Boron Ion Beam Production for the Future CERN BIO-LEIR Facility

Joshua Stafford-Haworth
jstaffor@cern.ch

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HZB Helmholtz Zentrum Berlin
JAI John Adams Institute for Accelerator Science
ROYAL HOLLOWAY UNIVERSITY OF LONDON

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Hadron Therapy Research

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Hadron Therapy Research

- Hadron therapy mostly conducted with protons
- Ions offer different radiobiological properties
- Comprehensive study needed to evaluate different species
- Protons -> Neon
- Re-use LEIR synchrotron at CERN for light ion medical research facility.

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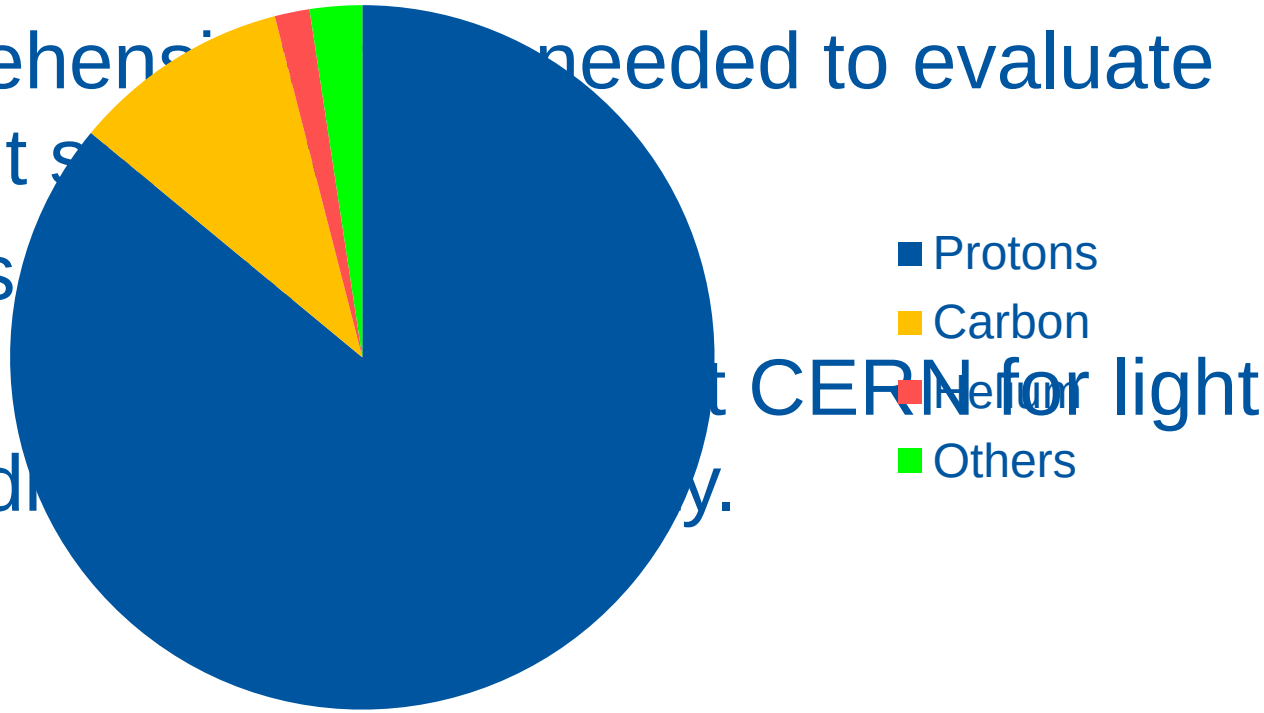

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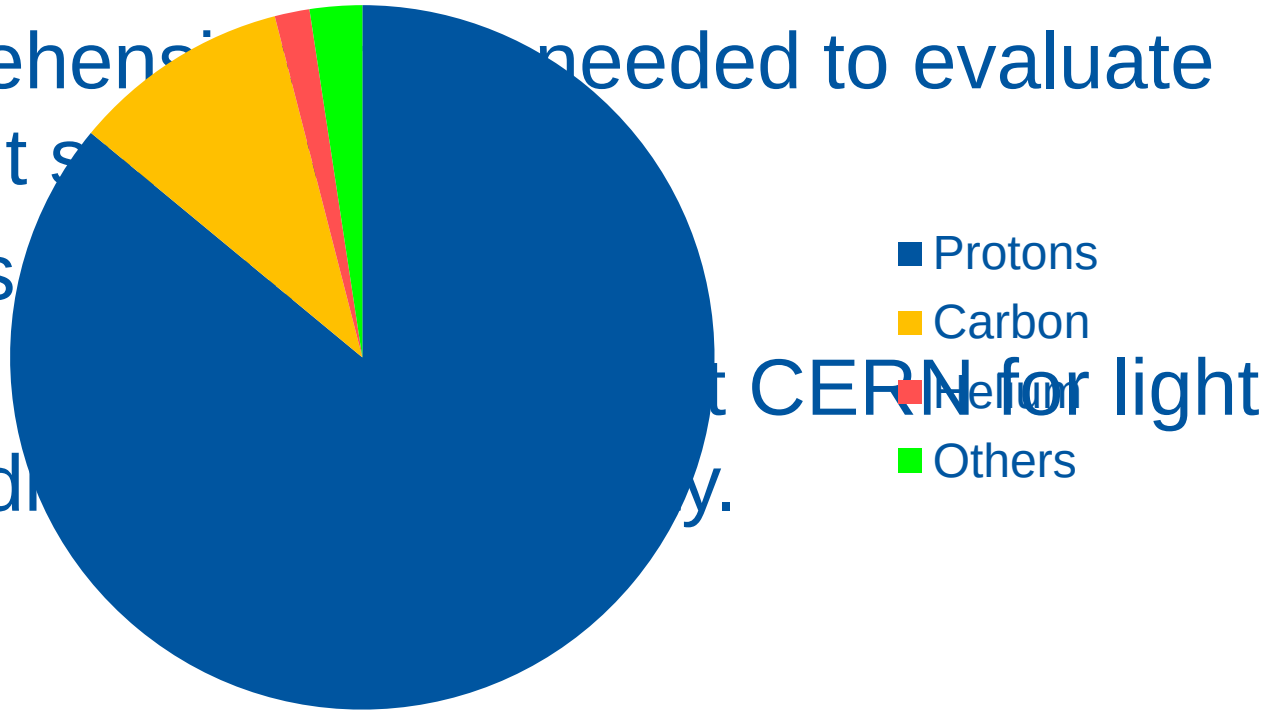

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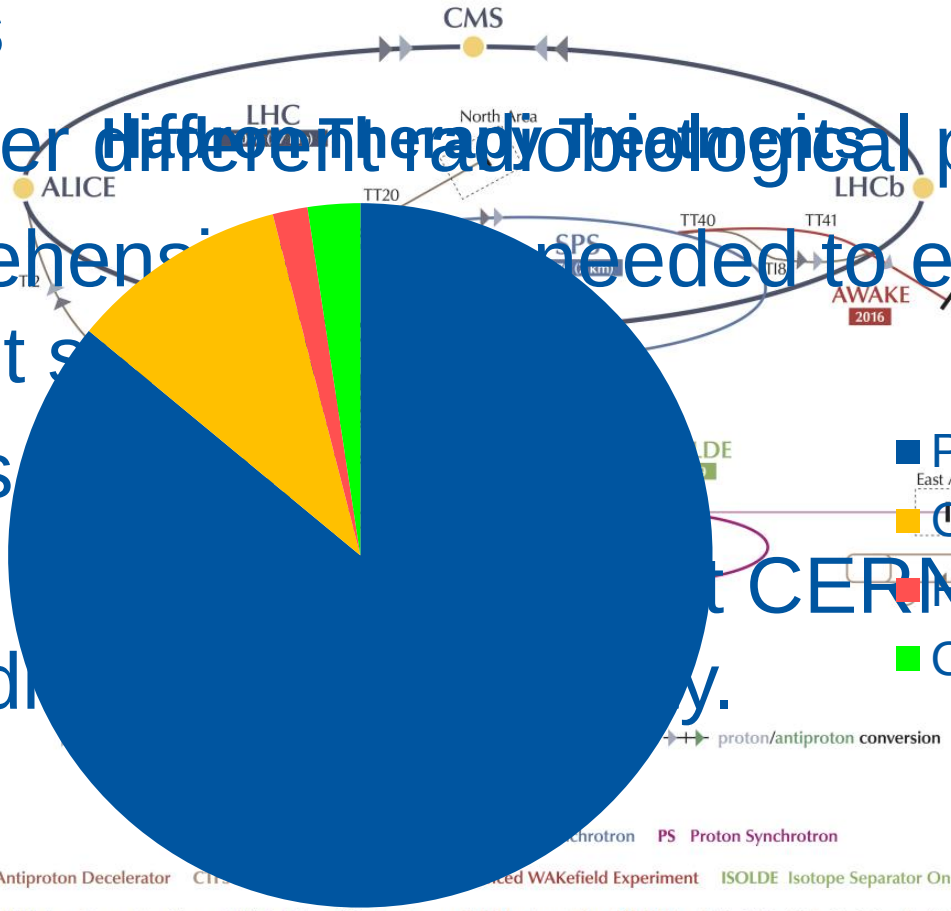

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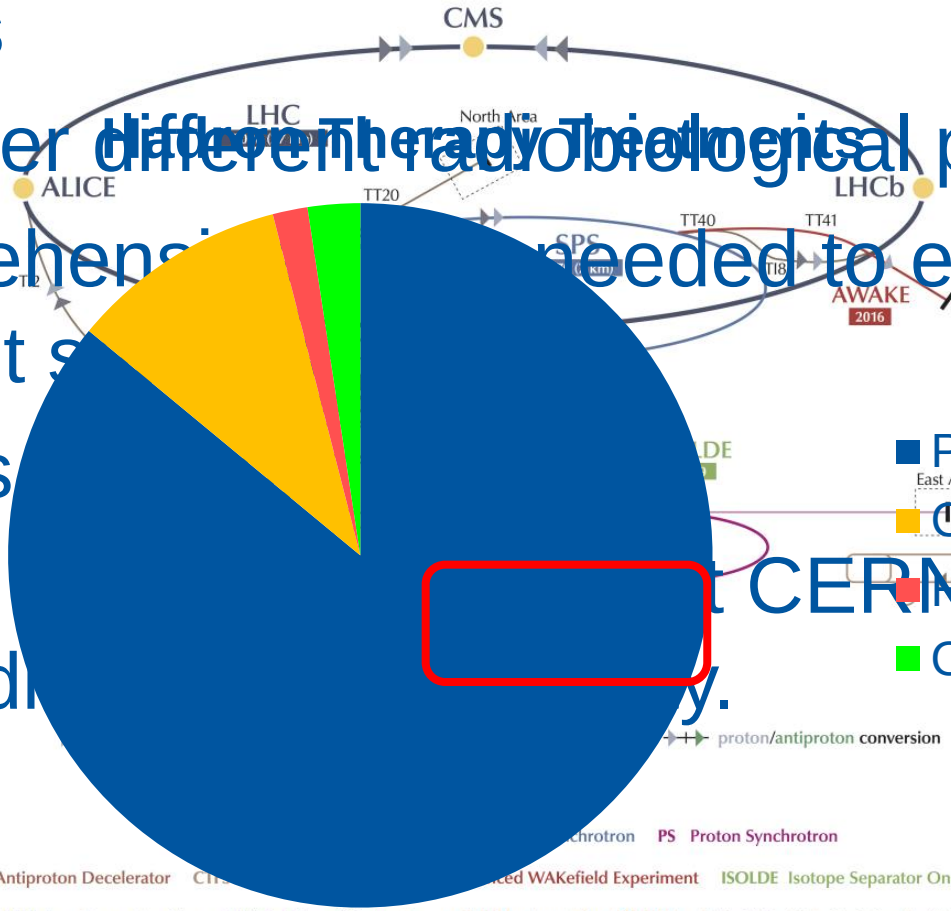

Hadron Therapy Research at LEIR

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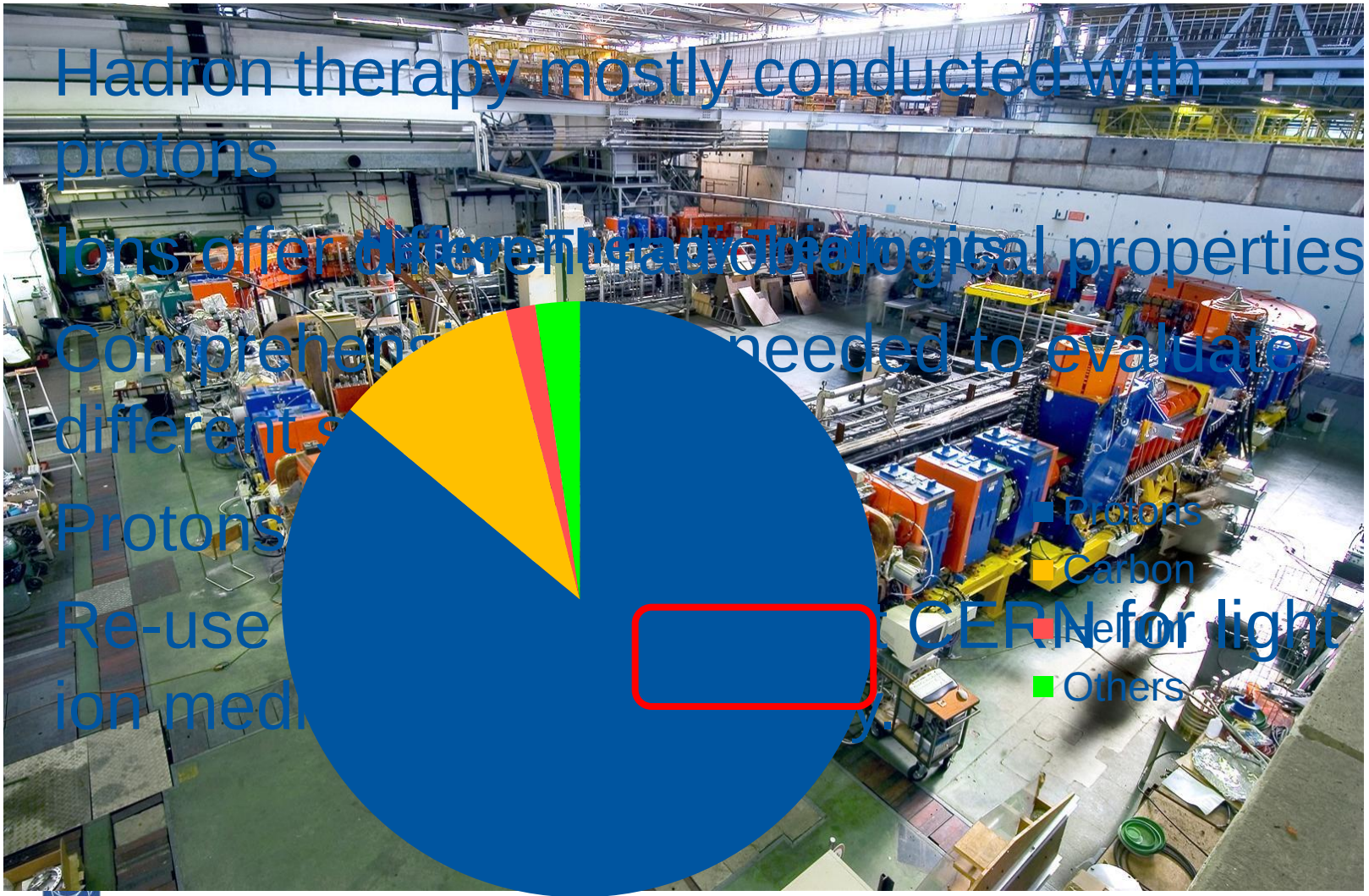

CERN for light

LEIR Low Energy Ion Ring LINAC LINear ACcelerator n-ToF Neutrons Time Of Flight HiRadMat High-Radiation to Materials

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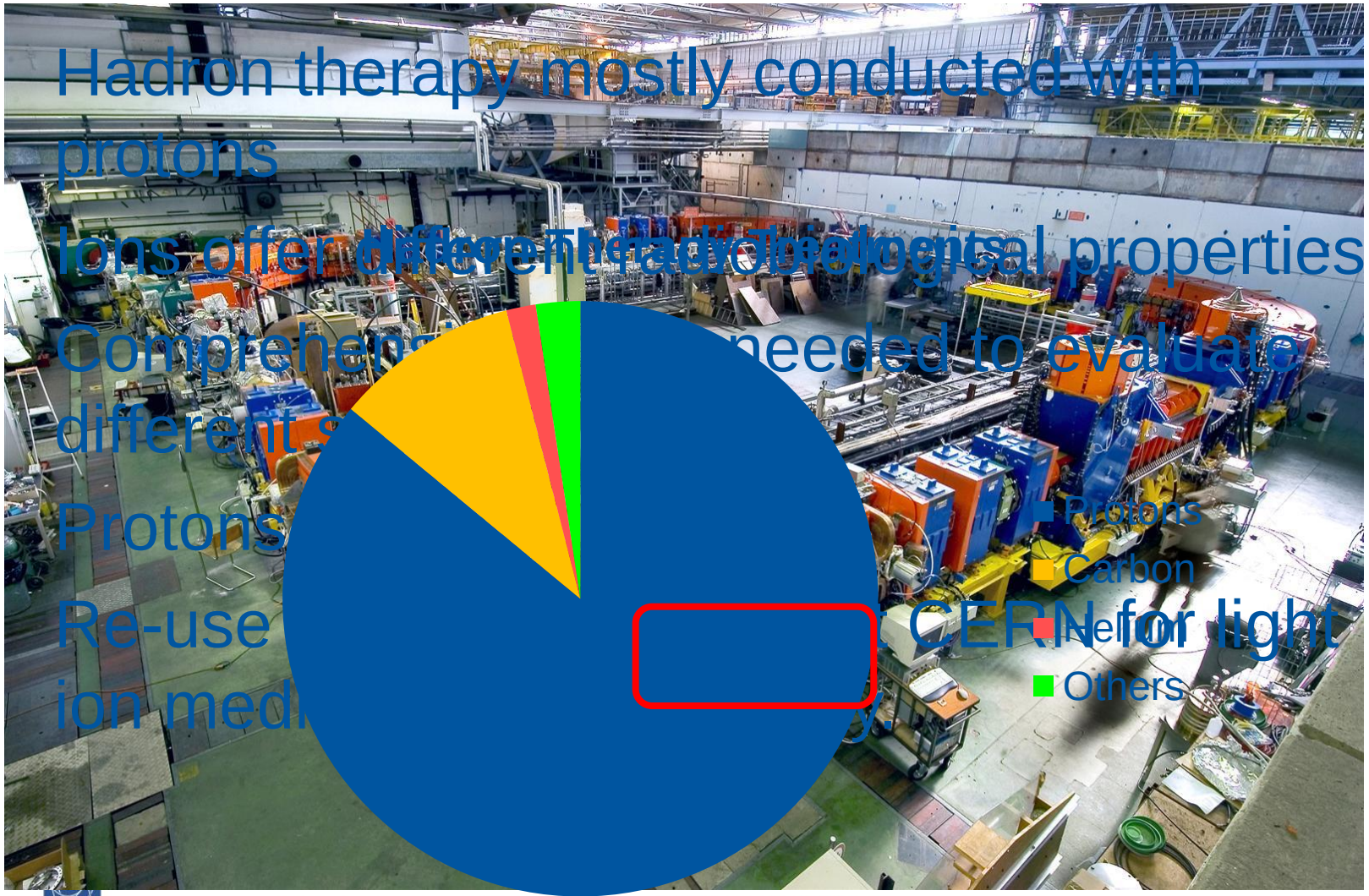

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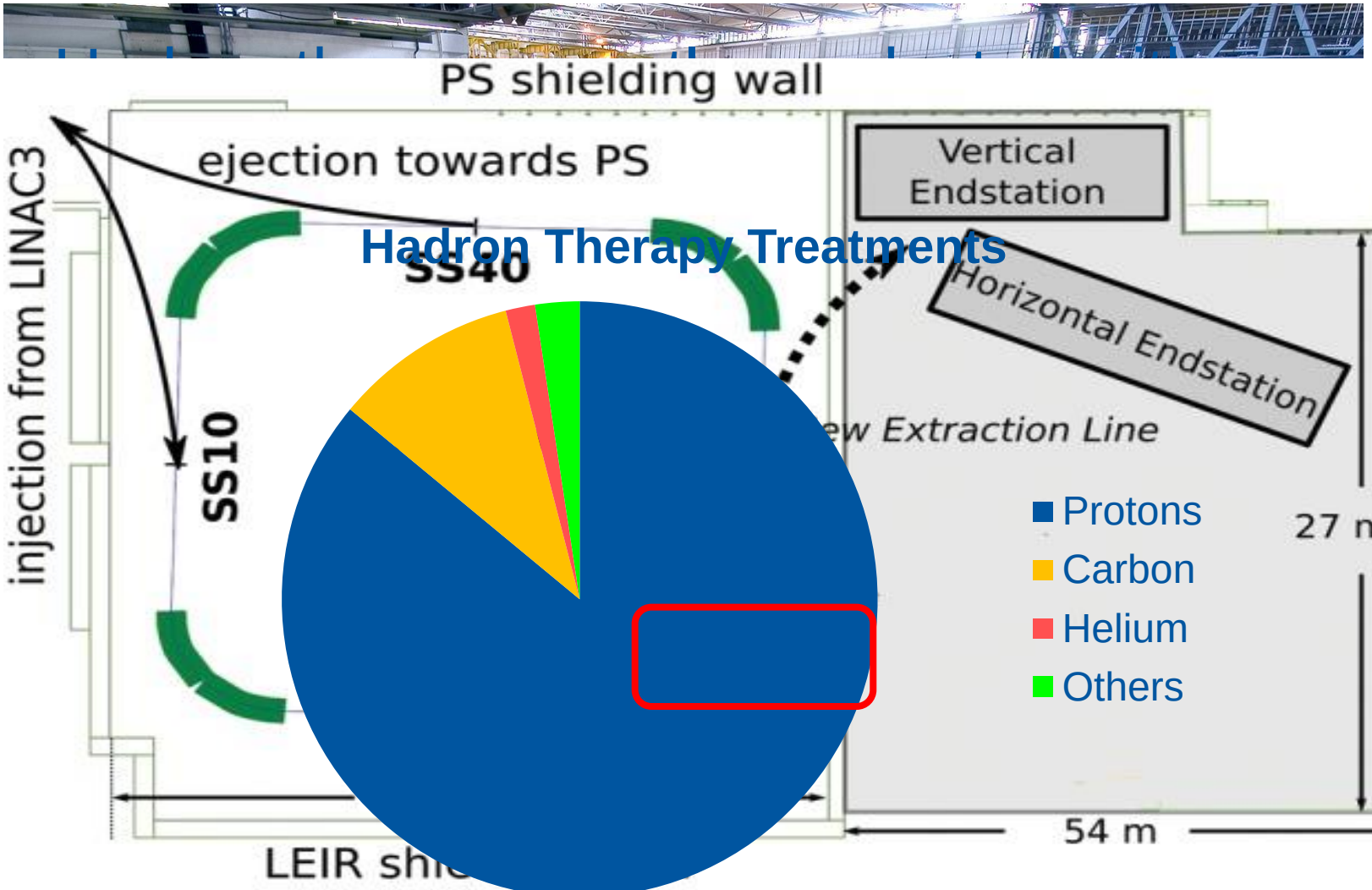
Hadron Therapy Treatments



Light Ion Injectors

Light Ion Injectors

- New Linac?
- Cyclotron?
- Re-use heavy ion injector, Linac 3?
- A new source is needed that can deliver p->Ne
- Pantechnik Supernanogan currently used at CNAO, HIT, MedAustron.
- Permanent Magnet 14.5 GHz ECR capable of oven technique with gas mixing.

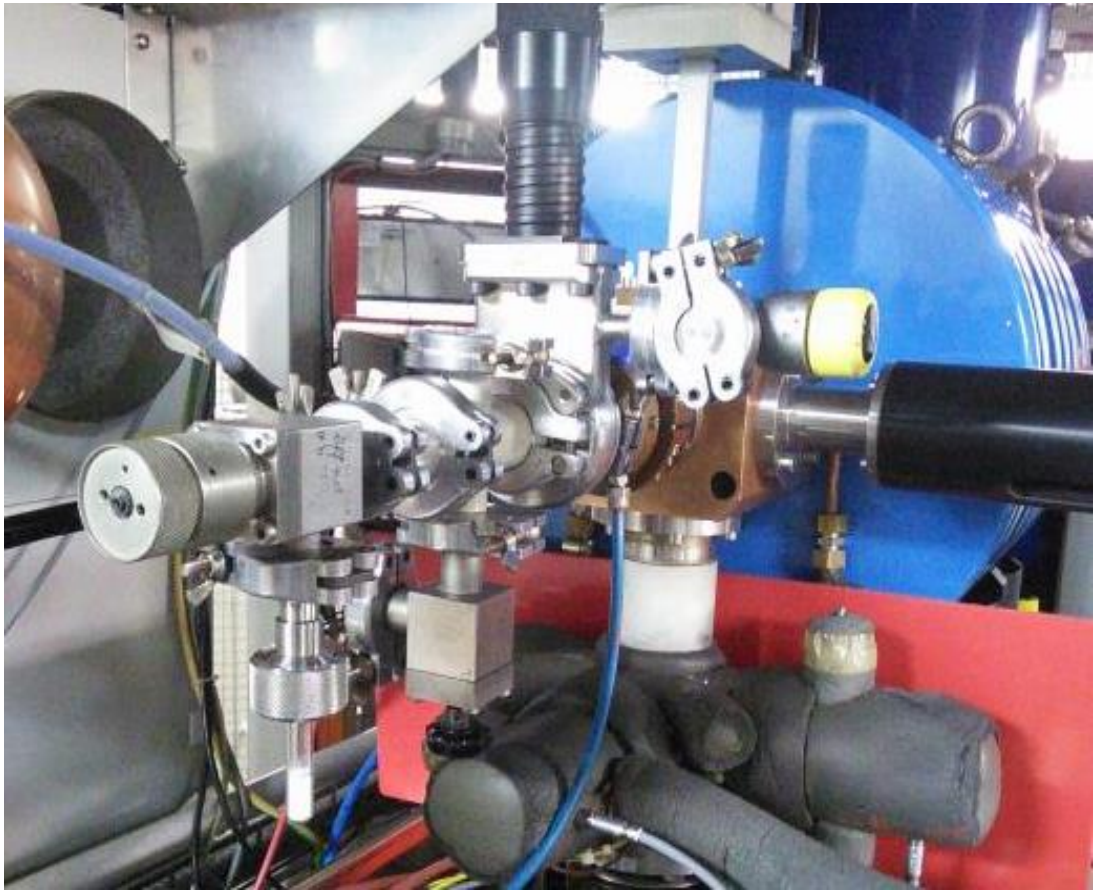
Boron Production

Boron Production

- JYFL (Jyväskylä) and FLNR (Dubna) have previously delivered Boron
- Both ECR sources, both much larger than Supernanogan, and not permanent magnet designs
- Verification required
- MIVOC technique with Supernanogan at Helmholtz-Zentrum, Berlin.

