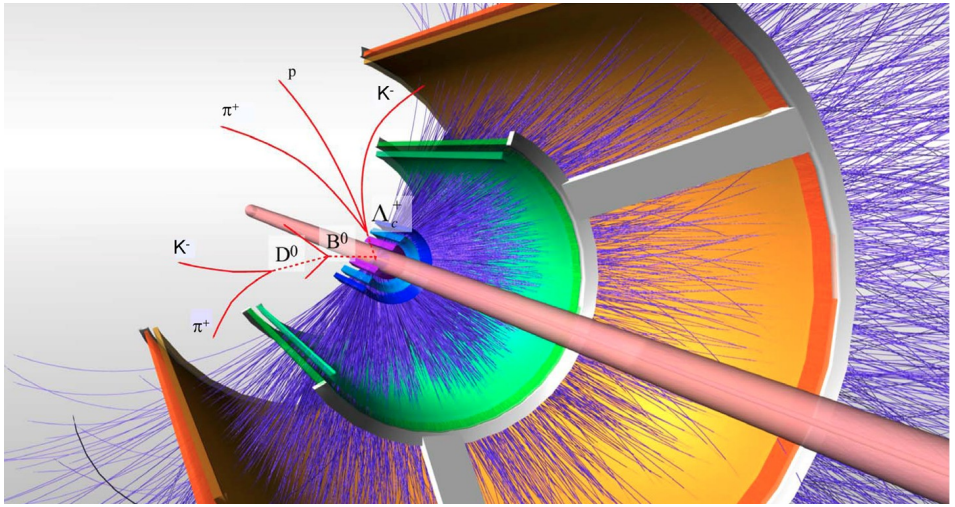
Antonin MAIRE, ALICE group – IPHC
Oct. 2020 – **Internship proposals**
Indico.in2p3:22360

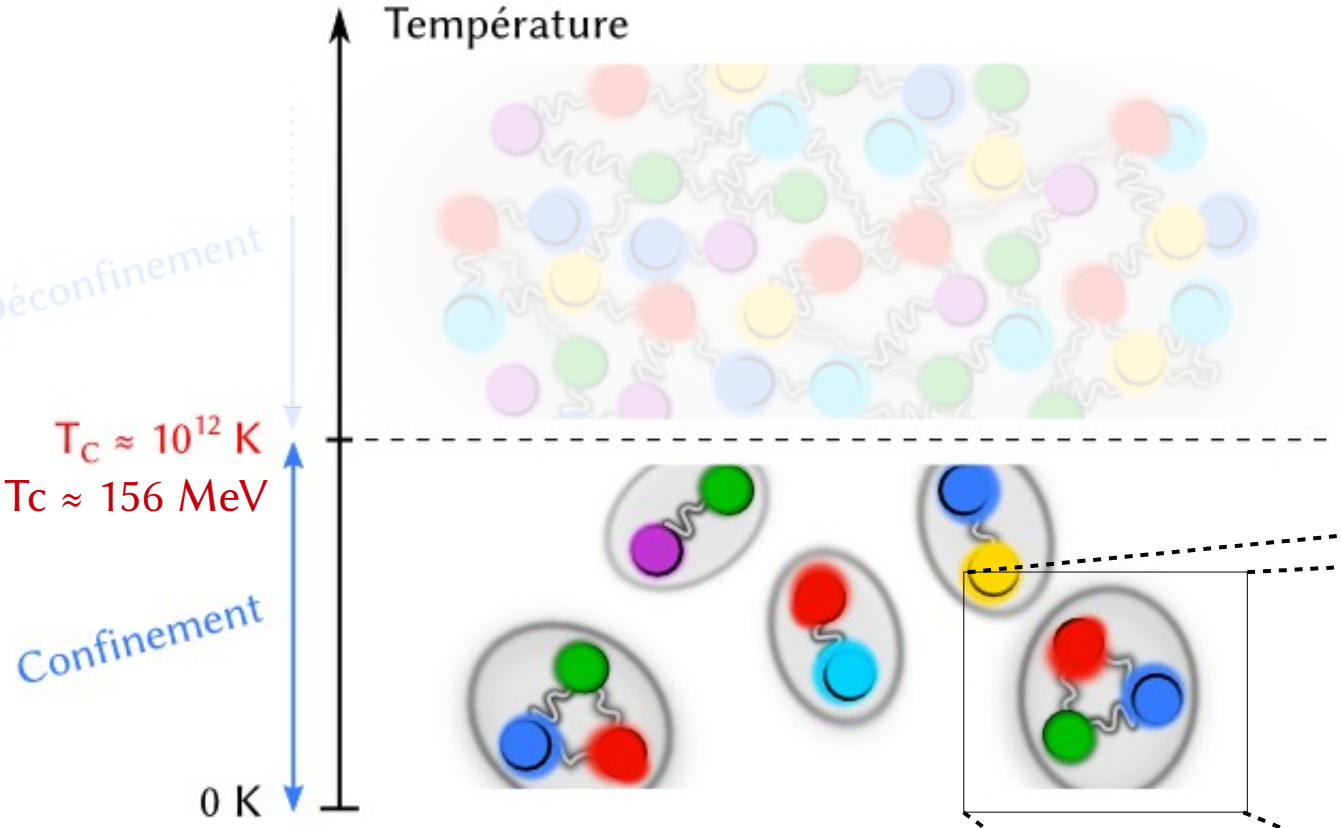


ALICE group :

QCD, Quark-Gluon Plasma
Strangeness, charm
Pixel trackers
LHC pp, p-Pb, Pb-Pb

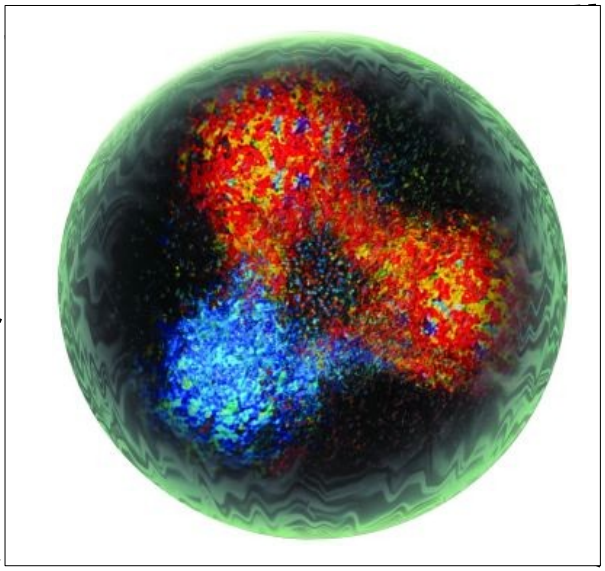
Institut Pluridisciplinaire Hubert CURIEN STRASBOURG

