A Brief History of Tagging

- CORNELIUS planned as framework for all tagging (multivariate, cut-based,...)
- N.O.T. (not optimal tagger) [in CORNELIUS and outside, later]
- NetTagger separate, neural-net based
- Physics-based vs optimal performance
- Elba Tagger
  - Four categories, two N.O.T, two NetTagger
  - Nearly optimal performance
  - Physics-based categories for best tags

New Framework

- Developed by Juerg Beringer
  - Discriminating variables (PID, momentum, etc.) are input to stand-alone taggers
  - Taggers are input to final neural net or to composite taggers
  - Allows implementation of N.O.T., NetTagger, Elba, etc.
  - Initial taggers:
    - Lepton (became three: electron, muon, kinematic)
    - Kaon (composite formed from best two K's from " KNet" + Nimp)
    - Slow Pion ($\approx$ QmaxPi)
    - Kaon- SlowPion (composite from Kaon + Slow Pion)
    - QMaxPstar: not yet actual tagger, but could be

BTagger

- Introduced by Juerg late summer 2001
- Multivariate analysis throughout
  - Developed and advocated by NetTagger team since Nov. 1998
  - Present in CORNELIUS even earlier
- Physics-based Output categories
  - As in CORNELIUS, N.O.T.
  - Beneficial for systematics, background fighting
  - Could have been done in NetTagger
- Same Q performance as NetTagger, better than Elba

Development of Moriond Tagger

- Derived from
  - BTagger
  - NetTagger and NetTagger+=NetTagger+physics-based output categories
- Convenor (RNC) considered each discriminating variable
- Each input neural net
- Each output category
- Used BAD's, presentations to Tagging Group
- Selected (and rejected [Nimp, XPmin]) various components
- Implemented by Juerg

Contributing Taggers

- Leptons
  - Some have e PID, some μ, some neither
  - All tracks with LNet > 0.5 have lepton ID though not required a priori
  - Make this explicit: Separate e, μ, no PID
  - Usual discriminating variables
    - p^*, E_{90}^W, $\cos(\theta_{miss})$
    - Each track studied in one of three lots: e, μ, NO lepton ID

- Kaons
  - Use PidKaonMicroSelector, which is built on Knet
  - Use three best ($\approx$ QmaxK, QmaxK2, QmaxK3) as input to composite kaon tagger
  - Let neural net figure out how to combine, rather than using sum
  - Do not use Nimp (number of high-impact parameter tracks) for now

Contributing Taggers

- Slow Pion Discriminating Variables
  - p^*
  - Angle θ_{thrust} between pion and direction of other tracks
  - Veto on kaon ID (can't hurt)

- Kaon - Slow Pion
  - Composite, from Slow Pion and Kaon
  - Use Slow Pion and Kaon outputs together with angle
  - Gives high-quality tag, probably low background

- Max p^*

Final neural net

- Inputs
  - electron tagger
  - muon tagger
  - kinematic lepton tagger
  - kaon tagger
  - slow pion tagger
  - kaon - slow pion tagger
  - max p^* tagger
- Nimp not used now, will be once better understood
- Final neural net determines tag and its quality

Output Categories

- Hierarchical

- Intermediate stage for detailed systematic studies
  - Lepton-Kaon (merge $eK + \mu K$)
  - Lepton (merge $e + \mu$)
  - Kaon - Slow Pion
  - Kaon I
  - Slow Pion
  - Kaon II
  - Other

