Particle ID studies on Bs->DsK for IDEA detector at FCC

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Introduction

- Bs->Ds K analysis
- Ntuple level
    - Pre-selection: Phi and Ds mass
    - Minimum momentum for all tracks: 0.3 GeV
    - Focus on the the bachelor particle (kaon from Bs)
- Several PID options have been explored (dE/dx, TOF, Combined)
- All of the analysis code (except PID) comes from **Emmanuel Perez** (many thanks !)

PID options

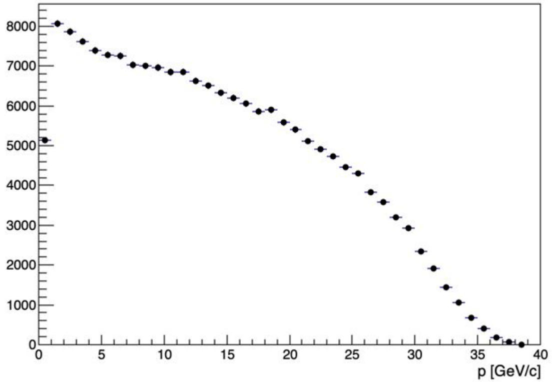
- Pull on pion dndx
- Pull on velocity* (deduced from TOF)
- Likelihood ratio (K/pi) on dndx (a priori identical to pull but one doesn’t need to flip the cut as a function of p)
- Likelihood ratio on velocity
- Combined (dndx+velocity) likelihood ratio

*Velocity is used instead of TOF to make truth information independent on the detector geometry.

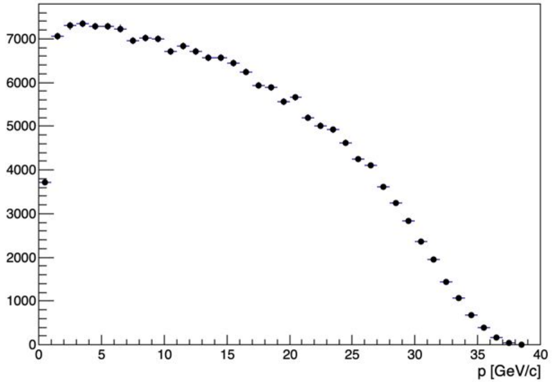
General PID studies

- Using DsK and DsPi samples, selecting the bachelor kaon or pion, one can study the inclusive PID performance
- The velocity deduced from TOF is however dependent on the kinematics since, to obtain a proper pull, one has to subtract the Bs proper time (computed from secondary Bs vertex and Bs momentum). In general it's not straightforward to define a TOF variable independent from the decay kinematics

