Эксперимент ALICE в 2012 году

Е. Крышень

Научная сессия ОФВЭ

25 декабря 2012

Contents

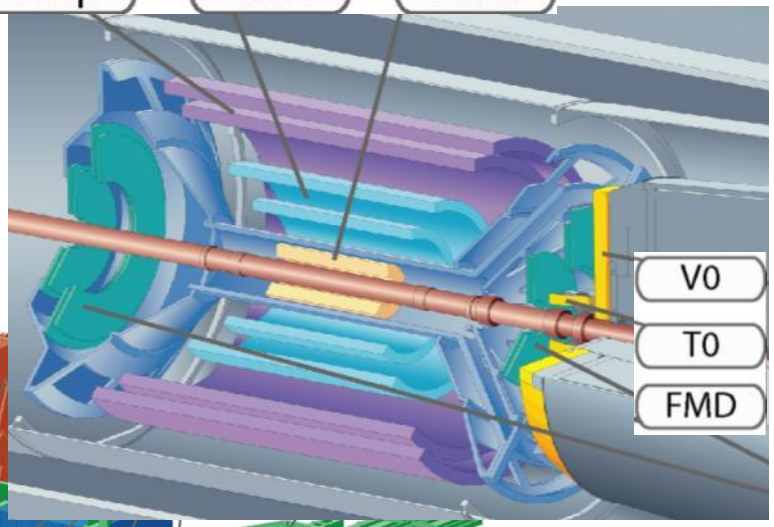
- ALICE data taking in 2012
- PNPI in ALICE data taking
- PNPI in ALICE data analysis
  - J/ψ in Pb-Pb UPC with muon arm
  - J/ψ in Pb-Pb UPC with central barrel
  - Preparation to J/ψ in p-Pb UPC
  - $\omega \rightarrow \pi^+\pi^-\pi^0$
  - $\phi \rightarrow K^+K^-$ w/o PID
  - $\rho, f^0 \rightarrow \pi^+\pi^-$
- Future plans and upgrade perspectives
- PNPI in ALICE upgrade
- Conclusions

…. Major heavy ion results will be discussed after lunch

ALICE experimental setup

Detector:
Length: **26** meters
Height: **16** meters
Weight: **10,000** tons

Central Barrel
2 π tracking & PID
$|\eta| < 1$



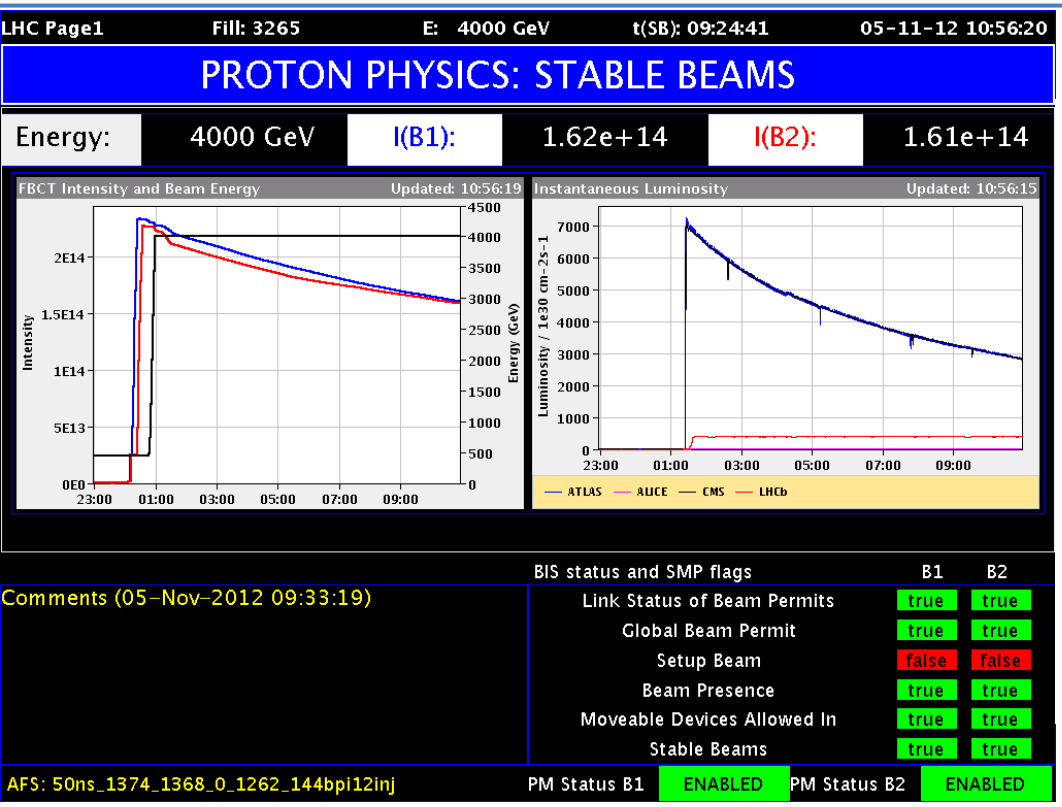
ACORDE
EMCAL
TRD
HMPID
ZDC
~116m from I.P.
PMD
V0
TPC
TRIGGER
CHAMBERS
ZDC
~116m from I.P.
TOF
PHOS
ITS
DIPOLE
MAGNET

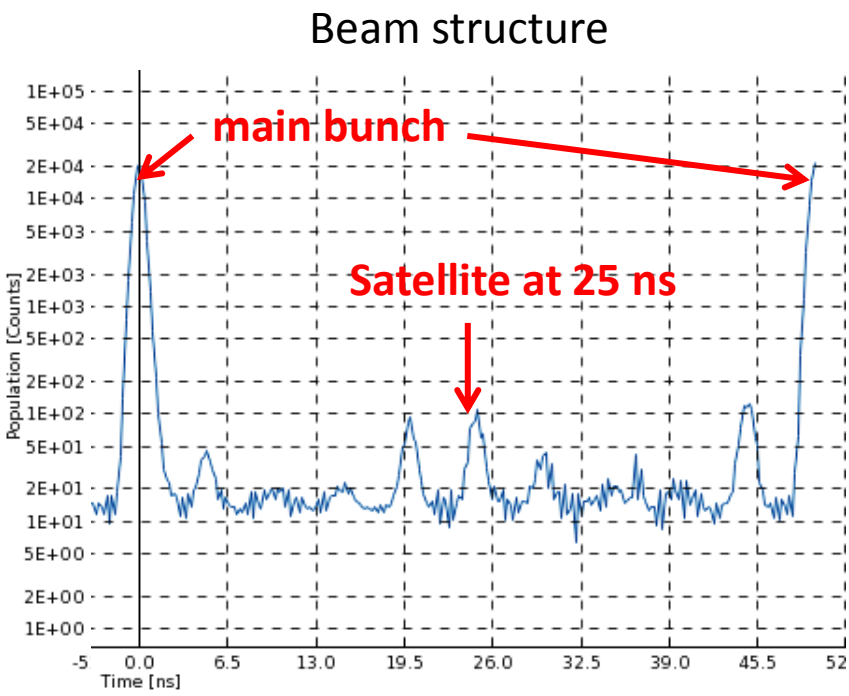
V0 (centrality)
η: -1.7– -3.7, 2.8–5.1
T0 (timing)
ZDC (centrality)
FMD (N_{ch} -3.4<h<5)

Muon Spectrometer
$-2.5 > \eta > -4$

Collaboration:
> **1000** Members
> **100** Institutes
> **30** countries

Data taking in 2012

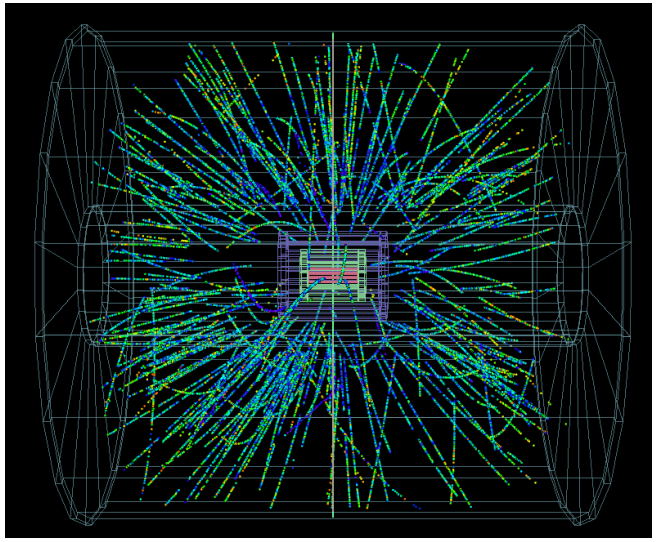




- Typical filling scheme: 50ns_1374_1368_0_1262_133bpi12inj: 0 colliding bunches in ALICE!
- Main-satellite collisions: low pile-up (μ<0.01, ~2000 main-satellite bunches)
- Too small luminosity ~1-2 Hz/ub – > 3 orders of magnitude less than in CMS/ATLAS. Satellite population enhanced starting from October. Lumi up to 10 Hz/ub
- Background issues: often impossible to bring up detectors due to high beam-gas interaction rate
- Had to wait several hours after declaration of stable beams

ALICE Data taking harvest

- Data taking in 2012
  - Long p-p run at 8 TeV:
    - ✓ minimum bias for soft physics and D-mesons (300M events)
    - ✓ High-multiplicity
    - ✓ neutral jet, charged jet, γ, electron
    - ✓ di-muon, single muon (~4 pb^{-1})
    - ✓ ultra-peripheral
  - 1 day p-Pb pilot run (1.8 M min. bias)
    - ✓ 3 papers already submitted (multiplicity, R_{pA}, dihadron correlations)
- Plan for 2013: p-Pb, Pb-p measurements (above 30 nb^{-1} expected)