- Consider categories from top down

- Merge into just four final categories for user tagging

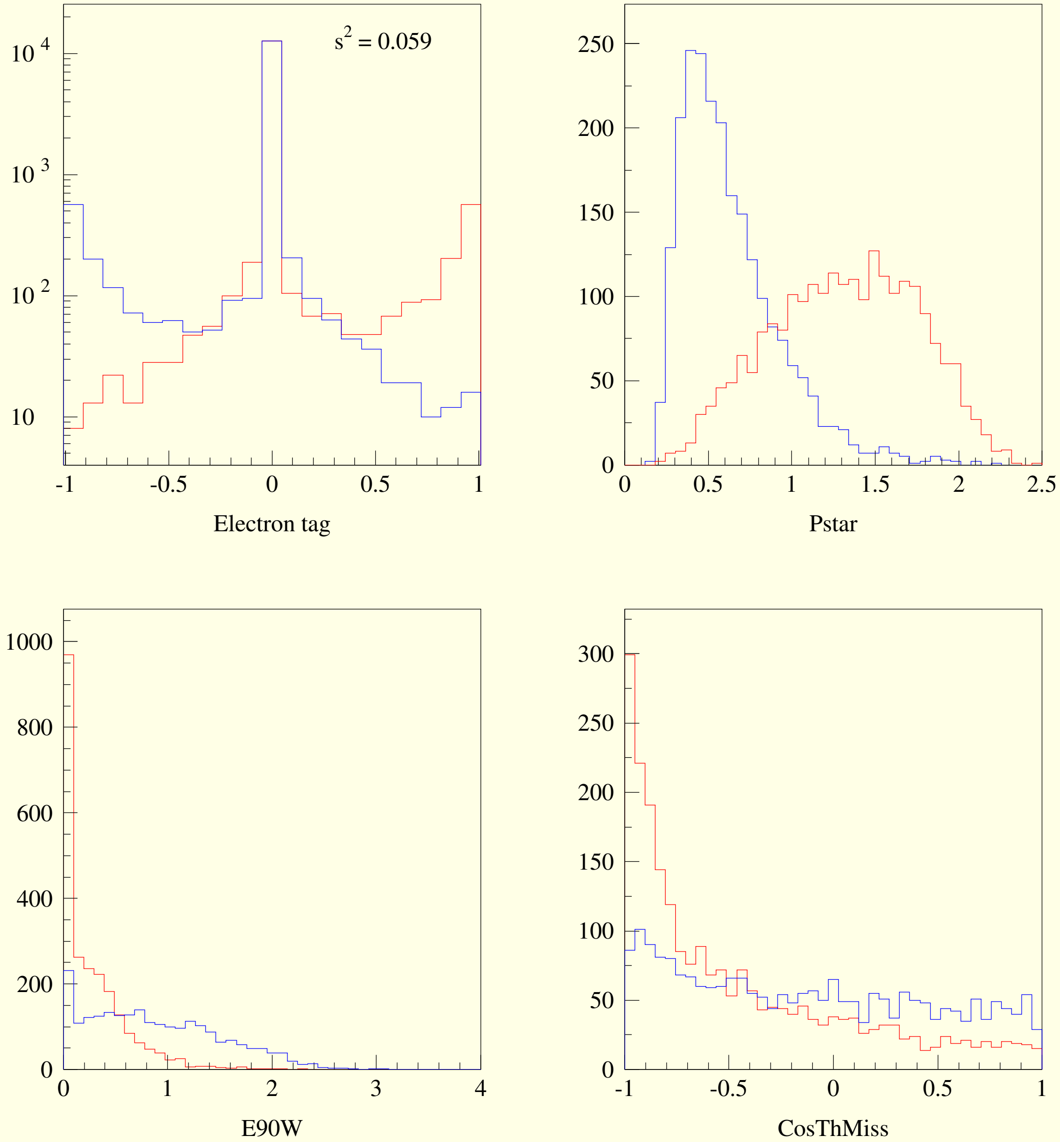
Definitions of Final Output Categories

Hierarchical: Put event into first category for which it qualifies

Category	Cuts on input tags	Cut on final tag
Lepton–kaon	$\lvert ElectronTag\rvert > 0.7$ and $\lvert KaonTag\rvert > 0.5$, or $\lvert MuonTag\rvert > 0.7$ and $\lvert KaonTag\rvert > 0.5$	$\lvert tag\rvert > 0.8$
Lepton	$\lvert ElectronTag\rvert > 0.7$ or $\lvert MuonTag\rvert > 0.7$	$\lvert tag\rvert > 0.8$
Kaon–slow pion	$\lvert KaonSlowPionTag\rvert > 0.1$	$\lvert tag\rvert > 0.8$
Kaon I	$\lvert KaonTag\rvert > 0.5$	$\lvert tag\rvert > 0.7$
Slow pion	$\lvert SlowPionTag\rvert > 0.1$	$\lvert tag\rvert > 0.5$
Kaon II	$\lvert KaonTag\rvert > 0.5$	$\lvert tag\rvert > 0.4$
Other	none	$\lvert tag\rvert > 0.2$

