FIGURE 1

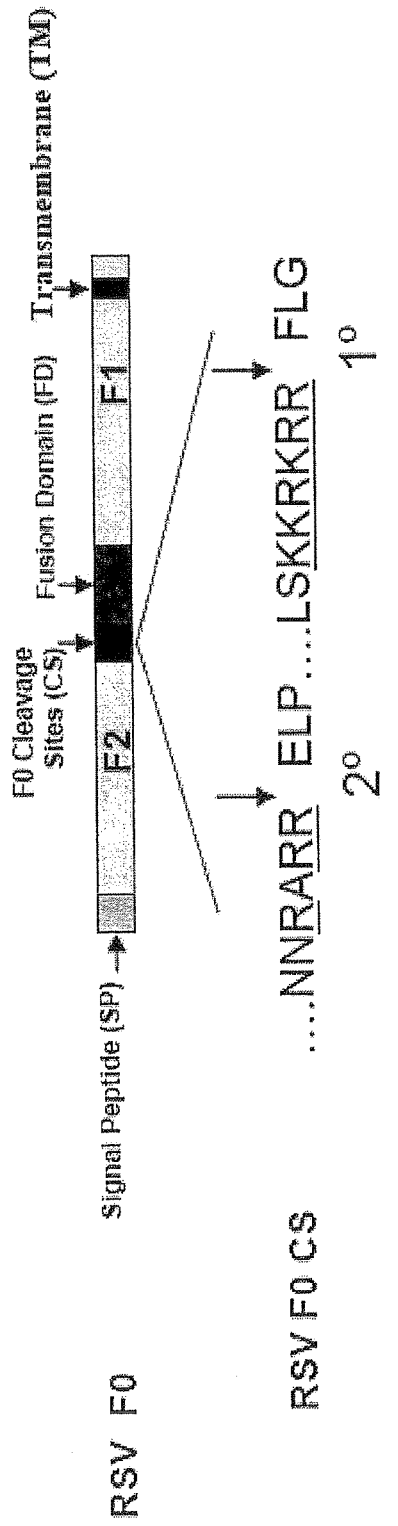

Transmembrane (TM)
Fusion Domain (FD)
F0 Cleavage Sites (CS)
F1
F2
Signal Peptide (SP)
RSV F0
RSV F0 CS
....NNRARR
ELP....LSKKRKRR
FLG
2°
1°

FIGURE 2

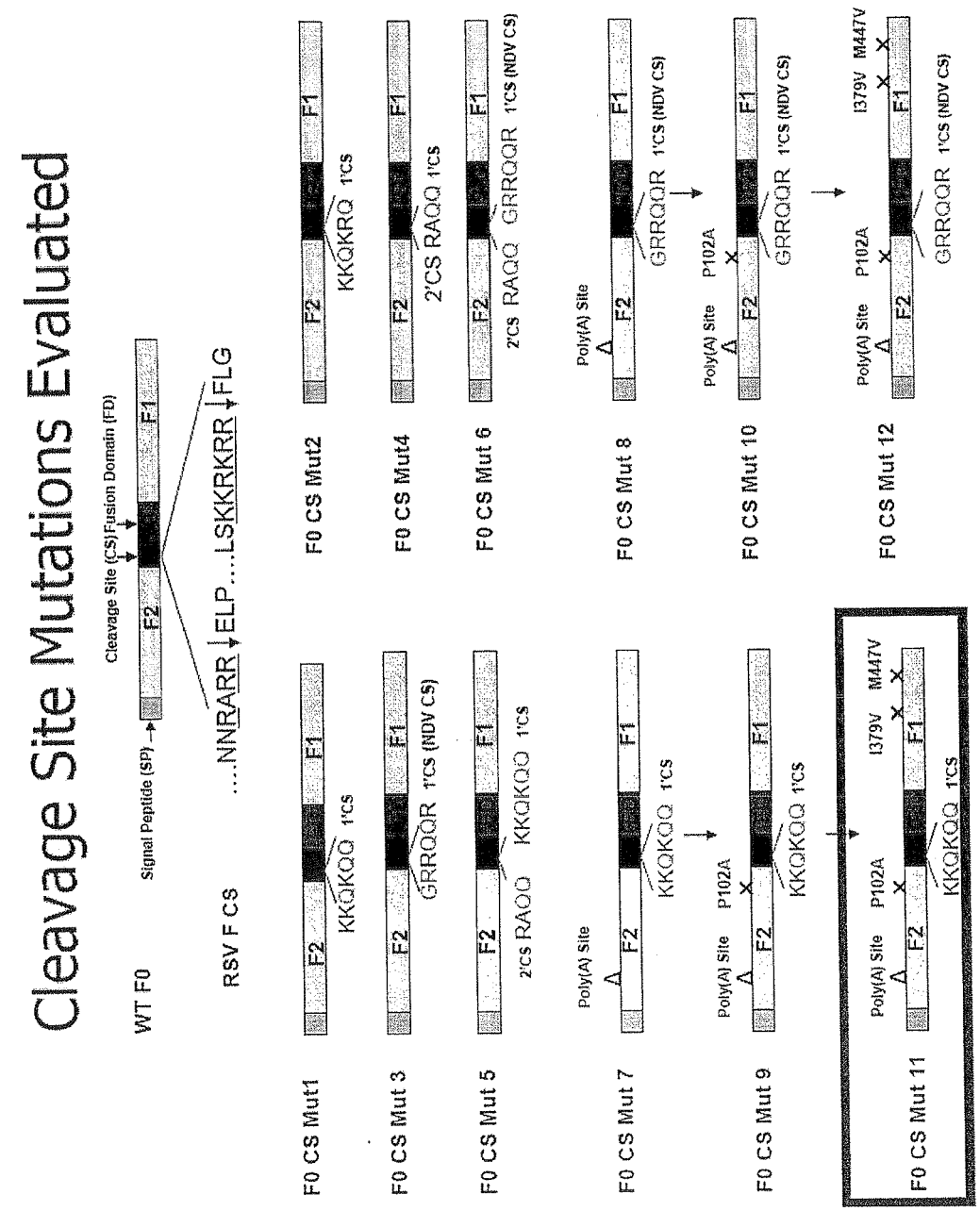
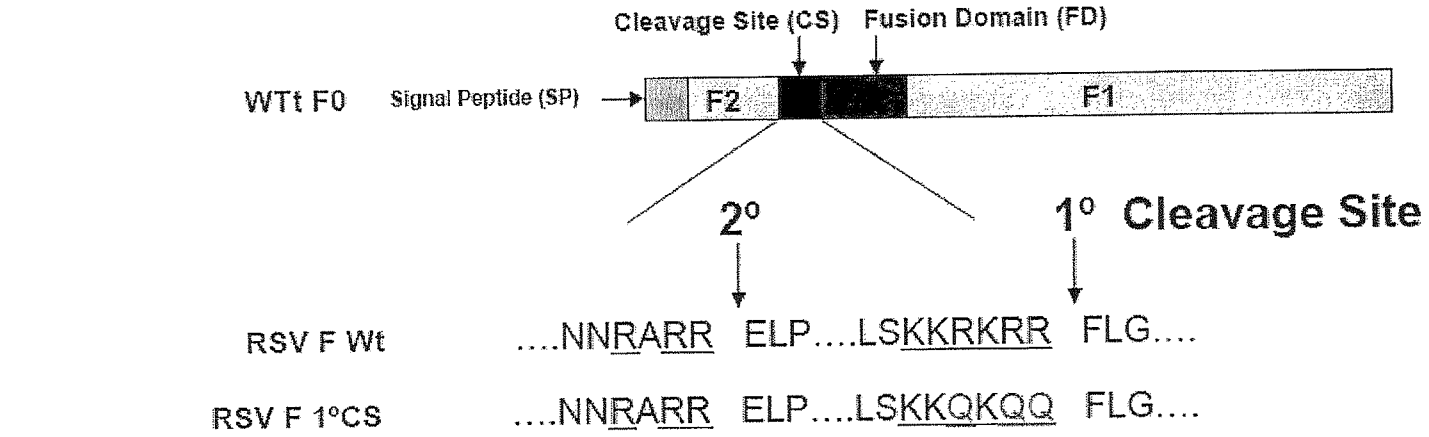
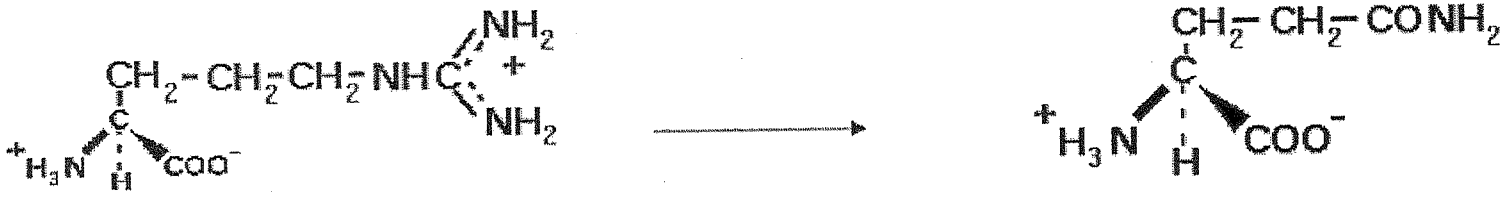

Cleavage Site Mutations Evaluated
Cleavage Site (CS)
Fusion Domain (FD)
WT F0
Signal Peptide (SP)
F2
F1
RSV F CS
....NNRARR↓ELP....LSKKRKRR↓FLG
F0 CS Mut1
KKQKQQ 1°CS
F0 CS Mut2
KKQKRQ 1°CS
F0 CS Mut 3
GRRQQR 1°CS (NDV CS)
F0 CS Mut4
2°CS RAQQ 1°CS
F0 CS Mut 5
2°CS RAQQ KKQKQQ 1°CS
F0 CS Mut 6
2°CS RAQQ GRRQQR 1°CS (NDV CS)
Poly(A) Site
F0 CS Mut 7
F0 CS Mut 8
F0 CS Mut 9
P102A
F0 CS Mut 10
I379V
M447V
F0 CS Mut 11
F0 CS Mut 12

FIGURE 3





Arginine (R)
polar - charged

- Preserve 3D structure
- Alter the charge
- Prevent cleavage
- Down regulate fusion

