Heptools in Katowice

Janusz Gluza

Heptools in Katowice

- Similarly as the Warsaw group, we are a subnode of IFJ-PAN Cracow
- Staff:
  M. Zrałek, K. Kołodziej, H. Czyż, J. Syska, J. G.
- Phd students:
  Sz. Szczypiński (finished last year), B. Dziewit, A. Smolin-Joniec, K. Kajda, A. Wapienik, M. Gunia, M. Ochman, R. Szafron
- ESR: T. Sabonis (12 months)

We are working within the following milestones

- Multi-particle amplitudes
- study of four and six fermion production at e+e- colliders
- completion and automatization of arbitrary tree level processes computations
- Computer algebra (development of packages for Feynman integral calculations)
- precision calculations (Bhabha scattering)
- Alternative new physics (neutrinos)

Cooperation within EU network

- DESY-Zeuthen, Aachen (J.G.)
- Karlsruhe, Bologna (H.Czyż)
- U. Granada (M. Zrałek)
- Humboldt U. Berlin, DESY Zeuthen (K. Kołodziej)

Conferences

- ***Matter to the deepest*: Recent developments in physics of fundamental interactions**.
  31st International Conference of theoretical physics, Ustron, Poland, September 5-11, 2007
- This year again, http://www.us.edu.pl/~us2009
- Many participants from the Heptools network

carlomat, *K. Kołodziej*

- a program written in Fortran 90/95
- generates the matrix element for a user specified process
- generates phase space parametrizations, which are later used for the multichannel Monte Carlo integration of the lowest order cross sections and event generation
- takes into account both the electroweak and QCD lowest order contributions
- fermion masses are not neglected
- the maximum number of external particles is 12
- only the Standard Model is implemented at the moment

Top quark pair production in e^+e^- annihilation

Final state	$\sqrt{s}$	carlomat	AMAGIC++	HELAC
$b\bar{b}u\bar{u}d\bar{d}$	360	32.98(11)	32.90(15)	33.05(14)
	500	50.31(19)	49.74(21)	50.20(13)
$b\bar{b}ud\bar{e}^-\bar{\nu}_e$	360	11.448(26)	11.460(36)	11.488(15)
	500	17.424(56)	17.486(66)	17.492(41)
$b\bar{b}e^+\nu_e\mu^-\bar{\nu}_\mu$	360	3.843(5)	3.847(15)	3.848(7)
	500	5.856(11)	5.865(24)	5.868(10)
$b\bar{b}\mu^+\nu_\mu\mu^-\bar{\nu}_\mu$	360	3.837(5)	3.808(16)	3.861(19)
	500	5.834(10)	5.840(30)	5.839(12)

#'s in [fb]. Agreement for ~ 80 reactions. [Gleisberg, et al.]

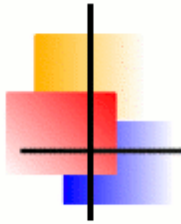
$e^+e^- \to b\bar{b}b\bar{b}ud\bar{\mu}^-\bar{\nu}_\mu$ (relevant for $e^+e^- \to t\bar{t}H$)

$\sqrt{s}$ [TeV]	$\sigma_{\text{all}}^{\text{Whiz.}}$ [ab]	σ_{all} [ab]	$\sigma_{\text{no QCD}}$ [ab]	σ_{signal} [ab]	$\sigma_{\text{signal}}^{\text{no cuts}}$ [ab]	$\sigma_{\text{NWA}}^{\text{no cuts}}$ [ab]
0.5	26.6(1)	26.8(4)	7.80(3)	3.095(3)	3.796(3)	3.920(1)
0.8	98.6(3)	100.2(8)	66.8(1)	46.27(2)	58.36(2)	60.03(2)
1	93.3(2)	93.1(3)	61.4(1)	40.18(2)	51.74(2)	52.42(3)
2	46.7(2)	47.4(2)	28.5(1)	15.14(3)	22.14(4)	20.68(3)

$$5^\circ < \theta(q,\text{beam}),\ \theta(l,\text{beam}) < 175^\circ,\ \ \theta(q,q'),\ \theta(l,q) > 10^\circ,$$

$$E_q,\ E_l,\ \not{E}^T > 15\ \text{GeV}$$

Large QCD and off resonance background!



