

Como observar o infinitamente pequeno?

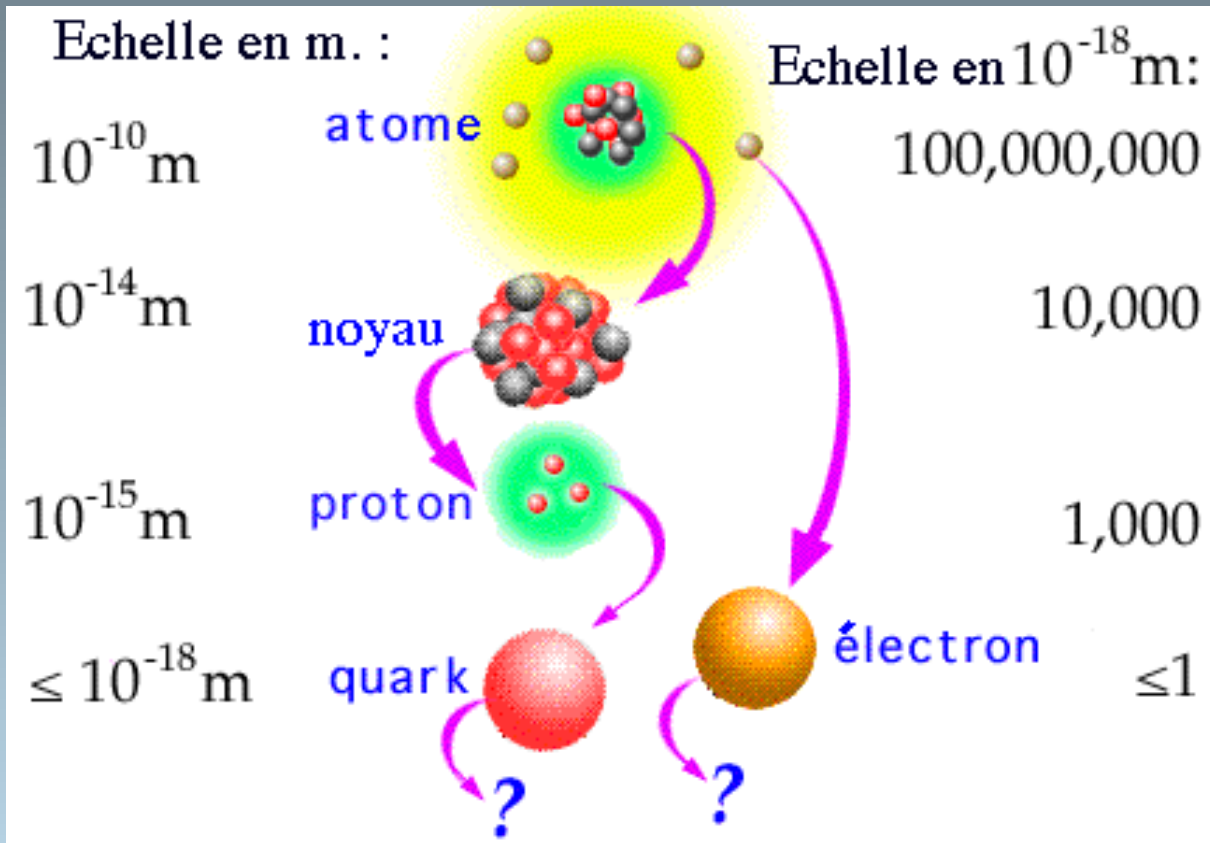
Fernando
Barão

IST/ Dep. Física

Tópicos

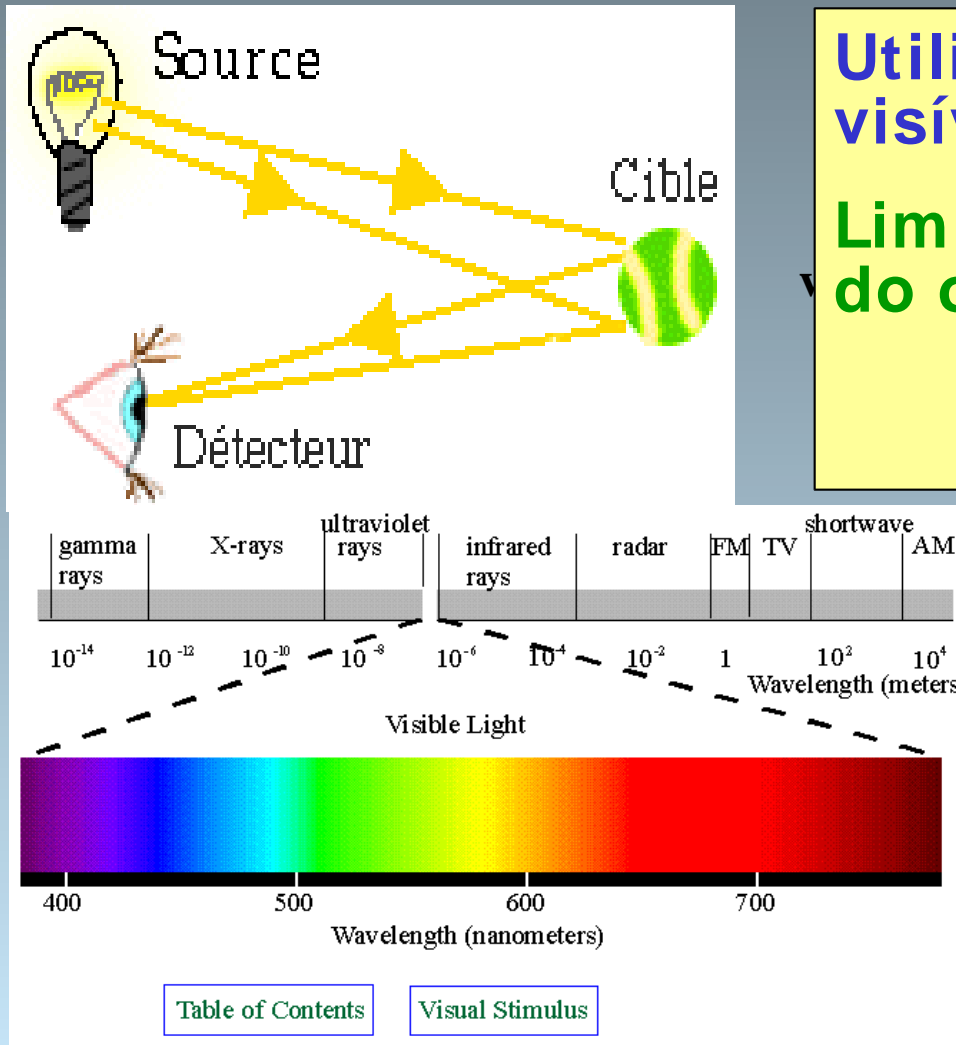
- *Partículas de Altas energias: porquê?*
- *Como se obtêm?*
 - *Raios cósmicos*
 - *Aceleradores*
- *Como se detectam as partículas?*
 - *Detectores*
- *Experiências tipo*

Composição da matéria



Núcleo/ electrões
Thomson (e) 1897
Rutherford (núcleo)
1909

Mecanismo básico de observação...



Utilização de luz visível

Limite no tamanho do objecto (10^{-7} m)

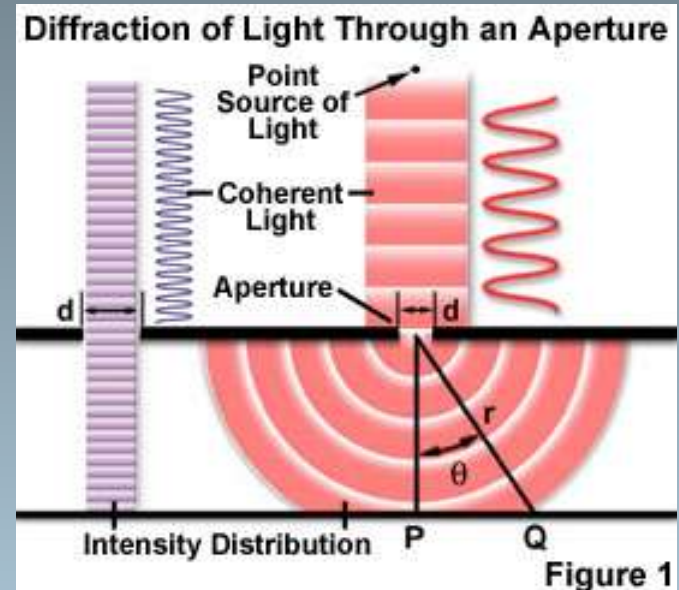
Sondar a matéria...

Luz: Einstein quanta

$$E = hc / \lambda$$

Constante de Planck

Comprimento de Onda



Sondar a estrutura da matéria $\Rightarrow \lambda < 10^{-10} \text{ m}$

E???

Escala de energias...

Electrão-volt: pequenas energias

$$1 \text{ eV} = 1.6 \cdot 10^{-19} \text{ Joule}$$

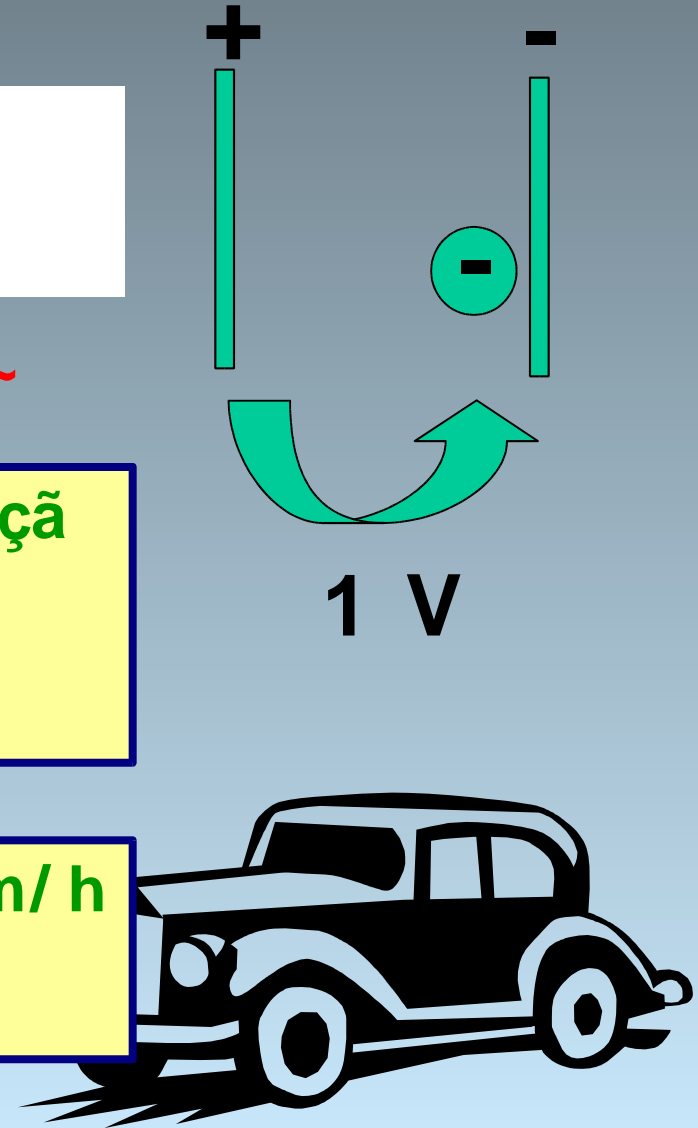
Luz visível ~
eV

Energia da maçã
(Newton!):

$$E \sim 1 \text{ Joule}$$

Carro 100 Km/h

$$E \sim 10^5 \text{ Joule}$$

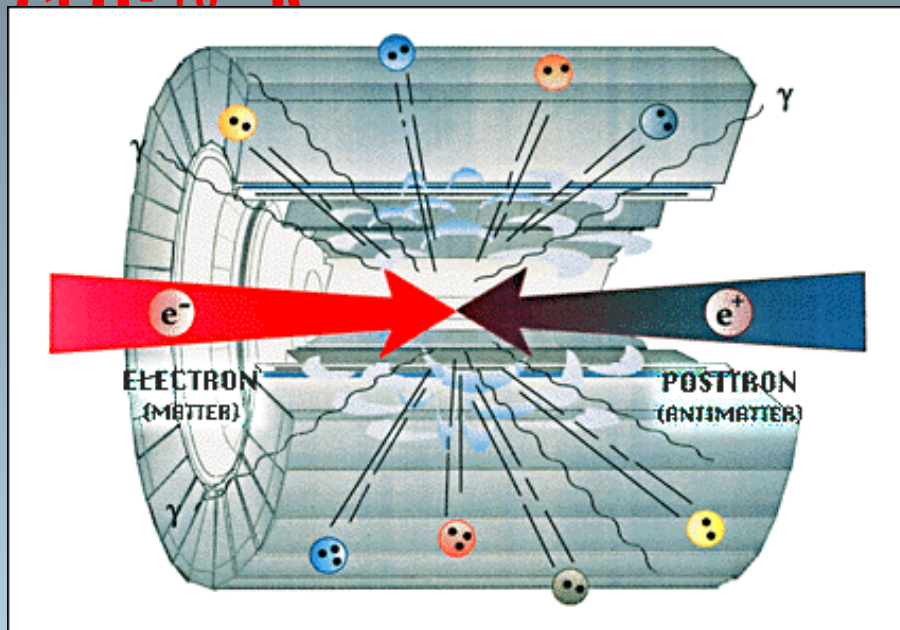


Escala de energias...

