Track3

Methodology of Computations in Theoretical Physics

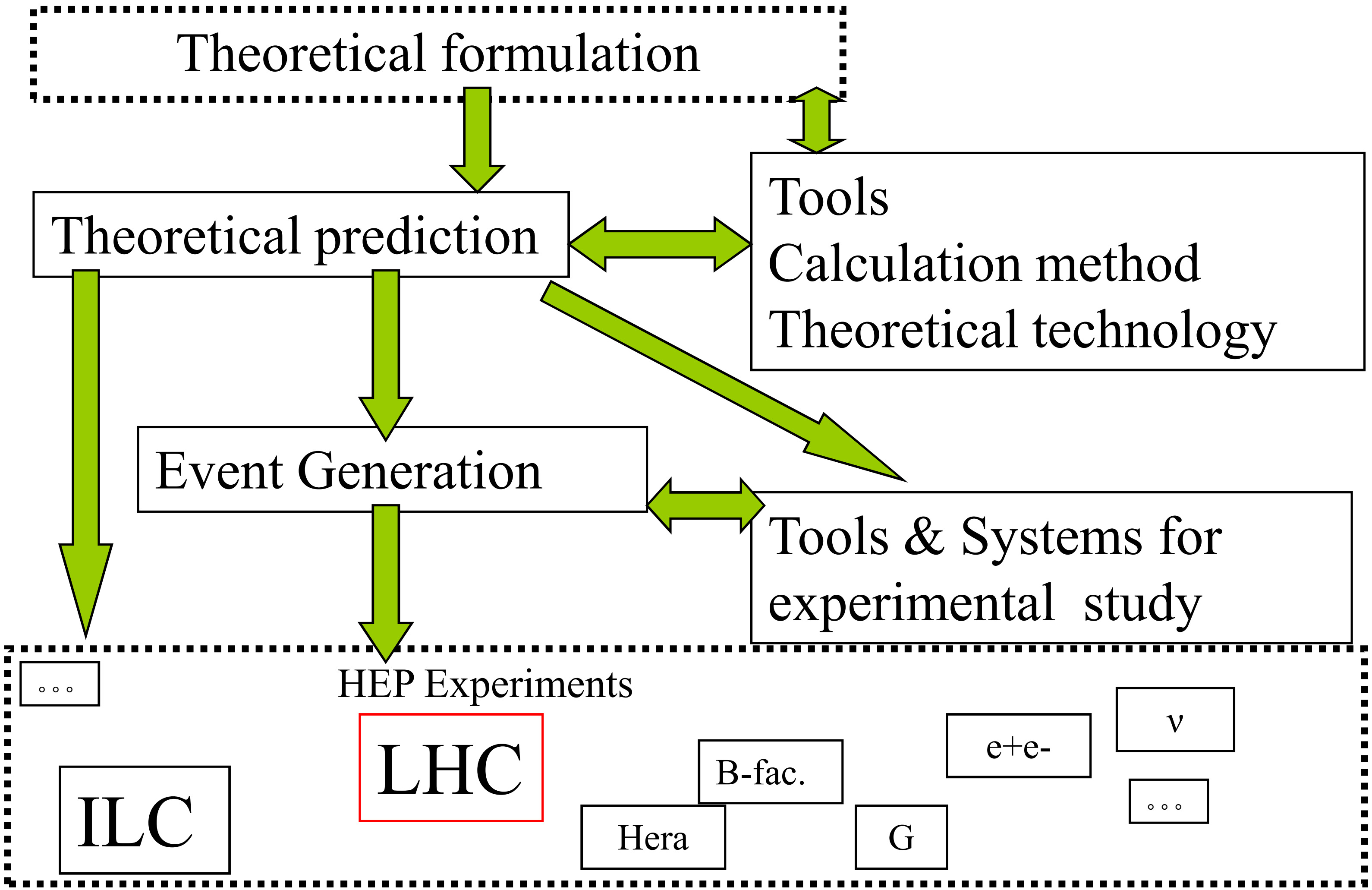
ACAT2008
2008.11.2-7, Erice
K.Kato(Kogakuin U.)

Track3

21 parallel presentations
(and several Plenary presentations) plenary

Advanced Computing and
Analysis Techniques
in Physics Research
… Most talks are on HEP.

HEP


Theoretical formulation
Theoretical prediction
Tools
Calculation method
Theoretical technology
Event Generation
Tools & Systems for
experimental study
HEP Experiments
。。。
ILC
LHC
B-fac.
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。。。

The Art of pert.QCD

GOOD TALKS! PLEASE LOOK SLIDES ON WEB

[6] Andrei KATAEV Higgs bbbar decay at NNLO and beyond : the uncertainties of QCD predictions *plenary*

$\Gamma(H \to b\bar{b})$ upto α_s^4

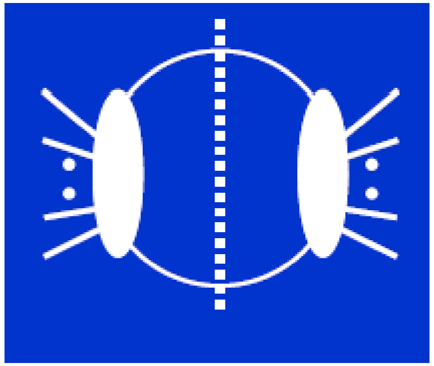
[181] Thomas BINOTH LHC phenomenology at next-to-leading order QCD: theoretical progress and new results *plenary*

Good review & GOLEM project including $pp \to b\bar{b}b\bar{b}$

Unitarity method

[206]W.Perkins Unitarity Methods for 1-loop amplitude

$$\frac{1}{(l-K)^2+i\epsilon} \to \delta((l-K)^2)$$



$$A_n^{1-\mathrm{loop}} = \sum_i c_i\, I_4^I + \sum_j d_j\, I_3^j + \sum_k e_k\, I_2^k + R$$

Boxes: quad cut, algebra
Triangles: triple cut leaves a 1 param. integral
Bubbles: double cut leaves 2 param. integral
Numerical Implementations
CutTools   BlackHat

- Canonical basis approach produces clean expressions
- Already used extensively for 6 gluon scattering

Unitarity Method vs Feynman

T.Binoth

colour ordered N-gluon amplitudes:

• unitarity based method

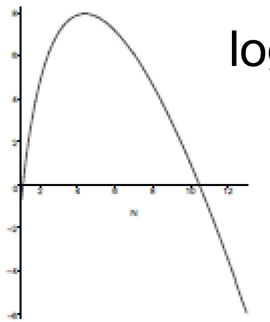
$\sim \tau(\text{Tree}) \times \tau(\#\text{ cuts}) \sim N^9$

• Feynman diagrams

$\sim \tau(\#\text{Formfactors}) \times \#\text{Diagrams} \sim \Gamma(N)\, 2^N$

• asymptotic behaviour not relevant for LHC region $N \leq 8$

• for LHC both methods can/will do the job!



$$\log \frac{N^9}{\Gamma(N) 2^N}$$

Multiloop, massive particles

•Unitarity method … In progress

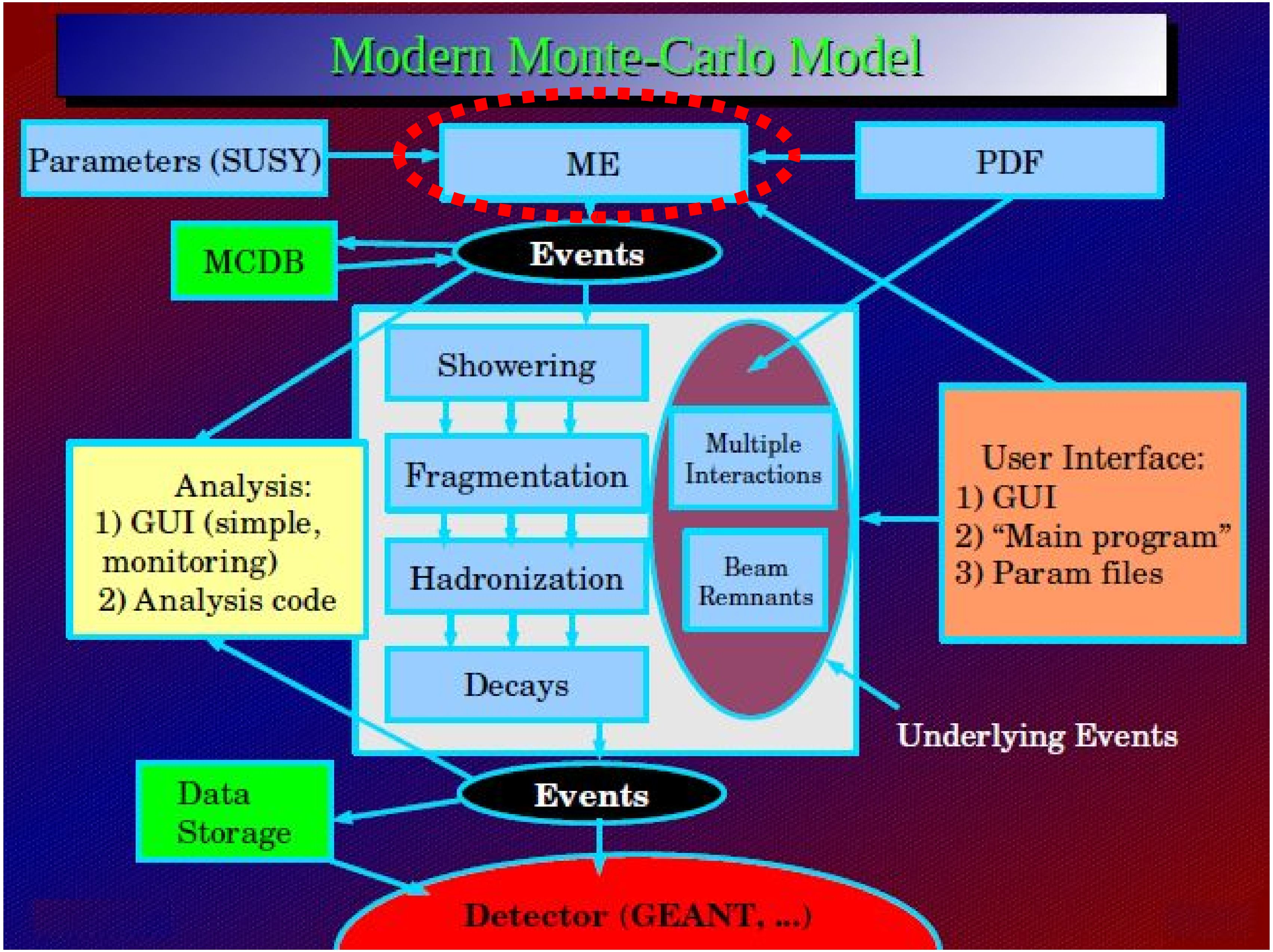
•Feynman diagrams … established, not easy

