

3L XFT Upgrade: Motivation, Simulation, & Hardware

Outline:

History of 3L tracks

Physics need for 3L XFT Upgrade

Possible Hardware implementation

Simulation Results

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Thanks to following people



- Sunny Chuang (Wisconsin) - Did trigger efficiency shown
- Jason Slaunwhite (OSU) - Did single top study shown
- Anyes Taffard (Illinois) - Did WH and ttbar shown
- Greg Veramendi (Illinois) - Studies on CEM & CMX

- Kevin Lannon (OSU) - Gave (giving) talk

- Until 2006 shutdown, we had 3-Layer tracks
 - Were produced in the XFT Linker boards using roads which only had segments in 3 out of 4 inner Axial superlayers
 - ❑ “road” is a track pattern formed from phi and slope of 3 or 4 segments found in XFT Finder boards
 - Were sent to XTRP
 - ❑ used for BMU-Front trigger
 - ❑ edges of CEM trigger
 - ❑ some tau triggers
 - Used Resources in the XFT Linker boards
 - ❑ time : Linker looped over 4L tracks and then 3L tracks
 - ❑ Logic Elements: Linker had a different set of roads for 3L tracks

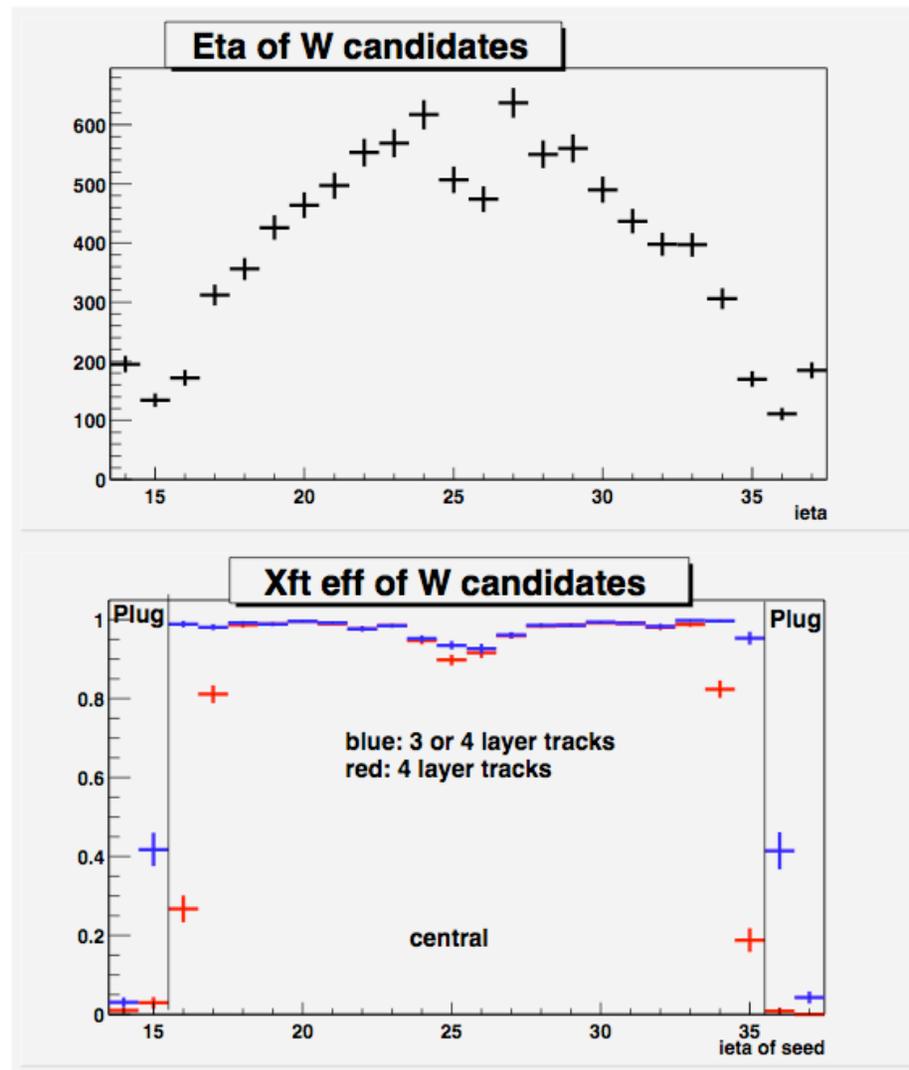
XFT Stereo Upgrade



- Stereo Linker Association Module (SLAM) added to Level 1 trigger
 - Combines stereo segments from new COT Stereo Superlayer Finder Boards with existing tracks from XFT Linkers
 - ❑ "Confirms" existing axial tracks by setting a bit on the way to XTRP
 - Improvement at L1 of ie) a factor of 5 - 10 in CMX trigger rates
- Intelligent design
 - To create enough time to run SLAM
 - ❑ Linker modified to remove loop over 3Layer tracks
 - ❖ Also provided extra space to do other tasks in parallel
 - These modifications allow us to get such a great gain from SLAM
- XFT 3-Layer tracks unfortunately had to be removed

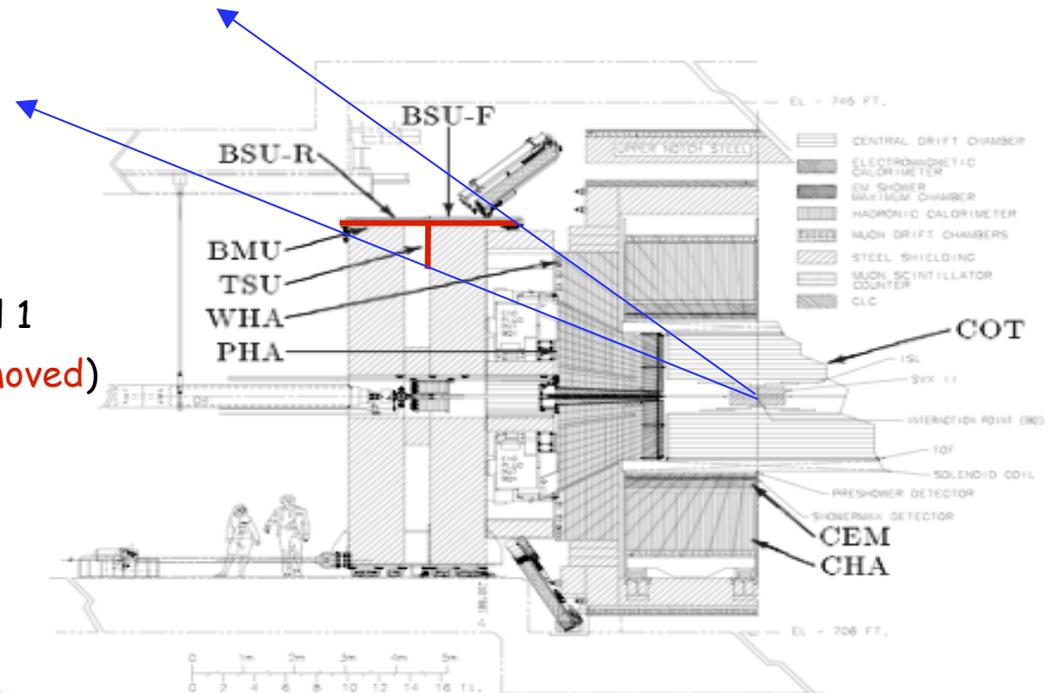
- CEM trigger :
 - Gains in outer CEM trigger towers using 3L tracks
 - ~ Perhaps 10% from right below plot

- These events could be reclaimed using other triggers
 - Z events : Z_NOTRACK, PLUG Z
 - W events : W_NOTRACK, MET PEM
 - etc ...



