

Update on Tracking on high Luminosity Data

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DC06 versus DC09

Many things have changed

- $\sqrt{s} = 10$ TeV, new GEANT version, more realistic geometry, residual misalignment in velo sim., wider time shape in velo, ...
→ efficiency: -1.0%, ghost rate: +1.0%
(see February lhcb week)
- changes in beam conditions
 - DC06: 25 ns bunch spacing → **spillover**
IA rate: **Poisson with $\nu = 0.7$** ;
 - DC09: large bunch spacing, **no spillover**;
default IA rate: **Poisson with $\nu = 1$**
- improved versions of pattern reco

If you run your physics analysis on a DC06 and a DC09 data set you see the sum of all these changes.

Data Samples

DC06 default:

- 20k DC06 mb MC with $\nu = 0.7$; 25 ns bunch spacing (rerun with Brunel v34r7; default for MC09 production)

MC09 default:

- 20k MC09 mb MC with $\nu = 1$; no spillover

MC09 high lumi:

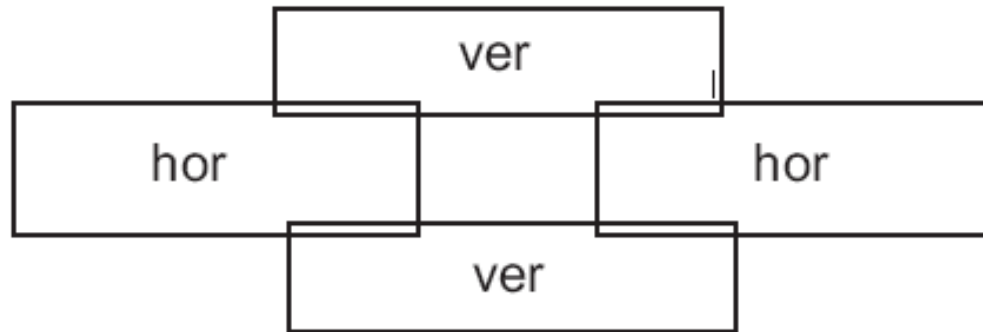
- 20k DC09 mb MC with $\nu = 2,3,4$; no spillover

	DC06	MC09			
sim. IA rate	0.7	1	2	3	4
IA rate after L0	1.5	2.1	2.9	4.1	5.2

For the rest of the talk only look at L0 accepted events.

Occupancy in T-Stations

Performance of MC09 already presented at LHCb week in May;
however bug in OT geometry → too high occupancy in OT and IT!



