B Physics at D0:
Recent results and Prospects

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Outline:

- Introduction to B physics
- D0 detector
- Recent Results
- Prospects for B_s mixing
- Other recent results from D0
- Conclusions

- 650 collaborators, 110 graduate students, 85 post-docs
- 80 institutions, 18 countries
- Approximately half of the collaboration is from outside US

Why B Physics?

- Weak decays, especially Mixing, CP violating and rare decays, provide an insight into short distance physics
- Short distance phenomena are sensitive to beyond-SM effects
- CKM matrix determines the charged weak decays of quarks: tree-level diagrams, one-loop transitions involving W,Z,H,gluons,γ...
- In most beyond-SM extensions , CKM matrix retains this role
- It is crucial to precisely determine the CKM matrix

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix} \equiv \hat{V}_{\rm CKM} \begin{pmatrix} d \\ s \\ b \end{pmatrix}$$

- Elements of the CKM matrix can be written in terms of λ - Cabbibo angle (≈ 0.22), A (≈ 0.22), $\overline{\rho}, \overline{\eta}$, where ($\overline{\rho} = \rho(1-\lambda^2/2)$)
- η specifies the magnitude of CP violation
- Unitarity of the CKM matrix leads to relationships between the terms

Formulae for the CKM terms (Buras hep-ph/0210291):

$$V_{ud} = 1 - \frac{1}{2}\lambda^2 - \frac{1}{8}\lambda^4, \qquad V_{cs} = 1 - \frac{1}{2}\lambda^2 - \frac{1}{8}\lambda^4(1 + 4A^2)$$

$$V_{tb} = 1 - \frac{1}{2}A^2\lambda^4, \qquad V_{cd} = -\lambda + \frac{1}{2}A^2\lambda^5[1 - 2(\varrho + i\eta)]$$

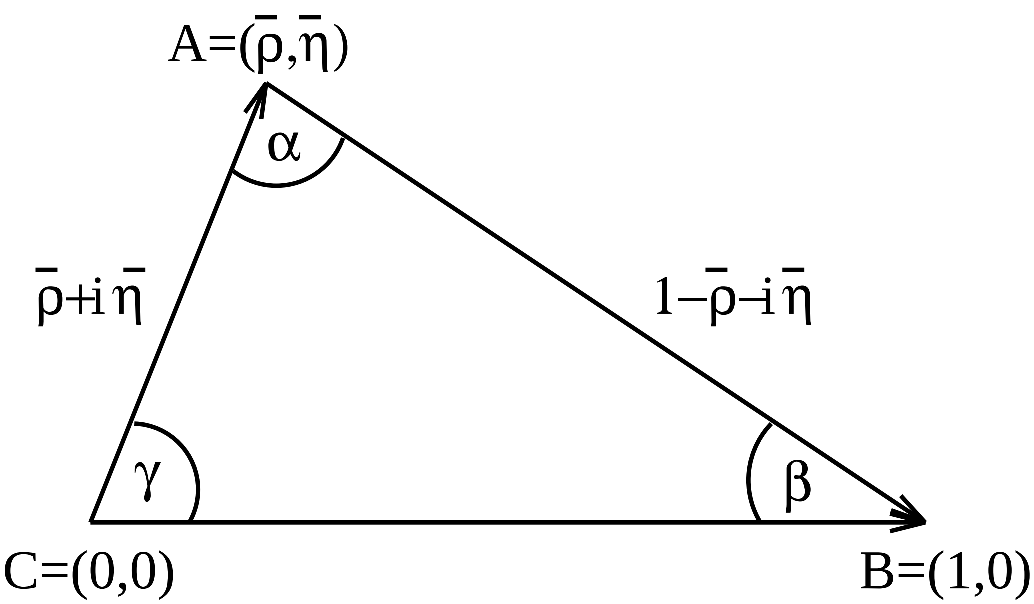
$$V_{us} = \lambda + \mathcal{O}(\lambda^7), \qquad V_{ub} = A\lambda^3(\varrho - i\eta), \qquad V_{cb} = A\lambda^2 + \mathcal{O}(\lambda^8)$$

$$V_{ts} = -A\lambda^2 + \frac{1}{2}A\lambda^4[1 - 2(\varrho + i\eta)] \qquad V_{td} = A\lambda^3(1 - \bar{\varrho} - i\bar{\eta})$$

$$R_t = 0.88 \left[\frac{\xi}{1.18}\right] \sqrt{\frac{18.0/ps}{\Delta M_s}} \sqrt{\frac{\Delta M_d}{0.50/ps}}, \qquad \xi = \frac{\sqrt{\hat{B}_{B_s}} F_{B_s}}{\sqrt{\hat{B}_{B_d}} F_{B_d}}.$$

One such relation is

$V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0$

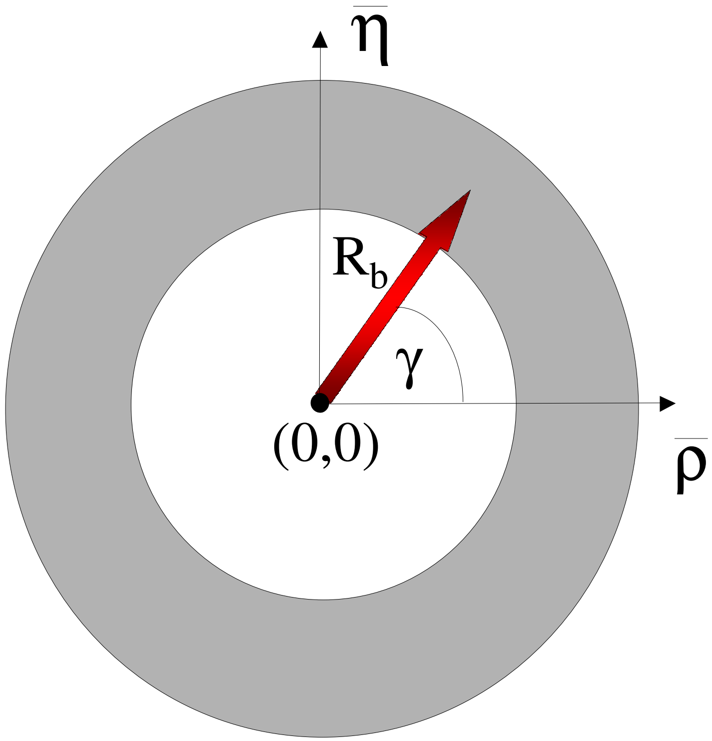


where sides CA and BA are given by R_b, R_t respectively

$$R_b \equiv \frac{|V_{ud}V_{ub}^*|}{|V_{cd}V_{cb}^*|} = \sqrt{\bar{\varrho}^2 + \bar{\eta}^2} = (1 - \frac{\lambda^2}{2})\frac{1}{\lambda}\left|\frac{V_{ub}}{V_{cb}}\right|,$$

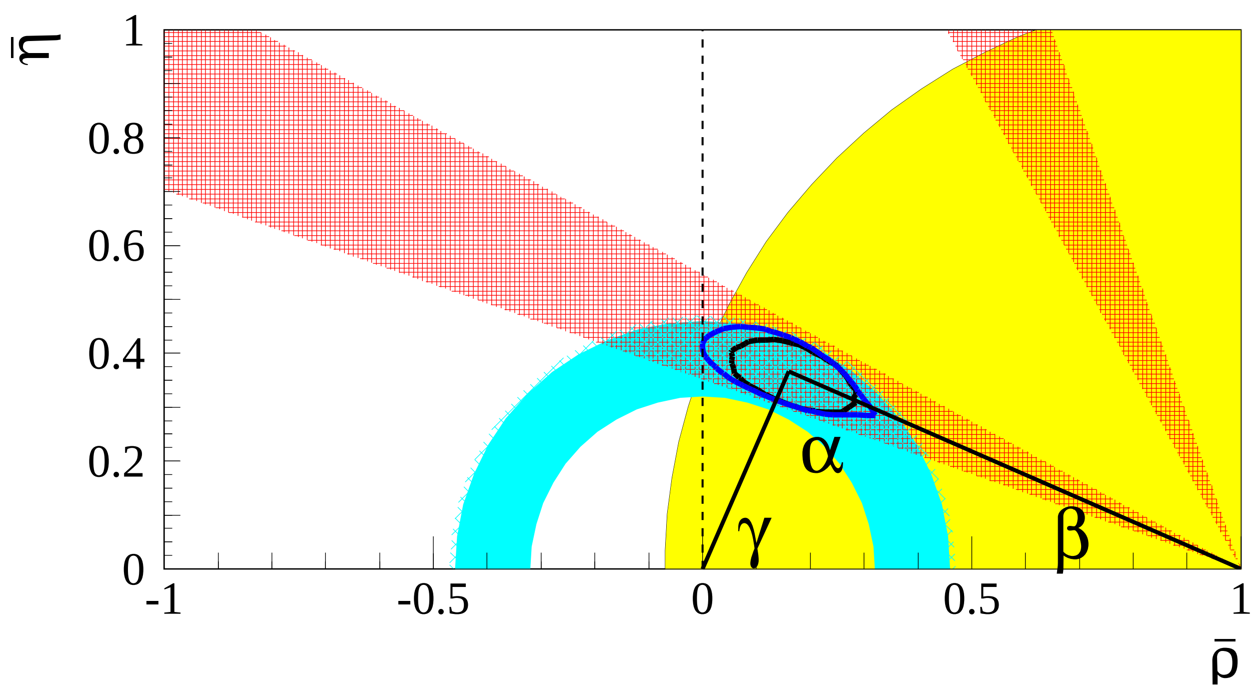
$$R_t \equiv \frac{|V_{td}V_{tb}^*|}{|V_{cd}V_{cb}^*|} = \sqrt{(1-\bar{\varrho})^2 + \bar{\eta}^2} = \frac{1}{\lambda}\left|\frac{V_{td}}{V_{cb}}\right|.$$

R_t can also be related to B_s oscillations (more later)



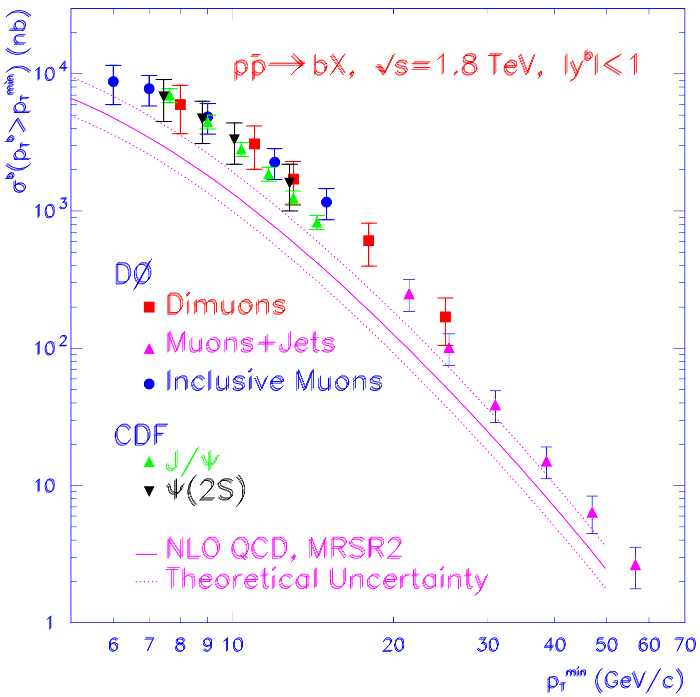
- Apex of UT is in the band determined by $|V_{ts}|, |V_{cb}|, |V_{ub}/V_{cb}|$
- All of these are tree-level processes and generally insensitive to New Physics
- In the case of 3 generations, Unitary CKM and SM is part of a bigger theory "...even if loop-induced processes put $(\overline{\rho}, \overline{\eta})$ outside this band, corresponding expressions of the grander theory must include corrections that bring the apex back into the band ..." - Buras hep-ph/0210291
- The thinner the band, more efficient to select the correct theory

- Study of B hadrons lead to $\eta, V_{ub}/V_{cb}, V_{cb}, V_{td}, V_{ts}$ -
  V_{td}, V_{ts} via B_d, B_s oscillations
  η can be inferred from CP violation in $B_d \to J/\Psi K_s^0$
- $\overline{\rho} > 0$ is from the lower limit on B_s mixing
- Within the SM, measurements of CP conserving decays sensitive to $|V_{us}|, |V_{ub}/V_{cb}|, |V_{cb}|, |V_{td}|$ can tell if $\eta \neq 0$
- Complementary measurements of η, V_{td} from $K \to \pi\nu\overline{\nu}$ decays
- New phenomena might affect K and B sectors differently



Narrower region is the 95% (SM) allowed region - Buras hep-ph/0210291

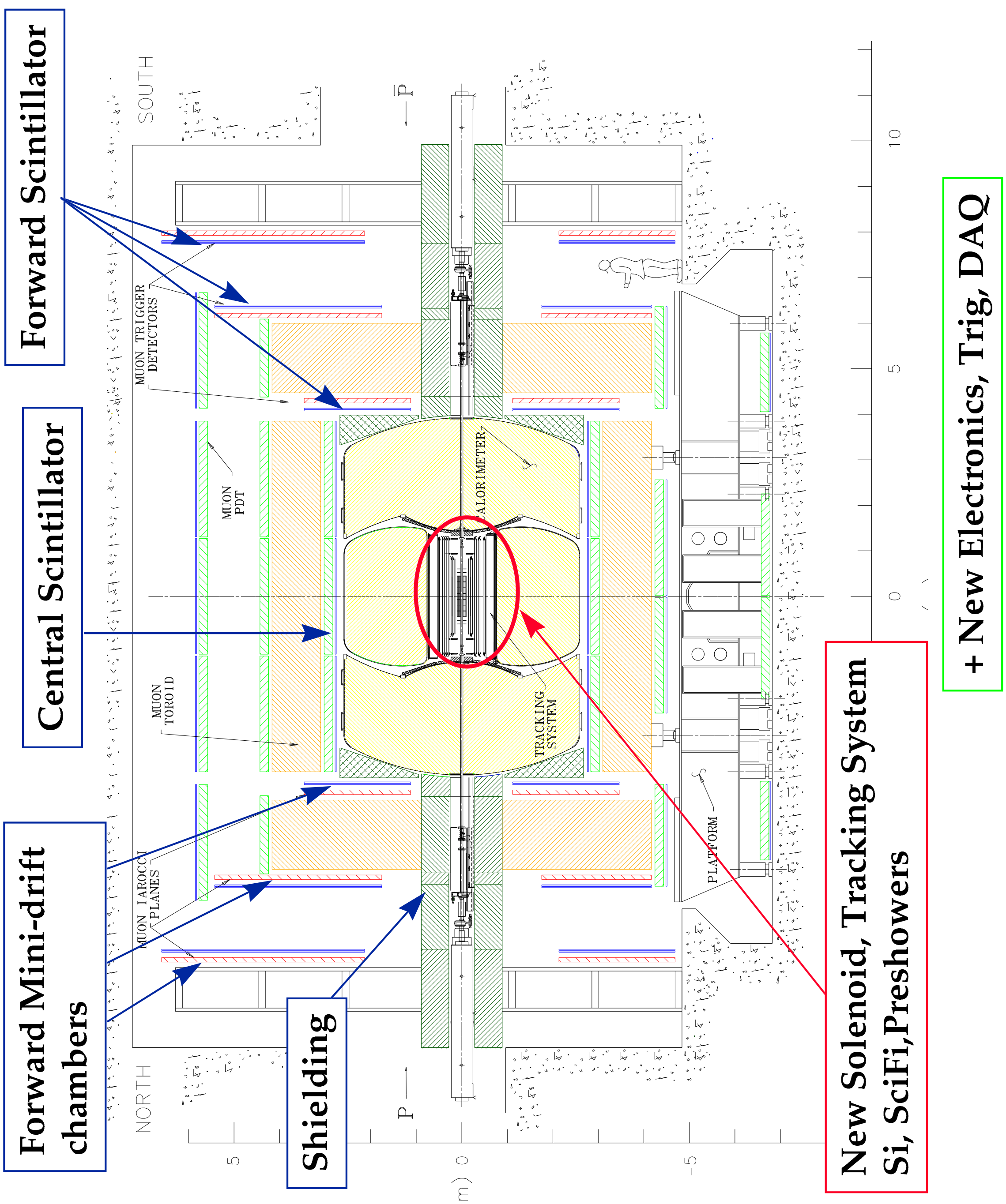
B physics at the Tevatron



$\sigma(\mathrm{p\bar{p}} \rightarrow \mathrm{b\bar{b}}) \approx 150\ \mu b$ at $\sqrt{s} = 2$TeV
$\sigma(\mathrm{e^+e^-} \rightarrow \mathrm{b\bar{b}}) \approx 7\ nb$ at Z°
$\sigma(\mathrm{e^+e^-} \rightarrow \mathrm{b\bar{b}}) \approx 1\ nb$ at Υ(4S)

All species produced, including B_s°, B_c, Λ_b
Environment not as clean as e^+e^- machines
Low trigger efficiencies

D0 Upgrade


Forward Scintillator
Central Scintillator
Forward Mini-drift chambers
Shielding
New Solenoid, Tracking System
Si, SciFi,Preshowers
+ New Electronics, Trig, DAQ
MUON TRIGGER DETECTORS
MUON PDT
MUON TOROID
MUON IAROCCI PLANES
CALORIMETER
TRACKING SYSTEM
PLATFORM
NORTH
SOUTH

D0 Run II Detector - Tracking

Silicon Tracker

- Four layer barrels (double/single sided)
- Interspersed double sided disks
- 840,00 channels

Fiber Tracker

- Eight layers sci-fi ribbon doublets (z-u-v, or z
- 77,800 835um fibers w/ VLPC readout

Central Preshower

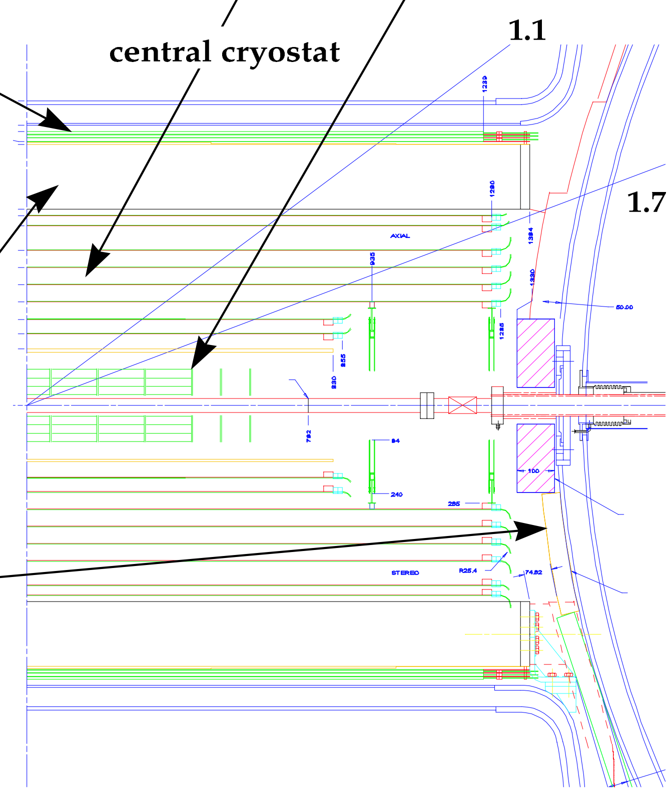
- Scintillator strips, WLS fiber readout
- 7,680 channels
- VLPC readout

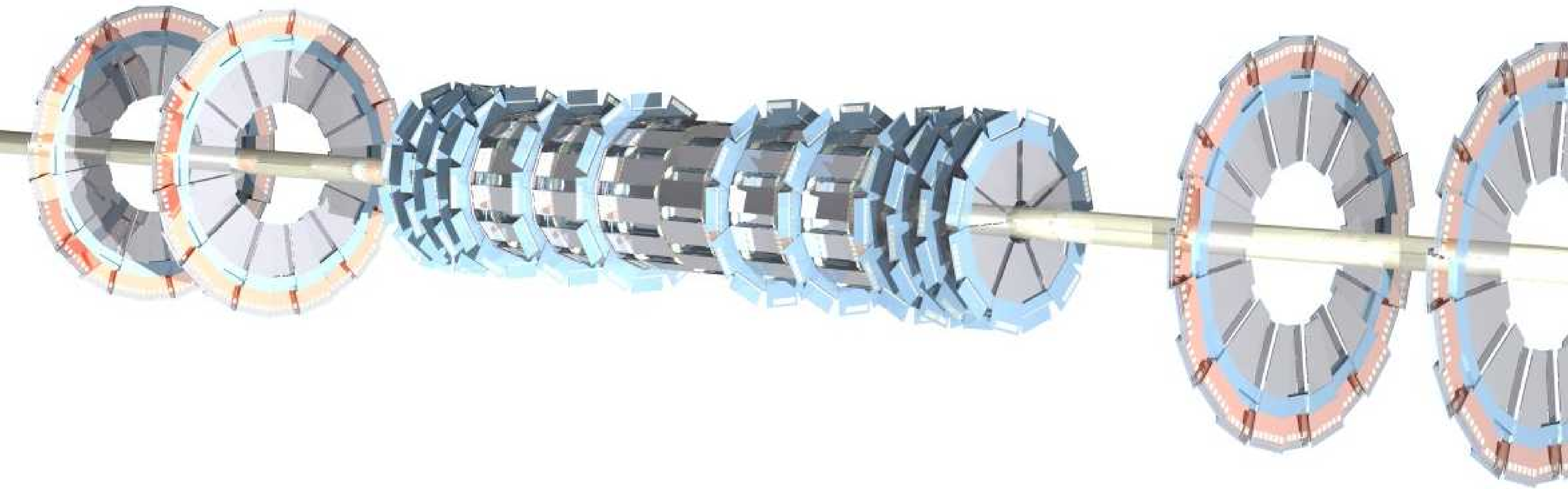
Solenoid

- 2T superconducting

Forward Preshower

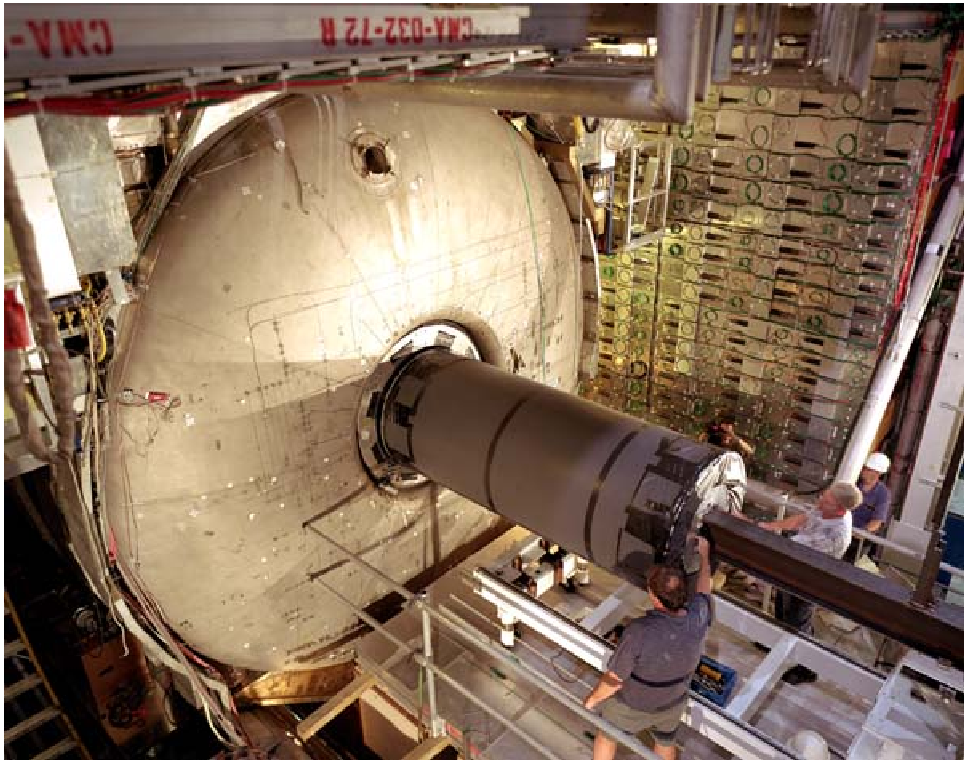
- Scintillator strips, stereo, WLS readout
- 14,968 channels
- VLPC readout

