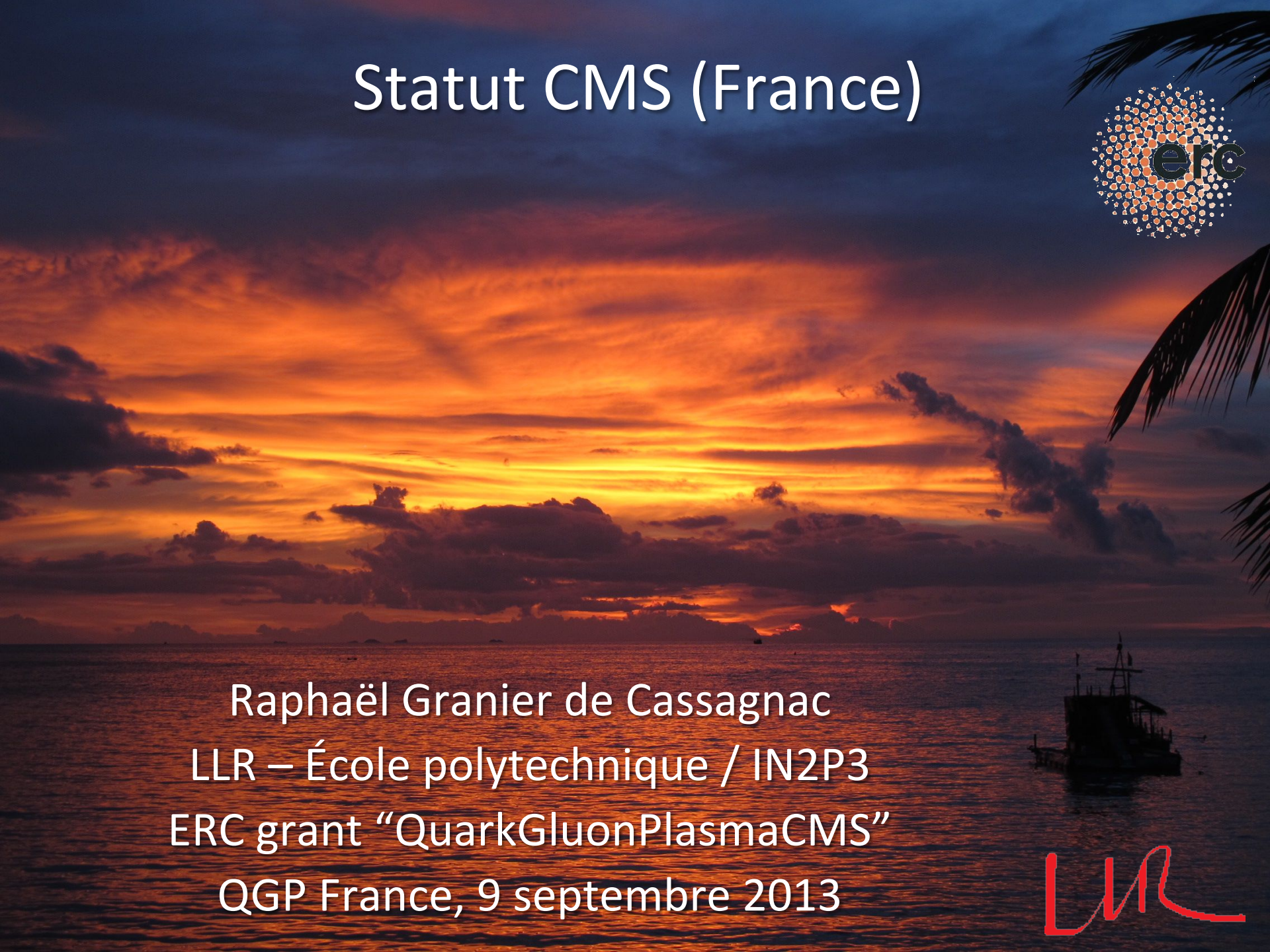
Statut CMS (France)



Raphaël Granier de Cassagnac
LLR – École polytechnique / IN2P3
ERC grant “QuarkGluonPlasmaCMS”
QGP France, 9 septembre 2013

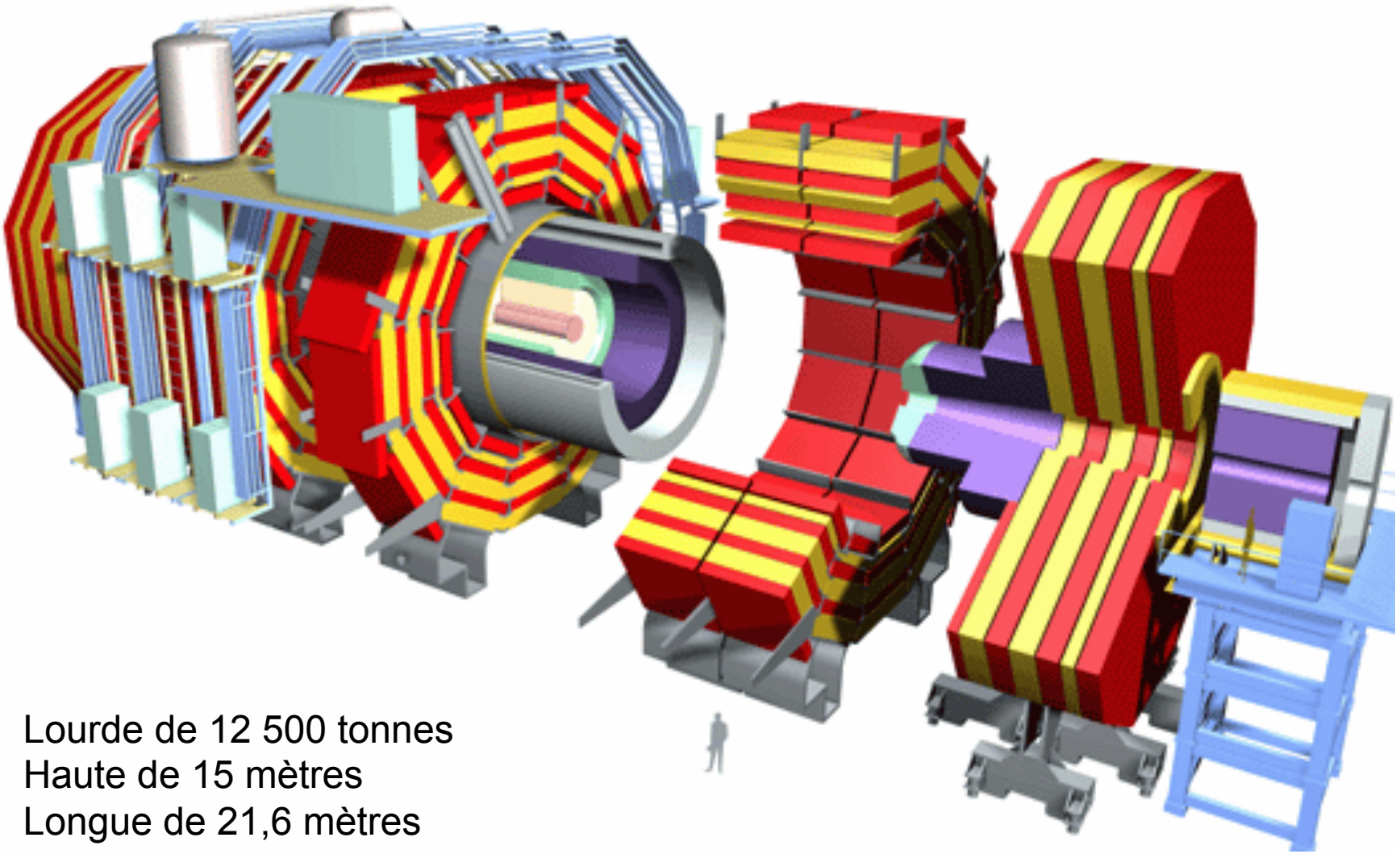
Project overview (in France)

Some (non French) Physics

What's next (in France)

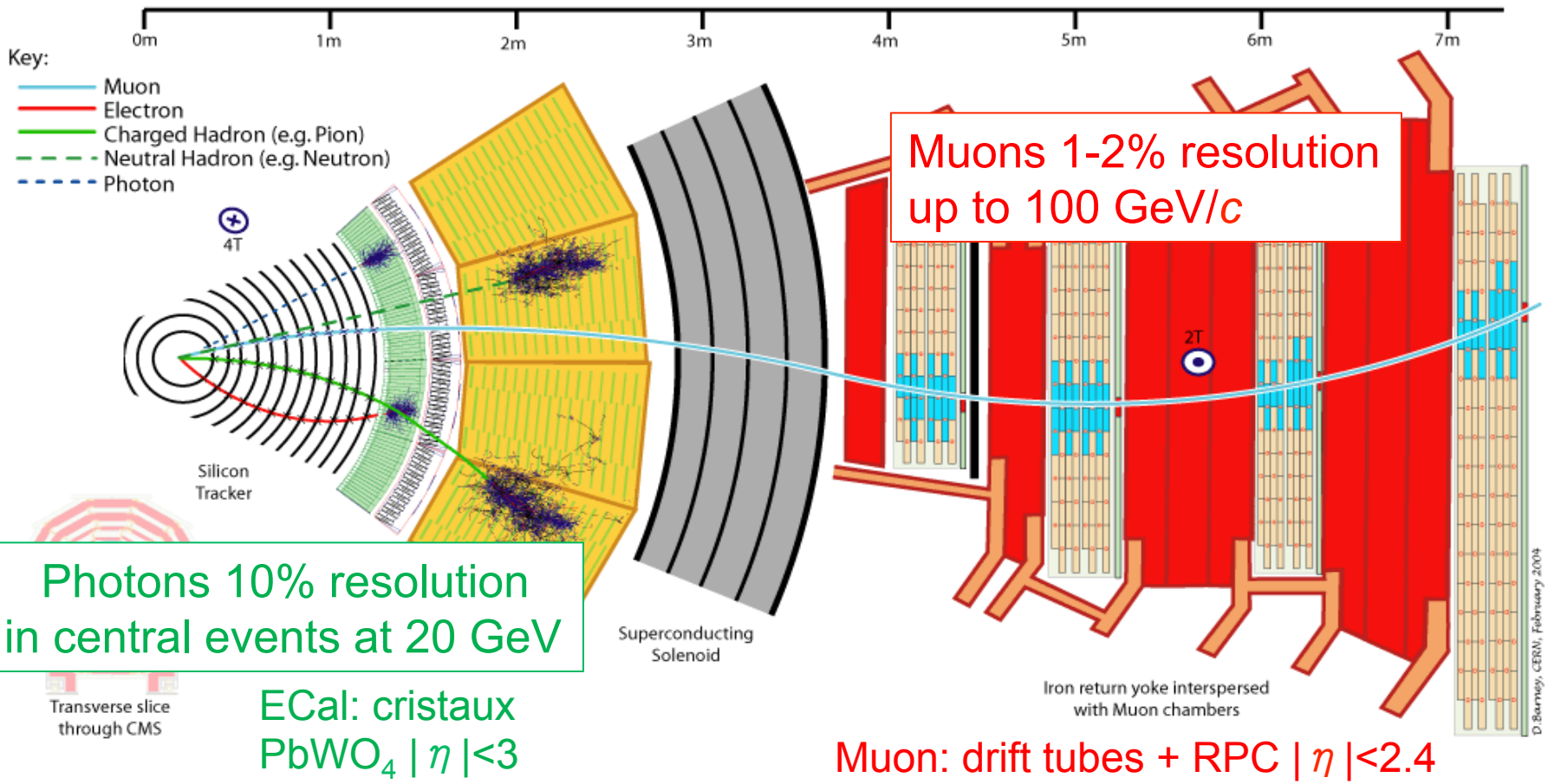
PROJECT OVERVIEW (IN FRANCE)

Compact Muon Solenoid



Lourde de 12 500 tonnes
Haute de 15 mètres
Longue de 21,6 mètres

Détection des particules |η|<2.4



Muons 1-2% resolution up to 100 GeV/*c*

Photons 10% resolution in central events at 20 GeV

ECal: cristaux $PbWO_4$ | η |<3

Muon: drift tubes + RPC | η |<2.4

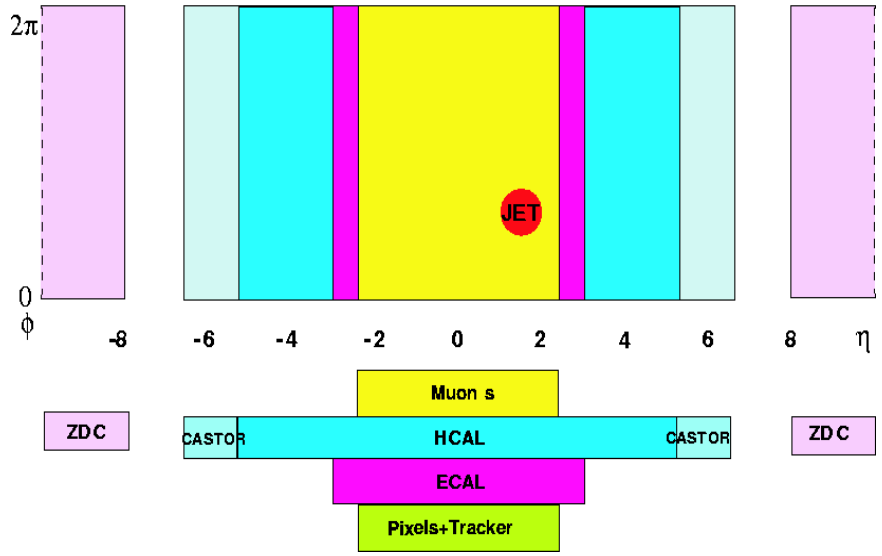
Silicium: pixels (3) and strips (10) | η |<2.4

HCal: Scintillateurs | η |<5

+ Extensions à grand angle

Quelques caractéristiques techniques

1. Large couverture angulaire

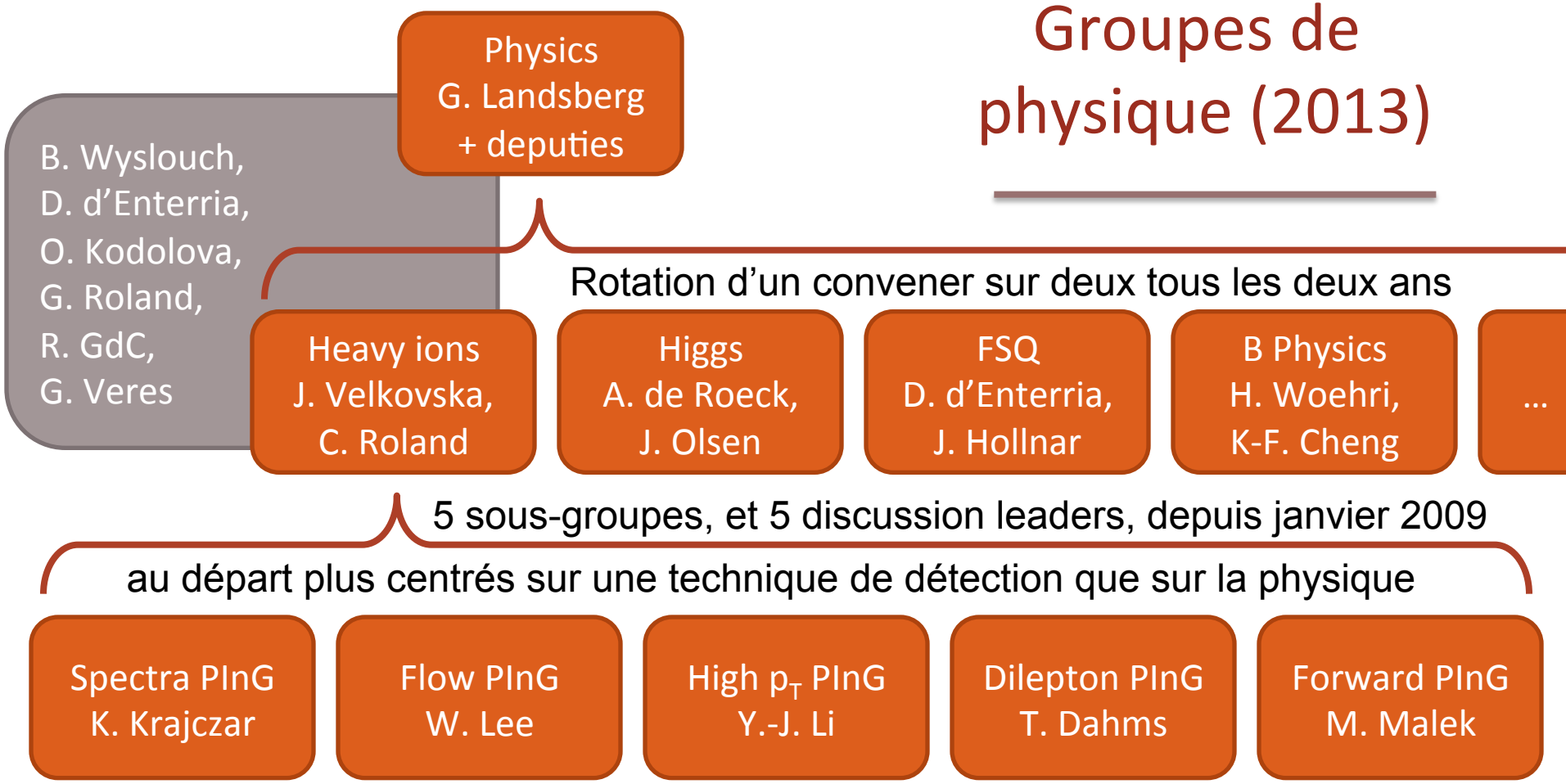


2. Stratégie initiale de déclenchement
   - Niveau 1 = toutes les collisions Pb-Pb (≈5 kHz)
   - Trigger de haut niveau (HLT) → 10 à 100 Hz

