

A Fixed-Target ExpeRiment (AFTER) using the LHC beams



Rune Elgaard Mikkelsen
PhD student at



&



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Kinematics

LHC 7 TeV proton beam

$\sqrt{s} \sim 115\text{GeV}$: pp, pd, pA

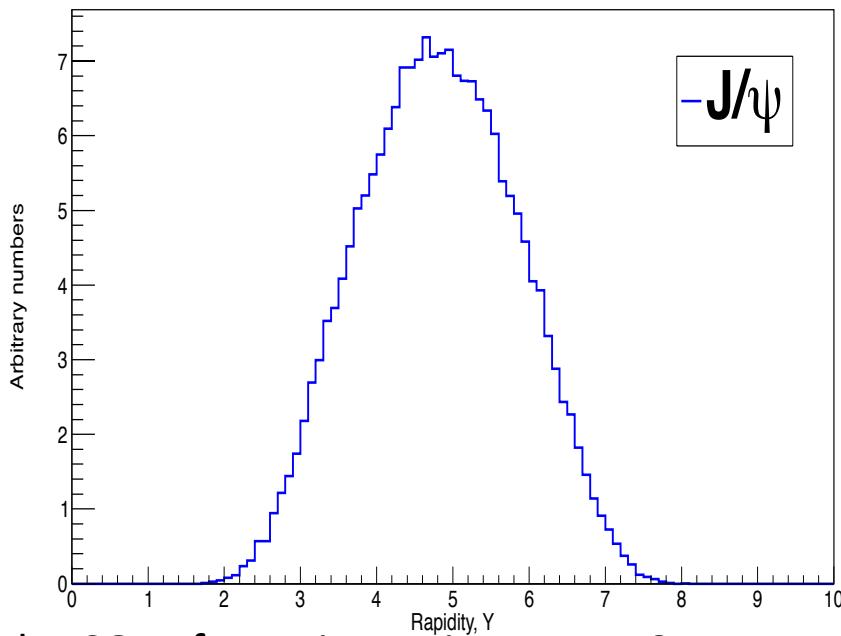
Comparable to RHIC energies

LHC 2.76 TeV lead beam

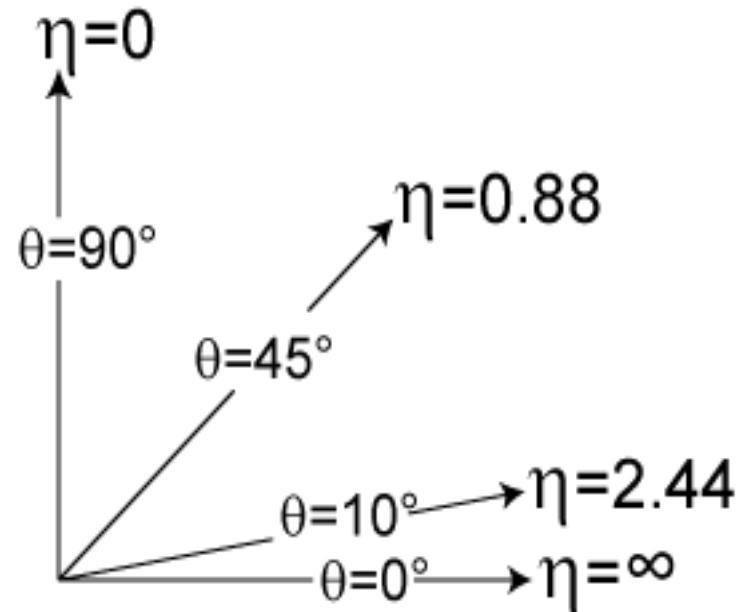
$\sqrt{s} \sim 72\text{GeV}$: Pb-p, PbA

Between SPS and top AA RHIC energies

Rapidity distribution of J/ψ events



The COM-frame is moving at $Y=4.8$



Beam extraction

The LHC beam may be extracted using “Strong crystalline field”
without any decrease in performance of the LHC !

E. Uggerhøj, U.I Uggerhøj, NIM B 234 (2005) 31, Rev. Mod. Phys. 77 (2005) 1131

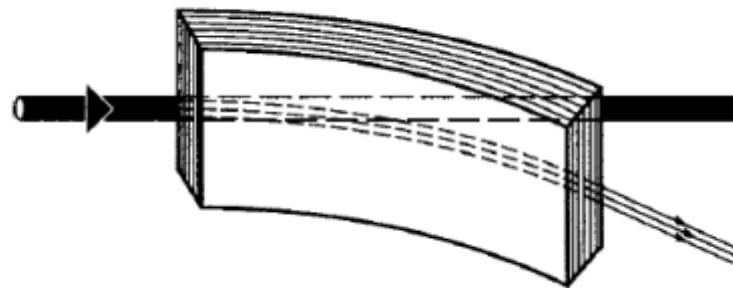
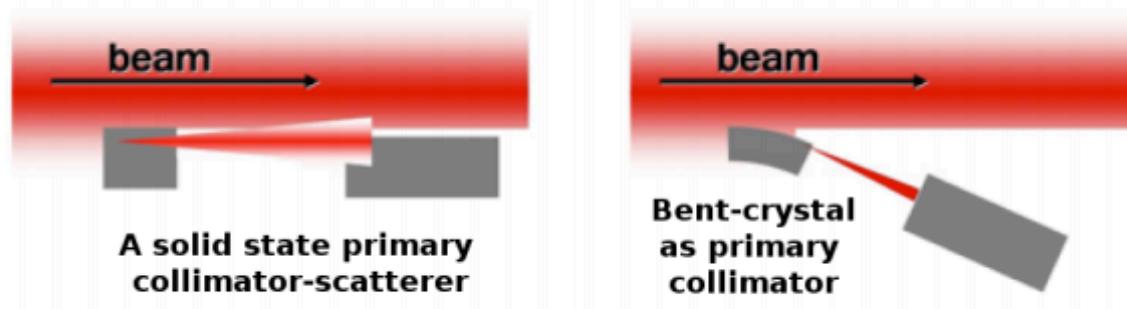


