Alice
l'esperimento e la fisica

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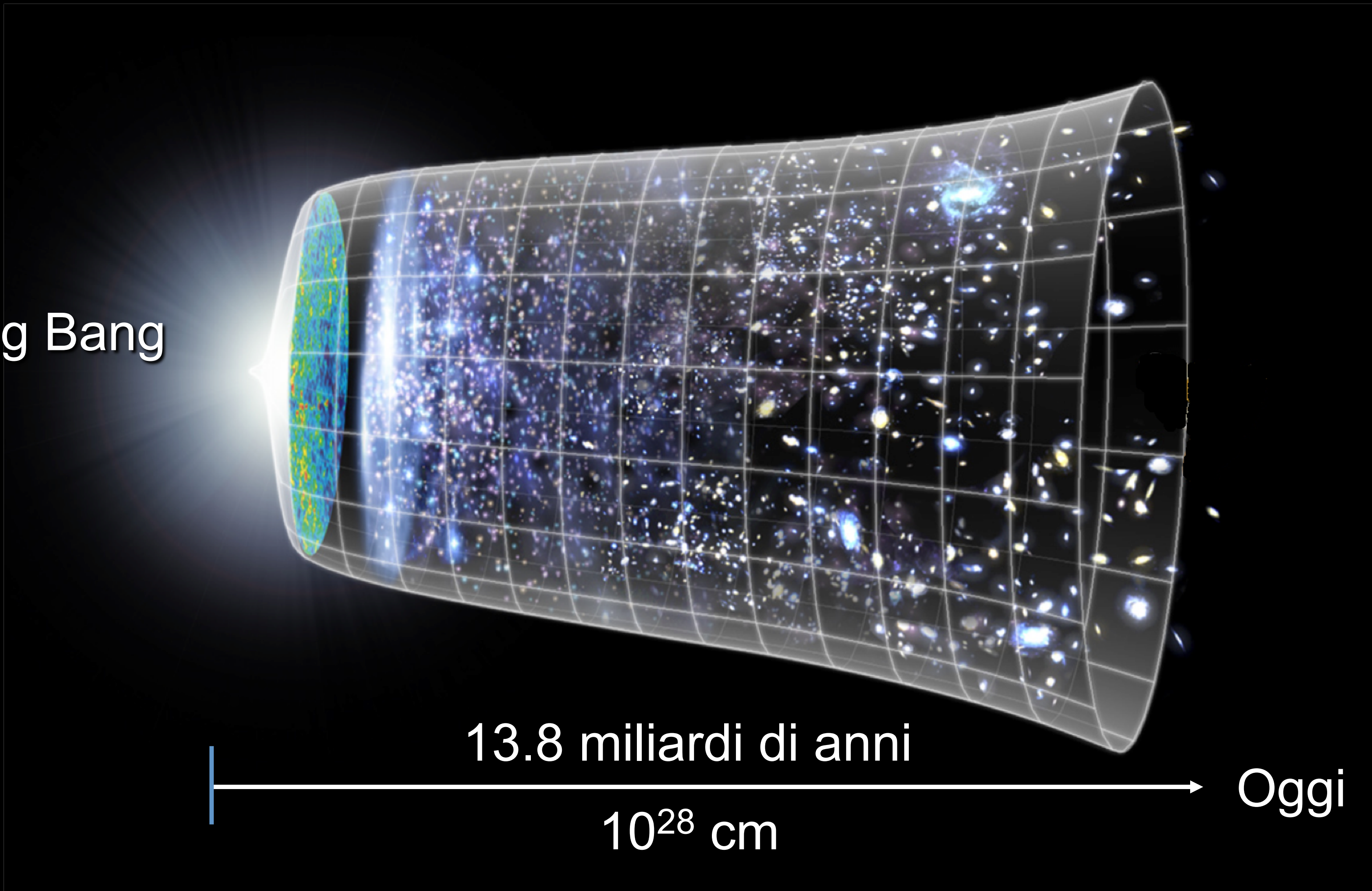
Laboratori Nazionali di Frascati

CERN

Incontri di Fisica 2014

Comprendere i primissimi istanti di vita del nostro Universo dopo il Big Bang



Per capire la natura intima della materia bisogna essere in grado di:

ricreare le condizioni dei primi istanti dell'Universo

ricreare i portatori d'informazione

ricreare le particelle

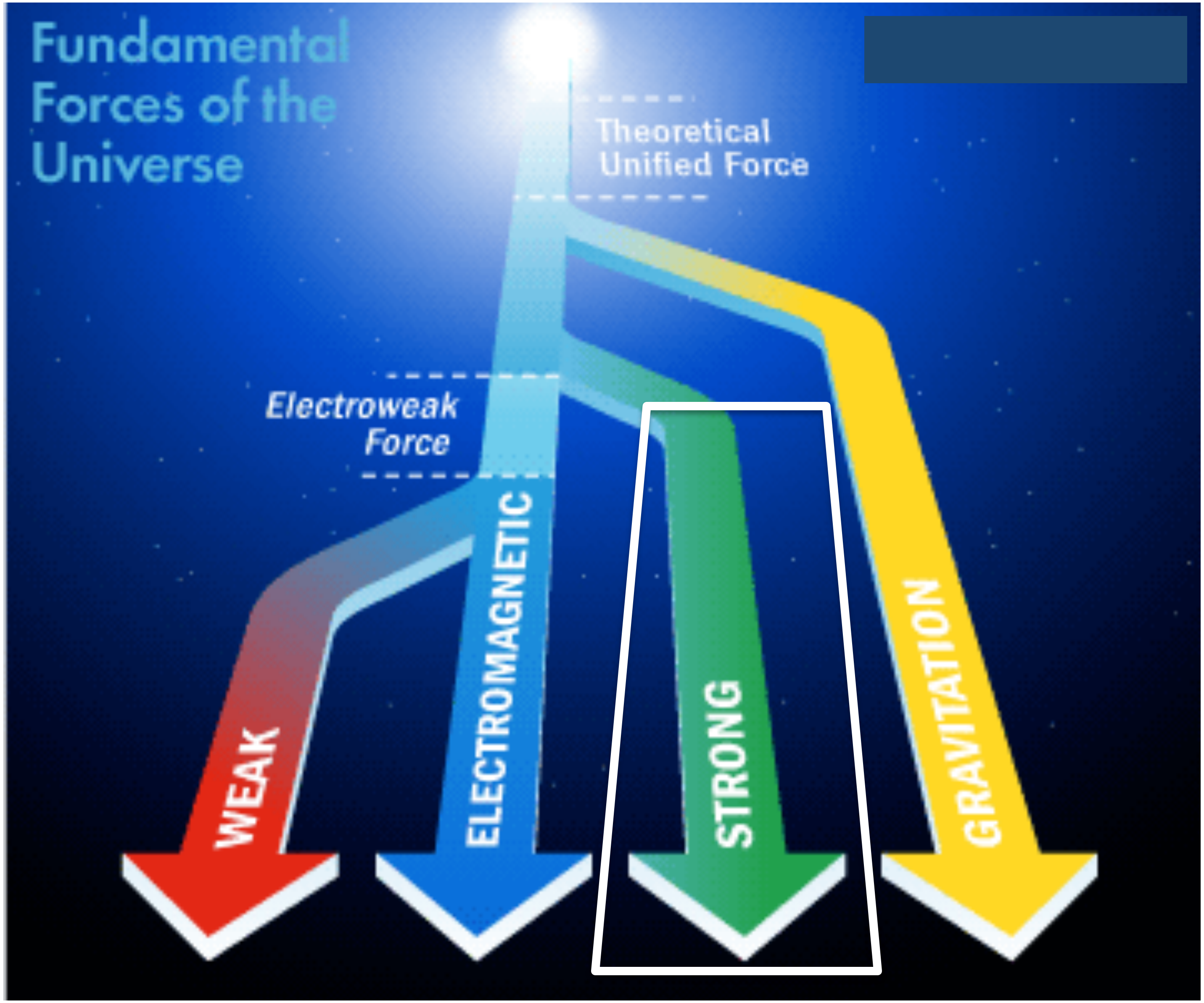
Alice … in viaggio nel tempo

Fino a circa un centomillesimo di secondo dal Big Bang (10^{-37} - 10^{-5} s) l'Universo era formato da una "zuppa" di quark e gluoni … il Quark Gluon Plasma (QGP)

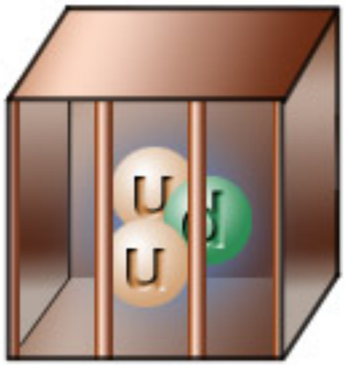
•Perchè studiare il QGP?

•Quali sono le caratteristiche del QGP?

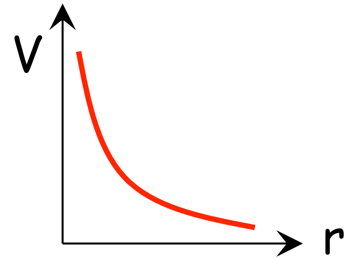
•E' possibile riprodurlo in laboratorio?

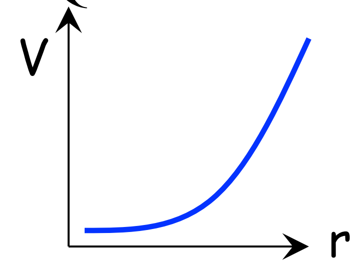

Fundamental Forces of the Universe
Theoretical Unified Force
Electroweak Force
WEAK
ELECTROMAGNETIC
STRONG
GRAVITATION

Liberta' Asintotica → Confinamento



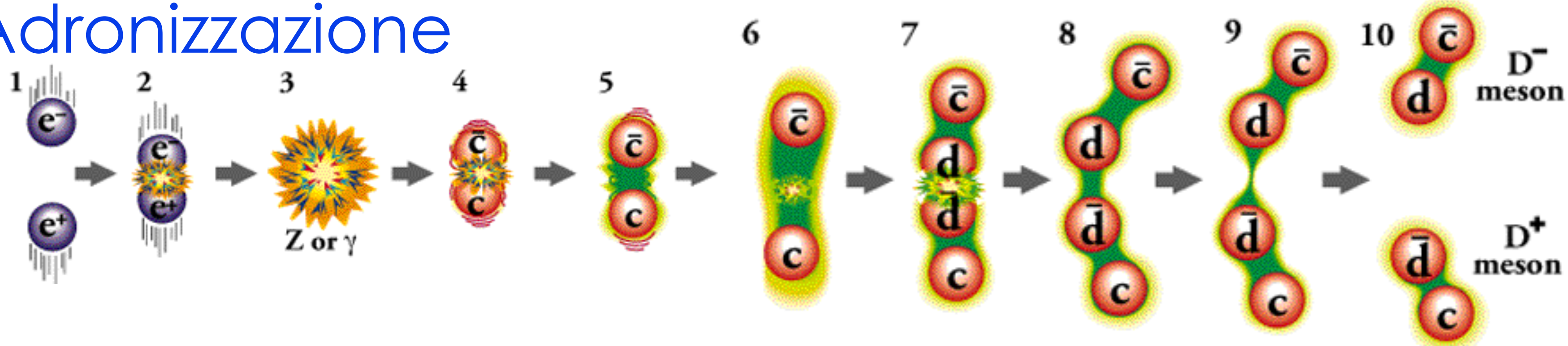
$$V_{Coulomb} \propto \frac{q_1 q_2}{r} \Rightarrow V_{QCD} \propto e^{k \cdot r}$$



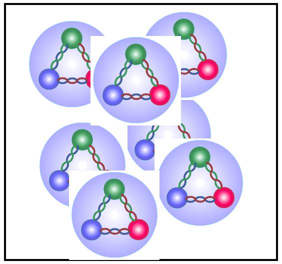


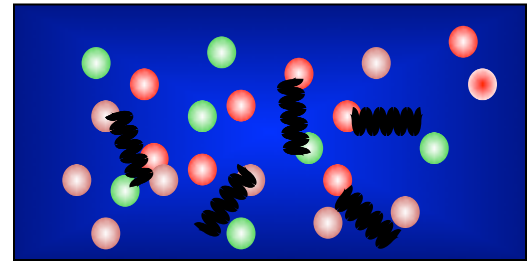
Allontanando i quark, si crea una tensione con energia sufficiente a creare altre particelle (1000 MeV / fm)

