

ESR at U. Silesia

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LHCphenOnet



Ravello, 19 September 2012

Background:

Education

- ❖ Bachelor in physics - Autonomous University of Madrid.
- ❖ MSc International Physics Studies - Leipzig University.

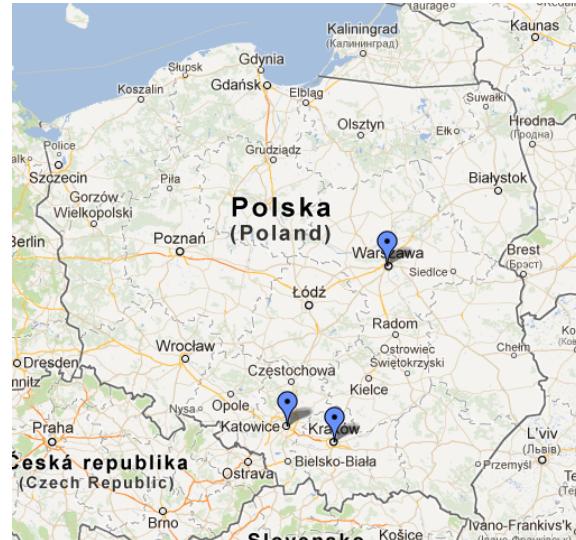
Master Thesis topic: Vacuum interaction between one-dimensional crystals
(pending paper).

Work experience

- ❖ Laser Shock Processing Simulations - Technical University of Madrid (1 paper).
 - ❖ Programmer, Data base administrator, Network engineer at Accenture, Telefonica, Atos.
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Present Status

- ❖ **Institute:** Institute of Physics (technical physics, medical physics, biophysics, nuclear physics, molecular physics and theoretical physics).
- ❖ **University:** University of Silesia, Katowice, Poland.
- ❖ **Project:** M1.4 On-Shell NLO amplitudes. M2.4 BSM decays.
- ❖ **Supervisors:** Professor J. Gluza (Silesia University) & Dr. T.Riemann (DESY-Zeuthen).



Project overview

- ❖ **Project focus I:** SM and BSM. Phenomenology of Left-Right symmetric models at the LHC. Calculation of branching ratios for heavy non-standard particles. Automated implementation with Calchep and FeynRules.
 - ❖ **Project focus II:** Implementation and improvement of tools for automation of loop calculations in the SM and beyond. Development of a numerical package based on a new approach to one-loop tensor reduction.
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Research project I: Left-Right Model

- ❖ Phenomenology of **Left-Right symmetric models** at LHC.
 - ❖ Using of **FeynRules**.
 - ❖ Calculation of branching ratios, total widths and processes for heavy non-standard particles with **Calchep & Madgraph**.
 - ❖ Publication: **Left-right symmetry at LHC and precise 1-loop low energy data** - J. Chakrabortty, J. Gluza, R. Sevillano, R. Szafron, JHEP 2012, arXiv:1204.0736
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Results: Calchep & Madgraph

