Testing Pomeron flavour symmetry with diffractive W charge asymmetry

Annabelle Chuinard

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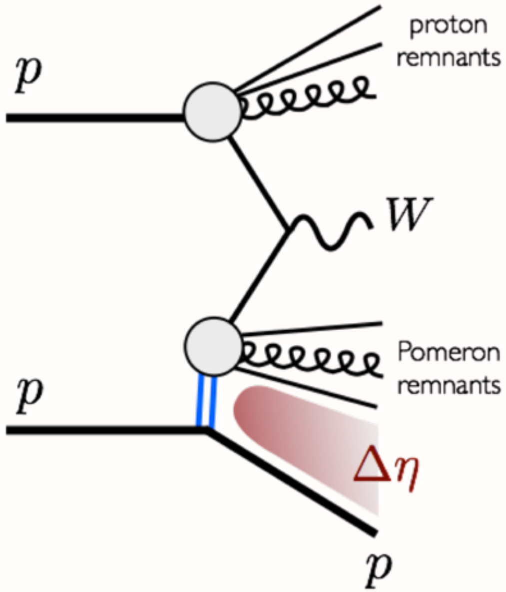
McGill

- At LHC reachable energy scales, partonic subprocesses resolved with perturbation theory assuming collinear factorization
- Regge theory extends the partonic model to soft processes : diffractive PDFs + Regge factorization in DIS
- But CDF[1] and theoretical studies (KMR) proved Regge factorization does not extend to hard hadron-hadron scattering (soft multi-parton interactions): rapidity gap survival probability.
- Test Pomeron universality btw HERA/LHC
- Diffractive Gauge Boson measurement:
    - CMS reported results on rapidity gap [2]
    - ATLAS/CMS TOTEM aims at proton tagging with AFP [3] /CT-PPS (not sensitive to dissociative proton): allows to test QCD evolution of DPDFs and compare with HERA



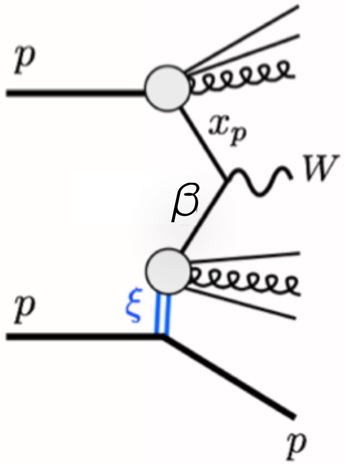
1. **Single Diffractive hard production of W boson**
2. Charge Asymmetry as a probe for Pomeron structure
3. Prospective results with FPMC

- Diffractive PDFs are obtained from DIS experiments and evolved up to NLO with DGLAP.
- Pomeron structure is taken into account in the DPDFs [4]

Flux: $\Phi_{\mathbb{P}/\mathbb{R}} = \frac{e^{B_{\mathbb{P}/\mathbb{R}} t}}{\xi^{2\alpha_{\mathbb{P}/\mathbb{R}}(t)-1}}$

$$f(x_{\mathbb{P}/\mathbb{R}}, \mu^2, \xi) = \Phi_{\mathbb{P}/\mathbb{R}}(\xi, t) \cdot f_{\mathbb{P}/\mathbb{R}}(\beta, \mu^2)$$

