

Fyzika těžkých iontů

Jaroslav Bielčík (FJFI ČVUT)

v spolupráci

Filip Křížek (ÚJF AV ČR), Martin Spousta (MFF UK), Ivan Králik (ÚEF SAV),
Marek Bombara (ÚJPŠ Košice),

Boris Tomášik, Jan Nemčík, Jan Čepila (FJFI ČVUT)

Obsah

- *Experimenty, jichž se CZ a SK komunity účastní*
 - ALICE na LHC
 - ATLAS těžké ióny na LHC
 - STAR, sPHENIX na RHIC
 - Electron-Ion Collider
 - Fenomenologie jadro-jadrových zrážok

(fyzikální program)

zhruba počty našich kolegů v těchto experimentech včetně studentů

zdroje financování

výhled do budoucna 2020+

Česká účast na experimentu ALICE

Počty pracovníků (stav k září 2018) - celkově 21 (Krizek, Sumbera, Bielcikova, Adamova, Kushpilova, Petracek, Contreras, Bielcik, Broz, Gajdosova, Zavada, Mares)

	Vědeční pracovníci	Postdoci	Ph.D. studenti	Diplomanti	Bakaláři	Technici
ÚJF AV ČR	5			2		1
FJFI ČVUT	3	2	2	3		
FzÚ AV ČR	2					1

Finanční podpora:

VI CERN

cesty do CERN, investice do infrastruktury, mzdy (příslib do konce roku 2022)

CERN computing (CERN-C)

investice do výpočetních kapacit, mzdy, cestovné na konference (do listopadu 2019)

INTERTRANSFER (LTT17018)

cestovné na konference (do konce roku 2021)

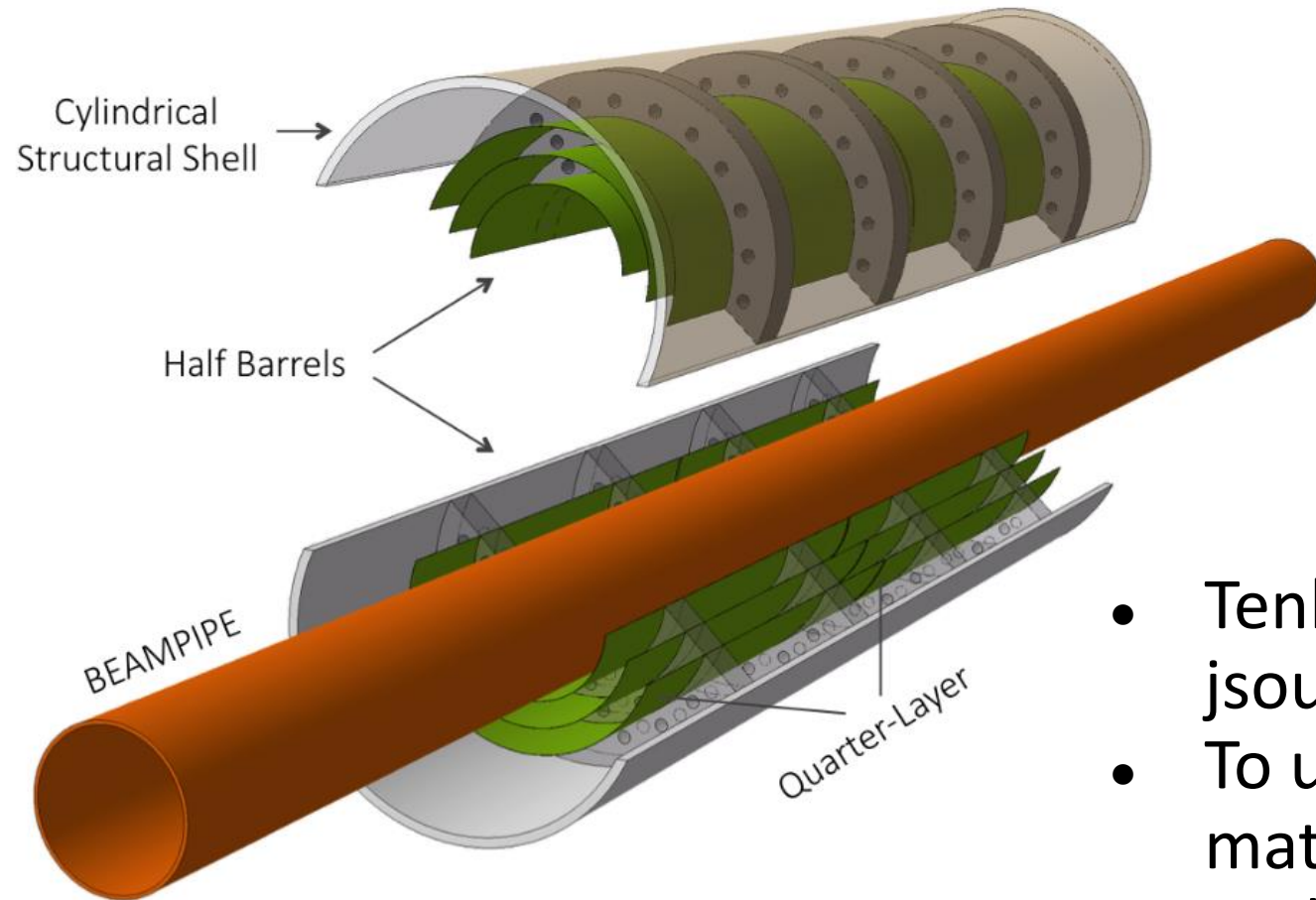
GAČR (Guillermo Contreras)

