Hadron ID: B0 Tagging Update

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Since Sitges (...past 2 weeks):

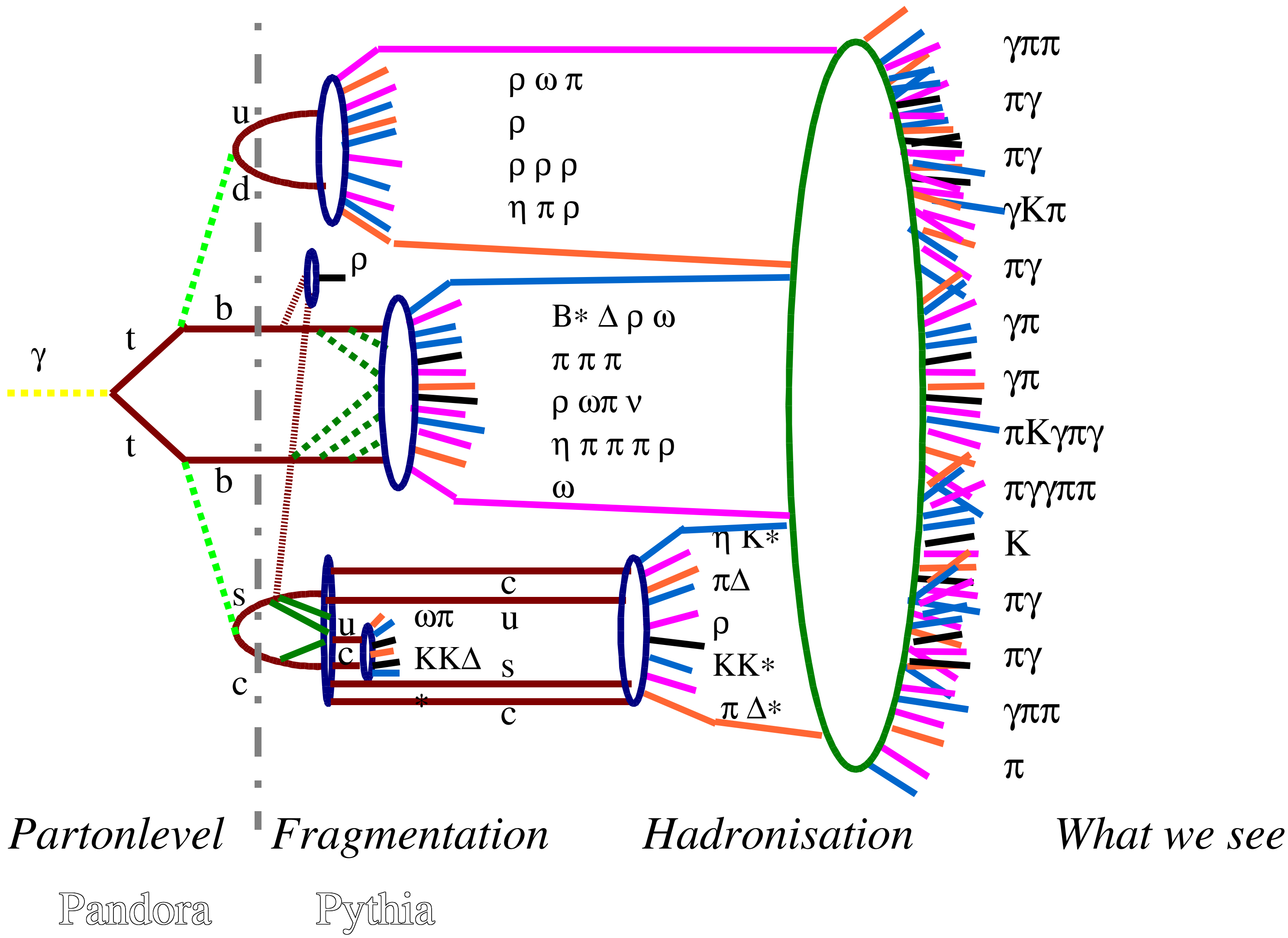
- Pandora 2.1 generator – M. Peskin
  - Parton level cross sections
  - Initial beams configuration
  - Retains polarisation information for hadronisation

- Pythia for fragmentation and hadronisation
  - Pythia 6.136, StdHEP 4.07 (CERNLIB 2000)
  - TAUOLA for tau decays
  - Pandora interface by T. Barklow & M. Iwasaki
    (I used example: gen_eetottbar.C)

... contd.

- Parametric detector simulation (LCD FastMC)
  - LCD configurations L2 & S2
    - $|\cos(\theta)| = 0.90$ (L2), 0.99 (S2)
  - No hadron ID parametrisation
    - I used a very crude one in the analysis
- JAS 2.2.1/LCD analysis package (Java)
  - Code developed to analye the MC decay chain
- Redhat 6.2 LINUX

The Challenge: “typical” t–tbar decay ...