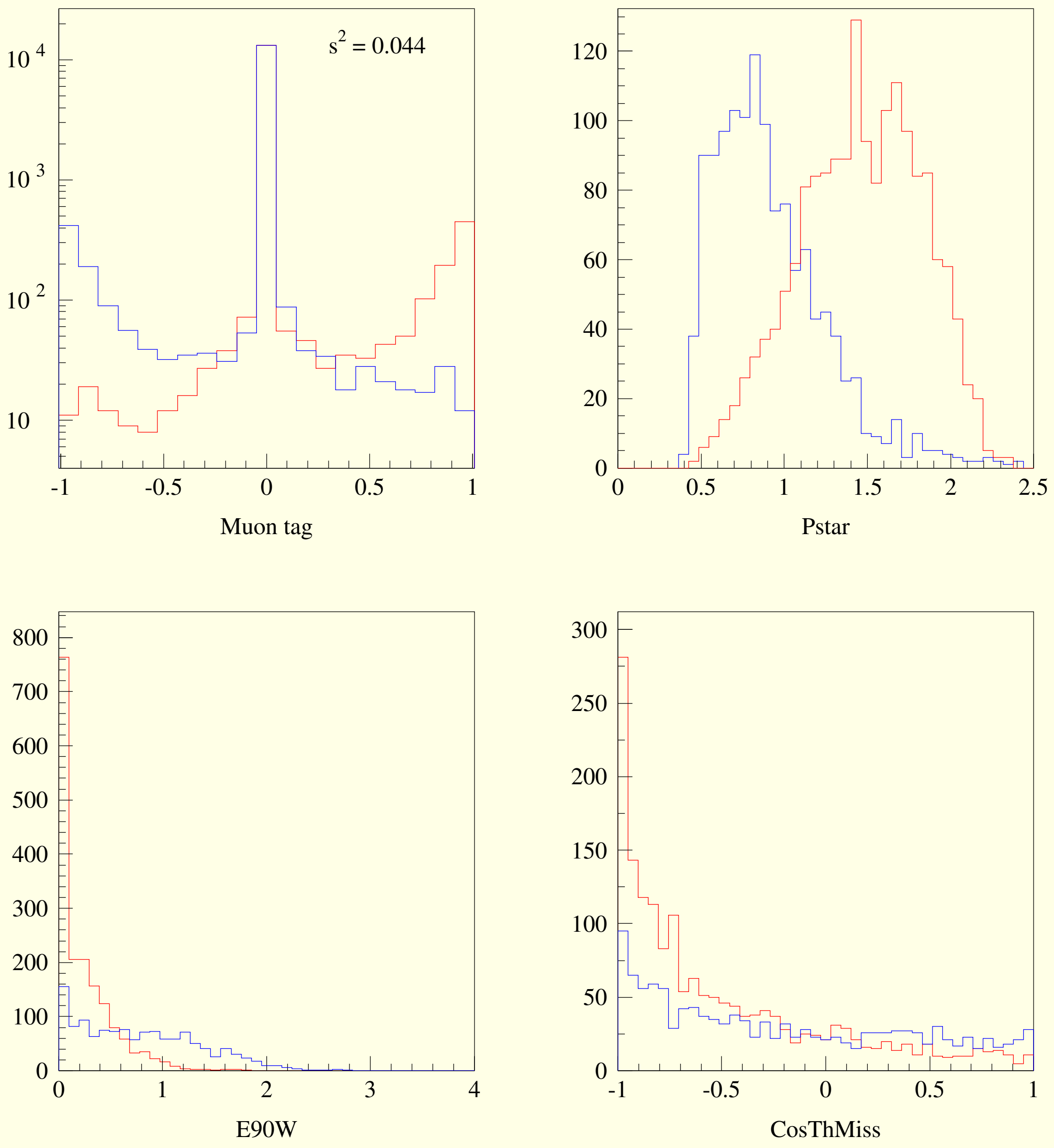
The four indicated super categories are used in final tagging.

