Latest results on light (anti-)hypernuclei production and lifetime measurement in Pb-Pb collisions at the LHC

Ramona Lea

Physics Department, University and INFN Trieste

For the ALICE Collaboration

36th Winter Workshop on Nuclear Dynamics

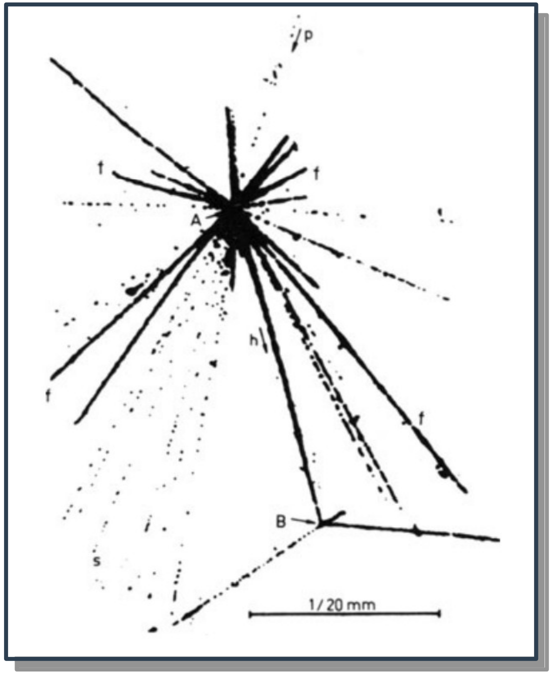
04 March 2020

Hypernuclei

A hypernucleus is a nucleus which contains at least one hyperon (a baryon containing one or more strange quarks) in addition to nucleons

Hypernuclei

A hypernucleus is a nucleus which contains at least one hyperon (a baryon containing one or more strange quarks) in addition to nucleons

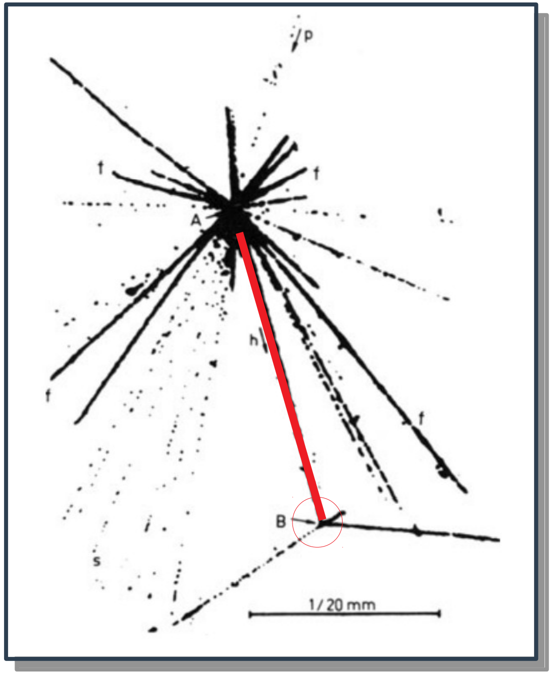


1952: first observation of hypernuclear decay from cosmic rays data

Photographic emulsion M. Danysz and J.Pniewski, Phil. Mag. 44 (1953) 348

Hypernuclei

A hypernucleus is a nucleus which contains at least one hyperon (a baryon containing one or more strange quarks) in addition to nucleons



1952: first observation of hypernuclear decay from cosmic rays data

Photographic emulsion M. Danysz and J.Pniewski, Phil. Mag. 44 (1953) 348

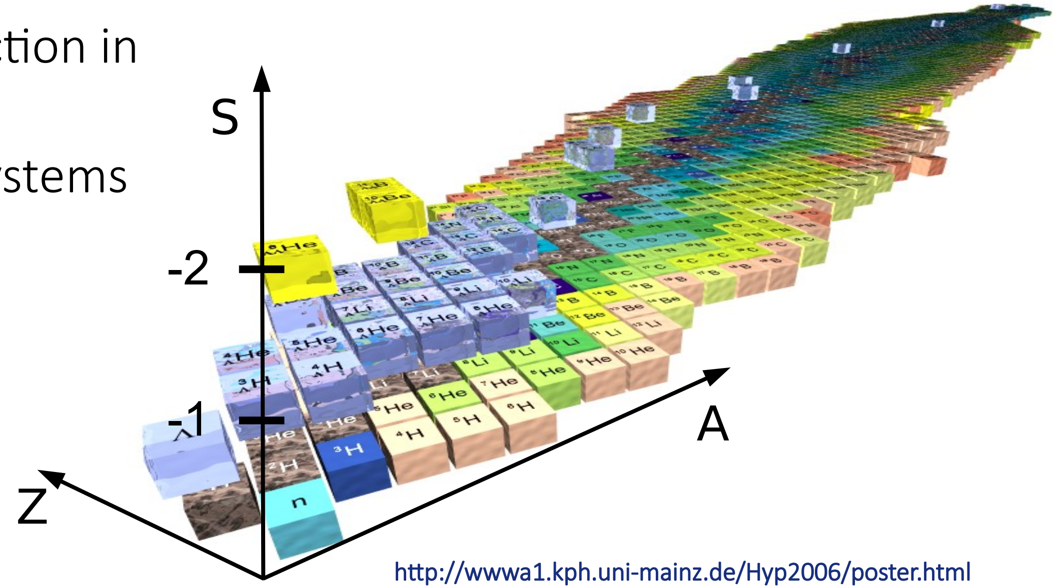
Hypernuclei

A hypernucleus is a nucleus which contains at least one hyperon (a baryon containing one or more strange quarks) in addition to nucleons

Main goals of hypenuclear physics:

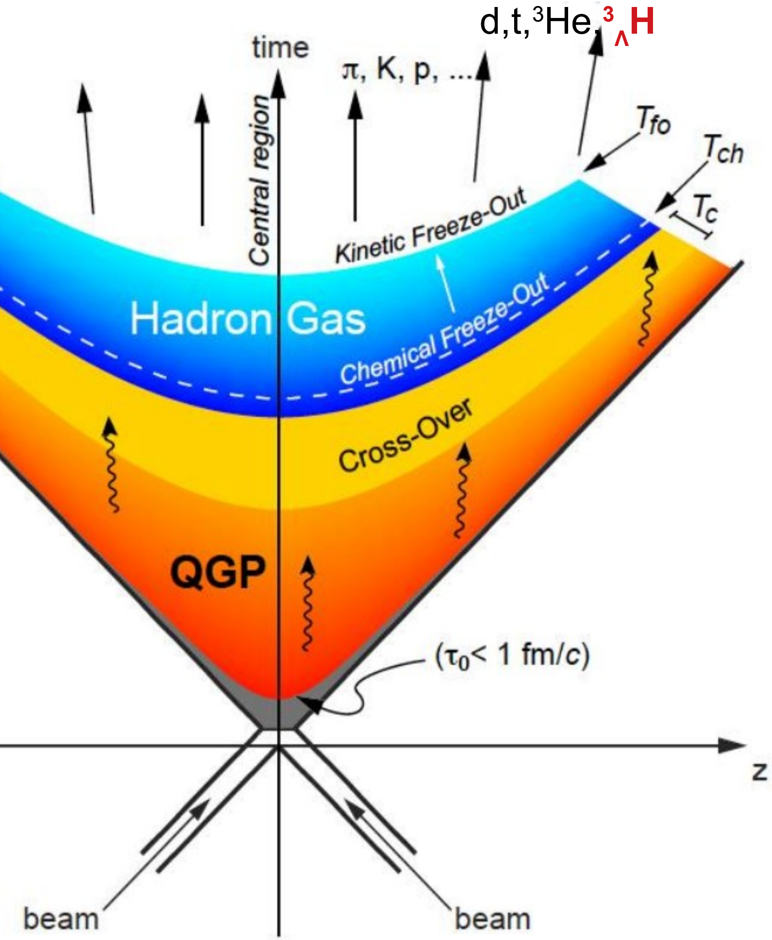
- Extension of nuclear chart
- Understand the baryon-baryon interaction in strangeness sector
- Study the structure of multi-strange systems

3D nuclear landscape



http://wwwa1.kph.uni-mainz.de/Hyp2006/poster.html

Hypernuclei production in heavy-ion collisions



- The study of the production yield of light (hyper-)nuclei is very important:
  - Production mechanism is not well understood
    - How/when do they form?
      - "early" at chemical freeze-out (thermal production)
      - or "late" at kinetic freeze-out (coalescence)?
    - Do they suffer for the dissociation by rescattering?

Low binding energy (few MeV) and Λ separation energy "Snowballs in hell": their formation is very sensitive to chemical freeze-out conditions and to the dynamics of the emitting source

Hypertriton ($^{3}_{\Lambda}H$)

$^{3}_{\Lambda}H$ is the lightest known hypernucleus and is formed by (p,n,Λ).

- Mass = 2.991 GeV/c^2
- **B_Λ = 0.13 ± 0.05 MeV** (B_d = 2.2 MeV, B_t = 8.5 MeV, B_{3He} = 7.7 MeV)

($^{3}_{\bar{\Lambda}}\bar{H}$) $^{3}_{\Lambda}H$ is unstable under weak decay. Possible decay modes:

$^{3}_{\Lambda}H \rightarrow {}^{3}He + \pi^-$ (~25%)
$^{3}_{\Lambda}H \rightarrow {}^{3}H + \pi^0$ (~13%)
$^{3}_{\Lambda}H \rightarrow d + p + \pi^-$ (~41%)
$^{3}_{\Lambda}H \rightarrow d + n + \pi^0$ (~21%)

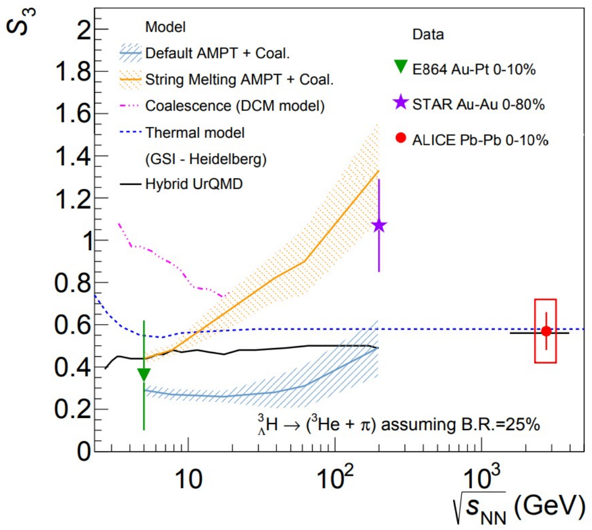
$^{3}_{\bar{\Lambda}}\bar{H} \rightarrow {}^{3}\overline{He} + \pi^+$ (~25%)
$^{3}_{\bar{\Lambda}}\bar{H} \rightarrow {}^{3}\bar{H} + \pi^0$ (~13%)
$^{3}_{\bar{\Lambda}}\bar{H} \rightarrow \bar{d} + \bar{p} + \pi^+$ (~41%)
$^{3}_{\bar{\Lambda}}\bar{H} \rightarrow \bar{d} + \bar{n} + \pi^0$ (~21%)

- Branching ratios are not well known
  - Only few theoretical calculations[1] available

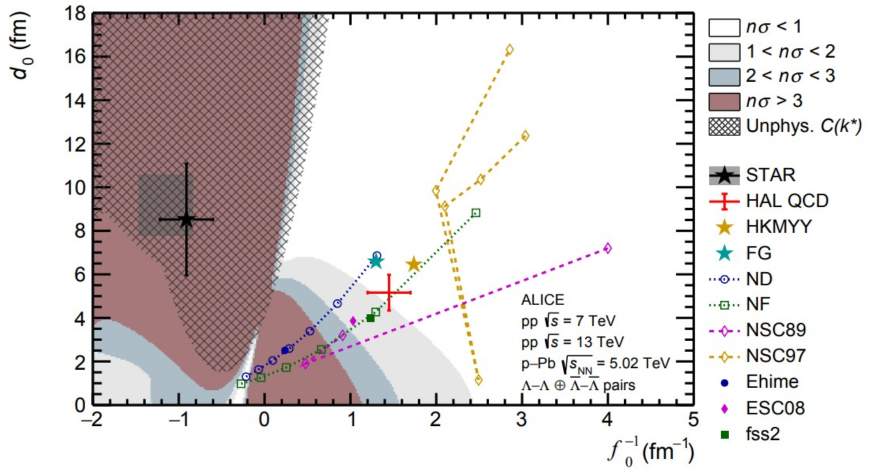
[1] Kamada et al., Phys. Rev. C57(1998)4

Motivations for hypertriton ($^{3}_{\Lambda}H$) study

- A=3 (anti-)(^{3}He, t, $^{3}_{\Lambda}H$), simple systems of 9 valence quarks:
  - $^{3}_{\Lambda}H$ /^{3}He and $^{3}_{\Lambda}H$ /t (and anti) → Λ-nucleon correlation (local baryon-strangeness correlation)
  - t /^{3}He (and anti) → local charge-baryon correlation
  - YN & YY interaction (strangeness sector of hadronic EOS, cosmology, physics of neutron stars)