fotoprodukce J/psi (2018-2020)

Přehled aktivit v ALICE

- Účast na upgradech a provozu detektorů
 - **Inner Tracking System** : ÚJF, testy radiační odolnosti, charakterizace křemíkových senzorů, simulace. **V budoucnu plán podílet se i na ITS3.**
 - **AD** : FJFI vývoj softwaru, QA. **Plán vstoupit do MFT a provést inovaci AD**
 - **PHOS** : FzU v minulosti se podílel na stavbě detektoru
- Účast na analýze
 - **Jety** (ÚJF) v budoucnu větší důraz na jety s heavy flavor
 - **UPC, luminosity** (FJFI) cíl: studium QCD v limitě vysokých E (gluonová saturace a stínění)
 - **Kolektivní toky** (FJFI, FzU)

ITS3 : inovace nejvnitřnější části ITS pro Run 4



- Tenké vrstvy křemíku (20 - 40 μm) jsou ohebné a samonosné
- To umožní zmenšit materiál detektoru -
-poloměr nejvnitřnější vrstvy (z 23 mm pro RUN3 na 18 mm)

Slovenská účasť v ALICE



Košický klaster

Ústav experimentálnej fyziky SAV, Košice



Bratislava



Fakulta matematiky, fyziky
a informatiky,
Univerzity Komenského,
Bratislava

Prírodovedecká fakulta
UPJŠ Košice



Fakulta elektroniky
a informatiky, TUKE Košice
(ALICE full member od 2015)

ALICE Slovensko

1) Počty participujúcich pracovníkov

- **Bratislava**, FMFI UK 5 + 1 PhD + 1 technik
- **Klaster Košice** (UPJŠ, UEF SAV, TUKE) 15 + 9 PhD + 5 Mgr
- **Spolu:** **20 + 10 PhD + 5 Mgr + 1 technik**

2) Zdroje financovania

Účelové projekty MŠ VVaŠ (min. školstva) SR dedikované na spoluprácu SR s CERN (materiál, VT, cesty, odmeny - nie platy)

3) Výhľad do budúcnosti

- **ľudské zdroje** - pri umiernenom optimizme predpokladáme približne rovnaké počty aj v budúcnosti (**25-35**)
- **experimenty** - **ALICE** (... RUN4 + uzavretie), spojenie s **ATLAS** na LHC, alebo **GSI, Dubna** ...

ALICE Bratislava

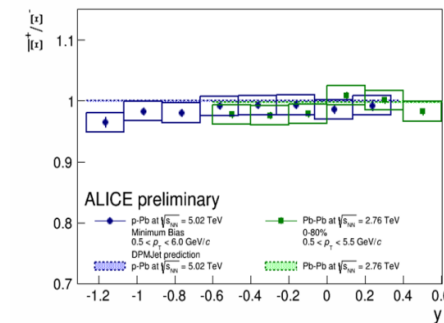
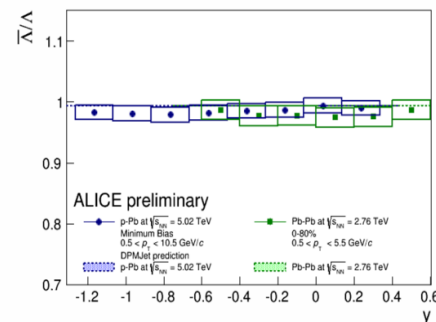
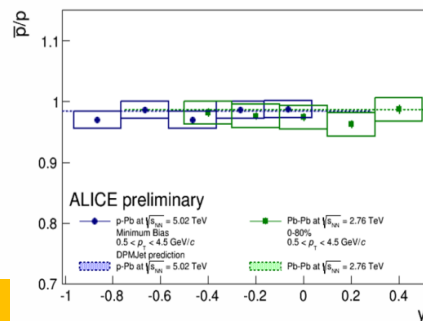
1) Hardware

