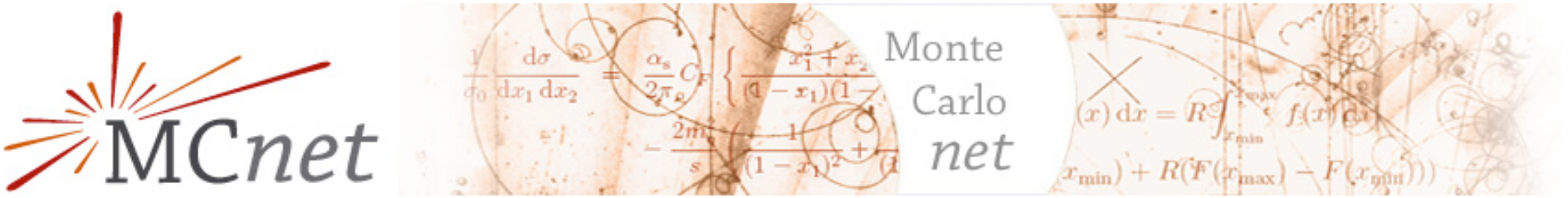


VI **MCnet Meeting**

"Matching VBF at NLO with parton showers"

Status of my work

Luca D' Errico

Lund, Tuesday June 30th 2009

Plan

- Introduction
- Status of Matching with Simon's PS
- Status of POWHEG Matching with Herwig++ PS
- Conclusion and Outlook

Why VBF?

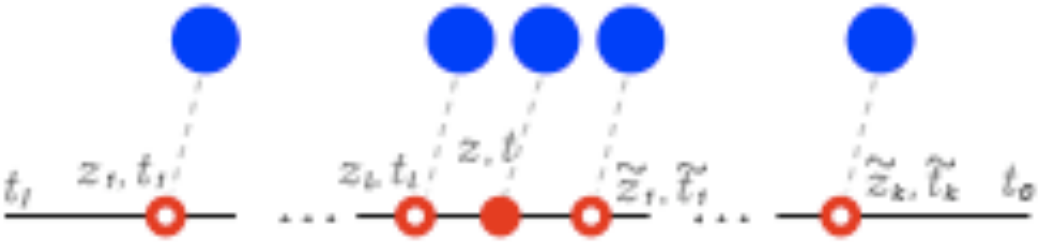
- VBF is expected to provide crucial information on Higgs couplings at LHC
- Success of Standard Model
- Understanding of the origin and nature of mass

POWHEG

[Nason hep-ph/0409146]

- Only positive weights
- Implementation indipendent of the event generator
- Required modification of the shower

$$\mathbb{S}(t_I) = \Delta(t_I, t_0)\,\mathbb{I} + \sum_{l,k=0}^{\infty} \int$$



- **Truncated Shower**: soft, wide angled radiation before HE
- **Hardest p_T Emission**: generated separately using a modified Sudakov FF (full ME for the emission of an extra parton)
- **Vetoed Showers**: radiation after HE, with p_T veto

n-body NLO cross section:

$$d\sigma = \overline{B}(v)\mathrm{d}v\left[\Delta_R^{(NLO)}(0) + \Delta_R^{(NLO)}(p_T)\frac{R(v,r)}{B(v)}\mathrm{d}r\right]$$

Modified Sudakov Form Factor:

$$\Delta_R^{(NLO)}(p_T) = \exp-\int \mathrm{d}r\frac{R(v,r)}{B(v)}\Theta(k_T(v,r) - p_T)$$

$$\overline{B}(v) = B(v) + V(v) + \int (R(v,r) - C(v,r))\mathrm{d}r$$

- $\mathrm{d}v$ correspond to n-body phase space
- $\mathrm{d}v\mathrm{d}r$ correspond n+1-body phase space
- $B(v)$ is the Born Term
- $V(v)$ unresolvable, real emission + virtual loop (finite)
- $R(v,r)$ parton flux multiplied by real emission matrix element
- $C(v,r)$ counterterms