Outlook, K. Kołodziej

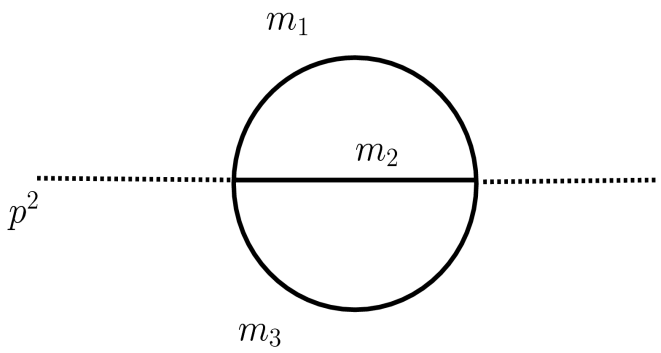
- `carlomat` can be used for automatic computation of cross sections of multiparticle reactions and as an MC generator of unweighted events, too.
- Interfaces to PDF's, or ISR within the structure function approach are practically ready.
- Interfaces to parton shower and hadronization programs should be worked on.
- Extensions of SM can be implemented and the corresponding lowest order cross sections can be calculated in a fully automatic way.
- Leading SM radiative corrections can be implemented, if corresponding subroutines are provided.

Developing numerical tools for two-loop calculations

BOKASUN: A Fast and precise numerical program to calculate the Master Integrals of the two-loop sunrise diagrams.

M. Caffo, R. Remiddi, INFN and Univ. of Bologna
H. Czyż, M. Gunia, Univ. of Silesia, Katowice

arXiv:0807.1959, to be published in Comp. Phys. Comm.



Neutrinos properties beyond the Standard Model,

possibility of experimental verification.

- M. Zrałek, F.del Aguila, R.Szafron, M. Ochman, J. Syska
- *"Impact of right-handed interactions on the propagation of Dirac and Majorana neutrinos in matter", Phys.Rev.D76:013007,2007*
- *"Neutrino production states in oscillation phenomena. Are they pure or mix?", J.Phys.G35:065003,2008*
- *"Neutrino oscillations beyond the Standard Model", J.Phys.Conf.Ser.136:042027,2008*

J.Phys.Conf.Ser.136:042027,2008

The main obtained results:

Beyond the SM:

1. **Neutrino production states are not pure QM states – density matrix,**
2. **Final detection rates do not factorize,**
3. **It is possible to distinguish Dirac from Majorana neutrinos,**
4. **Coherent and incoherent oscillations,**
5. **Density matrix is useful even for the nSM neutrino oscillation.**

Standard Model

Beyond the SM

1 $|\nu_\alpha(0)\rangle = \sum_{i=1}^{3} U^*_{\alpha i}|\nu_i\rangle$ → $\rho^\alpha_{\lambda,i;\mu,k} = \frac{1}{N_\alpha}\sum_{\lambda_i,\lambda_A,\lambda_B} A^\alpha_i(\lambda_A,\lambda_i;\lambda_B,\lambda)\, A^{\alpha*}_k(\lambda_A,\lambda_i;\lambda_B,\mu)$

2 $N(E,L) = \rho_\alpha(E)\ P_{\alpha\to\beta}(E,L)\ \sigma_\beta(E)\ N_T$ → $\sigma_{\alpha\to\beta}(E,L) = \frac{1}{32\pi s}\frac{p_f}{p_i}\frac{1}{2s_C+1}\sum_{spins}\int dLips\ A^\beta \rho^\alpha(T=L) A^{\beta*}$