Pion

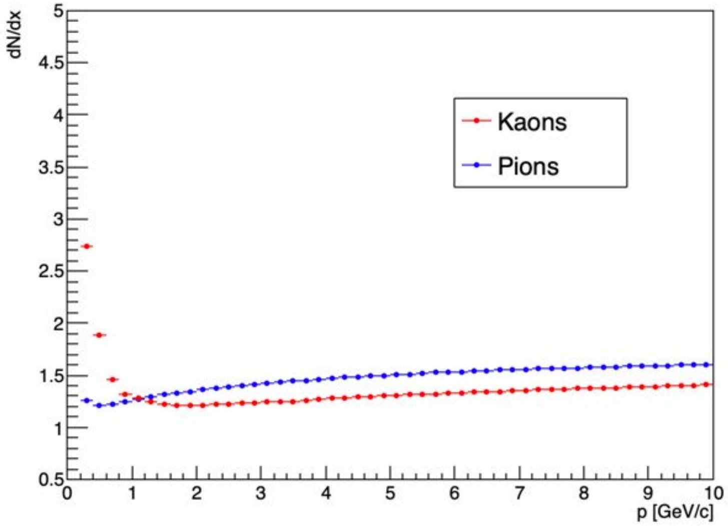


Kaon

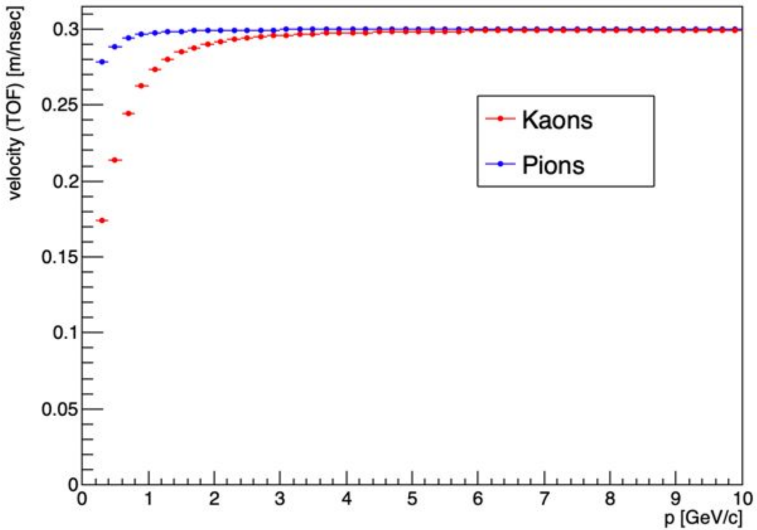


DNdx and velocity

DNdx

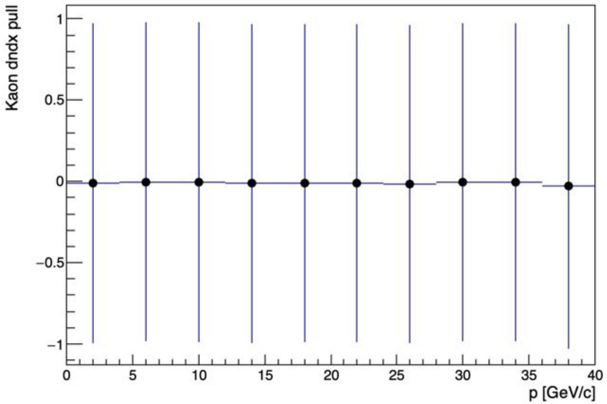


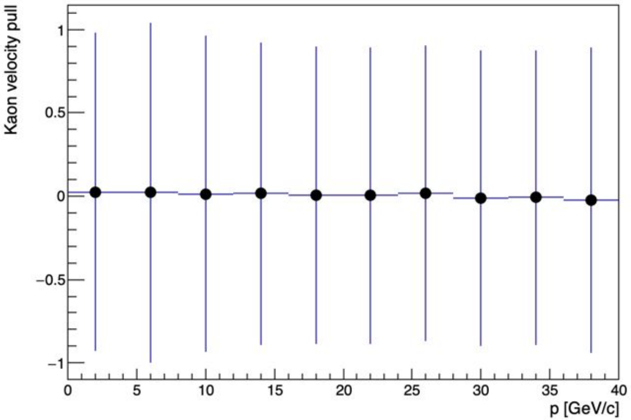
Velocity



Particle ID: resolution checks

- Pull test for dNdx and velocity (from TOF).





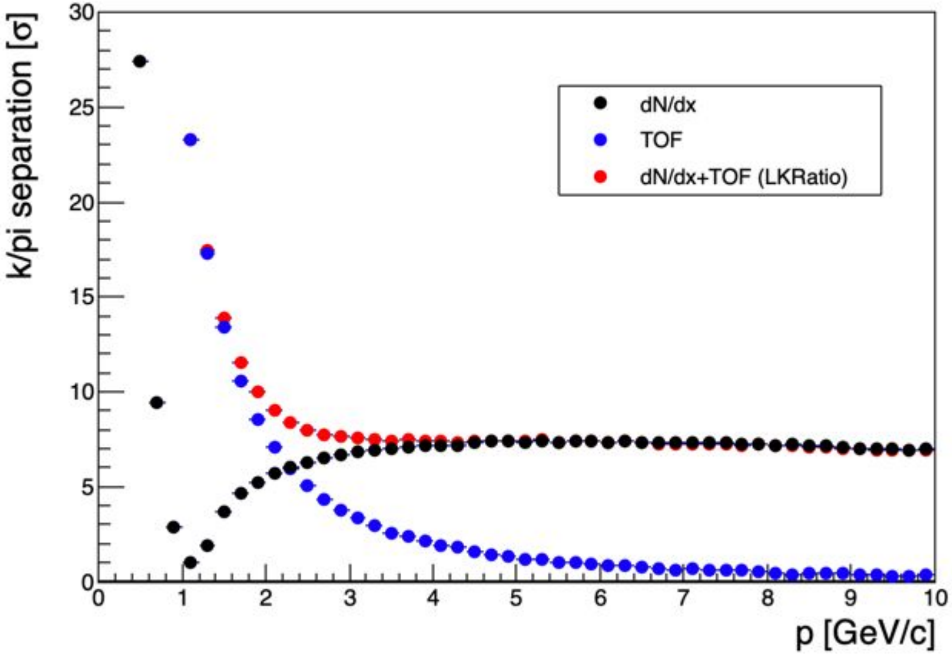
- Reasonably well described (dNdx: poisson uncertainty, velocity constant uncertainty)

