First Observation of Bottom Baryon Σ_b States at CDF

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1 – Outline

- Introduction: Heavy Baryons with HQET.
- Experimental Status.
- Principle of an Analysis.
- b-Physics at Tevatron with CDF II detector.
- CDF II Triggers and Datasets involved.
  - $\surd$ Λ_b^0 base signal.
  - $\surd$ Reconstruction of Σ_b Candidates - Blind.
  - $\surd$ Opened Box.
  - $\surd$ Fits.
  - $\surd$ Systematics.
  - $\surd$ Significance.
- Summary.

2 – Multiplets of Heavy Baryons

Bottom Baryon States with B=1,C=0,J^P = $1/2^+$, $3/2^+$

Notation	Quark content	J^P	SU(3)	(I,I_3)	S	B	Mass
Λ_b^0	b[ud]	$1/2^+$	3*	(0,0)	0	1	5619.7±1.2±1.2 MeV
Ξ_b^0	b[su]	$1/2^+$	3*	(1/2,1/2)	-1	1	5.80 GeV
Ξ_b^-	b[sd]	$1/2^+$	3*	(1/2,-1/2)	-1	1	5.80 GeV
Σ_b^+	buu	$1/2^+$	6	(1,1)	0	1	5.82 GeV
Σ_b^0	b{ud}	$1/2^+$	6	(1,0)	0	1	5.82 GeV
Σ_b^-	bdd	$1/2^+$	6	(1,-1)	0	1	5.82 GeV
$\Xi_b^{0\prime}$	b{su}	$1/2^+$	6	(1/2,1/2)	-1	1	5.94 GeV
$\Xi_b^{0\prime}$	b{sd}	$1/2^+$	6	(1/2,-1/2)	-1	1	5.94 GeV
Ω_b^0	bss	$1/2^+$	6	(0,0)	-2	1	6.04 GeV
Σ_b^{*+}	buu	$3/2^+$	6	(1,1)	0	1	5.84 GeV
Σ_b^{*0}	bud	$3/2^+$	6	(1,0)	0	1	5.84 GeV
Σ_b^{*-}	bdd	$3/2^+$	6	(1,-1)	0	1	5.84 GeV
Ξ_b^{*0}	bus	$3/2^+$	6	(1/2,1/2)	-1	1	5.94 GeV
Ξ_b^{*-}	bds	$3/2^+$	6	(1/2,-1/2)	-1	1	5.94 GeV
Ω_b^{*-}	bss	$3/2^+$	6	(0,0)	-2	1	6.06 GeV

Mass predictions from hep-ph/9406359

$\Rightarrow$ Motivation for an Experimental Search on Σ_b.

- Wealth of experimental data on B-mesons from e^+e^- and hadron beams.
- Yet **only one bottom baryon, the Λ_b^0,** has been directly observed:
  - $\Lambda_b^0 \to J/\psi\, \Lambda^0$
  - $\Lambda_b^0 \to \Lambda_c^+ \pi^-$
  - $\Lambda_b^0 \to \Lambda_c^+ \mu^- \overline{\nu}_\mu$
- World's largest data sample of bottom baryons at CDF...
  - $\sim 3000,\ \Lambda_b^0 \to \Lambda_c^+ \pi^-$
- **None of Σ_b states have been established so far.**
- Excellent track resolution of CDF tracker ...
- Precise vertex reconstruction by Si-Detector SVX II ...
- Provide fine mass resolution.
  - Make possible to observe $\Sigma_b^{(*)\pm} \to \Lambda_b^0 \pi^\pm$

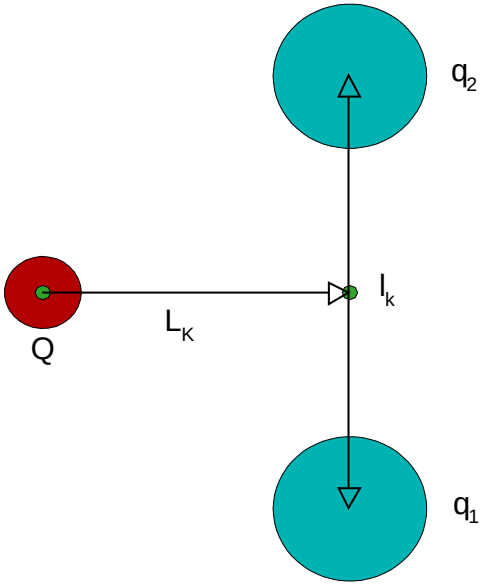
3 – Spectroscopy with QCD

⇒ H.Q.E.T. Phenomenology:

- QCD simplifies substantially in a presence of a heavy quark $\mathbf{Q}$, i.e.
- $\mathbf{m_Q \gg \Lambda_{QCD} \gg m_q}$, where
- $\mathbf{\Lambda_{QCD} \simeq 400\,MeV}$, typical scale of strong interaction's.
- $\mathbf{m_Q \simeq 4.8\,GeV,\ Q \equiv b}$.
- heavy quark spin **decouples** from light quark degrees of freedoms.
- $\mathbf{L_K}$ is orbital momentum of light $q_1 q_2$ w.r.t. heavy Q.
- $\mathbf{l_k}$ is internal, relative orbital momentum of light $\mathbf{q_1\ q_2}$ system.

⇒ Heavy Q - Light $(\mathbf{q_1\ q_2})$

Qq_1q_2 System: Orbital Angular Momenta.



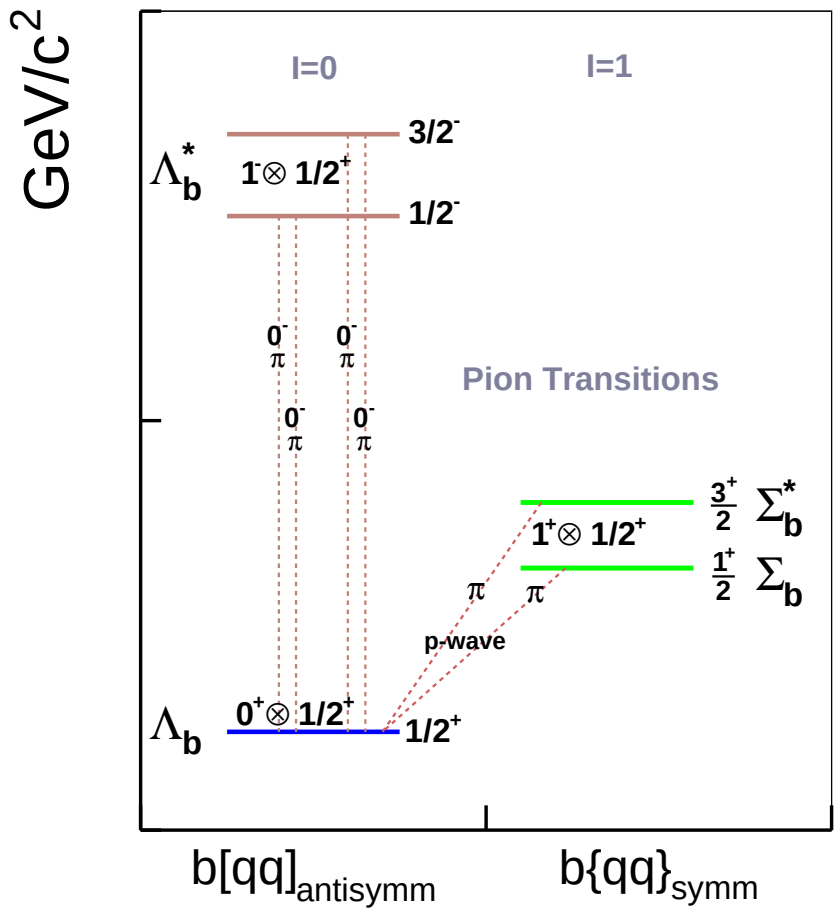
$$\Rightarrow \mathbf{j_{qq} = s_{qq} + L_{qq}}$$