Illustration for collimation



Is being tested by LUA9 at the LHC beam

Physics opportunities

7 TeV proton beam

Target (1 cm thick)	ρ (g cm $^{-3}$)	A	\mathcal{L} ($\mu\text{b}^{-1} \text{s}^{-1}$)	$\int \mathcal{L}$ ($\text{pb}^{-1} \text{yr}^{-1}$)
solid H	0.088	1	26	260
liquid H	0.068	1	20	200
liquid D	0.16	2	24	240
Be	1.85	9	62	620
Cu	8.96	64	42	420
W	19.1	185	31	310
Pb	11.35	207	16	160

Table 1: Instantaneous and yearly luminosities obtained with an extracted beam of $5 \times 10^8 \text{ p}^+/\text{s}$ with a momentum of 7 TeV for various 1cm thick targets

Spin physics, PDF and nuclear PDF at large x_B ,
heavy quarkonium, cold nuclear matter
effects, W/Z production near threshold

2.76 TeV lead beam

Target (1 cm thick)	ρ (g cm $^{-3}$)	A	\mathcal{L} ($\text{mb}^{-1} \text{s}^{-1}$)	$\int \mathcal{L}$ ($\text{nb}^{-1} \text{yr}^{-1}$)
solid H	0.088	1	11	11
liquid H	0.068	1	8	8
liquid D	0.16	2	10	10
Be	1.85	9	25	25
Cu	8.96	64	17	17
W	19.1	185	13	13
Pb	11.35	207	7	7

Table 2: Instantaneous and yearly luminosities obtained with an extracted beam of $2 \times 10^5 \text{ Pb}/\text{s}$ with a momentum per nucleon of 2.76 TeV for various 1cm thick targets

Ultra-Peripheral Collisions,
diffractive physics, QGP studies, High-
precision heavy-quarkonium studies,
Jets

Physics opportunities

Physics Reports 522 (2013) 239–255

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Physics Reports

journal homepage: www.elsevier.com/locate/physrep



1

$\int \mathcal{L}$
 $^{-1} \text{yr}^{-1}$)

11
8
10
25
17
13
7

obtained
omentum
gets

Physics opportunities of a fixed-target experiment using LHC beams

S.J. Brodsky ^a, F. Fleuret ^b, C. Hadjidakis ^c, J.P. Lansberg ^{c,*}

Table 1:
with an
7 TeV fo

^a SLAC National Accelerator Laboratory, Stanford University, Menlo Park, CA 94025, USA

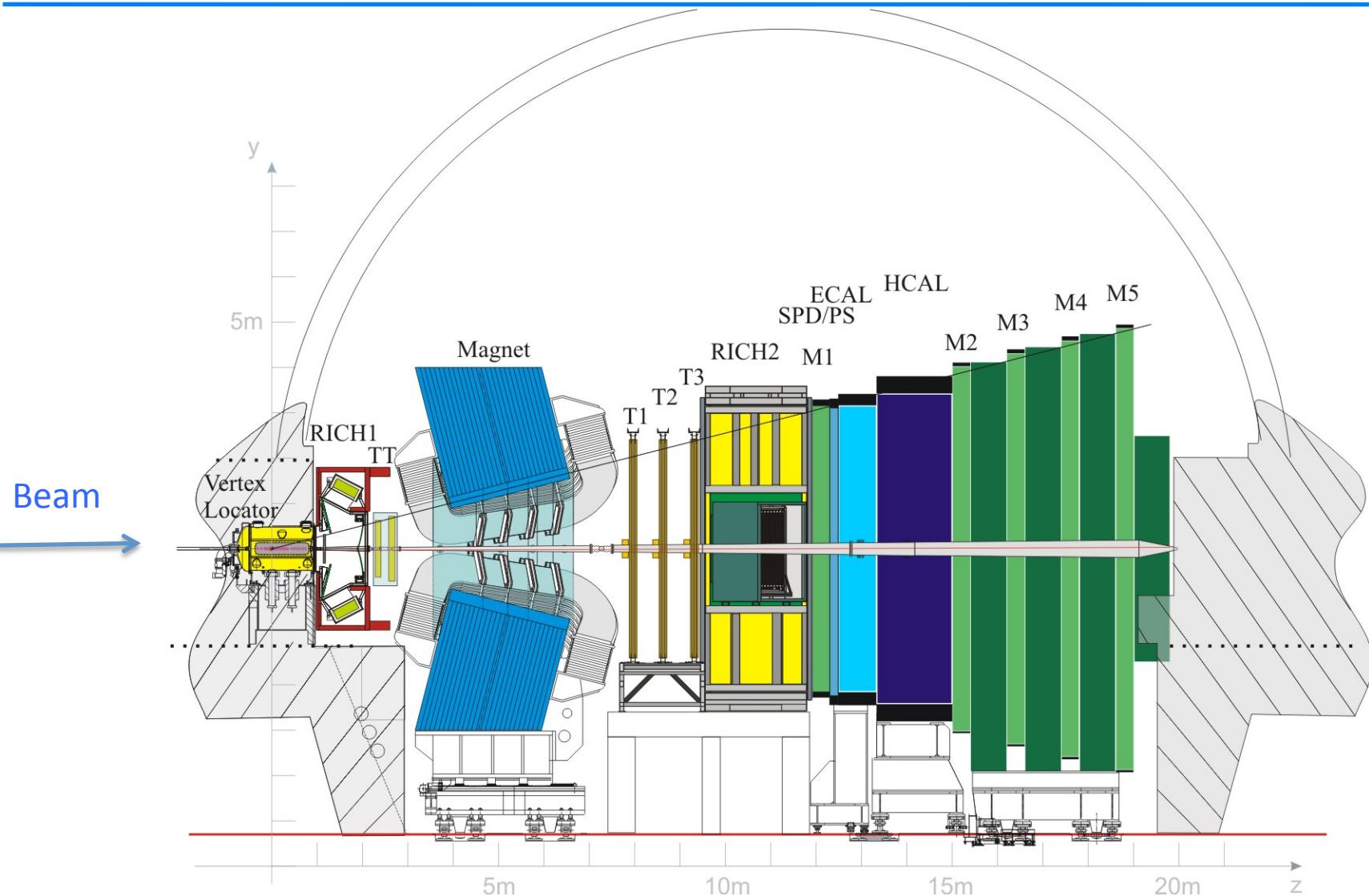
^b Laboratoire Leprince Ringuet, Ecole polytechnique, CNRS/IN2P3, 91128 Palaiseau, France