<i>Radiação de fundo (microondas)</i>	<i>$\sim 3 \times 10^4 \text{ eV}$</i>
<i>Luz visível</i>	<i>$\sim \text{eV}$</i>
<i>Raios X</i>	<i>$\sim 10^3 \text{ eV}$</i>
<i>Raios catódicos</i>	
<i>Acelerador LEP (Cern)</i>	<i>10^{10} eV</i>
<i>Acelerador LHC (Cern)</i>	<i>10^{12} eV</i>
<i>Raios Cósmicos de energia mais elevada</i>	<i>10^{21} eV</i>

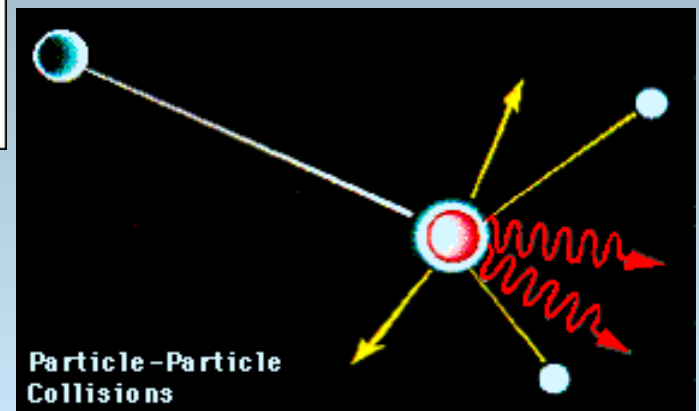
Sondar o muito pequeno...

Nucleões $\lambda < 10^{-16}$ m $\Rightarrow E \sim 10^9$ eV
(10-10 A)



Colisões entre partículas

- Produção de feixes de partículas de alta energia em laboratório



Aceleradores: princípios

Aceleradores: **lineares ou circulares**

Partículas: **ionização produzida por
descargas eléctricas**

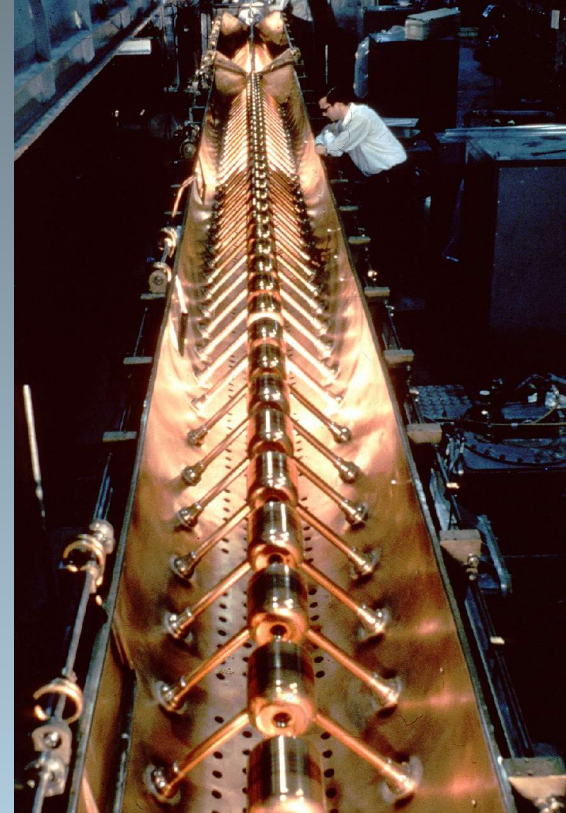
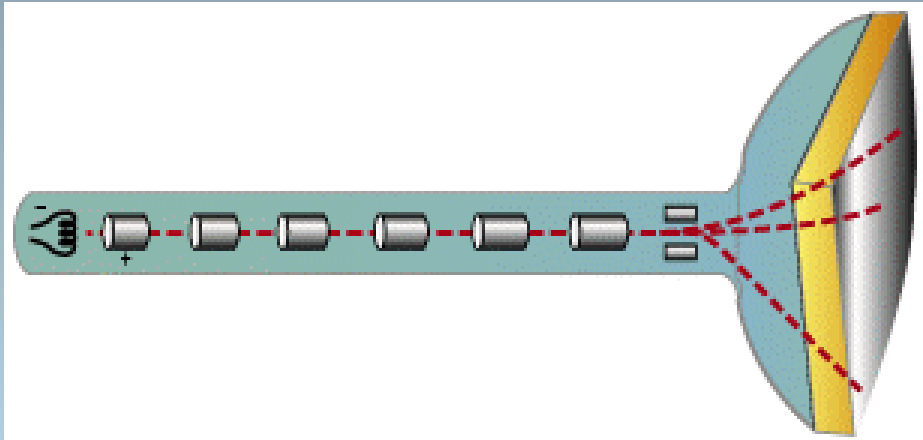
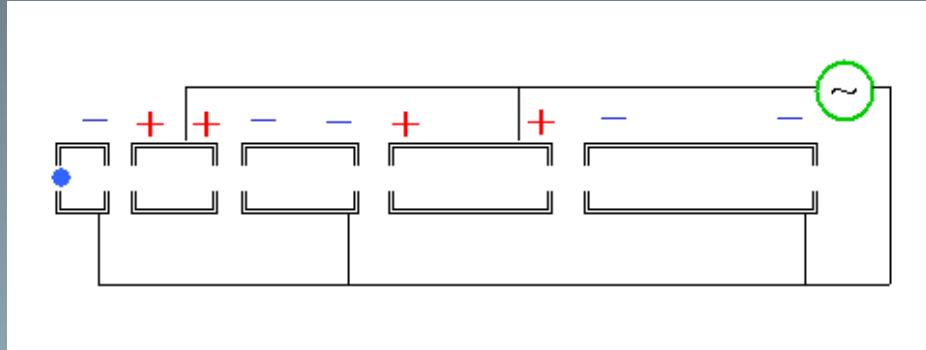
Aceleração: **campos eléctricos**



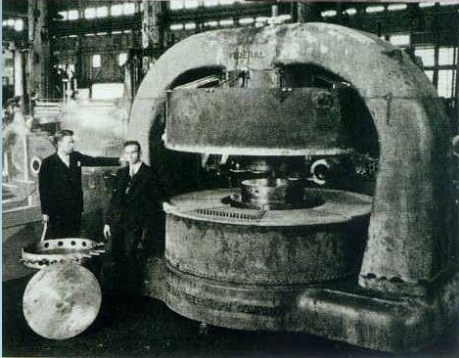
**Campos
magnéticos
curvam as
partículas**



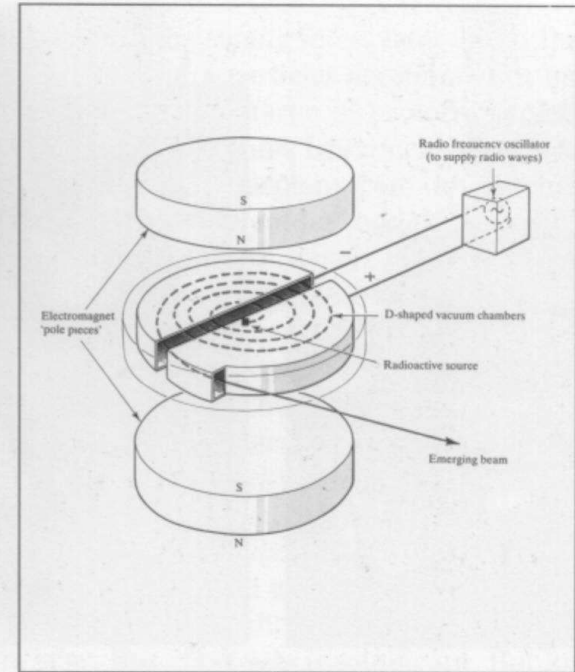
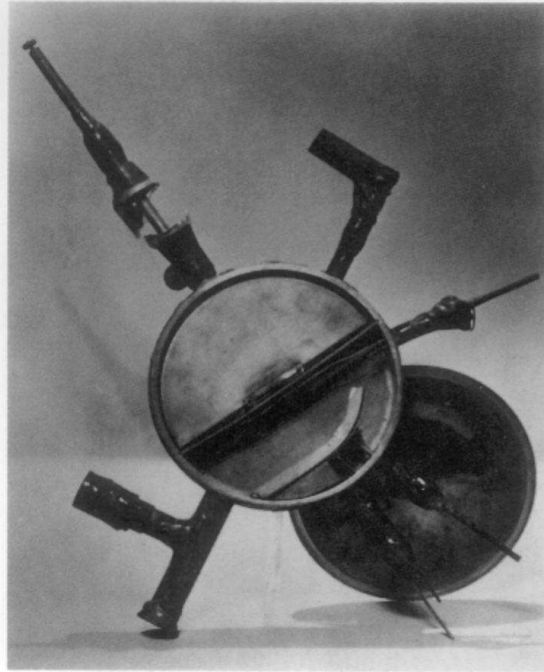
Acelerador linear...



Ciclotrão...



Diam. 1.5 m (100 MeV)



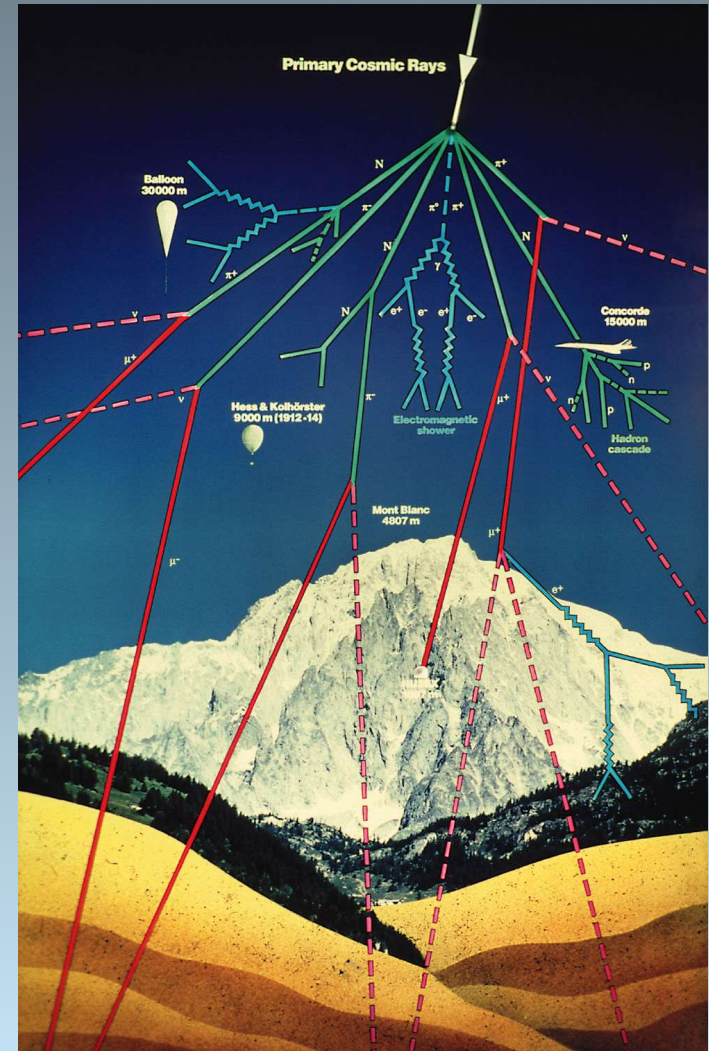
Ernest Lawrence: ciclotrão (1931)

Nobel (1939)

Diâmetro 28 cm: prótons 1 MeV

Raios C3smicos...o maior acelerador

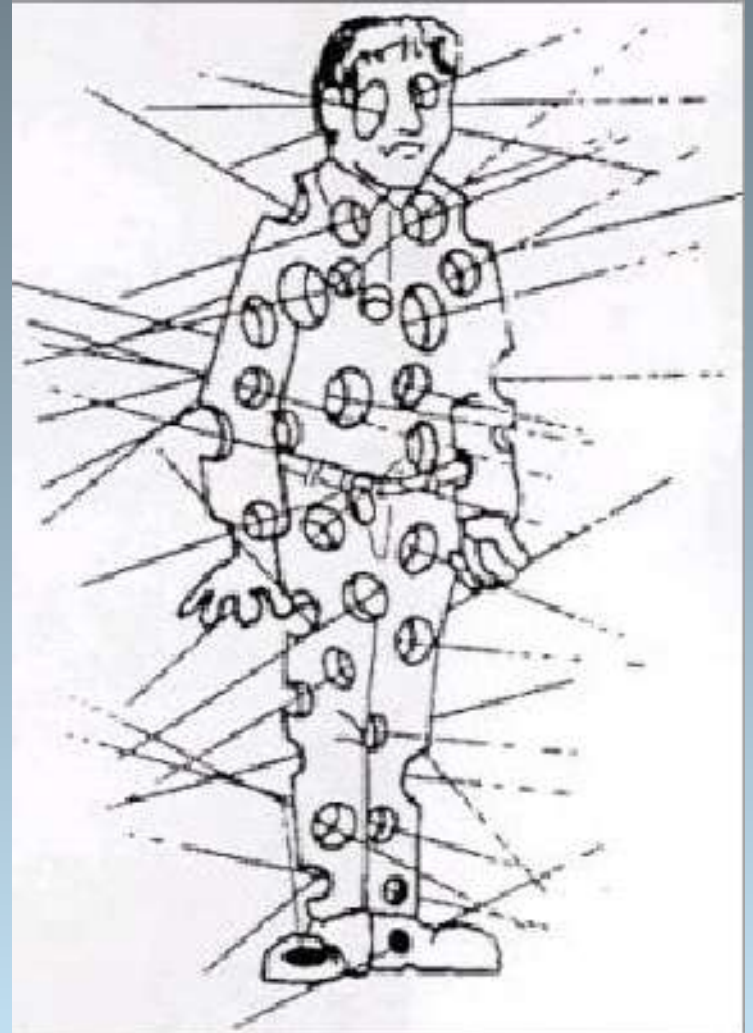
Energias at3 10²¹ eV (100 J)



Eles andam por aí...

