Diffraction and vector mesons working group summary

Theory part

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HELMHOLTZ GEMEINSCHAFT

DESY

had 15 theory talks

- dipole description of diffraction

  A Łuszczak, H Weigert*, T Lappi*, M Machado, C Marquet

- diffractive parton densities

  L Schoeffel

- generalized parton distributions

  T Teubner, D Müller, J Wagner

- diffraction in pp and $p\bar{p}$ collisions

  D Ivanov, V Khoze, C Weiss, F Chevallier, F Schwennsen

- interactions of metastable exotic hadrons

  D Milstead

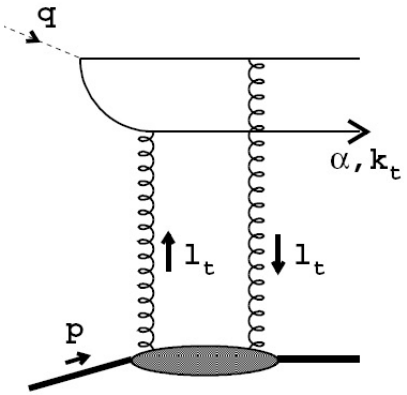
* in common session with Structure Functions

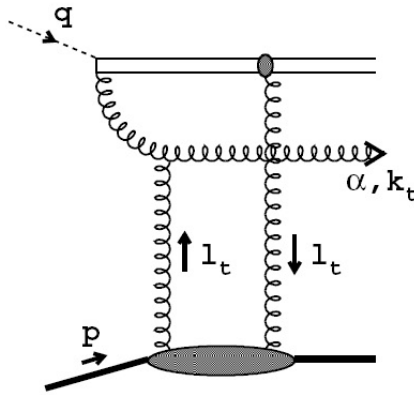
The color dipole formulation

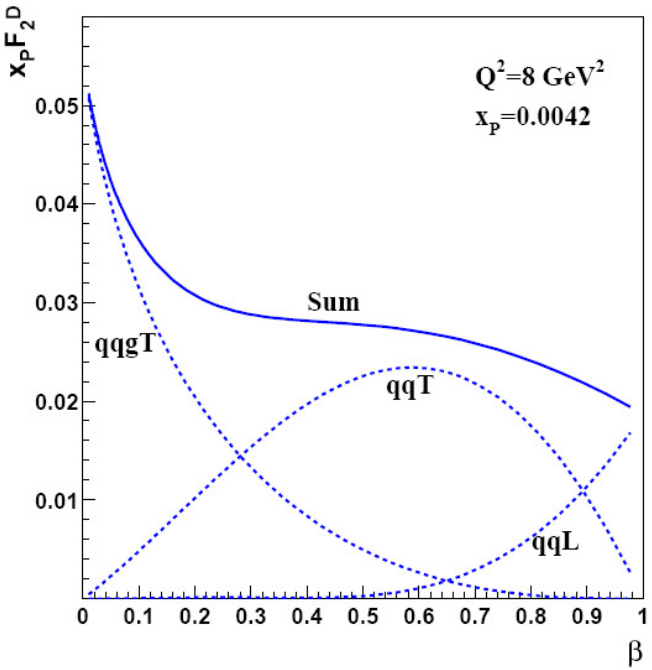
- describes variety of ep processes at small x
  with common input (dipole scattering amplitude)
  - inclusive ($F_2, F_L, F_2^{c\bar{c}}, F_2^{b\bar{b}}$)
  - exclusive (DVCS, vector meson production)
  - inclusive diffraction ($F_2^D, F_2^{D(c\bar{c})}$)
- allows incorporation of saturation dynamics
  non-linear evolution in x: JIMWLK, BK, ...
- provides tests (and helps fix parameters) of theory for
  color glass condensate
  $\rightarrow pp, pA, AA$ collisions plen. talk N Armesto

next slides: concentrate on description of inclusive diffraction

- $q\bar{q}$ fully calculated
  - scaling contrib'n to F_T
  - $1/Q^2$ suppressed contib'n to F_L at large β
  - contribution to $F_{2,L}^{D(c\bar{c})}$ negligible





