

# Filterstudie für einen Online Kaskaden-Filter zum Nachweis von GRB mit dem IceCube-Detektor

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# Inhalt

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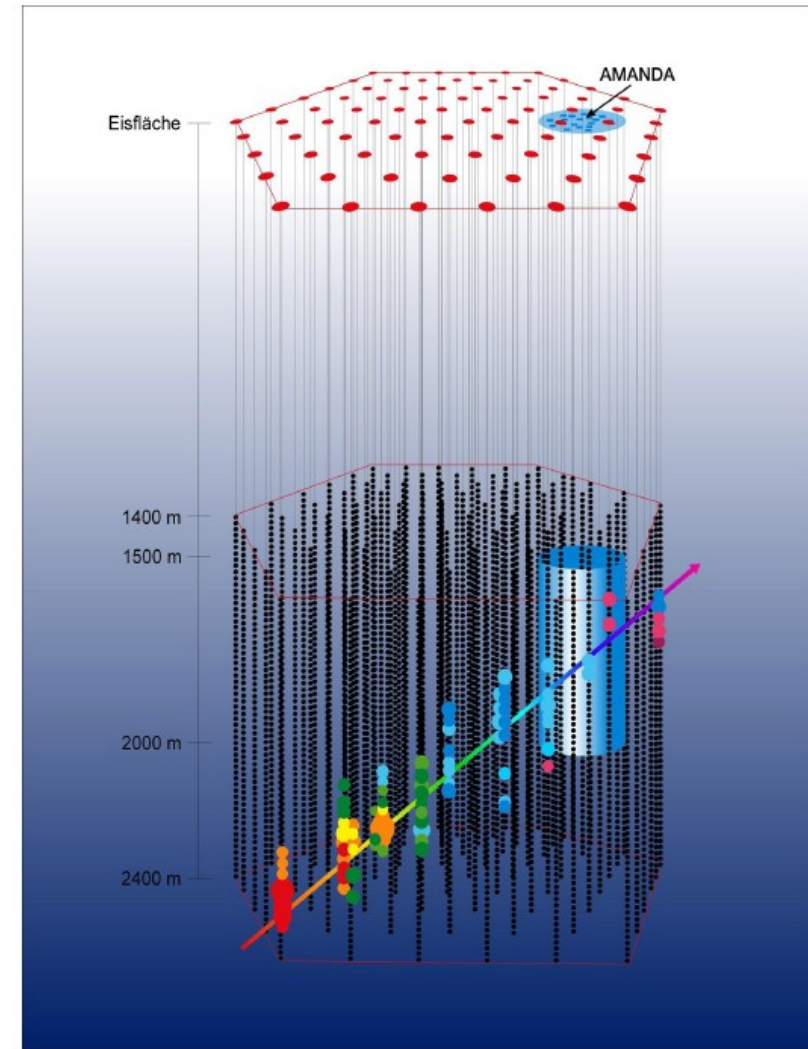
- IceCube Detector
- Motivation
- Filterstudie
  - Cutvariable basierend auf **Soft Local Coincidences**
  - Ergebnisse
- Zusammenfassung

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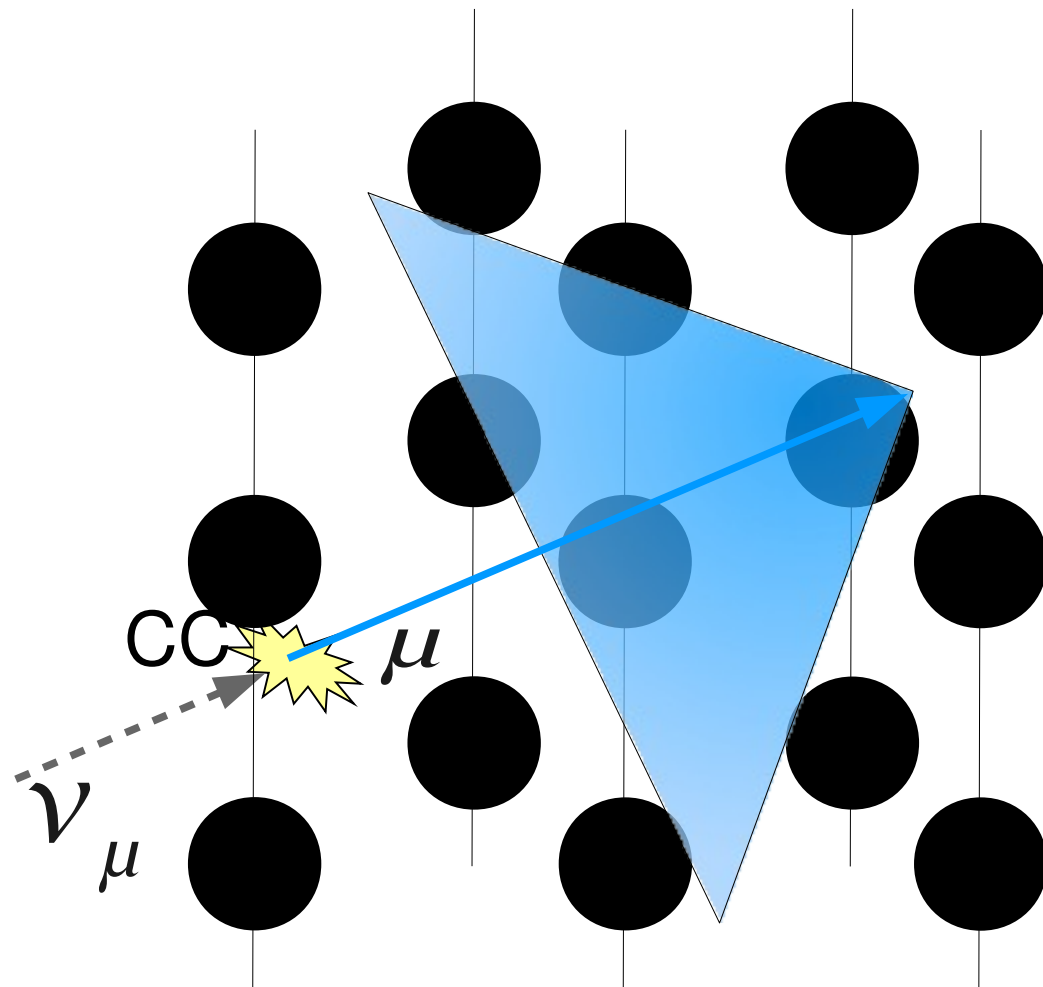
# IceCube Detector

# IceCube

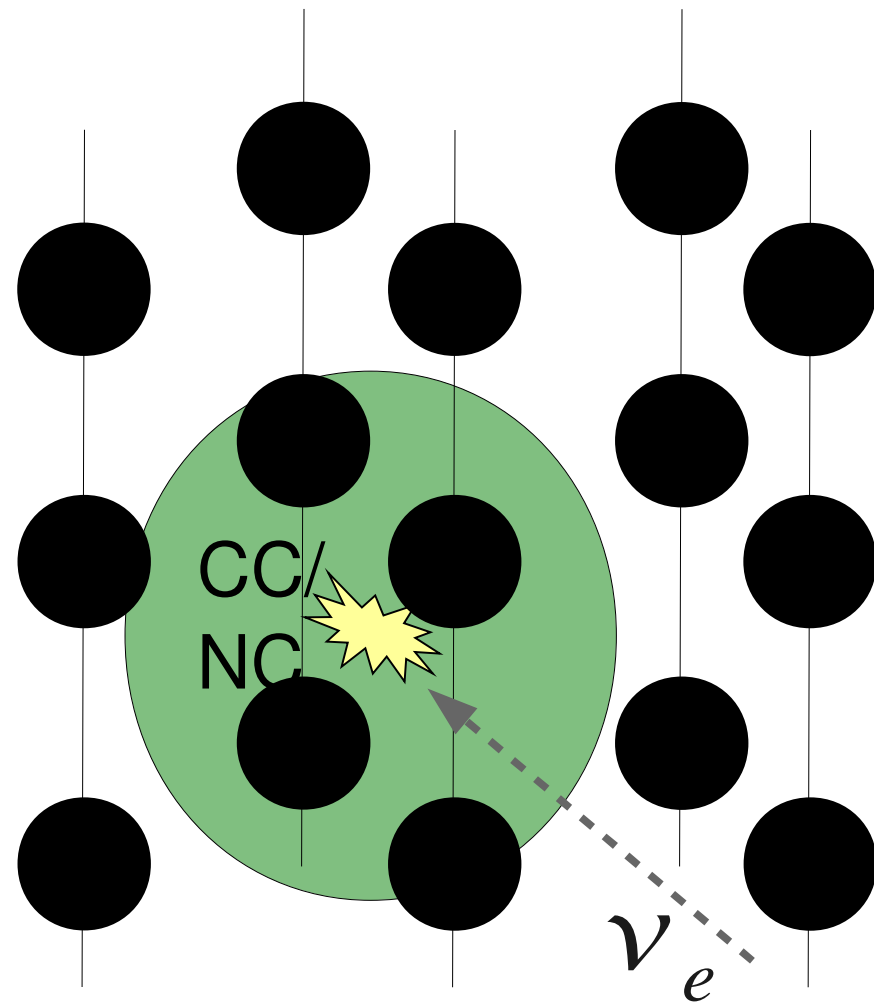
- Neutrino Detektor am Südpol
- **59 Strings installiert in 125 m Entfernung**
- 60 optische Module (DOMs) pro String in 17m Abstand
- Detektion von Muon Neutrinos über das emittierte Cherenkov-Licht entlang einer langen Spur
- Spurrekonstruktion aus einzelnen DOM-Hits -> Neutrino-Richtung
- Beschränkung auf hoch-laufende Events zur um Hintergrund durch atmosphärische Muonen zu verwerfen



# IceCube



$\mu$ -Neutrino

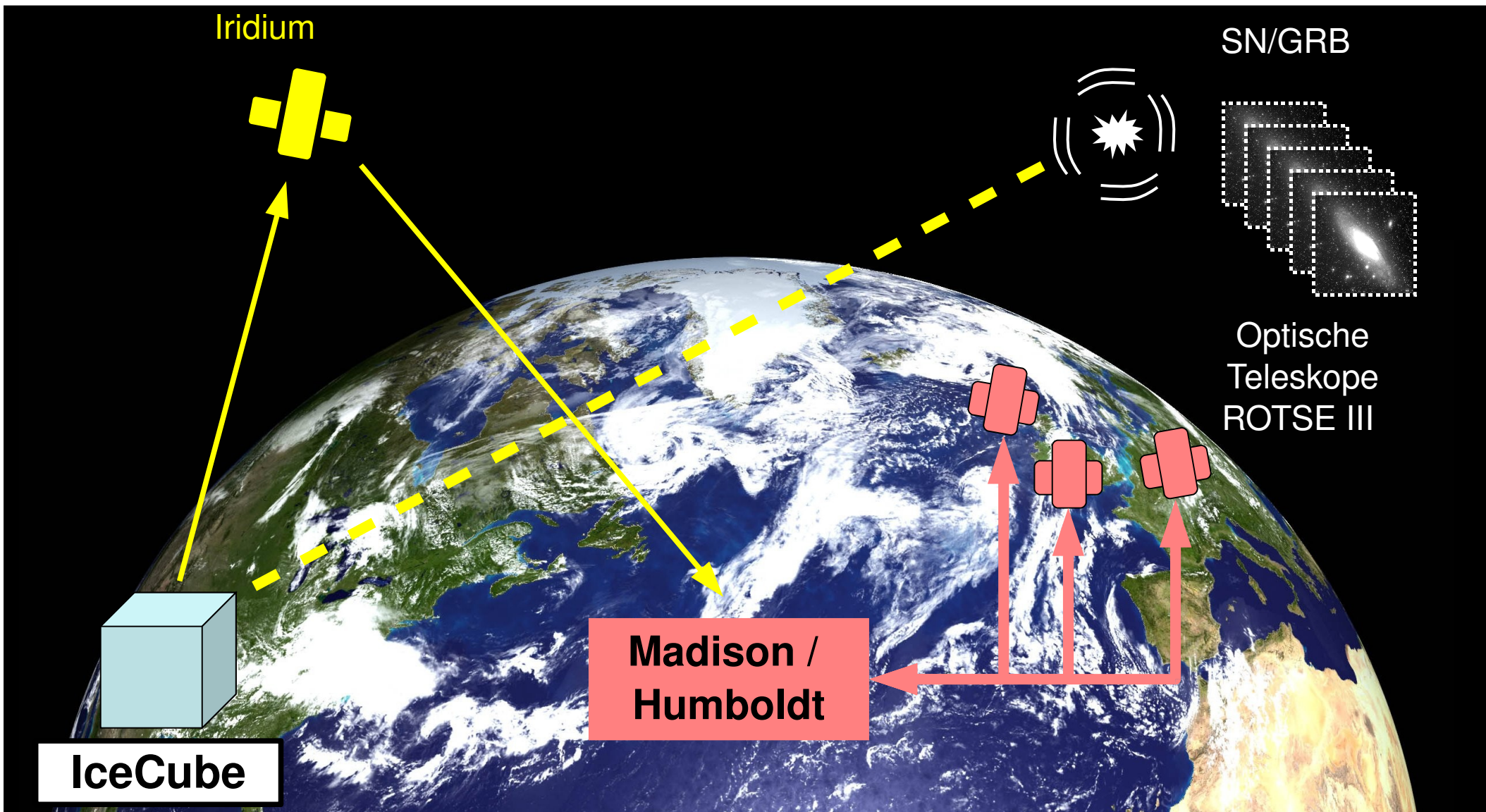


Elektron-Neutrino

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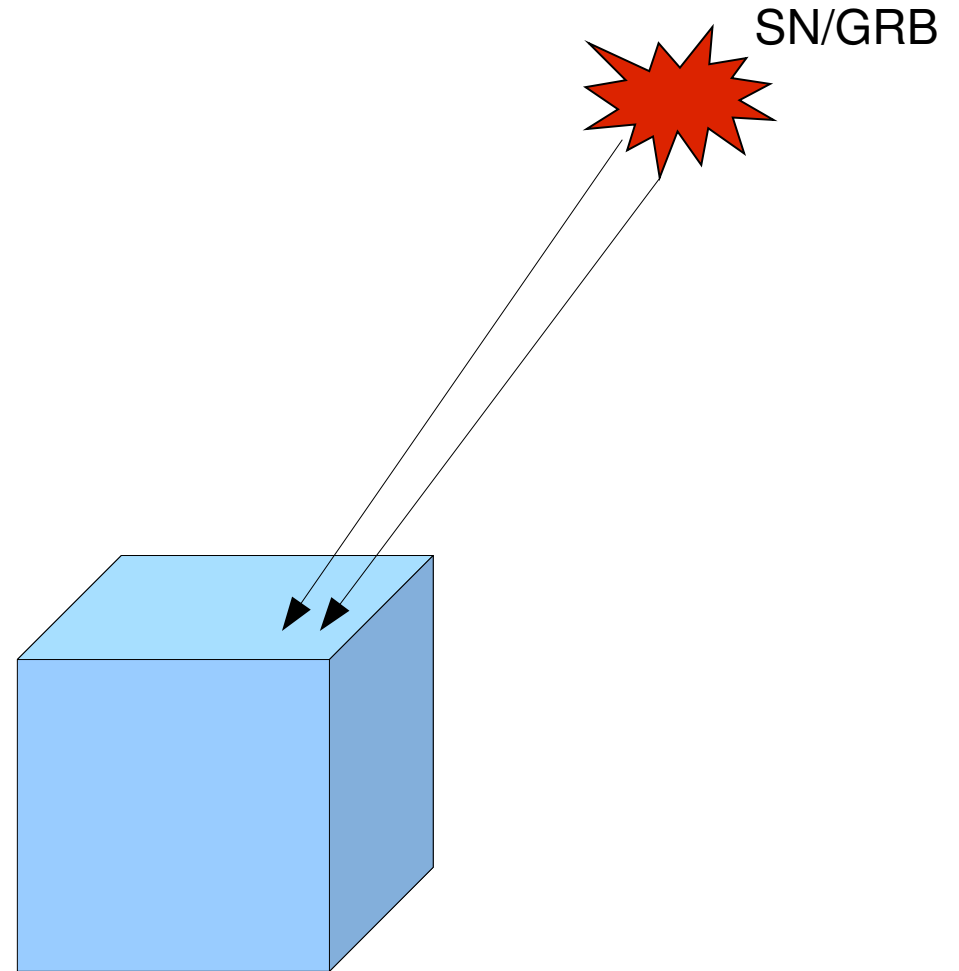
# Motivation

# Optical Follow Up



# Optical Follow Up

- Neutrinkoinzidenzen
  - Zwei  $\mu$ -Neutrinos innerhalb von 100 s und aus der gleichen Richtung
- Idee: Ausweitung auf andere NeutrinoKanäle
- Max. 25 Alerts pro Jahr





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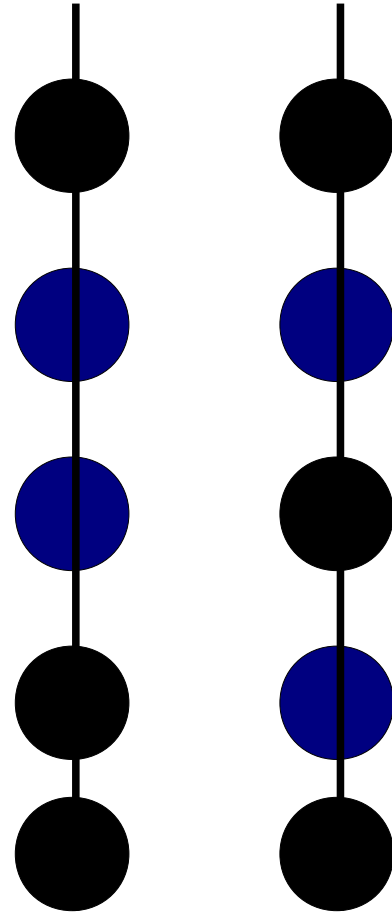
# Kaskaden-Filter

Cutvariable basierend auf Soft Local  
Coincidences (SLCs)

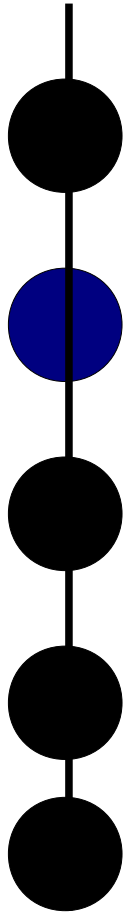
# SLC

- Was ist ein SLC?

