MECHANICAL ANALYSIS OF THE ATLAS INNER TRACKER STRIP ENDCAP GLOBAL SUPPORT





- Introduction
- Requirements
- Envisioned Design



- Simulation Goal
- Simulating the Endcap
- Endcap Simulation History & Software
- Physical prototype
- Comparing Results
- Conclusion

Presentation by: Jesse van Dongen Contact: jvdongen@nikhef.nl

Mechanical Analysis of the Atlas Strip Endcap Global Support

Work by:





Nikhef

INTRODUCTION



2026 HL-LHC

Mechanical Analysis of the Atlas Strip Endcap Global Support

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Inner Tracker (ITk)

INNERTRACKER (ITK) STRIP ENDCAP GLOBAL SUPPORT

ITk Strip Detector

Strip Endcap (EC) Global Support

Mechanical Analysis of the Atlas Strip Endcap Global Support



Petal

Wheel of Petals



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REQUIREMENTS & TASK

Goal of the ITk Strip Endcap (EC): Measurement of particle tracks/paths after collision at the interaction point

Work Environment:

- Radioactive environment (0.5MGy)
- Environment temperature -25 °C
- Dry (Flushed with Nitrogen)

Requirements for the global support:

- Radiation length <10% of Petal in a track \rightarrow Low Mass
- Stability Structure (short term) < 2um

Direction	Stability requirement	As Built Min Frequency Requirements	FEA Design Min Frequency Requirements		
Z (beamdir)	20 µm	3.2Hz	6.7Hz		
R	20 µm	3.2Hz	6.7Hz		
Rφ	2 µm	14.4Hz	31.6Hz		

Mechanical Analysis of the Atlas Strip Endcap Global Support

\rightarrow High Stiffness



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GOAL: HIGH STIFFNESS & LOW MASS FRAME, WHICH MINIMALLY BLOCKS TRACKS







Mechanical Analysis of the Atlas Strip Endcap Global Support



STRUCTURE FOR CONNECTING WHEELS







DELICATE PETALS CANNOT BE INSERTED AFTER FRAME IS ASSEMBLIED





Mechanical Analysis of the Atlas Strip Endcap Global Support



STRUCTURE CONNECTING WHEELS

























DELICATE PETALS CAN BE INSERTED AFTER FULL FRAME IS ASSEMBLED



ENDCAP (EC) GLOBAL SUPPORT OVERVIEW





ENDCAP (EC) DETECTOR OVERVIEW



Mechanical Analysis of the Atlas Strip Endcap Global Support

6 Wheels with 32 Petals

8 Service Trays, providing cabling and cooling to wheels

12 in- and outlet cooling connectors

8 panels with electrical and optical connectors



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SIMULATION GOAL

- Build a model of the detector
- Do tests and experiments on a simulated model (save time & money)

Important that simulations match reality. Warning: you always get pretty pictures!!!

> "With four parameters I can fit an elephant, and with five I can make him wiggle his trunk". - John von Neumann

Plan to validate simulations

Manual Calculations FEM Calculations Cocurrent simulation



 \bullet

-20

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Prototype tests





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CALCULATED GRAVITY DEFORMATIONS Petals & Services simulated as added mass



Assembly Position 0.670 [mm] (Supported on transport locks, will deform less with Airex and could be supported at center)

Operation Position 0.1 [mm] (Supported on rails)



SIMULATED FULL SYSTEM EIGEN FREQUENCIES

Petals & Services simulated as added mass

Mode	Frequency	Mode Shape	Affected DOF	
1	13 Hz	Pringle	Z	
2	16 Hz	Collapsingcabinet-Y	Z	
3	18 Hz	Railslide	X	
4	27 Hz	Squish	X	
5	28 Hz	Diagonal Pringle	Z	
6	30 Hz	Telescoping	Z	
7	32 Hz	Collapsingcabinet-X	Z	
8	47 Hz	Diagonal Pringle	Z	
9	49 Hz	Twist	PHI	
10	51 Hz	Servicetray Telescoping	Z	









