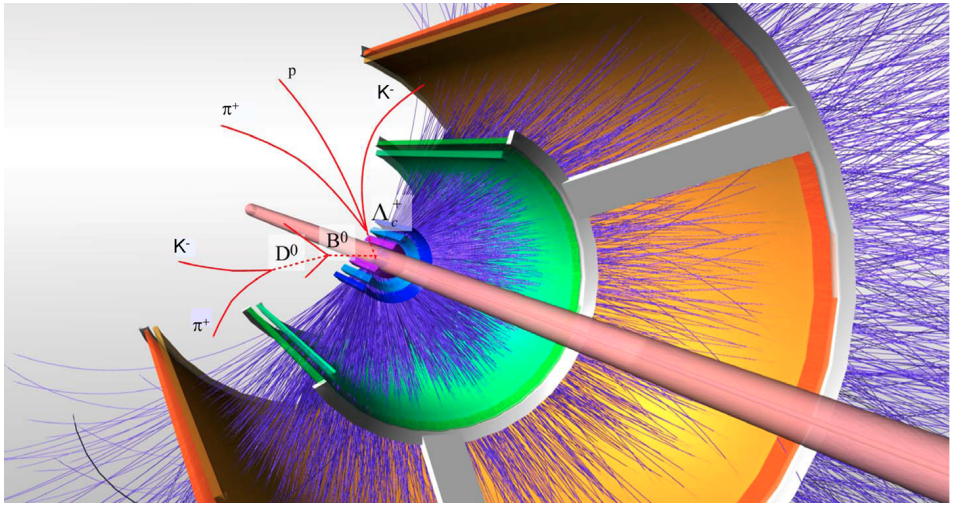
Antonin MAIRE, ALICE group – IPHC
Friday, Oct. 13th 2017 – **Internship proposals**



ALICE group :

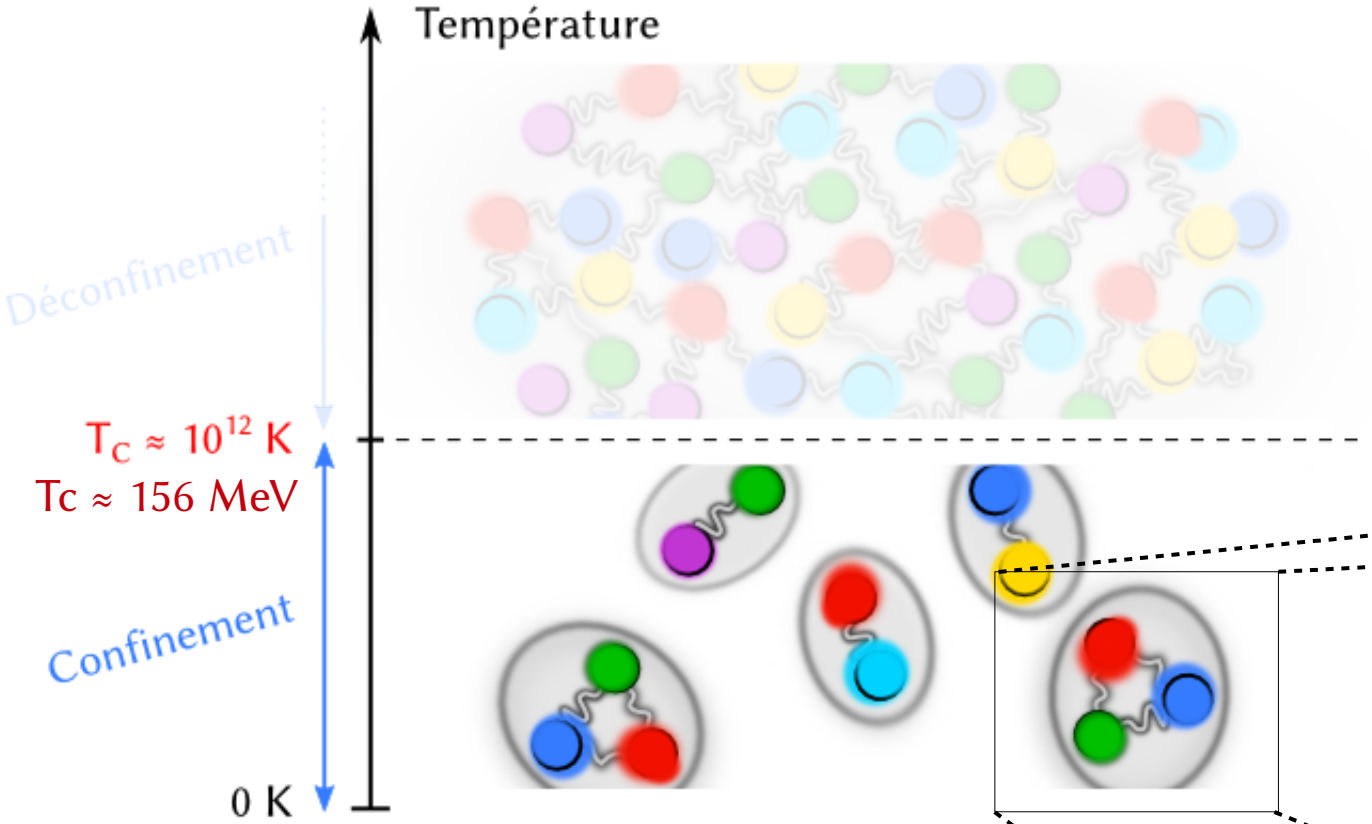
QCD, Quark-Gluon Plasma

Strangeness, charm

Pixel trackers

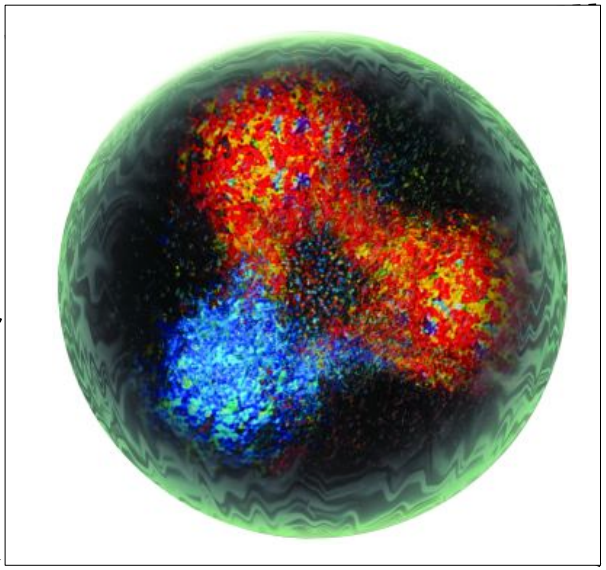
LHC pp, p-Pb, Pb-Pb

I.1 – Introduction : QCD phase transition



Hot and dense medium strongly interacting, made of deconfined quarks and gluons

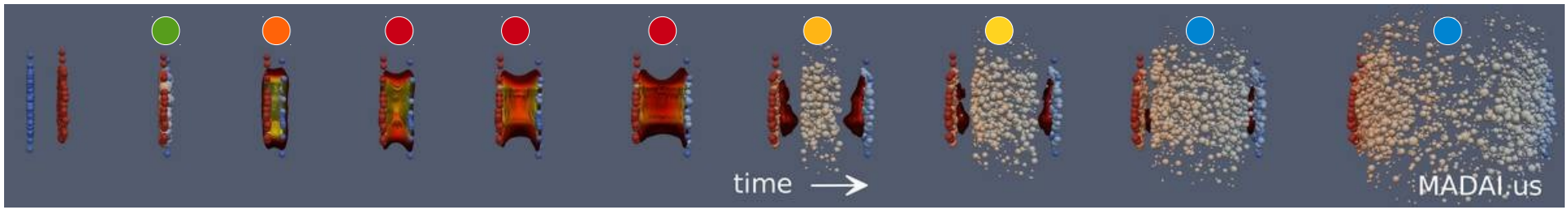
Parton Distribution Function

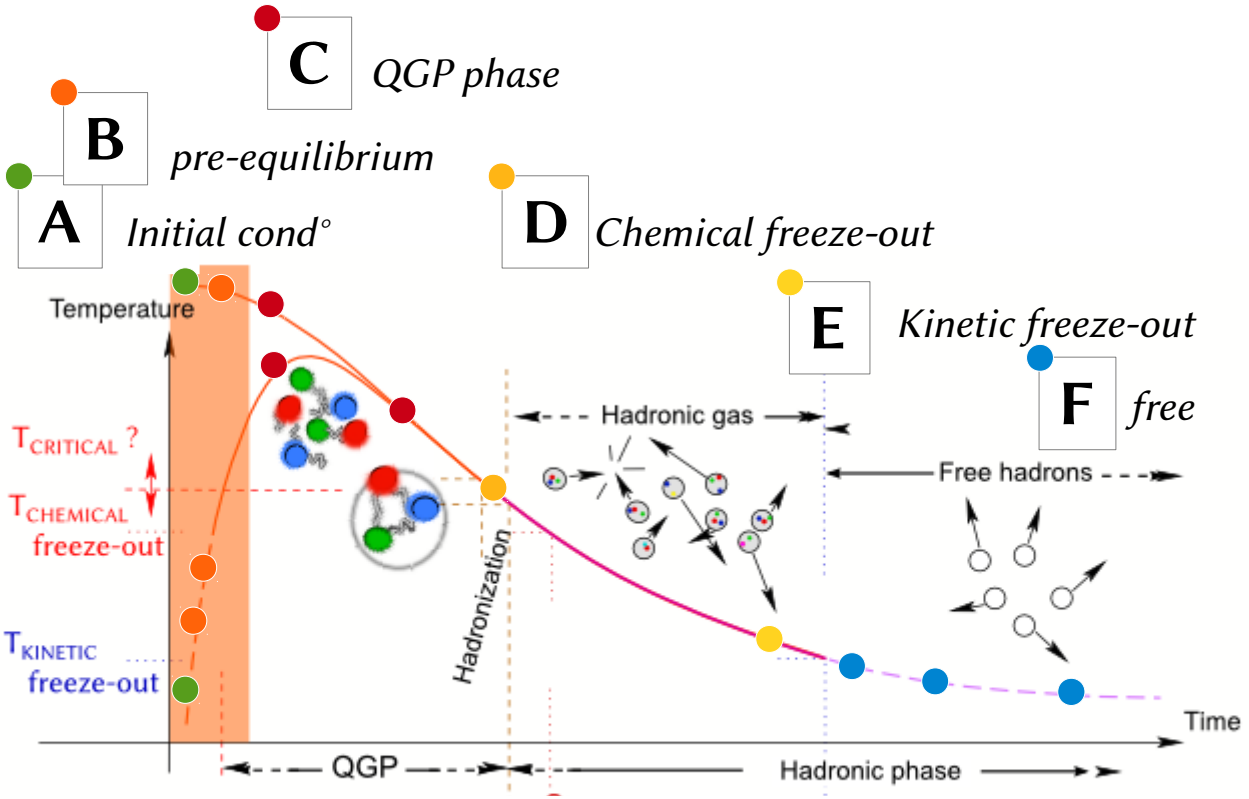


DOI : 10.1103/PhysRevD.27.140

I.2 – Intro. : Bjorken scenario in heavy-ion collisions

Courtesy of MADAI.us (see animation movie !)

