Neutron Background Studies at CMS

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CERN, September 20 2006

Redone the neutron background by using full CMS simulation (OSCAR) and Geant4 (Standalone) instead of Geant3.

For Geant3 study,

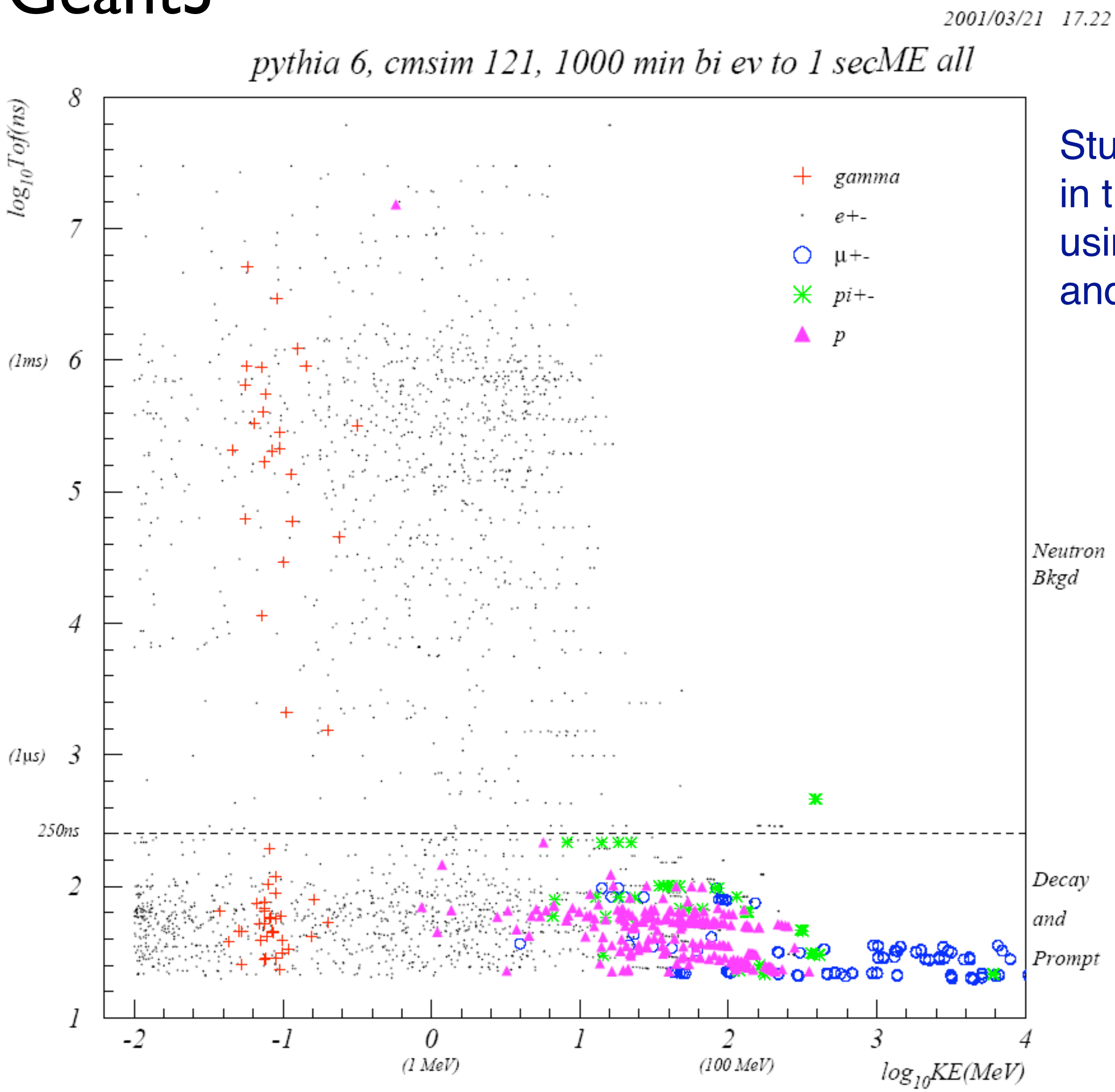
http://ptc.home.cern.ch/ptc/down/nbgnd.html

For full CMS simulation and G4 standalone studies,

http://agenda.cern.ch/askArchive.php?base=agenda&categ=a051142&id=a051142s1t0%2Ftransparencies%2FNeutronBackground_LCG.pd

http://ptc.home.cern.ch/ptc/down/presents/050618_n_bgnd.pdf

Geant3



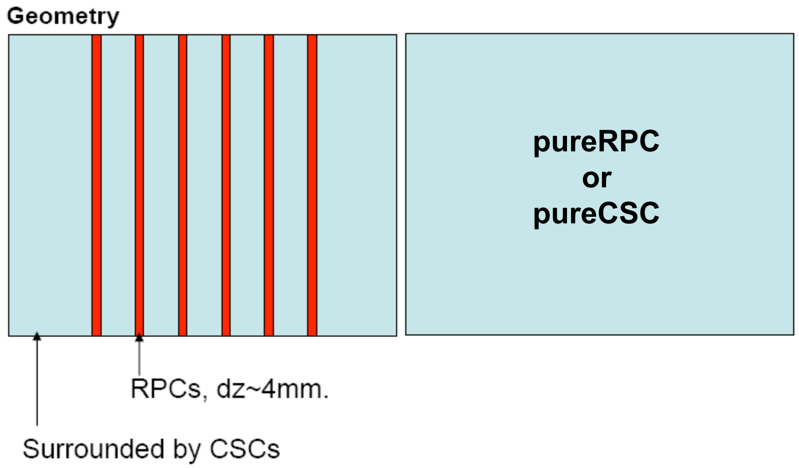
Studies of neutron background in the **endcap** chamber by using old version of PYTHIA and the CMSIM 121 (GEANT3).

We have run the full CMS simulation (OSCAR) and Geant4 (standalone with simple geometry) to count the number of neutron interactions in the sensitive gas.

CSC Gas	RPC Gas
Ar40 22.96 %	Ar40 1.76 %
C12 16.31 %	C12 25.89 %
	Cl35 3.12 %
F19 29.87 %	F19 1.67 %
O16 30.87 %	O16 67.56 %

Neutron energies
Vary from 1.E-4 - 1.E-3 MeV (G4)
Events
2K for OSCAR, 10K for G4
Physics
CMS: QGSP_BERT_HP 1.0 with G4.7.1
Geant4 (Standalone):
QGSP_HP 3.0 (G4.7.1.p01)
QGSP_BERT_HP 2.0 (G4.8.0.p01)
QGSP_BERT_HP 2.1 (G4.8.1.p01)