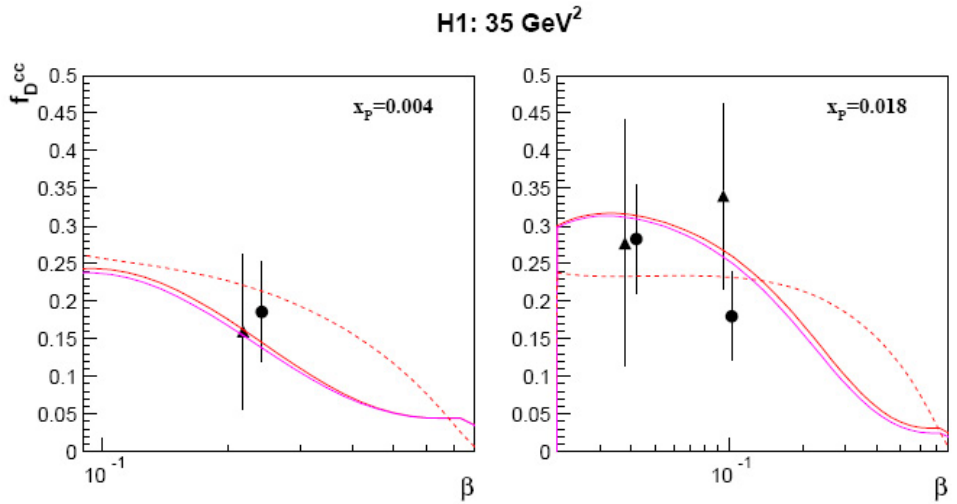


plot: A Łuszczak, K Golec-Biernat

arXiv:0812.3090

- $q\bar{q}g$ only calculated in limits
  - leading $\log Q^2$ talk A Łuszczak
    M Wüsthoff '97
  - leading $\log 1/\beta$
    Bartels et al '02; Munier, Shoshi '03
    cross-talk with JIMWLK evolution
    talk H Weigert
  - interpolation between two forms
    talk T Lappi
  - no evaluation for $c\bar{c}g$
    phenomen. analyses use workarounds

Fractional charm contribution

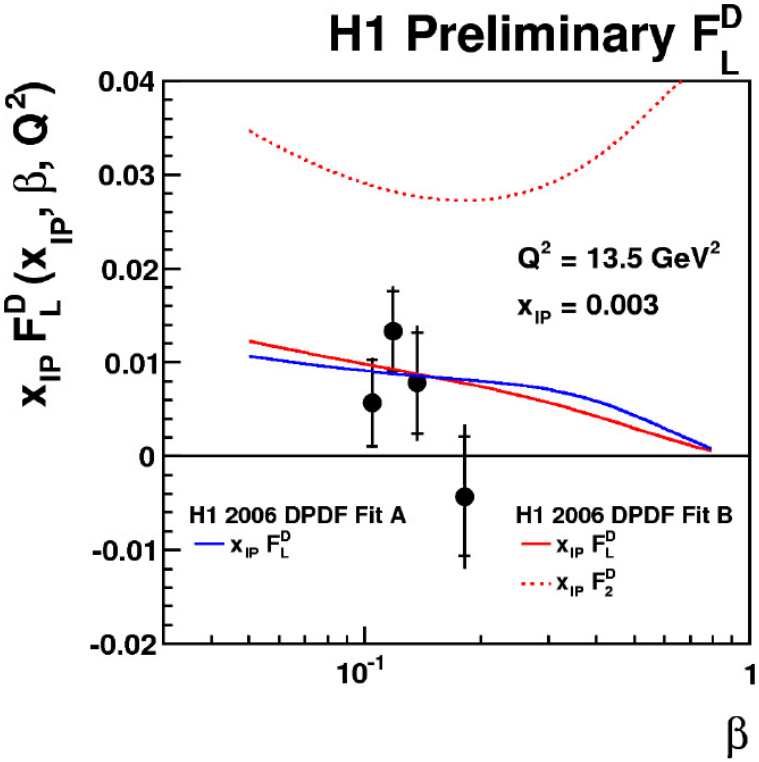


- Fractional contribution $f^{D(charm)} = \sigma_r^{D(charm)} / \sigma_r^D$ of the diffractive charm to total diffractive cross section.
- Up to $20 - 30\%$.

