Hadronic & Electroweak Observables

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Vector Bosons & Jets

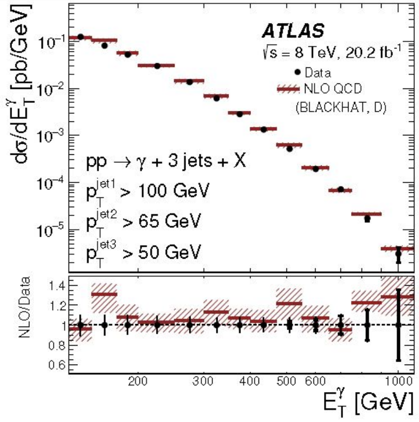
Photon production

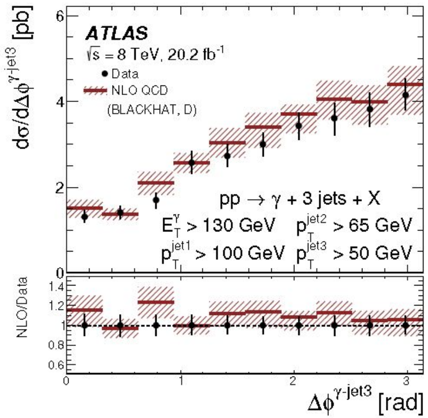
Several results on photon production
- Isolated, in association with up to 3 jets, di-photon at the LHC, direct photons at HERA

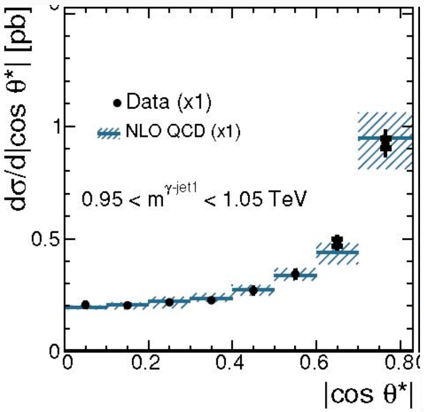
Test of pQCD, in general successful
- Other approaches (k_T factorization) have problem with emissions of extra gluons

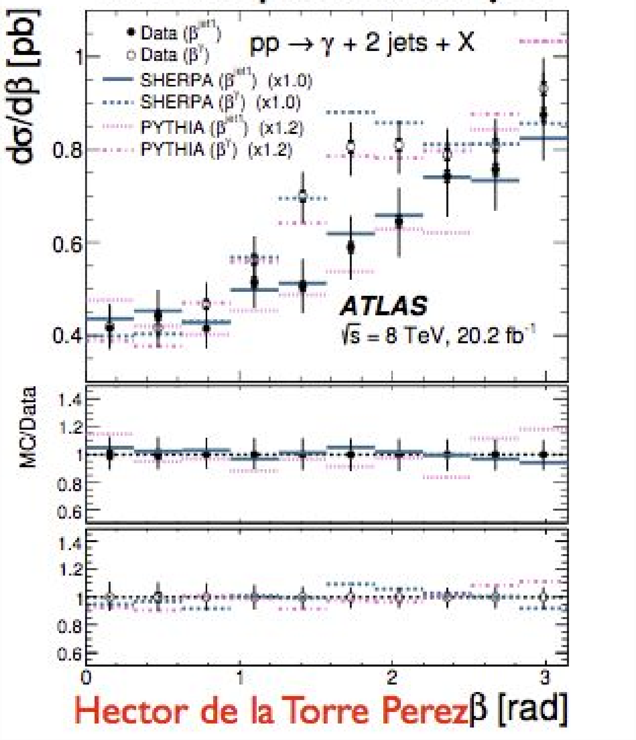
Investigation of new variables to study parton radiation
- Photons and jets show different QCD radiation pattern

η-Φ distance of 2nd jet and the photon/1st jet

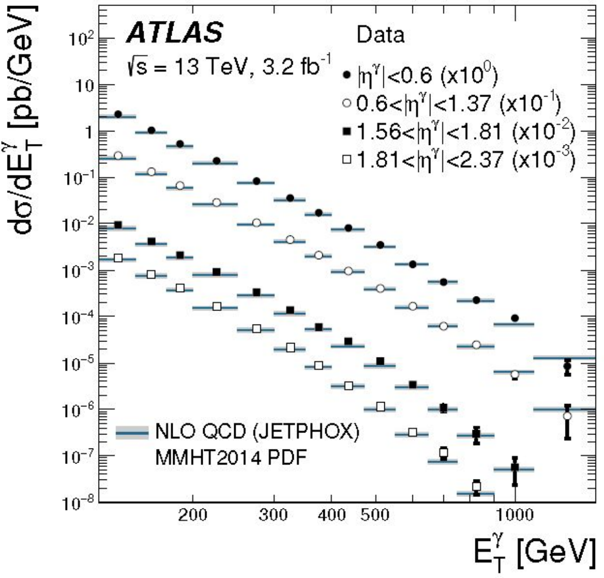


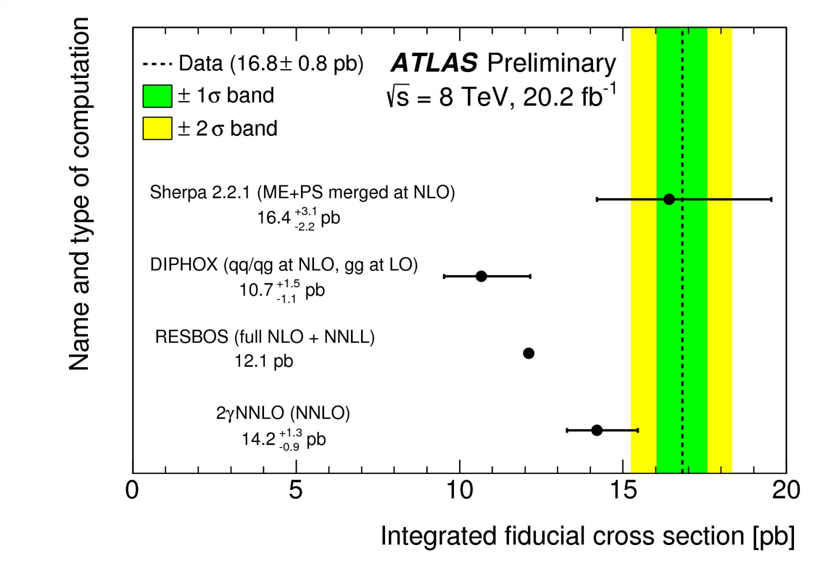


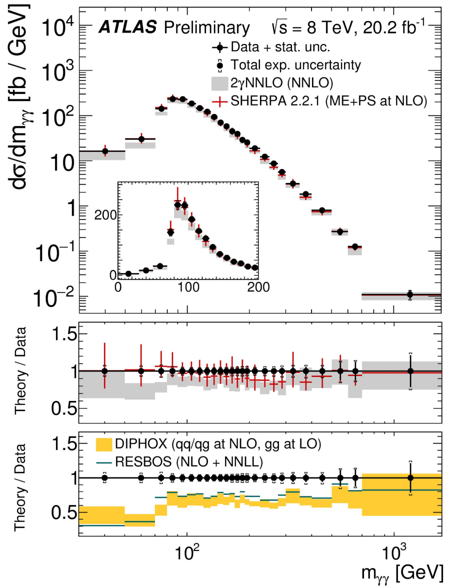




High E_T photons and photon pairs







Claudia Glasman

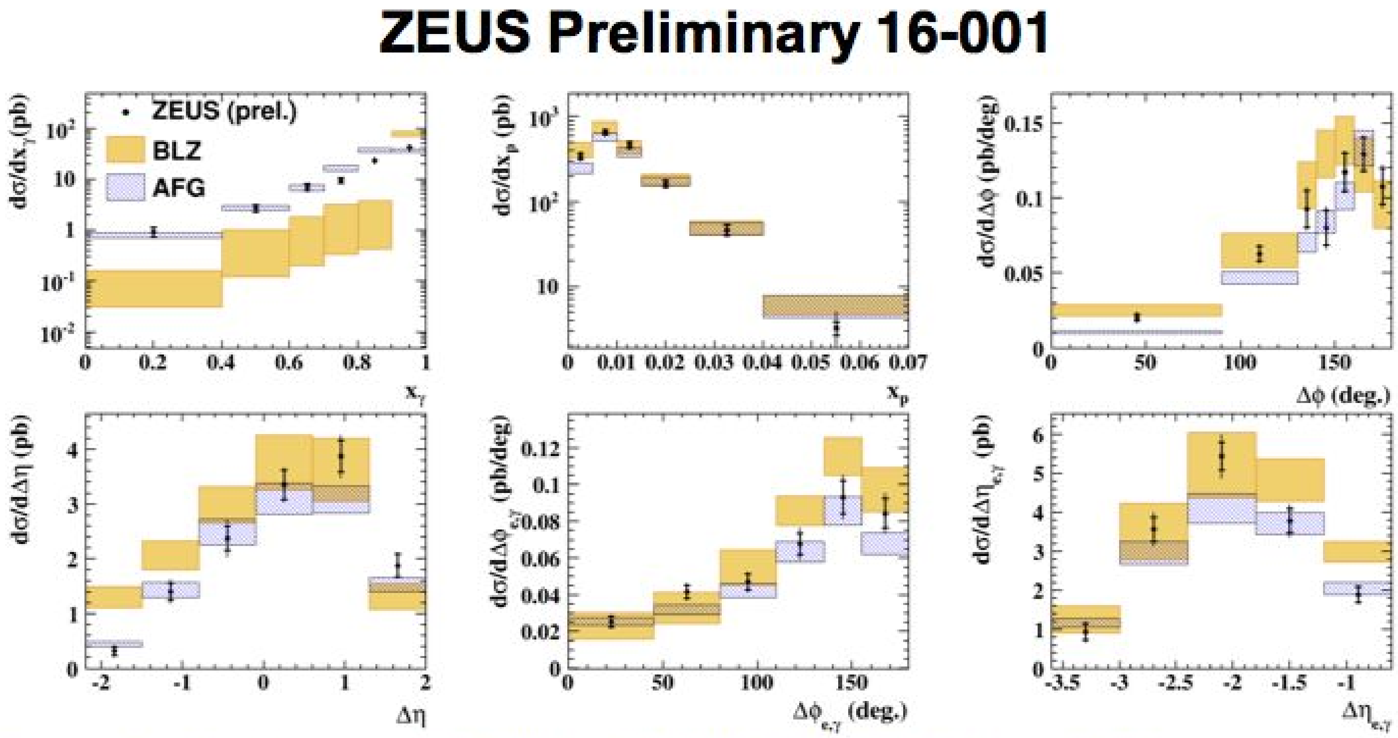
Isolated photon production, transverse energy up to 1.5TeV

- Good description by NLO MC; first NNLO calculations now available

Photon-pair production stringent test of pQCD

- NLO MC fails to describe data, whereas NNLO provides better match

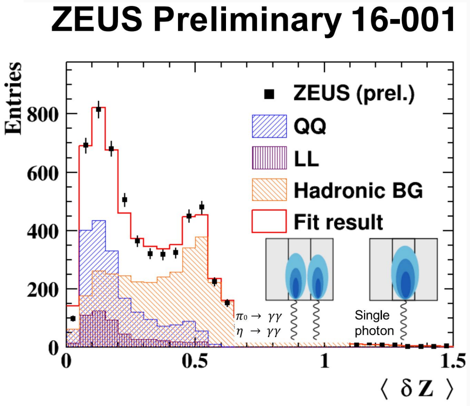
Photons at HERA



Aurenche, Fontannaz and Guillet : LAPTH-005/17 LPT-Orsay 16-88 ←NLO QCD

Baranov, Lipatov and Zotov: PRD81, 094034 (2010) ←k_T factorization

14 Correlated variables in isolated prompt photons production in DIS at HERA
Olena Hlushchenko| RWTH|



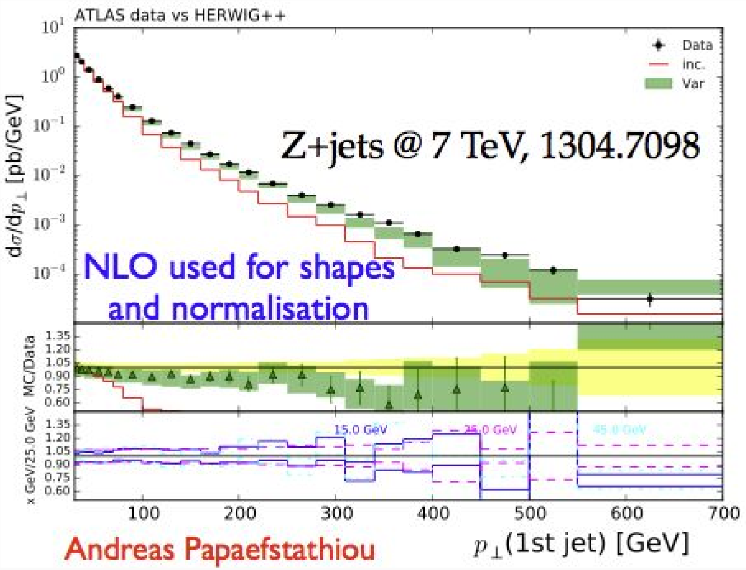
Olena Hlushchenko

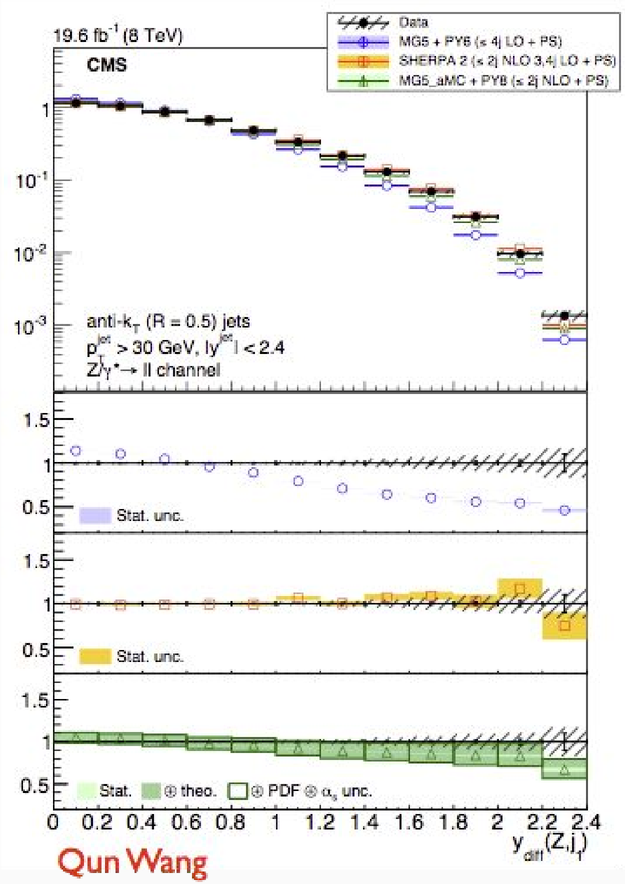
k_T-factorisation (BLZ) predictions show a fair agreement with the data with the exception of variables sensitive to gluon emission

Associated production of W/Z and jets

V+jets are a test bench for perturbative QCD, in particular for matrix-element merging techniques

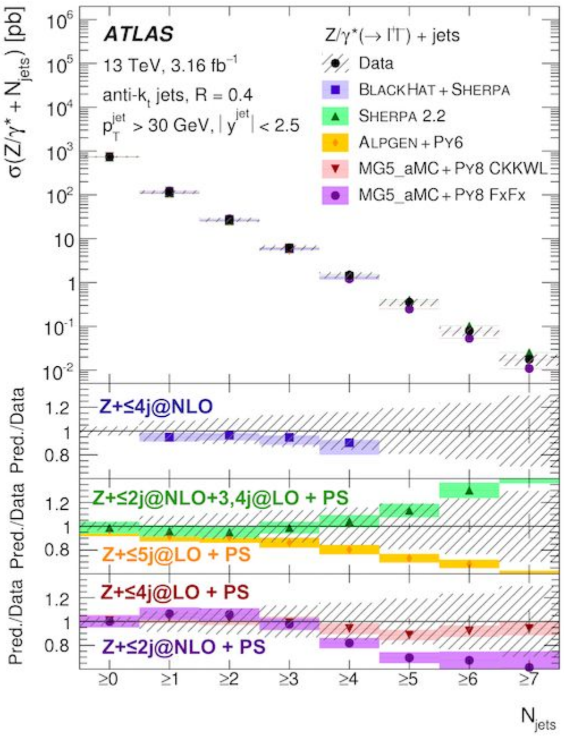
- Higher-order corrections improve theory/data agreement
- NLO merging gives a very satisfactory description of data