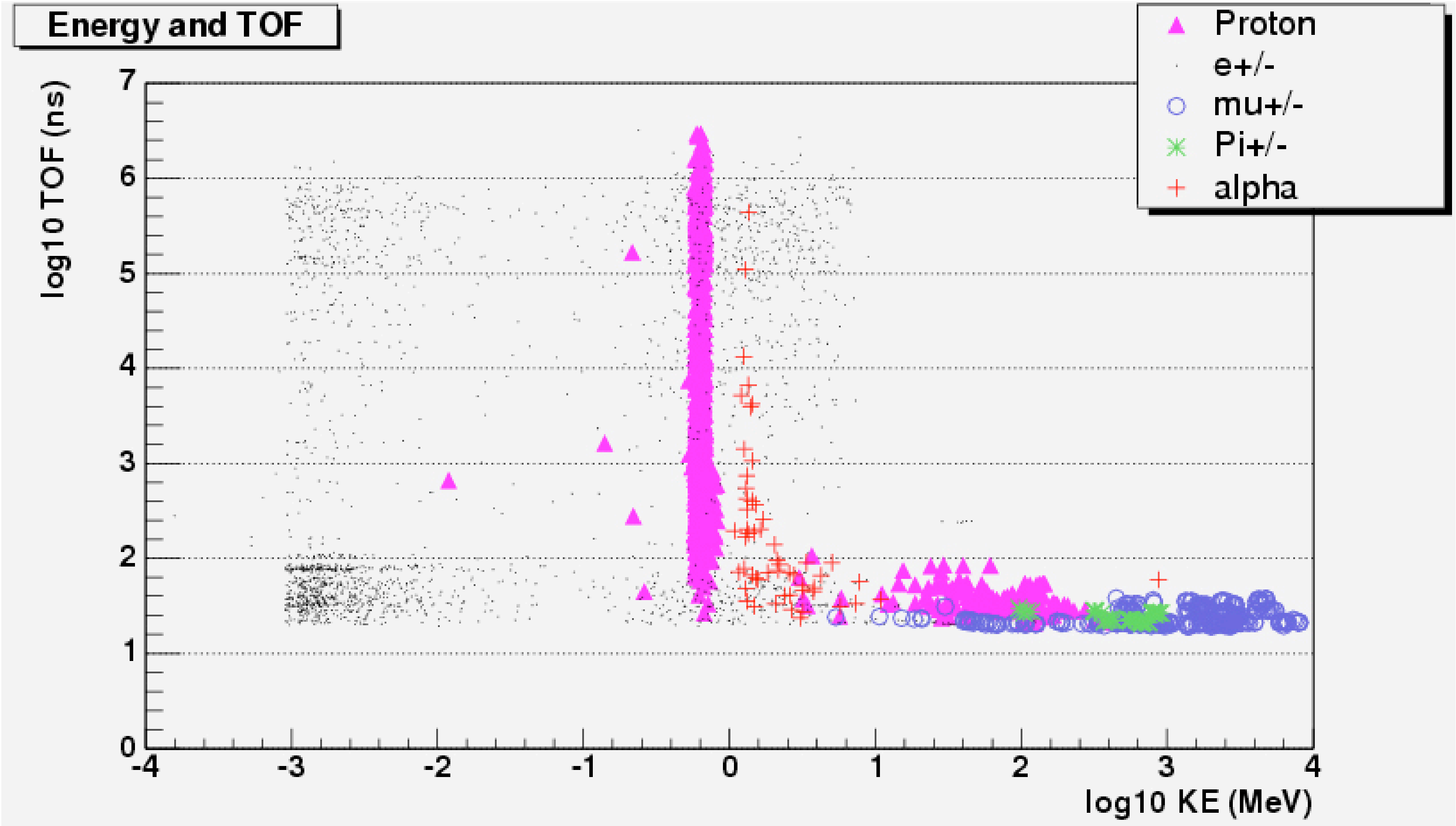
G4NDL 3.7	G4NDL 3.8	G4NDL 3.9



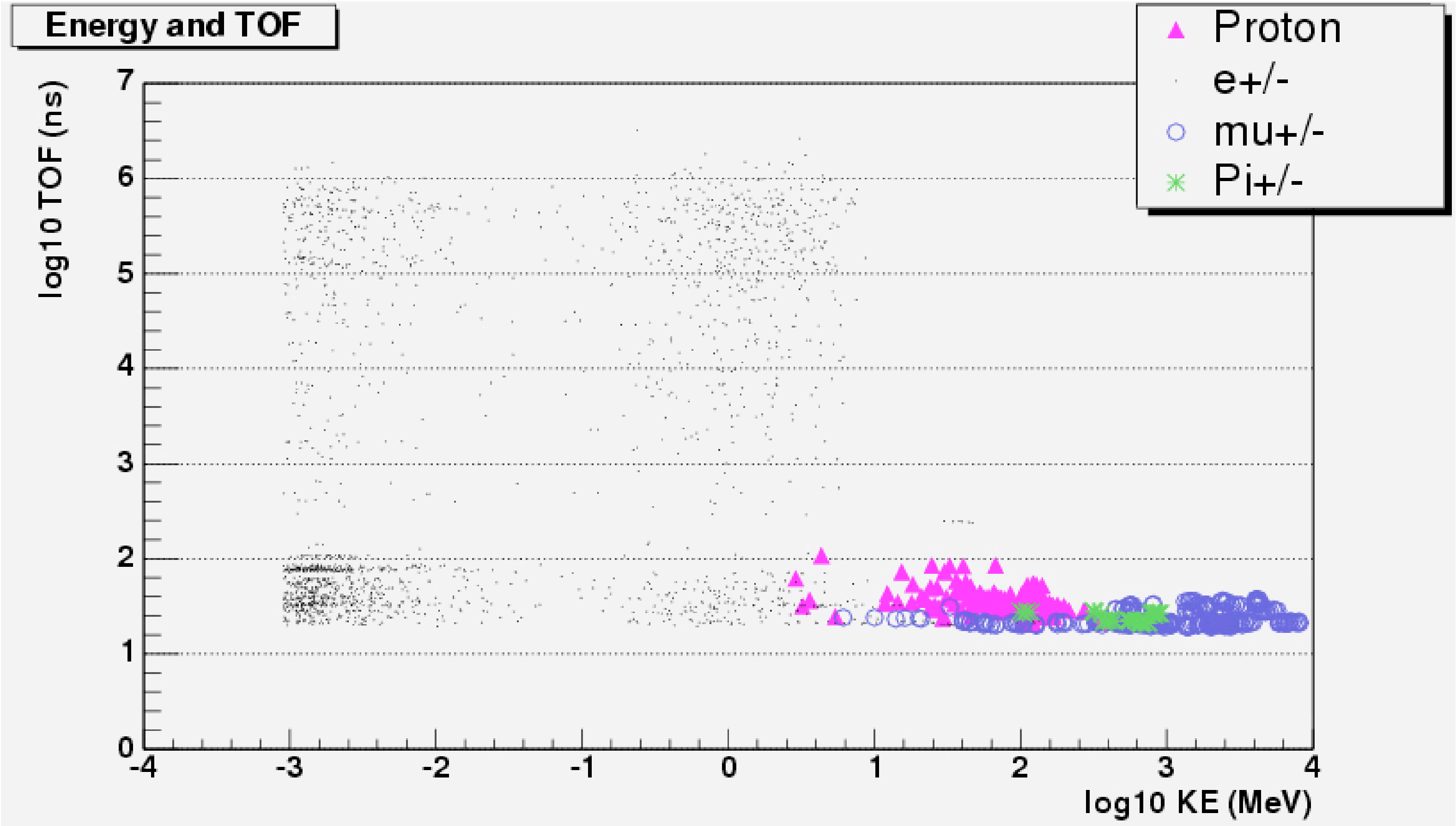
Geometry use with G4 standalone

Geant4 (OSCAR)

