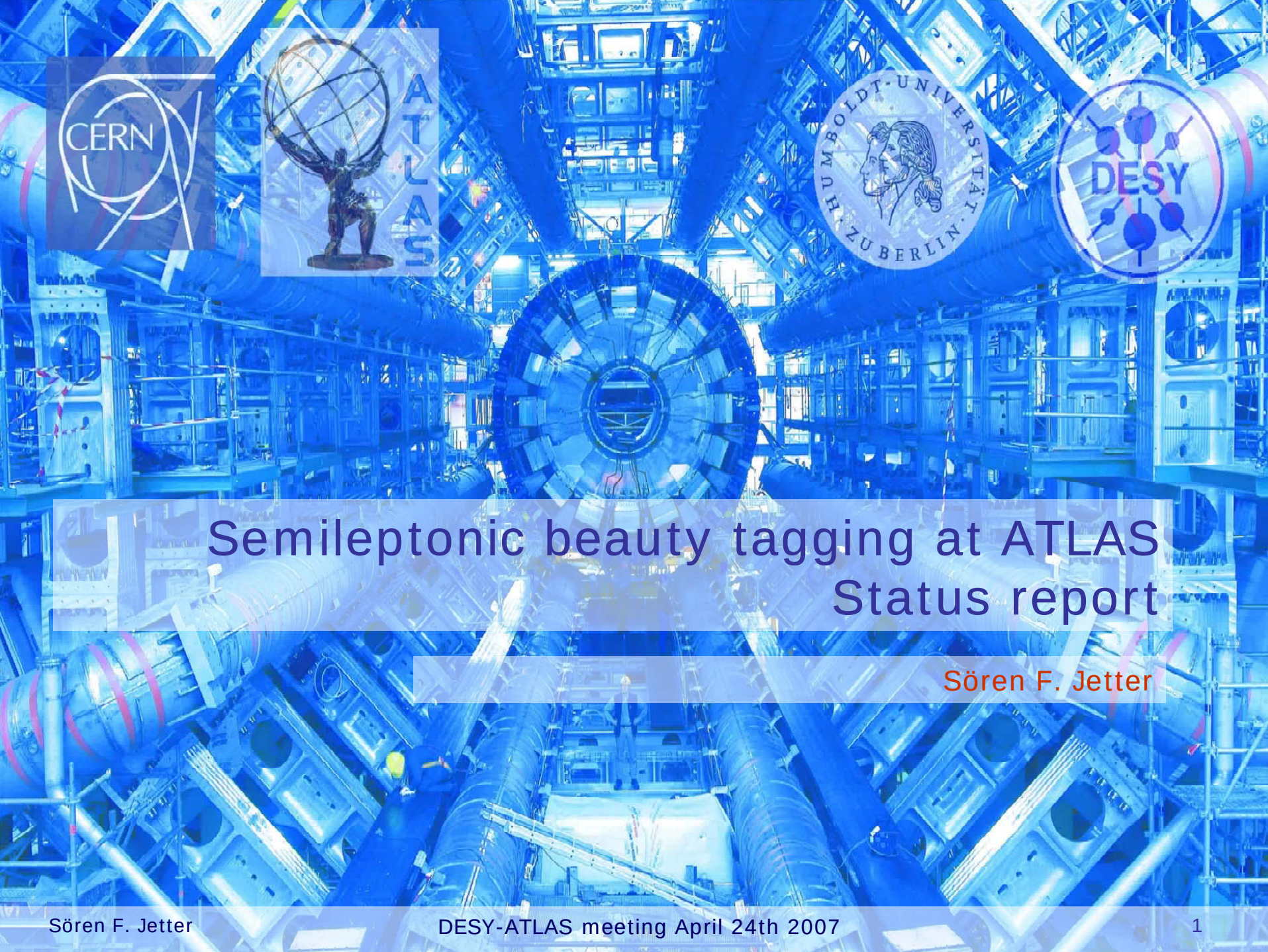


Semileptonic beauty tagging at ATLAS
Status report

Sören F. Jetter

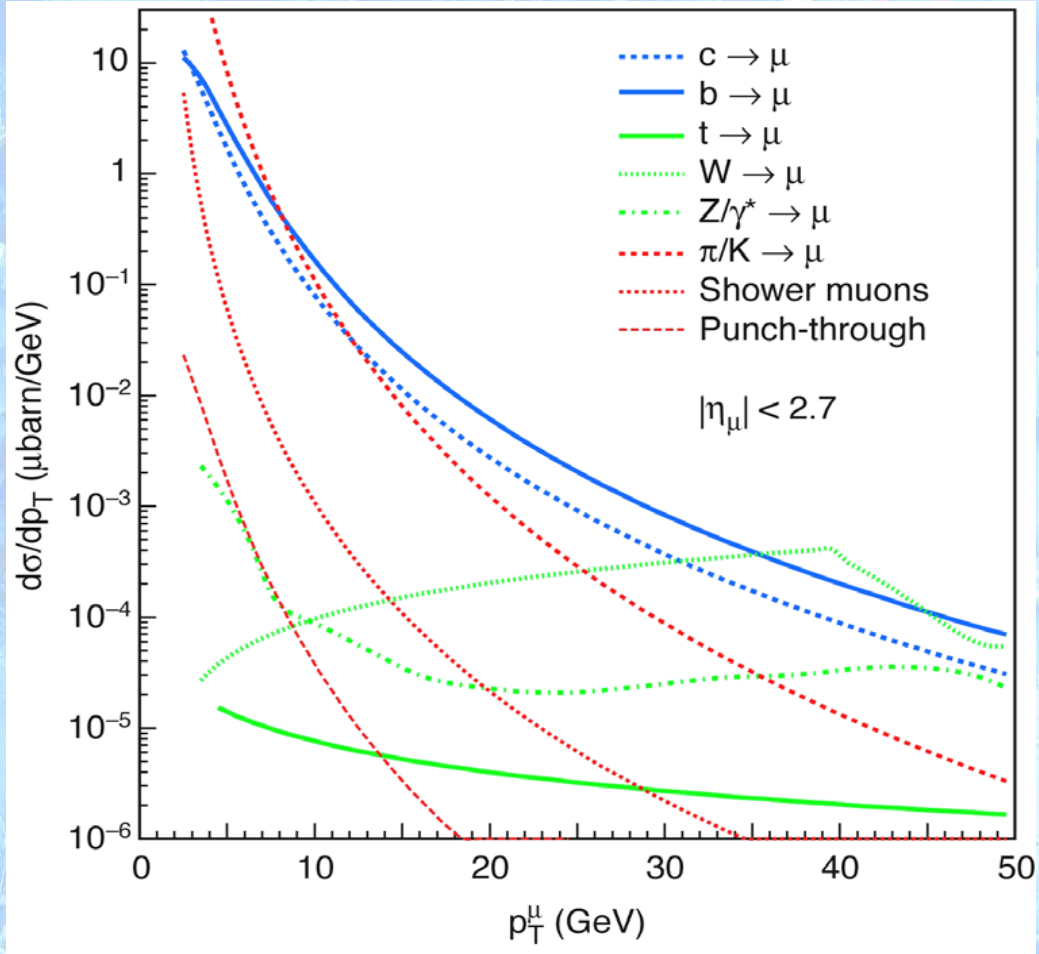
Studied B decay channel

- Semileptonic channel: $pp \rightarrow b\bar{b}\,X \rightarrow b\,\mu\nu\,XY$
  - Relatively large branching ratio
  - Background elimination not feasible, signal enhancement possible only
  - Expected trigger rate O(kHz) @ 10^{33} $cm^{-1}s^{-1}$
- Total b cross section ~500 µb
- LVL1 µ(6) cut