K/pi separation

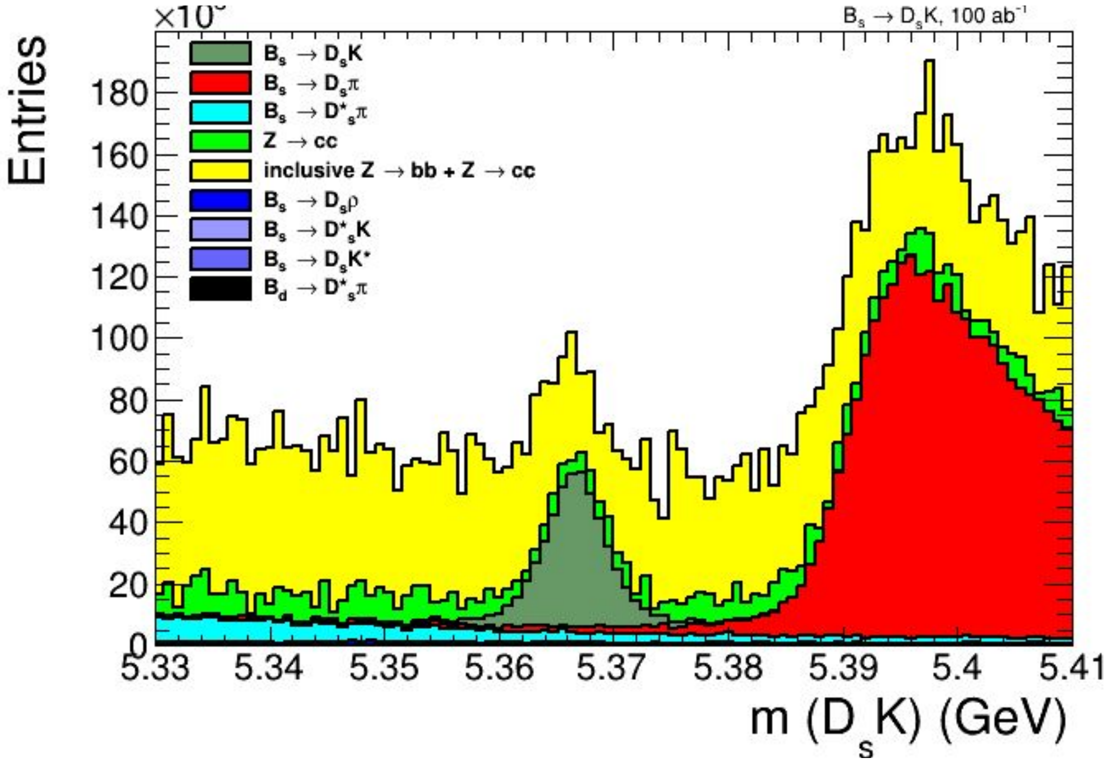
K/pi separation in dNdx and velocity (from TOF) on the bachelor particle in DsK decays

The combined separation deduced from Likelihood ratio using formula:

Separation [σ] = √ -2ln(LKRatio)



