Search for the Standard Model Higgs Boson in $ZH \rightarrow \mu^+\mu^- bb$ Channel

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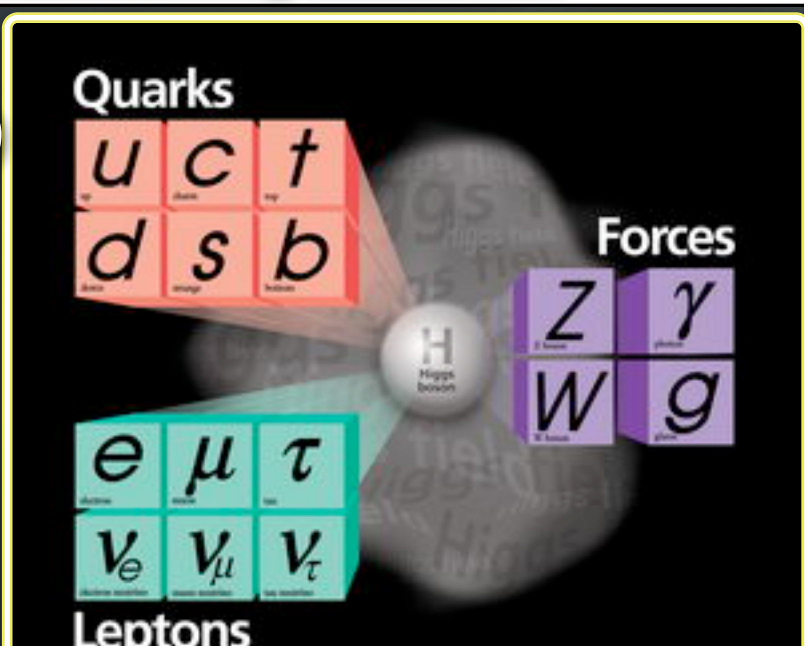
Outline

- **Introduction**
  - ◇ Standard Model (SM) and Higgs Boson (H)
  - ◇ Higgs Production & Search Strategies at Hadron Colliders
- **Experiment Apparatus: Hardware and Software**
  - ◇ Tevatron Collider and DØ Detector @ RunII
  - ◇ Event Reconstruction: DØ RECO
- **Backgrounds: Higgs-like Signals**
  - ◇ Signal Event Selection Criteria
  - ◇ Optimizations of the Criteria
    - ★ μ Isolation Probability and Di-μ Isolation Selection
    - ★ JLIP b-tagger & Double b-jet Tagging
- **Search for the Higgs Events**
  - ◇ Observed in Detector Data vs. Expected in Monte Carlo (MC)
  - ◇ Setting the Higgs Production Cross Section Limits
- **Summary and Prospects**
  - ◇ Combined Higgs Search Results of DØ
  - ◇ Future Plans

Standard Model: A Snapshot

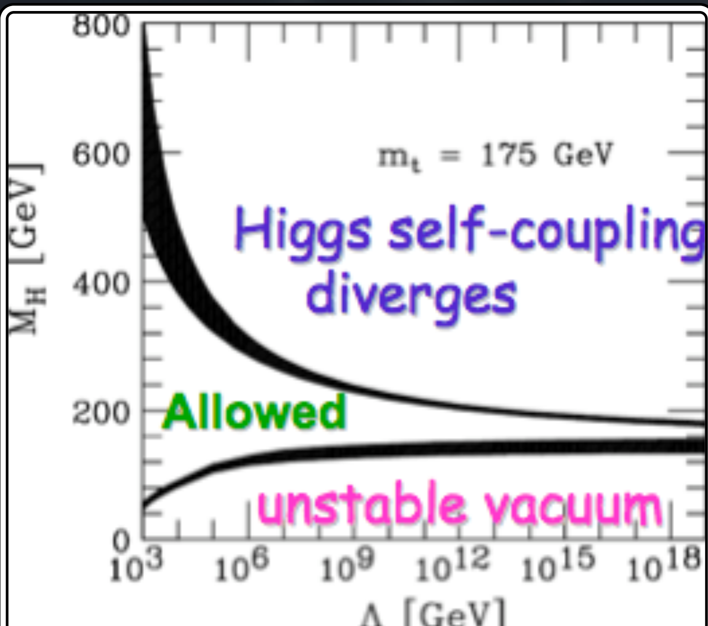
- **Experimental Facts:**
  - ◇ 3 generations of fermions (quark + lepton)
  - ◇ 3 kinds of bosons for 3 kinds of forces
- **Theory Frameworks:**
  - ◇ Quantum particles & Lorentz Symmetry
  - ◇ Interactions satisfy Gauge Symmetry
- **SM is just one of many theories:**
  - ◇ Use Gauge Fields to decribe interactions
    - ★ Strong Interactions = $SU(3)_C$
    - ★ Electro-Weak Interactions = $[SU(2)_L + SU(2)_R] \times U(1)_Y$
    - ★ SM is renormalizable
    - ★ No direct mass term for any particles is allowed
      - * Gauge Symmetry and Renormaliziblity forbid them
      - * Higgs boson and Spontaneous Symmetry Breaking (SSB) provide a solution...



The "explained" part of the world: matter, forces, and the Higgs boson. Gravity is too weak and ignored.

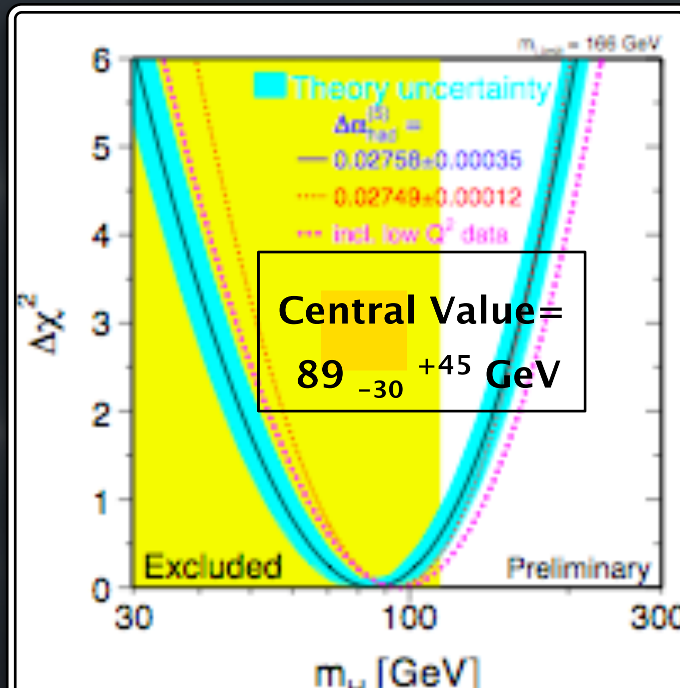
SM Higgs Boson: A Portrait

- **A lonely twin following the** $SU(2)_L$ **symmetry**
  - ◇ Charged brother is suppressed by unitary gauge
- **Has unique Lagrangian**
  - ◇ With non-zero vacuum expectation value (VEV) that causes SSB
- **Couples to every known particle**
  - ◇ Especially favors heavy particles
- **We have a rough estimation of its mass:**



Theoretical constrains on the Higgs

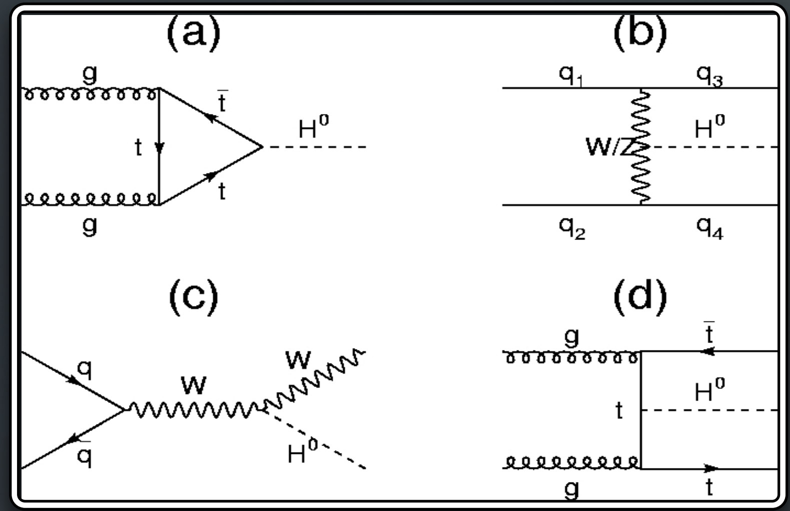
Constraints from the theory

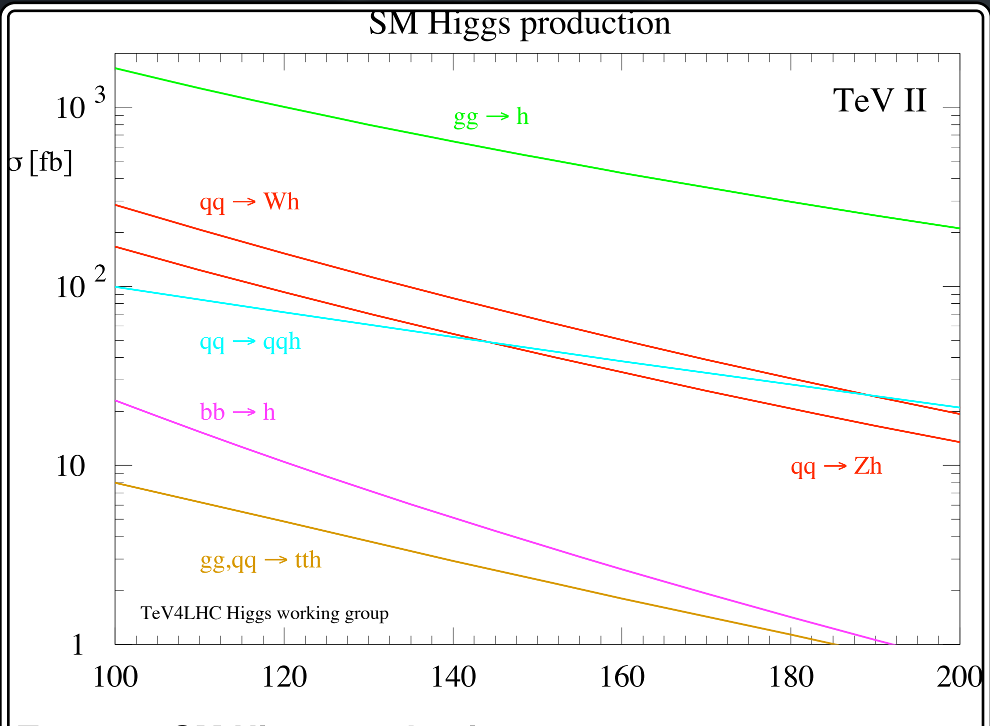


Constraints from experiments:
> 114.4 GeV @ 95% CL LEP2;
< 175 GeV @ 95% CL Global EW fit

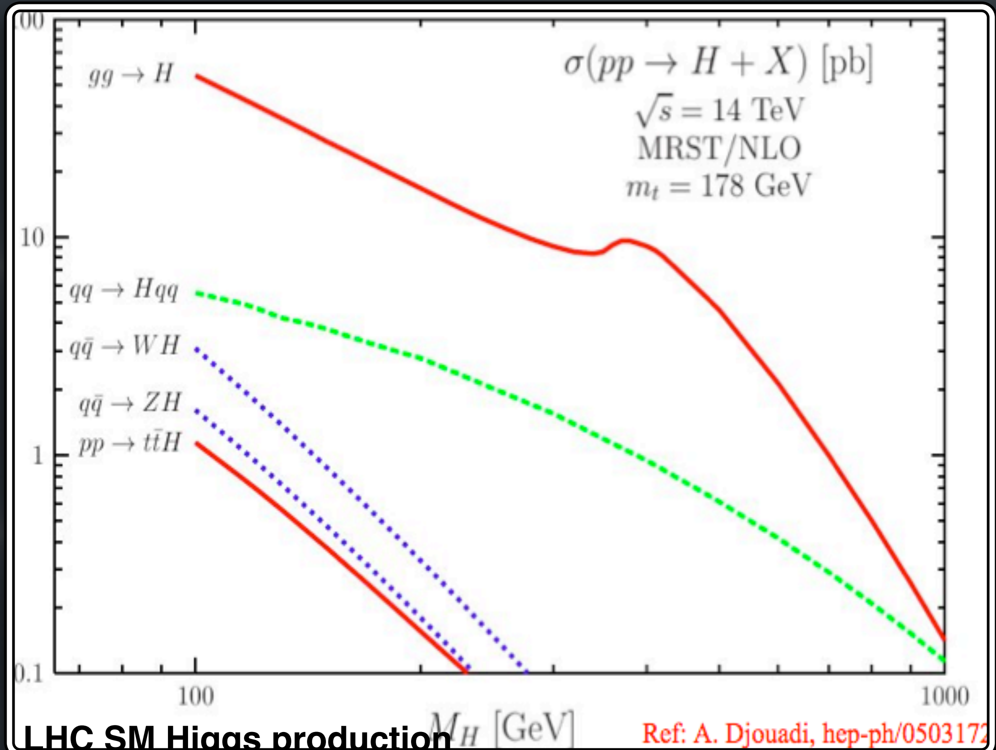
Producing H in Hadron Colliders

- Gluon fusion is the dominant process
- WH & ZH associated production follow
- Tevatron vs. LHC
  - ◇ Tevatron focus on WH & ZH
  - ◇ LHC focus on gluon fusion
  - ◇ LHC cross section >> Tevatron





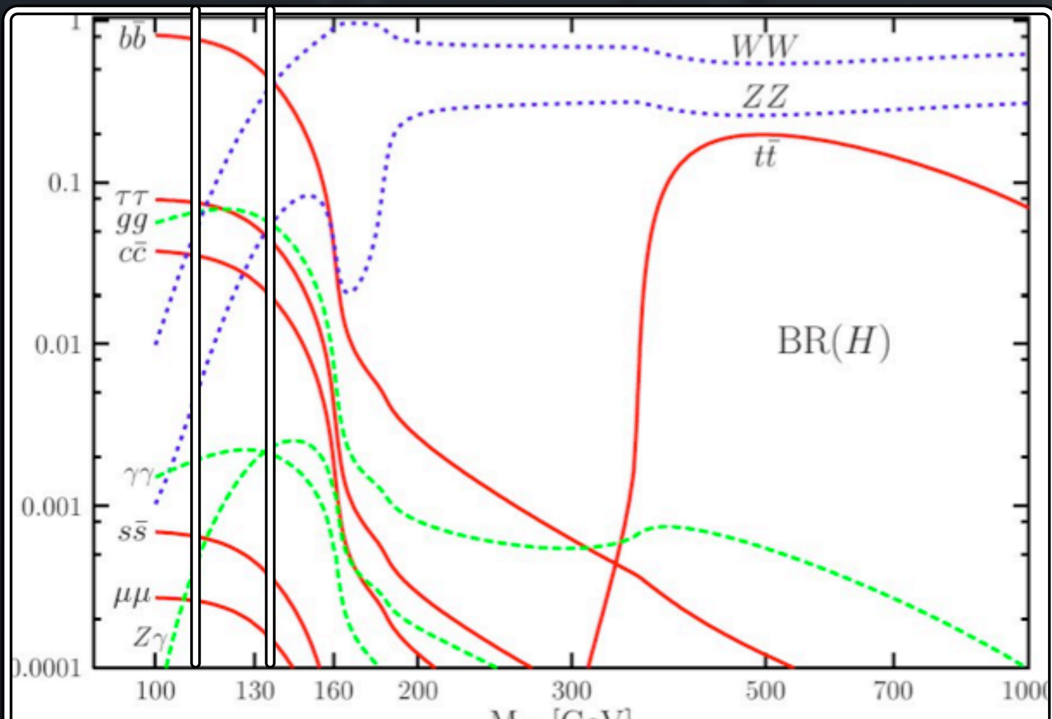
Tevatron SM Higgs production



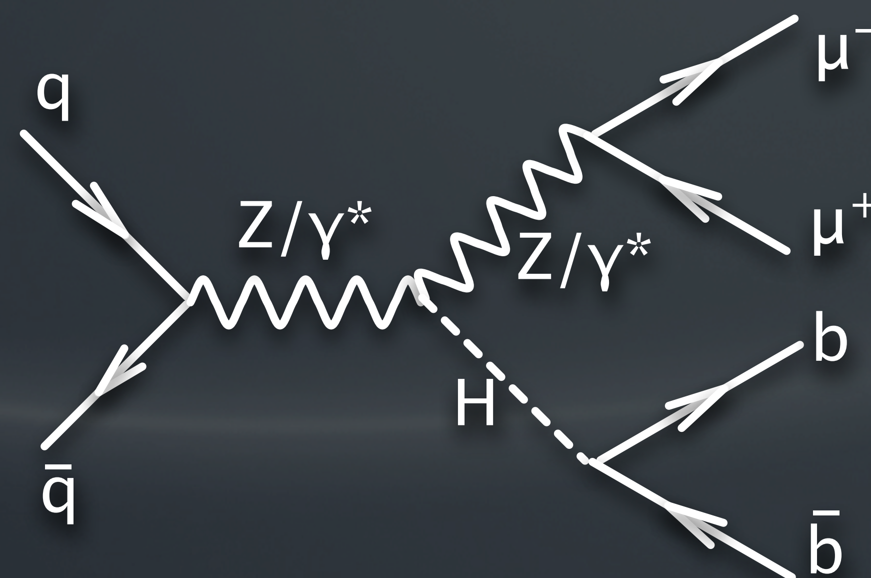
LHC SM Higgs production

Higgs Decay Channels

- **Low mass Higgs boson**
  - ◇ $b\bar{b}$: need b identification to suppress the QCD multi-jet events
  - ◇ $\gamma\gamma$: a good choice at LHC
- **High mass Higgs boson**
  - ◇ WW & ZZ is the way to go.