3. Champ magnétique de 3.8 Tesla

→ Grande acceptance, particulièrement à grand $p_{(T)}$

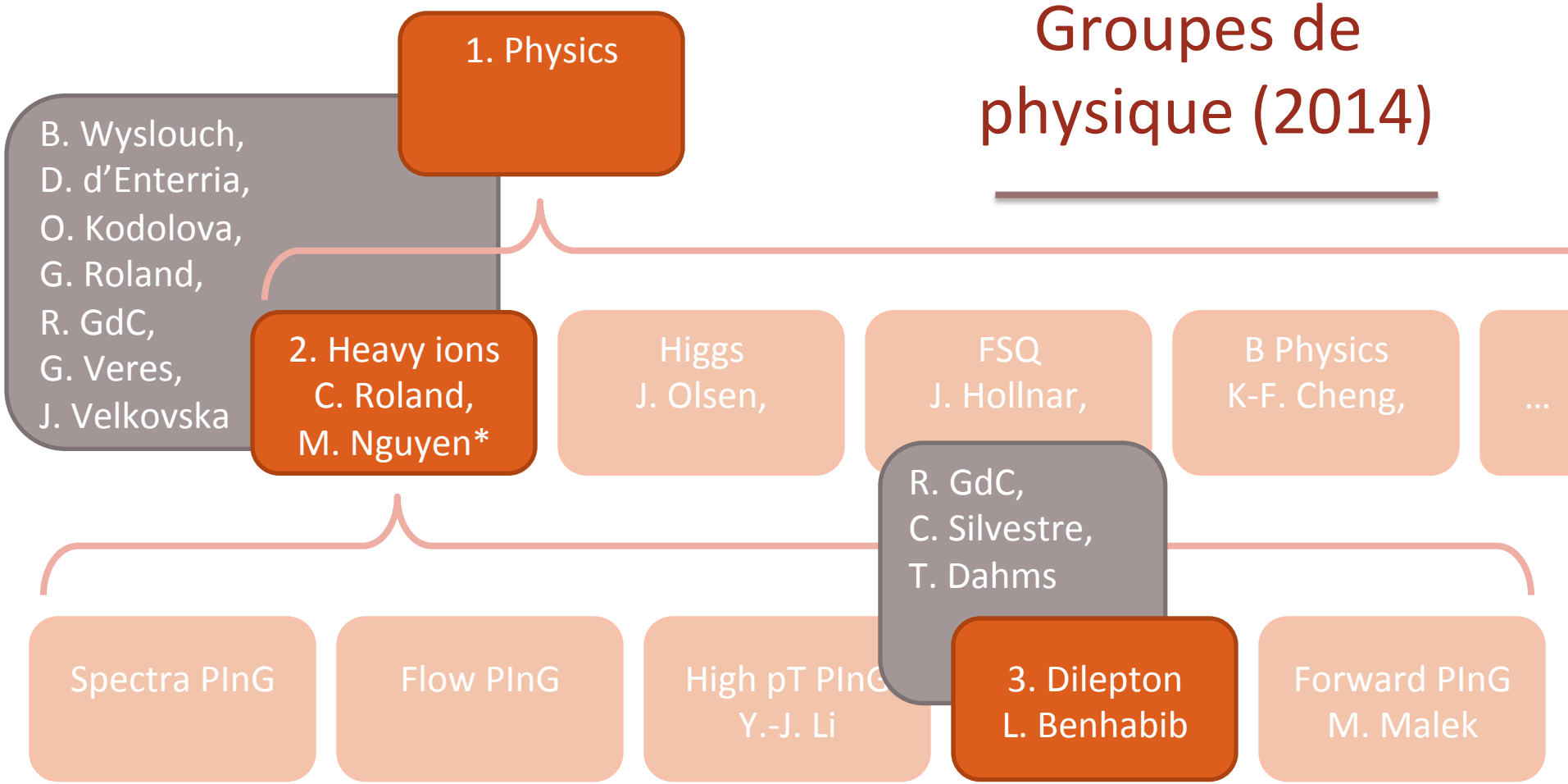
Groupes de physique (2013)



≈ 100 physiciens, 30-50 très actifs, 20 au CERN

- Concentrés sur les ions lourds (mesures p+p conduites dans les autres groupes, à part 2.76 TeV)
- Aspects techniques à assumer également (triggers, DAQ…)

Groupes de physique (2014)



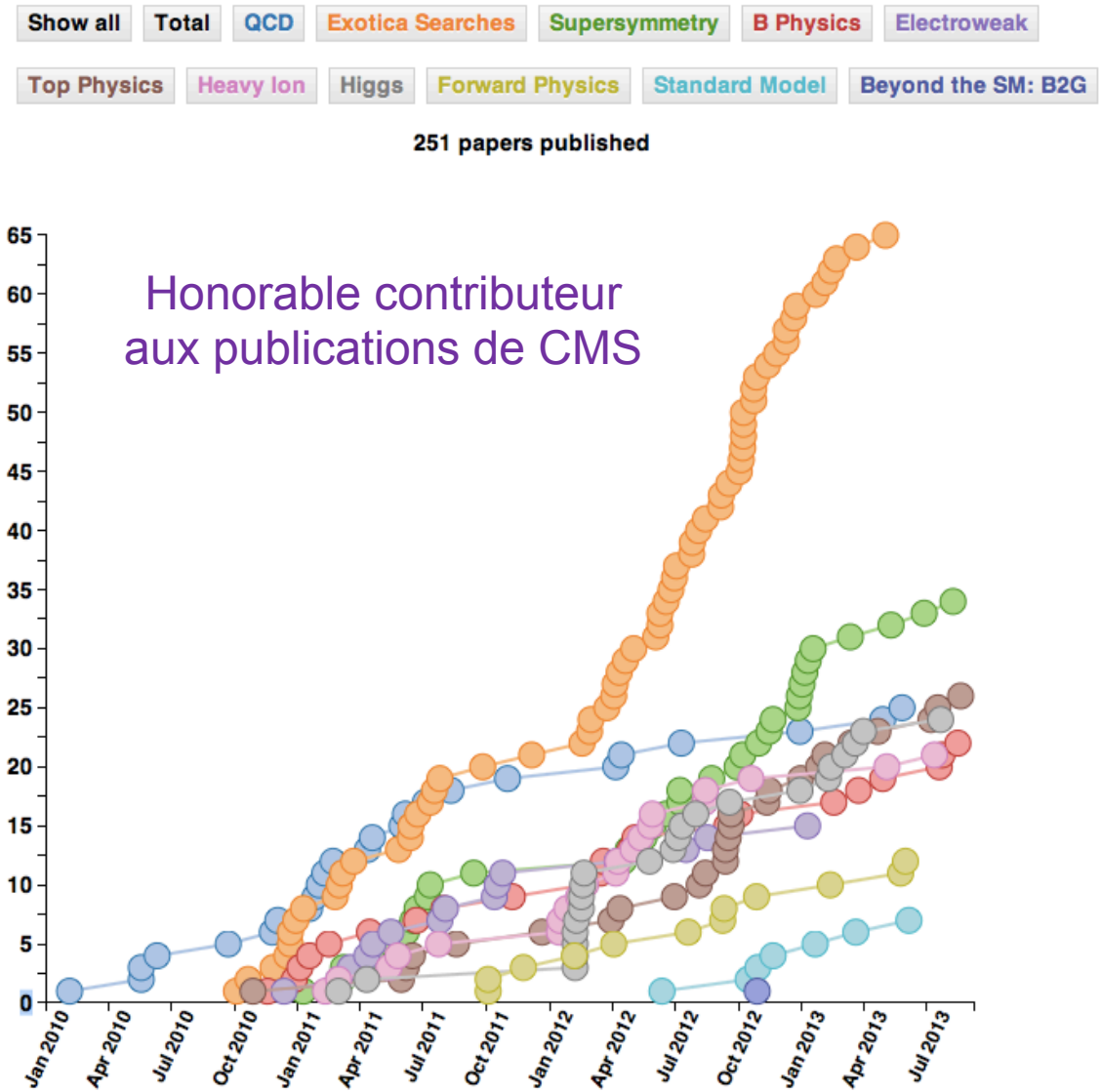
- Niveau 2 : Matt, seul à avoir accepté la nomination est très probablement le futur convener
- Niveau 3 : l'activité dilepton (quarkonia et bosons electrofaibles) dirigée par des « français » (et actuellement faible!)

En France, on tient encore sur une page

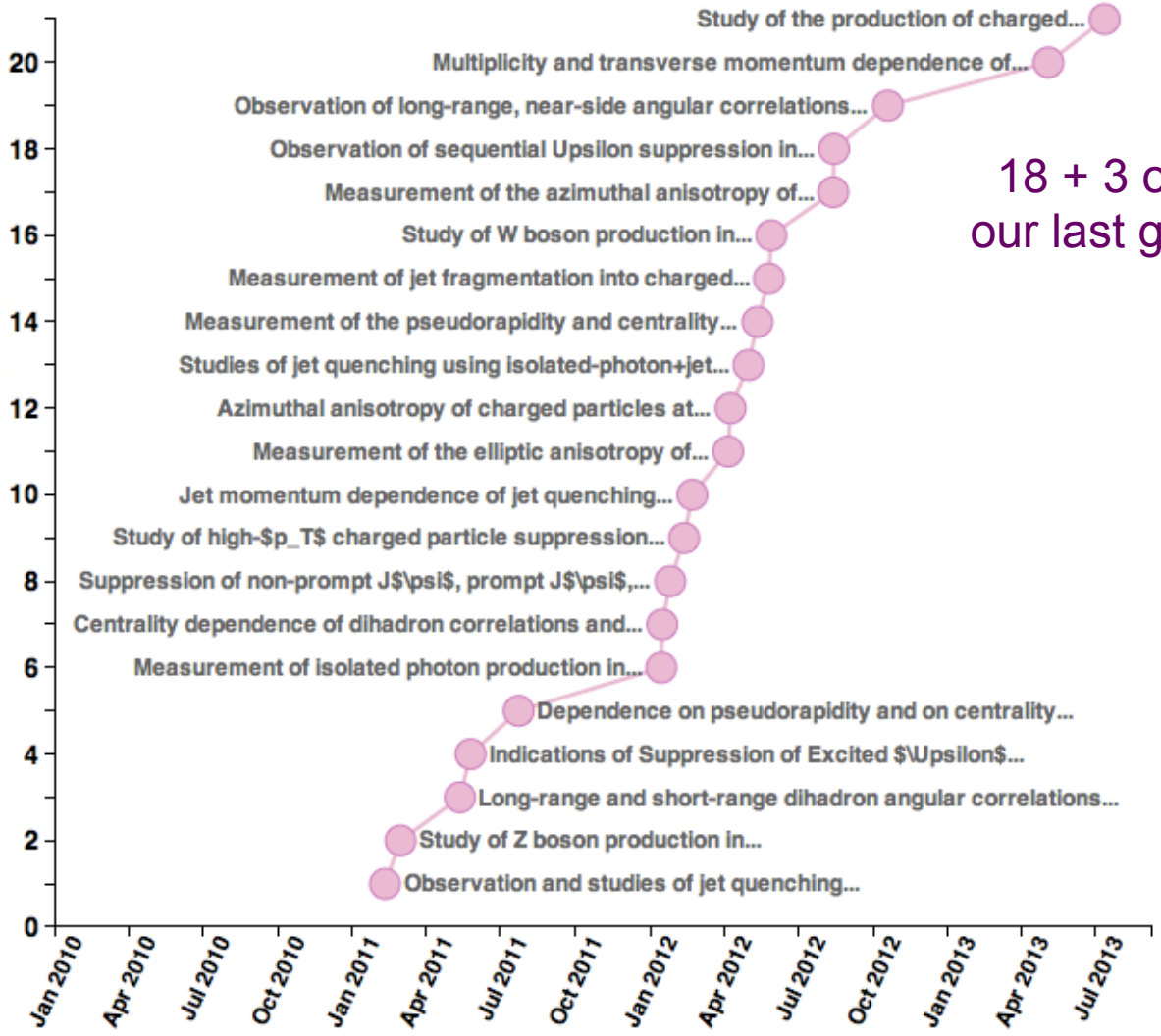
- Early contributions from Marc Bedjidian (IPNL) ;
- LLR group (2 staff + 3 postdocs + 3 PhD students as of today)
  - Raphaël GdC (since March 2009, approximately)
  - Lamia Benhabib (postdoc CNRS, 3+0.5 years, since Dec. 2009)
  - Sarah Porteboeuf (postdoc ReteQuarkonii, one year)
  - Camelia Mironov (postdoc Marie Curie, 2+1.5 years, since June 2010)
  - Bolek Wyslouch (MIT professor on 1-year sabbatical at Polytechnique)
  - Torsten Dahms (postdoc ERC, 3 years, since Nov. 2010)
  - Alice Florent (thésarde ERC, 3 years, since Sep. 2011)
  - Matthew Nguyen (CR2 + Marie Curie, since Oct. 2011)
  - Nicolas Filipovic (thésard ERC, 3 ans, since Oct. 2012)
  - François Arleo (théoricien associé)
  - Yetkin Yilmaz (postdoc ANR, since May 2013)
  - Émilien Chapon (postdoc ERC, since Sep. 2013)
  - Stanislav Lisniak (thésard, since Sep. 2013)
  - 10+ stagiaires (2 NPAC, 4 X, MIT, Ukraine, Inde, Centrale…).

(to a large extend funded by the European Community)

Publications par PAG



HIN publication timeline



18 + 3 only, since our last gathering ☹

21 papers with Pb ions

** "French" contact or author
* Or significant contribution

1.	HIN-10-004 (dijet inbalance):	PRC 84 (2011) 024906	[222 cites] (**)
2.	HIN-10-006 (quarkonia):	JHEP 05 (2012) 063	[99 cites] **
3.	HIN-11-007 (YNs/Y1s ratio):	PRL 107 (2011) 052302	[95 cites] **
4.	HIN-10-005 (R_{AA}):	EPJC 72 (2012) 1945	[82 cites]
5.	HIN-11-006 (correlations):	EPJC 72 (2012) 2012	[55 cites]
6.	HIN-10-001 ($dN_{ch}/d\eta$):	JHEP 08 (2011) 141	[50 cites]
7.	HIN-11-013 (dijets):	PLB 712 (2012) 176	[48 cites] (**)
8.	HIN-10-003 (Z):	PRL 106 (2011) 212301	[45 cites] **
9.	HIN-11-001 (correlations):	JHEP 07 (2011) 076	[44 cites]
10.	HIN-12-015 (pPb ridge):	PLB 718 (2013) 795	[43 cites]
11.	HIN-11-010 (γ-jet):	PLB 718 (2013) 773	[42 cites]
12.	HIN-10-002 (v_2 flow):	PRC 87 (2013) 014902	[40 cites]
13.	HIN-11-011 (Υ):	PRL 109 (2012) 222301	[37 cites] *
14.	HIN-11-002 (photons):	PLB 710 (2012) 256	[36 cites] *
15.	HIN-11-012 (high p_T v_2):	PRL 109 (2012) 022301	[34 cites]
16.	HIN-11-004 (jet FF):	JHEP 10 (2012) 087	[28 cites]
17.	HIN-11-008 (W):	PLB 715 (2012) 66	[18 cites] *
18.	HIN-11-003 ($dE_T/d\eta$):	PRL 109 (2012) 152303	[13 cites]
19.	HIN-13-002 (pPb flow):	PLB 724 (2013) 213	[9 cites]
20.	HIN-11-009 (π^0 v_2):	PRL 110 (2013) 042301	[6 cites]
21.	HIN-12-016 (pPb PID):	Submitted to EPJC	[4 cites]

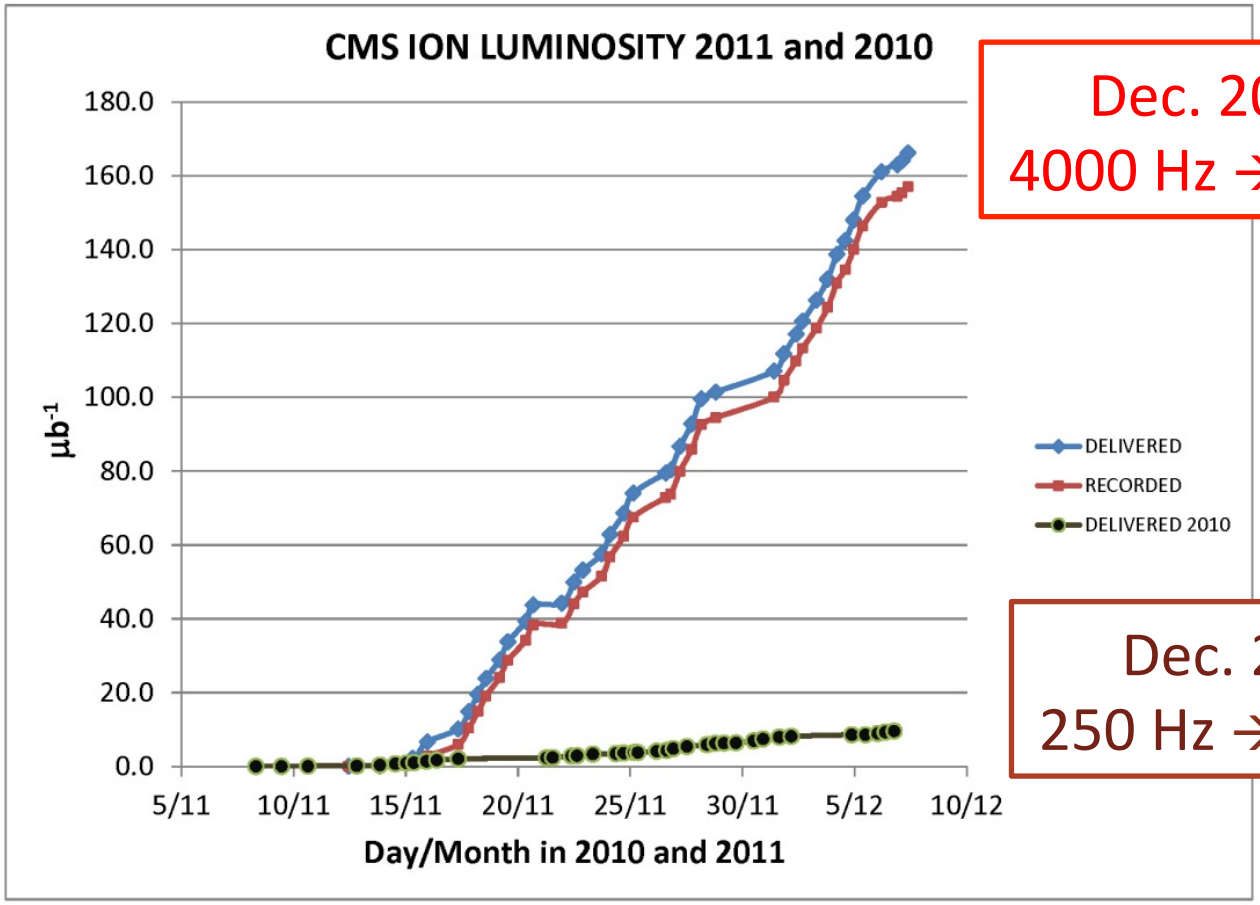
+13 documented preliminary results

- HIN-11-005 (v_n flow)
- HIN-12-003 (b-jets) **
- HIN-12-004 (jet R_{AA})
- HIN-12-006 (CASTOR energy flow)
- HIN-12-007 (Ψ(2S)) **
- HIN-12-008 (Z in 2011) **
- → HIN-13-004 (Z in 2011 + pp 2013) ** (see Lamia)
- HIN-12-010 (high-p_T dihadron corr)
- HIN-12-011 (UCC flow)
- HIN-12-013 (jet fragmentation)
- HIN-12-014 (J/Ψ with 2011 data) **
- HIN-13-001 (dijets in pPb) (*) (see Yetkin)
- HIN-13-003 (Y in pPb) ** (see Nicolas)

** "French" contact or author
* Or significant contribution

Follow us on https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsHIN

PbPb luminosities



Dec. 2011 ≈ 150 μb^{-1} PbPb
4000 Hz → 2700 (L1) → 200 (HLT)

x 20

Dec. 2010 ≈ 7 μb^{-1} PbPb
250 Hz → 150 (L1) → 120 (HLT)

Binary-scaled equivalent
→ as many Z, W, photons…

+ Mar. 2011 ≈ 230 nb^{-1} pp at 2.76 TeV

pp, pPb and PbPb luminosities

- Five runs:
  - Dec. 2010: PbPb, 2.76 TeV, 7 μb^{-1}
  - Dec. 2011: PbPb, 2.76 TeV, 150 μb^{-1}
  - Mar. 2011: pp, 2.76 TeV, 230 nb^{-1}
  - Jan. 2013: pPb, 5.02 TeV, 31 nb^{-1}
  - Fev. 2013: pp, 2.76 TeV, 5.4 pb^{-1}

All PbPb preliminary results being updated with new pp reference // pPb analyses

- Three systems now have equivalent N_{coll} scaled luminosities
  - (as many Z's and W's, modulo the $\sqrt{s}$ dependence)
- Somewhat lacking a 5.02 TeV pp reference

System	xsection (b)	Av. Ncoll	Lumi (inv. b)	Events
PbPb	7,650	360	1,50E+08	1,15E+09
pp	0,065	1	6,36E+12	4,13E+11
pPb	2,000	6,8	3,04E+10	6,08E+10

SOME (NON-FRENCH) PHYSICS

Où voir les résultats de CMS?