Mass spectrum without PID

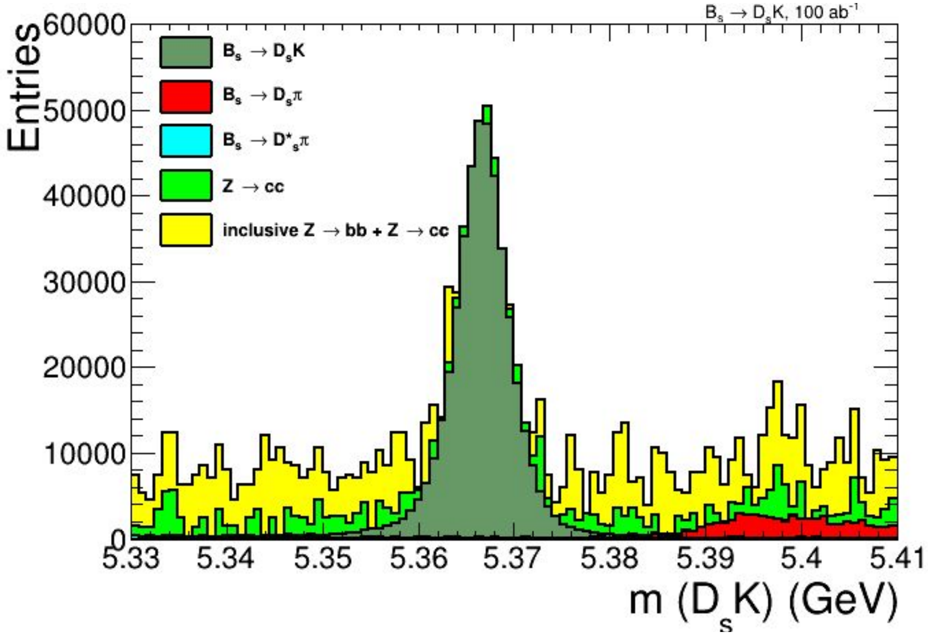


Additional kinematic cuts:

- m(Bs)> 5.33 GeV
- m(Bs) <5.41 GeV
- Vertex χ < 10%
- |cos(θ)_Bs - cos(θ)_bachelor|<0.5

