

# Welcome to Prague, AXRO 2024

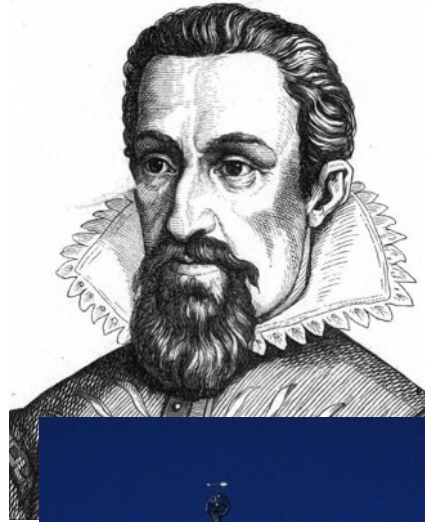
## City of Astronomy and X-ray Astronomy

René Hudec





# Prague – historical city of astronomy: Tycho de Brahe, Kepler, Einstein, Doppler ... and astronomical X ray optics

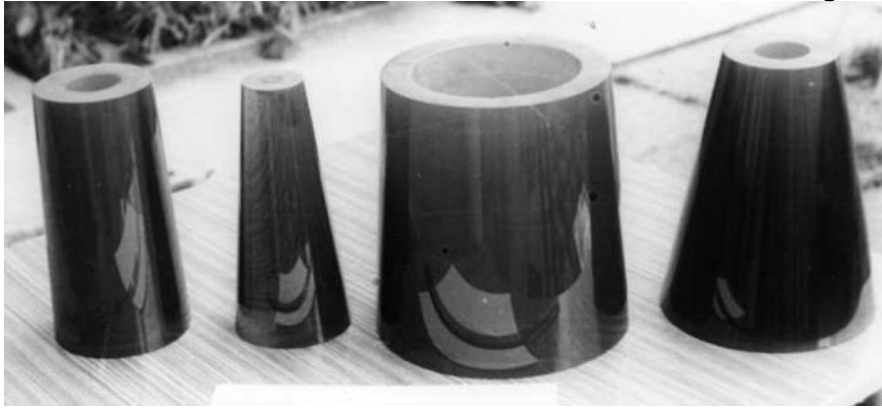


# History of Grazing Incidence X-Ray Optics in the Czech Republic

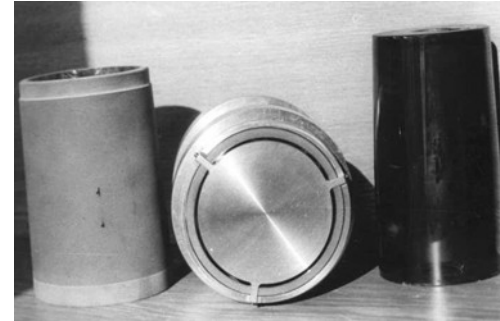
- 1st X-ray mirror in **1969/1970**, for solar telescope in INTERKOSMOS program
- The early stages of the X-ray optics developments in the Czech Republic are closely related to the INTERKOSMOS Space Program (Soviet and East European equivalent of ESA operated until 1989). All of the X-ray imaging telescopes onboard Soviet spacecrafts were equipped with the Czech X-ray optics (exception: X-ray normal incidence mirrors in the special channel of the TEREK telescope). Later on, laboratory applications have started.
- **Total number of X-ray mirrors produced: more than 50**
- Total number of mirrors flown in space: 10
- Total spacecrafts with Czech X-ray optics: 5
- Total number of space experiments with Czech X-ray optics onboard: 10



# X - ray mirrors produced by replication in the Czech Republic



The four mandrel used for the manufacture of X-ray mirror nested array for the RT-4M soft X-ray telescope (Glass ceramics Sital). Flown onboard the space station Salyut 7 in 1981.



TEREK  
Phobos 1  
1988



Two identical mirrors (large hyperbolas) of the RT-4M mirror array (Ni surfaces), 1981.