Log file created on Mon Oct 16 11:39:31 PDT 2000

#	ID	Name	Status Parent	
1:	11	e–	250.0	
2:	–11	e+	250.0	
3:	22	gamma	0.25194045210708005	
4:	22	gamma	0.524597629609741	
5:	83	unknown	499.2234619182832	
6:	6	t	242.64843775381132	
7:	–6	t_bar	256.5750241644718	
8:	5	b	95.81320025531572	
9:	24	W+	146.83523749849564	
10:	–5	b_bar	122.40795366769025	
11:	–24	W–	134.16707049678155	
12:	–1	d_bar	129.21572494264615	
13:	2	u	15.935584300333488	
14:	3	s	15.33729471148945	
15:	–4	c_bar	118.7041958209377	
16:	–5	b_bar		75.21834666770529
17:	21	gluon		7.241230956330152
18:	21	gluon		39.91862427388819
19:	21	gluon		0.16150468125252523
20:	21	gluon		1.4021544349774284
21:	21	gluon		1.0654908514790606
22:	5	b	95.03016898939183	
23:	–4	c_bar		22.5966439074987
24:	2	u	18.30191027996832	
25:	–2	u_bar		25.755488151757213
26:	4	c	2.6728304216911205	
27:	3	s	49.210387215897356	
28:	21	gluon		0.6731467698206786
29:	21	gluon		0.12864466562751672
30:	21	gluon		1.6230981631113033
31:	21	gluon		1.5216148892142014
32:	–4	c_bar		11.557726067840749
33:	–1	d_bar		128.20271736236083
34:	21	gluon		2.6823421486331864
35:	2	u	14.266249731985646	
36:	91	unknown		40.89855418746702
37:	–423	D*0–bar	34.90726216948528	
38:	–2	u_bar	25.755488151757213	
39:	21	gluon	5.991292017981745	
40:	4	c	2.6728304216911205	
41:	92	unknown	220.03752085502447	
42:	513	B*o	85.95328747086	
43:	211	pi+	6.281419405913725	
44:	–211	pi–	5.906449934478116	
45:	223	omega	12.36114040247235	
46:	113	rho0	2.722169856791701	
47:	–2112	n_bar	7.898173644184072	
48:	2212	p	1.246110123012387	
49:	–211	pi–	0.7035832810532527	
50:	211	pi+	0.30539077979825086	
51:	113	rho0	1.1025446970873323	
52:	–211	pi–	0.7667888343466578	
53:	223	omega		2.177603402814426
54:	–513	B*o_bar		92.61285902221222
55:	92	unknown	64.7146177715118	
56:	331	eta'	34.13828188169651	
57:	–313	K*o(892)_bar		3.623522310184961
58:	2214	Delta+		5.1687896753343265
59:	–2212	p_bar		5.213008216640077
60:	113	rho0	2.078795965612325	
61:	311	Ko	1.1937778840730977	
62:	–313	K*o(892)_bar	1.2208372348957675	
63:	–211	pi–	1.522316905270834	
64:	–423	D*0–bar	10.555287697803909	
65:	92	unknown	145.15130924297964	
66:	213	rho+	66.57726219397122	
67:	223	omega	23.133338066906084	
68:	111	pi0	13.277986598906924	
69:	–213	rho–	21.485883963040735	
70:	213	rho+	1.9226382085397304	
71:	–213	rho–	0.9349997704157276	
72:	213	rho+	2.3564676738836456	
73:	113	rho0	1.2458925493021065	
74:	113	rho0	1.373092261475893	
75:	221	eta	4.1758765015427235	

....

```
Log file created on Fri Oct 13 16:30:12 PDT 2000
#   ID   Name     Status  Parent
1:  11    e–        250.0  :daughters>
2:  –11    e+        250.0  :daughters>
3:  22    gamma        0.724276487134079  :daughters>
4:  22    gamma        1.6666584501390247E–6  :daughters>
5:  83    unknown       499.2757218462075  :daughters>
6:  6    t        249.54564179505456  :daughters>
     ––>  5  b         57.899663830197774
     ––>  24  W+     191.64597796485683
7:  –6    t_bar        249.7300800511529  :daughters>
     ––>  –5  b_bar     45.068608579964874
     ––>  –24  W–     204.66147147118804
8:  5    b        57.899663830197774  :daughters>
9:  24    W+        191.64597796485683  :daughters>
     ––>  –13  mu+        39.736416997331766
     ––>  14  nu_mu     151.69720028812958
10:  –5    b_bar        45.068608579964874  :daughters>
–– Trouble. Giving up –––
11:  –24    W–        204.66147147118804  :daughters>
     ––>  13  mu–            125.24552508746059
     ––>  –14  nu_mu_bar     79.41594638372743
12:  –13    mu+        39.736416997331766  :daughters>
13:  14    nu_mu      151.69720028812958  :daughters>
14:  13    mu–        125.24552508746059  :daughters>
15:  –14    nu_mu_bar     79.41594638372743  :daughters>
16:  –5    b_bar        45.068608579964874  :daughters>
–– Trouble. Giving up –––
17:  21    gluon            1.6531118367892679  :daughters>
     ––>  92  unknown     103.25577012108015
18:  5    b        56.45899871399095  :daughters>
     ––>  92  unknown     103.25577012108015
19:  –13    mu+        39.736416997331766  stable.
20:  14    nu_mu      151.69720028812958  stable.
21:  13    mu–        125.24552508746059  stable.
22:  –14    nu_mu_bar   79.41594638372743  stable.

23:  92    unknown        103.25577012108015  :daughters>
     ––>  521  B+     38.56106660105591
     ––>  –211  pi–     1.3877652835909786
     ––>  221  eta     3.937474295528693
     ––>  211  pi+     1.4132135400171724
     ––>  –211  pi–     0.35530196317174084
     ––>  113  rho0     1.2951965203622715
     ––>  223  omega     5.75568971652554
     ––>  –511  B0–bar     50.47501121049278
24:  521    B+        38.56106660105591  :daughters>
     ––>  –423  D*0–bar     17.25144006751542
     ––>  221  eta     4.276238522318574
     ––>  111  pi0     0.9723031703839528
     ––>  221  eta     6.147990646232265
     ––>  221  eta     3.6533074490253235
     ––>  213  rho+     6.2597867455803815
25:  –211    pi–        1.3877652835909786  stable.
26:  221    eta        3.937474295528693  :daughters>
     ––>  111  pi0     2.246669400655266
     ––>  111  pi0     0.6697051348970947
     ––>  111  pi0     1.021099759976332
27:  211    pi+        1.4132135400171724  stable.

.........
.......
.......
88:  –211    pi–        0.4816847678857214  stable.
89:  –211    pi–        4.598664375009734  stable.
90:  130    K0_L        2.847452952252446  stable.
91:  22    gamma        0.6739408296972992  stable.
92:  22    gamma        1.0146911174902156  stable.
93:  22    gamma        1.3665890654457864  stable.
94:  22    gamma        0.5802740525431395  stable.
```