- Dans d'autres talks
  - Matt → Revue jets
  - Yetkin → CMS dijets in pPb
  - Lamia → Revue électrofaible
  - Alice → CMS W's
  - Philippe → Revue quarkonia
  - Nicolas → CMS Upsilon in pp, pPb and PbPb (new)
  - Anton → Revue pPb
- Maintenant
  - Le ridge en pp, pPb et PbPb
  - PId in pPb

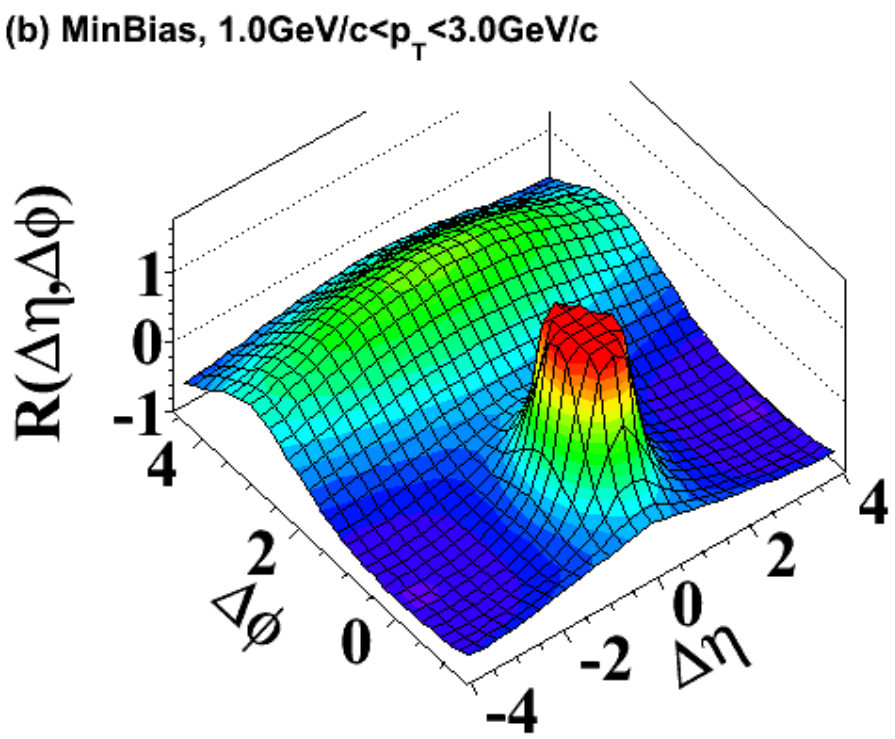
  } Les trois nouveaux papiers

  + Point sur le futur en France
  (jets, electroweak et quarkonia)

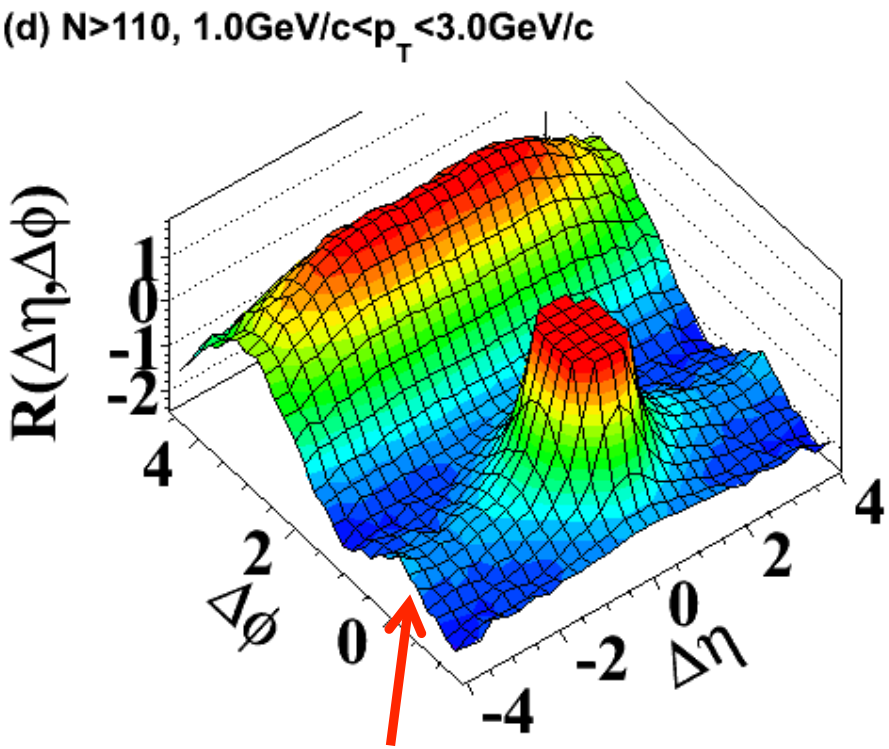
Reminder: Ridge en pp

JHEP09(2010)091

Minimum bias



High multiplicity (N>110)

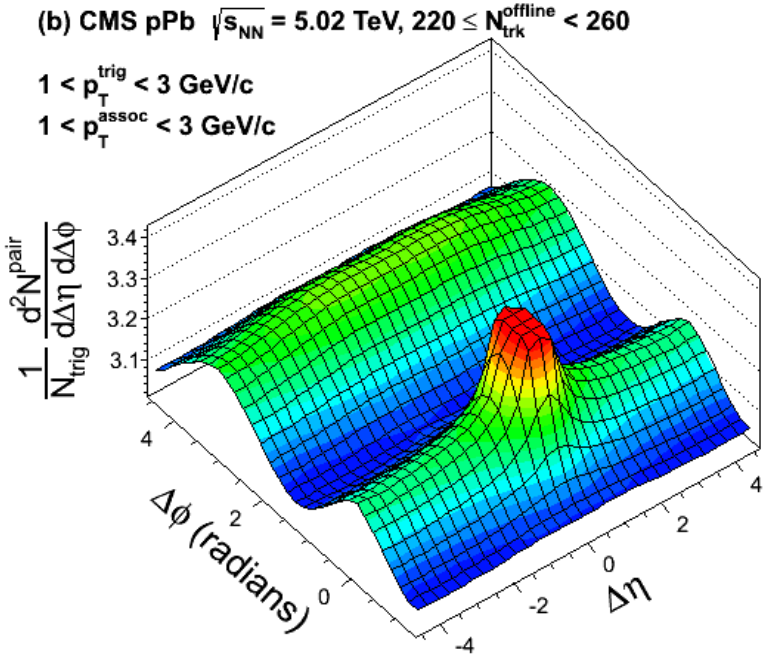


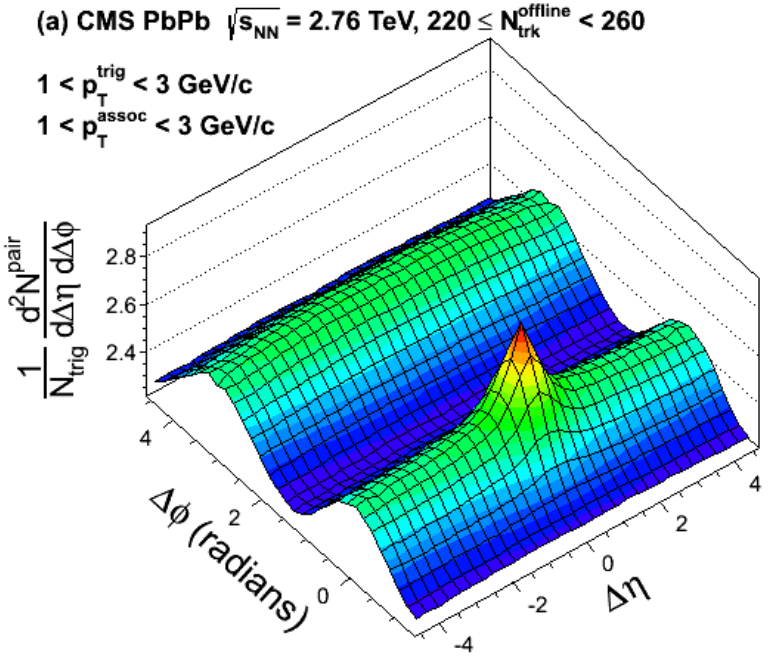
A new structure at $\Delta\phi \approx 0$ and large $\Delta\eta$

a "ridge" reminiscent of AA collisions @ RHIC…

Le ridge en pPb

pPb pilot: PLB718 (2013) 795
pPb 2013: PLB724 (2013) 213





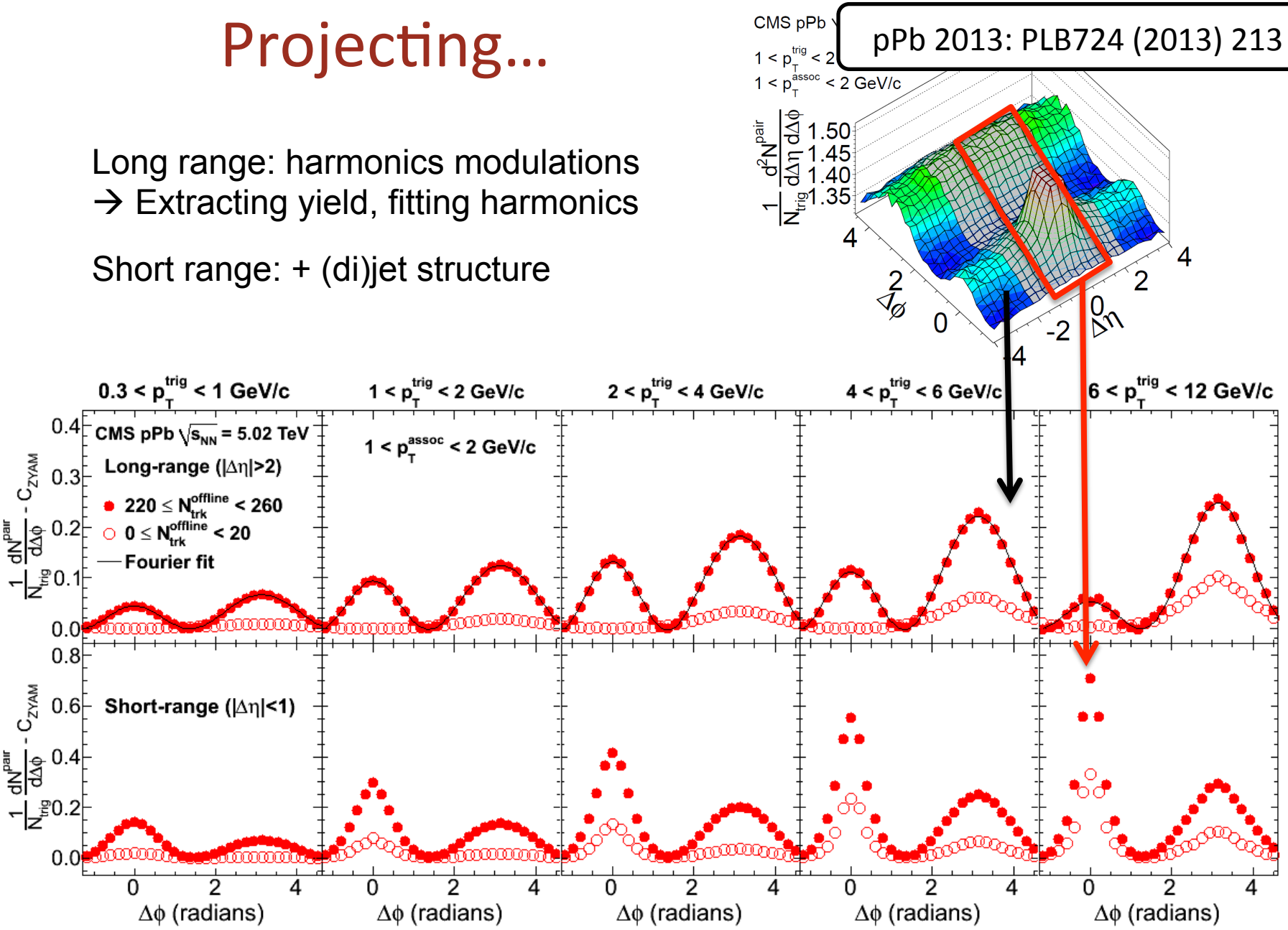
- The ridge is of course seen again in pPb collisions
- Enough statistic to look at same multiplicities in PbPb and pPb
  - e.g. 280 reco. tracks in both PbPb (55-60%) and pPb (0-0.0003%)
  - (at least in the soft regime, much less for rare hard probes)

Projecting…

pPb 2013: PLB724 (2013) 213

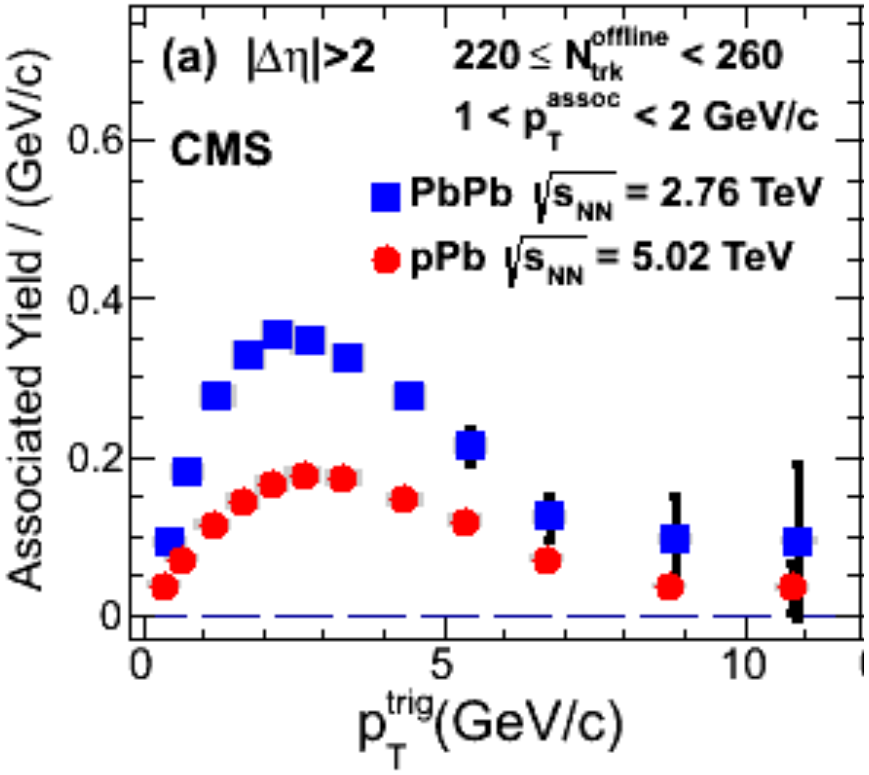
Long range: harmonics modulations
→ Extracting yield, fitting harmonics

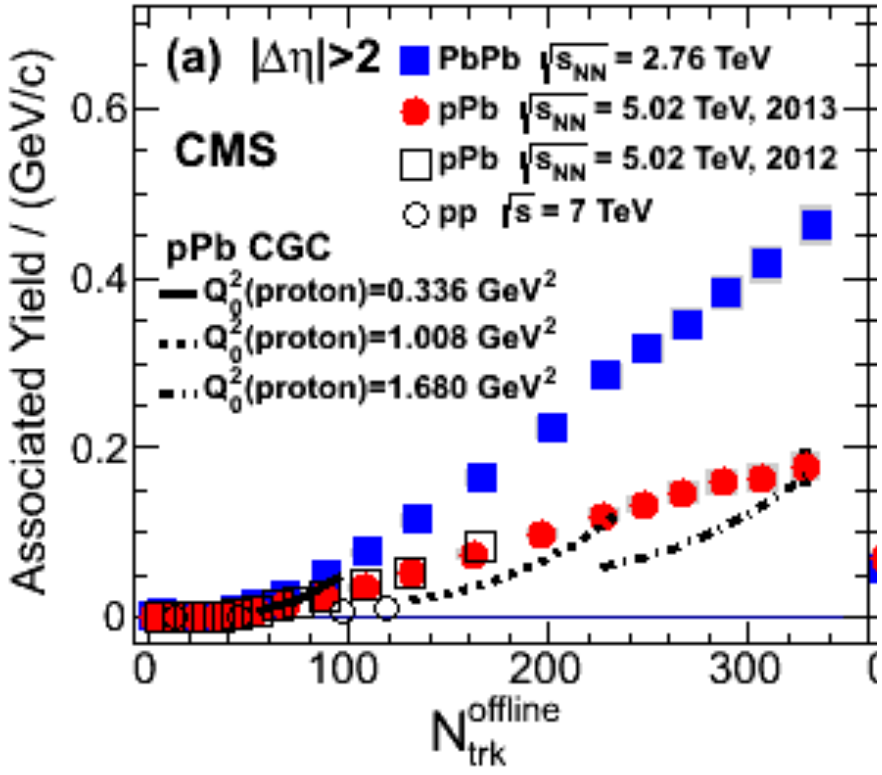
Short range: + (di)jet structure



The ridge yield

Similar p_T and multiplicity dependence, though larger in PbPb
Ridge becomes visible for Ntrk > 50 in the three systems