Plots made by Greg Veramendi years ago ...

- IMU / BMU system
- Has capability to trigger muons out to $1.0 < |\eta| < 1.5$
- Triggers divided into:
 - front (F) $1.0 < |\eta| < 1.25$
 - XFT 3- or 4- Layer track at Level 1
(as of Trigger Table 4.0 3L XFT removed)
 - rear (R) $1.25 < |\eta| < 1.5$
 - TSU + BSU-R coincidence
 - no XFT requirement



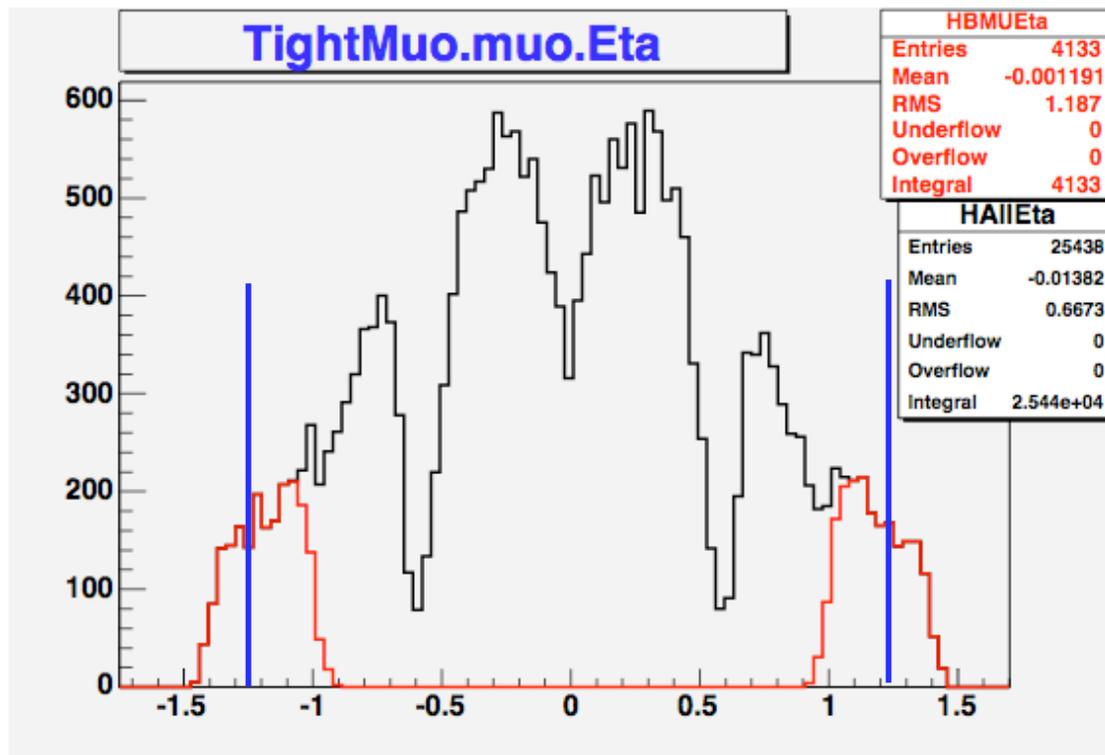
BMU-Front trigger currently not being used

- Forward muon trigger mainly useful for statistically limited analyses
 - Single top
 - Higgs analyses
 - ❑ W^+W^-
 - ❑ $ZH \rightarrow l^+ l^- bb$
 - ❑ $WH \rightarrow l \nu bb$

- D0 has muon trigger out to 2.0
 - big advantage for them

- Tev Higgs sensitivity report assumed forward muons

- Single top
 - BMU: 20% gain over just CMUP+CMX
 - in both s- and t-channels
 - Only 70% of this comes from BMU-Front ($\eta < 1.25$) where XFT can help
- BMU has overall 14% gain over just CMUP+CMX



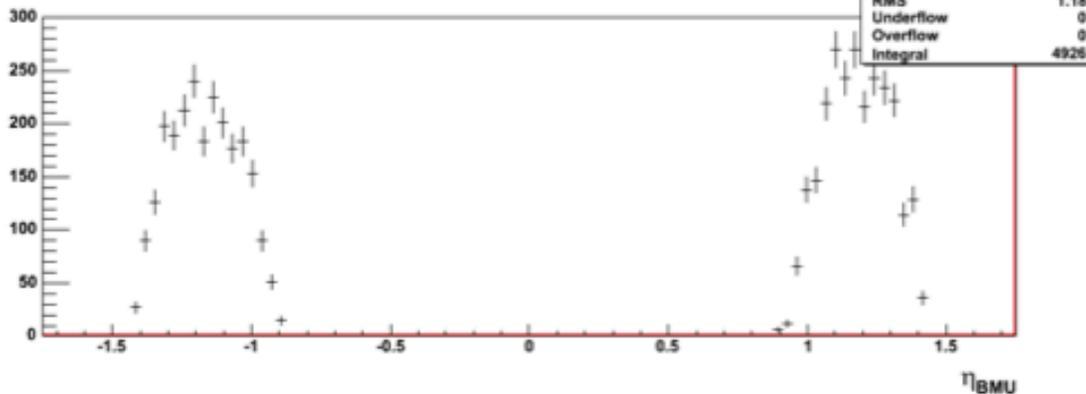
Study by Jason Slaunwhite

- Results similar for other channels
 - Anyes has looked at $WH \rightarrow l\nu_{bb}$ ~ reports 15% gain
 - Beate and I found 17% gain in $ZH \rightarrow llbb$

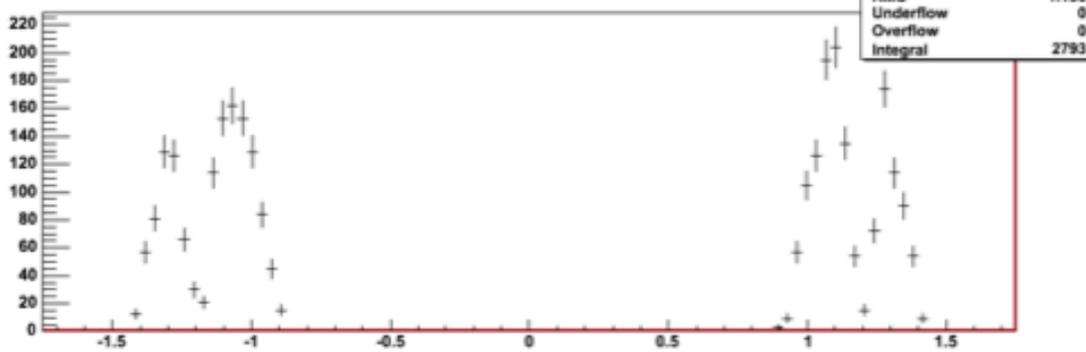
- But still need trigger efficiency !