REQUIREMENTS VS CAE RESULTS

Direction	Stability requirement	As Built Min Frequency Requirements	FEA D Fre Requ
Ζ	20 µm	3.2Hz	6
R	20 µm	3.2Hz	6
Rφ	2 µm	14.4Hz	3
Rφ	2 µm	14.4Hz	3



18Hz (X)

Mechanical Analysis of the Atlas Strip Endcap Global Support



esign Min quency irements

6.7Hz 6.7Hz 1.6Hz



13Hz (Z)

49Hz (Rφ)



SIMULATION DISCUSSION

- The Rail Support bar should be more optimized
- Otherwise the system agrees to CAE requirements.

Can we trust the CAE results?





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NX VS COMSOL



MANUAL CALCULATION EULER BEAMS 54 HZ



COMSOL BEAM ISOTROPIC 53 HZ





COMSOL SOLID RODCOMSOL SOLID BLADEORTHOTROPIC 47 HZORTHOTROPIC 50 HZ



NX NASTRAN SOLID BLADE ORTHOTROPIC 49 HZ



NX VS COMSOL



COMSOL BEAM ISOTROPIC 50 HZ



COMSOL SOLID ROD **ORTHOTROPIC 18 HZ**



COMSOL SOLID BLADE **ORTHOTROPIC 14 HZ**

Mechanical Analysis of the Atlas Strip Endcap Global Support



NX NASTRAN SOLID BLADE ORTHOTROPIC 13 HZ



NIKHEF SWITCHING FROM COMSOL MULTIPHYSICS **TO NX NASTRAN**

NX for geometry creation \rightarrow No clunky geometry modeler

- model
- information even with simplified representations



Mechanical Analysis of the Atlas Strip Endcap Global Support

\rightarrow Same software used for the actual CAD

→ Can reuse positional and dimensional



NIKHEF SWITCHING FROM COMSOL MULTIPHYSICS **TO NX NASTRAN**

Assembly Fem \rightarrow Simulating finally gets a bit more logical like CAD





NIKHEF SWITCHING FROM COMSOL MULTIPHYSICS **TO NX NASTRAN**

Laminate Modeller \rightarrow No need create new material for every layup \rightarrow Ability to drape "sheets" over surface \rightarrow Ability to check material orientation without solving

Layup Mod	leler										
ayup Definiti	on										
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tacking Recipe	Regular		•]							A second second	
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aste Repetition	n 1 📩			- 💼	Keverse Pl	ies and G					
Global Ply Id	Composition	Thi	An	Status	Description	Solid F					
⊟- Group_6	Group of 1 plies										
- 27	Unidirectional1	1	0	Up-to-date	1	Layered				E.	
Group_5	Group of 3 plies									H.H.	
- 26	Woven1	0.33	0	Up-to-date		Layered				A A A A A A A A A A A A A A A A A A A	
25	Woven1	0.33	30	Up-to-date		Layered			HHHHH		
24	Woven1	0.33	-30	Up-to-date		Layered		CHANNEN C			
Group_4	Group of 3 plies							HHHH			
23	Woven1	0.33	0	Up-to-date		Layered					
22	Woven1	0.33	30	Up-to-date		Layered					
- 21	Woven1	0.33	-30	Up-to-date		Layered					
	Group of 1 plies										
20	Unidirectional1	1	0	Up-to-date		Layered					
Group_2	Group of 4 plies							AN PROPERTY		7711	
19	Woven1	0.25	67.5	Up-to-date		Layered				1111	
18	Woven1	0.25	22.5	Up-to-date		Layered					
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16	Woven1	0.25	0	Up-to-date		Layered				NAMES OF TAXABLE PARTY.	
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- 15	Woven1	0.25	67.5	Up-to-date		Layered					
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Work by:



