New facilities in CalcHEP2.5

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http://theory.sinp.msu.ru/~pukhov/calchep.html

CalcHEP: old good features

- ***user friendly interface***
- ***easy to introduce new model, already has***

  SM,MSSM,NMSSM,LHT,LZP,LeptoQuarks and now 3-site model !
- ***automatic implementation of user model using LanHEP***

  A. Semenov, http://theory.sinp.msu.ru/~semenov/lanhep.html.
  - ***automatic feynman rules generaton for CalcHEP***
  - ***allows to deal with different gauges***

    – important for the cross check
  - ***has checks for***
    - the hermiticity
    - BRST invariance
    - em charge conservation
    - particle mixings, mass terms, mass matrices
- ***CalcHEP is the generator of generators, so (recalling Konstantin's talk)***

N model builders + LanHEP + CalcHEP = N MC4BSM writers

Three Site Model Implementation with LanHEP

LanHEP

$$\mathcal{L}_{F^2} = -\frac{1}{2}\mathrm{Tr}\left(F_0^2 + F_1^2 + F_2^2\right) \quad \text{where} \quad F_j^{\mu\nu} = \partial^\mu W_j^\mu - \partial^\nu W_j^\mu + i g_j \left[W_j^\mu, W_j^\nu\right]$$

```
%%%%%%%%%%  Kinetic and self interaction Lagrangian terms.
lterm  -F**2/4  where  F=deriv^mu*W23^nu-deriv^nu*W23^mu.
lterm  -F**2/4  where  F=deriv^mu*W0^nu^a-deriv^nu*W0^mu^a-g*eps^a^b^c*W0^mu^b*W0^nu^c.
lterm  -F**2/4  where  F=deriv^mu*W1^nu^a-deriv^nu*W1^mu^a-g/x*eps^a^b^c*W1^mu^b*W1^nu^c.
```

(gauge kinetic term as an example)

lhep 3-site.mdl

CalcHEP

```
Lagrangian
P1    |P2    |P3    |P4    |>   Factor
A     |W+    |W-    |      |-g*v0g
A     |~W+   |~W-   |      |-g*v0g
W+    |W-    |Z     |      |-g/x
W+    |W-    |~Z    |      |-g/x
W+    |Z     |~W-   |      |-g/x
W+    |~W-   |~Z    |      |-g/x
W-    |Z     |~W+   |      |-g/x
W-    |~W+   |~Z    |      |-g/x
Z     |~W+   |~W-   |      |-g/x
~W+   |~W-   |~Z    |      |-g/x
A     |A     |W+    |W-    |-g**2*v0g**2
A     |A     |~W+   |~W-   |-g**2*v0g**2
A     |W+    |W-    |Z     |-g**2*v0g/x
A     |W+    |W-    |~Z    |-g**2*v0g/x
A     |W+    |Z     |~W-   |-g**2*v0g/x
A     |W+    |~W-   |~Z    |-g**2*v0g/x
A     |W-    |Z     |~W+   |-g**2*v0g/x
A     |W-    |~W+   |~Z    |-g**2*v0g/x
A     |Z     |~W+   |~W-   |-g**2*v0g/x
A     |~W+   |~W-   |~Z    |-g**2*v0g/x
W+    |W+    |W-    |W-    |g**2/x**2
W+    |W+    |W-    |~W-   |g**2/x**2
W+    |W+    |~W-   |~W-   |g**2/x**2
W+    |W-    |W-    |~W+   |g**2/x**2
W+    |W-    |Z     |Z     |-g**2/x**2
W+    |W-    |Z     |~Z    |-g**2/x**2
W+    |W-    |~W+   |~W-   |g**2/x**2
W+    |W-    |~Z    |~Z    |-g**2/x**2
W+    |Z     |Z     |~W-   |-g**2/x**2
W+    |Z     |~W-   |~Z    |-g**2/x**2
W+    |~W+   |~W-   |~W-   |g**2/x**2
W+    |~W-   |~Z    |~Z    |-g**2/x**2
W-    |W-    |~W+   |~W+   |g**2/x**2
W-    |Z     |Z     |~W+   |-g**2/x**2
W-    |Z     |~W+   |~Z    |-g**2/x**2
W-    |~W+   |~W+   |~W-   |g**2/x**2
W-    |~W+   |~Z    |~Z    |-g**2/x**2
Z     |Z     |~W+   |~W-   |-g**2/x**2
Z     |~W+   |~W-   |~Z    |-g**2/x**2
~W+   |~W+   |~W-   |~W-   |g**2/x**2
~W+   |~W-   |~Z    |~Z    |-g**2/x**2
```

