

NLO MC Tools in ATLAS and CMS

LHC Higgs Workshop

Univ. of Freiburg

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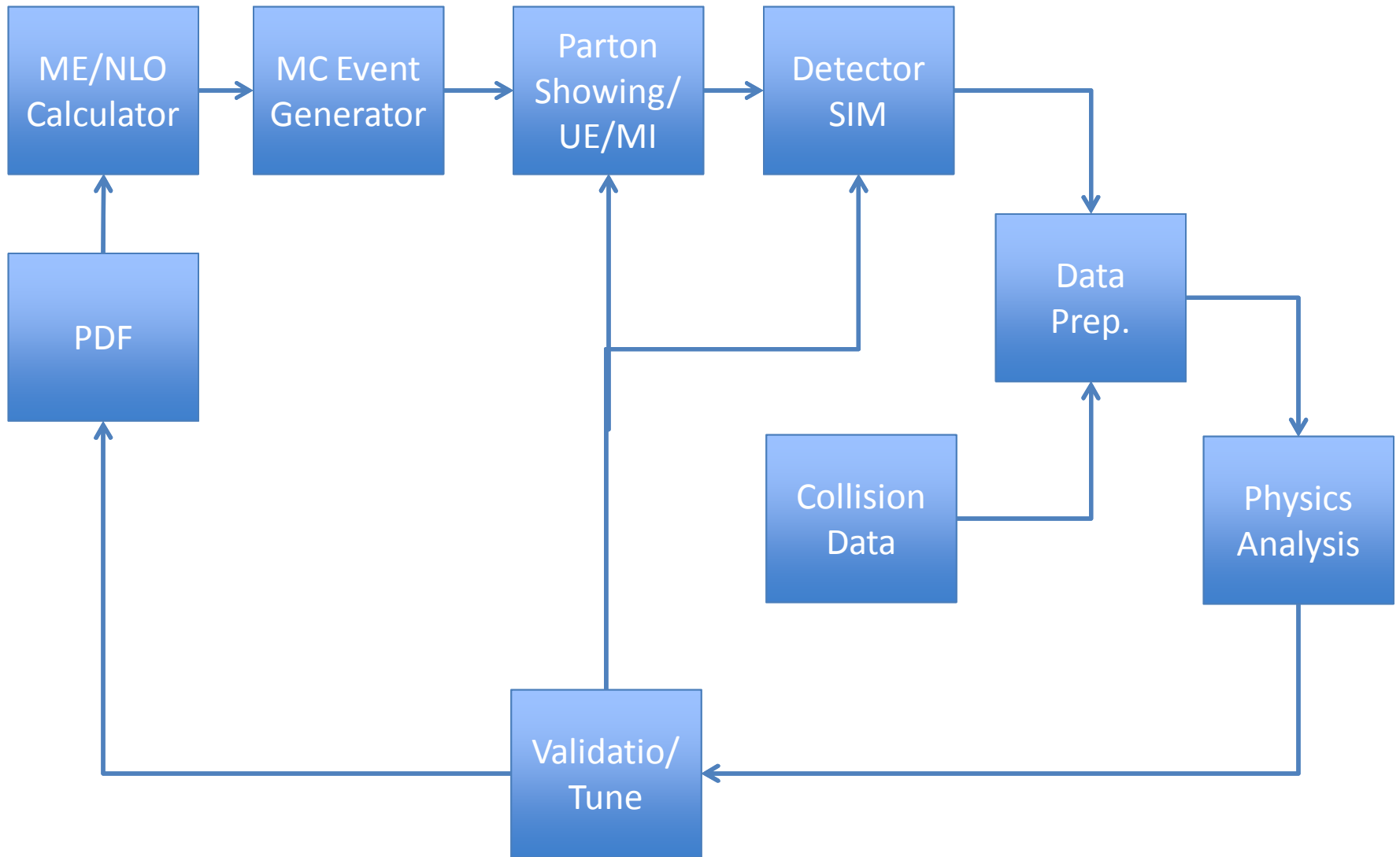
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For the NLO MC group