- ALICE TPC upgrade - continuous readout without gating grid
- Meranie mobility a driftu iónov v špeciálnej komore TPC
- Vývoj GEM TPC readoutu pre ALICE upgrade



2) Fyzikálna analýza

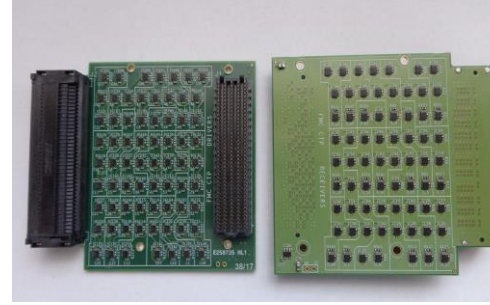
- Midrapidity antibaryon-baryon ratios in Pb-Pb and p-Pb collisions (p-Pb @ 5.02 TeV, Pb-Pb @ 2.76 TeV, pp @ 2.76 and 7 TeV)
- Pentaquark search in the ALICE experiment



ALICE Košice

1) Hardware

- Elektronika pre Centrálny trigger ALICE



2) Detector control system

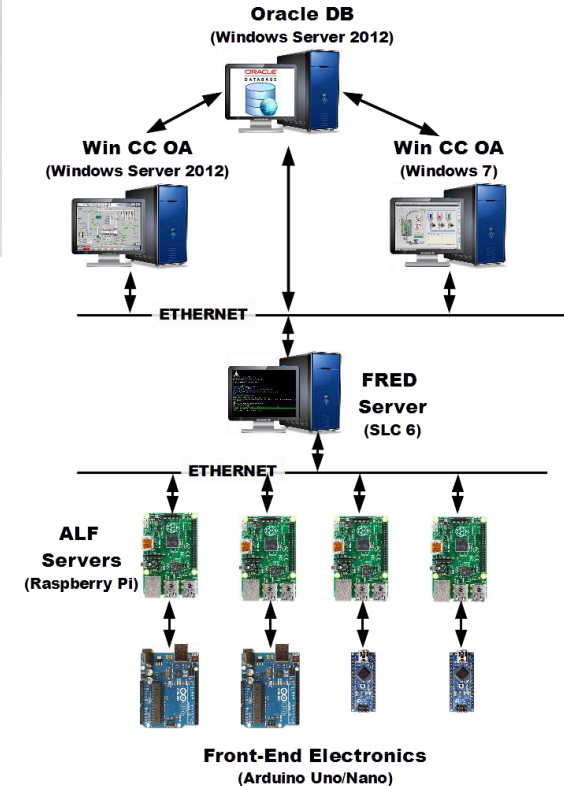
- Systém riadenia detektora ITS (aplikácia technológie pre automatizované výrobné linky)

3) Software

- Trigger Data Quality Monitoring pre RUN 2
- LHC Interface - online monitorovanie luminozity

