Update on same-side tagging for B_s-mixing

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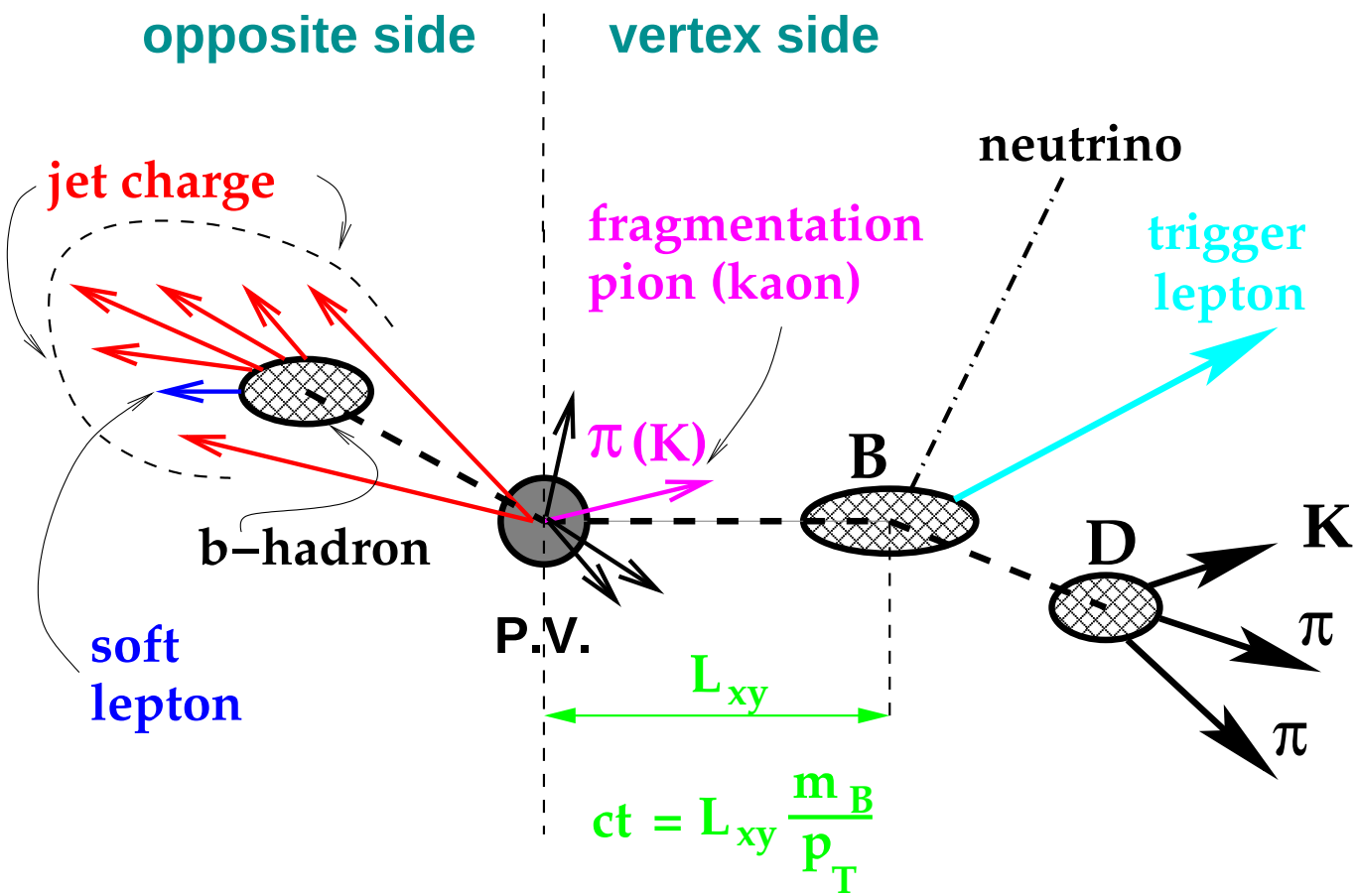
B-mixing and Lifetime Meeting

http://www-d0.fnal.gov/~rakitin/d0_private/tex/2006.Jul.13.Bmix/tr.pdf

Short introduction

To know if B-meson oscillated we need to know

- B-flavor at decay $\Longleftarrow$ can be inferred from trigger lepton charge
- B-flavor at production $\Longleftarrow$ obtained from OST (jet-charge, soft-lepton) or SST



I am going to talk about SST

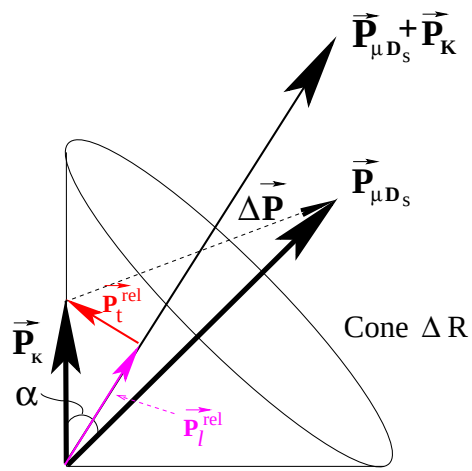
Outline of the analysis:

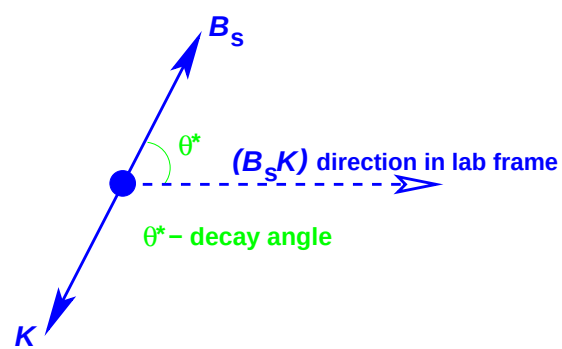
- Use **four** p17 MC samples (increase the statistics w.r.t. last talk):
  - $B_s \to \mu D_s, D_s \to \phi\pi, (x_s = 25)$, requests 29892, 29893 (150K events)
  - $B_s \to \mu\mu, (x_s = 25)$, requests 29215, 29216, 29283 (166K events)
  - $\bar{B}_s \to \mu\mu, (x_s = 25)$ requests 29213, 29214, 29282, (121K events)
  - $B_s \to \mu D_s X, D_s \to K_S K, (x_s = 25)$ requests 23838 (180K events)
- Look at tracks in cone $\cos\alpha > 0.8$ around $\vec{p}(B_s)$ (for consistency with OST)
- Use one of the following for same-side tagging:
  - Charge of one track selected with some kinematic algorithm
  - Charges of kaons coming from K^{*0} or pions from Λ (two-track taggers)
  - Average charge of all tracks around $\vec{p}(B)$, like "jet-charge" (many-track taggers)
- Choose a few best same-side taggers
- Combine them into "Comb. SST" algorithm and compute combined εD^2
- Apply both "Comb. SST" and "Comb. OST" to data and compute total εD^2

One-track taggers:

The following taggers are used:

- Min. p_t^{rel}
- Max. p_L^{rel}
- Max. p_t
- Min. $|\Delta\vec{P}| \equiv |\vec{p}(B_s) - \vec{p}(K)|$
- Min. ΔR
- Max. $\cos\alpha$
- Min. $\cos\theta^*$
- Max. $\cos\theta^*$
- Min. $m(B_sK)$
- Random track
- (dE/dx - in future)
- . . .





- p_t^{rel} and p_L^{rel} are $\perp$ and $||$ components of SST candidate's momentum $\vec{p}(K)$ w.r.t $\vec{p}(B_sK)$
- $\Delta R \equiv \sqrt{\Delta\phi^2 + \Delta\eta^2}$ and angle α are taken between $\vec{p}(B_s)$ and $\vec{p}(K)$
- θ^* – decay angle of B_sK-system, *i.e.* angle between directions of $\vec{p}(B_sK)$ and $\vec{p}(B_s)$ in reference frame of B_sK system

Two-track taggers:

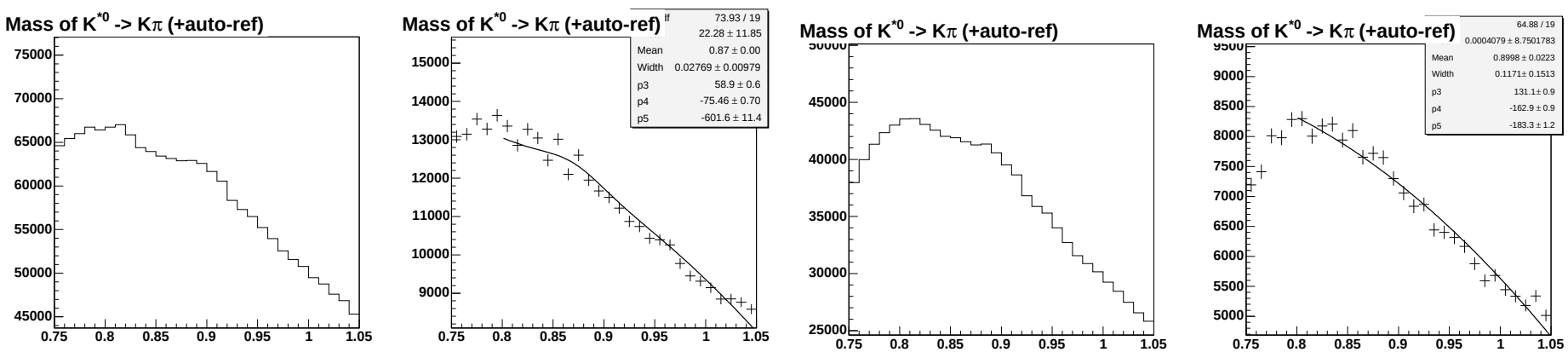
Using charge of kaon coming from $K^{*0} \to K\pi$ and $\Lambda \to p\pi$:

- ☞ Reconstruct $0.862 < m(K^{*0} \to K\pi) < 0.922$
  with auto-reflection being outside of this mass window,
  so that we know which track is kaon
- ☞ Apply cuts to reconstruction of $K^{*0} \to K\pi$
  – see if they improve tagging performance
- ☞ Reconstruct $\Lambda \to p\pi^-$ and $\bar{\Lambda} \to \bar{p}\pi^+$

– Particles reconstructed out of tracks in cone $\cos\alpha > 0.8$ around $\vec{p}(B_s)$

– B_s daughters are, obviously, excluded

Monte Carlo | Data | Monte Carlo (opt) | Data (opt)



Many-track taggers:

Using weigted-average charge of all the tracks around $\vec{p}(B_s)$

Thirty-one tagger used:

- ☞ $Q_{jet}(p_t, \kappa) = \frac{\sum q \cdot p_t^{\kappa}}{\sum p_t^{\kappa}}$
- ☞ $Q_{jet}(p_t^{rel}, \kappa) = \frac{\sum q \cdot (p_t^{rel})^{\kappa}}{\sum (p_t^{rel})^{\kappa}}$
- ☞ $Q_{jet}(p_L^{rel}, \kappa) = \frac{\sum q \cdot (p_L^{rel})^{\kappa}}{\sum (p_L^{rel})^{\kappa}}$

- $\kappa = 0.0, 0.1, 0.2, ...1.0$
- p_t^{rel} and p_L^{rel} here are $\perp$ and $||$ components of SST candidate's momentum $\vec{p}(K)$ w.r.t $\vec{p}(B_s)$

Obtaining *true* dilution in MC

For each tagger we measure numbers of events in which:

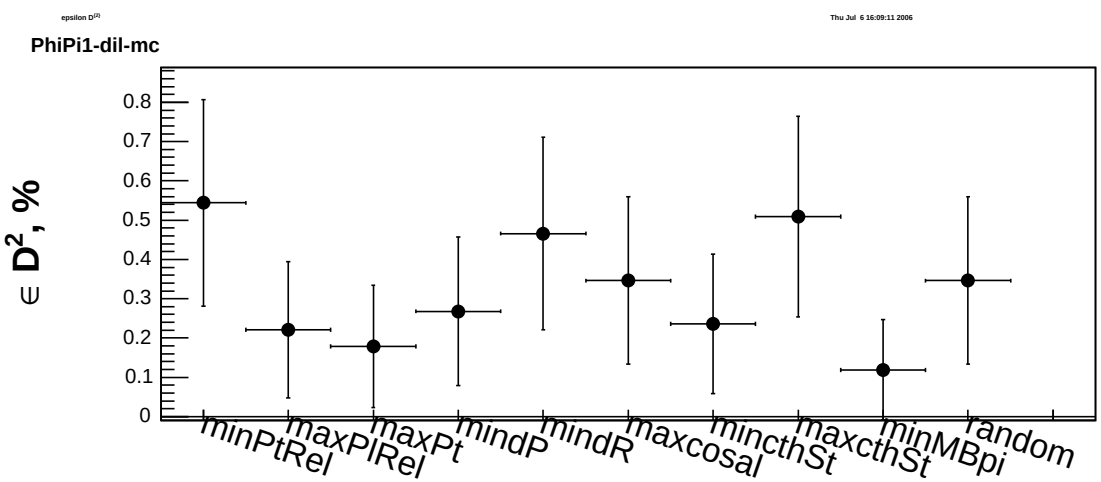
- tag charge corresponds to true B_d-flavor at production ("Right Tag")
- tag charge is opposite to true B_d-flavor at production ("Wrong Tag")
- no tag was found ("No Tag")

Mistag rate $p = \frac{N_{WT}}{N_{RT}+N_{WT}}$

True dilution D $= 1 - 2p = \frac{N_{RT}-N_{WT}}{N_{RT}+N_{WT}}$

Previous (low-statistics) results

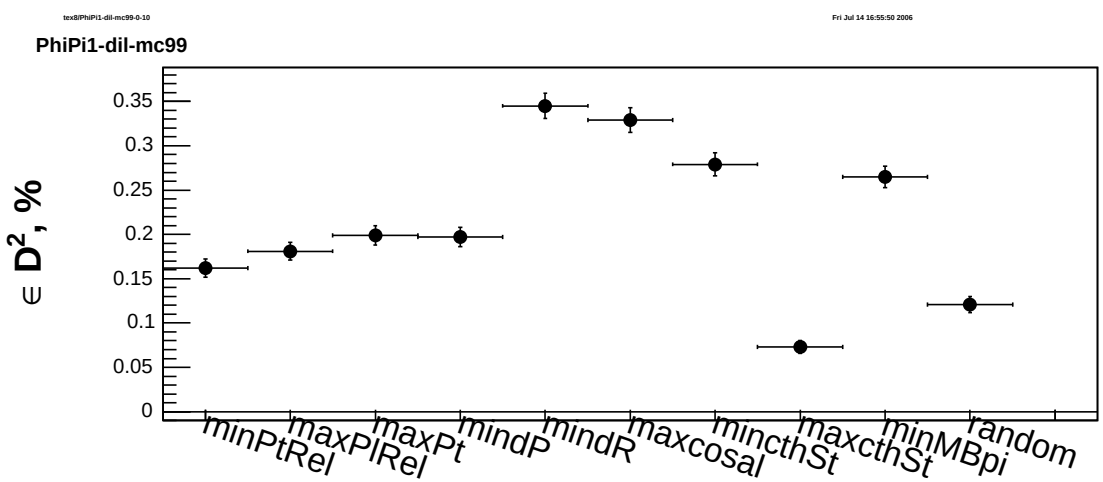
Tagger	RT	WT	NT	ε, %	D, %	εD^2, %
Min. p_t^{rel}	1300 ± 36	1112 ± 33	284 ± 17	89.5 ± 0.6	7.8 ± 2.0	0.544 ± 0.263
Max. p_L^{rel}	1266 ± 36	1146 ± 34	284 ± 17	89.5 ± 0.6	5.0 ± 2.0	0.221 ± 0.173
Max. p_t	1260 ± 35	1152 ± 34	284 ± 17	89.5 ± 0.6	4.5 ± 2.0	0.179 ± 0.156
Min. ΔR	1293 ± 36	1119 ± 33	284 ± 17	89.5 ± 0.6	7.2 ± 2.0	0.466 ± 0.245
Max. $\cos\alpha$	1281 ± 36	1131 ± 34	284 ± 17	89.5 ± 0.6	6.2 ± 2.0	0.346 ± 0.213
Min. $\lvert\Delta\vec{P}\rvert$	1272 ± 36	1140 ± 34	284 ± 17	89.5 ± 0.6	5.5 ± 2.0	0.268 ± 0.189
Min. $m(B_sK)$	1250 ± 35	1162 ± 34	284 ± 17	89.5 ± 0.6	3.6 ± 2.0	0.119 ± 0.128
Min. $\cos\theta^*$	1268 ± 36	1144 ± 34	284 ± 17	89.5 ± 0.6	5.1 ± 2.0	0.236 ± 0.178
Max. $\cos\theta^*$	1297 ± 36	1115 ± 33	284 ± 17	89.5 ± 0.6	7.5 ± 2.0	0.509 ± 0.255
Random track	1281 ± 36	1131 ± 34	284 ± 17	89.5 ± 0.6	6.2 ± 2.0	0.346 ± 0.213



"Min. p_t^{rel}" seems to be the best one-track tagger...