Em cada minuto
há cerca de *1000*
(!)

raios cósmicos
carregados
(muões) que nos
atravessam

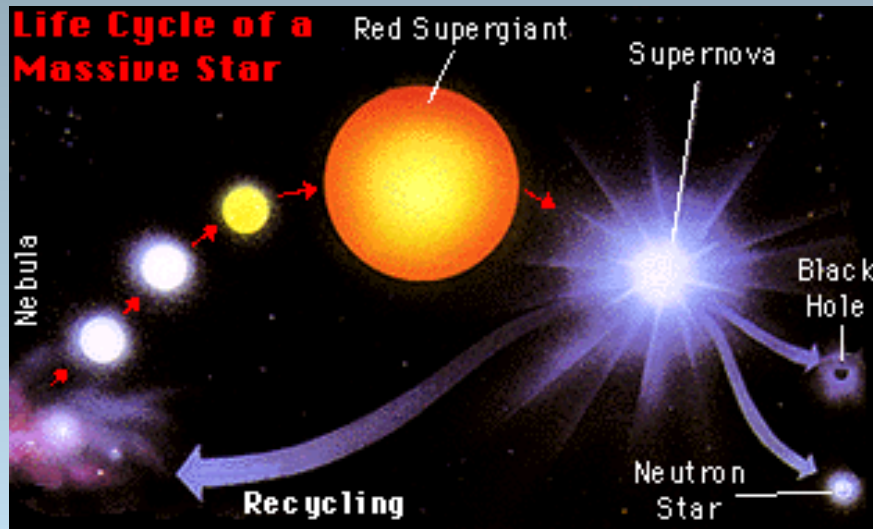


Origem dos raios cósmicos...

Estrelas com uma massa maior que 5 vezes a do Sol terminam em Supernovas.

A explosão ocorre quando a força gravítica não é compensada pela pressão da fusão - colapso gravítico.

Explosão de uma supernova



CERN- European Organization for Nuclear Research

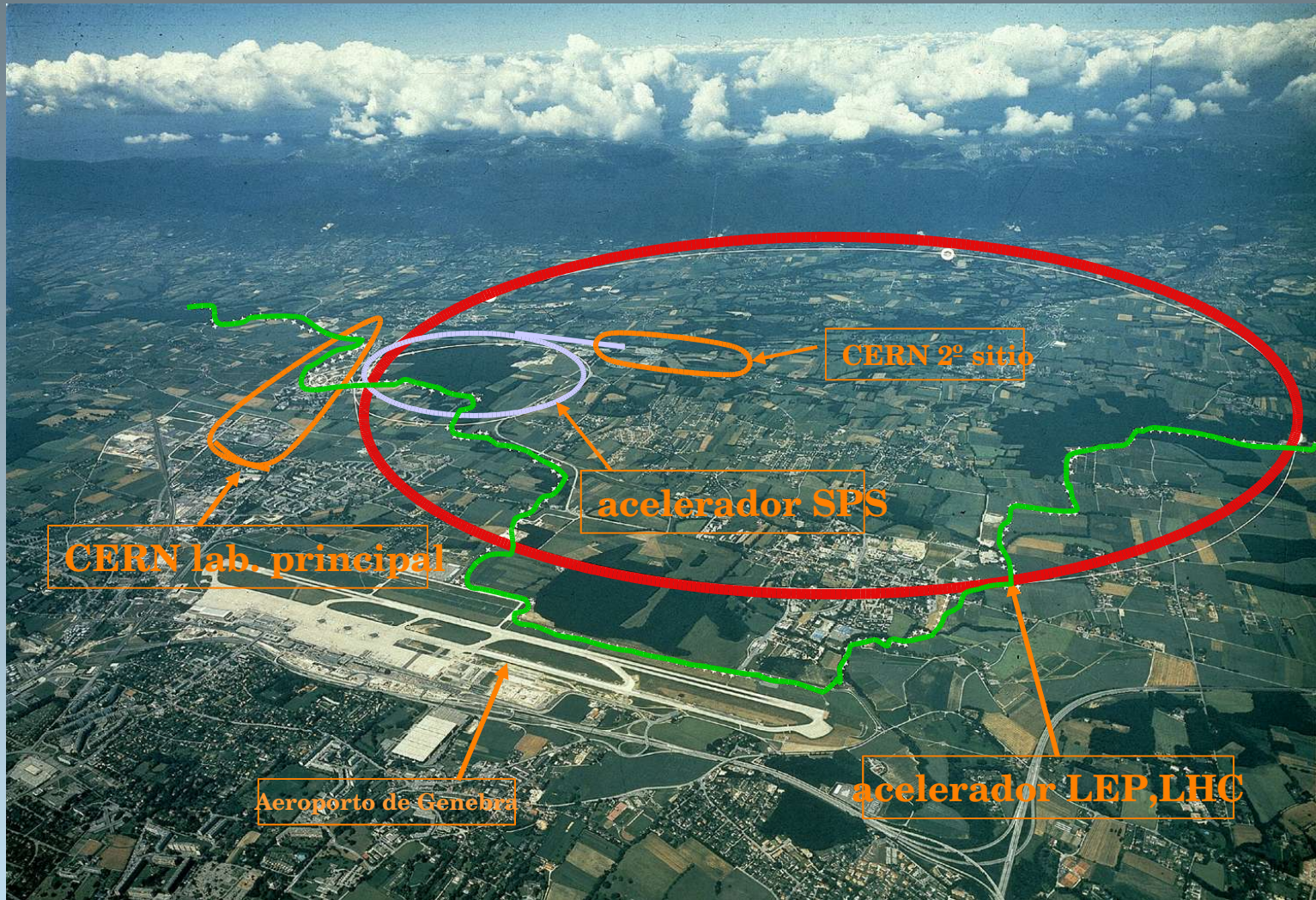


Felix Bloch, 10 June 1952

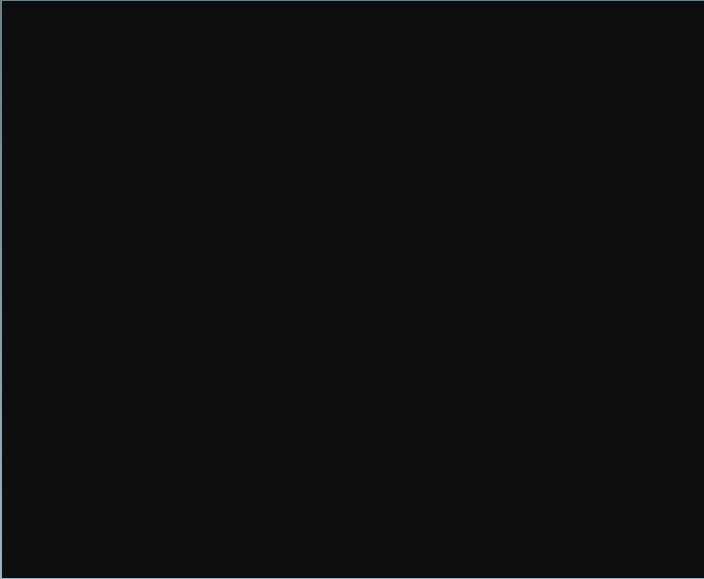


- Fundado em 1954 por 12 países
- Actualmente: 20 estados membros (1986- Portugal)
- Mais de 7000 utilizadores de todas as partes do mundo
- ~700 M€ de orçamento anual

Cern e os aceleradores

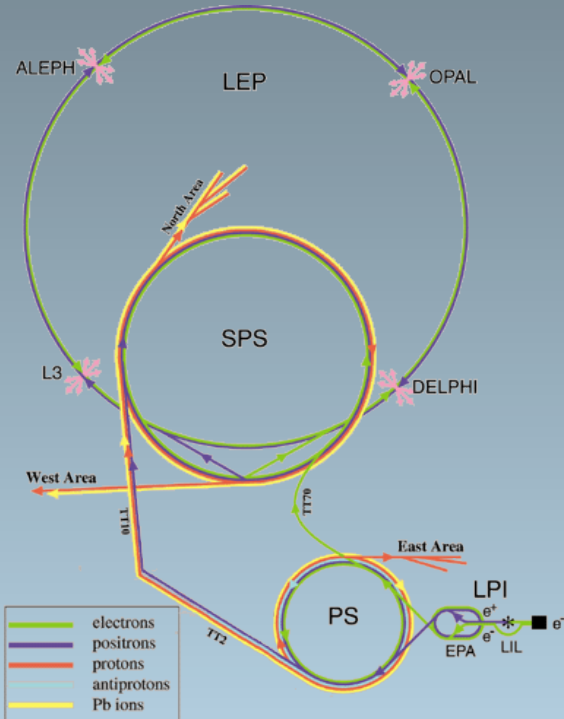


Actividades Cern



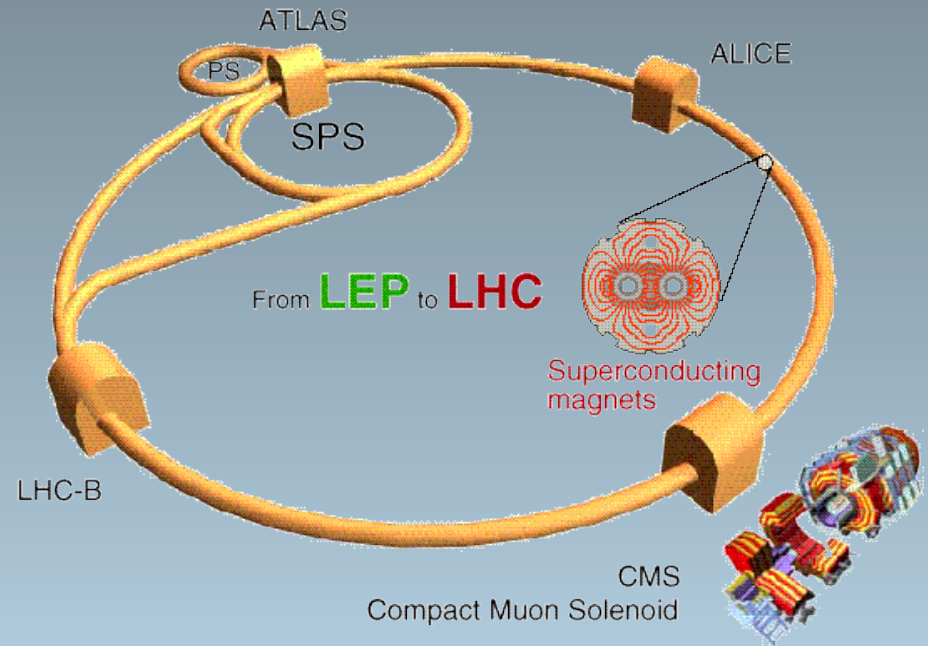
Sistema de aceleradores Cern

1990

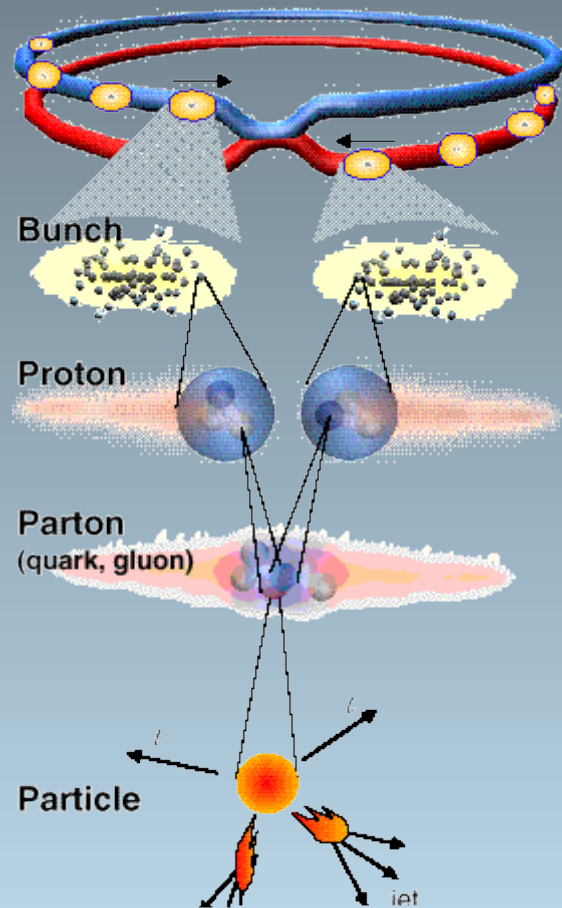


LEP: Large Electron Positron collider
 SPS: Super Proton Synchrotron
 PS: Proton Synchrotron
 LPI: Lep Pre-Injector
 EPA: Electron Positron Accumulator
 LIL: Lep Injector Linac

