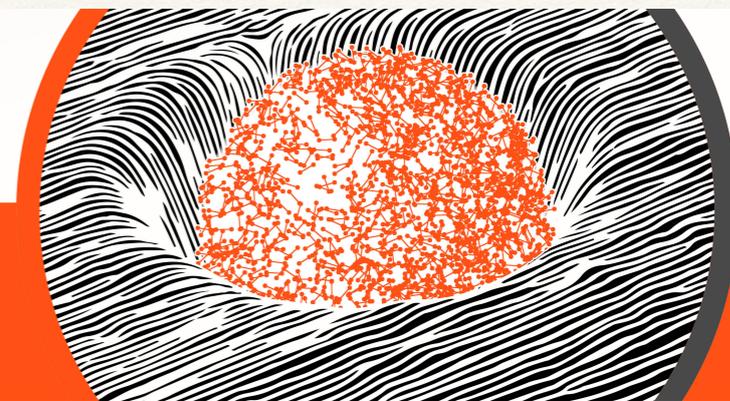




ElectroWeak **W mass**

Workshop

October 2-6, 2017 LAL-Orsay, France



Bruno Mazoyer - LAL Orsay 2017



<http://wpsist.lal.in2p3.fr/electroweakworkshop>

F. Balli (CEA Saclay, IRFU) on behalf of the organisers

Introduction

Precision electroweak
measurements at LHC
October 2017

A few words on the université Paris XI

- ❖ Created in 1971, is now a big scientific pole of the Paris area
- ❖ Earlier developments by Frédéric and Irène Joliot-Curie in the 1950s (IPN d'Orsay, then LAL)
- ❖ Several Nobel prizes and Fields medals associated to university : Albert Fert, Pierre-Gilles de Gennes, Jean-Christophe Yoccoz, Laurent Lafforgue, Ngô Bảo Châu, Wendelin Werner
- ❖ A few numbers :
 - ❖ 3 000 researchers
 - ❖ 3 200 engineers, technical and administrative staff
 - ❖ 80 employees at Bibliothèque Universitaire (library)
 - ❖ ~30 000 students
 - ❖ has 14 doctoral schools (is associated to 5 other)
 - ❖ ~500 theses defended per year



Practical details

- ❖ 2 wifi networks available : LAL-public and eduroam
- ❖ Lunch food : university restaurant price is ~12 euros
- ❖ Boulangeries, small shops in City center
- ❖ Conference dinner on Thursday evening (5th) will be entirely covered by the workshop
- ❖ Restaurant Le Loubnane (Lebanese food), 15 rue Lagrange, Paris, be there at 8pm

- ❖ Next to Saint-Michel RER station (line B)
 - ❖ Next to Notre-Dame
- ❖ Tel. numbers in case you need something :
 F. Balli : +33 7 68 34 67 19
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General idea of the two meetings

- ❖ Precision EW measurements at LHC raise some questions, several of them raised in previous LPCC meetings at Mainz and CERN
 - ❖ QCD : prediction of p_{TW} spectrum
 - ❖ EW : impact of missing higher order, incorporation of fermion pair corrections, $\sin^2\theta_{eff}$ variations in MC programs, new MCs NNLO QCD + NLO EW...
- ❖ Format of the first three days (working meeting) : one presentation per half day, and then discussion for the rest of the time
 - ❖ Expected reminder presentations (+ possible news and progress) from :
 - ❖ F. Tackmann : theoretical uncertainties to p_{TW}/p_{TZ} ratio, Geneva
 - ❖ A. Vicini : impact of HF quarks on p_{TZ}
 - ❖ G. Ferrera : uncertainties in DYRES
 - ❖ S. Camarda : parton shower vs resummation
 - ❖ F. Piccinini : Higher-order EW corrections, Powheg-EW
 - ❖ J. Bendavid : current direction from the CMS side
 - ❖ we can discuss the detailed schedule this morning
- ❖ Format of the last 2 days : more like a 'conventional' workshop with presentations but we strongly encourage to discuss them (also reserved a full slot for discussion)

