Bundesministerium
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RHEINISCH-
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Spectroscopy results from ATLAS and CMS

(minireview at $\sqrt{s} = 7$ TeV)

– HQL10 Frascati –

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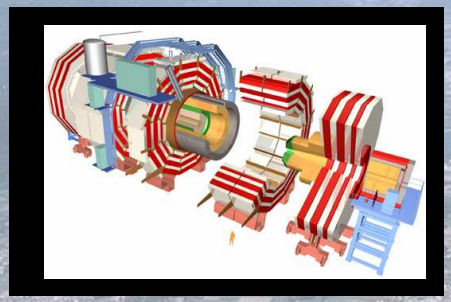
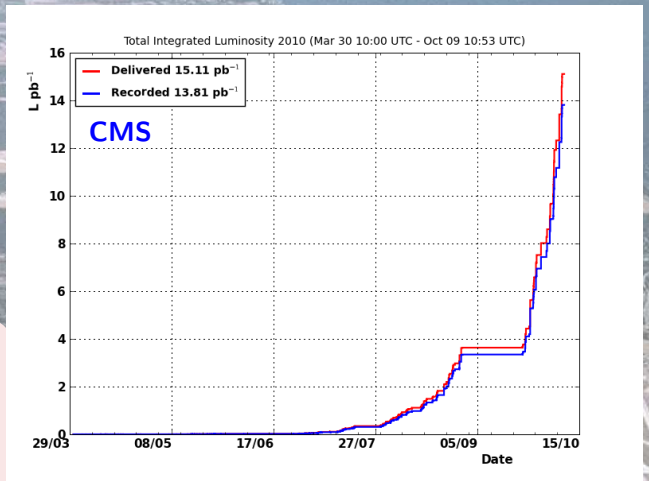
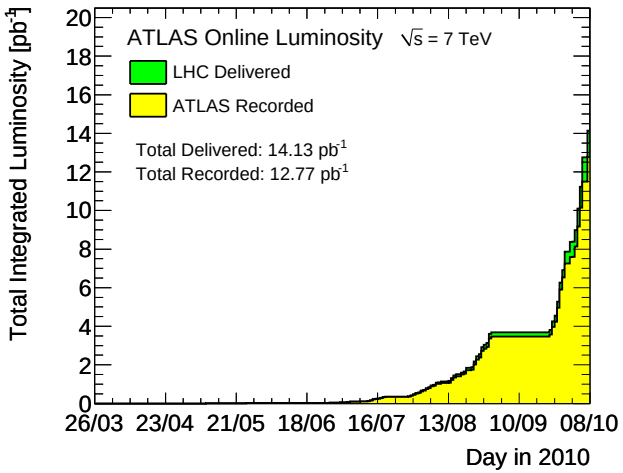
Outline

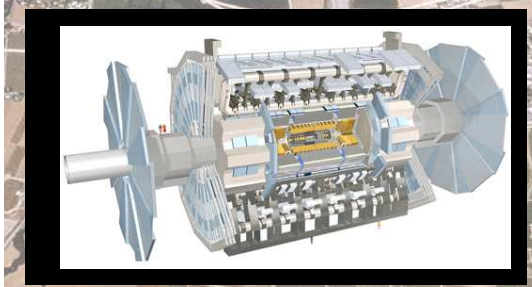


CMS



1. strange particles
2. charm particles
3. beauty particles



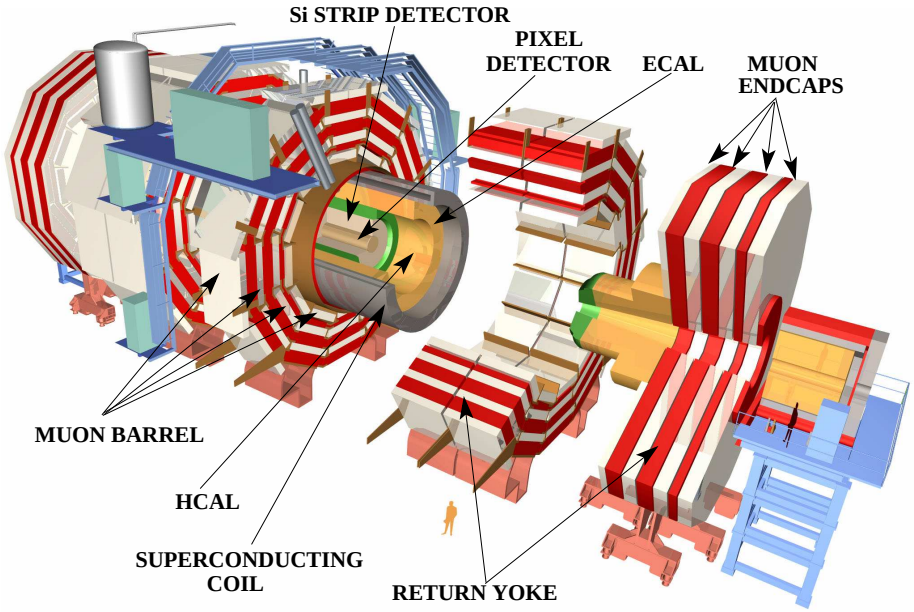


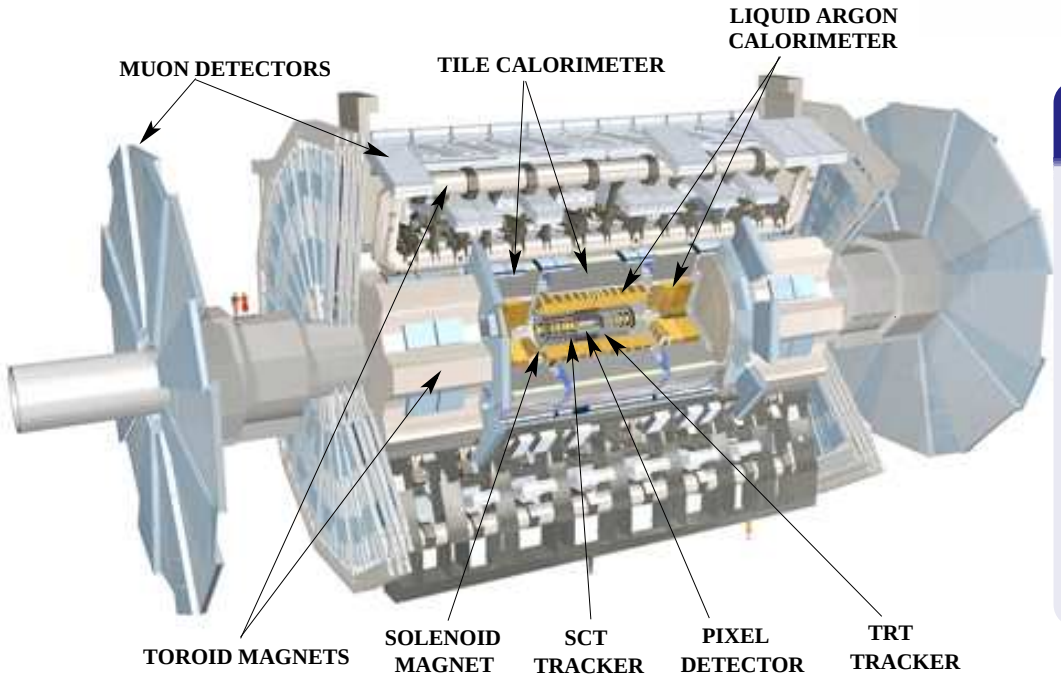
ATLAS

ATLAS & CMS

ATLAS

- Coverage:
  - tracking syst.$|\eta| < 2.5$
  - muon spectr. $|\eta| < 2.7$
- B: 2 T
- Resolution:
  - tracking syst.
    $\sigma_{p_T}/p_T = 0.05\% p_T \oplus 1\%$

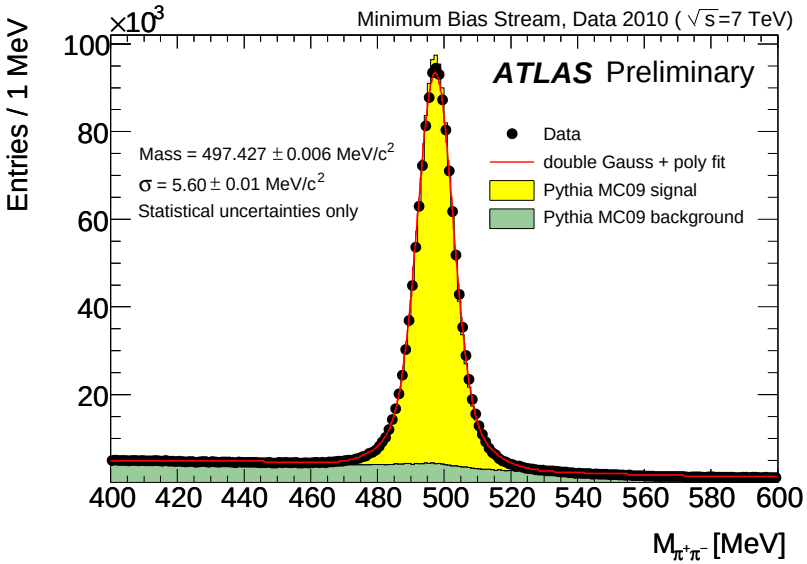


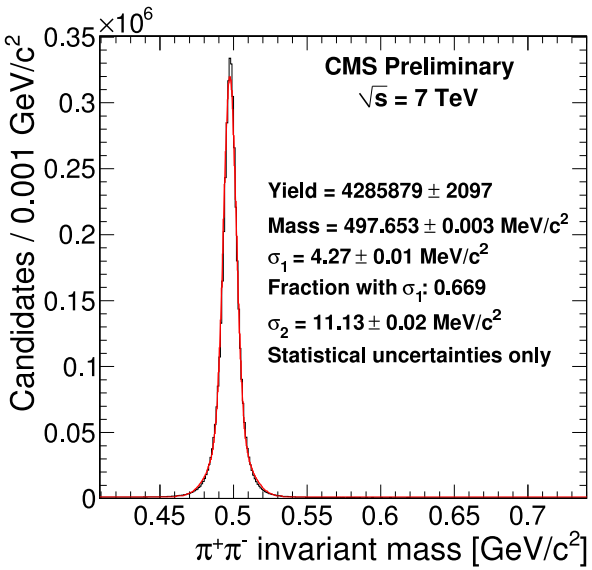


CMS

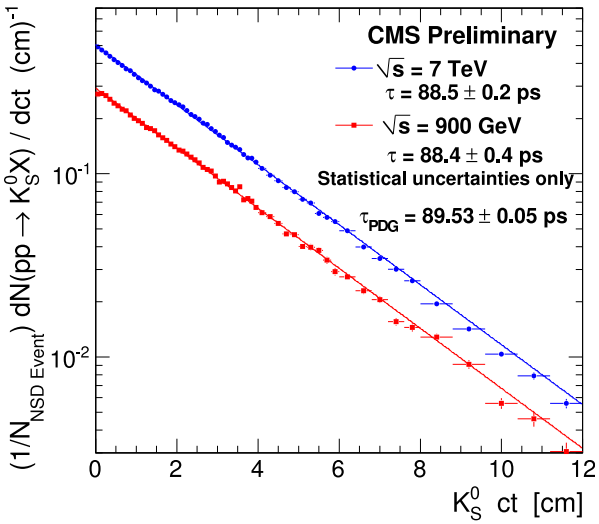
- Coverage:
  - tracking syst.$|\eta| < 2.5$
  - muon spectr. $|\eta| < 2.5$
- B: 3.8 T
- Resolution:
  - tracking syst.
    $\sigma_{p_T}/p_T = 0.015\% p_T \oplus 0.5\%$