  ⟶ Semileptonic µ(6) channel ~4 µb

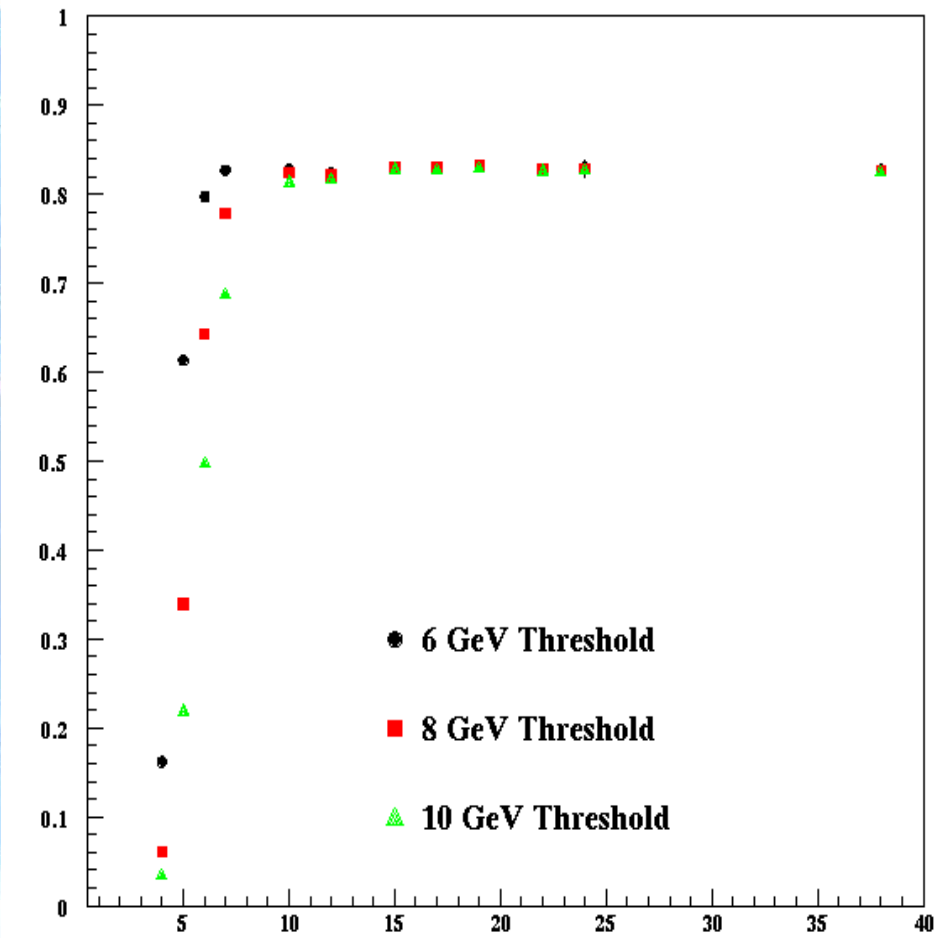
Inclusive muon cross section

- Prediction by F. Conventi, University of Rome
- For p_T>8 GeV cross sections dominated by semileptonic decays of b and c hadrons
- Fake muon cross section negligible at trigger level



LVL1 muon trigger efficiency

- Simulation by muon trigger group
- Plateau efficiency ~85%
- Similar results for high p_T thresholds



Expected LVL1 trigger rates

Lumi=$10^{34}s^{-1}cm^{-1}$

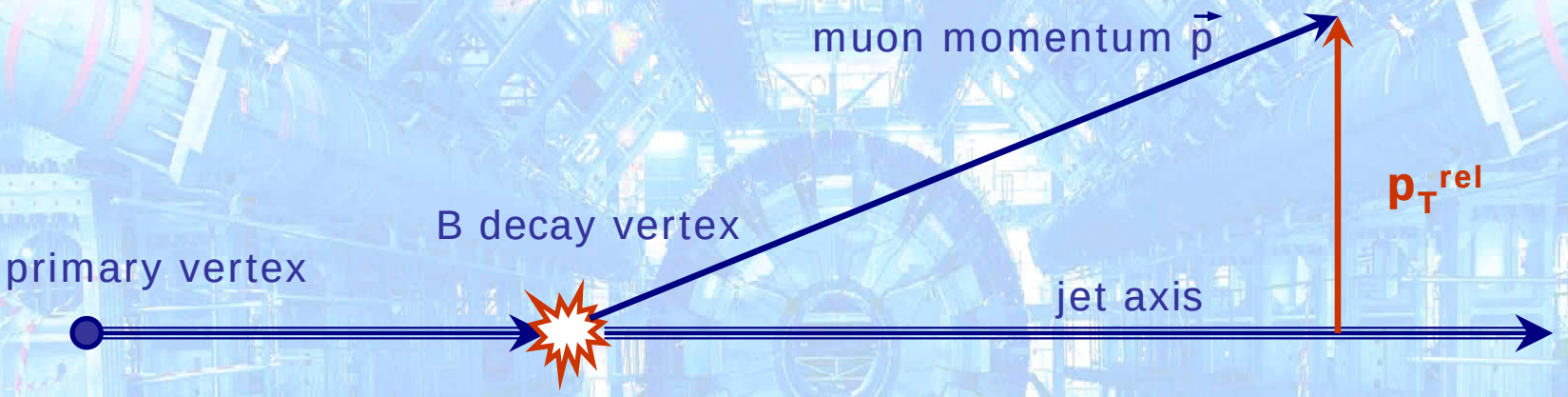
Muon sources	6 GeV threshold		11 GeV threshold	20 GeV threshold	
	μ trigger group Lumi=10^{33}	Conventi	μ trigger group	μ trigger group	Conventi
π/K	10470 Hz	7100 Hz	7420 Hz	3540 Hz	680 Hz
b	1650 Hz	1400 Hz	2330 Hz	760 Hz	500 Hz
c	970 Hz	800 Hz	1100 Hz	340 Hz	210 Hz
W	3 Hz	3 Hz	28 Hz	26 Hz	26 Hz
t	~0	~0	~0	~0	~0
Sum	13 kHz	9.3 kHz	12 kHz	4.7 kHz	1.4 kHz

Generated Monte Carlo sample

- All 5 flavours, $\sqrt{s}$ = 14 TeV
- Cuts at generator level make for strong event preselection
  - Require at least one muon with $\mathbf{p_T > 6\ GeV}$,
  - Light flavours strongly suppressed by muon p_T cut
  - Cuts to be replaced by LVL1 trigger simulation
- Flavour combination according to cross section calculated by Pythia
  - 12000 b-events: **5.8 µb**
  - 13000 c-quarks: **5.3 µb**
  - 10000 light flavour events: each ≈ **2 µb**
- High p_T muons in the sample
  - **b: 11,000**
  - **c: 13,000**
  - **π/K: 28,000**
- Light flavour background seems too small

