b-tagging at DØ

Experience, Performance, Lessons for LHC

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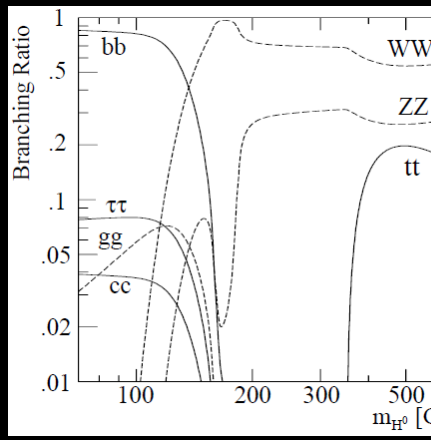
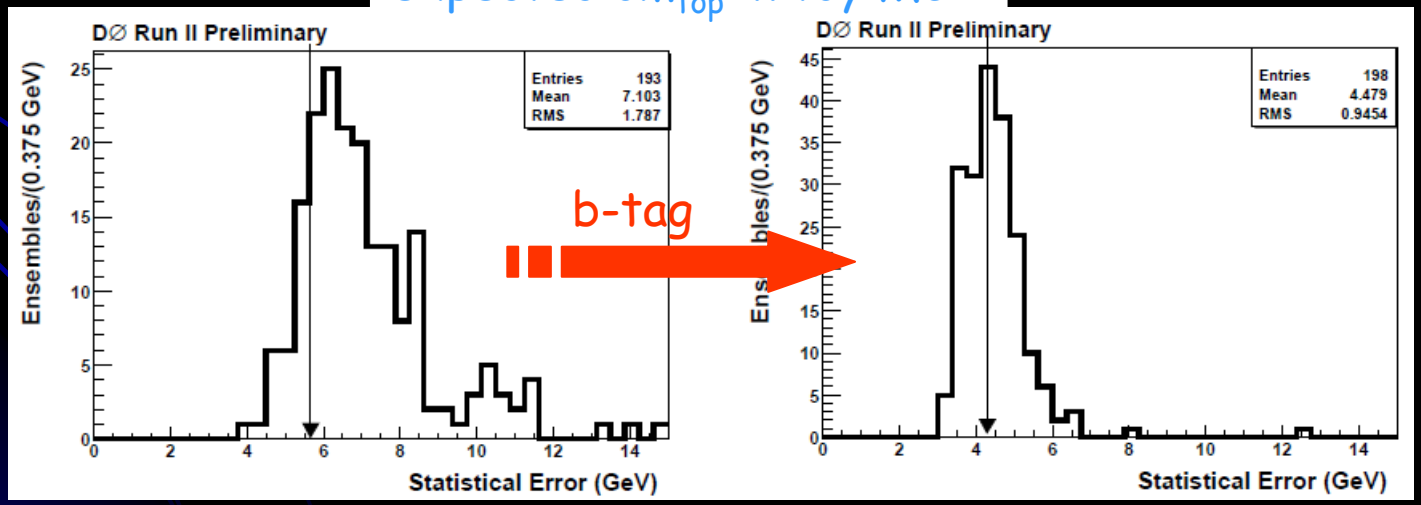
for the DØ collaboration

Motivation

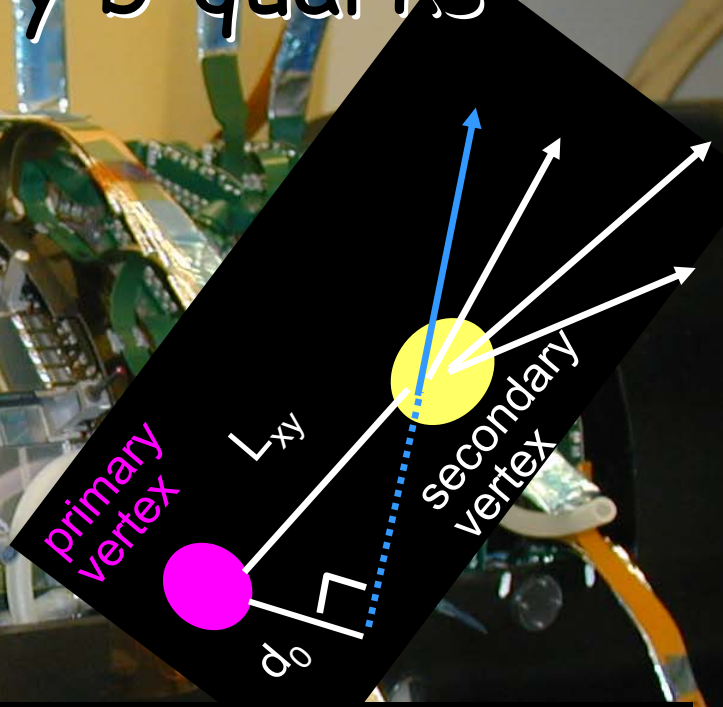
- Many high pt physics programs contain b-quark in final states
  - Low mass Higgs
  - Some SUSY signature
  - Br(t → bW) ~ 100%



expected δm_{top} in toy MC



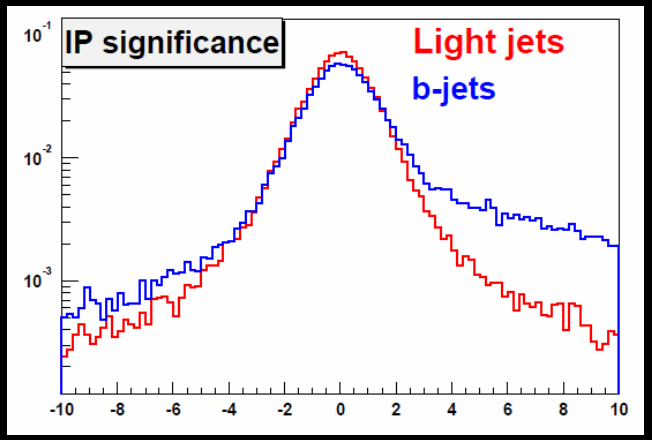
Idea to identify b-quarks

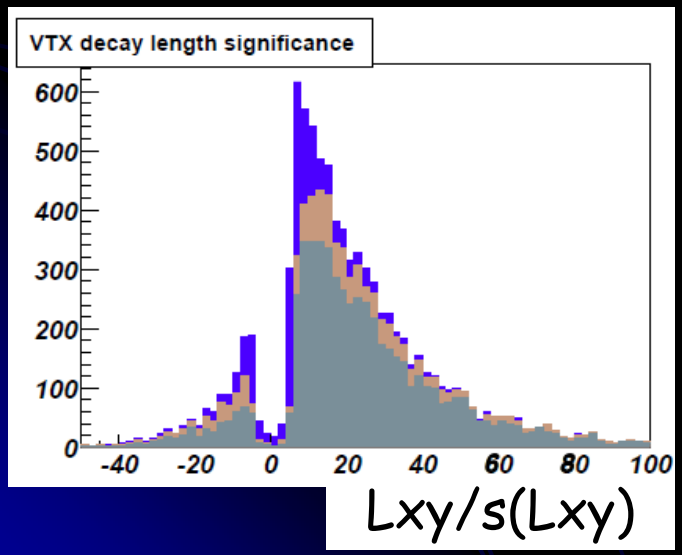


- $c\tau_{b\text{-hadron}}$ ~ 400-500 μm → travel by a few mm from primary ⟵ this talk
  - three algorithms, two based on $S(IP) = d_0/\sigma d_0$, one on $S(Lxy) = Lxy/\sigma(Lxy)$, with V^0 (Ks etc.) removal
- Soft lepton tagging [Br(b→lX)~11%]