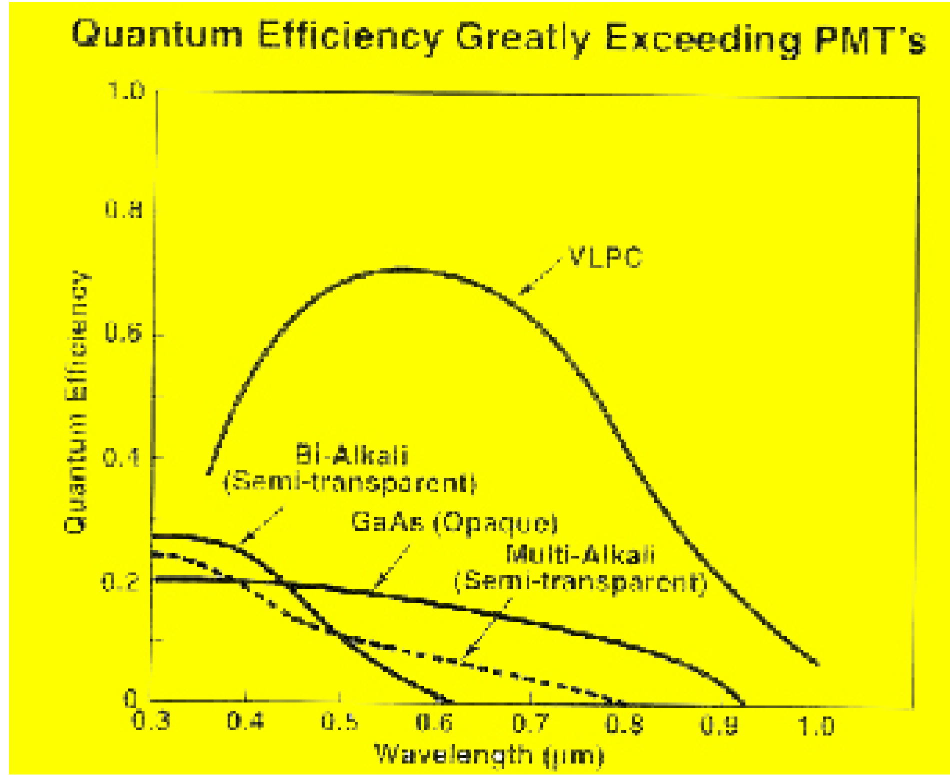




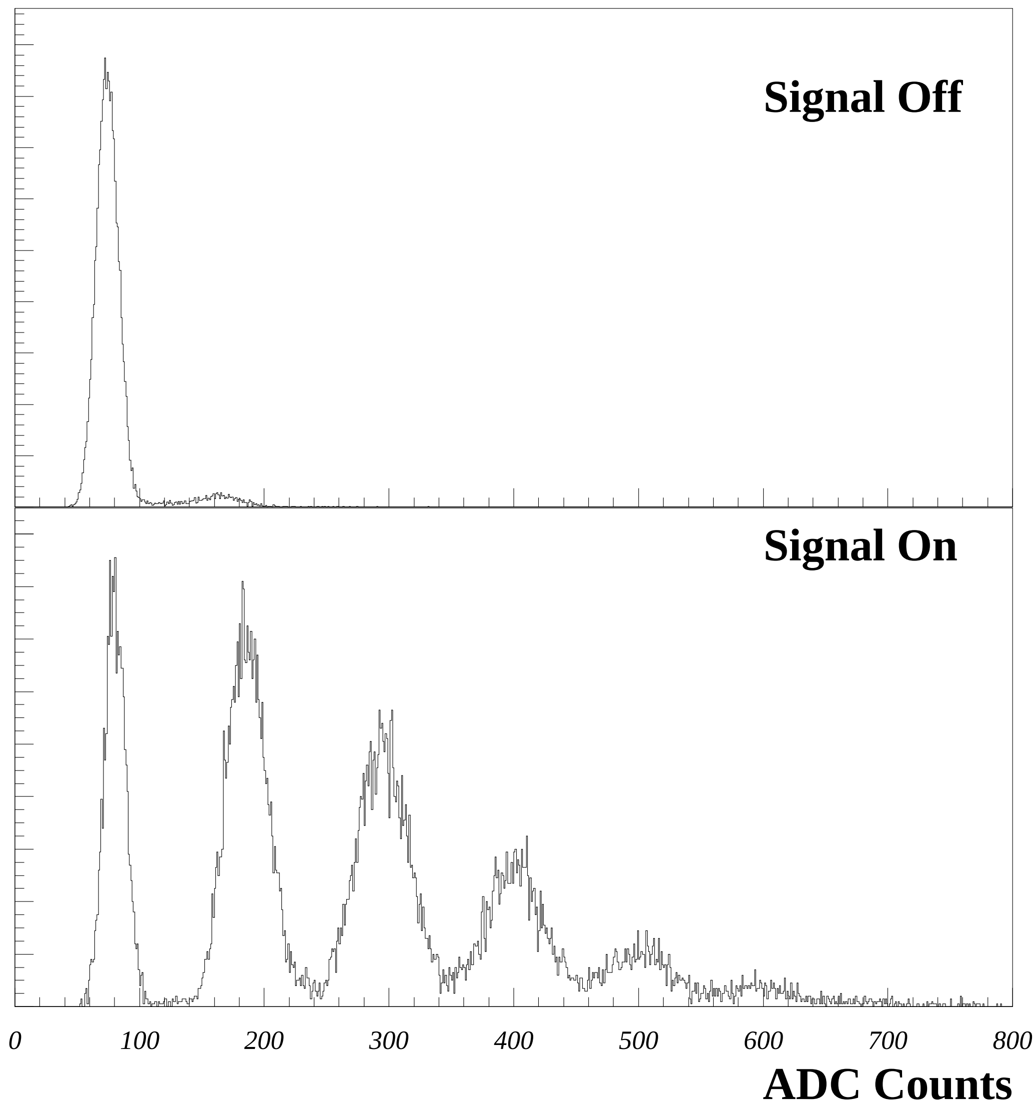
SMT

- 6 Barrels : 4 layers SS + DS, 2/90° stereo, $|z| < \pm 0.6$m, r: 2.7-10 cm
- 12 Central F disks, DS, 144 wedges, $\pm 15^\circ$ stereo
- 4 Forward H disks, SS, 96 wedges, $\pm 7.5^\circ$ stereo, z $= \pm$ 1.1/1.2 m, r: 9.5-20 cm
- Tracking to $\eta \approx 3$ $(\theta \approx 6^\circ)$
- 793K channels , $\approx 95\%$ of channels available, rad hard to 1 MRad
- S/N > 10 , 1 MIP ≈ 25 ADC counts
- Hit resolution $\approx 10\mu$

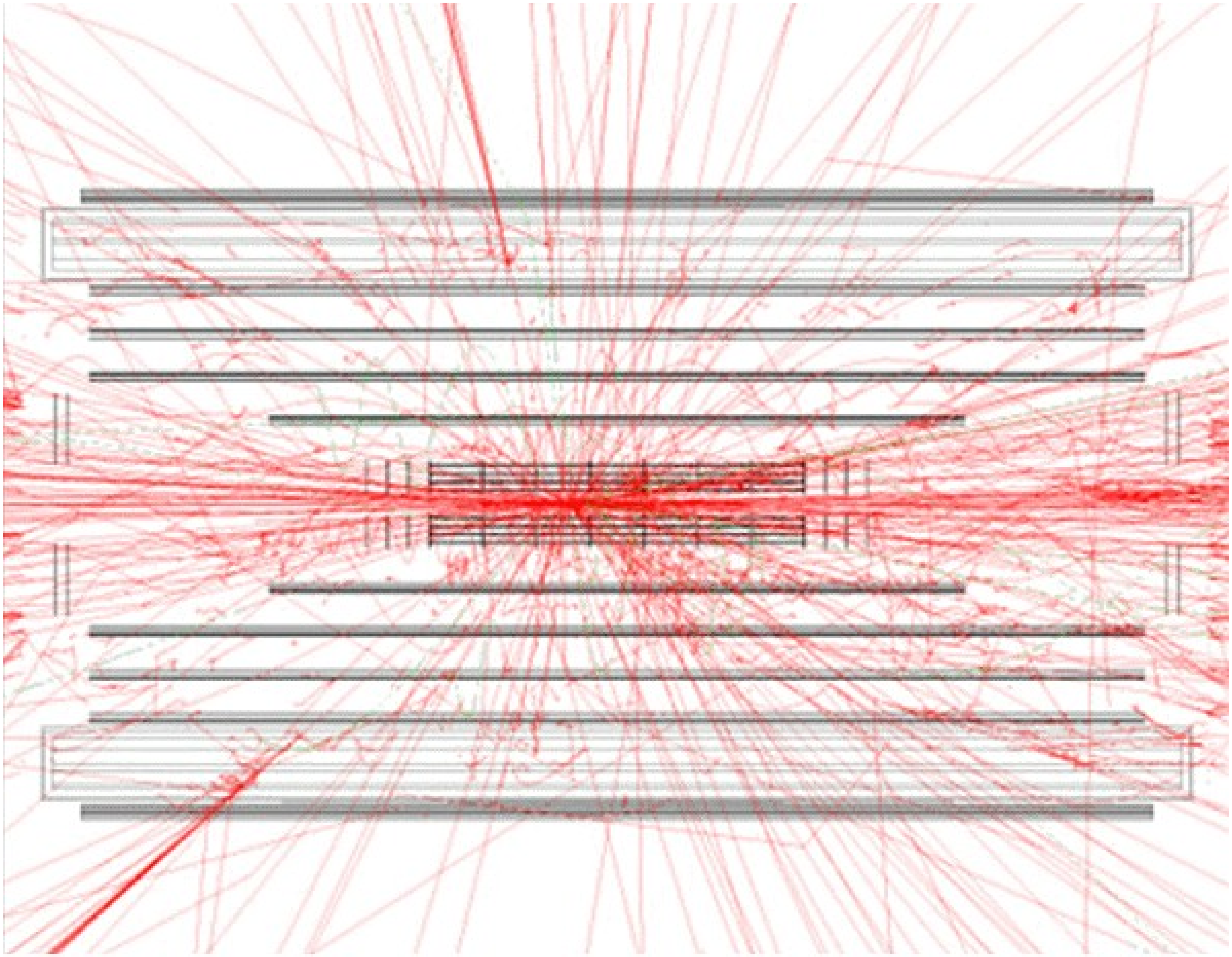




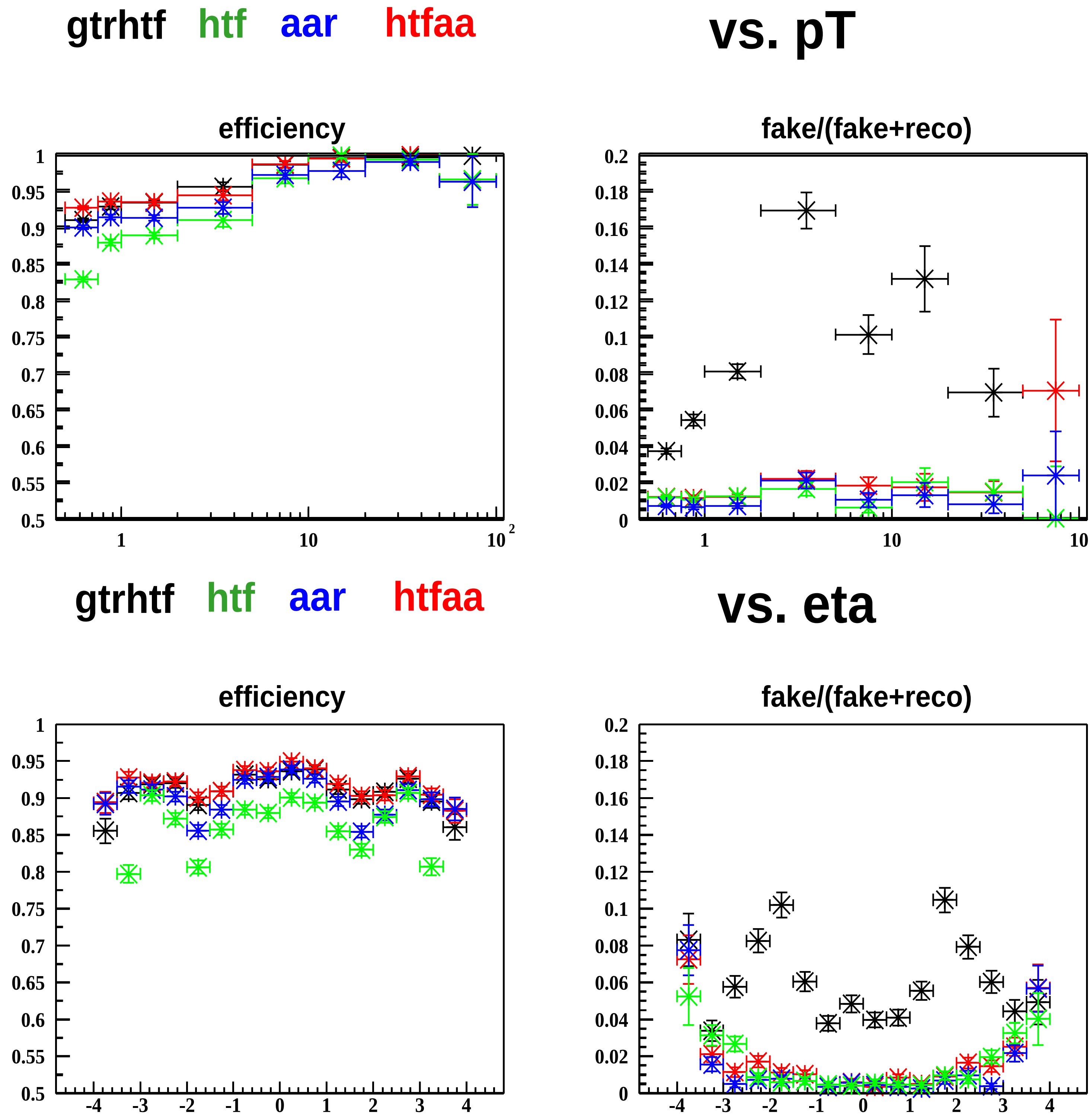
- 8 layers - Axial and Stereo ($\pm 3^\circ$)
- Radius: 20-50 cm
- VLPC ; high QE, very low dark noise, excellent pe resolution
  - Each pixel has 1mm diameter, ideal for use with fibers
  - Operated at about 8-9°K , gain of 20000-50000
- Good S/N; 10 photons/MIP (at z=0)
- Fast enough to be in Level 1 trigger



Signal ON - LED was set to ≈ 2 pe

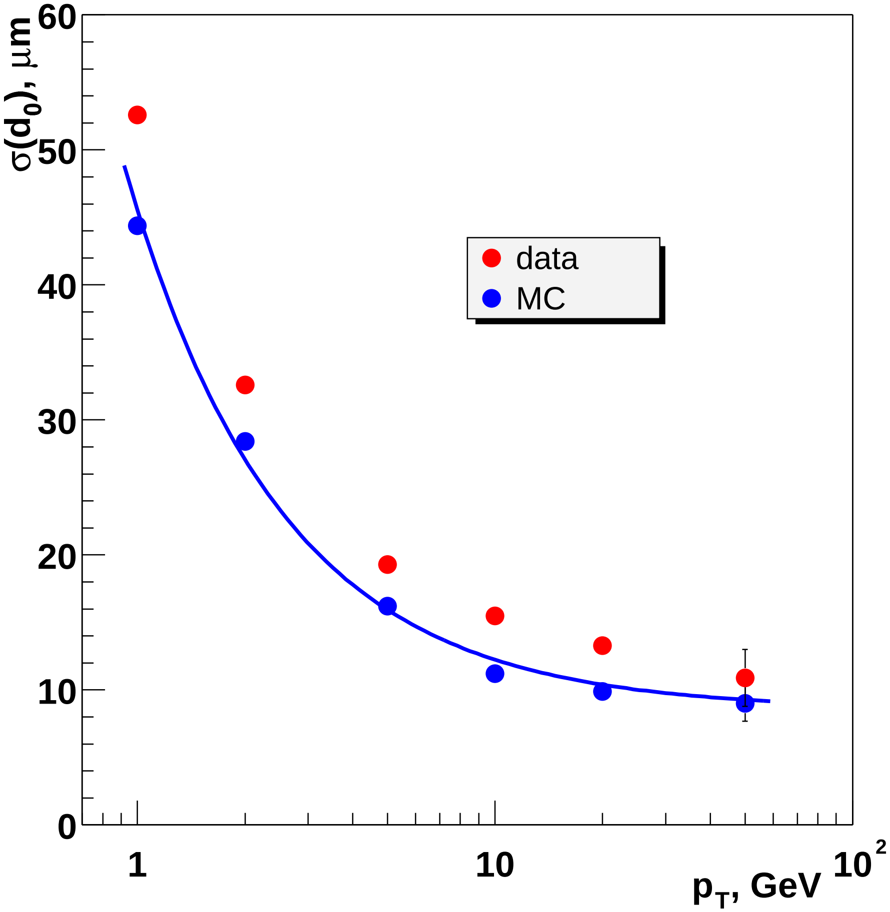


For $\mathcal{L} = 10^{32}$ cm^{-2} s^{-1} and bunch crossing = 396 ns,
N($b\bar{b}$) = 0.006, N(additional events) = 3 per crossing



gtrhtf htf aar htfaa
vs. pT
efficiency
fake/(fake+reco)
1
10
10 2
gtrhtf htf aar htfaa
vs. eta
efficiency
fake/(fake+reco)

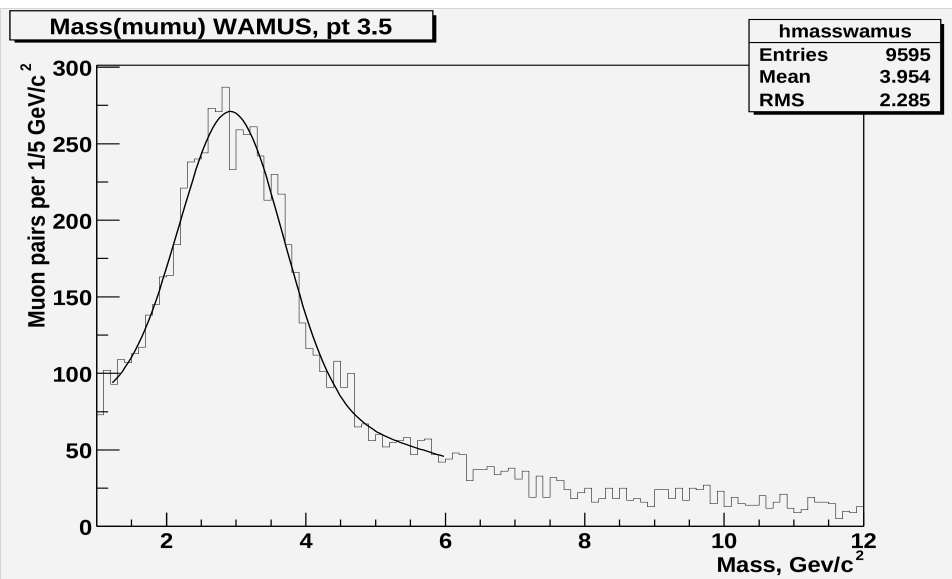
Resolution on DCA:

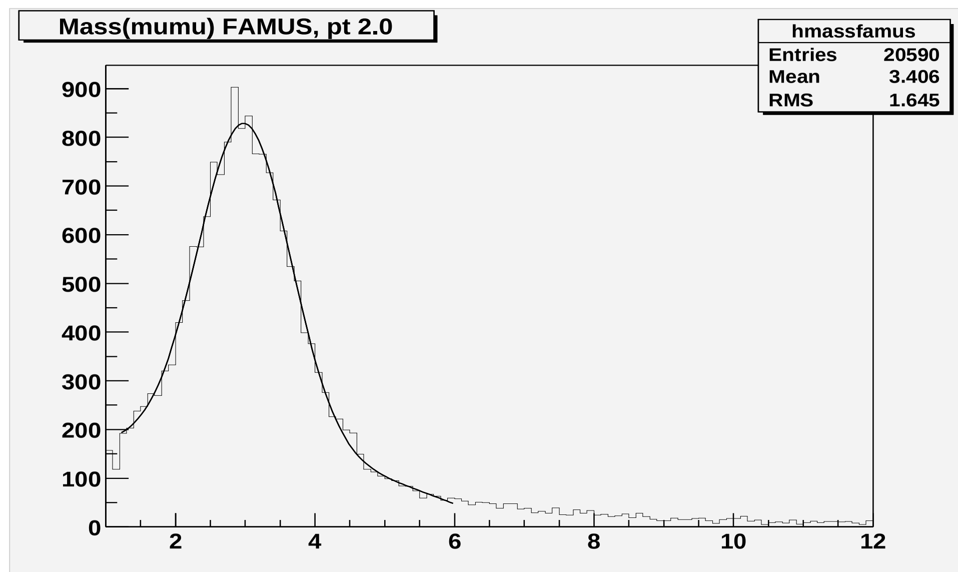


- Tracking : $dp_T/p_T^2 = 0.002$ GeV/c
- Vertex reconstruction : 40 μ (r-ϕ), 80 μ (r-z)