$N(E,L) = \rho_\alpha(E)\ \sigma_{\alpha\to\beta}(E,L)\ N_T$

3 Dirac and Majorana neutrinos oscillate in the same way → Both types of neutrinos can be distinguished in the oscillations processes

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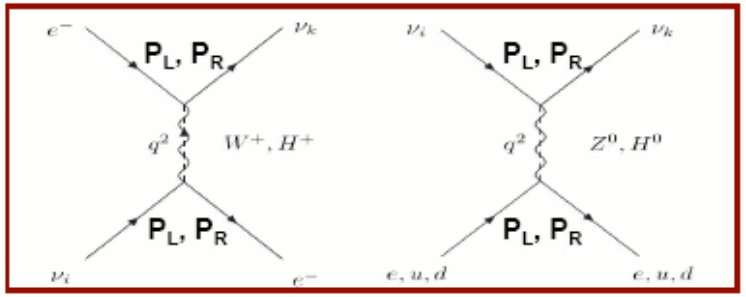
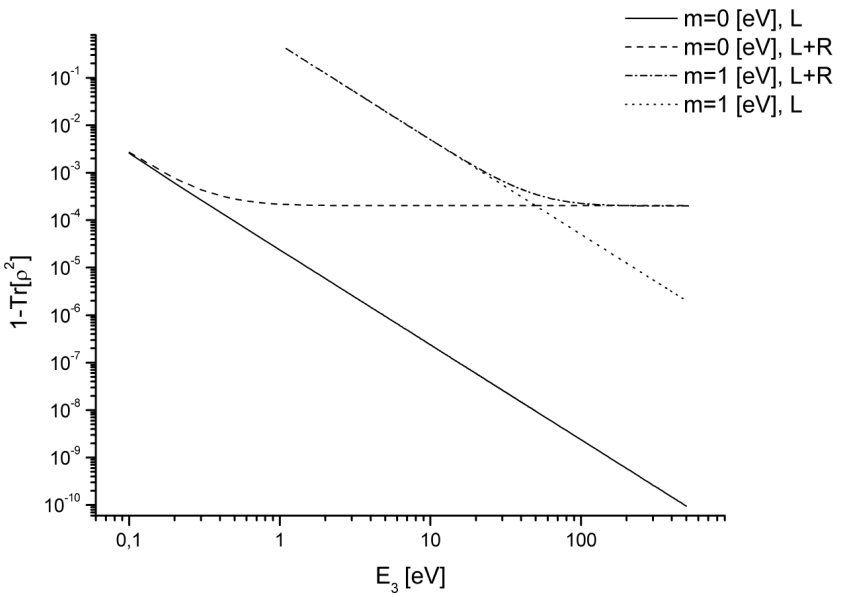
ρ^α_{CM} — Lorentz boost, Wigner spin rotation → $\rho^\alpha_{LAB}(L=0)$ — Neutrino propagation in a vacuum or in a matter → $\rho^\alpha_{LAB}(L=T\neq 0)$

$\pi^+ \to \mu^+\nu_i$ $\rho^\alpha_{LAB}(\lambda,\mu) \cong \rho^\alpha_{CM}(\lambda,\mu)$ Decay of moving pion $\rho^\alpha(T=L) = e^{-iHT}\rho^\alpha(L=T=0)e^{iHT}$