^c IPNO, Université Paris-Sud, CNRS/IN2P3, 91406 Orsay, France

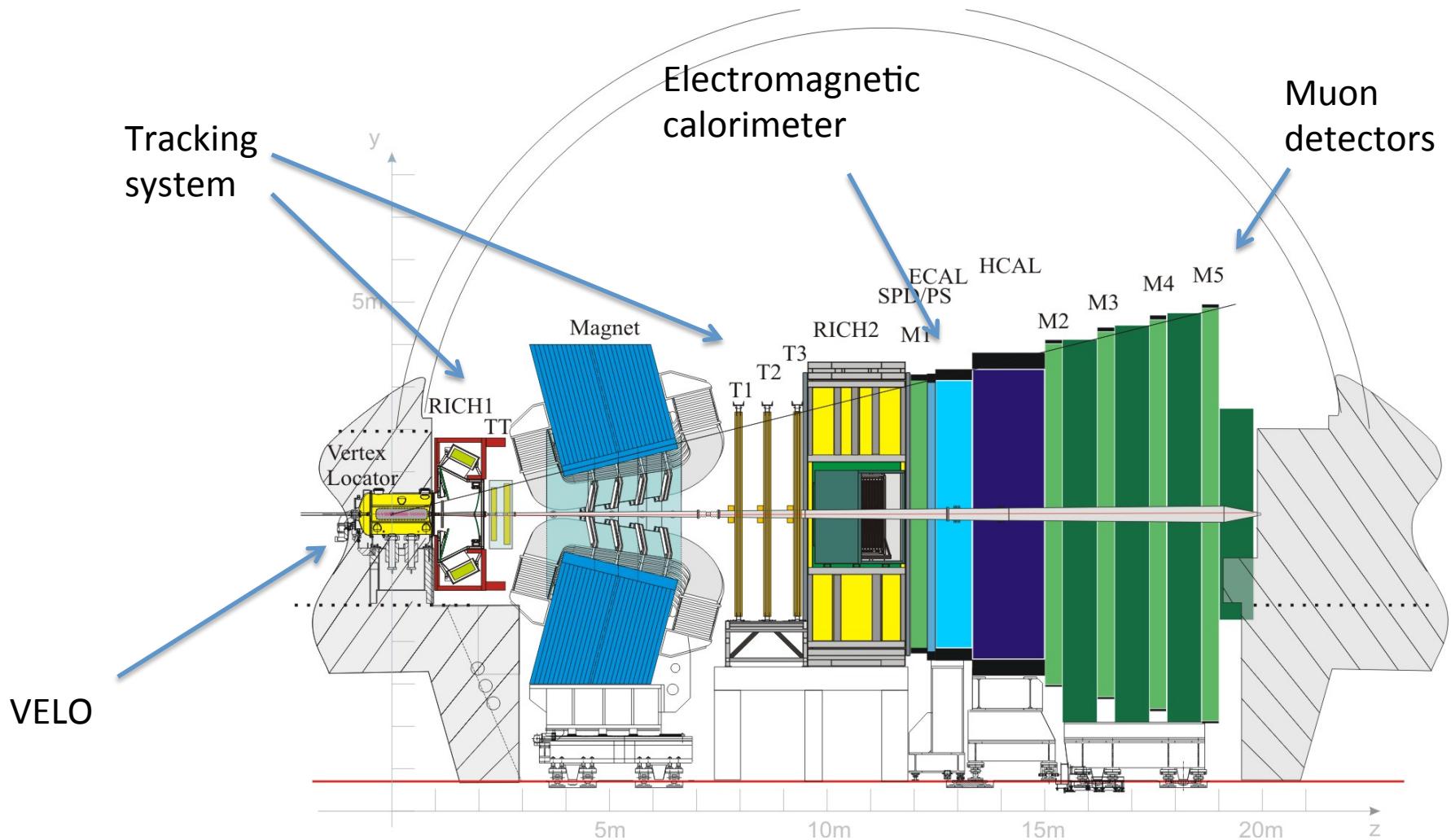
Spin physics, PDF and nPDF at large x_b
heavy quarkonium, cold nuclear matter
effects, W/Z production near threshold