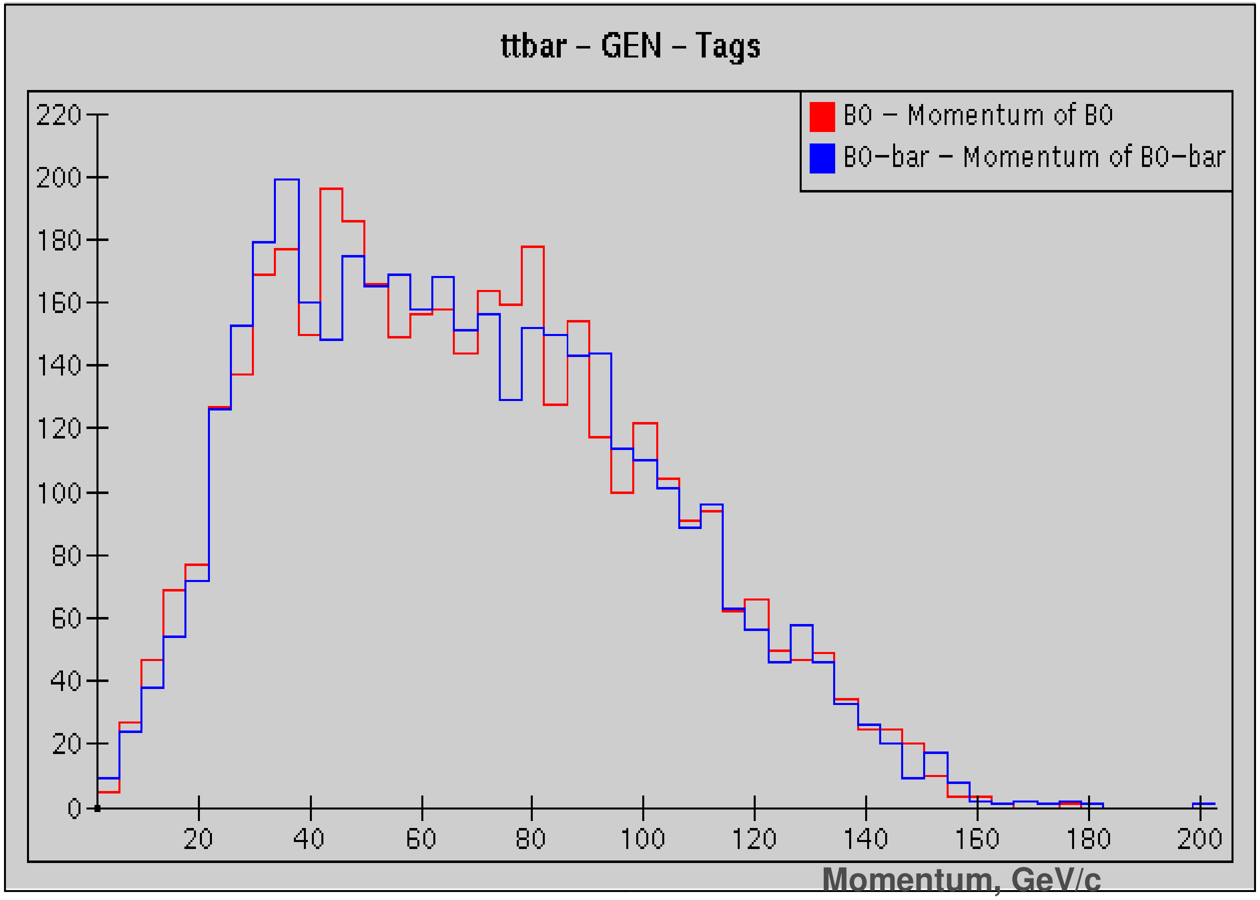
Finding ancestors of final tracks

```
Log file created on Tue Oct 17 17:36:49 PDT 2000
  ID=−321 Ancestors>  unknown : u_bar : s : W− : t_bar : c : s : W− : t_bar :
  ID=−321 Ancestors>  K*o(892)_bar : unknown : s : s : W− : t_bar : c_bar : s : W− : t_bar :
  ID=321 Ancestors>  K(892)*o : unknown : u_bar : s : W− : t_bar : c : s : W− : t_bar :
  ID=321 Ancestors>  B0 : B*o : unknown : b_bar : b_bar : t_bar : b : b : t :
  ID=−321 Ancestors>  D0 : D*+ : unknown : u_bar : s : W− : t_bar : c : s : W− : t_bar :
  ID=−321 Ancestors>  phi : D0−bar : D*0−bar : unknown : s : s : W− : t_bar : c_bar : s : W− : t_bar :
  ID=321 Ancestors>  phi : D0−bar : D*0−bar : unknown : s : s : W− : t_bar : c_bar : s : W− : t_bar :
  ID=−321 Ancestors>  D0 : D*0 : B0−bar : B*o_bar : unknown : b_bar : b_bar : t_bar : b : b : t :
  ID=321 Ancestors>  D0 : D*0 : B0−bar : B*o_bar : unknown : b_bar : b_bar : t_bar : b : b : t :
============================================================
  ID=321 Ancestors>  K(892)*o : unknown : c_bar : s : W− : t_bar : s : s : W− : t_bar :
  ID=−321 Ancestors>  K*o(892)_bar : unknown : c_bar : s : W− : t_bar : s : s : W− : t_bar :
  ID=321 Ancestors>  D0−bar : D*− : unknown : c_bar : s : W− : t_bar : s : s : W− : t_bar :
  ID=−321 Ancestors>  D0 : D*0 : B− : unknown : b_bar : b_bar : t_bar : b : b : t :
  ID=321 Ancestors>  D0−bar : D*− : B0 : B*o : unknown : b_bar : b_bar : t_bar : b : b : t :
============================================================
============================================================
  ID=−321 Ancestors>  unknown : u_bar : b_bar : t_bar : b : b : t :
  ID=−321 Ancestors>  K*o(892)_bar : unknown : u_bar : b_bar : t_bar : b : b : t :
  ID=−321 Ancestors>  phi : unknown : u_bar : b_bar : t_bar : b : b : t :
  ID=321 Ancestors>  phi : unknown : u_bar : b_bar : t_bar : b : b : t :
  ID=321 Ancestors>  K(892)*+ : unknown : u_bar : b_bar : t_bar : b : b : t :
  ID=−321 Ancestors>  K*o(892)_bar : unknown : d_bar : d_bar : W+ : t : u : d_bar : W+ : t :
  ID=−321 Ancestors>  K*o(892)_bar : unknown : d_bar : d_bar : W+ : t : u : d_bar : W+ : t :
  ID=321 Ancestors>  K(892)*o : unknown : d_bar : d_bar : W+ : t : u : d_bar : W+ : t :
  ID=321 Ancestors>  D− : B0 : B*o : unknown : u : b_bar : t_bar : b_bar : b_bar : t_bar :
============================================================
```