**Hard Local  
Coincidence**



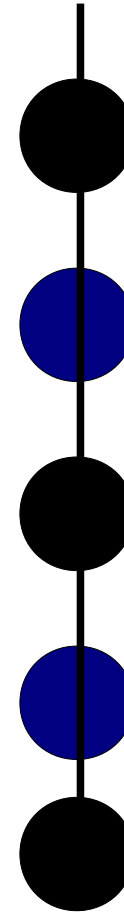
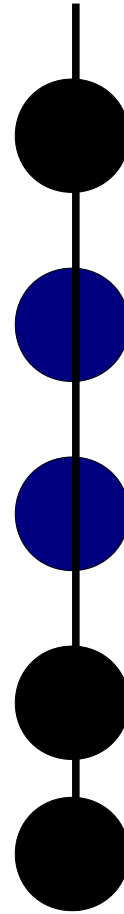
**SLC**



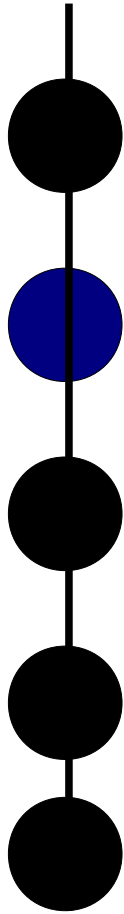
# SLC

- Was ist ein SLC?
- Zwei Nutzungsmöglichkeiten:
  - Nutze sie zur Rekonstruktion
  - Nutze sie als Veto

HLC

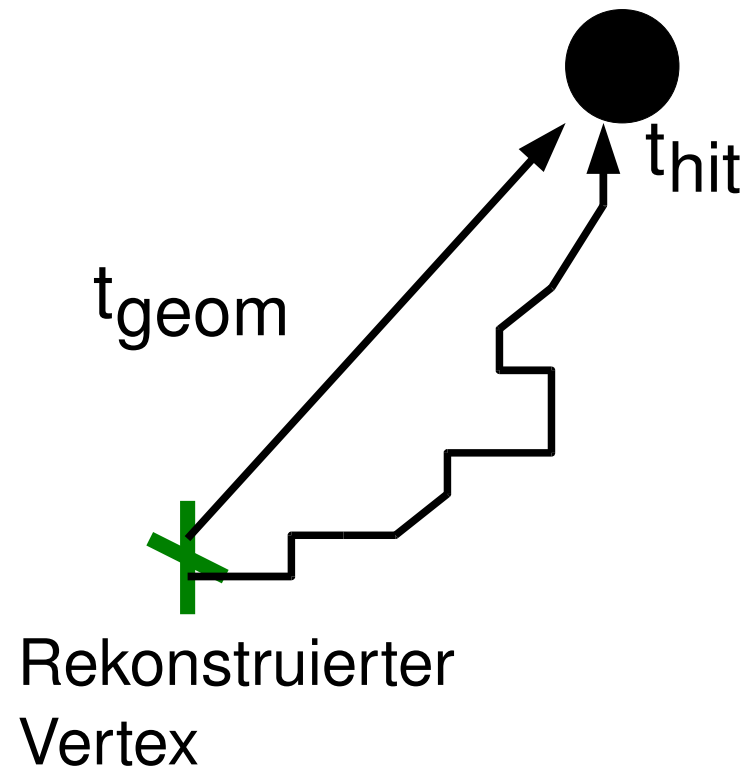


SLC



# SLCs – time residuals

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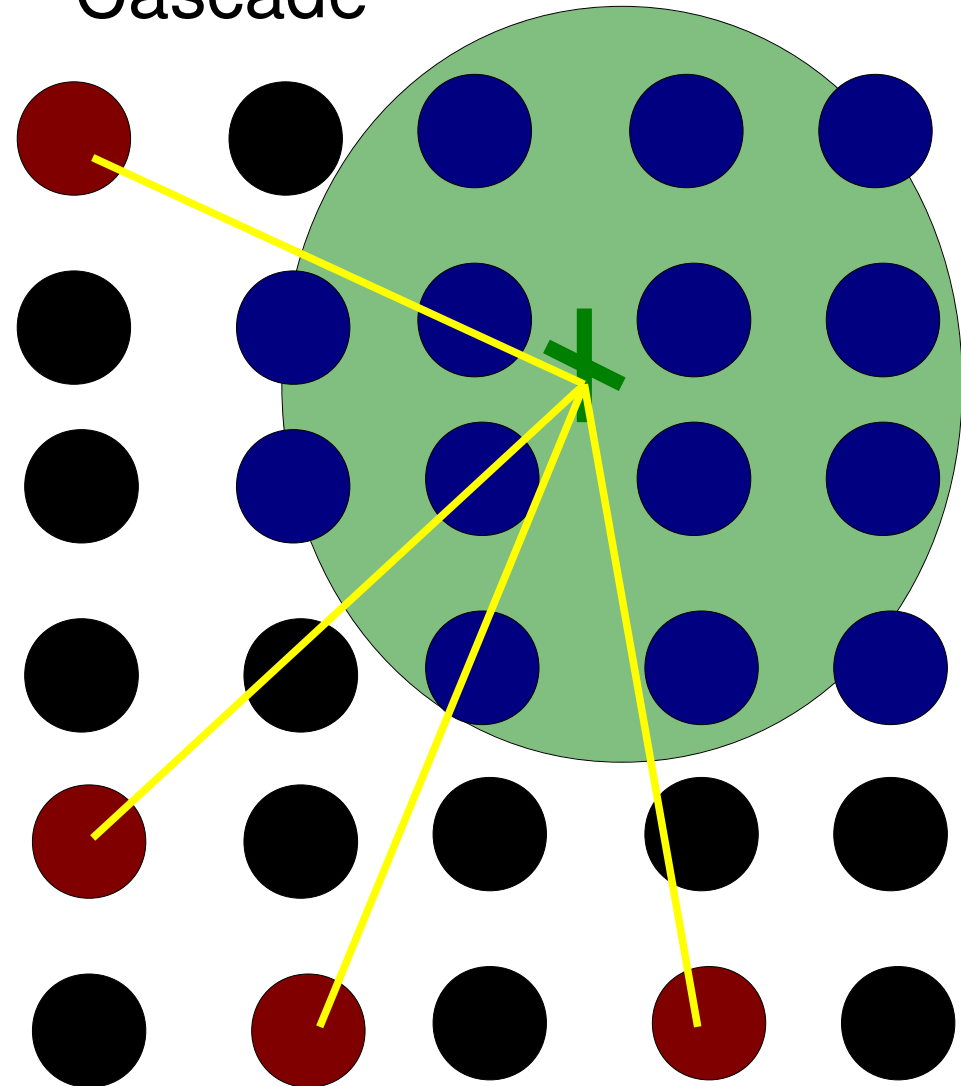


$$\begin{aligned} \text{Time residual} \\ &= \\ &t_{hit} - t_{geom} \end{aligned}$$

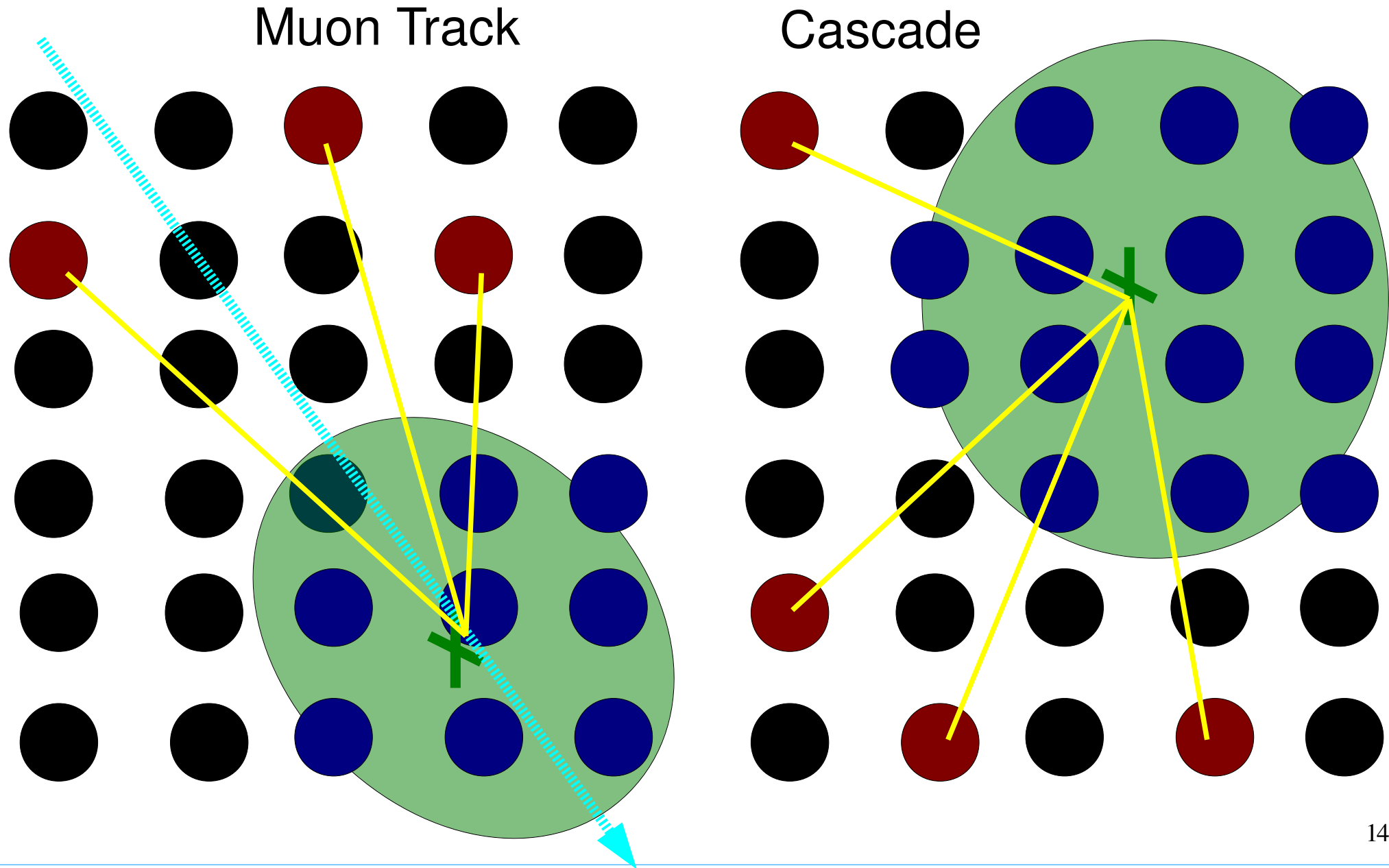
# SLCs – time residuals

- SLCs um “HLC-Kugel” verteilt
- Berechne Time-Residuals
- Time-residual sind größer bei höheren Energien

