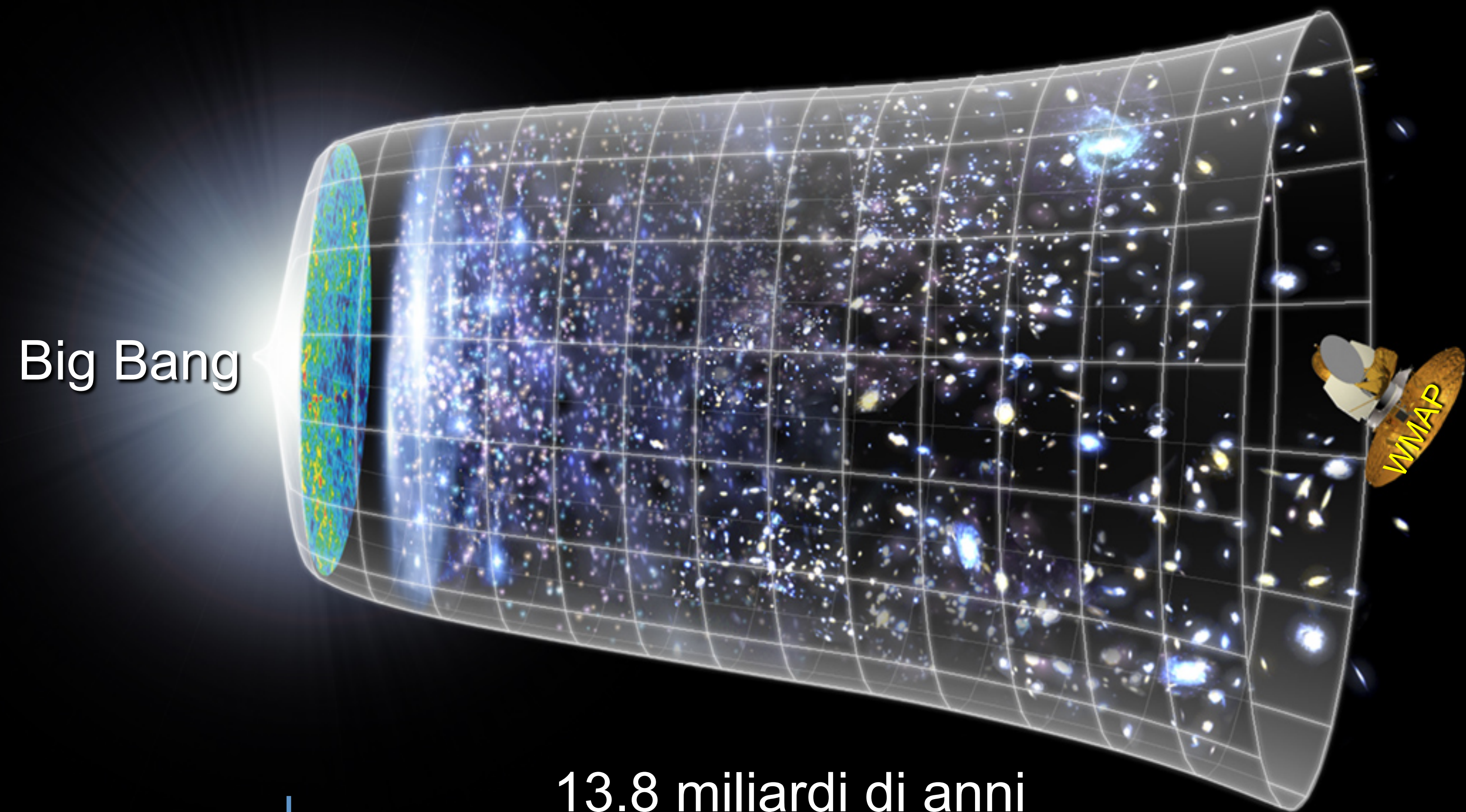
Alice
l'esperimento e la fisica

INFN Frascati

Pasquale Di Nezza

Masterclass 2014

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

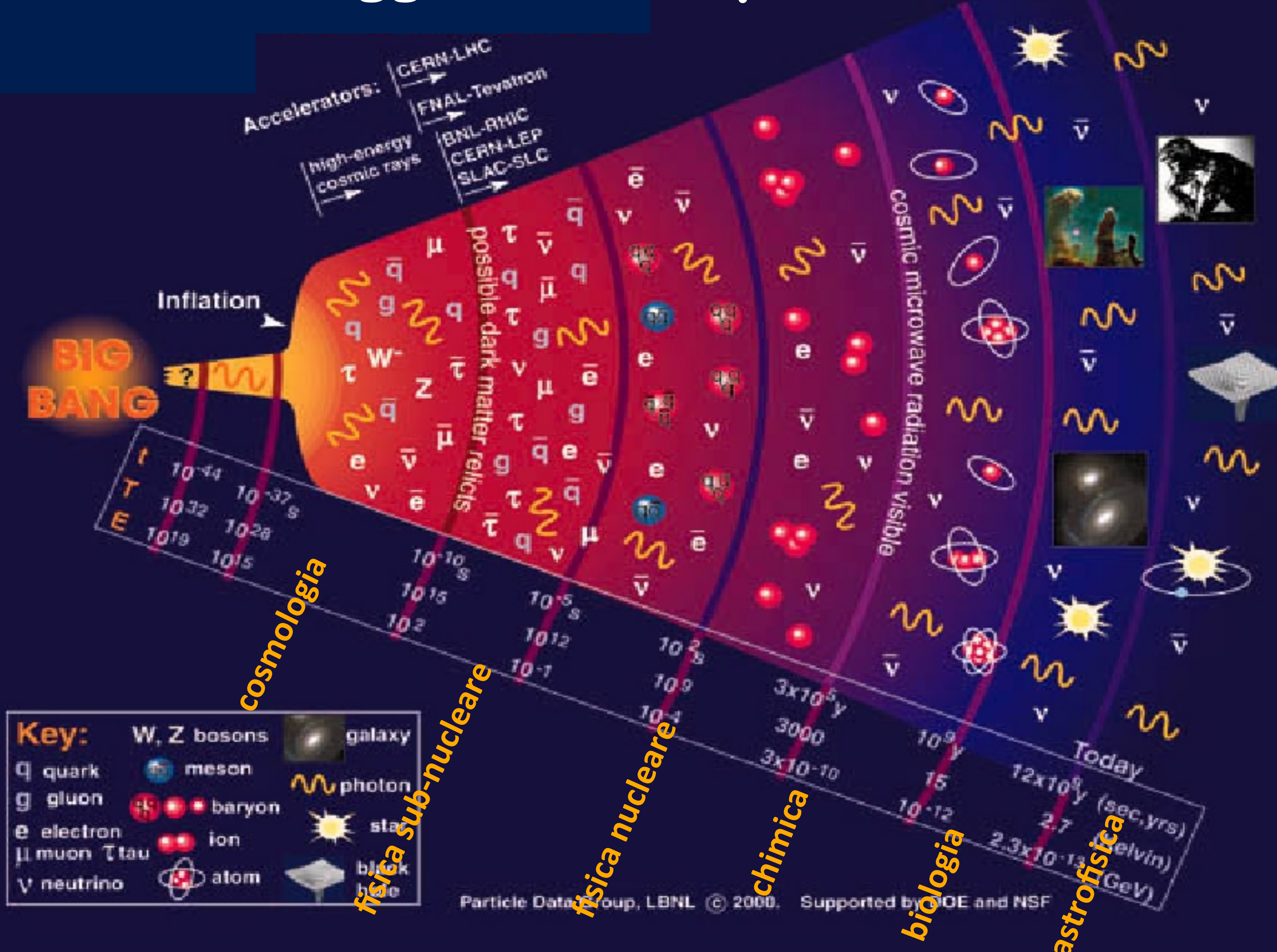


13.8 miliardi di anni

Oggi

10^{28} cm

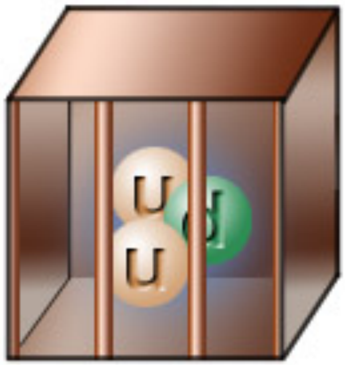
Alice … in viaggio nel tempo



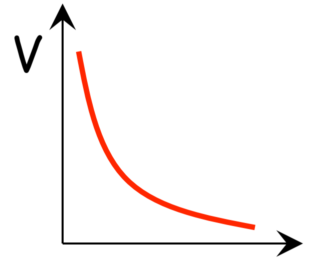
Fino a circa un centomillesimo di secondo dal Big Bang (10^{-37} - 10^{-5} s) l'Universo era formato da una "zuppa" di quark e gluoni … il Quark Gluon Plasma (QGP)

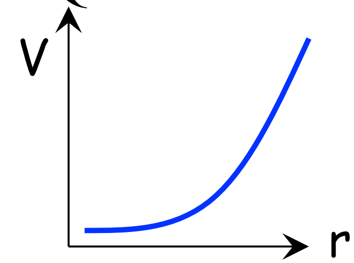
- Perchè studiare il QGP?
- Quali sono le caratteristiche del QGP?
- E' possibile riprodurlo in laboratorio?

Liberta' Asintotica → Confinamento



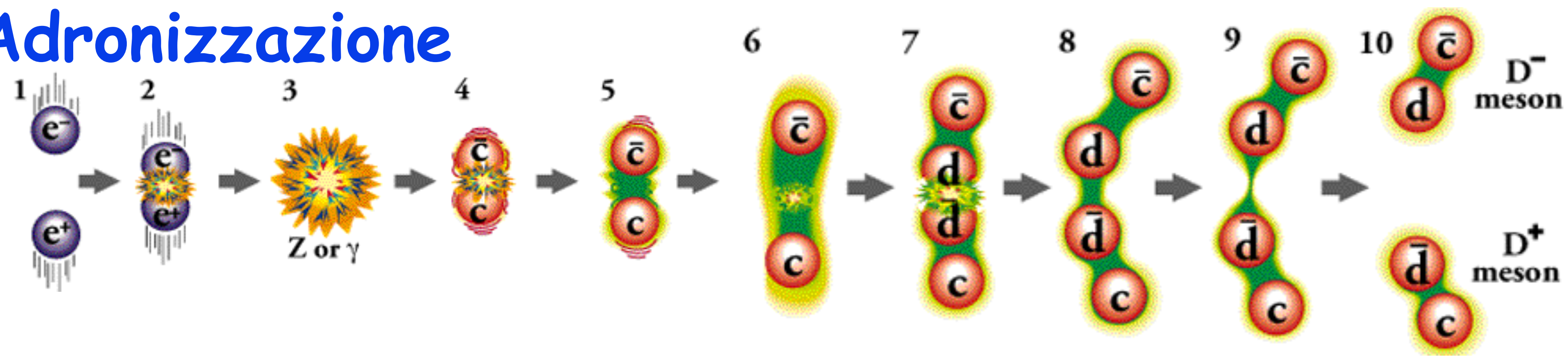
$$V_{Coulomb} \propto \frac{q_1 q_2}{r} \Rightarrow V_{QCD} \propto e^{k \cdot r}$$



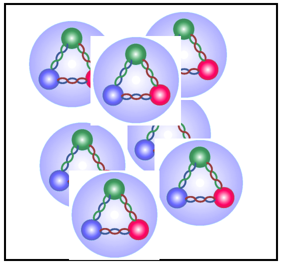


Allontanando i quark, si crea una tensione con energia sufficiente a creare altre particelle (1000 MeV / fm)