K_s^0 (PDG: 497.614 ± 0.024 MeV/c^2)

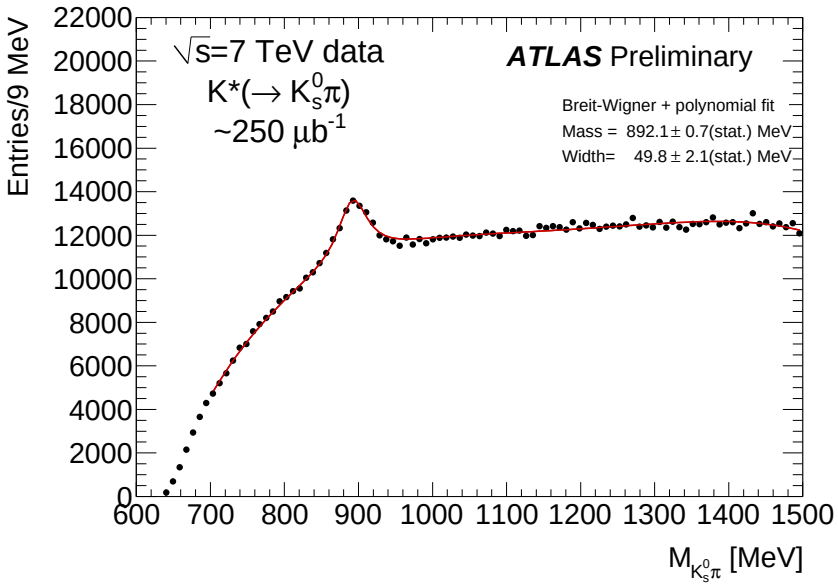


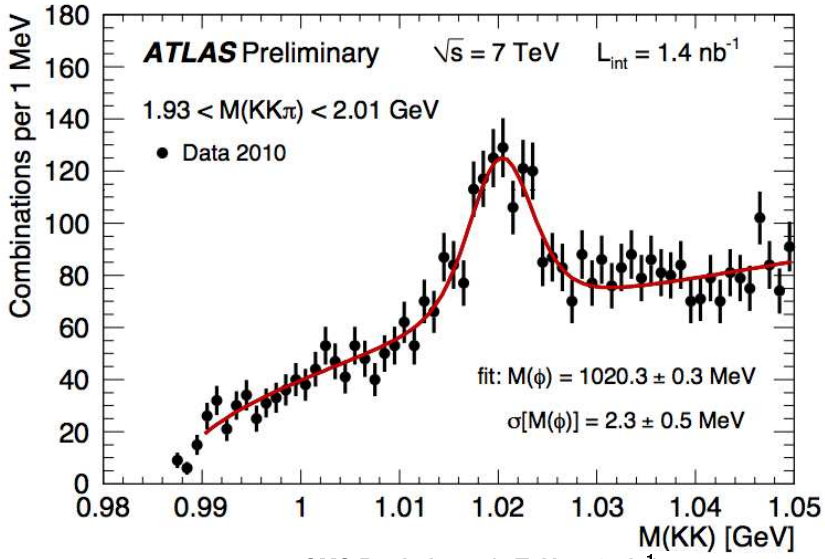


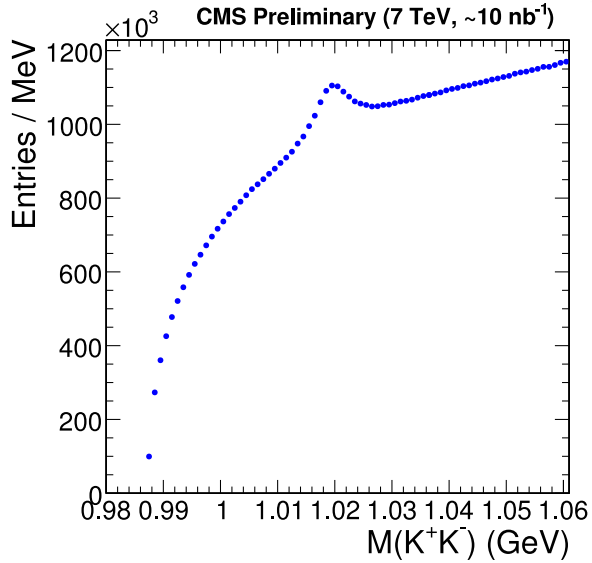
- simple selection (e.g. ATLAS):
  - Secondary Vertex (S.V.)
  - opposite charged tracks
  - $p_T(\pi) > 0.1$ GeV; $|\eta_\pi| < 1.2$
  - $L_{xy} > 0.4$ cm
  - $\cos\theta > 0.999$
    where θ: $\sphericalangle$ between flight and momentum direction
- $\sigma_{M_{\pi^+\pi^-}} \approx 5$ MeV/c^2:
  $\Rightarrow$very good momentum resolution



$K^*(890)$, $\phi(1020)$



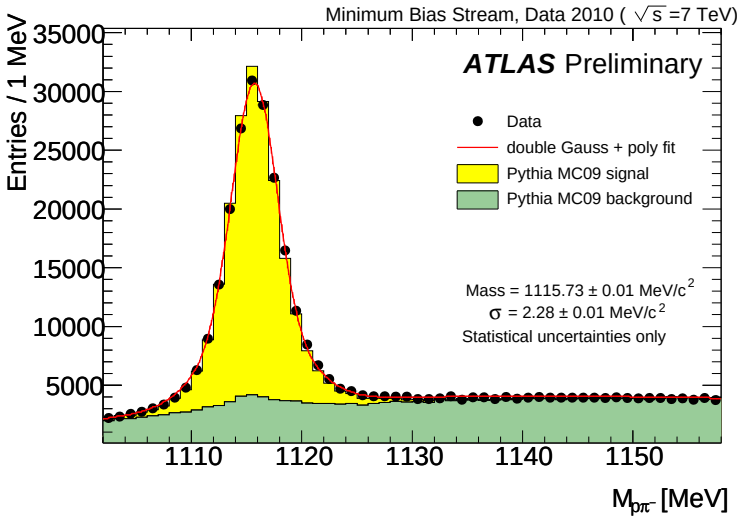


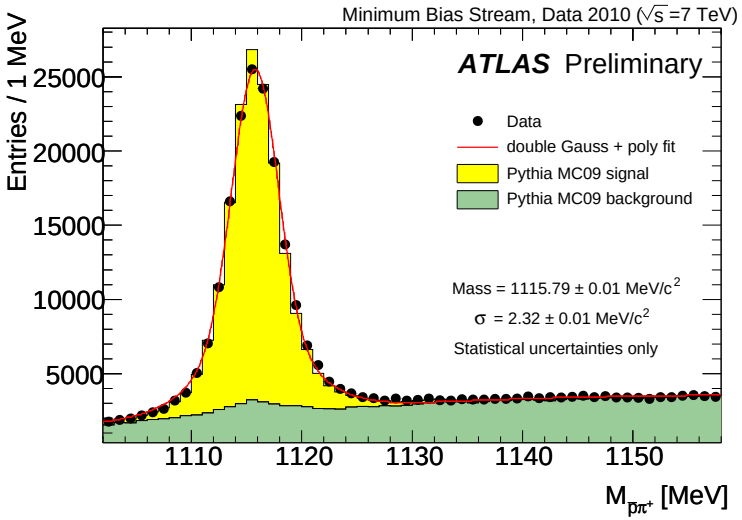


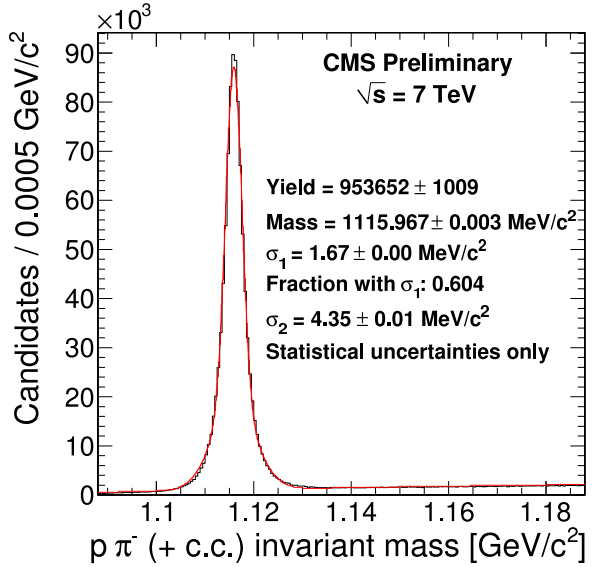
- **ATLAS**: $K^*(890) \rightarrow K^0_s\pi$
  - $d_{K^*} < 0.8$ mm
  - $p_{T\,K^*} > 1$ GeV
- **CMS**: $\phi(1020) \rightarrow K^+K^-$
  - $p_{T\,K} > 0.2$ GeV; $|\eta_K| < 2.4$
  - dE/dx; $\chi^2/ndf_K < 2$
- **ATLAS**: $\phi(1020) \rightarrow K^+K^-$
  - part of $D_s^{\pm} \rightarrow \phi(K^{\pm}K^{\mp})\pi^{\pm}$ analysis
  - $p_{T\,K} > 0.7$ GeV
  - $|\cos^3\theta'(K)| > 0.2$

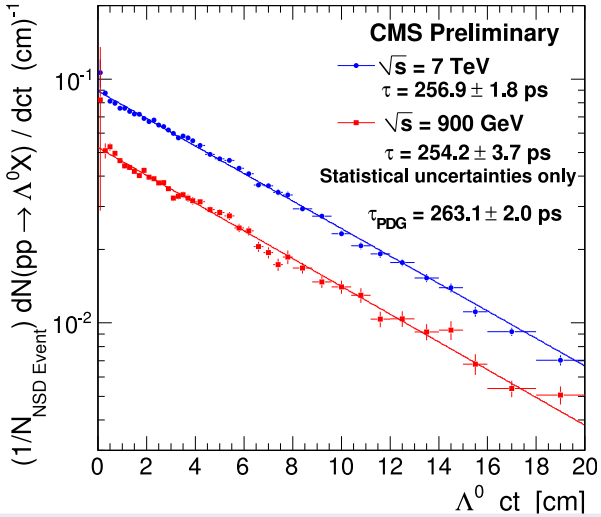
- more combinatorial background
- dE/dx limited to low p region