Higgs decay channels

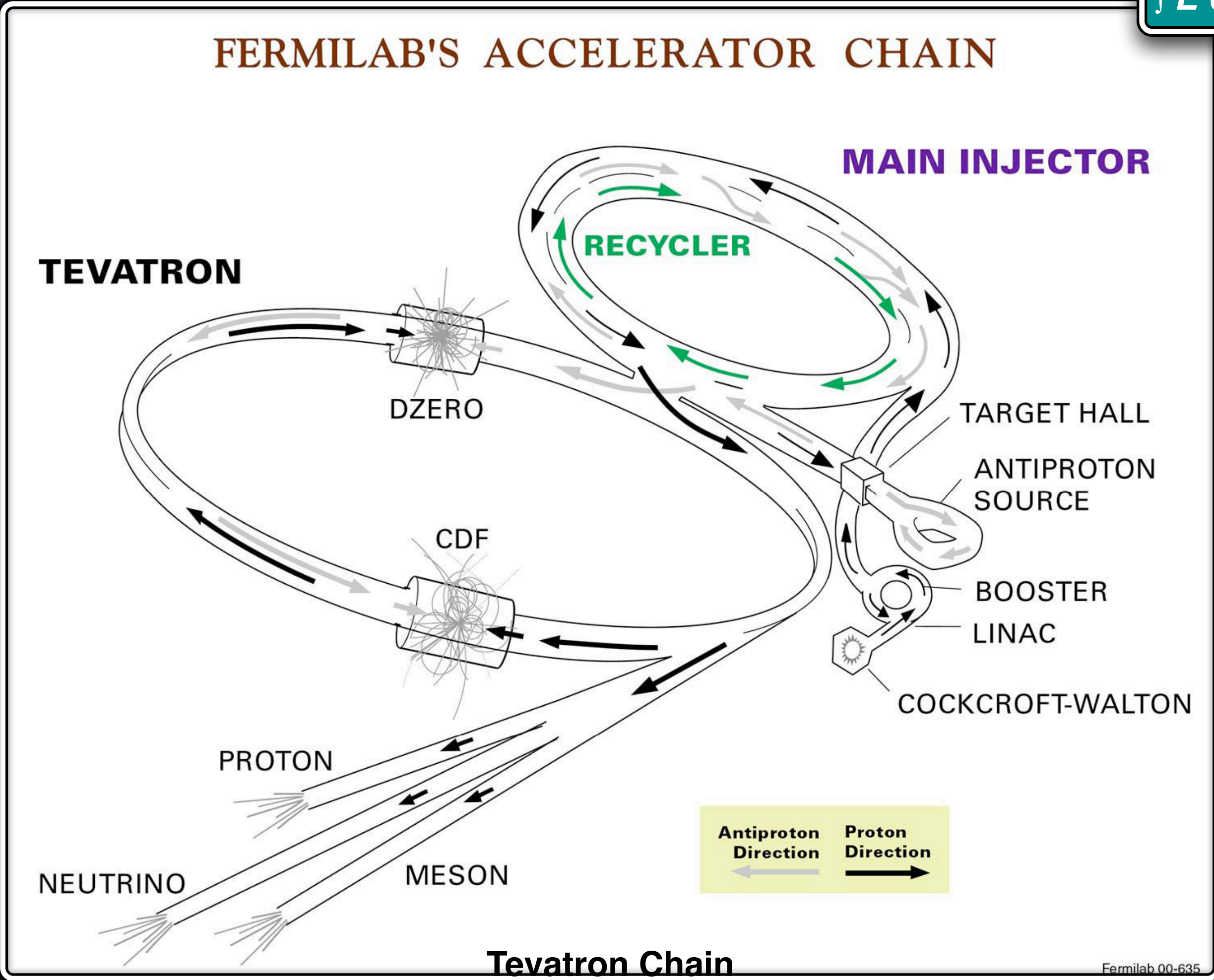


- **We will choose $p\bar{p} \rightarrow Z+H \rightarrow \mu^+\mu^- + b\bar{b}$**
  - ◇ It is the cleanest channel

Tevatron in RunII

- Tevatron is the last stage of a full acceleration chain
- Selling points of Tevatron:
  - ◇ Increased luminosity in Run II
  - ◇ Suitable energy for low mass Higgs

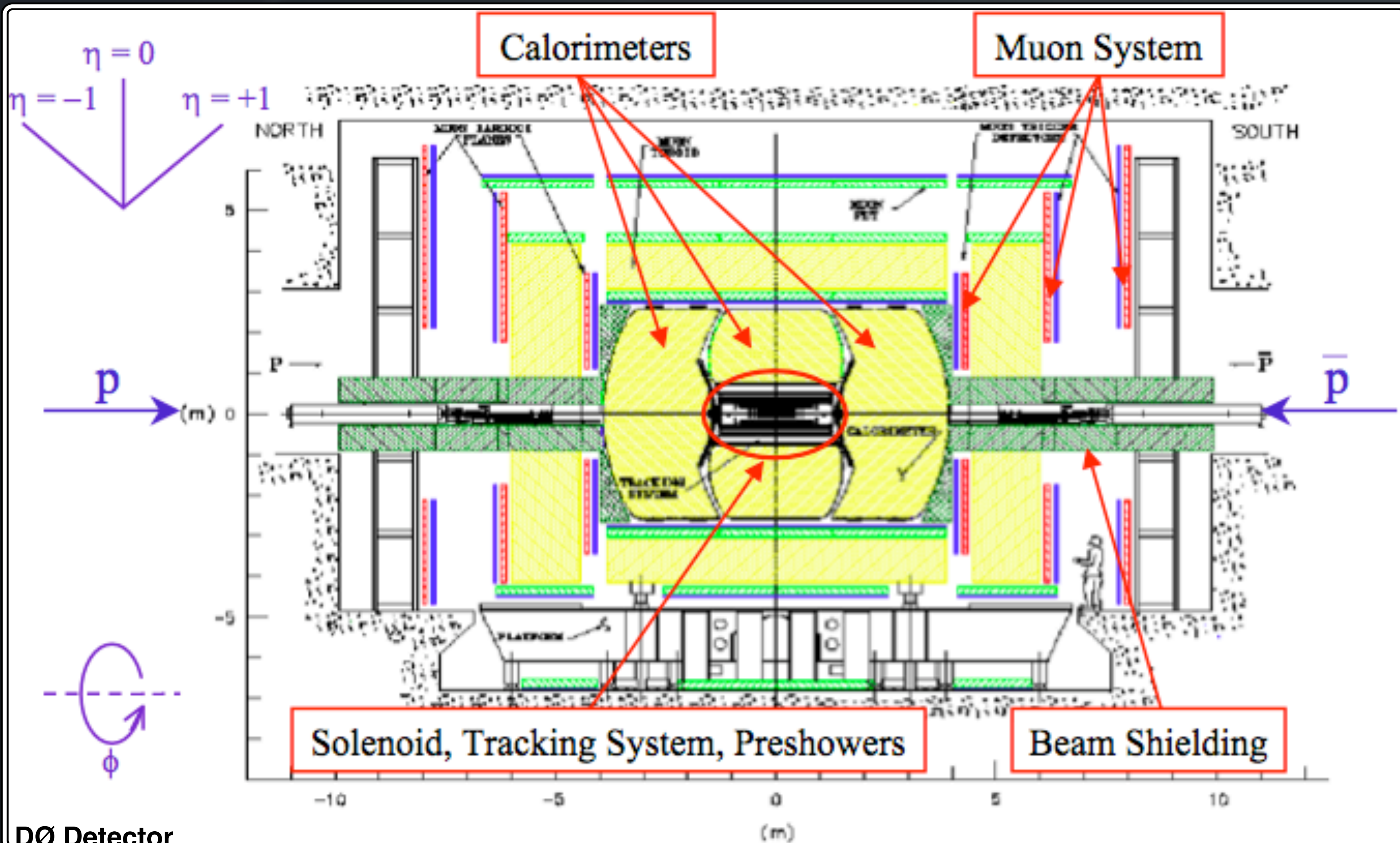
	Run I	Run II
Bunches in Turn	6 x 6	36 x 36
Bunch Crossing (ns)	3500	396
$\sqrt{s}$ (TeV)	1.8	1.96
$\int L\,dt$ (pb/week)	3.2	30



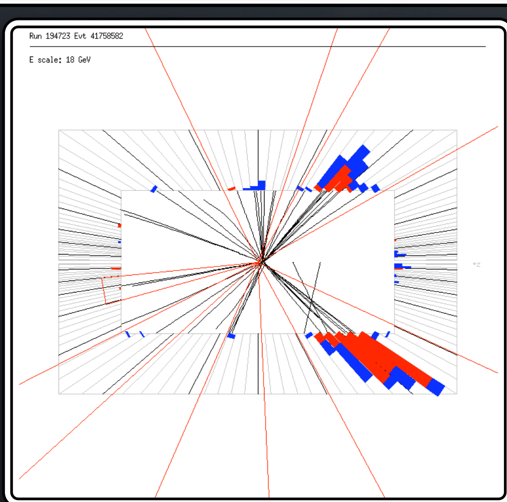
The main difficulty is the anti-proton source. This limits the luminosity growth...
LHC doesn't suffer from this

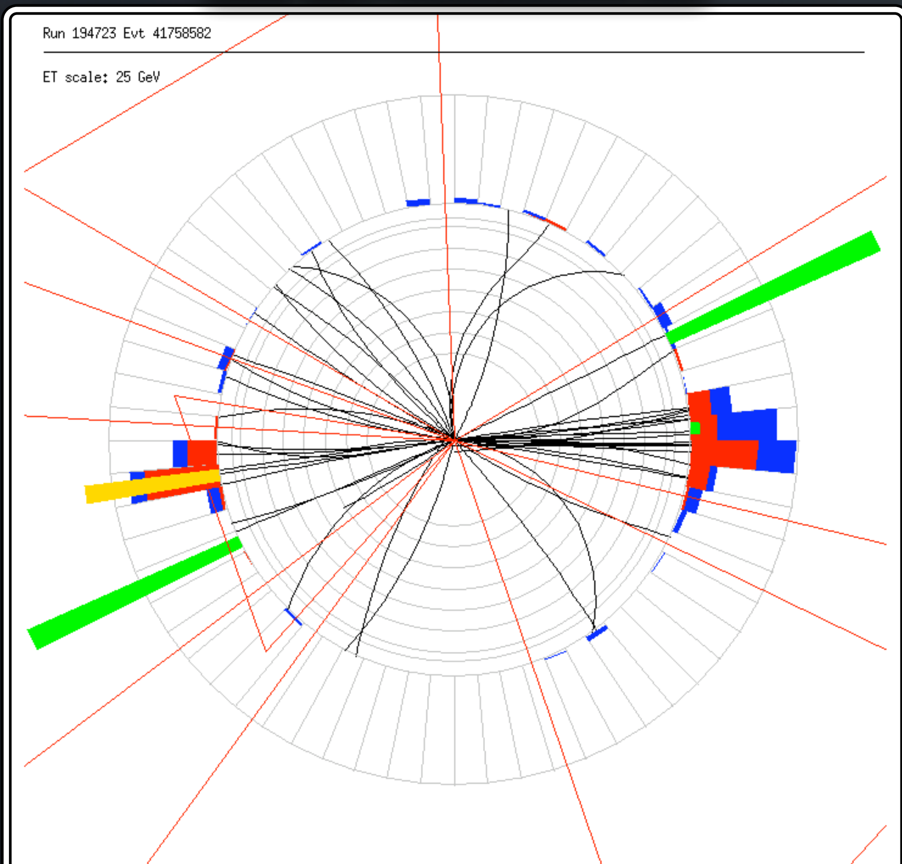
DØ RunII Detectors: A Sketch

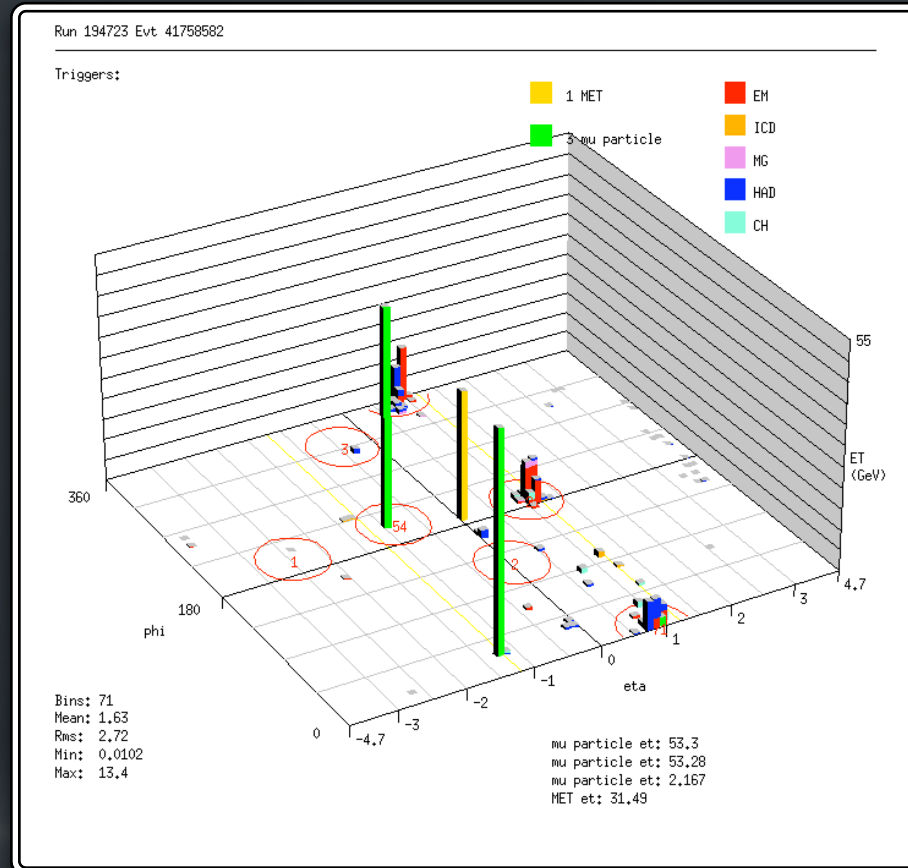
- A contemporary 4-π detector
- In RunII, solenoid and silicon detectors are added — better trk



What's Seen by DØ Detectors







An actual event containing 2 μ's and 2 (b) jets. Shown in the detectors are:

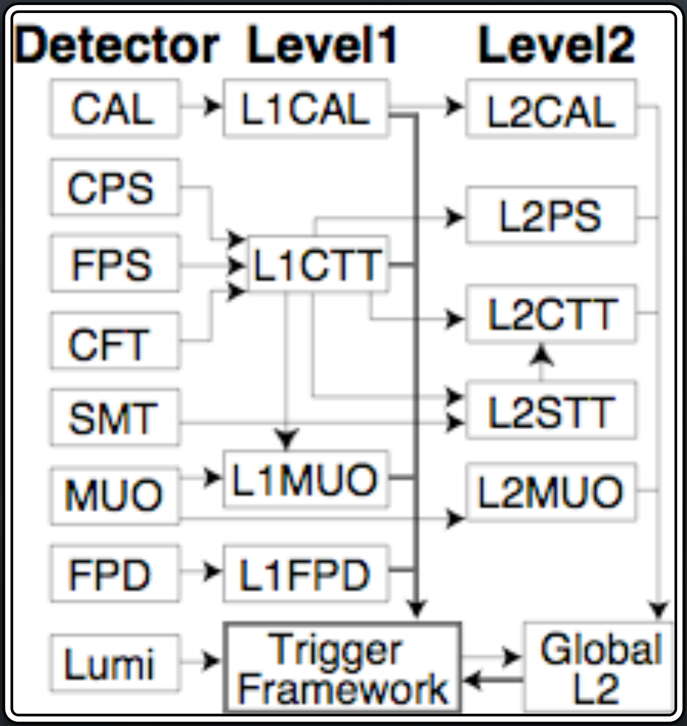
1. Energy clusters in CAL
2. Hits in Trackers & Muon Detectors.

DØ RECO: EE.101 → Phy.801

- **Charged particle tracks:**
  - ◇ ADC in Central Tracking systems → clusters and hits
  - ◇ Fit tracks using these clusters
- **Vertices:**
  - ◇ Fitted from the tracks
  - ◇ A list of primary and secondary vertices are generated
- **Hadronic jets (Jets):**
  - ◇ Calorimeter energy cells → Energy clusters
  - ◇ Cone jet algorithm with cone size $\Delta R \equiv (\Delta\eta^2 + \Delta\varphi^2)^{1/2} = 0.5$.
  - ◇ Jet energies are calibrated, noise is also removed
- **Muons: Combining muon detectors, charged tracks**
- **...(EM Objects, Missing Et, etc)**
- **RECO*ID Efficiency are measured by "Tag-Probe" method**
  - ◇ Detector data sets are used...

