Probing the Pomeron quark/gluon structure using γ+jet and dijet events

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AFP project

- **A**TLAS **F**orward **P**hysics (AFP)
  - **ATLAS upgrade project** : under review for an installation foreseen in **2015-16** (AFP 210m)
  - Setup 2 sets of **extra Si + timing detectors** 210m and 420m from the ATLAS interaction point
  - Baseline location **15** σ **from the beam** ($\simeq$ few mm)

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- Physics motivation : **Proton tagging**
  - Increase precision on existing measurements
  - Exclusive Higgs production and Higgs electroweak couplings
  - Quartic anomalous couplings (*WWZZ*, *WW*$\gamma\gamma$, ..)
  - Diffractive events : exclusive and **inclusive (Pomeron exchange)**

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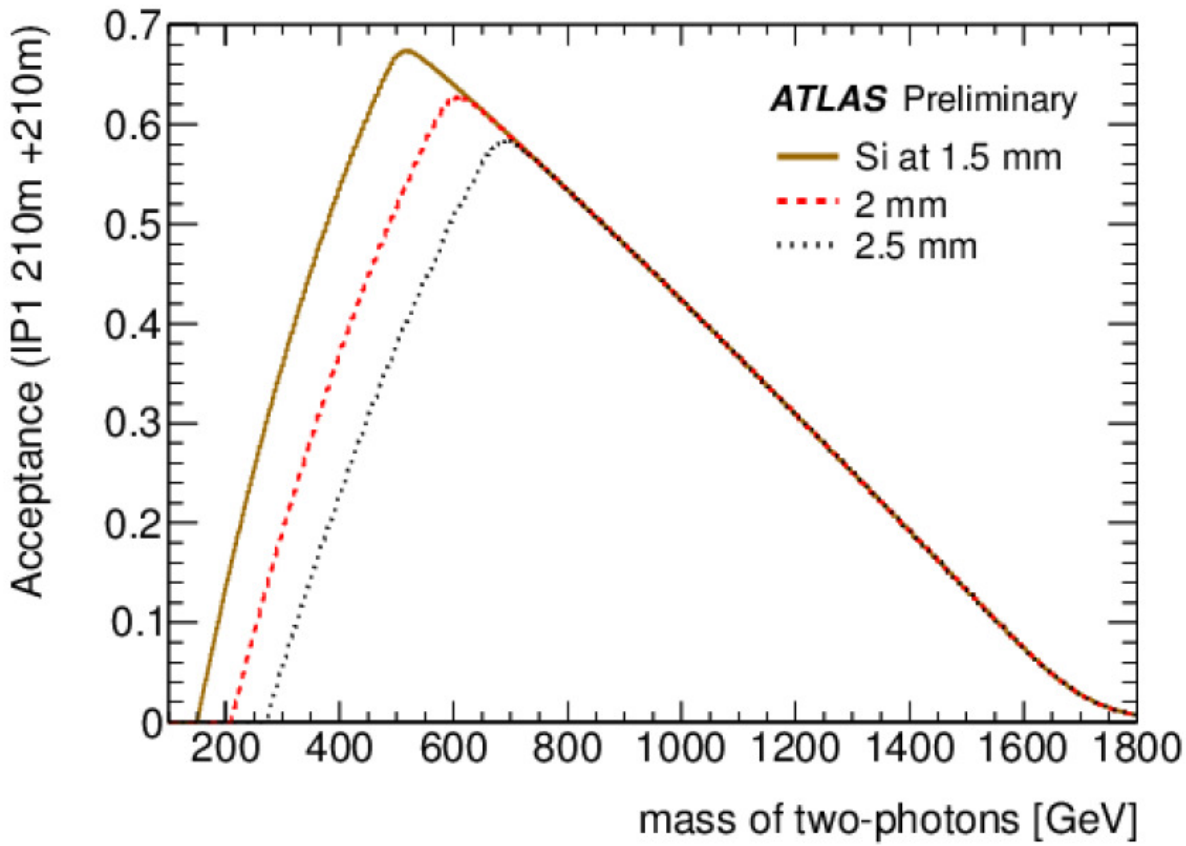
- **Acceptance :** (**0.0015**) **0.015** $< \xi <$ 0.15 **AFP (420m+)210m**. ξ, proton momentum fraction loss

AFP210 Acceptance in term of diffractive Mass $\sqrt{\xi_1 \xi_2 s}$

- ξ, proton momentum fraction loss
- $\sqrt{s}$, energy in the center of mass frame



Introduction

- Resolved Pomeron model for **inclusive double diffractive (DD) events**
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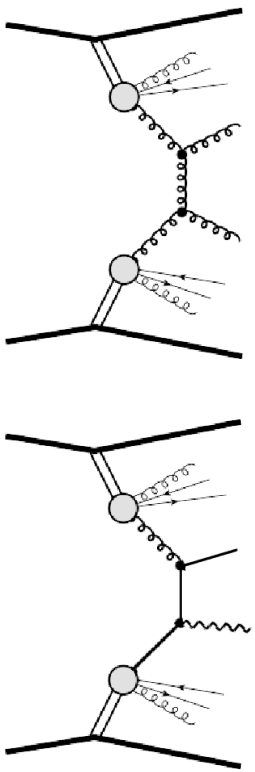
- Other models as **Soft Color Interaction (SCI)** model does not use Pomeron to describe DPE

Why γ+jet and dijet events?



- **dijet** inclusive DD production
  - Herwig process ID 1500
  - Main mechanism : g+g
  - High σ dependance on **gluon** PDFs
  - $\sigma \simeq$ 10,000 pb after cuts and selection
- γ**+jet** inclusive DD production
  - Herwig process ID 1800
  - Main mechanism : q+g
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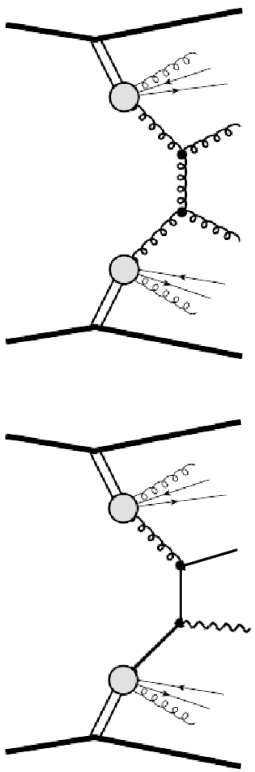

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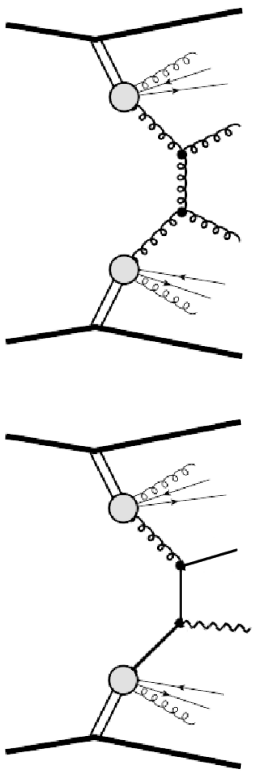

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Purpose: evaluate $\frac{\sigma_{\gamma+jet}}{\sigma_{dijet}}$ for various PDFs patterns to determine if measurement is sensitive to **Pomeron quark structure** + **test HERA fit of gluon PDF** at the LHC.

