PV Reconstruction for Upgrade vs. Run II

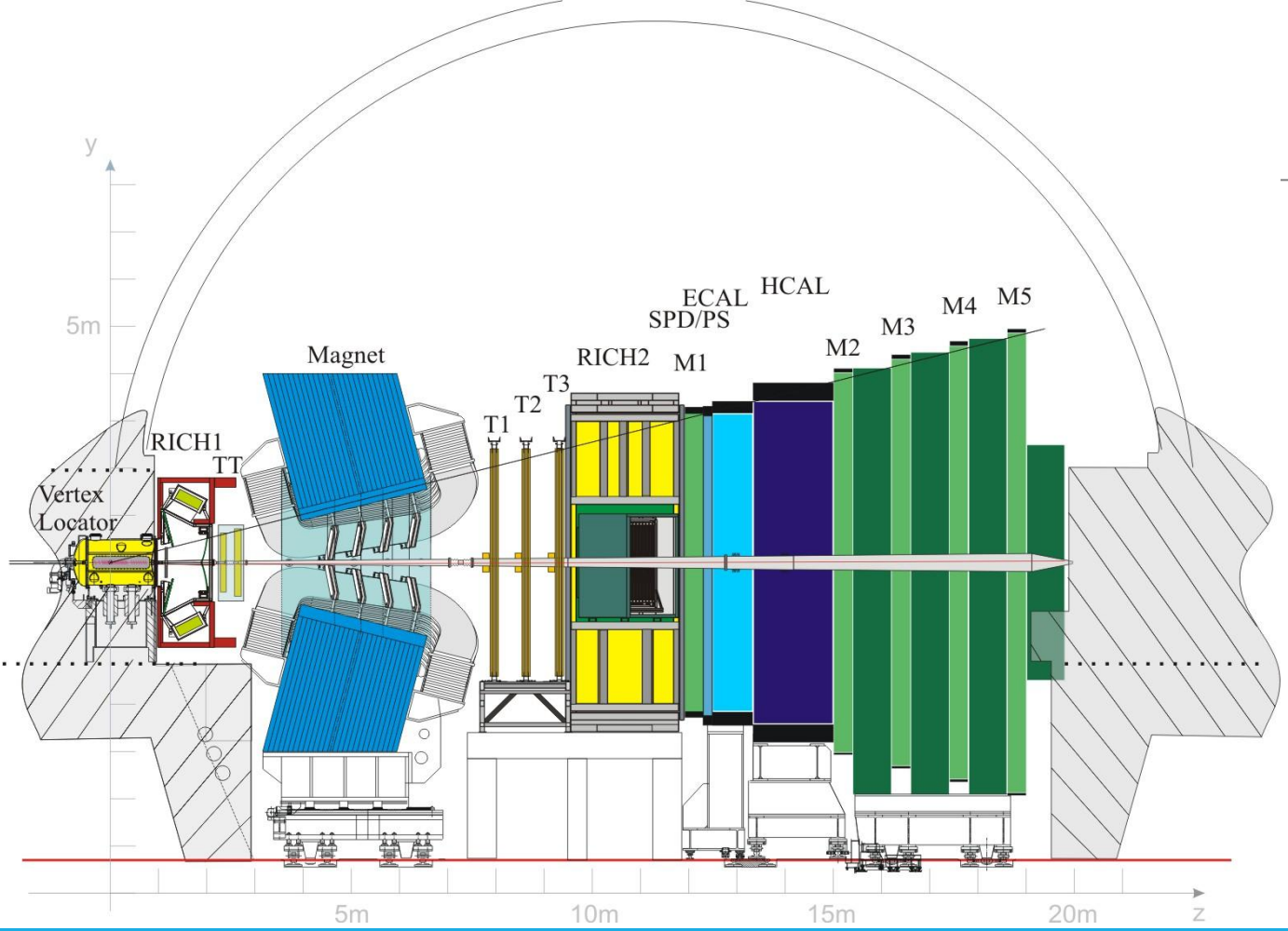
Michael May[1], Agnieszka Dziurda[2]

