Recent Experience with Viewports and Mirrors at CERN

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ARIES Workshop 23.06.2021

Outline

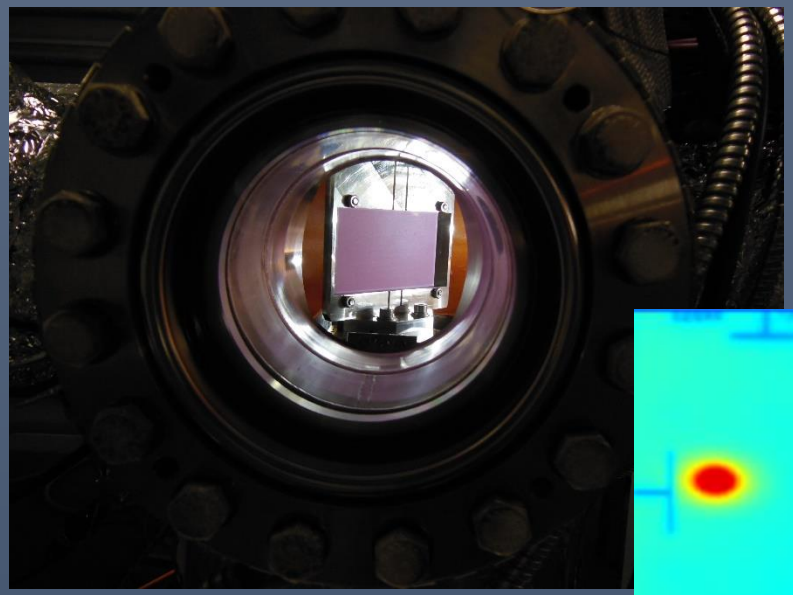
- Some CERN applications
- Window flange parts and types
- CERN’s experiences
- CERN’s requirements
- Experience with mirrors

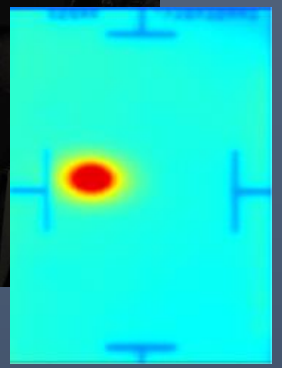
This is a workshop, your experience is very welcome, please share

CERN applications (selection)

Laboratory application,

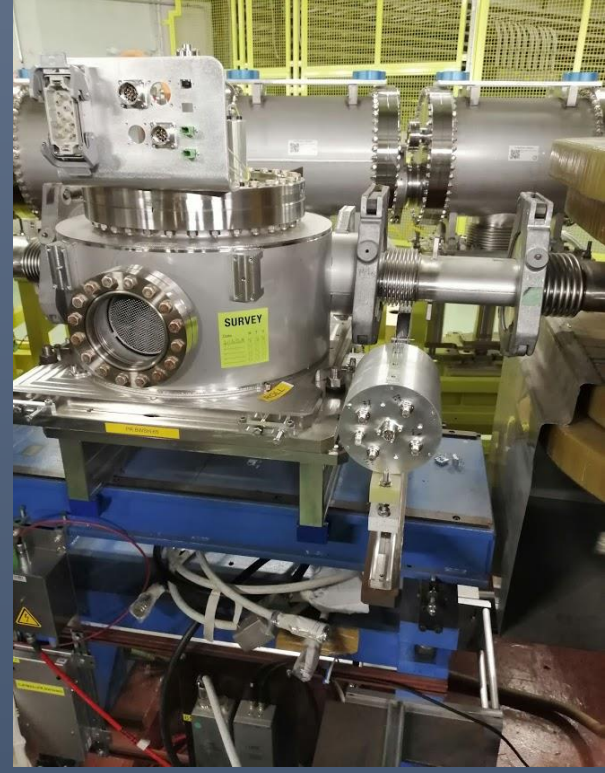
here amorphous Carbon coating





Observation of circulating beam,

here beam on target, BTV instrument, ~200 at CERN



Beam Wire Scanner,

Window flanges for visual inspection and position encoding

Other beam instruments with optics installed in CERN accelerator complex:

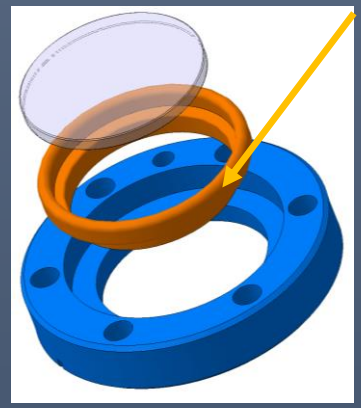
- Observation of mirrored synchrotron light (BSRT)
- Indirect beam-size related observation of electrons that hit a fluorescence target (BGI)
- Observation of fluorescence of circulating LHC beam using gas (BGC)
- … and many others

→ Total about 250 window flanges installed in CERN particle accelerators

Window flange parts Cookbook

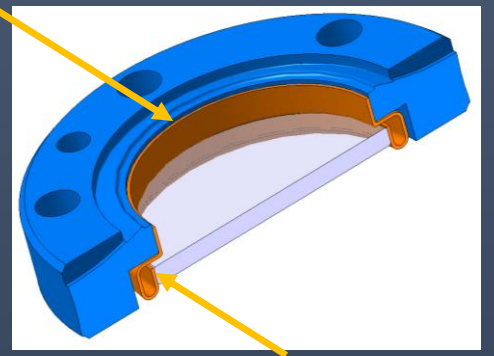
Flange

Weld Ring (Spinning)



Window

Weld flange to weld ring



Braze/Bond glass to weld ring

Connection

Flange material types

- Stainless steel types
  304L, 316L, 316LN,…
- Titanium
- Aluminium….

Flange design types

- Conflat
- KF
- ISO….

Window material choice

- Optical requirements
  - Wavelength (IR, visual light, UV)
  - Transmission
  - Laser Damage Threshold
- Bakeout temperature
- Dimensions
- Radiation Resistance

Window material types

- Borosilicate glass (Kodial)
- Fused silica (Quartz glass)
- Sapphire
- Many others:
  - MgF2, BaF2, CaF2, ZnSe, CVD diamond, Lead Glass…

Typical bakeout temperatures of window flanges

- Borosilicat (Kodial) glass 350 °C
- Fused Silica 200 °C
- Sapphire 200 °C, special constructions allow to 450 °C
- Lead glass 350 °C
- CVD Diamond 450 °C

Coatings

Wide spectrum of what is the purpose of the coating:

- non-reflective

- Passage of only a given wavelength

- Blockage of a given wavelength

Consider if Halogens are acceptable (Damage with radiation, Synchroton light?)

Bonded versus brazed

- When is brazing used and when is bonding used?

- Bonded
  - «polymer vacuum compatible adhesive» → limited to about 120°C
  - No stress on window due to the assembly process

- Brazing
  - More flexible in temperature
  - Radiation environment
  - Potential stress due to the assembly process

Weld ring material types

- Kovar

  Kovar (trademark of CRS Holdings, inc., Delaware) is a nickel-cobalt ferrous alloy , designed to have substantially the same thermal expansion characteristics as borosilicate glass (~5 × 10^{-6} /K between 30 and 200 °C) to allow a tight mechanical joint between the two materials over a range of temperatures. It finds application in glass-to-metal seals in scientific apparatus…. (From Wikipedia)

  Given in percentages of weight.

Fe	Ni	Co	C	Si	Mn
balance	29%	17%	< 0.01%	0.2%	0.3%

  Issues: Ferro-magnetic and high cobalt content for applications magnetic fields and radioactive environments

- Magnetic field:

  tantalum, titanium, non-magnetic steel, many options if below 120°C depending on the application

Physical properties, selection

Material	Youngs Modulus (GPa)	Ultimate Tensile (Yield) Strength (MPa)	Thermal Expansion (10^{-6} K^{-1})
Borosilicat Glass*	67 to 80	280* (some other references lower, big spread)	3.3 to 5.1
Fused Silica*	~73	~50	0.5
Synthetic Sapphire*	~450	~2470	5.3
CDV Diamond*	~1050	~750	1.0
Kovar	138	(~300)	5.5
Stainless Steel (316L)	200	(~210)	16

Reference:
*https://www.makeitfrom.com
Further reading: https://highlyeducatedti.com/blogs/information/thermal-shock-vs-tensile-strength

CERN Experience (1)

- Basically no problems with borosilicate (Kodial) glass

- For fused silica: Many window breaks or leaks after mounting or bakeout of new supplied window flanges with leak tightness certificates from various suppliers

Why?