Herwig ID 1800 and 1500: list of Subprocesses

IHPRO	1 + 2	®	3 + 4	c/f conn.
41	$q + q^-$	®	g + g	2 3 1 4
42	$q + g$	®	q + g	3 1 2 4
43	$q^- + q$	®	g + g	3 1 2 4
44	$q^- + g$	®	q^- + g	2 3 1 4
45	$g + q$	®	q + g	2 3 1 4
46	$g + q^-$	®	q^- + g	3 1 2 4
47	$g + g$	®	g + g	2 3 1 4
51	g+ q	®	g+ q	1 4 2 3
52	g+ q^-	®	g+ q^-	1 3 4 2
53	g+ g	®	$q + q^-$	1 4 2 3
61	$q + q^-$	®	g+g	2 1 3 4
62	$q^- + q$	®	g+g	2 1 3 4
63	$g + g$	®	g+g	2 1 3 4
71	g+ q	®	$M(S=0)$ +q'	1 4 3 2
72	g+ q	®	$M(S=1)_L$+q'	1 4 3 2
73	g+ q	®	$M(S=1)_T$+q'	1 4 3 2
74	g+ q^-	®	$M(S=0)$+q^-'	1 4 3 2
75	g+ q^-	®	$M(S=1)_L$+q^-'	1 4 3 2
76	g+ q^-	®	$M(S=1)_T$+q^-'	1 4 3 2

Table 12: Direct photon subprocesses.

IHPRO	1 + 2	®	3 + 4	c/f conn.
1	$q + q$	®	$q + q$	3 4 2 1
2	$q + q$	®	$q + q$	4 3 1 2
3	$q + q'$	®	$q + q'$	3 4 2 1
4	$q + q^-$	®	$q'+ q^-$'	2 4 1 3
5	$q + q^-$	®	$q + q^-$	3 1 4 2
6	$q + q^-$	®	$q + q^-$	2 4 1 3
7	$q + q^-$	®	$g + g$	2 4 1 3
8	$q + q^-$	®	$g + g$	2 3 4 1
9	$q + q^-$'	®	$q + q^-$'	3 1 4 2
10	$q + g$	®	$q + g$	3 1 4 2
11	$q + g$	®	$q + g$	3 4 2 1
12	$q^- + q$	®	q^-' +q'	3 1 4 2
13	$q^- + q$	®	$q^- + q$	2 4 1 3
14	$q^- + q$	®	$q^- + q$	3 1 4 2
15	$q^- + q$	®	$g + g$	3 1 4 2
16	$q^- + q$	®	$g + g$	4 1 2 3
17	$q^- + q'$	®	$q^- + q'$	2 4 1 3
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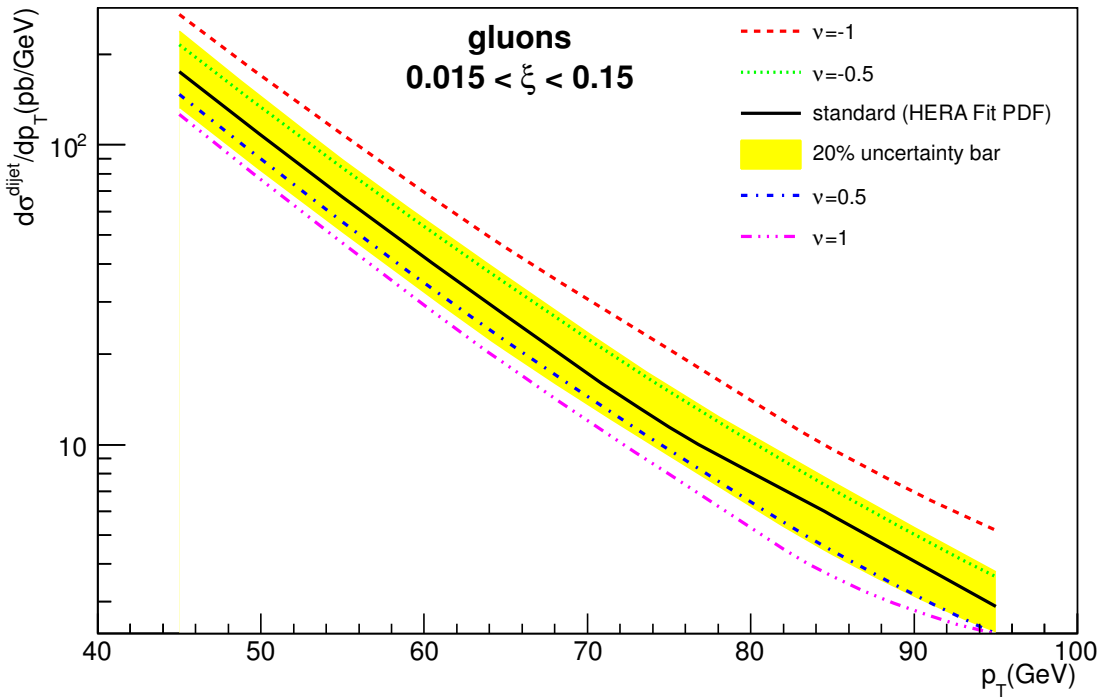
19	$q^- + q^-$	®	$q^- + q^-$	3 4 2 1
20	$q^- + q^-$'	®	$q^- + q^-$'	4 3 1 2
21	$q^- + g$	®	$q^- + g$	2 4 1 3
22	$q^- + g$	®	$q^- + g$	4 3 1 2
23	$g + q$	®	$g + q$	2 4 1 3
24	$g + q$	®	$g + q$	3 4 2 1
25	$g + q^-$	®	$g + q^-$	3 1 4 2
26	$g + q^-$	®	$g + q^-$	4 3 1 2
27	$g + g$	®	$q + q^-$	2 4 1 3
28	$g + g$	®	$q + q^-$	4 1 2 3
29	$g + g$	®	$g + g$	4 1 2 3
30	$g + g$	®	$g + g$	4 3 1 2
31	$g + g$	®	$g + g$	2 4 1 3

Table 11: QCD subprocesses.

