

Atmospheric muons rejection for ORCA

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Outline

- Monte Carlo simulation
- Event reconstruction
- Muon background studies

All plots
preliminary

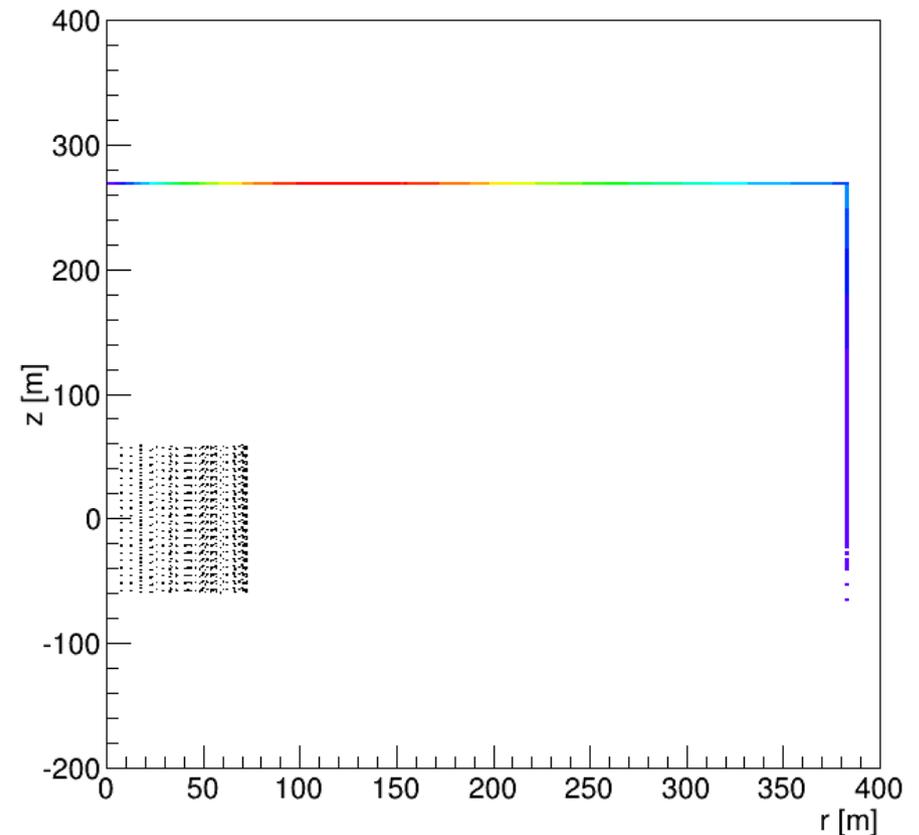
Production chain

Muon generation: **MUPAGE v3r5** – muon bundles at the can

- $1 < E_{\mu} < 10^5$ GeV
- $0^{\circ} < \theta < 85^{\circ}$
- Multiplicity < 200

Reference detector:

- 50 strings, 20 m spacing;
- 20 OMs per string, 6 m spacing;
- 31 3" PMT per OM.



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Muon propagation and light production: **km3 v4r4**

Optical background: **modk40**

Reconstruction: **recoLNSlowE20** (dedicated talk tomorrow)

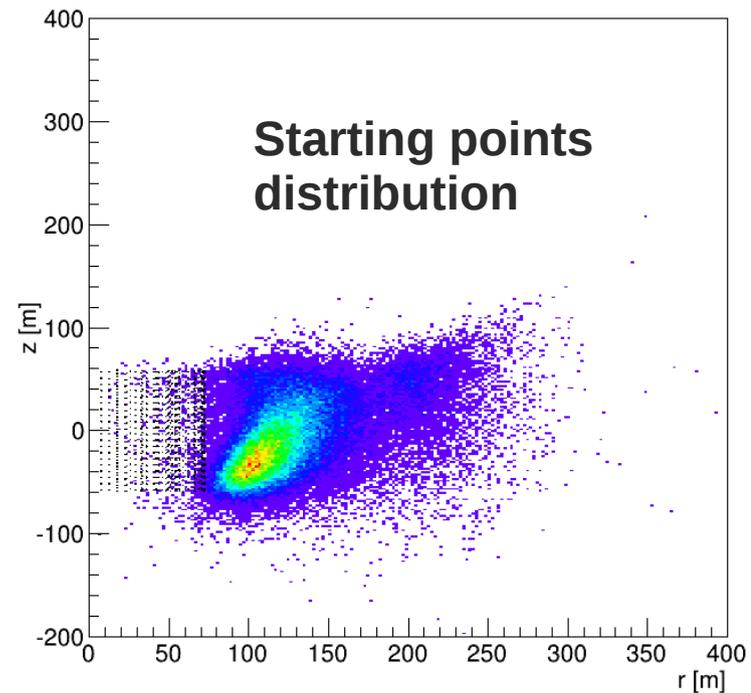
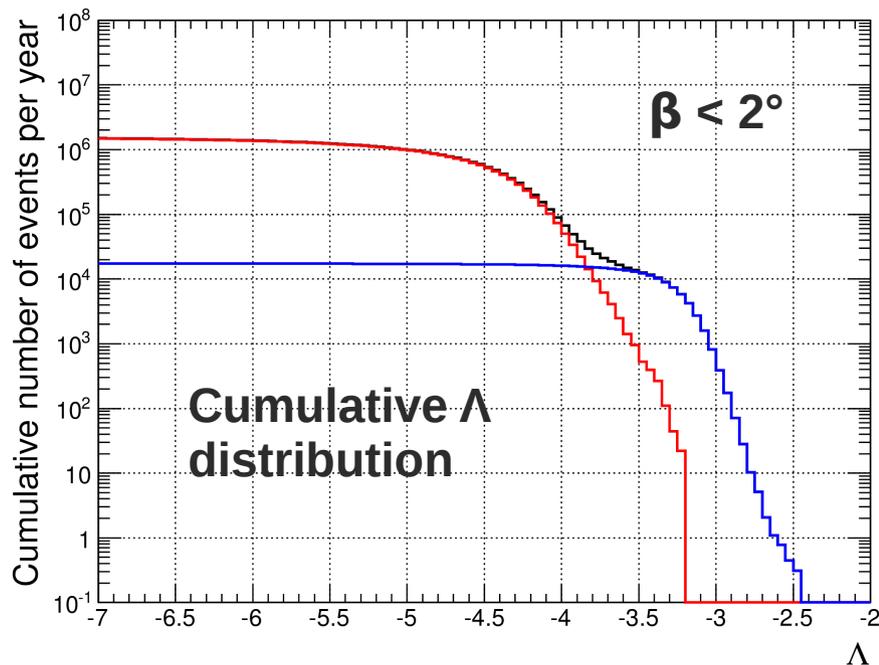
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Muon background rejection

reco* output: reconstructed direction, energy estimation with track length, track starting point.

- Quality parameter Λ and angular error estimate β .
- Look at **upward going** reconstructed tracks.



* Dedicated talk tomorrow by A.Trovato (Low Energy session)

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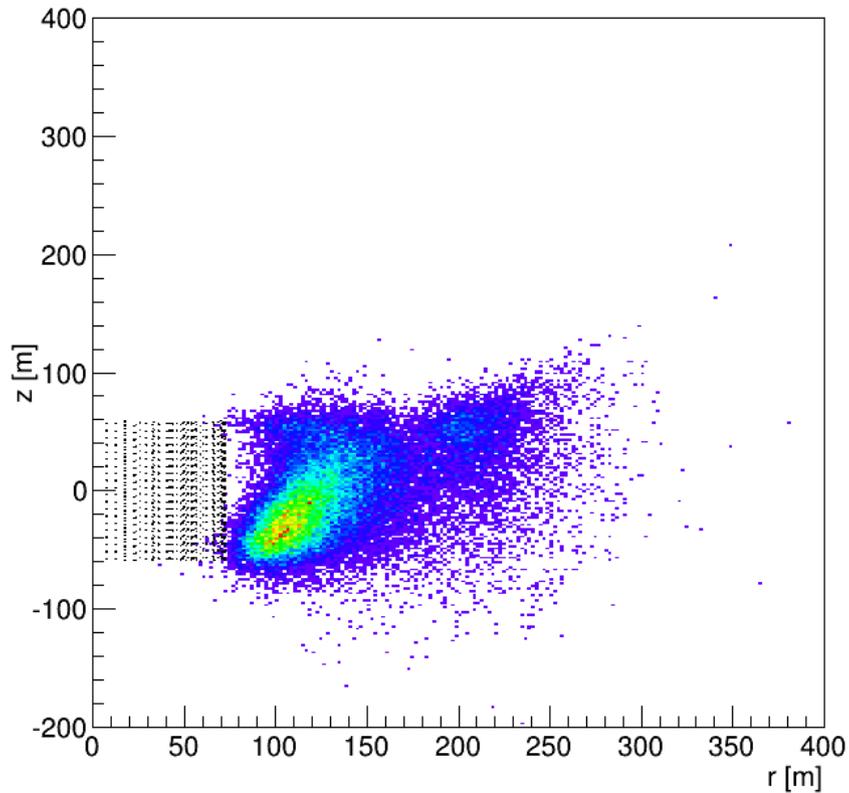
Possibility to reject wrongly reconstructed atmospheric muons with Λ and β .