Cascade

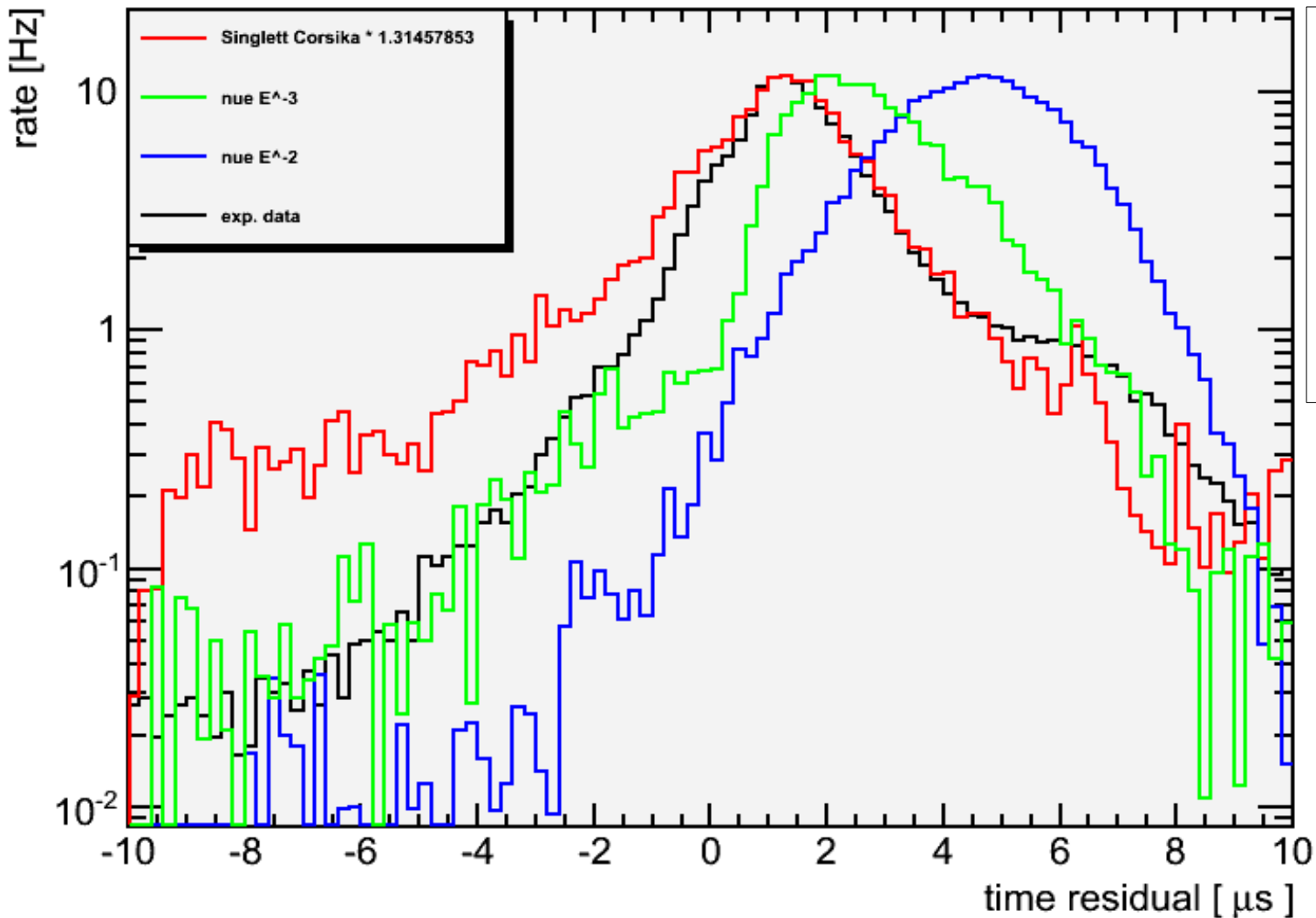


# SLCs – time residuals



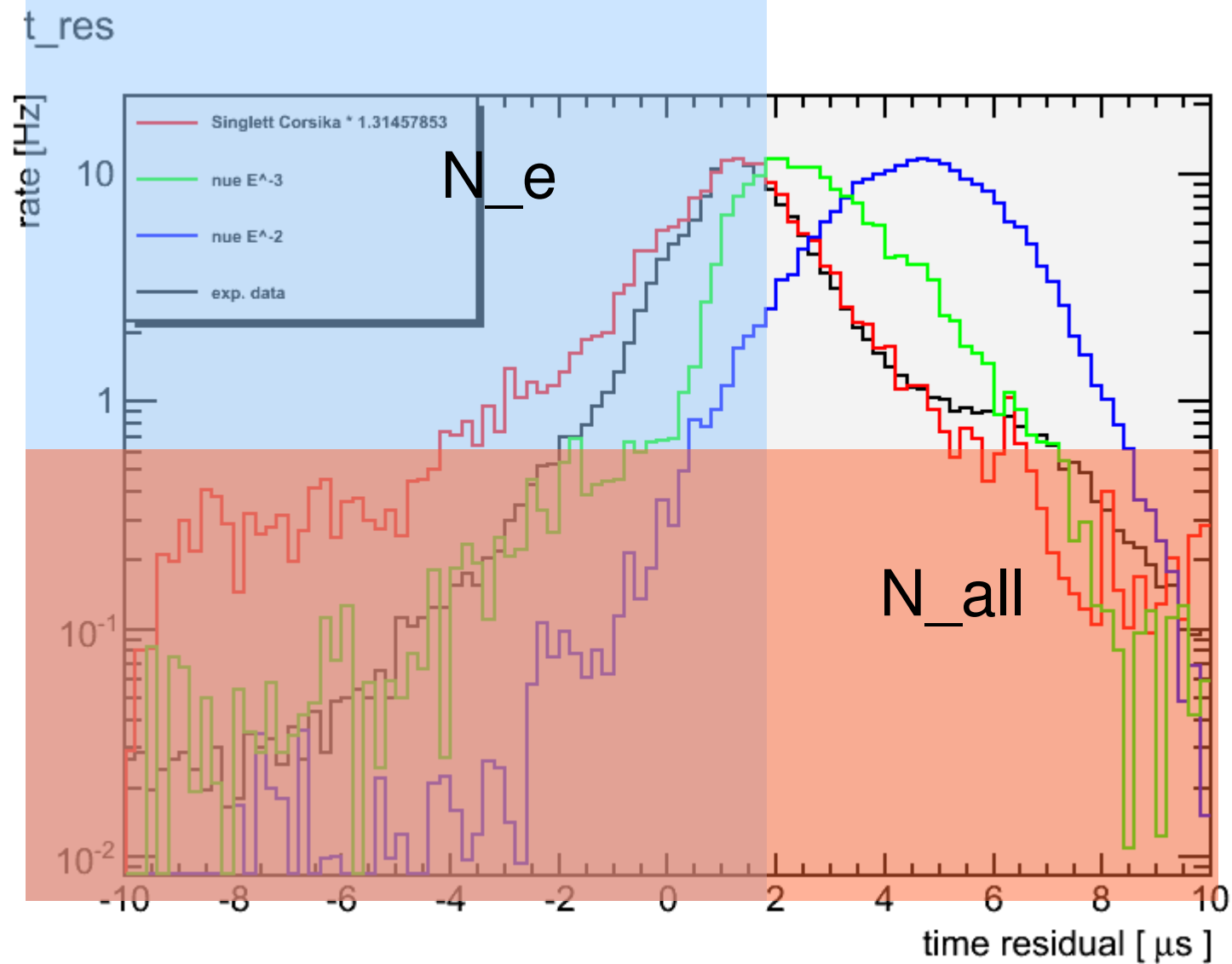
# Time residual

t\_res



Daten  
MC Hintergrund  
E<sup>-2</sup> Signal  
E<sup>-3</sup> Signal

# Time residual

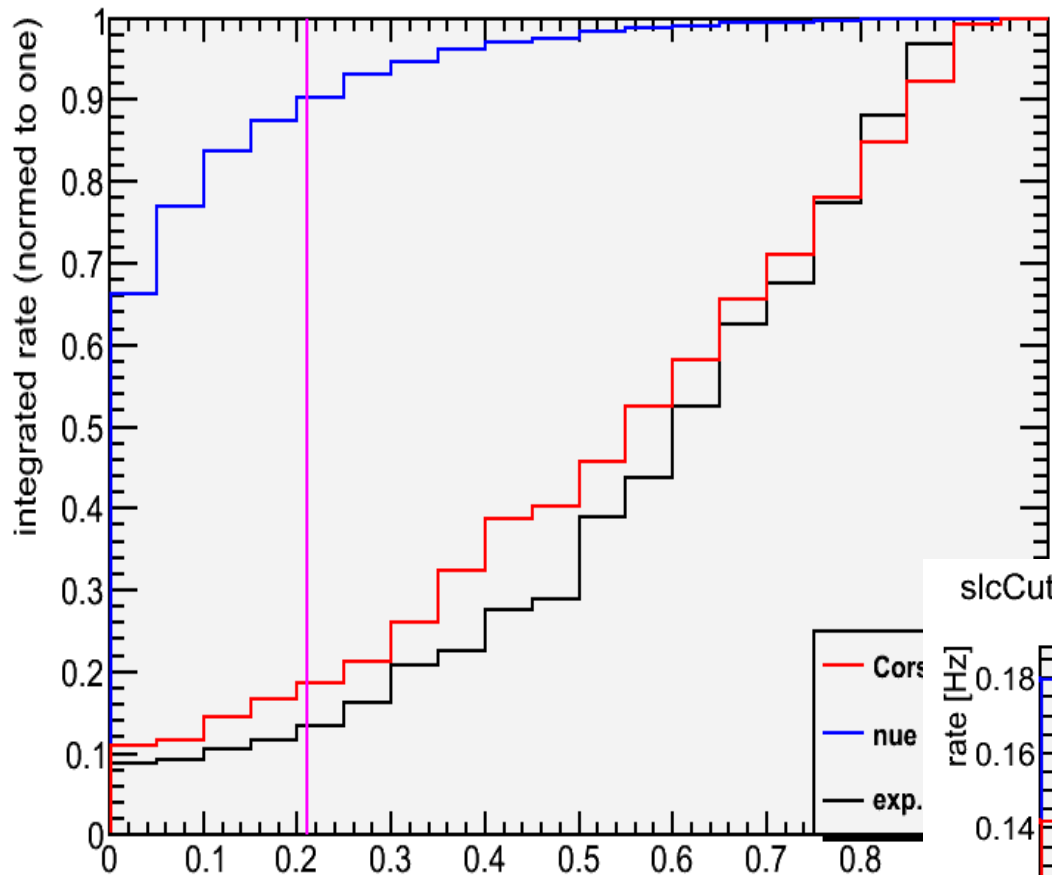


Daten  
MC Hintergrund  
 $E^{-2}$  Signal  
 $E^{-3}$  Signal

$$\text{SlcCut} = N_e / N_{all}$$

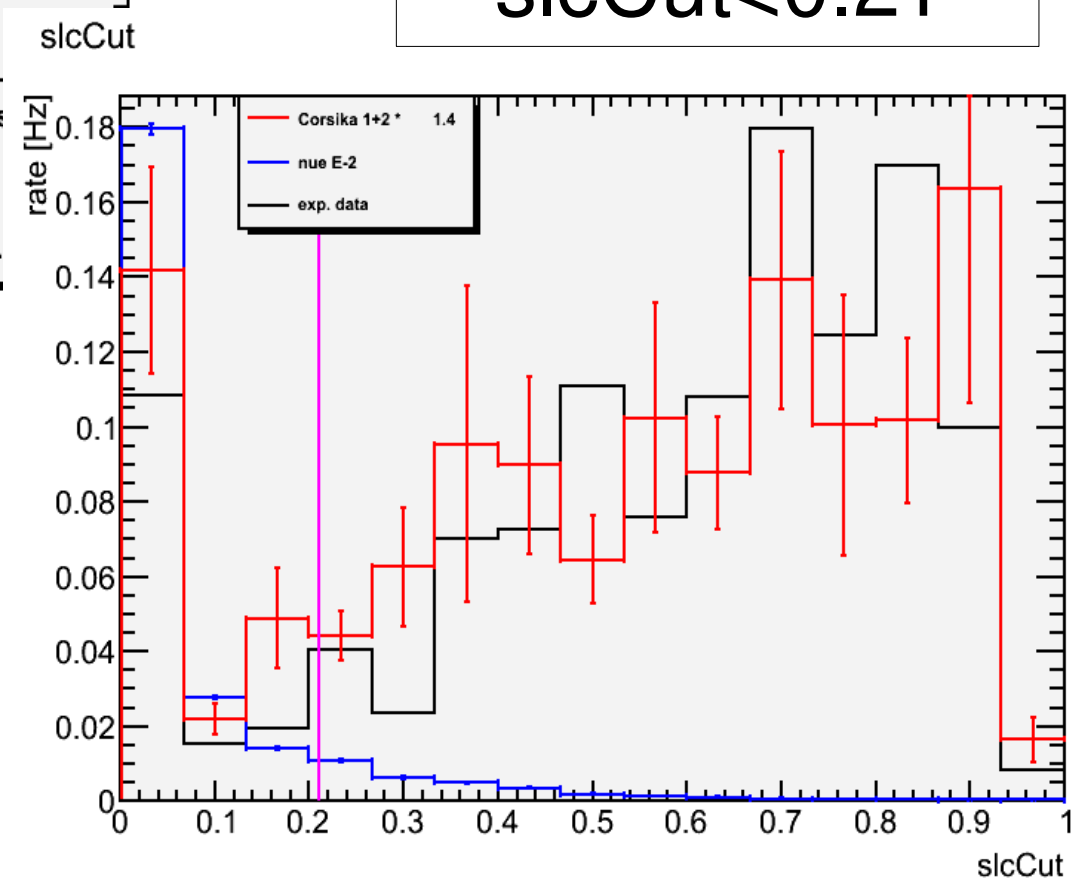


slcCut



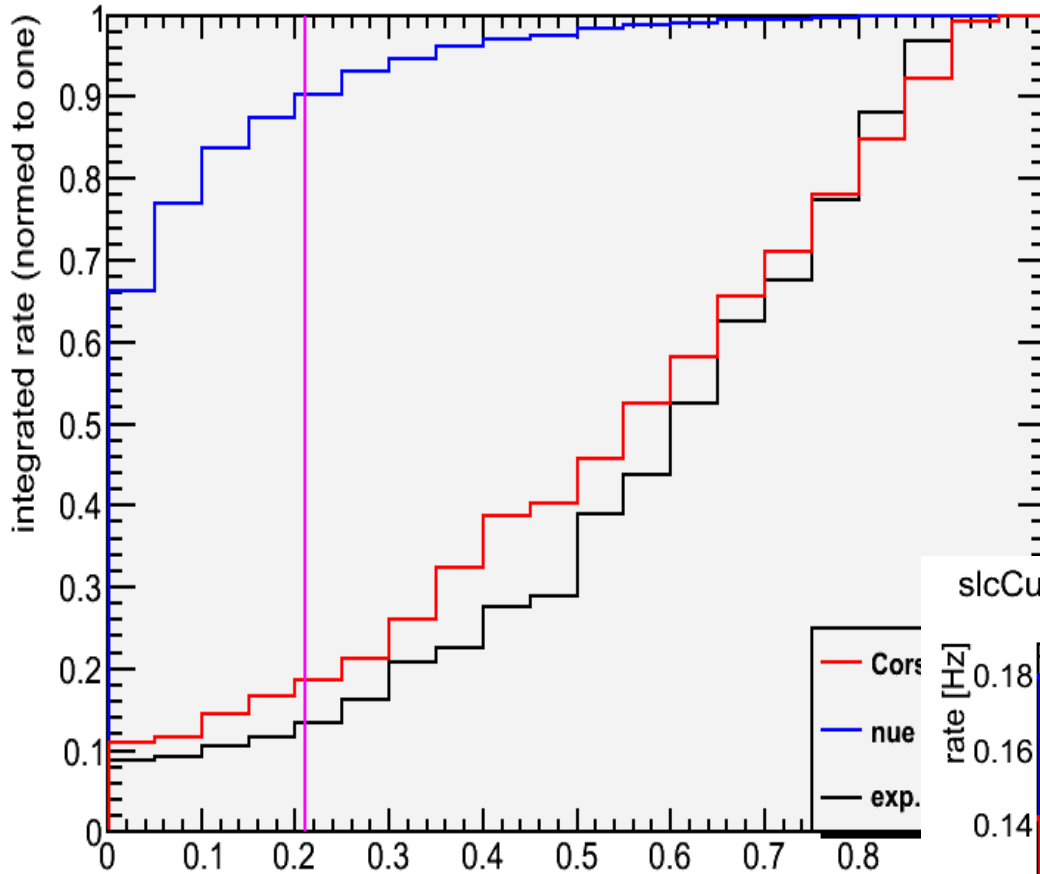
Level 2:  
Schneide bei  
 $\text{slcCut} < 0.21$

Daten  
MC Hintergrund  
 $E^{-2}$  Signal



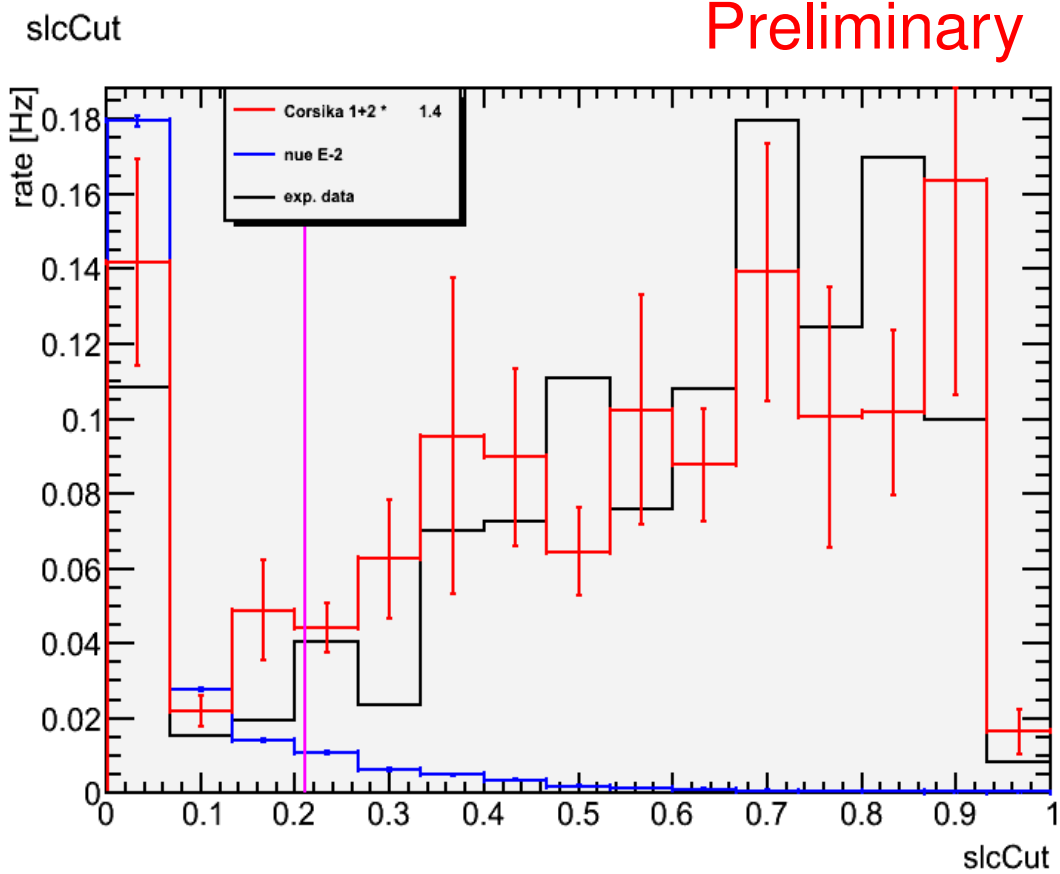
slcCut

# Ergebnisse



Ebene	Level 1	Level 4
Daten [Hz]	23.9	$2.4 \cdot 10^{-4}$
MC BG [Hz]	24.4	$10^{-4}$
MC Signal [%]	100	51.1

Daten  
 MC Hintergrund  
 E<sup>-2</sup> Signal



# Zusammenfassung

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- SLC
  - Mögliche neue Cut Variable
  - Weitere Optimierungen möglich
    - z.B. andere Hintergrundunterdrückungsmechanismen anwenden
- Kaskaden-Filter
  - Optimierung läuft noch
- Online Filter:
  - Teste Geschwindigkeit
  - Welche Bedingungen nötig für einen Alert

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Ich bedanke mich für die  
Aufmerksamkeit

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# Backup Slides

# Used Data

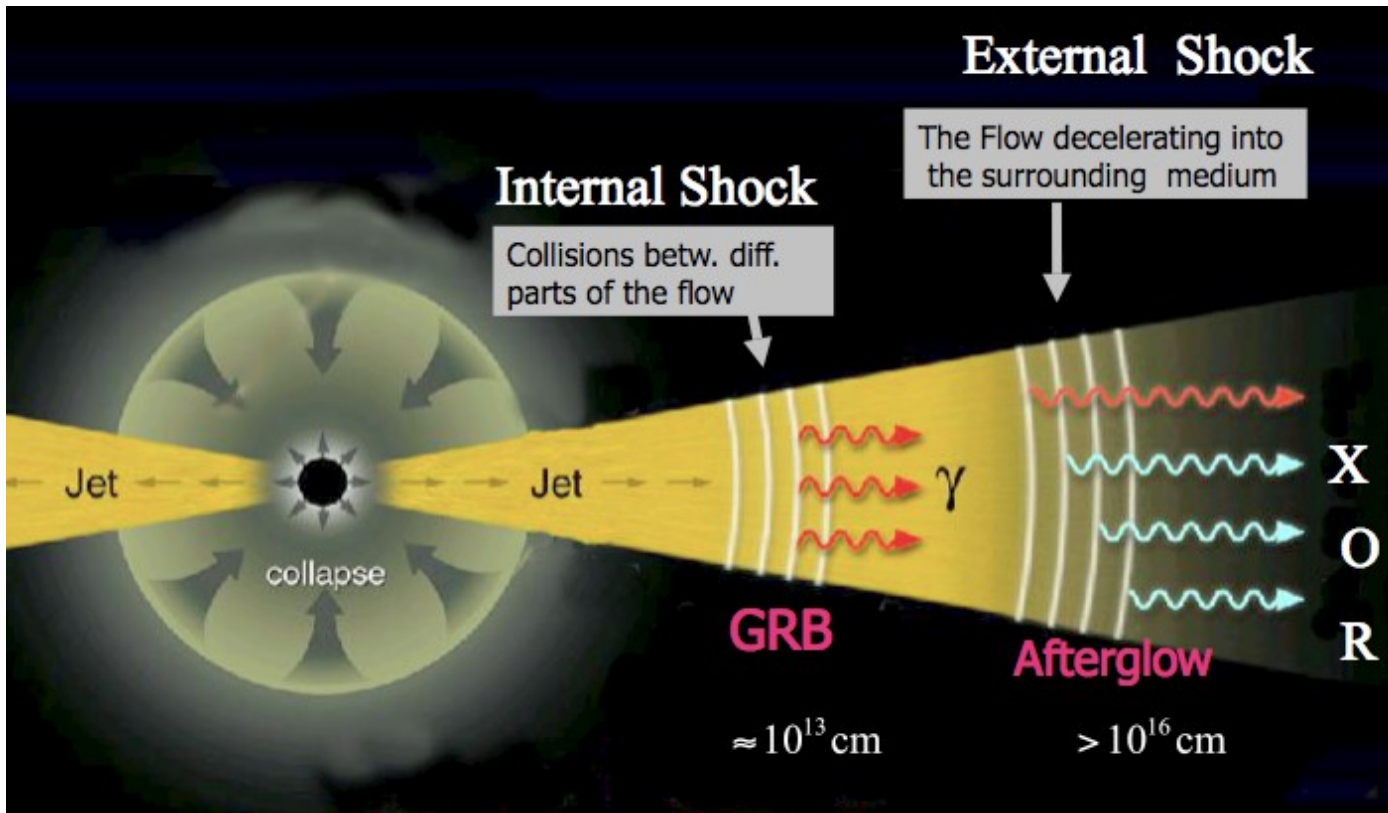
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- Exp data: Run 00113587
- MC
  - Signal: data set 1568 retriggered
  - Background
    - Singlet Corsika: data set 1516 retriggered
    - Doublett Corsika: data set 1511 retriggered

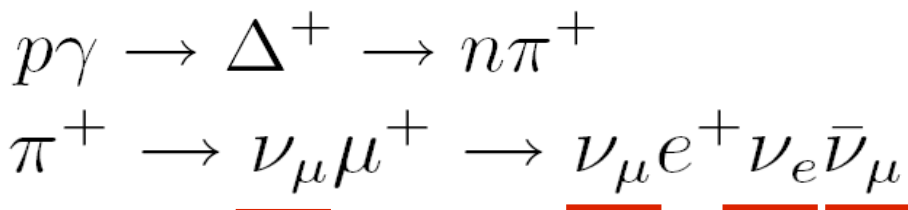
# Neutrino-Quellen:

## - Gamma Ray Bursts (GRBs) -

- Fireball Shock Modell (Meszaros, Rees 1994)
  - Relativistische Jets



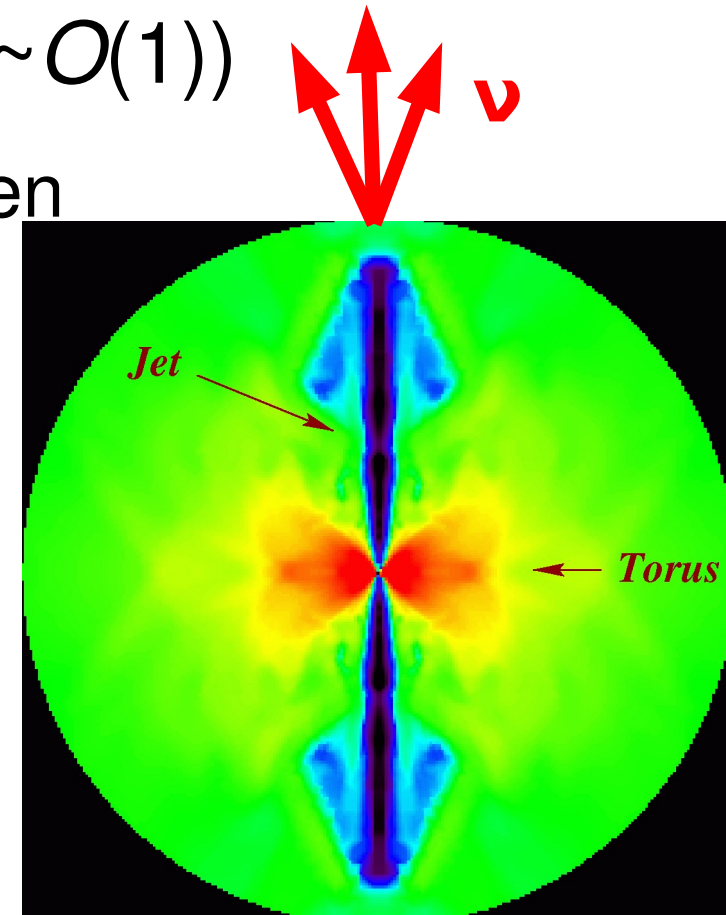
Dauer langer GRBs bis zu mehreren 100s



# Neutrinos-Quellen: Supernovae (SNe)

- Zeitliche und lokale Übereinstimmung von GRBs und SNe
- Hypothese: Ein Teil der SNe bildet einen schwach relativistischen Jet ( $\Gamma \sim O(1)$ )
  - Jet bleibt in der Sternhülle stecken
  - Photonen werden absorbiert

Vorhersage:  
Ein  $1\text{km}^3$  Detektor misst 30  
Neutrinos in 10s von einer SN im  
Abstand 10 Mpc

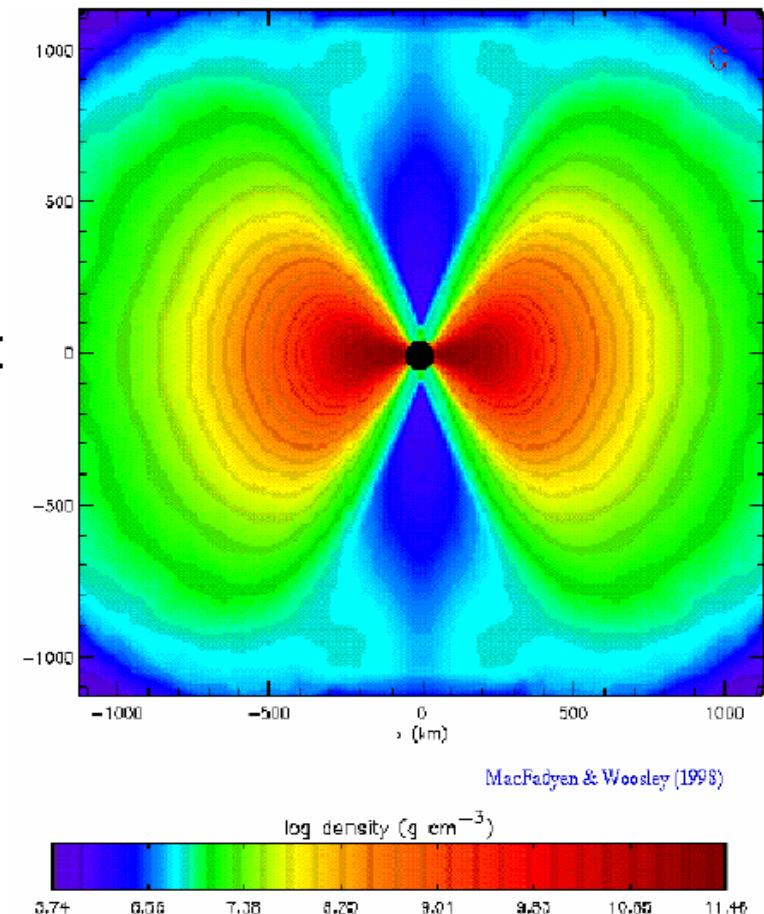




# Die Quellen: GRBs

## Das Collapsar Modell (Woosley 1993)

- Modell für den Antrieb für lange GRBs
- Massiver, schnell rotierender Stern
- Eisen-Kern kollabiert zu schwarzem Loch
- Akkretionsscheibe entsteht und speist schwarzes Loch mit Materie
- Evakuierung entlang der Rotationsachse
- Nach einigen Sekunden: Umkehrung des Materiestroms zu stark fokussierter ultrarelativistischer Jet treibt SN an und produziert GRB



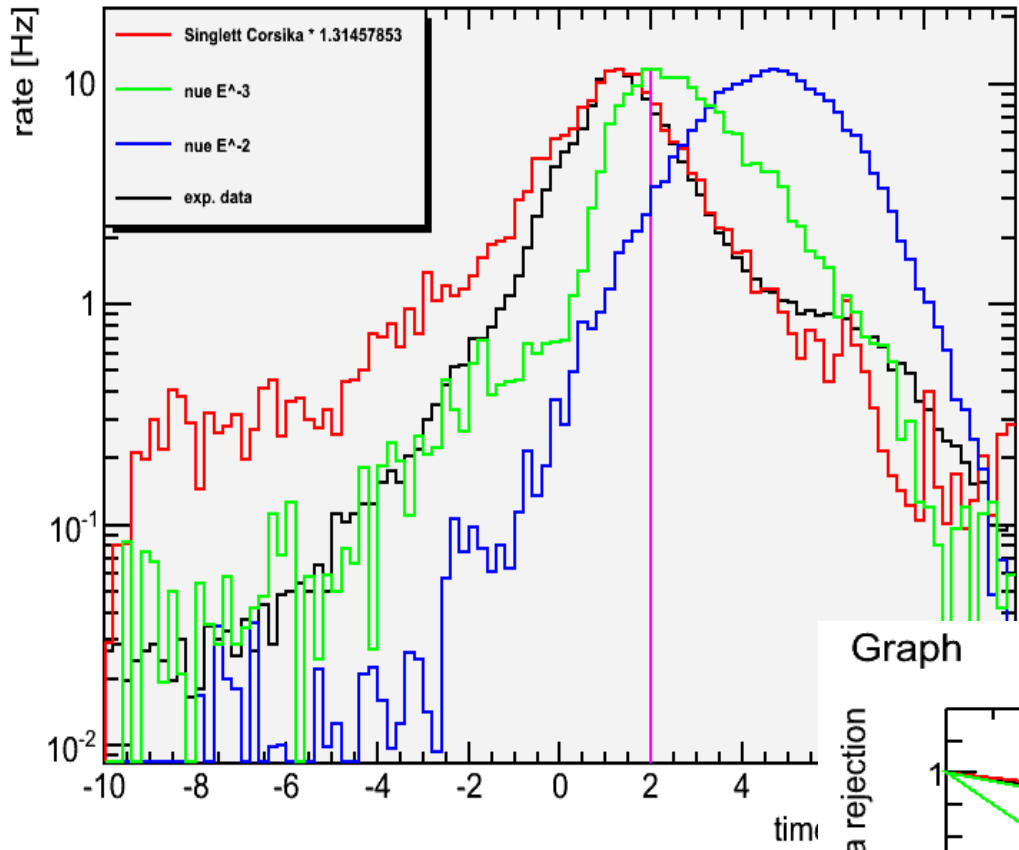
# Ergebnisse

Cut	Exp. Daten [Hz]	MC Hintergrund [Hz]	MC E <sup>-2</sup> Signal in %
Level 1	23.9	24.4	100
rllh<10	5.52	4.15	89.6
Zenith>70°	1.86	1.39	71.3
slc<0.21	0.16	0.18	62.5
fillratio>0.7	0.06	0.08	56.9
CHF<0.4	0.0024	0.002	51.2
NCh>20	0.00024	0.0001	51.1