Generator Parameters:

- Pandora beam configuration: NLC500
  - Center of mass energy = 500 GeV
  - Polarisation: $e^{-}= -0.80$, $e^{+}=0.0$
  - σ(ttbar) = 0.738 nb
- Most plots from 10,000 ttbar events
  - few months at design luminosity ($5\times10^{33} cm^{-2}s^{-1}$)

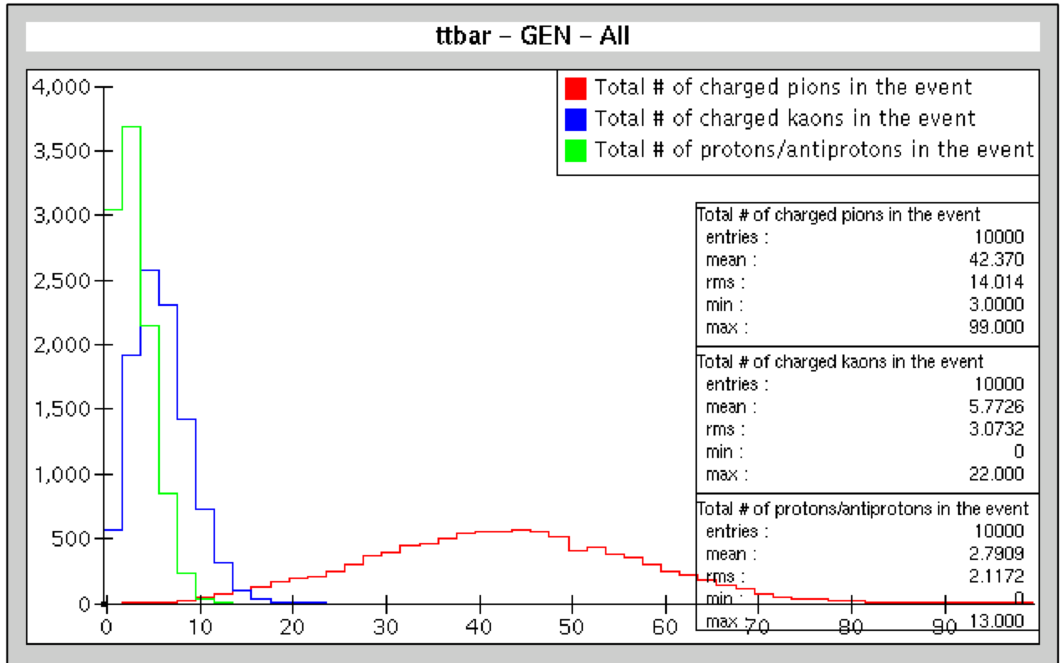
Spectra (Pandora check):