I.1 – Introduction : QCD phase transition



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

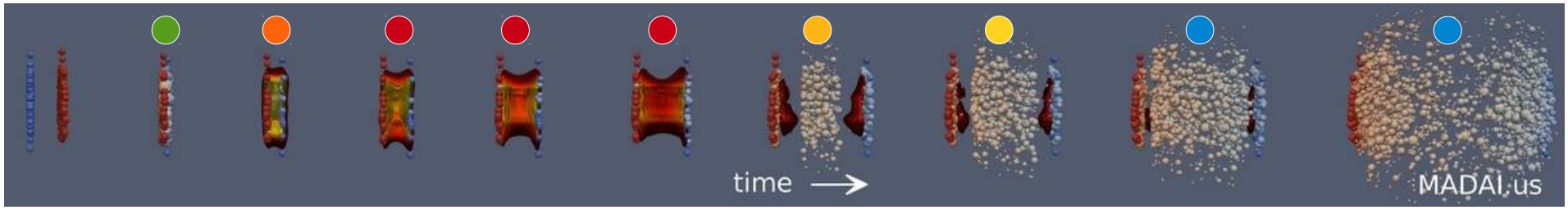
Parton Distribution Function

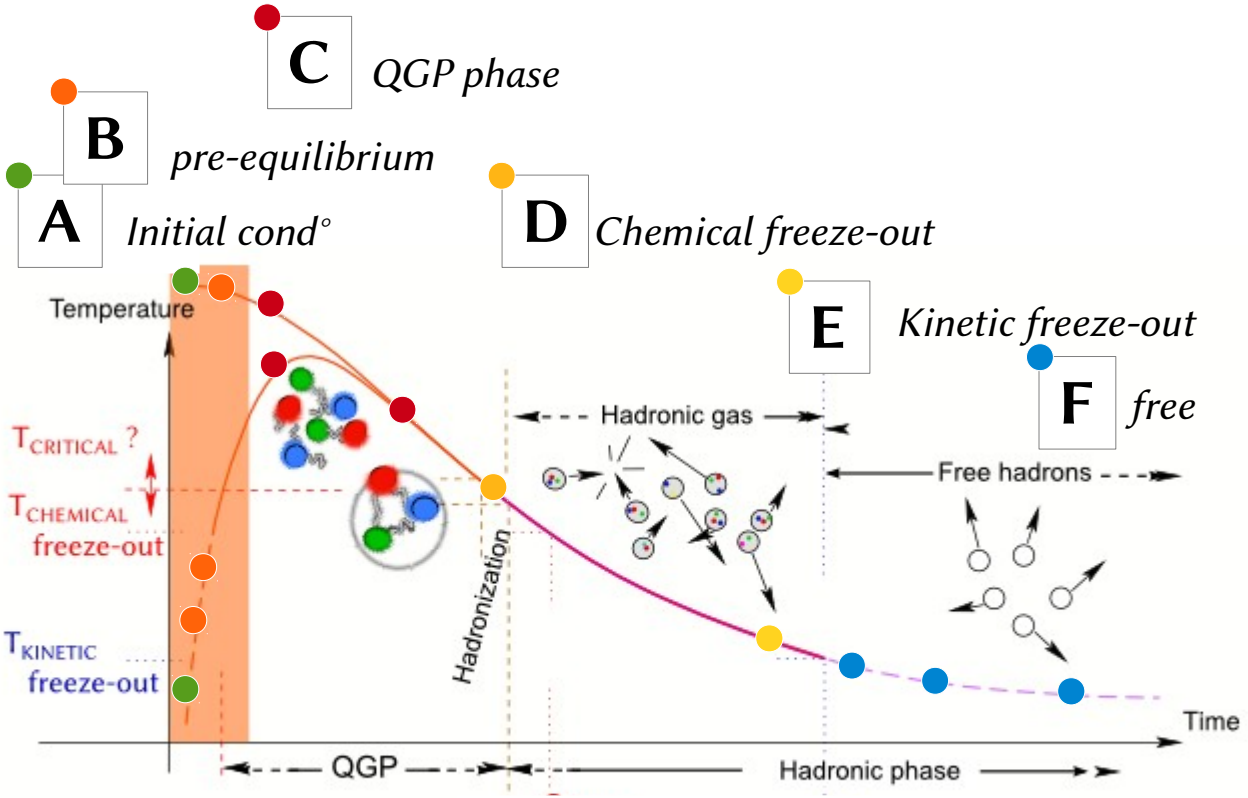


DOI : 10.1103/PhysRevD.27.140

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

Courtesy of MADAI.us (see animation movie !)

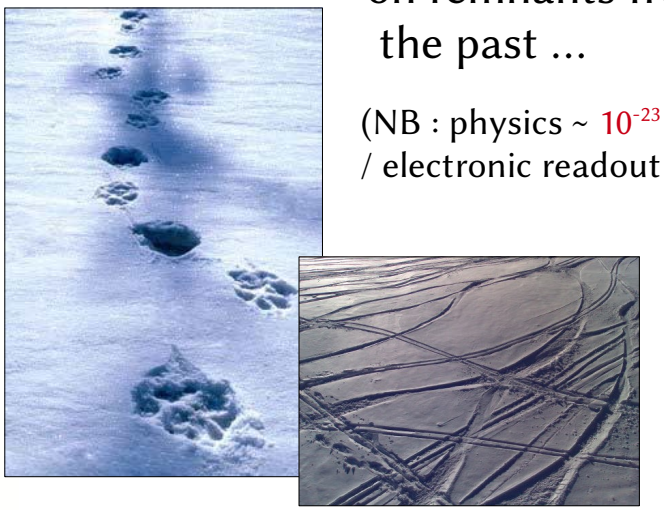




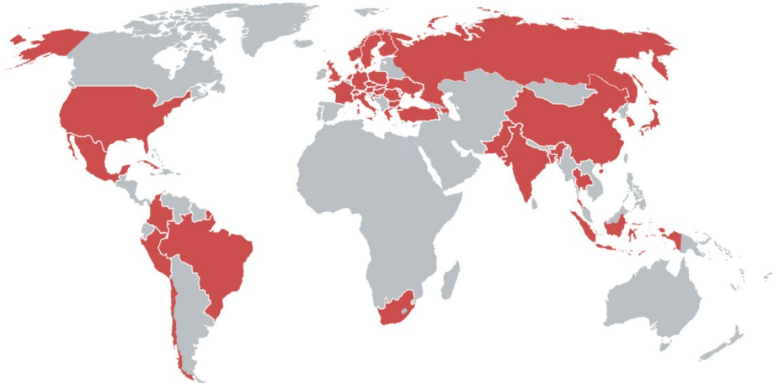
→ Remark :

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

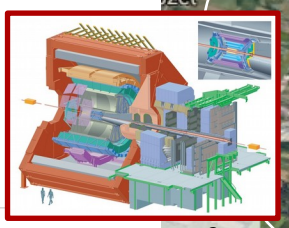
(NB : physics ~ 10^{-23} s / electronic readout > 10^{-12} s)



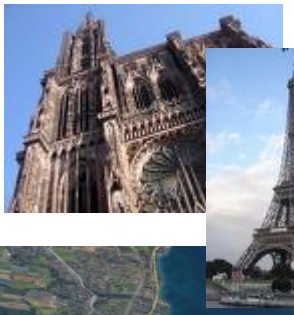
II.1 – ALICE : the experiment and the collaboration

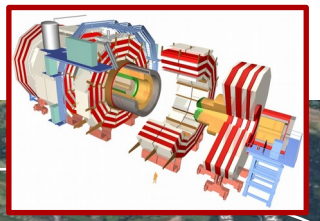


36 countries
147 institutes
≈2.8 x10^3 members
(1997-2019)
≈ 811 authors
(2019)