$\Lambda^0(uds)$ (**PDG:** 1115.683 ± 0.006 **MeV/c^2**)





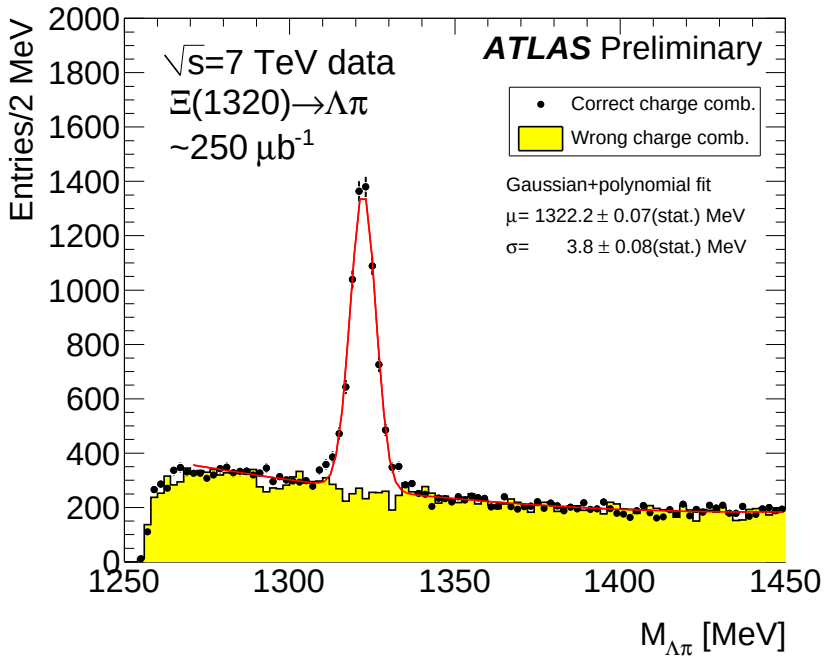


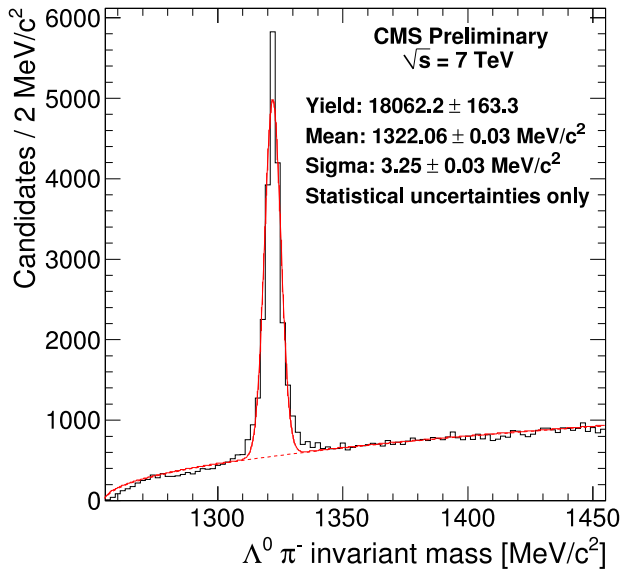


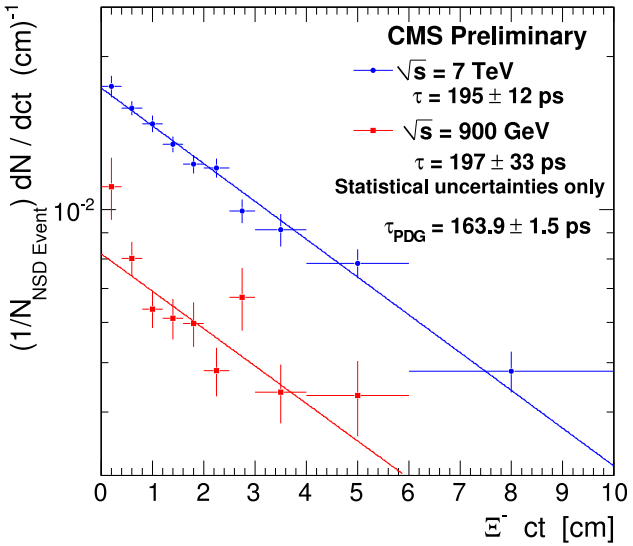
- **ATLAS** (similar as for K^0_s):
  - $L_{xyz} > 0.3$ cm; $\cos\theta > 0.9998$
  - for $|\eta_{track}| < 1.2$ less $\overline{\Lambda}^0$ reconstructed

- **CMS**
  - lower p track $\Rightarrow m_\pi$

$\Xi^-(dss)$ (PDG: 1321.71 ± 0.07 MeV/c^2)



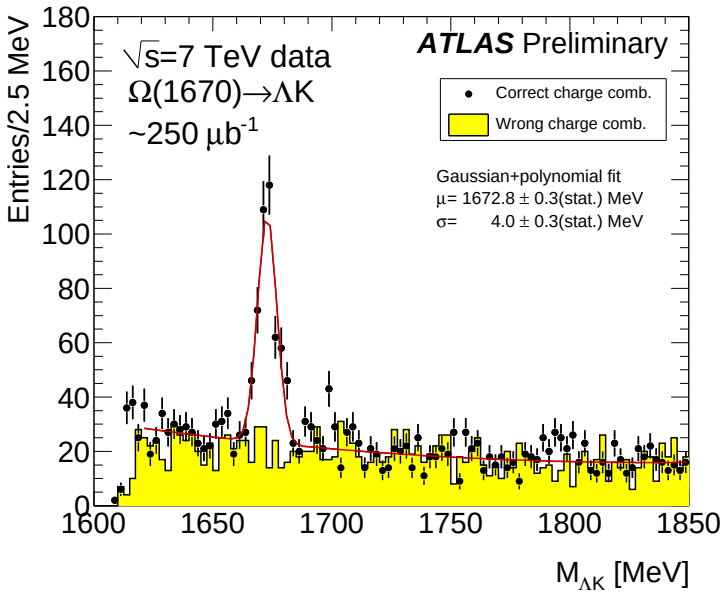




- $\Xi^{\pm}$: Λ^0 and additional charged track (m_π)
- **ATLAS**
  - $p_T > 0.15$ GeV; $d_0 > 0.5$ mm
  - $d_{\Xi\ S.V.-P.V.} > 4$ mm
- **CMS**
  - $d_{\Xi\ S.V.-P.V.} > 4\sigma_d$
  - trajectory pointing to PV within 3σ
- lifetime: more data need to be analyzed

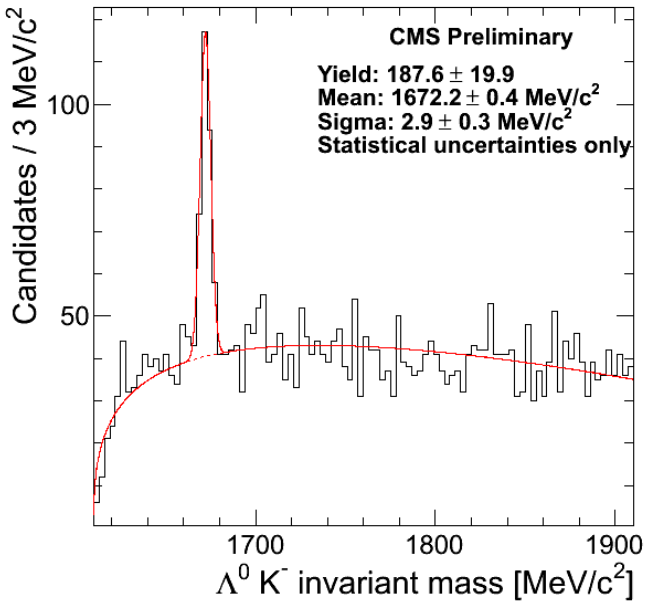
$\Omega^-(sss)$ (PDG: 1672.45 ± 0.29 MeV/c^2)

- selection (e.g. ATLAS):
  - $\Omega^{\pm}$:
    Λ^0 and additional charged track (m_K)
  - $p_T > 0.4$ GeV;
  - $d_0 > 1$ mm
  - $d_{\Xi\ S.V.-P.V.} > 6$ mm
  - $p_{T\ p\pi K} > 1.5$ GeV

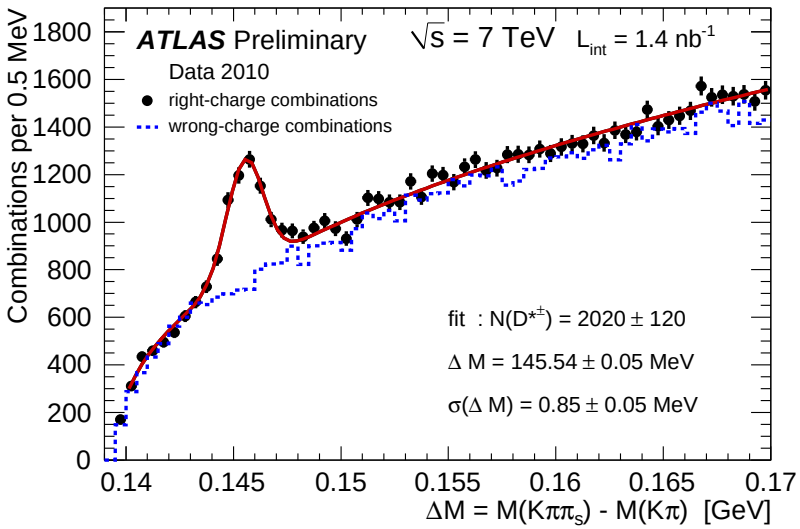


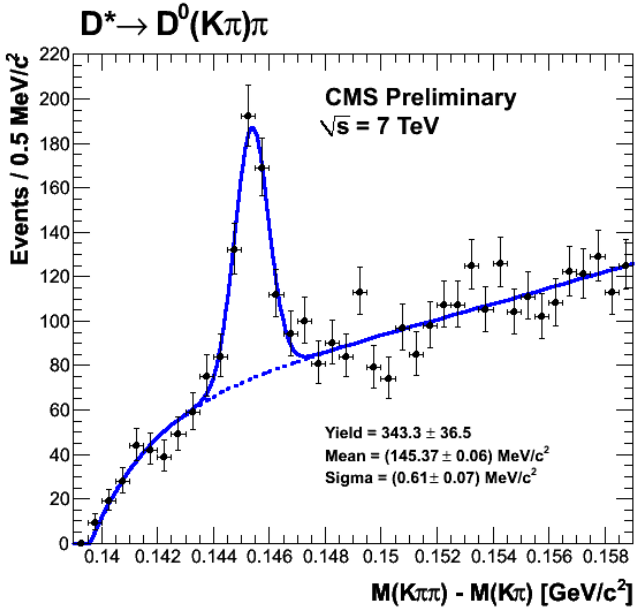
what else?