Replicated Wolter - 1 X-ray mirrors of the KORONAS satellite (aperture 80 mm), 1989

AXRO2022



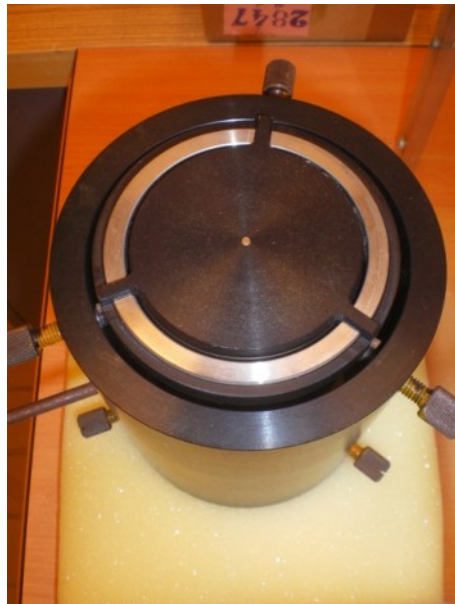
One of the first Czech X-ray Wolter mirrors, 1970, aperture 50 mm



The galvanoplastic (electroforming) replication adopted from gramophone industry



115 mm aperture X-ray mirror for AUOS-S-IK, solar, FWHM < 10 arcsec, thick Ni



Solar X-ray Wolter mirror 8'0 mm thick Ni



Thin Ni mirror for DSRI, 1986, thin Ni, 150 mm



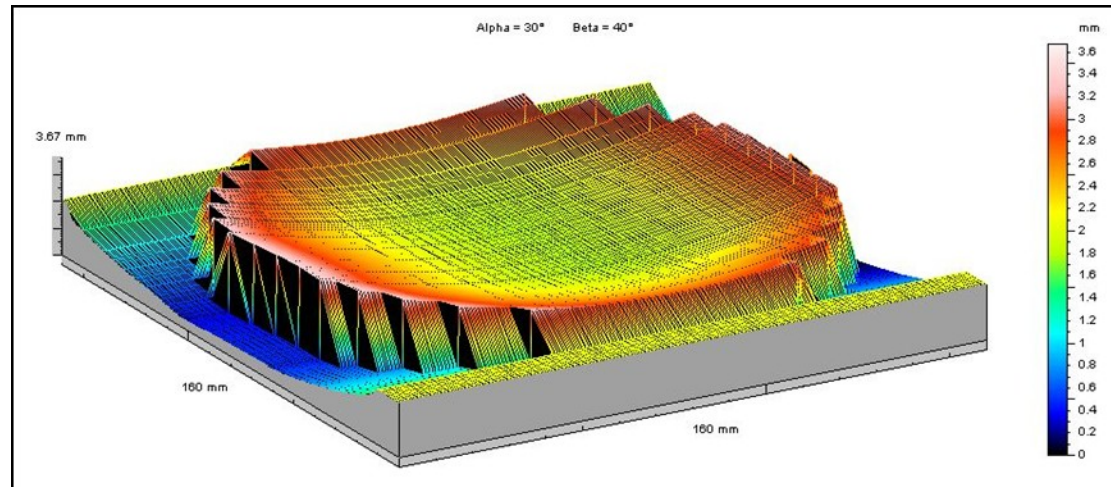
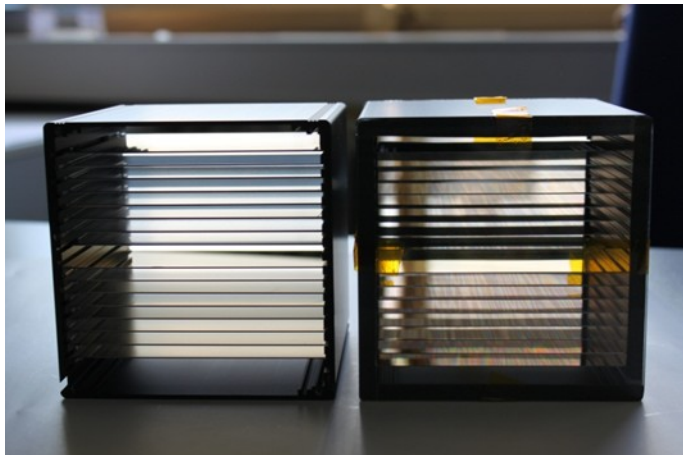
115 mm Wolter, Ni/epoxy, 1979