$p_T(W)$ in ATLAS W mass

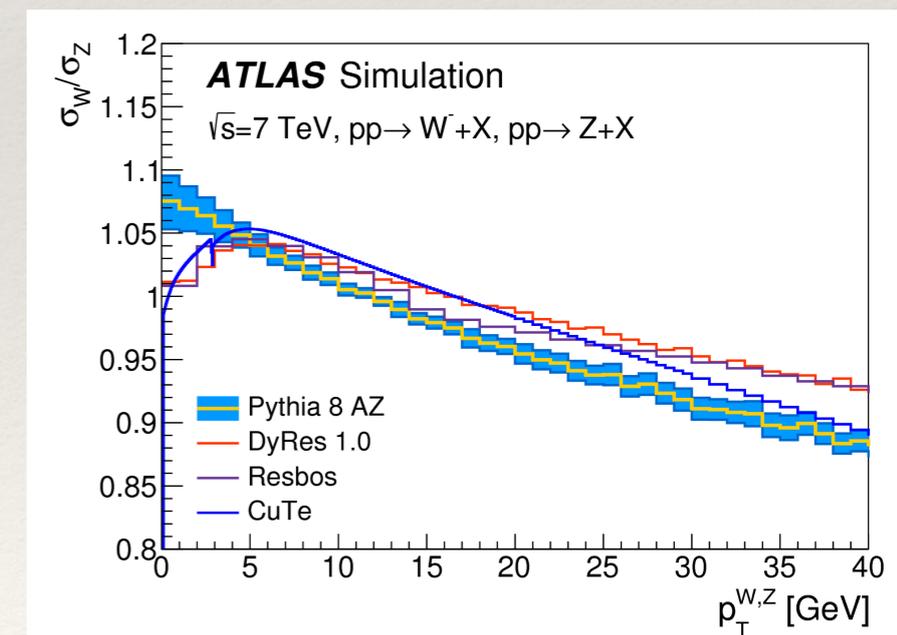
$$\frac{d\sigma}{dp_1 dp_2} = \left[\frac{d\sigma(m)}{dm} \right] \left[\frac{d\sigma(y)}{dy} \right] \left[\frac{d\sigma(p_T, y)}{dp_T dy} \left(\frac{d\sigma(y)}{dy} \right)^{-1} \right] \left[(1 + \cos^2 \theta) + \sum_{i=0}^7 A_i(p_T, y) P_i(\cos \theta, \phi) \right]$$

- ❖ Baseline is Powheg+Pythia, that we reweight for each term
- ❖ $d\sigma(m)/dm$ modeled with Breit Wigner
- ❖ Other terms : reweight MC according to various predictions that we validate with the data

1. $d\sigma(y)/dy$: fixed-order NNLO prediction (DYNNLO)
2. p_T at a given y : Pythia8 with 'AZ' tune
3. polarisation A_i : fixed-order NNLO prediction (DYNNLO)

- ❖ A few suggested studies towards an understanding of the origin of the hardening of the p_{TW} distribution (wrt p_{TZ}) when going to NNLL, and PS uncertainties (**non-exhaustive**)

- ❖ Comparisons of DYRes, Resbos, Cute, DIRE, Sherpa, and Geneva
- ❖ Comparisons of the 2 (now available) parton showers in Sherpa



Boson p_T distribution : ways forward

$$\frac{\partial \sigma_W^{\text{True}}}{\partial p_T}$$

~

$$\frac{\partial \sigma_W^{\text{TH}}}{\partial p_T}$$

~

$$\frac{\partial \sigma_Z^{\text{Exp}}}{\partial p_T}$$

×

$$\frac{\partial \sigma_W^{\text{TH}} / \partial p_T}{\partial \sigma_Z^{\text{TH}} / \partial p_T}$$

~

$$\frac{\partial \sigma_W^{\text{Exp}}}{\partial p_T}$$

2-5% (NNLO+NNLL)

0.5% \oplus 1-2% ? (NLL!)

$\delta m_W \sim 5-10$ MeV

(better at NNLL?)

~1% ? (experimental)

Need progress!!

Can we reach $\delta m_W < 5$ MeV from this source?

(note : Tevatron counts no uncertainty here)

Need data – 200 pb⁻¹ before the end of Run 2?

