JAMES STIRLING MEMORIAL CONFERENCE

17-18 SEPTEMBER 2019, IPPP DURHAM In conjunction with PDF4LHC Working Group meeting



KRYSTHAL (Forward physics@LHC)

(Khoze-Ryskin-Stirling-Harland-Lang)

in collaboration with Alan Martin, Alyosha Kaidalov, Marek Tasevsky , Georg Weiglein and Sven Heinemeyer

Valery Khoze, IPPP, Durham



25 years of enjoyable collaboration



Main directions of our joint studies

EW and QCD physics in e+e- collisions.

Coulomb threshold effects in the WW, tt production accounting for the instability effects. Found : the first-order correction results in the shift of the W-mass about 100 MeV, higher-order effects- shift about 3.5 MeV.

Complete analytical formula for all-order QED threshold corrections- FKMS-1995

(of importance for CEPC and FCC-ee studies).

Partonometry of mult-ijet states in hadron collisions. A tool to diagnose different patterns of colour flow in high ET jet events



Physics with forward protons at the LHC





Proton tagging: $pp \to p + X + p$

• Defining feature of exclusive events: protons intact after collision,







Tag and measure protons at ± 210 m both in ATLAS (AFP) and CMS-TOTEM (PPS) ۲

3D Si

214 m Timing

Standard candle central exclusive processes at the Tevatron and LHC

Eur. Phys. J. C (2010) 69: 179–199 DOI 10.1140/epjc/s10052-010-1404-5







(very wide spread of theory predictions)

Exclusive Processes pp $\rightarrow \gamma\gamma/jj$, χ_c , χ_b are standard candles for new physics searches @CEP





Links, Quotes, Bibliography, Sayings, Notes



CDF Run II

(Cannot detect p/pbar, down beam pipe, but BSC $\rightarrow \eta$ = 7.4 empty)





Comparison with Durham



More direct comparison

with Durham calculations including hadronization effects preferred

CDF out-of-cone energy measurement (cone R=0.7) : ▶20-25% at E_T^{jet}=10-20 GeV ▶10-15% at E_T^{jet}=25-35 GeV

Koji Terashi

Good agreement with data found by rescaling parton p_T to hadron jet E_T

XLIId Rencontres de Moriond, QCD and High Energy Hadronic Interactions, La Thuile, Italy, March 17–24, 2007



A killing blow to a wide range of theoretical models.







• Increasing $M_X \Rightarrow$ larger phase space for extra gluon emission stronger suppression in exclusive QCD cross section. Gluons like to radiate! + absorptive/rescattering effects- survival factor S_{soft}^2

FP420 AND RESURRECTION OF 'DIFFRACTIVE HIGGS' (15 YEARS ON)

- searching for lower mass new objects in CEP requires far away (~400m) FDs
- **•** THOU SHALT NOT ANNOY MACHINE PEOPLE.



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Universit



The FP420 R&D project (2004-2009)

- FP420 was a joint R&D collaboration between CMS and ATLAS to develop a forward proton detector system to tag outgoing protons.
- Key questions:
 - Can suitable forward detectors be placed close to the LHC beam
 - What is the physics potential of these detectors?
 - Will they cover an interesting region of Higgs mass?
- Final report is available at JINST 4:T10001,2009 [arXiv:0806.0302]
- QCD-initiated production: potential for e.g. exclusive jet and F studies analysed (though there are more).
 - ★ Jets: gg colour-singlet initial state range of unique QCD studies.
 - Higgs: completely unseen mode, Higgs properties (CP, couplings) via independent method.





96 GeV-'light Higgs'

Prospects for Proton Tagged Physics at the High Lumi LHC

P. Newman - C. Royon, for the LPCC Forward Physics WG Birmingham, UK - Lawrence, KS, USA

February 27 2019

LHCC open session, with inputs from ALICE, ATLAS, CMS, LHCb, TOTEM

- 210-250 m: medium to high mass sensitivities, similar to present AFP/PPS (region before Q4 and not good since acceptance cut by TCL4 and region before Q5 important to reach high mass)
- 400-450 m: sensitivity to low masses down to 40-50 GeV





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$\gamma\gamma$ vs. gg collisions at high mass

• Naively, $\alpha_S \gg \alpha$ and so expect gg to dominate (where possible).



- But QCD enhancement can also be weakness: exclusive event ⇒ no additional gluon radiation in final state.
- As system mass M_X increases, phase space for extra gluon emission \uparrow and $\sigma \downarrow$. Gluons like to radiate!
- Expect cross over where $\gamma\gamma$ collisions dominate as $M_X \uparrow$ (all thing equal).
- In $\gamma\gamma$ vs. gg luminosities, occurs before AFP acceptance, $M_X \sim 200 \text{ GeV}$. More precisely expect α from $\hat{\sigma}$, so moves to higher M_X .



10 Years on:CT-PPS(CMS-TOTEM), AFP(ATLAS) -today's configuration



- Tag and measure protons at ± 210 m both in ATLAS (AFP) and CMS-TOTEM (PPS) 0
- Detectors: measure proton position (3D pixel or strip Silicon detectors) and time-of-flight (Ultrafast Si, diamond, quartz timing detectors)
- About 100 fb $^{-1}$ of data have been accumulated by each experiment (\sim 110 for PPS, 80 for AFP) AFP mass acceptance for double tagged events