# Years 2005-2015

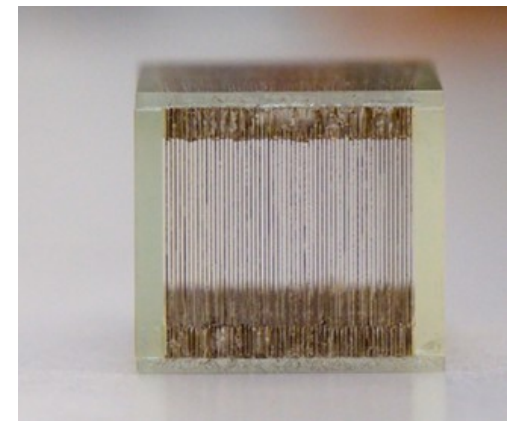
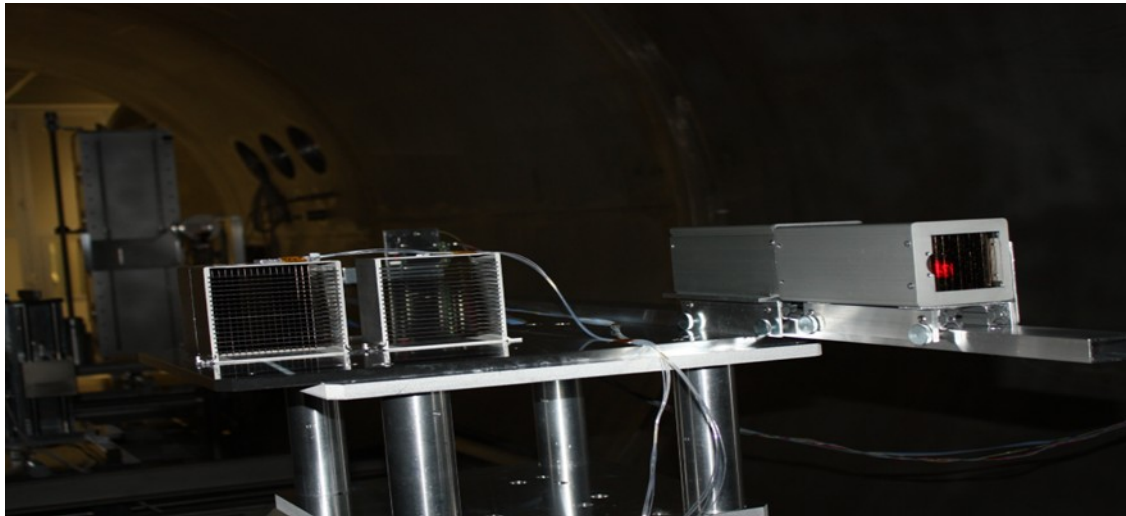
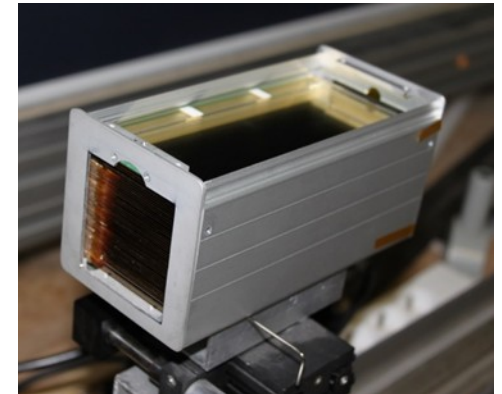