Preliminary

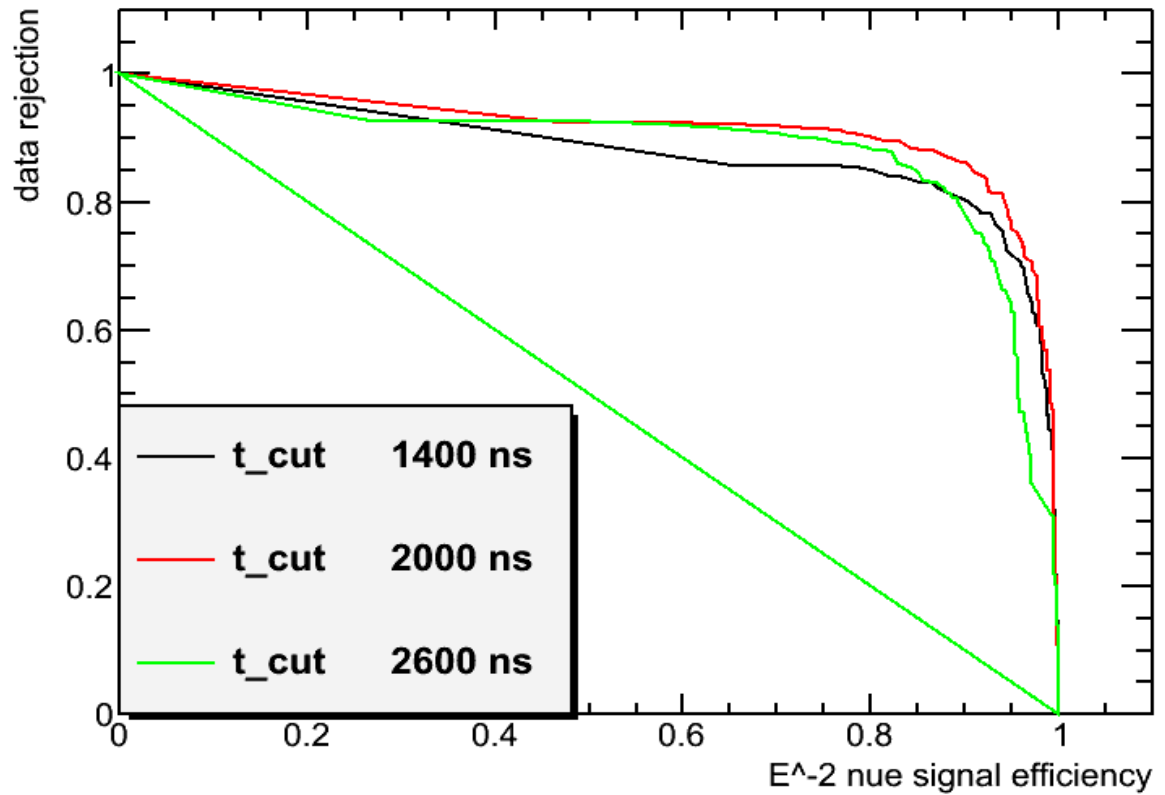
t\_res

# idual

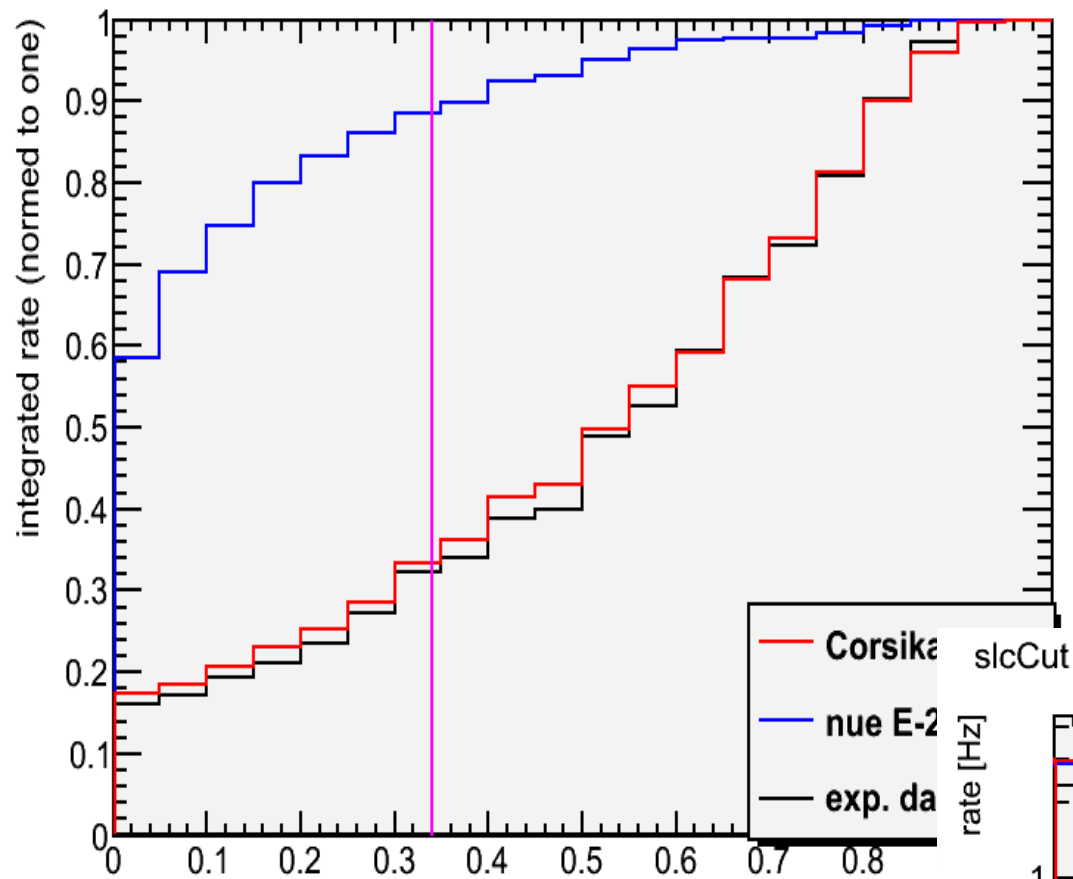


Best time = 2000 ns

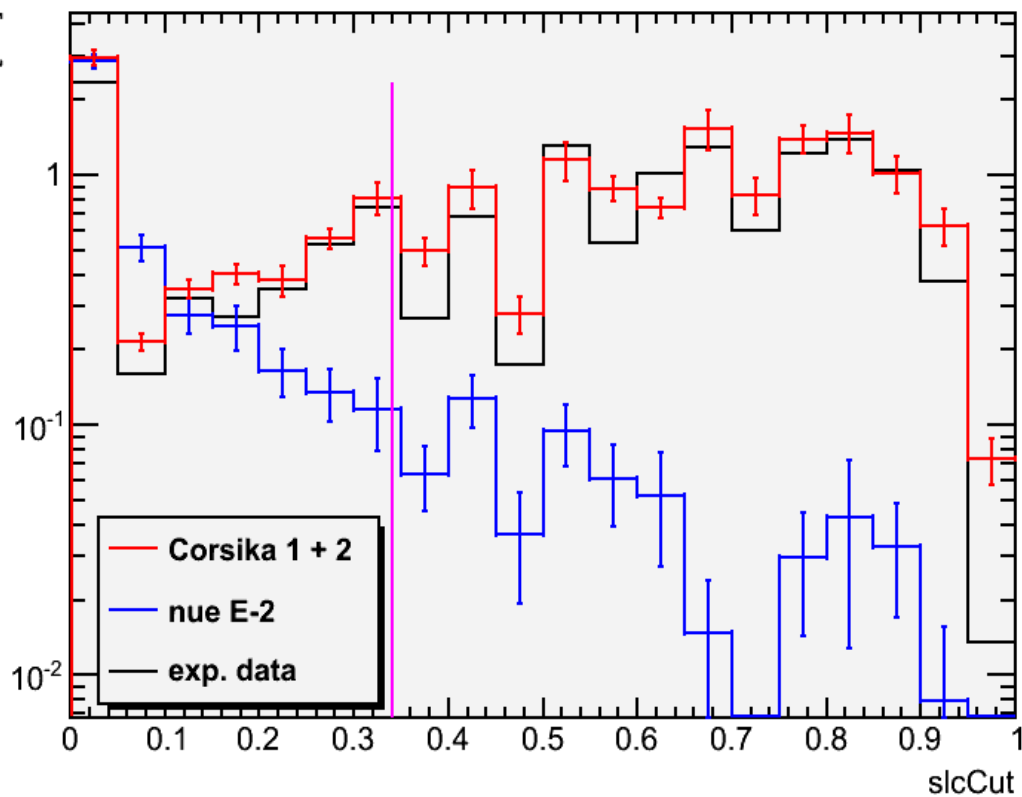
Graph



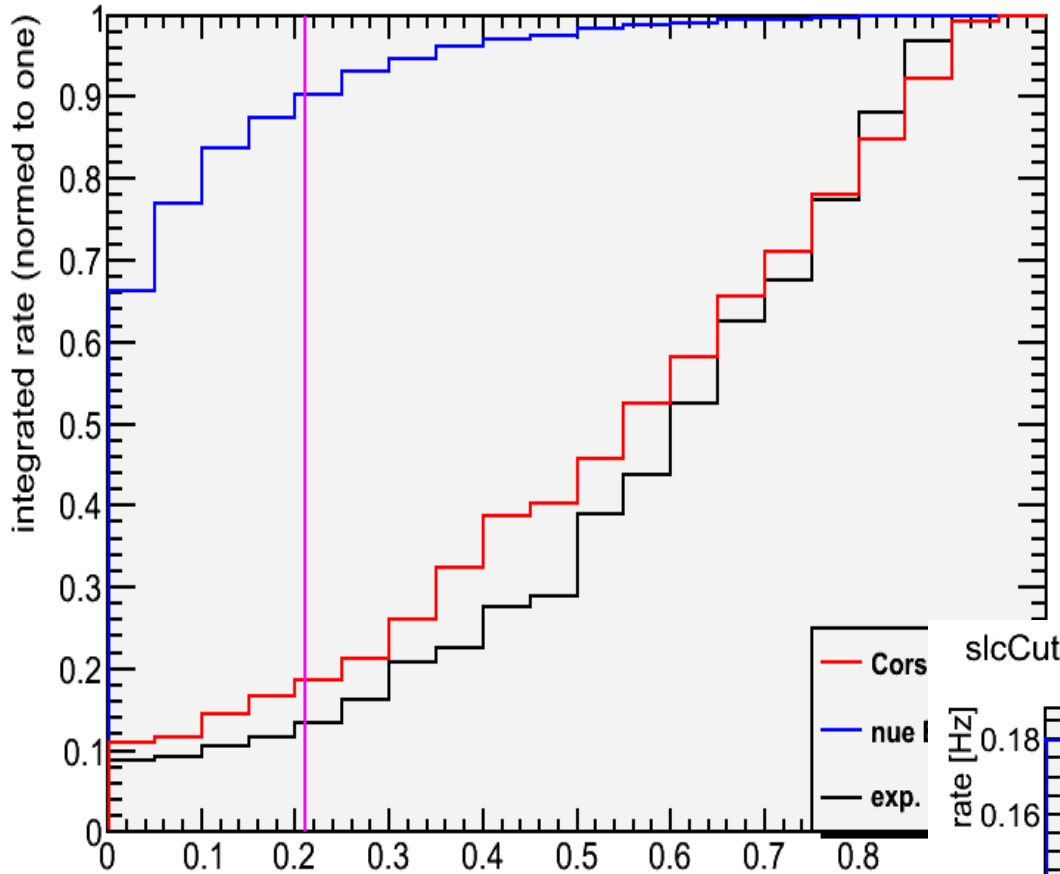
slcCut



Level 1:  
Schneide bei  
 $\text{slcCut} < 0.34$

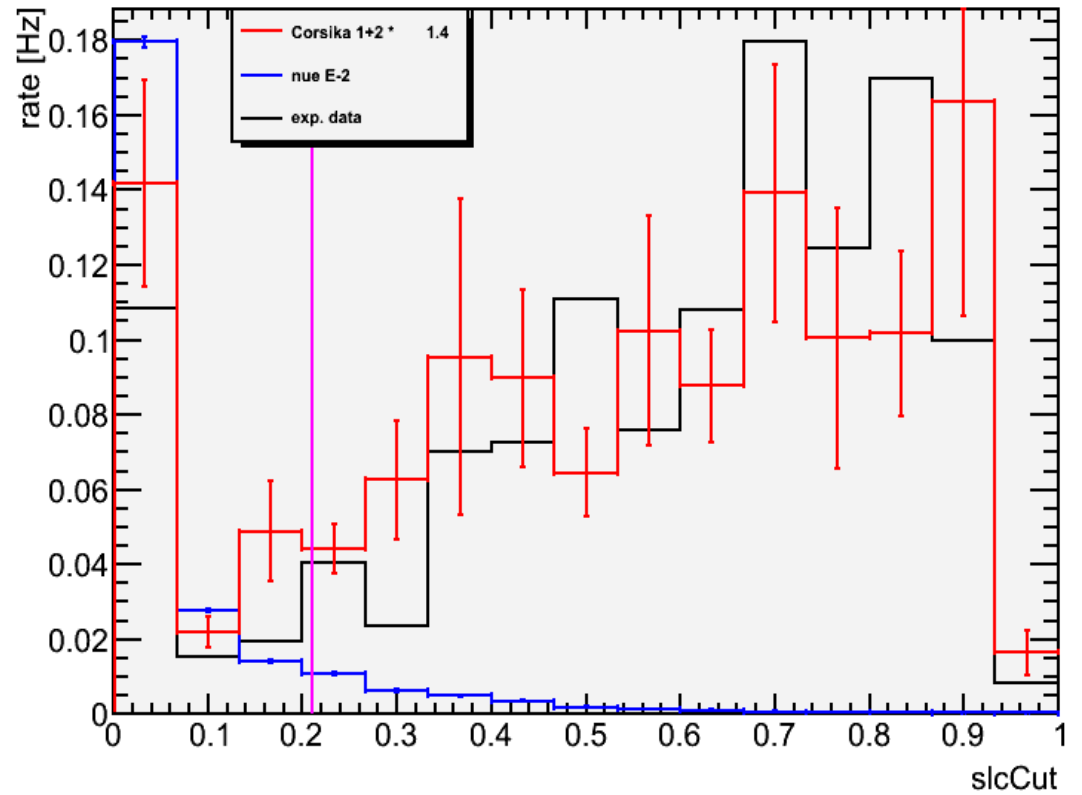


slcCut

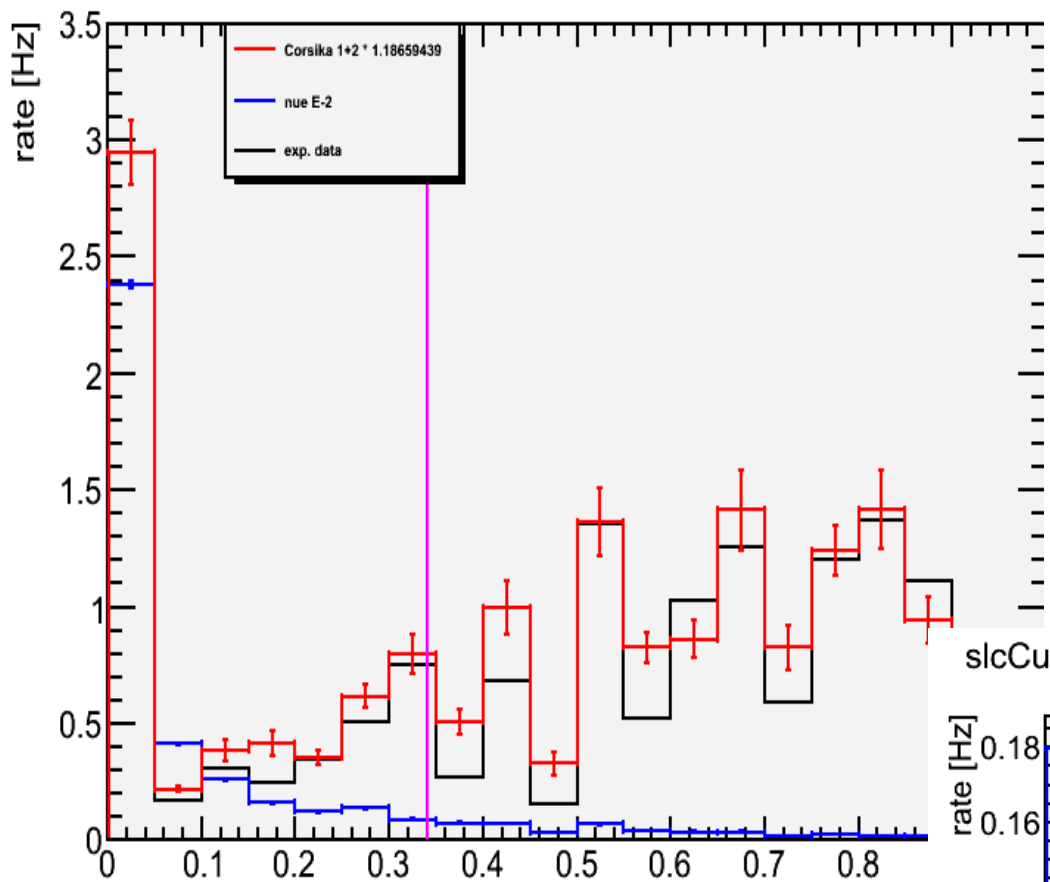


Level 2:  
Schneide bei  
slcCut < 0.21

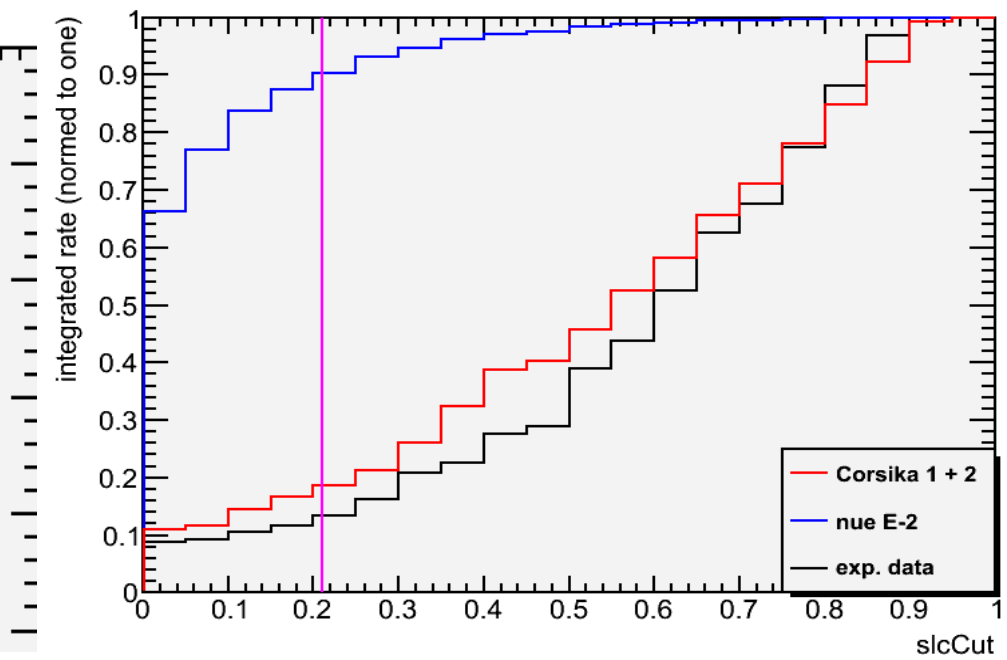
slcCut



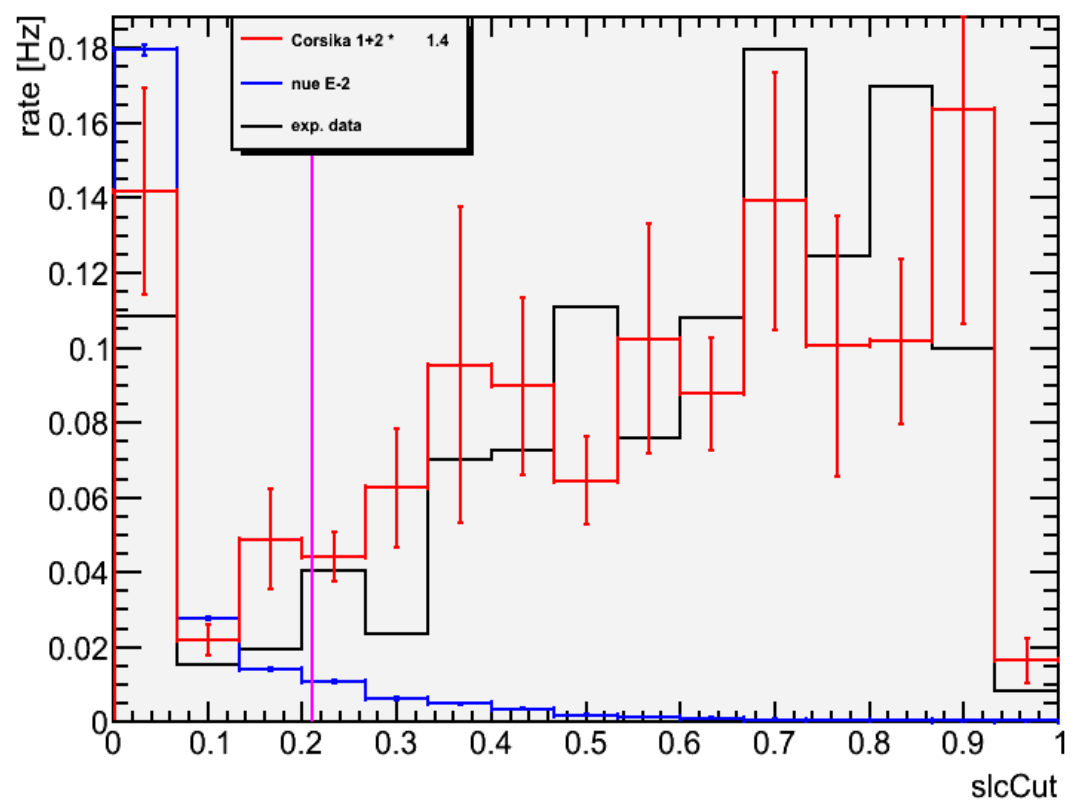
slcCut



slcCut

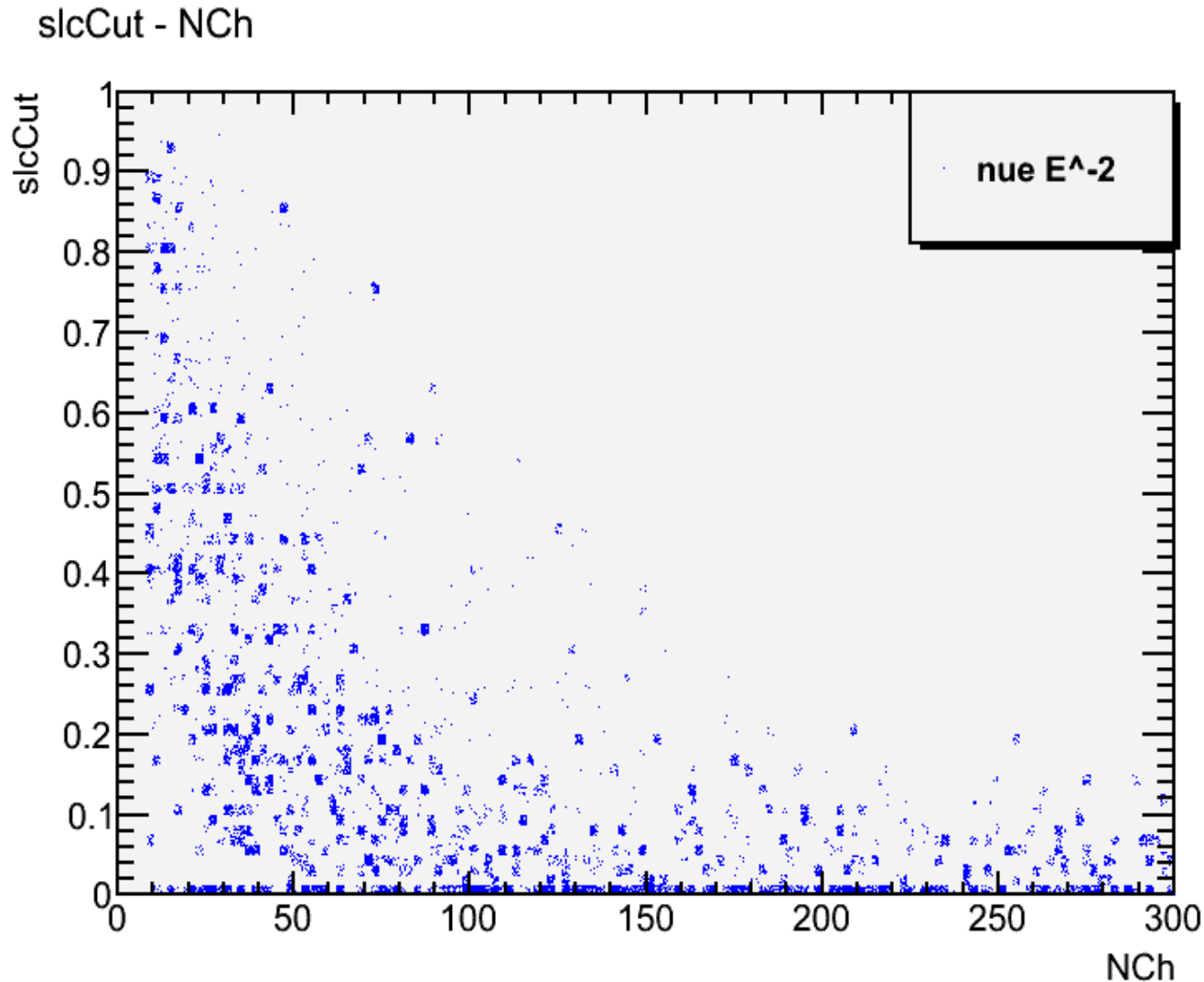


slcCut



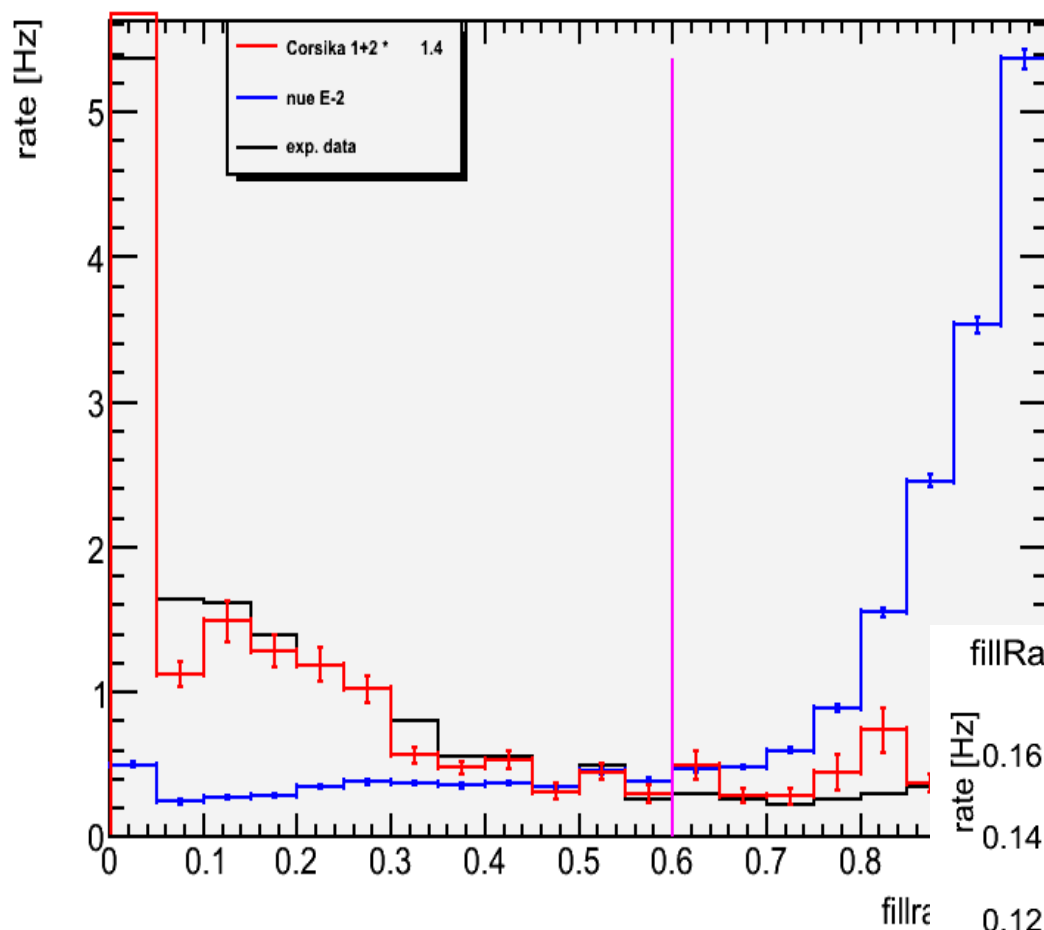
- Slc:
- level1 (oben)
  - level2 (rechts)
  - Oben rechts: level2 integriert

# SlcCut

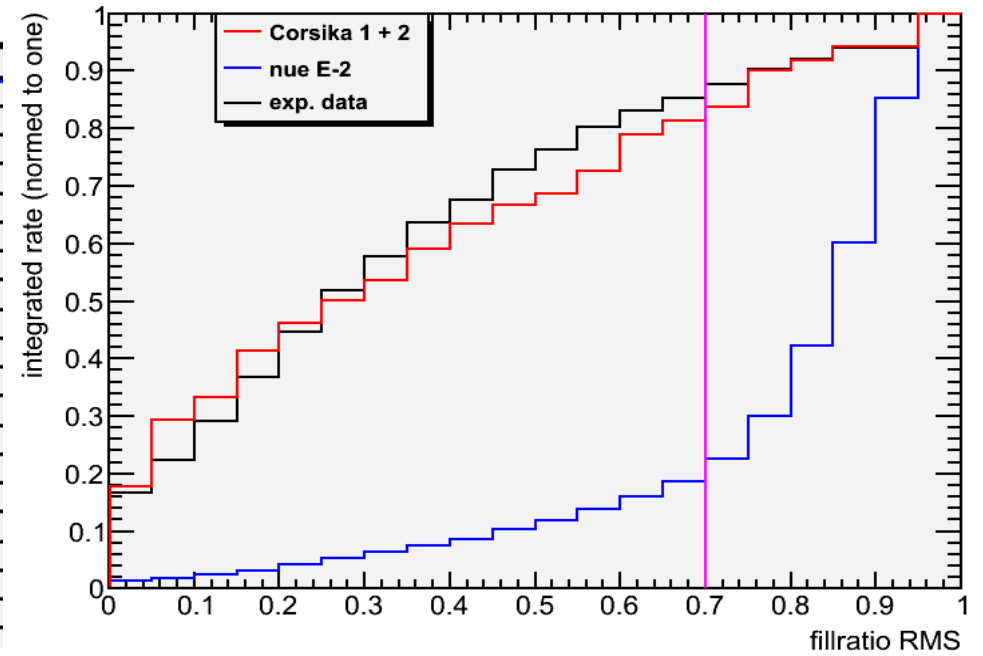


Signal loss  
due to  
slcCut  
mainly for  
lower  
energies.