MIVOC Setup

MIVOC Setup



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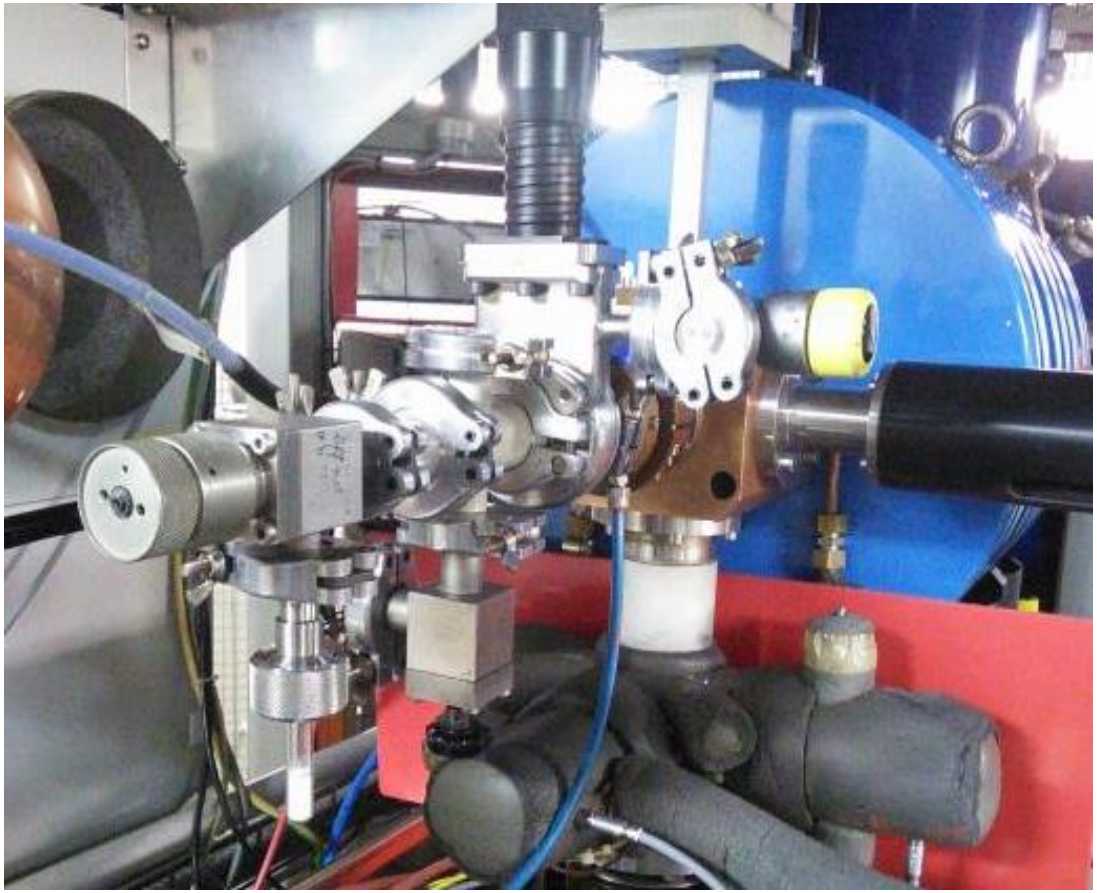

- MIVOC chamber
- Needle Valve
- Standard Valve
- RF waveguide
- Source plasma chamber

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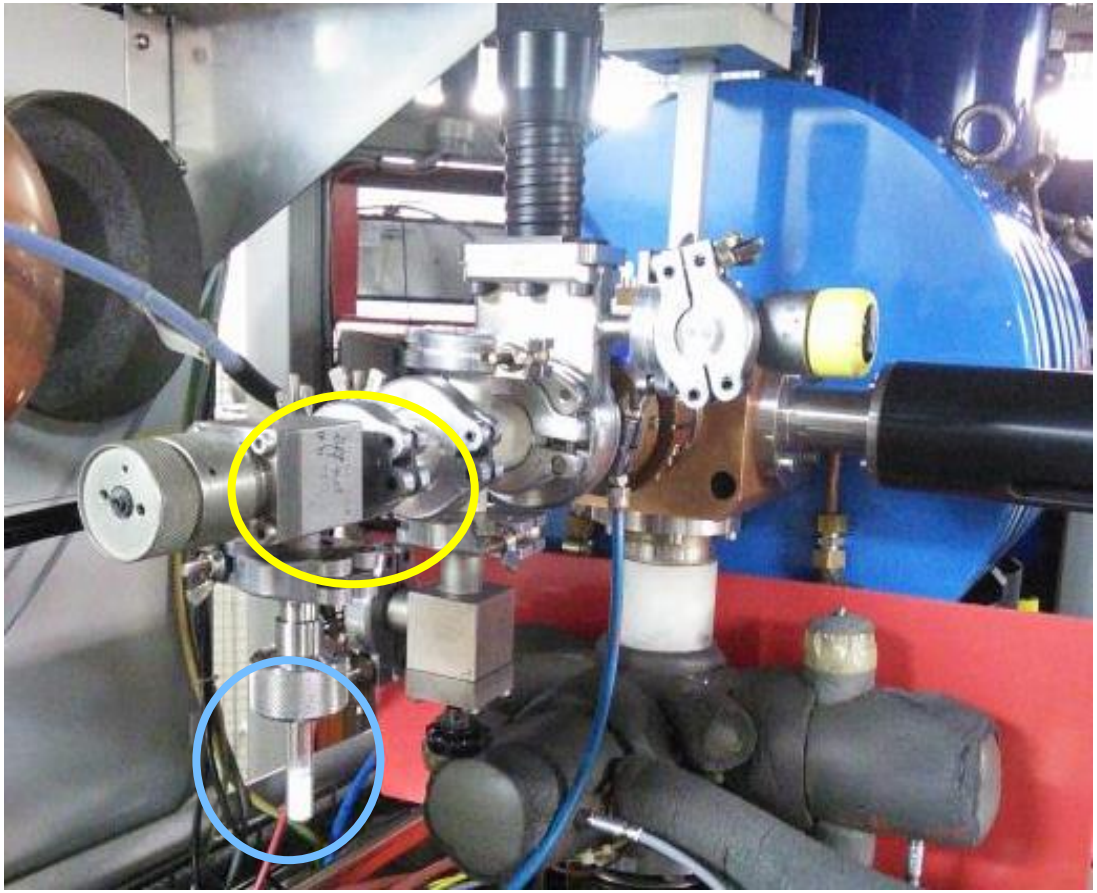

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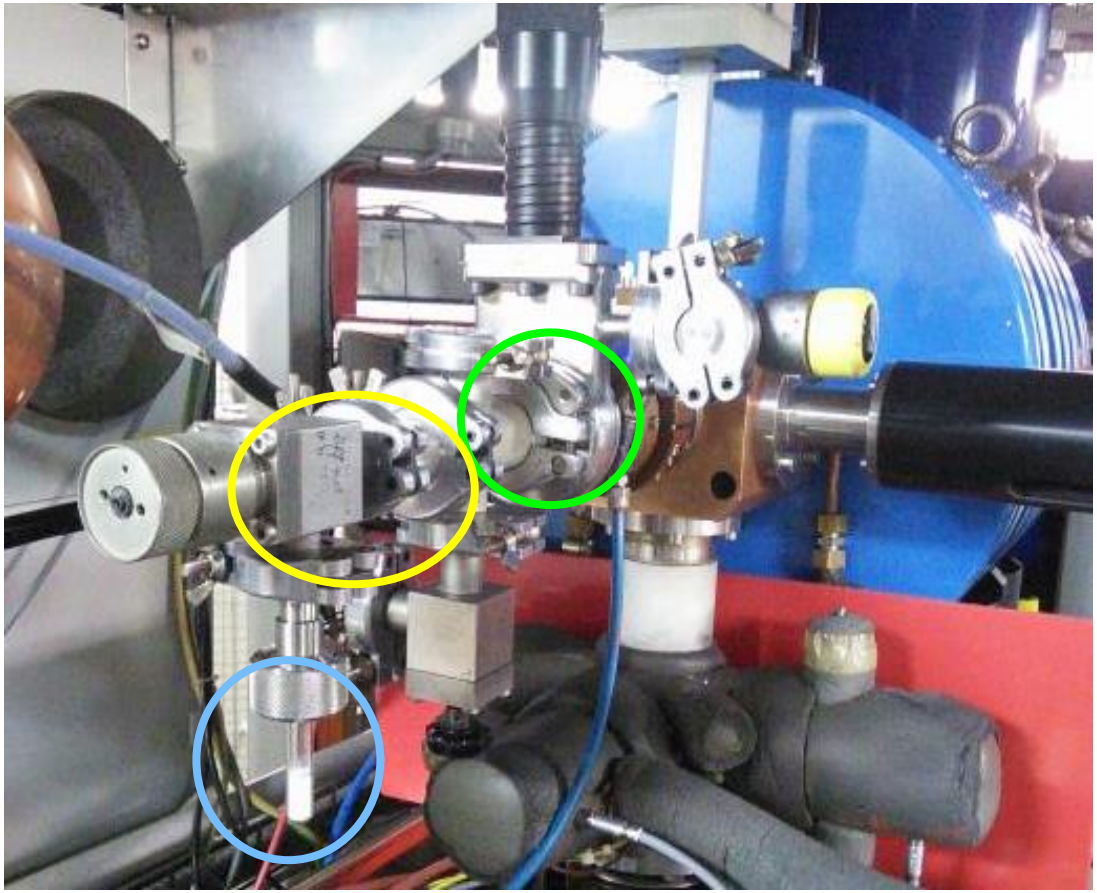

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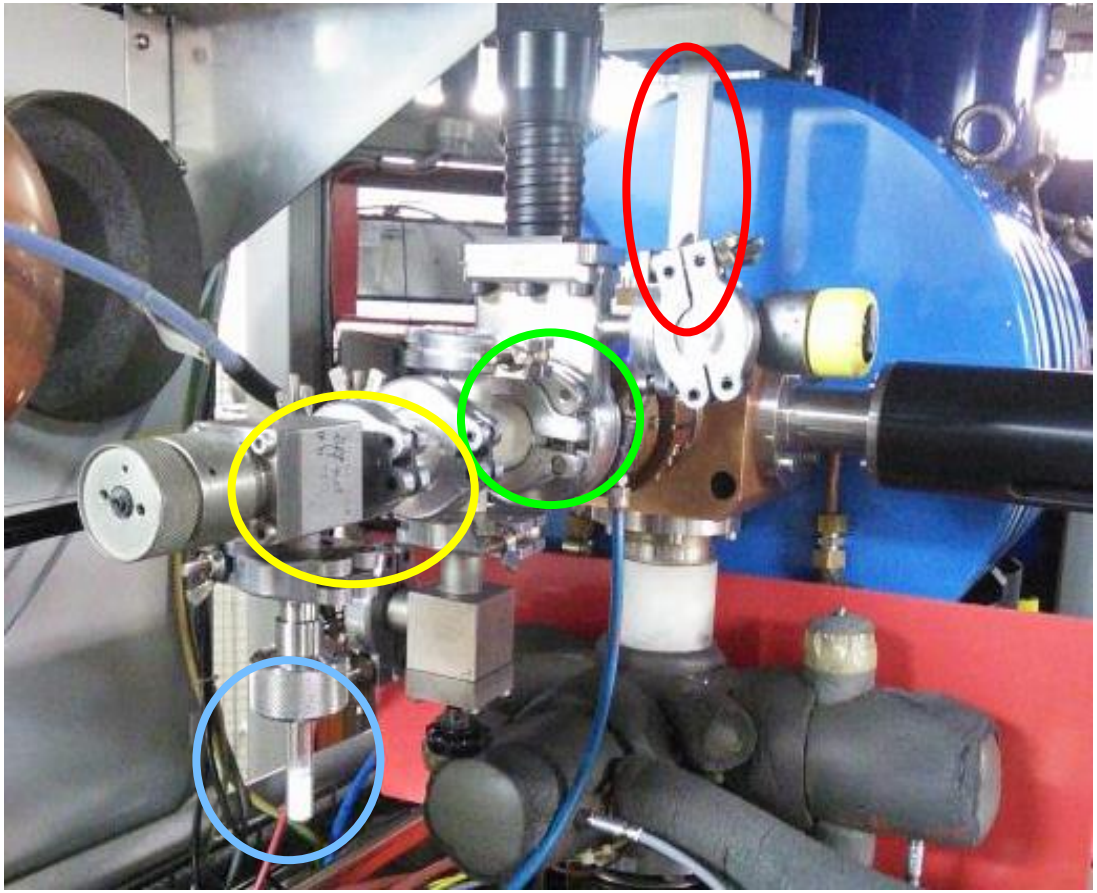

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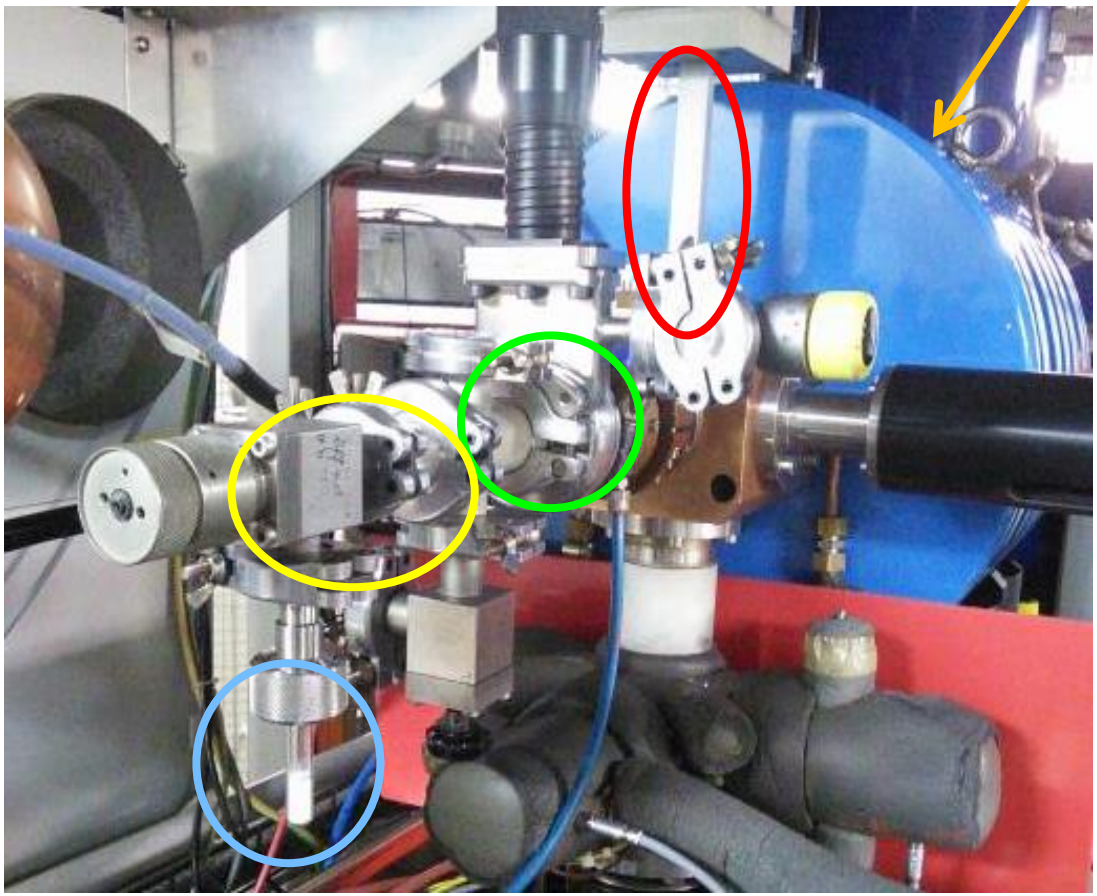

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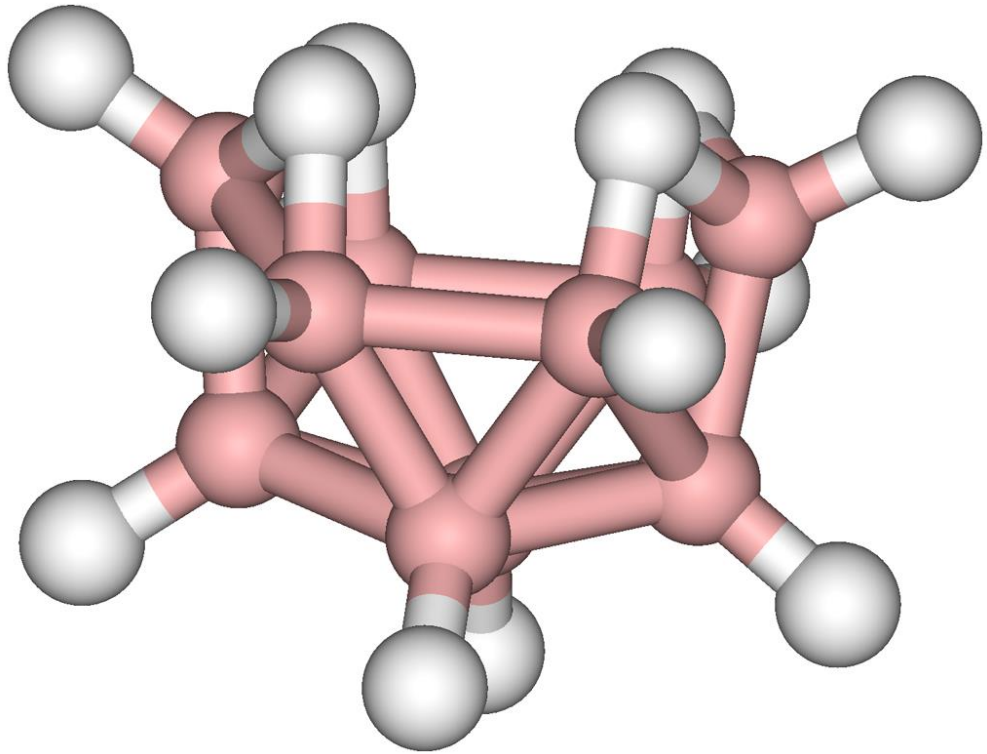

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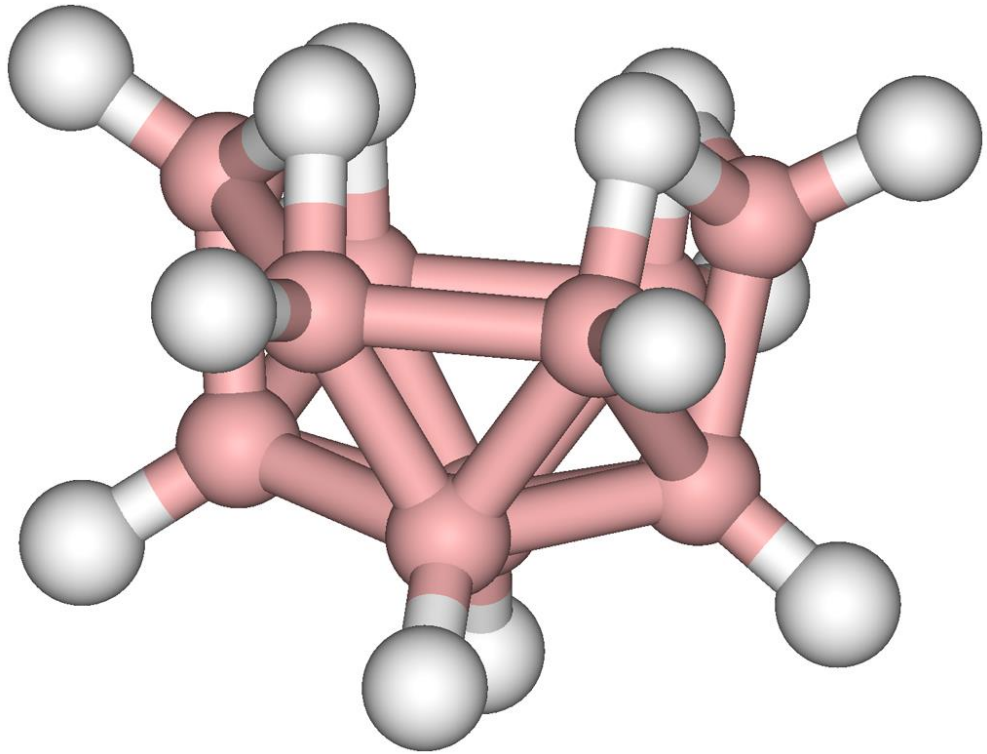

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Phase at 300k	Crystalline

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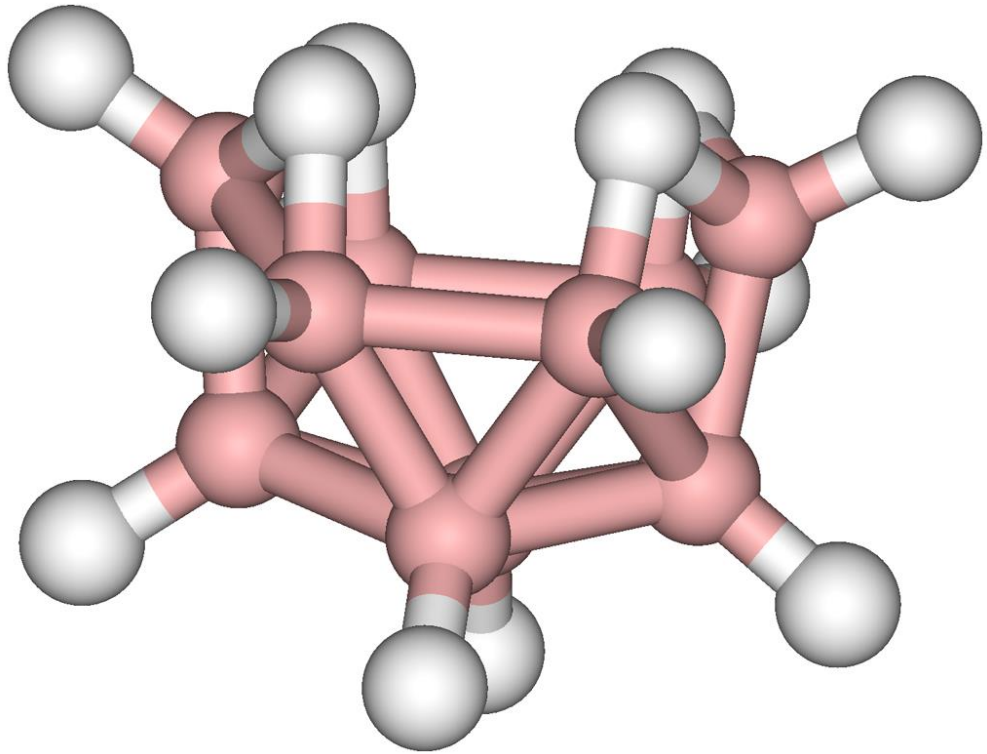