**Various modules of MFO Multi Foil Optics**  
**Novel substrates bent thin glass foils**  
**Lobster Eye Optics**  
**K-B Optics**



# Recent 2016-24

- Participation in AHEAD EU project, KB and LE modules
- LE VZLUSAT1 and 2 (cubesats)
- LE REX (rocket experiment)
- Glass foils/Si substrates
- More in relevant talks/posters



# Czech-US Seminar on Astronomical X-Ray Optics May 2007



Visit to Komorní Hrádek Chateau



# Train ride to ON Semiconductor



# International Workshop on Astronomical X-ray Optics AXRO2008 Prague Dec 2008



**A new tradition is born .....**

AXRO2022



# AXRO2009



AXRO2022

# AXRO2009 at the Komorní Hrádek Castle





# AXRO2010 at Liblice Chateau



# AXRO2011:with Prince Lobkowicz at Melnik Castle





# AXRO 2012





# AXRO2013





# AXRO 2014





# AXRO2015





# AXRO2016



AXRO2022



# AXRO2017 official photo





# AXRO2018





# AXRO2019





# AXRO2022





# AXRO AHEAD WORKSHOP PRAGUE 2023



# **AXRO 2024 Conference 1<sup>st</sup> Tour and Dinner on Nov 13 Wednesday**

- **Guided tour of Novoměstská radnice city hall and tower ..... 221 steps, 72 m high**
- **Meet 15.10 in Lanna lobby, departure 15.15 tram tickets will be provided ....TBC**
- **Dinner in the city hall , 18-22**
- **In emergency call my mobile phone  
00420731502542**