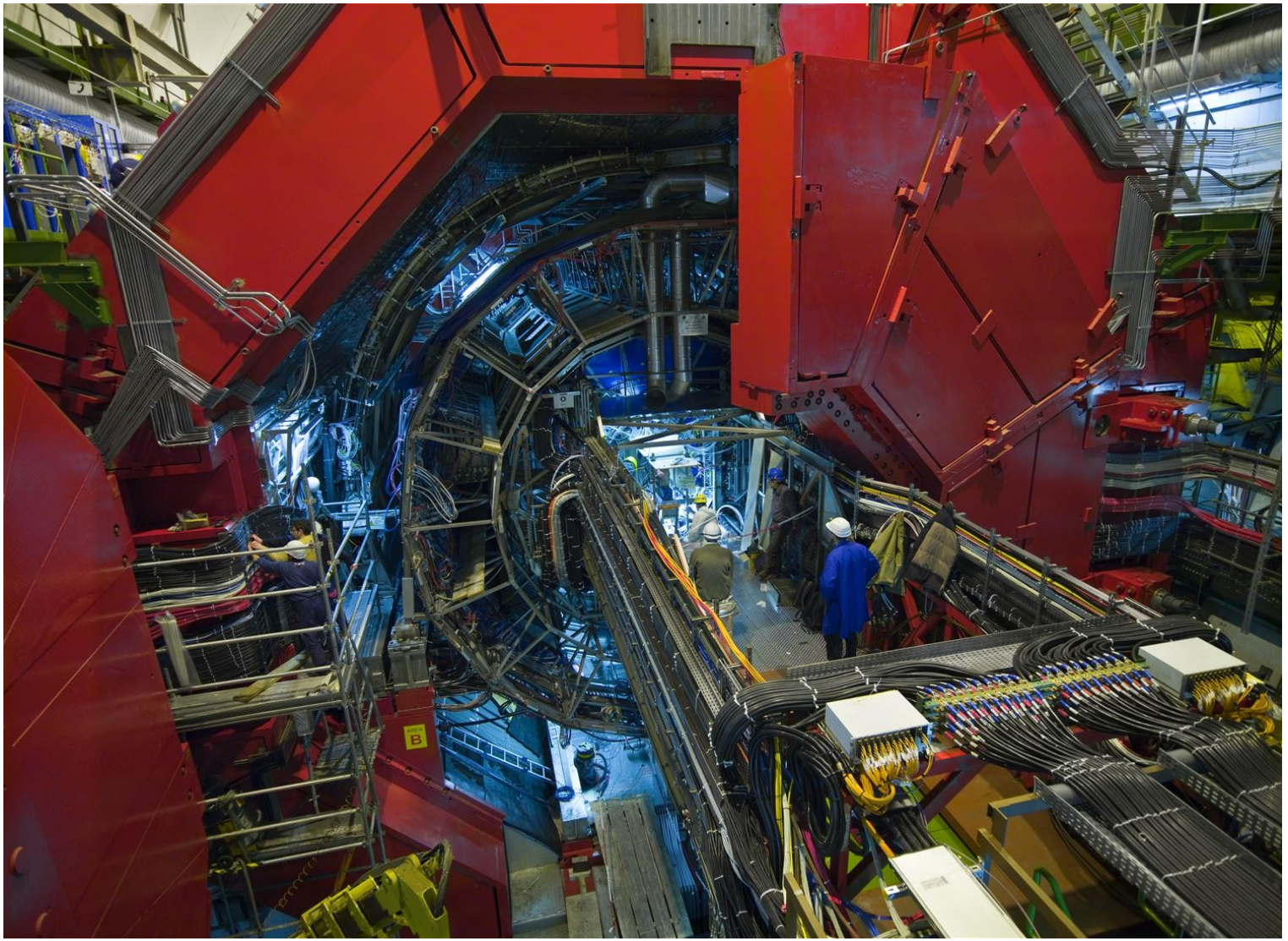


Dim : 16 x 16 x 26 m^3
Mass : 10 000 t
Costs : 80 M€



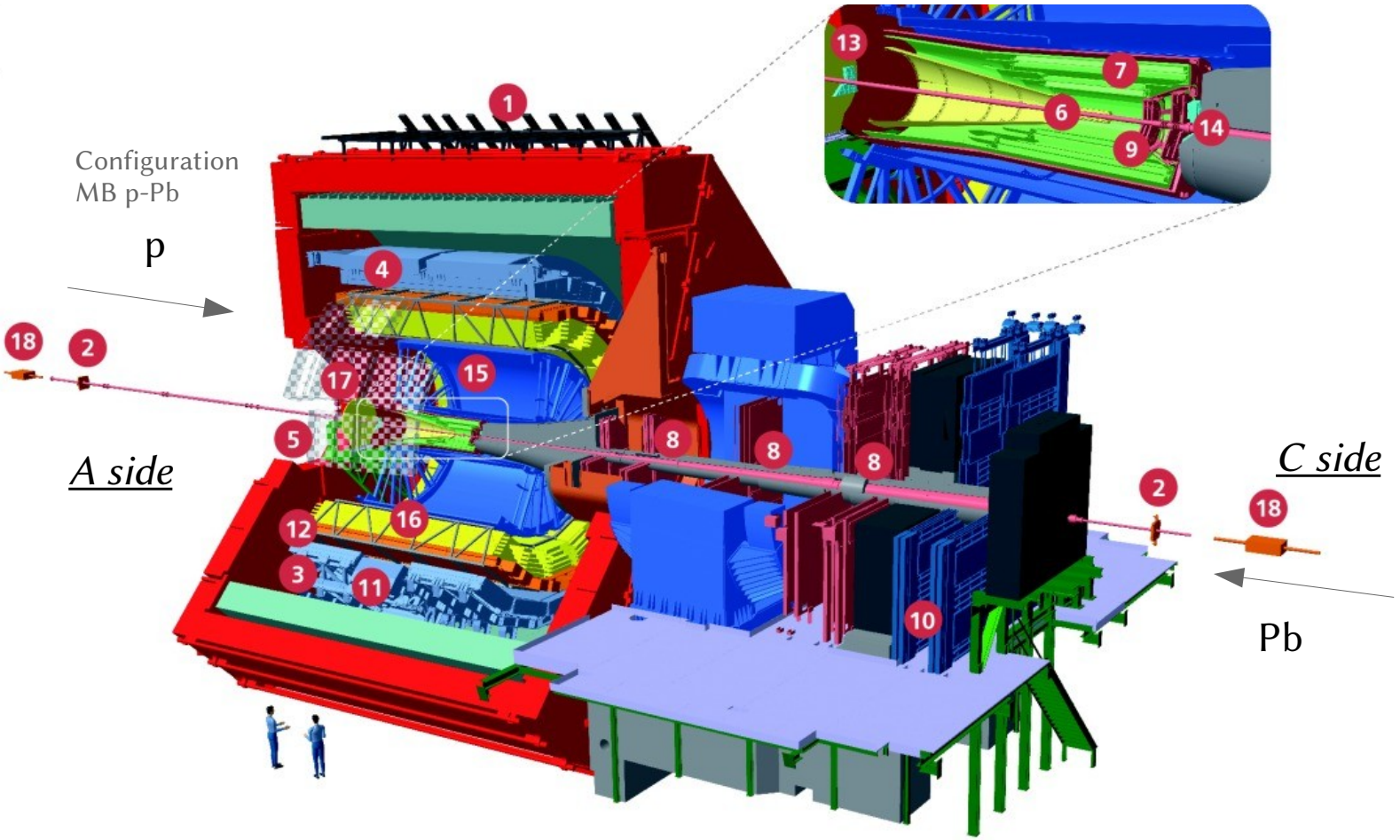


II.2 – ALICE : 19 sub-detectors



Here 2008, as before start of LHC run I

II.3 – ALICE : detector in LHC run III (2022-24), sketch



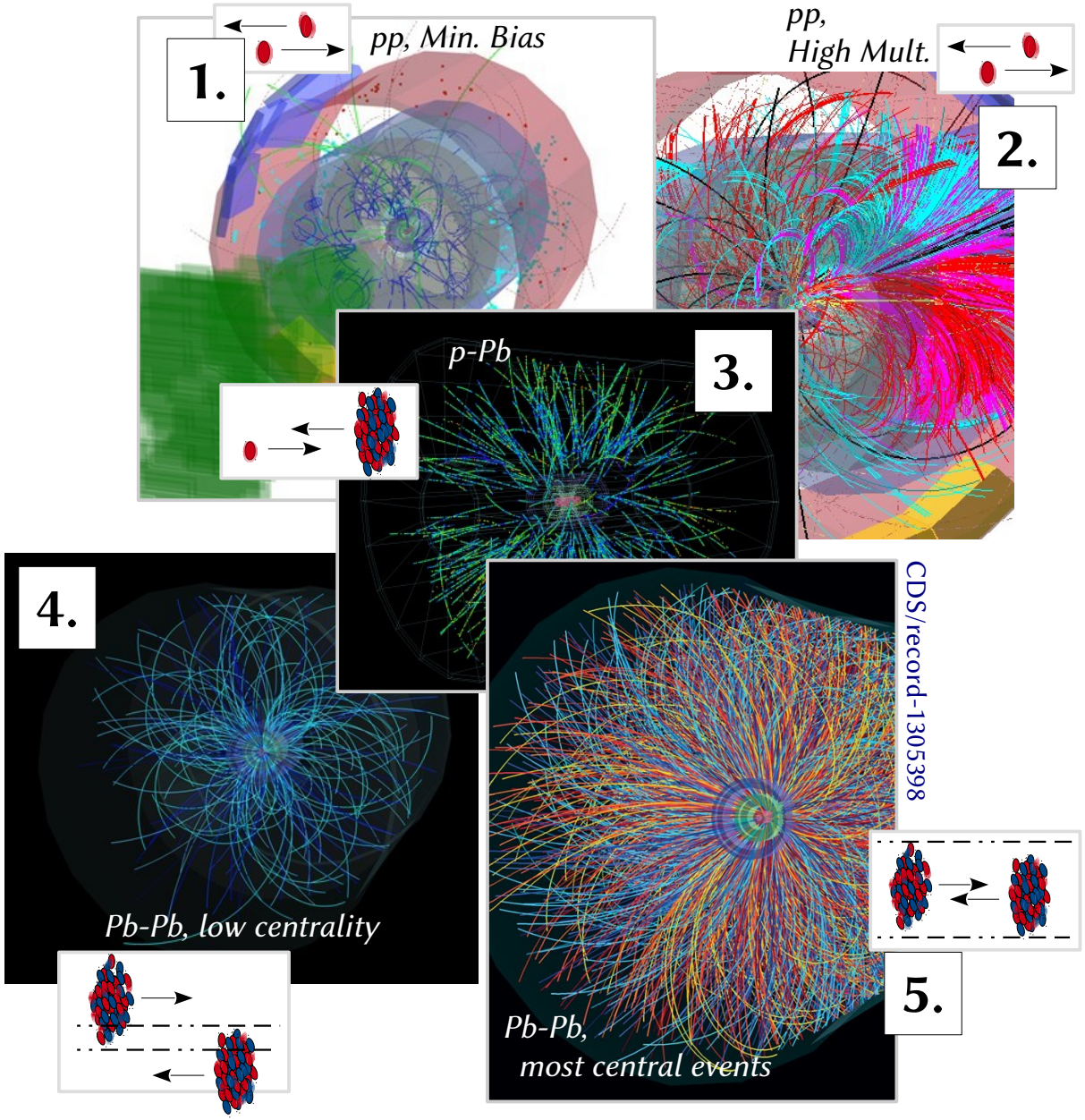
1 **ACORDE** | ALICE Cosmic Rays Detector
2 **AD** | ALICE Diffractive Detector
3 **DCal** | Di-jet Calorimeter
4 **EMCal** | Electromagnetic Calorimeter
5 **HMPID** | High Momentum Particle Identification Detector
6 **ITS-IB** | Inner Tracking System - Inner Barrel
7 **ITS-OB** | Inner Tracking System - Outer Barrel
