

Identification de ~~Suspects~~ Particules

The Usual Suspects



$e^{-/+}$

γ

$\mu^{-/+}$

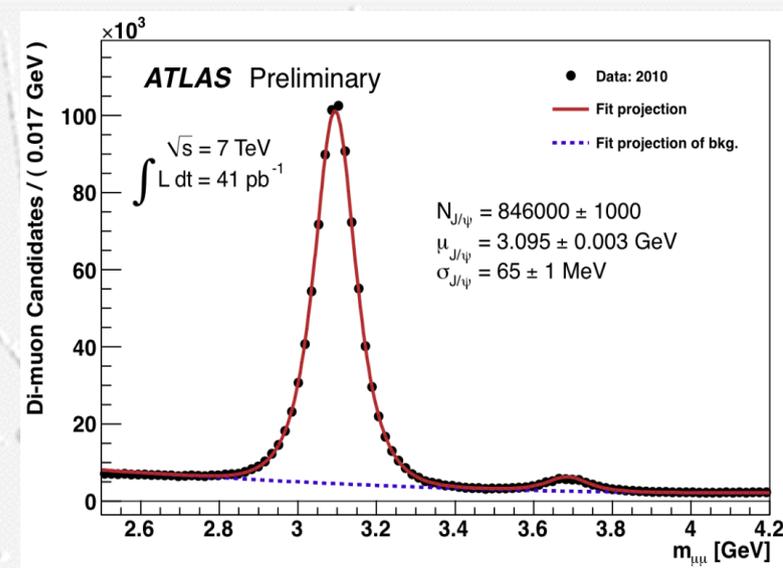
Hadrons
chargés
 $p, k^{-/+}, \pi^{-/+} \dots$

Hadrons
neutres
 n, π^0, λ, \dots

Introduction

Identification

- Découvrir la nature , l'identité
- Masse, charge
- Ne serait ce pas une question idiote $\Delta p \Delta x > h/2\pi$?



Particules à durée de vie courte ($< \sim 10^{-10} \text{ s}$)

- $W, Z, J/\psi, \pi^0 \dots$ (Interaction faible, em, forte)
- Identification passe par la reconstruction de leur produit de désintégration
- Identification au sens **statistique** (séparation bruit de fond / particule)
 - Efficacité, pureté...

Introduction

Particules « stables »

- Particules réellement stable
- Leur durée de vie excède le temps pour traverser le détecteur

Exemples

- $\mu^{+/-}$: laisse une trace dans chaque détecteurs
- $\pi^{+/-}, K^{+/-}(K_s, K_l), p, n...$: calorimètre hadronique
 - Identification va dépendre de leur vitesse
- **Neutrino** : Principalement énergie manquante
 - Ou à travers un muon (Cherenkov : Antares, SK,...)
- **Électron, photon, π^0** : mesures d'énergie dans les calorimètres
 - Avec ou sans trace chargée dans le trajectographe

Identification

Charge

- Champ magnétique
- Mesure du rayon de courbure
- Précision de l'alignement +
valeur du champ limite la séparation de charge

Masse

- Mesure simultanée pour : π, K, μ, e, p, \dots
 - Impulsion & énergie
 - Impulsion & vitesse
 - Énergie & vitesse

Identification directe

- μ, e

Identification

Principes de Physiques: Interactions électromagnétiques

- Mesure **simultanée** de l'impulsion &

- $dE dx$

- Temps de vol

- Cherenkov

$$\left\{ \begin{array}{l} p = \gamma M \beta c \\ \frac{dE}{dx} \propto \frac{1}{\beta^2} \ln(\beta^2 \gamma^2) \end{array} \right.$$

- Rayonnement de transition

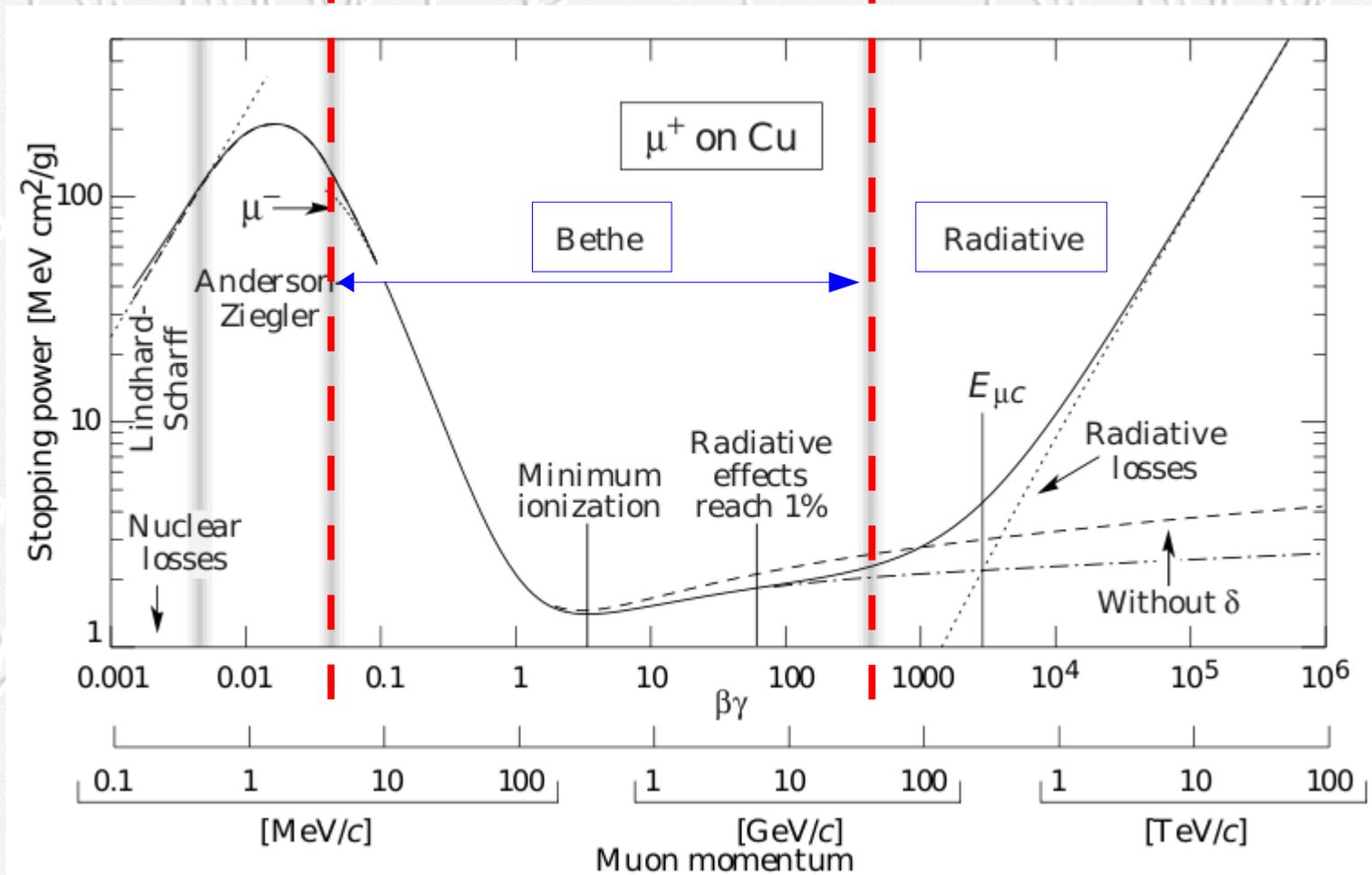
- Séparation π/e

- Identification directe des **électrons**

Identification

dE/dx

$$\bullet \frac{dE}{dx} = K z^2 \frac{Z}{A} \frac{1}{\beta^2} \left[\frac{1}{2} \ln \frac{2m_e c^2 \beta^2 \gamma^2 T_{max}}{I^2} - \beta^2 - \frac{\delta(\beta\gamma)}{2} \right] \propto \frac{1}{\beta^2} \ln(\beta^2 \gamma^2)$$

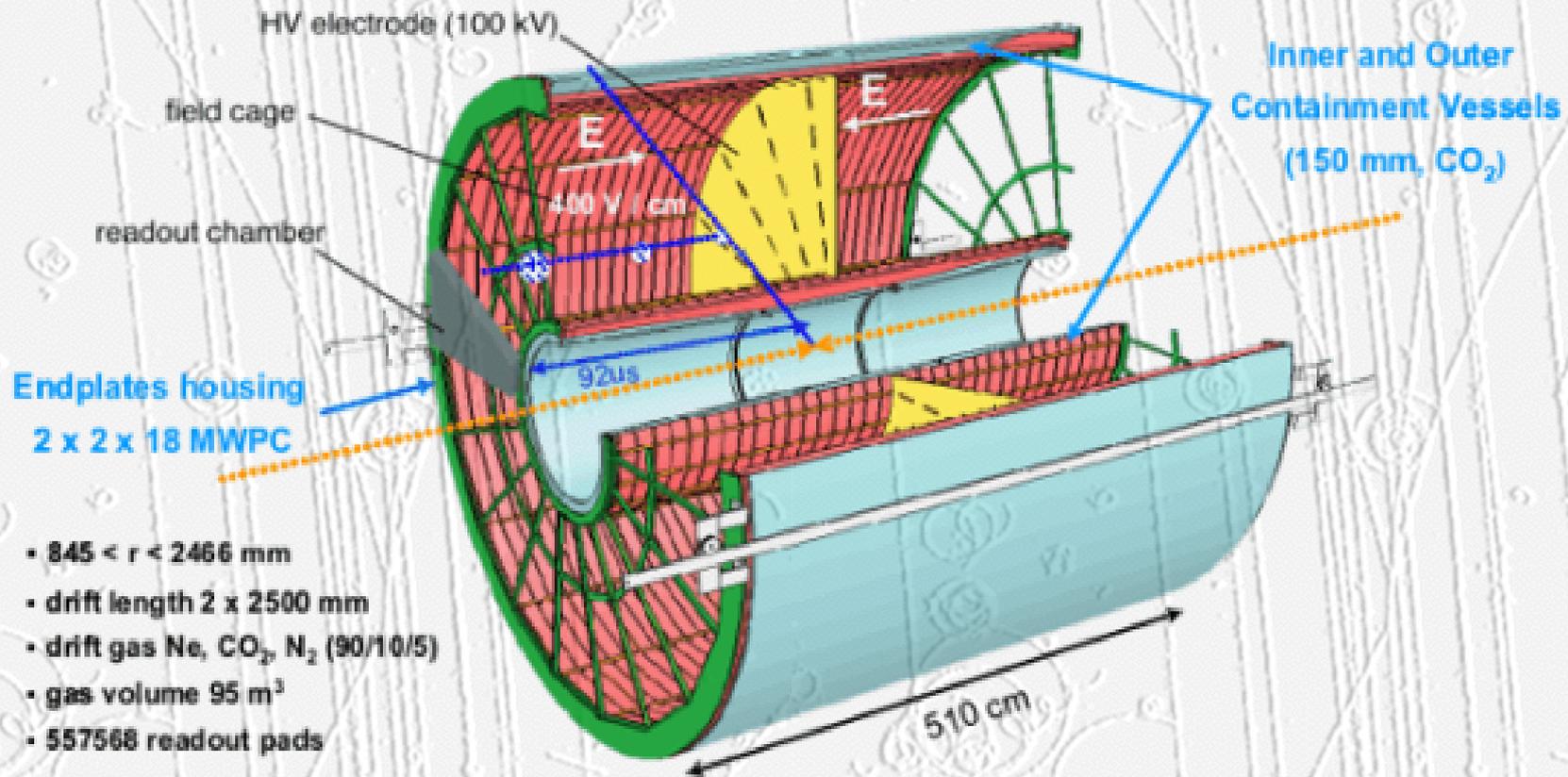


Identification

dE/dx

$$p = \gamma M \beta c$$

$$\frac{dE}{dx} \propto \frac{1}{\beta^2} \ln(\beta^2 \gamma^2)$$

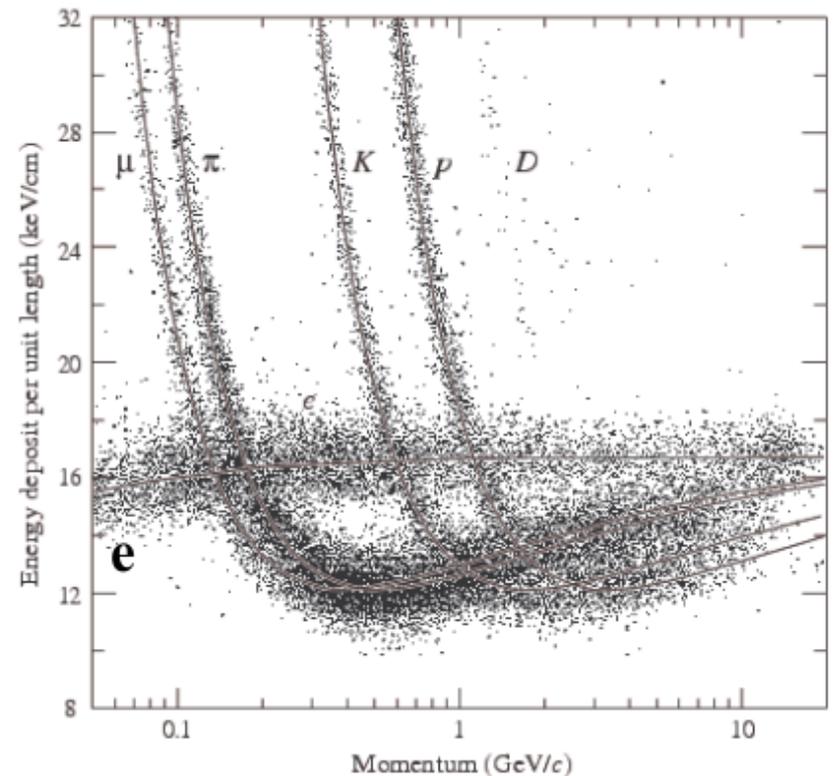
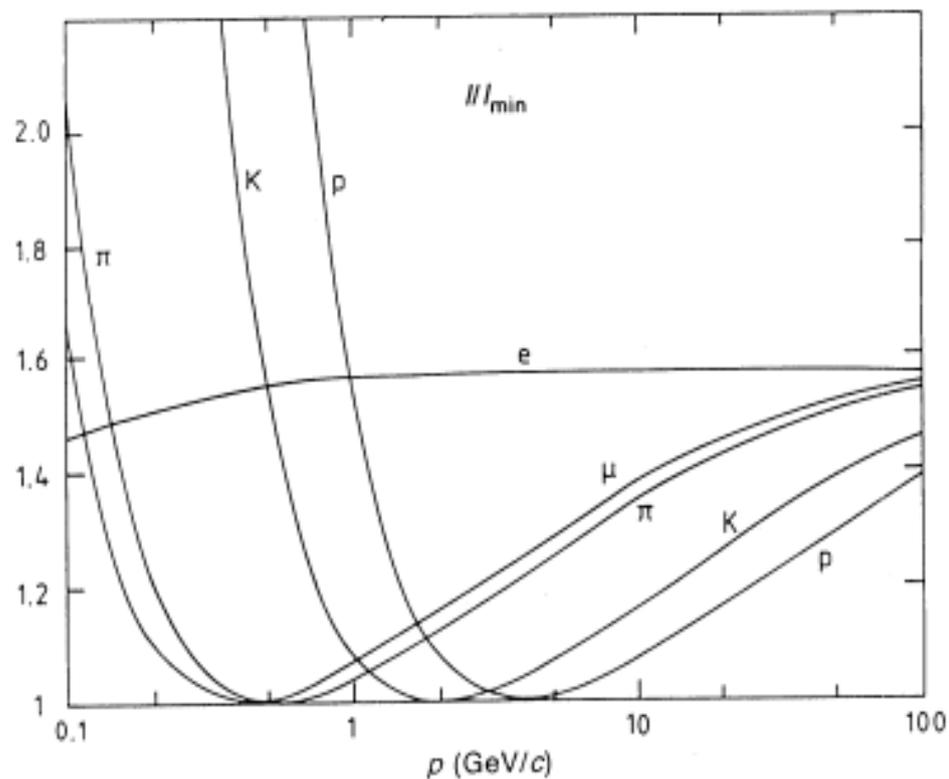