PNPI in ALICE data taking

Участие в поддержке работоспособности мюонной трекерной системы

- Участие в ремонтных работах во время новогоднего перерыва (2 человеко-месяца)
- Отработано 70 смен на уровне эксперта

Участие в работе триггерной группы

- Отработано 23 смены на уровне эксперта по центральному триггерному процессору
- Участие в координации триггерной системы ALICE:
  - разработка стратегии ALICE триггера
  - подготовка триггерных меню для pp2012, pilot pA, pA2013
  - разработка и поддержка триггерной базы данных
  - координация относящихся к триггеру проблем в анализе
  - анализ набранной и планируемой триггерной статистики

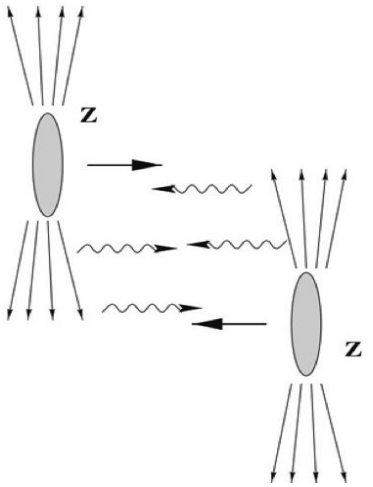
Участие в поддержке системы онлайн-мониторинга качества данных (DQM)

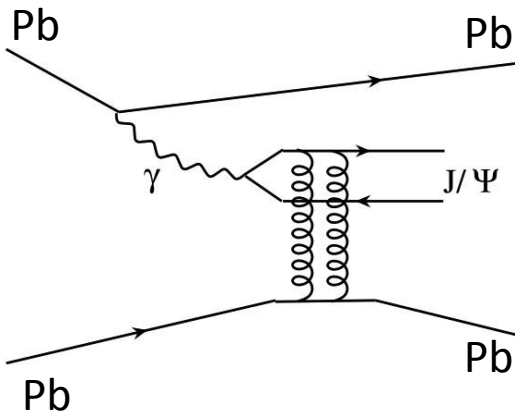
- Отработано 42 смены на уровне эксперта
- Разработка и поддержка мониторинга триггерных данных

Участие в наборе данных

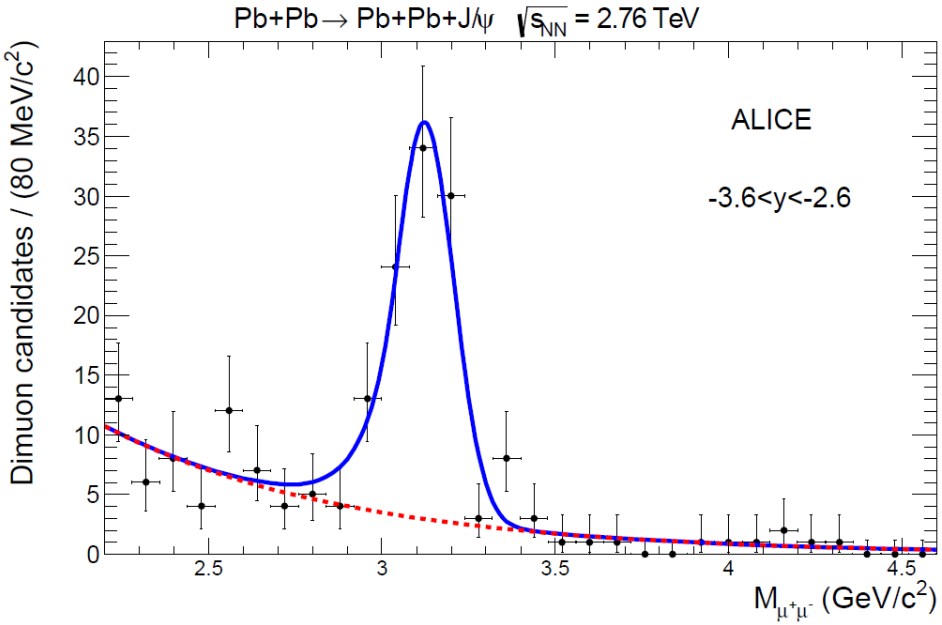
- X DAQ and DQM shifts

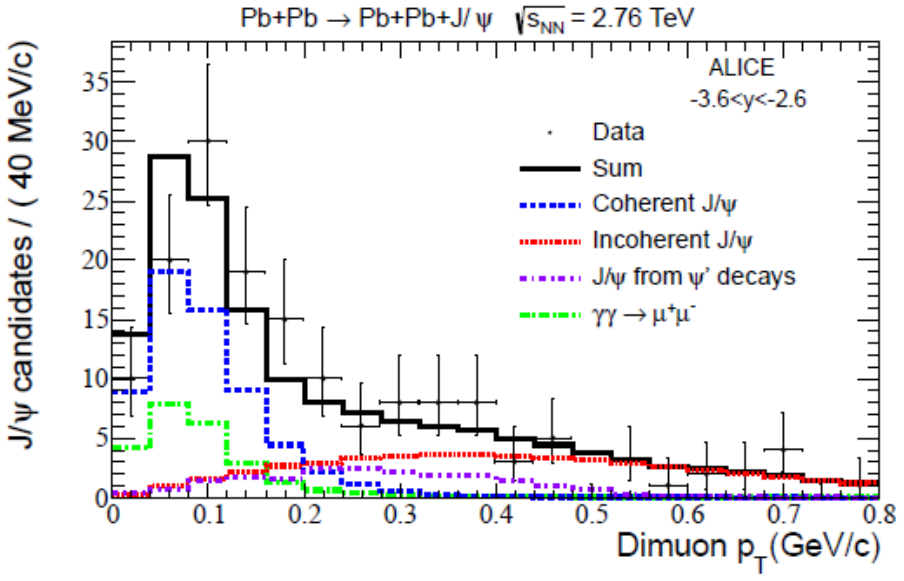
J/ψ in UPC with muon arm





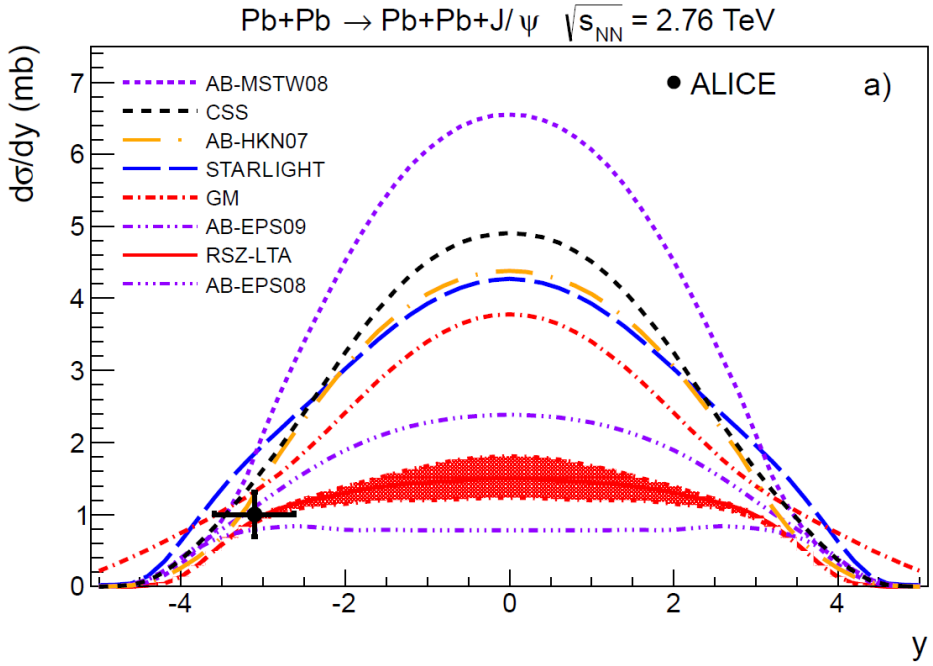
- Ultra-peripheral (UPC) heavy-ion collisions: impact parameter b larger than sum of the two radii 2R
  → hadronic interactions strongly suppressed
- high photon flux ~ Z^2
  → high σ for γ-induced reactions
- Coherent J/ψ cross-section sensitive to nuclear gluon shadowing