- Hard cuts required on these variables to obtain a safe rejection;
- Loss of low energy neutrinos.

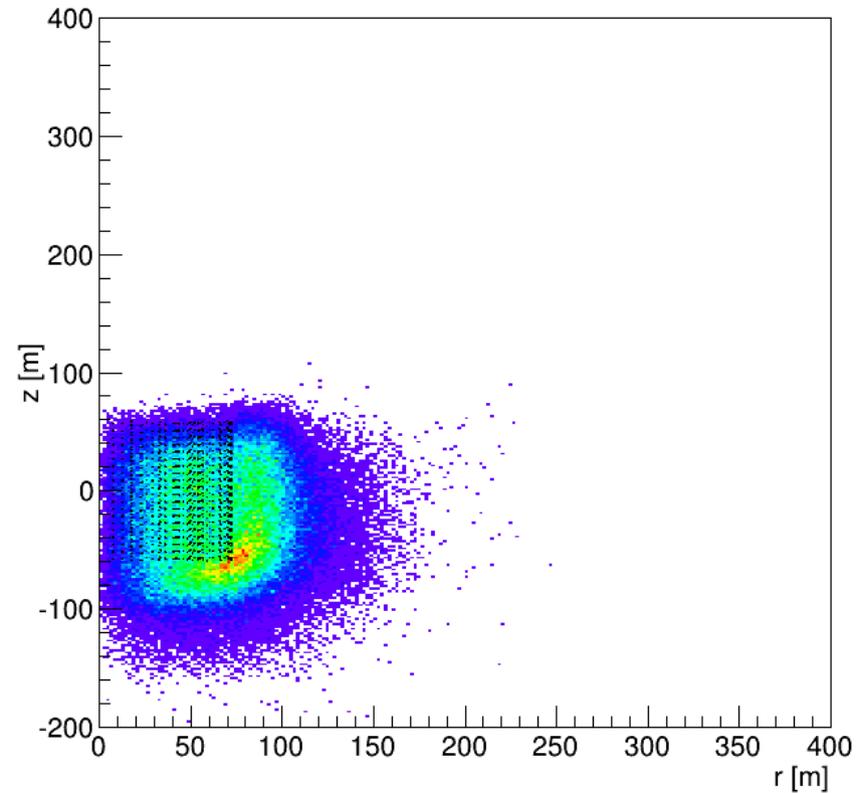
Adding the starting point information improves the rejection performances.

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Track starting point (upgoing - $\beta < 2^\circ$, $\Lambda > -4.8$)

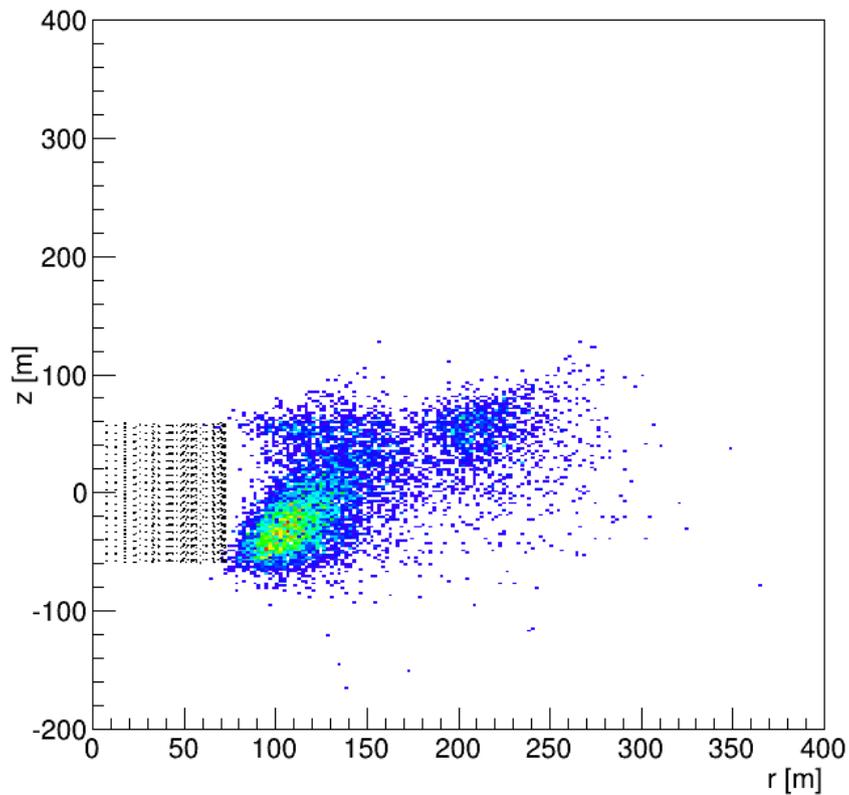


Atmospheric muons

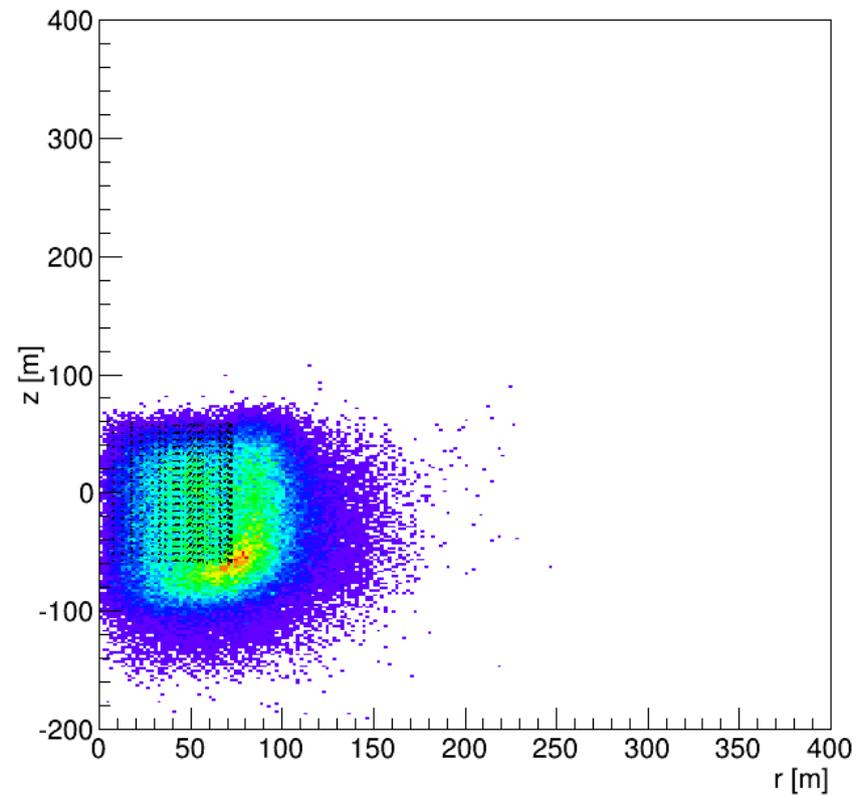


Atmospheric neutrinos

Track starting point (upgoing - $\beta < 2^\circ$, $\Lambda > -4.2$)

