Identification of kaons using Neural Networks in COMPASS and AMBER experiments at CERN

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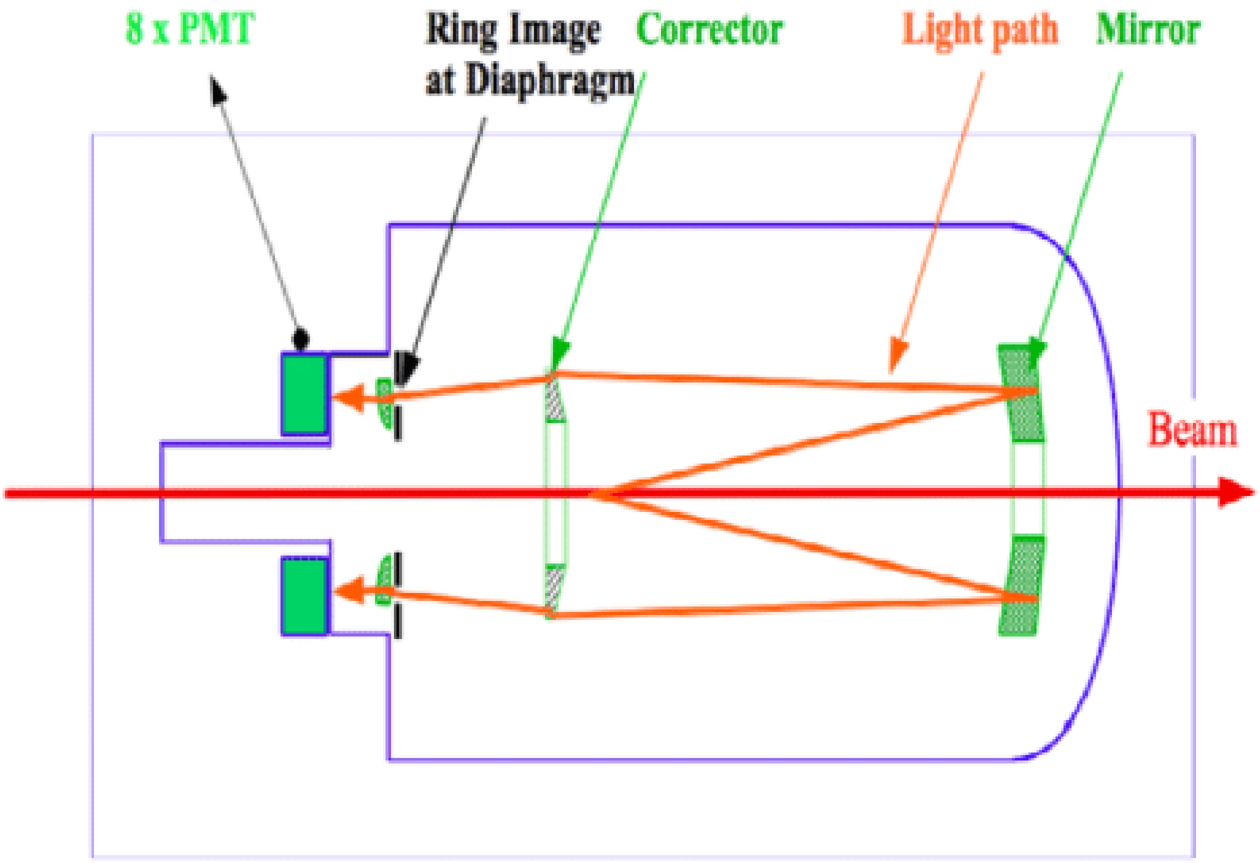
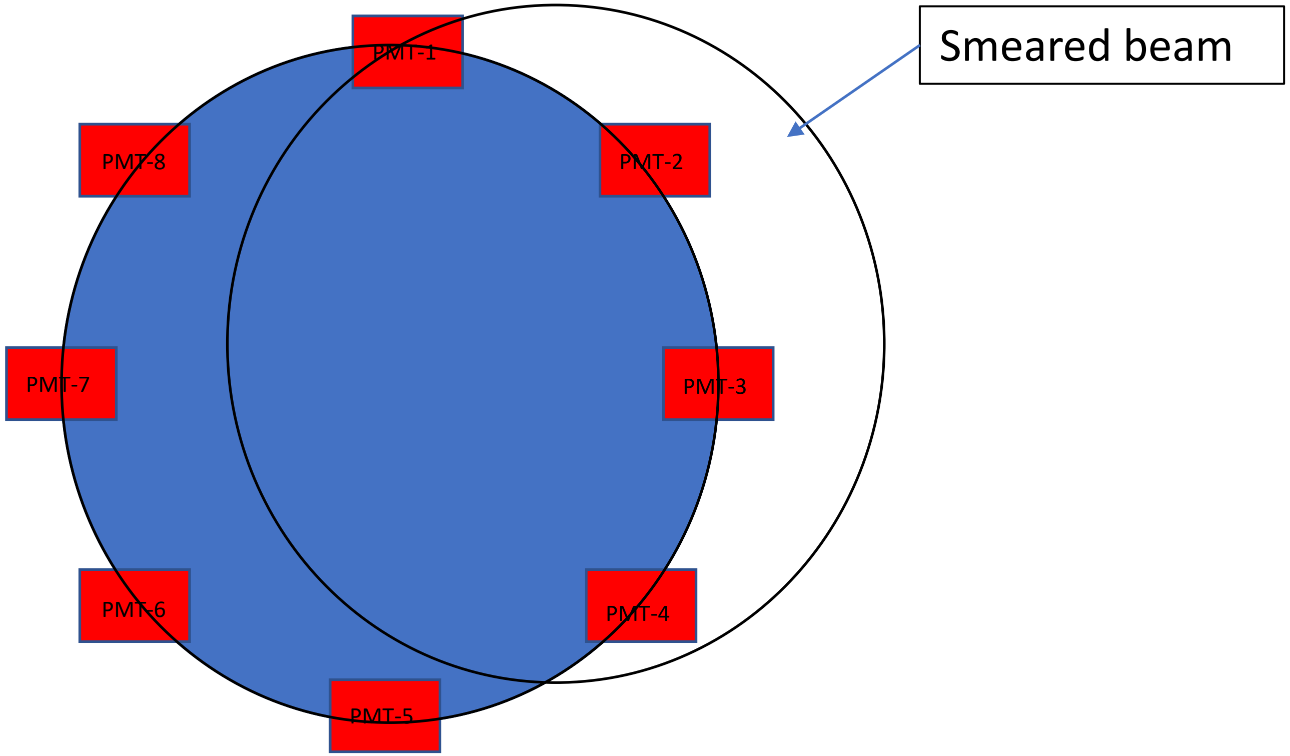
The CEDAR detector