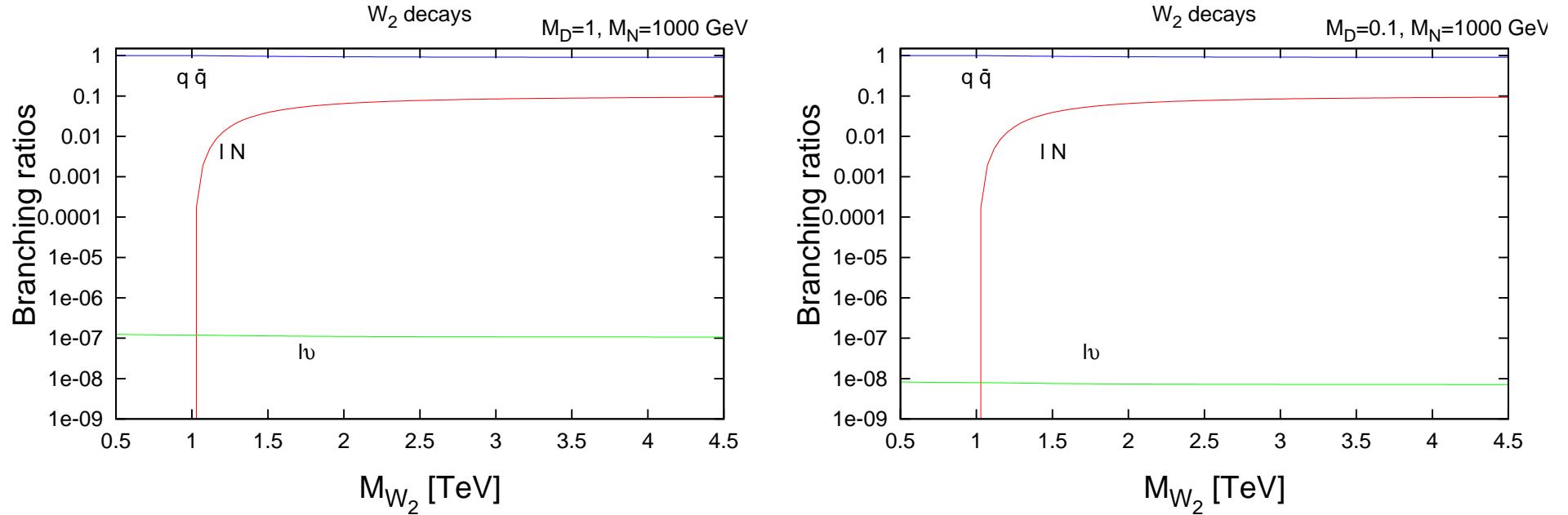


Figure 1: Branching ratios of W_2^+ to the sum of quarks, leptons, Higgs and heavy bosons for $M_D = 1 \& M_D = 0.1, \xi = M_D/M_N$

Z_2 decays

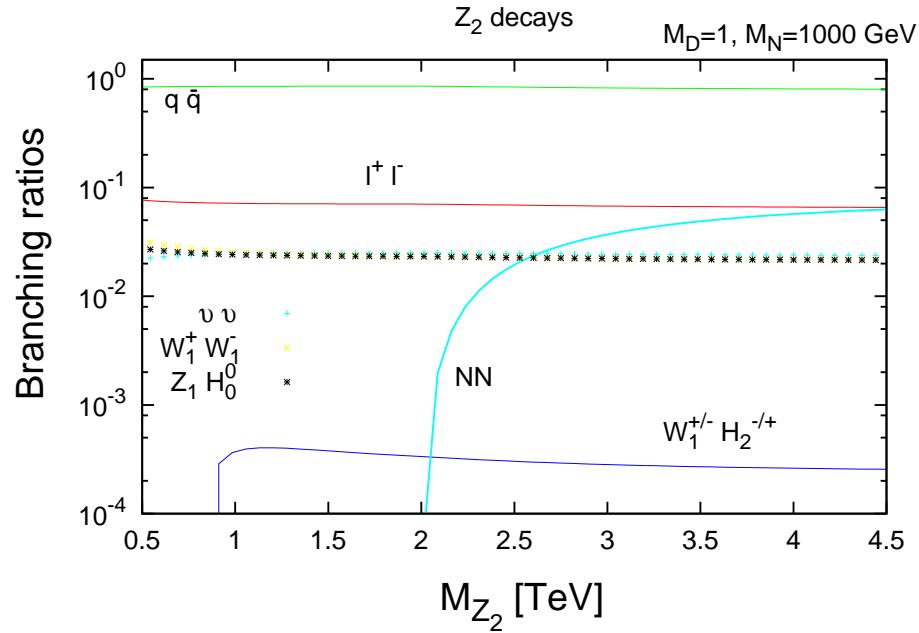


Figure 2: Branching ratios of Z_2 to the sum of quarks, leptons, Higgs and heavy bosons for $M_D = 1$ & $M_D = 0.1, \xi = M_D/M_N$