# New Prague City Hall



Built 1377–  
1398



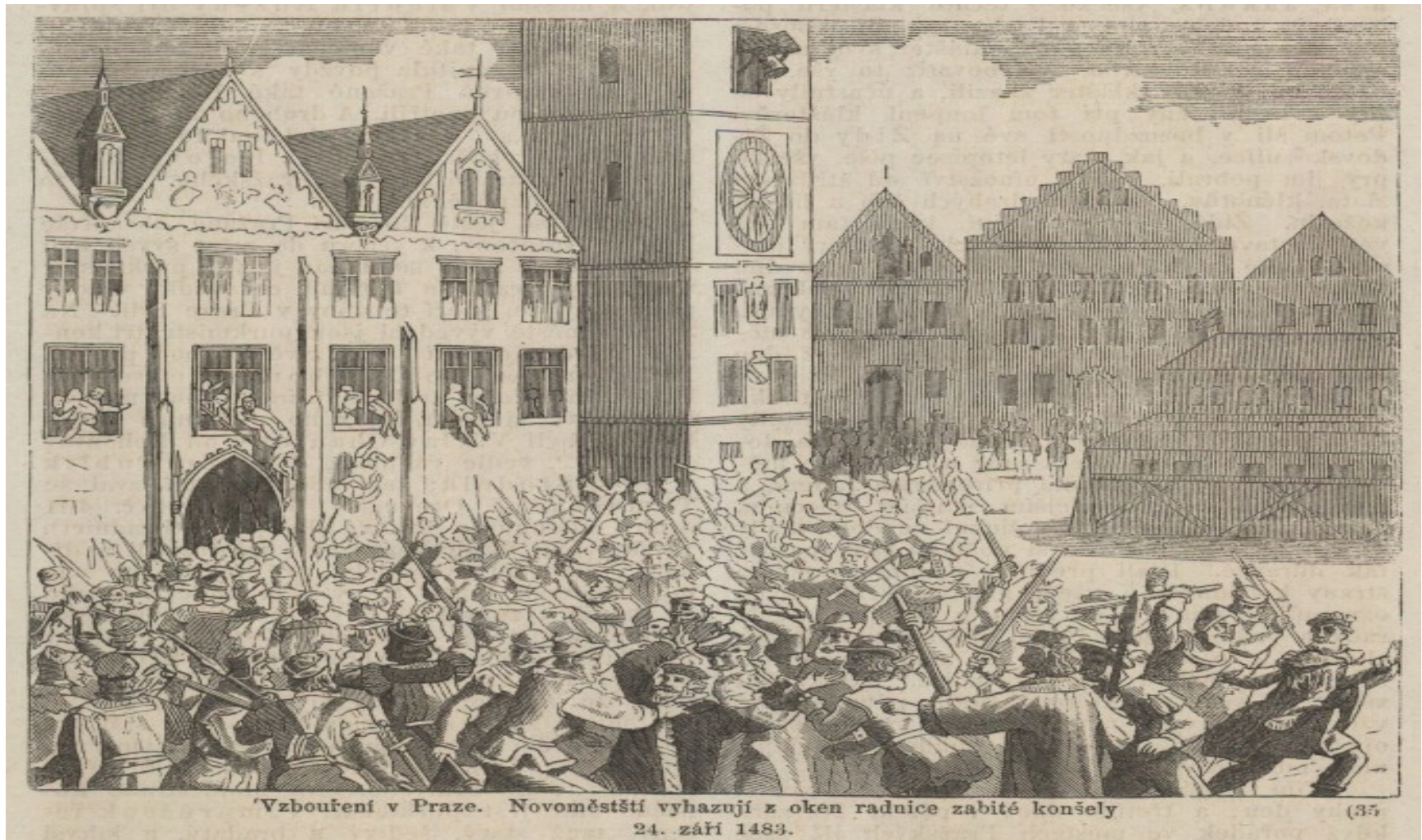
# The First defenestration of Prague

- The **First defenestration of Prague** happened on July 30, 1419. It marks the beginning of the Hussite wars





# The second defenestration ... the same place 64 years later in 1483

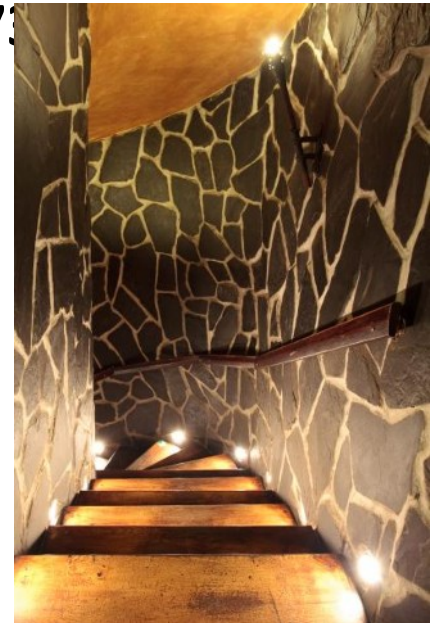


# **AXRO 2024 Conference Social Event and Dinner on Nov 14 Thursday**

- **Guided visit to TYN Church, after that**
- **Dinner in Restaurant U Sádľů, Klimentská 2, Prague 1, 18.00-22.00 provided by LOC**
- **Meeting 15.10 departure 15.15 Lanna Lobby tram tickets will be provided TBC**
- **In emergency call my mobile phone 0042073**



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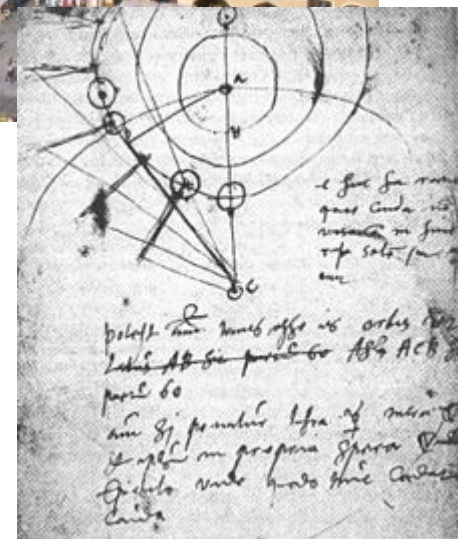