True dilutions in all 4 MC for one-track taggers

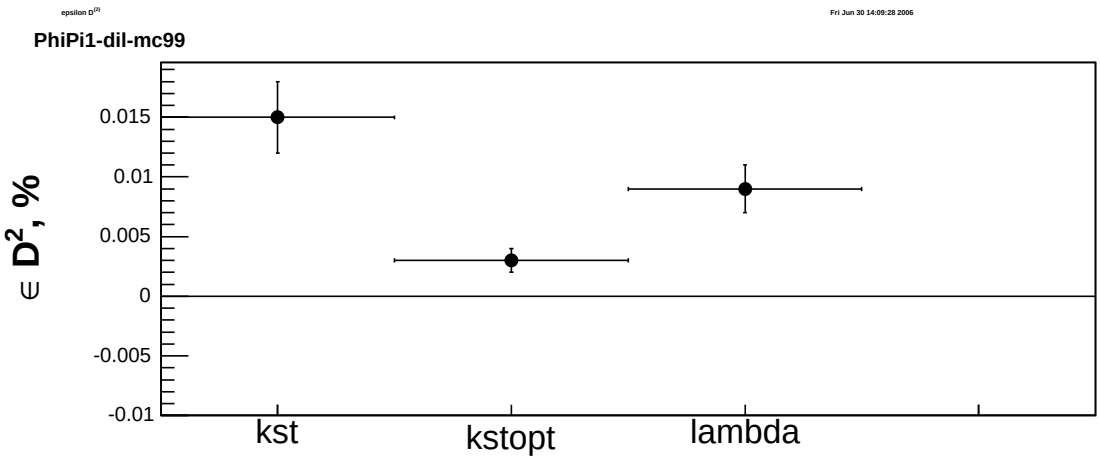
Tagger	RT	WT	NT	ε, %	D, %	εD^2, %
Min. p_t^{rel}	262644 $\pm$ 512	240178 $\pm$ 490	116774 $\pm$ 342	81.2 $\pm$ 0.0	4.5 $\pm$ 0.1	0.162 $\pm$ 0.010
Max. p_L^{rel}	263285 $\pm$ 513	239537 $\pm$ 489	116774 $\pm$ 342	81.2 $\pm$ 0.0	4.7 $\pm$ 0.1	0.181 $\pm$ 0.010
Max. p_t	263870 $\pm$ 514	238952 $\pm$ 489	116774 $\pm$ 342	81.2 $\pm$ 0.0	5.0 $\pm$ 0.1	0.199 $\pm$ 0.011
Min. ΔR	267795 $\pm$ 517	235027 $\pm$ 485	116774 $\pm$ 342	81.2 $\pm$ 0.0	6.5 $\pm$ 0.1	0.345 $\pm$ 0.014
Max. $\cos\alpha$	267412 $\pm$ 517	235410 $\pm$ 485	116774 $\pm$ 342	81.2 $\pm$ 0.0	6.4 $\pm$ 0.1	0.329 $\pm$ 0.014
Min. $\lvert\Delta\vec{P}\rvert$	263809 $\pm$ 514	239013 $\pm$ 489	116774 $\pm$ 342	81.2 $\pm$ 0.0	4.9 $\pm$ 0.1	0.197 $\pm$ 0.011
Min. $m(B_s K)$	265779 $\pm$ 516	237043 $\pm$ 487	116774 $\pm$ 342	81.2 $\pm$ 0.0	5.7 $\pm$ 0.1	0.265 $\pm$ 0.012
Min. $\cos\theta^*$	266163 $\pm$ 516	236659 $\pm$ 486	116774 $\pm$ 342	81.2 $\pm$ 0.0	5.9 $\pm$ 0.1	0.279 $\pm$ 0.013
Max. $\cos\theta^*$	258955 $\pm$ 509	243867 $\pm$ 494	116774 $\pm$ 342	81.2 $\pm$ 0.0	3.0 $\pm$ 0.1	0.073 $\pm$ 0.007
Random track	261105 $\pm$ 511	241717 $\pm$ 492	116774 $\pm$ 342	81.2 $\pm$ 0.0	3.9 $\pm$ 0.1	0.121 $\pm$ 0.009



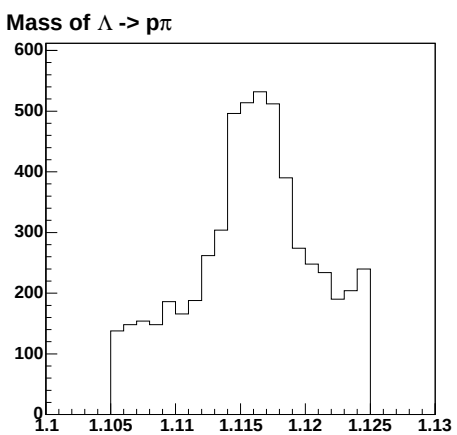
Now "Min. ΔR" is the best one-track tagger

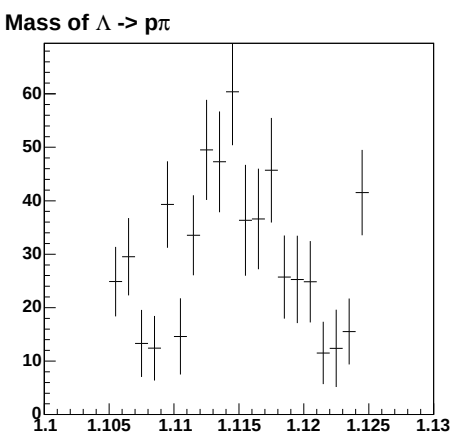
True dilutions in all 4 MC for two-track taggers

Tagger	RT	WT	NT	ε, %	D, %	εD^2, %
$K^{*0} \to K\pi$	69392 $\pm$ 263	65571 $\pm$ 256	484633 $\pm$ 696	21.8 $\pm$ 0.1	2.8 $\pm$ 0.3	0.017 $\pm$ 0.003
$K^{*0} \to K\pi$(opt)	5644 $\pm$ 75	5215 $\pm$ 72	608737 $\pm$ 780	1.8 $\pm$ 0.0	4.0 $\pm$ 1.0	0.003 $\pm$ 0.001
Λ	1669 $\pm$ 41	1246 $\pm$ 35	616681 $\pm$ 785	0.5 $\pm$ 0.0	14.5 $\pm$ 1.8	0.010 $\pm$ 0.002



Let's choose uncorrelated "Lambda" and "K^{*0}" (non-opt)

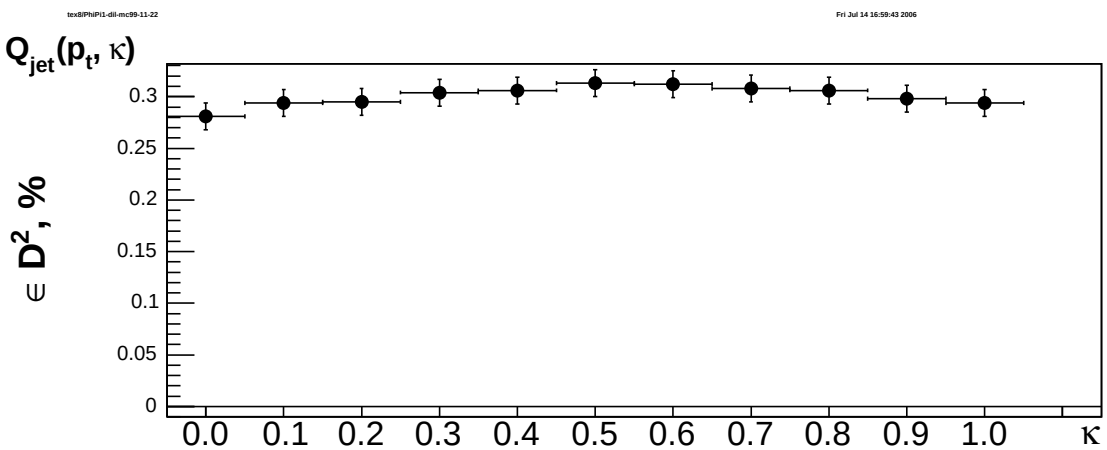




True dilutions in all 4 MC for many-track taggers

Weighted with p_t:

Tagger	RT	WT	NT	ε, %	D, %	εD^2, %
Aver. Q	197545 ± 444	172167 ± 415	249884 ± 500	59.7 ± 0.1	6.9 ± 0.2	0.281 ± 0.013
$Q_{jet}(p_t, \kappa = 0.1)$	188330 ± 434	163042 ± 404	268224 ± 518	56.7 ± 0.1	7.2 ± 0.2	0.294 ± 0.013
$Q_{jet}(p_t, \kappa = 0.2)$	188129 ± 434	162808 ± 403	268659 ± 518	56.6 ± 0.1	7.2 ± 0.2	0.295 ± 0.013
$Q_{jet}(p_t, \kappa = 0.3)$	189392 ± 435	163607 ± 404	266597 ± 516	57.0 ± 0.1	7.3 ± 0.2	0.304 ± 0.013
$Q_{jet}(p_t, \kappa = 0.4)$	192047 ± 438	165993 ± 407	261556 ± 511	57.8 ± 0.1	7.3 ± 0.2	0.306 ± 0.013
$Q_{jet}(p_t, \kappa = 0.5)$	195423 ± 442	168852 ± 411	255321 ± 505	58.8 ± 0.1	7.3 ± 0.2	0.313 ± 0.013
$Q_{jet}(p_t, \kappa = 0.6)$	198826 ± 446	172039 ± 415	248731 ± 499	59.9 ± 0.1	7.2 ± 0.2	0.312 ± 0.013
$Q_{jet}(p_t, \kappa = 0.7)$	202067 ± 450	175233 ± 419	242296 ± 492	60.9 ± 0.1	7.1 ± 0.2	0.308 ± 0.013
$Q_{jet}(p_t, \kappa = 0.8)$	205351 ± 453	178374 ± 422	235871 ± 486	61.9 ± 0.1	7.0 ± 0.2	0.306 ± 0.013
$Q_{jet}(p_t, \kappa = 0.9)$	208375 ± 456	181533 ± 426	229688 ± 479	62.9 ± 0.1	6.9 ± 0.2	0.298 ± 0.013
$Q_{jet}(p_t, \kappa = 1.0)$	211435 ± 460	184584 ± 430	223577 ± 473	63.9 ± 0.1	6.8 ± 0.2	0.294 ± 0.013