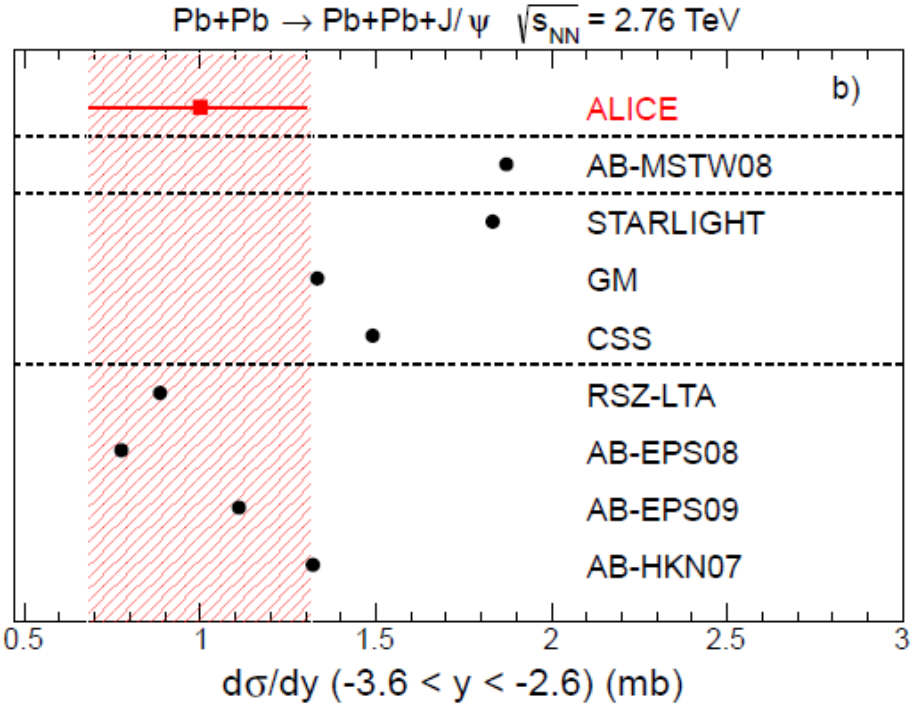




J/ψ in UPC with muon arm

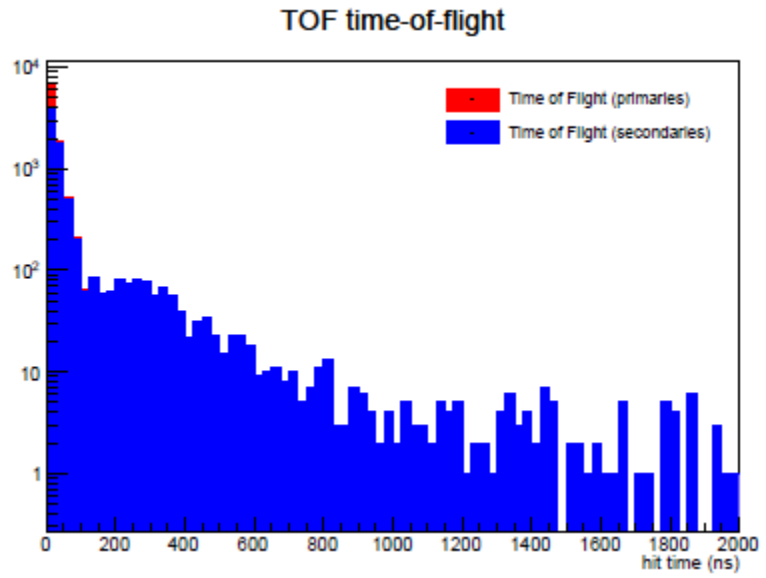
- ALICE Internal Note 2012: J. Adam, V. Canoa, J. G. Contreras, E. Kryshen, M. Rodriguez and J. D. Tapia Takaki. “Coherent J/psi photoproduction in ultra-peripheral Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV”.
- Preprint (accepted in PLB): B. Abelev et al (ALICE collaboration). “Coherent J/ψ photoproduction in ultra-peripheral Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV.” e-Print: arXiv:1209.3715 [nucl-ex]
- Data in good agreement with pQCD models which include gluon shadowing

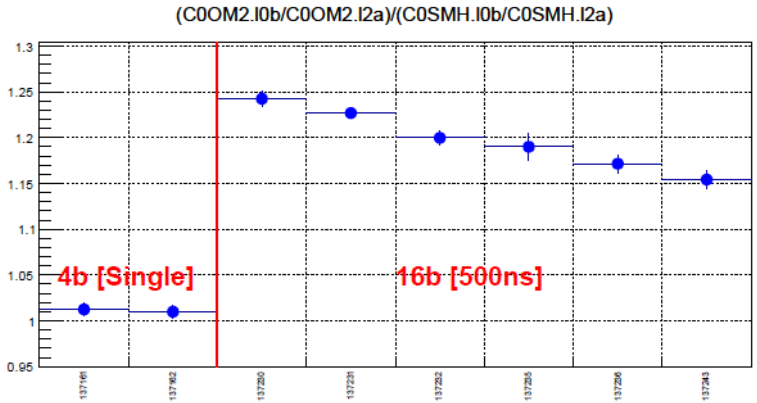




Luminosity for central barrel UPC

- Central barrel UPC triggers: ρ in 2010, J/ψ in 2011
- Involve vetoes on V0A and V0C (forward and backward scintillators)
  + minimal requirement in SPD and TOF
- SPD and TOF triggers suffer from afterpulses and remnants from previous PbPb collisions
  → high rate of spurious triggers
  → nontrivial dependence on filling scheme
  → difficult to estimate integrated lumi with standard methods
- Special luminosity determination method developed
- Trigger simulation package has been developed to emulate real data taking environment
- Systematic uncertainties carefully evaluated
- Dead time effects well understood, systematic uncertainties below 1%

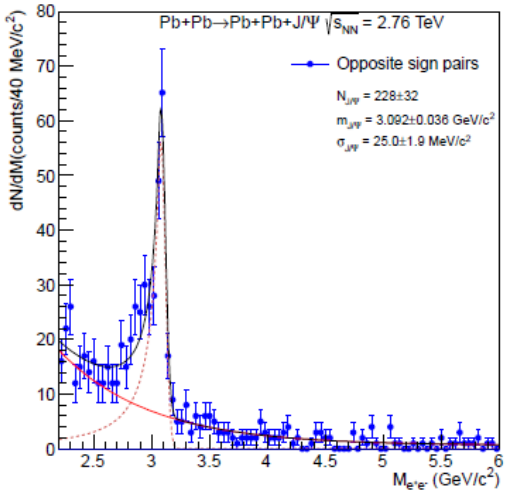


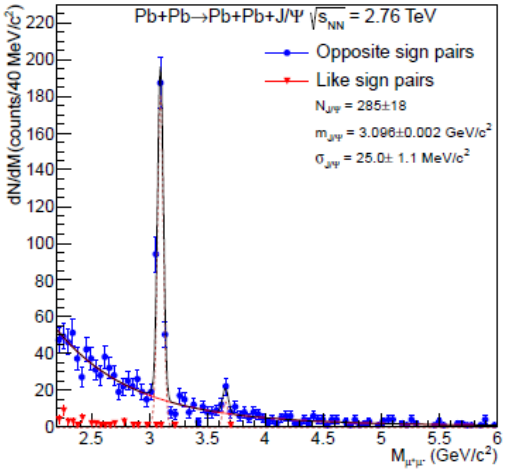


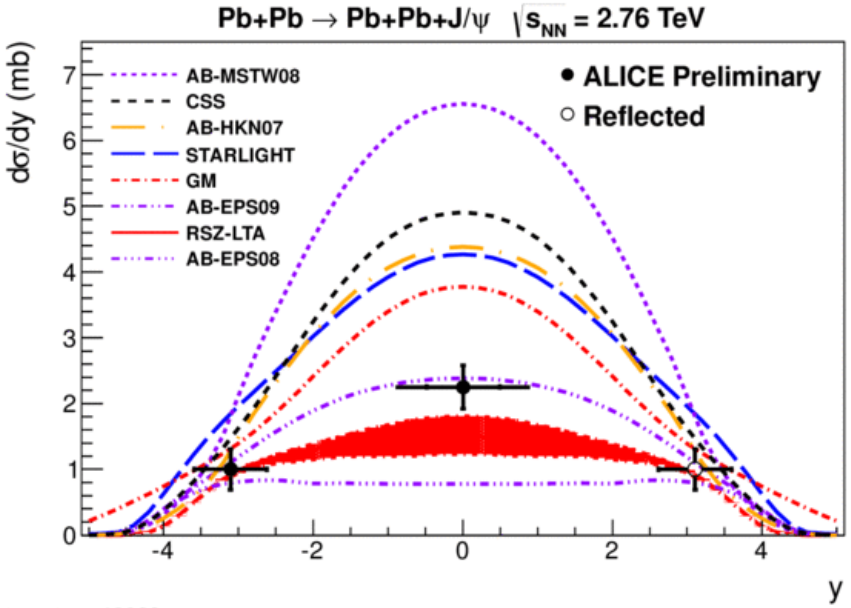
ALICE internal note submitted: C. Mayer, E. Kryshen.
Luminosity Determination for Central Barrel UPC Triggers in Pb-Pb runs

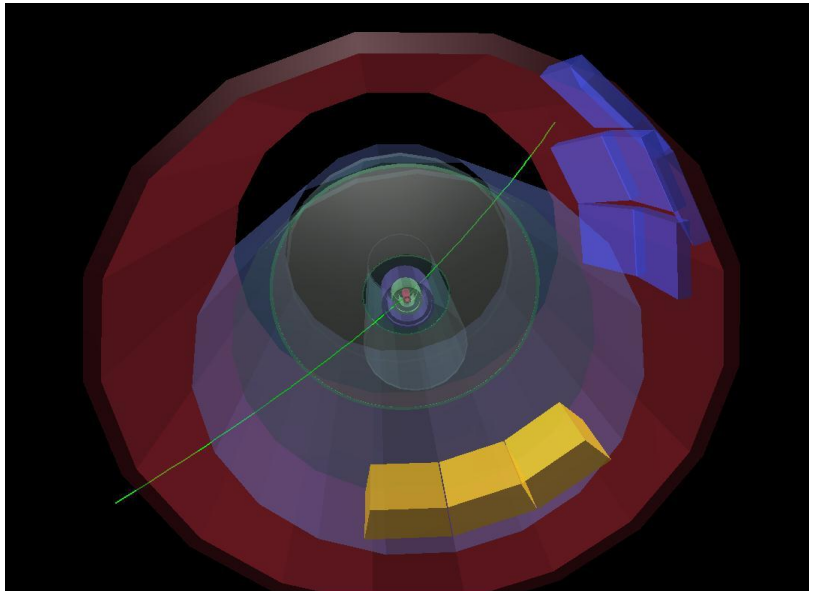
J/ψ in UPC with central barrel

- Both J/ψ→μμ, J/ψ →ee
- Extracted contributions from γγ →μμ and contamination from ψ’ and incoherent J/ ψ
- Preliminary results consistent with EPS09 nPDFs. Evidence for the strong nuclear gluon shadowing





