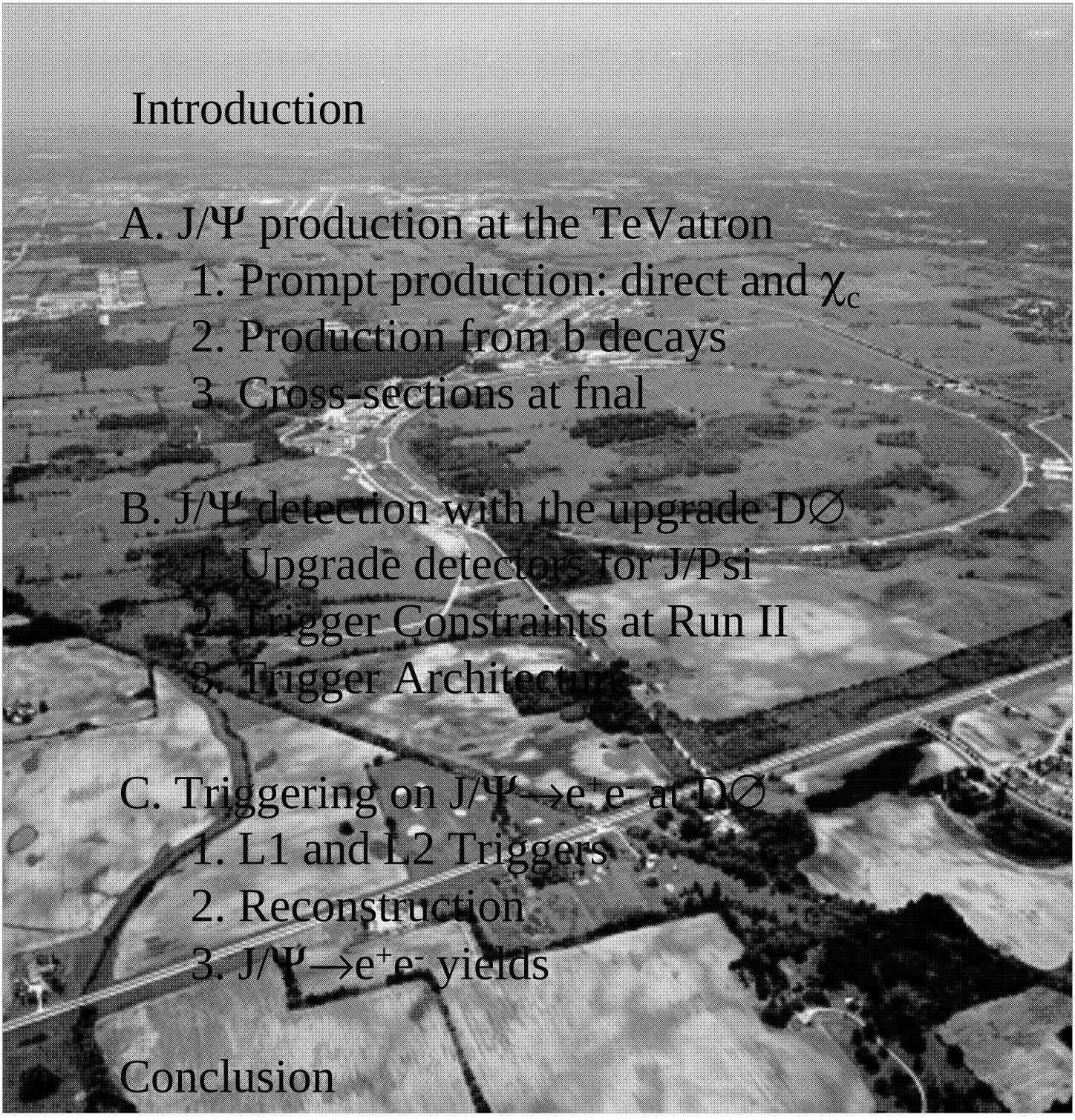
$J/\Psi \rightarrow e^+e^-$ selection at DØ RunII

Arnaud Lucotte
(ISN Grenoble)



Introduction

A. J/Ψ production at the TeVatron
   1. Prompt production: direct and χ_c
   2. Production from b decays
   3. Cross-sections at fnal

B. J/Ψ detection with the upgrade DØ
   1. Upgrade detectors for J/Psi
   2. Trigger Constraints at Run II
   3. Trigger Architecture

C. Triggering on $J/\Psi \rightarrow e^+e^-$ at DØ
   1. L1 and L2 Triggers
   2. Reconstruction
   3. $J/\Psi \rightarrow e^+e^-$ yields

Conclusion

Introduction: J/Psi at Run II

B Physics:

$\sigma_{bbar} \cong$ **50** μ**b (10kHz@10^{32}cm^{2}s^{-1}) w/** σ_{bbar}**<1/1000** σ_{dj}

- **Violation CP dans le systeme B_d^0 :**

$$A_{CP} = \frac{N(B^0 \to J/\psi K_s^0) - N(\bar{B}^0 \to J/\psi K_s^0)}{N(B^0 \to J/\psi K_s^0) + N(\bar{B}^0 \to J/\psi K_s^0)} \equiv -D_{mix} \sin 2\beta$$

- **B_S Oscillations**

  $B_s^0 \to D_S\, \pi\pi\pi$ (D_S) $\cong$ 2000 evts attendus

  (~70 fs time resolution)

- **Other b-topics:**

  Rare b Decays

  Spectroscopy B_C

Detector Calibration:

- **Calibration:**

  CC, EC-EC, EC-CC

  using $Z \to ee$, $\Upsilon, \Psi \to ee$

J/Ψ Production at TeVatron

1. Prompt Production of J/Ψ 's

(a) direct production

Color Singlet Model (CSM) (see graphs)

— built to describe ISR data

— predicts direct processus is dominant

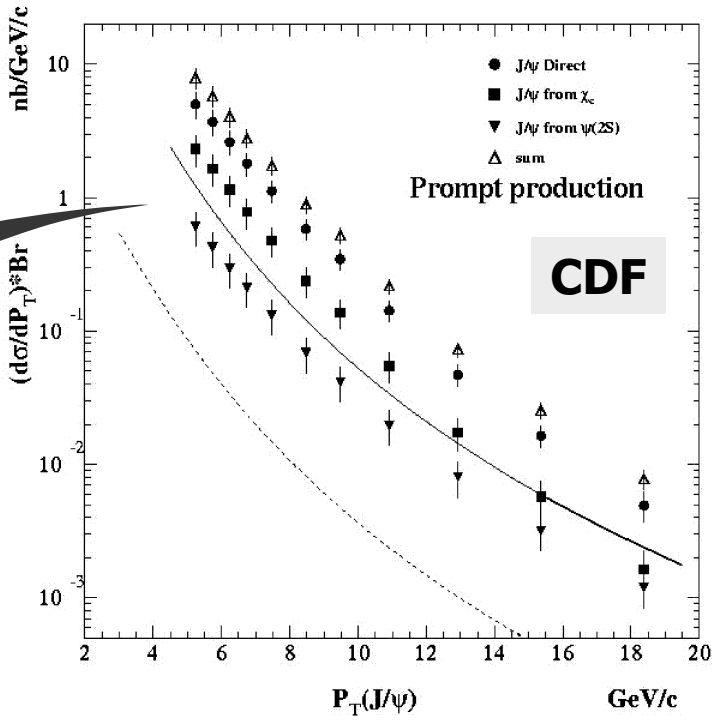
⇒ **factor 30-50 discrepancy vs fnal data !**