ALICE Collaboration, Phys. Lett. B 754 (2016) 360–372



ALICE Collaboration, Phys. Lett. B 797 (2019) 134822

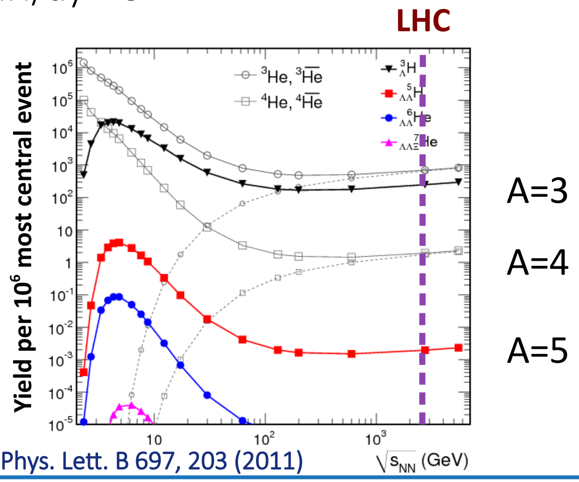
Hypernuclei production in heavy-ion collisions

ALICE

Statistical thermal model

- Thermodynamic approach to particle production in heavy-ion collisions
- Abundances fixed at chemical freeze-out (T_{chem}) : (hyper)nuclei are very sensitive to T_{chem} because of their large mass (M)
  - Exponential dependence of the yield:

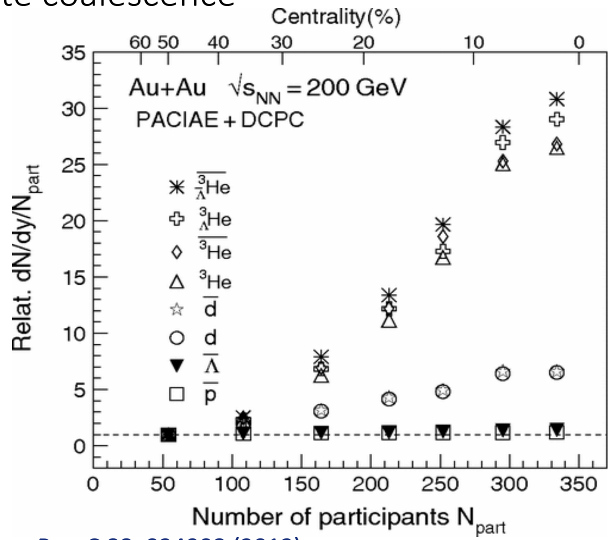
$$dN/dy \propto e^{(-m/T_{chem})}$$



A. Andronic et al., Phys. Lett. B 697, 203 (2011)

Coalescence

- Nuclei are formed by protons and neutrons which are nearby in space and have similar velocities (after kinetic freeze-out)
- Produced nuclei can break apart and be created again by final-state coalescence

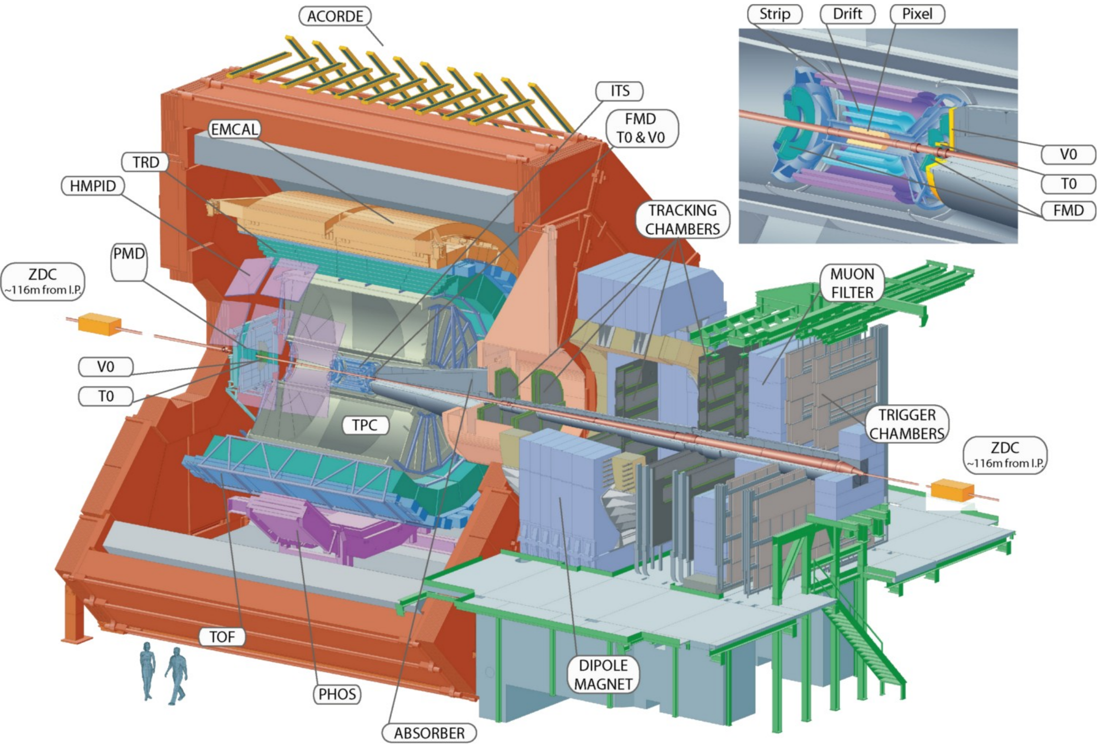


G. Chen et al., Phys. Rev. C 88, 034908 (2013)

Experimental apparatus

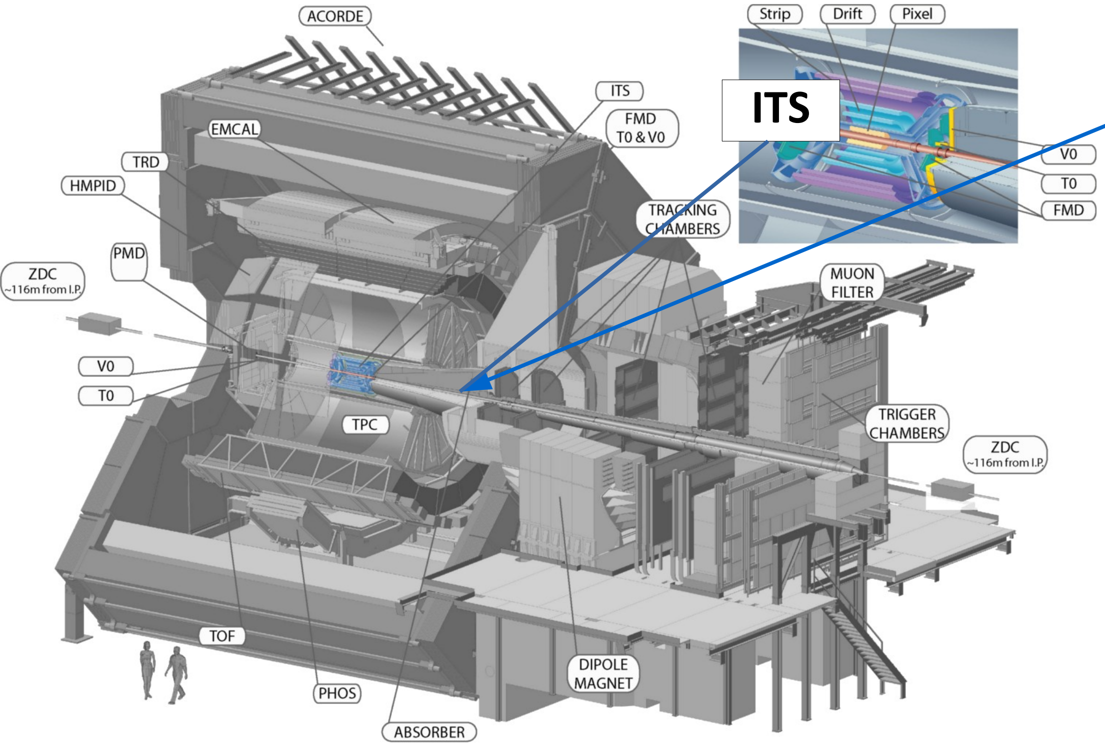
A Large Ion Collider Experiment

ALICE particle identification capabilities are unique. Almost all known techniques are exploited: specific energy loss (dE/dx), time of flight, transition radiation, Cherenkov radiation, calorimetry and decay topology (V^0, cascade).



ALICE Collaboration, Int. J. Mod. Phys. A 29 (2014) 1430044

ALICE particle identification capabilities are unique. Almost all known techniques are exploited: specific energy loss (dE/dx), time of flight, transition radiation, Cherenkov radiation, calorimetry and decay topology (V^0, cascade).

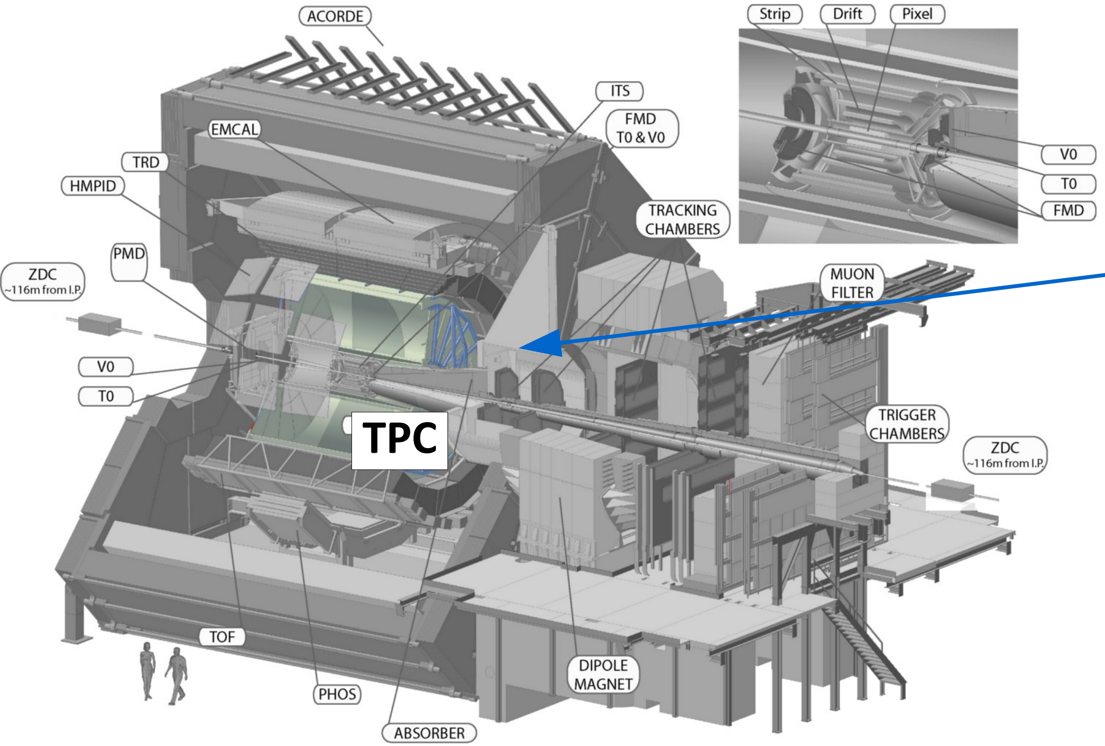


Inner Tracking System (ITS) :
- Primary vertex
- Tracking
- Particle identification via dE/dx

ALICE Collaboration, Int. J. Mod. Phys. A 29 (2014) 1430044

A Large Ion Collider Experiment

ALICE particle identification capabilities are unique. Almost all known techniques are exploited: specific energy loss (d*E*/dx), time of flight, transition radiation, Cherenkov radiation, calorimetry and decay topology (V^0, cascade).



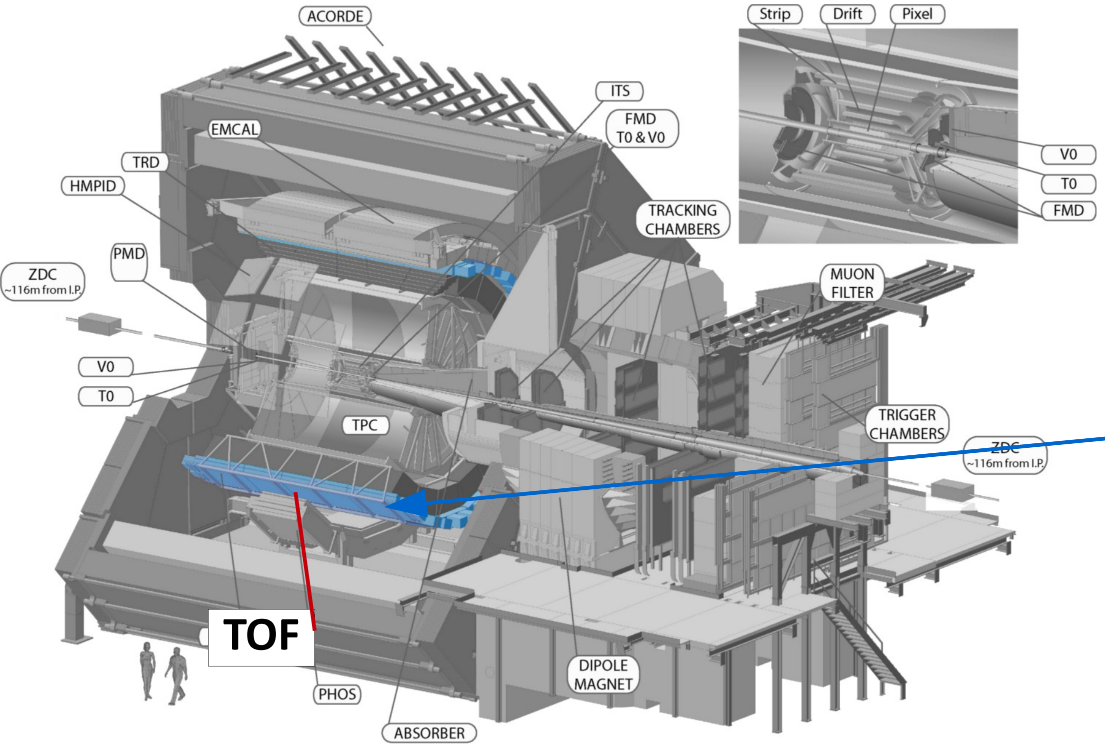
Inner Tracking System (ITS) :
- Primary vertex
- Tracking
- Particle identification via d*E*/dx

Time Projection Chamber (TPC):
- Global tracking
- Particle identification via d*E*/dx

ALICE Collaboration, Int. J. Mod. Phys. A 29 (2014) 1430044

A Large Ion Collider Experiment

ALICE particle identification capabilities are unique. Almost all known techniques are exploited: specific energy loss (dE/dx), time of flight, transition radiation, Cherenkov radiation, calorimetry and decay topology (V^0, cascade).