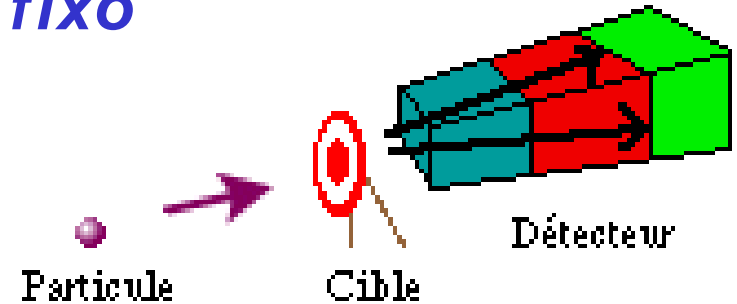
2007



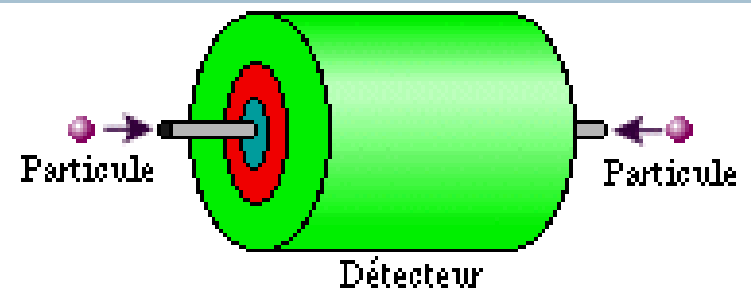
Colisões de partículas



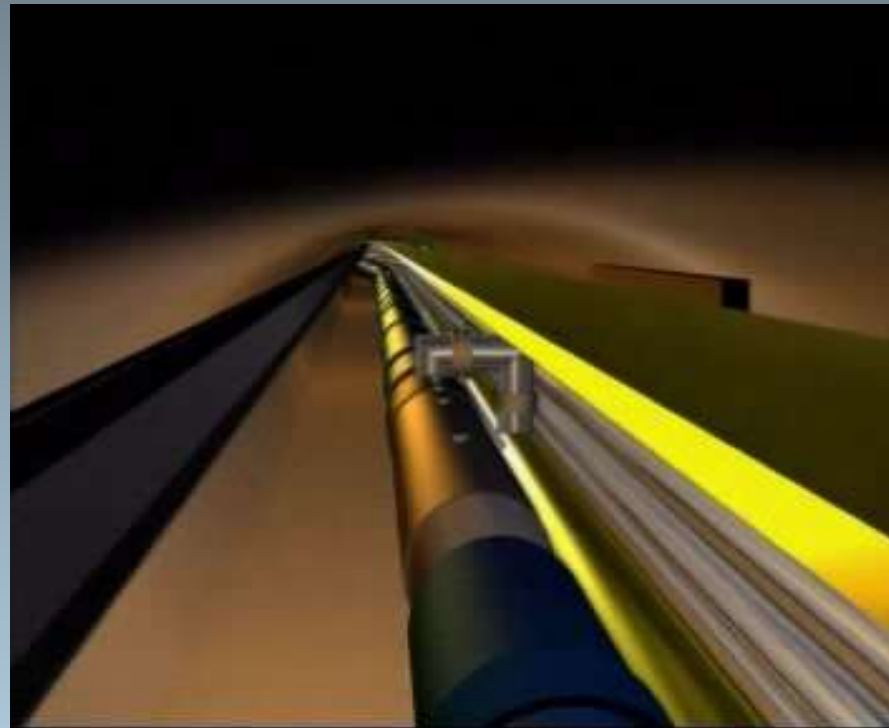
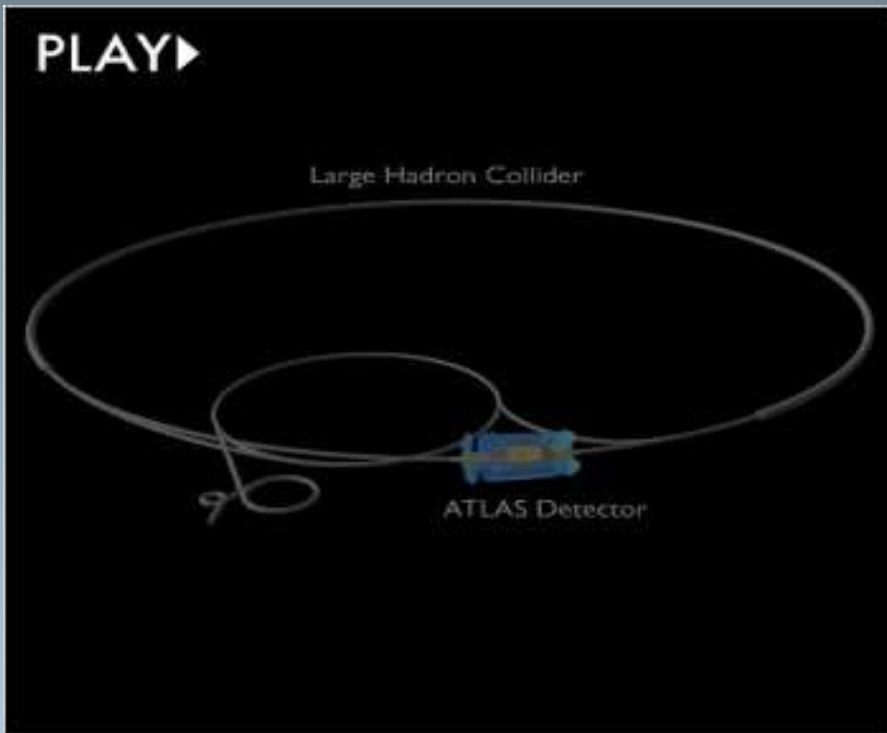
Colisões com alvo fixo



Colisões entre feixes





LHC- o maior acelerador (2007-)



Colisões entre prótons com energia de 7 TeV

Que partículas se detectam?

Detecção de forma directa

Leptões					
Tau		Carga Eléctrica -1	Neutrino Tau		0
Muão		-1	Neutrino Muão		0
Electrão		-1	Neutrino Electrão		0

Interacção muito fraca. Difíceis de detectar

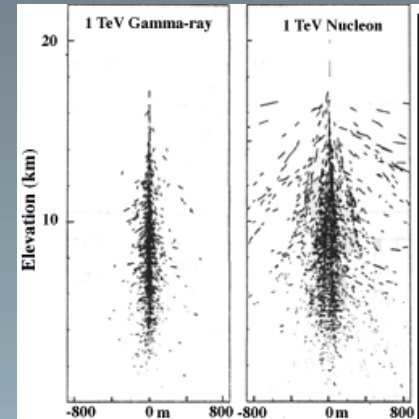
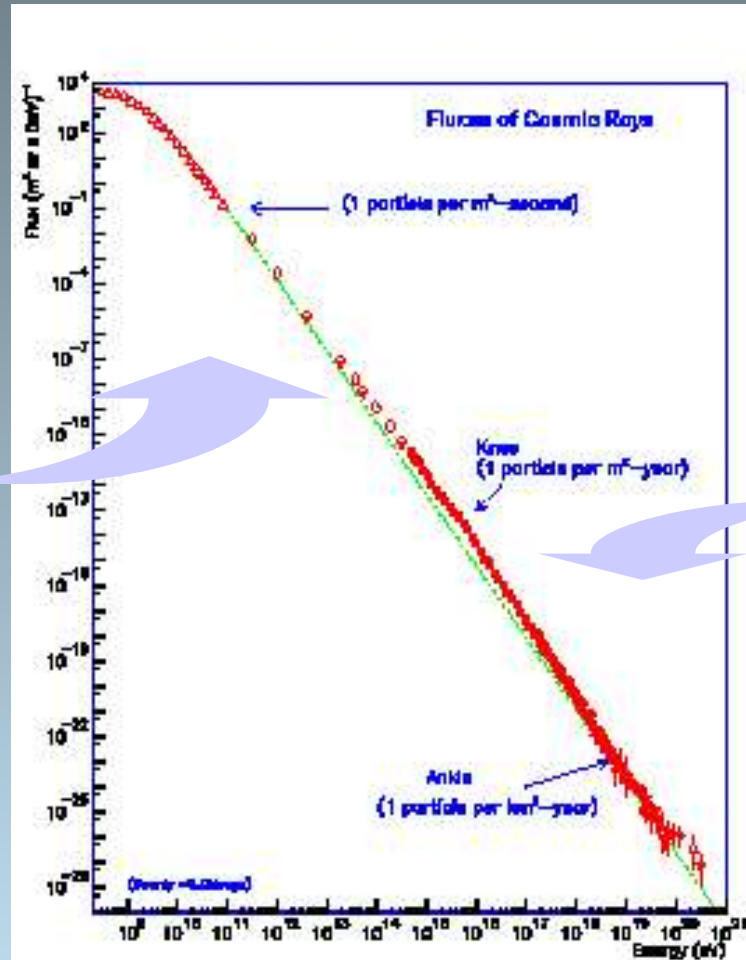
Detecção indirecta a partir de partículas ou jactos de partículas

Quarks					
Bottom		Carga Eléctrica -1/3	Top		Carga Eléctrica 2/3
Strange		-1/3	Charm		2/3
Down		-1/3	Up		2/3

cada quark  R,  B,  G 3 cores

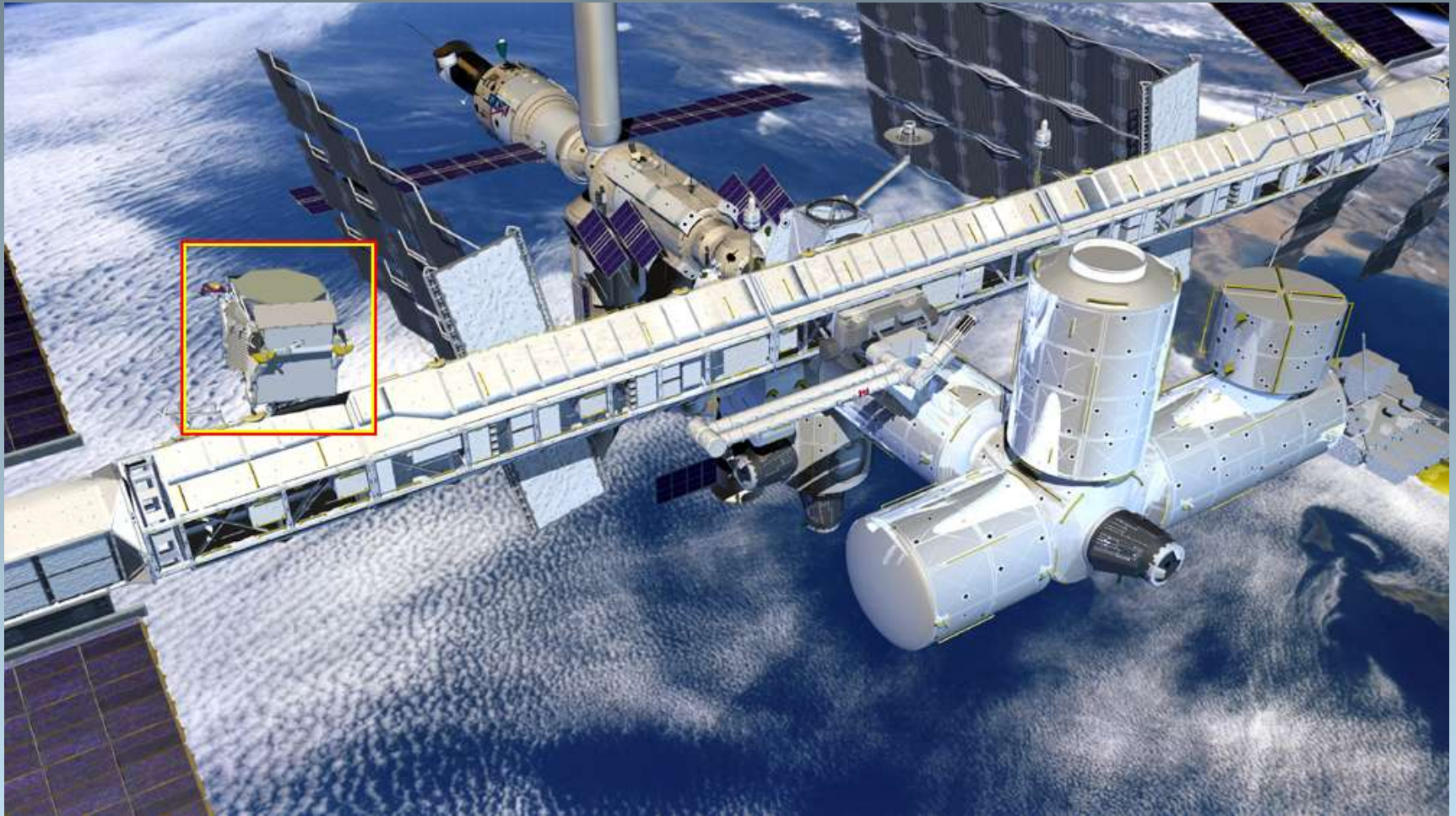
Detecção dos raios cósmicos...