Identification

dE/dx

$$p = \gamma M \beta c$$

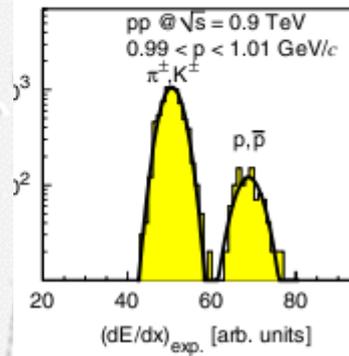
$$\frac{dE}{dx} \propto \frac{1}{\beta^2} \ln(\beta^2 \gamma^2)$$



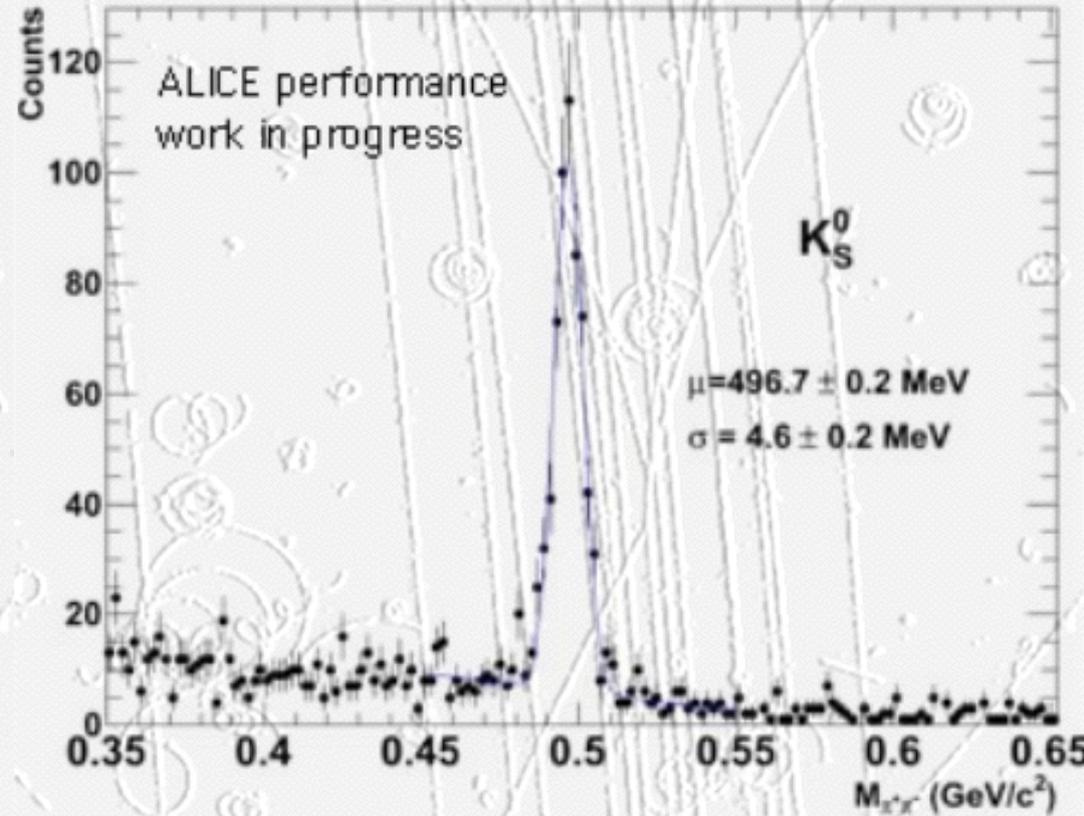
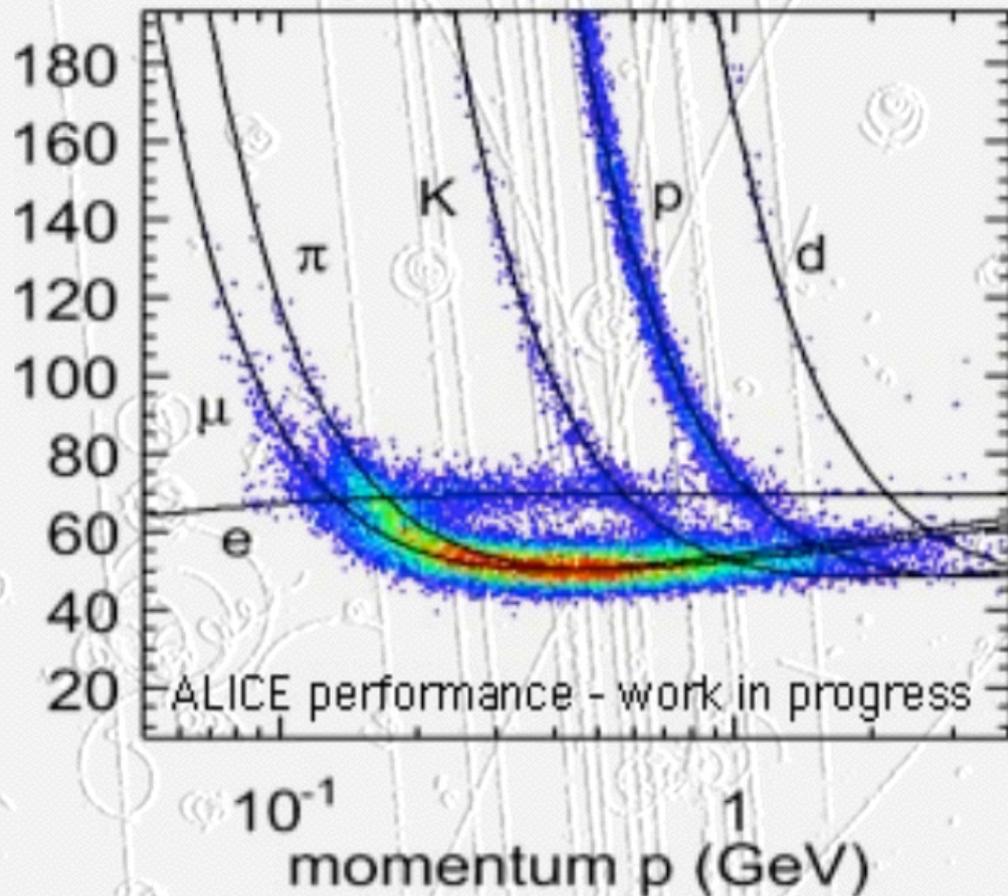
←→
Gamme d'énergie : $\sim 0.1 \rightarrow \sim 10$ GeV

Identification

dE/dx : Alice



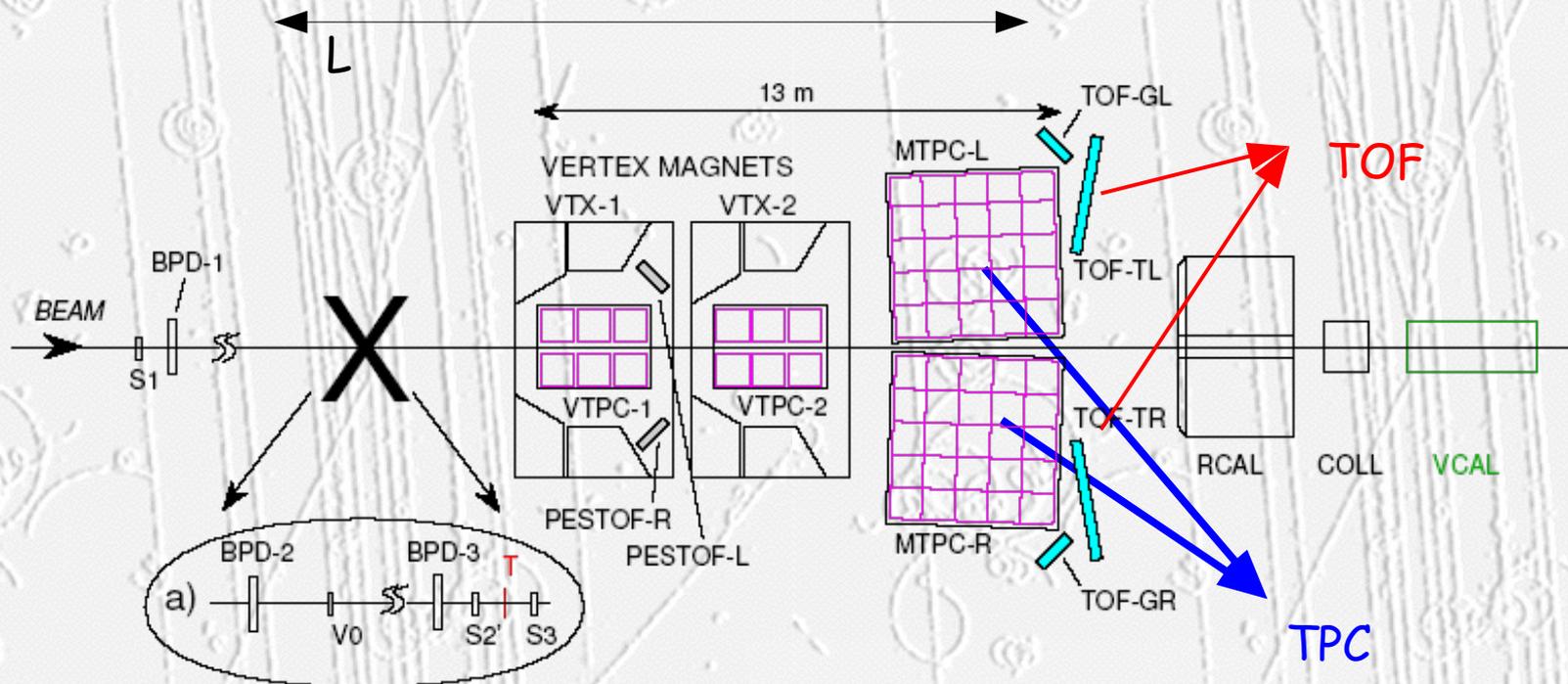
Ce n est pas le même K



Identification

Temps de vol

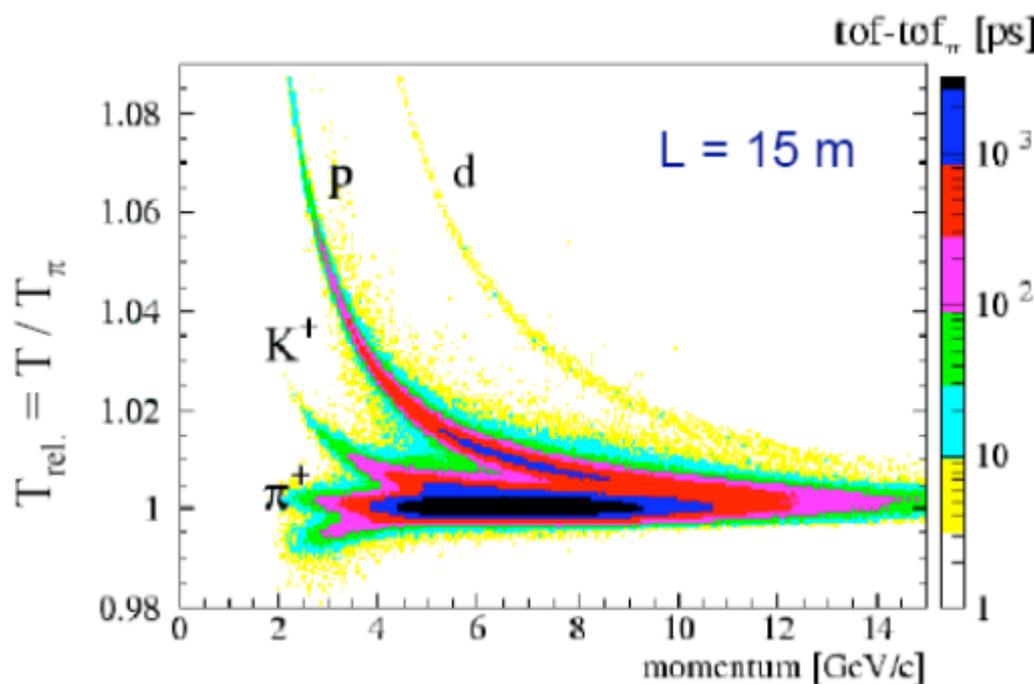
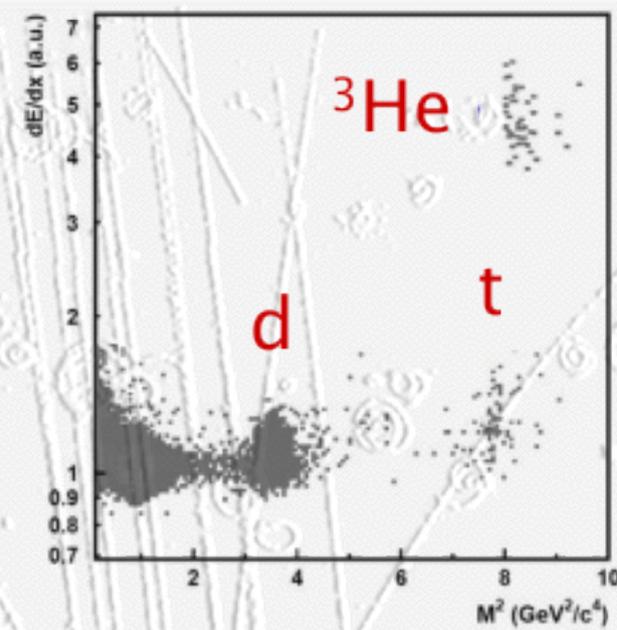
- Scintillateurs + PM:NA49
 - Entre le point d'interaction et un autre point
 - $\Delta t = L/\beta c$ et mesure de impulsion