Algorithm – CSIP & SVT

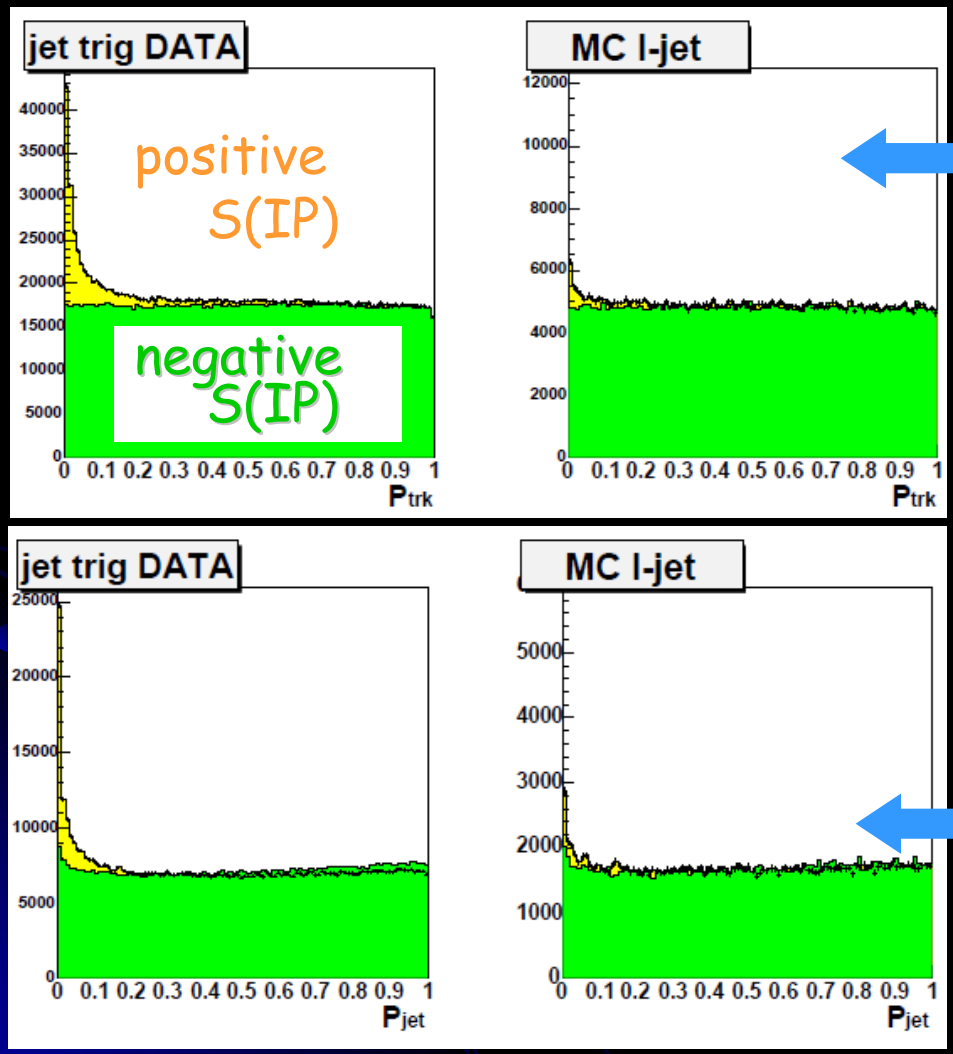
- CSIP: simple method
  - at least 2 tracks with S(IP) > 3
  - or at least 3 tracks with S(IP) > 2





- SVT
  - Secondary vertex (SV) from displaced tracks
  - Require direction from PV to SV same as jet
  - Cut on Lxy/σ(Lxy)

Algorithm – JLIP



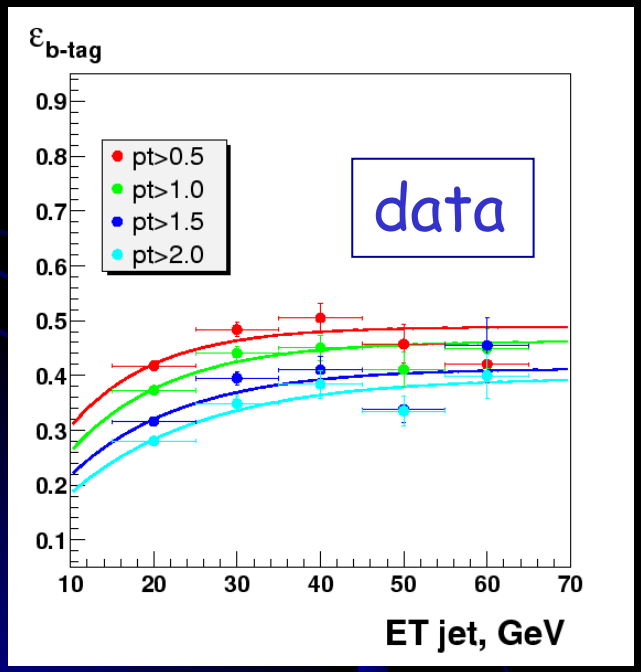
- Probability [=P(PV)] for a track coming from PV based on S(IP): many classification based on tracker's hit, pt, configuration, etc.
- Combine P(PV) in a jet to form a light jet probability

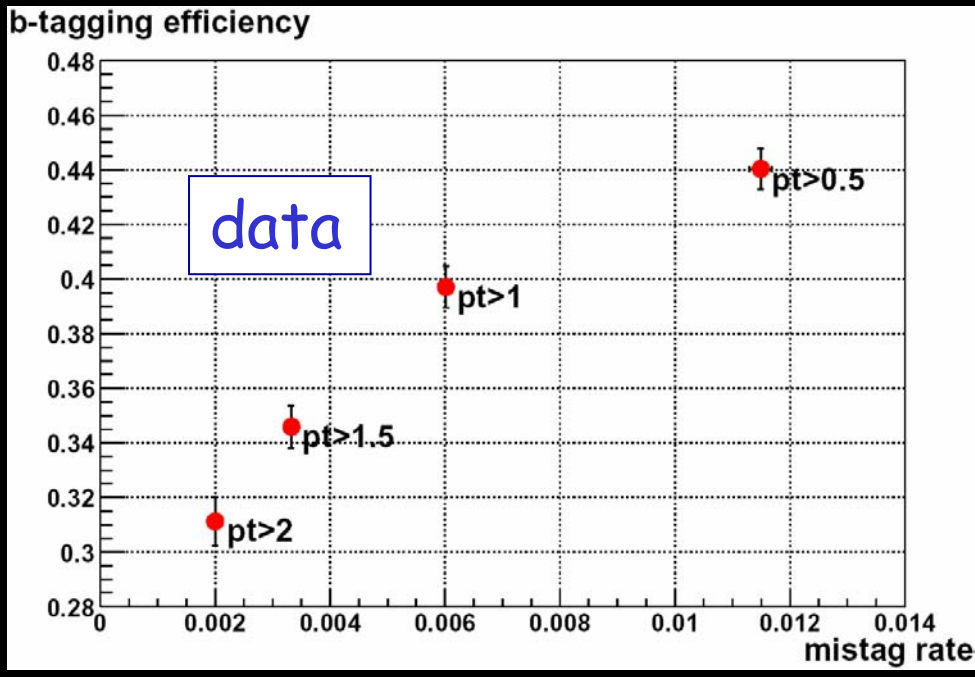
Measurement of efficiency

- Two data sample with different b fractions
  - muon+jet, muon+jet & opposite jet tagged
- Needs two different taggers
  - tagger to be tested & muon tagger
- Solve 8 equations for 8 unknowns (= #signal, #BG, efficiency,tag rate for BG for each sample, and each tagger)
- Rely on mostly data
- MC input is very little
- With respect to "taggable" jets