(b) production via χ_c states

χ_c states produced by gluon fragmentation

$pp \rightarrow \chi_c + X$

$\chi_c \rightarrow J/\Psi\ \gamma$



~24% of prompt J/Ψ from χ_c

⇒ **Still not enough to explain fnal data !**

(c) modified direct production

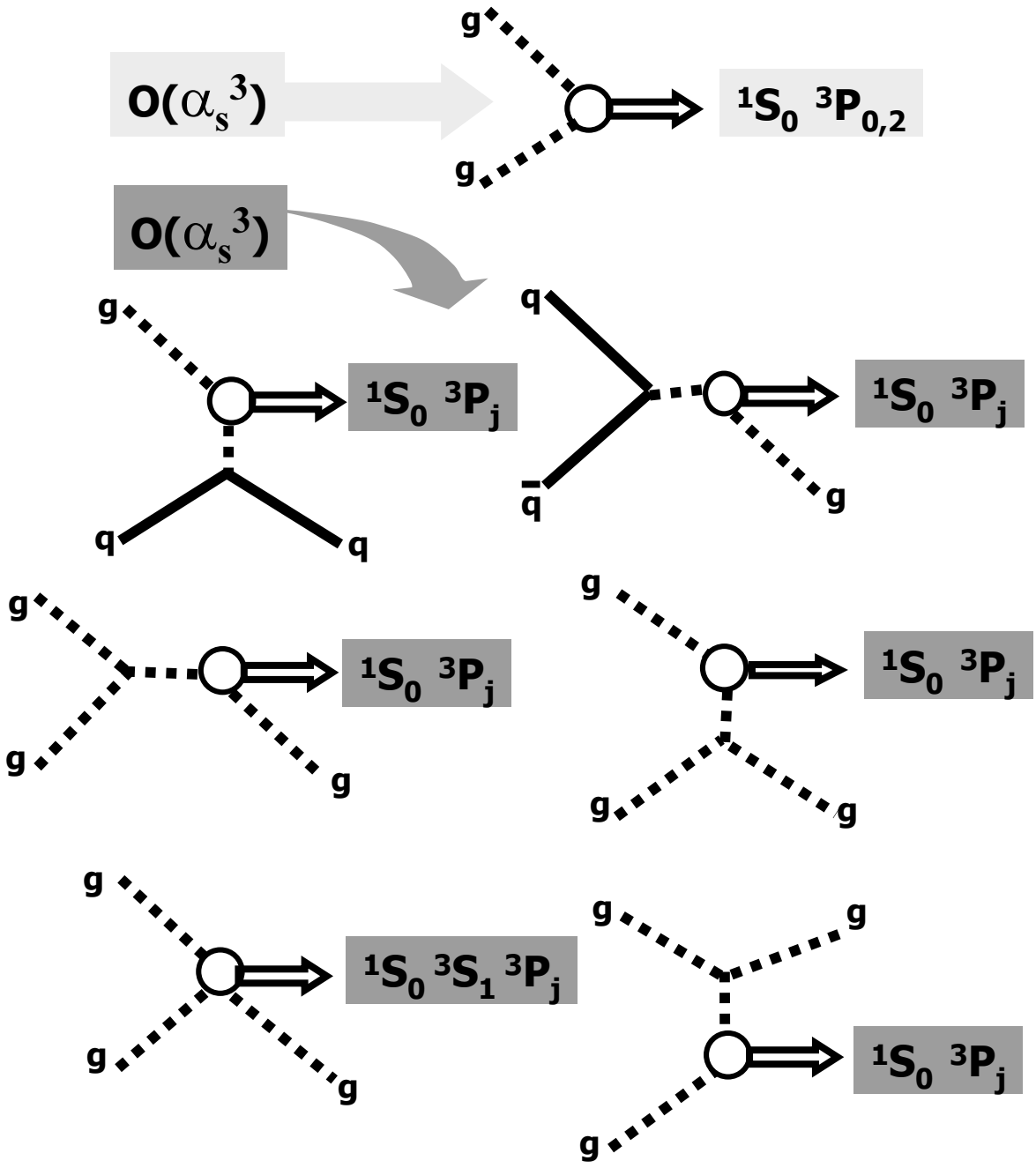
- **Color Octet Model (COM)**

— brings new predictions to direct production

⇒ **better agreement w/ fnal data**

J/Ψ Production at TeVatron

(a) Quarkonium Production (CSM)



J/Ψ Production at TeVatron

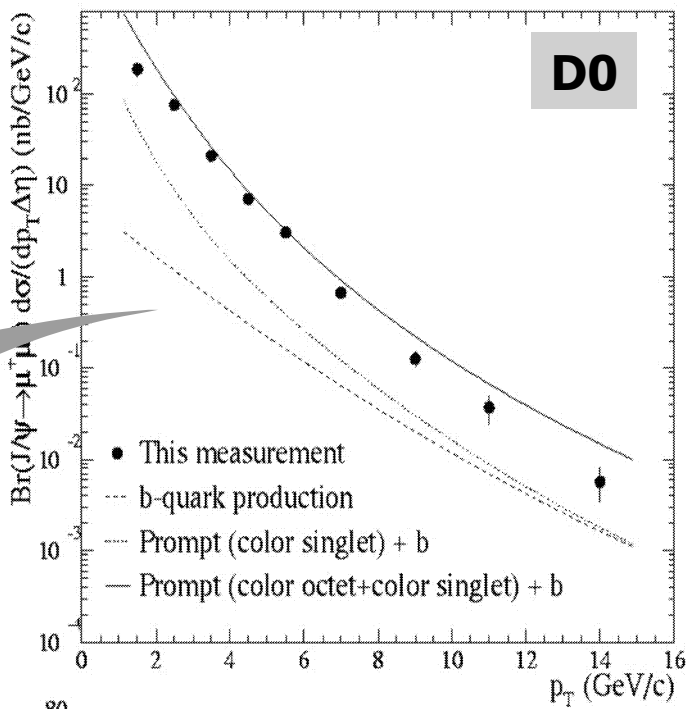
2. b-decay production

(a) b-decays contribution

CDF+D0:

— depends on p_T

— $d\sigma(\Delta p_T,\Delta\eta)$ vs p_T , η



1-30% J/Ψ from b-decays

3. J/Ψ Production Cross-section

CDF central:

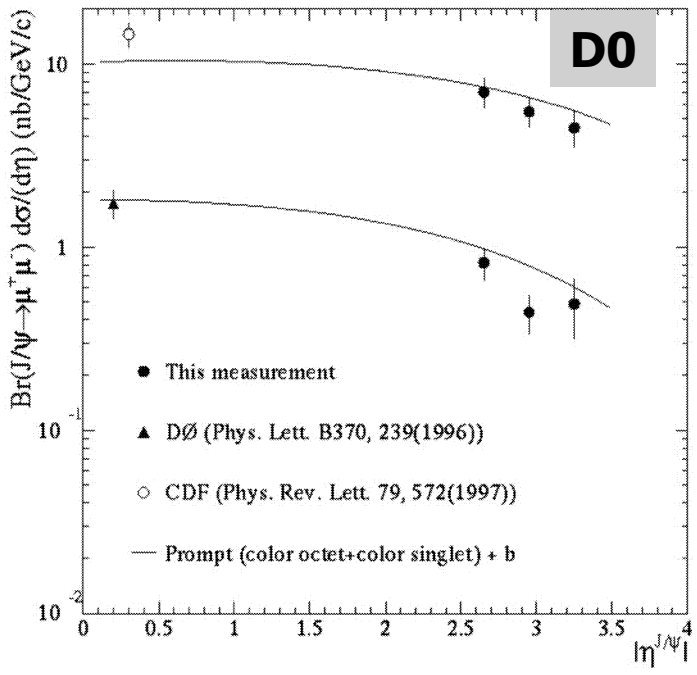
p_T>5GeV,η<0.6

σ=17.4±2.6 nb

D0 all detector:

$d\sigma(\Delta p_T,\Delta\eta)$ vs η

production ~centrale



J/Ψ Production at TeVatron

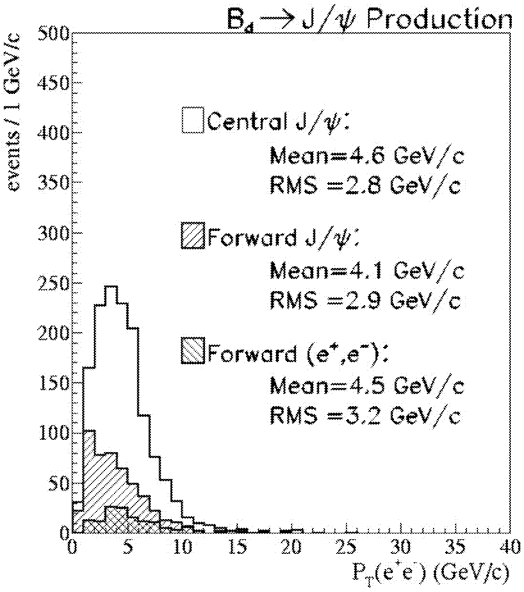
3. J/Ψ signal at the TeVatron

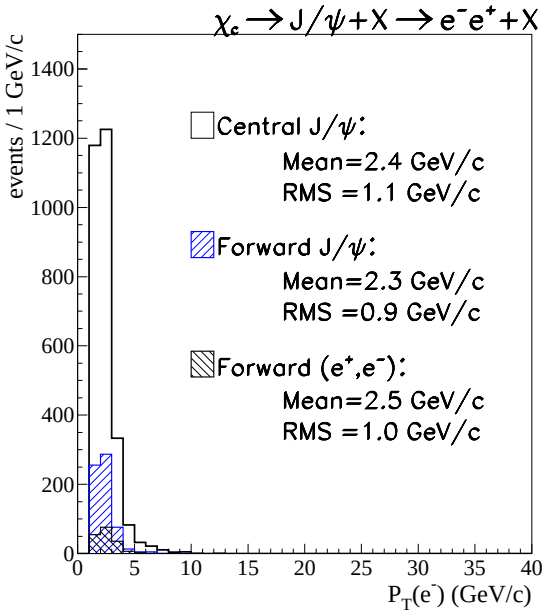
(a) Momentum:

$< p_T^{J/\Psi} > \sim 0.7 < p_T^B >$ with $< p_T^B > \sim M_B$,

$< p_T^l > \sim 2.5$ GeV/c

lepton even softer for prompt production

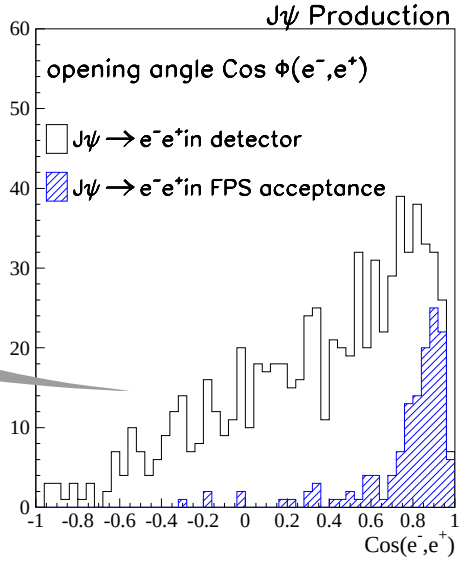




(b) Anglular distribution:

— $< \eta^{J/\Psi} >$ more central

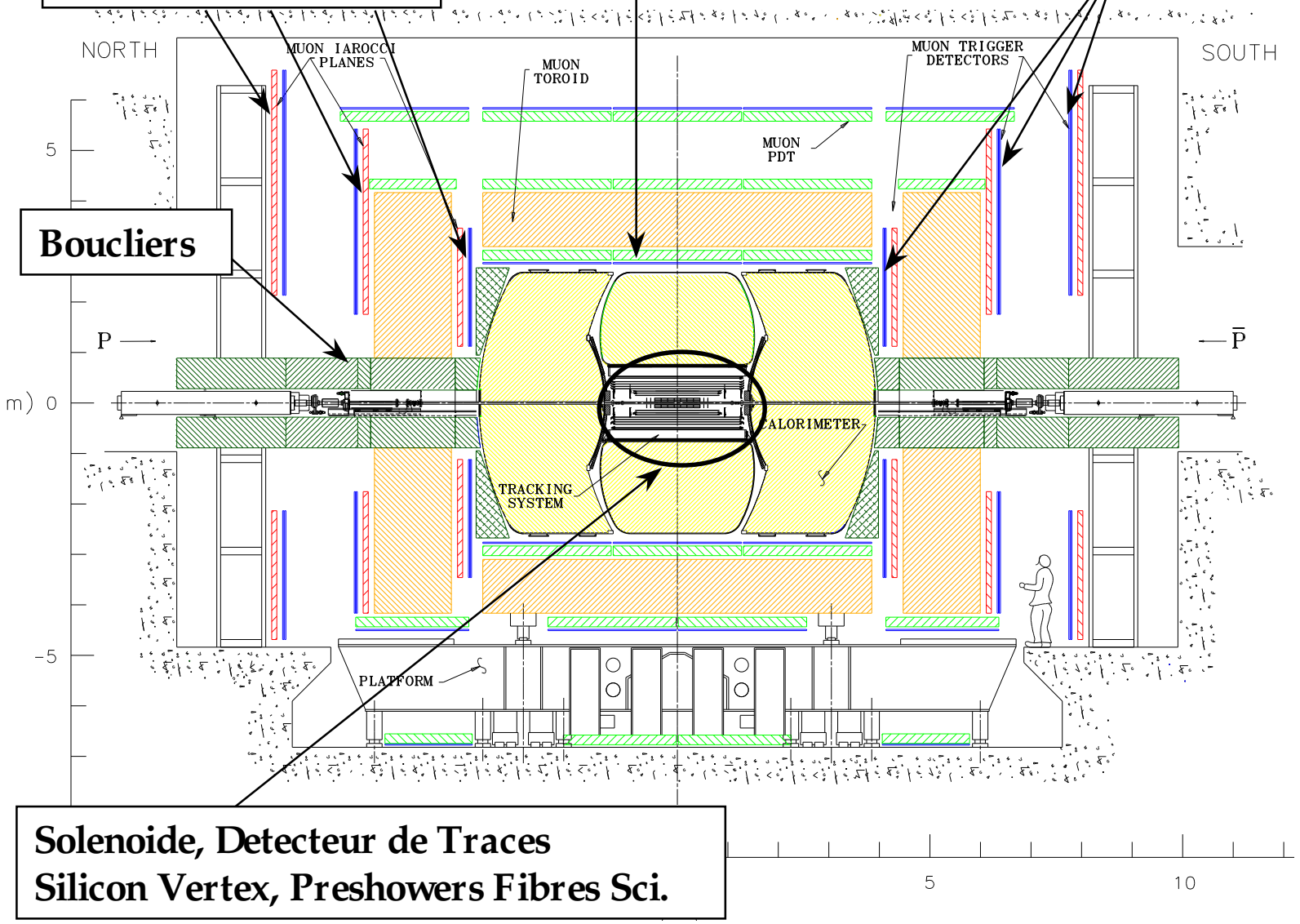
— (e+,e-) ã few degrees



Chambres a derive
(Mini-drift) Arrieres

Scintillateur Central

Scintillateurs Arrieres



Boucliers

Solenoide, Detecteur de Traces
Silicon Vertex, Preshowers Fibres Sci.

+ Nouvelle Electronique, Trig, DAQ

DØ Upgrade

Constraints on a $J/\Psi \rightarrow e^-e^+$ Trigger

Signal Characteristics:

B $\rightarrow$ J/Ψ X : $\langle p_T(J/\Psi)\rangle \cong 0.7 \langle p_T^B \rangle$ w/ $\langle p_T^B \rangle \sim M_B$

$\chi_c \rightarrow$ **J/ Ψ X:** $\langle p_T(J/\Psi)\rangle \cong 1.5$ GeV/c

$\Rightarrow$ Calorimeter threshold as low as: $E_T \cong 3.0$-4.0 GeV

Constraints on J/Ψ triggering

Against Dijet background: ~7 MHz @ $10^{32}cm^2s^{-1}$

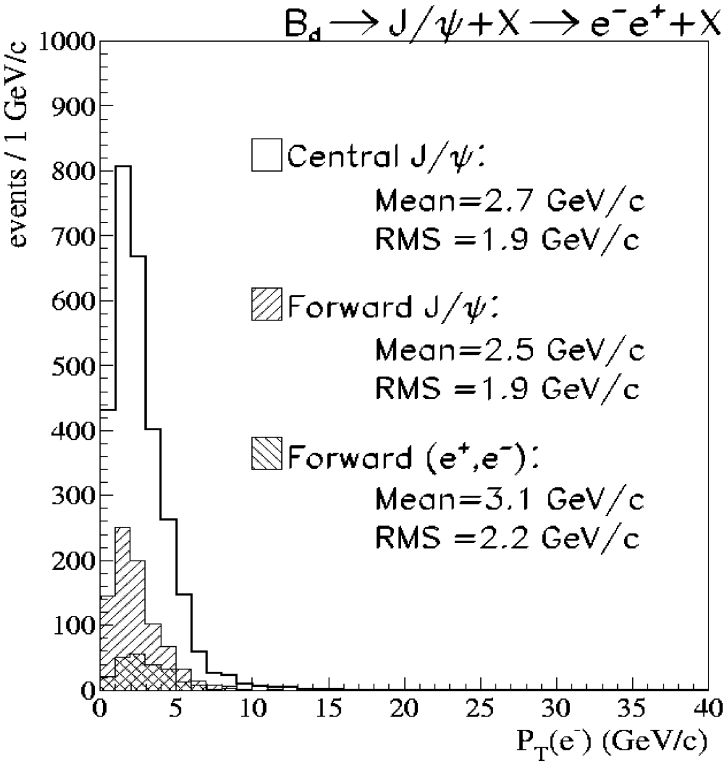
w/ band width: ~1 kHz at L1 , ~100Hz at L2