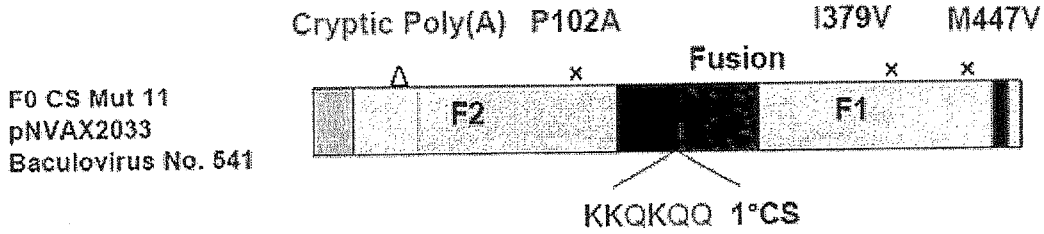
Glutamine (Q)
polar - neutral

FIGURE 4

Modified RSV F0 (GeneBank Assession AAB59858): pNVAX 2023 clone

MELLILKANA ITTILTAVTF CFASGQNITE EFYQSTCSAV SKGYLSALRT
GWYTSVITIE LSNIKENKCN GTDAKVKLIK QELDKYKNAV TELQLLMQST
PATNN[redacted]E LPRFMNYTLN NAKKTNVTLS KKKQKQGFLGF LLGVGSAIAS
GVAVSKVLHL EGEVNKIKSA LLSTNKAVVS LSNGVSVLTS KVLDLKNYID
KQLLPIVNKQ SCSISNIETV IEFQQKNNRL LEITREFSVN AGVTTPVSTY
MLTNSELLSL INDMPITNDQ KKLMSNNVQI VRQQSYSIMS IIKEEVLAYV
VQLPLYGVID TPCWKLHTSP LCTTNTKEGS NICLTRTDRG WYCDNAGSVS
FFPQAETCKV QSNRVFCDTM NSLTLPSEVN LCNVDIFNPK YDCKIMTSKT
DVSSSVITSL GAIVSCYGKT KCTASNKNRG IIKTFSNGCD YVSNKGVDTV
SVGNTLYYVN KQEGKSLYVK GEPIINFYDP LVFPSDEFDA SISQVNEKIN
QSLAFIRKSD ELLHNVNAGK STTNIMITTI IIVIIVILLS LIAVGLLLYC
KARSTPVTLS KDQLSGINNI AFSN

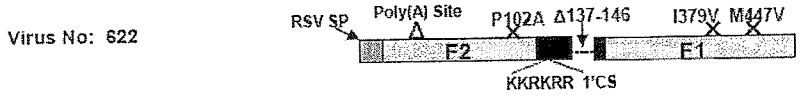
2° Cleavage Site 1° Cleavage Site Fusion domain



F0 CS Mut 11
pNVAX2033
Baculovirus No. 541

FIGURE 5

Partial deletion (Δ137-146) of F fusion domain




```
Δ137-146    MELLILKANAITTILTAVTFCFASGQNITEEFYQSTCSAVSKGYLSALRTGWYTSVITIE 60
WT F0       MELLILKANAITTILTAVTFCFASGQNITEEFYQSTCSAVSKGYLSALRTGWYTSVITIE 60
            ************************************************************

Δ137-146    LSNIKENKCNGTDAKVKLIKQELDKYKNAVTELQLLMQSTPATNNRARRELPRFMNYTLN 120
WT F0       LSNIKENKCNGTDAKVKLIKQELDKYKNAVTELQLLMQSTPATNNRARRELPRFMNYTLN 120
            ************************************************************

Δ137-146    NAKKTNVTLSKKRKRR----------AIASGVAVSKVLHLEGEVNKIKSALLSTNKAVVS 170
WT F0       NAKKTNVTLSKKRKRRFLGFLLGVGSAIASGVAVSKVLHLEGEVNKIKSALLSTNKAVVS 180
            ****************            ********************************

Δ137-146    LSNGVSVLTSKVLDLKNHIDKQLLPIVNKQSCSISNIETVIEFQQKNNRLLEITREFSVN 230
WT F0       LSNGVSVLTSKVLDLKNYIDKQLLPIVNKQSCSISNIETVIEFQQKNNRLLEITREFSVN 240
            ****************;*************************************

Δ137-146    AGVTTPVSTYMLTNSELLSLINDMPITNDQKKLMSNNVQIVRQQSYSIMSIIKEEVLAYV 290
WT F0       AGVTTPVSTYMLTNSELLSLINDMPITNDQKKLMSNNVQIVRQQSYSIMSIIKEEVLAYV 300
            ************************************************************

Δ137-146    VQLPLYGVIDTPCWKLHTSPLCTINTKEGSNICLTRTDRGWYCDNAGSVSFFPQAETCKV 350
WT F0       VQLPLYGVIDTPCWKLHTSPLCTINTKEGSNICLTRTDRGWYCDNAGSVSFFPQAETCKV 360
            ************************************************************

Δ137-146    QSNRVFCDTMNSLTLPSEVNLCNVDIFNPKYDCKIMTSKTDVSSSVITSLGAIVSCYGKT 410
WT F0       QSNRVFCDTMNSLTLPSEVNLCNVDIFNPKYDCKIMTSKTDVSSSVITSLGAIVSCYGKT 420
            ************************************************************

Δ137-146    KCTASNKNRGIIKTFSNGCDYVSNKGVDTVSVGNTLYYVNKQEGKSLYVKGEPIINFYDP 470
WT F0       KCTASNKNRGIIKTFSNGCDYVSNKGVDTVSVGNTLYYVNKQEGKSLYVKGEPIINFYDP 480
            ************************************************************

Δ137-146    LVFPSDEFDASISQVNEKINQSLAFIRKSDELLHNVNAGKSTTNIMITTIIIVIIVILLS 530
WT F0       LVFPSDEFDASISQVNEKINQSLAFIRKSDELLHNVNAGKSTTNIMITTIIIVIIVILLS 540
            ************************************************************

Δ137-146    LIAVGLLLYCKARSTPVTLSKDQLSGINNIAFSN- 564
WT F0       LIAVGLLLYCKARSTPVTLSKDQLSGINNIAFSN- 574
            ********************************
```

FIGURE 6

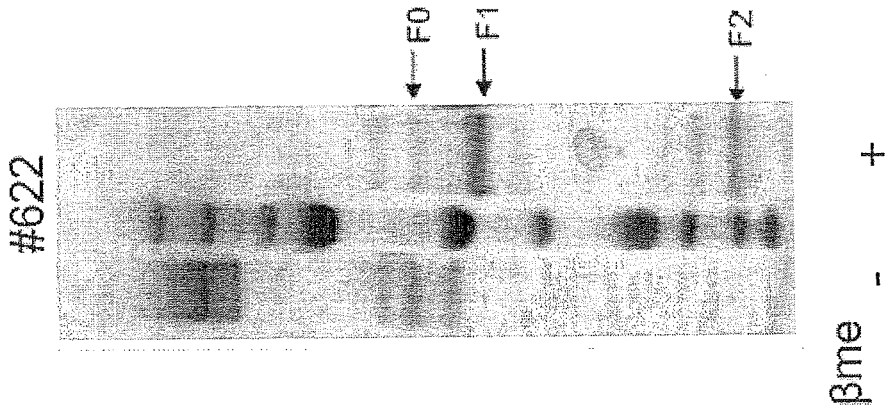
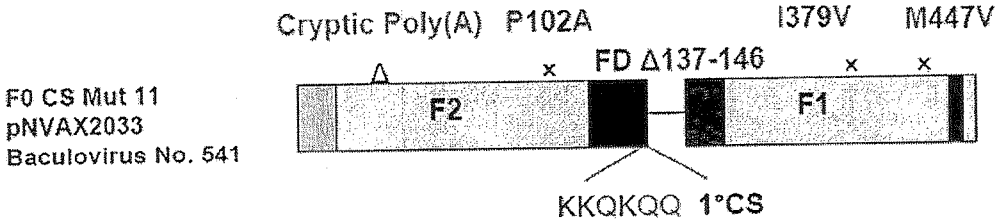


FIGURE 7

BV #683 Modified RSV F0



Codon optimized
1° cleavage site inactivation (3 conservative aa changes)
Cryptic poly(A) in F2 removed
3 aa corrections to GenBank sequence
Deletion of N-terminal half of the F1 fusion domain

FIGURE 8

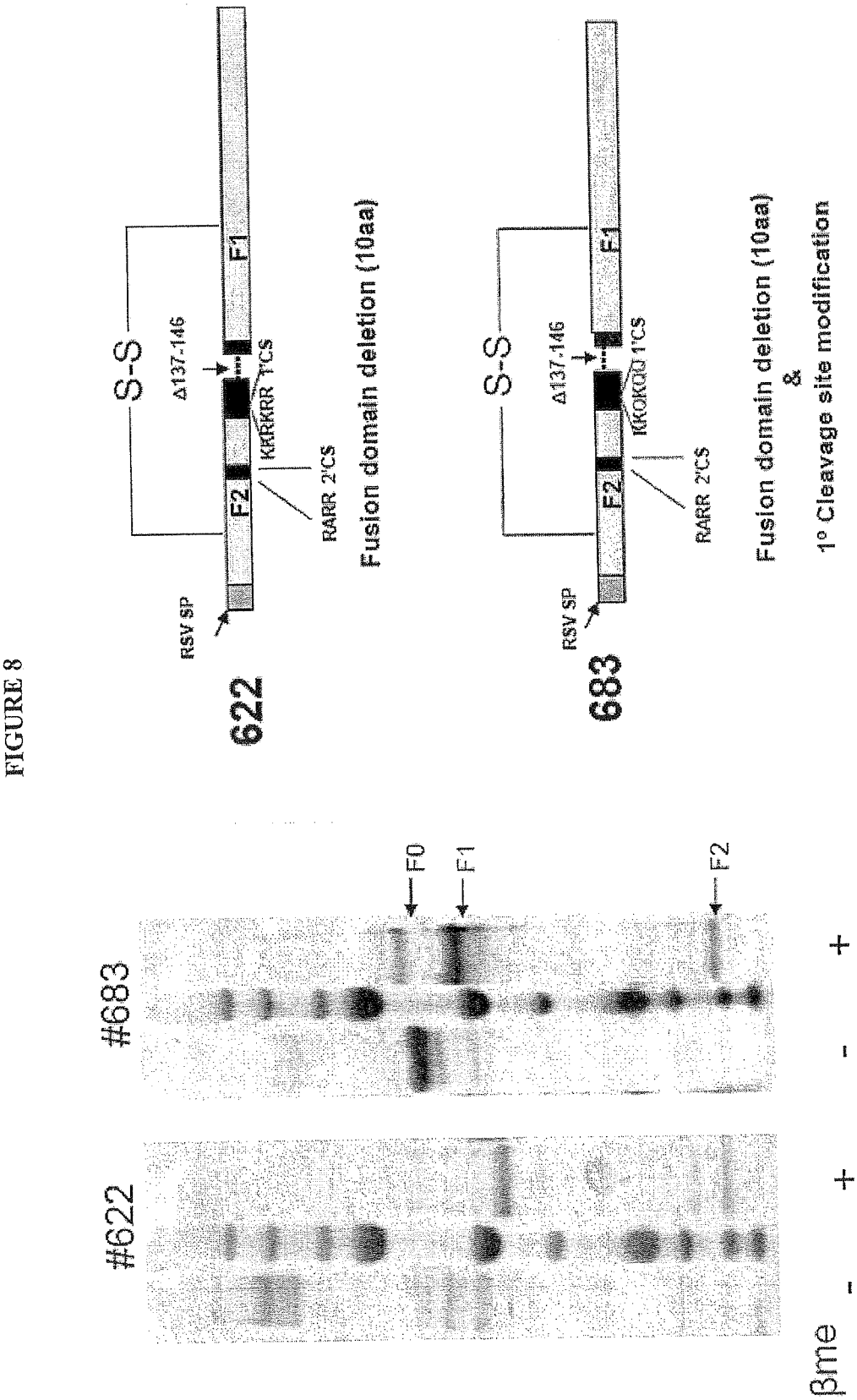

S-S
Δ137-146
F1
F2
KRRKRR 1°CS
RARR 2°CS
RSV SP
622
Fusion domain deletion (10aa)
S-S
Δ137-146
F1
F2
KKOKOO 1°CS
RARR 2°CS
RSV SP
683
Fusion domain deletion (10aa)
&
1° Cleavage site modification
F0
F1
F2
#683
#622
βme - + - +

