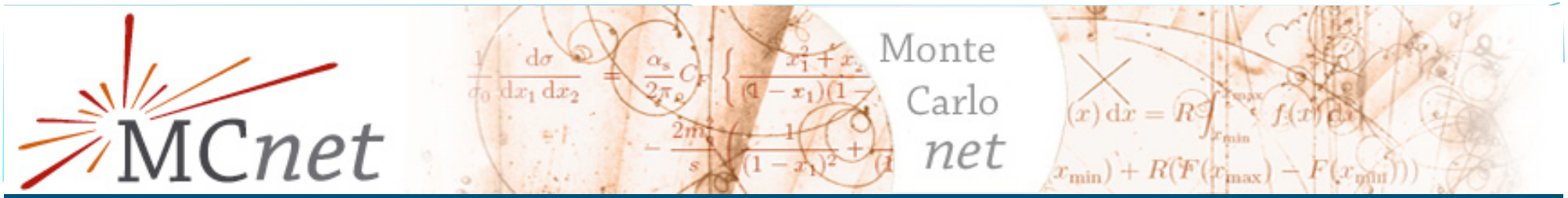


V MCnet network meeting

"Drell-Yan process & parton shower"

Updates of my work

Luca D' Errico

Durham, 15 January 2009

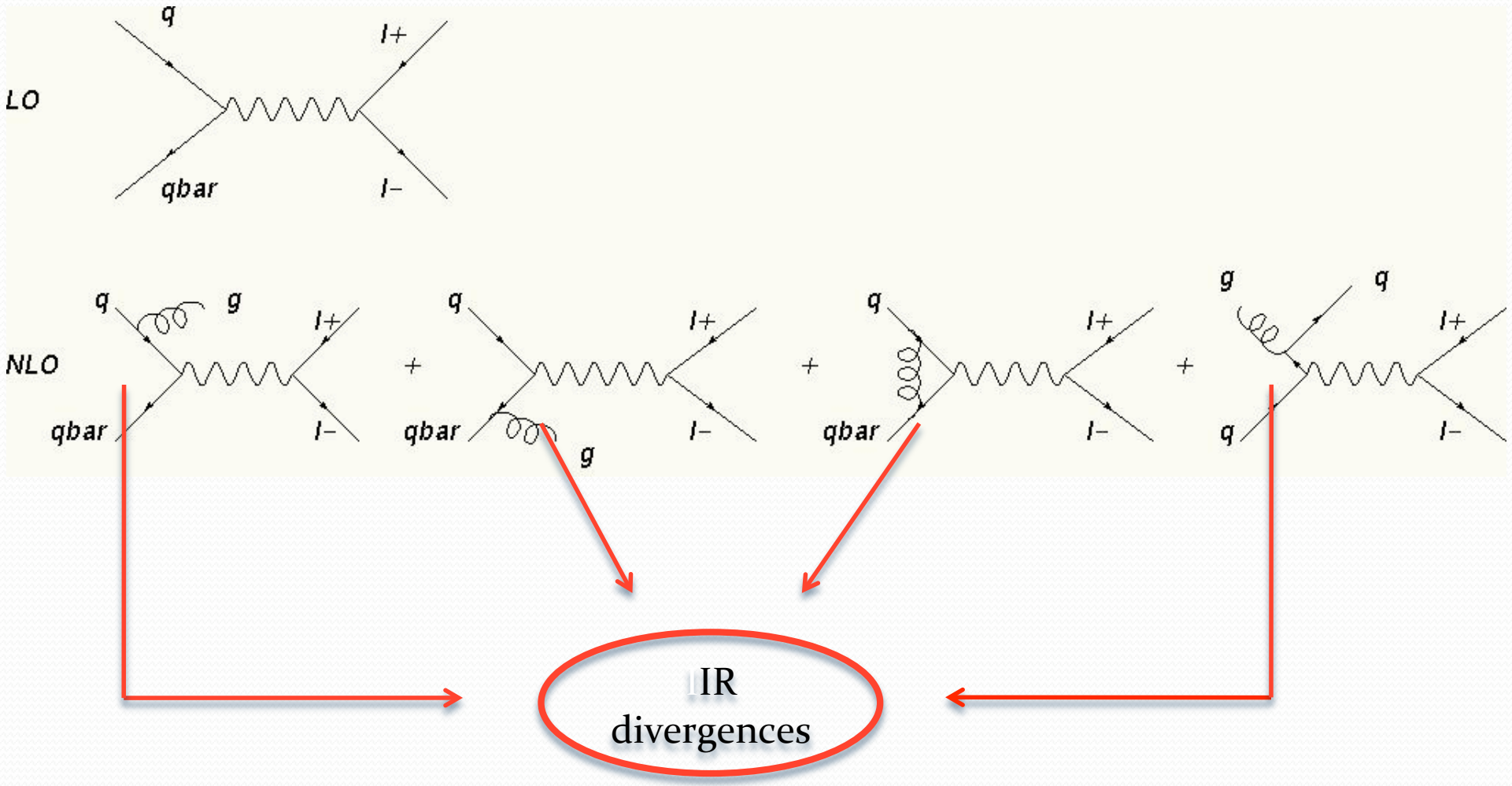
Plan

- Introduction
- Status of my work
- Summary and outlook of my studies

Why Drell-Yan process?

- Process-parton shower interface & matching
- Starting with easiest process
- Implement it in C++
- Use own code
- Integrate it in Herwig++

Drell-Yan process



Catani-Seymour subtraction method I

hep-ph/9605323

$$\sigma^{LO} = \int_m d\sigma^B \qquad \sigma^{NLO} = \int_{m+1} d\sigma^R + \int_m d\sigma^V$$

General idea:

$$d\sigma^{NLO} = \left[d\sigma^R - d\sigma^A \right] + d\sigma^A + d\sigma^V$$

$$\sigma^{NLO} = \int_{m+1} \left[d\sigma^R - d\sigma^A \right] + \int_{m+1} d\sigma^A + \int_m d\sigma^V$$

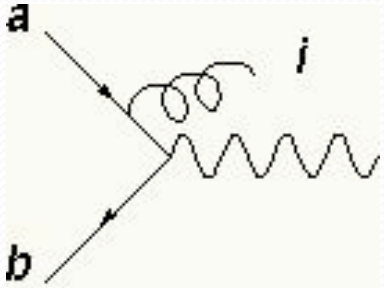
$$\sigma^{NLO} = \int_{m+1} \left[\left(d\sigma^R \right)_{\varepsilon=0} - \left(d\sigma^A \right)_{\varepsilon=0} \right] + \int_m \left[d\sigma^V + \int_1 d\sigma^A \right]_{\varepsilon=0}$$