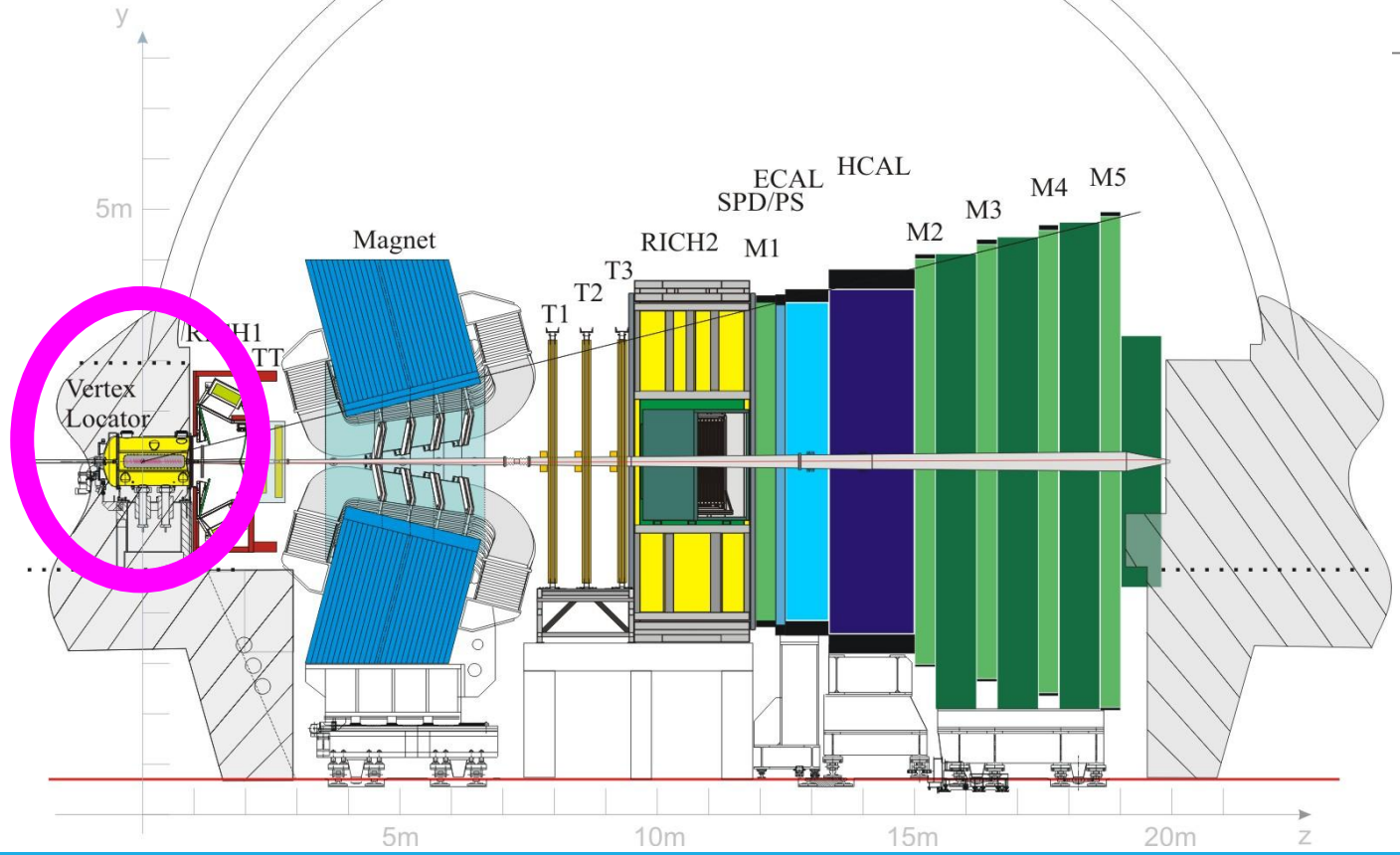
[1]Williams College
[2]CERN

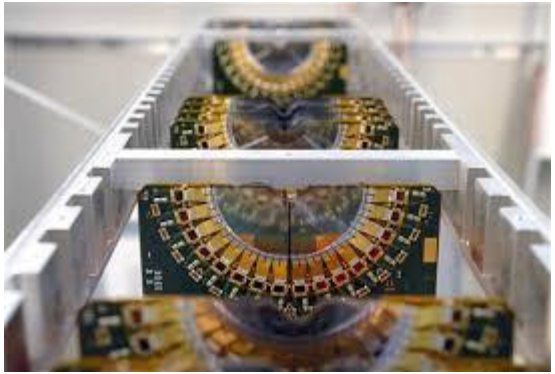
Where in LHCb?

- What is LHCb?
- Introduction to primary vertices
- The upgrade
- Cutting
- Toolkit for Multivariate Analysis

Where in LHCb?


y
5m
Magnet
RICH1
TT
Vertex
Locator
T1
T2
T3
RICH2
SPD/PS
ECAL
HCAL
M1
M2
M3
M4
M5
5m
10m
15m
20m
z


y
5m
Magnet
RICH2
M1
ECAL
SPD/PS
HCAL
M2
M3
M4
M5
T1
T2
T3
TT
Vertex
Locator
5m
10m
15m
20m
z

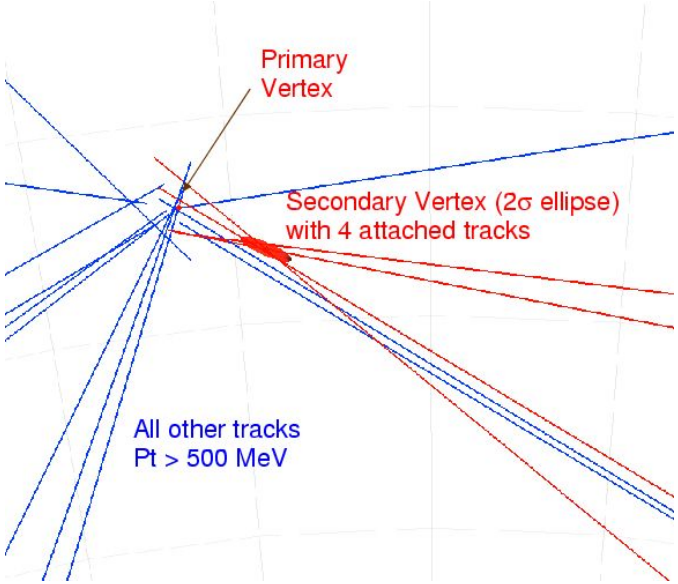


Introduction to Primary Vertices

- Data (30 MHz) ->
- L0 (1.1MHz) ->
- HLT1 (50kHz) ->
- HLT 2 (3kHz)->
- memory

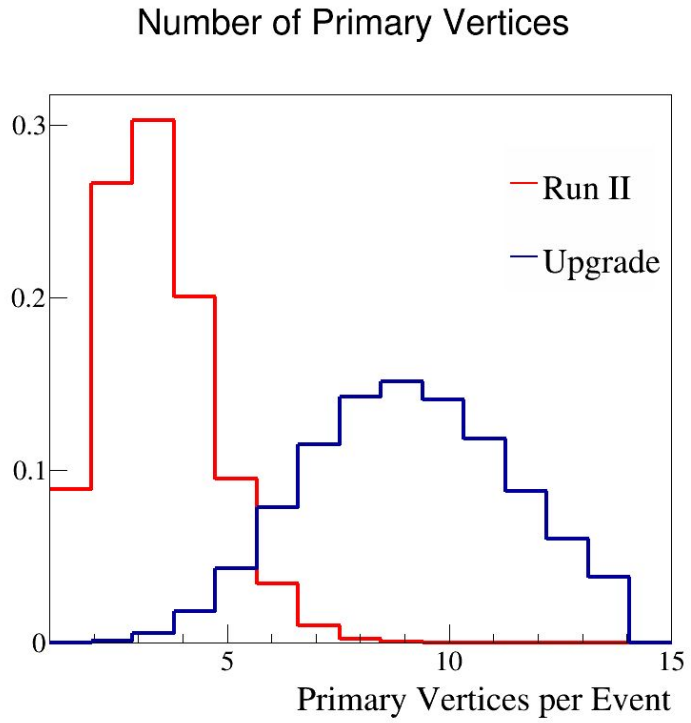
High Level Trigger 1

- VELO reconstruction
  - Primary Vertices
  - Their associated tracks
- Not all PV tracks are reconstructed
- Rough estimate