Nik[hef

Nik[hef
BUILDING AND ANALYZING INDIVIDUAL COMPONENTS









WORK BY: ARNOLD RIETMIJER (RIP) & MARTIN DOETS



BUILDING THE WHEELS



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BUILDING THE INNER CYLINDER





BUILDING THE STIFFENER DISC



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EPOXY RADIATION TESTS

- Epoxy shear samples have been sent to CERN for Radiation hardness testing
- 21 samples per Epoxy type have been made for THV500/355, Hysol AE9396, Harder W300/Resin L
- Hopefully more info will follow soon



WORK BY TJARDO SASSEN & MARTIN DOETS



COMPARISON OF COMPONENTS WITH RESPECTIVE SIMULATIONS

Displacement - Nodal, Magnitude



Mechanical Analysis of the Atlas Strip Endcap Global Support

StiffnerAssyFemSim : SelfWeight + 100Kg Result Subcase - Static Loads 1, Static Step 1 Min : 0.000, Max : 1.712, Units = mm Deformation : Displacement - Nodal Magnitude



VERTICAL AND HORIZONTAL LOADING OF A WHEEL



FullWheel_assyfem1_sim1 : Solution 1 Result Subcase - Static Loads 1, Static Step 1 Displacement - Nodal, X Min : -0.0065, Max : 0.0843, Units = mm Deformation : Displacement - Nodal Magnitude

0.0843
0.0767
0.0692
0.0616
0.0540
0.0465
0.0389
0.0313
0.0238
0.0162
0.0087
0.0011
-0.0065



FullWheel_assyfem1_sim1 : Horizontal 2KG Result Subcase - Static Loads 1, Static Step 1 Displacement - Nodal, Magnitude Min : 0.000, Max : 4.026, Units = mm Deformation : Displacement - Nodal Magnitude





VERTICAL AND HORIZONTAL LOADING OF A WHEEL

TestCase	Vertical 35kg	Horizor Selfwei
Physical Test	0.08- 0.12mm	1.2 mm
CAE Result	0.08 mm	1.25 mr

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ntal Horizontal ight 2KG

4.1mm

m 4 mm



INNER CYLINDER DEFORMATION





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ition 3 Result Implicit, Increment 20, 1.000 sec I, Magnitude 58, Units = mm sement - Nodal Magnitude





INNER CYLINDER DEFORMATION

TestCase	Height deform
Physical Test	27 – 34 (positio
CAE Result	30 cm

*CAE Test assumes 0.4mm innertube with 55:45 fiber epoxy ratio, with a 2.7GPa Epoxy stiffness

Mechanical Analysis of the Atlas Strip Endcap Global Support

after nation

1 cm onal dependence)



DEFORMATION STIFFENER DISC





StiffnerAssyFemSim : SelfWeight Result Subcase - Static Loads 1, Static Step 1 Displacement - Nodal, Magnitude Min : 0.000, Max : 0.173, Units = mm Deformation : Displacement - Nodal Magnitude





Mechanical Analysis of the Atlas Strip Endcap Global Support





Deformation : Displacement - Nodal Magnitude





DEFORMATION STIFFENER DISC



Mechanical Analysis of the Atlas Strip Endcap Global Support

Displacement under a



STIFFENER DISC EIGEN FREQUENCY









STIFFENER DISC EIGEN FREQUENCY

Frequency [Hz] TestCase						
Physical Test	43	53	58	124	-	-
CAE Result	44	52	60	124	148	1

* Note no validation regarding modeshapes







THERMAL DEFORMATION STIFFENER DISC Exact thermal profiles unknown so no FEA comparison