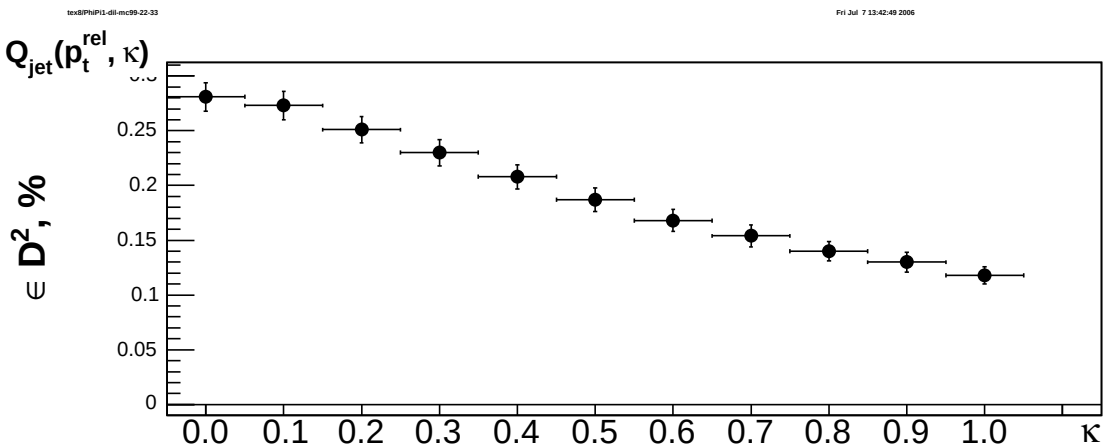


Best $\kappa = 0.5$

True dilutions in all 4 MC for many-track taggers

Weighted with p_t^{rel}:

Tagger	RT	WT	NT	ε, %	D, %	εD^2, %
Aver. Q	197545 ± 444	172167 ± 415	249884 ± 500	59.7 ± 0.1	6.9 ± 0.2	0.281 ± 0.013
$Q_{jet}(p_t^{rel}, \kappa = 0.1)$	188202 ± 434	163781 ± 405	267613 ± 517	56.8 ± 0.1	6.9 ± 0.2	0.273 ± 0.013
$Q_{jet}(p_t^{rel}, \kappa = 0.2)$	188421 ± 434	164974 ± 406	266201 ± 516	57.0 ± 0.1	6.6 ± 0.2	0.251 ± 0.012
$Q_{jet}(p_t^{rel}, \kappa = 0.3)$	190866 ± 437	168265 ± 410	260465 ± 510	58.0 ± 0.1	6.3 ± 0.2	0.230 ± 0.012
$Q_{jet}(p_t^{rel}, \kappa = 0.4)$	194136 ± 441	172415 ± 415	253045 ± 503	59.2 ± 0.1	5.9 ± 0.2	0.208 ± 0.011
$Q_{jet}(p_t^{rel}, \kappa = 0.5)$	197372 ± 444	176549 ± 420	245675 ± 496	60.3 ± 0.1	5.6 ± 0.2	0.187 ± 0.011
$Q_{jet}(p_t^{rel}, \kappa = 0.6)$	200681 ± 448	180750 ± 425	238165 ± 488	61.6 ± 0.1	5.2 ± 0.2	0.168 ± 0.010
$Q_{jet}(p_t^{rel}, \kappa = 0.7)$	203989 ± 452	184728 ± 430	230879 ± 480	62.7 ± 0.1	5.0 ± 0.2	0.154 ± 0.010
$Q_{jet}(p_t^{rel}, \kappa = 0.8)$	207201 ± 455	188658 ± 434	223737 ± 473	63.9 ± 0.1	4.7 ± 0.2	0.140 ± 0.009
$Q_{jet}(p_t^{rel}, \kappa = 0.9)$	210377 ± 459	192350 ± 439	216869 ± 466	65.0 ± 0.1	4.5 ± 0.2	0.130 ± 0.009
$Q_{jet}(p_t^{rel}, \kappa = 1.0)$	213159 ± 462	195837 ± 443	210600 ± 459	66.0 ± 0.1	4.2 ± 0.2	0.118 ± 0.008

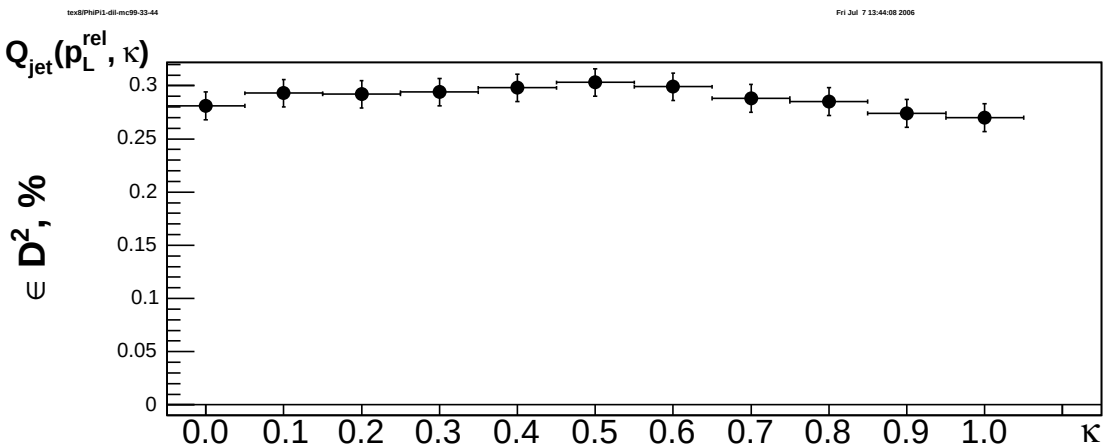


Best $\kappa = 0.0$

True dilutions in all 4 MC for many-track taggers

Weighted with p_L^{rel}:

Tagger	RT	WT	NT	ε, %	D, %	εD^2, %
Aver. Q	197545 ± 444	172167 ± 415	249884 ± 500	59.7 ± 0.1	6.9 ± 0.2	0.281 ± 0.013
$Q_{jet}(p_L^{rel}, \kappa = 0.1)$	188378 ± 434	163099 ± 404	268119 ± 518	56.7 ± 0.1	7.2 ± 0.2	0.293 ± 0.013
$Q_{jet}(p_L^{rel}, \kappa = 0.2)$	188263 ± 434	163068 ± 404	268265 ± 518	56.7 ± 0.1	7.2 ± 0.2	0.292 ± 0.013
$Q_{jet}(p_L^{rel}, \kappa = 0.3)$	190070 ± 436	164648 ± 406	264878 ± 515	57.2 ± 0.1	7.2 ± 0.2	0.294 ± 0.013
$Q_{jet}(p_L^{rel}, \kappa = 0.4)$	193133 ± 439	167339 ± 409	259124 ± 509	58.2 ± 0.1	7.2 ± 0.2	0.298 ± 0.013
$Q_{jet}(p_L^{rel}, \kappa = 0.5)$	196695 ± 444	170455 ± 413	252446 ± 502	59.3 ± 0.1	7.1 ± 0.2	0.303 ± 0.013
$Q_{jet}(p_L^{rel}, \kappa = 0.6)$	200279 ± 448	173930 ± 417	245387 ± 495	60.4 ± 0.1	7.0 ± 0.2	0.299 ± 0.013
$Q_{jet}(p_L^{rel}, \kappa = 0.7)$	203674 ± 451	177589 ± 421	238333 ± 488	61.5 ± 0.1	6.8 ± 0.2	0.288 ± 0.013
$Q_{jet}(p_L^{rel}, \kappa = 0.8)$	207043 ± 455	180880 ± 425	231673 ± 481	62.6 ± 0.1	6.7 ± 0.2	0.285 ± 0.013
$Q_{jet}(p_L^{rel}, \kappa = 0.9)$	210187 ± 458	184304 ± 429	225105 ± 474	63.7 ± 0.1	6.6 ± 0.2	0.274 ± 0.013
$Q_{jet}(p_L^{rel}, \kappa = 1.0)$	213312 ± 462	187417 ± 433	218867 ± 468	64.7 ± 0.1	6.5 ± 0.2	0.270 ± 0.013



Best $\kappa = 0.5$

Best many-track tagger

- The best tagger is $Q_{jet}(p_t, \kappa = 0.5)$
- We will use this tagger only, skipping the remaining 30

Chosen taggers

- So, we've chosen four taggers: "Min. ΔR", "K^{*0}", "Lambda" and "$Q_{jet}(p_t, \kappa = 0.5)$"
- Let's obtain one combined tagging variable for them

Combination of B-flavor taggers:

- Combination algorithm (developed by Guennadi *et al.* for OST):
  - Find uncorrelated discriminating variables x_i
    with p.d.f. $f_i^b(x_i)$ and $f_i^{\bar{b}}(x_i)$ being different for b and $\bar{b}$ quarks
  - Define tagging variables $y_i = \frac{f_i^b(x_i)}{f_i^{\bar{b}}(x_i)}$; $y_i > 1$ – b-quark, $y_i < 1$ – $\bar{b}$-quark
  - Define combined tagging variable $y = \prod y_i$
  - Compute *combined dilution* for each event $d = \frac{1-y}{1+y}$
  - Obtain combined ϵD^2

☞ Where to obtain p.d.f.'s?
  - For OST they were taken from B_d sample
  - For SST we have to take them from Monte Carlo

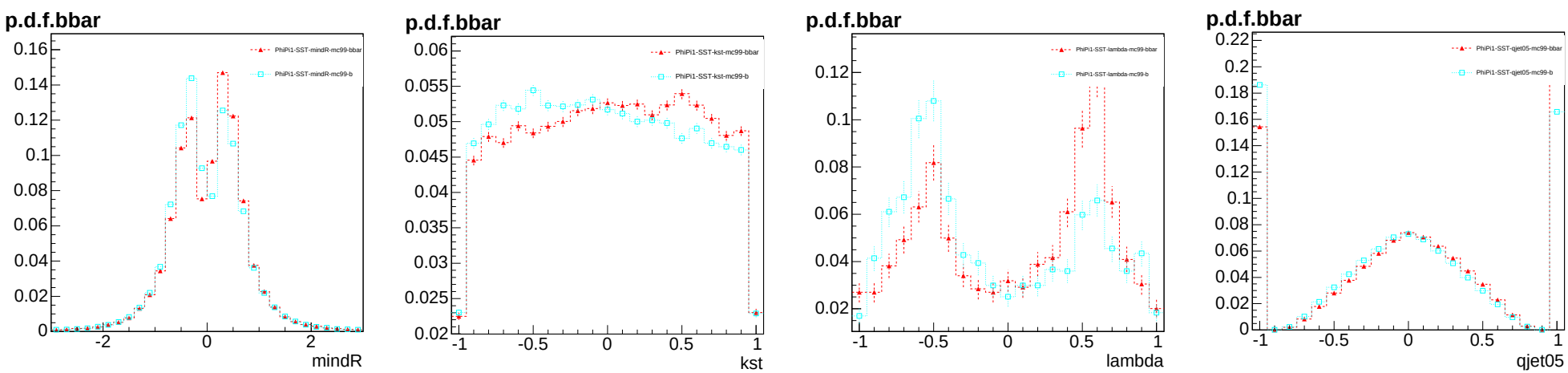
P.d.f's for chosen taggers:

Chosen variables are:

- $x_1 = q \cdot \Delta R$
- $x_2 = q \cdot (m(K^{*0}) - 0.862)/(0.922 - 0.862)$
- $x_3 = q \cdot (m(\Lambda) - 1.105)/(1.125 - 1.105)$
- $x_4 = Q_{jet}$

where q is charge of the tag

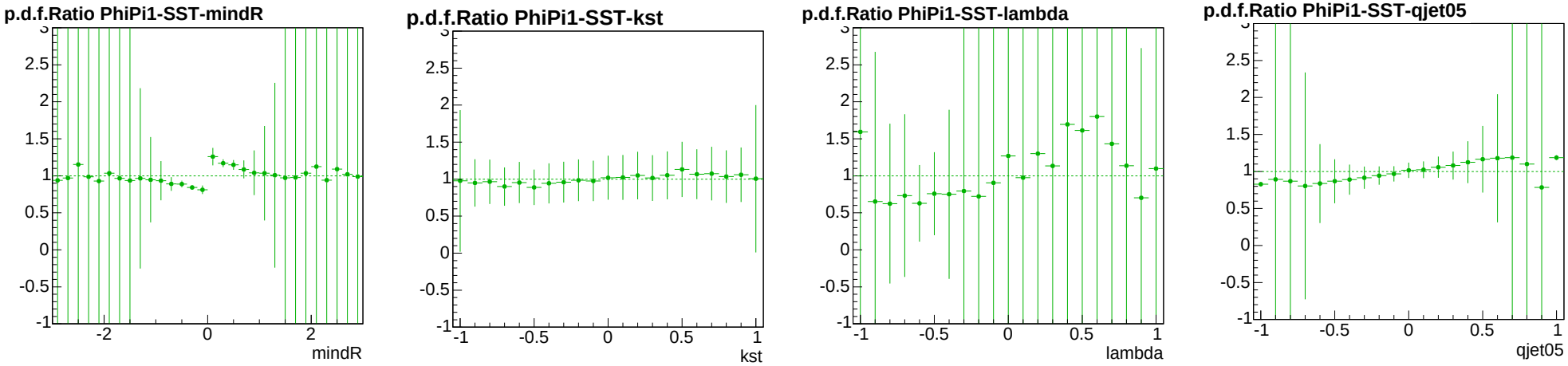
"Min. ΔR" "K^{*0}" "Lambda" "$Q_{jet}(p_t, \kappa = 0.5)$"



Red triangles - p.d.f.'s for $\bar{b}$-quark, cyan squares - p.d.f.'s for b-quark

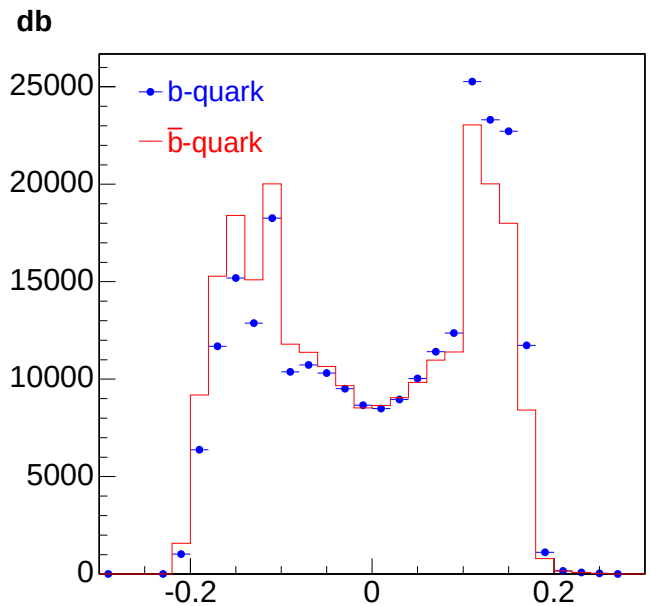
Ratios of p.d.f's for chosen taggers:

"Min. ΔR" "K^{*0}" "Lambda" "$Q_{jet}(p_t, \kappa = 0.5)$"



- Green circles – ratios of p.d.f.'s for $\bar{b}$-quark to p.d.f.'s for b-quark
- Combined variable $y = \prod y_i$ is a product of all the ratios y_i ($y > 1$ – $\bar{b}$-quark, $y < 1$ – b-quark)
- Combined dilution d for each event computed as $d = \frac{1-y}{1+y}$ ($d < 0$ – $\bar{b}$-quark, $d > 0$ – b-quark)

Combined dilution d



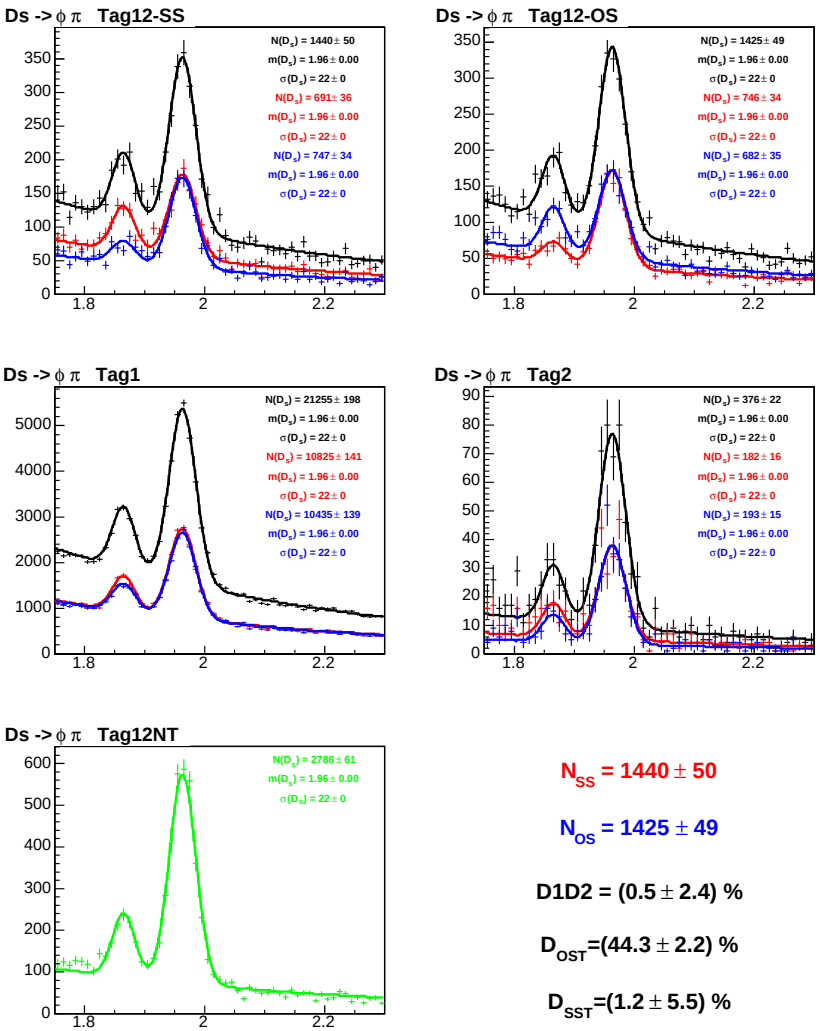
- d distribution has large discrimination power between b and $\bar{b}$ quarks
- Events with low d have lower discrimination power $\Longrightarrow$ skip them, $|d| > 0.086$
- Resulting $\varepsilon D^2 = 0.442 \pm 0.016\%$ to be compared to:
  - $\epsilon D^2(\text{Min.}\Delta R) = 0.345 \pm 0.014$ %
  - $\epsilon D^2(K^{*0}) = 0.017 \pm 0.003$ %
  - $\epsilon D^2(\text{Lambda}) = 0.010 \pm 0.002$ %
  - $\epsilon D^2(Q_{jet}(p_t, \kappa = 0.5)) = 0.313 \pm 0.013$ %