Adronizzazione

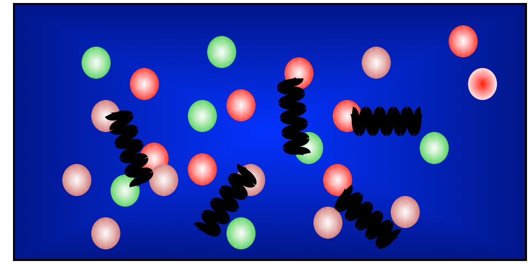


Bisogna creare un sistema che abbia una densità enorme (ptc a distanza infinitesima) tale da rendere trascurabile l'interazione forte



adroni

ENERGIA



Quark Gluon Plasma

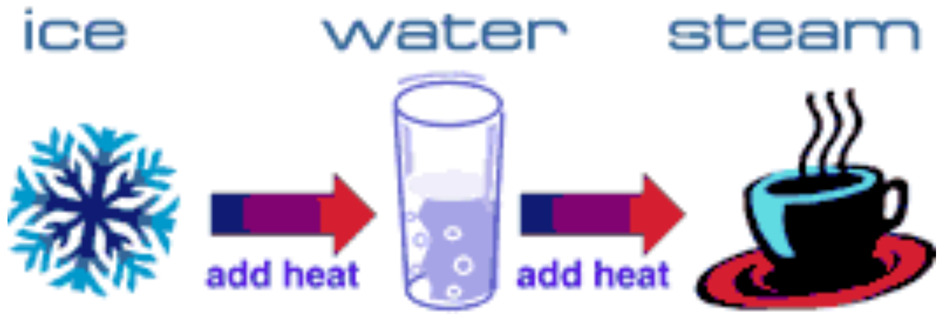
Nobel Prize 2005

D. Gross
H.D. Politzer
F. Wilczek

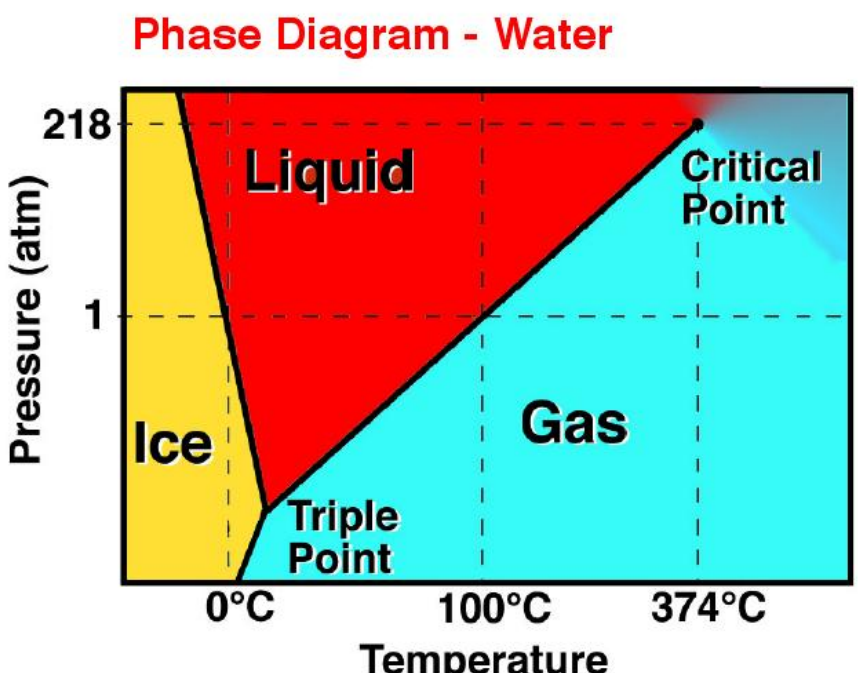
QCD Asymptotic Freedom (1973)

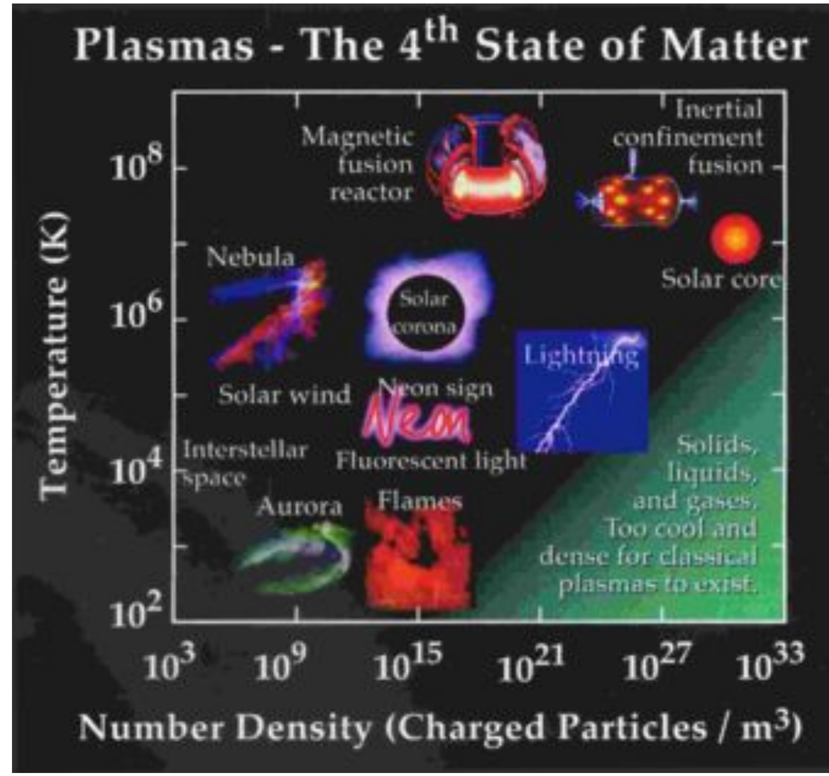
"Before [QCD] we could not go back further than 200,000 years after the Big Bang. Today…since QCD simplifies at high energy, we can extrapolate to very early times when nucleons melted…to form a quark-gluon plasma."
David Gross, Nobel Lecture (RMP 05)

Fasi della materia "normale"



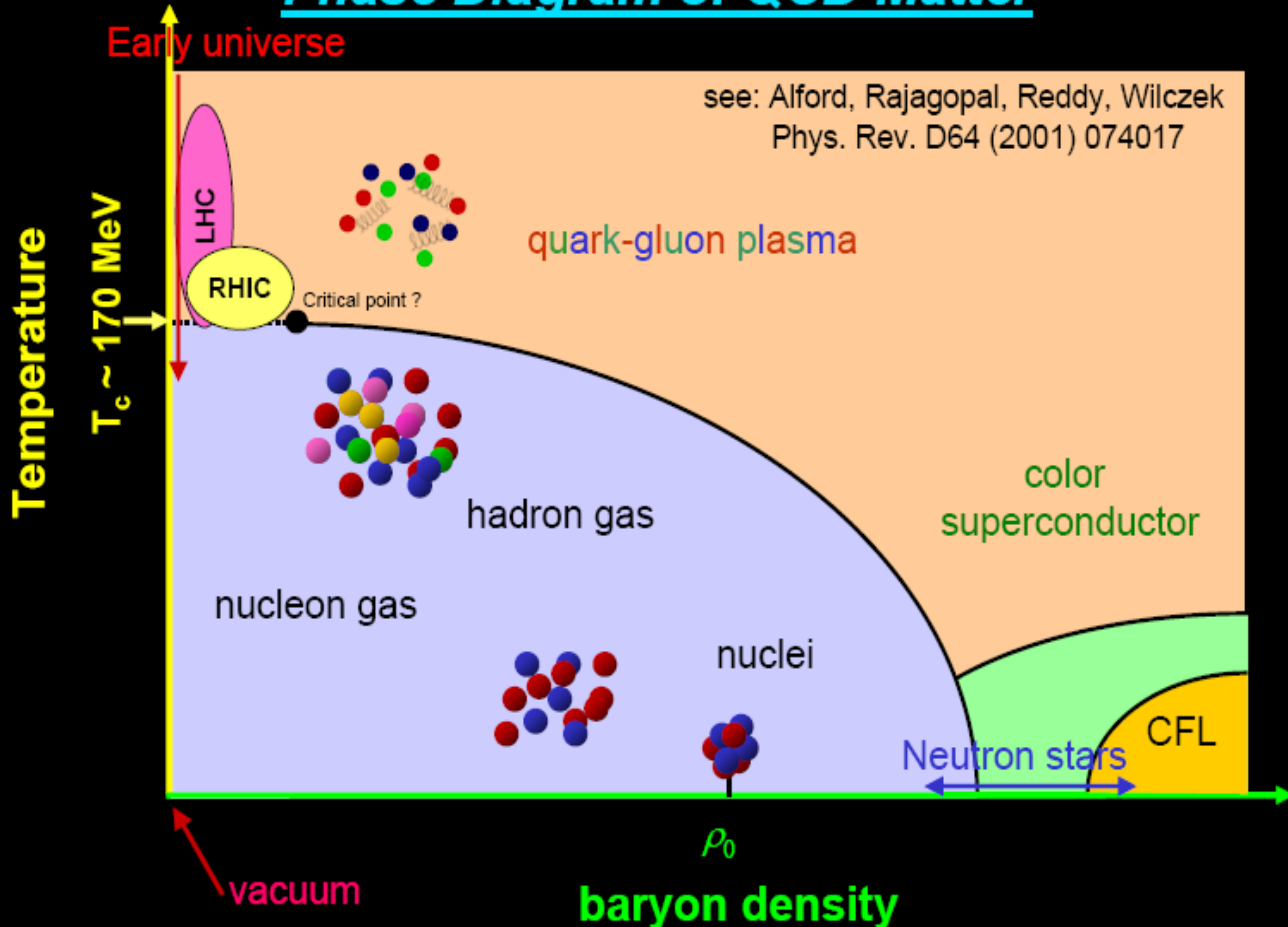
solido liquido gassoso





Plasma Classico

Phase Diagram of QCD Matter



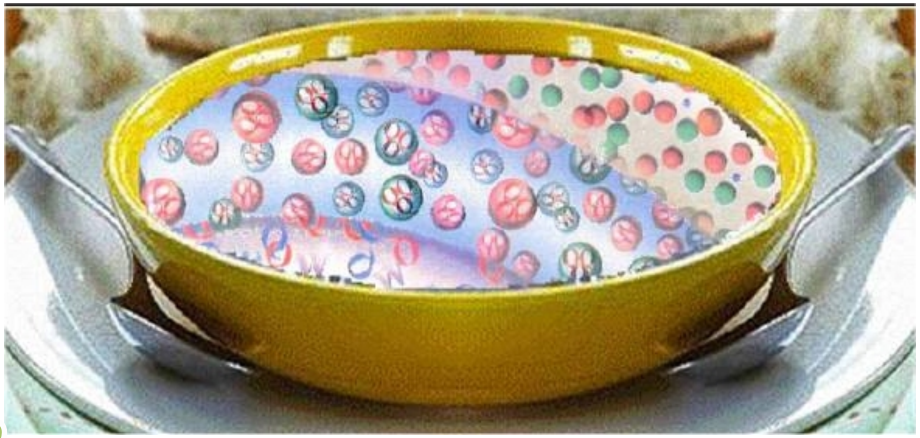
Una "zuppa" ricca di informazioni

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

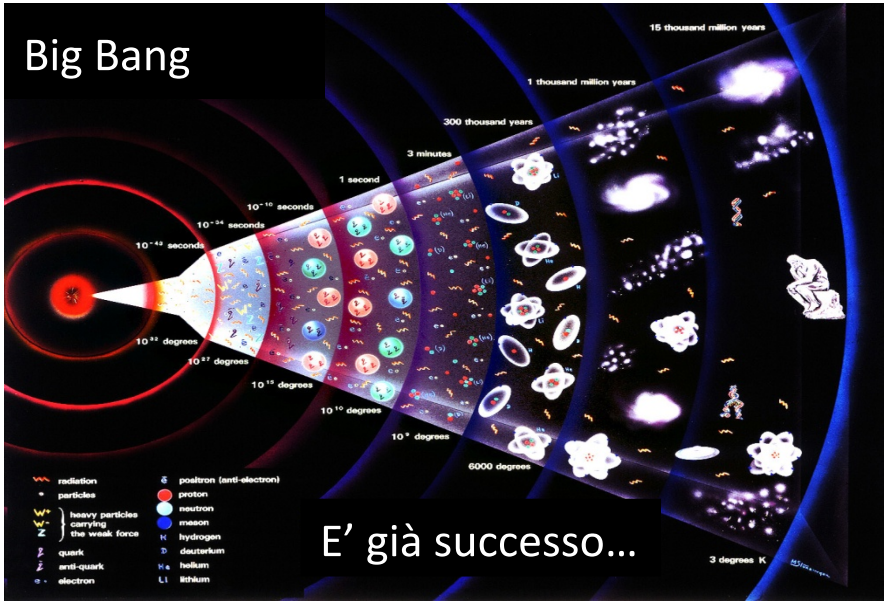
Transizione di fase q-g nelle teorie cosmologiche dell'Universo primordiale

