The future in H.I.

QM2012 + ESPG Cracow + personal biases

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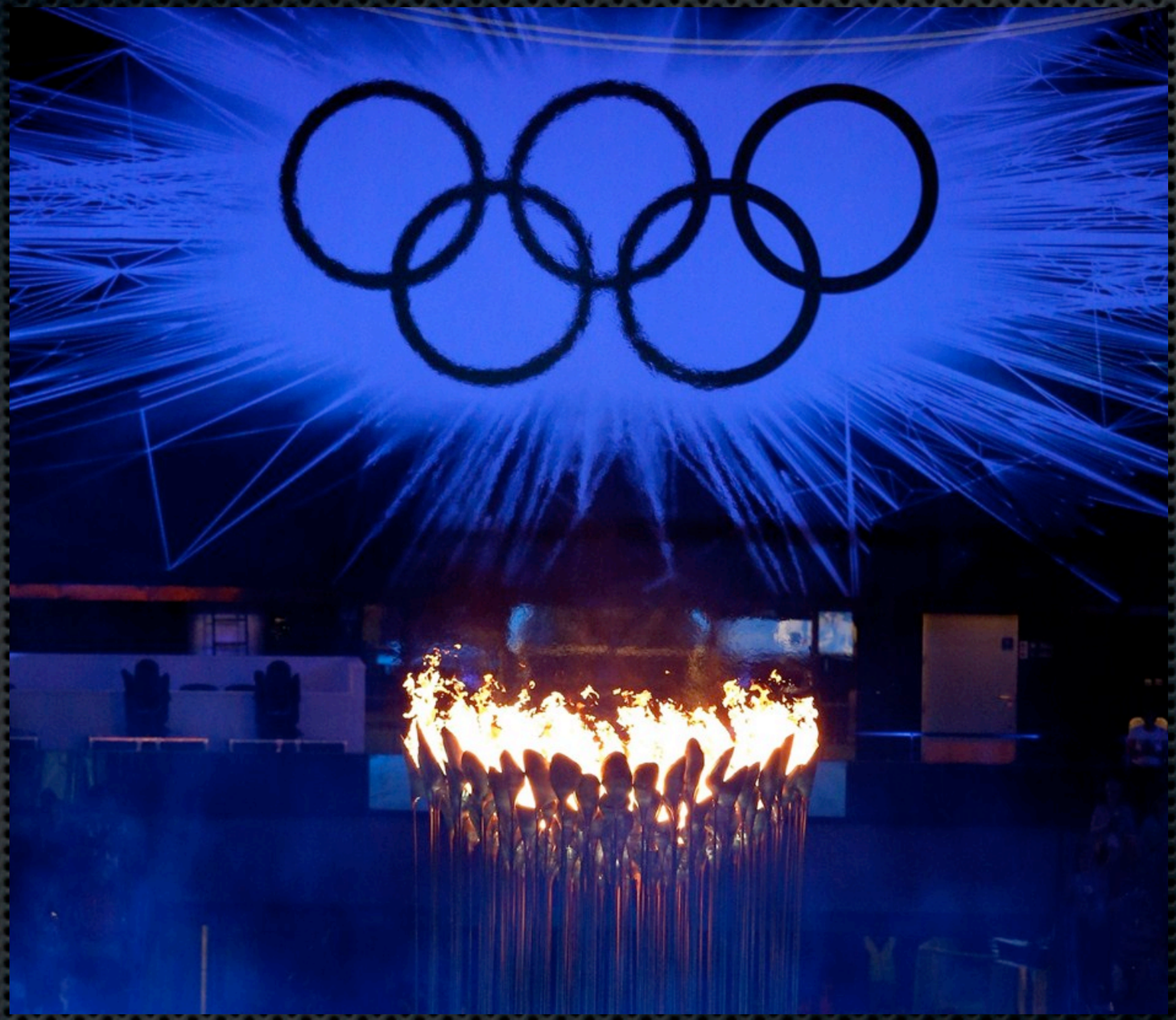
sur les lois fondamentales
de l'Univers

Rencontres QGP France - Étretat, Sept. 2012

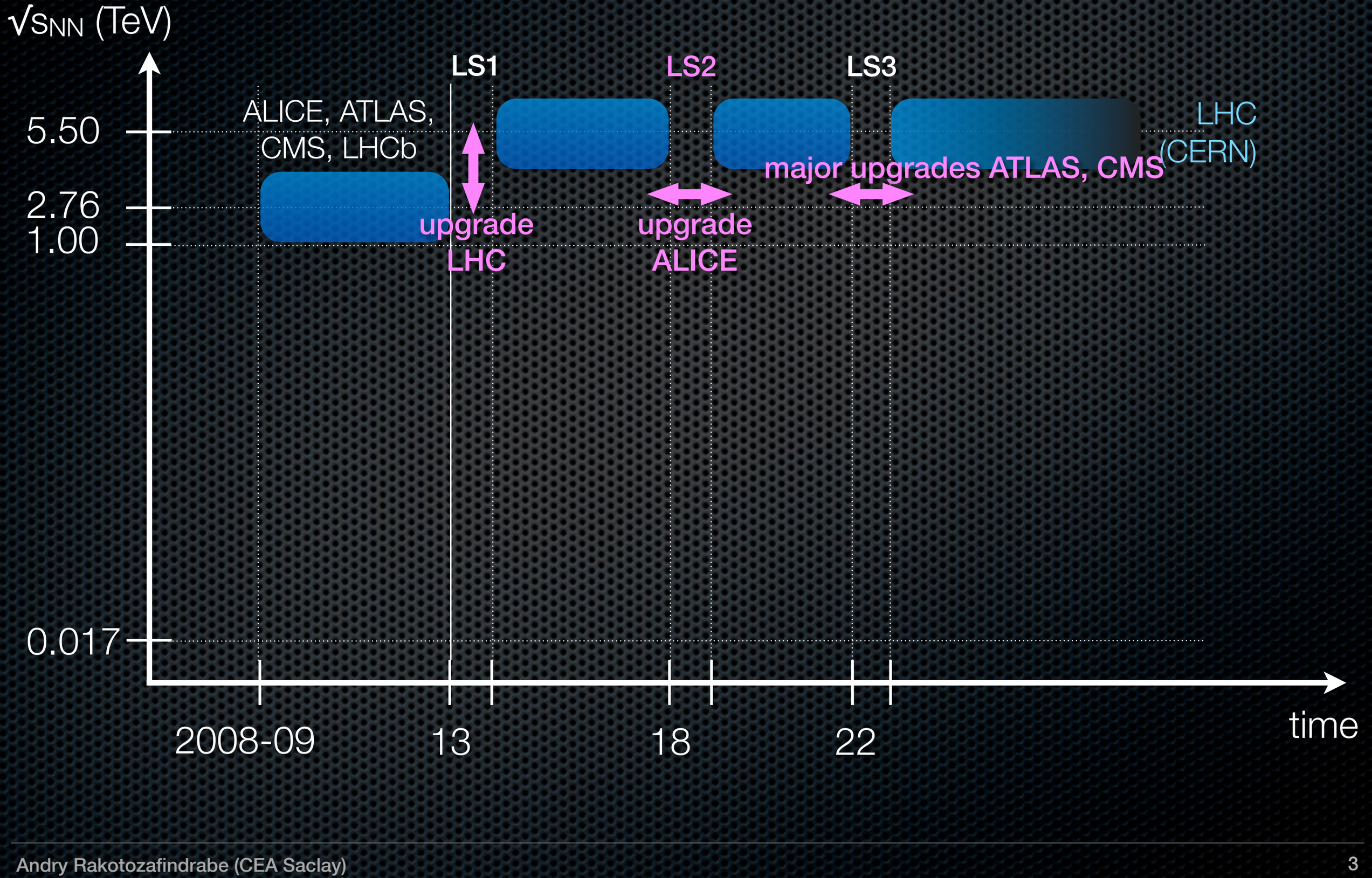
« Faster, Higher, Stronger »



Olympic games, London, 2012

A rough timeline*

(*) focusing on AA, pA, eA, collisions only



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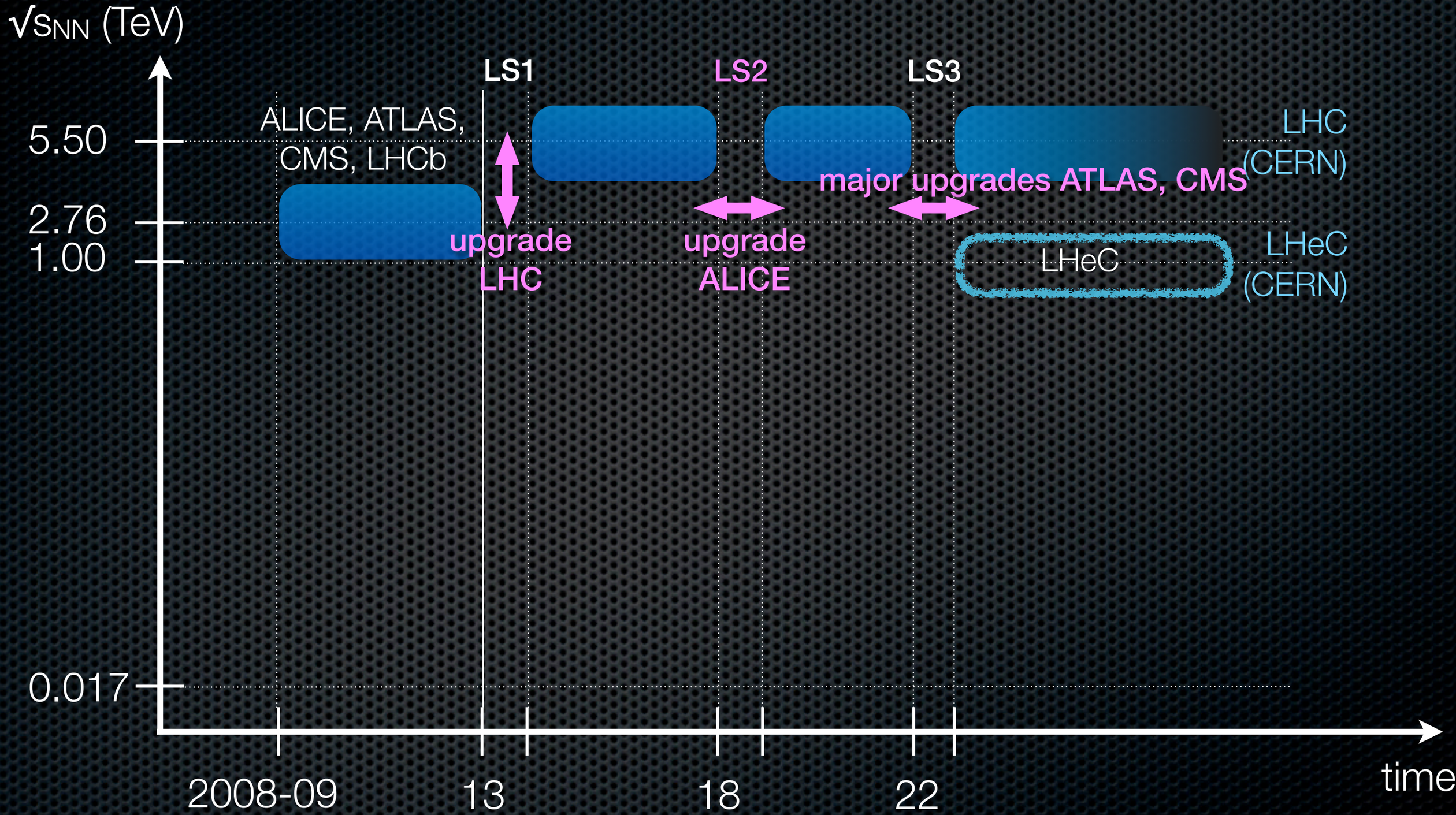

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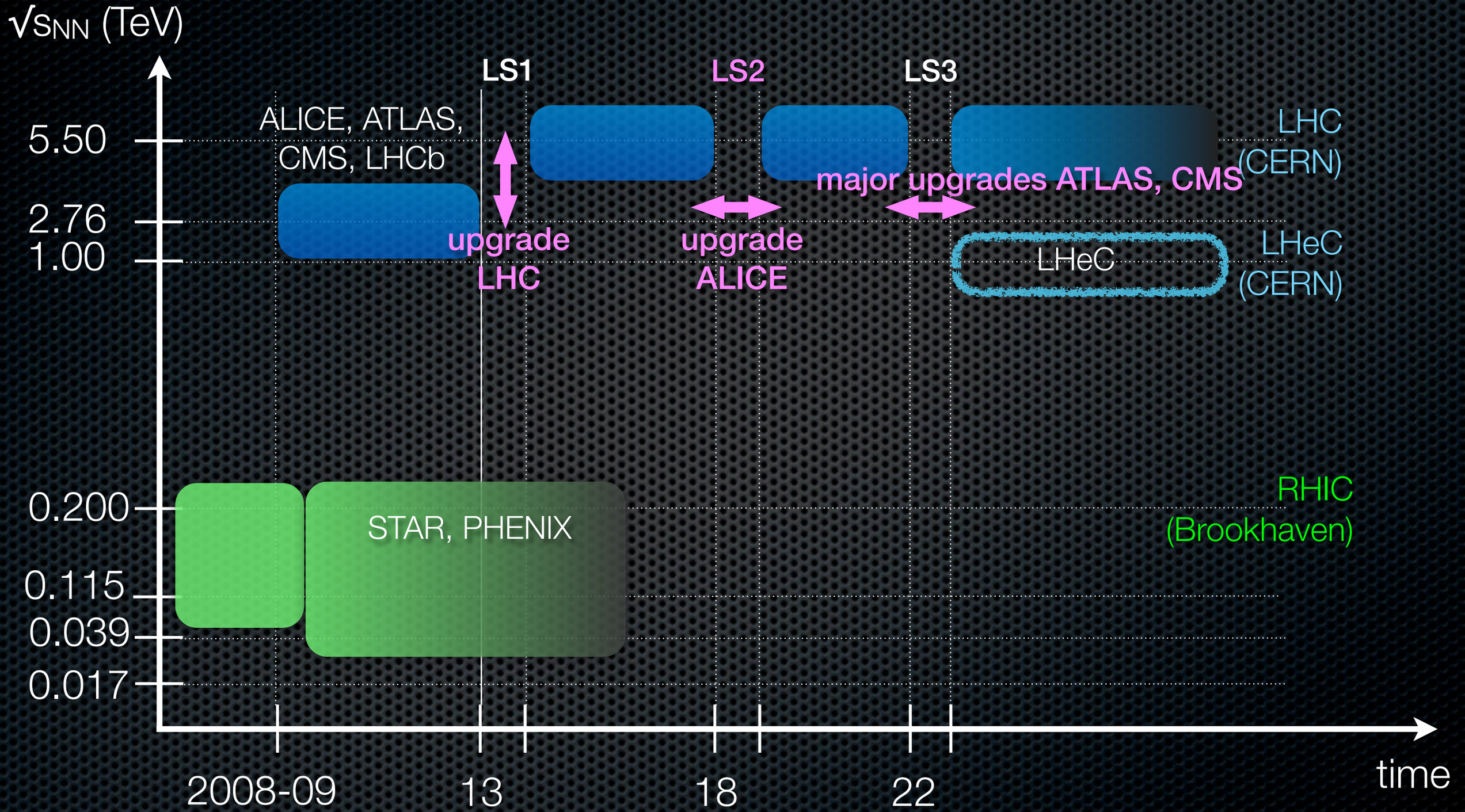

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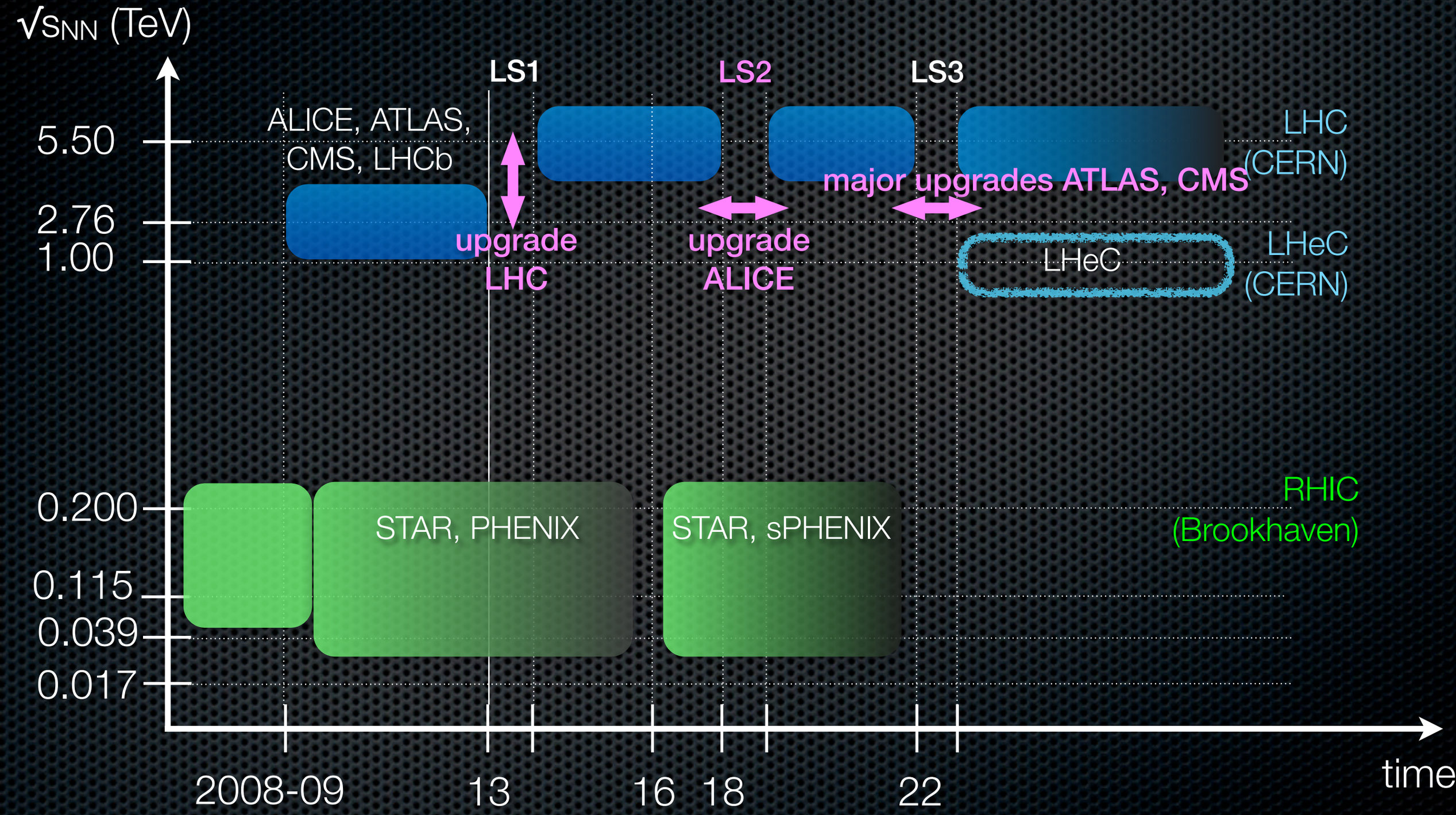

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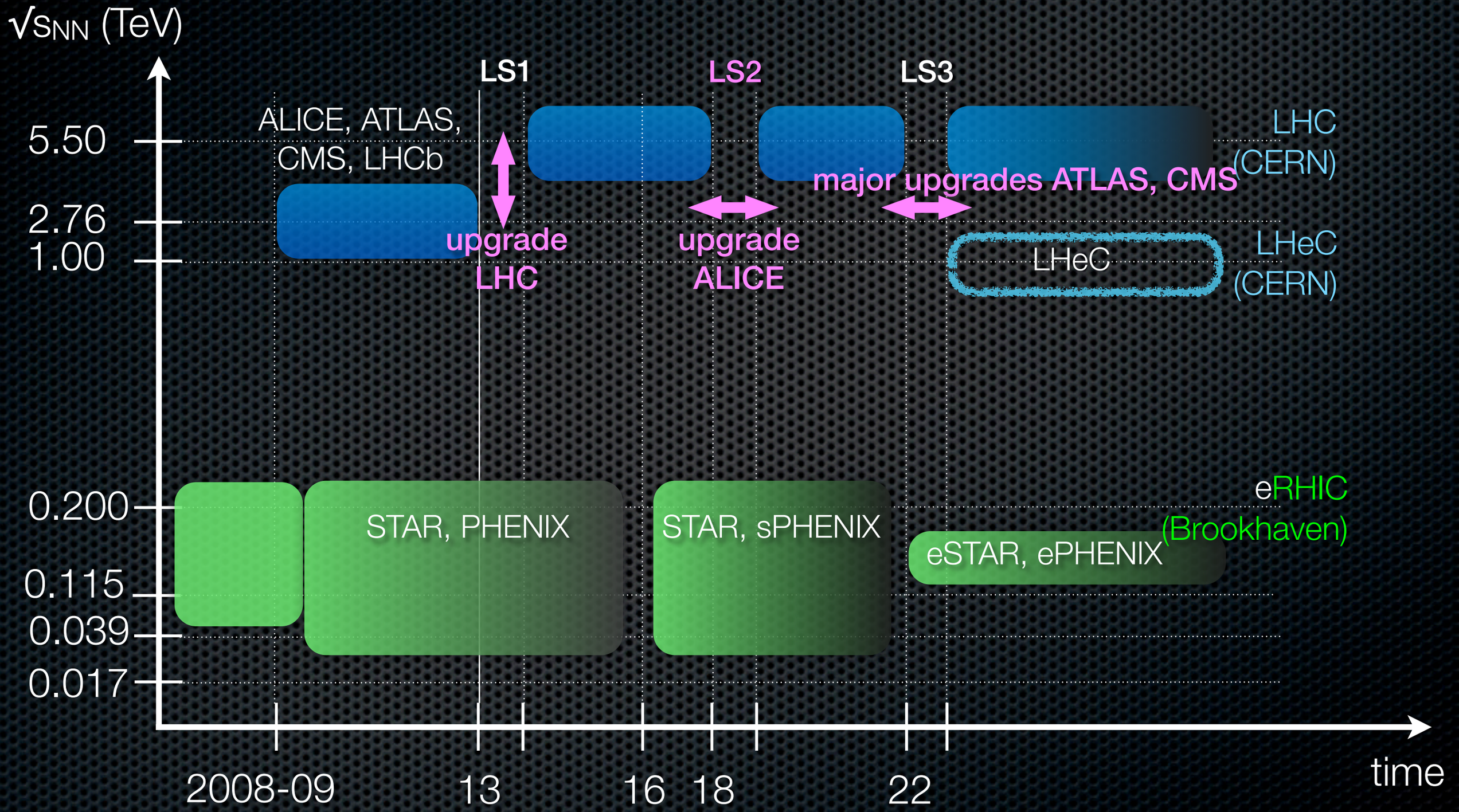

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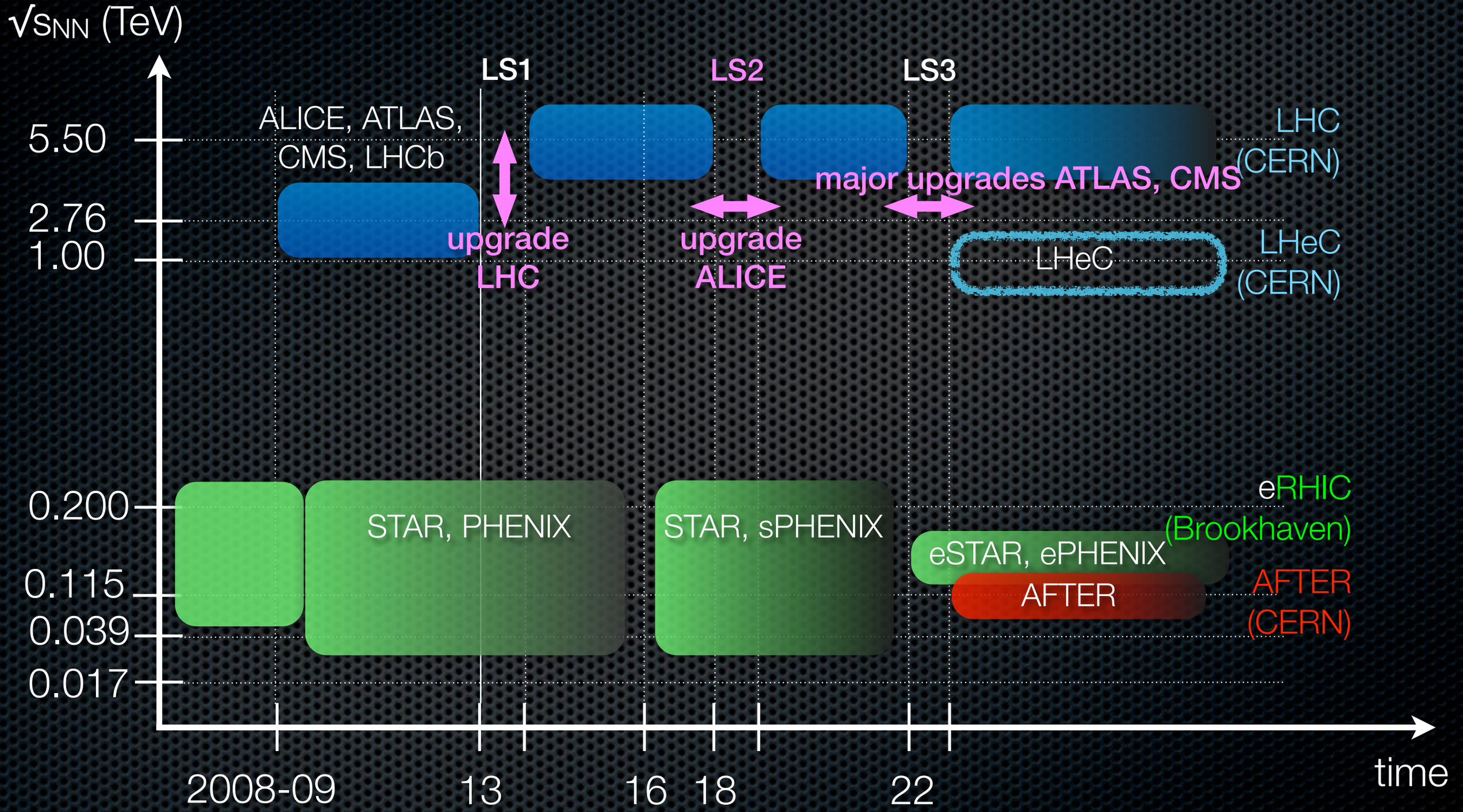