Three Site Model Implementation with LanHEP

LanHEP

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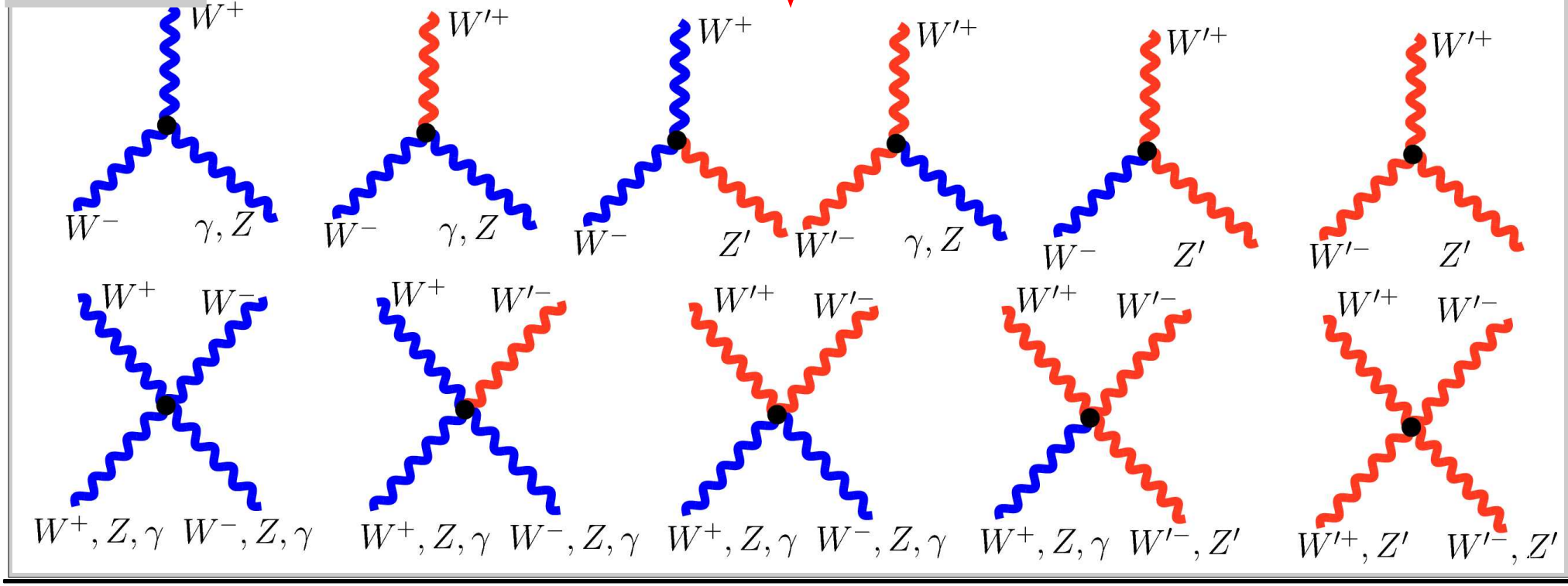
(gauge kinetic term as an example)

lhep 3-site.mdl

CalcHEP



$pp \to W^+Zjj$ signal and background calculation together

- **no effective WZ approximation**
- **complete set of signal and background diagrams incl interference**