2k events, QGSP_BERT_HP, All muon detectors

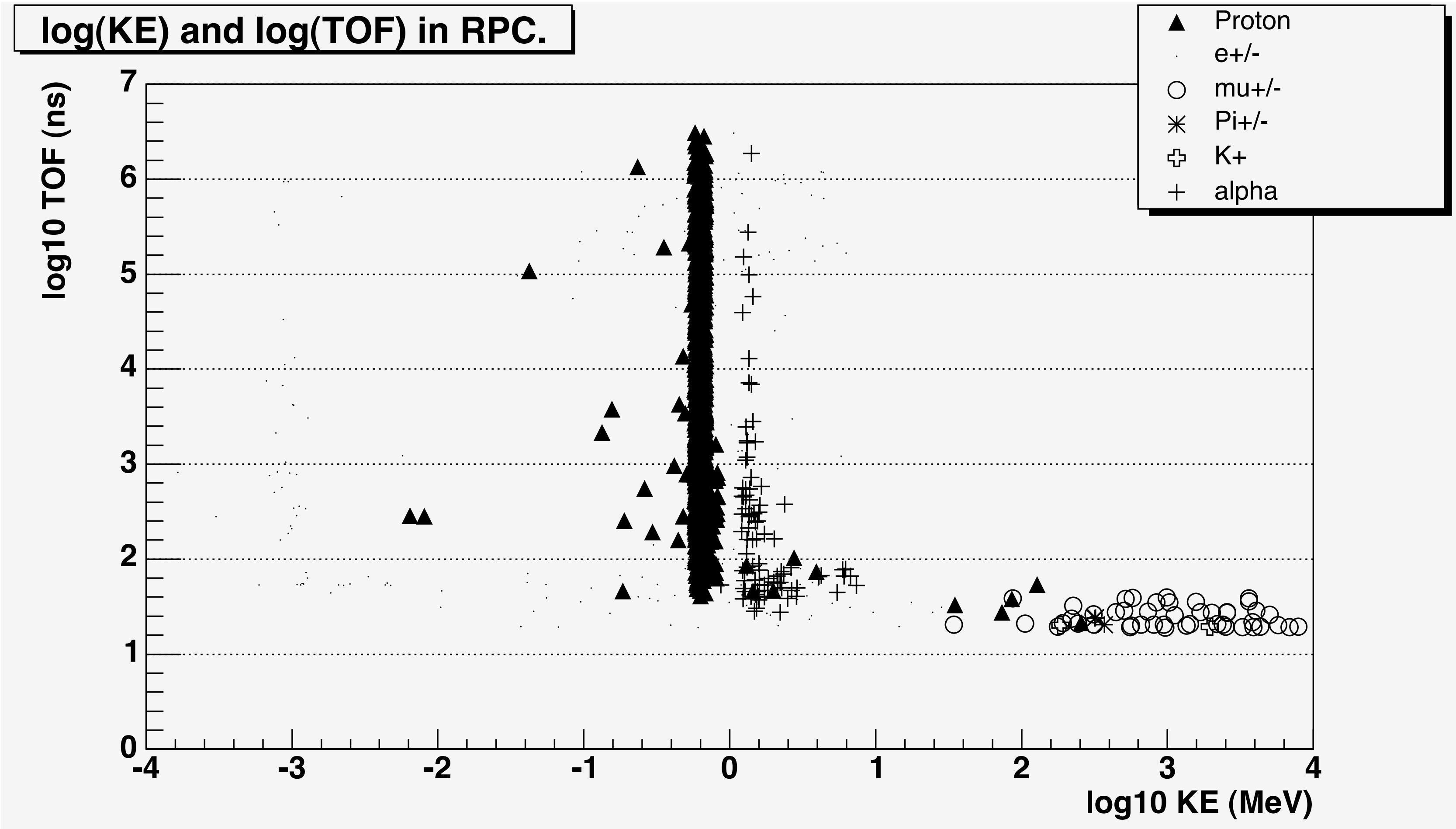


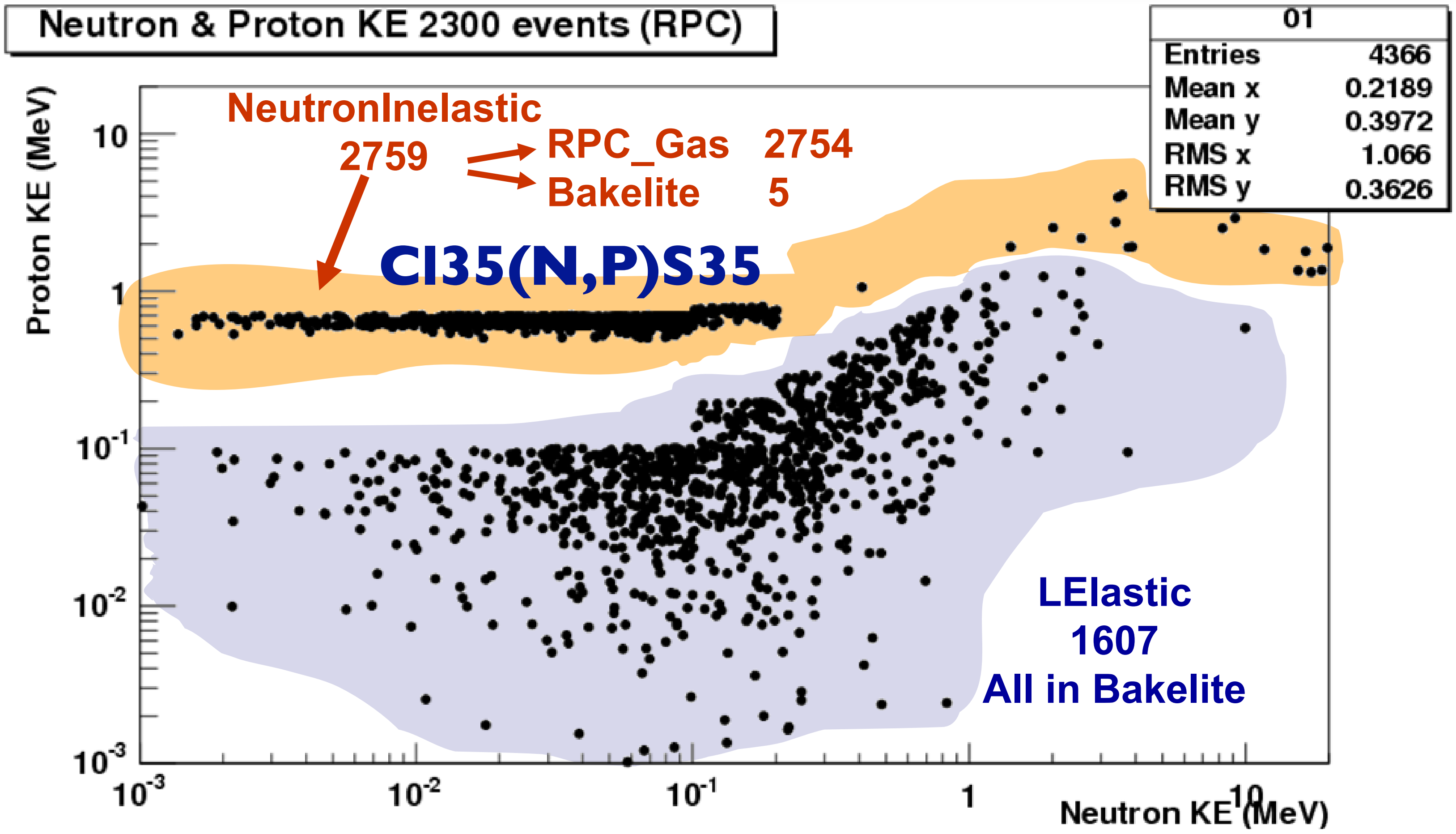
2k events, QGSP_BERT_HP, Muon endcap detectors