DØ Trigger System

- **3 layer triggers to select interesting hard scattering events**
  - ◇ L1: Simple and fast hardware triggers: 7MHz → 2.5kHz
    - ★ Up to 256 triggers, with const. decision time of 3.6 μs
  - ◇ L2: Hardware and software mixed triggers: 2.5kHz → 1kHz
    - ★ Simple fits and correlations. decision time of < ~100 μs
  - ◇ Trigger Frame Work
    - ★ Controls L1&L2 configurations; Combine L1 & L2 trigger decisions
  - ◇ L3: Simplfied RECO + Software triggers in PC's: 1kHz → 100Hz
    - ★ Up to 1024 triggers, decision time < ~ 0.1 s.
- **Trigger efficiency measurement**
  - ◇ Trigger Simulation
  - ◇ From detector data:
    - ★ Single object trigger eff. tag-probe
      - ∗ muon triggers — muo_cert
    - ★ Combine them for complex triggers



Observation: Detector Data

- **Possible events: 2MuHighPt skim**
  - Jul.2002-Apr.2004
  - p14 pass2, RECO and physics caliberation.
  - Require single muon triggers fired
    - To simplify the luminosity and trigger efficiency studies
    - And maintain good acceptance:

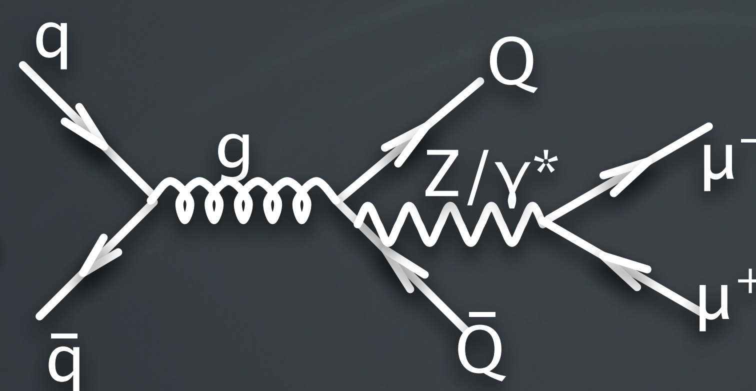
	Total	$Z+2j$	$Z+2j$ 1 b-tag	$Z+2j$ 2 b-tag
W/O Trigger	108451	676	85	11
W/ Trigger	89266	545	64	10

  - Data quality cuts applied
  - Total of 108,451 events remained, int. lumi. = 370 pb^{-1}

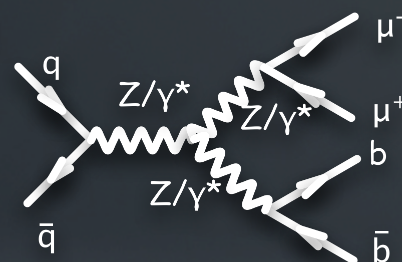
- **Control samples:**
  - Top group JetTrigger skim: for muon isolation study

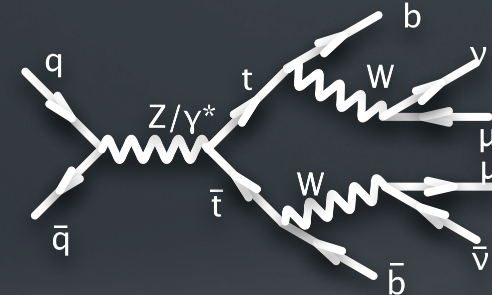
Background X: $p\bar{p} \to X \to \mu^+\mu^- b\bar{b}$

- **Reducible backgrounds X0 — X2:**
  - ◇ QCD multiple heavy flavor jet production
    - ★ Muons in b-/c-jets fake Z boson
    - ★ Reduce: require Z-like final state — muon isolation
  - ◇ Z+2j, Z+jc, Z+jb, Z+2c
    - ★ Light flavor jets & c-jets mis-tagged as b-jets
    - ★ Reduced by tightening the double b-tag cuts



- **Irreducible backgrounds X3 — X7:**
  - ◇ Di-boson production: ZZ, WZ, WW
  - ◇ Top pair production: $t\bar{t}$
  - ◇ Z/γ^* +2b
  - ◇ Look @ the di-b-jet invariant mass distribution
    - ★ Higgs signals produce a small peak around the Higgs mass





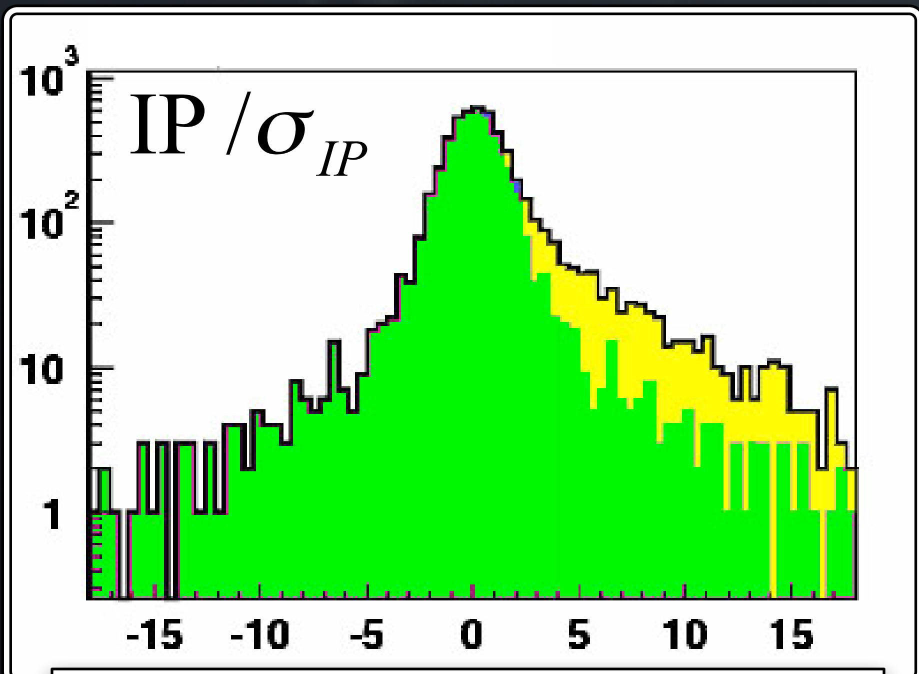
- **Study the expected backgrounds:**
  - ◇ For X1—X7: MC samples: Z+2j/2c/2b, ZZ/WZ, $t\bar{t}$,
    - ★ Pythia & Alpgen were used to produce the MC samples
  - ◇ For X0: QCD multi-jet from detector data

Event Signal Selection

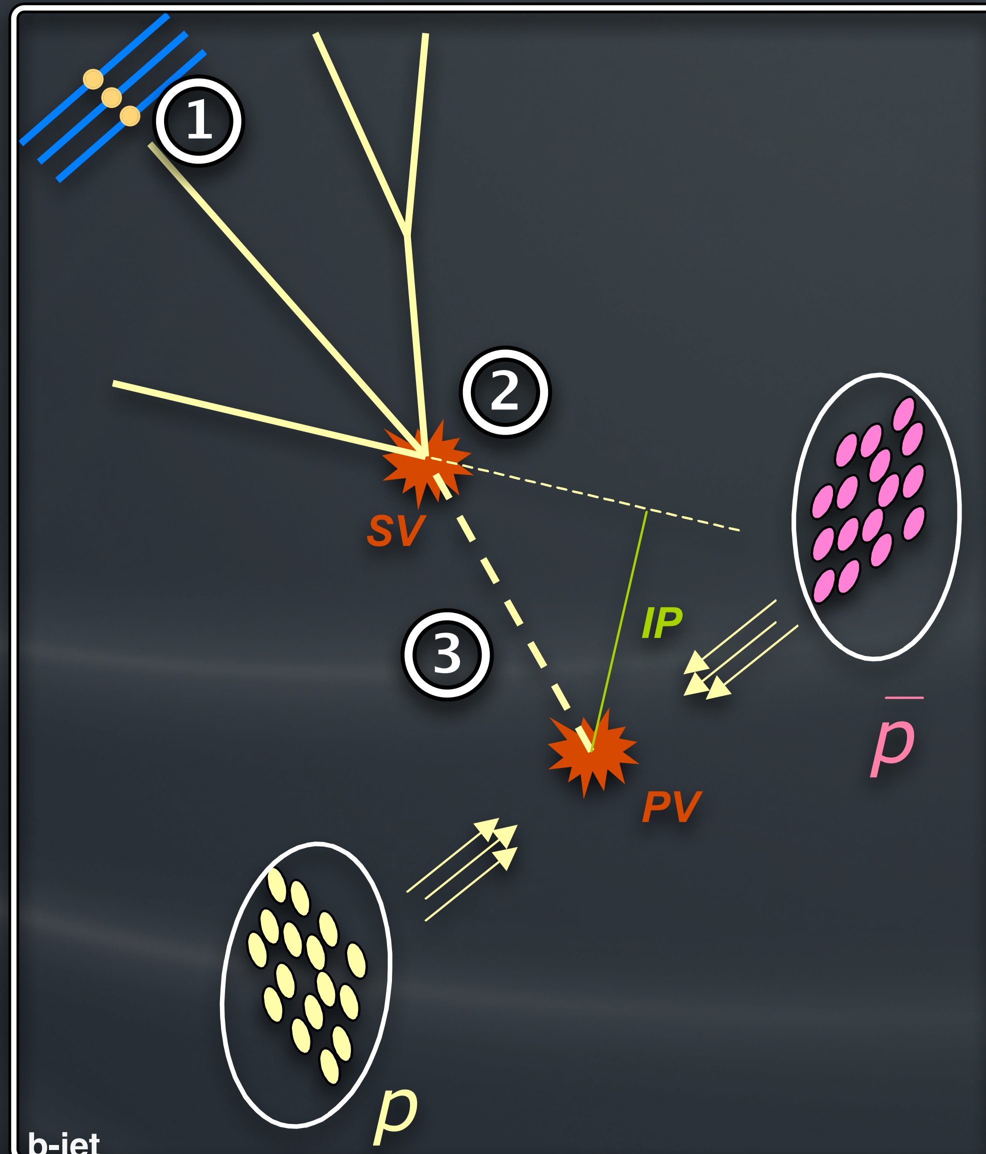
- **Jets selection criteria**
  - ◇ 2+ standard DØ jets (T42, JCCB, L1 confirm, EMF..., JES, JetCorr)
  - ◇ In the fiducial region ($|\eta|<2.5$, $E_T>20$ GeV)
  - ◇ Taggable & JLIP b-tagged (JLIP b-tagger @ 4% mistag rate)
- **Muons selection criteria**
  - ◇ 2+ Standard DØ loose ID-ed muons
  - ◇ Require central track match
  - ◇ At least one SMT hit
  - ◇ In the fiducial region ($|\eta|<2.0$, $P_T>15$ GeV)
  - ◇ Closest Approach to Vertex in r−φ plane (DCA) < 2.5 cm
  - ◇ 2 muons are like Z signals
    - ★ Opposite charge
    - ★ $\Delta\varphi > 0.4$
    - ★ Di-muon isolation probability ≤ 0.02
    - ★ Di-muon invariant mass between 65 and 115 GeV
    - ★ If more than 2 muons, the pair with invariant mass closest to 91 GeV is retained

b-jet Profile

- Semi-leptonic decays (to μ, BR~16%) from the B hadrons in jet
- Detectable secondary vertex (SVT) ~ 3 mm (τ*c ~ 500 μm)
- Positive impact parameters (IP)



Inclusive jet IP significance distribution in the detector data

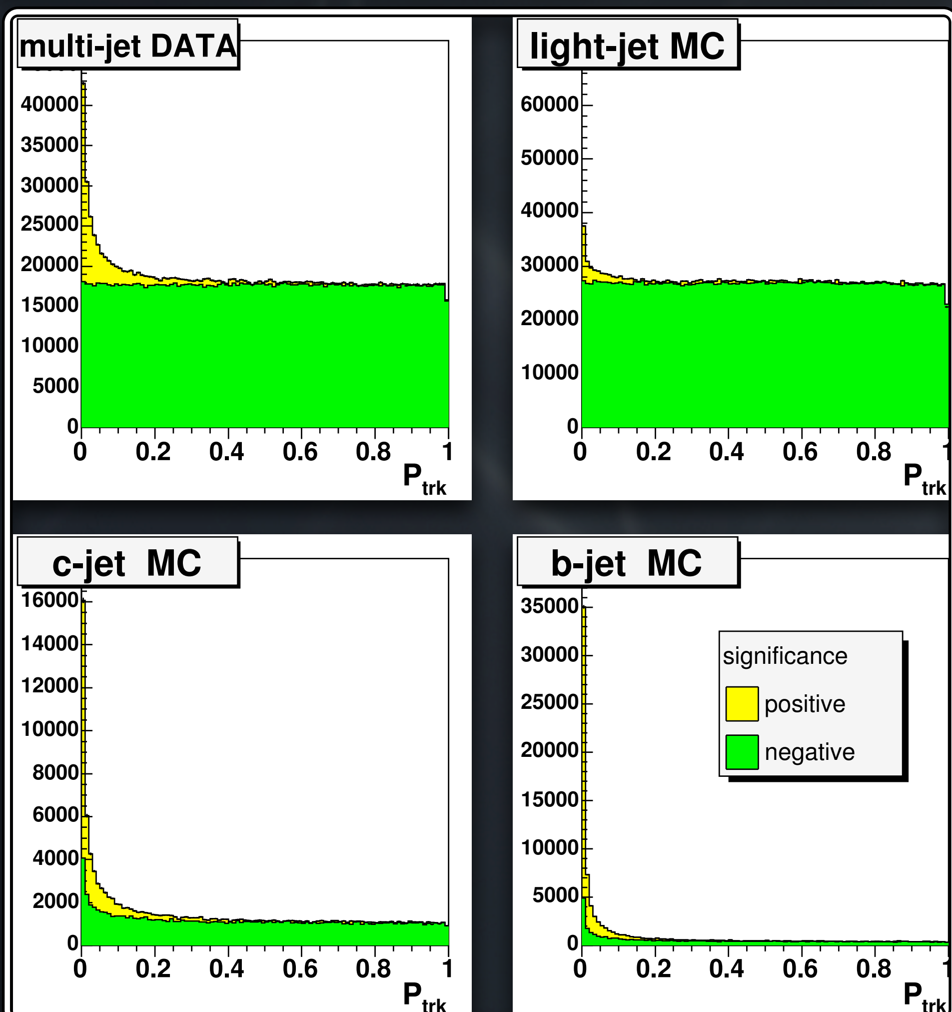


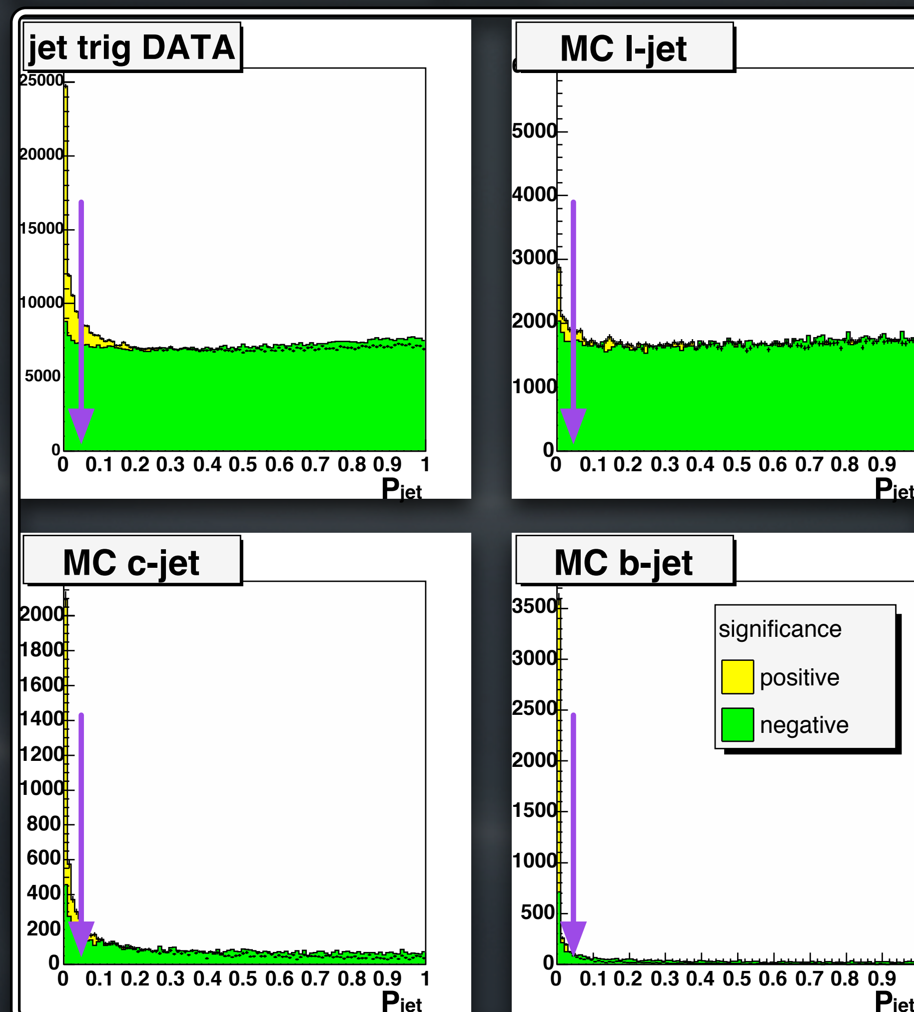
JLIP b-tagger

- Negative IP significance → b-trk probability → b-jet probability

$$\mathcal{P}_{trk}(\mathcal{S}_{IP}) = \frac{\int_{-50}^{-|\mathcal{S}_{IP}|} \mathcal{R}_{IP}(s)ds}{\int_{-50}^{0} \mathcal{R}_{IP}(s)ds}$$