8 **MCH** | Muon Tracking Chambers
9 **MFT** | Muon Forward Tracker
10 **MID** | Muon Identifier
11 **PHOS / CPV** | Photon Spectrometer
12 **TOF** | Time Of Flight
13 **T0+A** | Tzero + A
14 **T0+C** | Tzero + C
15 **TPC** | Time Projection Chamber
16 **TRD** | Transition Radiation Detector
17 **V0+** | Vzero + Detector
18 **ZDC** | Zero Degree Calorimeter

Main specificities :

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

Configuration
MB p-Pb

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



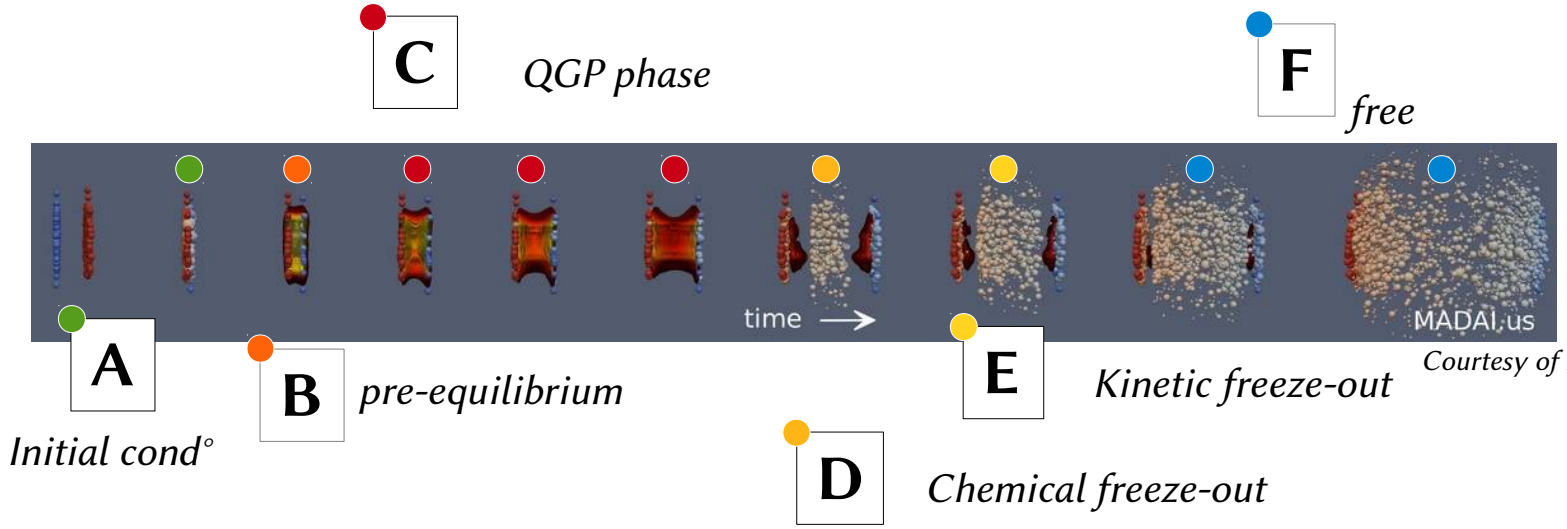
The starting plain question may be :
at the same $\sqrt{s_{NN}}$,