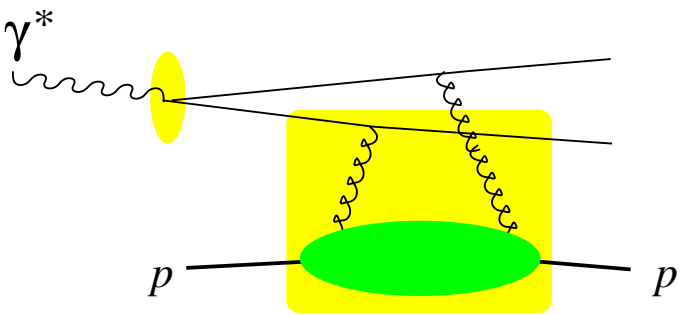
talk A Łuszczak

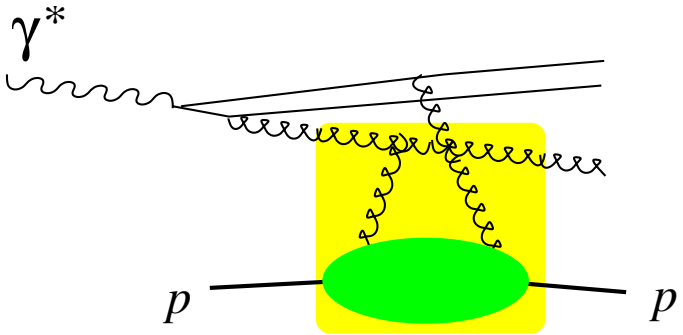
- charm component in F_2^D not generally negligible (same holds for charm component in F_2)
- data call for theory improvements

- $q\bar{q}g$ in leading $\log Q^2$ gives no F_L^D
- data urgently call for theory improvements



talk D Šalek





- from dipole formulation can extract diffractive PDFs
  same graphs in both approaches, reduce dipole formulae to appropriate kinematics

  realized long ago: Buchmüller, Gehrmann, Hebecker '98
- resulting PDFs to be understood at low scale
  DGLAP evolution $\longrightarrow$ further radiation $\longrightarrow$ $q\bar{q}g$, $q\bar{q}gg$, ...

blue curves from dipole model red curves from DGLAP fit to F_2^D

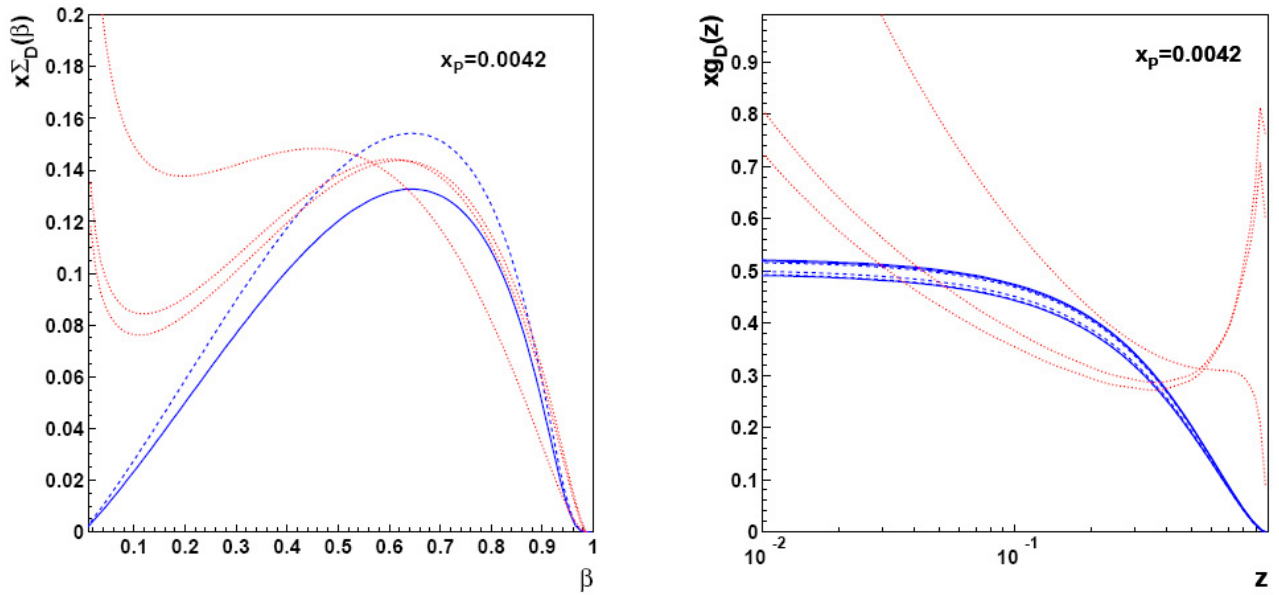
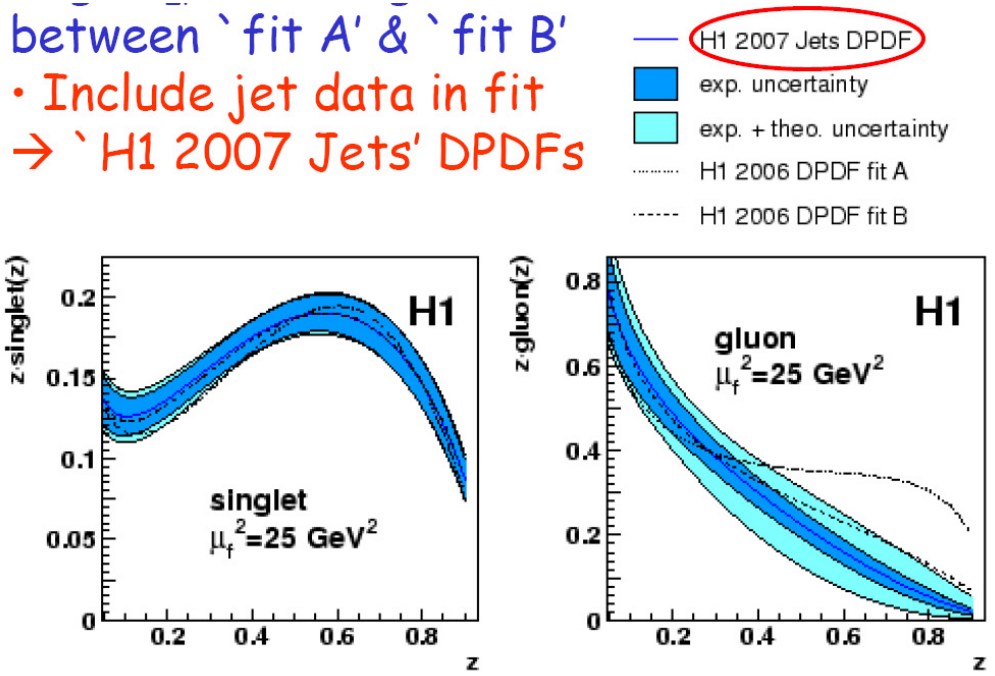