Inner Tracking System (ITS) :
- Primary vertex
- Tracking
- Particle identification via dE/dx

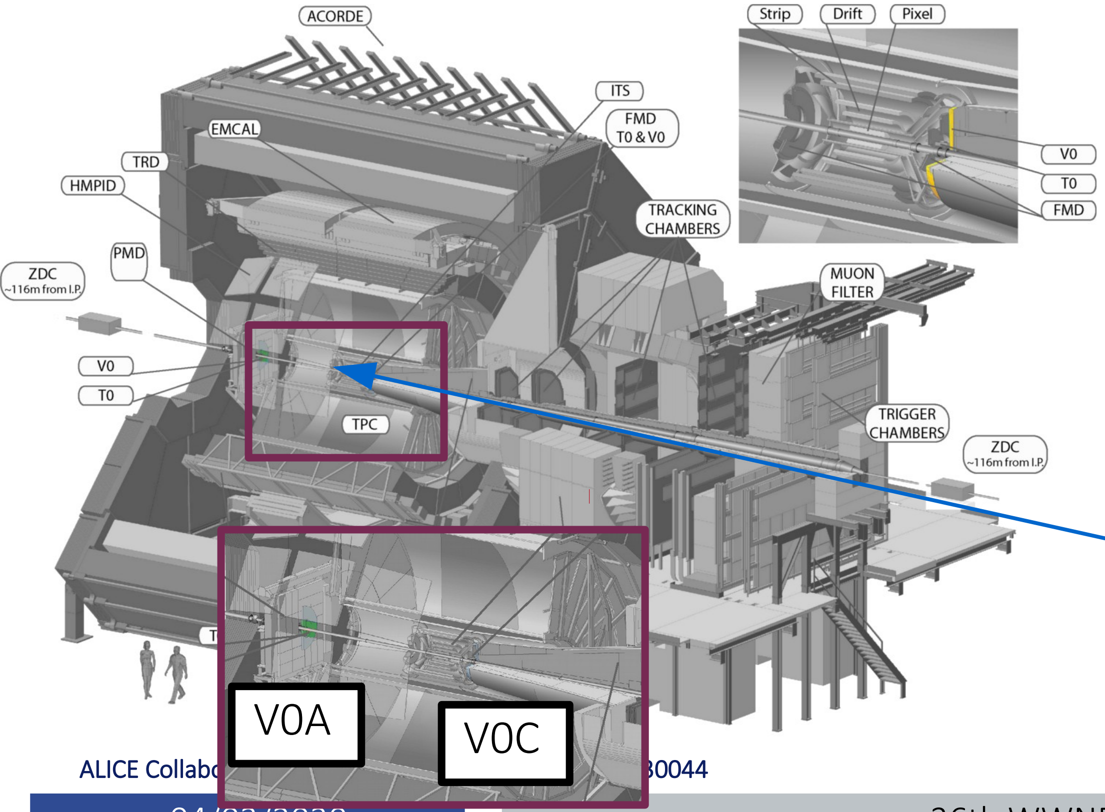
Time Projection Chamber (TPC):
- Global tracking
- Particle identification via dE/dx

Time Of Flight (TOF):
- Particle identification via velocity measurement

ALICE Collaboration, Int. J. Mod. Phys. A 29 (2014) 1430044

A Large Ion Collider Experiment

ALICE particle identification capabilities are unique. Almost all known techniques are exploited: specific energy loss (dE/dx), time of flight, transition radiation, Cherenkov radiation, calorimetry and decay topology (V^0, cascade).



ALICE Collabo… …30044

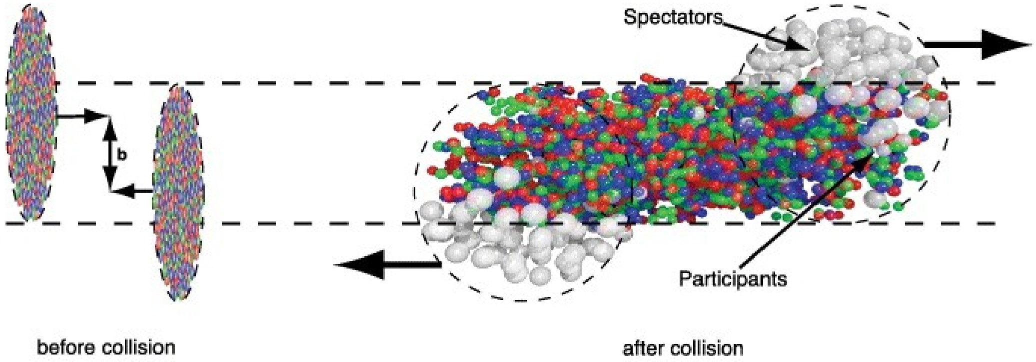
Inner Tracking System (ITS) :
- Primary vertex
- Tracking
- Particle identification via dE/dx

Time Projection Chamber (TPC):
- Global tracking
- Particle identification via dE/dx

Time Of Flight (TOF):
- Particle identification via velocity measurement

V0 (A-C): Trigger, beam-gas event rejection, centrality, multiplicity classes

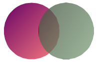
Centrality of the collisions



Centrality = degree of overlap of the 2 colliding nuclei

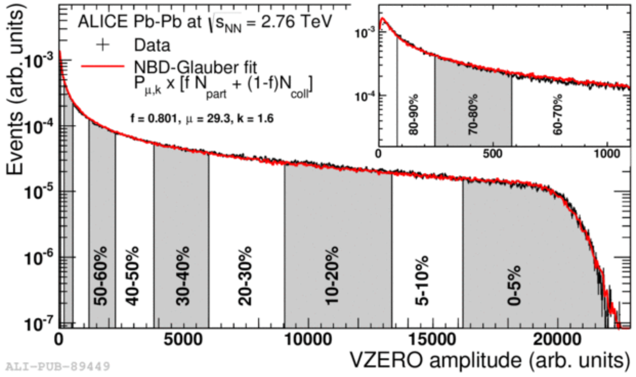
Central collisions: 

- small impact parameter *b*
- high number of participant nucleons → high multiplicity

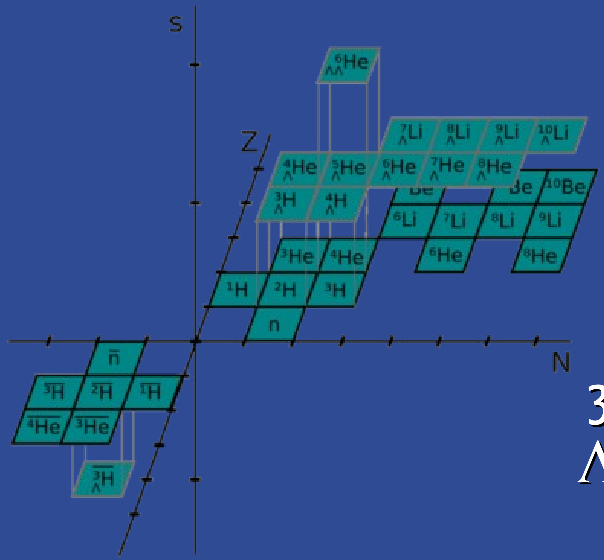
Peripheral collisions: 

- large impact parameter *b*
- low number of participant nucleons → low multiplicity

Centrality estimated with a Glauber model fit to the signal amplitude in the V0 scintillator arrays



ALICE Collaboration, Phys. Rev. Lett. 106, 032301 (2011)



$^{3}_{\Lambda}$H identification

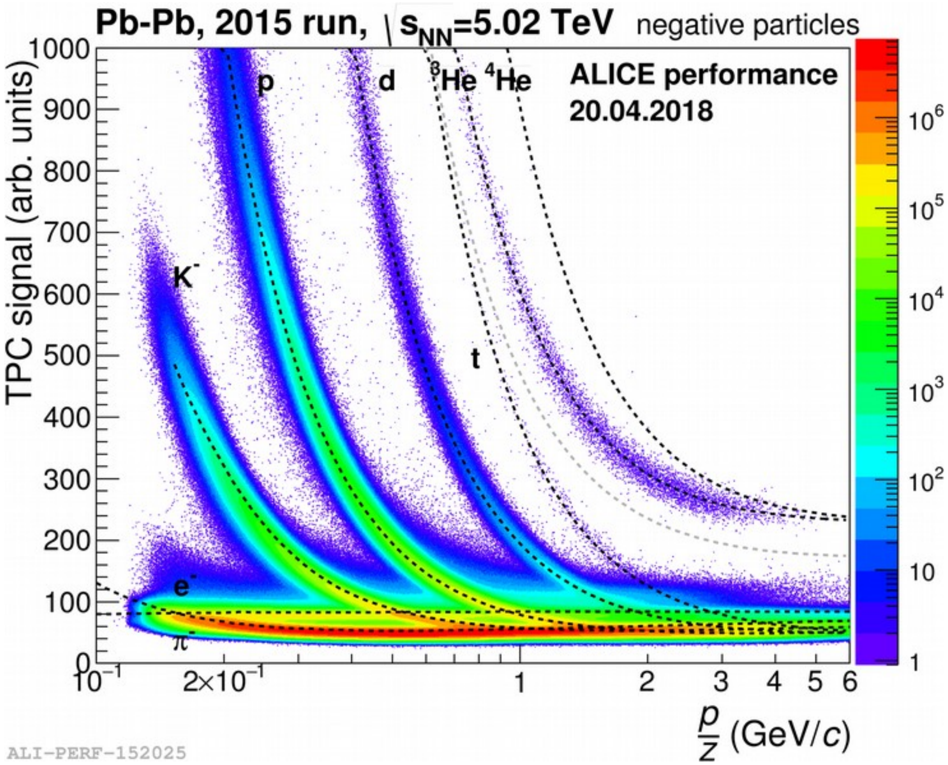
$(^{3}_{\bar{\Lambda}}\overline{H})\ ^{3}_{\Lambda}H$ identification

Decay Channels

$^{3}_{\Lambda}H \rightarrow {}^{3}He + \pi^{-}$	$^{3}_{\bar{\Lambda}}\overline{H} \rightarrow {}^{3}\overline{He} + \pi^{+}$
$^{3}_{\Lambda}H \rightarrow H + \pi^{0}$	$^{3}_{\bar{\Lambda}}\overline{H} \rightarrow \overline{H} + \pi^{0}$
$^{3}_{\Lambda}H \rightarrow d + p + \pi^{-}$	$^{3}_{\bar{\Lambda}}\overline{H} \rightarrow \overline{d} + \overline{p} + \pi^{+}$
$^{3}_{\Lambda}H \rightarrow d + n + \pi^{0}$	$^{3}_{\bar{\Lambda}}\overline{H} \rightarrow \overline{d} + \overline{n} + \pi^{0}$

$^{3}_{\Lambda}H$ and $^{3}_{\bar{\Lambda}}\overline{H}$ search via two-body decays into charged particles:

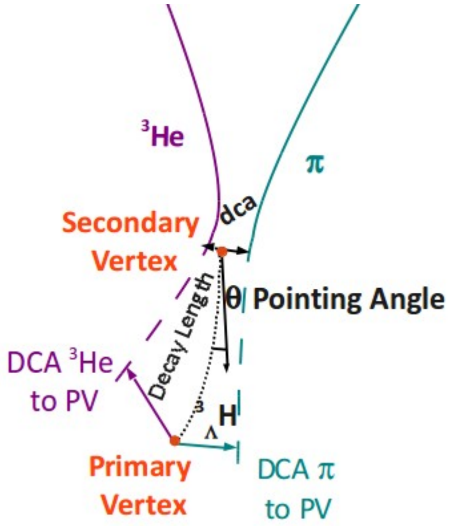
- Particle identification via specific energy loss in the TPC



$({}^{3}_{\bar\Lambda}\overline{\mathrm{H}})\ {}^{3}_{\Lambda}\mathrm{H}$ identification

Decay Channels

${}^{3}_{\Lambda}\mathrm{H} \rightarrow {}^{3}\mathrm{He} + \pi^{-}$	${}^{3}_{\bar\Lambda}\overline{\mathrm{H}} \rightarrow {}^{3}\overline{\mathrm{He}} + \pi^{+}$
${}^{3}_{\Lambda}\mathrm{H} \rightarrow \mathrm{H} + \pi^{0}$	${}^{3}_{\bar\Lambda}\overline{\mathrm{H}} \rightarrow \overline{\mathrm{H}} + \pi^{0}$
${}^{3}_{\Lambda}\mathrm{H} \rightarrow d + p + \pi^{-}$	${}^{3}_{\bar\Lambda}\overline{\mathrm{H}} \rightarrow \bar{d} + \bar{p} + \pi^{+}$
${}^{3}_{\Lambda}\mathrm{H} \rightarrow d + n + \pi^{0}$	${}^{3}_{\bar\Lambda}\overline{\mathrm{H}} \rightarrow \bar{d} + \bar{n} + \pi^{0}$



