



Electroweak Precision Tests at High Energy

Josh Ruderman (NYU) @Aspen, 3/20/2017

- Farina, Panico, Pappadopulo, JTR, Torre, Wulzer 1609.08157
- Alioli, Farina, Pappadopulo, JTR, to appear

lepton vs. hadron colliders

 e^+e^-

pp



precision tests

direct production

precision tests at the LHC?



*see also: talk by Alex Pomarol

plan

- 1. oblique parameters
- 2. electroweak tests from Drell-Yan
- 3. oblique parameters from jets

1. oblique parameters

 $V_i \vee \cdots ? \vee \vee \vee V_i$

Oblique Parameters $V_i \lor V_i \qquad V = \gamma, Z, W^{\pm}$ $\Pi_{V_i V_j}(q^2) = \Pi_{V_i V_j}(0) + q^2 \Pi'_{V_i V_j}(0) + \frac{1}{2} q^4 \Pi''_{V_i V_j}(0) + \dots$ form factor operator parameter $S = \frac{8\sin(2\theta_W)}{q^2\alpha} \frac{m_W^2}{\Lambda_C^2}$ $\frac{1}{\Lambda_{C}^{2}}H^{\dagger}W_{\mu\nu}HB_{\mu\nu}$ $\Pi'_{W_3B}(0)$ $T = -\frac{2}{q^2 \alpha} \frac{m_W^2}{\Lambda_T^2}$ $\frac{1}{\Lambda_{\pi}^2} |H^{\dagger} D_{\mu} H|^2$ $\Pi_{W_3W_3}(0) - \Pi_{W^+W^-}(0)$ $W = -4\frac{m_W^2}{\Lambda_W^2}$ $\frac{1}{\Lambda_{\mu\nu}^2} (D_{\rho} W^a_{\mu\nu})^2$ $\Pi_{W_2W_2}^{\prime\prime}(0)$

 $\frac{1}{\Lambda_V^2} (\partial_{
ho} B_{\mu\nu})^2$

Barbieri, Pomarol, Rattazzi, Strumia hep-ph/0405040

 $\Pi''_{RR}(0)$

Peskin, Takeuchi 1990

 $Y = -4\frac{m_W^2}{\Lambda^2}$

Drell-Yan with Oblique Parameters





2. electroweak tests from Drell-Yan



• Farina, Panico, Pappadopulo, JTR, Torre, Wulzer 1609.08157

High Mass Drell-Yan Probes W/Y



Theory vs. Drell-Yan Data



we include:

- experimental uncertainties (with correlations)
- NNLO scale uncertainty (from FEWZ)

 PDF uncertainty (NNPDF, with correlations)

LHC8 Limits





EFT Validity

 $pp \rightarrow l^+ l^-$



 $m_{l^+l^-} < \Lambda_{\rm cut}$





3. oblique parameters from jets



• Alioli, Farina, Pappadopulo, JTR, to appear



earlier bounds:

- Cho, Simmons hep-ph/9307345
- Domenech, Pomarol, Serra 1201.6510

LHC vs Z



 $\Lambda_Z \gtrsim 7 \text{ TeV}$

*13 TeV projections in progress

take away

$$\mathcal{L}_{\text{eff}} \supset \frac{1}{\Lambda_Y^2} (\partial_\rho B_{\mu\nu})^2 + \frac{1}{\Lambda_W^2} (D_\rho W^a_{\mu\nu})^2 + \frac{1}{\Lambda_Z^2} (D_\rho G^a_{\mu\nu})^2$$

- high mass neutral/charged Drell-Yan probes oblique parameters W,Y (LHC is about to beat LEP!)
- LHC jets constrain Z
- motivates effort to minimize exp/theory systematics in high energy tails