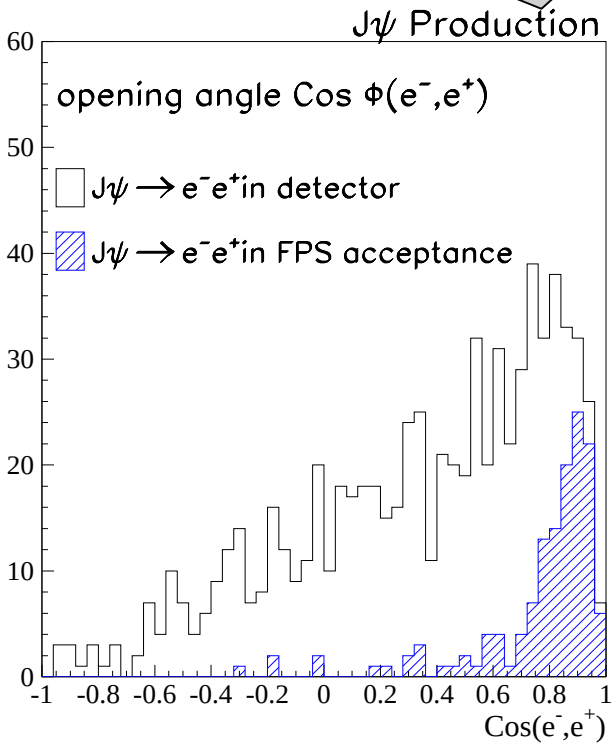
- **Needs:**

L1: Combination Track + Preshower + Calorimeter

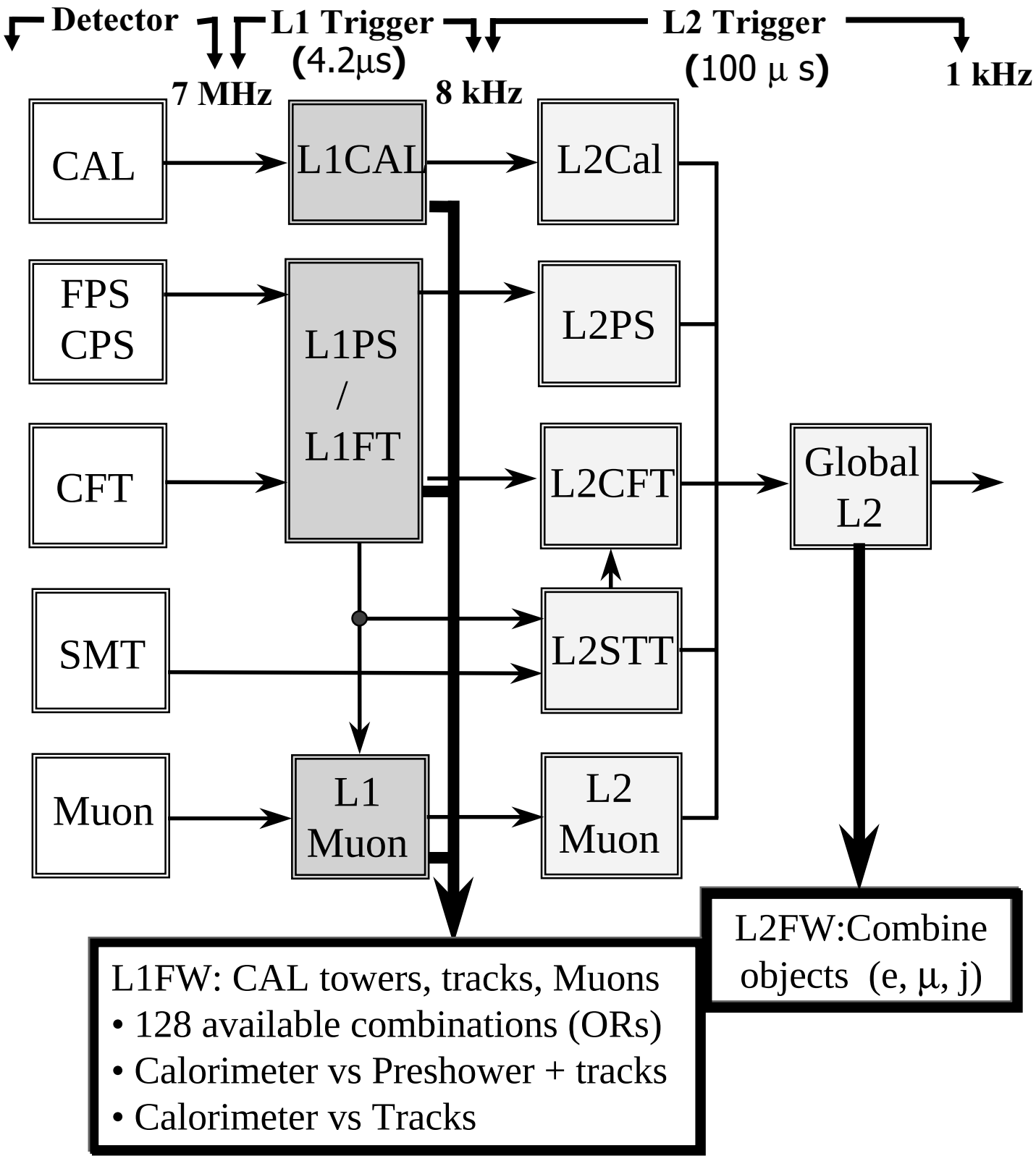
AND CAL/PS coincidence by Quadrant

L2: η,ϕ, Inv. Mass reconstruction etc...





Trigger Architecture



L1-Central EM Triggering

Detector-specific:

L1CAL **EM Calorimeter**

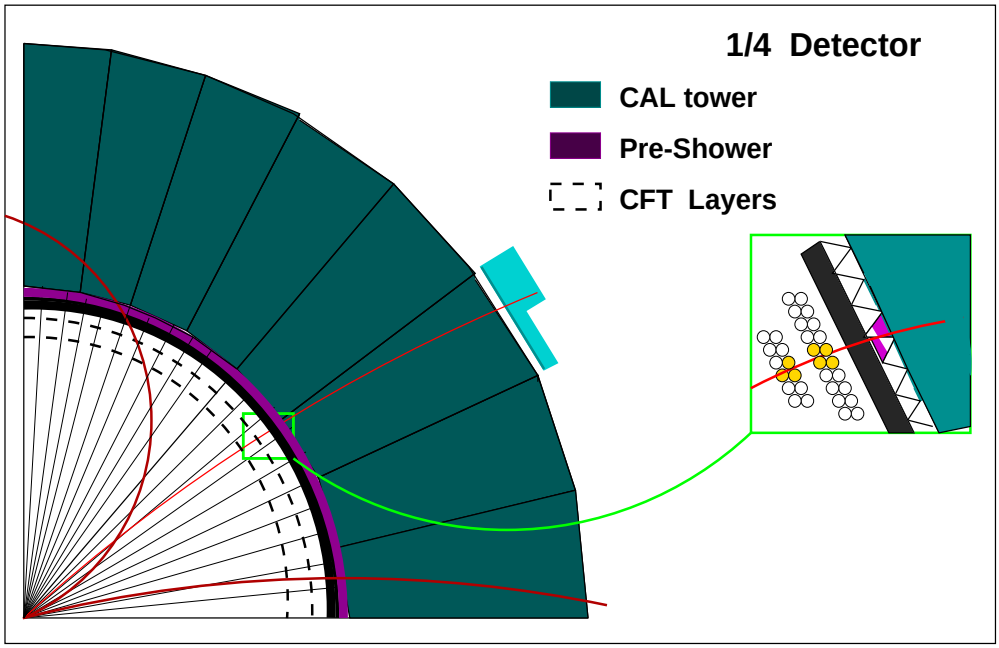
#tower ($\Delta\eta\times\Delta\Phi$= 0.2×0.2) & E_T > [2.5, 5, 7, 10] GeV

L1PS **Central PreShower**

#cluster = Σ adjacent strips such: E_{strip} > 2-5 MIPs

L1CFT **Fiber Tracker**

signed trajectories / bin p_T [1.5-3], [3-5],[5-10], [10-] GeV/c *counted in each 80 x 4.5° sectors*



Global-Level (Framework): **L1FW**

Coincidence by Quadrant:

1 tower EM + (1 CPS-cluster+Track p_T /sector)