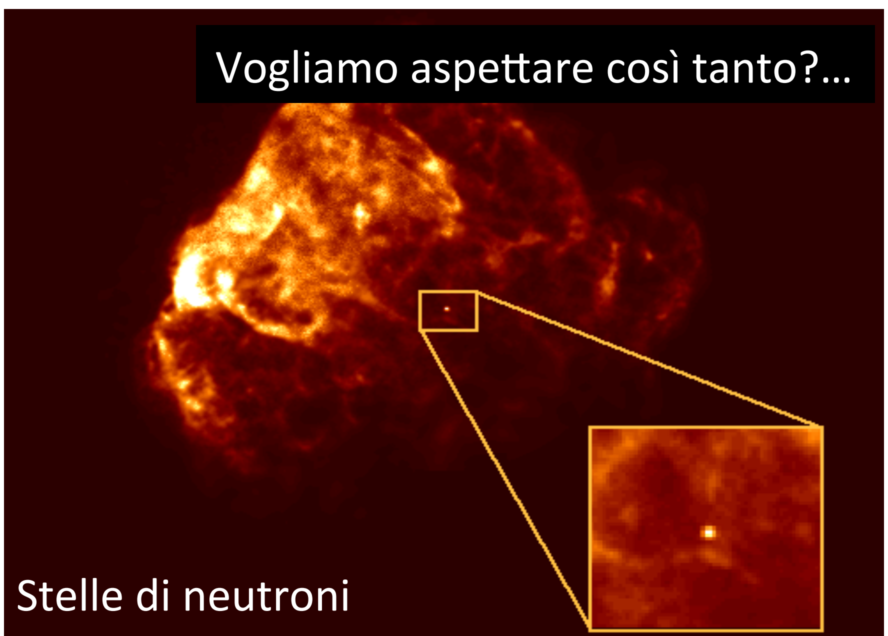
Equazione di stato della QCD

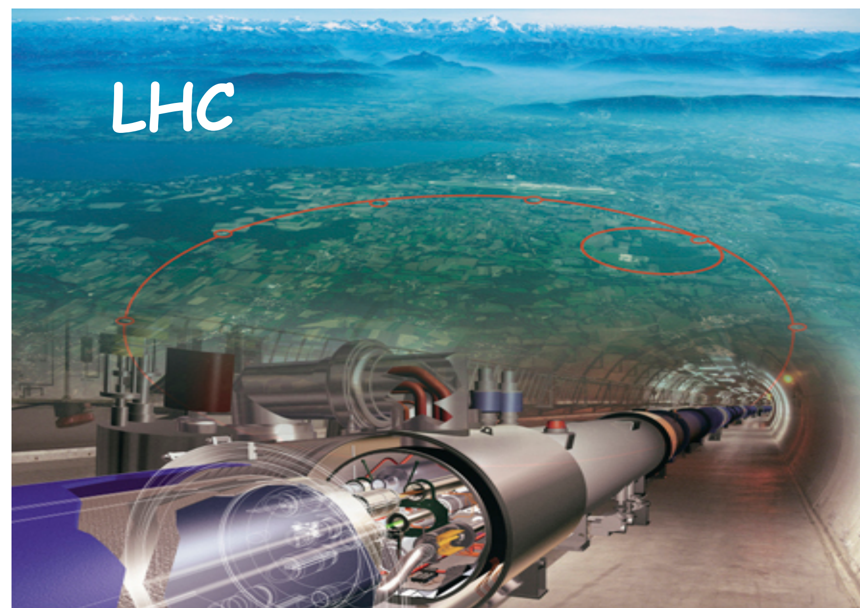
Perdita di energia partonica

Composizione chimica

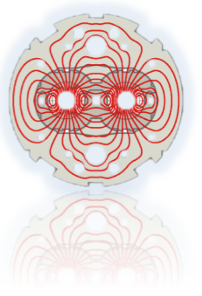
Dove si produce il QGP ?

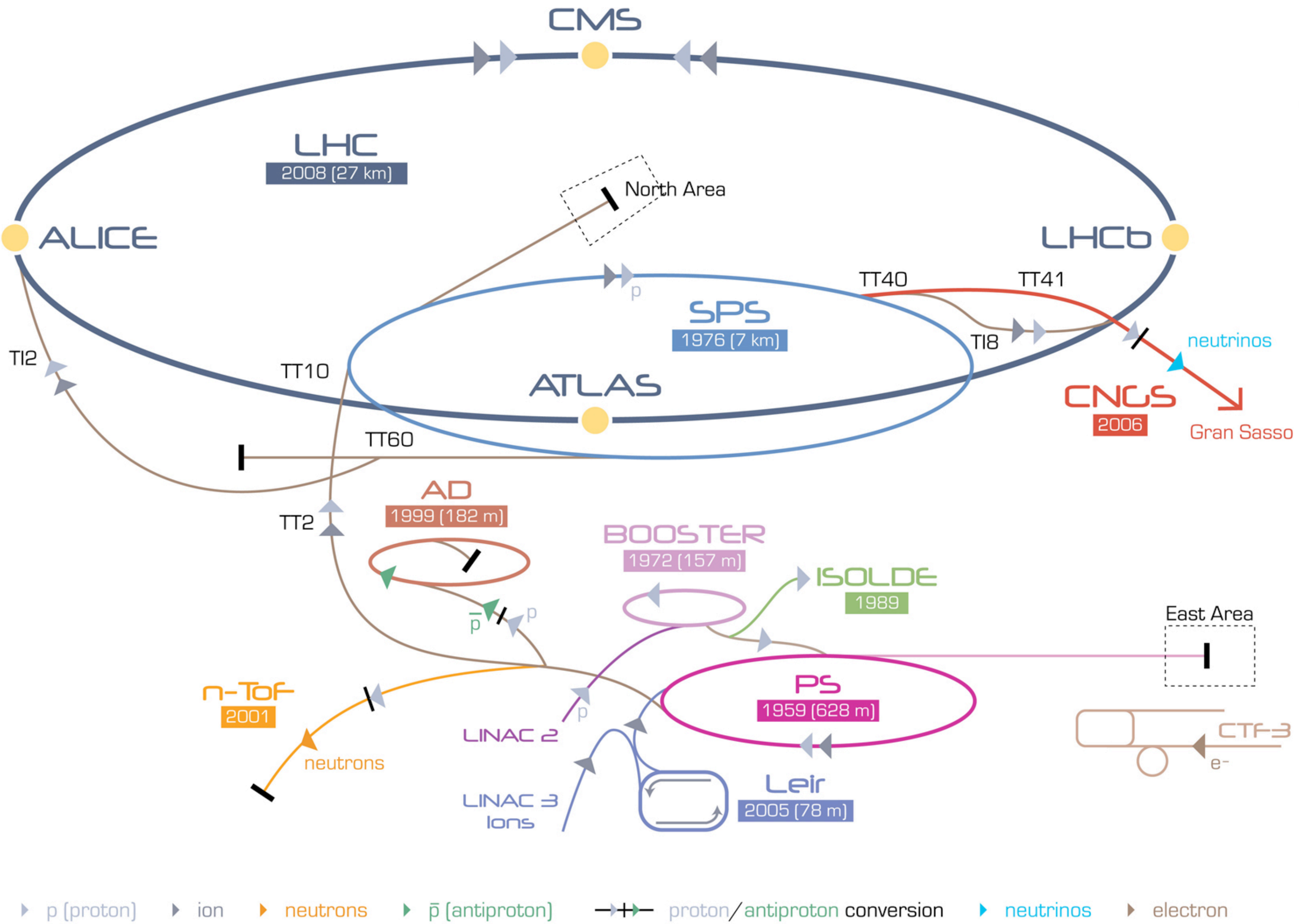






Complesso degli acceleratori del CERN





YEARS/ANS **CERN**

CERN, the European Organization for Nuclear Research, is celebrating its 60th birthday on September 29th.

The key messages engulfing all the celebrations are

- 60 years of Science for Peace
- Scientific Discoveries and the way ahead
- International Cooperation – Science as a motor for international dialogue
- 60 years of progress in Science and Technology
- Science Education and Training – Modern Science for Everyone

The celebrations happen at the site of the Organization in Meyrin in the Canton of Geneva and in all of the now 21 members states.

CERN | 60 YEARS/ANS CERN

Celebrating 60 years of Science for Peace

CERN-related Events	25 y	The World Wide Web
	30 y	Nobel Prize for Rubbia and Van der Meer
	50 y	ESRO – European Space Research Organisation
		ICTP – The Abdus Salam International Centre for Theoretical Physics
Other Anniversaries for Information	40 y	J/ψ Discovery
	50 y	Initial publications on spontaneous symmetry breaking
		Initial publications about quarks by Gell-Mann and Zweig
	135 y	Albert Einstein
	200 y	The Swiss Academy of Sciences
	450 y	Galileo Galilei

CERN | YEARS / ANS CERN

Relevant Anniversaries in 2014/15

- Several events will take place centrally
  - July 1st, UNESCO, Paris
    Celebration of the Convention
  - September 19th, CERN, Geneva
    Celebration of the First Council Session Anniversary
  - September 29th, CERN, Geneva
    Celebration of CERN's Anniversary

- Many other events will happen during the year, e.g.

