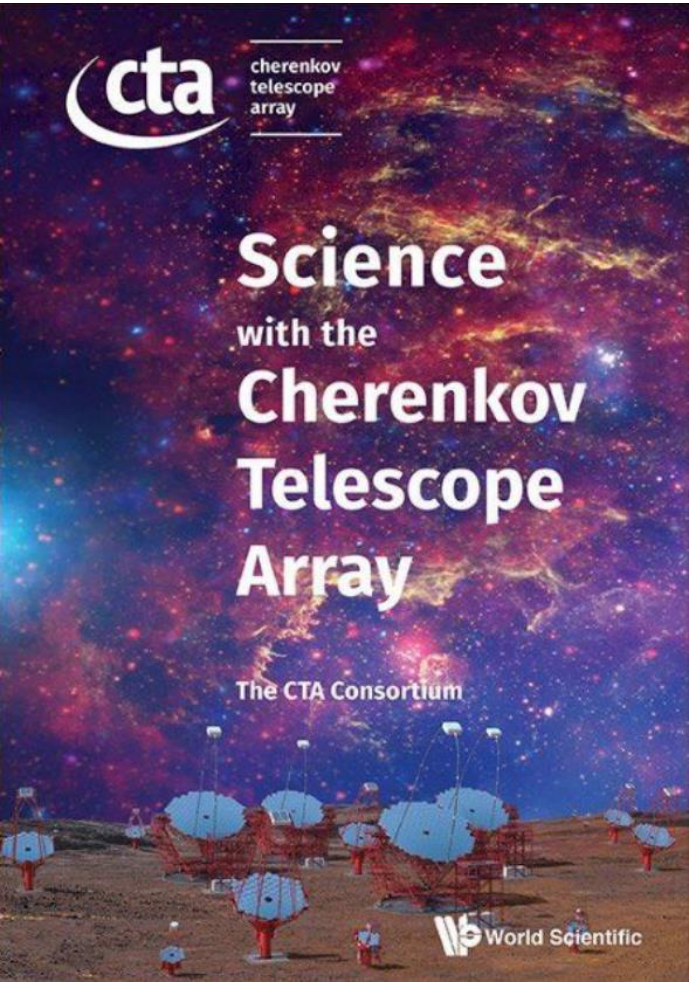
Instrumentation for the Cherenkov Telescope Array