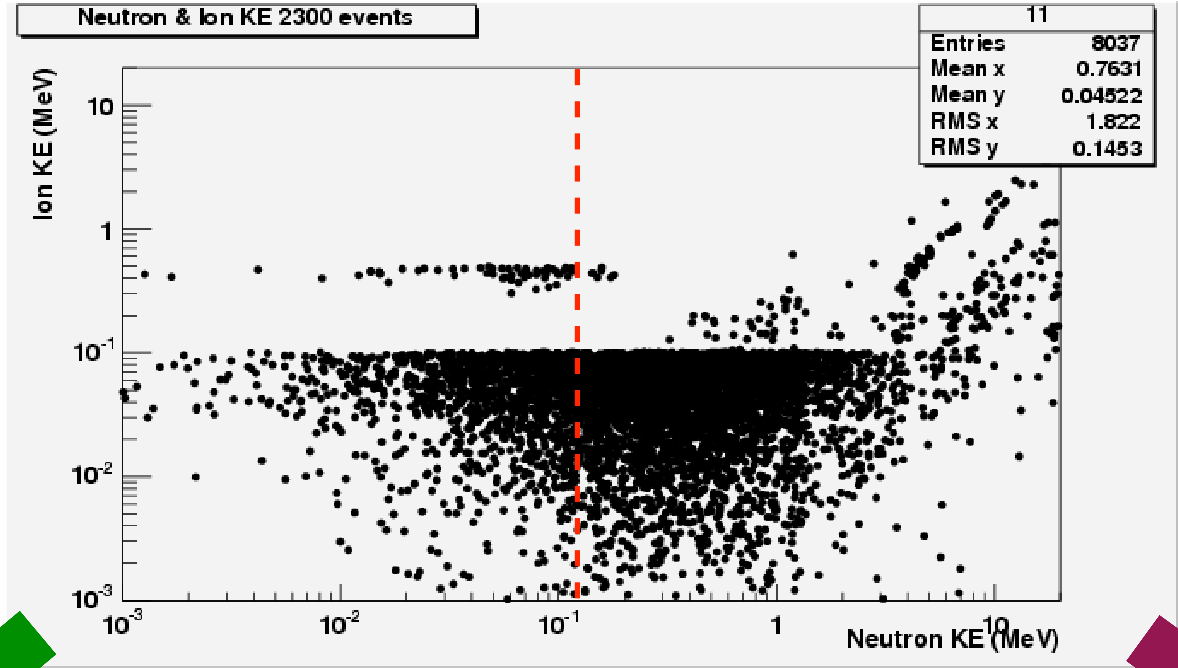
This results (in endcap) looks like the results from Geant3 study.

2k events, QGSP_BERT_HP, RPC muon chamber



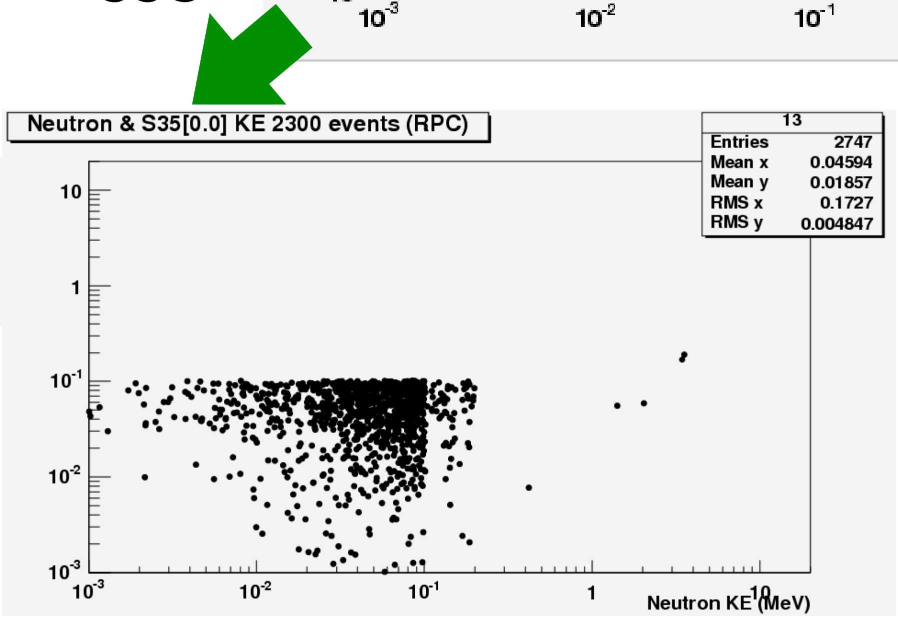


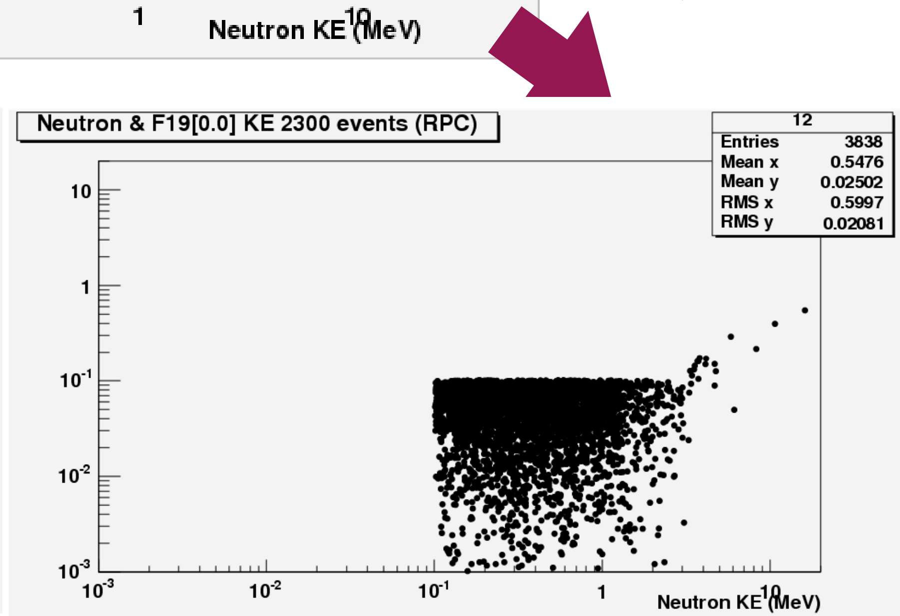
Neutron & Proton KE 2300 events (RPC)
01
Entries 4366
Mean x 0.2189
Mean y 0.3972
RMS x 1.066
RMS y 0.3626
NeutronInelastic
2759
RPC_Gas 2754
Bakelite 5
Cl35(N,P)S35
LElastic
1607
All in Bakelite
Proton KE (MeV)
Neutron KE (MeV)


Neutron & Ion KE 2300 events
11
Entries 8037
Mean x 0.7631
Mean y 0.04522
RMS x 1.822
RMS y 0.1453
Ion KE (MeV)
Neutron KE (MeV)