DsK: ~550k events
Dspi: ~2.7M events
Inclusive: ~8M events

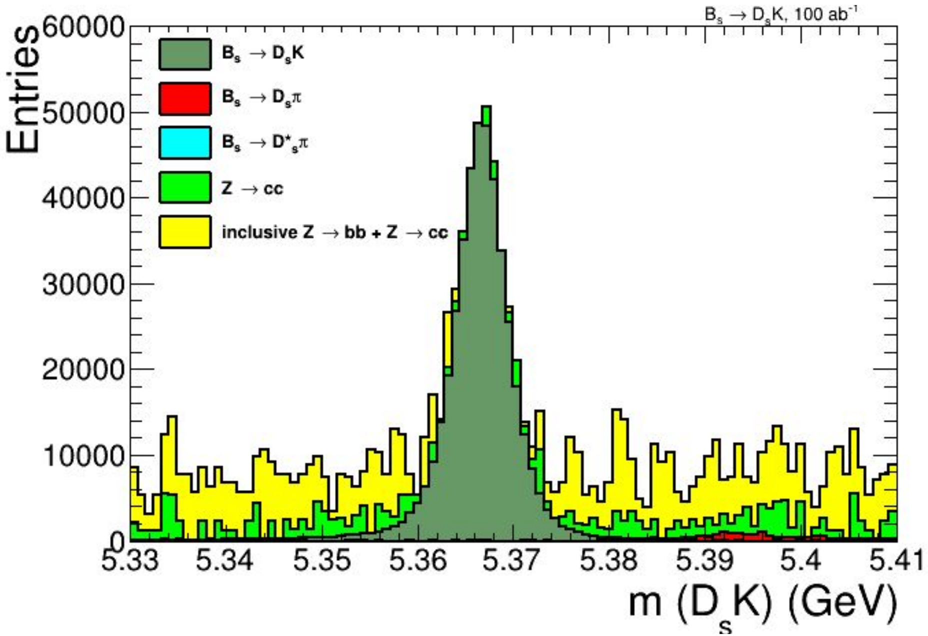
Dndx(pi) pull



Channel	Efficiency or # events
Dsk	96%
Dspi	2%
Z->bb	~900k

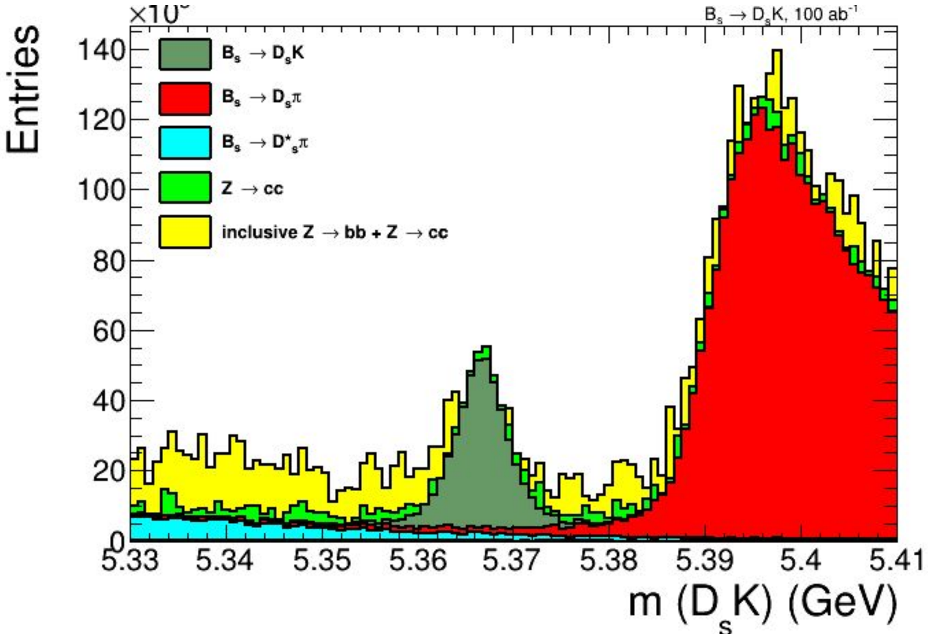
Start with a very simple cut on dNdx: (dNdx - dNdx(pi))/sigma<-2

Likelihood ratio (dNdx)



Channel	Efficiency or # events
Dsk	96%
Dspi	0.5%
Z->bb	~900k

Likelihood ratio (velocity)

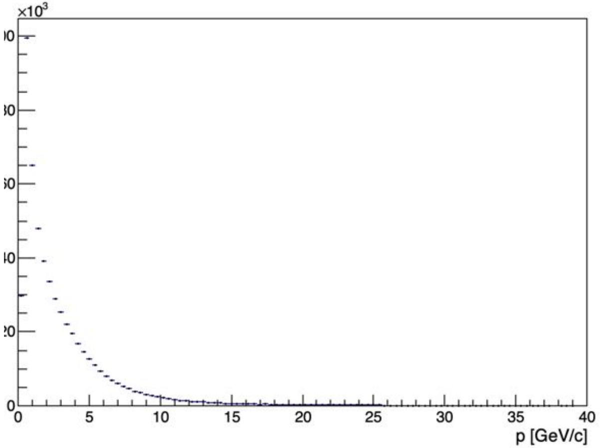


Channel	Efficiency or # events
Dsk	~96%
Dspi	~96%
Z->bb	~4M

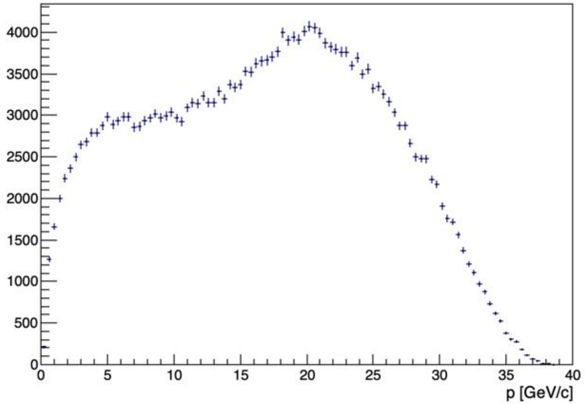
Likelihood ratio (velocity)

Why kaon/pion velocity has low (or no) impact on signal but reduces the inclusive background by a factor 2 ? This depends on the Bachelor momentum spectrum in the two samples.