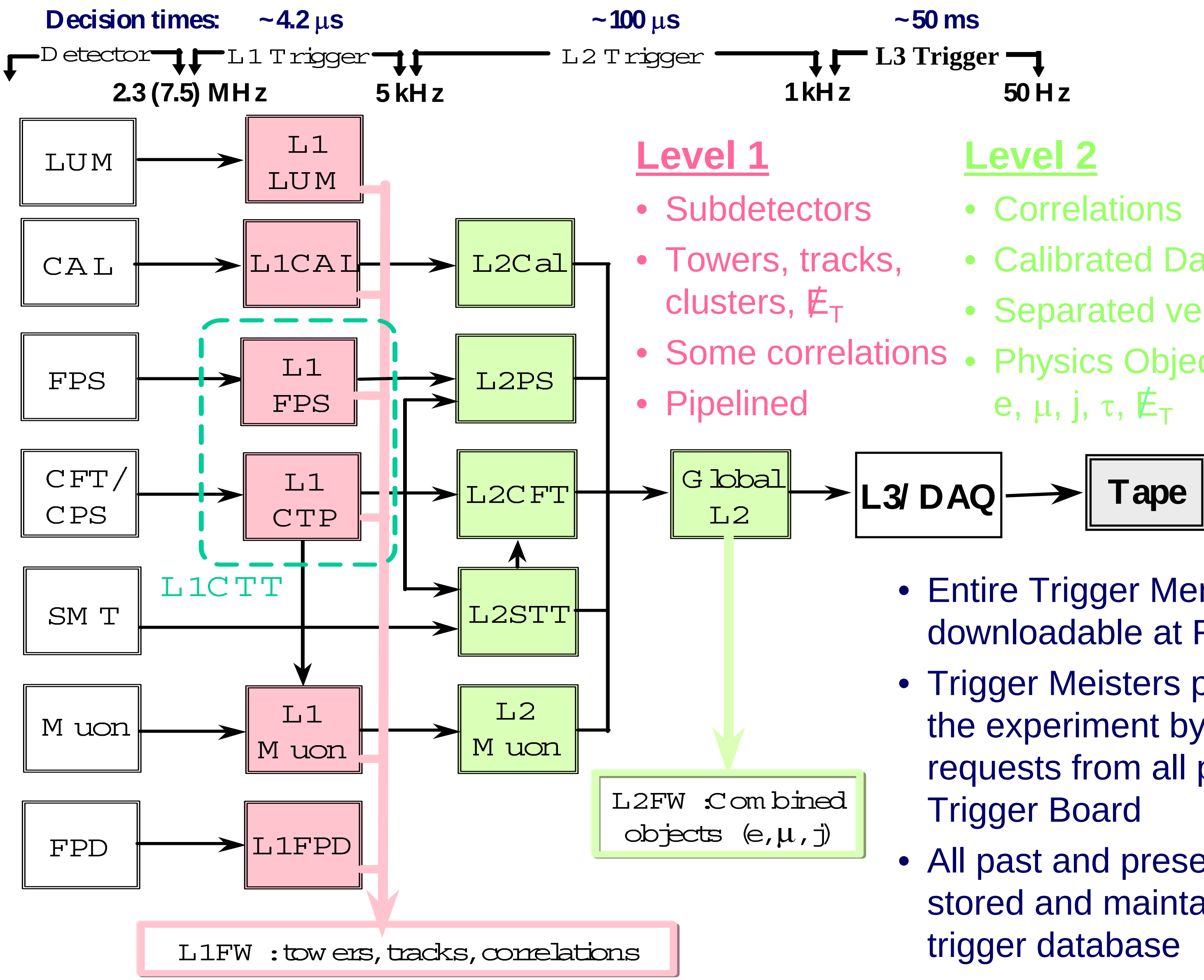
MUON system

- Central and Forward regions, up to $\eta = \pm 2 (\theta = \pm 15^\circ)$
- Three layers : one inside (A) - 5-6λ
  two outside the toroid magnets (2T) - $> 12\lambda$
- Both scintillators and drift tubes
- Muon system can be used stand-alone to get μ pT information
- Match muon hits to Tracks
- Fast enough to be in the Level 1 trigger





DØ Trigger System



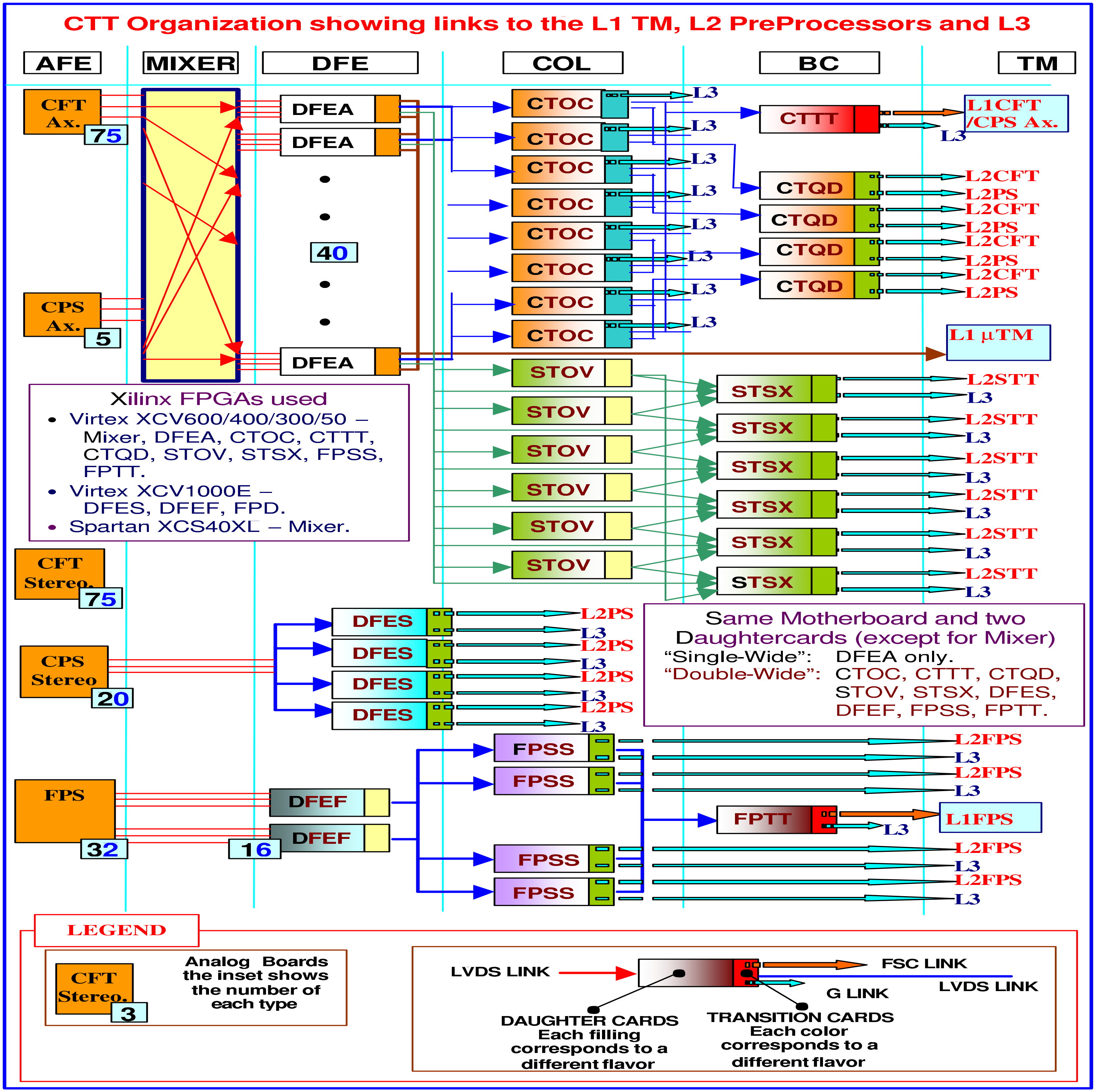
Level 1
- Subdetectors
- Towers, tracks, clusters, $\not{E}_T$
- Some correlations
- Pipelined

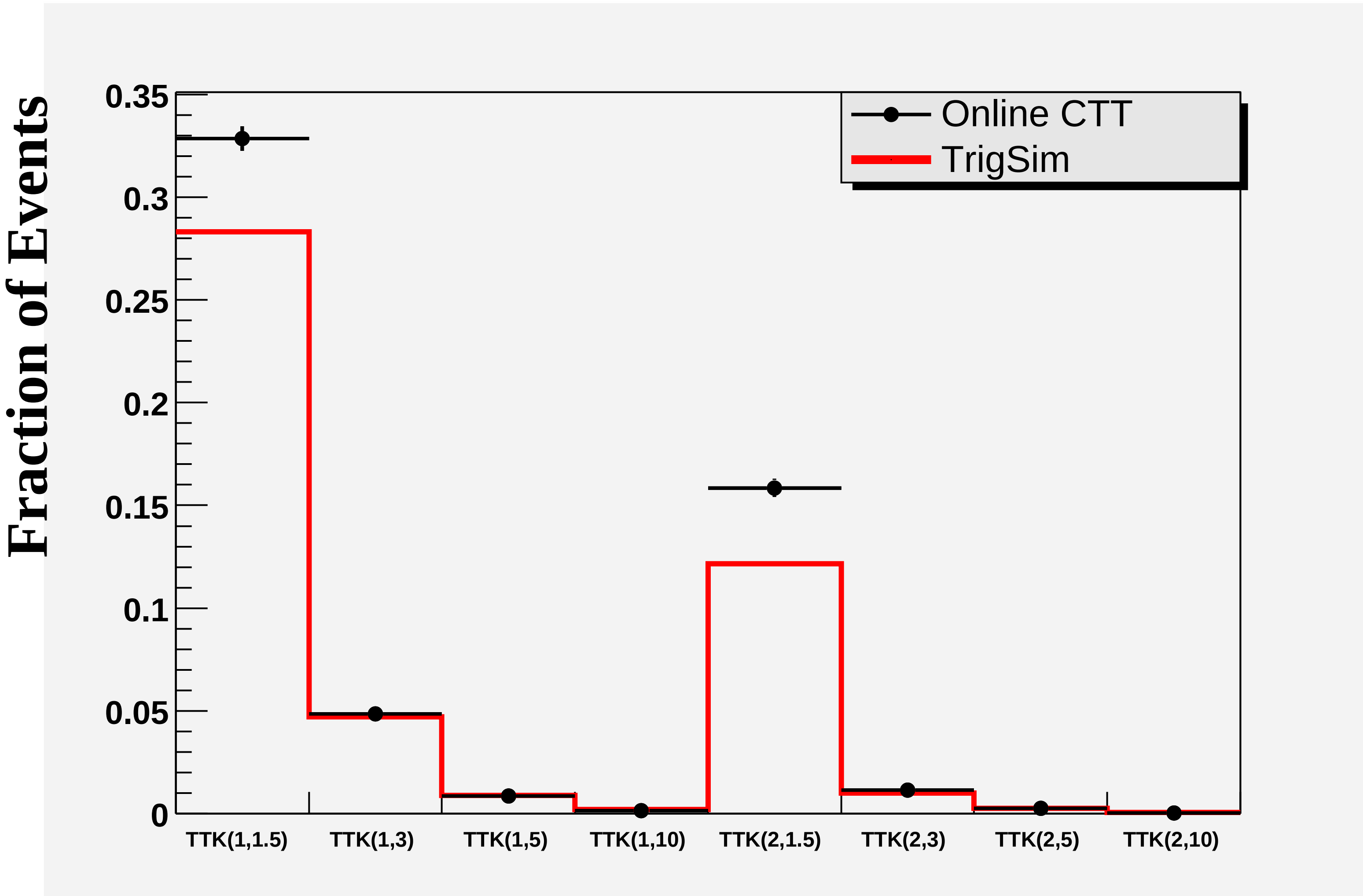
Level 2
- Correlations
- Calibrated Data
- Separated vertex
- Physics Objects e, μ, j, τ, $\not{E}_T$

Level 3
- Simple Reconstruction
- Physics Algorithms

- Entire Trigger Menu configurable and downloadable at Run start
- Trigger Meisters provide trigger lists for the experiment by collecting trigger requests from all physics groups in the Trigger Board
- All past and present trigger lists are stored and maintained in the dedicated trigger database

All trigger components have simulation software

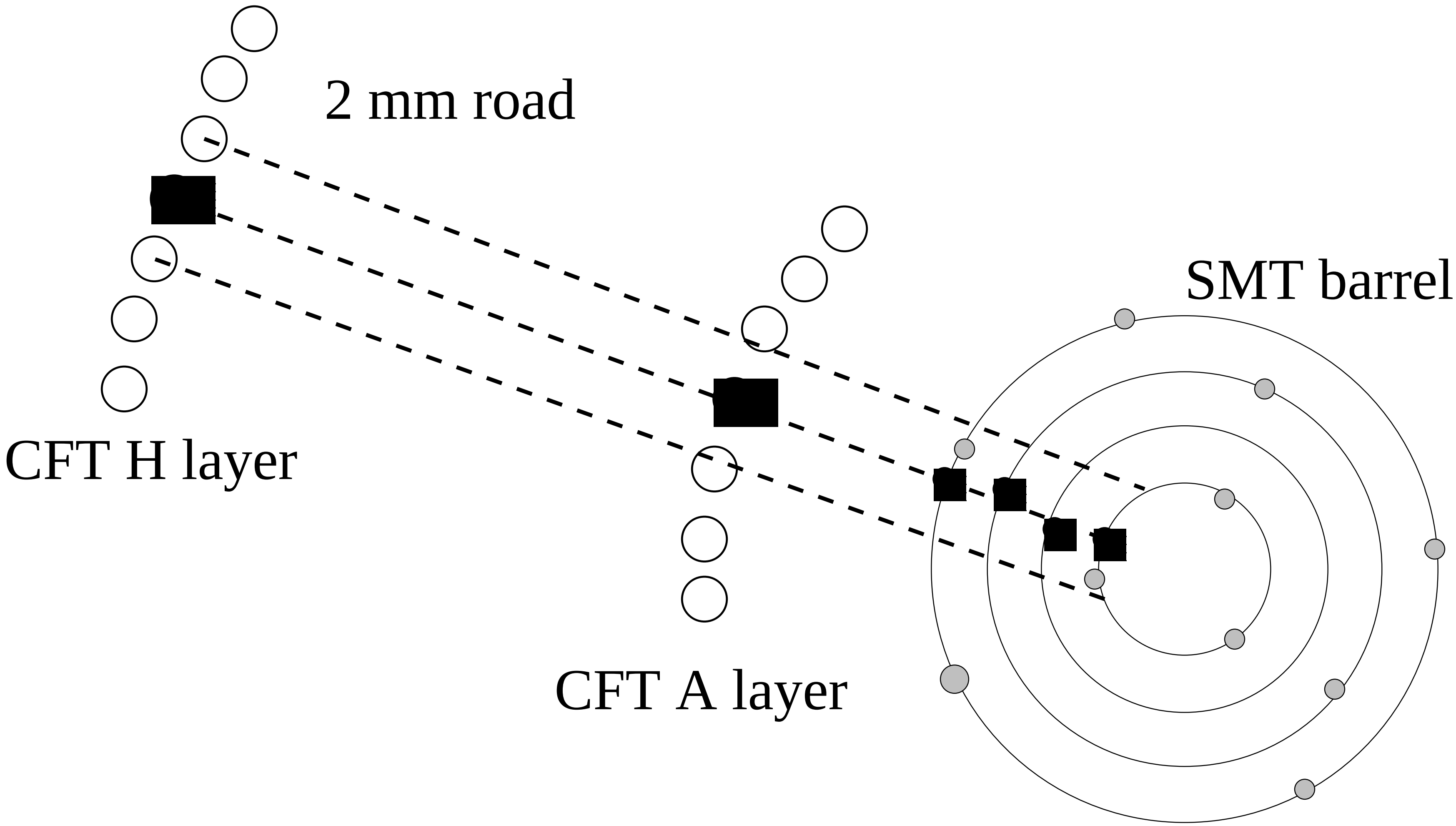

CTT Organization showing links to the L1 TM, L2 PreProcessors and L3
AFE
MIXER
DFE
COL
BC
TM
CFT Ax.
75
CPS Ax.
5
DFEA
DFEA
40
DFEA
CTOC
CTTT
CTQD
L3
L1CFT /CPS Ax.
L2CFT
L2PS
L1 μTM
STOV
STSX
L2STT
Xilinx FPGAs used
• Virtex XCV600/400/300/50 – Mixer, DFEA, CTOC, CTTT, CTQD, STOV, STSX, FPSS, FPTT.
• Virtex XCV1000E – DFES, DFEF, FPD.
• Spartan XCS40XL – Mixer.
CFT Stereo
75
CPS Stereo
20
DFES
L2PS
Same Motherboard and two Daughtercards (except for Mixer)
"Single-Wide": DFEA only.
"Double-Wide": CTOC, CTTT, CTQD, STOV, STSX, DFES, DFEF, FPSS, FPTT.
FPS
32
16
DFEF
FPSS
FPTT
L2FPS
L1FPS
LEGEND
CFT Stereo.
3
Analog Boards the inset shows the number of each type
LVDS LINK
FSC LINK
G LINK
LVDS LINK
DAUGHTER CARDS Each filling corresponds to a different flavor
TRANSITION CARDS Each color corresponds to a different flavor



Comparison of hardware and L1 CTT simulation

Track triggers are very important for B physics

Finding their way into the official trigger lists



L2 Silicon Track Trigger will be installed later this summer

Sample trigger(s) for B physics

- 2MU_A_L2M0 ("bread and butter" trigger)
  L1: 2 μ in $|\eta| < 2$
  L2: ≥ 1 medium μ
  At least one muon have hits in A&BC (most J/Ψ are forward)
  Rates: L1/L2/L3 = 18/7/7 Hz 4E31
- 2MU_C_2L2_2TRK
  L1: 2 μ in $|\eta| < 1$,
  L2: 2 μ separated in η, ϕ with ≥ 1 medium μ
  L3: 2 tracks with $p_T > 1.5$ GeV (one of them > 2.5 GeV)
  Rates: L1/L2/L3 = 27/13/3 Hz 4E31
- 2MT1_C_2L2L_2TRK - Future
  L1: 2 μ matched to CTT tracks (μ can have pT as low as 1.5 GeV)
  L2 : 2 μ not required to have hits in B or C layers
  L3: 2 tracks with $p_T > 1.5$ GeV
- Also have single muon triggers , but they usually pick up prescales