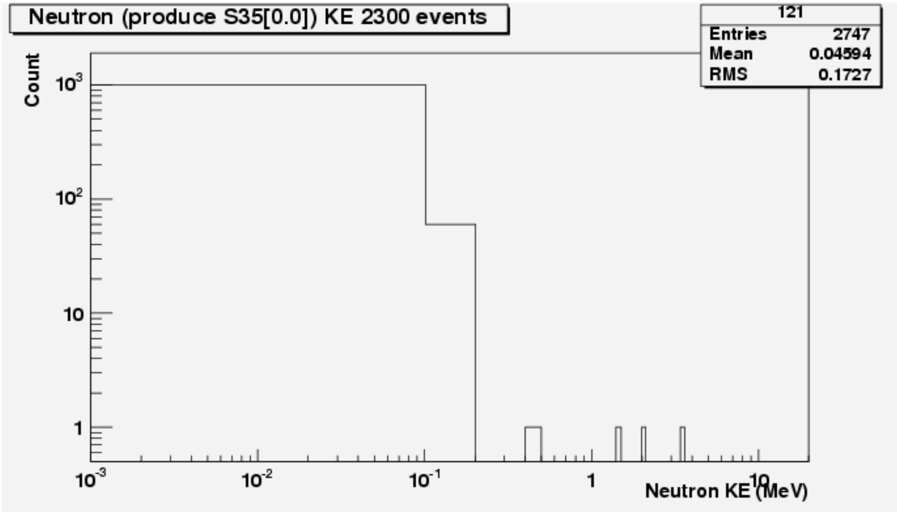
S35

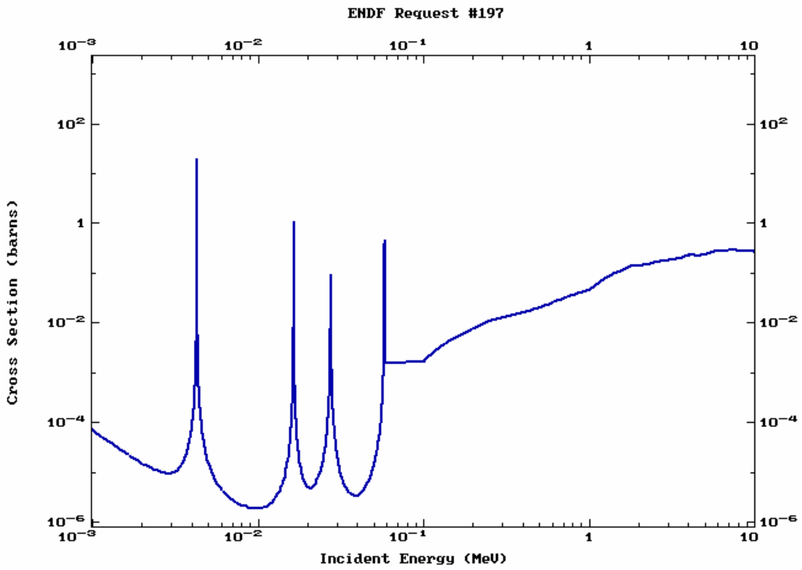
F19


Neutron & S35[0.0] KE 2300 events (RPC)
13
Entries 2747
Mean x 0.04594
Mean y 0.01857
RMS x 0.1727
RMS y 0.004847
Neutron KE (MeV)


Neutron & F19[0.0] KE 2300 events (RPC)
12
Entries 3838
Mean x 0.5476
Mean y 0.02502
RMS x 0.5997
RMS y 0.02081
Neutron KE (MeV)

Compare with ENDF data

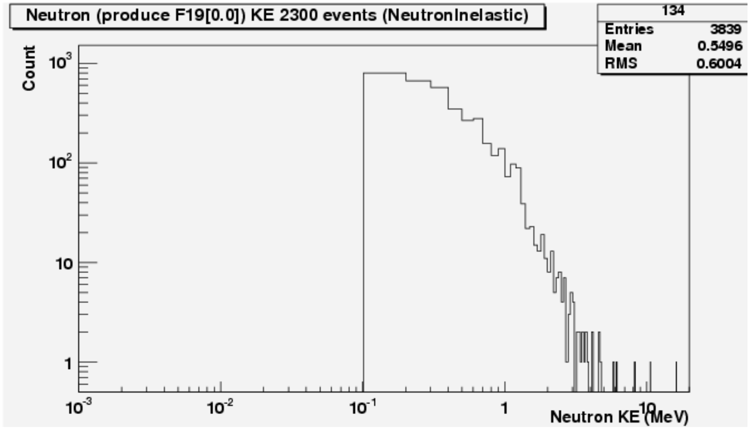


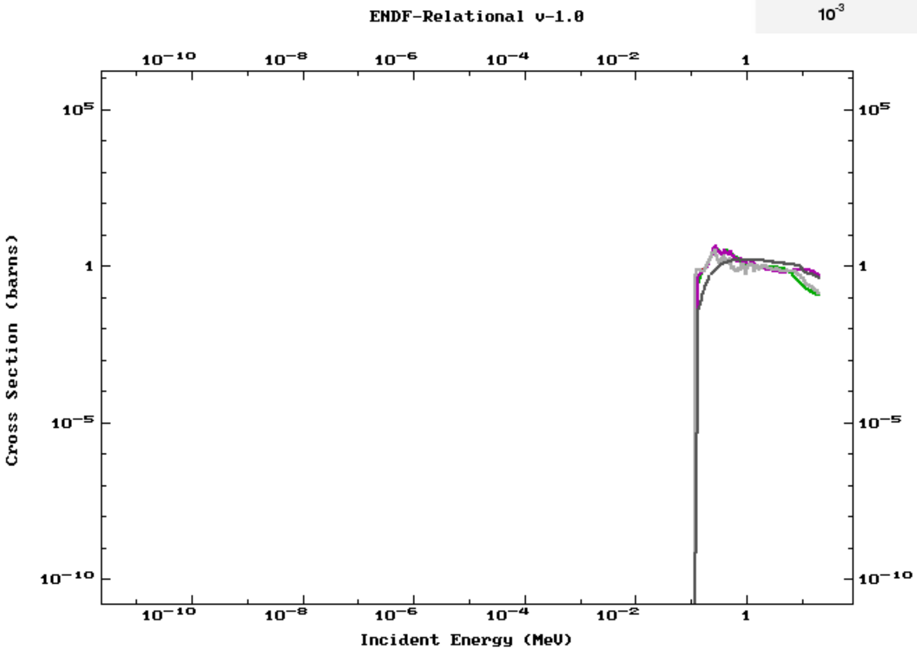


$$^{1}n_{0} + {}^{35}Cl_{17} \rightarrow {}^{1}p_{1} + {}^{35}S_{16}$$

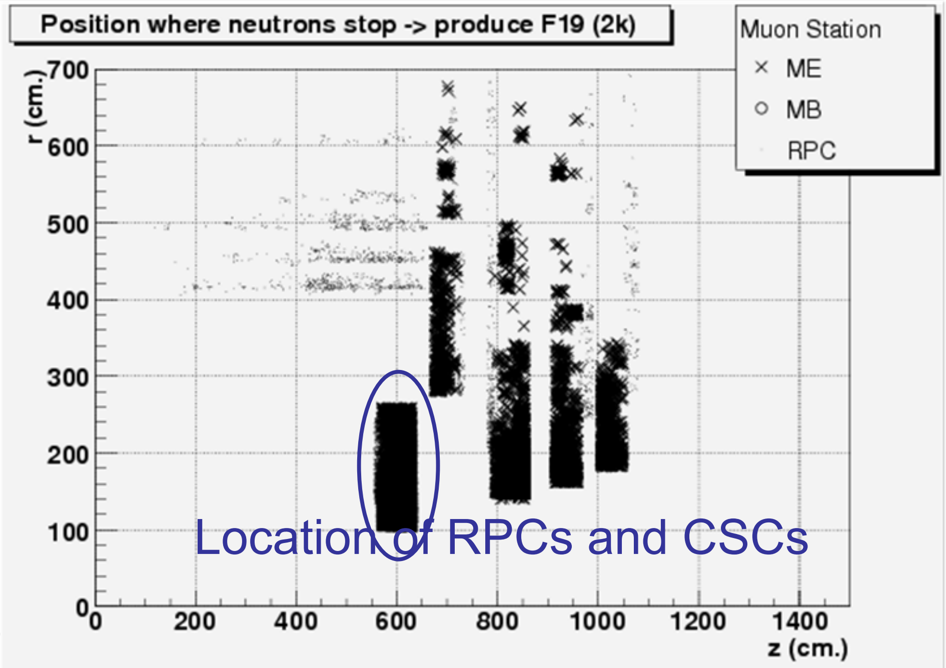
Cl-35 (N ,P) S-35

$${}^{1}n_{0} + {}^{19}F_{9} \rightarrow {}^{1}n_{0} + {}^{19}F_{9}$$ (+gamma)