UPC, diffractive physics, QGP studies,
High precision heavy quarkonium, Jets

LHCb-like detector



LHCb-like detector



Fast Simulation

p-p collisions

Detector performances
used for the fast simulation
Photon-Energy resolution:

$$\Delta E/E = 20\%/\sqrt{E}$$

Muon-momentum resolution:
 $\Delta p/p = 1\%$

Geometry:

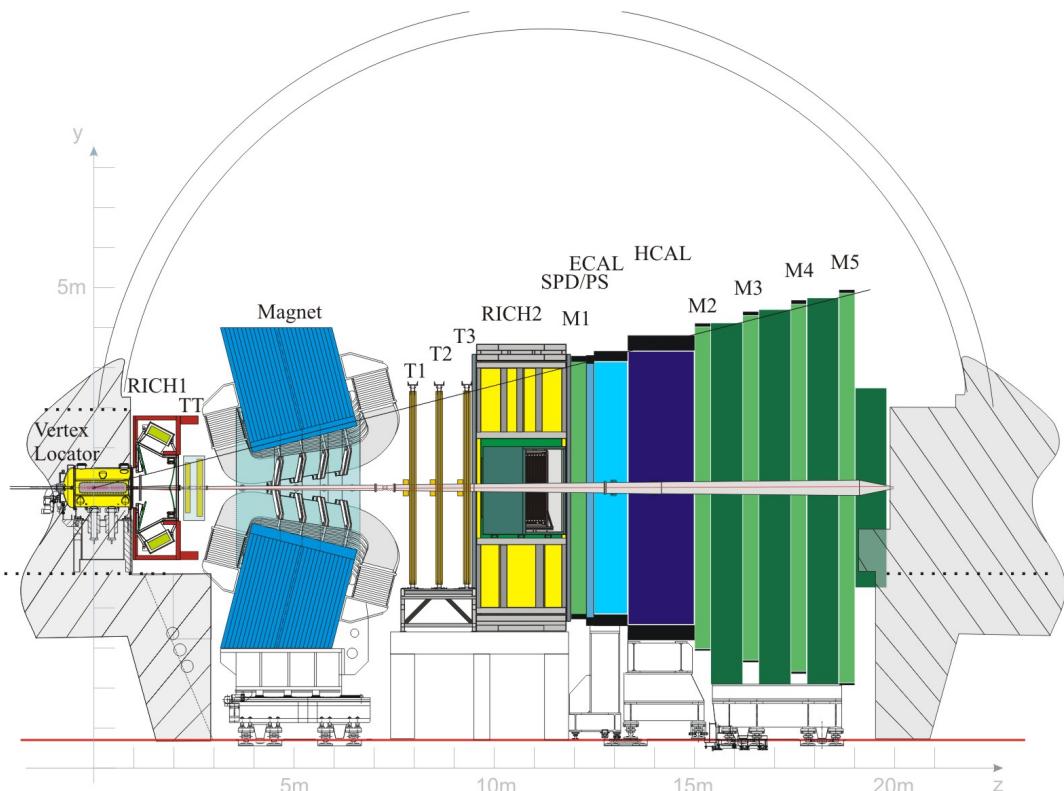
$$2 < \eta < 5$$