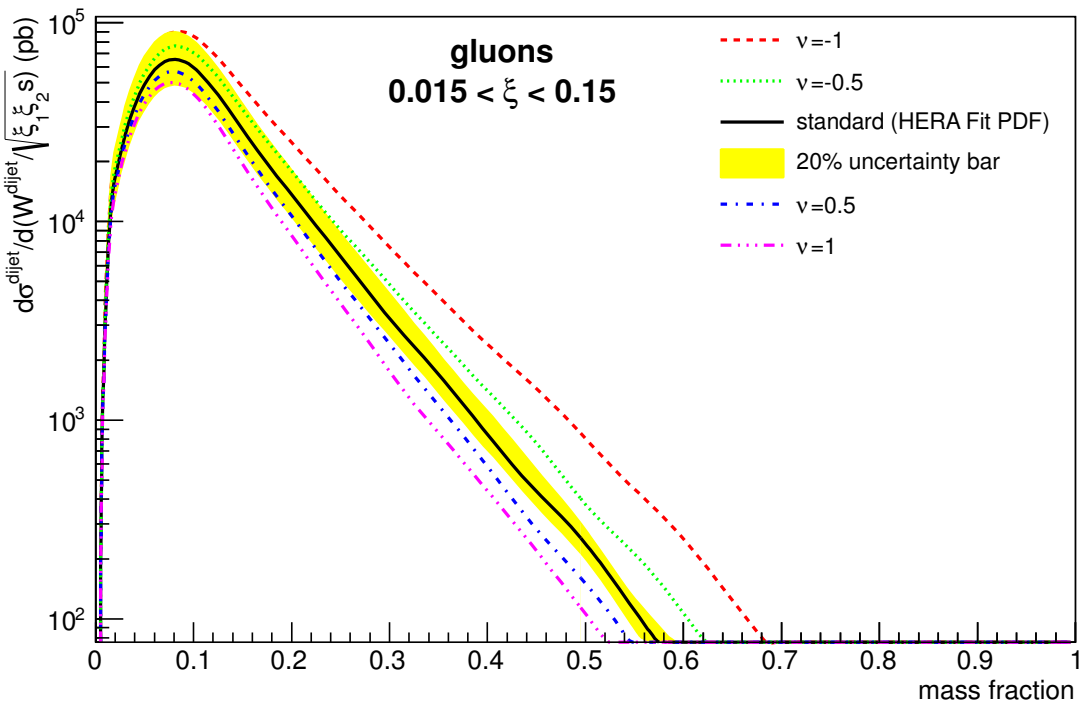
Dijet gluon PDF dependance : jet p_T observable



- "Standard case", "20% uncertainty bar" and "Standard case * $(1-\beta)^{\nu}$" scenarios

- β, Pomeron momentum fraction loss
- FPMC generator with antikT jet algorithm used, $R = 0.6$

Dijet gluon PDF dependance : Mass fraction $W^{dijet}/\sqrt{\xi_1\xi_2 s}$ observable



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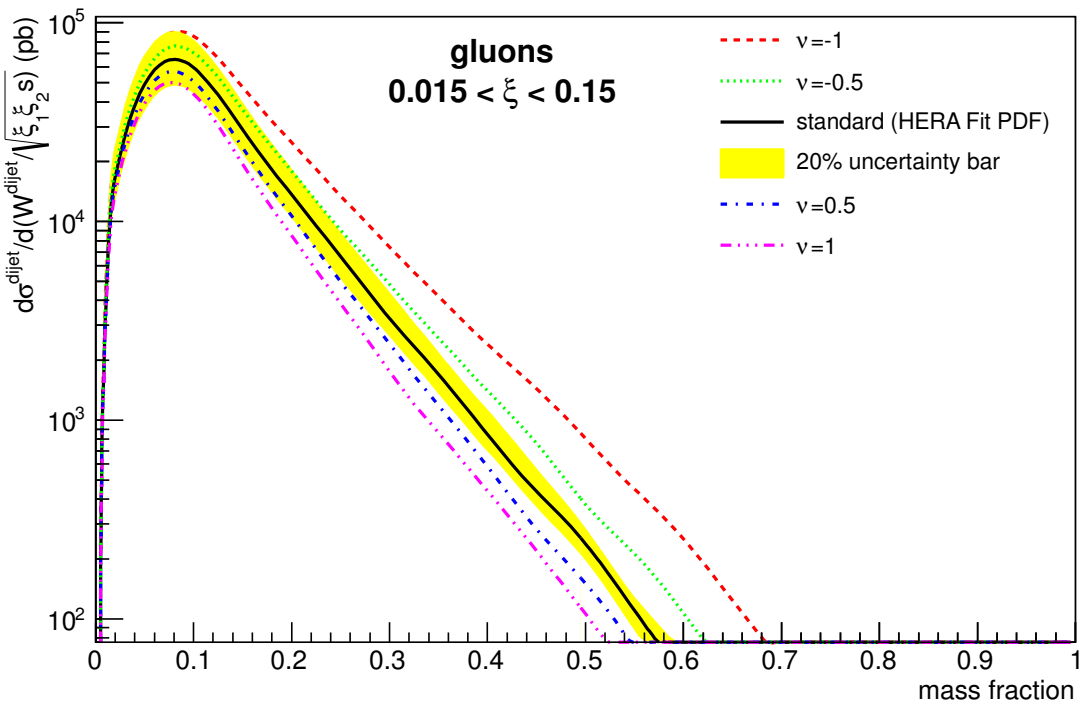

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- β, Pomeron momentum fraction loss
- FPMC generator with antikT jet algorithm used, $R = 0.6$, $p_{T,min} = 20\ \mathrm{GeV}$
- Mass fraction = $\sqrt{\beta_1\beta_2}$, **direct access to Pomeron gluon structure**

Quark densities, $\frac{\sigma_{\gamma+jet}}{\sigma_{dijet}}$ calculation : simulation and selection

- **FPMC generator** has been used. 2 cases considered
  - $0.015 < \xi < 0.15$ (AFP 210 metres)
  - $0.0015 < \xi < 0.15$ (AFP 210+420 metres)

