PEOPLE
MARIE CURIE ACTIONS

International Outgoing Fellowships (IOF)
Call: FP7-PEOPLE-2010-IOF

"THINK outside the box" design practices for optimal, more competitive and durable structural COMPOSITEs

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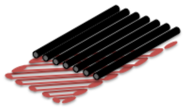
"THINKCOMPOSITE"

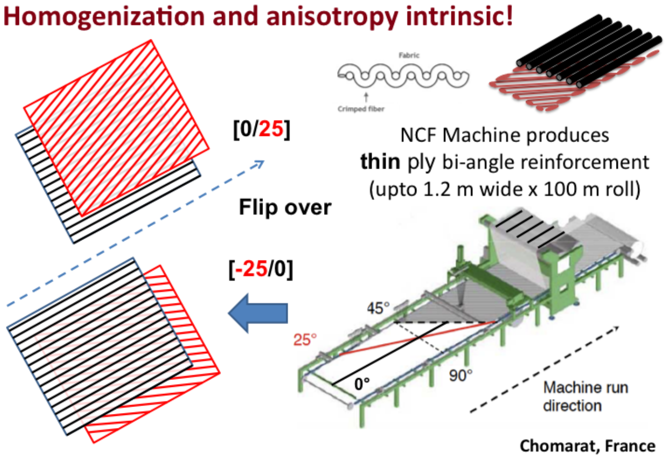
Summarizing Figures for thin-ply bi-angle NCF composites and their design

Why Bi-angle Thin-ply NCF?

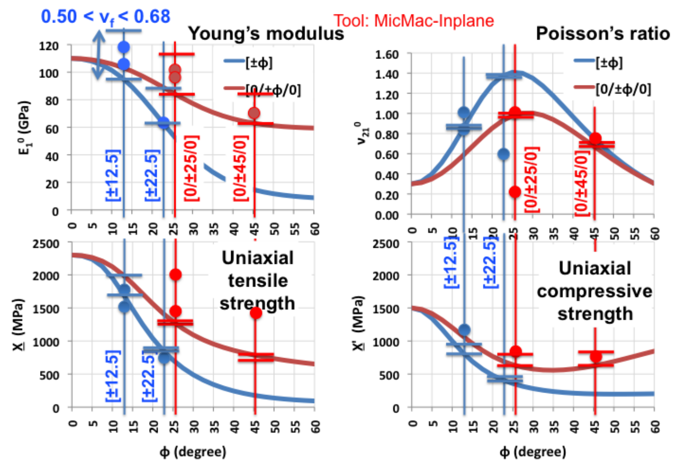


Why Bi-angle?	Why Thin-ply?	Why NCF?
Simpler building block	Tougher laminate	Mass producible
Anisotropy	Improved quality	Shallow angle
No micro crack	Less delamination	Handling
Asymmetry	Homogenization	1-axis layup

How and Why Bi-angle Non-crimp fiber/fabric- NCF? Homogenization and anisotropy intrinsic!



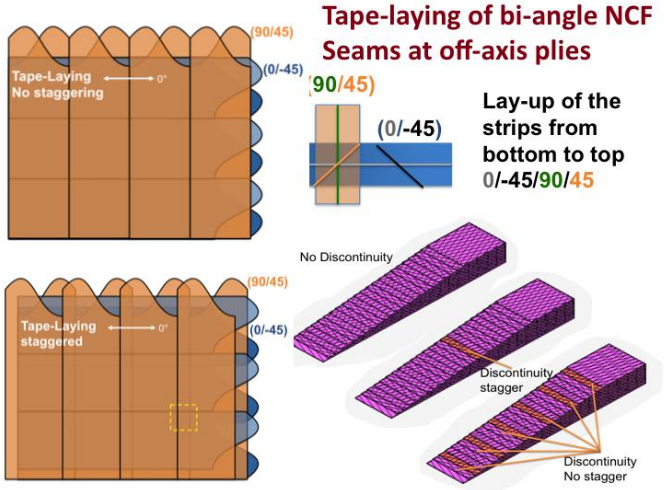
Stiffness and Strength: Theory vs Data



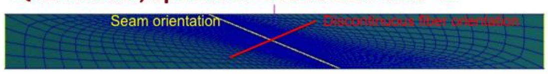
T700/EPOXY NCF equivalent properties (V_f=0.64)

	[0]	[0/25]	[0/±25/0]	[0/45]	[0/±45/0]	[π/4]
E_x, GPa	140.8	91.1	109.5	78.5	81.2	54.8
E_y, GPa	9.3	10.2	11.1	13.9	23.7	54.8
ν_x	0.3	0.45	0.96	0.36	0.67	0.3
E_s, GPa	5.8	10.5	14.8	10.6	21.1	21.1
X, MPa	2944	690	1290	645	750	423
X', MPa	1983	772	751	967	775	790
Y, MPa	66	72	80	93	180	423
Y', MPa	220	217	222	236	378	790
S, MPa	93	201	207	205	298	299
S', MPa	93	107	207	90	298	299
E_{xy}*	-0.50	-0.29	-0.87	-0.26	-0.82	-0.69

Tape-laying of bi-angle NCF Seams at off-axis plies

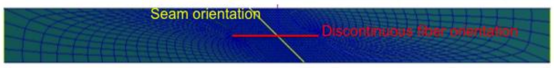


Test Specimen (with 0/-45 NCF)-Restored Strength QI laminate, specimen cut at 22.5 and 45