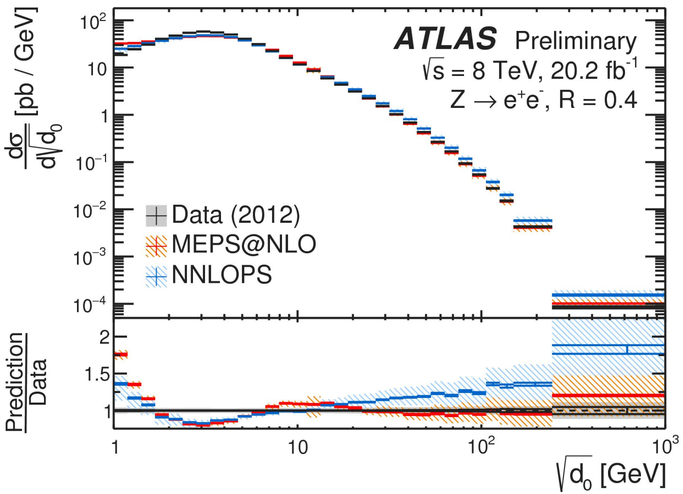


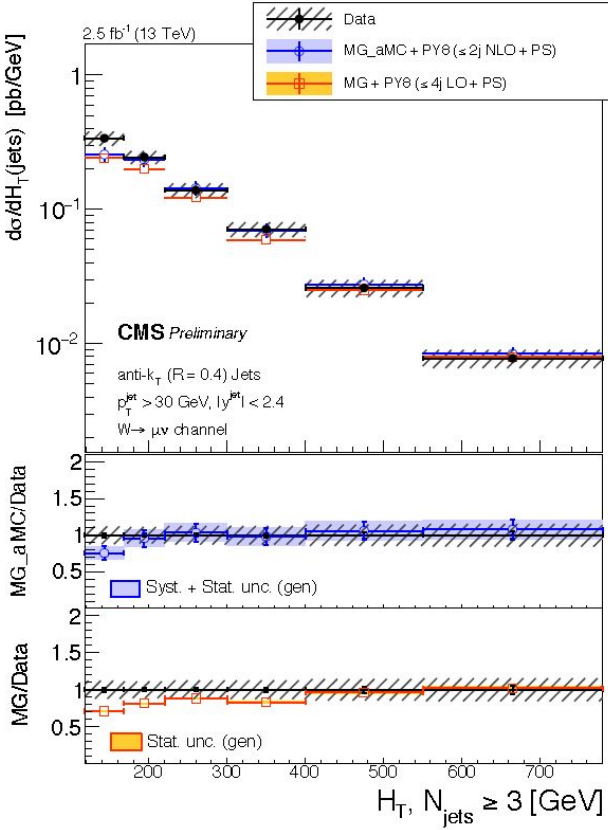


W/Z + Jets Highlights

Nataliia Kondrashova







Z + up to 7 jets
W + jets @ 13TeV
- Stringent tests of pQCD

Splitting scale measurement
- Probes QCD evolution

Qun Wang

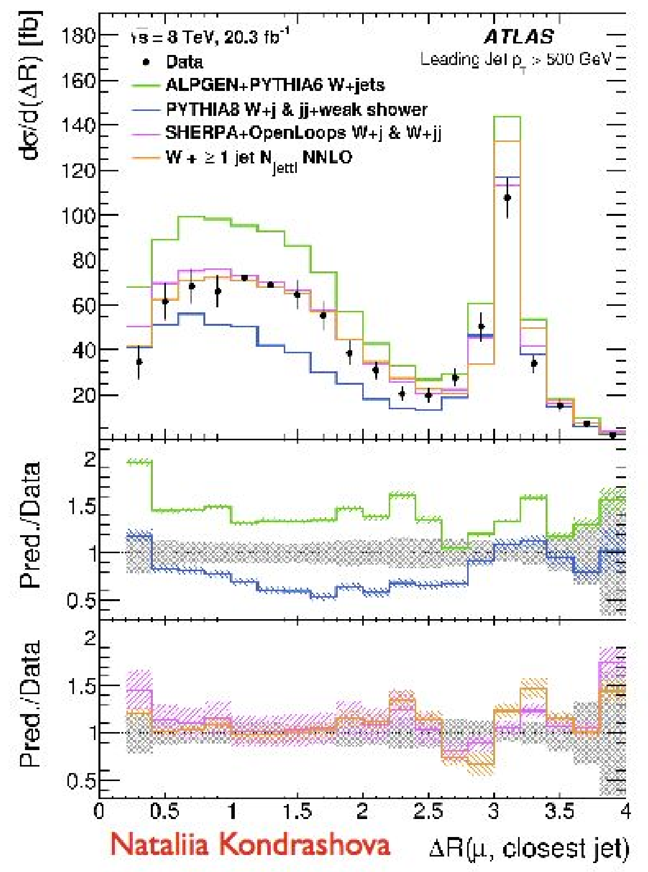
Study of collinear W-jet topologies

V+jets make it possible to study the emission of vector bosons from quarks in events with hard jets

- Important contribution for V+jets at large p_T
- Impact also on vector-boson scattering, dijets at large m_{jj}, boosted top,and new physics searches

Best agreement found with predictions with higher-order QCD predictions

- Best: Njetti NNLO and Sherpa+OpenLoops NLO QCD+EWK



Nataliia Kondrashova

LHCb Electroweak Programme

Inclusive W→eν production at 8 TeV NEW!

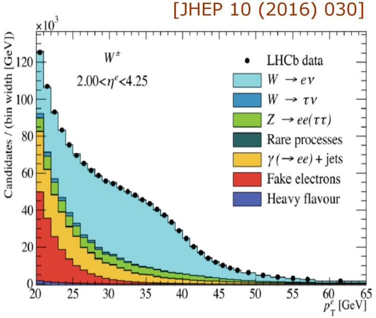
[JHEP 10 (2016) 030]

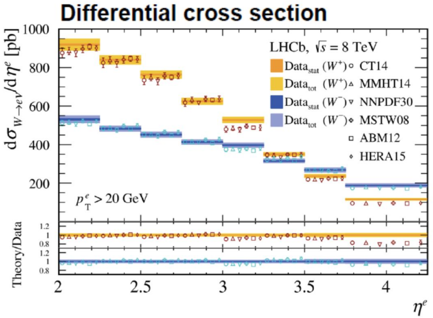
First measurement of $W \to e\nu$ at LHCb with 2 fb^{-1}

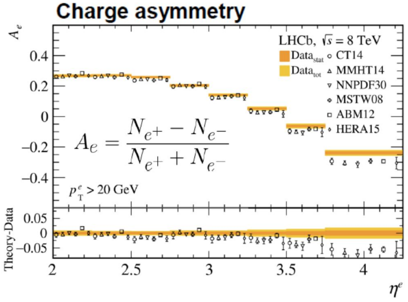
Fiducial acceptance

→ *single electron with p_T > 20 GeV, 2 < η_e < 4.25*

- purity ~60%
- additional $\gamma \to ee$ background
- softer p_T spectrum compared to W→μν
- efficiencies data driven







Good agreement between measured cross-section and theoretical predictions with different PDFs

Marcin Kucharczyk

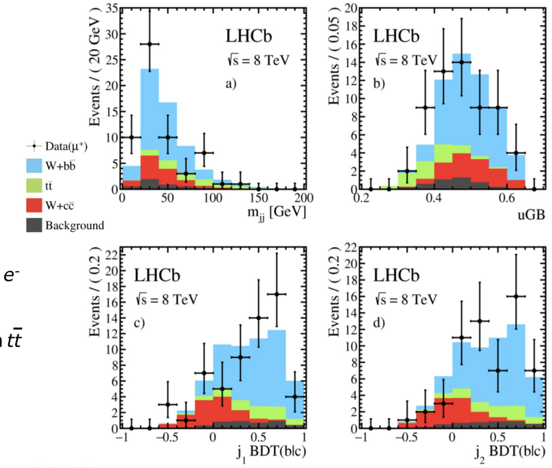
$Wb\bar{b}$, $Wc\bar{c}$ and $t\bar{t}$ cross-section at 8 TeV NEW!

[Phys. Lett. B767 (2017) 110]

Analysis extended to one isolated lepton *(muon or electron)* and two heavy-flavour tagged jets using 2 fb^{-1}

- leptons:
  - → *isolated*
  - → *p_T >20 GeV*
  - → *2 < η < 4.5 (4.25) for μ (e)*
- jets:
  - → *p_T > 12.5 GeV*
  - → *2.2 < η < 4.2*
- ΔR(*lepton-jet*) > 0.5

Fit projection on μ^+



- simultaneous 4D fit to μ^+, μ^-, e^+, e^-
  - → *$Wb\bar{b}$, $Wc\bar{c}$ and $t\bar{t}$ floated*
- MVA (uGB) to separate $Wb\bar{b}$ from $t\bar{t}$
  - → *topology*
  - → *kinematic variables*
  - → *sub-combination masses*

Novel measurement of W + cc production

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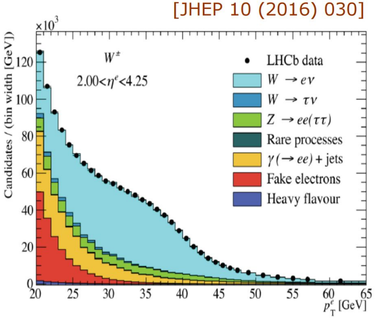
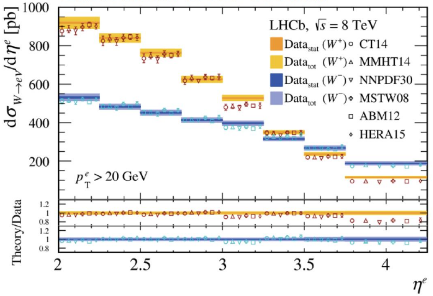
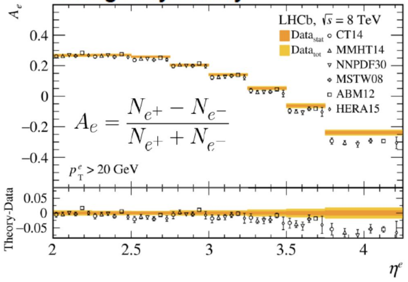


Differential cross section



Charge asymmetry



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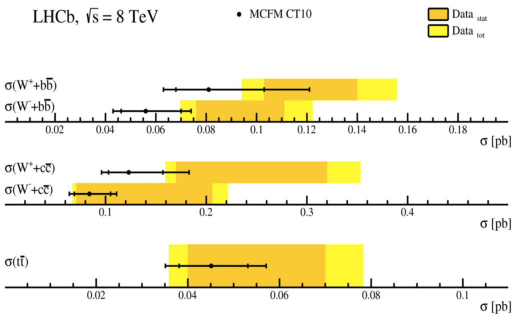
$Wb\bar{b}$, $Wc\bar{c}$ and $t\bar{t}$ cross-section at 8 TeV NEW!

[Phys. Lett. B767 (2017) 110]

- MCFM NLO prediction with PDF set CT10
- Showering and hadronization using Pythia 8



Sample	Significance
$t\bar{t}$	4.9σ
$W^+ + b\bar{b}$	7.1σ
$W^- + b\bar{b}$	5.6σ
$W^+ + c\bar{c}$	4.7σ
$W^- + c\bar{c}$	2.5σ

Good Agreement with NLO predictions

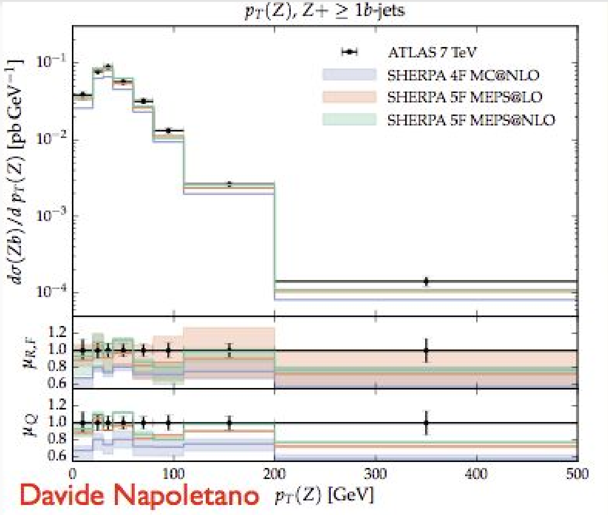
Theoretical progress highlights

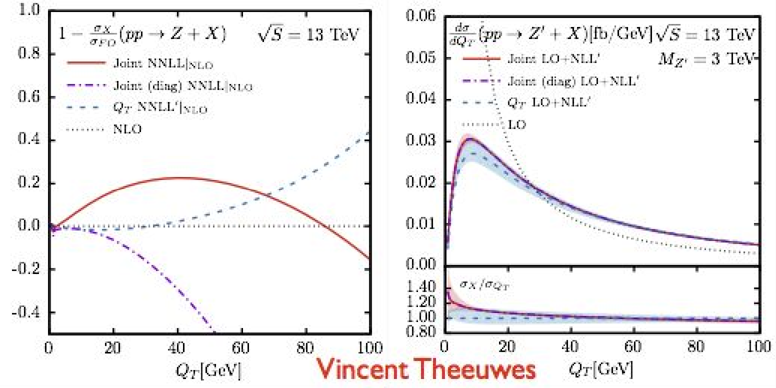
Study of Z production in association with b-jets, and comparison with different flavour schemes

- 4FS and 5FS agree in shape, 4FS normalisation undershoots data when one b-jet is outside the acceptance

Joint q_T and threshold resummation for Drell-Yan available

- Unfortunately, power corrections remain large at the LHC because of qg-initiated channel
- OK for Tevatron and for heavy Z’





More theoretical progress

- Development of loop-tree duality techniques towards their application at realistic processes
- High-multiplicity loop integrals (up to 10 external legs) can be efficiently tackled
- Timings are quite competitive
- Will this change the way we do higher-order computations?

Tensor pentagons

	Rank	Tensor Pentagon	Real Part	Imaginary Part	Time [s]
P16	2	LoopTools	-1.86472×10^{-8}		
		SecDec	$-1.86471(2) \times 10^{-8}$		45
		LTD	$-1.86462(26) \times 10^{-8}$		1
P17	3	LoopTools	1.74828×10^{-3}		
		SecDec	$1.74828(17) \times 10^{-3}$		550
		LTD	$1.74808(283) \times 10^{-3}$		1
P18	2	LoopTools	-1.68298×10^{-6}	$+i\ 1.98303 \times 10^{-6}$	
		SecDec	$-1.68307(56) \times 10^{-6}$	$+i\ 1.98279(90) \times 10^{-6}$	66
		LTD	$-1.68298(74) \times 10^{-6}$	$+i\ 1.98299(74) \times 10^{-6}$	36
P19	3	LoopTools	-8.34718×10^{-2}	$+i\ 1.10217 \times 10^{-2}$	
		SecDec	$-8.33284(829) \times 10^{-2}$	$+i\ 1.10232(107) \times 10^{-2}$	1501
		LTD	$-8.34829(757) \times 10^{-2}$	$+i\ 1.10119(757) \times 10^{-2}$	38

$(\ell \cdot p_3) \times (\ell \cdot p_4)$

$(\ell \cdot p_3) \times (\ell \cdot p_4) \times (\ell \cdot p_5)$

Grigorios Chachamis

Electroweak

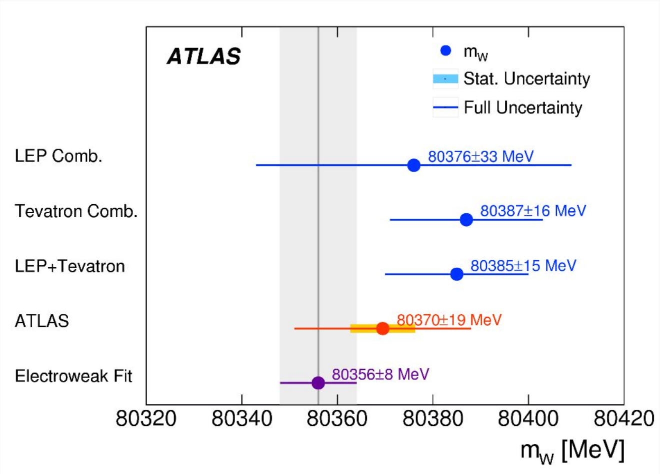
W mass measurement

Precision W mass result from ATLAS joins Tevatron(+LEP) combination

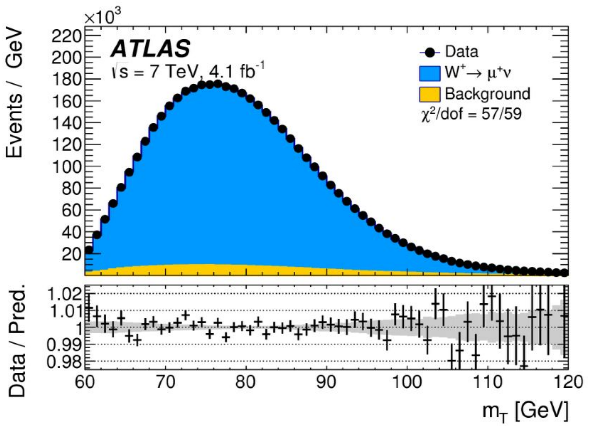
- Consistent within 2%% uncertainty

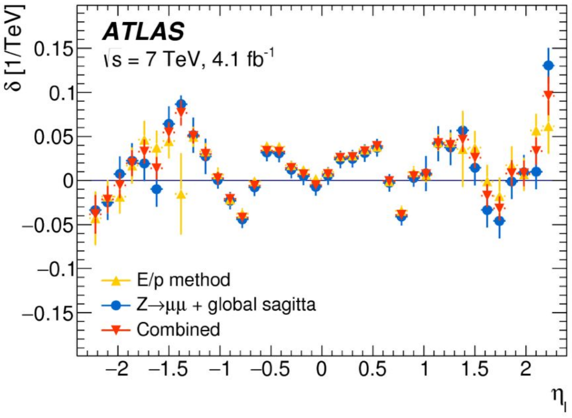
Some highlights on painstaking analysis

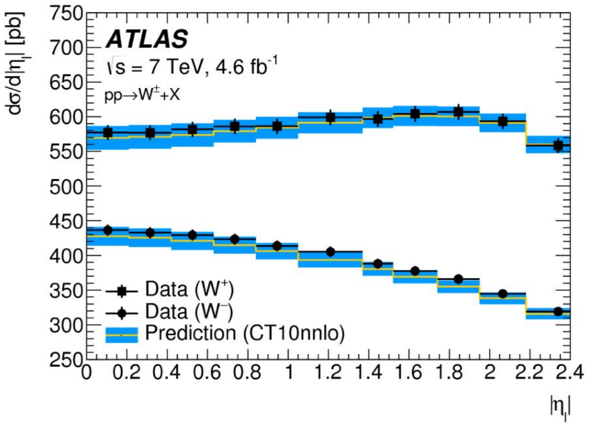
- W sample, correction for detector effects, modeling of boson kinematic