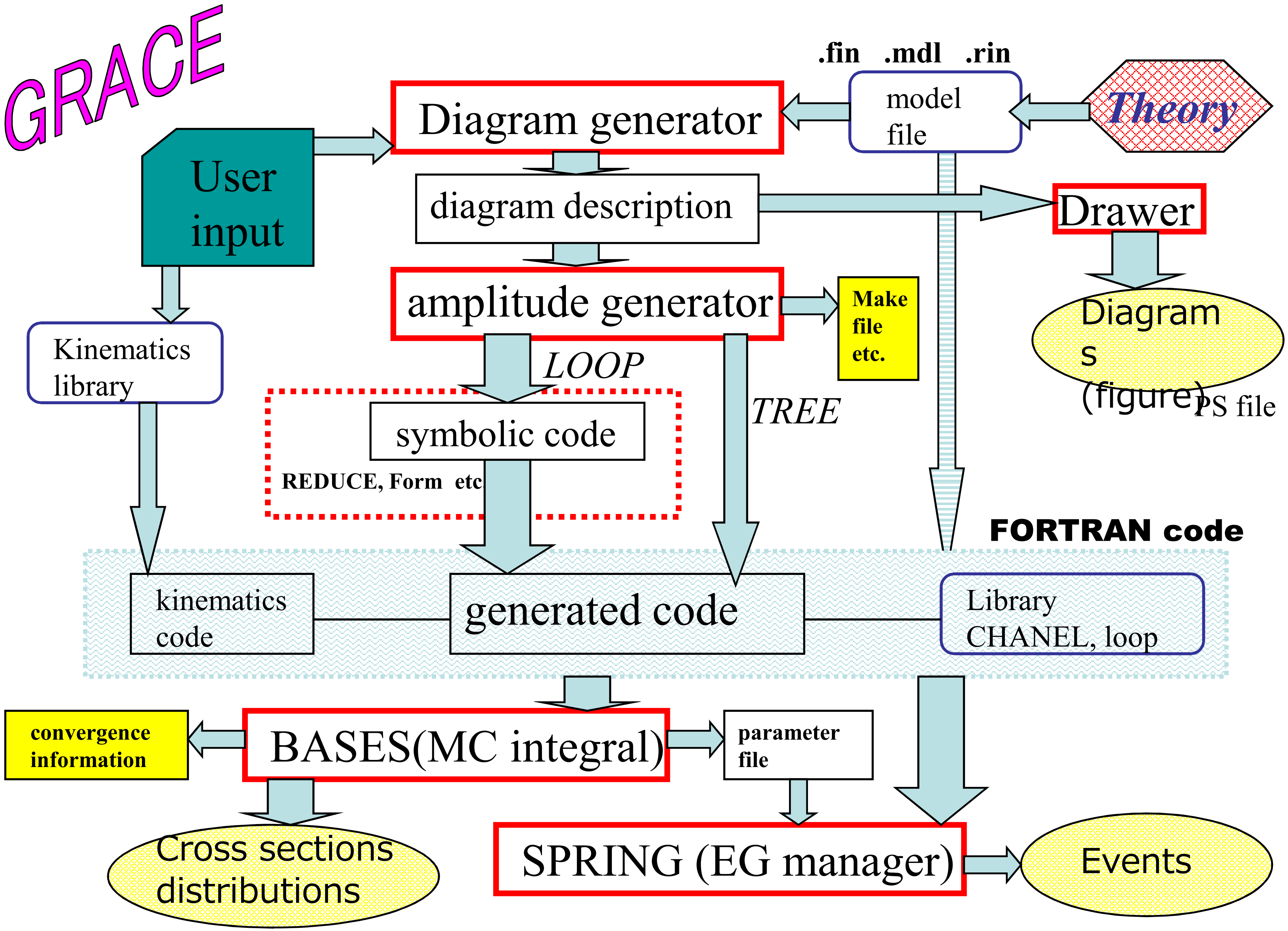
Automated systems

GRACE	Prog. Theor. Phys. Suppl. 138 (2000) 18
	Comput. Phys. Commun. 153 (2003) 106
CompHEP	Nucl. Instrum. Meth. A534 (2004) 250
CalcHEP	hep-ph/0412191
FeynArt/FormCalc	Comput.Phys.Commun. 140 (2001) 418; 143 (2002) 54
MadGraph	JHEP 0302 (2003) 027

Increasing collider energy and luminosity require calculations of processes
with more and more particles in the final state
with better and better precision
→ large scale computation
→ beyond man power (Human sometimes mistakes!)

[209]A.Sherstnev Monte-Carlo event generator CompHEP (version 4.5) *plenary*
[226]Y.Kurihara Recent developments of GRACE
[216]T.Hahn FormCalc 6


Modern Monte-Carlo Model
Parameters (SUSY)
ME
PDF
MCDB
Events
Showering
Fragmentation
Hadronization
Decays
Multiple Interactions
Beam Remnants
Analysis:
1) GUI (simple, monitoring)
2) Analysis code
User Interface:
1) GUI
2) "Main program"
3) Param files
Underlying Events
Data Storage
Events
Detector (GEANT, ...)


GRACE
.fin .mdl .rin
Theory
model file
Diagram generator
User input
diagram description
Drawer
amplitude generator
Make file etc.
Diagram s (figure)
PS file
Kinematics library
LOOP
TREE
symbolic code
REDUCE, Form etc
FORTRAN code
kinematics code
generated code
Library CHANEL, loop
convergence information
BASES(MC integral)
parameter file
Cross sections distributions
SPRING (EG manager)
Events

CompHEP *plenary*

Sherstnev

Goals:

- Automation of tree level diagram calculations
- "Unification" of symbolical and numerical calculation a full computational chain for phenomenologists
- Interfacing to other generators (for showering and hadronization) and further (full simulation)
- Interfacing to NLO codes: cross section calculators, mass spectrum calculators

Flexibility for New (user-defined) Models

LanHEP – a program for generation of Feynman rules for user-defined model (**developed by A.Semenov**)

Works with super-multiplets and superpotential

Generates all needed files for CompHEP (also FeynArts and LaTeX format)

Options for self-checking (charge conservation, BRST invariance, etc.)

Has been used for CompHEP SUSY models and many other BSM models

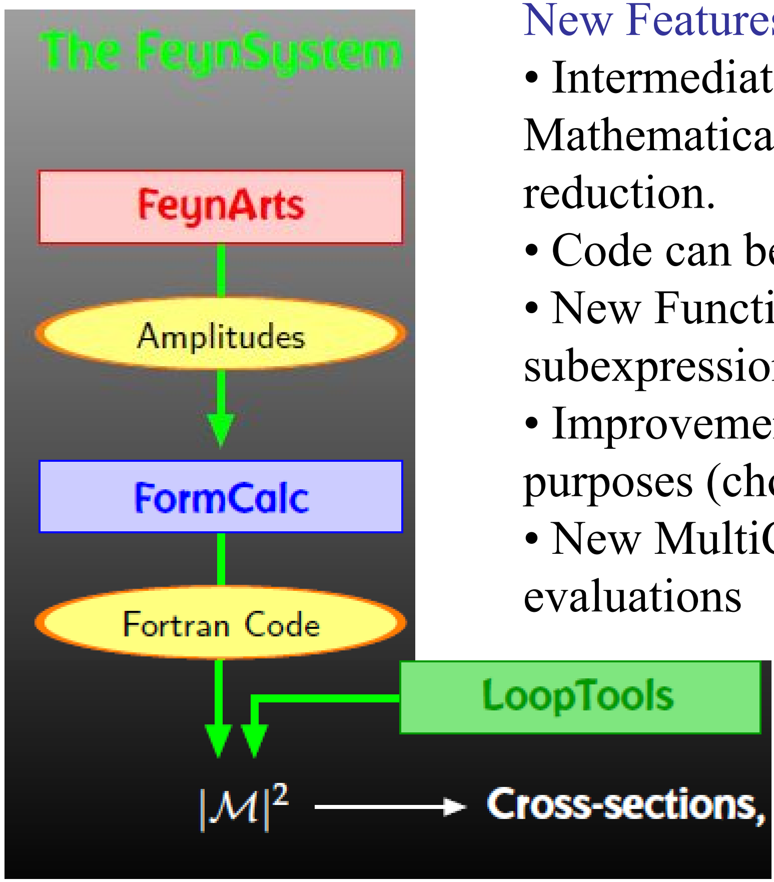
GRACE

Kurihara

- GRACE (EW, QCD, MSSM)
  tree-level computation, available from GRACE Web
- GRACE/SUSY/loop EW/MSSM 1-loop processes
  RC for ILC Higgs physics, RC for *ino decay
- NLO-QCD event generators in GRACE
  toward full automation for QCD processes
  (based on subtraction method, phase-space slicing)
- NLO event generators in GR@PPAframework
- Tool development (other talks)