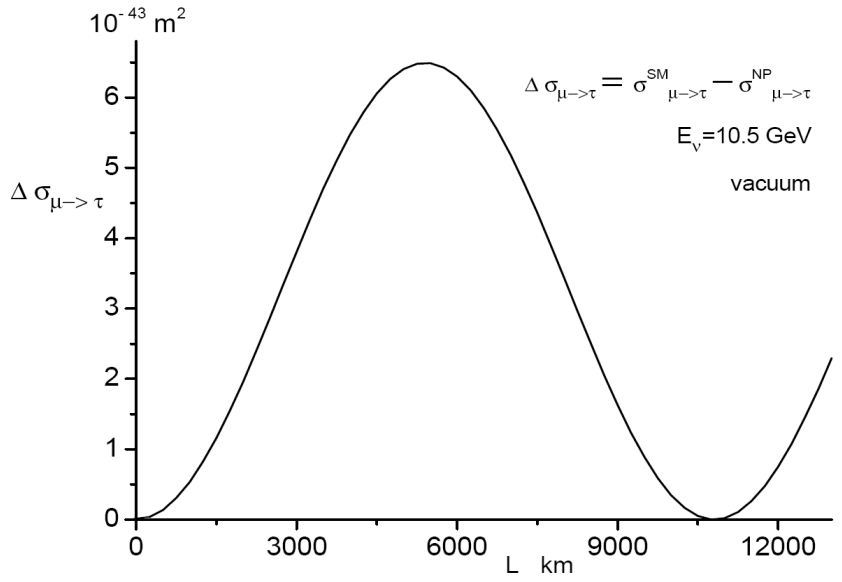
Relativistic neutrinos, not very dense matter

The interactions beyond the SM are parameterized by two diagrams, parameters of NP are bounded from muon and beta decays