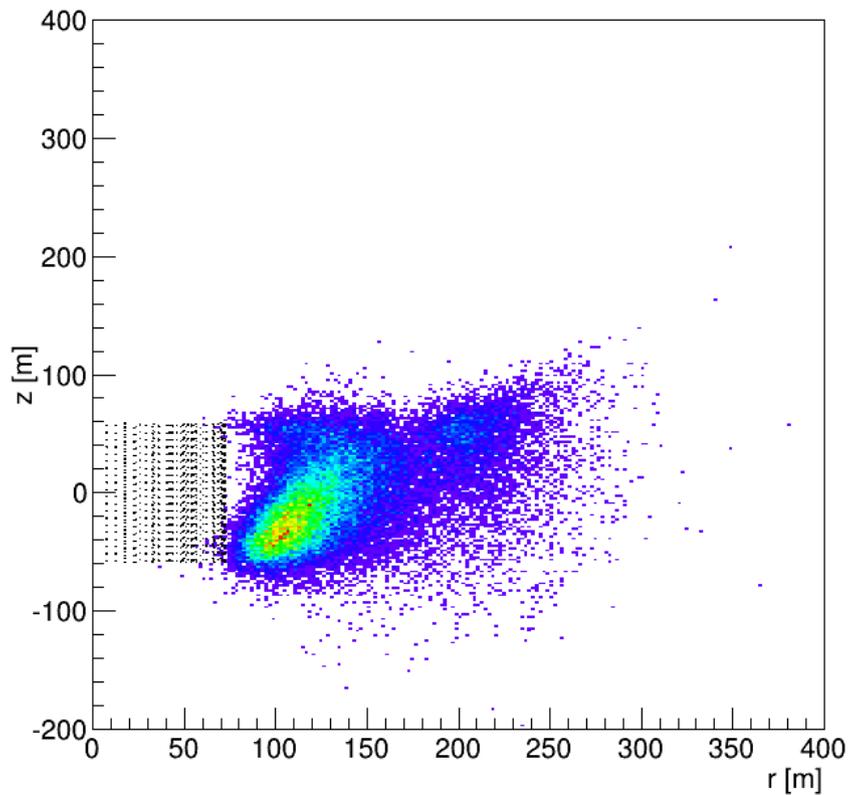


Atmospheric muons

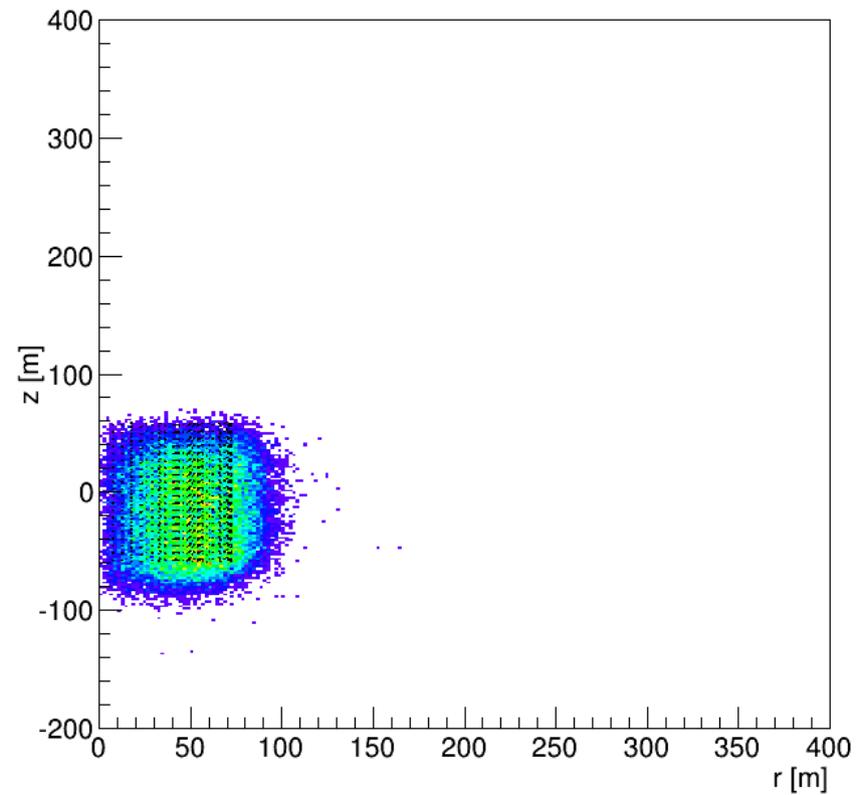


Atmospheric neutrinos

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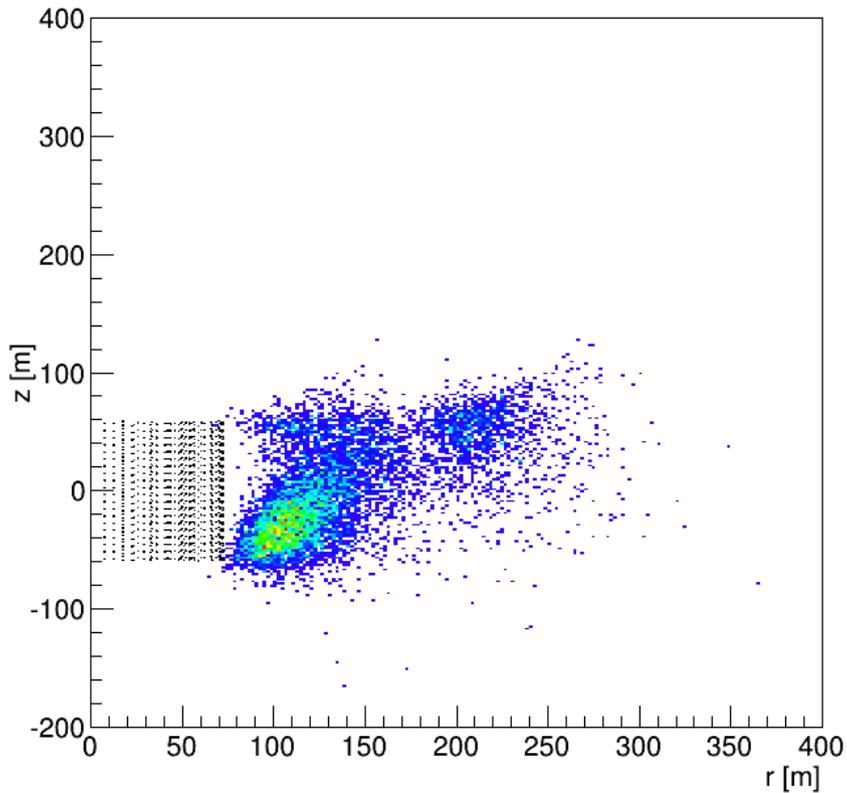


Atmospheric muons

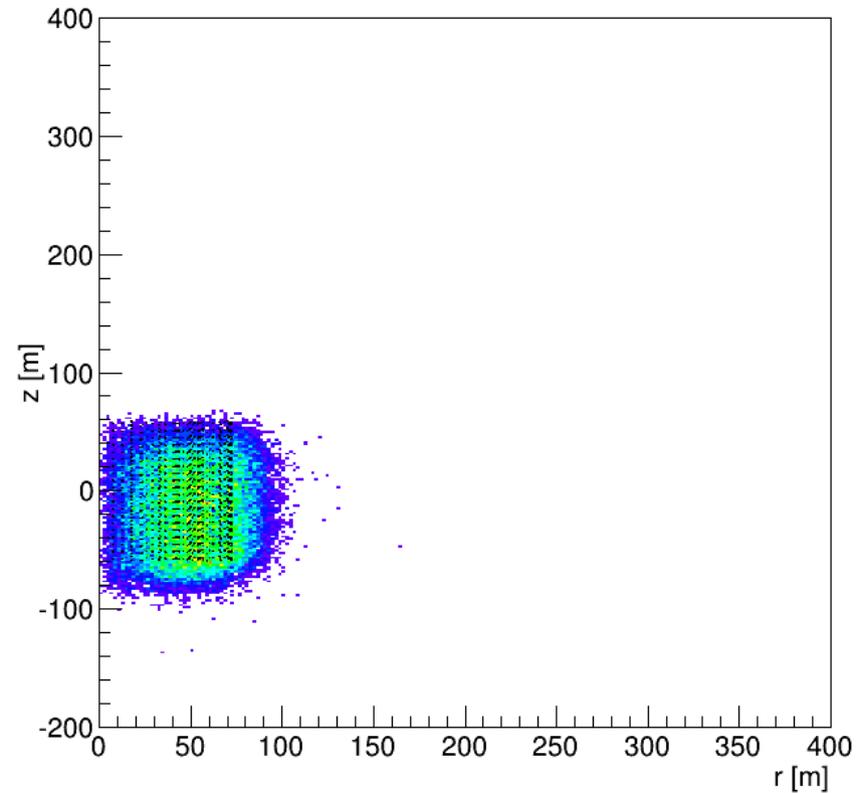


Atmospheric neutrinos,
 $E_\nu < 20$ GeV

Track starting point (upgoing - $\beta < 2^\circ$, $\Lambda > -4.2$)