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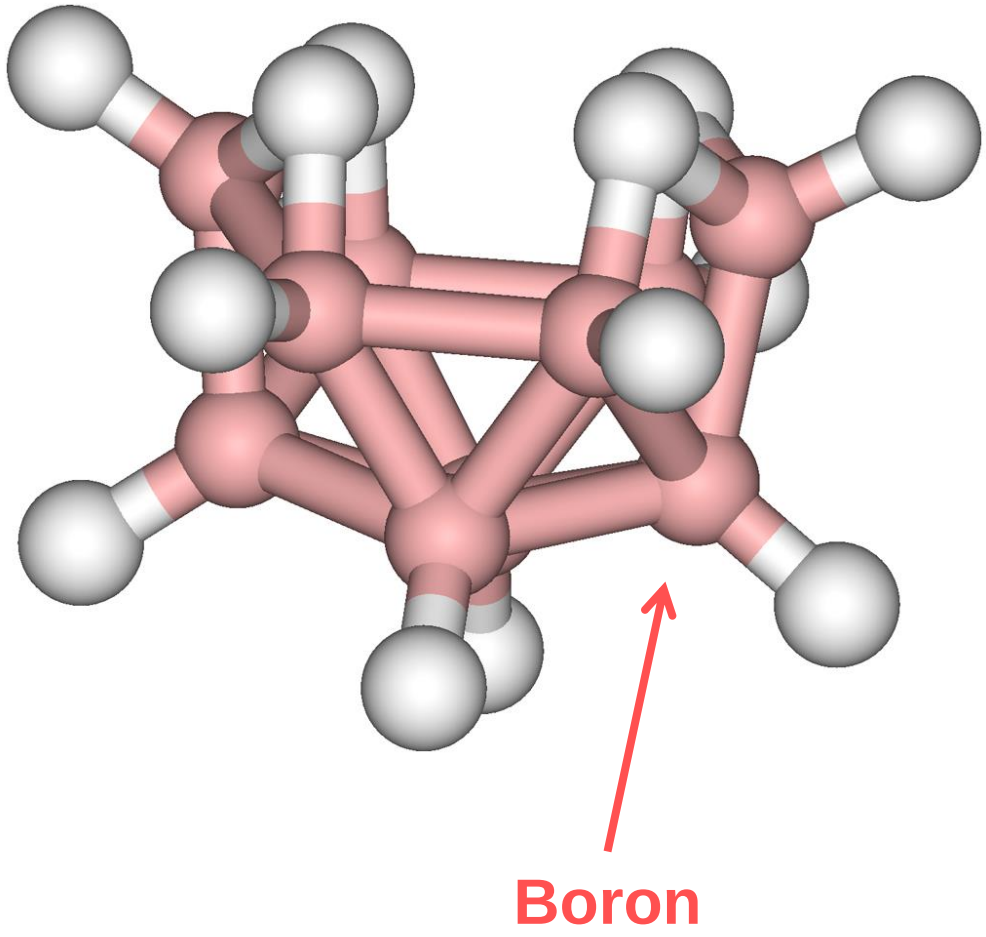

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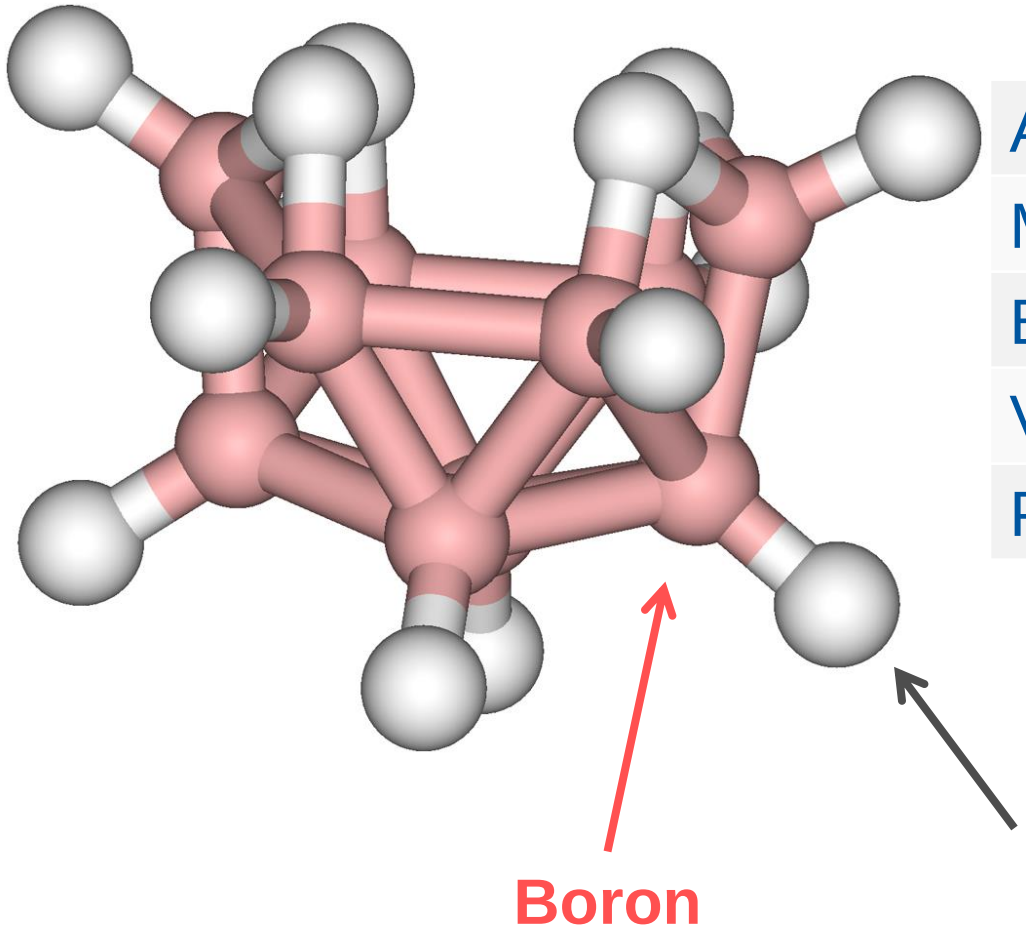

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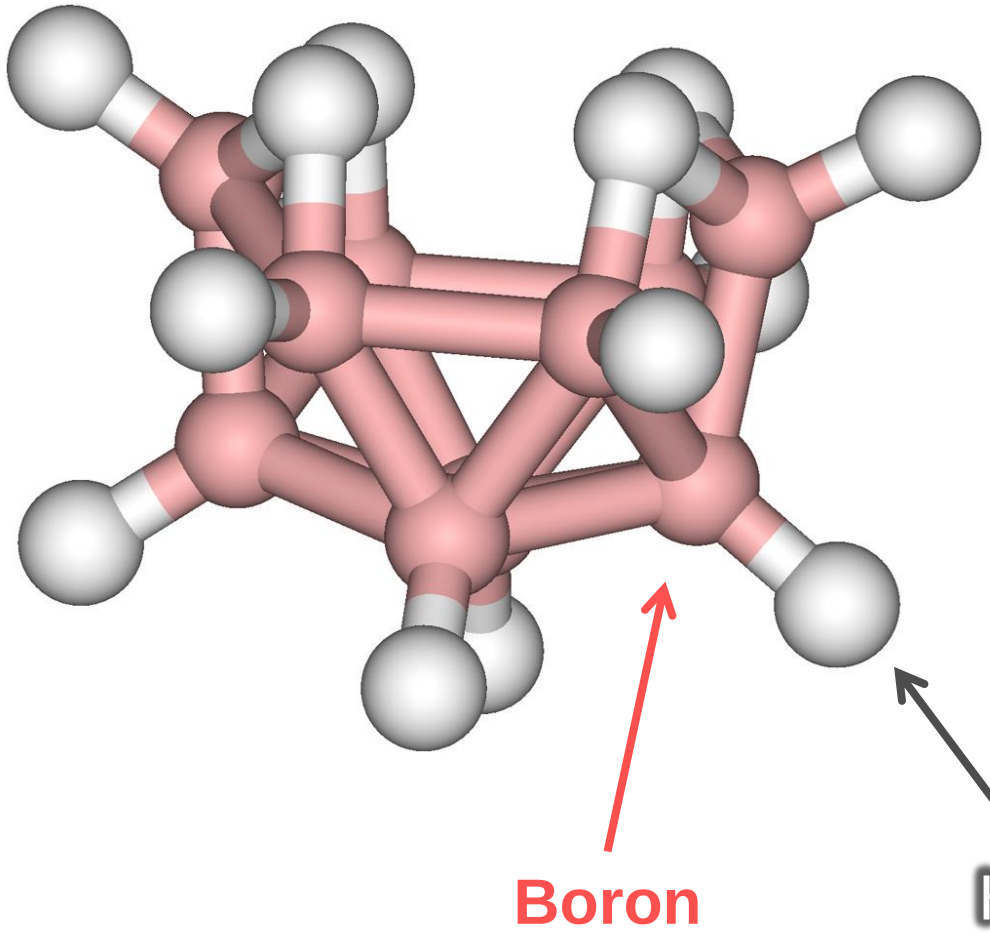

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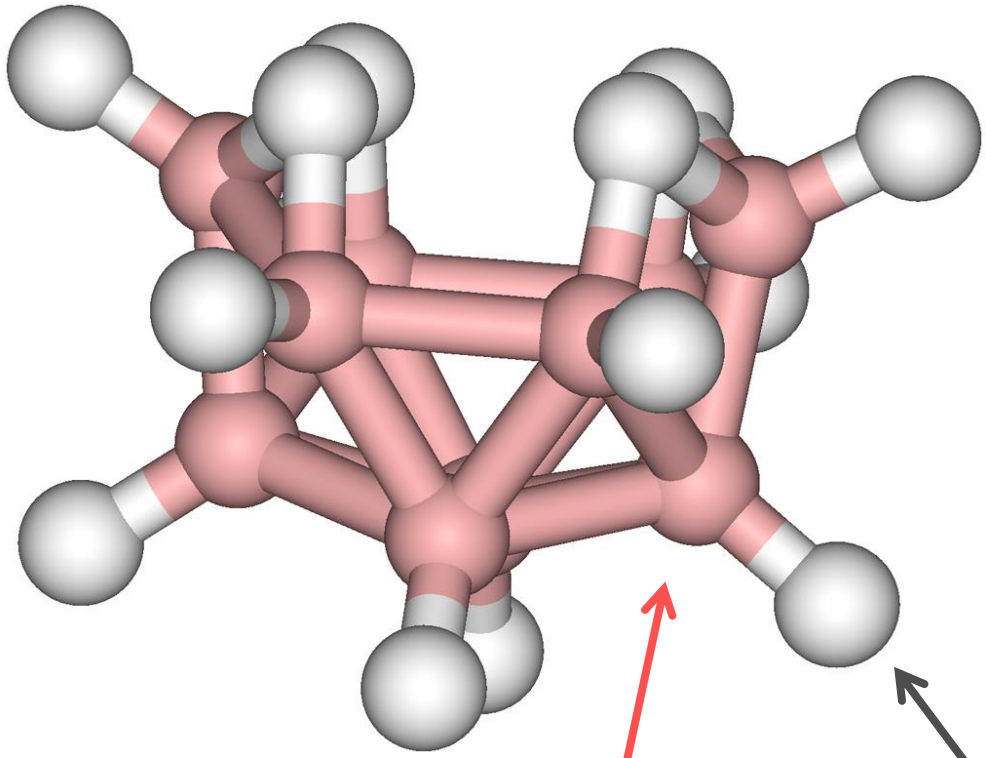

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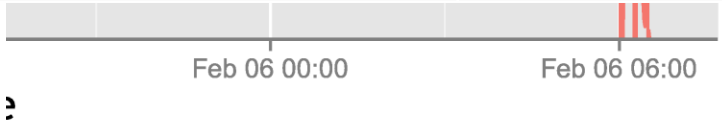

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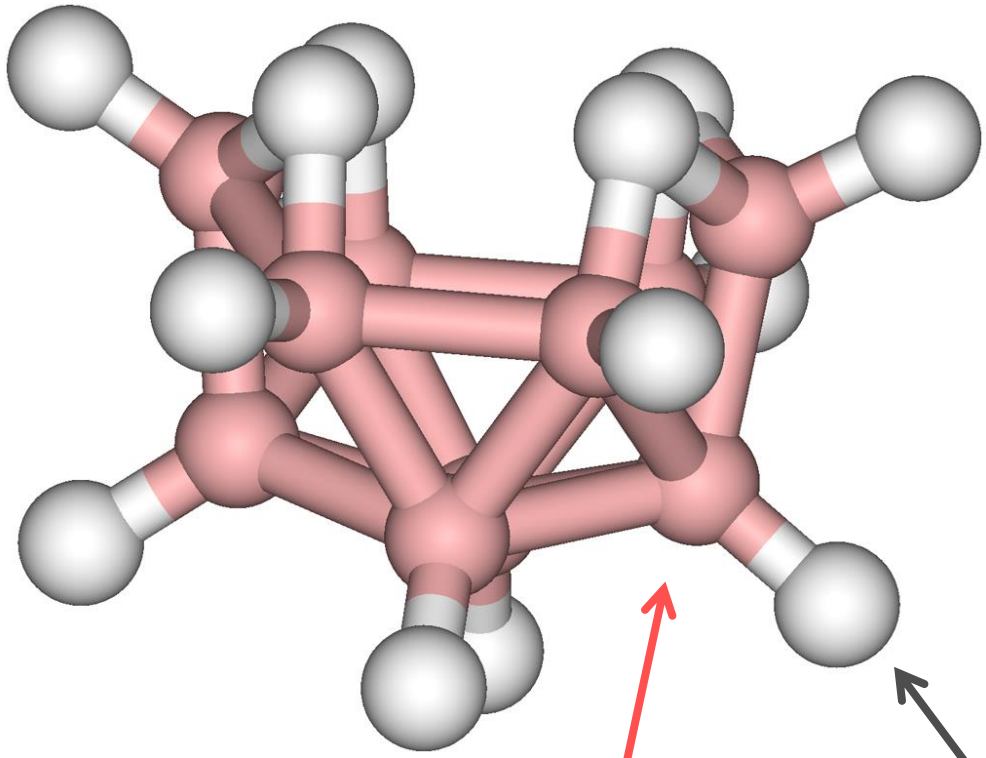

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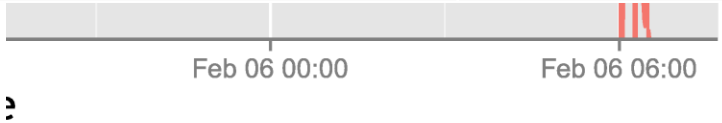

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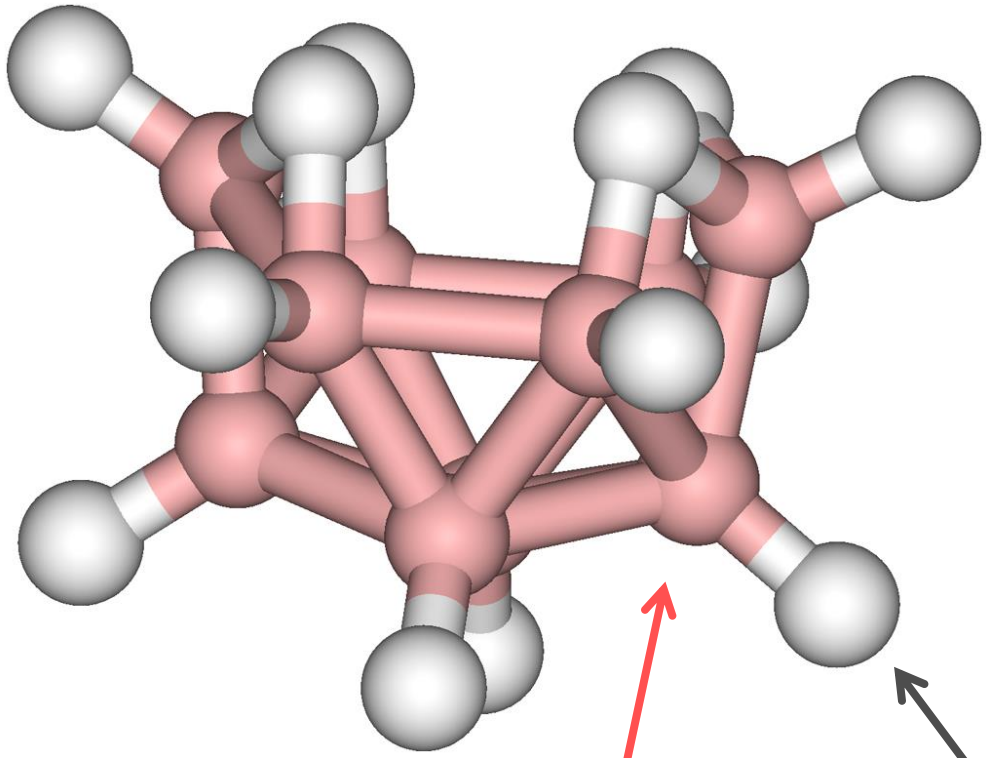

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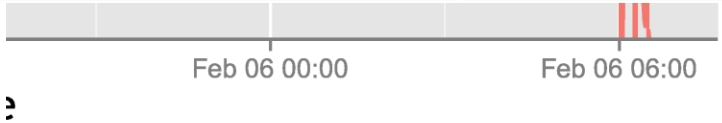

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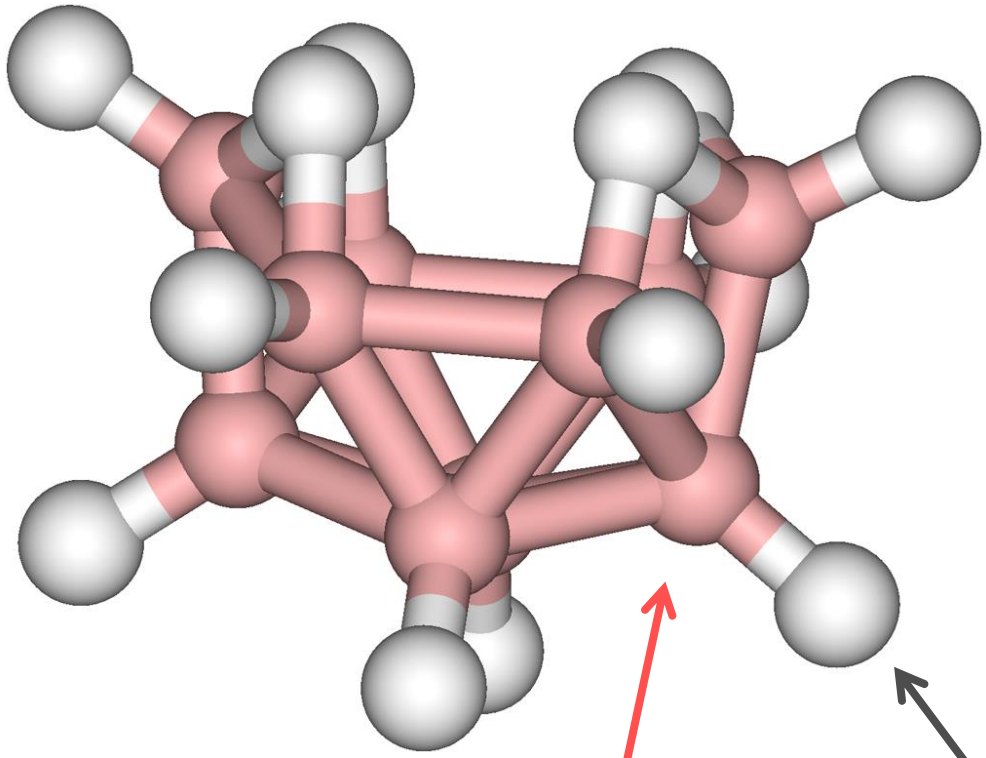

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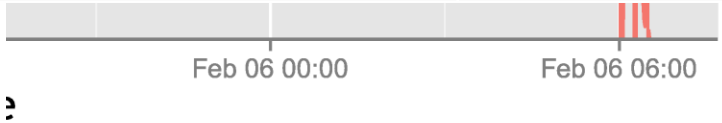

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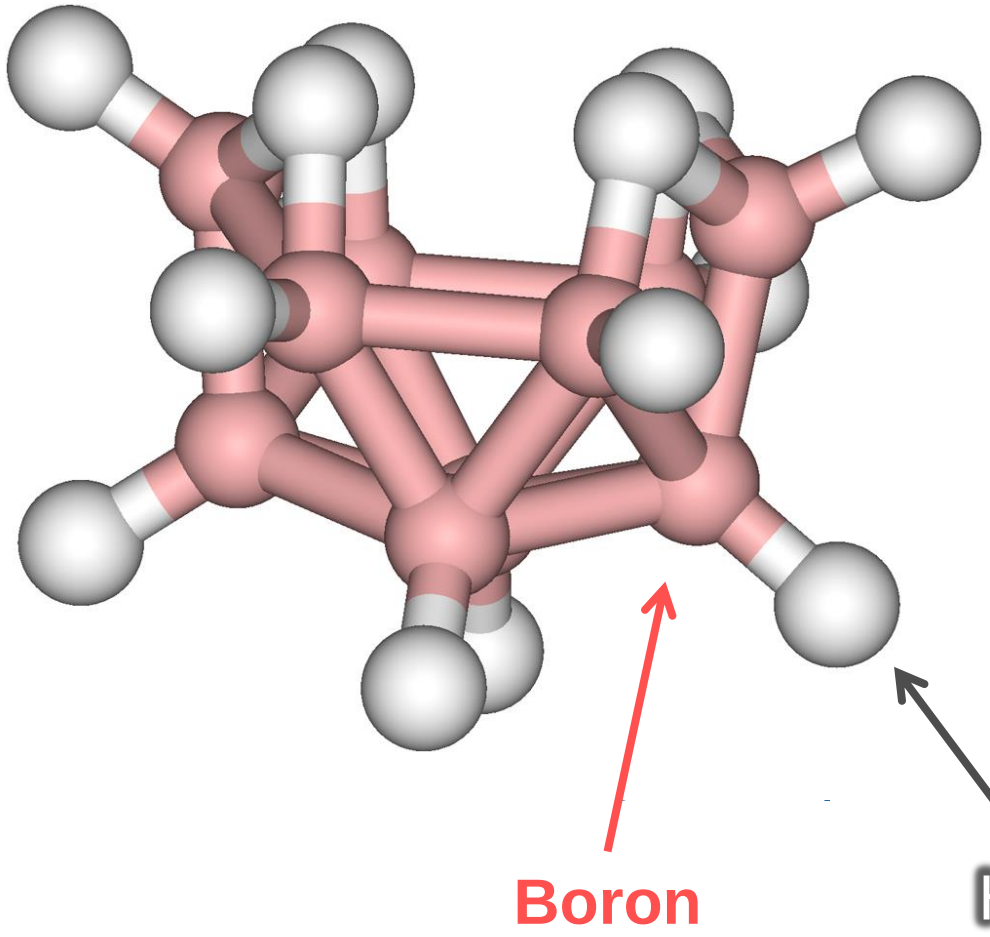

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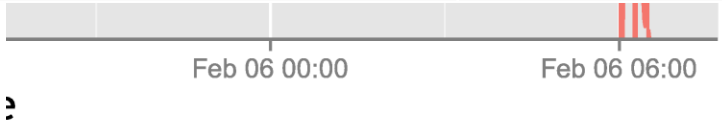

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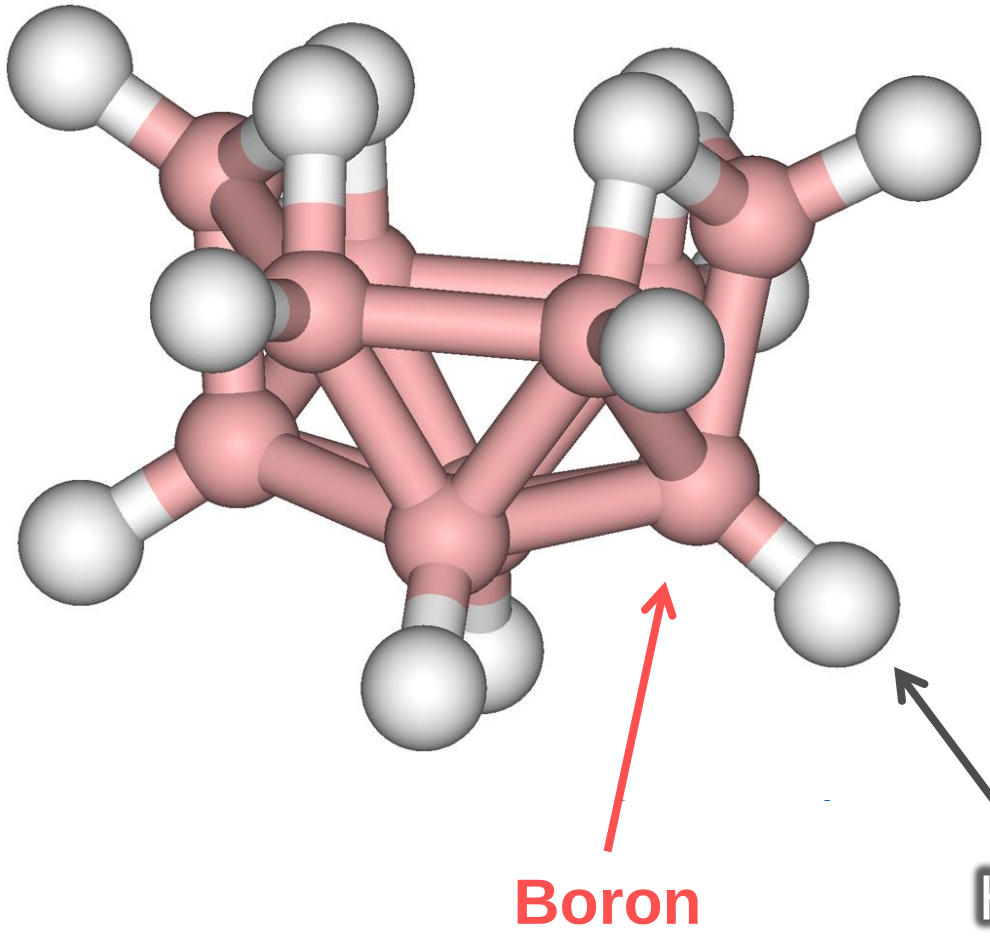

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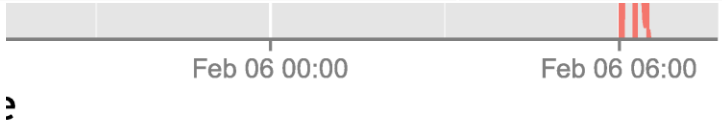