N1 decays

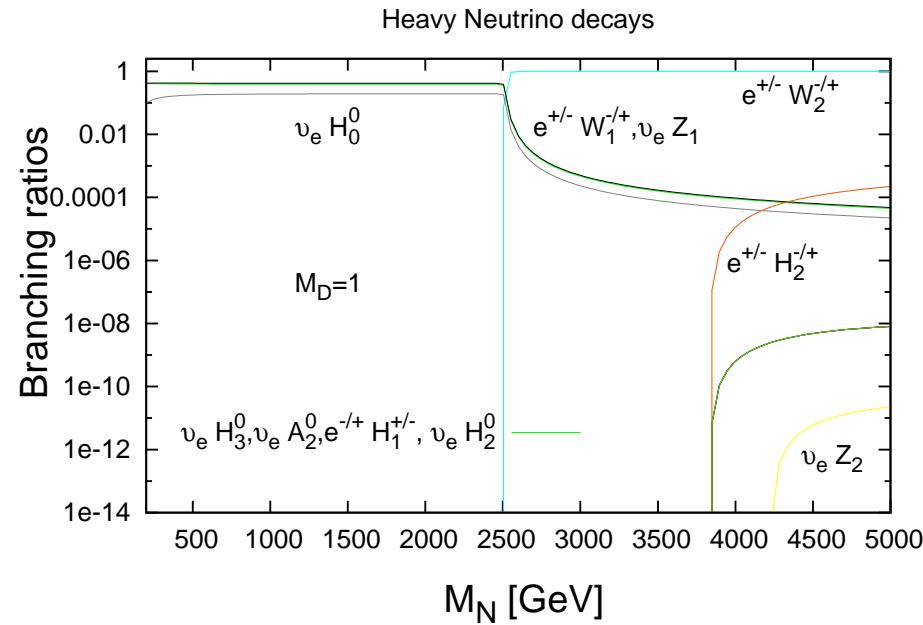


Figure 3: Branching ratios of $N1$ to the sum of leptons, Higgs and heavy bosons for $M_D = 1$ & $M_D = 0.1$

Cross-section for process $pp \rightarrow e^+ N_4$

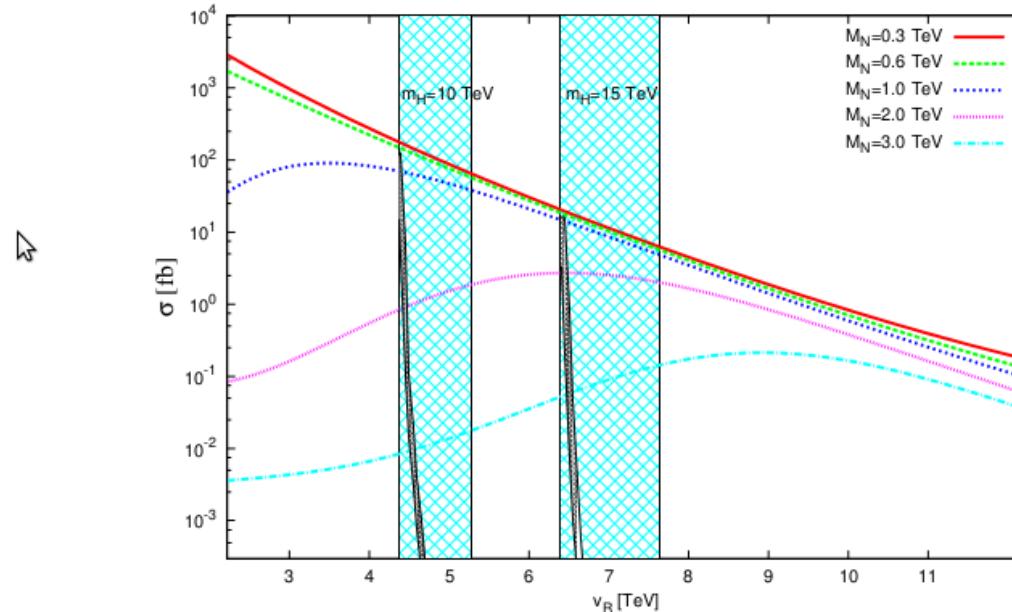


Figure 3.7: Cross-section for process $pp \rightarrow e^+ N_4$ for different sets of heavy neutrino masses M_N , $\sqrt{s} = 14$ TeV. The results are for degenerate heavy neutrino and Higgs particle masses. m_H masses are fixed at 10 TeV and $m_H = 15$ TeV. The whole shaded bands correspond to parameters labeled as **Set A** in Table 2.1 and Fig. 2.2. In addition, for each v_R between $(v_R)_{min}$ and $(v_R)_B$ in Fig. 2.2, heavy neutrino mass spectrum which is in agreement with muon decay data is obtained (we call it **Set B**). In this way a possible cross-section for allowed $M_{W_2} - M_N$ masses is constrained dramatically. These regions are denoted by almost vertical and thin black stripes within the wider shaded regions.