- Trigger efficiency
 - Brand new!
- In Front BMU, trigger efficiency is ~ 63%

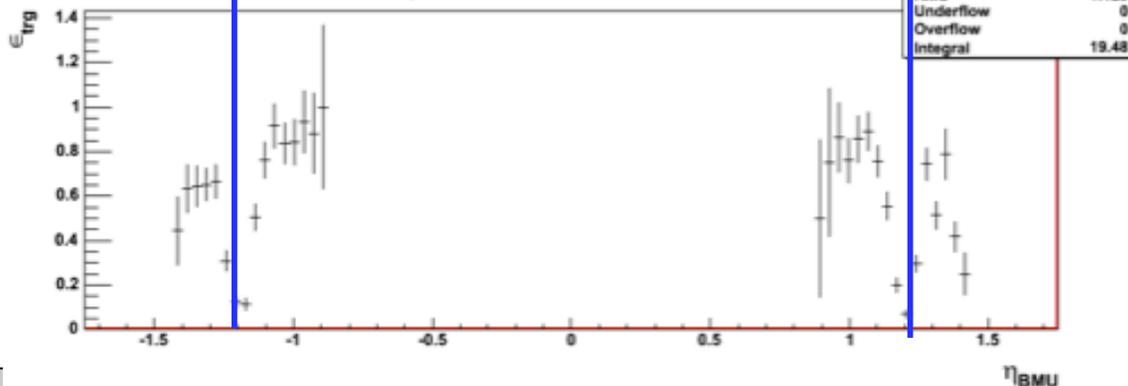
BMU front+rear from bhmu0all



BMU passL1front+rear from bhmu0all



BMU L1 passL1front+rear ϵ_{trg} vs η_{BMU} from bhmu0all



From Sunny Schuang

- Single top:
 - 20% acceptance improvement in muons
 - 70% in BMU-Front
 - 63% trigger efficiency in BMU-Front
 - $0.63 \cdot 0.7 \cdot 20$
 - ❖ 9% gain in muon acceptance from XFT+BMU-Front

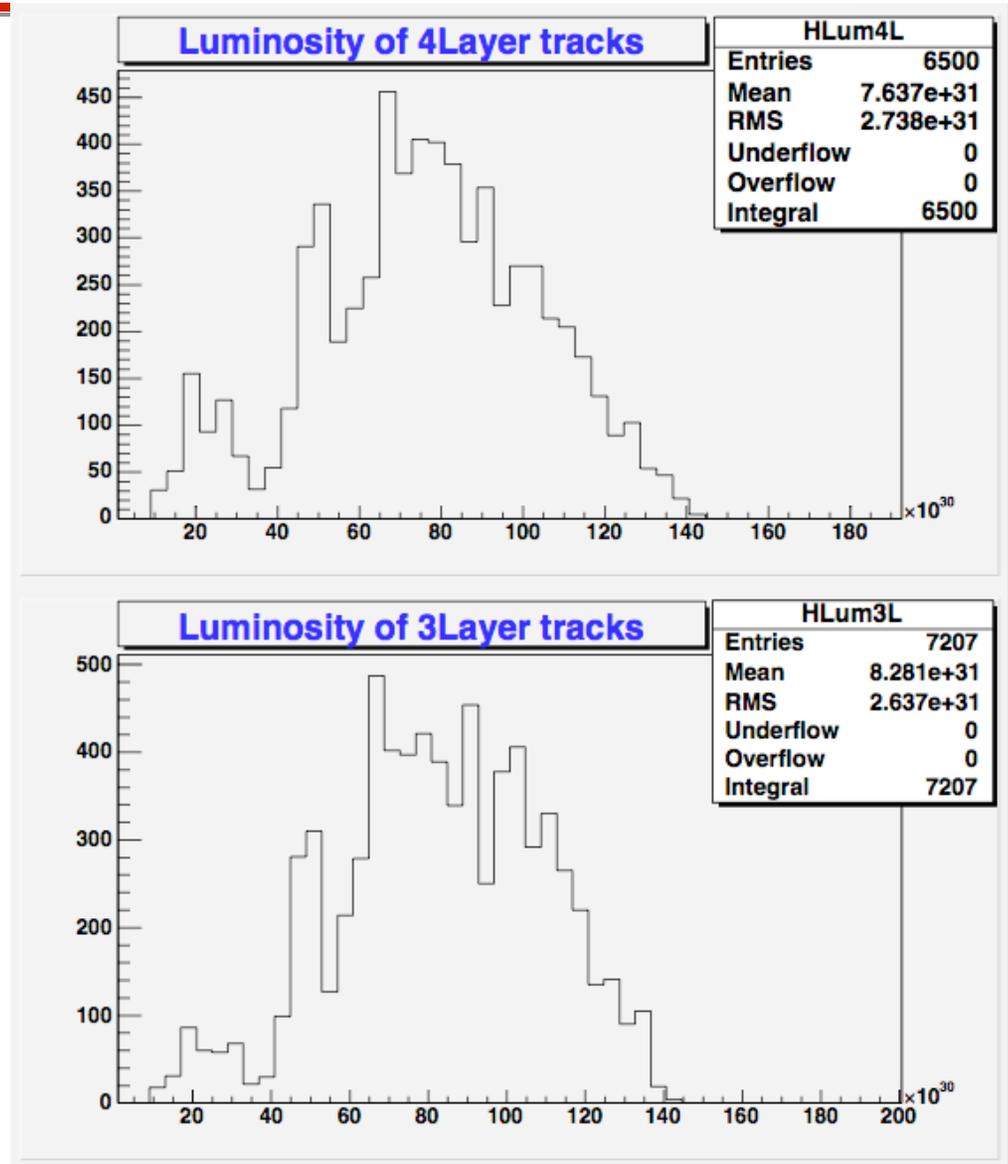
- Not possible to confirm 3L tracks at L1
- Only possibility so far is to do the following
 1. First, Linker sends 4L tracks to SLAM, then it sends 3L tracks
 2. SLAM does stereo confirmation on 4L tracks (making them 7L tracks) while receiving 3L tracks
 3. SLAM combines 7L and 3L tracks into track list for XTRP giving preference to 7L tracks
- ∅ Linker does not have enough space to do dedicated 3L track roads
 - ∅ Instead it “turns on” all segments in outer layer and reruns its track finding with the same 4L track roads
 - ∅ Effectively a 3L track although there could be some loss in track quality
 - ∅ At high luminosity, large fake rate
 - ∅ Would require additional objects in trigger