Adronizzazione



Bisogna creare un sistema che abbia una densità enorme (ptc a distanza infinitesima) tale da rendere trascurabile l'interazione forte





adroni

ENERGIA

Quark Gluon Plasma

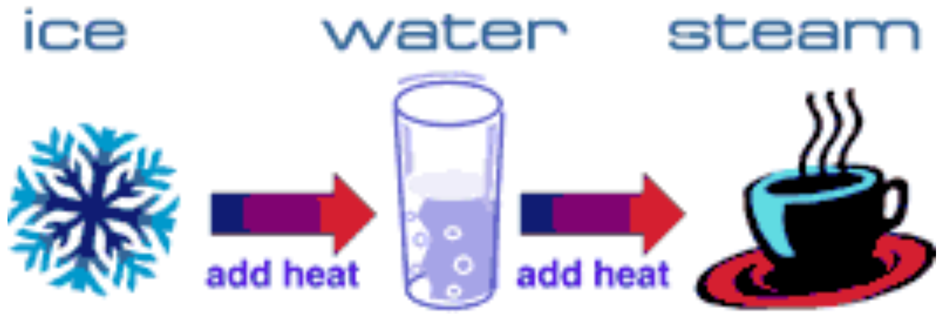
Nobel Prize 2005

D. Gross
H.D. Politzer
F. Wilczek

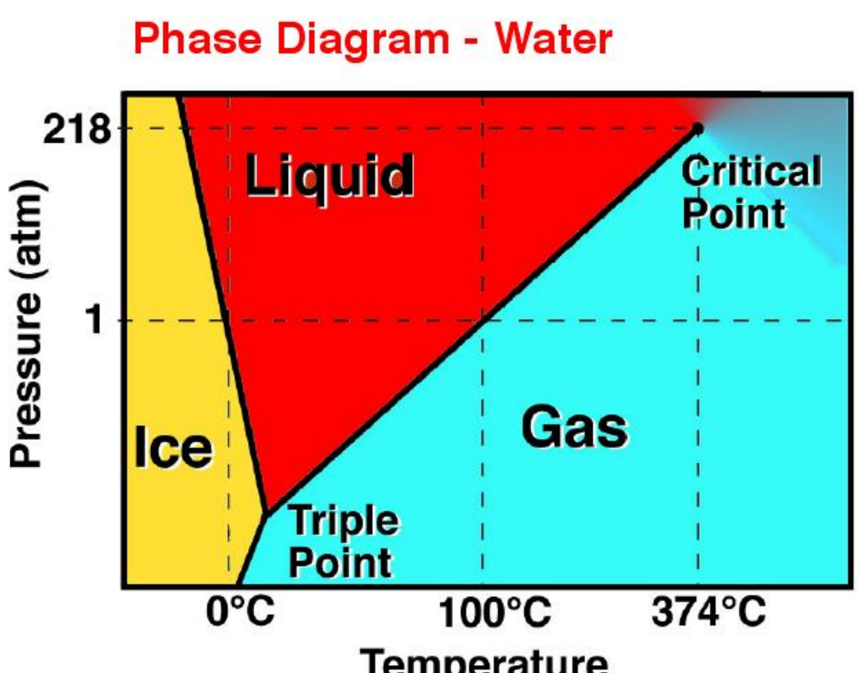
QCD Asymptotic Freedom (1973)

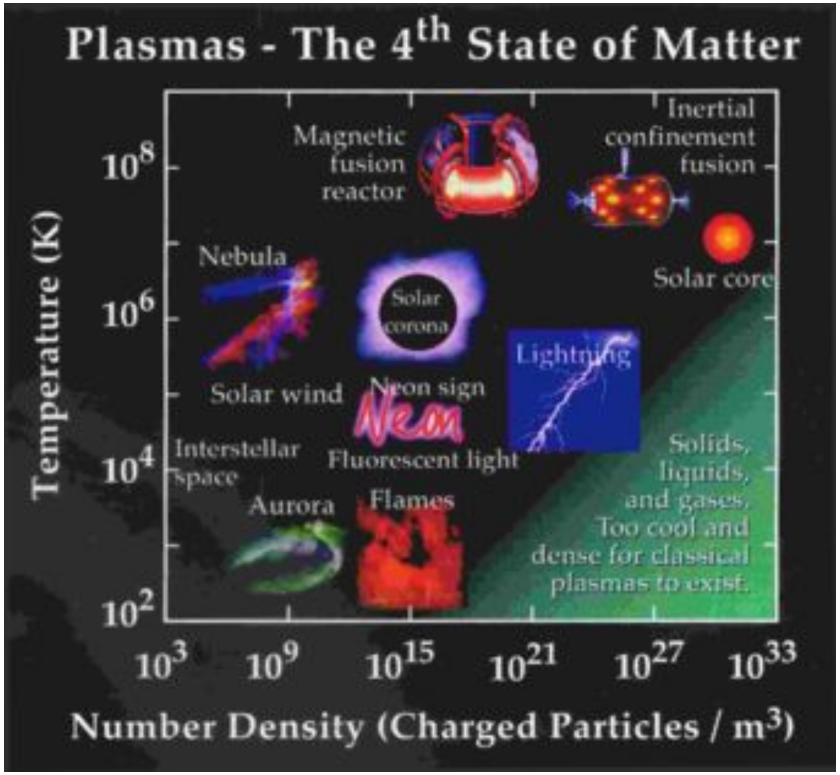
"Before [QCD] we could not go back further than 200,000 years after the Big Bang. Today…since QCD simplifies at high energy, we can extrapolate to very early times when nucleons melted…to form a quark-gluon plasma."
David Gross, Nobel Lecture (RMP 05)

Fasi della materia "normale"



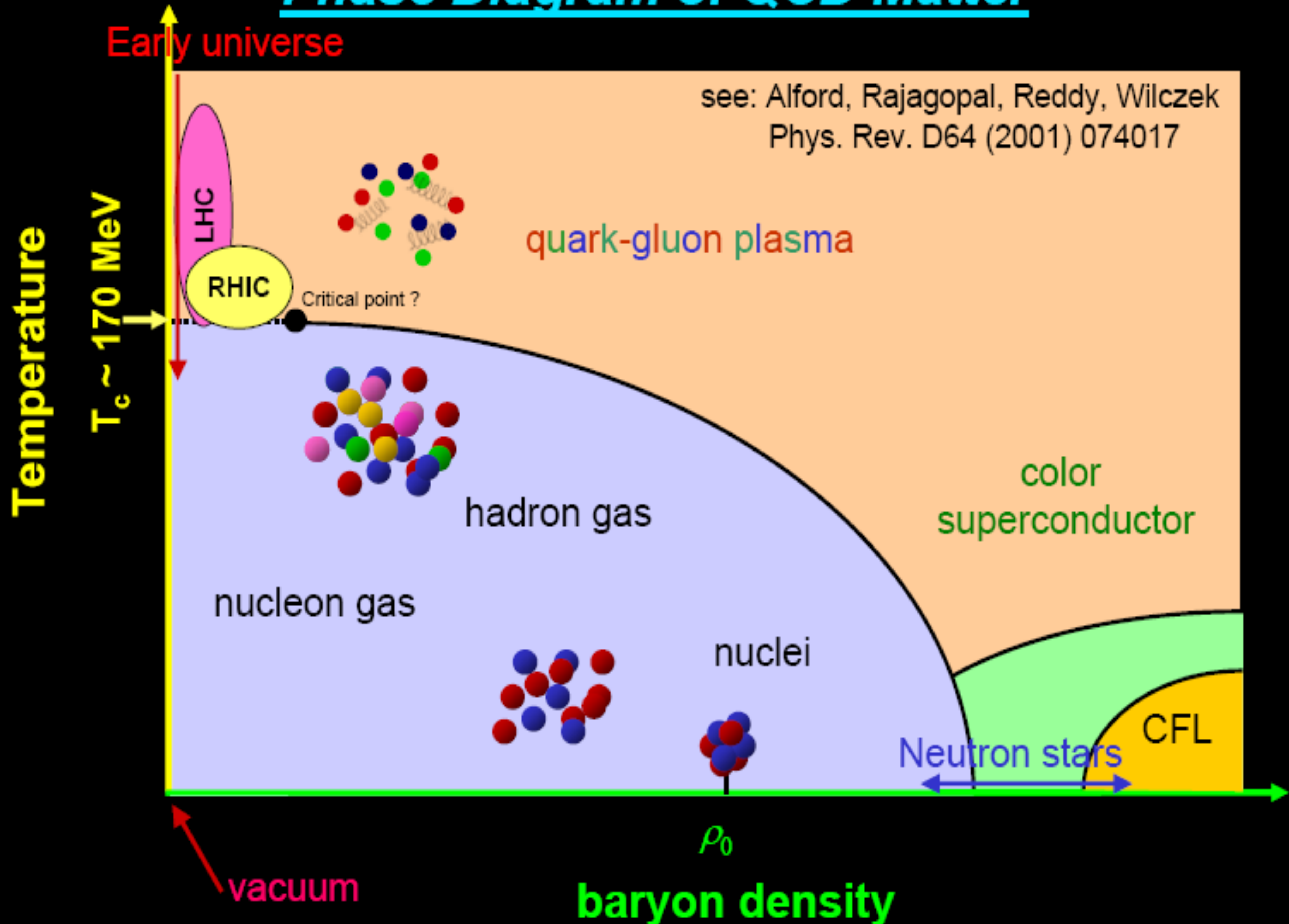
solido liquido gassoso





Plasma Classico

Phase Diagram of QCD Matter



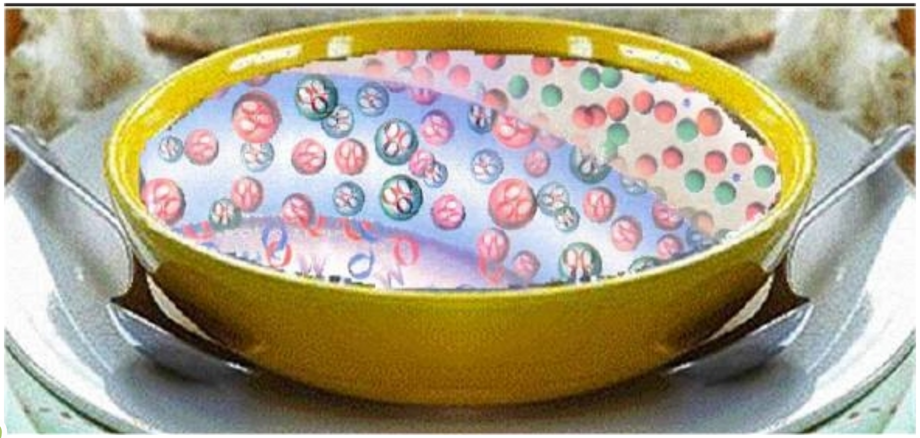
Il QGP: una "zuppa" ricca di informazioni

Evoluzione spazio-temporale della nascita di un adrone

Proprietà della QCD ad alte temperature: gradi di libertà, viscosità, conduttività, …

Flusso ellittico

Restaurazione della simmetria chirale



Freezout

Puzzle barionico

Instabilità di plasma, caos di colore

Transizione di fase q-g nelle teorie cosmologiche dell'Universo primordiale

Equazione di stato della QCD

Perdita di energia partonica

Composizione chimica

Il QGP: una “zuppa“ ricca di informazioni

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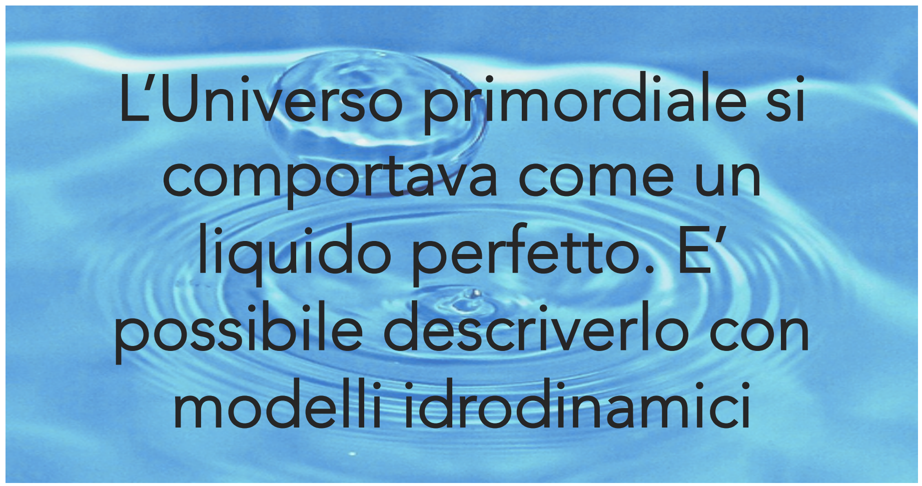