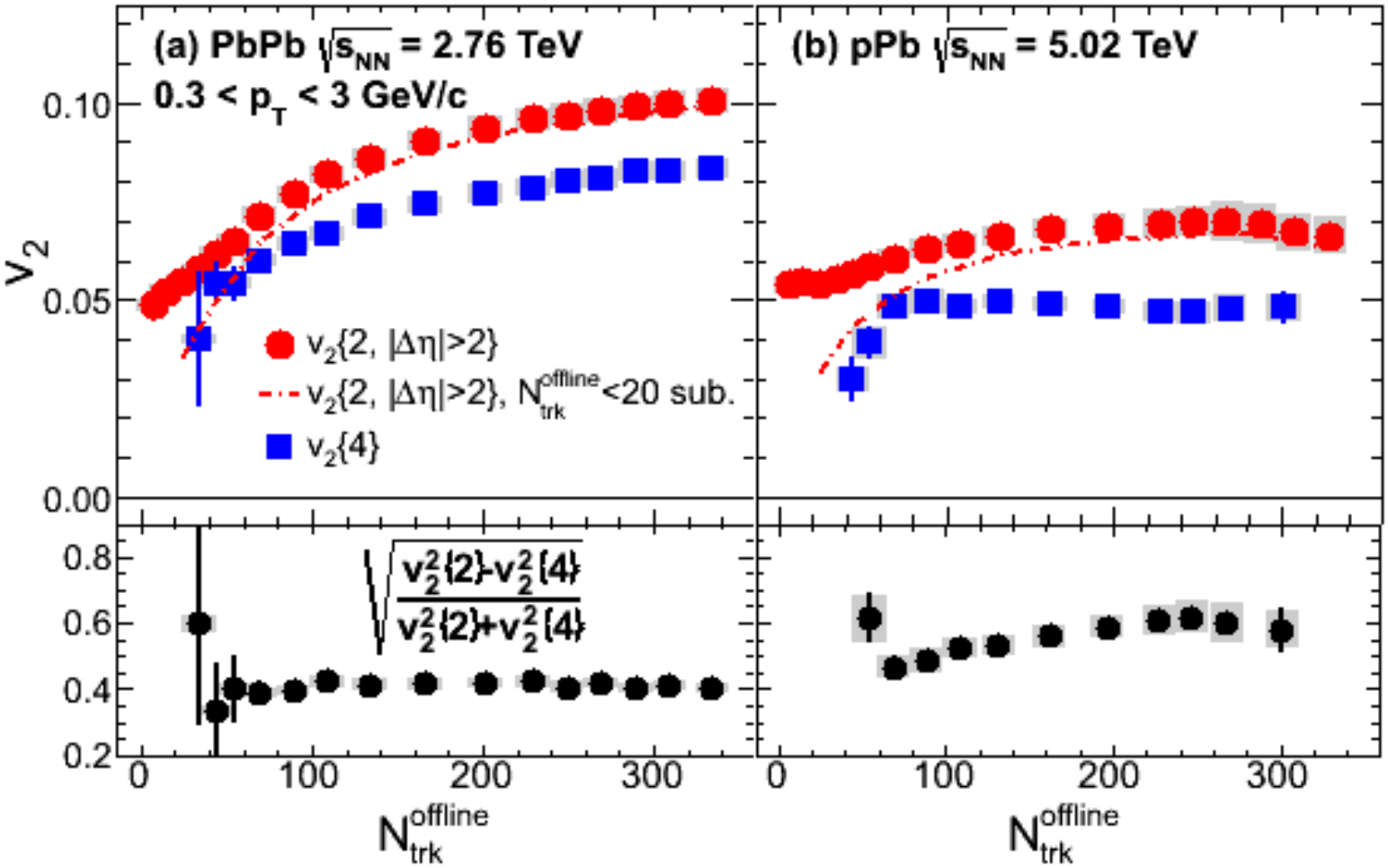




pPb 2013: PLB724 (2013) 213

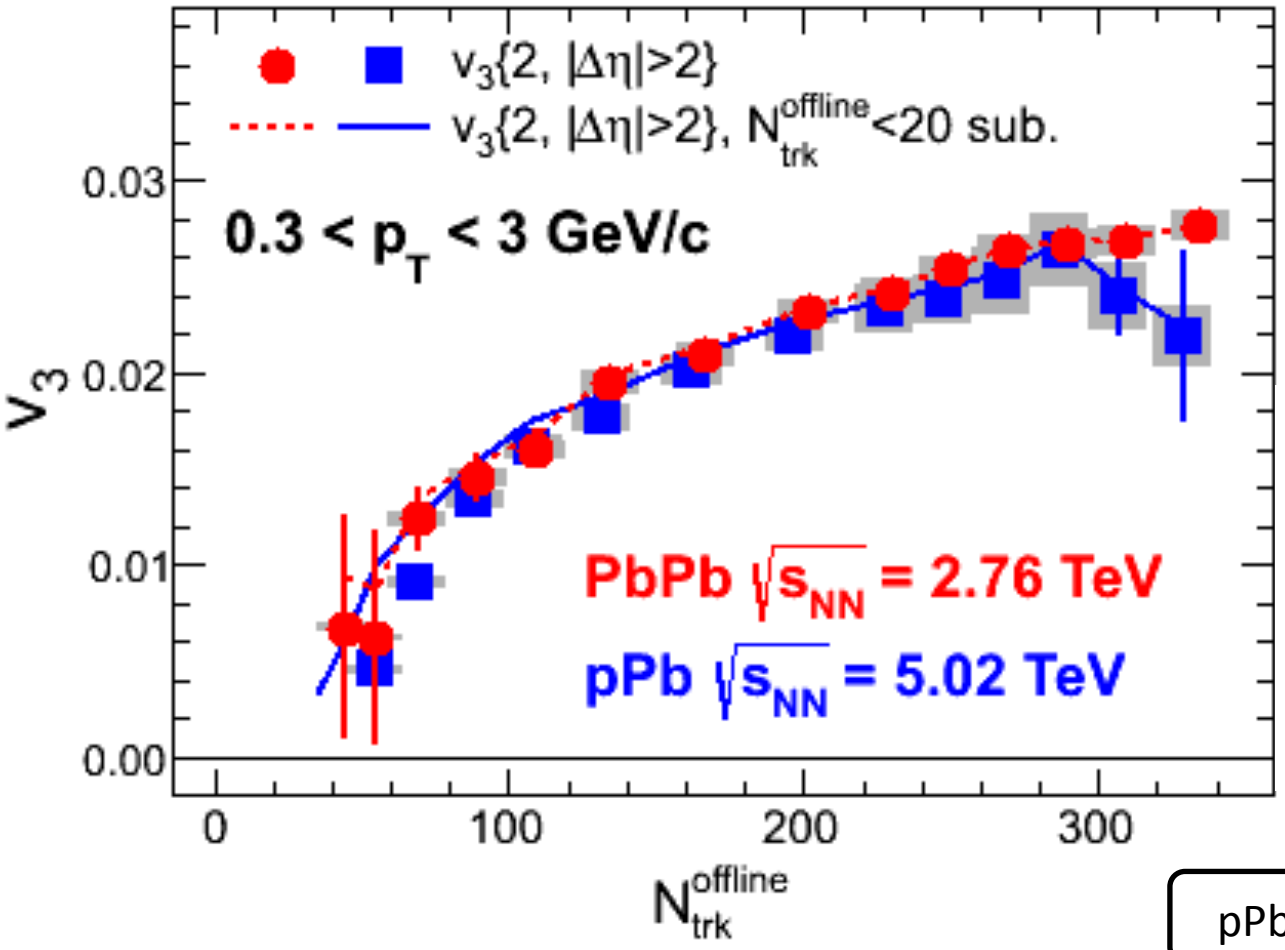
Elliptic flow

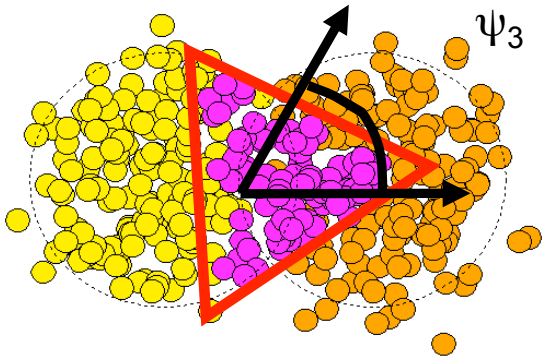
From a fit to the long-range distribution, also with a cumulant method
Stronger in PbPb than in pPb, weak multiplicity dependence
Larger fluctuations in pPb



Triangular flow

Remarkable similarity in the v_3 signal as a function of multiplicity in pPb and PbPb





pPb 2013: PLB724 (2013) 213

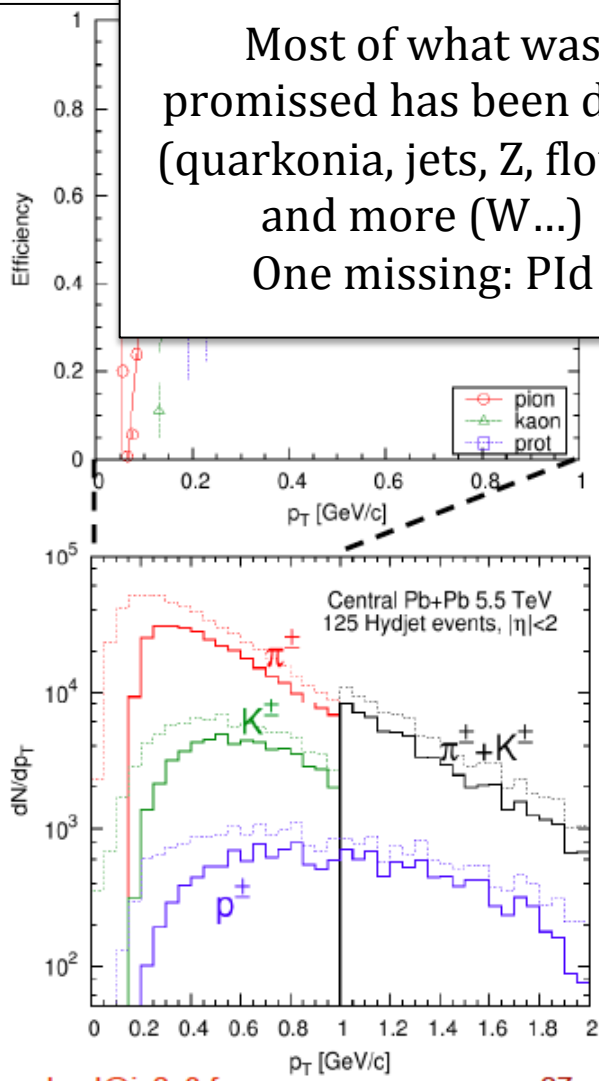
Back to Étretat in 2008

RGdC, QGP France 2008

Identification et spectres et à bas p_T

- Tracking dans 3 couches de silicium (66 Mpixels)
  - Occupation < 2%
  - p_T > 200 MeV/c
  - Résolution p_T 6 à 10%
  - Fake < 10%
- Identification de pion/kaon/proton
- dE/dx
  - π/K @ p_T < 1 GeV/c
  - p @ p_T < 2 GeV/c

F. Sikler, QM08



Most of what was promissed has been done (quarkonia, jets, Z, flow…) and more (W…)
One missing: PId

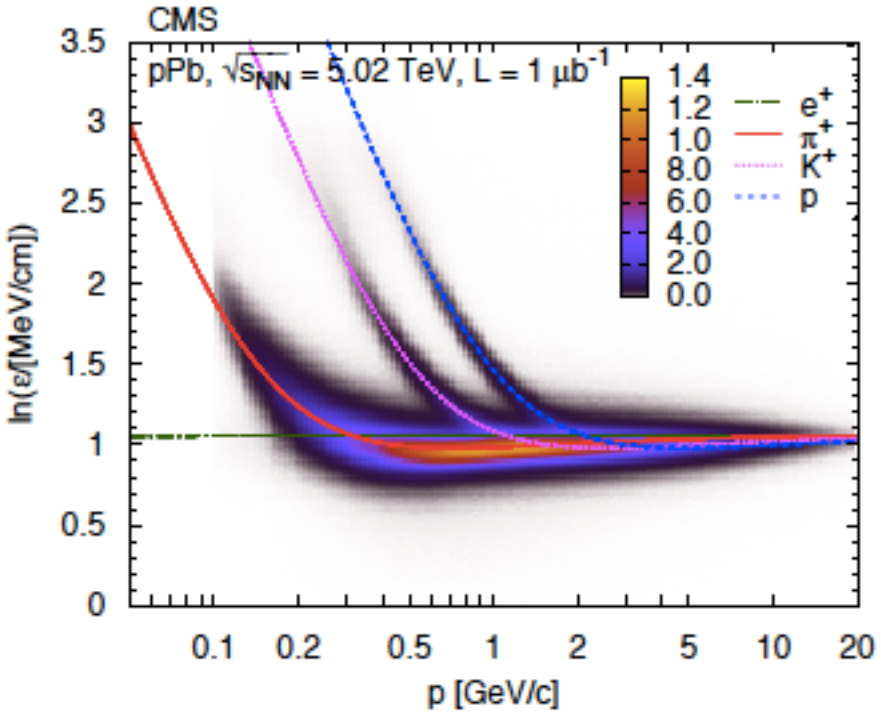
16 septembre 2008 Perspectives CMS - raphael@in2p3.fr 27

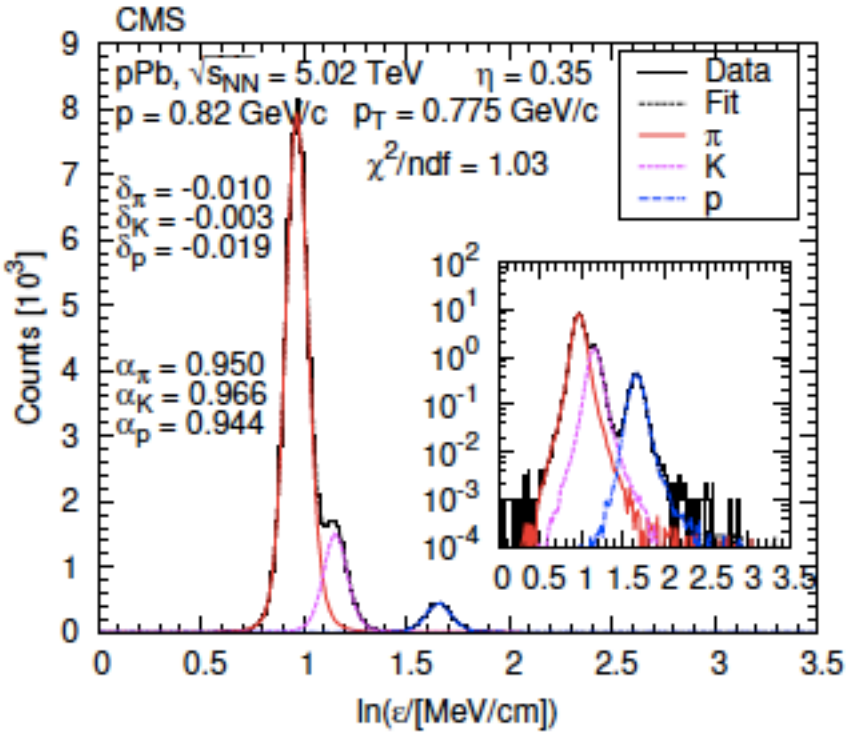
Fait en pPb…

arXiv:1307.3442 (from the pilot run)

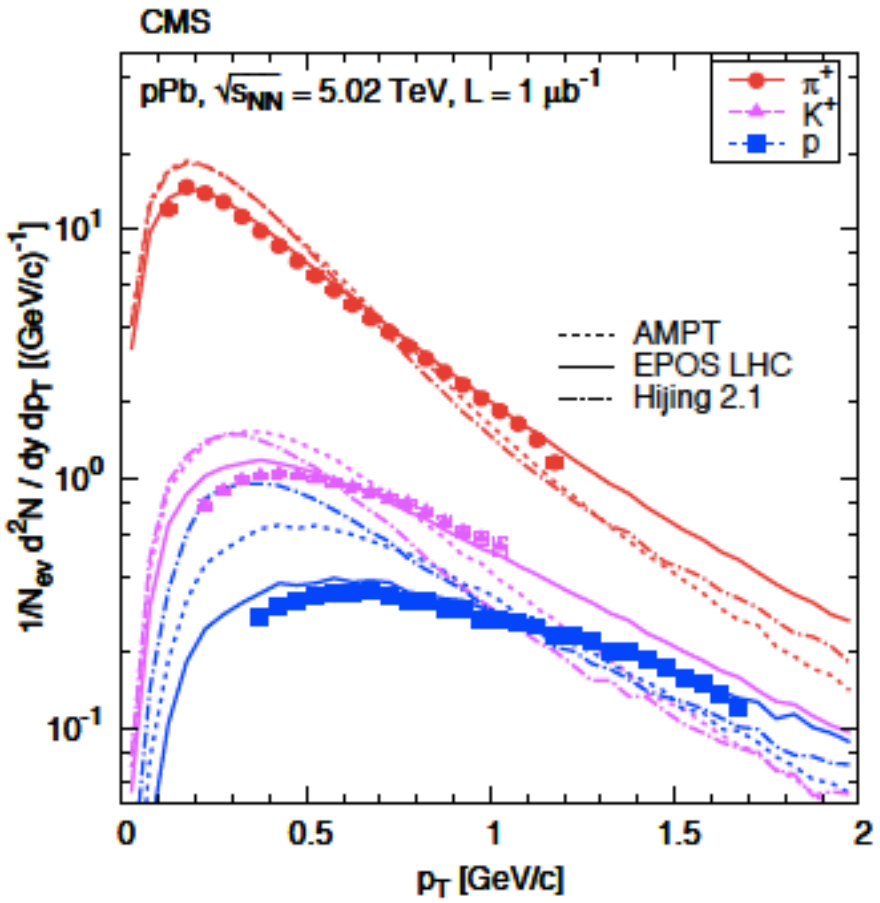
- p < 1.2 GeV pion
- p < 1.05 GeV kaon
- p < 1.7 GeV proton

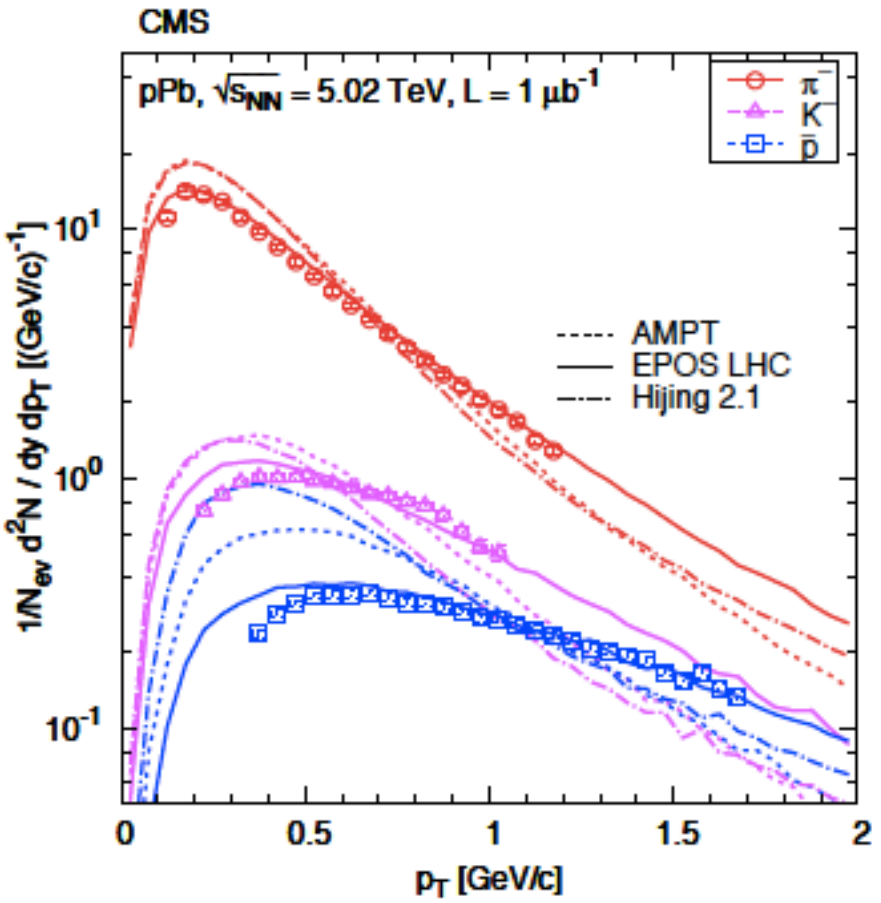
Epsilon : the most probable energy loss rate at a reference path length 450 um