${}^{3}_{\Lambda}\mathrm{H}$ and ${}^{3}_{\bar\Lambda}\overline{\mathrm{H}}$ search via two-body decays into charged particles:

- Two body decay: low combinatorial background
- Charged particles: ALICE acceptance for charged particles higher than for neutrals

Signal Extraction:

- Identify ^{3}He and π
- Evaluate (^{3}He,π) invariant mass
- Apply topological cuts in order to:
  - identify secondary decay vertex
  - reduce combinatorial background
- Extract signal

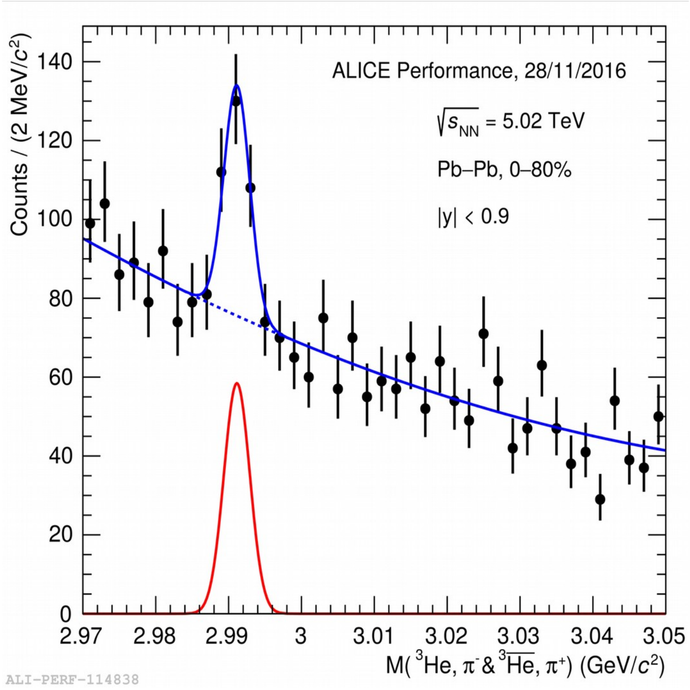
$(^{3}_{\bar{\Lambda}}\overline{\mathrm{H}})\ ^{3}_{\Lambda}\mathrm{H}$ identification

Decay Channels

$^{3}_{\Lambda}\mathrm{H} \rightarrow {}^{3}\mathrm{He} + \pi^{-}$	$^{3}_{\bar{\Lambda}}\overline{\mathrm{H}} \rightarrow {}^{3}\overline{\mathrm{He}} + \pi^{+}$
$^{3}_{\Lambda}\mathrm{H} \rightarrow \mathrm{H} + \pi^{0}$	$^{3}_{\bar{\Lambda}}\overline{\mathrm{H}} \rightarrow \overline{\mathrm{H}} + \pi^{0}$
$^{3}_{\Lambda}\mathrm{H} \rightarrow d + p + \pi^{-}$	$^{3}_{\bar{\Lambda}}\overline{\mathrm{H}} \rightarrow \bar{d} + \bar{p} + \pi^{+}$
$^{3}_{\Lambda}\mathrm{H} \rightarrow d + n + \pi^{0}$	$^{3}_{\bar{\Lambda}}\overline{\mathrm{H}} \rightarrow \bar{d} + \bar{n} + \pi^{0}$

$^{3}_{\Lambda}\mathrm{H}$ and $^{3}_{\bar{\Lambda}}\overline{\mathrm{H}}$ search via two-body decays into charged particles:

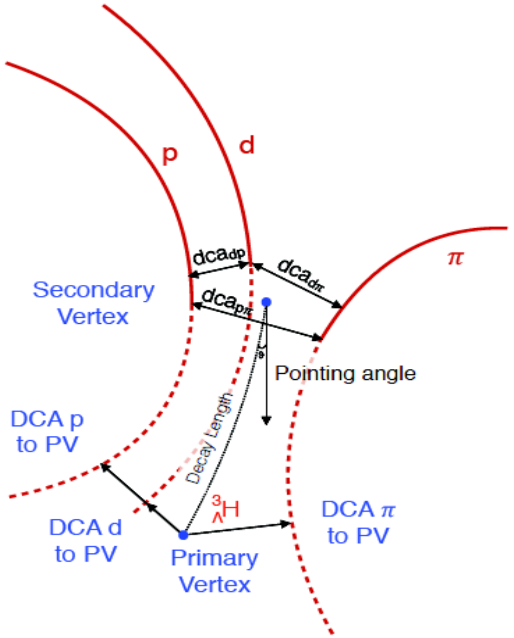
- Two body decay: low combinatorial background
- Charged particles: ALICE acceptance for charged particles higher than for neutrals



$(^{3}_{\bar{\Lambda}}\overline{\mathrm{H}})\ ^{3}_{\Lambda}\mathrm{H}$ identification

Decay Channels

$^{3}_{\Lambda}\mathrm{H} \rightarrow {}^{3}\mathrm{He} + \pi^{-}$	$^{3}_{\bar{\Lambda}}\overline{\mathrm{H}} \rightarrow {}^{3}\overline{\mathrm{He}} + \pi^{+}$
$^{3}_{\Lambda}\mathrm{H} \rightarrow \mathrm{H} + \pi^{0}$	$^{3}_{\bar{\Lambda}}\overline{\mathrm{H}} \rightarrow \overline{\mathrm{H}} + \pi^{0}$
$^{3}_{\Lambda}\mathrm{H} \rightarrow d + p + \pi^{-}$	$^{3}_{\bar{\Lambda}}\overline{\mathrm{H}} \rightarrow \bar{d} + \bar{p} + \pi^{+}$
$^{3}_{\Lambda}\mathrm{H} \rightarrow d + n + \pi^{0}$	$^{3}_{\bar{\Lambda}}\overline{\mathrm{H}} \rightarrow \bar{d} + \bar{n} + \pi^{0}$



$^{3}_{\Lambda}\mathrm{H}$ and $^{3}_{\bar{\Lambda}}\overline{\mathrm{H}}$ search via three-body decays into charged particles:

- Larger combinatorial background
- High B.R. (~41%)

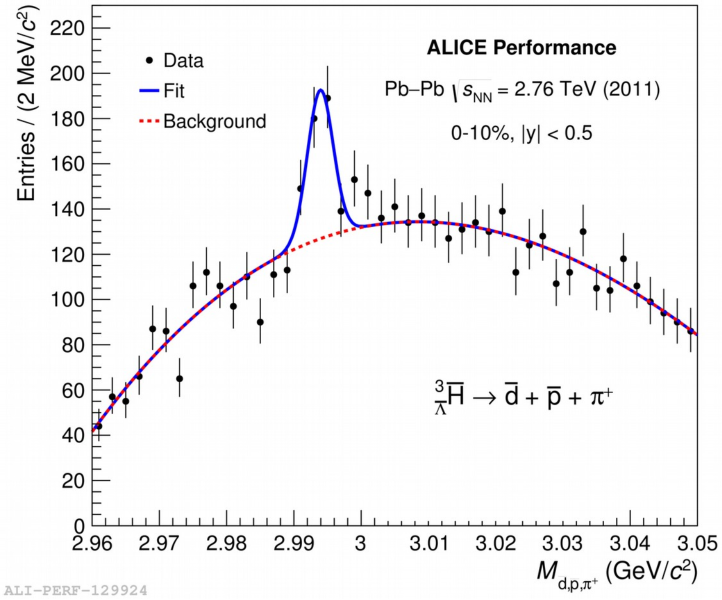
$({}^{3}_{\bar{\Lambda}}\overline{H})\ {}^{3}_{\Lambda}H$ identification

Decay Channels

${}^{3}_{\Lambda}H \rightarrow {}^{3}He + \pi^{-}$	${}^{3}_{\bar{\Lambda}}\overline{H} \rightarrow {}^{3}\overline{He} + \pi^{+}$
${}^{3}_{\Lambda}H \rightarrow H + \pi^{0}$	${}^{3}_{\bar{\Lambda}}\overline{H} \rightarrow \overline{H} + \pi^{0}$
${}^{3}_{\Lambda}H \rightarrow d + p + \pi^{-}$	${}^{3}_{\bar{\Lambda}}\overline{H} \rightarrow \bar{d} + \bar{p} + \pi^{+}$
${}^{3}_{\Lambda}H \rightarrow d + n + \pi^{0}$	${}^{3}_{\bar{\Lambda}}\overline{H} \rightarrow \bar{d} + \bar{n} + \pi^{0}$

${}^{3}_{\Lambda}H$ and ${}^{3}_{\bar{\Lambda}}\overline{H}$ search via three-body decays into charged particles:

- Larger combinatorial background
- High B.R. (~41%)



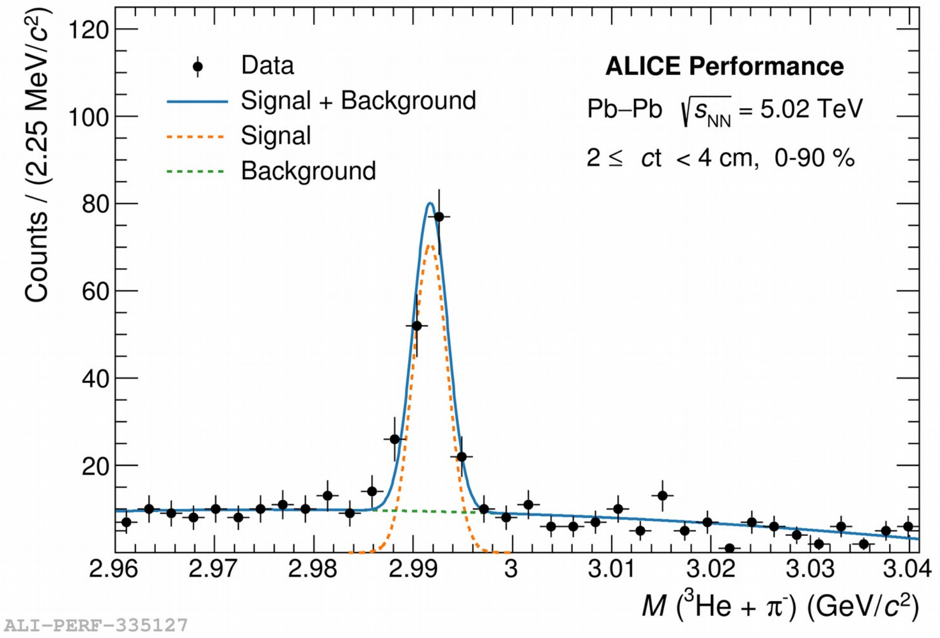
$({}^{3}_{\bar{\Lambda}}\overline{\mathrm{H}})\ {}^{3}_{\Lambda}\mathrm{H}$ identification

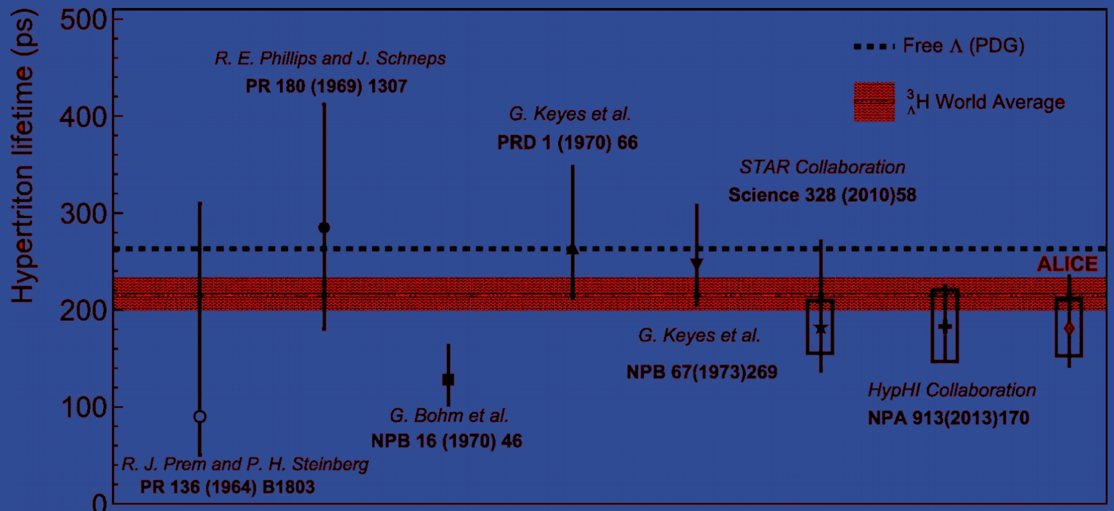
Decay Channels

${}^{3}_{\Lambda}\mathrm{H} \rightarrow {}^{3}\mathrm{He} + \pi^{-}$	${}^{3}_{\bar{\Lambda}}\overline{\mathrm{H}} \rightarrow {}^{3}\overline{\mathrm{He}} + \pi^{+}$
${}^{3}_{\Lambda}\mathrm{H} \rightarrow \mathrm{H} + \pi^{0}$	${}^{3}_{\bar{\Lambda}}\overline{\mathrm{H}} \rightarrow \overline{\mathrm{H}} + \pi^{0}$
${}^{3}_{\Lambda}\mathrm{H} \rightarrow d + p + \pi^{-}$	${}^{3}_{\bar{\Lambda}}\overline{\mathrm{H}} \rightarrow \bar{d} + \bar{p} + \pi^{+}$
${}^{3}_{\Lambda}\mathrm{H} \rightarrow d + n + \pi^{0}$	${}^{3}_{\bar{\Lambda}}\overline{\mathrm{H}} \rightarrow \bar{d} + \bar{n} + \pi^{0}$