Measuring SST dilution in data:

- Divide sample of N events into five subsamples:
  - N_1 events tagged only by first tagger with *true* dilution D_1
  - N_2 events tagged only by second tagger with *true* dilution D_2
  - N_{12} events tagged by both taggers identically with *true* dilution $\mathsf{D}_{12} = \frac{\mathsf{D}_1+\mathsf{D}_2}{1+\mathsf{D}_1\mathsf{D}_2}$
  - $\bar{N}_{12}$ events tagged by both taggers differently with *true* dilution $\bar{\mathsf{D}}_{12} = \frac{|\mathsf{D}_1-\mathsf{D}_2|}{1-\mathsf{D}_1\mathsf{D}_2}$
  - N_{NT} events not tagged by both taggers
- A simple formula holds: $\mathsf{D}_1\mathsf{D}_2 = \frac{N_{12}-\bar{N}_{12}}{N_{12}+\bar{N}_{12}}$
- Use one (more trustworthy) *true* dilution from other sources and measure another (D0 Note 4991:$D_{OST} = 44.3 \pm 2.2$)
- Calculate $\epsilon D^2 = \frac{1}{N}(N_1\mathsf{D}_1^2 + N_2\mathsf{D}_2^2 + N_{12}\mathsf{D}_{12}^2 + \bar{N}_{12}\,\bar{\mathsf{D}}_{12}^2)$

Measuring SST dilution in data:

PhiPi1-SST-minPtRel-combOST Thu Jul 6 18:02:44 2006



N_{SS} = 1440 ± 50

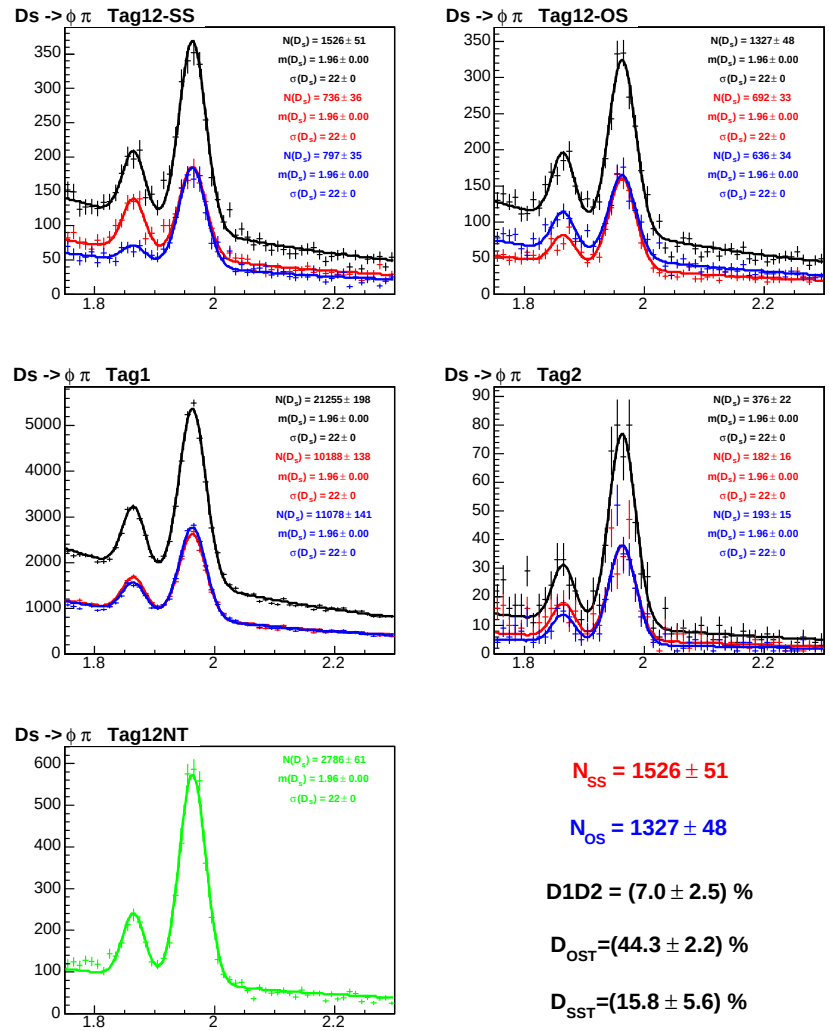
N_{OS} = 1425 ± 49

D1D2 = (0.5 ± 2.4) %

D_{OST}=(44.3 ± 2.2) %

D_{SST}=(1.2 ± 5.5) %

PhiPi1-SST-mincthSt-combOST Thu Jul 6 18:05:40 2006



N_{SS} = 1526 ± 51

N_{OS} = 1327 ± 48

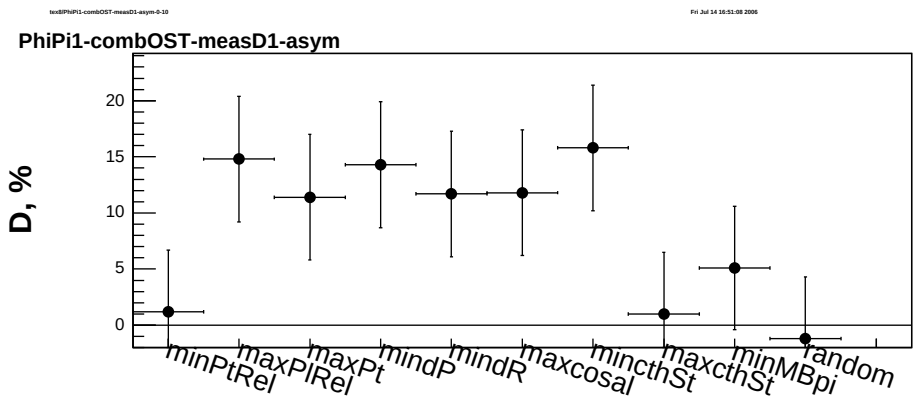
D1D2 = (7.0 ± 2.5) %

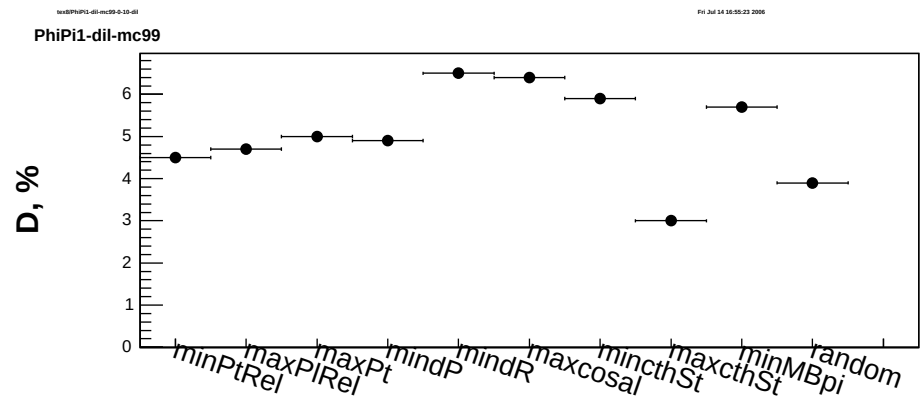
D_{OST}=(44.3 ± 2.2) %

D_{SST}=(15.8 ± 5.6) %

Measured SST dilutions in data

	N_1	N_2	N_{NT}	N_{12}	$\bar{N}_{12}$	$\frac{N_{12}-N_{12}}{N_{12}+\bar{N}_{12}}$	D_{OST}	D_{SST}^{meas}	D_{12}^{calc}	$\bar{D}_{12}^{calc}$	εD^2(calc), %
Min. p_t^{rel}	21255±198	376±22	2786±61	1440±50	1425±49	0.005±0.024	44.3 ± 2.2	1.2±5.5	45.2±4.9	43.4±5.0	2.343±0.345
Max. p_L^{rel}	21255±198	376±22	2786±61	1521±51	1334±48	0.066±0.024	44.3 ± 2.2	14.8±5.6	55.5±4.4	31.6±5.7	4.181±1.327
Max. p_t	21255±198	376±22	2786±61	1498±51	1354±48	0.050±0.024	44.3 ± 2.2	11.4±5.6	53.0±4.5	34.7±5.5	3.416±1.038
Min. $\lvert\Delta\vec{P}\rvert$	21255±198	376±22	2786±61	1517±51	1337±48	0.063±0.024	44.3 ± 2.2	14.3±5.6	55.1±4.4	32.1±5.7	4.052±1.283
Min. ΔR	21255±198	376±22	2786±61	1503±51	1354±48	0.052±0.024	44.3 ± 2.2	11.7±5.6	53.3±4.5	34.3±5.5	3.496±1.068
Max. $\cos\alpha$	21255±198	376±22	2786±61	1505±51	1355±48	0.052±0.024	44.3 ± 2.2	11.8±5.6	53.3±4.5	34.3±5.5	3.508±1.073
Min. $\cos\theta^*$	21255±198	376±22	2786±61	1526±51	1327±48	0.070±0.025	44.3 ± 2.2	15.8±5.6	56.1±4.3	30.7±5.8	4.430±1.412
Max. $\cos\theta^*$	21255±198	376±22	2786±61	1438±50	1426±49	0.004±0.024	44.3 ± 2.2	1.0±5.5	45.1±4.9	43.5±5.0	2.339±0.341
Min. $m(B_sK)$	21255±198	376±22	2786±61	1465±50	1400±48	0.023±0.024	44.3 ± 2.2	5.1±5.5	48.3±4.7	40.1±5.2	2.555±0.550
Random	21255±198	376±22	2786±61	1419±50	1435±49	-0.005±0.024	44.3 ± 2.2	-1.2±5.5	43.3±5.0	45.3±4.9	2.338±0.345



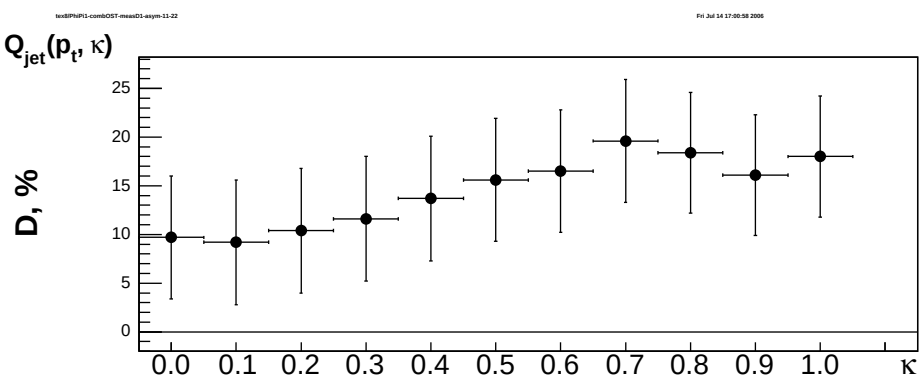


. Data Monte Carlo

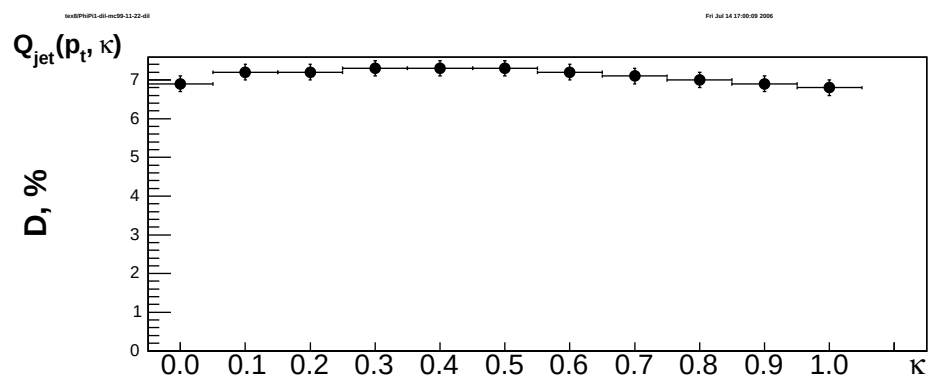
Disagreement to be understood...

Measured SST dilutions in data

	N_1	N_2	N_{NT}	N_{12}	$\bar{N}_{12}$	$\frac{N_{12}-N_{12}}{N_{12}+\bar{N}_{12}}$	D_{OST}	D_{SST}^{meas}	D_{12}^{calc}	$\bar{D}_{12}^{calc}$	εD^2(calc), %
Aver. Q	15447±165	1150±44	8602±125	1087±42	997±40	0.043±0.028	44.3 ± 2.2	9.7±6.3	51.8±5.0	36.1±6.0	2.910±0.744
$Q_{jet}(p_t, \kappa = 0.1)$	14532±159	1251±46	9511±132	1031±41	950±38	0.041±0.028	44.3 ± 2.2	9.2±6.4	51.4±5.1	36.6±6.1	2.818±0.682
$Q_{jet}(p_t, \kappa = 0.2)$	14492±159	1261±46	9555±133	1029±41	939±38	0.046±0.028	44.3 ± 2.2	10.4±6.4	52.3±5.1	35.6±6.1	2.947±0.758
$Q_{jet}(p_t, \kappa = 0.3)$	14601±160	1277±46	9447±132	1032±41	932±38	0.051±0.028	44.3 ± 2.2	11.6±6.4	53.1±5.1	34.5±6.2	3.107±0.841
$Q_{jet}(p_t, \kappa = 0.4)$	14803±161	1246±45	9249±129	1056±41	935±38	0.060±0.028	44.3 ± 2.2	13.7±6.4	54.6±5.0	32.6±6.3	3.427±0.987
$Q_{jet}(p_t, \kappa = 0.5)$	15070±162	1201±44	8978±128	1088±42	948±39	0.069±0.028	44.3 ± 2.2	15.6±6.3	56.0±4.8	30.8±6.4	3.790±1.128
$Q_{jet}(p_t, \kappa = 0.6)$	15338±164	1158±44	8713±125	1113±43	962±39	0.073±0.028	44.3 ± 2.2	16.5±6.3	56.7±4.8	30.0±6.4	3.990±1.206
$Q_{jet}(p_t, \kappa = 0.7)$	15689±166	1118±43	8360±123	1150±43	966±39	0.087±0.028	44.3 ± 2.2	19.6±6.3	58.8±4.6	27.0±6.6	4.737±1.450
$Q_{jet}(p_t, \kappa = 0.8)$	16027±168	1078±42	8021±121	1167±44	992±40	0.081±0.027	44.3 ± 2.2	18.4±6.2	58.0±4.7	28.2±6.5	4.486±1.376
$Q_{jet}(p_t, \kappa = 0.9)$	16345±170	1043±41	7704±118	1175±44	1018±40	0.071±0.027	44.3 ± 2.2	16.1±6.2	56.4±4.7	30.3±6.3	4.020±1.230
$Q_{jet}(p_t, \kappa = 1.0)$	16618±172	1002±40	7429±116	1205±45	1027±41	0.080±0.027	44.3 ± 2.2	18.0±6.2	57.7±4.6	28.6±6.4	4.477±1.385