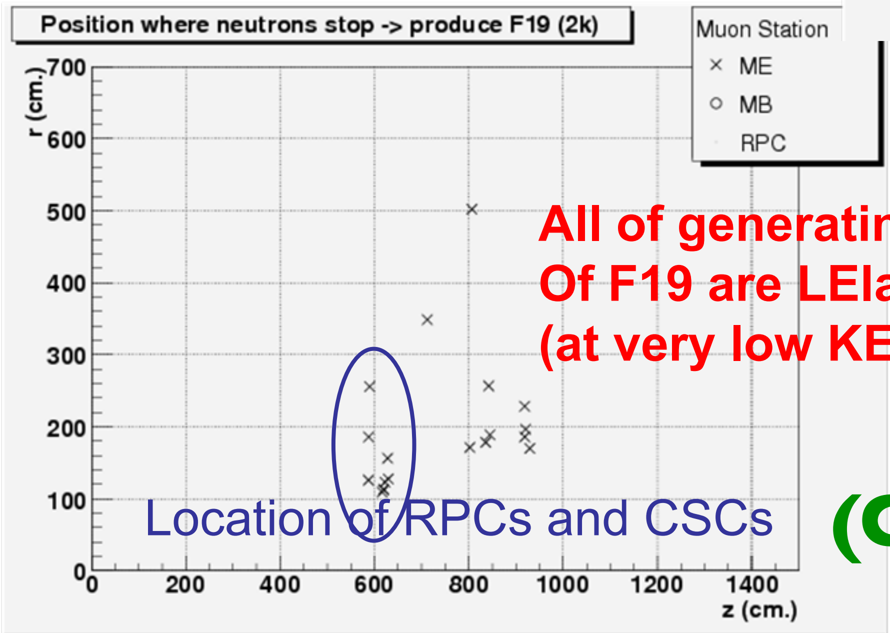




The problem should come from material cross sections, shouldn't come from CMS geometry (alignment of muon station).
We tested by changing material at muon station.



(RPC Gas)



All of generating process Of F19 are LElastic (at very low KE)

(CSC Gas)

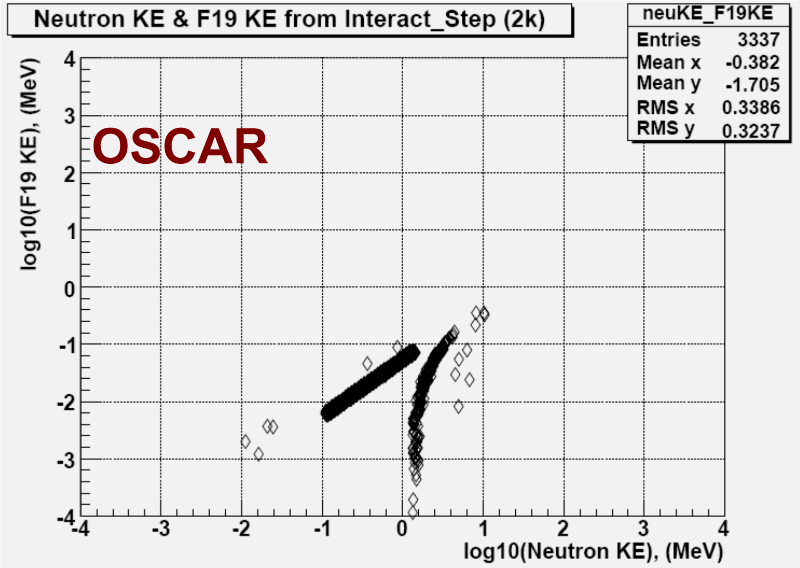
From result 10-31-2005

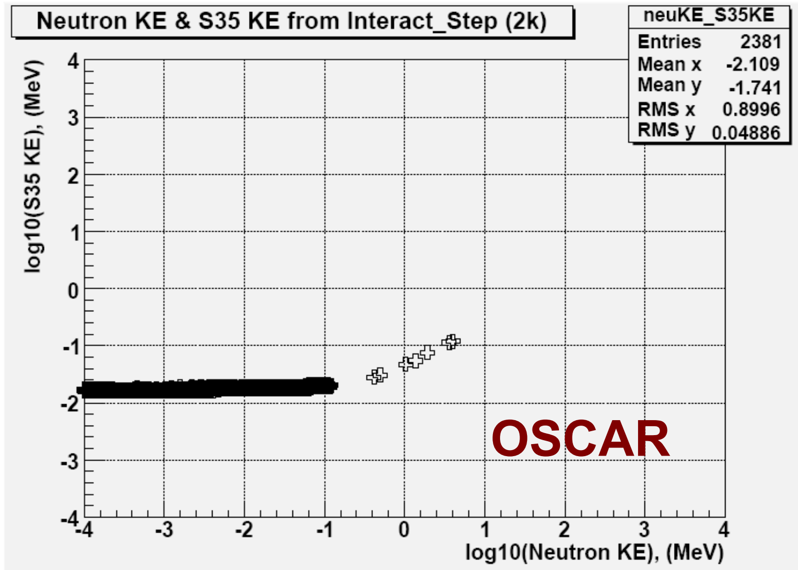
	OSCAR 3.7.0 (2k events, QGSP_BERT_HP 1.0)	
	G4NDL 3.7	G4NDL 3.8
F19	3515 (RPC region)	8
S35	2476	0
Proton	2482	0

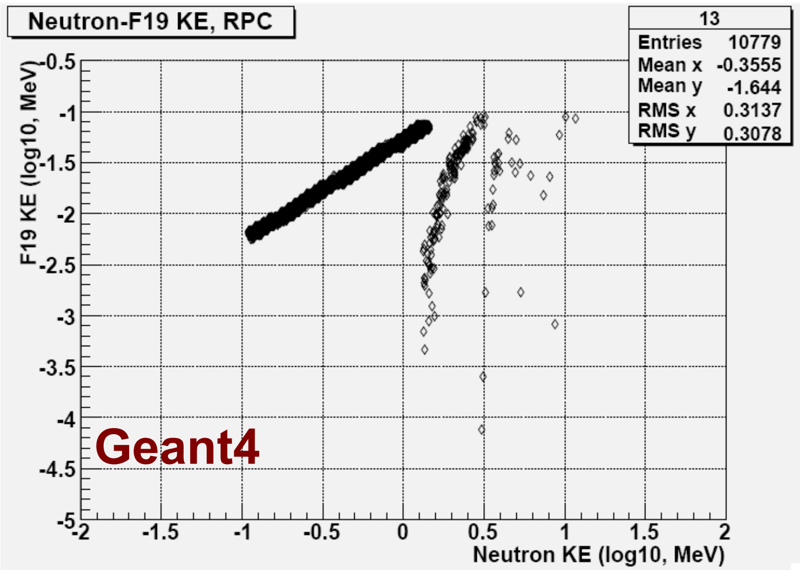
	Geant4.8.1.p01 (QGSP_BERT_HP 2.1)							
	G4NDL 3.7 (100K events)				G4NDL 3.8 (1M events)			
	RPC & CSC		pure CSC	pure RPC (1000 events)	RPC & CSC		pure CSC	pure RPC
	RPC	CSC			RPC	CSC		
F19	519392	718	512	288959	20	5364	5338	295
S35	24111	2	0	365	0	2	4	2
Proton	24427	68	98	368	18	738	861	696