“ 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



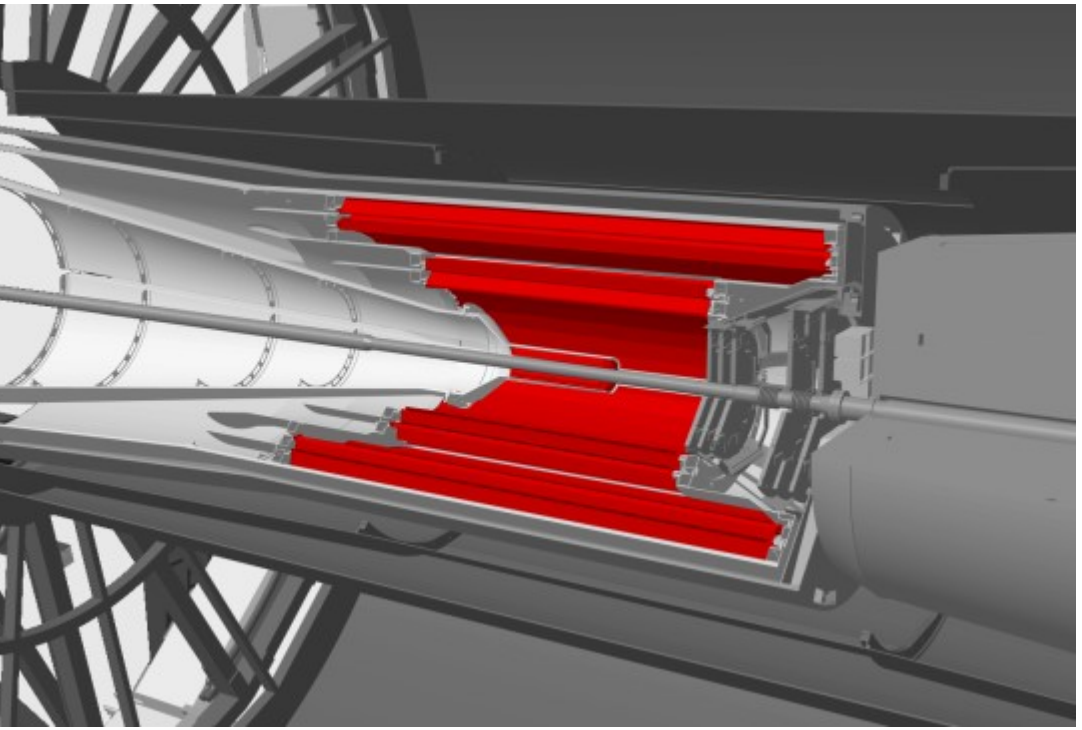
Courtesy of MADAI.us

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

V.1 – ITS upgrade : ITS-2, design and layout

See TDR ITS-2, *CERN-LHCC-2013-024*



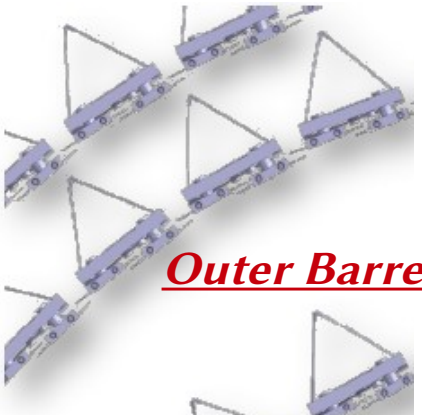
η coverage: $|\eta|<1.22$ (for 90% of luminous region)
R coverage: 22 – 400 mm

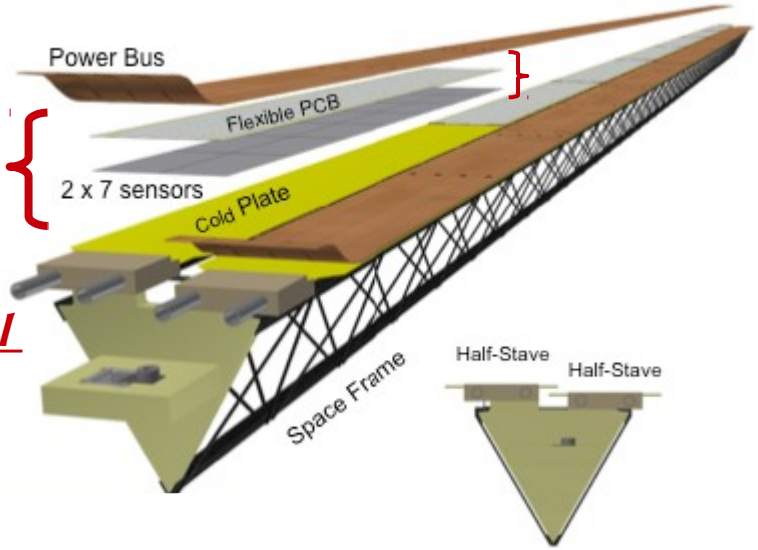
12.6×10^9 pixel camera
≈ 10 m² of Si, ≈ 12.8×10^6 CHF

7 layers of MAPS (Monolithic Active Pixel Sensor)
= *ALPIDE* CMOS chips

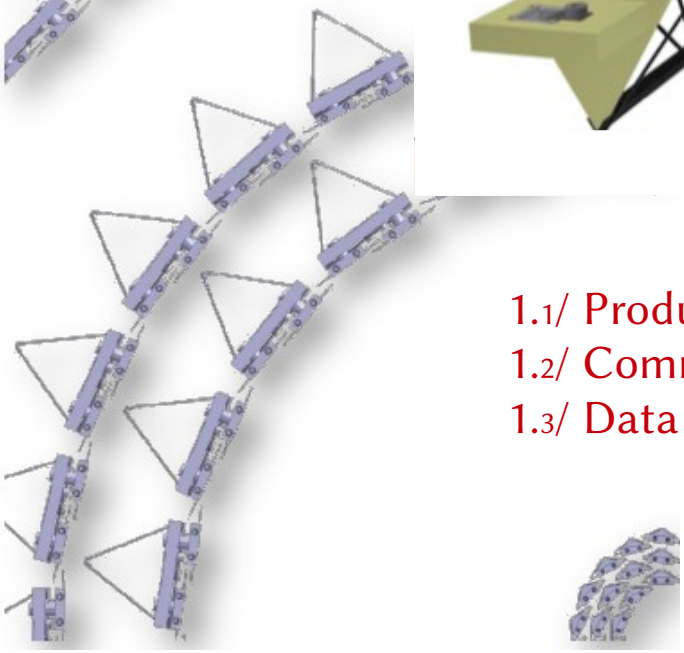
ALPIDE
- Space point resolution: ~5 µm
- Time resolution: ~2 µs
- Continuous readout

V.2 – ITS upgrade : 1. hardware

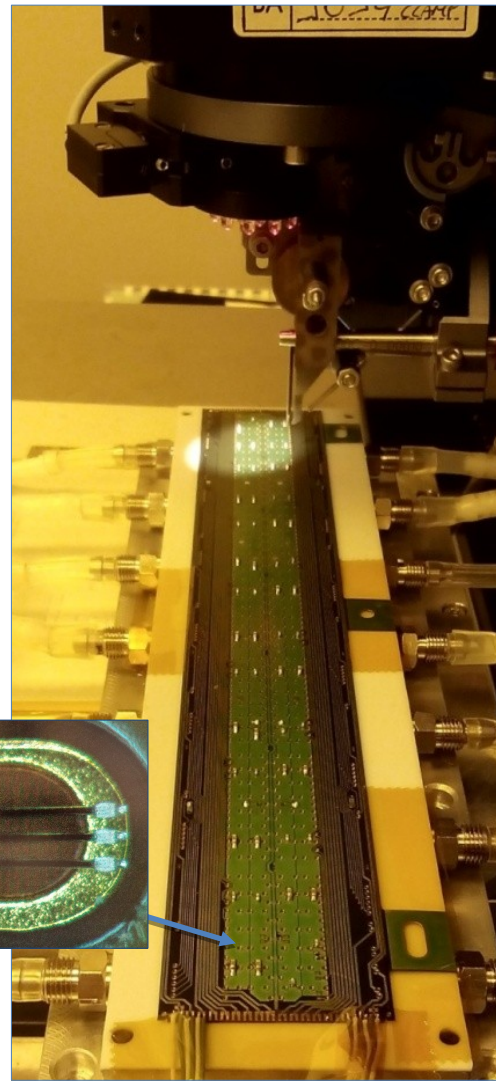


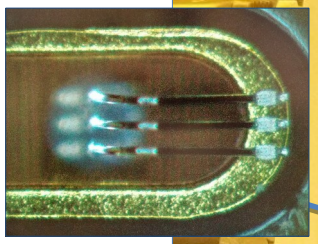


Outer Barrel



1.1/ Production of 585 modules (2018-2019)
1.2/ Commissioning (2019-2021)
1.3/ Data taking (2022-)