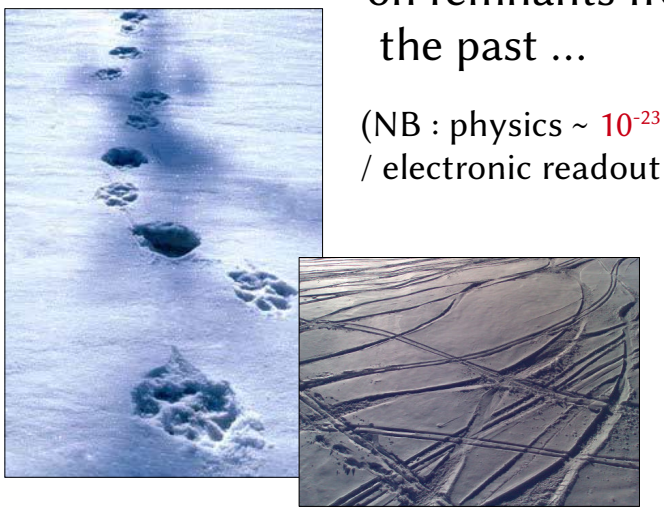




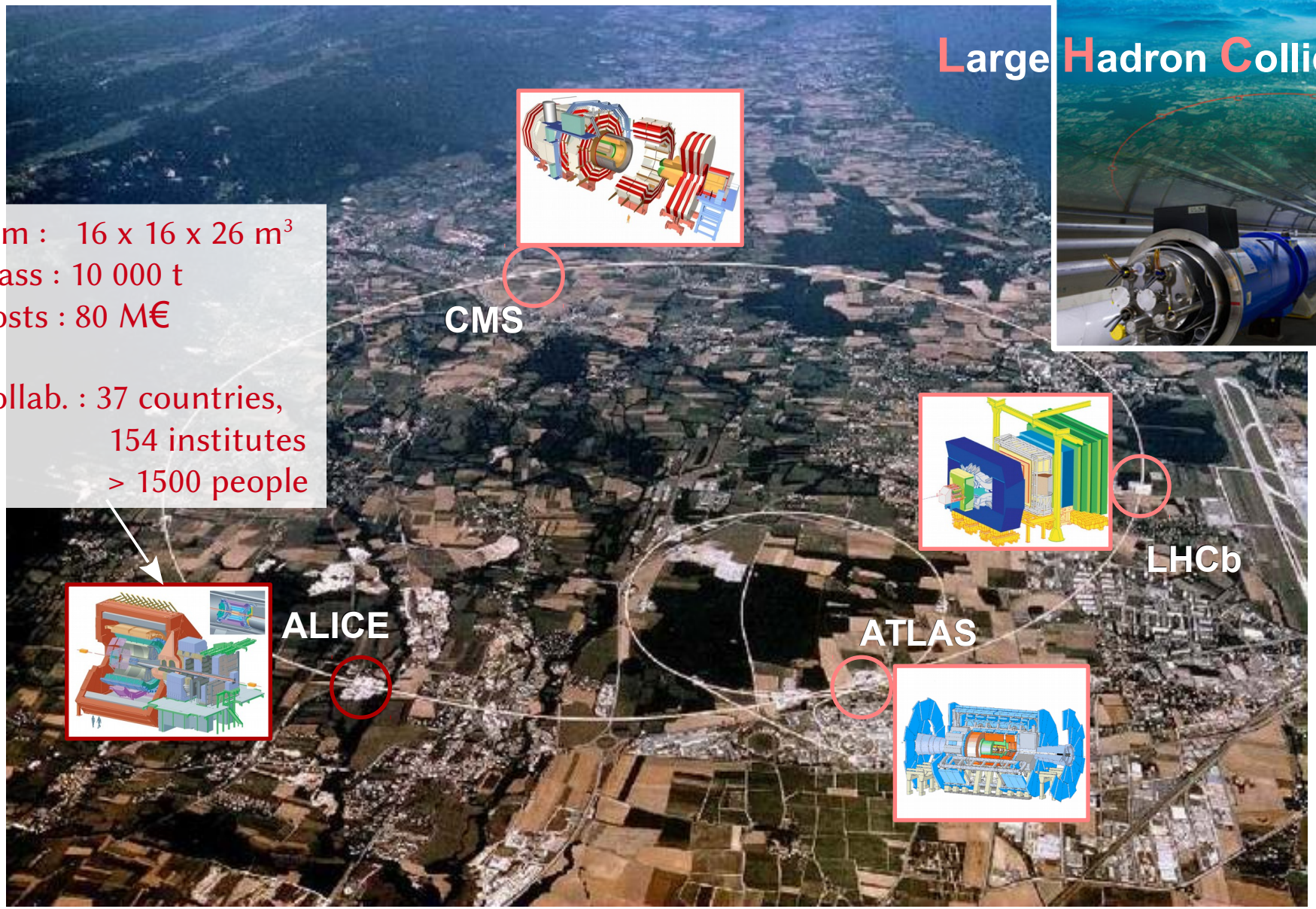
→ Remark :

No such thing as a live vision !
but always, an observation based on remnants from the past ...

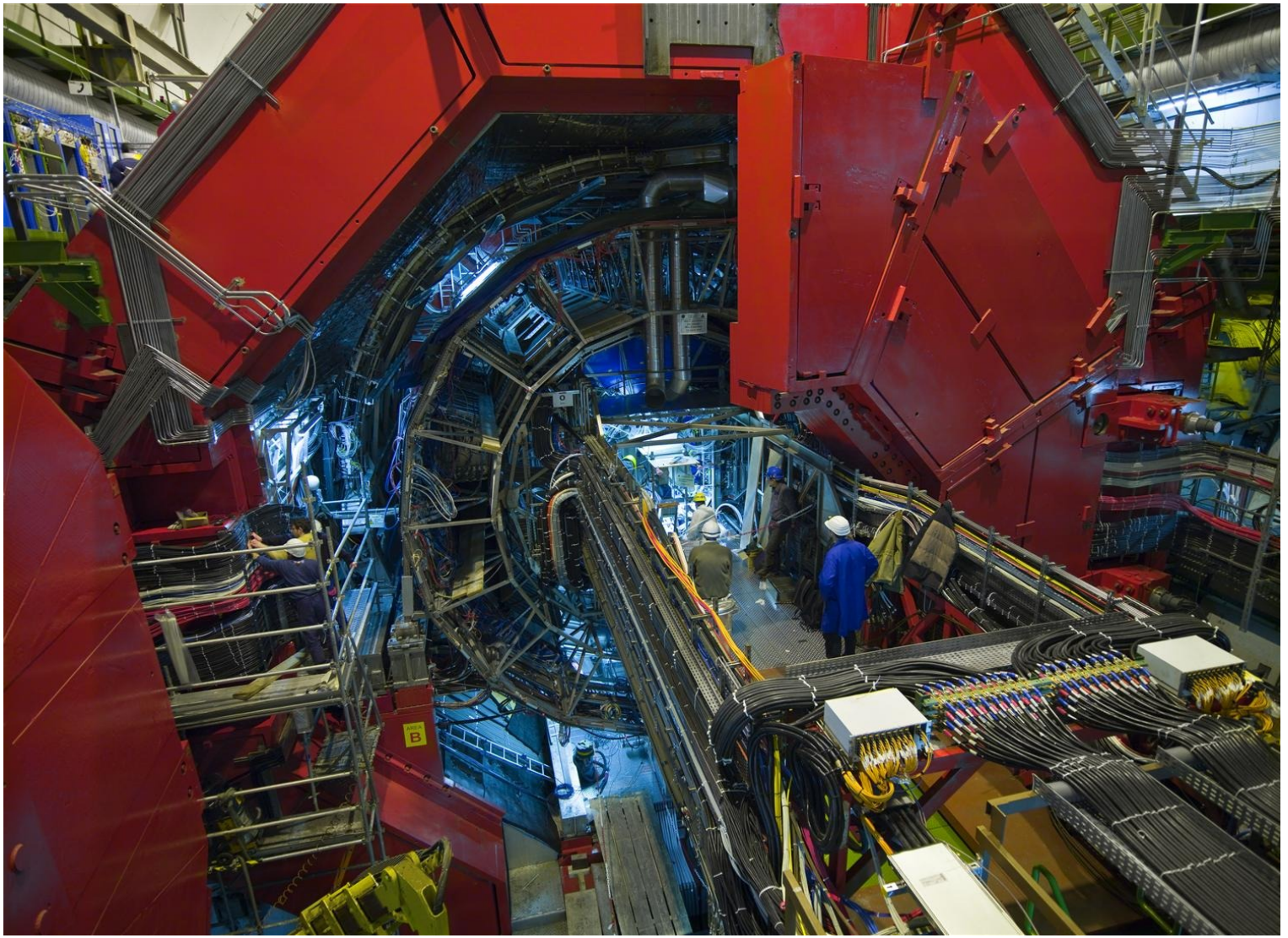
(NB : physics ~ 10^{-23} s / electronic readout > 10^{-12} s)