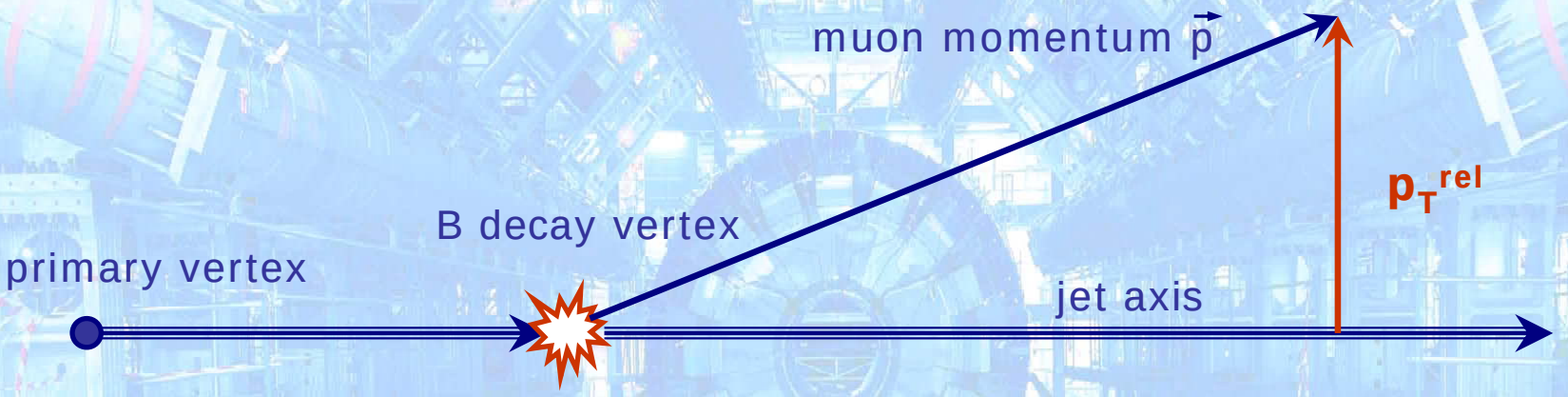
  ⟶ Studies under way

Muon relative transverse momentum p_T^{rel}



- Maximum p_T^{rel} ~ Δm of initial and final states of semileptonic B decay
- Large B-mass → p_T^{rel} suitable for b-flavour selection cuts
- Calculation possible with recourse to muon and calo data only, inner detector data not necessarily needed

Muon relative transverse momentum p_T^{rel}

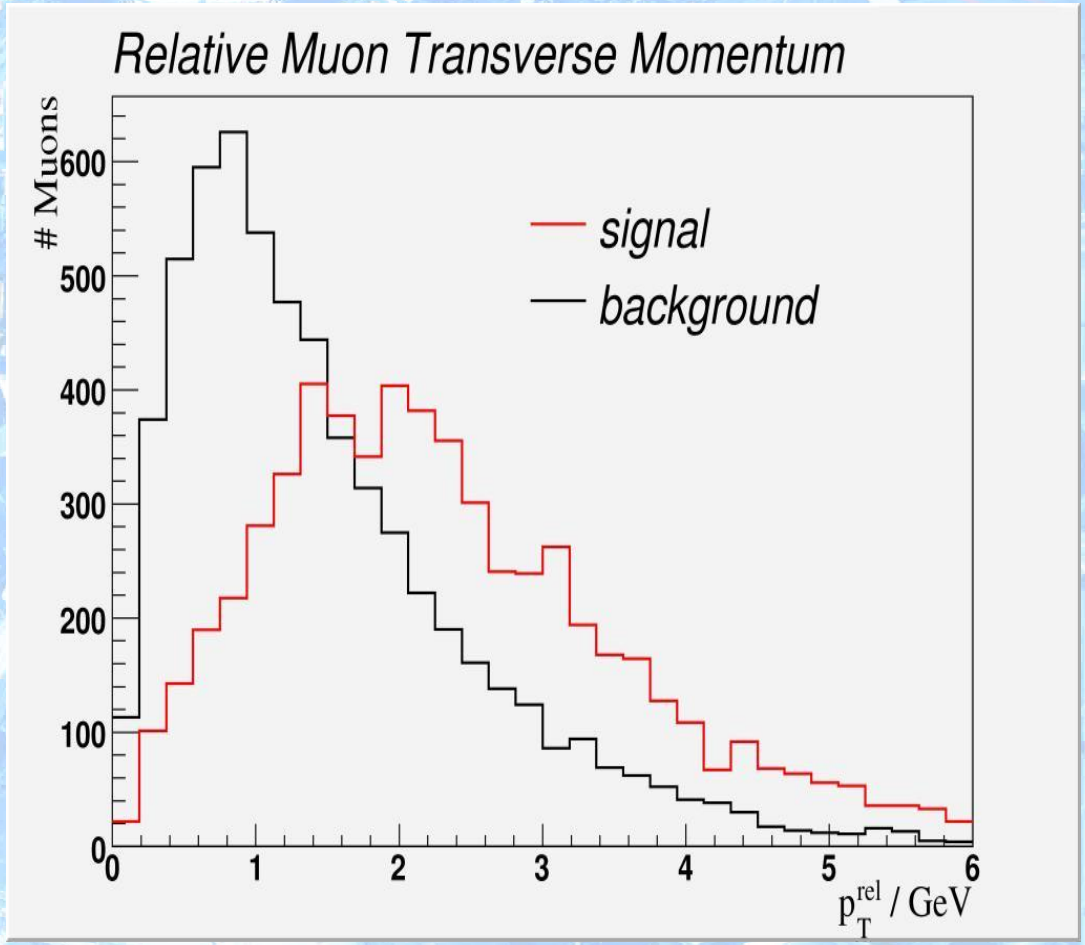


- Muon identification and reconstruction by *MuidComb* reconstruction class using data from both inner detector and calo/muon system
- Assignment muon ↔ associated jet

  ⟶ Require exactly one jet within a cone $\Delta^2\varphi + \Delta^2\acute{\eta} < 0{,}8^2$ around the muon
- Efficiency for muon finding and jet matching 55%
- Purity 45%

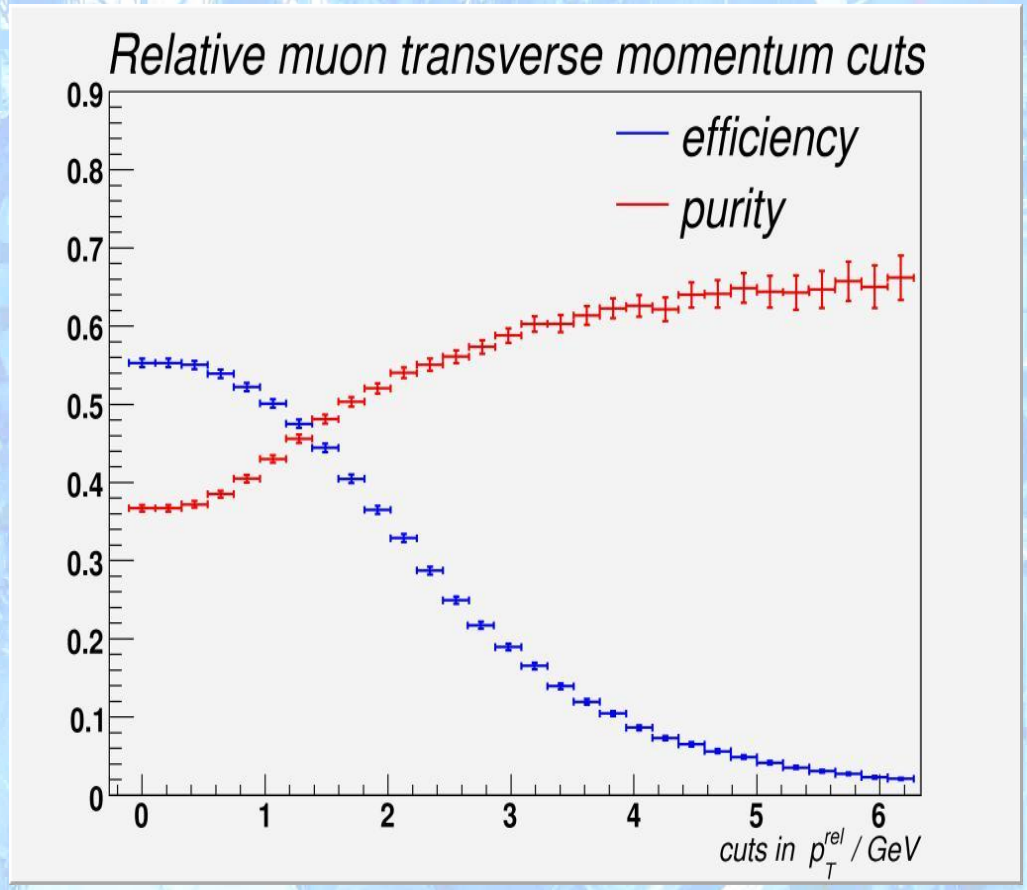
Muon relative transverse momentum p_T^{rel}