4) Fyzikálna analýza

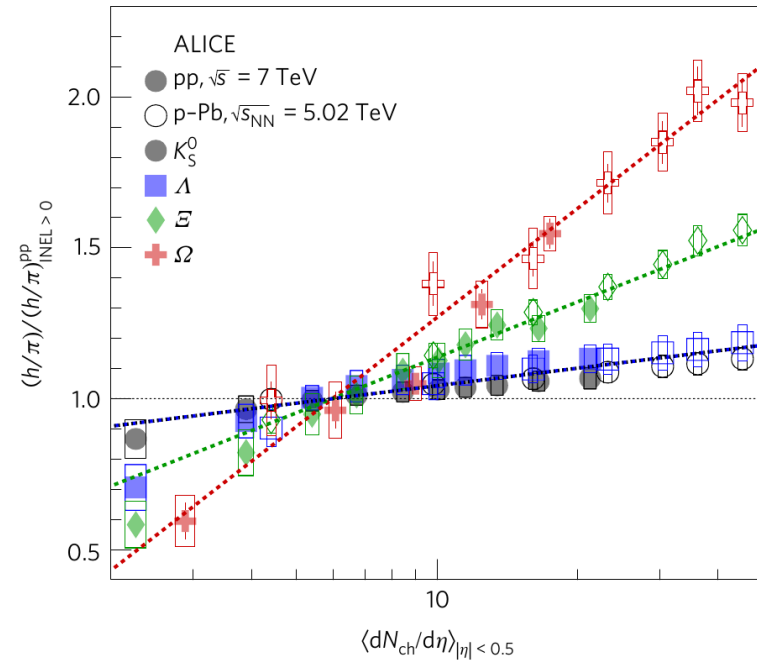
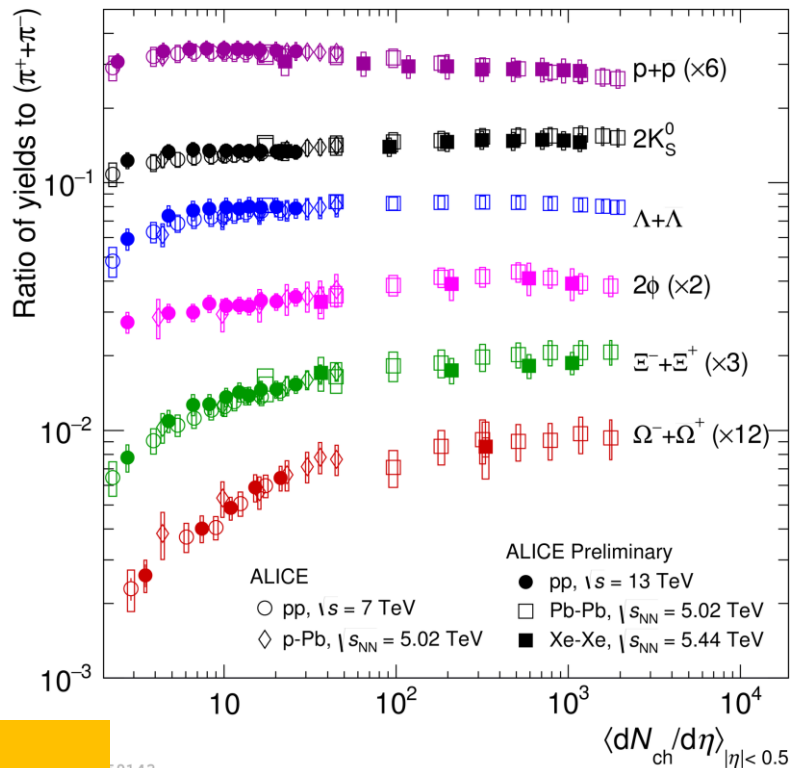
- Strange and multi-strange particle production in p-p and Pb-Pb collisions
- Angular correlations between strange and non-strange particles
- Normalization cross section measurement using Van der Meer scans



ALICE Slovensko - vedecké výsledky

Recent observation:

The production of strange and multi-strange particles in the high multiplicity p-p collisions exhibits behaviour observed in Pb-Pb collisions



Nature Physics 13 (2017) 535-539

ATLAS Heavy ion group at Charles University

- Current **structure** of the group:
 - 2 senior scientists (Jiří Dolejší, Martin Spousta)
 - 2 post docs (Radim Slovák, Souvik Adhya)
 - 2 students (Tomáš Kosek – defending soon Ph.D., Martin Krivoš – defending soon Mgr.)
- Continuously 2-3 students, **4-6 people together** (small group)
- Financial **resources**:
 - CERN-CZ (infrastructure) & Inter-excelence: grants MEYS, GAČR, institutional research support & grants of Charles University
- Subject of **interest**:
 - **Measurements** of jets and jet structure, charmonia, and high-pt charged particles **with ATLAS** in pp, p+Pb, and Pb+Pb collisions
 - **Phenomenology** of jet quenching and charmonia suppression, **new methods and tools** for jet measurements in dense environments

Impact of the group in ATLAS

- **Main contributors** to >10 papers by ATLAS

Observation of a Centrality-Dependent
Dijet Asymmetry in Lead-Lead ...
Phys. Rev. Lett. 105 (2010) 252303
[Cited by 698 records](#)

