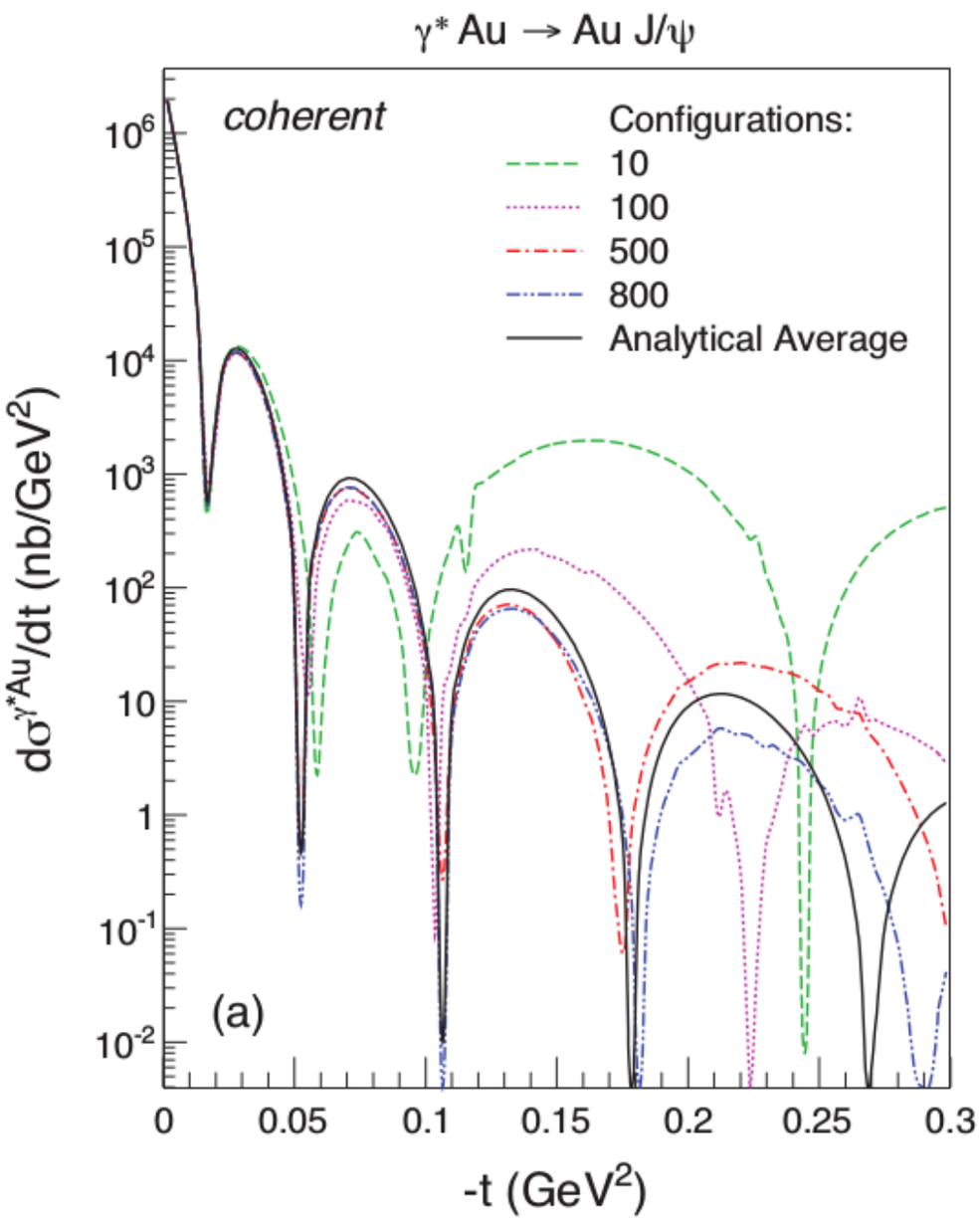
$$= \langle i \left| |\mathcal{A}|^2 \right| i\rangle - |\langle i|\mathcal{A}|i\rangle|^2 = \langle |\mathcal{A}|^2 \rangle - |\langle \mathcal{A} \rangle|^2$$