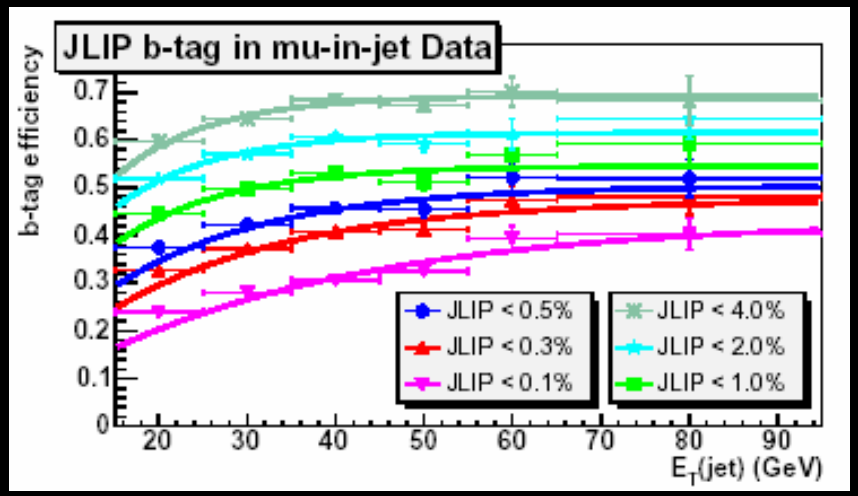
CSIP performance

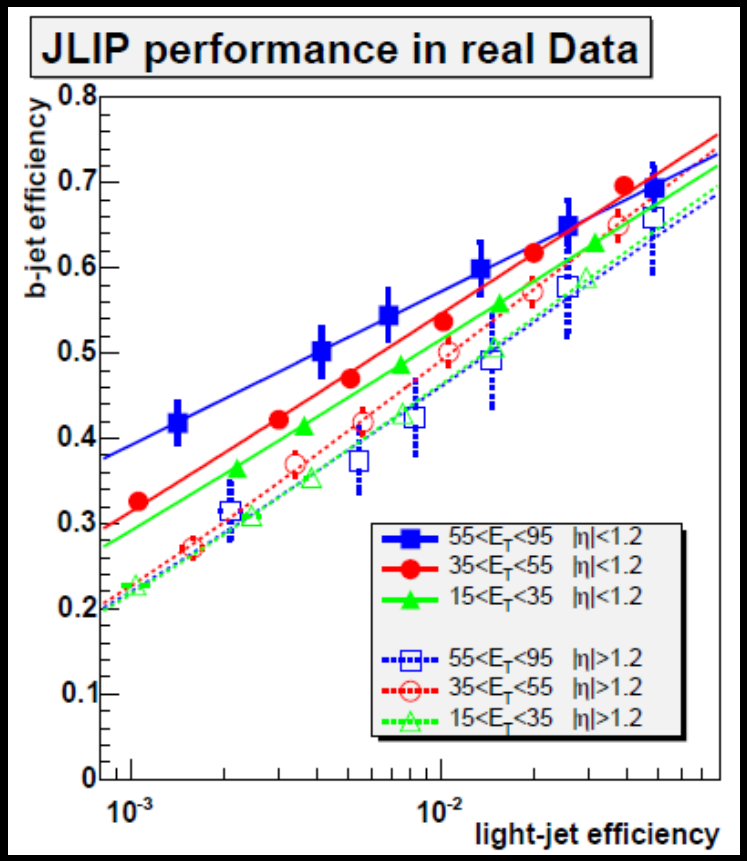
- 4 different operating points
  - Required S/N depends on physics analysis, ex. one loose vs two tight





JLIP performance

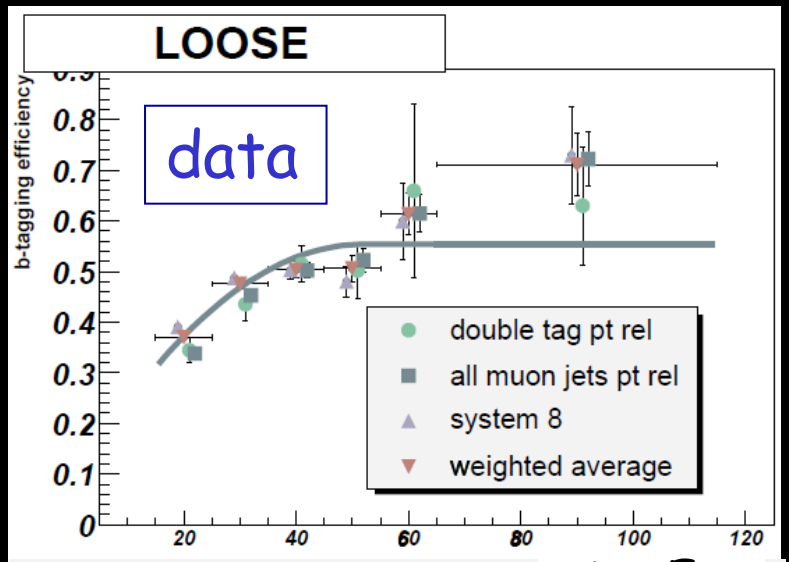


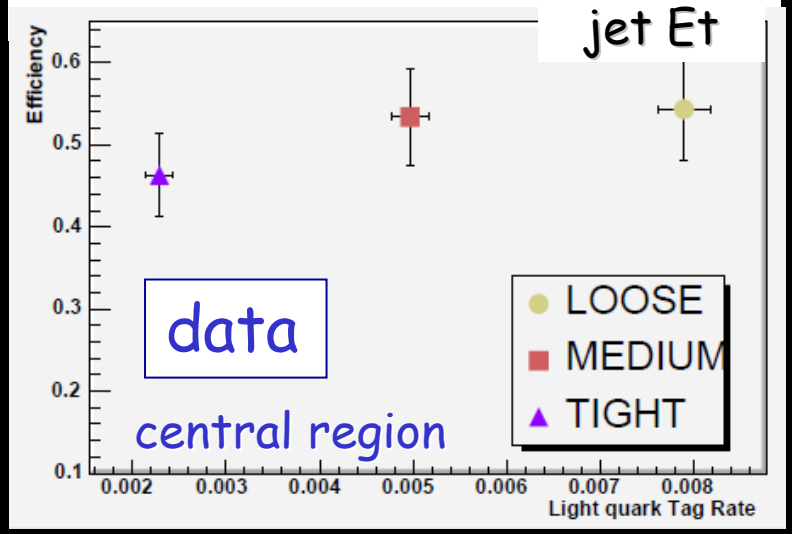


- 6 operating points

SVT performance

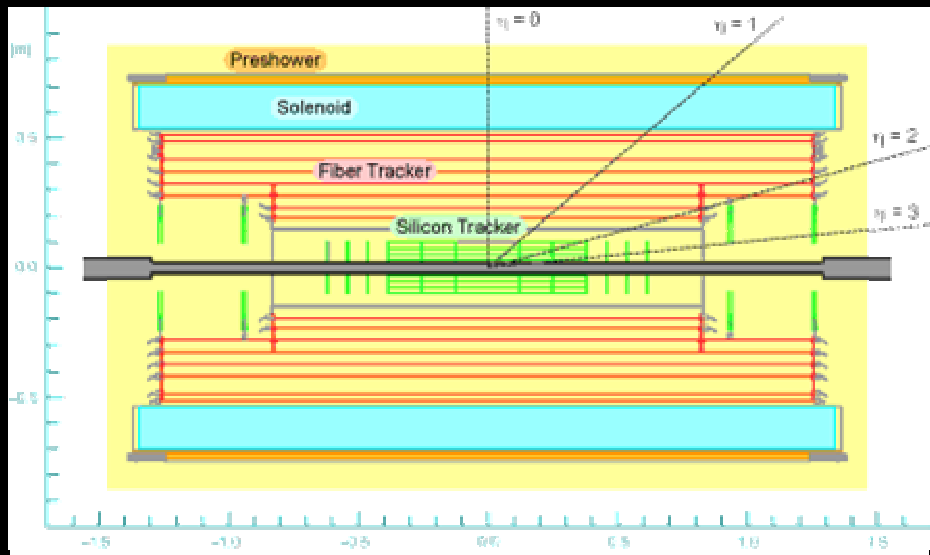
- 3 operating points
  - reconstruction of secondary vertex becomes rather tighter in construction than the other two