Results from Simulation



- Wrote an XFT simulation of this hardware option
 - Simulated from COT banks in unbiased gr^* data
 - Almost exactly what real XFT hardware would do
 - ❖ some slosh between TDC and XTC readout

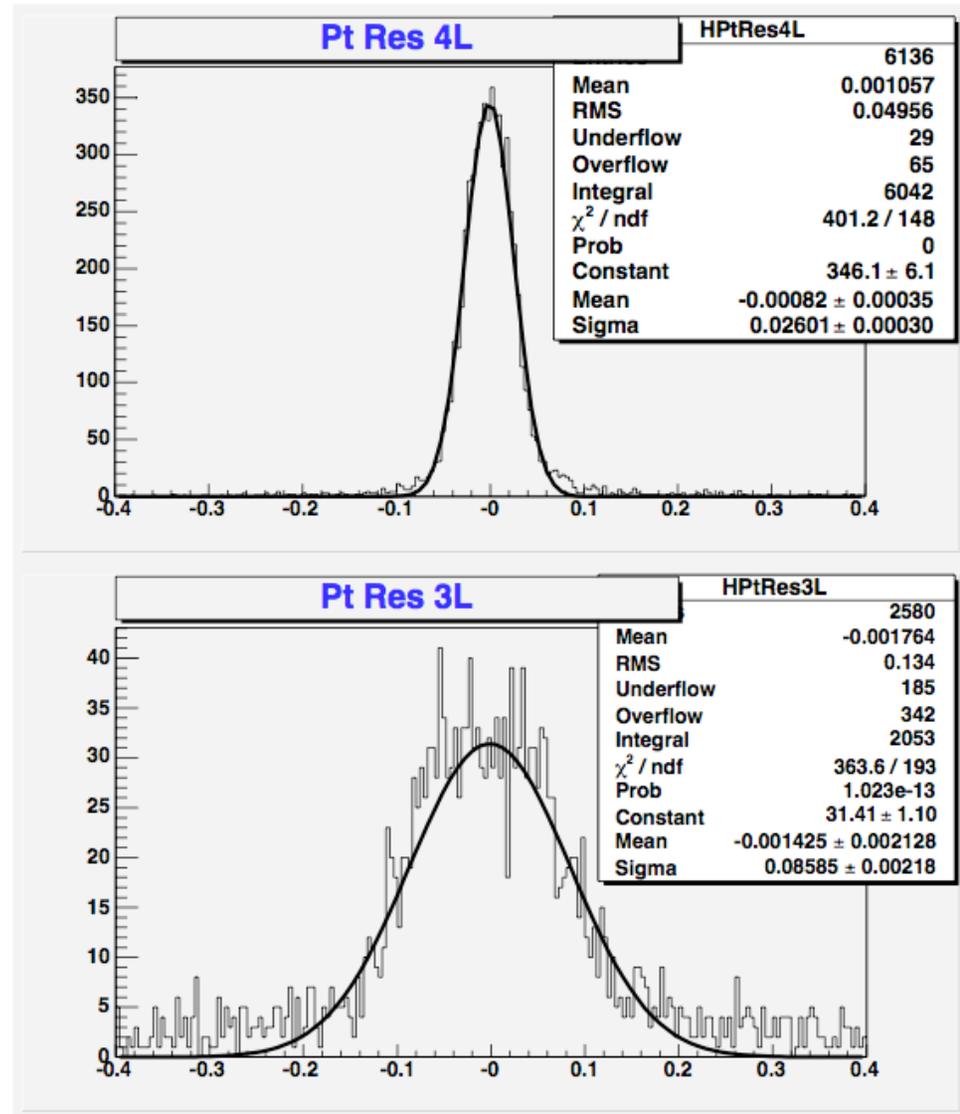
- In 30,000 events
 - Lum : 20E30 - 140 E30 in bunch luminosity
 - 6500 4L tracks
 - 7200 3L tracks



Resolution of 3L tracks



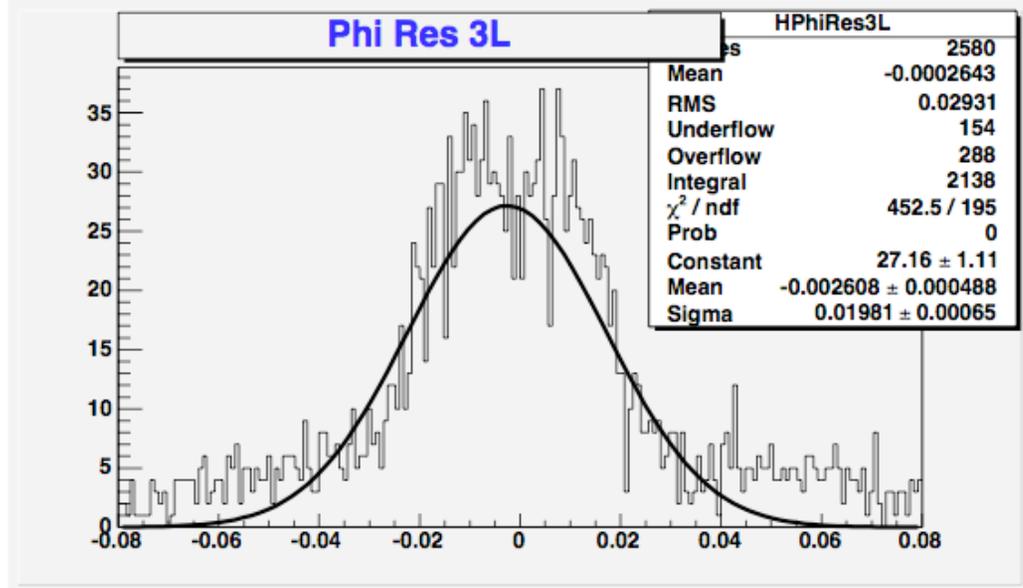
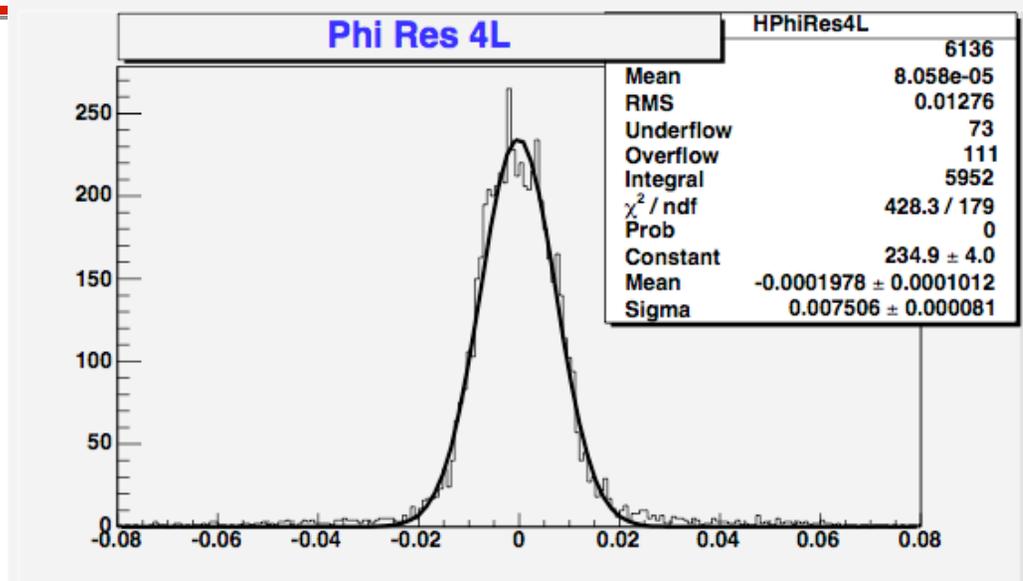
- Top : 4L tracks
- Bottom : 3L tracks
 - only counted if no 4L track in 1.25 ° linker chip
- Pt resolution :
 - Matched to offline track
 - dPt/Pt^2
 - 4L : $\sigma = 0.026 \text{ GeV}^{-1}$
 - 3L : $\sigma = 0.086 \text{ GeV}^{-1}$
 - 3 times bigger