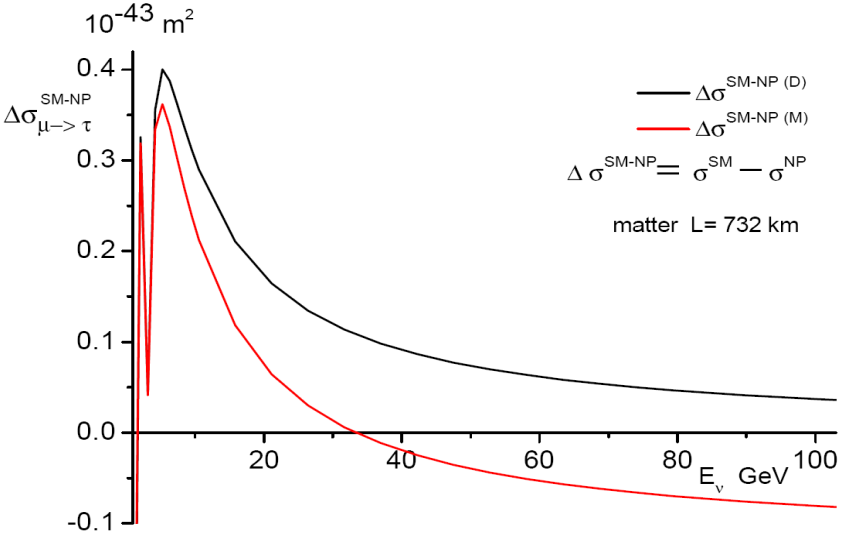




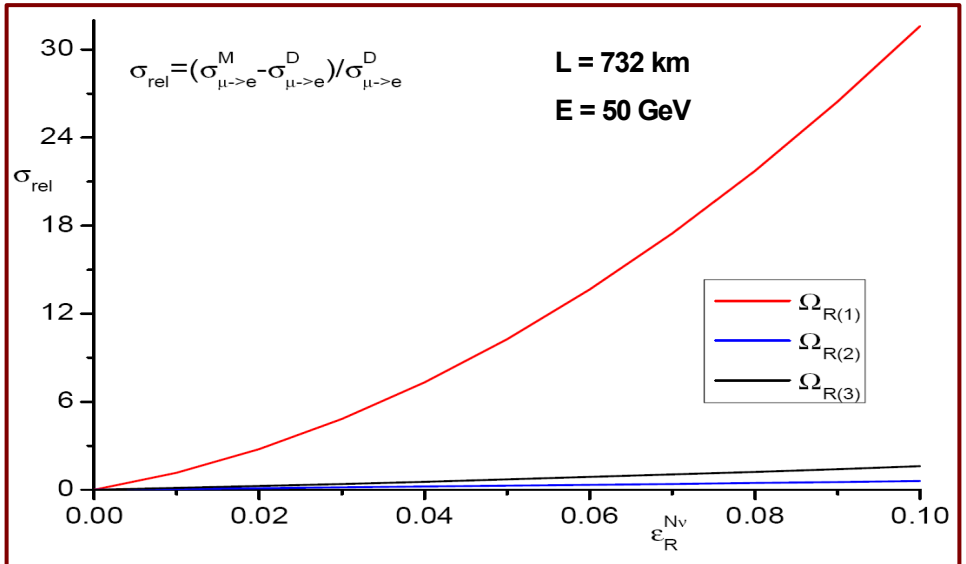
Neutrino produced states are mixed



Mixed state has the impact on neutrino oscillations



Influence of the NP on the Dirac and Majorana neutrino oscillation



Difference between D and M neutrino oscillation strongly depends on the model parameters

Plans for the future:

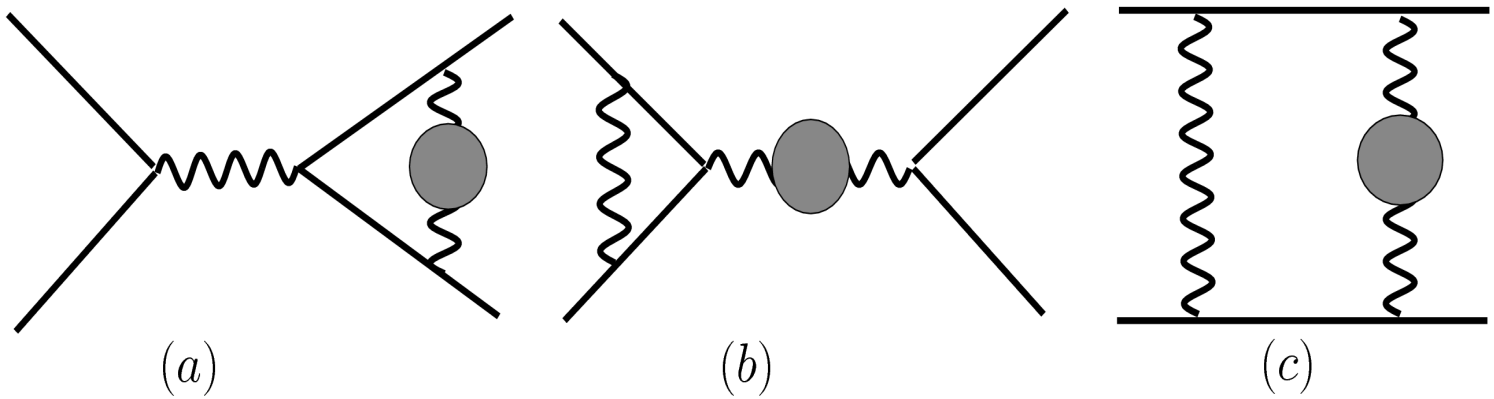
1. SM calculation of the neutrino detection rates for new neutrino beams and detectors (superbeam, neutrino factory, beta beam and aqua, liquid scintillator, argon as a detector material).