$$\Rightarrow \mathbf{J_{Qqq} = s_Q + j_{qq}}$$

⇒ **Low Lying Bottom Baryons**

⇒ **Theoretical Expectations:**

Σ_b **property**	MeV/c^2
$m(\Sigma_b) - m(\Lambda_b^0)$	$180 - 210$
$m(\Sigma_b^*) - m(\Sigma_b)$	$10 - 40$
$m(\Sigma_b^-) - m(\Sigma_b^+)$	$5 - 7$
$m(\Lambda_b^0)$, **fixed**	5619.7
from CDF II	$\pm 1.2 \pm 1.2$
$\Gamma(\Sigma_b), \Gamma(\Sigma_b^*)$	$\sim 8, \sim 15$
see next slide...	



⇒ HQET

⇒ Potential models

⇒ $1/N_c$ expansions

⇒ Lattice QCD calc.

⇒ $\Lambda_b^0 \to \Lambda_c^+ \pi^-$, weak decay.

⇒ $\Sigma_b^{(*)\pm} \to \Lambda_b^0 \pi^\pm$, strong decay.

⇒ $\Lambda_b^{*0} \to \Lambda_b^0 \pi^+ \pi^-$, strong decay.

⇒ phase space allowing...

4 – Natural Width of $\Sigma_b^{(*)\pm}$ Baryons

$\Rightarrow$ **Important to understand a structure of the exp. signal.**

- Dominated by single P-wave pion transitions.

$$\Gamma_{\Sigma_Q \to \Lambda_Q \pi} = \frac{1}{6\pi} \frac{M_{\Lambda_Q}}{M_{\Sigma_Q}} |f_p|^2 |\vec{p}_\pi|^3$$

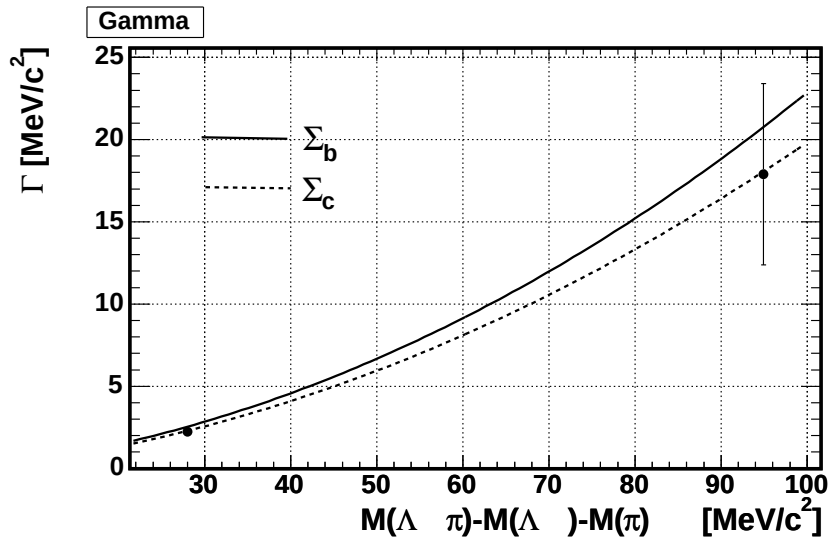
$f_p \equiv g_A / f_\pi$; $f_\pi = 92\,\mathrm{MeV}$; $g_A = 0.75$;

- **Excellent agreement with $\Gamma_{\mathrm{PDG}}(\Sigma_c^{(*)})$.**
- **Fit to $\Gamma_{\mathrm{PDG}}(\Sigma_c^{(*)})$: $g_A = 0.75 \pm 0.05$**

$\Rightarrow$ Natural width Γ of Σ_c and Σ_b baryons

$\Rightarrow$ as a function of the decay Q-value

$\Rightarrow$ $\mathbf{Q = M(\Sigma_b) - M(\Lambda_b^0) - M(\pi)}$



Using fitted g_A and $M_{\mathrm{CDF\,II}}(\Lambda_b^0)$:

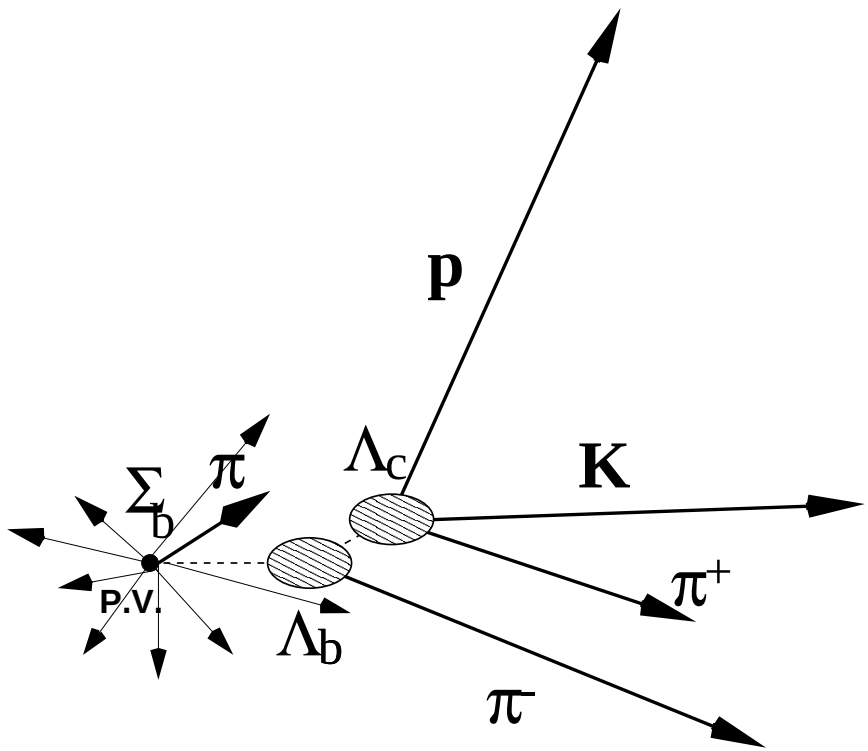
$\Gamma(\Sigma_b) \approx 8\,\mathrm{MeV/c^2}$ and