FIGURE 9

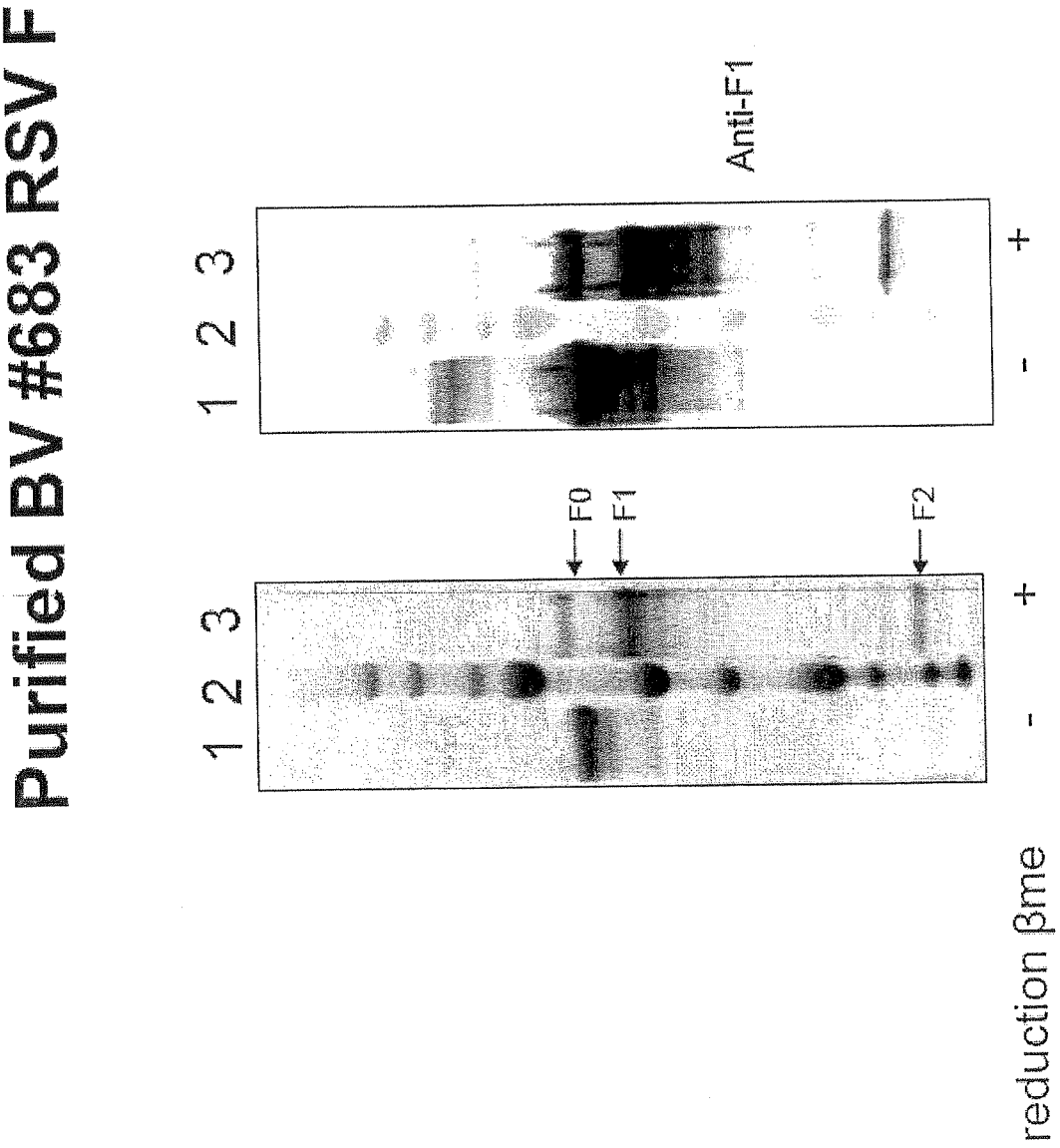
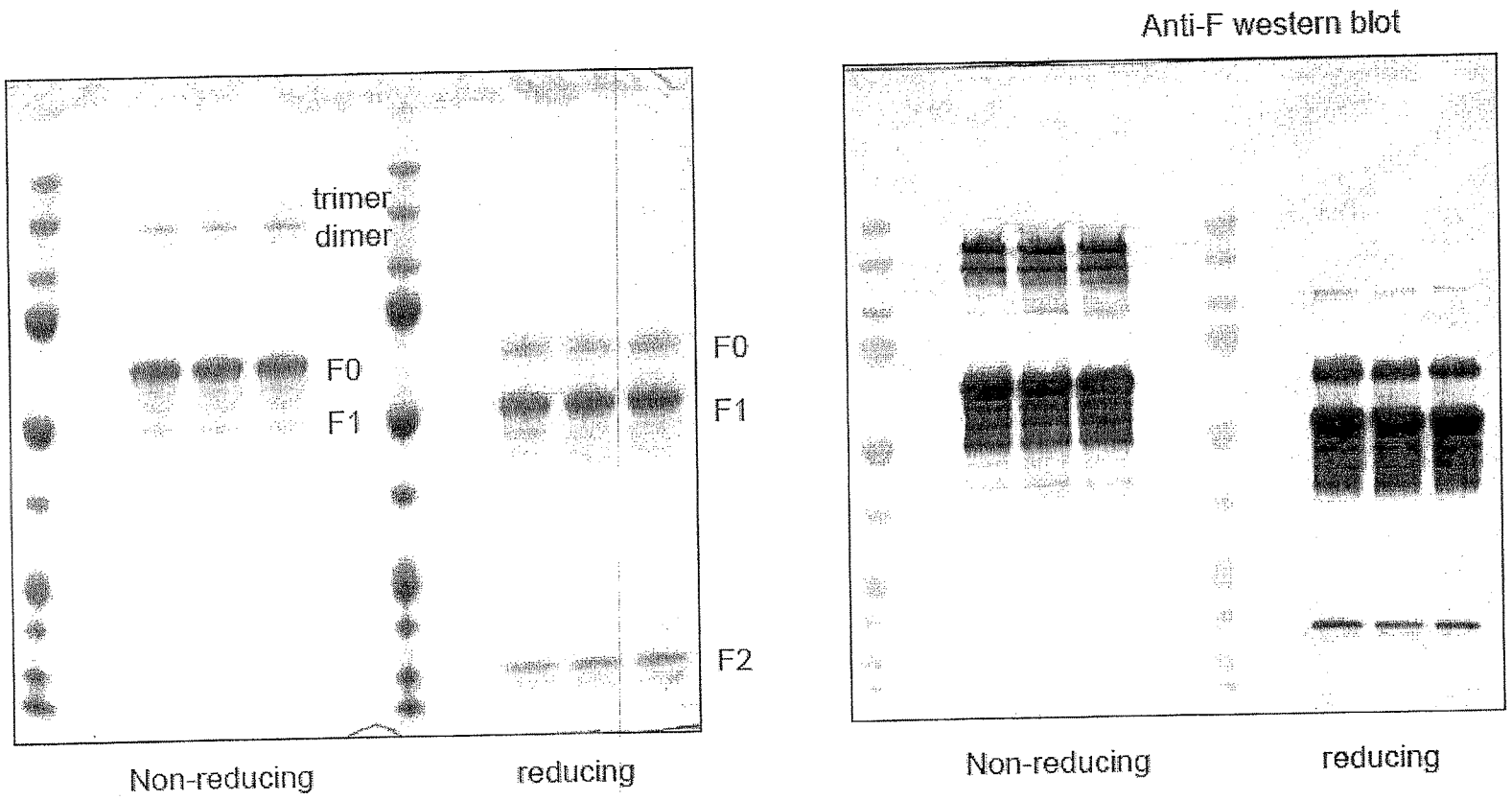