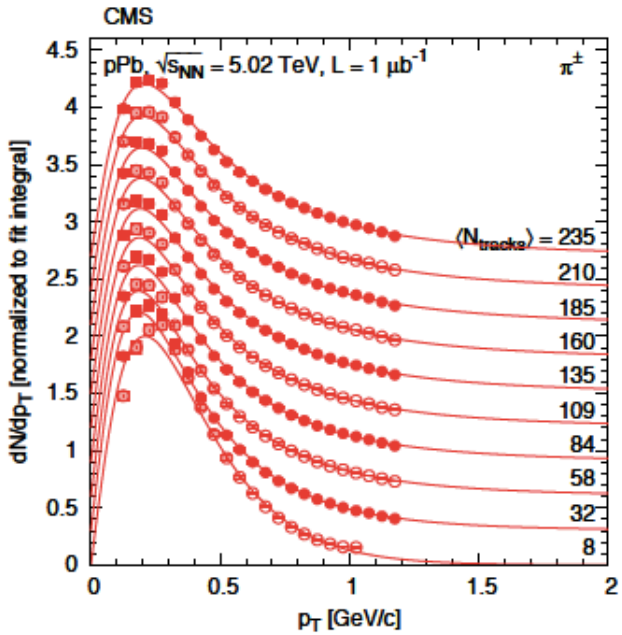
Résultats inclusifs

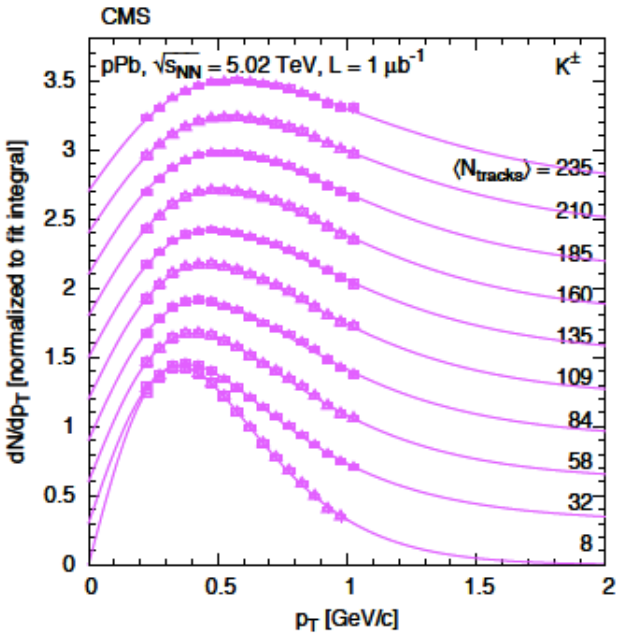


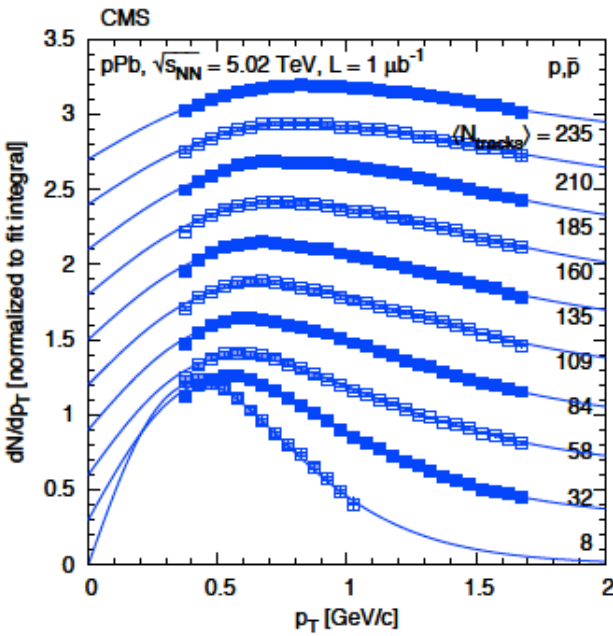


All generators too steep, EPOS LHC gives the best description

Versus multiplicity



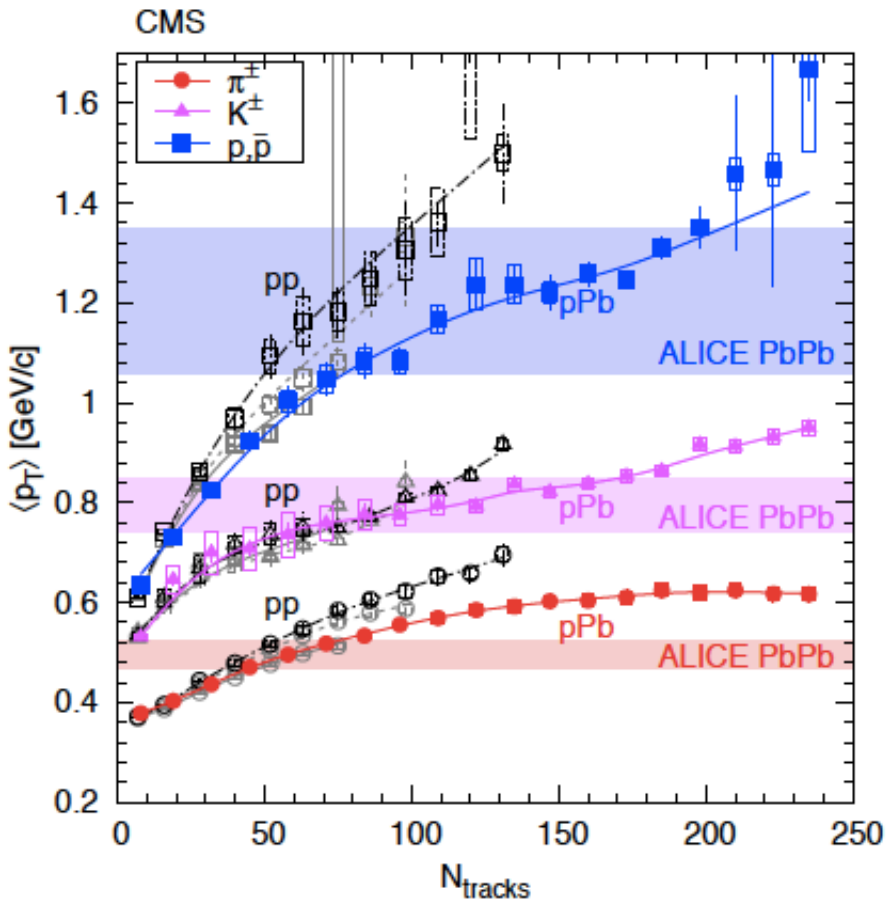


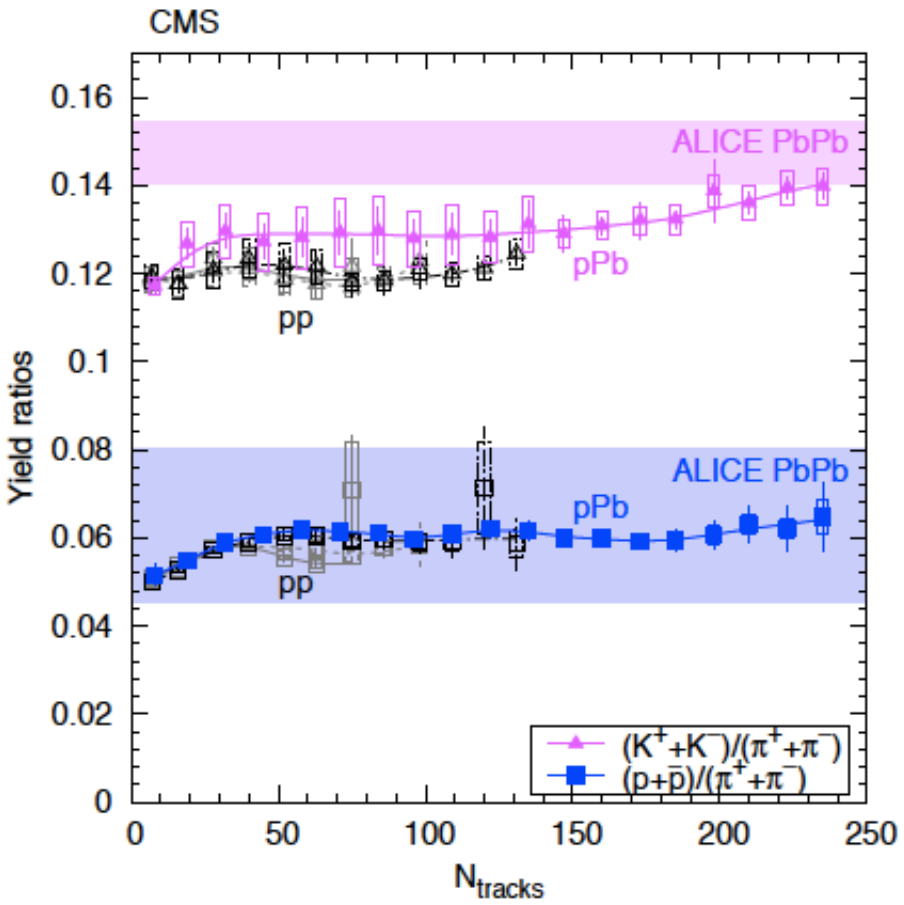


Strong modifications, larger for protons than kaons than pions

Average pT versus multiplicity

Average p_T raising with particle mass and event multiplicity
(pPb similar to pp with 0.55 Ntracks) higher values than in PbPb…





Some pPb conclusions

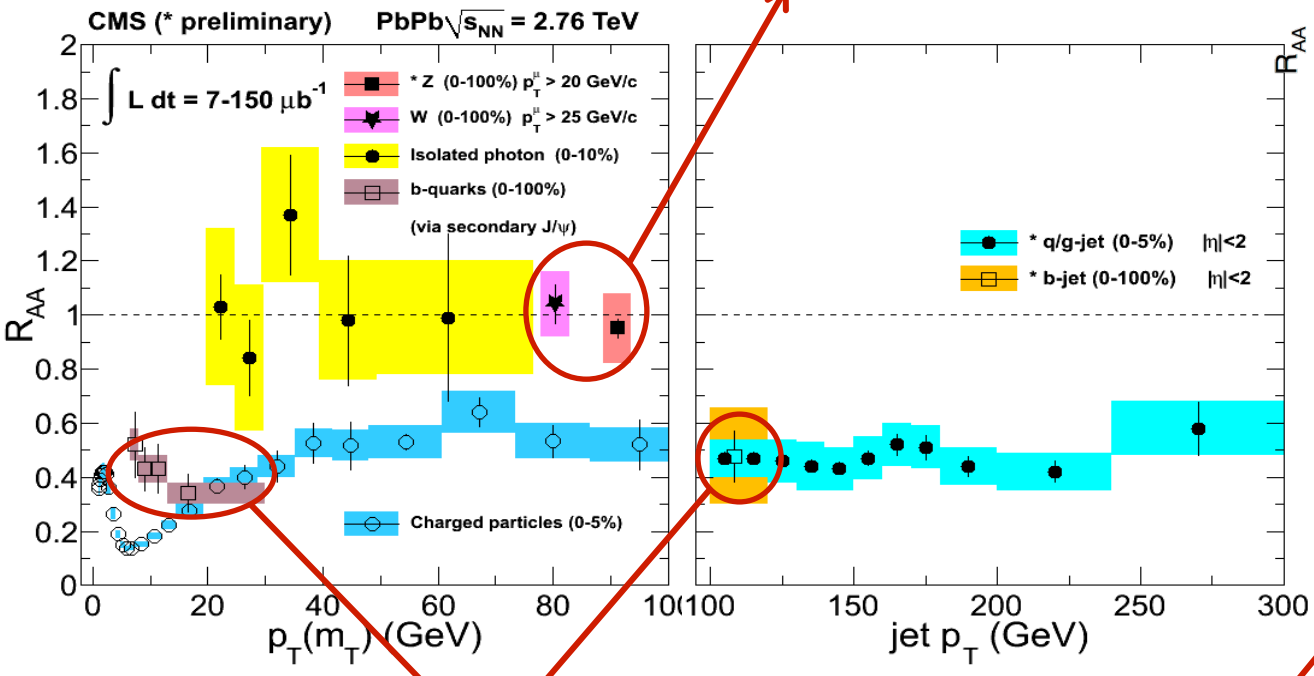
- Particle (bulk) production is strongly correlated to multiplicity in pp and pPb
  - Strong v_2, v_3 and radial flow
- More on pPb from CMS in Yetkin's (jets) and Nicolas' (Upsilons) talks

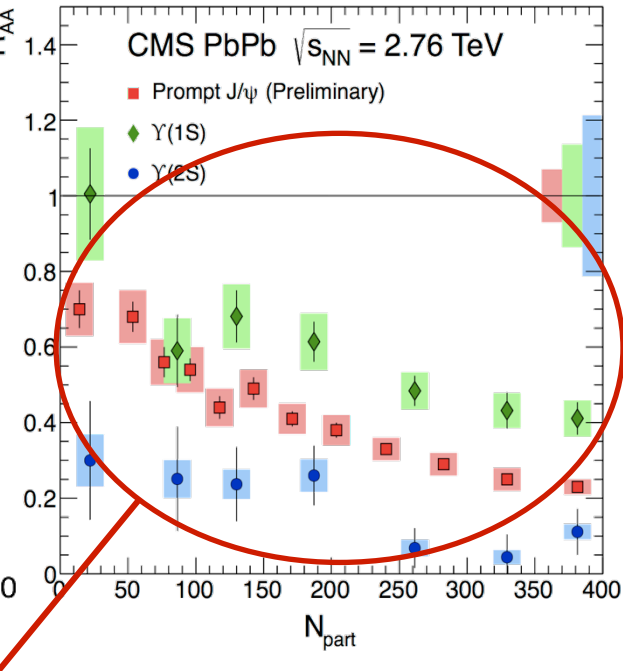
Short-term perspectives

WHAT'S NEXT (IN FRANCE)

Nos figures zoologiques

Les bosons faibles ne sont pas supprimés
(à part un effet attendu d'isospin sur W^+ et W^-)



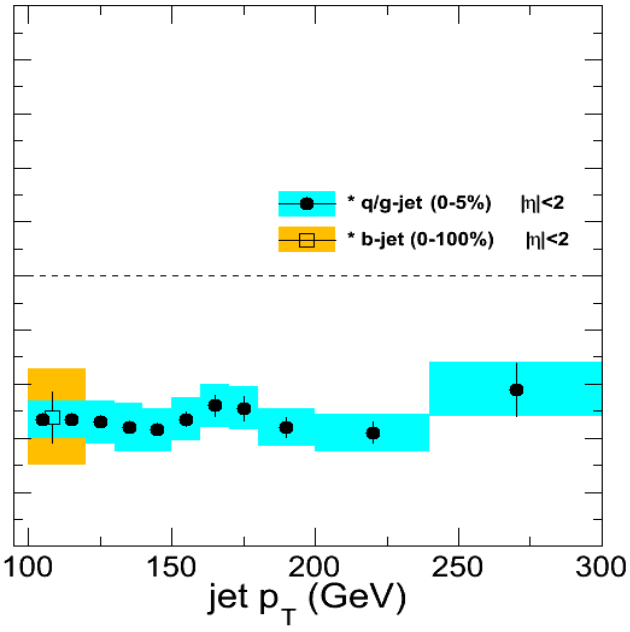


Les quarks b perdent de l'énergie

Cinq quarkonia sont supprimés

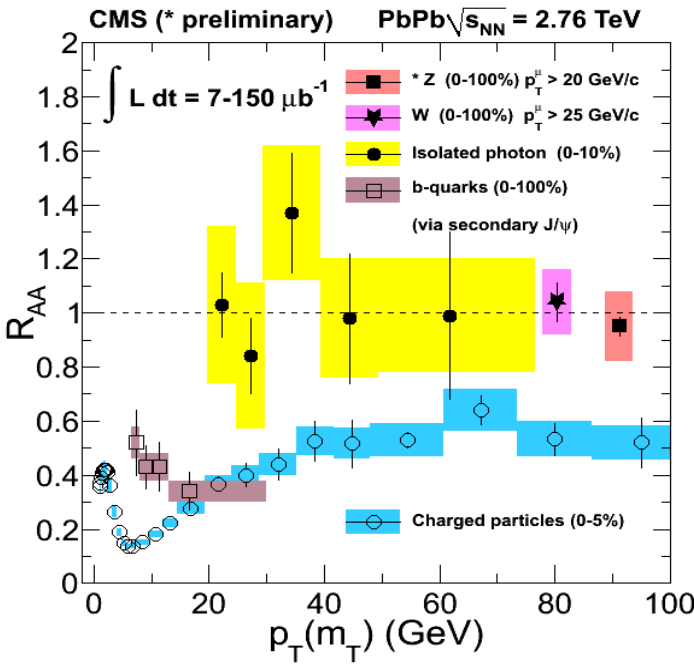
What's next (in France)

1. Jets (Stas, Yetkin, Matt)
   - First b-jet study done by Matt (HIN-12-003, large uncertainty)
   - Being refined with updated pp reference, reaching lower p_T
   - Getting prepared to trigger on them with the next run (displaced tracks)
   - And more, in the spirit of separating gluon, light-quark and heavy-quark jets…



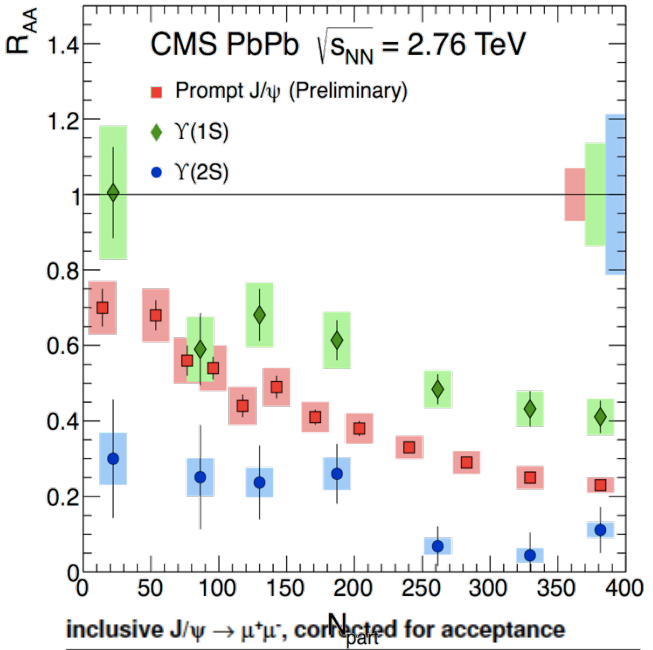
What's next (in France)

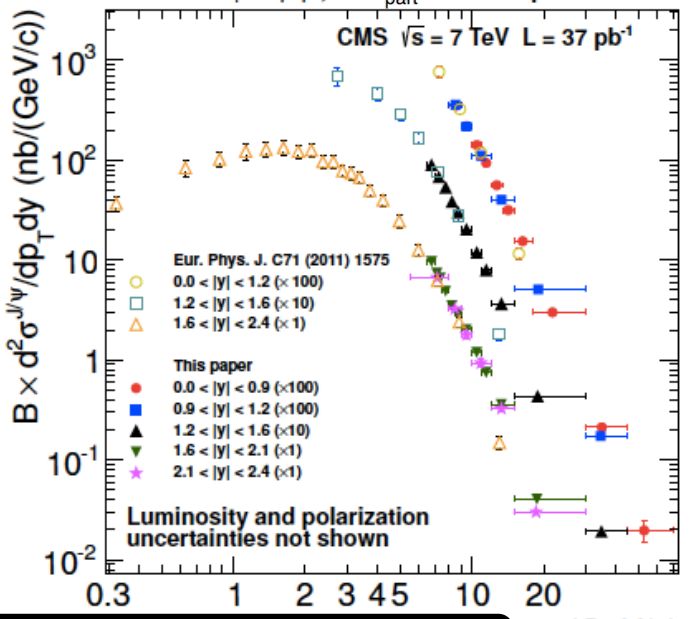
2. Electroweak bosons (Alice, Lamia, Raphael)
   - Z's from the second PbPb run in both the dimuon and dielectron channels: done!
     - New muon reconstruction raising yield by 40%
     - New pp reference, data-driven R_{AA}
   - Working on ≈ 20 000 W's from the pPb run (Alice's PhD)
     - Most constraining data set for (high Q^2) nPDF



What's next (in France)