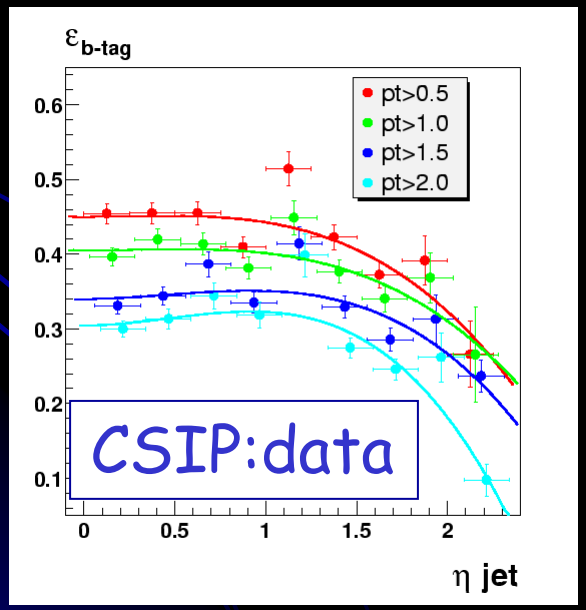


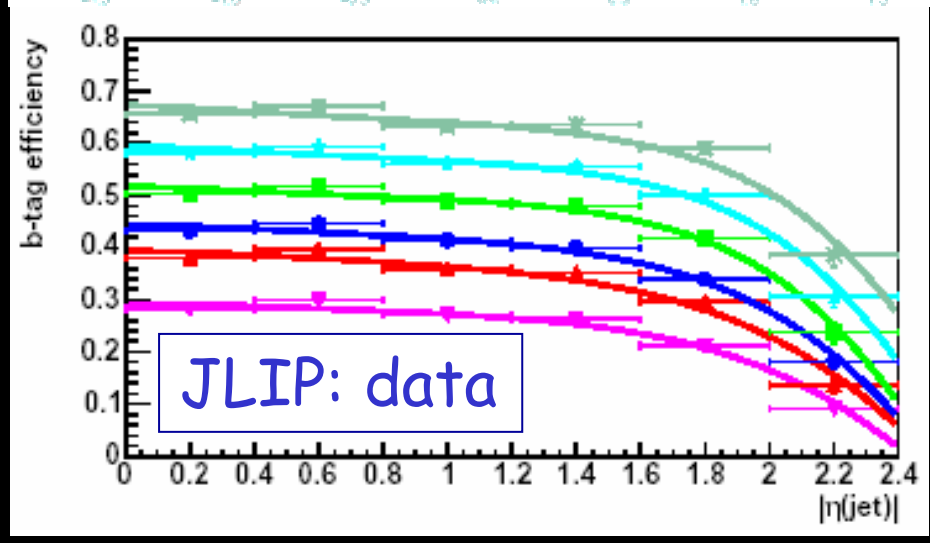


Large Coverarge

- Large acceptance thanks to excellent tracking coverage

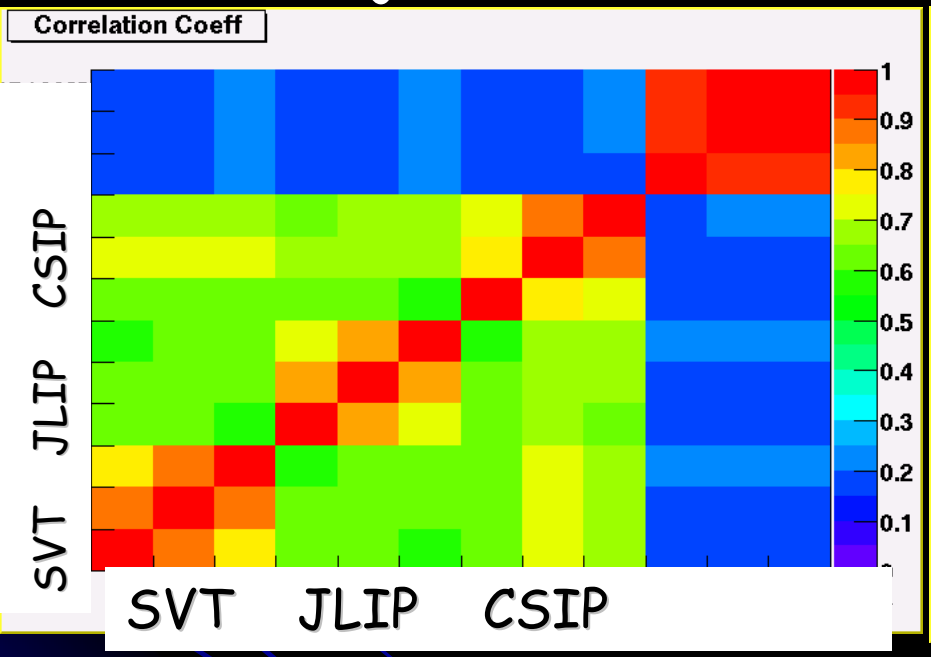




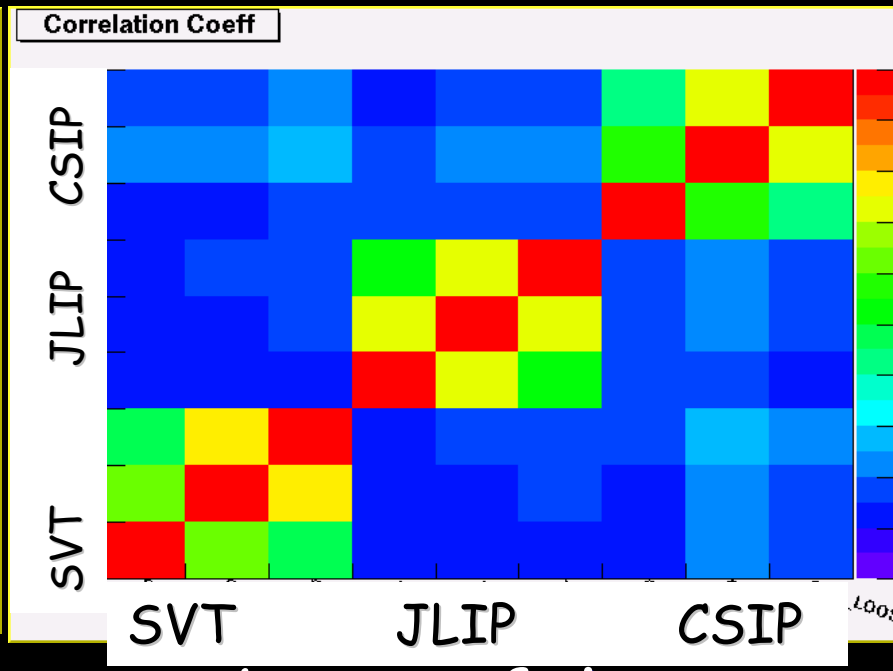


Correlation of three Taggers

μ + jet data



QCD data

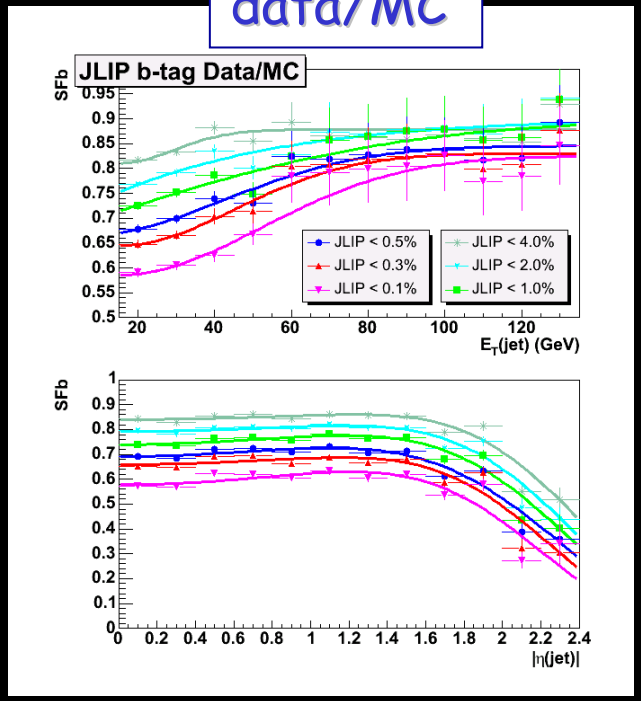


- Correlation in efficiency, but in fake
  ← improvement by combination
  - Very good progress