Analysis cuts

$$p_T^u > 1.8 \text{ GeV}/c$$

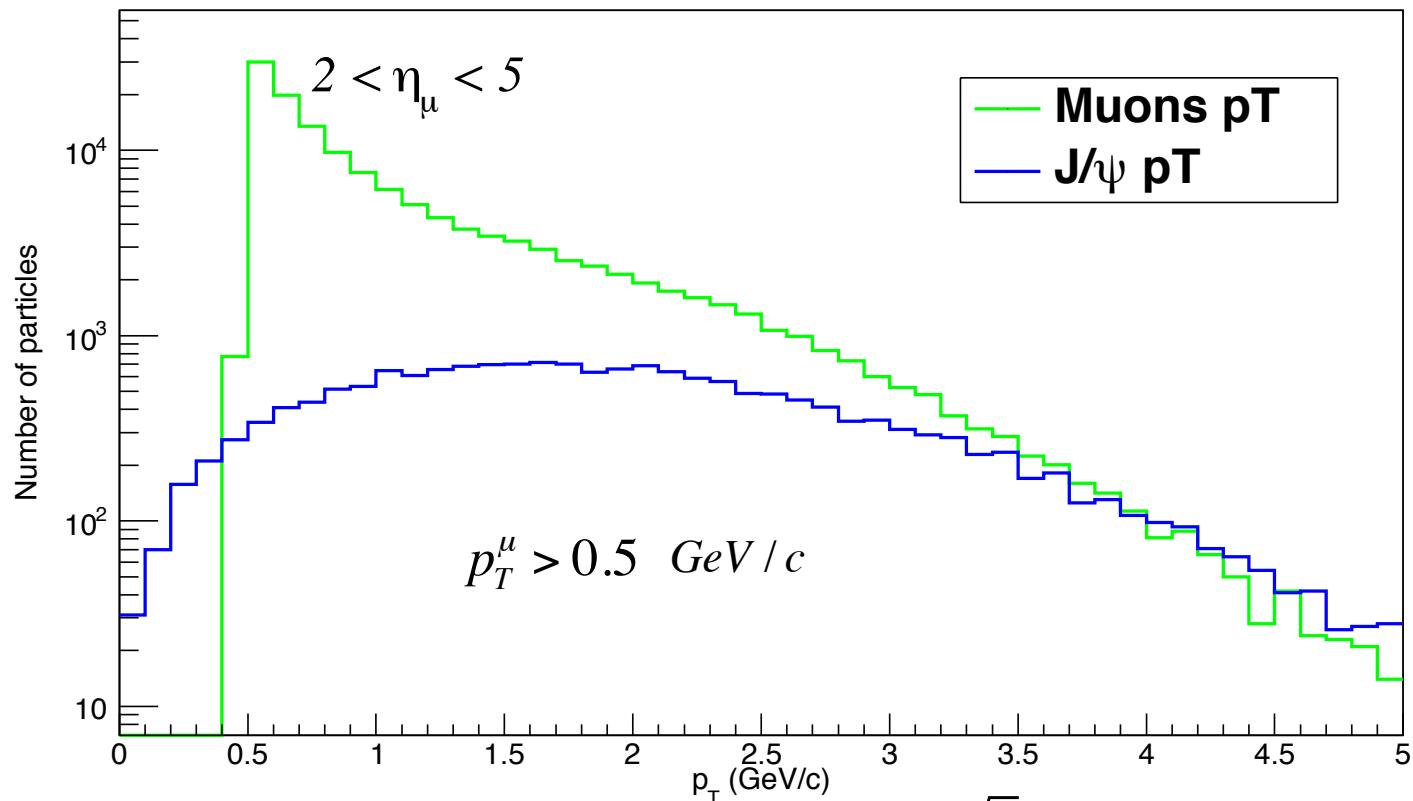
or

$$p_T^{u1} > 0.56 \text{ GeV}/c$$
$$p_T^{u2} > 0.48 \text{ GeV}/c$$



First Studies

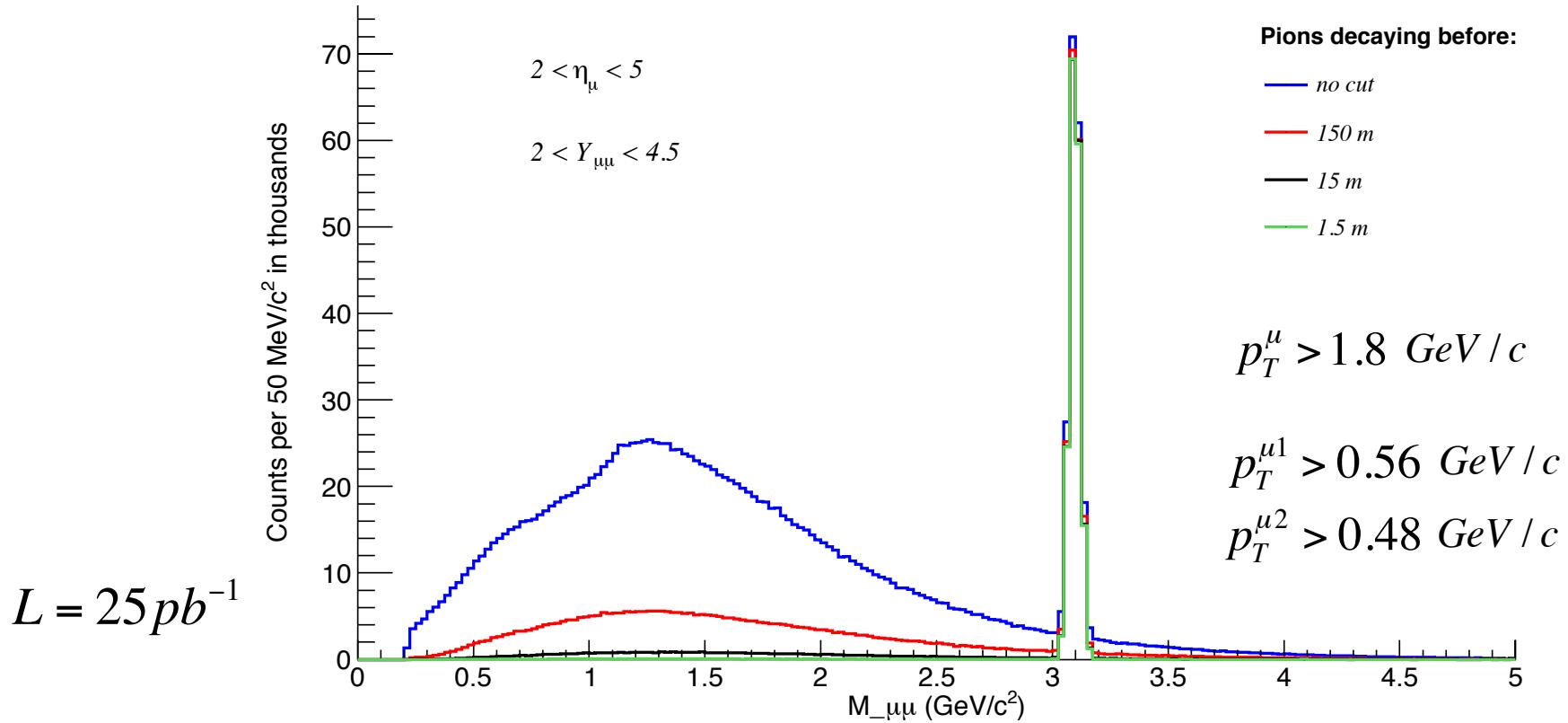
Transverse momentum of muons and J/ ψ in 50 k events



PYTHIA v. 8.183, process: Charmonium:gg2QQbar[3S(1)]g at $\sqrt{s} = 115 \text{ GeV}$
Pile-up not included