Marcelo A. Leigui de Oliveira

on behalf of the MST-CTA Brazilian team

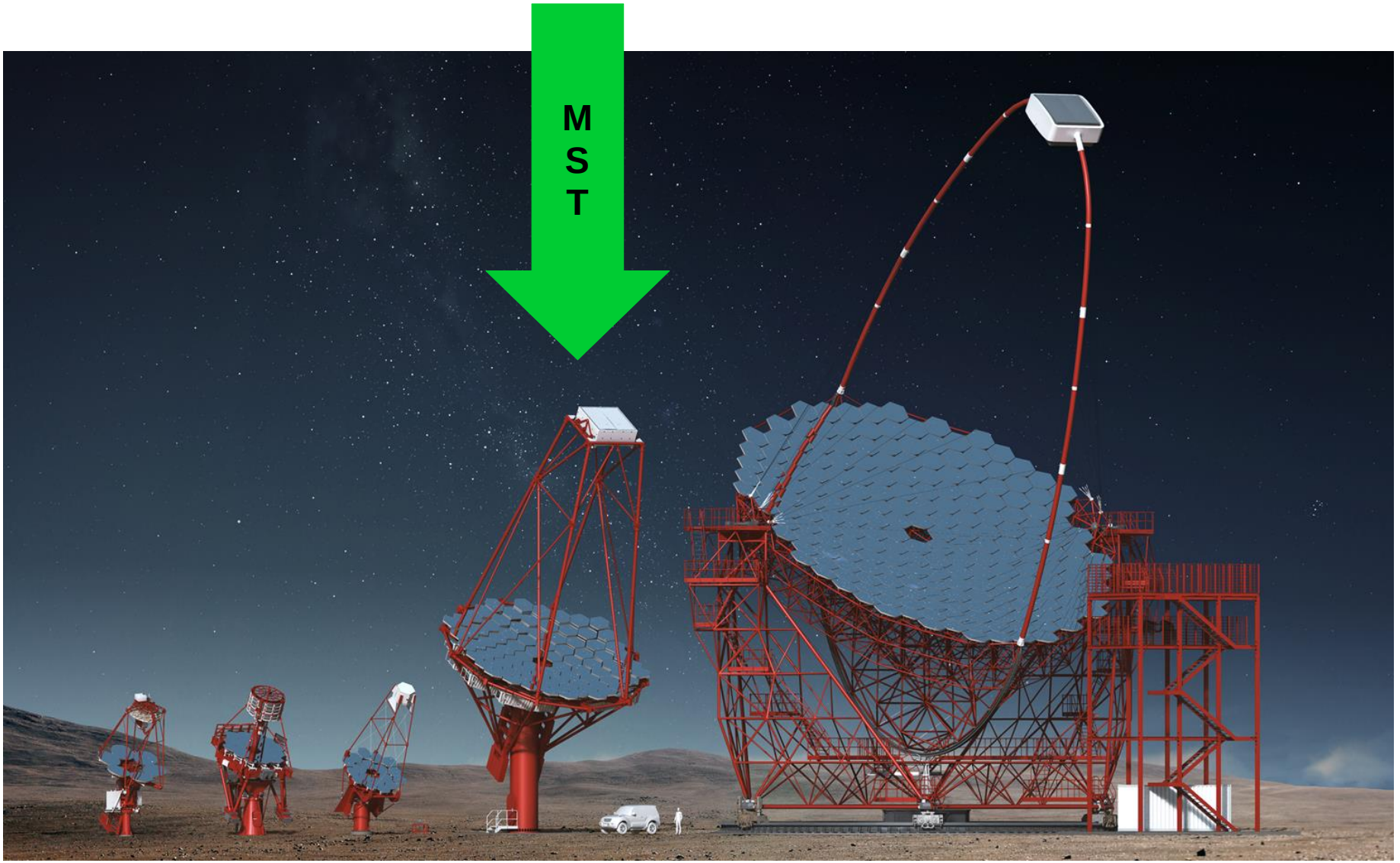


KEY SCIENCE PROJECTS

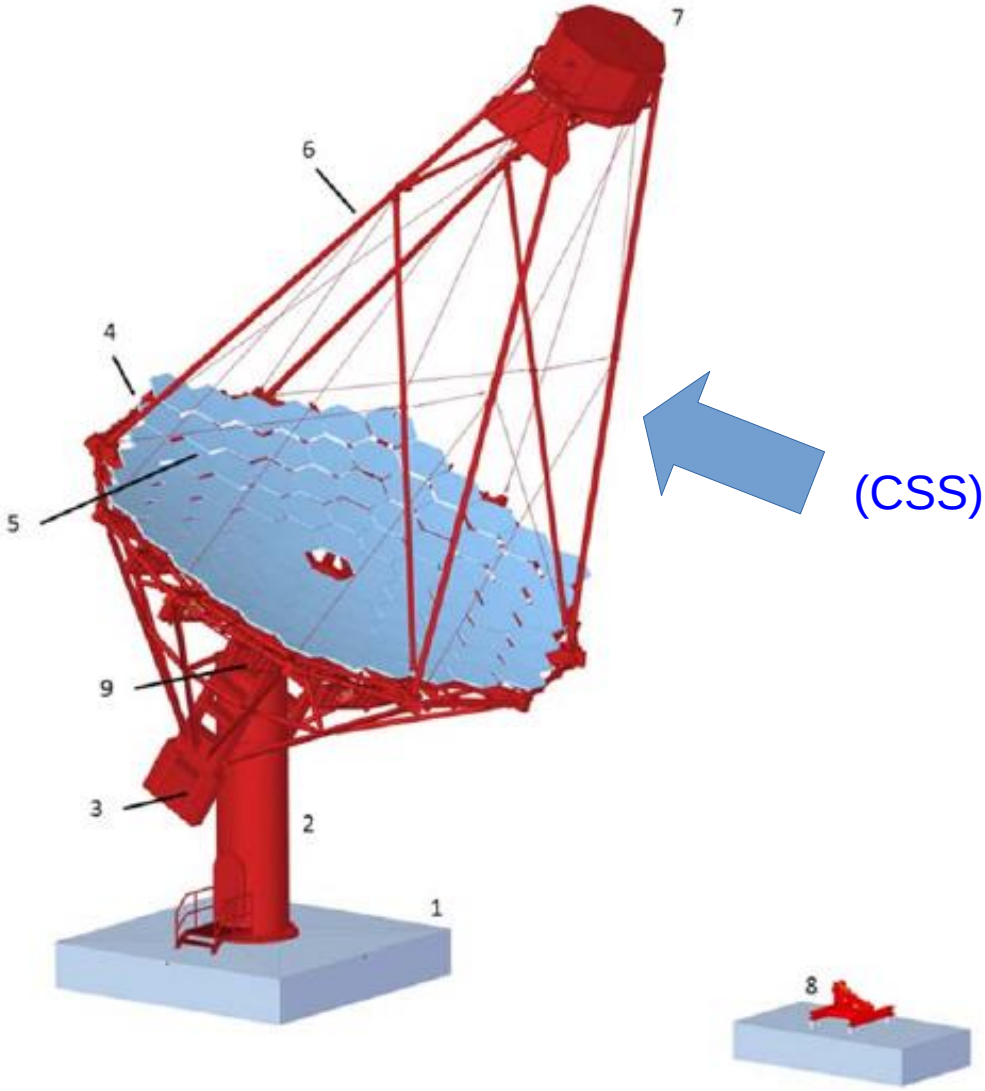
1. CTA Galactic Plane Survey
2. CTA Extragalactic Survey
3. Exploring extreme particle acceleration in the Galaxy
4. Probing DM with precision measurements of the Galactic Center
5. CTA studies on active galaxies
6. On the connection between cosmic rays and the star-formation process
7. Observations of clusters of galaxies
8. Observations of the LMC
9. Observations of the Cygnus region
10. Observation of Galactic DM dominated targets
11. Observations of transient phenomena


cta
cherenkov telescope array
CBPF
Centro Brasileiro de Pesquisas Físicas
IFSC UNIVERSIDADE DE SÃO PAULO
Instituto de Física de São Carlos
IAG INSTITUTO DE ASTRONOMIA, GEOFÍSICA E CIÊNCIAS ATMOSFÉRICAS
IFUSP
Instituto de Física da USP
UFRN
UNIVERSIDADE FEDERAL DO RIO GRANDE DO NORTE
unesp
Itupeva
UFPR
UNIVERSIDADE FEDERAL DO PARANÁ
ICTP SAIFR
ICT
Instituto de Ciência e Tecnologia
UNESP
ORBITAL ENGENHARIA
EEL-USP
EACH USP
UNIFESP
UNIVERSIDADE FEDERAL DE SÃO PAULO
1933
Universidade Federal do ABC
Universidade Cruzeiro do Sul
Unifal MG
Universidade Federal de Alfenas
ufscar
opto
Science in Sight
Elemar
Metal-mecânica e Soluções

Nossa contribuição instrumental no Medium Size Telescope (MST)



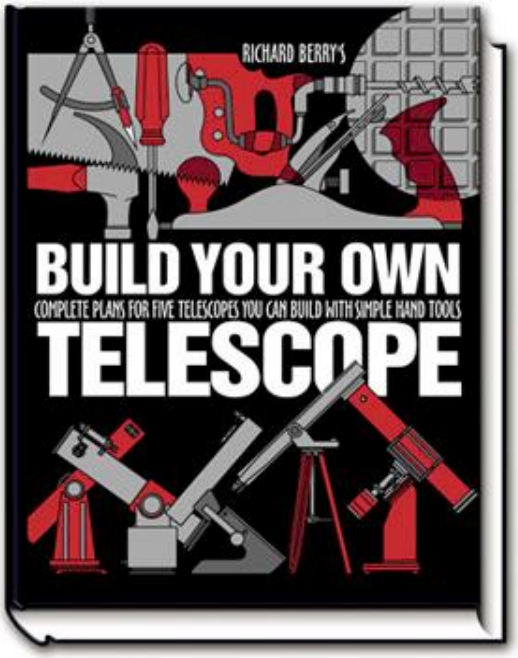
Construindo o telescópios MST



(CSS)

1 – Foundation
2 – Tower
3 – Counterweight
4 – Optical Support Structure
5 – Mirrors
6 – Camera Support Structure
7 – Camera
8 – Camera Lock
9 - Head

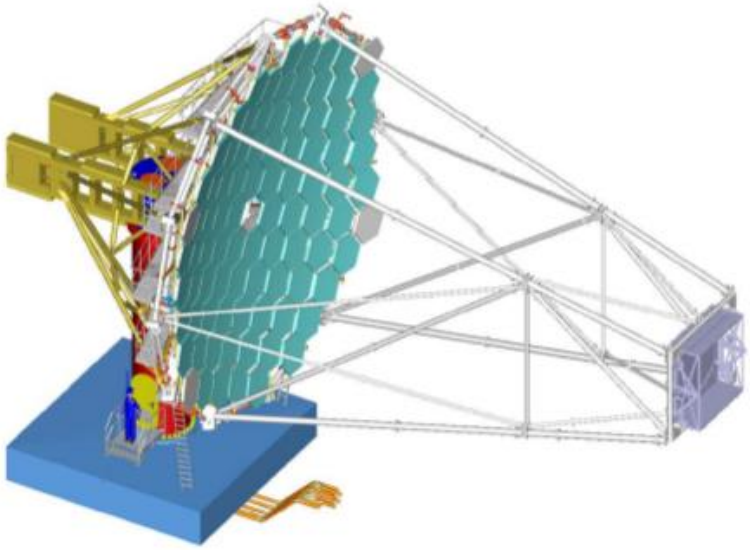
Figure 1: Description of the telescope structure



CSS Brasileiro

- 2010: Auxílio Regular FAPESP: Início;
- 2011: Estudando os requisitos e procurando por parceiros;
- 2012: Auxílio Regular FAPESP: projeto e protótipo 0;
- 2013: Desenvolvimento e aprovação do projeto 0;
- 2014: Construção, instalação e teste do protótipo 0;
- 2015: Protótipo aprovado e melhorias sugeridas;
- 2016: Auxílio Temático FAPESP: projeto melhorado e pré-produção;
- 2017: Projeto de versão de melhorada e construção do protótipo 1;
- 2018 - 2020: Dados de calibração e teste das CSS;
- 2022: Aprovação de recursos para 9 CSS (FAPESP) + 1 CSS (Fundação Araucária);
- 2025: Dados preliminares;
- 2027: Início da tomada de dados científicos.