Fabrice Balli







Electroweak Tevatron results

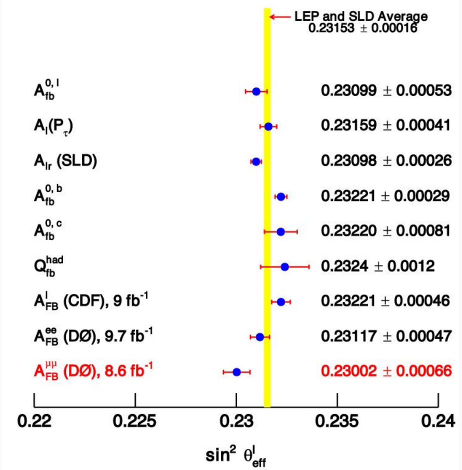
New results from D0 Collaboration

- Weak mixing angle in di-muon final state
- Direct measurement of top mass, full data sample
- Top pole mass from differential cross section

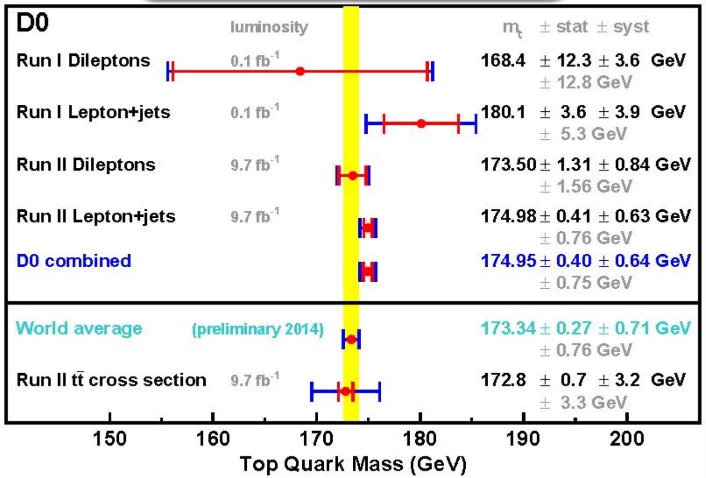
Preliminary combination of Tevatron weak mixing angle measurements

Iain Bertram

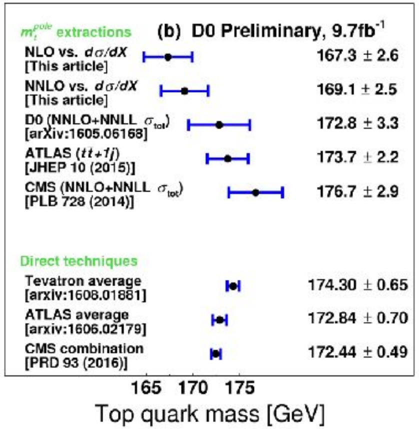
$$\sin^2\theta^l_{\mathrm{eff}} = 0.23002 \pm 0.00066$$



$$m_t = 174.9 \pm 0.75\,\mathrm{GeV}/c^2$$



$$m_t = 169.1 \pm 1.4\,(\mathrm{theo}) \pm 2.2\,(\mathrm{exp})\,\mathrm{GeV}/c^2$$

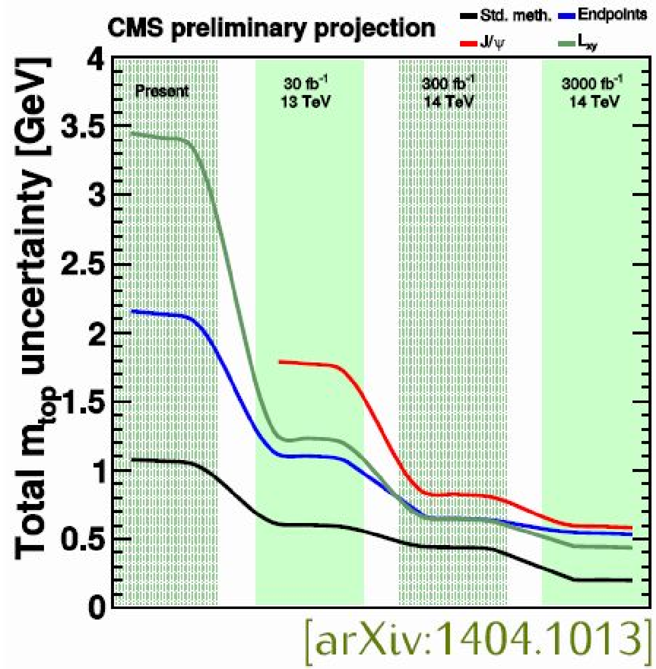


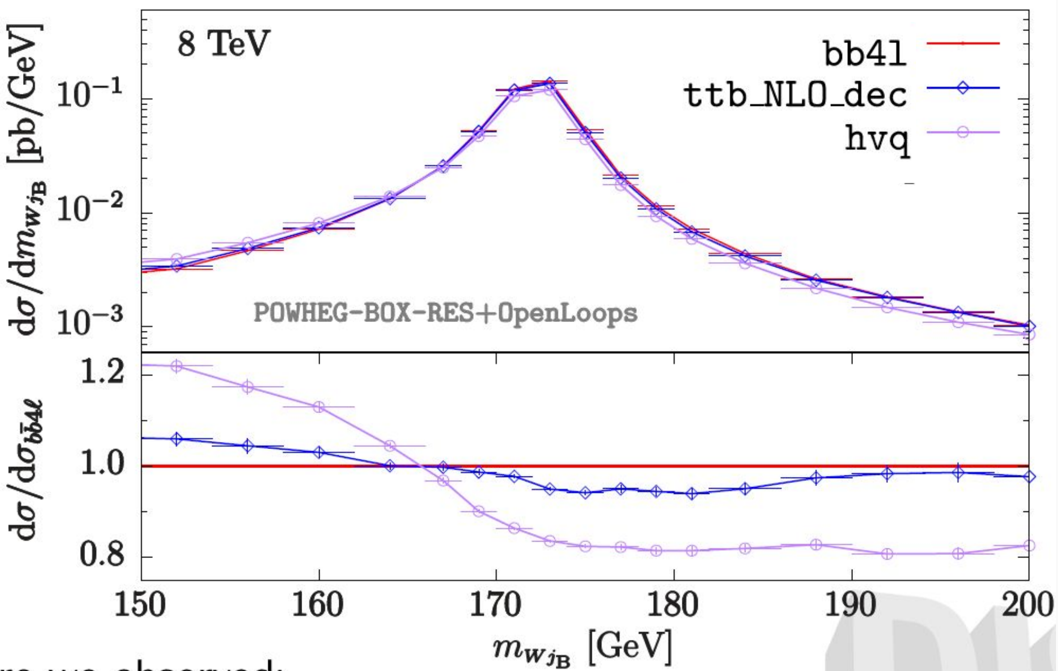
Improvements on generators for top quark production

Proposed method to generate top states with full interference term at NLO

- Experimental precision reaching O(0.1GeV)
- Includes exact off-shell effects and interference of radiation from production and decay

Tomas Jezo



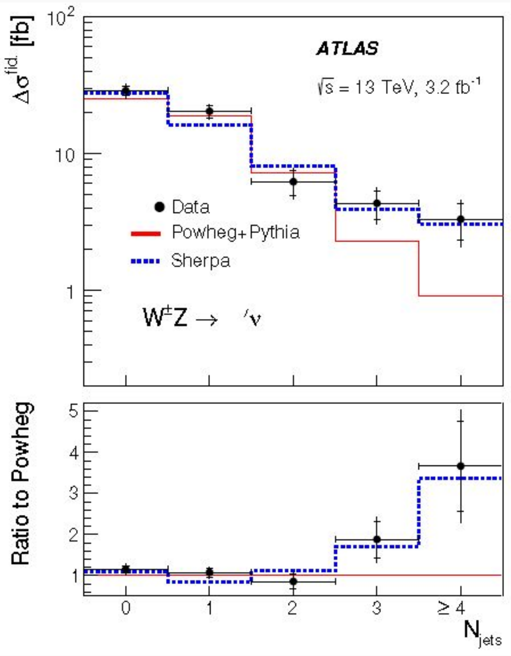


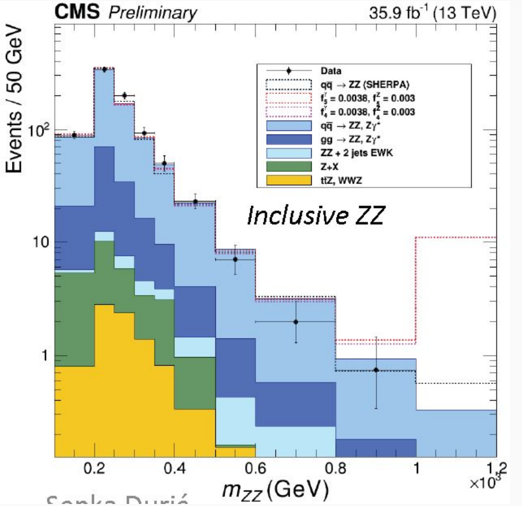
Multi-boson final states: experimental updates

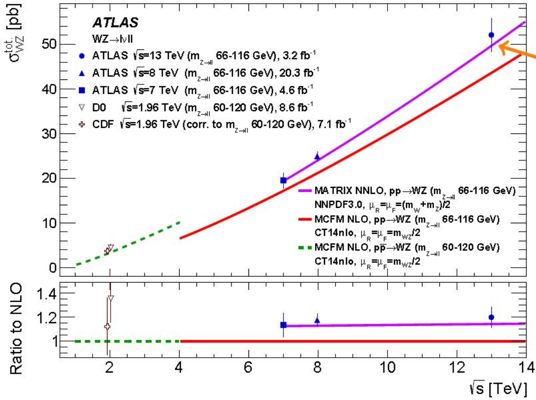
Very large scenario of measurements:
- Multi-boson final states; EWK production of vector bosons; VBS

Highlights:
- Fiducial cross sections sensitive to NNLO vs. NLO (WW)
- Differential cross sections challenge NLO predictions

Most recent results:
- ZZ in full 13 TeV data sample, WZ 8 TeV differential measurement
- VBF W, EW-produced Zγ, WWW production

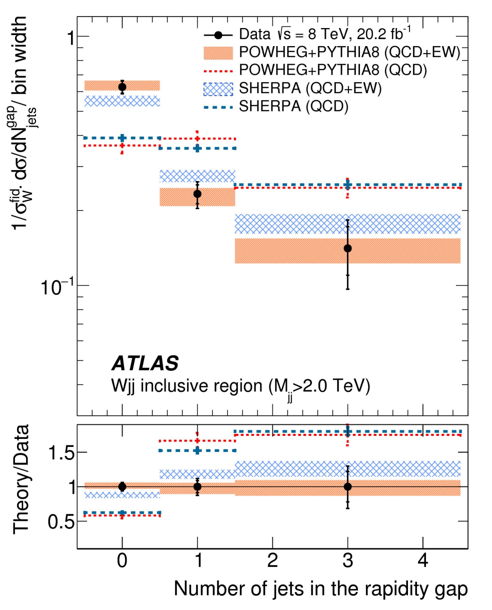






Angela Burger (WZ)
Senka Duric (ZZ)

More multi-boson highlights

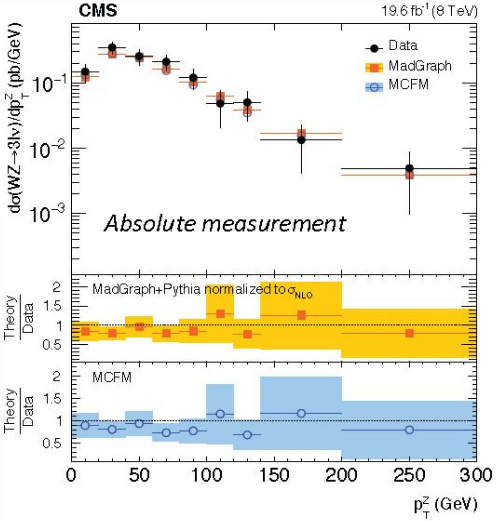


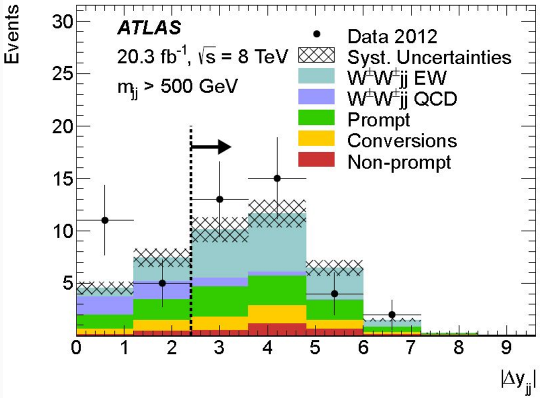
Chris Hays

VBF W: sensitive to EWK corrections

WZ cross section: MC/data normalization 10% off: consistent with expected NNLO QCD corrections

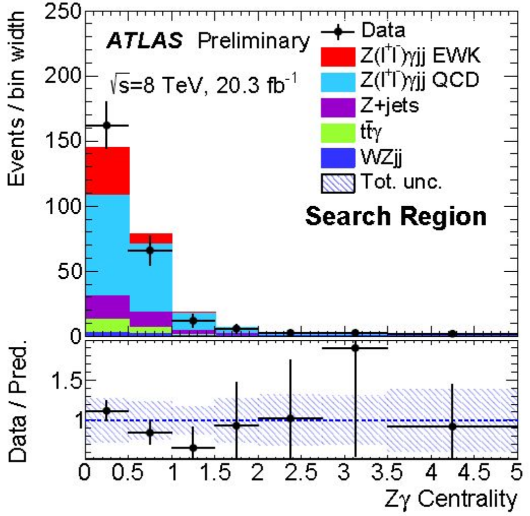
Senka Duric





Christian Johnson

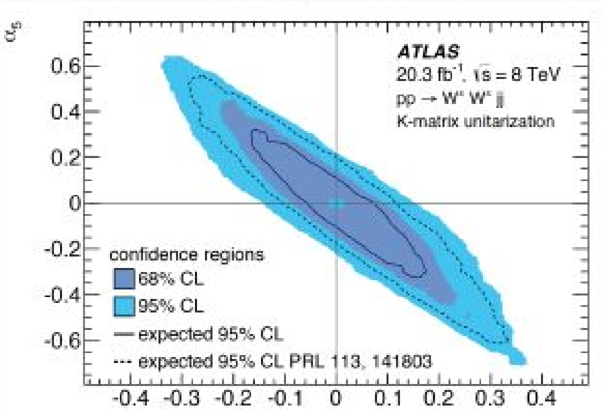
Search region for same-sign WW (above) and Zγ electroweak production (right)



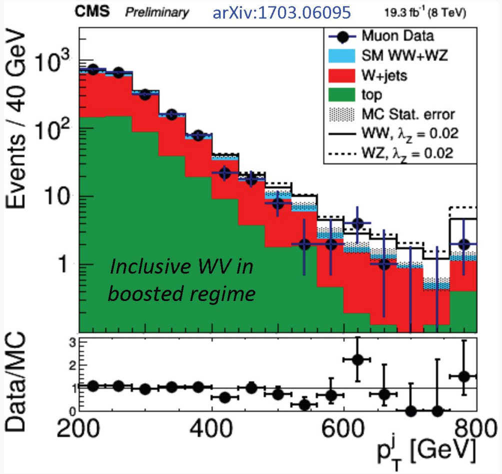
Limits on anomalous gauge couplings

Not yet observed anomalies in electroweak gauge couplings (!)
- Larger sensitivity to anomalies due to increase in centre-of-mass energy
- Limits comparable to LEP results