Pomeron/Reggeon structure



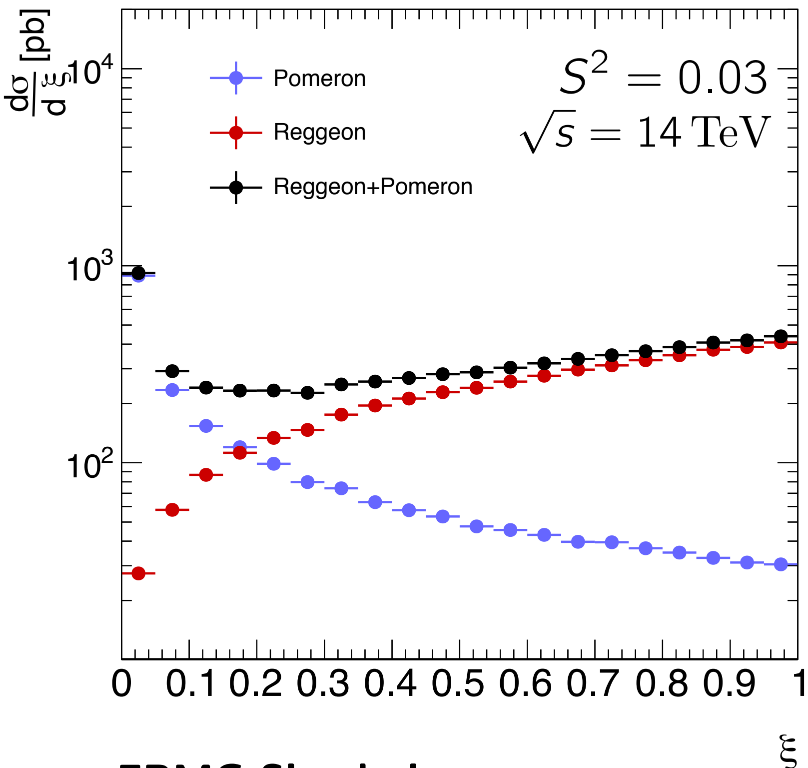
ξ : fractional momentum loss of the intact proton

t : momentum squared transferred from intact proton into collision

$x_{\mathbb{P}/\mathbb{R}}$: fraction of intact proton momentum involved into interaction

$\beta = x_{\mathbb{P}/\mathbb{R}}/\xi$: fraction of Pomeron/Reggeon momentum carried by interacting parton

At low ξ, Reggeon contribution is negligible = only consider Pomeron amplitude. Fo rather high ξ, Pomeron picture not reliable.



FPMC Simulation

Inclusive cross-section $W \to \mu\nu_\mu$

parton-parton

$$d\sigma = S^2 \sum_{i,j} \int dx_p \, d\beta \, \mathcal{F}_{ij}(\xi, t, x_{\mathbb{P}}, x_p, \mu^2) \, d\hat{\sigma}^{ij \to W}$$

$$\mathcal{F}_{ij}(\xi, t, \beta, x_p, \mu^2) = \underbrace{\Phi_{\mathbb{P}}(\xi, t) \cdot f^i_{\mathbb{P}}(\beta, \mu^2)}_{\text{diffractive proton PDFs}} \cdot \underbrace{f^j_p(x_p, \mu^2)}_{\text{hard proton PDFs}}$$

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- **FPMC [4] based on HERWIG 6.5:**
  - uses matrix elements of inelastic production to calculate LO cross-sections
  - follows HERWIG numbering scheme for processes involving non-diffractive matrix elements + new numbers for typical diffractive process
  - replace e+/e- beam by diffractive protons and two-photon exchanges by Pomerons/Reggeons objects

- **Can define in FPMC:**
  - type of process : exclusive/inclusive, DPE/SPE...
  - type of Regge flux
  - type of DPDFs (HERA Fit A/B) [5]
  - Rescattering correction (Rapidity Gap survival probability S^2)

- HERA DIS measurement of the DPDFs consider Pomeron to be composed of quarks ➤ charge neutrality of the Pomeron = symmetry conditions on the DPDFs

$$u_{\mathbb{P}} = \bar{u}_{\mathbb{P}}, \;\; d_{\mathbb{P}} = \bar{d}_{\mathbb{P}}, \;\; s_{\mathbb{P}} = \bar{s}_{\mathbb{P}}$$

- At HERA, not able to distinguish between different quark flavours ➤ assume they are all equal: $u_{\mathbb{P}} = d_{\mathbb{P}} = s_{\mathbb{P}} \equiv q$

- Releasing this constraint ➤ other sets of DPDFs such that $\mathbf{F_2}^{\mathbf{D}}$ **constant**:

$$F_2^{D(4)} \propto \left(\frac{2}{3}\right)^2 u_{\mathbb{P}} + \left(\frac{1}{3}\right)^2 d_{\mathbb{P}} + \left(-\frac{1}{3}\right)^2 s_{\mathbb{P}}$$