The Problems

- Correlated Noise
- Inefficiency
- Random noise
- Angle smearing



The Method

- Neural Network to identify kaons
- Input: Angle of beam + #PMTs + individual PMT response
- Output is not a likelihood
- We set a threshold and above that implies kaon

The Method

- 11 inputs

Angle of the Beam		#PMTs	PMTs							
0.22347	-0.03058	3	1	1	0	0	0	1	0	0

- 2 outputs

Pion	Kaon
0.67123	0.32877

Neural Network

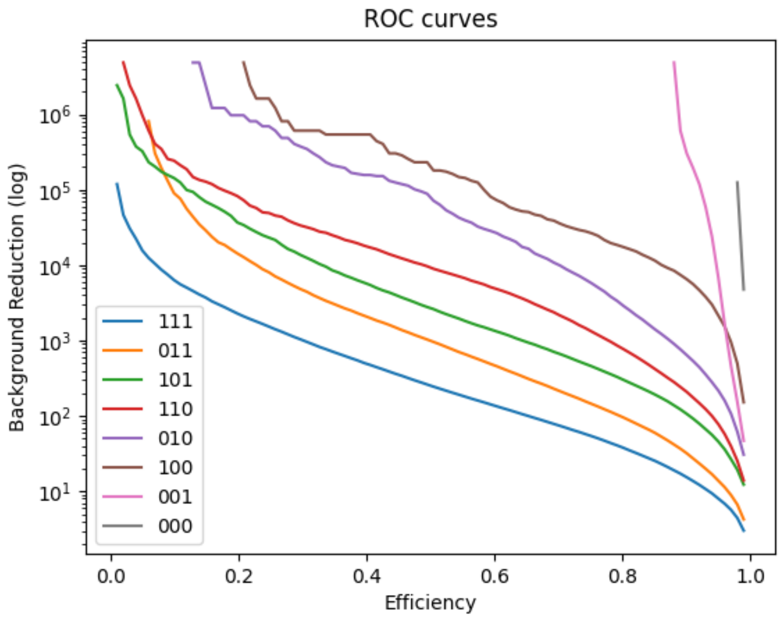
*the values are just examples

Efficiency and BG reduction

- Signal event – Kaons
- Back Ground event – Pions and everything else
- Efficiency as the ratio of selected signal events over all signal events:
  - $Efficiency = \frac{\#selected\ signal\ events}{\#signal\ events}$
- Background reduction (BG) factor:
  - $BG\ \text{reduction} = \frac{\#BG\ events}{\#selected\ BG\ events}$

The starting point

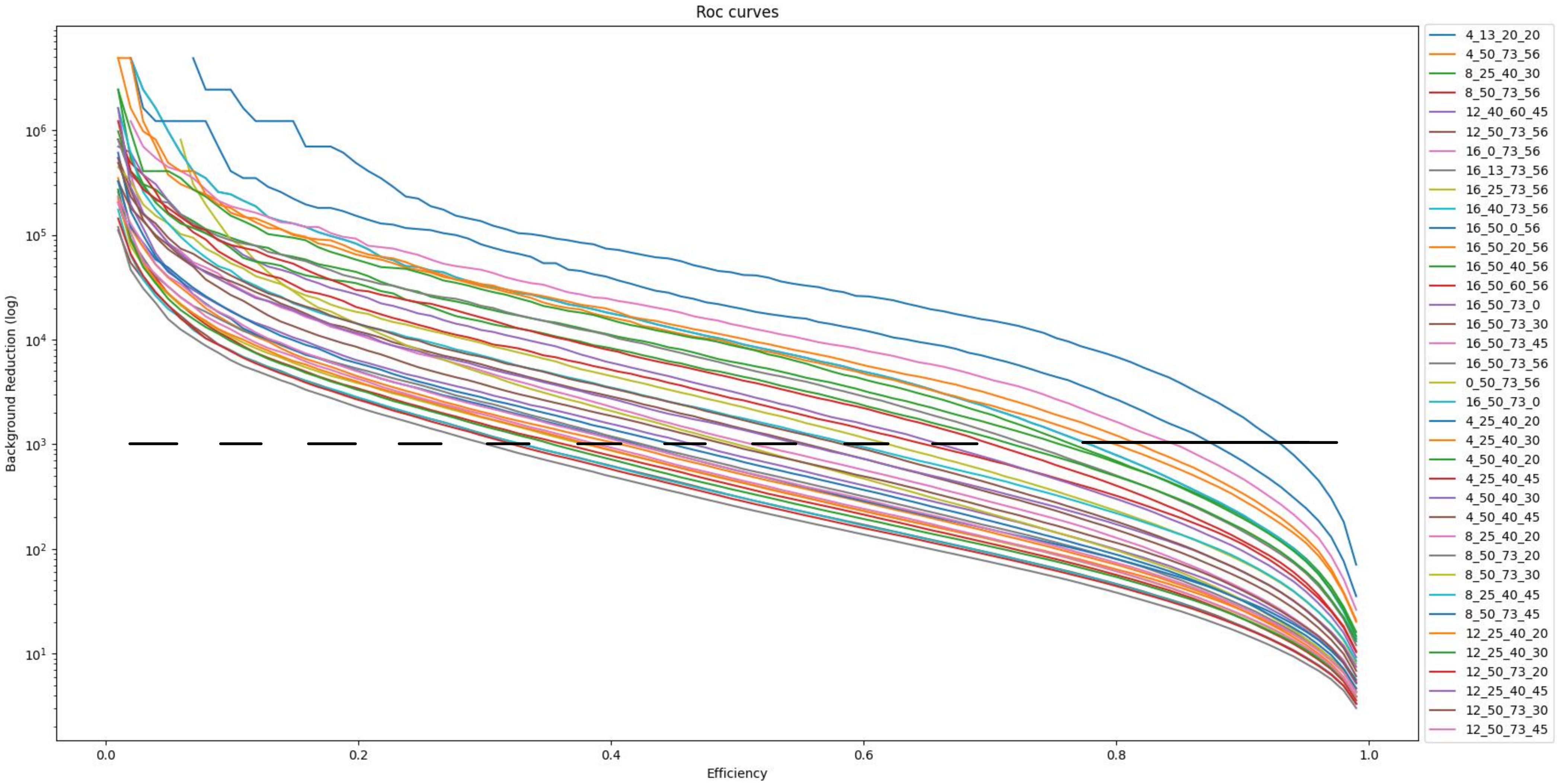
- x1x – inefficiency and random noise
- 1xx – correlated noise
- xx1 – angle smearing
- 000 – perfect conditions
- 111 – actual conditions