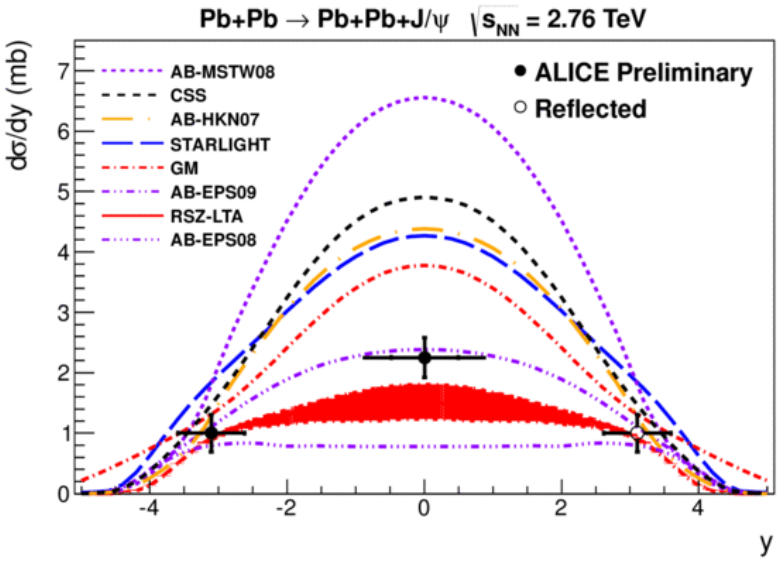


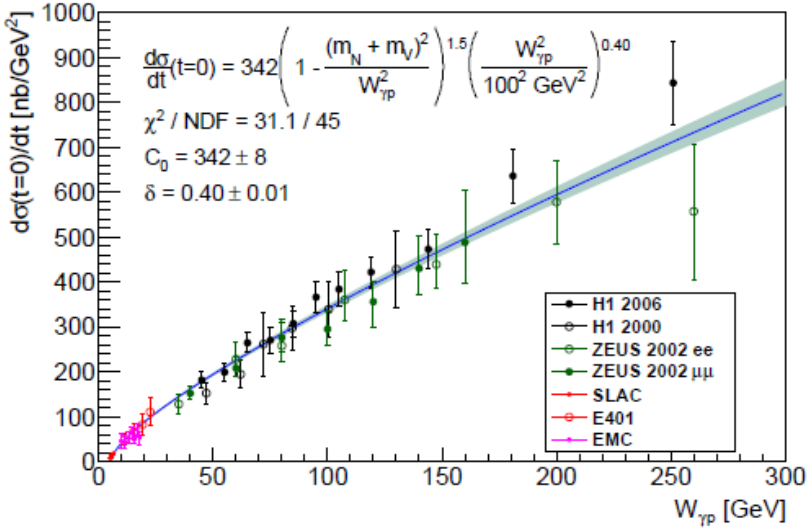


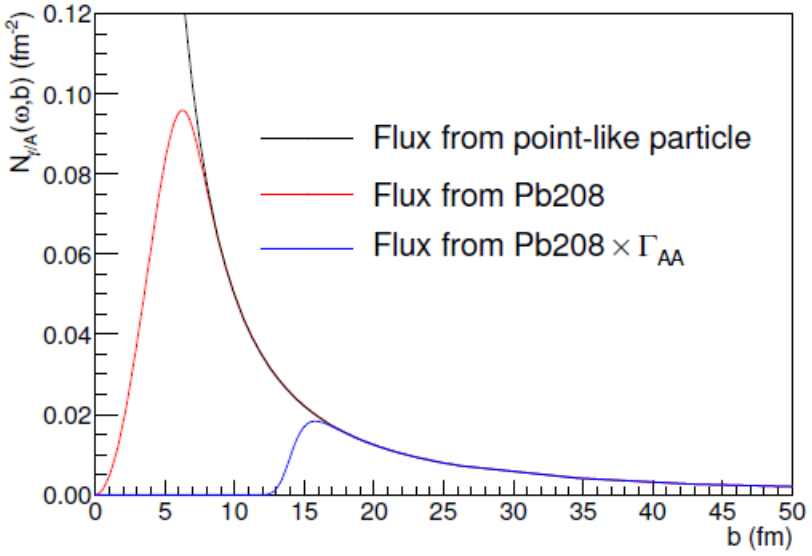
Analysis of UPC results

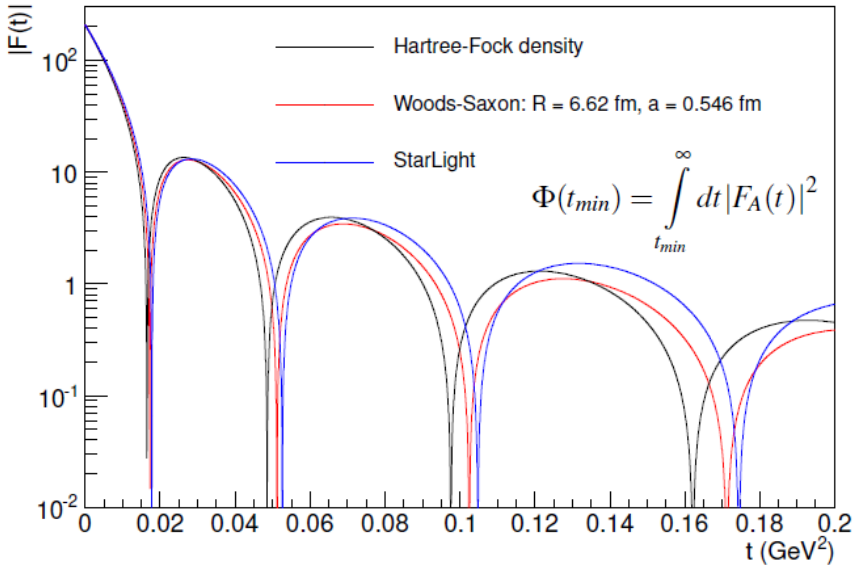
$$\frac{\sigma_{AA\to AAJ/\psi}(y)}{dy} = N_{\gamma/A}(y)\sigma_{\gamma A\to AJ/\psi}(y) + N_{\gamma/A}(-y)\sigma_{\gamma A\to AJ/\psi}(-y)$$

$$\sigma^{IA}_{\gamma Pb\to PbJ/\psi}(W_{\gamma p}) = \frac{d\sigma_{\gamma p\to J/\psi p}(W_{\gamma p}, t=0)}{dt}\Phi(t_{min})$$









Analysis of UPC results

- **Nuclear suppression factor:**

$$S(W_{\gamma p}) = \frac{\sigma^{\rm exp}_{\gamma Pb\to PbJ/\psi}(W_{\gamma p})}{\sigma^{\rm IA}_{\gamma Pb\to PbJ/\psi}(W_{\gamma p})} \qquad \begin{aligned} S(W_{\gamma p} = 19.6\ {\rm GeV}) &= 0.55^{+0.16}_{-0.18}, \\ S(W_{\gamma p} = 92.4\ {\rm GeV}) &= 0.36 \pm 0.05. \end{aligned}$$

- Suppression factor in Starlight

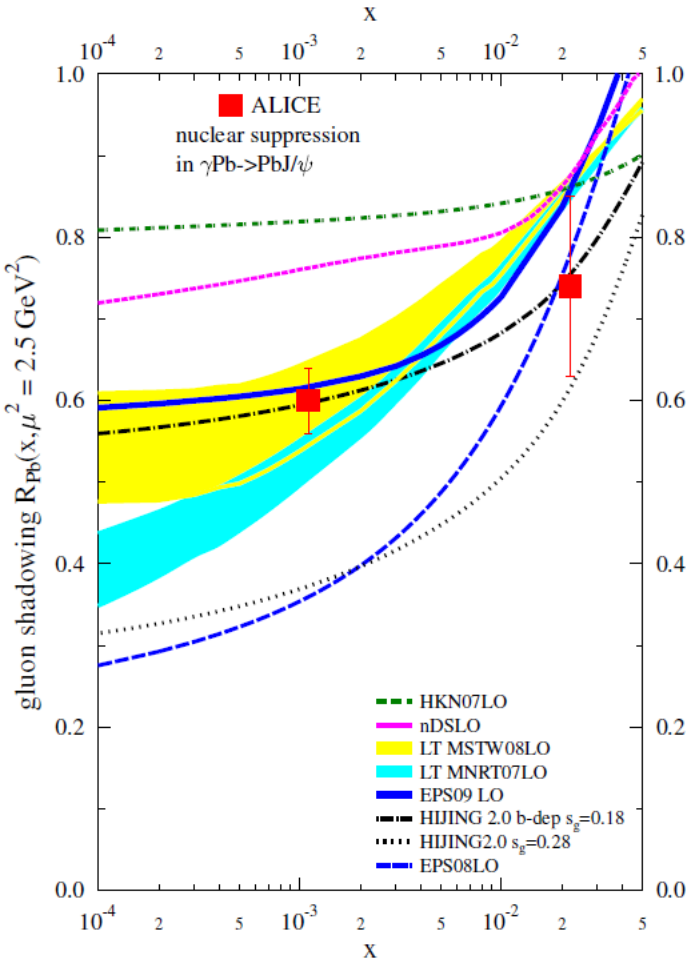
$$S^{\rm SL}(W_{\gamma p}) = \left[\frac{\sigma_{J/\psi A}(W_{\gamma p})}{A\sigma_{J/\psi N}(W_{\gamma p})}\right]^2 \qquad \begin{aligned} S^{\rm SL}(W_{\gamma p} = 19.6\ {\rm GeV}) &= 0.91 \\ S^{\rm SL}(W_{\gamma p} = 92.4\ {\rm GeV}) &= 0.84 \end{aligned}$$

much weaker cross section predicted.