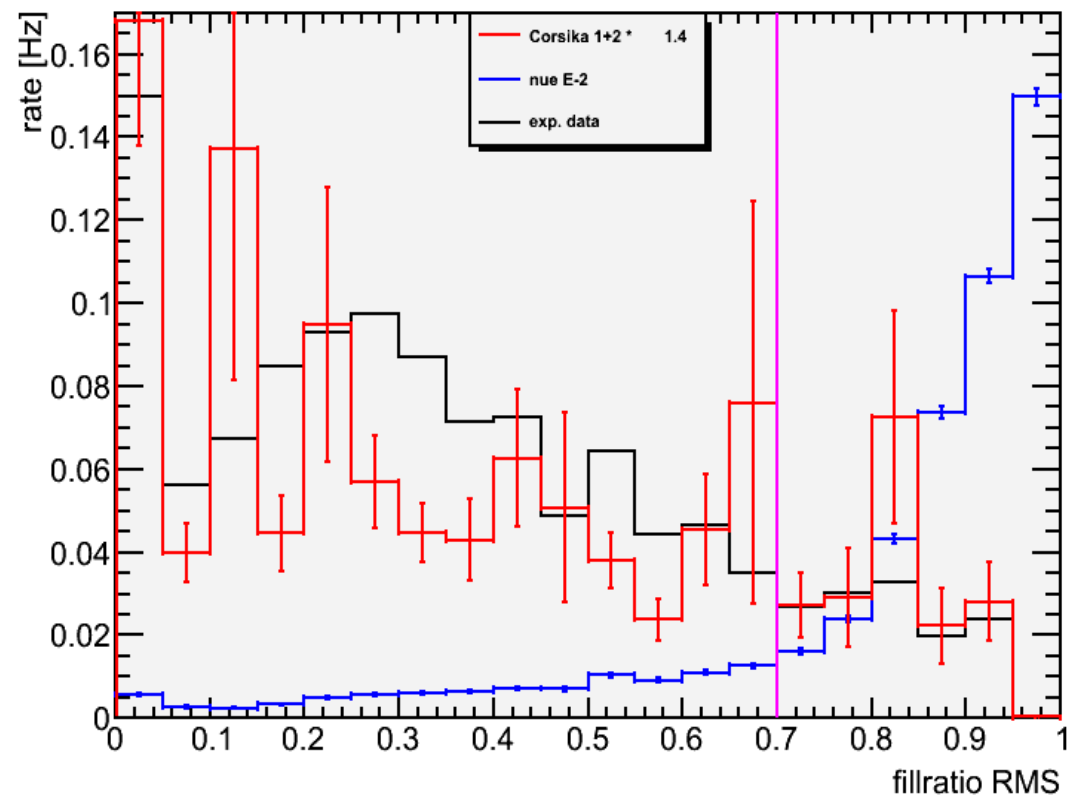
fillRatio



fillRatio



fillRatio

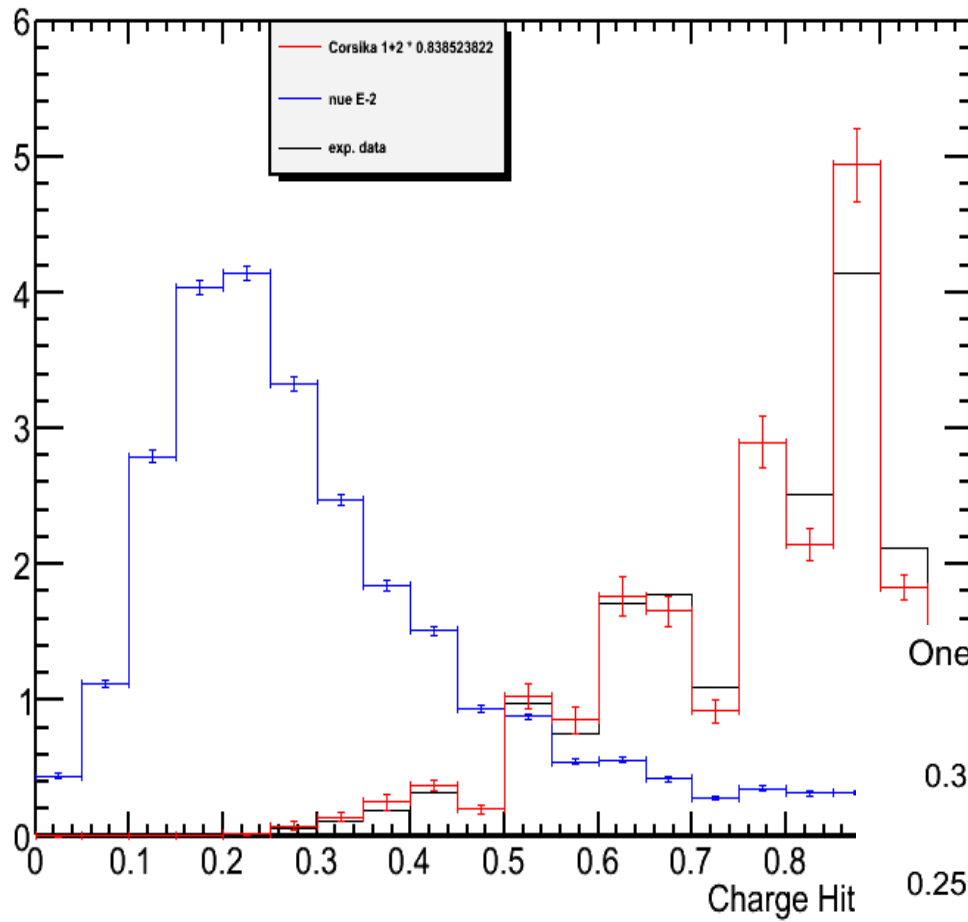


fillratio:

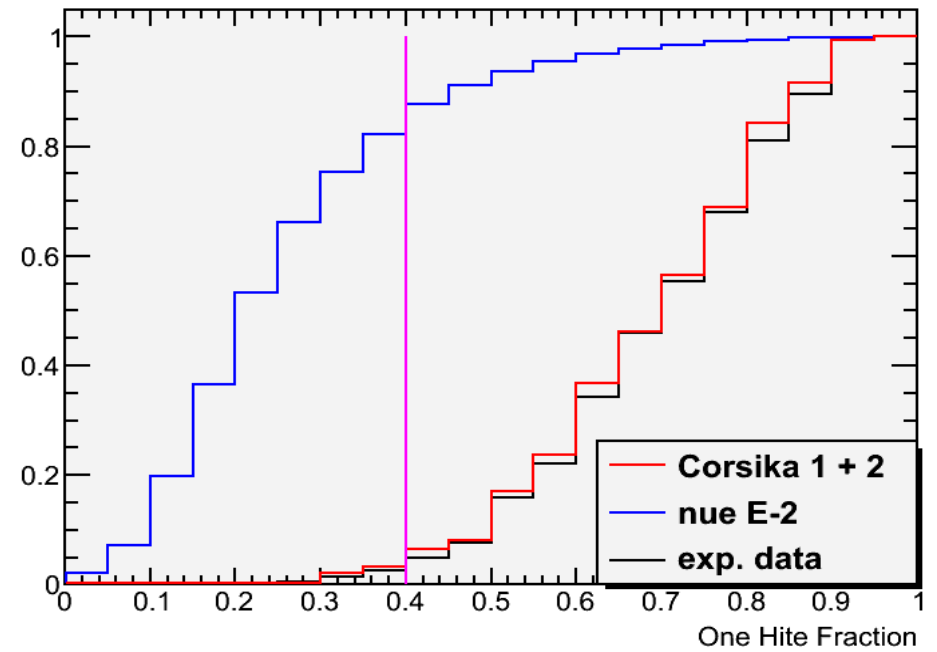
- level1 (oben)
- level2 (rechts).
- Oben rechts: level2 integriert



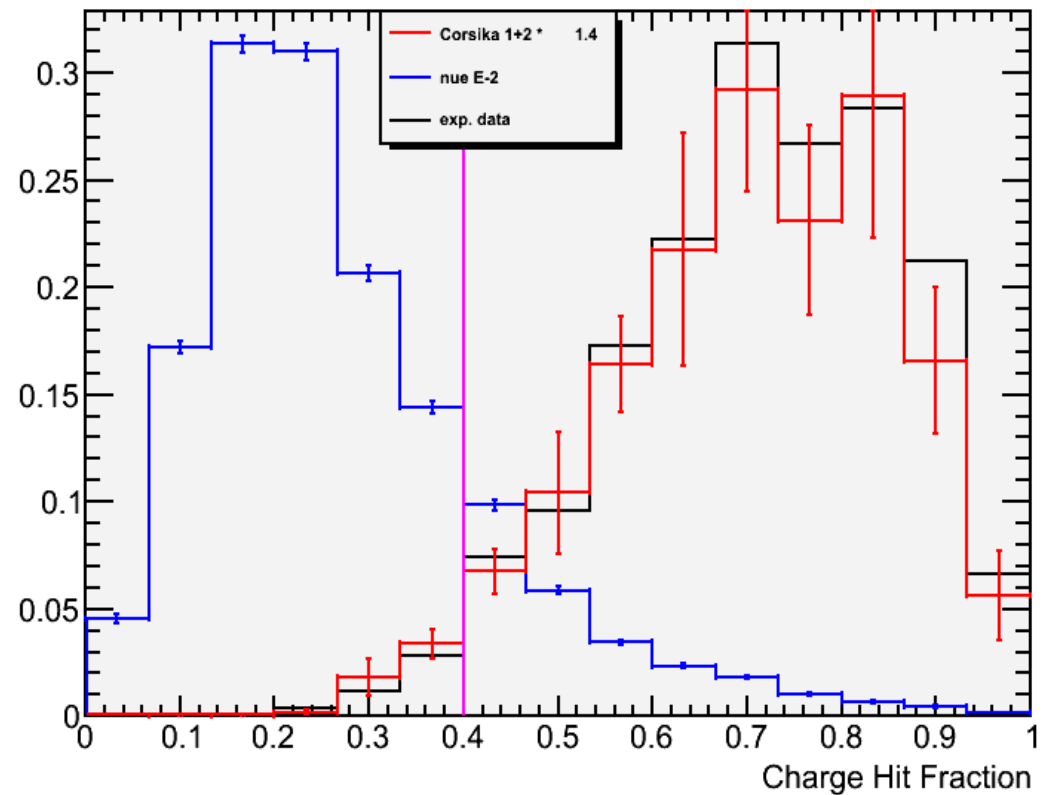
# OneHitFraction



# OneHitFraction



# OneHitFraction



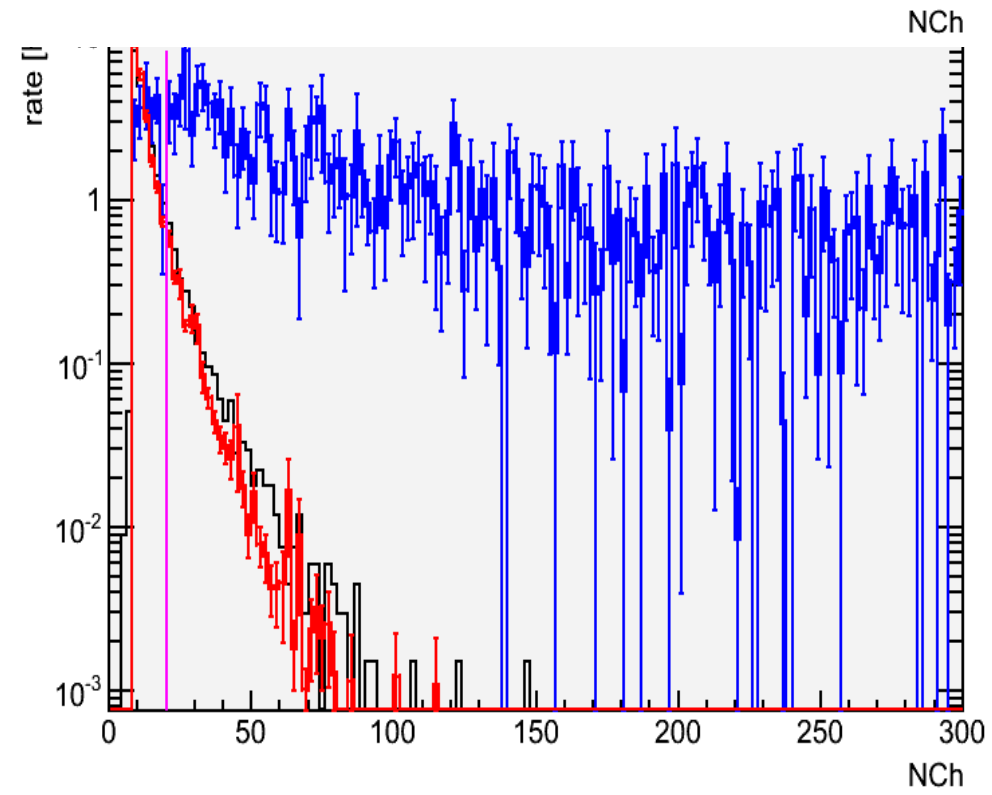
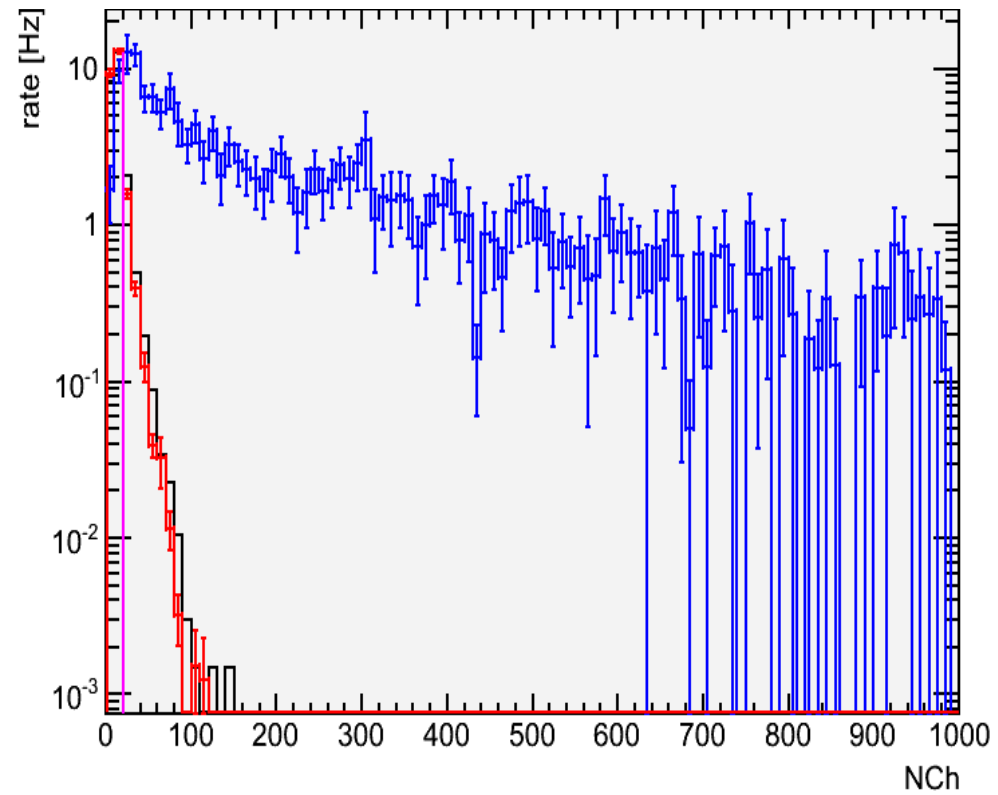
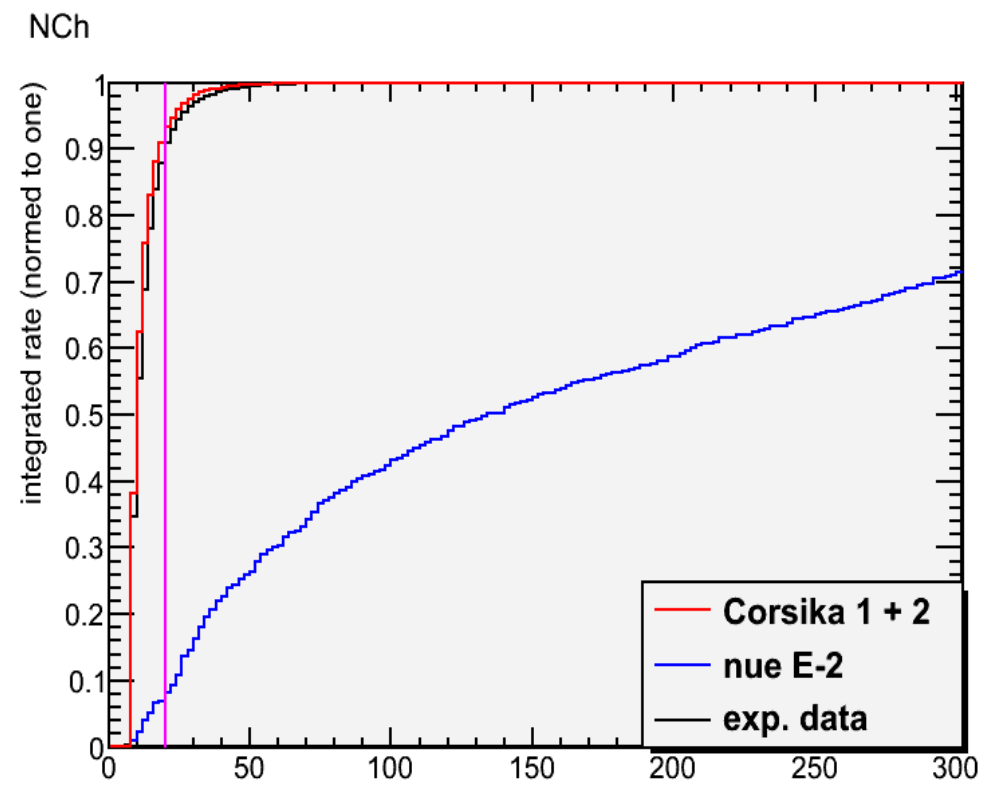
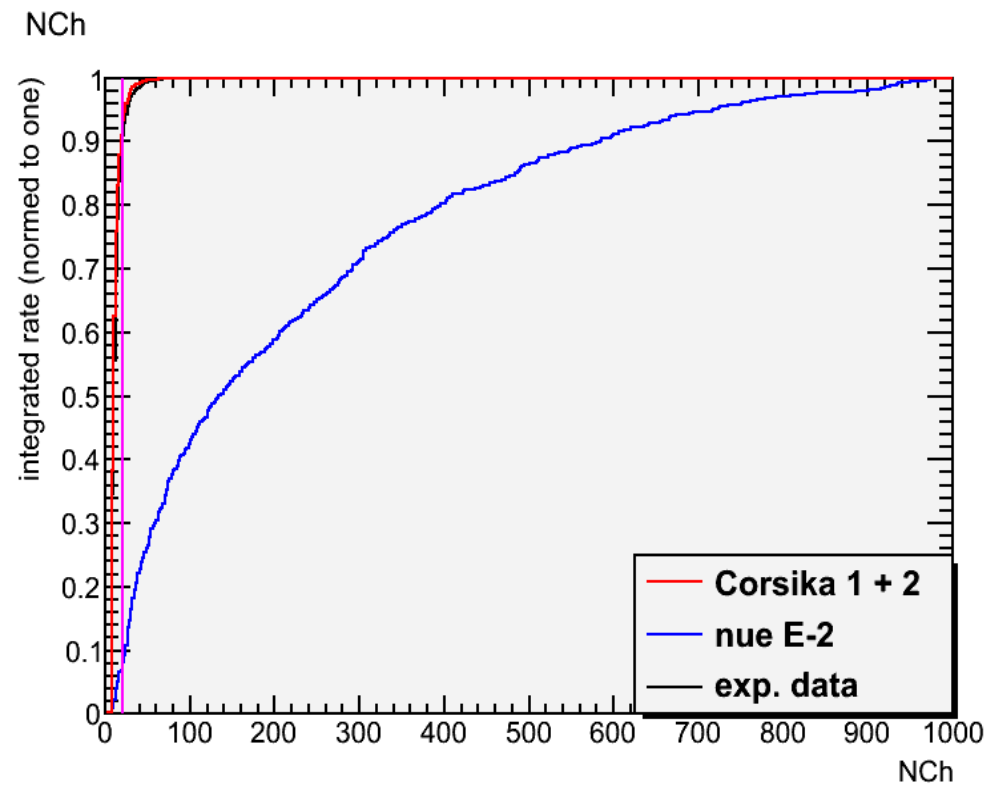
CHF: level1 (oben); level2 (rechts). level2 integriert (oben rechts)