now possible with CalcHEP in t'Hoof-Feynman gauge

CalcHEP/symb

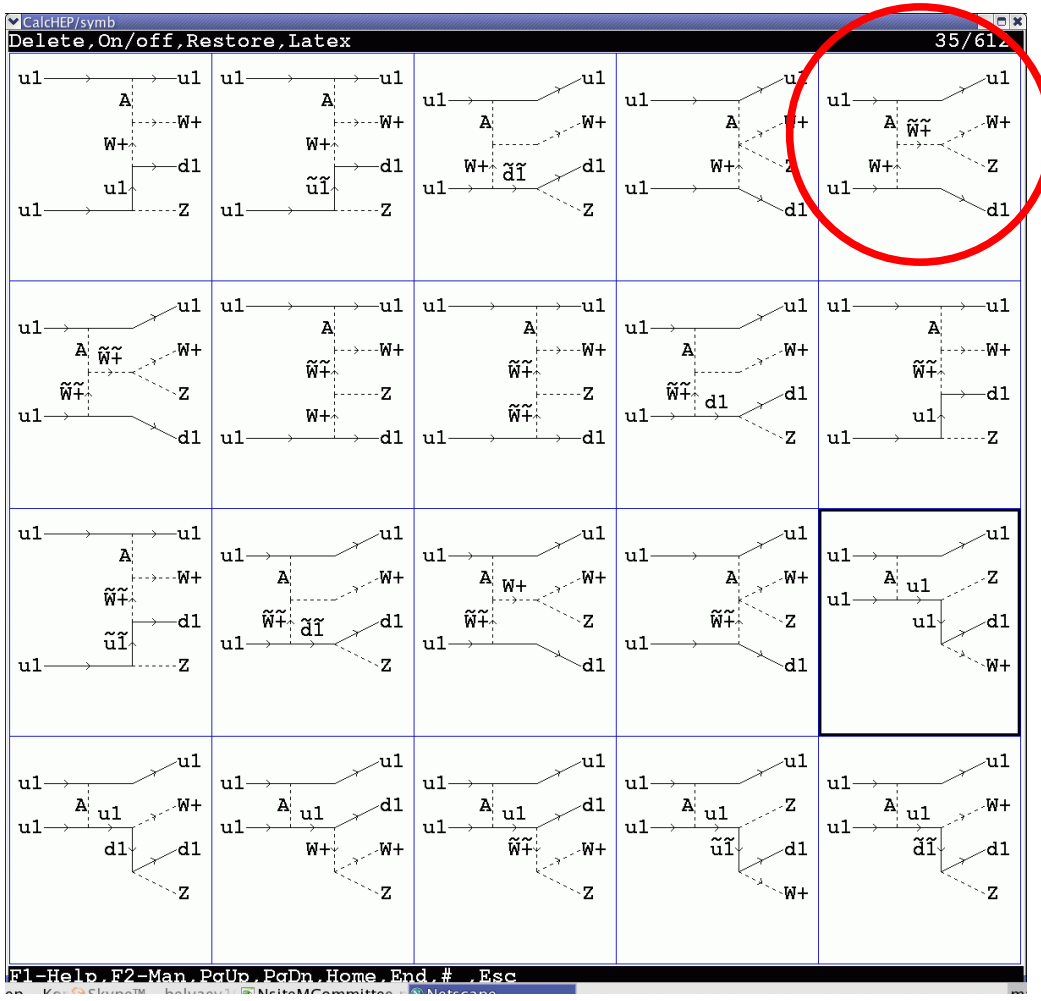
Model: 3-site-tfg

Process: p,p->W+,Z,j,j

Feynman diagrams

7816 diagrams in 21 subprocesses are constructed.
0 diagrams are deleted.