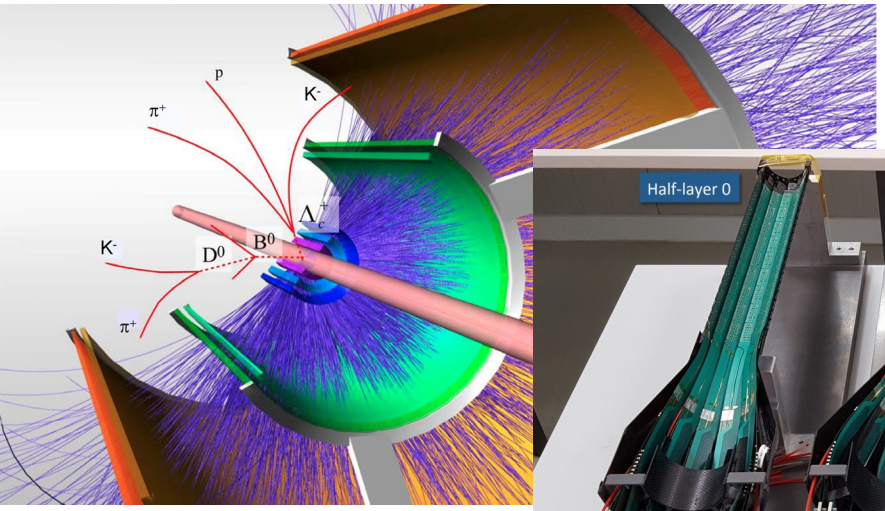




= assembly + tests of 2x7 CMOS sensors
for the 4 external layers of the ITS (out of 7 layers)
~24% of [2+2 layers = 2.3 + 6.9 m² = 25% +73% of the total active surface]

Bonding : YouTube

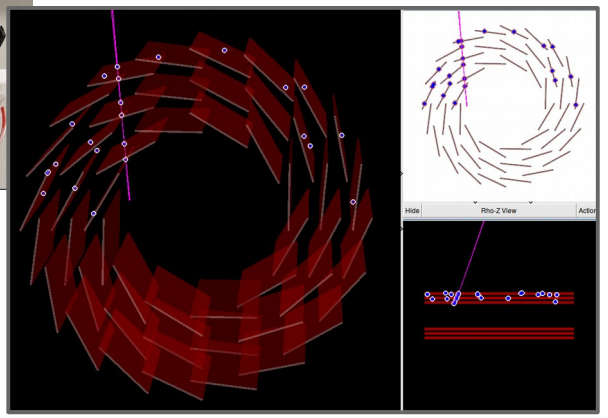
V.3 – ITS upgrade : 2. software



Main objectives :

a. ITS geometry
b. ITS simulations
c. ITS reconstruction
(tracking + vertexing algorithms)

→ *from detector response to physics performances*



Current businesses :

- Cosmic data taking and reconstruction and commissionning
- Event reconstruction :
  - Parallel algorithm (GPU, Xeon Phi, FPGA) : Cellular automaton, Kalman smoother, ... → C++17 as basis
  - Issue of fake track at low p_T
- Calibration (dead/noisy pixels / topologies of hit clusters)
- Quality Control & event display

- O² devices (online/offline combined treatment)
- Geant4 multi-threaded simulation

VI.1 – Flavours : extend (*u,d,**s***) to (***c***,*b*)

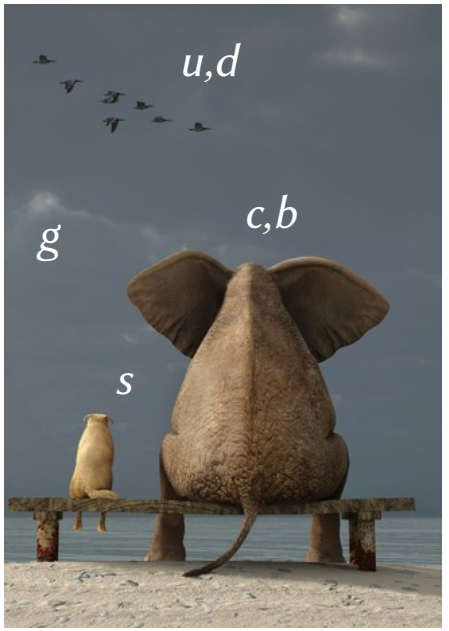
- **Strangeness** (u,d +s) // **Open charm** (u,d,s +c)

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

  - production cross-sections ($d^2N/dp_T dy$, R_{AA}, particle ratios)
  - hadronisation mechanisms (angular correlations),
  - thermalisation, hydrodynamisation (radial flow, v_n)

  ... in various systems :

  - pp Min. Bias
  - pp High Multiplicity
  - p-Pb
  - Pb-Pb



Local expertise : **topological hadronic reconstruction**

= unstable (rather) long-lived particles

Strangeness : $c\tau \approx \mathcal{O}(5\ \text{cm})$

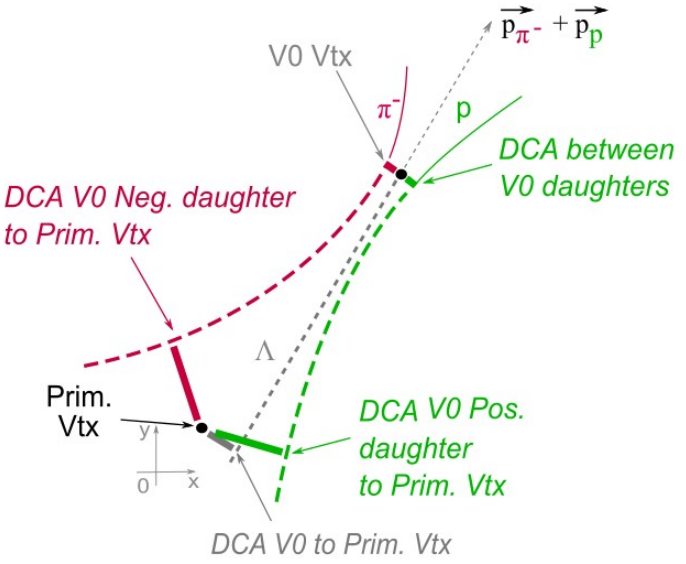
Charm : $c\tau \approx \mathcal{O}(10^2\ \mu\text{m})$

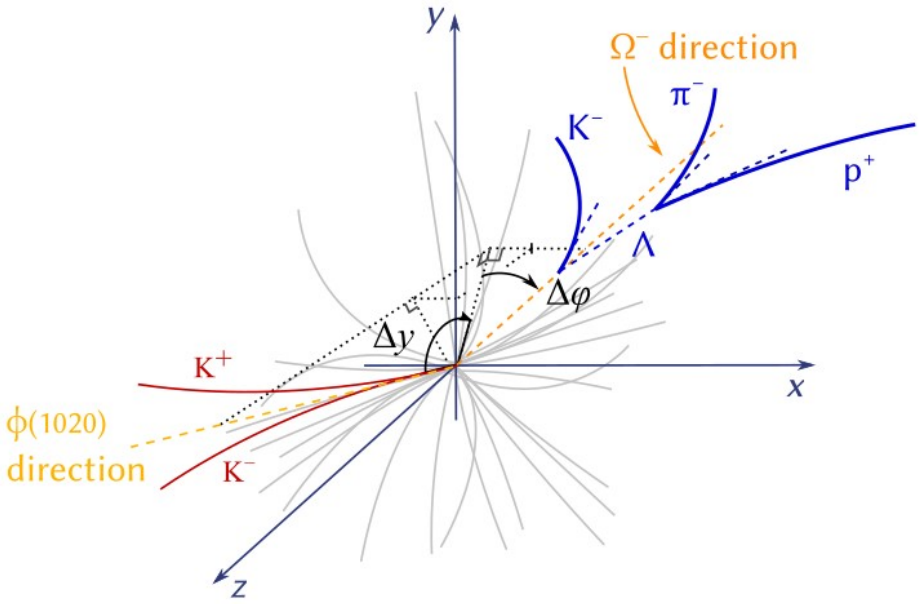
VI.2 – Flavours : PhD proposal 1 (2021-24) – strangeness = f(dN_{ch}/dη)