- Suppression factor in LO pQCD:

$$S^{\rm pQCD}(W_{\gamma p}) = \left[\frac{G_A(x,\mu^2)}{AG_N(x,\mu^2)}\right]^2 = \left[R(x,\mu^2)\right]^2$$

$$\begin{aligned} R(x = 0.022, \mu^2) &= \sqrt{S(19.6\ {\rm GeV})} &&= 0.74^{+0.11}_{-0.12}, \\ R(x = 0.001, \mu^2) &= \sqrt{S(92.4\ {\rm GeV})} &&= 0.60 \pm 0.04. \end{aligned}$$



- Strong nuclear shadowing: in agreement with LTA, HIJING2.0 b-dependent parameterization and central set EPS09LO

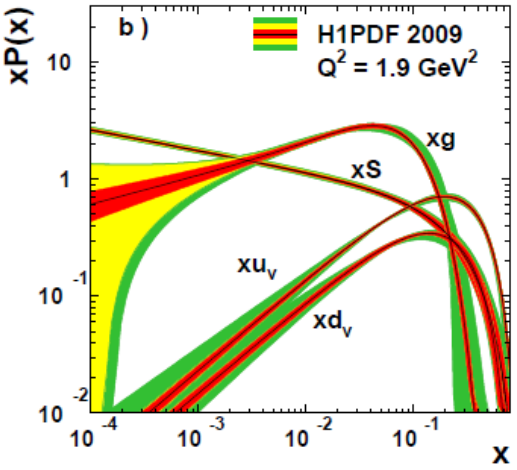
ALICE internal note submitted: E. L. Kryshen, M. B. Zhalov. *Evidence for the strong nuclear gluon shadowing from the ALICE measurement of the ultra-peripheral J/ψ production at central rapidity at* $\sqrt{s_{NN}}$ *= 2.76 GeV.*

pA physics potential: J/ψ in UPC

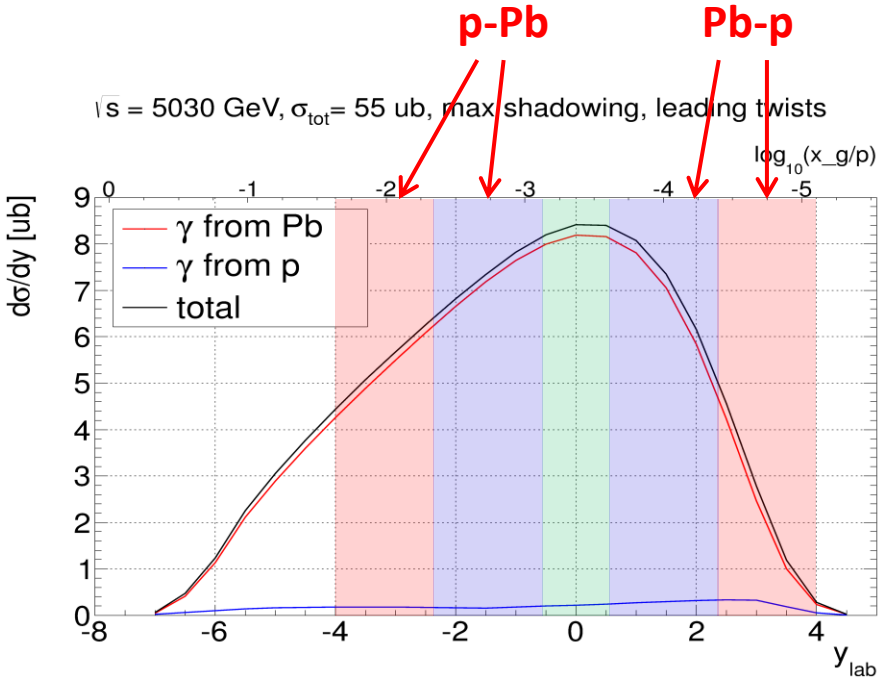
- High flux from Pb → large cross section of J/ψ photoproduction on p
- Allows to study gluon PDFs in proton up to very small x (~10^{-5}):

$$\frac{d\sigma_{\gamma p\to pJ/\psi}}{dt} = \frac{\Gamma_{ee}M_{J/\psi}^3\pi^3}{48\alpha_{em}}\cdot\frac{\alpha_S^2(\bar{Q}^2)}{\bar{Q}^8}\left[xg_N(x,\bar{Q}^2)\right]^2\exp[B_{J/\psi}(s)t]$$

- Gluon PDF up to x~10^{-4} extracted from J/psi photoproduction at HERA.
- UPC J/psi production measured in CDF at midrapidity (x~10^{-3}). Consistent with HERA results.



- σ_{tot} (5030 GeV) ~ 55 ub
- L_{int} = 30 nb^{-1} ⇒ 99k J/psi →μμ decays
- No two fold ambiguity: small contribution from J/psi produced on Pb: can be removed by pt cut
- 3 options:
  - Forward: both muons in the muon arm
  - Central: Both muons/electrons in the barrel
  - Semi-forward: one muon in the muon arm, second in the barrel
- Wide x coverage: 10^{-2} -10^{-5}
- MC generator (model by Zhalov et al) developed
- Realistic simulations performed
- Trigger strategy proposed for 3 options



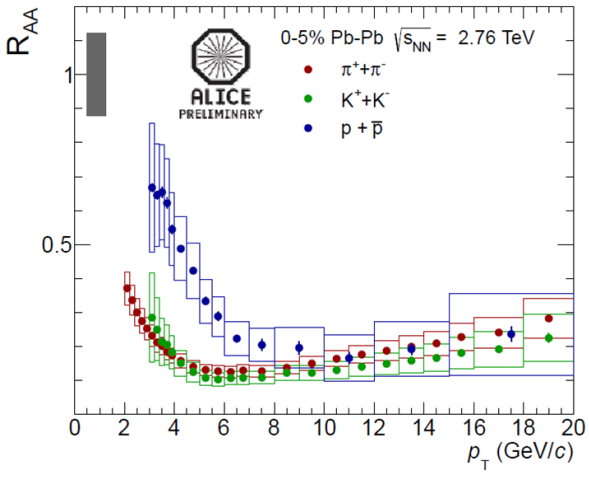
ω and ϕ: motivation

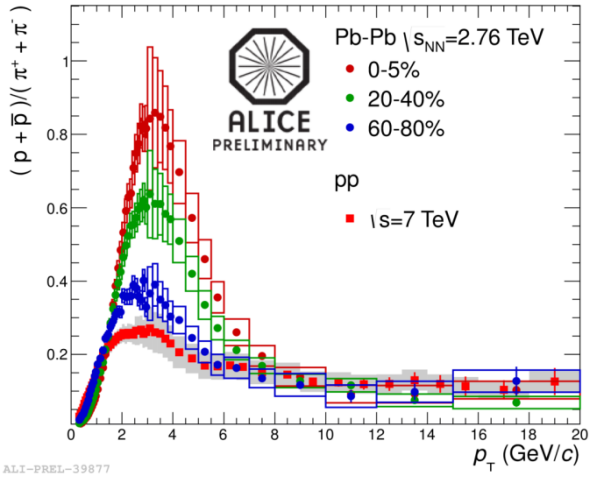
In pp:

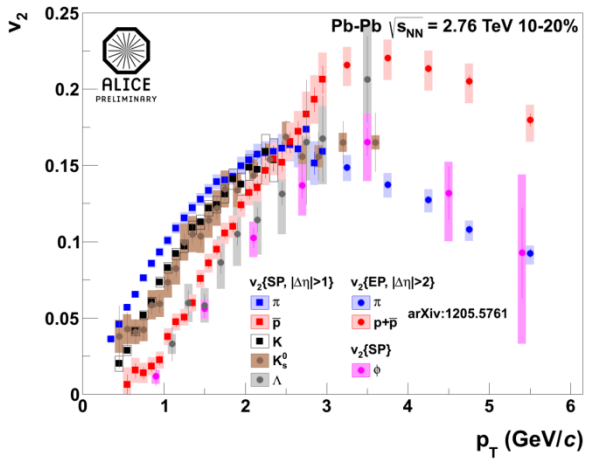
- Measurement of ω/φ contributes to precision tests of the pQCD at high p_T, currently available parameterizations for fragmentation functions.
- ω /φ is an important component of different cocktails crucial for HF lepton and direct γ studies.
- ω /φ results can also be used for tuning of the MC generators of hadronic interactions used in HEP.

In AA:

- High-pt (> 7 GeV/c): particle production dominated by jet fragmentation. ALICE: π/K/p - indications of no modification of jet fragmentation functions + strong charm suppression same as π/K/p… ω and ϕ → valuable input for jet quenching chemistry.
- Intermediate pt (2-7 GeV/c): complicated picture: bulk production from recombination (hydrodynamics, flow) + jet fragmentation. Hierarchy of R_{AA} and v_2 for identified particles sensitive to recombination mechanisms (thermalized quarks, hadrons?).
- Identified particle flow: mass ordering, NCQ scaling at high pt?