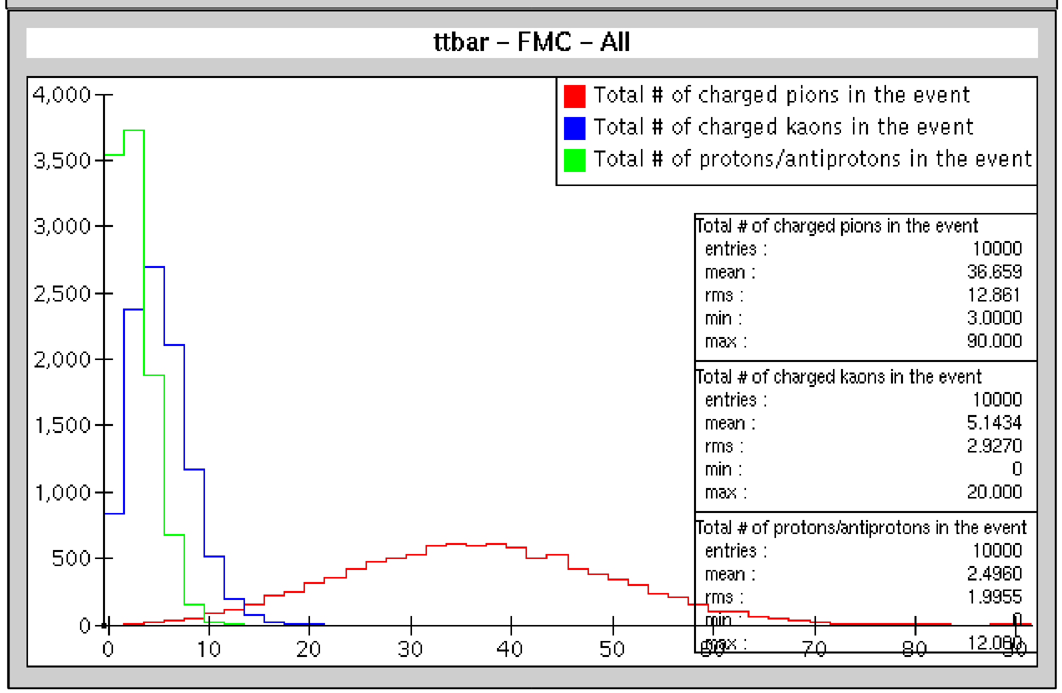


Assume these will be well reconstructed by tracking/vertexing...

π/K/p multiplicity:

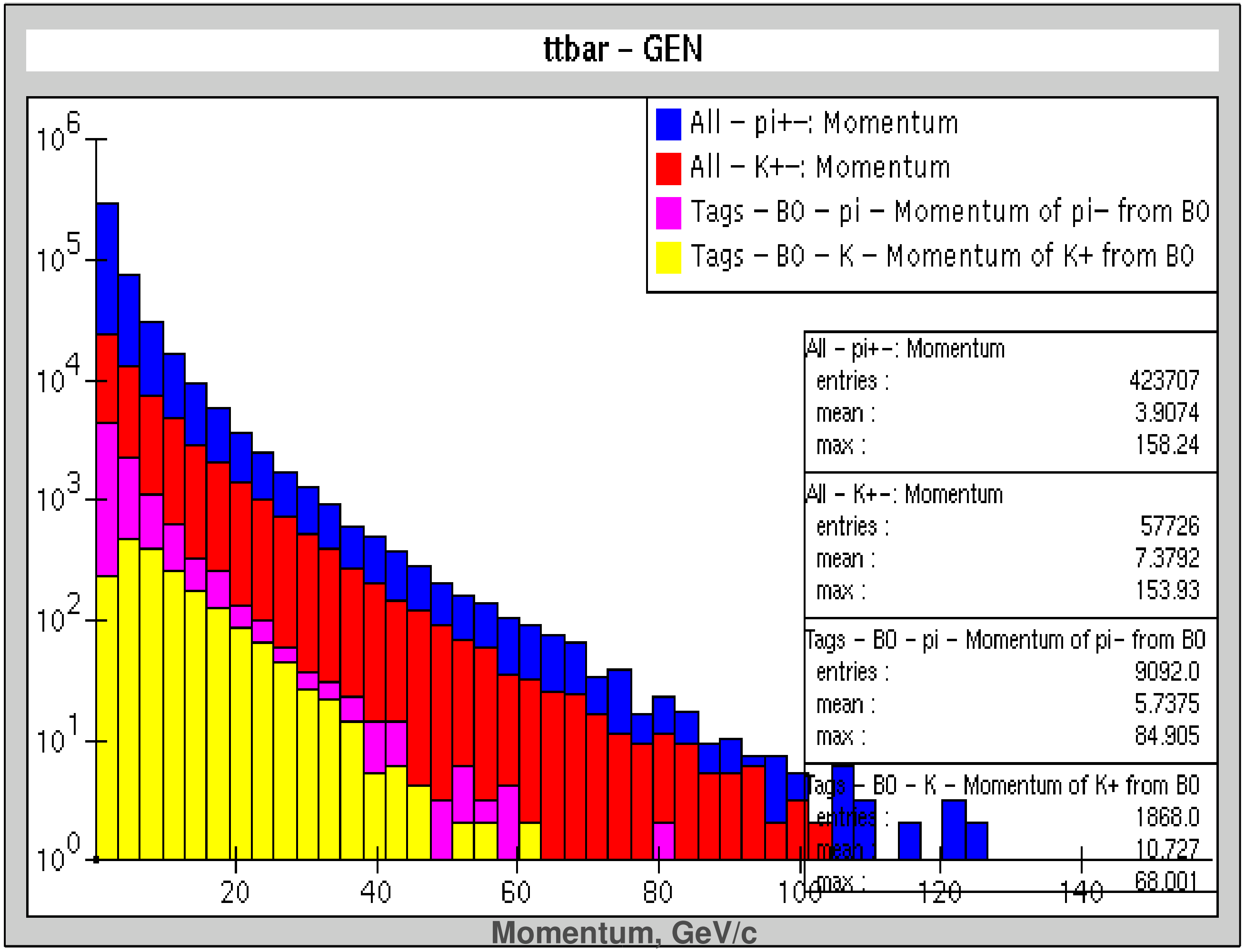
10,000 ttbar	<Nπ>	<NK>	<Np>
GEN	42	6	3
FMC/L2	37	5	2.5