Resolution of 3L tracks

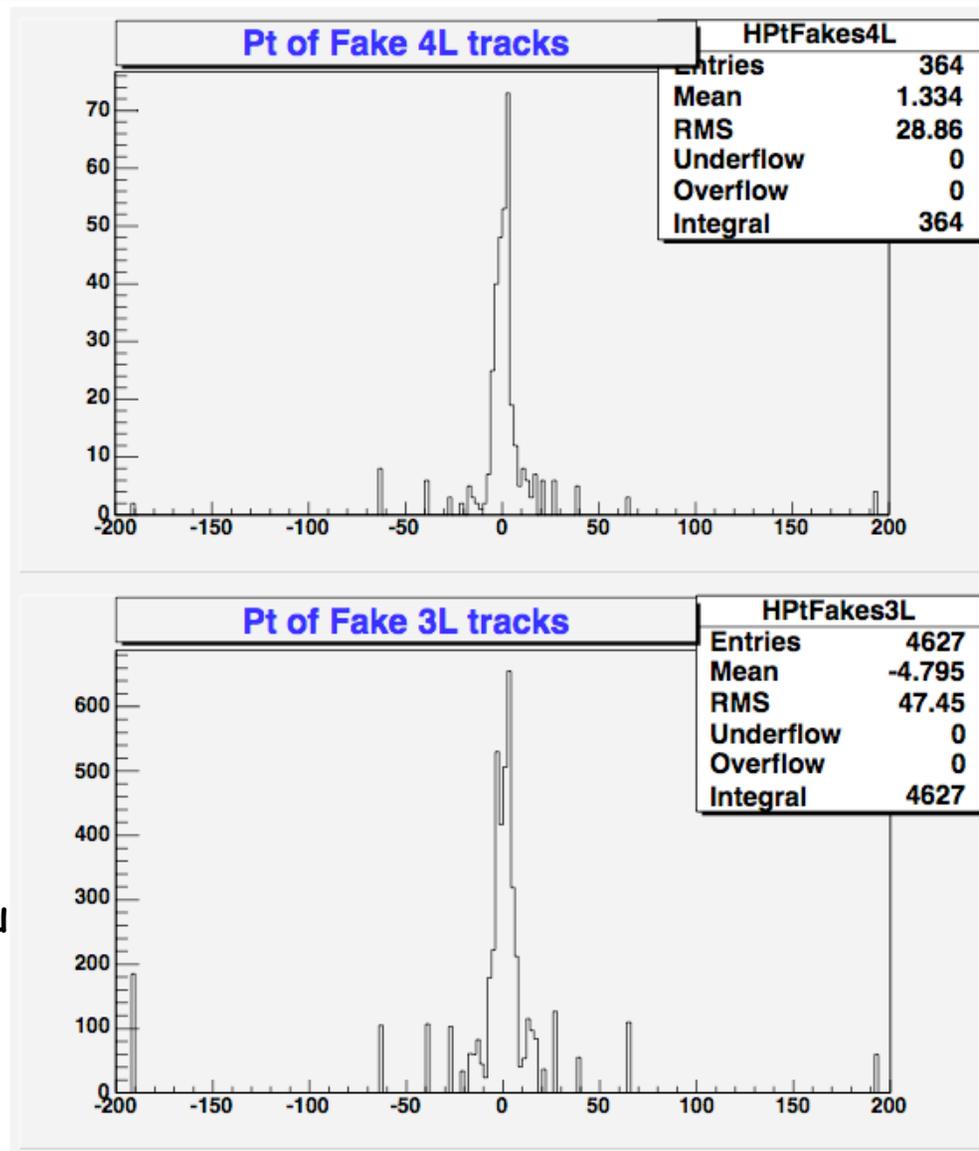


- Phi Resolution :
 - matched to offline track
 - delta Phi (offline track - xft track)
 - 4L : $\sigma = 0.0075$ radians
 - 3L : $\sigma = 0.020$ radians
 - θ 2.7 times bigger



- Fake Pt distribution
 - 4L : 364/6500 fake
 - 5.6% fake
 - 3L : 4627/7207 fake
 - 64% fake