Electron Tag Performance



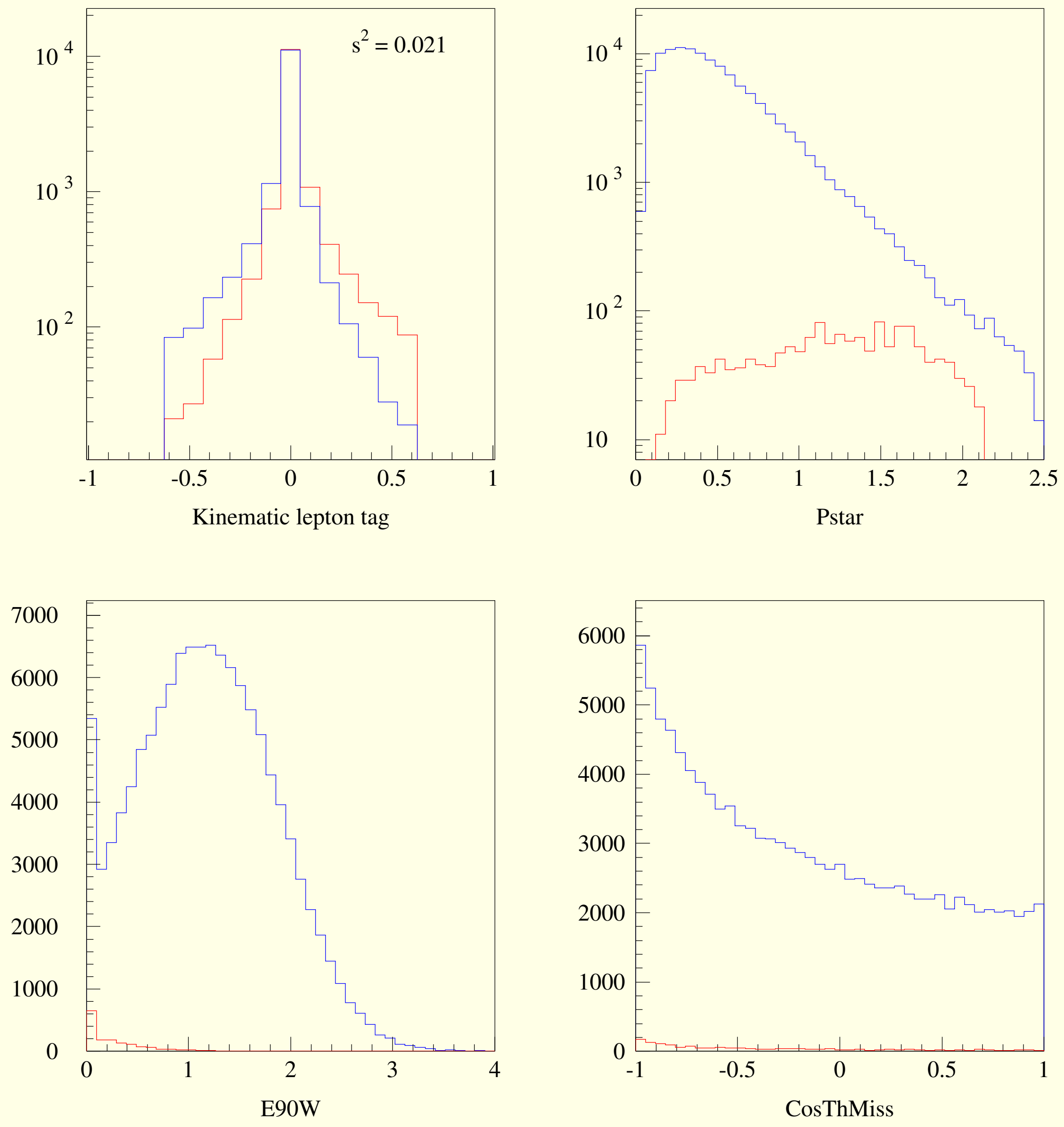
- Neural Net Output ($s^2 = 0.059$)
- p^*
- E_{90}^W
- $\cos\theta_{miss}$