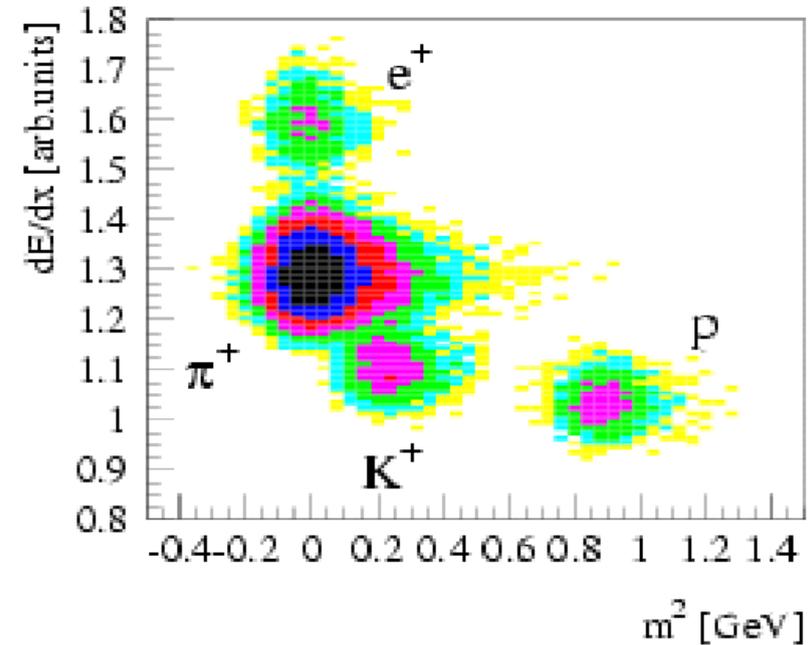
Identification

Temps de vol

- Scintillateurs + PM: Na 49



+dEdx

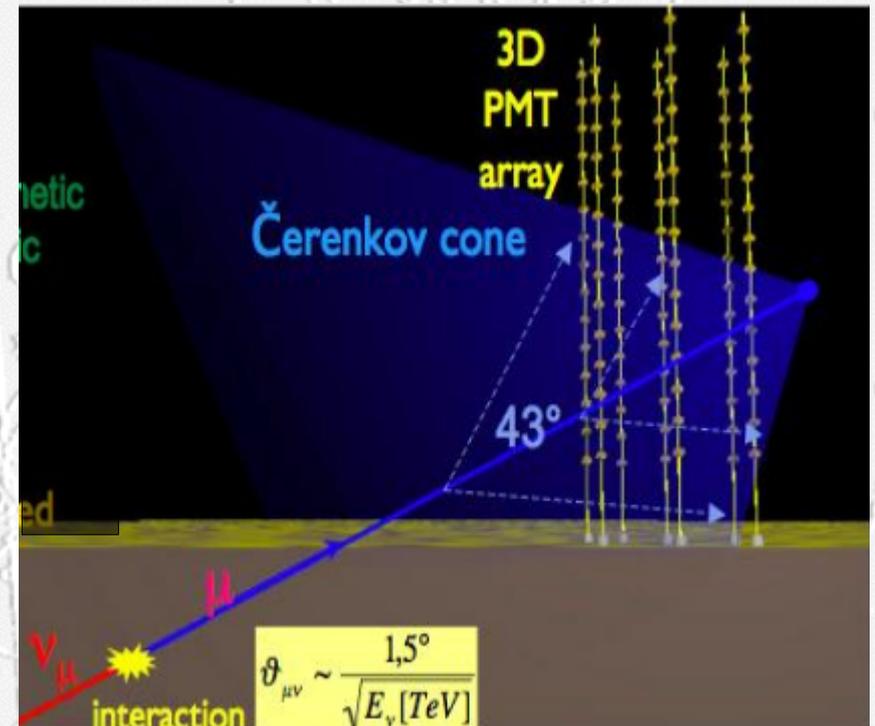
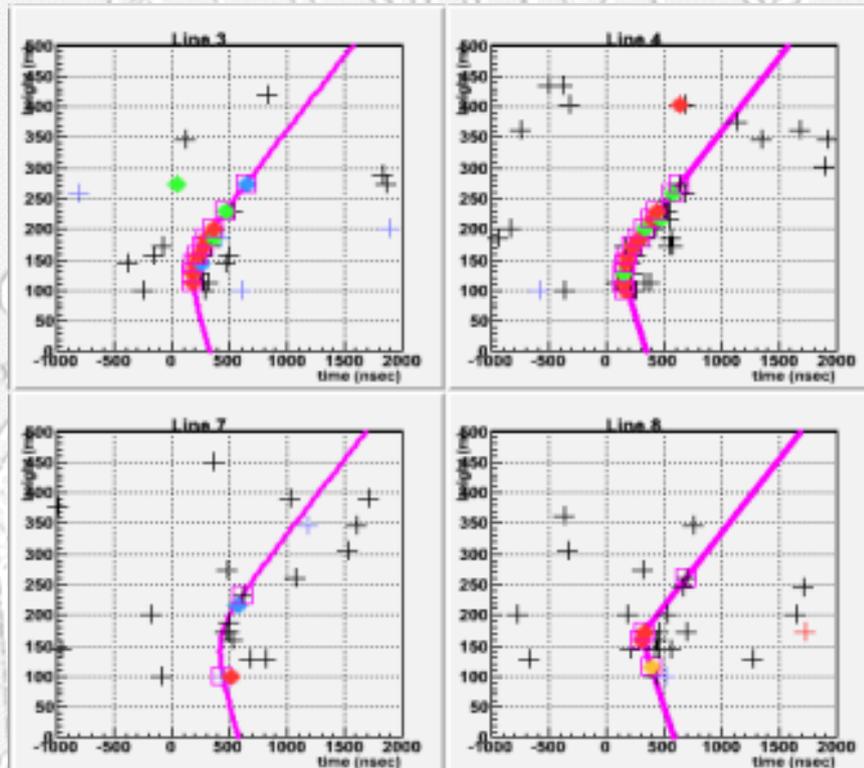
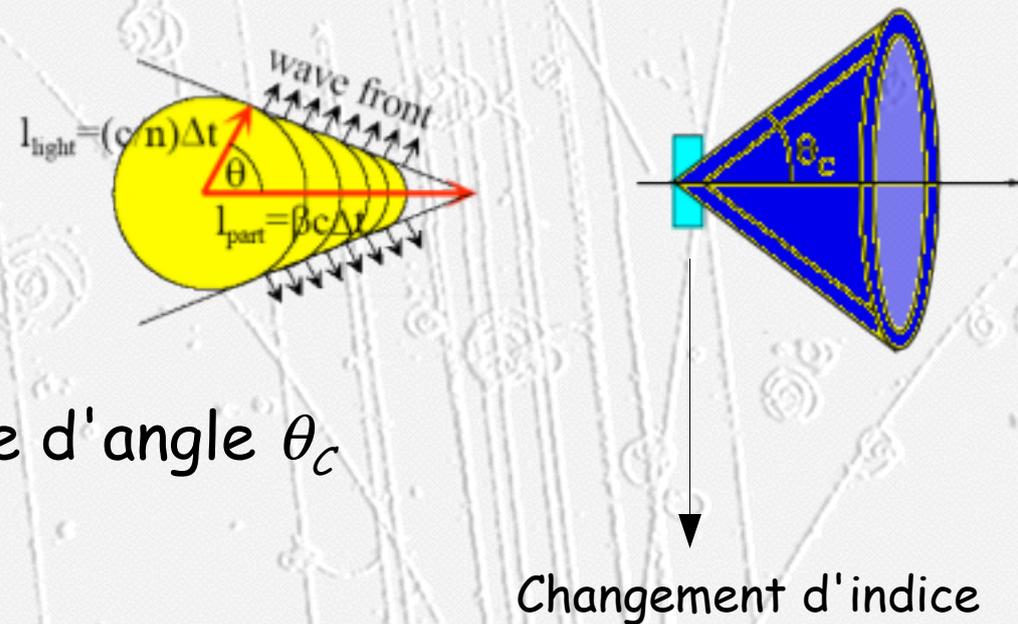


← Gamme d'énergie : $\sim 1 \rightarrow \sim 10 \text{ GeV}$ →

Identification

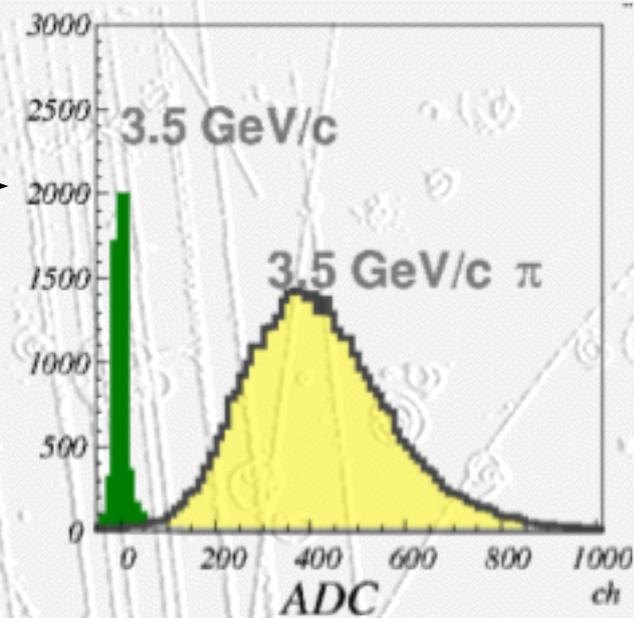
Rayonnement Cherenkov

- Radiation (photons) tangent à cône d'angle θ_c autour de la trace: $\cos\theta_c = (n\beta)^{-1}$



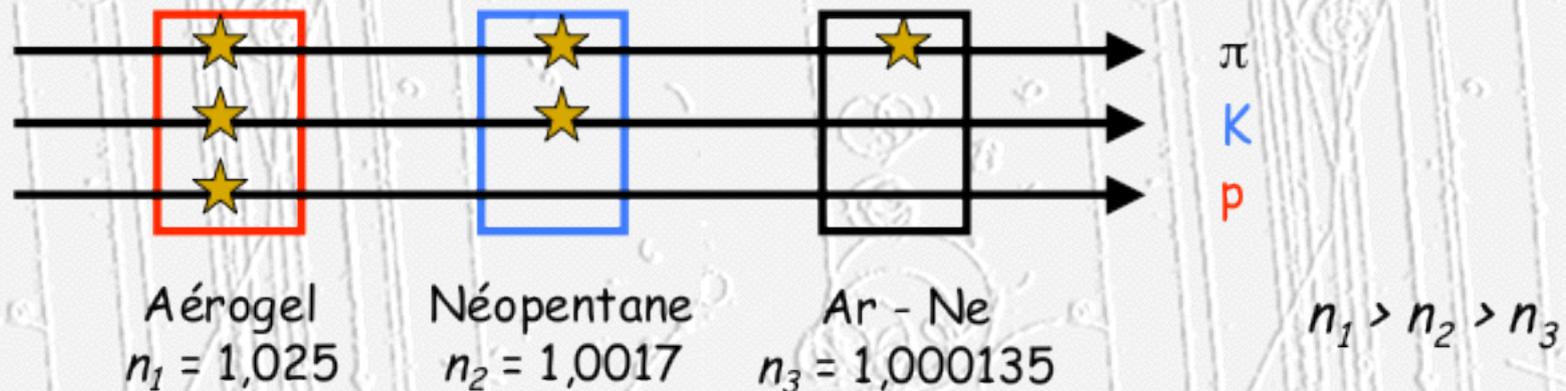
Identification

Belle : séparation π/K



Rayonnement Cherenkov

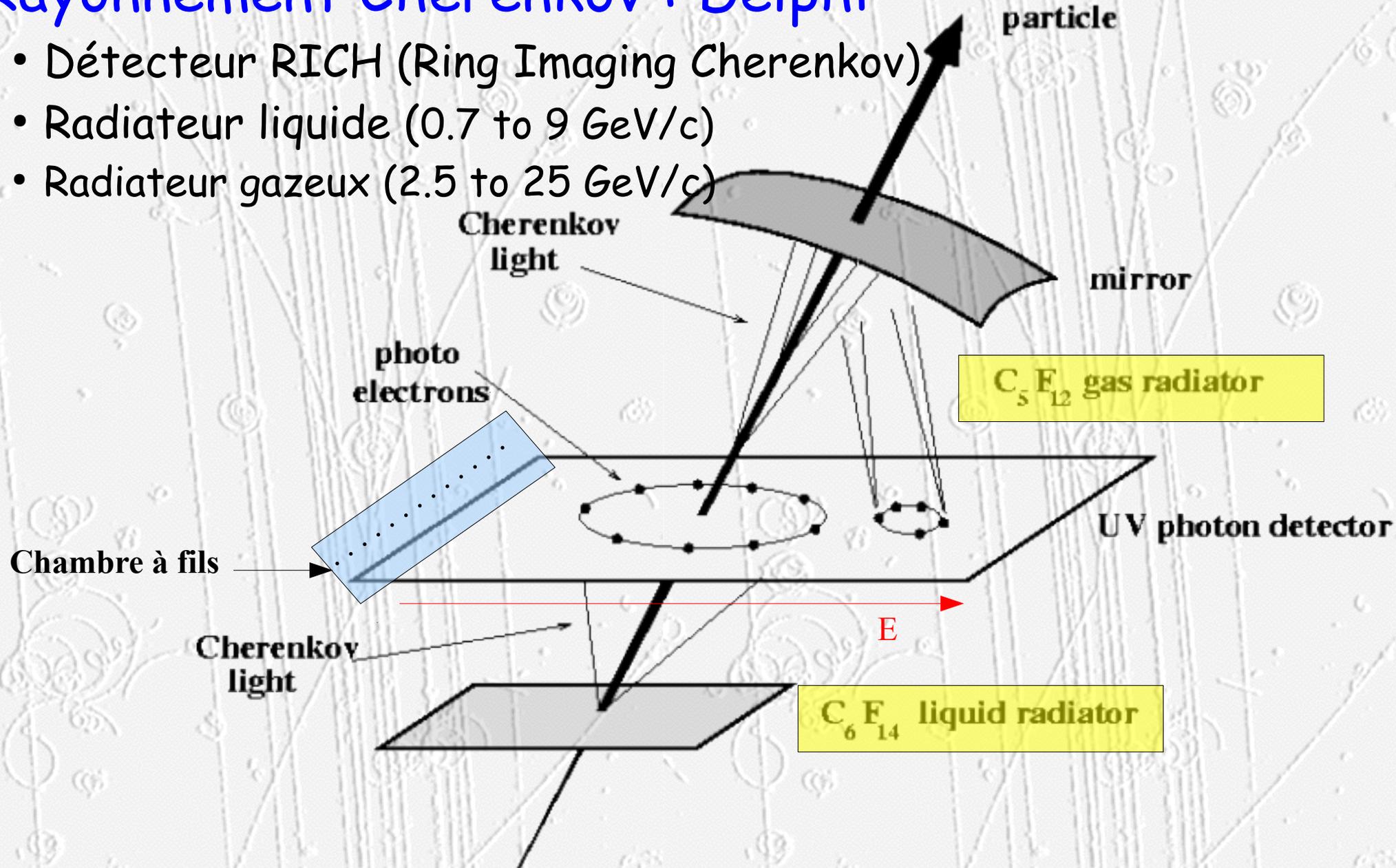
- Détecteur à seuil
- Choix astucieux du milieu va permettre de produire ou non la radiation Cherenkov $\beta > 1/n$