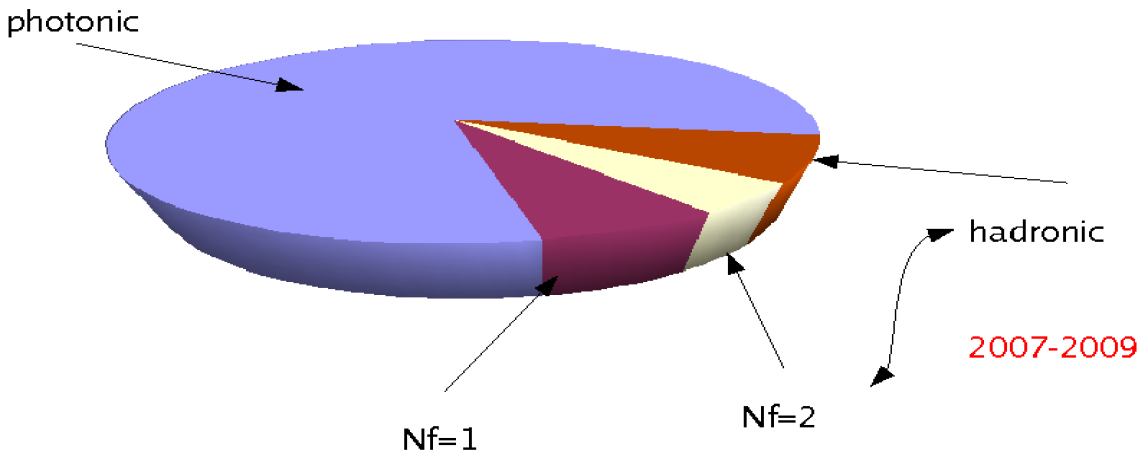
2. Calculation of the neutrino detection rates for future experiments if neutrino production, oscillation inside matter and detection are described by New Physics (NP).

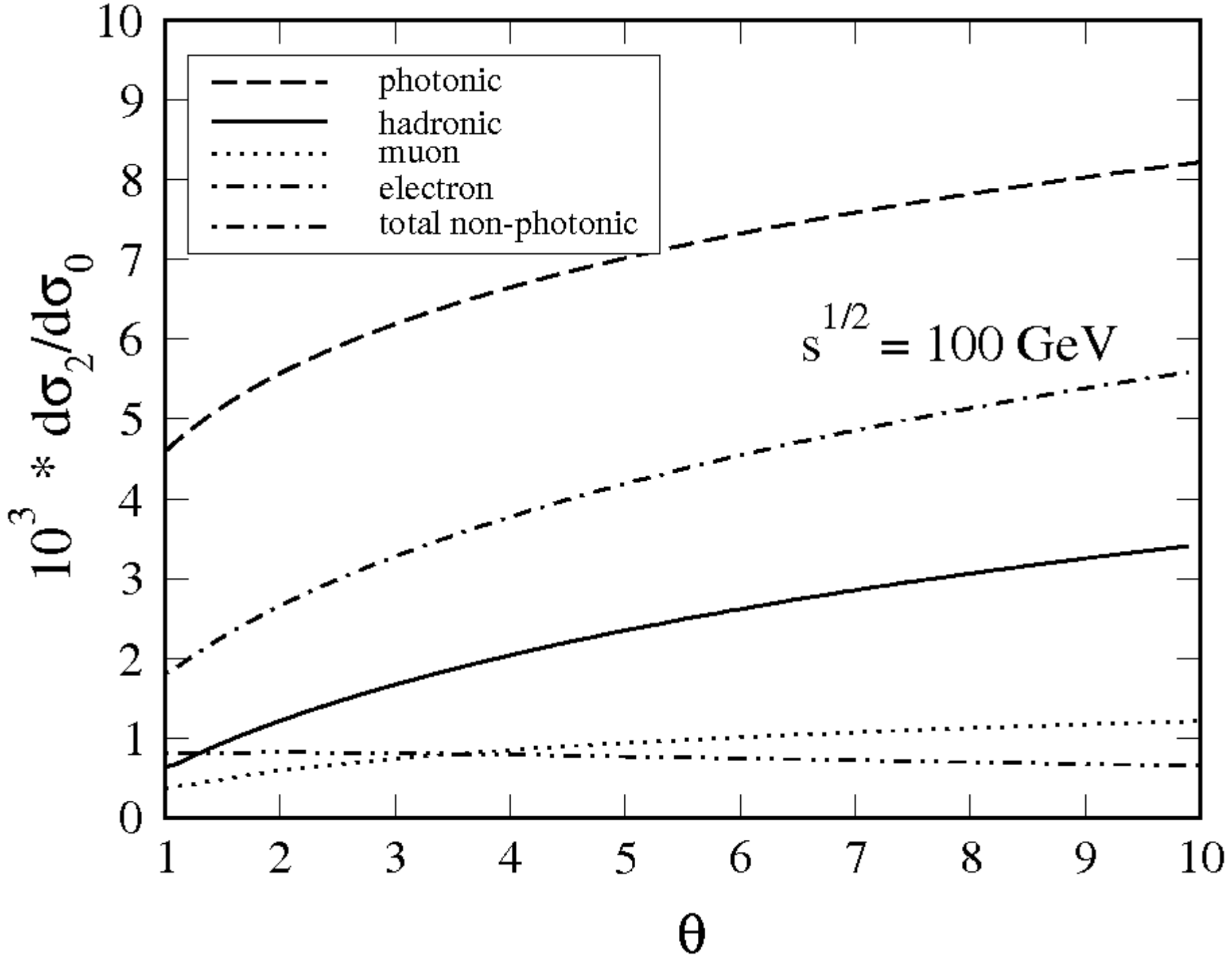
3. Search for the bounds on the NP parameters in the model independent effective Lagrangian from new existing experimental data.