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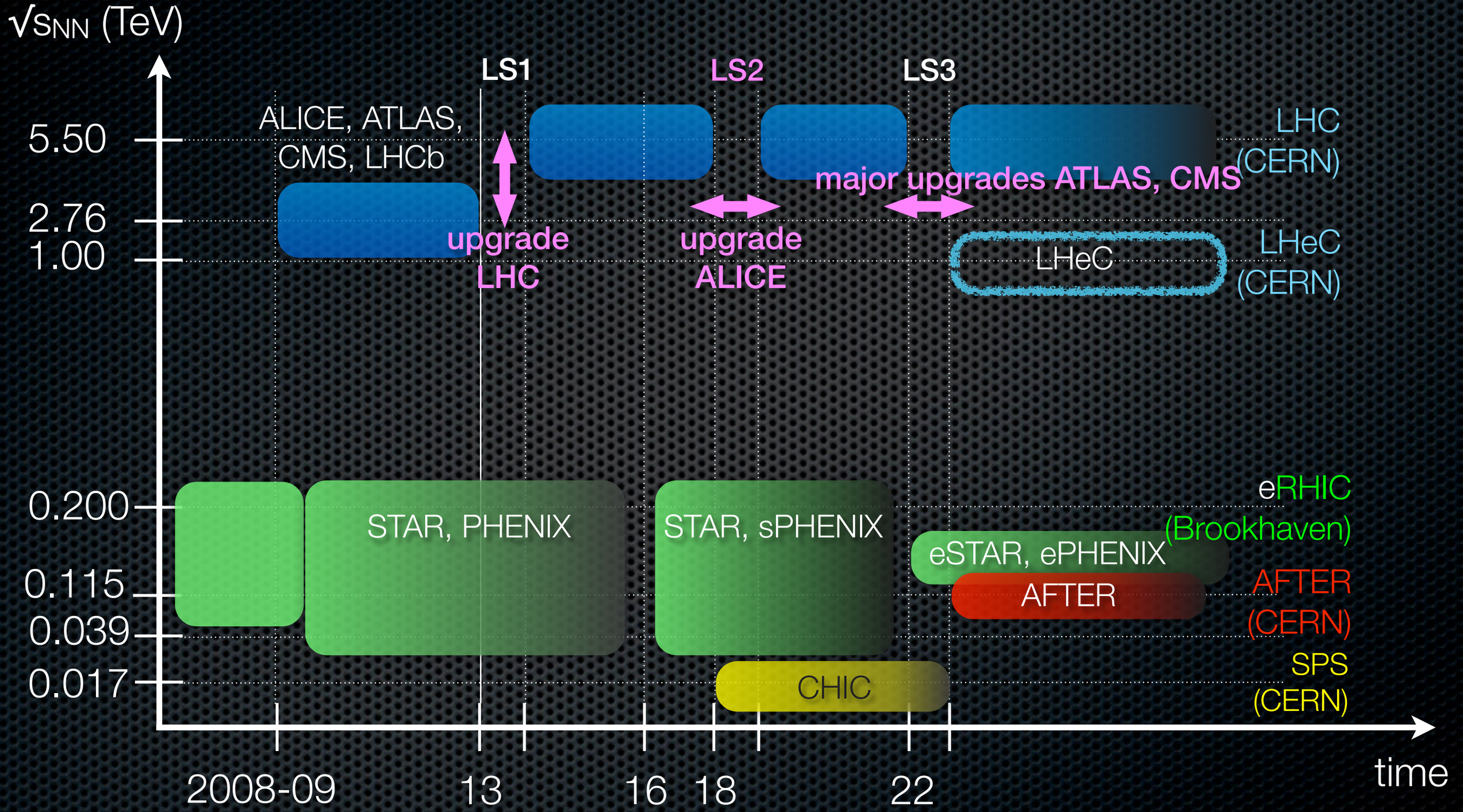

H.I. collisions @ LHC

[H. Appelshäuser, ESPG Symposium, Cracow, Sept. 2012]

- unique opportunities to study QCD at $\mu_B \sim 0$ in H.I. collisions via hard and electroweak probes
- initial T and energy density : the highest achievable in the lab
- large $\sqrt{s_{NN}}$ ➠ abundant production of hard probes
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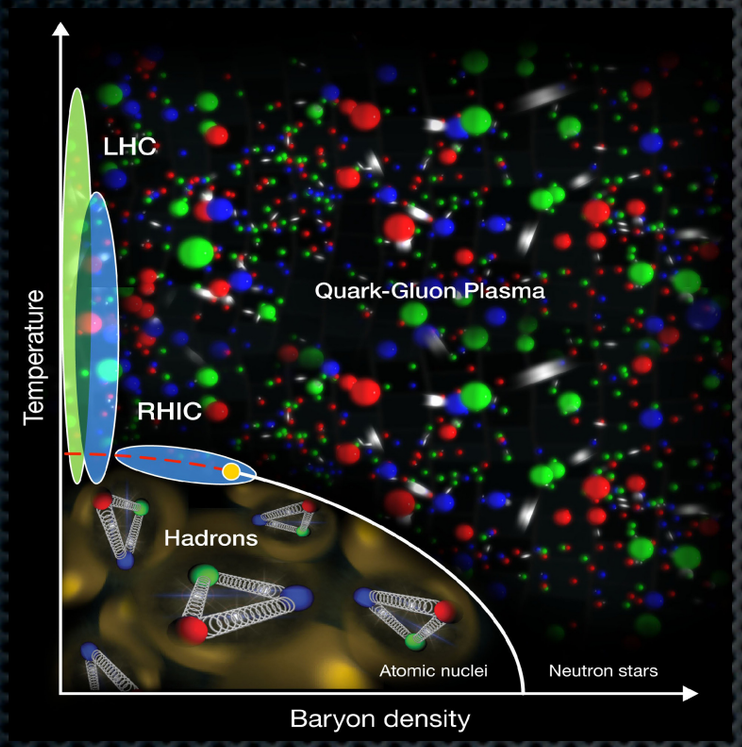

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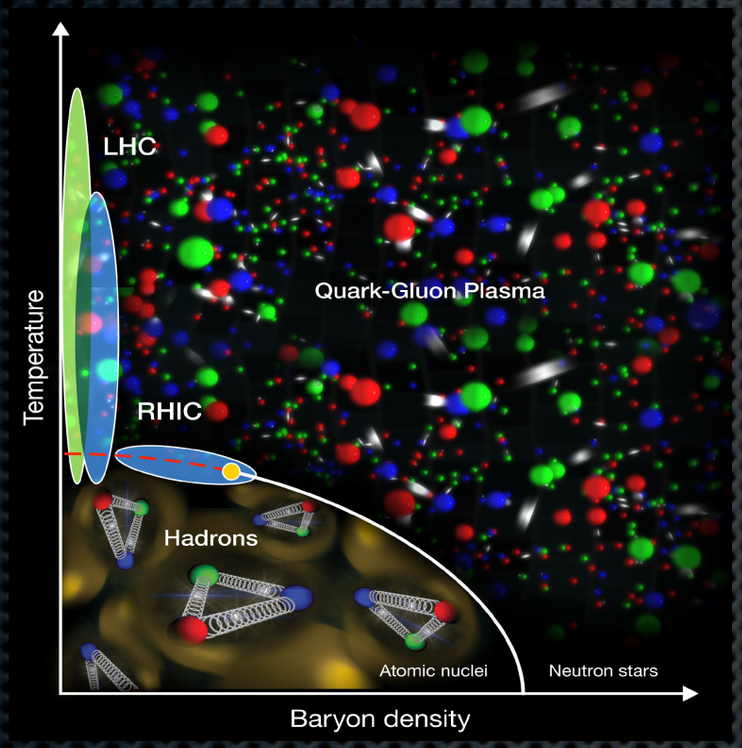

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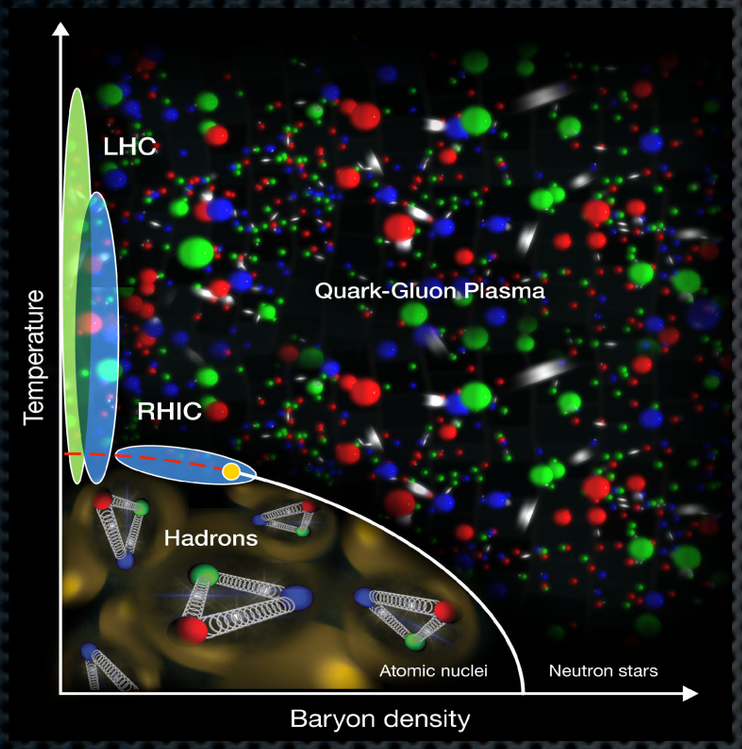

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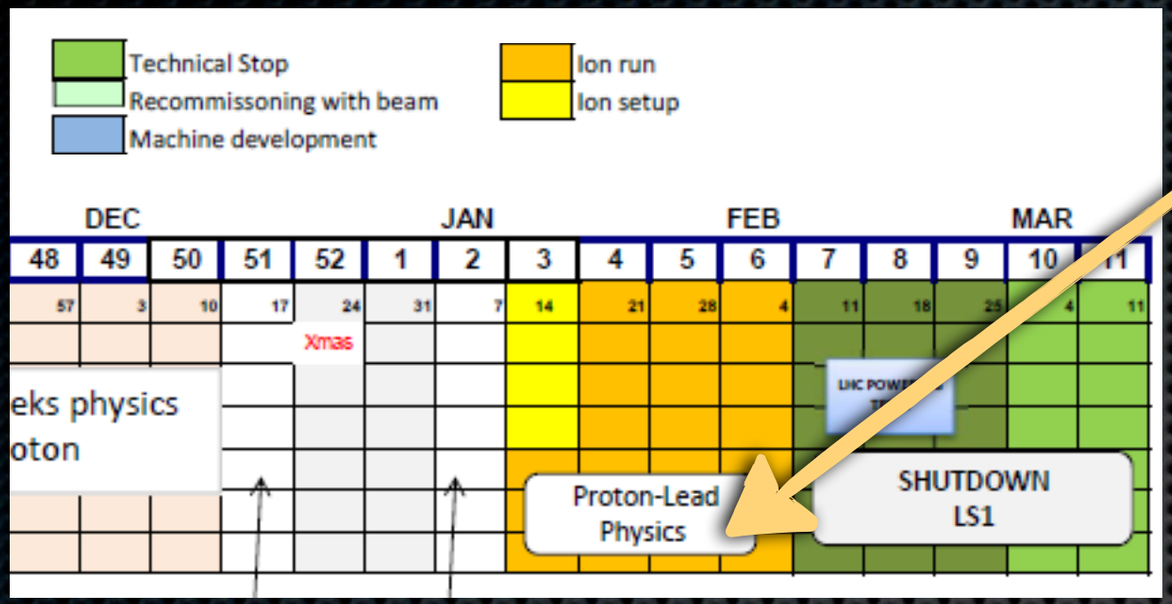
- currently approved program (1 nb^{-1}) : essential step towards an era of precision measurements
- extension to 10 nb^{-1} : full exploitation of LHC physics potential + experiments complementarity

➠ H.I. beyond LS3

LHC - short term (2013 - 2014)



p-Pb + Pb-p (Jan. 2013) : CNM effects

- $\sqrt{s}$ = 5 TeV, target luminosity 30 nb^{-1}
- 22 days of stable beams

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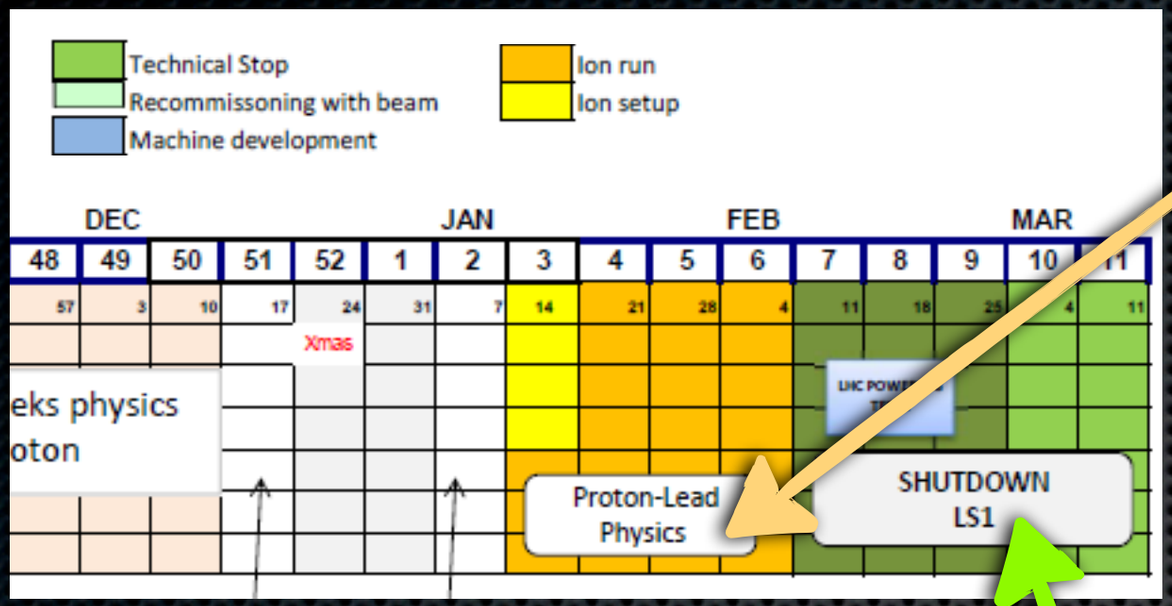

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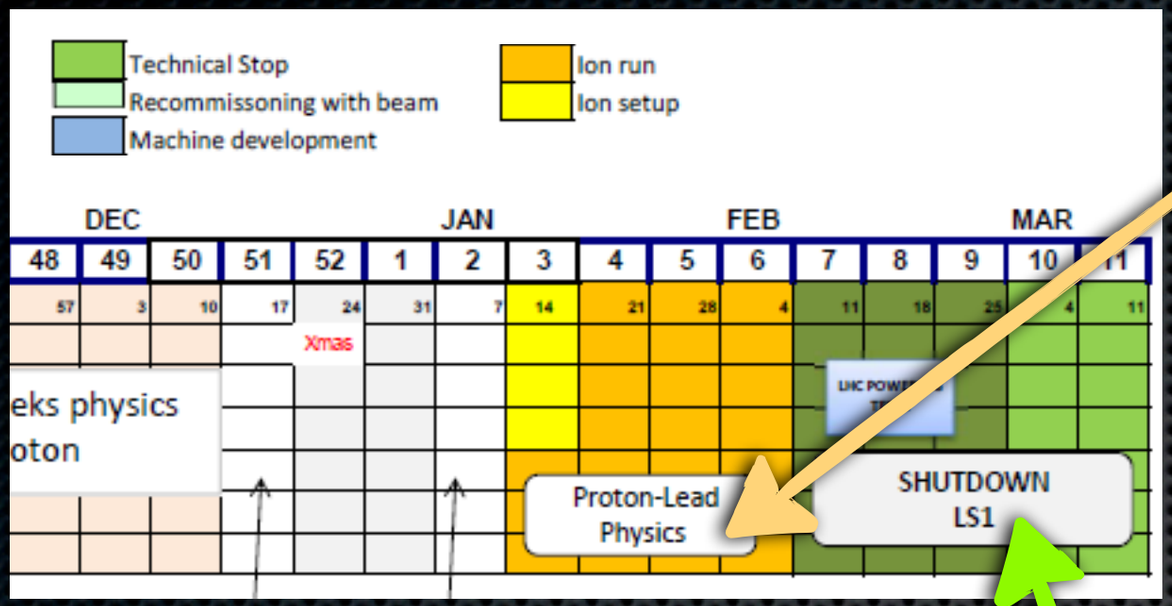

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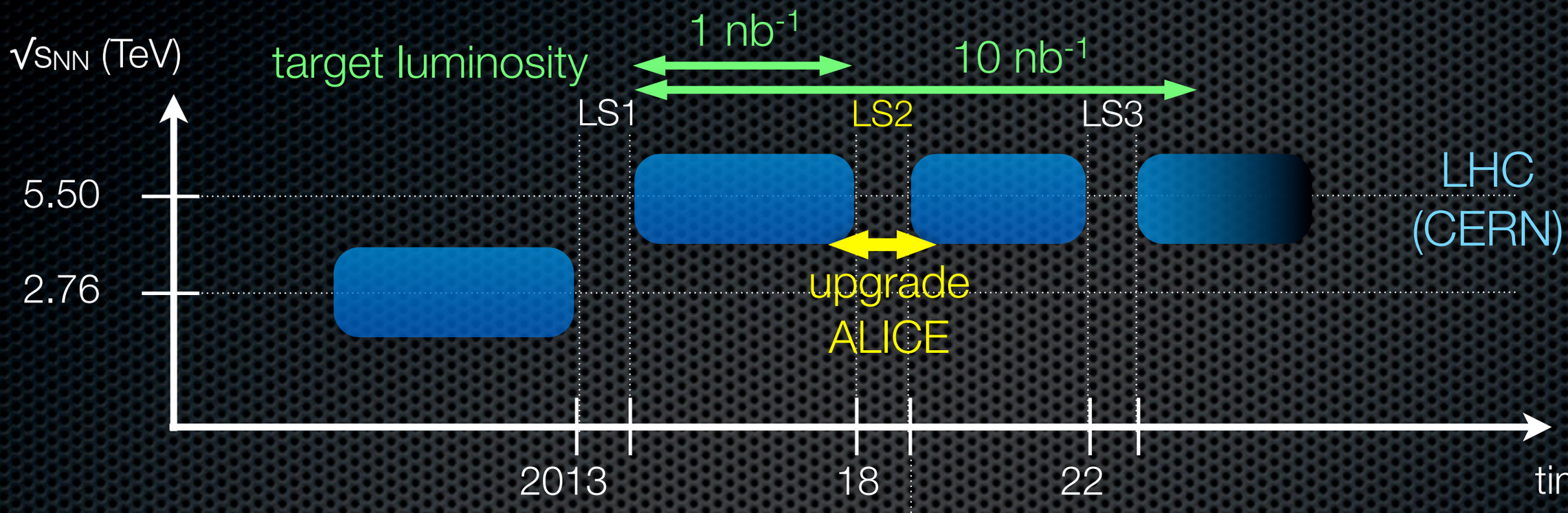
Followed by 3 years of data taking at the LHC *design energy*

LHC - mid/long term



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50 kHz collision rate
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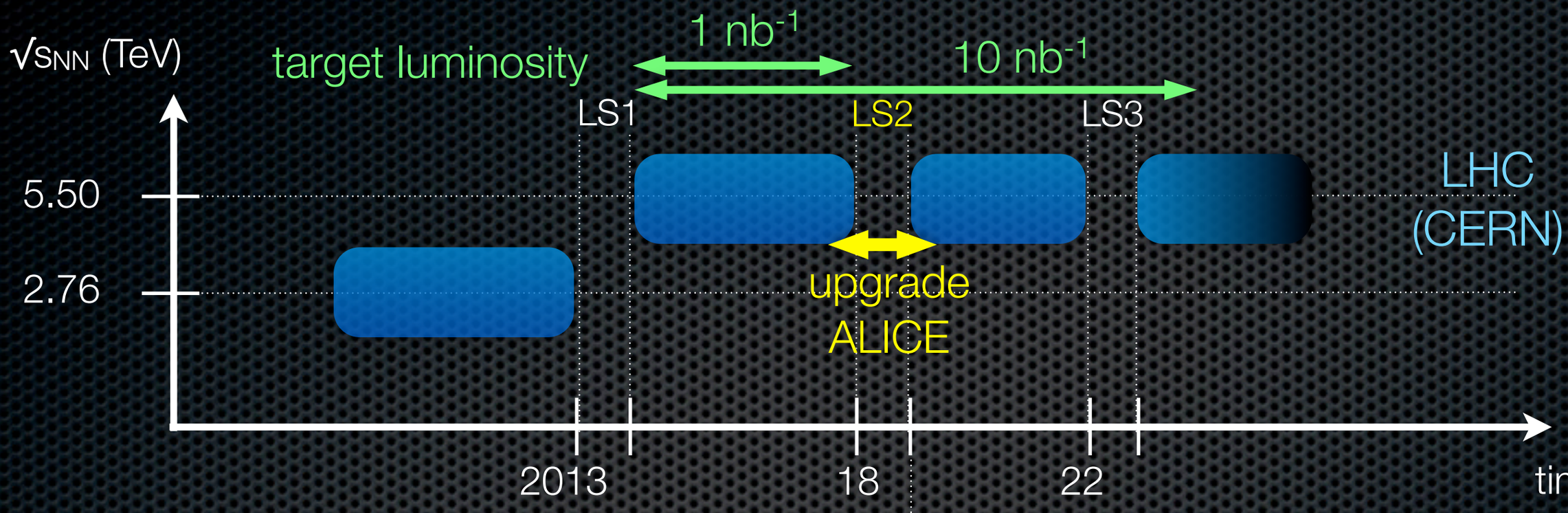

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- ALICE LoI (Sept. 2012) : upgrade ITS, TPC, Muon Arm, ...
  - ✓ improve low p_T tracking, vertexing, PID capabilities, reduce material budget
  - ✓ many key observables do not allow low-level triggering ➠ high rate capability of detectors and readout system
- ALICE LoI addendum : Muon Forward Tracker (MFT), VHMPID, FoCal

ALICE ITS upgrade

new ALICE Inner Tracking System:

→ 7 Si-layers (7 pixel or 3 pixel + 4 strip)

→ low material budget X/X_0= 0.3% per layer (currently 1.14%)

→ improve vertex resolution by factor 3

→ improve low p_T tracking efficiency

→ allow for 50 kHz readout

CERN-LHCC-2012-05 / LHCC-G-159

Parallel 6C: R. Lemmon
Poster: G. Contin

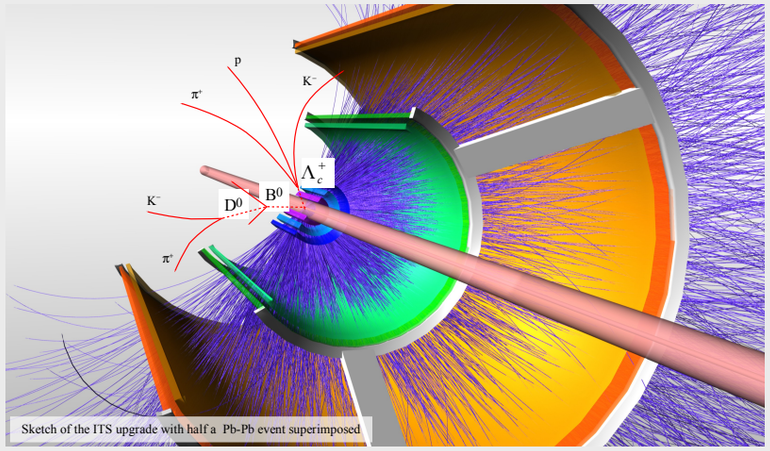
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN-LHCC-2012-05 / LHCC-G-159
March 6, 2012