${}^{3}_{\Lambda}\mathrm{H}$ and ${}^{3}_{\bar{\Lambda}}\overline{\mathrm{H}}$ search via two-body decays has been also performed using machine learning:

- **BDT** (Boosted Decision Tree) method using a selection that maximize the significance x BDT efficiency



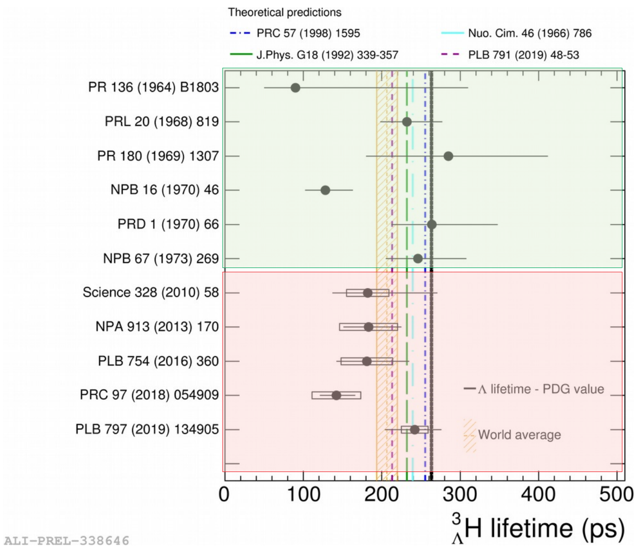


${}^{3}_{\Lambda}$H lifetime “puzzle”

ALICE Collaboration, Phys. Lett. B 754 (2016) 360–372

$^{3}_{\Lambda}$H lifetime "puzzle"

- Very small $E_{B\Lambda}$ (~130 keV) led to the hypothesis that the $^{3}_{\Lambda}$H lifetime is slightly below the free Λ lifetime (263.2 ± 2 ps [1])
- Few theoretical predictions available
  - first one by Dalitz and Rayet (1966) → τ range 239.3- 255.5 ps
  - most recent by Congleton (1992) and Kamada (1998) → 232 ps and 256 ps
- Many experiments faced this challenge with different experimental techniques

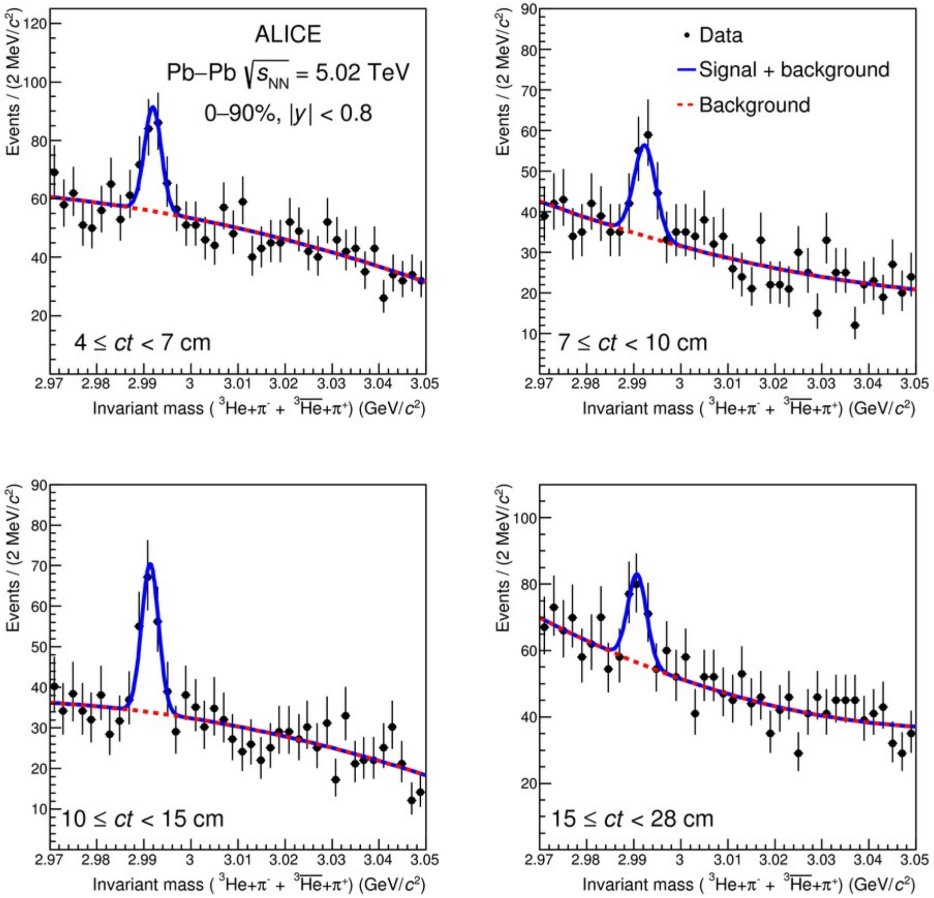


Experimental results

- Emulsion and bubble chamber experiment results tend to agree with free Λ value → limited number of events satisfying the selection criteria → large errors
- Heavy-ion results are systematically below the expected free Λ lifetime

[1] C.Patrignani et al. (Particle Data Group), Chin. Phys. C 40 100001 (2016)

${}^{3}_{\Lambda}$H lifetime puzzle nears resolution



The lifetime estimate is performed:

- using the full data sample of Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV collected in 2015
- selecting both hypertriton and anti-hypertriton candidates
- using "*ct* distribution"
- Signal extraction in four different ct bins- 4-7, 7-10, 10-15, 15-28 cm

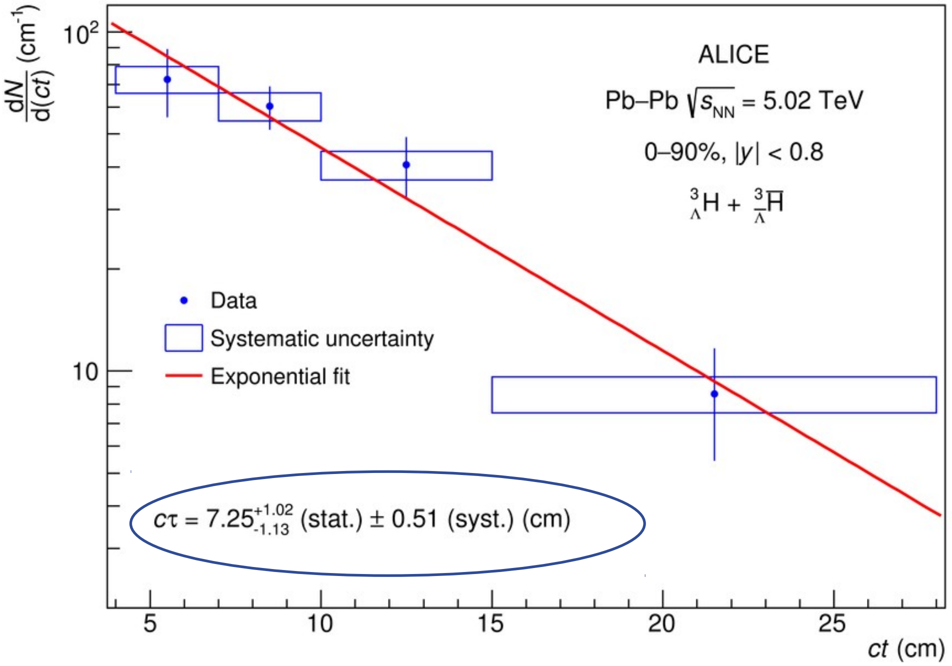
ALICE Collaboration, Phys. Lett. B 797 134905

${}^{3}_{\Lambda}$H lifetime puzzle nears resolution

Direct decay time measurement is difficult (~ps), but the excellent determination of primary and decay vertex allows measurement of lifetime (cτ) via:

$$N(t) = N(0)\exp\left(-\frac{ct}{c\tau}\right)$$

Where *ct = mL/p*
With *m* the hypertriton mass, *L* the decay length and *p* the total momentum



ALICE Collaboration, Phys. Lett. B 797 134905

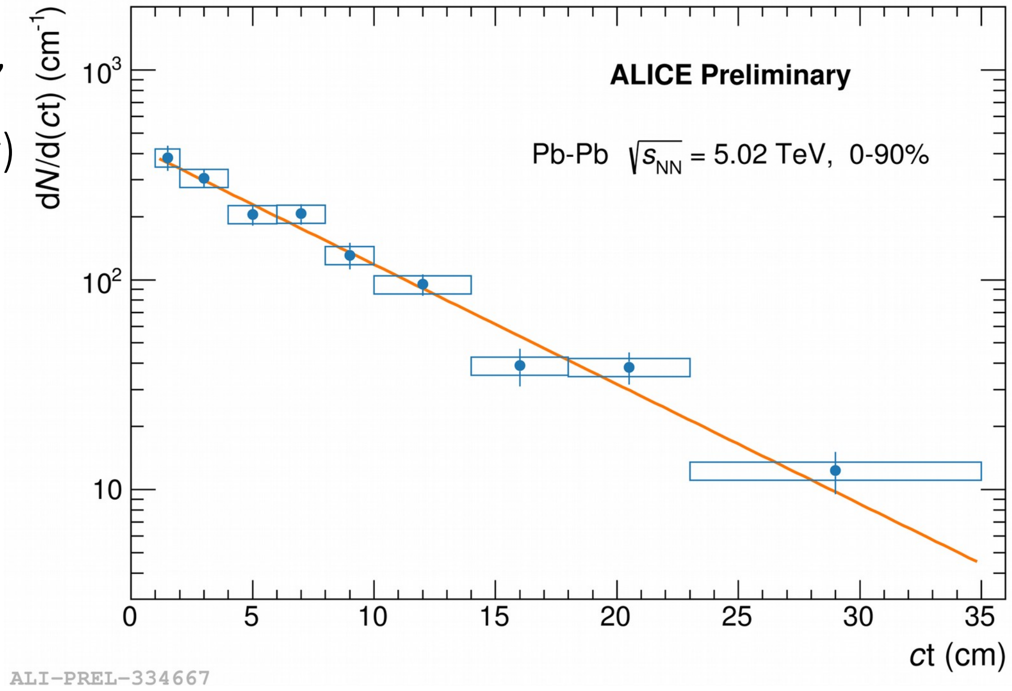
${}^{3}_{\Lambda}$H lifetime puzzle nears resolution

Direct decay time measurement is difficult (~ps), but the excellent determination of primary and decay vertex allows measurement of lifetime (cτ) via:

$$N(t) = N(0)\exp\left(-\frac{ct}{c\tau}\right)$$

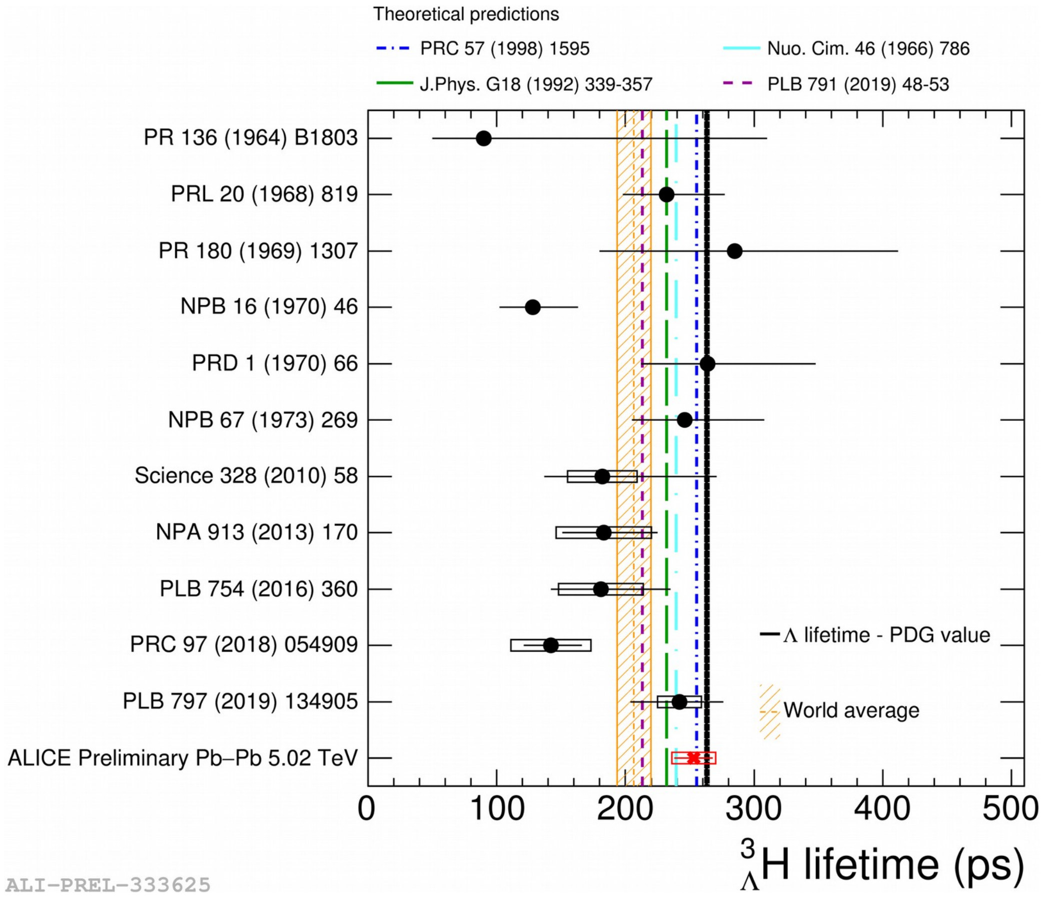
Where *ct = mL/p*
With *m* the hypertriton mass, *L* the decay length and *p* the total momentum