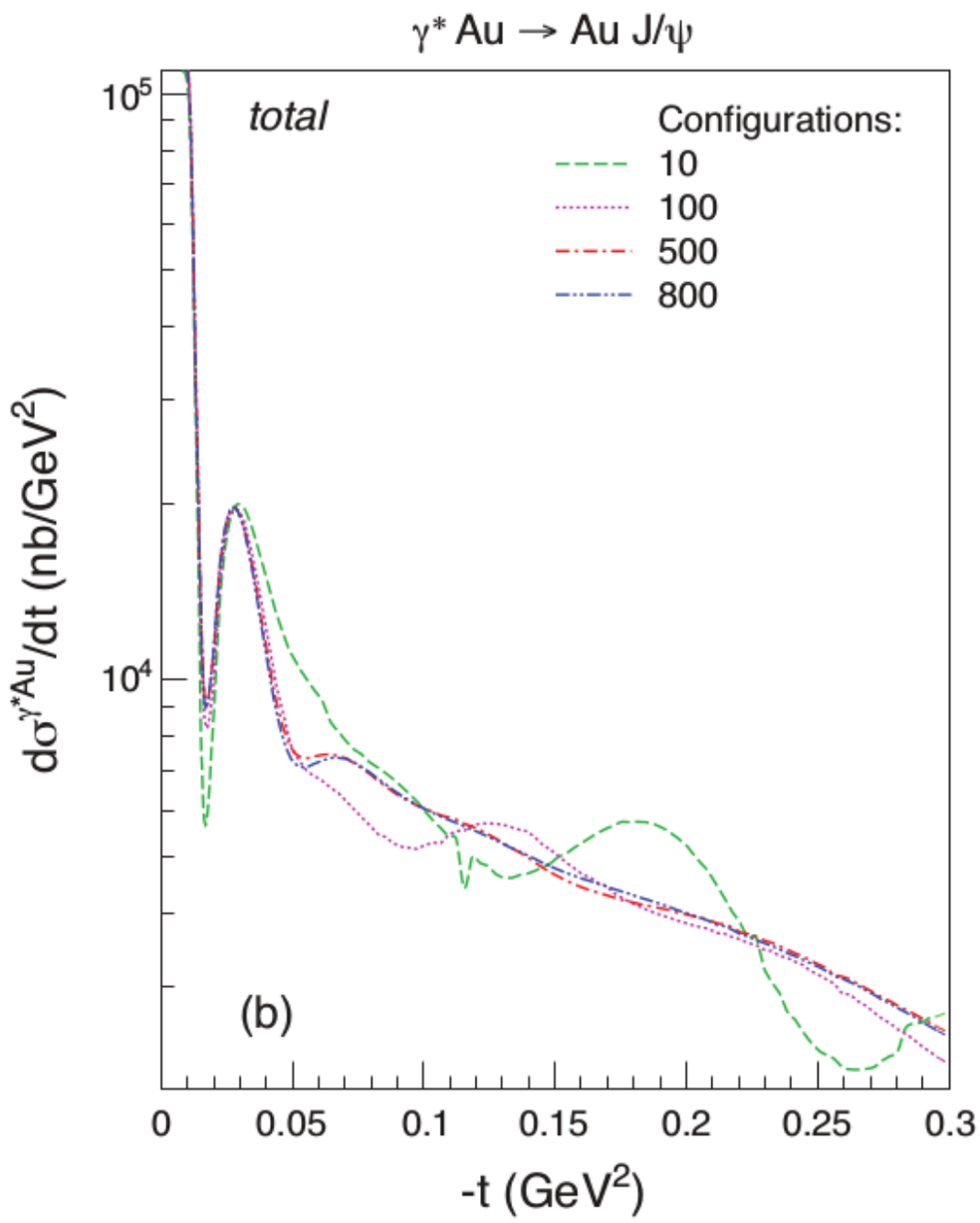


the incoherent Cross-Sec. is the variance of the amplitude!!

$$\frac{\mathrm{d}\sigma_{\text{total}}}{\mathrm{d}t} = \frac{1}{16\pi} \left\langle |\mathcal{A}|^2 \right\rangle$$

$$\frac{\mathrm{d}\sigma_{\text{coherent}}}{\mathrm{d}t} = \frac{1}{16\pi} |\langle \mathcal{A} \rangle|^2$$





A few things to note:

For t=0, there is **no** variance.

For large $|t|$, mean<<variance, making coherent convergence slow.

Also Total convergence slower for large $|t|$

There is an analytic solution for the Coherent cross-section.

The total cross-section vary **extremely** fast as a function of t for small $|t|$.

Calculating Cross-Sections

Total Cross Section:

$$\frac{\mathrm{d}\sigma^{\gamma^* \mathrm{A}}}{\mathrm{d}t}(x, Q^2, t) = \frac{1}{16\pi}\frac{1}{C_{\max}}\sum_{i=1}^{C_{\max}} \left|\mathcal{A}(x, Q^2, t, \Omega_i)\right|^2$$

Sum over 500 configuations!

Need to calculate 2 4D integrals 1000 times for each event.
(2 polarisations)
CPU time ~ 1h/event.

Solution: **Lookup tables**.
We calculate tables with grid-points in (t, Q^2, W^2) for each:
Polarisation (*T, L*).
Final State (DVCS, ρ, φ, J/ψ).
Nuclear Species.
Using the GRID.

Calculating Lookup Tables

Extremely time consuming.
2 ways to increase efficiency:
A) Make integration faster.
B) Make interpolation better => reduce #points needed in the table.

For (A) Lance Oom (Student of Will Horowitz') is working on improving the integration routine. Early results indicate a 10% improvement.

Calculating Lookup Tables

For (B): there are two problems, one conceptual and one practical.

Conceptually there is no clear way to interpolate on a grid in (t, Q^2, W^2), since there is no metric.

Usually integration is using nearest neighbours to come up with interpolated value, but there is no objective way to define "nearest neighbours" in this case. (We do it anyway)

Practically we want a routine with as small an error as possible. That way we need fewer grid-points which reduces the time to produce tables.

