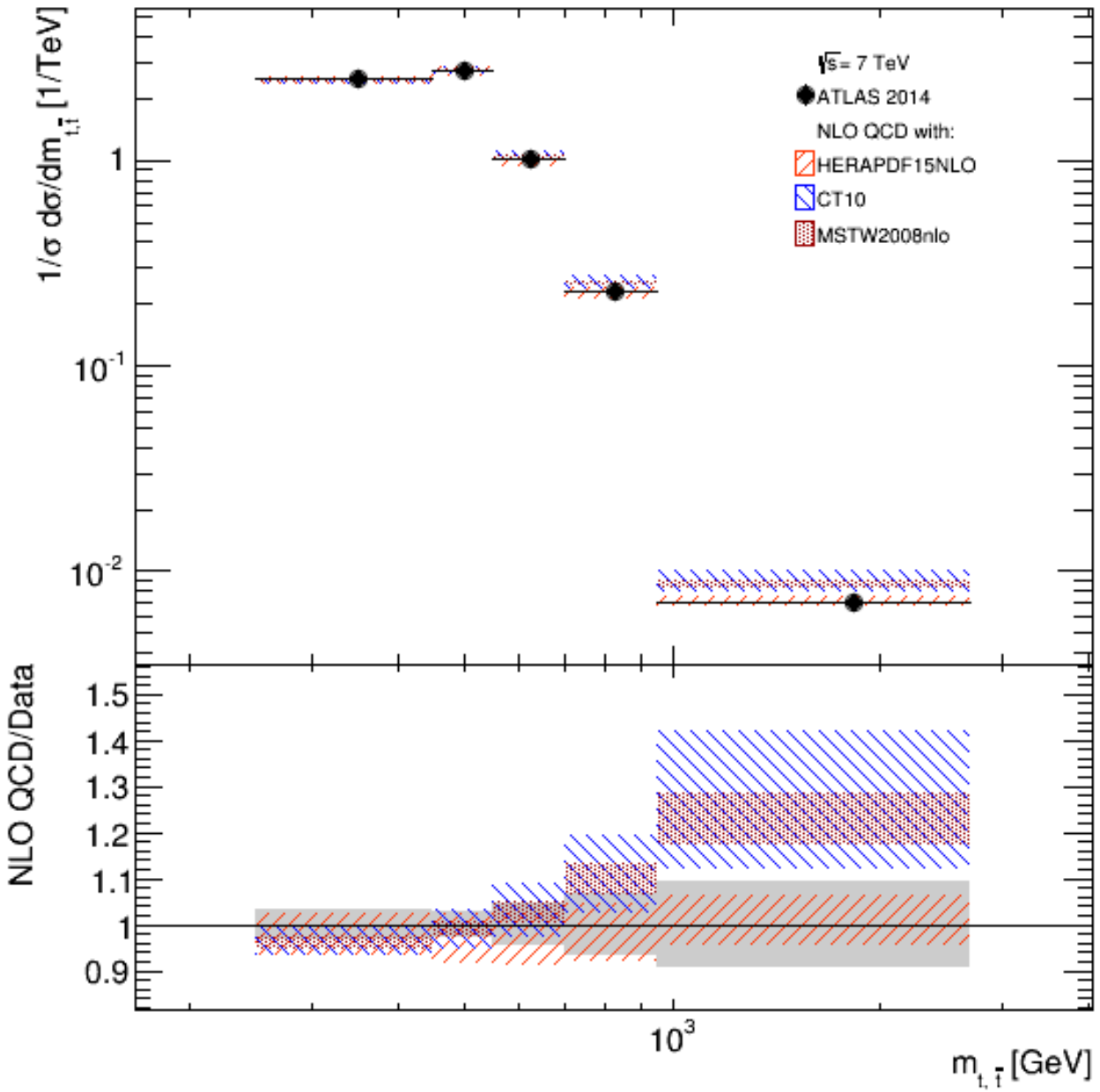
SPECTRUM

CERN – ATLAS Research Semester: Fall ‘14

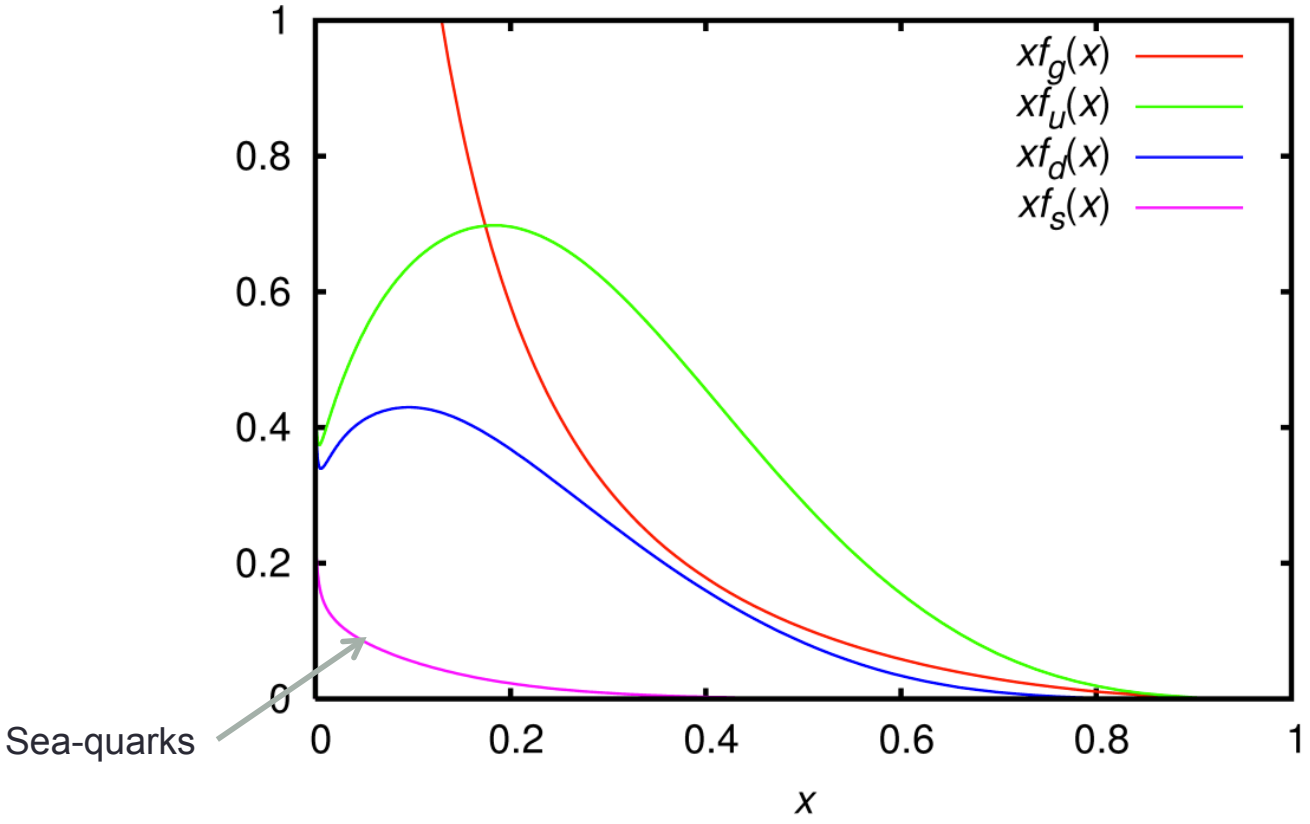
Joe Gibson, Computer Engineering

Grand Valley State University


$\sqrt{s}$ = 7 TeV
ATLAS 2014
NLO QCD with:
HERAPDF15NLO
CT10
MSTW2008nlo
$1/\sigma\ d\sigma/dm_{t,\bar{t}}$ [1/TeV]
1
10^{-1}
10^{-2}
NLO QCD/Data
1.5
1.4
1.3
1.2
1.1
1
0.9
10^{3}
$m_{t,\bar{t}}$ [GeV]

Parton Density Function

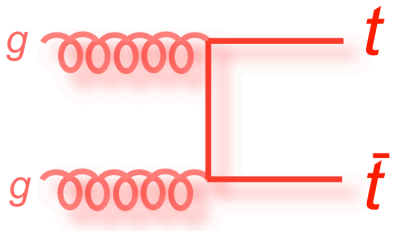
Defined as: probability density for finding a particle with a certain longitudinal momentum fraction x at resolution scale Q2