Full 2018 Pb-Pb data sample + Machine Learning for signal extraction

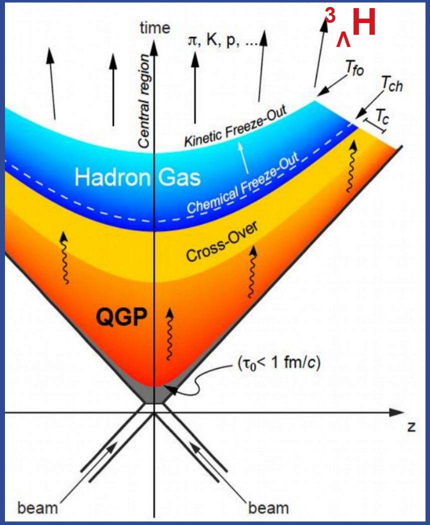


${}^{3}_{\Lambda}H$ lifetime puzzle resolution

ALICE

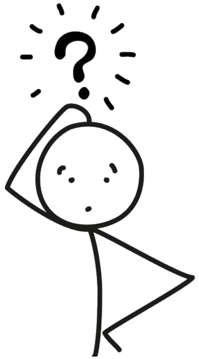


- ALICE can be used also for hypernuclear physics measurements:
  - ➢ Results from 2018 Pb-Pb data + Machine Learning methods represents the **best world measurement**
  - ➢ More precision can be reached:
    - ✔ lifetime measured in the 3-body decay channel
    - In the next future constraints also on the B.R. determination can also be set



$^{3}_{\Lambda}H$ production yield

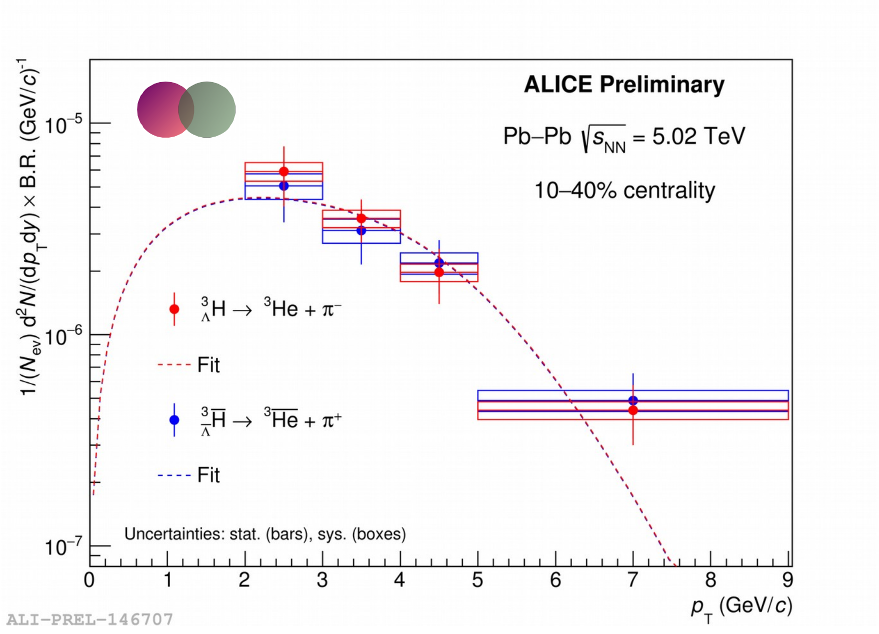
Is $^{3}_{\Lambda}H$ produced inside the hadron gas, or is it produced with all the other particles at the chemical freeze-out?

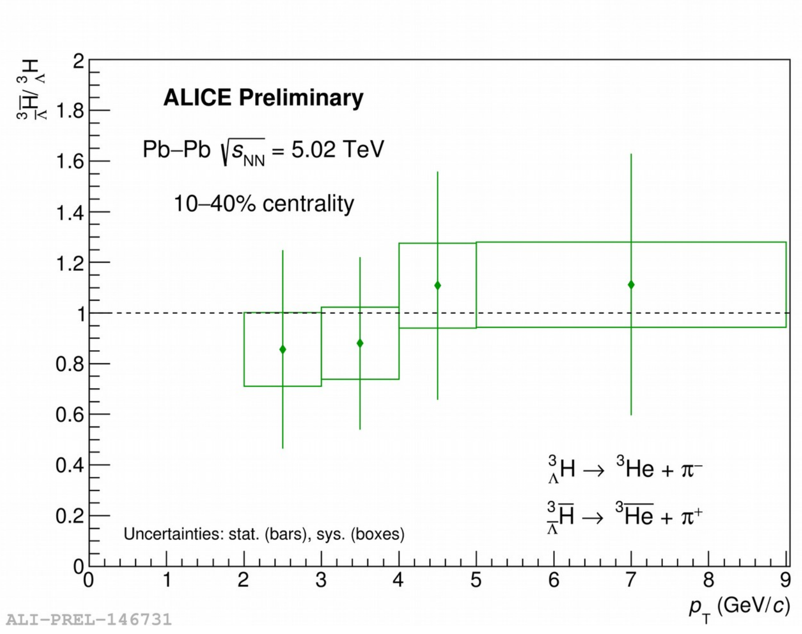


$^{3}_{\Lambda}H$ p_T spectra and yields

Transverse momentum spectra:

- Measured in central (0-10%) and semi-central collisions (10-40%)



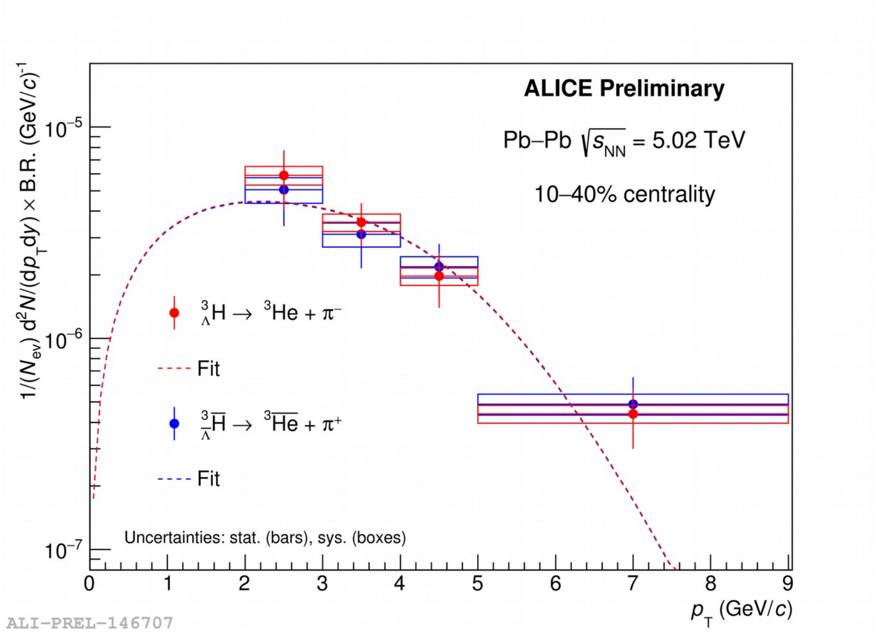


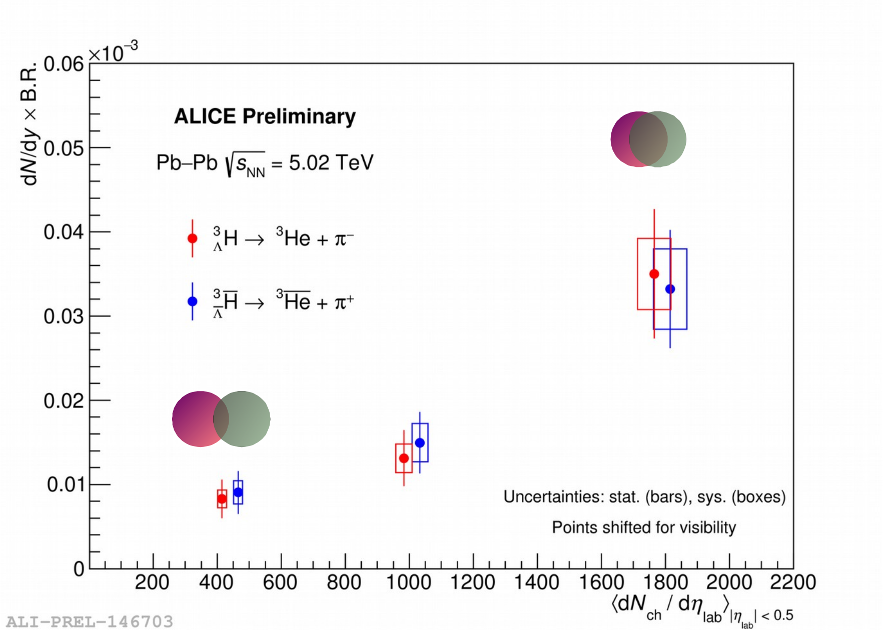
Anti-hypertriton/Hypertriton ratio consistent with unity vs. p_T

$^{3}_{\Lambda}H$ p_T spectra and yields

Transverse momentum spectra:

- Measured in central (0-10%) and semi-central collisions (10-40%)

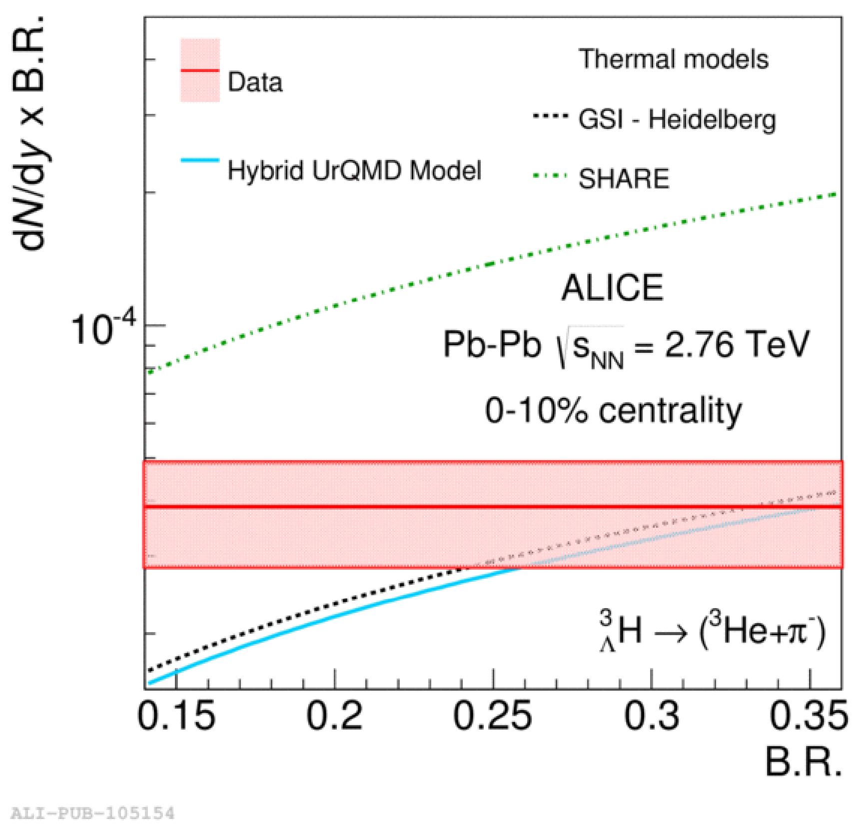




Production in 3 centrality classes shows increase of production probability with increasing multiplicity

${}^{3}_{\Lambda}$H production yield

ALICE Collaboration: PLB 754, 360 (2016)