Calculating Lookup Tables

Improvements (not mutually exclusive):

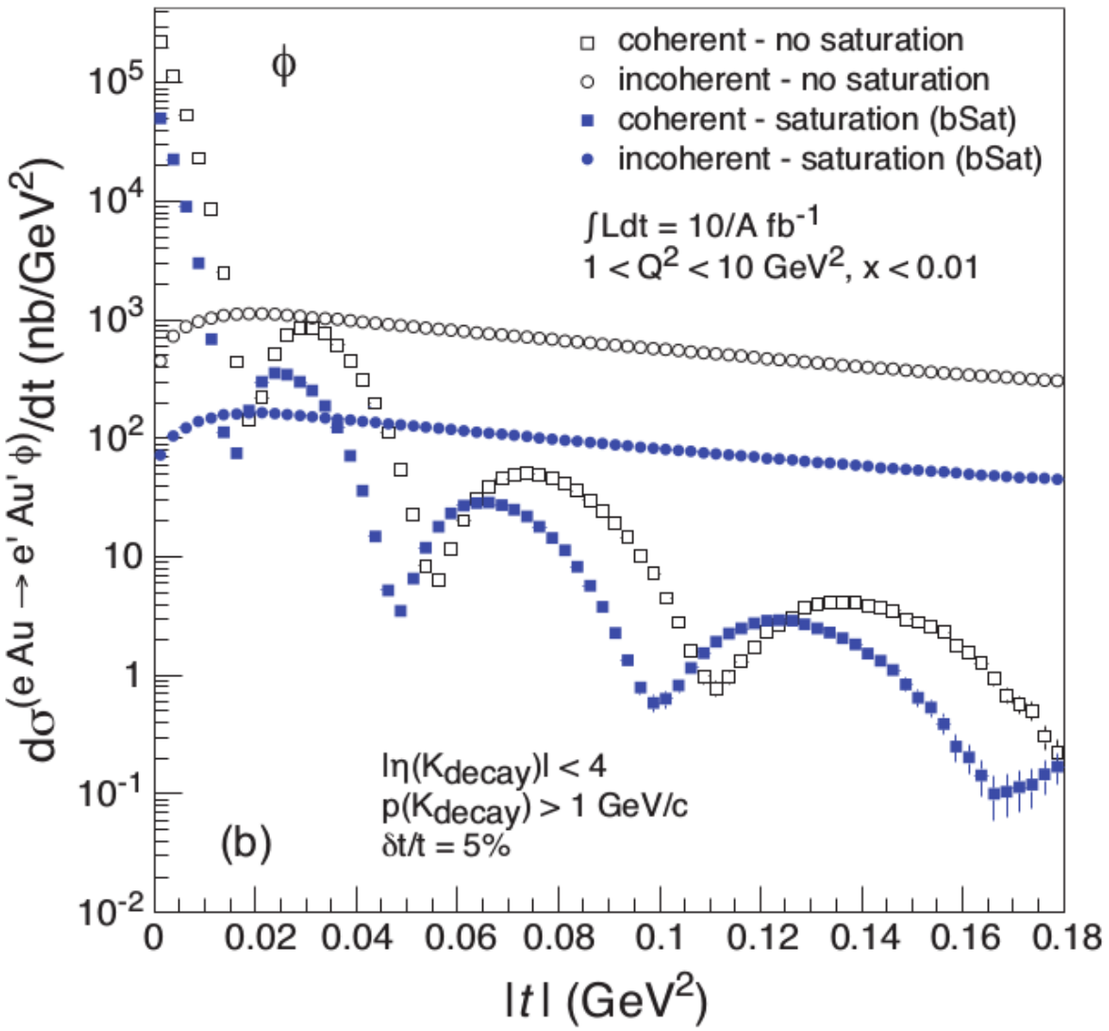
1) Use neural networks:

Benefits: does not impose a metric on tables, result more precise than linear interpolation

Drawback: need to spend much time training a network on each table produced.

2) Use pairs of Incoherent-Coherent tables instead of Total-Coherent tables as we do now (Mark's suggestion).

Incoherent Cross-Section vary much less for small $|t|$ which would imply that we need fewer grid-points to reach the same accuracy. This is one of the aims of the next subversion of Sar*t*re (1.3).



To Do for Sar*t*re 1.3

Create Incoherent tables:
Where possible, from existing Total and Coherent Tables
Elsewhere create new coherent tables to match existing total tables,
or
create Incoherent tables by interpolating on existing Coherent Tables
(I favour the former option.)

Coding:
Simple program to create Incoherent from existing Total and Coherent tables (done)

New Cross-Section routine
((almost) done)

New Table Generator routines
(not started)

Create new tables to match existing? (will take a few weeks)

Other Stuff: Ultra-Peripheral Collisions, Parameters etc. (will not affect this project)

To Do for LDRD

Test which granularity is needed in the new format

Test how to extrapolate Au->Pb

Create new tables using Sartre 1.3

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