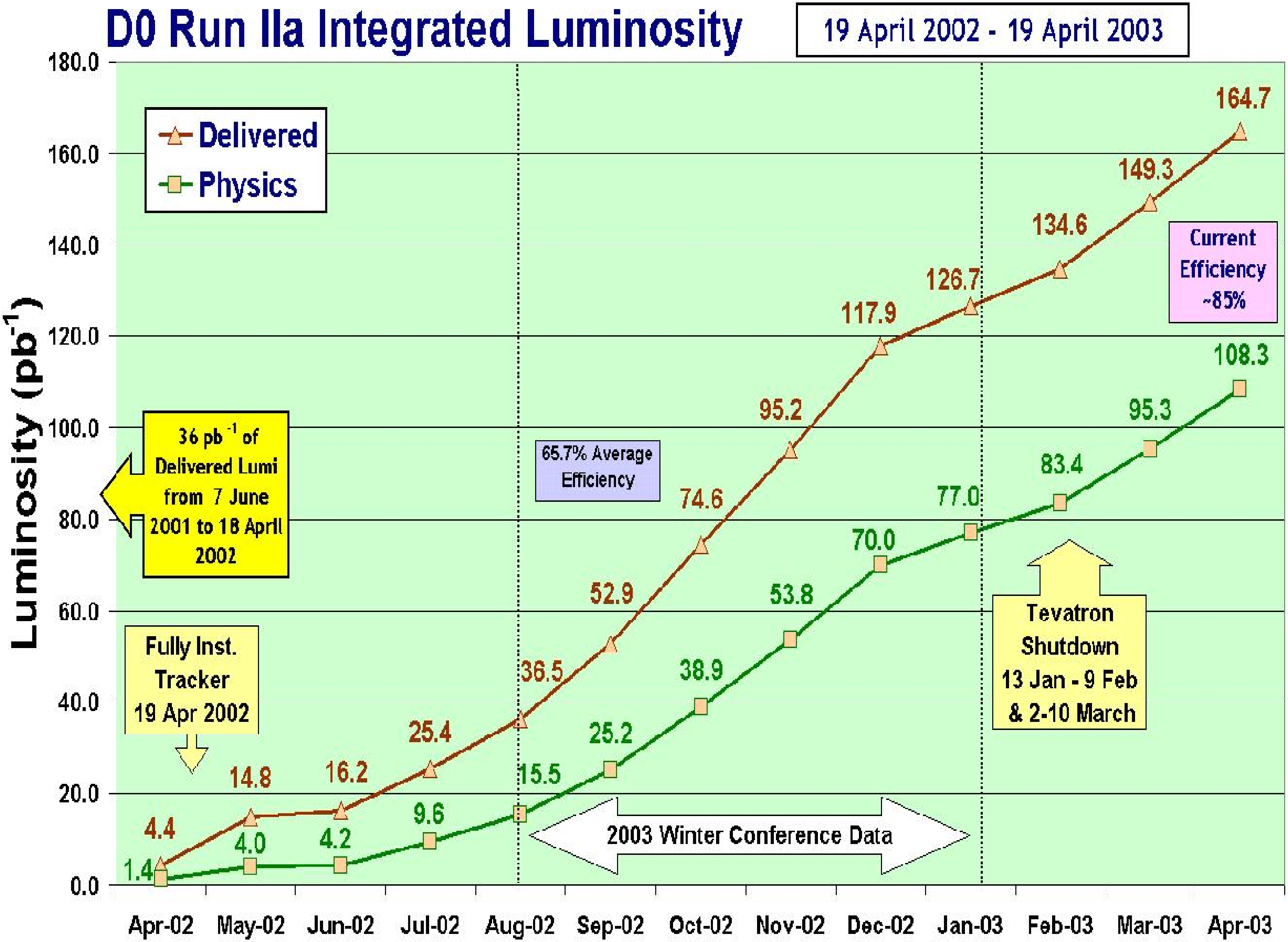
Accelerator performance

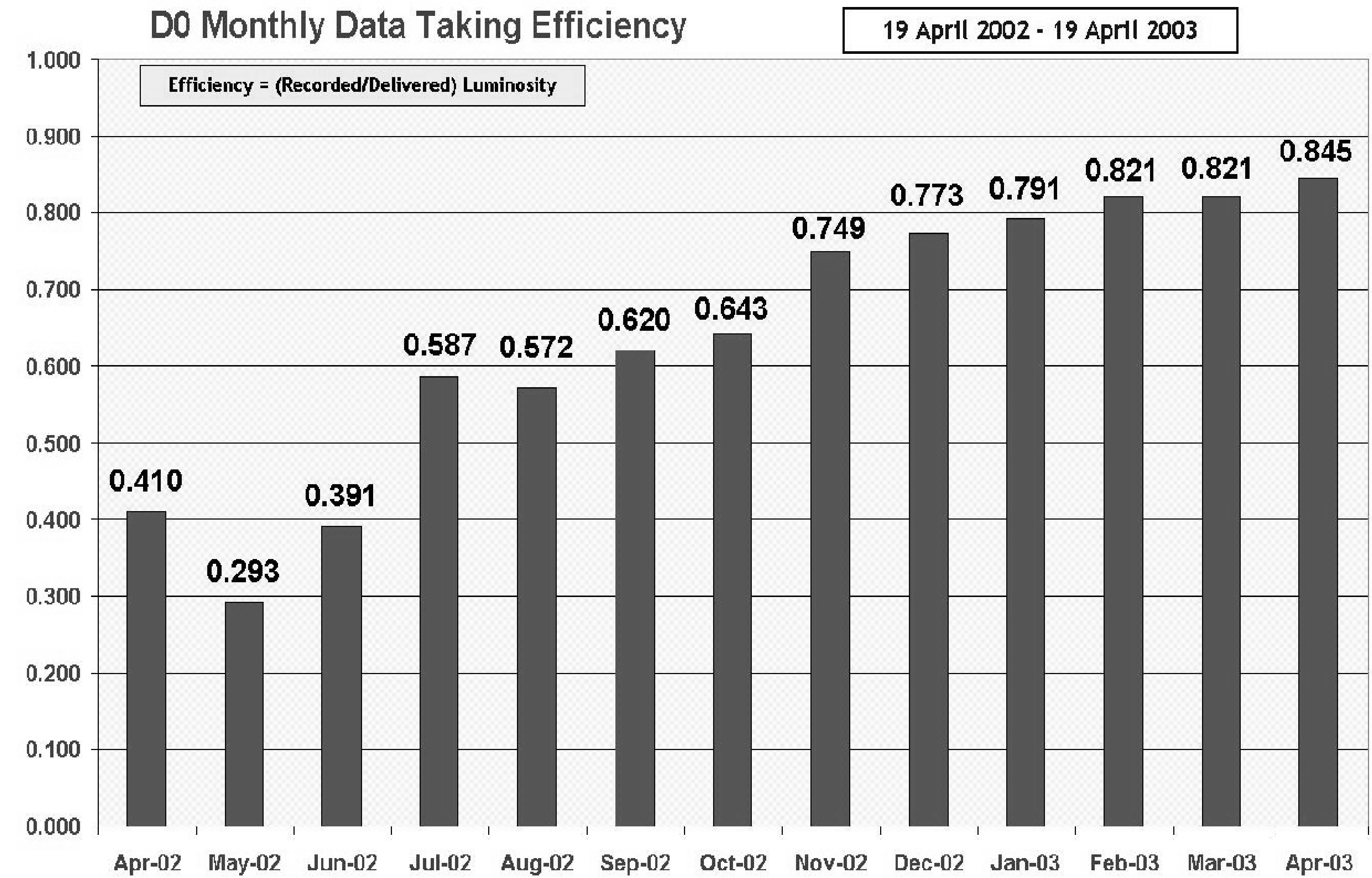
	Run Ib	Run IIa	Run IIb
# bunches	6X6	36X36	140X103
$\sqrt{s}$(TeV)	1.8	1.96	1.96
$\mathcal{L}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$	1.6×10^{31}	8×10^{31}	$2 - 5 \times 10^{32}$
bunch x-ing (ps)	3500	396	132(?)
interactions/x-ing	2.8	2.4	2-5

Currently, $\mathcal{L}_{inst} \approx 3 - 4 \times 10^{31}$

By end of FY03, expect $\int \mathcal{L} \approx 250\ \mathrm{pb}^{-1}$

Run IIa 2001-2005: $\int \mathcal{L} \approx 2\mathrm{fb}^{-1}$


D0 Run IIa Integrated Luminosity
19 April 2002 - 19 April 2003
Delivered
Physics
Luminosity (pb-1)
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Apr-02
May-02
Jun-02
Jul-02
Aug-02
Sep-02
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
36 pb-1 of Delivered Lumi from 7 June 2001 to 18 April 2002
Fully Inst. Tracker 19 Apr 2002
65.7% Average Efficiency
Current Efficiency ~85%
Tevatron Shutdown 13 Jan - 9 Feb & 2-10 March
2003 Winter Conference Data
4.4
14.8
16.2
25.4
36.5
52.9
74.6
95.2
117.9
126.7
134.6
149.3
164.7
1.4
4.0
4.2
9.6
15.5
25.2
38.9
53.8
70.0
77.0
83.4
95.3
108.3



Data taking efficiency for Apr 14-20'03 was 87% - Recorded $\mathcal{L} = 6$ pb^{-1}

B physics program at D0

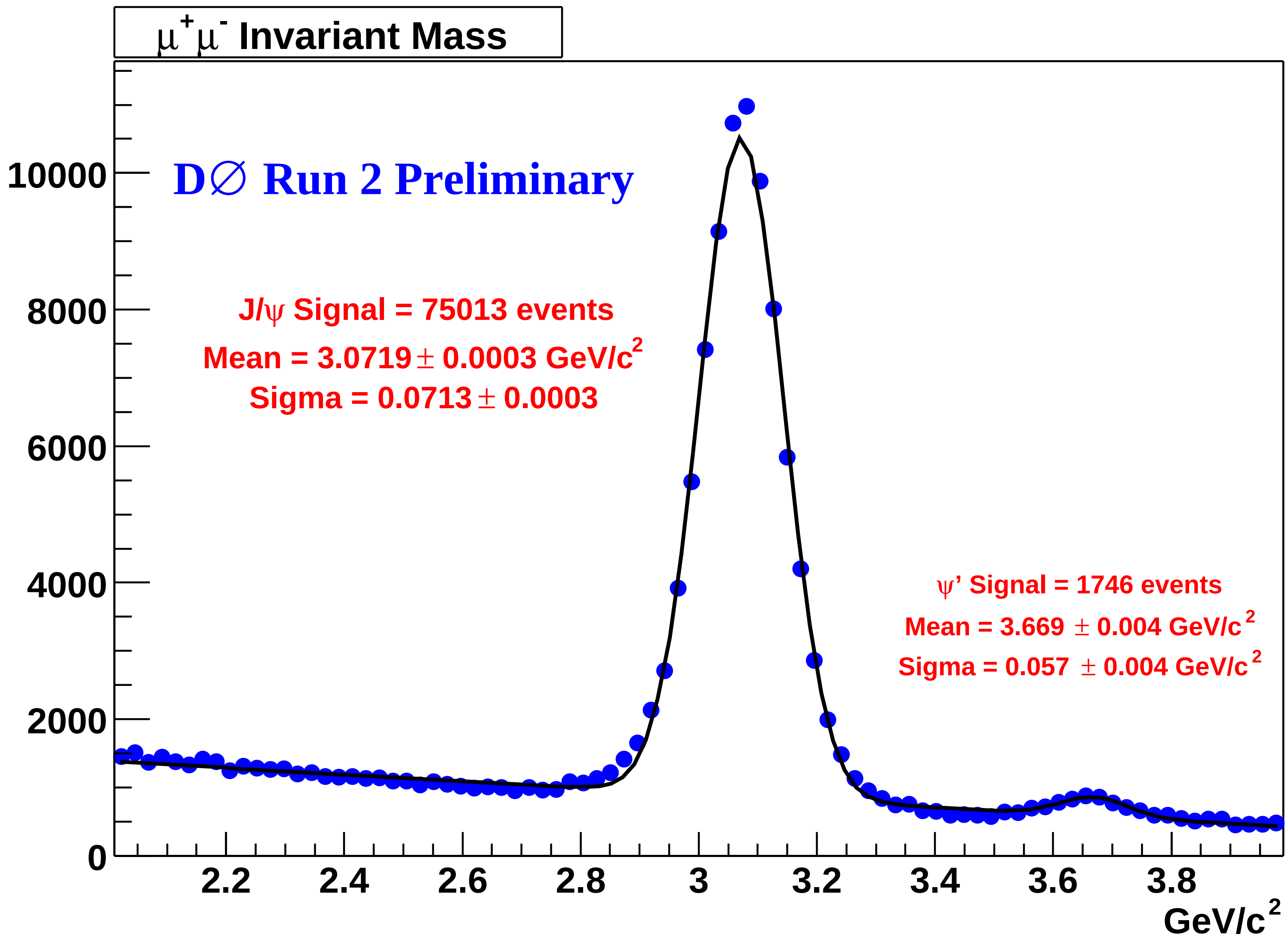
- Complementary to program at $\Upsilon(4S)$ machines
- B_s mixing (more later)
- Beauty baryons
  e.g. $\tau(\Lambda_b)/\tau(B^\circ) = 0.8 \pm 0.06$, expectation is closer to 0.95
  Previous measurements with semileptonic mode - Use $(\Lambda_b \rightarrow J/\Psi\Lambda)$
  Study other baryons, $\Omega_b, \Xi_b, \ldots$
- Rare decays - l^+l^- final states
  e.g. Some SUSY models (large tanβ) have enhanced rates for $B^0_{d,s} \rightarrow \mu^+\mu^-$
- b production cross-section - Run I measurements were ($\times 2-3$)higher than theory
- Charmonium - $J/\Psi, \Upsilon$ production, polarization studies
- Study B_c meson
- Also do B_d mixing, sin(2β) - mainly for cross-checks
- No Particle ID , so very hard to do $B \rightarrow \pi\pi, K\pi$...
  or mixing via $B_s \rightarrow J/\Psi K^{*\circ}$ (good trigger and reconstruction efficiency)
- Unique opportunity to do B physics during the current run
  When $\mathcal{L} \approx 10^{32}$ cm^{-2} s^{-1}, very hard to keep low pT triggers unprescaled

For this program, we need

- Exclusive final state reconstruction
  $B \rightarrow J/\Psi X$, $D^{(*)} l\nu, D^{(*)}(n\pi)$
- Proper time measurement
- Flavour tagging at production and decay
- Jet reconstruction (for b production)

Recent results

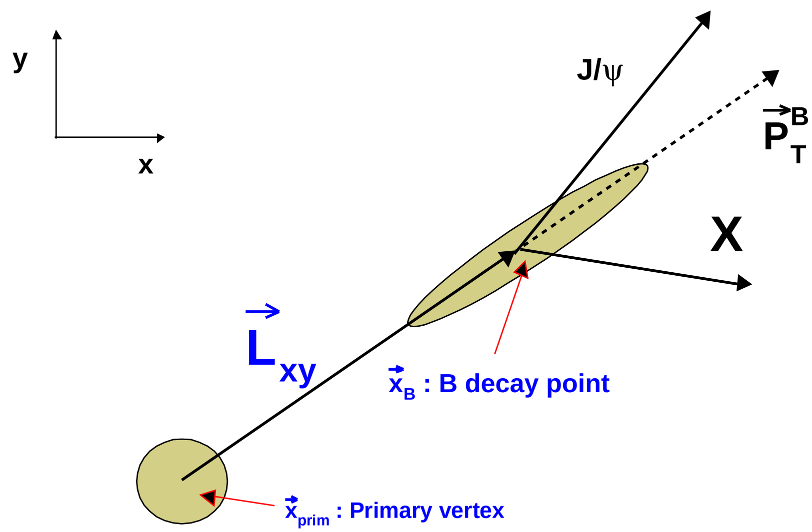
Recent results are based on the J/Ψ sample ($\approx 45pb^{-1}$)

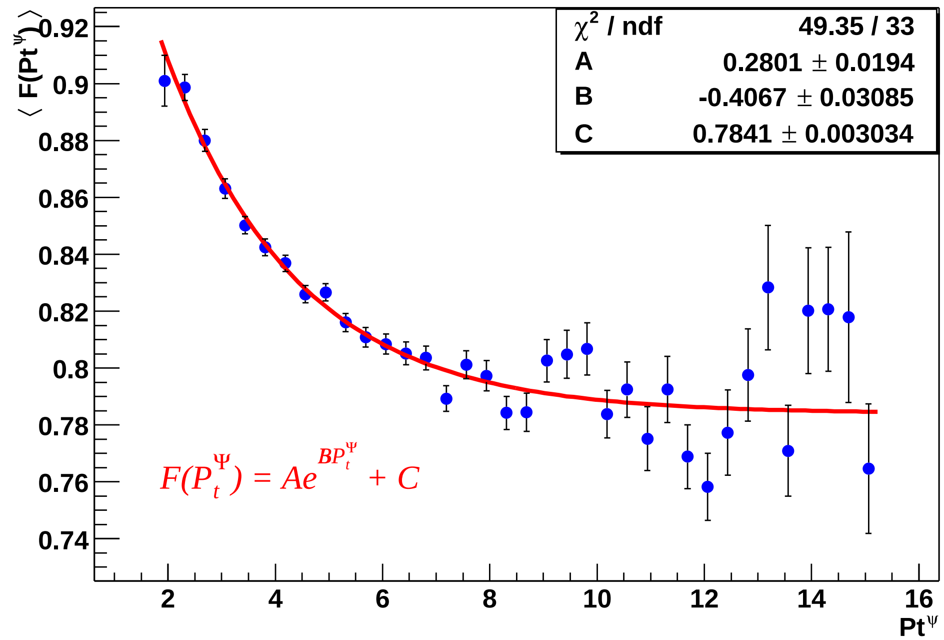


Simple cuts on Muon pT and vertex

Inclusive B lifetime

J/Ψ are prompt as well as from B hadrons

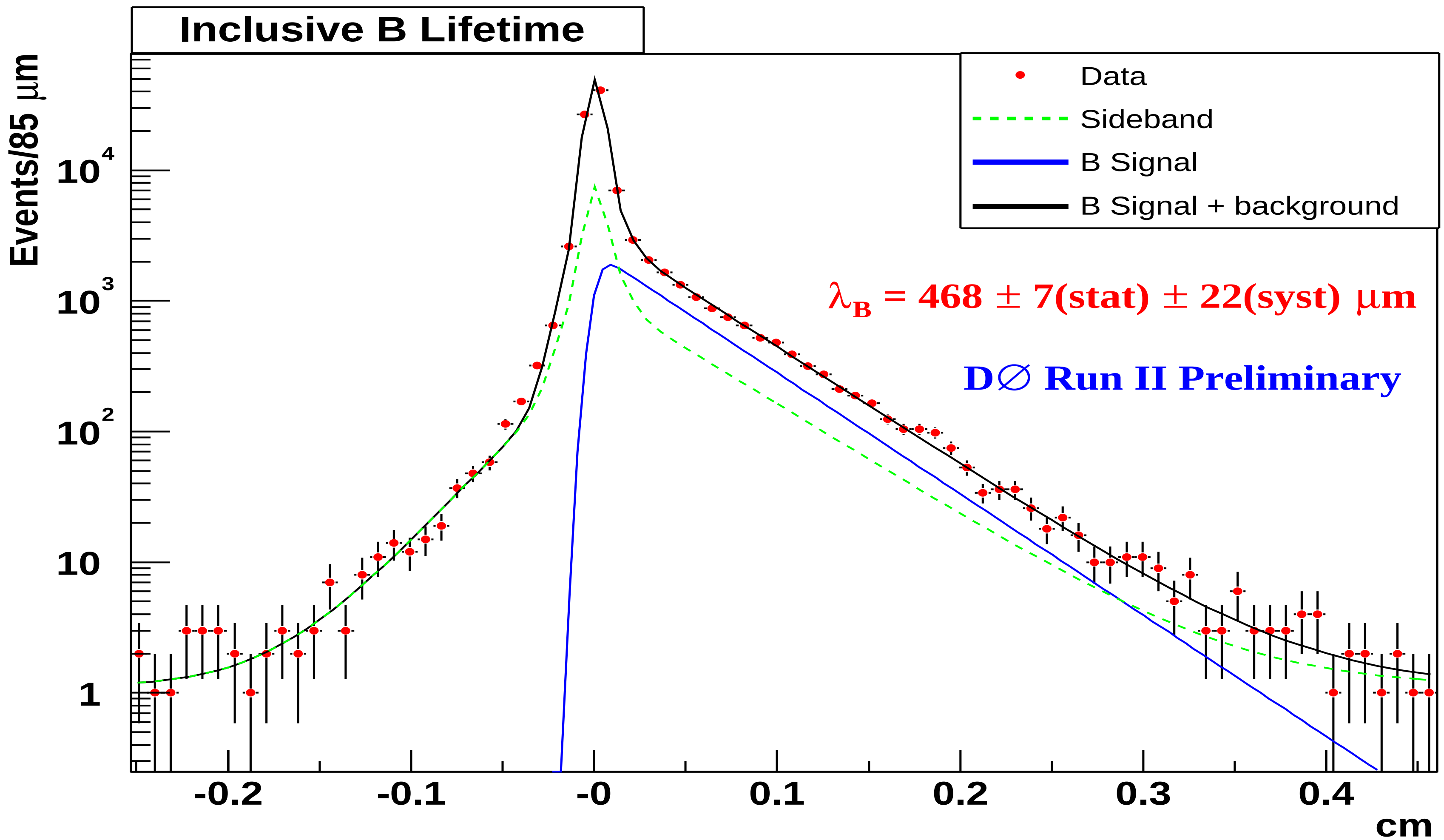




Use Correction factor from MC to relate λ_Ψ to λ_B

$$\lambda_B = L_{xy} \frac{M^\Psi}{P_T^\Psi \langle F(P_T^\Psi) \rangle} \qquad \langle F(P_T^\Psi) \rangle = \frac{M^\Psi}{M^B} \frac{P_T^B}{P_T^\Psi}$$

λ_B distribution



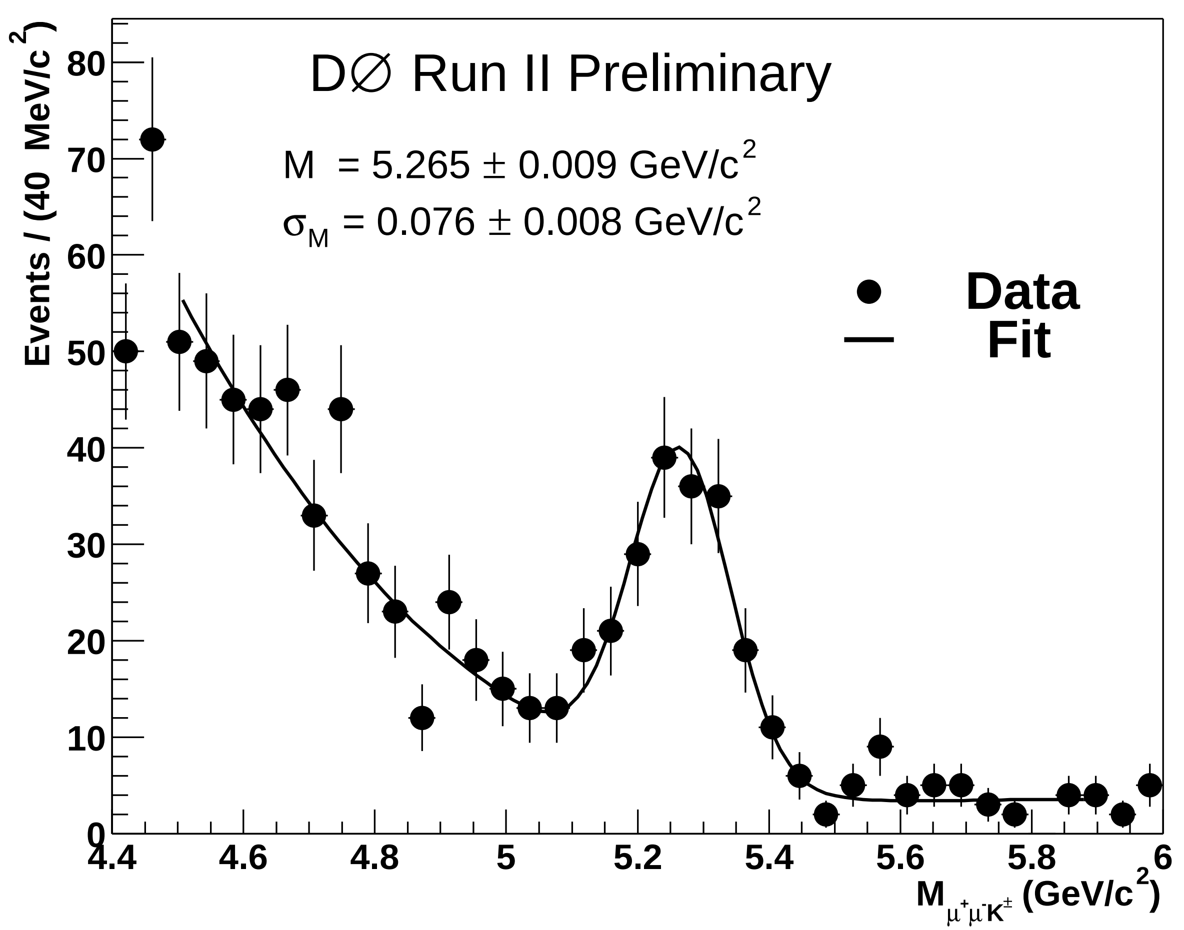
$\langle\tau\rangle = 1.561 \pm 0.024(\mathrm{stat}) \pm 0.074(\mathrm{syst})$ ps (PDG 1.564 ± 0.014)

Dominant Syst. errors :

Correction Factor - 15.9μm, Fitting bias - 14.0μm

(Fraction of outliers - 1×10^{-3})