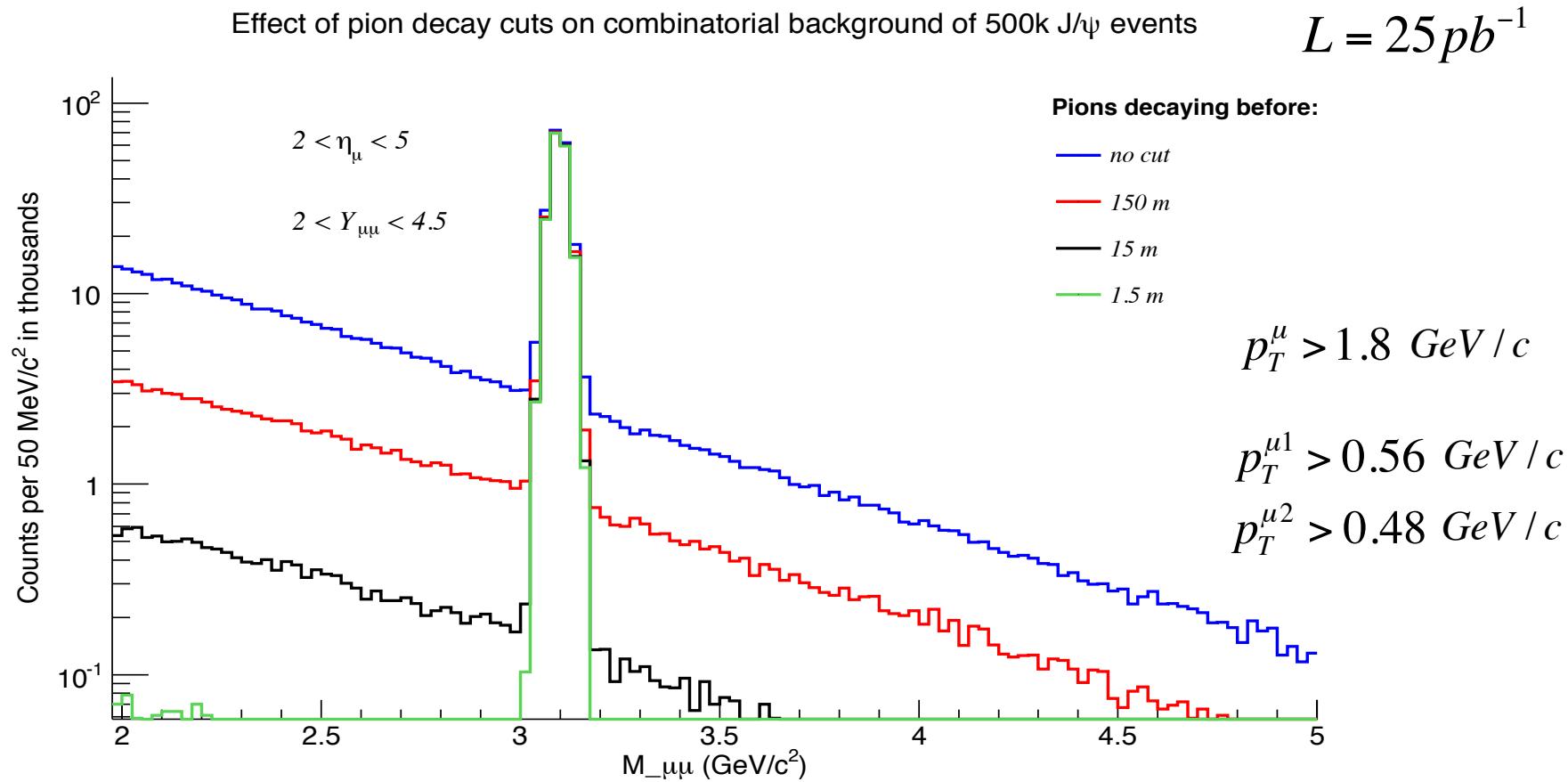
Underlying event J/ψ

Effect of pion decay cuts on combinatorial background of 500k J/ψ events



PYTHIA v. 8.183, process: Charmonium:gg2QQbar[3S(1)]g at $\sqrt{s} = 115 \text{ GeV}$
Pile-up not included