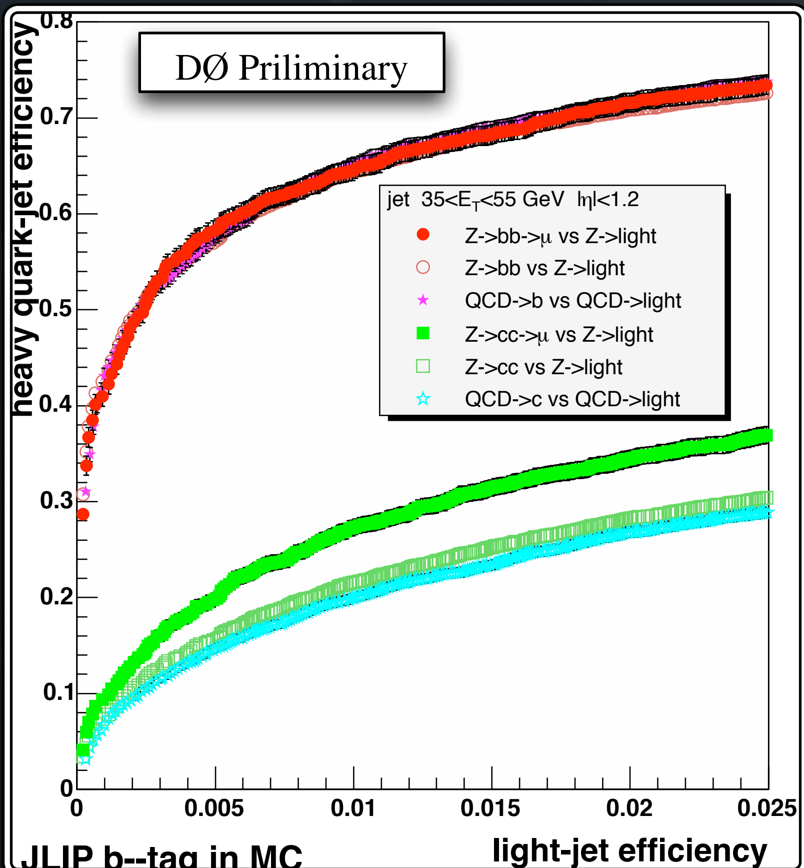
$$\mathcal{P}^{+}_{jet} = \Pi^{+} \sum_{k=0}^{N^{+}_{trk}-1} \frac{(-\ln \Pi^{+})^{k}}{k!}$$

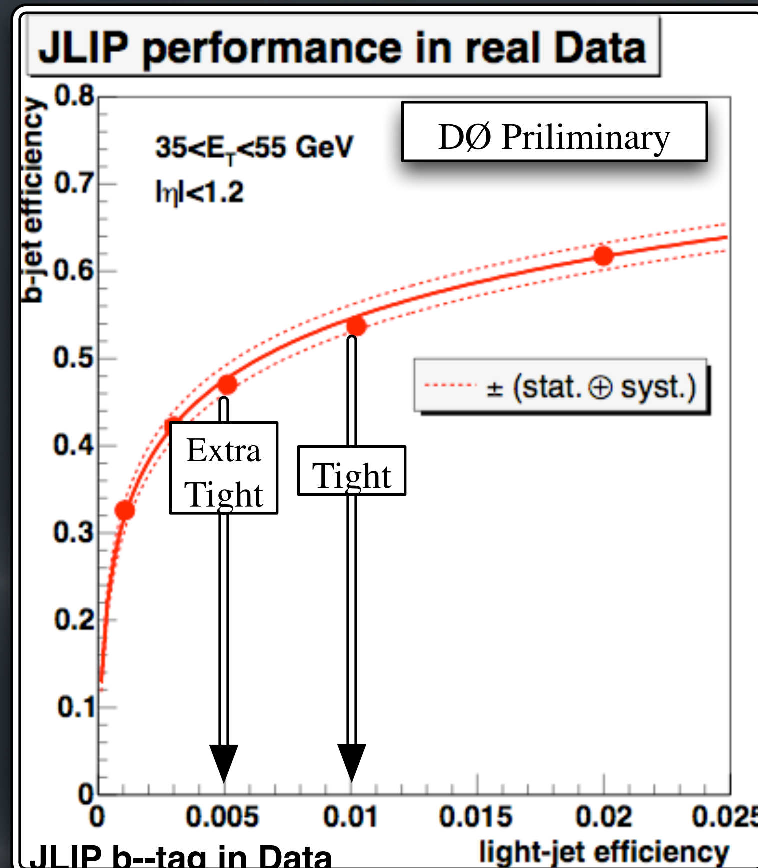




JLIP b-tagging Efficiency

- Light flavor jet mis-tag rate measured for detector data
- b-/c-jet tag rate measured for MC samples
  - ◇ Data/MC SF is also parameterized as function of jet E_T, η



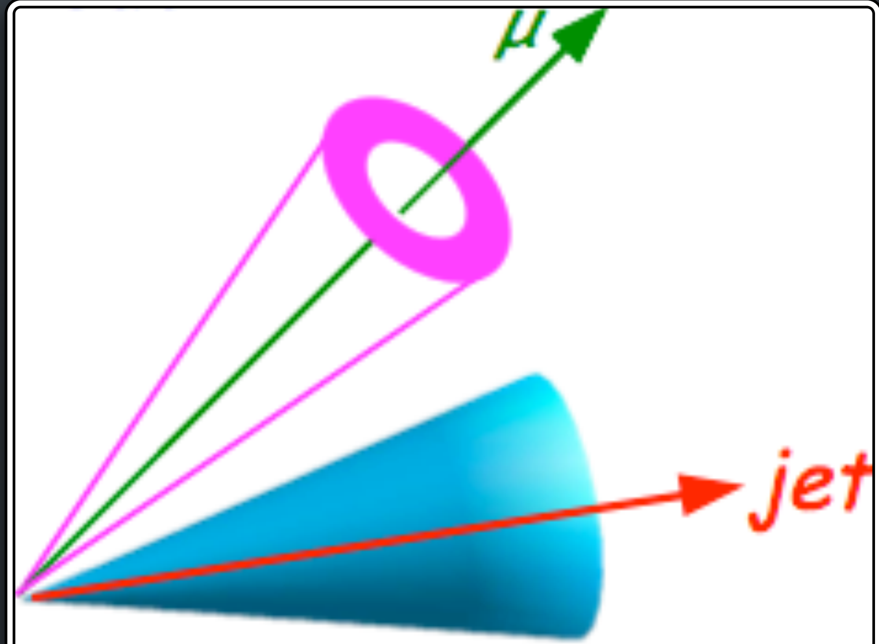


- Selection requirement is ExtraLoose, eg. Prob. < ~0.04
  - ◇ Optimized for double b-tagging of Z+2jets events

Z Muon Profile

- μ's from Z decays: usually isolated from jets
- Define isolation variables:
  - ◇ $\Delta R = (\Delta\eta^2 + \Delta\varphi^2)^{1/2} > 0.5$
  - ◇ TrackCone(0.5) pT < 2.5 GeV
  - ◇ Halo(0.1, 0.4) < 2.5 GeV

$$\text{Halo} = \sum_{0.1<dR<0.4}^{N_{cell}} E_{\mathrm{T}} \qquad \text{TrkCone} = \sum_{dR<0.5}^{N_{track}} p_{\mathrm{T}}$$



Isolated Muons from Z boson decays

  - ◇ TrackCone/pT < 0.06
  - ◇ Halo/pT < 0.08
    - ★ pT scaled is better: muon radiation
- We will define a muon isolation discriminant f_{iso}
  - ◇ Similar to signed IP significance of JLIP b-tagger

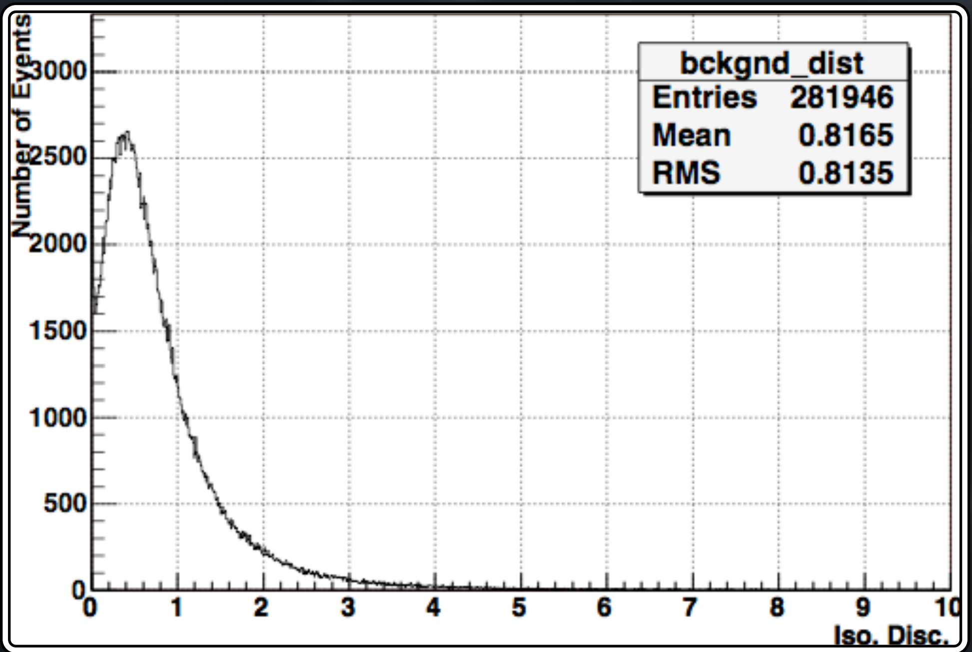
$$f_{iso} = \frac{\text{TrkCone} + \text{Halo}}{|\vec{p}_\mu|}$$

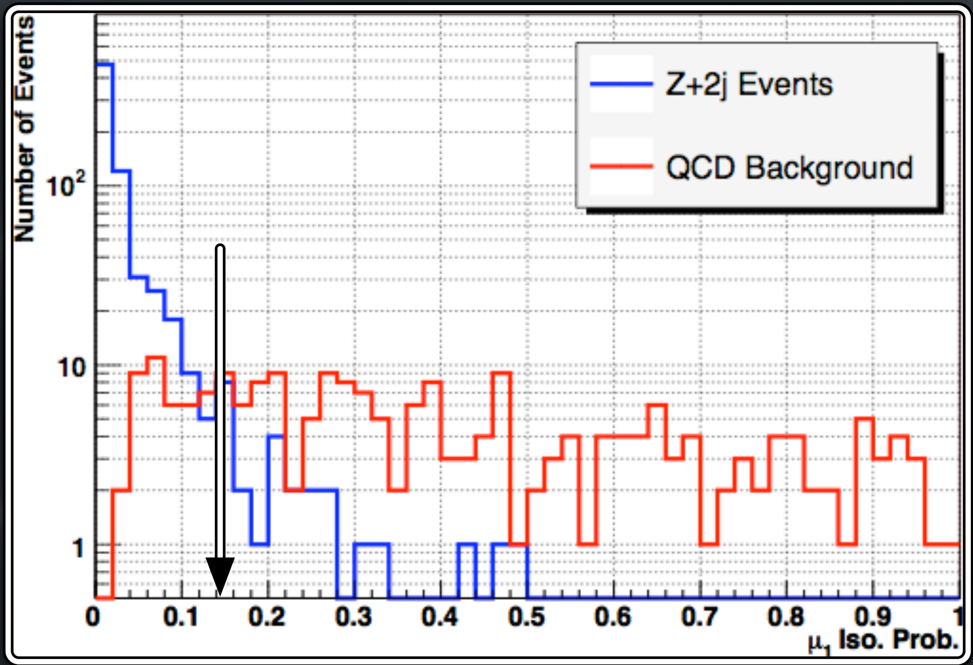
  - ◇ A muon isolation probability can be constructed...

Muon Isolation Probability

- Get the muon from jet f_{iso} distribution
  - Use the JetTrigger events
- Define the μ Iso. Prob.

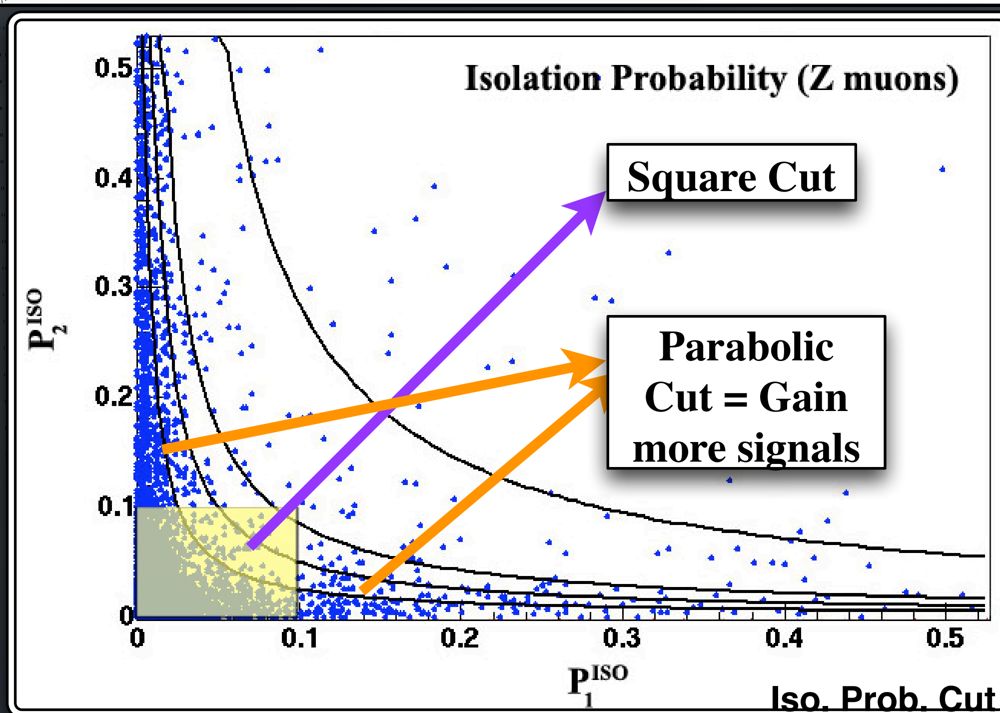
$$P_{iso}(f) = \frac{\int_0^f \mathcal{F}_{iso}^{QCD}(x)dx}{\int_0^\infty \mathcal{F}_{iso}^{QCD}(x)dx}$$

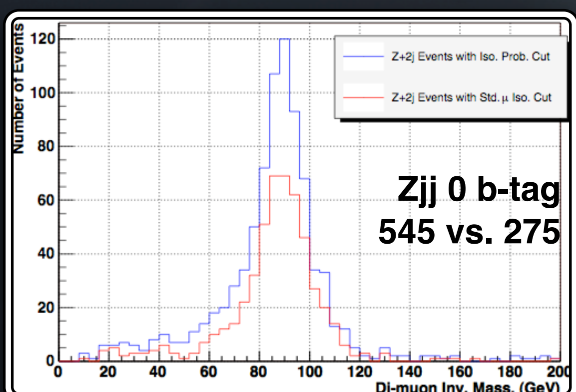


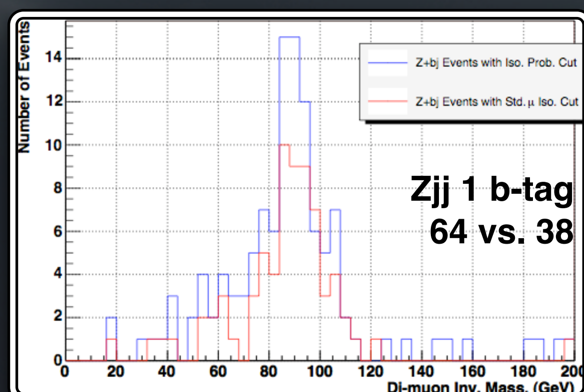


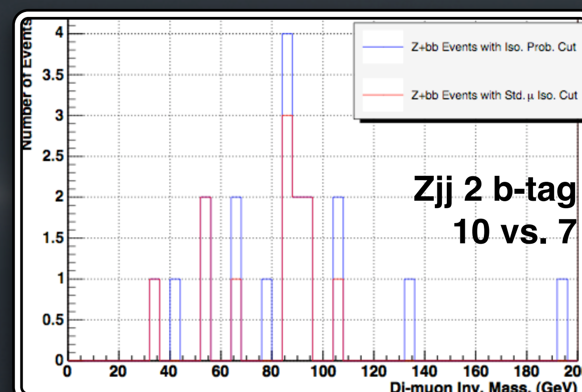
What About Di-Muon Pair

- Both of the muons are isolated
- And <u>correlated</u>
  - Since μ pair inv. mass ~ 91 GeV
  - Very energetic μ, $P_{iso} \rightarrow 0$
  - The other μ, $P_{iso} \gg 0$
- For μ's from QCD heavy jets
  - P_{iso} 's are not correlated
  - Evently distributed in unit square
- Cut on $(P_{iso} X P'_{iso})$
  - Roughly 2 times more signal & background
  - Good for rare signal searching experiments