$\Gamma(\Sigma_b^*) \approx 15\,\mathrm{MeV/c^2}$

5 – Principle of the Analysis

- Reconstruct Λ_b^0 baryon candidates:
  - $\mathbf{\Lambda_b^0 \to \Lambda_c^+ \pi^-}$
  - $\mathbf{\Lambda_c^+ \to pK^- \pi^+}$
- Candidates: $\mathbf{\Sigma_b \to \Lambda_b^0 \pi^\pm_{\Sigma_b}}$
- $\pi^\pm_{\Sigma_b}$, **soft track from Prim. Vtx.**
- **To remove the mass resolution of each Λ_b^0 candidate search for narrow signatures in**
- $\mathbf{Q = M(\Lambda_b^0 \pi^\pm_{\Sigma_b}) - M(\Lambda_b^0) - M_{PDG}(\pi^\pm)}$
- **Blind signal region.**
- **The S.B. represent $\mathbf{\Sigma_b}$ bgr.**

$\Rightarrow$ Topology of Σ_b event

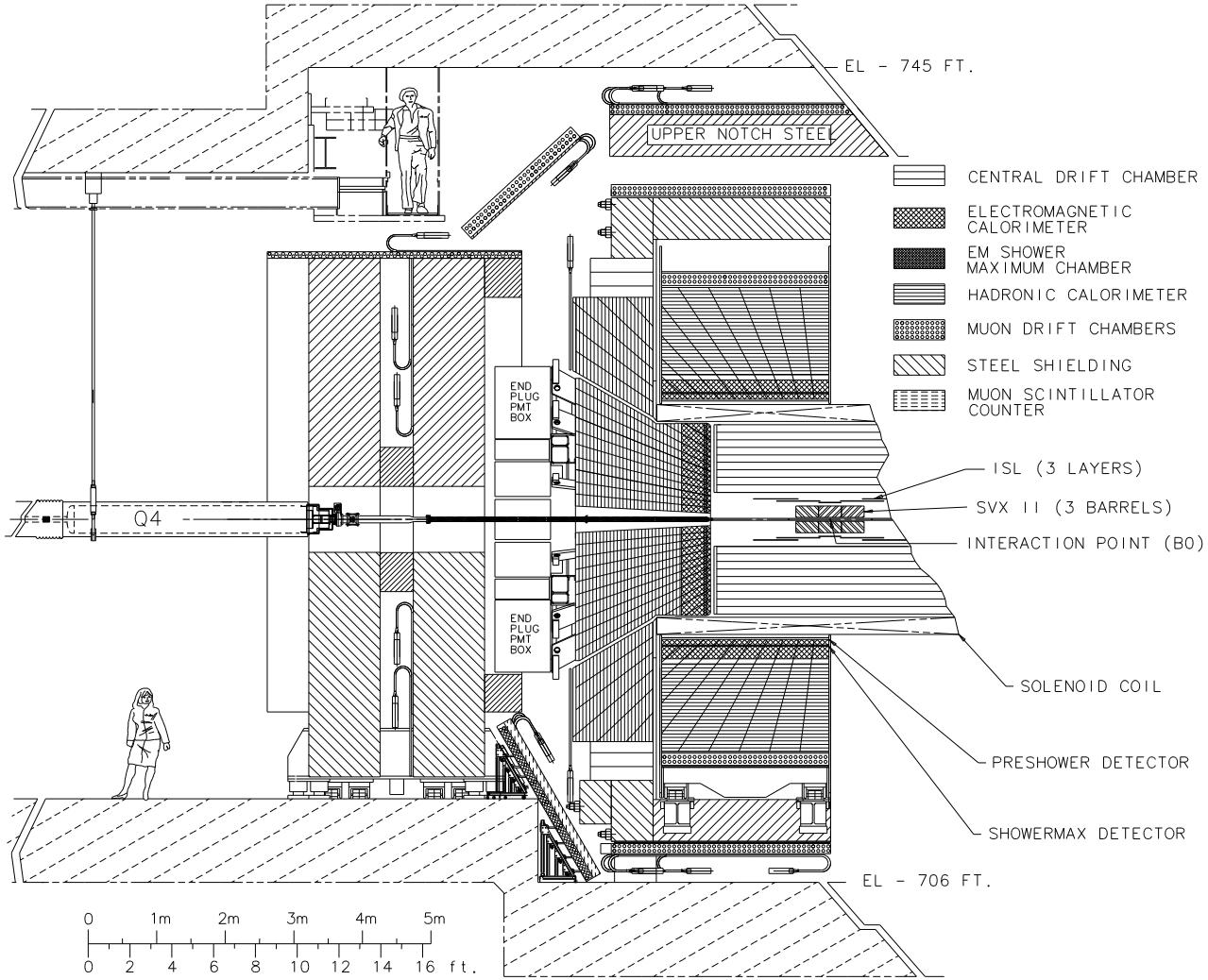


$\Rightarrow$ **Use bgr. from S.B. for cut optim.**

$\Rightarrow$ **Use signal from PYTHIA for cut optim.**

$\Rightarrow$ **Fix cuts and unblind ...**

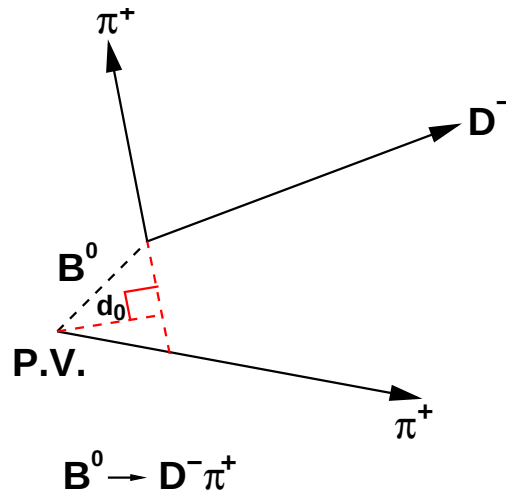
6 – CDF II Detector at Tevatron

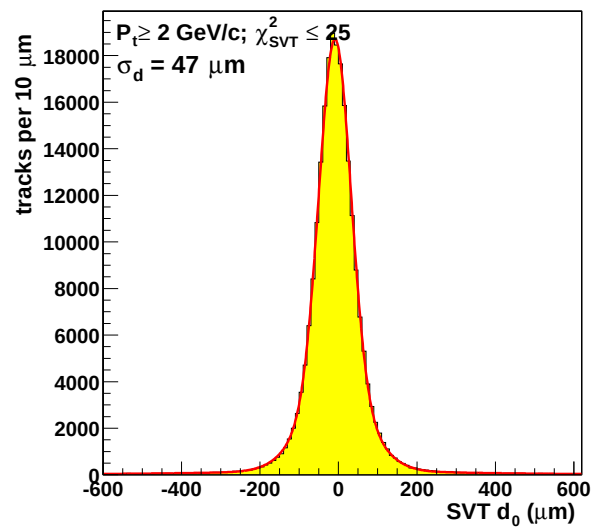


$\Rightarrow$ Critical for present results: COT (central tracker), SVX II (Si) vertex detector