$B^+(\rightarrow J/\Psi K^+)$ lifetime

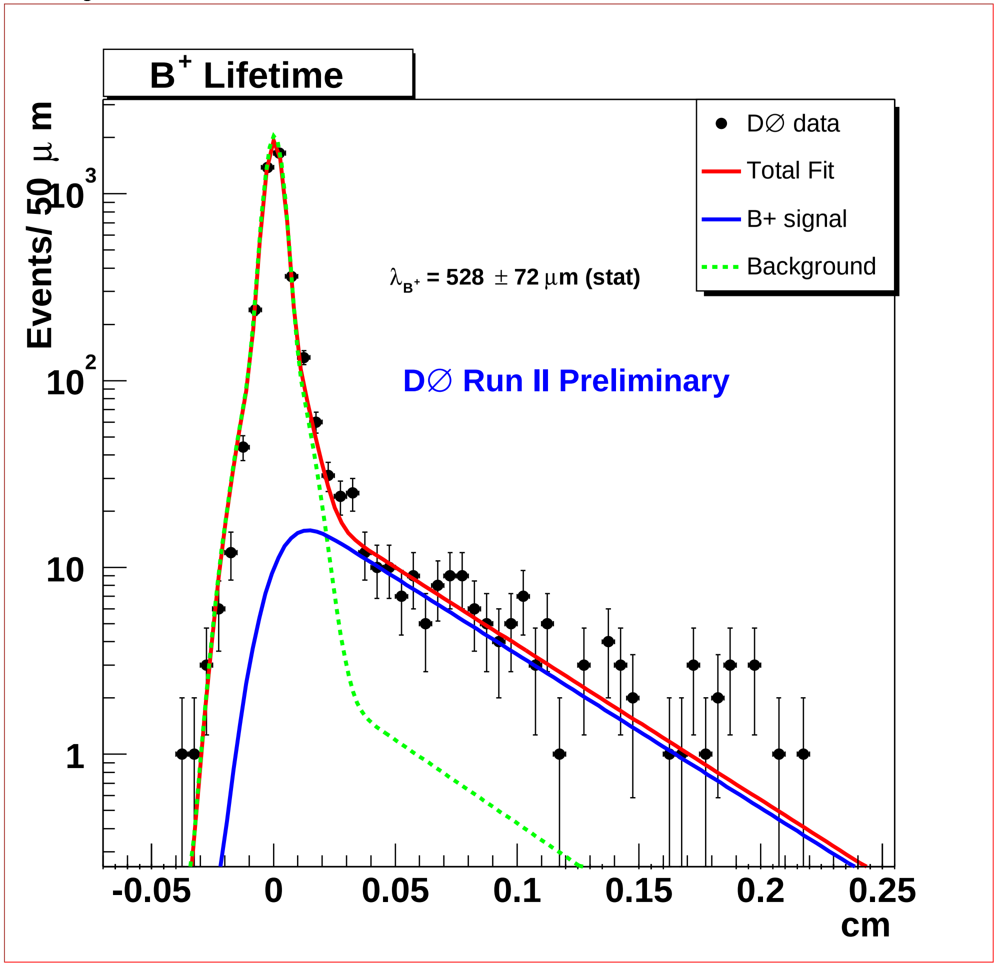


Cuts: $2.8 < J/\Psi\text{mass} < 3.3$ B decay length > 0.3mm
K $P_T > 2$ GeV Collinearity > 0.9

To measure lifetime, remove decay length cut

$\lambda_{B^\pm}$ distribution

Fully reconstructed, so no need for correction factor



$\langle\tau\rangle = 1.76 \pm 0.24(\mathrm{stat})$ ps (PDG 1.674 ± 0.018)

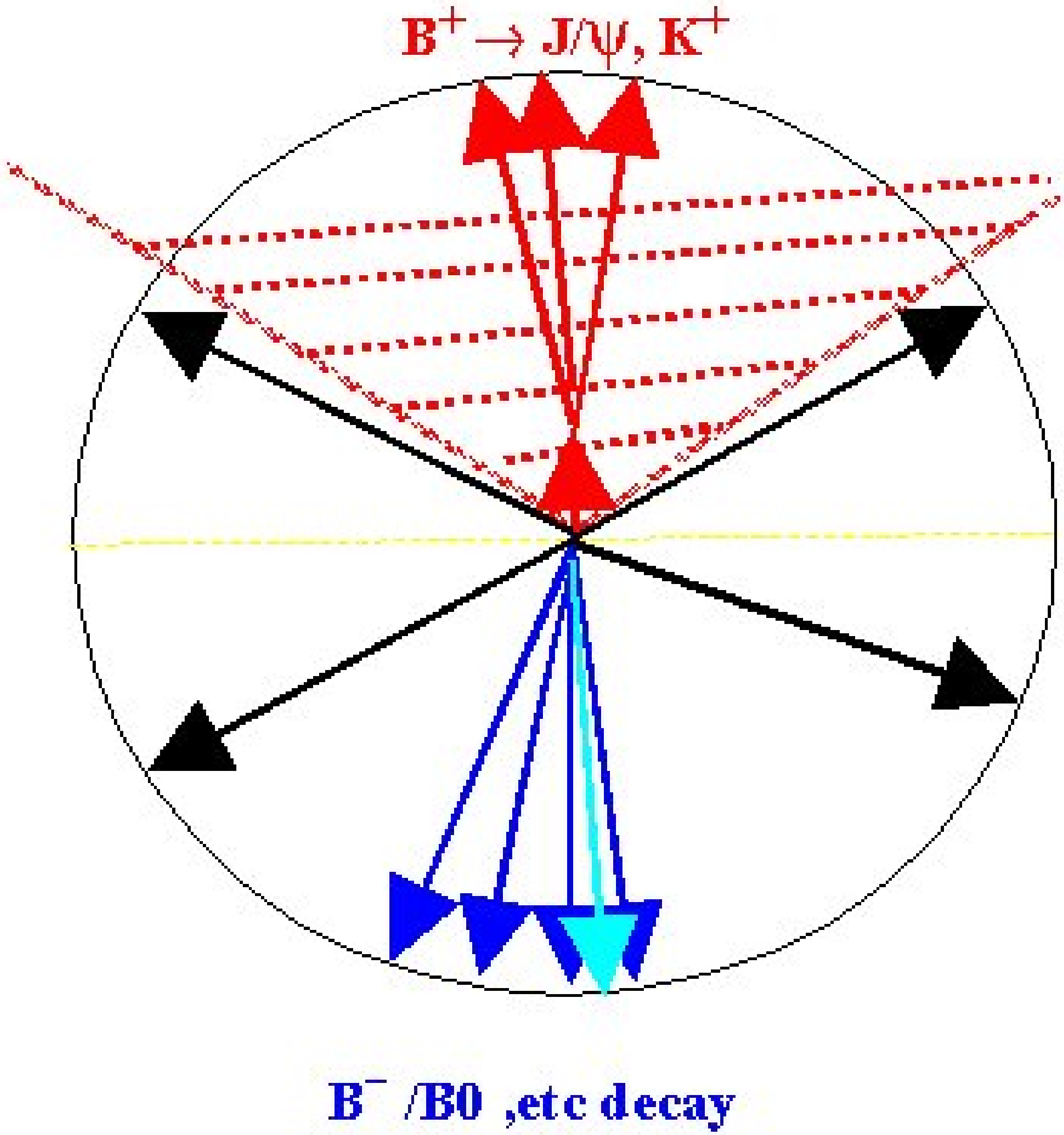
Better tracking available - Reanalyzing

Use Charged B sample to study Flavour tagging techniques

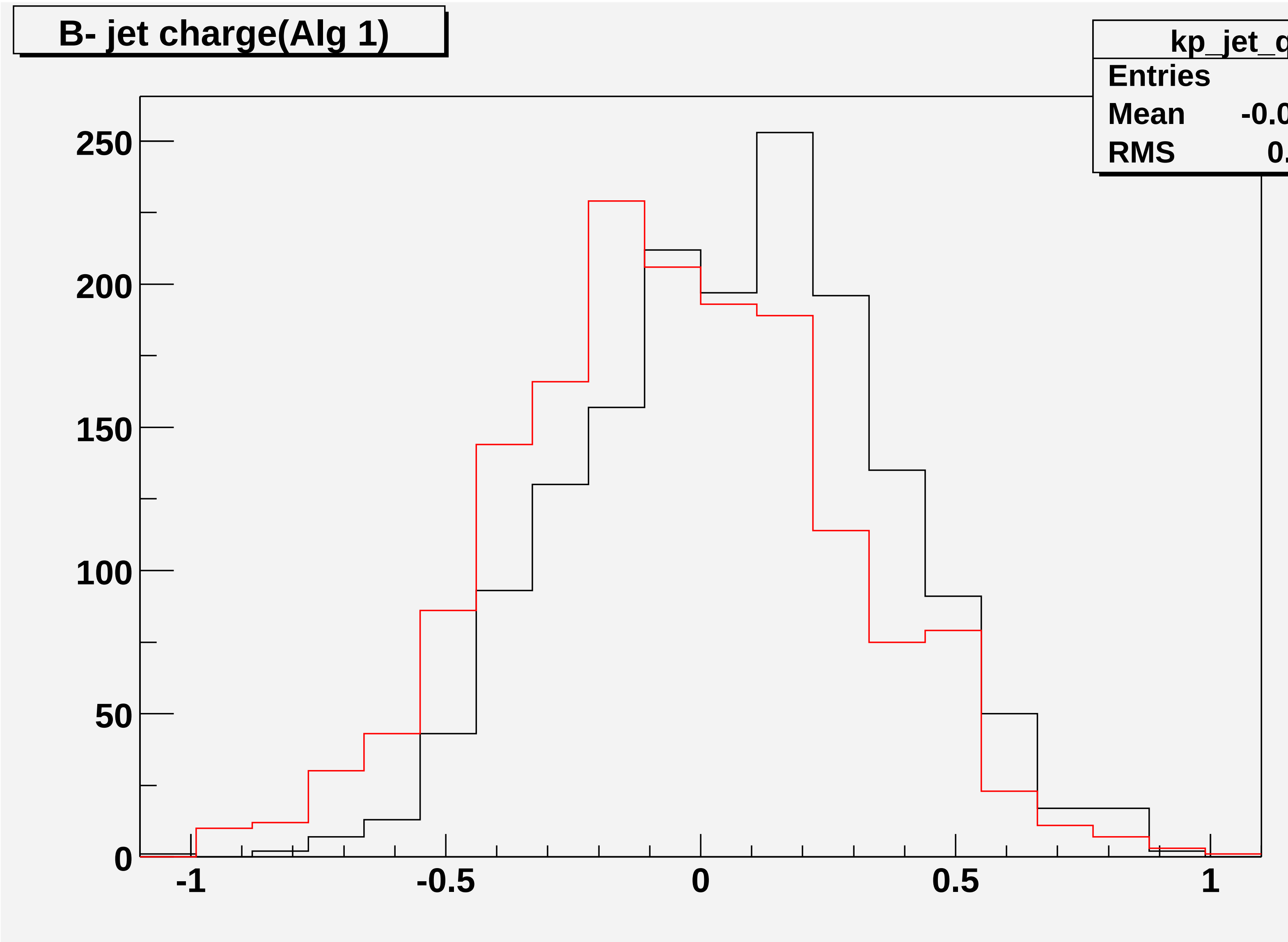
- Soft lepton tagging
  - Muon $\Delta R > 2$ from B^+, Muon $P_T > 1.9$ GeV
  - Muon charge $\Rightarrow$ b-tag
- Jet Charge tagging
  - Remove B^+ daughters
  - Use all tracks with Imp Param < 0.2 cm and in cone opposite to B direction

$$Q = \frac{\Sigma pT_i \times Q_i}{\Sigma pT_i}$$

  - Take events with $|Q| > 0.2$
- Same side tagging
  - Consider all tracks on side as B - underway



bbbar events on the transverse plane.


B- jet charge(Alg 1)
kp_jet_q
Entries
Mean -0.0
RMS 0.
250
200
150
100
50
0
-1
-0.5
0
0.5
1

Tagging Performance

$$\epsilon = \frac{N_{correct} + N_{wrong}}{N_{correct} + N_{wrong} + N_{notag}} \qquad D = \frac{N_{correct} - N_{wrong}}{N_{correct} + N_{wrong}}$$

- ϵ , D are the efficiency and Dilution
- Mixing measurements $\propto$ ϵD^2

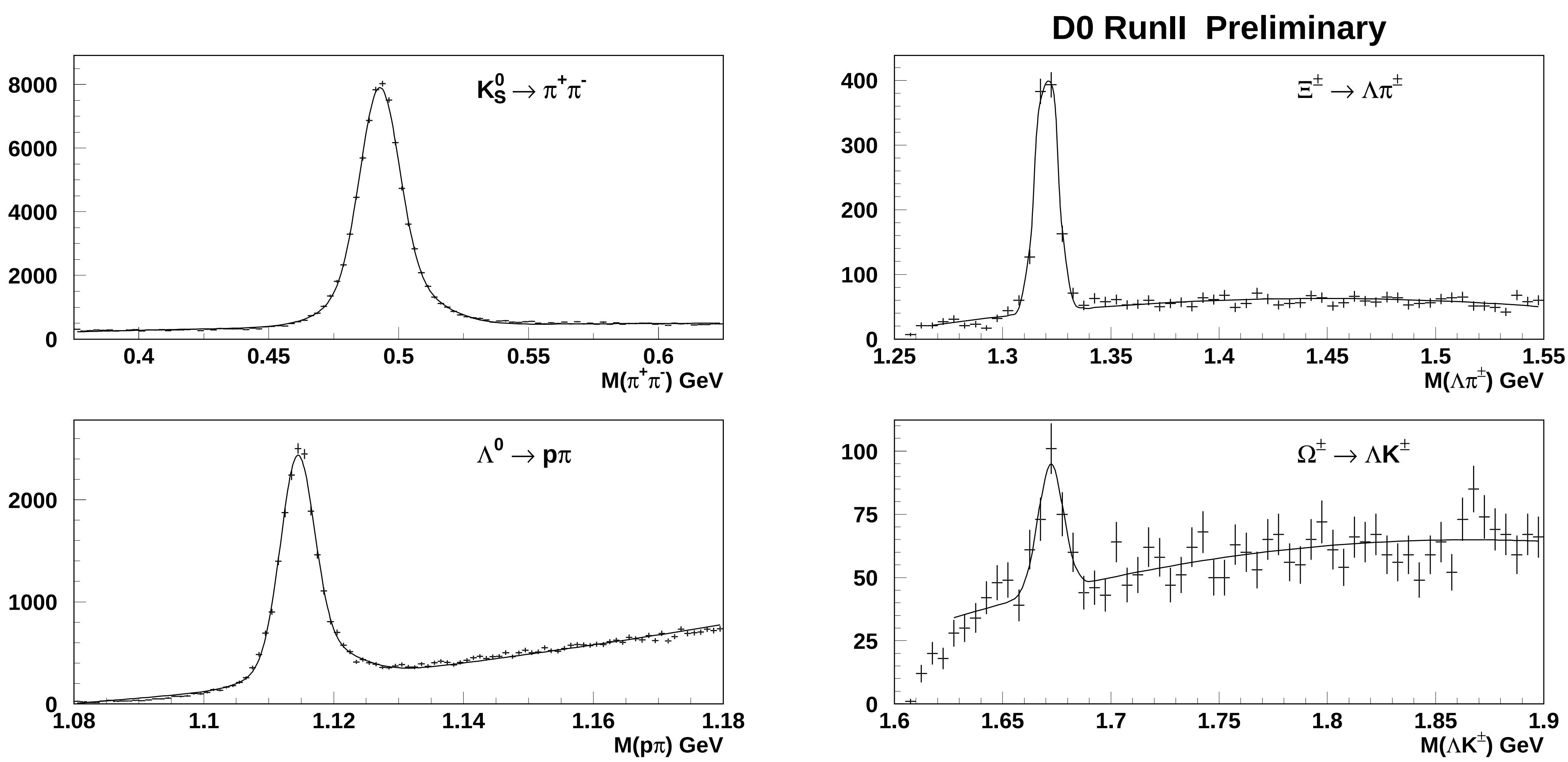
	Jet Tag	Muon Tag
Signal Region: ϵ	$63.0 \pm 3.6\%$	$8.3 \pm 1.9\%$*
Dilution	$15.8 \pm 8.3\%$	$44.4 \pm 21.1\%$
Sideband Region: ϵ	$65.8 \pm 2.4\%$	$8.5 \pm 1.6\%$*
Dilution	$2.4 \pm 4.1\%$	$-3.7 \pm 19.2\%$
ϵD^2 for signal	$2.4 \pm 1.7\%$	$3.3 \pm 1.8\%$

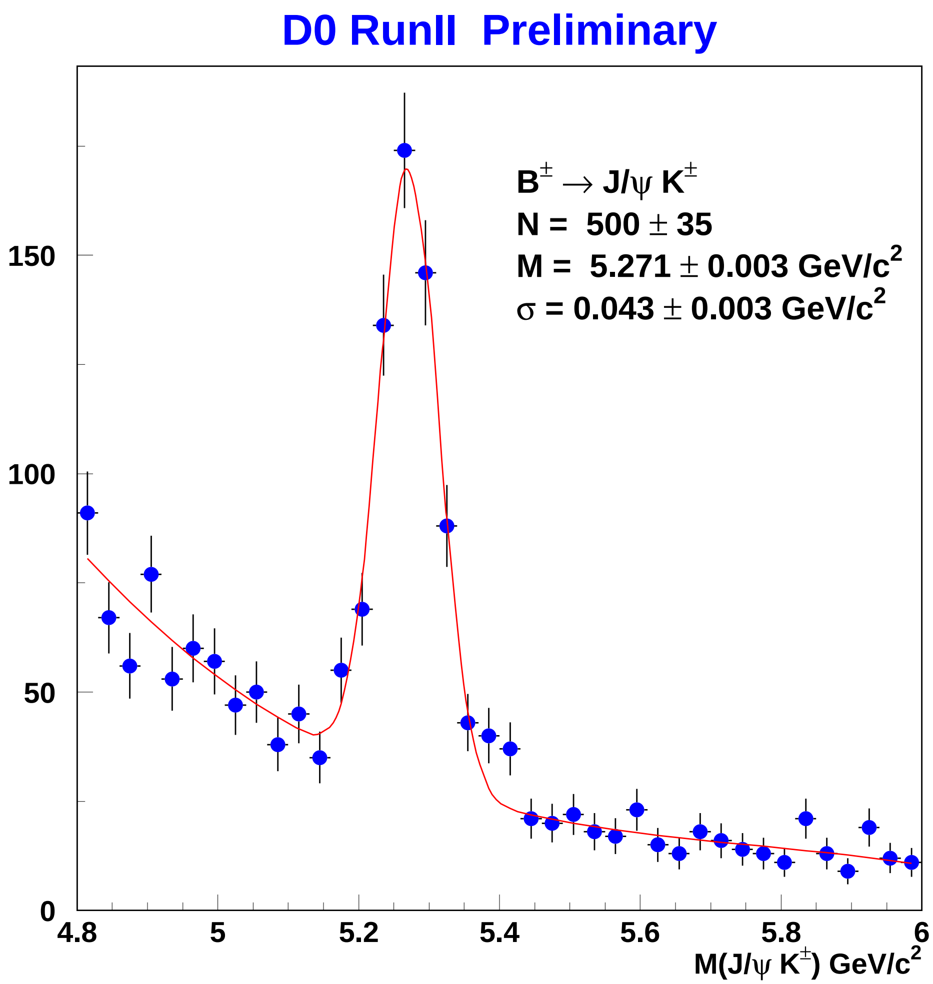
* (Muon Tag efficiency includes semileptonic branching fraction)

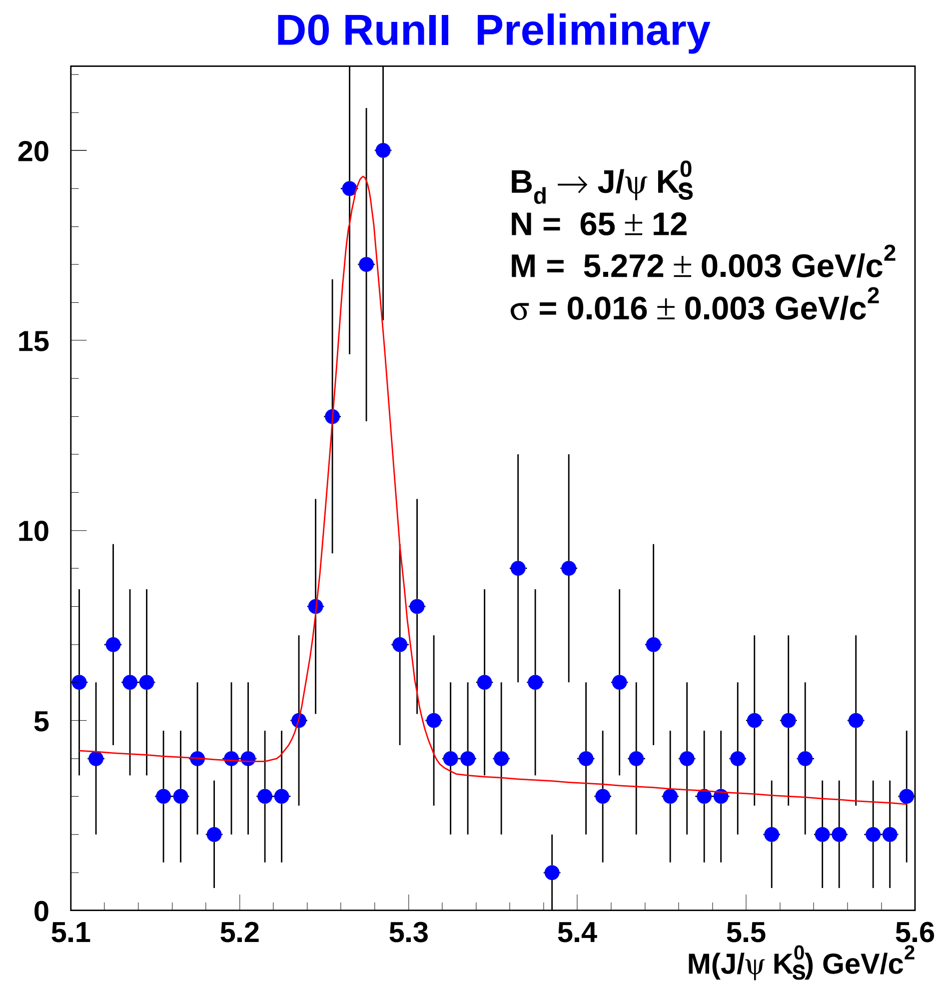
Better tracking available - Reanalyzing

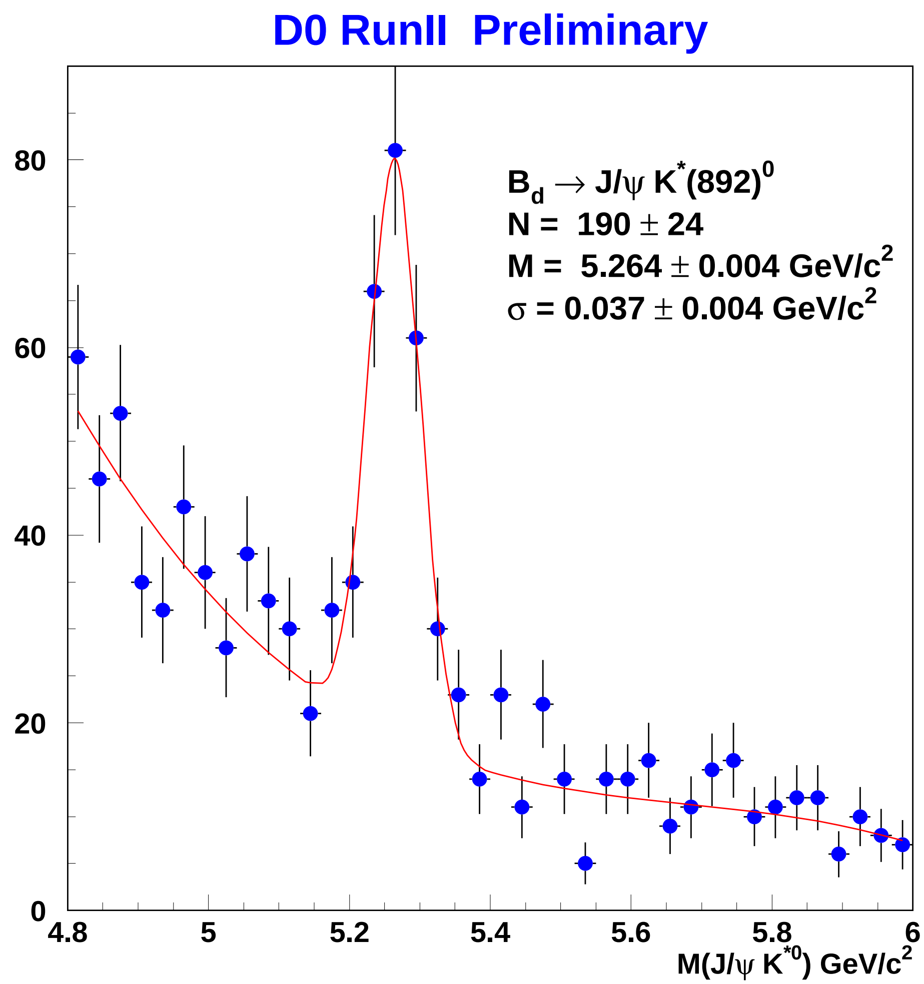
New Tracking Algorithm has been developed