Atmospheric muons

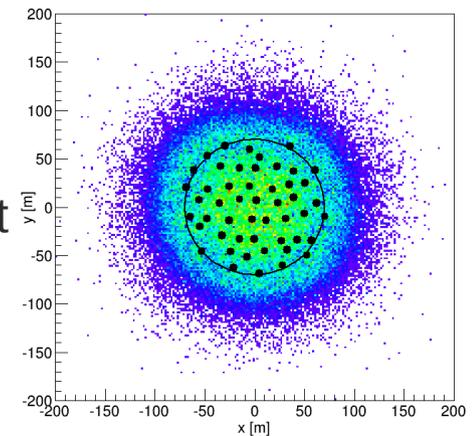
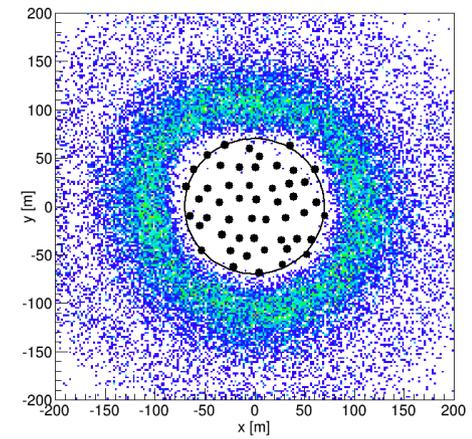
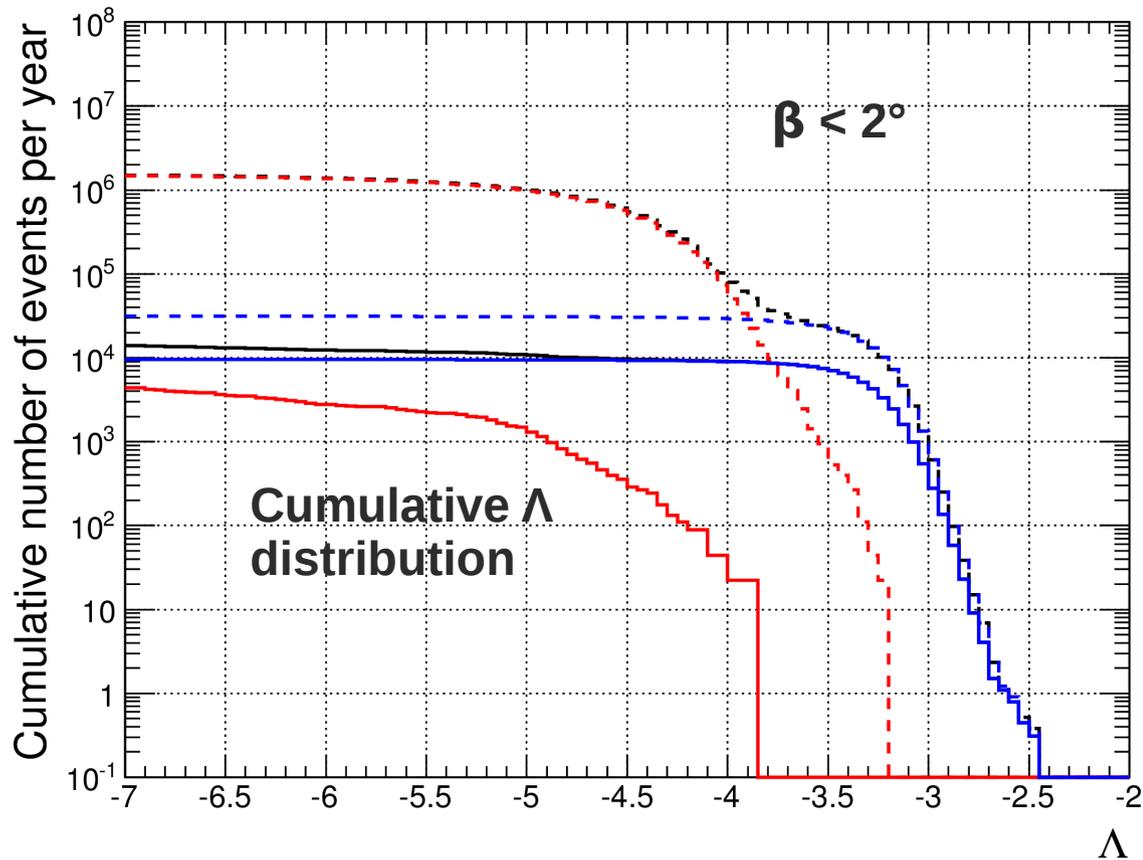


Atmospheric neutrinos,
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Using the track starting point

A combination of Λ , β and R_v is effective in the rejection of upgoing reconstructed atmospheric muons

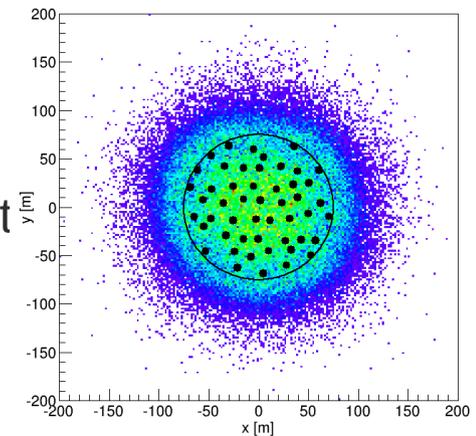
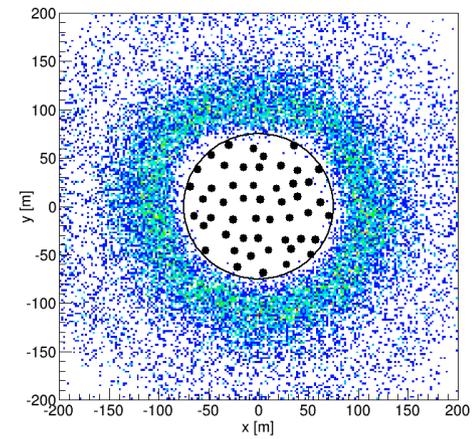
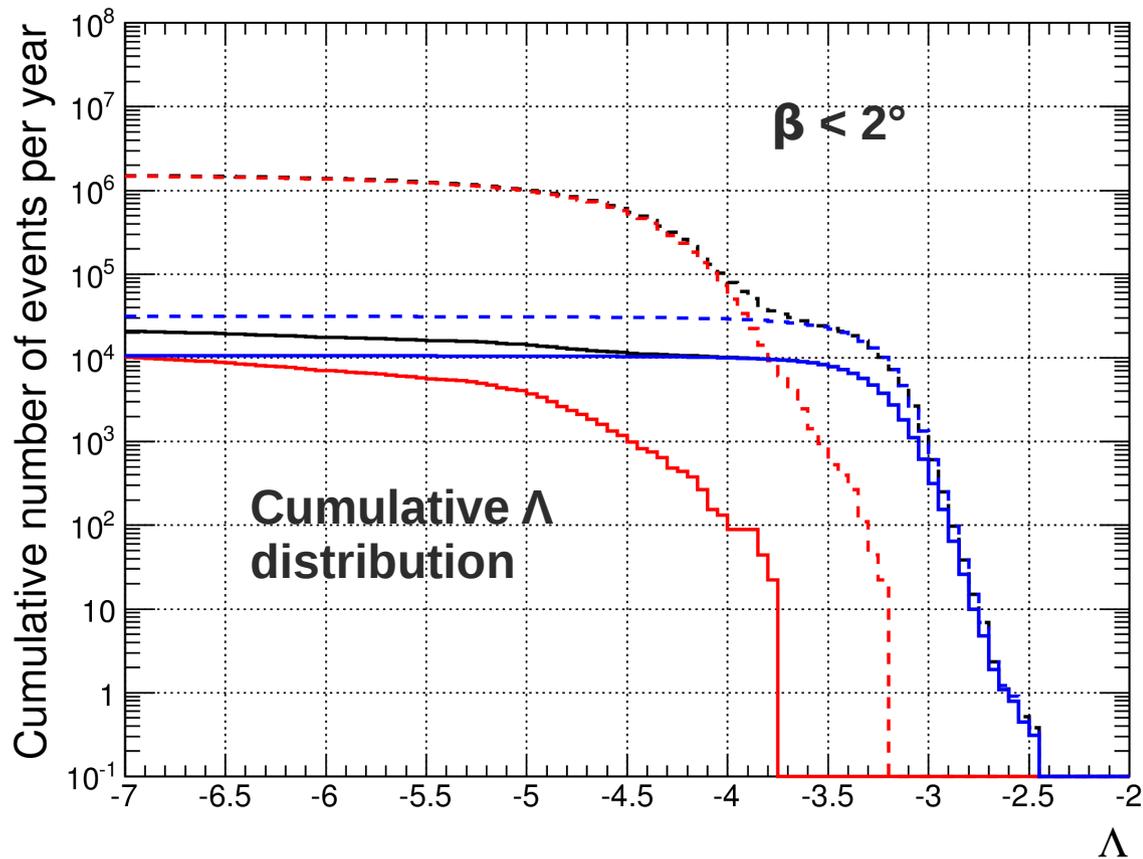
C_μ 10%
 $\Lambda > -4.8$