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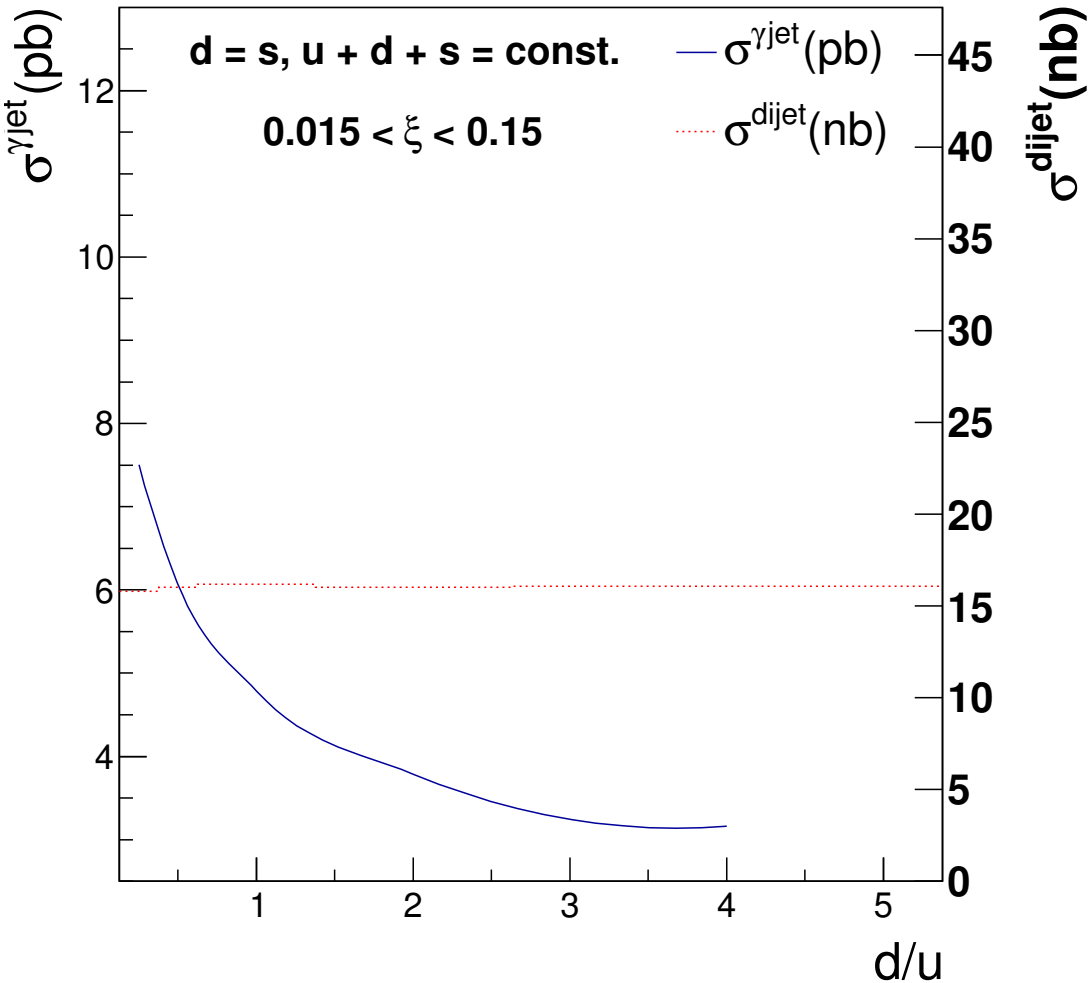
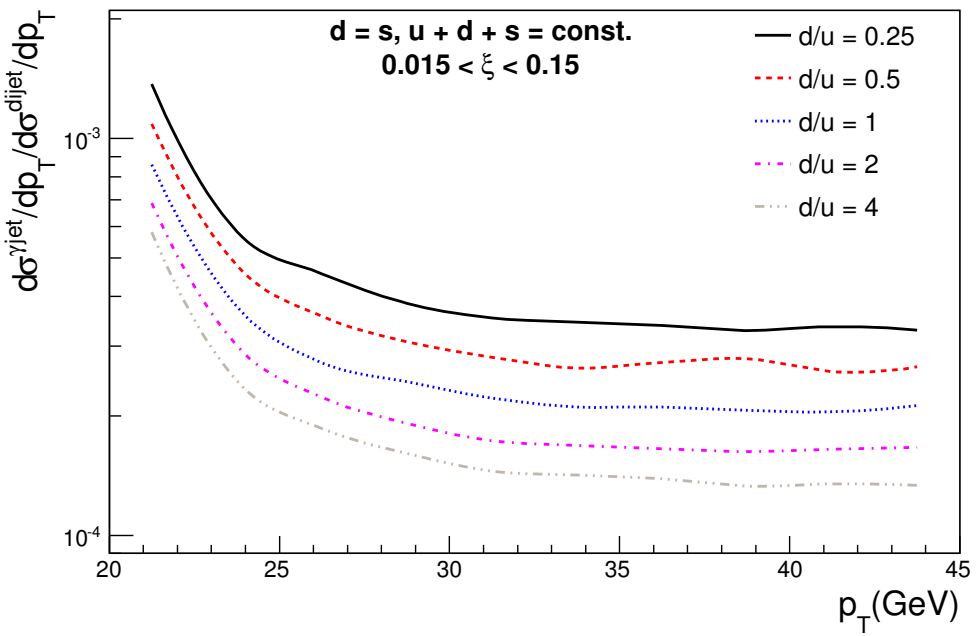
d/u results : cross-section ratio

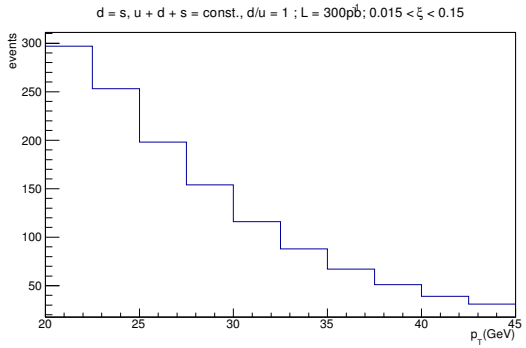


- Cross-sections **after** jet and γ selection ($p_T > 20$ GeV)
- Cross-sections ratio varies by **a factor 2.5**

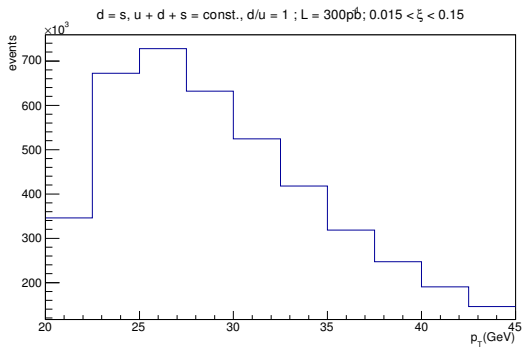
d/u results : $p_{T,jet}$ differential cross-section ratio, $\sqrt{s} = 14\ \mathrm{TeV}$