FIGURE 10



Purity >98% scanning densitometry

FIGURE 11

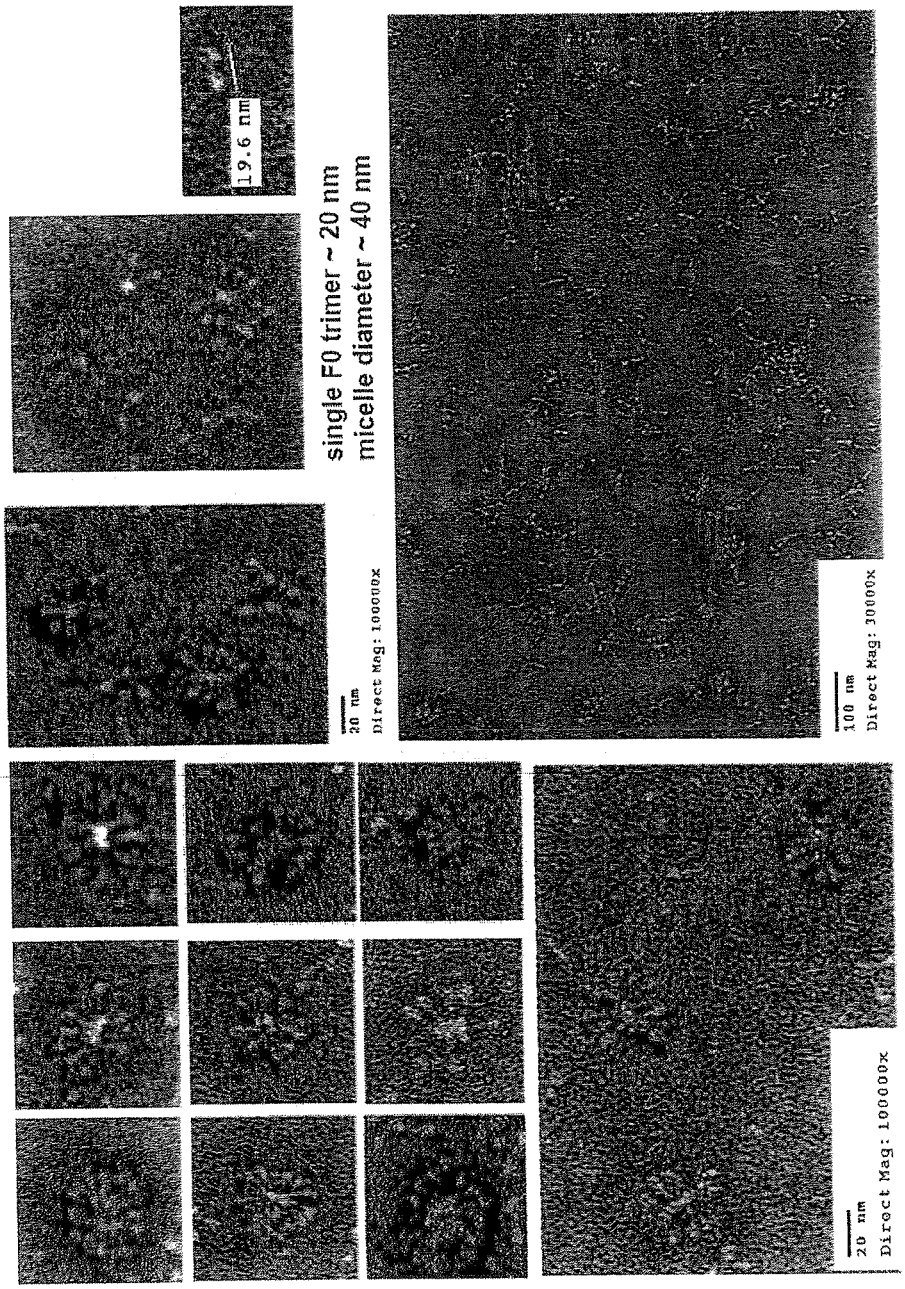

Purified RSV - F #683 micelles (rosettes)
19.6 nm
single F0 trimer ~ 20 nm
micelle diameter ~ 40 nm
20 nm
Direct Mag: 100000x
100 nm
Direct Mag: 30000x
20 nm
Direct Mag: 100000x

FIGURE 12

Particle size analysis shows RSV 683 F0 forms 40 nm particles

Results

Z-Average (d.nm):	40.2
PdI:	0.383
Intercept:	0.823

	Diam. (nm)	% Intensity	Width (nm)
Peak 1:	91.3	98.4	155
Peak 2:	4390	1.6	938
Peak 3:	0.00	0.0	0.00

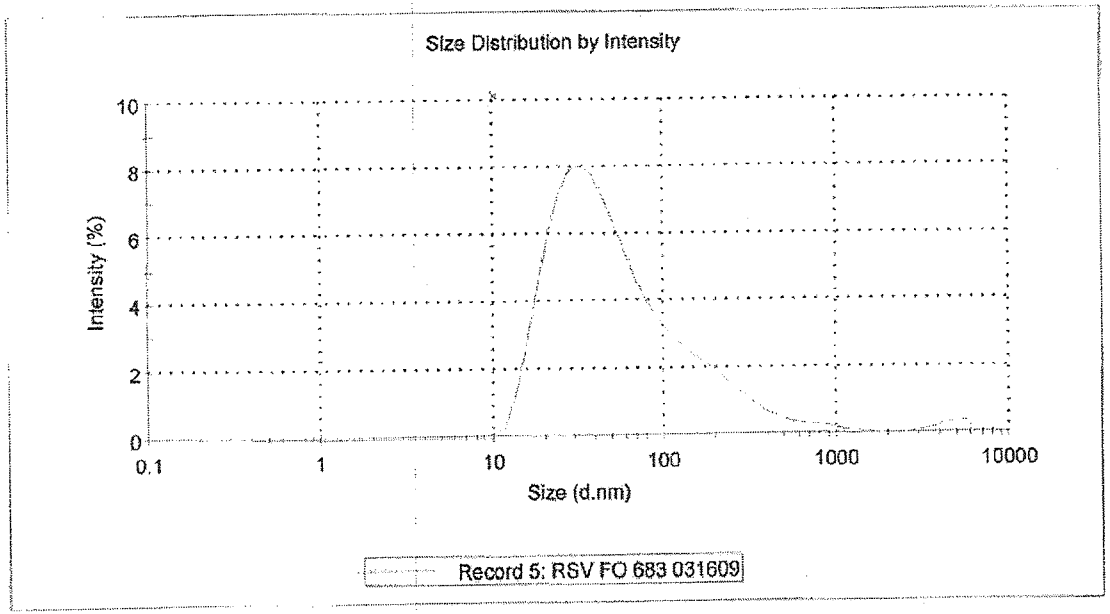
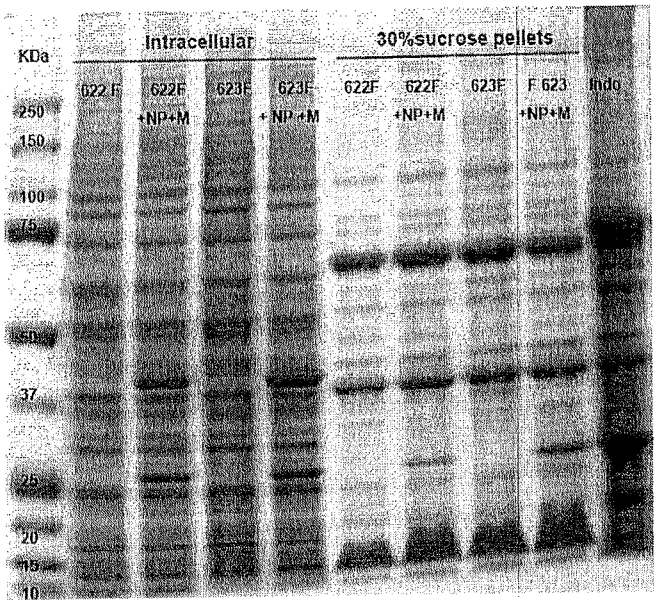
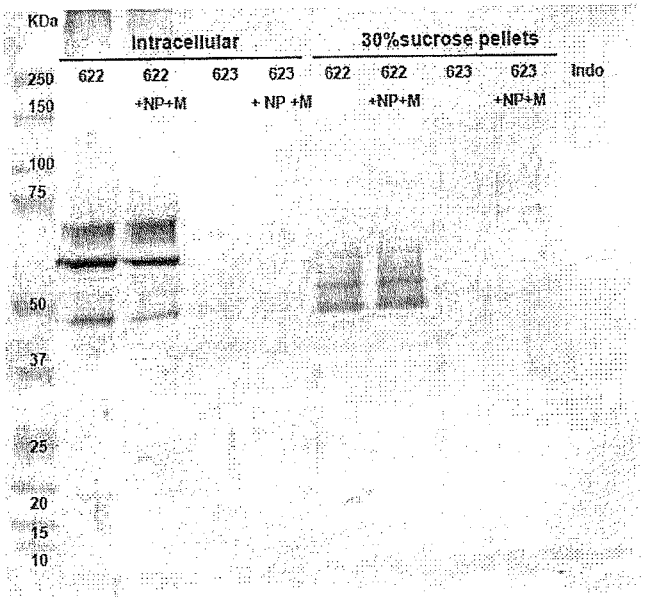


FIGURE 13

Modified RSF F: BV #622 and #623





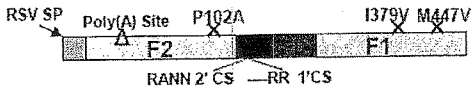
Anti-RSV F

Virus No: 622



Fusion domain partial deletion

Virus No: 623



Both cleavage site mutate.