$p^T(W)/p^T(Z)$

F. Tackmann

	Uncertainty or size	Analytic resummation	Pythia	Leftover effect on W/Z
Singular resummation	5-10%	✓✓✓	✓	\lesssim % (?)
Power corrections	few %	(×)	(✓)?	?
Nonperturbative	few %	(✓)	(✓)	?
Massive quarks	few % (?)	× (\rightarrow ✓)	?	few % (?)
QED	\lesssim % (?)	×	✓ (?)	\lesssim % (?)
PDFs	2%	✓	✓	✓
$\alpha_s(m_Z)$	up to 5%??	✓	✓	✓

- ❖ On what points did we make progress since then, or should we discuss in details in the coming days ?

Resummation

S.Catani, D. de Florian, MG (2000)
G. Bozzi, S.Catani, D. de Florian, MG(2005)

Parton distributions factorized at $\mu_F \sim M$

avoids PDF extrapolation to small scales

$$\frac{d\hat{\sigma}_{ac}^{(\text{res.})}}{dp_T^2} = \frac{1}{2} \int_0^\infty db b J_0(bp_T) \mathcal{W}_{ac}(b, M, \hat{s}; \alpha_S(\mu_R^2), \mu_R^2, \mu_F^2)$$

process
dependent

$$\mathcal{W}_N^F(b, M; \alpha_S(\mu_R^2), \mu_R^2, \mu_F^2) = \mathcal{H}_N^F(M, \alpha_S(\mu_R^2); M^2/\mu_R^2, M^2/\mu_F^2, M^2/Q^2) \\ \times \exp\{\mathcal{G}_N(\alpha_S(\mu_R^2), L; M^2/\mu_R^2, M^2/Q^2)\}$$

universal

where the large logs are
organized as:

$$\mathcal{G}_N(\alpha_S, L; M^2/\mu_R^2, M^2/Q^2) = L g^{(1)}(\alpha_S L) \\ + g_N^{(2)}(\alpha_S L; M^2/\mu_R^2, M^2/Q^2) + \alpha_S g_N^{(3)}(\alpha_S L; M^2/\mu_R^2, M^2/Q^2) + \dots$$

includes parton evolution
from M to $1/b$ at LO

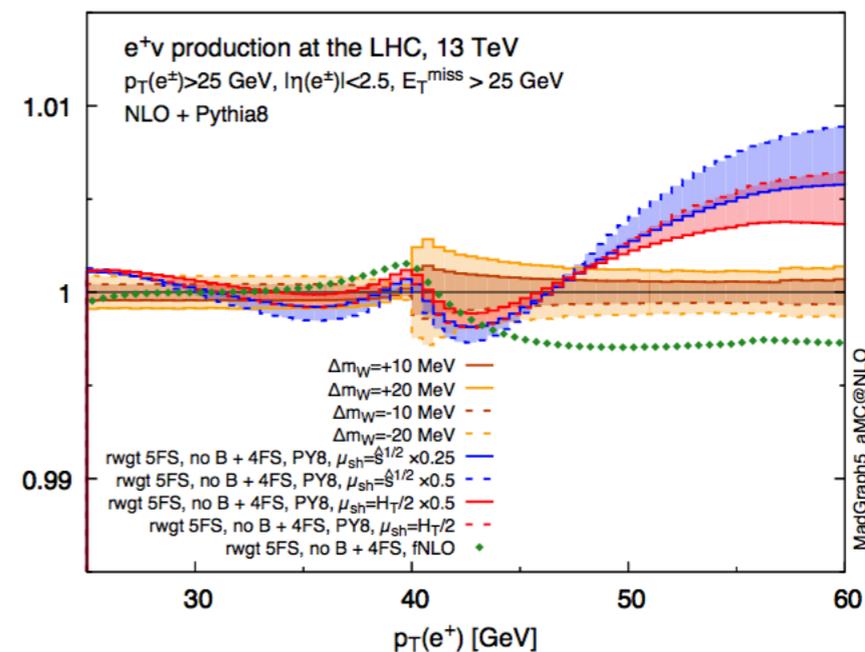
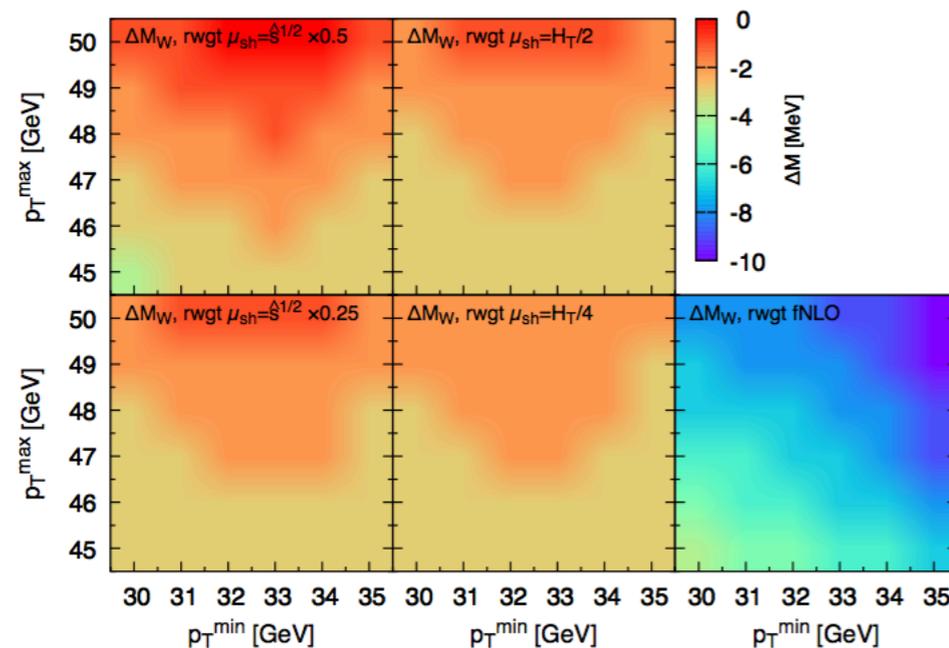
includes parton evolution
from M to $1/b$ at NLO