7 – b- Physics Triggers in CDF II

- Enormous inelastic total cross-section of $\sigma_{\mathbf{tot}}^{\mathbf{inel}} \sim \mathbf{60}\,\mathrm{mb}$ at Tevatron.
- $\sigma_{\mathbf{b}} \approx \mathbf{20}\,\mu\mathrm{b}\,(|\eta| < \mathbf{1.0})$, $@\mathbf{1.96\,TeV}$
- Selective three-level trigger.
- Trigger on Hadron Modes .
- Exploit "long" $\mathbf{c}\tau$(b-hadrons)
  - Trigger on ≥ 2 tracks with large d_0.
- Present $\mathbf{\Sigma_b}$ analysis, base mode: $\mathbf{\Lambda_b^0 \to \Lambda_c^+ \pi_b^-}$, $\mathbf{\Lambda_c^+ \to pK^- \pi^+}$, $(\mathbf{p}, \pi_{\mathbf{b}}^-)$ are in trigger.





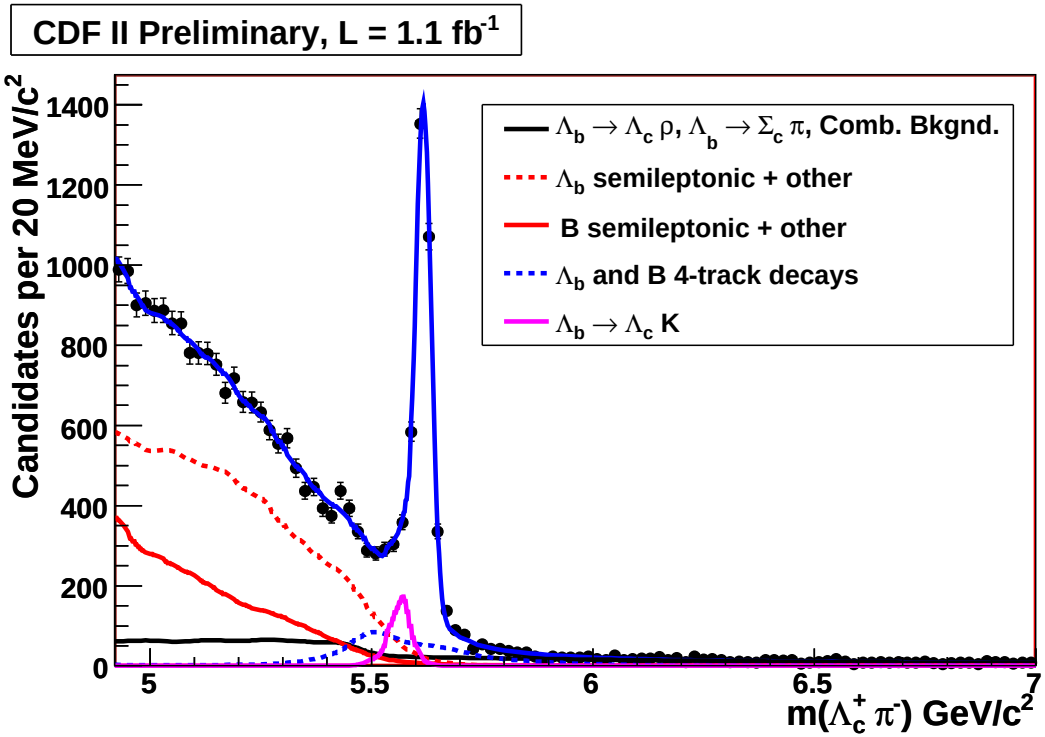
8 – Λ_b^0 Candidates and Signal

⇒ **Reconstruction of Candidates in Modes:**

$\Lambda_b^0 \to \Lambda_c^+ \pi_b^-$,
$\Lambda_c^+ \to pK^- \pi^+$

- $\mathcal{L} = 1070 \pm 60\,\mathrm{pb}^{-1}$
- **The yield of ~ 2800 candidates...**
- **in the signal region** $M(\Lambda_b^0) \in [5.565, 5.670]\,\mathrm{GeV}$
- **World largest Λ_b^0 sample.**
- **Right side band - comb. bgr.**
- **Left side band - reflections.**

⇒ **The Λ_b^0 invariant Mass Plot**



⇒ **Unbinned max. Neg.Log.Likelihood fit,**

⇒ **projection**

9 – Σ_b Candidates: Blind Analysis

$\Rightarrow$ **Reconstruction of Candidates**

$\Rightarrow$ Σ_b^-, Σ_b^{*-} + chrg. conj.

$\Rightarrow$ Σ_b^+, Σ_b^{*+} + chrg. conj.

$\Rightarrow$ $\Sigma_b \to \Lambda_b^0 \pi^{\pm}_{\Sigma_b}$ + chrg. conj.

- **Based on a collection of reconstructed Λ_b^0 cands:**
- $''\Lambda_b^0''[(''\Lambda_c^+'')\,\pi_b^-] \in (5.565, 5.670)\,\mathrm{GeV}/c^2$
- **Couple $''\Lambda_b^0''$ with direct soft π_{Σ_b} with very loose quality reqs.**
- $[(''\Lambda_b^0'')_{\mathrm{VxFit}}\,\pi_{\Sigma_b}]_{\mathrm{VxFit}}$, NO $M(\Lambda_b^0)$ constraint, $\mathrm{Prob}(\chi^2_{3D}) > 0.1\%$

- $Q = M(\Lambda_b^0 \pi^{\pm}_{\Sigma_b}) - M(\Lambda_b^0) - M_{\mathrm{PDG}}(\pi^{\pm})$
- **Blind signal region:** $Q \in (30, 100)\,\mathrm{MeV}/c^2$
- R.S.B.: $Q \in (100, 500)\,\mathrm{MeV}/c^2$
  L.S.B.: $Q \in (0, 30)\,\mathrm{MeV}/c^2$

- **The cuts to be applied and optimized while signal is blinded:**
  - $p_T(\mathbf{\Sigma_b}) > \mathrm{cut};$
  - **Significance of an impact parameter:** $|d_0/\sigma_{d_0}|\,(\pi_{\mathbf{\Sigma_b}})$
  - **Polar angle of the soft pion in a "$\mathbf{\Sigma_b}$"-rest frame:** $\cos\theta^*\,(\pi_{\mathbf{\Sigma_b}}) = \vec{\mathbf{p}}_{\mathbf{\Sigma_b}} \cdot \vec{\mathbf{p}}^*_\pi / (|\vec{\mathbf{p}}_{\mathbf{\Sigma_b}}| \cdot |\vec{\mathbf{p}}^*_\pi|)$
- **Optimize cuts maximizing** $\epsilon(\mathbf{S})/\sqrt{(\mathbf{B})}$
- **Signal is taken from PYTHIA**
- **Background is taken from side bands of** $Q(\Sigma_b)$