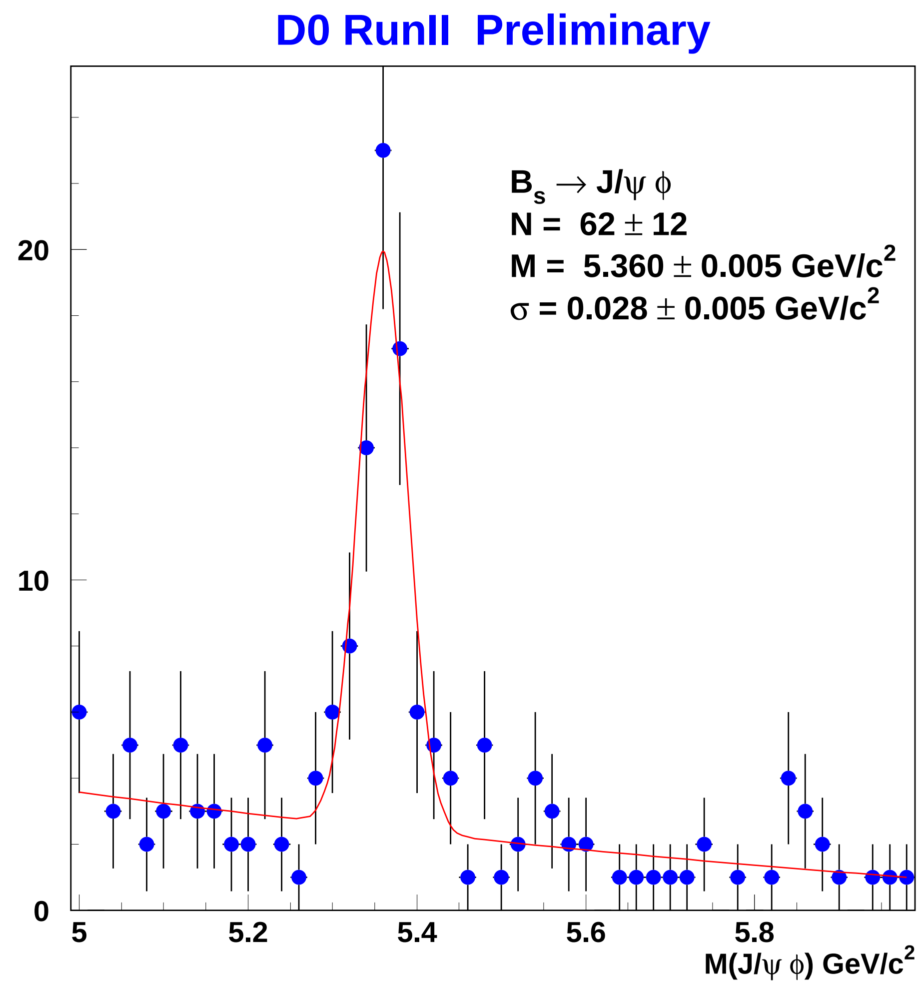
Better performance for lower pT tracks (0.18 GeV/c), K_{s}, λ daughters




D0 RunII Preliminary
$B^{\pm} \to J/\psi K^{\pm}$
N = 500 ± 35
M = 5.271 ± 0.003 GeV/c^2
σ = 0.043 ± 0.003 GeV/c^2
$M(J/\psi K^{\pm})$ GeV/c^2


D0 RunII Preliminary
$B_d \to J/\psi K^0_S$
N = 65 ± 12
M = 5.272 ± 0.003 GeV/c^2
σ = 0.016 ± 0.003 GeV/c^2
$M(J/\psi K^0_S)$ GeV/c^2

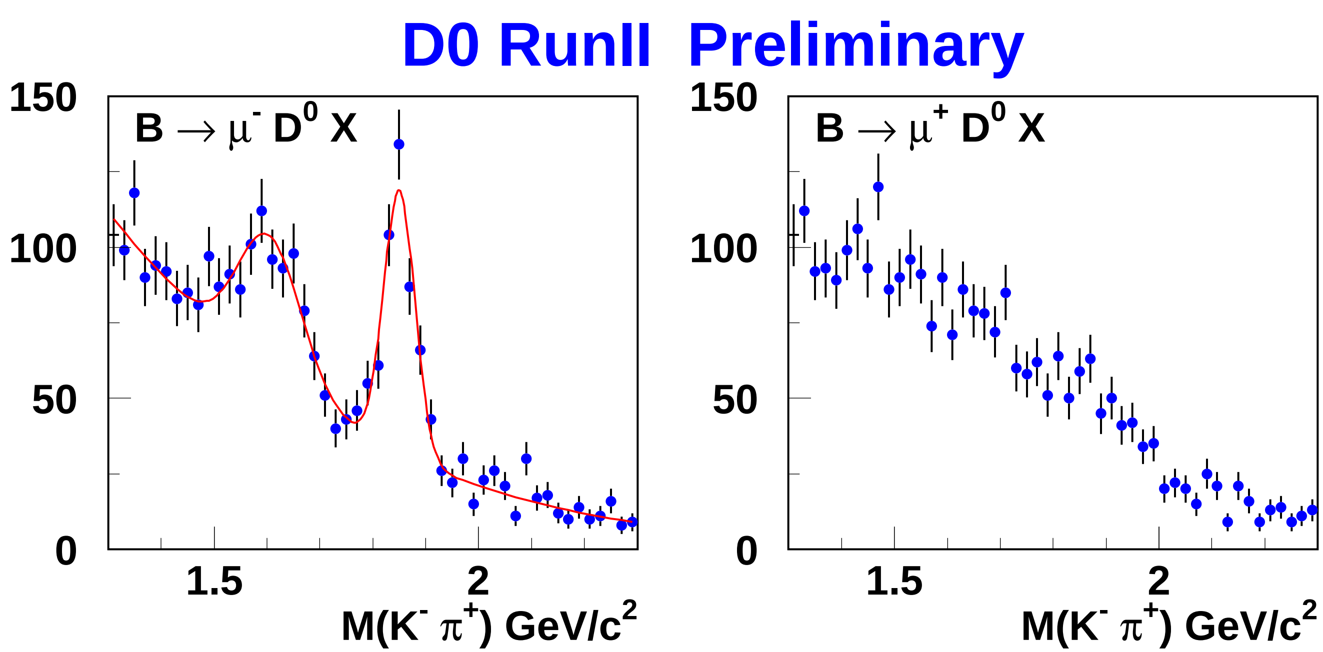

D0 RunII Preliminary
$B_d \to J/\psi\ K^*(892)^0$
N = 190 ± 24
M = 5.264 ± 0.004 GeV/c²
σ = 0.037 ± 0.004 GeV/c²
$M(J/\psi\ K^{*0})$ GeV/c²


D0 RunII Preliminary
$B_s \to J/\psi\ \phi$
N = 62 ± 12
M = 5.360 ± 0.005 GeV/c²
σ = 0.028 ± 0.005 GeV/c²
$M(J/\psi\ \phi)$ GeV/c²

B $\rightarrow D^0 \mu X$

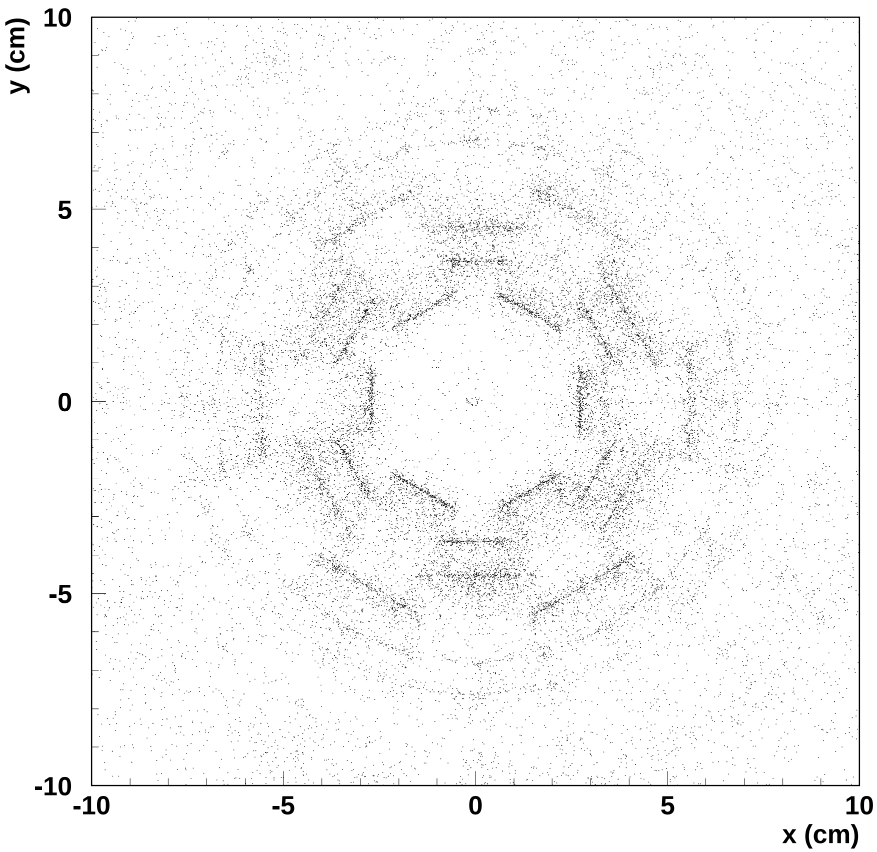
Simple cuts:

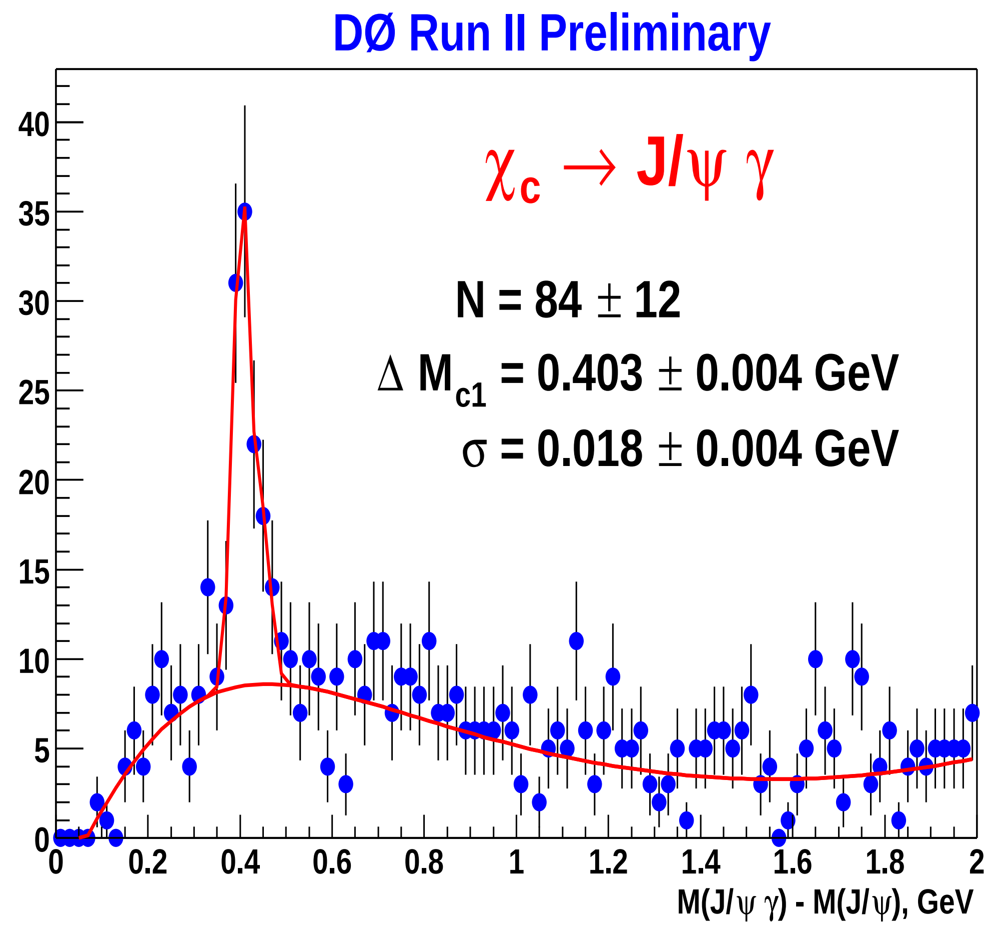
- Cut on Imp Param significance of D^0 daughters
- Decay length significance cut ($l_{xy}/\sigma_l > 4$) on D^0 vertex
- Collinearity cut on D^0, χ^2 cut on the μD^0 vertex
- B mass - $2.3 < \mu D^0 < 5.5$



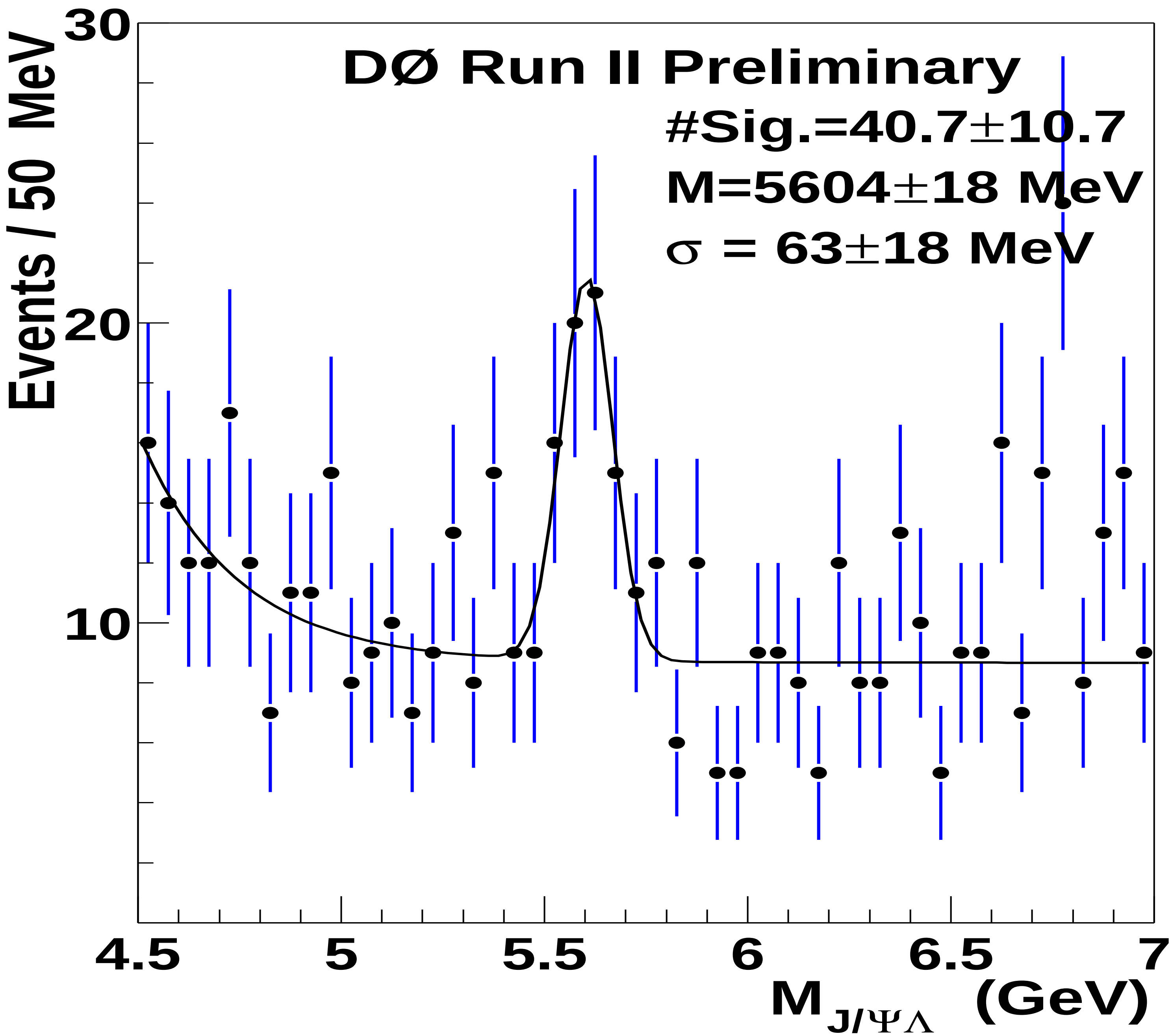
We reconstruct ≈ 400 such events/pb^{-1}

From Run I: J/Ψ (& $\Psi(2S)$) yield is much higher than predictions
CDF Run I: Fraction of J/Ψ coming from $\chi_c = 27.4 \pm 5.4\%$



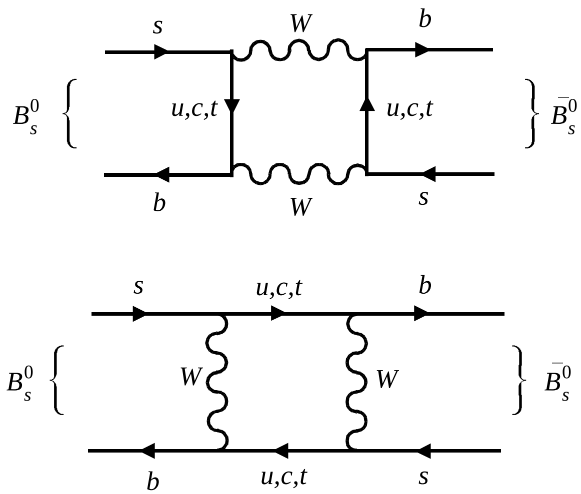


Cuts: pT $\mu > 2$ GeV, pT $\gamma > 1$GeV
Fit to ΔM peak : Sum of two Gaussians - χ_{c1}, χ_{c2}
fixed diff. between the peaks (46 MeV) and same sigma
Working to improve resolution - better tracking available



This signal does not use the best available tracking

B_s oscillations



Proceeds via a second order weak transition

B_s mixing very important in constraining CKM

$\overline{\rho} < 0$ is disfavoured from lower bound on ΔM_s

- Side CA of the Unitarity triangle ($\propto |V_{td}|$) is also

$$R_t = 0.88 \left[\frac{\xi}{1.18}\right] \sqrt{\frac{18.0/\text{ps}}{\Delta M_s}} \sqrt{\frac{\Delta M_d}{0.5/\text{ps}}}, \qquad \xi = \frac{\sqrt{B_{B_s}} F_{B_s}}{\sqrt{B_{B_d}} F_{B_d}}$$

- Mass eigenstates can be written in terms of flavour eigenstates

$$|B_s^L\rangle = p|B_s^0\rangle + q|\overline{B}_s^0\rangle$$
$$|B_s^H\rangle = p|B_s^0\rangle - q|\overline{B}_s^0\rangle$$

- $\Delta M_s \equiv M_H - M_L$, $\Delta\Gamma_s \equiv \Gamma_L - \Gamma_H$

- An initially pure B_s^0 state can evolve in time

$$|B_s^0(t)\rangle = g_+(t)|B_s^0\rangle + g_-(t)\frac{p}{q}|\overline{B}_s^0\rangle$$
$$|\overline{B}_s^0(t)\rangle = g_-(t)\frac{q}{p}|B_s^0\rangle + g_+(t)|\overline{B}_s^0\rangle$$

- Mixed/Unmixed probability can be written as

$$\mathcal{P}_{u,m}(t) = \frac{\Gamma_s e^{-\Gamma_s t}}{2}\left[\cosh\left(\frac{\Delta\Gamma_s t}{2}\right) \pm \cos(\Delta m_s t)\right]$$

- For $\Delta\Gamma_s \approx 0$ (SM expectation)

$$\mathcal{P}_{u,m}(t) = \frac{\Gamma_s e^{-\Gamma_s t}}{2}\left[1 \pm \cos(\Delta m_s t)\right]$$

Experimental Considerations

- Measure asymmetry $\mathcal{A}_f(\mathrm{t})$,

$$\mathcal{A}_f(\mathrm{t}) = \frac{\mathcal{P}_u - \mathcal{P}_m}{\mathcal{P}_u + \mathcal{P}_m} = \frac{\cos(\Delta \mathrm{m_s t})}{\cosh(\frac{\Delta\Gamma_s \mathrm{t}}{2})}$$

- Crucial component is proper time resolution, $\mathrm{t} = \mathrm{m}_B \mathrm{L}/\mathrm{p}$,

$$\sigma_t = \frac{\mathrm{m}_B}{\mathrm{p}} \sigma_L \oplus \frac{\sigma_p}{\mathrm{p}} \mathrm{t}$$

- Also need
  - Exclusive final state reconstruction: $\mathrm{B} \to \mathrm{D}_{(s)}^{(*)} l\nu, \mathrm{D}_{(s)}^{(*)}(\mathrm{n}\pi)$
  - Flavour tagging at production and decay
- Significance of mixing measurement (likelihood fit to $\mathcal{A}_f(\mathrm{t})$)