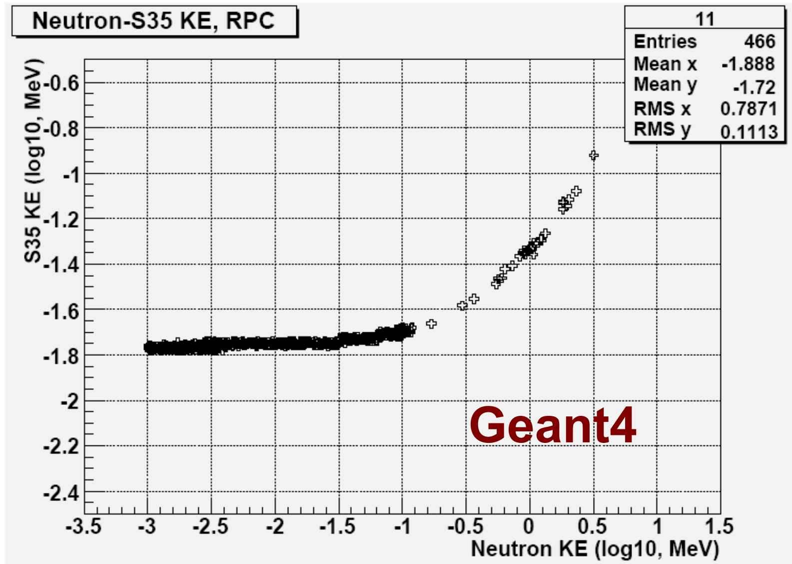
Run with Linux SLC3, gcc 3.2.3

Compare results between OSCAR & Geant4 (standalone)





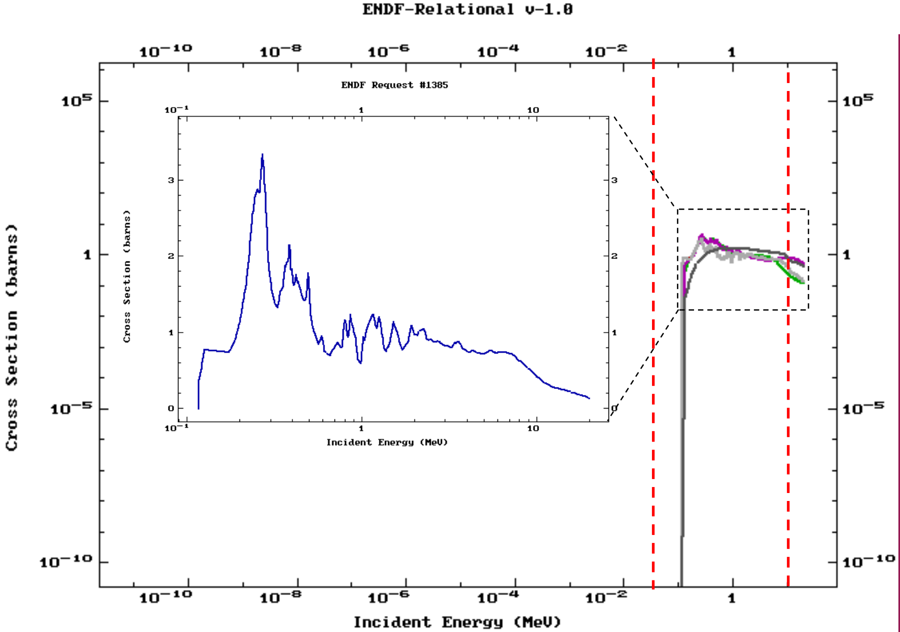


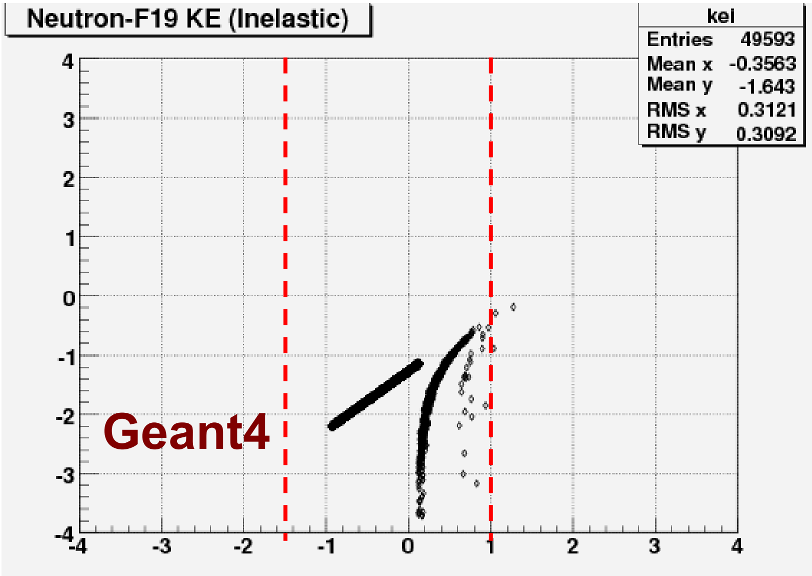


F19[0.0]

S35[0.0]

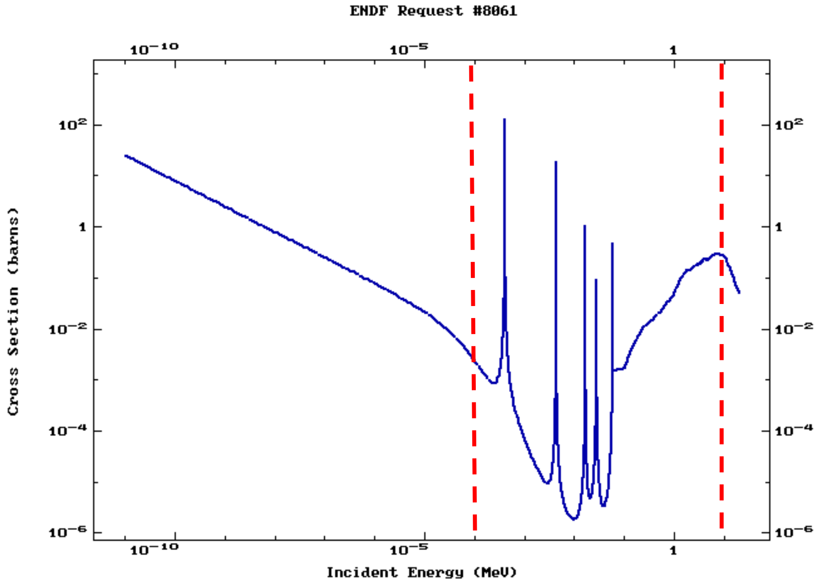
Compare F19(n,inel)F19 Cross-Sections with G4 results

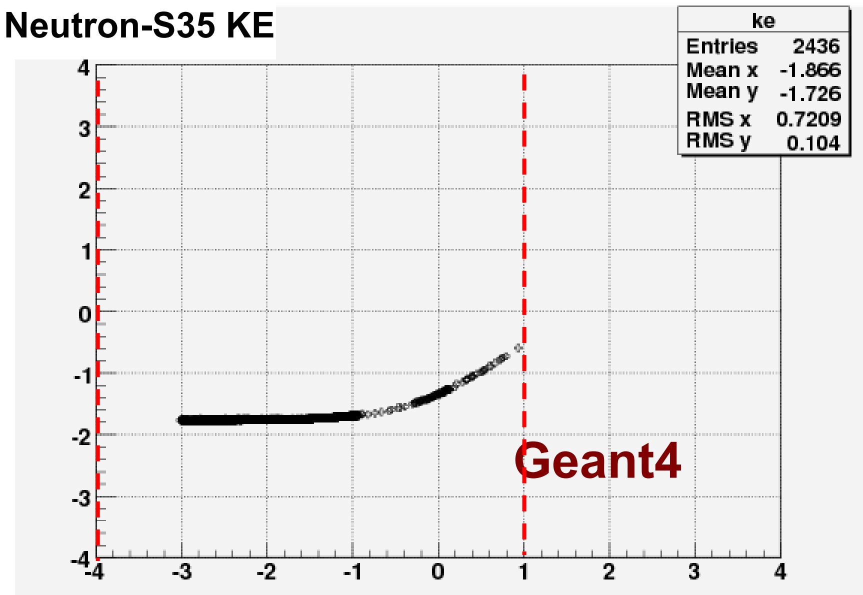




F19[0.0]