Measurement of inclusive jet
suppression in Pb+Pb ...
Phys. Lett. B719 (2013) 220-241
[Cited by 258 records](#)

- Subdominant contributors to many papers by ATLAS
- Other contributions:
 - Various **technical aspects** of ATLAS heavy-ion program (software, trigger, calibration, tracking optimization, validation, data-management)
 - Active **editorial board** members and chairs
 - Roles in **coordination**: Jet sub-group convener, Trigger Menu group coordinator, ATLAS Heavy Ion **WG convener** (50-60 people)

Outlook and goals for beyond 2020

- ATLAS will continue to provide opportunity to study **wide range** of physics in HI collisions, e.g.: ultra-peripheral collisions (ligh-by-light), measurements of vector bosons (nPDF effects), jets and high-pt particles (parton energy loss), ...
Excellent tools, small group of dedicated people running heavy ions.
- **Continue working on ATLAS** (main effort), no new experiment.
- Continue working on **phenomenology** and **new tools** for HI / HEP measurements.
- Person-power:
 - keep **2 senior** scientists
 - **0-2 post-docs** depending on financial support
- Financial resources: same structure as now.
- Attract more students (potential to make large impact; collaboration with various institutes in USA, EU, Israel; success of former students).

Participation STAR experiment

- Current **structure** of the group:

Upgrades to take data also after 2022+

FJFI ČVUT

- 3 senior scientists (Jaroslav Bielčík, Petr Chaloupka + (Barbara Trzeciak from 2019))
- 2 post docs (Leszek Kosarzewski, Pavla Federičová)
- 9 students (Kramárik, Holub, Kocan, Ličeník, Moravcová, Truhlář, Kubát, Štorek, Češka)

ÚJF AV ČR

- 2 senior scientists (Jana Bielčíková, Michal Šumbera)
- 1 post doc (Pavol Federič)
- 7 students (Makatun, Šimko, Vaněk, Agafonová, Robotková, Bobek, Ponimatkin)

- Financial **resources**:

- BNL-CZ (infrastructure) & OPVVV BNL-CZ, Inter-excelence: grants MEYS, institutional research support & grants of CTU Prague, OPVVV Excelent research CAAV

- Subject of **interest**:

- Measurements of heavy flavor production, jet properties, femtoscopy, critical point search
- HF PWG covener, STC chair, Charing paper committees, support of HFT and ZDC detectors

Participation PHENIX/sPHENIX

sPHENIX – CD1 review passed; 20-22 construction; 23+ taking data for 5 years

- **Team:**

- MFF UK (Miroslav Finger) 13 members

- FJFI ČVUT (Vaclav Vrba) 21 members

- **Subject of interest:**

- significant role in the construction of sPHENIX Vertex Detector (MVTX) role in the construction of sPHENIX Vertex Detector (MVTX)

Participation EIC

- Teams from STAR, sPHENIX are interested to get more involved also in EIC in USA
- Electron-Ion Collider to study gluon structure of proton
- US National Academy of Sciences recommended project in July 2018
- e (4-20 GeV) + Au (30 GeV up to 300 GeV)
- depending on budget – construction starts 22-23

Fenomenológia kolektívnych javov

- Skúmané témy:

- Kolektívne chovanie fireballu v relativistických jadrových zrážkach (RJZ)
- Fluktuácie počtu protónov v RJZ Phys.Rev. C92 (2015) no.6, 064908.
- Produkcia podivnosti
- Triedenie zrážkových udalostí podľa tvaru Eur.Phys.J. A53 (2017) no.8, 161
- Relativistická hydrodynamika
- Femtoskopia
- Stavová rovnica pri vysokej hustote baryónov

- Zapojené inštitúcie

- FJFI ČVUT (Boris Tomášik, Jakub Cimerman, Radka Sochorová)
- Univerzita Mateja Bela, Banská Bystrica (Evgeni Kolomeitsev)
- Žilinská univerzita (Ivan Melo)
- Univerzita Pavla Jozefa Šafárika, Košice (Zuzana Paulinyova)

- Personál: 3 seniori, 3 doktorandi

+ P. Závada FzU AV ČR

Parton saturation phenomenology

Group:

Jan Čepila, J.G.Contreras, Michal Křelina + 2 PhD students (Marek Matas, Dagmar Bendová) FJFI ČVUT