Feynart/Calc

Hahn



New Features in Version 6

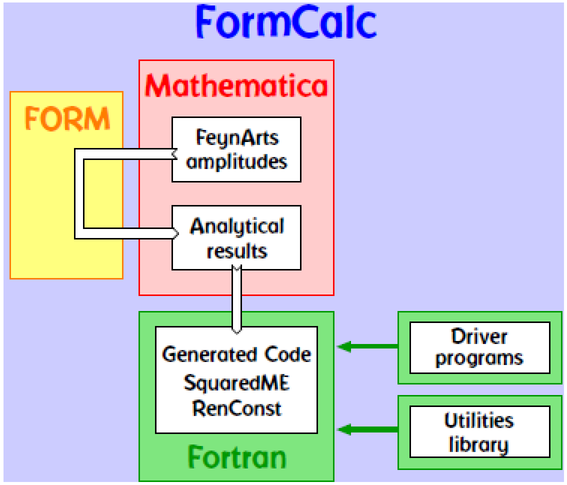
• Intermediate FORM expressions get sent to Mathematica for abbreviations → significant size reduction.

• Code can be generated for the CutTools library.

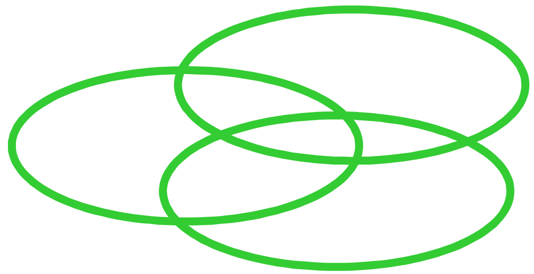
• New Functions for registering abbreviations and subexpressions allow to `resume' sessions.

• Improvements in 4D Dirac chains for analytical purposes (choice of ordering, antisymmetrization).

• New MultiCore Package parallelizes Mathematica evaluations



Loop world



[196] Takahiro UEDA New implementation of the sector decomposition on FORM

[170] Tord RIEMANN New results for loop integrals

[194] Fukuko YUASA Numerical Evaluation of Feynman Integrals by a Direct Computation Method

Loop calculation is the key tool for higher order computation.
Many trial can be possible… including experimental stage…

Sector decomposition

- Sector decomposition algorithm disentangle such singularities

(for example)

T.Binoth & G.Heinrich, NPB585 (2000) 741
T.Binoth & G.Heinrich, NPB680 (2004) 375

$$\int_0^1 dx \int_0^1 dy \frac{f(x,y)}{(x+y)^{2-\epsilon}}$$

singular when $x, y \to 0$

split integration domain

$$= \int_0^1 dx \int_0^x dy \frac{f(x,y)}{(x+y)^{2-\epsilon}} + \int_0^1 dy \int_0^y dx \frac{f(x,y)}{(x+y)^{2-\epsilon}}$$

$x > y$ $\quad$ $y > x$

map to [0,1] $\quad y \to xy$

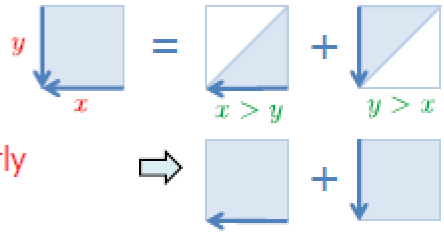
similarly

$$\int_0^1 dx \int_0^1 x dy \frac{f(x,xy)}{(x+xy)^{2-\epsilon}}$$

factorize x

$$= \int_0^1 dx \int_0^1 dy\, x^{-1+\epsilon} \frac{f(x,xy)}{(1+y)^{2-\epsilon}} + \int_0^1 dx \int_0^1 dy\, y^{-1+\epsilon} \frac{f(xy,y)}{(1+x)^{2-\epsilon}}$$

singular when $x \to 0$ $\quad$ singular when $y \to 0$



- Then one can easily extract poles as

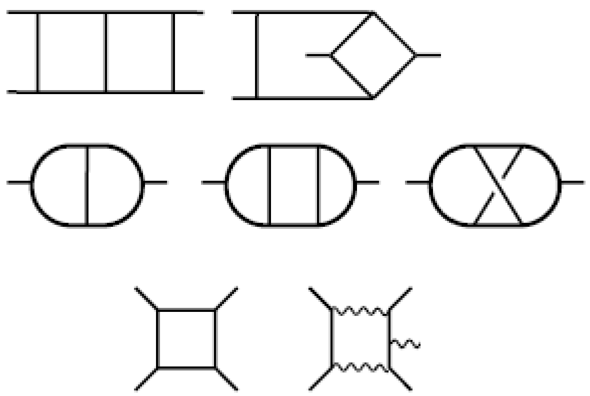
$$\int_0^1 dx\, x^{-1+\epsilon} f(x) = \frac{f(0)}{\epsilon} + \int_0^1 dx\, x^{\epsilon} \frac{f(x) - f(0)}{x}$$

singular when $x \to 0$ $\quad$ pole $\quad$ non-singular

	B	DB	TB	QB
# sectors	12	293	10915	661484

Use symbolic manipulation program FORM
→overcome the memory problem

Numerical Results given

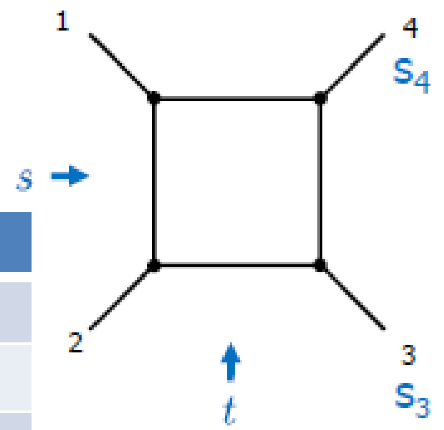


Ueda

An example of results

- Massless box with two adjacent off-shell legs

$I_4^{2mh}/\Gamma(2+\epsilon)$ s=123, t=-200, s_3=50, s_4=60



		Numerical Result	Analytic Result(*)
ϵ^{-2}	Re	-0.406504064273E-04	-0.406504065041E-4
	Im	0.763198172102E-16	0
ϵ^{-1}	Re	-0.341563066836E-03	-0.341563069952E-3
	Im	-0.127707015460E-03	-0.127707018439E-3
ϵ^{0}	Re	-0.149295025998E-02	-0.149295024564E-2
	Im	-0.287455792563E-03	-0.287455926817E-3

19min @ Core2 2.6GHz, DQAG
(double precision, requested $E_{rel}=10^{-8}$ for each integrals)

* Analytic result can be found in
G.Duplancic & B.Nizic, Eur.Phys.J.C20 (2001) 357
Y.Kurihara, Eur.Phys.J.C45 (2006) 427

T.Riemann

hexagon.m – A new code for algebraic reduction of one-loop tensor integrals to scalar 2-,3-,4-point functions [new]

CSectors.m – Use sector decomposition to tensor integrals – numerical approach [an interface]

AMBRE.m – Derive Mellin-Barnes representations for multi-loop tensor integrals without restriction to the loop-by-loop-method [an update]

Riemann

A five-point tensor coefficient: $p_1^\mu p_1^\nu p_1^\lambda E_{\mu\nu\lambda}$
Point: $p_1^2 = p_2^2 = p_3^2 = p_5^2 = 1,\ p_4^2 = 0,\ m_1^2 = m_3^2 = 0,\ m_2^2 = m_4^2 = m_5^2 = 1,$ $s_{12} = -3,\ s_{23} = -6,\ s_{34} = -5,\ s_{45} = -7,\ s_{15} = -2$
`In: RedE3[` $p_1^2, \ldots, p_5^2, s_{12}, s_{23}, s_{34}, s_{45}, s_{15}, m_1^2, \ldots, m_5^2$ `]/.{D4->D0,C3->C0,B2->B0}`   `Out: 0.218741`
A six-point scalar function: F_0
Point: $p_1^2 = p_2^2 = p_3^2 = p_4^2 = p_5^2 = p_6^2 = -1,\ m_1^2 = m_2^2 = m_3^2 = m_4^2 = m_5^2 = m_6^2 = 1,$ $s_{12} = s_{23} = s_{34} = s_{45} = s_{56} = s_{16} = s_{123} = s_{234} = -1,\ s_{345} = -5/2$
`In: RedF0[` $p_1^2, \ldots, p_6^2, s_{12}, s_{23}, s_{34}, s_{45}, s_{56}, s_{16}, s_{123}, s_{234}, s_{345}, m_1^2, \ldots, m_6^2$ `]/.{D4->D0}`   `Out: 0.013526`
Several five-point vector and tensor coeff.: $E_0,\ E_1,\ E_2,\ E_3,\ E_4,\ E_{34},\ E_{123},\ E_{002}$
Point: $p_1^2 = p_2^2 = 0,\ p_3^2 = p_5^2 = 49/256,\ p_4^2 = 9/100,\ m_1^2 = m_2^2 = m_3^2 = 49/256,\ m_4^2 = m_5^2 = 81/1600,$ $s_{12} = 4,\ s_{23} = -1/5,\ s_{34} = 1/5,\ s_{45} = 3/10,\ s_{15} = -1/2$