- Maxima of the distributions clearly separated
- Allows for soft cuts

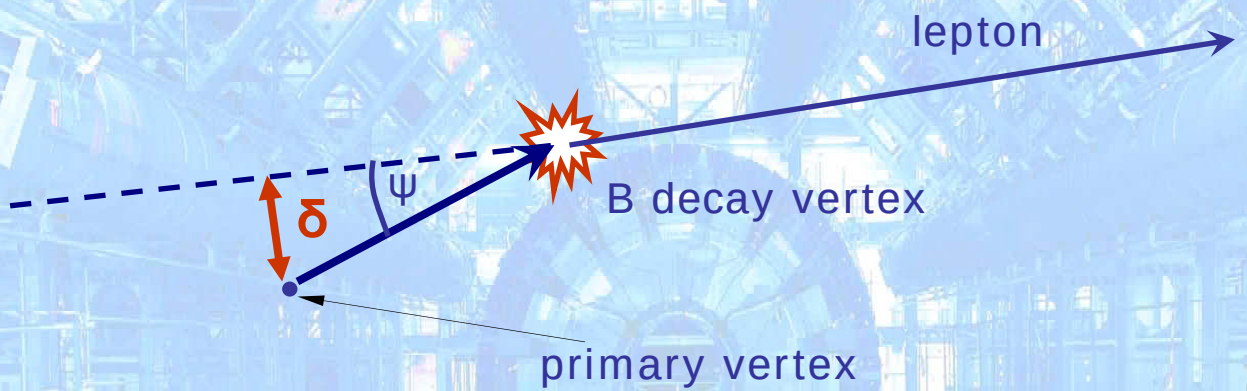


Cuts in muon rel. transv. momentum p_T^{rel}

- Matching of generated and reconstructed samples
  - → *Efficiency*
  - → *Purity*

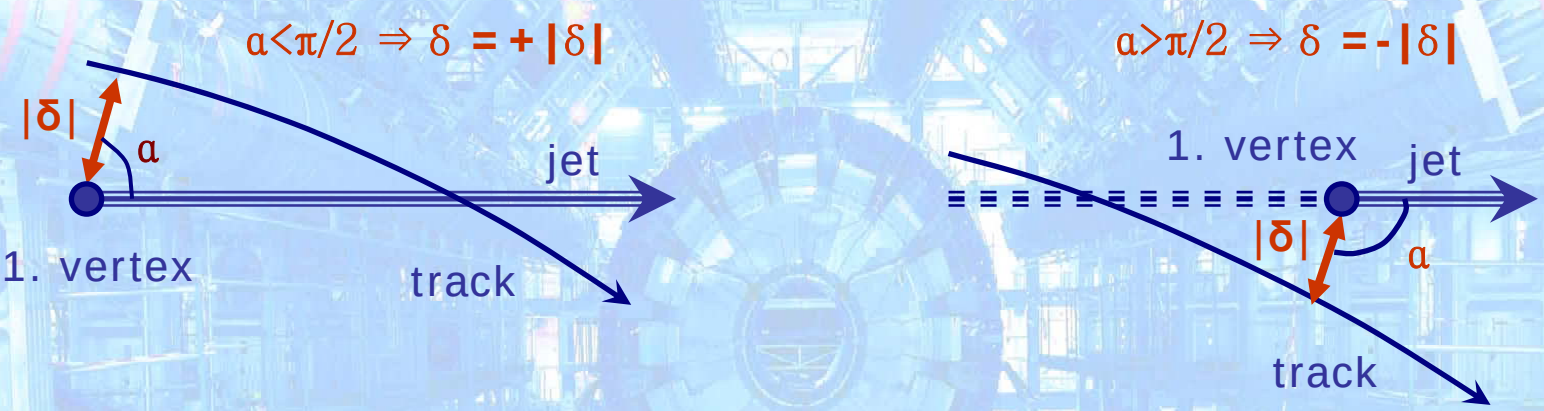


Impact parameter δ



- Shortest transverse distance between lepton trajectory and primary vertex
- In highly relativistic limit (>10 GeV): δ ~ lifetime τ
- Long B-lifetime ⟶ δ suitable for B-selection
- Dominant background: leptons from charmed hadrons
  - $\tau_D = 1.0$ ps $\Rightarrow \langle\delta_D\rangle \approx 140\mu$m
  - $\tau_B = 1.4$ ps $\Rightarrow \langle\delta_B\rangle \approx 200\mu$m