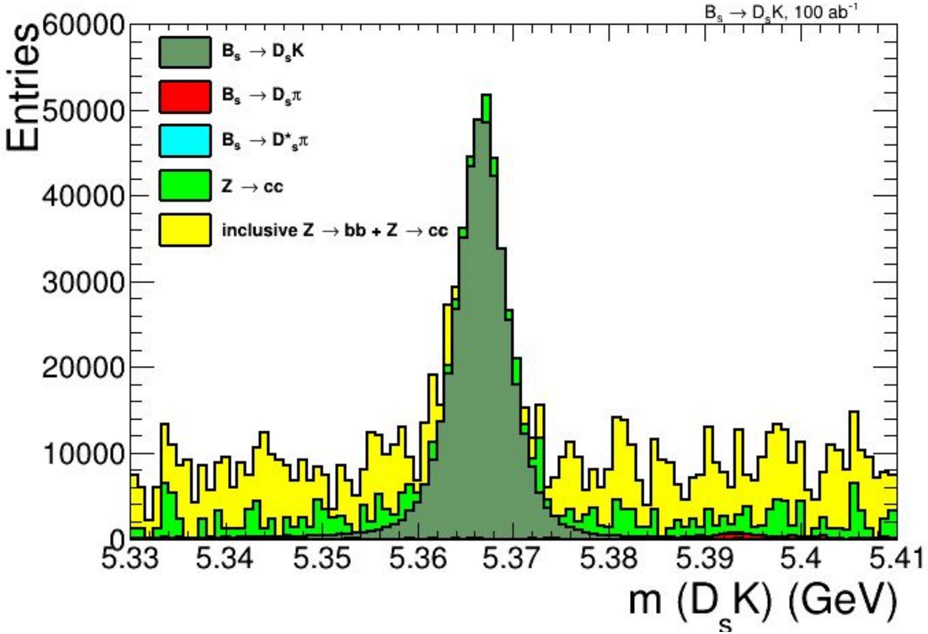
Z->bb sample



DsK+DsPi samples



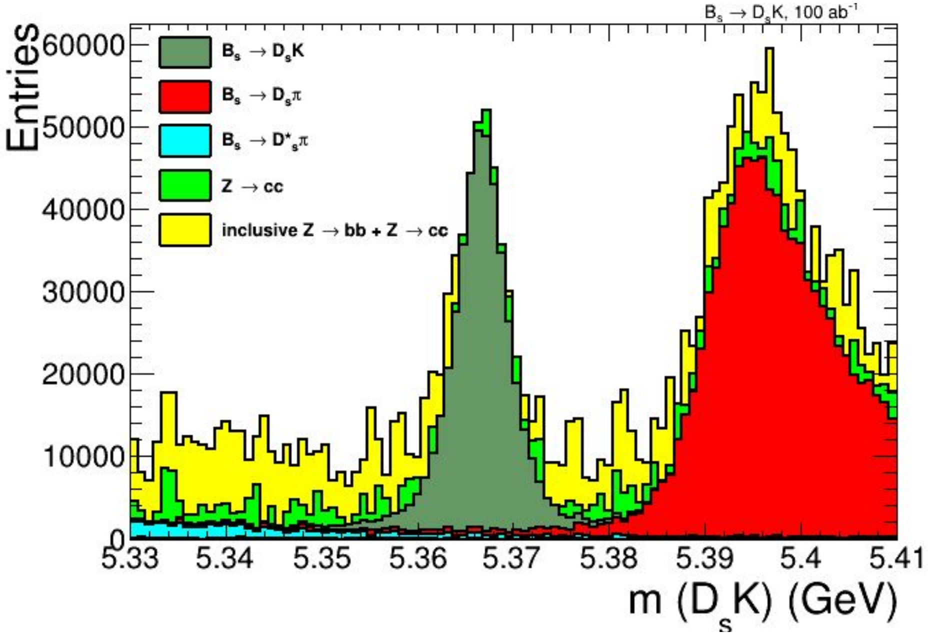
Combined Likelihood



Channel	Efficiency or # events
Dsk	96%
Dspi	0.3%
Z->bb	~900k

Combined ID is only marginally improving dNdx due the bachelor pion kinematics.

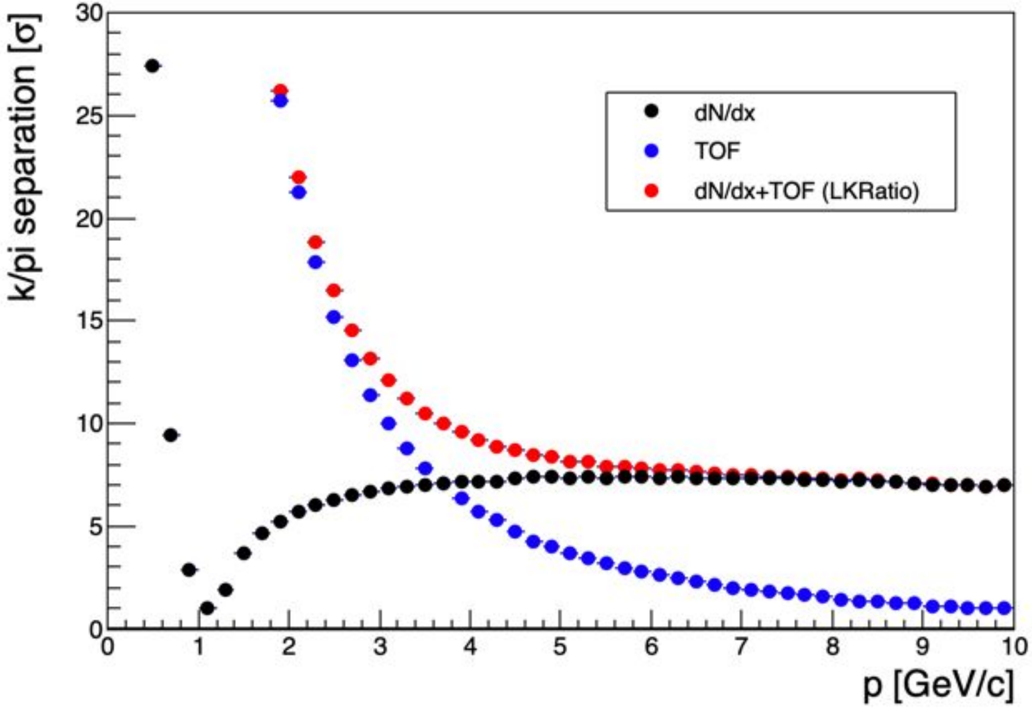
Combined Likelihood (with x2 Dndx resolution degradation)