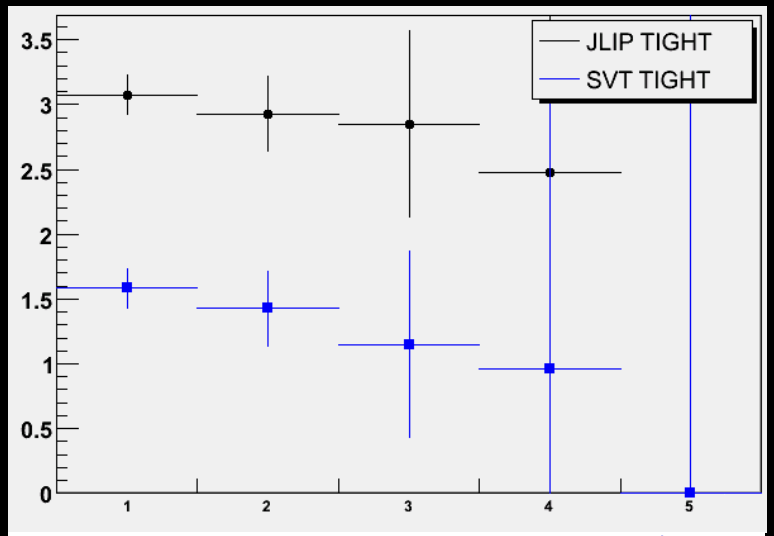
Issues

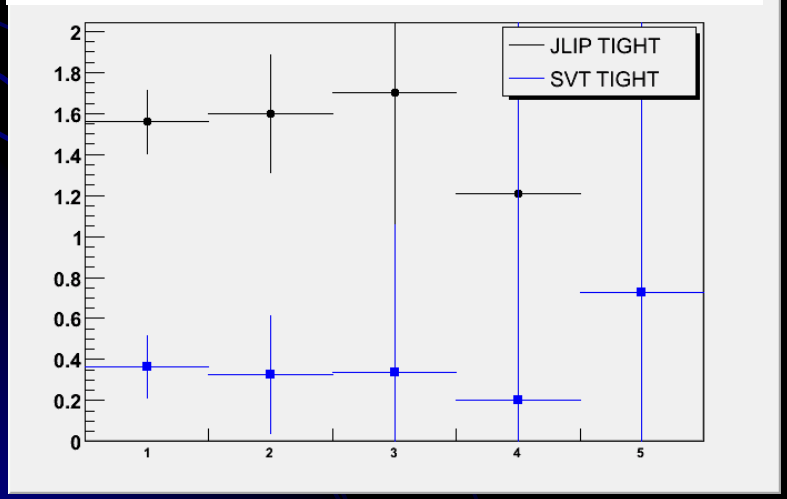
- No calibration source
  - muon + jet data are used, but not pure → understanding of systematics
  - t t-bar events for future (?)
- MC does not describe reality
  - 2-D parameterization (pt,η) in physics analysis
- Higher luminosity

data/MC



Towards higher luminosity





- Number of primary vertex as the measure of luminosity
- Efficiency drops

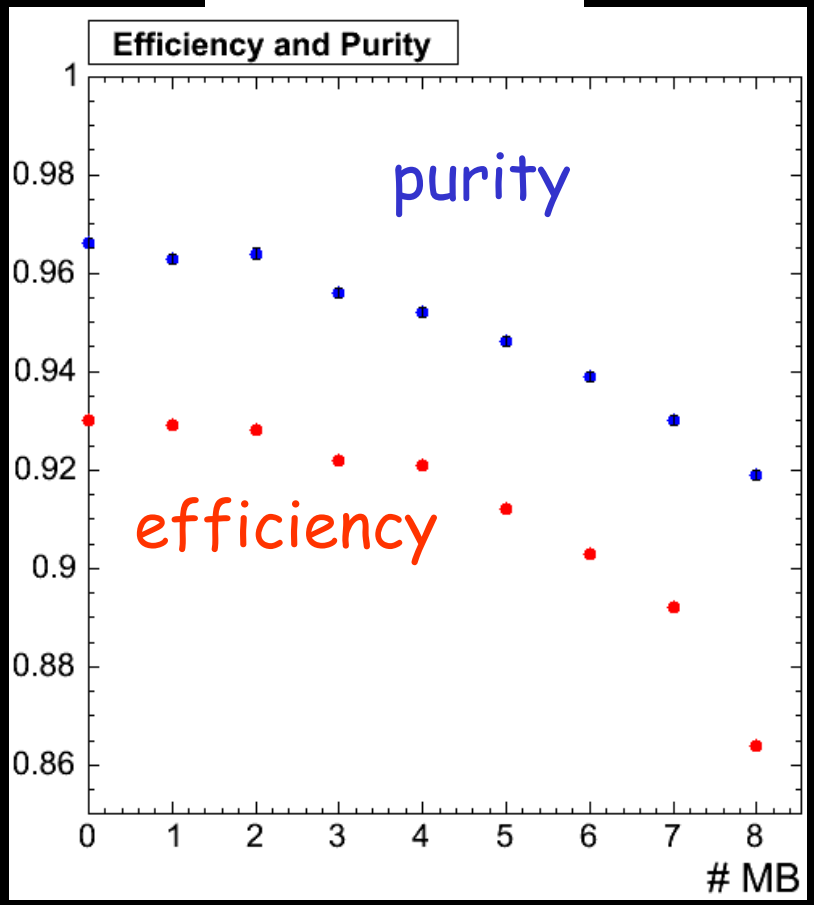
➔ Loss of S/N

- Detailed study not yet

Tracking

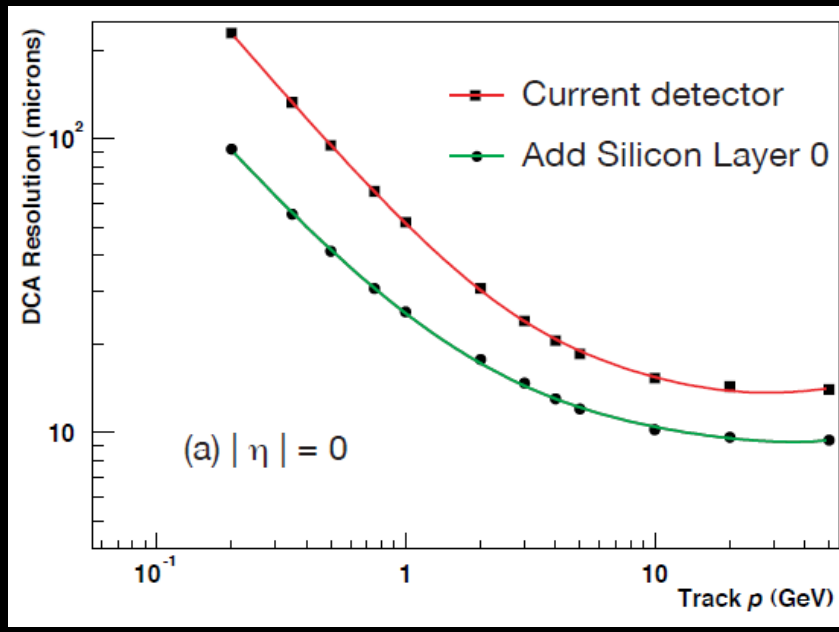
- Both purity and efficiency are affected by underlying events
- Effect will become more significant in future
- Some effects are already seen in data

t t-bar MC



The Future

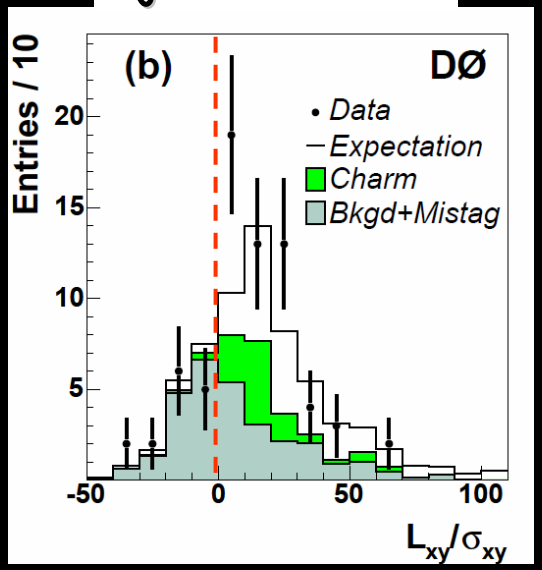
- Addition of SMT Layer 0
  - r@L1 = 2.7 cm → r@L0 = 1.6 cm : better impact parameter resolution
  - More redundancy in pattern recognition for higher luminosity
  - Keep functionality in case of degradation of Layer 1 due to radiation damage



Conclusions

- Excellent performance
  - Large acceptance
- A lot of physics results with b-tagging
- Some issues
  - No calibration source
  - Scale factor
  - Operation under higher luminosity
- Combination of taggers promising and in good progress