L1-Forward EM Trigger

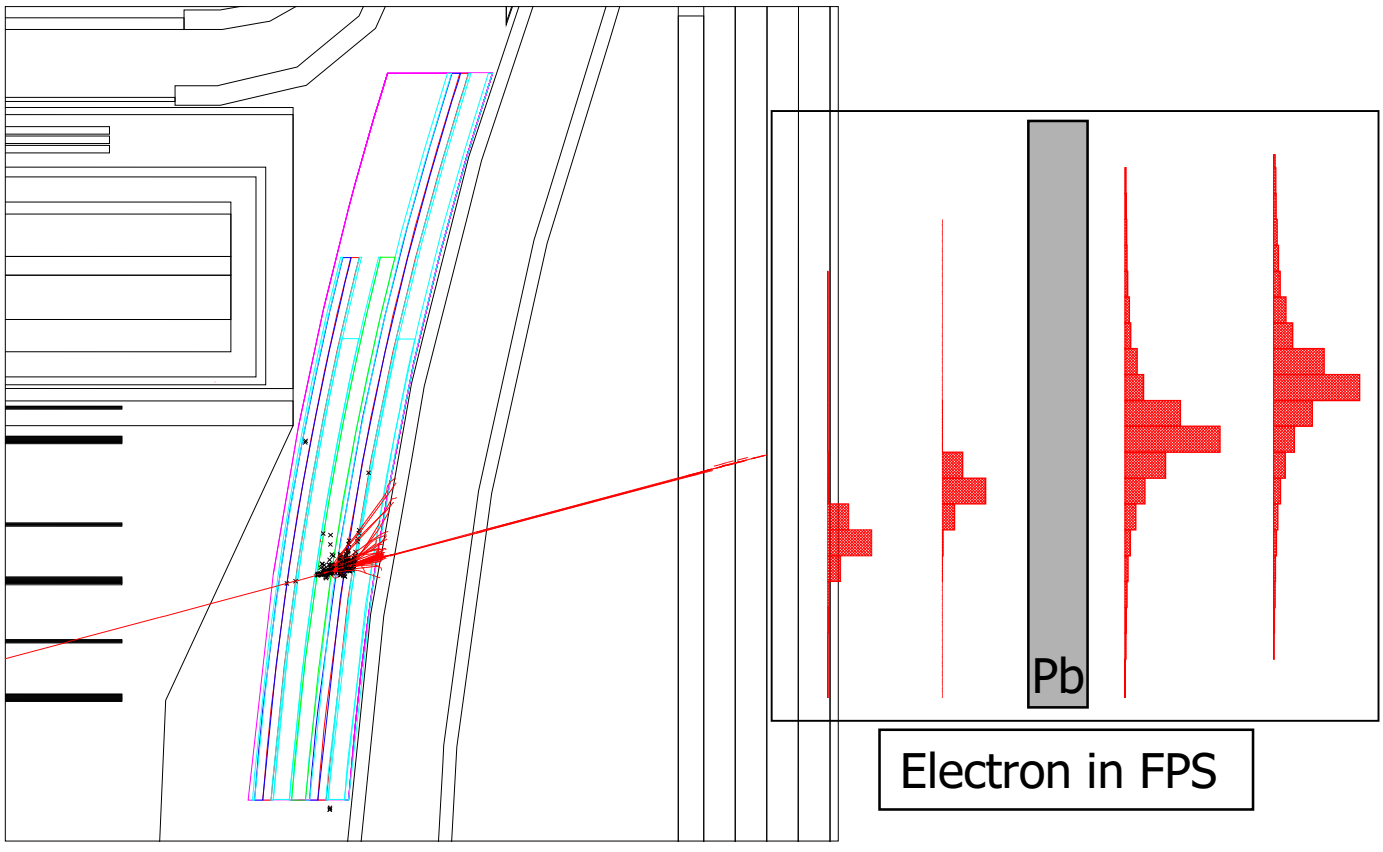
L1CAL **EM Calorimeter EM**

tower ($\Delta\eta \times \Delta\Phi$ = 0.2×0.2) & E_T >[2.5, 5, 7, 10] GeV

L1PS **Forward PreShower**

PS cluster = $\sum$ adjacent strips w/ E_{strip} > 5-10 MIPs

electron = PS cluster (u or v) + MIP (u or v)



L1FW **Global Trigger (Framework)**

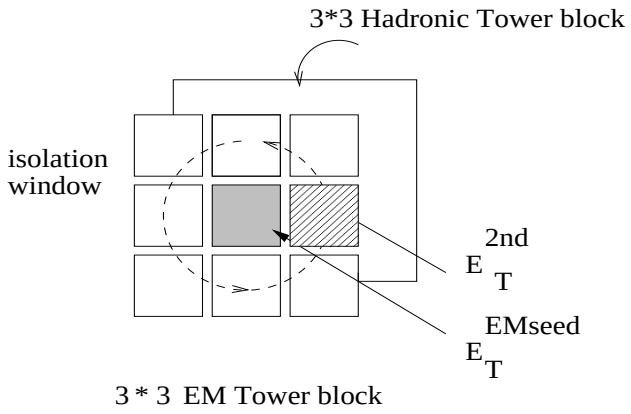
Coincidence by Quadrant

1 tour EM + 1 electron (u et v) FPS

L2-Central EM Triggering

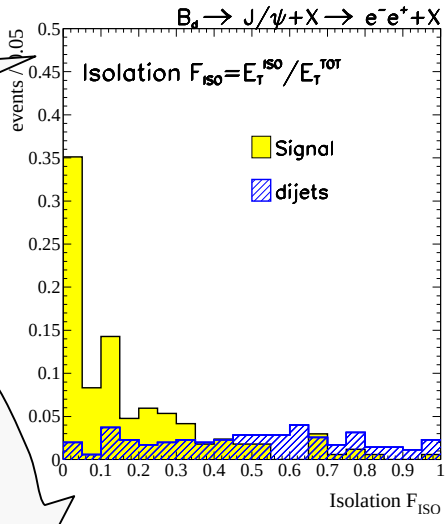
L2CAL EM Calorimeter

- **L1 calo tower as "seed"**
- **Total EM cluster Energy:** $E_T^{EM} = E_T^{SEED} + E_T^{2nd\_max}$
- **EM Fraction:** $EMF = E_T^{EM}/(E_T^{EM}+E_T^{HAD})$
- **Cluster Isolation:** $T_{ISO} = E_T^{EM}/\Sigma(E_T^{EM}+E_T^{HAD})$ (3×3 including "seed")



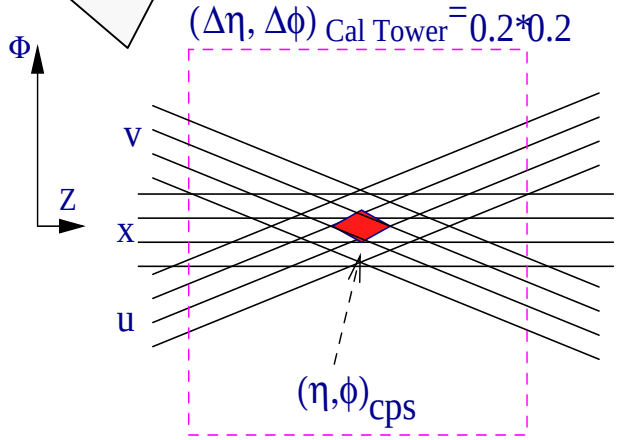
L2PS Central Preshower:

- **3D cluster(u,v,x) e-γ tagged**



L2CFT Fiber Tracker

- **convert L1 p_T → track p_T** (Look Up Table)
- **extrapolate to EM(3)**



L2CTT Vertex Detector

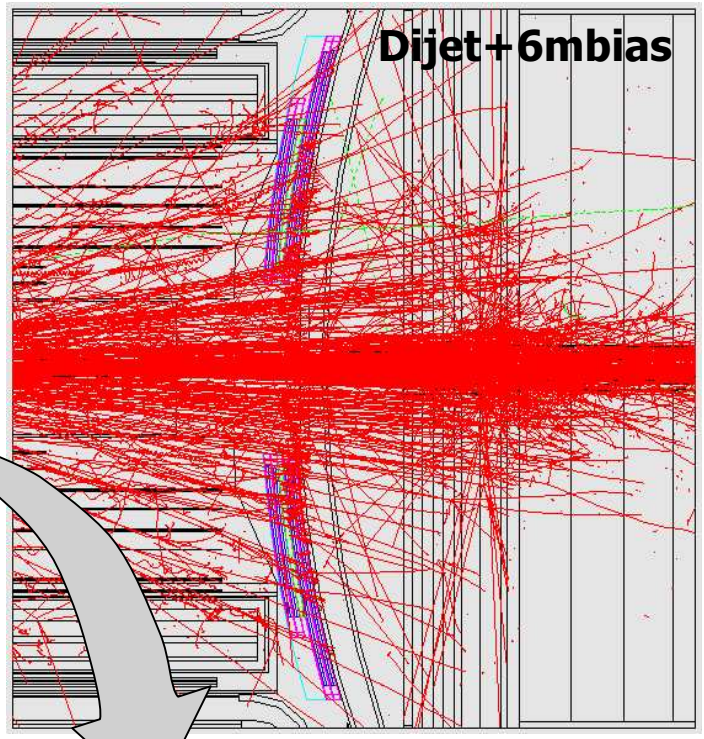
- **combine CFT tracks**
- **re-fit tracks :** p_T, $\chi 2$, impact parameter