With respect to Load direction: [-67.5/67.5/22.5/-22.5]$_{6T}$

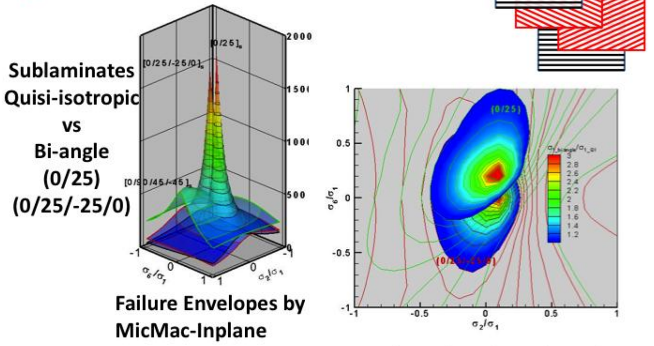
Discontinuity	Model	Test (seamless 600 MPa)
No staggering (all 22.5 plies)	0.45	0.65 – 0.72
Staggering (one of the 22.5 plies)	0.79 - 0.95	0.83 – 1.00



With respect to Load direction: [90/45/0/-45]$_{6T}$

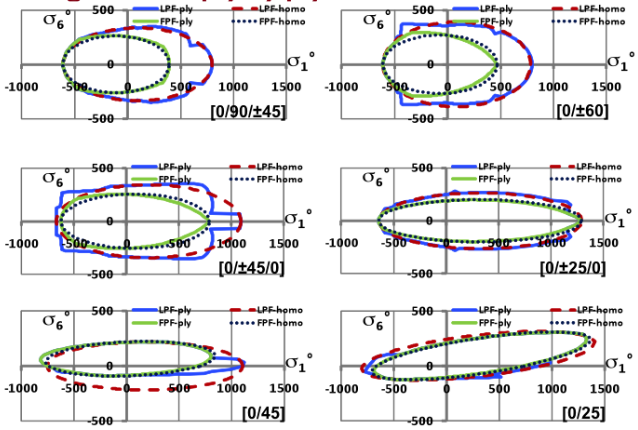
Discontinuity	Model	Test (seamless 750 MPa)
No staggering (all 0 plies)	0.38	0.33
Staggering (one of the 0 plies)	0.74 - 0.91	0.80 – 0.93

Why Anisotropy?
In-plane stress state – Failure criteria

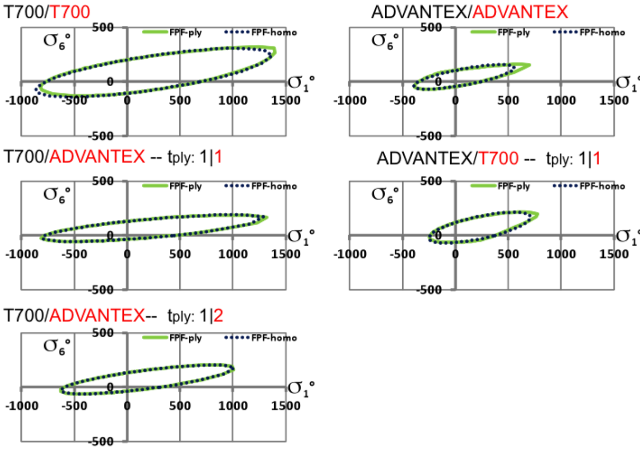


Region of Combined Loading where (0/25) sublaminates superior than QI

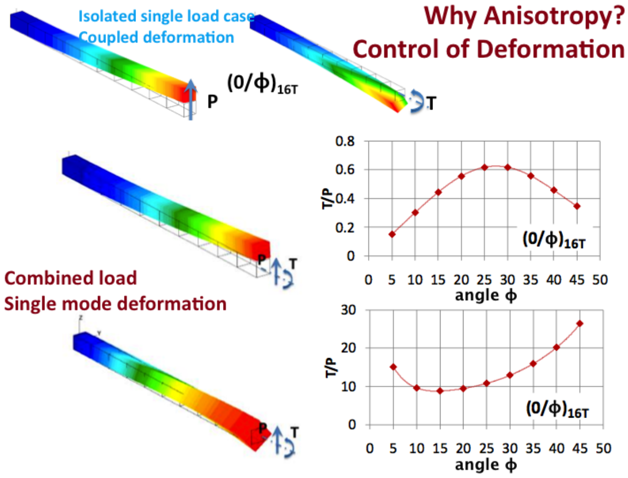
Failure envelopes, FPF and LPF
Homogenized vs ply-by-ply



(0/25)NCF/epoxy -- V_f=0.64 FPF envelopes-stress space



Why Anisotropy?
Control of Deformation



Why Homogenize?
Equivalent/sublaminate properties in design

Treat stack of sublaminates as homogenous shell of the same total thickness

	$[0/\theta]_{rT}$	Homogenous single shell layer
Thickness	$t_{tot} = t_{ply}N$	t_{tot}
Stiffness	Ply stiffness Ply strength	Equivalent sublaminate stiffness Equivalent sublaminate strength
Analysis	Ply-by-ply	Single shell layer

Homogenized laminate
Optimization: for constrained tip displacement, |dtip|< 30 mm