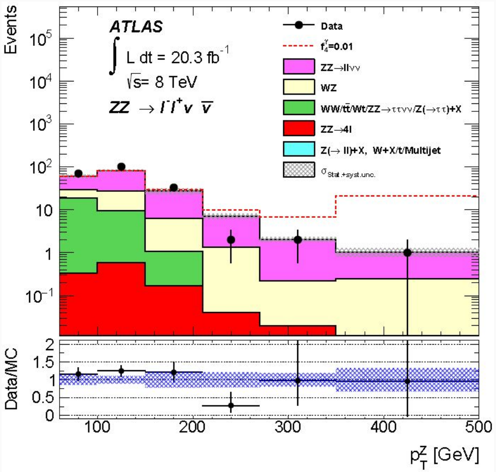
Limits set using all multi-boson final states
- TGC (charged and neutral) in diboson production and VBF
- QCG in VBS and triple-boson final states



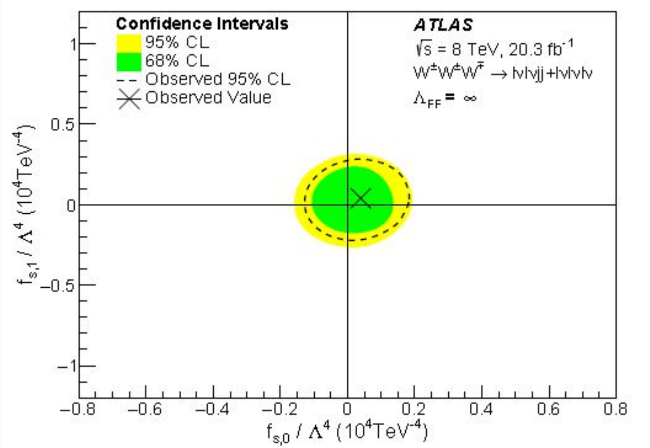
Senka Duric



Angela Burger



Christian Johnson

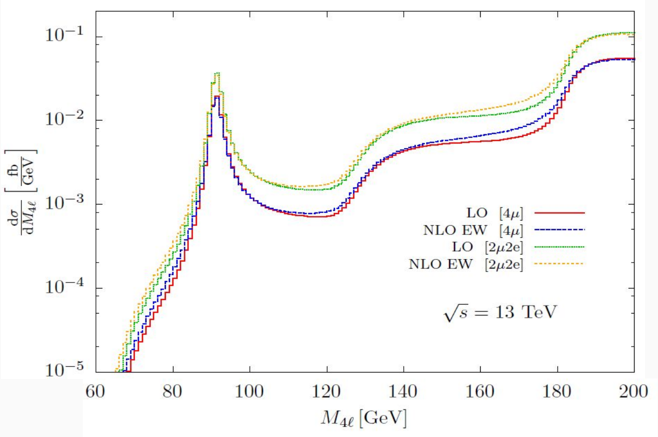


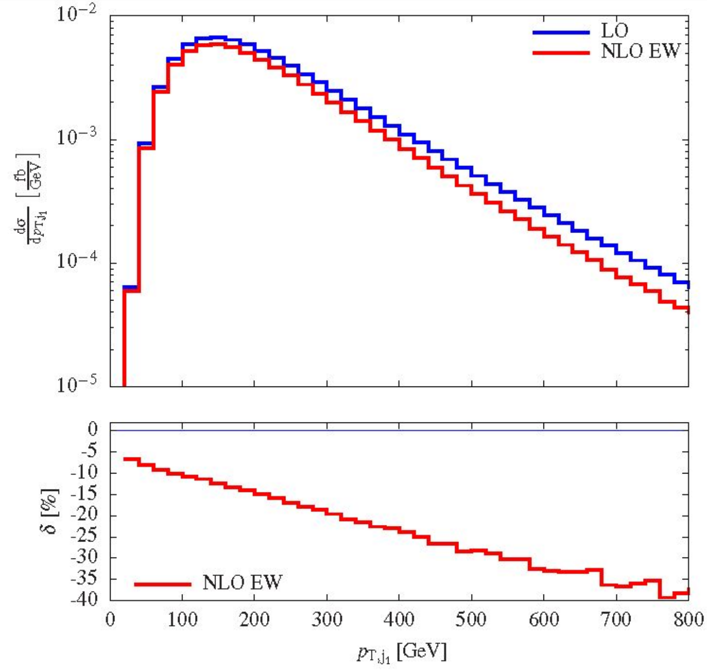
Theory updates: multi-boson final states

NLO electroweak corrections to di-boson production and vector-boson scattering

- Full set of NLO EW corrections to diboson production; dependence on different phase space selections evaluated (inclusive, Higgs analysis, TGC)
- First calculation of NLO EW corrections to VBS same-sign WW: they are large!

Benedikt Biedermann





Mathieu Pellen

α_s and Double Parton Scattering

NNLO α_s fit using jets in DIS

- Recent NNLO computation of jet production in DIS (Currie et al, 1606.03991 and 1903.05977) makes it possible to extract extract α_s with a proper NNLO fit
- Sensitivity from hard matrix elements and from PDF separately studied
- Excellent experimental accuracy and improved theoretical errors. Scale uncertainties still the dominant source, followed by PDF
- Running confirmed between 7 and 90 GeV

Fits to

- Inclusive jet or dijet data
- Separate fits to low-μ and high-μ data points
- Fits including PDF uncertainties in χ^2 or not

Fits with two free α_s parameters

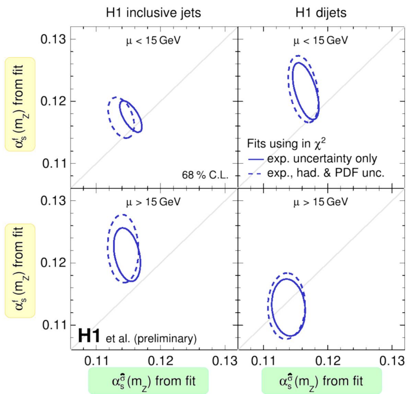
$$\sigma_i = f(\alpha_s^f(m_Z)) \otimes \hat{\sigma}_k(\alpha_s^{\hat{\sigma}}(m_Z)) \cdot c_{\text{had}}$$

Results

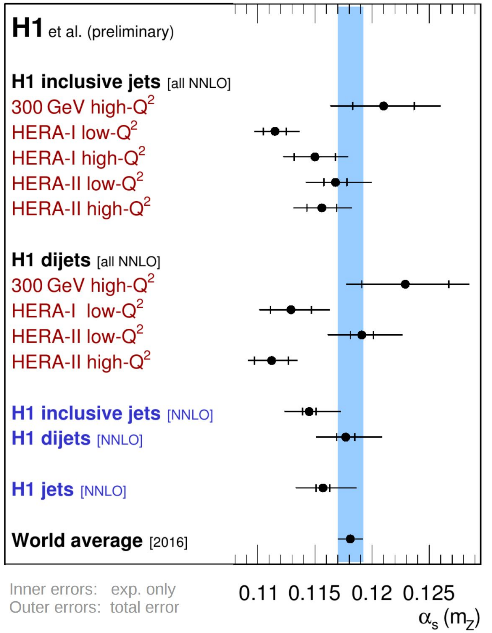
- Most sensitivity arises from matrix elements
- Best-fit α_s-values in PDF's and ME's are consistent
- Significant anti-correlation at lower scales -> Increased sensitivity if both α_s-values identified to be identical
- PDF uncertainties do not yield significant shift -> PDF uncertainties with small correlation to α_s^{PDF}

H1 jets (203 data points)

$$\alpha_s(M_Z) = 0.1157\,(6)_{\text{exp}}\,(3)_{\text{had}}\,(6)_{\text{PDF}}\,(12)_{\text{PDF}\alpha_s}\,(2)_{\text{PDFset}}\,(^{+27}_{-21})_{\text{scale}}$$



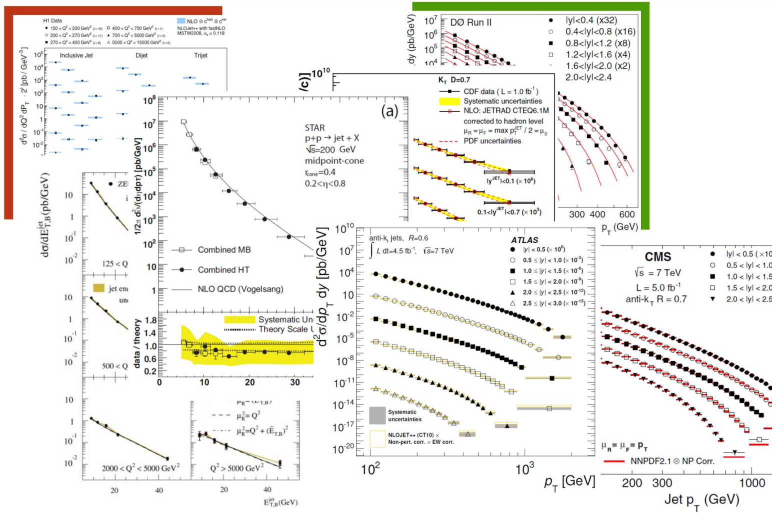
Daniel Britzger



Global fit of α_s using jet cross sections

- Aim: extract α_s using the measurements of jet cross sections by various experiments, within an unified framework (ALPOS) and fitting procedure
- Old results are reproduced exactly. Possible improvements by including new theoretical predictions (NNLO)

Add more datasets



K. Rabbertz | Birmingham, UK, 05.04.2017 | DIS 2017 Workshop

Klaus Rabbertz

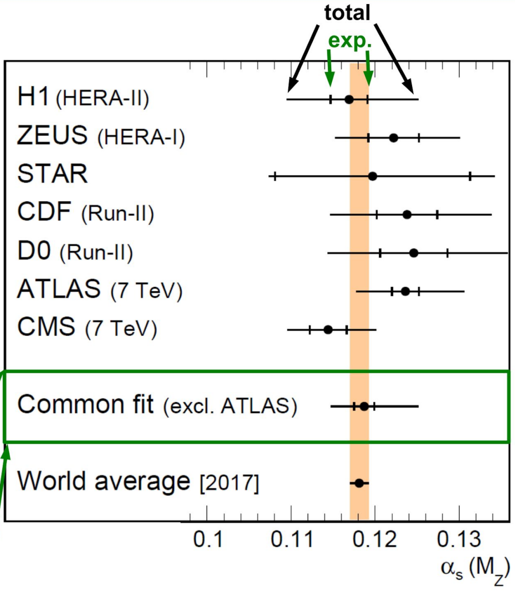
Unified fit result (2)

Simultaneous fit to H1, ZEUS, STAR, CDF, D0, and CMS

- **consistent result**
- **reduced experimental uncertainty**
- **scale uncertainty (NLO) dominating in full uncertainty breakdown**

$$\alpha_s(M_Z) = 0.1187(\pm 12)_{\text{exp}}\,(\pm 5)_{\text{NP}}\,(\pm 6)_{\text{PDF}}\,(^{+18}_{-3})_{\text{PDFset}}\,(^{+11}_{-8})_{\text{PDF}\alpha_s}\,(^{+59}_{-38})_{\text{scale}}$$

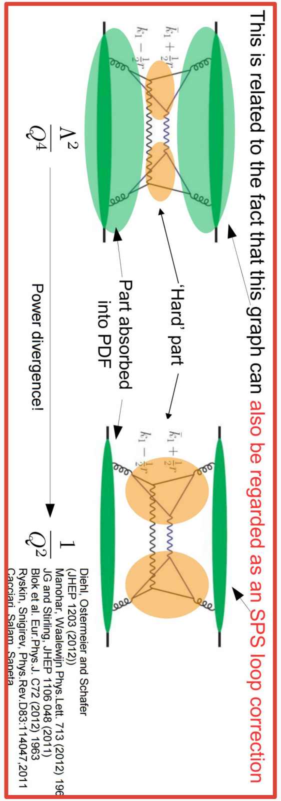
$$[\chi^2_{\text{min}}/\text{ndf} = 0.87]$$



K. Rabbertz | Birmingham, UK, 05.04.2017 | DIS 2017 Workshop | 19

Perturbative splitting can occur in both protons (1v1 graph) – gives power divergent contribution to DPS cross section!

$$\int \frac{d^2y}{y^4} = ?$$

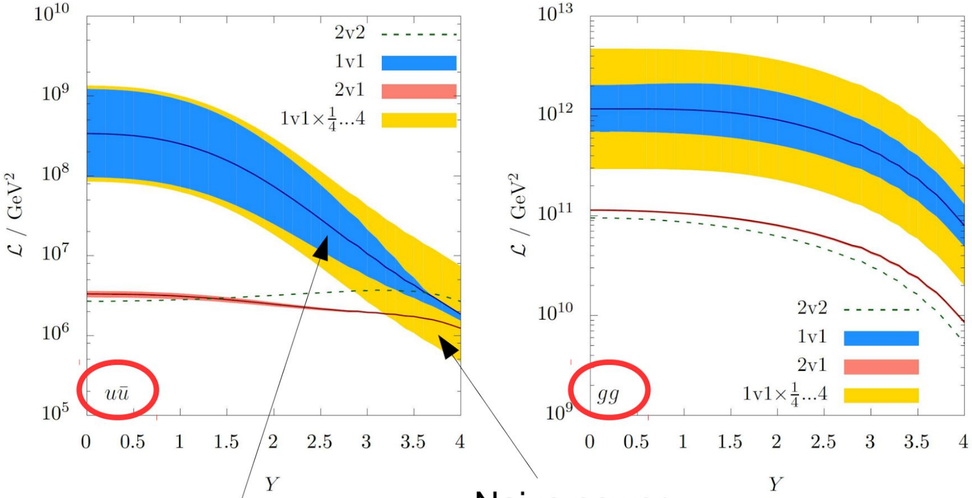


DPS luminosities

$Q_A = Q_B = 80\text{ GeV}, \sqrt{s} = 14\text{ TeV}$

Vary scale ν between *Q*/2 and 2*Q*

Here: plot luminosities againsts rapidity of one hard system (other kept central):



Actual ν variation

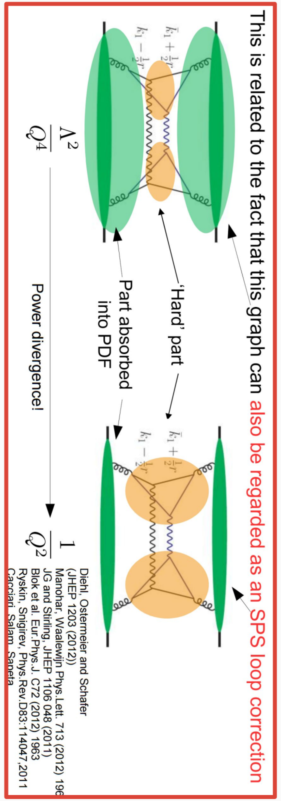
Naive power counting expection for ν variation $\propto \nu^2$

2v2 much larger than others, with large ν variation – need SPS contribution up to order containing double box, and subtraction!

Jonathan Gaunt

Perturbative splitting can occur in both protons (1v1 graph) – gives power divergent contribution to DPS cross section!

$$\int \frac{d^2y}{y^4} = ?$$



DPS luminosities

$Q_A = Q$ ...

Vary sc...

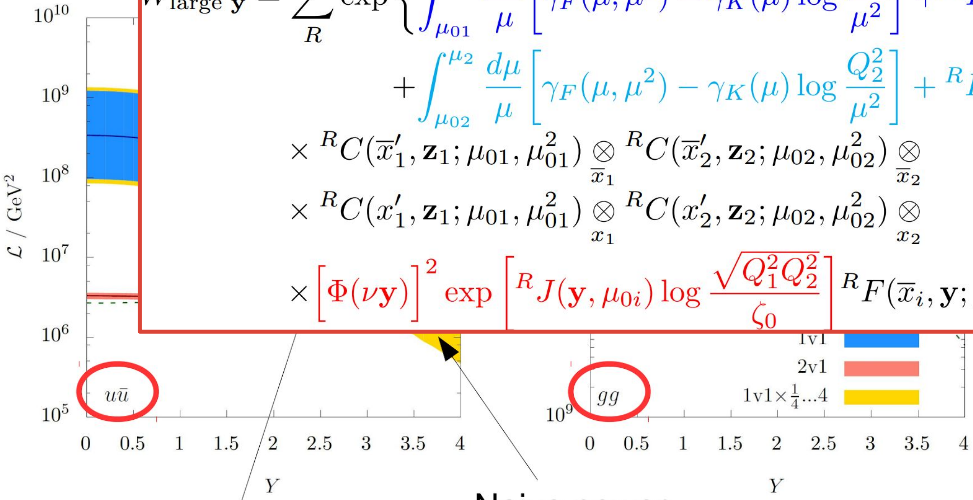
Here: p...