γ+jet



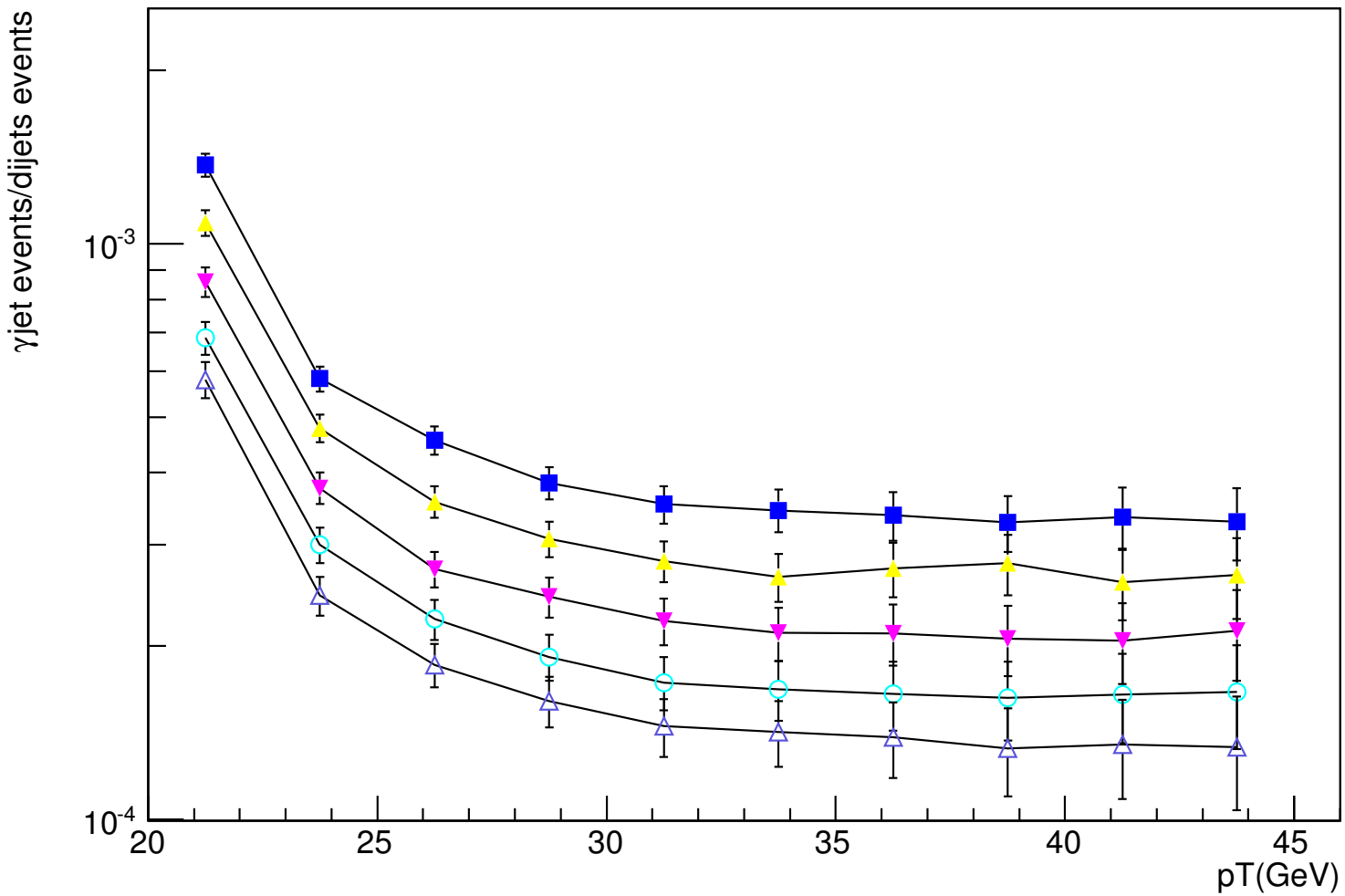
Dijet



- Cross-sections integrated on **2.5 GeV bins**
- Cross-sections ratio varies by **a factor 4**
- Jet Energy Scale (JES) systematics should compensate (but not resolution)
- Statistical uncertainty driven by γ+jet

d/u results : $p_{T,jet}$ differential cross-section ratio, $\sqrt{s} = 14$ TeV

Statistical uncertainty ($L = 300\ pb^{-1}$, AFP 210m)



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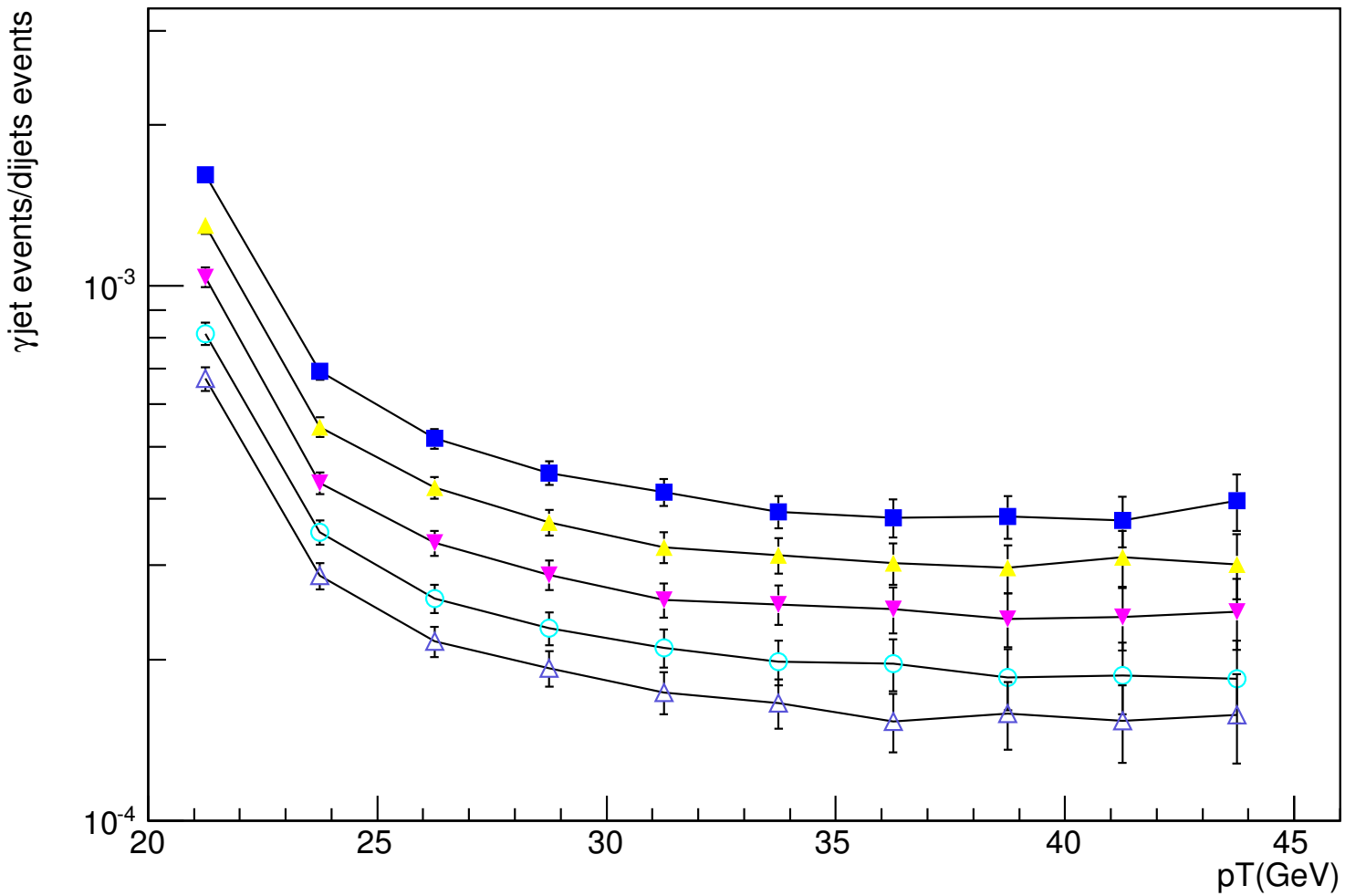
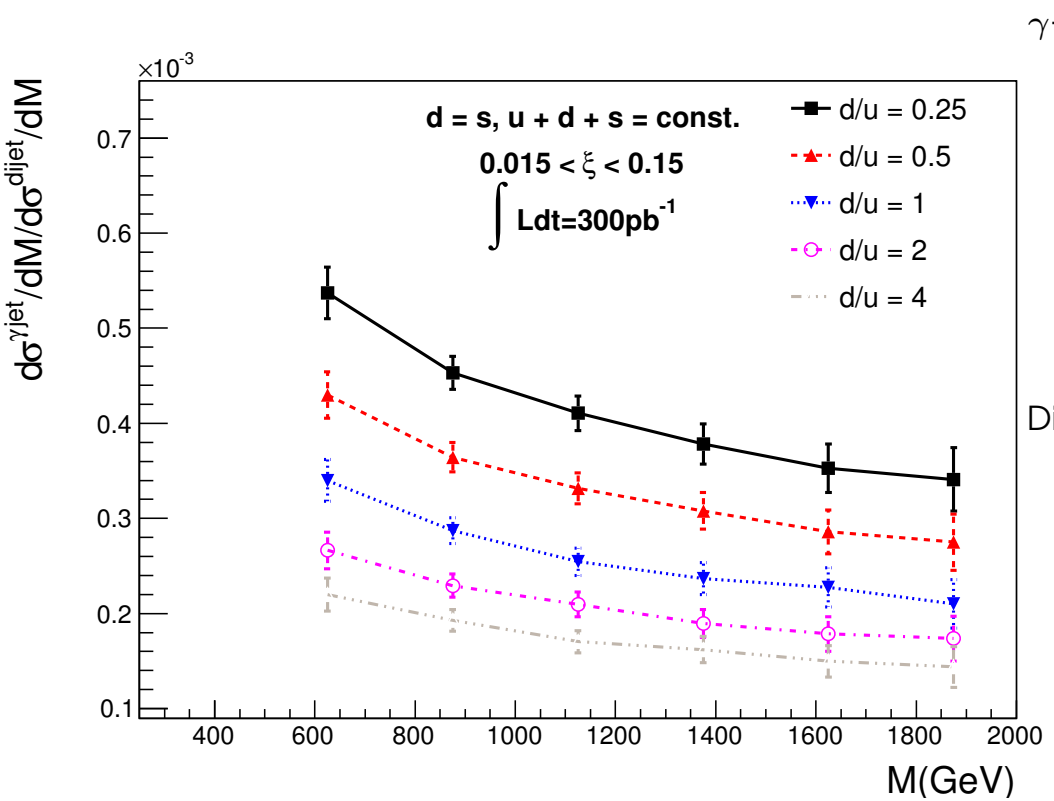
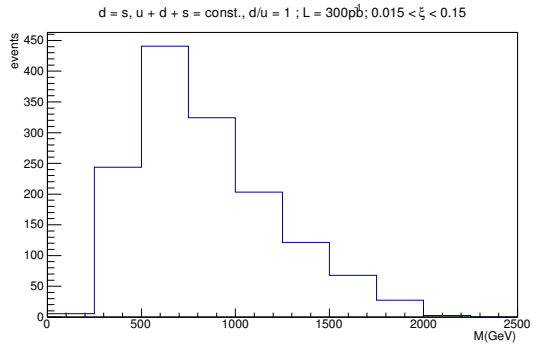