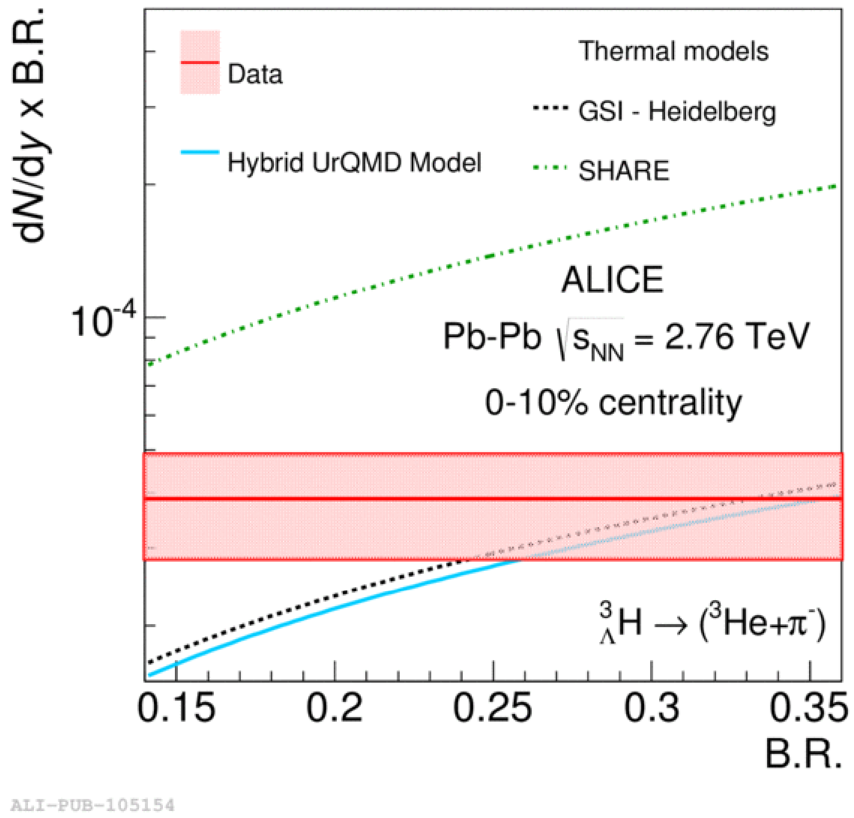


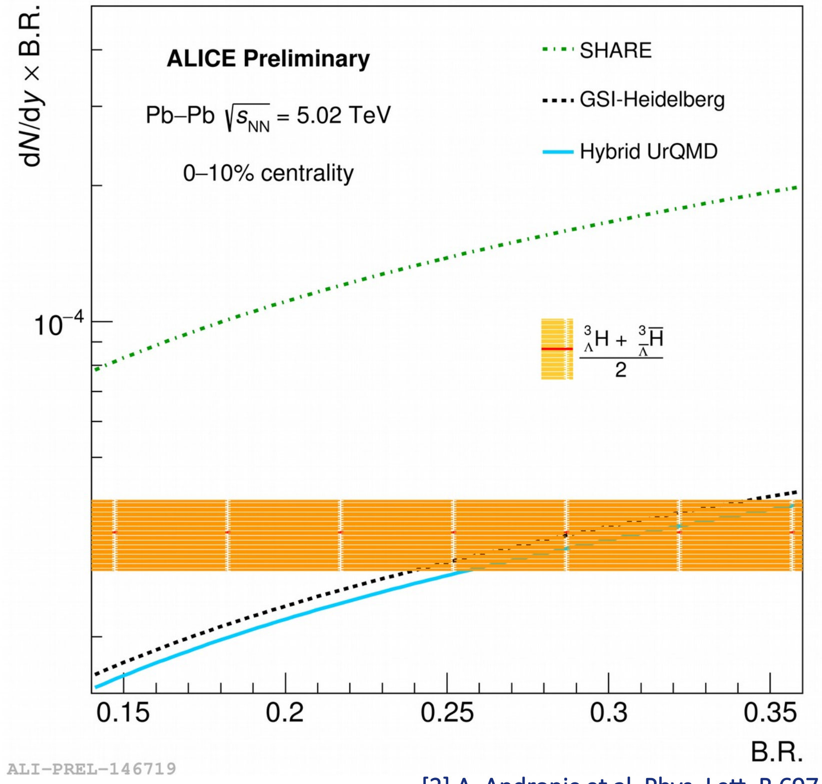
- The ${}^{3}_{\Lambda}$H → ^{3}He + π branching ratio is not well known, only constrained by the ratio between all charged channels containing a pion
- The preferred BR is ~ 25 % [1] (→ lifetime similar to free Λ)
- Extracted yield is in good agreement with equilibrium thermal model prediction for T_{chem} = 156 MeV, such as GSI-Heidelberg model [2], but not with non-equlibrium models, like SHARE[3].
- Result also in agreement with Hybrid UrQMD [4]

[1]Kamada et al., Phys. Rev. C57(1998)4
[2] A. Andronic et al. Phys. Lett. B 697, 203 (2011)
[3]M. Pétran et al. Phys. Rev. C 88 (3) (2013) 034907
[4]J. Steinheimer et al. Phys. Lett. B 714 (2012) 85–91

${}^{3}_{\Lambda}H$ production yield

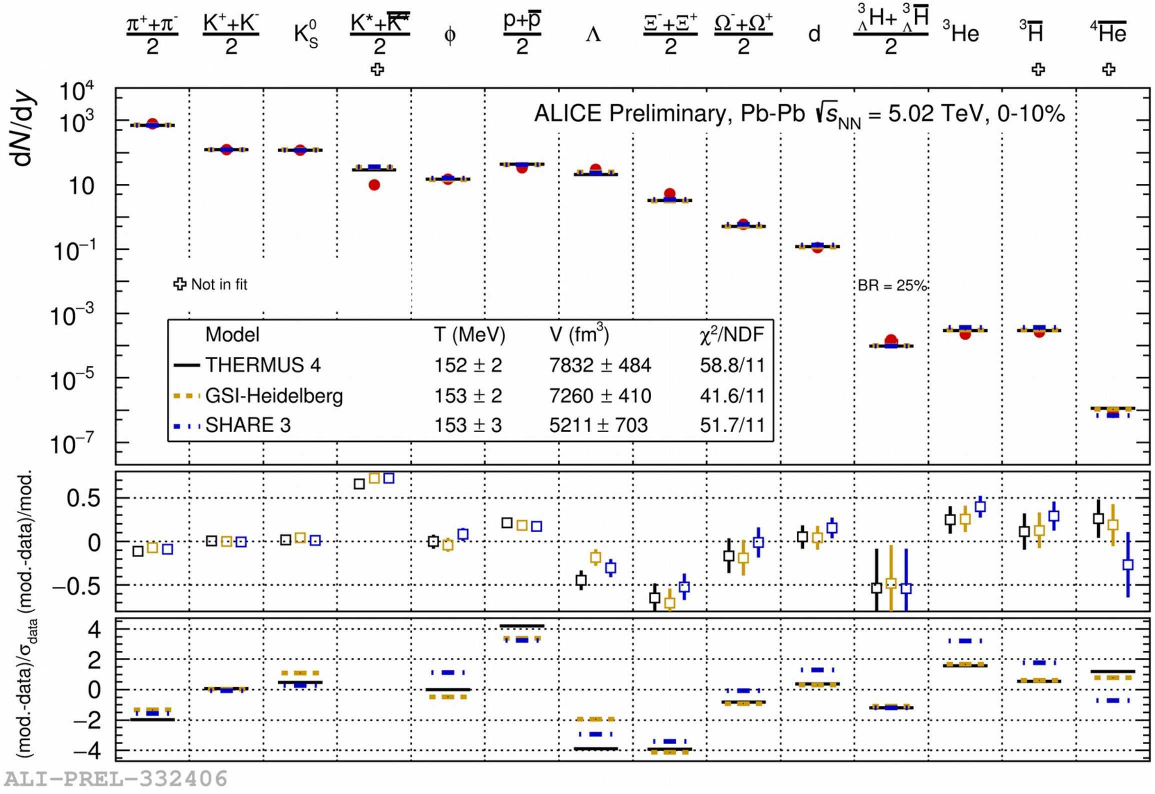
ALICE Collaboration: PLB 754, 360 (2016)





[2] A. Andronic et al. Phys. Lett. B 697, 203 (2011)
[3]M. Pétran et al. Phys. Rev. C 88 (3) (2013) 034907
[4]J. Steinheimer et al. Phys. Lett. B 714 (2012) 85–91

Hypertriton in thermal fit



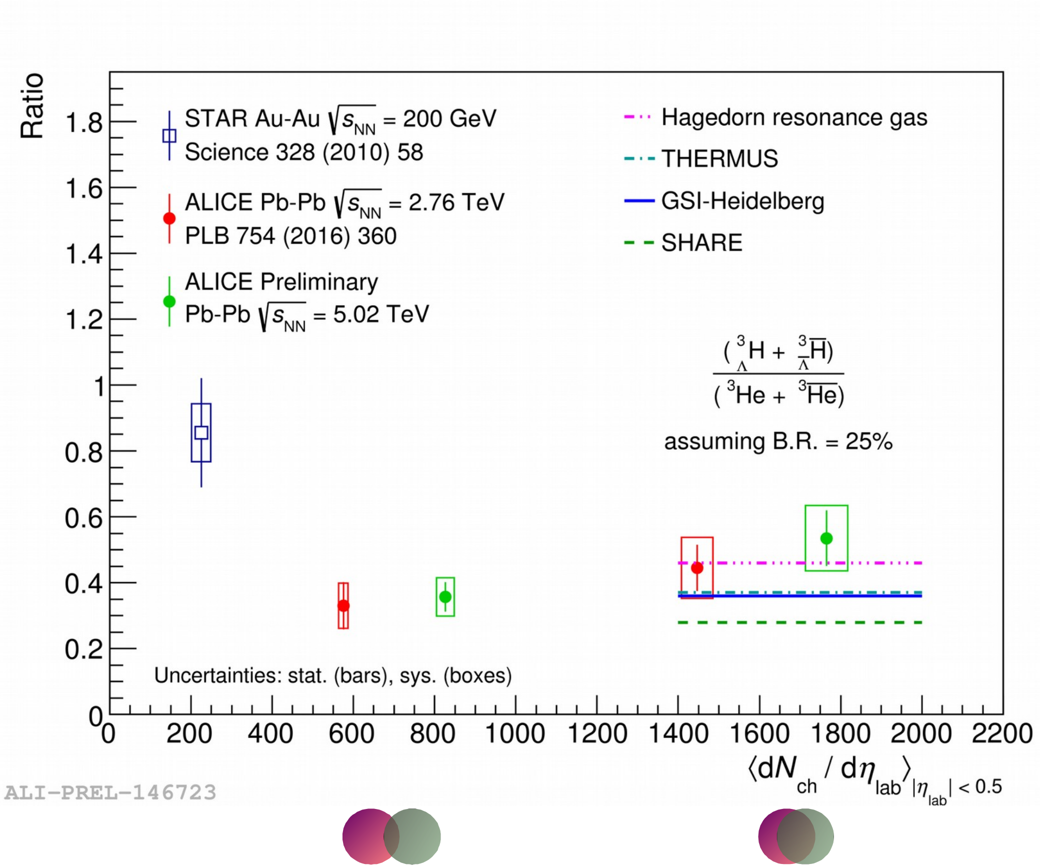
THERMUS: S. Wheaton, et al., CPC 180, 84 (2009)
GSI-Heidelberg: A. Andronic, et al., PLB 697, 203 (2011); PLB 673, 142 (2009) 142
SHARE3: G. Torrieri, et al., CPC 167, 229 (2005); CPC 175, 635 (2006); CPC 185, 2056 (2014)

K* not included in the fit

- Particle production yields measured by ALICE in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV
- Hypertriton and nuclei (d and ^{3}He) yields are included in the fit
- d*N*/dy described over a wide range (10^{-4} - 10^{3}) assuming thermal equilibrium and a chemical freeze-out temperature T_{chem} = 152-153 MeV
- The temperature values are compatible with the chemical freeze-out temperature ranges obtained from the ratios to deuteron and proton yields

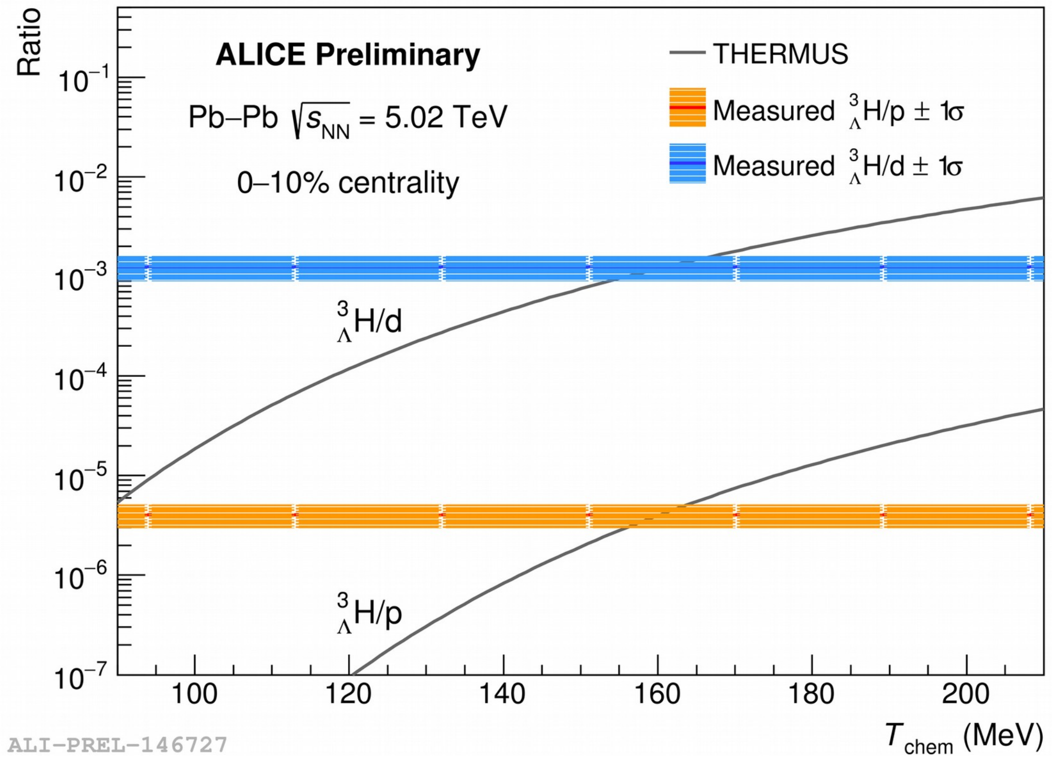
Particle ratios

- ${}^{3}_{\Lambda}H/{}^{3}He$ ratio
  - Ratios for most central collisions in agreement with theoretical predictions from Hagedorn resonance gas (HRG) and thermal models