$\Rightarrow$ **Optimized cuts**

Variable	Cut value
$p_T(\Sigma_b)$	$> 9.5\,\mathrm{GeV}/c$
$\lvert d_0/\sigma_{d_0}\rvert(\pi_{\Sigma_b})$	< 3.0
$\cos\theta^*(\pi_{\Sigma_b})$	> -0.35

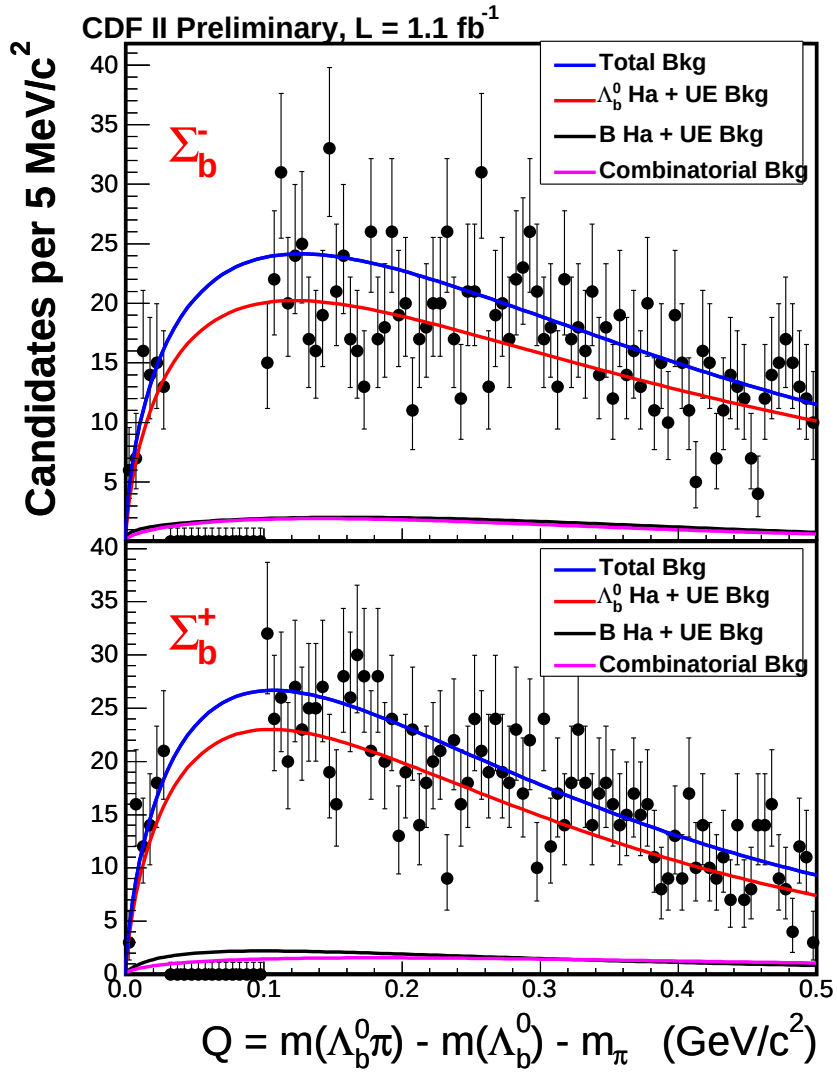
$\Rightarrow$ **Only** $\cos\theta^*(\pi_{\Sigma_b})$ **has substantial**

$\Rightarrow$ **rejection power.**

$\Rightarrow$ **The sources of background:**

$\Rightarrow$ **before unblinding...**

- Λ_b^0 **hadronization**
  - **Using PYTHIA, analyze (Λ_b^0 +soft random trk.). Dominating source.**
- B **meson hadronization: faked Λ_b^0 +soft random trk; use data.**
- **comb. background underneath the Λ_b^0 peak; use Λ_b^0 right s.b.$[5.8, 7.0]$**
- **5-track background from B or B_J decays; use MC; negligible.**
- **Fit all three sources with the same functional form.**



$\Rightarrow$ Λ_b^0 **hadr.: normalized to $N(\Lambda_b^{0\,\mathrm{exp.}})$**

$\Rightarrow$ **SMOOTH BGR. SHAPE in signal area!**

10 – Σ_b Candidates: Unblinded

⇒ **Upon unblinding the signal**

⇒ **in $Q \in (30, 100)\,\mathrm{MeV}/c^2$**

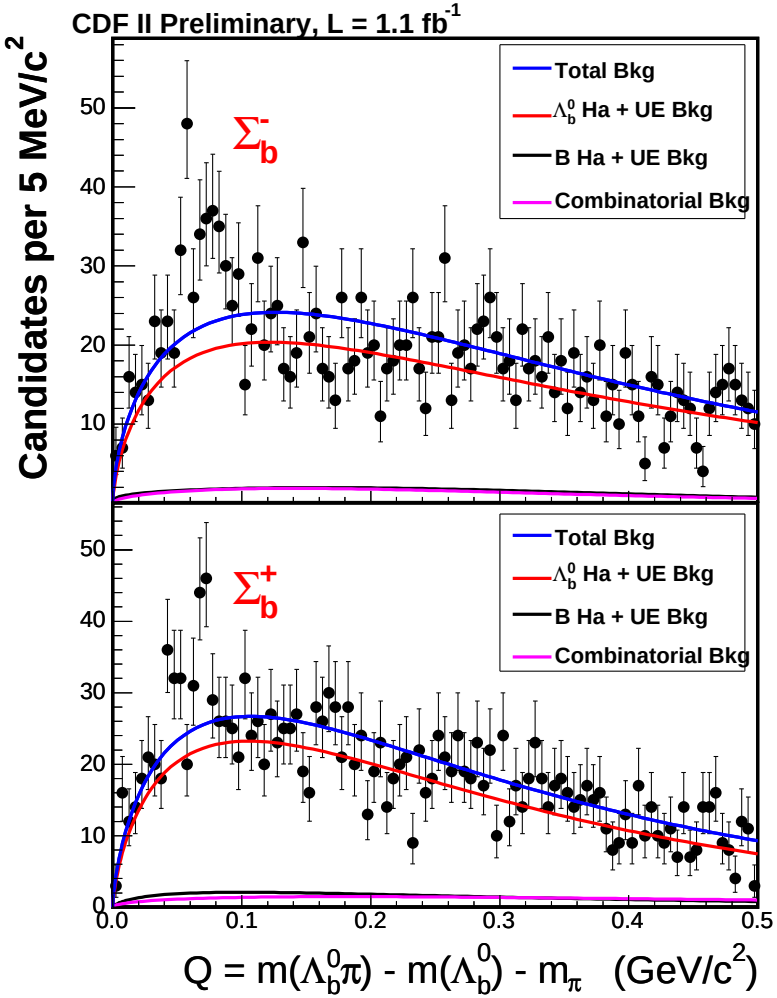
⇒ **count number of evts:**

Statistics	$\Lambda_b^0\pi^-$	$\Lambda_b^0\pi^+$
$S+B$	416	406
B	268	298
S	148	108
$S/\sqrt{S+B}$	7.3	5.4