FIG. 7: The diffractive distributions for singlet quark $x\Sigma_D(x_{I\!P}, \beta)$ and gluon $xg_D(x_{I\!P}, z, Q^2)$ for $Q^2 = 4m_c^2 = 7.84$, 10, 100 GeV^2 (from bottom to top) and $x_{I\!P} = 0.0042$. The solid lines correspond to the GBW parameterisation while the dashed lines to the CGC parameterisation. The dotted lines show the parton distributions from the DGLAP fit [25] to the H1 data.

talk A Łuszczak, plots: arXiv:0812.3090

- good agreement for diffract. quark dist.
  at small z dipole model misses evolution effects
- from dipole model no peak of diffract. gluon dist. at large z

- DGLAP fits to F_2^D alone poorly constrain $g^D(z)$ at large z talk L Schoeffel
  - find full agreement within errors for fits to latest published H1 and ZEUS data
  - even within large uncertainties on $g^D(z)$ cannot describe CDF exclusive dijets without genuine exclusive mechanism
- but: $g^D(z)$ with strong peak at large z strongly disfavored by diffractive dijet electroproduction talk P Newman



Impact parameter dependence of dipole scattering amplitude

- gives t dependence in diffraction and exclusive channels
  essential input from HERA measurements of t slopes
- interest in itself: transverse distribution of color charge
  in nucleon and in nuclei
- talk T Lappi: non-trivial preferred b for $q\bar{q}$ and $q\bar{q}g$ final states
  $\longrightarrow$ in diffraction on nuclei find enhancement at large β
  suppression at low β
- studies for DVCS and vector meson production on nuclei
  roles of elastic contribution and breakup of nucleus