Status of Matching with Simon's PS

- Interfacing ME
- Testing

Simon's PS

- Comes with generic NLO interface
- Automatically builds POWHEG
- NLO matrix elements for simple processes available

Interfacing ME

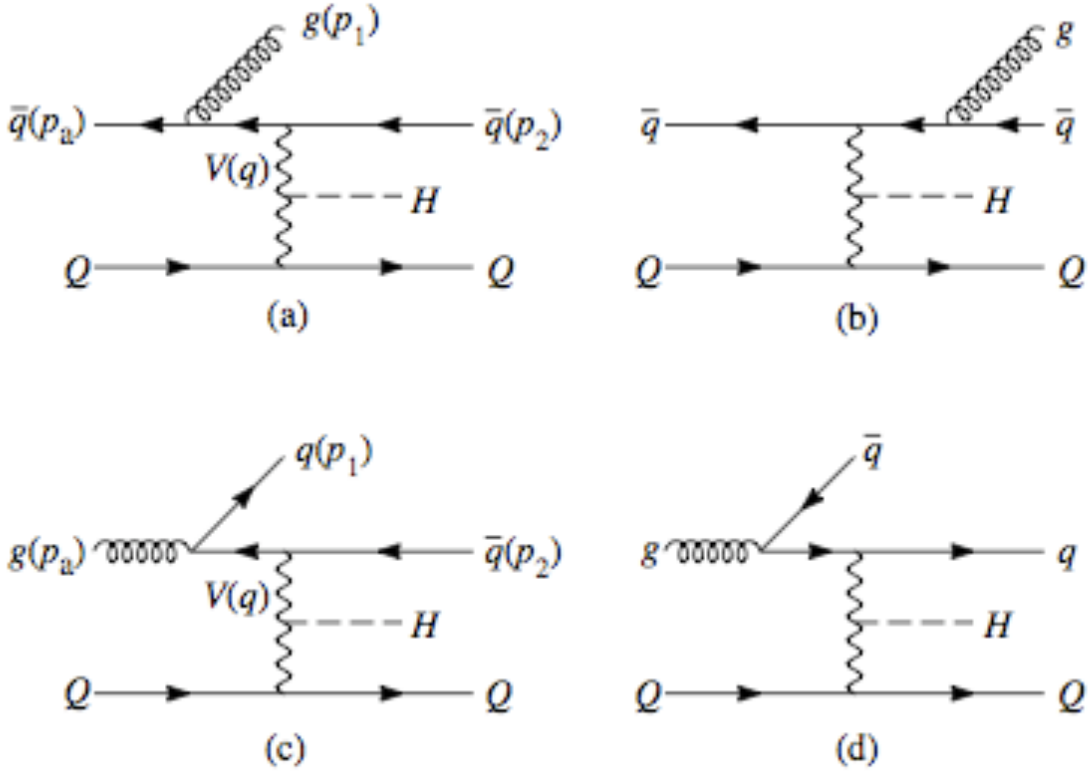
- Fill the interface with processes
- Assembled pieces for Drell-Yan and DIS
  - Subtraction terms and collinear remainders
  - Cuts
- Currently testing

Status of POWHEG Matching with Herwig++ PS

- Shower off
- Implementation of $\overline{B}(v)$
- Implementation of the Real Emission ME into Modified Sudakov Form Factor

Factorization of the Real Emission Term I

[Seymour hep-th/9410244]



1. Gauge introduced by the CALKUL collaboration [Nucl.Phys. B206 (1982) 53]
2. Four-vectors $r_{1,2}$

$$r_1 = -p_a / x_1 \qquad r_2 = -p_2 / x_2 \qquad x_i = 2 p_i \cdot q / q \cdot q$$