⇒ **The fit of the background**

⇒ **predicts B at signal area.**

⇒ **There is an excess in both spectra...**



11 – Fit of Σ_b Spectra

⇒ **Fit Description:**

- Signals: 2 peaks Σ_b^-, Σ_b^{*-} and 2 peaks Σ_b^+, Σ_b^{*+}.
- Signal terms:

$$\mathbf{G_{1,2}} \otimes \mathbf{BW}(\mathbf{Q}; \mathbf{Q_{\Sigma_b}}, \sigma^{1,2}_{\Sigma_b}, \mathbf{\Gamma_{\Sigma_b}}) + \mathbf{G_{1,2}} \otimes \mathbf{BW}(\mathbf{Q}; \mathbf{Q_{\Sigma_b^*}}, \sigma^{1,2}_{\Sigma_b^*}, \mathbf{\Gamma_{\Sigma_b^*}})$$

- **The shape and normalization of a background is frozen.**
- **Resolutions (narrow and wide components) $\sigma^{1,2}_{\Sigma_b^{(*)}}$ (from CDF MC sim.)**
- **Natural widths are constrained by HQET formula $\Gamma(\mathbf{Q}^{\text{being fit}}_{\Sigma_b^{(*)\pm}})$.**
- **Seven parameters floating:**
  - $\mathbf{Q}(\Sigma_b^-)$, $\mathbf{Q}(\Sigma_b^+)$
  - $\mathbf{Q}(\Sigma_b^*) - \mathbf{Q}(\Sigma_b)$, constrained to be **the same** for both charged cands.
  - Number of events: $\mathbf{N}(\Sigma_b^{(*)\pm})$
- **Perform a simultaneous unbinned negative likelihood fit using full statistics of both spectra.**

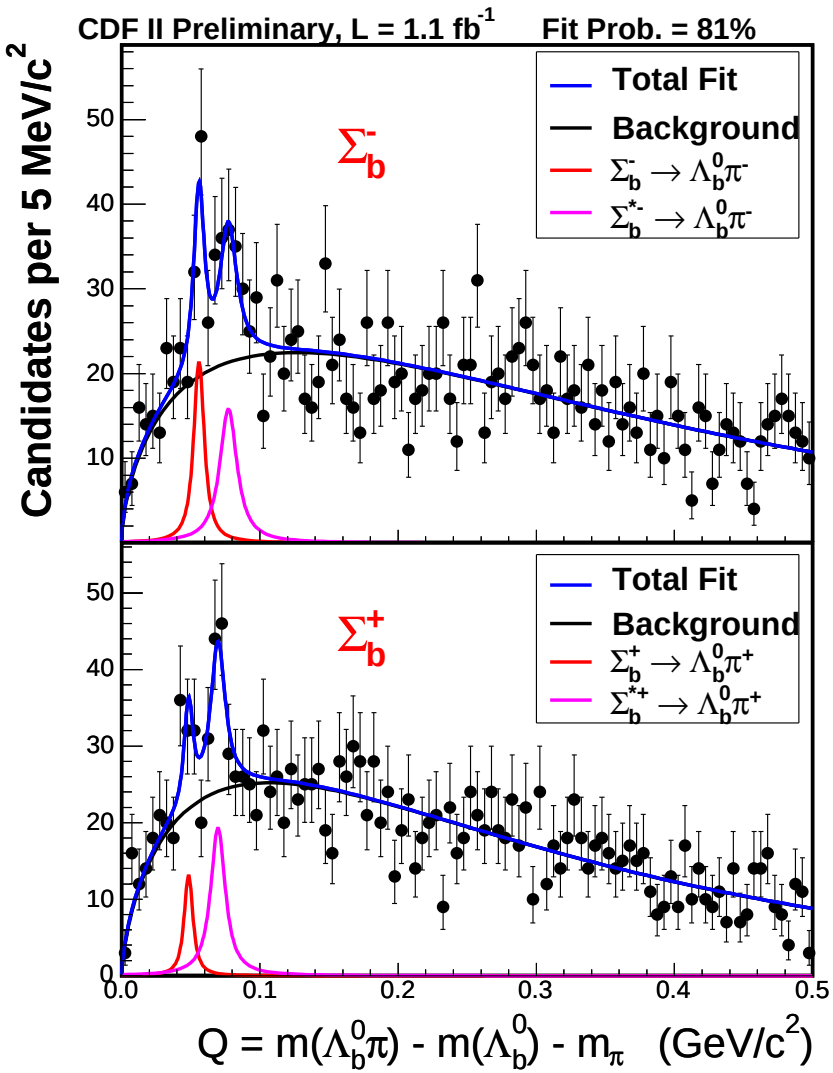
$\Rightarrow -\ln(\mathrm{Lh})$ Fit Results:

Parameter	Value$\pm\delta(\mathrm{stat})$
$Q(\Sigma_b^+)\,\mathrm{MeV}/c^2$	$48.4^{+2.02}_{-2.29}$
$Q(\Sigma_b^-)\,\mathrm{MeV}/c^2$	$55.9^{+0.99}_{-0.959}$
$[Q(\Sigma_b^*)$	$21.3^{+2.03}_{-1.94}$
$-Q(\Sigma_b)]\,\mathrm{MeV}/c^2$	
Σ_b^+ events	$29^{+12.4}_{-11.6}$
Σ_b^- events	$60^{+14.8}_{-13.8}$
Σ_b^{*+} events	$74^{+17.2}_{-16.3}$
Σ_b^{*-} events	$74^{+18.2}_{-17.4}$

$\Rightarrow$ **Errors come from MINOS.**

$\Rightarrow$ Σ_b^+ **yield is weak** $\Rightarrow$

$\Rightarrow$ $Q(\Sigma_b^+)$ **has large correlation with** ΔQ



12 – Σ_b: Systematics

⇒ Contributions to Systematics

- **Tracking, due to the calibration**
  - Check out $\mathbf{M(D^{*+}) - M(D^0)}$
  - $\mathbf{\Delta\, M(\mathrm{data}) - \Delta\, M(\mathrm{MC})}$, $\sim \mathbf{0.06}\,\mathrm{MeV/c^2}$
- **Assumptions of the Fit.**
  - The predicted width fitted to Σ_c PDG, $\mathbf{g_A = 0.75 \pm 0.05}$
  - **Uncertainty of resolution** $\sigma^{1,2}_{\Sigma_b^{(*)}}$ **(from CDF MC sim.)**
  - **Uncertainty of the weights of the** Λ_b^0 **background components.**
  - **Normalization of the** Λ_b^0 **hadronization background.**

⇒ Assumptions of the Fit cont-d ...