TEDx
x = independently organized TED event

International FameLab
TALKINGSCIENCE

S'Cool LAB

CineGlobe
Festival International de Films au CERN
INSPIRÉ PAR LA SCIENCE

GE200.CH

CERN | 60 YEARS / ANS CERN

Stay tuned ...

cern.ch/cern60

YEARS / ANS CERN

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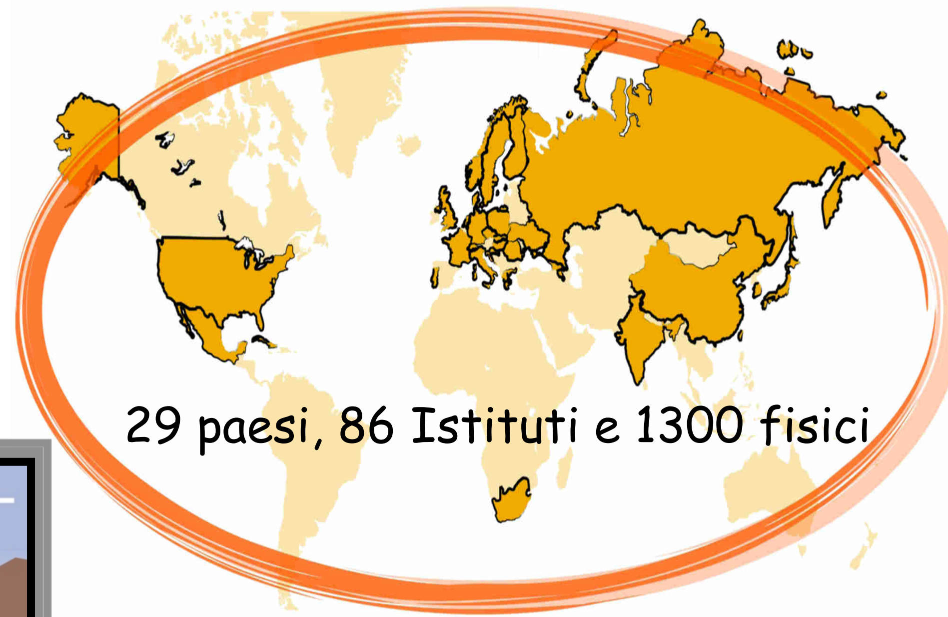
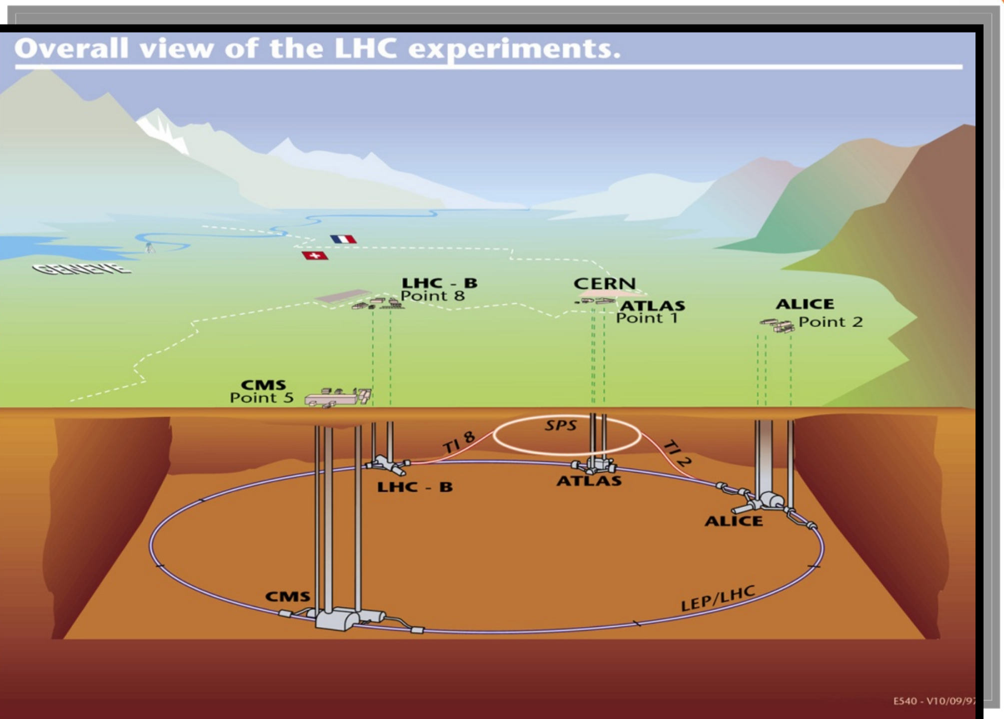
LHC, il più potente acceleratore del mondo

ALICE: A Large Ion Collider Experiment

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





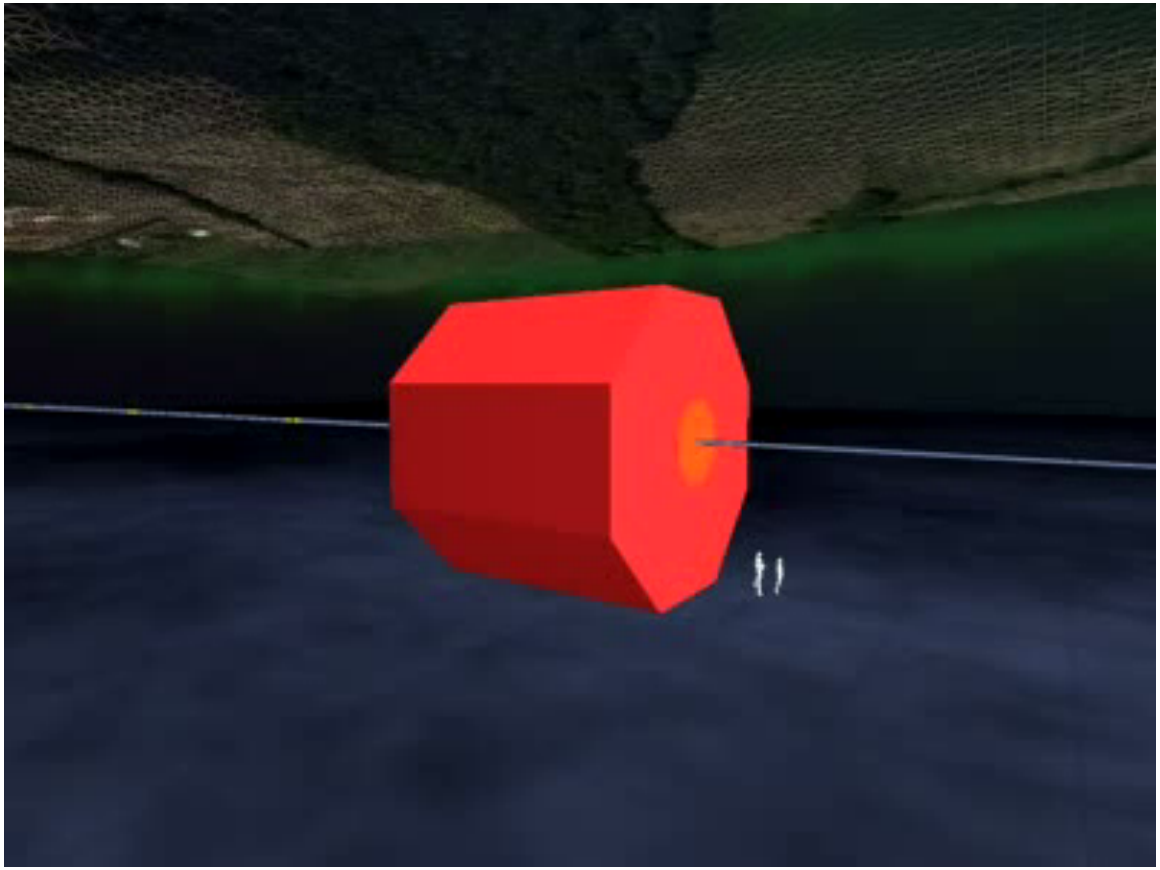
200 fisici Italiani: BA, BO, CA, CT, LNF, LNL, PD, RM1, SA, TO, TS

QGP attraverso gli Heavy Ions

Energia: $$E_{beam} = 7\frac{Z}{A}\text{TeV} \Rightarrow \sqrt{s} = 5.5\ \text{TeV/A per Pb - Pb}$$

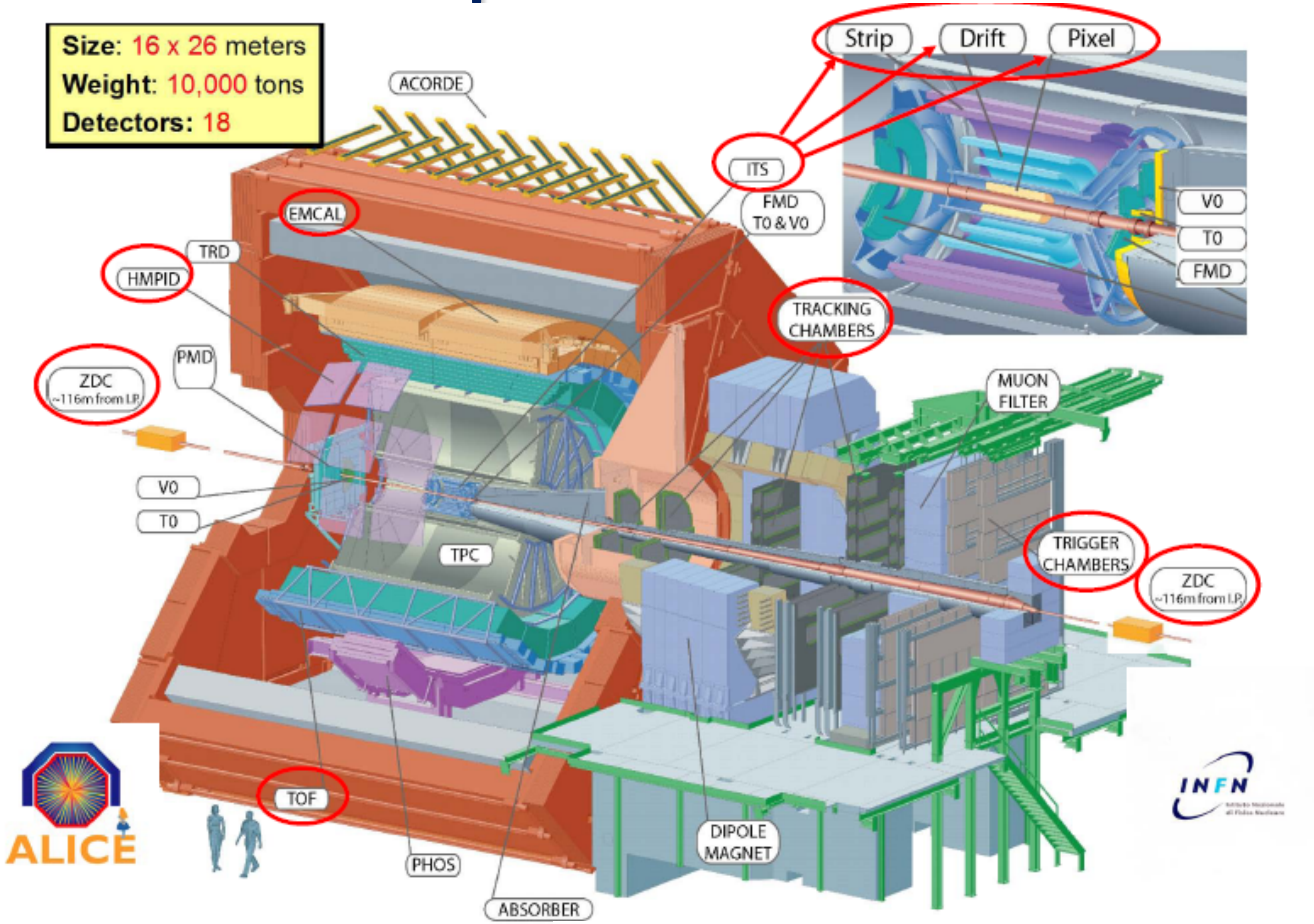
2 nuclei di Piombo collidono ad altissima energia creando un sistema ad altissima densità