Wikipedia

Cross Section for Specific Process

$$g + g \rightarrow t + \bar{t}$$



Cross section

Factorization scale

Renormalization scale

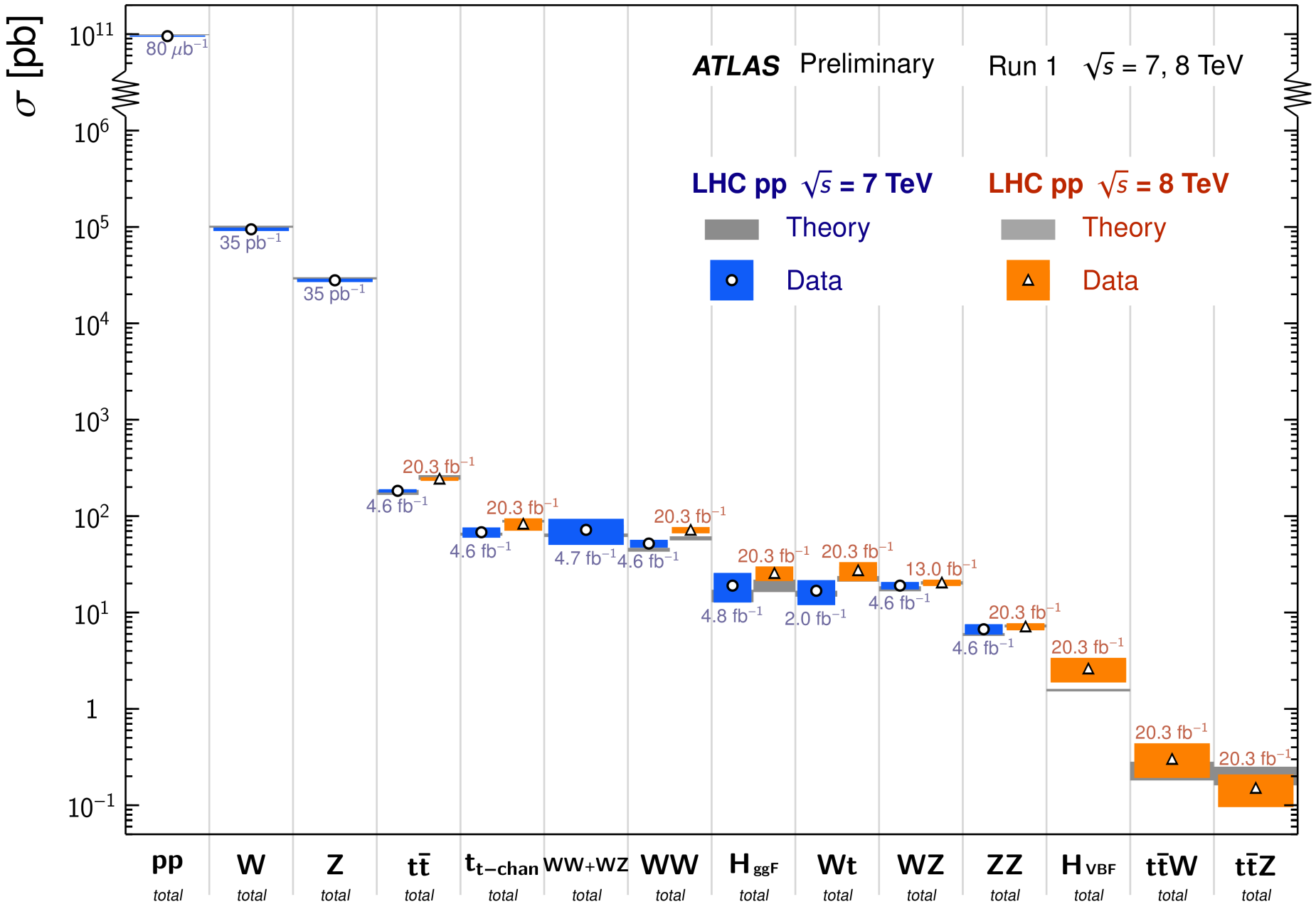
$$\sigma = \Sigma \alpha_s(\mu_R{}^2) \int f(x_1, x_2, \mu_F{}^2)\, \mathbb{M}(x_1, x_2, \mu_R{}^2, \mu_F{}^2) dx_1 dx_2$$

PDF
Obtained by comparing experimental cross section to calculations

Matrix element: Calculated with Feynman rules for specific process

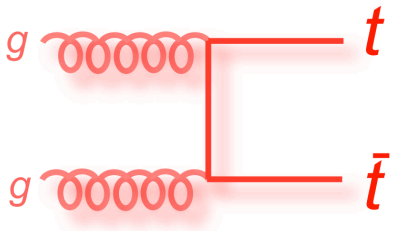
Standard Model Total Production Cross Section Measurements

Status: July 2014



Cross Section for Specific Process

$$g + g \rightarrow t + \bar{t}$$



Cross section

Factorization scale

Renormalization scale

$$\sigma = \Sigma \alpha_s(\mu_R{}^2) \int f(x_1, x_2, \mu_F{}^2)\, \mathbb{M}(x_1, x_2, \mu_R{}^2, \mu_F{}^2) dx_1 dx_2$$