II.1 – ALICE : an LHC experim^{t} focusing on QCD physics

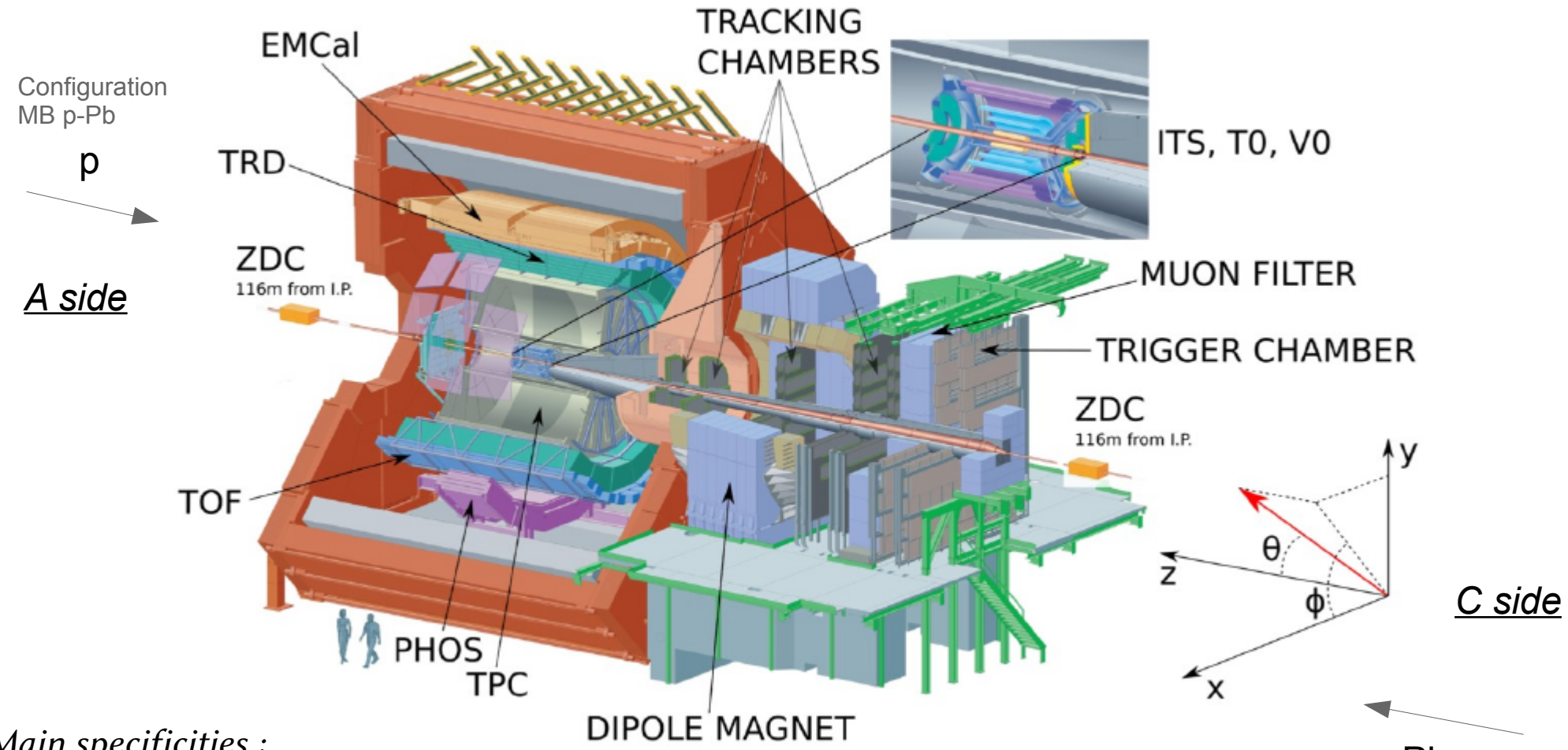


II.2 – ALICE : 19 sub-detectors



Here 2008, as before start of LHC run I

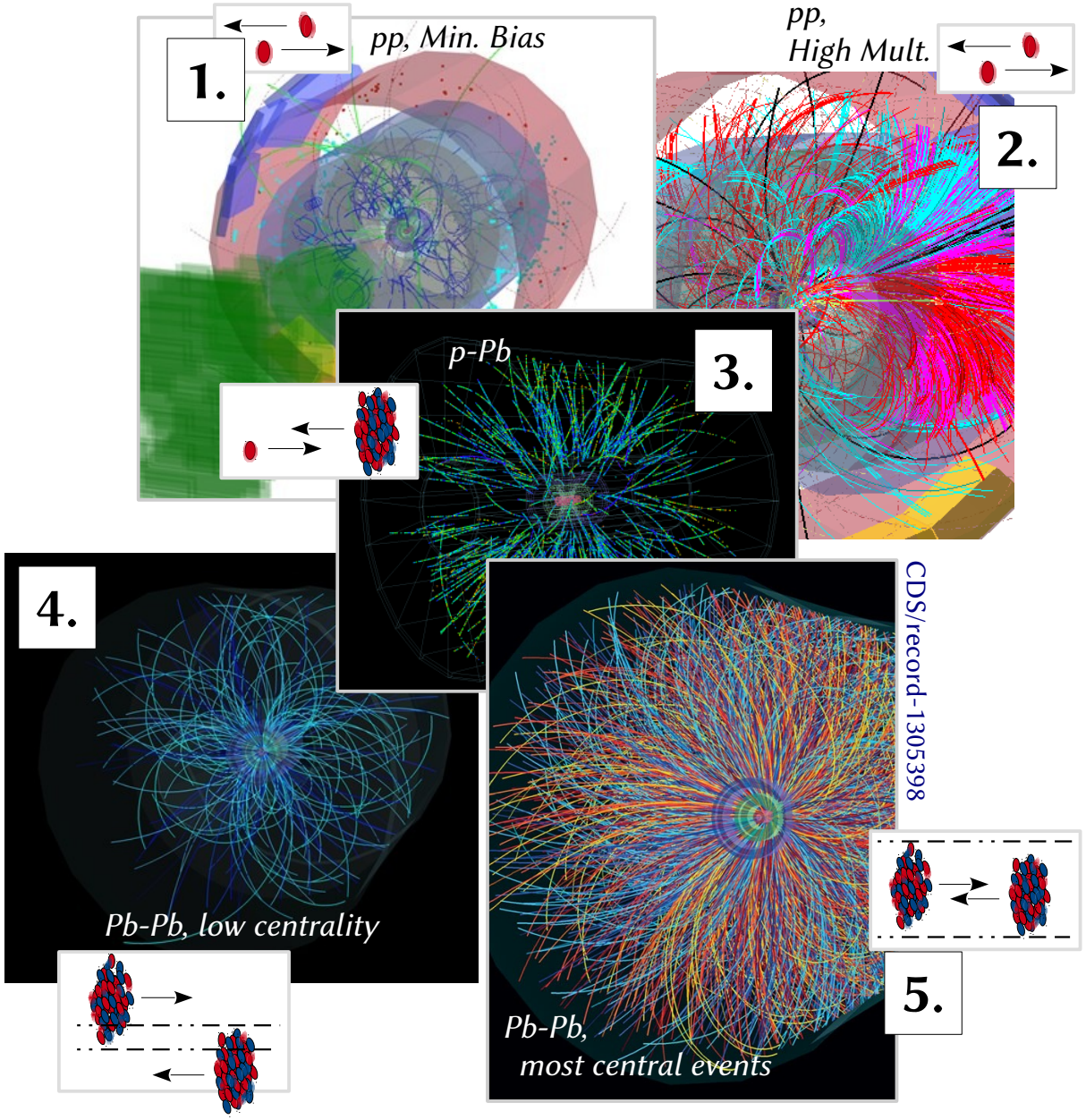
II.3 – ALICE : detector in LHC run II (2015-18), sketch



Main specificities :

- Particle Identification
- Low (p_T < 2-3 GeV/c)
  and intermediate p_T ($p_T \in$ [2-8] GeV/c)

III.1 – pp, pA, AA : continuum of physics ?



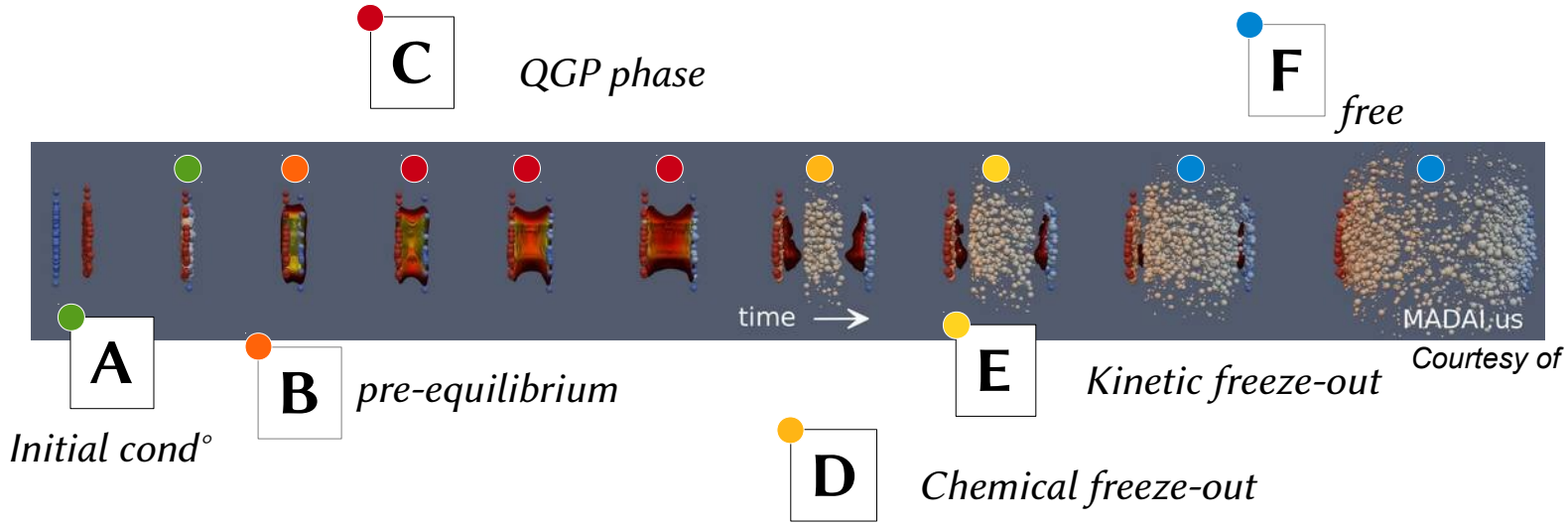
The starting plain question may be :
at the same $\sqrt{s_{NN}}$,

“ 1 x (Pb-Pb) ≠ n x (pp) ? ”

Current stakes :
⟶ qualifying the binary answer

“ pp, p-Pb ⟶ no QGP. ”
“ Pb-Pb ⟶ QGP ! ”

III.2 – *u,d,s* and pp : probes of the bulk phenomena



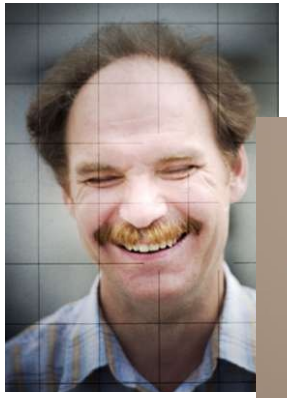
Courtesy of MADAI.us

flavour physics :

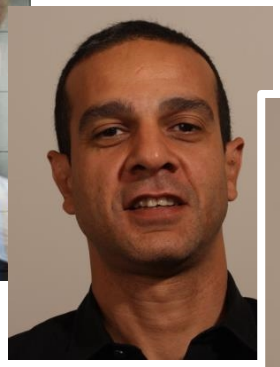
u,d,s,c,b (t) <=> $\pi^{\pm}$, π^{0}, $K^{\pm}$, K^{0}_{S}, ... , p, Λ, Ξ^{-}, Ω^{-}, ... η, $K^{0}(892)$, $\phi(1020)$, $\Sigma^{\pm}(1385)$, $\Xi^{0}(1530)$
D^{0}, $D^{\pm}$, $D^{*\pm}$, D_{S}, J/ψ, χ_{Ci}, $\psi(2S)$, ... , Λ_{C}, B^{0}, $B^{\pm}$, B^{0}_{S}, $\Upsilon(1S,2S,3S)$,
γ, $W^{\pm}$, Z^{0}
d, t, ^{3}He, ^{4}He, ... + anti-particles

