FASTKERNEL AND APFELGRID: ACCELERATING PDF FITS

Valerio Bertone, Stefano Carrazza, NH

Nathan Hartland

University of Oxford

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PDF4BSM

Parton Distributions in the Higgs Boson Era

erc

European Research Council

FASTKERNEL (FK) TABLES

The FastKernel (FK) procedure simplifies the convolution step in PDF fits by pre-computing the PDF evolution and combining it with interpolated weight grids

APPLgrid/FastNLO

$$\sigma_{pp\to X} = \sum_{p}^{N_\alpha} \sum_{s}^{N_{\rm sub}} \sum_{\alpha,\beta,\tau} \alpha_s^{p+p_{\rm LO}}(Q_\tau^2) W_{\alpha\beta,\tau}^{(p)(s)} F_{\alpha\beta,\tau}^{(s)}$$

$$f_i(x_\alpha, Q_\tau^2) = \sum_{k} \sum_{\beta} A_{\alpha\beta,ik}^{\tau} f_k(x_\beta, Q_0^2)$$

PDF evolution with APFEL

Absorb evolution into precomputed coeff.

$$\sigma_{pp\to X} = \sum_{k,l} \sum_{\delta,\gamma} \widetilde{W}_{kl,\delta\gamma} f_k(x_\delta, Q_0^2) f_l(x_\gamma, Q_0^2)$$

FK Table

FASTKERNEL (FK) TABLES

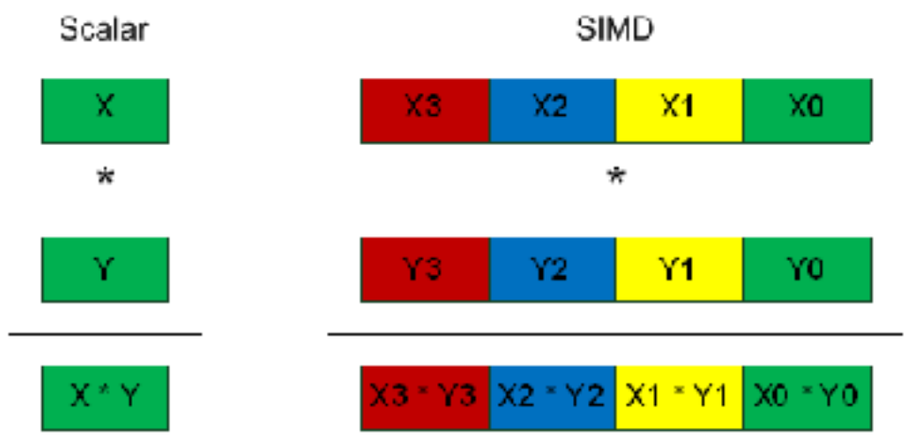
$$\sigma_{pp\to X} = \sum_{k,l} \sum_{\delta,\gamma} \widetilde{W}_{kl,\delta\gamma}\, f_k(x_\delta, Q_0^2) f_l(x_\gamma, Q_0^2)$$

Speed improvements over typical APPLgrid/FastNLO convolution

- *PDF Evolution comes 'for free'*
- *Precompute sums over hard scale*
- *Precompute sums over perturbative order*
- *PDF basis reduced to active flavours at initial scale*

FK product is simple in structure:

- *Simple to express as a scalar product*
- *Easy to make efficient use of SIMD/OpenMP*



(software.intel.com)

LIMITATIONS OF FASTKERNEL TABLES

FK tables are **not** a replacement for APPLgrids

> *By themselves, FK tables cannot perform any parameter variation other than that of PDFs.*

FK tables precompute essentially all theory parameters

> *Variations of e.g* $\alpha_S(M_Z)$ *can be performed by re-computing the table using the information stored in APPLgrids.*

Classic Space-Time tradeoff: FK tables are faster but require more space

INTERPOLATION ACCURACY

The FastKernel procedure can help decouple grid precision from fitting cost

$$\sigma^{(\mathrm{APPL})}_{pp\to X} = \sum_{\alpha,\beta}^{N_x^{(\mathrm{APPL})}} (\ldots) \longrightarrow \sigma^{(\mathrm{FK})}_{pp\to X} = \sum_{\alpha,\beta}^{N_x^{(\mathrm{FK})}} (\ldots)$$