The equation to be fulfilled is:

$$4u_{\mathbb{P}} + d_{\mathbb{P}} - s_{\mathbb{P}} = 6q$$

2 degrees of freedom:

$$R_{ud} = \frac{u_{\mathbb{P}}}{d_{\mathbb{P}}} \quad R_{sd} = \frac{s_{\mathbb{P}}}{d_{\mathbb{P}}}$$

Express the DPDFs in terms of R_{ud} and R_{sd}:

$$u_{\mathbb{P}}(\beta,\mu^2) = \frac{6R_{ud}}{1+R_{sd}+4R_{ud}}\cdot q(\beta,\mu^2)$$
$$d_{\mathbb{P}}(\beta,\mu^2) = \frac{6R_{sd}}{1+R_{sd}+4R_{ud}}\cdot q(\beta,\mu^2)$$
$$s_{\mathbb{P}}(\beta,\mu^2) = \frac{6}{1+R_{sd}+4R_{ud}}\cdot q(\beta,\mu^2)$$

Derive the cross-sections for W^+ and W^-:

$$\frac{d\sigma_{W^+}}{dx_p d\beta} = S^2\frac{2\pi G_F M_W^2}{3\sqrt{2}s}\Phi_{\mathbb{P}}(\xi,t)\cdot\left(|V_{ud}|^2\left[u_{\mathbb{P}}(\beta)\cdot\bar{d}_p(x_p)+\bar{d}_{\mathbb{P}}(\beta)\cdot u_p(x_p)\right]+|V_{us}|^2\left[\bar{s}_{\mathbb{P}}(\beta)\cdot u_p(x_p)\right]\right)$$
$$\frac{d\sigma_{W^-}}{dx_p d\beta} = S^2\frac{2\pi G_F M_W^2}{3\sqrt{2}s}\Phi_{\mathbb{P}}(\xi,t)\cdot\left(|V_{ud}|^2\left[\bar{u}_{\mathbb{P}}(\beta)\cdot d_p(x_p)+d_{\mathbb{P}}(\beta)\cdot\bar{u}_p(x_p)\right]+|V_{us}|^2\left[s_{\mathbb{P}}(\beta)\cdot\bar{u}_p(x_p)\right]\right)$$

Express in term of the asymmetry:

$$\frac{1-\mathcal{A}}{1+\mathcal{A}} = \frac{|V_{ud}|^2\left[R_{ud}\cdot d_p + R_{sd}\cdot\bar{u}_p\right]+|V_{us}|^2\bar{u}_p}{|V_{ud}|^2\left[R_{ud}\cdot\bar{d}_p + R_{sd}\cdot u_p\right]+|V_{us}|^2 u_p}$$