La collisione in Alice

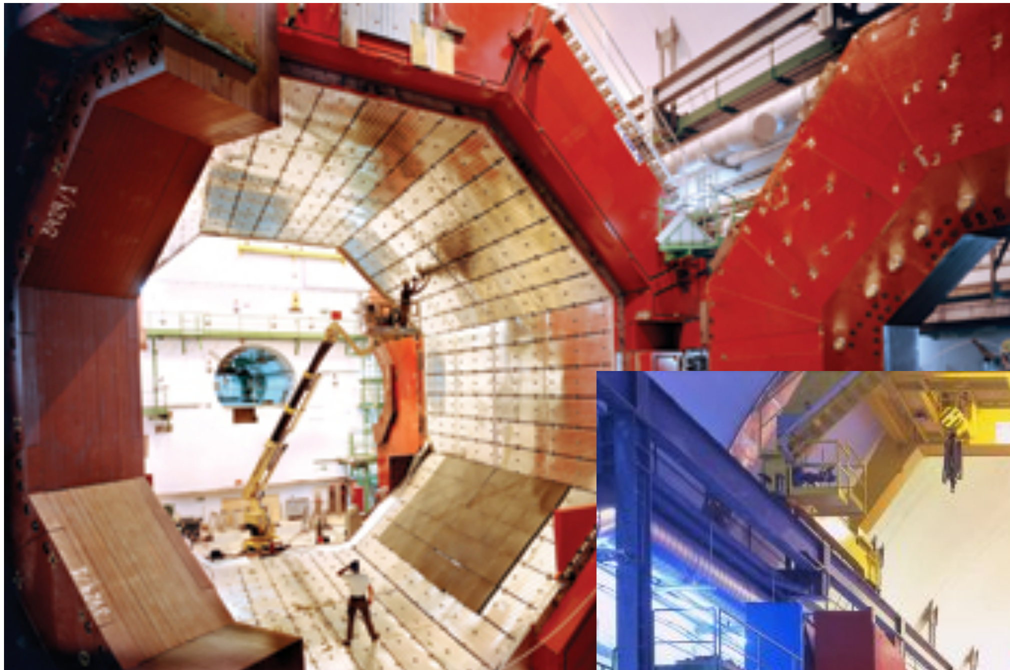


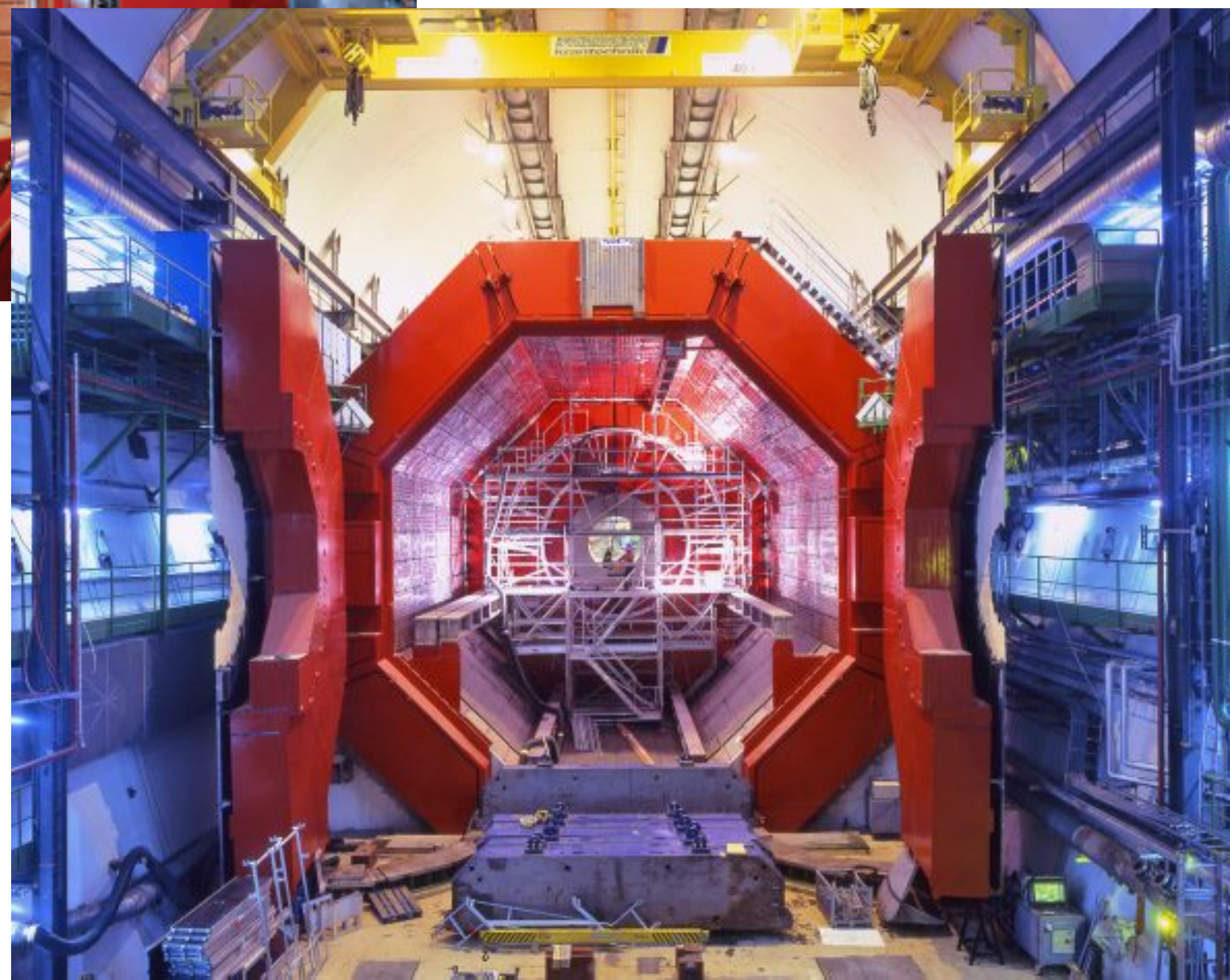
Lo spettrometro

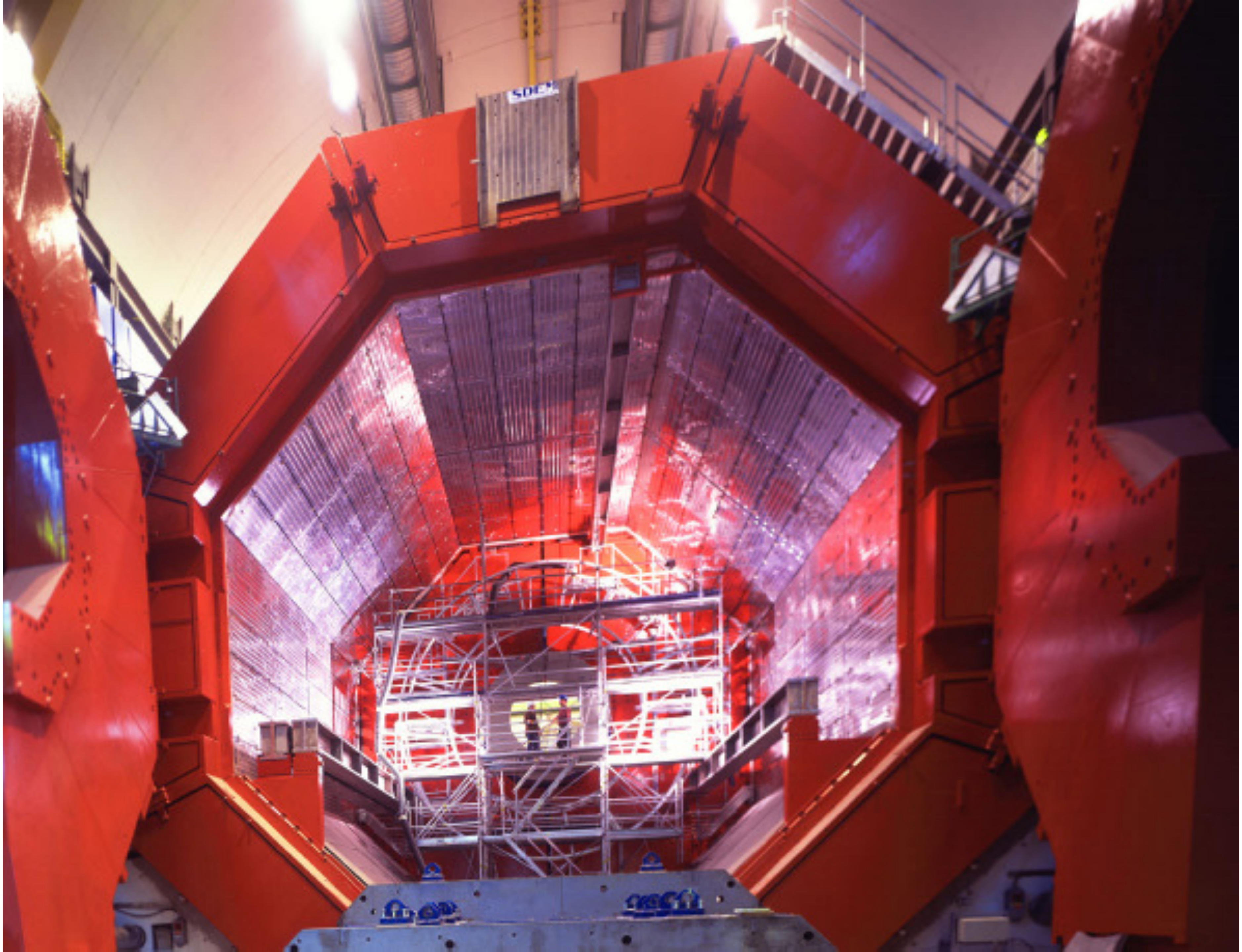
Size: 16 x 26 meters
Weight: 10,000 tons
Detectors: 18