Conceptual Design Report for the Upgrade of the ALICE ITS

The ALICE Collaboration*

Version: CDR-0



Sketch of the ITS upgrade with half a Pb-Pb event superimposed

*See Appendix A for the list of collaboration members

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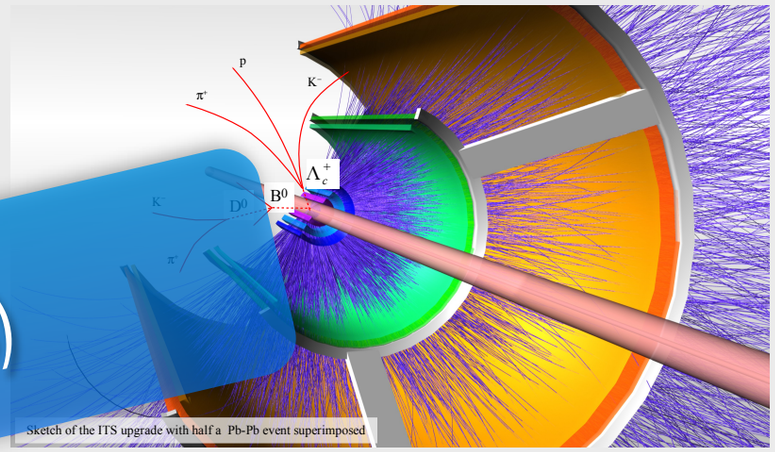

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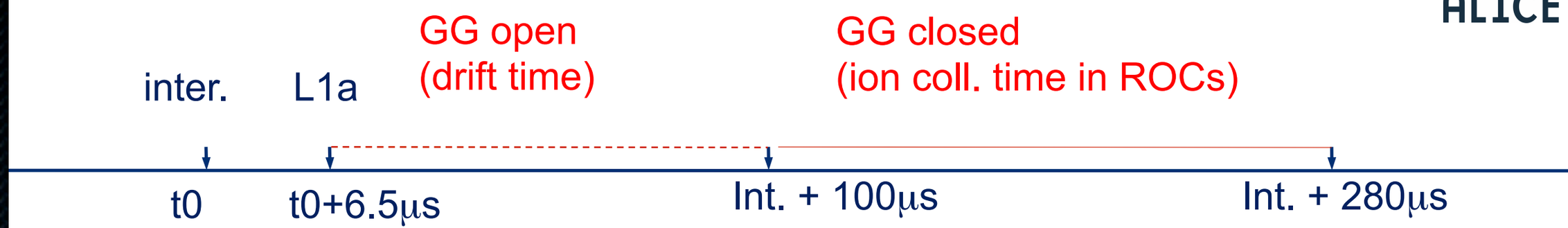
ALICE TPC upgrade



Parallel 6C: T. Peitzmann

Poster: T. Gunji

Limitation of the present system:

Readout rate limited to 3.5 kHz due to Gating Grid closing time

- Needed to prevent ions from drifting back into the drift volume

→ drift distortions from space charge

Solution:

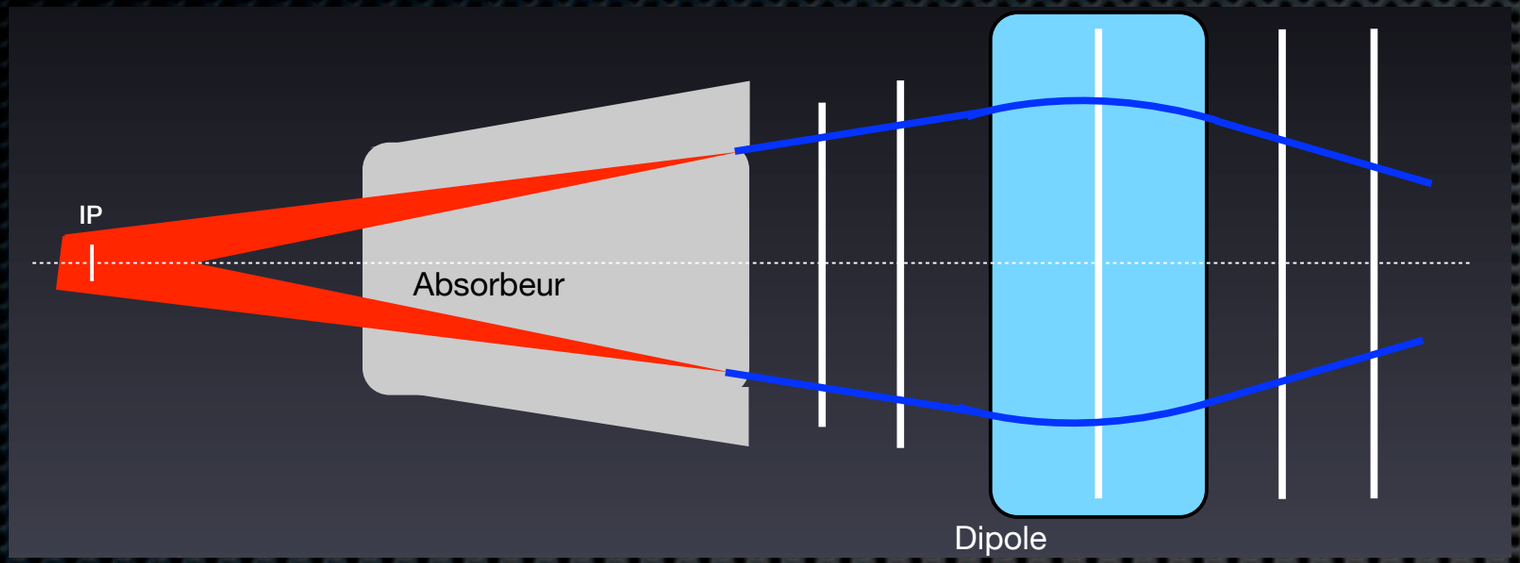
Replace present MWPC-based readout chambers by GEMs

- GEMs have intrinsic property to block back-drifting ions

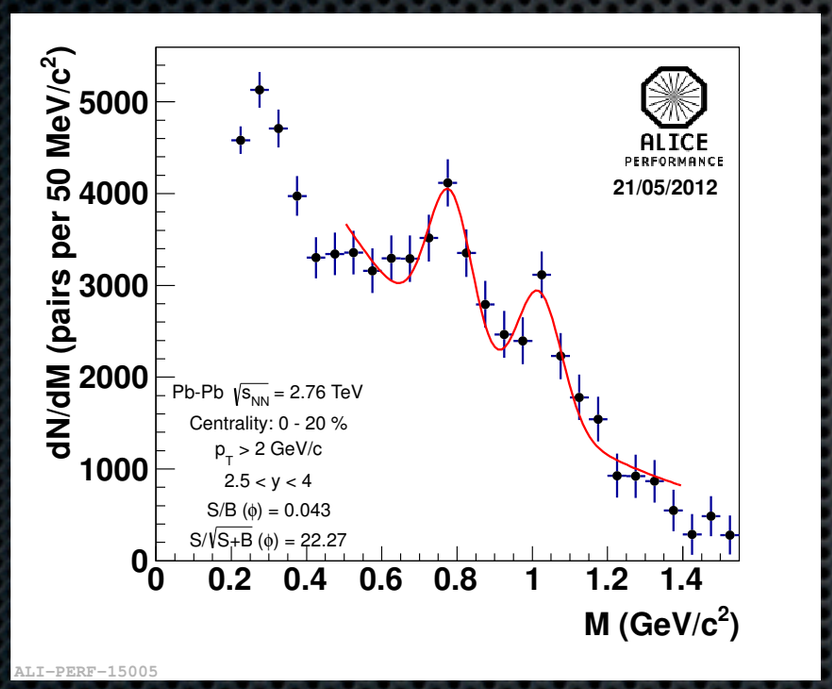
→ allows continuous operation at 50 kHz

→ preserves the present momentum and d*E*/d*x* resolution

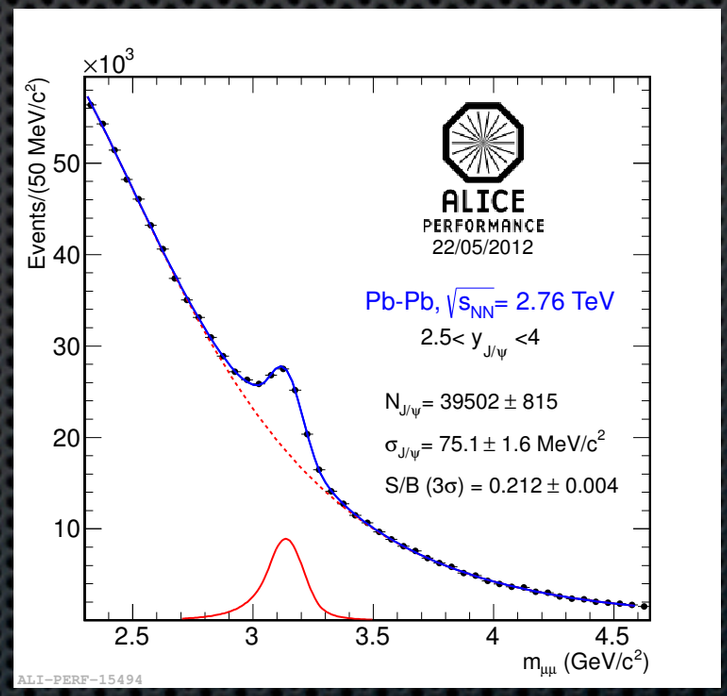
MFT



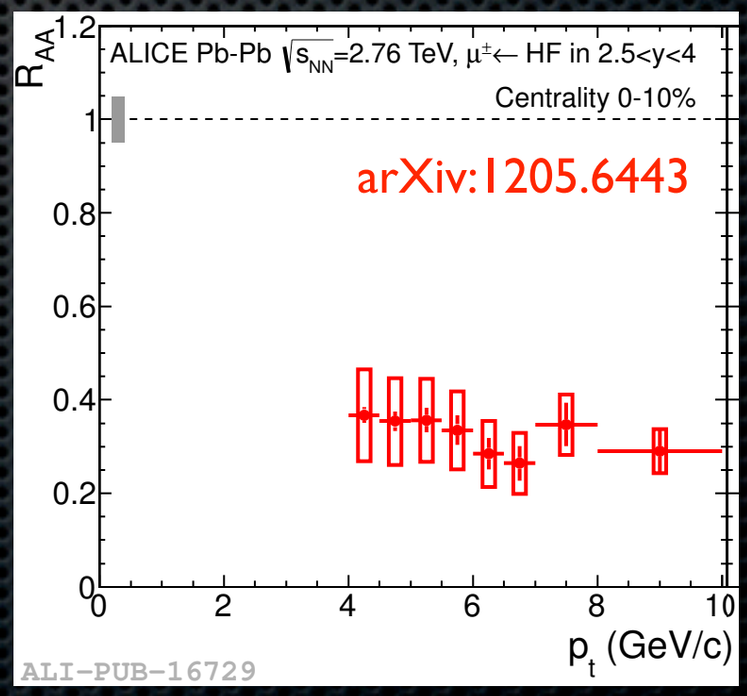
Multiple scatterings in the absorbeur ~$60X_0$
⇛ blur track extrapolation to vertex



low mass vector mesons

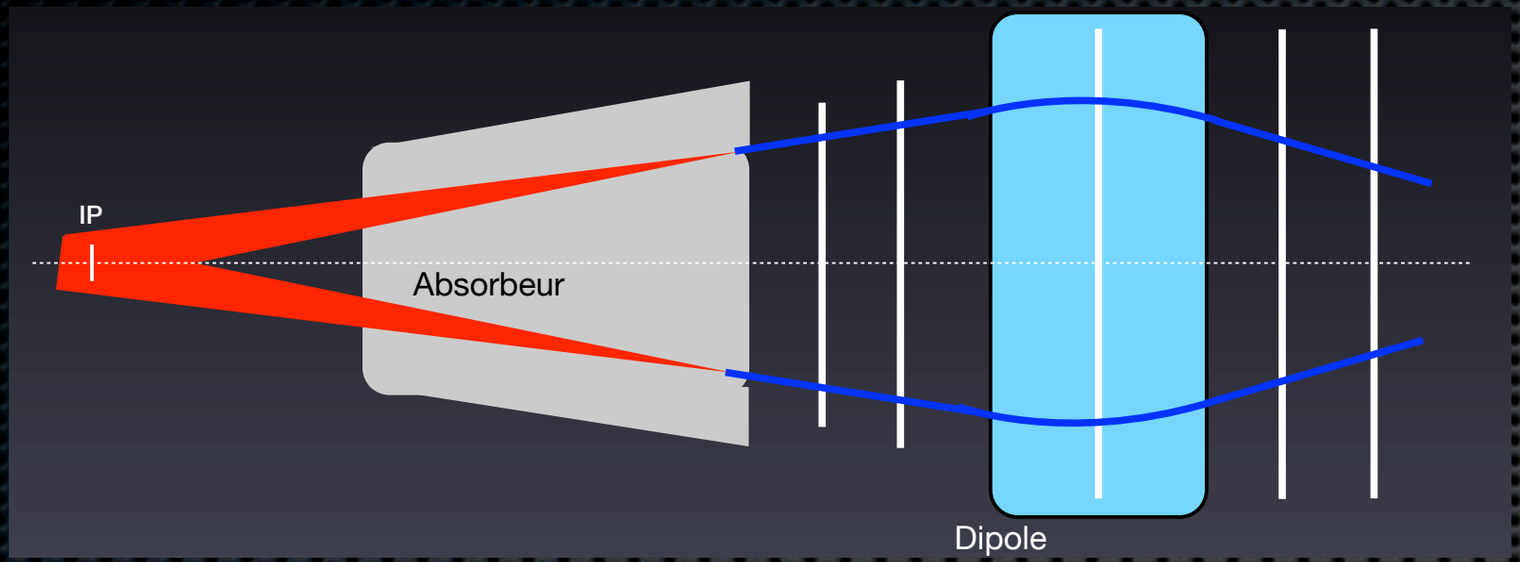


inclusive J/ψ



open heavy flavor (D+B) from single μ

MFT



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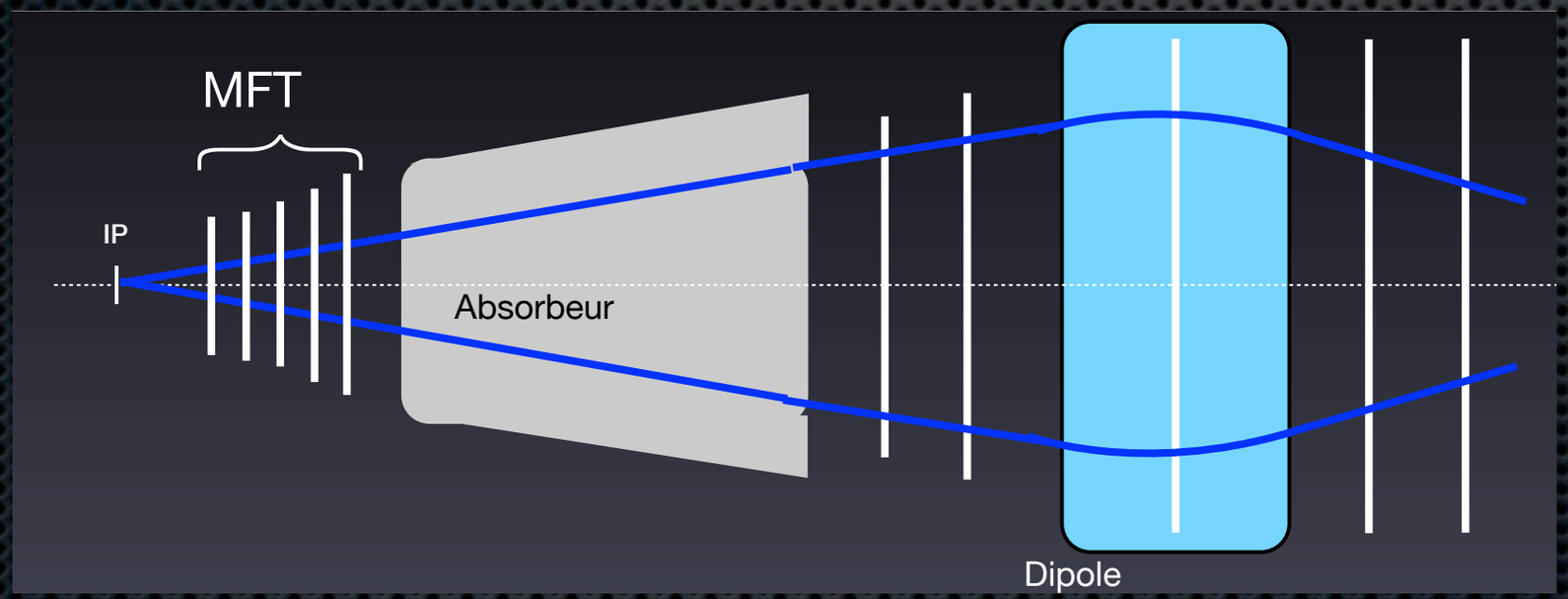

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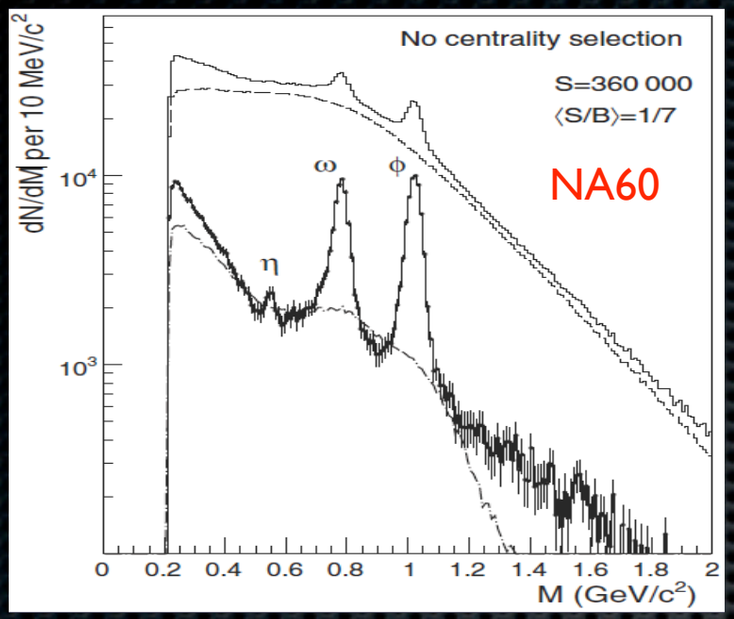

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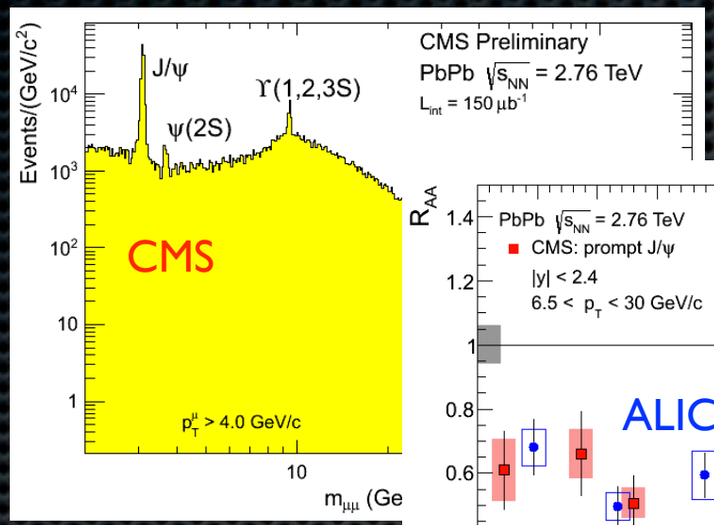
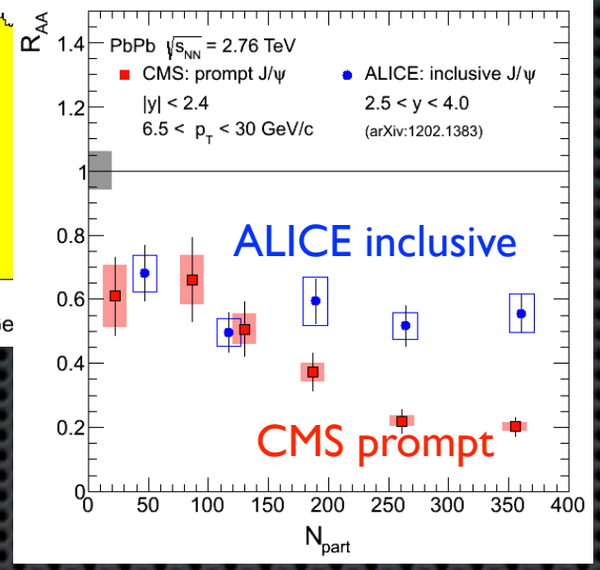
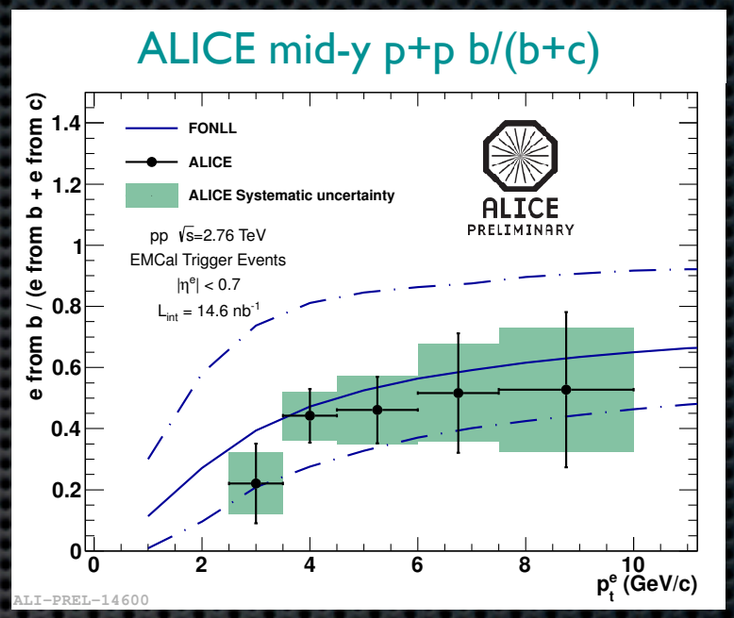


prompt J/ψ + ψ(2S)





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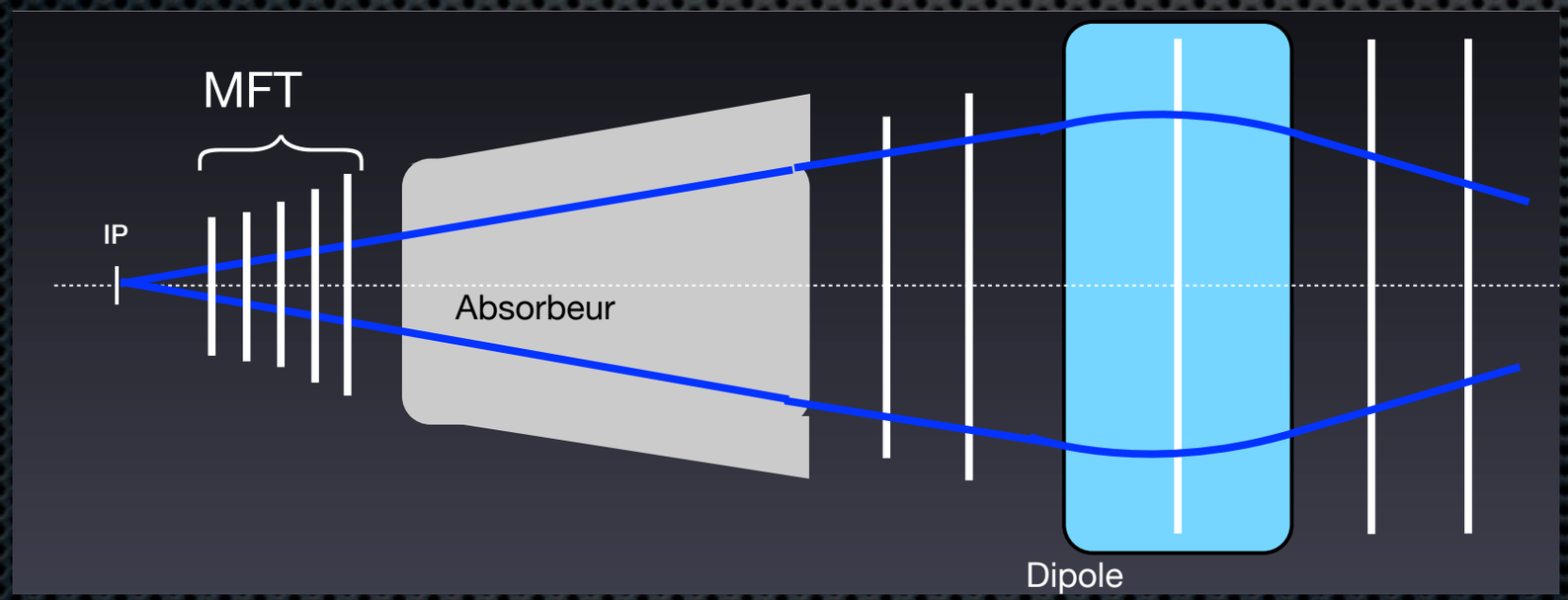