• Grants:

- network COST CA15213 - Theory of hot matter and relativistic heavy-ion collisions (2015-2019)
- GA17-04505S - Aspekty silných interakcí při extrémních podmínkách (2017-2019)
- LTC17038 - Struktura hadronů v těžko-iontových srážkách (2017-2020)
- OPVVV BNL-CZ - Brookhavenská národní laboratoř – účast České republiky (2016-2019)

Recent publications:

- J. Cepila, J. G. Contreras, M.Krelina, J. D. Tapia Takaki, Mass dependence of vector meson photoproduction off protons and nuclei within the energy-dependent hot-spot model, arXiv:1804.05508
- J. Cepila, J. G. Contreras, M. Krelina, Coherent and incoherent J/ψ photonuclear production in an energy-dependent hot-spot model, arXiv:1711.01855
- J. Cepila, J. G. Contreras, J. D. Tapia Takaki, Energy dependence of dissociative J/ψ photoproduction as a signature of gluon saturation at the LHC, arXiv:1608.07559

Parton saturation phenomenology

Topics:

- Diffractive vector meson production on protons and ions
- Evolution equations in QCD (BFKL, Balitsky-Kovchegov equation)
- Signatures of parton saturation
- EIC/LHeC physics

Future plans:

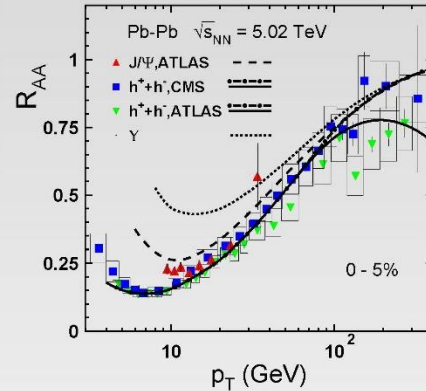
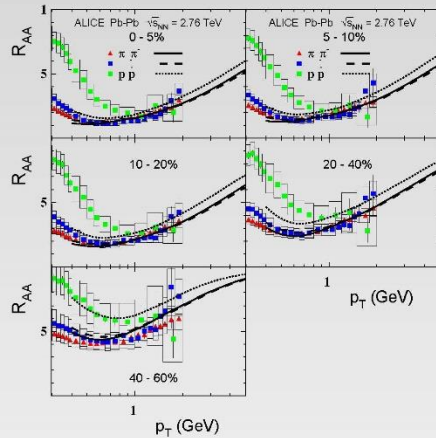
- Vector meson production – calculate correctly the scalar part of WF in the light cone approach by solving the Schrodinger equation in the rest frame and boost the solution to proper frame, analyze the effect of the rotation of the spin between photon and meson wave function (in collaboration with R. Pasechnik, J. Nemchik)
- **Vector meson production** – study the effect of hot-spots in nuclear vector meson exclusive and diffractive photo and electro-production
- **QCD evolution equations** – solve BK equation with explicit impact parameter dependence and study the initial conditions and the connection to other dipole cross-sections parametrizations, solve BK equation with NLO kernel
- **Study the effect of hot-spots in DVCS** and in vector meson production involving more complex dipoles (qqg) (in collaboration with Victor Goncalves)
- **Study the connection between TMDs and dipole model with the solution of BK equation** in particular in forward di-hadron production correlations (in collaboration with Cyrille Marquet)

Suppression of high- p_T particles



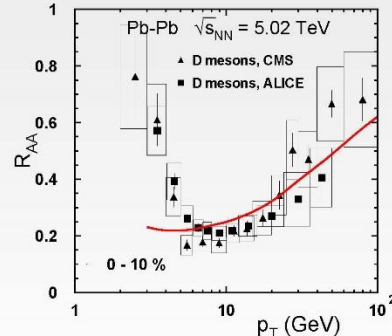
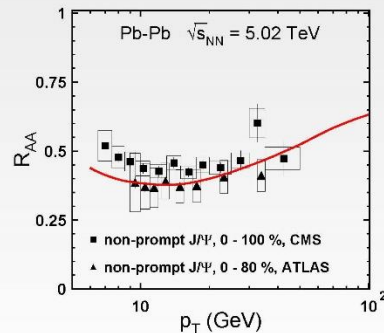
Jan Nemcik (CTU, PNSPE, Prague) & R. Pasechnik (NPI, Řež)

The mechanism of suppression is not based on the energy loss scenario of jet quenching but is based on propagation and evolution of colorless pre-hadrons in the medium. [Phys.Rev. C86, 054904 (2012); Eur.Phys.J. C75, 95 (2015)]



Universality of suppression in production of light hadrons, J/Ψ and Υ .