Introduction

- NLO MC Contacts
 - Theory: Fabio Maltoni (Fabio.Maltoni@cern.ch) and Paolo Nason (Paolo.Nason@mib.infn.it)
 - Experiment: Jae Yu (jaehoonyu@uta.edu) for ATLAS and Marta Felcini (Marta.Felcini@cern.ch)
- This group's work overlaps largely with other groups
- What is the most useful function of this group?
- Goal is to obtain the answers to this question

Theory and Experiment Iteration Process



PDF's for MC Tools in ATLAS

- For LO $2 \rightarrow 2$ MC Generators, MRST2007modLo pdf
 - Other LO ME generators, such as Alpgen, MadGraph, CTEQ6.1L is used
- For NLO, CTEQ6.6 is used for MC@NLO
 - Parton showering/UE/MI done through HERWIG+JIMMY
 - Dedicated tune was done for HERWIG+JIMMY using CTEQ6.6

Event Generation Tools

Multi-Purpose Generators			
Physics process	Generator	Version	Comment
EWK, QCD, SM Higgs MSSM Higgs SUSY, Exotica	PYTHIA6	v. 6.422	Standard tune D6T with Q ² shower
QCD Dijet	PYTHIA8	v. 8.130	
QCD studies	HERWIG6	v. 6.510	Comparison to PY6 Also used as shower/hadronizer for MC@NLO & POWHEG
QCD studies	HERWIG++	v. 2.4.2	Comparison to HW6/PY6
W/Z production	SHERPA	v. 1.2.0	

see F. Cossutti, F. Stoeckli, *MC4LHC: CMS Input Document, March 2010*

<http://indico.cern.ch/getFile.py/access?resId=0&materialId=paper&confId=74601>

Event Generation (cont.)

Multi-Leg Matrix-Element Generators

Physics process	Generator	Version	Comment
QCD VB(-pairs)+Jets HQ(-pairs)+Jets (di)photon(+VB)+Jets Z' production	MADGRAPH	v. 4.4.13	Main CMS LO Multi-Leg generator Interfaced to PY6 & HW for shower/hadronization
top-pair VB(+HQ)+Jets QCD high jet multiplicity + MI	ALPGEN+ HERWIG+JIMMY	v.2.13	For many legs generation For systematic comparison to MADGRAPH

NLO Event Generators

top-pair, single top, Drell-Yan, W-pairs gluon-fusion Higgs	MC@NLO	v. 3.41	Showering/UE/MI through HW+JIMMY
Drell-Yan, Higgs	POWHEG		Used for qqH, H->WW->qqln

SM MC Parameters

Parameter	ATLAS Higgs = LHC H x-sec group	ATLAS MC
PDF	MSTW2008/CTEQ6.6 (NLO)	MSTW2008/CTEQ6.6 (NLO)
M_t	172.5 ± 2.5 (GeV)	172.5 ± 2.5 (GeV)
M_b	4.75	4.75
M_c	1.40	1.40
M_W	80.398	80.403
M_Z	91.1876	91.1876
Γ_W	2.141	2.141
Γ_Z	2.4952	2.4952
M_u	0.190	0.190
M_d	0.190	0.190
M_s	0.190	0.190

Toward common SM MC parameter set vs Higgs

<https://twiki.cern.ch/twiki/bin/view/LHCPhysics/SMInputParameter>

Higgs NLO MC Tools in ATLAS&CMS

Name	Order	Mode	Channel
HIGLU	NLO	inclusive	ggF
Hpro	NLO	exclusive	ggF
MCFM	NLO	exclusive	ggF, WH/ZH
VV2H	NLO	inclusive	VBF
V2HV	NLO	inclusive	WH/ZH
VBFNLO	NLO	exclusive	VBF
HAWK	NLO (QCD+EW)	No H decays	VBF
HQQ	LO		ttH
HggTotal	NNLO	Inclusive	ggF
De Florian & Grazzini	NNLO	Inclusive	ggF
FEHiPro/HEPLiP	NNLO	Exclusive	ggF
HNNLO	NNLO	Exclusive	ggF
4 flavor (private)	NLO	Exclusive	MSSM Neutral H
Feynhiggs	NLO	Exclusive	MSSM Charged H
bbh@nnlo	NNLO	inclusive	MSSM Neutral H