Identification

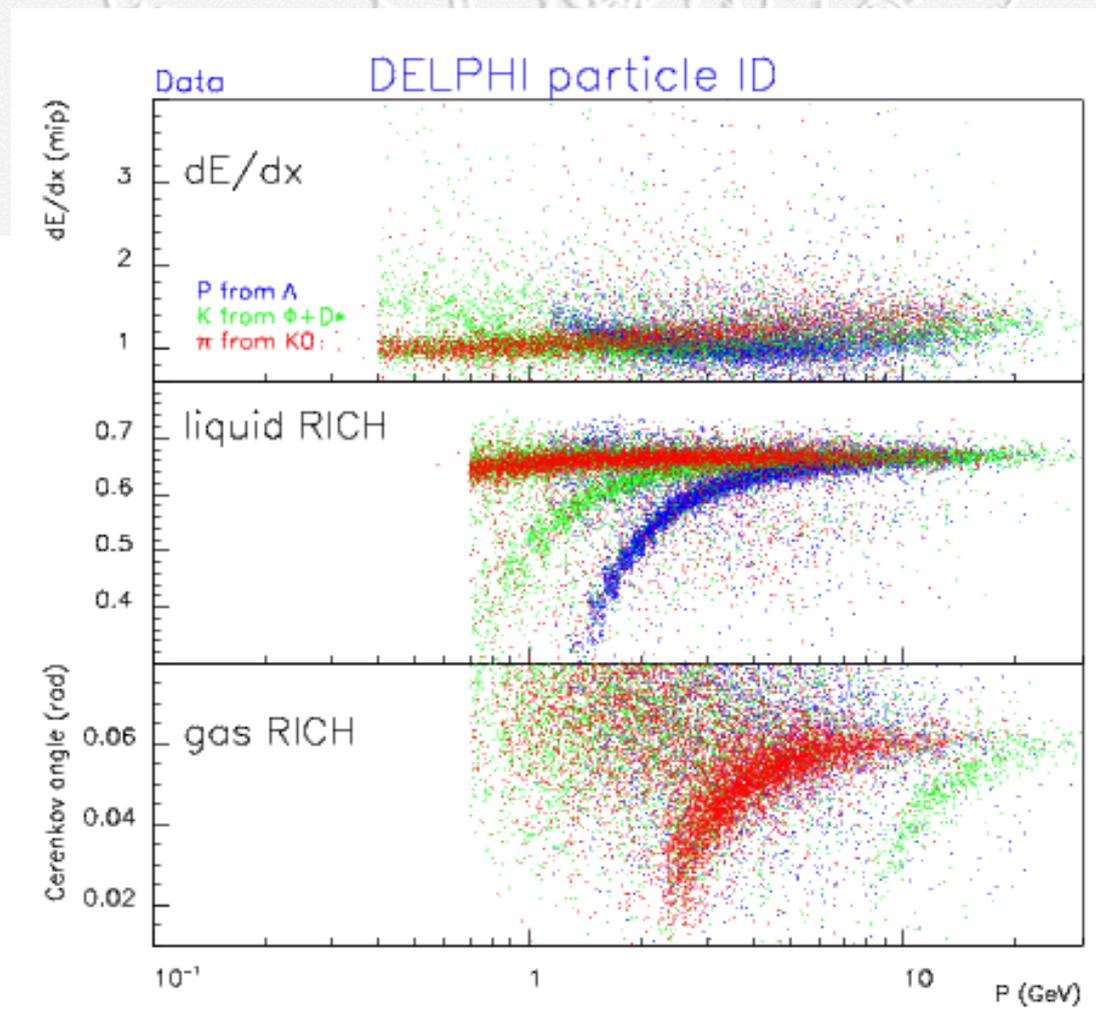
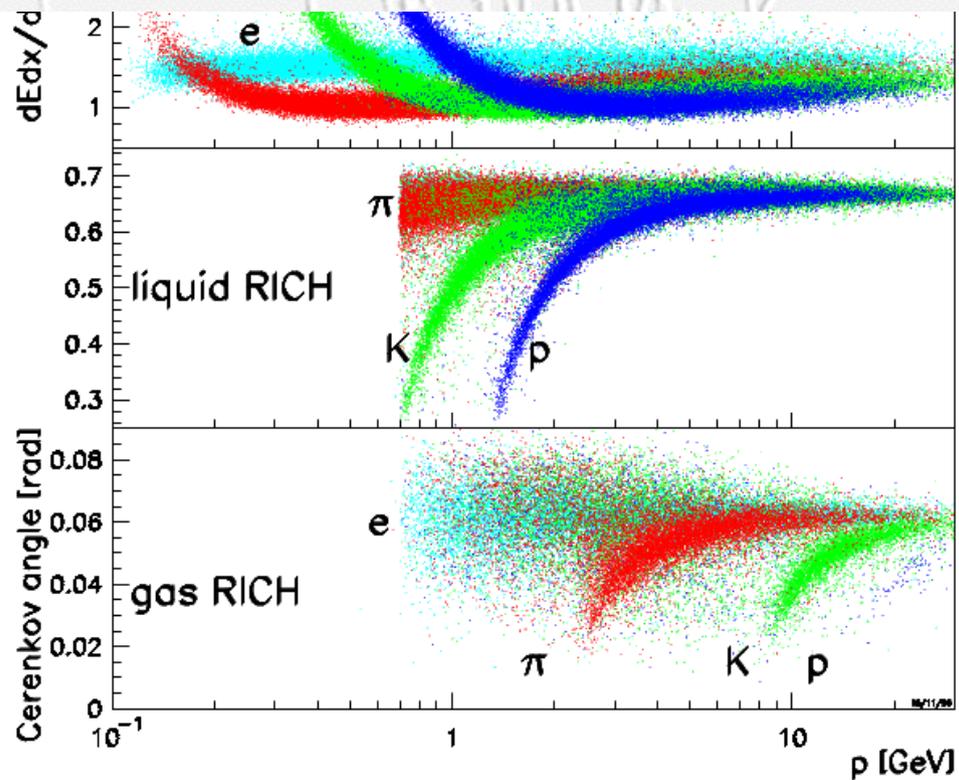
Rayonnement Cherenkov : Delphi

- Détecteur RICH (Ring Imaging Cherenkov)
- Radiateur liquide (0.7 to 9 GeV/c)
- Radiateur gazeux (2.5 to 25 GeV/c)



Identification

Rayonnement Cherenkov: Delphi

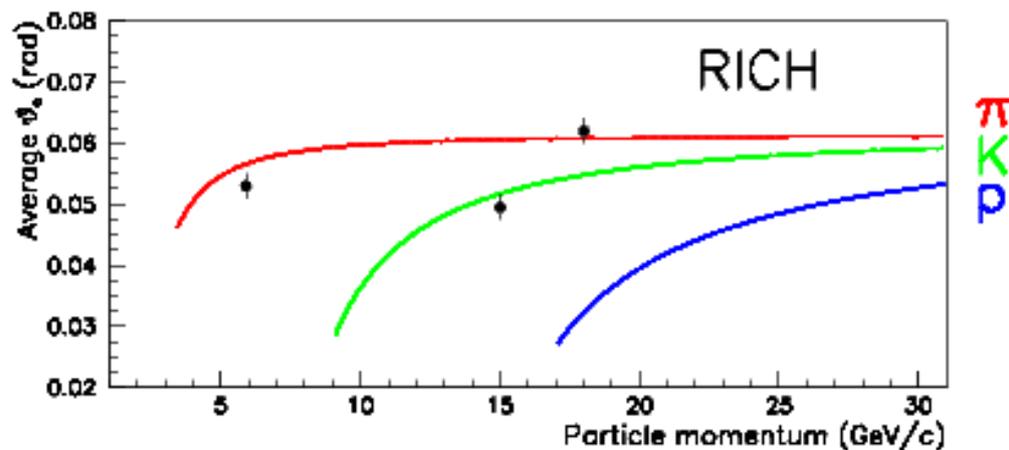
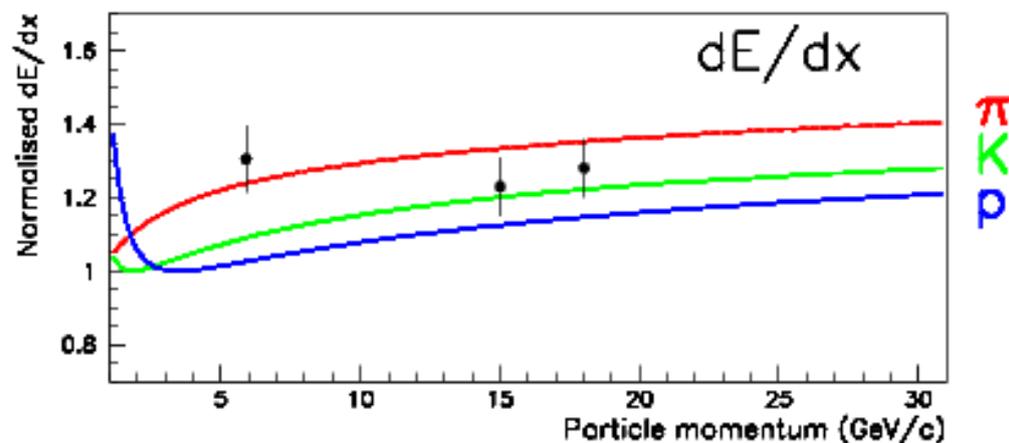
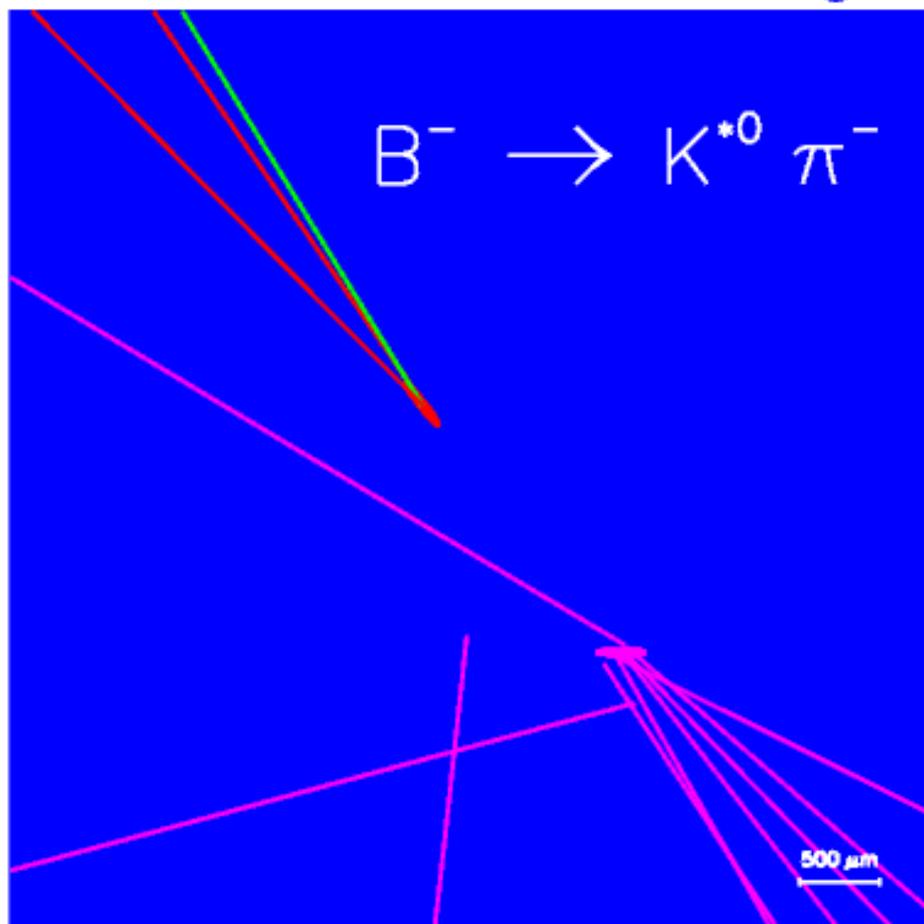