- **Use another functional form of the background PDF.**
- **Extreme reweighting of** $p_T(\mathrm{track})$ **in PYTHIA.**
- Mass measurements: (syst) uncertainties are much smaller than (stat) ones.
- Signal yields: (syst) errors are comparable with the (stat) ones.
- The largest contribution to a yield (syst) comes from the track reweighting in PYTHIA.

13 – Σ_b: Significance of the Signals

- **In total a very significant signal:**
  - **Naive estimation with $S/\sqrt{S+B}$ gives $\sim 9\sigma$**
  - **Prove the strength of 4-peak $\Sigma_b^{(*)\pm}$ hypothesis using Likelihood Ratio LR :**

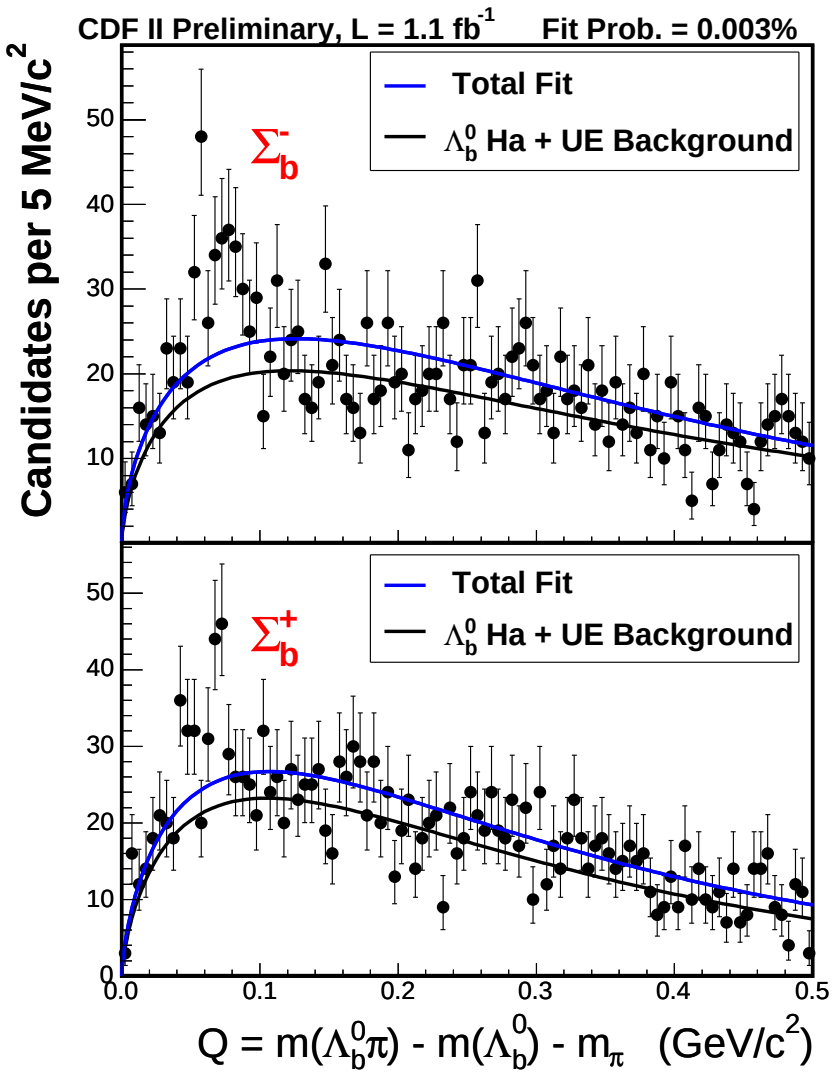
$$LR \equiv \frac{L_{\text{no peak fit}}}{L_{\text{4 peak fit}}}$$

Hypothesis	$\Delta(-\ln L)$	$1/LR$
Null	**44.7**	**2.6e19**
2 peaks	14.3	1.6e6
No Σ_b^- Pk.	10.4	3.3e4
No Σ_b^+ Pk.	1.1	3
No Σ_b^{*-} Pk.	10.1	2.4e4
No Σ_b^{*+} Pk.	9.8	1.8e4

$\Rightarrow$ **It is $2.6 \cdot 10^{19}$ more likely**

$\Rightarrow$ **that it is a 4-peak $\Sigma_b^{(*)\pm}$**

$\Rightarrow$ **than that it is a background fluctuation!**



$\Rightarrow$ **Fit with Null Hypothesis.**

14 – Summary

- The lowest lying charged $\Lambda_b^0\pi^\pm$ resonant states are observed in 1 fb^{-1} of data collected by the CDF detector.
  - ~ 240 evts in total.
- These are consistent with the lowest lying charged $\Sigma_b{}^{(*)\pm}$ baryons.
- The Q values of Σ_b^- and Σ_b^+, and the $\Sigma_b^* - \Sigma_b$ mass difference, are measured to be:
  - $M(\Sigma_b^-) - M(\Lambda_b^0) - M(\pi) = 55.9^{+1.0}_{-1.0}(\text{stat}) \pm 0.1(\text{syst})\,\text{MeV}/c^2$
  - $M(\Sigma_b^+) - M(\Lambda_b^0) - M(\pi) = 48.4^{+2.0}_{-2.3}(\text{stat}) \pm 0.1(\text{syst})\,\text{MeV}/c^2$
  - $M(\Sigma_b^{*-}) - M(\Sigma_b^-) = M(\Sigma_b^{*+}) - M(\Sigma_b^+) =$
    $= 21.3^{+2.0}_{-1.9}(\text{stat})^{+0.4}_{-0.2}(\text{syst})\,\text{MeV}/c^2$

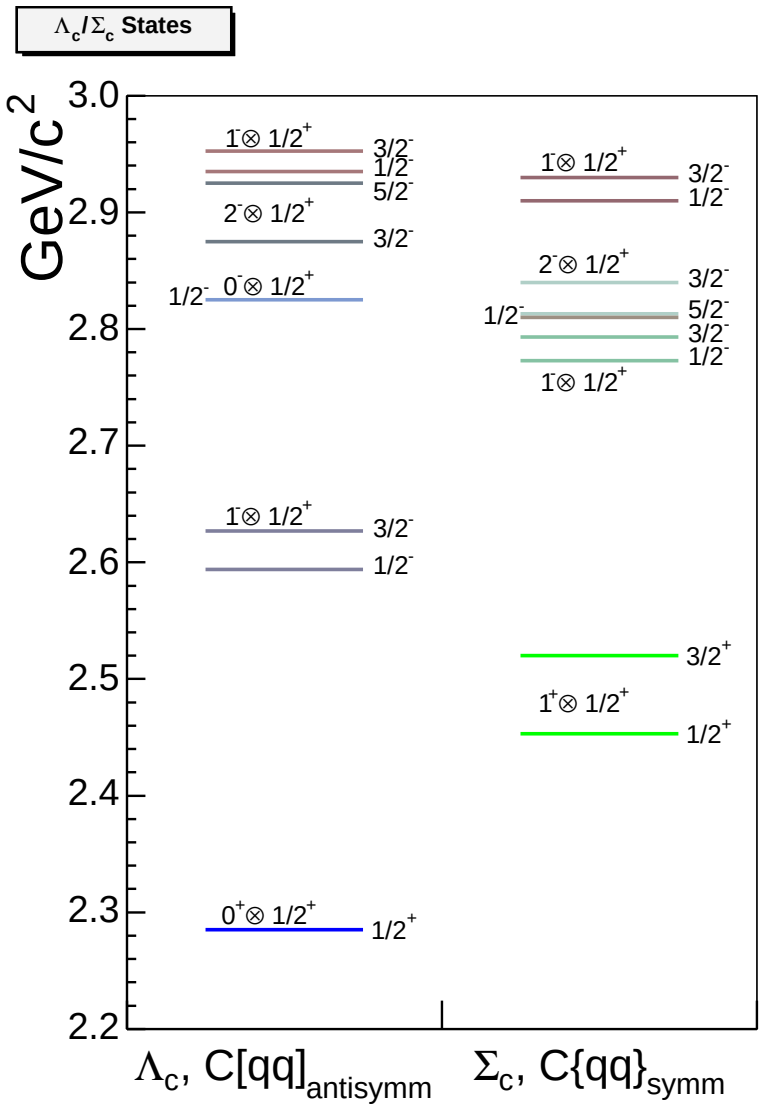
THE END OF THE TALK.