Factorization of the Real Emission Term II

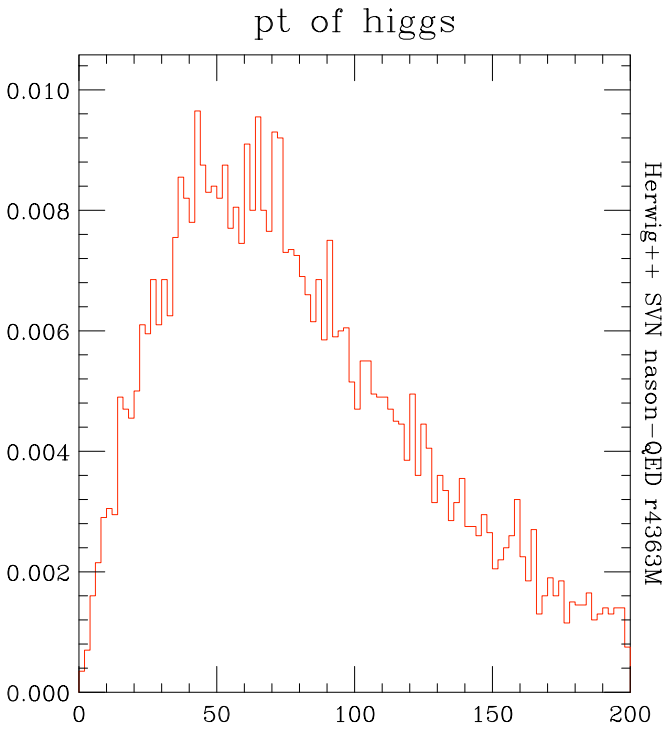
- $$\frac{\mathrm{d}\sigma_3}{\mathrm{d}\sigma_0} = C(x_p, z_p)\left\{\frac{\left|M_2(r_1, q + r_1)\right|^2}{B} + (x_p^2(x_2^2 + p_T^2))\frac{x_2^2}{x_2^2 + p_T^2}\frac{\left|M_2(r_2 - q, r_2)\right|^2}{B}\right\}$$

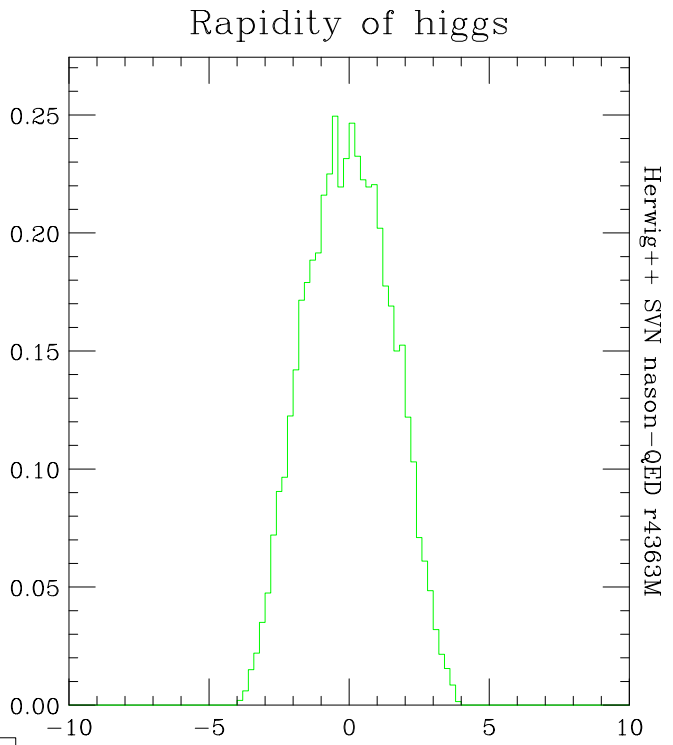
$$x_p = x_p(x_1) \qquad z_p = z_p(x_1, x_2) \qquad p_T^2 = p_T^2(x_1, x_2)$$