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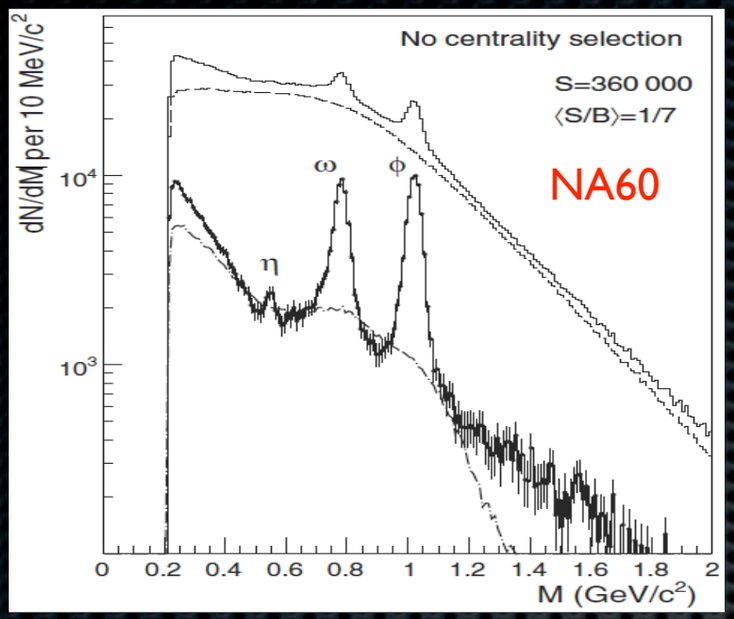

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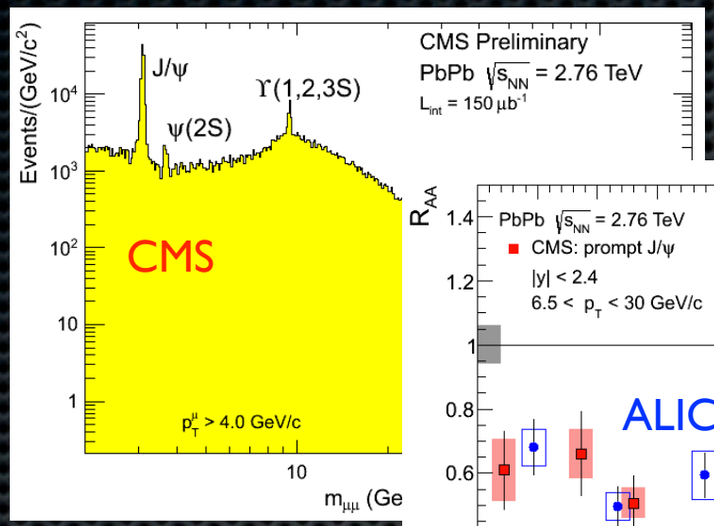

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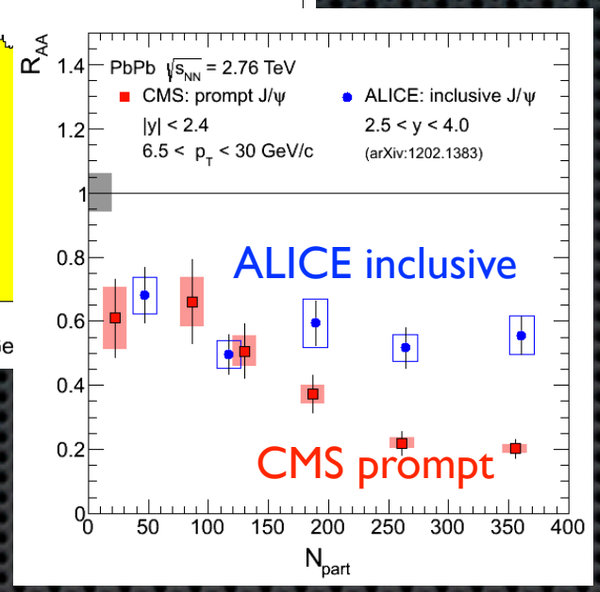

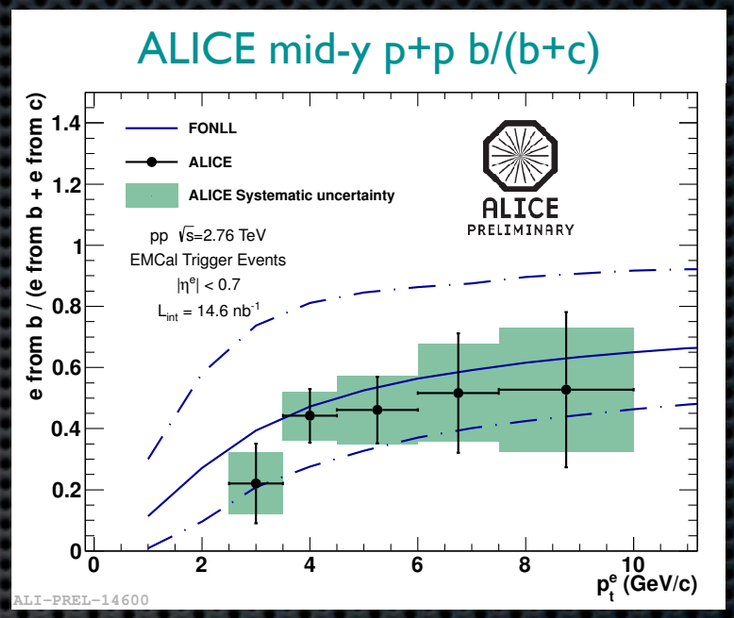

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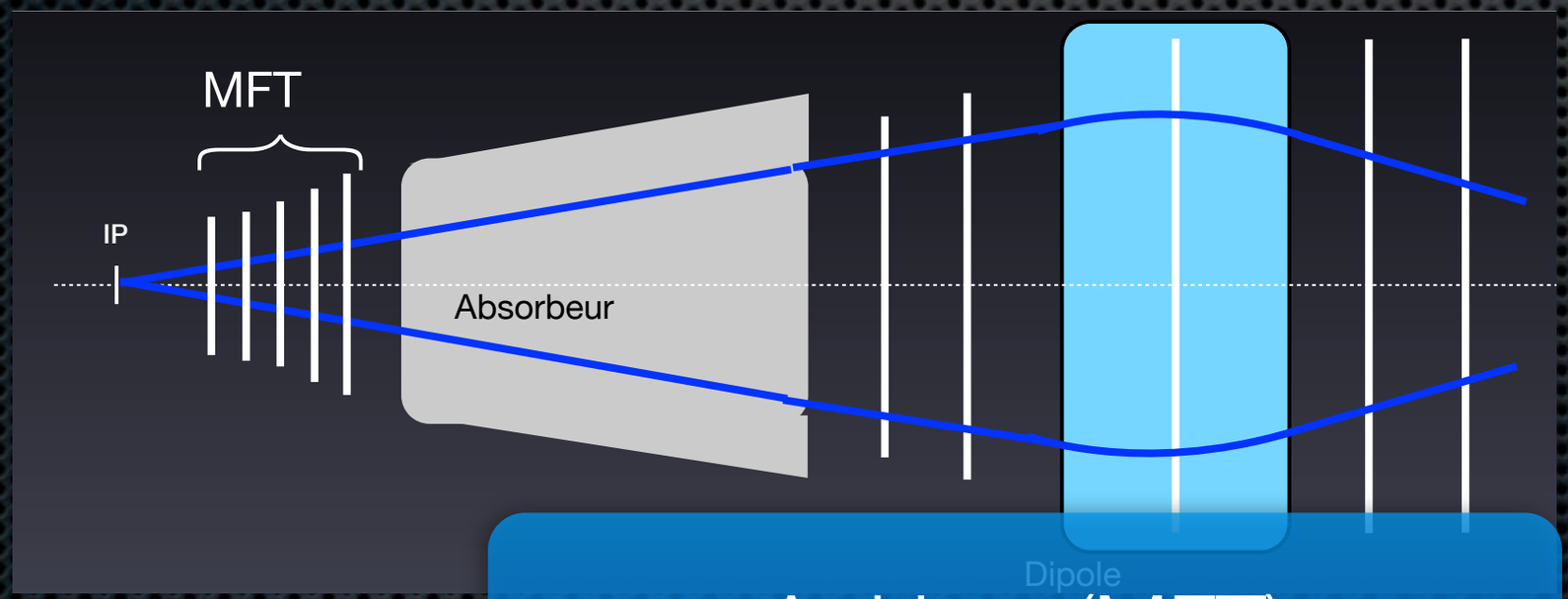

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[H. Appelshäuser, ESPG Symposium, Cracow, Sept. 2012]

Jets - precision measurements:
γ-Jet, b-Jet, Z-Jet, multi-Jet,
PID fragmentation functions,
TeV-scale jet quenching

ϒ spectroscopy - 1s, 2s, 3s states, onset-behaviour

Charmonia - low p_T J/ψ over wide rapidity range, ψ', X_c

Heavy Flavors - comprehensive measurement of D, D^*, D_s, Λ_c, B, Λ_b:
Baryon/Meson ratios down to low p_T, R_{AA}, v_2
accurate normalization for quarkonia

EM radiation - low mass dileptons

Exotica - anti- and hypernuclei

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I. Belikov (ITS)
L. Massacrier (Quarkonia)
A. Uras (MFT)

Future opportunities @ LHC

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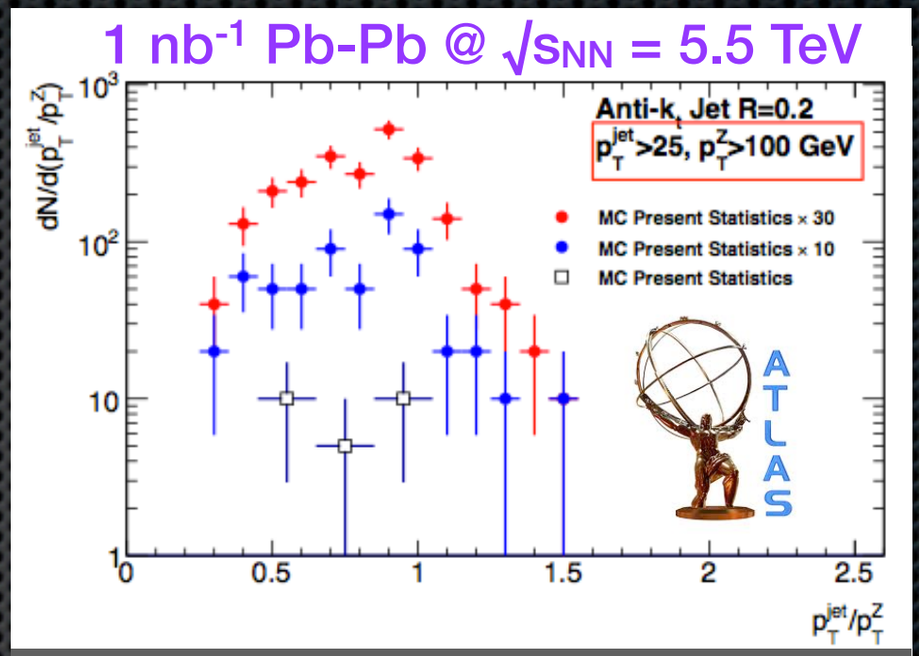

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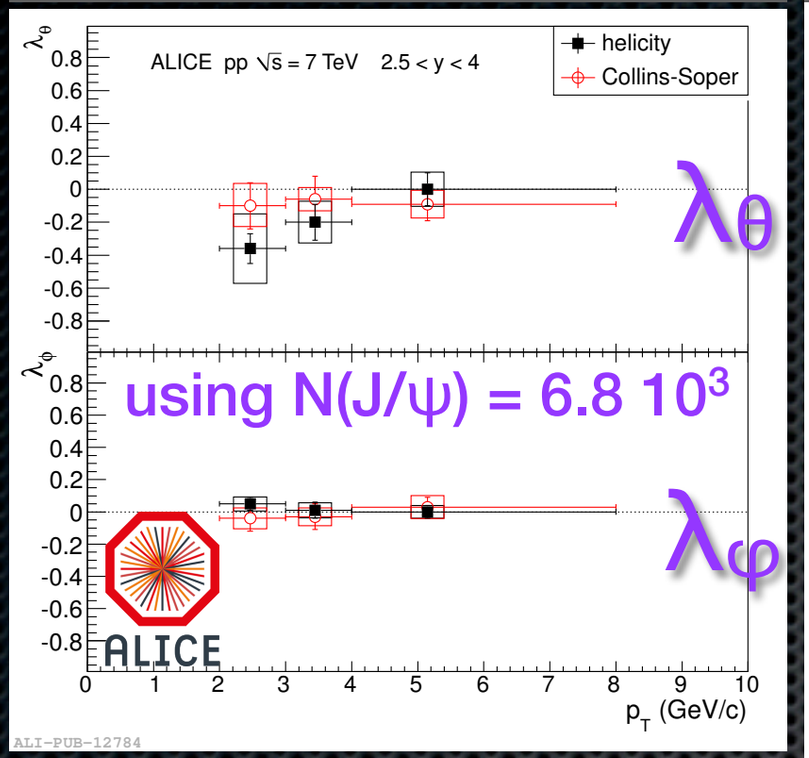
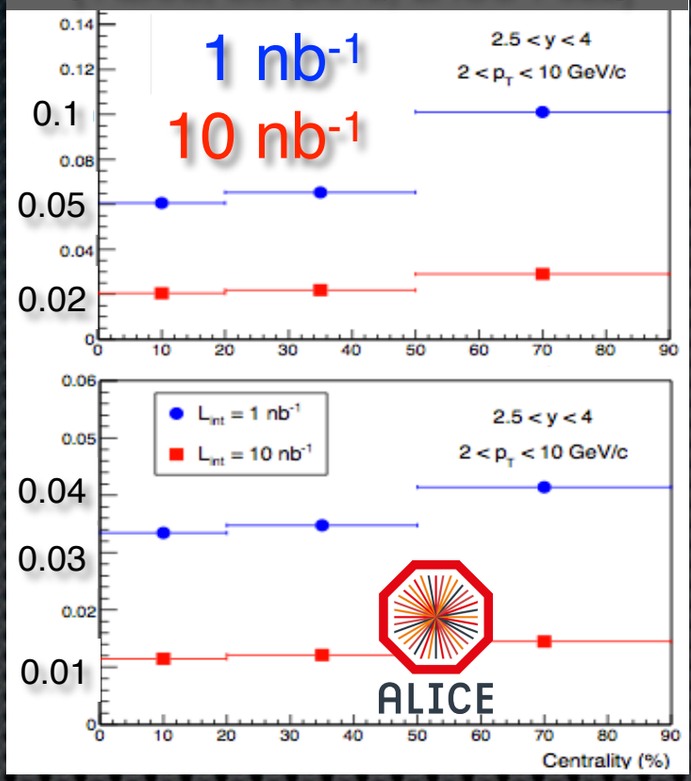
J/ψ polarisation p-p @ 7 TeV

[ALICE, PRL 108 (2012) 082001]



absolute error in Pb-Pb

[ALICE, LoI (2012) LHCC-I-022]



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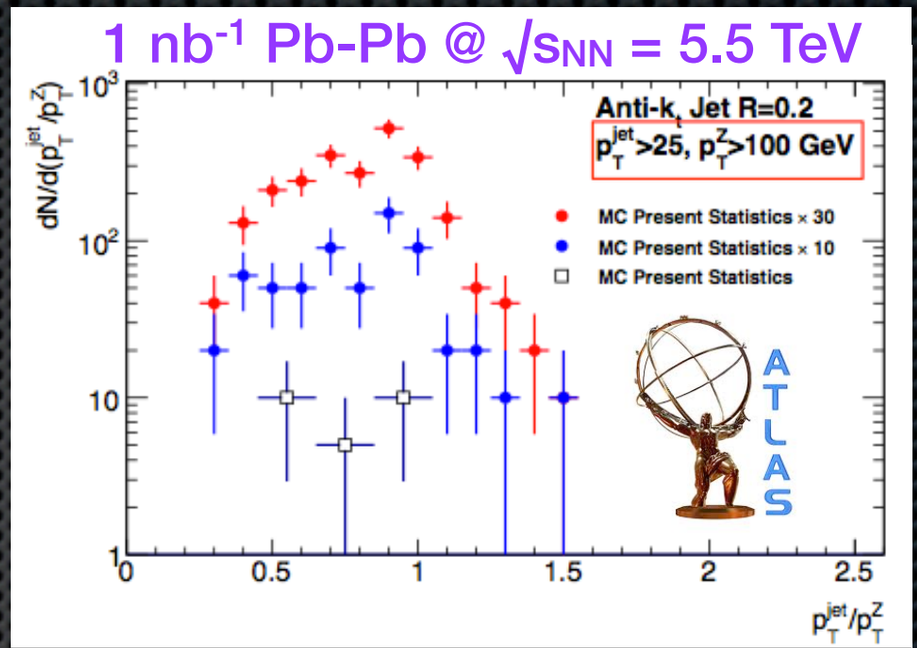

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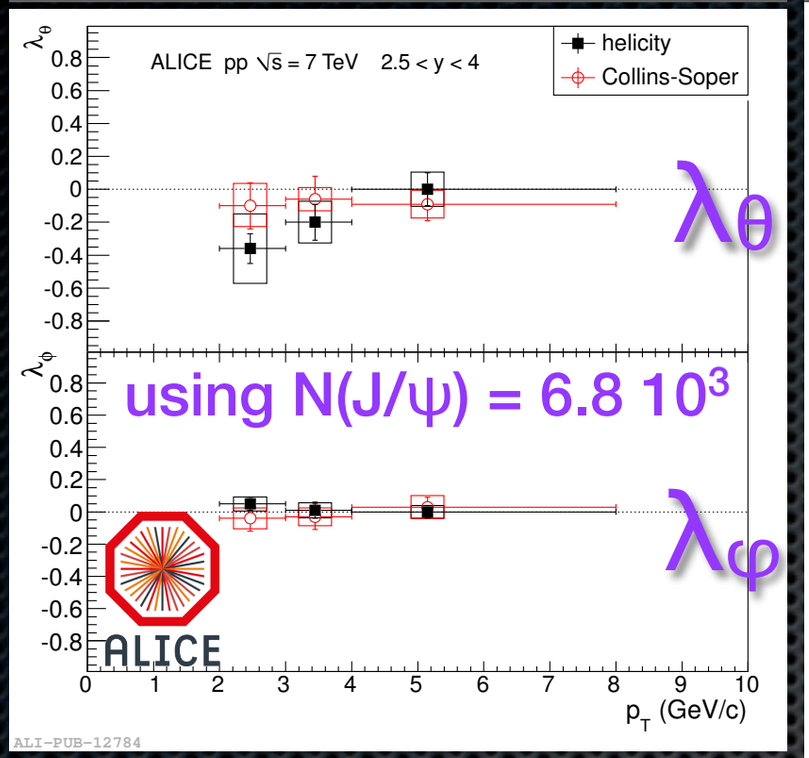

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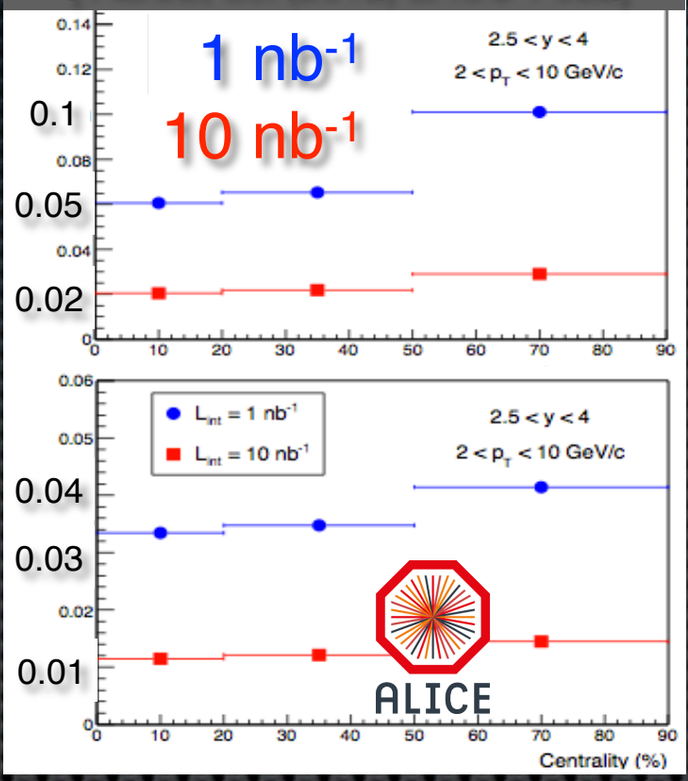
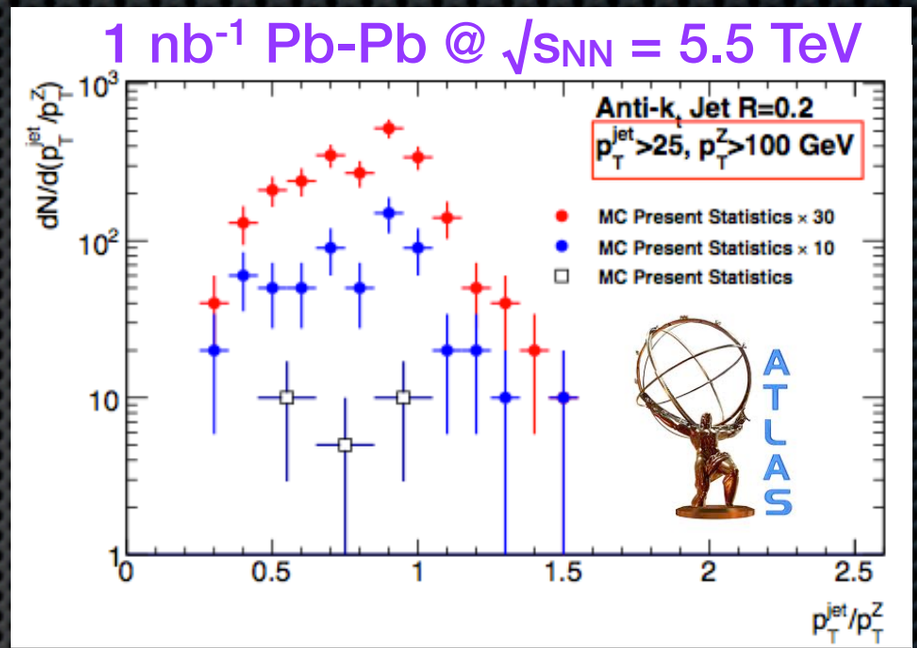
[ALICE, LoI (2012) LHCC-I-022]



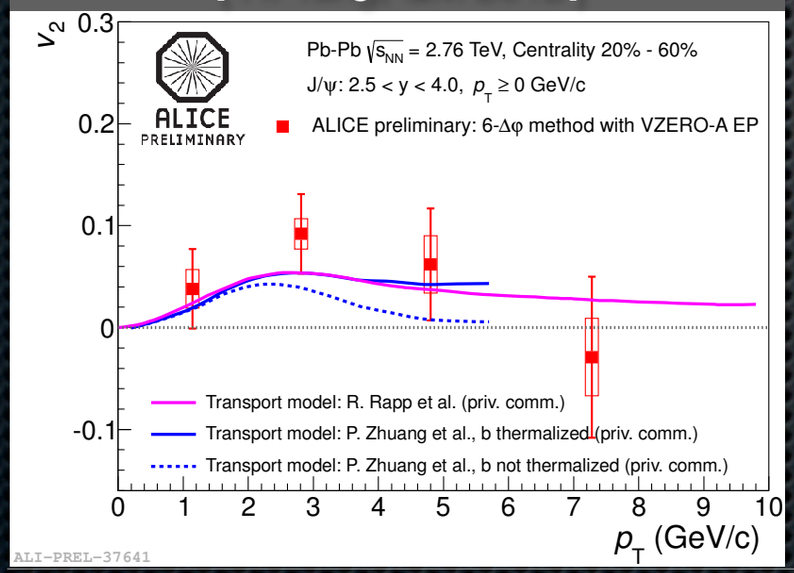
First measurement of Z-jet correlations



[H. Appelshäuser, ESPP Symposium, Cracow, Sept. 2012]