NN	Subprocess	Del	Rest
1	u1,u1 -> Z,W+,u1,d1	0	612
2	u1,U1 -> Z,W+,U1,d1	0	612
3	u1,d1 -> Z,W+,d1,d1	0	306
4	u1,D1 -> Z,W+,u1,U1	0	612
5	u1,D1 -> Z,W+,d1,D1	0	612
6	u1,D1 -> Z,W+,G,G	0	46
7	u1,G -> Z,W+,G,d1	0	76
8	U1,u1 -> Z,W+,U1,d1	0	612
9	U1,D1 -> Z,W+,U1,U1	0	306
10	d1,u1 -> Z,W+,d1,d1	0	306
11	d1,D1 -> Z,W+,U1,d1	0	612
12	D1,u1 -> Z,W+,u1,U1	0	612
13	D1,u1 -> Z,W+,d1,D1	0	612
14	D1,u1 -> Z,W+,G,G	0	46
15	D1,U1 -> Z,W+,U1,U1	0	306
16	D1,d1 -> Z,W+,U1,d1	0	612
17	D1,D1 -> Z,W+,U1,D1	0	612
18	D1,G -> Z,W+,G,U1	0	76
19	G,u1 -> Z,W+,G,d1	0	76
20	G,D1 -> Z,W+,G,U1	0	76
21	G,G -> Z,W+,U1,d1	0	76



CalcHEP 2.5: new features for event generation and interface with MC generators

- ***generates of events in cycle***
  $CALCHEP/bin/subproc_cycle [Luminosity/nEvens] [nMax]

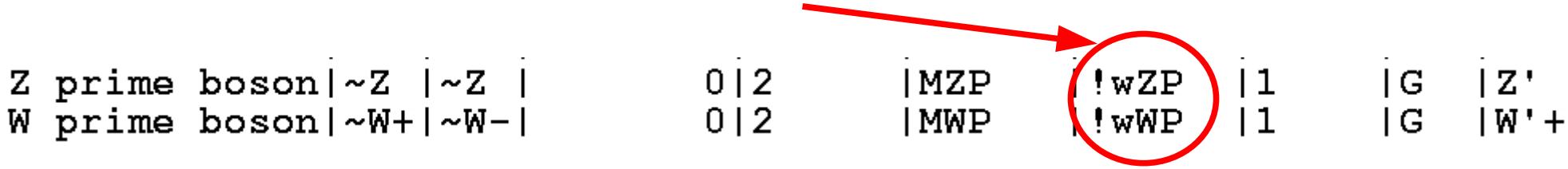
- ***links production and decay events***
  NSUB=SCANDIR(dir_name)

- ***has an interface with event generators***

  - **creates mixed events in Les Houches Accord format**
    COMMON/HEPRUP/ , /HEPEUP/
    event2pyth.c , event_mixer.f
    f77 -o event_mixer.x event_mixer.f event2pyth.c -lm
  - **reads mixed events from file into PYTHIA**
    call_pyth_mix.f
    f77 -o call_pyth_mix.x call_pyth_mix.f pythia6406.o