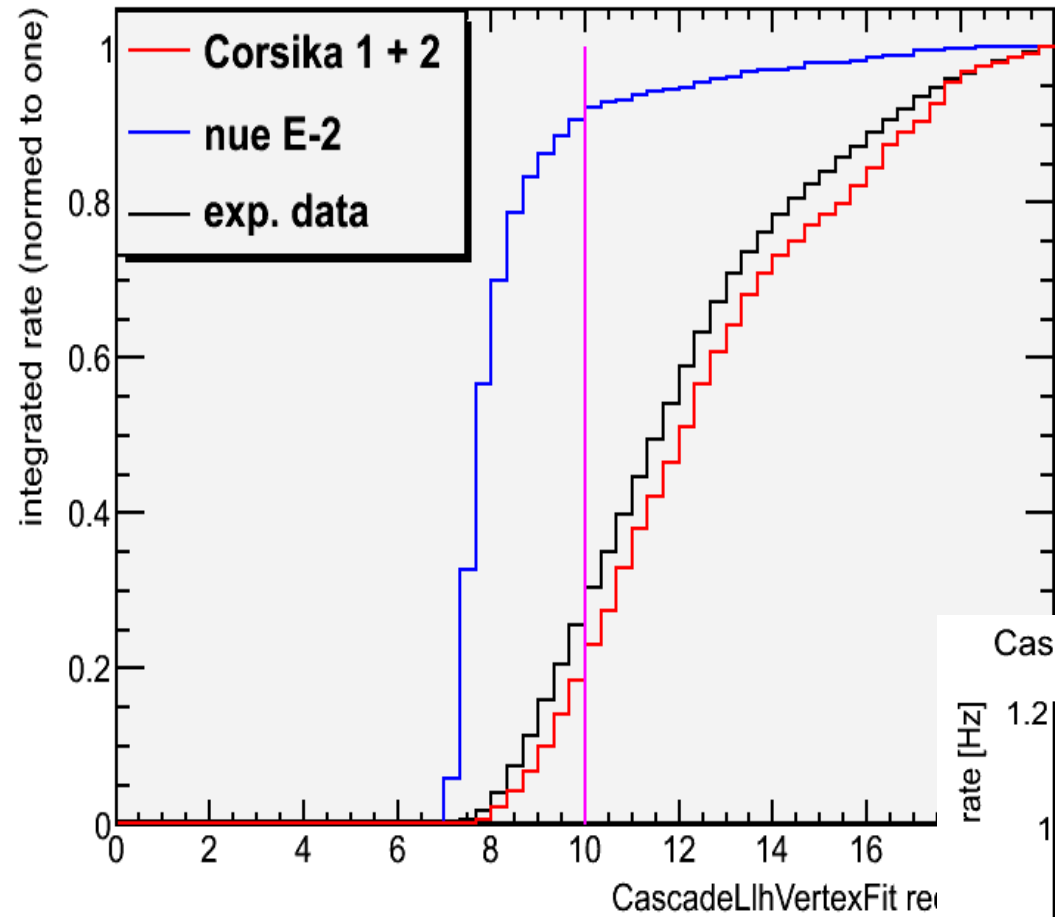
- Es werden die Anzahl der Domhits unter einer bestimmten Charge gezählt und durch Nch geteilt. Für Signal hat man eher größere ladung