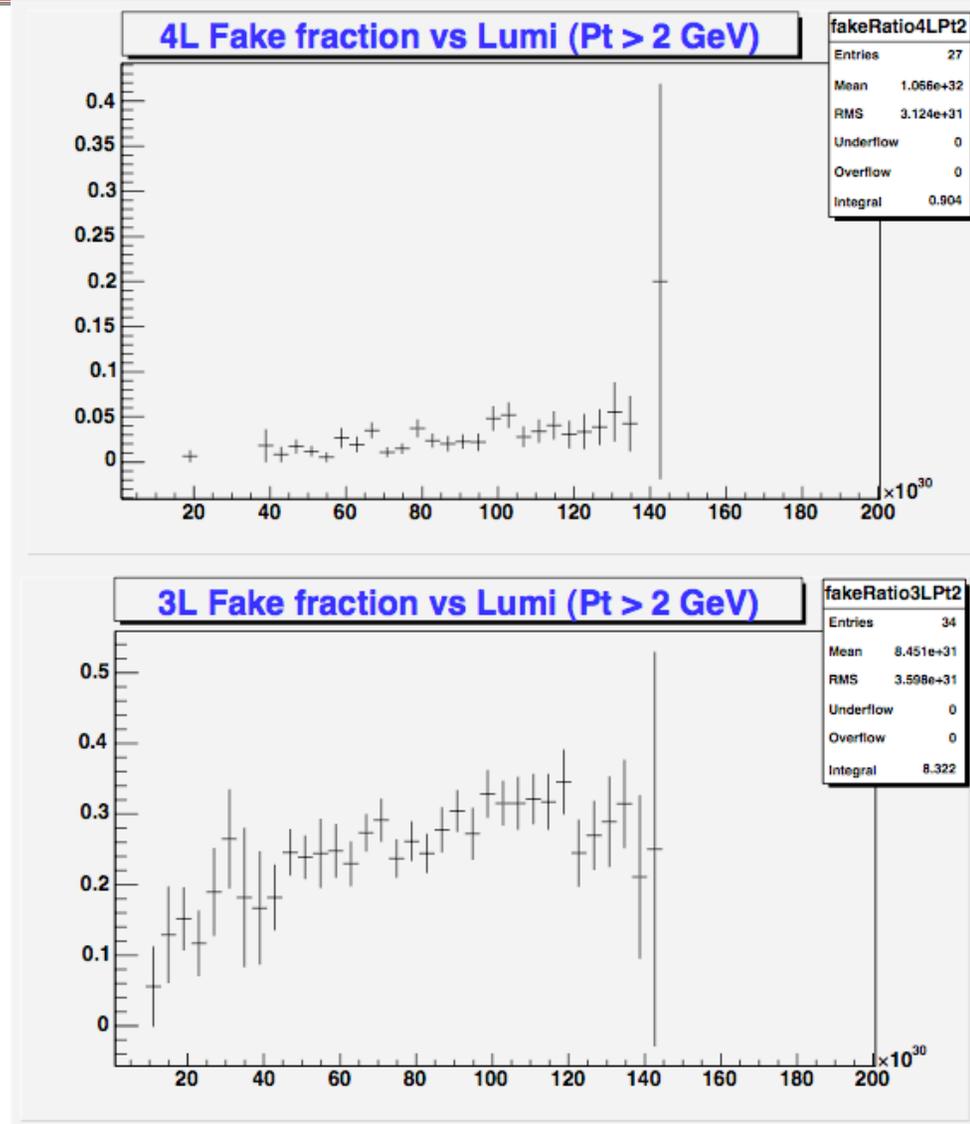
- Remember :
 - These are "4L tracks" I'm comparing to
 - I haven't added in the stereo confirmation which would reduce 4L fakes down to 1% but not change 3L fakes



Fake rate for $P_t > 2 \text{ GeV}$



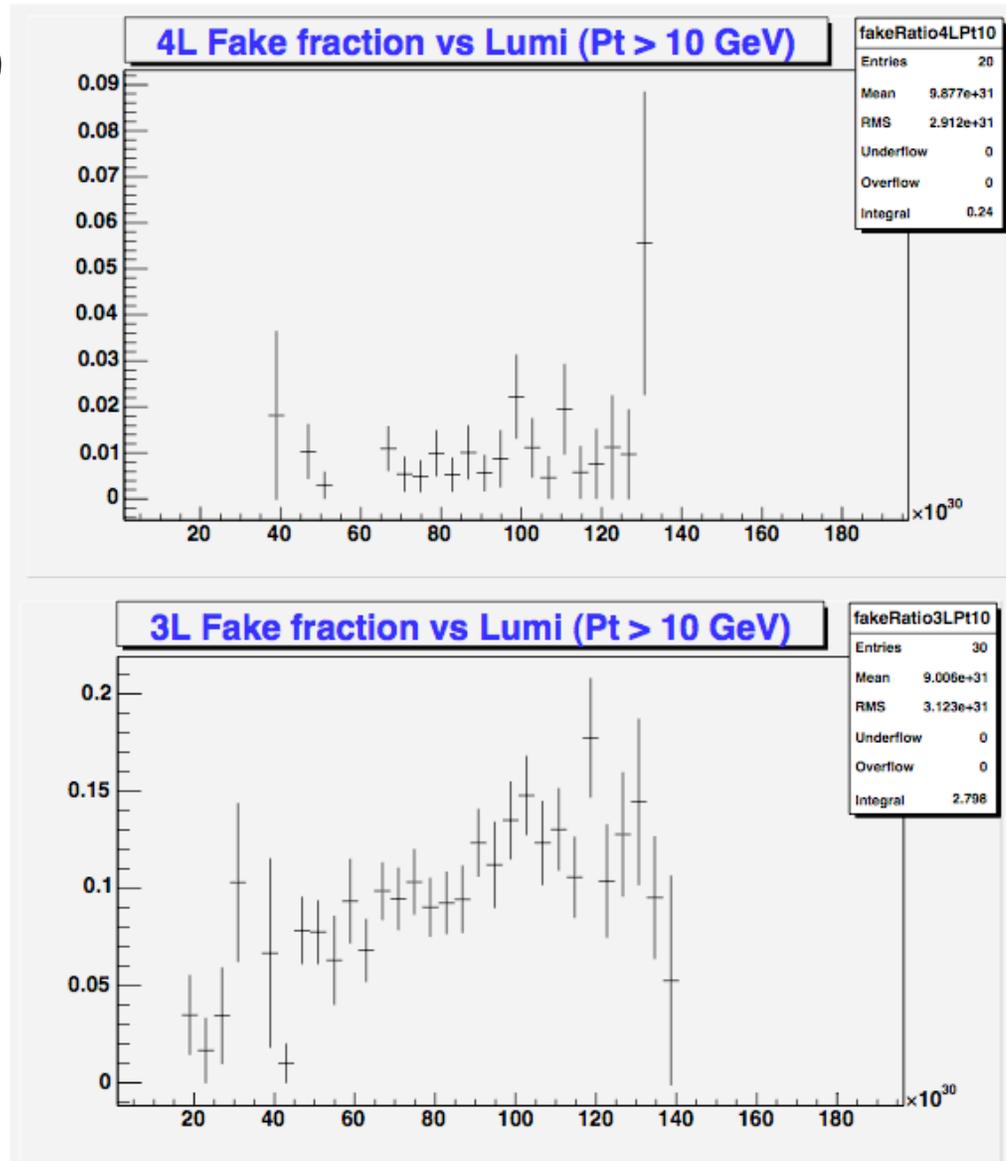
- Fraction of XFT tracks $P_t > 2 \text{ GeV}$ which are unmatched to offline tracks
 Grows with luminosity
- 4L tracks: $\sim 2\%$
- 3L tracks: 25%



Fake rate for $P_t > 10$ GeV



- Fraction of XFT tracks $P_t > 10$ GeV which are unmatched to offline tracks
 Grows with luminosity
- 4L tracks: 0.5%
- 3L tracks: 9%



- XFT Stereo Upgrade is ongoing
 - No serious work has been done in seeing if 3L tracks will be feasible
 - OSU group is still busy on main XFT Upgrade
 - ❑ Does not have manpower for this
 - Several obstacles have been thought of however ...
 - ❑ Current Linker is a 132 ns device (divisible into Tevatron bunch structure)
 - ❖ Does not know which bunch it is
 - ❖ 3L upgrade would require that Linker becomes aware of bunch and abort gap structure
 - ❖ Not trivial !
 - ❑ Not clear if SLAM has resources or time to add in 3L tracks
 - ❖ Would require logic to choose between high Pt 4L tracks and 3L tracks