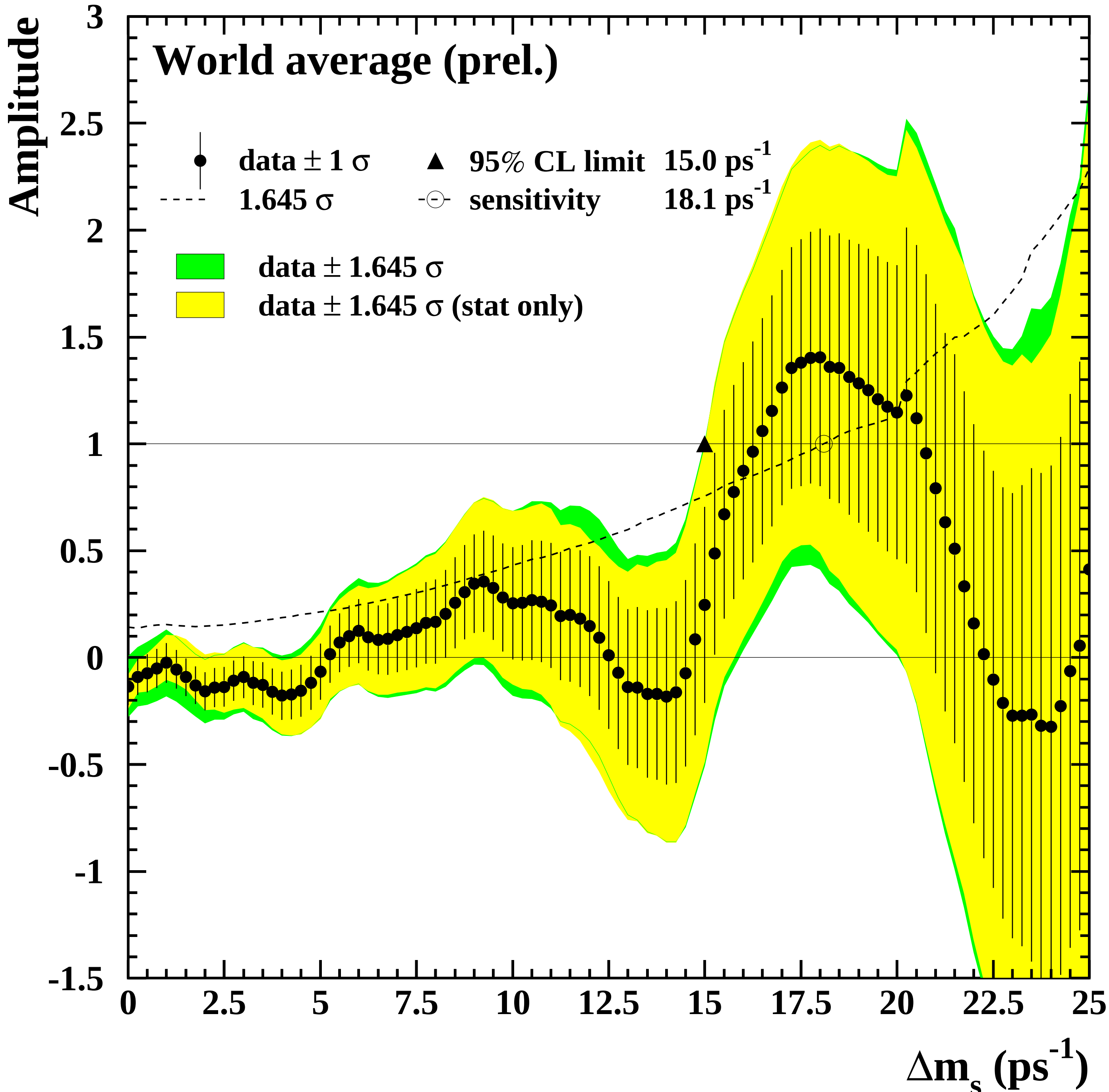
$$= \sqrt{\frac{\mathrm{N}\epsilon \mathrm{D}^2}{2}} e^{-(\Delta \mathrm{m_s} \sigma_t)^2/2} \sqrt{\frac{\mathrm{S}}{\mathrm{S}+\mathrm{B}}}$$

Current limits

- Another way to is to measure $\mathcal{A}$ for every value of ω

$$\mathcal{P}_{u,m}(t) = \frac{\Gamma_s e^{-\Gamma_s t}}{2}[1 \pm \mathcal{A}\cos(\omega t)]$$

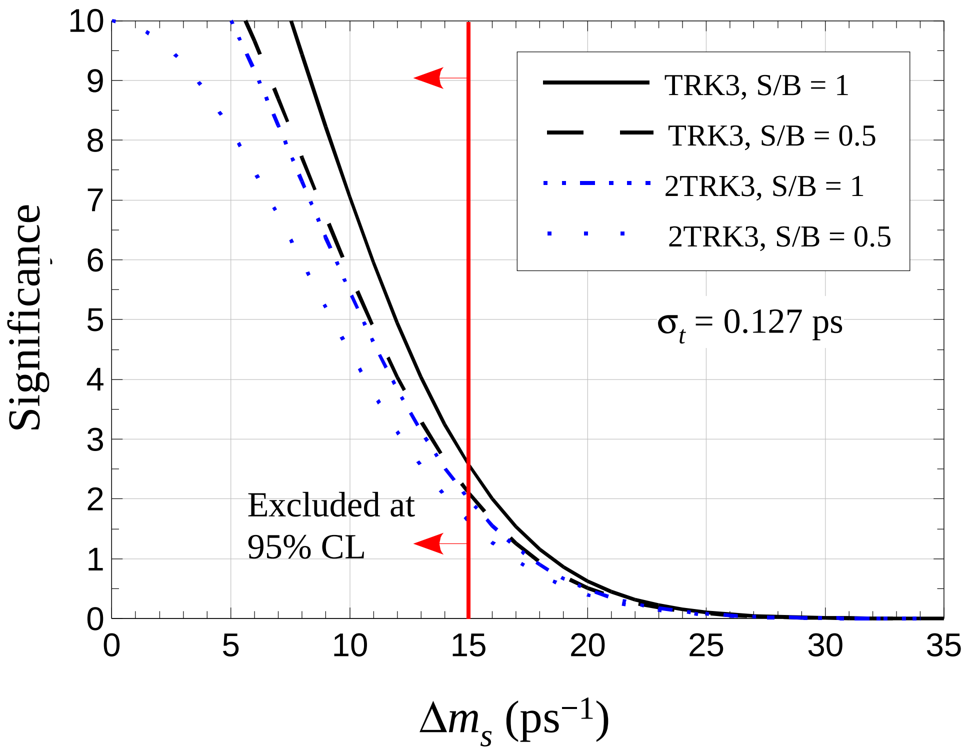
- If $\omega \ll \Delta M_s$ $\mathcal{A}$=0 , while at the true frequency
  $\omega = \Delta M_s$ $\mathcal{A}$ expected to be 1
- All values of the test frequency ω
  for which $\mathcal{A} + 1.645\sigma_{\mathcal{A}} < 1$ were excluded at the 95% CL
- Current limit $\Delta m_s > 15.0 ps^{-1}$
  Sensitivity was 18 ps^{-1}
  Poorer result due to a "hint" of signal at 17 ps^{-1} ($\approx 2.5\sigma$)
- If we remove Δm_s from Unitarity triangle fits
  current measurements prefer Δm_s around $15 \pm 4 ps^{-1}$
- Standard Model upper limit $\Delta m_s \leq 31$ ps^{-1} at 95% CL

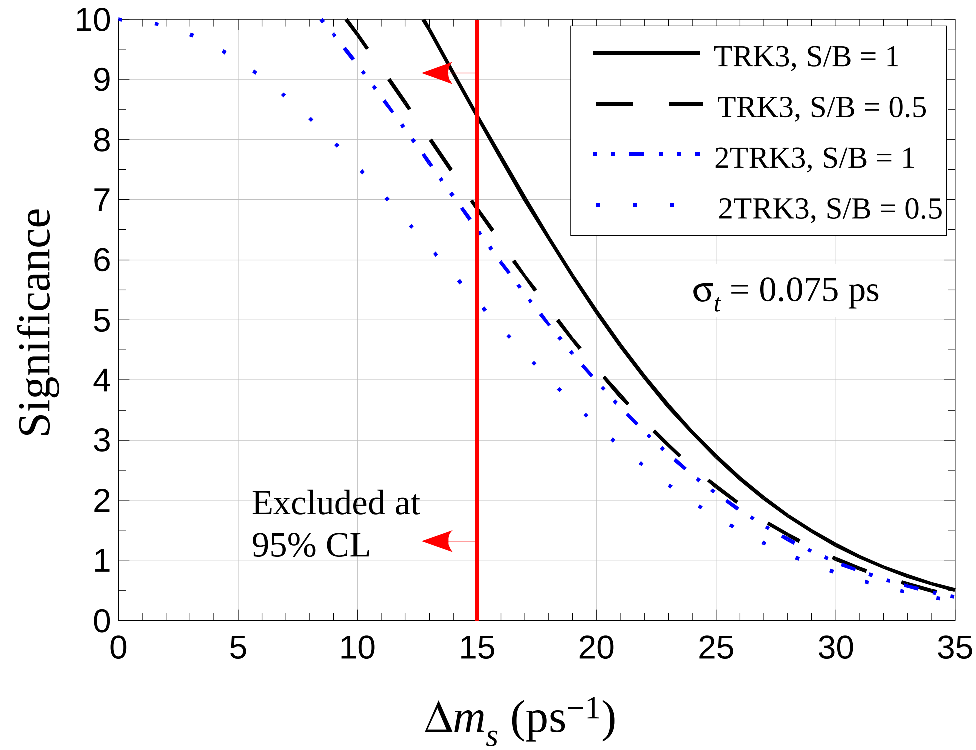

World average (prel.)
data ± 1 σ
1.645 σ
95% CL limit 15.0 ps-1
sensitivity 18.1 ps-1
data ± 1.645 σ
data ± 1.645 σ (stat only)
Amplitude
Δms (ps-1)
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25

Prospects for D0

- $B_s \to D_s^{(*)}(n\pi)$
  - Good reconstruction efficiency
  - Good proper time resolution
  - Low branching fractions $\approx 0.4\%$
  - Low trigger efficiency - Single muon triggers
- $B_s \to D_s^{(*)} l\nu$
  - Good reconstruction efficiency
  - Poorer proper time resolution
  - Large branching fractions $\approx 6 - 10\%$
  - Good trigger efficiency - Single and dimuon triggers
- Tracker & Silicon based Triggers will improve prospects

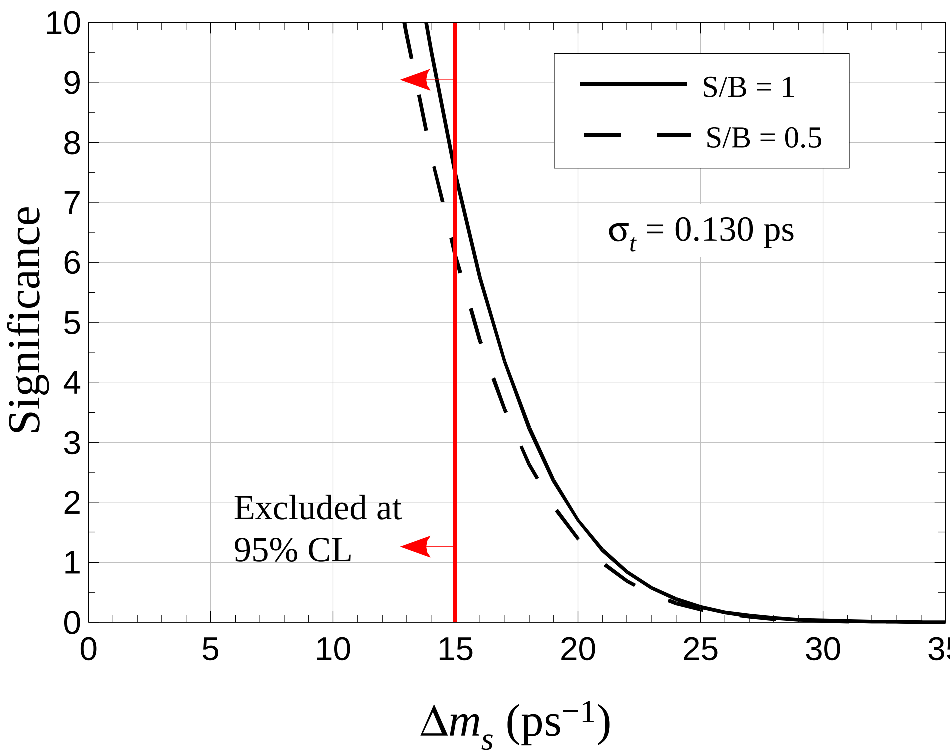
- $B_s \to D_s^{(*)}\pi$
- Reconstruction eff. $\approx 15\%$
- Trigger Eff. is 0.1/0.2% for the two triggers
- Since each event has ≥ 1 muon, ϵD^2 is high
- Total Number of reconstructed events (MC sample): 1300-1900 (includes all trigger, reconstruction efficiencies, assume 2 fb^{-1})

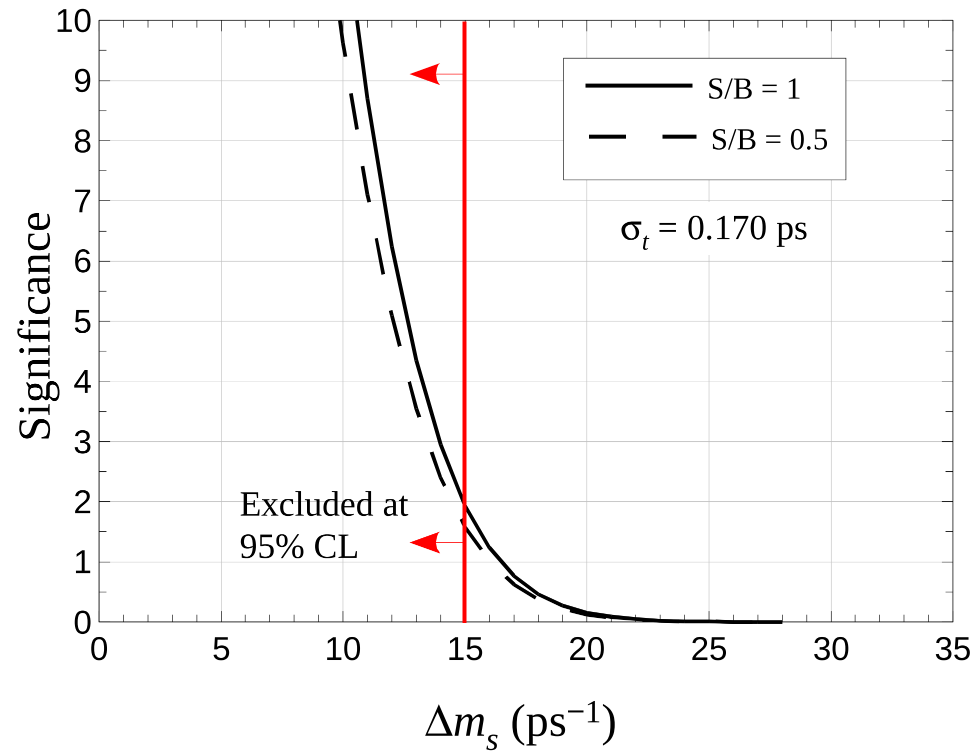




Use of CTT and STT triggers will improve Event Yields and S/B

- $B_s \to D_s^{(*)}\mu\nu$
- Number of events extrapolated from $B \to D^0\mu\nu$ signal -20K
- Infer proper time resolution from inclusive B lifetime study

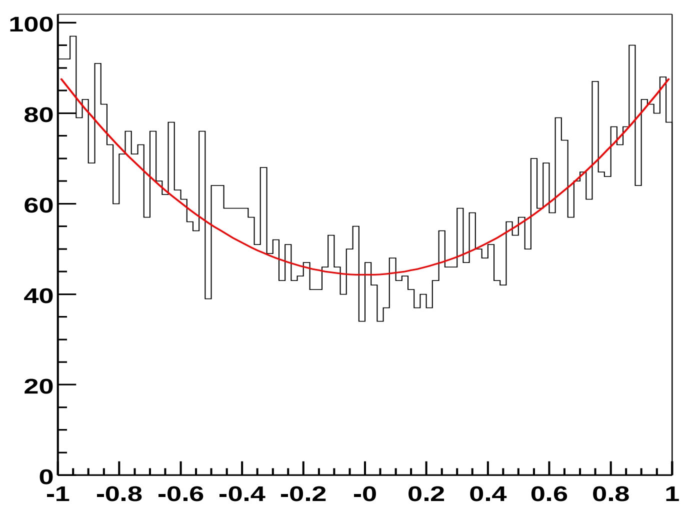


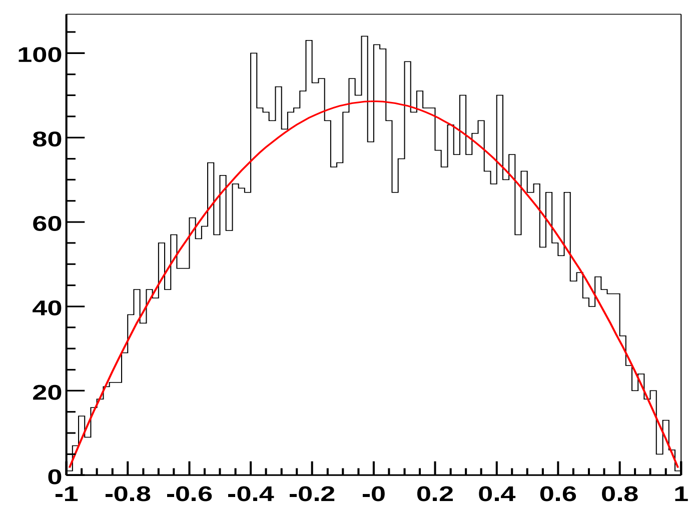


Work is underway - Hopefully will have something to say by next year

$B_s \to J/\Psi\Phi$

- Ideal mode to measure B_s lifetime
- Also 2 vectors in the final state $\Rightarrow$ L=0,1,2
- Final state will be a mixture of CP even and odd states
- Use Transversity basis to separate the CP even and odd states related to the usual helicity basis amplitudes
  - $A_0 = H_0$, $A_\parallel = \frac{1}{\sqrt{2}}(H_+ + H_-)$ - CP even states
  - $A_\perp = \frac{1}{\sqrt{2}}(H_+ - H_-)$ - CP odd
- Transversity angle - between μ and Z-axis is different for CP even: $3/8(1+\cos^2(\theta_t)$ and CP odd: $3/4\sin^2(\theta_t)$





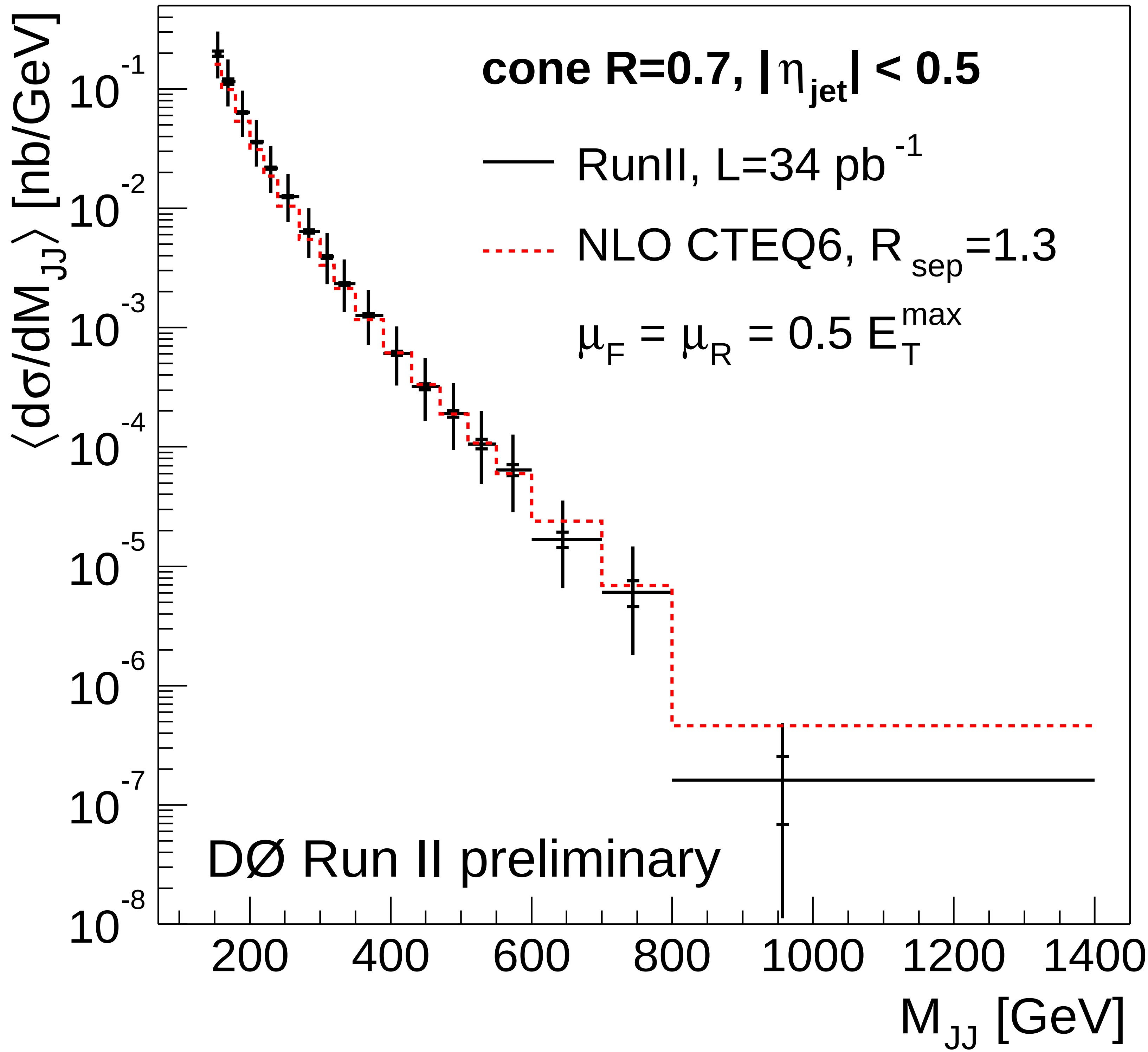
- CP violation in B_s is expected to be small - B_s mass eigenstates are nearly CP-eigenstates
- Combining Transversity & Lifetime analyses , one can access $\Delta\Gamma$ in the B_s system
- In the Standard Model,

$$\frac{\Delta\Gamma_s}{\Delta m_s} = -\frac{3}{2}\pi \frac{m_b^2 \eta_{QCD}^{\Delta\Gamma}}{m_t^2 \eta_{QCD}^{\Delta_s}}$$