IV.1 – ALICE + µTech IPHC : 2018 team members

Iouri Belikov (DR)



Boris Hippolyte (MCf /HDR)



Arthur Gal (PhD student)

Christian Kuhn (DR)

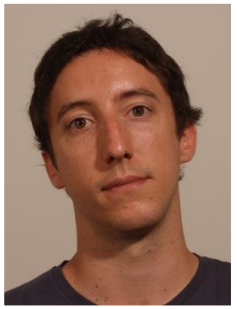
Antonin Maire (CR)

Fouad Rami (CR)

Yves Schutz (DR)

Sergey Senyukov
(Post-doc)

(in Oct. 2018)

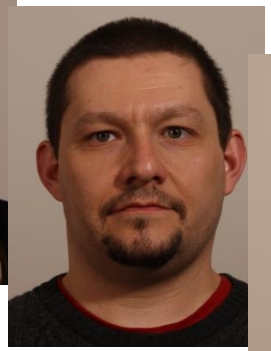


Julien Hamon
(PhD ~~student~~)

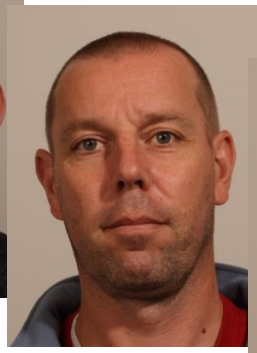
Christelle Roy (DR)

+ microtechnics team :
Marc Imhoff,

Franck Agnese,

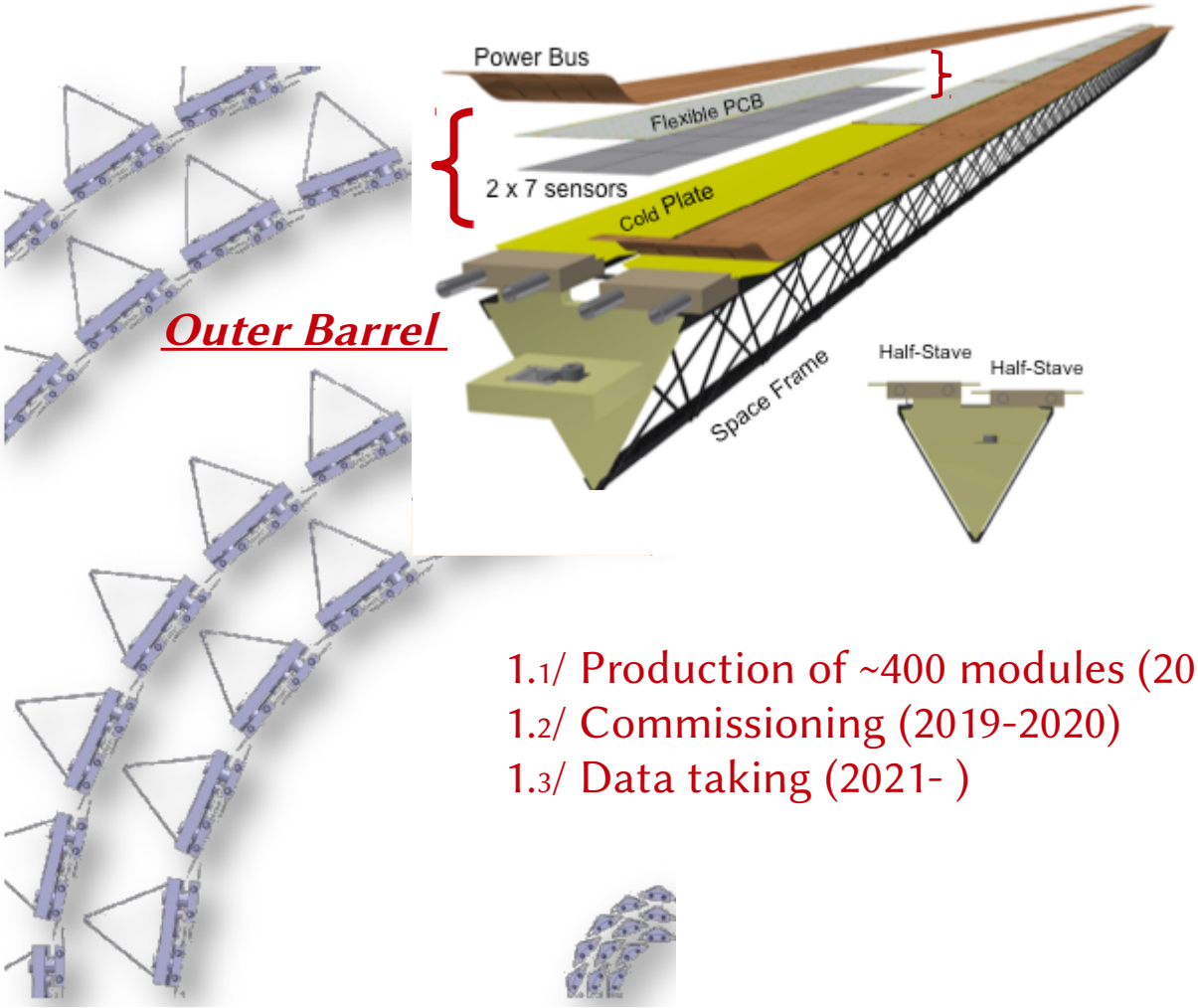


Olivier Clausse,

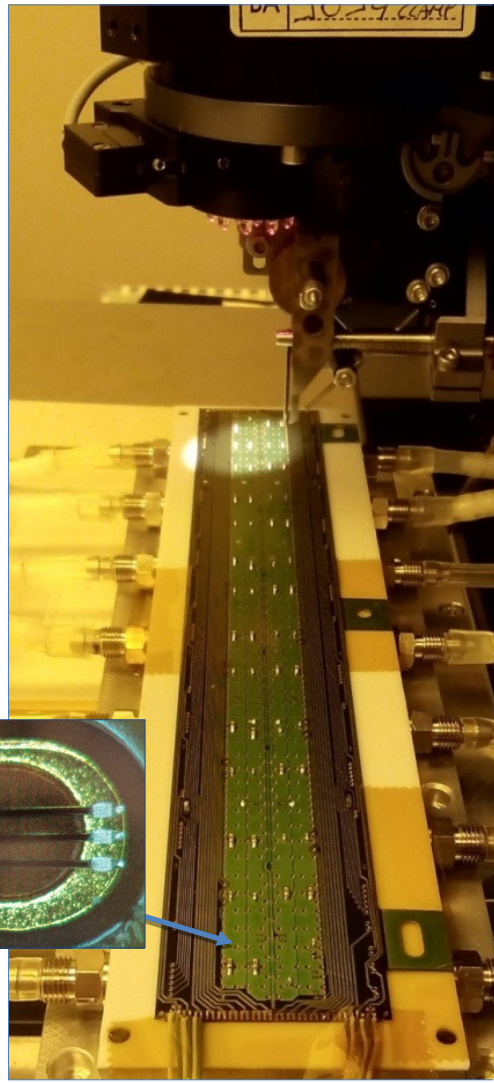


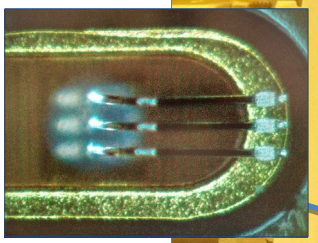
Christophe Wabnitz

IV.2 – ITS upgrade : hardware



1.1/ Production of ~400 modules (2017-2018)
1.2/ Commissioning (2019-2020)
1.3/ Data taking (2021-)

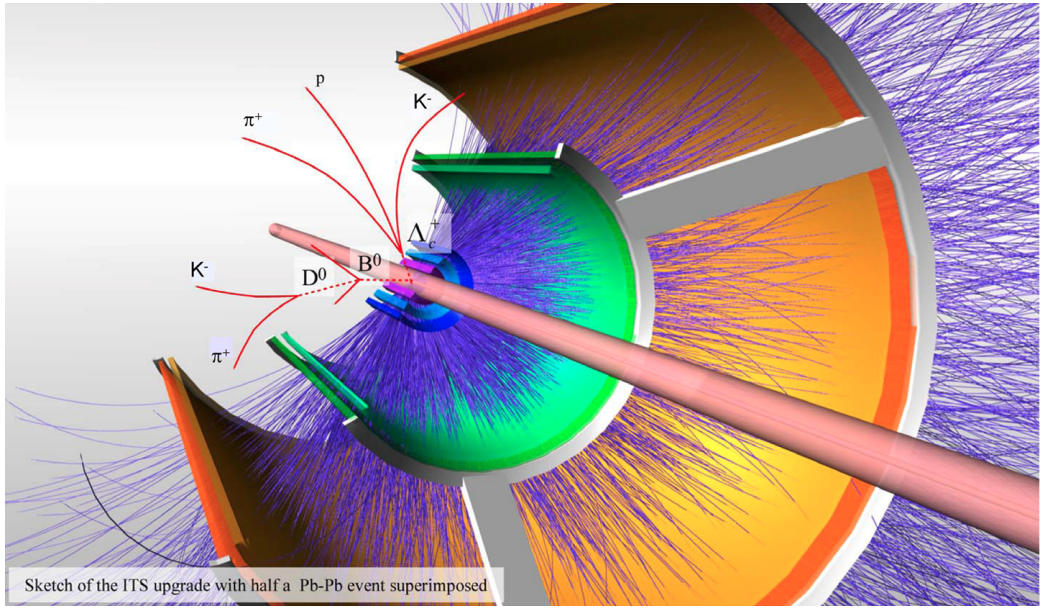




= assembly + tests of 2x7 CMOS sensors
for the 4 external layers of the ITS (out of 7 layers)
~24% of [2+2 layers = 2.3 + 6.9 m² = 25% +73% of the total active surface]

Bonding : YouTube

IV.3 – ITS upgrade : software



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

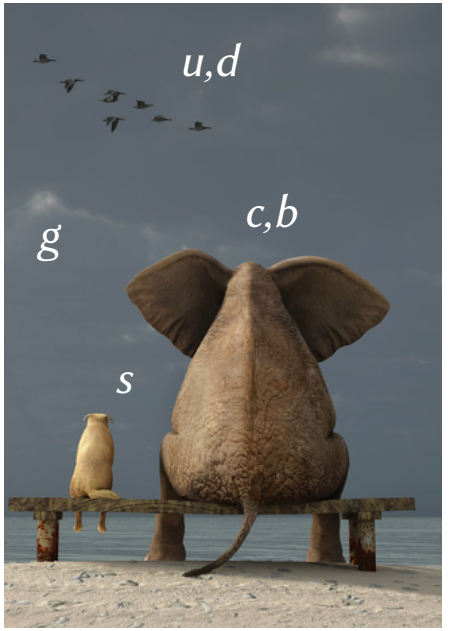
2./ ITS software

tracking algorithms
geometry
simulations
from detector response to physics performances