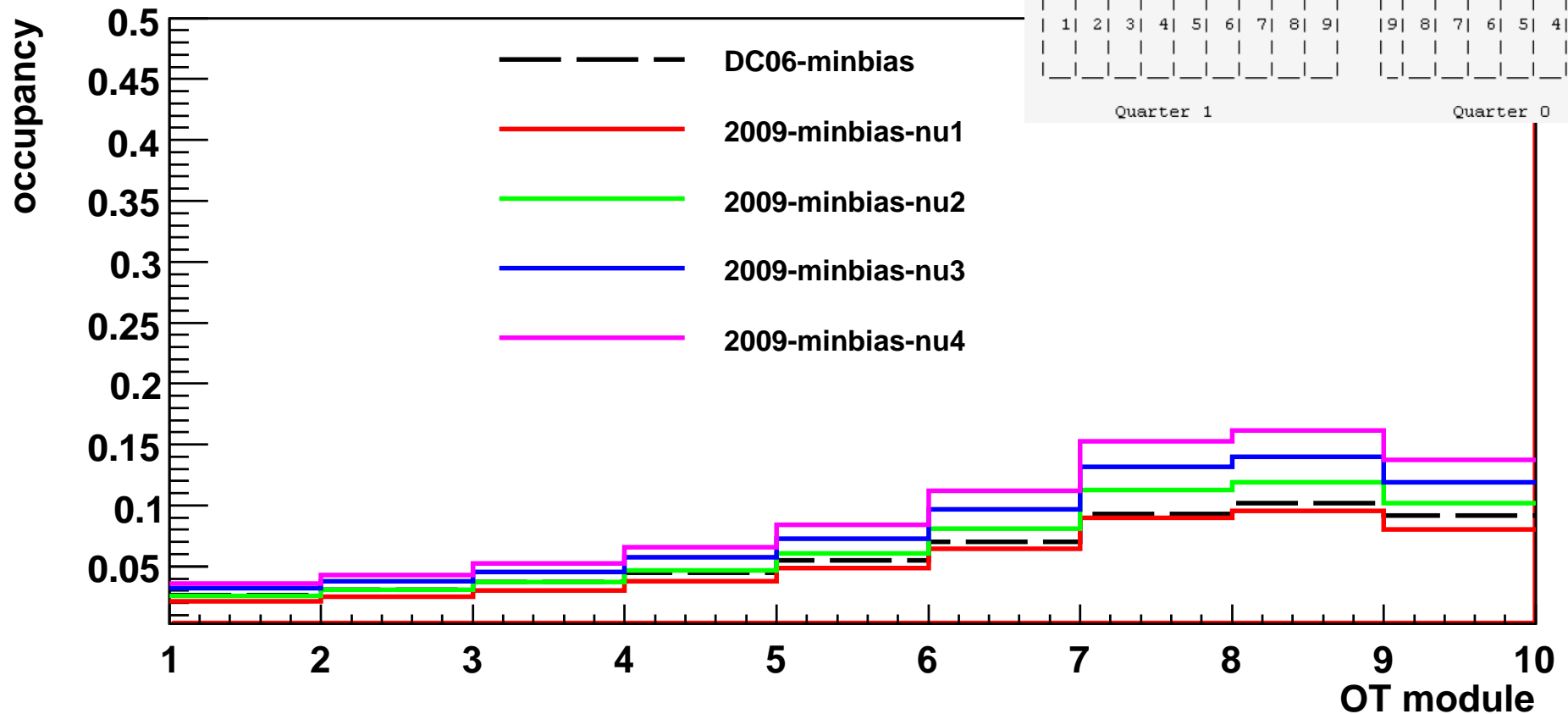
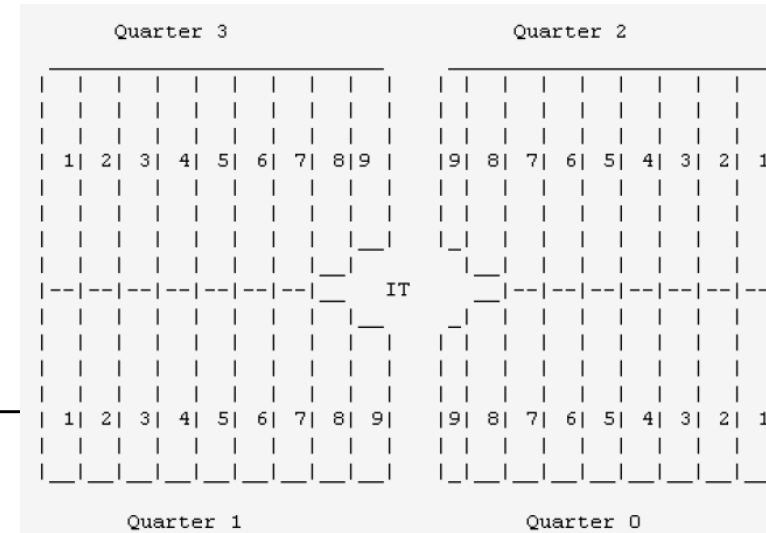
[%]	OT	IT(hor)	IT (ver)
DC 06 $\nu=0.7$	6.0	0.9	0.4
MC 09 $\nu=1.0$	4.5 5.4	0.9 1.2	0.4 0.6
MC 09 $\nu=2.0$	5.0 6.7	1.0 1.6	0.4 0.7
MC 09 $\nu=3.0$	6.4 8.1	1.3 1.9	0.6 0.9
MC 09 $\nu=4.0$	7.3 9.3	1.5 2.2	0.7 1.0

