Considerations for resist outgas testing with EUV and hydrogen at NIST

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Resist Outgas TWG
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Outline

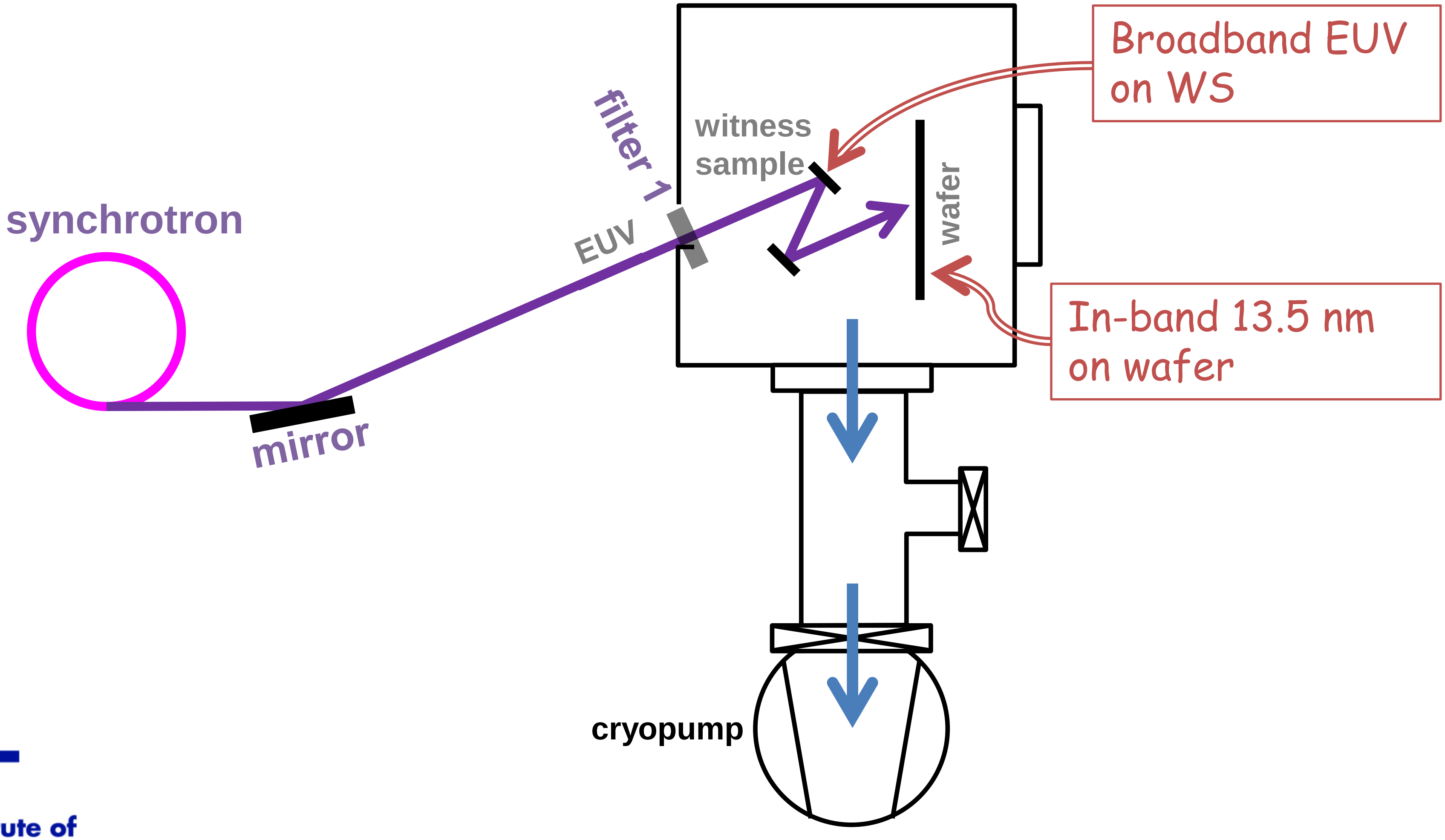
Existing outgas testing facility at NIST