*Balões ISS
Satélites*



*Experiência em Terra e
no Espaço:
Cascatas Atmosféricas*

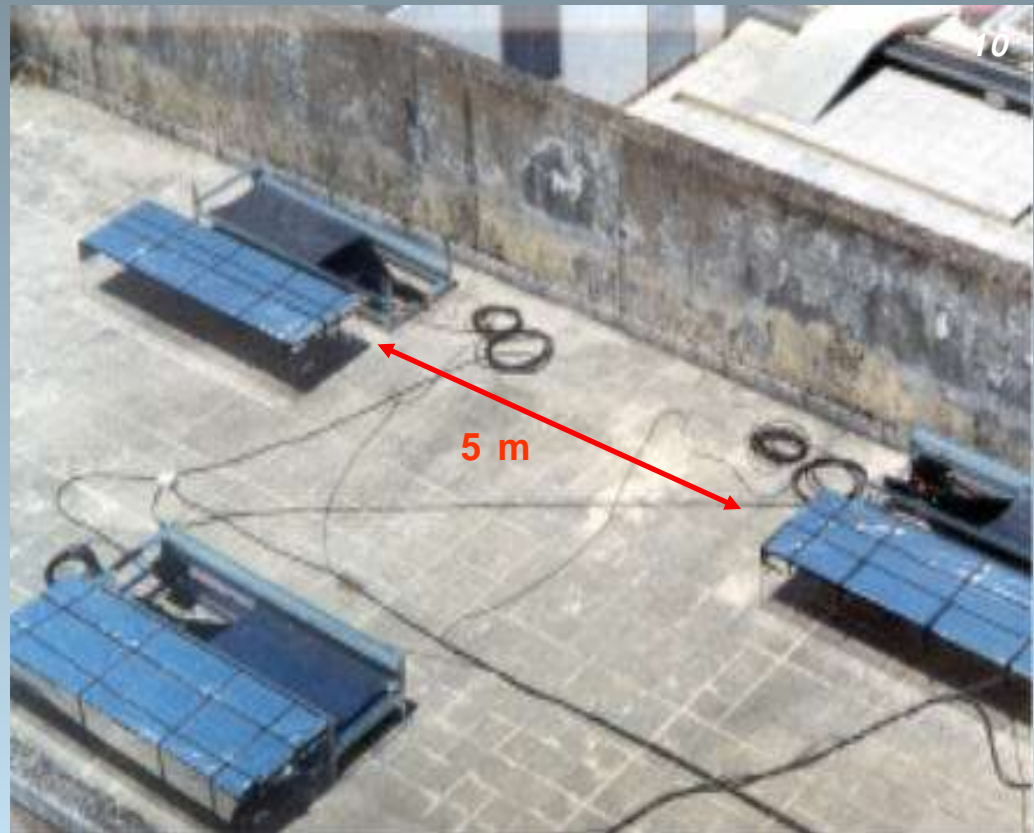
Detector AMS de raios cósmicos na ISS



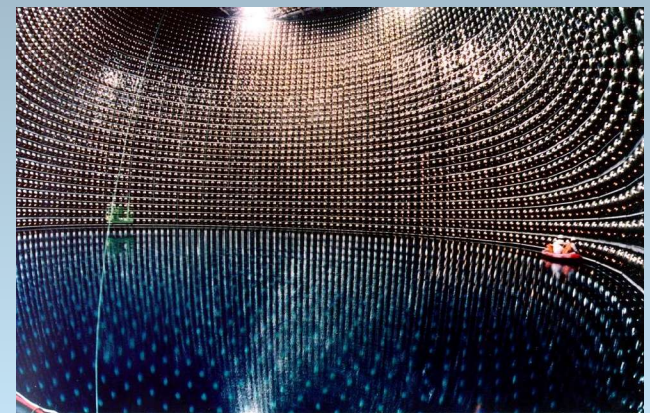
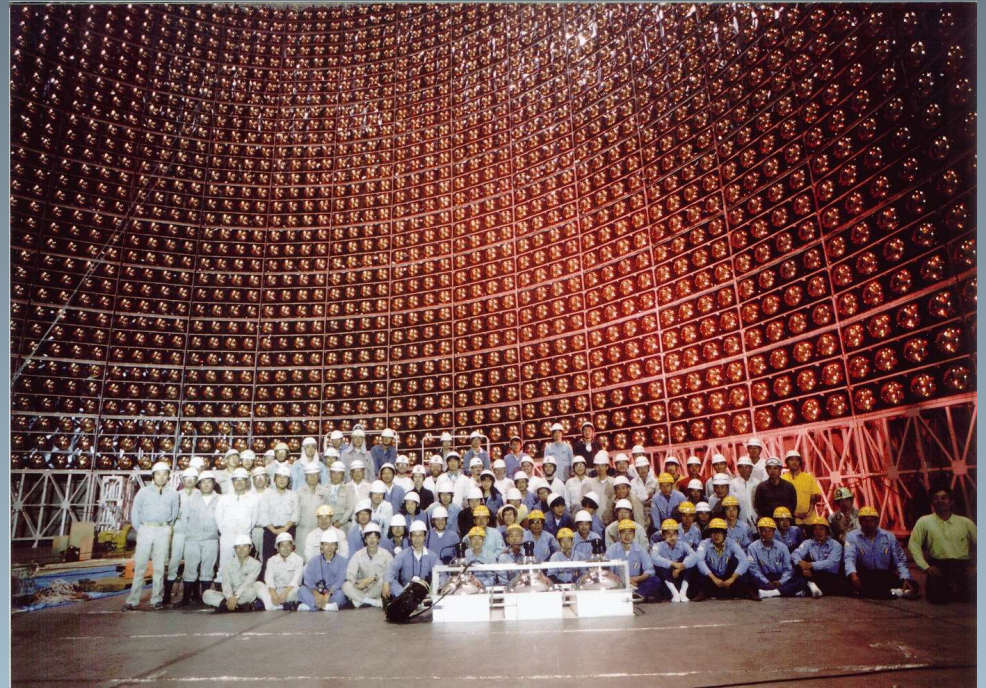
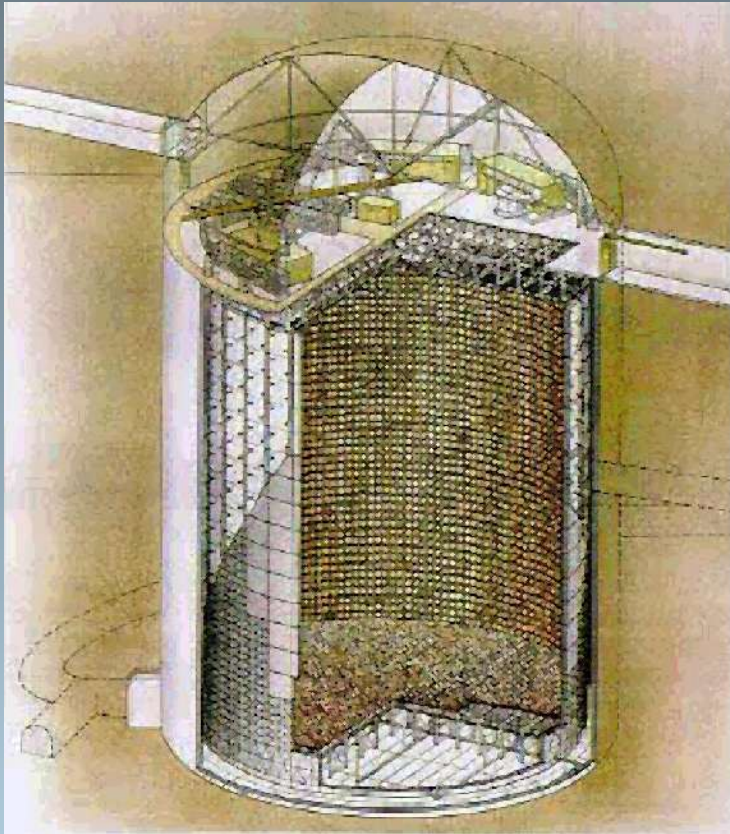
Detecção raios cósmicos no IST/Escolas

É uma rede de estações detectoras espalhada por Escolas Secundárias para observação de raios cósmicos de alta energia

- *Cada escola possui uma estação composta por três módulos detectores*
- *Cada módulo:*
 - 1 cintilador*
 - 1 placa de chumbo*
 - 1 fotomultiplicador*
 - 1 transformador de alta tensão (1500 V)*










Detecção de neutrinos...

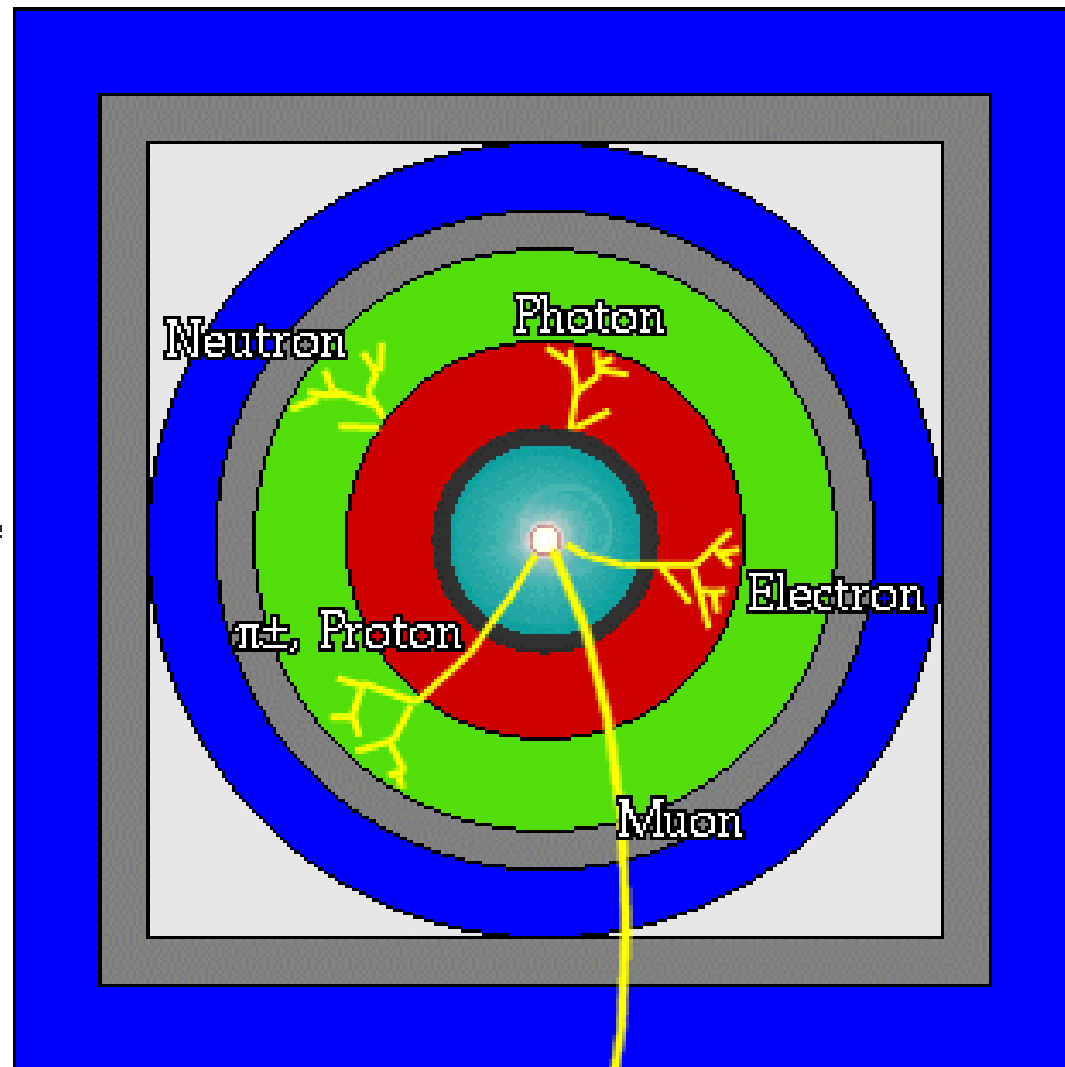


SuperKamiokand
e

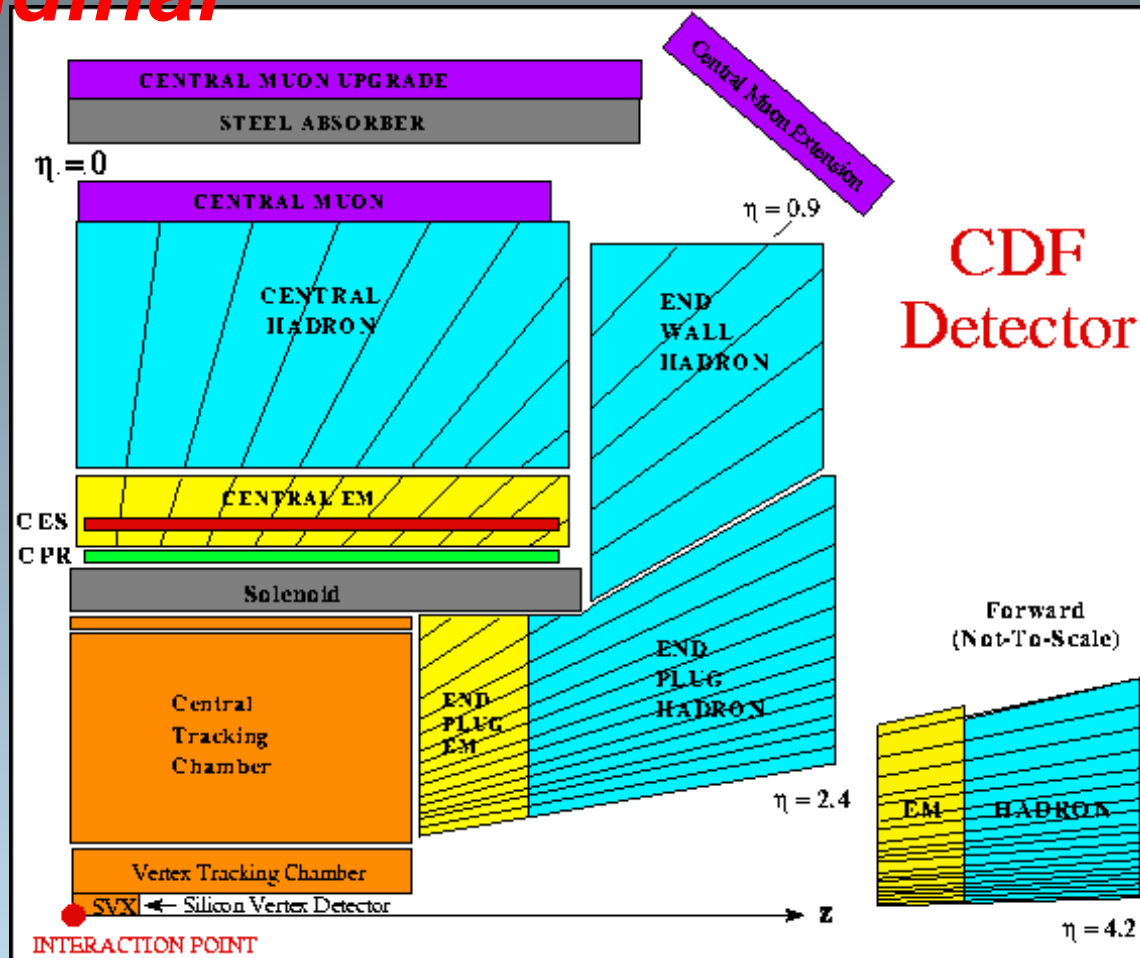
Detector em anéis de colisão: transversal