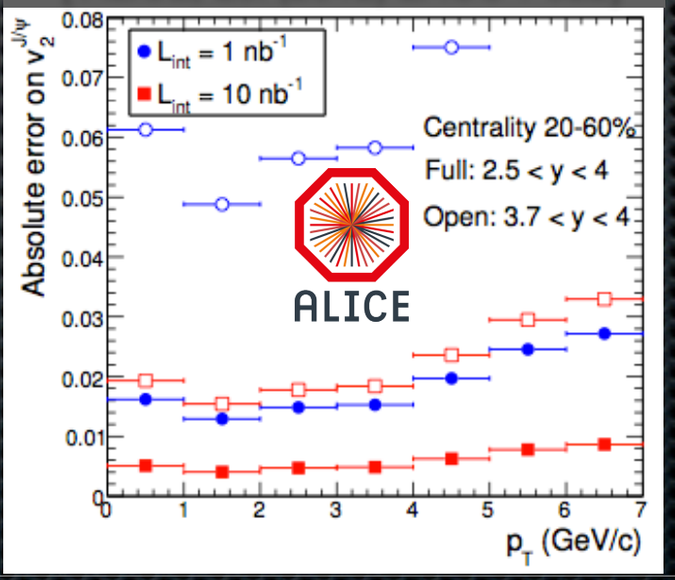
J/ψ v2 in Pb-Pb @ 2.76 TeV

[H. Yang, QM 2012]



absolute error @ 5.5 TeV

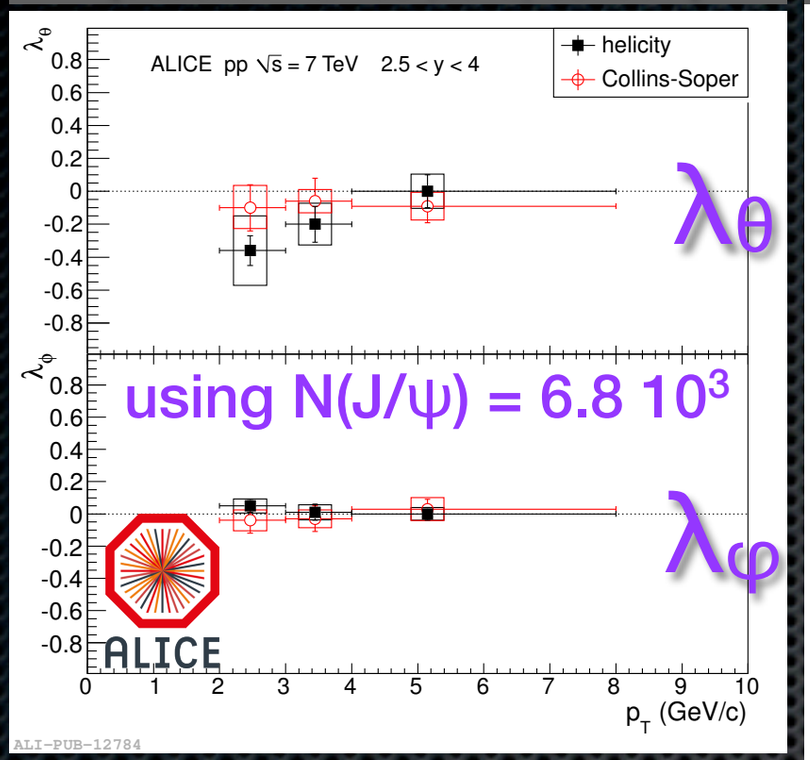
[ALICE, LoI (2012) LHCC-I-022]



Future opportunities @ LHC

J/ψ polarisation p-p @ 7 TeV

[ALICE, PRL 108 (2012) 082001]



absolute error in Pb-Pb

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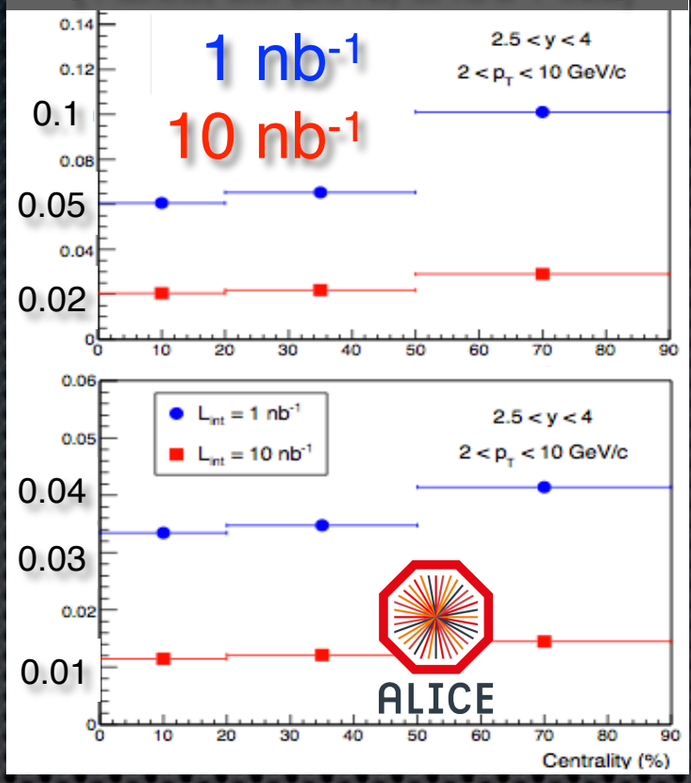

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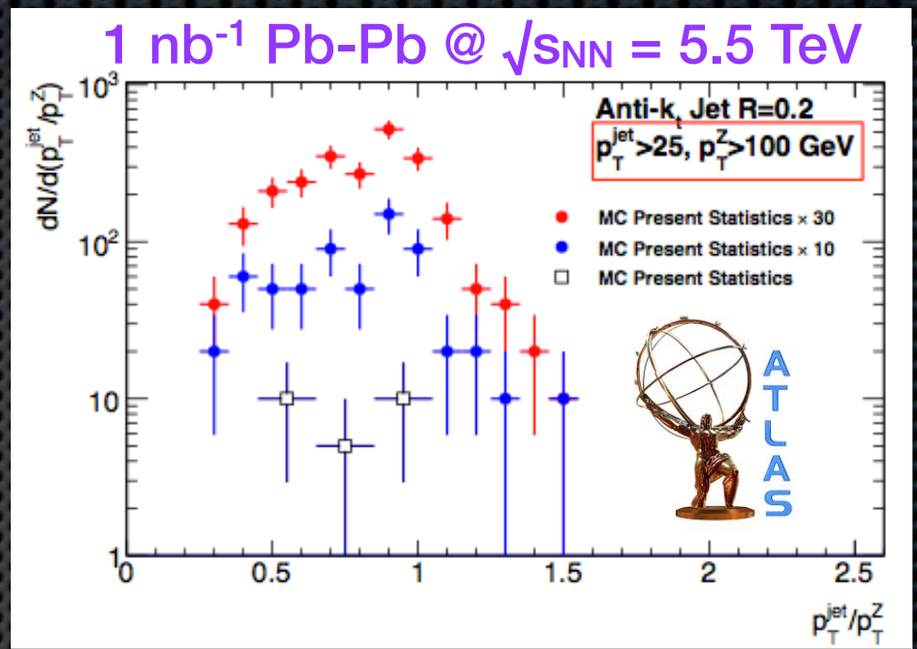

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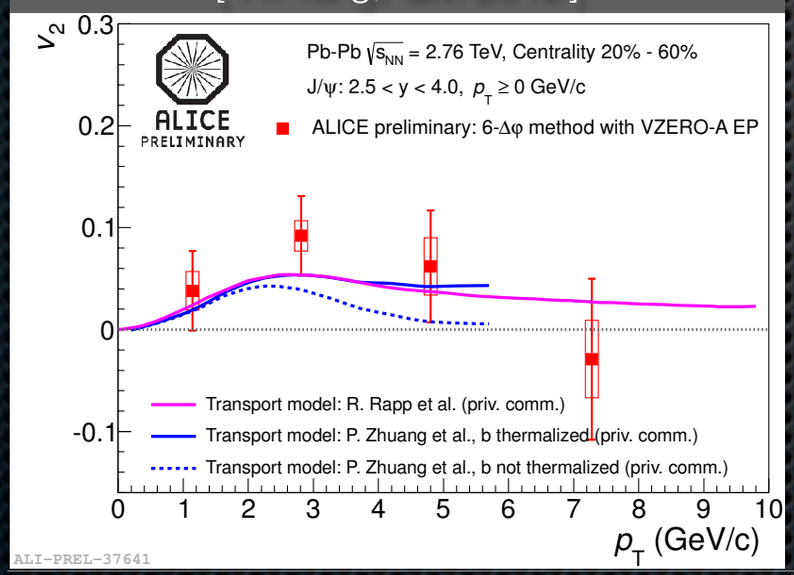

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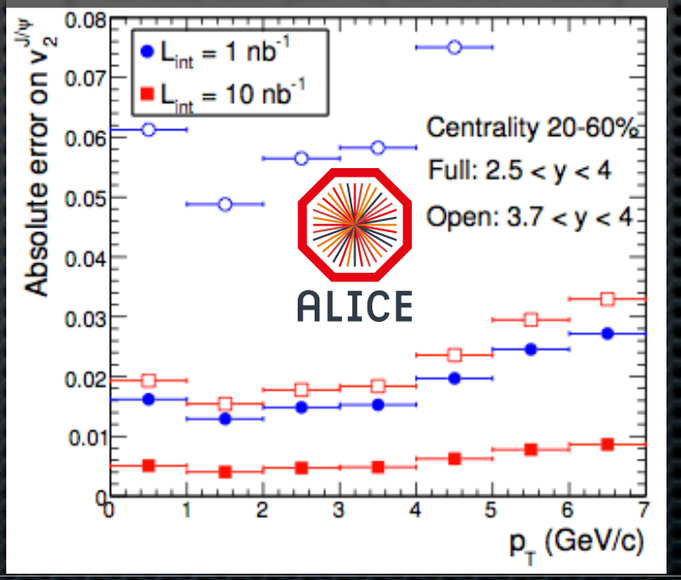
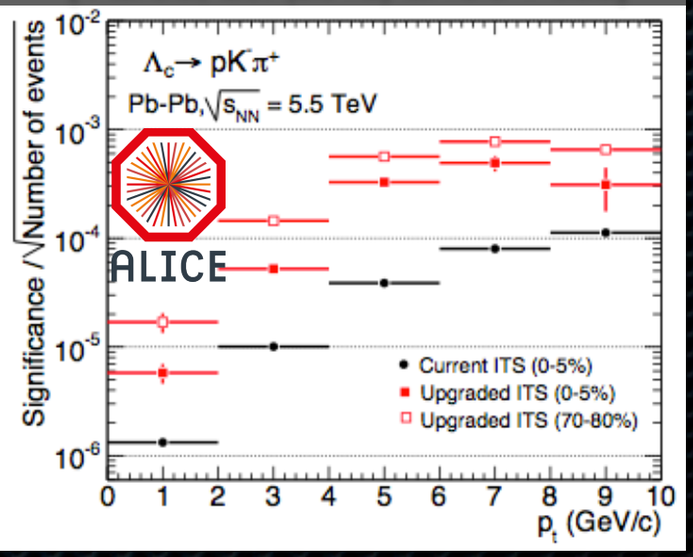


open charm Λ_c @ 5.5 TeV

[ALICE, LoI (2012) LHCC-I-022]



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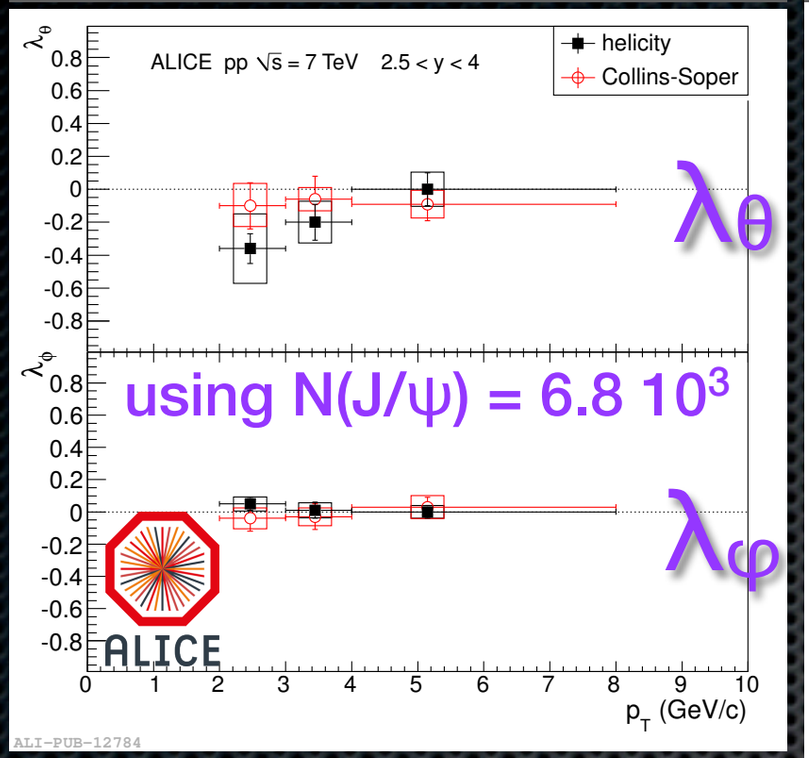

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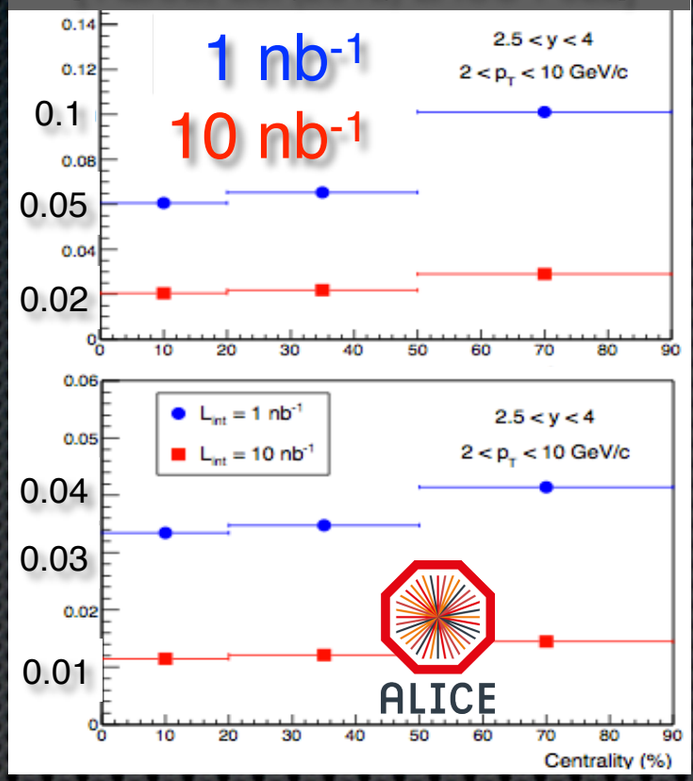

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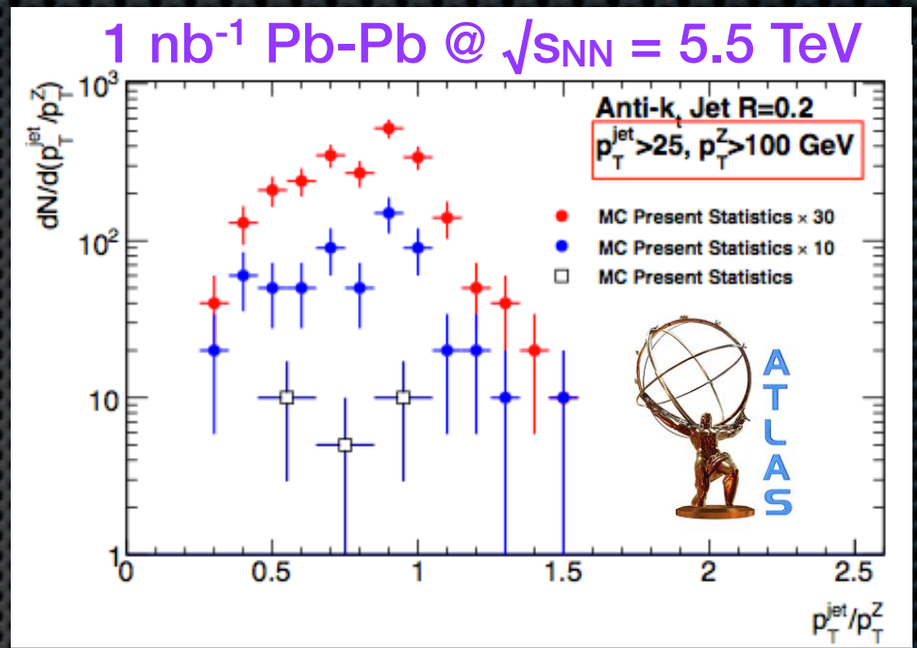

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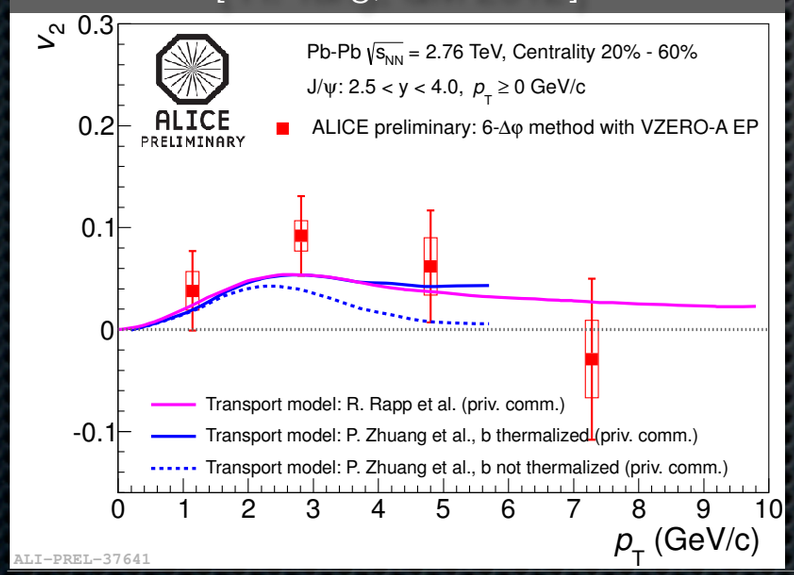

absolute error @ 5.5 TeV

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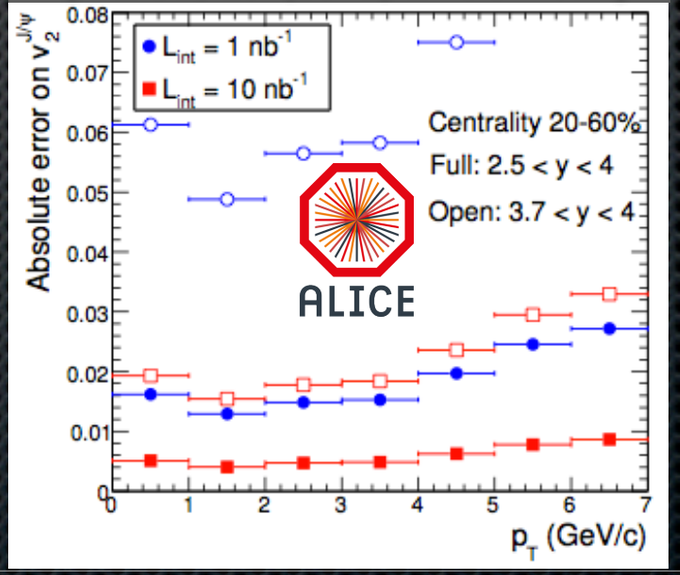
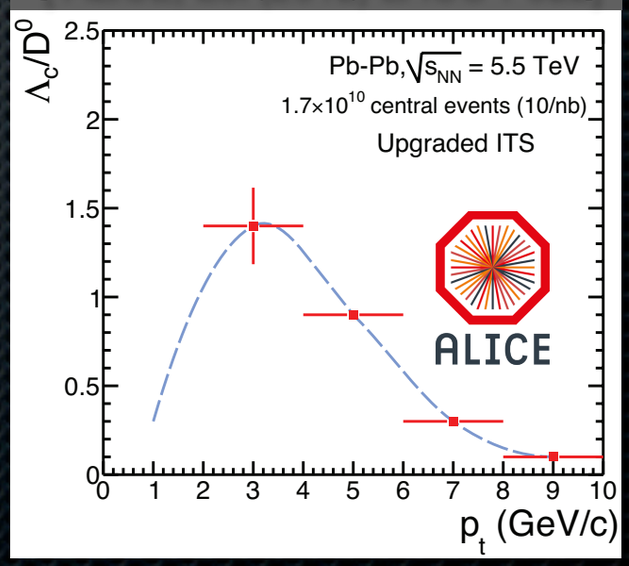


charm baryon/meson @ 5.5 TeV

[ALICE, LoI (2012) LHCC-I-022]



A rough timeline*

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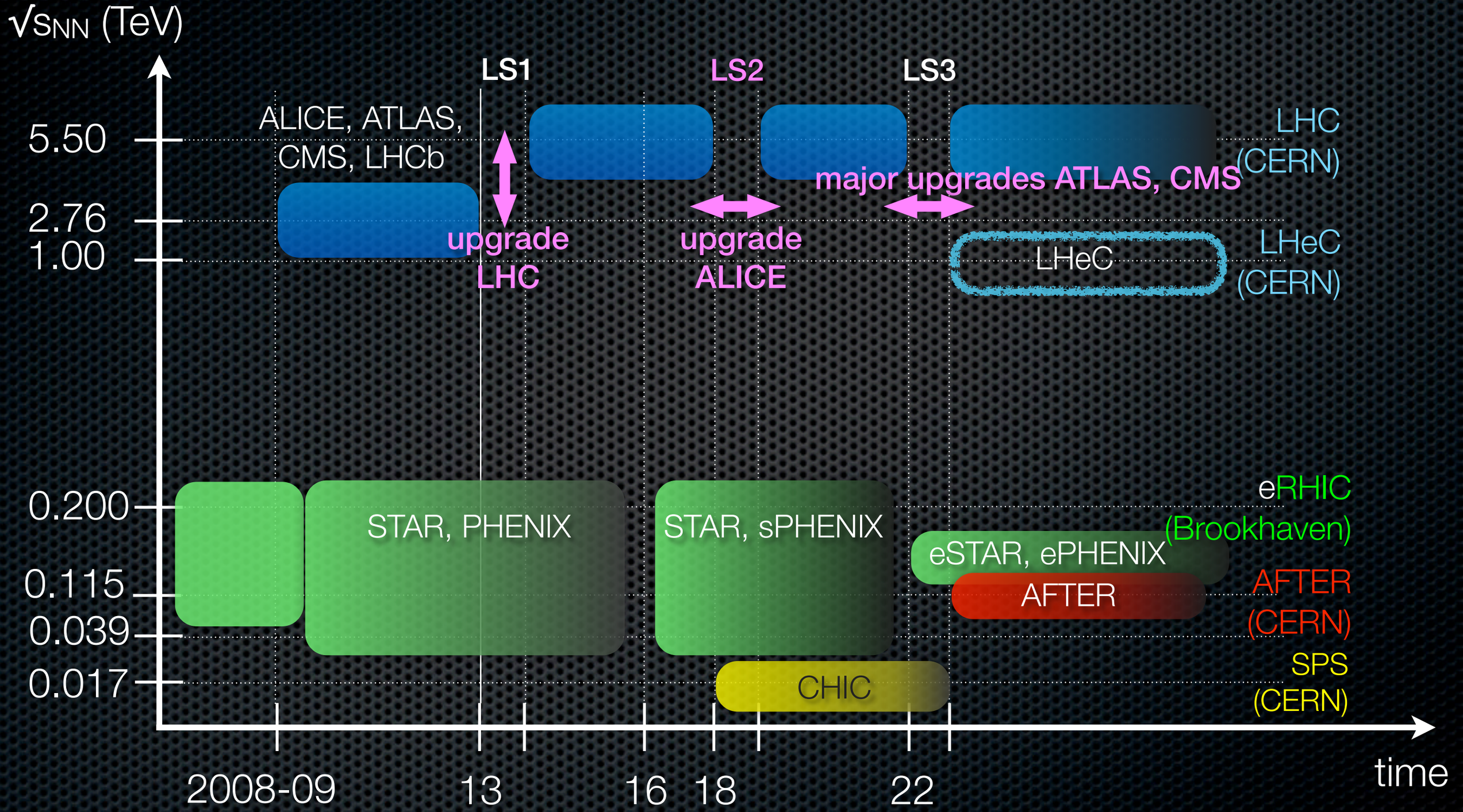
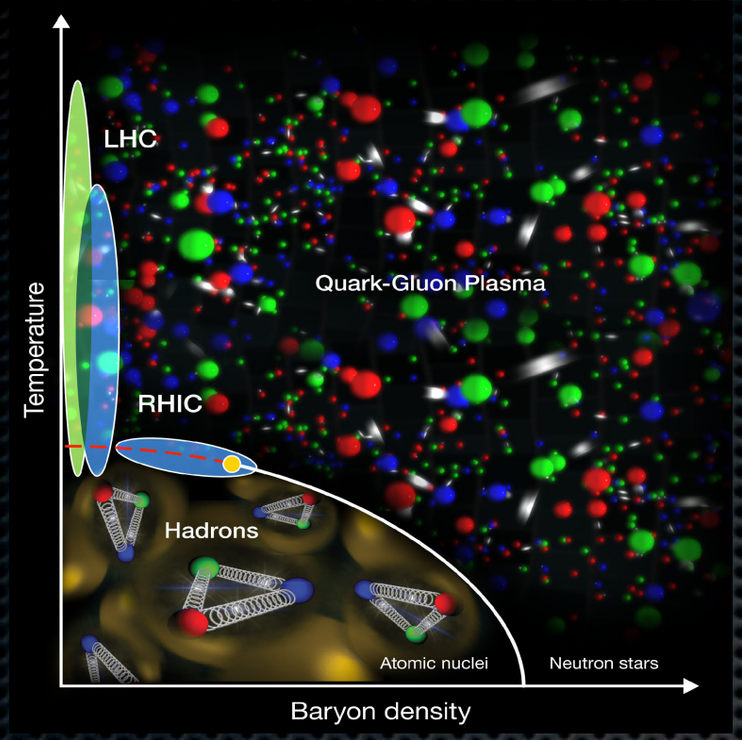


H.I. collisions @ RHIC



« The complementarity of LHC and RHIC is an essential resource in efforts to quantify properties of the Quark-Guon plasma. »

Conclusions of the Heavy-Ion Town meeting (June 2012, CERN), in the preparation of the European Strategy Preparatory Group for Particle Physics (ESPG)

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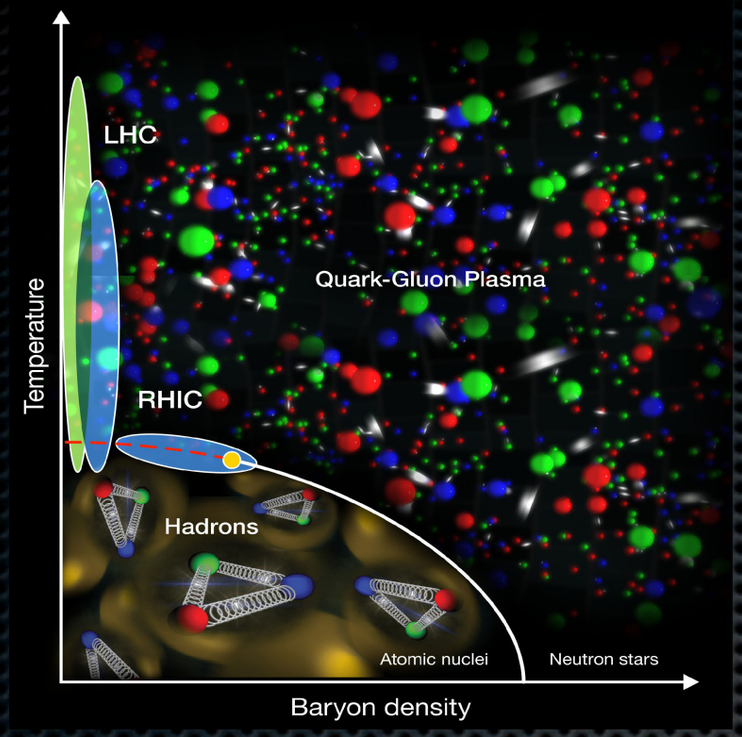

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[J. Nagle, H. Z. Huang, QM 2012]

what is the nature of the QGP at $\mu_B > 0$?