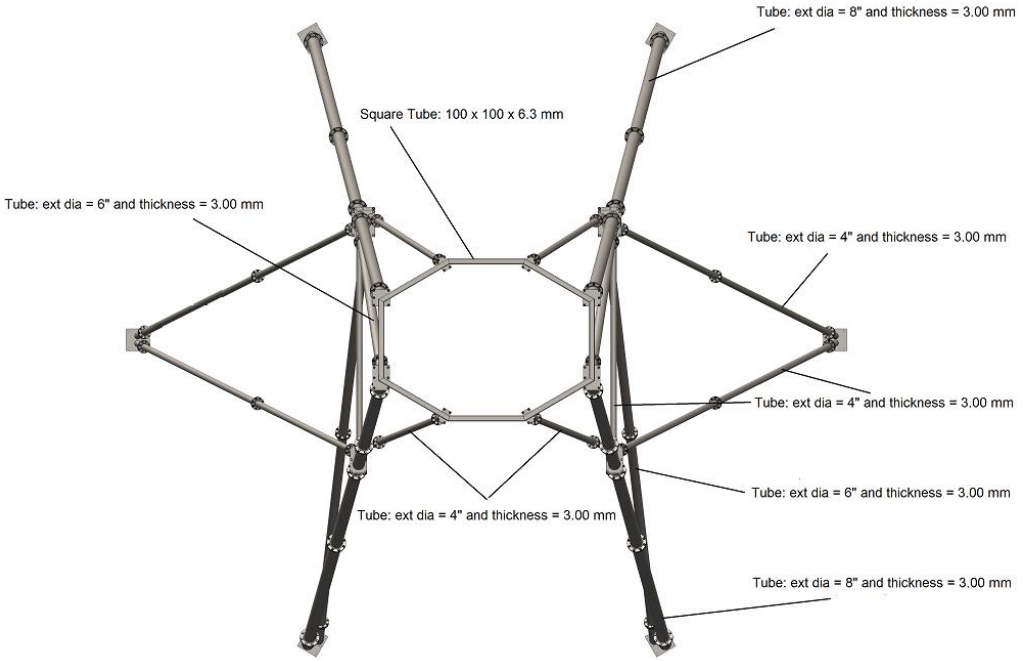
Projeto e construção do protótipo

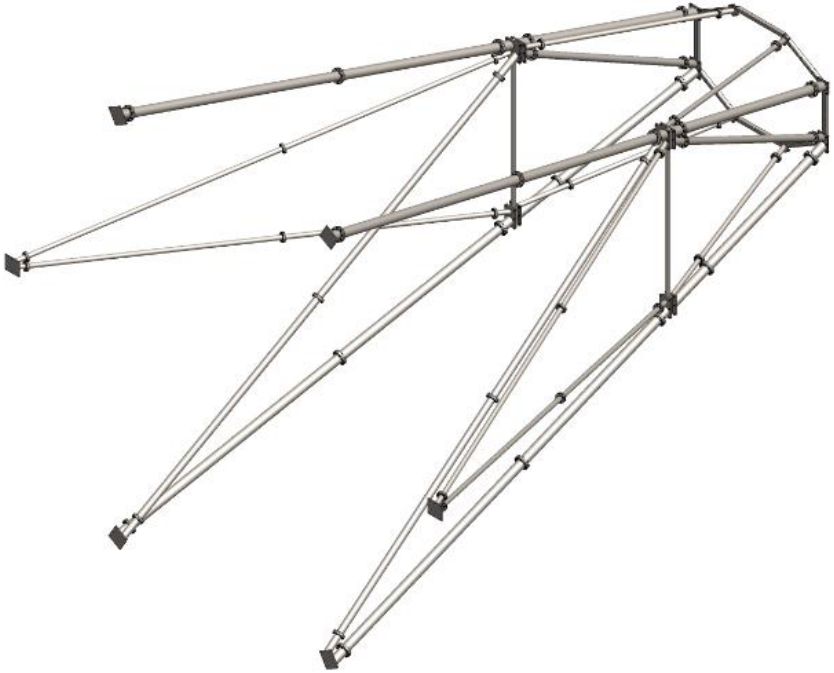


Parameter	Definition
Life expectancy (for bearings and structure)	30 years
Eigenfrequency (whole structure)	≥ 2.5 Hz
Amplitude of camera due to vibrations	≤ 3 mm
Tracking accuracy	≤ 1.2 arcmin
Displacement of camera due to loading	≤ ½ pixel ~ 19 mm
Angular misalignment of camera	not significant
Weight of mirrors including mirror control units	≤ 35 kg/m^2
Weight camera	≤ 2.5 t

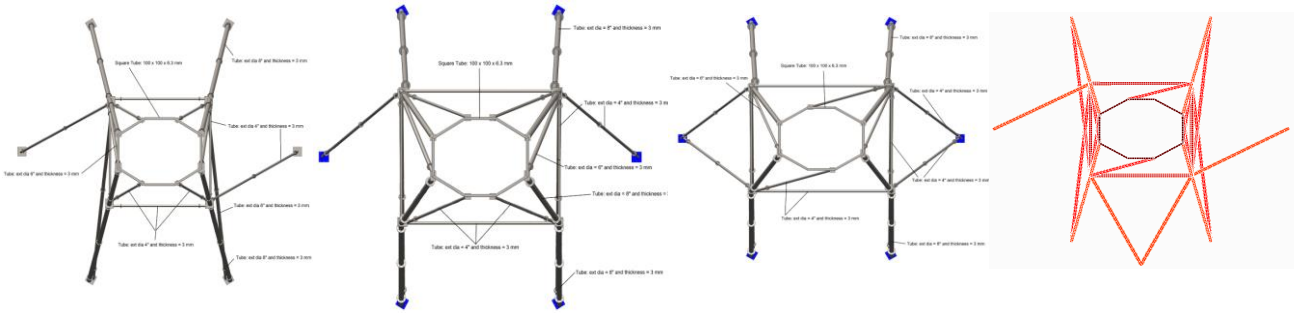
Parameter	Definition	Remarks
Telescope Design	Modified Davies-Cotton	Mirror centre layout on a sphere
Diameter of dish (D)	~12 m	
Radius of the dish	1.2 * focal length	
Focal length (f)	16 m	Distance centre of the hypothetical middle mirror to the camera
Camera field of view	8°	
Gross mirror area	> 100 m^2	
Point spread function (mirror misalignment due to loading)	≤ 1 mrad	