Section transversale d'un détecteur montrant les trajectoires des particules

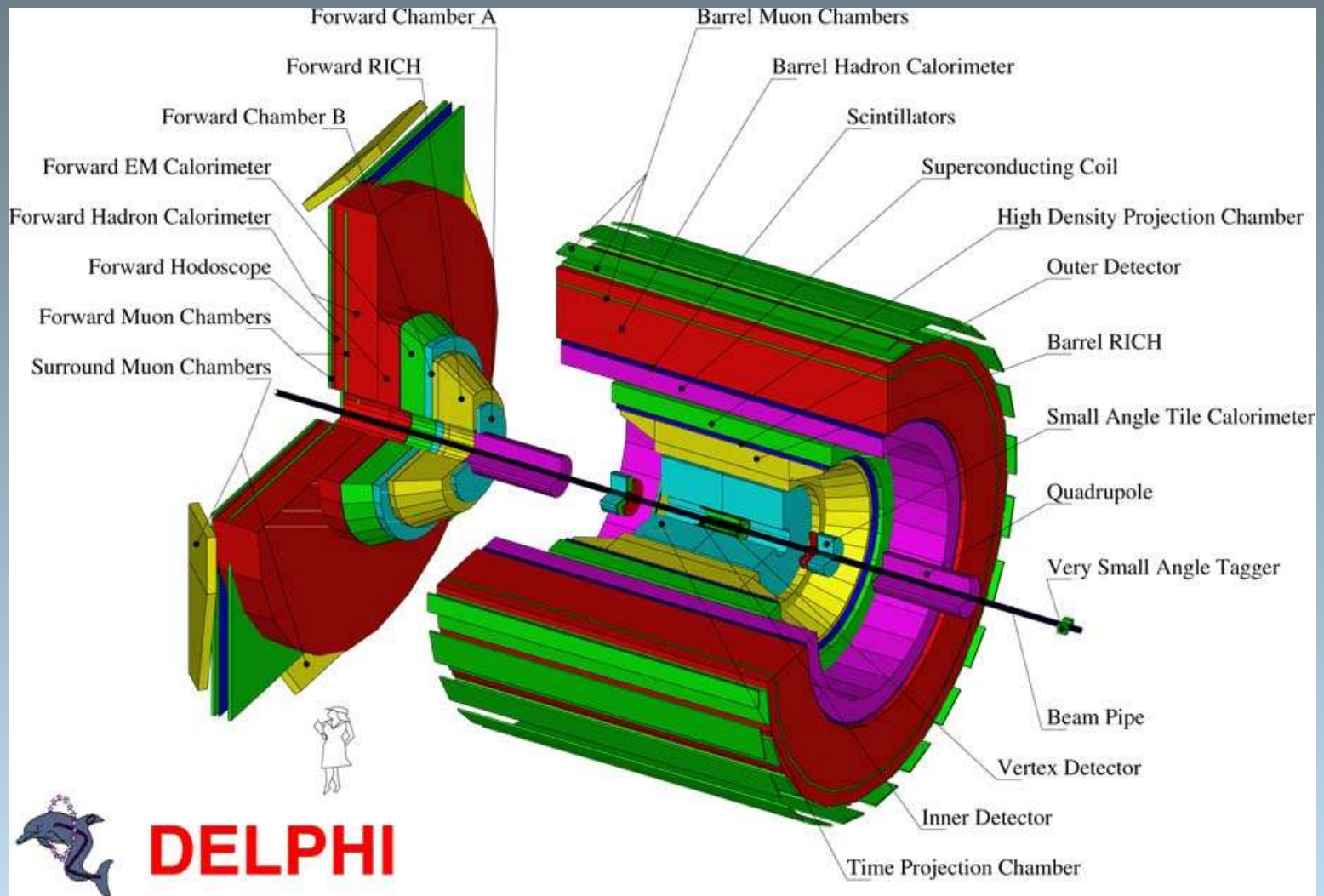
-  Tube à vide contenant le faisceau
-  Détecteur de traces
-  Bobine magnétique
-  Calorimètre électromagnétique
-  Calorimètre hadronique
-  Fer magnétique
-  Chambres à muons



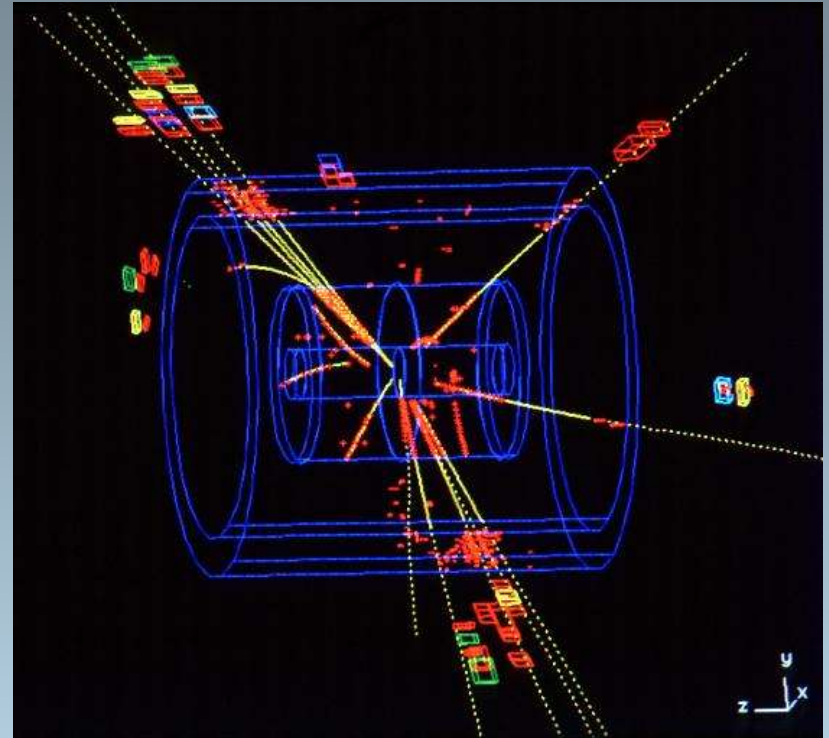
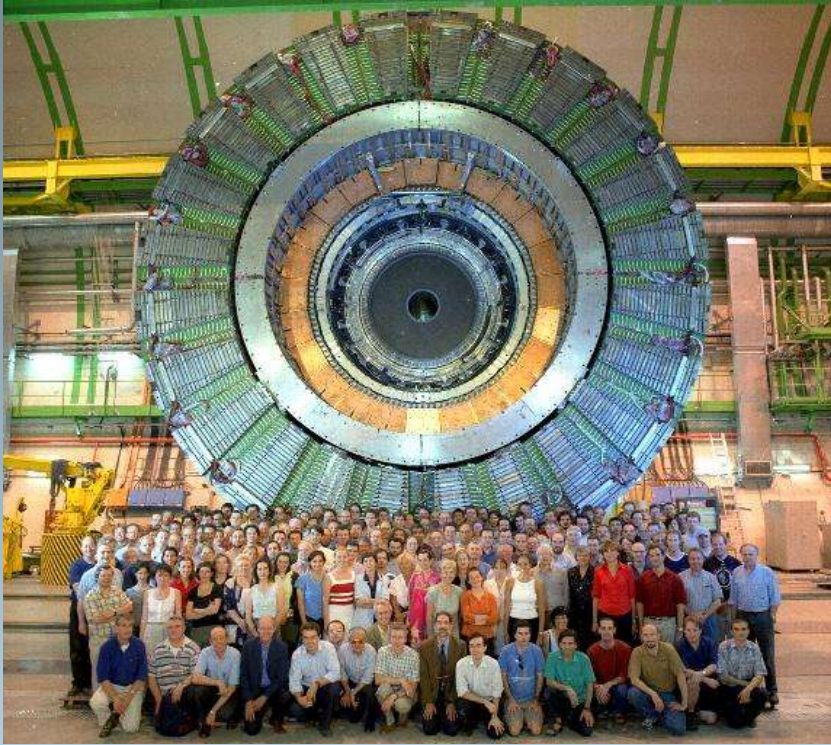
Detector em anéis de colisão: longitudinal



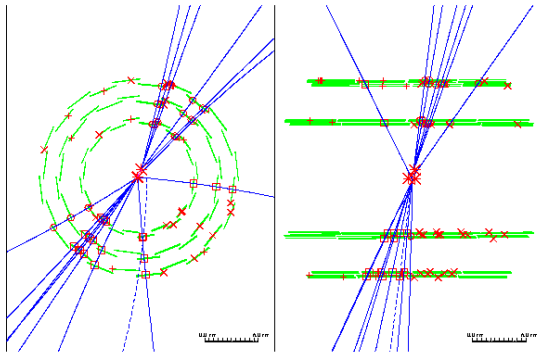
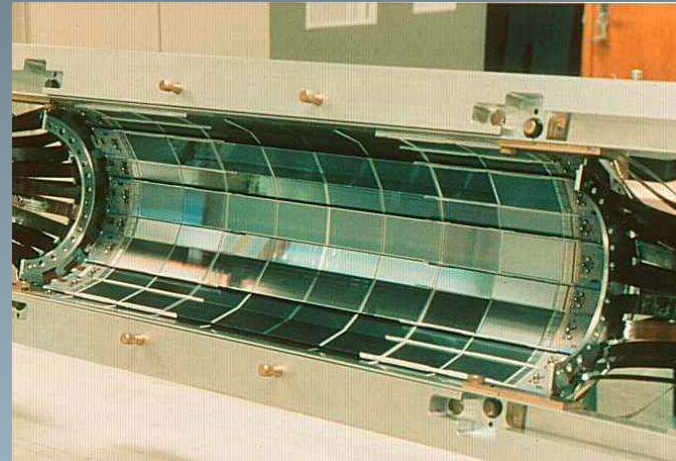
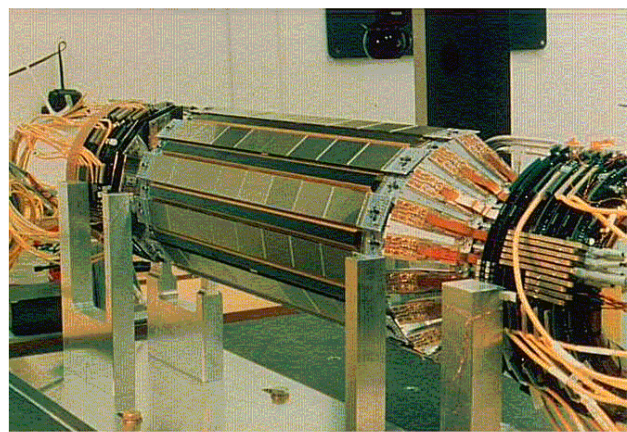
Detector DELPHI do colisionador LEP