Тор Т	Bottom T	Rel POS		Тор Т	Bottom T	Rel POS	
20°C	20°C	0 mm		20°C	20°C	0 mm	
20°C	-6°C	-0.3 mm		18°C	-16°C	-1.4 mm	
16°C	-25°C	-0.4 mm		20°C	-20°C	0 mm	
5.8°C	-29°C	-0.4 mm					
20°C	20°C	0 mm					· · · ·
level viewe				Top T			os
			and the	20°C	20°C	0 mm	
20°C -6°C -0.3 mm 1 16°C -25°C -0.4 mm 2 5.8°C -29°C -0.4 mm 2 20°C 20°C 0 mm 1 20°C 1 1 20°C 1 1 20°C 1 1			19°C	-14°C	-1.4 r	nm	
				4.8°C	-29.3°C	-1.3 r	nm
20°C 20°C 0 mm 20°C 20°C 0 mm 20°C -6°C -0.3 mm 18°C -16°C -1.4 mm 16°C -25°C -0.4 mm 20°C -20°C 0 mm 5.8°C -29°C -0.4 mm 20°C -20°C 0 mm 20°C 20°C 0 mm			nm				
11	N			20°C	20°C	0 mm	

Mechanical Analysis of the Atlas Strip Endcap Global Support

Тор Т	Bottom T	Rel POS
20°C	20°C	0 mm
18°C	-18°C	0.1 mm



Тор Т	Bottom T	Rel POS
20°C	20°C	0 mm
19°C	-19°C	-1.5 mm
16°C	-25°C	-1.5 mm
5.8°C	-29°C	-1.3 mm
20°C	20°C	0 mm

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CREATING A PHYSICAL (SIMPLIFIED) PROTOTYPE









NIKHEF TEAM (RIGHT TO LEFT): ACTUAL WORK: ROB LEGUYT, MARTIN DOETS SUPPORT TEAM: MARCEL VREESWIJK, LORENZO QUARTERO, ERIC HENNES, MARCO KRAAN, JESSE VAN DONGEN



PUTTING TOGETHER THE ASSEMBLY FRAME





PLACING COMPONENTS OF THE ASSEMBLY FRAME ON THE MOCKUP







ALIGNING ASSEMBLY CROSSHAIRS







ALIGNING TOP AND BOTTOM OF THE ALIGNMENT FRAME







PLACING THE TAYLOR HOBSON ALIGNMENT TELESCOPES







ADJUSTING THE IN PLANE MOVEMENT OF A WHEEL





CHECKING WITH A WATER LEVEL IF THE ALL SUPPORT "SPACER TUBES" REACH THE SAME HEIGHT







PUTTING A TENSIONED CABLE INSIDE THE SPACER RODS







PLACEMENT OF THE RAIL SEGMENT WITH WIDE FLAPS TO INCREASE GLUE SURFACE





FINALIZED PRODUCT REMOVED FROM ASSEMBLY FRAME





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MEASURING THE MOCKUP





MEASUREMENT SYSTEM

- Sensor: 4x Analog piezo electric accelerometers
- National Instruments DAQ
- Processing: Matlab & Labview

Excitation by impact hammer and sine sweep

- Signal generator
- Speaker
- Impact hammer



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VALIDATION OF THE MEASUREMENT SYSTEM

Validation by comparison of the different methods using simple objects:

- Analytical Solutions
- Homemade
 MATLAB FEA
- NX FEA
- Actual Measurements

215				1								
216	%output data				100							
217 -	disp('FEM')	1	t / /		-			-				
218 -	<pre>freq(1:maxeig,1) = zeros();</pre>				10					de-states.		
219 -	for i = 1:maxeig				U		Not the	1. N.Y.	(Strange	and a state	ALC: N	1-4-1
220 -	freq(i,1) = sqrt(W(i,i))/(2*pi())	0.5	t//			5155			1000		A Date	
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229	<pre>% i = i+1:</pre>			and the second	Q - 2	1 22 100			a france		1	100
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235 -	case 'doubleclamp'			the second	12.10	200		1	1113	1118-3	25	
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237 -	<pre>for j = 1:size(V,2)</pre>				-	1	1	114				
238 -	for i = 1:size(V,1)/2	Figure 1					1	100		2007		
239 -	py(i,j) = V(i*2-1,j)	· · · · · · · · · · · · · · · · · · ·		10			11				and an	
240 -	- end	File Edit	View Ins	1				-		all's a		131
241 -	- end	1 🗃 🔂	🌢 🛛 🕹							100	Car le	Cart .
242 -	<pre>px(1:size(py,1),1) = linspace</pre>		- 1								and the	Carlos I
243 -	<pre>f1 = figure;</pre>										- 0	6.00
244 -	<pre>for i=1:maxeig</pre>	0	<u> </u>	Page 1							100	
245 -	<pre>subplot(maxeig,1,i)</pre>	-1	-	- The						6		2.
246 -	plot(px,py(:,i))	-2		P	2					100	22.45	
247 -	- end) 100	1	4 . Cir 8					133	The second	
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256 -	end	2	, 100	200	500	400	500	000	700	000	300	I.
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258 -	f1 = figure;	0										
259 -	<pre>for i=1:maxeig</pre>	-2) 100	200	300	400	500	600	700	800	900	10
260 -	<pre>subplot(maxeig,1,i)</pre>	2		200								
261 -	plot(px(1:end-1,1),py(1	-		/								
262 -	end	0	<u> </u>				~				~	_
263 -	<pre>f2 = figure;</pre>	-2) 100	200	300	400	500	600	700	800	900	10
264 -	plot (px(1:end-1),py(1:end-1											
265 -	case 'singleclamp'											
266 -	py(1:size(V,1)/2,1:size(V,2)) = zeros	();									1
267 -	<pre>for j = 1:size(V,2)</pre>											
268 -	<pre>for i = 1:size(V,1)/2</pre>											



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MEASUREMENT SYSTEM WORKS→ TIME TO MEASURE



```
for fv = 1:length(x2)
    if xm < x2(1, fv)
        x^{2m} = x^{2}(1, fv^{-1});
        break
    end
end
% iterate until fitting factor is found
for it = 1:1000
    fitFactor = ym*(1.0 + 0.01*it);
    y2 = 1/(sqrt(2*pi)* sigma ) * exp( - (x2-mu).^2 / (2*sigma^2))*fitFactor;
    % break out when gauss data aligns
    if y2(1, fv-1) > ym
        %disp(fitFactor)
        break
    end
end
% find phase indexes around mu
for phI = 1:size(x,2)
    if x(1,phI) > mu
        phasex1 = phI - 1;
        phasex2 = phI;
        break
    end
end
% find smallest value
if min(y2) < min(yp)</pre>
    sv = min(y2);
else
    sv = min(yp);
end
% find phase frequency intersection
xc = [ x(phasex1) mu; x(phasex2) mu]; % [ start{x1 x2}; end{x1 x2}]
yc = [yp(phasex1) yp(phasex1); yp(phasex2) yp(phasex2)];
dx = diff(xc); % take the differences down each column
dy = diff(yc);
den = dx(1) * dy(2) - dy(1) * dx(2); % precompute the denominator
ua = (dx(2) * (yc(1) - yc(3)) - dy(2) * (xc(1) - xc(3))) / den;
ub = (dx(1)*(yc(1)-yc(3))-dy(1)*(xc(1)-xc(3)))/den;
% phase frequency intersection coordinates
xi = xc(1) + ua * dx(1);
yi = yc(1) + ua * dy(1);
% phase value
%phs = yi*1e5;
phs = yi;
% compute q factor (3db method)
db3 = max(y2) * 1/sqrt(2);
c = 1;
f3db(1:2) = zeros();
for i = 1: length(x2)
```



MEASUREMENT RESULTS

	FEA	Measured	Q factor	
Mode 1	50 Hz	49.4 Hz	71	
Mode 2	53 Hz	55.2 Hz	71	
Mode 3	77 Hz	74.3 Hz	88	
Mode 4	88 Hz	87.7 Hz	70	
Mode 5	94 Hz	93.7 Hz	90	