CalcHEP 2.5: other new features

- ***Automatic witdh calculation ("on the fly")***



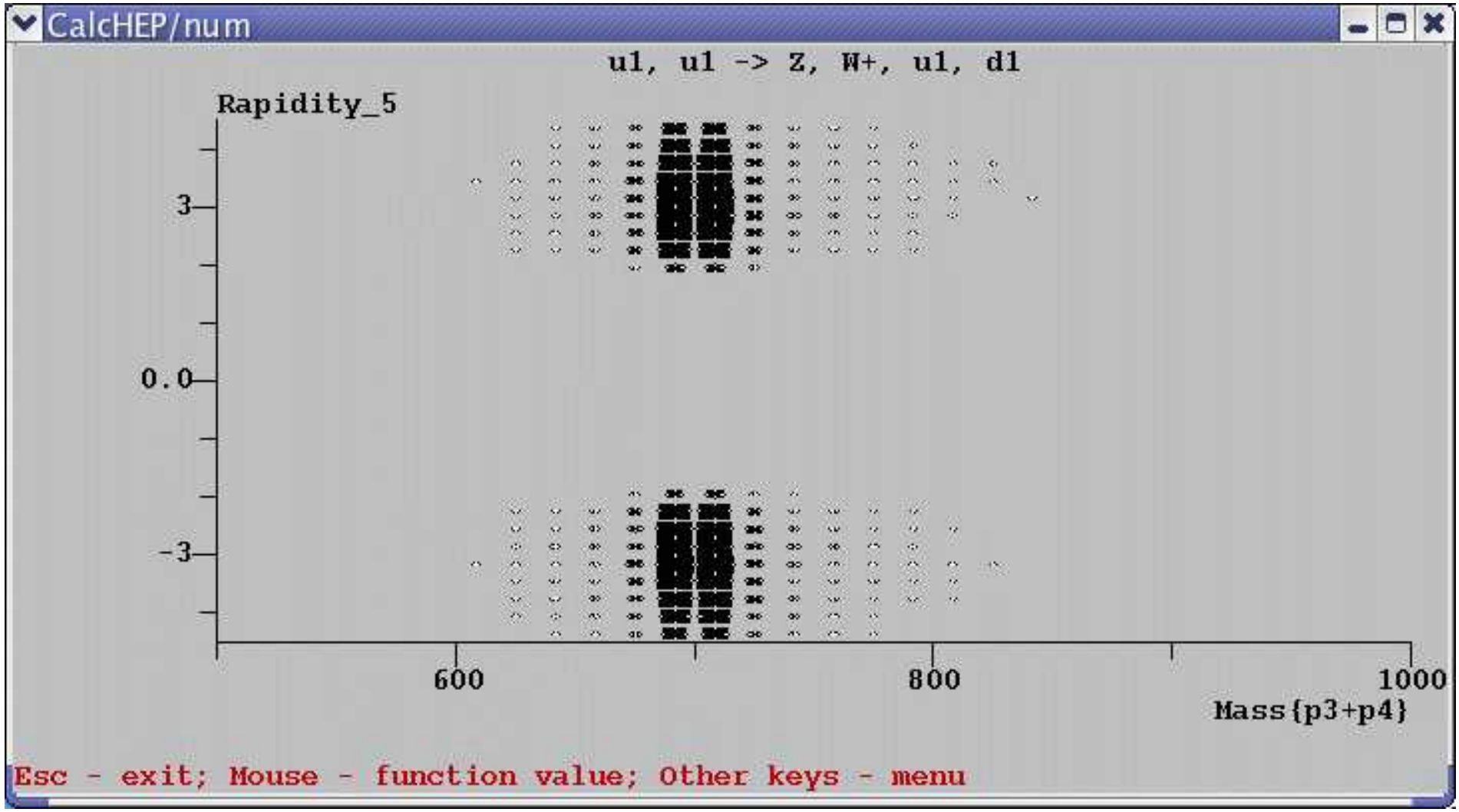
```
Z prime boson|~Z  |~Z  |        0|2      |MZP    |!wZP   |1      |G   |Z'
W prime boson|~W+|~W-|        0|2      |MWP    |!wWP   |1      |G   |W'+
```

- ***Polarized beams:*** $E\%, e\% \rightarrow 2 * x \quad or \quad A\%, A\% \rightarrow 2 * x$
- ***Spin 3/2 and spin 2 massive particles are available in CalcHEP now***
- ***2 d distributions***
- ***PAW and Gnuplot for plots***