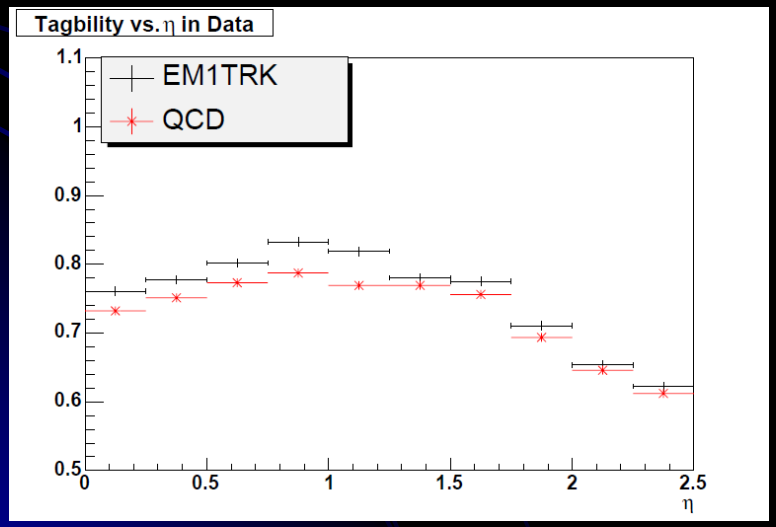
jets with Z

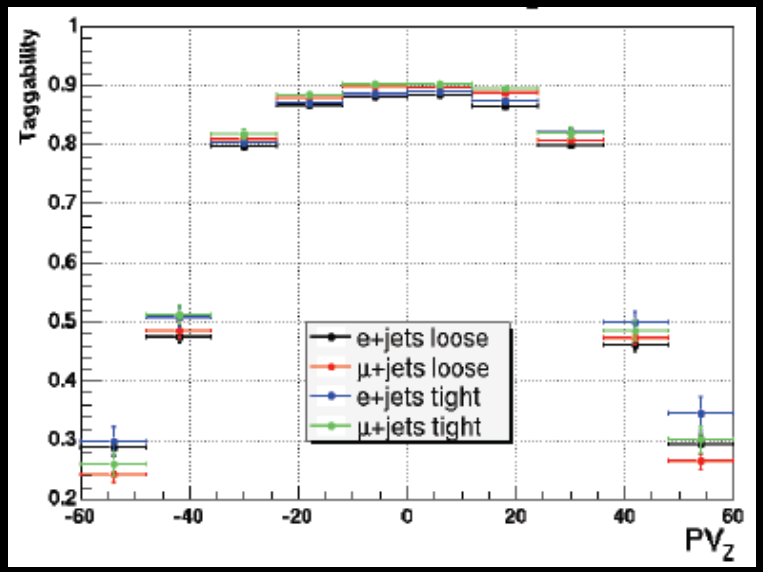


backup

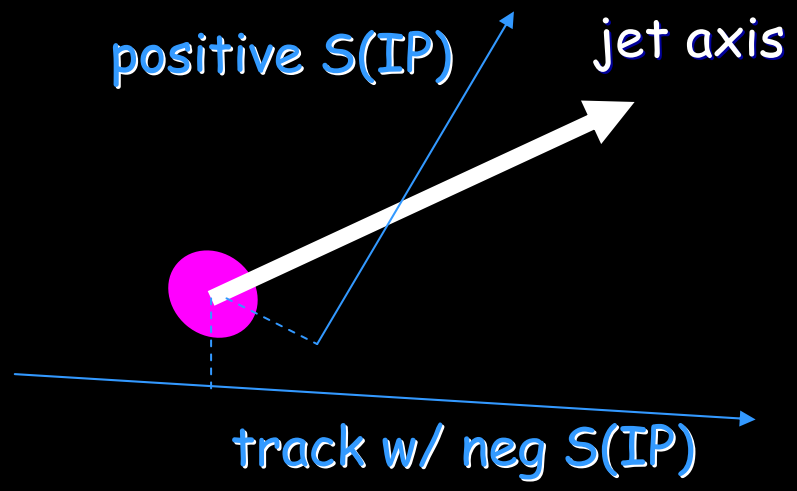
Taggability

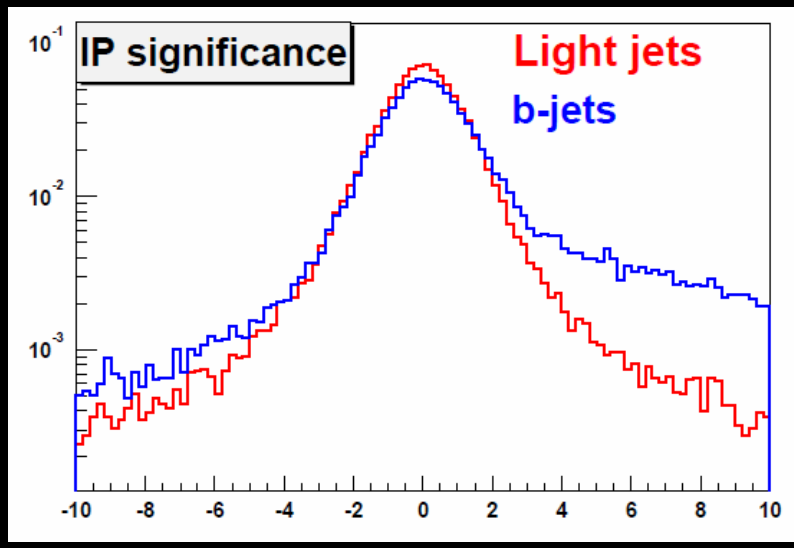
- Calorimeter jet && track jet
- Requirements to
  - remove fake jets due to calorimeter noise
  - select clean jets for comparisons of various algorithm