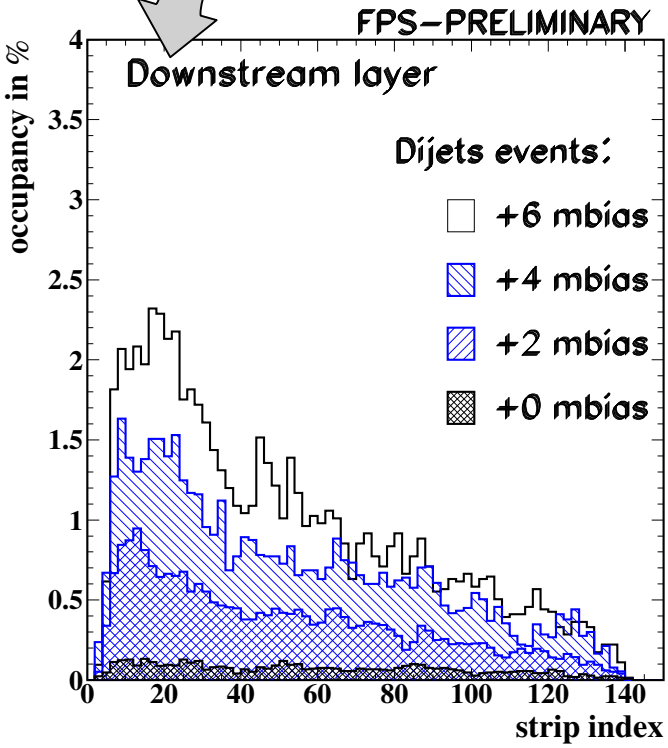
Forward-EM Trigger

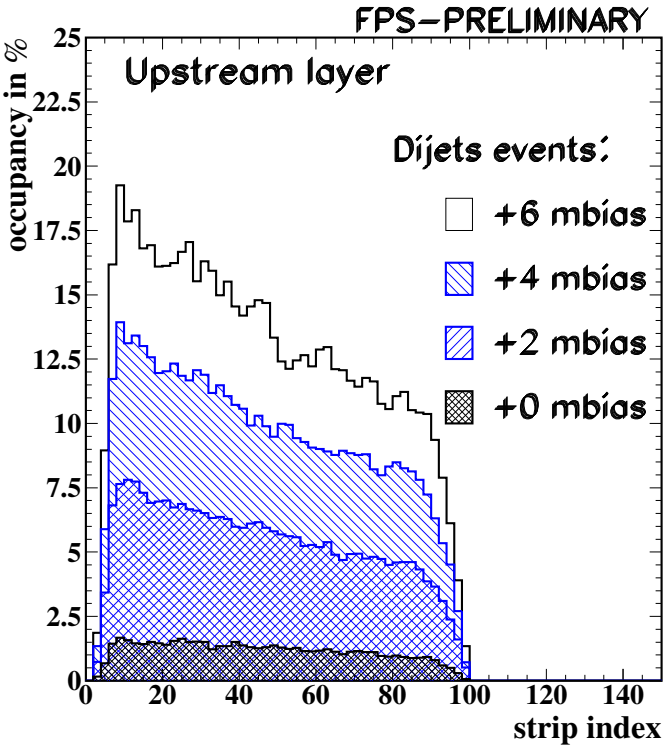
Occupation dans le Preshower:

- **Interactions/cros.**
  <#> = 2.1 (Poisson)
  @ 2. 10^{32} cm^2s^{-1}

- **MIP detection:**
  T>0.3 MIP
  occ = 7-10%
- **cluster detection:**
  T > 5 MIPs
  occ = 0.5-2.0%

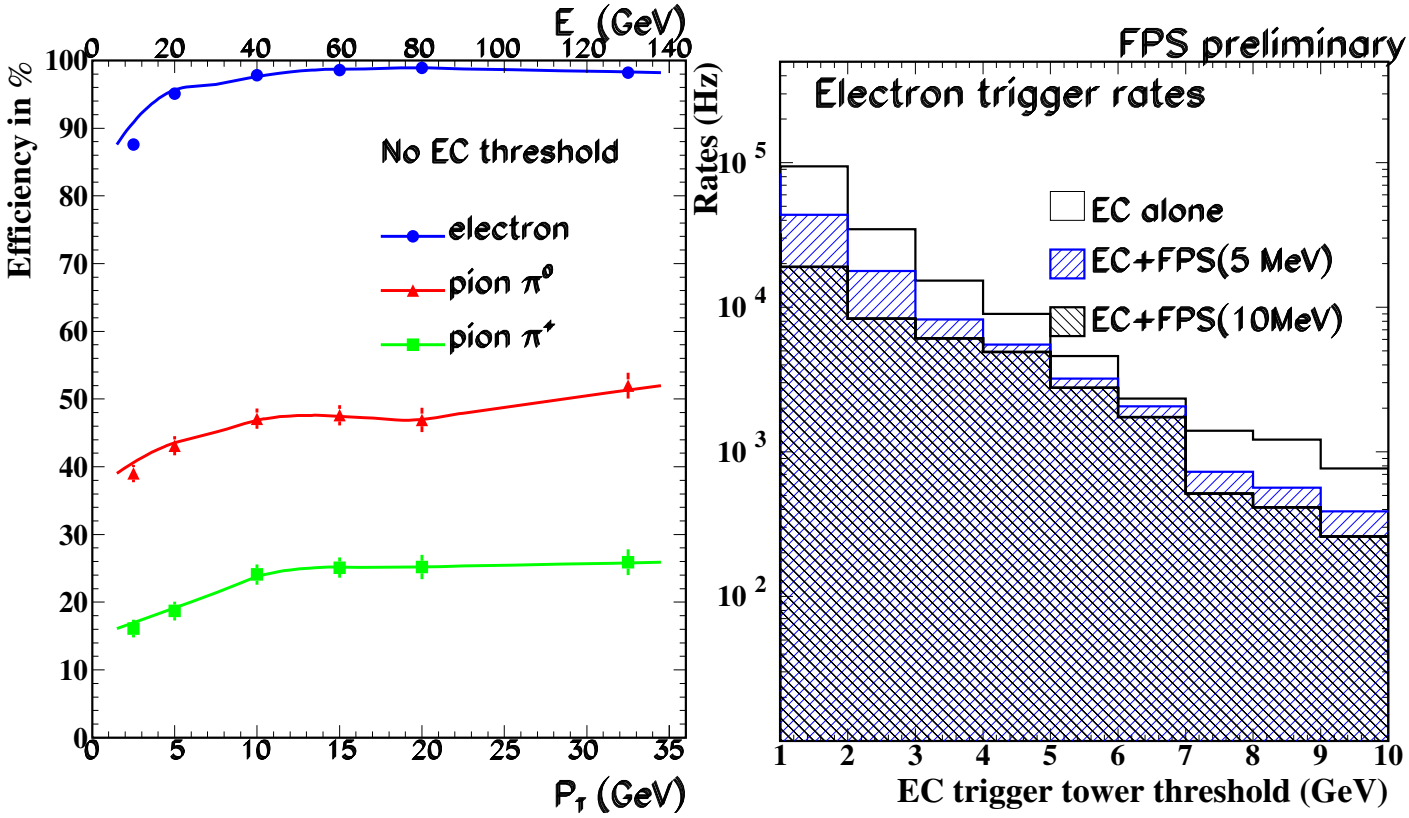






Forward EM Triggering

Efficiency:



Background rates (QCD dijets):

Pion Rejection

20-25% de conversions de □⁰'s avant PS (avant/arr.)