Identification

Rayonnement Cherenkov + dE/dx: Delphi

DELPHI Vertex Display

Run: 41541 Event: 1151

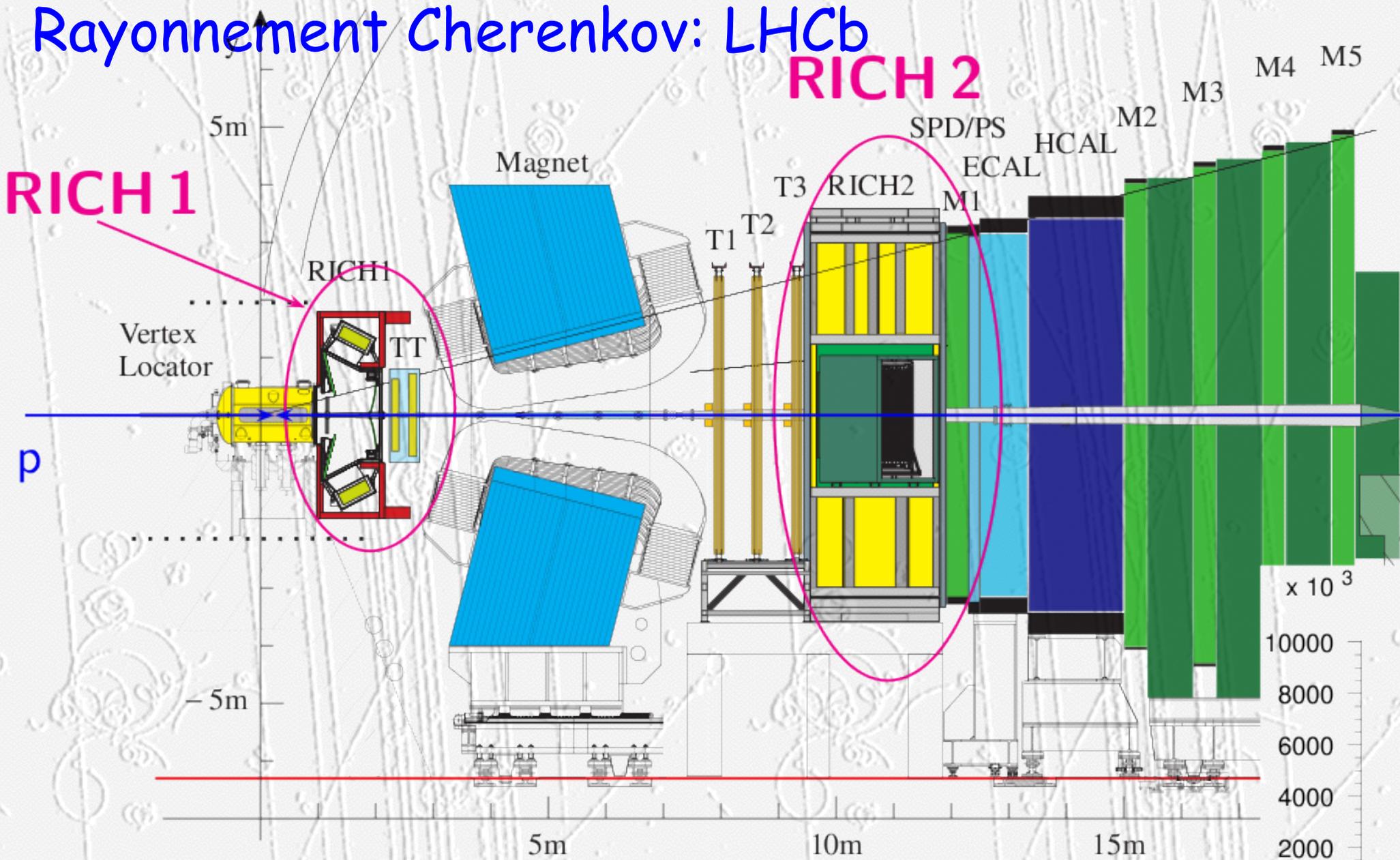


Identification

Rayonnement Cherenkov: LHCb

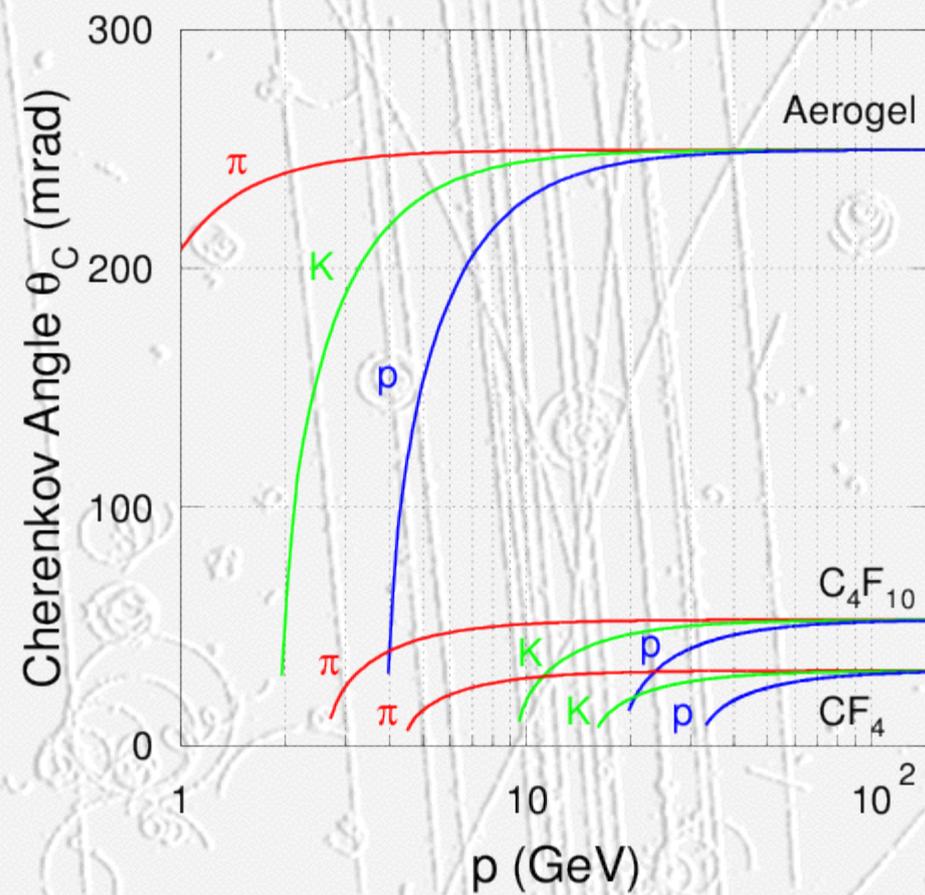
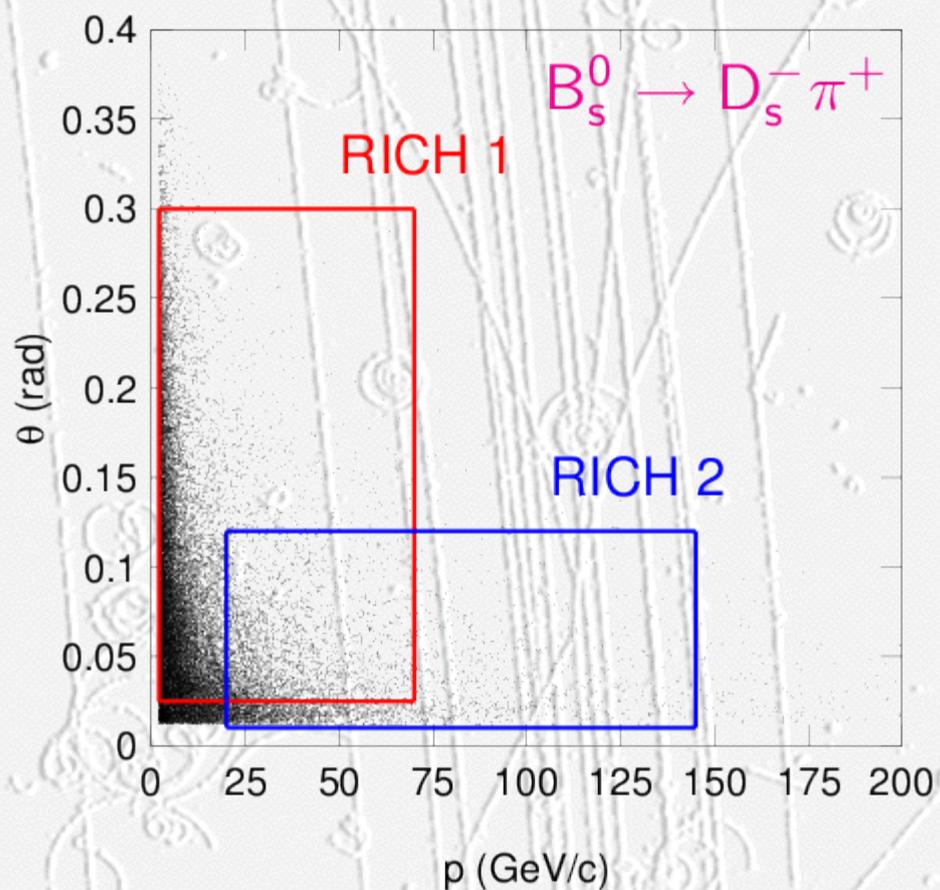
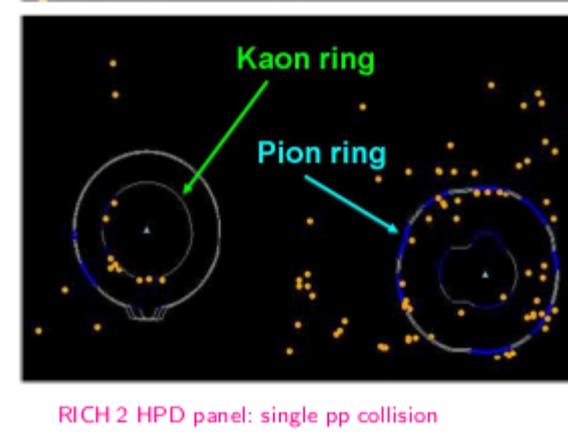
RICH 2

RICH 1



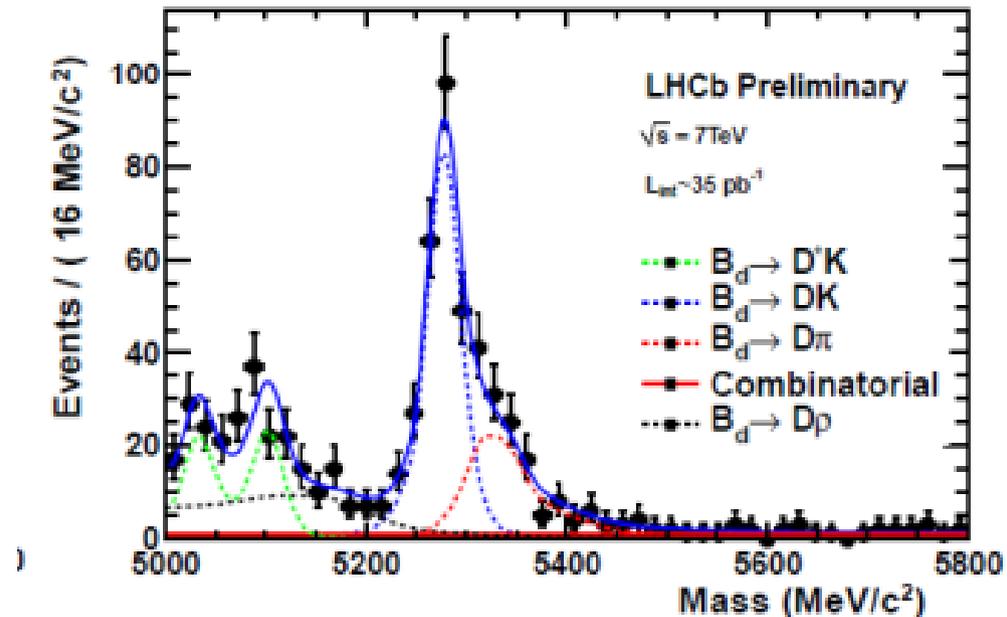
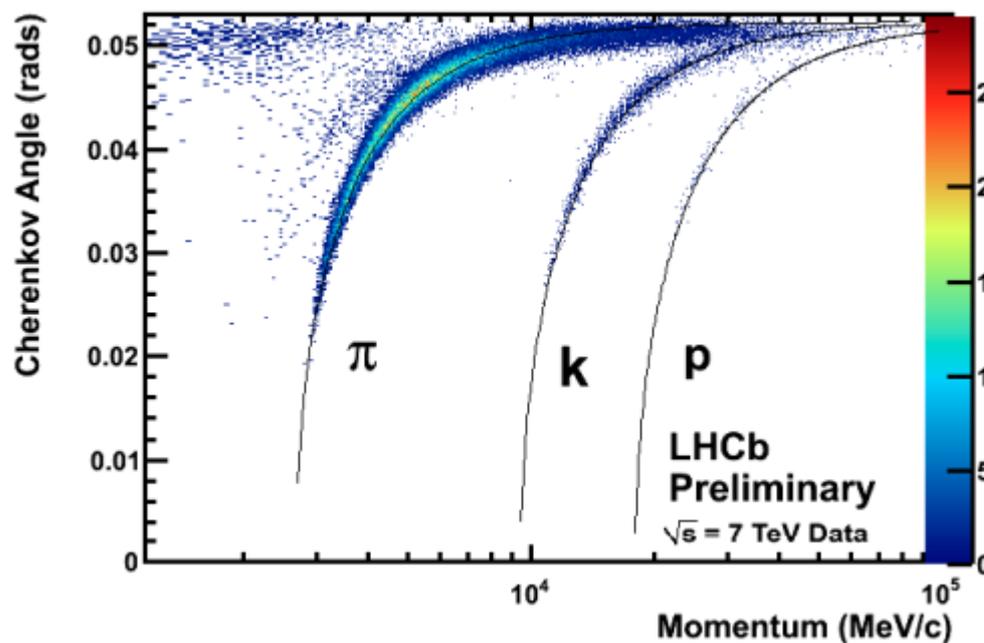
Identification

Rayonnement Cherenkov: LHCb



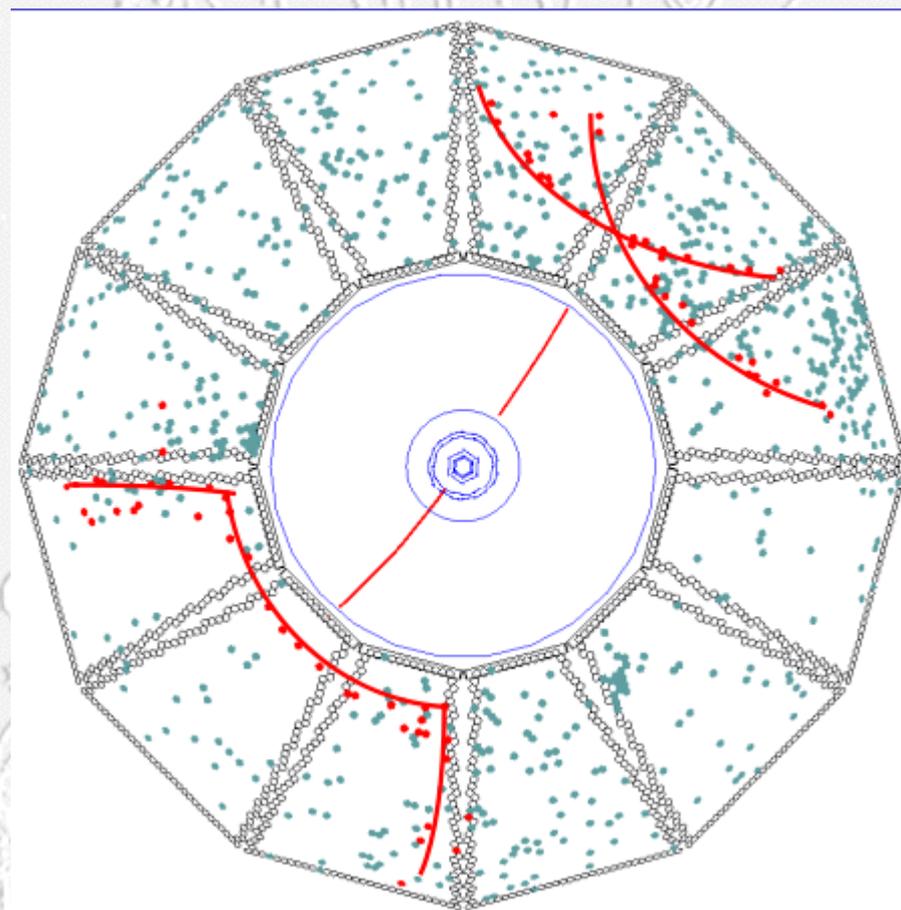
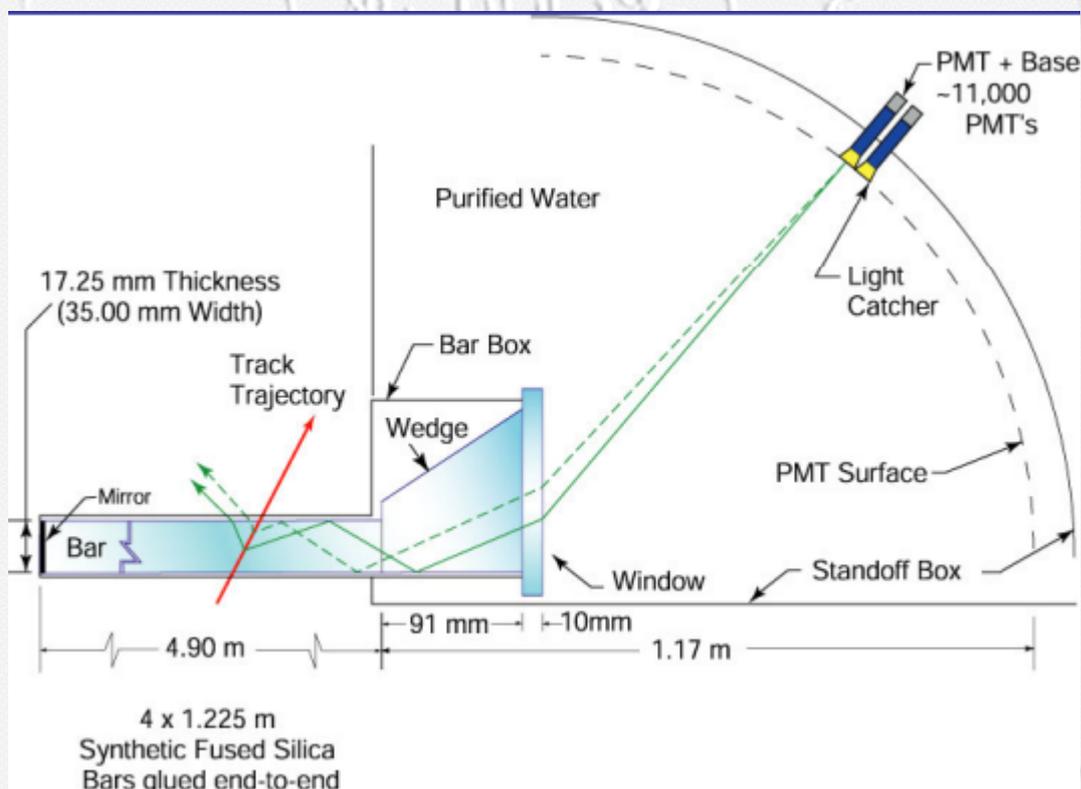
Identification