Instabilità di plasma, caos di colore

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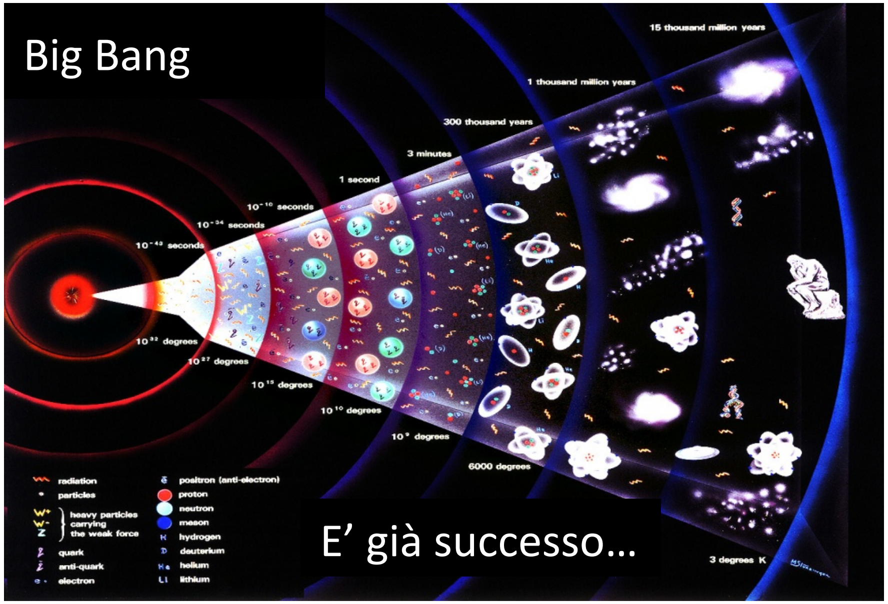
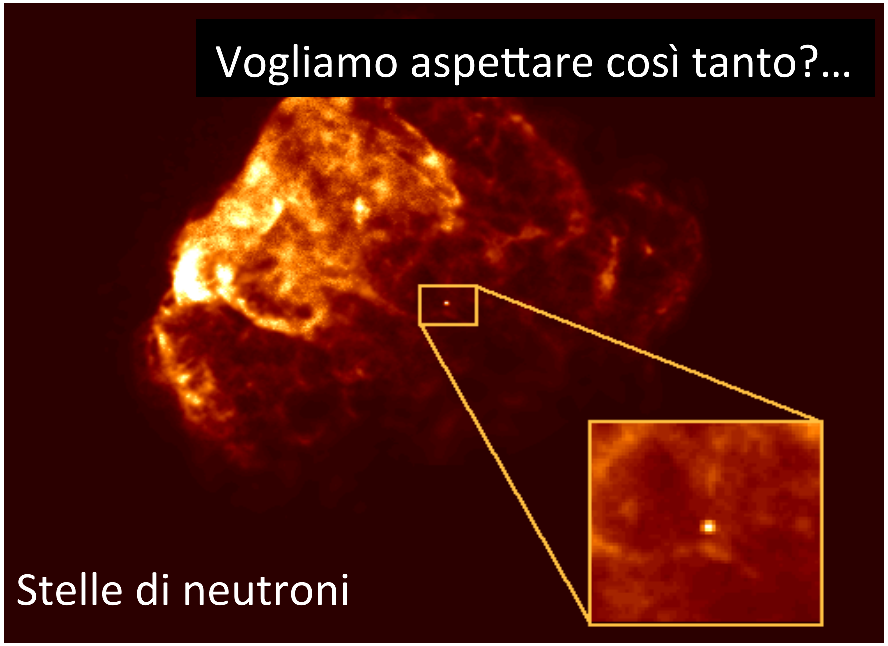
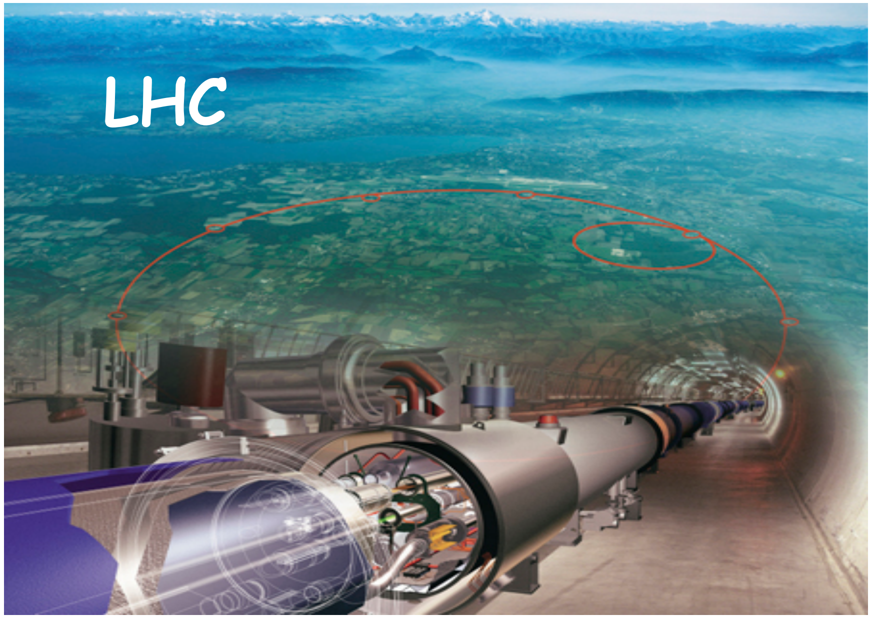
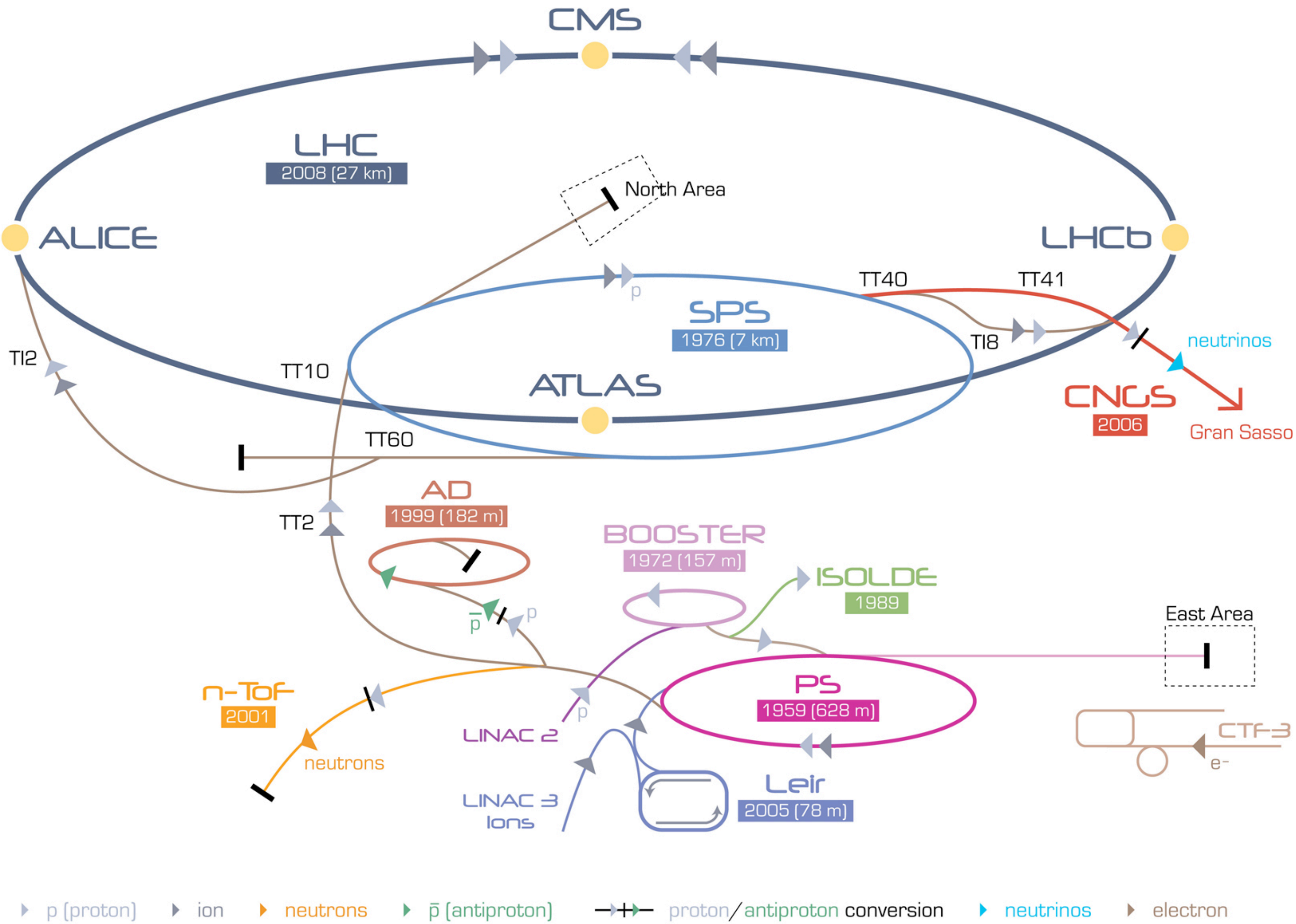
Dove si produce il QGP ?







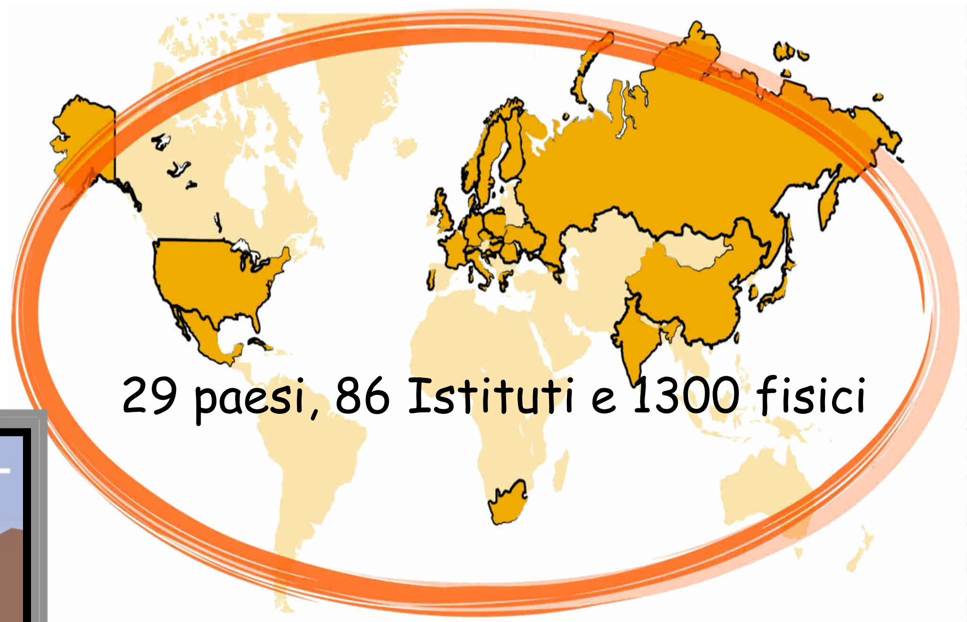
Complesso degli acceleratori del CERN



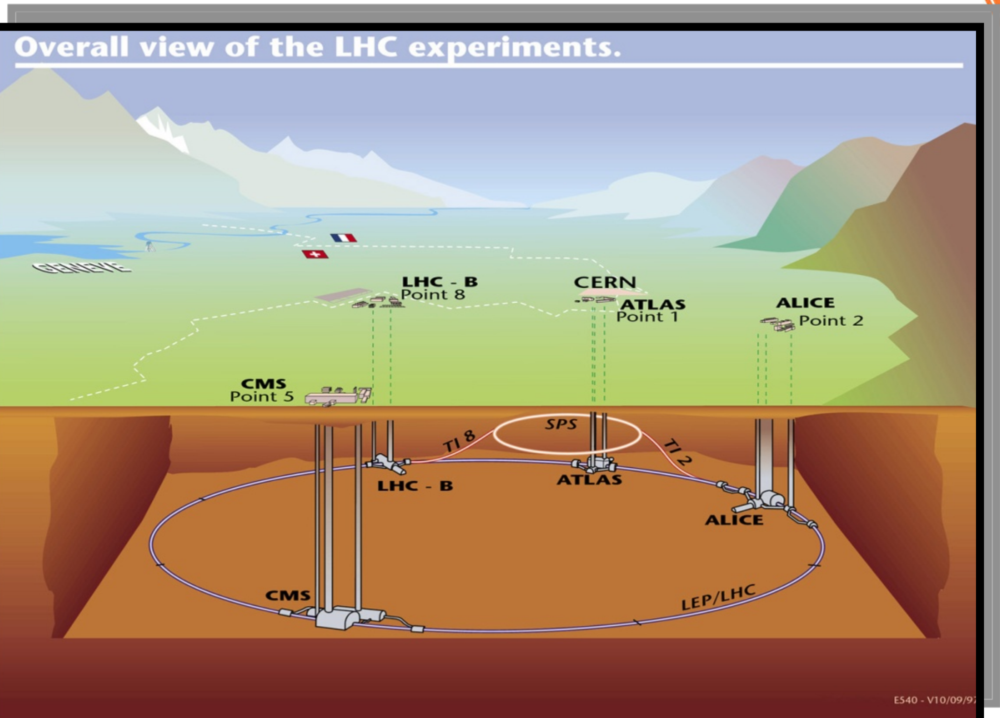
LHC, il più potente acceleratore del mondo