Using the track starting point

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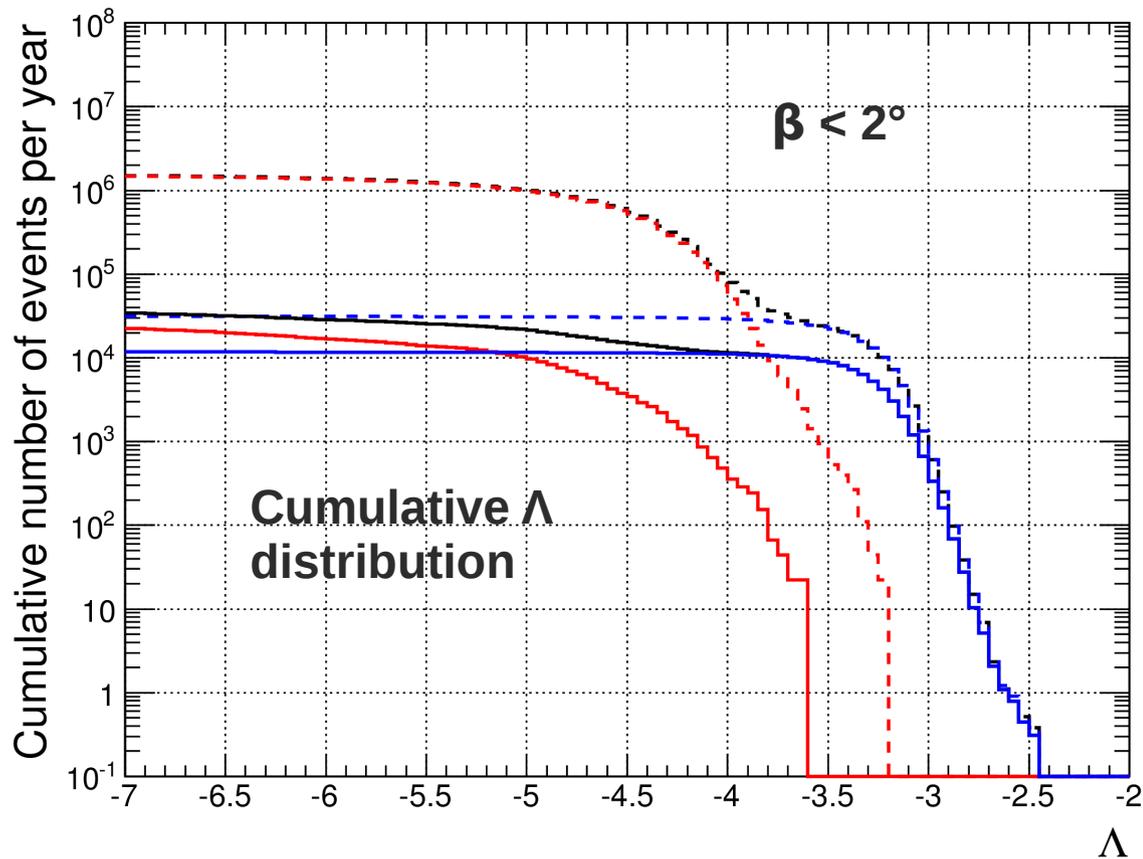
C_μ 10%
 $\Lambda > -4.5$



Using the track starting point

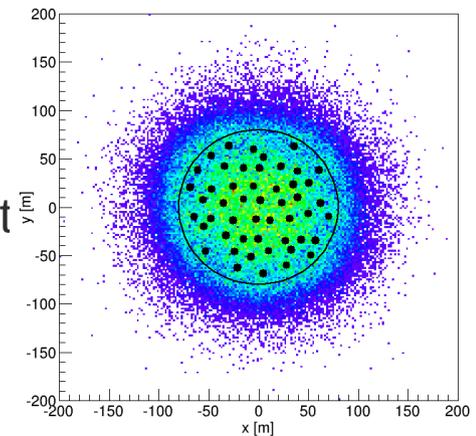
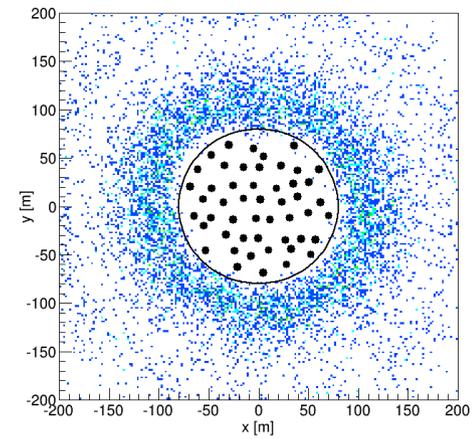
A combination of Λ , β and R_v is effective in the rejection of upgoing reconstructed atmospheric muons

C_μ 10%
 $\Lambda > -4.2$



Atms. μ
 Atms. ν
 ALL MC

Solid: $R_v < 80\text{m}$
 Dashed: no R cut



Using the track starting point

$$\beta < 2^\circ$$

$R_v < 70$ m

C_μ	Λ cut	# ν /yr	# ν_L /yr	# μ /yr
10%	-4.8	~ 10 k	~4.2 k	~ 1 k
1%	-4.2	~ 9 k	~4.1 k	~ 90

$R_v < 75$ m

C_μ	Λ cut	# ν /yr	# ν_L /yr	# μ /yr
10%	-4.5	~ 10 k	~4.8 k	~ 1 k
1%	-4.0	~ 9 k	~4.4 k	~ 90

$R_v < 80$ m

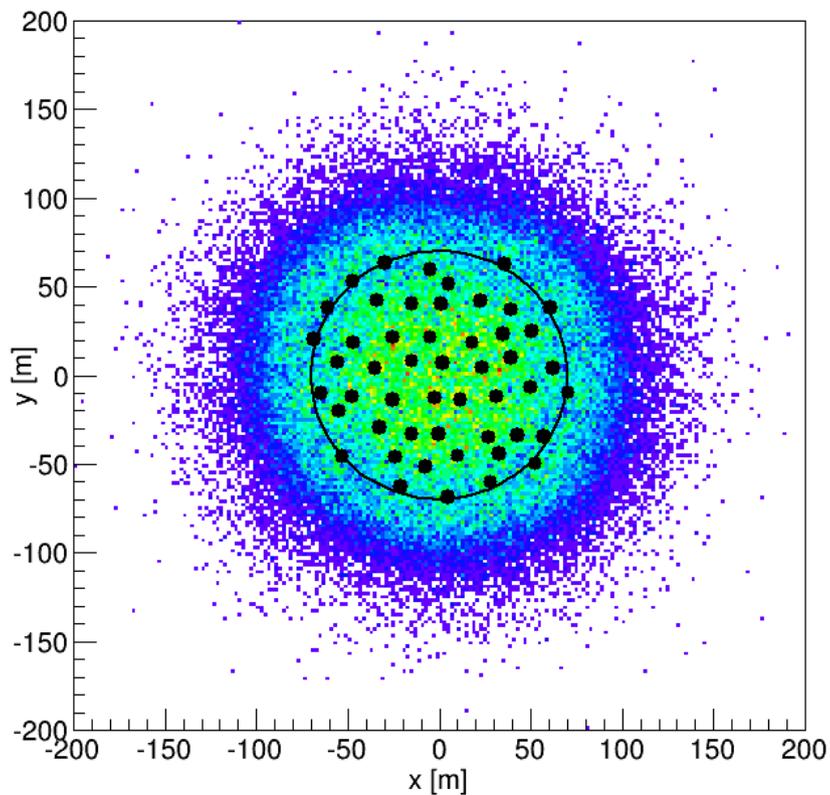
C_μ	Λ cut	# ν /yr	# ν_L /yr	# μ /yr
10%	-4.2	~ 11 k	~ 4.5 k	~ 1 k
1%	-3.7	~ 9 k	~4.2 k	~ 90