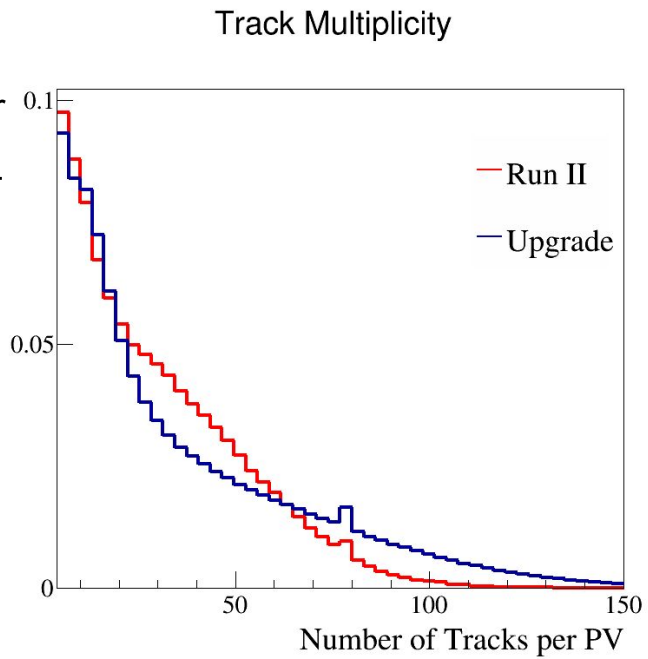
The Upgrade

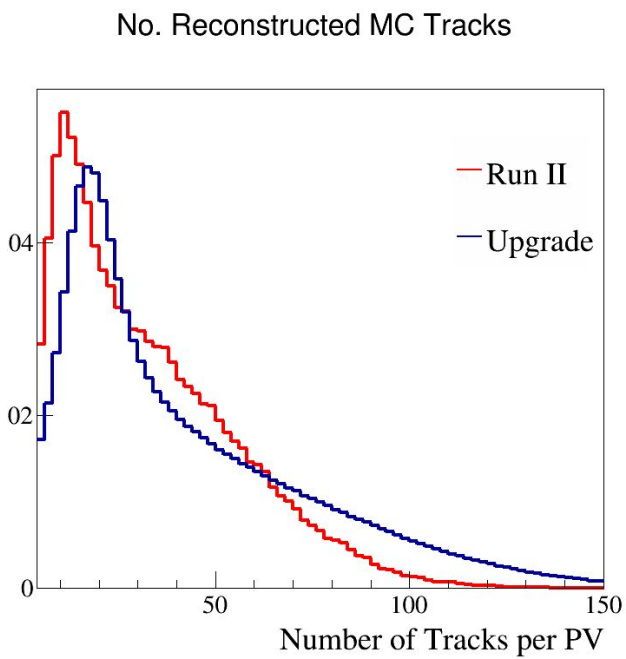
- The LHCb upgrade will increase the average number of PVs per event from 3-4 to 8-9.
- This will take place from 2018-2019



Track Multiplicity and Reconstruction

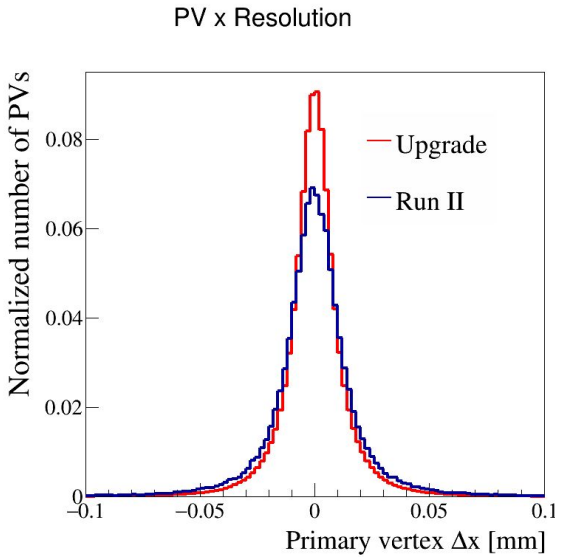
- The number of tracks per PV will decrease for PVs with multiplicity 20-60 and increase for multiplicity >60.
- PVs with low track multiplicity are less likely to be reconstructed than in Run II.

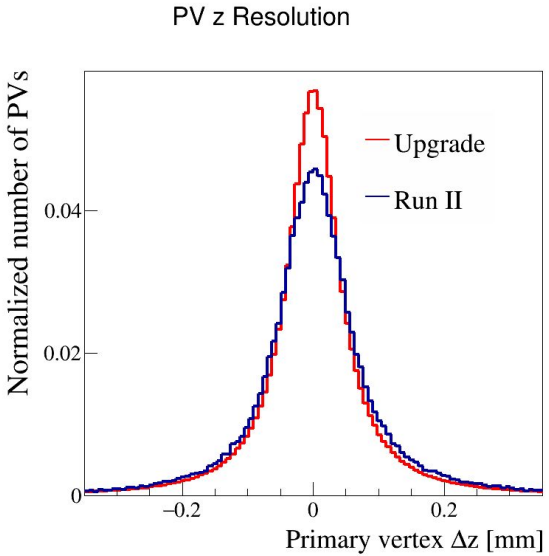




Global Resolution

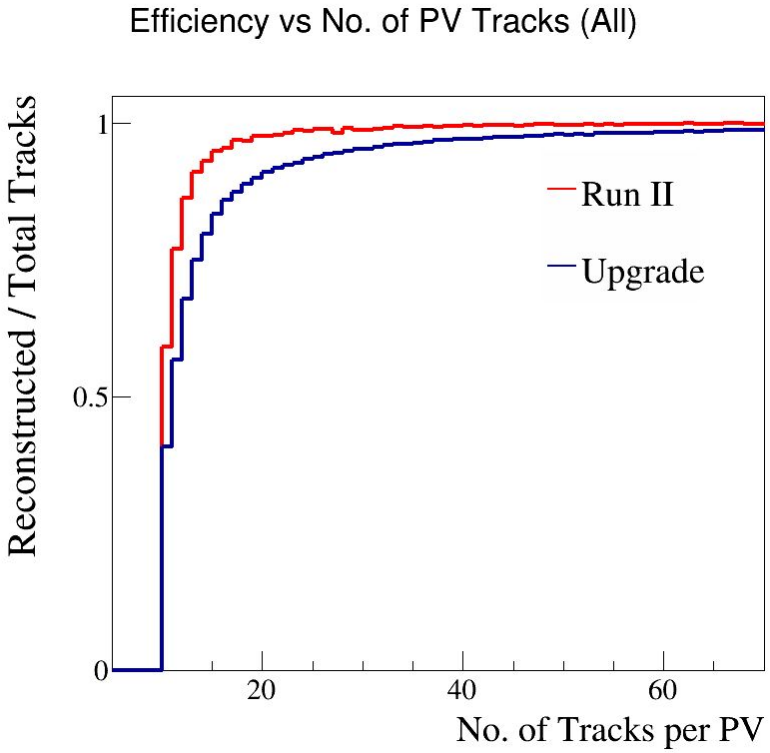
- Resolution is the difference between the calculated and generated position of the PV.
- The Upgrade has noticeably better resolution than Run II.
- Perhaps this is an effect of higher average track multiplicity.