EIGENFREQUENCY 1: MODE SHAPE COMPARISON



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FEA frequency: 50 Hz



EIGENFREQUENCY 2: MODE SHAPE COMPARISON





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FEA frequency: 53 Hz

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EIGENFREQUENCY 3: MODE SHAPE COMPARISON





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CONCLUSION

- A FEA model of the Atlas strip Endcap has been made
- The FEA model appears to correspond well to prototypes
- The FEA model agrees with the requirements

The Endcap detector will likely meet its mechanical frequency requirements.

ndcap has been made spond well to prototypes requirements



BACKUP SLIDES

Mechanical Analysis of the Atlas Strip Endcap Global Support

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FUTURE WORK

- Setting up frequency based QC tests for produced components
- Updating the EC FEA with new wheel positions
 - Computing displacement with actual measured ASD & Q factor
 - Computing displacement with transport using ASD & Q factor
- Testing the Thermal & Hydroscopic behavior of the Structure and comparing that to the FEA and its materials.

broduced components sitions asured ASD & Q factor using ASD & Q factor vior of the Structure and Is.



Simulation Details

- Note full system is modelled using the PU80 & 35 foam in the stiffner disc. So I could compare results in NX from previous calculations in Comsol, and with the current prototype.
- Additional mass: 5.33kg per innerrim (1/3rd of petals)
- Additional mass: 12.86kg per outerrim (2/3rd of petals + CO2 hoops)
- Additional mass 2.375kg per service tray (CO2) piping + Cabling)

JESSE VAN DONGEN

Nik hef

26-6-2018

Mechanical Analysis of the Atlas Strip Endcap Global Support

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Used Material Properties

	Rho [kg/m3]	Emod [Pa]	Poisson	CTE [m/m-°C]	k [W/m*K]	CP [J/kg-K]
THV500/355	1120	2.7 ^e 9	0.33	5.75 ^e -5	0.2	1 ^e 3
AE9396	1140	2.75 ^e 9	0.33	7 ^e -5	0.2	1 ^e 3
ResL/HardW	1098	2.66 ^e 9	0.33	5.75 ^e -5	0.2	1 ^e 3
Gen Fiber (T700)	1800	230 ^e 9	0.2	-3.8 ^e -7	9.37	7.5 ^e 2
CT50-4.0/240 (T400)	1800	240 ^e 9	0.285	-4.5 ^e -7	10.54	7.5 ^e 2
PU80	80	18 ^e 6	0.35	6 ^e -5	0.025	1800
PU35	35	4.2 ^e 6	0.35	7.2 ^e -5	0.021	1800
Fiber/Freese unstiges llemennede CERD, FE/1E, lieductin, CERD, CO/10						

Fiber/Epoxy mix ratios: Homemade CERP : 55/45 ; Industry CERP 60/40

Orthotropic (same units as isotropic)

Isotropic

	Rho	E1	E2	E3	v12	v23	v13	G12	G13	G23	CTE	k	СР
Aramid Honey Comb	32	1 ^e 4	1 ^e 4	55 ^e 6	0.3	0	0	1 ^e 4	26 ^e 6	10 ^e 6	-4 ^e -6	0.025	1 ^e 3
R82.110	110	64 ^e 6	64 ^e 6	83 ^e 6	0.32	0.27	0.27	30 ^e 6	30 ^e 6	30 ^e 6	4 ^e -5	0.04	625
Nikh	ef	JESSE VA	N DONG	EN				26-6-	-2018	ATLAS ST	AL ANALYS RIP ENDCA	P GLOBAL SUPPORT	79

/s. 1	MECHANICAL ANALYSIS OF THE	
2018	ATLAS STRIP ENDCAP GLOBAL	79
	SUPPORT	

NOTE ON THE Q FACTOR

Remember the frequency requirements?