PDF
Obtained by comparing experimental cross section to calculations

Matrix element: Calculated with Feynman rules for specific process

Traditional NLO Programs

- Calculate cross section for specific processes
  - MCFM
  - NLOJet++
- Can take days or even weeks to perform calculation

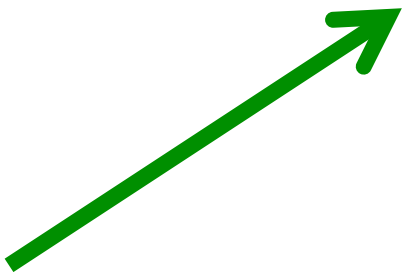
- Longest Spectrum Plot takes ~20 seconds

Spectrum Changes (v0.7.1)

- https://github.com/gibsjose/Spectrum/blob/master/RELEASE.md
- Major Changes
  - Single data format
  - Data/Grid Metadata (author, journal, year, arXiv, etc.)
  - Re-design of Cross Section Normalization
    - Issues with ‘divided by bin width’ and ‘normalize to total sigma’
  - Convolute/Reference and Convolute/Nominal ratios
  - Overriding plot bounds for overlay/ratio
  - Bin matching
  - Grid electroweak and hadronization corrections

Data Format Consolidation

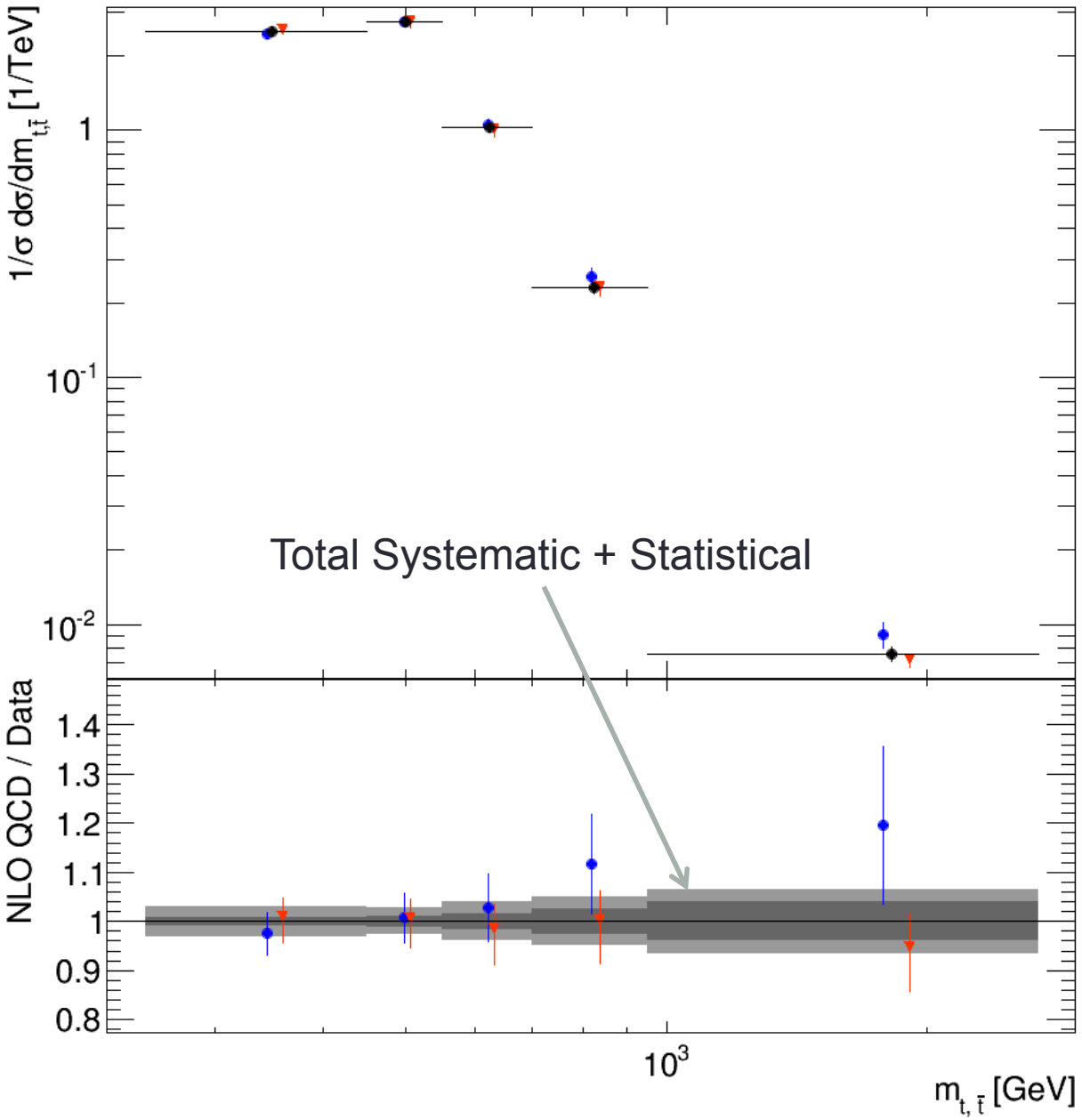
- ~~Data formats~~
  - ~~Spectrum T1S~~
  - ~~Spectrum T1A~~
  - ~~Spectrum T2S~~
  - ~~Spectrum T2A~~
  - **~~Spectrum T3S~~**
  - **~~Spectrum T3A~~**
  - ~~HERAFitter~~
- ~~Systematic Errors~~
  - ~~Symmetric or Asymmetric (S/A)~~
  - ~~Total or Total + Individual (T1/T2)~~
  - **~~Individual Systematic Errors (T3)~~**
  - ~~Explicit (HERAFitter)~~