On the To-Do list :

- parallel event reconstruction (GPU, Xeon Phi, FPGA)
  parallel algorithms on various architectures ⟶ C++11 as basis
- O² devices
- Geant4 multi-threaded
- calibration (dead/noisy pixels)
- Quality Control & event display

IV.4 – Flavours : extend (*u,d,s*) to (***c,b***)



- **Strangeness** (u,d +s) // **Open charm** (u,d,s +c)

  differential measurements (p_T, event activity) in run II or for run III

  production cross-sections (R_{AA}, R_{pA}, particle ratios)
  hadronisation mechanisms (angular correlations),
  thermalisation (radial flow, v_n)

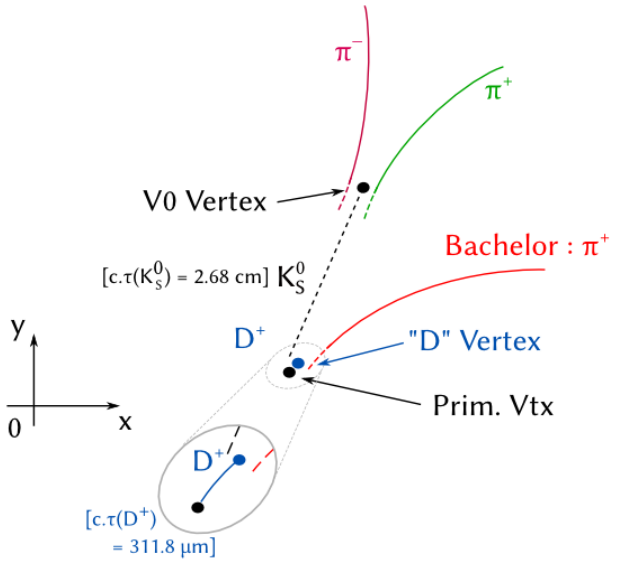
  Local expertise : $K^0s(\bar{d}s) \longrightarrow \pi^+\pi^-$, $\Lambda(uds) \longrightarrow p\pi^-$,
  $\Xi^-(dss) \longrightarrow \Lambda\pi^-$, $\Omega^-(sss) \longrightarrow \Lambda K^-$

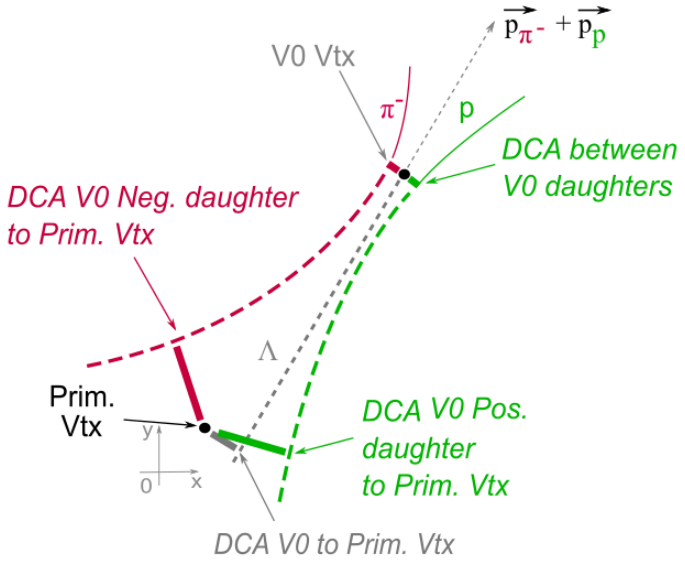
  Extension : $D_s^+(c\bar{s}) \longrightarrow \pi^+ [\phi(1020) \longrightarrow K^+K^-]$ ou K^+K^0s
  $\Lambda_c^+(udc) \longrightarrow pK^0s$ ou $\Lambda\pi^+$

  $\longrightarrow$ <u>Common parts :</u> topological hadronic reconstruction

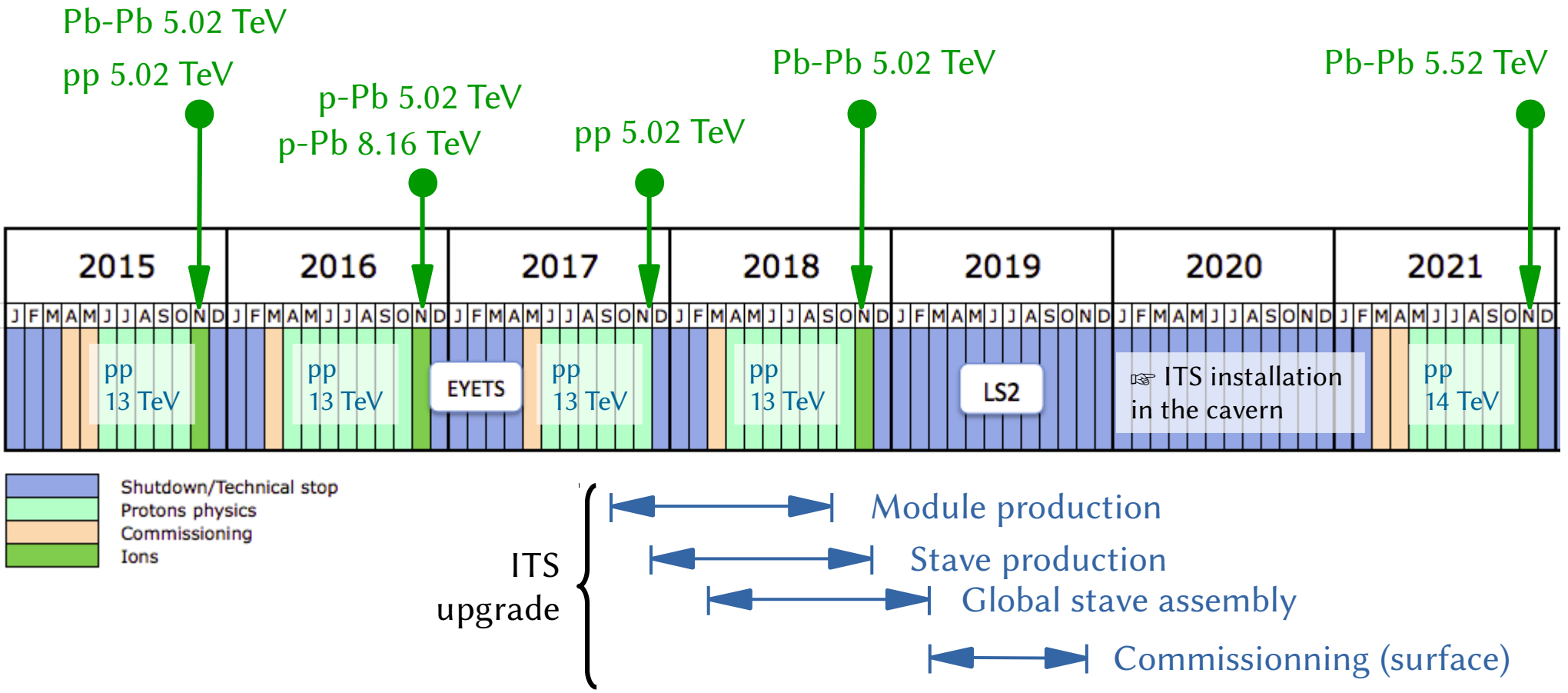
- in various systems :

  pp
  pp high multiplicity
  p-Pb
  Pb-Pb





V.1 – LHC timeline : data taking and shutdown



Appendices

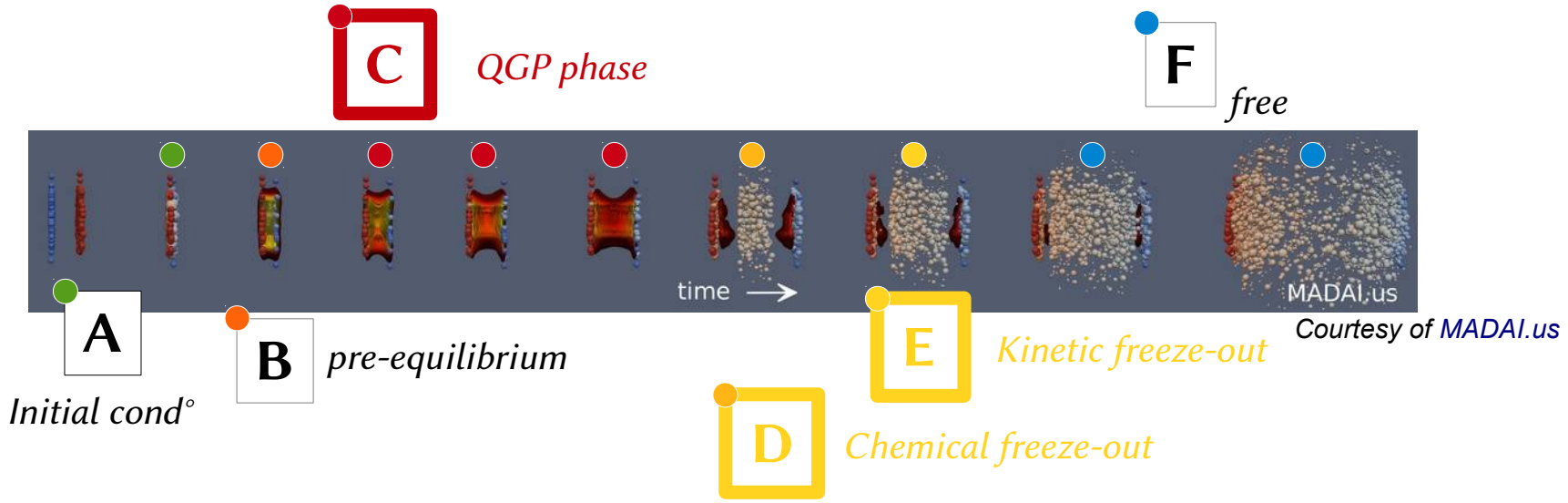
A – Λ in various systems

B – low B-field runs

C – pp, p-Pb, Pb-Pb multiplicities

D – ALICE tracker upgrade

IV.1 – *u,d,s* and pp : probes of the bulk phenomena



Courtesy of MADAI.us

flavour physics :

u,d,s,c,b,(t) <=> $\pi^{\pm}$, π^{0}, $K^{\pm}$, $\mathbf{K^{0}_{S}}$, ... , p, $\mathbf{\Lambda}$, $\mathbf{\Xi^{-}}$, $\mathbf{\Omega^{-}}$, ... η, $K^{0}(892)$, $\phi(1020)$, $\Sigma^{\pm}(1385)$, $\Xi^{0}(1530)$