- **Unitarity constraint enforces correct total cross section**
- **Allows a consistent study of perturbative uncertainties**

❖ Why does parton evolution at NLO result in a worse description of the data than LO evolution ?

Impact of HF on pTZ

Dependence of the MW shifts on the fit window



- ❖ The authors use a combination of 4FS and 5FS to better assess the impact of massive quarks (here b) on pTZ, and subsequently on mW fit by building a new tune in PS (incorporating the difference btw 5FS and improved description)
 - ❖ Shift is negligible for mT fit, ~ 5 MeV for pT(lep) fit
- ❖ Effect of c-quark ?

NLO-EW

A. Vicini

Carloni Calame, Chiesa, Martinez, Montagna, Nicrosini, Piccinini, AV, arXiv:1612.02841

After the matching at NLO-(QCD+EW)

the impact on M_W of weak contribution, QED ISR and interferences is tiny

This conclusion is specific for M_W :

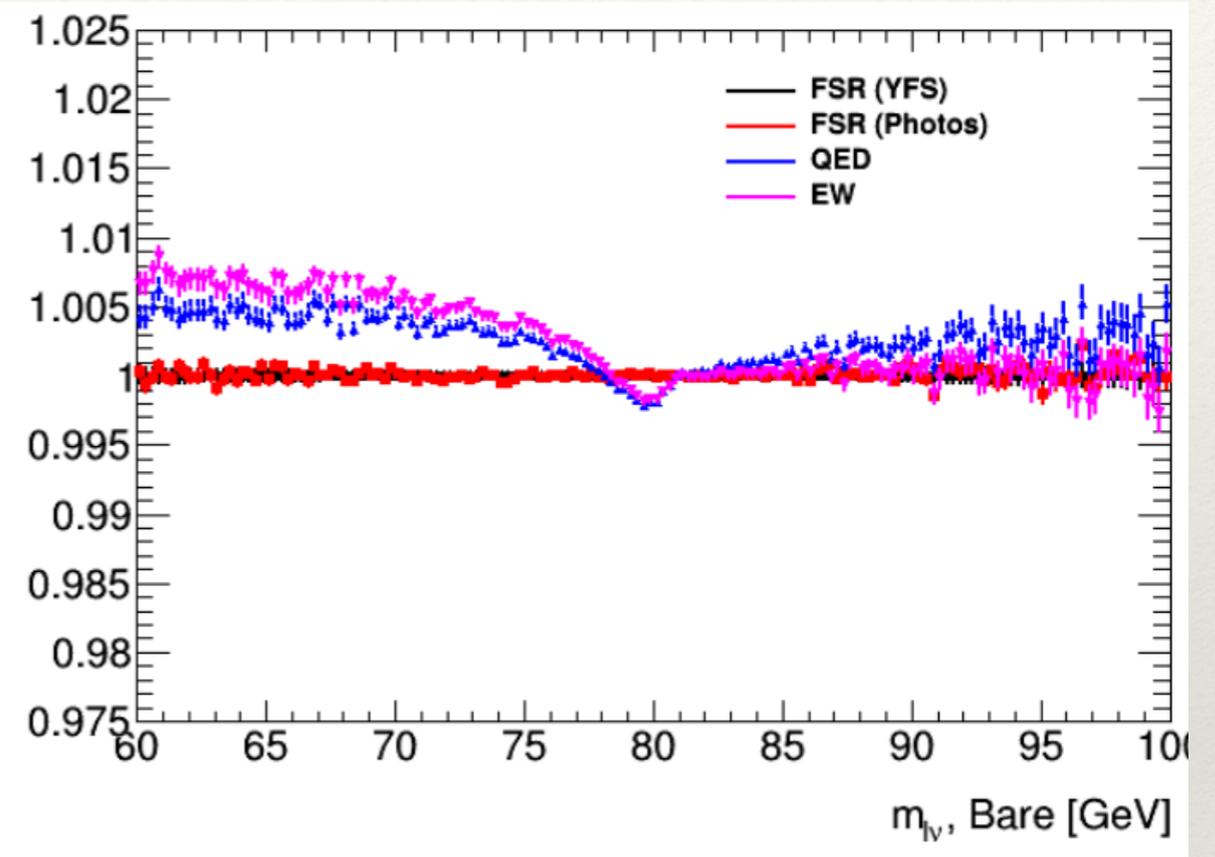
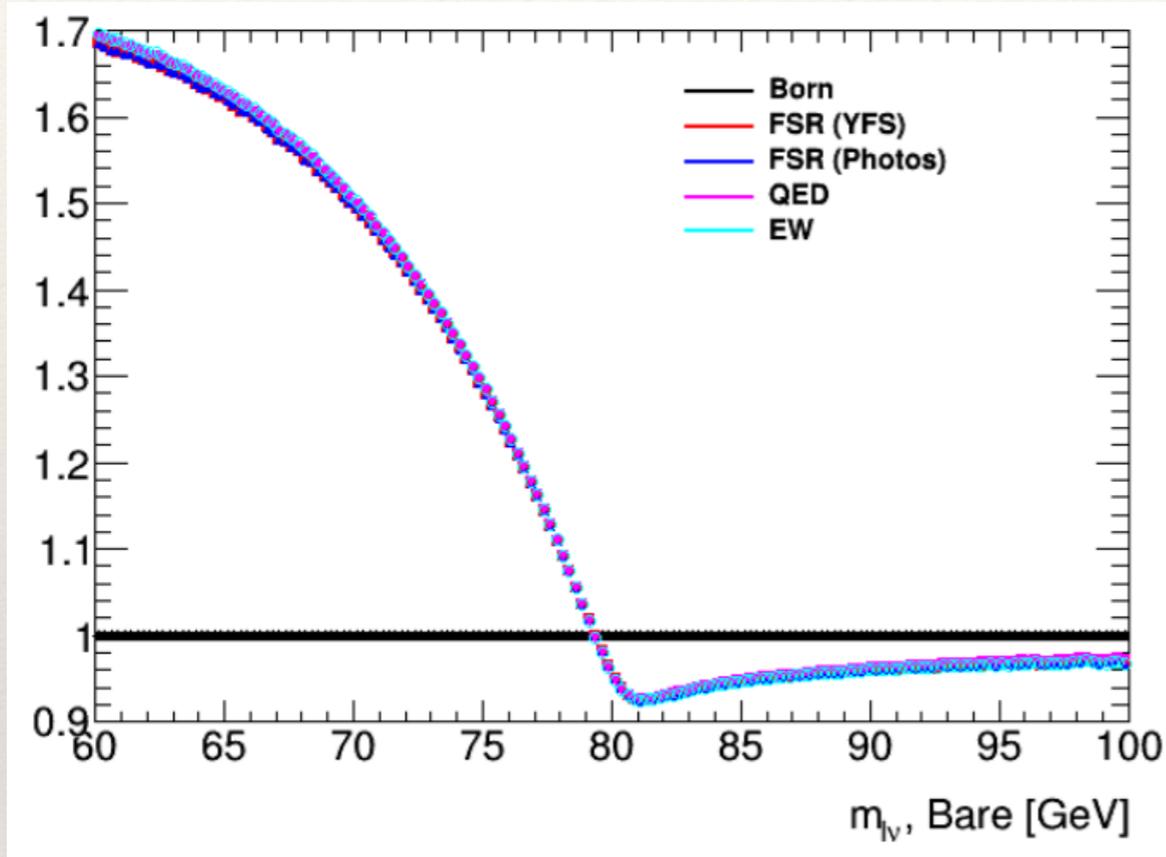
we study the **shape** of the distributions at the W resonance, virtual effects are normalised out