`In: RedE0[` $p_1^2, \ldots, p_5^2, s_{12}, s_{23}, s_{34}, s_{45}, s_{15}, m_1^2, \ldots, m_5^2$ `]/.D4->D0`
 `Out: 41.3403 - 45.9721*I`
 `In: RedEget[rank1 ,` $p_1^2, \ldots, p_5^2, s_{12}, s_{23}, s_{34}, s_{45}, s_{15}, m_1^2, \ldots, m_5^2$ `]/.D4->D0`
 `Out: ee1 =-2.38605 + 5.27599*I, ee2 =-5.80875 + 0.597891*I,`
 `ee3 =-14.4931 + 20.8149*I, ee4 =-11.3362 + 18.1593*I`
 `In: RedEcoef[ee34 ,` $p_1^2, \ldots, p_5^2, s_{12}, s_{23}, s_{34}, s_{45}, s_{15}, m_1^2, \ldots, m_5^2$ `]/.{D4->D0,C3->C0}`
 `Out: 7.1964 + 3.10115*I`
 `In: RedEcoef[ee123 ,` $p_1^2, \ldots, p_5^2, s_{12}, s_{23}, s_{34}, s_{45}, s_{15}, m_1^2, \ldots, m_5^2$ `]/.{D4->D0,C3->C0,B2->B0}`
 `Out:-0.149527 - 0.31059*I`
 `In: RedEcoef[ee002 ,` $p_1^2, \ldots, p_5^2, s_{12}, s_{23}, s_{34}, s_{45}, s_{15}, m_1^2, \ldots, m_5^2$ `]/.{D4->D0,C3->C0,B2->B0}`
 `Out: 0.154517 - 0.387727*I`

Numerical example of `hexagon.m`

“Direct” Computation Method

$$I[\varepsilon] = \int \frac{1}{(D - i\varepsilon)^n}[dx]$$

Take ε→ 0. Integrand : Hyperfunction

Keep εfinite. Purely numerical evaluation possible.

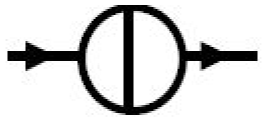
Estimate ε→ 0 limit from I[ε_j] series.

Numerical Integration
- DQAGE in QUADPACK
by E. de Doncker et al.
- Double Exponential formulas (DE)

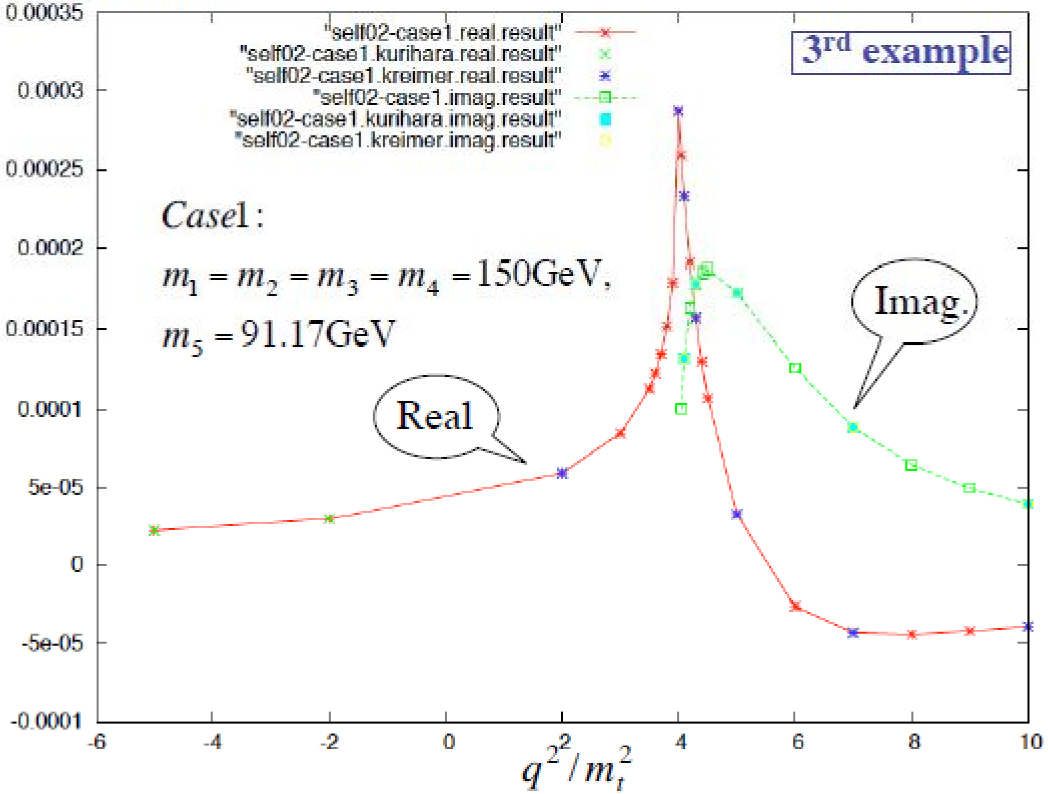
εextrapolation
- Wynn’s epsilon algorithm
- Aitken extrapolation

Parallel computation is introduced and tested scalability.

2-loop integration : self energy



Case1



13

DIS, Moments, Sums…

[56] Mikhail ROGAL Computational aspects for three-loop DIS calculations

[180] Johannes BLUEMLEIN From moments to functions in higher order QCD

[207] Yoshimasa KURIHARA Numerical calculations of Multiple Polylog functions

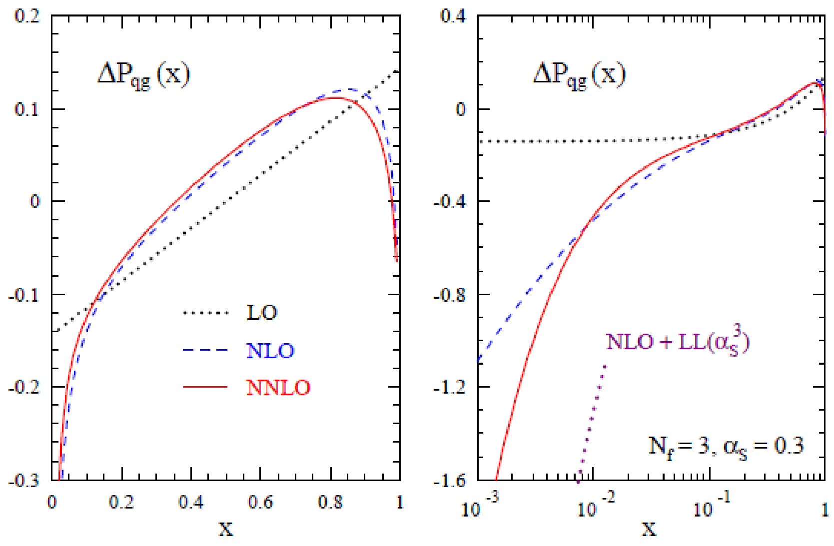
3-loop DIS

Rogal

- The *recipe* for higher order DIS calculations has been described
- Application examples:
  - Charged Current DIS
    S. Moch, M. Rogal, Nucl.Phys.B782 '07
    S. Moch, M. Rogal, A. Vogt, Nucl.Phys.B790:317-335, '07
    M. Rogal, arXiv:0711.0521 [hep-ph]
  - 3-loop splitting functions for polarized DIS
    A. Vogt, S. Moch, M. Rogal, J.A.M. Vermaseren, arXiv:0807.1238 [hep-ph] '08

Polarized DIS: The spin splitting function ΔP_{qg} to NNLO

Vogt, Moch, Rogal, Vermaseren '08



From Moments to Functions in Higher Order QCD

•Single Scale quantities depend on a scale z $\in$ [0, 1], with z a ratio of Lorentz invariants. One may perform a Mellin Transform over z

$$\int_0^1 dz z^{N-1} f(z) = M[f](N)$$

• Here one assumes N $\in$ N,N > 0.
Due to this the problem on hand becomes discrete.
• One may seek a description in terms of difference equations.

Problem: Rreconstruct the general formula for Single Scale quantities out of a finite number of fixed moments.
• Possible for recurrent quantities.
→Design a general formalism to solve the problem

Example: Harmonic Sums or linear combinations

$$F(N+1) - F(N) = \frac{\text{sign}(a)^{N+1}}{(N+1)^{|a|}} \longrightarrow S_a(N)$$

Application to 3-Loop Anomalous Dimensions and Wilson coefficients

- We carry out all algebraic reductions, J.B. 2003.
- Different color factor contributions lead to the same or nearly the same amount of sums at a given quantity.
- This points to the fact that the amount of harmonic sums is governed by topology rather than the fields and color.
- The linear harmonic sum representations by Vermaseren et al. 2004/05 require many more sums than our representation.
- There are reductions in the number of sums as $264 \longrightarrow 29$.
- Further use of structural relations will lead to maximally 35 sums for the 3-loop Wilson coefficients; J.B. 2008.