Systematic approach to tensor reductions:

1,2,3,4-point functions:

- ❖ Passarino, Veltman 1978

Open source programs for 5,6-point reductions:

- ❖ LoopTools/FF ($n \leq 5$), T. Hahn 1998,1990.
- ❖ Golem95 T. Binoth et al. 2008
- ❖ PJFry V. Yundin, PhD thesis 2012 + Fleischer, T.R. 2010

Need in addition a library of scalar functions:

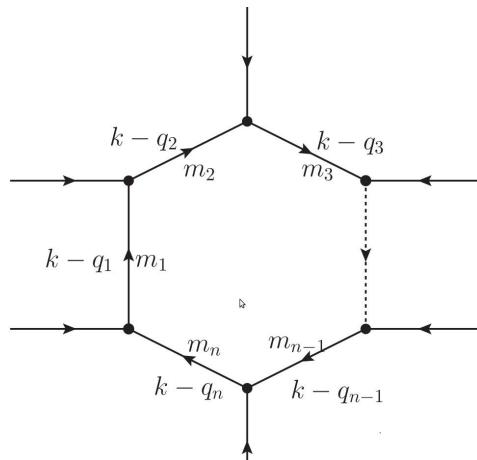
- ❖ 't Hooft, Veltman 1979
 - ❖ QCDloop/FF K. Ellis and G. Zanderighi 2007,1990
 - ❖ LoopTools/FF T. Hahn 1998,1990
 - ❖ OneLoop (complex masses) van Hameren 2010
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Research project II: Tensor reduction of Feynmann integrals

Main source: **New results for algebraic tensor reduction of Feynman integrals** - Jochem Fleischer, Tord Riemann, Valery Yundin, arXiv:1202.0730 *n*-point tensor integrals of rank *R*.

$$E^\mu = \sum_{i=1}^4 q_i^\mu E_i, E^{\mu\nu} = \sum_{i,j=1}^4 q_i^\mu q_j^\nu E_{ij} + g^{\mu\nu} E_{00}, \quad (1)$$

$$I_n^{\mu_1 \dots \mu_R} = \int \frac{d^d k}{i\pi^{d/2}} \frac{k^{\mu_1} \dots k^{\mu_R}}{((k - q_1)^2 - m_1^2) \dots ((k - q_n)^2 - m_n^2)},$$



Contractions with external momenta p_i

We expect improvements of efficiency by using **contracted tensor integrals**

[Fleischer,TR: PLB 2011]

$$I_5^\mu = EQ_0^\mu - \sum_{s=1}^5 I_4^s Q_s^\mu, \quad E = \frac{1}{\binom{0}{0}_5} \sum_{s=1}^5 \binom{s}{0}_5 I_4^s.$$

$$(q_a \cdot I_5) = -\frac{1}{2}E (Y_{a5} - Y_{55}) - \frac{1}{2} \sum_{s=1}^5 I_4^s (\delta_{as} - \delta_{5s}) = \sum_{i=1}^4 q_i^\mu E_i$$

where $Y_{ij} = -(q_i - q_j)^2 + m_i^2 + m_j^2$

$$()_n = \begin{vmatrix} 0 & 1 & 1 & \dots & 1 \\ 1 & Y_{11} & Y_{12} & \dots & Y_{1n} \\ 1 & Y_{12} & Y_{22} & \dots & Y_{2n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & Y_{1n} & Y_{2n} & \dots & Y_{nn} \end{vmatrix}$$

Project II summary

- ❖ Proper isolation of inverse Gram determinants.
 - ❖ Numerical C++ and F90 package.
 - ❖ Perform multiple sums with signed minors and scalar products after contractions with chords or external momenta.
 - ❖ Collaboration with J.Fleischer of Bielefeld University and T.Riemann from DESY-Zeuthen in Germany. Meetings in Zeuthen and Wernigerode.
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Overview of Training

- ❖ Helmholtz Lattice QCD school 2011 in **Dubna**, Russia (September 2011)
- ❖ **DESY-Zeuthen**, Germany (December 2011).
- ❖ Winter School in **Locarno**, Switzerland (January 2012).
- ❖ LHCPhenoNet Annual Workshop 2012, **Durham**, UK (March 2012).
- ❖ Loops and Legs 2012, **Wernigerode**, Germany (April 2012).
- ❖ Planck 2012: from the Planck scale to the electroweak scale, **Warsaw**, Poland (June 2012).
- ❖ **Silesia University**: Phd courses: **Montecarlo methods** (Prof. M. M. Maska), **Computational Algebra Systems** (Prof. J.Gluza), Internal Theoretical Physics seminars and lectures from visiting scientists.

Seminars given:

- ❖ Using FeynRules, CalcHEP and MadGraph for BSM at LHC studies (Katowice, Poland and Durham, UK).

Future plans:

- ❖ 2 months internship in **RISC GmbH** at Linz, Austria (October-December 2012). Will work on efficient solution method for a large scale and sparse system of linear equations.
 - ❖ Application of program packages at **LHC**.
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