- BMU-Front trigger should somehow get added back to trigger for low statistics Higgs/Single top analyses
- We have an XFT hardware possible design for adding 3L tracks for BMU-front trigger
 - Untested and issues not fully thought out
 - Probably a lot of work
- We have XFT simulation of this option
 - 3L Tracks are low quality and have high fake rate by themselves
 - ❑ possibly useful in combination with BMU stub
- Should start with a BMU+jet trigger right now
 - Add additional jet if rate is too high
 - ❑ since ZH,WH,single top all have at least 2 central jets

- XFT Upgrade
 - http://www-cdf.fnal.gov/internal/run2b/trig-daq/xft/Run2b_XFT.html
- BMU ID blessing
 - Salvador Carrillo, Sunny Schuang, Fabiola Vazquez, ... others
 - http://www-cdf.fnal.gov/internal/WebTalks/Archive/0604/060407_joint_physics/
- BMU systematics
 - Salvador Carrillo (U. Iberoamericana), James Bellinger (UW)
 - http://www-cdf.fnal.gov/internal/WebTalks/Archive/0607/060712_Lepton/
- BMU trigger efficiencies talk
 - Sunny Schuang, Mike Glatzmaier (UW)
 - http://www-cdf.fnal.gov/internal/WebTalks/Archive/0607/060712_Lepton/
- Top analyses acceptance in 1 fb^{-1}
 - Anyes Taffard (Illinois)
 - http://www-cdf.fnal.gov/internal/physics/top/RunIITopProp/anaInternal/SecVtxXs/Anyes_secVtx1fb.html
- Higgs Physics gain of BMU / CMU-only / CMP-only triggers
 - Beate Heinemann, BJK,
 - http://www-cdf.fnal.gov/internal/run2b/trig-daq/xft/Run2b_XFT.html

- BMU-F and BMU-R trigger rates are high
- Previously ...
 - BMU-only triggers are prescaled
 MUON_BMU9_L1_BMU10_BSU_PT11
 BSU stub, hadron TDC timing
 11.29 GeV XFT 3 or 4 layer track
rate limited 2 Hz
 - BMU + jet triggers :
 - For ZH, WH, single-top, events share the fact that they have at least two jets, at least one must be central enough to b-tag
 REAR : MUON_CENTRAL_JET20_L1_BMU10_BSUR
 requires L2 15 GeV cluster
 20 GeV L3 Jet
 no XFT requirement
 - FRONT : MUON_CENTRAL_JET20_L1_BMU10_PT11
 requires L2 15 GeV cluster
 20 GeV L3 Jet
 XFT 3 or 4 layer track required (basically 3 layer)

BMU trigger efficiency

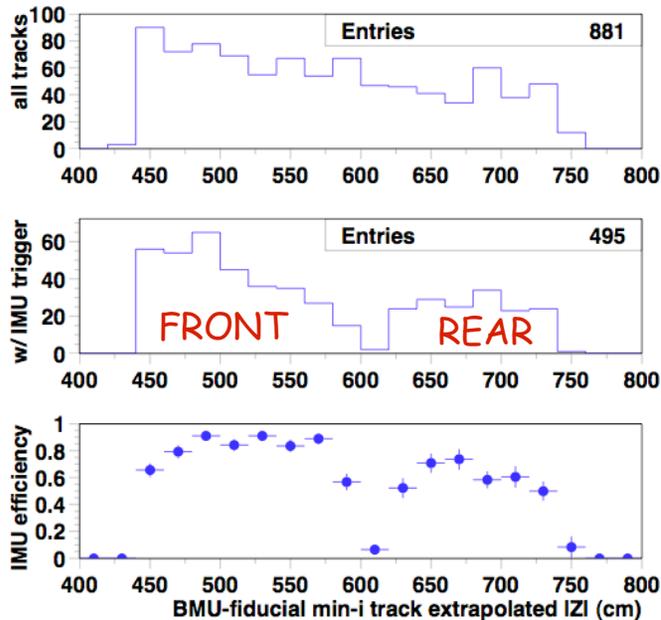


Trigger efficiency from Z's : 2nd leg of central muon triggered events

Data up to June 2005 262 pb⁻¹

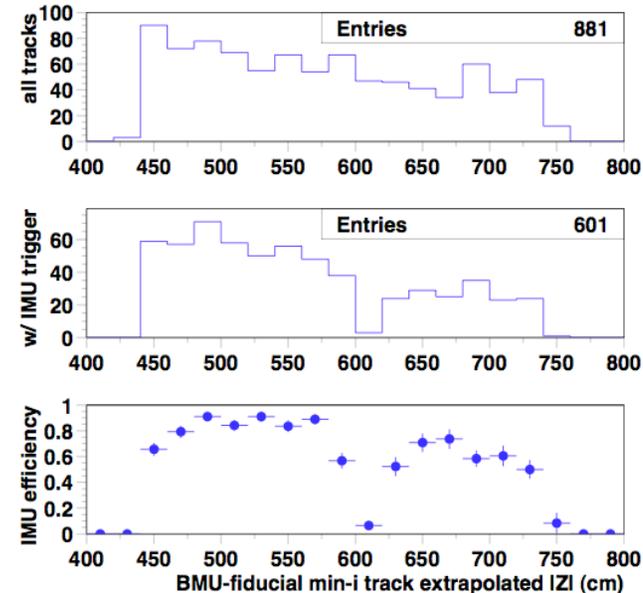
Thanks to Camille Ginsburg for plots

Default configuration



No XFT requirement

• affects only front ($|Z| < 600$ cm)



denominator = fiducial BMU muons

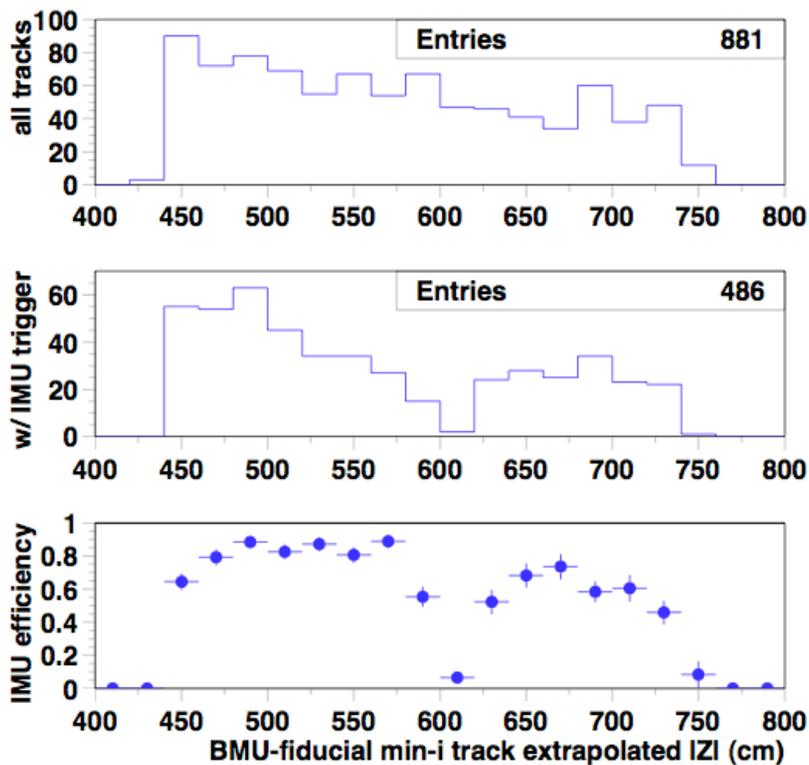
numerator = Camille's trigger simulation w/ and w/out XFT requirement