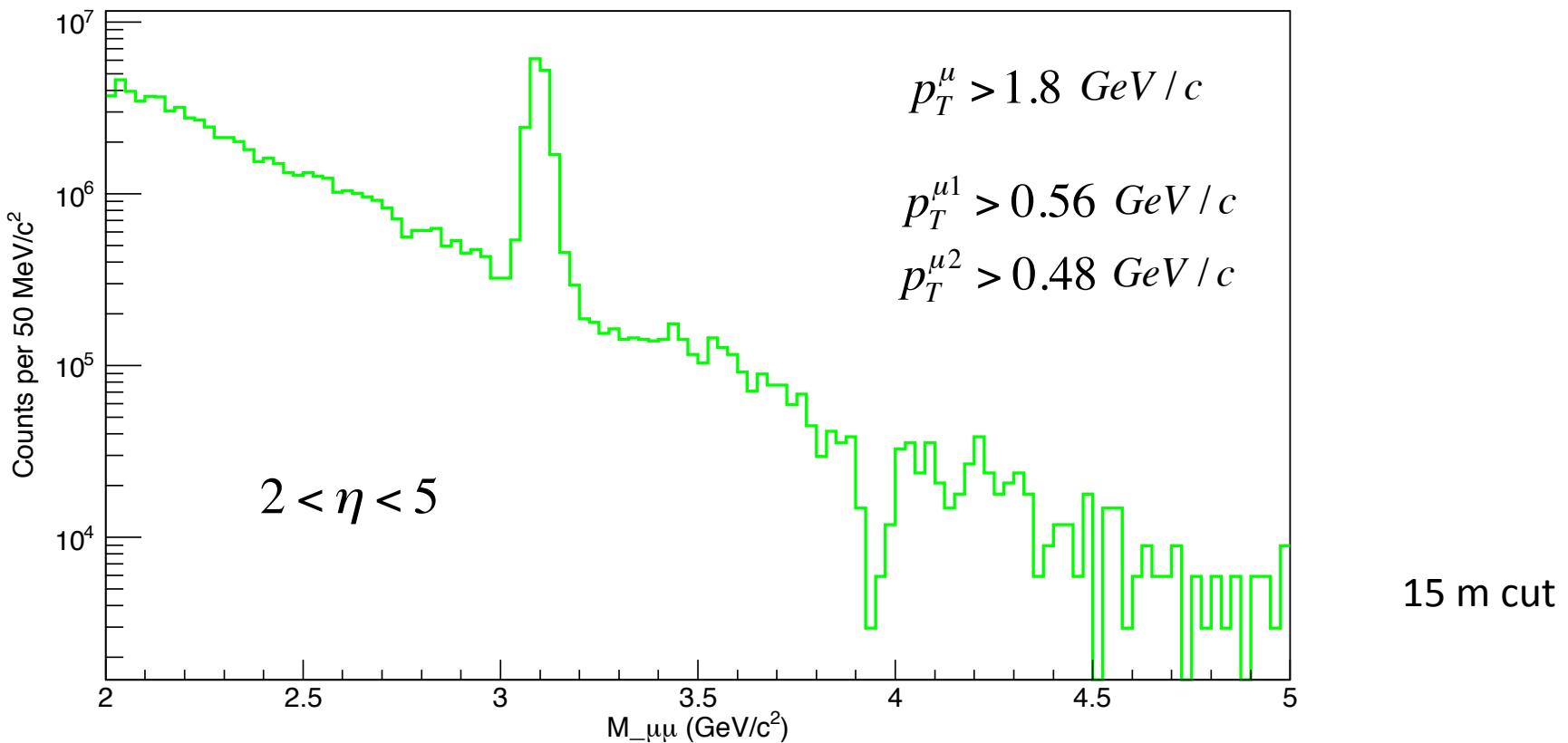
Underlying event J/ψ



A few hours of data taking with 1 m H₂ target

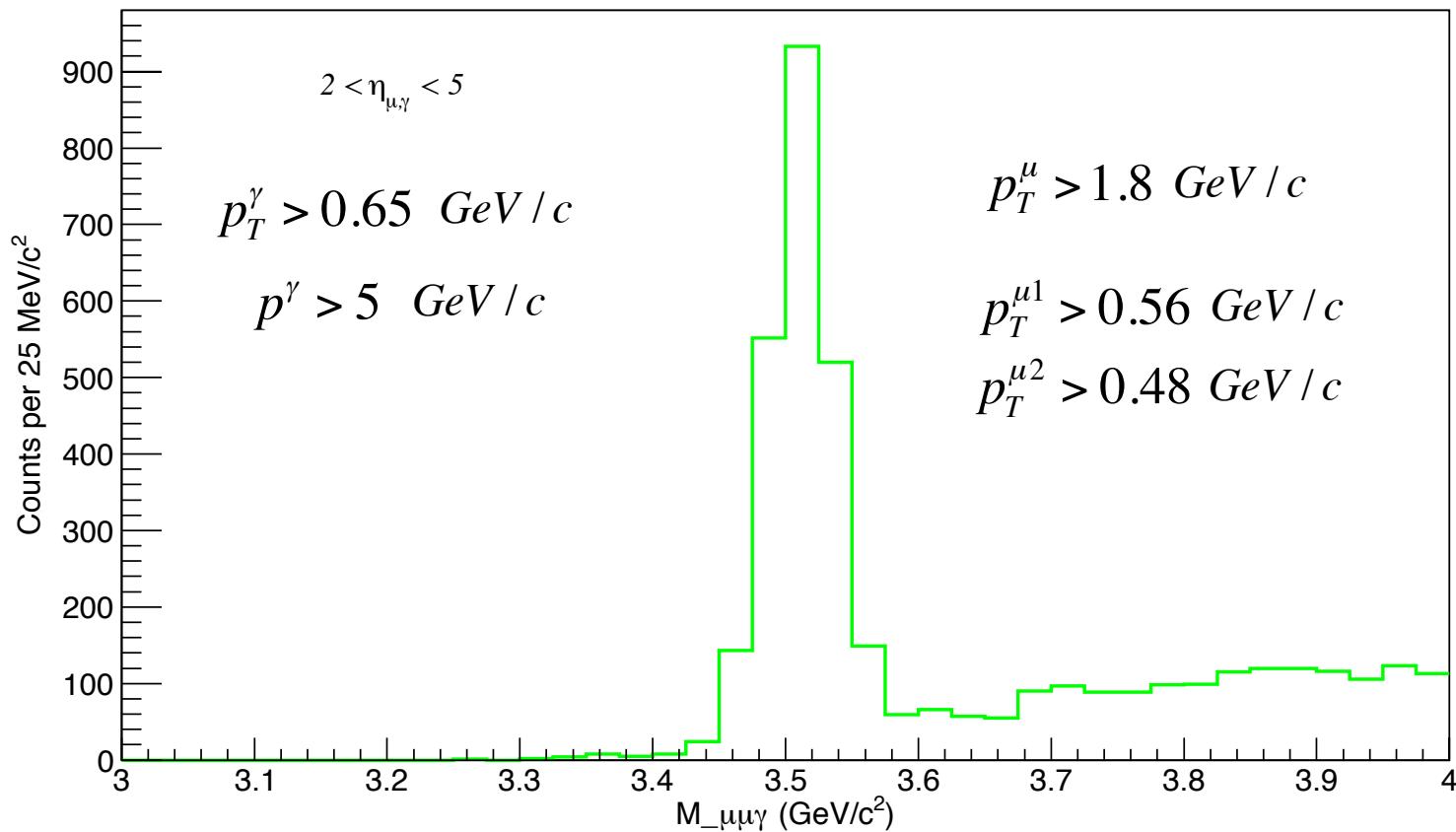
PYTHIA v. 8.183, process: Charmonium:gg2QQbar[3Si(1)]g at $\sqrt{s} = 115 \text{ GeV}$