Combining matching and evolution

Maarten Buffing

- Cross section contribution given by

$$W_{\text{large } \mathbf{y}} = \sum_R \exp\Bigg\{ \int_{\mu_{01}}^{\mu_1} \frac{d\mu}{\mu}\Big[\gamma_F(\mu,\mu^2) - \gamma_K(\mu)\log\frac{Q_1^2}{\mu^2}\Big] + {}^RK(\mathbf{z}_1,\mu_{01})\log\frac{Q_1^2}{\mu_{01}^2}$$
$$+ \int_{\mu_{02}}^{\mu_2} \frac{d\mu}{\mu}\Big[\gamma_F(\mu,\mu^2) - \gamma_K(\mu)\log\frac{Q_2^2}{\mu^2}\Big] + {}^RK(\mathbf{z}_2,\mu_{02})\log\frac{Q_2^2}{\mu_{02}^2}\Bigg\}$$
$$\times {}^RC(\bar{x}_1', \mathbf{z}_1; \mu_{01}, \mu_{01}^2) \underset{\bar{x}_1}{\otimes} {}^RC(\bar{x}_2', \mathbf{z}_2; \mu_{02}, \mu_{02}^2) \underset{\bar{x}_2}{\otimes}$$
$$\times {}^RC(x_1', \mathbf{z}_1; \mu_{01}, \mu_{01}^2) \underset{x_1}{\otimes} {}^RC(x_2', \mathbf{z}_2; \mu_{02}, \mu_{02}^2) \underset{x_2}{\otimes}$$
$$\times \Big[\Phi(\nu \mathbf{y})\Big]^2 \exp\Big[{}^RJ(\mathbf{y},\mu_{0i})\log\frac{\sqrt{Q_1^2 Q_2^2}}{\zeta_0}\Big]\, {}^RF(\bar{x}_i, \mathbf{y}; \mu_{0i}, \zeta_0)\, {}^RF(x_i, \mathbf{y}; \mu_{0i}, \zeta_0)$$



double box, and subtraction!

Jonathan Gaunt

Actual v variation

Naive power counting expection for v variation $\propto \nu^2$

Event Shapes, Particle Correlations, Medium Effects

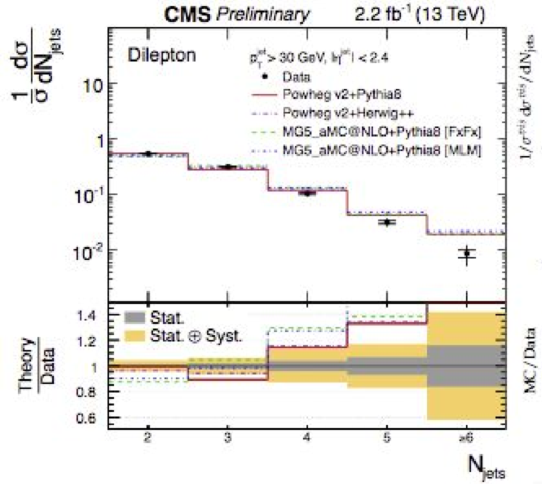
Underlying event tune in CMS

- Tuning of MC generators is needed to achieve a proper description of data
- A new Pythia8 tune is being developed by CMS
- UE tune improves the description e.g. of jets multiplicities in *ttbar* events
- Future plans to extend to HW++ and Sherpa

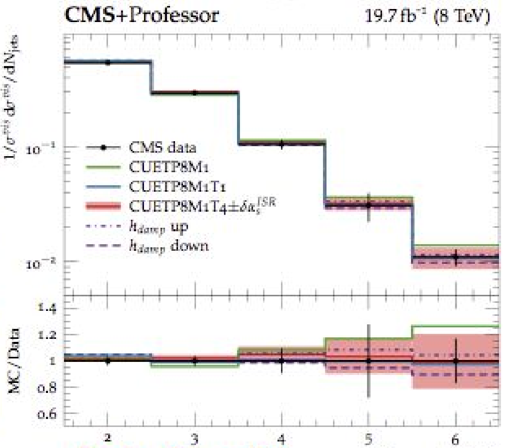
Results

$\alpha_S^{ISR} = 0.1108^{+0.0144}_{-0.0142}$ $\quad h_{damp} = 1.581^{+0.658}_{-0.585}$

Before



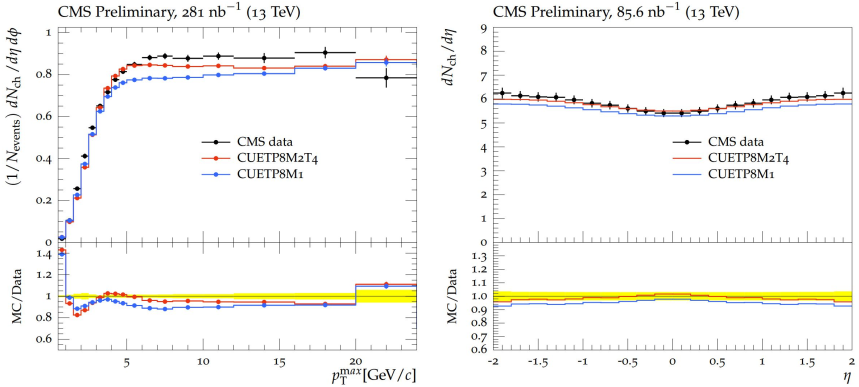
After



Paolo Gunnellini

Performance of the new tune

Charged particle mult. in the MIN region and dN/dη @13 TeV



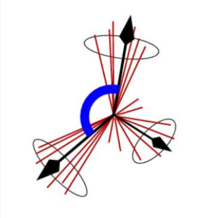
The new tune has a better description of the plateau region

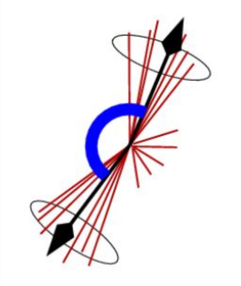
Rising part of the spectrum seems to prefer a double gaussian matter distribution profile

NEW!

CMS-FSQ-15-007 | PLB 751 (2015) 143 | CMS-TOP-16-021

Jet correlations in CMS



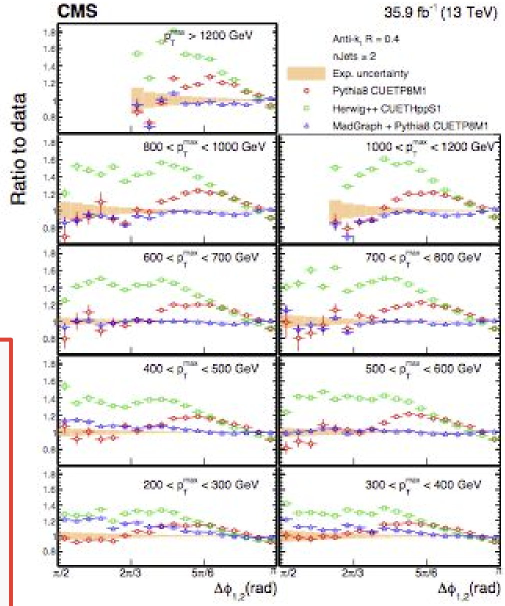


No tool can describe correlations both in 2 and 4 jets.

Why?

Can things be improved?

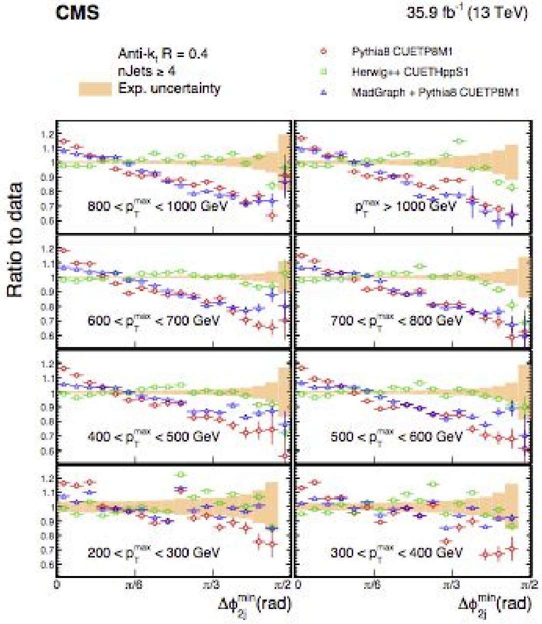
Inclusive 2-jets: $\Delta\phi_{1,2}$



- Herwig++ exhibits the largest deviations.
- Pythia8 behaves better.
- Best description by MadGraph.

Armando Bermudez Martinez

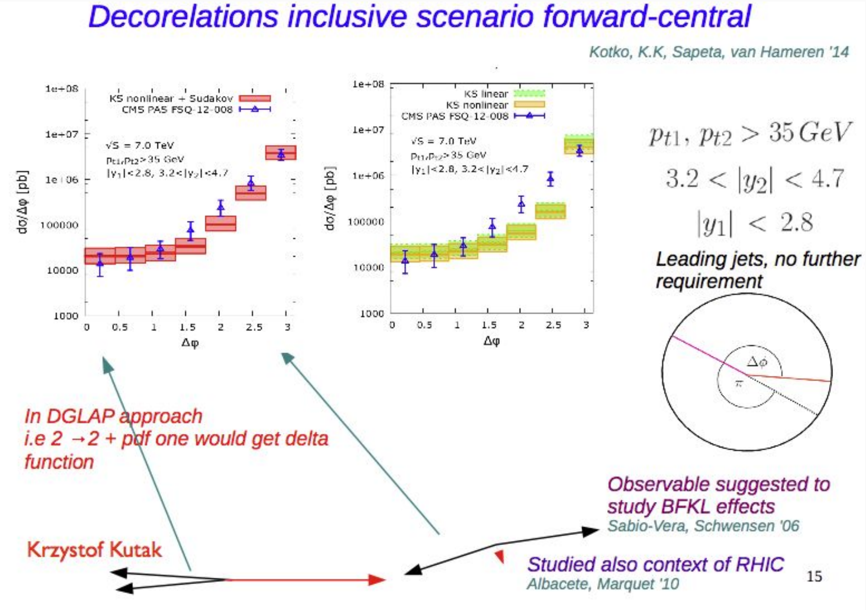
Inclusive 4-jets: $\Delta\phi_{2J}^{min}$

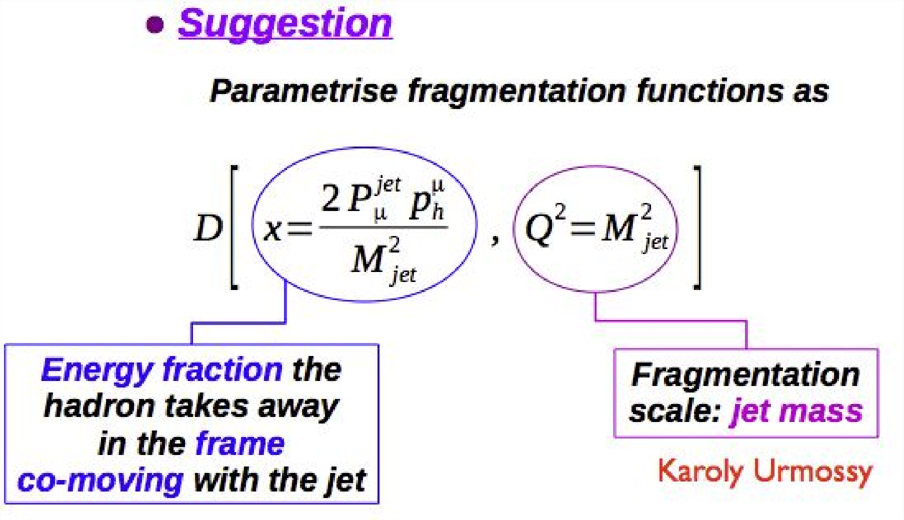


- Pythia8 and MadGraph fail to describe data.
- Herwig++ provides a reasonable description of the data.

New ideas for jet physics

- A new framework `improved TMD' for calculations of forward dijets has been developed, and phenomenological predictions can be obtained
- Forward-forward and forward-central di-jets studied
- Shall we use the jet mass to characterise jets and fragmentation functions?

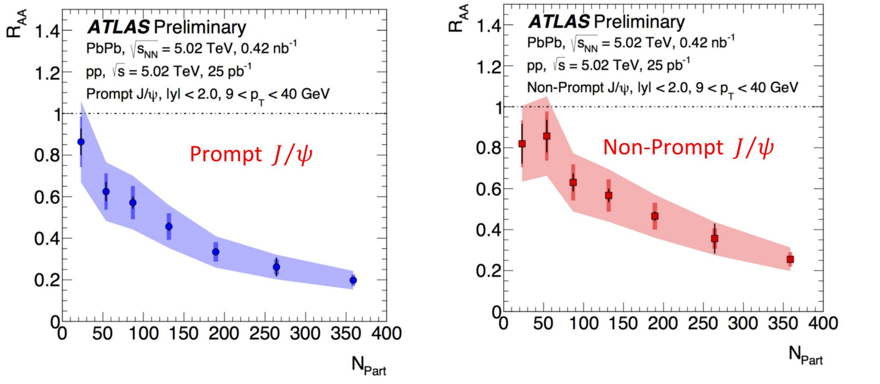




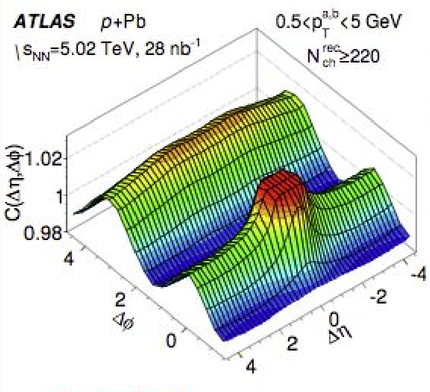
Results from heavy ions collisions

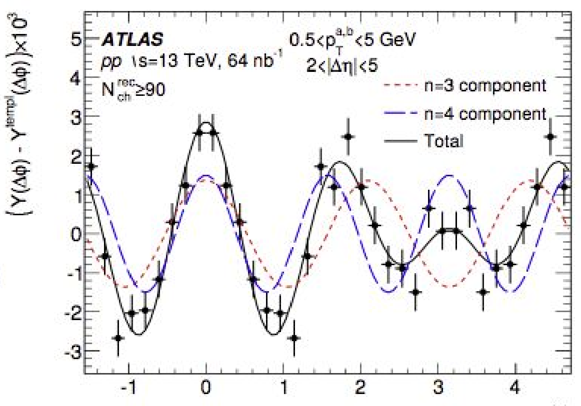
- Measurement of particle correlations and of the production of J/**ψ** and vector bosons in heavy-ion collisions have been presented
- Measurement of Fourier coefficient of correlations in heavy-ion collisions performed by ATLAS, lack of theoretical predictions to compare with
- The measurement of the ratio N_{ψ}/N_Z is independent of event activity and could be used as a benchmark for the nucleonic luminosity T_{AA} and N_{coll}

Nuclear modification factor of J/ψ (R_{PbPb}) **Petr Gallus**



Suppression is strongly centrality dependent, regardless of on production mechanism





Piotr Janus

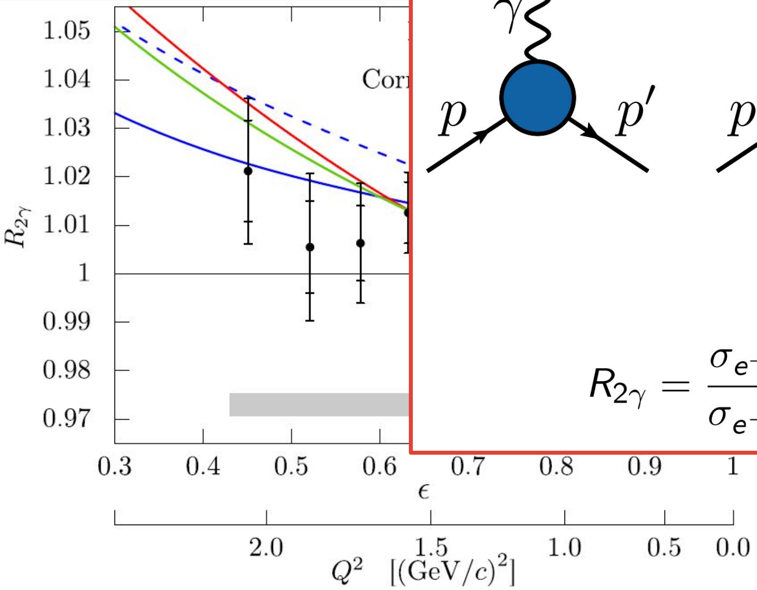
arXiv:1609.06213

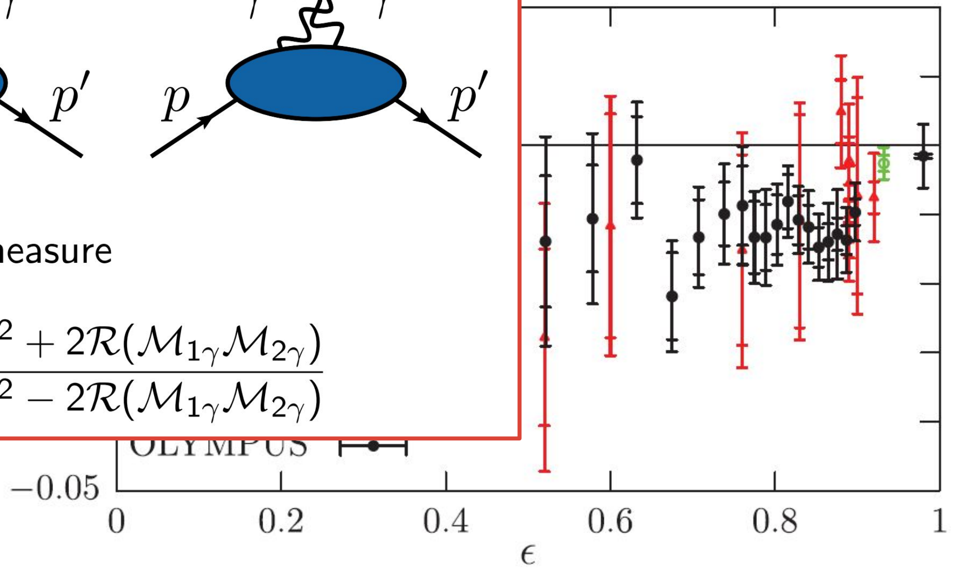
Two-photon contribution to elastic lepton-proton scattering