→ Window flanges are usually tested at room temperature with an elastomerseal

→ CERN uses “standard” non-annealed copper gaskets in order to minimise logistic problems (change in hardness higher risk of leaks in the long term?)

CERN Experience (2)

- All window flange suppliers propose/insist to use annealed copper gaskets and propose to supply them with the window flange delivery

- Should we change our seal specification or insist on it?

CERN PS 1959

CERN PS during technical stop 2019

CERN Window Flange Technical Specification

Philosophy: Use the seals and bakeout condition as used in the machines at the window flange manufacturer site

→ CERN supplied copper gaskets

→ Bakeout followed by leak test at the manufacturers premisis

→ Witness mount and bakeout

→ Cross check tests at CERN

Result from “harsh” technical specification

- Initial price higher
- Less tests at CERN → lower cost
- Easier stock management
- Low brakeage rate at CERN
- Works when needed
- Global financial and logistics gain

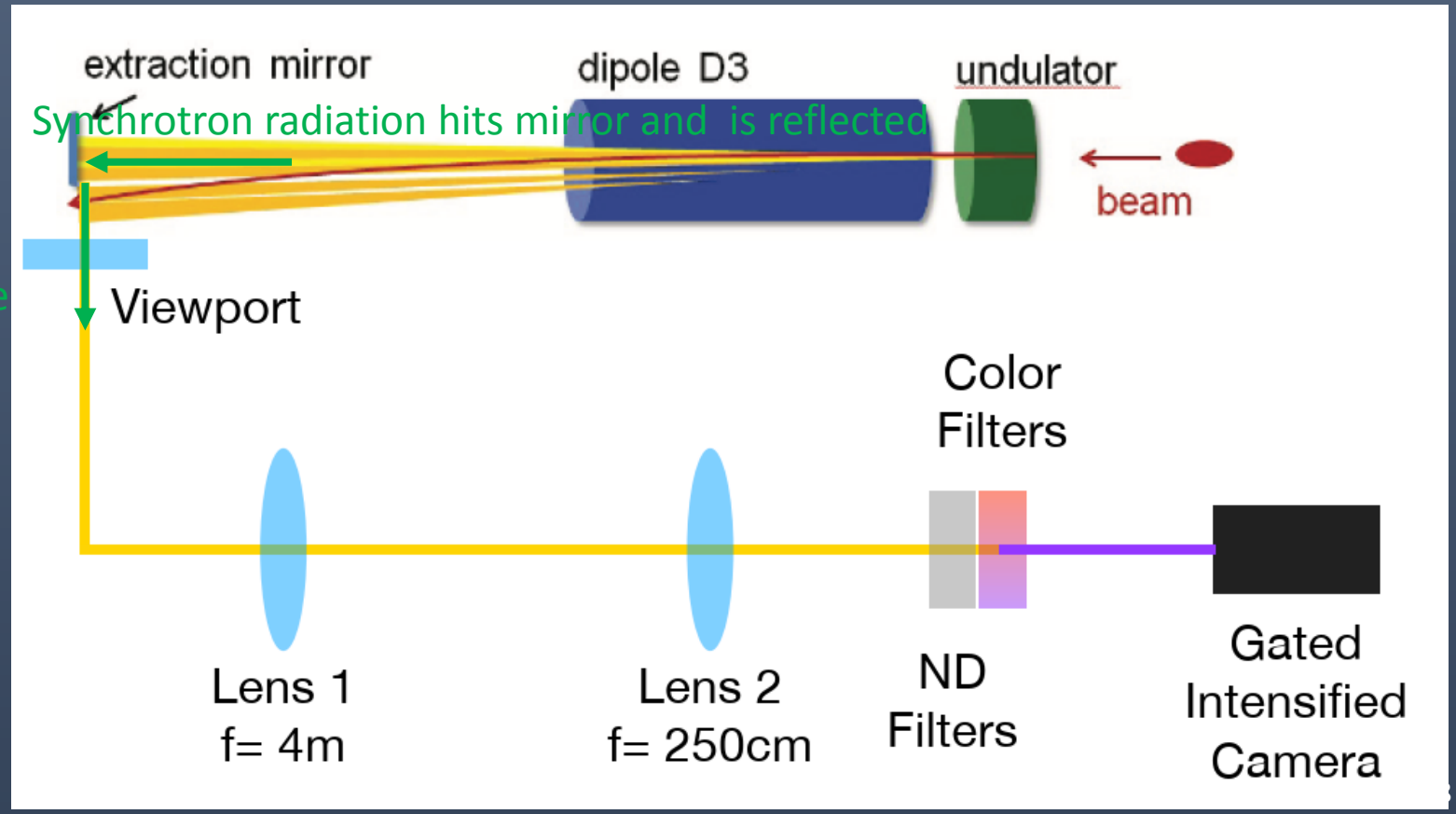
….but not still no guarantee for full success