Multiple polylogarithm function

Multiple Polylog functions are often appered in the higher loop calculations.
Fast and numericaly stable evaluation for MPLs is highly desireble.

$$Li(w_1,\ldots,w_n;x_1,\ldots,x_n)=\sum_{0<i_1<i_2<\ldots<i_n}^{\infty}\frac{x_1^{i_1}}{i_1^{w_1}}\frac{x_2^{i_2}}{i_2^{w_2}}\cdots\frac{x_n^{i_n}}{i_n^{w_n}}$$

w=weight
=sum of w_j

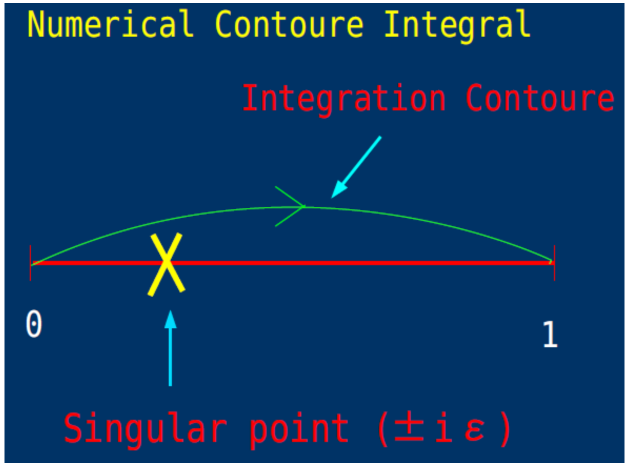
n=deapth

Kurihara

Numerical evaluation of MPLs

Mathematica
- Generation of MPL formula
- Integrate first variable
- Partial Fractioning
- Transformation

FORTRAN
- Numerical integration of NCI Procedure



Li		NCI		GiNaC (*)	
w	x	Real	Imag	Real	Imag
1,1	8/3,1/5	-0.82059	-0.70103	-0.8205920	-0.7010261
2,2,1	0.1,0.2,0.3	3.5544E-07	0	3.55437E-07	0
2,2,1	3.0,2.0,0.2	-0.7889	0.5792	-0.78907	0.57917
2,3,2	0.1,0.2,0.3	1.7734E-07	0	1.77328E-07	0
2,3,2	2.0,3.0,4.0	-10.043	2.123	-	-
2,1,2,3	0.1,0.2,0.3,0.4	1.621E-10	0	1.62105E-10	0
2,1,2,3	2,3,4,5	75.38	-72.26	-	-

[38] mikhail KALMYKOV Feynman Diagrams, Differential Reduction and Hypergeometric Functions

Hypergeometric Functions

- as an integral of the Euler or Mellin-Barnes type;
- by a series whose coecients satisfy certain recurrence relations;
- as a solution of a system of dierential and/or dierence equations (holonomic approach).

Application to Feynman diagrams: a few examples

- The all-order ε-expansion of the one-loop propagator with an arbitrary values of masses and external momentum in terms of Nielsen polylog.
  A.I.Davydychev, 1999; A.I.Davydychev & M.K., 2000, 2001;
- The term linear in ε for the one-loop vertex diagram with onexceptional kinematics in terms of Nielsen polylogarithms
  Nierste, Mueller, Boehm, 1993
- The all-order ε-expansion for the one-loop vertex with non-exceptional kinematics in terms of multiple polylogarithms of two variables:
  Davydychev, 2006; Tarasov, 2008

q-loop sunset-type propagator

M.K., JHEP, 2006

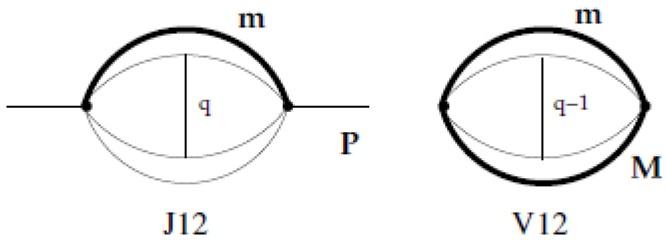


Figure 1: Bold and thin lines correspond to massive and massless propagators, respectively.

$$J_{12}(\alpha_1, \alpha_2, \cdots, \alpha_q, \beta, m^2, p^2) = \int \frac{d^n k_1 d^n k_2 \cdots d^n k_q}{[k_1^2 + m^2]^{\beta}[(k_1 - k_2 - \cdots - k_q - p)^2]^{\alpha_1}[k_2^2]^{\alpha_2} \cdots [k_q^2]^{\alpha_q}}$$

$$= \left[\Pi_{l=1}^{q} \frac{\Gamma\left(\frac{n}{2} - \alpha_l\right)}{\Gamma(\alpha_l)}\right] \pi^{qn/2} (m^2)^{qn/2-\beta-\alpha} \times \frac{\Gamma\left(\alpha + \beta - \frac{n}{2} q\right) \Gamma\left(\alpha - \frac{n}{2}(q-1)\right)}{\Gamma(\beta)\Gamma\left(\frac{n}{2}\right) \Gamma^q\left(3 - \frac{n}{2}\right)} \times {}_2F_1\left(\begin{array}{c} \alpha - \frac{n}{2}(q-1), \alpha + \beta - \frac{n}{2} q \\ \frac{n}{2} \end{array} \middle| -\frac{p^2}{m^2} \right),$$

$$\alpha = \sum_{r=1}^{q} \alpha_r$$

$$V_{12}(\alpha_1, \alpha_2, \cdots, \alpha_p, \beta_1, \beta_2, m^2, M^2) = \int \frac{d^n k_1 d^n k_2 \cdots d^n k_q}{[k_p^2 + m^2]^{\beta_1}[(k_{p-1}^2 + M^2]^{\beta_2}[k_1^2]^{\alpha_1} \cdots [(k_p - k_1 - k_2 - \cdots - k_{p-1})^2]^{\alpha_{\cdot}}}$$

$$= \left[\Pi_{l=1}^{q-1} \frac{\Gamma\left(\frac{n}{2} - \alpha_l\right)}{\Gamma(\alpha_l)}\right] \frac{\pi^{qn/2} (m^2)^{qn/2-\beta_1-\beta_2-\alpha}}{\Gamma(\beta_1)\Gamma(\beta_2)\Gamma\left(\frac{n}{2}\right) \Gamma^q\left(3 - \frac{n}{2}\right)}$$

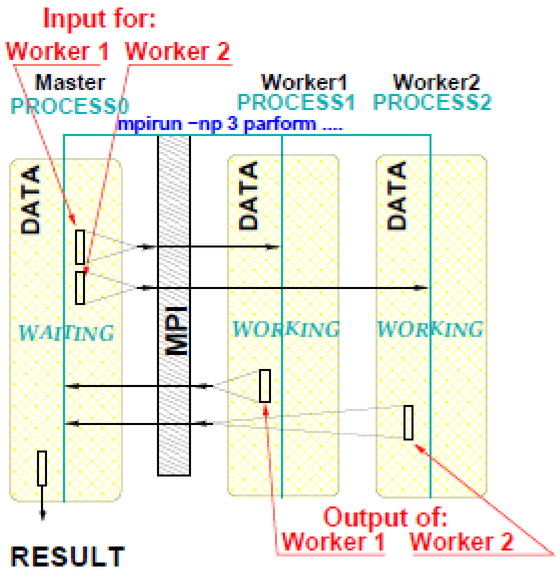
$$\times \left\{ \Gamma\left(\frac{n}{2} - \beta_2\right) \Gamma\left(\alpha + \beta_2 - \frac{n}{2}(q-1)\right) \Gamma\left(\alpha + \beta_1 + \beta_2 - \frac{n}{2} q\right) \times {}_2F_1\left(\begin{array}{c} \beta_1 + \beta_2 + \alpha - \frac{n}{2} q, \alpha + \beta_2 - \frac{n}{2}(q-1) \\ 1 + \beta_2 - \frac{n}{2} \end{array} \middle| \frac{M^2}{m^2} \right) \right.$$

$$\left. + \Gamma\left(\beta_2 - \frac{n}{2}\right) \Gamma\left(\alpha + \beta_1 - \frac{n}{2}(q-1)\right) \Gamma\left(\alpha - \frac{n}{2}(q-2)\right) \left(\frac{M^2}{m^2}\right)^{n/2-\beta_2} {}_2F_1\left(\begin{array}{c} \alpha - \frac{n}{2}(q-2), \alpha + \beta_1 - \frac{n}{2}(q-1) \\ 1 - \beta_2 + \frac{n}{2} \end{array} \middle| \frac{M^2}{m^2} \right) \right\}$$

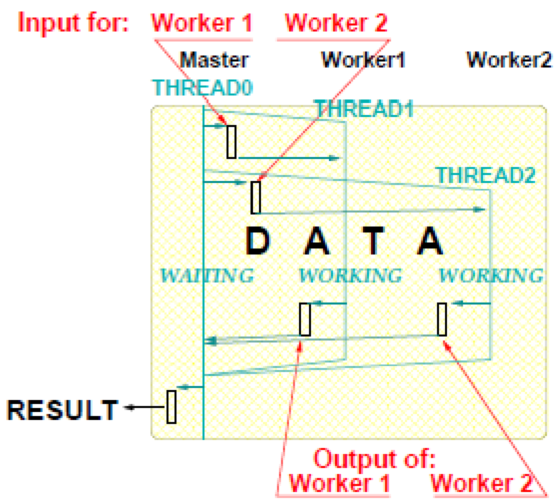
FORM: parallelize

[39] Mikhail TENTYUKOV Current status of FORM parallelization

SMP and Clusters: MPI
(Message Passing Interface)



SMP computer:
Multithreaded processes



ParFORM: uses MPI
Karlsruhe, 1998

TFORM: uses POSIX Threads
NIKHEF, 2005

◆Both ParFORM and TFORM are able to execute almost all FORM programs in parallel.