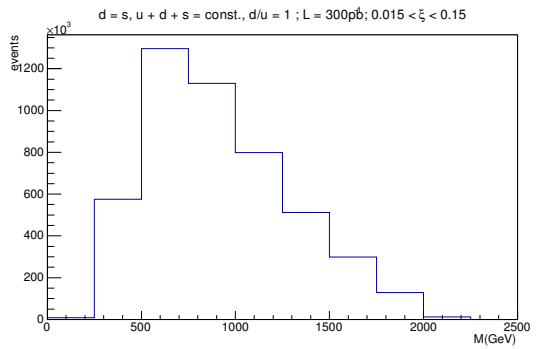
d/u results : $M_{p-p}(= \sqrt{\xi_1 \xi_2 s})$ differential cross-section ratio, $\sqrt{s} = 14\ \mathrm{TeV}$



γ+jet

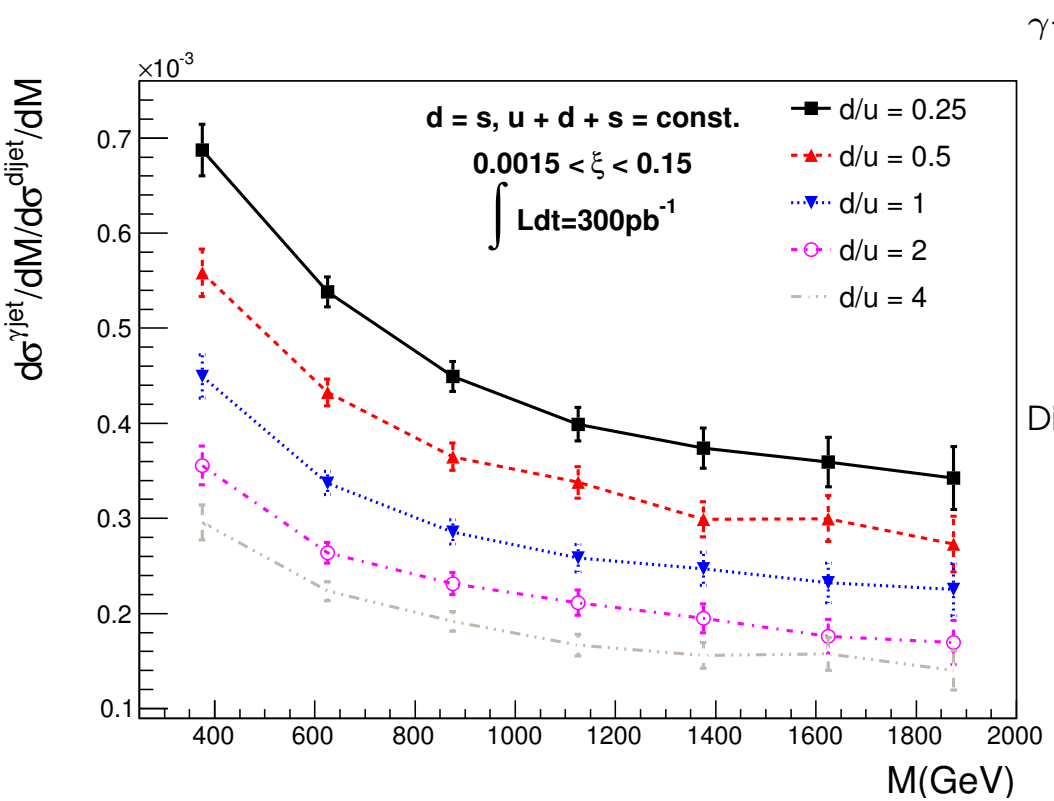


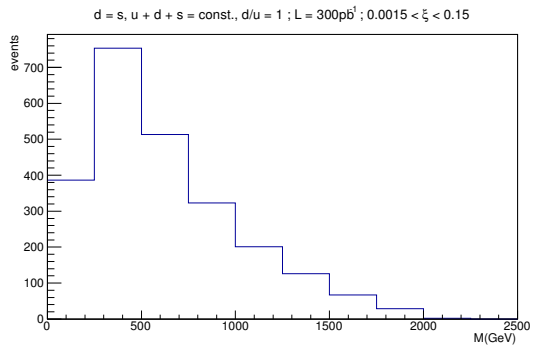
Dijet

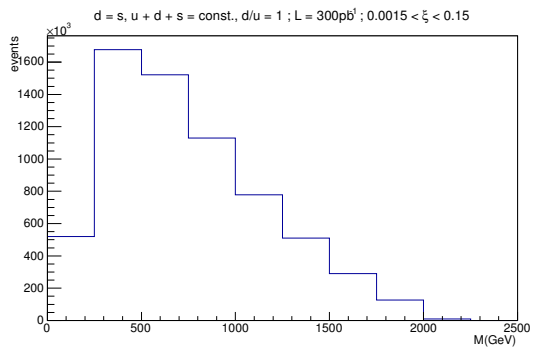


- Cross-sections integrated on **250 GeV bins**
- Cross-sections ratio varies by **a factor 1.5**
- Systematics should almost compensate (AFP measurement)
- Statistical uncertainty driven by γ+jet

d/u results : $M_{p-p}(= \sqrt{\xi_1 \xi_2 s})$ differential cross-section ratio, $\sqrt{s} = 14\ \mathrm{TeV}$