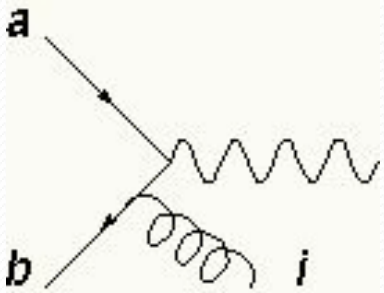
$$d\sigma^A = \sum_{dipoles} d\sigma^B \otimes dV_{dipole}$$

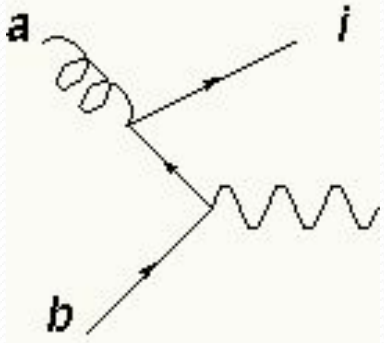
The counterterm:

- Has to exactly match the singular behaviour of real term
- Has to be integrable analytically over the single parton subspace leading IR divergences
- Has to be convenient for MC integration
- Is constructed in a way that is process indipendent

Dipoles for Drell-Yan process

$D^{ai,b}$ 

$D^{bi,a}$ 

$D^{(n)\,ai,b}$ 

Checked by hand that these dipoles cancel the singular behaviour of cross section at NLO!

LO Drell-Yan subprocesses

$$q\bar{q} \to \gamma^* \to l^+ l^- \longrightarrow$$ Completely implemented at NLO

$$q\bar{q} \to Z^0 \to l^+ l^- \longrightarrow \ldots$$

$$q\bar{q} \to Z^0 \to \nu_l \bar{\nu}_l \longrightarrow \ldots$$

$$q\bar{q} \to W^+ \to \nu_l l^+$$

$$q\bar{q} \to W^- \to \bar{\nu}_l l^-$$

The subprocesses have been studied by hand!