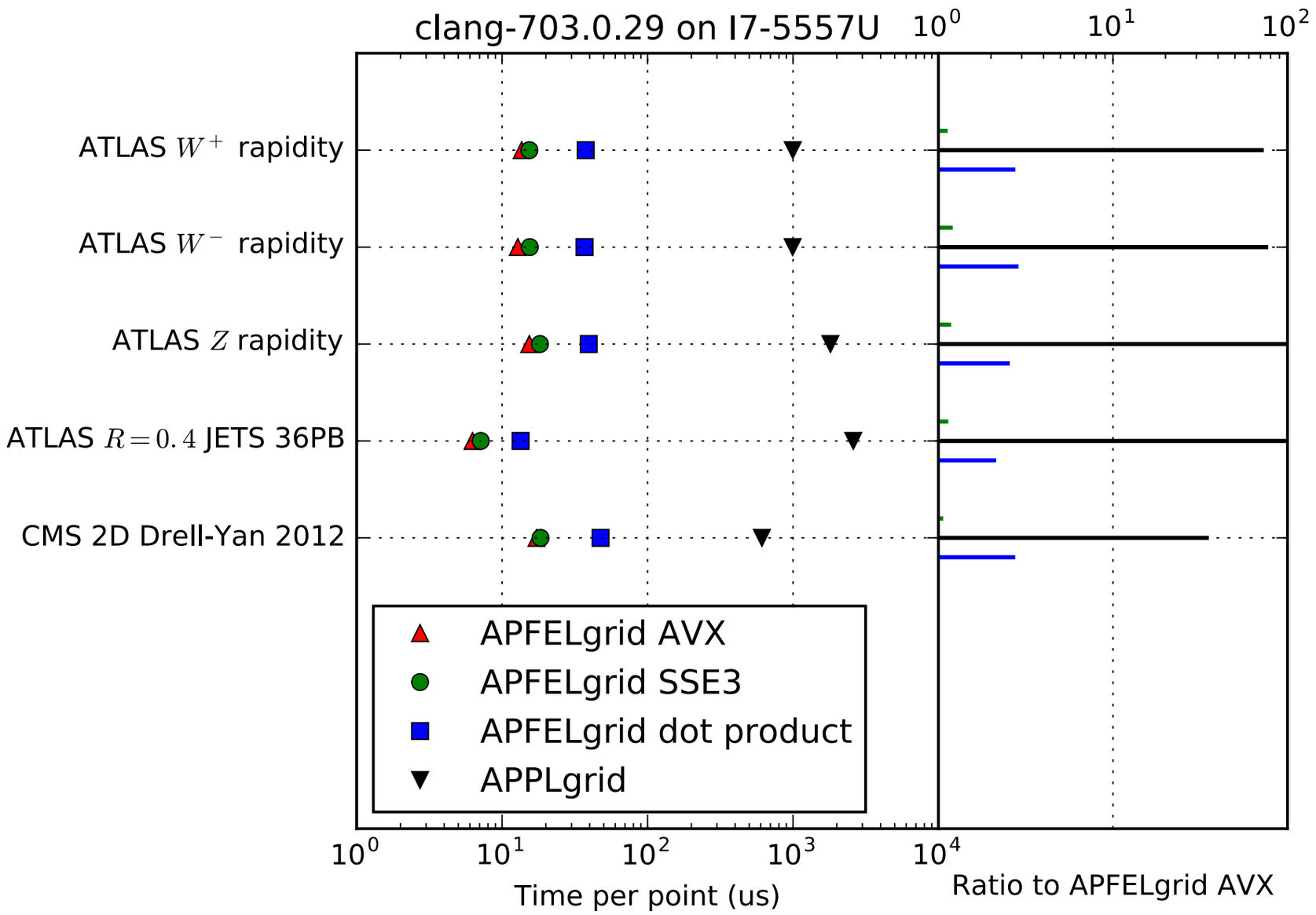
Sum over APPLgrid x-grid **Sum over PDF evolution x-grid**

While $N_x^{(\mathrm{APPL})}$ is fixed by the APPLgrid, $N_x^{(\mathrm{FK})}$ is set according by the user

From a single (high accuracy) APPLgrid, the user can generate FK tables with varying interpolation accuracy as per their requirements/preferences.

PRACTICAL EXAMPLE

Comparison of APPLgrid speed vs FK tables as used in NNPDF fits



Dataset	Speedup
ATLAS W+	73x
ATLAS W-	78x
ATLAS Z	117x
ATLAS Jets	414x
CMS 2D-DY	35x

APFELGRID

- Public tool to perform the combination of APPLgrid weight grids and APFEL PDF evolution into FastKernel tables

Release version almost complete - ETA ~weeks.

- APFELgrid plugin

```
NNPDF::FKTable<double>* FK = APFELgrid::computeFK(Q0, setname, grid, gridpath);
```

Attaches to APFEL and provides routines for the generation of FK tables to APFEL

- FastKernel driver

```
FK.Convolute(pdf_pointer, iMember, results);
```

Supplied as a single C++ header, handles FK table I/O and convolution

Suggestions/Comments welcome!