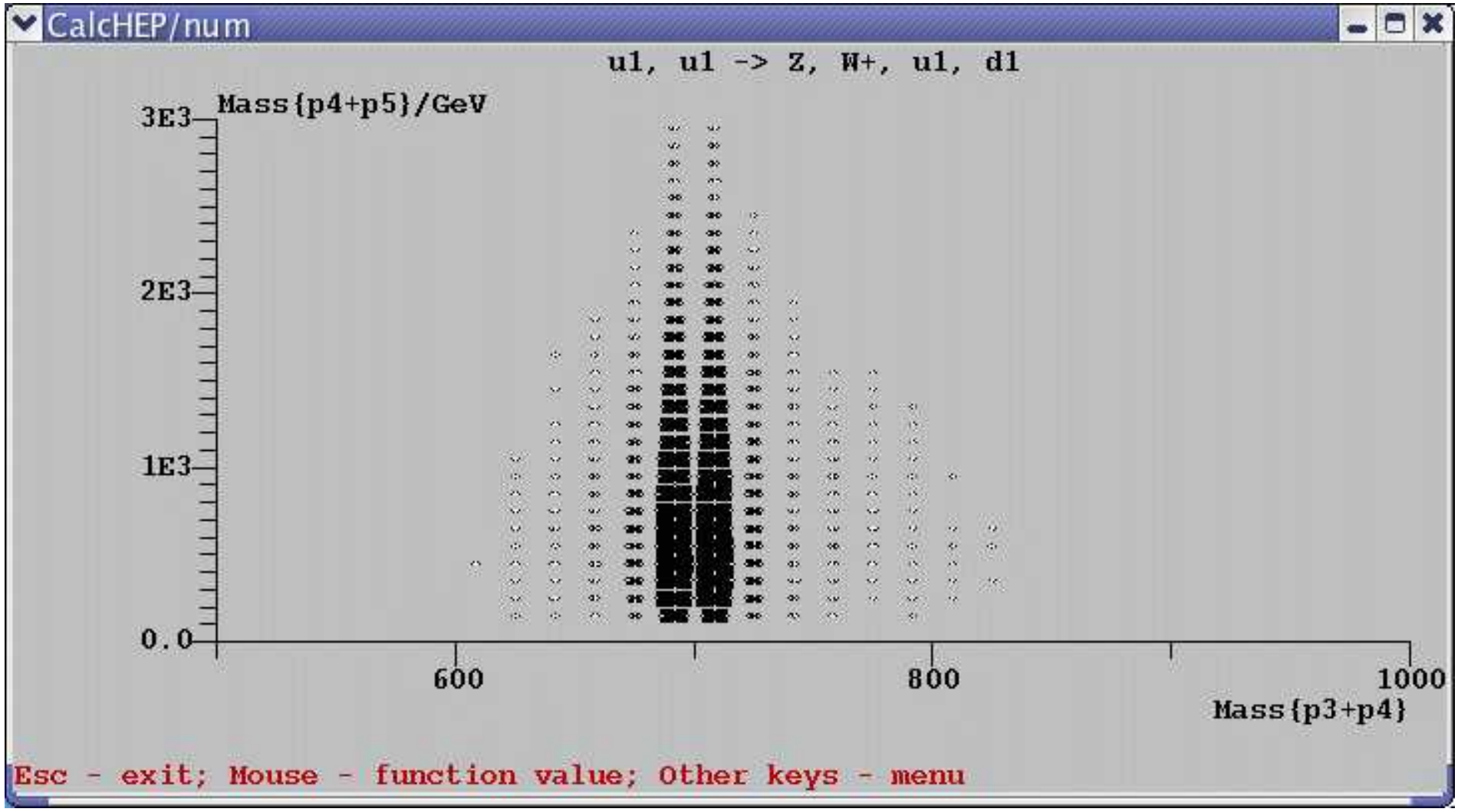
```
#--- GNUPLOT section ---
#GNUPLOT set title  'E,e ->m,M'
#GNUPLOT set xlabel 'cos(p1,p3)'
#GNUPLOT set ylabel 'Diff. cross section [pb]'
#GNUPLOT plot[-1:1] 'plot_1.txt' using (-1 +$0*0.02):1 w l
```

```
#--- PAW section ---
#PAW  TITLE 'E,e ->m,M'
#PAW  vector/Create X1(101)
#PAW  sigma X1=ARRAY(101,-1#1)
#PAW  vector/Create Y1(101)
#PAW  vector/Read Y1 'plot_1.txt' ' ' 'OC
#PAW  GRAPH 101 X1 Y1
```