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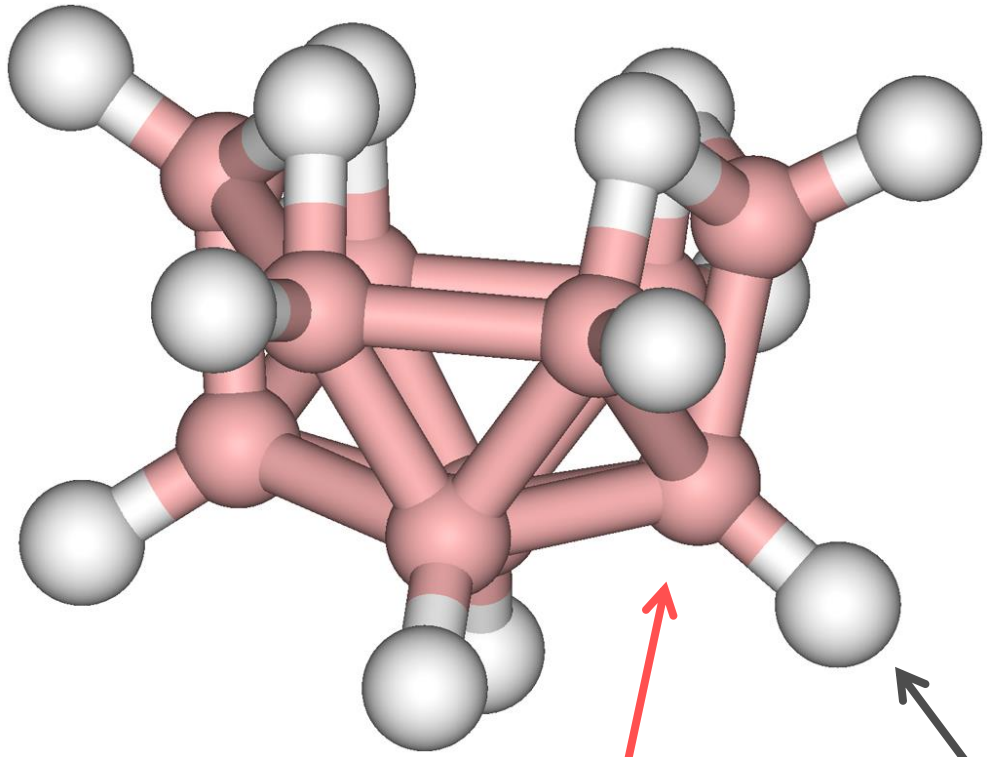

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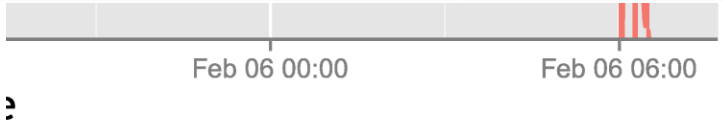

rnight Conditioning

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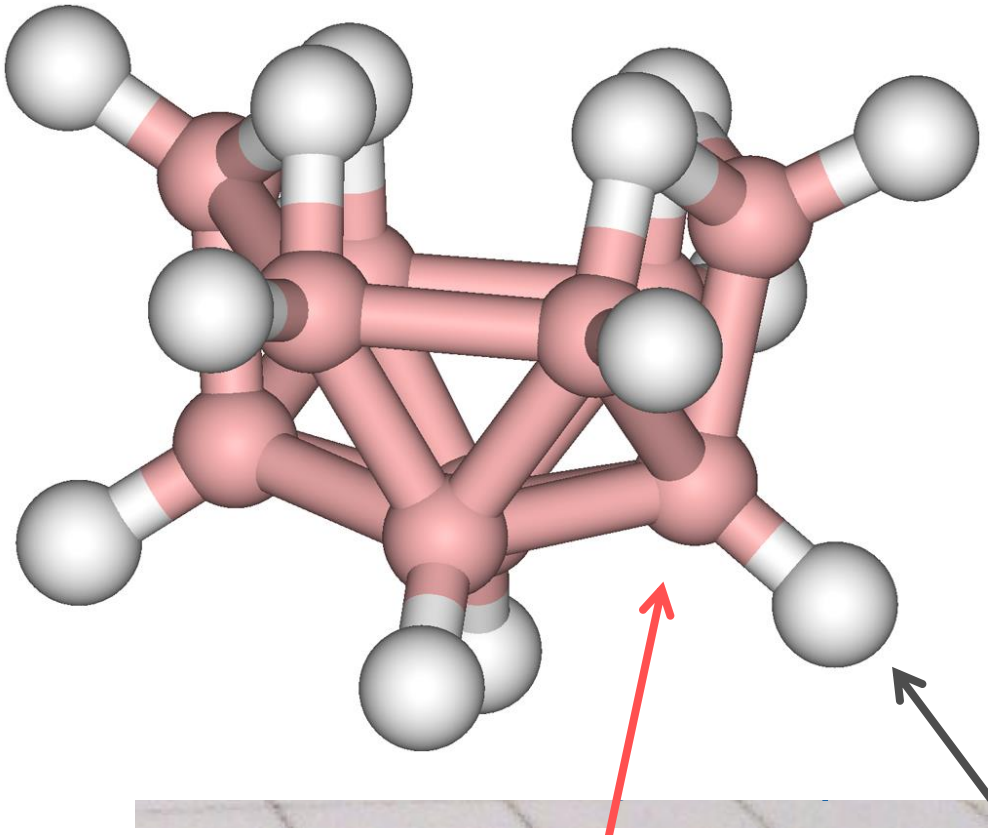

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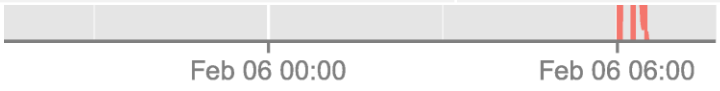

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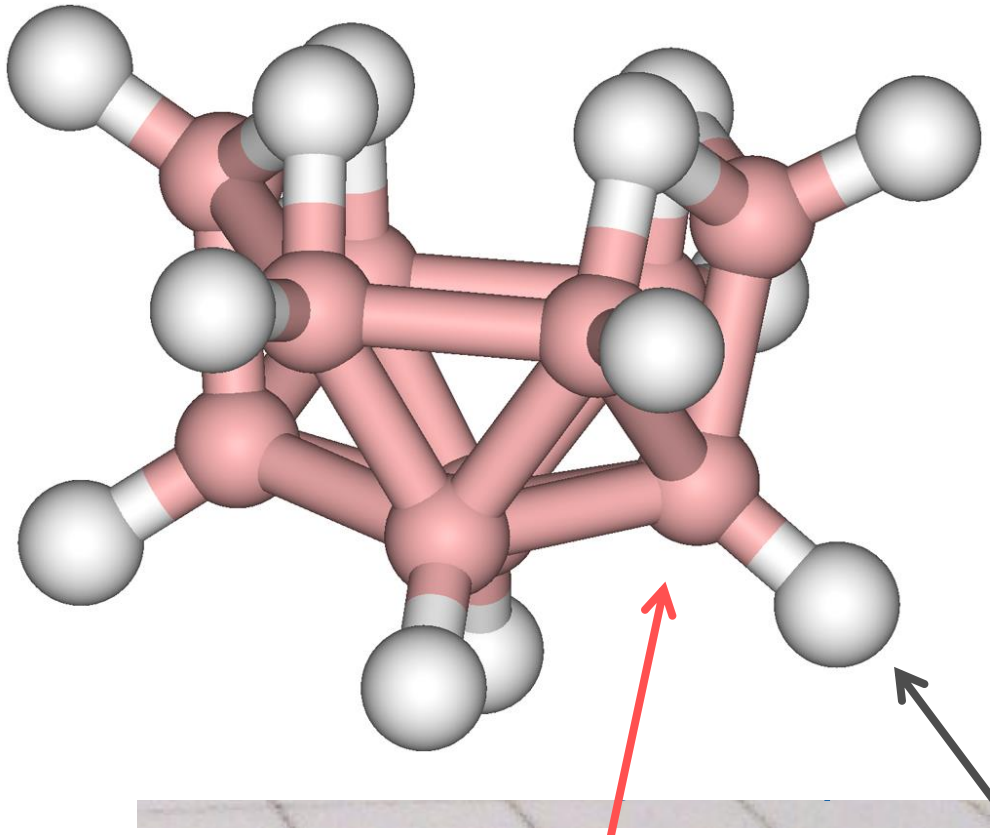

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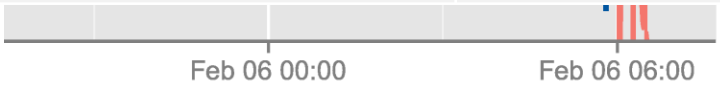

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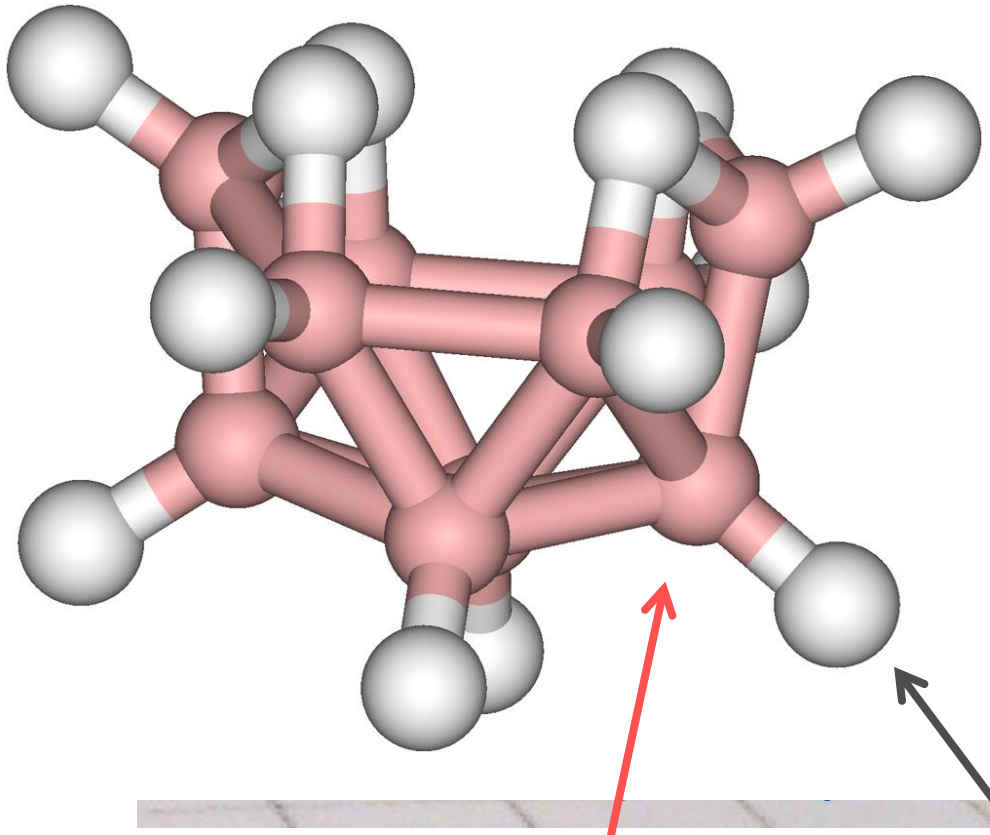

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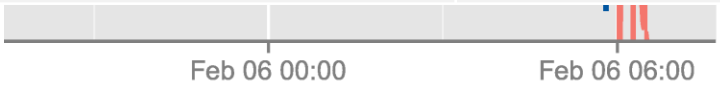

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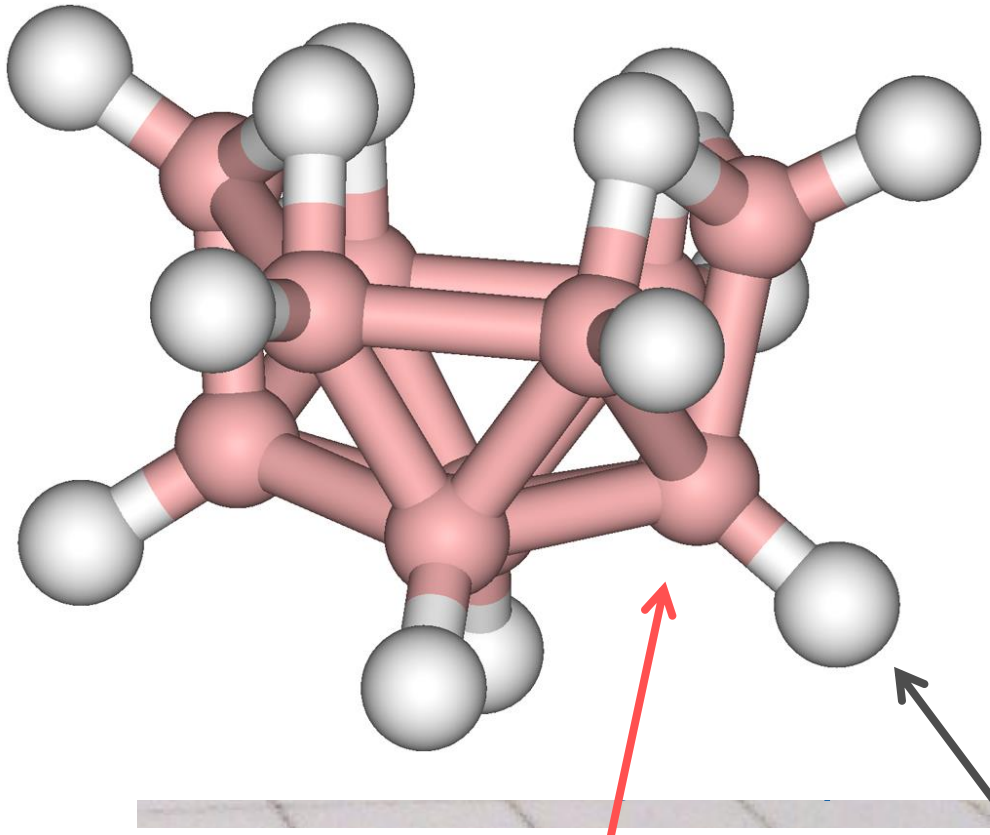

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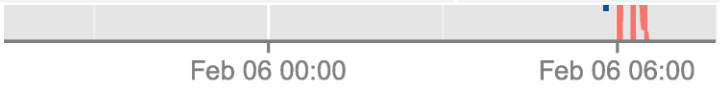

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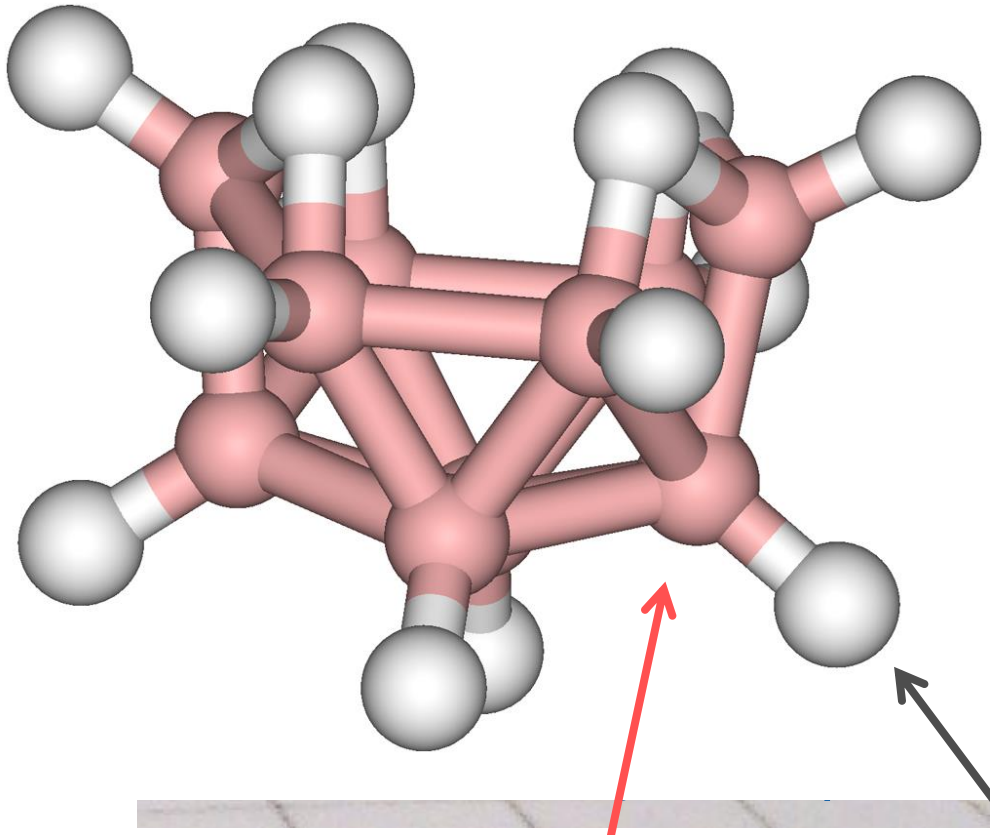

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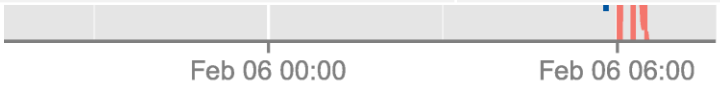

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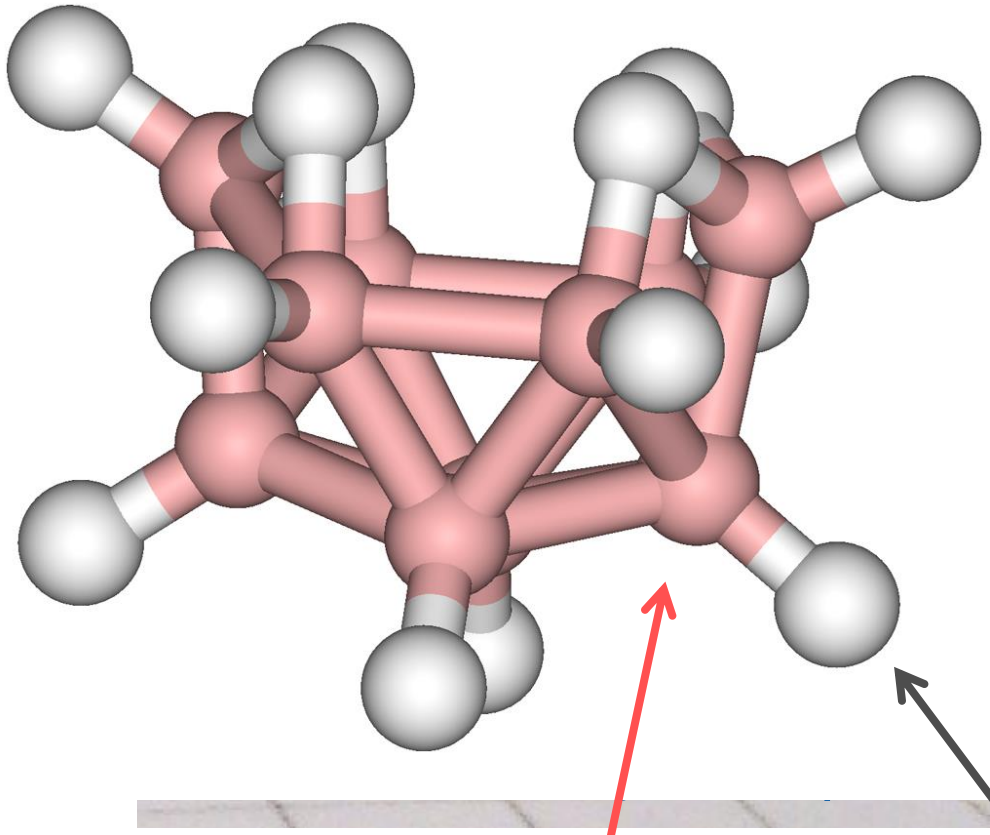

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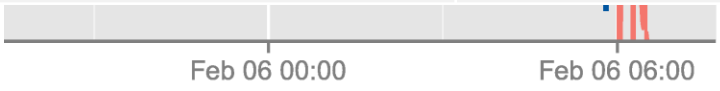
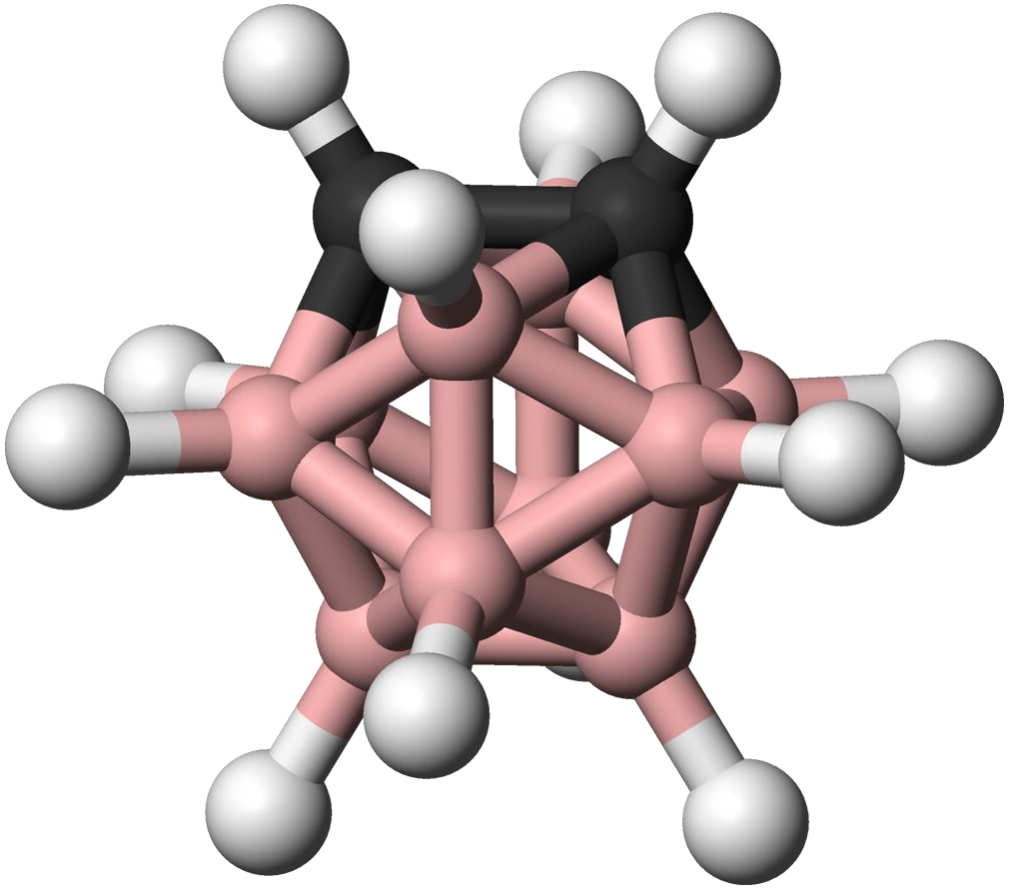