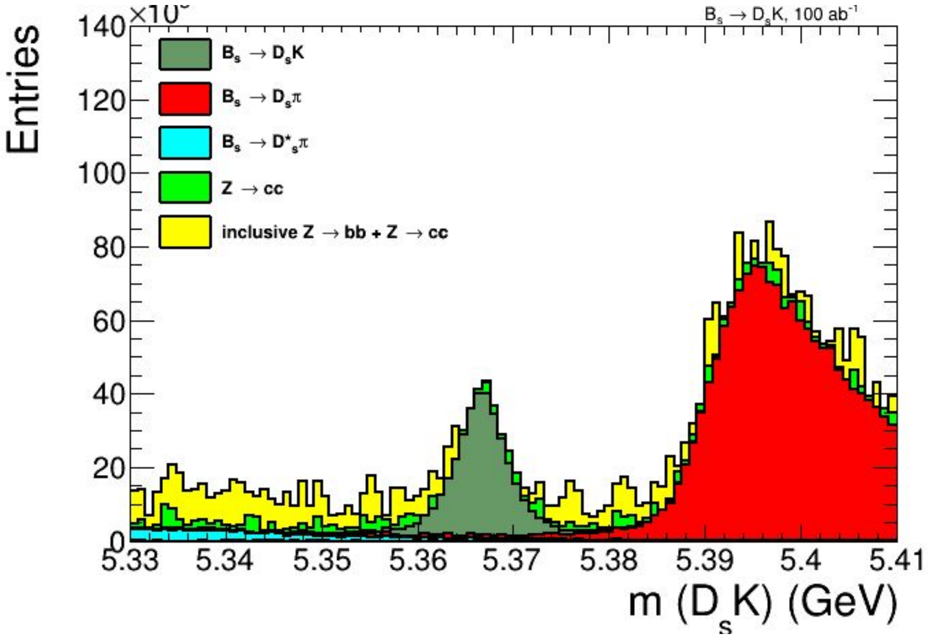
Channel	Efficiency or # events
Dsk	96%
Dspi	33%
Z->bb	~1.9M

Combined ID is only marginally improving dNdx due the bachelor pion kinematics.