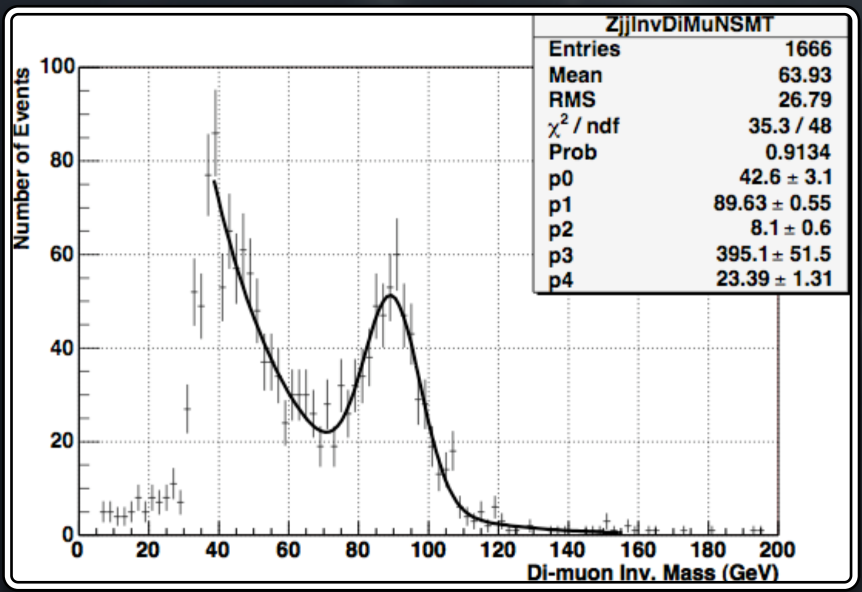


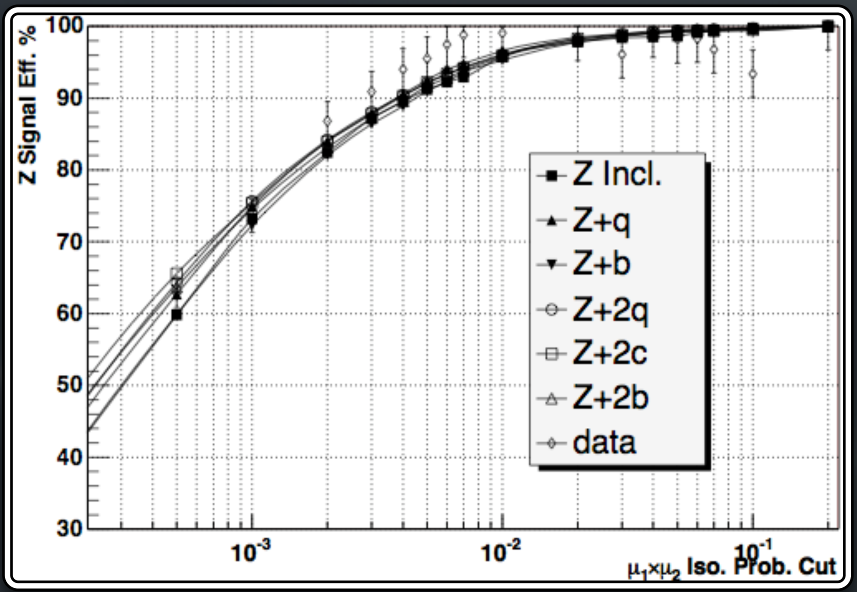




Di-μ Isolation Cut Efficiency

- **For $\mu\mu$+jj events in detector data**
  - ◇ Fit Z peak to get # of Z events
  - ◇ Eff. = Ratio of # of Z's w/ and w/o iso. cut
- **For Z+2j/c/b, tt, ZZ/WZ MC samples**
  - ◇ Eff. = Ratio of # of events within 65-115 GeV w/ and w/o iso cuts
- **For QCD multijet**
  - ◇ Use 2 [0, 1] random numbers to model iso. prob. of the 2 μ's
  - ◇ Eff. = (# of pairs pass di-μ cut) / (total # of random number pairs)





Normalizing MC Samples

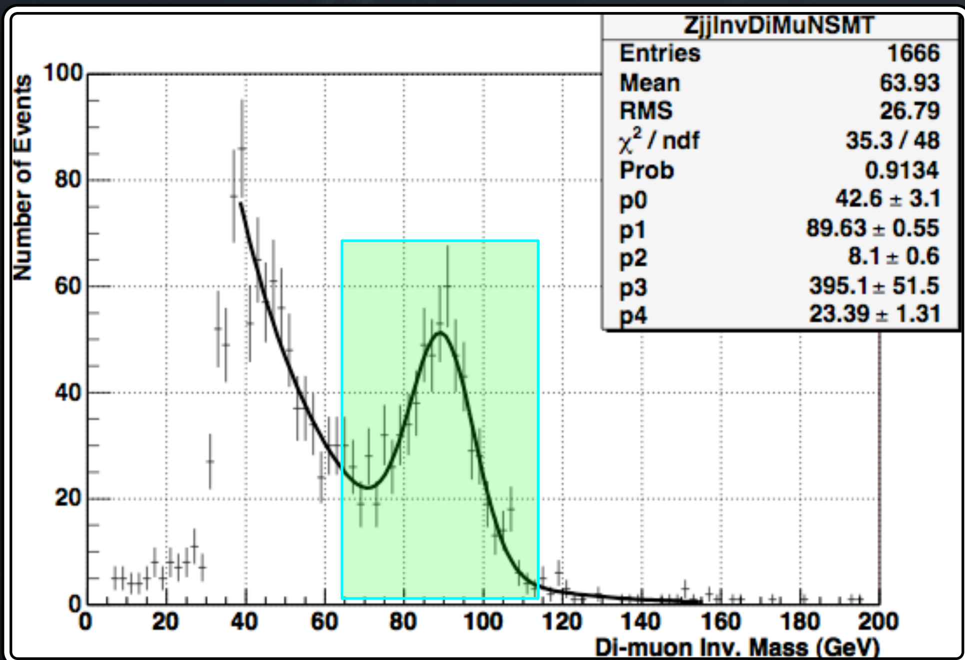
- **MC samples are normalized to the recorded luminosity**
- **Additional correction SF's are:**
  - Single muon trigger efficiency
  - Muon RECO*ID*Tracking efficiency SF
  - Muon opposite charge
  - Jet RECO*ID efficiency SF
  - Jet taggability efficiency SF
  - JLIP b-tag rate function SF
- **Folding the SF's into MC samples — Convolution Method**
  - For each muon/jet in a MC event, SF's are calculated
  - Calculate the probability of the event passing the correspoding cut
  - The event probability averaged over the whole samples is obtained
  - Apply the event averaged SF is to the MC distributions

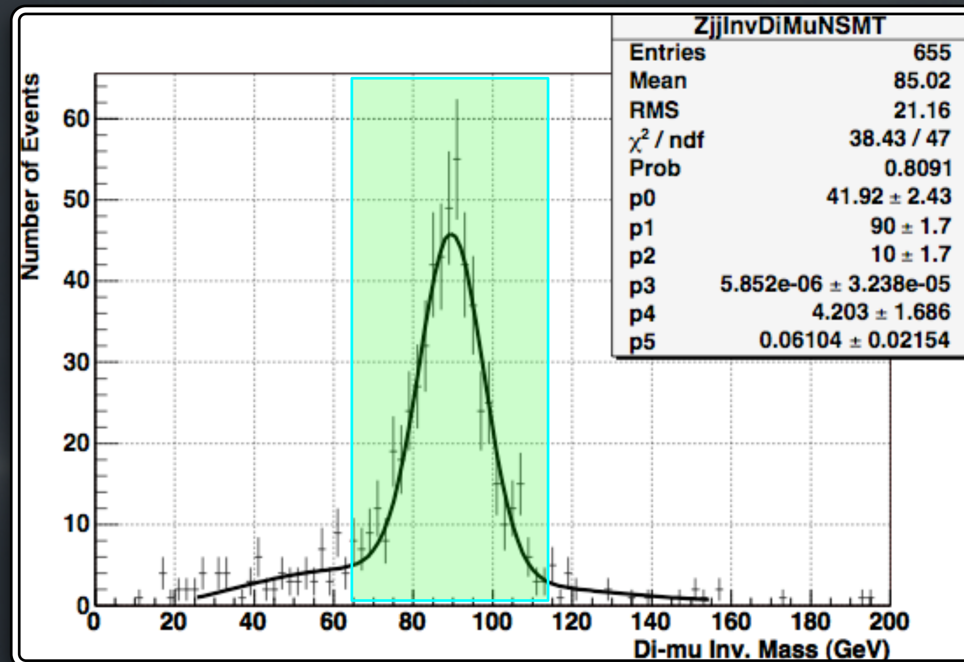
Expected QCD Background

- First, estimate the # of QCD background
  - ◇ Comparing loose/tight cut samples : Known Unknown

$$QCD + DY + Z = N_{non-iso}$$

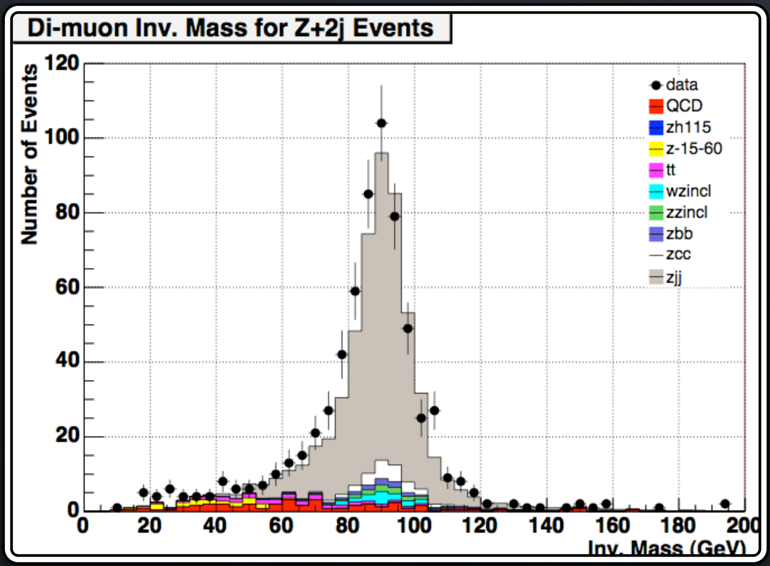
$$\epsilon_{QCD} \cdot QCD + \epsilon_{DY} \cdot DY + \epsilon_Z \cdot Z = N_{iso}$$

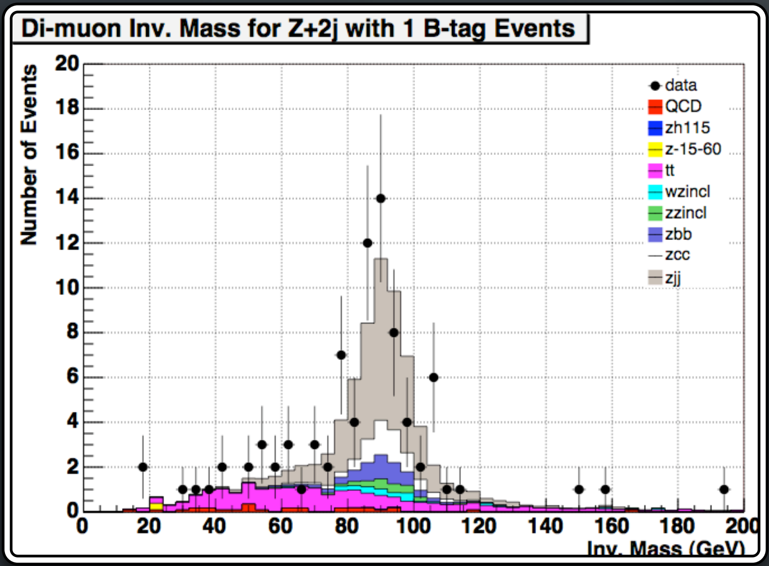


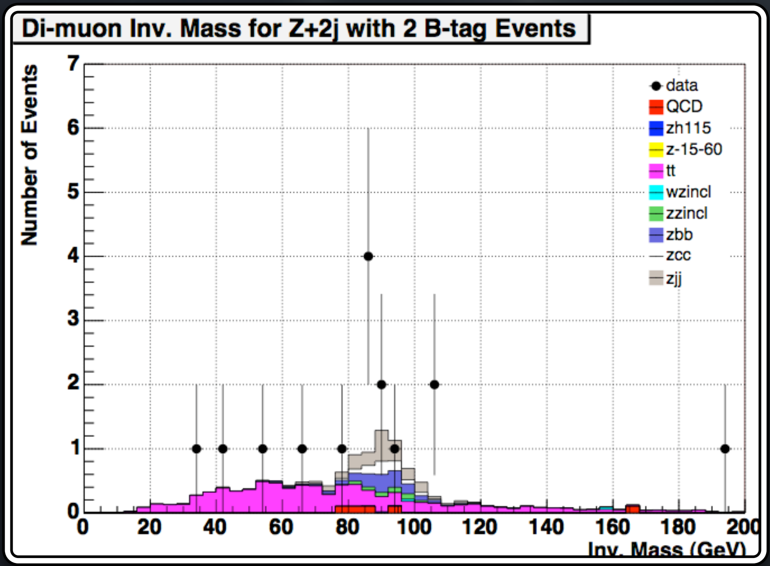


- Second, get the shape
  - ◇ Distribution(Iso. Prob. < 0.05) - Distribution(Iso. Prob. < 0.01)
- Normalize the shape by the # of QCD w/i 65-115 GeV

Observed vs. Expected: μμbb





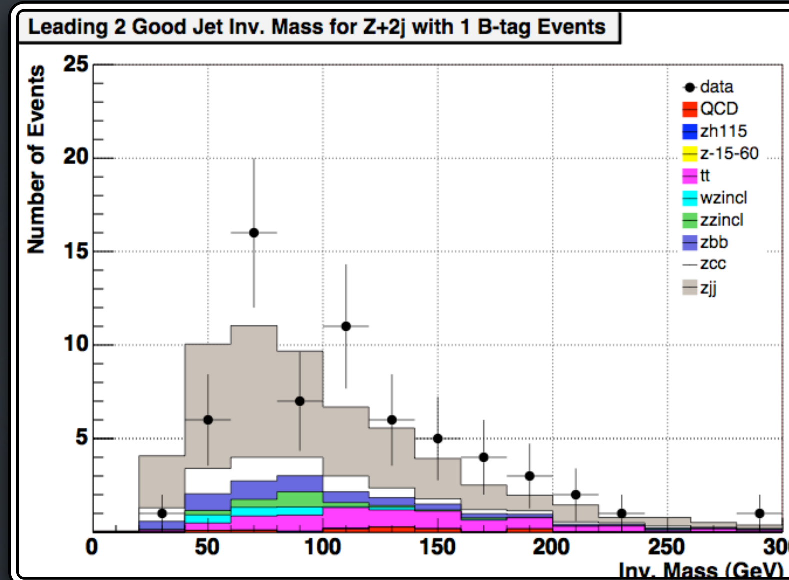


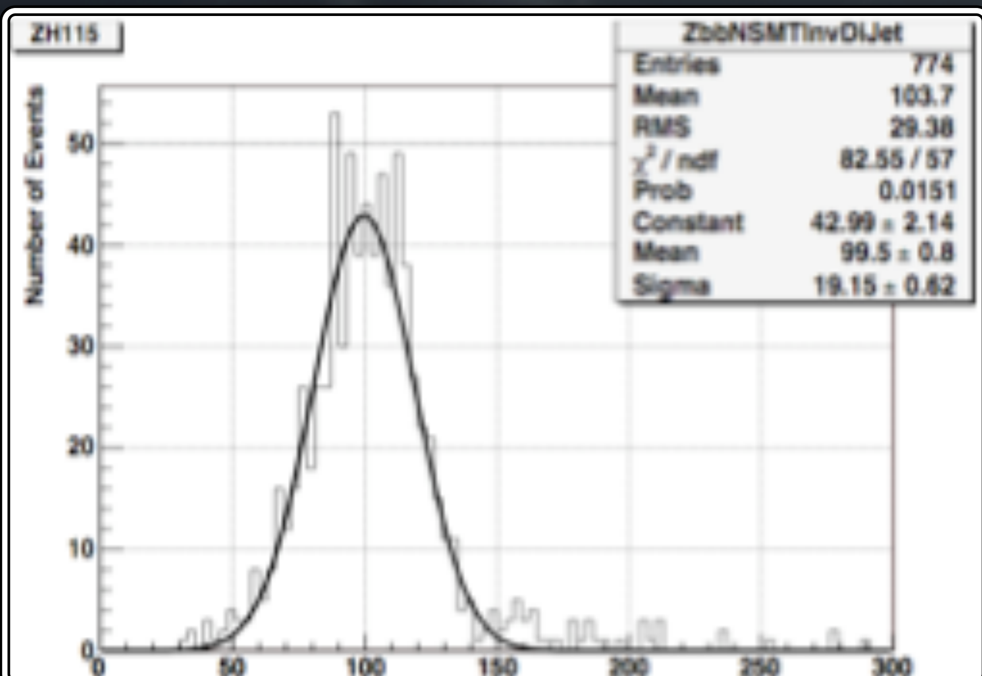
MC sample	0 btag	1 btag	2btag
Zjj	431	44.8	2.70
Zcc	22.1	6.90	0.76
Zbb	8.32	5.19	1.32
ZZ	8.90	2.11	0.39
WZ	12.5	1.63	0.03
$t\bar{t}$	9.57	7.69	3.06
ZH	0.22	0.17	0.06
QCD	16.13	0.96	0.41
MC Total	510	69.6	10.6
Data	545	64	10

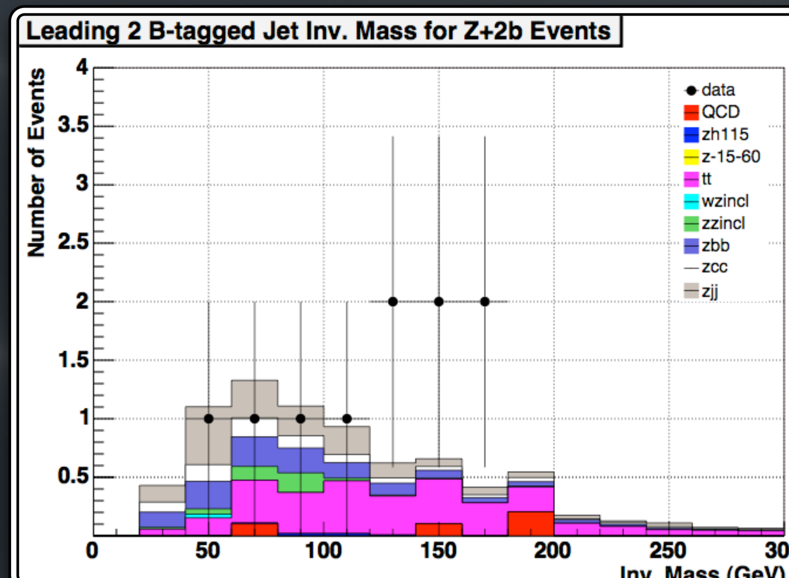
Observed vs. Expected: Z+bb

- Create the Higgs search windows

m_H (GeV)	mean	width	$\sigma(\%)$	search window
105	91.3	17.7	19.3	65 - 118
115	99.5	19.1	19.2	70 - 128
125	107.9	19.7	18.3	78 - 137
135	115.8	21.1	18.2	84 - 147
145	125.7	22.6	18.0	92 - 160
155	131.4	24.8	18.9	94 - 169







Systematic Uncertainties (I)