◆ParFORM supports more hardware architectures.
TFORM supports parallelization of more FORM features.

◆ParFORM requires MPI,
TFORM doesn't: much easy to deploy.

◆TFORM is optimal for parallelization on small (<=8) number of CPUs.
ParFORM is optimal for parallelization on large (>=6) number of CPUs.

◆The present development model inspired: new features first appear in TFORM and then in ParFORM.

LHC generators

[41] Paolo BARTALINI The Monte Carlo generators in CMS

[8] Mikhail KIRSANOV Development, validation and maintenance of Monte Carlo event generators and generator services in the LHC era

[61] Sergey BELOV LCG MCDB and HepML, next step to unified interfaces of Monte-Carlo Simulation

CMS group

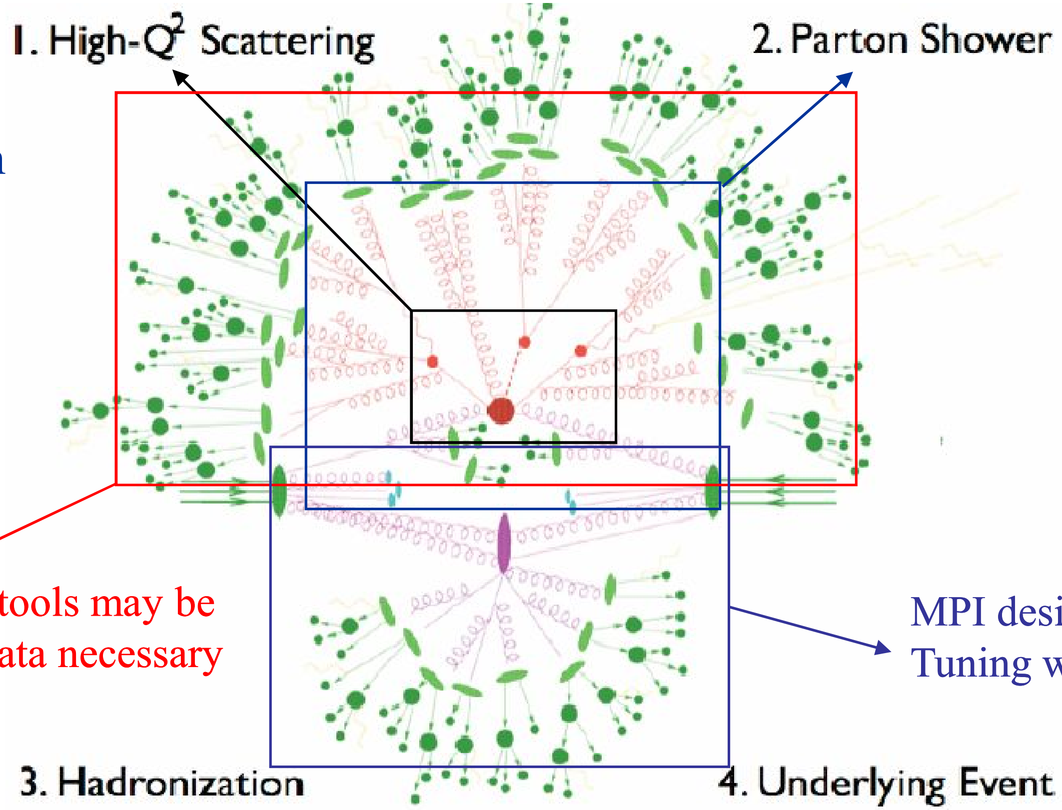
(Feature of ATLAS group is also referred sometimes.)

Physics requirements

Extra gluon emission described with ME at the highest possible order (+matching). Spin correlations needed

Interface to dedicated tools may be needed. Tuning with data is essential

The MC description of LHC events is tremendously complex



Interface to dedicated tools may be needed. Tuning with data necessary

MPI desirable
Tuning with data needed

Other desirable features, from the experimentalist's viewpoint:

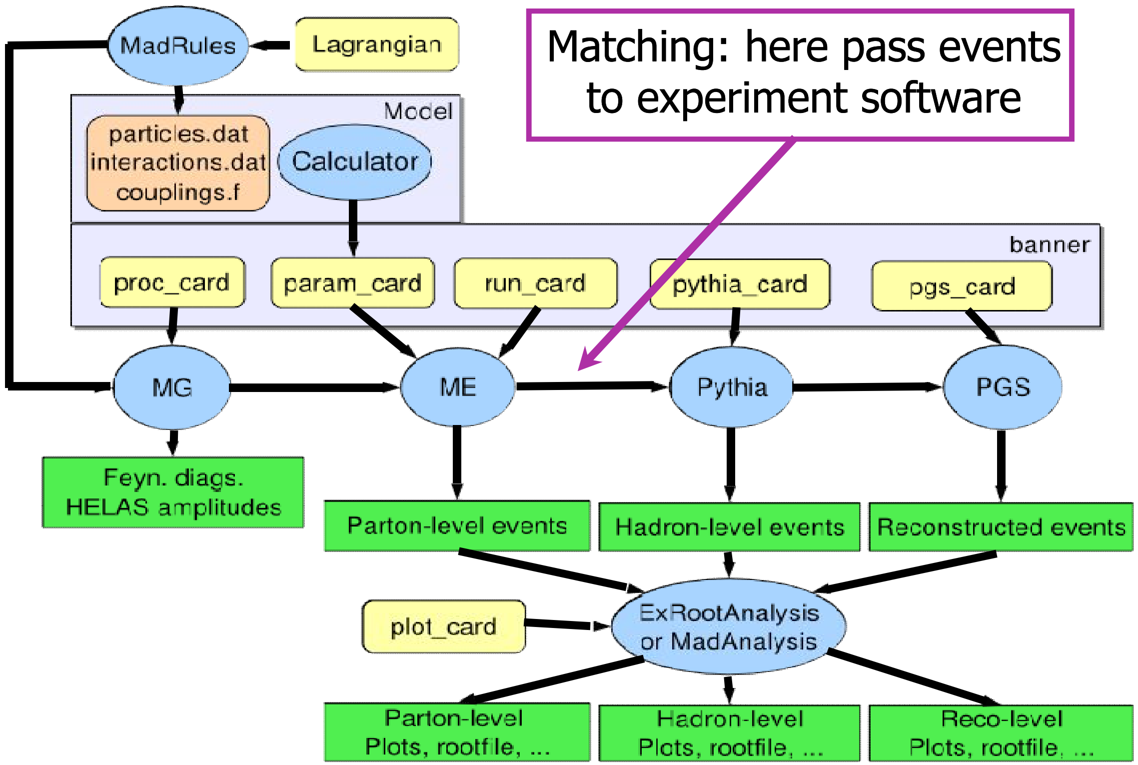
- output in the Les Houches standard format
- as much complete as possible coverage of SM phase space
- user friendly inclusion of new physics signals
- support ☺

MC Production: choice of the reference generators

The CMS way: MadGraph$_{+PYTHIA}$ as a reference ME generator for both SM and BSM

→ can treat all phase space coherently, including SM+BSM interferences
→ do not give up higher leading order matched QCD contribution
→ flexibility of including any new physics

+ Use ALPGEN$_{+PYTHIA}$ and MCatNLO$_{+HERWIG}$ as primary comparisons for the analyses



Definition of different portions of phase space in collaboration with the MadGraph/MadEvent team, with theory-validated LHE files and corresponding binaries for Monte Carlo productions.

→ Agree on the file contents (processes, cuts, settings)

Large scale SM Production successfully accomplished in 2008, now moving toward the BSM points using the same tools/procedures

Further details here: http://cp3wks05.fynu.ucl.ac.be/twiki/bin/view/Library/MadGraphSamples

LCG Generator

GOAL: to guarantee the event generator support for the LHC

- WP1: GENERATOR SERVICES LIBRARY (GENSER)
- WP2: EVENT FORMATS AND EVENT INTERFACES
- WP3: SHARED EVENT FILES: FRAMEWORK & DATA BASE (MCDB)
- WP4: TUNING AND VALIDATION

KIRSANOV

WP1. The LCG Generator Library (GENSER)

GOAL: to replace the obsolete CERN Library for what concerns the Generator Services

→Mandate:

- ❖ To collaborate with MC authors to prepare LCG Compliant Code
- ❖ To maintain older MC packages on the LCG supported platforms

→Clients:

- ❖ Addressed to LHC experimentalists and theorists both at CERN and in external laboratories (Other users are welcome!)