Measurement of fake rate

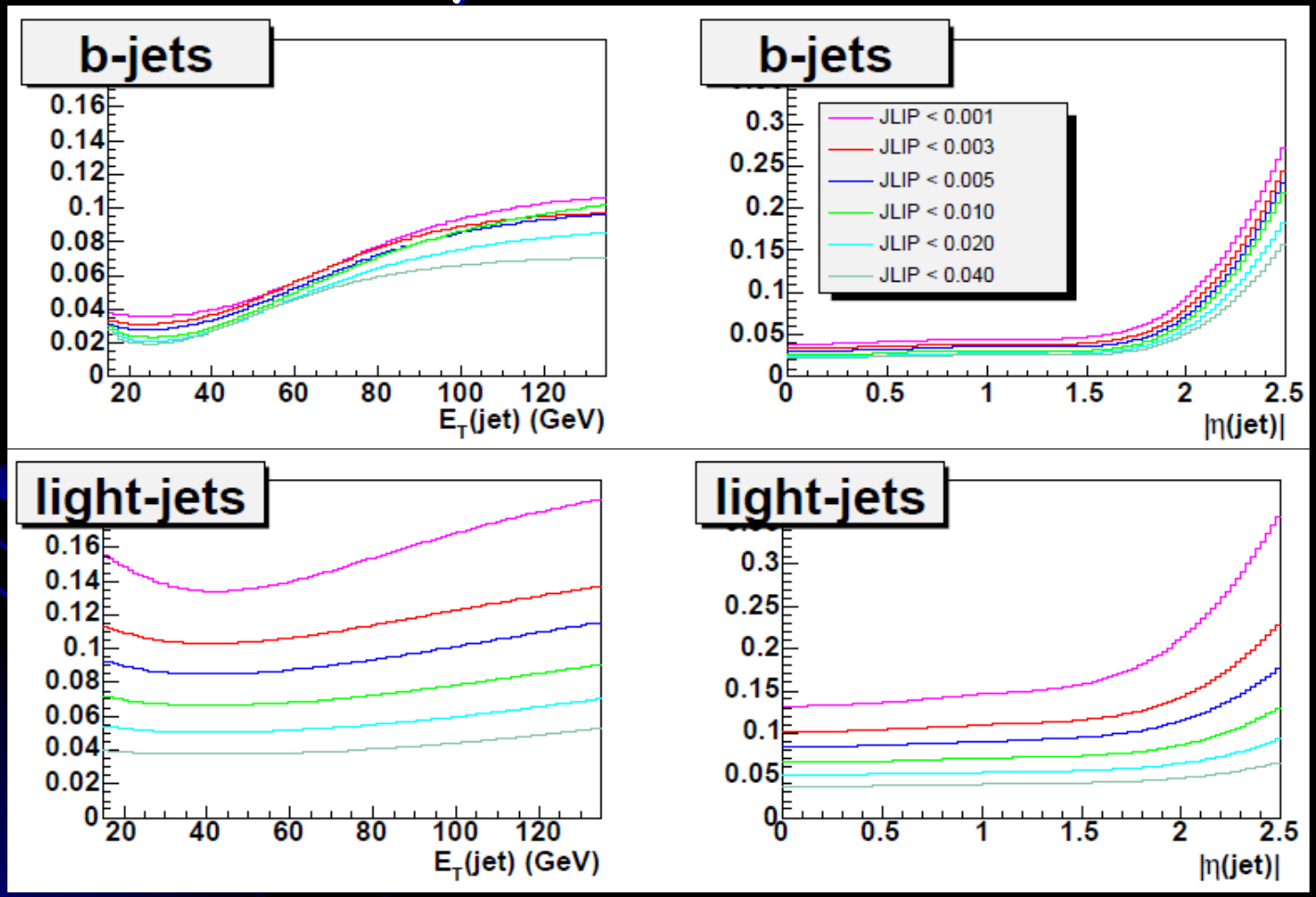




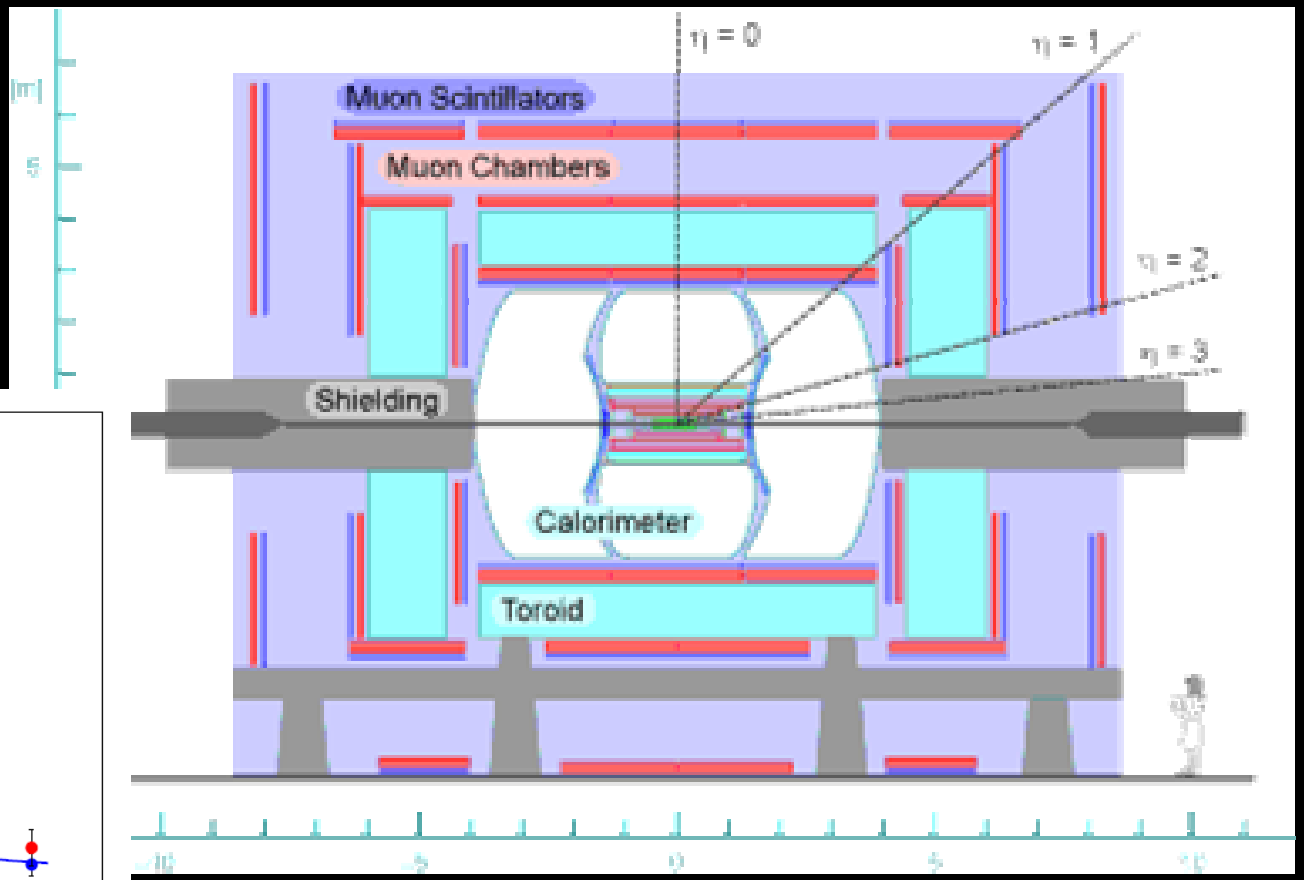
- S(IP) symmetric in S(IP)
  - negative S(IP) by resolution effect → good measure to estimate light jet tagging rate
- Two corrections from MC
  - S(IP) still asymmetric in light jets
  - b/c quark fractions