(gray: buggy numbers)

OT Occupancy

Up to 10% occupancy in inner modules for $\nu=4$

Was 15% before ... (with bug)



Efficiency

[%]	Velo	Forward	T-Track	Match	Best
DC06 $\nu=0.7$	98.6	92.9	96.8	89.7	94.9
MC09 $\nu=1$	97.9	92.2	95.9	88.6	94.4
MC09 $\nu=2$	97.7	91.4	92.5	87.3	93.8
MC09 $\nu=3$	97.4	90.5	94.0	85.3	93.1
MC09 $\nu=4$	97.1	89.7	93.2	84.0	92.5

efficiencies quoted for long tracks > 5 GeV
for best container, long tracks only in the numerator

Almost no loss in efficiency for default IA rate from DC06 to MC09

Current tunings yield high efficiencies as well on high lumi events.

Ghost Rates

[%]	Velo	Forward	T-Track	Match	Best
DC06 $\nu=0.7$	4.7	11.4	6.6	9.4	14.2
MC09 $\nu=1$	5.4	11.8	4.1	10.4	15.1
MC09 $\nu=2$	6.3	14.0	5.2	12.2	17.8
MC09 $\nu=3$	8.4	16.6	6.9	14.8	21.9
MC09 $\nu=4$	10.1	20.2	8.5	16.8	24.8

ghost rates quote are event averaged;
for best container long tracks only

There are handles to reject ghosts (see later in the talk)

Ghosts in Best Container

Which part of the long track “causes” the ghost?

[%]	Velo	T-Station	Mismatch	total
MB DC06 $\nu=0.7$	1.8	1.7	10.7	14.2
MB DC09 $\nu=1$	2.1	1.9	11.1	15.1
MB DC09 $\nu=2$	2.6	2.4	12.8	17.8
MB DC09 $\nu=3$	3.4	3.4	14.8	21.9
MB DC09 $\nu=4$	4.1	4.8	15.9	24.8

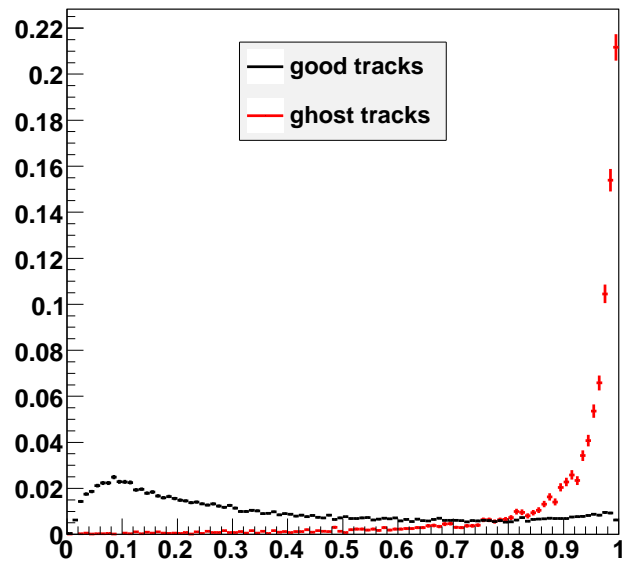
event averaged

Ghosts in the Velo harm us most on HLT

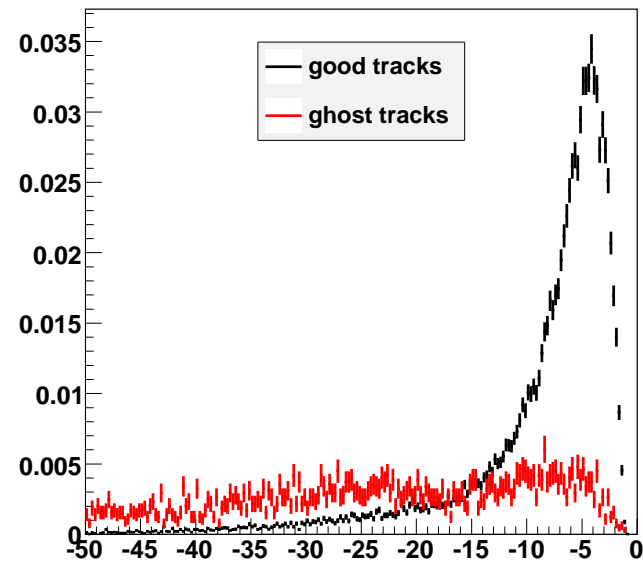
True for offline analysis as well ?