GENSER2 and MCDB in production

Level 1 validation package TESTS in GENSER tests all available generators

RIVET and MC-TESTER are also used for the generators validation

New cross-platform tools (PKGSRC, Autotools) are being evaluated

BELOV

OUTLINE

LCG Monte-Carlo Data Base (MCDB)

– provides storage, bookkeeping and access to MC simulated events

– numerous ways to access both MC data and metadata

– way to automatize passing data from ME to SH generators

• **HepML**

– schemes and libraries; automatic documentation of MC samples

– usage inside LHEF-formatted event samples

• **LCG MCDB + HepML + LHEF**

STATUS

LCG MCDB Knowledge Base is already in use

• APIs for MCDB and HepML are available

• Detailed documentation allows users and experts easily begin to work with LCG MCDB

• Using MCDB + HepML allows to make Monte-Carlo simulation more automatic and reliable

SANC

[33] Vladimir KOLESNIKOV Standard SANC Modules

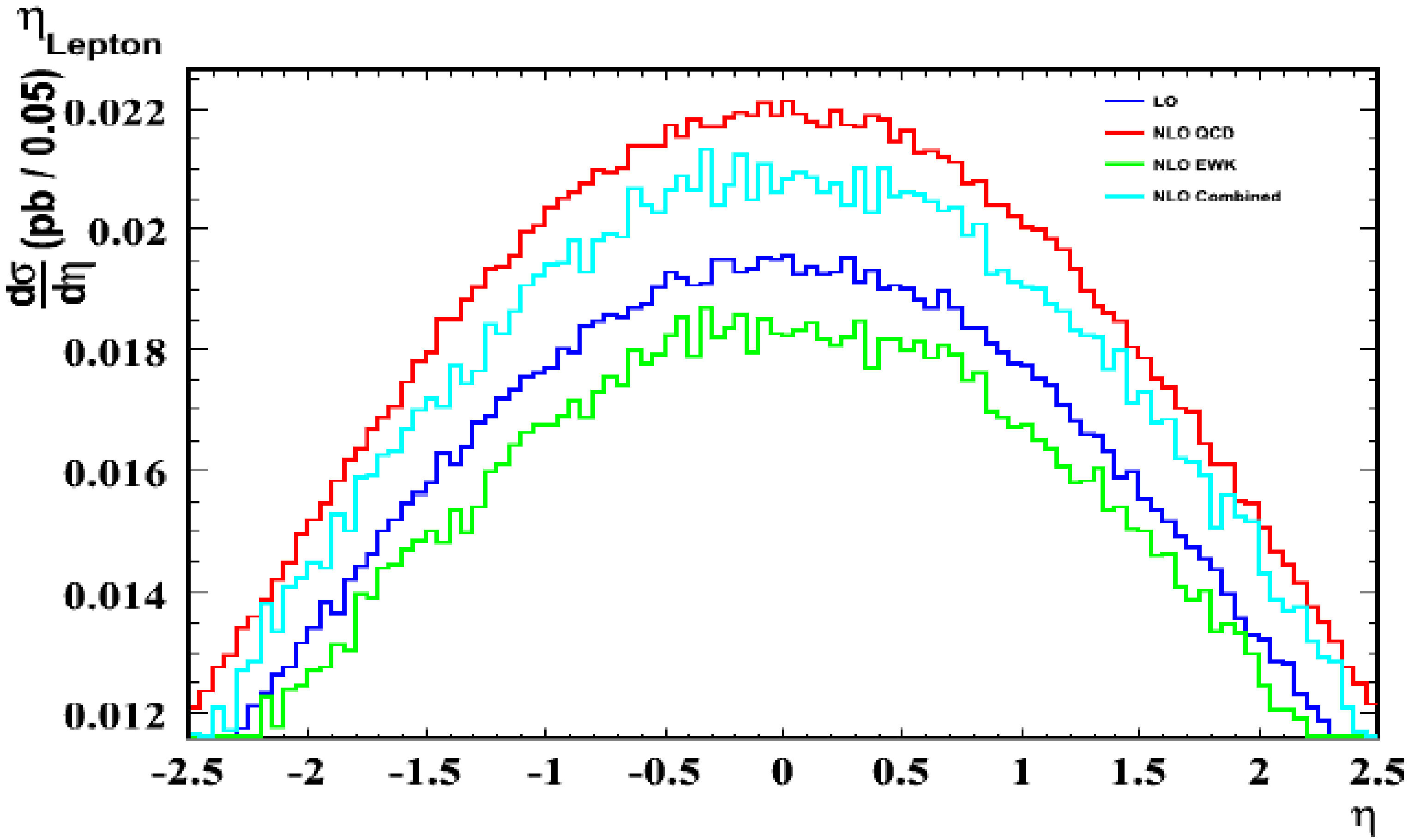
[31] Andrej ARBUZOV Radiative corrections to Drell-Yan like processes in SANC

Support of **A**nalytic and **N**umerical Calculations for Experiments at **C**olliders

Computer system for semi-automatic calculations of realistic and pseudo-observables for various processes of elementary particle interactions from the SM Lagrangian to event distributions at the one-loop precision level

→ FORM+FORTRAN modules

$$d\hat{\sigma}^{1-\mathrm{loop}} = d\hat{\sigma}^{\mathrm{Born}} + d\hat{\sigma}^{\mathrm{Subt}} + d\hat{\sigma}^{\mathrm{Virt+Soft}}(\bar{\omega}) + d\hat{\sigma}^{\mathrm{Hard}}(\bar{\omega}).$$



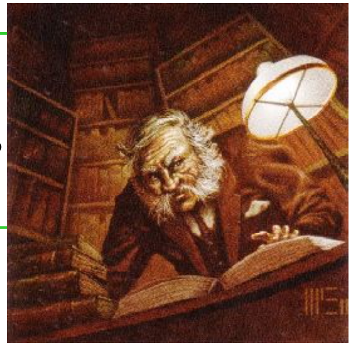
QCD/EW corrections for Drell-Yang by SANC

Rivet & Professor

[187] Andy BUCKLEY Tools for systematic event generator tuning and validation

Rivet itself is primarily a library of tools (event shape calculators, jet algorithms, various definitions of a final state, . . .) and a growing collection of analysis routines which use them.

•Calculation tools ("projections") automatically cache their results
•Histograms can be auto-booked from the reference data files
•User analyses can be loaded at runtime as plugins

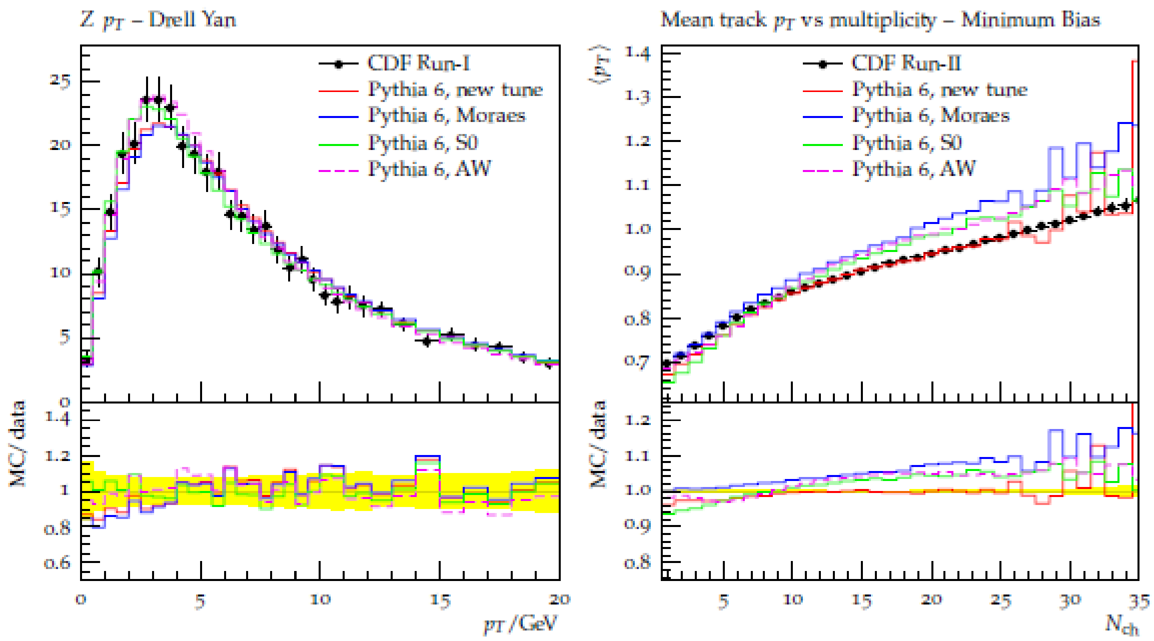


Professor Search "best" parameter set for a generator:
uses Rivet analyses to sample generater in multi- parameter spaces, interpolate the results, and predict optimal tunes.