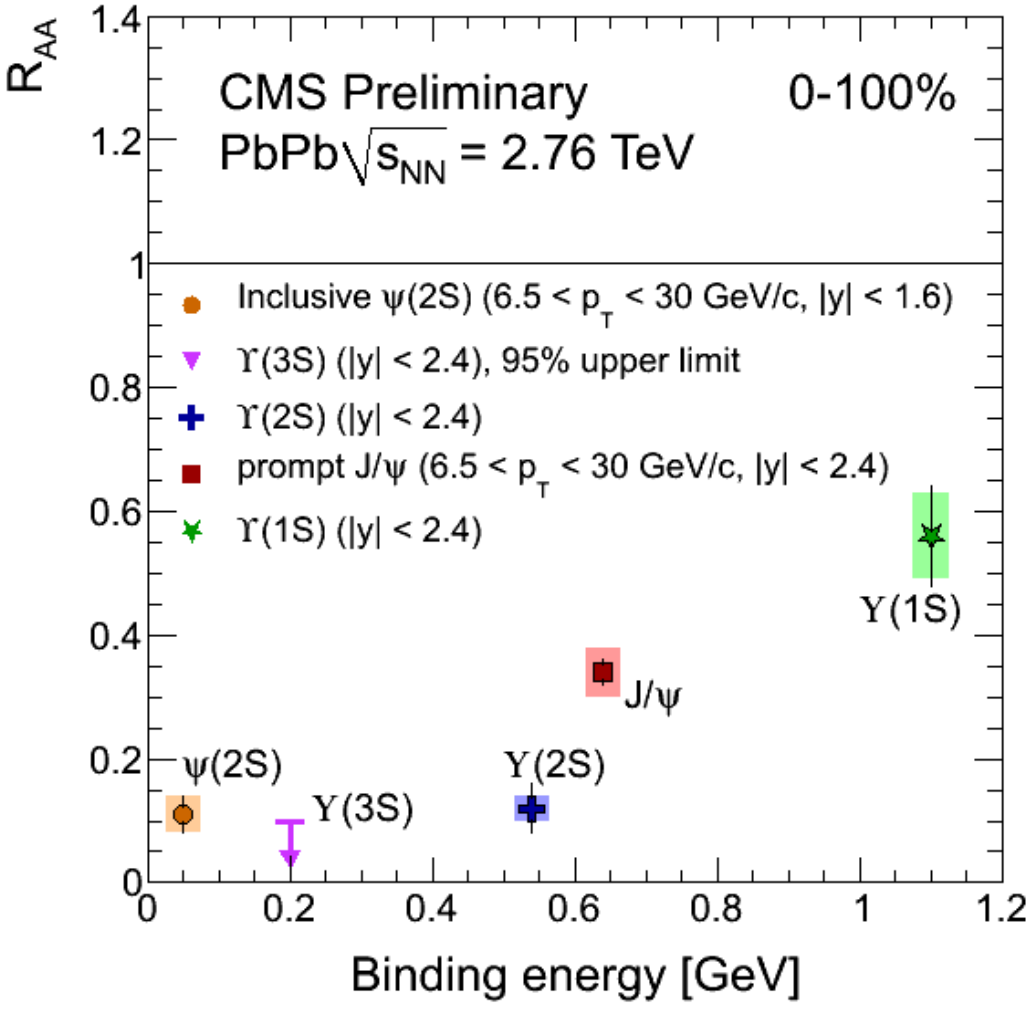
3. Quarkonia (Nicolas, Émilien, Torsten, Camelia, Raphael)
   - First Y results in pPb will be out tomorrow ☺
   - PbPb results on J/ψ, ψ' and Y (Nicolas' PhD) to be updated with:
     - New muon reconstruction
     - New pp references, allowing more differential analyses vs p_T and rapidity
   - Going down to (charmonium) lower p_T in pPb and PbPb
     - Done in pp →
   - Globally… lacking manpower!





pp collisions from JHEP 02 (2012) 011

Five states to bind them all



Forgetting low p_T J/ψ and ψ' (regeneration?) for a while…

R_{AA}(MB) vs binding energy looks ordered…

TBD with more data vs centrality and unfolding cold effects (pA) & feeddown

Could they start acting as a thermometer?

Watch out for p_T…

CMS @ QM'12

Back up

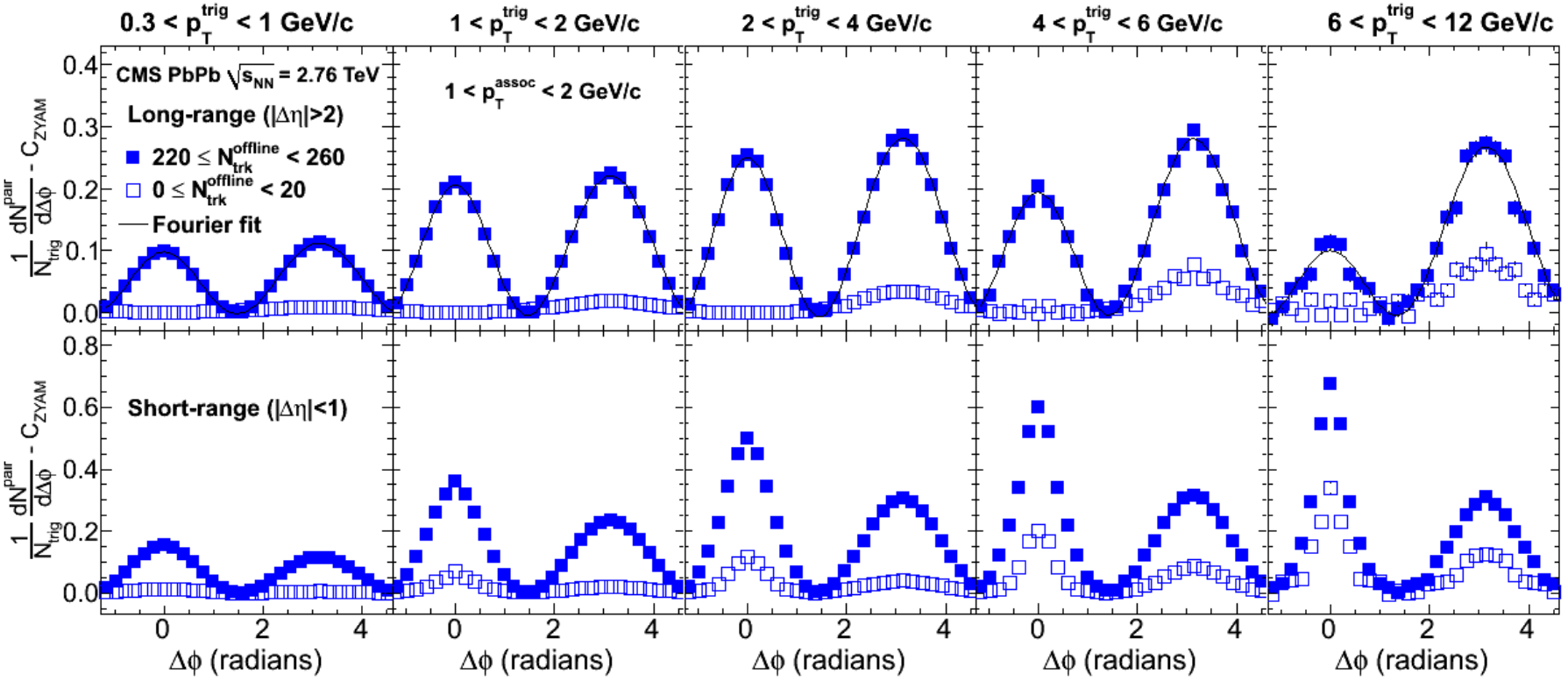
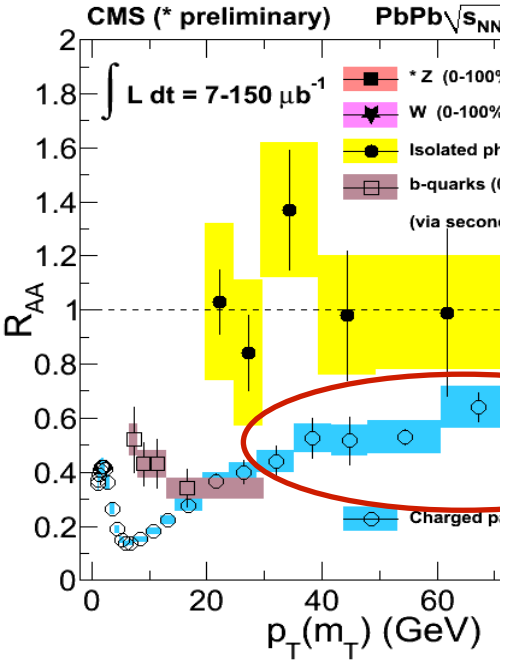
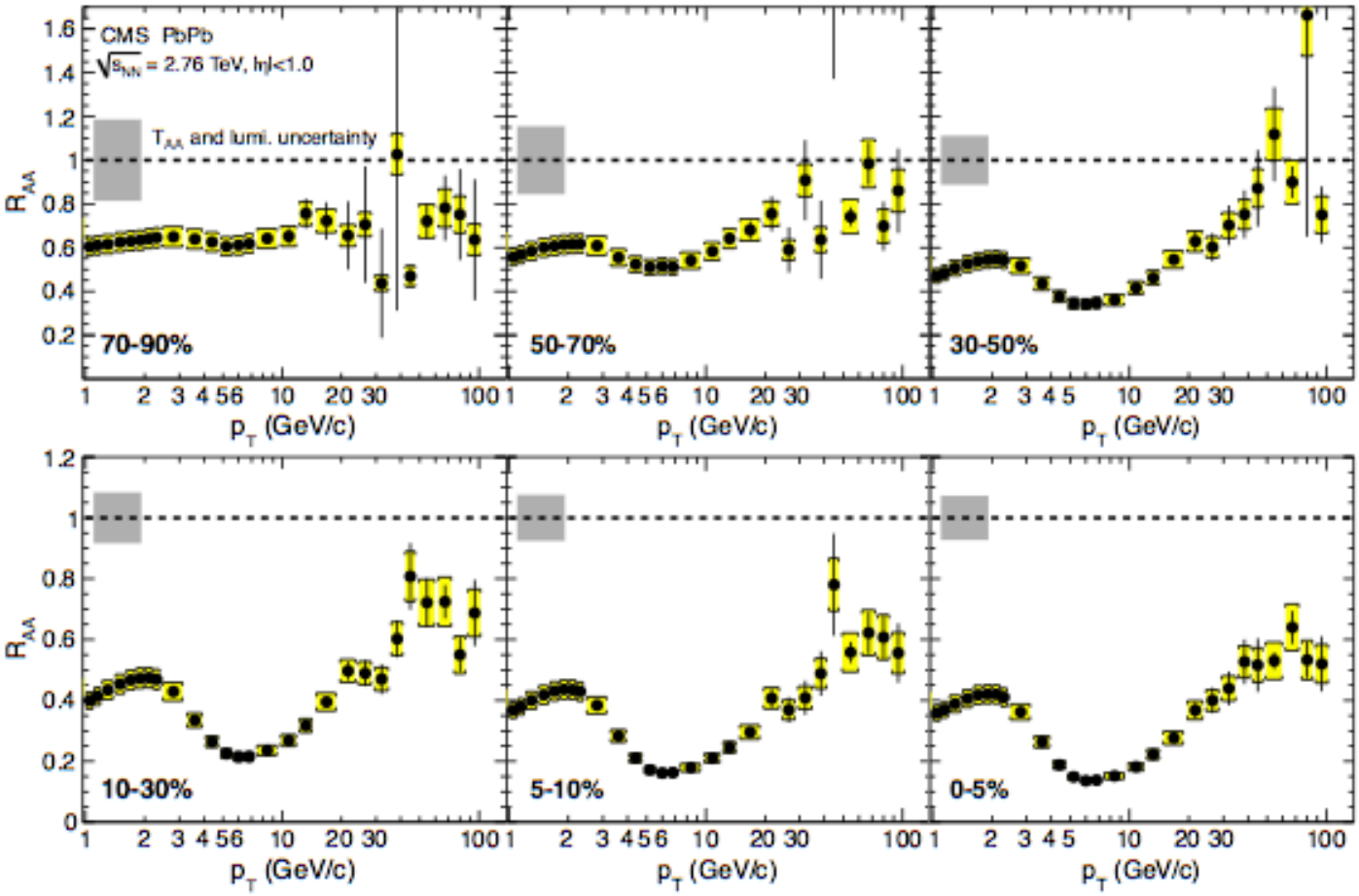

0.3 < p_T^trig < 1 GeV/c
1 < p_T^trig < 2 GeV/c
2 < p_T^trig < 4 GeV/c
4 < p_T^trig < 6 GeV/c
6 < p_T^trig < 12 GeV/c
CMS PbPb √s_NN = 2.76 TeV
1 < p_T^assoc < 2 GeV/c
Long-range (|Δη|>2)
220 ≤ N_trk^offline < 260
0 ≤ N_trk^offline < 20
Fourier fit
Short-range (|Δη|<1)
1/N_trig dN^pair/dΔφ - C_ZYAM
Δφ (radians)

Table 1: Fraction of MB triggered events after event selections in each multiplicity bin, and the average multiplicity of reconstructed tracks per bin with $|\eta| < 2.4$ and $p_T > 0.4\,\mathrm{GeV}/c$, before ($N_{\mathrm{trk}}^{\mathrm{offline}}$) and after ($N_{\mathrm{trk}}^{\mathrm{corrected}}$) efficiency correction, for 2.76 TeV PbPb and 5.02 TeV pPb data.

	PbPb data			pPb data		
$N_{\mathrm{trk}}^{\mathrm{offline}}$ bin	$\langle$Centrality$\rangle$ $\pm$ RMS (%)	$\langle N_{\mathrm{trk}}^{\mathrm{offline}} \rangle$	$\langle N_{\mathrm{trk}}^{\mathrm{corrected}} \rangle$	Fraction	$\langle N_{\mathrm{trk}}^{\mathrm{offline}} \rangle$	$\langle N_{\mathrm{trk}}^{\mathrm{corrected}} \rangle$
$[0, \infty)$				1.00	40	50±2
$[0, 20)$	92±4	10	13±1	0.31	10	12±1
$[20, 30)$	86±4	24	30±1	0.14	25	30±1
$[30, 40)$	83±4	34	43±2	0.12	35	42±2
$[40, 50)$	80±4	44	55±2	0.10	45	54±2
$[50, 60)$	78±3	54	68±3	0.09	54	66±3
$[60, 80)$	75±3	69	87±4	0.12	69	84±4
$[80, 100)$	72±3	89	112±5	0.07	89	108±5
$[100, 120)$	70±3	109	137±6	0.03	109	132±6
$[120, 150)$	67±3	134	168±7	0.02	132	159±7
$[150, 185)$	64±3	167	210±9	4×10^{-3}	162	195±9
$[185, 220)$	62±2	202	253±11	5×10^{-4}	196	236±10
$[220, 260)$	59±2	239	299±13	6×10^{-5}	232	280±12
$[260, 300)$	57±2	279	350±15	3×10^{-6}	271	328±14
$[300, 350)$	55±2	324	405±18	1×10^{-7}	311	374±16

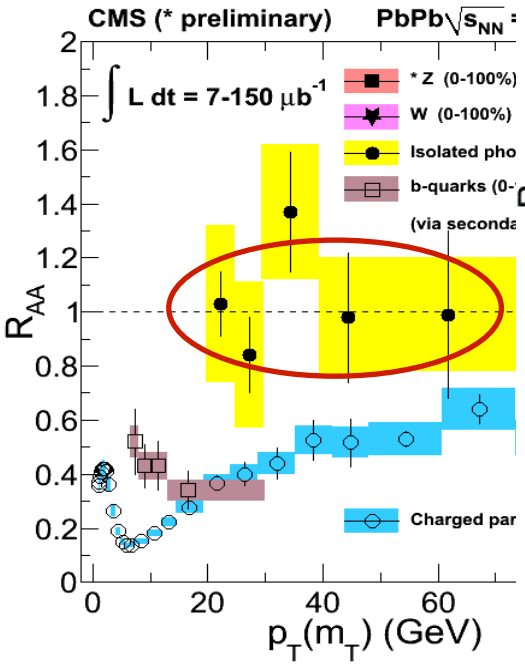
Modified hadrons (150 μb^{-1})

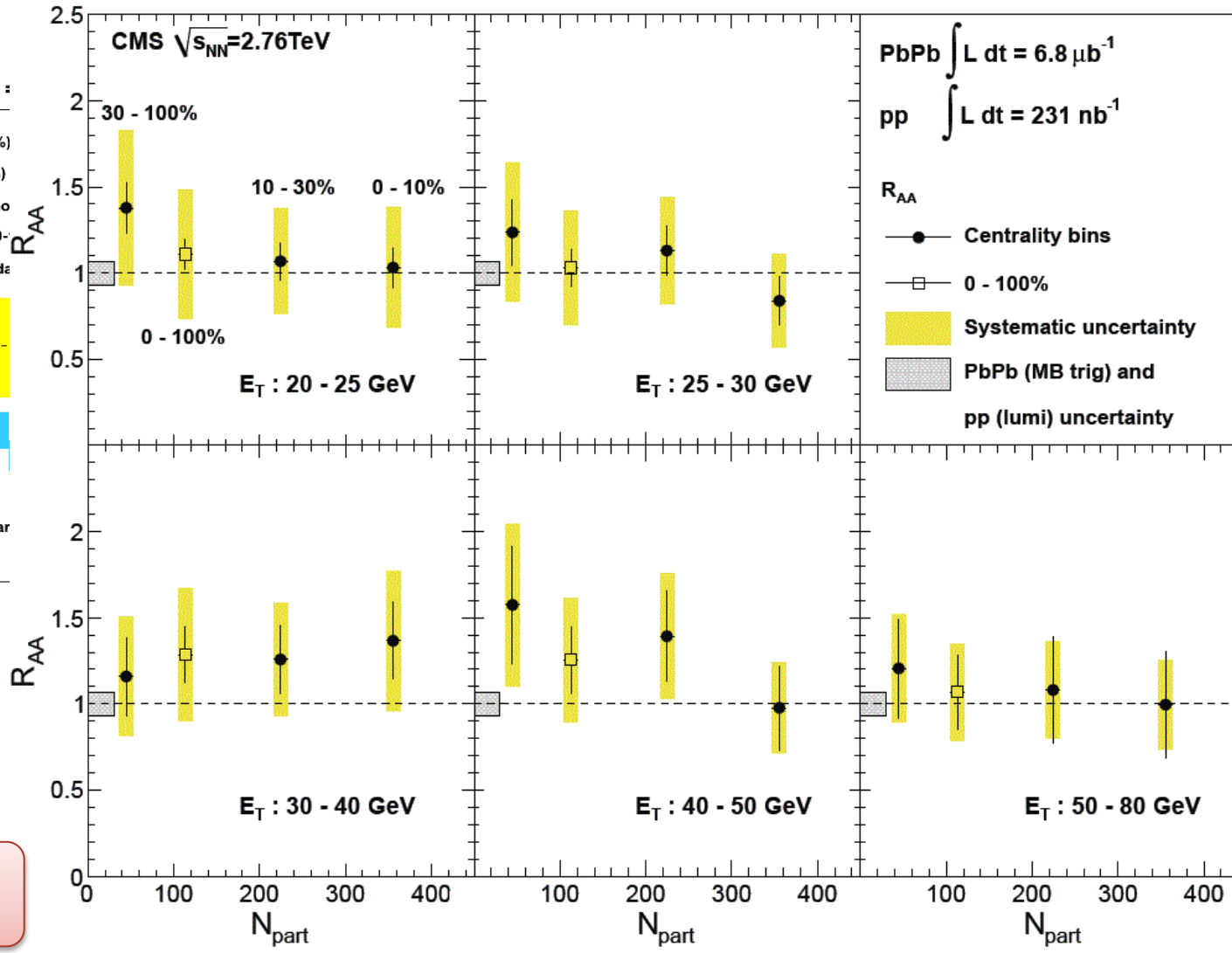




EPJC 72 (2012) 1945

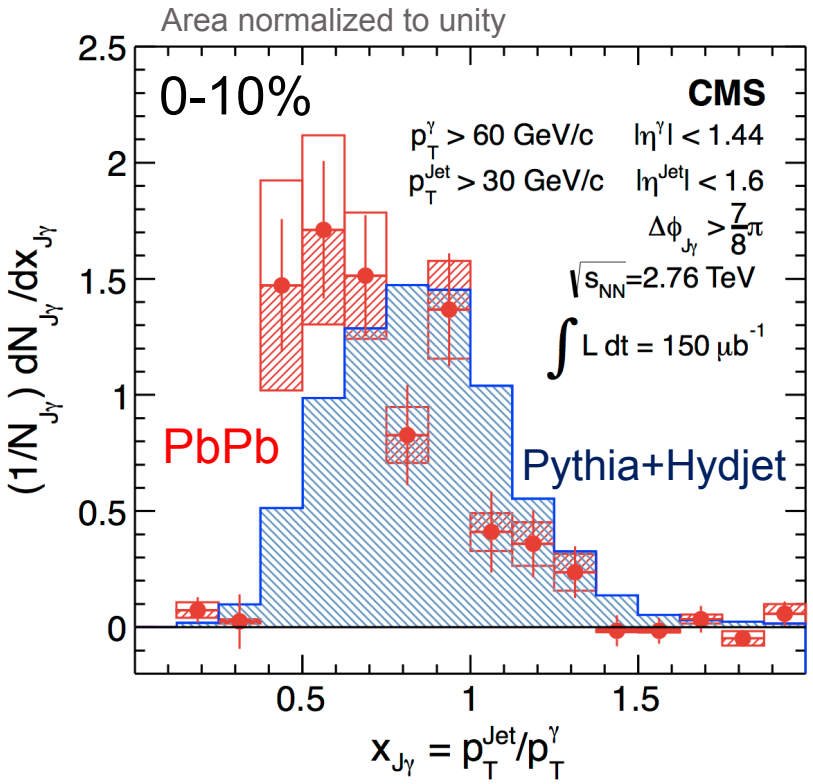
Unmodified photons (6.8 μb^{-1})