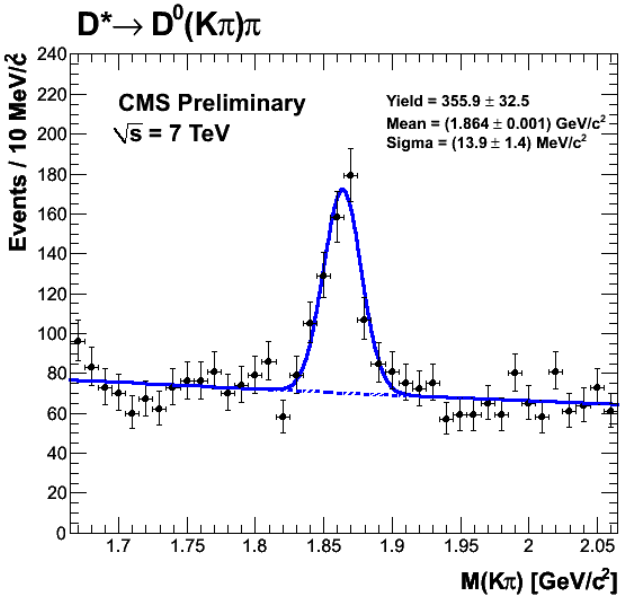
- maybe soon $K^0_s K^0_s$ - resonance states:
  - $f_2(1270)/a^0_2(1320)$
  - $f_2(1525)$
  - $f_0(1710)$
    observed by ZEUS (HERA) and L3(LEP)



$D^*(2010)$ & D^0

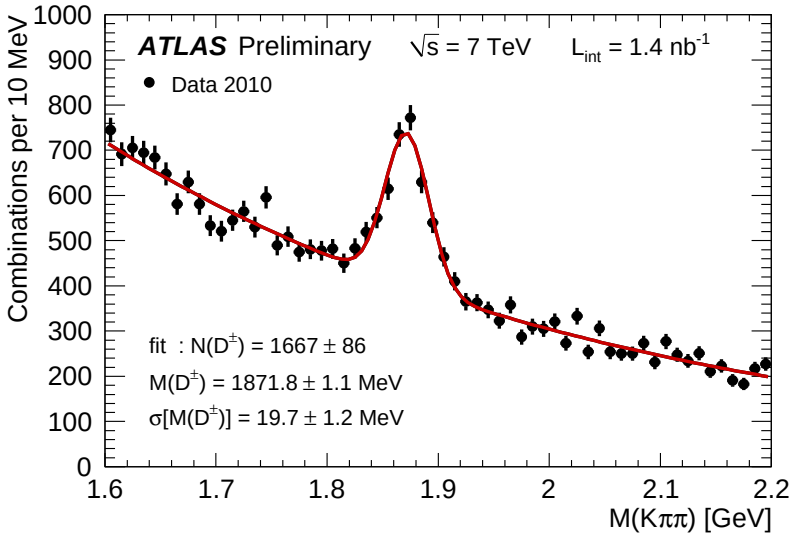


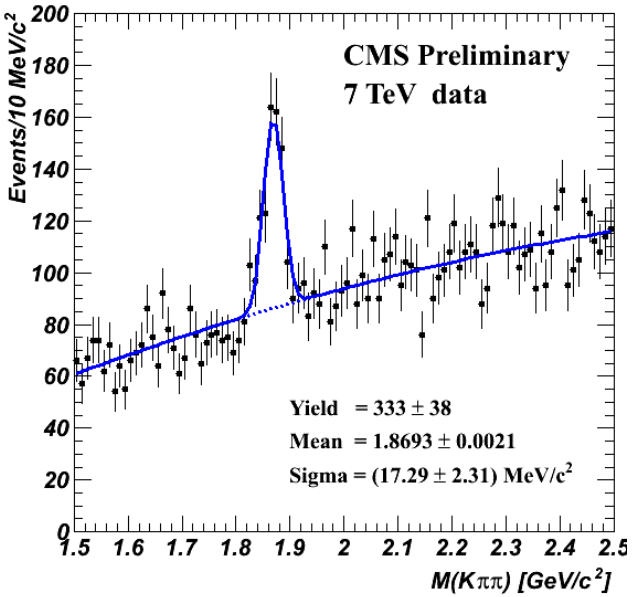




- "Golden Channel":
  $D^{*+} \longrightarrow D^0\pi_s^+ \longrightarrow K^-\pi^+\pi_s^+$ (+c.c.)
- **ATLAS**
  - $p_{T\ K/\pi} > 1$ GeV; $p_{T\ \pi_s} > 0.25$ GeV
  - $p_{T\ D^*} > 3.5$ GeV; $|\eta_{D^*}| < 2.1$
  - $1.83 < M_{K\pi} < 1.9$ GeV
- **CMS**
  - $p_{T\ K/\pi} > 0.6$ GeV; $p_{T\ \pi_s} > 0.25$ GeV
  - $p_{T\ D^*} > 5$ GeV
  - $|M_{K\pi} - M_{D^0}^{PDG}| < 25$ MeV

$D^+(c\bar{d})$ (PDG: 1869.60 ± 0.16 MeV/c^2)



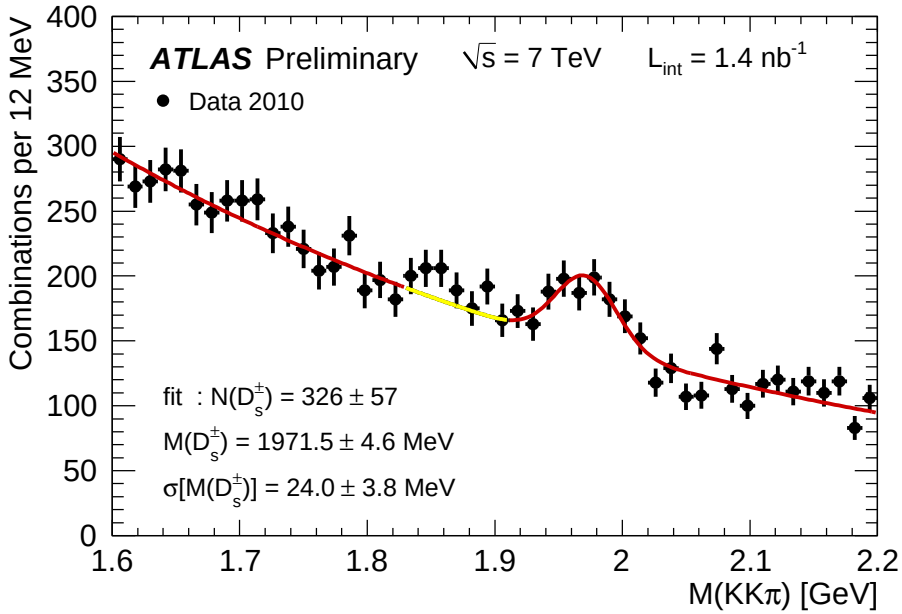


- $D^{\pm} \longrightarrow K^{\mp}\pi^{\pm}\pi^{\pm}$
- **ATLAS**
  - $p_{T\ K} > 1$ GeV; $p_{T\pi} > 0.8$ GeV
  - $p_{T\ D^+} > 3.5$ GeV; $|\eta_{D^+}| < 2.1$
  - $L_{xy\ D^+} > 1.3$ mm

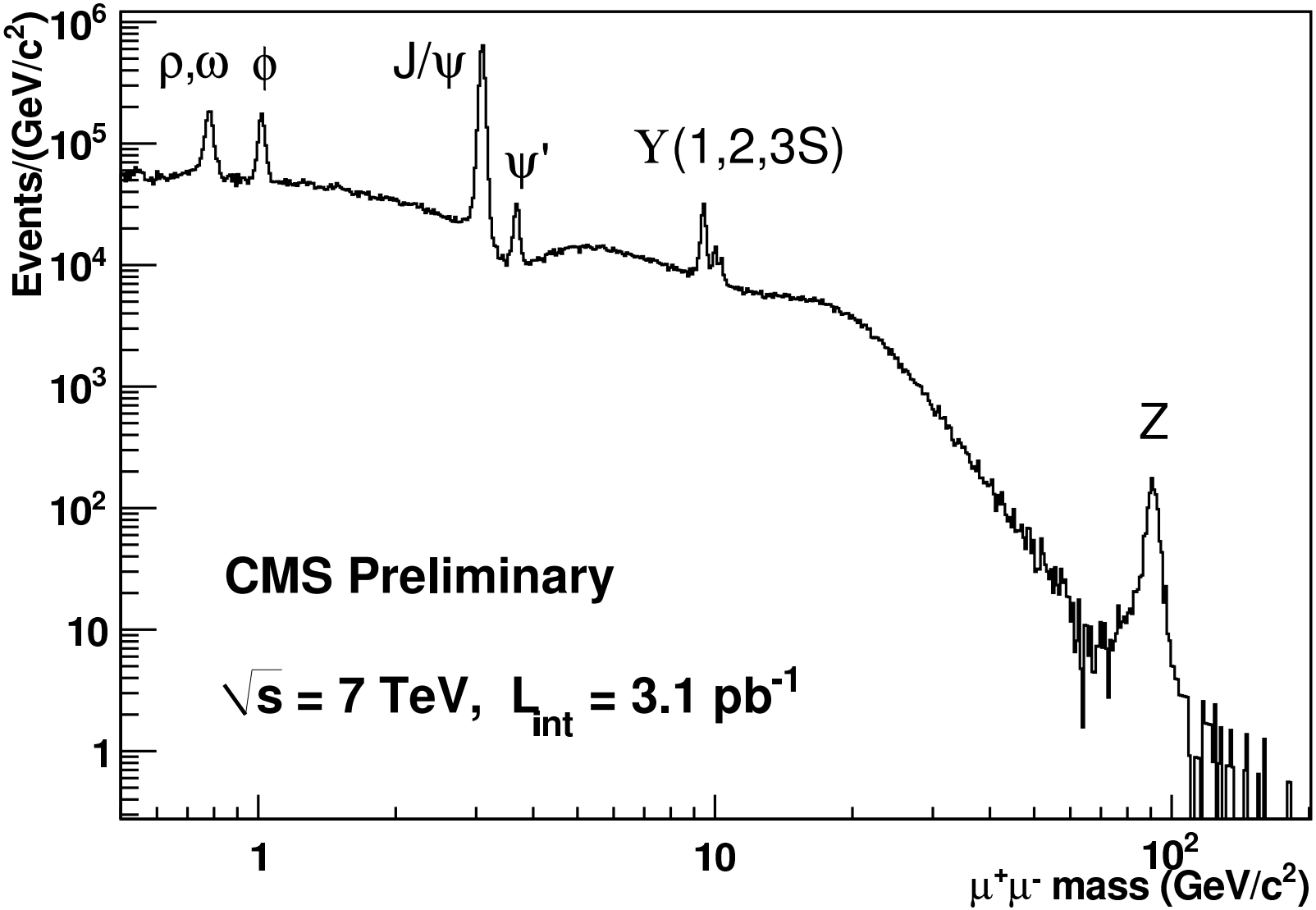
- **CMS**
  - $p_{T\ tr} > 0.1$ GeV; $p_{tr} > 1.5$ GeV
  - S.V.
  - $L/S > 7$: detachment
    P.V - S.V divided by its error