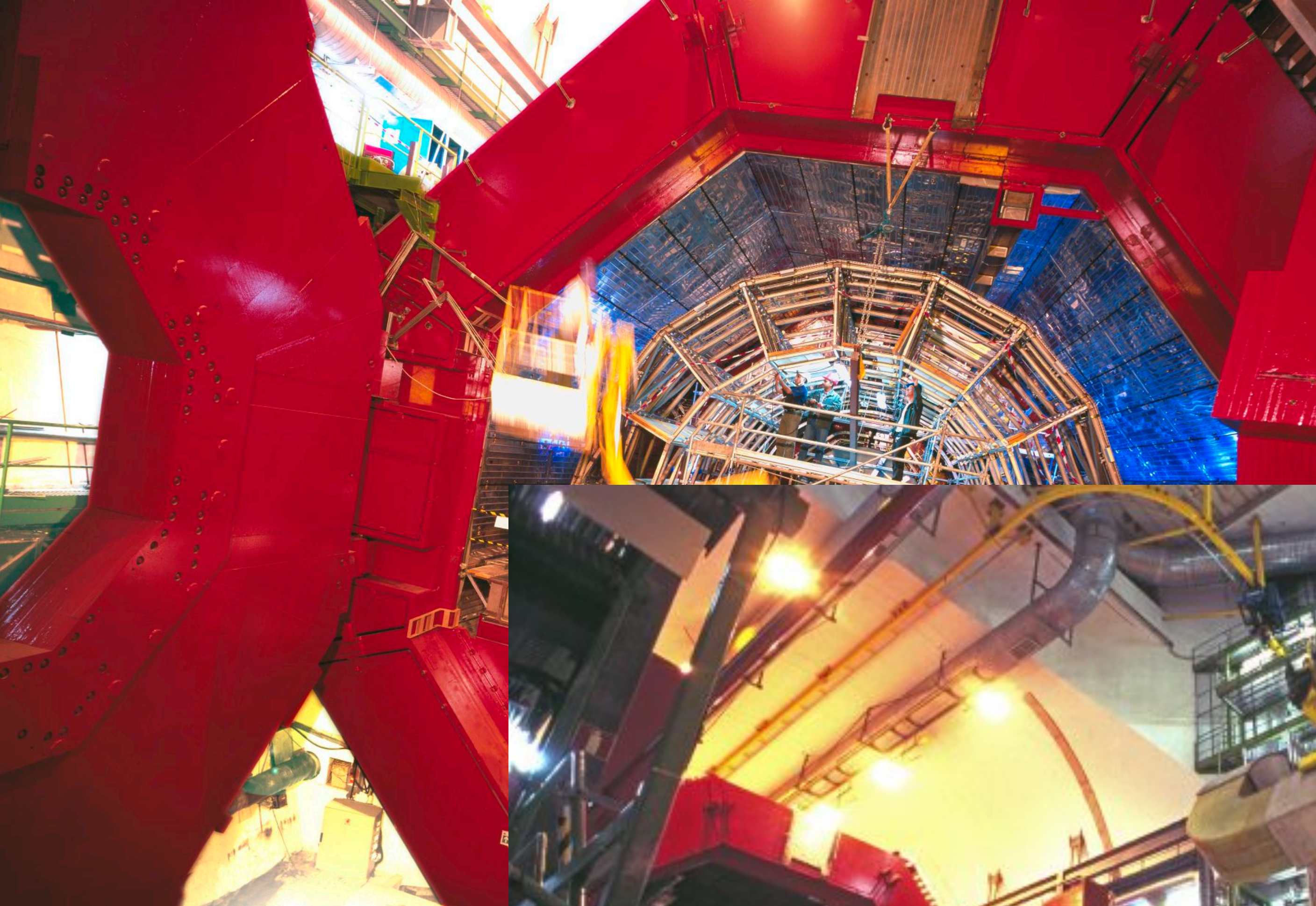


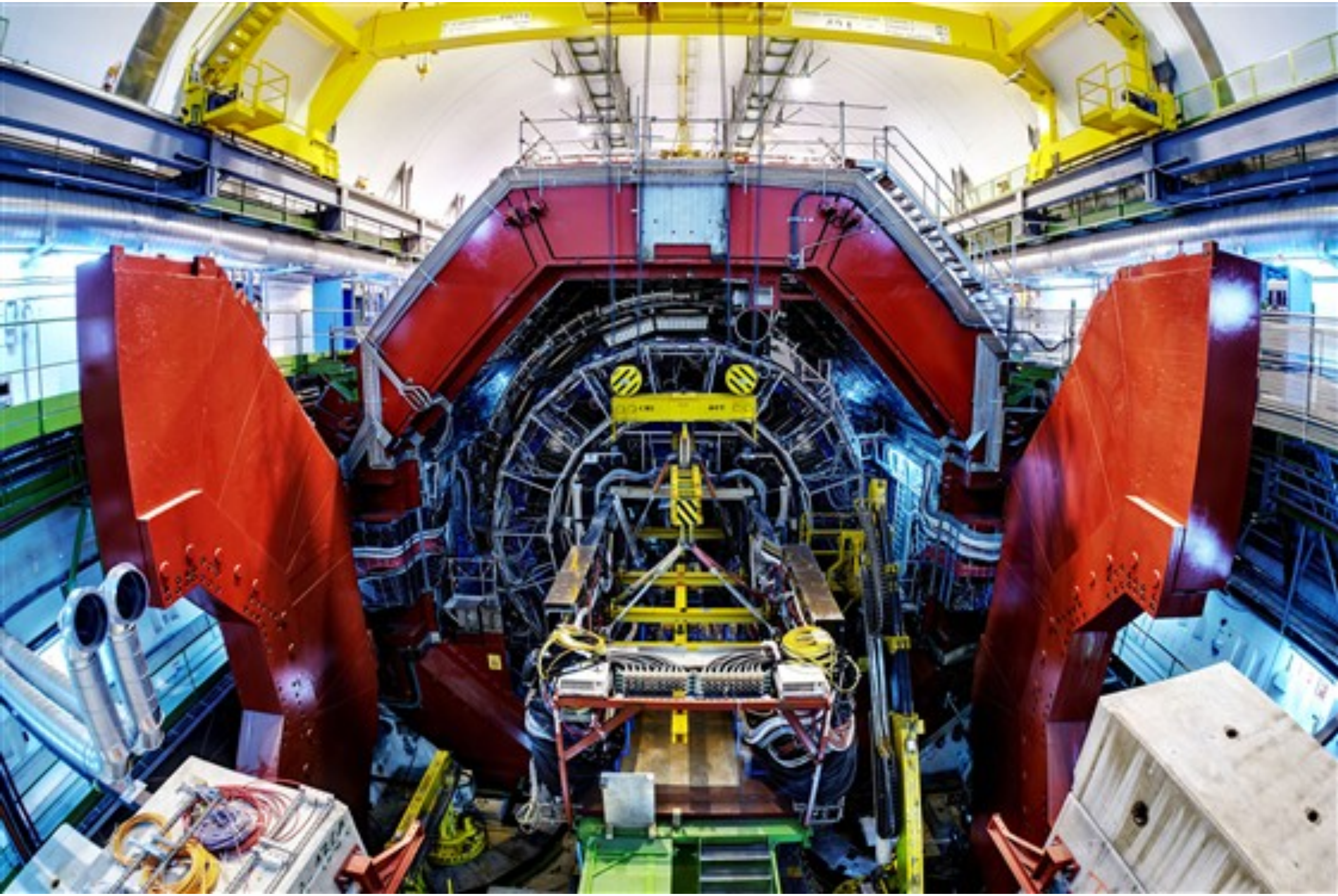
: Rivelatori sotto la completa o parziale responsabilità INFN