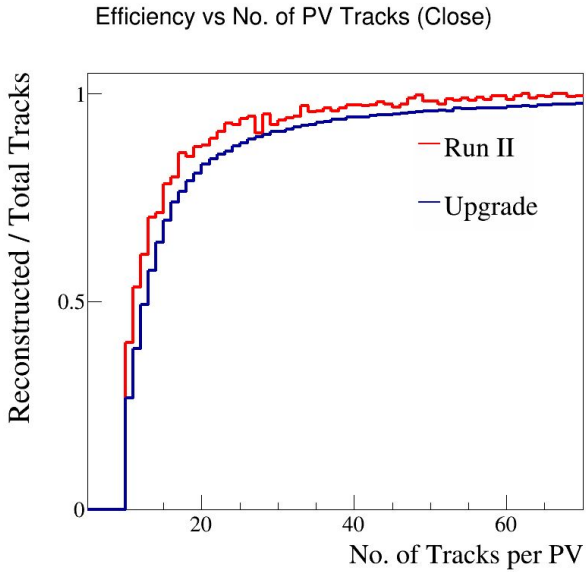
Reconstruction Efficiency of PV Tracks

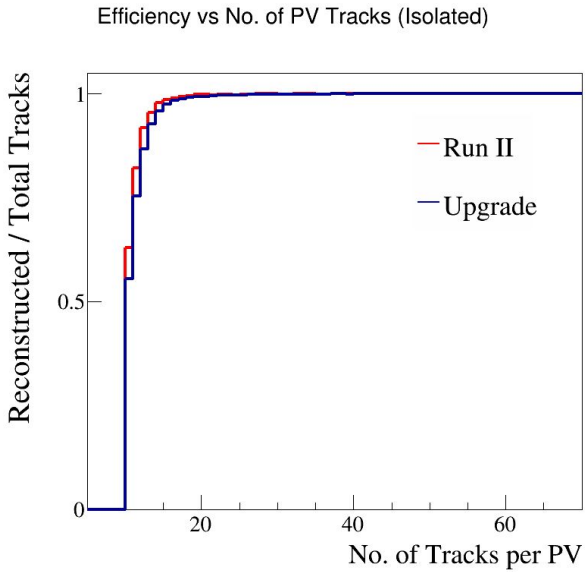
- Reconstruction efficiency of PV tracks is generally lower in the Upgrade than Run II. The difference between the Upgrade and Run II diminishes with higher PV multiplicity.



Reconstruction Efficiency of PV Tracks

- Reconstruction efficiency is almost identical for isolated PVs (> 1mm from another track) , while close PVs (< 1mm) are less likely to have their tracks reconstructed in the Upgrade.





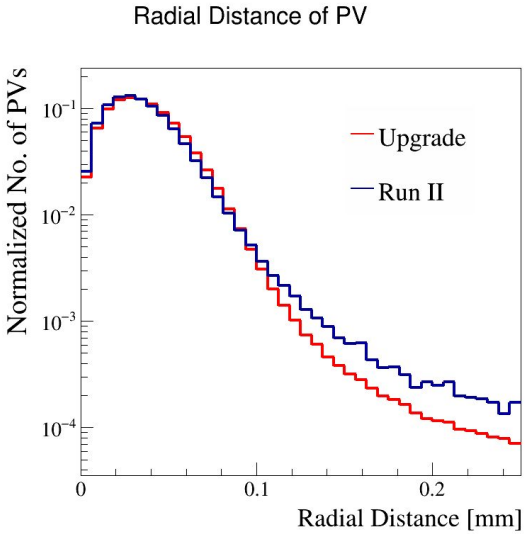
Reconstruction Efficiency of PV Tracks

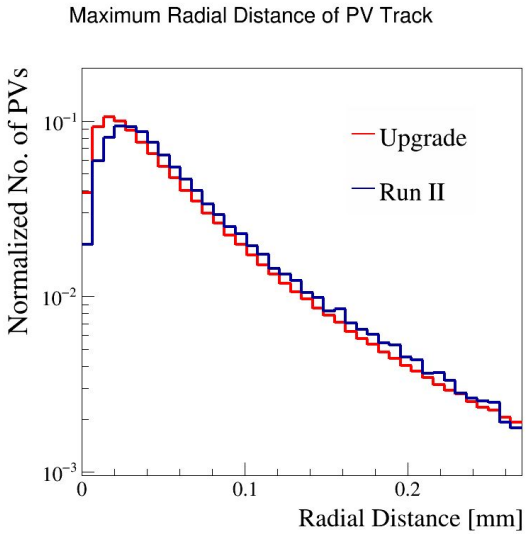
- As might be expected, the Upgrade generally has lower efficiencies than Run II.
- Efficiencies for isolated PVs are almost identical.
- Efficiencies for both the 1st and 2nd PVs are better for the Upgrade than Run II. This may be due to higher average track multiplicity in the Upgrade.

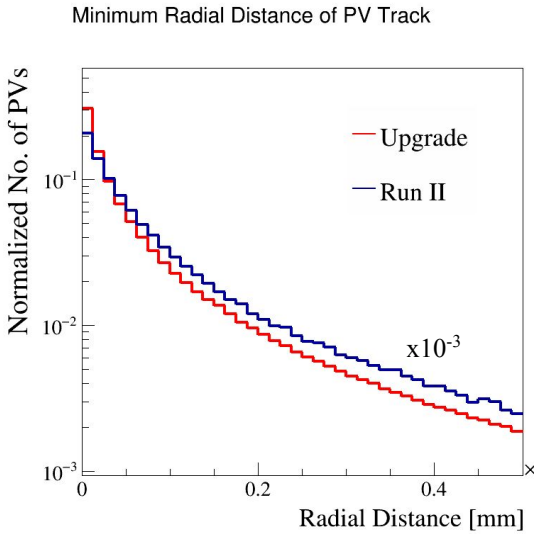
PV Type	Efficiency [%] Upgrade	Efficiency [%] Run II
All Reconstructable	94.1	97.5
Isolated	98.8	98.8
Close	89.4	90.8
1st PV	98.7	98.3
2nd PV	97.4	97.0
3rd PV	95.8	96.5
Beauty	98.0	99.4
Charm	97.8	99.2
No Beauty or Charm	92.5	95.1

Radial Distance of PVs

- Tracks from PVs in the Upgrade are more likely to have lower maximum and minimum radial distances than in Run II.
- The radial distance of the average PV will be lower in the Upgrade as well.