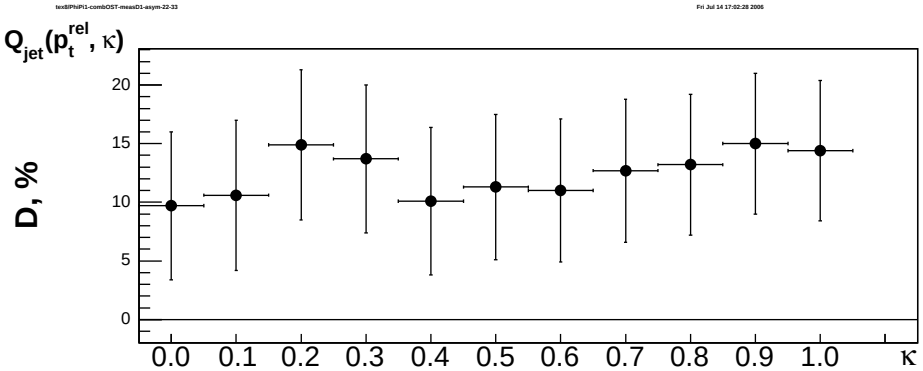
Data



Monte Carlo

Measured SST dilutions in data

	N_1	N_2	N_{NT}	N_{12}	$\bar{N}_{12}$	$\frac{N_{12}-\bar{N}_{12}}{N_{12}+\bar{N}_{12}}$	D_{OST}	D_{SST}^{meas}	D_{12}^{calc}	$\bar{D}_{12}^{calc}$	εD^2(calc), %
$Q_{jet}(p_t^{rel}, 0.1)$	14541±159	1251±46	9504±132	1039±41	946±38	0.047±0.028	44.3 ± 2.2	10.6±6.4	52.4±5.1	35.4±6.1	2.977±0.769
$Q_{jet}(p_t^{rel}, 0.2)$	14598±160	1236±46	9444±131	1066±41	934±38	0.066±0.028	44.3 ± 2.2	14.9±6.4	55.6±4.9	31.5±6.4	3.626±1.056
$Q_{jet}(p_t^{rel}, 0.3)$	14776±161	1205±45	9268±129	1075±42	952±39	0.061±0.028	44.3 ± 2.2	13.7±6.3	54.7±4.9	32.6±6.3	3.437±0.983
$Q_{jet}(p_t^{rel}, 0.4)$	15062±163	1170±44	8981±128	1079±42	987±39	0.045±0.028	44.3 ± 2.2	10.1±6.3	52.0±5.0	35.8±6.0	2.936±0.752
$Q_{jet}(p_t^{rel}, 0.5)$	15449±165	1086±43	8595±125	1129±43	1022±40	0.050±0.027	44.3 ± 2.2	11.3±6.2	52.9±4.9	34.8±6.0	3.111±0.835
$Q_{jet}(p_t^{rel}, 0.6)$	15837±167	1049±42	8207±122	1147±43	1040±40	0.049±0.027	44.3 ± 2.2	11.0±6.1	52.7±4.9	35.0±6.0	3.095±0.836
$Q_{jet}(p_t^{rel}, 0.7)$	16085±169	990±41	7958±120	1183±44	1057±41	0.056±0.027	44.3 ± 2.2	12.7±6.1	54.0±4.8	33.5±6.0	3.360±0.952
$Q_{jet}(p_t^{rel}, 0.8)$	16378±171	954±40	7667±117	1201±44	1069±41	0.058±0.027	44.3 ± 2.2	13.2±6.0	54.3±4.8	33.1±6.0	3.454±0.999
$Q_{jet}(p_t^{rel}, 0.9)$	16720±173	927±39	7330±114	1224±45	1071±42	0.067±0.027	44.3 ± 2.2	15.0±6.0	55.6±4.7	31.4±6.1	3.827±1.150
$Q_{jet}(p_t^{rel}, 1.0)$	16996±174	874±38	7055±112	1249±45	1099±42	0.064±0.026	44.3 ± 2.2	14.4±6.0	55.2±4.6	31.9±6.0	3.732±1.110



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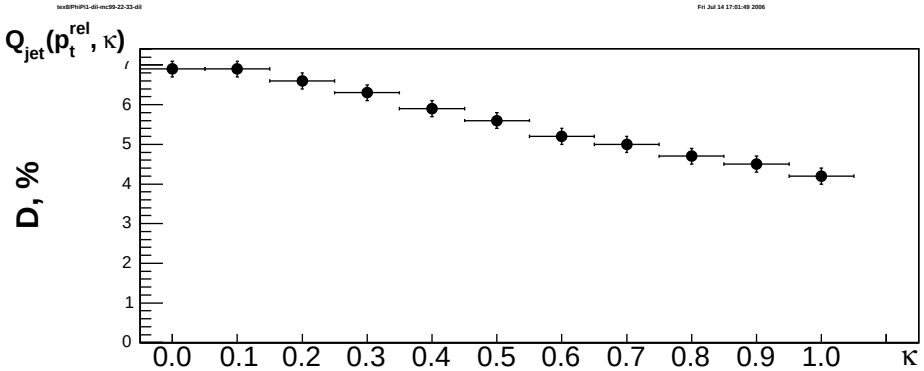
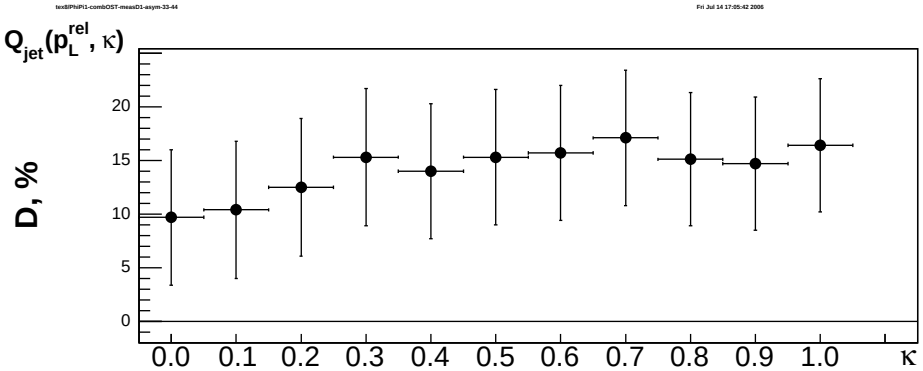


Monte Carlo

Measured SST dilutions in data

	N_1	N_2	N_{NT}	N_{12}	$\bar{N}_{12}$	$\frac{N_{12}-\bar{N}_{12}}{N_{12}+\bar{N}_{12}}$	D_{OST}	D_{SST}^{meas}	D_{12}^{calc}	$\bar{D}_{12}^{calc}$	εD^2(calc), %
$Q_{jet}(p_L^{rel}, 0.1)$	14535±159	1255±46	9510±132	1035±41	944±38	0.046±0.028	44.3 ± 2.2	10.4±6.4	52.3±5.1	35.6±6.1	2.949±0.756
$Q_{jet}(p_L^{rel}, 0.2)$	14502±159	1265±46	9543±132	1040±41	931±38	0.056±0.028	44.3 ± 2.2	12.5±6.4	53.8±5.0	33.6±6.3	3.237±0.897
$Q_{jet}(p_L^{rel}, 0.3)$	14720±160	1256±46	9334±131	1058±41	924±38	0.068±0.028	44.3 ± 2.2	15.3±6.4	55.8±4.9	31.1±6.4	3.702±1.096
$Q_{jet}(p_L^{rel}, 0.4)$	14911±161	1212±45	9139±130	1077±42	952±39	0.062±0.028	44.3 ± 2.2	14.0±6.3	54.9±4.9	32.3±6.3	3.490±1.005
$Q_{jet}(p_L^{rel}, 0.5)$	15192±163	1183±44	8856±127	1098±42	958±39	0.068±0.028	44.3 ± 2.2	15.3±6.3	55.8±4.8	31.1±6.4	3.750±1.114
$Q_{jet}(p_L^{rel}, 0.6)$	15497±165	1141±43	8544±125	1119±43	973±39	0.070±0.028	44.3 ± 2.2	15.7±6.3	56.1±4.8	30.7±6.3	3.857±1.158
$Q_{jet}(p_L^{rel}, 0.7)$	15777±167	1107±43	8271±122	1144±43	983±40	0.076±0.028	44.3 ± 2.2	17.1±6.3	57.1±4.7	29.4±6.4	4.166±1.273
$Q_{jet}(p_L^{rel}, 0.8)$	16099±169	1046±41	7944±120	1165±44	1019±40	0.067±0.027	44.3 ± 2.2	15.1±6.2	55.7±4.8	31.3±6.2	3.788±1.137
$Q_{jet}(p_L^{rel}, 0.9)$	16443±171	1018±41	7602±117	1180±44	1036±41	0.065±0.027	44.3 ± 2.2	14.7±6.2	55.4±4.8	31.6±6.2	3.750±1.133
$Q_{jet}(p_L^{rel}, 1.0)$	16721±173	997±40	7326±114	1199±45	1036±41	0.073±0.027	44.3 ± 2.2	16.4±6.2	56.6±4.7	30.1±6.3	4.116±1.272



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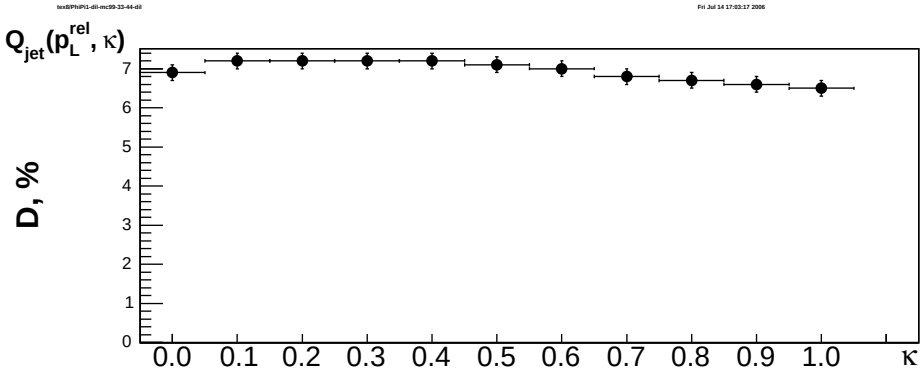

Monte Carlo

Summary

- Investigated 44 different SST algorithms with four Monte Carlo samples
  - 10 one-track taggers
  - 3 two-track taggers
  - 31 many-track tagger
- Taggers in groups are correlated to each other
- Selected one best tagger from each group:
  - "Min. ΔR"
  - "K^{*0}"
  - "Lambda"
  - "$Q_{jet}(p_t, \kappa = 0.5)$"
- Combine four SST algorithms $\Longrightarrow$ combined dilution d has the largest discrimination power
- Resulting tagging power $\varepsilon \mathrm{D}^2 = 0.442 \pm 0.016\%$
- Used double-tagged events to measure SST dilution directly from data
  - Disagreement between Monte Carlo and data is to be understood