Muon Tag Performance



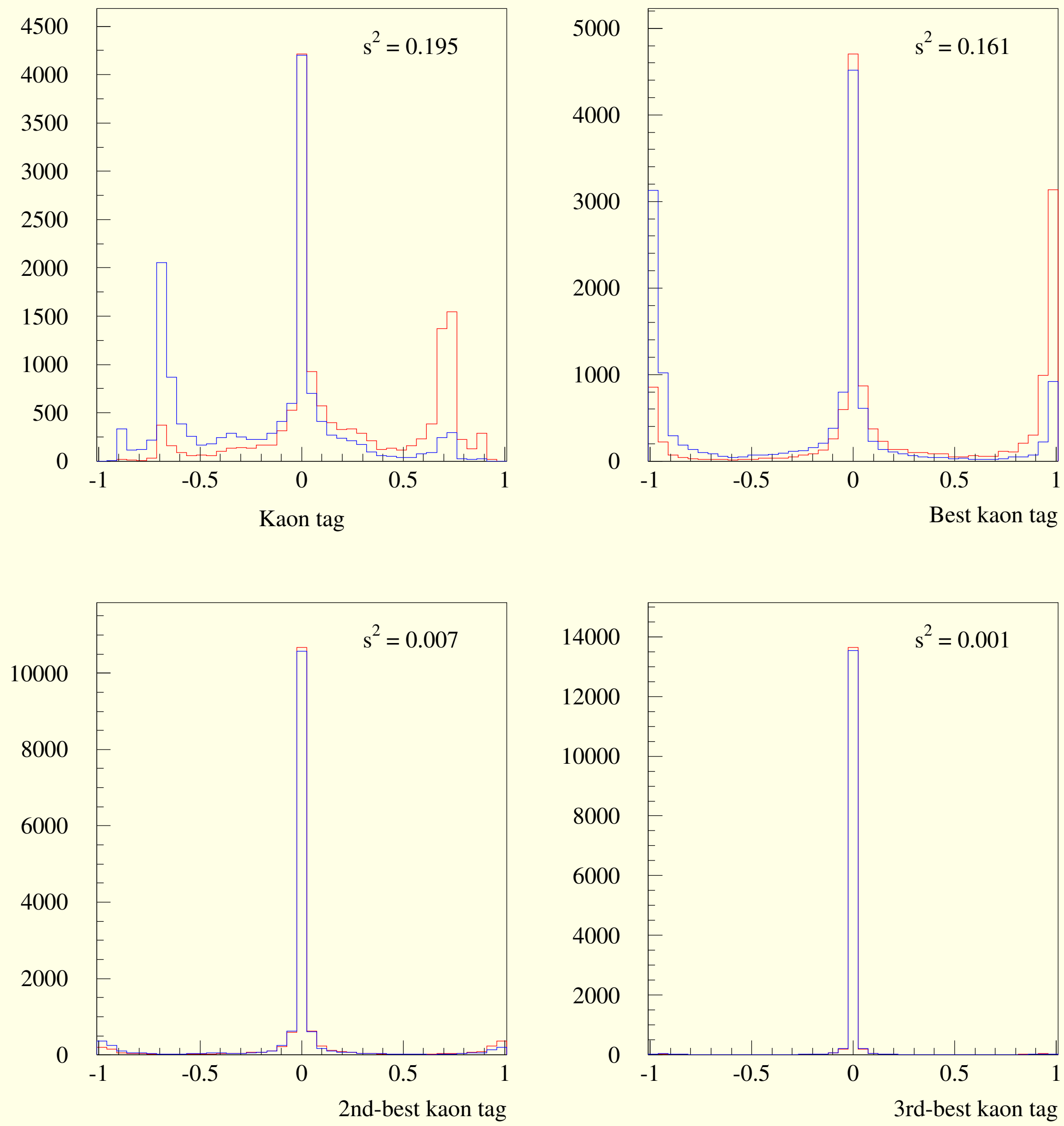
- Neural Net Output ($s^2 = 0.044$)
- p^*
- E_{90}^{W}
- $\cos\theta_{miss}$