First results from OLYMPUS

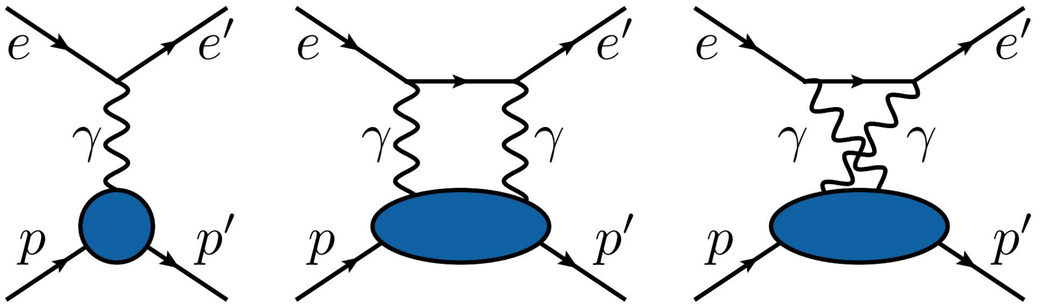
- Experiment aims at measuring two-photon contribution to p-e scattering
- Measures si
- Confirms VE
  OLYMPUS r ... ions

Dmitry Khaneft





Unaccounted hard two-photon exchange



How to measure

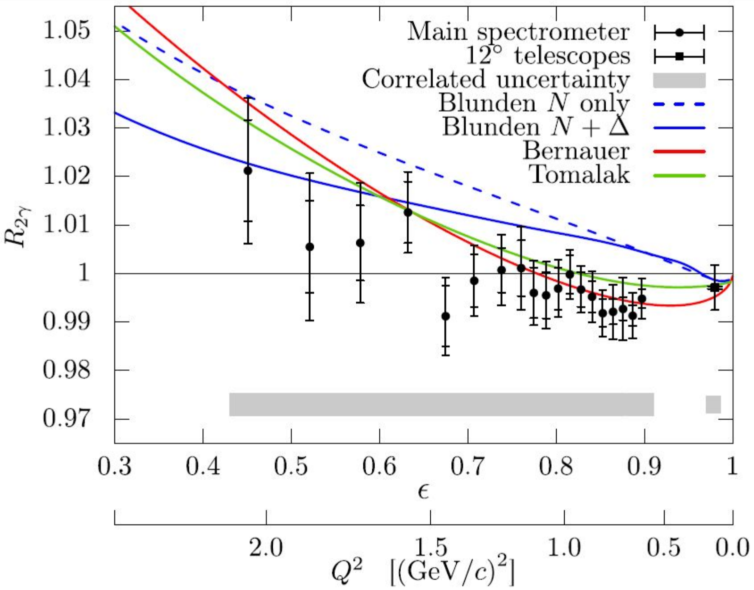
$$R_{2\gamma} = \frac{\sigma_{e^+p}}{\sigma_{e^-p}} = \frac{|\mathcal{M}_{1\gamma}|^2 + 2\mathcal{R}(\mathcal{M}_{1\gamma}\mathcal{M}_{2\gamma})}{|\mathcal{M}_{1\gamma}|^2 - 2\mathcal{R}(\mathcal{M}_{1\gamma}\mathcal{M}_{2\gamma})}$$

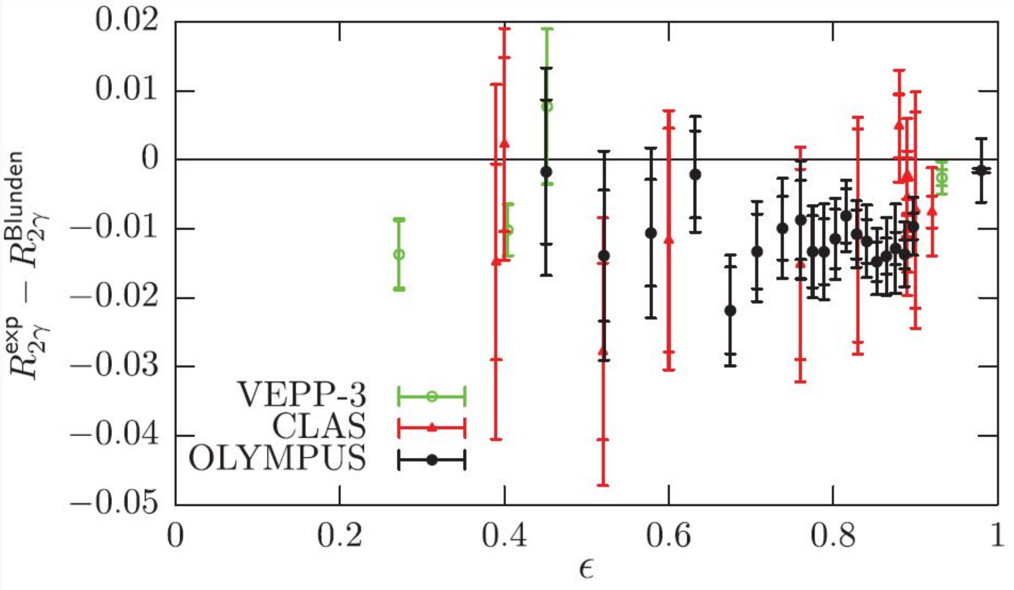
Two-photon contribution to elastic lepton-proton scattering

First results from OLYMPUS

- Experiment aims at measuring two-photon contribution to *p-e* scattering
- Measures size of two-photon contribution vs. Q^2: up to 2% at high-Q^2
- Confirms VEPP-3 and CLAS measurements; smaller uncertainties of OLYMPUS measurement seem to identify disagreement with calculations

Dmitry Khaneft





Energy-loss Effects

E906/SeaQuest: measure **quark energy loss in cold matter with Drell-Yan**

- Baseline for understanding heavy-ion collision
- Key point w.r.t. E866: low x(target) minimizes shadowing effects

First results

- Sea PDF: disagreement with E866 being investigated
- Energy loss (Fe, W and C targets) ~ $A^{-1/3}$

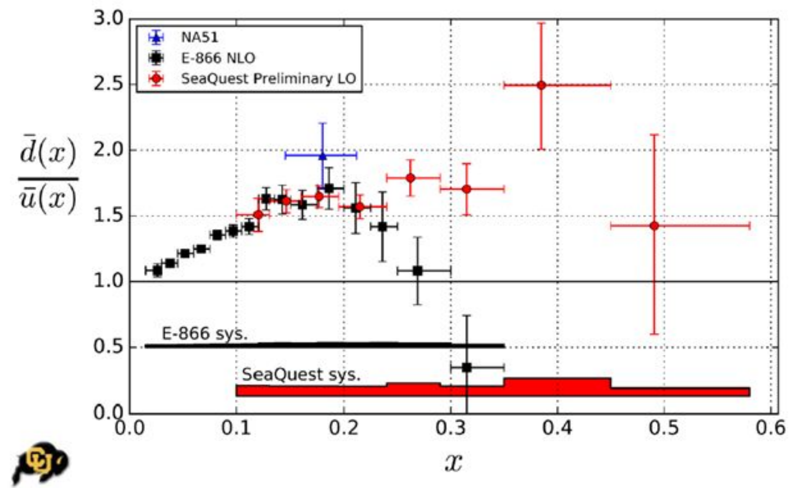
$$\frac{d^2\sigma}{dx_b\, dx_t} = \frac{4\pi\alpha^2}{9 x_b\, x_t} \frac{1}{s} \sum_q e_q^2 \left[\bar{q}_t(x_t) q_b(x_b) + q_t(x_t) \bar{q}_b(x_b)\right]$$

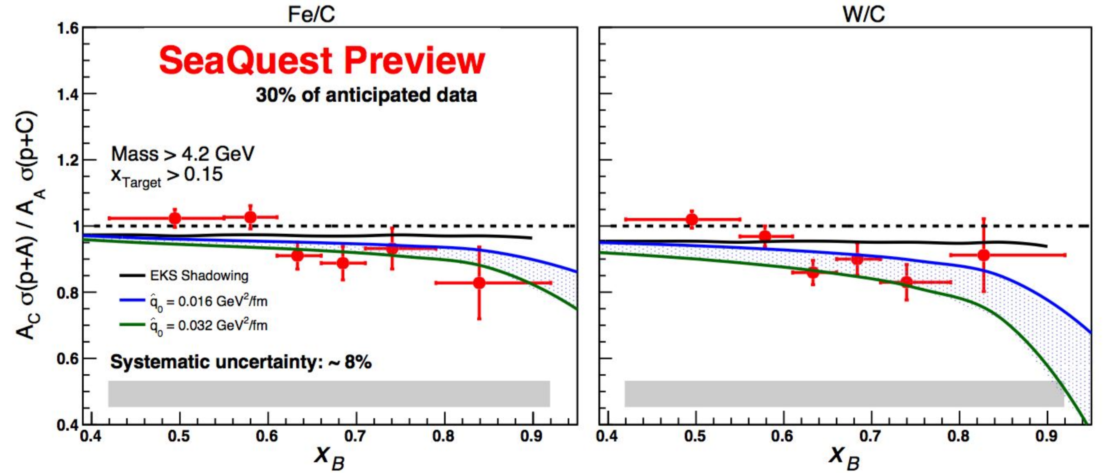
$\bar{q}_t(x_t)$: target sea quark at low/intermediate x

$q_b(x_b)$: beam valence quark at high x

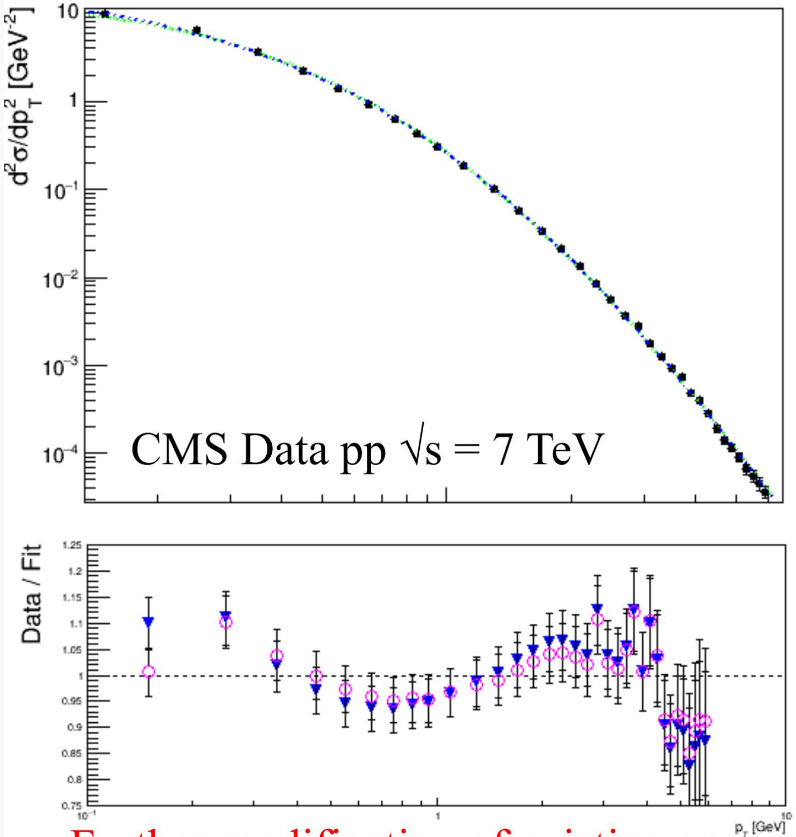
Small in fix target exp. with very forward acceptance

Po-Ju Lin





Hadro-production Form Factors



1952 E. Fermi

$$\sim \exp(-\frac{E_T}{T})$$

1983 R. Hagedorn

$$\sim (\frac{p_0}{p_0 + p_T})^N$$

1987 C. Tsallis

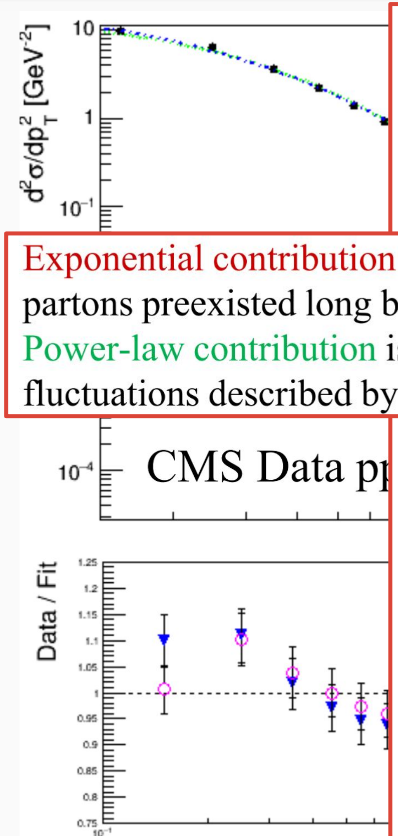
$$\sim (\frac{1}{1 + \frac{E_T}{T \cdot N}})^N$$

2010 ???

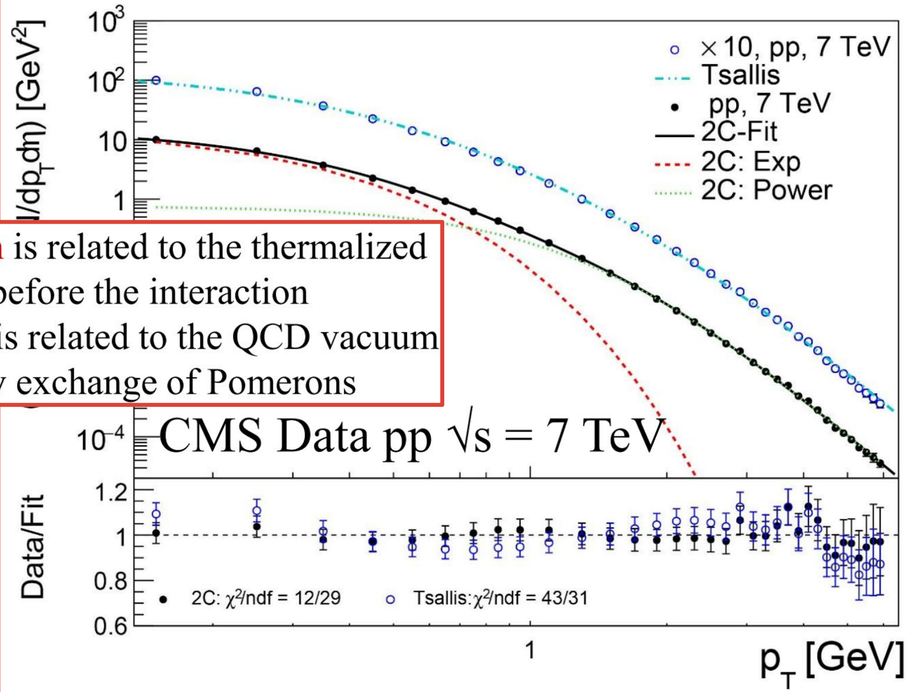
Alexander Bylinkin

Further modification of existing approaches is needed.