$D_s^+(c\bar{s})$ (**PDG:** 1968.47 ± 0.33 **MeV/c**^{2})

- $D_s^{\pm} \longrightarrow \phi\pi^{\pm} \longrightarrow K^{\mp}K^{\pm}\pi^{\pm}$
- **ATLAS**
  - $p_{T\,K} > 0.7$ GeV; $p_{T\pi} > 0.8$ GeV
  - S.V. $\chi^2/ndf < 6$
  - $L_{xy} > 0.4$ mm
  - $\cos\theta^*(\pi) < 0.4$ where $\theta^*(\pi)$: $\sphericalangle$ between π in $KK\pi$ rest frame and $KK\pi$ line of flight in LAB. frame
  - $|\cos^3\theta'(K)| > 0.2$ where $\theta'(K)$: $\sphericalangle$ between one K and π in KK rest frame

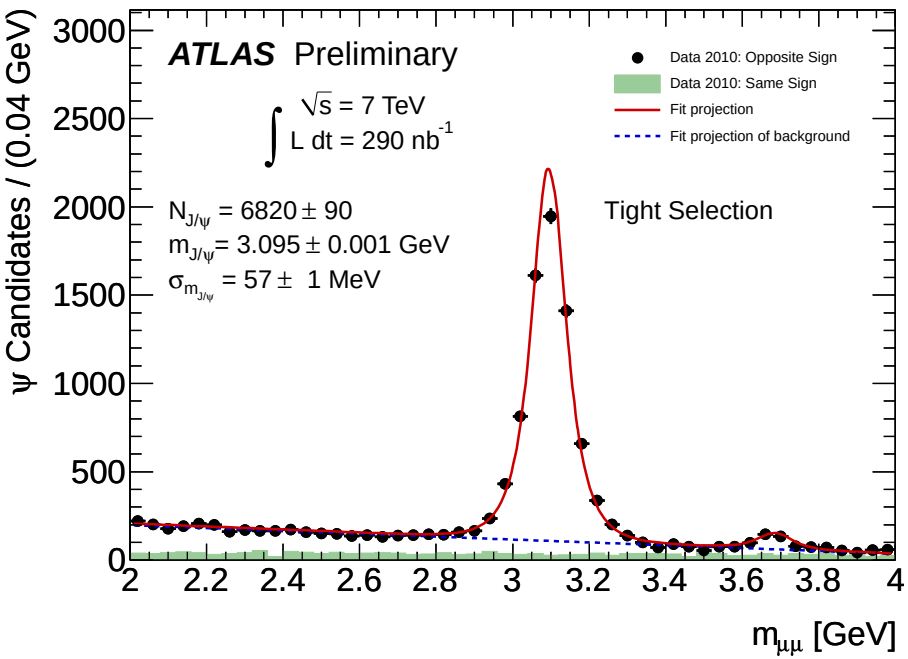


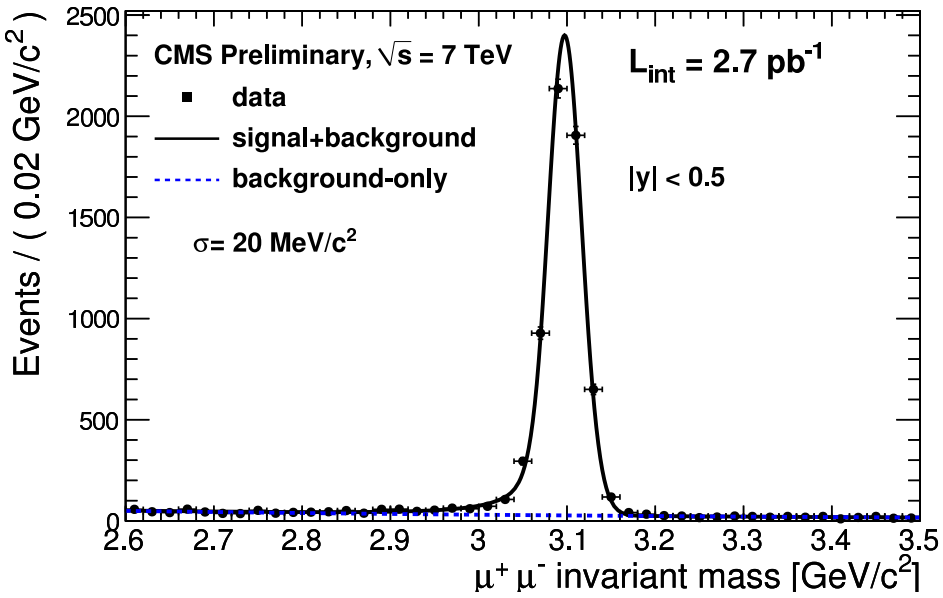
Welcome to diμdorado !

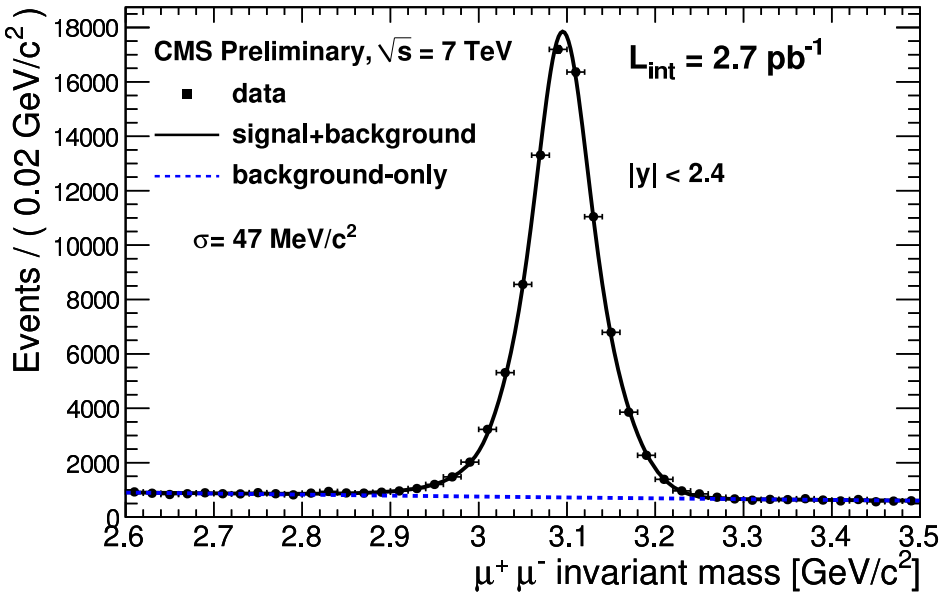


similar spectrum observed also by ATLAS

$J/\Psi(1S)(c\bar{c})$ (**PDG:** 3096.916 ± 0.011 **MeV/c^2**)

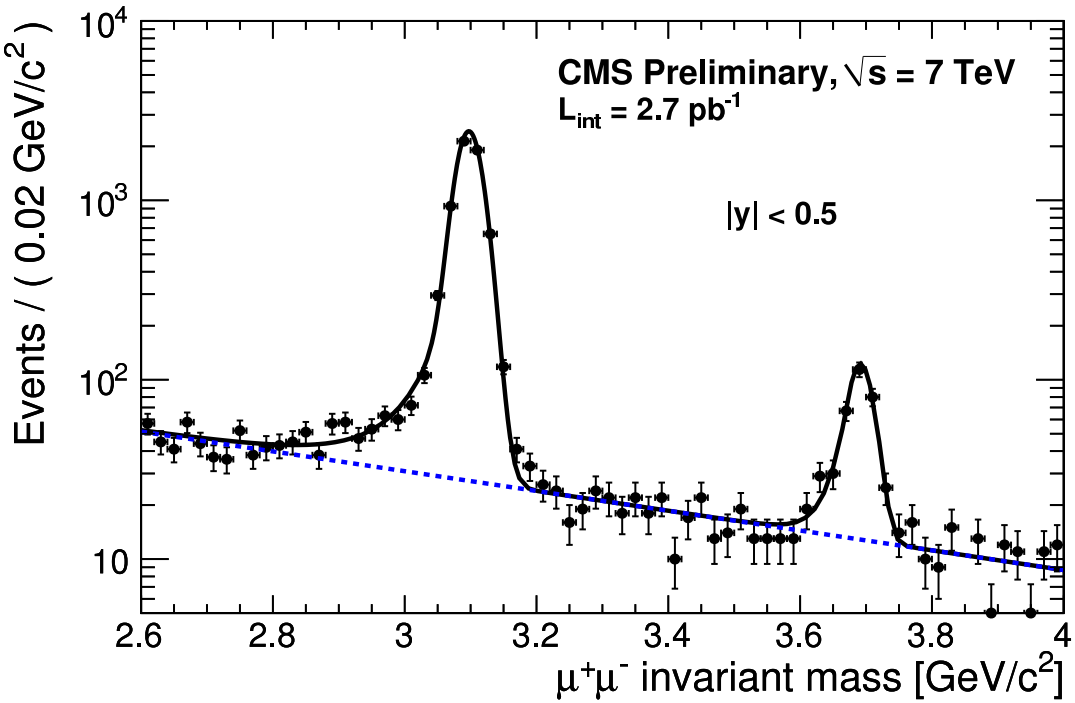






- **CMS**
  - $P(\mu^+\mu^-_{S.V.}) > 0.1\%$
  - for $|y_{J/\Psi}| < 0.5$:
    $p_{T\mu} > 3.3$ GeV
    Mass: 3.0945 ± 0.0008 GeV/c^2
    $N(J/\Psi(1S)) = 710 \pm 29$
- **ATLAS**
  - $p_{T\mu 1} > 2.5$ GeV; $p_{T\mu 2} > 4$ GeV

$\Psi(2S)$ (**PDG:** 3686.09 ± 0.04 **MeV/c^2**)