talks by M Machado and C Marquet

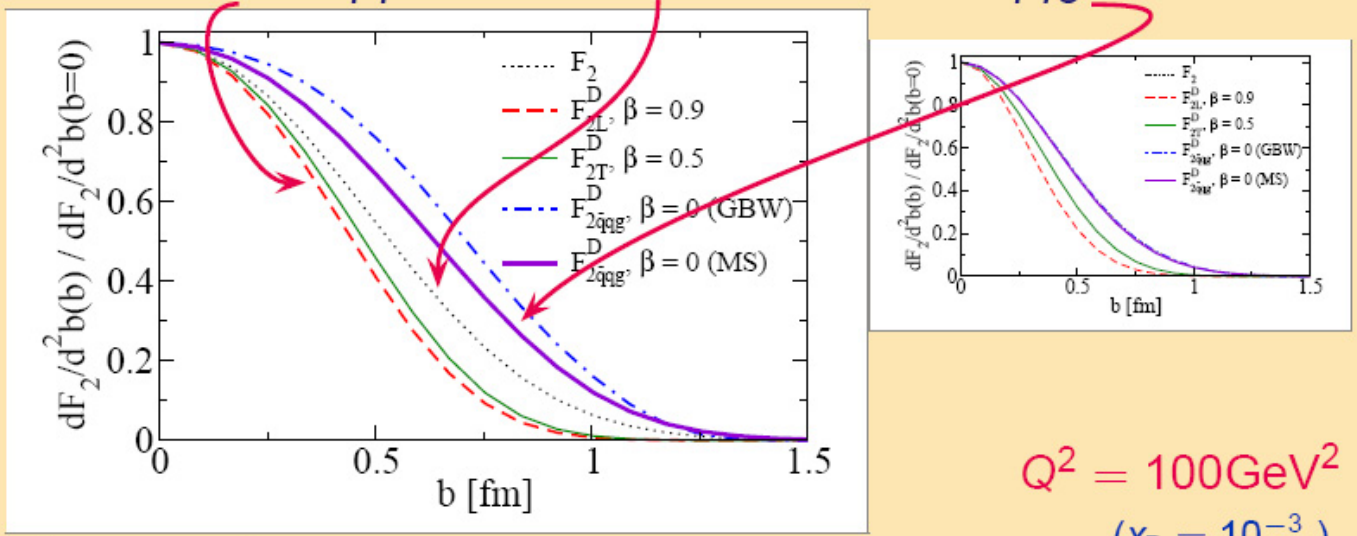
$\mathbf{b}_T$–dependence of different components

Dominant impact parameters different

$$b^{\text{diff}}(q\bar{q}) < b^{\text{incl}} < b^{\text{diff}}(q\bar{q}g)$$

Integrand vs. $\mathbf{b}_T$ for

diff. $q\bar{q}$ — inclusive — diff $q\bar{q}g$



$Q^2 = 1\text{GeV}^2$

$Q^2 = 100\text{GeV}^2$

($x_{\mathbb{P}} = 10^{-3}$)

11/16

talk T Lappi

Generalized parton distributions

- description of exclusive processes from small-x regime up to fixed-target energies
  - deeply virtual Compton scattering and meson production
    exp. talks in common session with Spin WG
    plenary talk E Aschenauer
  - encouraging prospects for γp and γA collisions at LHC
    - J/Ψ and Υ: talk M Csanád
    - timelike Compton scattering: $\gamma p \to \gamma^* p \to \ell^+ \ell^- p$
      talk J Wagner
  - exclusive diffraction in pp collisions talk C Weiss
- combined t- and x-dependence
  $\to$ three-dimensional imaging of partons in nucleon or nuclei

towards agreement in a long standing theoretical dispute

talks by T Teubner, D Müller

- previous claim (A Shuvaev et al. '99): at small x can calculate generalized distribution (at $t = 0$) from usual PDF
  - "pocket formula"

$$\frac{H^g(x, x, t = 0)}{xg(x)} = \frac{2^{\lambda+3}}{\sqrt{\pi}} \frac{\Gamma(\lambda + 5/2)}{\Gamma(\lambda + 3)} \quad \text{if} \quad xg(x) \sim x^{-\lambda}$$

    and analogous expression for quarks
  - original argument based on approximating x-moments of GPDs fails due to subtleties in inverse moment transform
  - explicit examples of GPDs violating Shuvaev formula but consistent with all known requirements
- Shuvaev formula to be regarded as an ansatz to be checked against data — fits to DVCS: talk D Müller
- ansatz can readily be extended to case where $xg(x)$ or $xq(x)$ not following a power law — talk T Teubner

exclusive diffraction $pp \to pp +$ Higgs: a window for detailed studies of Higgs in scenarios beyond Standard Model