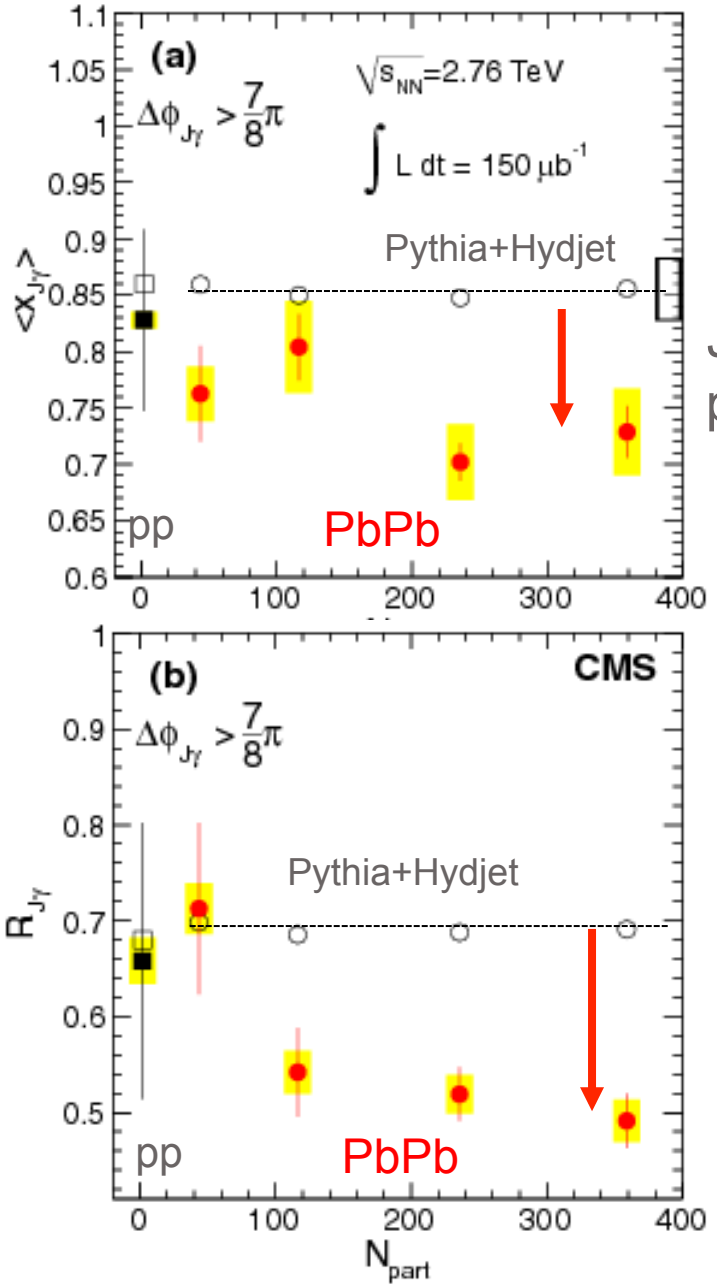


PLB 710 (2012) 256

Photon+jet (150 μb^{-1})



Photon-jet momentum balance

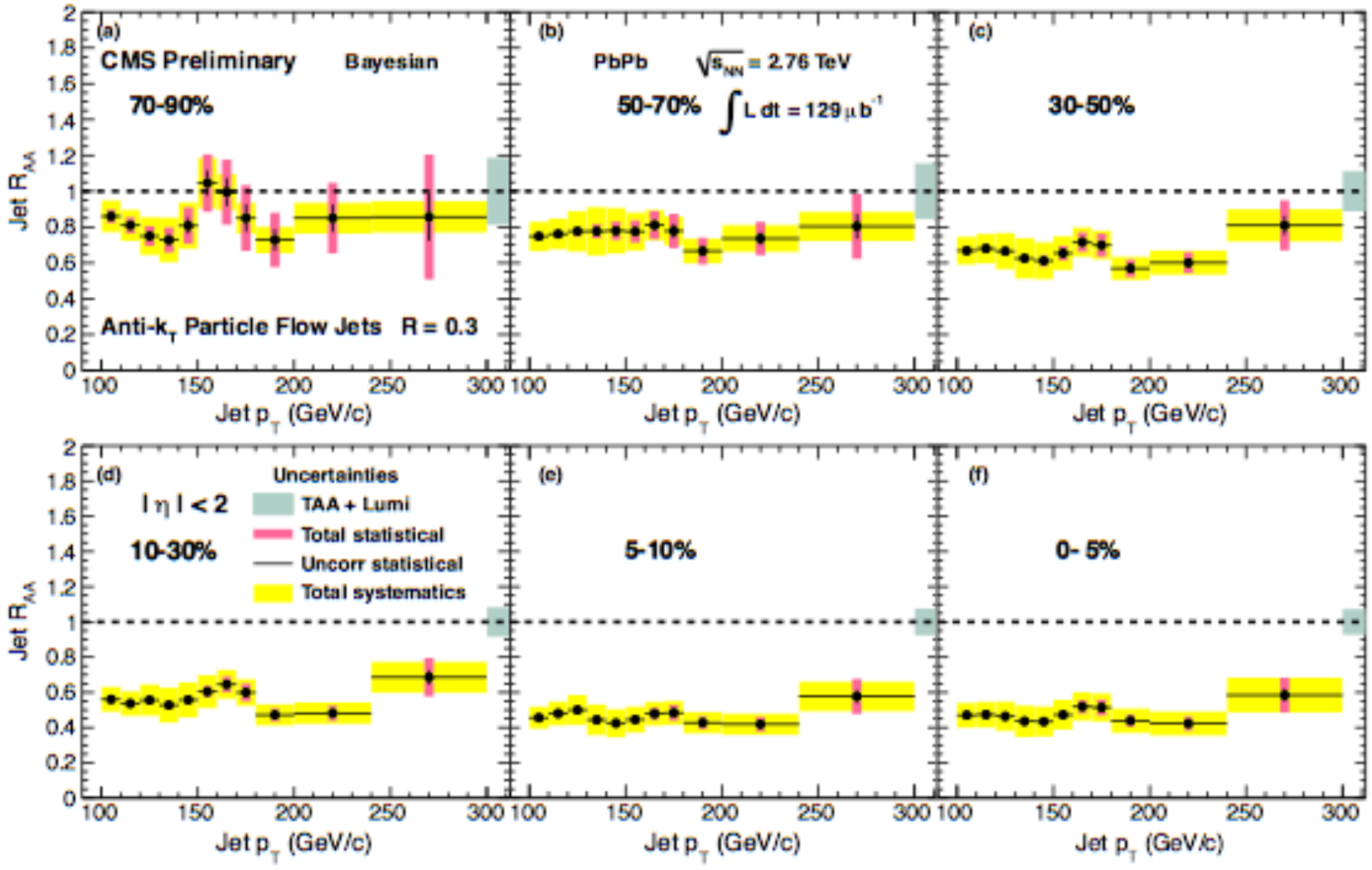


Jet-photon p_T balance 14% drop

20% lose jet partner

arXiv:1205.0206

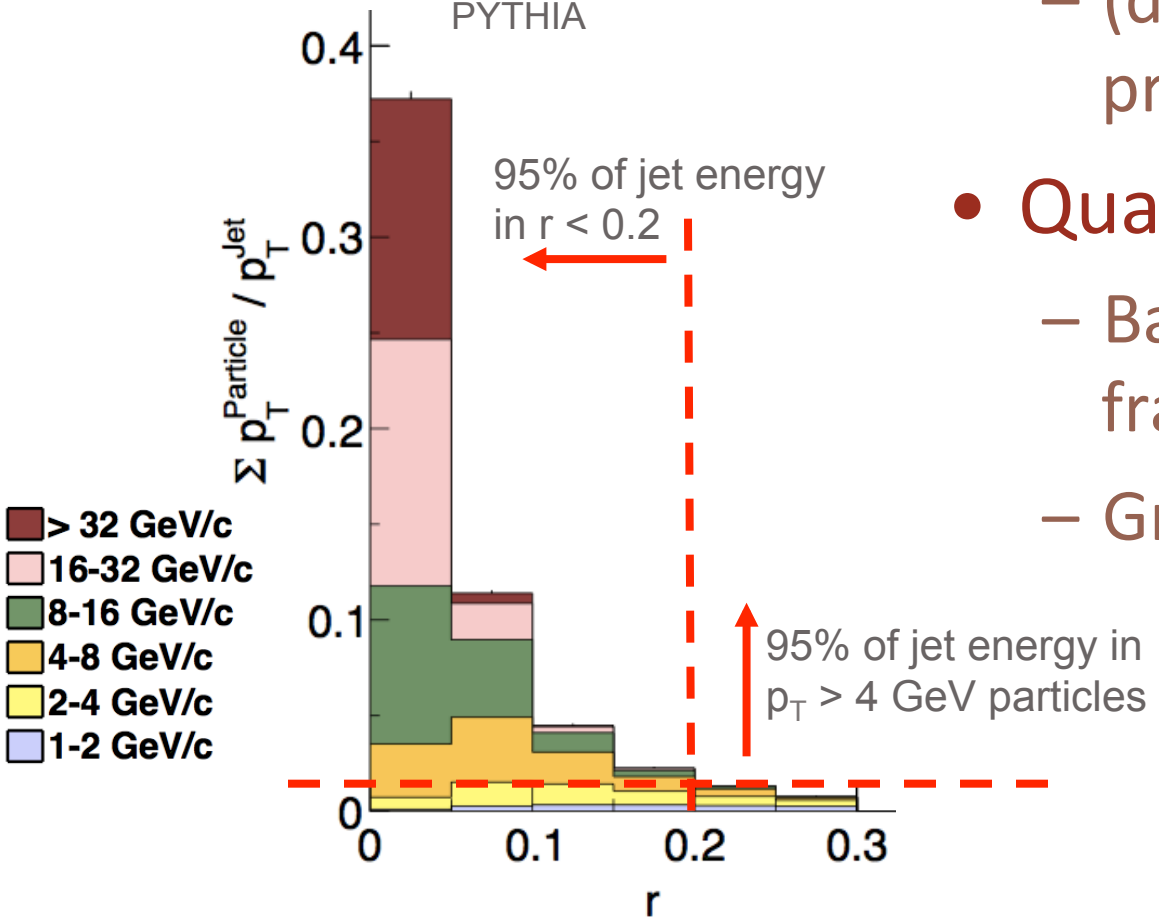
Jet R_{AA}



HIN-12-004

Cone size R = 0.3, but does not vary a lot for R = 0.2 or 0.4

Où passe l'énergie ?

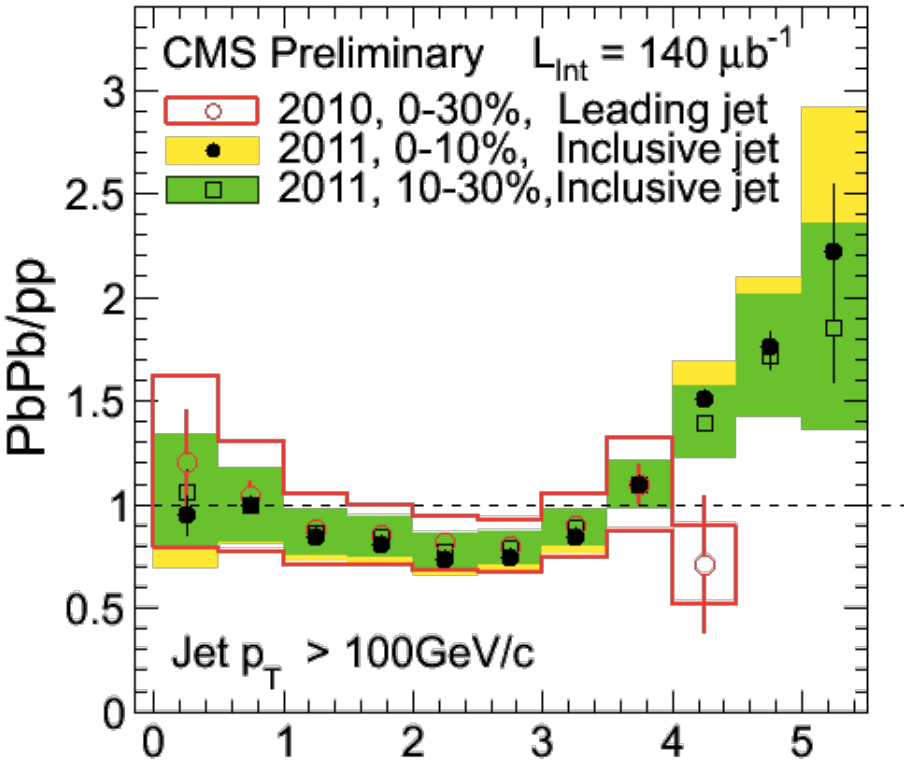


- À grand angle et bas p_T
  - (déjà une idée dans le premier papier di-jet)
- Quantitativement:
  - Bas p_T, fonction de fragmentation
  - Grand angle, jet shape

PRC 84 (2011) 024906
G. Roland at QM'12

Fragmentation des jets

- À première vue (QM'11, run 1, p_T(track) > 4 GeV & p_T(jet) > 100 GeV), la fragmentation des jets survivants n'est pas modifiée
- En regardant mieux (QM'12, run 2, p_T(track) > 1 GeV & jets plus énergétiques), les modifications apparaissent

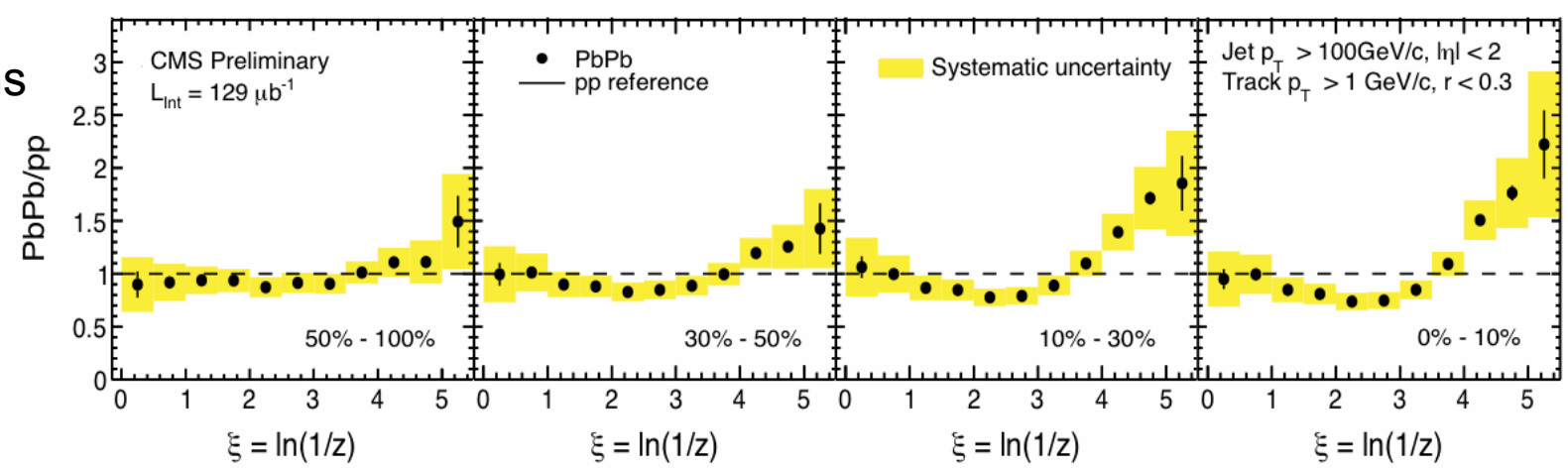


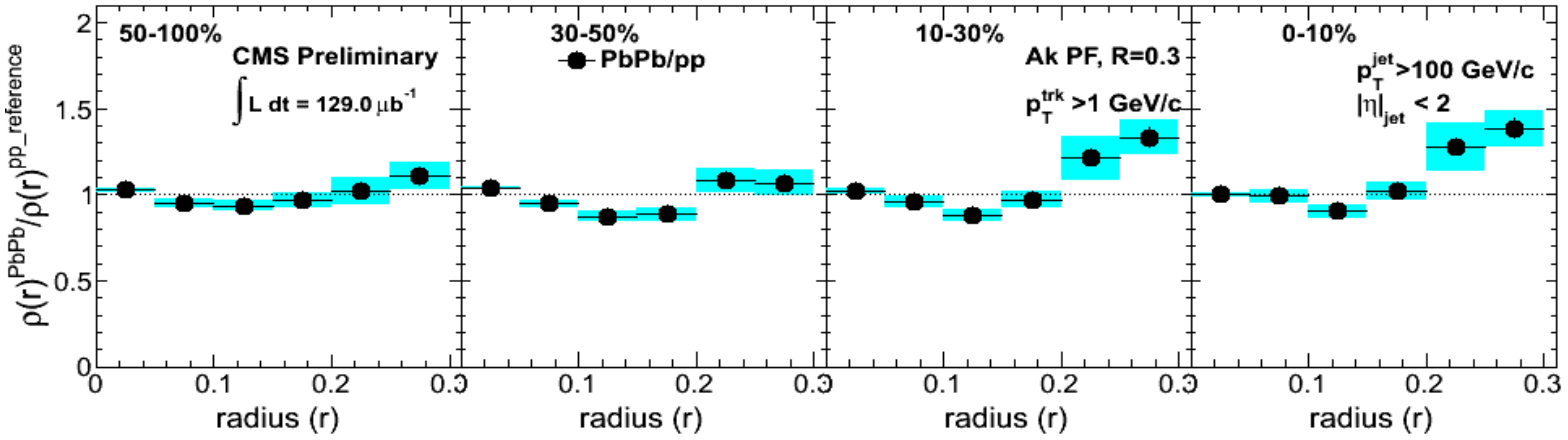
arXiv:1205.5872 accepted by JHEP
vs HIN-12-013