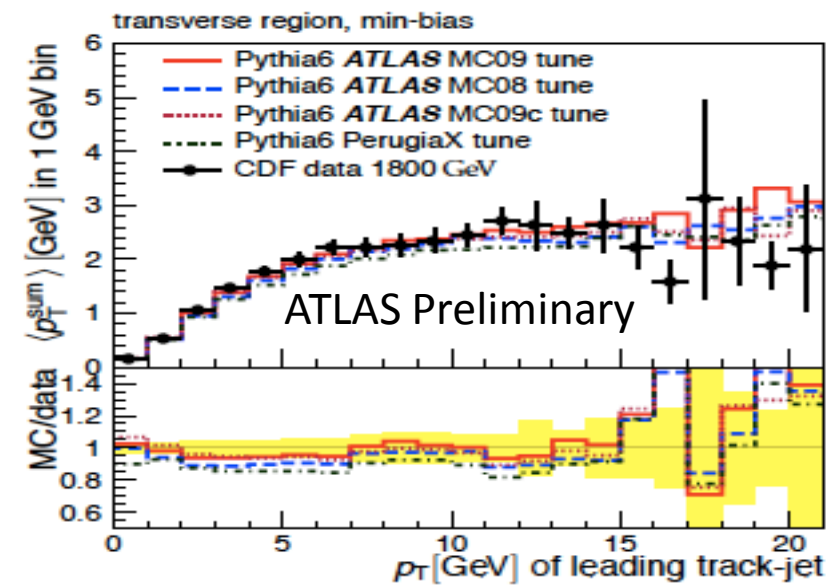
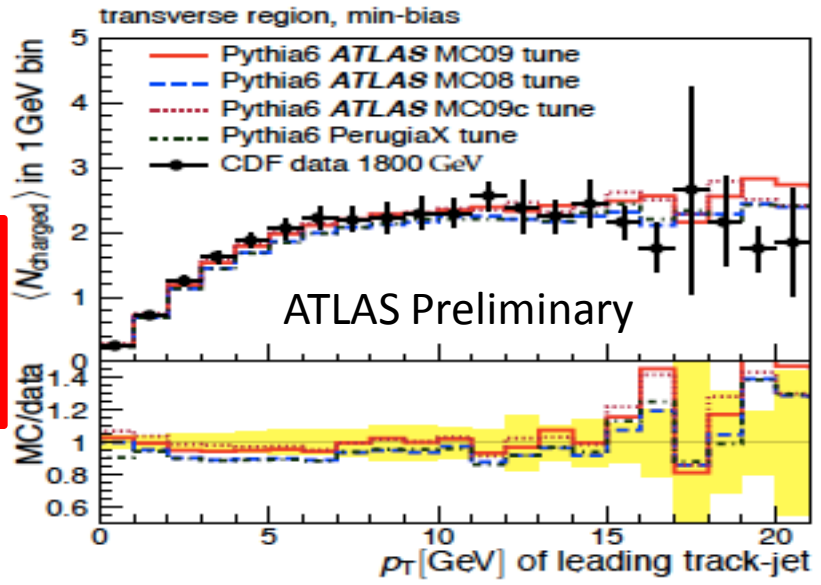
Some Example Tunes – PYTHIA6

- Newest version of the color reconnection
- Bowler fragmentation function for heavy quarks
- Latest tune to LO*PDF set derived based on previous MC tunes → Increased cut-off scale (PARP(82)) of 2.3GeV and rescale exponent (PARP(90)) to 0.25
- Significantly lower UE at the LHC energy than the previous version