New conditions

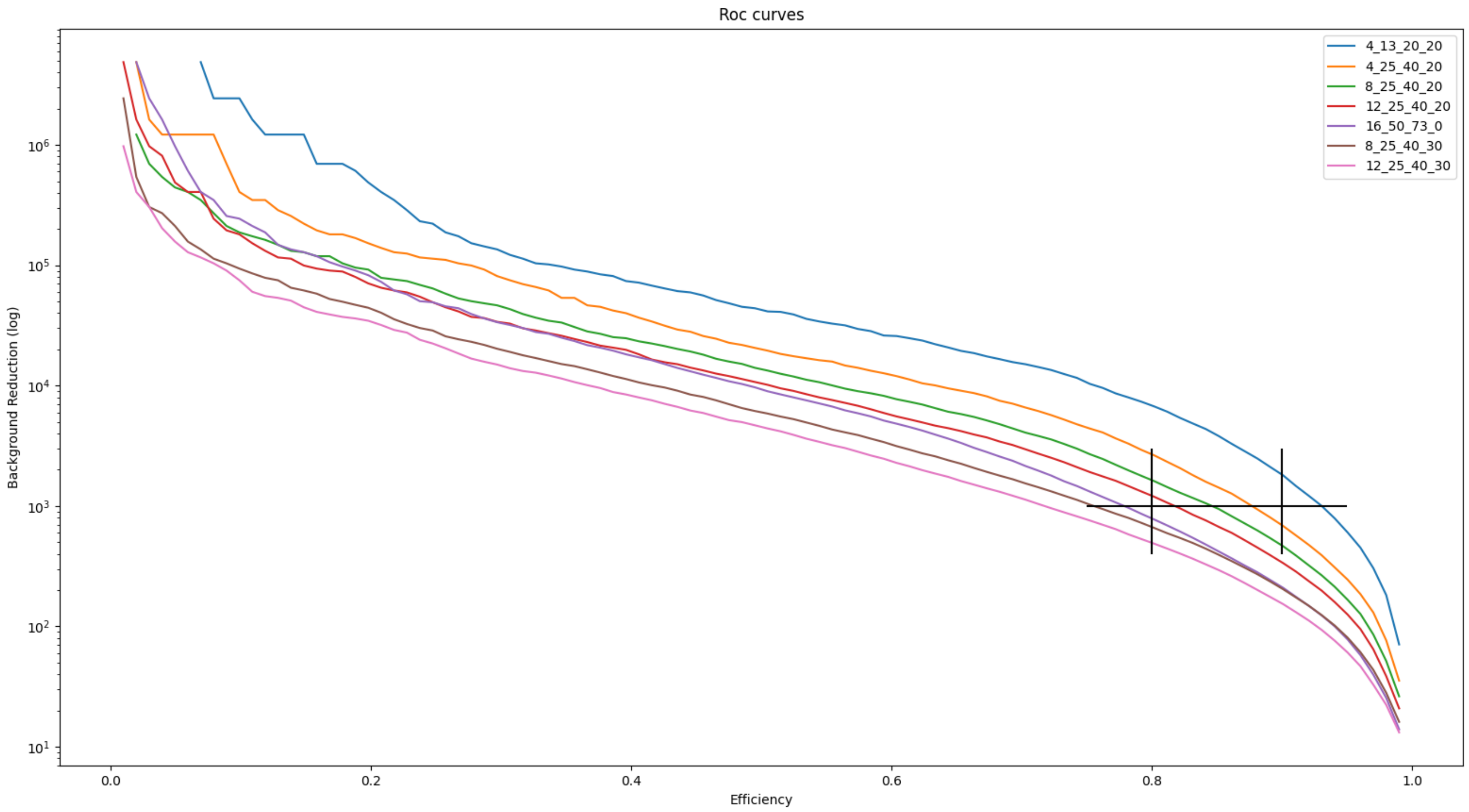
- 1xxx – correlated noise
  - 0.00 to 0.16
- x1xx – random noise
  - 0.000 to 0.050
- xx1x – inefficiency
  - 0.000 to 0.073
- xxx1 – angle smearing
  - 0.000 to 0.056
- 0.00_0.000_0.000_0.000 – perfect conditions
- 0.16_0.050_0.073_0.056 – actual conditions