15 – Backup Slides...

$\Rightarrow \mathbf{j_{qq}} = \mathbf{s_{qq}} + \mathbf{L_{qq}}$

$\Rightarrow \mathbf{J_{Qqq}} = \mathbf{s_Q} + \mathbf{j_{qq}}$

- **Ground states,** $L_{qq} = 0$
  - Total qq momentum j_{qq}: $\frac{1}{2}^+ \otimes \frac{1}{2}^+ \rightarrow 0^+ \oplus 1^+$
  - $0^+ \otimes \frac{1}{2}^+ \rightarrow \frac{1}{2}^+$, Λ_Q- like states
  - $1^+ \otimes \frac{1}{2}^+ \rightarrow \frac{1}{2}^+ \oplus \frac{3}{2}^+$, Σ_Q- like states.
  - $m_Q \rightarrow \infty : (\Sigma_Q, \Sigma_Q^*)$ degenerates, but...
    - m_Q is finite: splitting due to $s_Q \cdot s_{qq}$ interaction.
    - $I = 1$: $(\Sigma_Q^{(*)-}, \Sigma_Q^{(*)+})$ isospin splitting.
- $L_{qq} = 1$, orbital qq excitations add more **higher lying states due to** $s \cdot L$



$\Rightarrow$ The picture is based on L. A. Copley *et al.*,Phys. Rev. D **20**,768(1979)

⇒ Reconstruction of Candidates

$\mathbf{\Lambda_b^0 \to \Lambda_c^+ \pi_b^-}$, $\mathbf{\Lambda_c^+ \to pK^- \pi^+}$

- $\mathcal{L} = \mathbf{1070 \pm 60}$ pb^{-1} with Two displaced Track Trigger
- The trigger conditions are confirmed for any 2 out of 4 tracks $(\mathbf{pK^- \pi^+}, \pi_\mathbf{b}^-)$
- 3-d Vertex Fit for $''\Lambda_c^+''(pK^-\pi^+)$ constrained to $M_{PDG}(\Lambda_c^+)$
- 3-d Vertex Fit for $''\Lambda_b^0''(\Lambda_c^+ \pi_b^-)$
- L_{xy} and d_0 are decay path and I.P. of Λ_b^0 vertex.
- $c\tau = L_{xy} \cdot (M/p_T)_{\Lambda_b^0}$
- **Optimize cuts to get max. of** $S/\sqrt{(S+B)}$

$p_T(\pi_b^-)$	$> 2\,\mathrm{GeV}/c$
$p_T(p)$	$> 2\,\mathrm{GeV}/c$
$p_T(p)$	$> p_T(\pi^+)$
$p_T(K^-)$	$> 0.5\,\mathrm{GeV}/c$
$p_T(\pi^+)$	$> 0.5\,\mathrm{GeV}/c$
$c\tau(\Lambda_b^0)$	$> 250\,\mu\mathrm{m}$
$c\tau(\Lambda_b^0)/\sigma_{c\tau}$	> 10
$\lvert d_0(\Lambda_b^0)\rvert$	$< 80\,\mu\mathrm{m}$
$c\tau(\Lambda_c^+ \leftarrow \Lambda_b^0)$	$> -70\,\mu\mathrm{m}$
$c\tau(\Lambda_c^+ \leftarrow \Lambda_b^0)$	$< 200\,\mu\mathrm{m}$
$\lvert\Delta_{\Lambda_c^+} M(pK^-\pi^+)\rvert$	$< 16\,\mathrm{MeV}/c^2$
$p_T(\Lambda_b^0)$	$> 6.0\,\mathrm{GeV}/c$
$p_T(\Lambda_c^+)$	$> 4.5\,\mathrm{GeV}/c$
$\mathrm{Prob}(\chi^2_{3D}; \Lambda_b^0)$	$> 0.1\%$

⇒ **The systematics is summarized in a table below:**

Parameter	Track.	Λ_b^0 Comp.	Λ_b^0 Nrm.	Λ_b^0 Shp.	Rewght.	Reso.	Σ_b Width	Total
$Q(\Sigma_b^+)$	0.06	0.03	0.013	0.013	0.0	0.0	0.01	**0.07**
MeV/c^2	-0.06	0.0	-0.013	0.0	-0.11	-0.014	-0.02	**-0.13**
$Q(\Sigma_b^-)$	0.06	0.0	0.009	0.0	0.04	0.0	0.009	**0.07**
MeV/c^2	-0.06	-0.03	-0.002	-0.011	-0.0004	-0.011	-0.005	**-0.07**
$Q(\Sigma_b^*)$	0.06	0.05	0.14	0.04	0.32	0.02	0.07	**0.37**
- $Q(\Sigma_b)$	-0.06	0.0	-0.13	0.0	0.0	0.0	-0.07	**-0.16**
Σ_b^+ evts	0.0	3.3	2.1	1.2	**2.3**	0.3	1.8	5.0
	0.0	0.0	-2.1	0.0	**-1.8**	0.0	-2.0	-3.4
Σ_b^- evts	0.0	0.7	2.2	0.3	**7.4**	0.3	3.4	8.5
	0.0	0.0	-2.2	0.0	**0.0**	0.0	-3.4	-4.0
Σ_b^{*+} evts	0.0	7.3	4.8	2.8	**4.6**	0.2	0.8	10.3
	0.0	0.0	-4.8	0.0	**-2.9**	0.0	-0.8	-5.7
Σ_b^{*-} evts	0.0	0.4	4.8	0.3	**14.7**	0.1	1.7	15.6
	0.0	0.0	-4.7	0.0	**0.0**	0.0	-1.7	-5.0

⇒ **Track p_T reweighting is largest for yields...**

⇒ **While total systematics for mass measurements is small.**