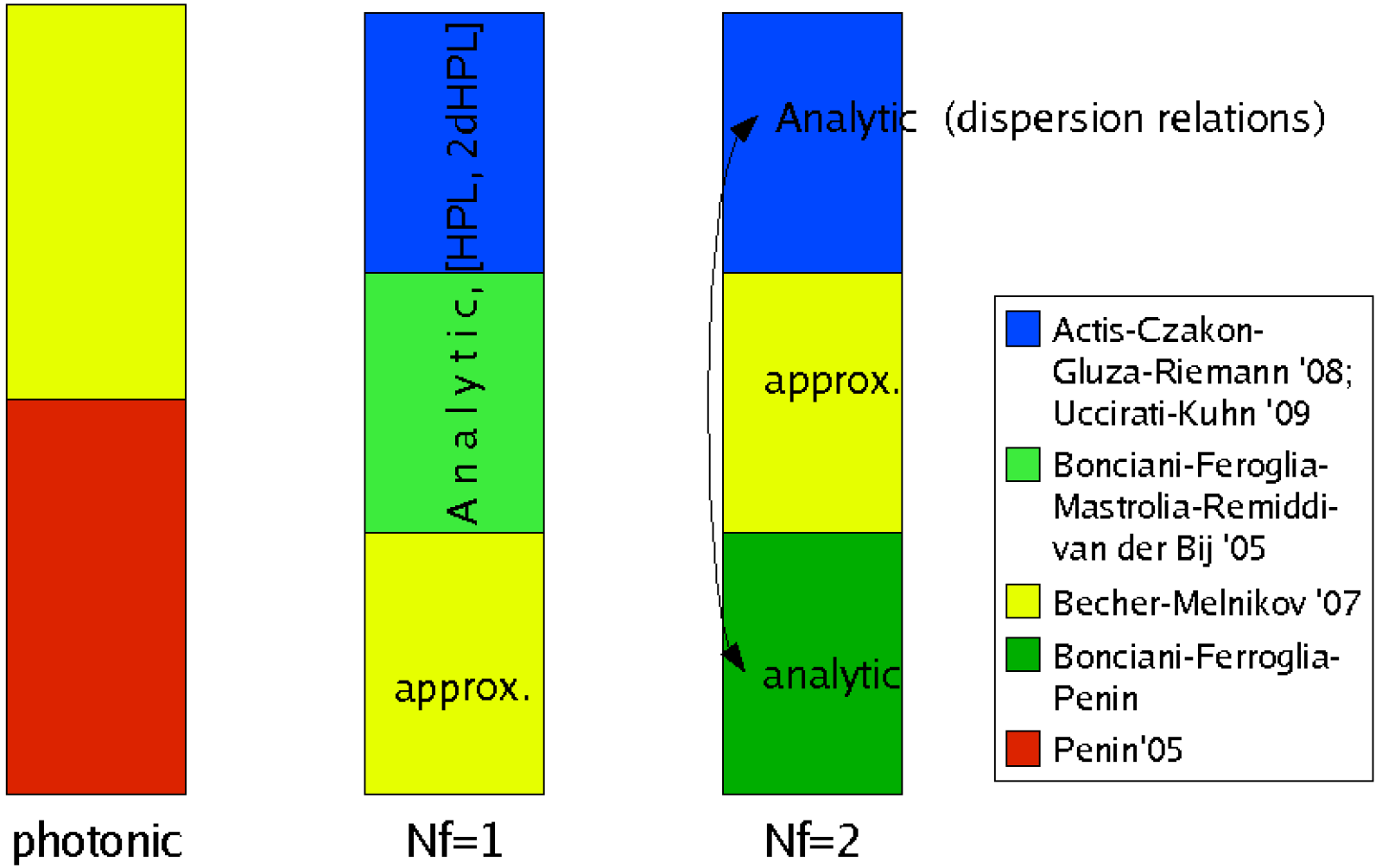
4. Neutrino oscillation in new physics models (experimental and theoretical bounds on the oscillation parameters beyond the SM: supersymmetry, unparticles, new gauge bosons, new Higgses, extra dimensions).