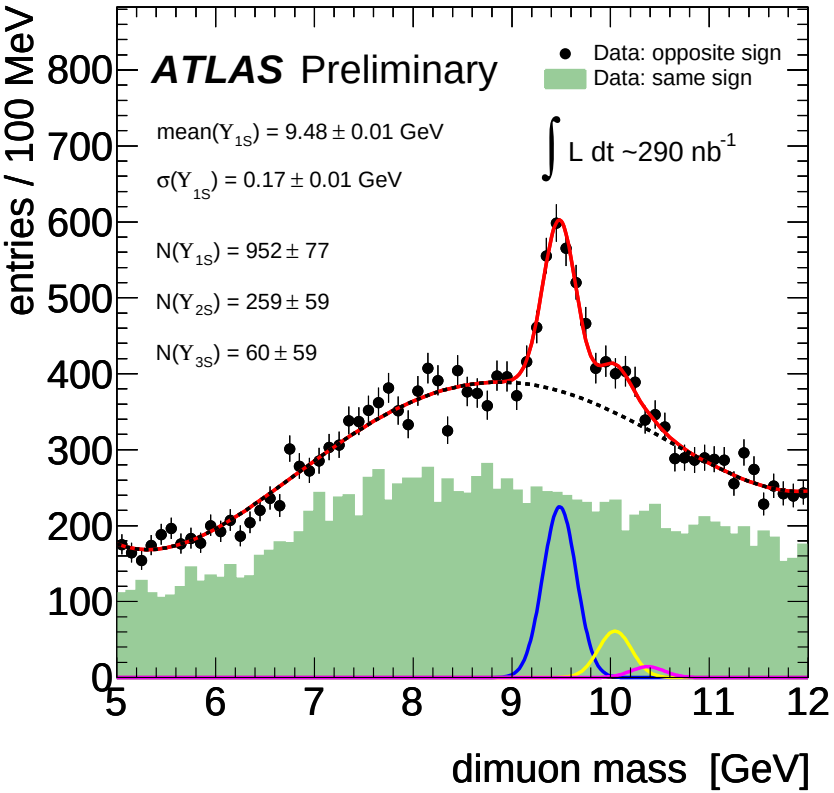


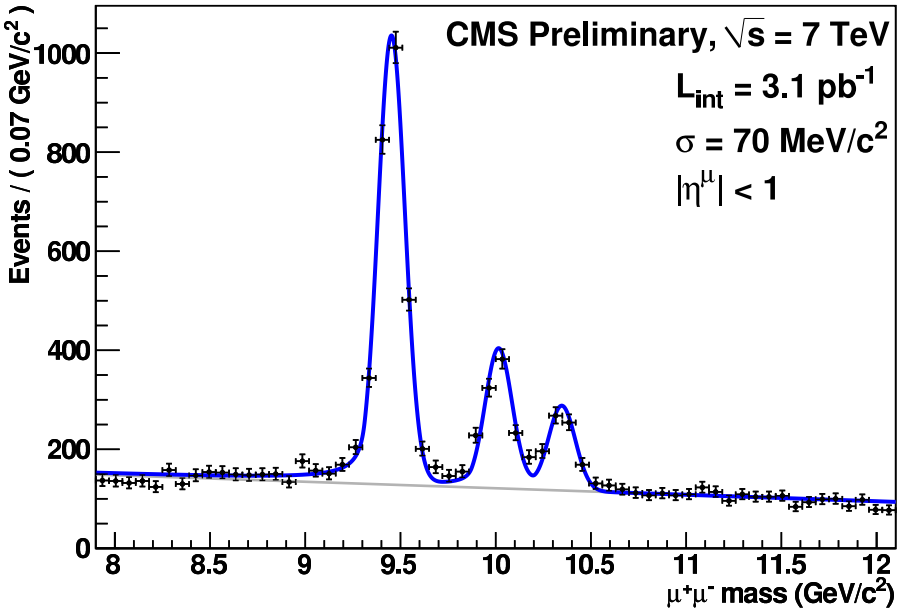
- **CMS**
  - same selection as for $J/\Psi(1S)$
  - $|y_{\mu^+\mu^-}| < 0.5$

what else?

- maybe checking for X(3872)

$\Upsilon(1S)(b\bar{b})$ (**PDG:** 9460.30 ± 0.26 **MeV/c^2**)





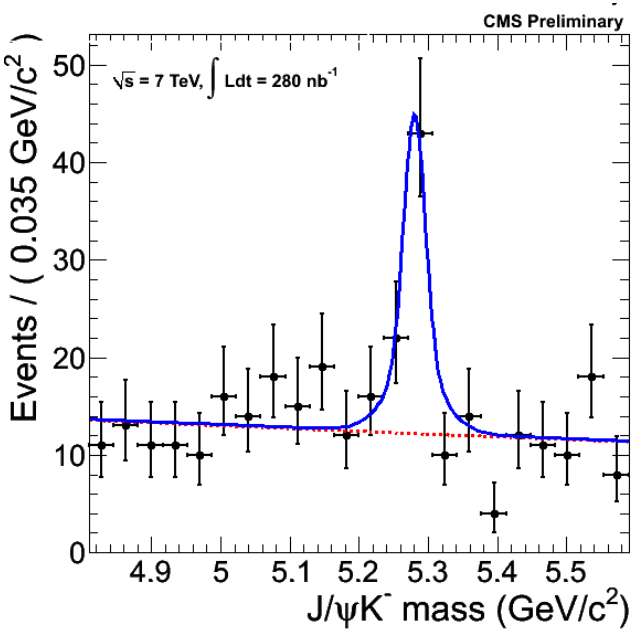
- **ATLAS**
  - Trigger:
    L1 muon trigger(no pT cut), or a LHT muon: $p_{T\mu} > 4$ GeV
  - $p_{T\mu 1} > 2.5$ GeV; $p_{T\mu 2} > 4$ GeV

- **CMS**
  - $p_{T\mu} > 3.5$ GeV; $|\eta_\mu| < 1.0$; $|y_\Upsilon| < 2$
  - $P(\mu^+\mu^-_{S.V.}) > 0.1\%$
  - $|z_{\mu^+} - z_{\mu^-}| < 0.2$ cm:
    - $N(\Upsilon(1S)) = 2440 \pm 61$
    - $N(\Upsilon(2S)) = 757 \pm 40$
    - $N(\Upsilon(3S)) = 464 \pm 34$

$B^-(\bar{u}b)$ (PDG: 5279.17 ± 0.29 MeV/c^2)

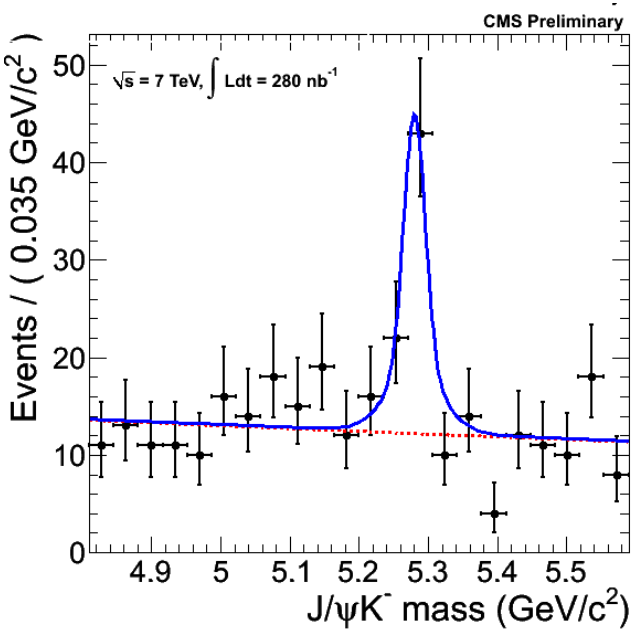
- **CMS**
  - High Level Trigger: $p_{T\mu} > 3$ GeV & $ct/\sigma_{ct} > 1$
  - $p_{T\mu} > 3$ GeV; $|\eta_\mu| < 2.4$
  - $P(J/\Psi_{S.V.}) > 0.1\%$
  - $p_{T\ tr} > 0.9$ GeV; track: m_K
  - $P(B^-_{S.V.}) > 0.1\%$
  - if $N_{B-} > 1$ in one event: choose highest p_T one

  - Mean: 5280 MeV/c^2
  - Resolution: 32 MeV/c^2
  - $N_{B\pm}$: 48 ± 8



$B^-(\bar{u}b)$ (PDG: 5279.17 ± 0.29 MeV/c^2)

- **CMS**
  - High Level Trigger: $p_{T\mu} > 3$ GeV & $ct/\sigma_{ct} > 1$
  - $p_{T\mu} > 3$ GeV; $|\eta_\mu| < 2.4$
  - $P(J/\Psi_{S.V.}) > 0.1\%$
  - $p_{T\ tr} > 0.9$ GeV; track: m_K
  - $P(B^-_{S.V.}) > 0.1\%$
  - if $N_{B-} > 1$ in one event: choose highest p_T one
  - Mean: 5280 MeV/c^2
  - Resolution: 32 MeV/c^2
  - $N_{B\pm}$: 48 ± 8



what else?

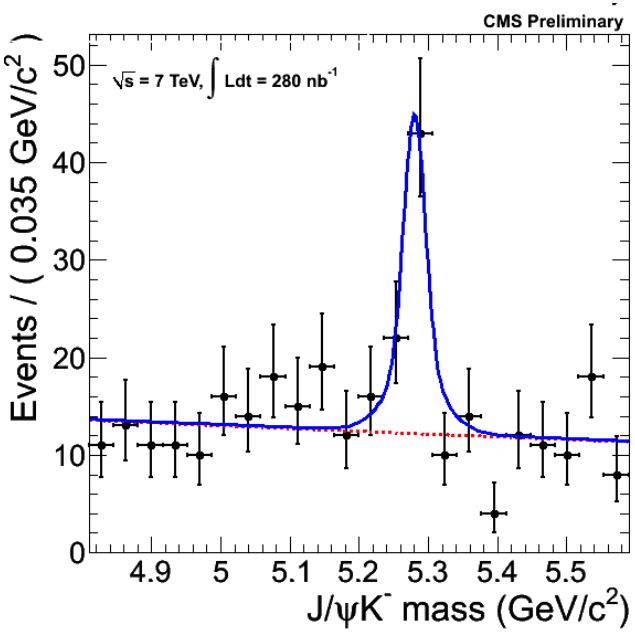
- $B^0 \to J/\Psi K^0_s$, $\Lambda^0_b \to J/\Psi \Lambda^0$, $B^0 \to J/\Psi K^{*0}(K\pi)$, $B^+ \to J/\Psi K^{*+}(K^0_s\pi^+)$
- or $B^0_s \to J/\Psi(\mu^+\mu^-)\phi(K^+K^-)$

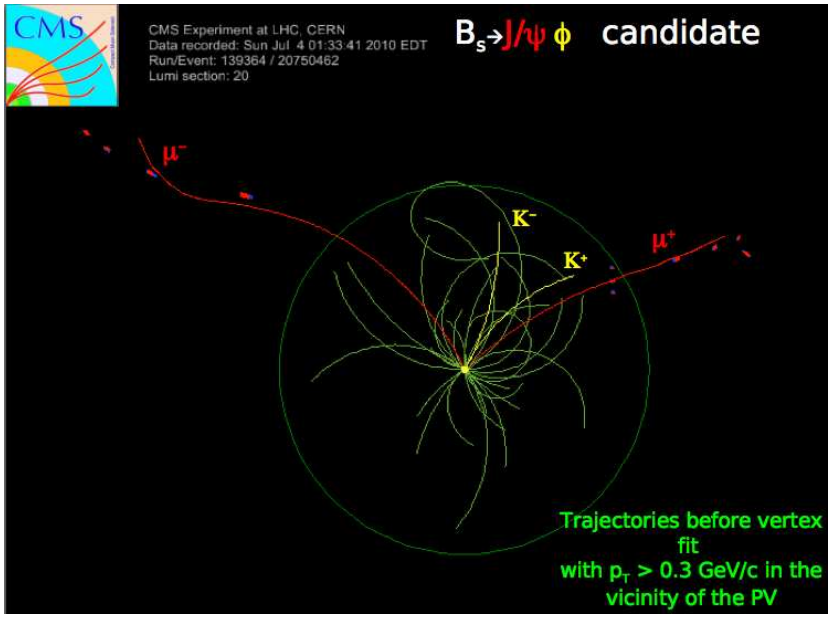
$B^-(\bar{u}b)$ (**PDG:** 5279.17 ± 0.29 **MeV/c^2**)

- **CMS**
  - High Level Trigger: $p_{T\mu} > 3$ GeV & $ct/\sigma_{ct} > 1$
  - $p_{T\mu} > 3$ GeV; $|\eta_\mu| < 2.4$
  - $P(J/\Psi_{S.V.}) > 0.1\%$
  - $p_{T\ tr} > 0.9$ GeV; track: m_K
  - $P(B^-_{S.V.}) > 0.1\%$
  - if $N_{B-} > 1$ in one event: choose highest p_T one
  - Mean: 5280 MeV/c^2
  - Resolution: 32 MeV/c^2
  - $N_{B\pm}$: 48 ± 8

what else?