- Muon Trigger Efficiency
- Muon ID*Tracking Efficiency SF
- Jet Energy Scale
- Jet RECO*ID efficiency SF
- Jet Taggability
- JLIP B-tagging tag rate SF

1. Assume they are uncorrelated
2. Shift the center value by ±1 σ and re-run the analyses
3. Assume all MC samples are uncorrelated

- QCD background
  - ◇ Z peak/background shape fit
  - ◇ Isolation cut efficiencies

Propagate the uncertainties from the fitting/statistics into matrix equations

- Luminosity → Official DØ value
- Cross sections → from MCFM calculation

Systematic Uncertainties (II)

- Systematics dominated by the statistics of the control samples

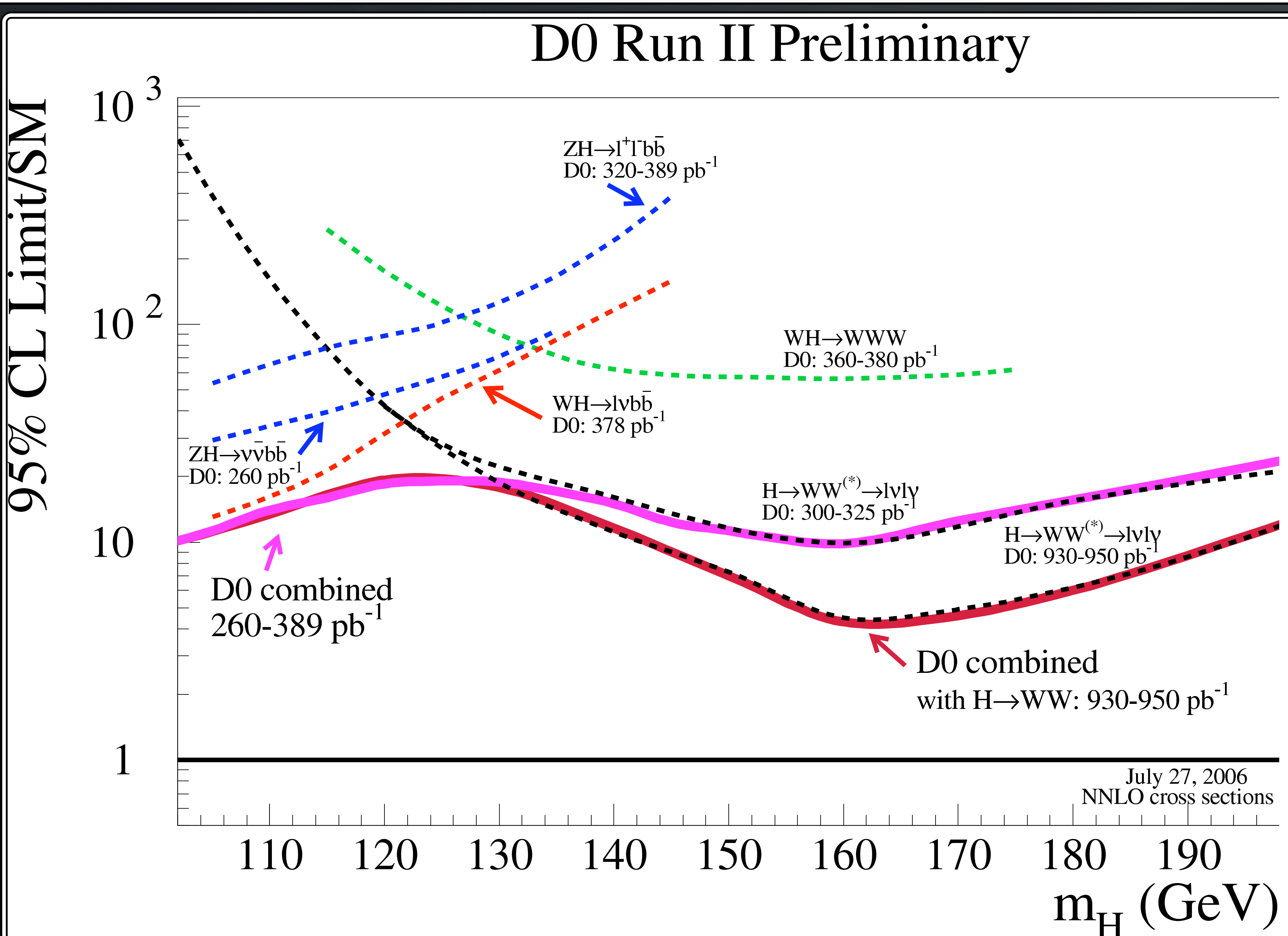
Err. Sources	ZH Signal	Background
Muon Trigger	~6.3%	~8.4%
Muon RECO*ID	~12.3%	~14.6%
Jet RECO*ID	~6.4%	~10%
JES	~3.3%	~4.6%
b-tag	~16.2%	~15.3%
Cross Section	~7%	~15%
Luminosity	6.5%	6.5%
Syst. Total	~24%	~30%
Stat. Err.	~4%	~12%
Syst.+Stat.	~25%	~32%

Setting the Limit

- Use the standard DØ Bayesian CL limit setting package: 2-btag

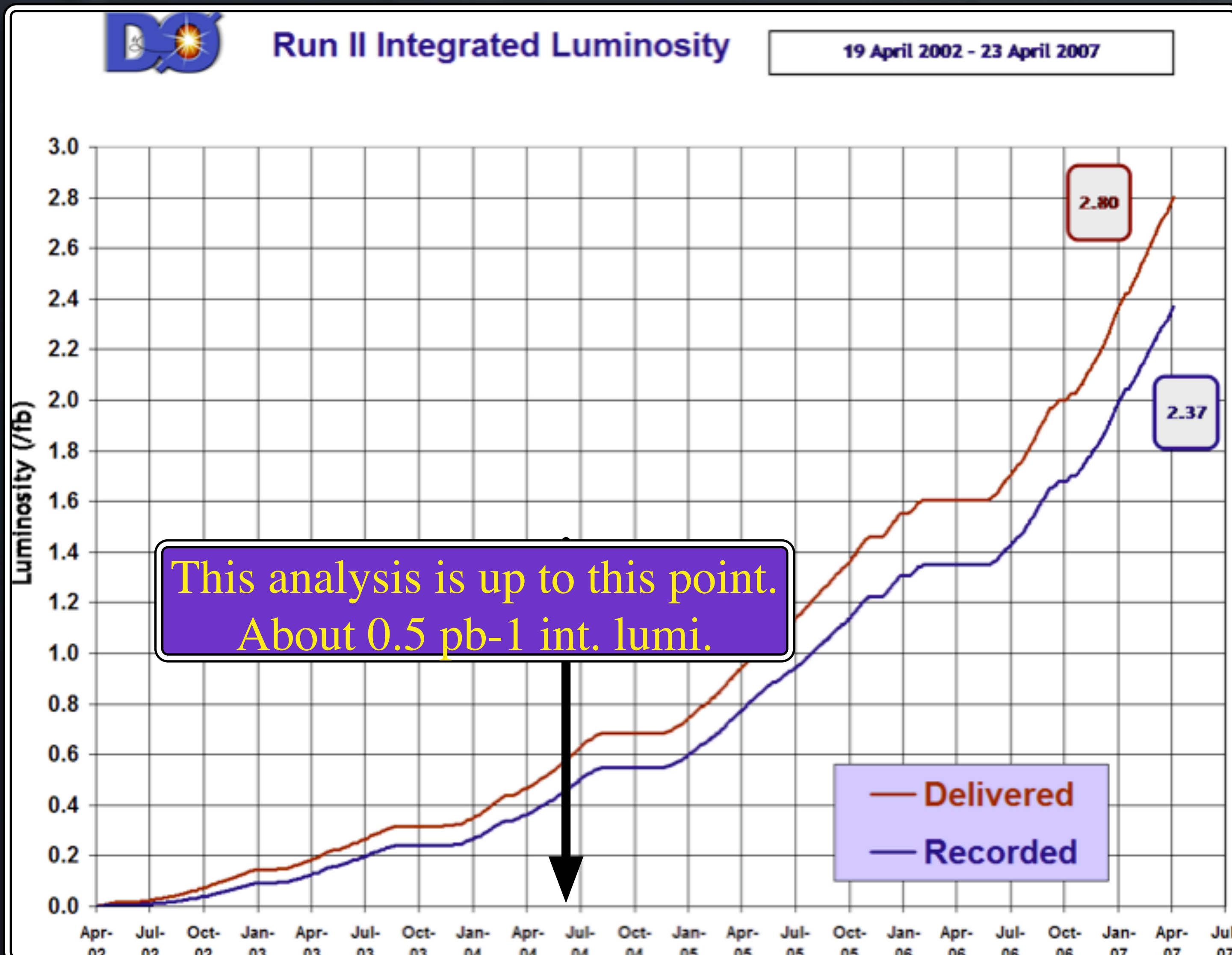
m_H (GeV)	105	115	125	135	145
Expected ZH Acceptance	0.0588 0.0014	0.0473 0.0016	0.0327 0.0017	0.0221 0.0019	0.0103 0.0019
$t\bar{t}$	1.08	1.17	1.13	1.26	1.30
ZZ	0.292	0.278	0.219	0.175	0.088
Zbb	0.545	0.526	0.478	0.436	0.398
Zcc	0.290	0.278	0.232	0.201	0.194
Zjj	0.765	0.685	0.590	0.637	0.590
QCD	0.17	0.16	0.17	0.17	0.20
Total BKGD	3.11	3.09	2.82	2.89	2.77
Total BKGD Syst. Err.	0.57	0.55	0.49	0.50	0.49
Total BKGD Stat. Err.	0.17	0.16	0.14	0.15	0.15
Total BKGD Err.	0.59	0.57	0.51	0.52	0.51
Events in Data	3	3	4	5	6
95% Obs. Limit (pb)	10.5	9.2	10.6	11.1	13.1
95% Exp. Limit (pb)	10.5	9.2	7.3	6.5	6.5
SM prediction (pb)	0.119	0.083	0.054	0.031	0.015

Combined Results



Tevatron is Pushing

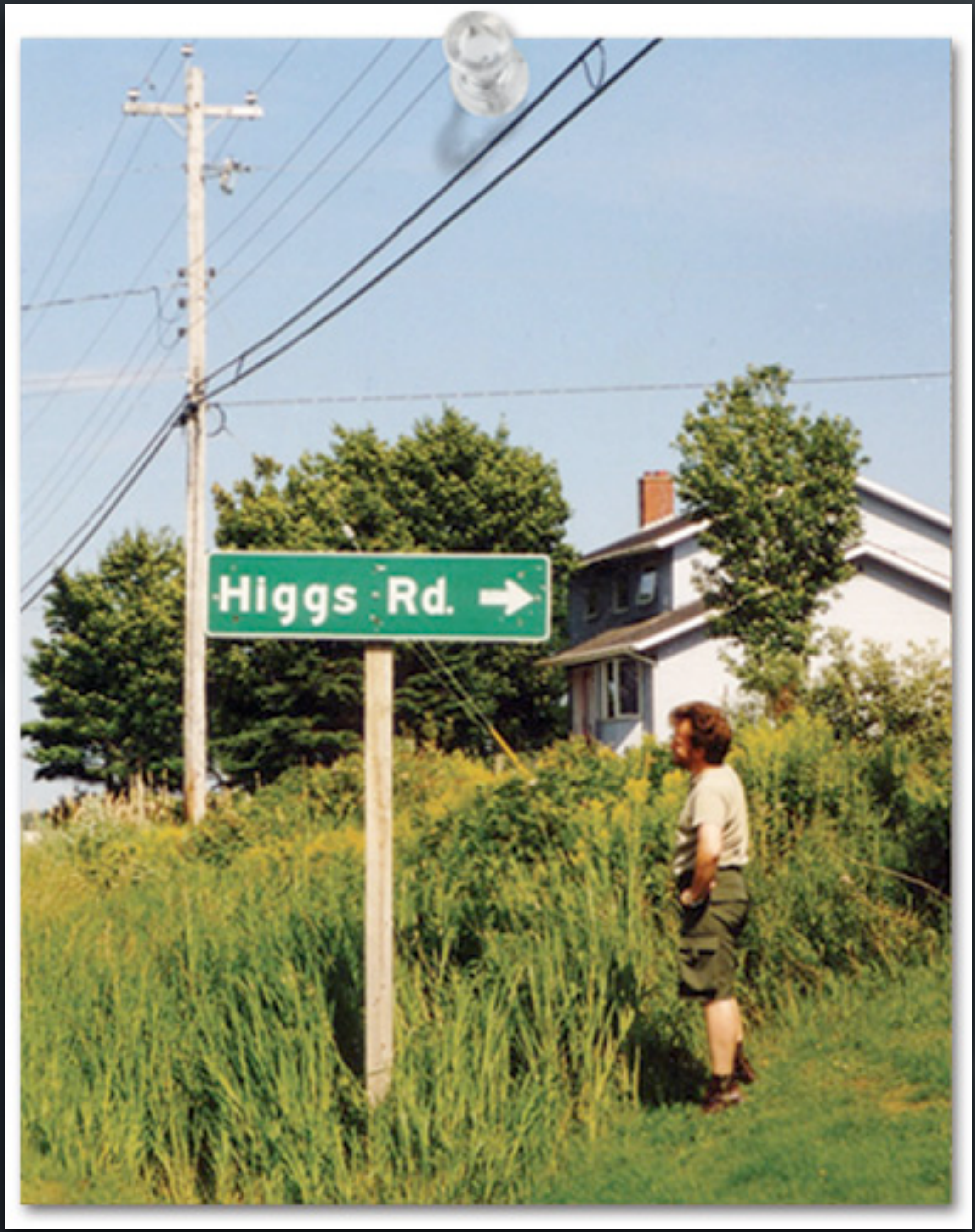
- Improved $\bar{p}$ source and beam operation — finally in shape
- Expecting 8-9 fb^{-1} data before 2009
  - ◇ ~20 Z+H produced, Maybe we can observe a couple of them?



Possible Analysis Improvements

- **Biggest obstacle is b-ID**
  - ◇ NN is combining the JLIP, SVT, SLT. Fine.
  - ◇ New ideas on improving JLIP?
    - ★ Make use of the negative IP tracks?
    - ★ Combine positive and negative IP tracks to form new discriminant?
  - ◇ New ideas on improving double b-tagging?
    - ★ A NN specialized in double b-tag?
    - ★ Parabolic-like cut?
- **Reducing uncertainties**
  - ◇ Taggability
  - ◇ Muon trigger, tracking...
  - ◇ Jet RECO*ID
- ...

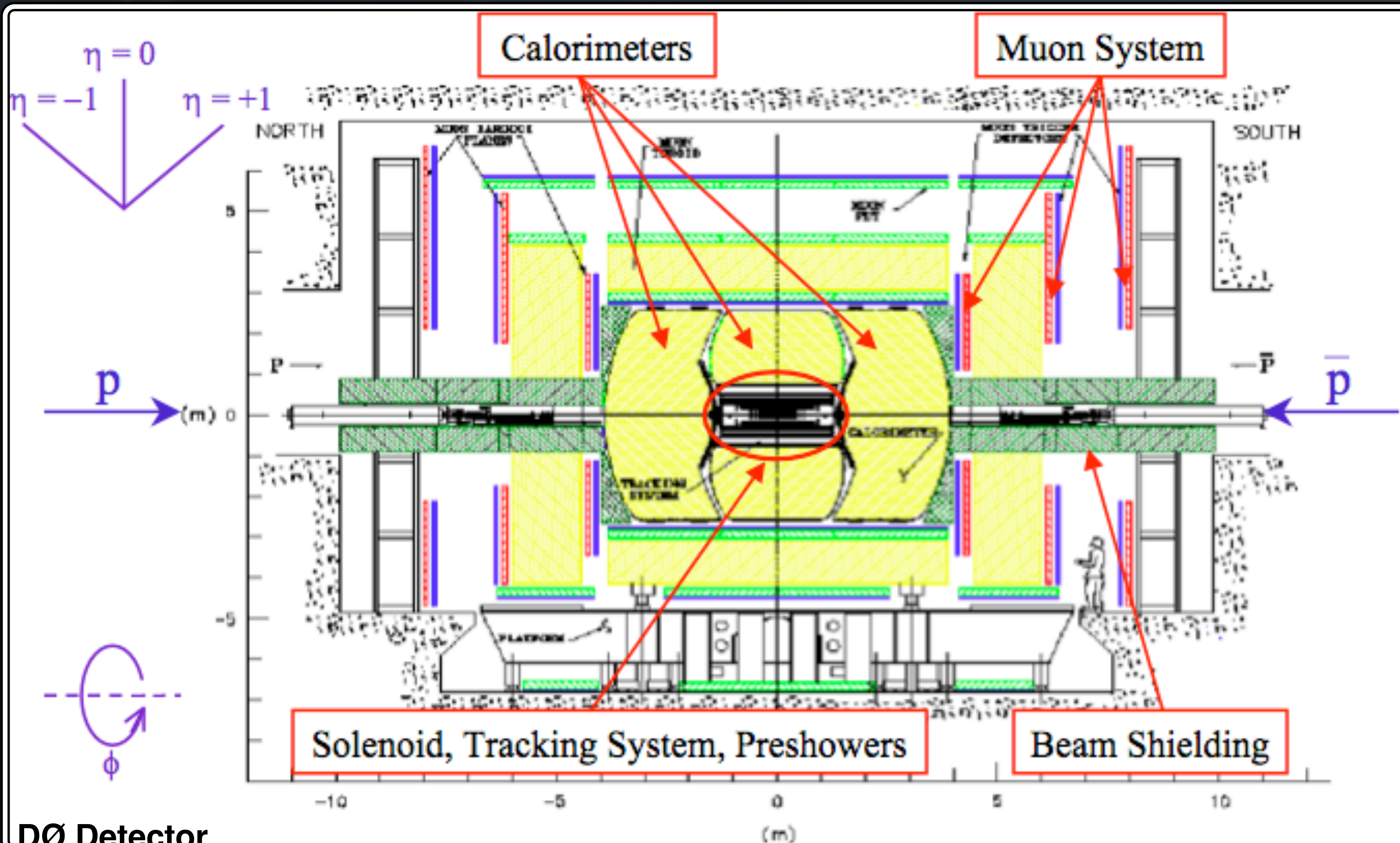
The End



Backups

DØ RunII Detectors: A Sketch

- **A contemporary 4-π detector**
  - ◇ Strong point (vs. CDF): good calorimeter (but not as good as RunI...)
  - ◇ Weak Point (vs. CDF): Tracking.
    - ★ In RunII, we added solenoid and silicon detectors and improved on it but...
    - ★ the calorimeter performance is affected as a trade-off.