- Take care of possible interference term ✓
- Characterise completely the massive final states ✓
- Random number generator and phase space generator ✓
- Cuts: Rapidity and Lego Plot Separation ✓

Once the code is done

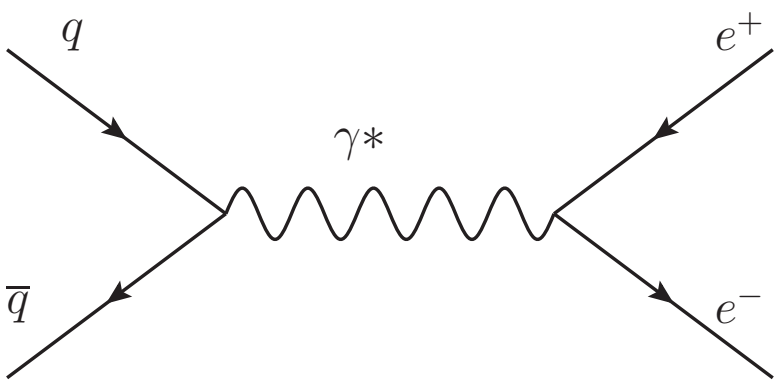
Fixed a subprocess:

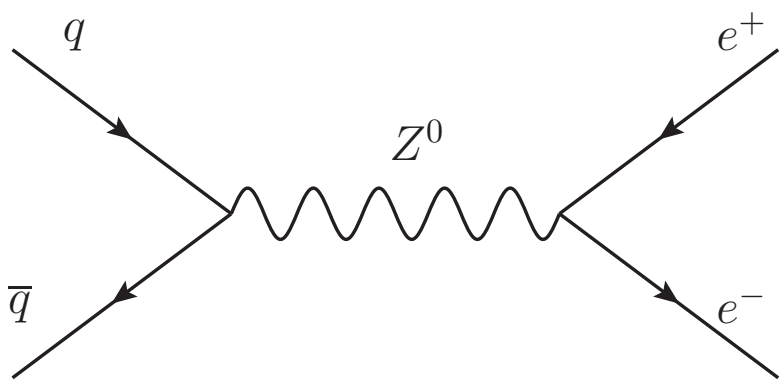
- Debug it at LO ✓
- Implement LO-code in ThePEG ✗
- Checks ✗
- Debug it at NLO ✗
- Implement NLO-code in ThePEG ✗
- Checks ✗
- Matching ✗

Debug

Fixed subprocess: $q\bar{q} \to \gamma^*/Z^0 \to e^+e^-$

$$\frac{\mathrm{d}\sigma}{\mathrm{d}\cos\theta\,\mathrm{d}\phi} = \frac{\alpha^2}{12Q^2}\left[\left(1+\cos^2\theta\right)A + \cos\theta\, B\right]$$