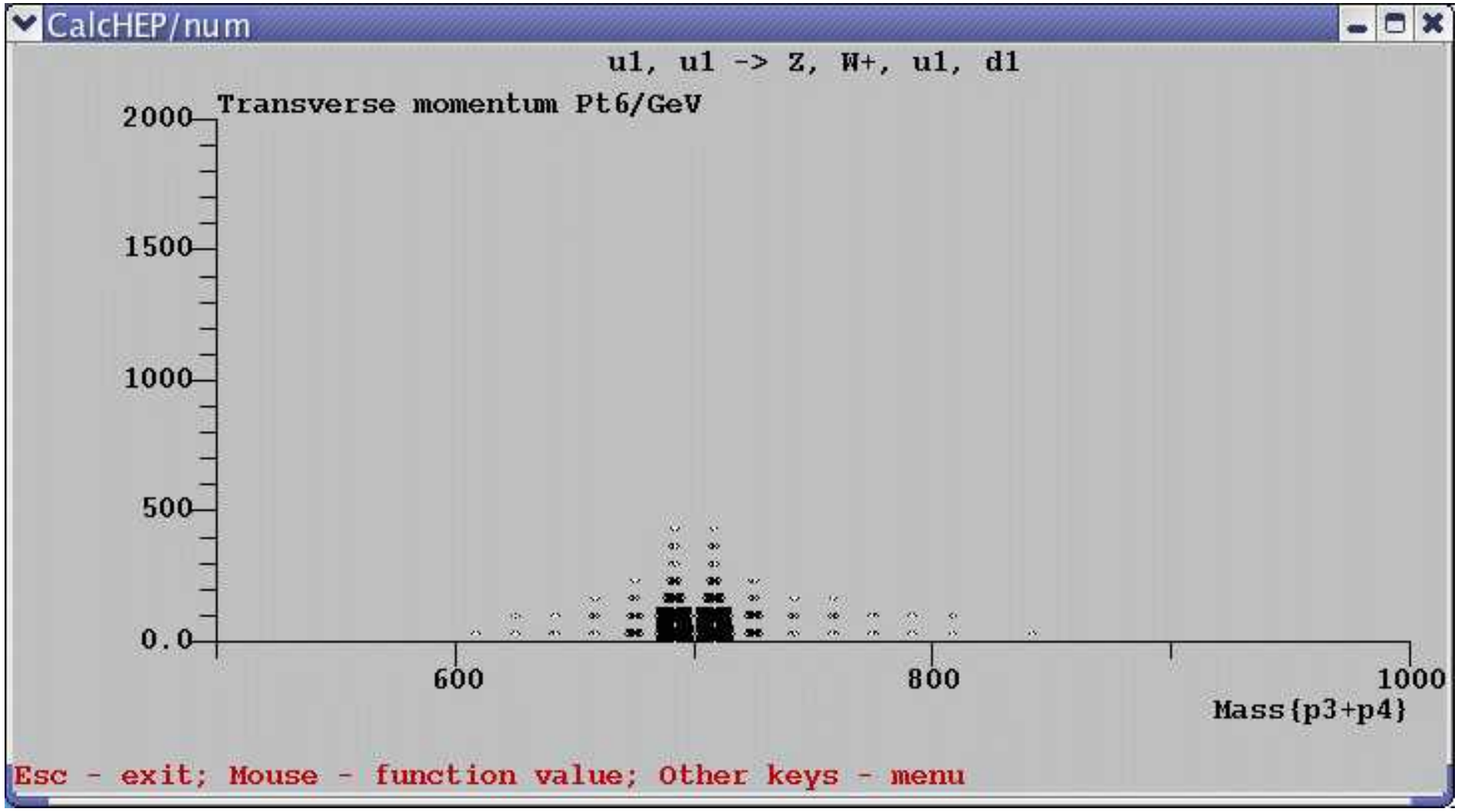
CalcHEP 2.5: examples of 2d plots



CalcHEP 2.5: examples of 2d plots



CalcHEP 2.5: examples of 2d plots



Future prospects

- *cuts generalization*
- *QCD scale definition (leading diagram)*
- *laser photon distribution sensitive to polarizations of incoming electron beam and photon*
- *polarization for massive particles*
- *dynamical linking, like in micrOMEGAs package*