Minimum bias



χ_{c1}

60000 χ_c events



$$\chi_c \rightarrow \gamma J/\psi \rightarrow (\gamma)\mu\mu$$

$$3.062 \text{ GeV}/c^2 < M_{\mu\mu} < 3.12 \text{ GeV}/c^2$$

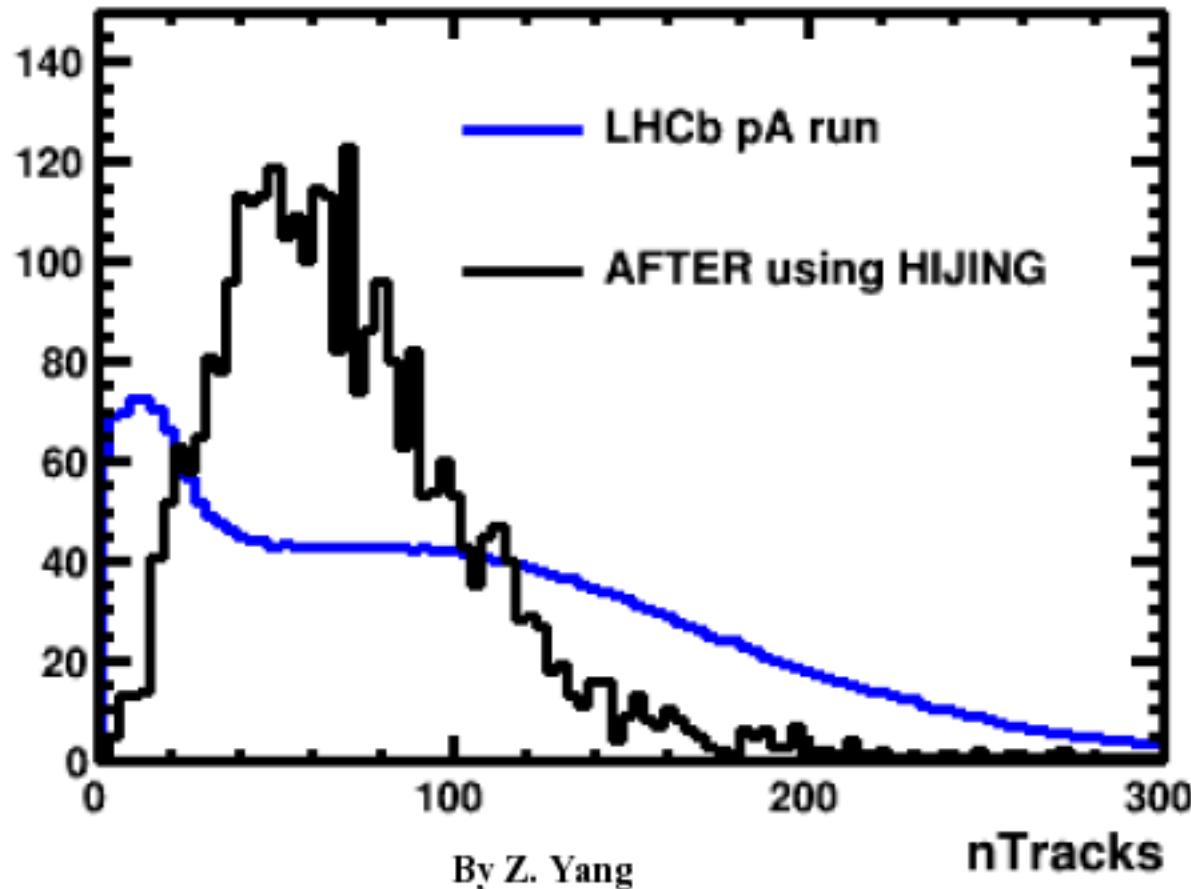
Branching ratios at 100 %

No vertex cuts

Track multiplicity

In p+A collisions with AFTER vs LHCb collider

By Z. Yang using HIJING



By Z. Yang

Proton beam on lead target. $\sqrt{s} = 115\text{GeV}$ per nucleon pair, with LHCb set-up

Conclusions

- State-of-the-art detectors should have no problem to work in the fixed-target-mode environment at the LHC
- First simulations to evaluate the performance are on-going (and very promising)
- New collaboration with Tsinghua U. both for fast simulations and for full simulations using LHCb
- Theory survey of the total J/ψ cross section from fixed-target to LHC energies with IHEP Beijing



Thanks for your attention



<http://16/16after.in2p3.fr>

M. Anselmino (Torino), R. Arnaldi (Torino), S.J. Brodsky (SLAC),
V. Chambert (IPN), J.P. Didelez (IPN), B. Genolini (IPN),
E.G. Ferreiro (USC), F. Fleuret (LLR), Y. Gao (Tsinghua), C. Hadjidakis (IPN),
J.P Lansberg (IPN), C. Lorcé (IPN), [Rune Mikkelsen \(Aarhus\)](#)
A. Rakotozafindrabe (CEA), P. Rosier (IPN), I. Schienbein (LPSC),
B. E. Scomparin (Torino), U.I. Uggerhøj (Aarhus), R. Ullrich (KIT) Z. Yang
(Tsinghua)...