ALICE: A Large Ion Collider Experiment

Alice è l'unico esperimento a LHC dedicato alla fisica con fasci di ioni (5.5 TeV PbPb)



29 paesi, 86 Istituti e 1300 fisici

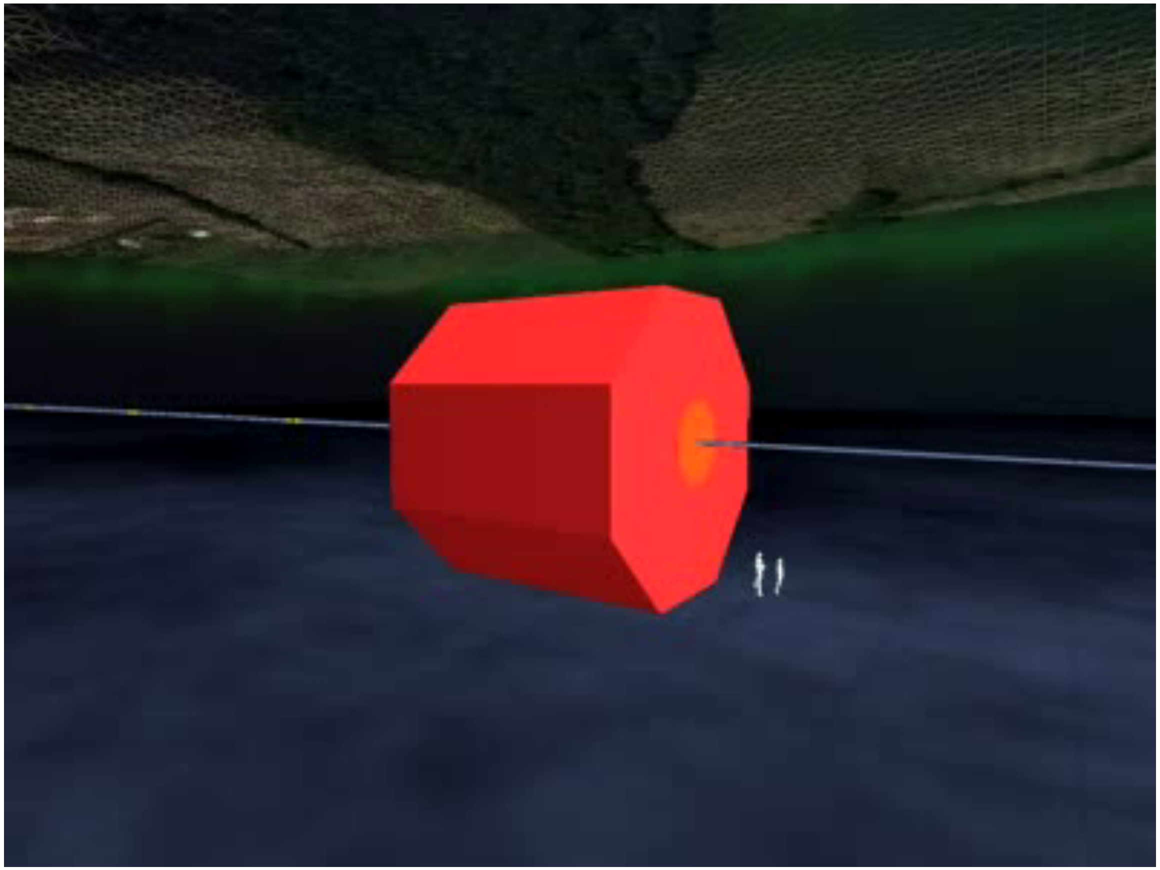


200 fisici Italiani: BA, BO, CA, CT, LNF, LNL, PD, RM1, SA, TO, TS

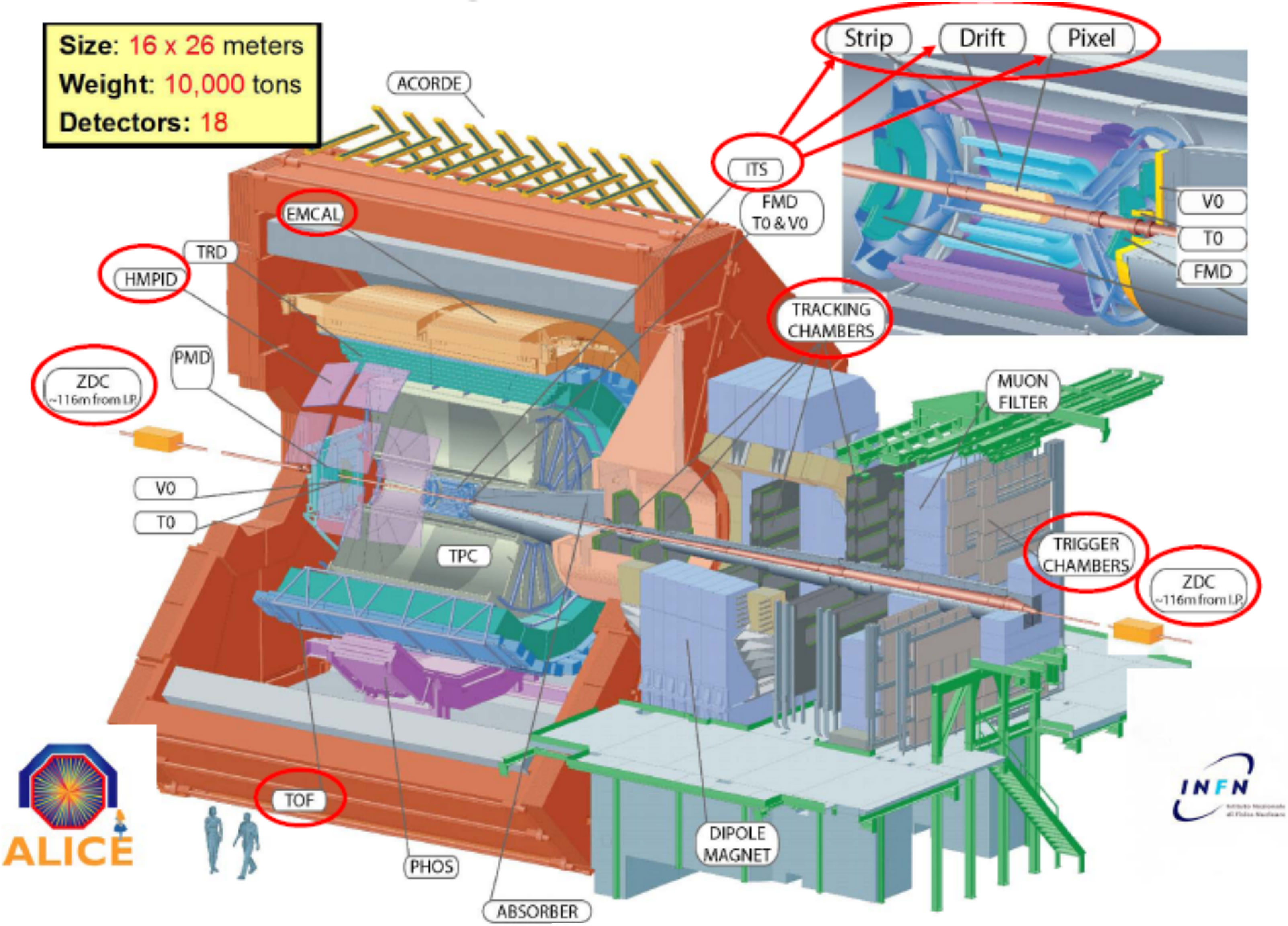
QGP attraverso gli Heavy Ions

2 nuclei di Piombo, completamente ionizzati, collidono ad altissima energia creando un sistema ad altissima densità