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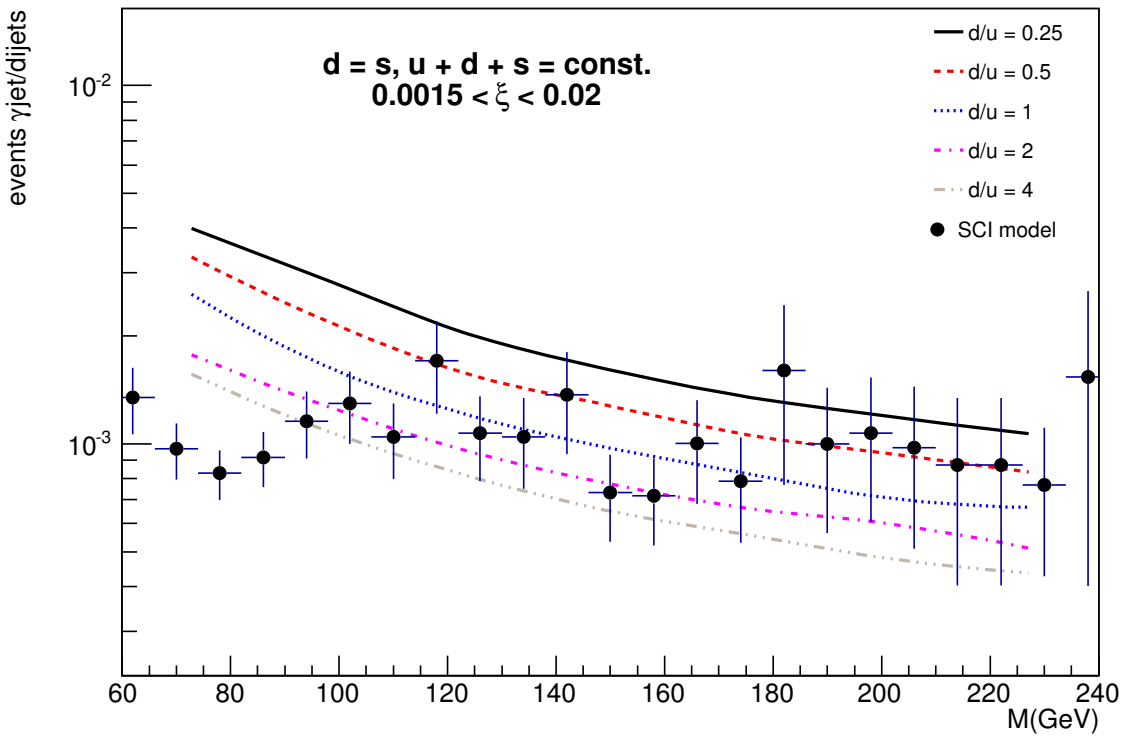
$M_{p-p}(=\sqrt{\xi_1\xi_2 s})$ observable : A way to discriminate Pomeron from SCI model?



- Need to be out of the SCI **background** : $\xi < 0.02$ (probably overestimated)
- SCI : **flat** distribution
- **Preliminary plot**

Experimental issues

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- **Need dedicated low luminosity runs**. 300 $pb^{-1} \simeq 3$ weeks at no pile-up
- Possible low pile-up measurement (μ = 2,3) would decrease significantly required dedicated runtime

Conclusion

- γ+jet/dijet DD events study is a good probe of **Pomeron structure**
  - Requires dedicated **low luminosity runs**
  - Measurement would be relevant as of $\boldsymbol{L = 300\ pb^{-1}}$ ($\simeq$ 3 weeks of data) with AFP 210 m to probe **quark densities**
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- Possible way to discriminate Pomeron model from **Soft Color Interaction model** (preliminary results)
- Study of **d/s** in progress. **A paper is being drafted**.

Back-up slides

Photon 2013 Conference

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CEA Saclay - Irfu/SPP

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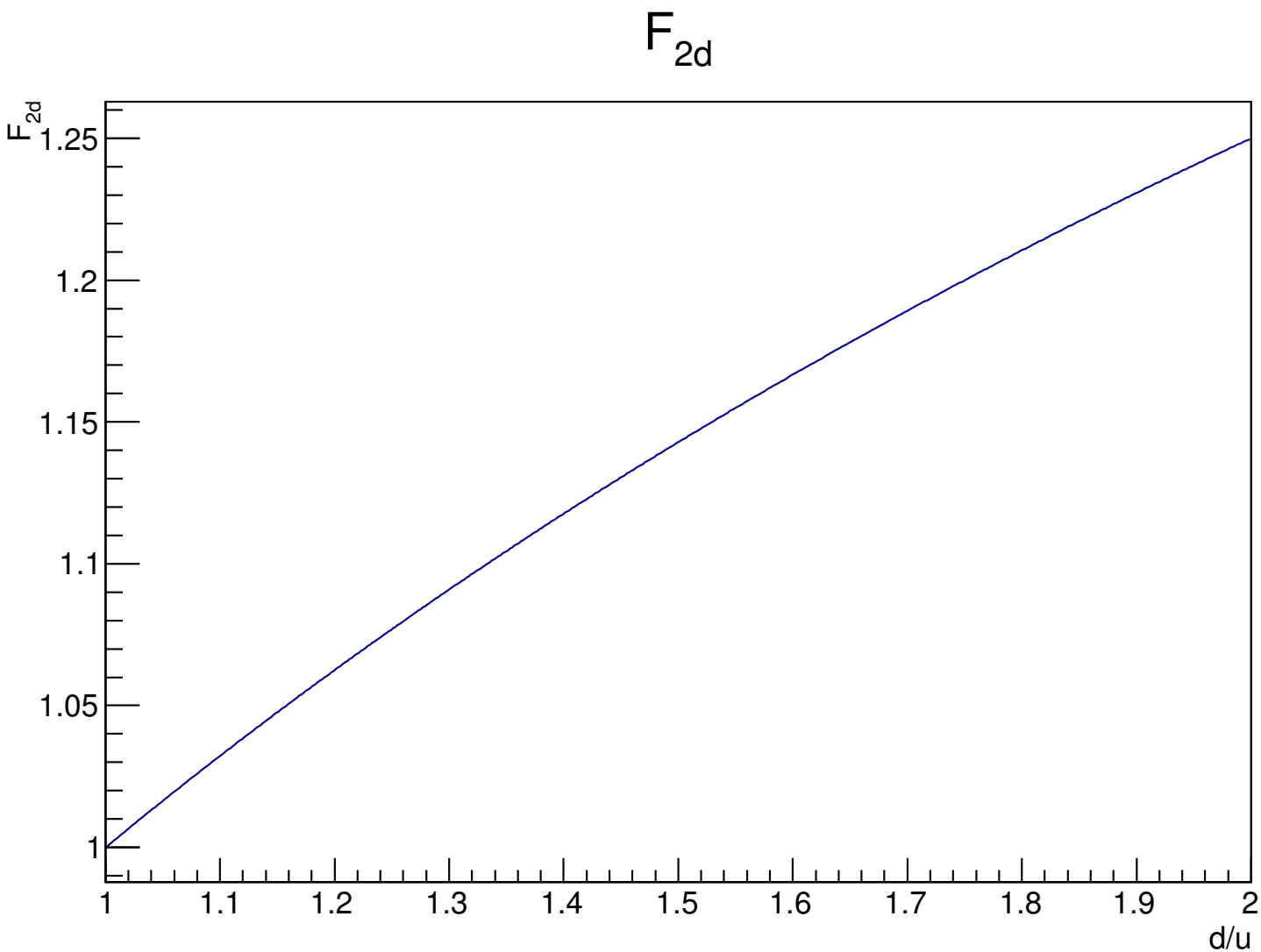
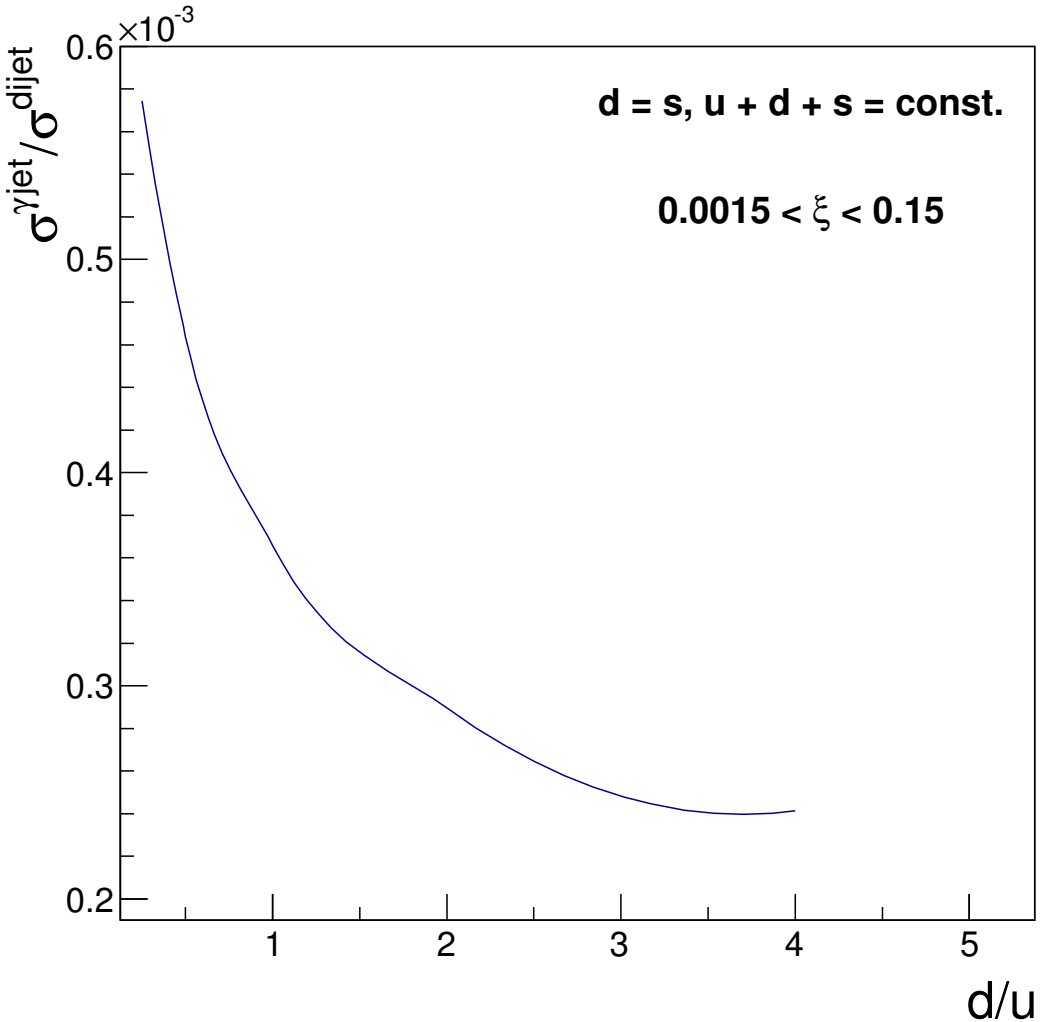
F_2^D variations