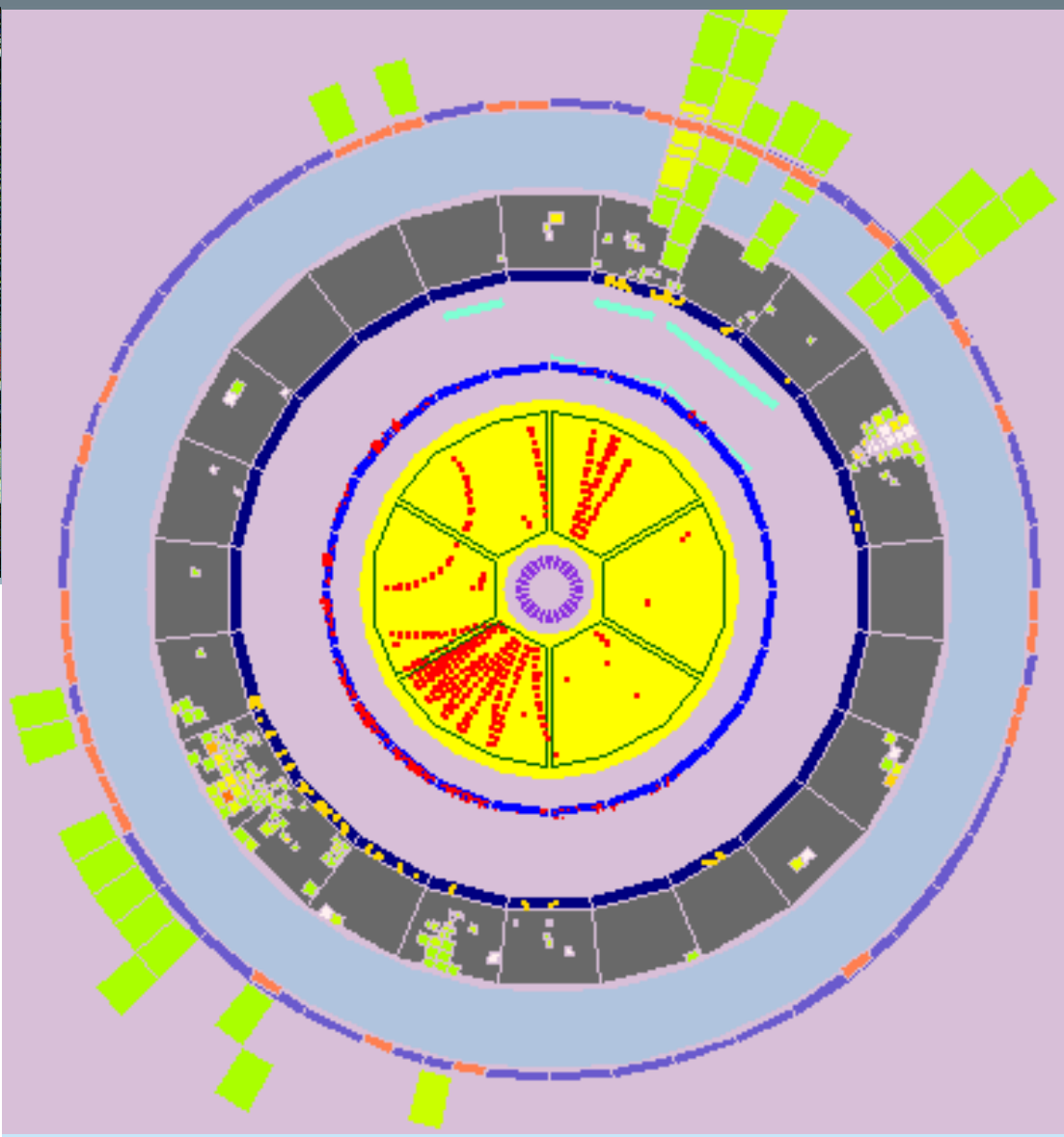
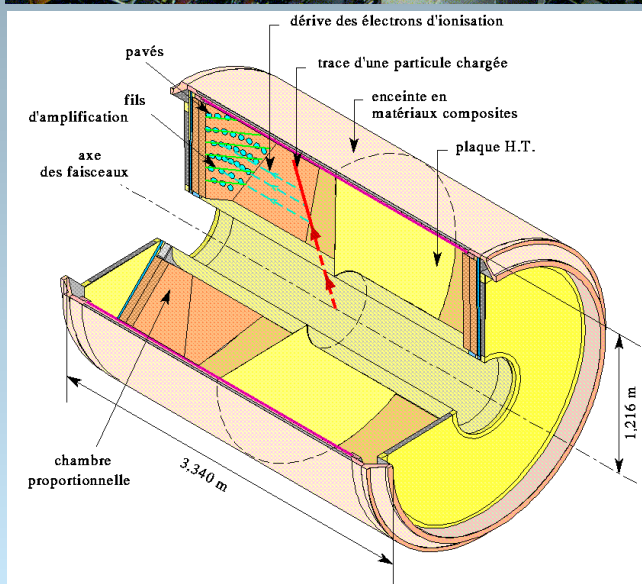
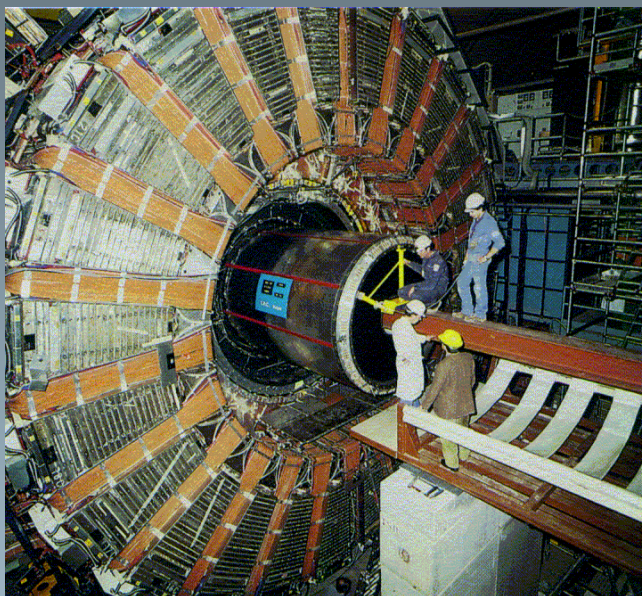
Escola do detector e acontecimento



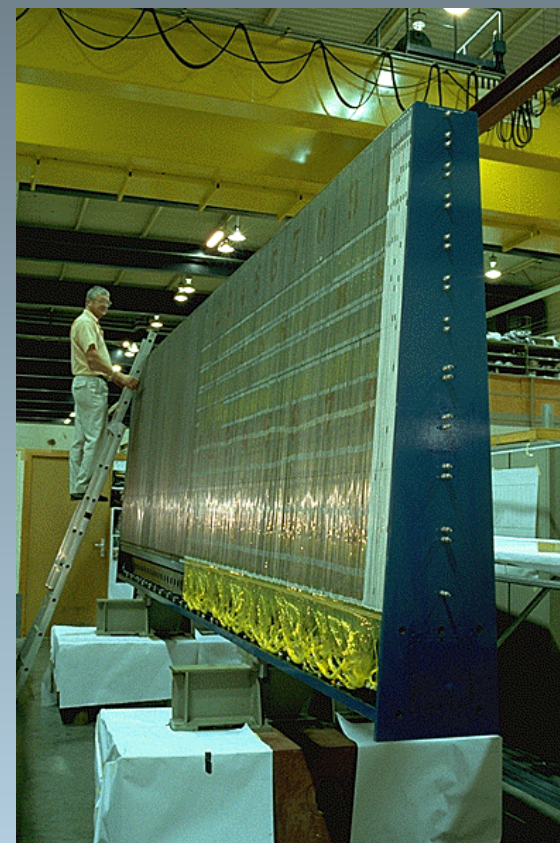
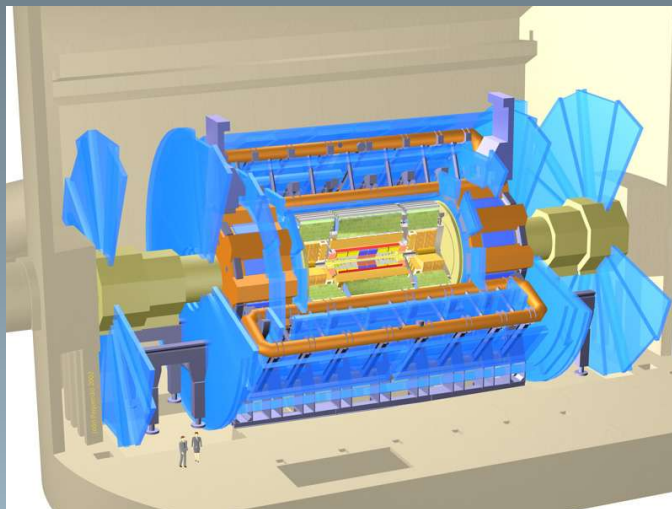
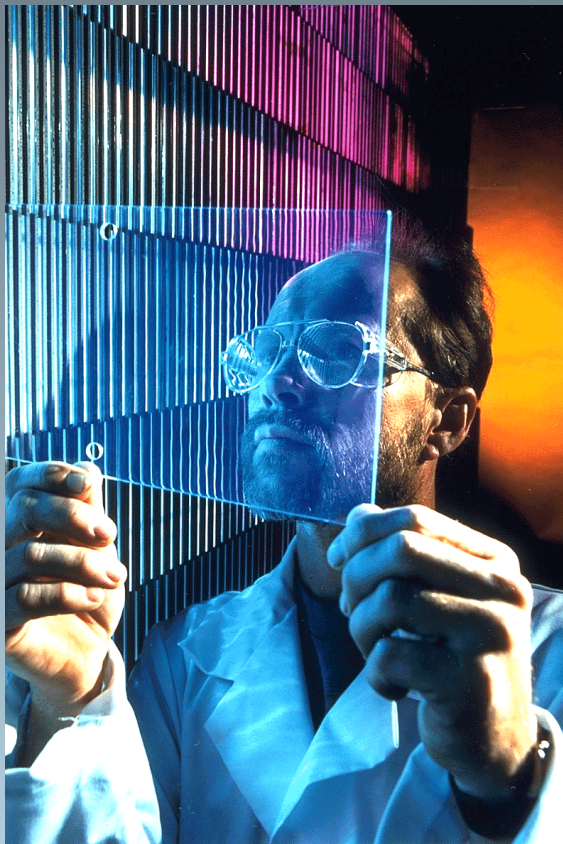
Detector de vértices (silício)