$$\mathcal{A} = \frac{N^+ - N^-}{N^+ + N^-}$$

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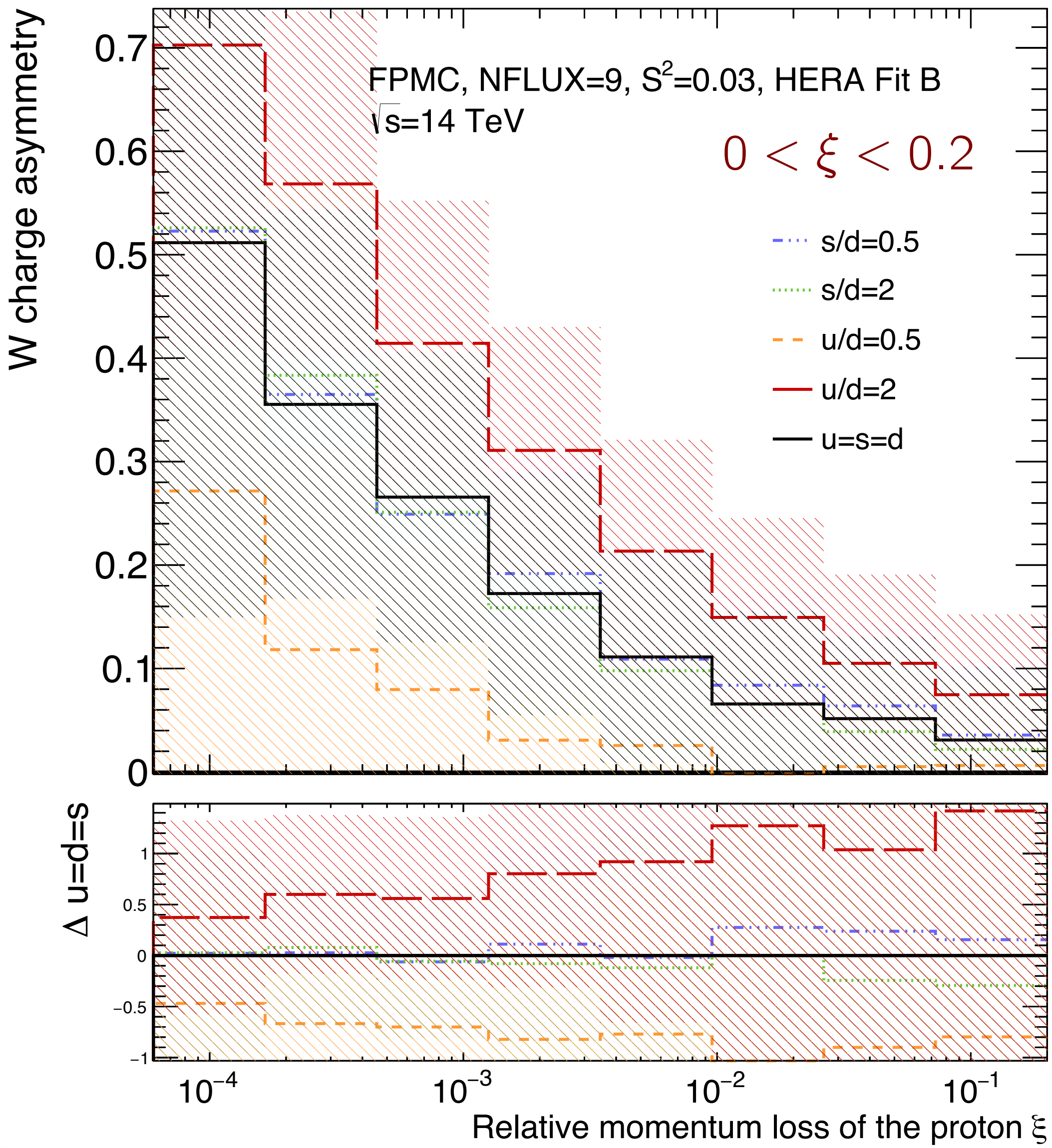
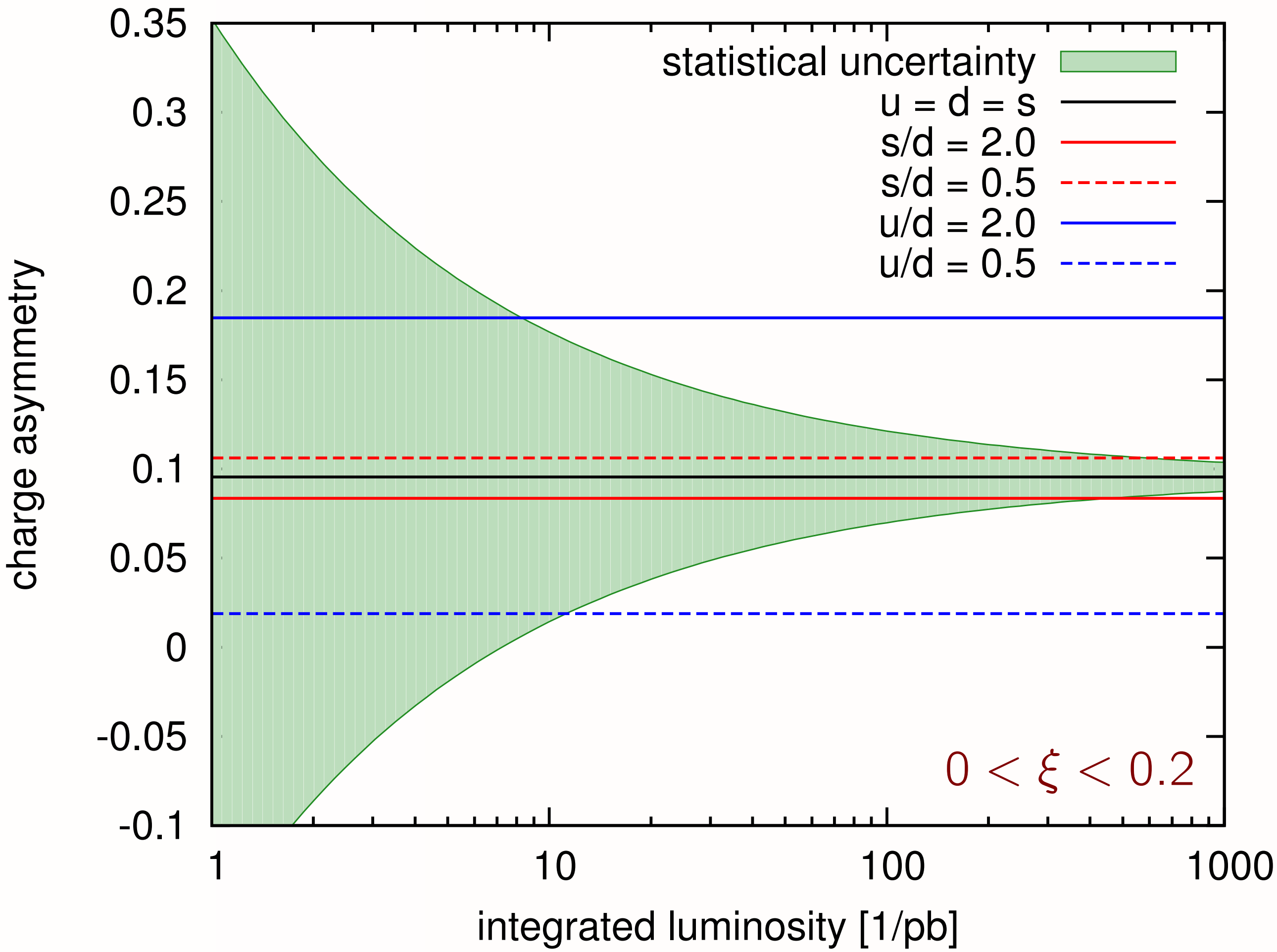