Hadro-production Form Factors



Exponential contribution is related to the thermalized partons preexisted long before the interaction
Power-law contribution is related to the QCD vacuum fluctuations described by exchange of Pomerons



Further modifica

1952 E. Fermi

$$\sim exp(-\frac{E_T}{T})$$

1983 R. Hagedorn

$$\sim(\frac{p_0}{p_0 + p_T})^N$$

1987 C. Tsallis

$$\sim(\frac{1}{1 + \frac{E_T}{T \cdot N}})^N$$

2010 A. Bylinkin & A. Rostovtsev

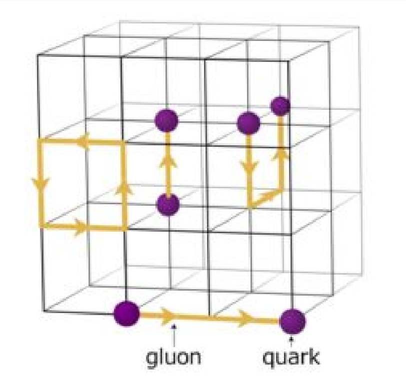
Alexander Bylinkin

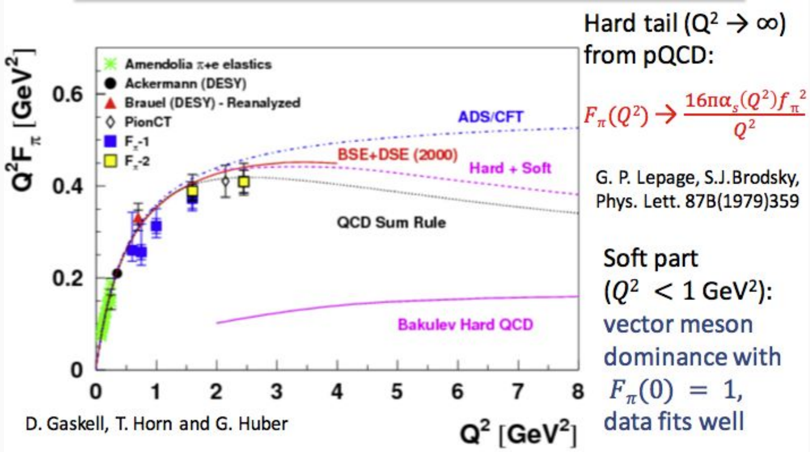
$$\frac{d^2\sigma}{\pi dy(dp_t^2)} = A_1 exp(-E_{Tkin}/T_e) + \frac{A_2}{(1+\frac{P_T^2}{T^2 N})^N}$$

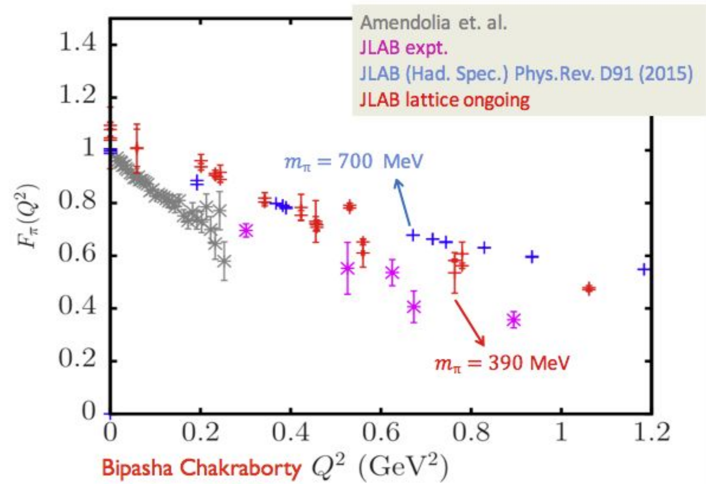
Light Mesons

Lattice studies on π form-factors

- Aim to understand the transition to pQCD
- Lattice simulations very complicated. So far, results only for low values of Q^2 and high (unphysical) values of m_π
- Need for simulations with higher statistic and smaller spacing







Results: Branching fraction

$$\mathrm{BR}(K^{\pm} \to \pi^{\pm}\pi^{0}e^{+}e^{-}) = \frac{N_S - N_{BS}}{N_N - N_{BN}} \times \frac{A_N}{A_S} \times \frac{\varepsilon_{L1N} \times \varepsilon_{L2N}}{\varepsilon_{L1S} \times \varepsilon_{L2S}} \times \mathrm{BR}(K^{\pm} \to \pi^{+}\pi^{0}) \times \mathrm{BR}(\pi^0_D)$$

A_S = weighted average of IB, DE, INT acceptances using expected relative contributions

Radiative corrections taken into account by using PHOTOS in MC simulations and Prague group π^0_D generator [PRD 92(2015)054027] in MC for normalization mode

Signal		Normalization	
Candidates N_S	5076	Candidates N_N	16774613
Background N_{BS}	289	Background N_{BN}	25517
Accept(rad) A_S	0.666(1) %	Accept(rad) A_N	4.083(2) %
L1 eff. ε_{L1S}	99.73(1) %	L1 eff. ε_{L1N}	99.767(3) %
L2 eff. ε_{L2S}	99.46(2) %	L2 eff. ε_{L2N}	98.584(7) %

Preliminary result:

$$\mathrm{BR}(K^{\pm} \to \pi^{\pm}\pi^{0}e^{+}e^{-}) = (4.22 \pm 0.06_{\mathrm{stat}} \pm 0.04_{\mathrm{syst}} \pm 0.13_{\mathrm{ext}}) \times 10^{-6}$$

- Error is dominated by external error on $\mathrm{BR}(\pi^0_D)$
- Good agreement with ChPT predictions [EPJ C72(2012)]:
  - without radiative and isospin breaking corrections: $\mathrm{BR(IB)} = 4.19 \times 10^{-6}$
  - with isospin breaking: $\mathrm{BR(IB)} = 4.10 \times 10^{-6}$

NA48 Observation

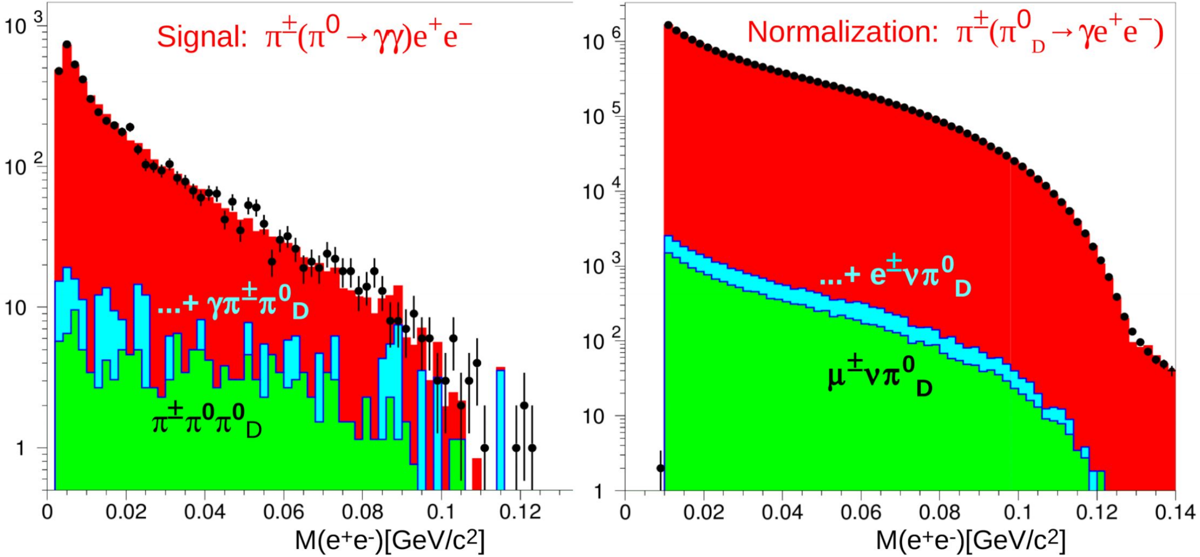
Andrea Bizzeti

Results: Branching fraction

$$\mathrm{BR}(K^\pm \to \pi^\pm\pi^0 e^+ e^-) = \frac{N_\mathrm{S} - N_\mathrm{BS}}{N_\mathrm{N} - N_\mathrm{BN}} \times \frac{A_\mathrm{N}}{A_\mathrm{S}} \times \frac{\varepsilon_\mathrm{L1N} \times \varepsilon_\mathrm{L2N}}{\varepsilon_\mathrm{L1S} \times \varepsilon_\mathrm{L2S}} \times \mathrm{BR}(K^\pm \to \pi^+\pi^0) \times \mathrm{BR}(\pi^0_D)$$

NA48 Observation

Results: signal and normalization M_{ee} spectra



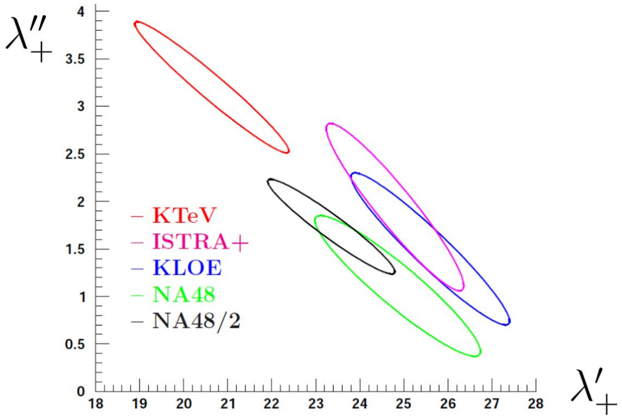
Andrea Bizzeti

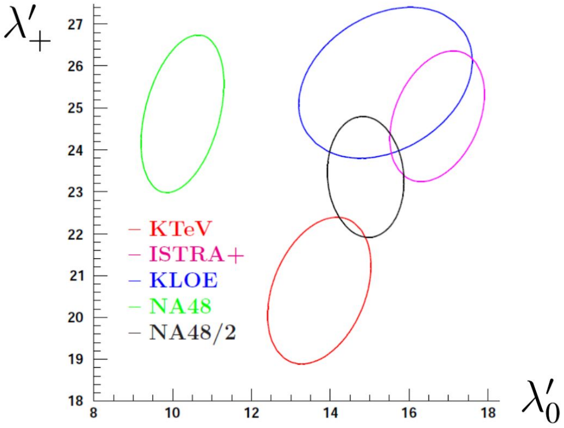
NA48 Form-Factor Fits (Quadratic)

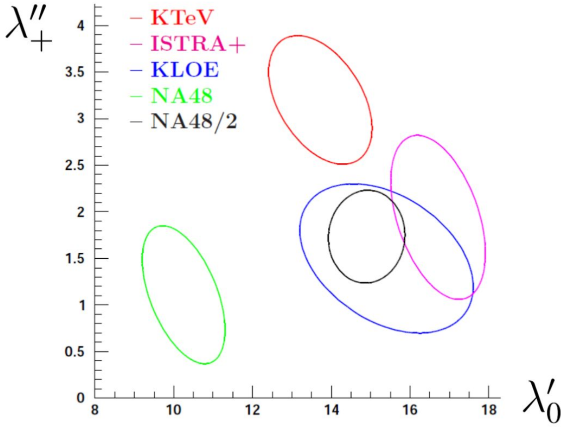
$K^{\pm} \rightarrow l^{\pm}\pi^{0}\nu$

Results for the joint K_{l3} analysis

- Quadratic fit: $\rightarrow \lambda'_{+}\,,\ \lambda''_{+}\,,\ \lambda'_{0}$
- Parameter correlation (1σ ellipses)
- black ellipse = NA48/2
- comparison to other experiments





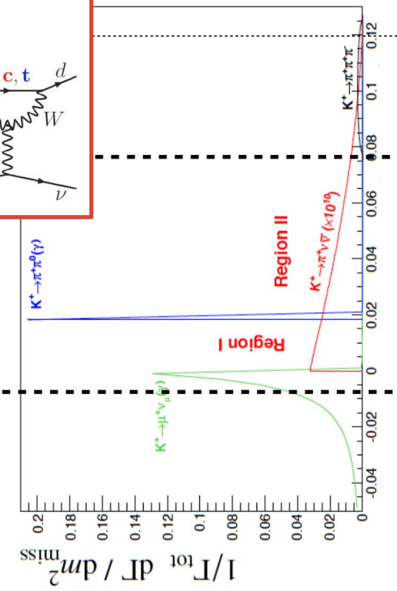


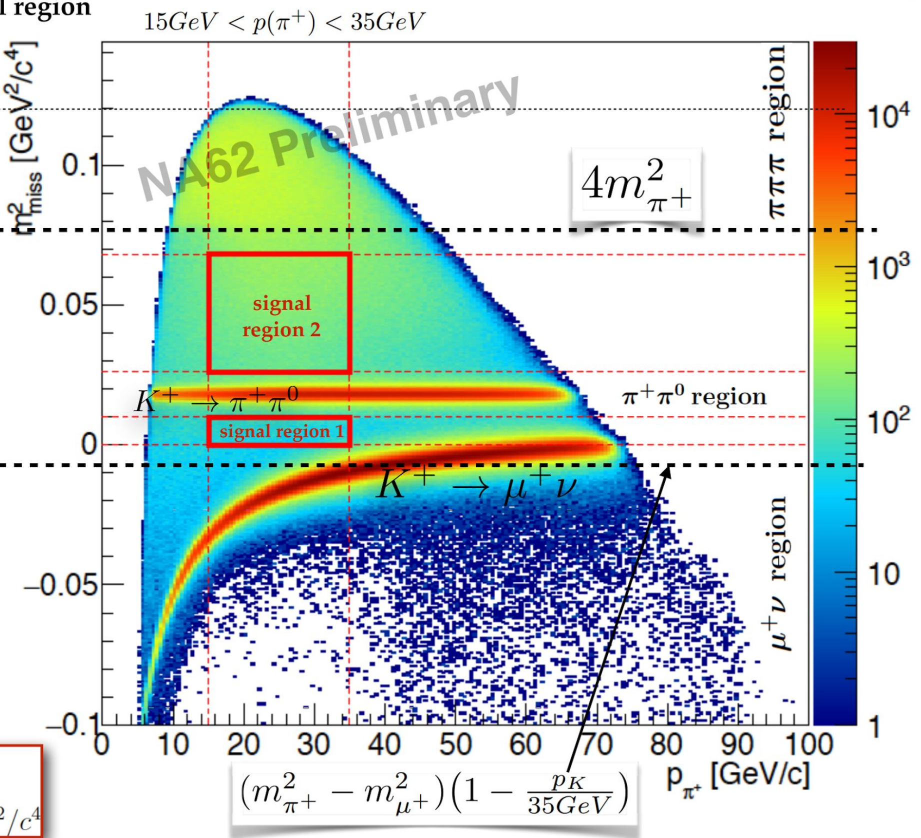
Andrea Bizzeti

Roberta Volpe

Signal region definition

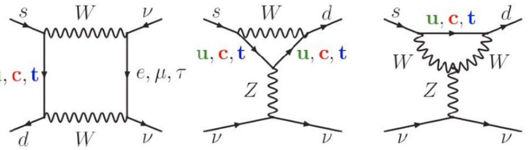
K⁺ events after the cut on fiducial region





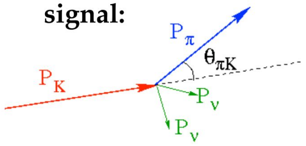
- **Region 1**: $(0,\ 0.01)\ \mathrm{GeV}^2/c^4$;
- **Region 2**: $(0.026,\ 0.068)\ \mathrm{GeV}^2/c^4$

s-d transitions via FCNC loop



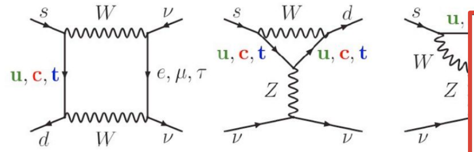
- O(100) SM signal events
  - 10% acceptance
  - 10^{13} K⁺ decays
- background rejection > 10^{12} !
- background yield < 20%
- background measurement with 10% precision

signal:



Roberta Volpe

s-d transitions via FCNC loop



- O(100) SM signal events
  - 10% acceptance
  - 10^{13} K^+ decays
- background rejection > 10^{12} !
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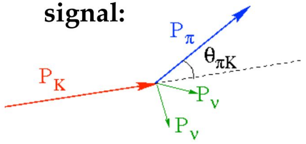
signal:

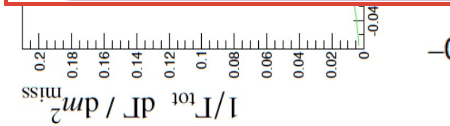


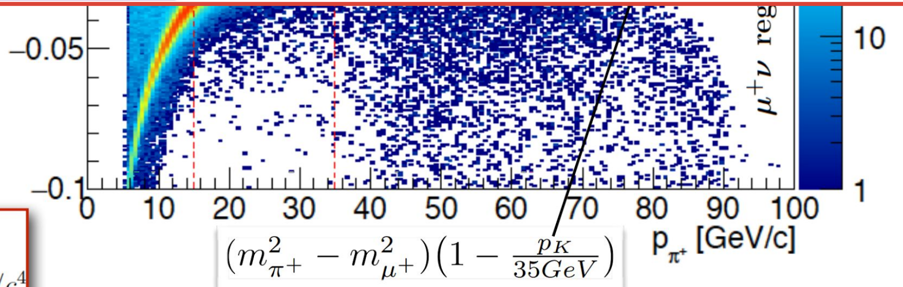
Signal region definition

NA62

K^+ events after the cut on fiducial region

$15GeV < p(\pi^+) < 35GeV$





Expected signal and Bkg with 5% of 2016 sample

NA62

$$N^{exp}_{\pi\nu\nu} = D^{control} \cdot N^{control}_{\pi\pi} \cdot \frac{BR_{\pi\nu\nu}}{BR_{\pi\pi}} \cdot \frac{A_{\pi\nu\nu}}{A_{\pi\pi}} \cdot \epsilon^{trig} = 0.064$$

normalisation: $K^+ \to \pi^+\pi^0$

control trigger data passing the signal selection but the photon rejection

~ 0.6/0.86 from MC and cancellations

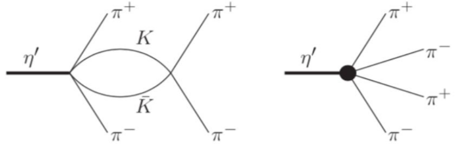
~ 85% (preliminary) measured with data

- Region 1: $(0,\ 0.01)\ \mathrm{GeV}^2/c^4$;
- Region 2: $(0.026,\ 0.068)\ \mathrm{GeV}^2/c^4$

$$(m^2_{\pi^+} - m^2_{\mu^+})(1 - \frac{p_K}{35GeV})$$

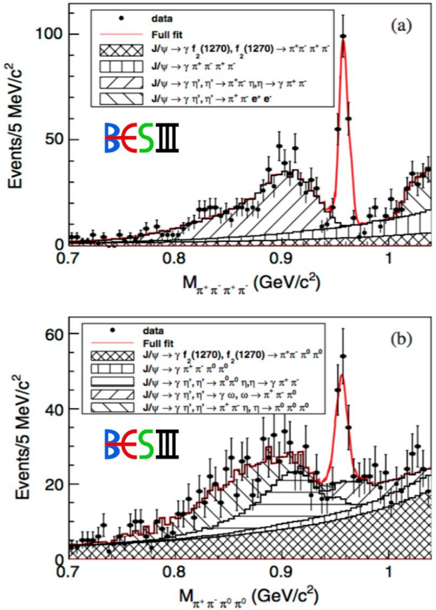
First observation of $\eta' \to \pi^+\pi^-\pi^+\pi^-$, $\pi^+\pi^-\pi^0\pi^0$

- $\eta' \to 4\pi$ suppressed by tiny phase space
- Only $\eta \to 4\pi^0$ is kinematically allowed
- ChPT: the amplitude goes to zero at leading order; non-zero contributions only at $\mathcal{O}(p^6)$



PRD**85**,014014 (2012)

ChPT+VMD: $\mathcal{B}(\eta' \to 2(\pi^+\pi^-)) = (1.0 \pm 0.3) \times 10^{-4}$, $\mathcal{B}(\eta' \to \pi^+\pi^-2\pi^0) = (2.4 \pm 0.7) \times 10^{-4}$.