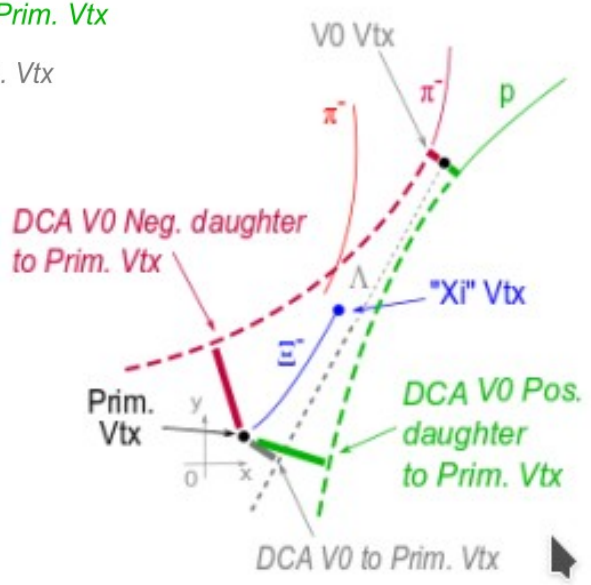
PDGlive.lbl.gov

Correlated production :

$\phi(1020) \longrightarrow K^+K^-$ + $K^0s(d\bar{s}) \longrightarrow \pi^+\pi^-$
or $\Lambda(uds) \longrightarrow p\pi^-$
or $\Xi^-(dss) \longrightarrow \Lambda\pi^-$
or $\Omega^-(sss) \longrightarrow \Lambda K^-$

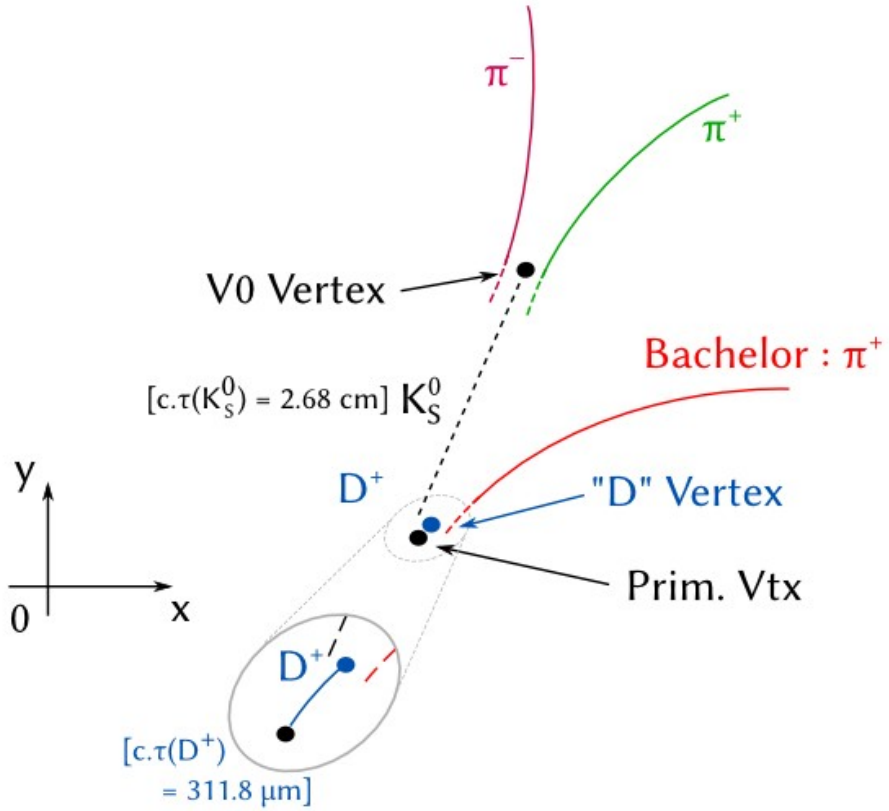






VI.3 – Flavours : PhD prop. 2 (2021-24) = charm baryons or beauty

PDGlive.lbl.gov



Charm and beauty production :

$D^0\,(c\bar{u}) \longrightarrow K^-\pi^+$,
$D_s^+(c\bar{s}) \longrightarrow \pi^+\,[\phi(1020) \longrightarrow K^+K^-]$ or K^+K^0s

$\Lambda_c^+(udc) \longrightarrow pK^0s$ or $pK^-\pi^+$ or $\Lambda\pi^+$
$\Xi_c^0(dsc) \longrightarrow \Xi^-\,\pi^+$
$\Omega_c^0(ssc) \longrightarrow \Omega^-(sss)\,\pi^+$

———

$B^0\,(d\bar{b}) \longrightarrow \overline{D}^0\,\pi^+$,
$B^+\,(u\bar{b}) \longrightarrow \overline{D}^0\,\pi^+$
$B_s^0(s\bar{b}) \longrightarrow \overline{D}_s^-\,K^+$

VI.4 – Flavours : one M2 internship (spring 21) ...

1. Participation to commissionning of the tracking of ITS-2 in the ALICE-2 experiment

Keywords : simulation, données cosmiques, fake tracks, alignment...
Supervisor : Iouri

2. Reconstruction topological reconstruction of strange baryons (Λ, Ξ, Ω) with O^2
i.e. Online-Offline software for ALICE-2 = Run III (2022-24)

Keywords : simulations + Run II (2015-18) data converted into O^2
Supervisor : Romain (Antonin)

3. Topological reconstruction of the D° mesons stemming from beauty

Keywords : non-prompt D°, with original vertex that is displaced; simulation first then real data)
Supervisors : Iouri + Christian

VI.4 – Flavours : challenges for a PhD (2021-24)

ALICE-2 challenges

Strangeness	***Heavy flavours***

1/ Run III(2022-24) data taking + simulations

2.s+c / *ITS-2 framework + reconstruction algorithms*

3/ *statistics demanding :*

→ **3.s /** *multi-differential analysis (p_T, evt mult.)*
(pp, high-mult pp run / Pb-Pb, p-O, O-O)

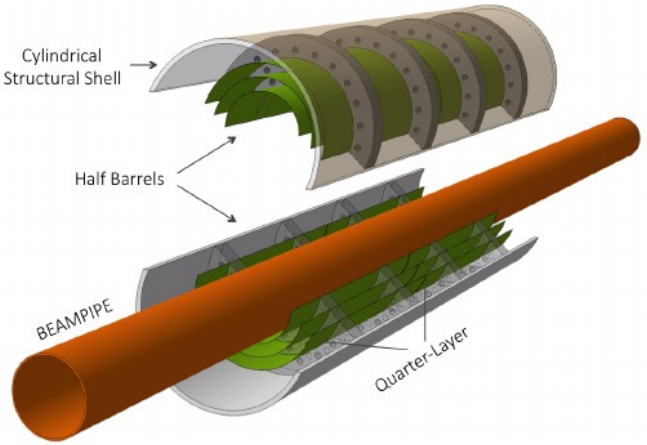
→ **3.c /** *Minimum Bias analysis*
(pp / Pb-Pb)