- can we map the transition from plasma to hadron gas ?
- is there a critical point in the phase diagram ?
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QGP transition from strong (RHIC) to weak coupling (LHC?)

- do QGP properties change from T=170 to 400 MeV ?
- quasi-particles ?
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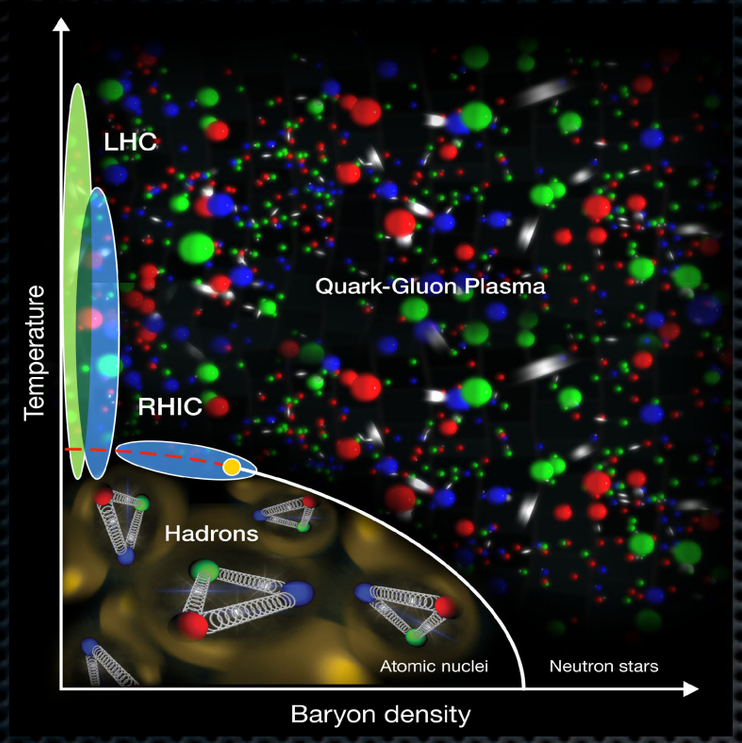

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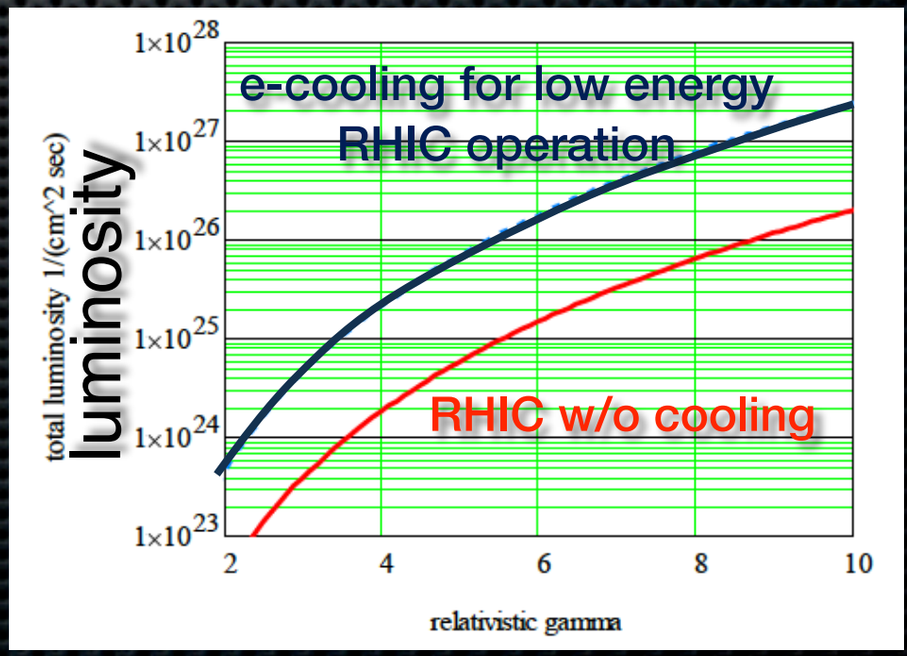

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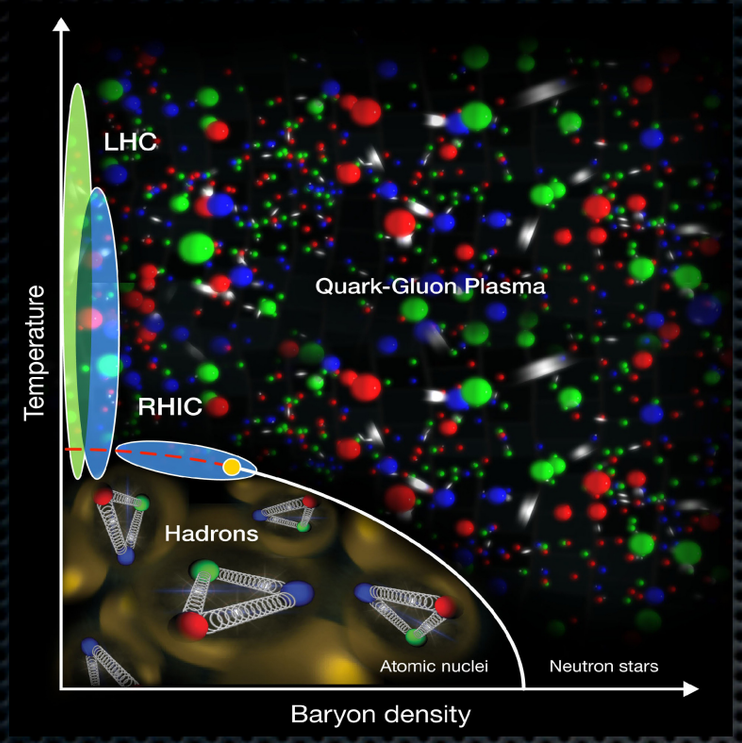

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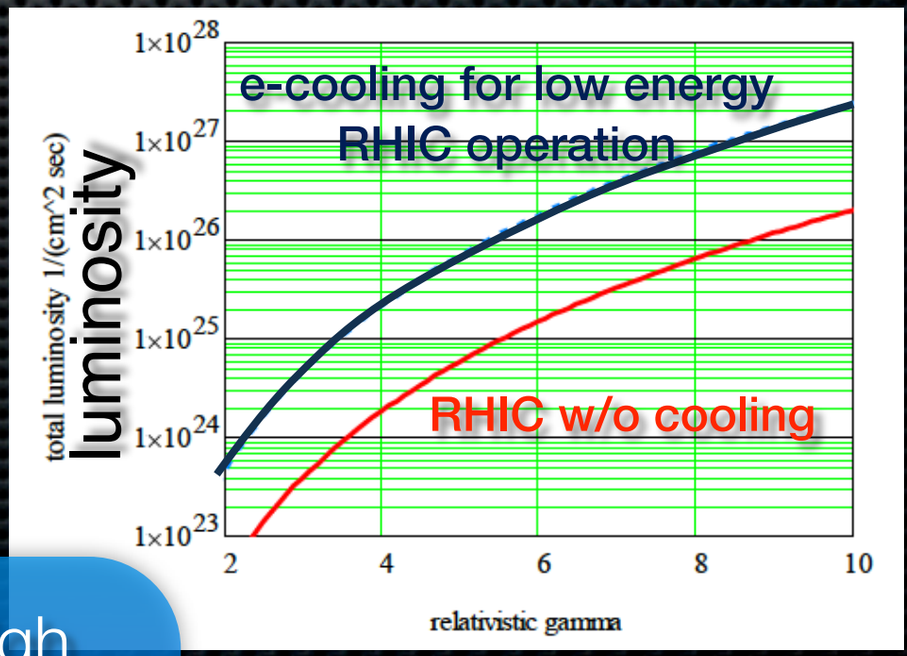
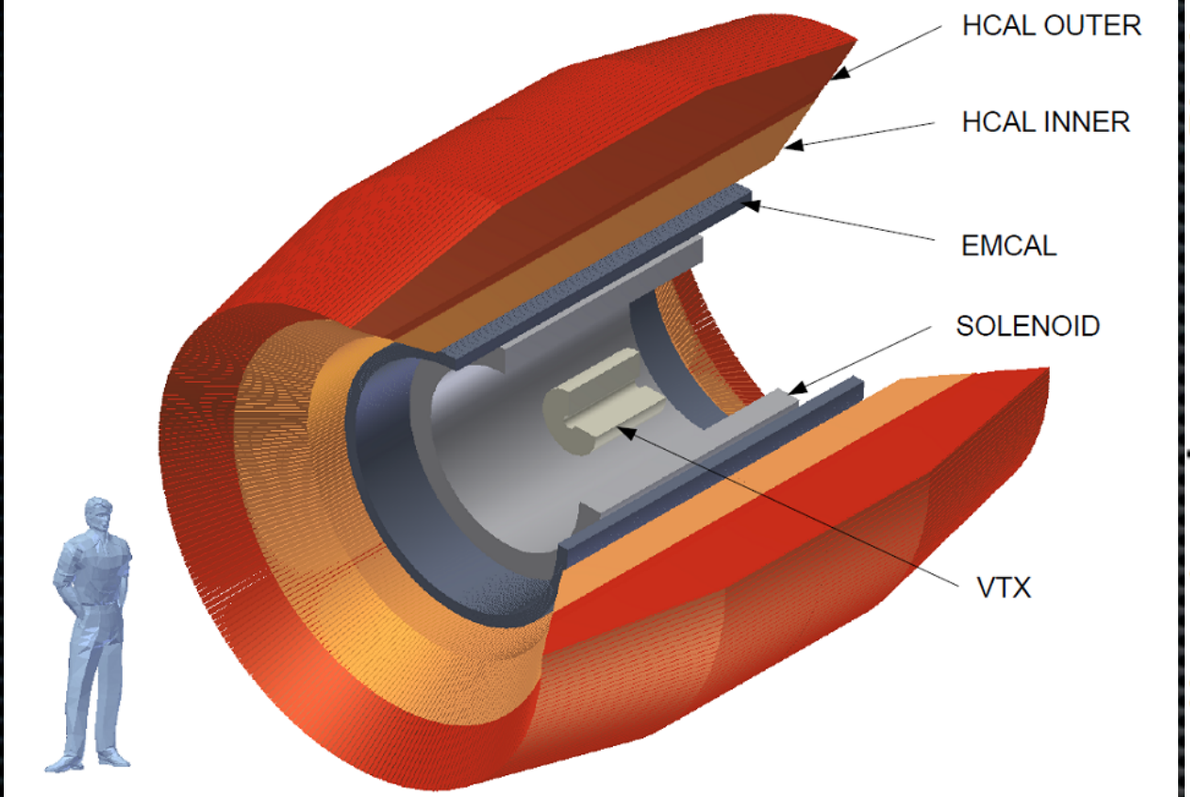


RHIC II high luminosities

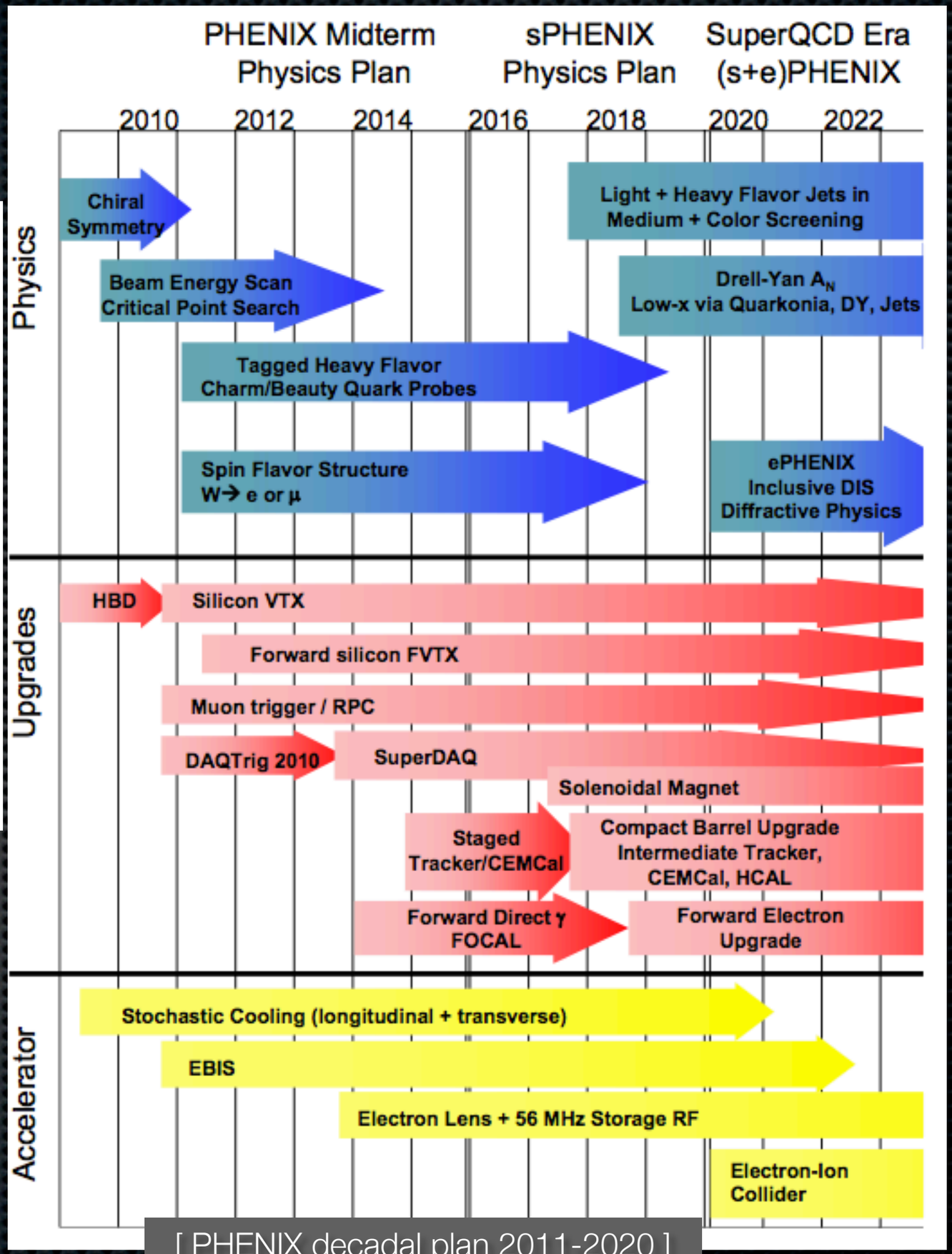
sPHENIX

[J. Haggerty, QM2012]
[sPHENIX, arXiv:1207.6378]



- Emphasizes jet physics observables with calorimetry initially
- Full jet reconstruction
- Compact detector
- Data acquisition capable of recording > 10 kHz

EBIS = Electron Beam Ion Source



[PHENIX decadal plan 2011-2020]

sPHENIX

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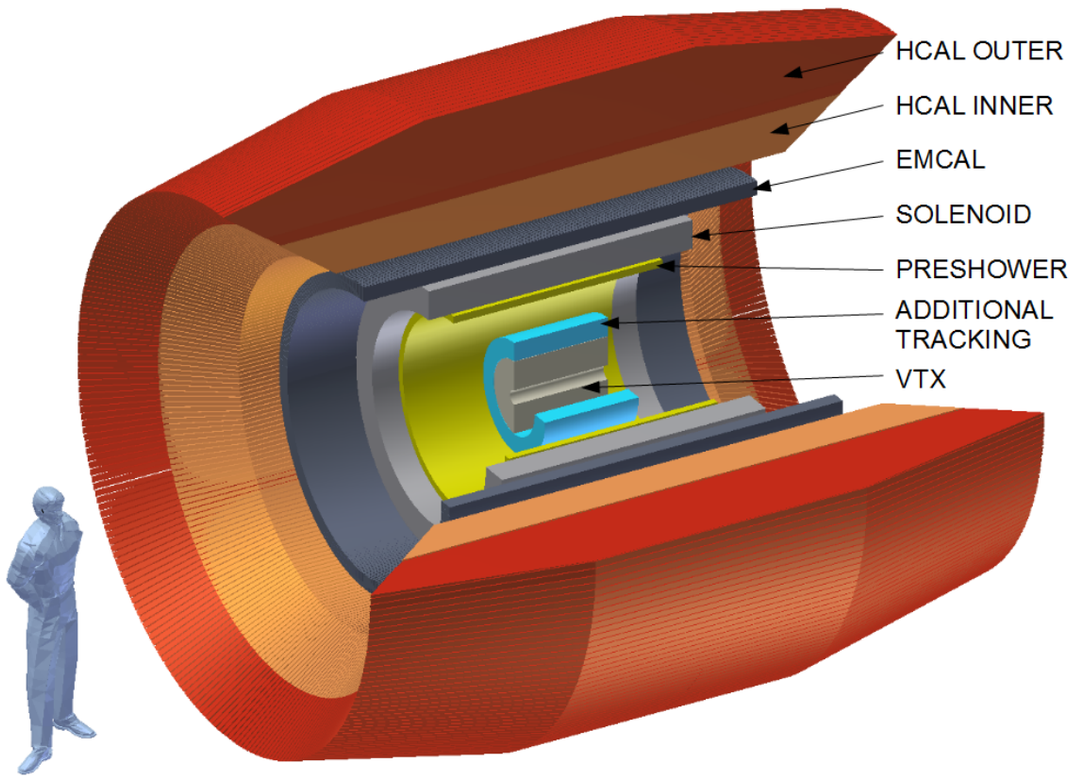
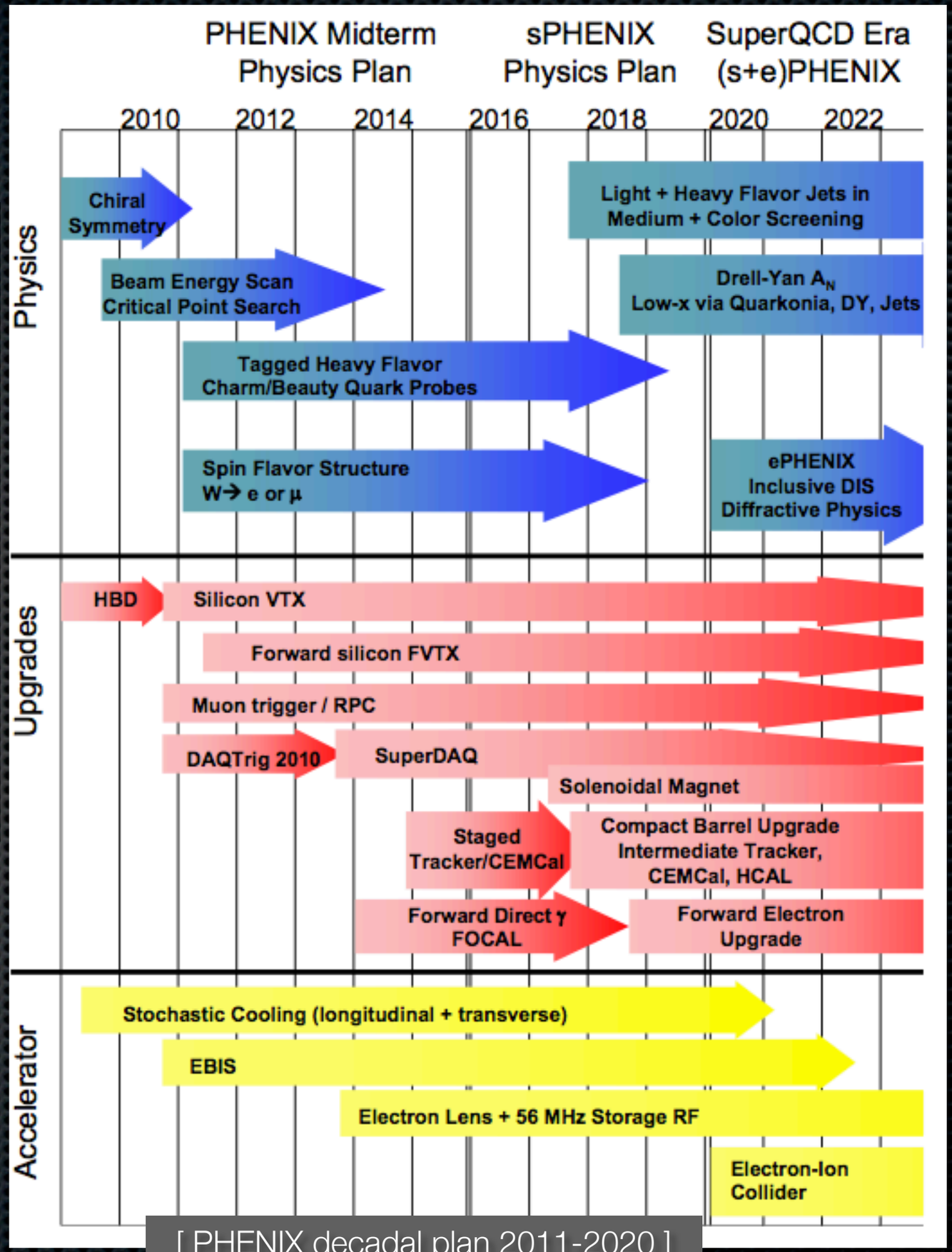


upgrade option # 1 :

- separation of Υ states (add. tracking)
- extend up to $p_T > 50$ GeV single γ from $\pi^0 \rightarrow \gamma\gamma$ separation (preshower)