ROC curves



Roc curves
Background Reduction (log)
Efficiency
10^6
10^5
10^4
10^3
10^2
10^1
0.0
0.2
0.4
0.6
0.8
1.0
4_13_20_20
4_50_73_56
8_25_40_30
8_50_73_56
12_40_60_45
12_50_73_56
16_0_73_56
16_13_73_56
16_25_73_56
16_40_73_56
16_50_0_56
16_50_20_56
16_50_40_56
16_50_60_56
16_50_73_0
16_50_73_30
16_50_73_45
16_50_73_56
0_50_73_56
16_50_73_0
4_25_40_20
4_25_40_30
4_50_40_20
4_25_40_45
4_50_40_30
4_50_40_45
8_25_40_20
8_50_73_20
8_50_73_30
8_25_40_45
8_50_73_45
12_25_40_20
12_25_40_30
12_50_73_20
12_25_40_45
12_50_73_30
12_50_73_45

ROC curves



Roc curves
Background Reduction (log)
Efficiency
10^6
10^5
10^4
10^3
10^2
10^1
0.0
0.2
0.4
0.6
0.8
1.0
4_13_20_20
4_25_40_20
8_25_40_20
12_25_40_20
16_50_73_0
8_25_40_30
12_25_40_30

Best configurations

0.04_0.013_0.020_0.020

efficiency	bg reduction
0.9	1.823801e+03
0.8	6.794801e+03
0.7	1.519834e+04
0.6	2.595036e+04
0.5	4.169801e+04
0.4	7.281593e+04
0.3	1.250940e+05
0.2	4.878667e+05
0.1	2.439334e+06

0.04_0.025_0.040_0.020

efficiency	bg reduction
0.9	689.466789
0.8	2679.114223
0.7	6692.272977
0.6	12257.957286
0.5	19994.536885
0.4	38414.700787
0.3	78688.177419
0.2	147838.393939
0.1	406555.583333

0.08_0.025_0.040_0.020

efficiency	bg reduction
0.9	468.832116
0.8	1640.439475
0.7	4145.001699
0.6	7919.913961
0.5	13742.723944
0.4	24271.975124
0.3	45595.018692
0.2	85590.649123
0.1	187641.038462