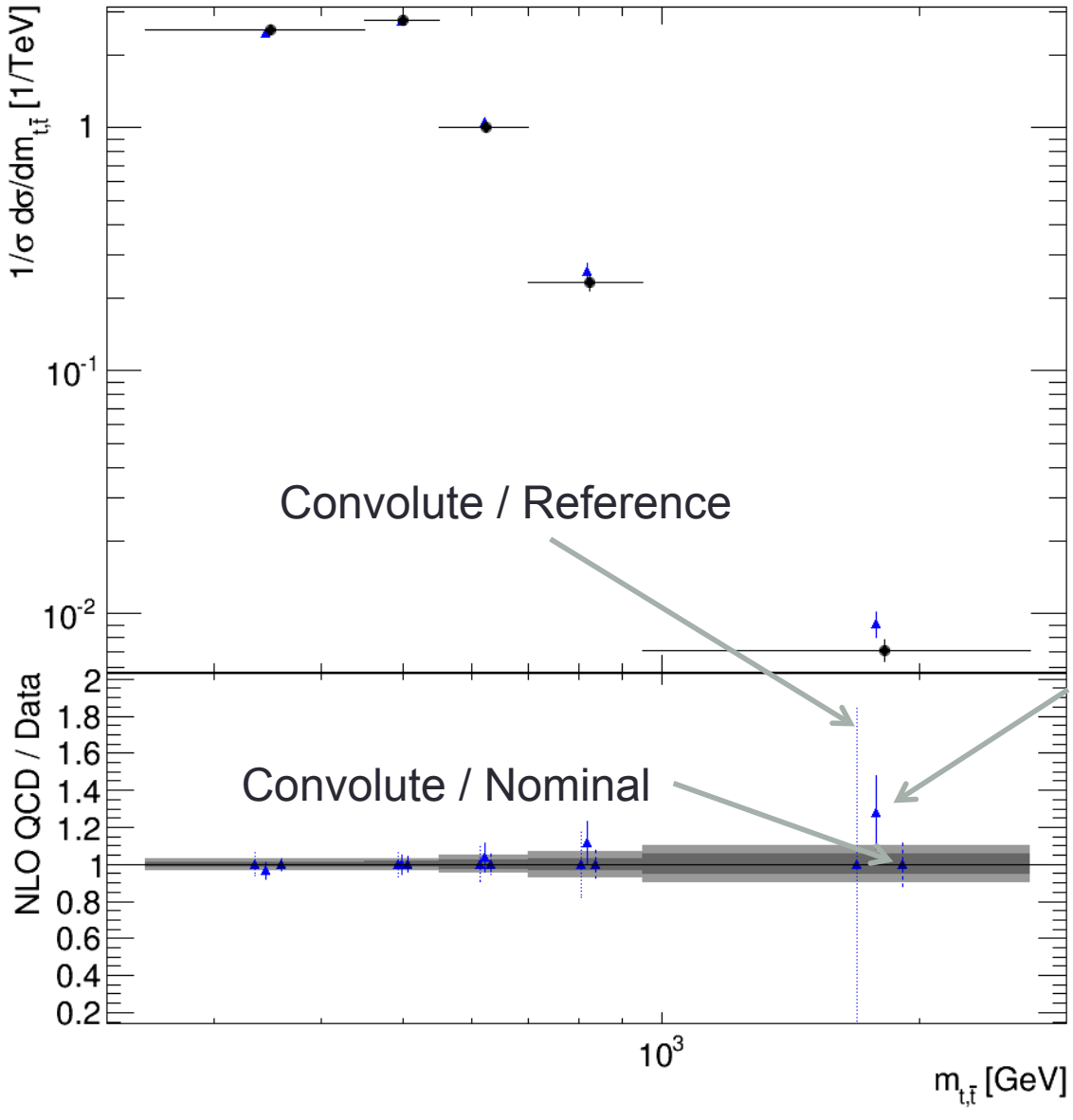


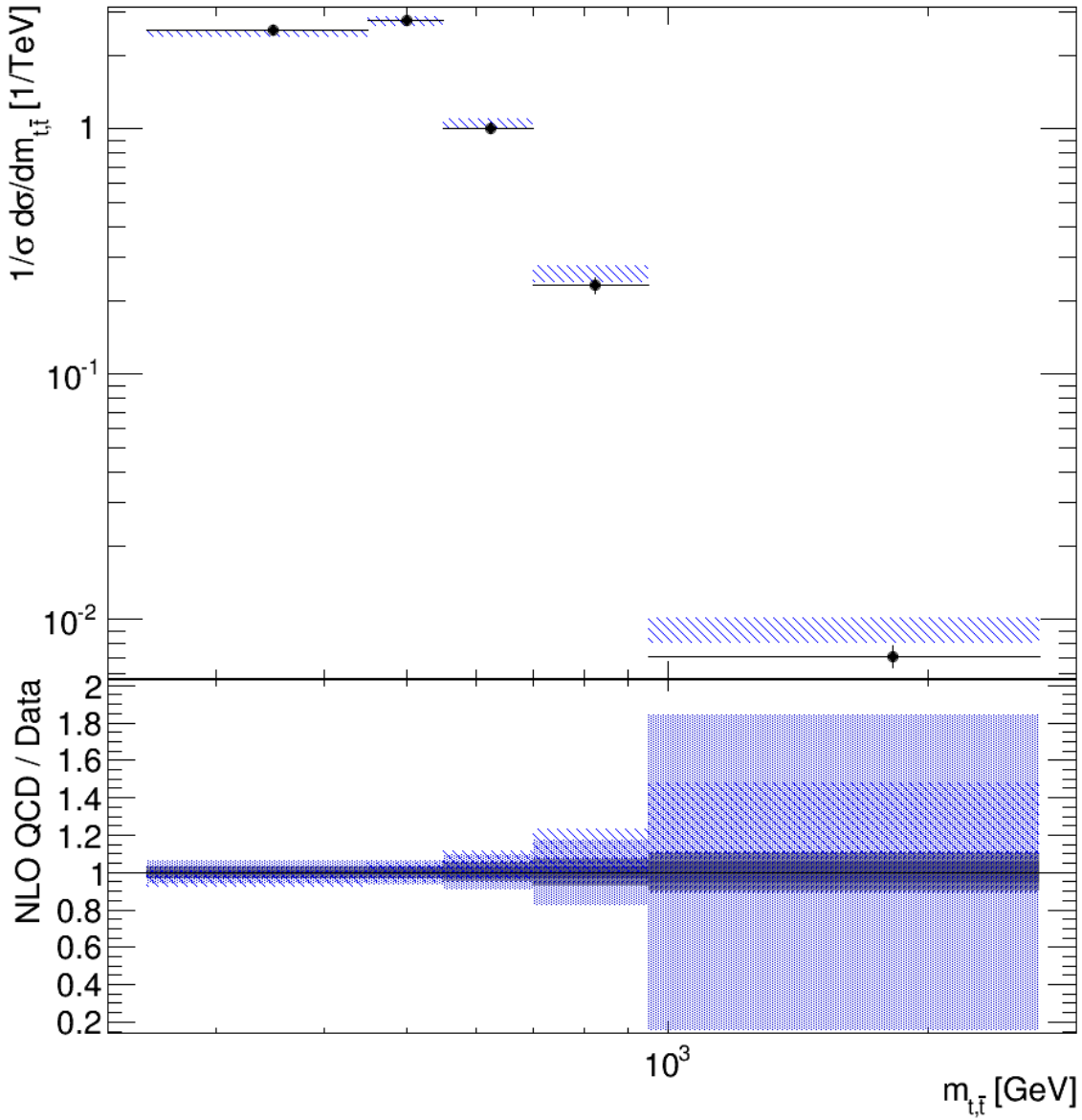
Single Spectrum Format

Ratios

- Data Total Error
- Data Statistical Error
- Convolute / Data
- Data / Convolute
- Convolute / Reference
- Convolute / Nominal
- Data / Data