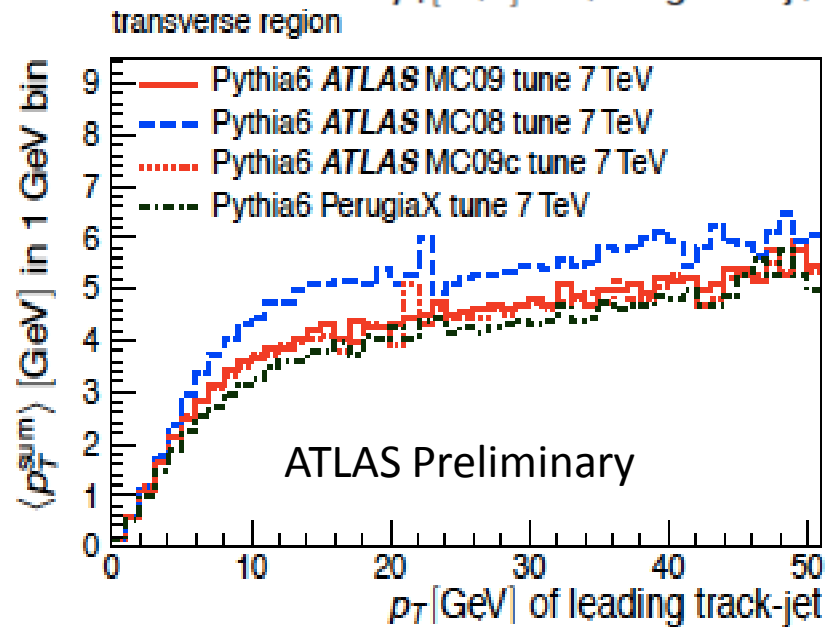
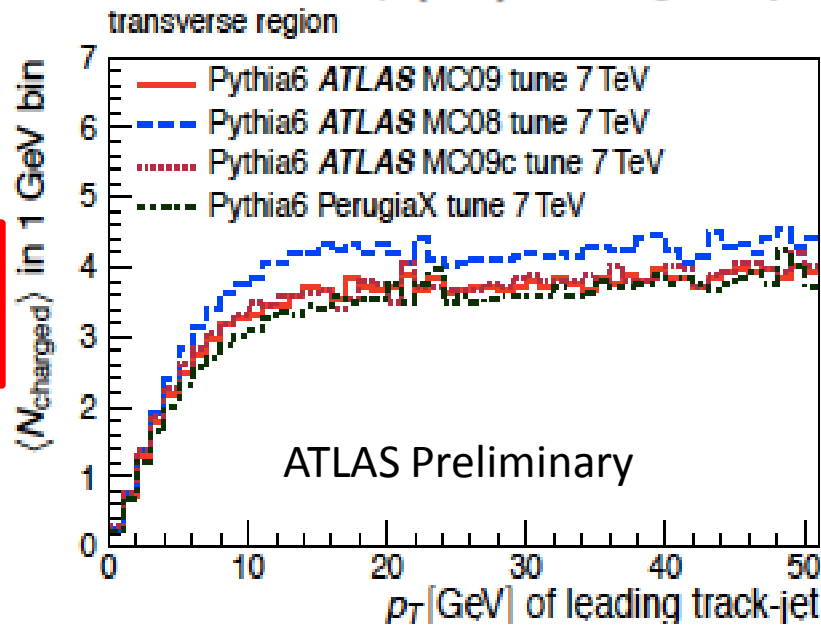
ATL-COM-PHYS-2010-040(<http://cdsweb.cern.ch/record/1235388>)