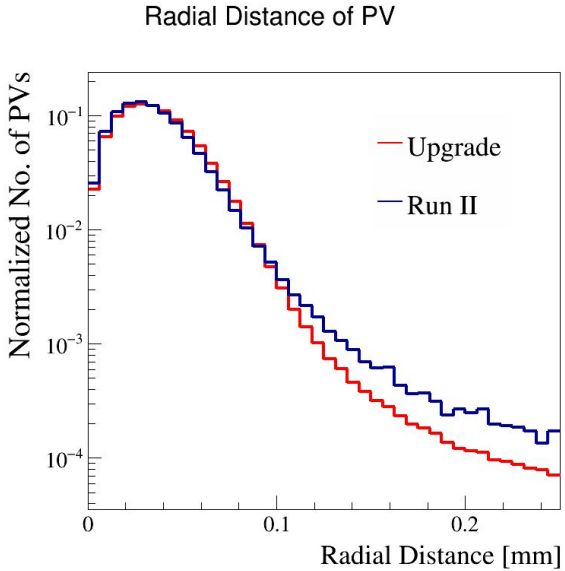


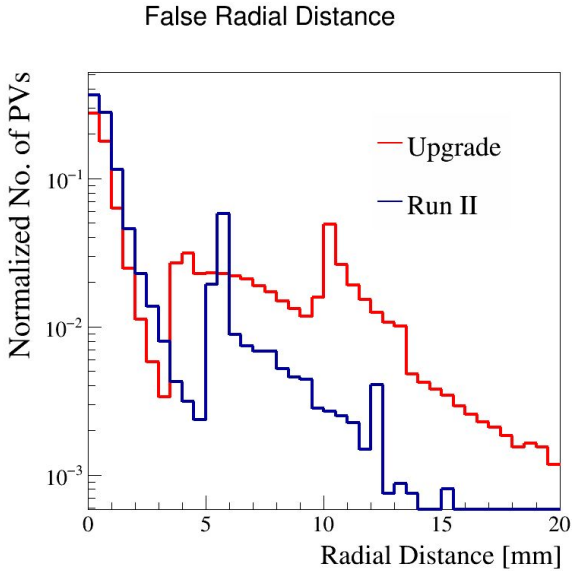




Radial Distance of True vs. False PVs

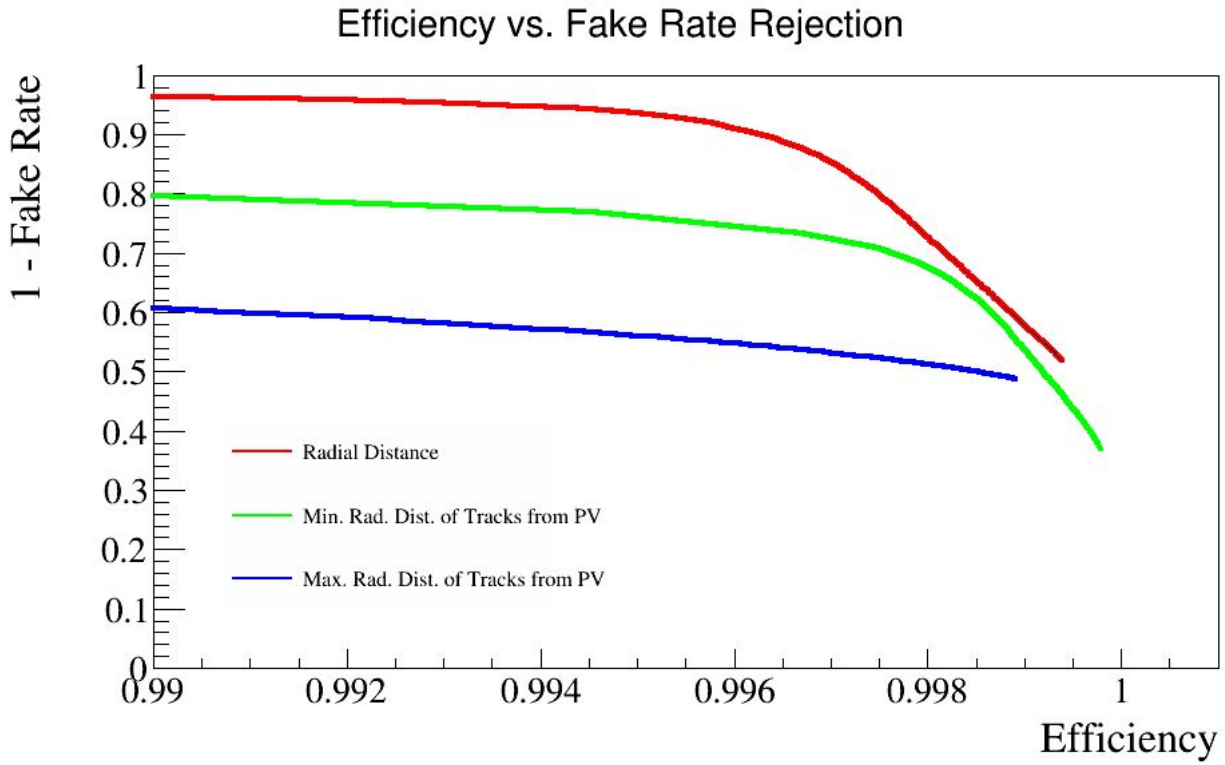
- While true PV radial distances decrease, false PV radial distances increase with the Upgrade.





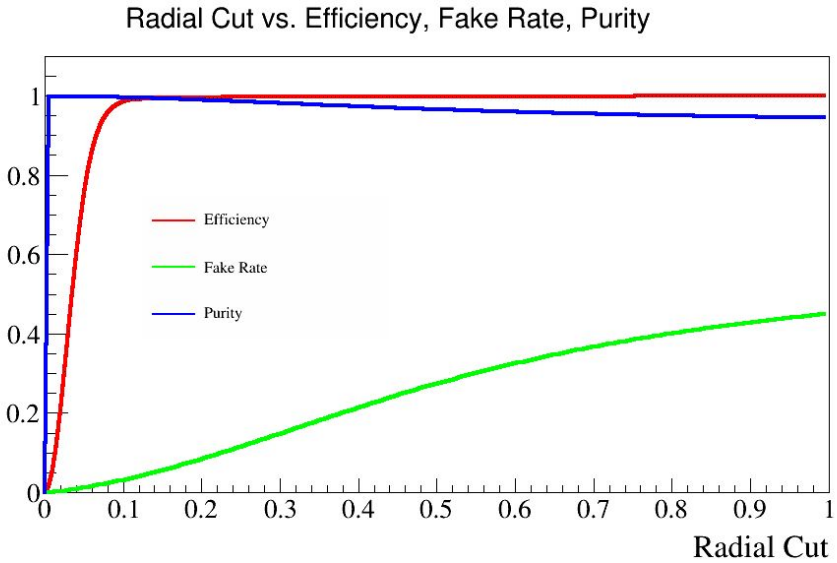
ROC Curve of Min/Max Radial Distance

- As was the case for Run II, the radial distance has better predictive power (higher true PV efficiency and lower false PV efficiency for a radial cut) than either the min. or max. radial distances, so we will optimize radial distance.