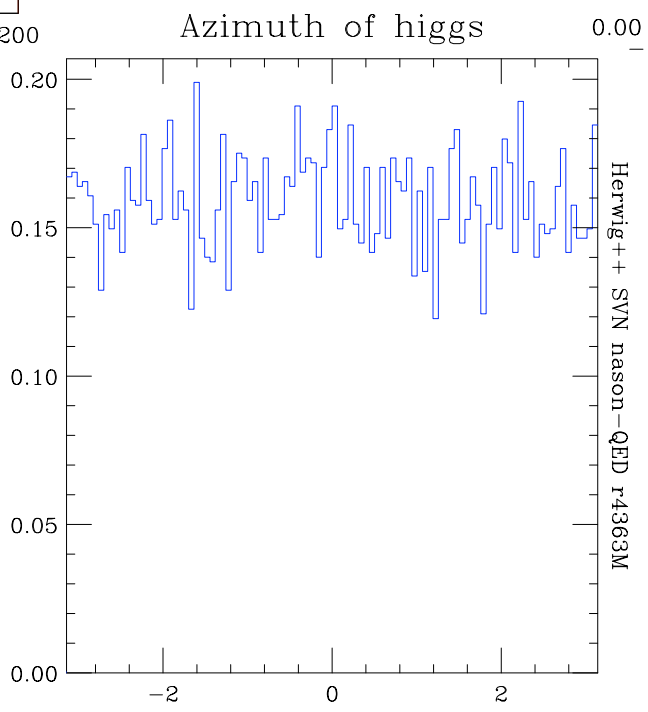
- Analogously for the gluon initiated process

Bulding $\overline{B}(v)$:

- VBF details - Zeppenfeld & co. [hep-th/0306109]:
  - $$V_\varepsilon(v) = B(v)\frac{\alpha_s(\mu_R)}{2\pi}C_F\left(\frac{4\pi\mu_R^2}{Q^2}\right)^\varepsilon \Gamma(1+\varepsilon)\left[-\frac{2}{\varepsilon^2} - \frac{3}{\varepsilon} + c_{virt}\right]$$
  - Dipoles
  - Collinear Reminders


pt of higgs
0.010
0.008
0.006
0.004
0.002
0.000
0
50
100
150
200
Herwig++ SVN nason-QED r4363M


Rapidity of higgs
0.25
0.20
0.15
0.10
0.05
0.00
−10
−5
0
5
10
Herwig++ SVN nason-QED r4363M


Azimuth of higgs
0.20
0.15
0.10
0.05
0.00
−2
0
2
Herwig++ SVN nason-QED r4363M

Hardest Emission

$$\Delta_R^{(NLO)}(p_T) = \exp - \int_{p_T}^{p_{T_{\max}}} \mathrm{d}r \frac{R_{ab}(v,r)}{B(v)} \equiv \exp - \int_{p_T}^{p_{T_{\max}}} \mathrm{d}r W_{ab}(v,r)$$

- The radiative variables are generated using the *veto algorithm* - Sjöstrand & co. [hep-th/0603175]:
  - Bounding Function: $g_{ab}(p_T) \equiv \frac{a_{ab}}{p_T^3} \rightarrow \Re$
- The Generation Procedure:
  1. p_T is set to p_{Tmax}
  2. A new (x_p, z_p) configuration is generated:
     - $p_T^2 = 1/\left(\frac{1}{(p_T^{\max})^2} - \frac{2}{a}\ln\Re\right) \rightarrow x_p$
     - z_p random number
  3. If $p_T < p_{Tmin}$ → No radiation generated
  4. Configuration outside p.s. boundaries → 2.
  5. If $W_{ab}/g_{ab} > \Re$ accept the configuration, otherwise → 2.

Summary and outlook

- Simon's Parton Shower
  - Interfaced Drell-Yan & DIS ME
  - Presently testing
- POWHEG implementation in Herwig++ for VBF
  - Implementation of $\overline{B}(v)$
  - Implementation of the Real Emission ME into Modified Sudakov Form Factor
  - Testing NLO ME with VBFNLO
  - Switch on the shower and do matching