Tools for Ghost Rejection

- `LHCb::Track::Likelihood`
(available in DC06 reprocessed data & in MC09)
- `LHCb::Track::GhostProbability`
(can be computed on DC06 reprocessed data; available in MC09)



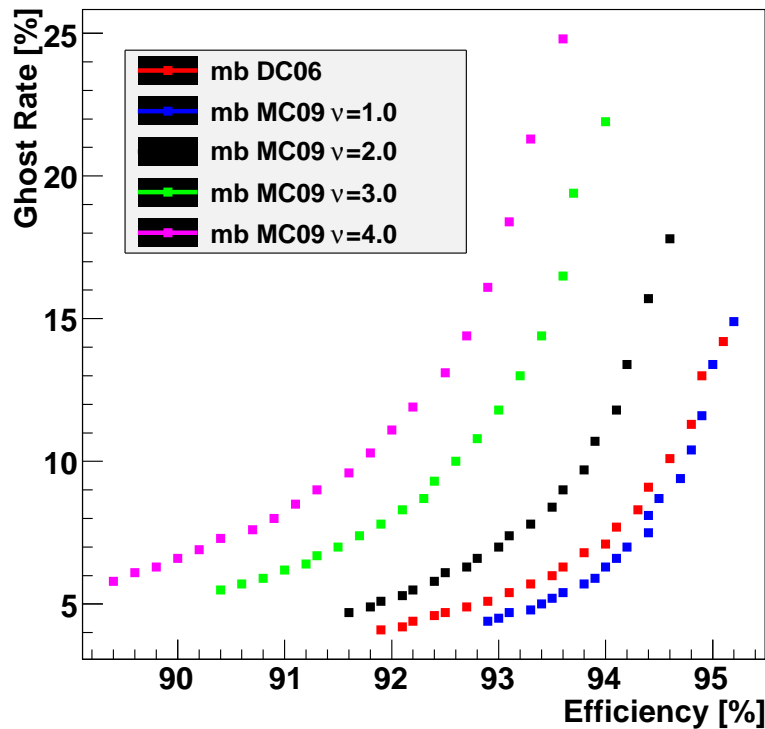
GhostProbability (on DC06)



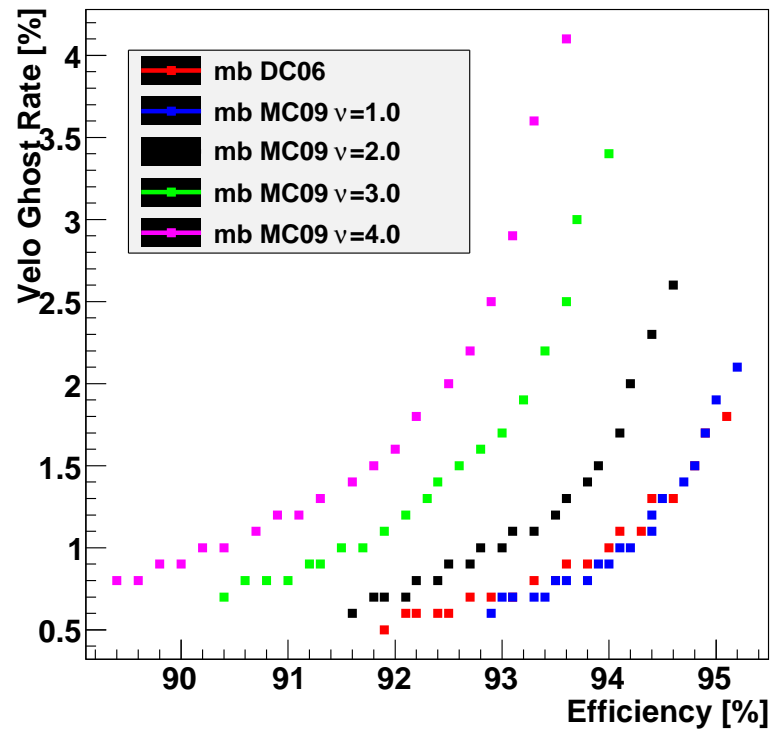
Likelihood (on DC06)