Bhabha scattering






photonic
hadronic
muon
electron
total non-photonic
$s^{1/2} = 100$ GeV
$10^3 * d\sigma_2/d\sigma_0$
θ
0
1
2
3
4
5
6
7
8
9
10


Analytic, [HPL, 2dHPL]
approx.
Analytic (dispersion relations)
approx.
analytic
Actis-Czakon-Gluza-Riemann '08; Uccirati-Kuhn '09
Bonciani-Feroglia-Mastrolia-Remiddi-van der Bij '05
Becher-Melnikov '07
Bonciani-Ferroglia-Penin
Penin'05
photonic
Nf=1
Nf=2

Developing analytical tools for loop calculations

- Mbtools
- http://projects.hepforge.org/mbtools/

- Home
- Downloads
- Mailing list
- Tracker
- Wiki

MB Tools

This project is a collection of tools devoted to the evaluation of Mellin-Barnes integrals.

The project has been started by Michael Czakon; currently the web-page is also being updated by Alexander Smirnov.

The project is at the development stage, so expect more codes to appear here.

Currently the following codes can be downloaded:

- **MB.m** : version 1.2 of MB (last updated January 2nd, 2009) by Michal Czakon,
  the main collection of routines for the resolution of singularities and the numerical evaluation of Mellin-Barnes integrals;
  for details see hep-ph/0511200;
  the current version is documented in the **Manual** ;
  the distribution contains two example notebooks, MBexamples1.nb and MBexamples2.nb;
- **MBasymptotics.m** : a routine which expands Mellin-Barnes integrals in a small parameter by Michal Czakon;
  example usage is illustrated in MBasymptotics.nb;
- **MBresolve.m** : a tool by Alexander Smirnov and Vladimir Smirnov realizing another strategy of resolving singularities of Mellin-Barnes integrals. This code should be loaded together with **MB.m** since it uses some of its routines. For details see arXiv:0901.0386
- **AMBRE.m** : a tool by Janusz Gluza, Krzysztof Kajda and Tord Riemann for constructing Mellin-Barnes representations. It works both for planar multiloop scalar and one-loop tensor Feynman integrals. This is version 1.2, for previous versions and detailed description of the package with examples see the **home**

AMBRE still developing to include multiloop tensor integrals

Other packages

- hexagon is a new package for the tensor reduction of one-loop 5-point and 6-point functions with rank R=3 and R=4, respectively; T.Diakonidis's talk
- CSectors is an interface for the package sector_decomposition by Bogner and Weinzierl and allows a convenient, direct evaluation of tensor Feynman integrals (still not published)

Summary

- We continue to work on many important aspects of particle physics
- We hope for further close and fruitful cooperation with EU scientists within the Heptools network,