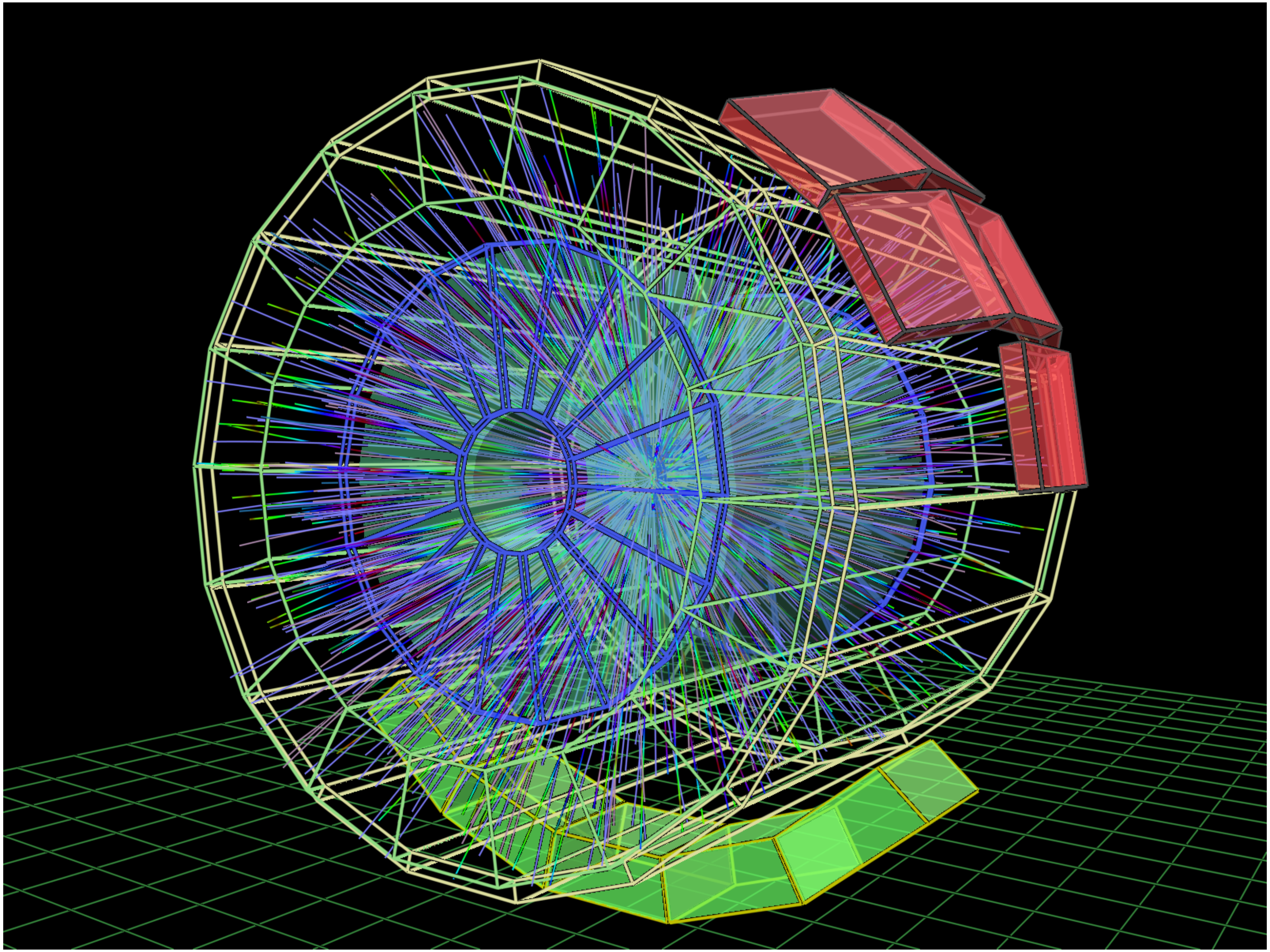




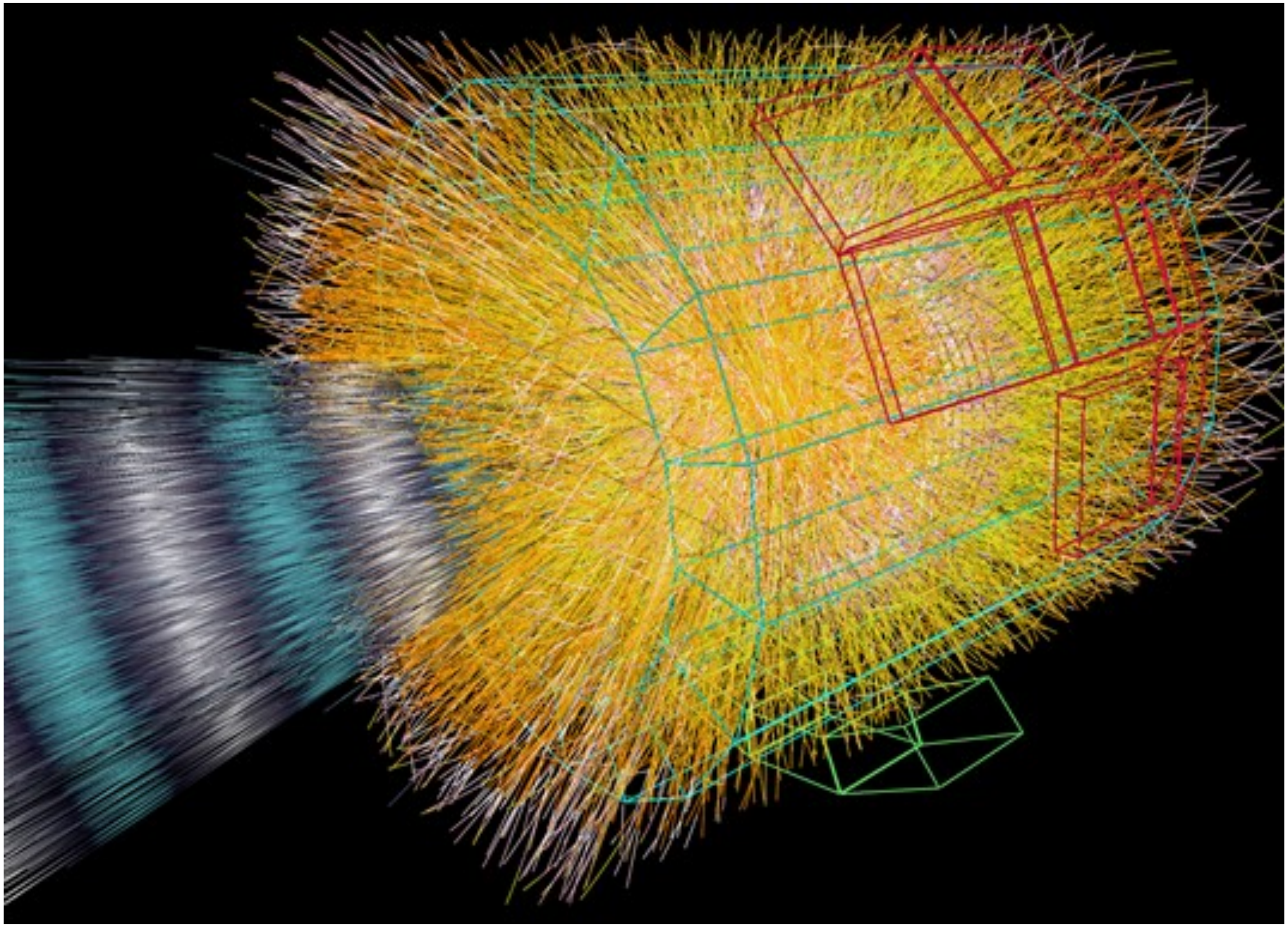


Eventi pp in Alice



Eventi PbPb in Alice

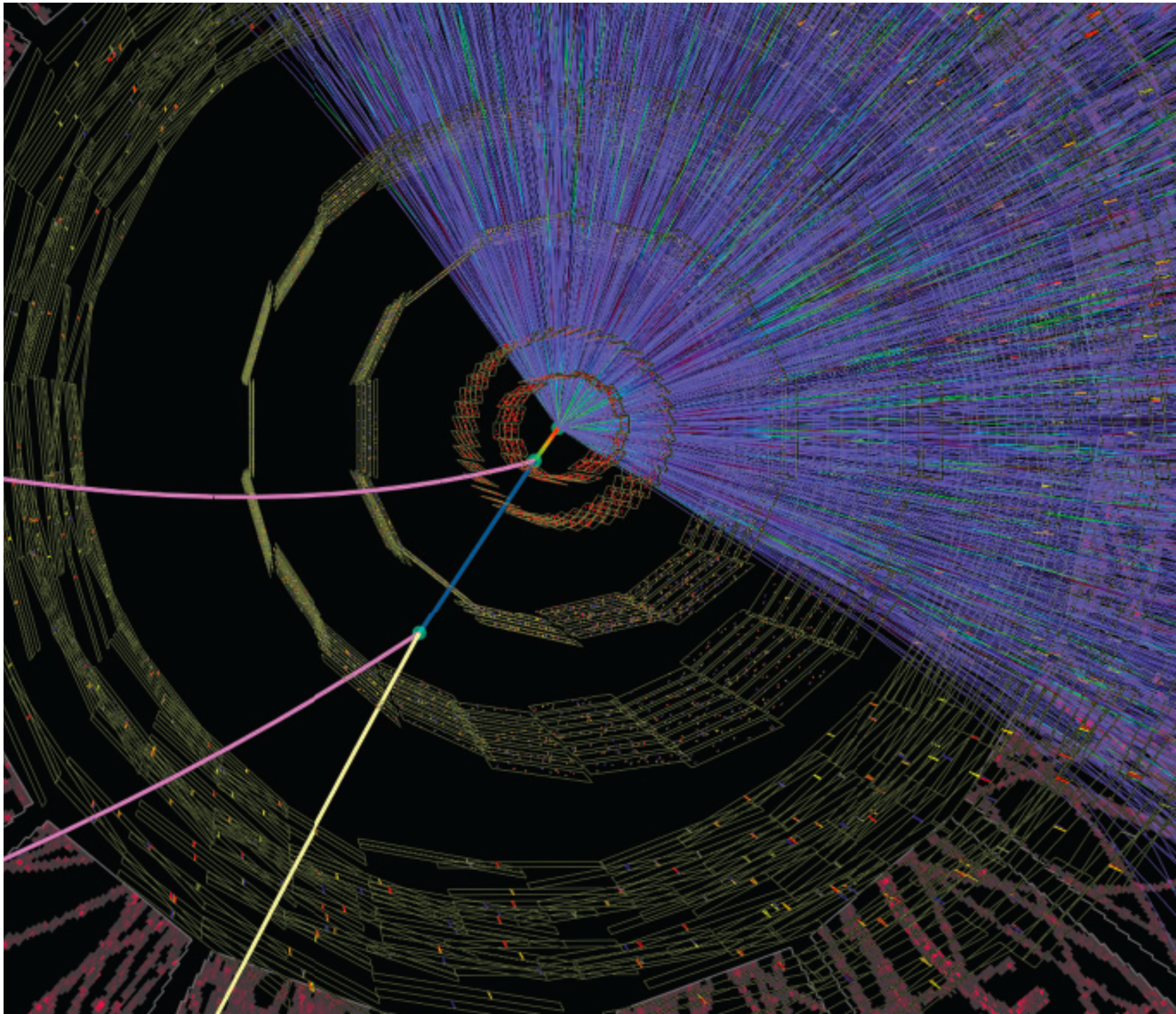


Migliaia di tracce prodotte ad ogni interazione (25 ns)

Selezione di tracce "buone"

Eccellente tracking + vertice + Identificazione di particelle (PID)

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



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

$Ks(d\overline{s})$

$p(uud)$

$n(udd)$

$\Lambda(uds)$

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

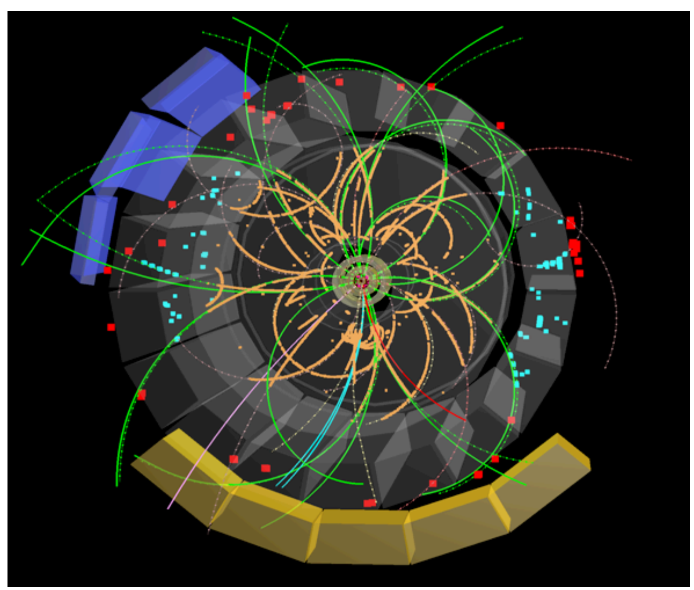
τ = 0.89 x 10^{-10} s

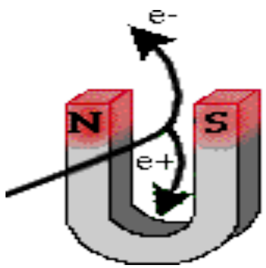
cτ = 3×10^{10} cm s^{-1} x 0.89 x10^{-10} s = 2.67 cm dal punto d’interazione

$\Lambda \rightarrow \pi^- p$

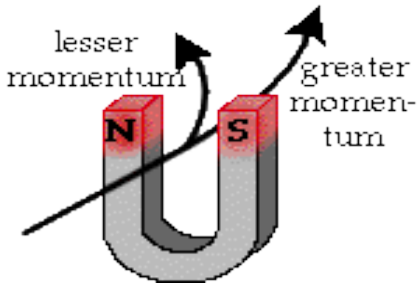
τ = 2.6 x 10^{-10} s

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





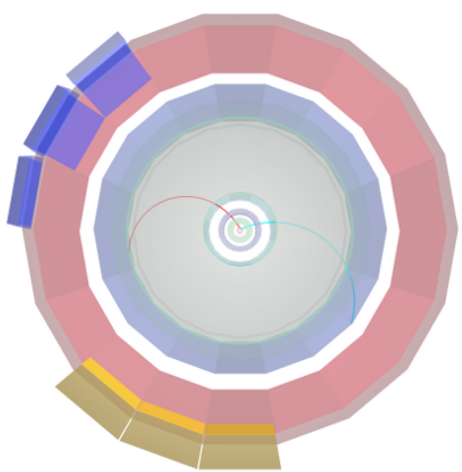
Identifica
la carica

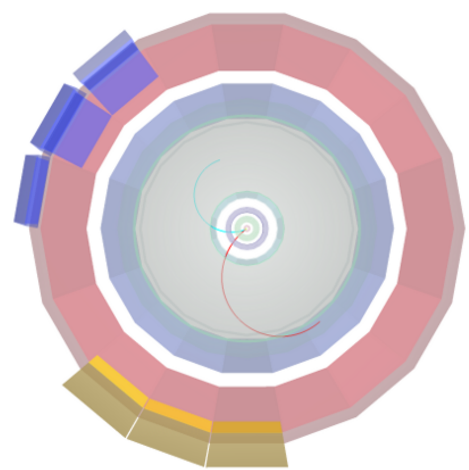


Misura
l'impulso

Simmetrico

Asimmetrico





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

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

Prima parte

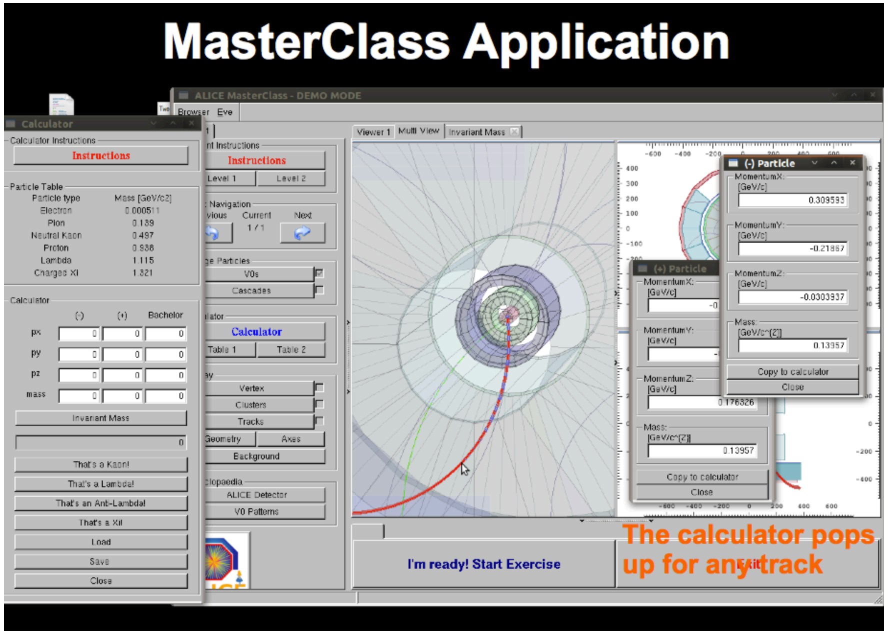
- Identificare i V0 (K^0_s, Λ, anti-Λ) dai decadimenti