# Tycho de Brahe Thumb, Týn Church



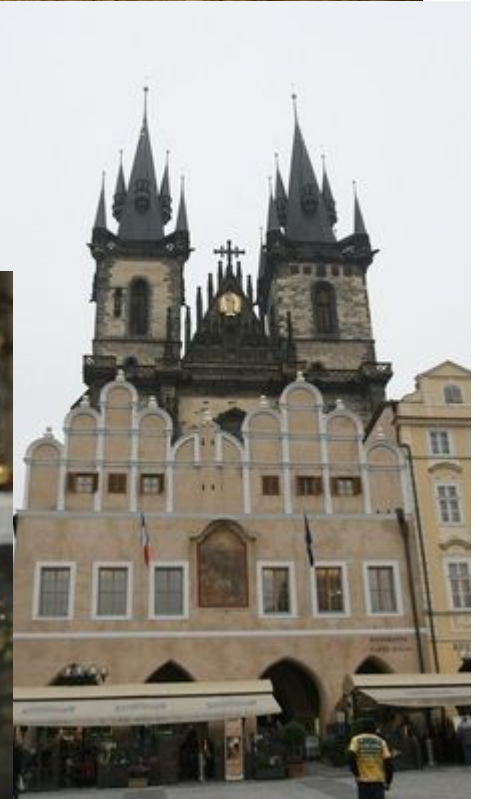
www.alamy.com - CW2100

Tycho Brahe





# Tycho de Brahe grave opened and investigated November 2010



AXRQ2010



# Scientific investigation of Tycho de Brahe relics (Czech-Danish project)



**Why Tycho died?**

- Killed by Czech beer?
- Intoxicated by Arsenic from scientific experiments?
- Intoxicated by Arsenic to kill him?

**Analyses of Tycho beard may help to answer**



AXRO2010

# Some logistics

- Breakfast included in accommodation price
- All lunches included in the fee
- Conference evenings events included in the fee
- Guest tickets 50 Euro/1000 CZK each event
- Time of conf photo today before lunch TBC
- Please sign the AXRO page in the Lanna guest book
- **Public transport in Prague is free for everybody over 65 ..... picture ID or passport required**



# Places to see in Prague

- **Klementinum with astronomical tower**
- **Kepler house and Kepler Museum inside**
- **Thumb of Tycho Brahe in Tyn church,  
Staromestske namesti**
- **Astronomical clock, old city hall Staromestske  
namesti = place of Christmass market**
- **Monument of Kepler and Brahe at Pohorelec,  
Tram station 22 near Prague castle**
  - **Belvedere Tycho observing place**

# Visit to Astronomical Prague



**Monument Tycho and Kepler and Belvedere**



# Belveder: Former Observing Place of Tycho de Brahe



# Kepler House in Prague (and Kepler museum inside)



<http://www.keplerovomuzeum.cz/en/>





# Johannes Kepler – modern Astronomy begin in Prague



- 1599 – Kepler hired by Tycho Brahe
  - Work on the orbit of Mars
  - Kepler worked in Prague 1600 to 1612
- 1609 – Kepler's 1<sup>st</sup> and 2<sup>nd</sup> Laws
  - Planets move on ellipses with the Sun at one focus
  - The radius vector sweeps out equal areas in equal times
- 1618 – Kepler's 3<sup>rd</sup> Law
  - The square of a planet's orbital period  $P$  is proportional to the cube of its semi-major axis  $R$ :  $P^2 \sim a^3$

Kepler 1<sup>st</sup> and 2<sup>nd</sup> law discovered in Prague perhaps in relation to the elliptical church near the Prague Kepler house