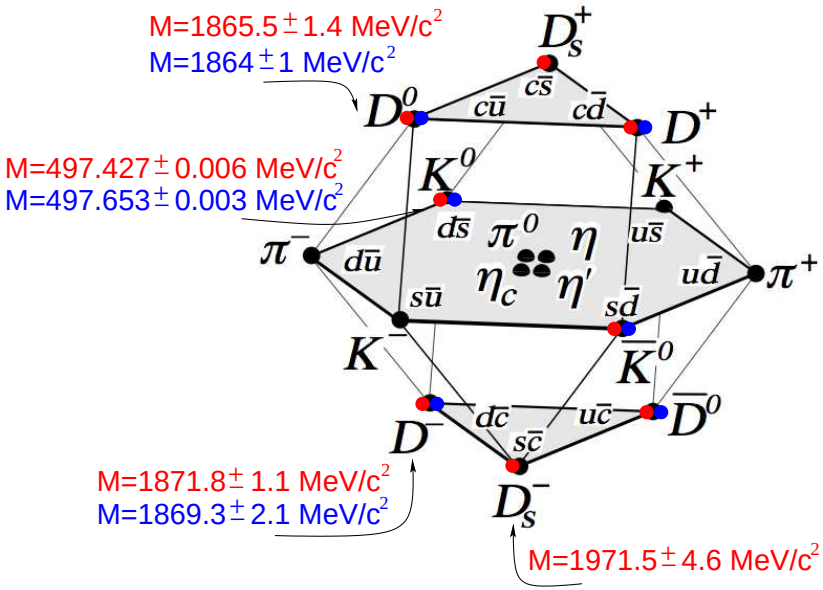
- $B^0 \to J/\Psi K^0_s$, $\Lambda^0_b \to J/\Psi \Lambda^0$, $B^0 \to J/\Psi K^{*0}(K\pi)$, $B^+ \to J/\Psi K^{*+}(K^0_s\pi^+)$
- or $B^0_s \to J/\Psi(\mu^+\mu^-)\phi(K^+K^-)$

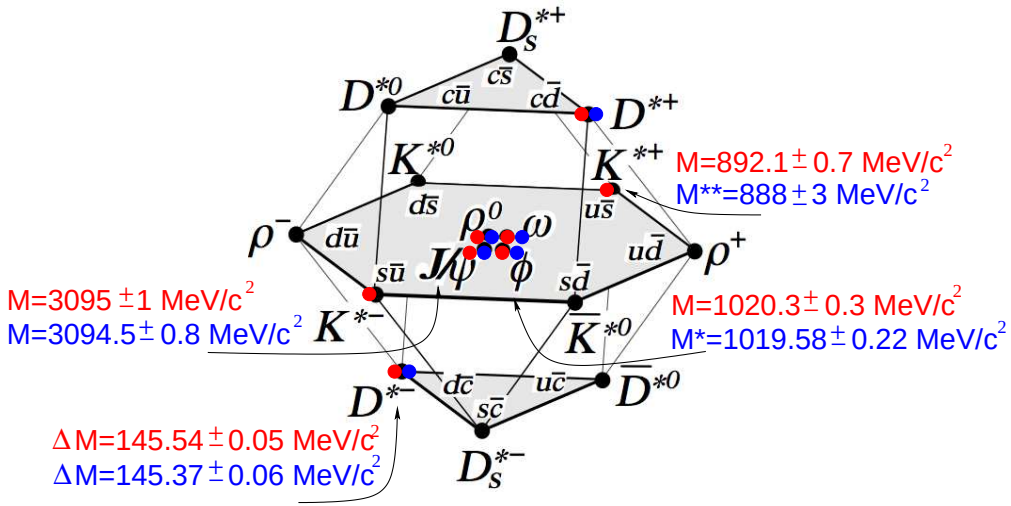


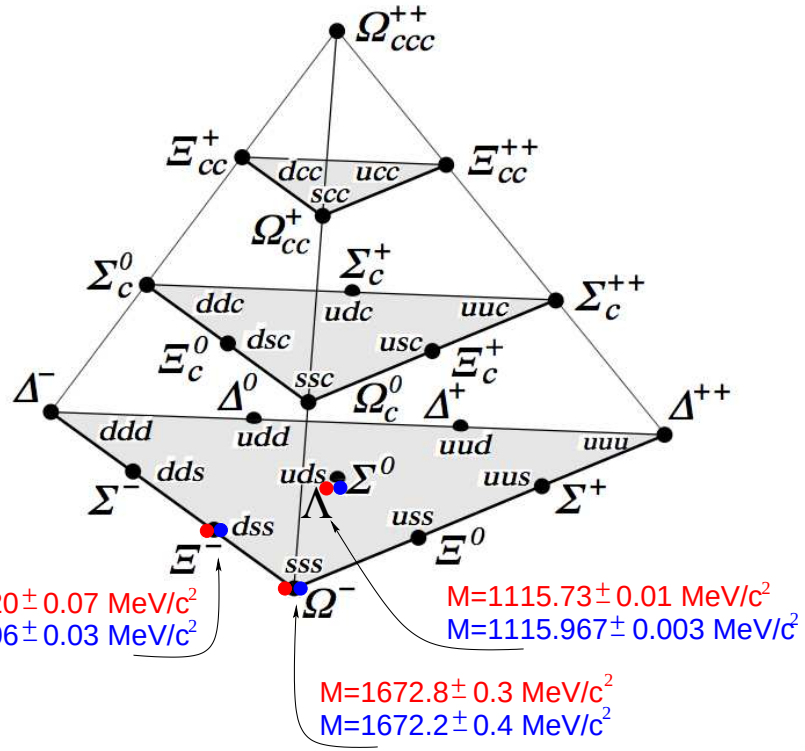


Summary

ATLAS CMS







- $\Psi(2S)$
- $\Upsilon(1S)$, $\Upsilon(2S)$, $\Upsilon(3S)$
- $B^- \rightarrow J/\Psi(\mu^+\mu^-)\, K^-$
- $B_s^0 \rightarrow J/\Psi(\mu^+\mu^-)\phi(K^+K^-)$

statistical errors only
M^*: result from $\sqrt{s} = 900$ GeV data
M^{**}: result from $\sqrt{s} = 900$ GeV and 2.76 TeV data

Back-Up Slides

References

http://cdsweb.cern.ch/record/1277668/files/ATLAS-CONF-2010-033.pdf
http://cdsweb.cern.ch/record/1279344/files/QCD-10-007-pas.pdf
http://cdsweb.cern.ch/record/1279137/files/TRK-10-004-pas.pdf
https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2010-032/
https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2010-034/
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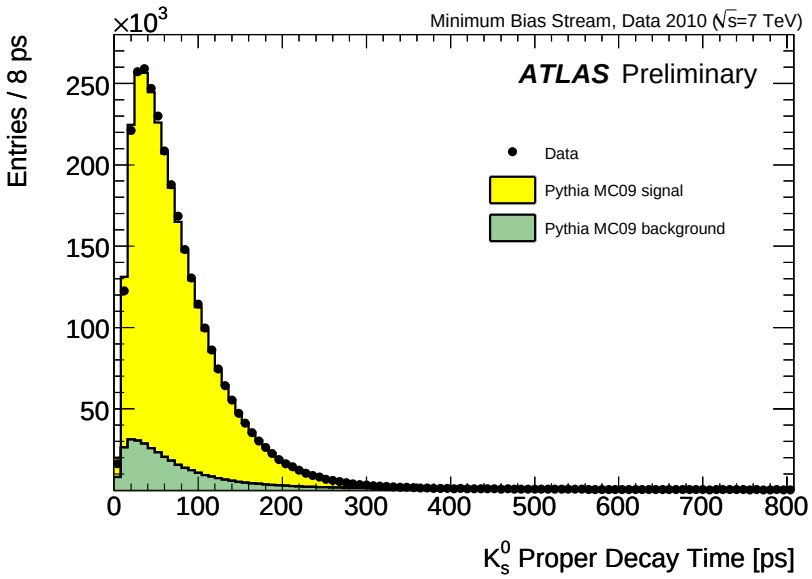
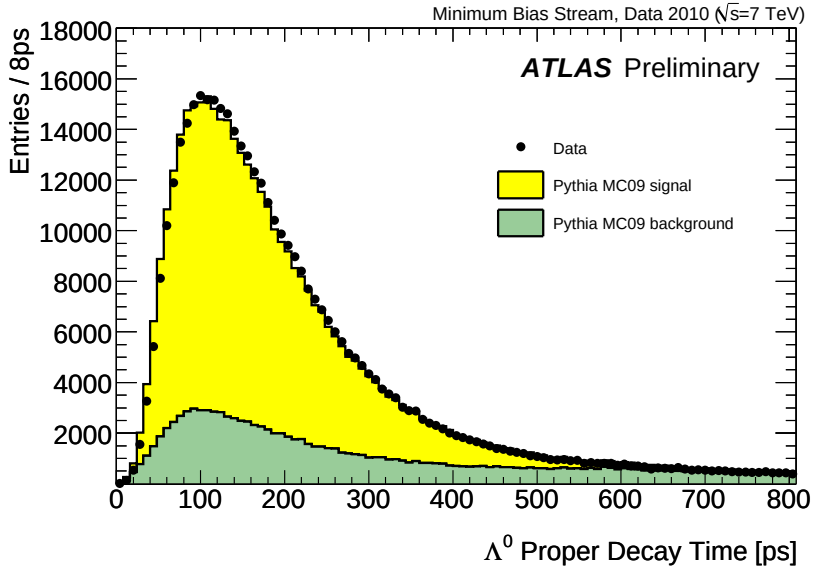
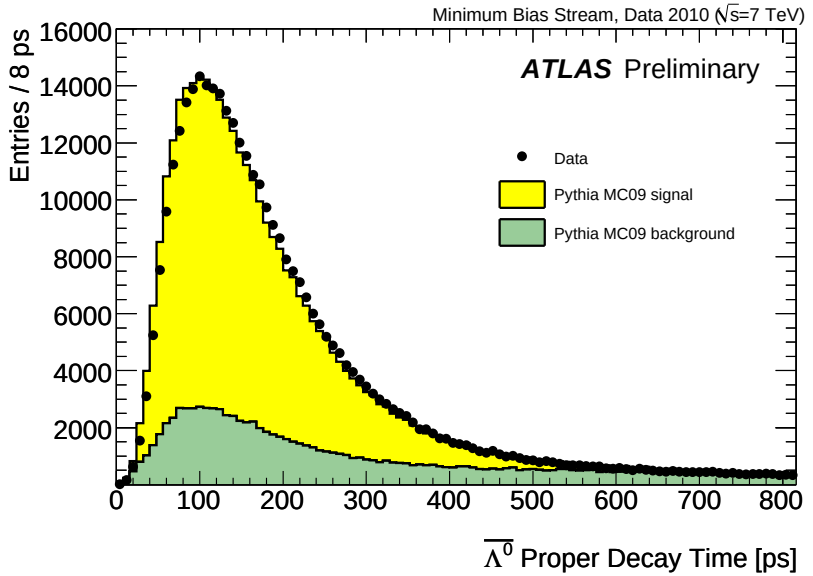
http://cdsweb.cern.ch/record/1279616/files/BPH-10-002-pas.pdf
http://cdsweb.cern.ch/record/1279134/files/DP2010_024.pdf
https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2010-023/
http://cdsweb.cern.ch/record/1258204/files/TRK-10-001-pas.pdf