Signing of the impact parameter

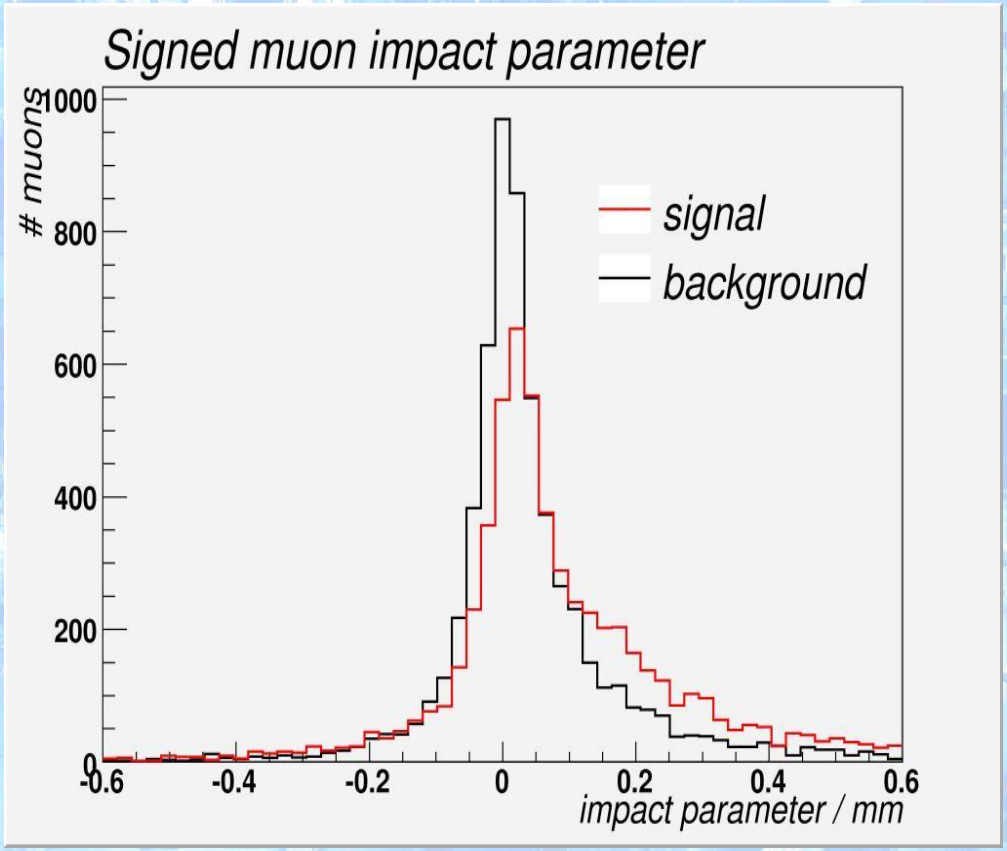


- Positive sign corresponds to B → muon candidates
- Negative sign due to
  - → Wrong assignment jet ↔ muon
  - → Misreconstructed tracks
  - → Detector resolution
  - → Fragmentation effects
- Sign of impact = sign $(p_{jet} x p_{\mu})(p_{\mu} x p_{DCA})$

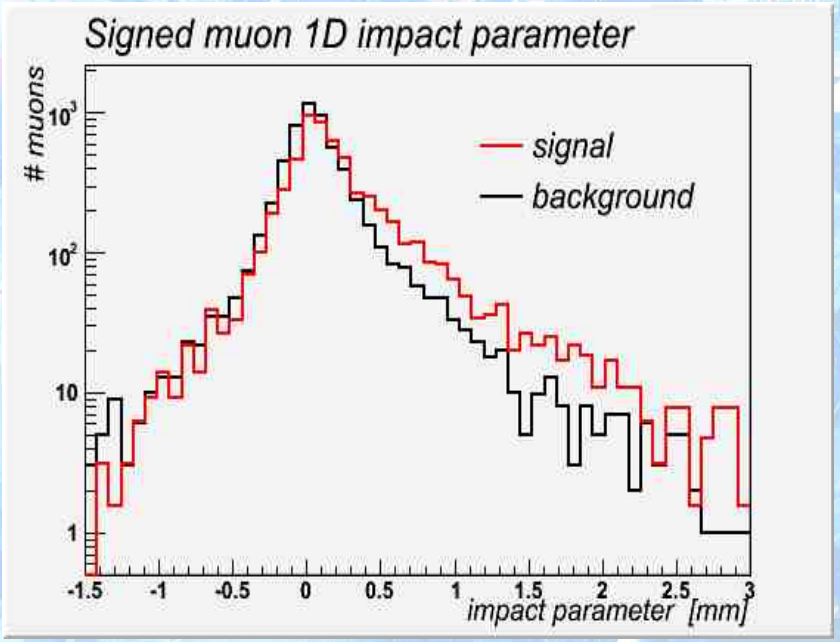
Signing of the impact parameter

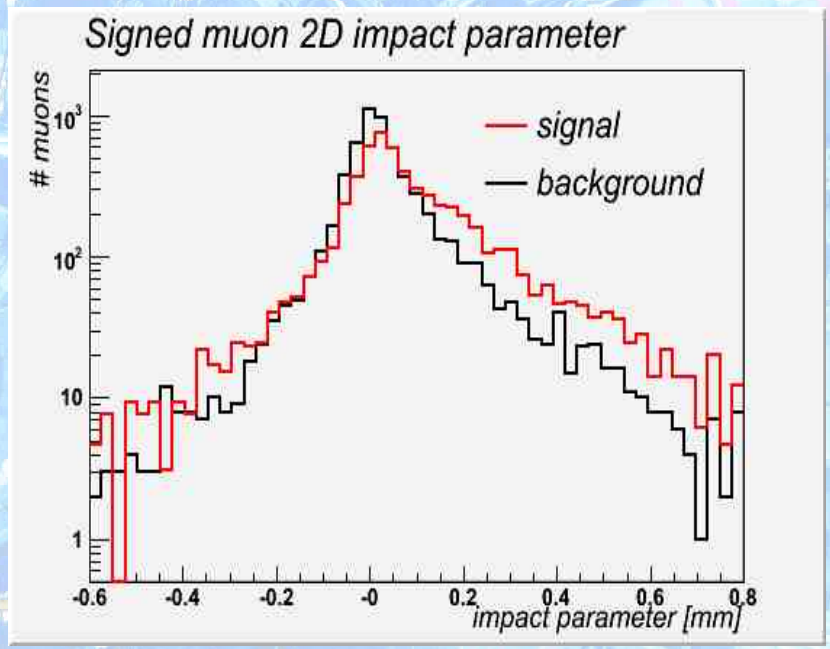
- Gaussian peak around the origin due to finite detector resolution
- For negative values signal and background distribution identical
- Exponential descent for large impact parameters