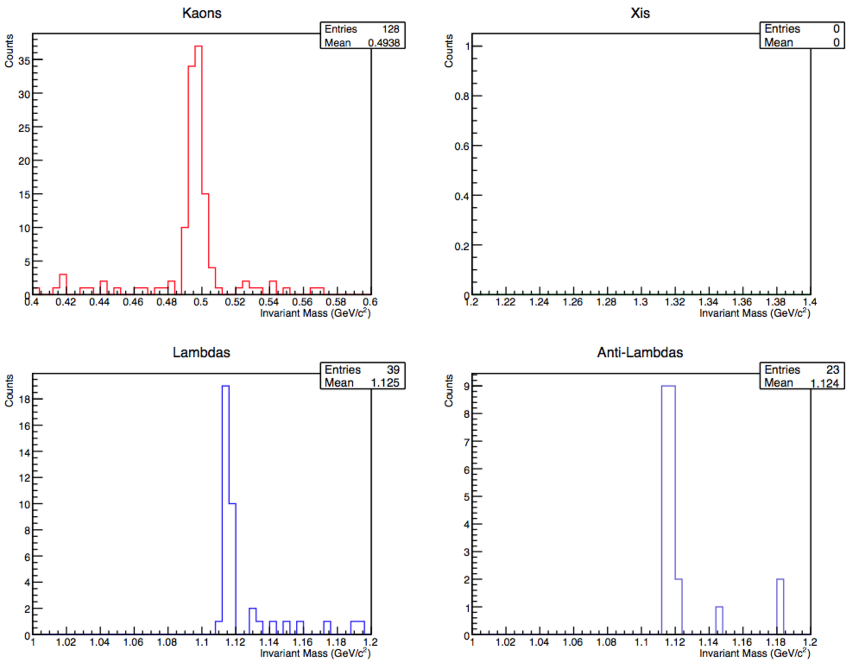
  (V0 : due tracce con carica opposta

  provenienti da uno stesso vertice secondario)

- Calcolo della massa invariante

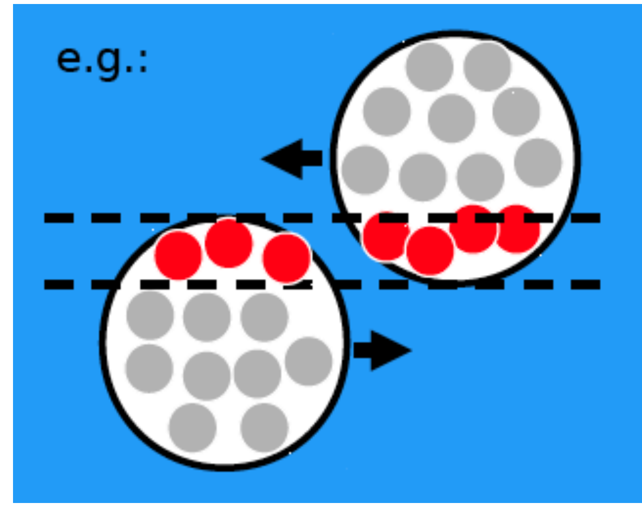
- Classificare le particelle secondo la loro massa invariante ed il tipo di particelle di decadimento



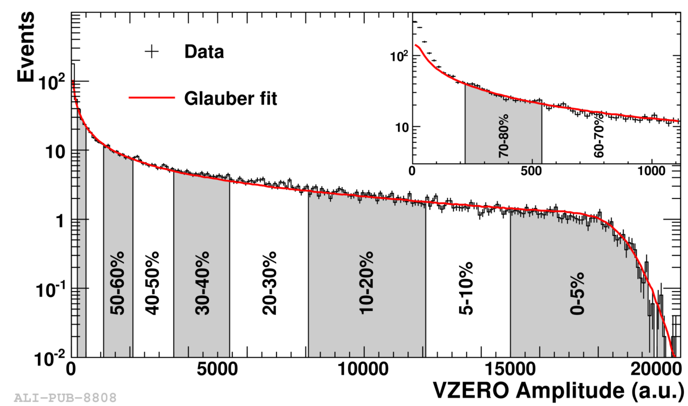


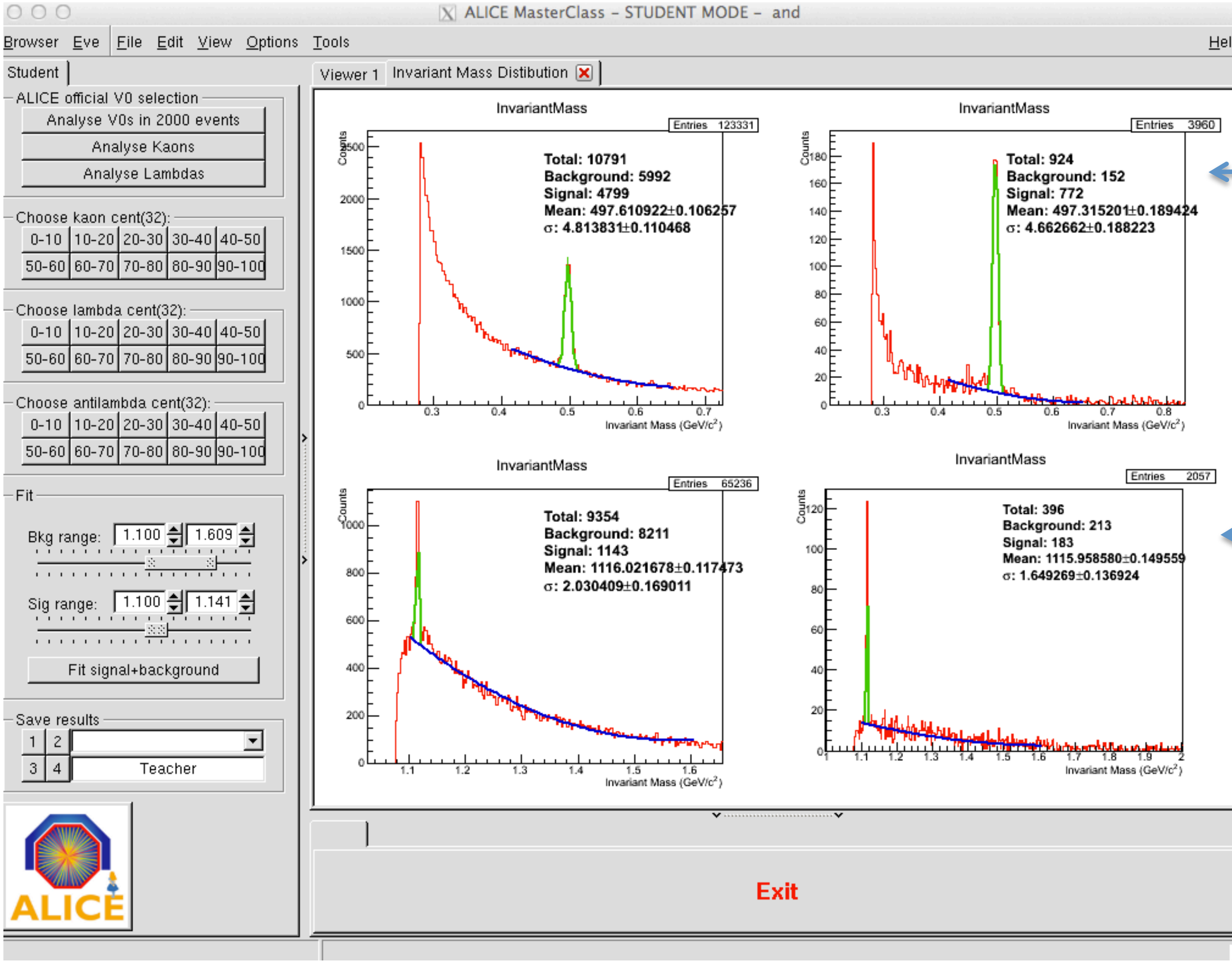
Seconda parte

- 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)

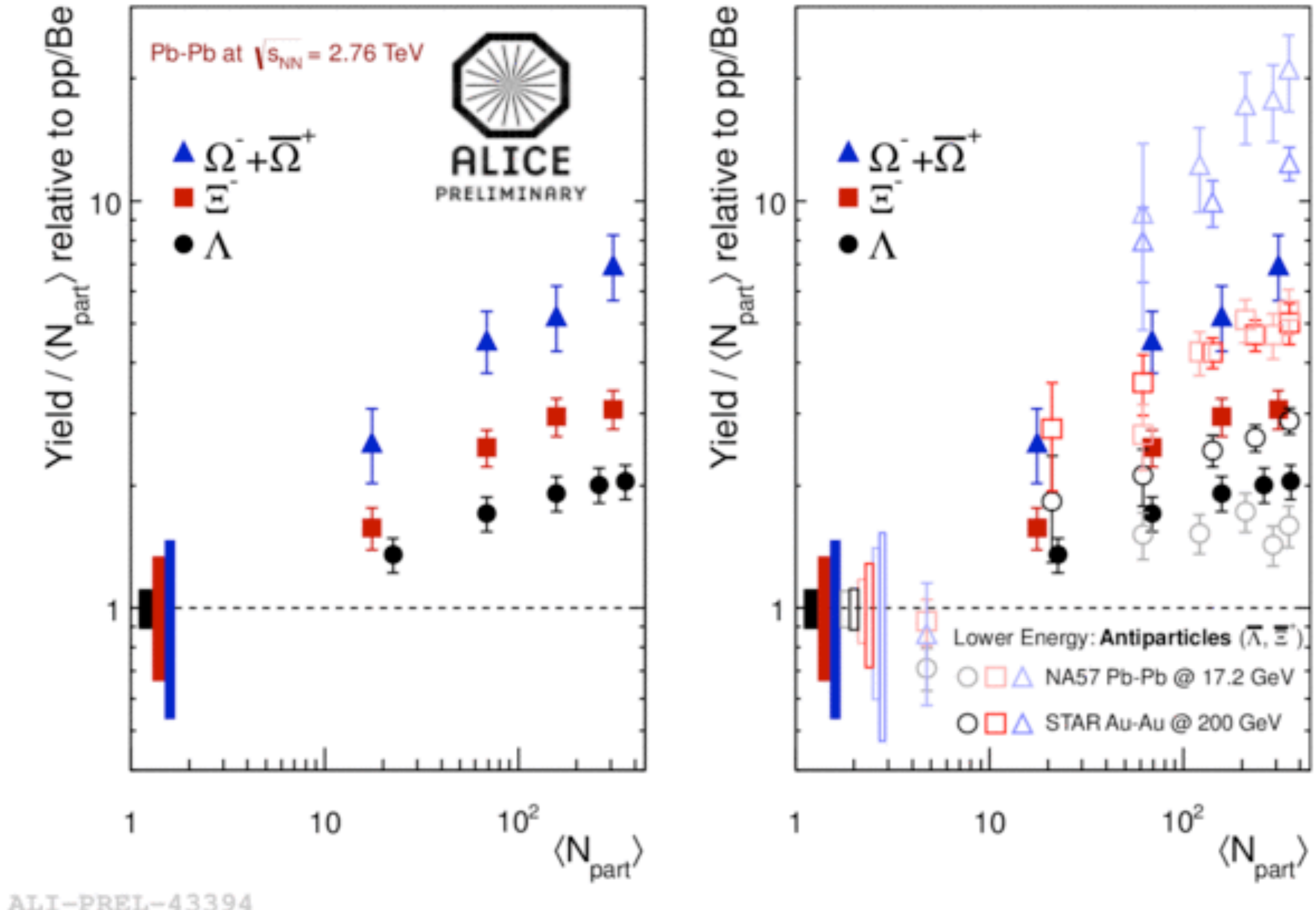
Yield : numero di particelle prodotte per interazione
Yield = Nparticelle(prodotte)/Neventi = Nparticelle(misurate)/(efficienza x Neventi)

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 ; $\langle N_{part} \rangle = 2$ per pp

Dove scaricare il materiale

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



Pb-Pb at $\sqrt{s_{NN}}$ = 2.76 TeV
ALICE
PRELIMINARY
$\Omega^- + \overline{\Omega}^+$
Ξ^-
Λ
Yield / ⟨N_{part}⟩ relative to pp/Be
⟨N_{part}⟩
1
10
10^2
Lower Energy: **Antiparticles** ($\overline{\Lambda}$, $\overline{\Xi}^+$)
NA57 Pb-Pb @ 17.2 GeV
STAR Au-Au @ 200 GeV
ALI-PREL-43394