Rayonnement Cherenkov: LHCb



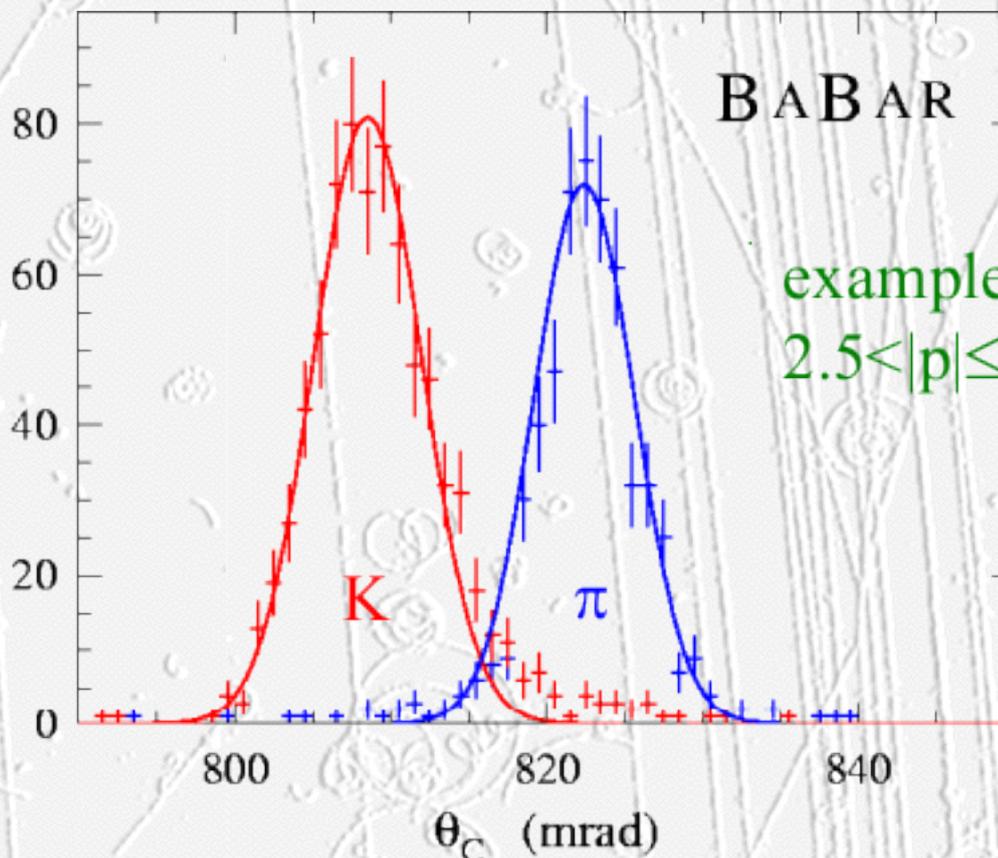
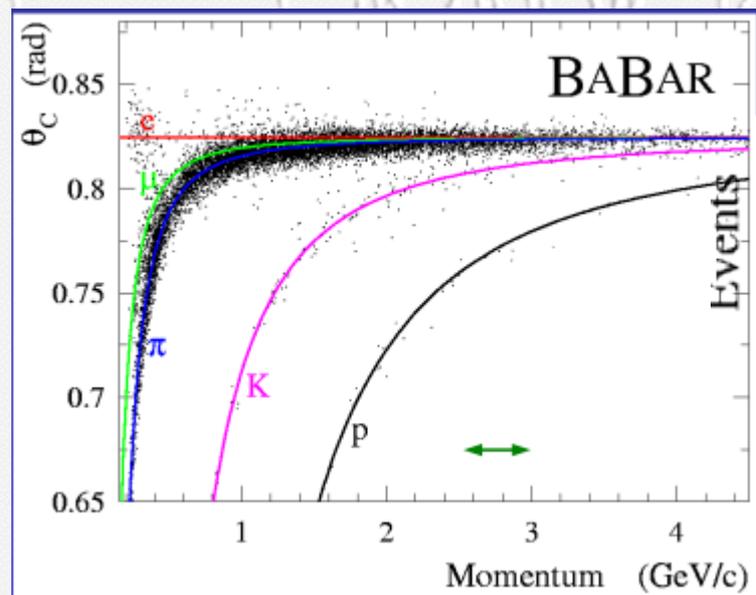
Identification

Rayonnement Cherenkov: BaBar



Identification

Rayonnement Cherenkov: BaBar

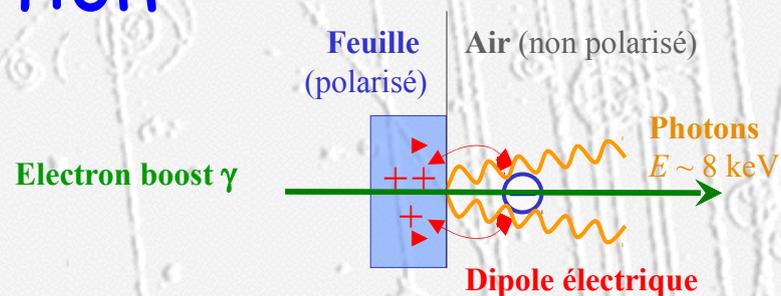


example:
 $2.5 < |p| \leq 3 \text{ GeV/c}$

Identification

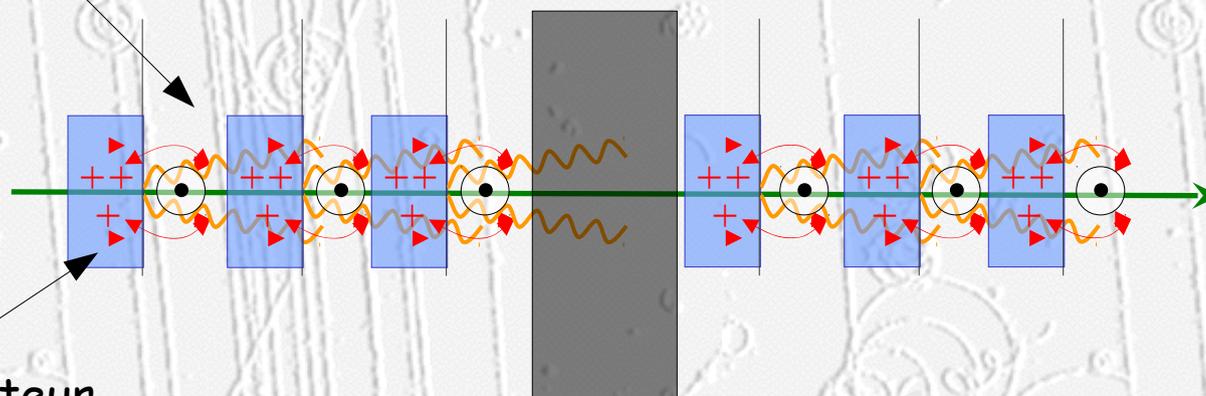
Rayonnement de Transition

- Atlas : TRT



Radiation si $\gamma > 1000$ & > 100 transitions

Détecteur

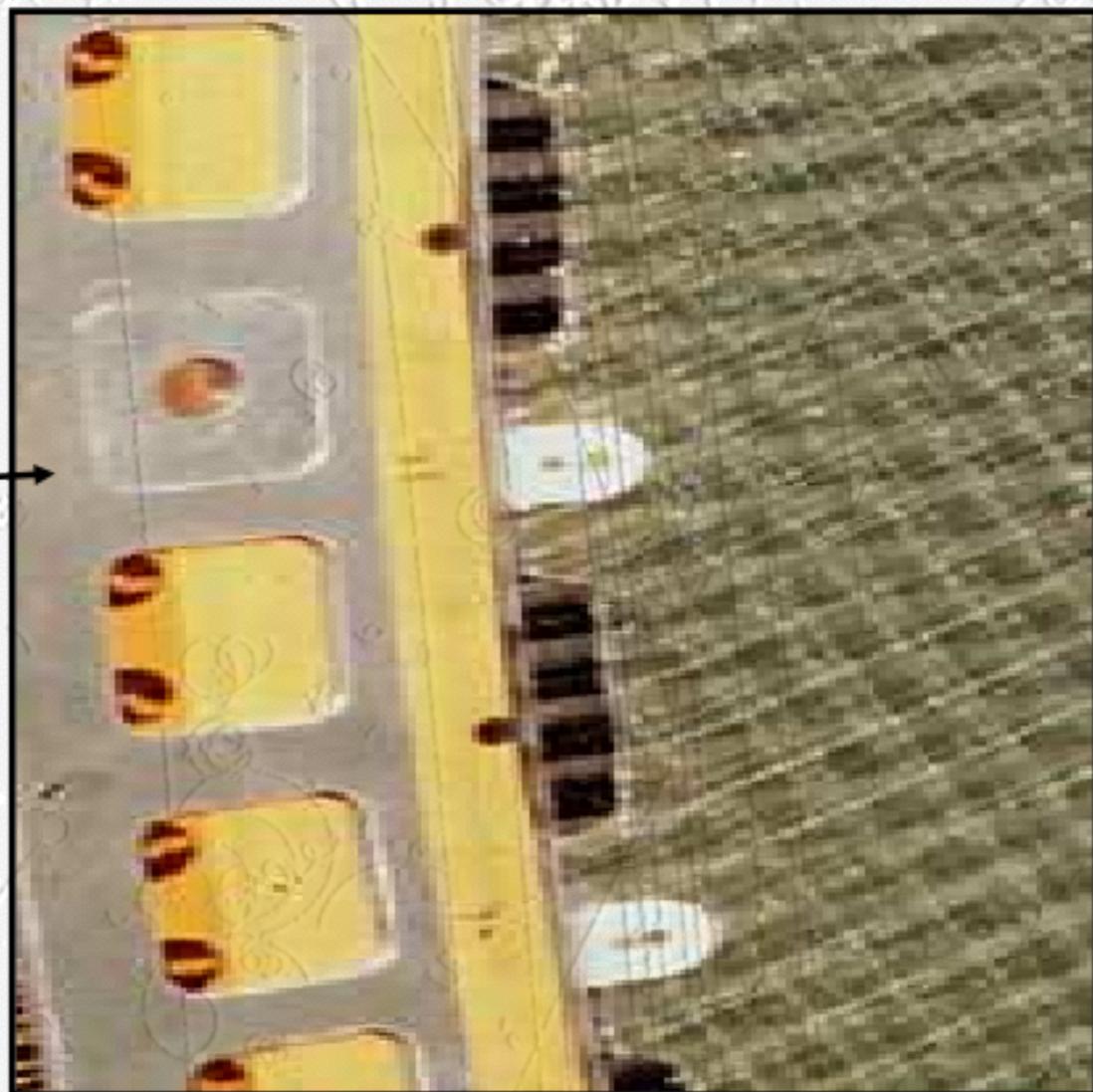
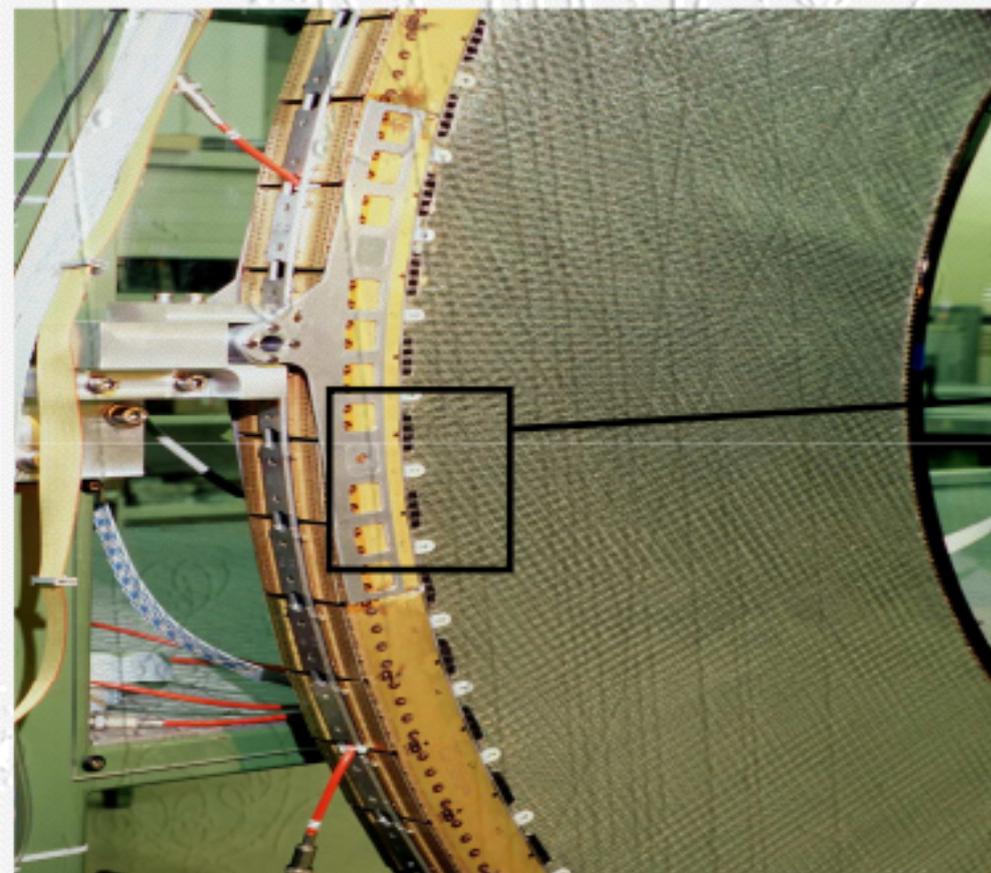