EBIS = Electron Beam Ion Source



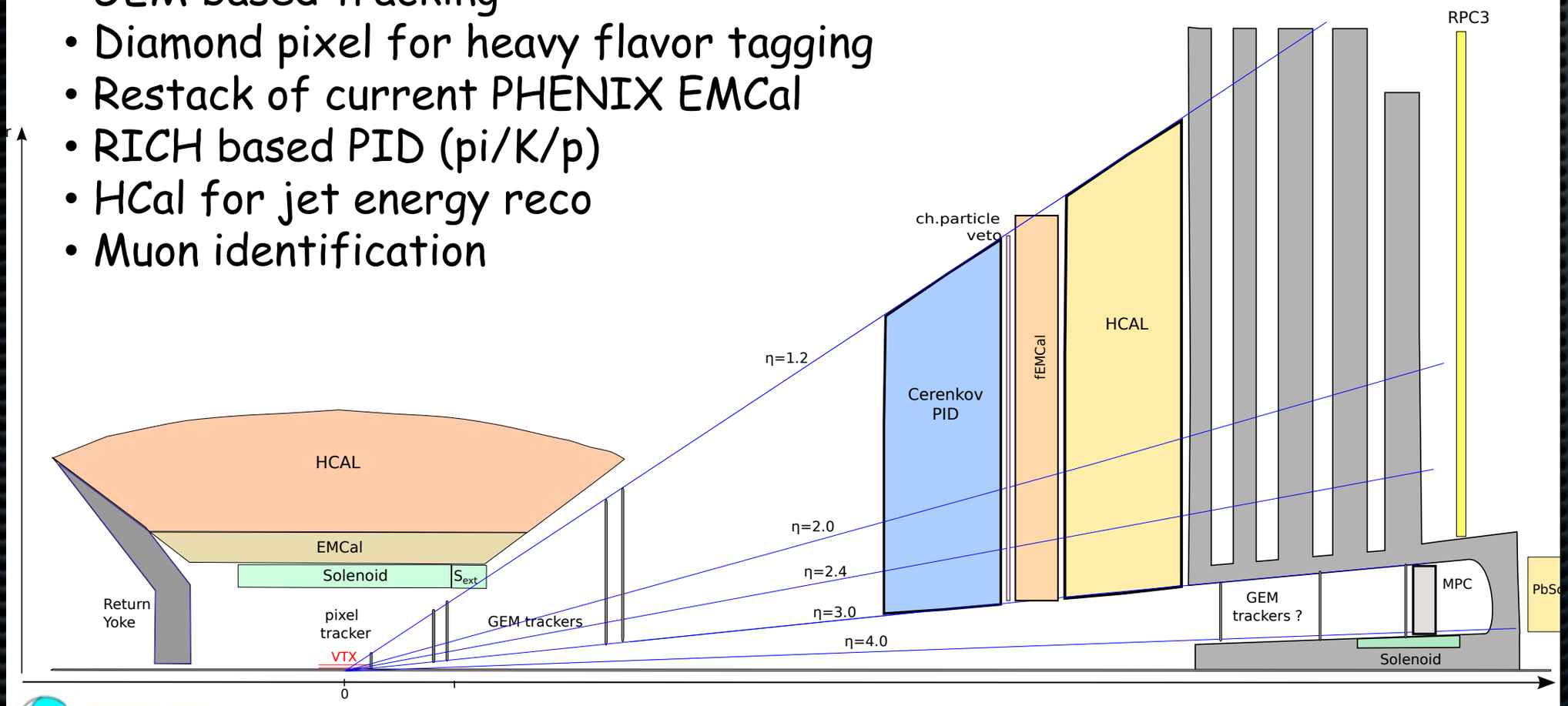
[PHENIX decadal plan 2011-2020]

sPHENIX - ePHENIX

[J. Seele, QM2012]
[sPHENIX, arXiv:1207.6378]

Optimized for jets and photons/DY over a large range in rapidity (η~4)

- Extension/modification of the central solenoid for B field
- GEM based tracking
- Diamond pixel for heavy flavor tagging
- Restack of current PHENIX EMCal
- RICH based PID (pi/K/p)
- HCal for jet energy reco
- Muon identification

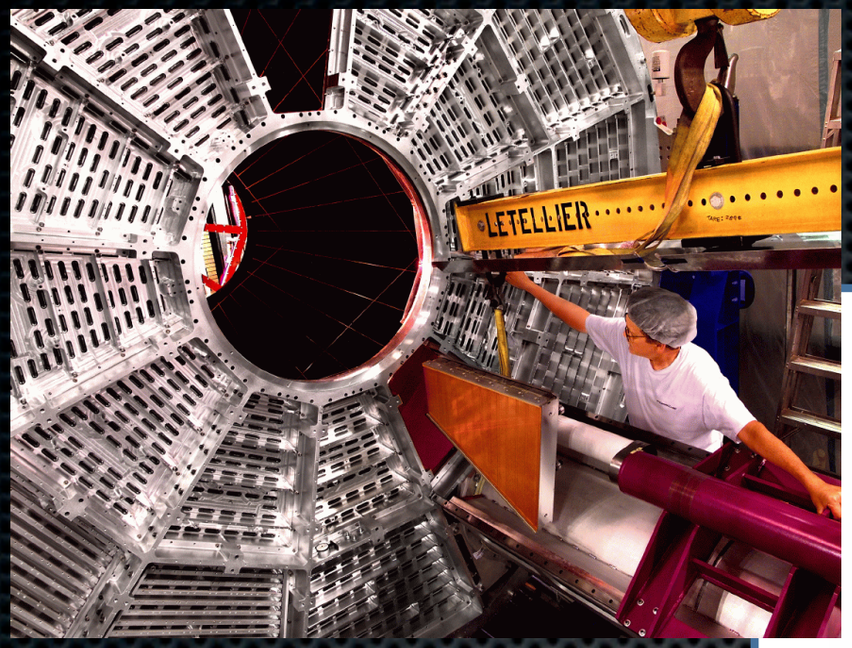


RIKEN BNL Research Center

J. Seele (RBRC) - QM2012 9

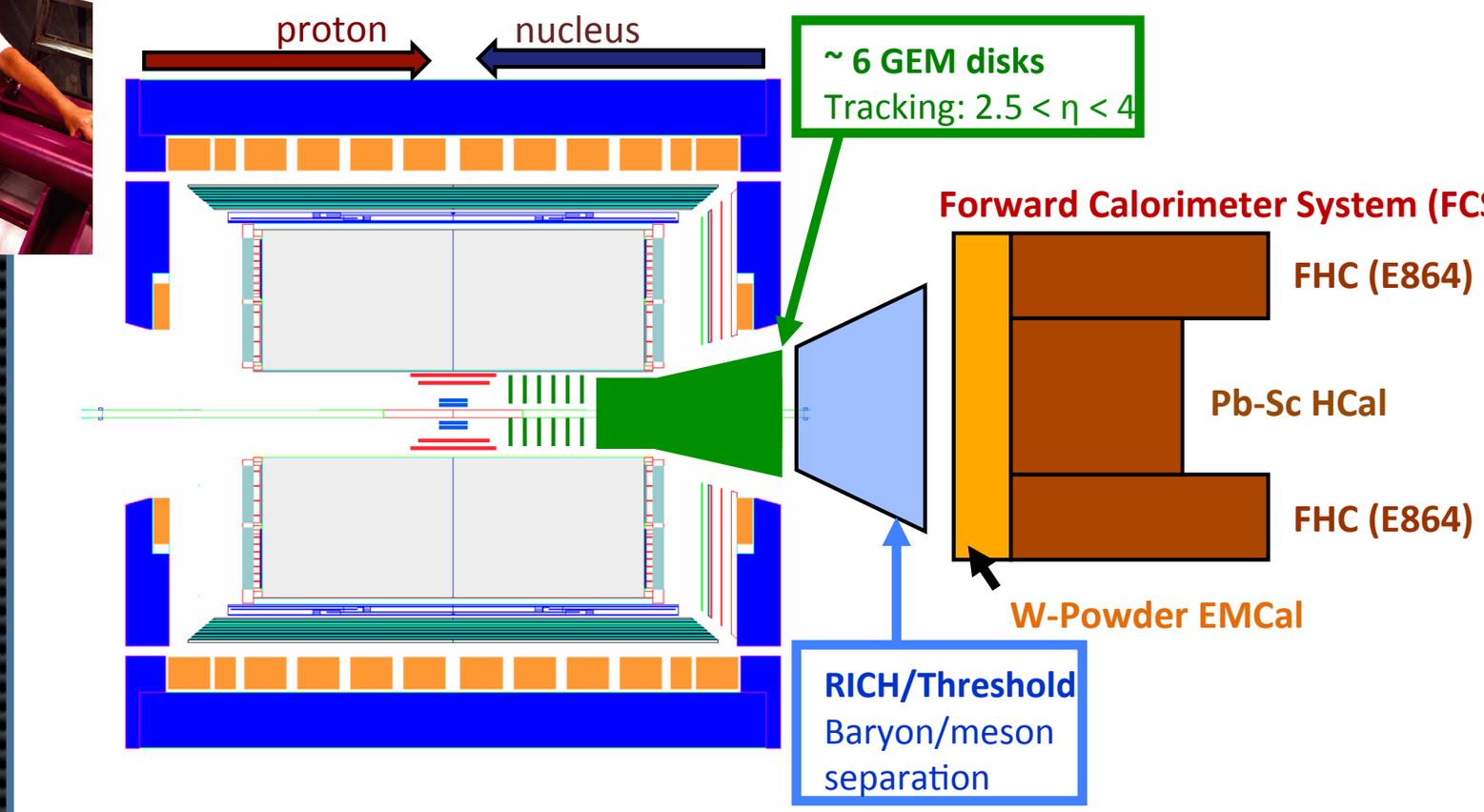
- upgrade option # 2
- also Cold Nuclear Matter studies, spin physics

STAR



STAR Inner TPC Readout
Improved tracking and dE/dx PID
Extend η coverage 1.0-1.7

[H. Z. Huang, J. Nagle, QM2012]



also designed for evolution into EIC detector

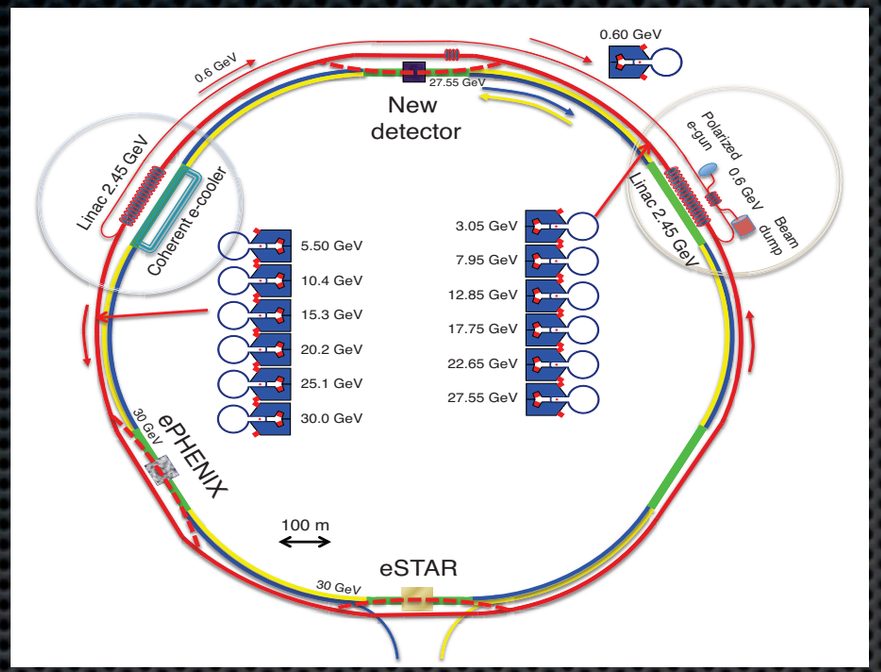
LHeC / eRHIC : electron-ion colliders

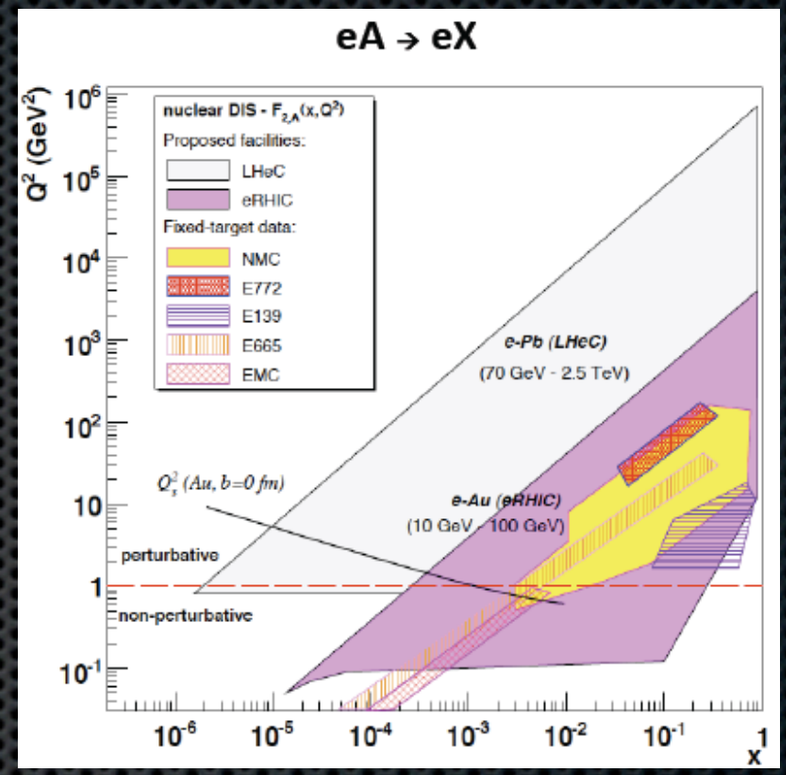
[A. L. Deshpande, C. Marquet, A. Stasto, J.H. Lee, QM 2012]

RHIC @ BNL

up to 140 (90) GeV ep (eA)

INT Report: arXiv:1108.1713v2

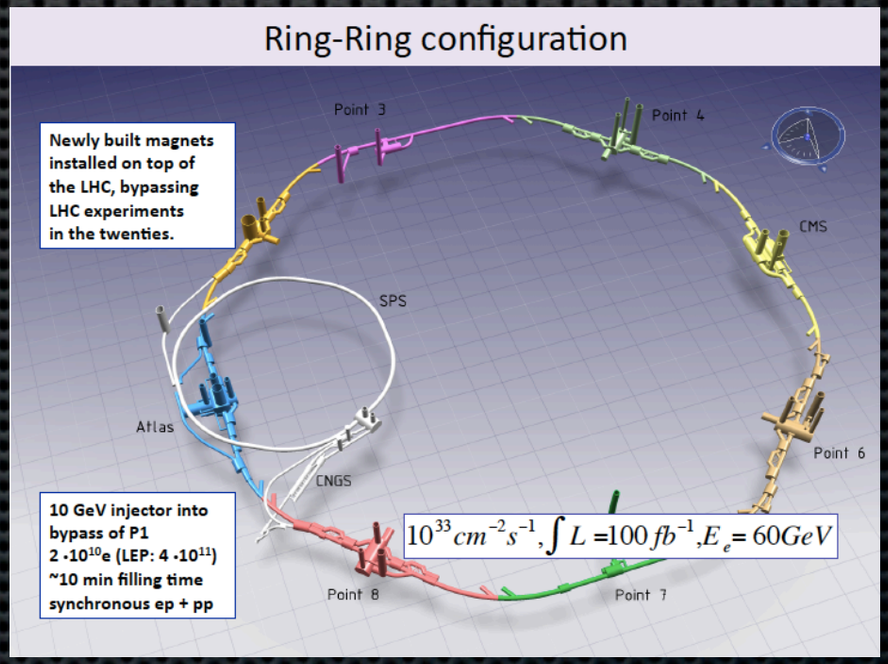


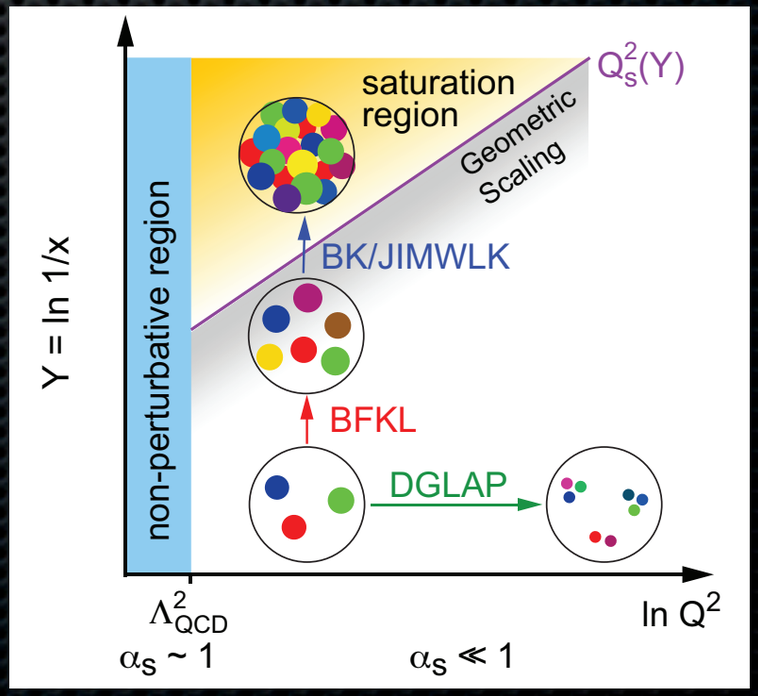


LHC @ CERN

up to 2 (1.2) TeV ep (eA)

CDR arXiv:1206.2913





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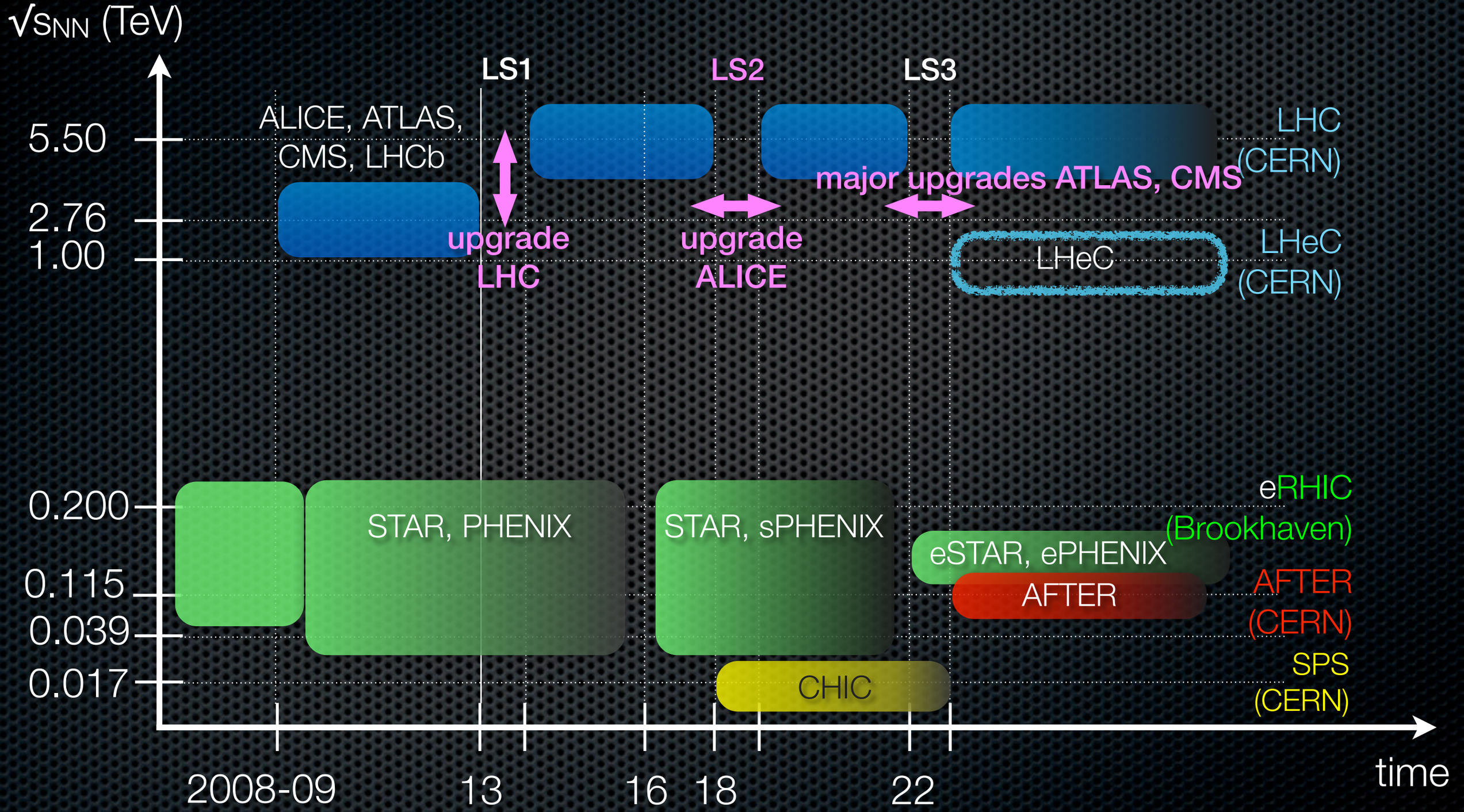
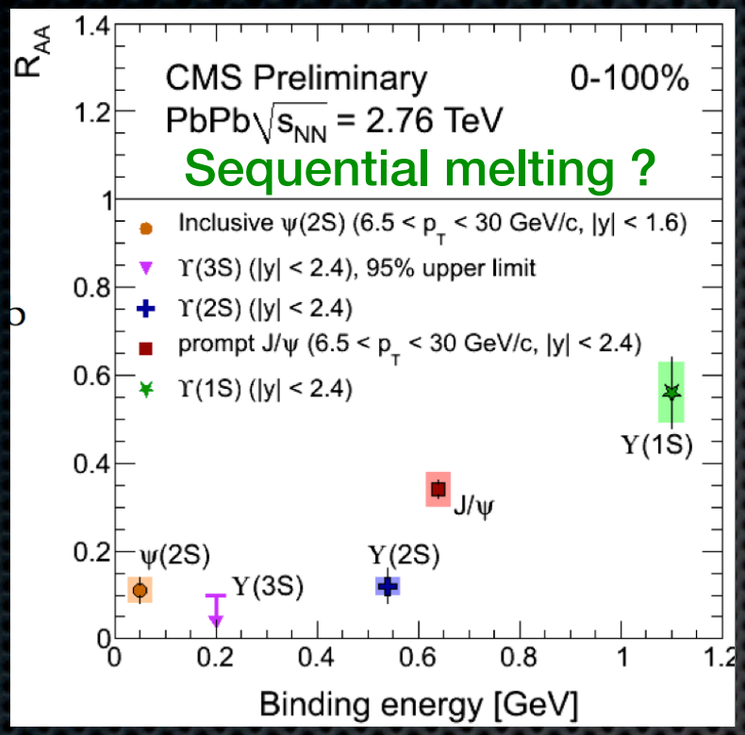


CHIC : χ_c at SPS

high p_T J/ψ, ψ(2S)
ϒ(1S, 2S, 3S)



A fixed target experiment at SPS, specialized in dilepton measurement

Charmonium family as a thermometer at SPS energy

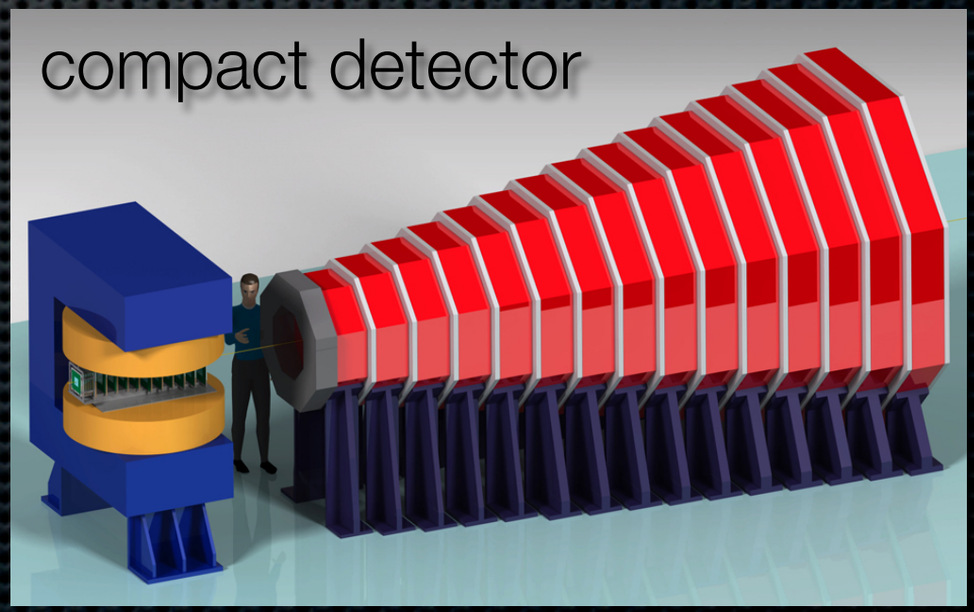
- sequential melting ?
- χ_c is the missing piece (30% prompt J/ψ yield)

Cold Nuclear Matter effects at SPS

- high luminosity in p-A
- wide (x_F) rapidity range $-0.5 < y_{cms} < 2$
- charmonia, open charm

Binding energy

state	η_c	J/ψ	χ_{c0}	χ_{c1}	χ_{c2}	ψ'
mass [GeV]	2.98	3.10	3.42	3.51	3.56	3.69
ΔE [GeV]	0.75	0.64	0.32	0.22	0.18	0.05



CHIC : χ_c at SPS

F. Fleuret (CHIC)

high p_T J/ψ, ψ(2S)
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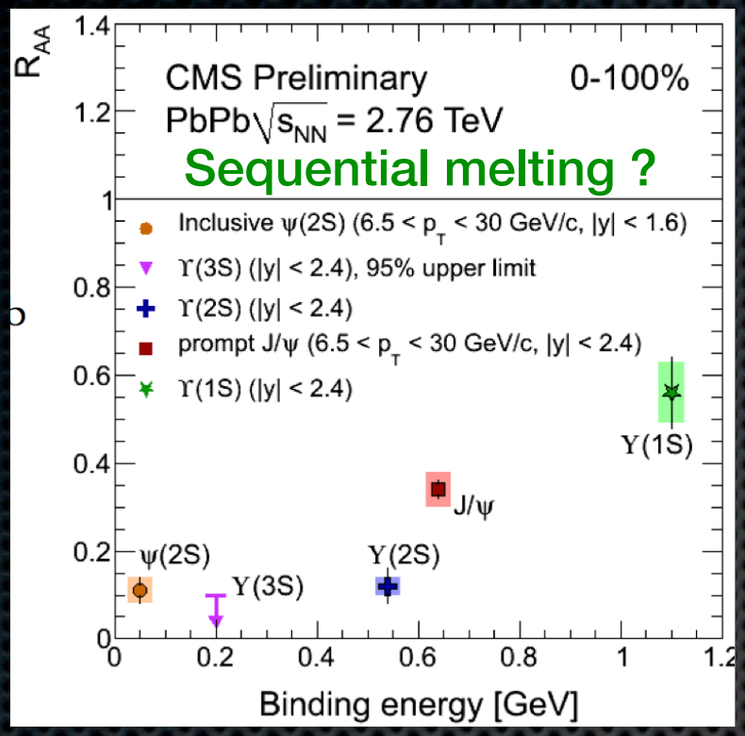