  → Signal accumulation



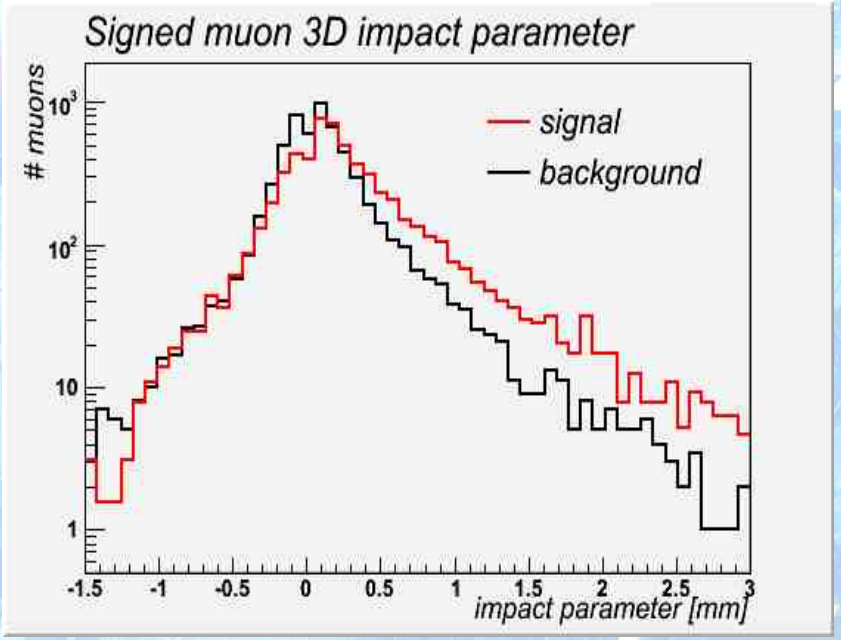
Longitudinal impact parameter

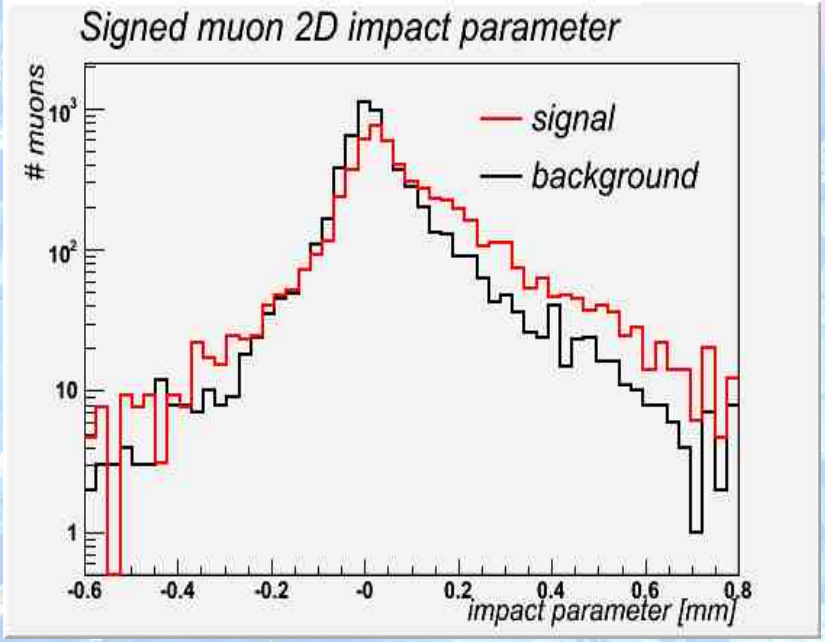




> Longitudinal impact parameter: z-component of point of closest approach

Longitudinal impact parameter



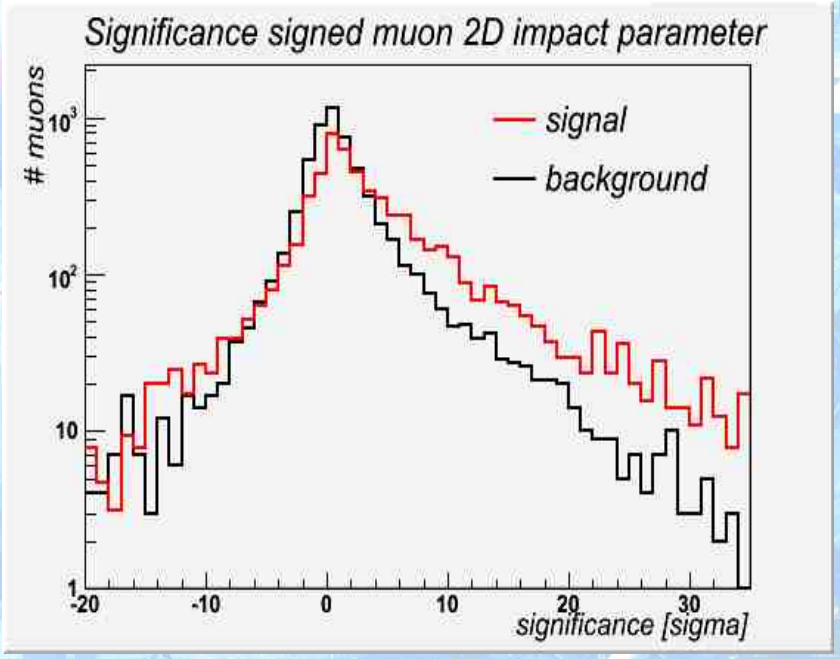


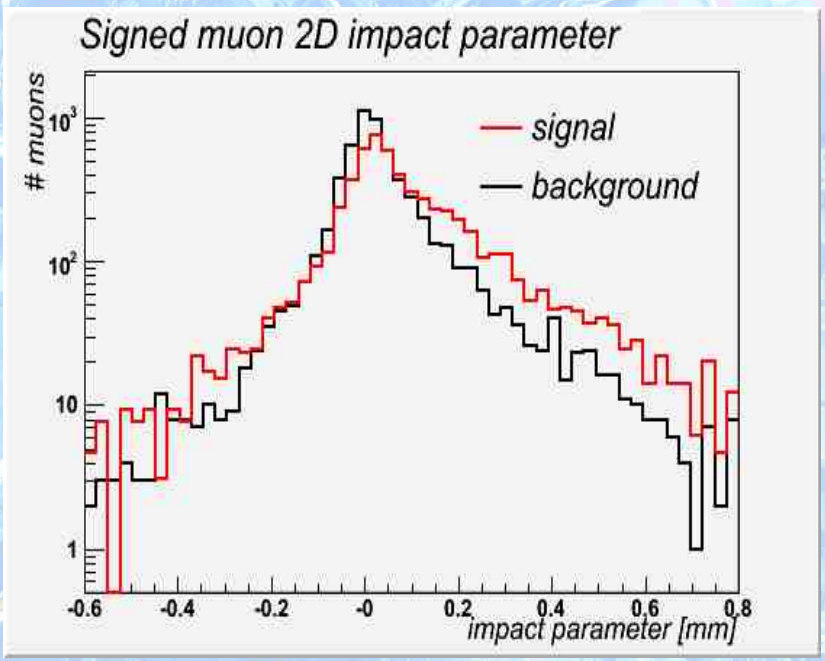
- Longitudinal impact parameter: z-component of point of closest approach
- 3D: $\sqrt{(d0^2+z0^2)}$

  ⟶Signal accumulation slightly improved compared to 2D impact parameter

  ⟶Longitudinal impact parameter not expected to be reliable due to longitudinal vertex smearing