$pp \rightarrow W^+, \sqrt{s} = 14 \text{ TeV}$			M_W shifts (MeV)			
Templates accuracy: NLO-QCD+QCD _{PS}		QED FSR	$W^+ \rightarrow \mu^+ \nu$		$W^+ \rightarrow e^+ \nu(\text{dres})$	
Pseudodata accuracy			M_T	p_T^ℓ	M_T	p_T^ℓ
1	NLO-QCD+(QCD+QED) _{PS}	PYTHIA	-95.2±0.6	-400±3	-38.0±0.6	-149±2
2	NLO-QCD+(QCD+QED) _{PS}	PHOTOS	-88.0±0.6	-368±2	-38.4±0.6	-150±3
3	NLO-(QCD+EW)+(QCD+QED) _{PS} two-rad	PYTHIA	-89.0±0.6	-371±3	-38.8±0.6	-157±3
4	NLO-(QCD+EW)+(QCD+QED) _{PS} two-rad	PHOTOS	-88.6±0.6	-370±3	-39.2±0.6	-159±2

❖ ~Agrees with estimations from ATLAS m_W analysis

❖ Should treat FSR matching correctly when incorporating EW effects

NLO-EW



- ❖ FSR effects $\sim 100x$ larger than the further EW corrections
- ❖ when combining everything, the FSR accuracy should not be spoiled (eg by the matching procedure), or we risk to lose more than we gain

EW corrections : open points/questions

- ❖ Are there further studies to confirm the small impact from NLO EW corrections ?
- ❖ Comparisons with KKMC-hh (talk by Scott Yost in general meeting)
- ❖ fermion pair corrections : validation with the data
- ❖ $\sin^2\theta$:
 - ❖ how to vary $\sin^2\theta W_{\text{eff}}$ in MC generators consistently ?
 - ❖ is the size of EW corrections comparably small ?

Working meeting : Monday to Wednesday

10:25 → 10:55	coffee break	30m
10:55 → 11:25	W over Z transverse momentum ratio Speakers: Frank Tackmann , Frank Tackmann (Deutsches Elektronen-Synchrotron (DE))	30m
11:25 → 12:15	discussion	50m
12:15 → 13:45	lunch break	1h 30m
13:45 → 14:15	Comparisons of resummed calculations	30m
14:15 → 18:15	discussion	4h

TUESDAY, 3 OCTOBER

09:30 → 10:00	Heavy flavour effects in pTZ and impact on mW Speaker: Alessandro Vicini (Università degli Studi e INFN Milano (IT))	30m
10:00 → 12:15	discussion	2h 15m
12:15 → 13:45	lunch break	1h 30m
13:45 → 14:15	EW effects and related uncertainties Speaker: Fulvio Piccinini (Universita e INFN, Pavia (IT))	30m
14:15 → 18:15	discussion	4h

WEDNESDAY, 4 OCTOBER

10:00 → 12:15	discussion	2h 15m
12:15 → 13:45	lunch break	1h 30m
13:45 → 14:15	Parton shower versus resummation Speaker: Stefano Camarda (CERN)	30m
14:15 → 18:15	discussion	4h

- ❖ Suggestion for a general splitting, but no strict compartments needed
 - ❖ Today : resummation day
 - ❖ Tomorrow : EW corrections day
 - ❖ Wednesday : parton shower day, overflow, preparation of summary talks for the second session
- ❖ Several rooms booked if people need to look at technical points in details on laptops in a quiet environment
- ❖ Can we manage to converge and make a publication 'a la PDF4LHC' containing studies and recommendations for EW and QCD uncertainties for these precision measurements at LHC ?
 - ❖ Would be good to work on a skeleton note in this respect