F0 : 70 KD
F1 : 48 KD
NP : 43.5 KD
M : 28 KD

FIGURE 14

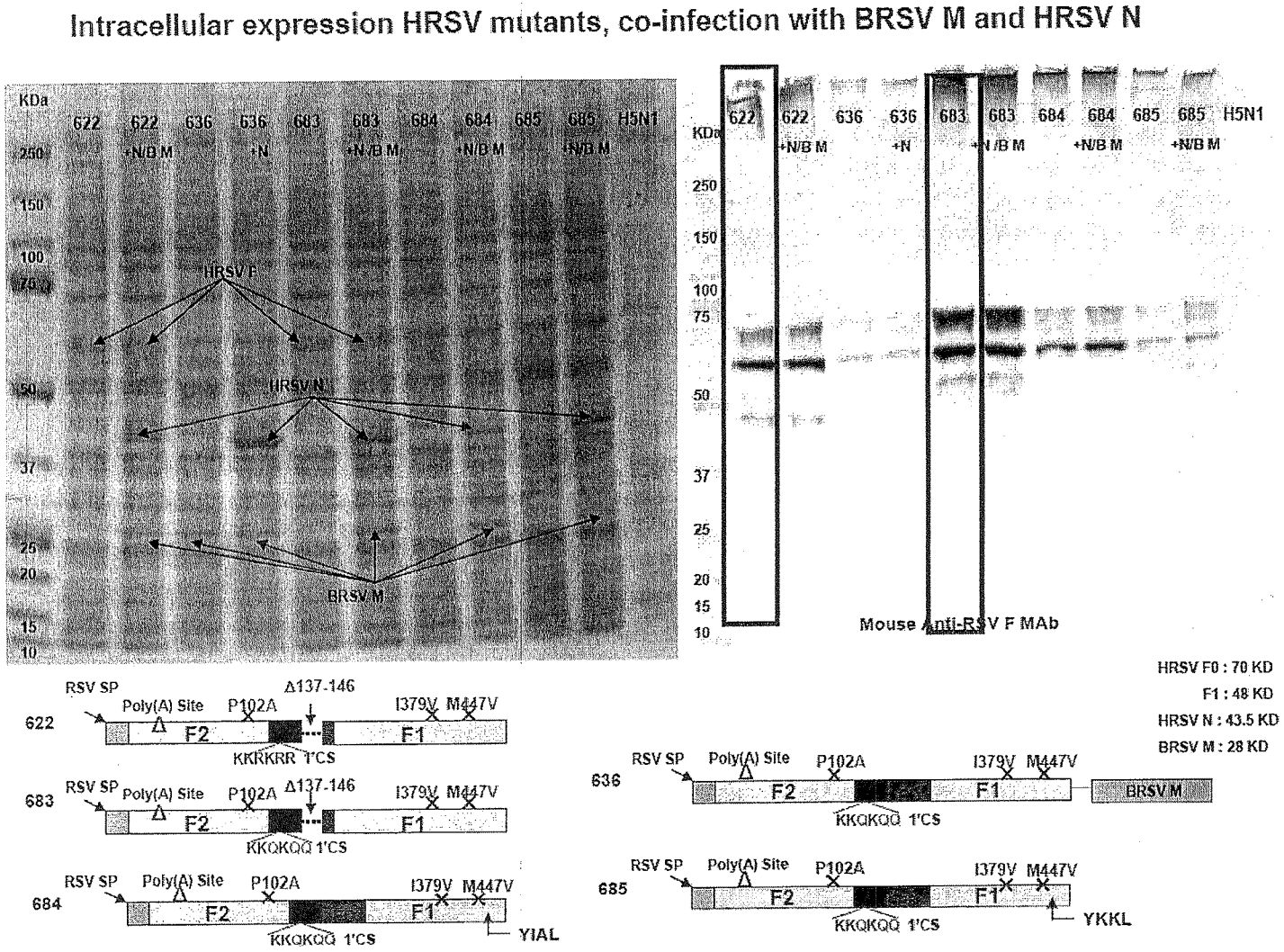
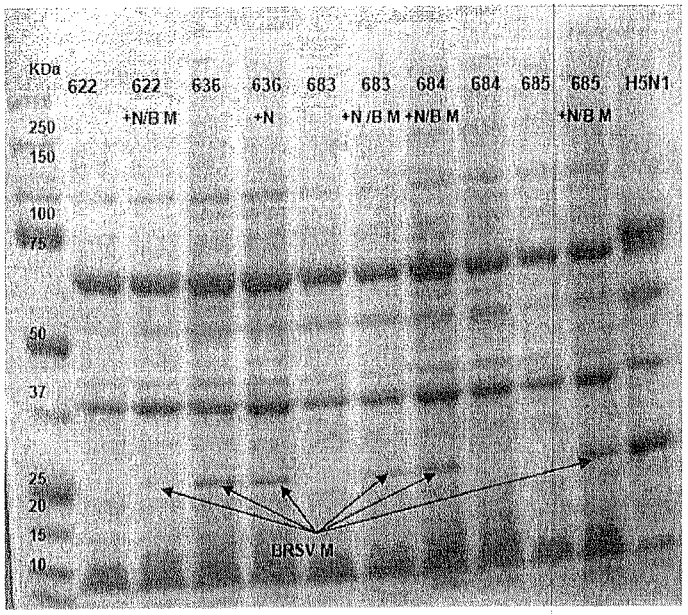
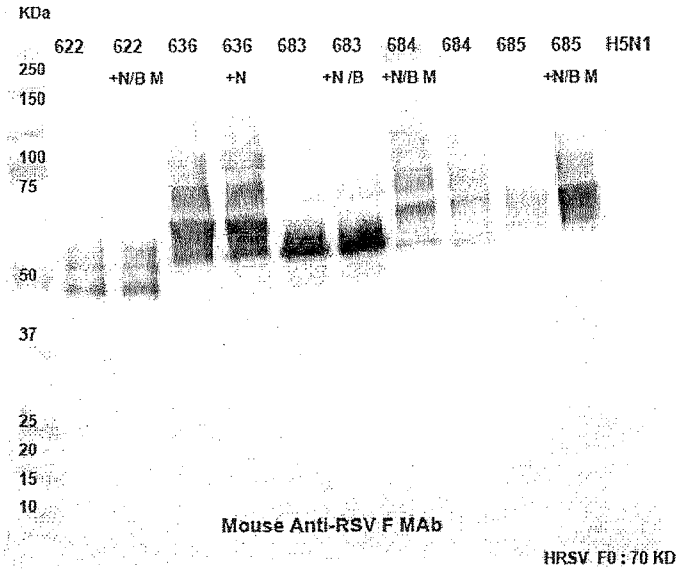
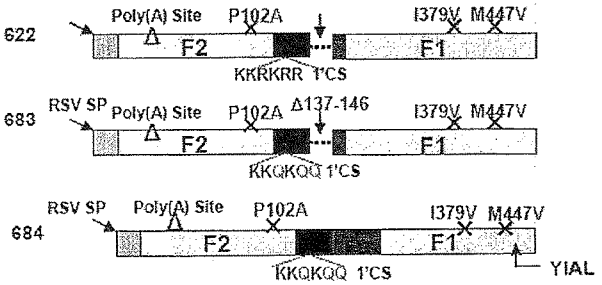

Intracellular expression HRSV mutants, co-infection with BRSV M and HRSV N
KDa
622
622 +N/B M
636
636 +N
683
683 +N/B M
684
684 +N/B M
685
685 +N/B M
H5N1
250
150
100
75
50
37
25
20
15
10
HRSV F
HRSV N
BRSV M
Mouse Anti-RSV F MAb
RSV SP
Poly(A) Site
P102A
Δ137-146
I379V
M447V
F2
F1
KKRKRR 1'CS
KKQKQQ 1'CS
BRSV M
YIAL
YKKL
HRSV F0 : 70 KD
F1 : 48 KD
HRSV N : 43.5 KD
BRSV M : 28 KD

FIGURE 15

30% sucrose VLPs HRSV mutants, co-infection with BRSV M and HRSV N







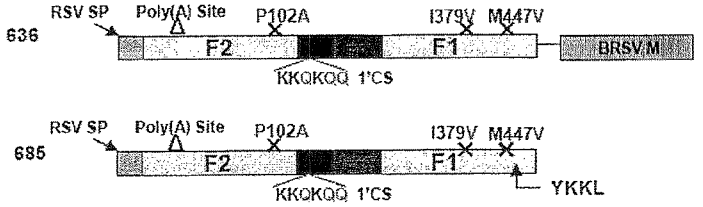
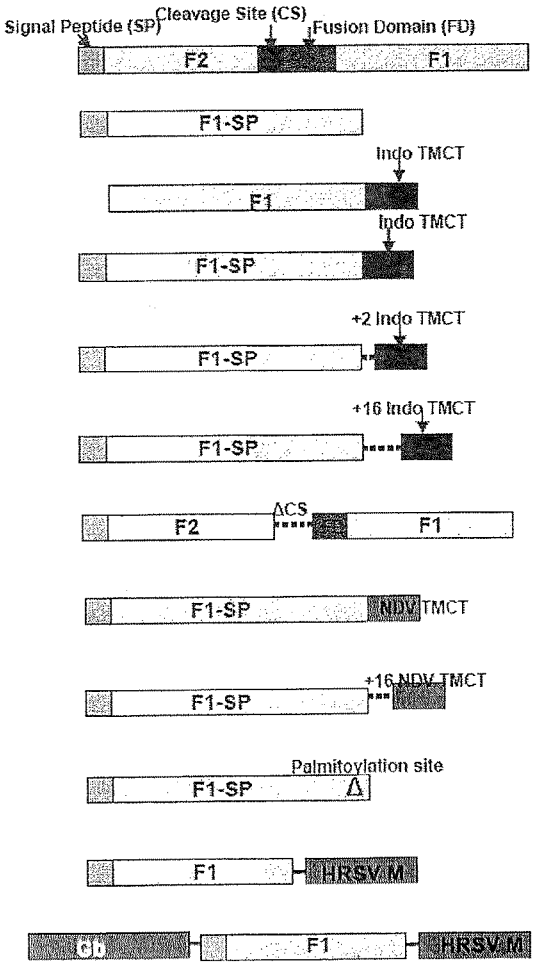
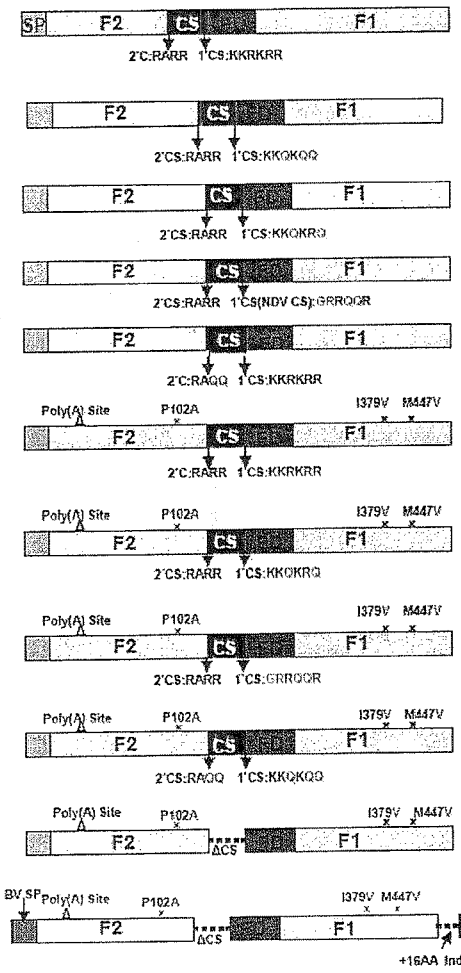


FIGURE 16a



Clone Name	Description	WB/Coomassie	Conclusion
WT HRSV F0	Genebank	+ / -	express really poor
F1-SP	ΔF2	++++ / ++++	express good but insoluble, might be misfolded
F1 w/ Indo TMCT	ΔF2, Chimeric F1 No SP	+++ / +++	express good but insoluble, might be misfolded
F1-SP w/ Indo TMCT	ΔF2,Chimeric F1 w Indo TMCT	+++ / +++	express good but insoluble, might be misfolded
F1-SP w/ Indo	ΔF2,Chimeric F1 with TMCT+2AA	+++ / +++	express good but insoluble, might be misfolded
F1-SP w/ Indo	Δ F2,Chimeric F1 with TMCT+16 AA	+++ / +++	express good but insoluble, might be misfolded
F0 Δ CS	CS(KKRKRR) replace with GASGAG	- / -	No protein express
F1-SP w/	Chimeric F1 with NDV HA NDV TMCT	+++ / +++	express good but doesn't assemble with NDV M well
F1-SP w/NDV TMCT+16AA	Chimeric F1 with NDV HA TMCT+ upstream 16AA	+++ / +++	express good but doesn't assemble with NDV M well
F1-SP ΔPalm site	Delete Palmitoylation site in F1, improve the solubility of F1	+++ / +++	express good but still insoluble
MF1 tandem	F1+ HRSV M	F1+++, M+++ / F1-, M+	both F1 and M express well in tandem, but VLP yield is poor. M expression inhibited when co-infection with F1
GbMF1 tandem	F1+ HRSV M+ Gb	F1++, M++/F1-, M+	both F1 and M express better in triple tandem than co-infection, but VLP yield is very poor.