Upgoing
reconstructed tracks

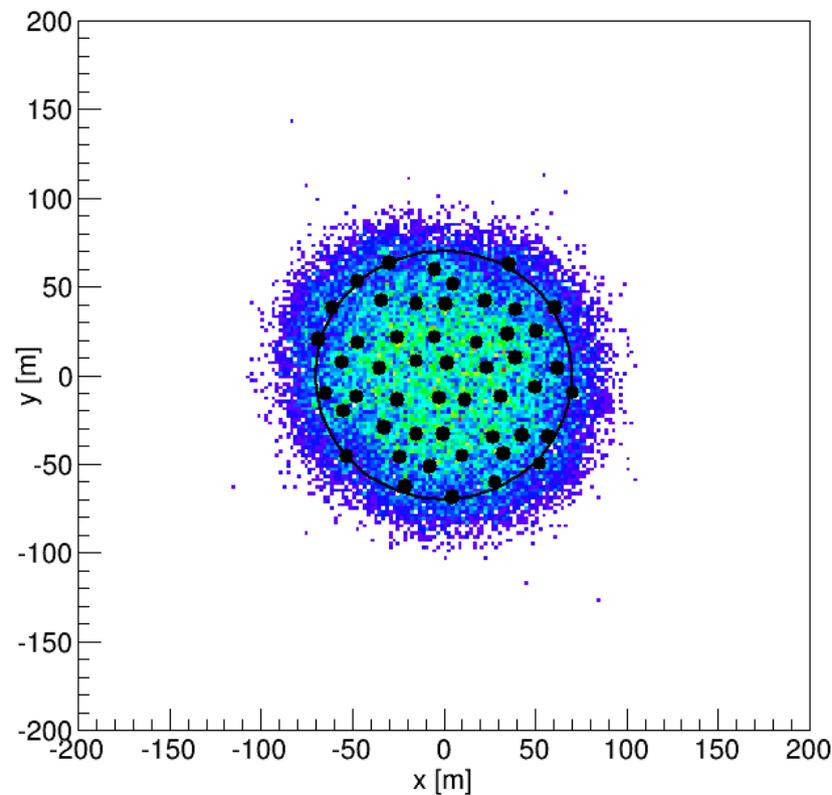
Track starting point (upgoing – $\beta < 2^\circ$, $\Lambda > -4.8$)

70 m radius

C_μ 10%



Atmospheric neutrinos,
all energies

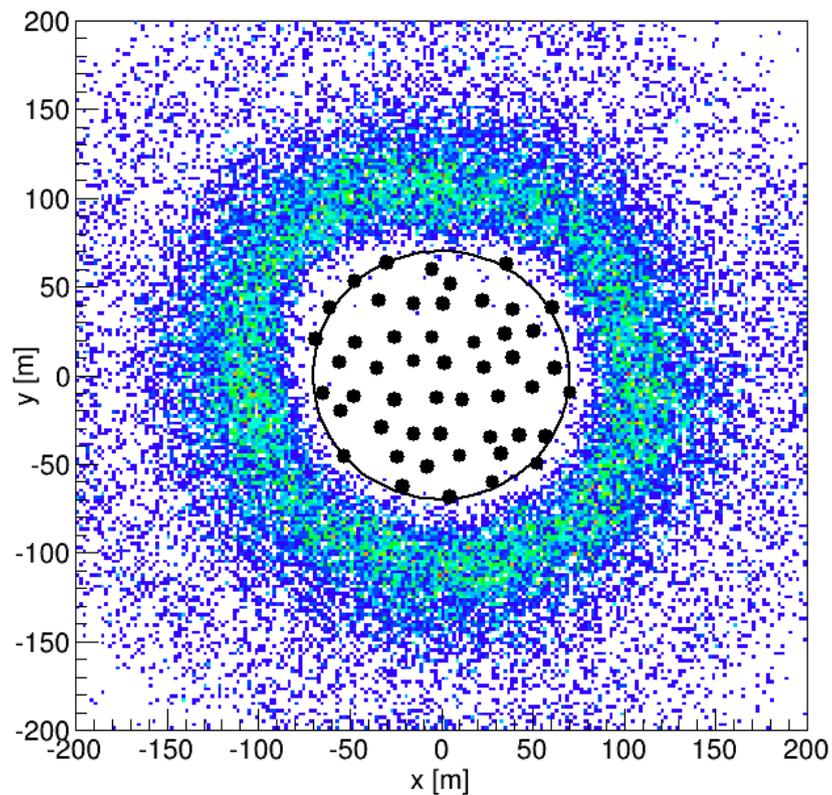


Atmospheric neutrinos,
 $E_\nu < 20$ GeV

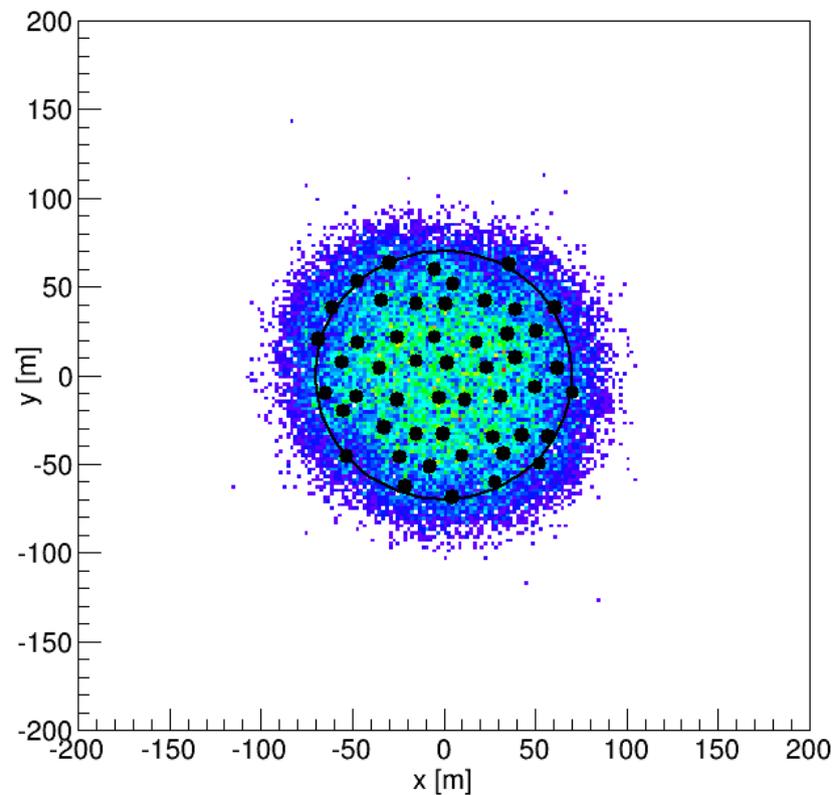
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Atmospheric muons