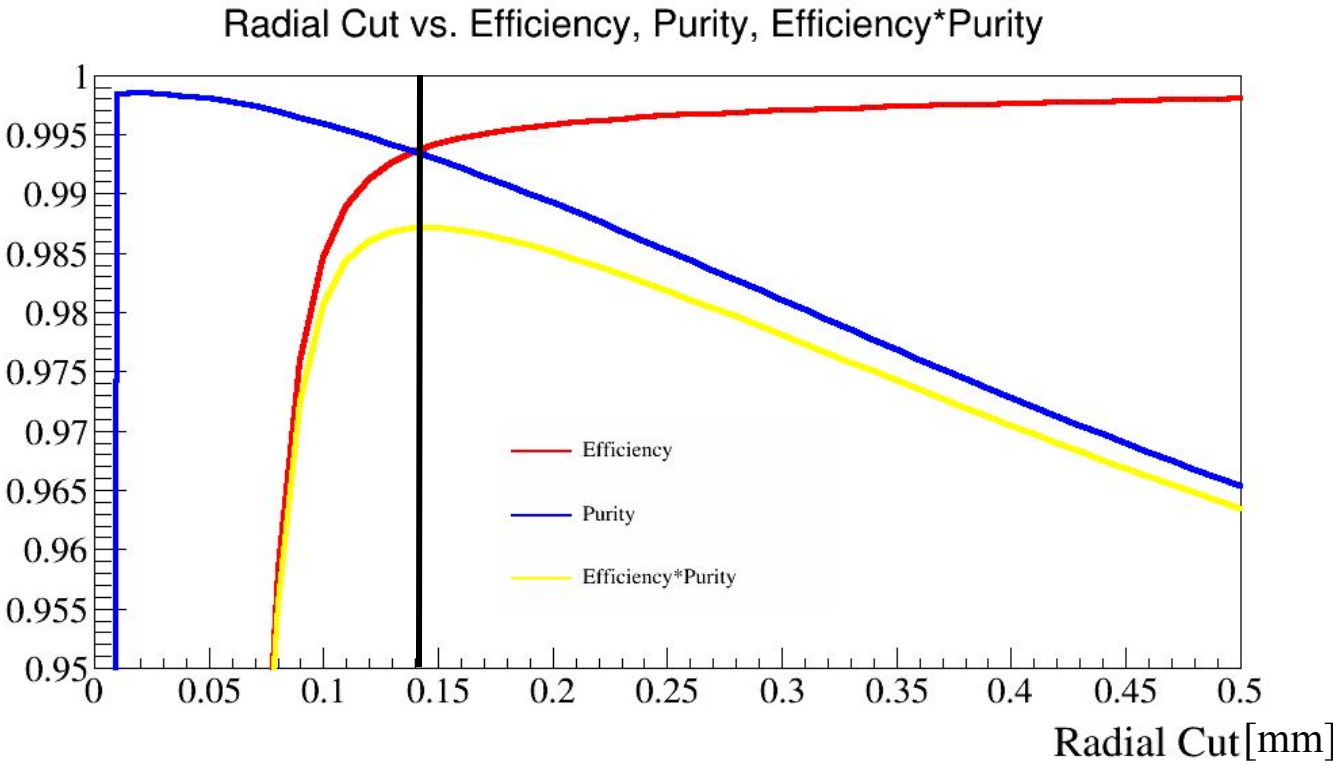
Finding the Optimal Cut Point

- Efficiency = True PVs After Cut / True PVs Before Cut
- Fake Rate = False PVs After Cut / False PVs Before Cut
- Purity = True PVs After Cut / Total PVs After Cut



Finding the Optimal Cut Point

- The maximum of the efficiency*purity curve indicates the optimal cut point for the radial distance variable.
- Optimal Cut = .140
- Efficiency = 99.4%
- Purity = 99.3%
- Fake Rate = 5.0%



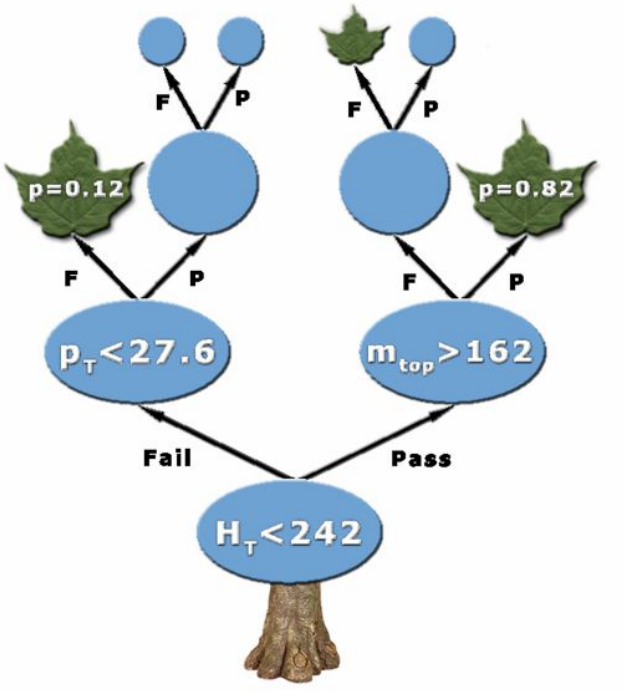
Comparison of Upgrade and Run II Optimal Radial Cut

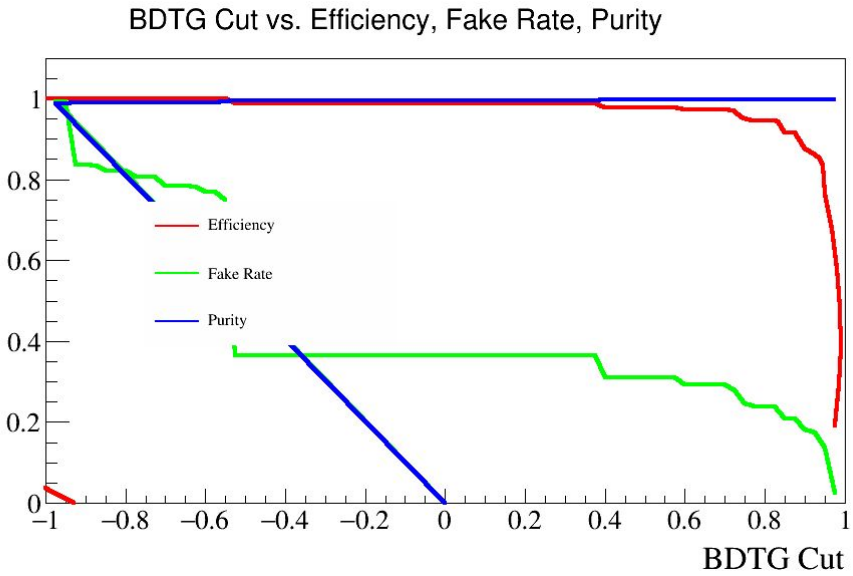
- Using this method on the Run II data indicates that a radial cut in the Upgrade will more significantly discriminate true PVs from false than in Run II.

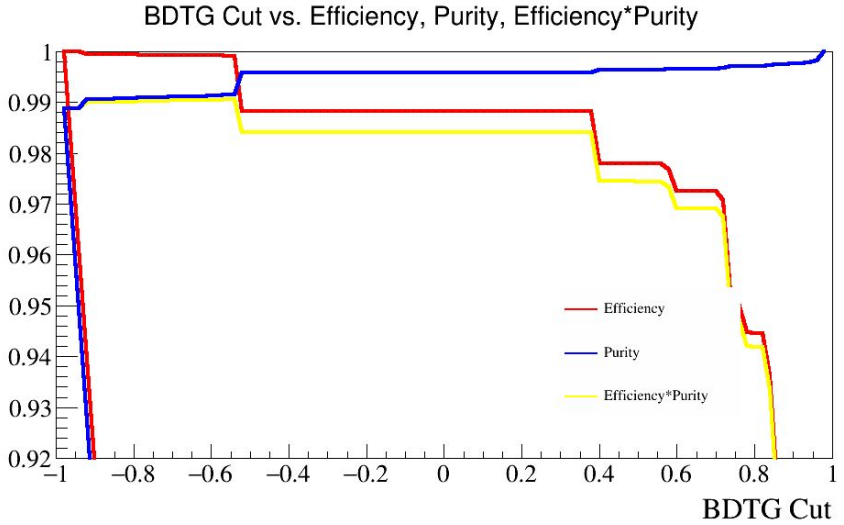
	Upgrade	Run II
Radial Cut	.14	.20
True PV Efficiency	99.35	99.14
False PV Efficiency	4.96	12.14

Toolkit for Multivariate Analysis

- TMVA includes a package which can create BDTs.
- After creating BDTs, run through all data, classifying it, and then append original TTree.
- Determine optimal cut points (nominally p = 0).