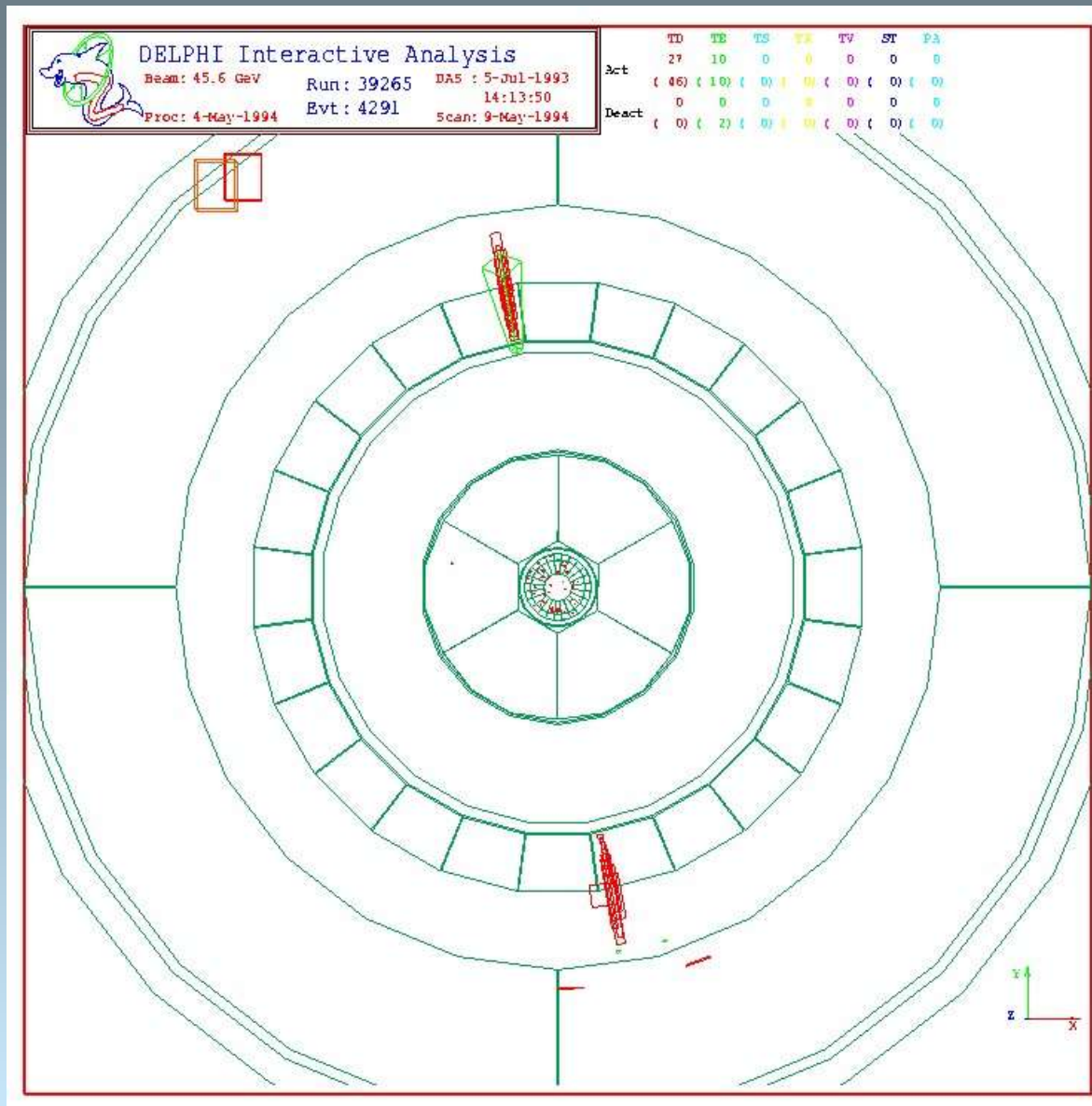
Quantidade de movimento: Det de traços



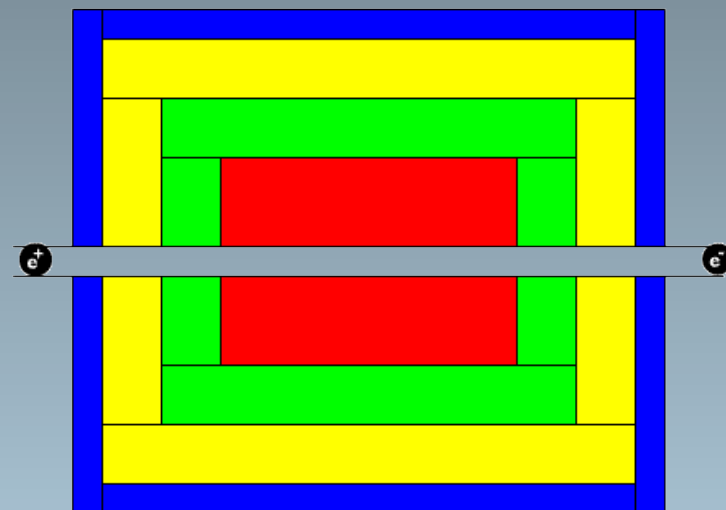
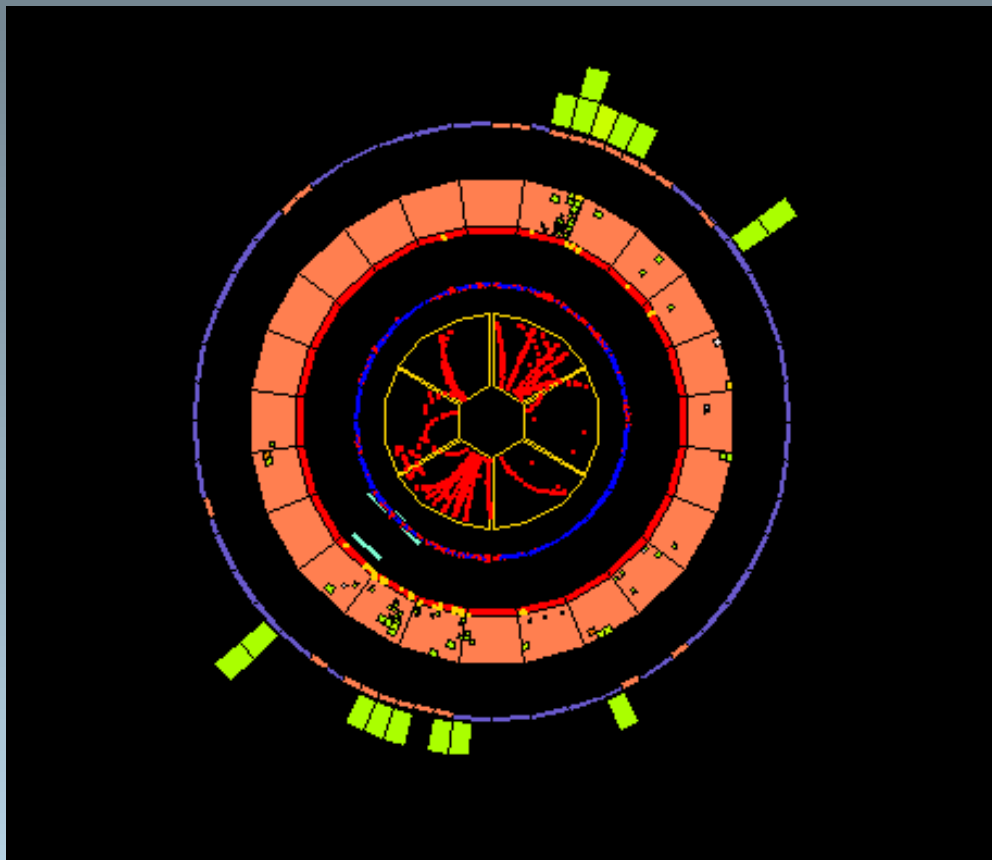
Medição de energia: Calorímetros



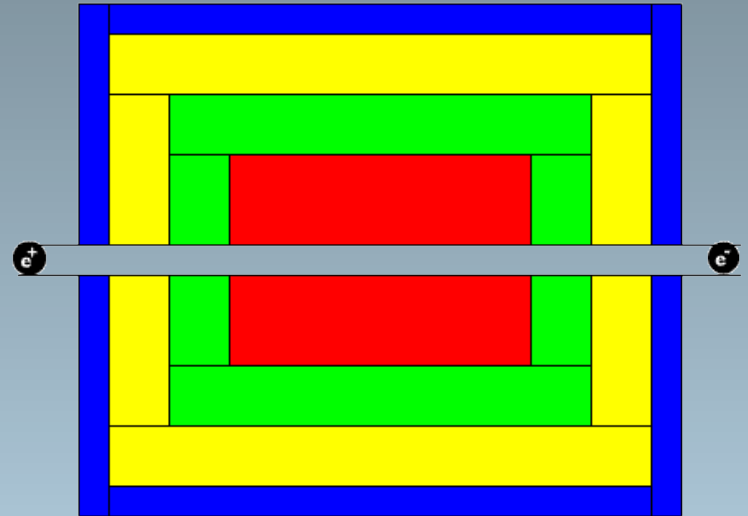
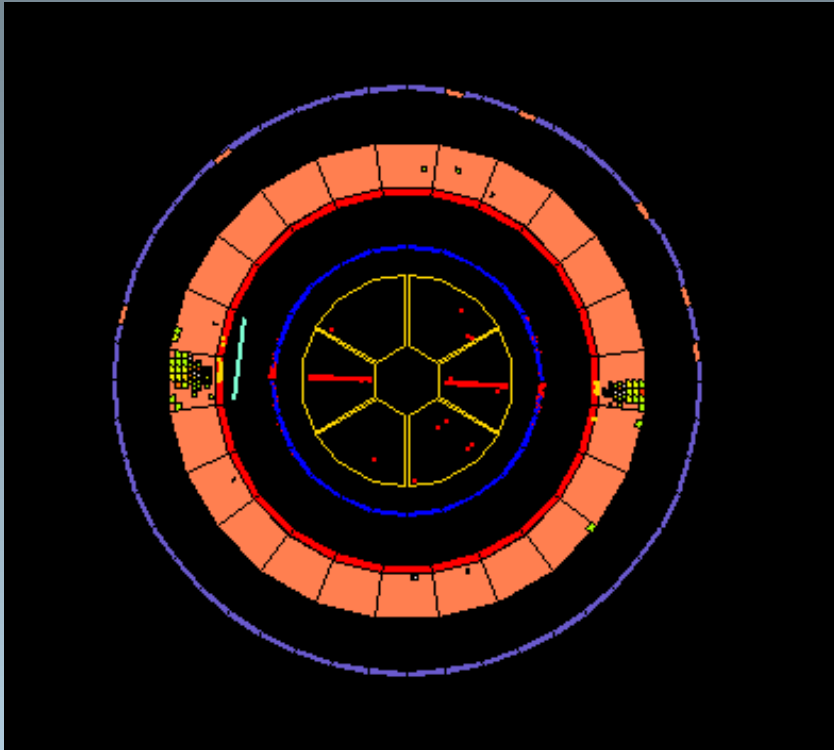
Detecção de fótons



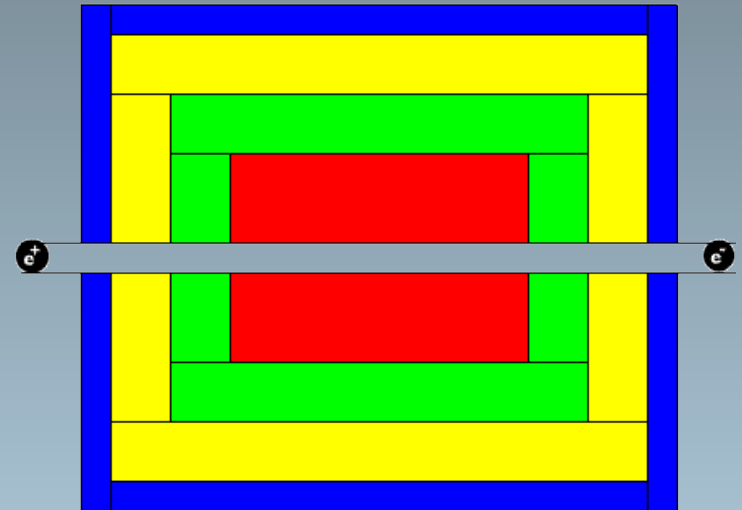
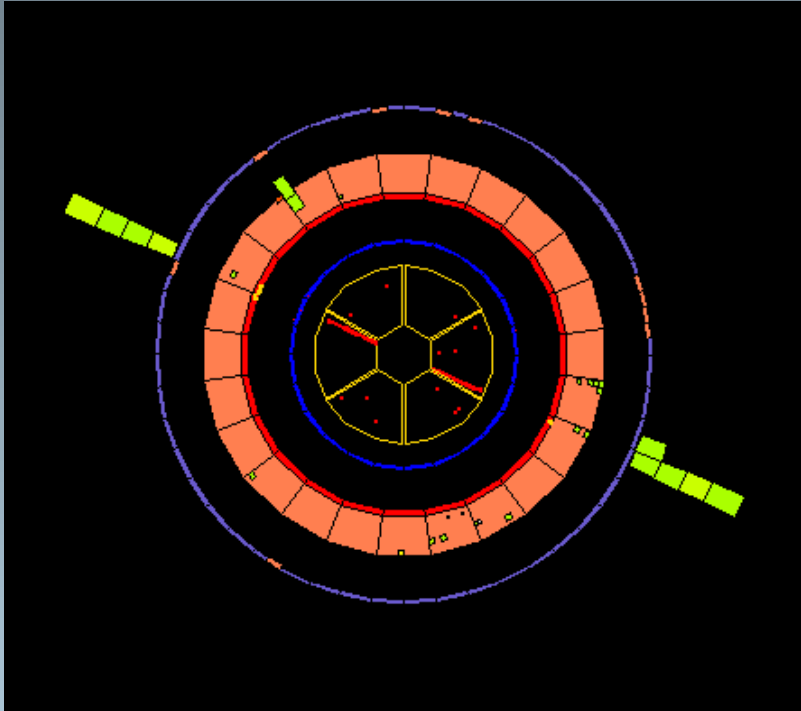
Produção de quarks



Detecção de electrões

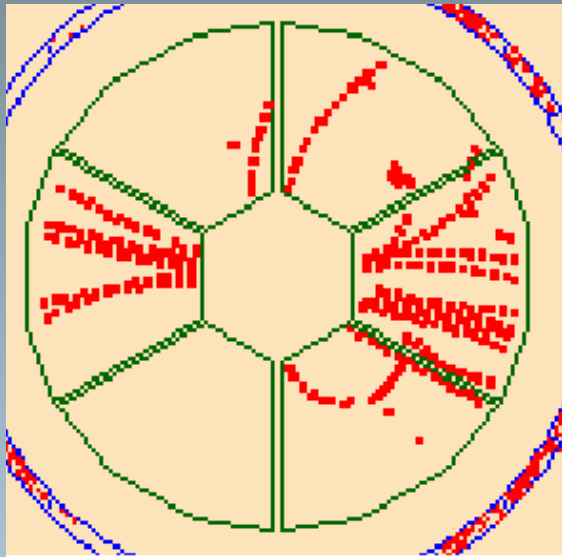


Detecção de muões

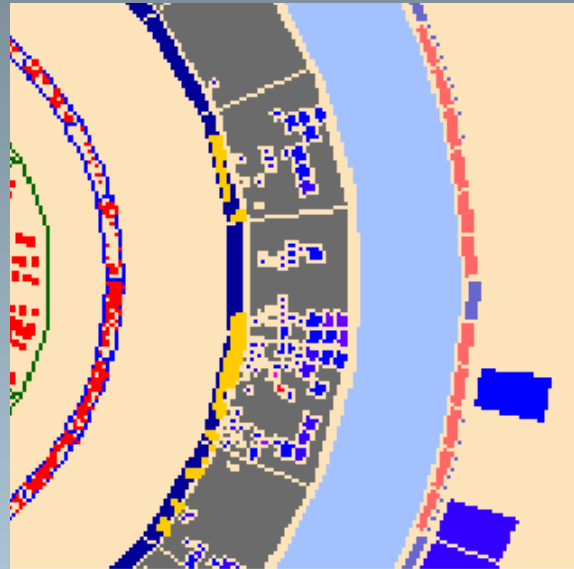


Detector zoom...

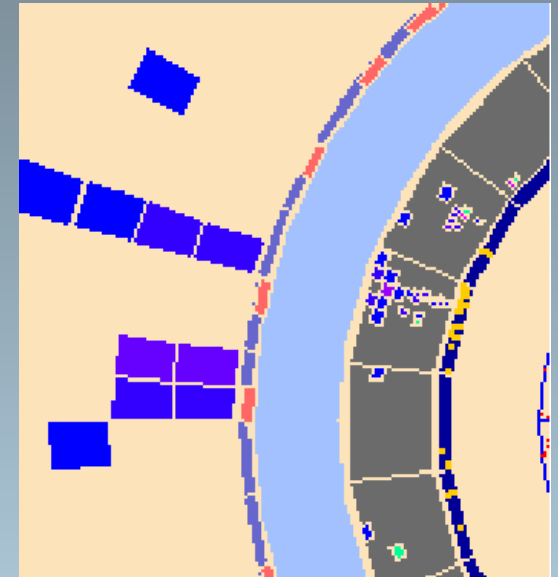
detector



Detector de
traços



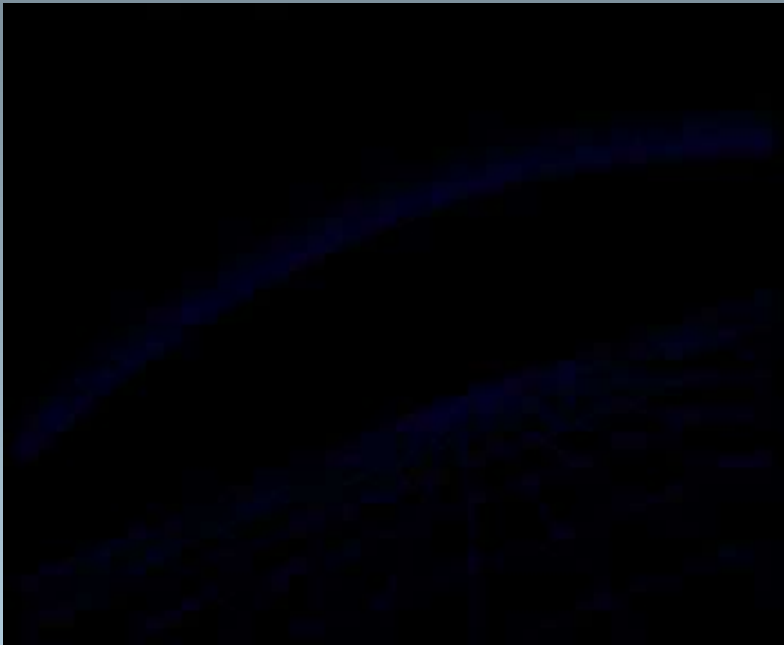
Calorímetro
electromagnético



Calorímetro Hadrónico

Construção de um grande detector

detector



FIM