D^{0}, $D^{\pm}$, $D^{*\pm}$, D_{S}, J/ψ, χ_{Ci}, $\psi(2S)$, ... , Λ_{C}, B^{0}, $B^{\pm}$, B^{0}_{S}, $\Upsilon(1S,2S,3S)$,

γ, $W^{\pm}$, Z^{0}

d, t, ^{3}He, ^{4}He, ... + anti-particles

Soft probes ?! = *u,d,s quarks*

something (~abundantly) produced in the deconfined thermalised medium (***stage C***)
and/or possibly still at the phase boundary (***stages D to E***)
⟶ reflection of the *bulk* production

Link : PDG live

V.1 – Λ baryon : a strange baryon, as seen in ALICE

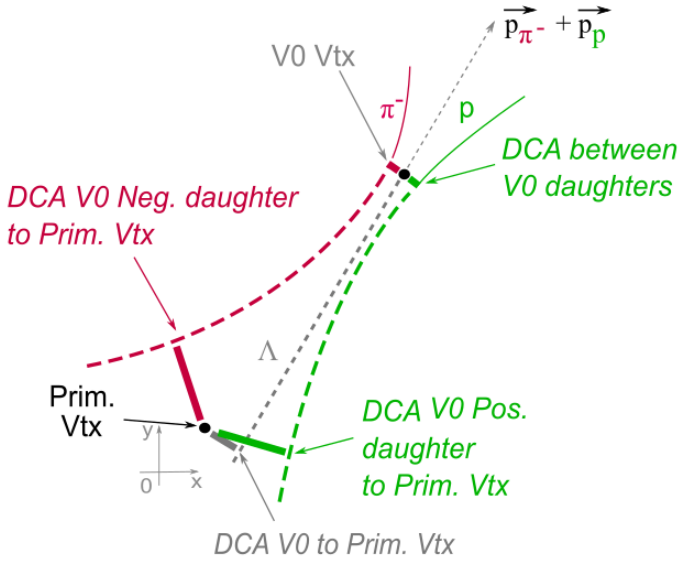
Λ (*uds*)

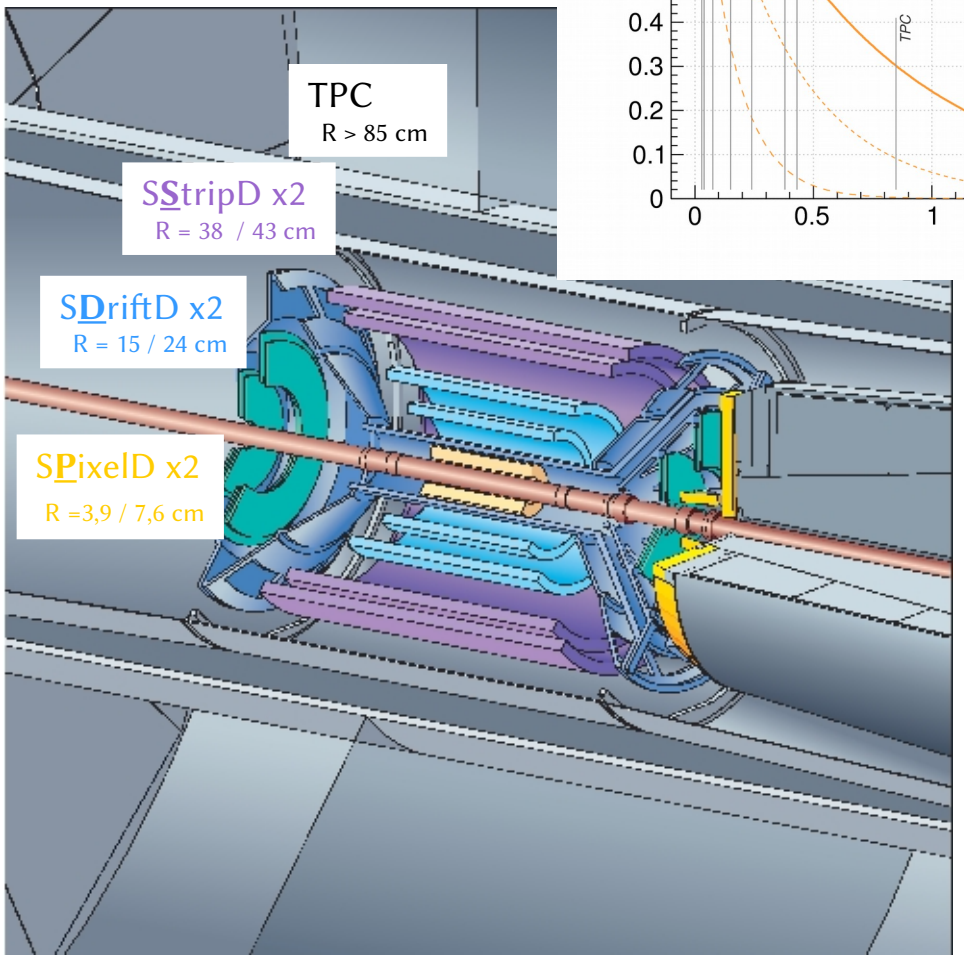
$\tau(\Lambda) = 2{,}63\ 10^{-10}$ s

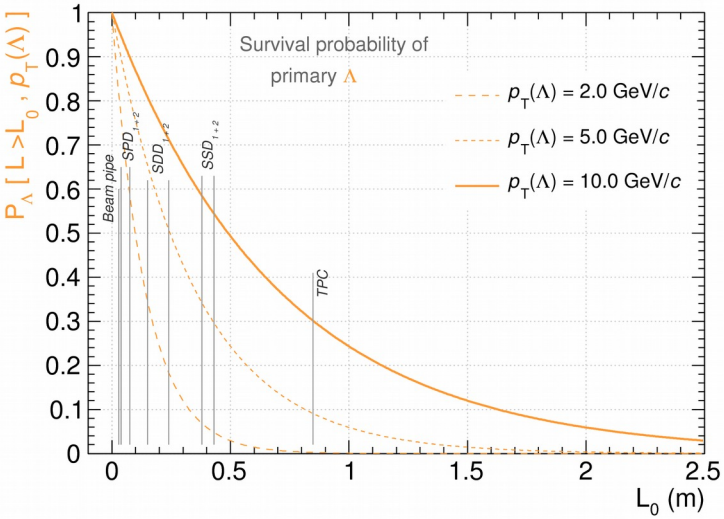
$c.\tau\ (\Lambda) = 7{,}89$ cm

Decay channel in use :

$\Lambda \longrightarrow p^+ \pi^-$ (B.R. = 63,9 %)





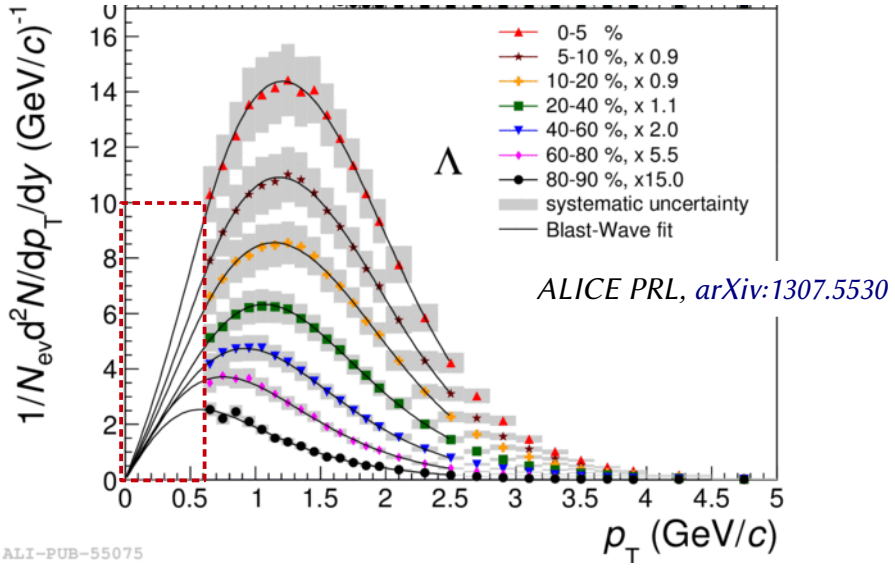


V.2 – Λ baryon : M2 internship, setting the ground

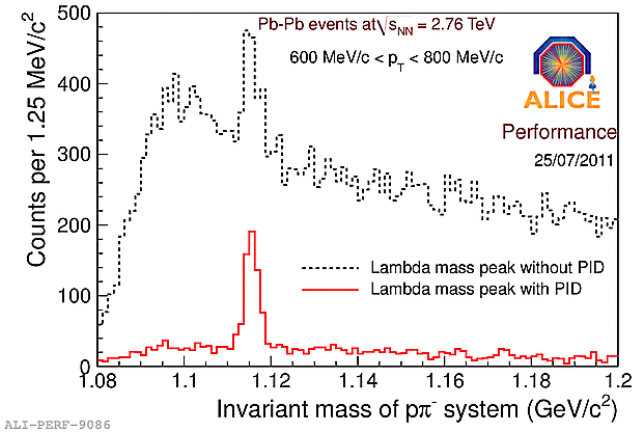
Main idea : reconstruction and signal extraction of Λ, $\bar{\Lambda}$ at <u>*low p_T (p_T < 0,4-0,6 GeV/c)*</u>

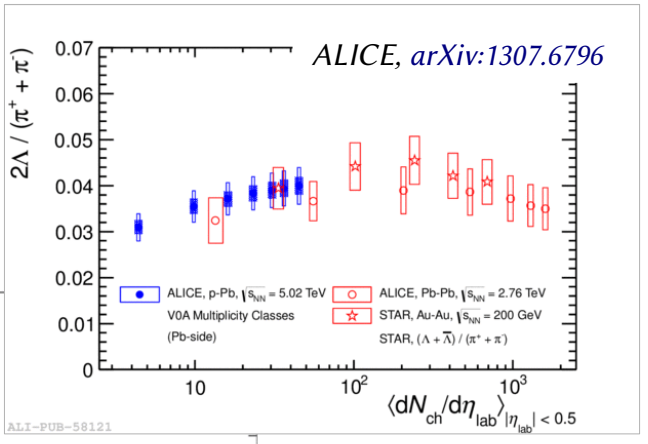
<u>Basic incentives :</u>

Less <u>extrapolation</u> at low p_T → reduction of uncertainties on integrated yield per event, d*N*/d*y*