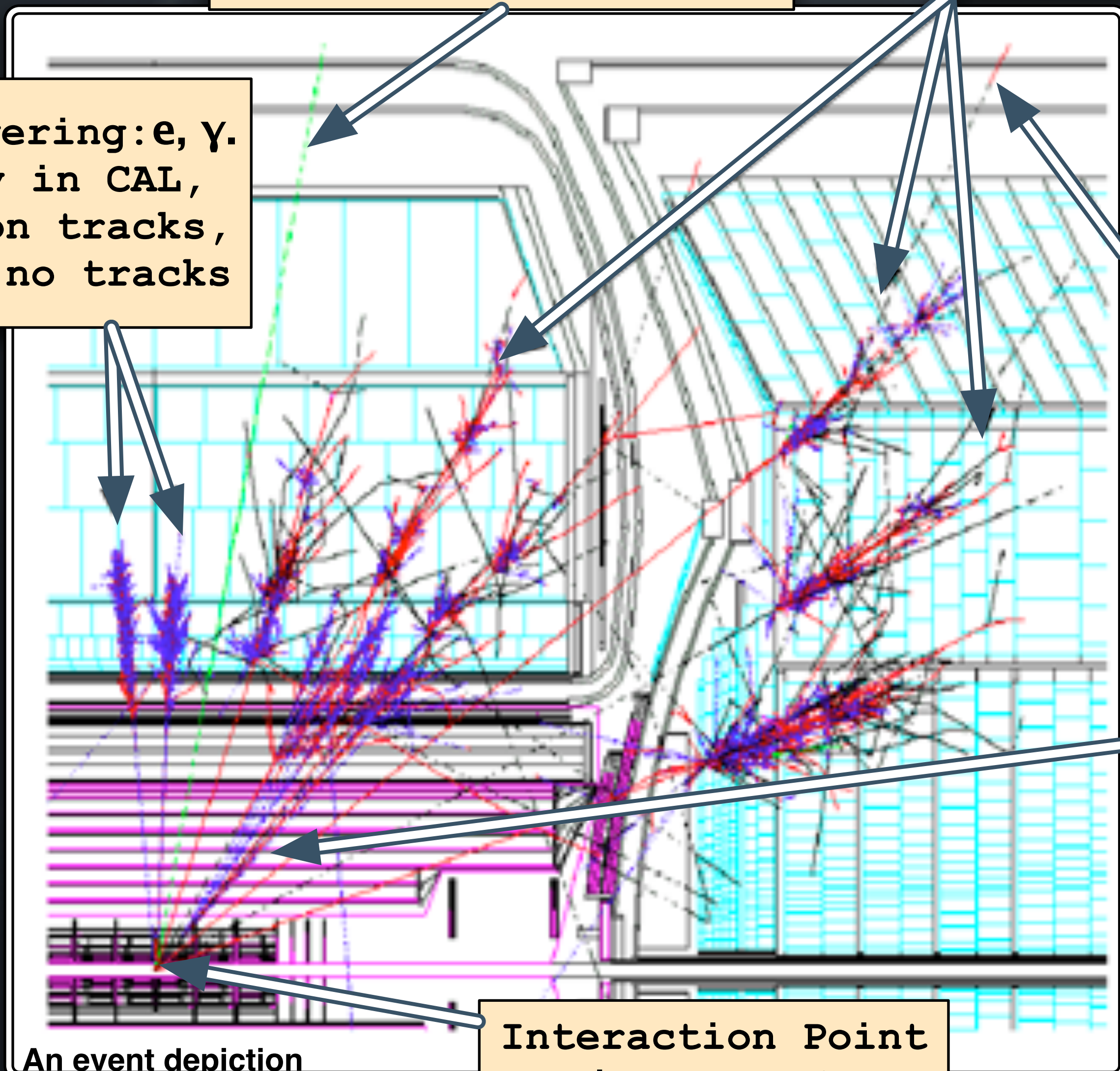
What's Happening in DØ

Muons: central track, MIP in CAL, Signal in muon detectors

Hadronic Showering: π, K energy in CAL, Tracks in CFT+SMT.

EM Showering: e, γ. Energy in CAL, Electron tracks, Photon no tracks

Muon from jets. No central track match. "Close" to a jet.



An event depiction

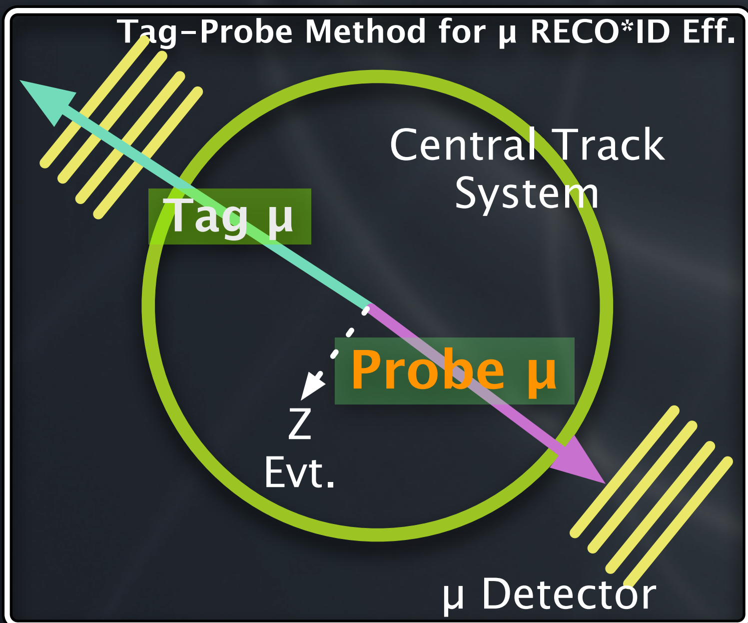
Charged Particle Trakcs: e, μ, π, K.

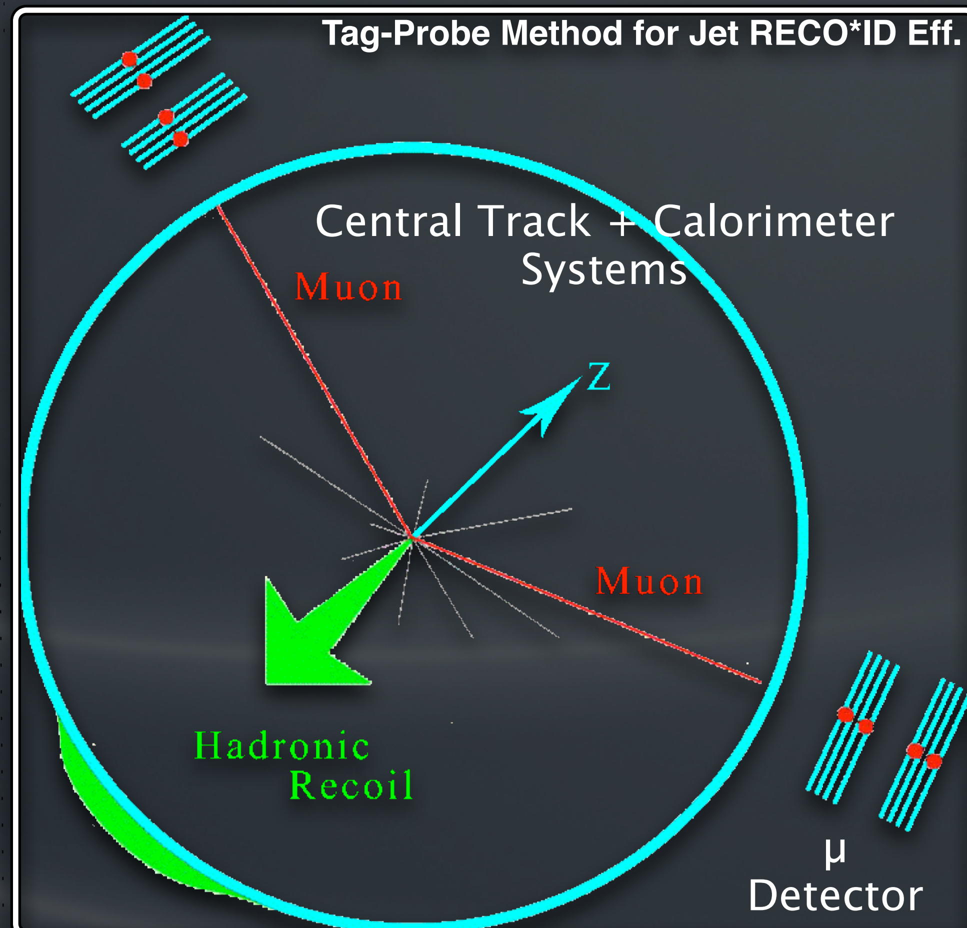
Interaction Point Primary vertex

Neutrinos are detected by the missing Et

Measuring RECO Efficiencies

- **Tag-Probe method**
  - ◇ Pick events containing tag and probe
  - ◇ Cut tight on the RECO-ed tag
  - ◇ Probe: No RECO-ed
  - ◇ RECO Eff. = Probability of Probe passes RECO





- **Jet RECO*ID Efficiency:**
- **Muon RECO*ID Efficiency:**
  - ◇ Both measured in detector data

Observation: Detector Data

- **Possible events: 2MuHighPt skim (p14 pass2, Jul.2002-Apr.2004)**
  - ◇ Require single muon triggers fired
    - ★ To simplify the luminosity and trigger efficiency studies
  - ◇ Data quality cuts
    - ★ Bad runs and runs with bad MUON/CAL detectors are removed
    - ★ Bad luminosity blocks within a run are removed
    - ★ Bad events that contain CAL noise are removed
  - ◇ Total of 108,451 events remained, int. lumi. = 370 pb^{-1}
- **Control samples:**
  - ◇ 1MuTrk skim: for un-biased muon trigger/RECO*ID efficiencies
  - ◇ Top group JetTrigger skim: for muon isolation study

Run Range	Trigger Name	$\int \mathcal{L}\ (pb^{-1})$
173522-175517	MUW_W_L2M3_TRK10	17.9
175518-194566	MUW_W_L2M3_TRK10	312.6
194567-196584	MUH1_TRK10	39.4

Expectation: MC Samples

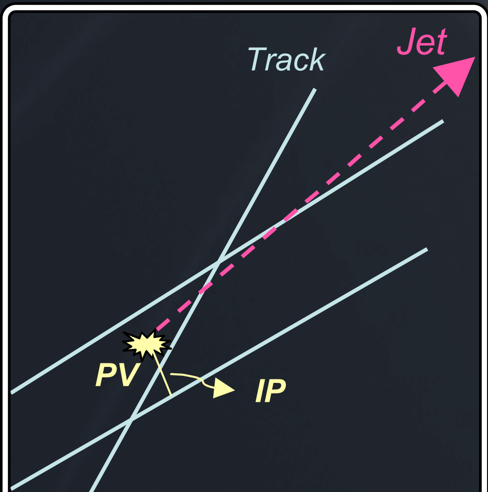
- Produced with PYTHIA v6.203 & ALPGENv1.31

M_H (GeV)	$\sigma\times$Br (pb)	SAM req. ID	# of events
105	0.0040	11667	5000
115	0.0028	11668	5000
125	0.0018	11669	5000
135	0.0011	11670	5000
145	0.0005	11671	5000

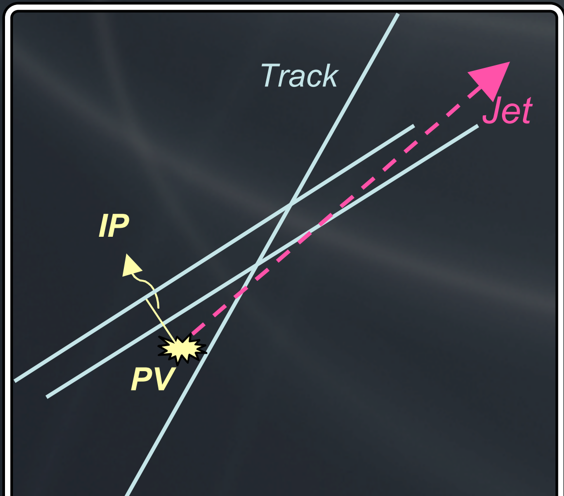
Process	$\sigma\times$Br (pb)	SAM req. ID	Generator	# of events
$Zbb \to \mu\bar{\mu}b\bar{b}$	0.533	11409, 11410	Alpgen+Pythia	96500
$Zcc \to \mu\bar{\mu}b\bar{b}$	1.15	15553-15560	Alpgen+Pythia	46250
$Zjj \to \mu\bar{\mu}b\bar{b}$	29.4	10721-10724	Alpgen+Pythia	188000
ZZ inclusive	1.56	15528	Pythia	53500
WZ inclusive	3.68	15527	Pythia	34250
$t\bar{t} \to \ell\nu b\ell\nu\bar{b}$, $M_t =$ 175 GeV	0.671	15385	Alpgen+Pythia	36000
$t\bar{t} \to \ell bbjj$, $M_t =$ 175 GeV	2.676	15326, 15343, 15344	Alpgen+Pythia	1353000
$Z \to \mu\mu$	266.7	12014, 12016	Pythia	202000

b-jet Profile

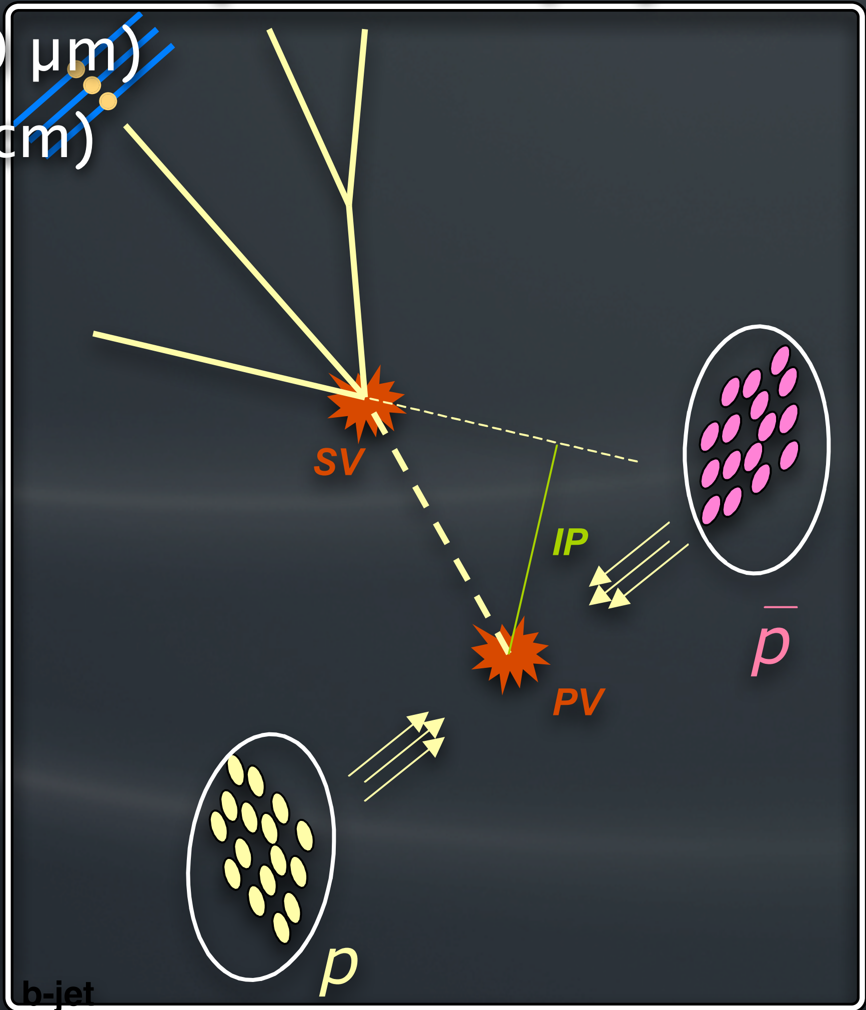
- **Semi-leptonic decays (to μ, BR~16%) from the B hadrons in jet**
  - ◇ c-quark (D^0 mesons) also decays to μ, BR~6.6%
  - ◇ Light flavor jets ($\pi^{\pm}$) won't decay to μ within DØ detectors (BR~100%)
- **Detectable secondary vertex (SVT) ~ 1 mm (τ*c ~ 500 μm)**
  - ◇ D^0 also has detectable SVT (τ*c ~ 120 μm)
  - ◇ Also K_S^0 (τ*c ~ 2.7 cm), Λ (τ*c ~ 7.9 cm)
  - ◇ Also energetic photon pair production
- **Positive impact parameters (IP)**
  - ◇ Also mis-vertexing produces +IP