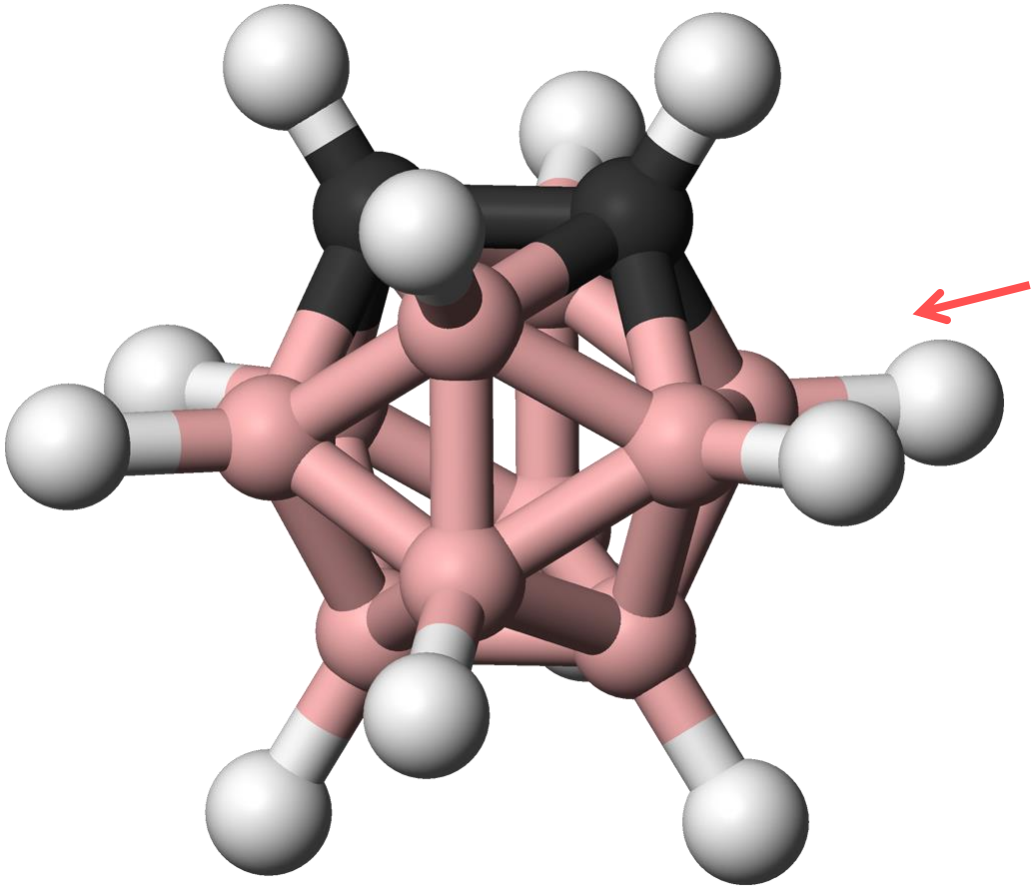
rnight Conditioning

M-carborane

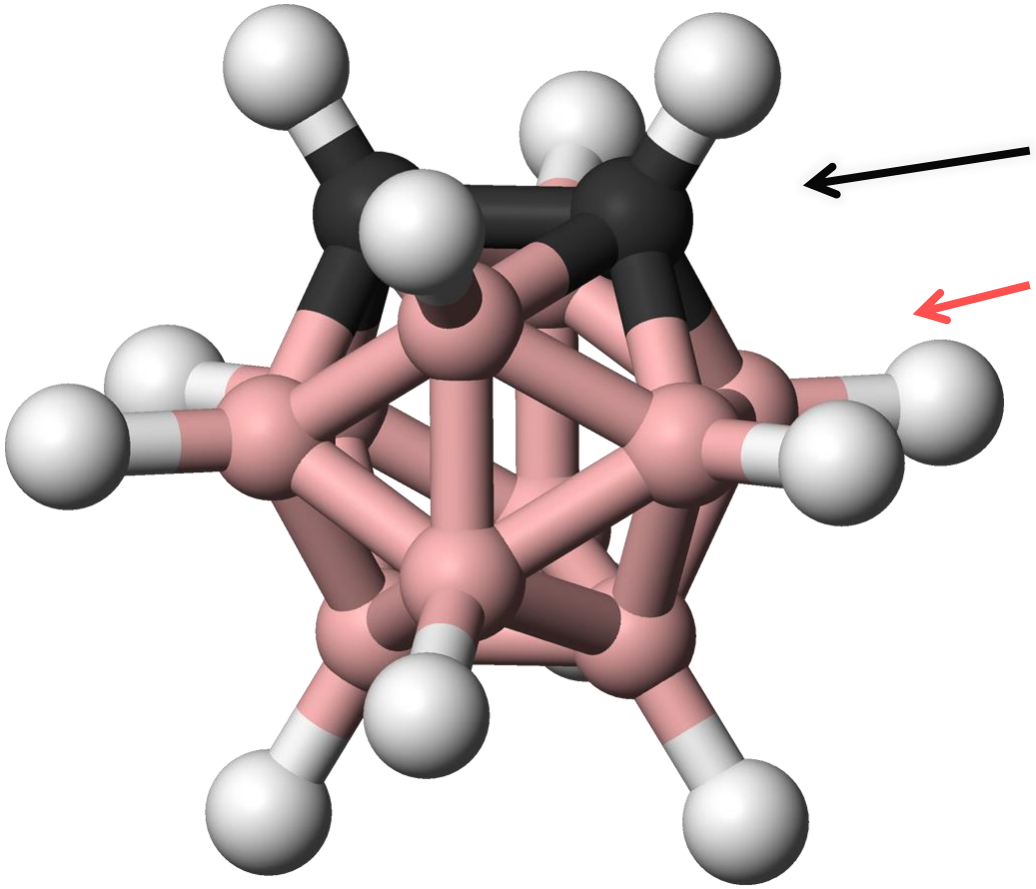
M-carborane



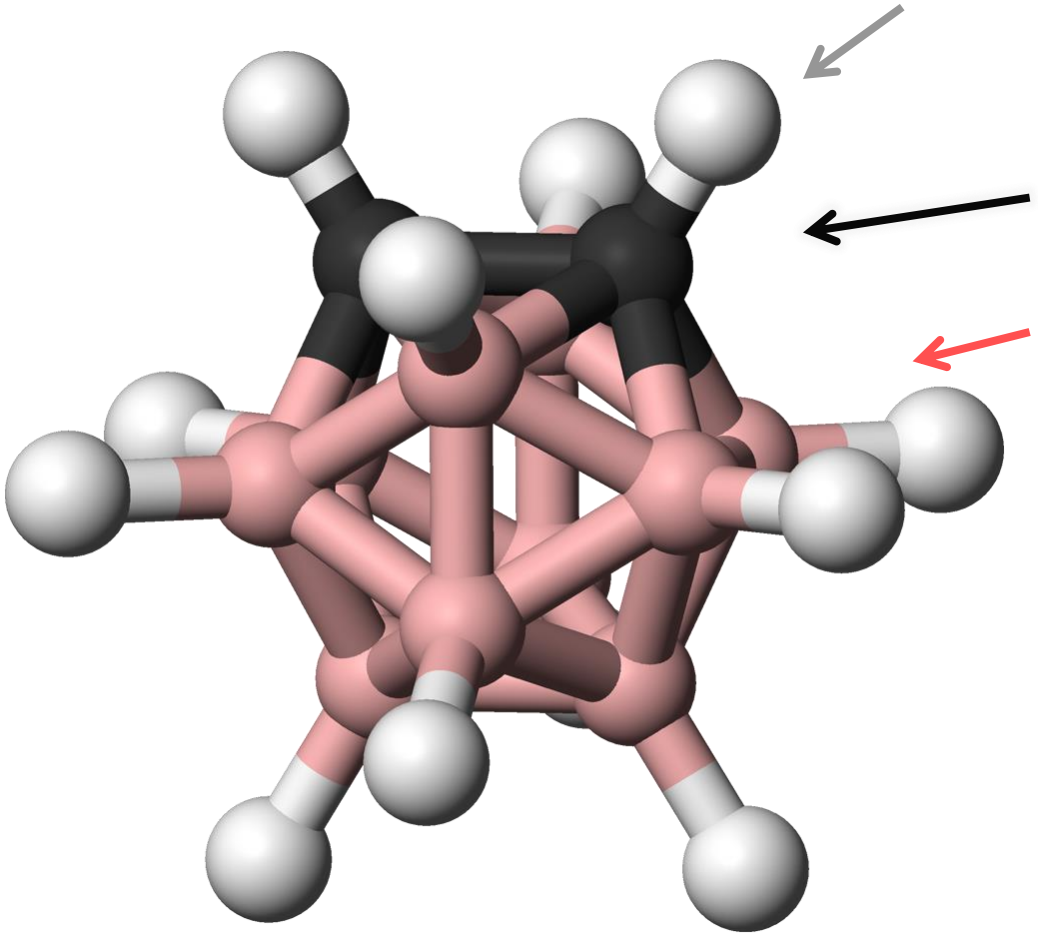
M-carborane



M-carborane



M-carborane



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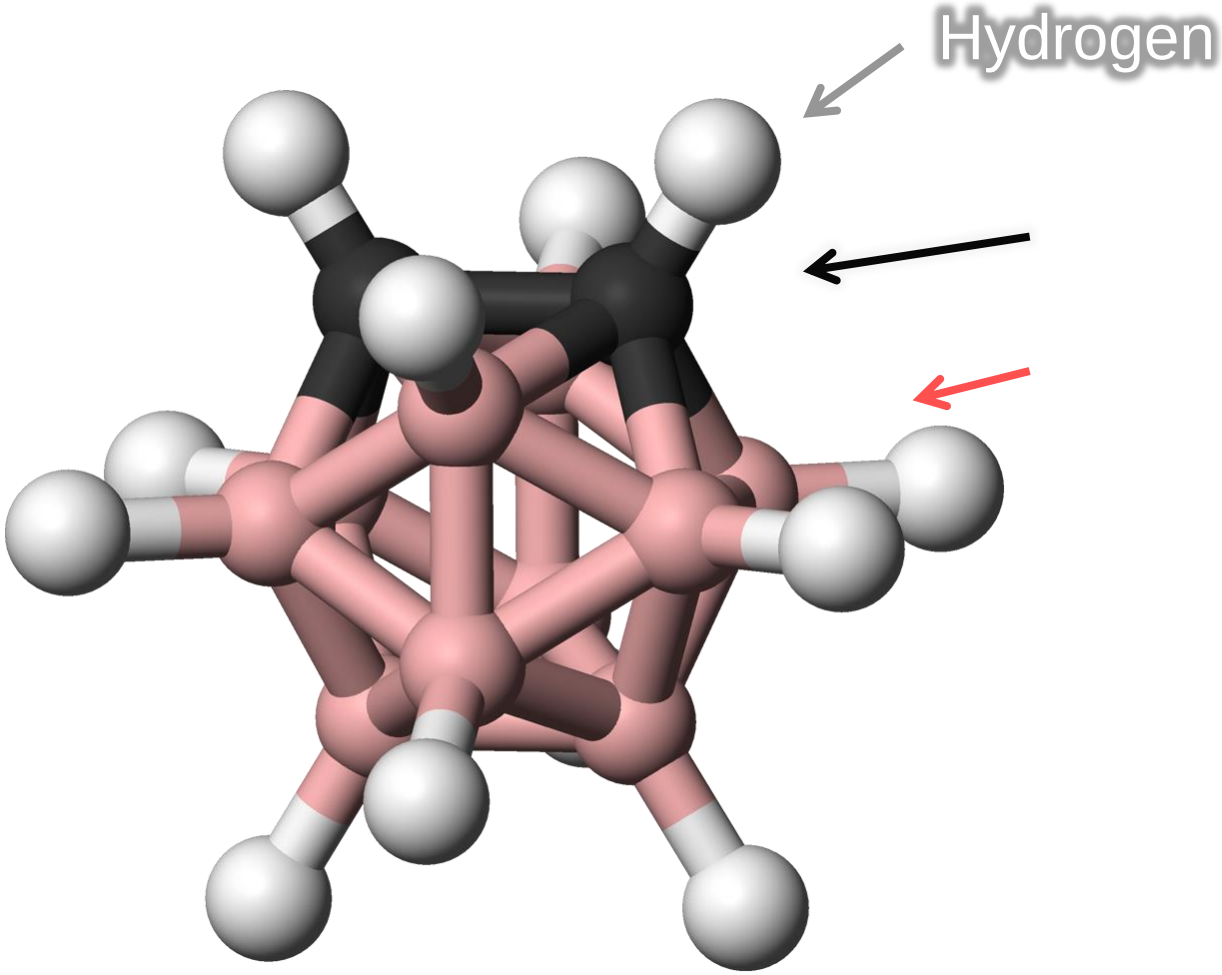

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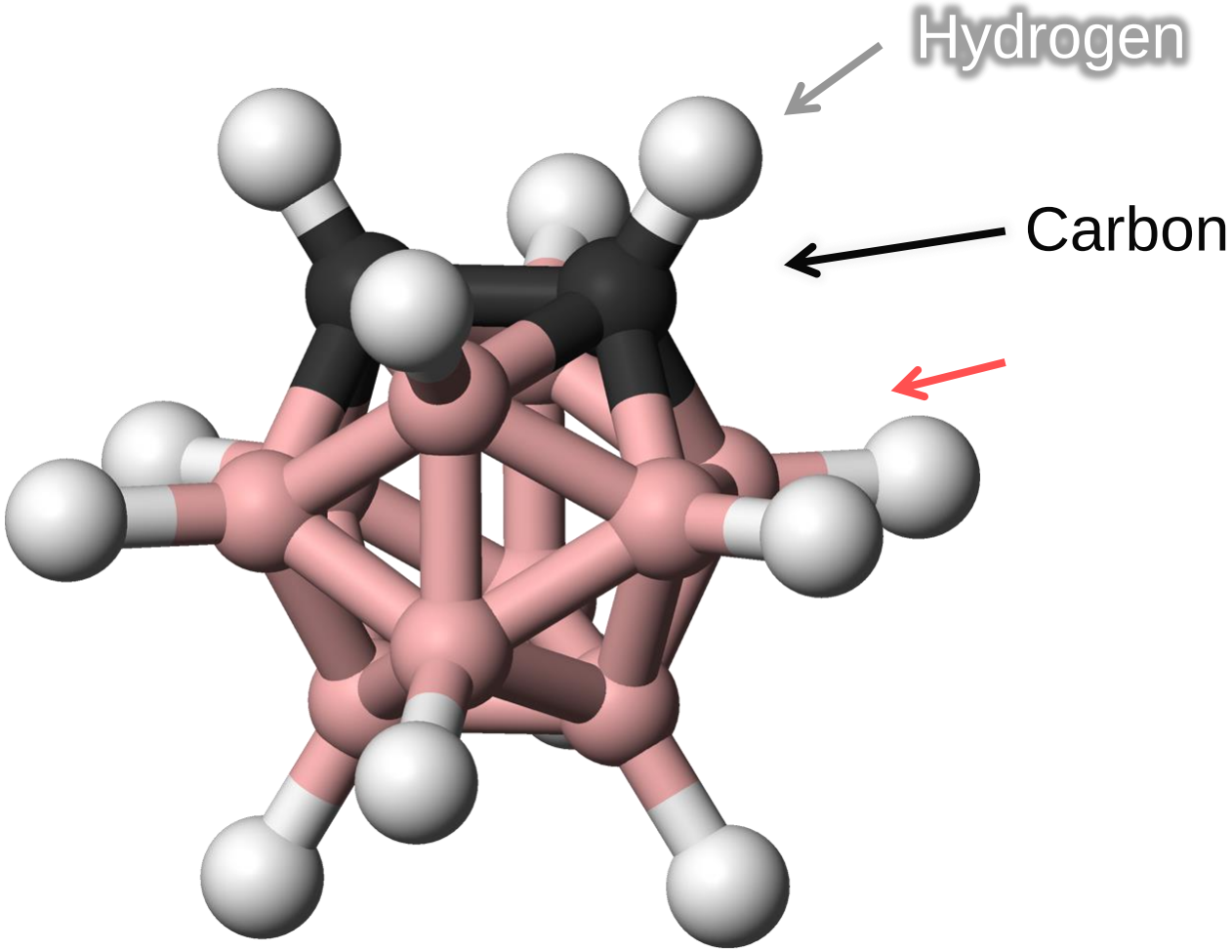

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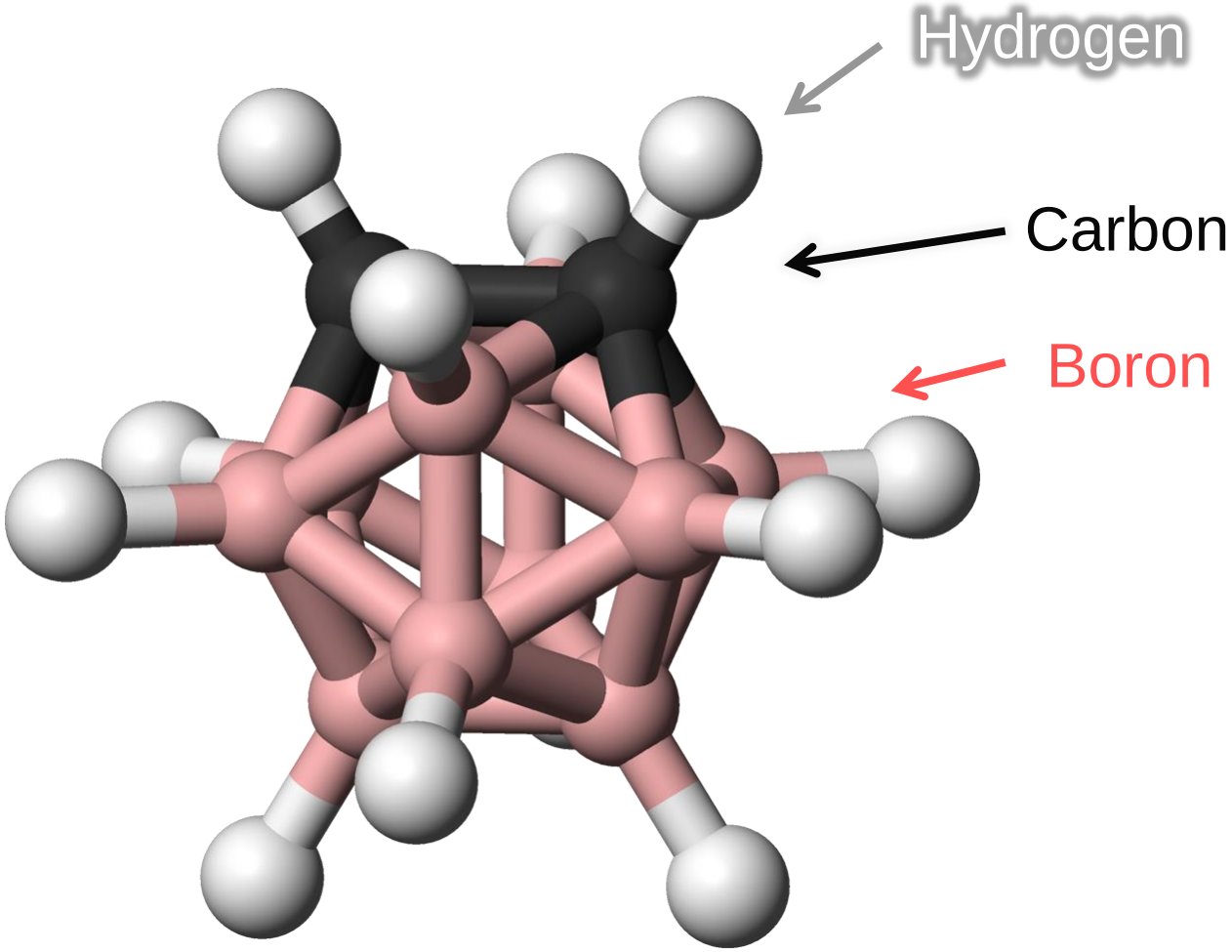

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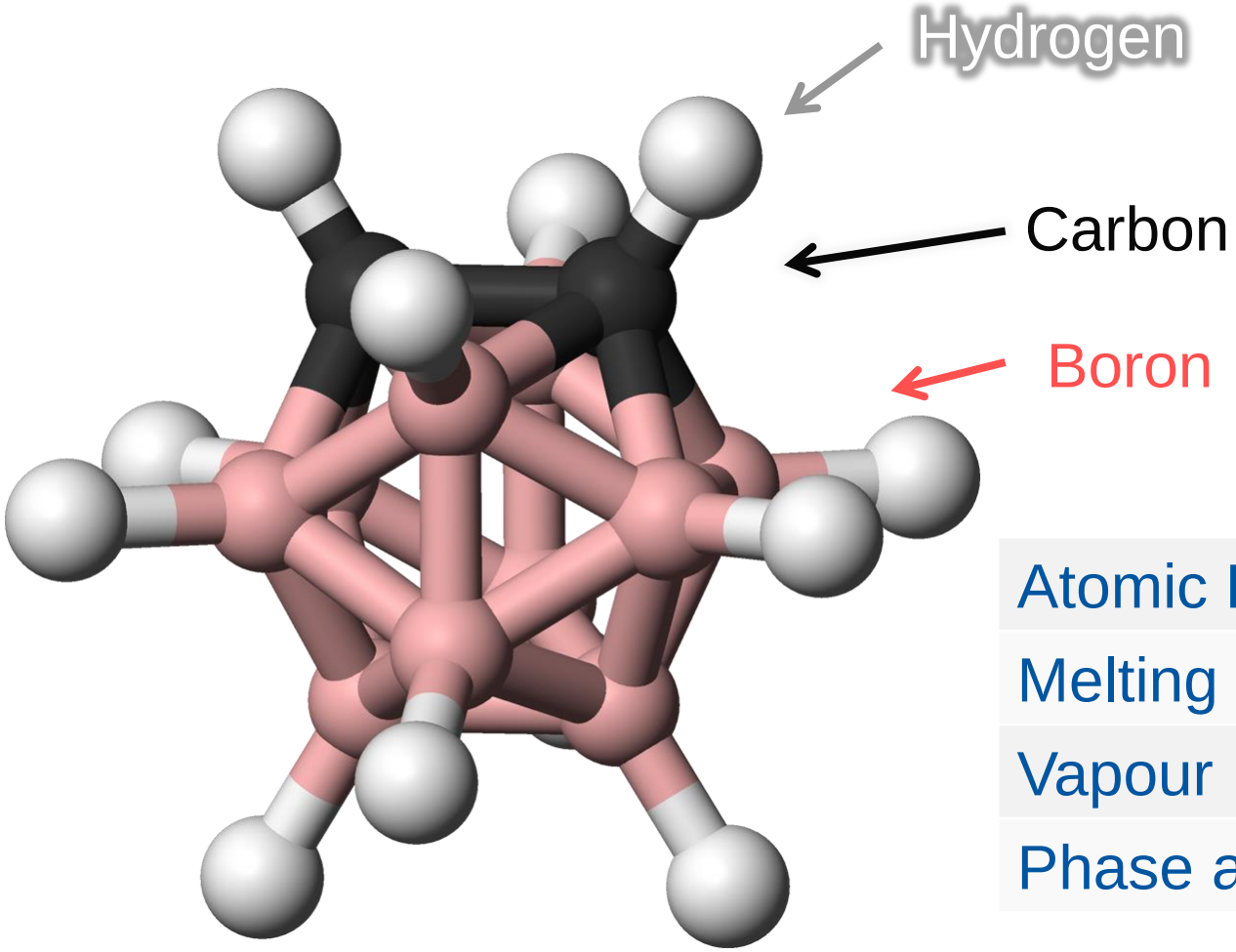
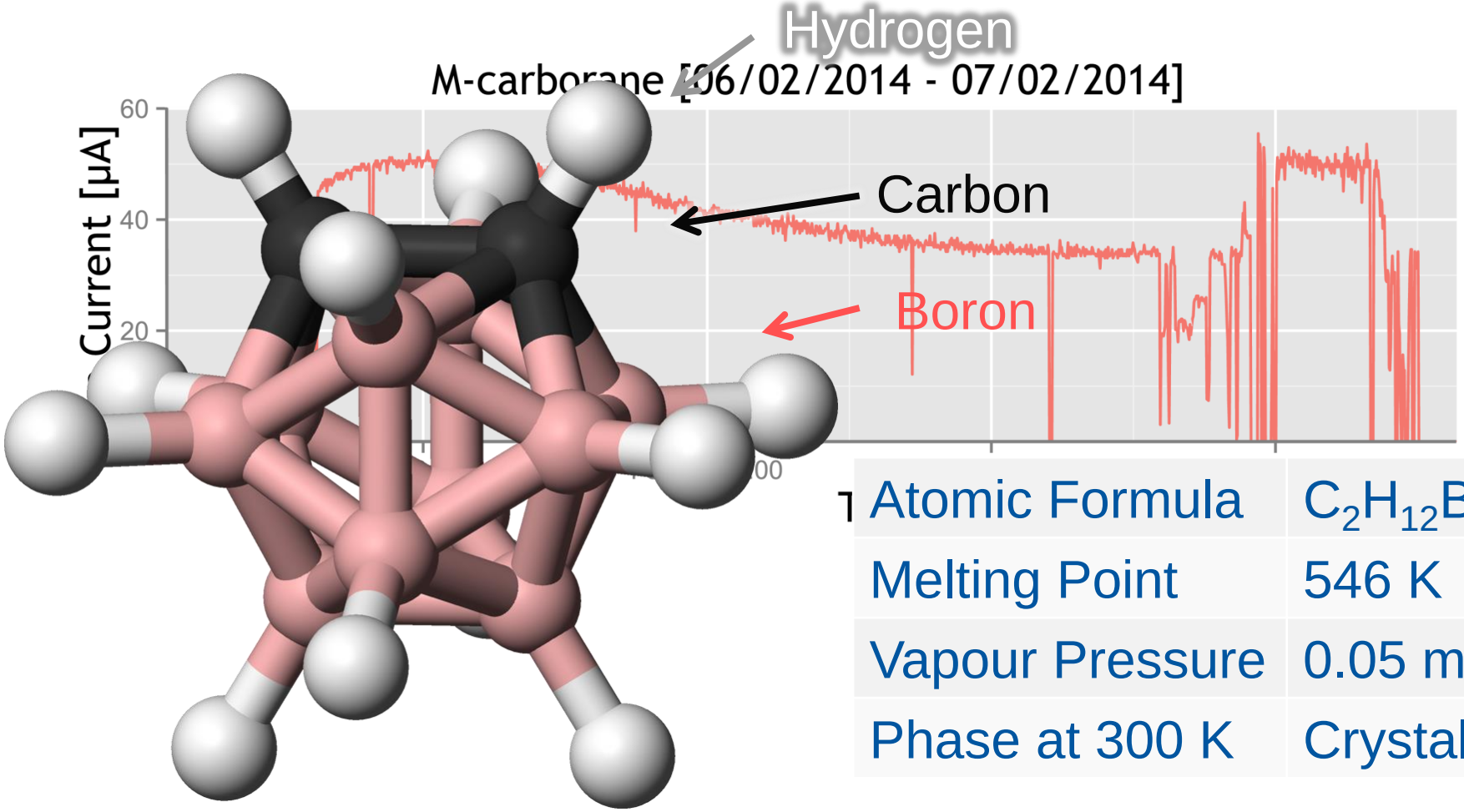


Atomic Formula	$C_2H_{12}B_{10}$
Melting Point	546 K
Vapour Pressure	0.05 mbar
Phase at 300 K	Crystalline