For BMU passing CMIO reqs

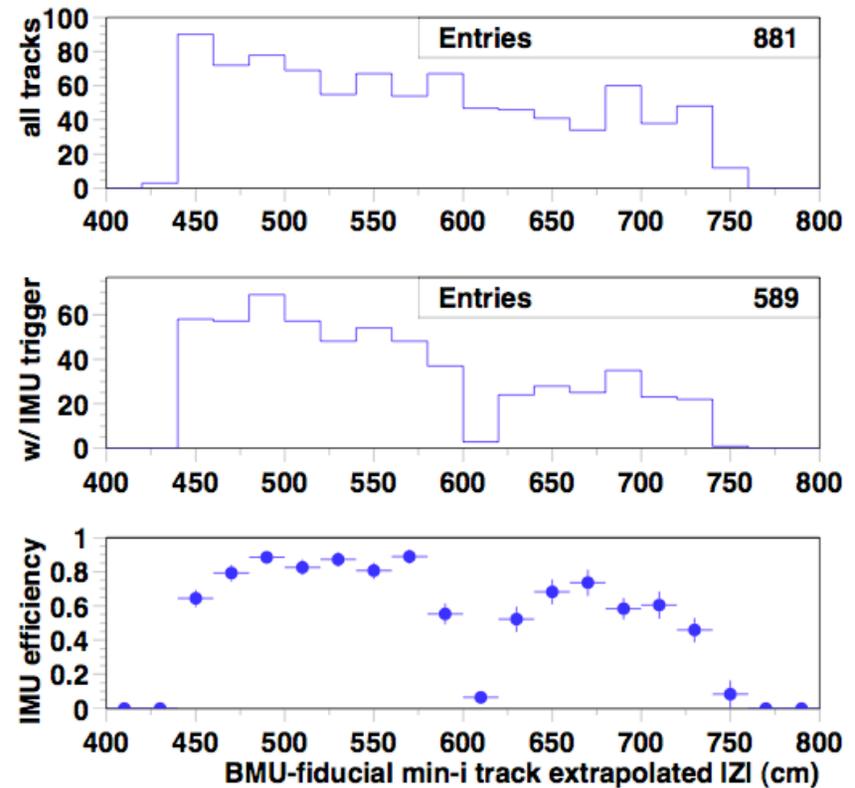


Includes trigger efficiency + **simple BMU reconstruction**

Default configuration



No XFT requirement



Plots from Camille Ginsburg

Summary of trigger efficiencies



Configuration	Numerator (Denom = 881)	Eff
BMU-F: XFT trigger only	495	56%
BMU-F: No XFT trigger only	601	68%
BMU-F: XFT trigger + CMI reco	486	55%
BMU-F: No XFT trigger + CMI reco	589	67%

XFT requirement is 82% efficient

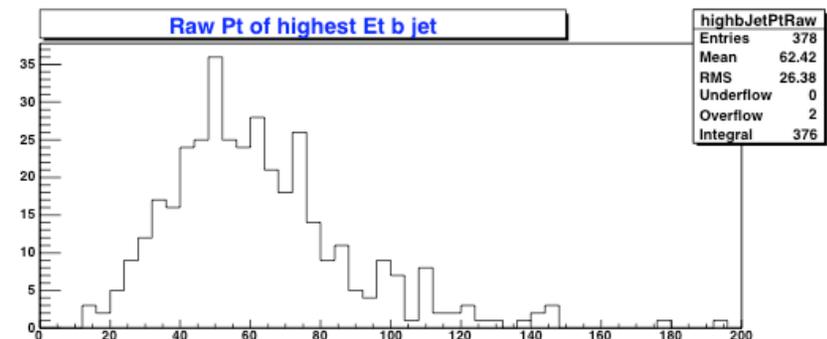
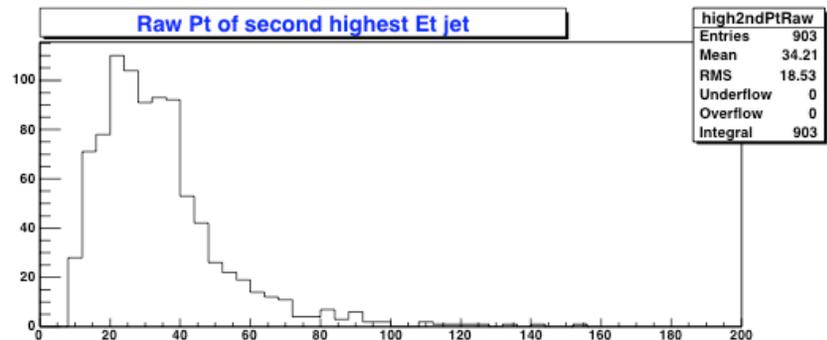
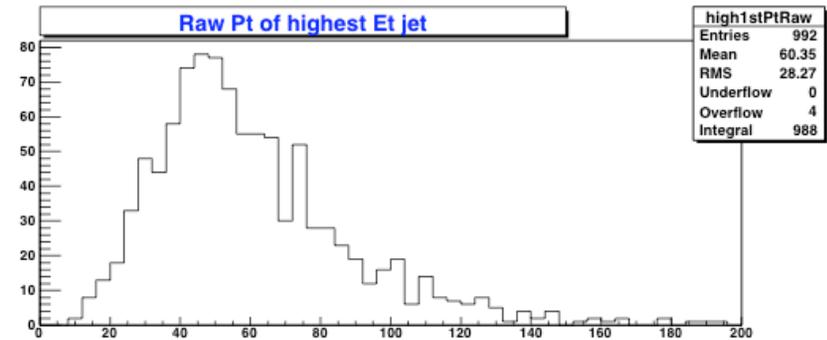
Could extra jets be used instead of
XFT for BMU-Front ?

Jet distributions for ZH



From ZH ($M_H = 120 \text{ GeV}$) MC, Plots of :

- Raw Jet Et of highest Et jet (top)
- Second highest Et jet (middle)
- Highest Et jet with b-tag (bottom)



Can be ~100% efficient with raw jet Et requirement of 15 GeV

- Current jet requirement is
 - L2 15 GeV cluster
 - L3 20 GeV jet
- 20 GeV requirement is 95% efficient