Particle ratios

- ${}^{3}_{\Lambda}H/p$ and ${}^{3}_{\Lambda}H/d$
  - Ratio to light hadron yields more sensitive to the chemical freeze-out temperature T_{chem}
  - ${}^{3}_{\Lambda}H/p$ and $3_{\Lambda}H/d$ compared with THERMUS predictions as a function of T_{chem}
  - $\rightarrow T_{chem}$ = 153-165 MeV
  - In agreement with T_{chem} = 156 MeV obtained from the fit to particle yield

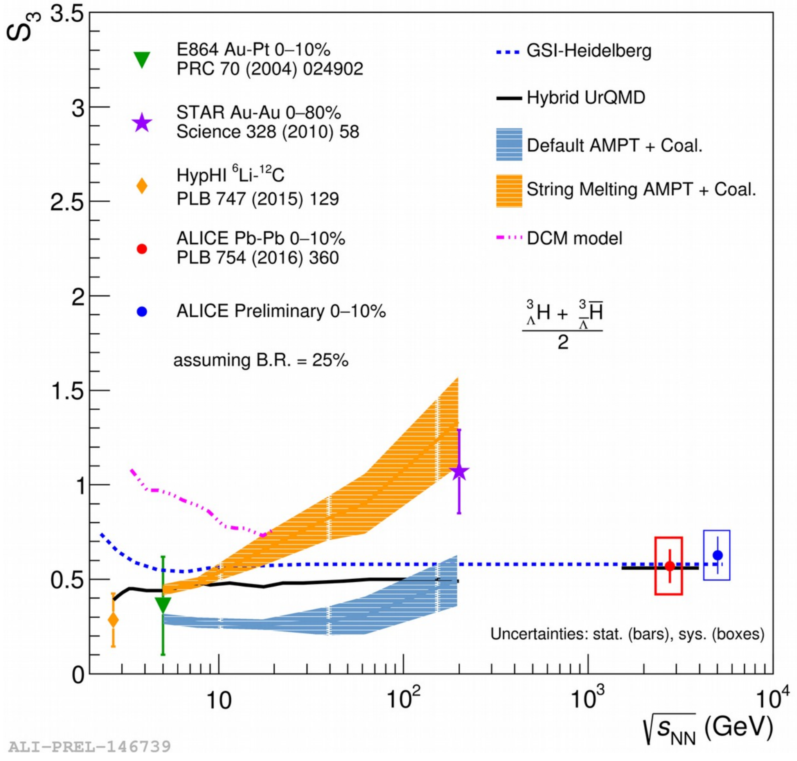


Strangeness population factor

Strangeness population factor S_3 [1,2] is defined as:

$$S_3 = \frac{^{3}_{\Lambda}H}{^{3}He} \times \frac{p}{\Lambda}$$

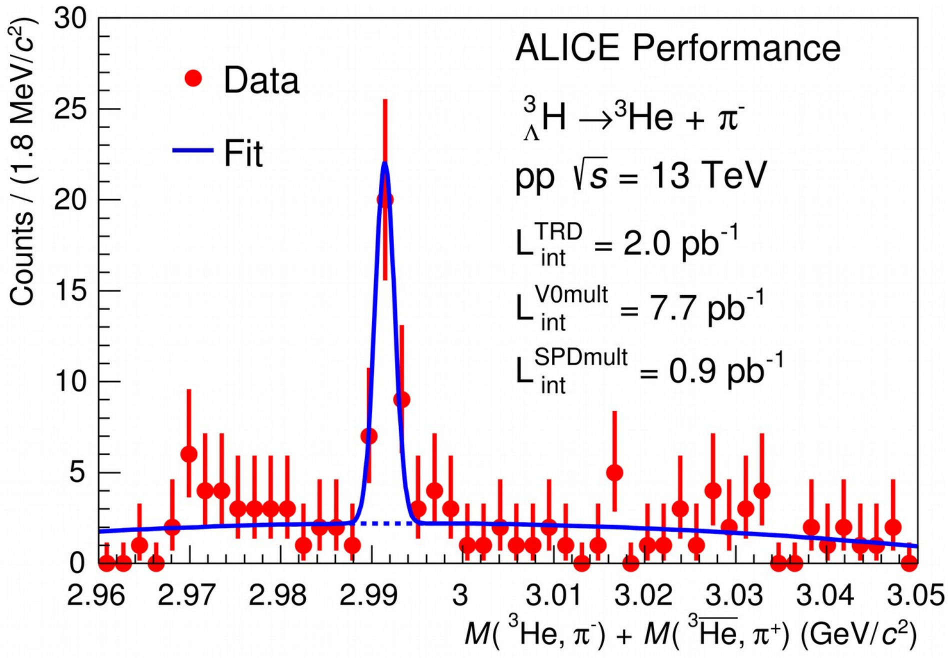
- It is independent on the chemical potential of the particles and any additional canonical correction factor for strangeness is canceled
- ALICE results obtained at 5.02 TeV is:
  - compatible with the published results at 2.76 TeV and with those at lower energies
  - in agreement with the prediction of the equilibrium thermal model (GSI-Heidelberg) and of the Hyrbrid UrQMD model
  - Coalescence predictions available only up to top RHIC energies, needed at the LHC energies



[1] E864 Collaboration, T. A. Armstrong et al. Phys. Rev. C 70, 024902 (2004)
[2] S. Zhang et al. Phys. Lett. B 684, 224-227 (2010)

Hypertriton in pp collisision

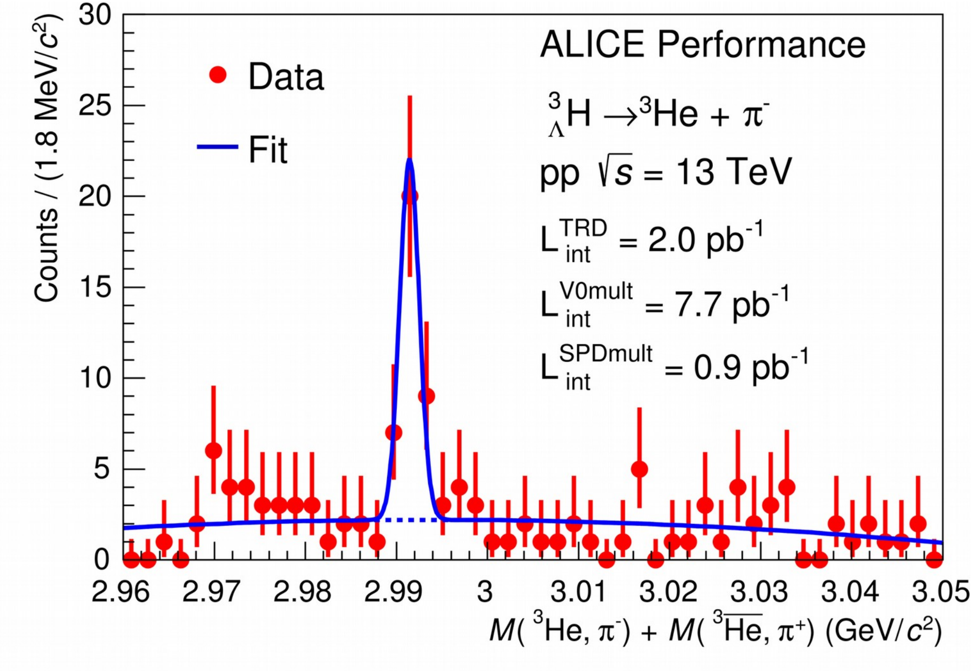
- First observation of (anti)hyper-nuclei production in pp collisions at the LHC
- Extremely rare : dedicated trigger devised in the ALICE Transition Radiation Detector using the signal from the highly ionizing ^{3}He



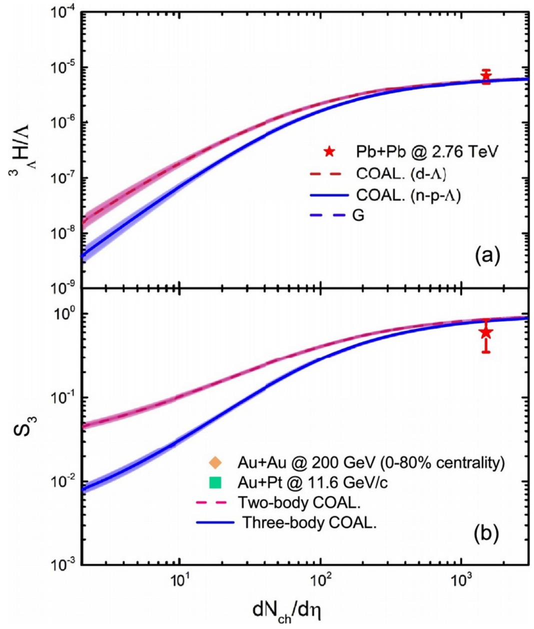
ALI-PERF-328598

Hypertriton in pp collisision

- First observation of (anti)hyper-nuclei production in pp collisions at the LHC
- Extremely rare : dedicated trigger devised in the ALICE Transition Radiation Detector using the signal fro
  the highly ionizing ^{3}He
- Yield measurement in pp will help for a better understanding of the production mechanism



ALI-PERF-328598

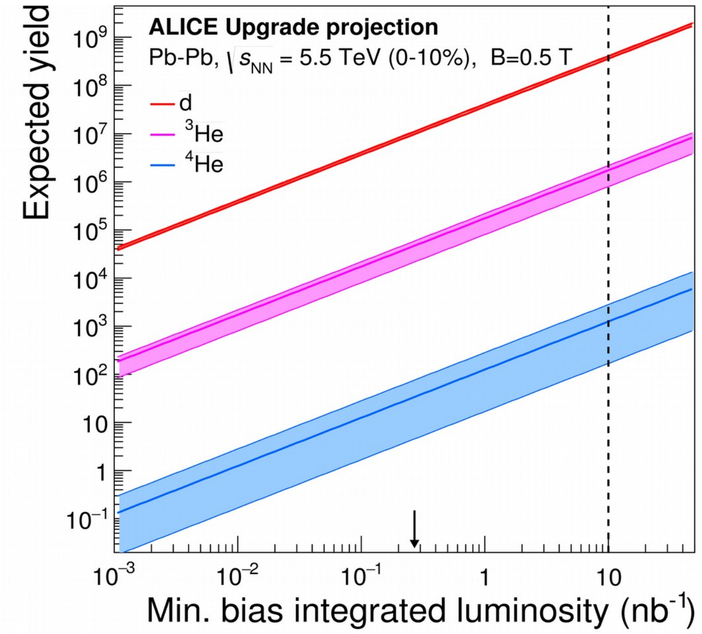


K. Sun, C.M. Ko, B. Dönigus Phys. Lett. B 792 (2019)132

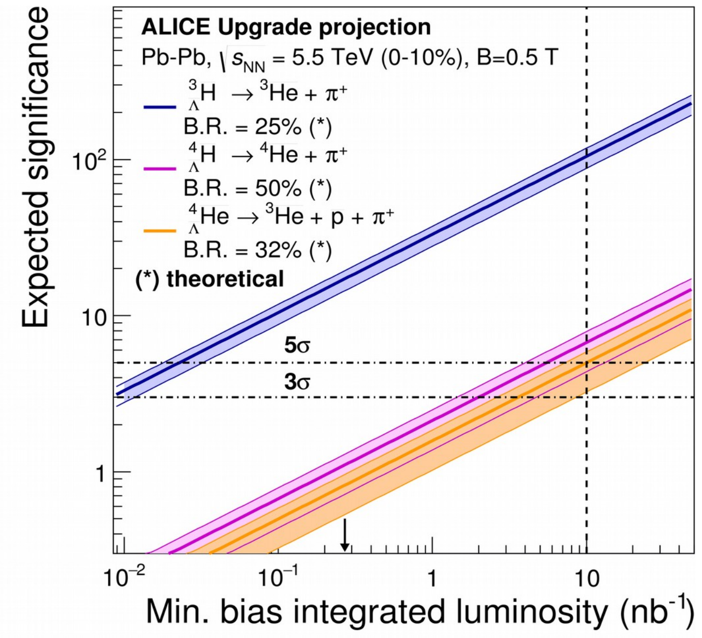
Outlook – ALICE upgrade

After the LS2 ALICE will be able to collect data with better performance at higher luminosity

- Expected integrated luminosity: ~10 nb^{-1} (~ $8x10^9$ collisions in the 0-10% centrality class)
- New ITS: less material budget and more precise tracking for the identification of hyper-nuclei
- All the physics which is now done for A = 2 and A = 3 (hyper-)nuclei will be done for A = 4



ALI-SIMUL-312336



ALI-SIMUL-312332

Summary

- Measurements of the (anti-)hypertriton production and lifetime have been performed with the most recent LHC Run2 data exploiting the excellent performance of the ALICE detector
- Thermal model can successfully describe particular aspects of the (hyper-)nuclei measurements:
  - Integrated yields and ratios are well described by thermal models
- Recent hypertriton lifetime measurement shows an improved precision and a value closer to the Λ lifetime with respect to the previous heavy-ion results
- New theoretical calculations for the lifetime are needed as well as more precise measurements of the value of $E_{B\Lambda}$
- New and more precise data are expected from the LHC on the presented topics in the next years. These will provide stricter constraints to the theoretical models