Formula

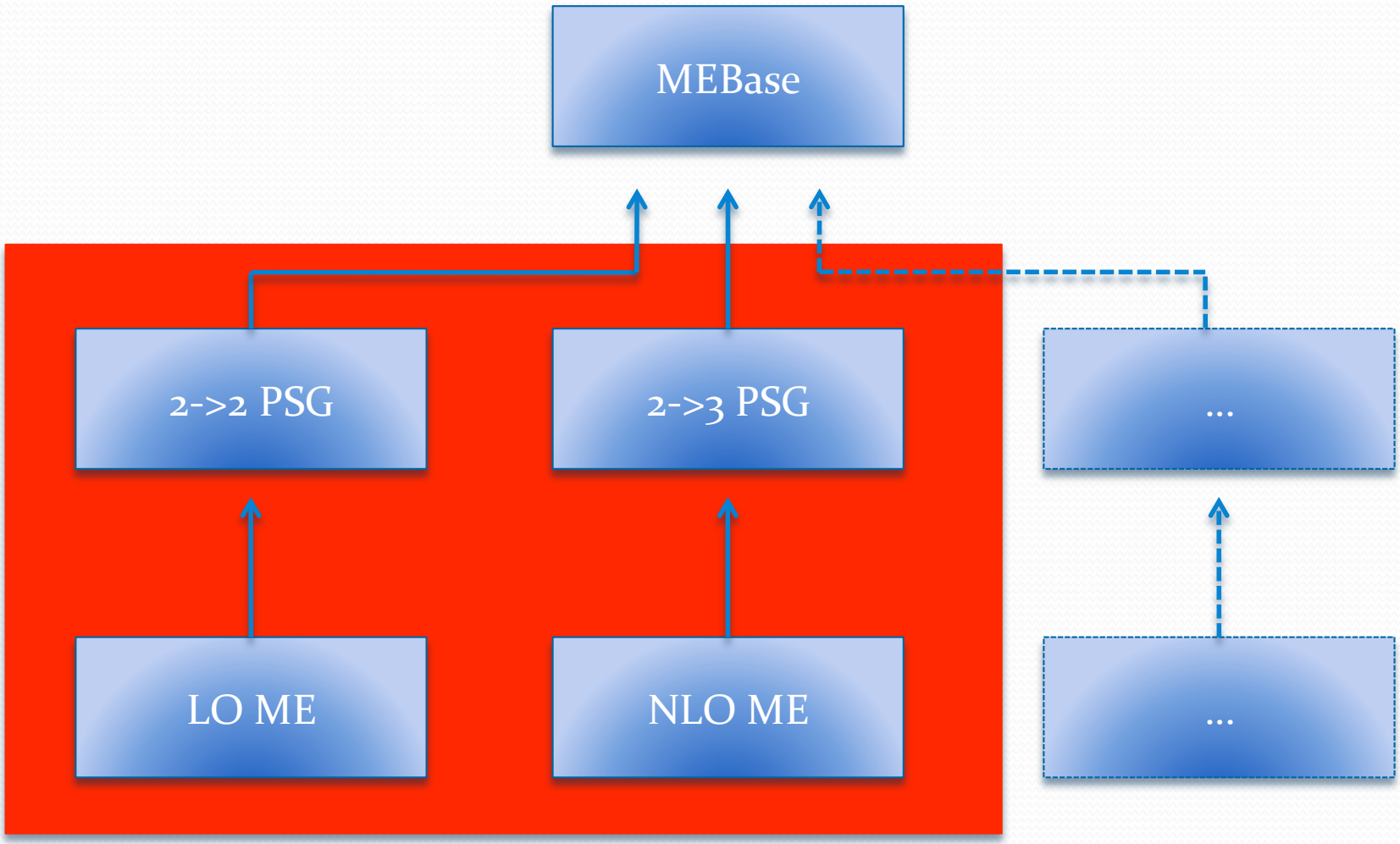
$$A = Q_q^2 + 2 g_V^e g_V^q \,\mathrm{Re}\,\chi(Q^2) + \left[\left(g_A^e\right)^2 + \left(g_V^e\right)^2\right]\left[\left(g_A^q\right)^2 + \left(g_V^q\right)^2\right]\left|\chi(Q^2)\right|^2$$

$$B = 4 g_A^e g_A^q \,\mathrm{Re}\,\chi(Q^2) + 8 g_A^e g_V^e g_A^q g_V^q \left|\chi(Q^2)\right|^2$$

$$g_V^e = -\frac{1}{2} + 2\sin^2\theta_w, \quad g_V^q = \frac{1}{2} - 2Q_q \sin^2\theta_w, \quad g_A^e = -\frac{1}{2}, \quad g_V^e = \frac{1}{2},$$

$$\chi(Q^2) = \frac{Q^2}{4\sin^2\theta_w \cos^2\theta_w} \frac{1}{Q^2 - M_Z^2 + i\Gamma_Z M_Z}$$

Implementation as ThePEG ME



Summary and outlook

- QCD Phenomenology
- Monte Carlo Method
- C++ structures
- External Herwig++ libraries (LHAPDF, CLHEP)
- Root
- Debug (Checks by hand, HELAC)
- ThePEG (MEBase, ME2to2Base, …)
- Interface my code with Simon's shower
- Other processes (VBF)

Long term outlook

- Become familiar with such interface
- Deal with more complicate processes
- Write interface for general matrix element