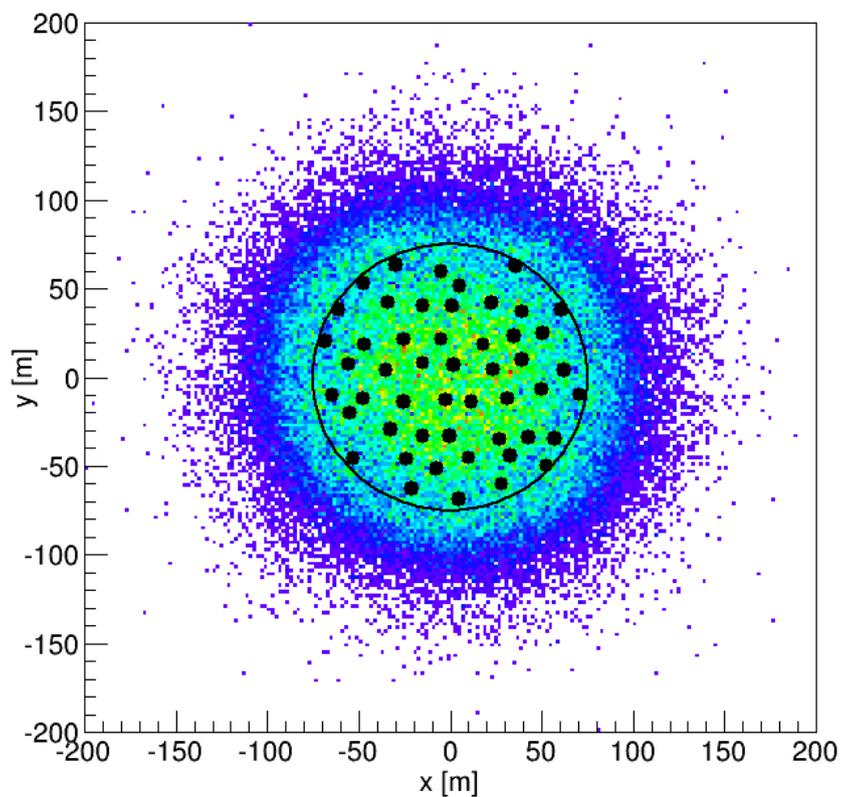


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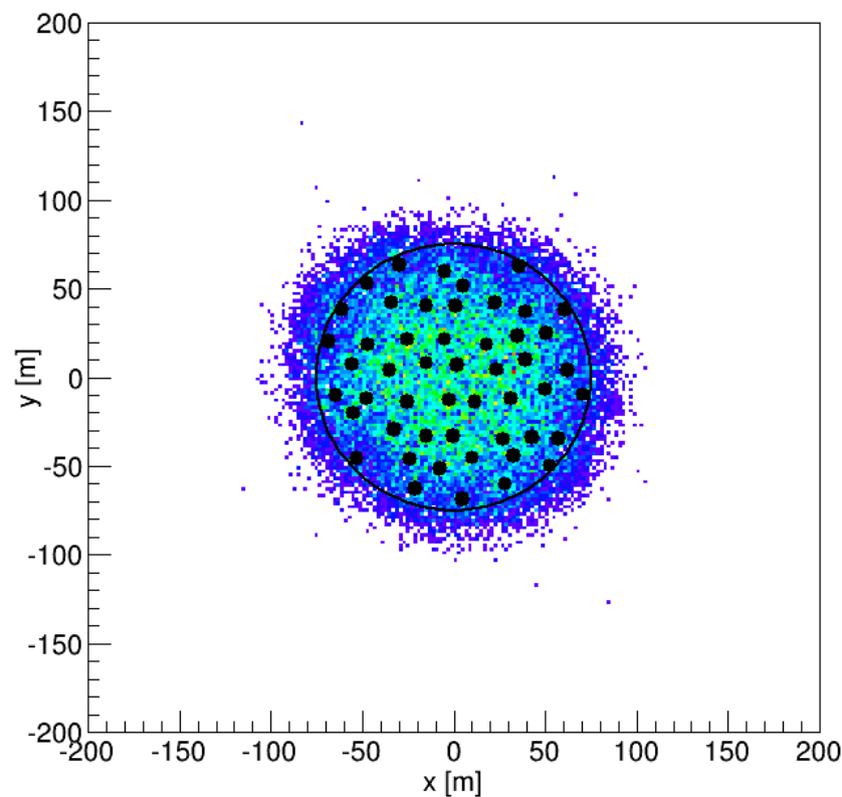
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75 m radius

C_μ 10%



Atmospheric neutrinos,
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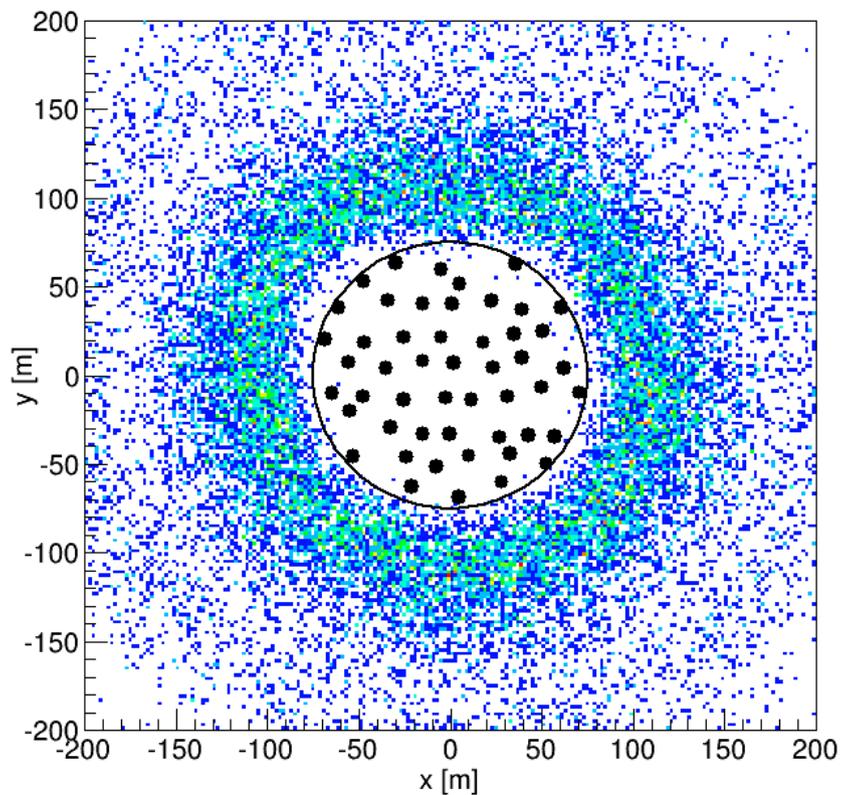


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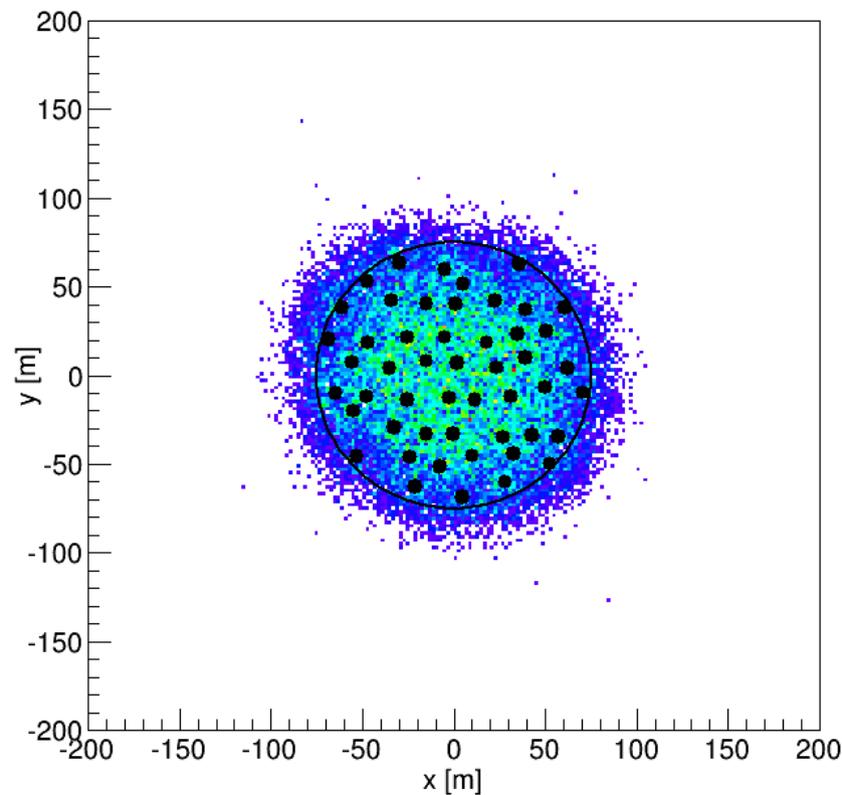
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C_μ 10%