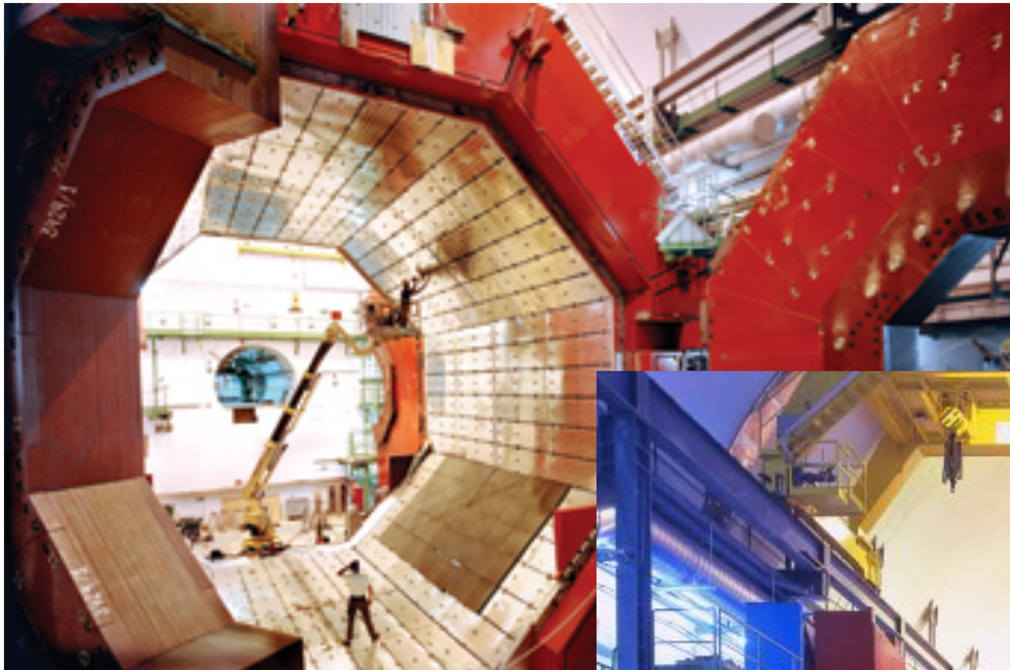
La collisione in Alice

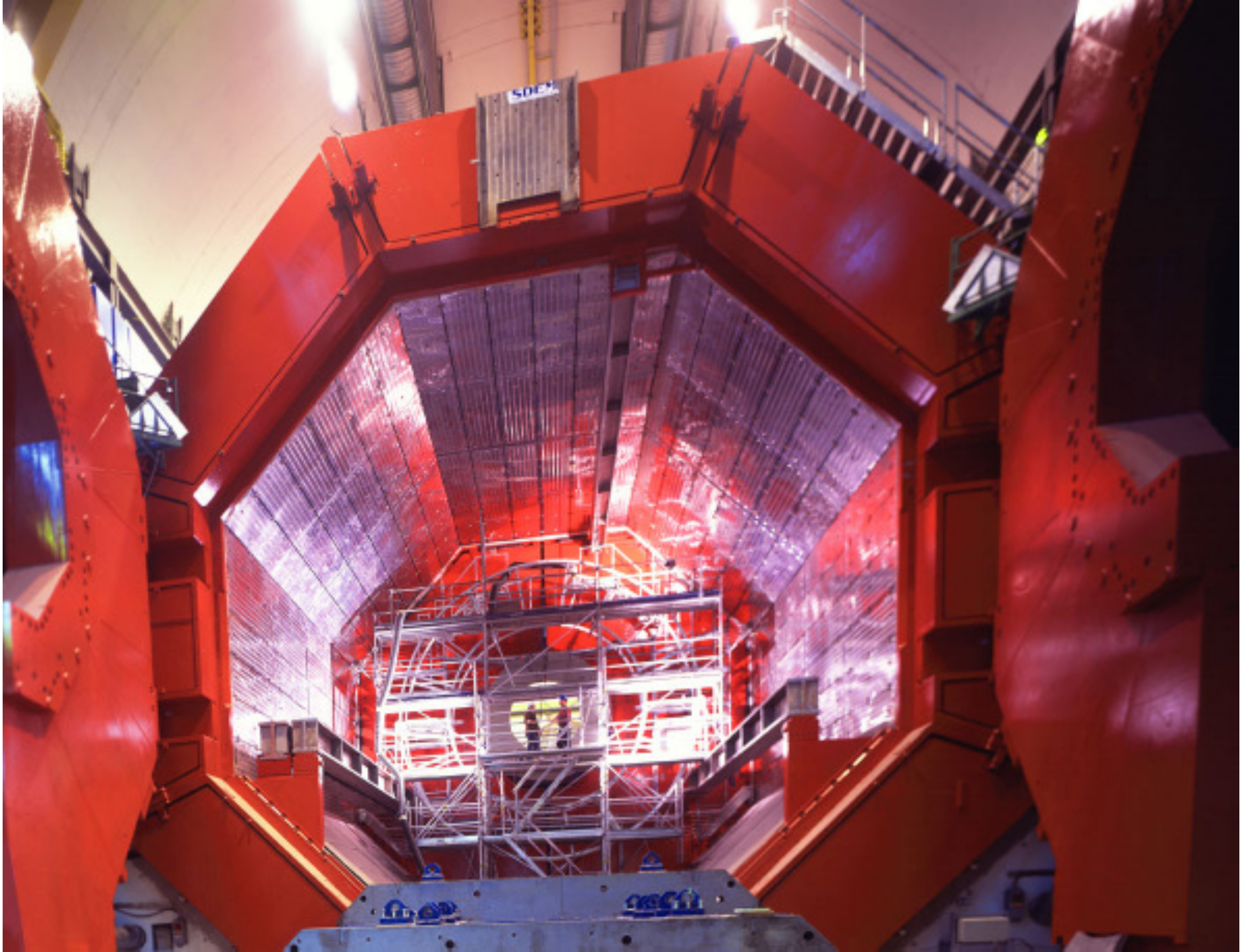


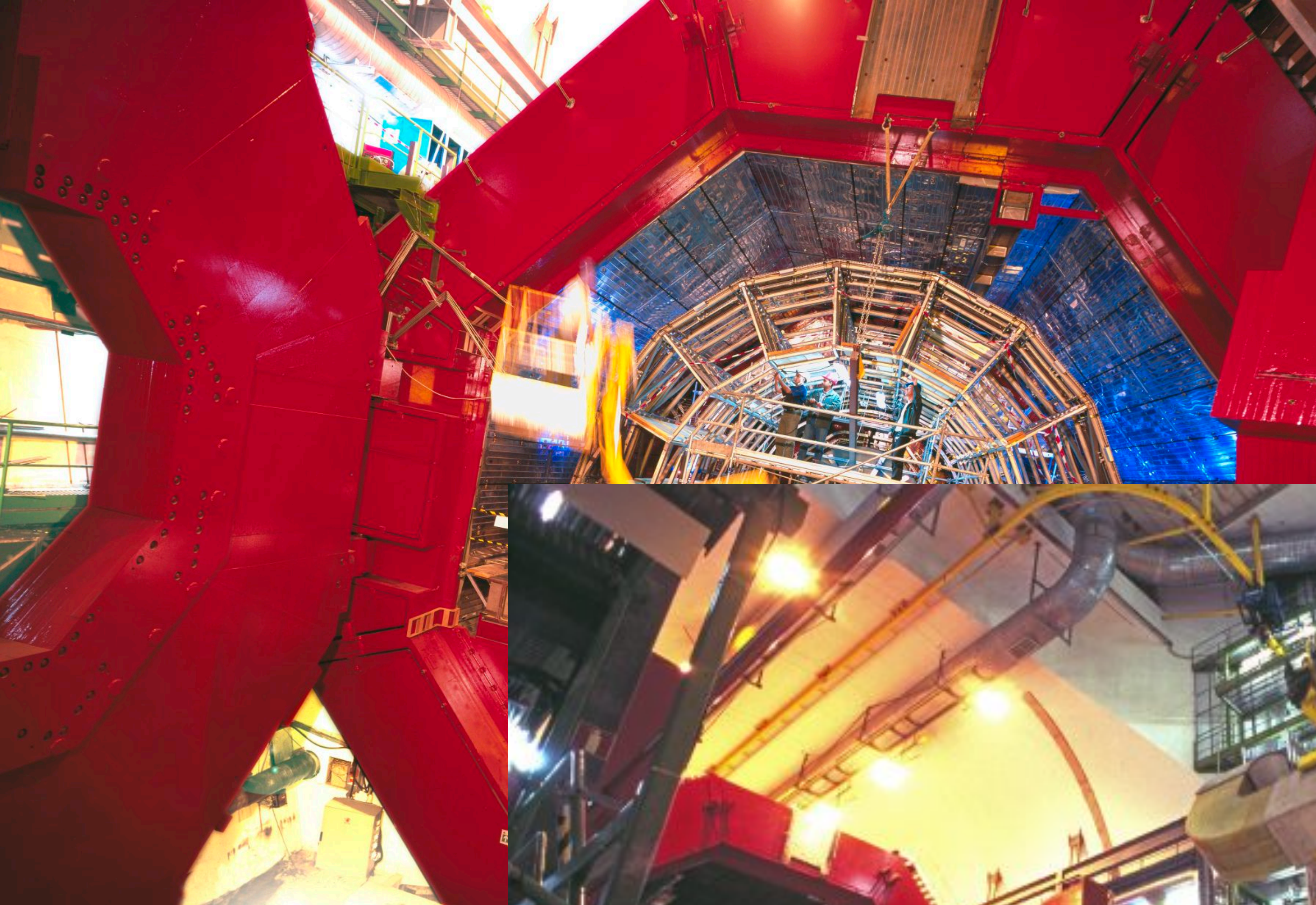
Lo spettrometro

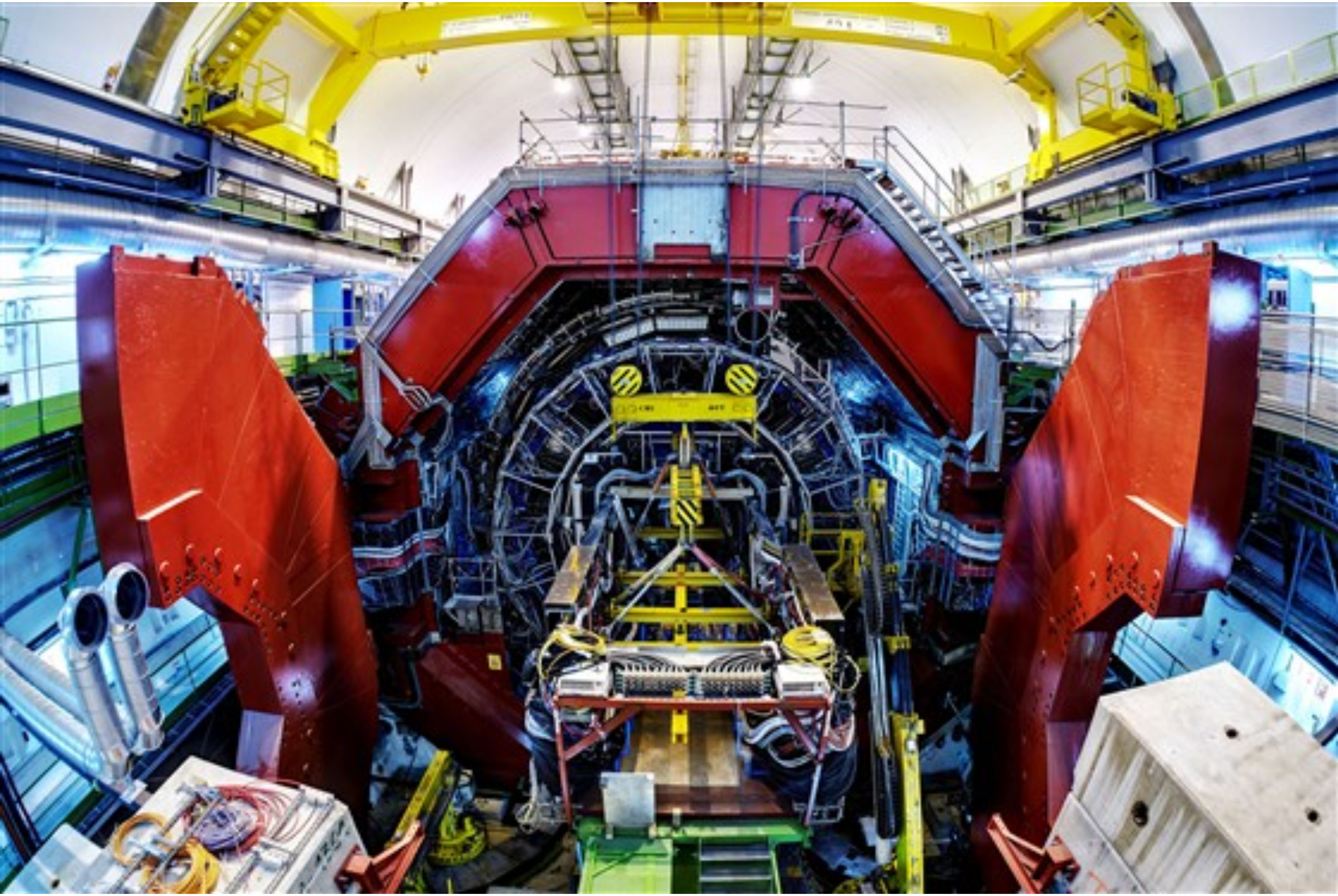


: Rivelatori sotto la completa o parziale responsabilità INFN

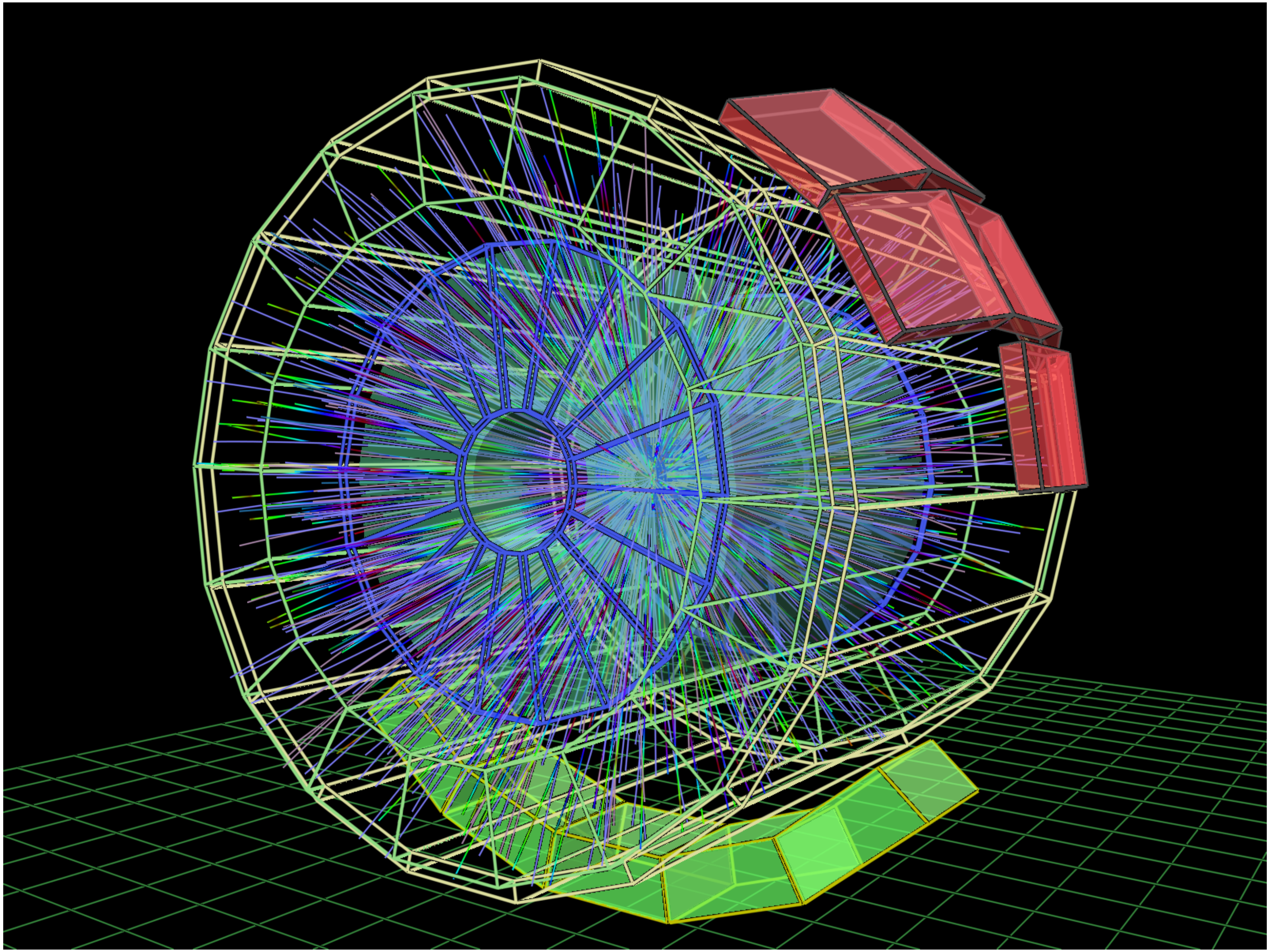




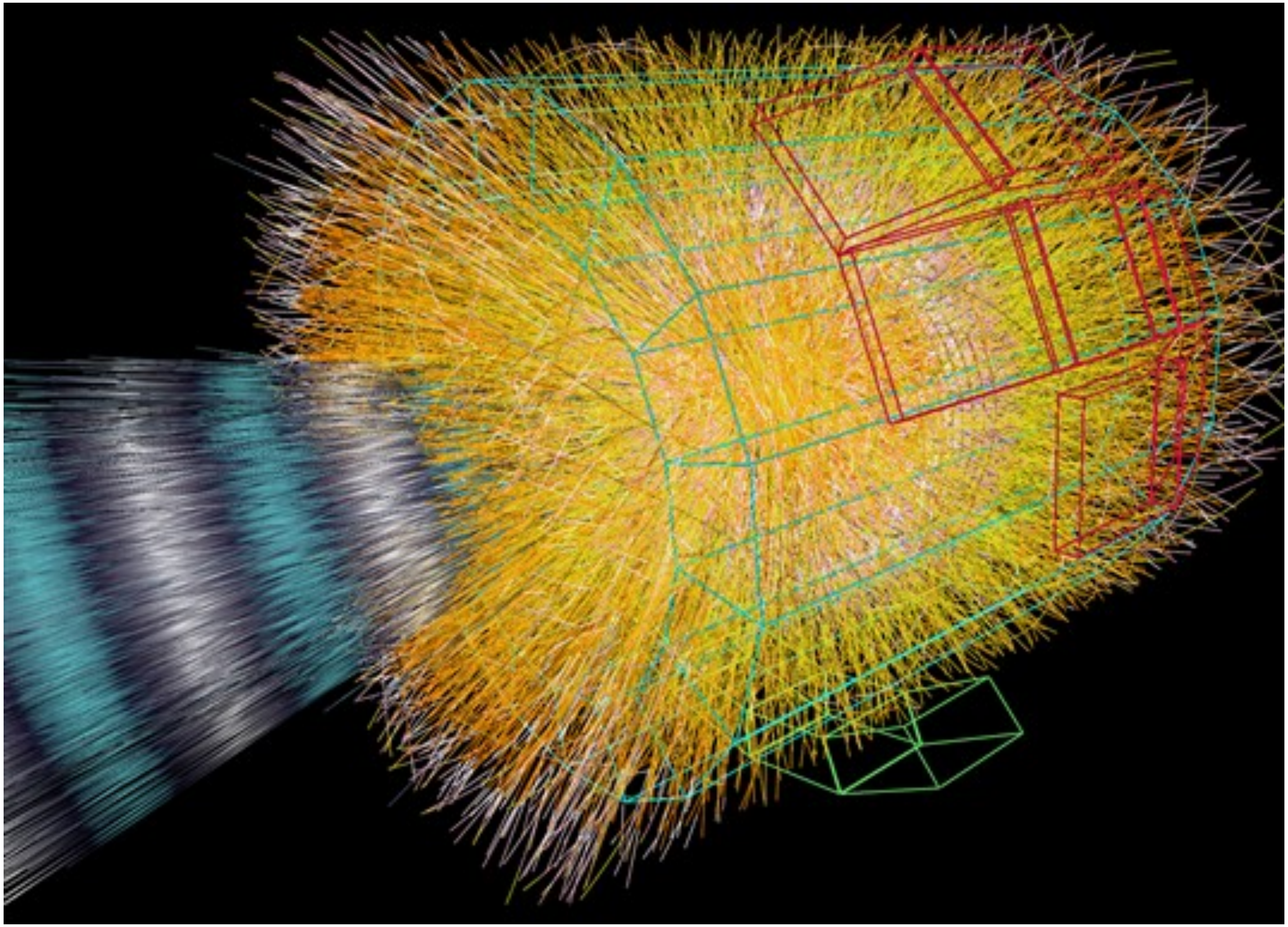


Eventi pp in Alice



Eventi PbPb in Alice



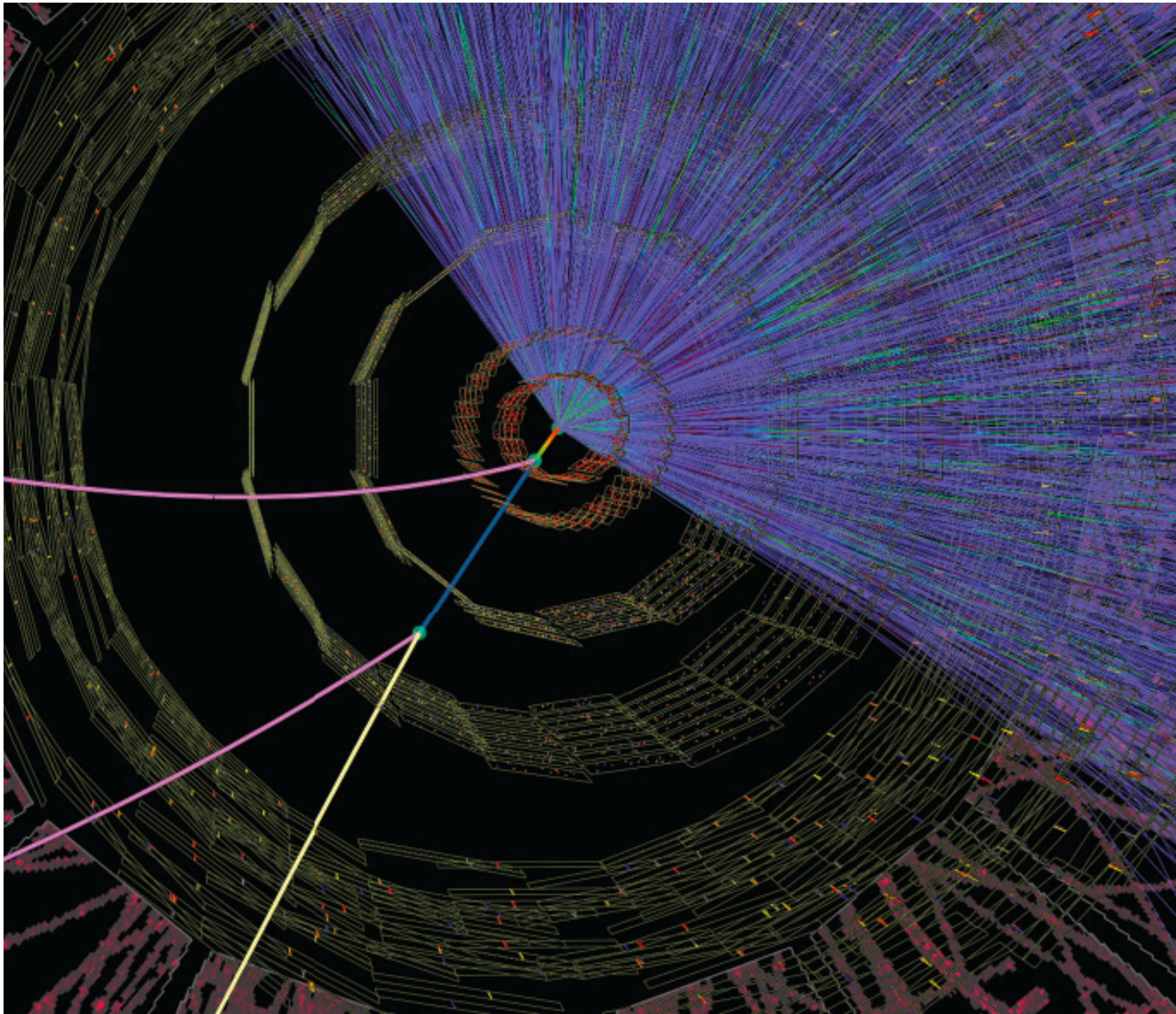
Migliaia di tracce prodotte ad ogni interazione (25 ns)