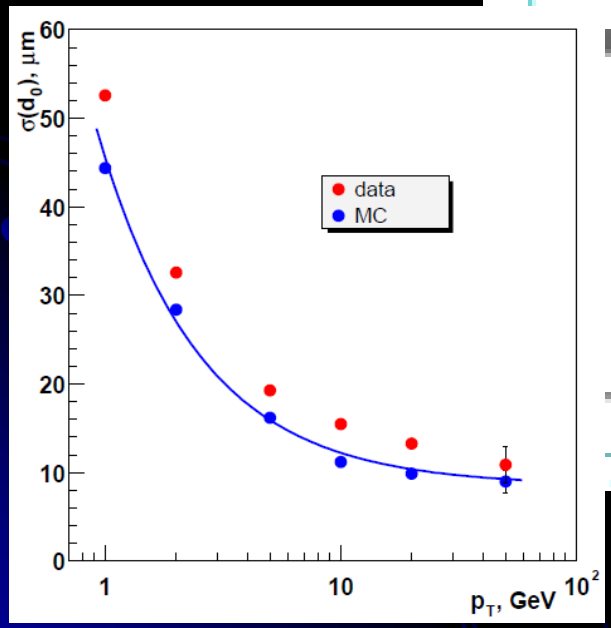
Systematic uncertainty

- statistical ⊕ systematic in JLIP

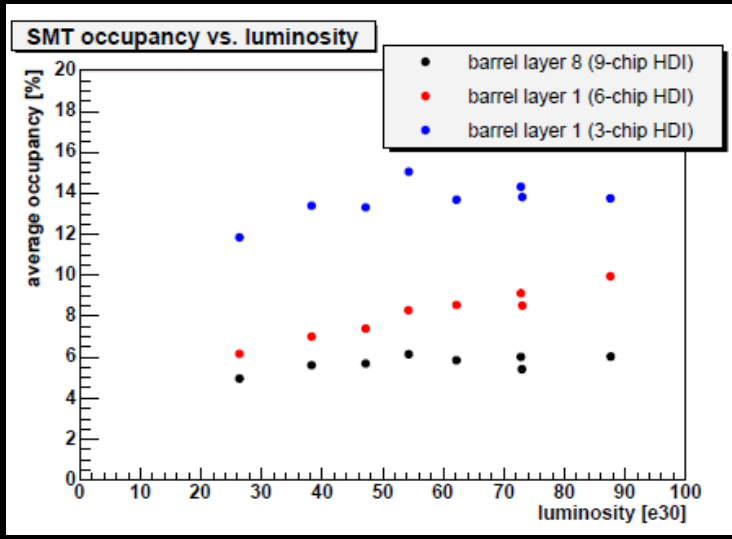


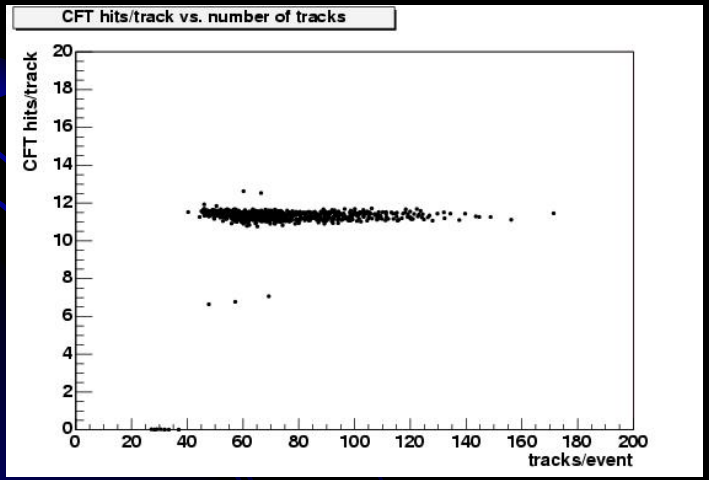
The detector

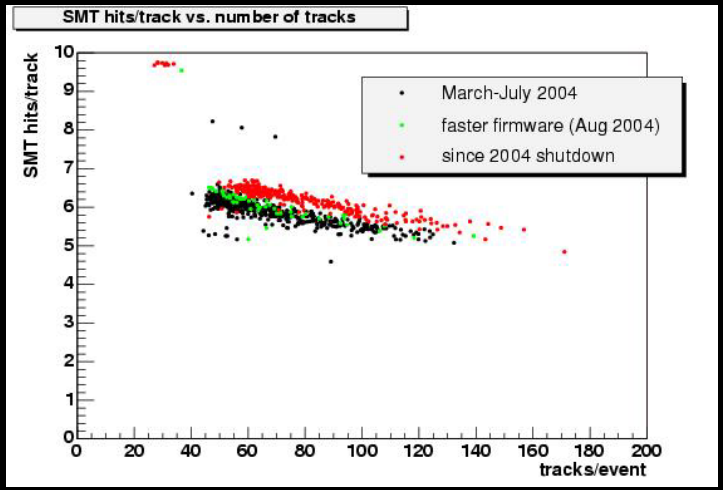




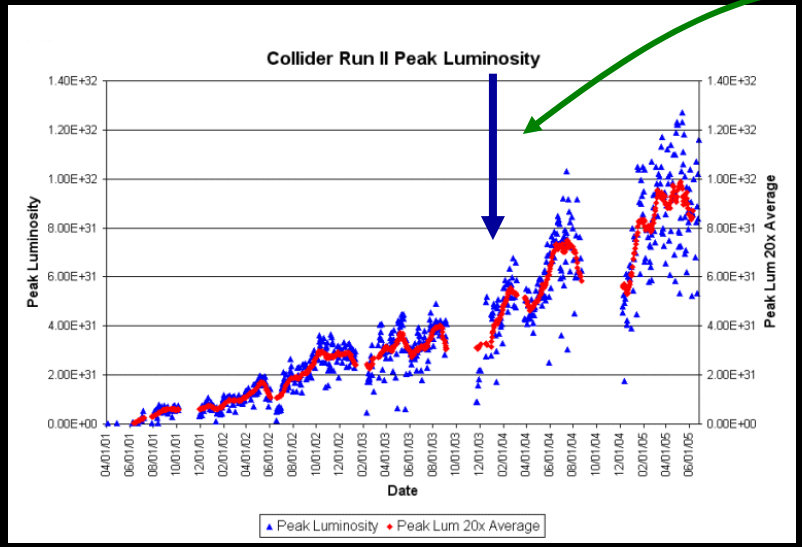
Tracker vs luminosity

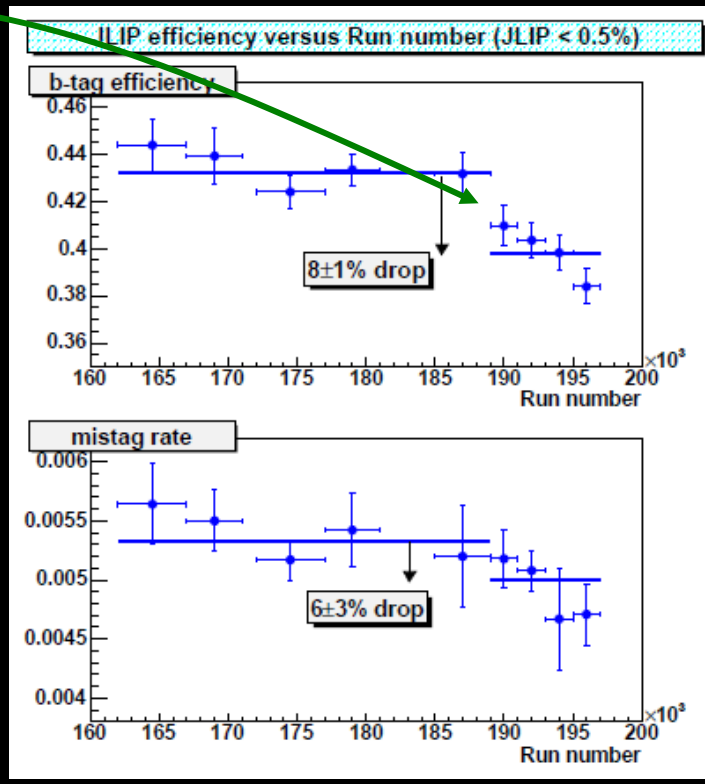






Run Dependence

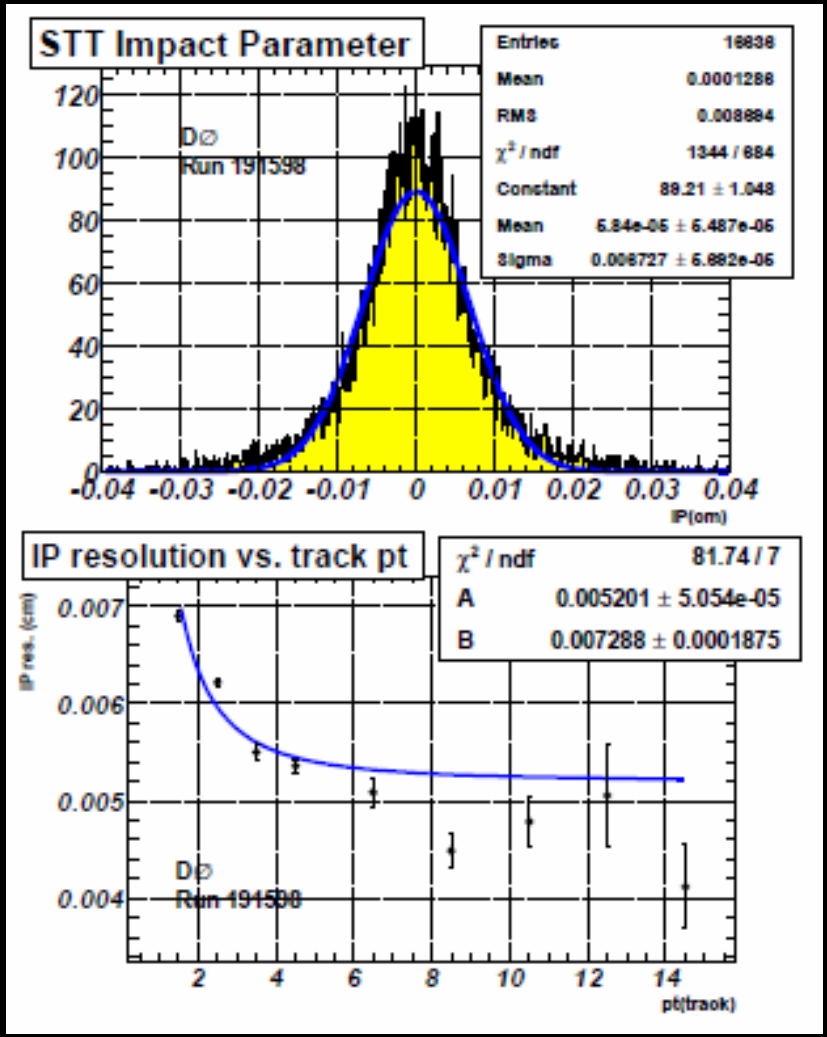




- Performance changes as increase of luminosity
  - No further study
    - luminosity effect, or aging of detector, or something else ???

System 8

$$
\begin{aligned}
n &= n_b + n_{cl} \\
p &= p_b + p_{cl} \\
n^{\mu} &= \varepsilon_b^{\mu} n_b + \varepsilon_{cl}^{\mu} n_{cl} \\
p^{\mu} &= \varepsilon_b^{\mu} p_b + \varepsilon_{cl}^{\mu} p_{cl} \\
n^{JLIP} &= \varepsilon_b^{JLIP} n_b + \varepsilon_{cl}^{JLIP} n_{cl} \\
p^{JLIP} &= \beta\, \varepsilon_b^{JLIP} p_b + \alpha\, \varepsilon_{cl}^{JLIP} p_{cl} \\
n^{\mu,JLIP} &= \kappa_b\, \varepsilon_b^{\mu} \varepsilon_b^{JLIP} n_b + \kappa_{cl}\, \varepsilon_{cl}^{\mu} \varepsilon_{cl}^{JLIP} n_{cl} \\
p^{\mu,JLIP} &= \kappa_b\, \beta\, \varepsilon_b^{\mu} \varepsilon_b^{JLIP} p_b + \kappa_{cl}\, \alpha\, \varepsilon_{cl}^{\mu} \varepsilon_{cl}^{JLIP} p_{cl}
\end{aligned}
$$

Silicon Track Trigger

- Not only CDF but also DØ has capability of triggering by displaced tracks