BDTG Cut vs. Efficiency, Fake Rate, Purity
Efficiency
Fake Rate
Purity
BDTG Cut


BDTG Cut vs. Efficiency, Purity, Efficiency*Purity
Efficiency
Purity
Efficiency*Purity
BDTG Cut

Next Steps

- Refine BDT training parameters
- Include more variables for (hopefully) increased performance
- Create optimal BDTs and determine their best cut points for all HLT1 parameters.

PV Reconstruction for Upgrade vs. Run II

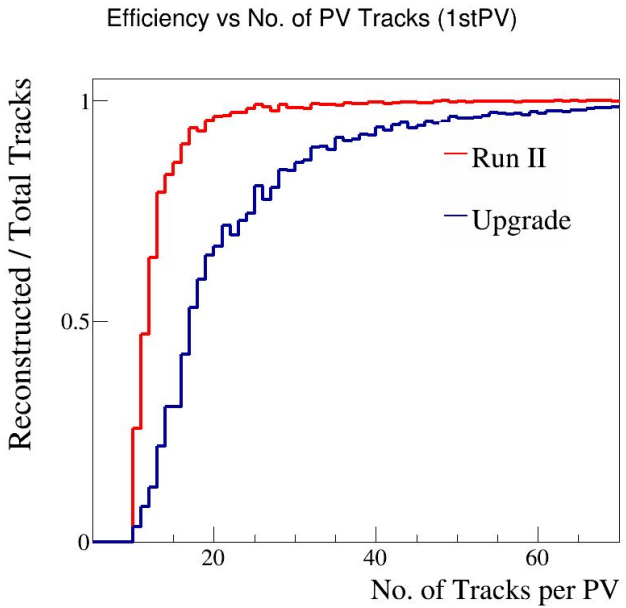
Michael May[1], Agnieszka Dziurda[2]

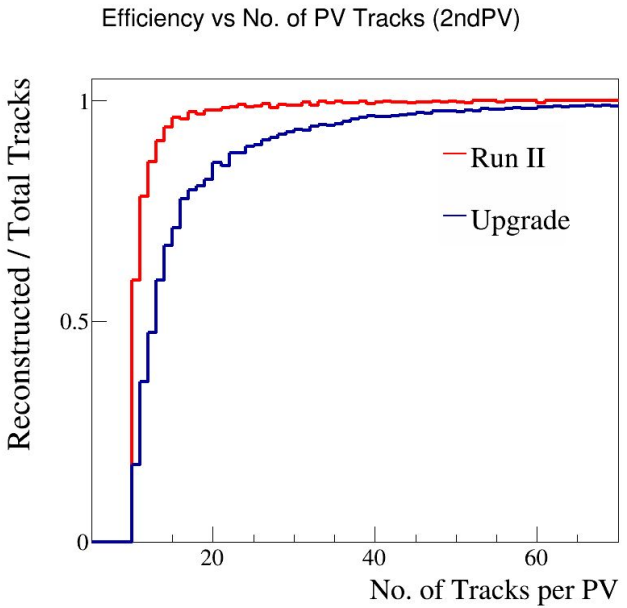
[1]Williams College
[2]CERN

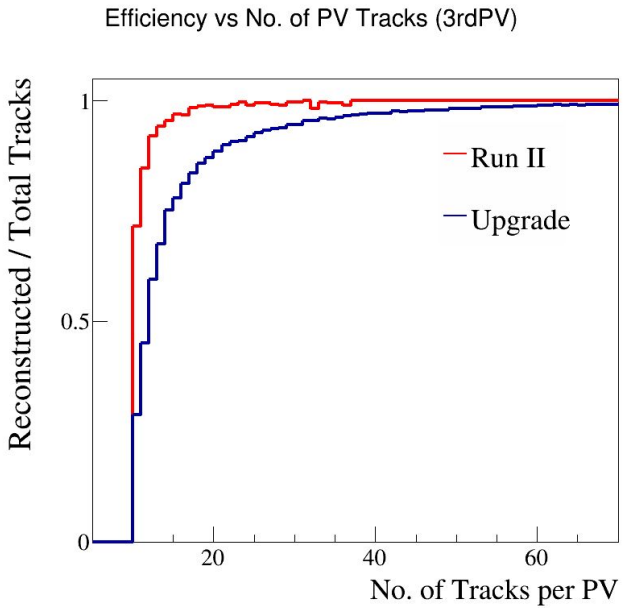
Backup Slides

Reconstruction Efficiency of PV Tracks (by relative multiplicity)

- The 1st PV has the highest track multiplicity in an event, the 2nd PV has the second highest, etc.