Tutto chiaro fin qui?
Caption City

Selezione di tracce “buone”

Eccellente tracking + vertice + Identificazione di particelle (PID)

$$\Xi^- \rightarrow \Lambda\pi^-$$



$\pi(u\overline{u})$

$Ks(d\overline{s})$

$p(uud)$

$n(udd)$

$\Lambda(uds)$

$K^0_s \rightarrow \pi^+\pi^-$

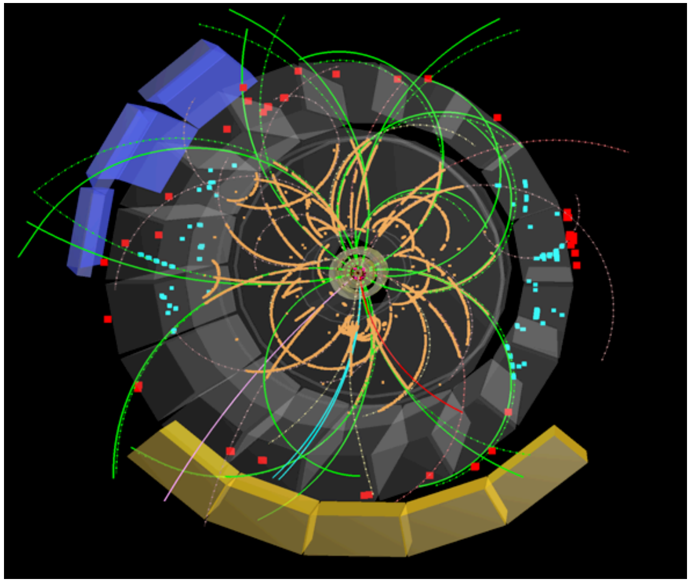
τ = 0.89 x 10^{-10} s

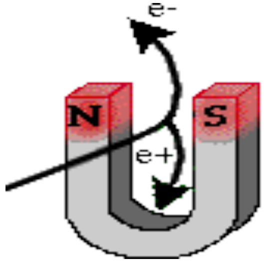
cτ = 3x10^{10} cm s^{-1} x 0.89 x10^{-10} s = 2.67 cm dal punto d'interazione