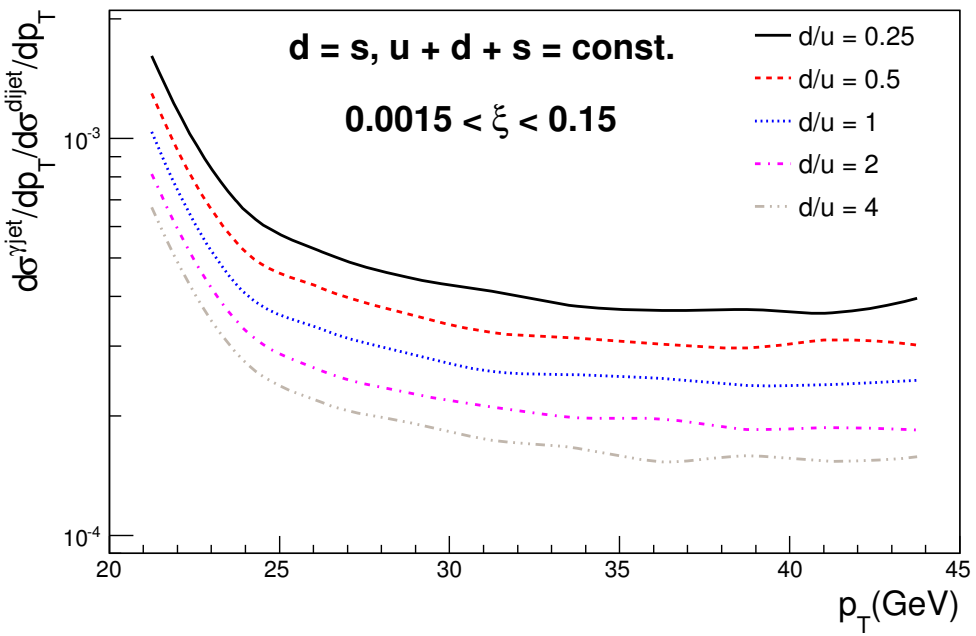


d/u results : cross-section ratio

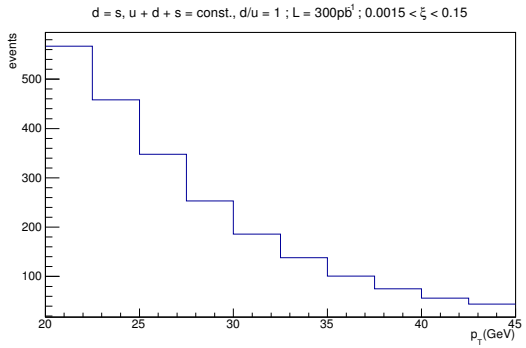


- Cross-sections **after** jet and γ selection ($p_T > 20$ GeV)
- Cross-sections ratio varies by **a factor 2.5**

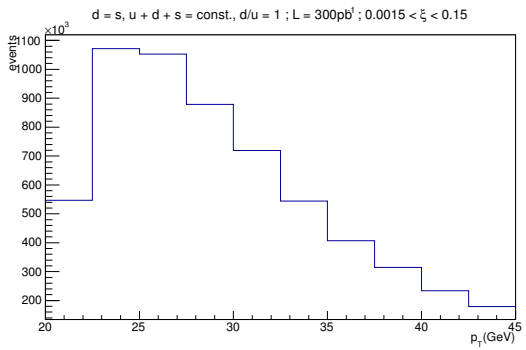
d/u results : $p_{T,jet}$ differential cross-section ratio



γ+jet



Dijet



- Cross-sections integrated on **2.5 GeV bins**
- Cross-sections ratio varies by **a factor 4**
- Jet Energy Scale (JES) systematics should compensate (but not resolution)
- Statistical uncertainty driven by γ+jet