1/σ dσ/dm$_{t,\bar{t}}$ [1/TeV]
1
10^{-1}
10^{-2}
Total Systematic + Statistical
NLO QCD / Data
1.4
1.3
1.2
1.1
1
0.9
0.8
10^{3}
m$_{t,\bar{t}}$ [GeV]


1/σ dσ/dm$_{t,\bar{t}}$ [1/TeV]
1
10^{-1}
10^{-2}
Convolute / Reference
Convolute / Data
Convolute / Nominal
NLO QCD / Data
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
10^3
m$_{t,\bar{t}}$ [GeV]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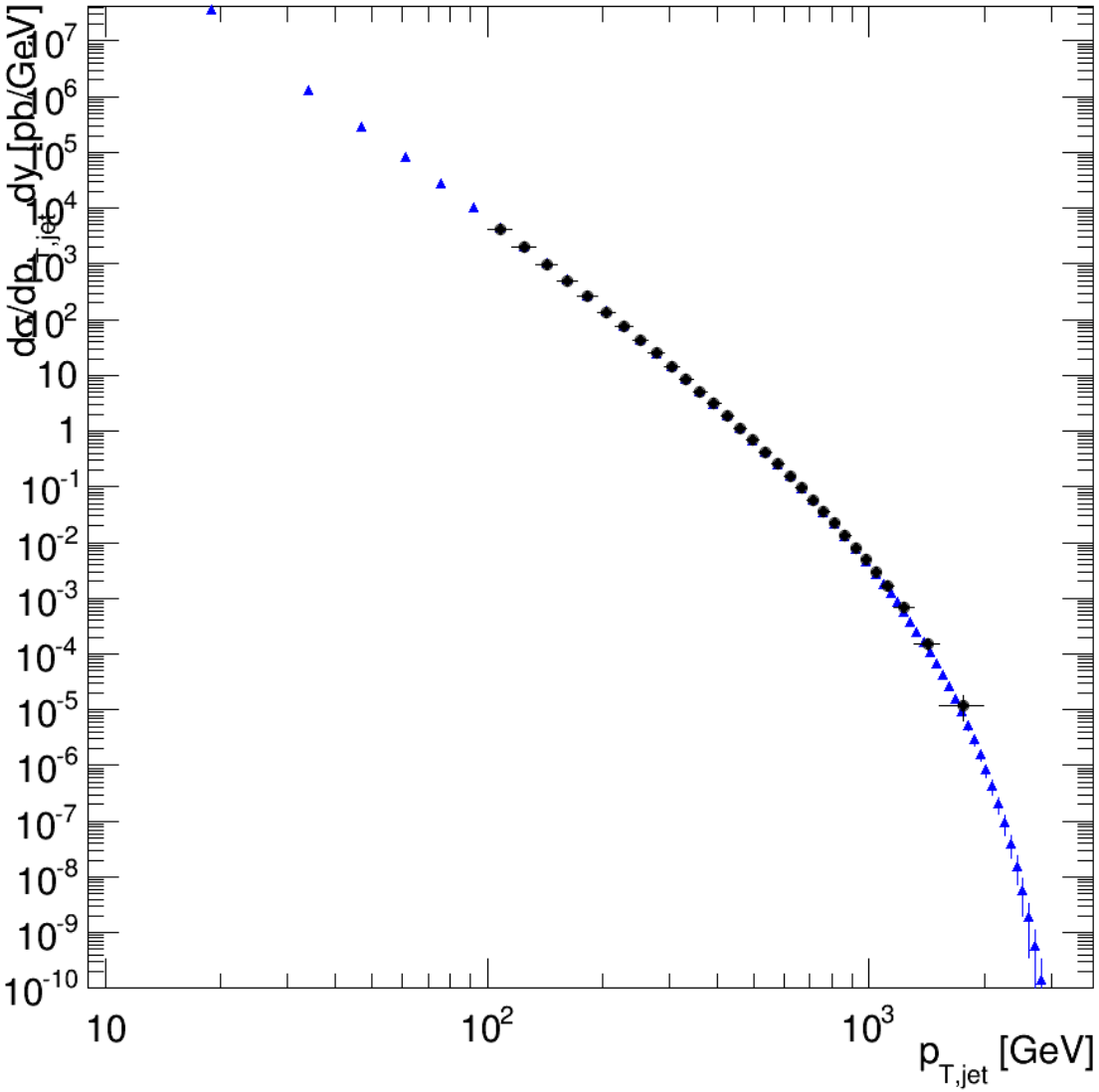
m$_{t,\bar{t}}$ [GeV]