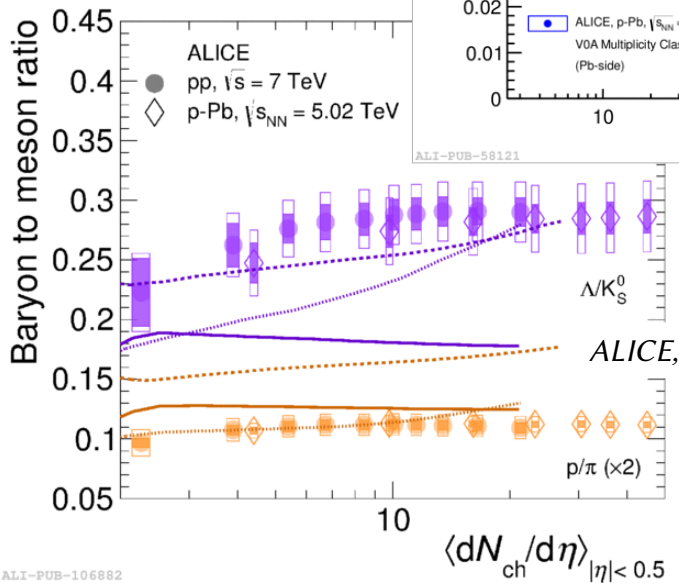


ALICE PRL, arXiv:1307.5530





ALICE, arXiv:1307.6796



ALICE, arXiv:1606.07424

V.2 – Λ baryon : M2 internship, setting the ground

Main idea : reconstruction and signal extraction of Λ, $\overline{\Lambda}$ at *low p_T (p_T < 0,4-0,6 GeV/c)*

Data set : run II, pp at √s = 13 TeV (2015 and/or 2016)
NB : ∃ low-B field runs (B = 0,2 T instead of B = 0,5 T)

Timeline : Mar 2016 – June 2016 + (July 2016 – September 2016)

Milestones :

1. getting familiar with the analysis framework (Grid, C++)
2. reconstruction and signal extraction
3. cross-check overlap with existing analyses
   (pp 13 TeV, Min Bias or High Mult)
4. possible extensions :
   - *4.1.a)* signal = f(low p_T) in *Pb-Pb 2015, p-Pb 2016*
   - *4.1.b)* signal = f(p_T, *multiplicity*) in pp
   - *4.1.c)* signal = f(*high* p_T) i.e. p_T > 8-10 GeV/*c*

   4.2 Modelling : Λ production as seen in *Statistical Hadronisation Model*

Keywords :

low p_T tracking, multiple scattering, topological reconstruction, Signal extraction, systematic uncertainties

VI.1 – PhD proposal : Oct. 2017 – Sept. 2020

Internship thought to *set the ground for a* PhD proposal...

Study of the bulk production in high-multiplicity data of LHC run II with the ALICE *detector*

= K^0s, Λ, Ξ, Ω hadrons as entry point ...

⟶ differential analysis of production rates (f[p_T, system, *event activity*, ...])

⟶ new $\sqrt{s_{NN}}$ + larger data sets

- Since Apr. 2015 ⟶ pp, $\sqrt{s}$ = 13 TeV (was 7 and 8 TeV in run I)
  NB : low B-field or High Multiplicity triggers
- Dec. 2015 ⟶ Pb-Pb, $\sqrt{s_{NN}}$ = 5.02 TeV (was 2.76 TeV in run I)
- Dec. 2016 ⟶ p-Pb, $\sqrt{s_{NN}}$ = 5.02 + 8 TeV (was 5.02 TeV in run I)

Incentives :

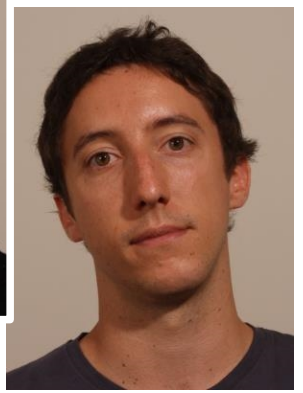
strong interaction; collective phenomena and hadronisation in the different systems

VII.1 – ALICE team at IPHC: building 20, 1st floor

Yves Schutz (DR)

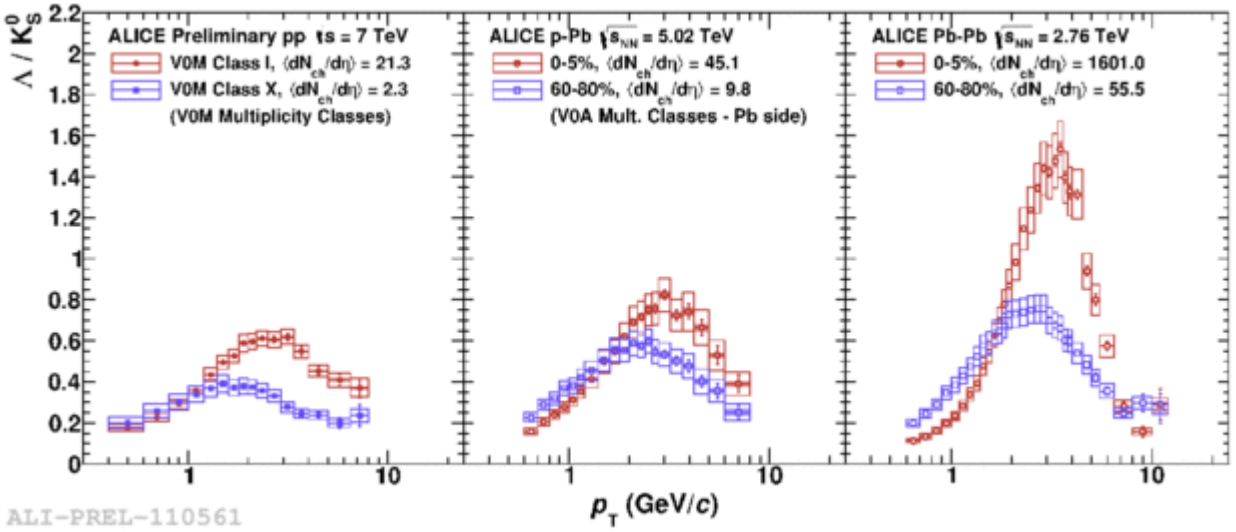
Fouad Rami (CR)

Sergey Seniukov
(Post-doc)

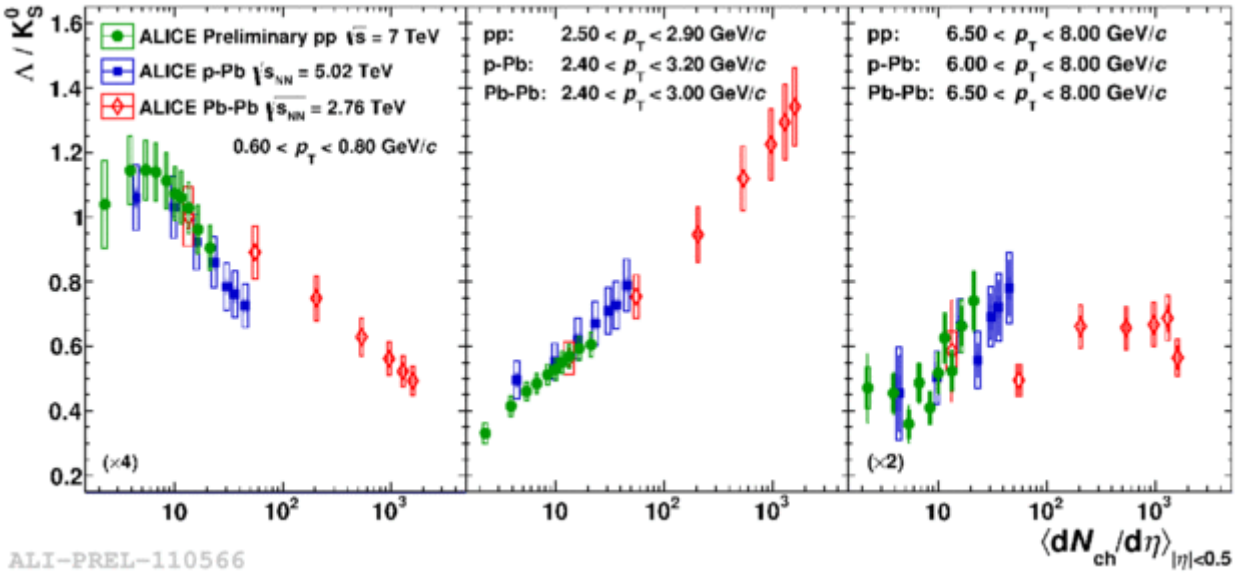


Julien Hamon
(PhD student)

A.1 – Λ/K0s ratio : in various systems



ALI-PREL-110561



ALI-PREL-110566

B.1 – Run-II data : low B-field runs

Highlight : low B field for L3 = 0.2 T, in pp 13 TeV !

- *In LHC15g*, 10 runs : *B*(L3)=0.2 T / 50-ns filling scheme / with ITS, TPC on

  e.g. 7h-long run 229245 : **23.10⁶** evts reco ⟶ 13.10⁶ after physics sel° + events cuts
  Comparison γ conversion : run 229245 (0.2 T) vs LHC15f (0.5 T)
  - reco π^0/evt : ~2x more at 1 GeV/c / ~14x more at 0.5 GeV/c
  - reco η/evt : ~2x more at 1 GeV/c (large p_T bin, too limited stat to properly conclude)

- *In LHC16f, 19 runs : B*(L3)=0.2 T / 25-ns filling scheme

  > 20x10⁶ MB already taken in low *B*(L3)
  period stopped because of disk space usage (cf. HLT mode B still ongoing + RCU2)
  ⟶ further data taking postponed later this year, for the time being.