Pythia 6 – new tuning: Tevatron

	default	tune DW	new tune	
PARP(62)	1.0	1.25	2.97	ISR cut-off
PARP(64)	1.0	0.2	0.12	ISR scale factor for α_S
PARP(67)	4.0	2.5	2.74	max. virtuality
PARP(82)	2.0	1.9	2.1	$p_\perp^0$
PARP(83)	0.5	0.5	0.84	matter distribution
PARP(84)	0.4	0.4	0.5	matter distribution
PA[illegible](85)	0.9	1.[illegible]	[illegible]	[illegible]lour connec[illegible]on

Some examples



GEANT4 upgrade

[17] Vladimir IVANTCHENKO Recent Progress of Geant4 Electromagnetic Physics and Readiness for the LHC Start

[37] Vladimir IVANTCHENKO Hadronic Physics in Geant4: Improvements and Status for LHC Start

Geant4 is a toolkit for simulation of particle transport and interaction with matter
Includes components for LHC and other applications:

- Geometry
- Tracking in electromagnetic fields
- Physics interactions
- Scoring and interfaces
- Visualization

New EM physics available with G4 9.2

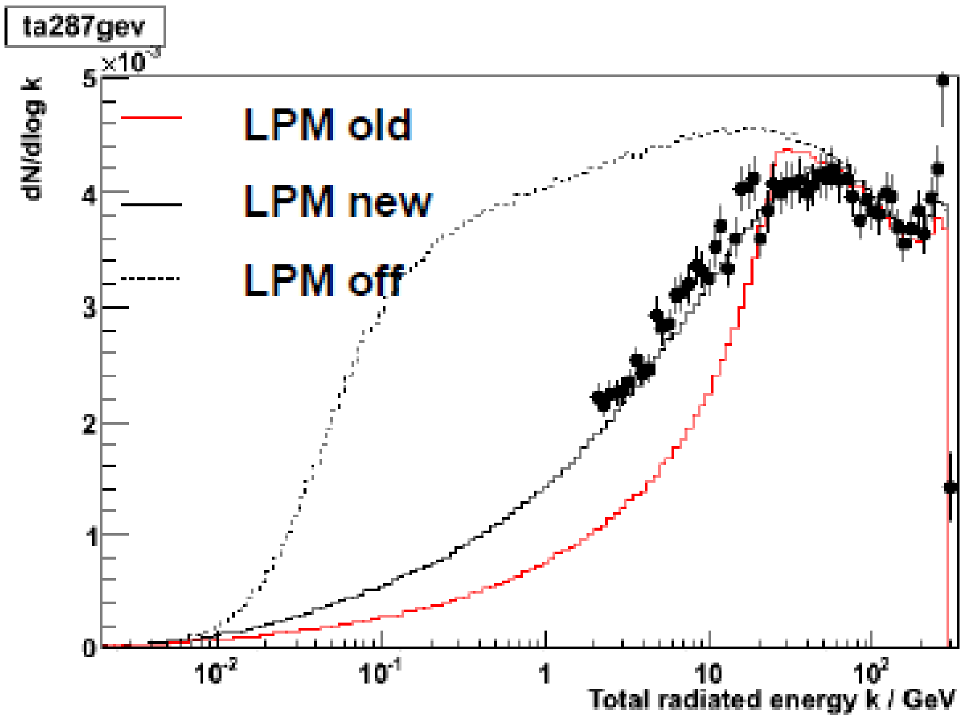
- Updated models for ionisation for hadrons/ions
- Relativistic bremsstrahlung model for electrons and positrons with E > 1 GeV
- Hadron-induced bremsstrahlung and e+e-pair production
- Updated positron annihilation to hadrons
- Tuned model for electron multiple scattering
- Alternative model for muon-multiple scattering

Coming December 2008

New relativistic bremsstrahlung model

- Bethe-Heitler formula with corrections
- Complete screening with Coulomb correction
  - Valid for E > 1 GeV
- **Density & LPM-Effect**
  - **consistent combination a'la Ter-Mikaelian**

287 GeV e⁻ at Ta target (4%X_0)



Data from the CERN experiment: H.D.Hansen et al, PR D 69, 032001 (2004)

Geant4 hadronic physics

General hadronic processes:

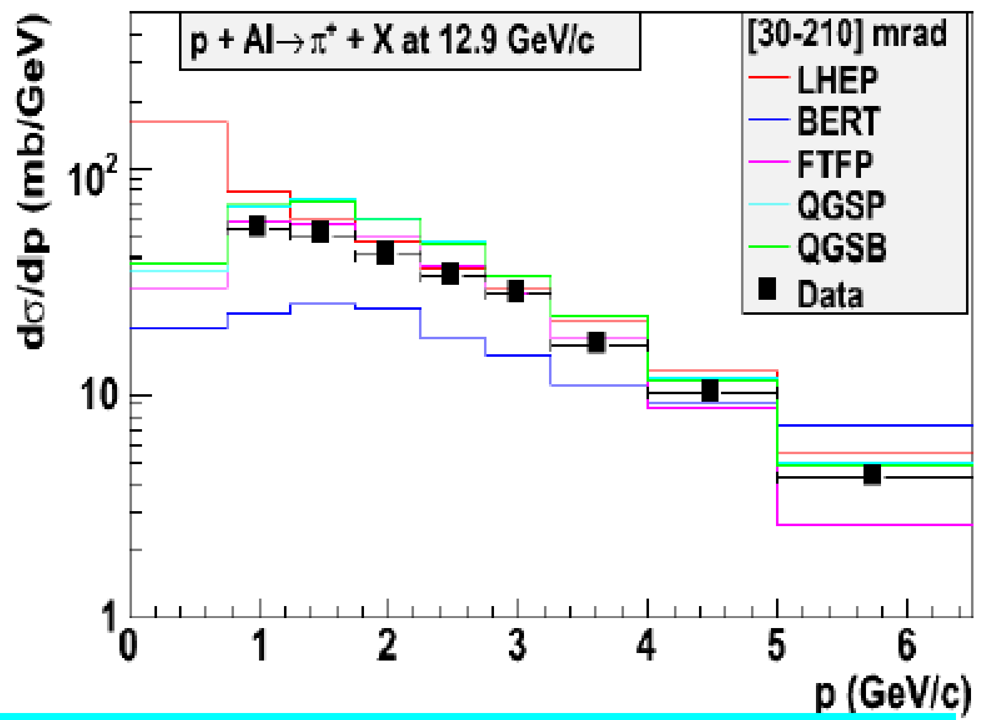
- Elastic
- Inelastic
- Neutron capture
- Neutron fission
- Lepton Lepton-nuclear
- Capture at rest
- Charge exchange

Main recent developments focused on LHC test-beam problems:

- Quasi Quasi-elastic for longitudinal shower shape
- FTF(Fritiof: a classical string) model reviewed
- Bertini cascade reviewed
- PreCompound reviewed
- Deexcitation reviewed

Inclusive forward π^+ production by proton 12.9 GeV/c beam

- QGS more close to the data at high energies
- FTFP more close to the data at moderate energies
- Cascade models not applicable above 10 GeV
- LHEP overestimate π^+ yield



M.G.Catanesi et al.,Nucl. Phys.B732, 1 (2006)

General research ($\overline{\text{HEP}}$)

[59] S.Zub Mathematical model of magnetically interacting rigid bodies

Poisson structure for two magnetic-interacting bodies

Computational modeling in Maple/MatLab

The Hamiltonian formalism has been developed which results in a contact-free form of equations of motion for a system of magnetically interacting bodies.

[0] S.Bityukov Two approaches to Combinig Significance

Suppose one experiment sees a 3-sigma effect and another experiment sees a 4-sigma effect. What is the combined significance?

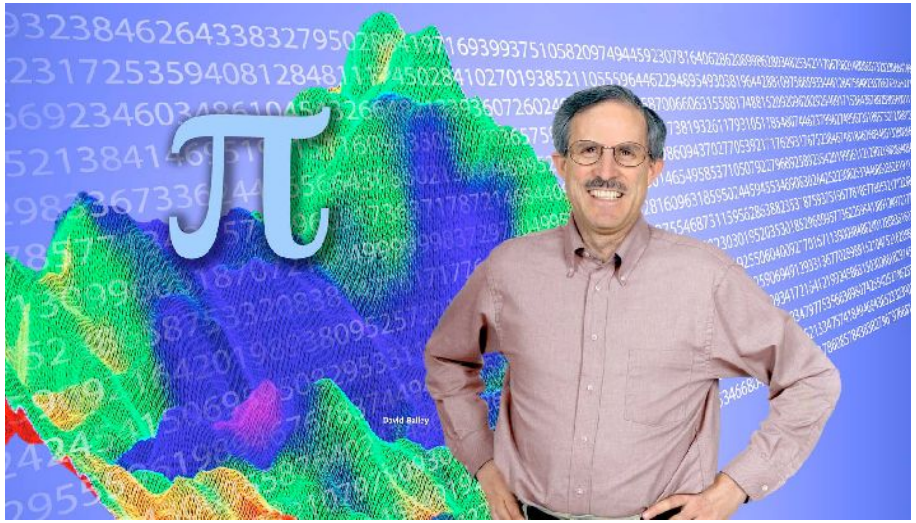
Stouffer's method (inverse normal method)

→The combining significances works for significances which obey the normal distribution.

High precision computing

[166] David BAILEY High-Precision Arithmetic and Mathematical Physics

plenary



Interesting review for the software status and MANY examples which require HIGH precision.

Binoth: Blackhat →use of multi-precision library for a few percent of phase space points

And by many authors here in ACAT, the necessity of HIGH precision is demanded.

Yuasa: quadruple precision by Fortran Compiler
octuple and higher precision with HMLib

Wish commercial hardware to support QUAD or more!

⋮

Final words

Many good works presented in **ACAT2008**, Track3,
Methodology of Computations in Theoretical Physics

Thank you for the organizers!

LHC=Long and Hard Calculation (T.Binoth)

~~Wait and see next ACAT~~

Let's work and bring results
to next ACAT!