# How Kepler discovered his 1<sup>st</sup> and 2<sup>nd</sup> law?

## The Italian (Vlašská) Chapel of the Assumption of the Virgin Mary

Křižovnické nám. 2, 110 00 Praha

It is speculated that the elliptical shape of the Italian Chapel of the Church of the Assumption of Virgin Mary (1590-1597) in Old Town's Charles Street inspired Johannes Kepler to think of the movement of Mars on an elliptical path (with a focus in the Sun). At that time, it was the only elliptical structure north of the Alps. Even in Italy, there were barely ten.

The chapel was built in 1590 (consecrated by 1600) by Italian craftsmen from the Italian colony living in Prague, but it is still managed by the Italian state.





# Tycho de Brahe House



**House No. 76 Nový Svět 1  
Praha 1 Hradčany (Prague  
Castle)**

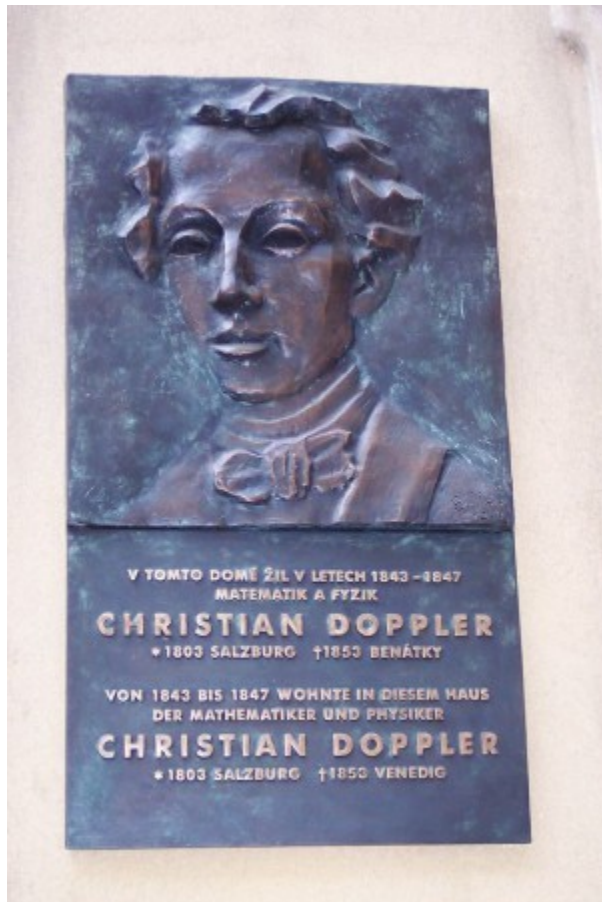


# Doppler and Prague

**High school professor in Prague  
1835-1847**

Professor in Prague 1835-1847

In 1843, at the proposal of František Palacký, he became a full member of the Royal Czech Society of Science. At the meeting of the science section of the Society, he lectured on May 25, 1842, "On the Color of the Binary Stars", where he described the so-called Doppler phenomenon. However, since he had no experimental evidence, the work did not receive too much attention