[paper in preparation]

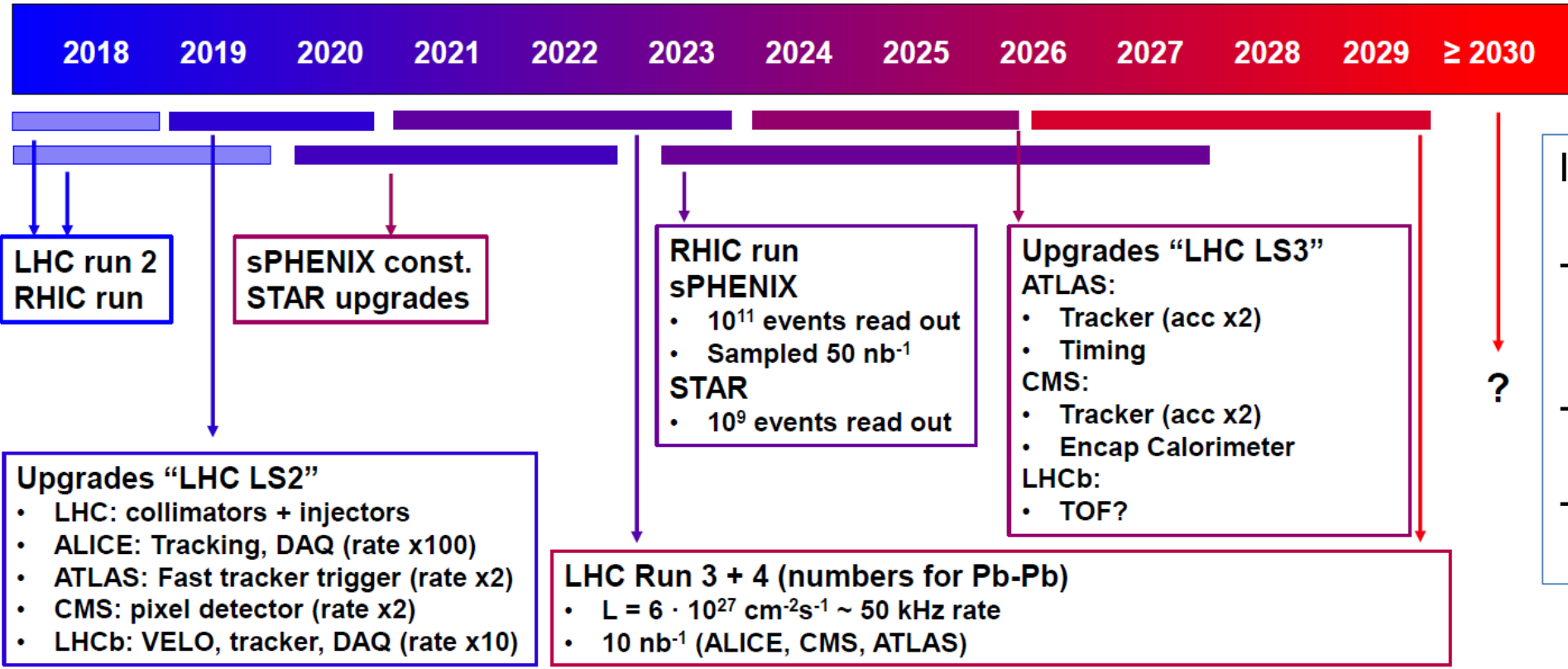


Predictions for $R_{PbPb}(p_T)$ in production of heavy flavored D and B mesons

[Phys.Rev. D96, 014010 (2017);

EPJ Web Conf. 164, 01018 (2017).]

Summary



- Interest:
- Keep heavy ion program in strategy document ATLAS and ALICE HL
 - Possibility to keep involvement in RHIC/EIC
 - Education+Outreach IPPOG

• ALICE ČR	12 (senior) + 9 (postd.&stud.)
• ALICE SK	21 +15
• ATLAS HI	2 + 4
• STAR/EIC	5 +19
• sPHENIX/EIC	34
• Phenomenology	10 +5



Community of cca 130 scientists involved in heavy ion research in CZ - SK