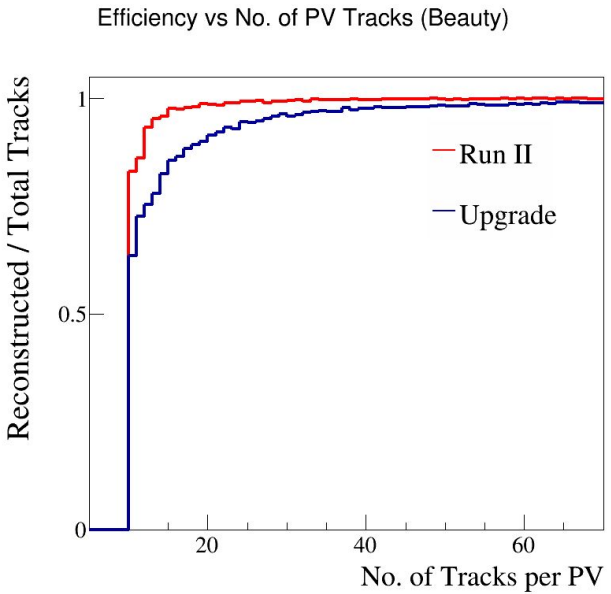


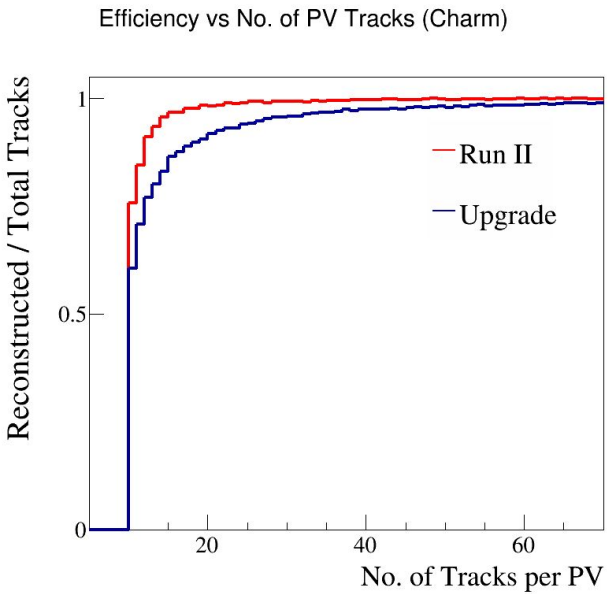


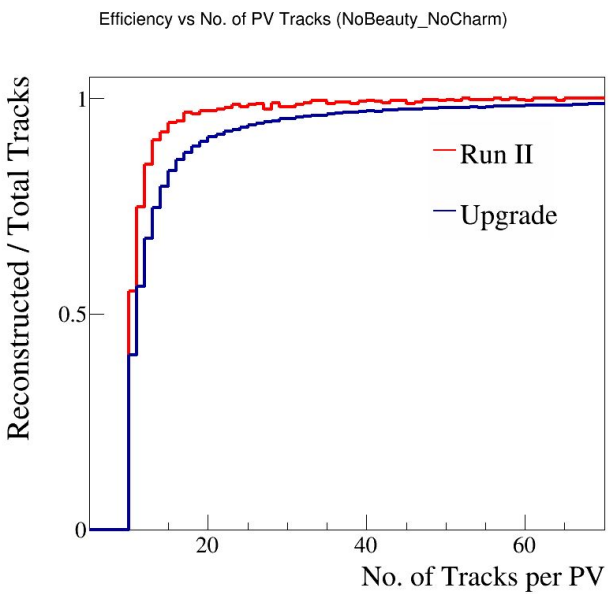


Reconstruction Efficiency of PV Tracks (by decays)

- Beauty, Charm, and NoBeauty_NoCharm indicate the decay products of the PV from which the track originated.

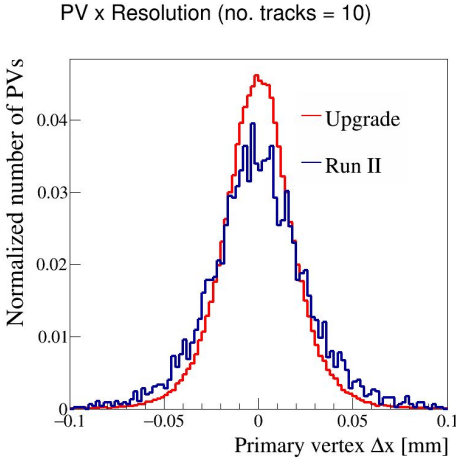


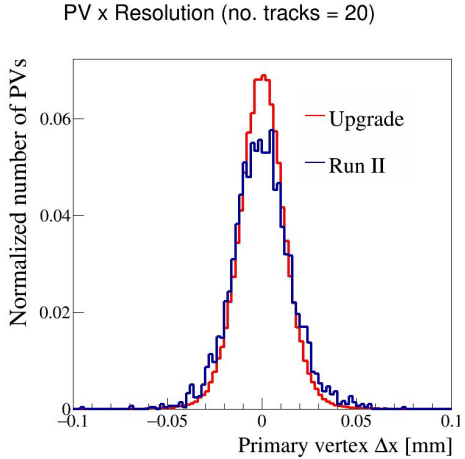


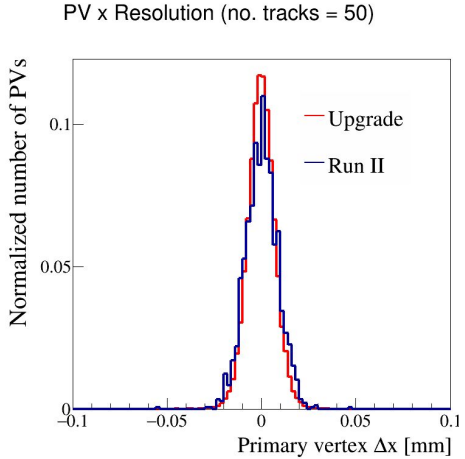


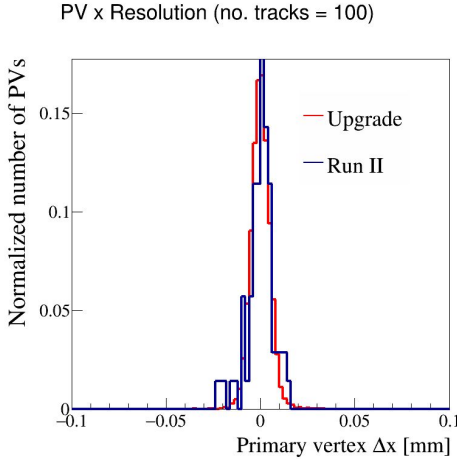
Resolution by Track Multiplicity (x)

- For primary vertices with specific numbers of tracks (10, 20, 50, 100), the Upgrade still has better resolution.



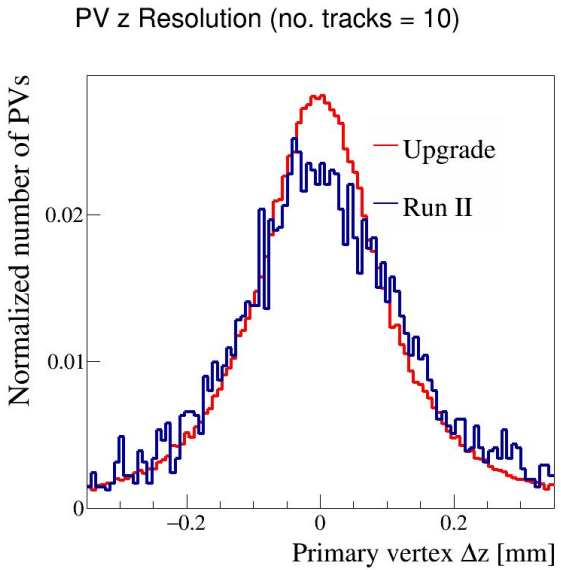


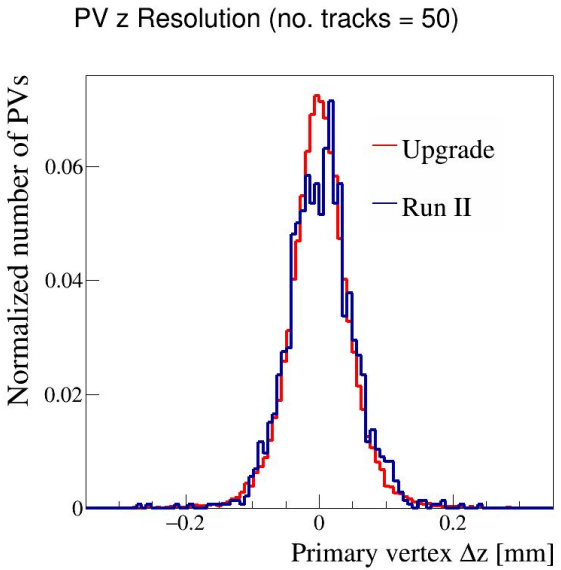




Resolution by Track Multiplicity (z)

- The difference in resolution is less noticeable in the z direction.





Max./Min. Radial Dist. of Tracks of True vs. False PVs

- Both the maximum and minimum radial distance of PV tracks follow the same trend. False PVs in the Upgrade are more likely to be at a greater distance than in Run II.