π/K momenta:

	<p(π)>	<p(K)>
All	3.9	7.4
Tagged B0	5.7	10.7



Note: TPC dE/dx roughly

1σ π/K sep. 1.5<p<20 GeV/c

2σ π/K sep. 2<p<8 GeV/c

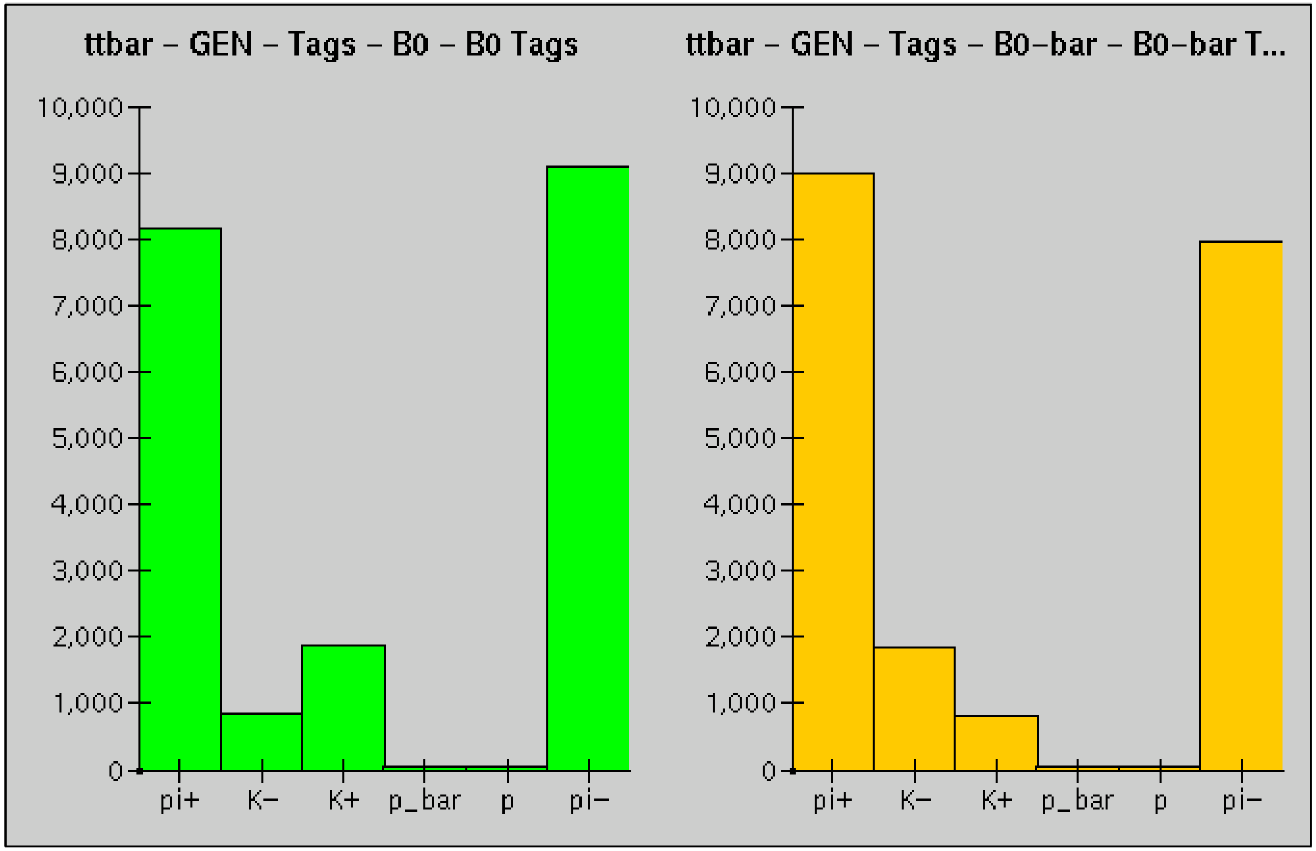
Generator level B efficiency w/ K tag:

Use charged K to tag B:

10,000 ttbar	B0bar	B0	B–	B+
GEN	3925	3950	4025	4000
FMC/L2	1930	1970	2250	2240
FMC/S2	2145	2180	2480	2475