Potential for outgas testing in hydrogen at NIST

Future plans

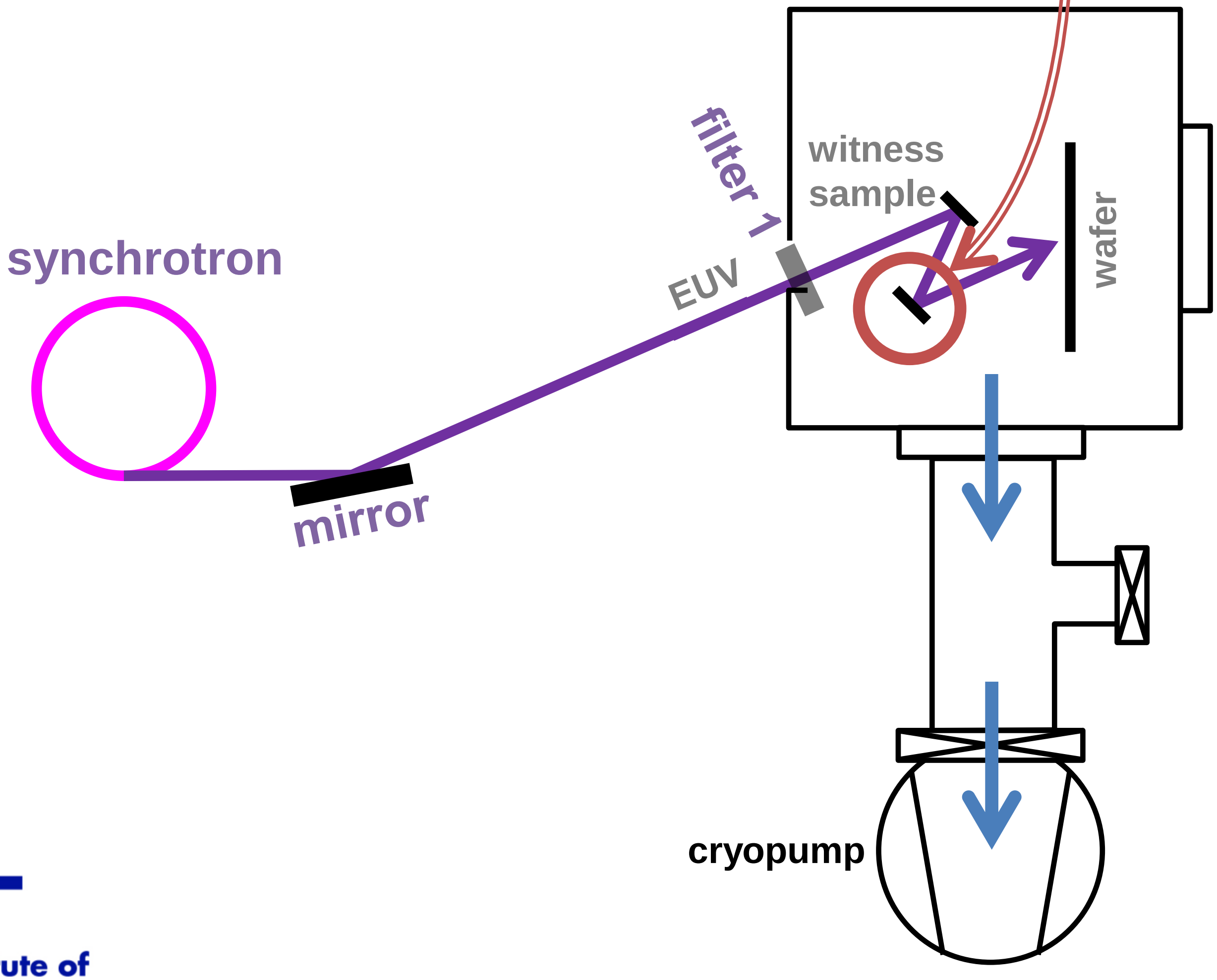
- **New commitments to NASA/NOAA**
- **Continued support of EUVL**