FIGURE 16b



Clone Name	Description	WB/Coomassie	Conclusion
WT HRSV F0	Genebank, intact cleavage sites	+ / -	express really poor
HRSV F0 triple mutation	1' CS mutate to KKQKQQ	+ / -	1' CS mutation improve expression a little
HRSV F0 double mutation	1' CS mutate to KKQKRQ	+ / -	1' CS mutation doesn't improve expression
HRSV F0 with NDV CS	1' CS mutate to NDV CS (GRRQQR)	+ / -	1' CS mutation doesn't improve expression
HRSV F0 with 2' CS mutation	2'CS mutate to RAQQ	++ / -	2' CS mutation improve expression a little
HRSV F0(fixed) WT	Found errors in WT F0 derived from genebank, remove ploy(A)sitebut change P to A, I to V and M to V	++ / -	Error fixed F0 express better than genebank F0, but still doesn't express well, can't be detected by blue stained gel
HRSV F0 (fixed) WT with 1'CS mutation(541)	mutate 1'CS to KKQKQQ	+++ / -	1'CS mutate to KKQKQQ improve F0 expression, can assemble with BRSV M, HRSV N to form VLP, yield poor and rBV titerlow, need to improve
HRSV F0 (fixed) WT with 1'CS mutation	mutate 1'CS to NDV CS	+ / -	1'CS mutate to NDV CS doesn't improve F0 expression
HRSV F0 (fixed) with 1'CS and 2'CS mutation	mutate both 1'CS and 2'CS	- / -	No F0 expression
HRSV F0(fixed) ΔCS	delete entire CS	++ / -	doesn't express well
HRSV F0 (fixed) w/ ΔCS BV SP, Indo TMCT+16AA	delete CS, replace HRSV SP with BV SP, swap HRSV TMCT with Indo HA TMCT,+ upstream 16AA	++/-	VLP assemble efficient with Indo M1 poor

FIGURE 16c

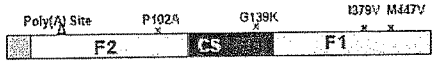
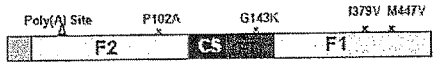
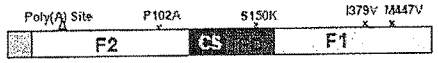
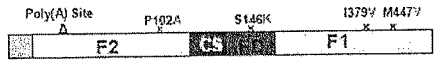
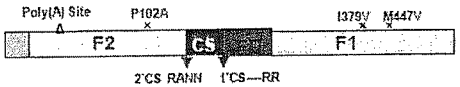
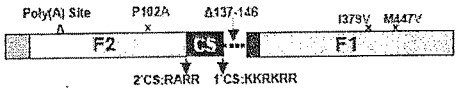
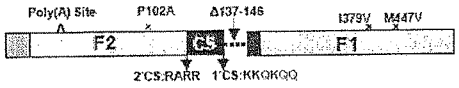
	Clone Name	Description	WB/Coomassie	Conclusion
	HRSV F0 (541) W/ BRSV F0 CT	HRSV F0 CT replaced by BRSV F0 CT	+++/-	Intracellular level is similar to 541, but inhibit BRSV M when co-infection. VLP yield is not as good as 541
	HRSV F0(541)+BRSV M	double genes tandem	F+++, M+++/ F-, M++	Both intracellular and VLP yield is better than 541 co-infection with BRSV M
	HRSV F0 (541) W/BRSV F0 CT+BRSV M	double genes tandem	F+++, M+++ F-, M++	Both intracellular and VLP yield is better than co-infection, inhibition of BRSV M solved
	HRSV F0 FD(G139K)	introduce G139K Point mutation (G139K) into Fusion domian	++/ -	FD(G139K) doesn't improve F0 expression
	HRSV F0 FD(G143K)	introduce G143K Point mutation (G139K) into Fusion domian	++/ -	FD(G143K) doesn't improve F0 expression
	HRSV F0 FD(S150K)	introduce S150K Point mutation (G139K) into Fusion domian	++/ -	FD(S150K) doesn't improve F0 expression
	HRSV F0 FD(S153K)	introduce S153K Point mutation (G139K) into Fusion domian	++/ -	FD(S153K) doesn't improve F0 expression
	HRSV F0 FD(S146K)	introduce S146K Point mutation (G139K) into Fusion domian	++/ -	FD(S146K) doesn't improve F0 expression
	HRSV F0 CS mut	delete 4AA in 1'CS, change 2'CS from RARR to RANN	++/ -	very poor F0 expression
	HRSV F0 CS mut (622)	F0 Fusion domain partial deletion(10AA) Intact Cleavage Site	++++/ +++	excellent F0 intracellular expression, strong band on coomassie gel
	HRSV F0 CS mut (683)	F0 Fusion domain partial deletion(10AA) Intact Cleavage Site	++++/ ++++	excellent F0 intracellular expression, strong band on coomassie gel

FIGURE 16d

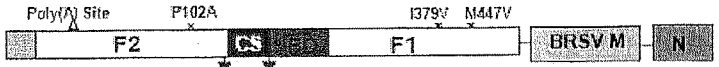
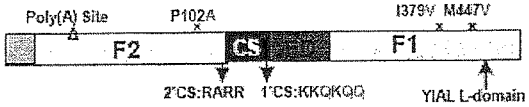
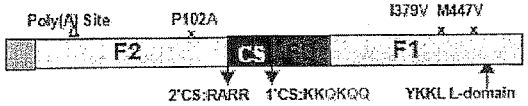
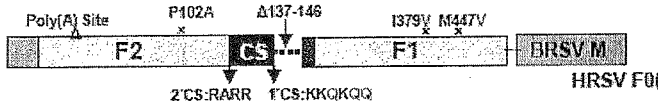
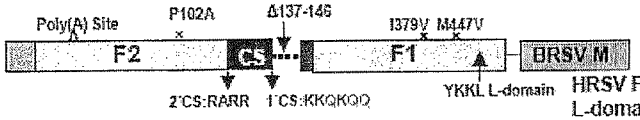
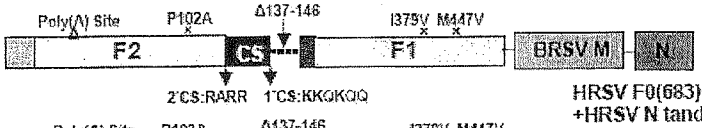
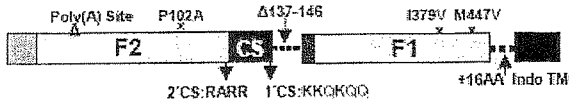
	Clone Name	Description	WB/Coomassie	Conclusion
	HRSV F0(541)+BRSV M +HRSV N tandem	triple genes tandem	F+++, M+++/ F-, M++	rBV with triple genes has much better titer than double tandem and 541. VLP yield is better than double tandem co-infection N or 541 co-infection BRSV M, N
	541 W/ YIAL L-domain	Introduce YIAL L-domain into 541 TM	+++ / -	Introduced YIAL L-domain doesn't affect the intracellular expression of 541, doesn't improve the secretion of VLP when co-infection BRSV M, N
	541 W/ YKKL L-domain	Introduce YKKL L-domain into 541 TM	+++ / -	Introduced YKKL L-domain doesn't affect the intracellular expression of 541, but enhance the secretion of VLP 2~3 folds when co-infection BRSV M, N
	HRSV F0(683)+BRSV M tandem	double genes tandem	ongoing	ongoing
	HRSV F0(683) w YKKL L-domain +BRSV M tandem	double genes tandem	ongoing	ongoing
	HRSV F0(683)+BRSV M +HRSV N tandem	triple genes tandem	ongoing	ongoing
	HRSV F0(683) w/Indo TMCT +16AA	chimeric HRSV F0(683) with Indo HA TMCT+ upstream 16AA	ongoing	ongoing

FIGURE 17

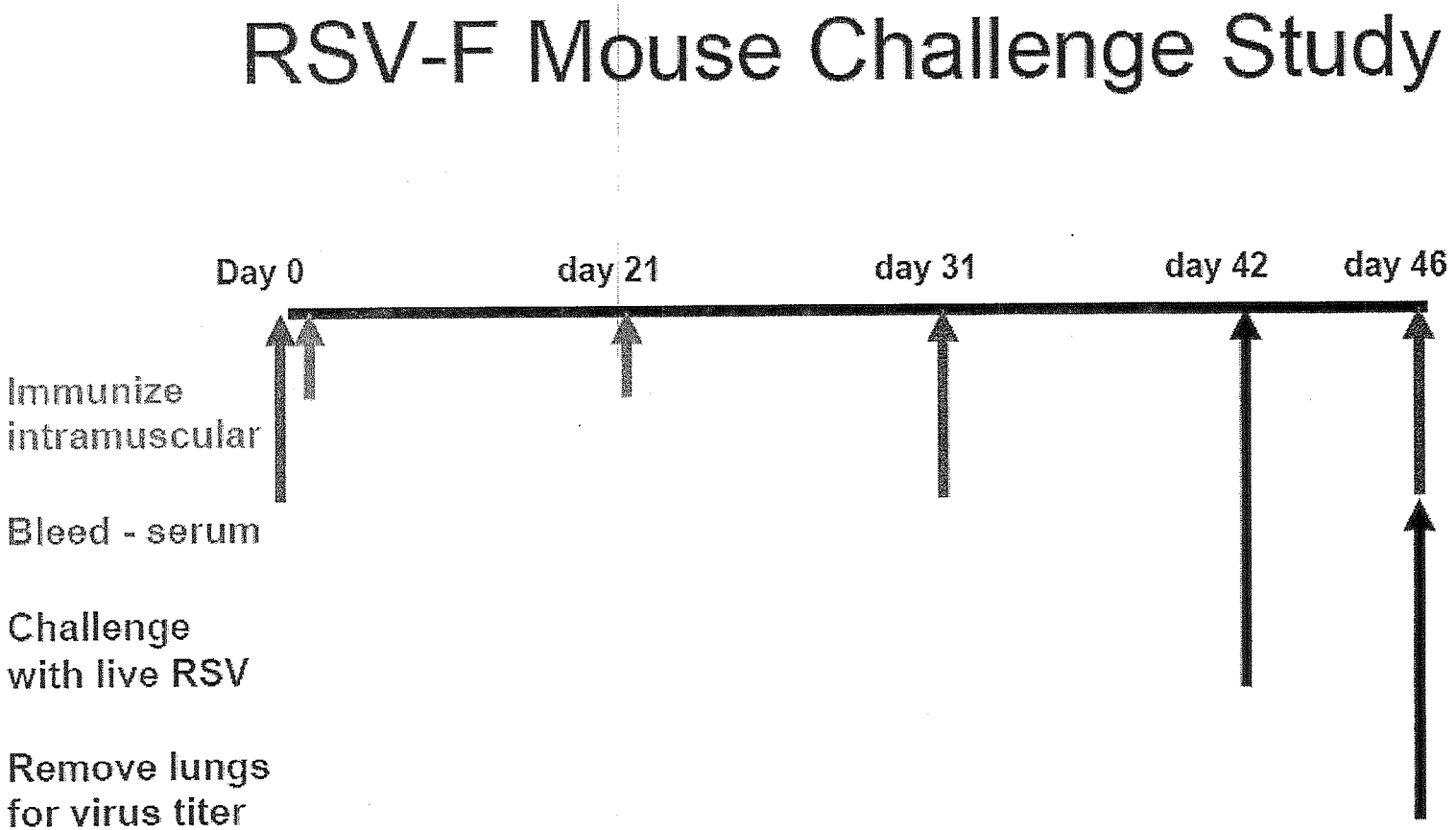

RSV-F Mouse Challenge Study
Day 0
day 21
day 31
day 42
day 46
Immunize
intramuscular
Bleed - serum
Challenge
with live RSV
Remove lungs
for virus titer