$\Lambda \rightarrow \pi^- p$

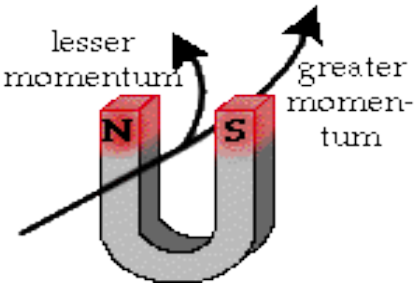
τ = 2.6 x 10^{-10} s

cτ = 3x10^{10} cm s^{-1} x 10^{-9} s = 7.2 cm dal punto d'interazione



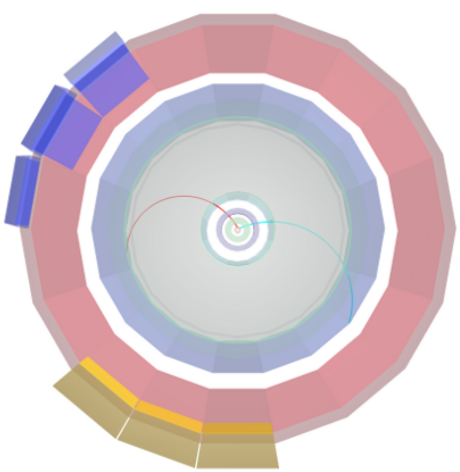


Identifica
la carica



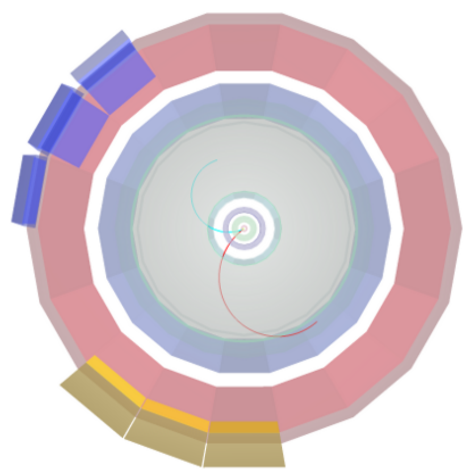
Misura
l’impulso

Simmetrico



$\boxed{K^0_s \rightarrow \pi^+\pi^-}$

Asimmetrico



$\Lambda \rightarrow \pi^- p^+$

Prima parte

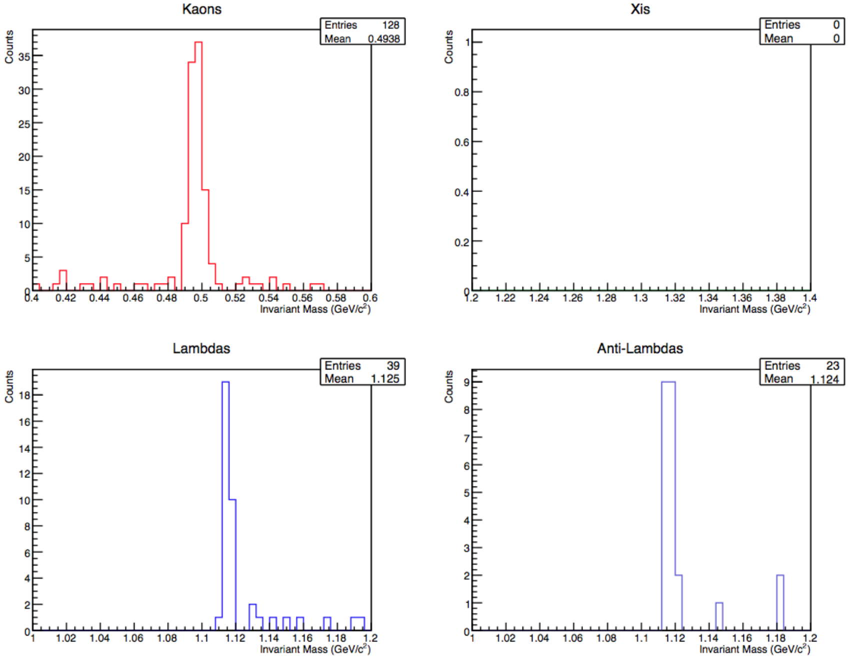
- Identificare i V0 (K^0_s, Λ, anti-Λ) dai decadimenti

  (V0 : due tracce con carica opposta

  provenienti da uno stesso vertice secondario)

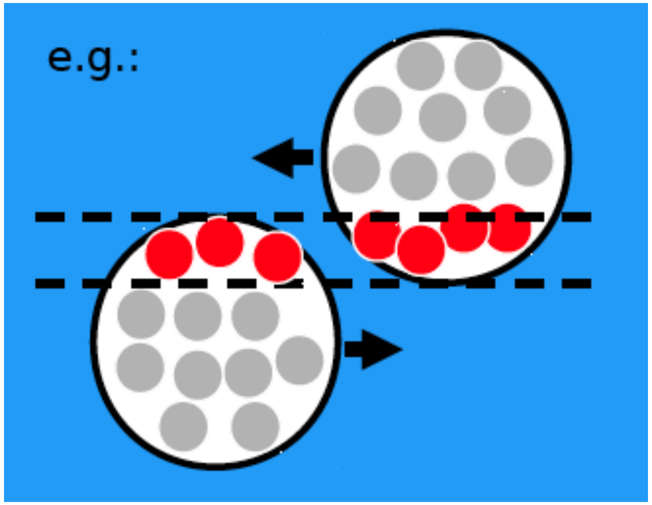
- Calcolo della massa invariante
- Classificare le particelle secondo la loro massa

  invariante ed il tipo di particelle di decadimento

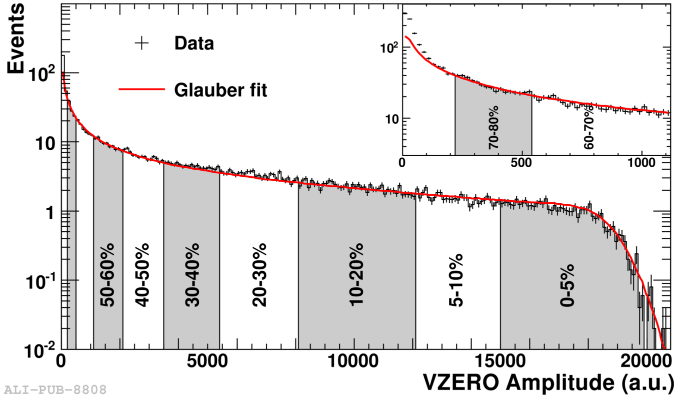


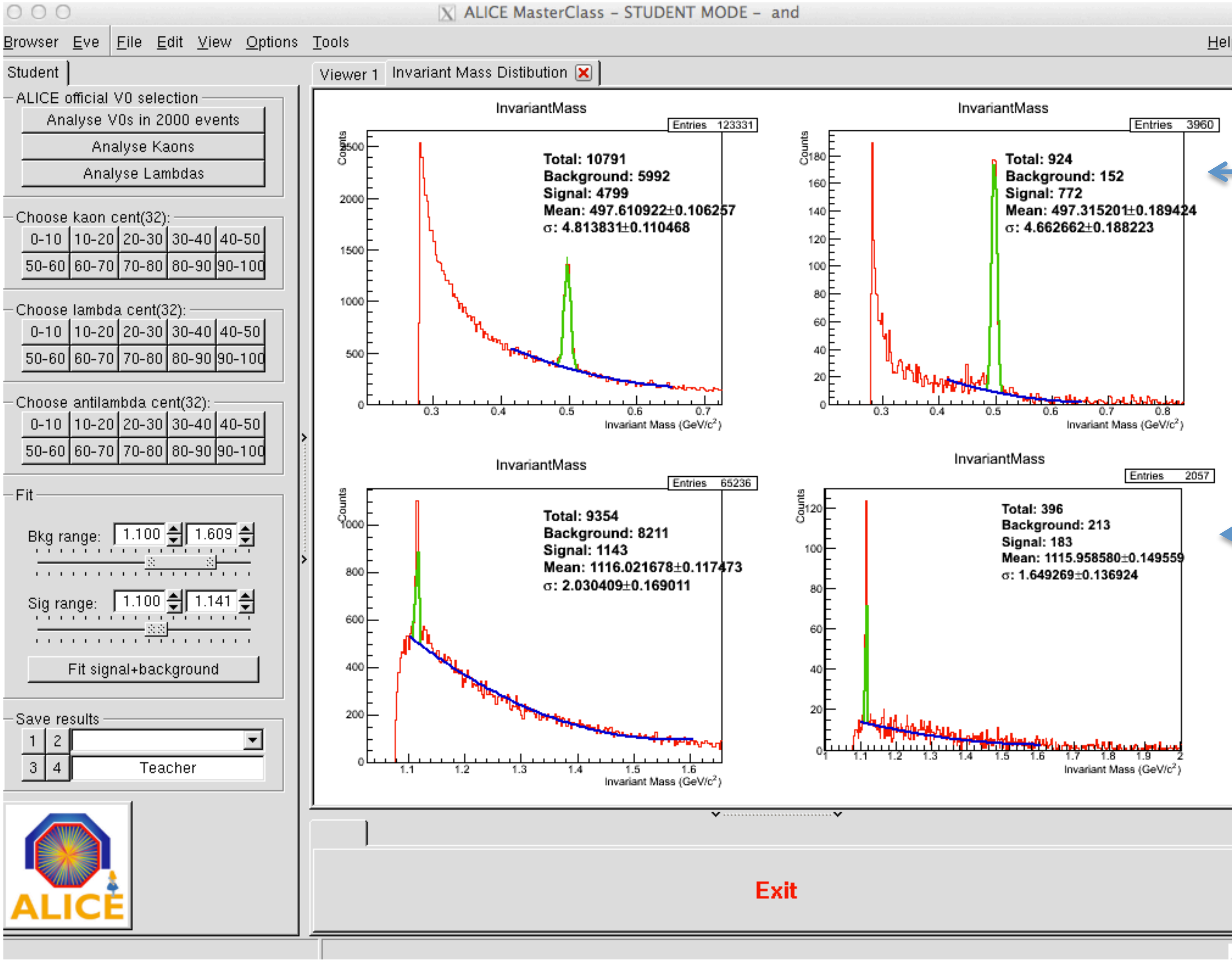
Seconda parte

- Analisi di un campione di migliaia di eventi
- Riempire gli istogrammi di massa invariante per K_s, Λ anti-Λ
- Fit del fondo (background) con polinomio di secondo e segnale (gaussiana)
- Trovare il numero di K_s, Λ, anti-Λ dopo la sottrazione del fondo in differenti bin di centralità nelle collisioni Pb-Pb



Centrality	$dN_{ch}/d\eta$	$\langle N_{part} \rangle$	$(dN_{ch}/d\eta)/(\langle N_{part} \rangle/2)$
0%–5%	1601 ± 60	382.8 ± 3.1	8.4 ± 0.3
5%–10%	1294 ± 49	329.7 ± 4.6	7.9 ± 0.3
10%–20%	966 ± 37	260.5 ± 4.4	7.4 ± 0.3
20%–30%	649 ± 23	186.4 ± 3.9	7.0 ± 0.3
30%–40%	426 ± 15	128.9 ± 3.3	6.6 ± 0.3
40%–50%	261 ± 9	85.0 ± 2.6	6.1 ± 0.3
50%–60%	149 ± 6	52.8 ± 2.0	5.7 ± 0.3
60%–70%	76 ± 4	30.0 ± 1.3	5.1 ± 0.3
70%–80%	35 ± 2	15.8 ± 0.6	4.4 ± 0.4





K_s

Sinistra: 0-10% centralità

Destra : 50-60% centralità

Λ

Sinistra: 0-10% centralità

Destra: 50-60% centralità

centrality	<Npart>	Nevents	NKs	efficiency Ks	yield Ks	Ks enhancem
0-10	360	213	4816	0.26	86.963	1.933
10--20	260	290	4638	0.26	61.512	1.893
20-30	186	302	3750	0.29	42.818	1.842
30-40	129	310	2610	0.29	29.032	1.800
40-50	85	302	1493	0.29	17.047	1.604
50-60	52	300	777	0.29	8.931	1.374
60-70	30	315	409	0.35	3.710	0.989
70-80	16	350	149	0.26	1.637	0.819

conosciuto dato misurato dato calcolato

Efficienza = Nparticelle(misurate)/Nparticelle(prodotte)

Yield : numero di particelle prodotte per interazione
Yield = Nparticelle(prodotte)/Neventi = Nparticelle(misurate)/(efficienza x Neventi)