Kinematic Lepton Tag Performance



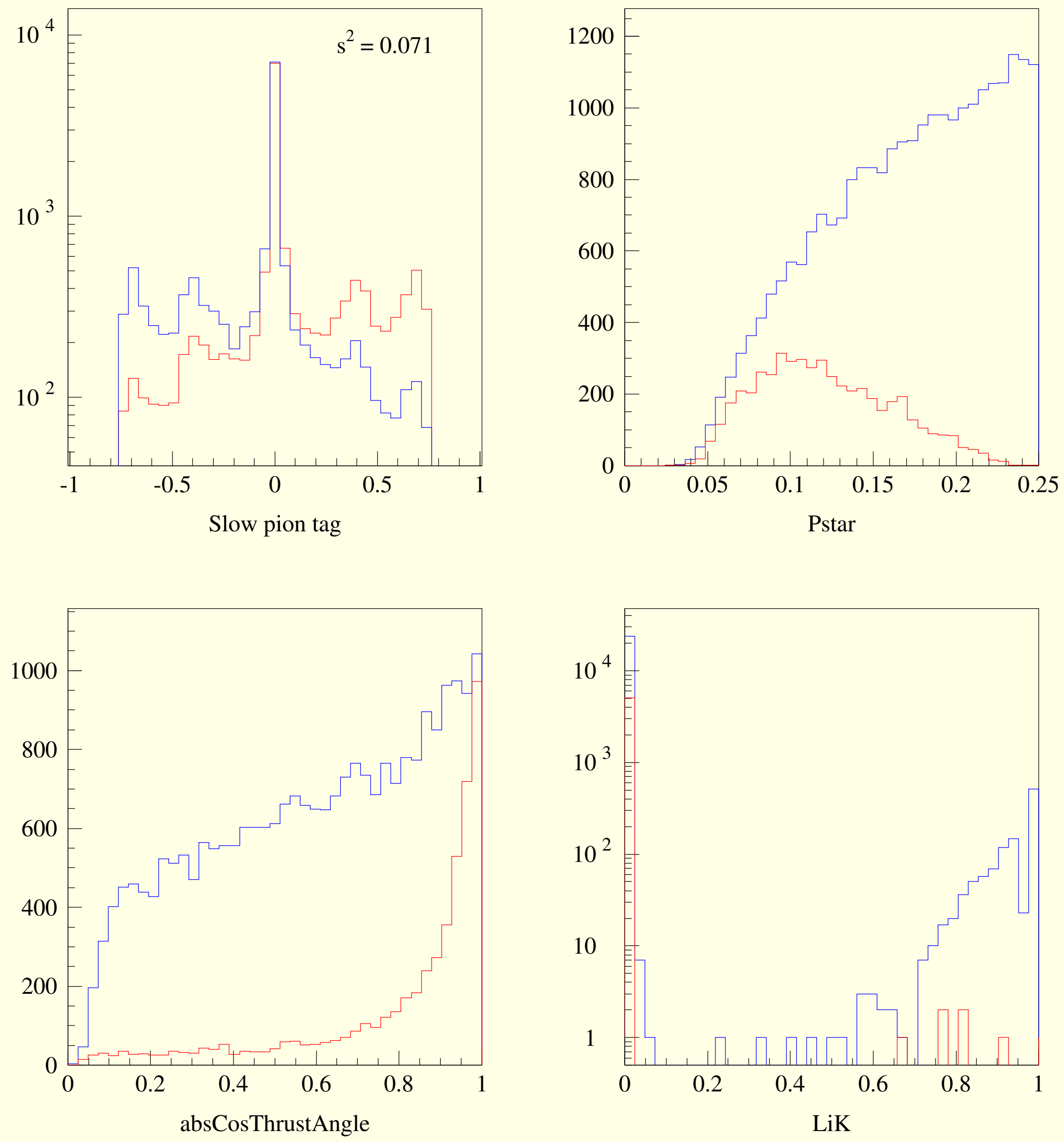
- Neural Net Output ($s^2 = 0.021$)
- p^*
- E_{90}^W
- $\cos\theta_{miss}$

Kaon Tag Performance



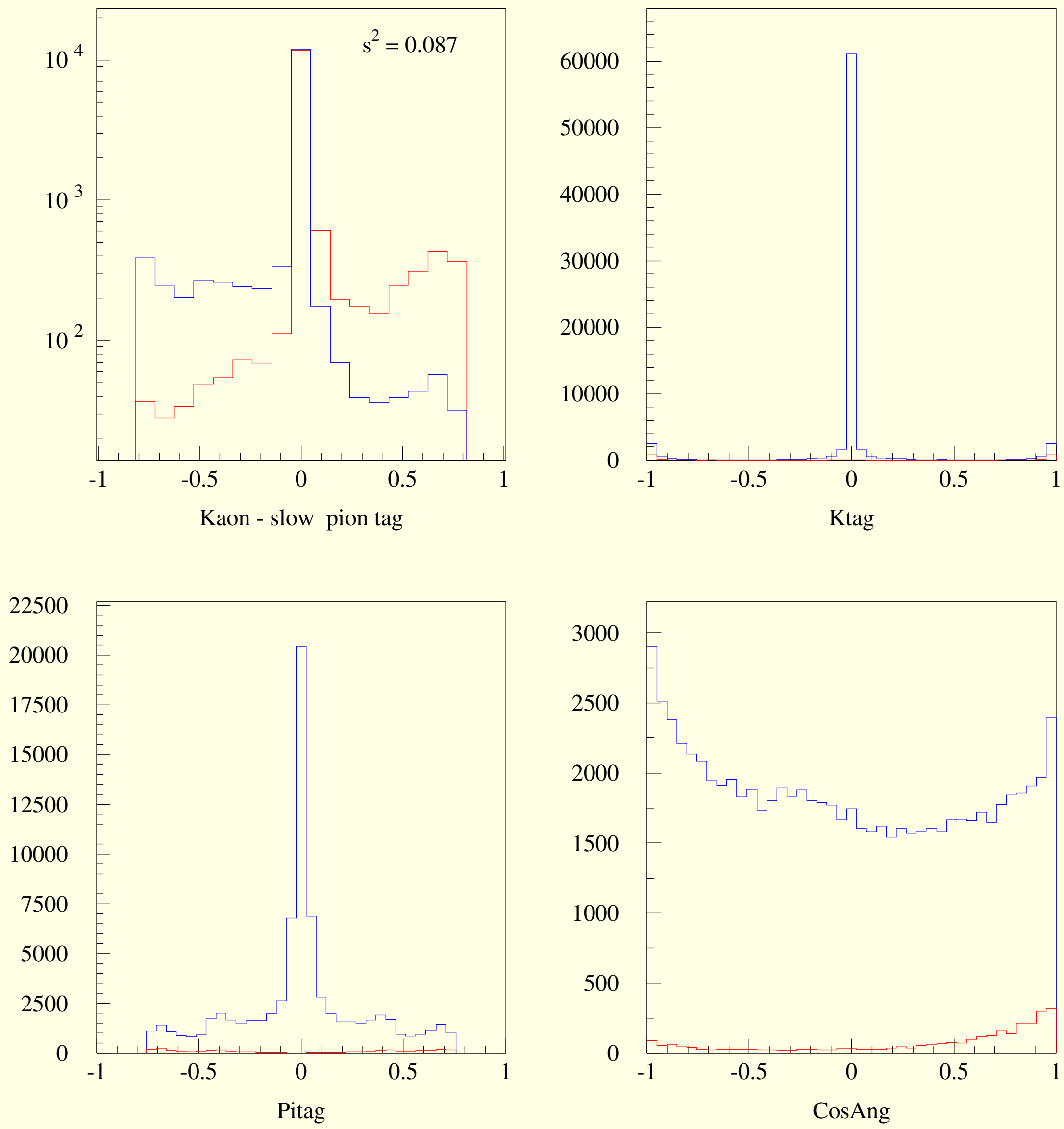
- Composite Neural Net Output ($s^2 = 0.195$)
- Best kaon tag ($s^2 = 0.161$)
- Second Best kaon tag ($s^2 = 0.007$)
- Third Best kaon tag ($s^2 = 0.001$)