Compare Cl35(n,p)S35 Cross-Sections with G4 results





S35[0.0]

From summary 21-06-2006

F19 S35	LINUX (gcc 3.2.3)					
	3.7		3.8		3.9	
	RPC CSC	pure CSC	RPC CSC	pure CSC	RPC CSC	pure CSC
4.7.1 .p01	51935 2431	34 0	26 0	34 0	26 0	34 0
4.8.0 .p01	52904 2452	38 0	30 0	38 0	30 0	38 0
4.8.1	-	-	-	-	-	-
4.8.1 .p01	52356 2485	64 0	45 0	64 0	45 0	64 0

F19
S35

QGSP_HP 2.3, QGSP_BERT_HP 2.0, QGSP_BERT_HP 2.1

If we use G4NDL 3.8 (3.9) instead of G4NDL 3.7 we found that the number of interactions with Chlorine and Fluorine goes to almost zero.

What are the changes in G4NDL3.8 (3.9)?

Replace
Inelastic/CrossSection/17_nat_Chlorine
source: Cl-NAT (neutron) from ENDF/B-VI
Tape 101

The problem comes from G4NDL

The problem of G4NDL 3.7 is
"The inelastic neutron scattering cross section data for chlorine contains a NaN, leading to significant discrepancies."

From http://pcitapiww.cern.ch/asdcgi/geant4/problemreport/show_bug.cgi?id=750

With New G4NDL (3.8, 3.9), This problem had been fixed since January 2006.

Thanks Alexander HOWARD for suggestions.

F19 S35	LINUX (gcc 3.2.3)						MAC (INTEL, Xcode 2.4)					
	3.7		3.8		3.9		3.7		3.8		3.9	
	RPC CSC	pure CSC	RPC CSC	pure CSC	RPC CSC	pure CSC	RPC CSC	pure CSC	RPC CSC	pure CSC	RPC CSC	pure CSC
4.7.1 .p01	51935 2431	34 0	26 0	34 0	26 0	34 0	29 0	35 0	37 0	35 0	37 0	35 0
4.8.0 .p01	52904 2452	38 0	30 0	38 0	30 0	38 0	37 0	37 0	22 0	37 0	22 0	37 0
4.8.1 .p01	52356 2485	64 0	45 0	64 0	45 0	64 0	43 0	58 0	58 0	58 0	58 0	58 0

QGSP_HP 2.3, QGSP_BERT_HP 2.0, QGSP_BERT_HP 2.1

It is possible that Mac resets the NaN value of Chlorine cross-sections as zero.

Summary

1. There are strange behaviors when we used G4NDL3.7
   RPC (F19 ~2%, CL35 ~3%) There are too many inelastic process

$$^{1}n_{0} + ^{35}Cl_{17} \rightarrow ^{1}p_{1} + ^{35}S_{16}$$

$$^{1}n_{0} + ^{19}F_{9} \rightarrow ^{1}n_{0} + ^{19}F_{9} \quad \text{(+gamma)}$$

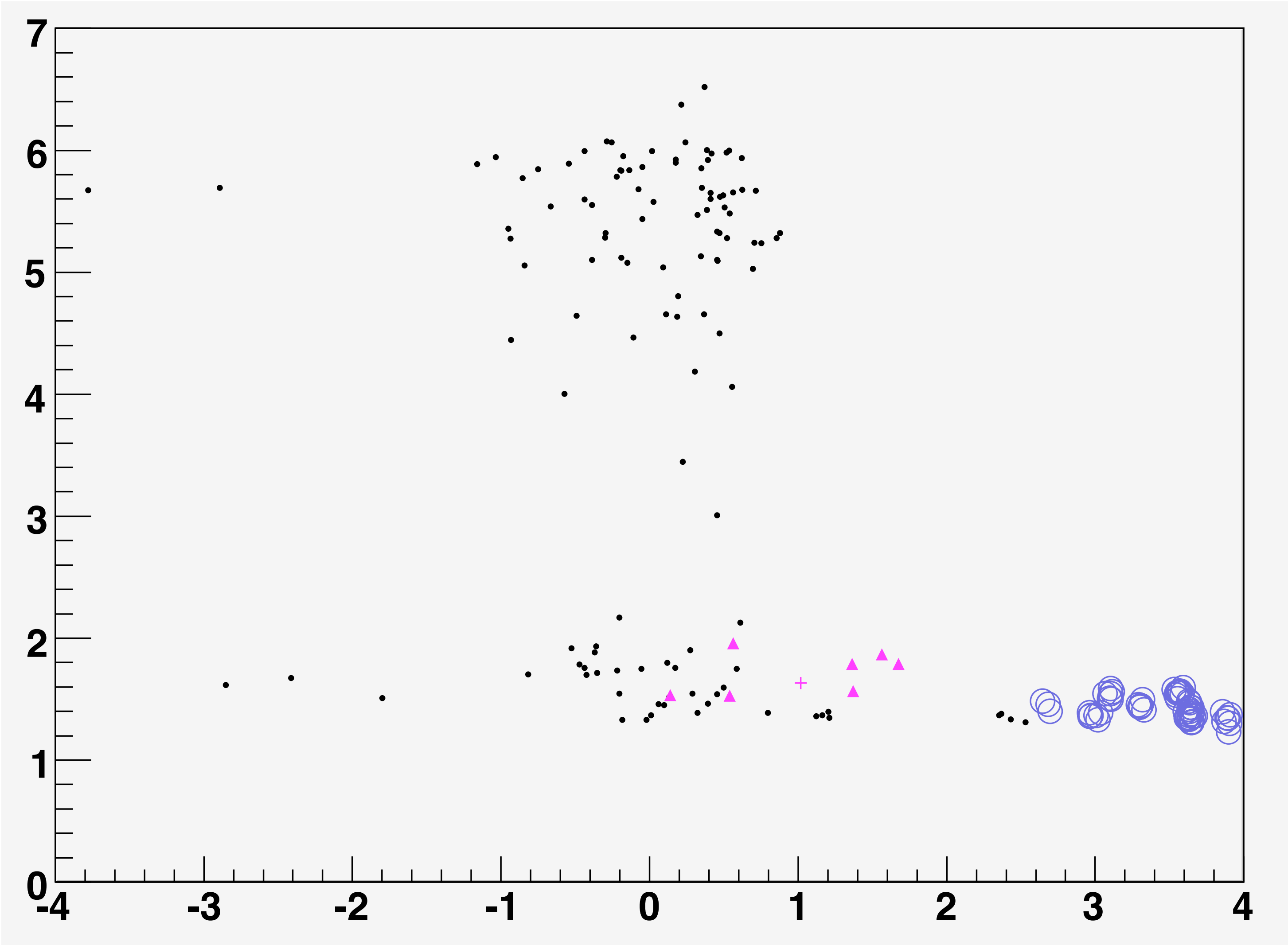
   CSC (F19 ~30%, No CL35) Few (Elastic) interactions which give F19 as daugther.

This problem comes from Chlorine data of G4NDL 3.7 which contains NaN data.

2. Behaviors in (1) appeared only when we used Linux. They didn't appear when we tried with Mac.

It's possible that Mac reset NaN as zero for chlorine cross-sections.

3. With G4NDL3.8 (3.9), results look reasonable. Mac and Linux gave results in the same way.



No. of hits/events (above 250 ns)
Geant 3 1.1 (1000 events)
Geant4 0.82 (147 events)