Significance of the impact parameter



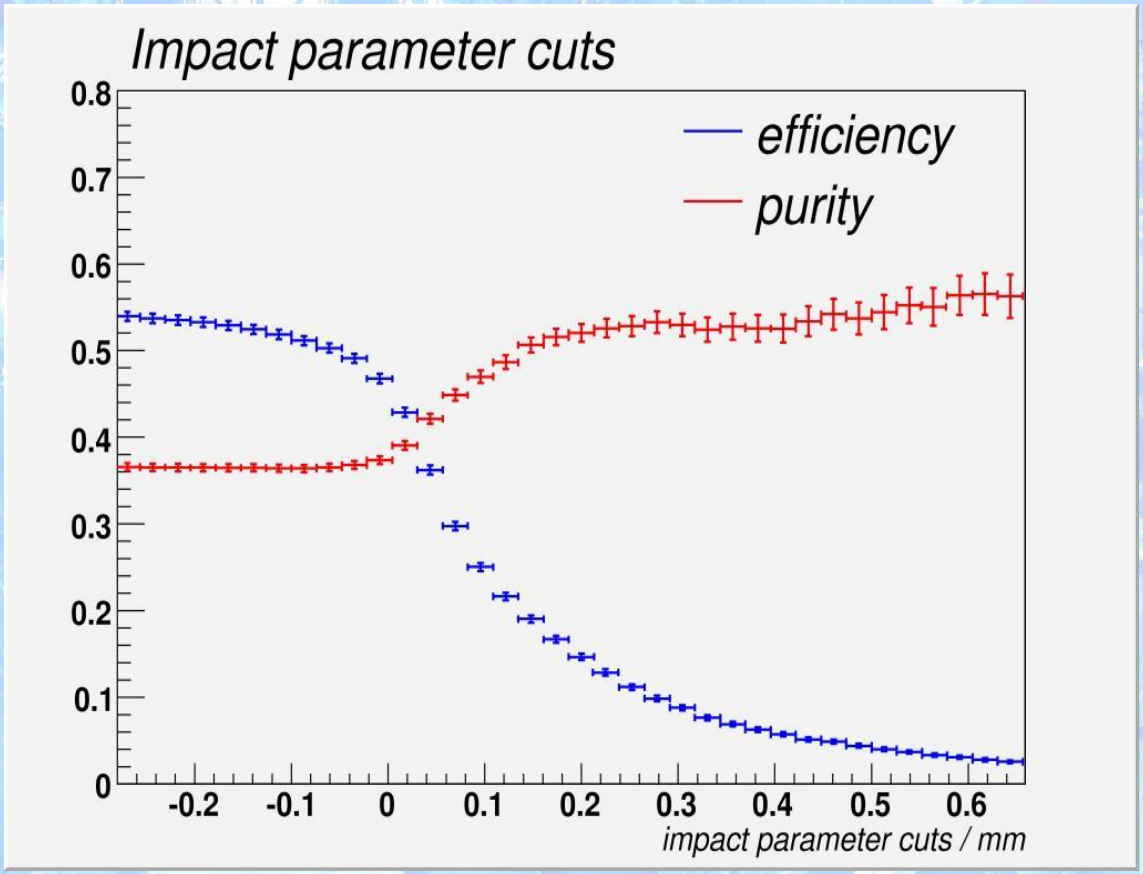


- Signal accumulation again just slightly improved
- Feasibility of significance calculation at trigger level questionable

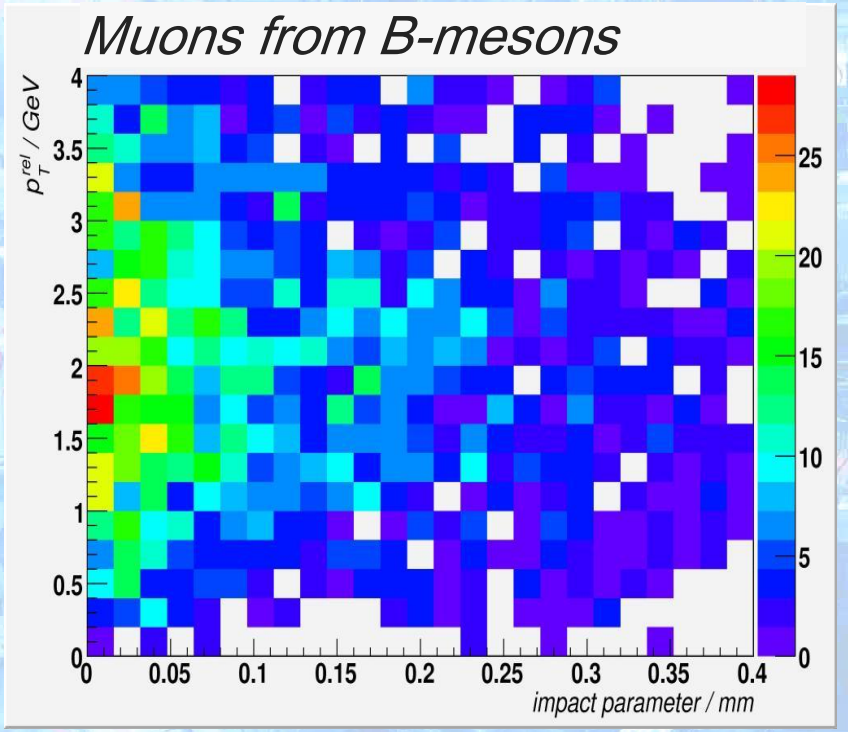
  → Choose transverse impact parameter to select muons from B

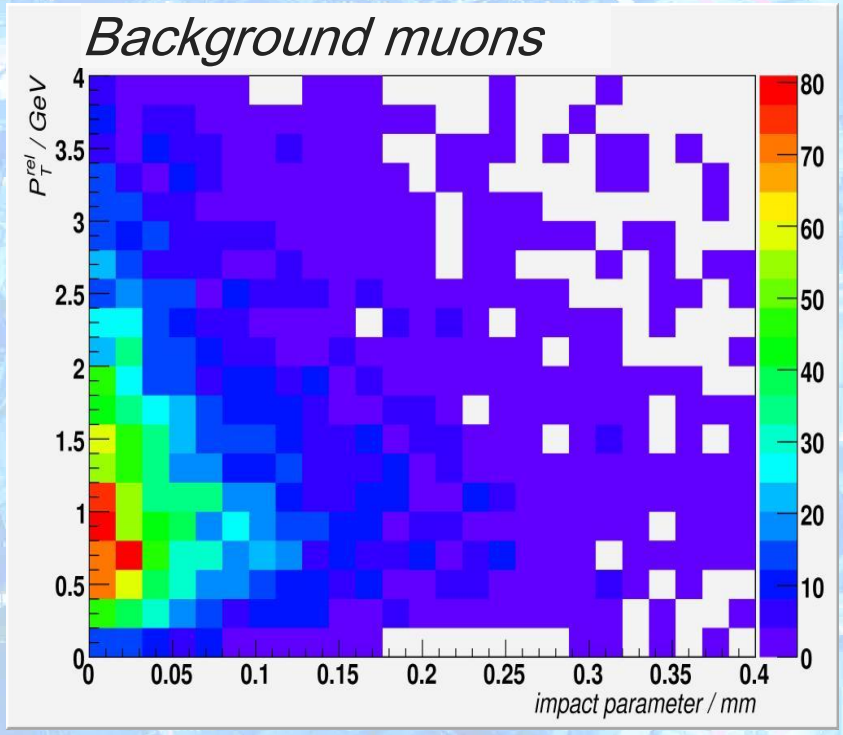
Impact parameter cuts

- No soft cuts possible
- Hard cuts possible at heavy signal loss
- Plateau for $\delta > 200\ \mu m$