CSS: projetos



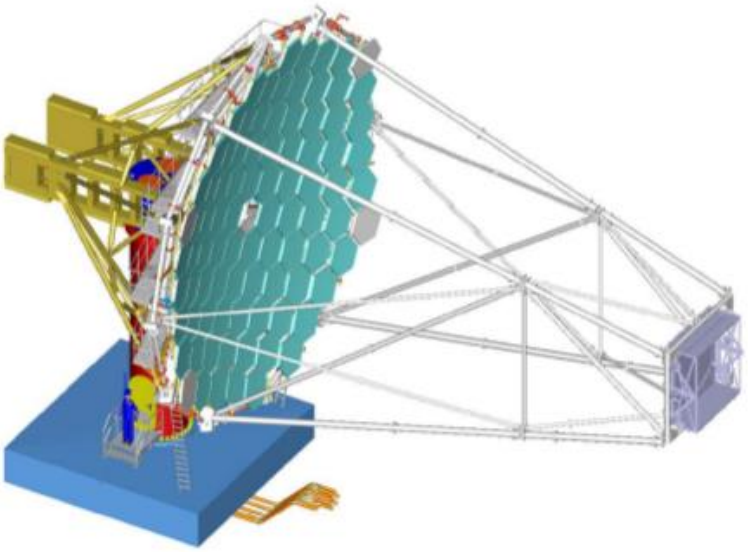


Conception 1: **Front View** **Isometric View**

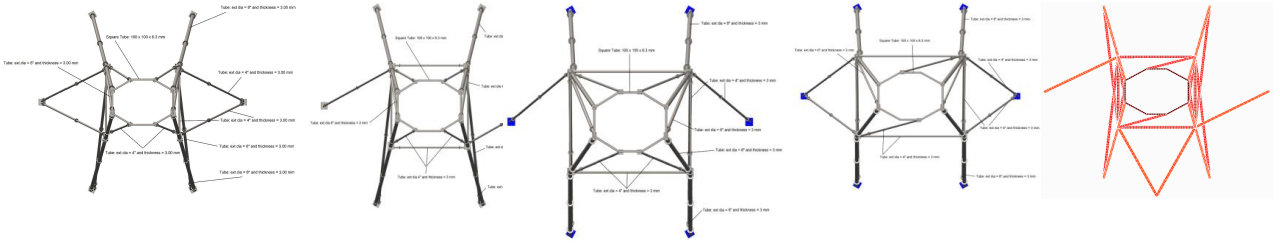


Other conceptions (discarded)

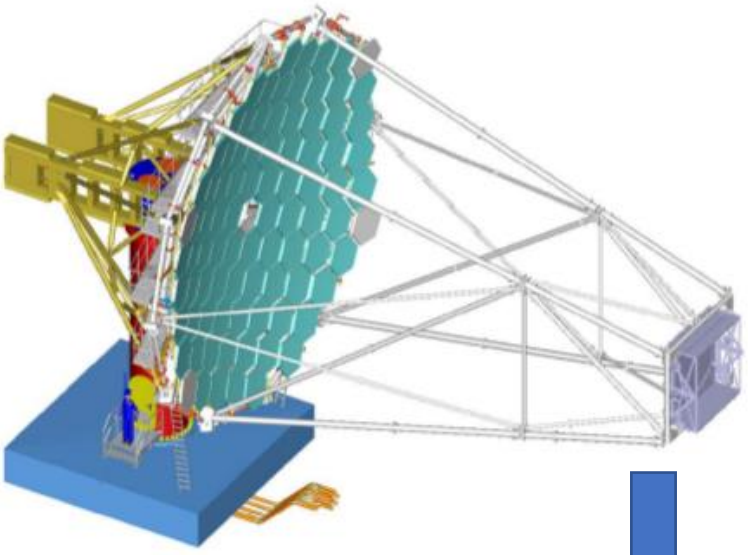
CSS: especificações



Description	Requirements	Conception 1	Conception 2	Conception 3	Conception 4	Conception 5
Fundamental Frequency	> 3.00 Hz	3.60	3.10	3.00	3.50	3.63
Amplitude due to Vibration of the Camera Structure	< 3.00 mm	2.80	2.80	2.94	2.80	2.90
Shadow on the mirror projected by the Structure (see note #1)	< 8.48 %	9.6%	9.3%	10.0%	10.2%	13.5%
Mass (ton)	-	3.1	2.9	3.0	3.1	2.4



CSS: especificações



Conception 1 was chosen and further analysed

Description	Requirements	Conception 1	Conception 2	Conception 3	Conception 4	Conception 5
Fundamental Frequency	> 3.00 Hz	3.60	3.10	3.00	3.50	3.63
Amplitude due to Vibration of the Camera Structure	< 3.00 mm	2.80	2.80	2.94	2.80	2.90
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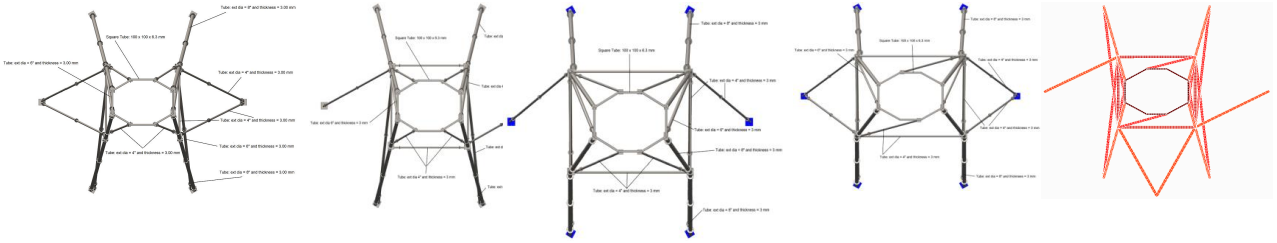
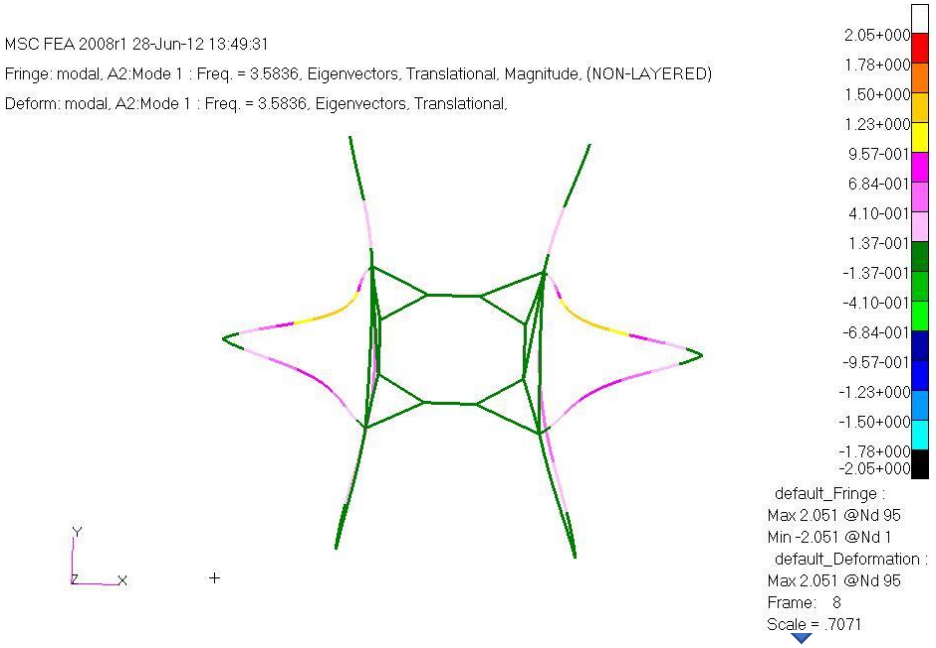
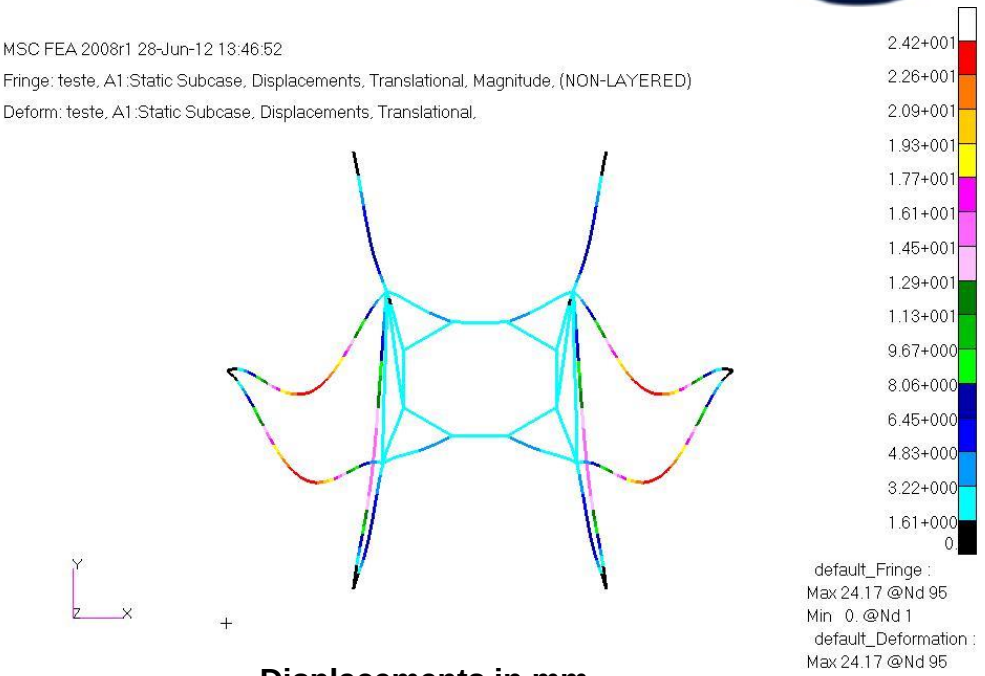