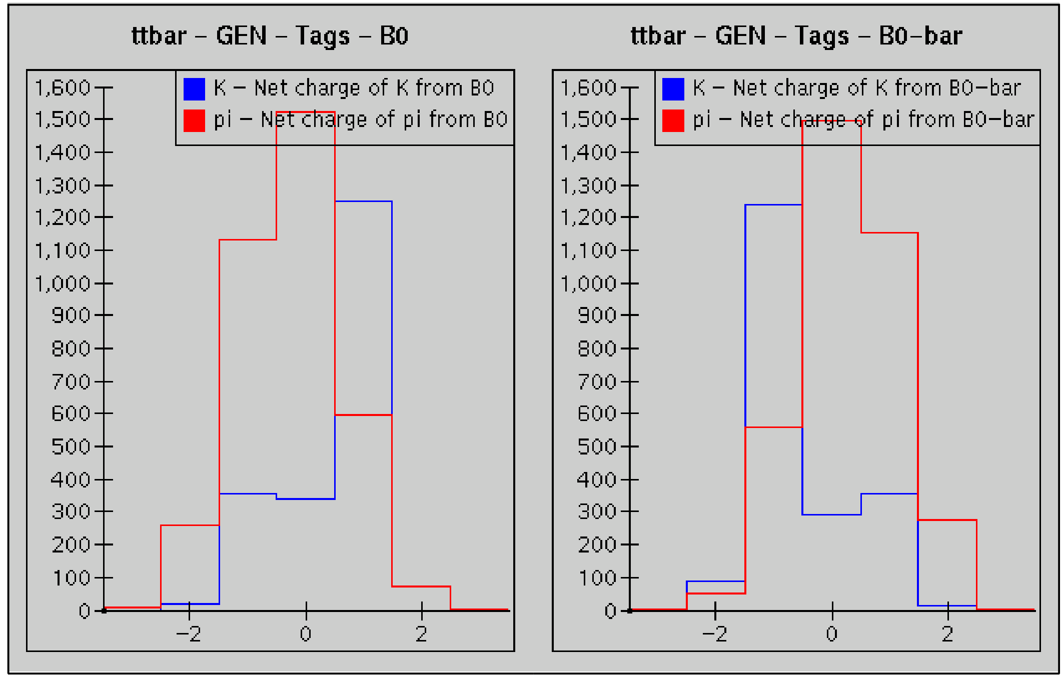
... vertex tagging more efficient (80%?) even at generator level ID

B0/B0bar Charged Hadron Tags:

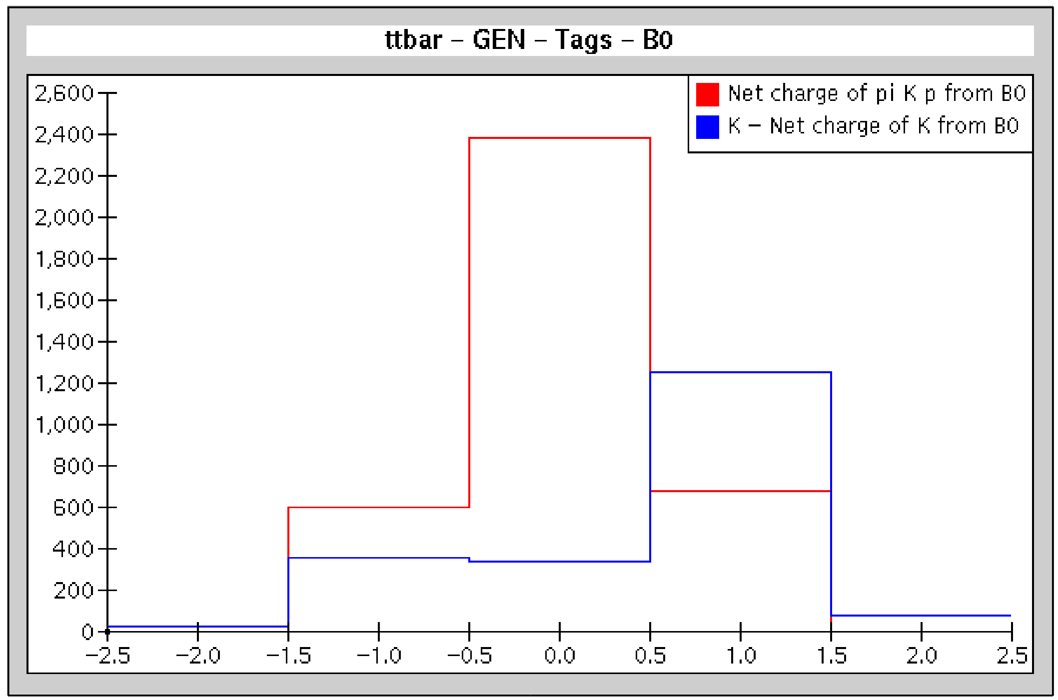


Net charge:

Perfect hadron ID –
note opposite asymmetry for pi & K



... so no hadron ID ==>
almost zero asymmetry

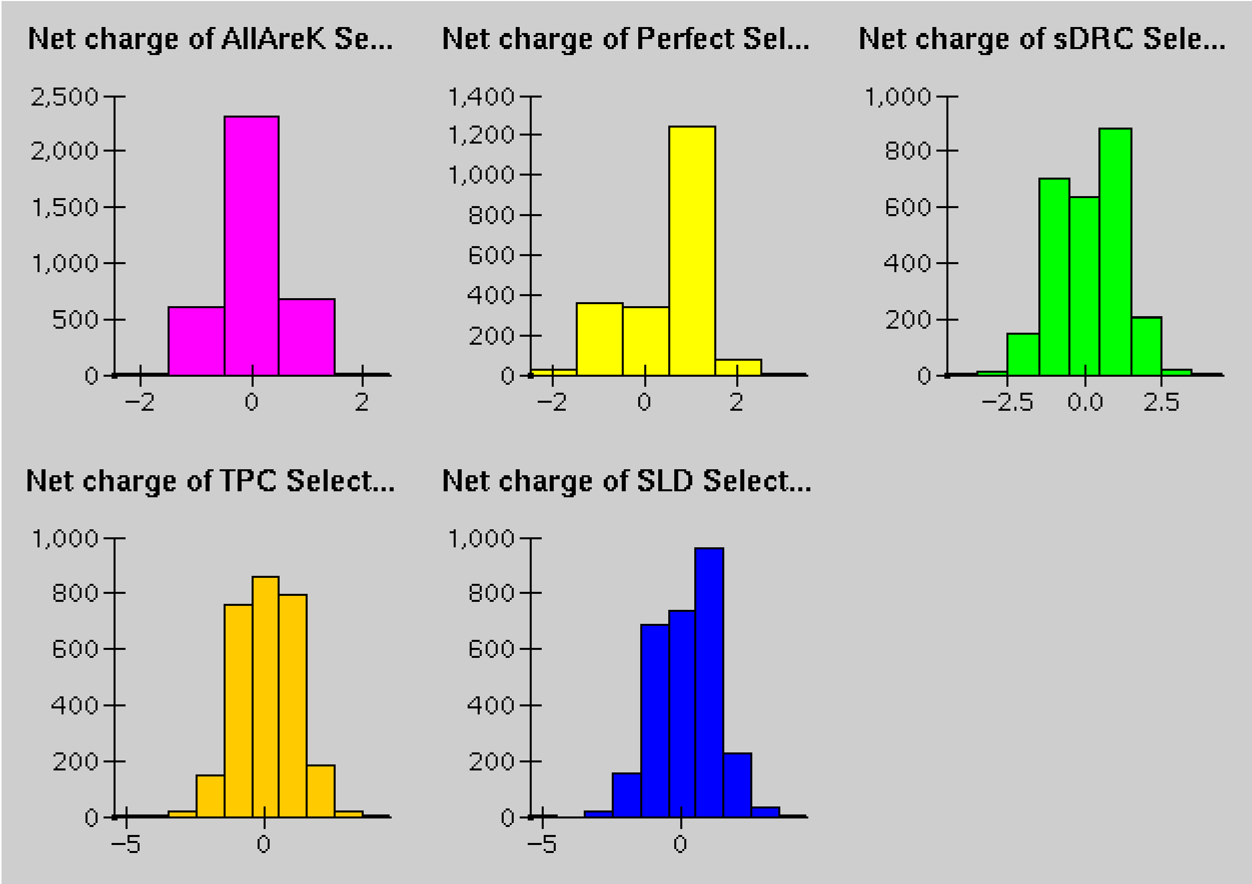


<u>Very</u> Crude PID:

No optimisation of efficiency vs purity

```
public boolean isaK(int abspID, double ptot, String detector)
{
Random sepPiK = new Random();
boolean _isaK = false;
double pmaxID=0.;
double Kprob = 0;
double Piprob = 1.0;

if (detector =="SLD")  // SLD CRID
{
        if ((ptot > 1.5) && (ptot < 20 )){ Kprob = 0.95; Piprob = 0.03;}
        if ((ptot > 20.) && (ptot < 30 )){ Kprob = 0.50; Piprob = 0.05;}
        if ((ptot > 2.0) && (ptot <  3 )){ Kprob = 0.95; Piprob = 0.06;}
}

if (detector =="sDRC") // "Super DIRC" + modest TPC?
{
        if ((ptot > 1.0) && (ptot <  7 )){ Kprob = 0.99; Piprob = 0.02;}
        if ((ptot > 8.0) && (ptot < 30 )){ Kprob = 0.50; Piprob = 0.16;}//TPC
}
if (detector =="TPC")  // Sitges TPC
{
        if (ptot > 1.5 && ptot < 20 ){ Kprob = 0.50; Piprob = 0.16;}// 1sigma
        if (ptot > 2.0 && ptot <  8 ){ Kprob = 0.84; Piprob = 0.16;}// 2 sigma
}
if (detector =="Perfect") // Perfect ID for all momenta
{
        Kprob = 1.00; Piprob = 0.00;
}

if (detector =="AllAreK") // No ID (Treat everything as a K)
{
        Kprob = 1.00; Piprob = 1.00;
}

double _sepPiK = sepPiK.nextDouble();
//if it is a pi put in mis-ID
if (abspID == PionID ) _isaK = _sepPiK < Piprob;
if (abspID == KaonID ) _isaK = _sepPiK < Kprob;
return _isaK;
 }
```

Analyzing power w/ PID:



a.p. = (N(Q_{net}>0) – N(Q_{net}<0)) / (N(Q_{net}>0) + N(Q_{net}<0))

10,000 ttbar	No ID	Perfect	sDIRC	TPC	SLD
B0 a.p.	0.05	0.55	0.12	0.03	0.18
B0 entries	3606	2040	2617	2822	–0.17

B^+/B^-(generator check):

- Average π/K momenta a little higher
  - B^+/B^-: $\langle p_\pi \rangle = 6.3$ GeV/c, $\langle p_K \rangle = 11.6$ GeV/c
  - B^0/B^0bar: $\langle p_\pi \rangle = 5.7$ GeV/c, $\langle p_K \rangle = 10.7$ GeV/c

- Right–sign charged K in $\approx$ 2000 of 3800 B^+/B^-

Summary:

- Only a little work since Sitges, but...
  - Some new tools in place – Pandora, analysis code
  - No major differences with old generator found
  - Perfect K ID => very significant improvement
  - SLD/DELPHI RICH much better than TPC
  - TPC considerably enhanced by super–DIRC
- Near future
  - Improve hadron ID parametrisation
  - Higher statistics
  - Investigate physics potential of B^0/B^0bar tagging
  - Is precision vertexing sufficient for tagging?