support :
tous les photons de RT sont absorbés

Identification

Rayonnement de Transition

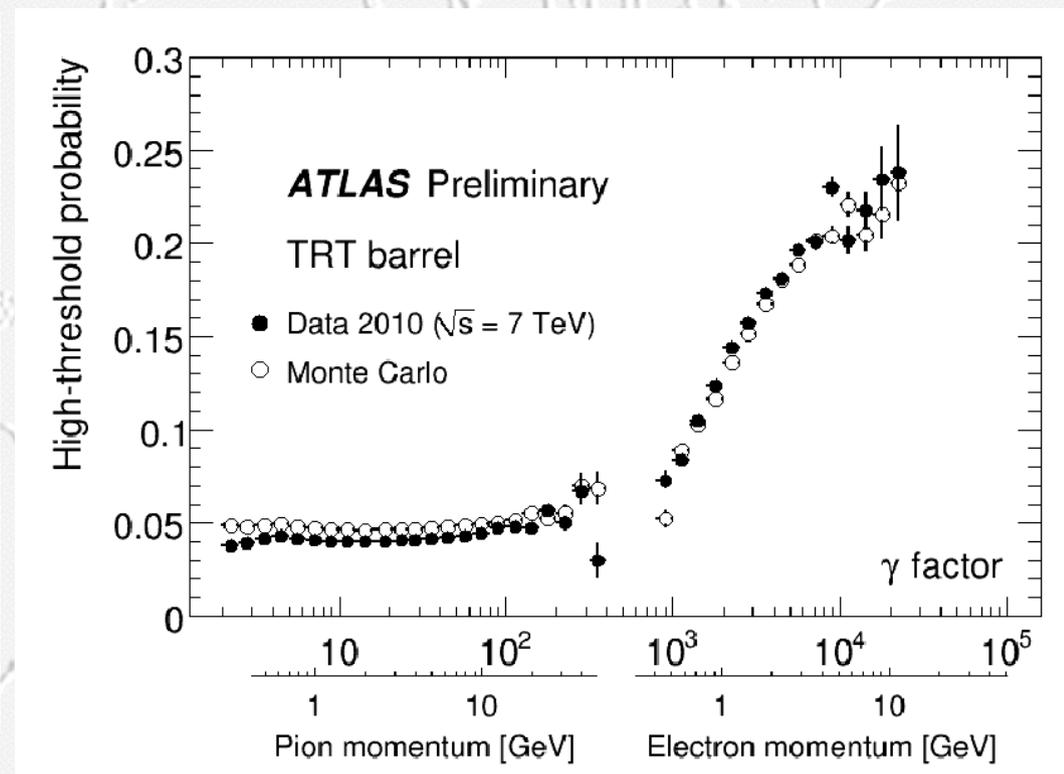
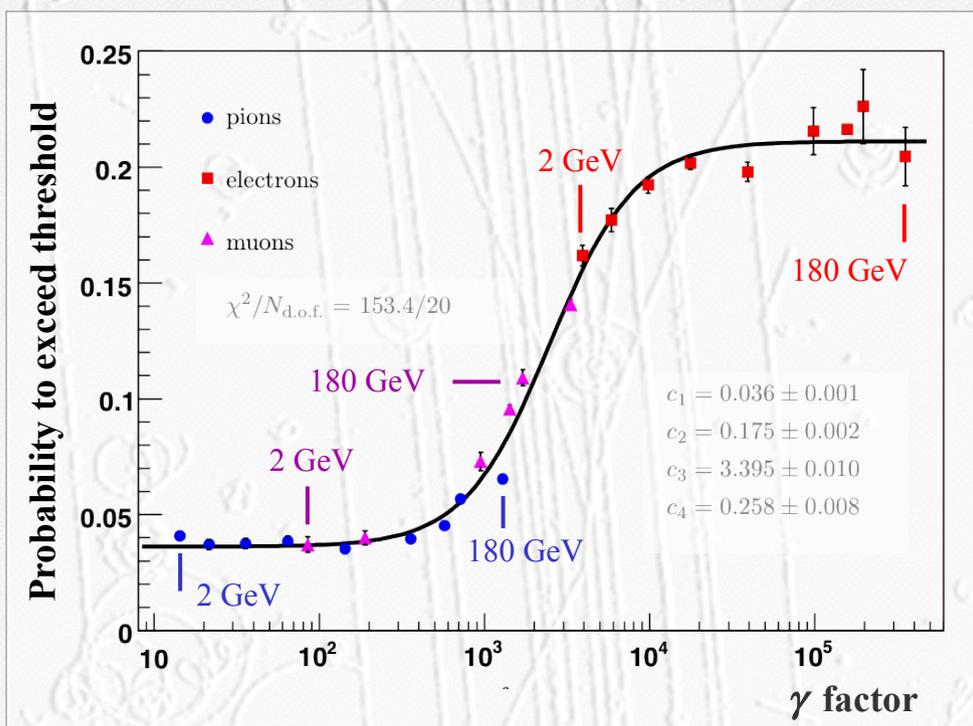
- Atlas : TRT