M-carborane



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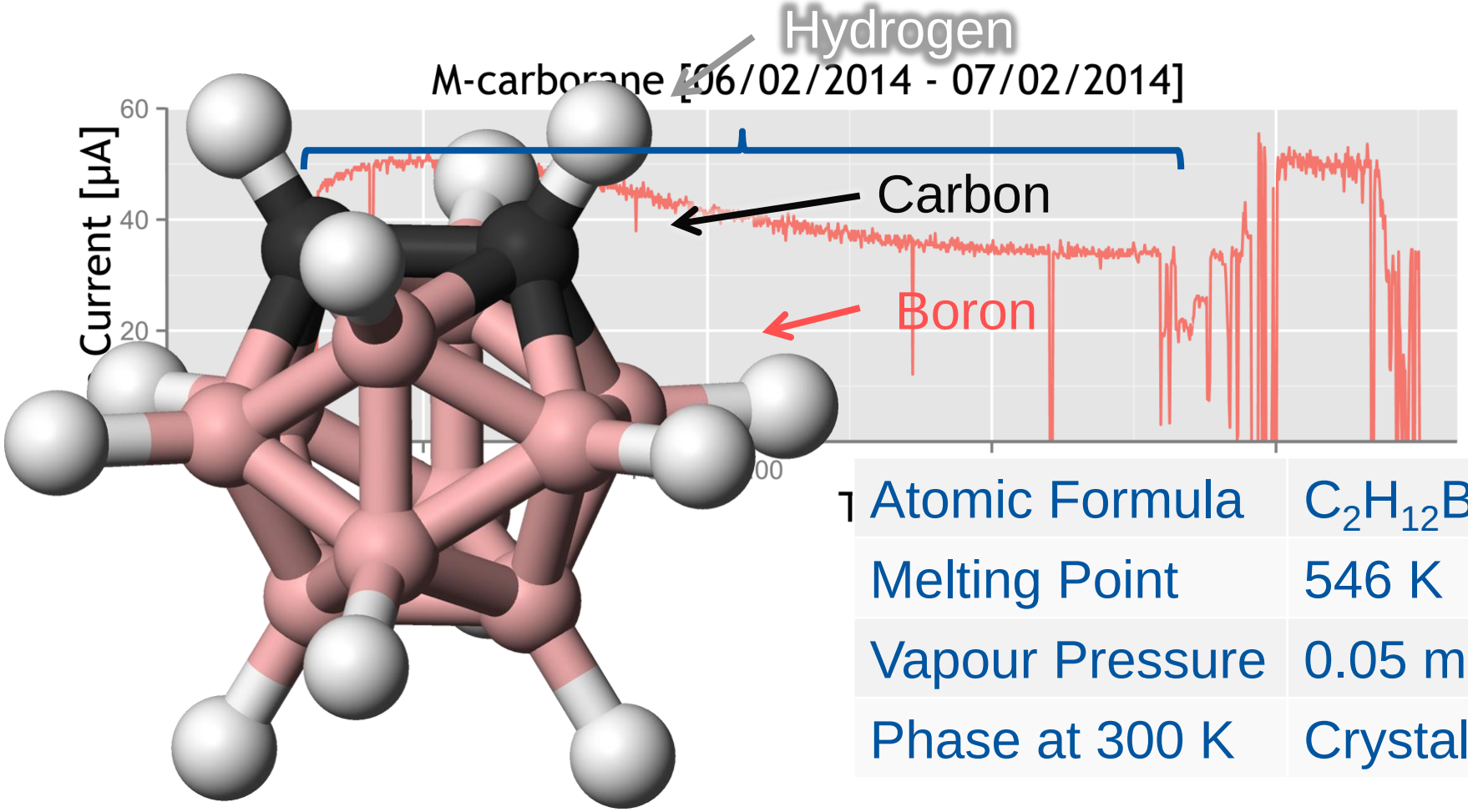

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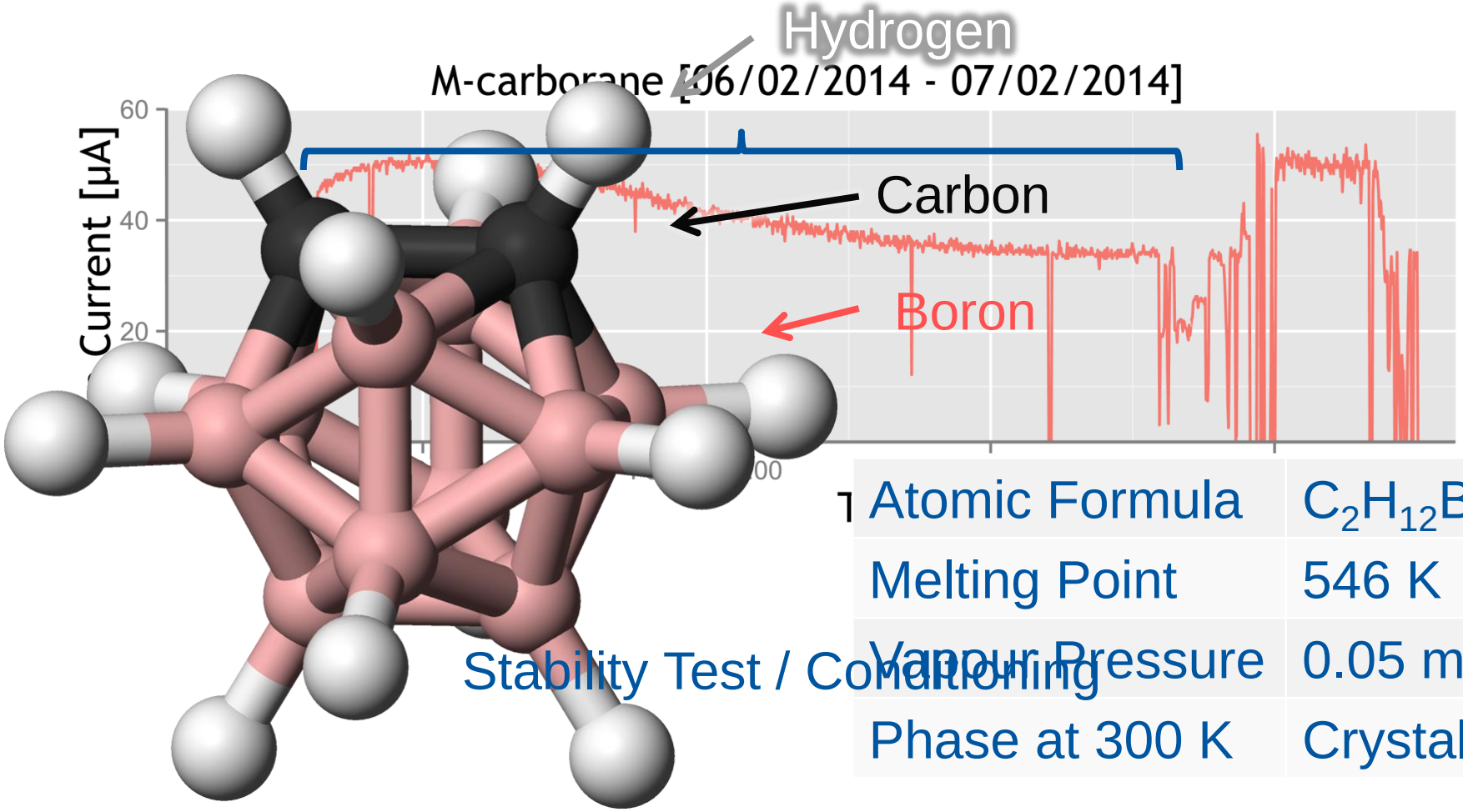

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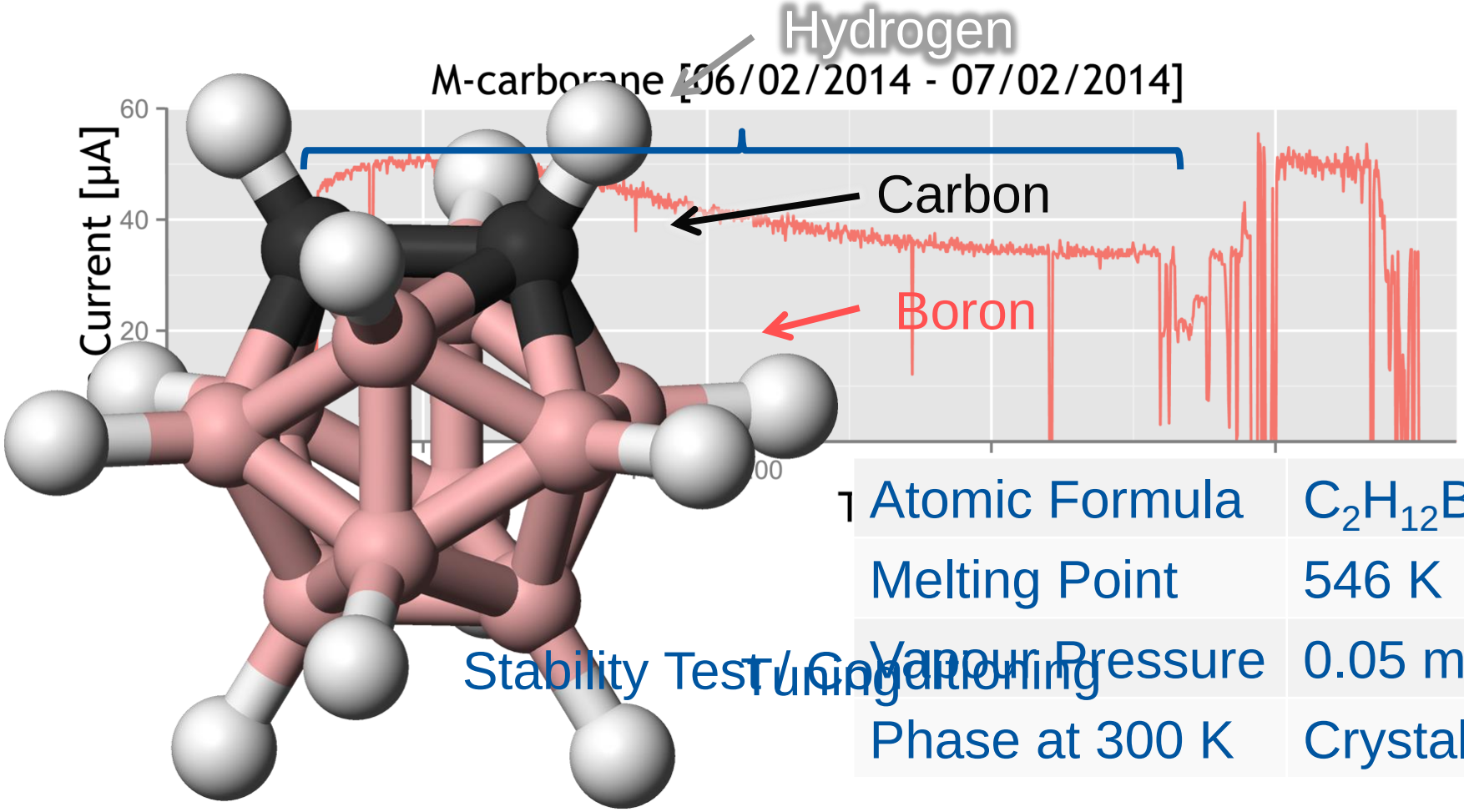
Melting Point	546 K
Vapour Pressure	0.05 mbar
Phase at 300 K	Crystalline

Stability Test / Conditioning

M-carborane



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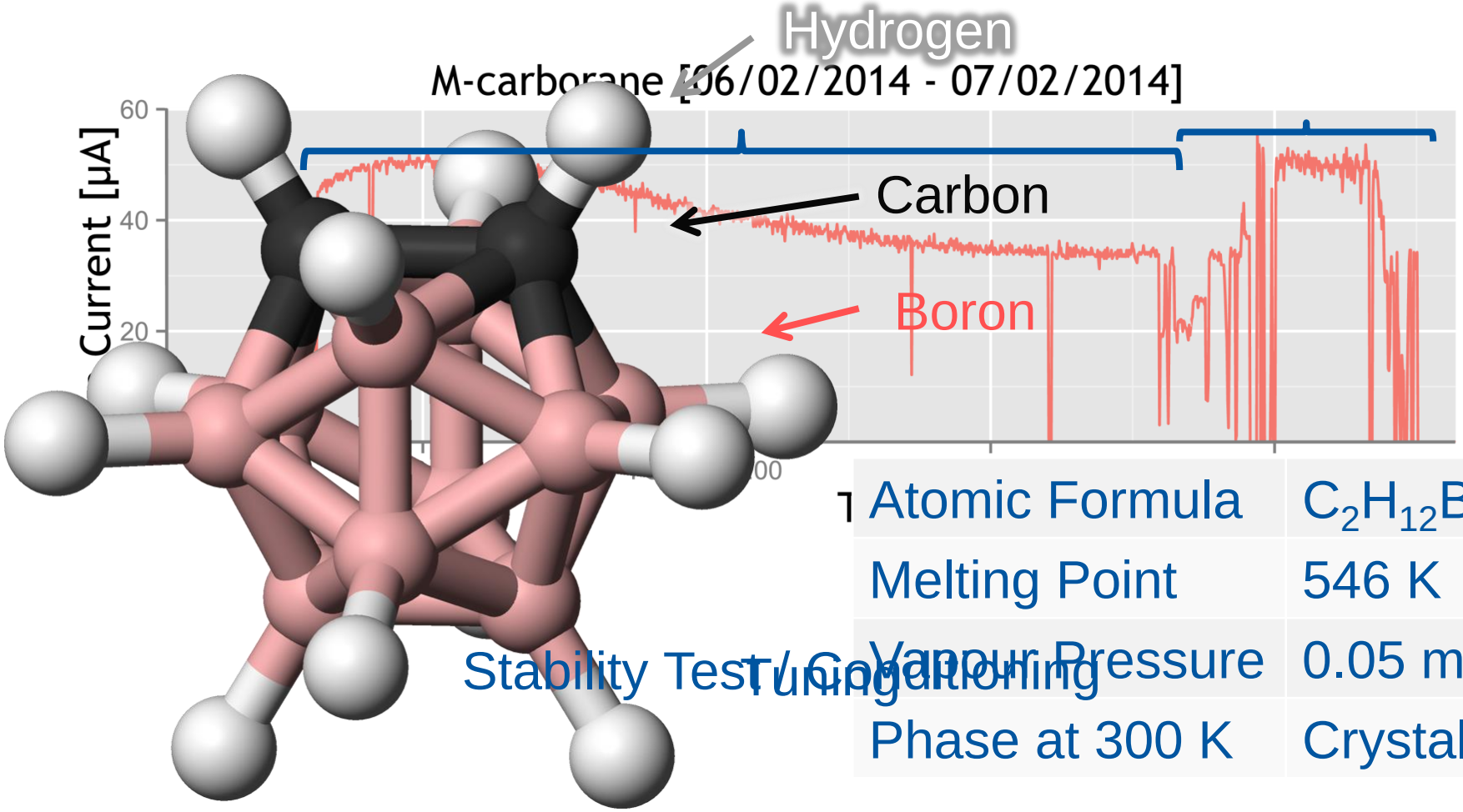
Stability Test / Conditioning

M-carborane



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Stability Test / Conditioning

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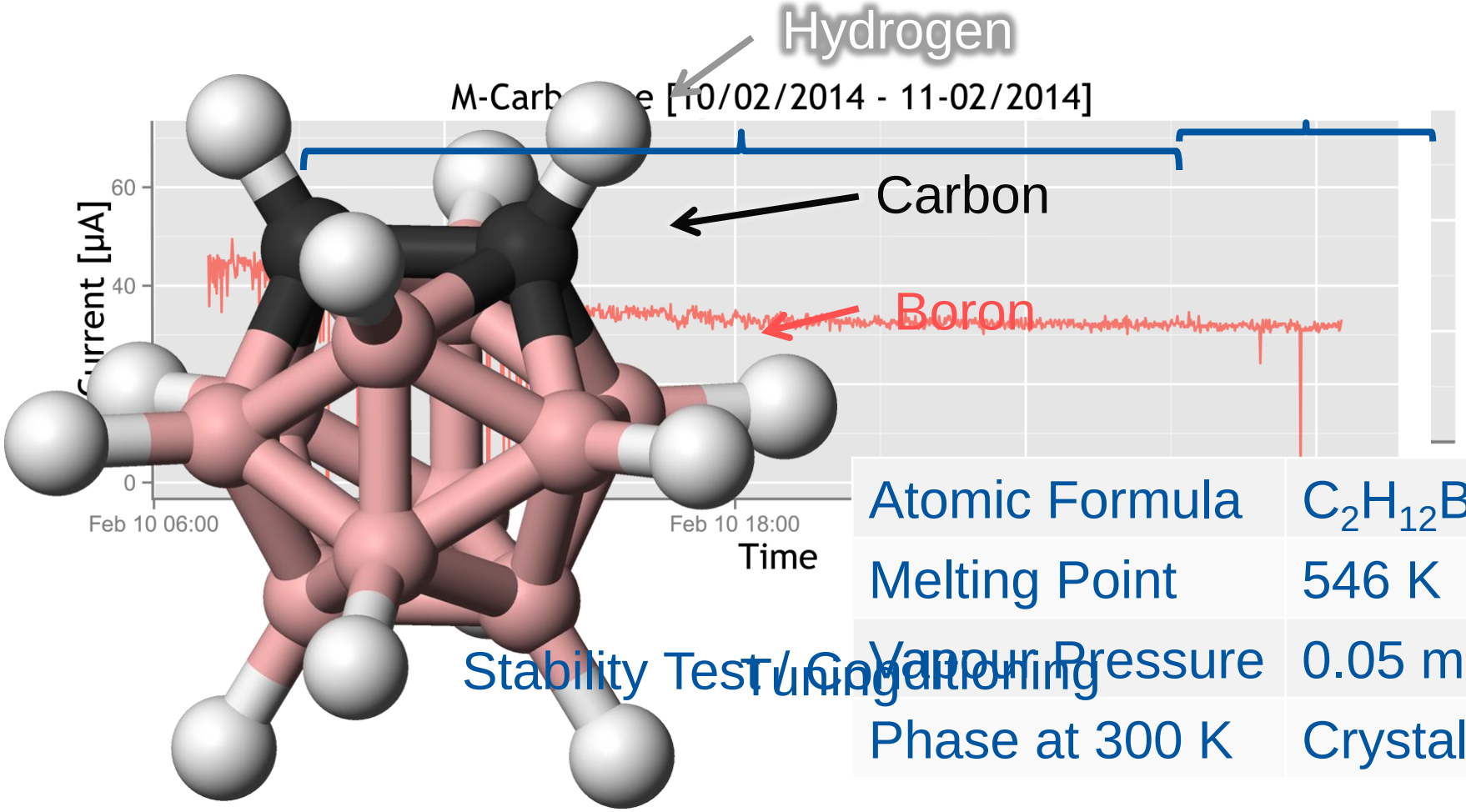

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Stability Test / Conditioning

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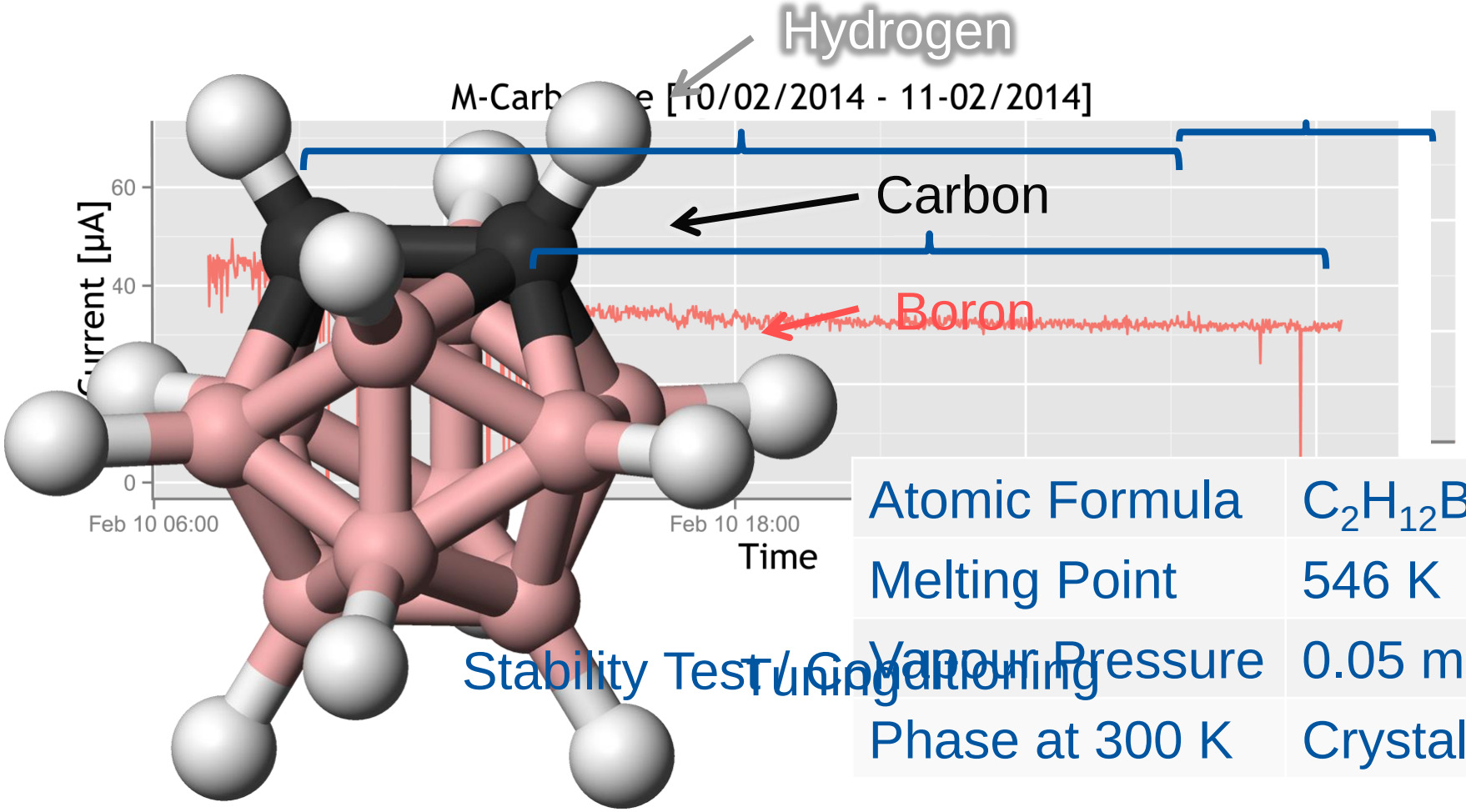

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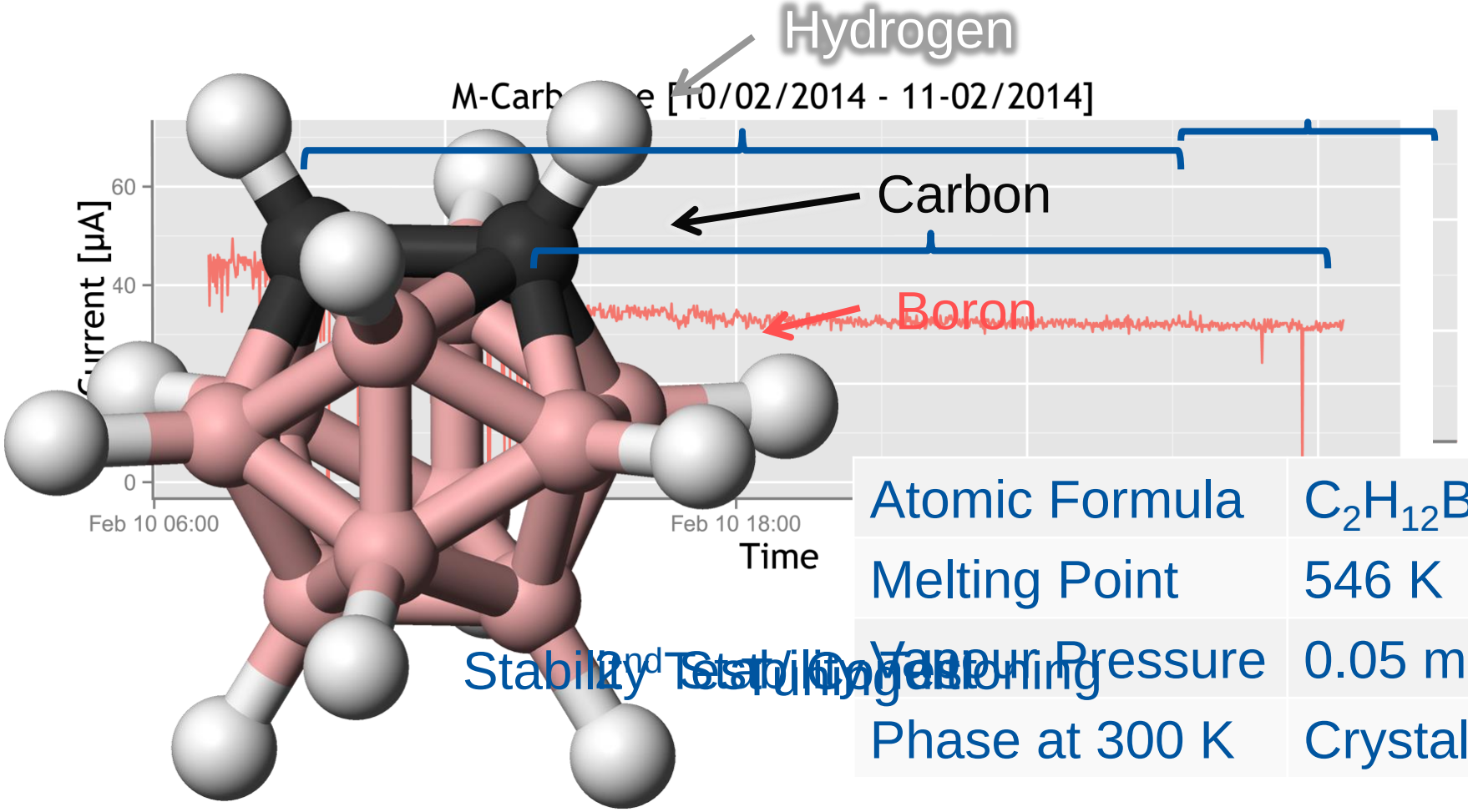
Stability Test / Conditioning