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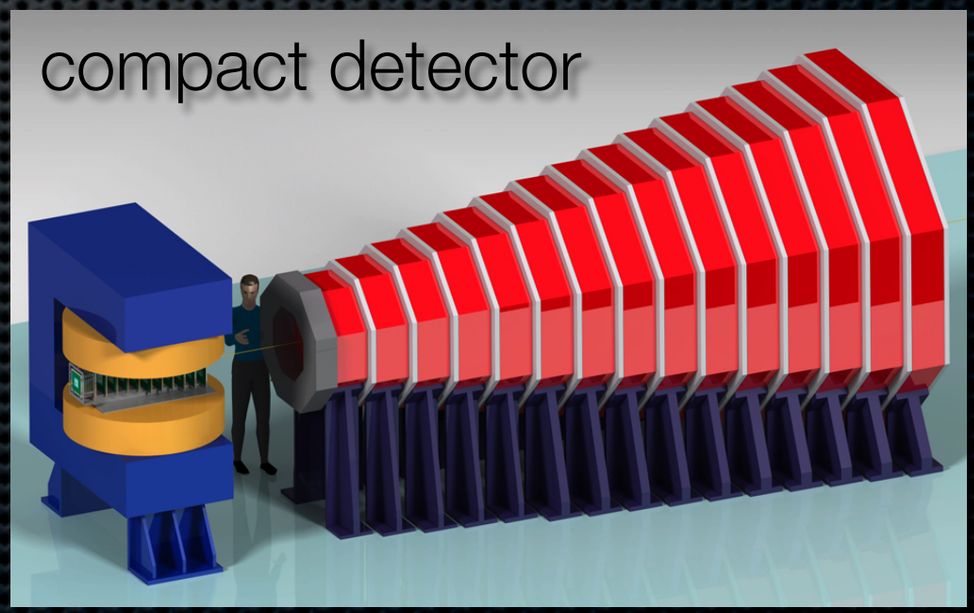
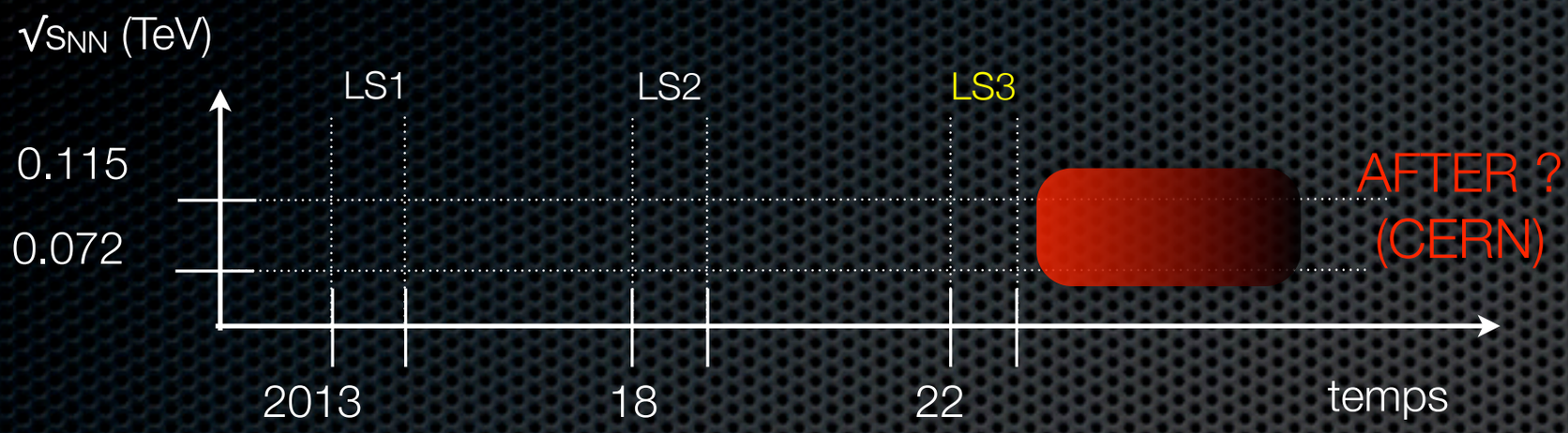


Long term prospectives



- fixed target experiment that will « recycle» the LHC halo, LS3 horizon
- extend RHIC physics to the high x region for gluons
- era of precision measurement : quarkonium observatory (10^2-10^3 x projected RHIC yields)
- complementary to LHeC

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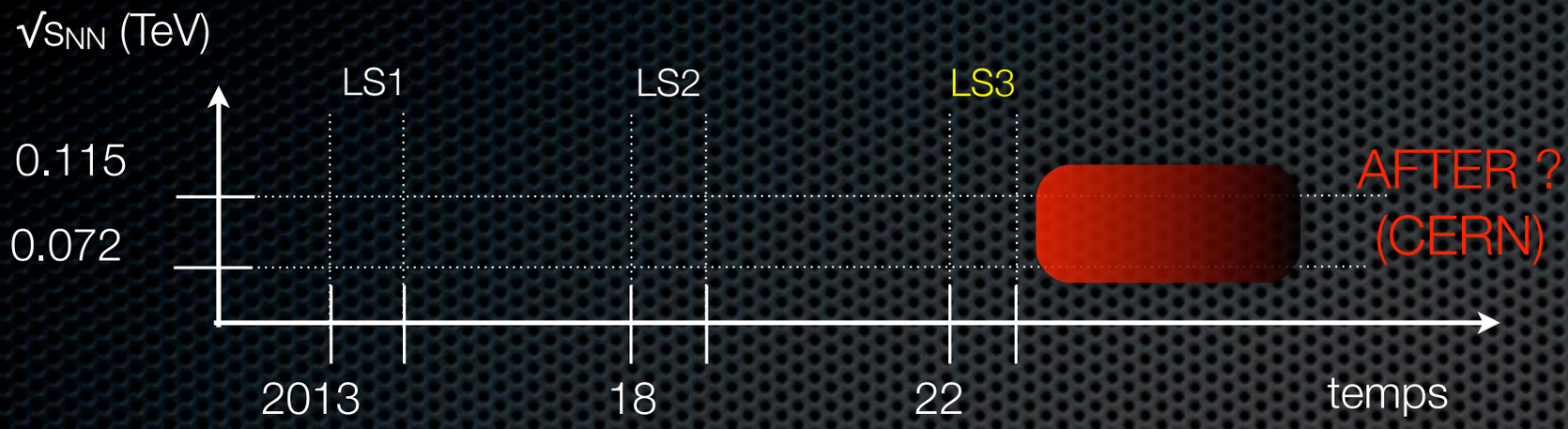

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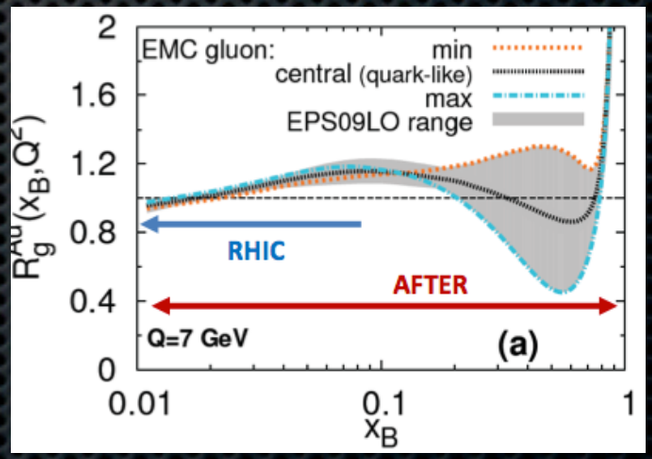
nuclear modification of g PDF in Au



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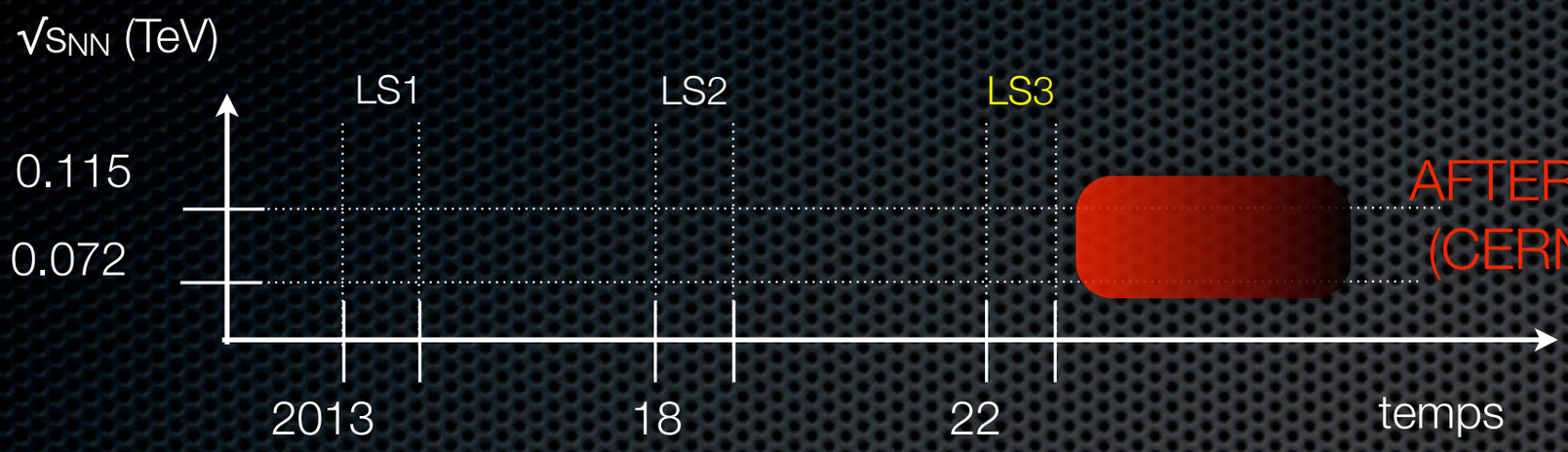

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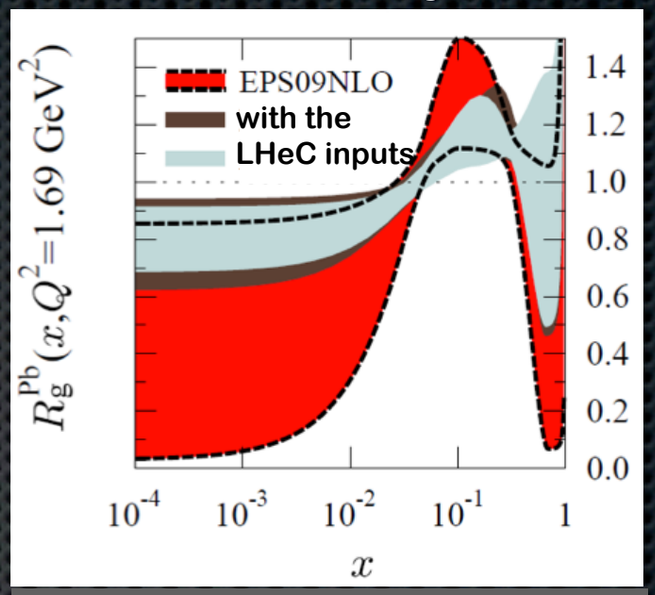
nuclear modification of g PDF in Pb



[LHeC CDR, J. Phys. G 39 (2012) 075001]

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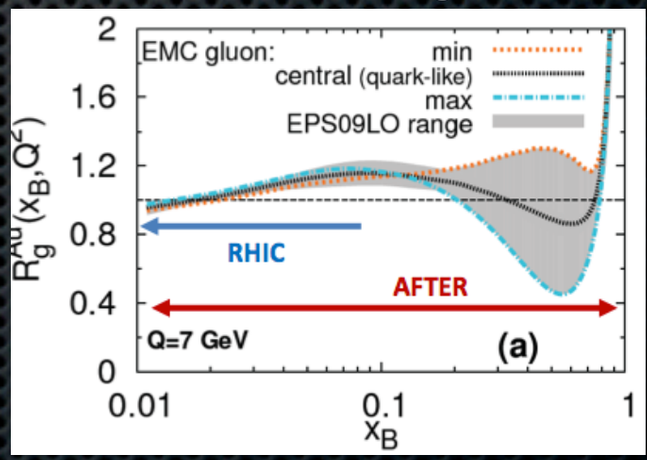

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« Relatively small cost extension to LHC program. No timeline yet, but LHCC recommended further studies. »

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- fixed target experiment that will « recycle» the LHC halo, LS3 horizon
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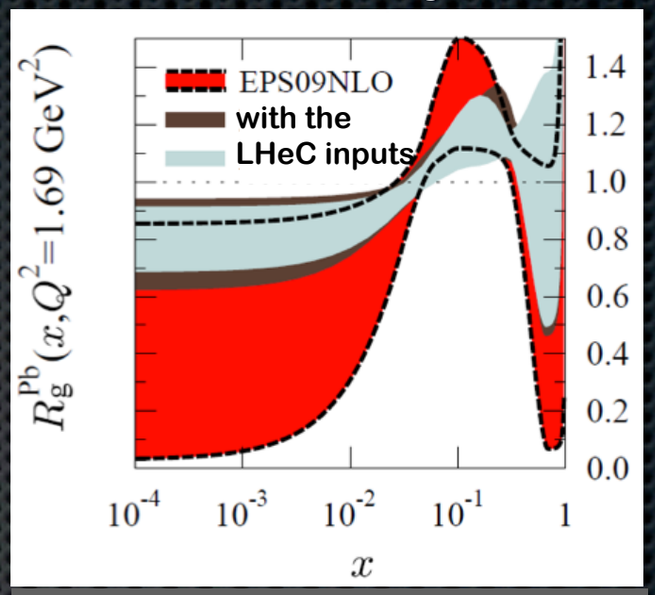

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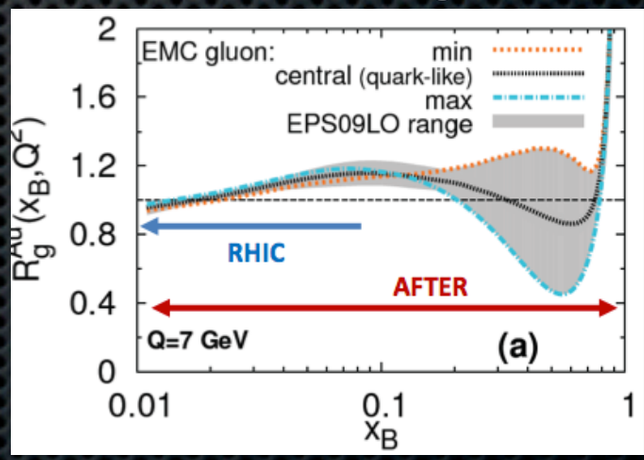

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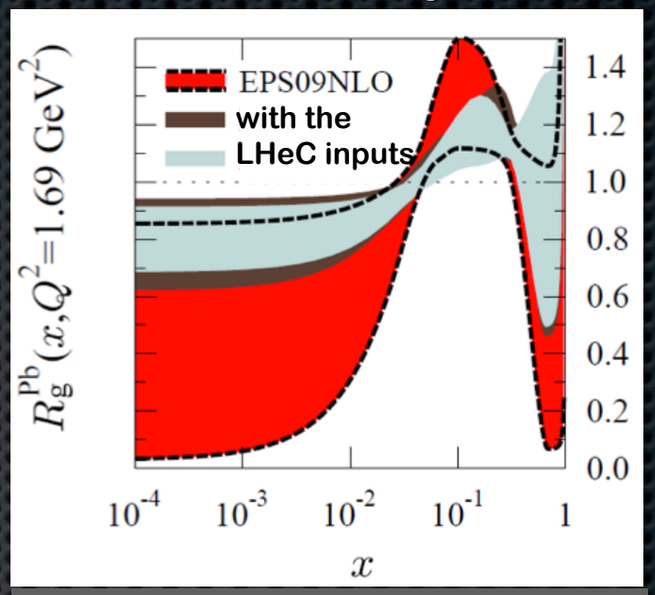

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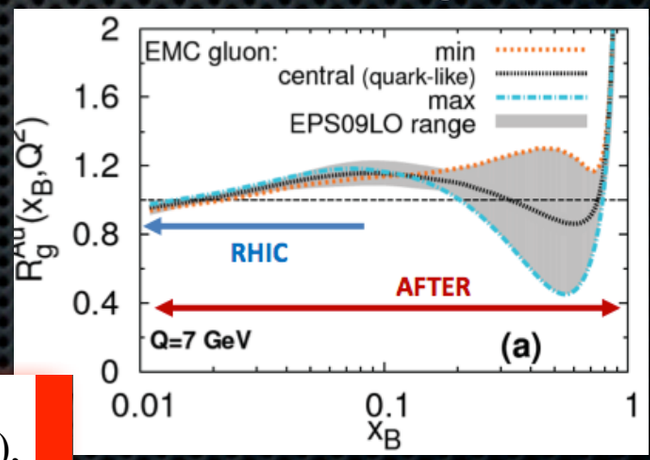

AFTER @ LHC

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- first paper on physics opportunities arXiv:1202.6585
- webpage after.in2p3.fr
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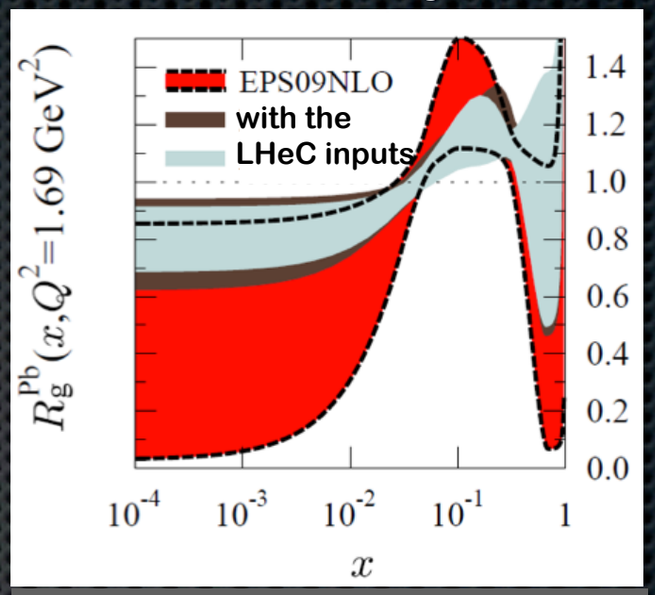

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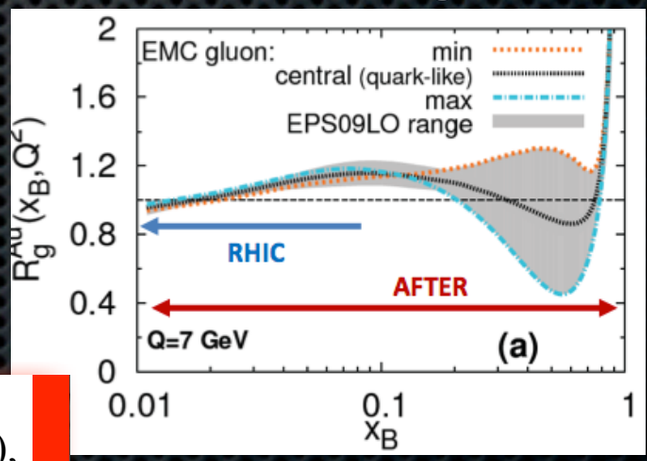

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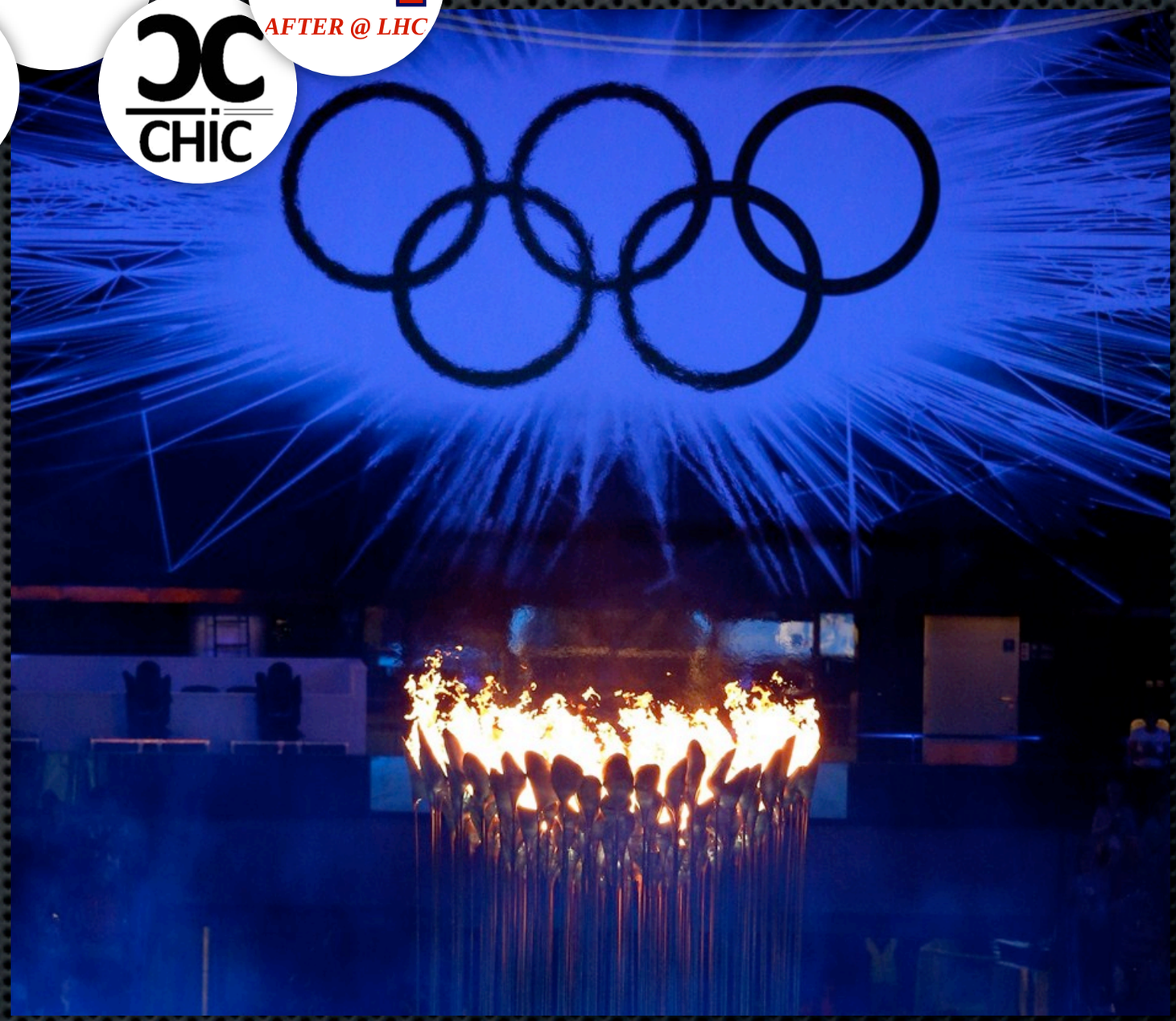
J.-P. Lansberg (AFTER)

« Faster, Higher, Stronger »

and complementary !



Olympic games, London, 2012

EXTRA

detector upgrades - ATLAS

LS1(2013-14): - additional pixel layer (Insertable B-layer, IBL)

→ improve b-tagging

LS2(2017-18): - fast tracking trigger (FTK)

→ improve high-multiplicity tracking

- calorimeter readout and trigger upgrade

→ improve selectivity of photon and electron trigger

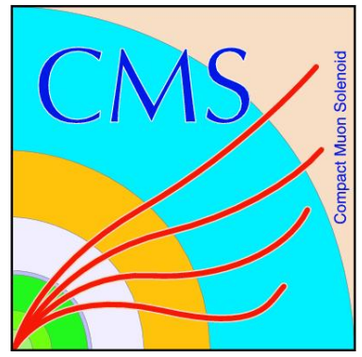
- new forward muon detectors

→ improved muon triggers

LS3(2022): - replacement of inner detector (pixel and strips, reduced material budget)

→ improve tracking and resolution

detector upgrades - CMS



By end of LS2:

- new pixel vertex detector
- upgraded trigger
- extension of forward muon system
- refurbishment of hadron calo electronics
- DAQ upgrade

Important for Heavy-ion running at 50 kHz:

- HLT input limitation (3kHz) requires 0.95 rejection at Level 1 (0.5 achieved so far)

→ dedicated R&D effort started on Level 1 upgrade, largely driven by HI needs and HI community

LS3 (2022):

- new inner tracker
- trigger and DAQ
- ...