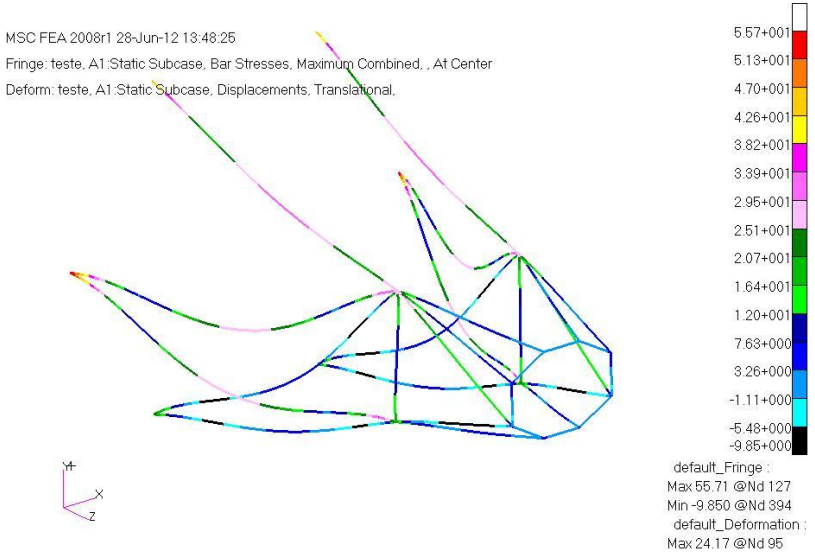
CSS: análises detalhadas



First vibrational mode (frequencies)



Displacements in mm



Stress in MPa

CSS: análises detalhadas

LOAD CASE 03:

- Horizontal
- 50 km/h
- Ice load
- Wind load X

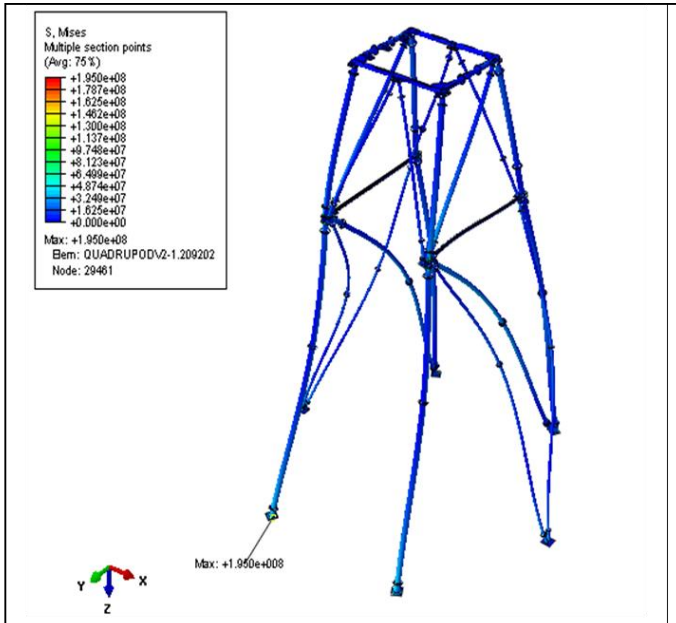


Figure 14: Case 03 stress and displacement analysis

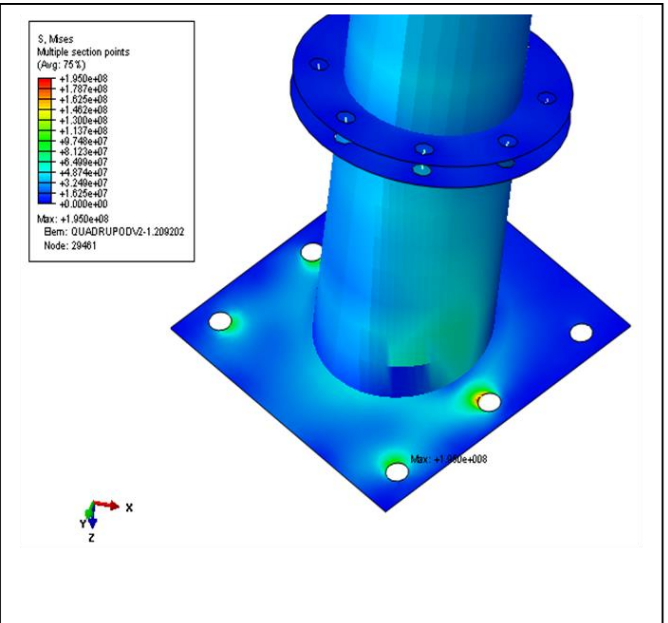
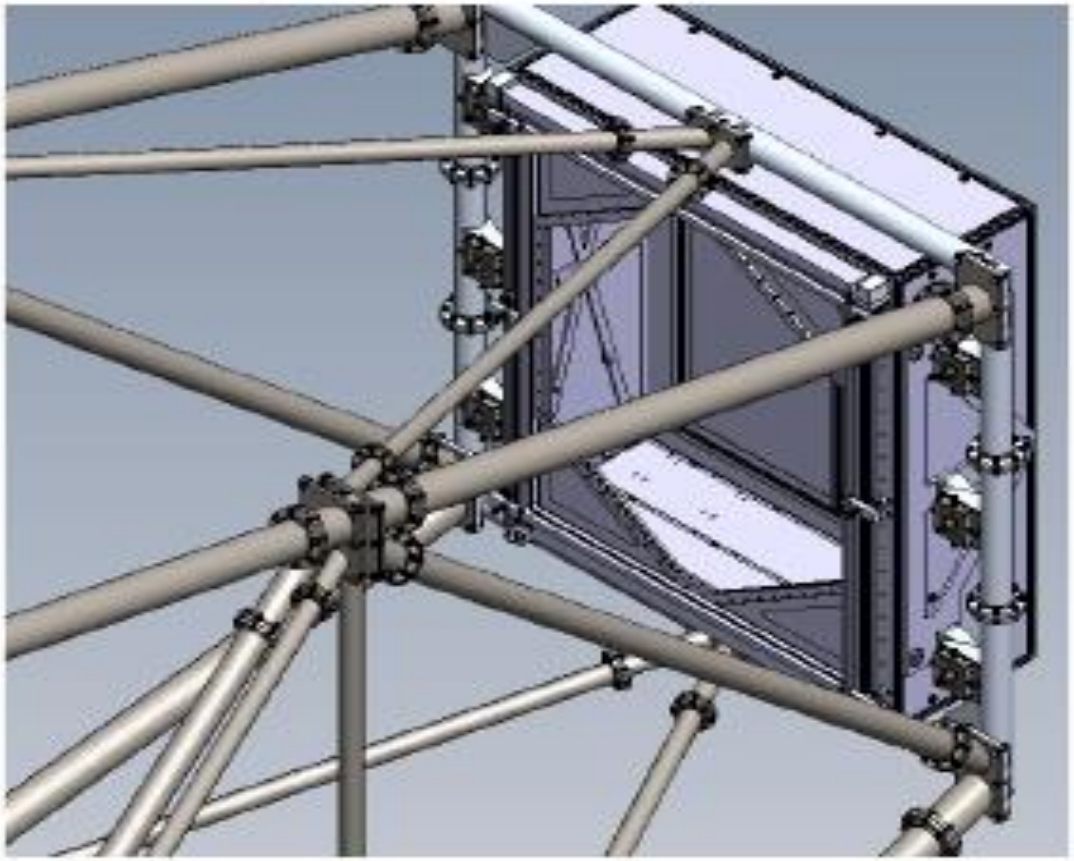


Figure 15: Case 03 stress detail

	Wind Load	Ice Load	Gravity	Global Displacement (mm)	Camera Displacement (mm)	Stress (MPa)	Buckling factor	Safety Coefficient
	X+ 50 km/h	Superior	Y-	23,31	5,31	195	7,11	**1,59**

APROVADO EM TODOS OS TESTES

Dispositivo de ajuste de posição e ângulo



Inovação:

Mover e alinhar
2 toneladas
com precisão de mm

Patente obtida em 2019

IFSC USP Instituto de Física de São Carlos

Universidade Federal do ABC

ORBITAL ENGENHARIA

USP inovação

INOVAUFABC AGÊNCIA DE INOVAÇÃO

CSS: construção @ Brasil

IFSC USP
Instituto de Física de São Carlos

Universidade Federal do ABC

ORBITAL ENGENHARIA

CSS Brasileiro: Montagem @ Berlim

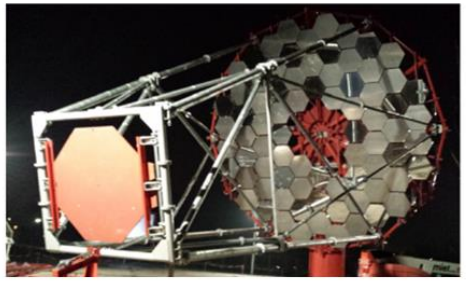
CSS Brasileiro: protótipo montado @ Berlim