4.s / *low p_T reco. for hyperons (p_T < 0.8 GeV/c)*

5.s / *Theory comparison : MCnet*

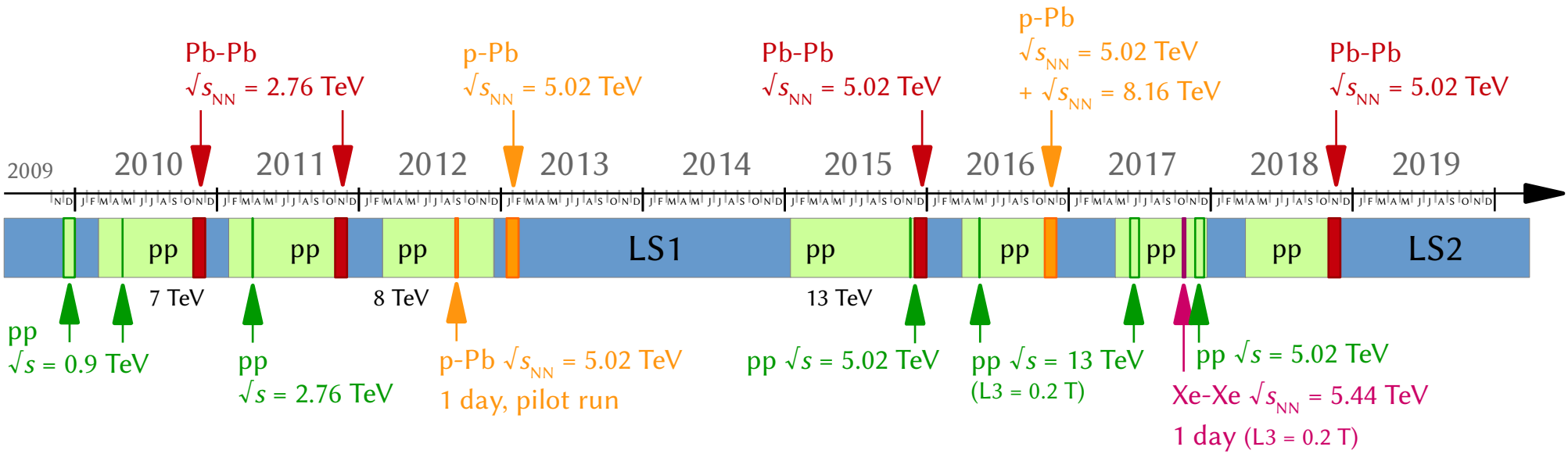
4.c / *Rare signal (rare prod, low Signal/Noise, ...)*

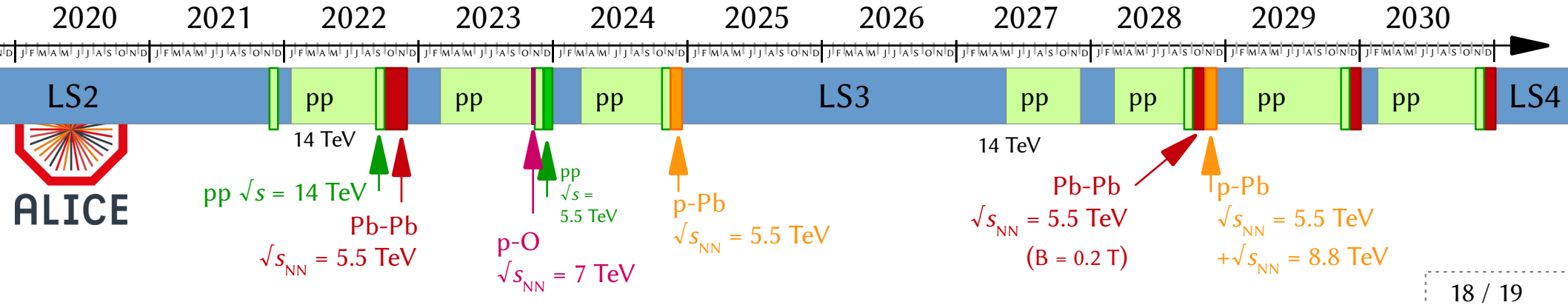
5.c / *...*



6/ Next upgrade :
ITS-3 (2027-30)

VII.1 – LHC timeline : data taking and shutdown

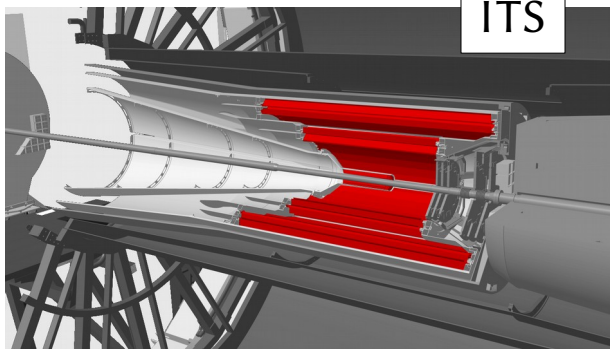


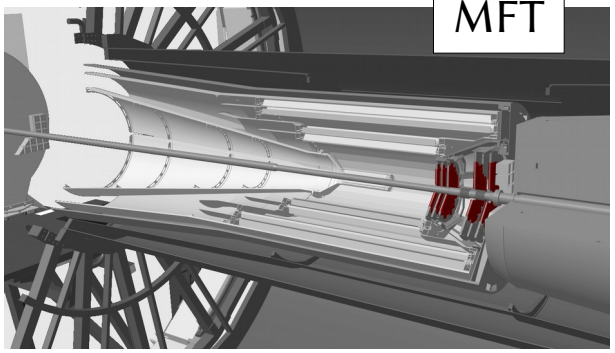


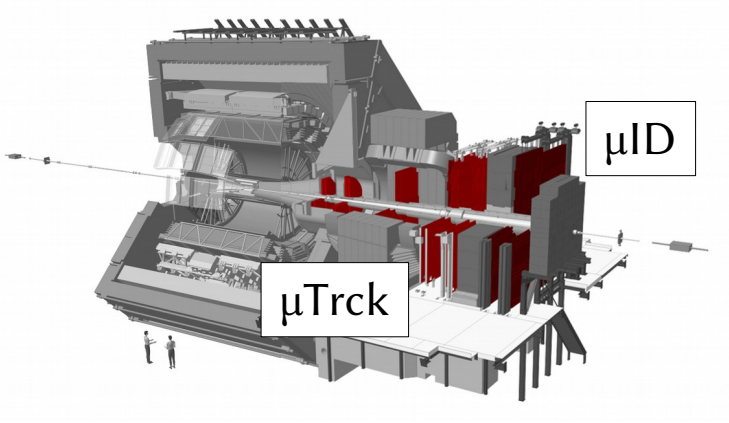
ALICE

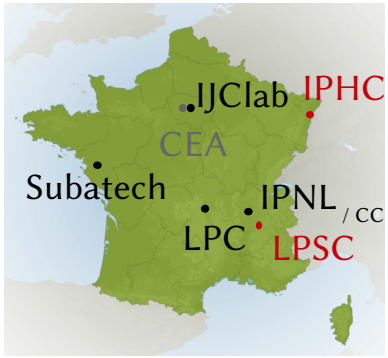
2022 : full pp year ? (pp High-mult. trigger)

VII.2 – LHC run III (2022-24): ALICE-France commitments









+ LLR Polytechnique : CMS [jets, Y(nS)]
+ LLR Polytechnique + IJCLab Orsay LHCb [SMOG, p-Pb, Heavy-flavours]

Appendices

A – Λ in various systems

B – low B-field runs

C – pp, p-Pb, Pb-Pb multiplicities

D – ALICE tracker upgrade