PRL**112**, 251801(2014)

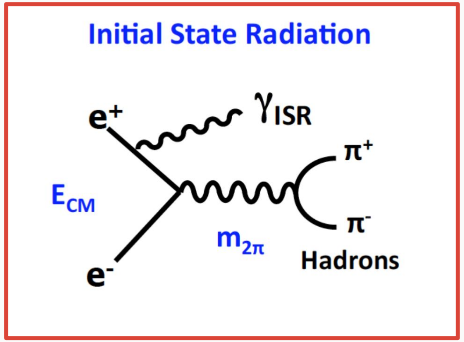
$$\mathcal{B}(\eta' \to \pi^+\pi^-\pi^+\pi^-) = (8.53 \pm 0.69 \pm 0.64) \times 10^{-5}$$
$$\mathcal{B}(\eta' \to \pi^+\pi^-\pi^0\pi^0) = (1.82 \pm 0.35 \pm 0.18) \times 10^{-4}$$

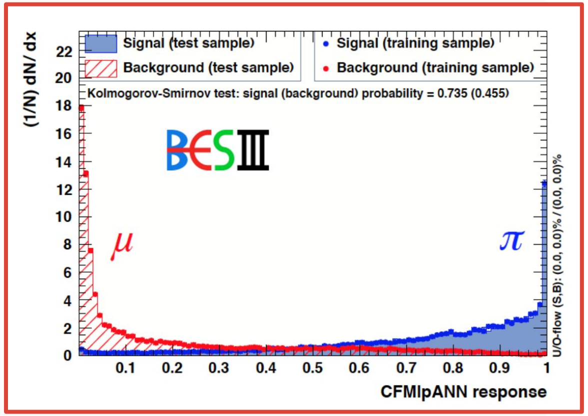
Good agreement between BESIII measurements and ChPT+VDM predictions

Isabella Garzia

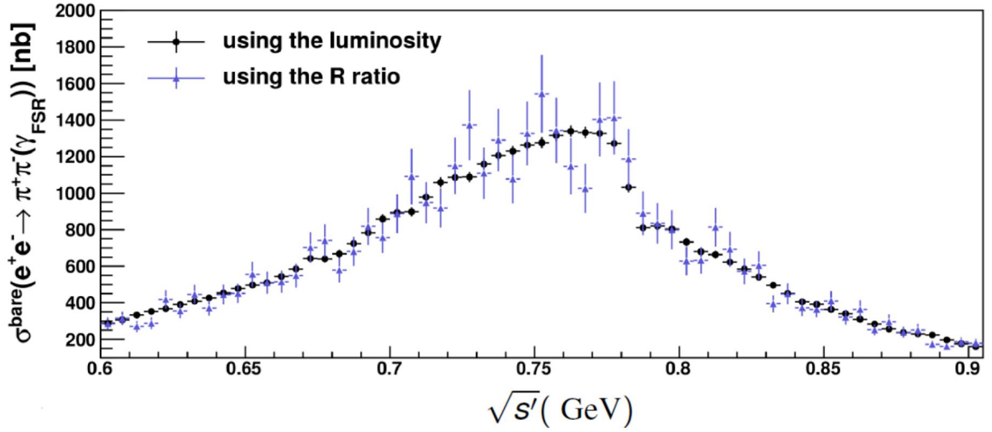
$e^+e^- \to \gamma_{ISR}\pi^+\pi^-$: cross section

Cui Li





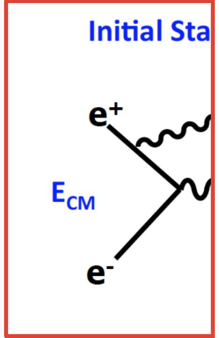
$$\sigma^{\rm bare}_{\pi\pi(\gamma_{\rm FSR})} = \frac{N_{\pi\pi\gamma}\cdot(1+\delta^{\pi\pi}_{\rm FSR})}{\mathcal{L}\cdot\epsilon^{\pi\pi\gamma}_{\rm global}\cdot H(s)\cdot\delta_{\rm vac}} \qquad \sigma^{\rm bare}_{\pi\pi(\gamma_{\rm FSR})} = \frac{N_{\pi\pi\gamma}}{N_{\mu\mu\gamma}}\cdot\frac{\epsilon^{\mu\mu\gamma}_{\rm global}}{\epsilon^{\pi\pi\gamma}_{\rm global}}\cdot\frac{1+\delta^{\mu\mu}_{\rm FSR}}{1+\delta^{\pi\pi}_{\rm FSR}}\cdot\sigma^{\rm bare}_{\mu\mu}$$

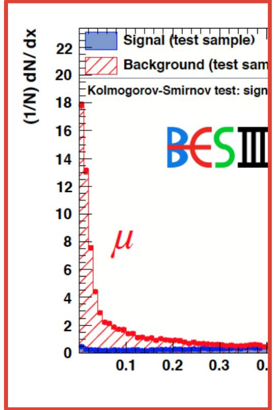


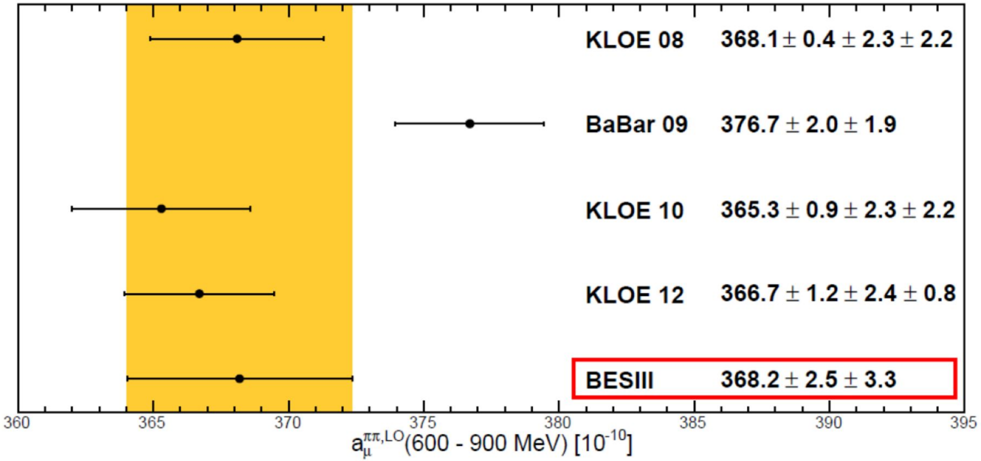
- Good agreement between two methods with relative difference $(0.85\pm1.68)\%$

Impact on Hadronic Vacuum Polarization

Cui Li







$\cdot\ \sigma_{\mu\mu}^{bare}$

- BESIII measurement agrees with KLOE
- Deviation on $(g\text{-}2)_\mu$ between experiment and SM has been confirmed.

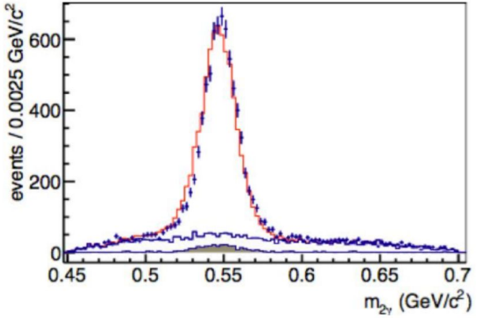
difference

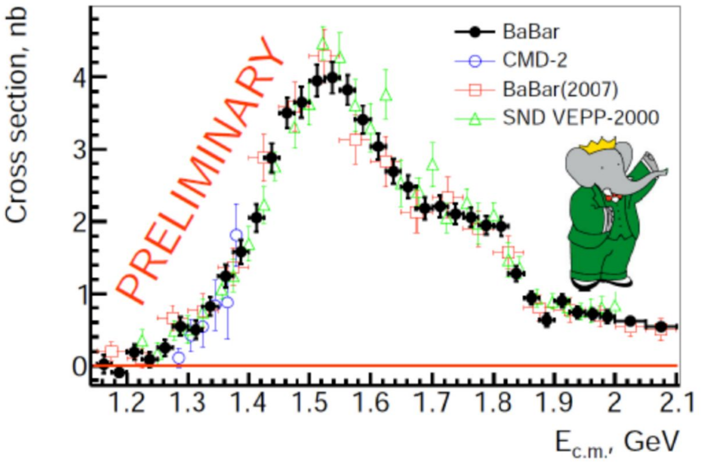
Physics Letters B 753 (2016) 629-638

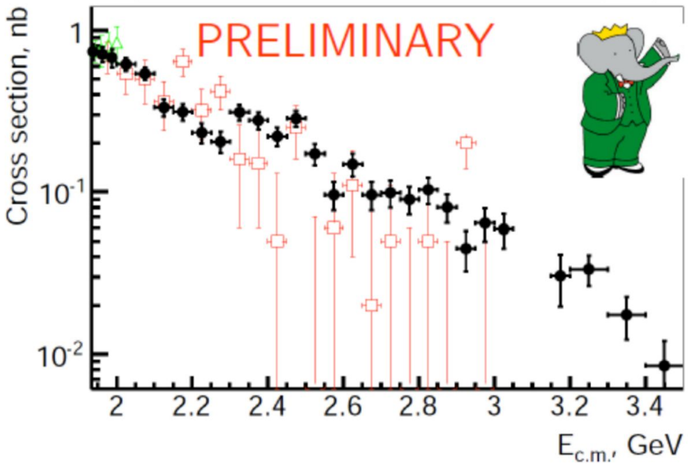
Peter Lukin

Process $\pi^+\pi^-\eta$

- $\eta \to \gamma\gamma$ decay is used
- The most precise measurement
- Extending energy range up 3.5 GeV
- $a_\mu^{had\ LO}(\sqrt{s} < 1.8\ \text{GeV}) = (1.18 \pm 0.06) \cdot 10^{-10}$







Systematic uncertainty is (4.5-12)%


Hadronic & Electroweak
Observables
Thanks to all the
presenters

Claudia Glasman

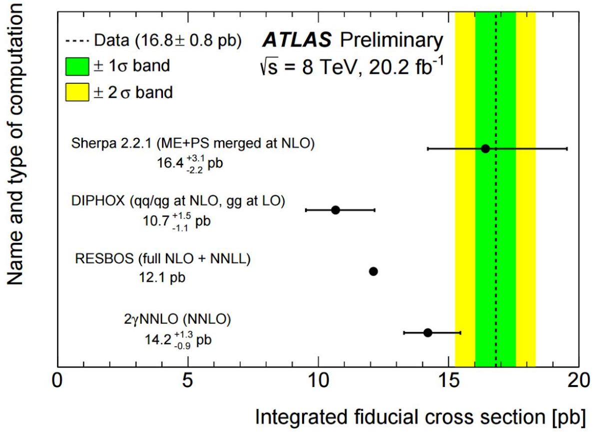
Inclusive isolated photon pairs @ 8 TeV ($\mathcal{L} = 20.2$ fb^{-1})

- Photon selection: $E_T^\gamma > 40, 30$ GeV and $|\eta^\gamma| < 2.37$, excluding the region $1.37 < |\eta^\gamma| < 1.56$
- Photon isolation: $E_T^{iso} < 11$ GeV; signal purity: $\approx 75\%$ ($60 - 98\%$ depending on observable)

- Main irreducible background to $H \to \gamma\gamma$
- Theoretical predictions (uncertainty): ($\mu_R = \mu_F (= \mu_f) = m_{\gamma\gamma}$; PDFs: CT10)
  - → SHERPA 2.2.1: ME+PS merged at NLO ($10 - 40\%$)
  - → DIPHOX: DP+F at NLO, $gg \to \gamma\gamma$ at LO (30%)
  - → RESBOS*: NLO + NNLL (* uncertainties not given)
  - → 2γNNLO: DP at NNLO (20%) (Frixione isolation!)
  - → PDF uncertainty: 2%
  - → NP uncertainty: $< 5\%$

⇒ The prediction from SHERPA 2.2.1 is in best agreement with the data

$\sigma_{meas} = 16.8 \pm 0.8$ pb



→ experimental uncertainty: 4.7%
→ major sources: γID (2.5%)
modelling of E_T^{iso} (2%)
luminosity (1.9%)

ATLAS Collab, https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PAPERS/STDM-2015-15 (preliminary)

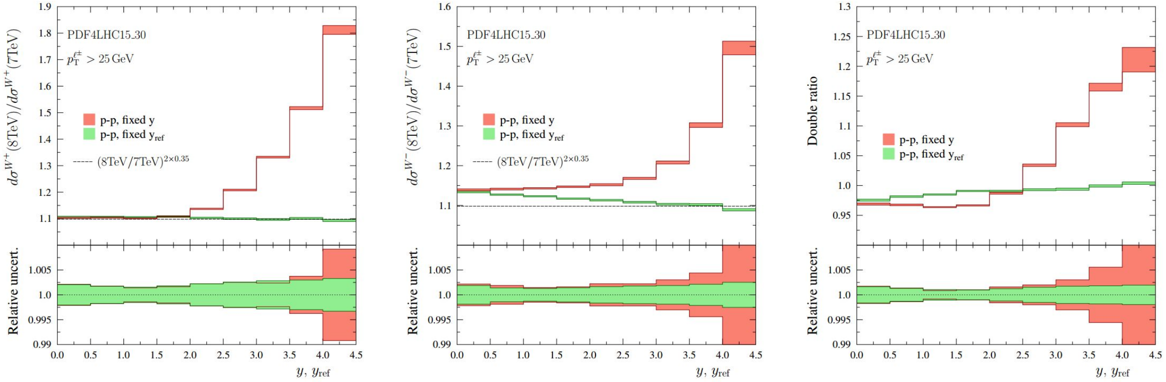
√s Scaling Variable Development

Cross-section ratios (fixed y vs. fixed y_{ref}): 8TeV/7TeV

- Cross-section ratios between different c.m. energies

$$R^{+}_{8/7} = \frac{d\sigma^{\mathrm{W}^+}(\sqrt{s} = 8\,\mathrm{TeV})}{d\sigma^{\mathrm{W}^+}(\sqrt{s} = 7\,\mathrm{TeV})},\; R^{-}_{8/7} = \frac{d\sigma^{\mathrm{W}^-}(\sqrt{s} = 8\,\mathrm{TeV})}{d\sigma^{\mathrm{W}^-}(\sqrt{s} = 7\,\mathrm{TeV})},$$

and the double ratio $\mathcal{D}_{8/7} = (R^{+}_{8/7})/(R^{-}_{8/7})$:



$\Longrightarrow$ The PDF uncertainties partly suppressed when the ratios are formed at fixed y_{ref}.

- Define a scaling variable ξ_1,

$$\xi_1 \equiv \frac{M_{\mathrm{W}}}{\sqrt{s}} e^{y} \;\Longrightarrow\; x_1^{\pm} \to \frac{M_{\mathrm{W}}}{2p_T}\xi_1 \left[1 \mp \sqrt{1 - 4p_T^2/M_{\mathrm{W}}^2}\right]$$

$\Longrightarrow$ Cross-sections at fixed ξ_1 are sensitive to PDFs of H_1 at particular values of x independently of $\sqrt{s}$.

- Compare charge asymmetry across various collision systems at various centre of mass energies
- Improve sensitivity

Hannu Paukkunen