M-carborane



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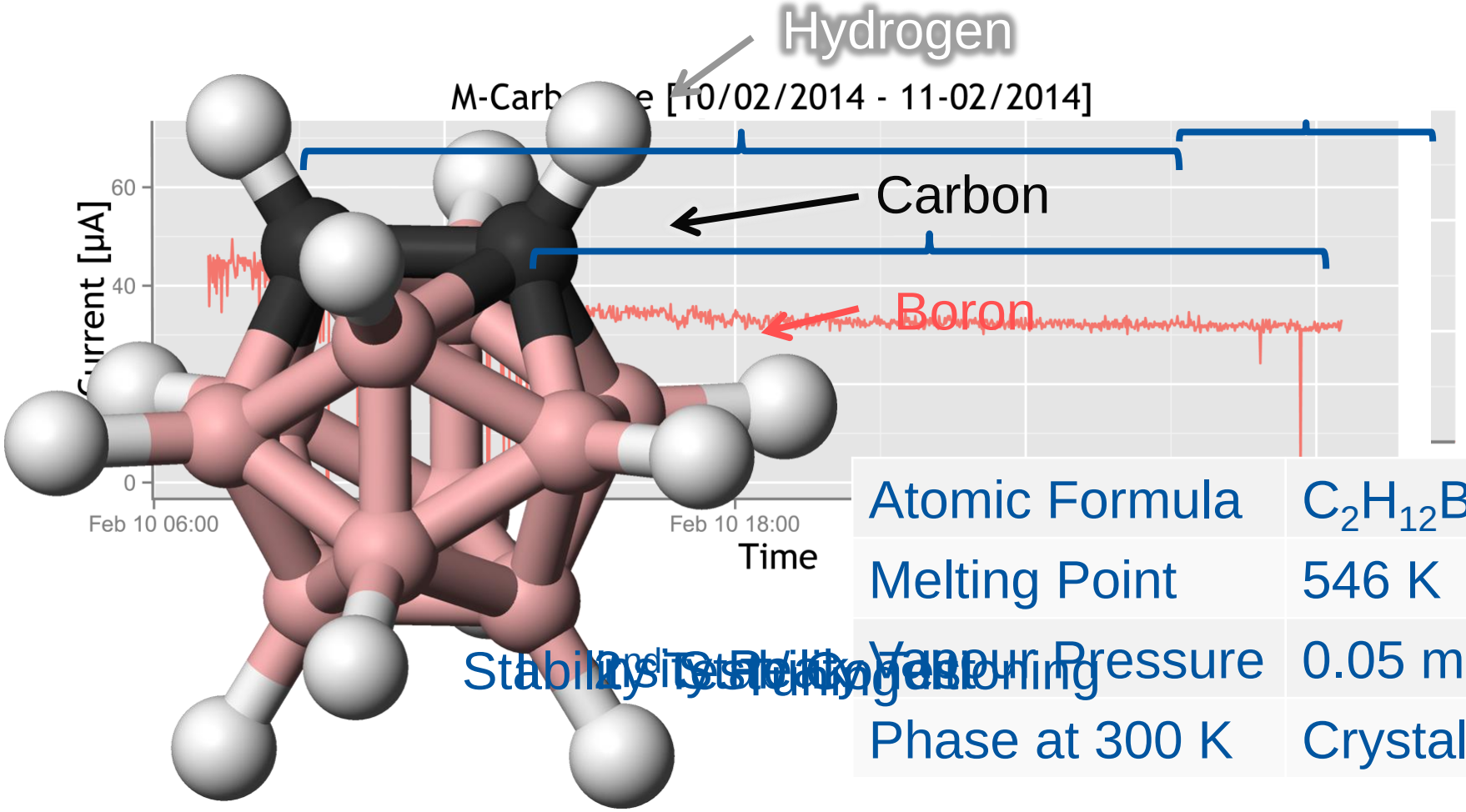
Vapour Pressure	0.05 mbar
Phase at 300 K	Crystalline

Stability Testing and Characterization

M-carborane



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Melting Point	546 K
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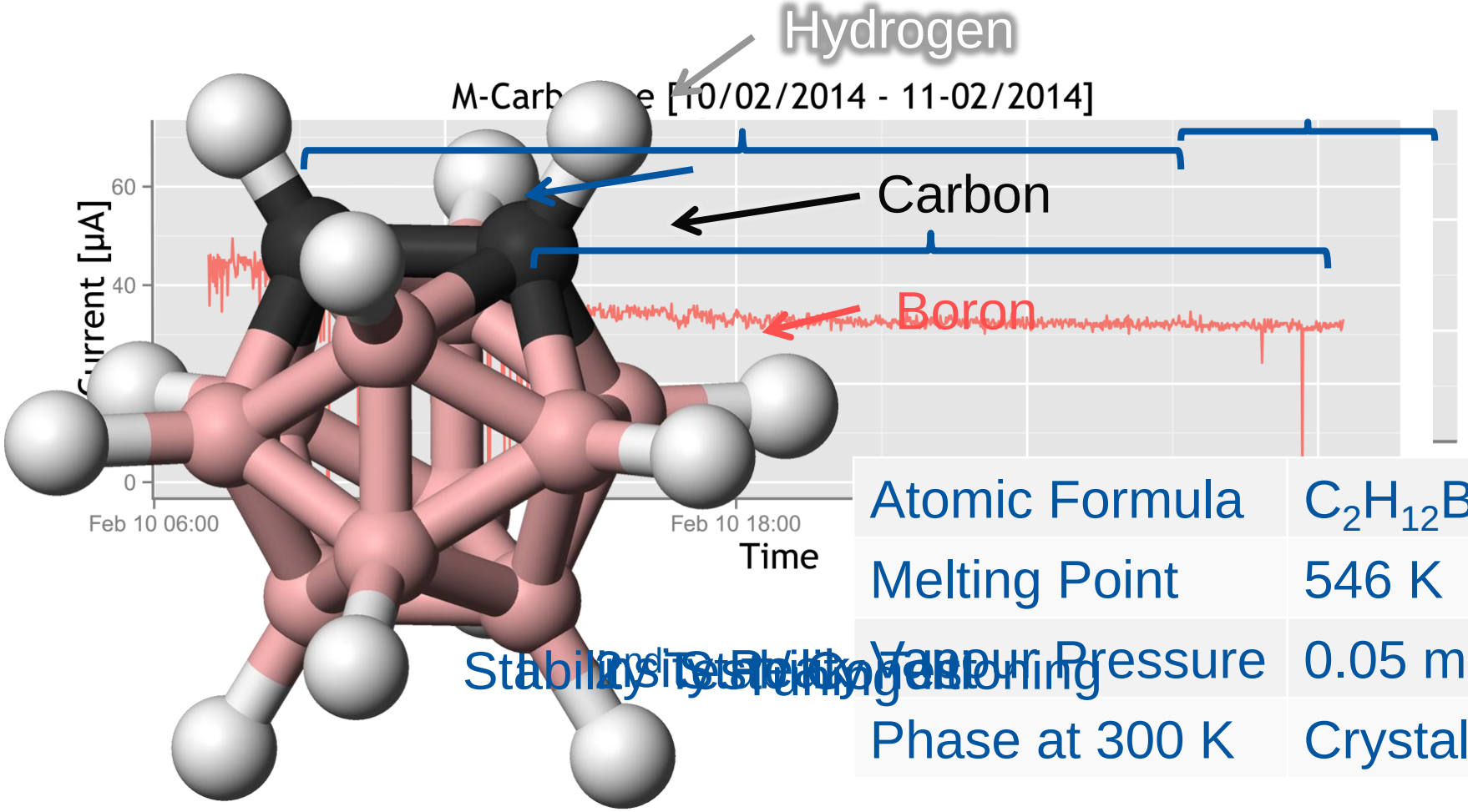
Stability Testing

M-carborane



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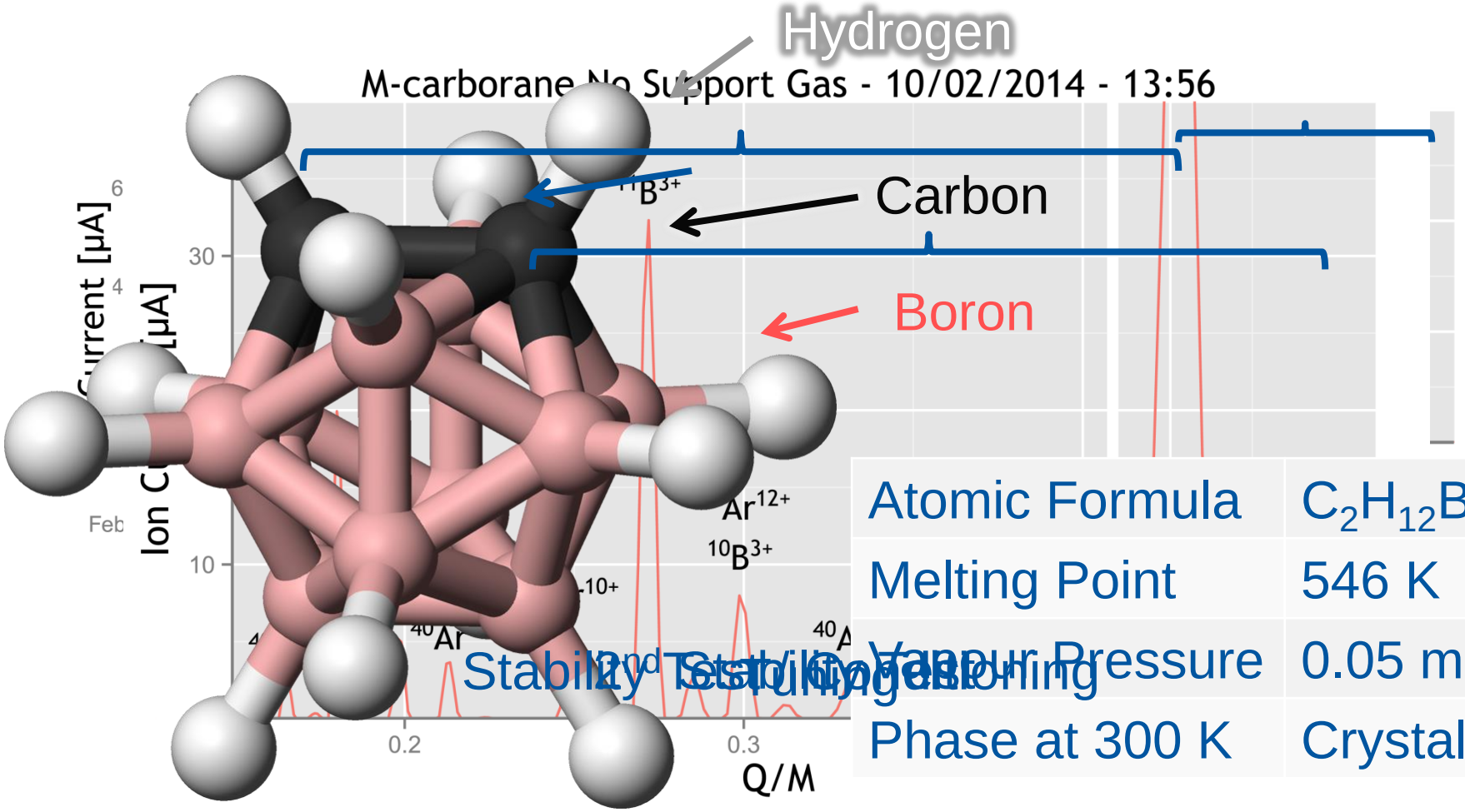
Stability Testing

M-carborane



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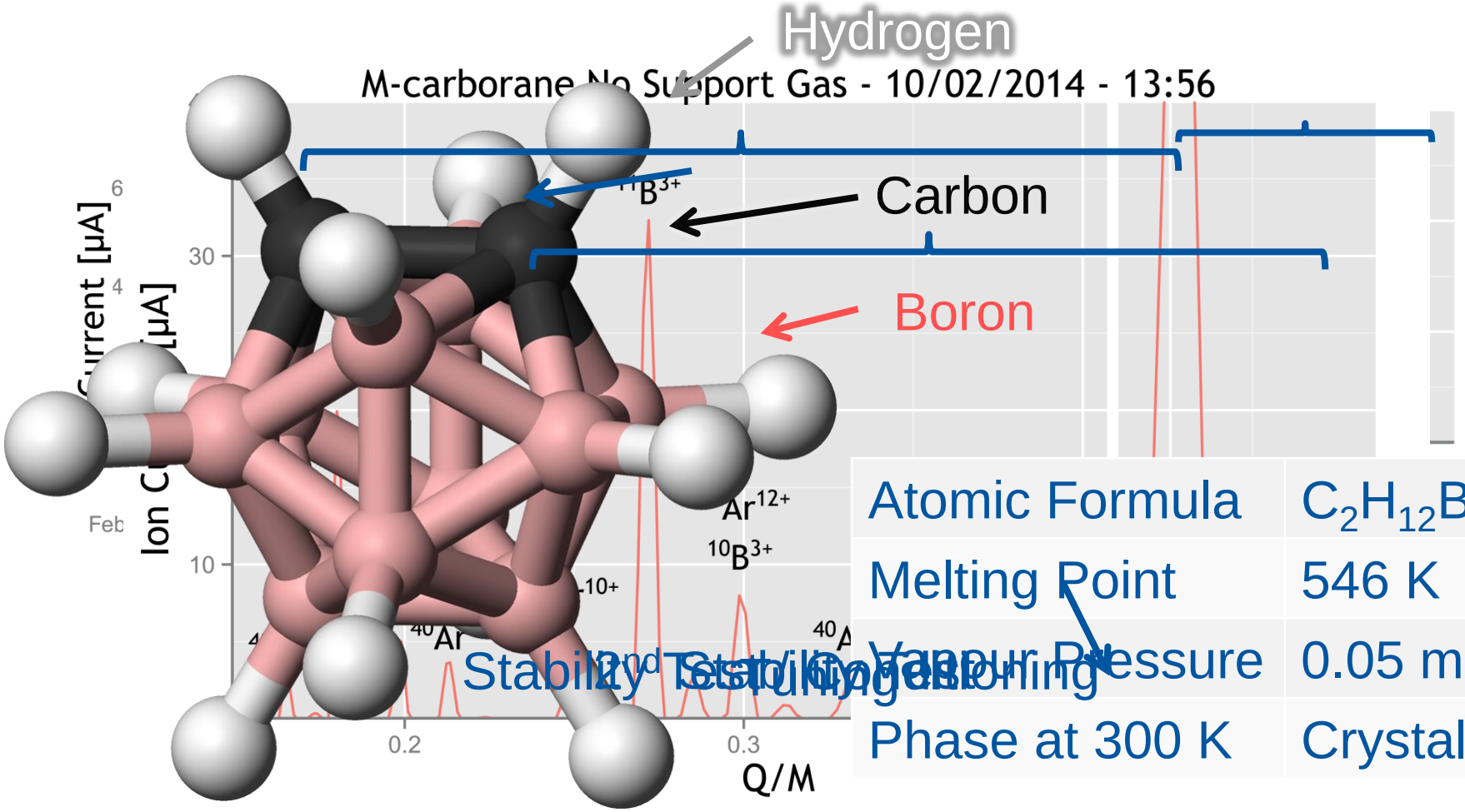
Stability testing

M-carborane



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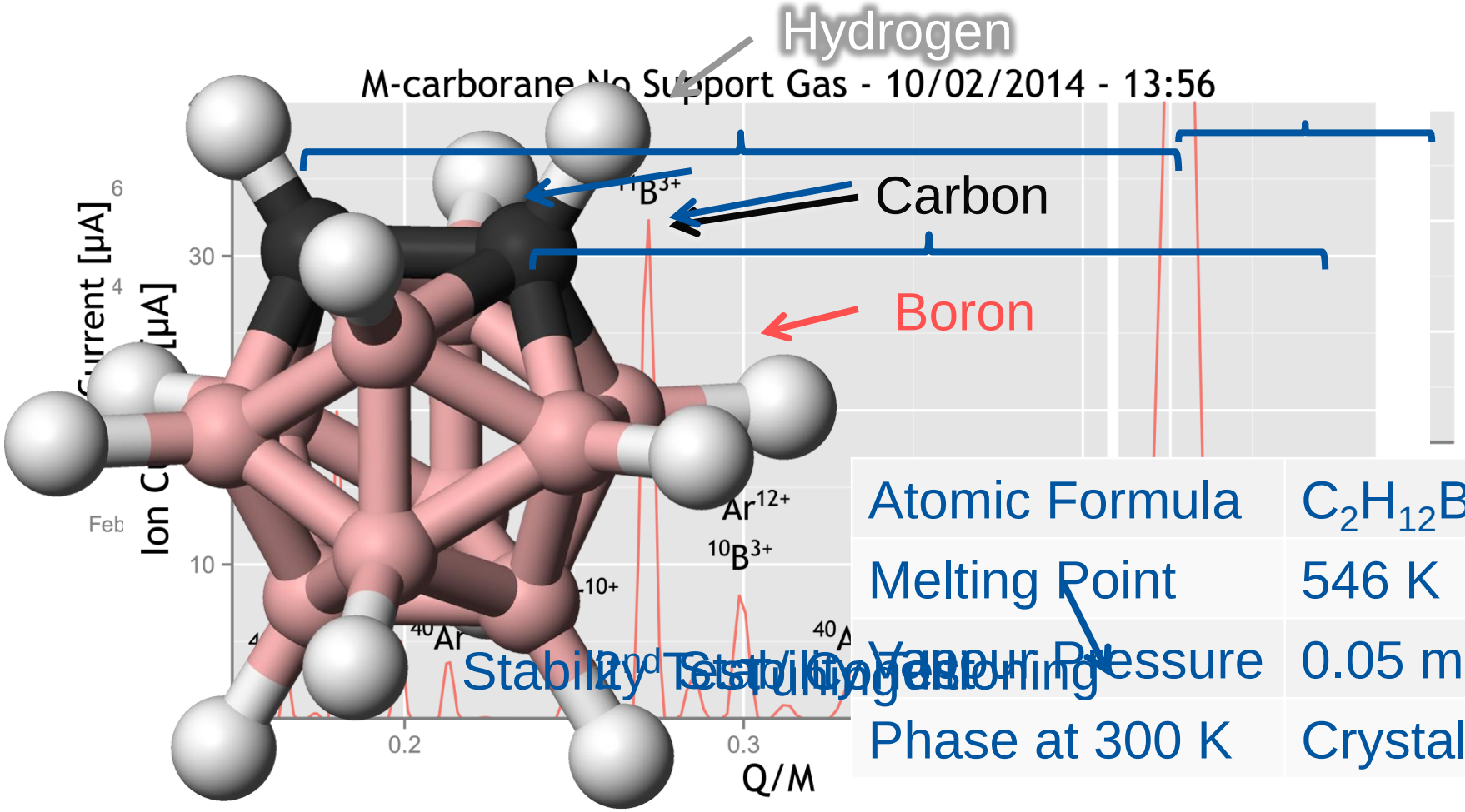
Stability Testing

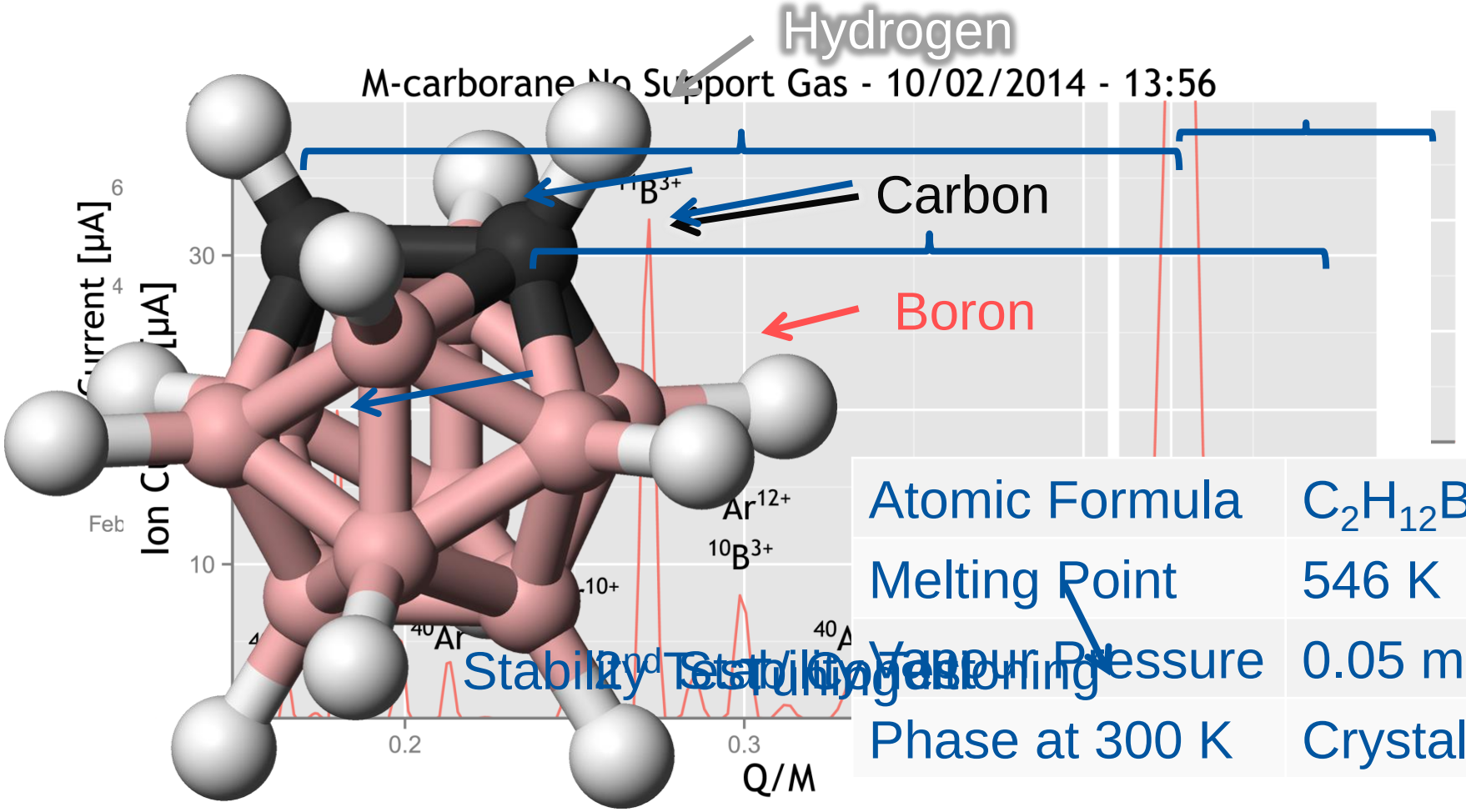
M-carborane



Atomic Formula	$C_2H_{12}B_{10}$
Melting Point	546 K
Vapour Pressure	0.05 mbar
Phase at 300 K	Crystalline

Stability testing ongoing

M-carborane



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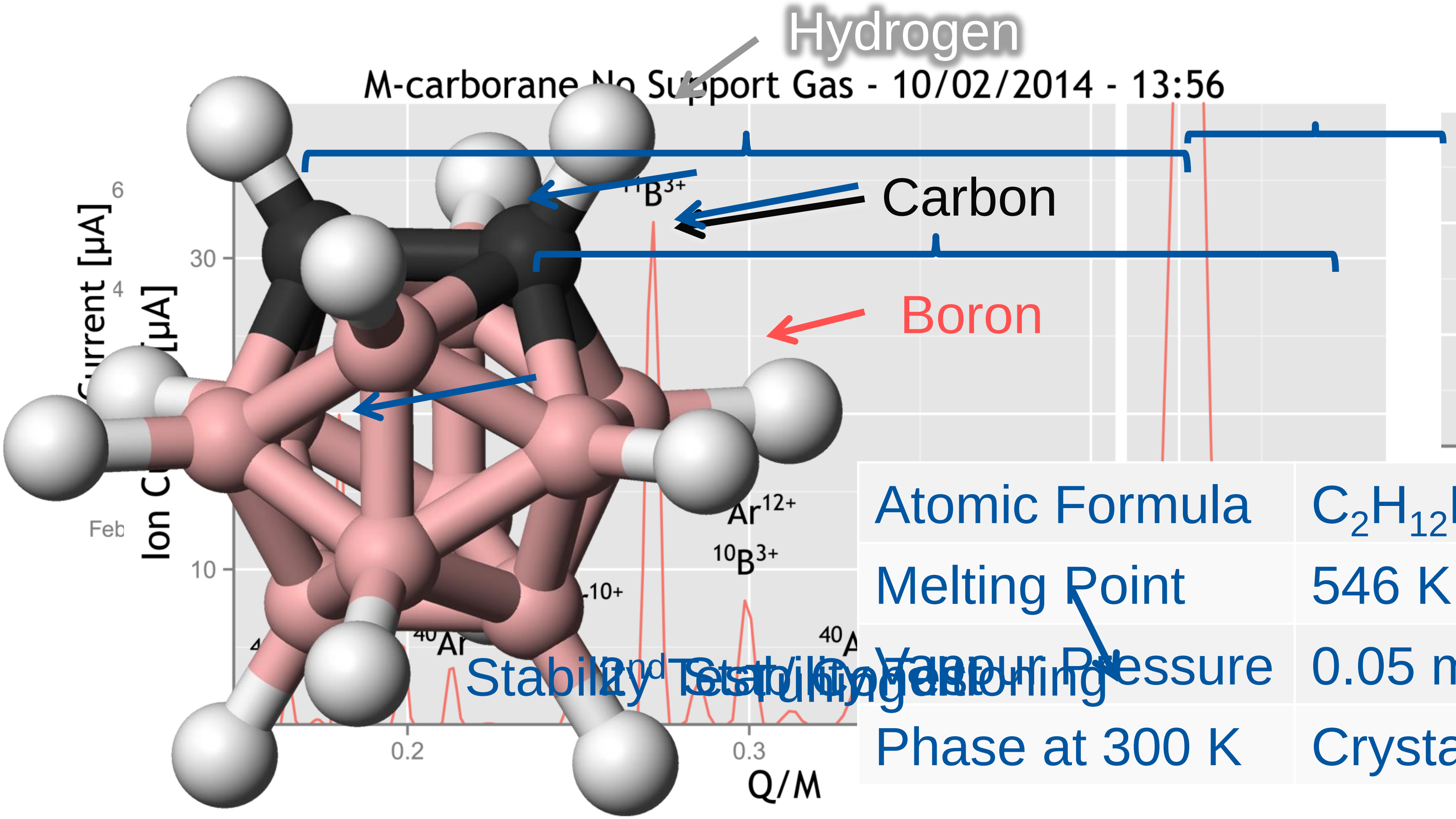
Stability Testing