PYTHIA6 Tuning Performance in MB

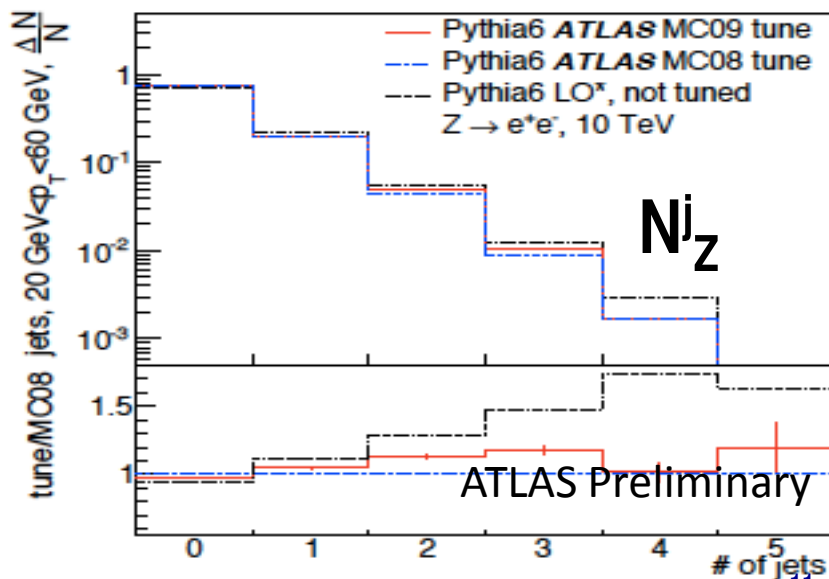
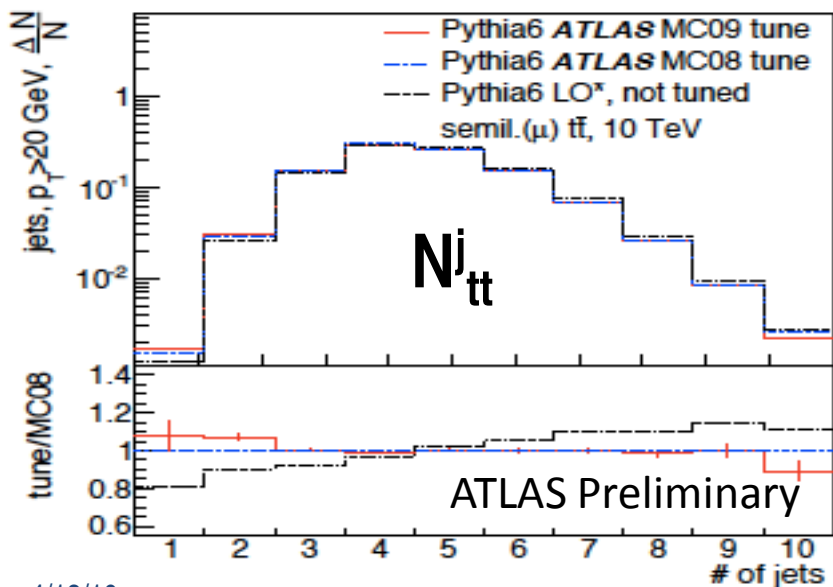
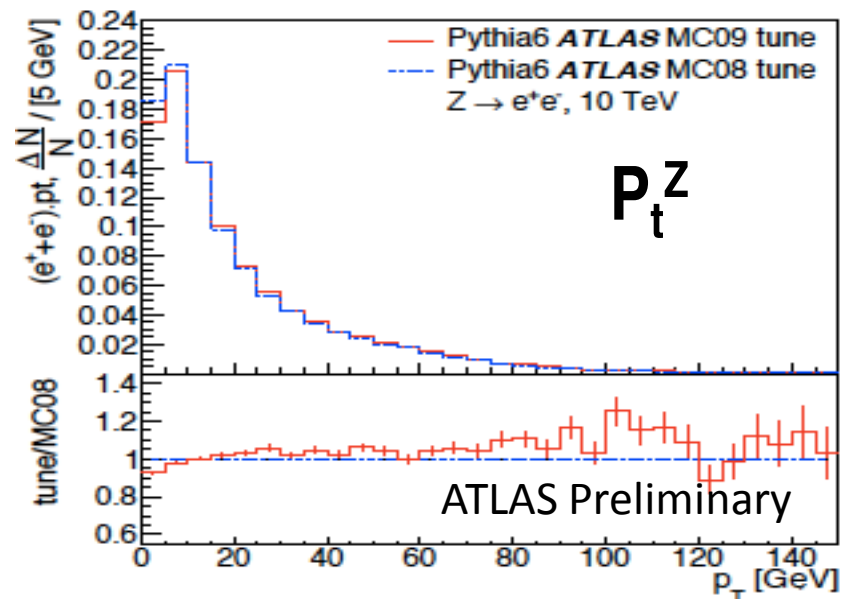
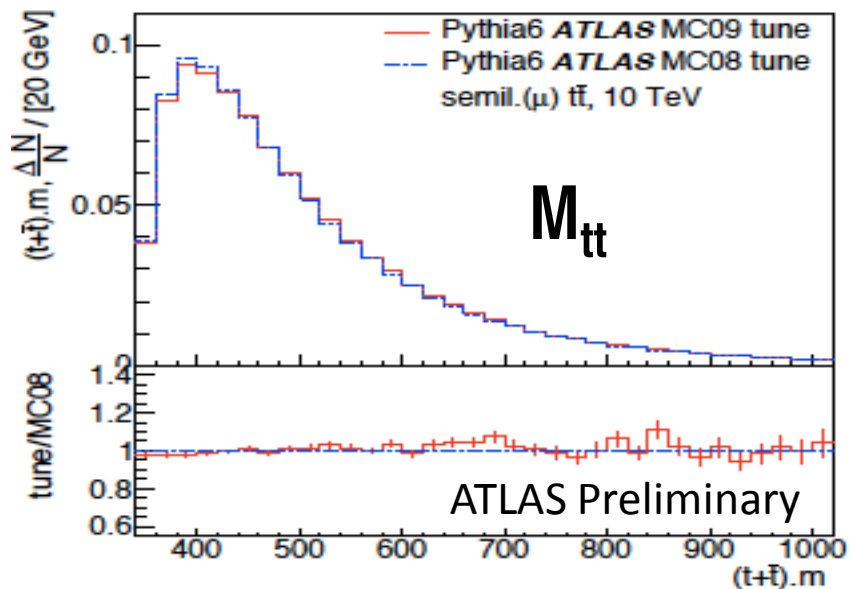
1.8TeV