Note: these tools have been tuned on DC06 data.

GhostProbability



all long track ghost



all long tracks with velo ghost part

With 2.5% efficiency loss, similar ghost-rate for $\nu=4$ as for $\nu = 1$!
(Plots for Likelihood in the backup, similar rejection power)

Timing

ms/event*	Velo Sequence	T-Station + fit Sequence	T-Track	Forward
DC06 $\nu=0.7$ (1.5)	7	650	50	25
MC09 $\nu=1$ (2.1)	8	860	43	30
MC09 $\nu=2$ (2.9)	9	960	56	40
MC09 $\nu=3$ (4.1)	13	1360	88	80
MC09 $\nu=4$ (5.2)	14	1570	110	110

*) 1.75 of 2.8 GHz Xeon

T-Station sequence dominated by fitter.

Fitting time scales per definition linear.

Time spend in strategies does not explode

(still have to check for single time consuming event)

Improvements in Pattern Reco

	Velo	Forward	T-Track	Match	Best
Brunel v34r7, DC06 mb	4.7	11.4	6.6	9.4	14.2
Brunel v34r7, MC09 mb $\nu = 1$	5.4	11.8	4.1	10.4	15.1
Brunel v35r0p1, MC09 mb $\nu = 1$	4.1	11.2	4.1	10.3	14.6

Velo ghosts in v35r0p1 back to - DC06 level (w/o efficiency loss)
(tuning of # of holes & hit errors, for details see T-Rec 30.03.09, O. Callot)

Work on Velo Fit (in pattern recognition) ongoing (David H.)
better parameter estimate for HLT (RMS reduced by 5-10%)

All other (T-station) improvements presented last LHCb week,
were tuned for the buggy samples ... they do not help here.

More work is ongoing, however $\nu = 1$ samples very similar to
DC06, not much room for improvement.

First Look on Physics Samples

Compare $B_d \rightarrow J/\psi K_s$ events:

- DC06, reprocessed with Brunel v34r7
- $\sim 40\text{k}$ MC09, $\nu = 3$ events; $\equiv 2000$ reconstructed events (private production)

DaVinci v23r0, standard biased selection:

```
$CCBARROOT/options/DoDC06SelBd2JpsiKS_Jpsi2MuMu_lifetime_biased.opts
```

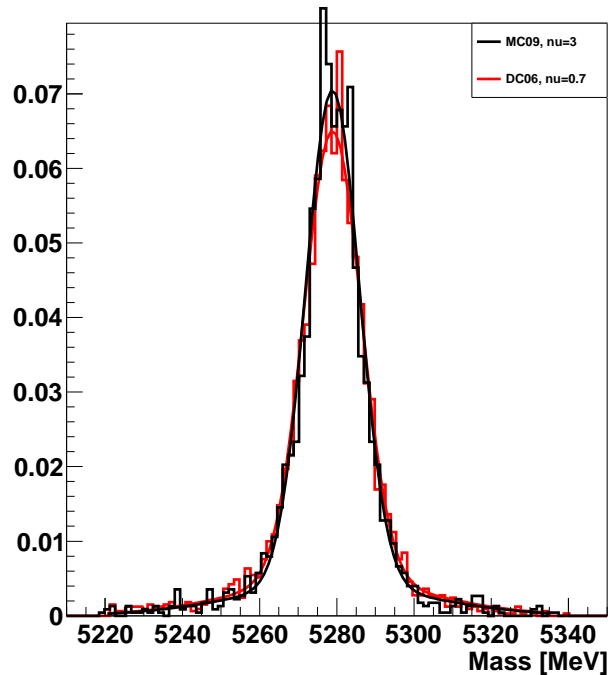
More detailed plots/numbers in next T-Rec meeting:

Sascha Stahl: $B_d \rightarrow J/\psi K_s$

Alexander Bien: $B_s \rightarrow J/\psi \phi$

Mass & Proper time Resolution

Mass resolution
(double Gaussian):



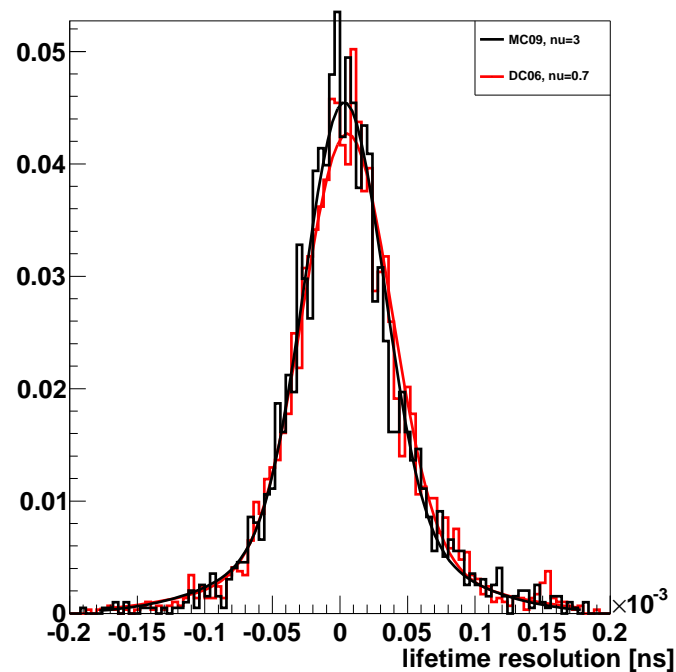
DC06 $\sigma \sim 13.2$ MeV

MC09 ($\nu = 3$): $\sigma \sim 12.4$ MeV

Proper time resolution:
(double Gaussian)

DC06: 49 ps

MC09 ($\nu = 3$): 45 ps



Profits from better momentum resolution.
(new GEANT version).

Trigger Efficiencies & Tagging Power

Trigger efficiencies	DC06	MC09 $\nu = 3$
$\epsilon\left(\frac{off. rec}{generated}\right)$	8.5%	5.9%
$\epsilon\left(\frac{off. rec \& L0}{off. rec}\right)$	94.2%	94.9%
$\epsilon\left(\frac{off. rec \& L0 \& HLT1}{off. rec \& L0}\right)$	94.7%	94.9%
$\epsilon\left(\frac{off. rec \& L0 \& HLT1 \& HLT2}{off. rec \& L0 \& HLT1}\right)$	96.7%	90.0%
fraction of non-assoc B candidates	4.2%	7.8%

→ K_S reconstruction

→ higher ghost rate

uncertainties $\pm 0.5\%$

Drop in HLT2 efficiency comes from J/ψ trigger; not related IA rate (as well present in $\nu = 1$ samples)! ... under investigation (Johannes A.)