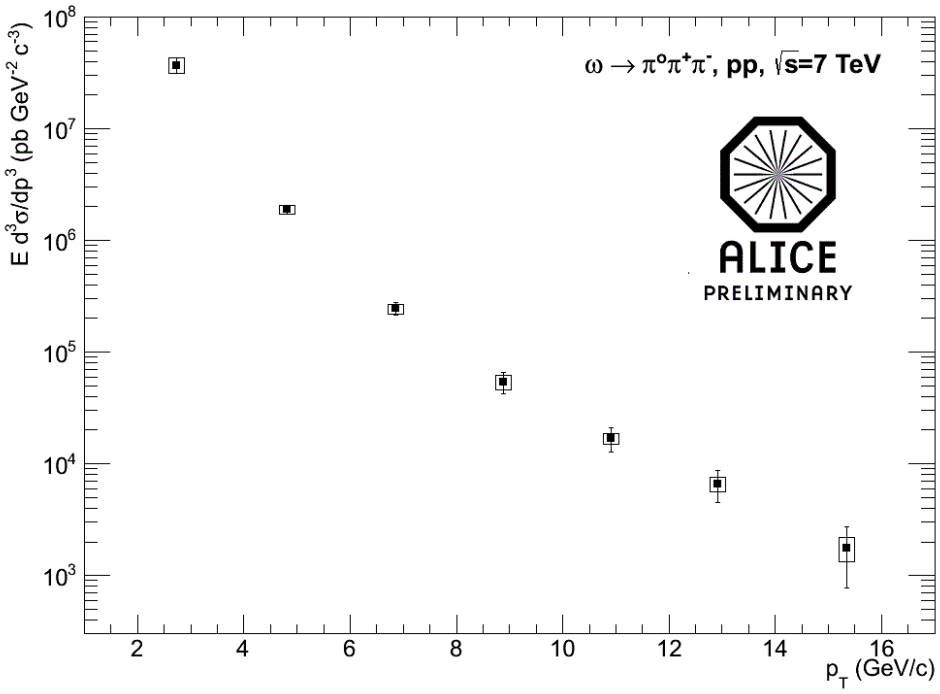


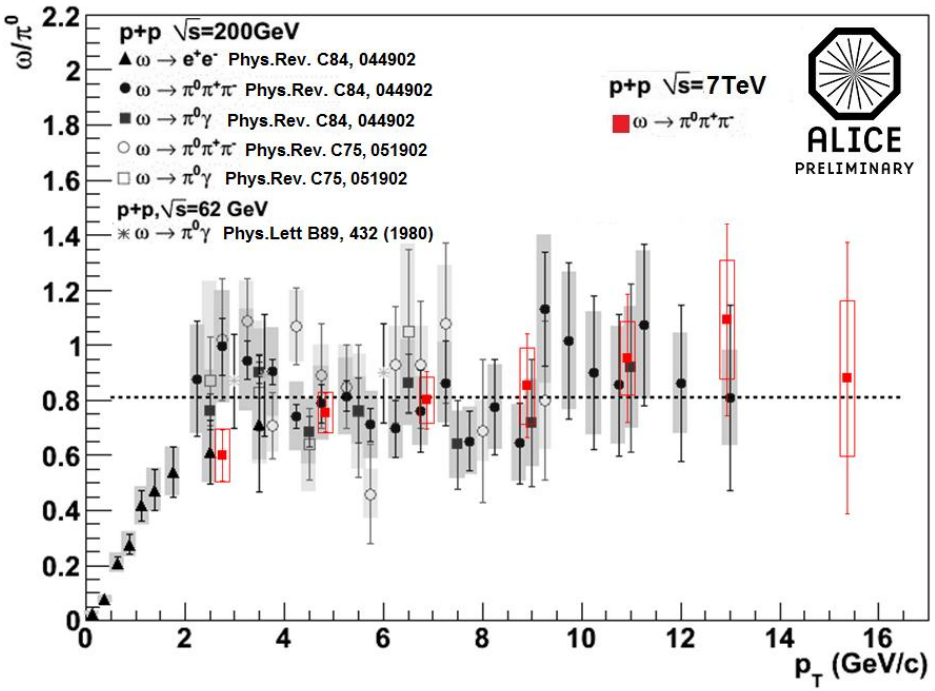


$\omega \rightarrow \pi^0\pi^+\pi^-$ in pp @ 7 TeV

- Analysis based on minimum bias data from pp 2010
- First analysis in ALICE combining charged particle tracking and EMC:

  $\pi^+\pi^-$ in central barrel (ITS, TPC), $\pi^0 \rightarrow \gamma\gamma$ in PHOS
- Invariant differential production cross section extracted up to 16 GeV/c
- ω/π^0 ratio: no p_T dependence, no dependence on collision energy (from few GeV up to 7 TeV)

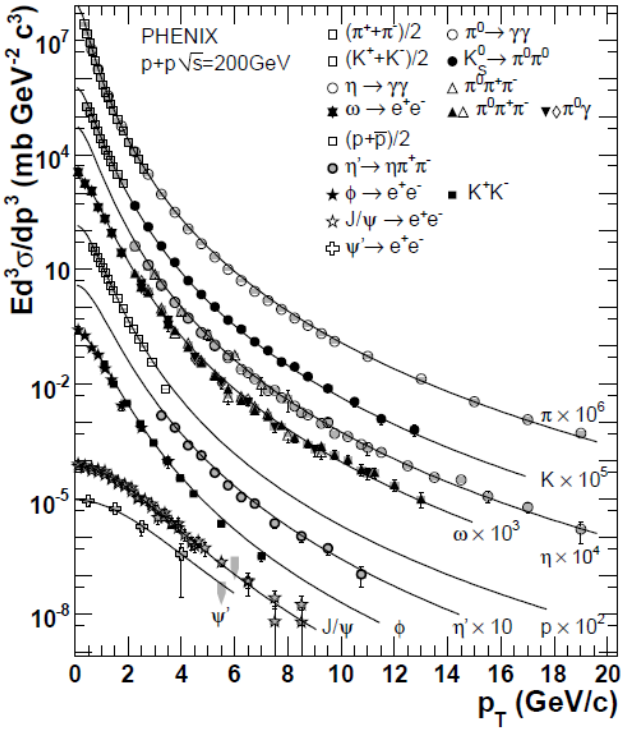


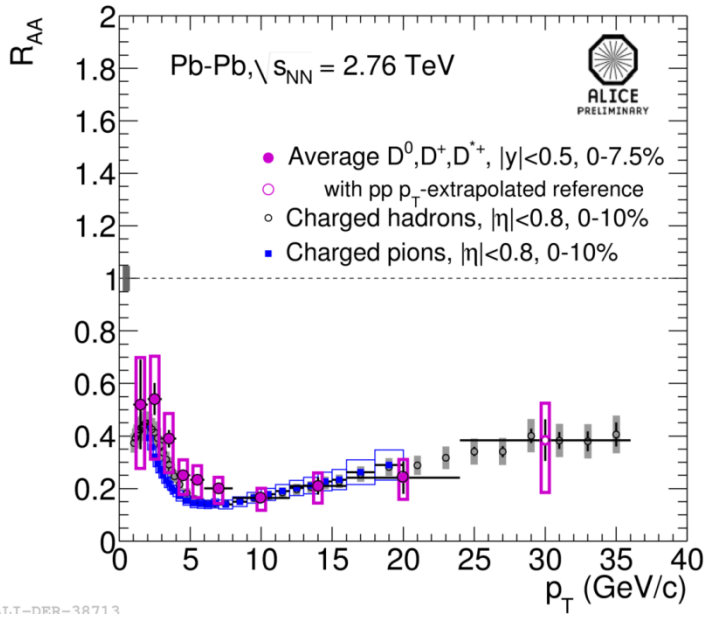


Analysis note: M. Malaev, V. Riabov and Yu. Riabov.
"Omega production measured in the $\pi^0\pi^+\pi^-$ channel in pp collisions at 7 TeV"

Work in progress…

- PbPb2011 and pp @ 2.76 TeV – work in progress
- Decay channels involving γ reconstructed in calorimeters allows to cover much higher p_T range not accessible for identified charged particles
- γ trigger allows to integrate much higher luminosity than accessible by minimum bias trigger (PHOS trigger in pp2012 very promising)