U obecního dvora 5, Praha 1  
Staré Město

L



# Tycho de Brahe Thumb



# Klementinum Old Prague Observatory



**Jesuit College**

**1st Prague Observatory  
Observatory tower from 1722  
Today National Library**

AXRO2013



# Astronomical Clock

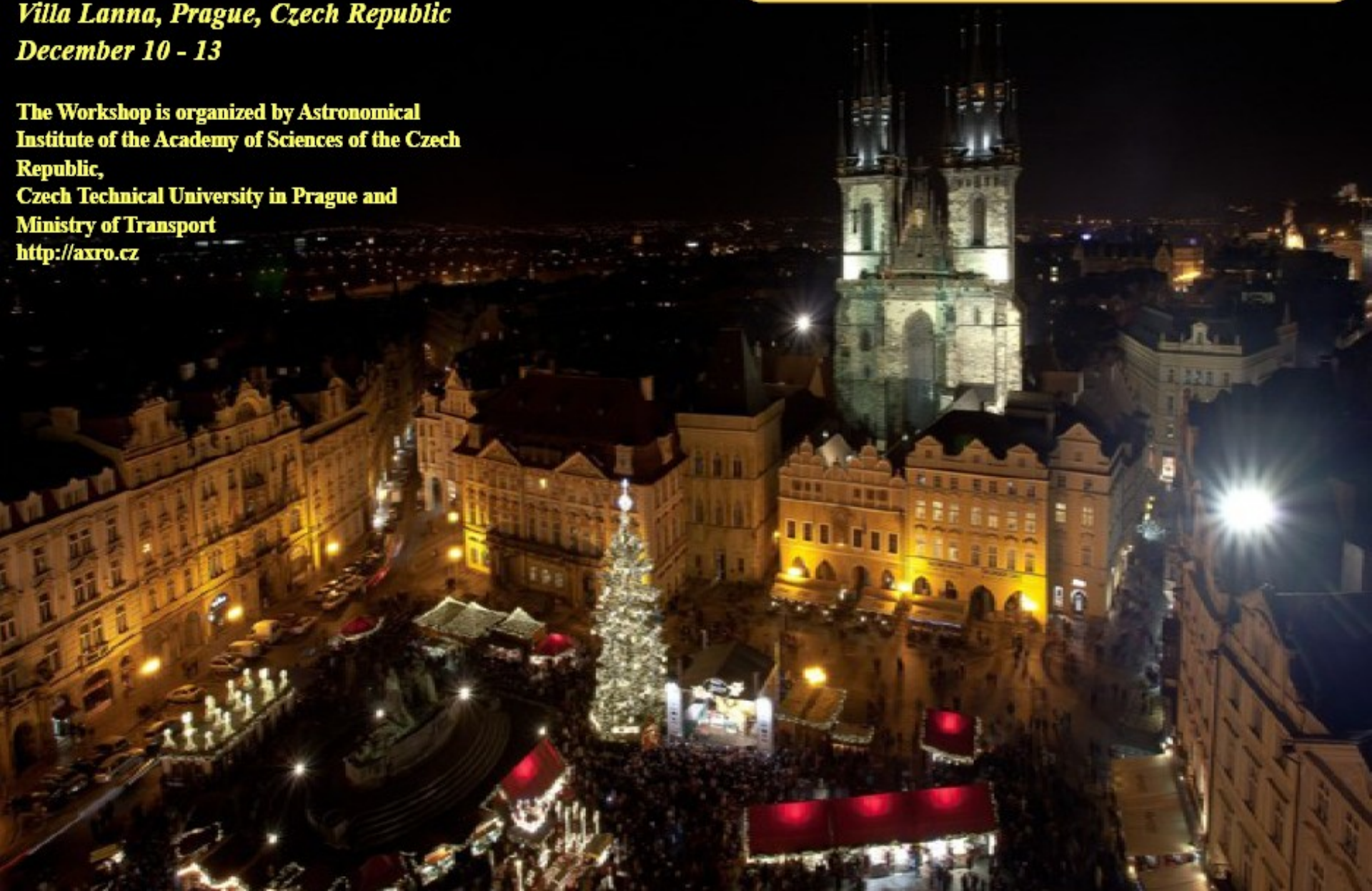




# ***V. International Workshop on Astronomical X-Ray Optics 2012***

***Villa Lanna, Prague, Czech Republic  
December 10 - 13***

**The Workshop is organized by Astronomical  
Institute of the Academy of Sciences of the Czech  
Republic,  
Czech Technical University in Prague and  
Ministry of Transport  
<http://axro.cz>**





# Enjoy the meeting .... and Prague