7TeV



ATLAS MC09 Tune Validation



Summary

- Most of the advanced and popular MC tools are implemented in ATLAS and CMS experiments
 - Including many NLO and NNLO x-sec calculators and event generators
 - Validation/tuning are in progress for 7TeV min-bias data
 - Not all Higgs processes are fully incorporated
- MSSM MC tools not fully incorporated
- Tunes need to be re-established as components in tools change
 - PDF changes
 - Order of calculation changes
 - New code and physics process inclusions

Some immediate issues

- Tunes
 - How and what do we tune MC generators to?
 - How and what do we test the tune on?
 - Validities, kinematic phase spaces the tunes are valid on?
 - Tunes done on one SM channel, applicable to Higgs?
- Theory handling
 - Consistent treatment of theoretical parameters for systematic uncertainties...
 - Need reasonable range of parameters by the theorists
 - Proper set of PDF for the given set of NLO/NNLO MC?

Wish List

- Some privately provided codes are used → need to have more uniform prescription to incorporate them
- Flexibility of the tools to allow fully usability in experimental analyses
 - Usability of the advanced calculations by turning them into event generators (preferably un-weighted)
 - Distributions for cuts
- Guaranteed access and consistency of theoretical tools by establishing a central repository
 - GENSER?

Tasks for NLO MC Group

- Compile and inform subgroups of most optimal NLO MC tools both ME and PS level and provide guidelines for input parameters and other specifics
 - Fabio and Paolo has begun documentation
- Propose and maintain guidelines for combination of results across the subgroups within the LHC Higgs X-sec group for uniform and consistent treatment of the results
- Channel the requests from experimental side – in particular regarding the implementation - to the theory side
- Channel most advanced information from the theory side back to experiments and provide guidelines to experiments on implementation and treatment of input/output

Some observations on tools

- ggF
 - Highest production cross section at the LHC
 - Calculations at NLO and NNLO
 - Uncertainties of order 10% for scale and 10% for pdf at NNLO
- VBF
 - Calculations at NNLO
 - Theoretical uncertainty at 2 – 3%
 - Is UE of the existing MC (PY or HW) trustable?
- WH/ZH
 - Calculations and MC at NLO
 - Theoretical uncertainties few %
 - How's the background such as W/Z+QQ predictions?
- tth
 - Calculations at NLO
 - Inclusion to existing MC tools