M-carborane

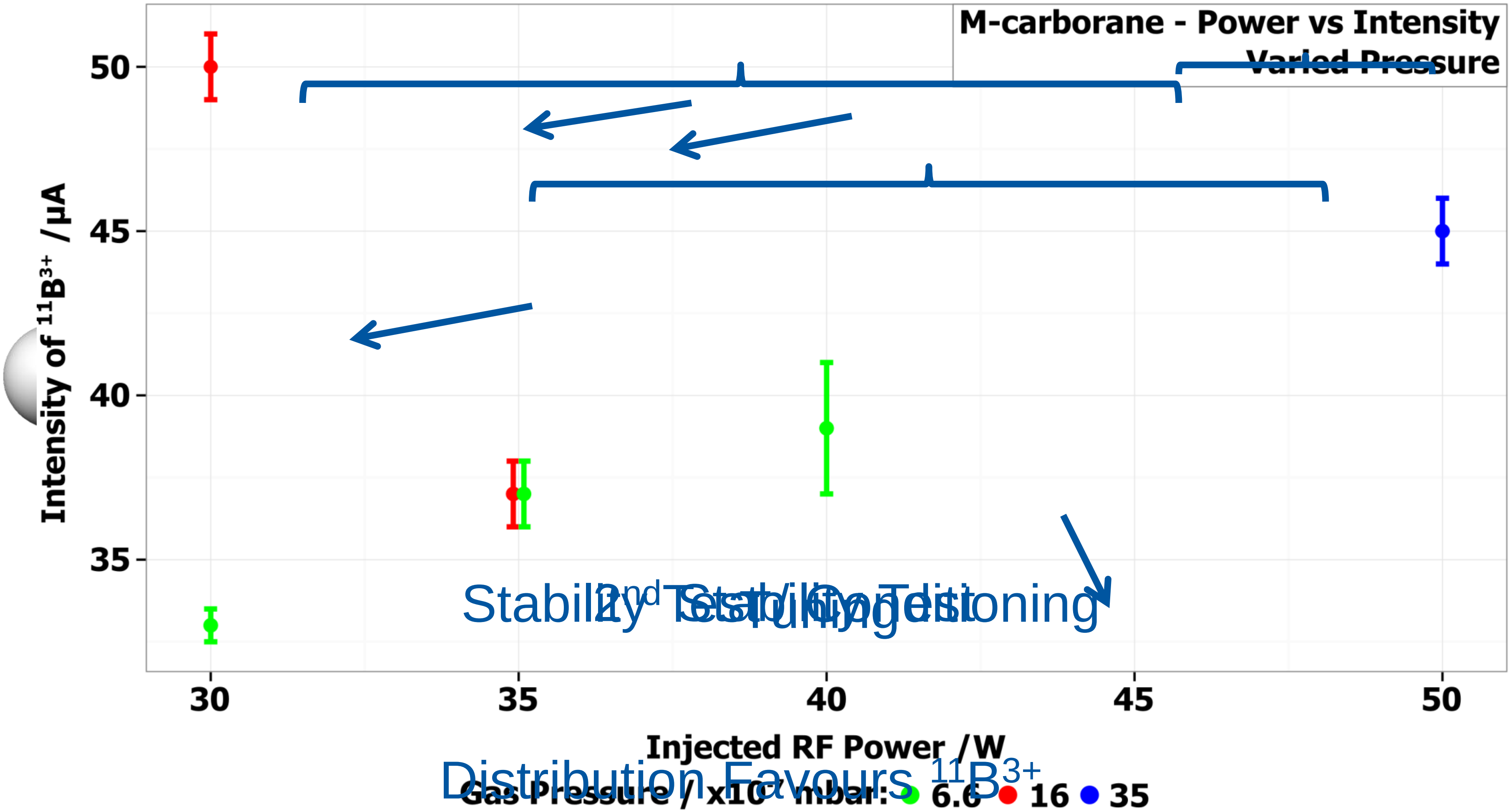


Atomic Formula	$C_2H_{12}B_{10}$
Melting Point	546 K
Vapour Pressure	0.05 mbar
Phase at 300 K	Crystalline

Distribution Favours $^{11}B^{3+}$

M-carborane

Hydrogen



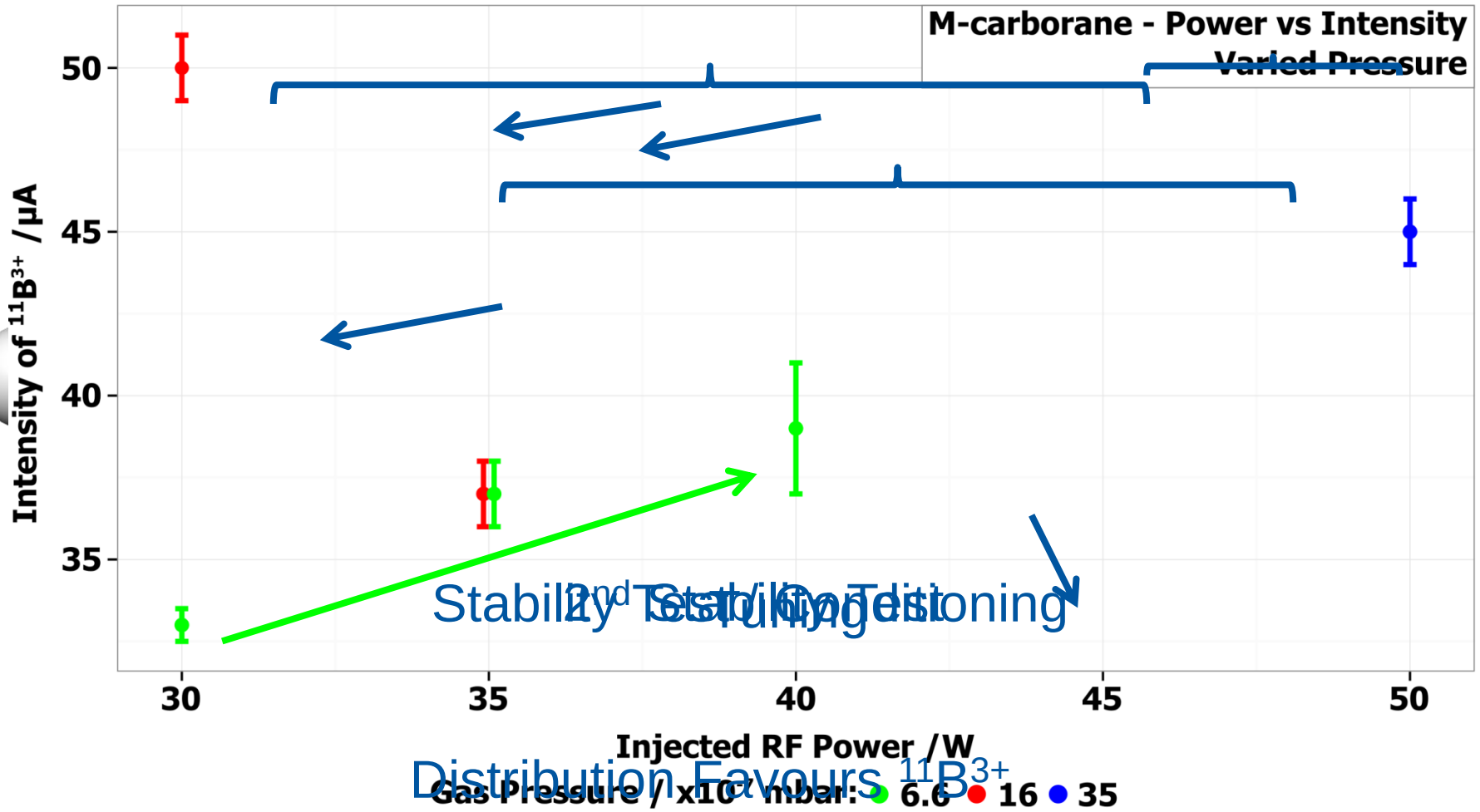
Stability Test/Conditioning

2nd Stability Test

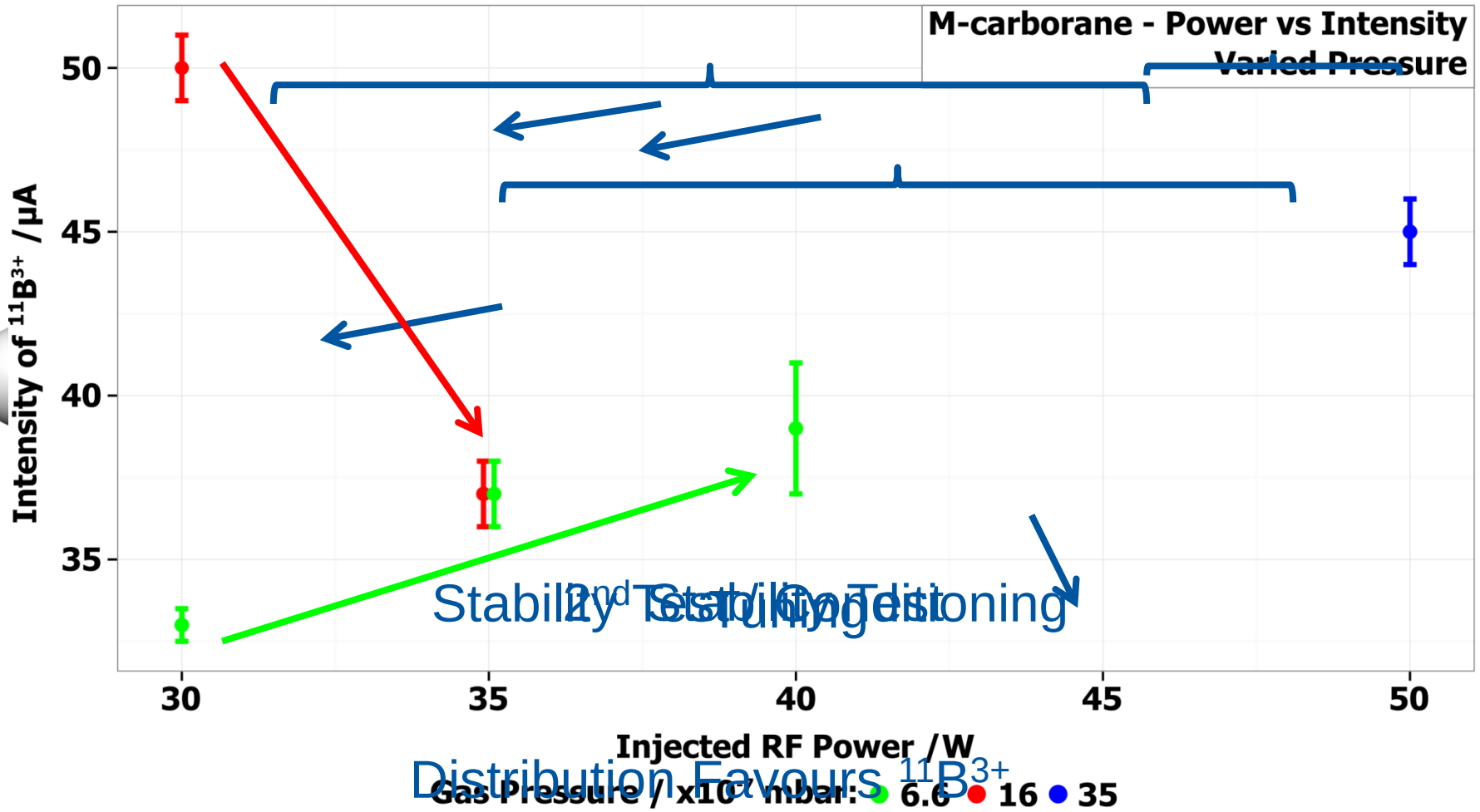
Tuning

Distribution Favours $^{11}B^{3+}$

M-carborane


Hydrogen
M-carborane - Power vs Intensity
Varied Pressure
Intensity of $^{11}B^{3+}$ /µA
50
45
40
35
30
35
40
45
50
Injected RF Power /W
Gas Pressure / x10⁻⁷ mbar: 6.6 16 35
Stability Testing
2nd Stability Testing
Distribution Favours $^{11}B^{3+}$

M-carborane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Stability Testing
2nd Stability Testing
Distribution Favours $^{11}B^{3+}$

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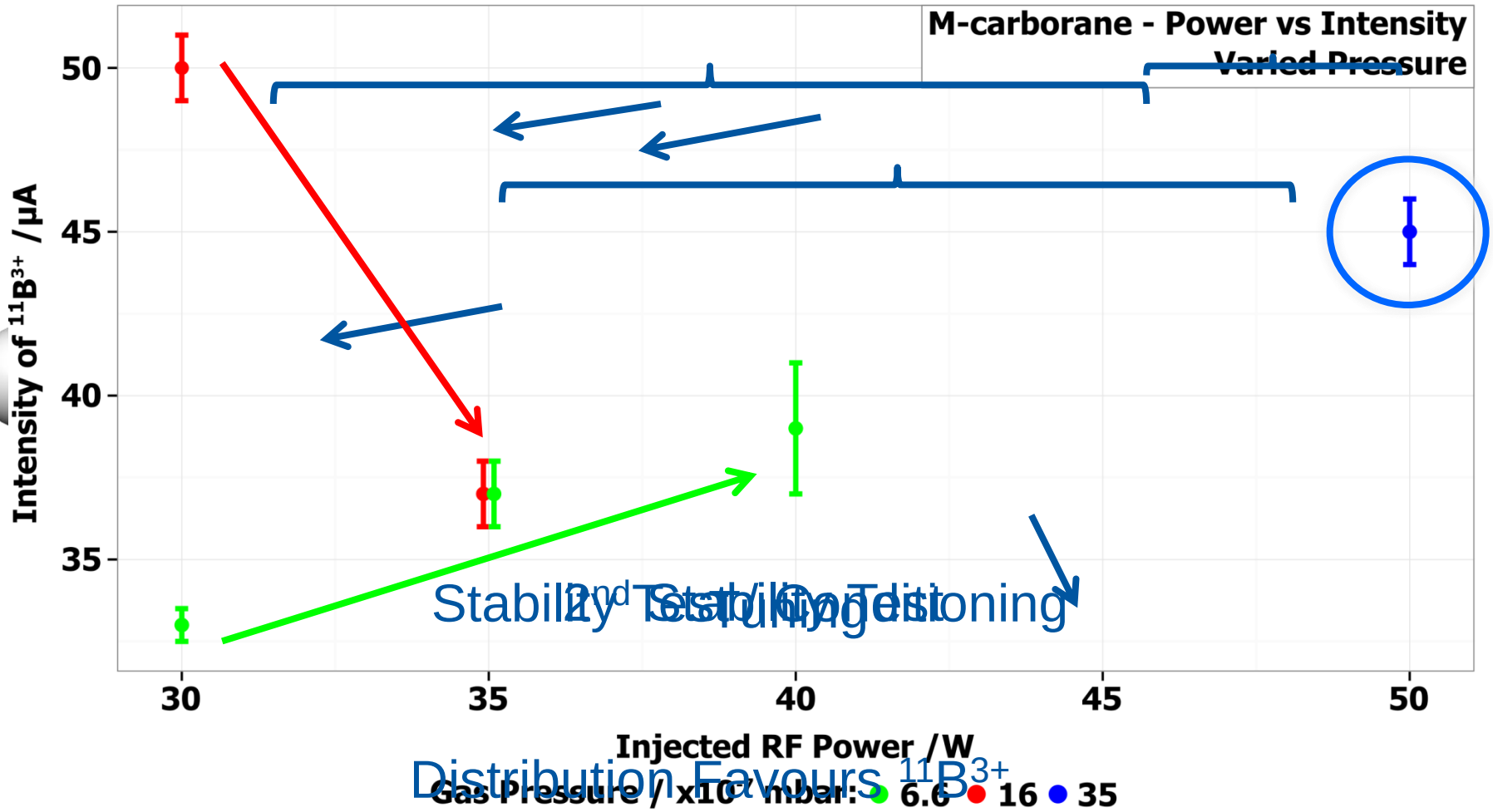


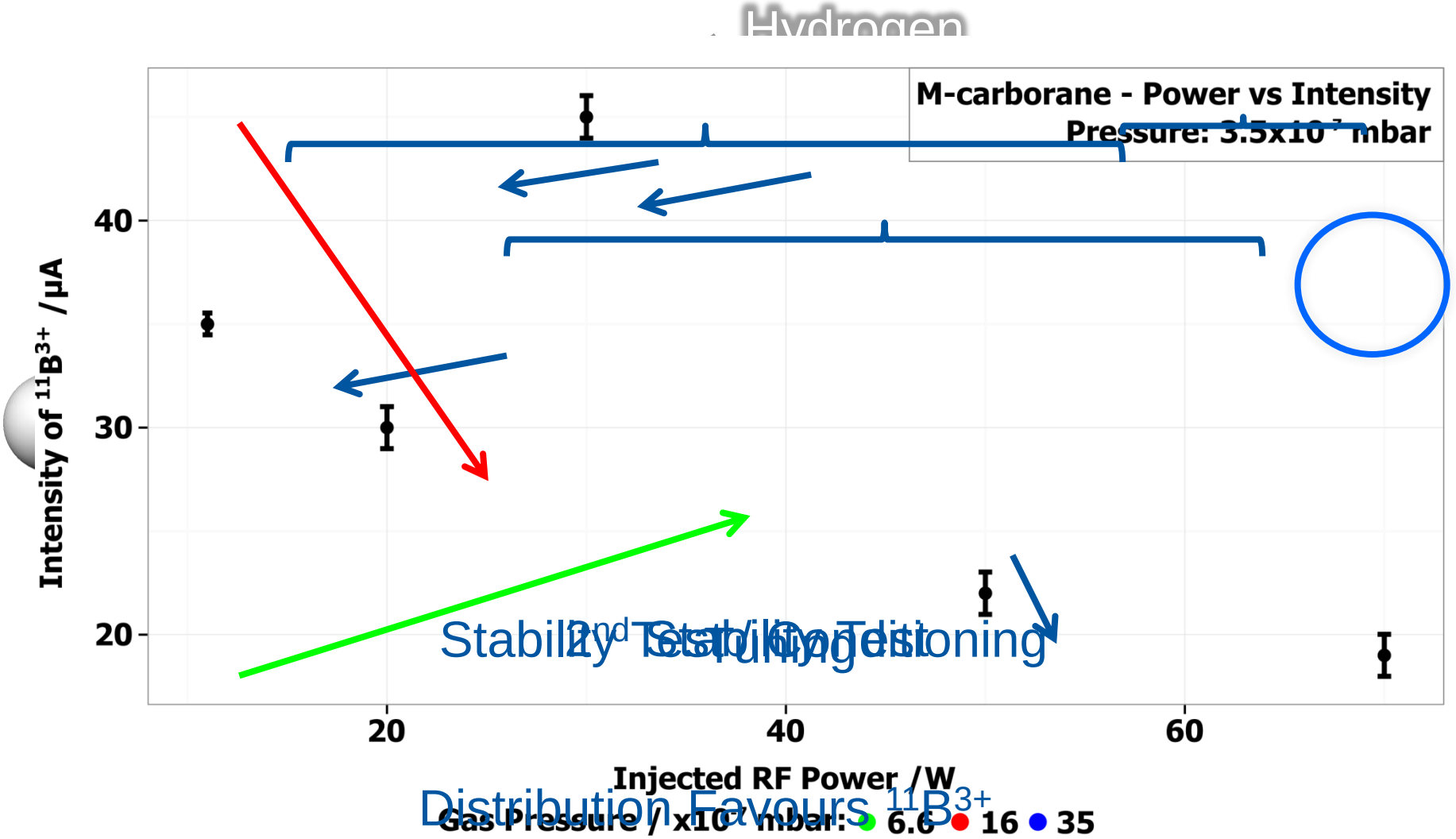
Hydrogen

Stability Testing

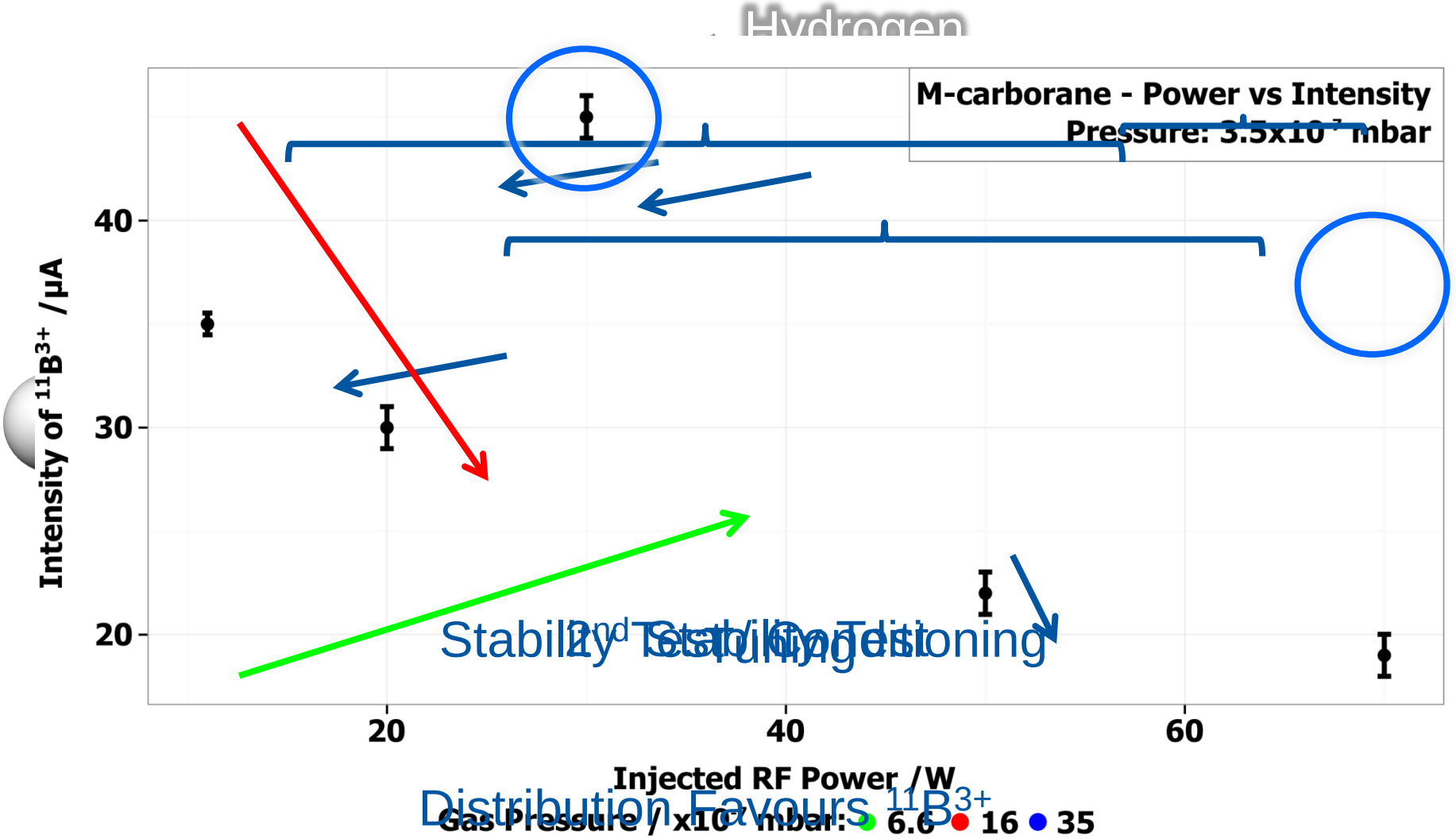
2nd Stability Testing

Distribution Favours $^{11}B^{3+}$

M-carborane


Hydrogen
M-carborane - Power vs Intensity
Pressure: 3.5x10⁻⁷ mbar
Intensity of $^{11}B^{3+}$ /µA
40
30
20
20
40
60
Injected RF Power /W
Gas Pressure / x10⁻⁷ mbar: 6.6 16 35
Stability Testing
2nd Stability Testing
Distribution Favours $^{11}B^{3+}$

M-carborane


Hydrogen
M-carborane - Power vs Intensity
Pressure: 3.5x10⁻⁷ mbar
Intensity of $^{11}B^{3+}$ /µA
40
30
20
20
40
60
Injected RF Power /W
Gas Pressure / x10⁻⁷ mbar: 6.6 16 35
Stability
2nd Stability
Distribution Favours $^{11}B^{3+}$

Success!

Success!

- Supernanogan can deliver Boron for medical research!
- M-carborane without support gas can deliver up to 50 μA of $^{11}B^{3+}$
- Decaborane, less successful. Pyrolysis makes a dirty source!

Boron Ion Beam Production for the Future CERN BIO-LEIR Facility

Joshua Stafford-Haworth
jstaffor@cern.ch

CERN
HZB Helmholtz Zentrum Berlin
JAI John Adams Institute for Accelerator Science
ROYAL HOLLOWAY UNIVERSITY OF LONDON

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