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# Cascade Filter

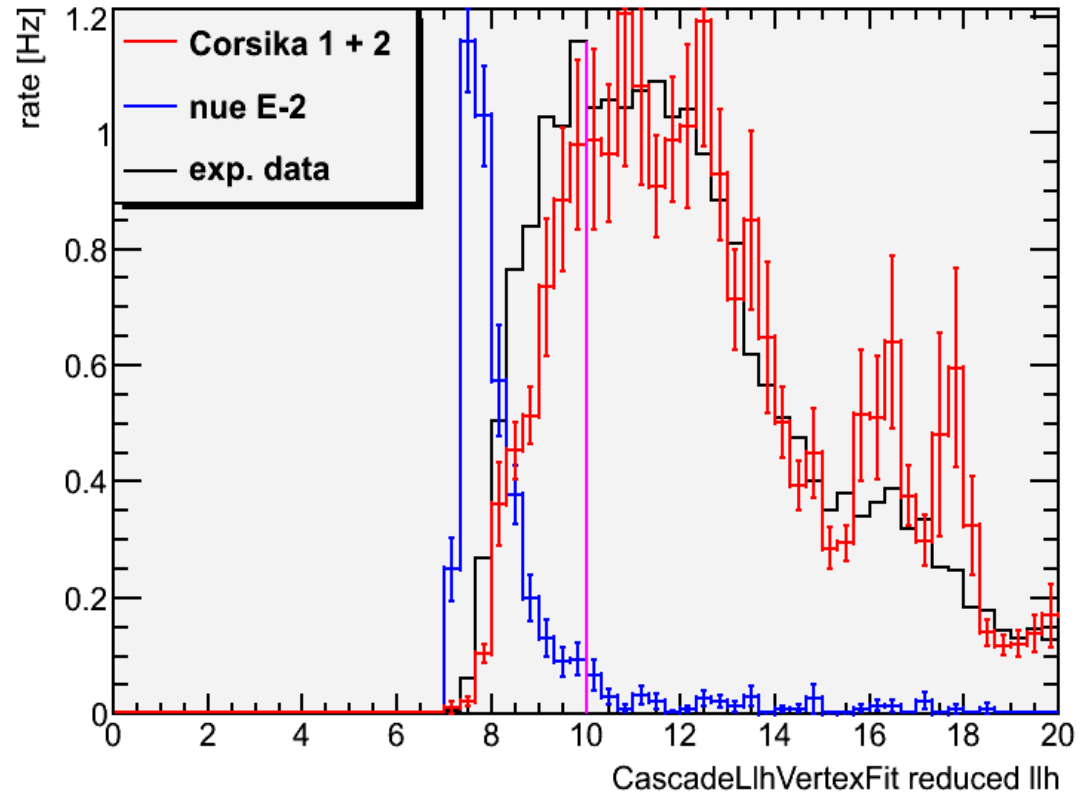
Other Cut Variables



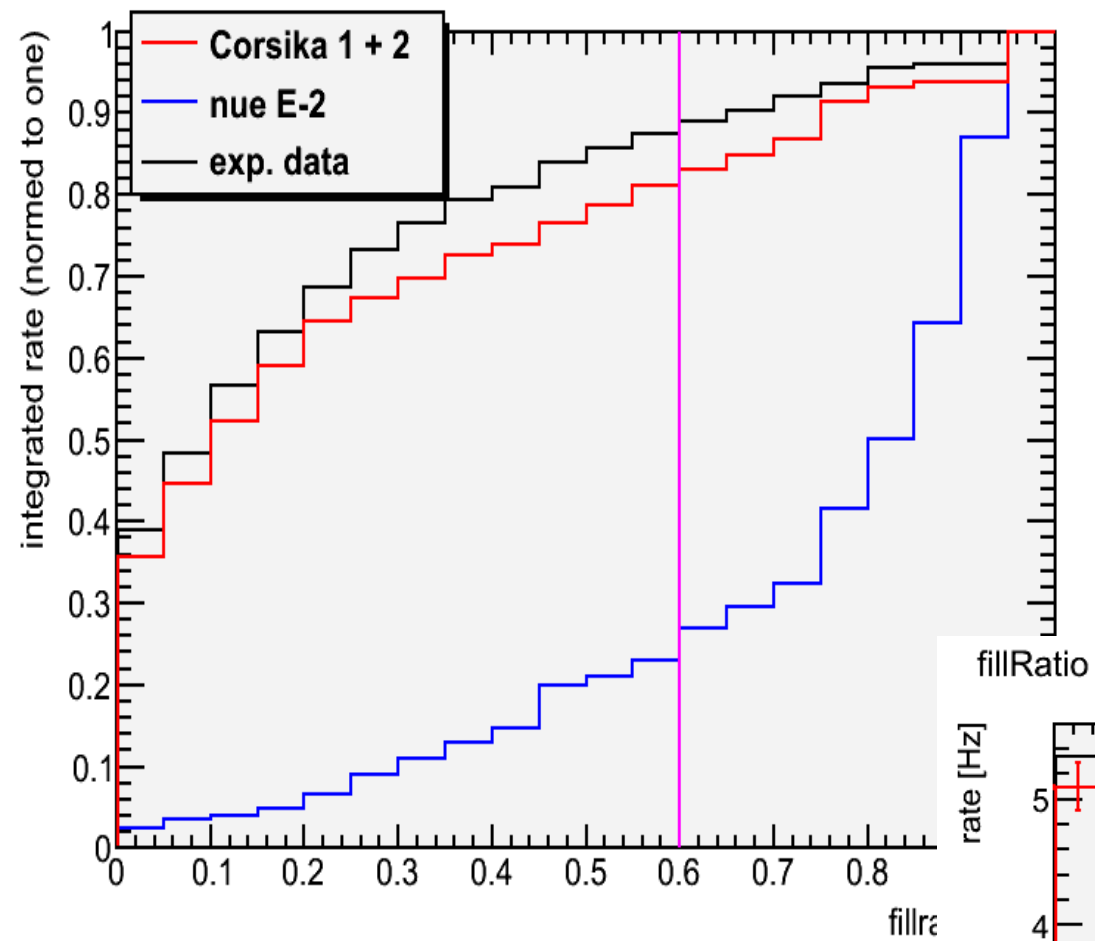


Cutting at  
Cascade Llh Reco  
reduced\_llh < 10

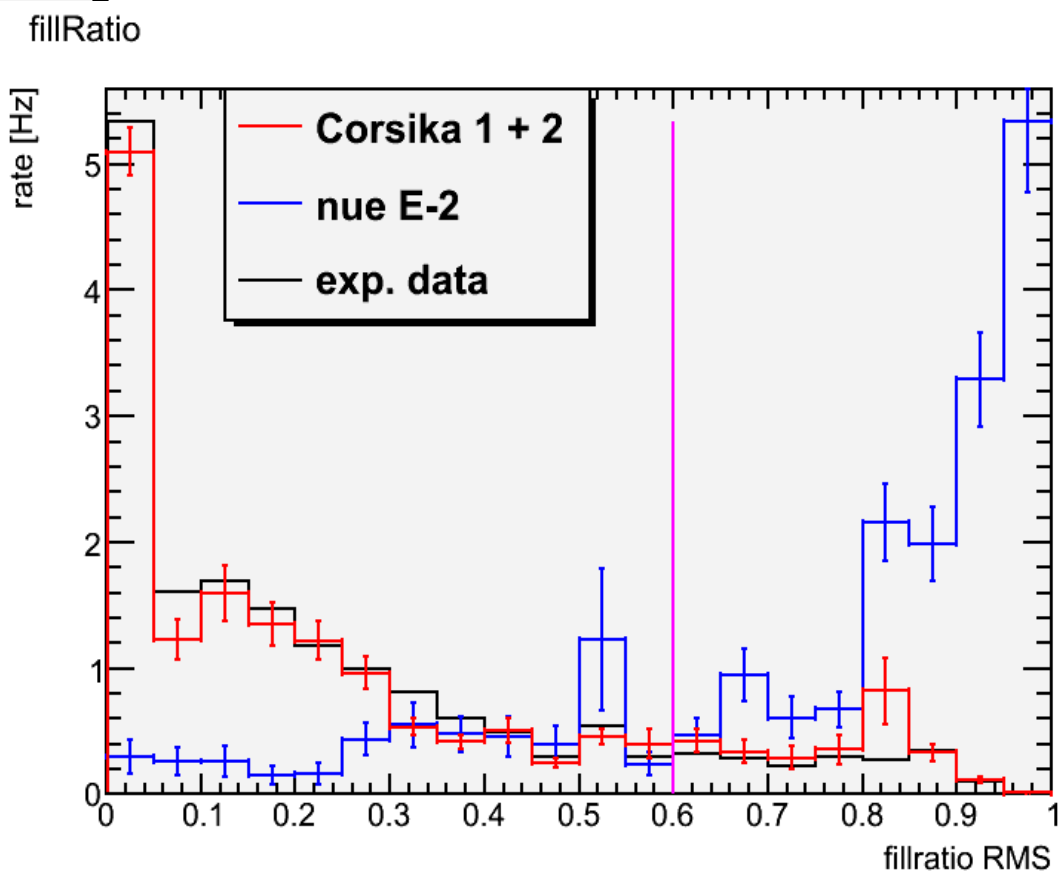
Cascade Reco rllh



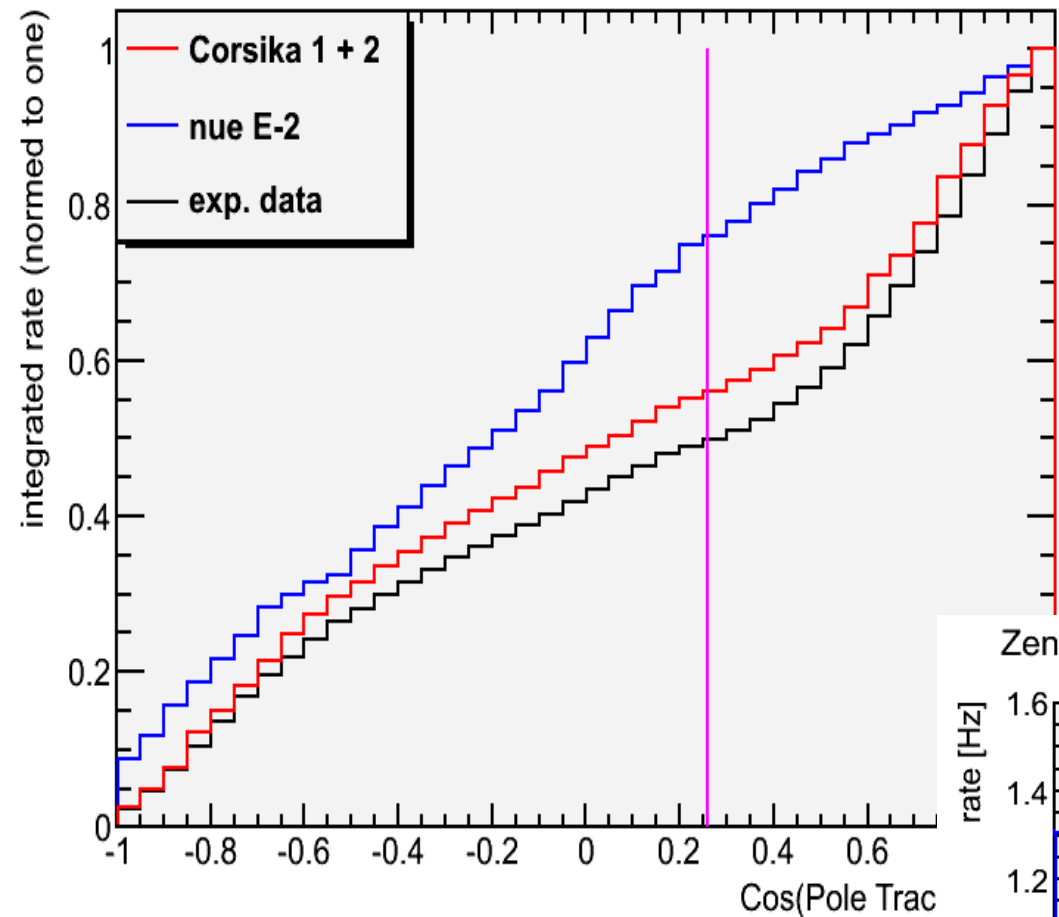
fillRatio



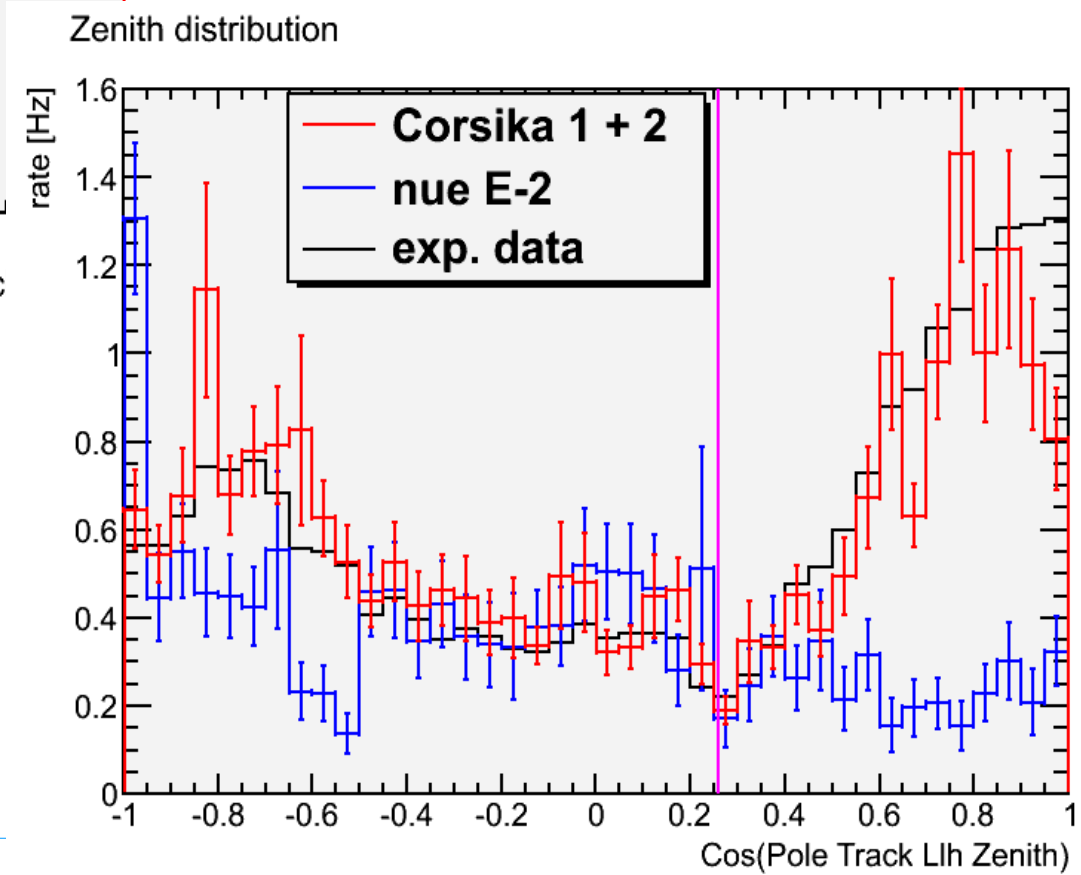
Cutting at  
fillratio > 0.6



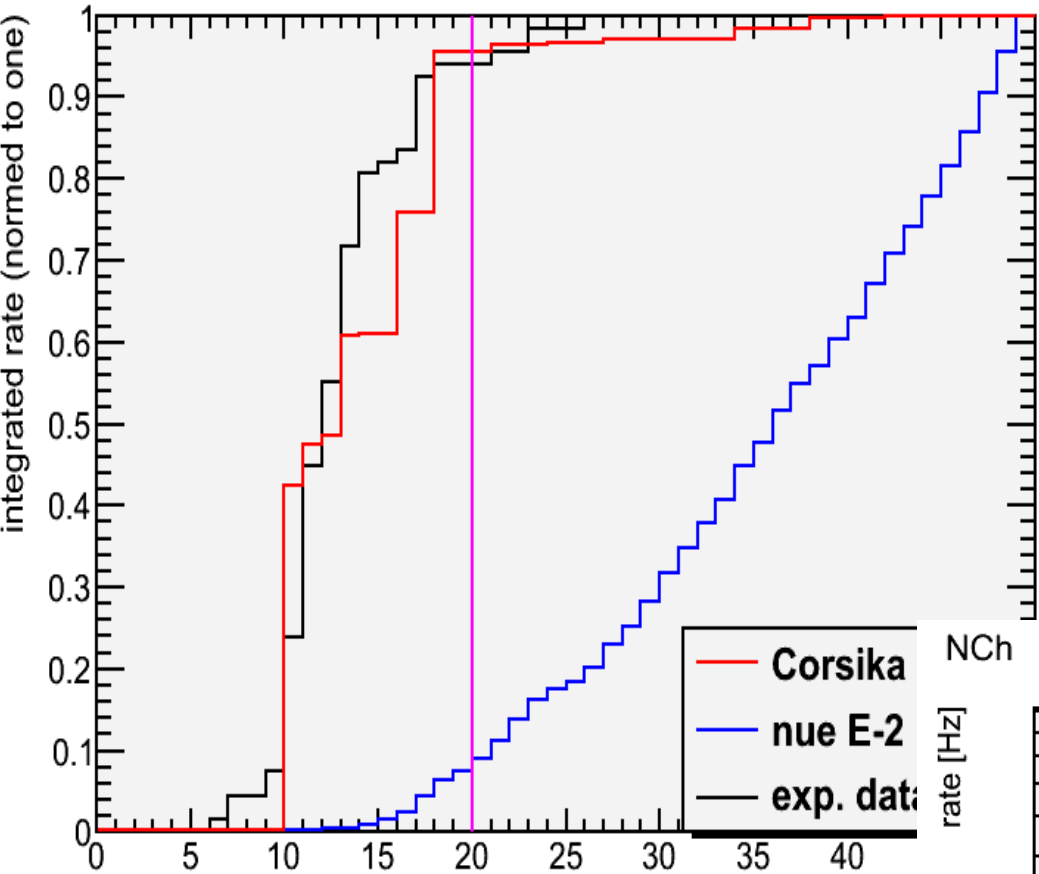
# Zenith distribution



Cutting at  
Track Lh Zenith  $> 75^\circ$   
 $\sim 0.25$



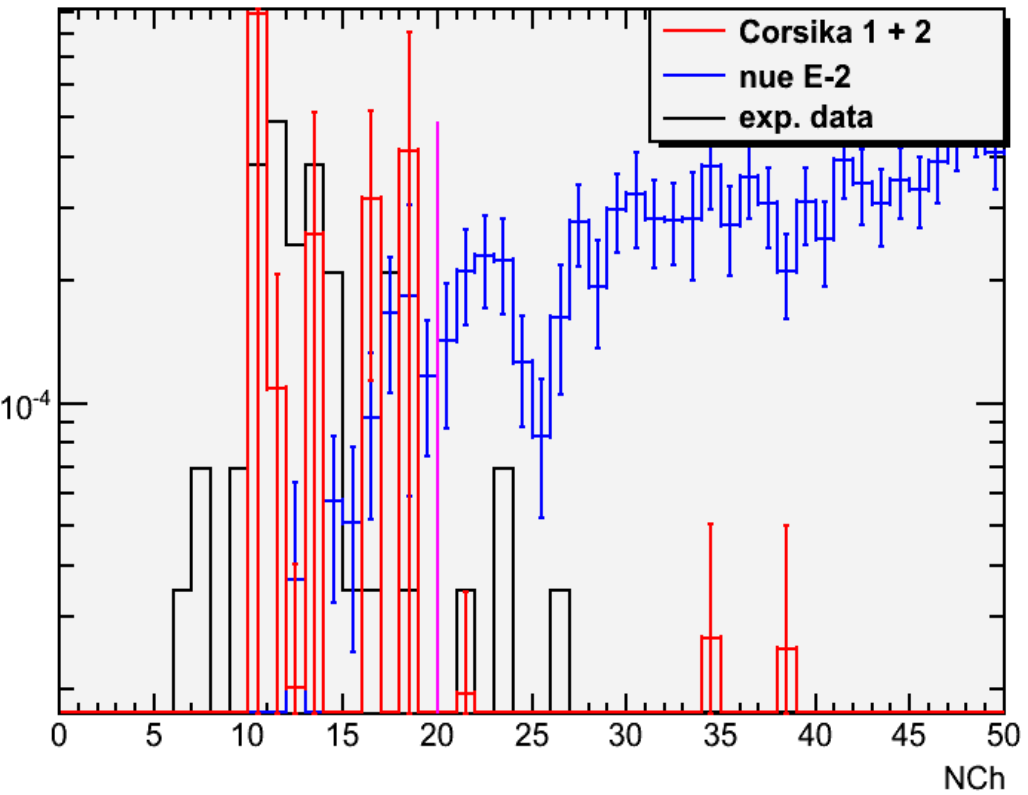
NCh



Cutting at  
NCh > 20

NCh

rate [Hz]



# Ergebnisse

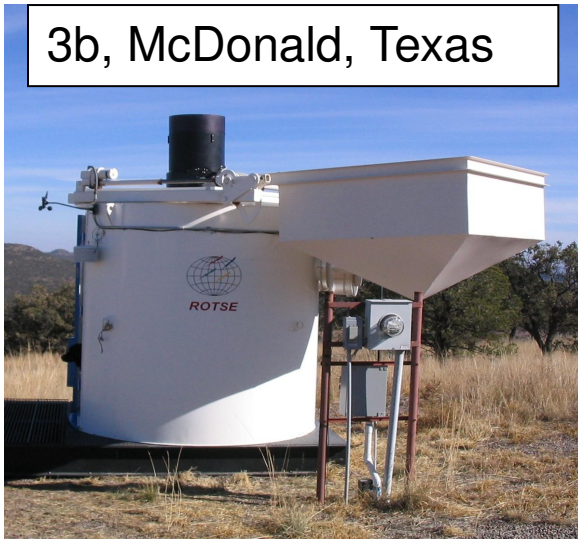
IceCube Konfiguration	Exp. data [Hz]	MC Background [Hz]	MC E <sup>-2</sup> Signal in %
22 Strings	0.02	0.01	9.2
<b>59 Strings</b>	<b>0.022</b>	<b>0.0089</b>	<b>56</b>
40 Strings	0.2		56

Preliminary



# Optische Nachfolge: Robotic Optical Transient Search Experiment

3b, McDonald, Texas



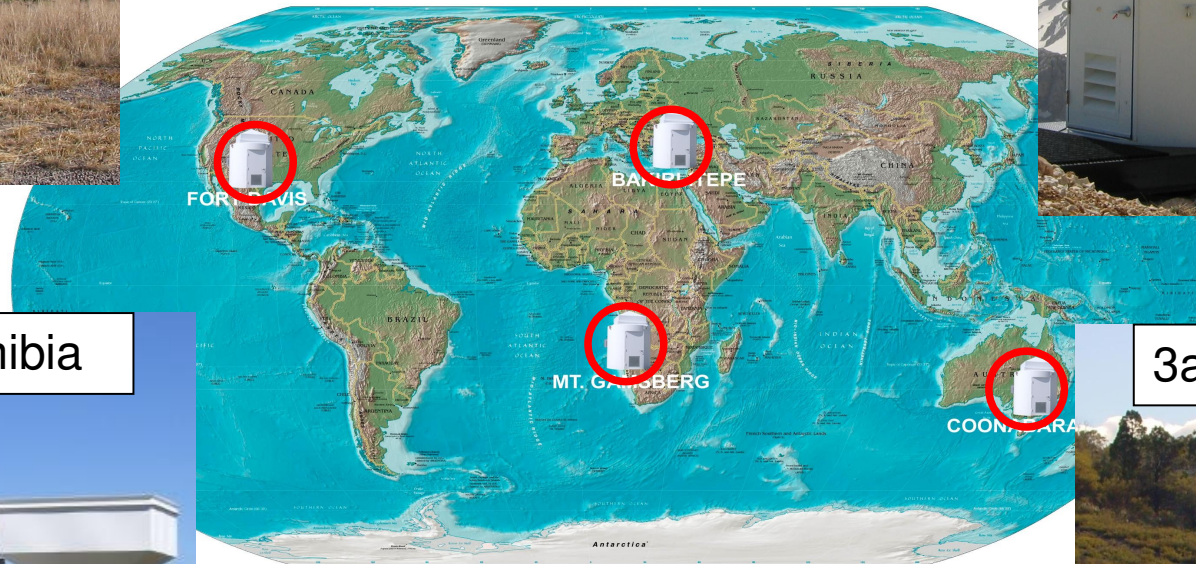
3d, TUG, Turkey



3c, H.E.S.S., Namibia



3a, SSO, Australia



2007-2008:  
18 strings

2006-2007:  
13 Strings

2005-2006: 8 Strings

2004-2005 : 1 String

**AMANDA**

19 Strings  
677 Modules

**IceTop**

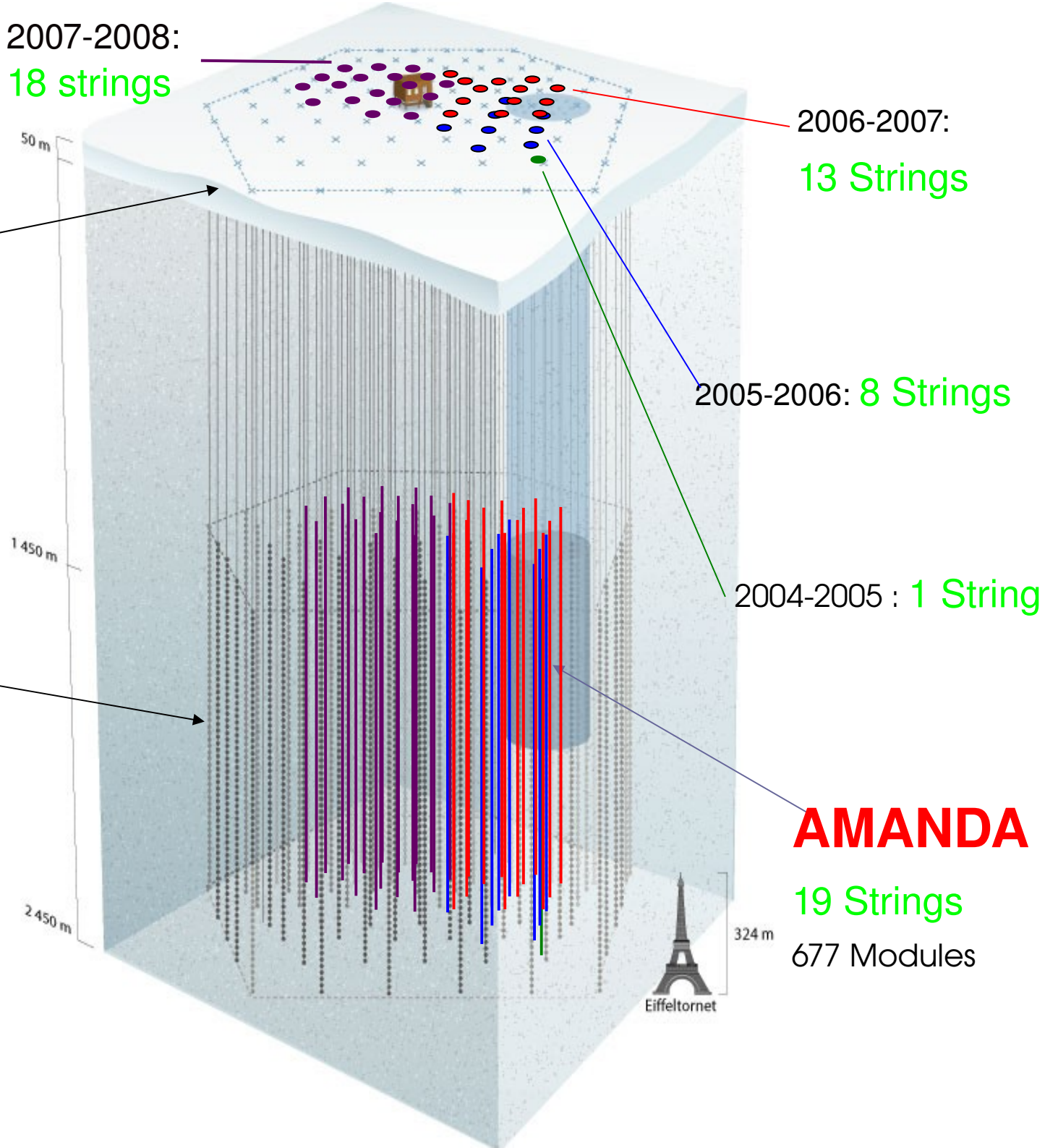
Luftschauer-Detektor

**InIce**

70-80 Strings ,  
60 Optische Module  
17 m zwischen Module  
125 m zwischen Strings

**Momentan**

59 Strings



# Ergebnisse

Cut	Exp. data [Hz]	MC Back-ground [Hz]	MC E <sup>-2</sup> Signal in %
Level 1	23.9	24.4	100
rllh<10	5.51703	4.15	89.59
Zenith>70°	1.86	1.39	71.28
slc<0.21	0.16	0.18	62.46
RatioRMS>0.7	0.058	0.083	56.91
CHF<0.4	0.0024	0.0021	51.2
NCh<20	0.00024	0.000101	51.05
contained	0.000104	0	42.91

Preliminary