Slow Pion Tag Performance



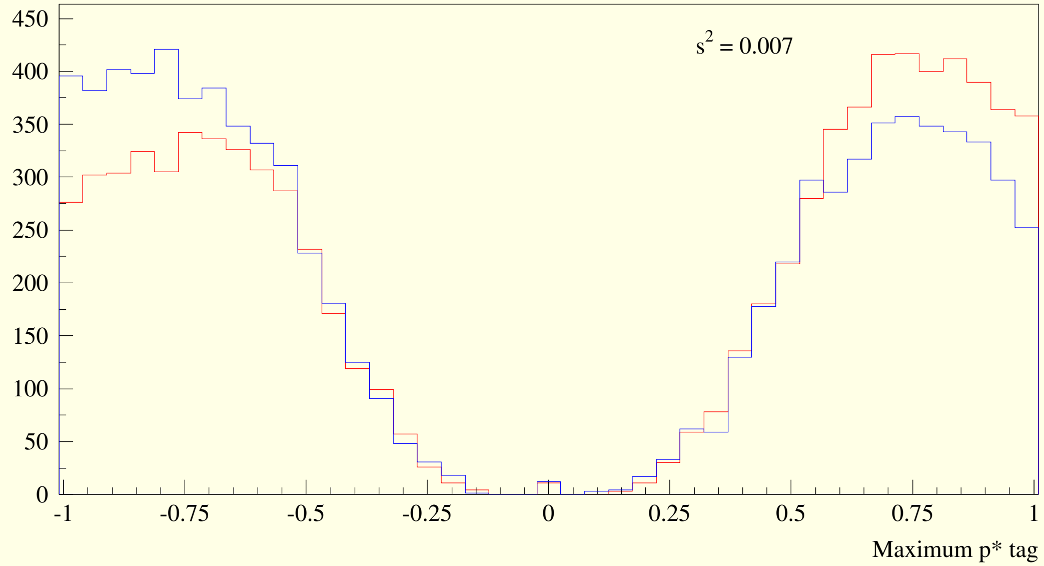
- Neural Net Output $(s^2 = 0.071)$
- p^*
- $\cos\theta_{thrust}$
- K likelihood

Kaon Slow Pion Tag Performance



- Neural Net Output ($s^2 = 0.087$)
- Ktag
- Pi tag
- $\cos\theta_{\pi K}$

Qmax p^* Performance



- Neural Net Output ($s^2 = 0.007$)