talk V Khoze

MSSM SUMMARY

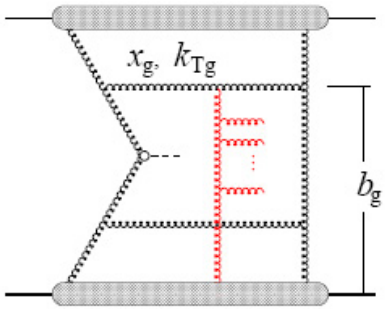
- Detailed analysis of prospects for CED production of $\mathcal{CP}$-even MSSM Higgs bosons, $pp \to p \oplus h, H \oplus p$
- Light MSSM Higgs boson, $h \to b\bar{b}$ channel: almost complete coverage of $M_{\rm A}$–$\tan\beta$ plane (and case of light SM Higgs) at the 3σ level with $600\ \text{fb}^{-1} \times 2$
  $\Rightarrow$ CED channel may yield crucial information on bottom Yukawa coupling and $\mathcal{CP}$ properties
- Heavy $\mathcal{CP}$-even Higgs boson, $H \to b\bar{b}$ channel: discovery of a $140\ \text{GeV}$ Higgs for all values of $\tan\beta$ with $600\ \text{fb}^{-1} \times 2$
  In high $\tan\beta$ region: discovery reach beyond $M_{\rm H} \approx 200\ \text{GeV}$ also for lower luminosities
- 'Semi-exclusive' production of A looks challenging

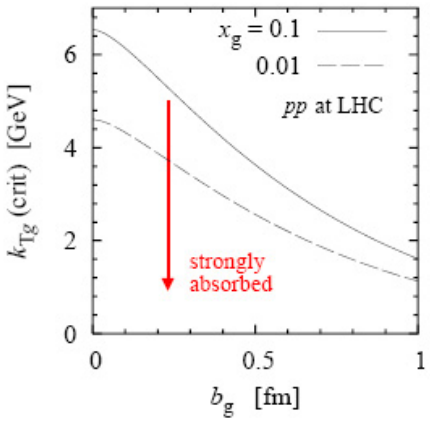
$\Rightarrow$ Interesting physics potential for probing MSSM Higgs sector; further experimental + theoretical efforts desirable

How large is rapidity gap survival probability?
(physics of multiple parton interactions) cf. plenary talk J Bartels

talk C Weiss:

Correlations: Absorption of hard spectators





- Black–disk regime of QCD:
  Parent partons in evolution experience strong absorptive interactions with small–x gluons in other proton
  - Critical k_T and impact parameter dependence from QCD dipole model (gluon dipoles!)
  - No emissions: Possible, but Sudakov–suppressed
- Reduces S^2 at LHC by at least factor ~ 3, much weaker effect at Tevatron
- Larger impact parameters
  $\rightarrow$ steeper p_{1T}, p_{2T} dependence!

Important, should be studied in detail

FHSW, PRD **75**:054009, 2007

Newsticker: more headlines

- unified description of diffraction with intact proton (low t) and proton breakup (high t)
  $\langle p|T_{q\bar{q}}|p\rangle\langle p|T_{q\bar{q}}|p\rangle$ and $\langle p|T_{q\bar{q}}T_{q\bar{q}}|p\rangle$ in CGC — talk C Marquet
- BFKL for jets at Tevatron and LHC
  azimuthal dist. of Mueller-Navelet jets, gaps between jets
  study with NLO BFKL kernels — talk F Chevallier
- Exclusive forward jets at LHC: $pp \to p + 3\text{jets}$
  k_T unintegrated gluon GPD, qqq wave fct. of proton — talk D Ivanov
- perturbative odderon in ultraperipheral collisions at LHC
  from odderon-pomeron interference in $\gamma\gamma \to (\pi^+\pi^-) + (\pi^+\pi^-)$
  talk F Schwennsen
- Interaction of metastable heavy hadrons in detectors
  bound states of heavy new particles with $q, \bar{q}, g$; hadronic interactions turning charged into neutral particles — talk D Milstead

Summary

- new diffractive data from HERA and Tevatron
  demand and help theory to improve
- many prospects and new ideas to study QCD in diffraction
  at LHC and hopefully at a future facility for ep and eA collisions

Apologies

to those speakers whose work I have only mentioned but not discussed

Special thanks

- to my co-convenors
  and the convenors of the Structure Function and Spin WGs
- to J Bartels, K Golec-Biernat, C Marquet, D Müller, and T Teubner
  for discussions
- to Agustin, Cecilia, Claudia, and Juan for being wonderful hosts