- If Δm_s is too large , $\Delta\Gamma_s$ might be accessible!
- Current estimates of $\Delta\Gamma_s/\Gamma_s$ from
  - Inclusive B_s decays which contain both components fit with two exponentials : decay constants $\Gamma_s \pm \Delta\Gamma_s$
  - $J/\Psi\Phi, D_s^{(*)+}D_s^{(*)-}$ final states
- $\Delta\Gamma_s/\Gamma_s = 0.15^{+0.08}_{-0.09}$ (< 0.30 at 95% CL)
  Uses the constraint that $\langle\tau_{B_s}\rangle = \tau_{B_d}$ - B oscillations Working Group
- Implied value of $\Delta m_s = 16^{+8}_{-9} \pm 5 ps^{-1}$ (using input from NLO+Lattice)

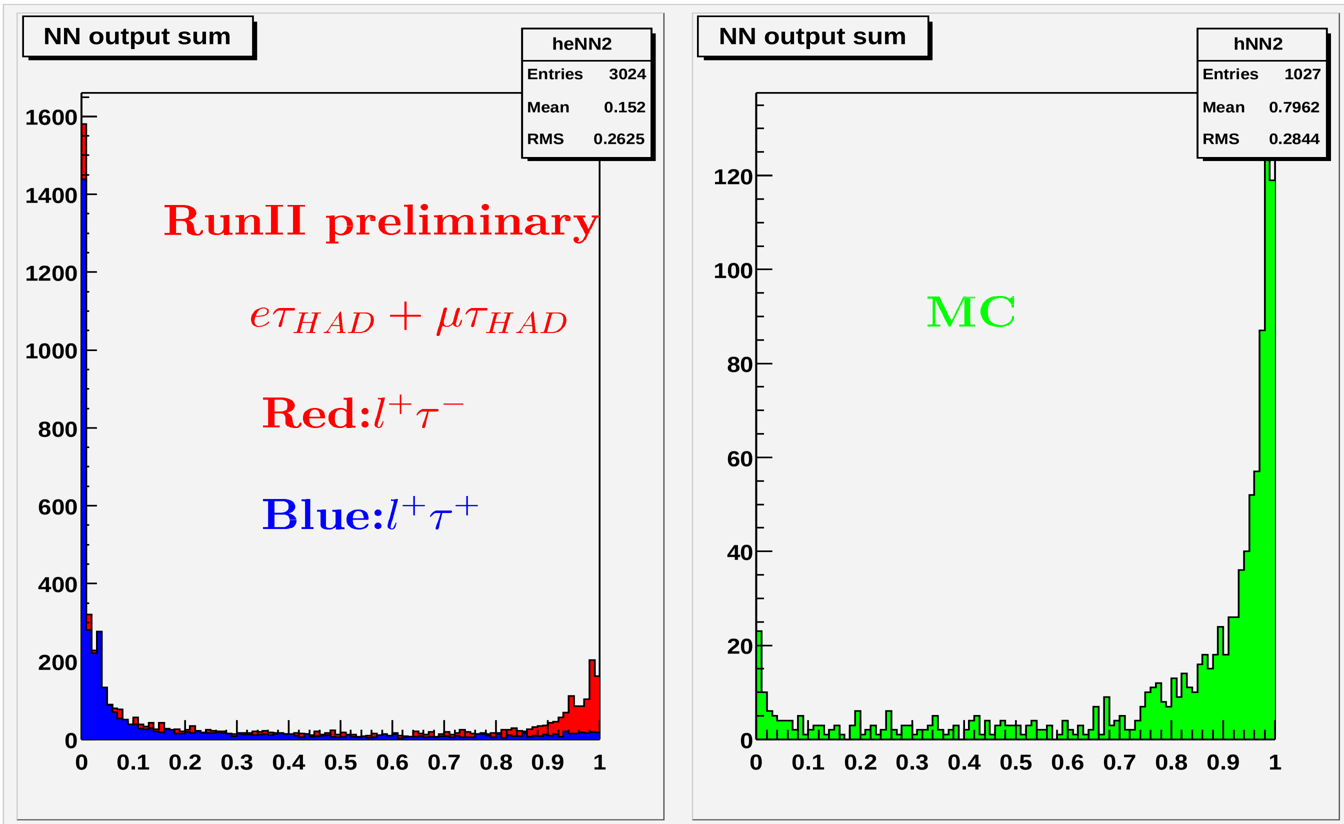
Other Recent Physics Results from D0

- QCD
  - Di-jet cross-section at $\sqrt{s} = 1.96$ TeV
    Probe of proton structure, quark compositeness, etc.
- τ Identification - Z $\rightarrow \tau^+\tau^-$
  - τ can be used in SUSY and Higgs searches
- Higgs Search
  - First step towards W/Z ($\rightarrow$ leptons) + H($\rightarrow \mathrm{b\bar{b}}$) is to understand W/Z + di-jets
- Top Physics
  - Top cross-section at $\sqrt{s} = 1.96$ TeV
  - Improved top mass measurement using Run I data
- Electroweak Physics
  - Z$\rightarrow \mu^+\mu^-$ cross-section at $\sqrt{s} = 1.96$ TeV


cone R=0.7, |η_jet| < 0.5
RunII, L=34 pb^-1
NLO CTEQ6, R_sep=1.3
μ_F = μ_R = 0.5 E_T^max
DØ Run II preliminary
⟨dσ/dM_JJ⟩ [nb/GeV]
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
200
400
600
800
1000
1200
1400
M_JJ [GeV]

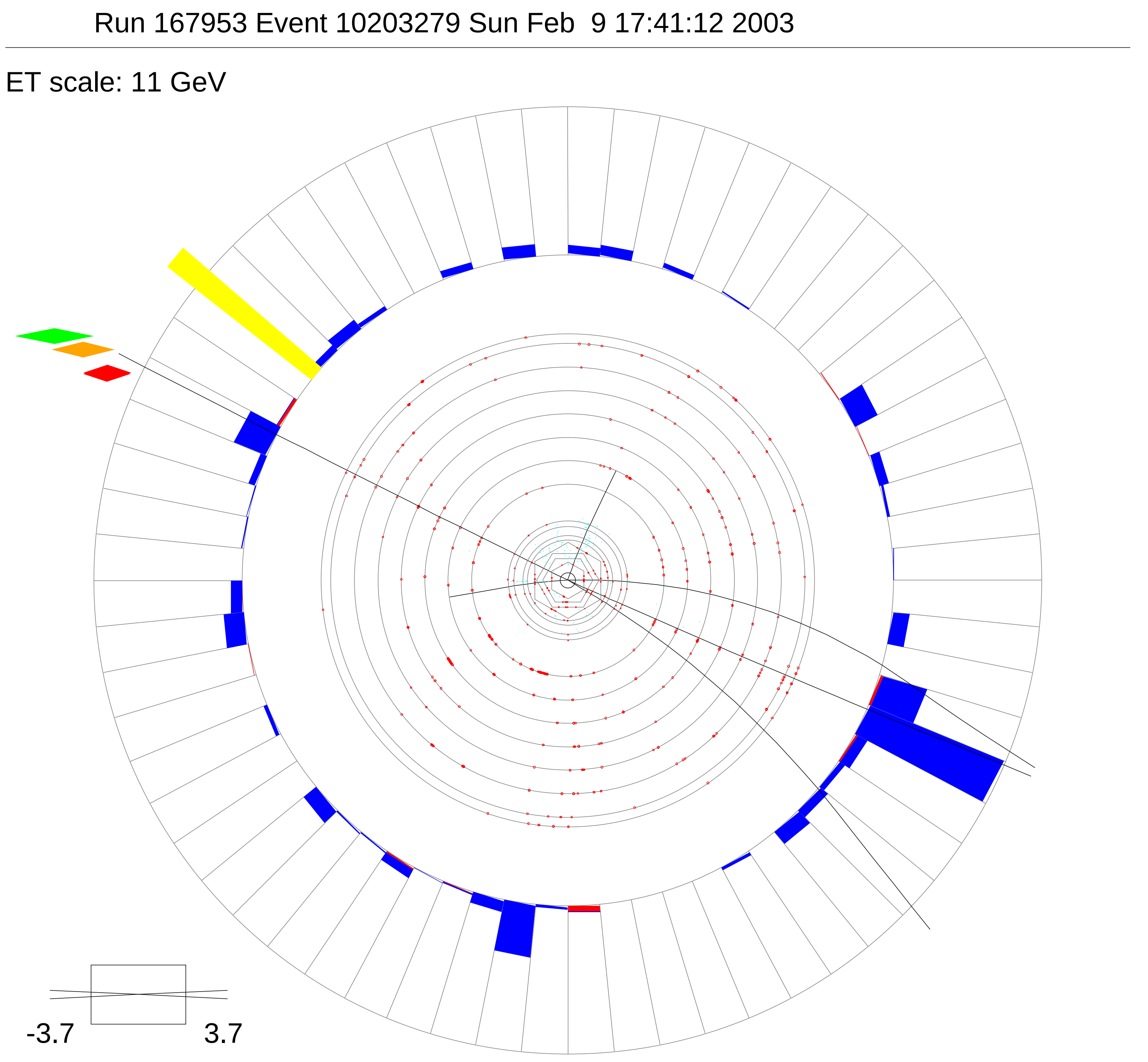
$Z \to \tau\tau$ in RunII Data

Select events with good e and μ and 1-prong τ candidates.
Use Neural Network to identify τ's.



NN output **NN ouput**

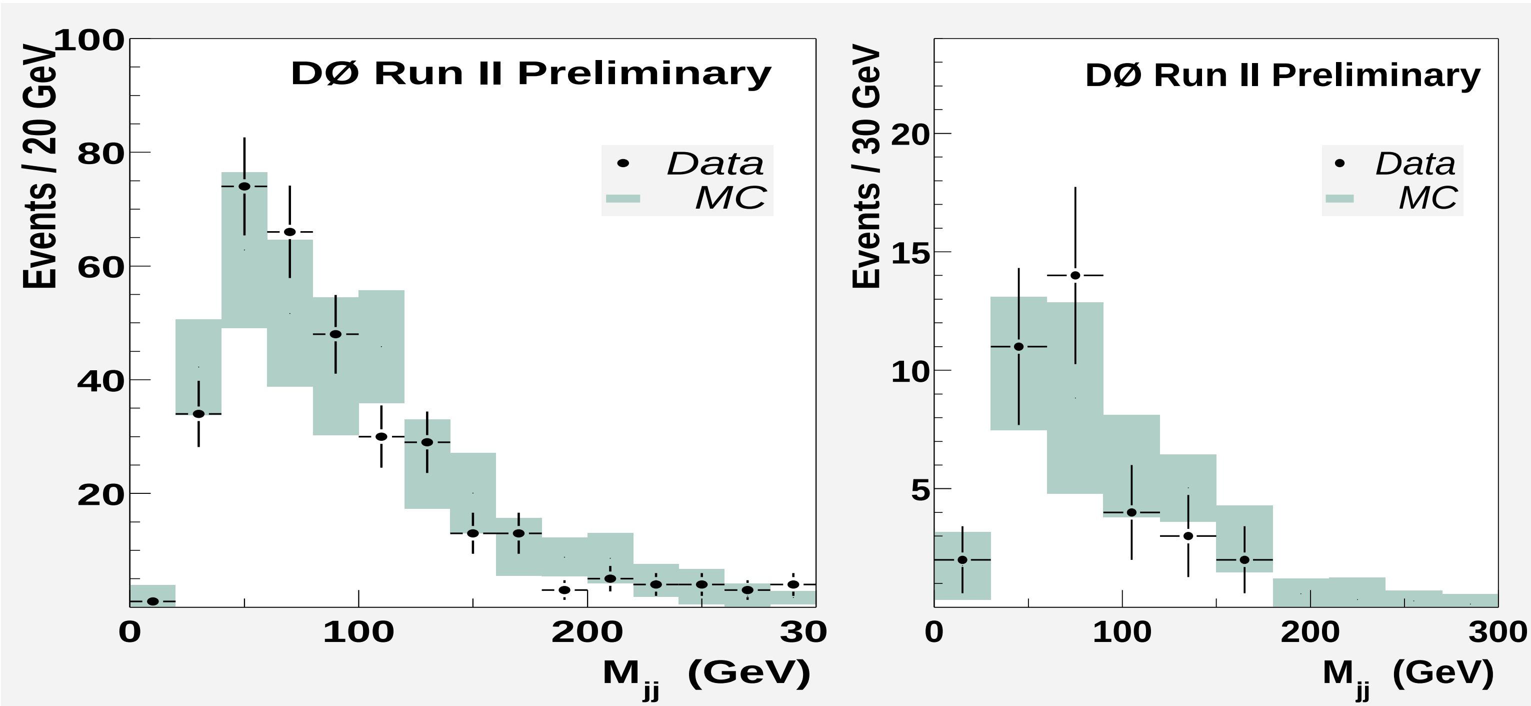
NN uses calorimeter and track energy distributions as inputs



$p_T^{\mu} = 25$ GeV, $p_T^{h} = 14$ GeV

Di-jet mass (in W/Z+jets sample)

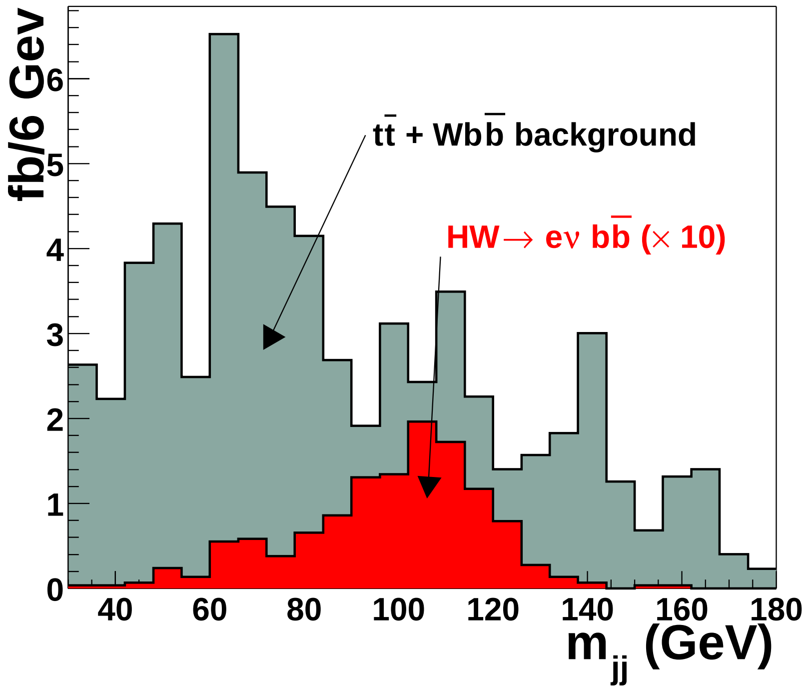
W+jets　　　　Z+jets

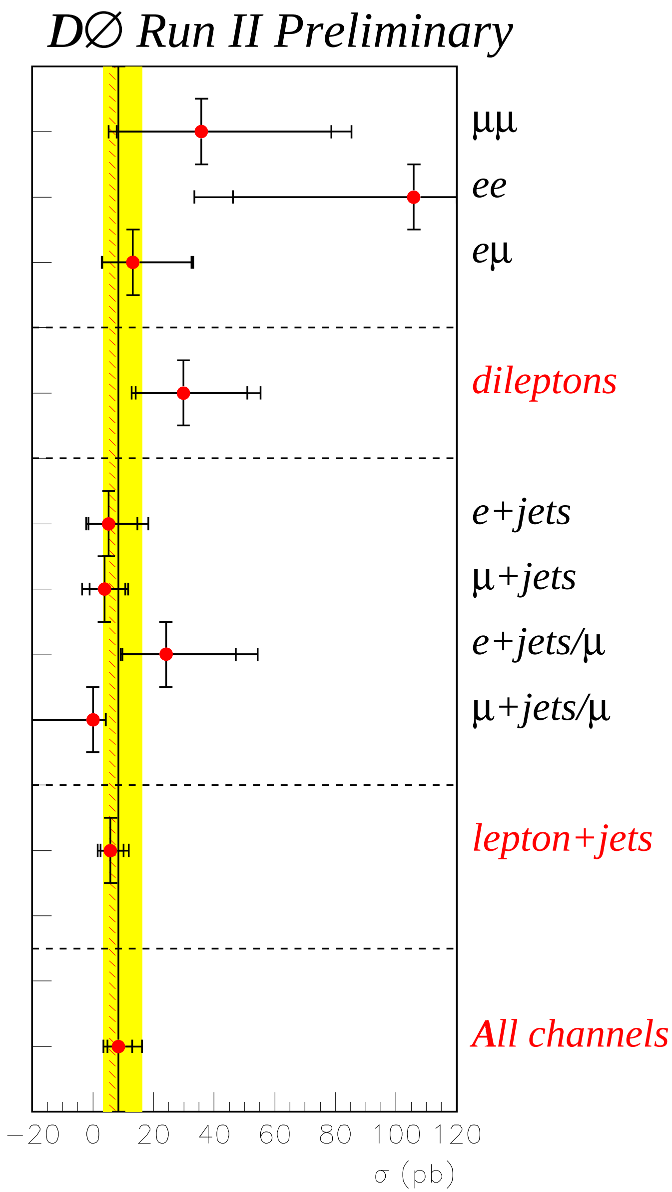


Next step is to understand b-tagging of jets

Di-jet mass (in W/Z+jets sample) - contd.

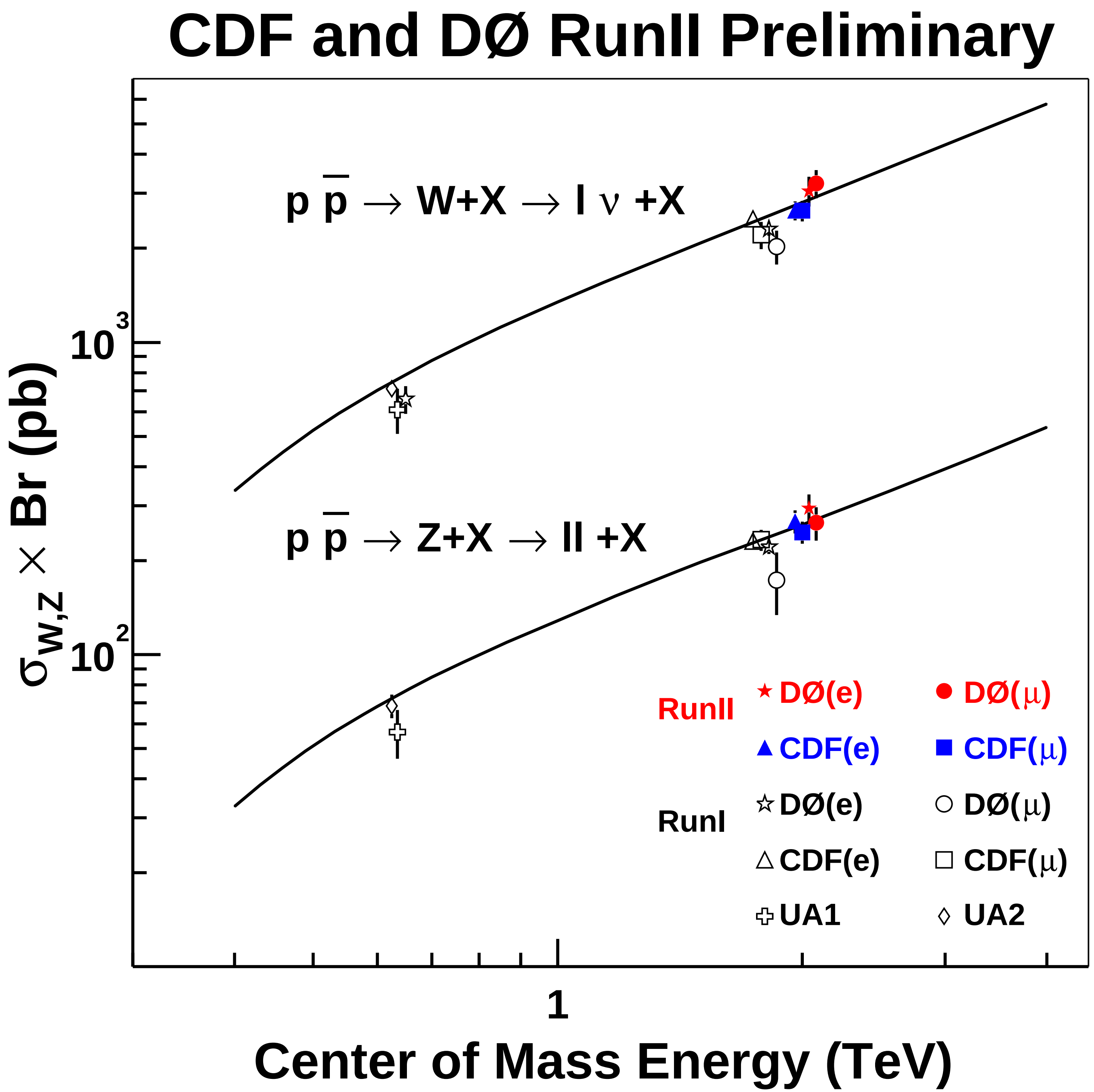
MC expectation for a 115 GeV Higgs





$$\sigma_{t\bar{t}} = [8.5\ ^{+4.5}_{-3.6}(\mathrm{stat})\ ^{+6.3}_{-3.5}(\mathrm{syst})\ \pm 0.8(\mathrm{lumi})]\ \mathrm{pb}$$

At $\sqrt{s} = 1.96$ TeV, Predictions between 6.7-7.5 pb


CDF and DØ RunII Preliminary
$p\bar{p} \rightarrow W+X \rightarrow l\nu + X$
$p\bar{p} \rightarrow Z+X \rightarrow ll + X$
$\sigma_{W,Z} \times Br$ (pb)
10^3
10^2
1
Center of Mass Energy (TeV)
RunII
DØ(e)
DØ(μ)
CDF(e)
CDF(μ)
RunI
DØ(e)
DØ(μ)
CDF(e)
CDF(μ)
UA1
UA2

RunIIb Upgrade

- Collect > 6 fb^{-1} for Higgs/SUSY/New Phenomena Searches
- Expected to start in Oct. 2006
- Silicon
  - Six layer device - all single sided sensors
  - Ready for installation May '06, ready-for-beam Oct '06
  - Replace current Silicon with a more rad-hard version
  - Current detector designed for 2 fb^{-1} -
    Most radiation hard technology available at that time
- Trigger Upgrade
  - In Run IIb, instantaneous $\mathcal{L} = 2 - 4 \times 10^{32}\mathrm{cm}^{-2}\mathrm{s}^{-1}$
  - Lead to unacceptable increase in rates, especially at Level 1
  - Improving Level 1 rejection in CAL, CTT, CAL-Track match
  - Modest upgrades to,
    Level 2 Silicon Track Trigger - to accommodate new Si detector
    Level 2 β processors - additional processors
- Upgrades to DAQ/Online systems for long-term, high rate running

Conclusions

- Run IIa is underway - lots of exciting physics
- Run IIb upgrade is progressing well