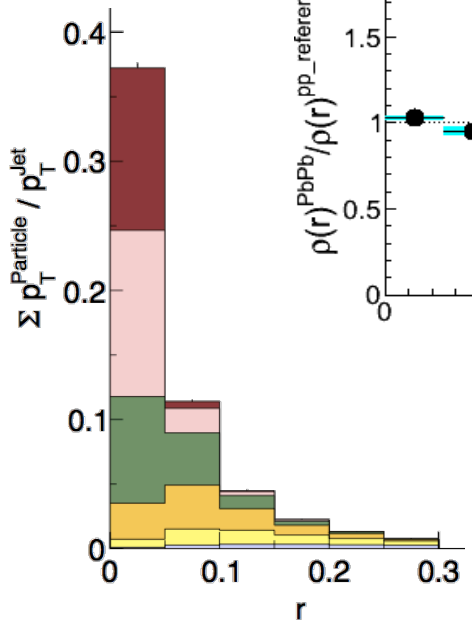
ξ = ln(1/z) & z=p_T(track)/p_T(jet)

Fragmentation et forme des jets

PbPb/pp distributions



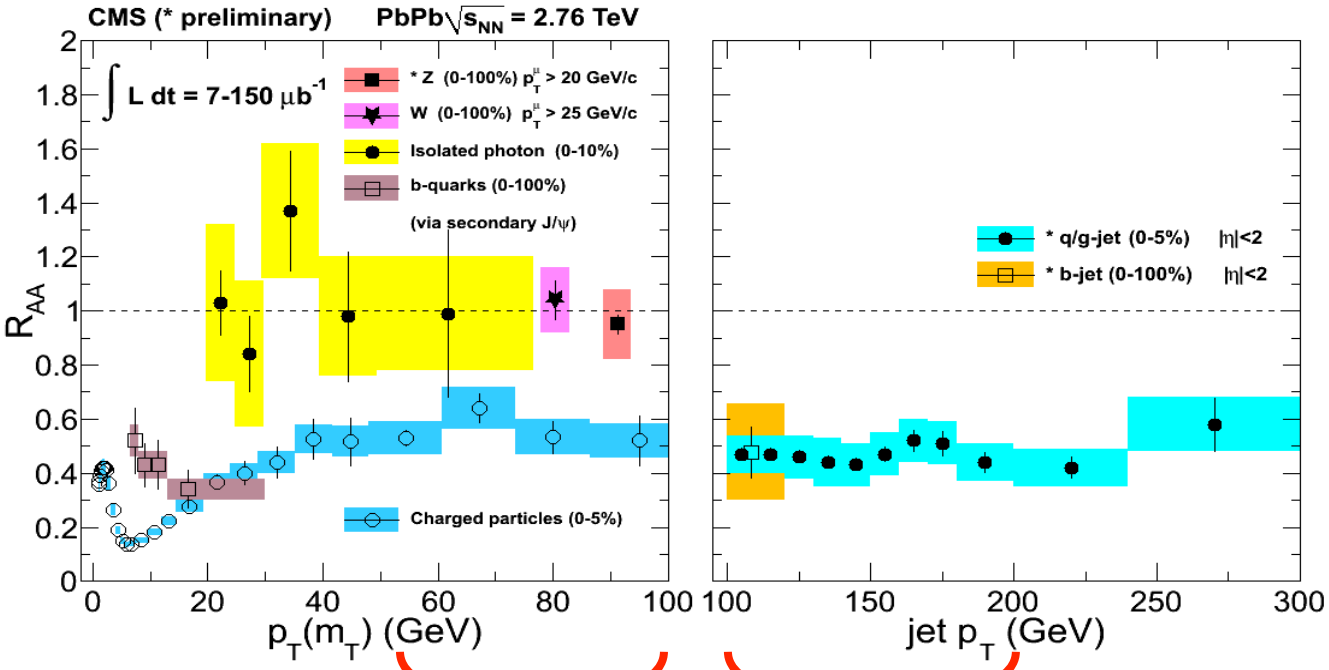




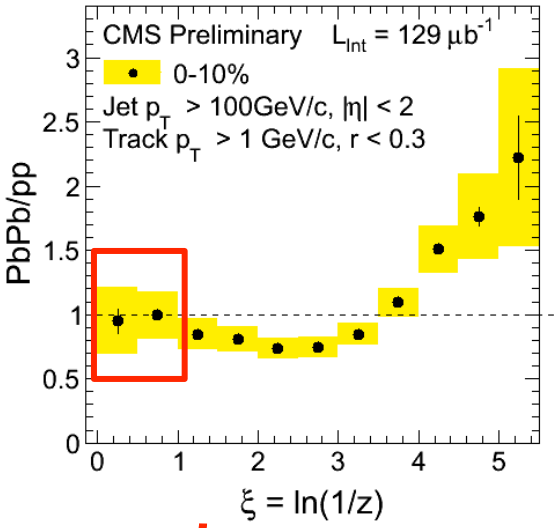
No change at small r, high p_T
Narrowing/depletion at intermediate p_T
Broadening/excess at large r low p_T

HIN-12-013

Cohérence des résultats



G. Roland at QM'12

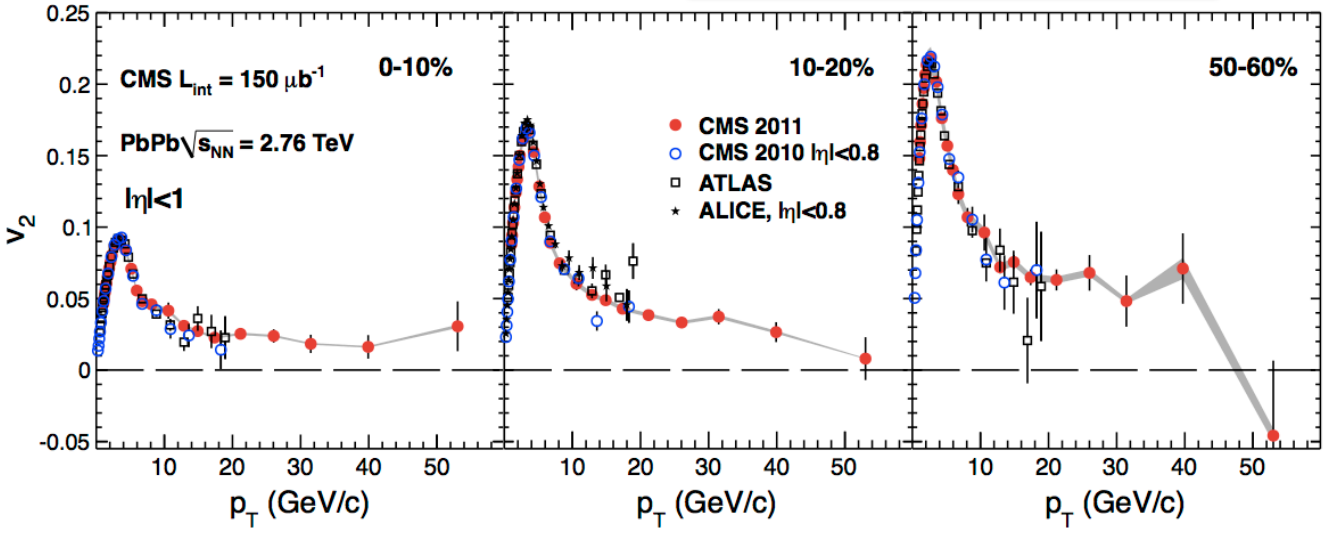


Looking at the same parton p_T range

Charged particles from
p_T = 50-100 GeV/c
$z = p_T(\text{track})/p_T(\text{jet})$ = 0.4-0.6
ξ < 1

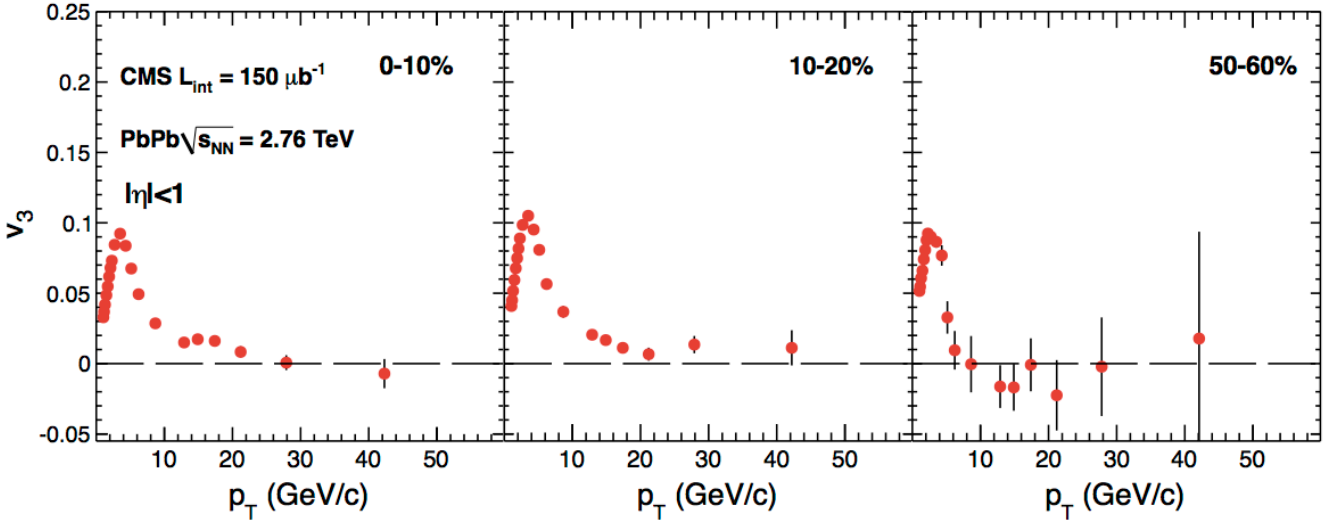
PbPb fragmentation function = pp for ξ <1

Harmoniques des grand p_T



PRL 109 (2012) 022301

v_2 (hadron) persiste jusqu'à 40 GeV
Jet quenching

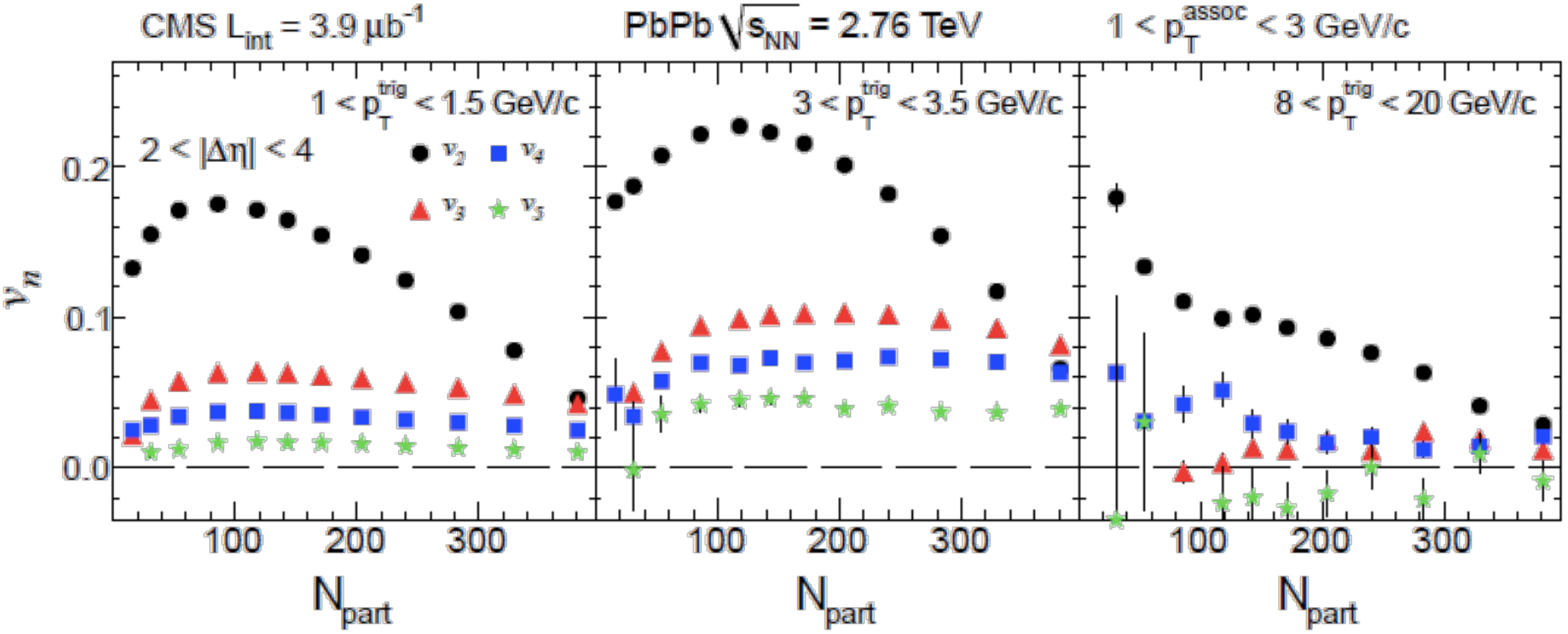


alors que v_3 (et v_4) s'évanouit

HIN-12-010

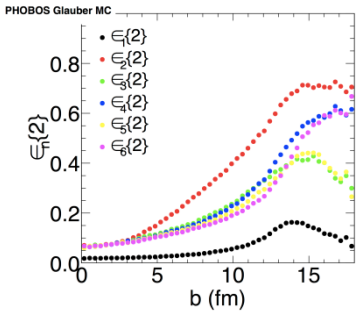
Harmoniques des petits p_T

EPJC 72 (2012) 2012



Extrait des corrélations de hadrons à grande portée (2 < |Δη| < 4)
Factorisation vérifiée jusqu'à 3 – 3.5 GeV ($V_{n\Delta}$ (p_T^1, p_T^2) = v_n (p_T^1) x vn (p_T^2))

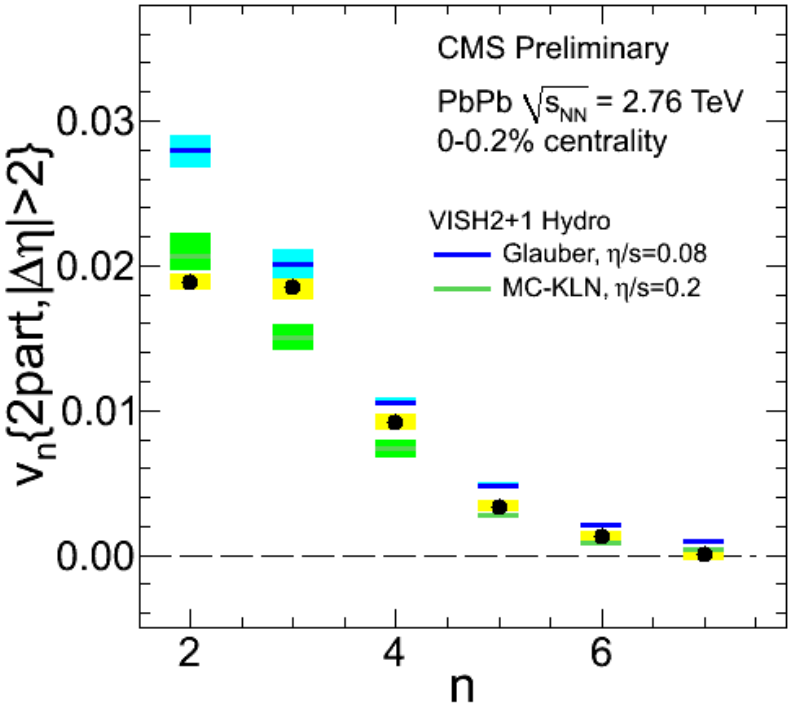
Harmoniques des ultra-centrales



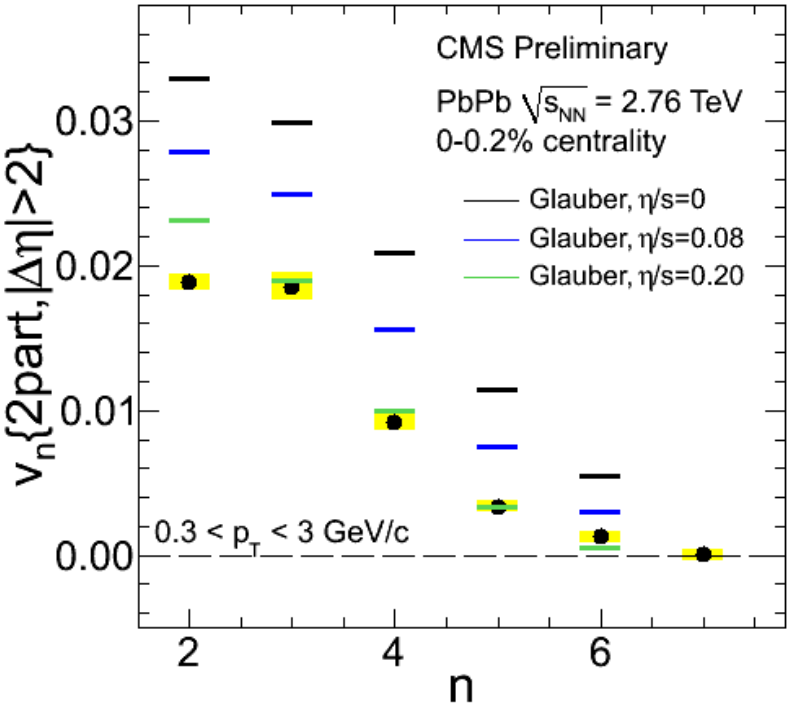
HIN-12-011

Dans les collisions les plus centrales, la forme elliptique disparaît et toutes les harmoniques sont dominées par les fluctuations. Ici, pour les 0.2% collisions les plus centrales…

Calculation by Heinz et al.



Calculation by Luzum et al.



18 papers with PbPb collisions (Etretat 2012)

1. HIN-10-004 (dijet inbalance): PRC 84 (2011) 024906 [144 cites] **
2. HIN-11-007 (YNs/Y1s ratio): PRL 107 (2011) 052302 [52 cites] **
3. HIN-10-001 ($dN_{ch}/d\eta$): JHEP 08 (2011) 141 [34 cites]
4. HIN-10-006 (quarkonia): JHEP 05 (2012) 063 [33 cites] **
5. HIN-11-001 (correlations): JHEP 07 (2011) 076 [30 cites]
6. HIN-10-005 (R_{AA}): EPJC 72 (2012) 1945 [30 cites]
7. HIN-10-003 (Z): PRL 106 (2011) 212301 [25 cites] **
8. HIN-11-006 (correlations): EPJC 72 (2012) 2012 [16 cites]
9. HIN-11-013 (dijets): PLB 712 (2012) 176 [16 cites]
10. HIN-11-012 (high p_T v_2): PRL 109 (2012) 022301 [13 cites]
11. HIN-11-002 (photons): PLB 710 (2012) 256 [10 cites] *
12. HIN-11-004 (jet FF): JHEP (accepted) [4 cites]
13. HIN-11-008 (W): PLB 715 (2012) 66 [2 cites] *

14. HIN-11-003 ($dE_T/d\eta$): PRL [5 cites]
15. HIN-11-010 (γ-jet): PLB [7 cites]
16. HIN-10-002 (v_2 flow): PRC [9 cites]
17. HIN-11-011 (Υ): PRL [0 cites] *
18. HIN-11-009 (π^0 v_2) : PRL [0 cites]

** “French” contact or author
* Or significant contribution

http://aliceinfo.cern.ch/ArtSubmission/publications
If up to date, as many as ALICE ?!...

+10 documented preliminary results (Etretat 2012)

- HIN-12-007 (Ψ(2S)) **
- HIN-11-005 (v_n flow)
- HIN-12-008 (Z in 2011) **
- HIN-12-011 (UCC flow)
- HIN-12-004 (jet R_{AA})
- HIN-12-006 (CASTOR energy flow)
- HIN-12-014 (J/Ψ with 2011 data) **
- HIN-12-003 (b-jets) **
- HIN-12-010 (high-p_T dihadron corr)
- HIN-12-013 (jet fragmentation)

** “French” contact or author
* Or significant contribution

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