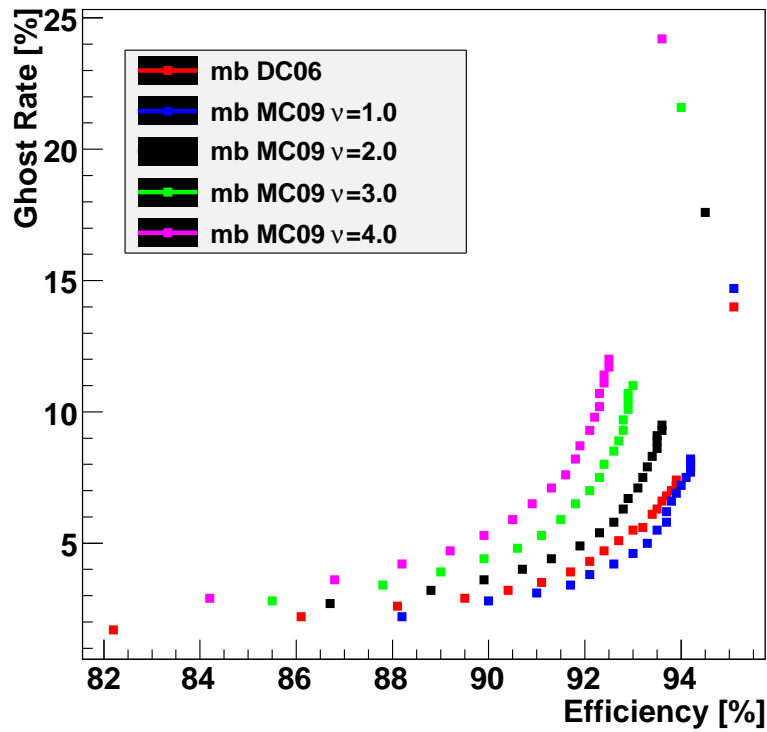
Tagging Power	DC06	MC09 $\nu = 3$
ω	36 %	39 %
ϵ	53 %	55 %
ϵ_{eff}	4.2 %	2.7 %

All numbers with any retuning!

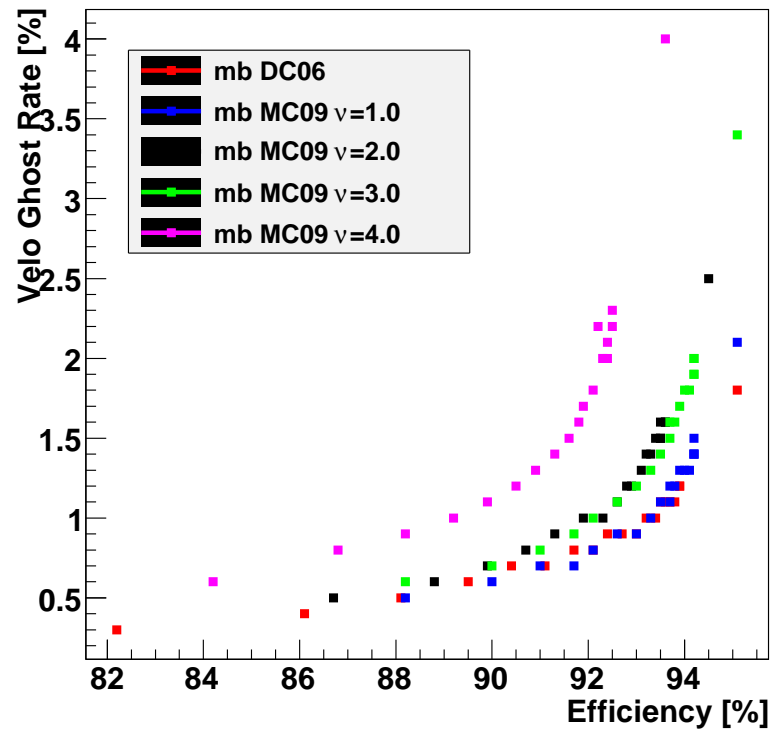
uncertainties $\pm 1\%$

- Bug in OT geometry fixed
→ significant impact on high lumi samples
- MC09 default ($\nu = 1$) slightly better than DC06
for $\nu = 2, 3, 4$ samples: similar ghost rates as DC06 can be obtained with drop of efficiency of 1-3% (w. offline tools)
- Work ongoing:
tuning likelihood, ghostprobability, algorithms
($\nu = 1$ very similar to DC06, no huge gain expected)
- First look at key physics quantities in $\nu = 3$ sample:
Very similar resolution as in DC06,
however reco & trigger and tagging need further investigation

Likelihood



all long track ghost



all long tracks with velo ghost part