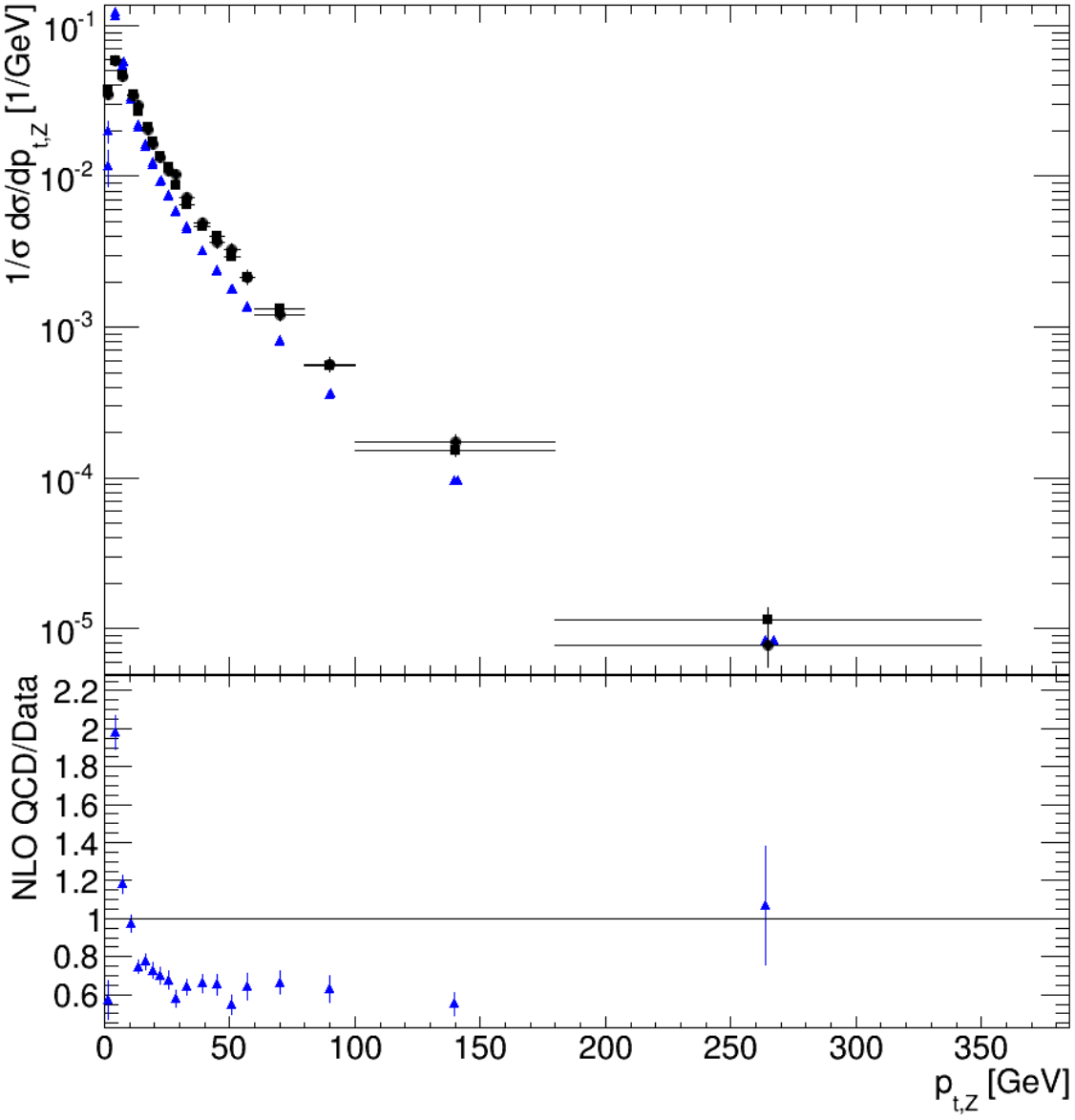
Bin Matching

- Overlay
  - Matches grid bins to data bins
- Ratio
  - MUST match bins for ratio
  - SPXGraphUtilities::Divide will throw SPXGraphException

No bin matching



Bin matching



Spectrum Website

- http://spectrum.web.cern.ch/spectrum/

Spectrum Technologies

- C++
- Python
- JavaScript
- HTML
- CSS
- PHP
- ~~CGI~~
- AJAX
- ~~CherryPy~~
- jQuery
- ~~REST~~
- Pure
- ~~Bootstrap~~
- ~~Node.js~~

Remaining Work

- Spectrum
  - Alpha S and Scale Uncertainty cross section bands
  - Legends
  - PDF-only overlay plot
  - Bug fixes

- Spectrum Website
  - Refine UI
  - Display data/grid metadata
  - Allow user to download grids and data files
  - Bug fixes

Spectrum