Credit: R. Shellard

CSS Test Report

DESY and Humboltd University Berlin

CEA/IRFU - France



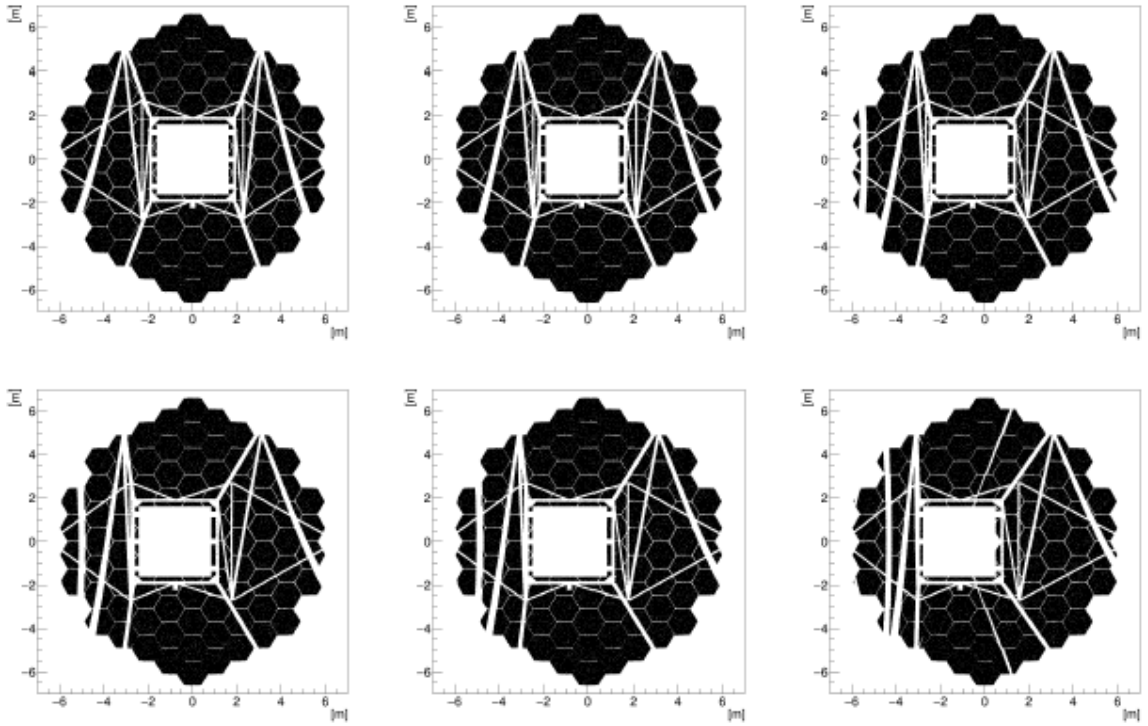
IFSC/USP - UFABC - Orbital Brazil

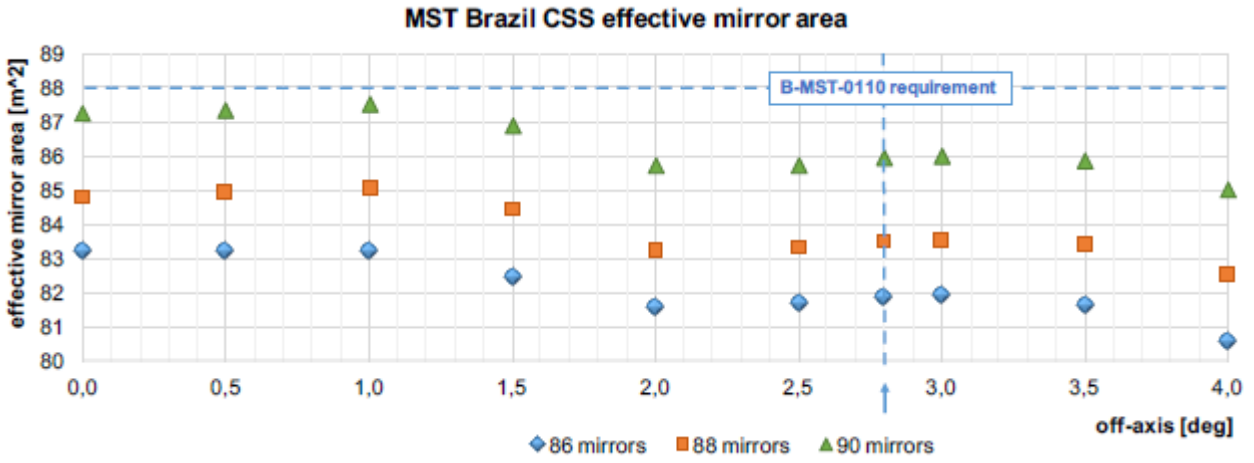
- Vibration studies: both proposals meets the requirements
- Displacement under control for both structures
- Lack of pre-tension ropes is an **advantage** of the Brazilian proposal
- **Better** temperature balance of the Brazilian proposal
- Galvanized steal in the Brazilian structure **garantees** 30 years operation
- Adjustment device in the Brazilian proposal is **advantange**
- The increased shadowing of the Brazilian structure can be compensated with the use of two extra mirror facets

Authors: Anja Schubert, Dirk Naumann, Stefan Schlenstedt, Louise Oakes and Ulrich Schwanke

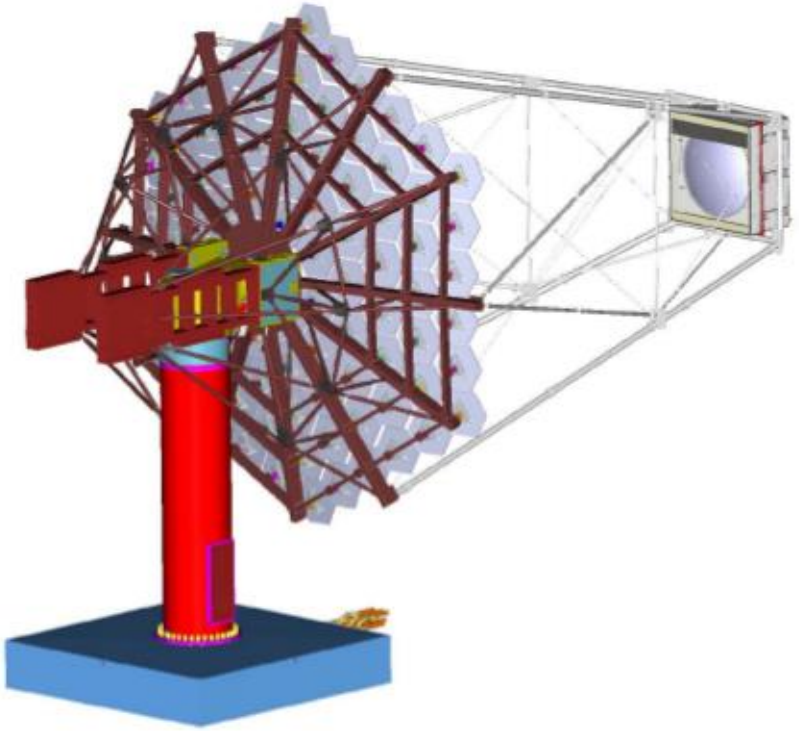
CSS Ray tracing

DESY and Humboltd University Berlin





CSS Versão Melhorada



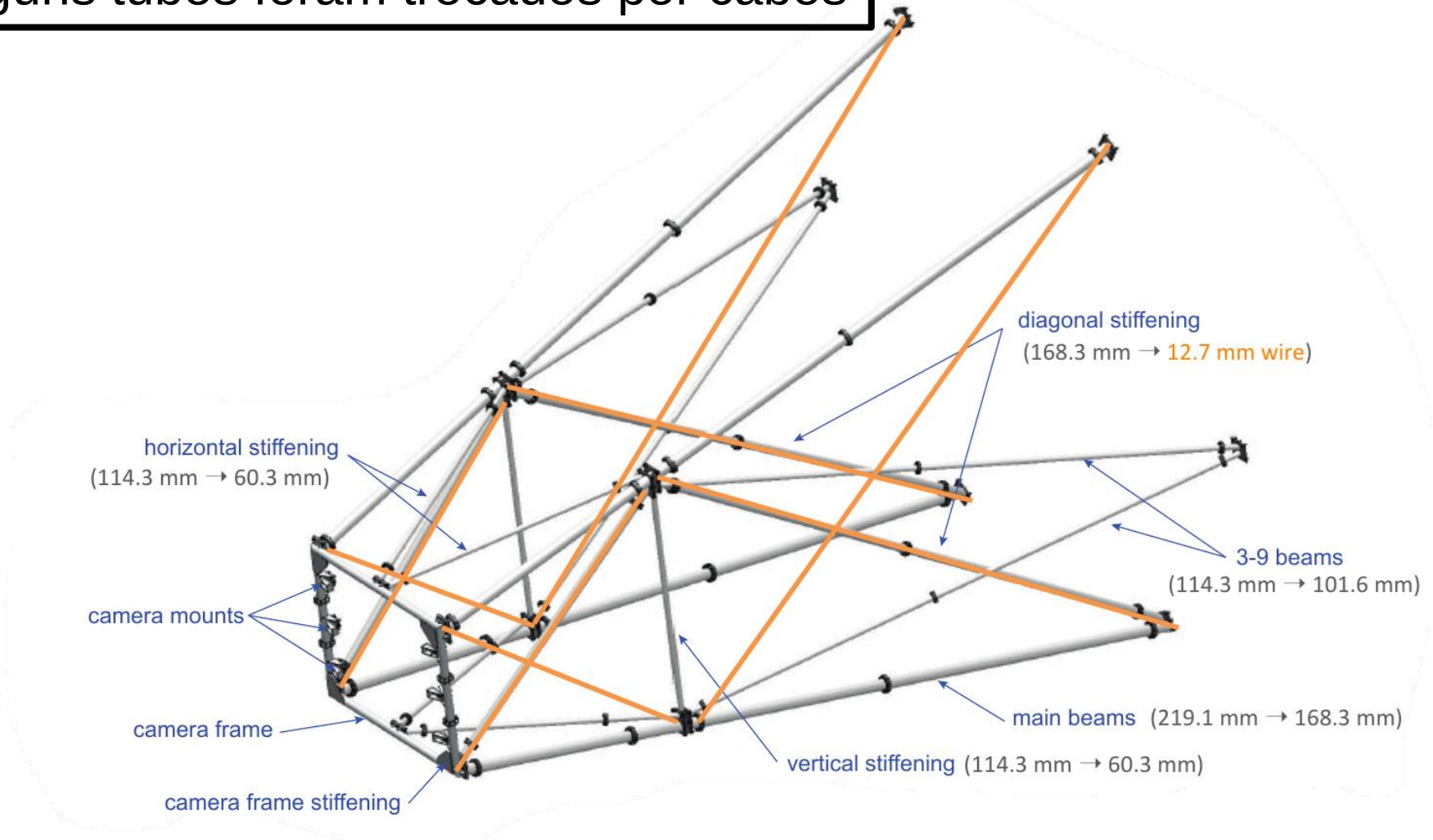
Objetivos Re-design:

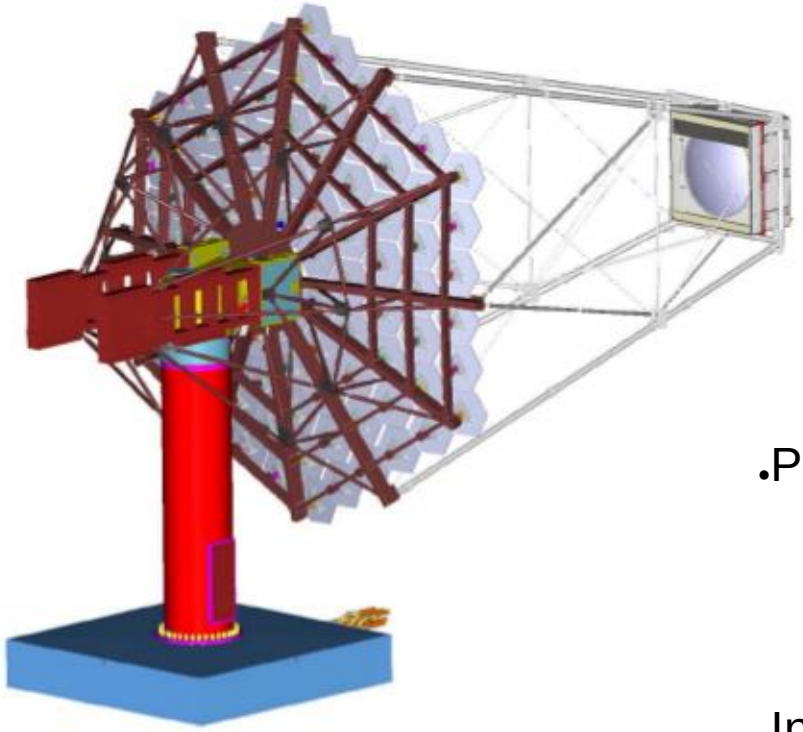
Reduzir peso e sombreamento

	old design	new design
weight [kg]	4.479	3.843
shadow [% / m^2]	19.0 / 86.8	17.2 / 88.7

Principal Modificação

Alguns tubos foram trocados por cabos





Conclusão

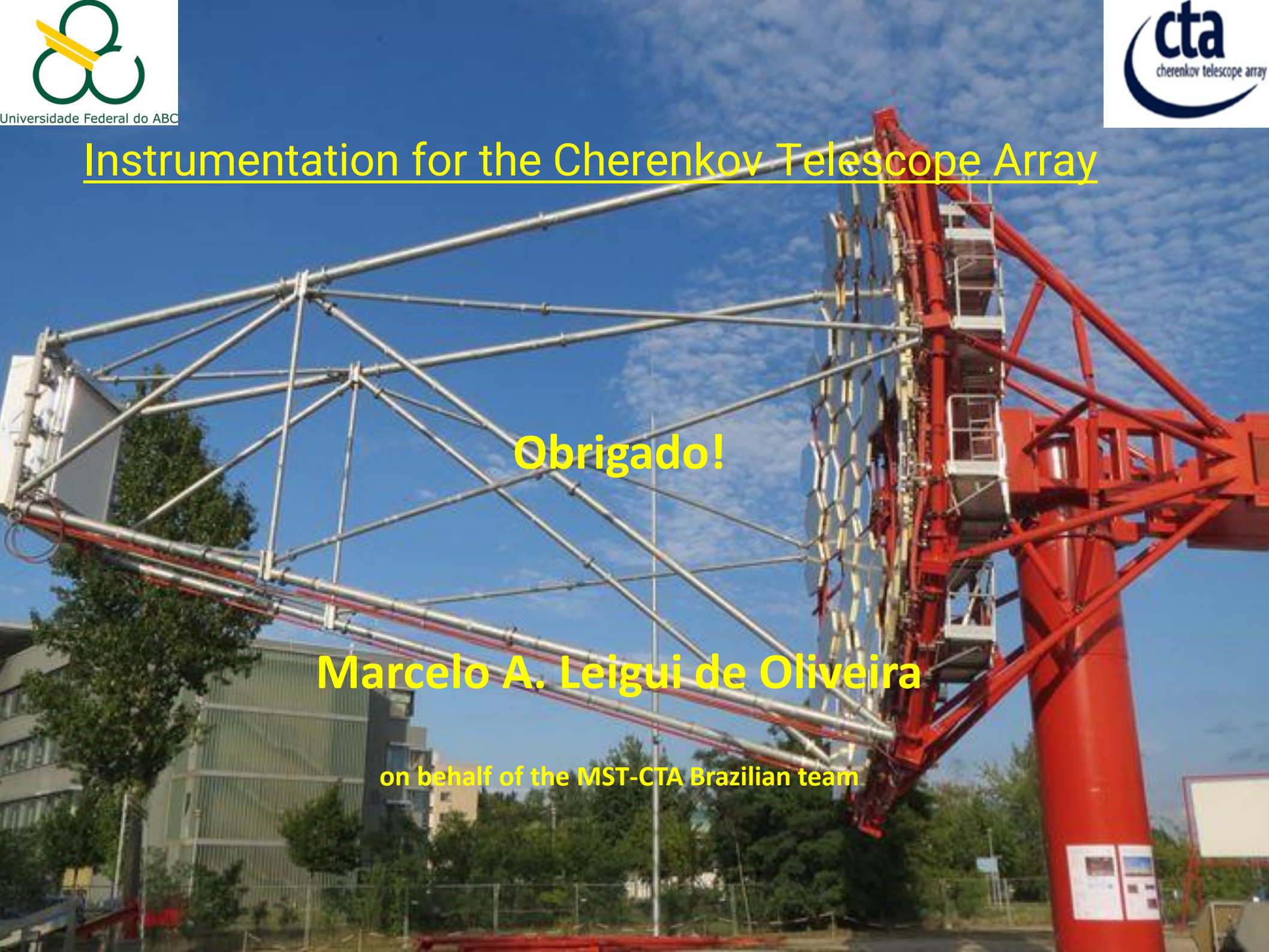
- Projeto e construção no Brasil:
  - protótipos aprovados (0 e 1) + melhorias implementadas;

- Instalação, calibração e testes sob nossa responsabilidade;

- Patente depositada;

- Construção/pré-produção (9+1) a partir deste ano;

- Recursos ainda necessários para outras 13 CSS.


Universidade Federal do ABC
cta
cherenkov telescope array
Instrumentation for the Cherenkov Telescope Array
Obrigado!
Marcelo A. Leigui de Oliveira
on behalf of the MST-CTA Brazilian team