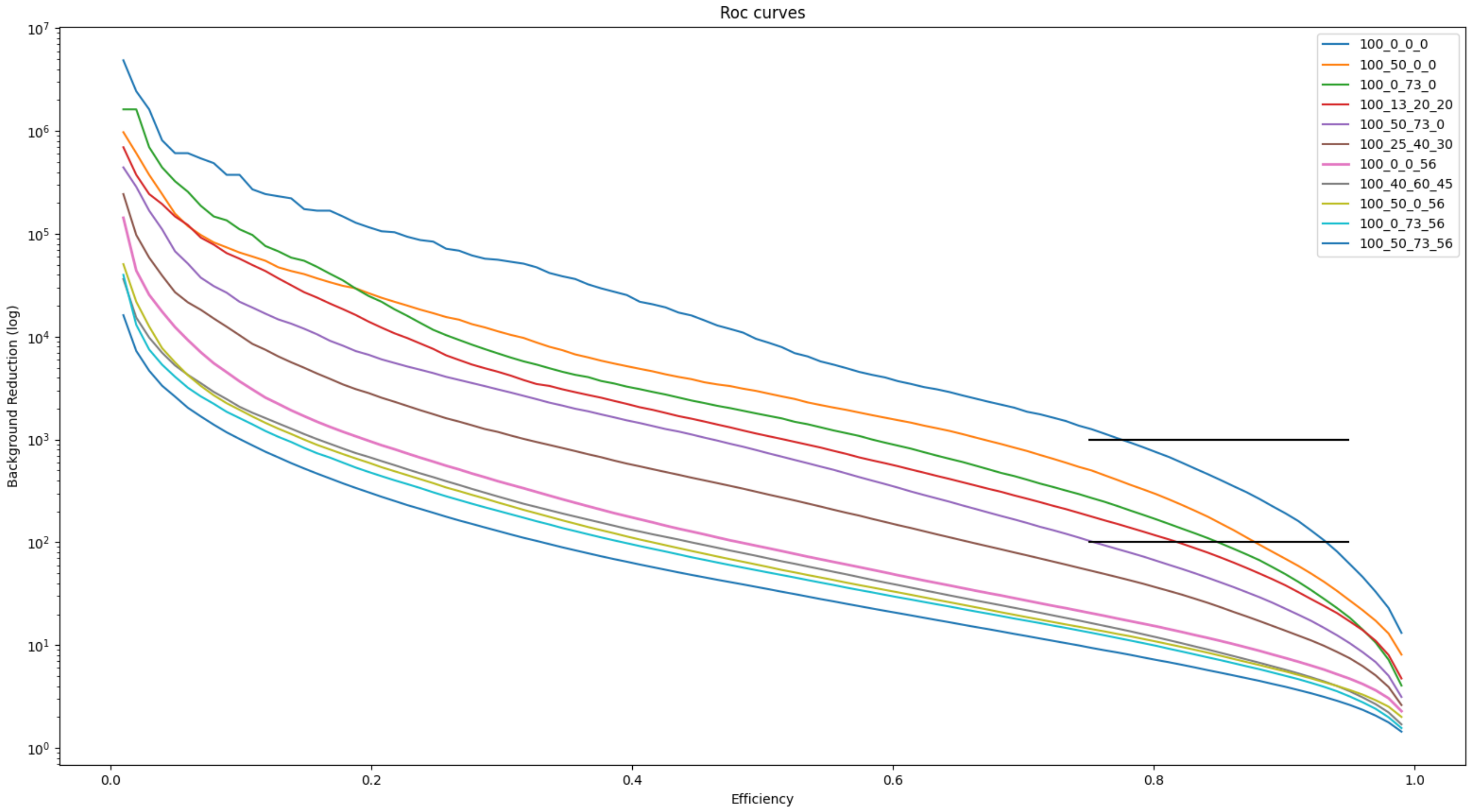
0.04_0.025_0.040_0.030

efficiency	bg reduction
0.9	340.024185
0.8	1216.625187
0.7	3022.718092
0.6	5712.724824
0.5	10402.275053
0.4	19132.027451
0.3	33188.210884
0.2	67759.263889
0.1	180691.370370

0.12_0.013_0.020_0.020

efficiency	bg reduction
0.9	293.312511
0.8	991.196059
0.7	2371.738940
0.6	4764.323242
0.5	8870.303636
0.4	16101.211221
0.3	32096.493421
0.2	65048.893333
0.1	157376.354839

ROC curves – always 2nd track



Conclusions

- Angle smearing needs to be greatly reduced
- Small changes will not be enough
- Having always a second track ruins the performance of the network