FIGURE 18

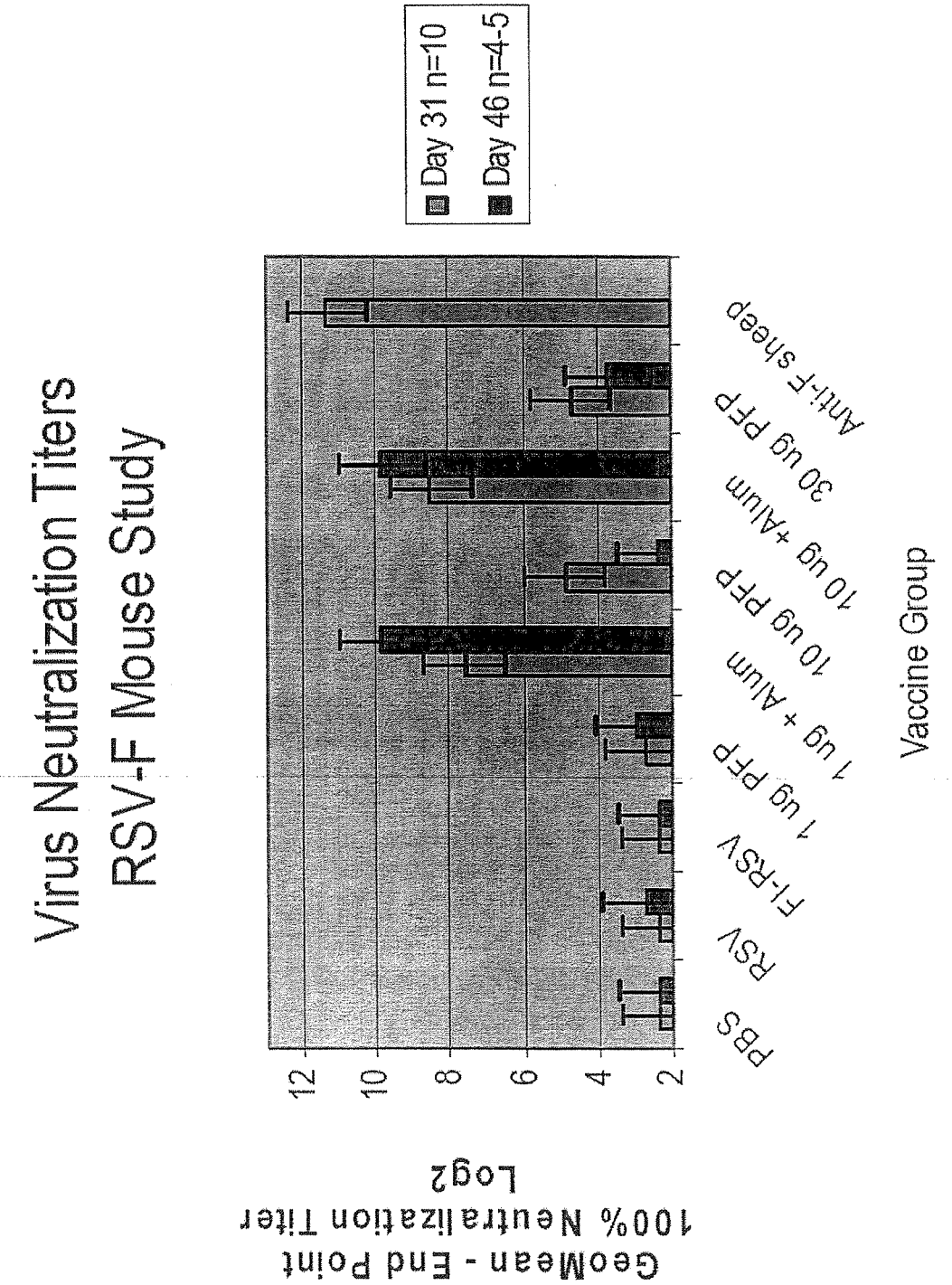

Virus Neutralization Titers
RSV-F Mouse Study
Day 31 n=10
Day 46 n=4-5
GeoMean - End Point
100% Neutralization Titer
Log2
12
10
8
6
4
2
PBS
RSV
F1-RSV
1 ug PFP
1 ug + Alum
10 ug PFP
10 ug +Alum
30 ug PFP
Anti-F sheep
Vaccine Group

FIGURE 19

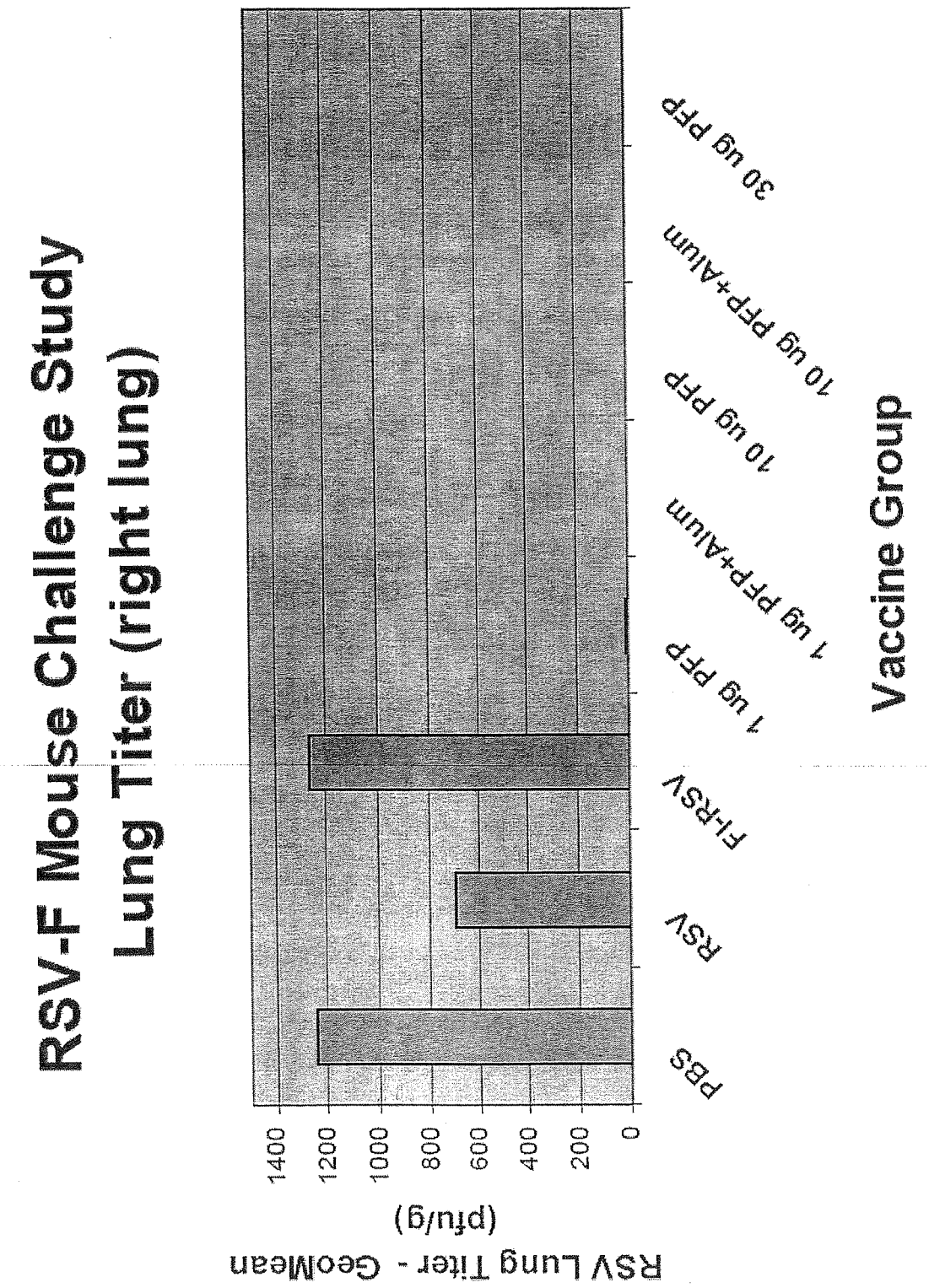

RSV-F Mouse Challenge Study
Lung Titer (right lung)
RSV Lung Titer - GeoMean
(pfu/g)
1400
1200
1000
800
600
400
200
0
PBS
RSV
F-RSV
1 ug PFP
1 ug PFP+Alum
10 ug PFP
10 ug PFP+Alum
30 ug PFP
Vaccine Group