Lifetime: K^0_s, Λ^0_s, $\bar{\Lambda}^0_s$

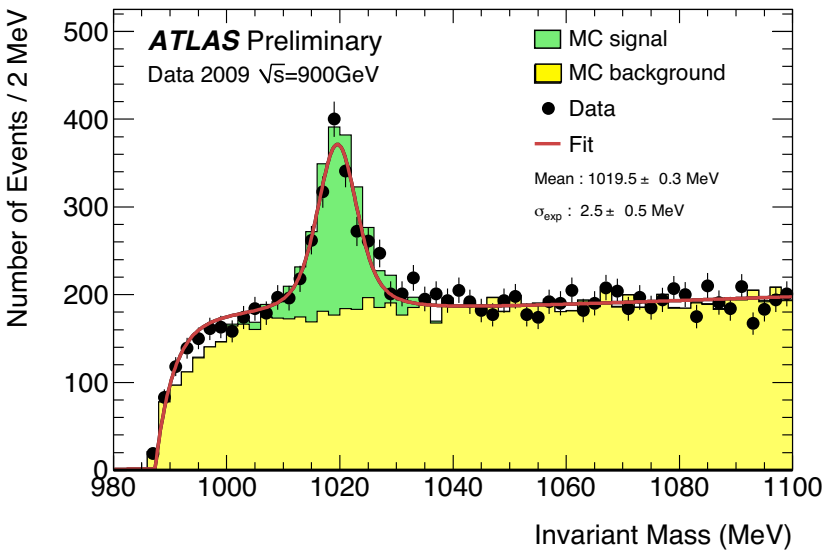


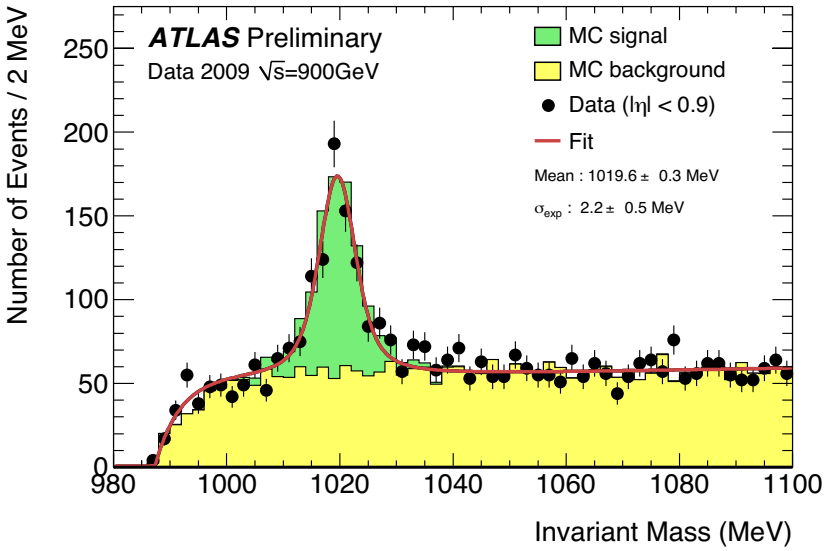


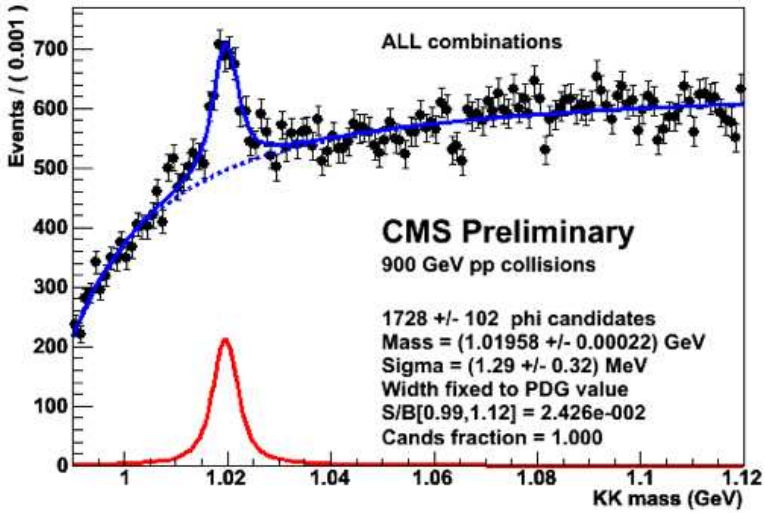


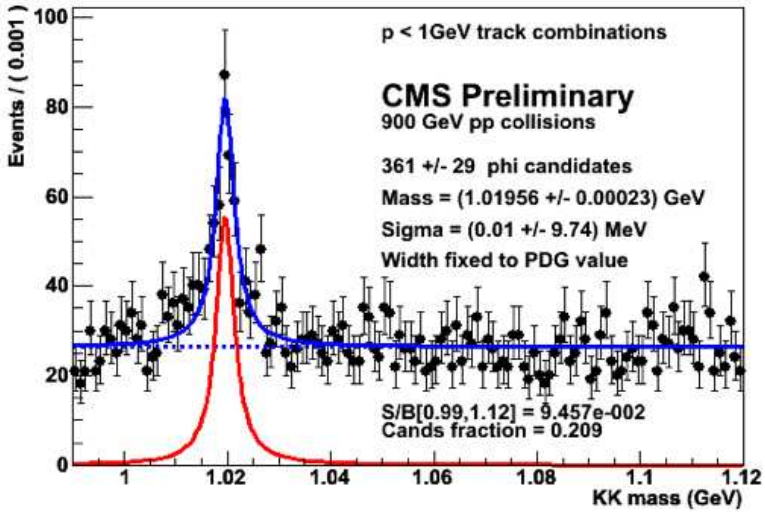
- good DATA description by the MC:
  - signal
  - background

$\phi(1020) \rightarrow K^+K^-$ at 900 GeV





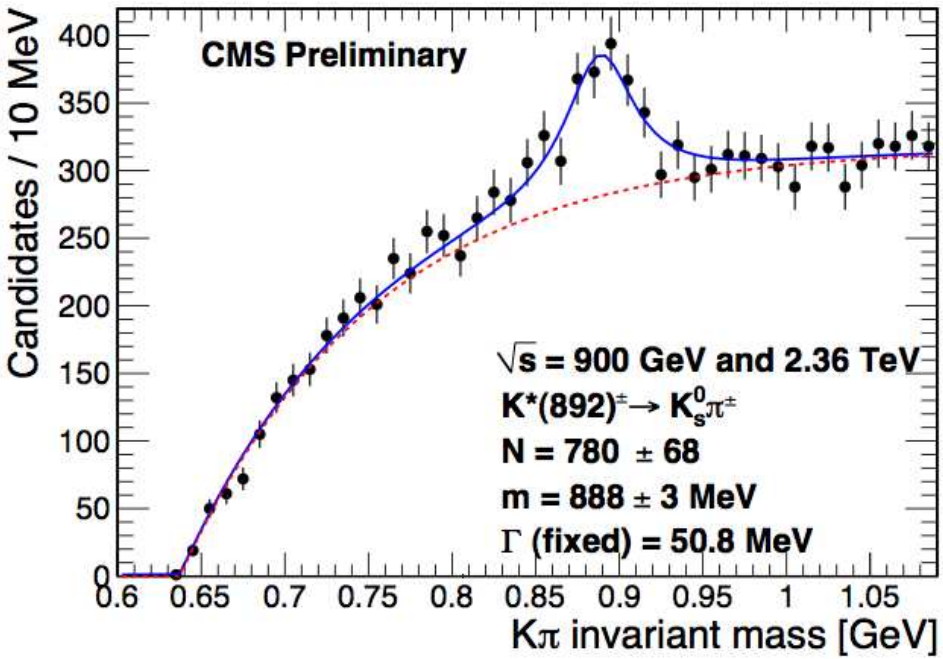




- dE/dx can be used up to $p \approx 1$ GeV
- **ATLAS**: $p \leq 0.8$ GeV

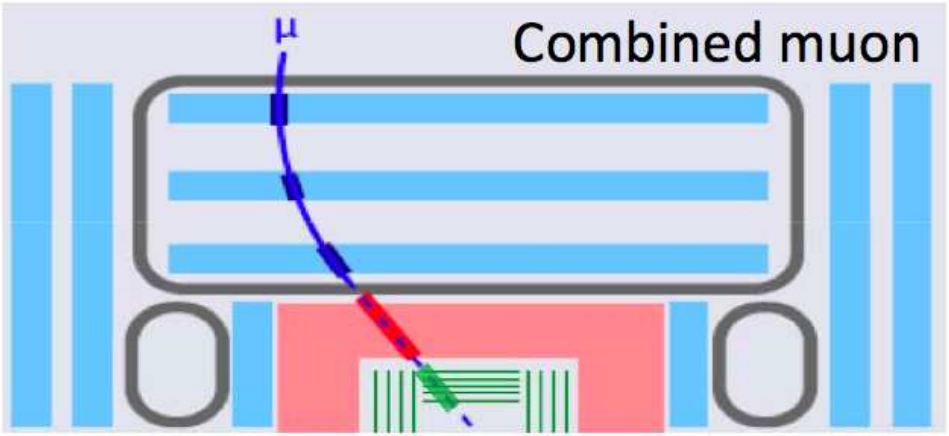
$K^{*\pm}(892) \rightarrow K^0_s\pi^\pm$ at 900 GeV and 2.36 TeV

- one of the first measurements
- limited statistics



Muon Reconstruction:

ATLAS



Muon System
Calorimeter
Inner Detector

http://cdsweb.cern.ch/record/1298275/files/ATL-PHYS-SLIDE-2010-342.pdf

CMS