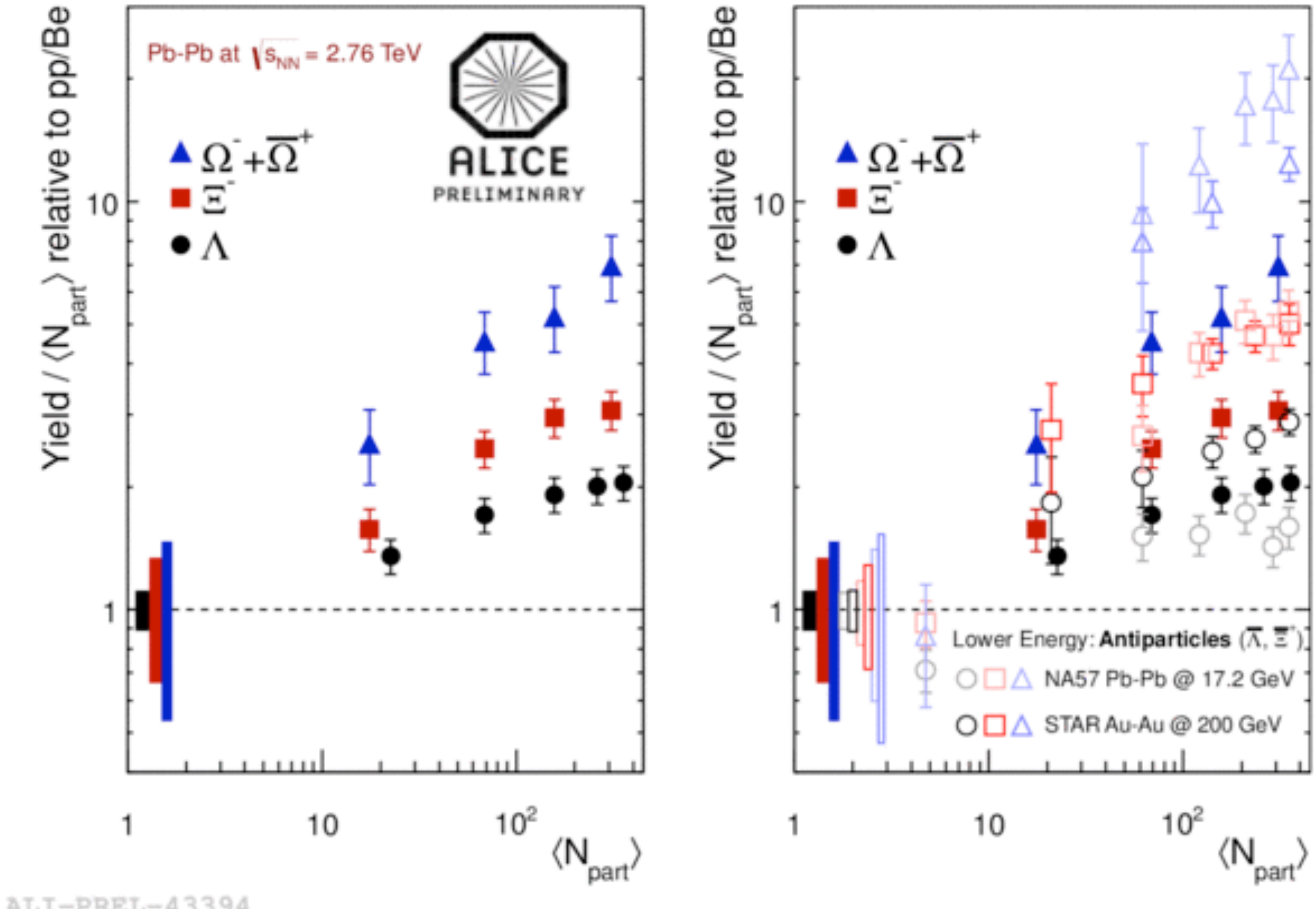
Strangeness enhancement: yield per particella normalizzato al numero di nucleoni partecipanti nella collisione e diviso per lo yield delle collisioni protone-protone

K_s-Yield (pp) = 0.25 /interazione ; Λ-Yield(pp) = 0.0617 /interazione ; $<N_{part}>$ = 2 per pp

Dove scaricare il materiale

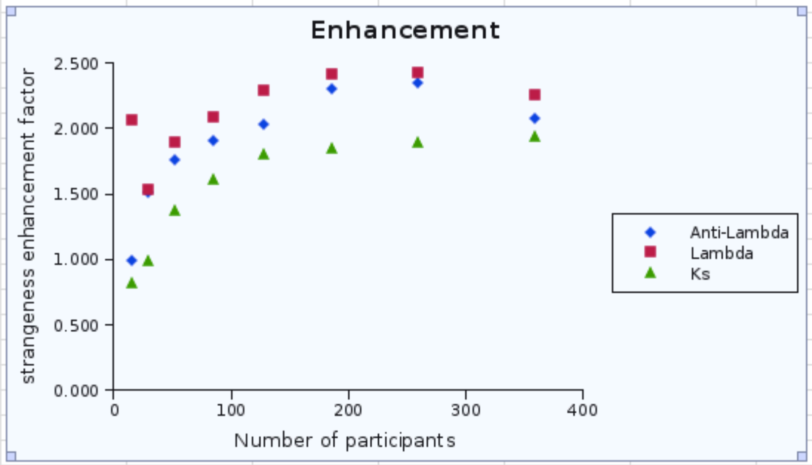
http://alice.physicsmasterclasses.org/MasterClassWebpage.html

PASQUALE.DINEZZA@LNF.INFN.IT



Pb-Pb at $\sqrt{s_{NN}}$ = 2.76 TeV
ALICE
PRELIMINARY
$\Omega^- + \overline{\Omega}^+$
Ξ^-
Λ
Yield / $\langle N_{part} \rangle$ relative to pp/Be
$\langle N_{part} \rangle$
Lower Energy: **Antiparticles** ($\overline{\Lambda}$, $\overline{\Xi}^+$)
NA57 Pb-Pb @ 17.2 GeV
STAR Au-Au @ 200 GeV
ALI-PREL-43394

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
centrality	<Npart>	Nevents	NKs	efficiency Ks	yield Ks	Ks enhancem	Nlambda	efficiency L	Yield Lambda	Lambda enh	Nantilambda	effic antiL	yield antiLam	antiL enha
0-10	360	213	4816	0.26	86.963	1.933	1066	0.2	25.023	2.253	980	0.2	23.005	2.071
10--20	260	290	4638	0.26	61.512	1.893	1185	0.21	19.458	2.426	1142	0.21	18.752	2.338
20-30	186	302	3750	0.29	42.818	1.842	917	0.22	13.802	2.405	875	0.22	13.170	2.295
30-40	129	310	2610	0.29	29.032	1.800	621	0.22	9.106	2.288	550	0.22	8.065	2.026
40-50	85	302	1493	0.29	17.047	1.604	363	0.22	5.464	2.084	332	0.22	4.997	1.906
50-60	52	300	777	0.29	8.931	1.374	182	0.2	3.033	1.891	169	0.2	2.817	1.756
60-70	30	315	409	0.35	3.710	0.989	89	0.2	1.413	1.526	88	0.2	1.397	1.509
70-80	16	350	149	0.26	1.637	0.819	71	0.2	1.014	2.055	34	0.2	0.486	0.984



http://www.editgrid.com/user/alice-masterclass/centr-results-example+plot.csv example spreadsheet
http://www.editgrid.com/user/alice-masterclass/centr-results-institute1.csv spreadsheet filled by each institute

Compare all institutes results, for example for Lambdas

EditGrid Welcome, alice-masterclass
Preferences | Logout

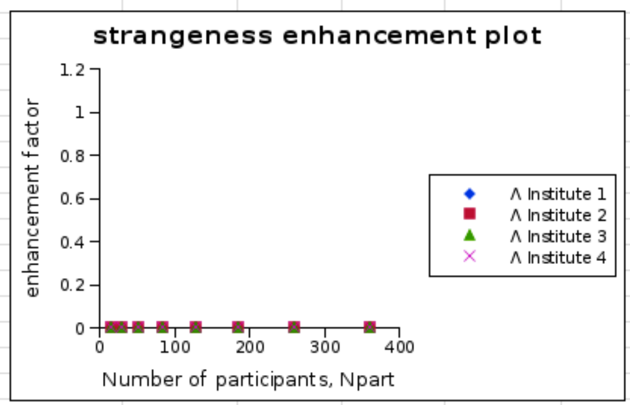
Home | Spreadsheets

Spreadsheet /alice-masterclass / centr-results-lambda-all.csv

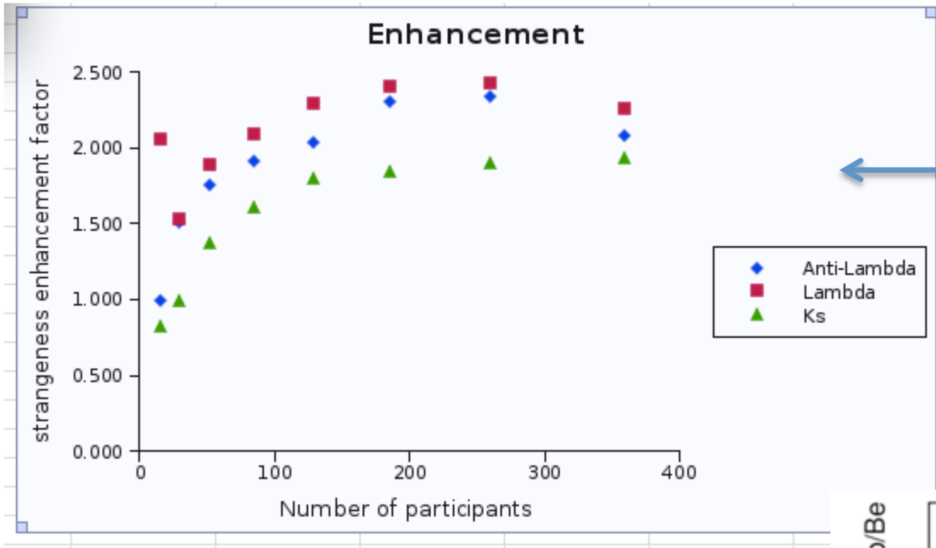
File Edit View Format Insert Data Share Publish Collaborate Macro Help

A1 centrality

centrality	<Npart>	Nevents	Λ Inst.1	Λ Inst2	Λ Inst.3	Λ Inst. 4	eff. Λ	yield Inst1	yield Inst 2	yield inst3	yield inst4	Λ enh. inst1	Λ enh. iinst.2	Λ enh. inst3	Λ enh. inst.4
0-10	360	213	0	0	0	0	0.2	0.00	0.00	0.00	0.00	0.000	0.000	0.00	0.00
10--20	260	290	0	0	0	0	0.21	0.00	0.00	0.00	0.00	0.000	0.000	0.00	0.00
20-30	186	302	0	0	0	0	0.22	0.00	0.00	0.00	0.00	0.000	0.000	0.00	0.00
30-40	129	310	0	0	0	0	0.22	0.00	0.00	0.00	0.00	0.000	0.000	0.00	0.00
40-50	85	302	0	0	0	0	0.22	0.00	0.00	0.00	0.00	0.000	0.000	0.00	0.00
50-60	52	300	0	0	0	0	0.2	0.00	0.00	0.00	0.00	0.000	0.000	0.00	0.00
60-70	30	315	0	0	0	0	0.2	0.00	0.00	0.00	0.00	0.000	0.000	0.00	0.00
70-80	16	350	0	0	0	0	0.2	0.00	0.00	0.00	0.00	0.000	0.000	0.00	0.00

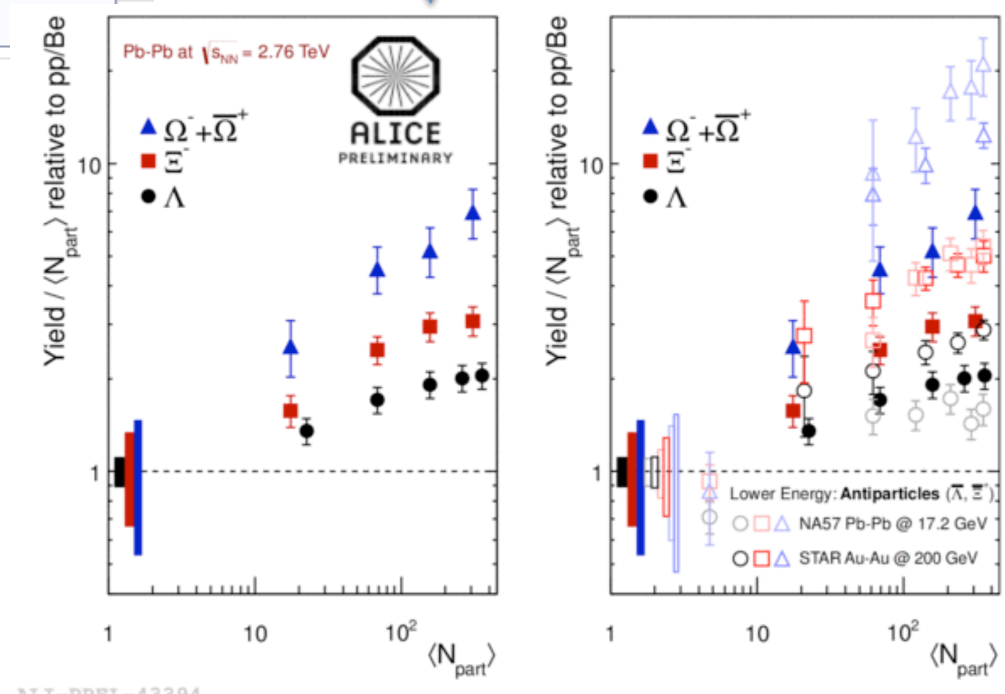


To combine results of all institutes in one plot, use
http://www.editgrid.com/user/alice-masterclass/centr-results-lambda-all.csv to be filled by moderator



Example of presentation of results

Preliminary ALICE results
+ lower energy (STAR, NA57) results



Possible comments

Enhancement increases with number of strange quarks in the hadron
(Λ has 1 strange quark, Ξ has 2, Ω has 3)

Enhancement decreases with collision energy (going from SPS to RHIC to LHC)