Combined cuts in both variables

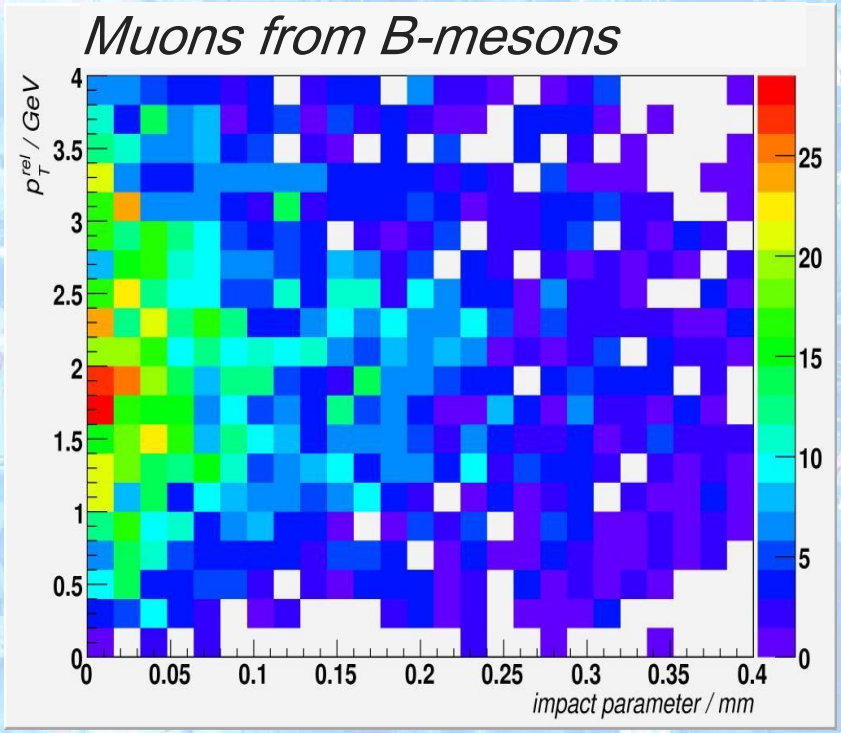


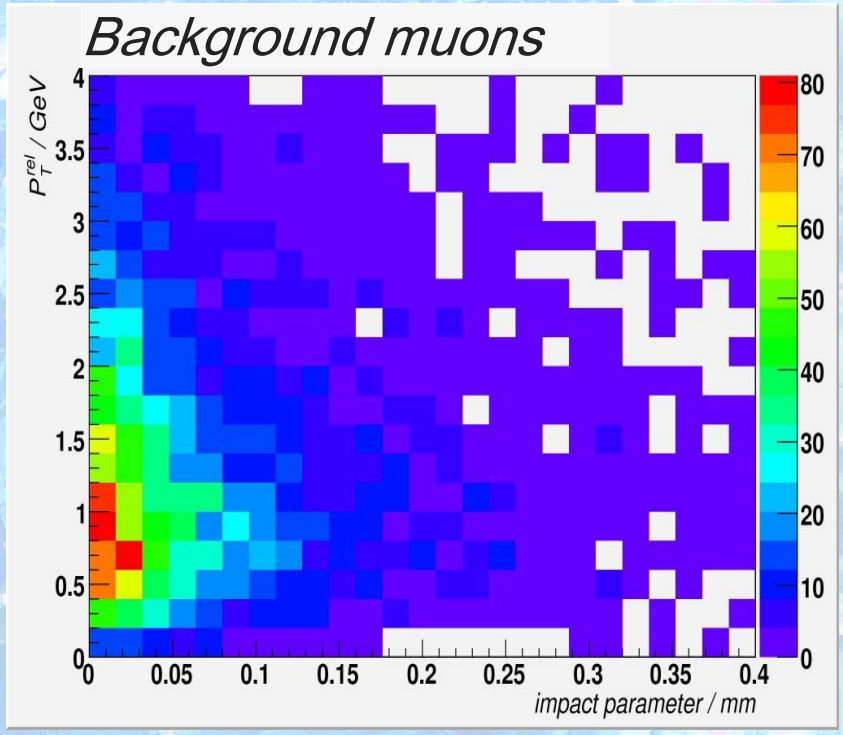


- Relative transverse momentum and impact parameter only weakly correlated

  → Combined cuts allow for higher purity at the same efficiency

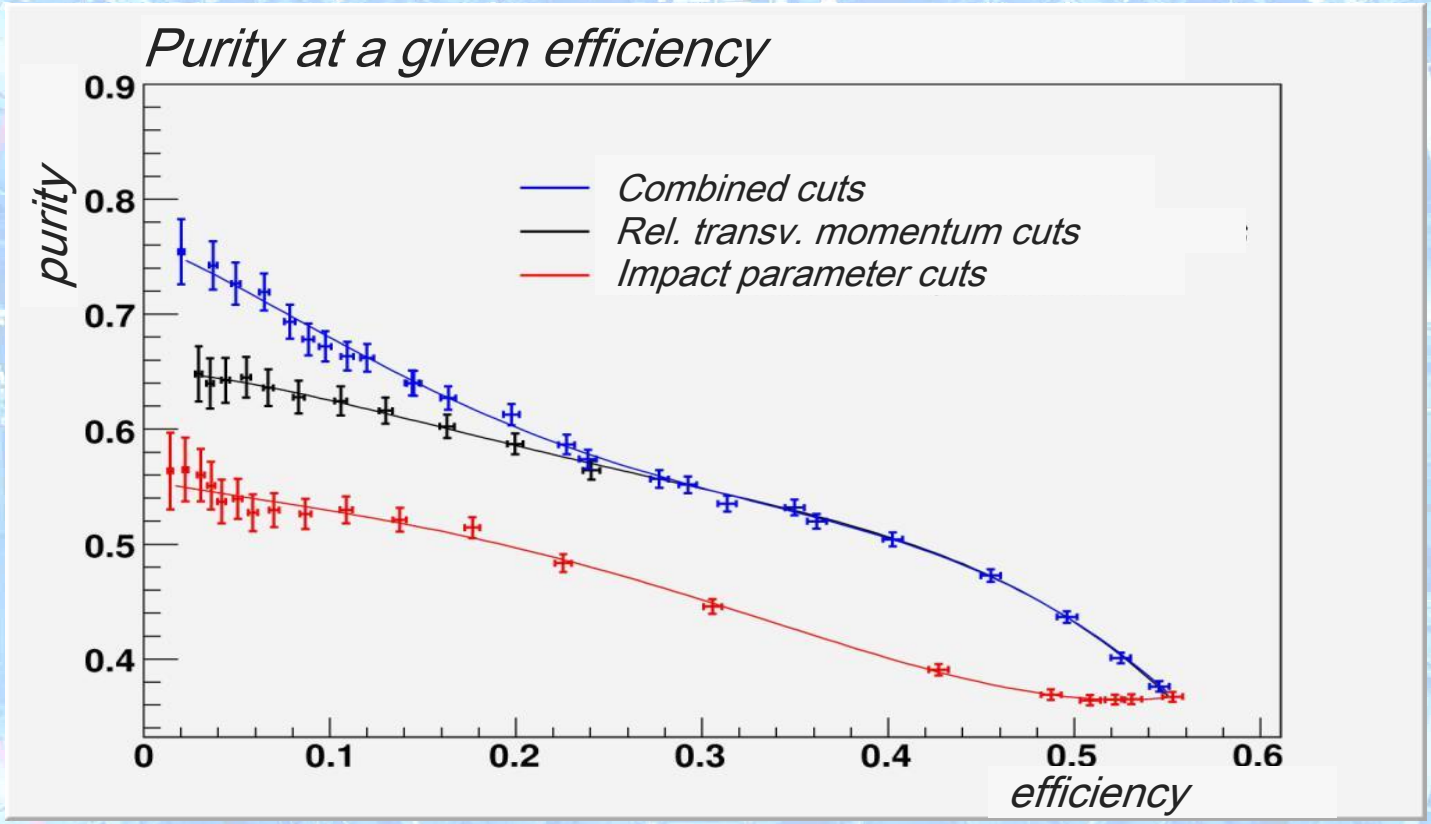
Combined cuts in both variables





- High efficiency → soft cuts in p_T^{rel} only
  - ⟶Due to extremely high trigger rates high efficiency not needed
- High purity → hard combined cuts in both variables
- Optimize box cuts for purity at given efficiency

Combined cuts in both variables



- Efficiency in respect to the B → μ(6)X channel with 1% branching ratio of the total b cross section
- Total b efficiency ~ 0.002
- Estimated trigger rate ~ 1 kHz at LVL2 without downscaling

Outlook

- So far only offline analysis
  - ⟶Next step developement of LVL2 trigger simulation featuring the selection cuts studied in offline analysis
  - ⟶Simulated LVL1 μ trigger replacing cuts at generator level
  - ⟶Use LVL1 μ trigger > 6 GeV to improve purity and get trigger rate down
- Background generation
  - Charm flavour background OK
  - Light flavour background questionable, statistics insufficient
  - Jet event sample athena 12.x or 13.x needed
  - Alternatively decays in flight sample could be used
- Box cuts implemented, more complex cuts under development
- Assignment jet ↔ muon still to be optimized