HMTF, May 19th 2016, Indico:532704 (Ana Marin)
Low-mass dielectron, May 19th Indico:489908

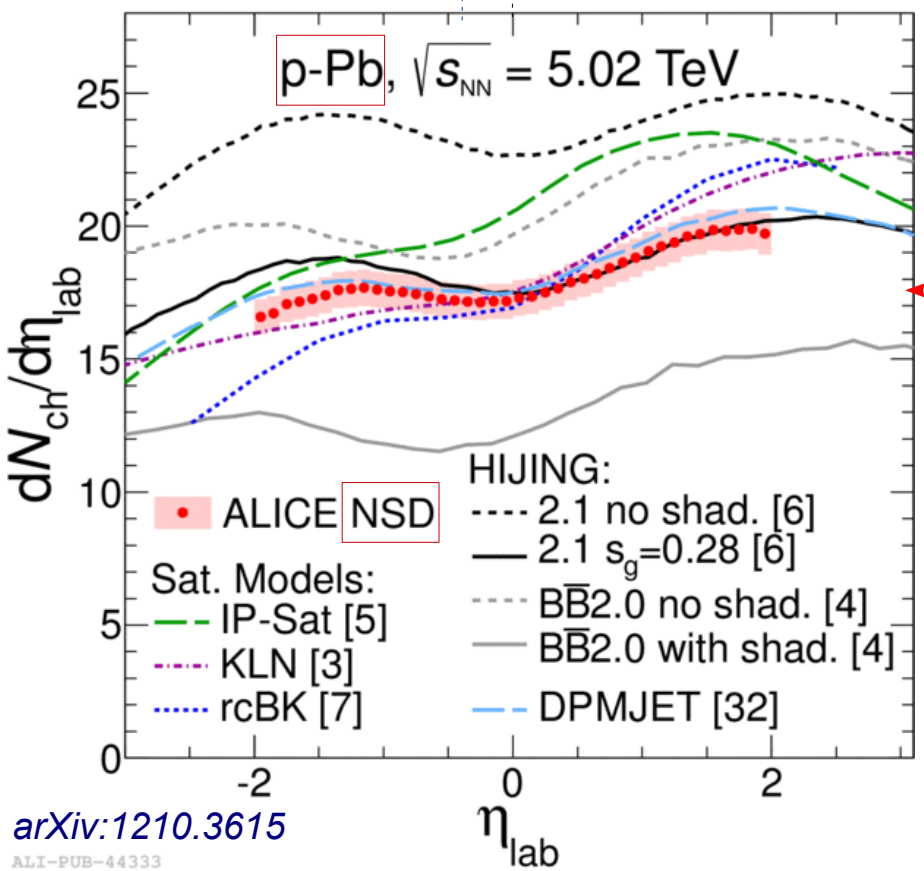
C.1 – pp, pA, AA : $dN_{ch}/d\eta = f(\eta_{LAB})$

Center-of-mass system moved by $\Delta y_{NN} = 0.465$

Pb → E_{beam} = 1.58 TeV

← p E_{beam} = 4 TeV

C side A side



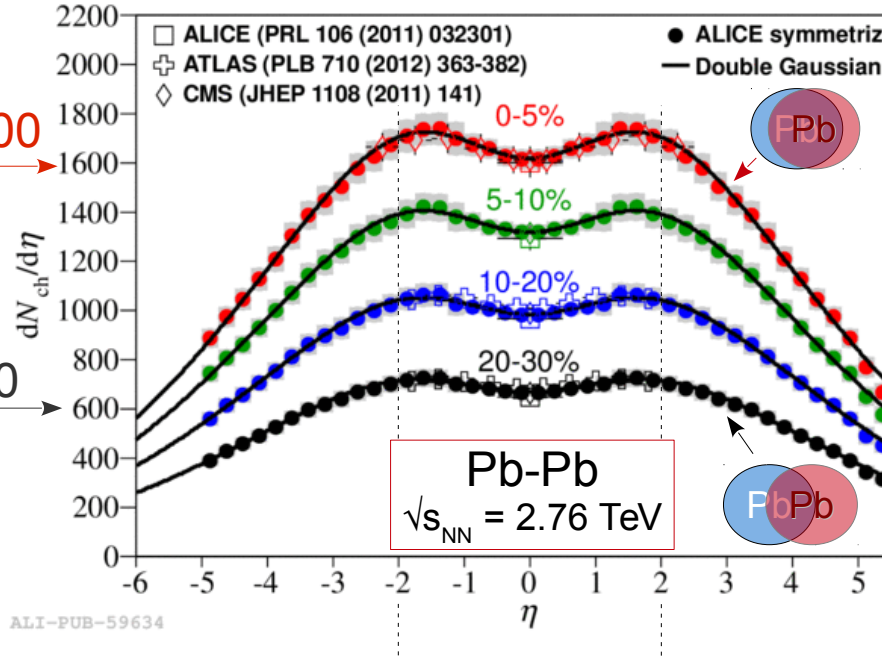
arXiv:1210.3615

ALI-PUB-44333

$dN_{ch}/d\eta \approx 1600$ in 0-5%

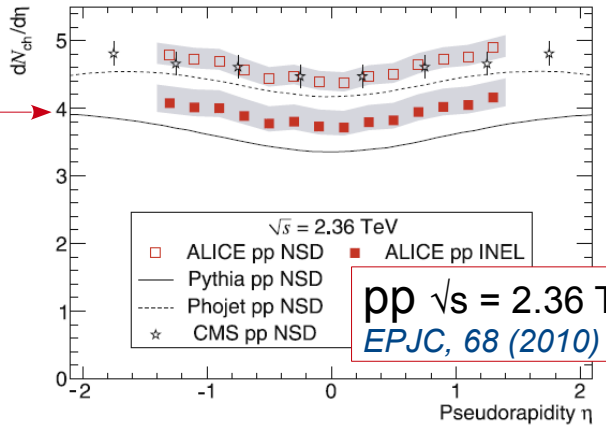
$dN_{ch}/d\eta \approx 600$ in 20-30%

arXiv:1304.0347



$dN_{ch}/d\eta_{lab} \approx 17$

$dN_{ch}/d\eta \approx 4$



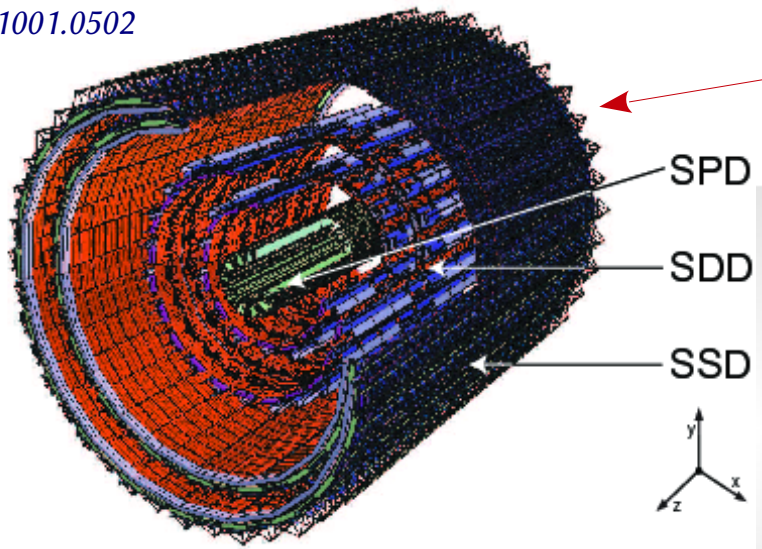
pp $\sqrt{s}$ = 2.36 TeV

EPJC, 68 (2010) 89-108

D.1 – ALICE : ITS upgrade, 2013 vs. 2018

arXiv:1001.0502

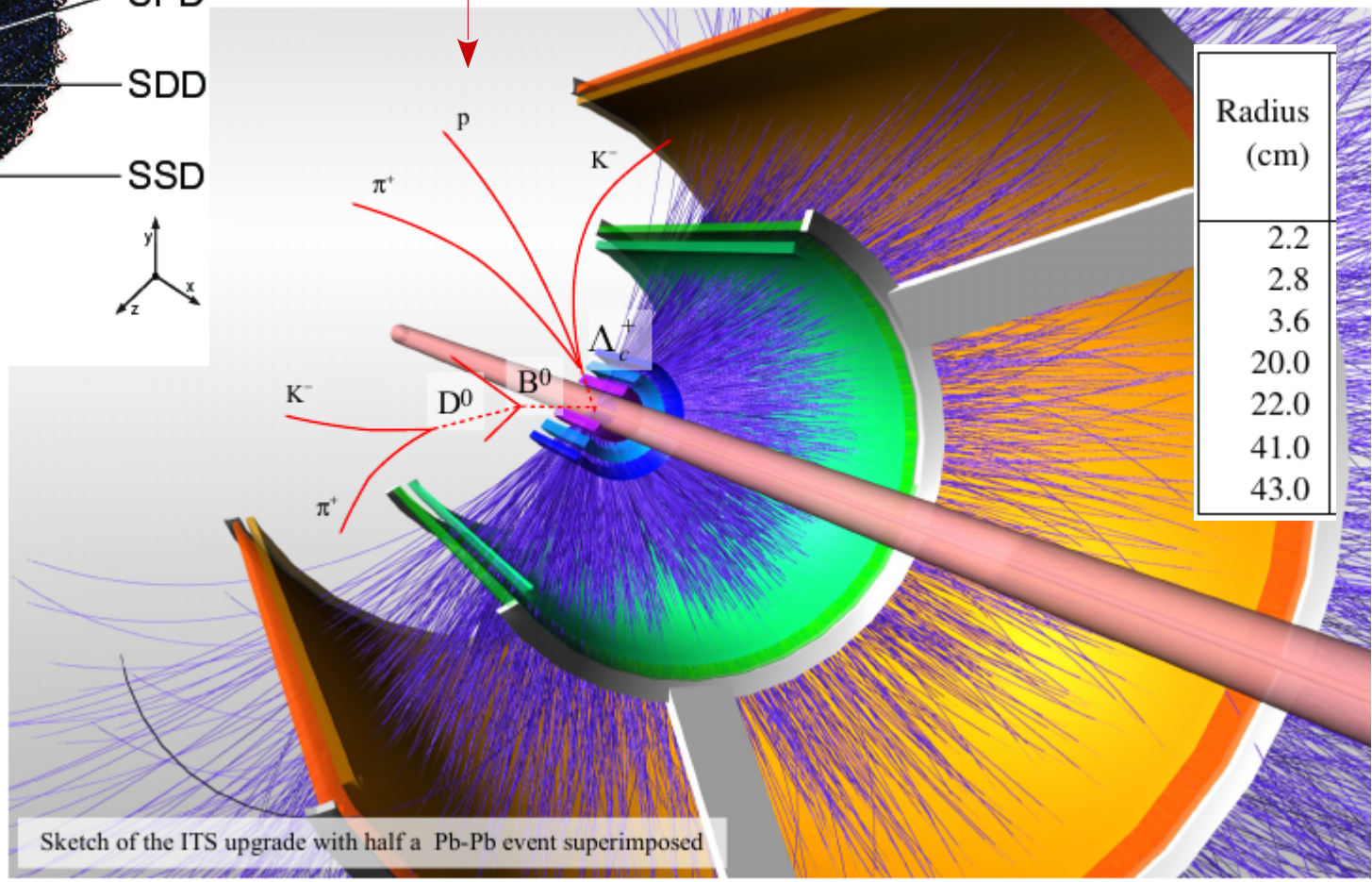
r [cm]
3.9
7.6
15.0
23.9
38.0
43.0



• Current ITS

• Upgraded ITS

CDS: LoI ALICE upgrade



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

YouTube Video

Upgrade keywords :

- LHC Run III, >2019
- 7 pixel layers
- high granularity
- 50-kHz readout

- Pb-Pb, $\sqrt{s_{NN}}$ = 5.52 TeV
- (heavy-)flavour physics !

→ tracking revision...

Prospectives

ALICE IPHC Strasbourg, 2017~2028