Direction	Stability requirement	As Built Min Frequency Requirements
Ζ	20 µm	3.2Hz
R	20 µm	3.2Hz
Rφ	2 µm	14.4Hz

Based on relative translation of the miles equation

- - Actual ASD ~ 10^-10 G^2/Hz

WE SHOULD STILL BE SAFE ③

Nik hef

10^-8 G^2/Hz As Built

$Y_{\text{RMS}} = \sqrt{\frac{Q [ASD_{\text{input}}]}{32\pi^{3}(f_{n})^{3}}} \xrightarrow{\text{Assumed } Q = 12.5, Q \text{ empty structure} = ~80$ Assumed ASD 10^-7 G^2/Hz FEA

Frequency Requirements
6.7Hz
6.7Hz
31.6Hz

FEA Design Min

USED CONSTRAINTS



ARROWS POINT IN DIRECTION OF CONSTRAINT

Mechanical Analysis of the Atlas Strip Endcap Global Support



USED CONSTRAINTS (ASSEMBLY POSITION)



ARROWS POINT IN DIRECTION OF CONSTRAINT

Mechanical Analysis of the Atlas Strip Endcap Global Support



EIGENMODE 1 & 2



MODE 1, 13HZ "Z-WINGFLAP"

Mechanical Analysis of the Atlas Strip Endcap Global Support



MODE 2, 16HZ "Z-SHEARFLAP"



EIGENMODE 3 & 4



MODE 3, 17.6HZ "X-RAILBEND"

Mechanical Analysis of the Atlas Strip Endcap Global Support



MODE 4, 27HZ



EIGENMODE 5 & 6



MODE 5, 28HZ "Z-DIAGFLAP"

Mechanical Analysis of the Atlas Strip Endcap Global Support



MODE 6, 29.5HZ "Z-TELESCOPE"

EIGENMODE 7 & 8



MODE 7, 32HZ "Z-DIAGTELESCOPE"

Mechanical Analysis of the Atlas Strip Endcap Global Support

MODE 8, 47HZ "Z-DIAGFLAP"



EIGENMODE 9 & 10



MODE 9, 49HZ "PHI TWIST"

Mechanical Analysis of the Atlas Strip Endcap Global Support

Nikhef

MODE 10, 51HZ "SERVICE TRAY WOBBLE"

CONTENTS

- Introduction
- Requirements
- Envisioned Design
- Simulation Goal
- Simulating the Endcap
- Endcap Simulation **History & Software**
- Physical prototype
- Comparing Results
- Conclusion



Work by:



Nik[hef

Nik[hef

Part 1

- Introduction (1 mins) lacksquare
- --> Reason for new detector --> HL-LHC --> new electronics --> new support structure
- --> Short Overview of purpose & location of Endcap
- --> Short overview of tasks for Nikhef, Valencia & Desy
- Requirements (2 mins)
- --> Environmental properties
- --> Requirements on structure
- --> Workable requirements --> Miles equation --> Q 12.5
- Basic EC Design (3 mins)
- --> Basic Ideas behind the Endcap Global Support Design

Part 2

- Simulation History (2 mins)
- General simulation problems --> you Always get numbers out are they correct?
 - --> Validative Testing
 - --> Parallel Calculations Valencia & Nikhef
 - --> Manual Calculations
- Nikhef Switch from Comsol --> NX --> quick showcase of some handy features NX over Comsol (5 mins)
- --> Laminate modeller
 - --> Quick Show of Draping
 - --> Directly work on model & Assembly Fem

Part 4

- Mockup & Measurements (5 mins)
- --> Quick intermezzo about building real mockup.
- --> FEA of full system adjusted to represent mockup
 - --> Measuring mockup
 - --> Comparison Mockup & FEA Mockup
- Discussion NX Analysis (2 mins)
- --> Mockup FEA & Mockup match
- --> Makes it more likely that Real system will match simulation