- Black line is HERA hypo of equality of DPDFs
- No deviation observed for R_{sd}
- R_{ud} deviation is increasing for less soft processes
- Errors bars = statistical uncertainty scaled to correct cross-section and integrated luminosity = **100 pb^{-1}**

Ratio	Integrated Asym
u=d=s	0,096
R_{ud}	0,019
R_{ud}	0,185
R_{sd}	0,106
R_{sd}	0,084

$>$**15 pb^{-1}** needed to be able to distinguish R_{ud}=0.5 from R_{ud}=2.0



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u=d=s	0,096
R	0,019
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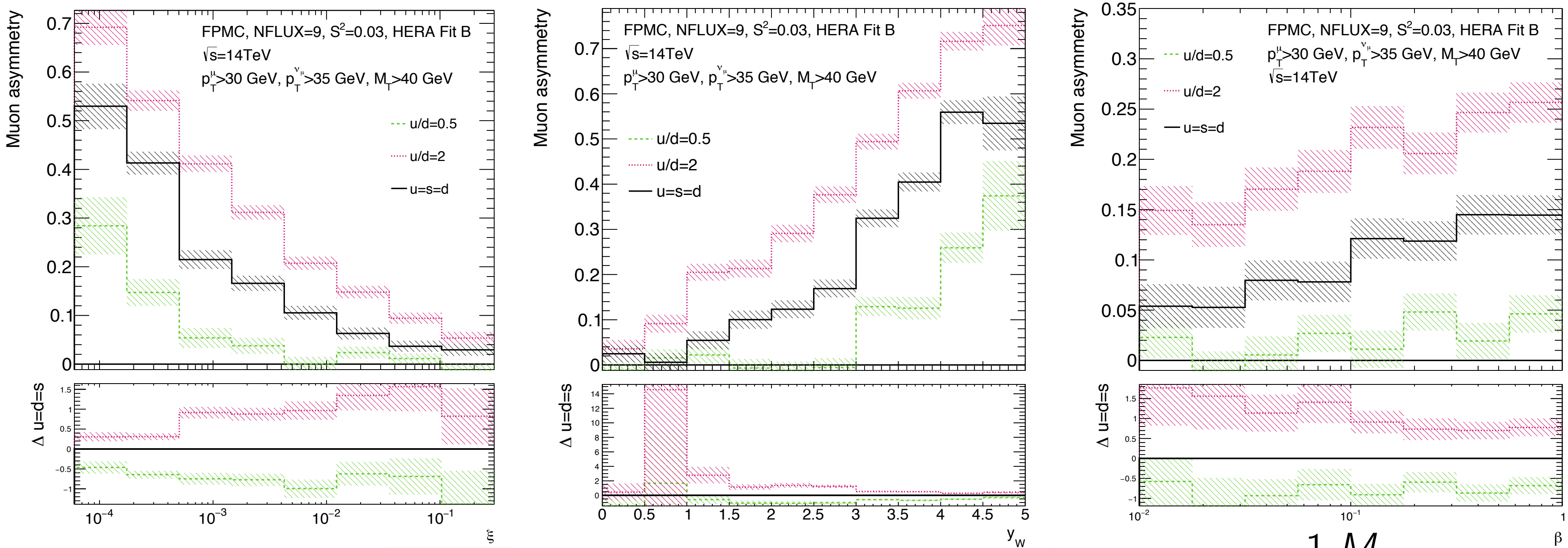
R	0,106
R	0,084

Selection (standard ATLAS):

- Transverse momentum of the muon: $p_T^{\mu} > 30$ GeV,
- Missing energy: $p_T^{\nu_\mu} > 35$ GeV,
- Transverse mass of the W boson:

$$M_T = \sqrt{(E_{T,\mu} + E_{T,\nu_\mu})^2 - (\vec{p}_{T,\mu} + \vec{p}_{T,\nu_\mu})^2} > 40\ \mathrm{GeV}$$



$$y_W = \frac{1}{2}\ln\left(\frac{E_W + p_{z,W}}{E_W - p_{z,W}}\right) = \frac{1}{2}\ln\left(\frac{x_{\mathbb{P}}}{x_p}\right) \qquad \beta = \frac{1}{\xi}\frac{M_W}{\sqrt{s}}e^{-y_W}$$

- Study in progress...
- Around 100 pb^{-1} would be sufficient to be able to distinguish between different partonic structures of the Pomeron in the xi range 0<xi<0.2
- We assumed R_{ud} and R_{sd} constant but the β dependance has to be investigated
- Measurement will have to wait until AFP installation

[1] T. Affolder et al. (CDF), Phys. Rev. Lett. 84, 5043 (2000).

[2] S. Chatrchyan et al. (CMS), Eur.Phys.J. C72, 1839 (2012), arXiv: 1110.0181 [hep-ex].

[3] http://atlas-project-lumi-fphys.web.cern.ch/atlas-project-lumi-fphys/

[4] M. Boonekamp, A. Dechambre, V. Juranek, O. Kepka, M. Rangel, et al., (2011), arXiv:1102.2531 [hep-ph].

[5] A. Aktas et al. (H1), Eur.Phys.J. C48, 715 (2006),arXiv:hep-ex/ 0606004 [hep-ex].

Thank you!

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