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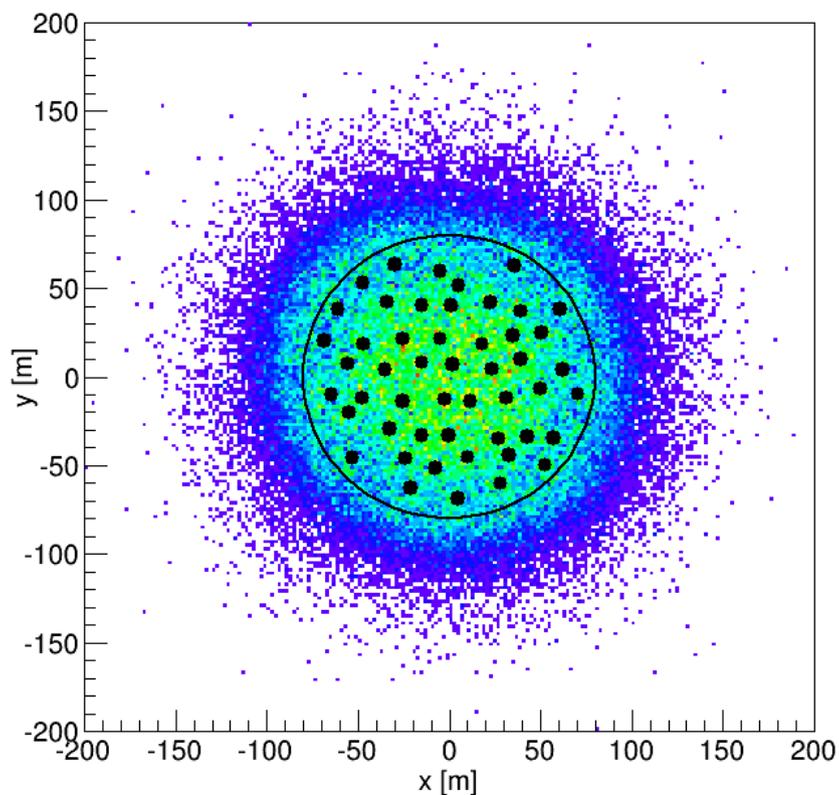


Atmospheric neutrinos,
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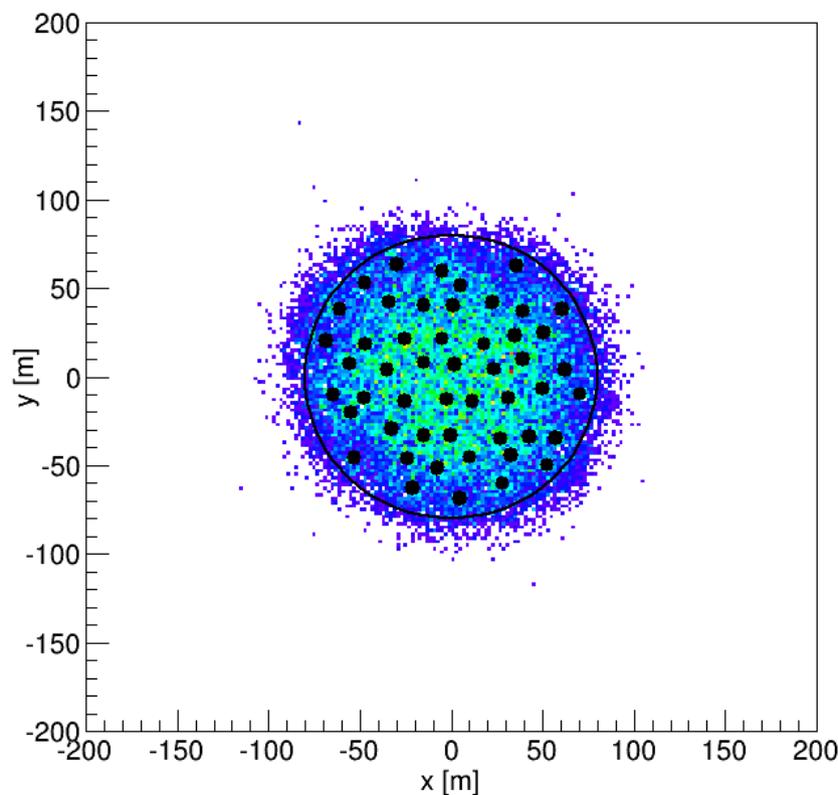
Track starting point (upgoing – $\beta < 2^\circ$, $\Lambda > -4.2$)

80 m radius

C_μ 10%



Atmospheric neutrinos,
all energies

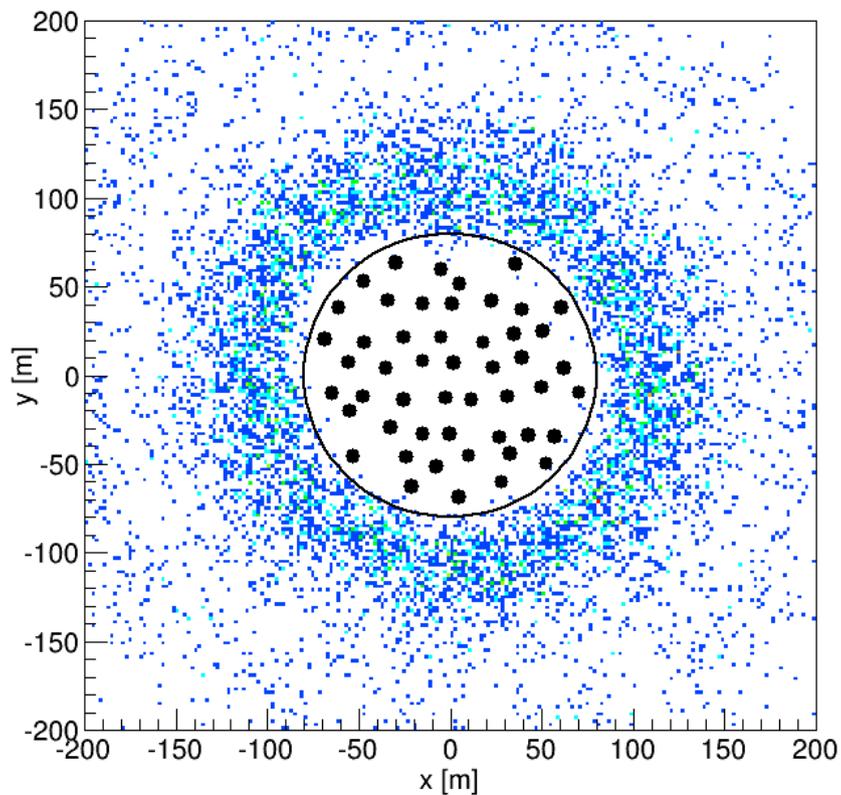


Atmospheric neutrinos,
 $E_\nu < 20$ GeV

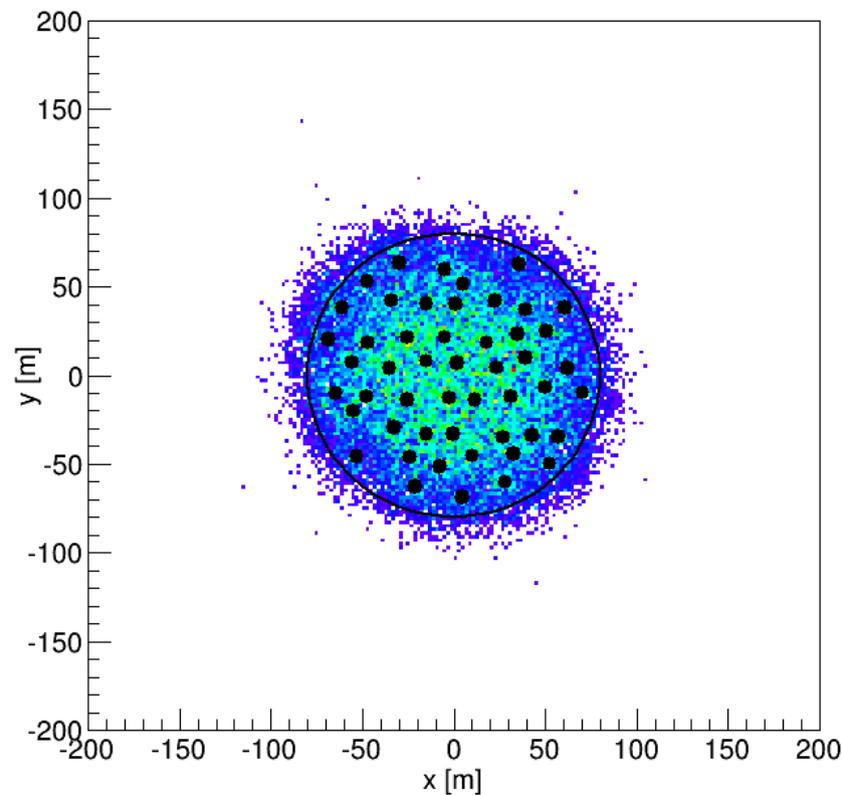
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Atmospheric muons



Atmospheric neutrinos,
 $E_\nu < 20$ GeV

Conclusions

- Hard track quality parameter cuts allow muon rejection – significant loss of low energy neutrinos.

⇒ Track starting point requirement

- Loose β cut and quite loose Λ cut region accessible for a few percent muon contamination.
- 3 possible combinations of R_ν , Λ and β give similar results.
- Atmospheric muon rejection is feasible with ORCA.