Failure here:

- Fused Silica glass «popped out» while tightening the bolts
- Experienced mechanic
- Incident after re-installation → previously fully leak tight

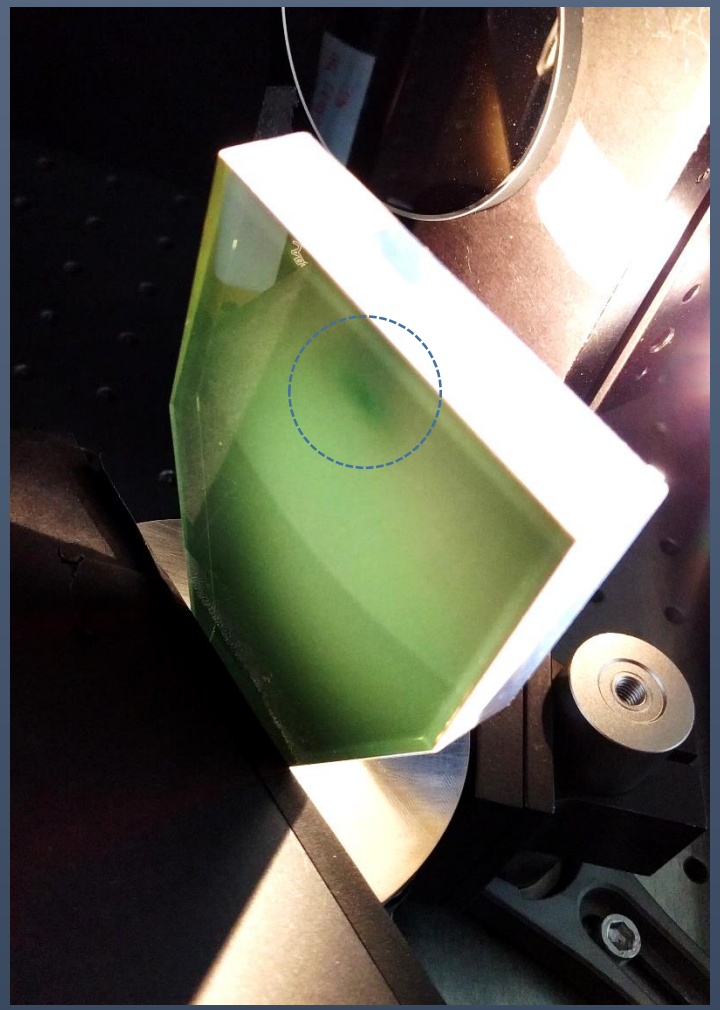
BSRT Mirror and Flange damage

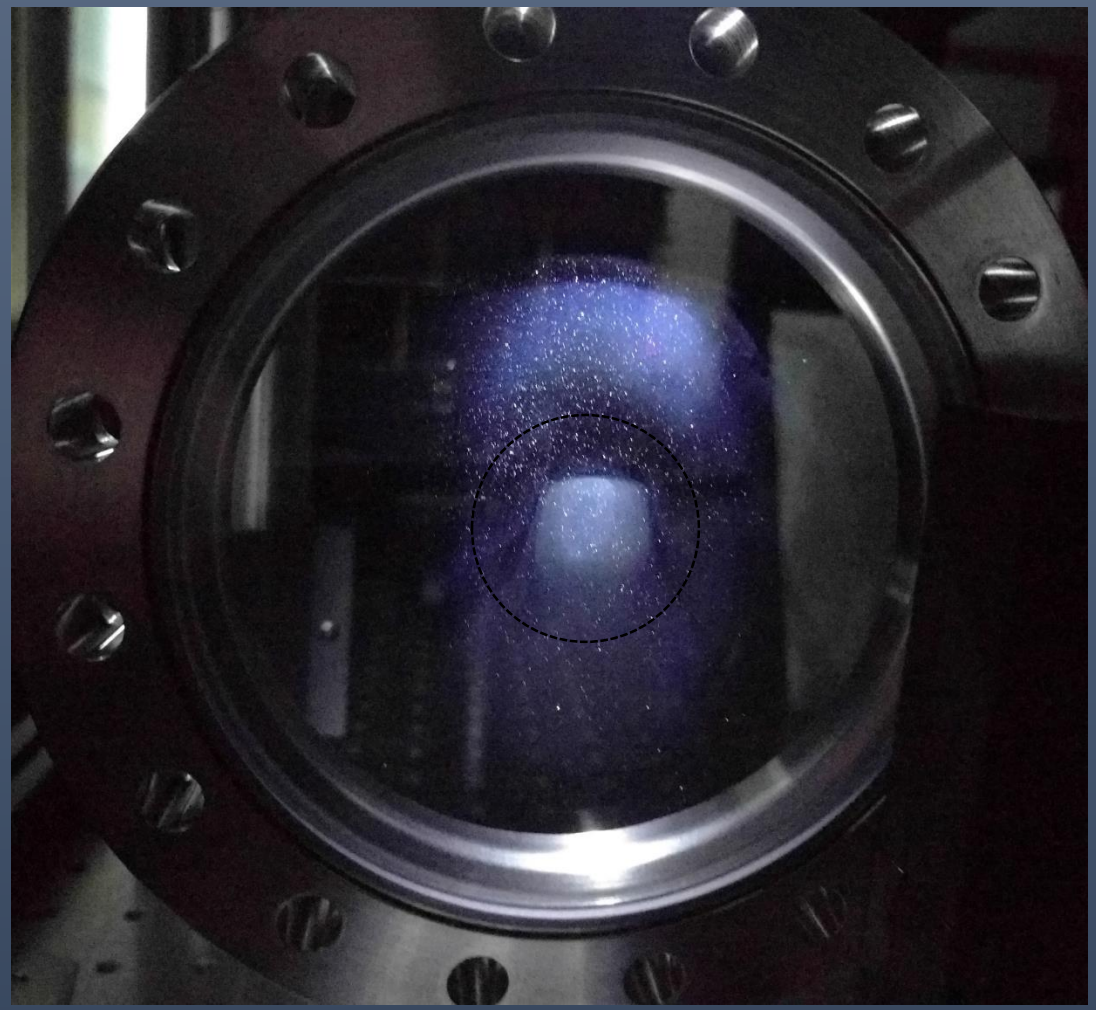
- Beam Synchrotron Radiation Telescope (BSRT)



Courtesy: E. Bravin

SR Damage on Mirror and on window flange





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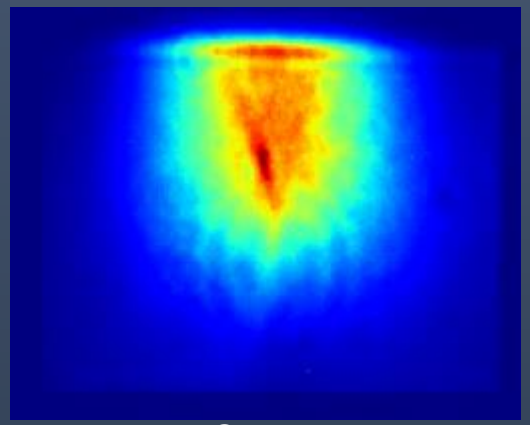

SR footprint on VP

Courtesy: E. Bravin

Result of investigation:

- **Damage is caused by etching**
- **Cause of the etching not identified, maybe halogens from optical coatings near-by**
- **No «external» elements found on damaged surface**

Summary

- CERN uses mostly window flanges in accelerator environment → Costly exchange
- Window flange breakages with fused silica windows leading to “test-as-used” technical specification
- CERN witnesses test from CERN member state manufacturers on-site
- Window flange manufacturer mechanical expertise is the Weld Ring design including brazing (or bonding) to the window and welding to the flange
- Please feel free to share your experience

Thank you!

Questions and what is your experience?