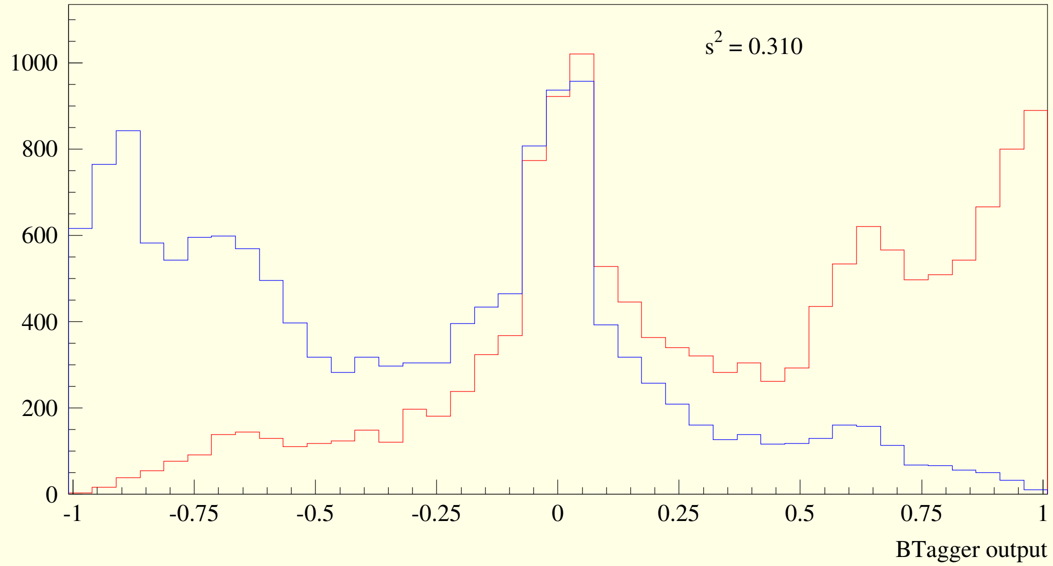
Moriond Tagger Performance Unmerged Categories

Category	$\epsilon(\%)$	$w(\%)$	$Q(\%)$
Lepton-Kaon	3.2 ± 0.1	0.4 ± 0.2	3.1 ± 0.1
Lepton	7.2 ± 0.1	3.7 ± 0.4	6.1 ± 0.2
Kaon-Slow Pion	6.3 ± 0.1	5.6 ± 0.5	5.0 ± 0.2
Kaon I	10.6 ± 0.2	10.7 ± 0.5	6.5 ± 0.2
Slow Pion	8.5 ± 0.2	19.1 ± 0.8	3.2 ± 0.2
Kaon II	10.8 ± 0.2	22.4 ± 0.8	3.3 ± 0.2
Other	21.0 ± 0.2	31.7 ± 0.6	2.8 ± 0.2
Total	67.5 ± 0.5		30.1 ± 0.5

Moriond Tagger Performance
Merged Categories

Category	$\epsilon(\%)$	$w(\%)$	$Q(\%)$
Lepton, Lepton-Kaon	10.4 ± 0.2	2.7 ± 0.3	9.2 ± 0.2
Kaon I, Kaon-Slow Pion	16.9 ± 0.2	8.8 ± 0.4	11.5 ± 0.3
Kaon II, Slow Pion	19.1 ± 0.2	20.4 ± 0.6	6.5 ± 0.2
Other	21.0 ± 0.2	31.3 ± 0.6	2.8 ± 0.2
Total	67.5 ± 0.5		30.1 ± 0.5

Moriond Tagger Performance
Multivariate



- Neural Net Output ($s^2 = 0.310$)

Directions for Use

- Required package tags
  - AbsBTagging jb-111701
  - BTaggingTools jb-111701
  - BTaggingUser jb-111701
  - BTaggingUtils jb-111701
- plus
  - BetaCoreTools V00-00-27
  - BetaMicroTruth V00-00-05
  - BetaPid jb-110701
  - CompositionFactory V00-00-12
- Packages depending on these tags should be recompiled.
- Get "BtgMoriondTagger" from the tagging factory.

Next Steps

- Additional validation
- Moriond Tagger BAD in preparation
- Use by mixing, $\sin 2\beta$, $\sin 2\alpha$ groups
- Important technical project: reading NN training from data files
  - Benefits all neural net taggers (Moriond, BTagger, NetTagger)
  - Simplifies framework: e.g. universal lepton tagger
- Try new ideas: easier in new framework
- Opportunities for new participants!