PS+CAL: facteur 2-4 (eleve pour faibles p_T)

Bkgd rejection:

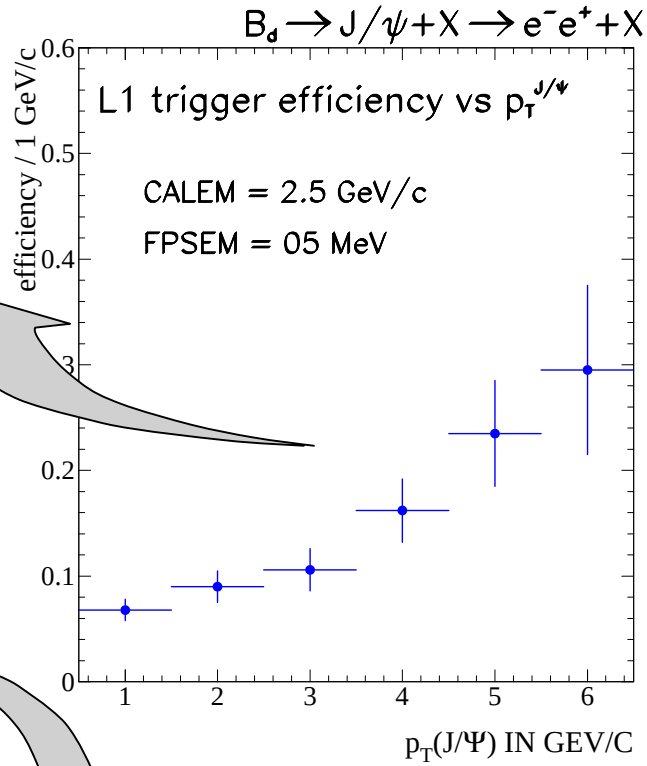
E_T ~10 GeV: 700~Hz (CAL) vs 200 Hz (CAL+PS)

L1 Trigger $J/\Psi \rightarrow e^-e^+$

Efficiency:

- **central $\cong$ 25-30%**
- **forward $\cong$ 5-10%**
- **depends on CAL thresh.**

$E_T^{CAL} \cong 2.75\text{-}3.5$ GeV



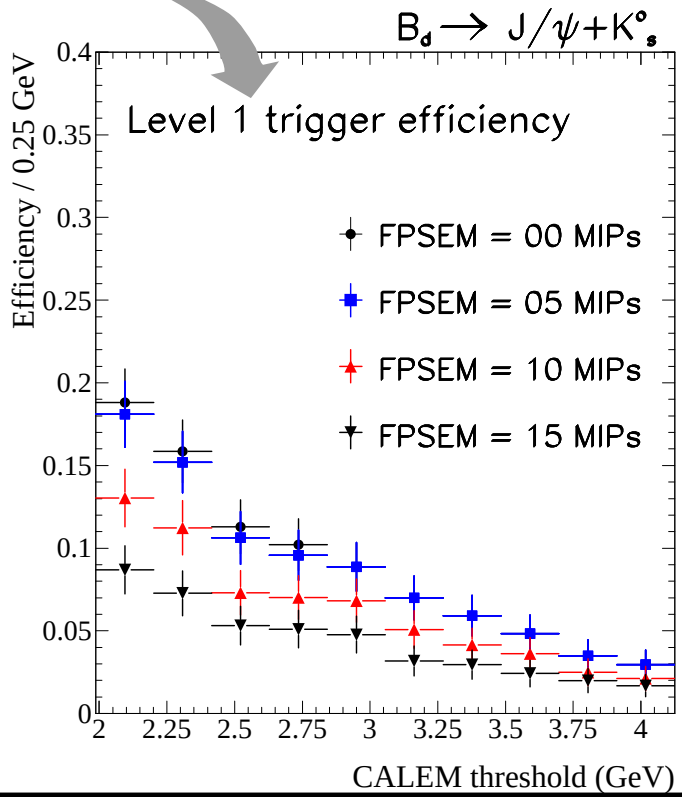
Dijet background:

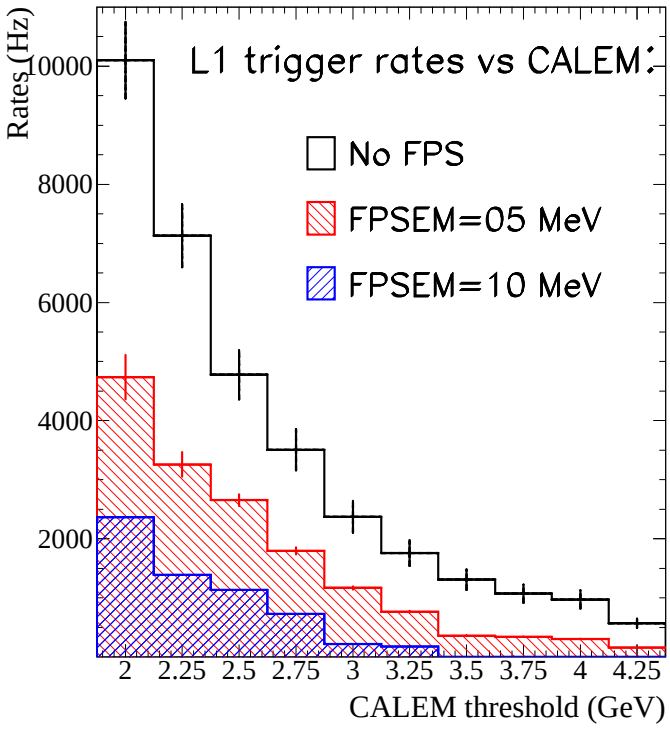
- **Rate: 200-1000 Hz**
- **controled with**

PS/CAL Quadrant Match

PS/Track sector Match(4.5°)

Threshold E_{FPS} , & E_T^{CAL}





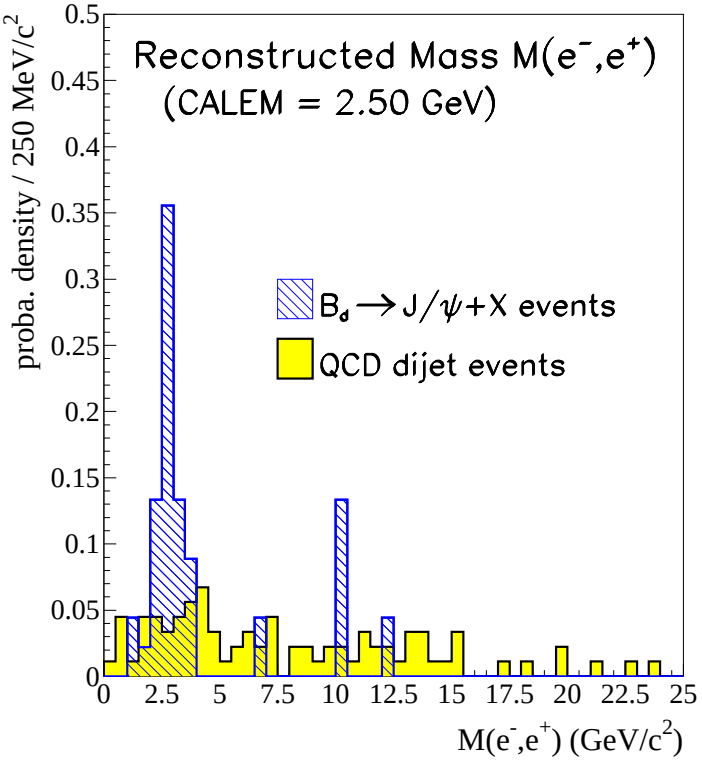
L2 Trigger $J/\Psi \rightarrow e^-e^+$

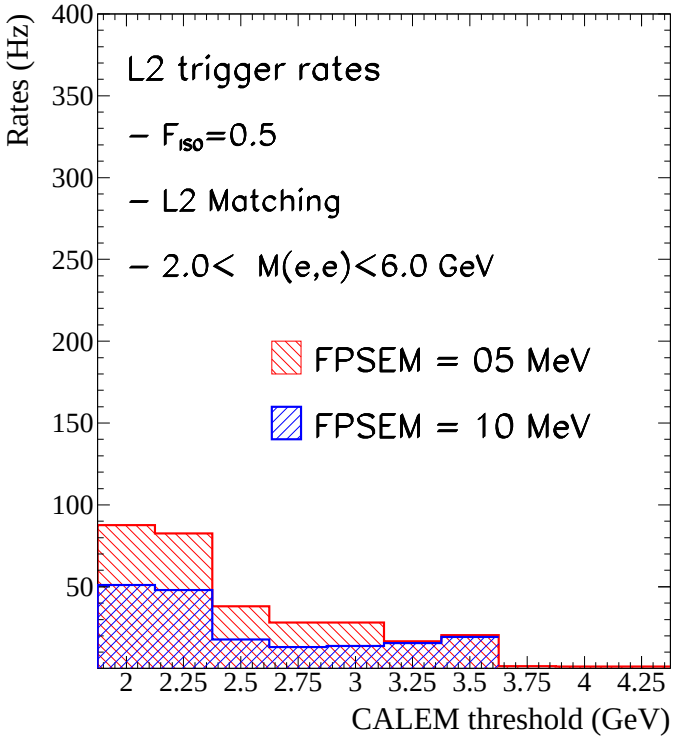
Efficiency:

- **Central** $\cong$ **20-25%**
- **Forward** $\cong$ **4- 8%**
- **depends on L1 CAL E_T thresholds**

Dijet Background:

- **Rates: 50-100 Hz:** region centrale - avant/arriere
- **Reduced by** Mass Window
  EM isolation
  Coincidence TT vs PS
- **reducible:** vertex information (for b-decays)
  ¤ 2 tracks / large impact parameter $S_B = B/\sigma_B$





DAQ / Trigger for PS

Signal Readout:

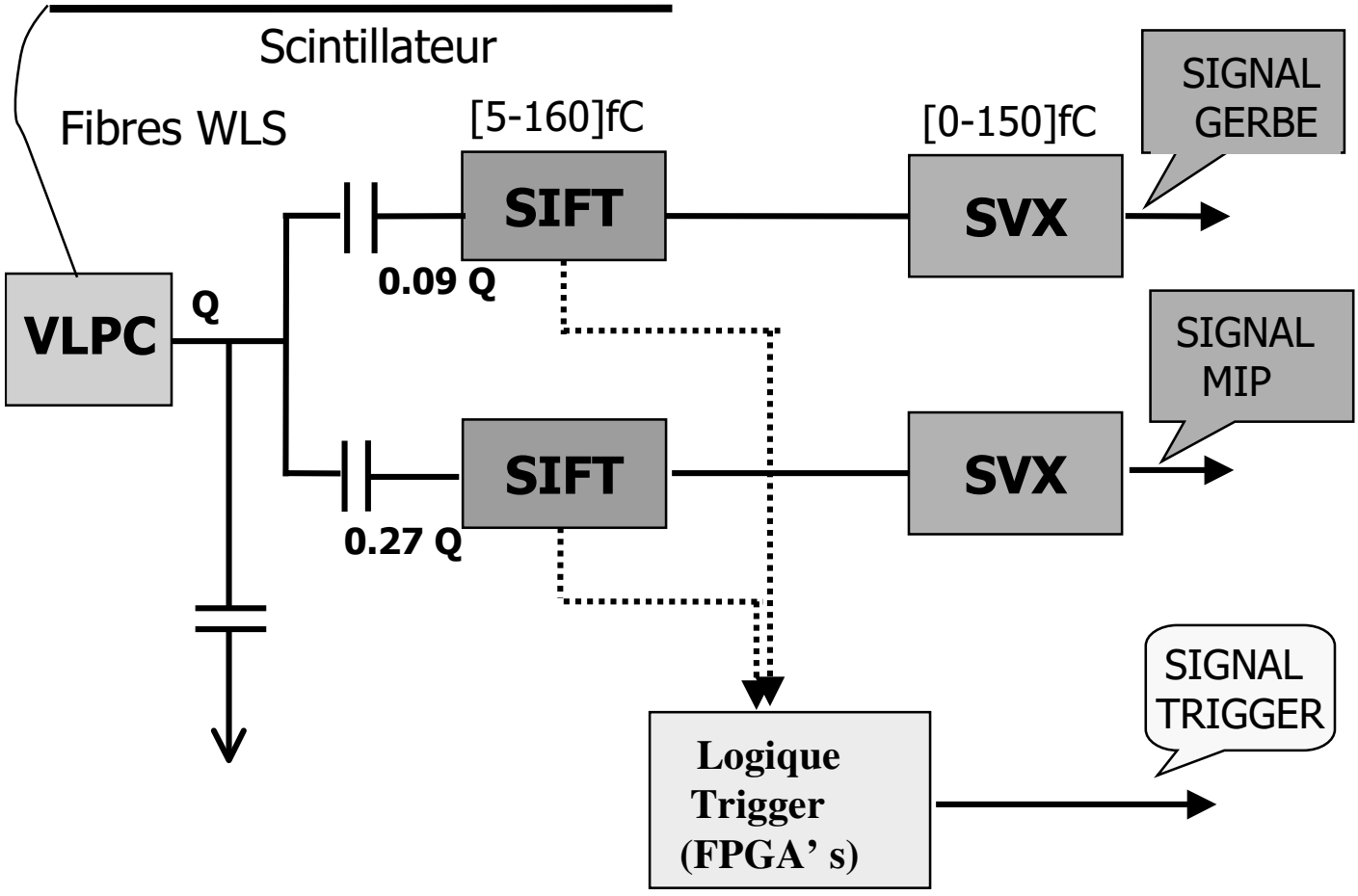
How is it possible to read such signal ?

→ **Two thresholds**

- calibration: MIP detection (1 MIP ≅ 0.9 MeV)
- cluster reconstruction (e,γ) 5 to 60 MIPs

→ **Trigger and Readout:**

- L1: chips SIFT [0/1] (FPGA)
- L2: chips SVX-II [analog] (pre-processors)



CP violation with $B^0_d \to J/\Psi\, K_S$

Projection pour ♎sin2♌ (temps integre)

$$\delta\sin 2\beta = \frac{1}{D_{mix} D_{fond}} \times \frac{1}{\sqrt{\epsilon_{tag} D^2_{tag}}} \times \frac{1}{\sqrt{N_{reco}}}$$

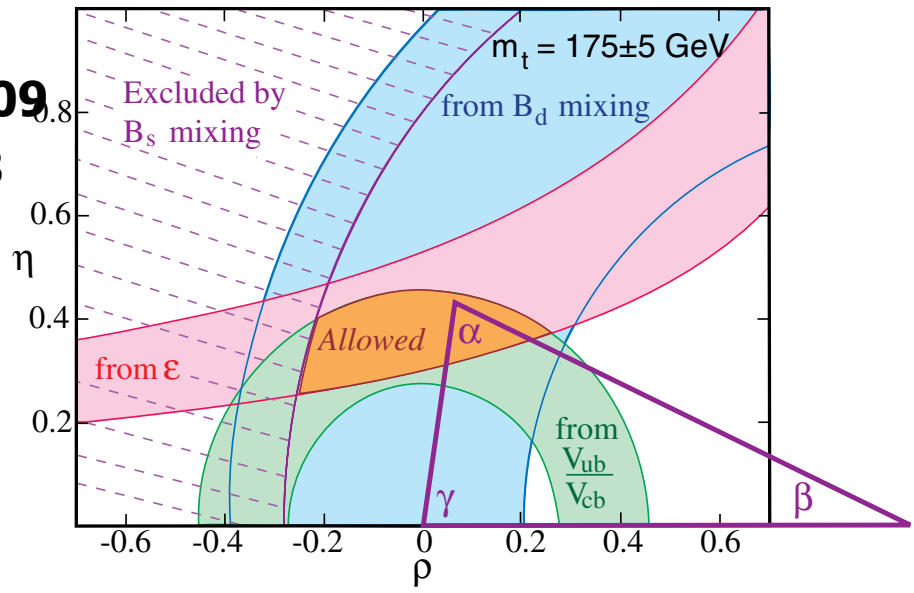
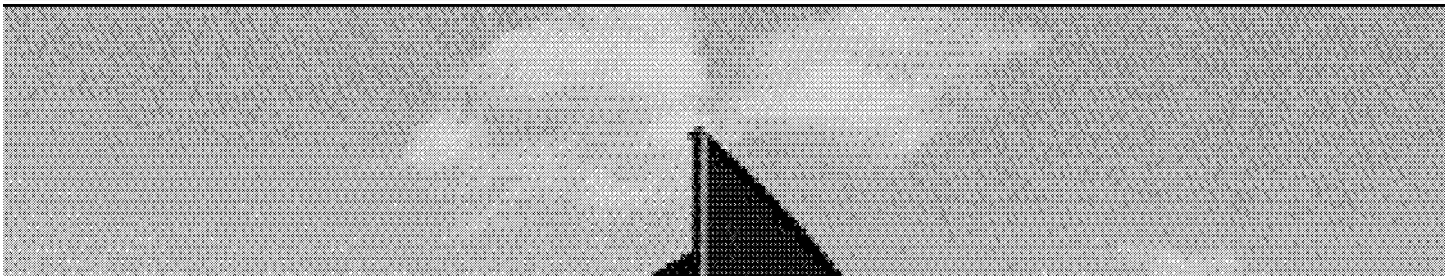
- efficacité reco des traces: 95%
- D_{mix} ✍ 0.47 , D_{fond} = ⌧S(S+B) ~ 0.7
- $\varepsilon_{Tag}\, D^2_{tag}$ ~ 0.05

♎ sin2♌ ✍ 13.40 🖃 ⌧N_{RECO}

Canal	$B^0_d \to J/\Psi(\mu\mu)K_s$	$B^0_d \to J/\Psi(ee)K_s$
Luminosité	2 fb^{-1}	2 fb^{-1}
Evts declenchés	10600	4000
Evts reconstruits	8600	3300
$\delta sin2\beta$	0.14	0.23

Contraintes indirectes:

Sin2♌=0.75⌖ 0.09
CERN-EP/98-133



Conclusion