Identification

Rayonnement de Transition

- Atlas : TRT

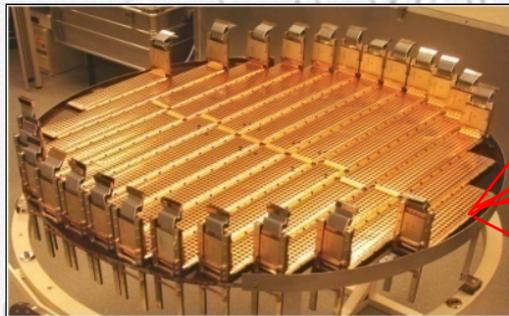


Identification

TRD
Identification e^+ , e^-



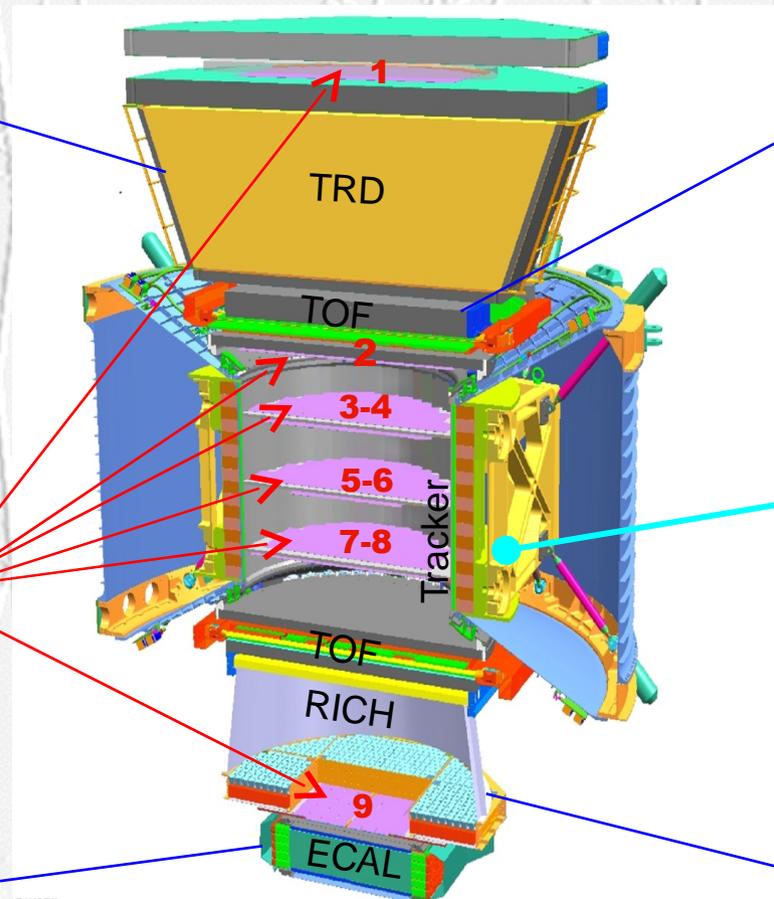
Silicium
 Z , P



ECAL
 E of e^+ , e^- , γ



Exemple AMS2



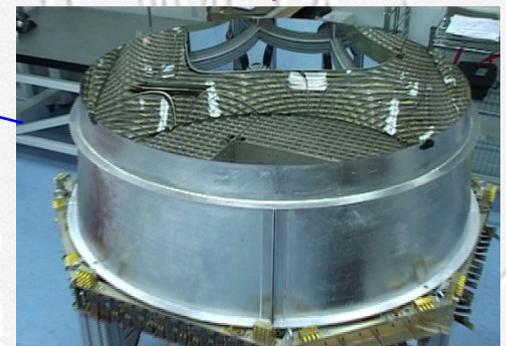
TOF
 Z , E



Magnet
 $\pm Z$



RICH
 Z , E

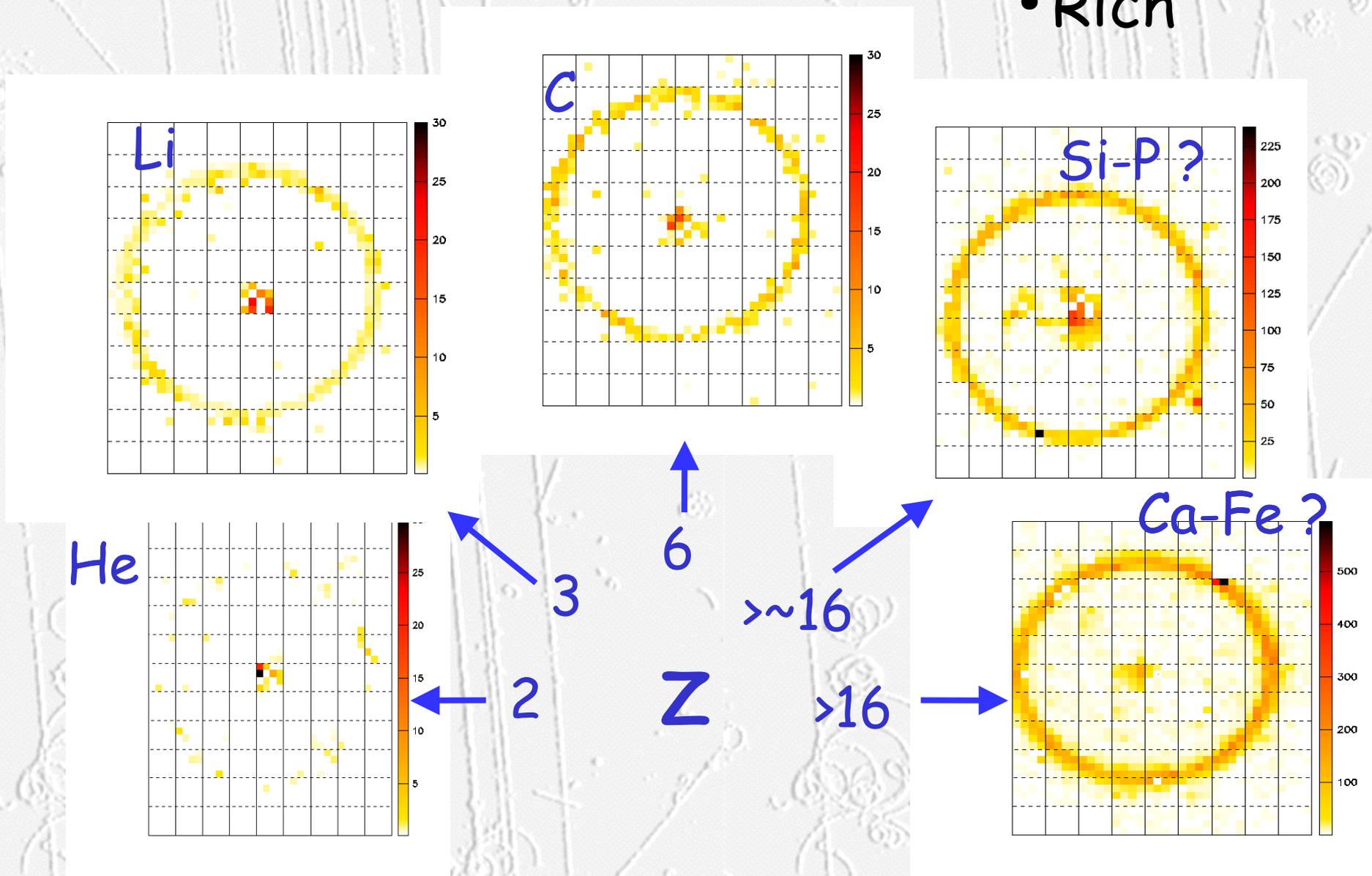


Z , P sont mesurés indépendamment par Tracker, RICH, TOF and ECAL

Identification

Exemple AMS2

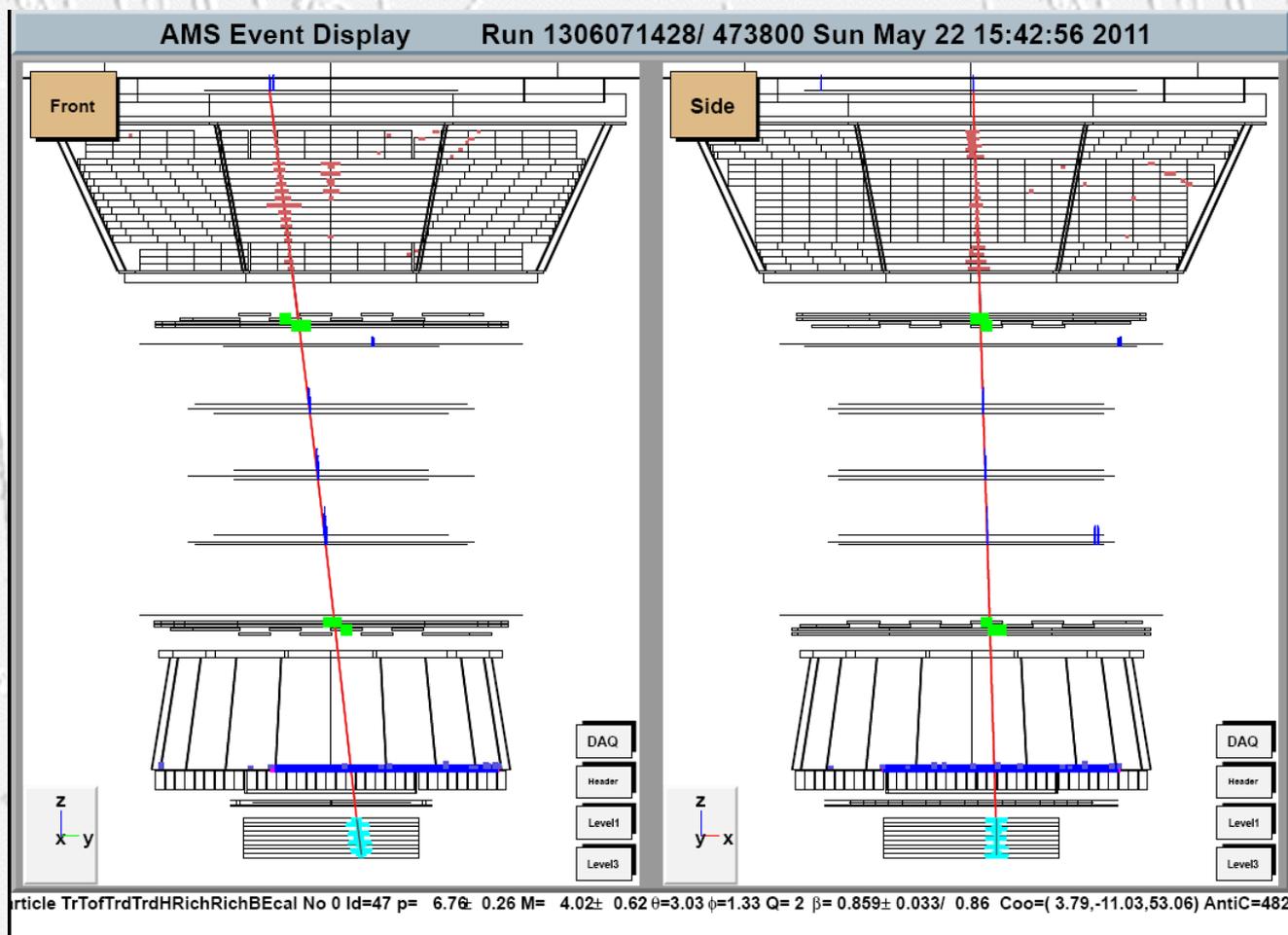
- Rich



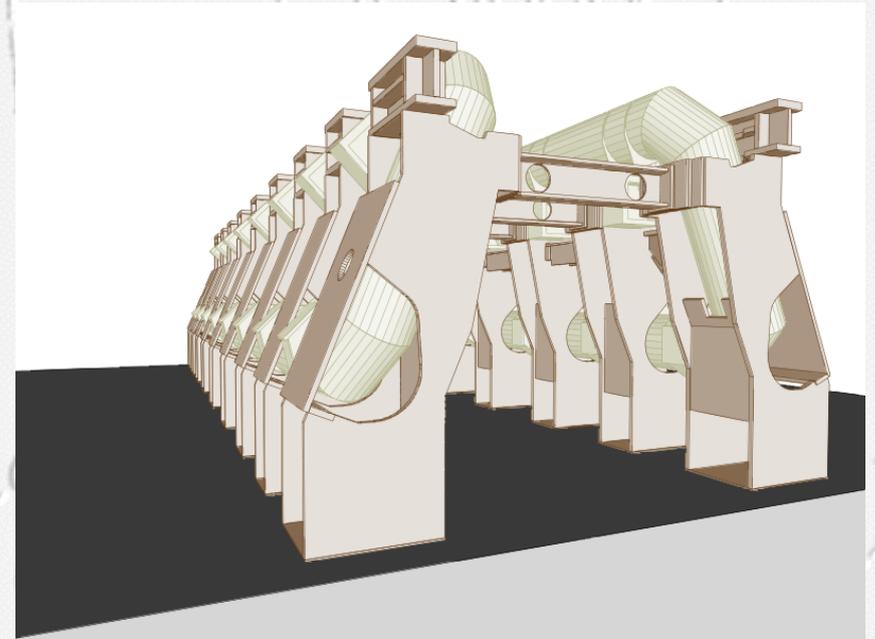
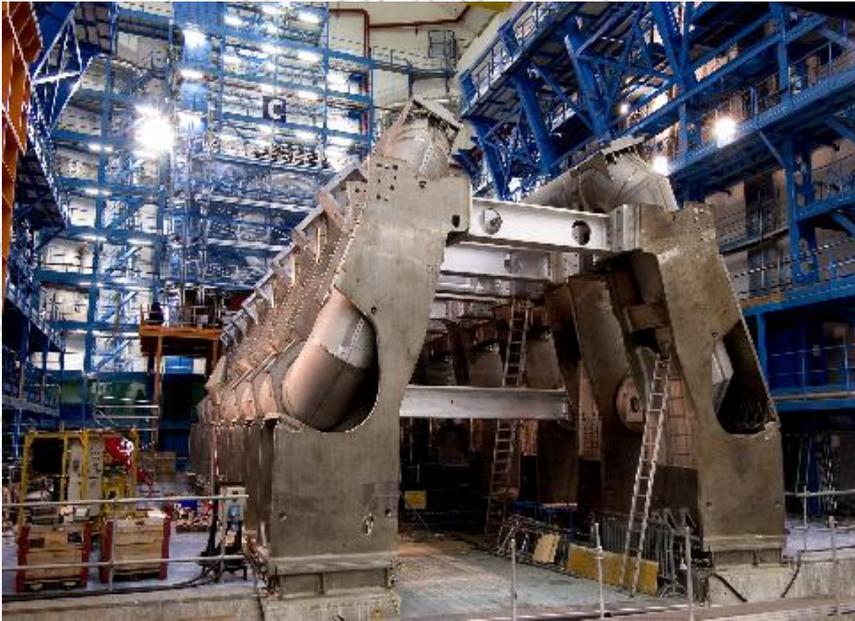
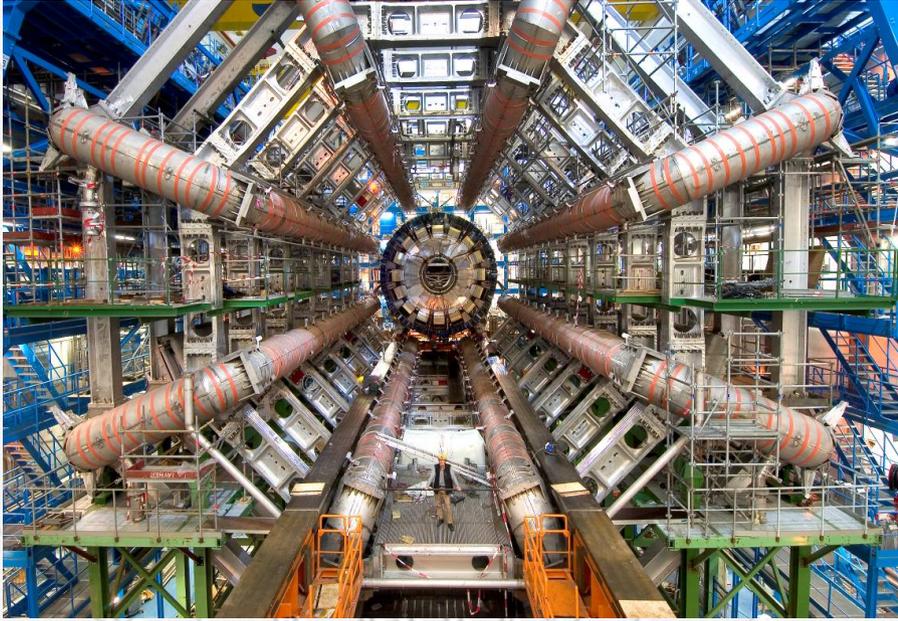
Identification

Exemple AMS2

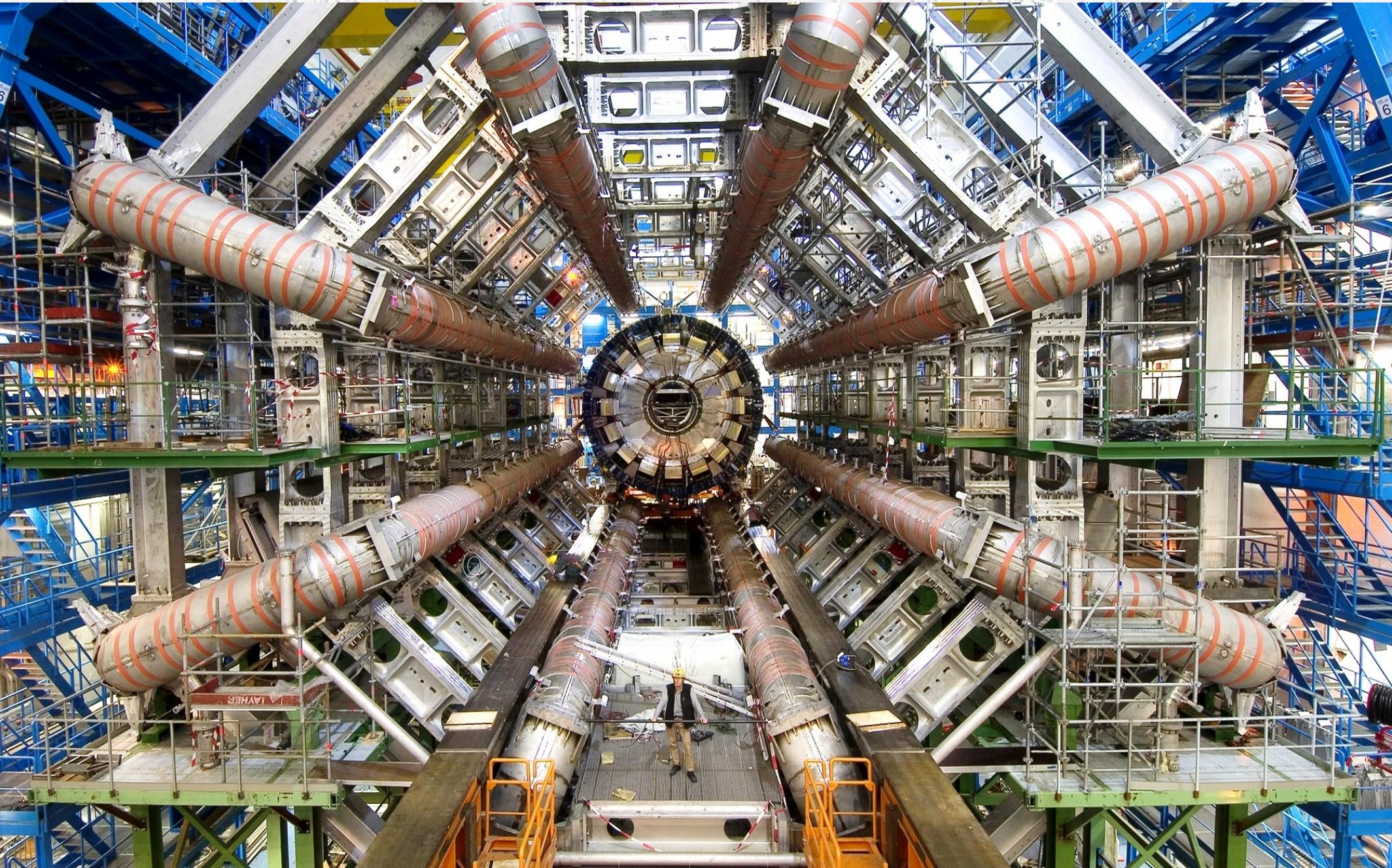
- Candidat He



ATLAS



ATLAS



ATLAS

Valence, Espagne

HECTOR BERLIOZ

Les Troyens

NOVA PRODUCCIÓ - NUEVA PRODUCCIÓN
Palau de les Arts Reina Sofia
Teatro Marinski, San Petersburgo
Teatr Wielki (Opera Narodowa), Varsovia

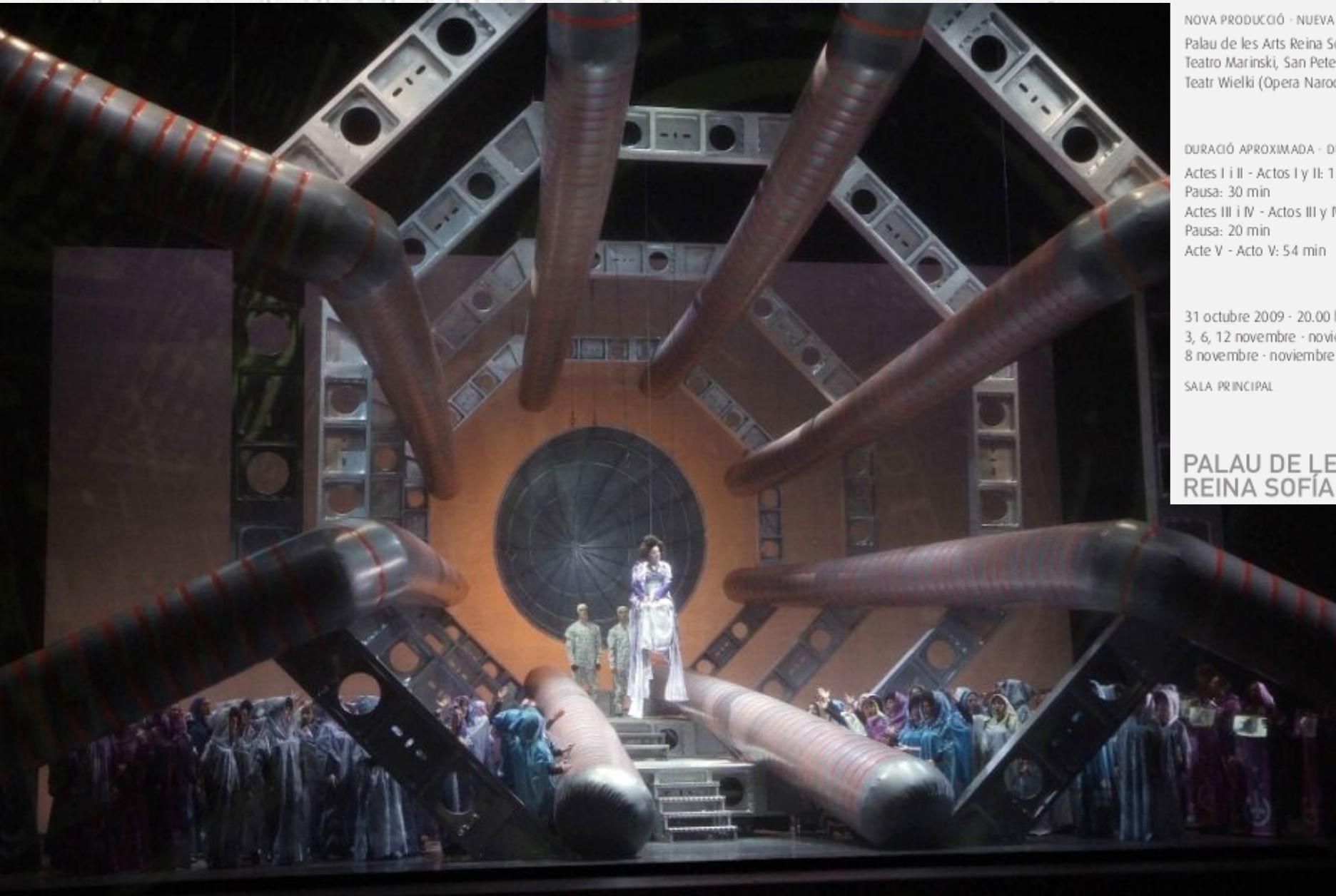
DURACIÓ APROXIMADA - DURACIÓN APROXIMADA

Actes I i II - Actos I y II: 1 h 21 min
Pausa: 30 min
Actes III i IV - Actos III y IV: 1 h 42 min
Pausa: 20 min
Acte V - Acto V: 54 min

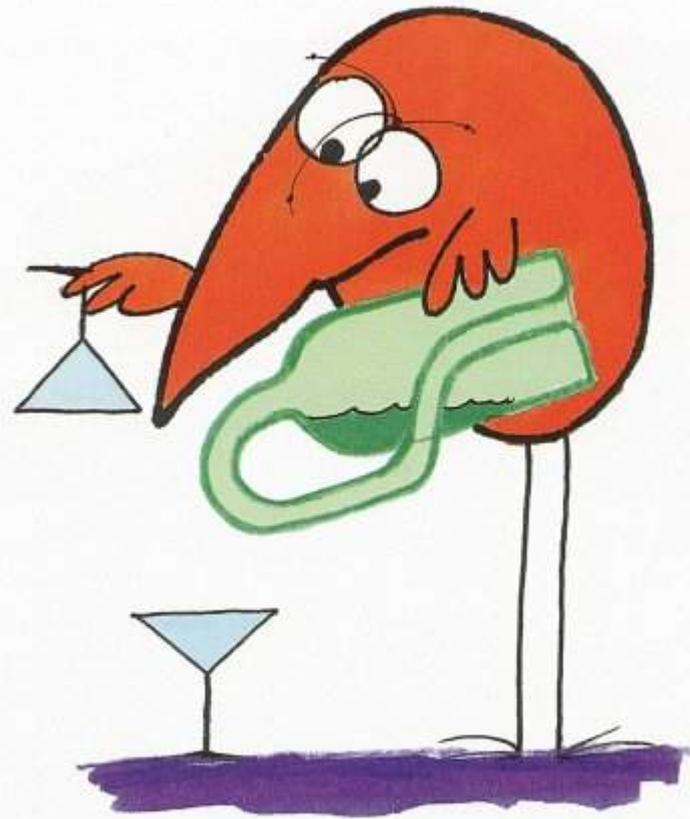
31 octubre 2009 - 20.00 h
3, 6, 12 novembre - noviembre 2009 - 20.00 h
8 novembre - noviembre 2009 - 19.00 h

SALA PRINCIPAL

**PALAU DE LES ARTS
REINA SOFÍA** Temporada 21



Les devises Shadok



S'IL N'Y A PAS DE SOLUTION
C'EST QU'IL N'Y A PAS DE PROBLÈME.