Negative IP — mis-vertex



Positive IP — long lived jets

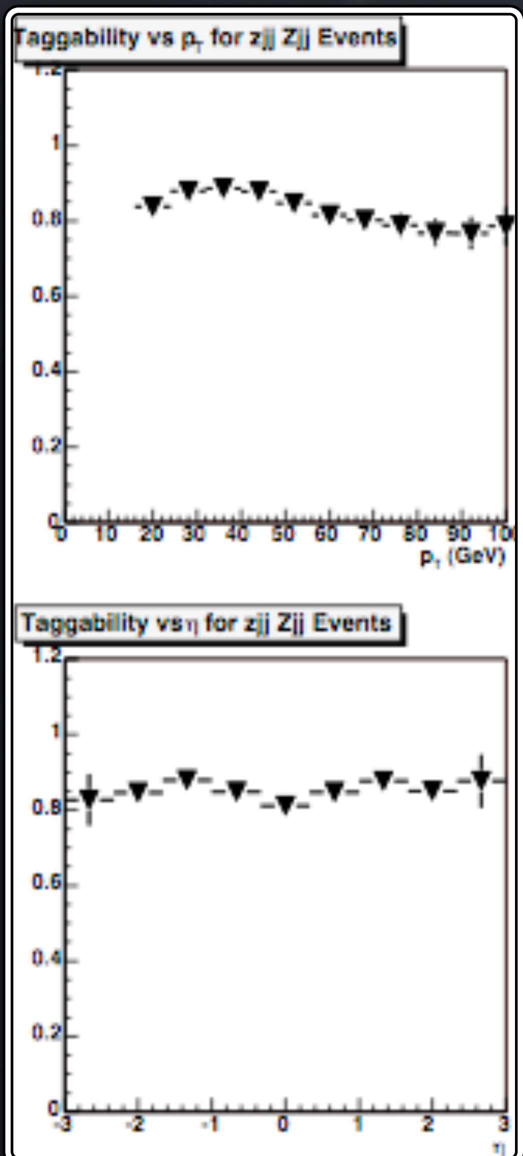


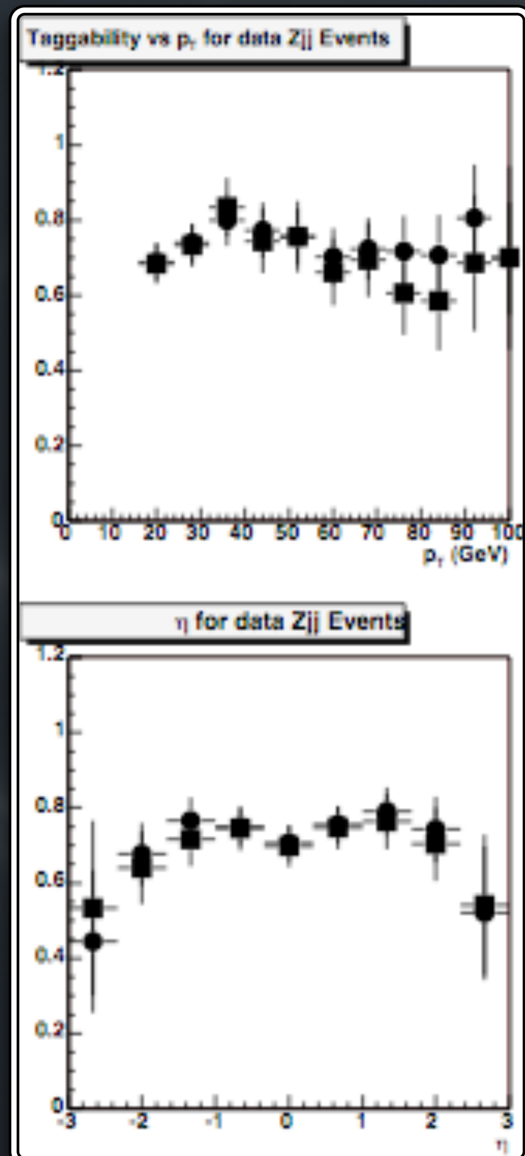
Preparations for b-tagging

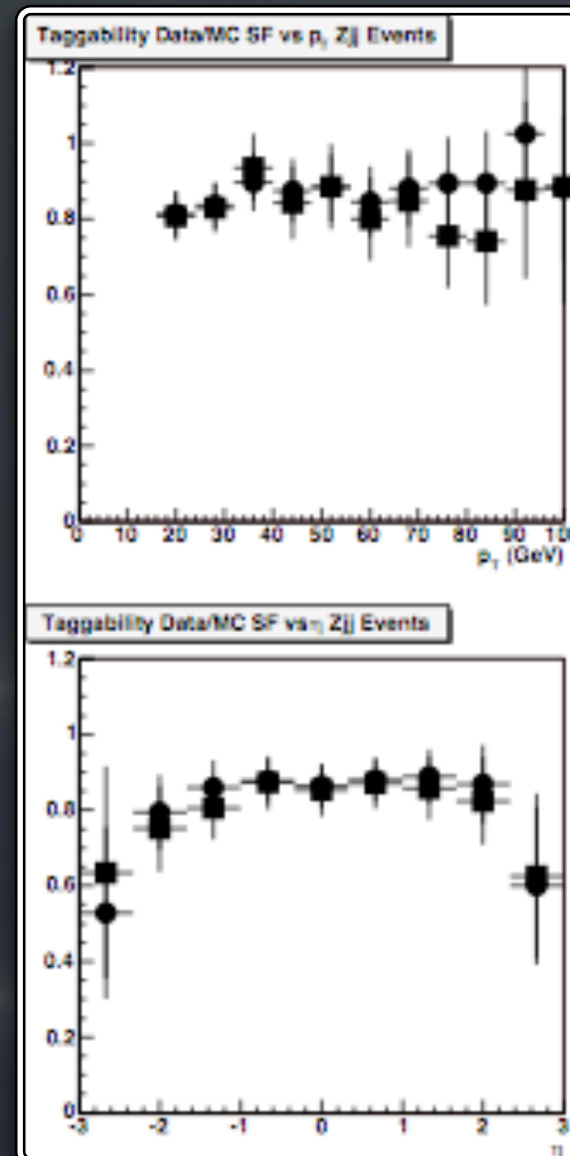
- **Taggability**
  - SVT & JLIP b-tag are actually based on tracks produced by jets
  - Require a jet match to a "track-jet"
  - A track-jet is a jet RECO-ed from tracks that are:
    - pT > 0.5 GeV, at least one SMT hit, # of tracks > 2
    - x-y DCA < 0.2 cm, z DCA < 0.4 cm
- V^0 **removal**
  - 6-8% in the un-tagged jets, 20-25% in b-tagged jets
  - Tracks that look like from γ, Λ, K are removed from track-jet
- **Determine the Taggability Efficiency**
  - Eff. = ratio of taggable jets and all good jets
  - Parameterize the efficiency as functions of jet pT and η
  - Measure eff. in detector data and MC samples
  - Data/MC scale factor (SF) is also determined.
    - basically SF = (Taggability. in data) / (Taggability. in Zjj MC sample)

Taggability Efficiencies

- Topic



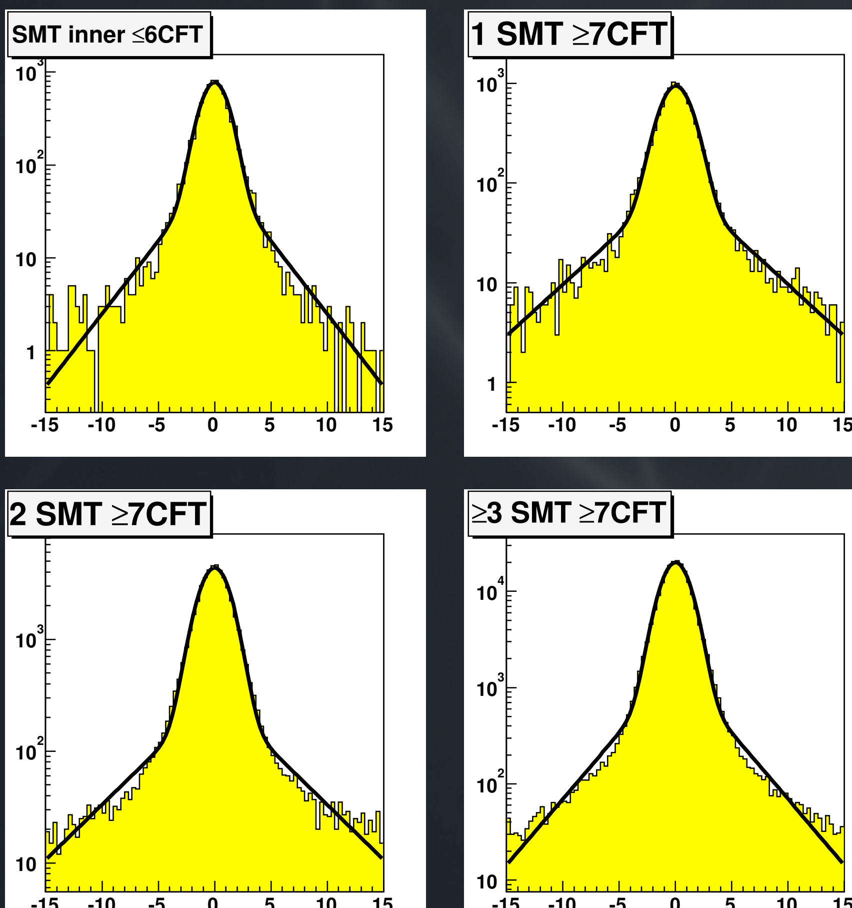


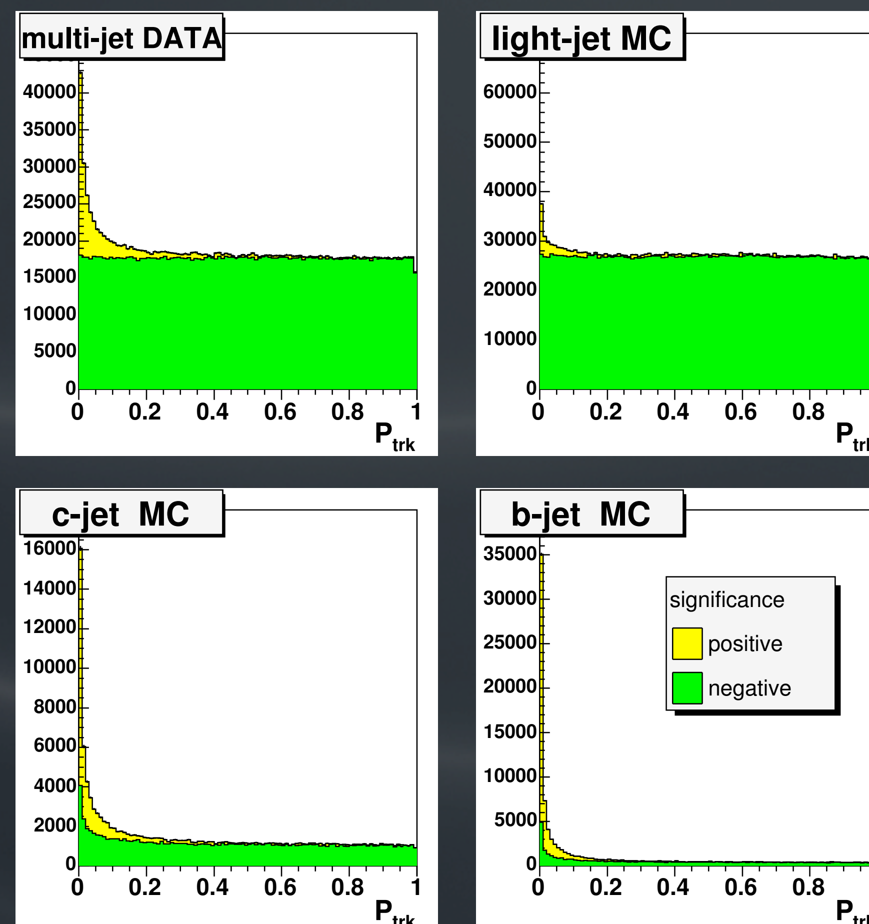


JLIP b-tagger (I)

- Negative IP significance distribution → b-track probability

$$\mathcal{P}_{trk}(S_{IP}) = \frac{\int_{-50}^{-|S_{IP}|} \mathcal{R}_{IP}(s)ds}{\int_{-50}^{0} \mathcal{R}_{IP}(s)ds}$$

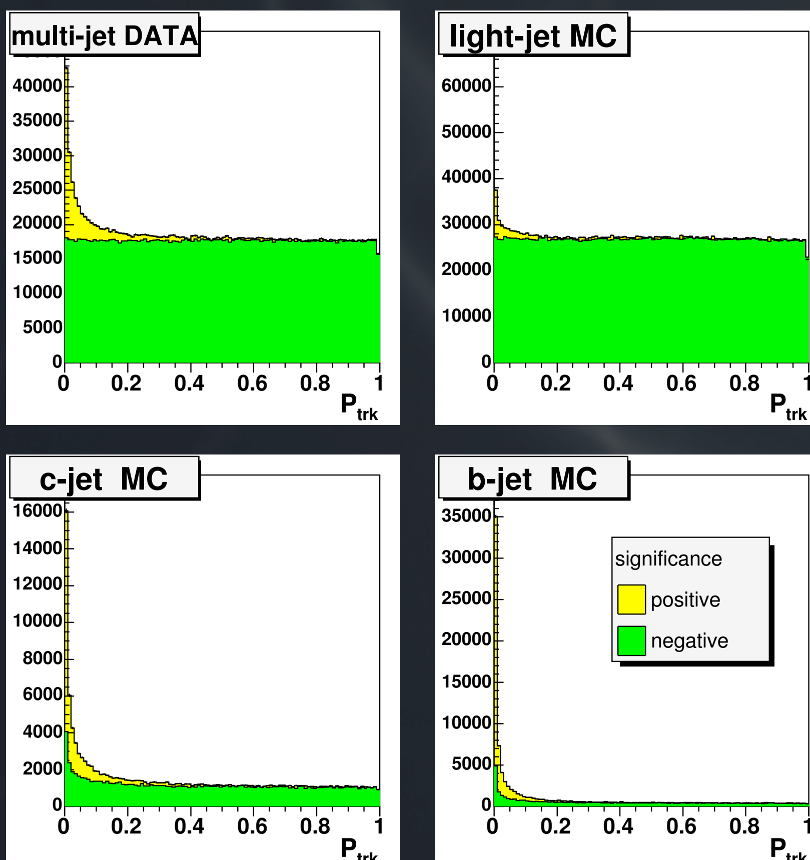


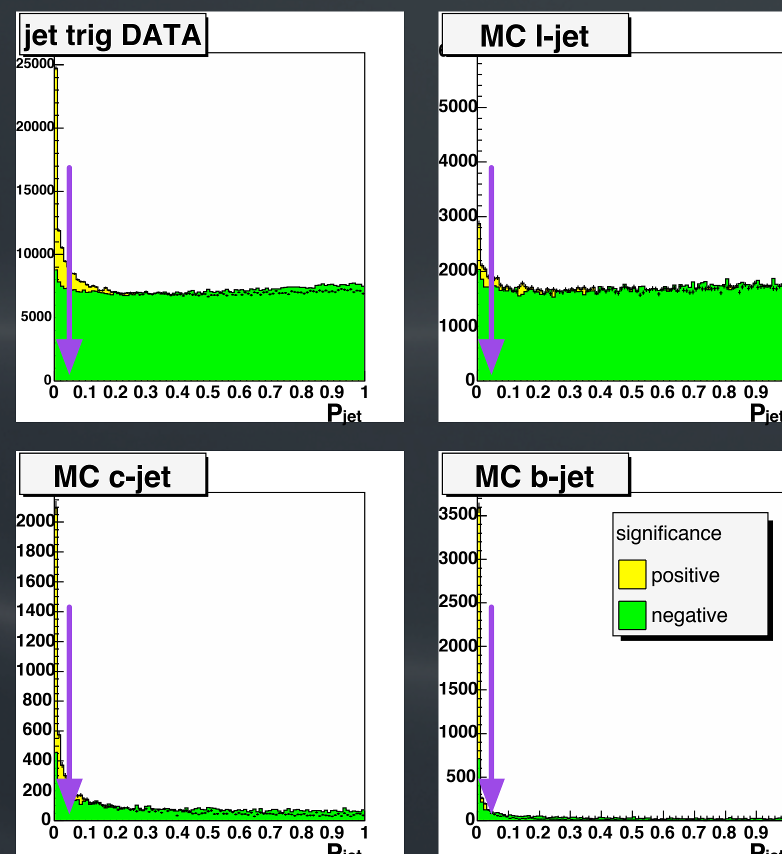


JLIP b-tagger (II)

- b-track probability → b-jet probability
- Cut point is ExtraLoose, eg. Prob. < ~0.04
  - ◇ Optimized for double b-tagging of Z+2jets events

$$\mathcal{P}^{+}_{jet} = \Pi^{+} \sum_{k=0}^{N^{+}_{trk}-1} \frac{(-\ln \Pi^{+})^{k}}{k!}$$





DØ is Pushing

- Layer-0 silicon tracker installation finished
- L2 Silicon Track Trigger (STT) running since 2005
- L1 CAL-CTT match
- L1 CTT improved tracking
- Upgrade trigger lists for the high luminosity
- Can we get better tracking (for muons)?
- Can we get better b-jet efficiency from the STT's IP trigger?
- Progress on the b-ID algorithm — Neural Networks
- Better jet energy scale and MC jet corrections
- ...

Prospect of the Big Picture

- **We are working hard...**
- **Can we declare observation before LHC?**
- **What if LHC found nothing? And ILC is delayed?**
- **What's next if Standard Model & Higgs is proven right?**
  - ◇ Precision W/Z & top quark measurements are not as crucial?
  - ◇ Higgs measurement will be HOT. (Not as significant as discovery?)
  - ◇ SUSY particles? Dark matter candidate?
  - ◇ CP problem, neutrinos... not much affected.
- **And what else after that? Quantum Gravity?**
  - ◇ Accelerator energy upper limit?
  - ◇ Detector & electronics upper limit?
- **In short: We need new testable theories and doable experiments!**
  - ◇ otherwise we will be a suffered generation.

Thanks

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Gregorio Bernardi, Qizhong Li, Suyong Choi...

Friends @ SBU & DØ & Fermilab

Many more (DØ collaboration, FNAL)...

and the Committee