TOF resolution at 10 ps



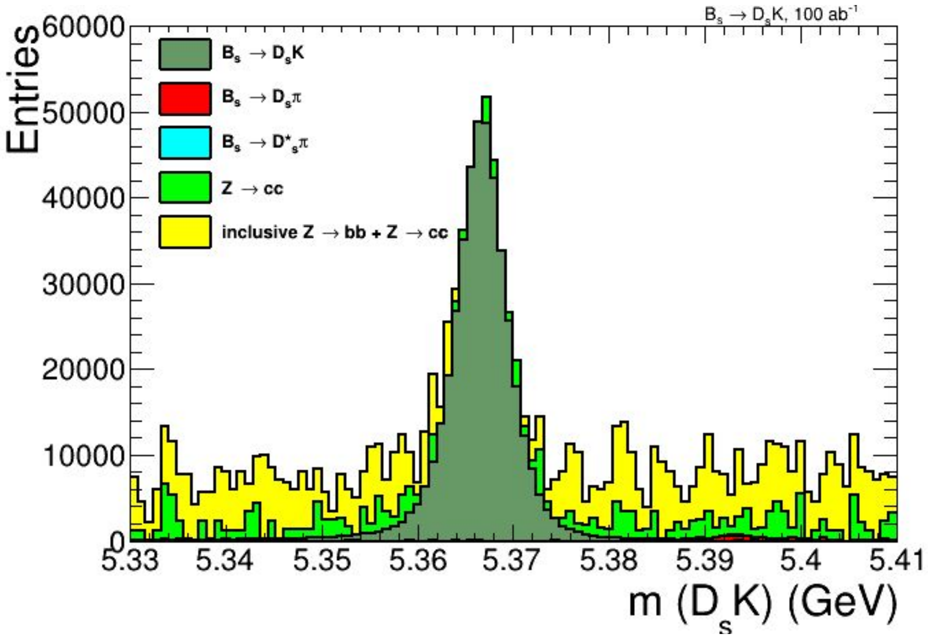
Likelihood ratio (velocity) (TOF resolution 10 ps)



Significant improvement for TOF-PID

Channel	Efficiency or # events
Dsk	~96%
Dspi	~60%
Z->bb	~2.5M

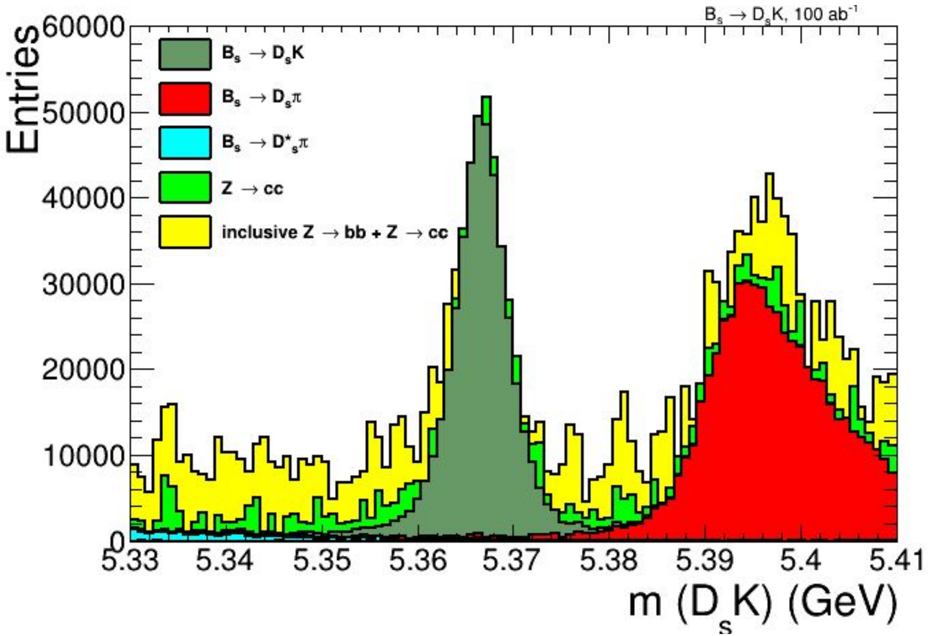
Combined Likelihood (TOF resolution: 10 ps)



Channel	Efficiency or # events
Dsk	~96%
Dspi	~0.3%
Z->bb	~900k

Combined almost unchanged (in the kinematic range of the bachelor kaon dNdx has more impact)

Combined Likelihood (TOF resolution 10 ps, x2 dNdx res)



Channel	Efficiency or # events
Dsk	~96%
Dspi	~20%
Z->bb	~1.5M

Conclusion

- PID using Likelihood ratio shows a relevant improvement vs pull cut (factor 4 in pion rejection)
- Due to the analysis kinematics the TOF PID is not particularly relevant (still it allows to reduce the pion contamination in the combination)
- Tests on samples with TOF resolution of 10 ps (instead of 30 ps) shows improved PID performance. However, due to sample kinematics, the impact on DsK analysis is limited (need to extend to other benchmarks)
- However if dNdx resolution is increased by a factor 2, TOF is becoming more relevant (especially in the 10 ps configuration)

Next steps

- Measure efficiency and purity in the region under the peak (more realistic).
- TOF performance depends on the topology (need to subtract heavy flavour time of flight): try to explore more agnostic taggers (or incorporate the information in the likelihood).