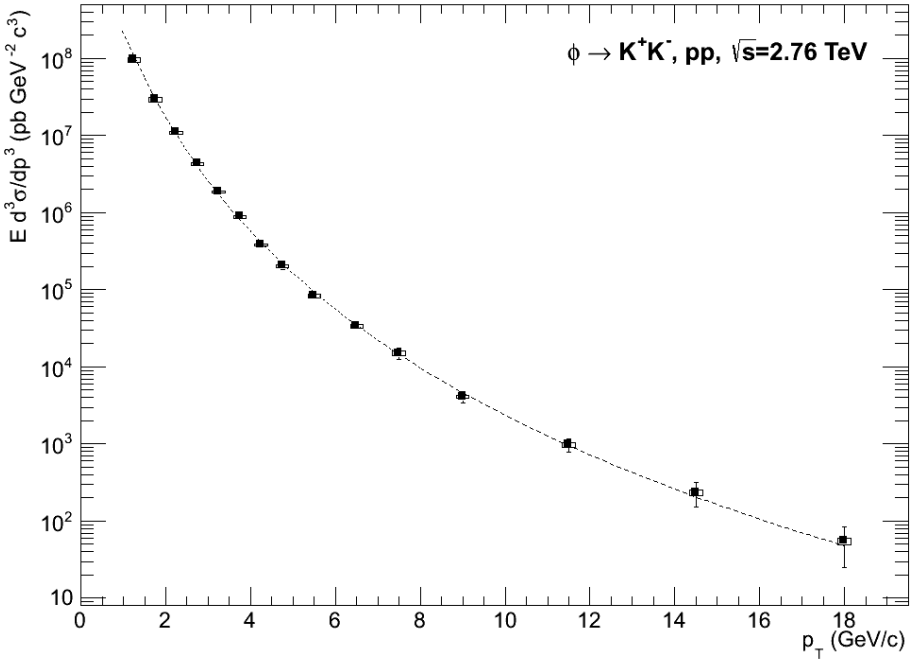


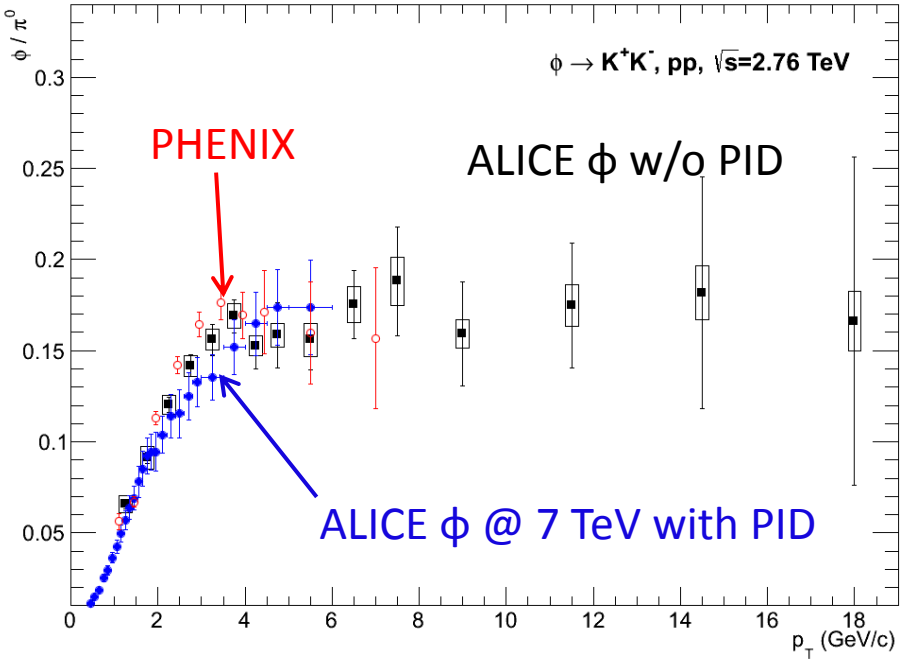


- Main interest: D→ π^0Kπ
- Reconstruction of charged decays of D mesons is based on minimum bias data sample → limited p_T reach (no chance to extend it before LS2)
- γ trigger allows to extend D-meson pt reach → study charm suppression at high p_T

$\phi \rightarrow K^+K^-$ w/o PID

- pp @ 2.76 TeV (PbPb reference)
- Very preliminary results
- $\phi \rightarrow h^+h^-$. No PID requirement allows to extend pT reach
- Invariant differential production cross section extracted up to 18 GeV/c
- Consistent with results obtained with PID and PHENIX data

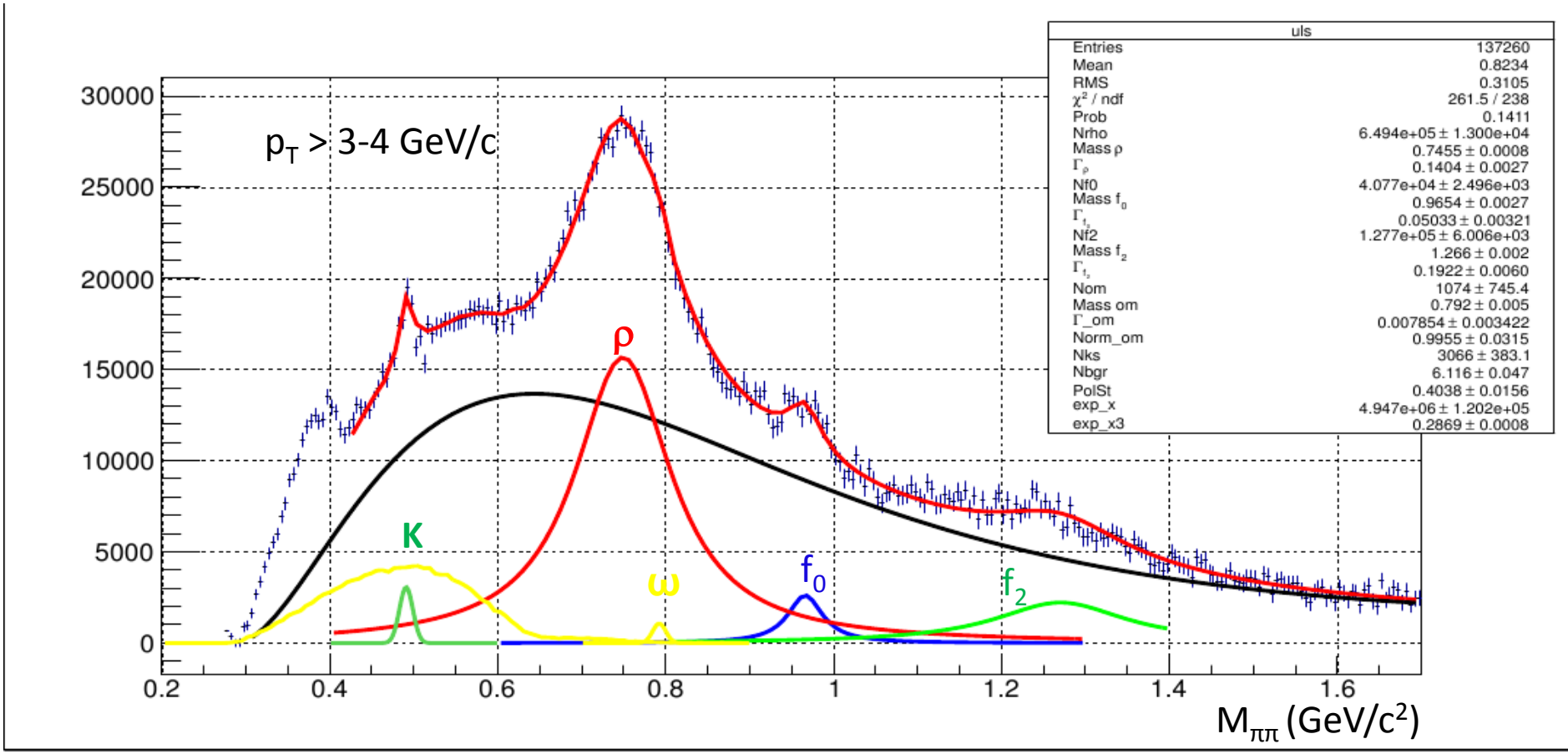




$\rho, f \rightarrow \pi^+\pi^-$

Мотивация:

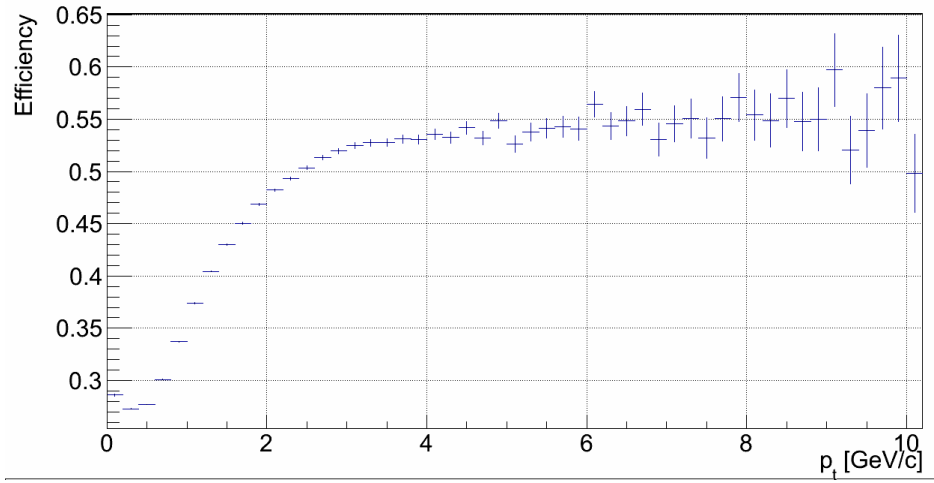
- Измерение выходов ρ и f0 мезонов позволяет улучшить настройку моделей, основанных на КХД
- Модификация ширины и массы резонансов может сигнализировать о частичном восстановлении киральной симметрии;
- Фактор ядерной модификации f0 резонанса чувствителен к его кварковой структуре;

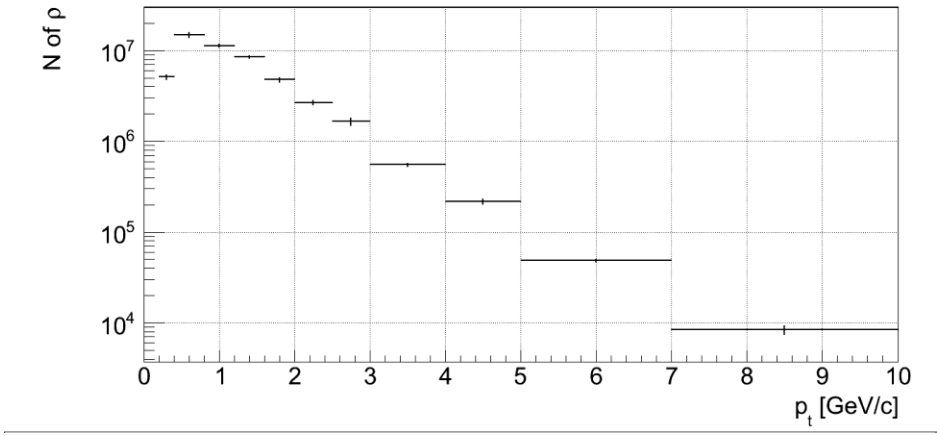


ρ,f →π⁺π⁻: results

Статус:

- Проанализированы данные pp 2010 года;
- Анализ распределения по инвариатной массе проводился с использованием коктейля частиц (ρ, f_0, f_2, ω→3π, ω → 2π, K);
- Проведено MC моделирование, получены распределения эффективности vs p_T
- Получены значения для масс, ширин и выходов частиц для ρ, f_0 и f_2-мезонов в диапазоне по поперечному импульсу от 0.2 до 10 ГэВ/c^2;





Планы:

- Анализ данных 2011 года pp@2.76 ТэВ и PbPb@2.76 ТэВ;
- Получение факторов ядерной модификации;

LHC and ALICE schedule

LHC Phase 0

- 2010-11: long run with p-p collisions at 7 TeV, 1 month/year Pb-Pb
- 2012: long run with p-p at 8 TeV ⇐ **we are here**
- 2013: 1 month p-Pb control measurement

LHC LS1 (long shutdown 1)

- 2013-14: LHC consolidation and training
  ALICE detector completion and upgrades

LHC Phase 1

- 2015-17: p-p and Pb-Pb at full energy (+ probably Ar+Ar, p-Pb)
  start ALICE upgrade during last p-p run before LS2 (optional)

LHC LS2

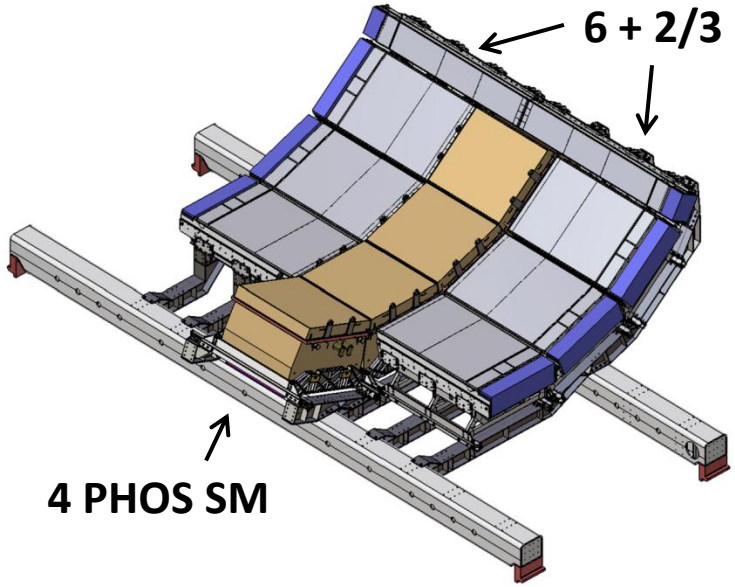
- 2018: LHC luminosity upgrades
  ALICE detector upgrades

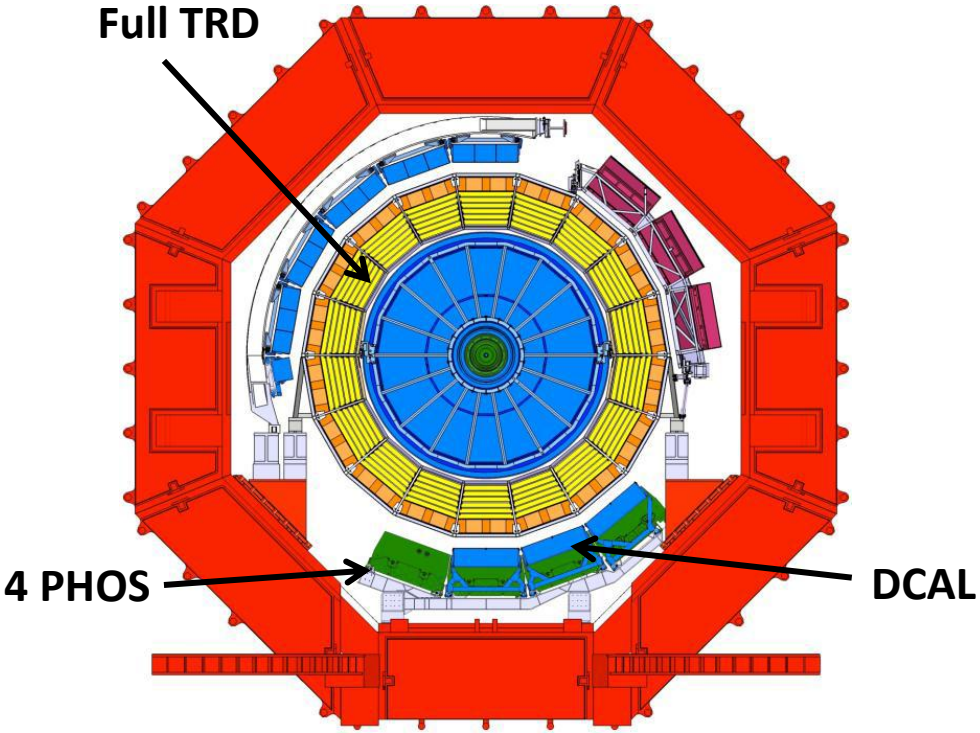
LHC Phase 2

- 2019-22: p-p and Pb-Pb at full energy at High-Luminosity LHC

ALICE LS1 upgrade

- complete **PHOS** (PWO)
- complete **TRD**
- consolidate jet capability by introducing **EMCal (DCAL)** at opposite position to the current EMCal





ALICE LS2 upgrade strategy

LoI completed and endorsed by LHCC

Goal: multi-dimensional, low p_T obsevables with unprecedented stat. and syst. accuracy:

- Record 100 times more statistics: (10 nb^{-1}), O(10^{10}) central collisions
  - LHC rate after upgrade up to 50 kHz Pb-Pb (i.e. L ~ $6x10^{27}$ $cm^{-1}s^{-1}$ … factor 10 more)
  - present ALICE: < 500Hz at 50% trigger dead time
    → in realistic trigger setup, only 10% of min.bias can be recorded
  - need to record all minimum bias (pipeline, continuous readout) … no trigger!
  - requires high-rate upgrade for the detectors (including MWPC → GEMs in TPC)
  - requires new DAQ and HLT systems
- Improve vertexing and tracking at low p_T:
  - new, smaller radius beam pipe
  - new inner tracker (ITS)

Plan:

- run 6 years with upgraded detector, i.e. until 2026
- including low B-field run & p-A control run

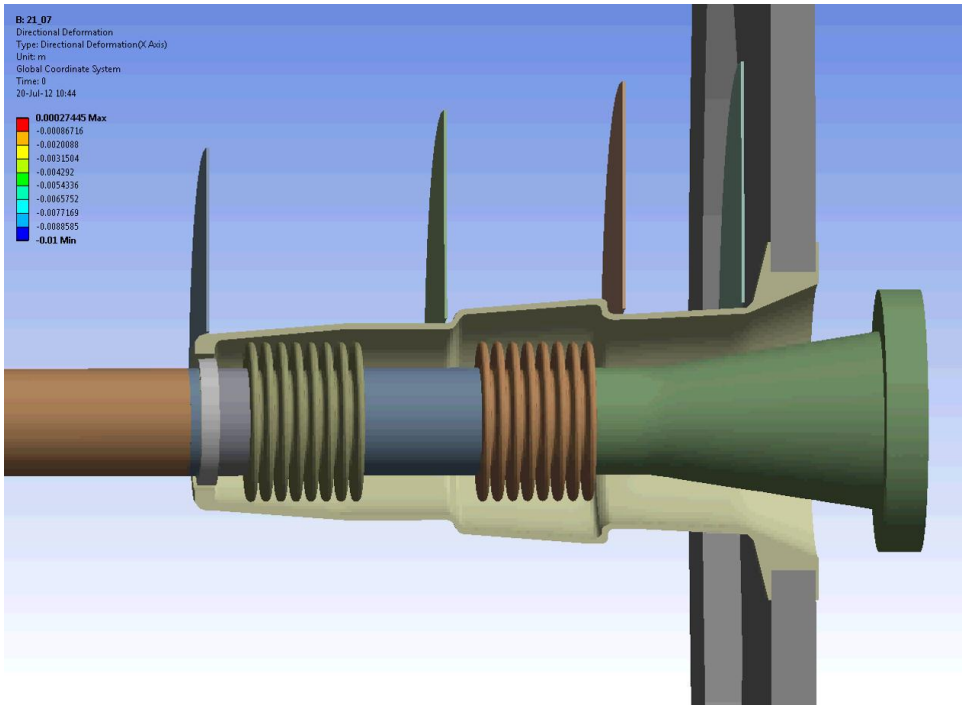
Also extending physics scope is under discussion:

- VHMPID: new high momentum PID capabilities
- MFT: b-tagging for J/ψ, low-mass di-muons
- FoCAL: low-x physics with identified γ/π^0

PNPI in ALICE upgrade

MFT: Разработка поддержки пучковой трубы

- Предложенная конструкция поддержки, крепится на TPC и фиксирует положение трубы с помощью конусоподобной консоли
- В таком подходе МФТ может быть легко извлечен вслед за ITS, таким образом будет доступен во время коротких (рождественских) остановок БАК
- Поддержка предусматривает возможные поперечные смещения поглотителя мюонного спектрометра до +/-10 мм, причем результирующие деформации трубы не превысят заданные 1 мм
- Поддерживающий конус планируется изготовить из Российского бериллия



Участие в модернизации триггера

- Подготовлена нота: E. Kryshen and B. von Haller, “Detector readout time and event size”
- Оценка скоростей счета и триггерного меню после модернизации
- Разработка требований на Центральный триггерный процессор

Conclusions

- ALICE performance in pp2012:
  - … could be better
  - looking forward to pA2013 data
  - clear upgrade strategy, promising perspectives
- Good performance and visibility of ALICE-PNPI team:
  - Experts in muon tracker, trigger, DQM
  - Long-anticipated analysis on J/ψ production in PbPb UPC completed
  - looking forward to interesting physics in pA UPC
  - Preliminary results on $\omega \rightarrow \pi^0\pi^+\pi^-$ in pp approved by ALICE
  - Finalizing results on φ, ρ, f^0 in pp
  - Next steps: ω, φ in PbPb; ω, D$\rightarrow \pi^0 K\pi$ with PHOS trigger
  - 5 internal notes
  - > 70 talks at internal meetings