FIGURE 20

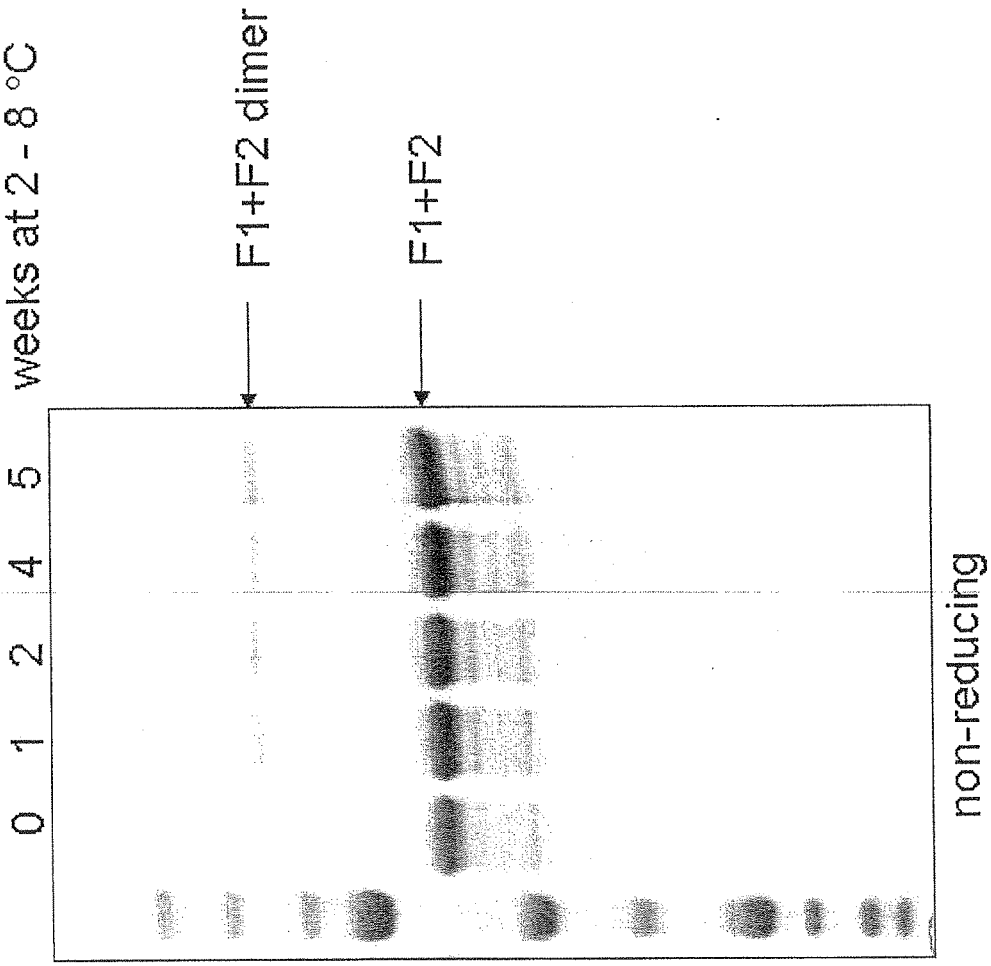
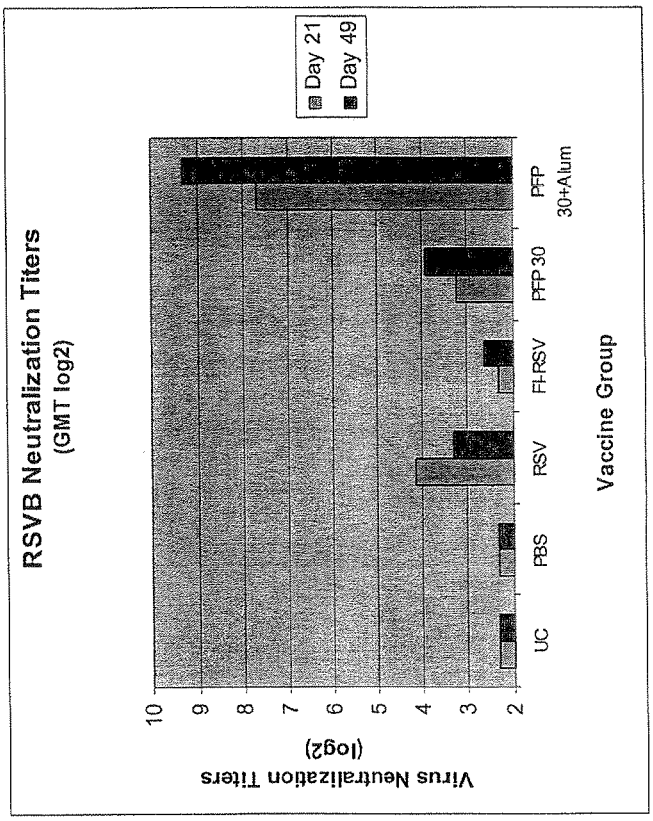


FIGURE 21


RSVB Neutralization Titers
(GMT log2)
Day 21
Day 49
Virus Neutralization Titers
(log2)
10
9
8
7
6
5
4
3
2
UC
PBS
RSV
FI-RSV
PFP 30
PFP 30+Alum
Vaccine Group

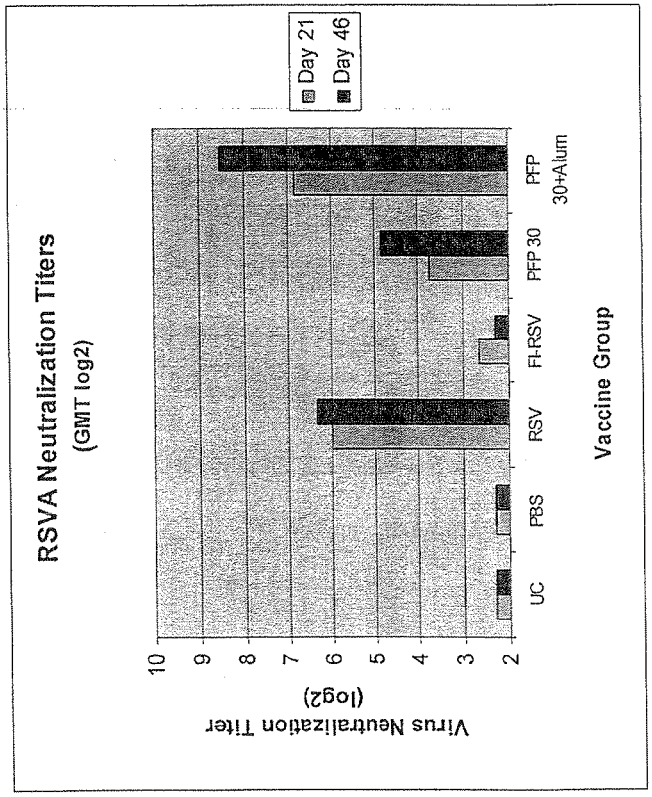
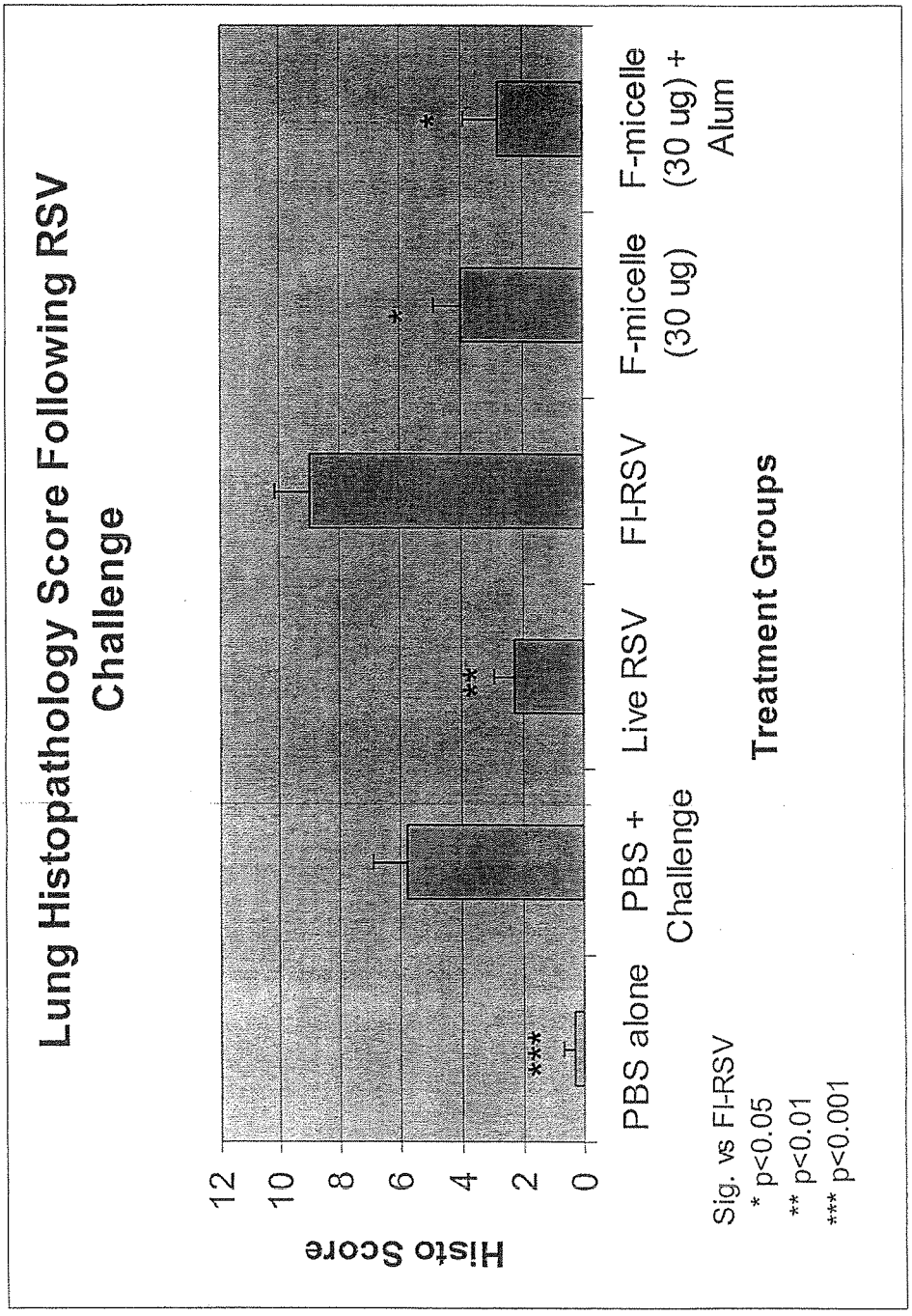

RSVA Neutralization Titers
(GMT log2)
Day 21
Day 46
Virus Neutralization Titer
(log2)
10
9
8
7
6
5
4
3
2
UC
PBS
RSV
FI-RSV
PFP 30
PFP 30+Alum
Vaccine Group

FIGURE 22


Lung Histopathology Score Following RSV Challenge
Histo Score
0
2
4
6
8
10
12
PBS alone
PBS + Challenge
Live RSV
FI-RSV
F-micelle (30 ug)
F-micelle (30 ug) + Alum
Treatment Groups
Sig. vs FI-RSV
* p<0.05
** p<0.01
*** p<0.001