Existing outgas testing facility



Plan to increase power on wafer

- Remove relay mirror



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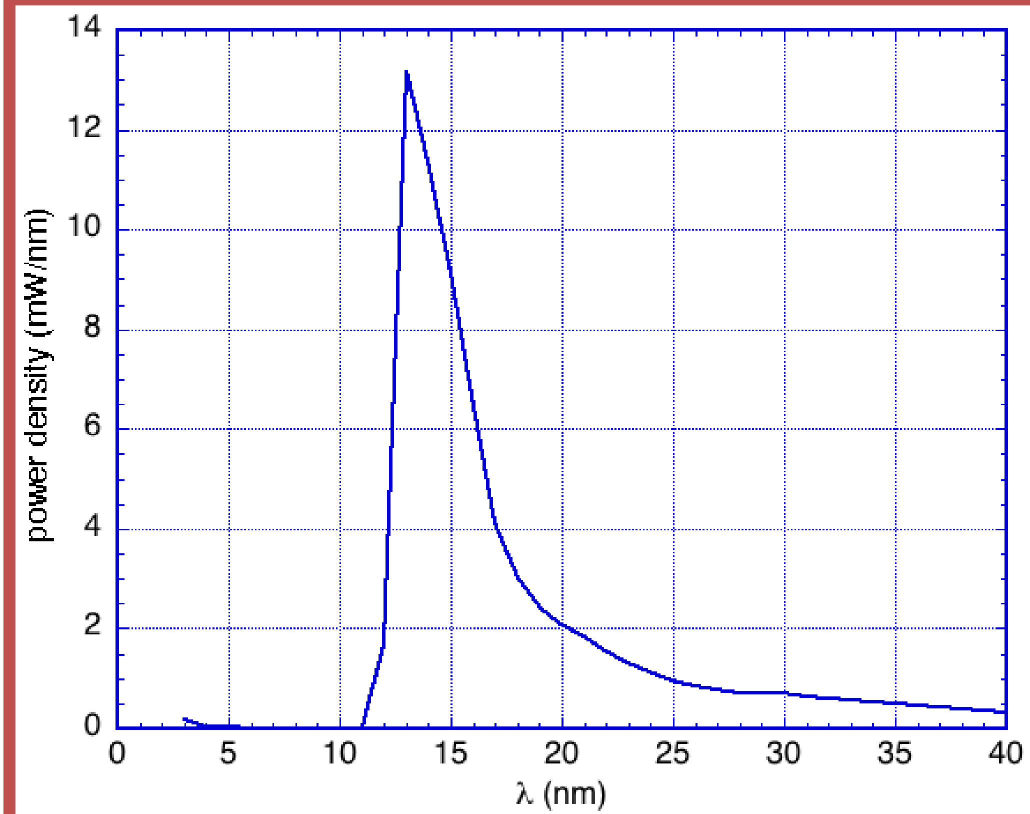
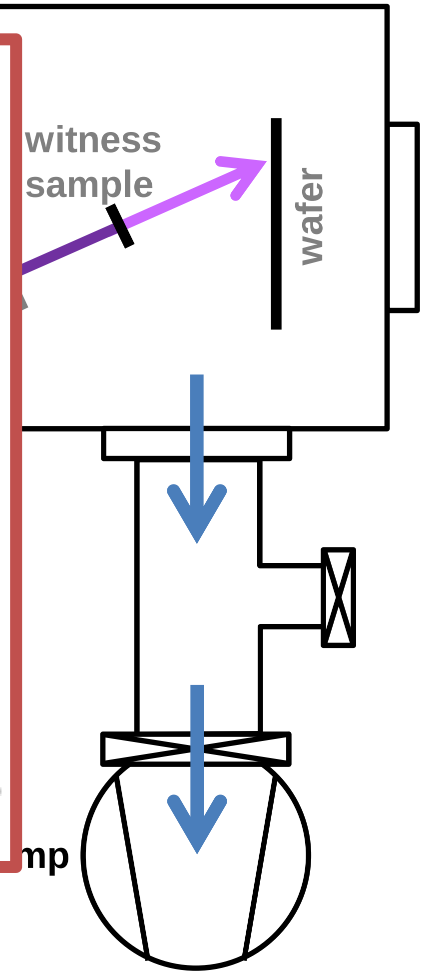
Plan to increase power on wafer

- Remove relay mirror
- WS intercepts central 40 % of beam

Broad-band EUV on WS and wafer



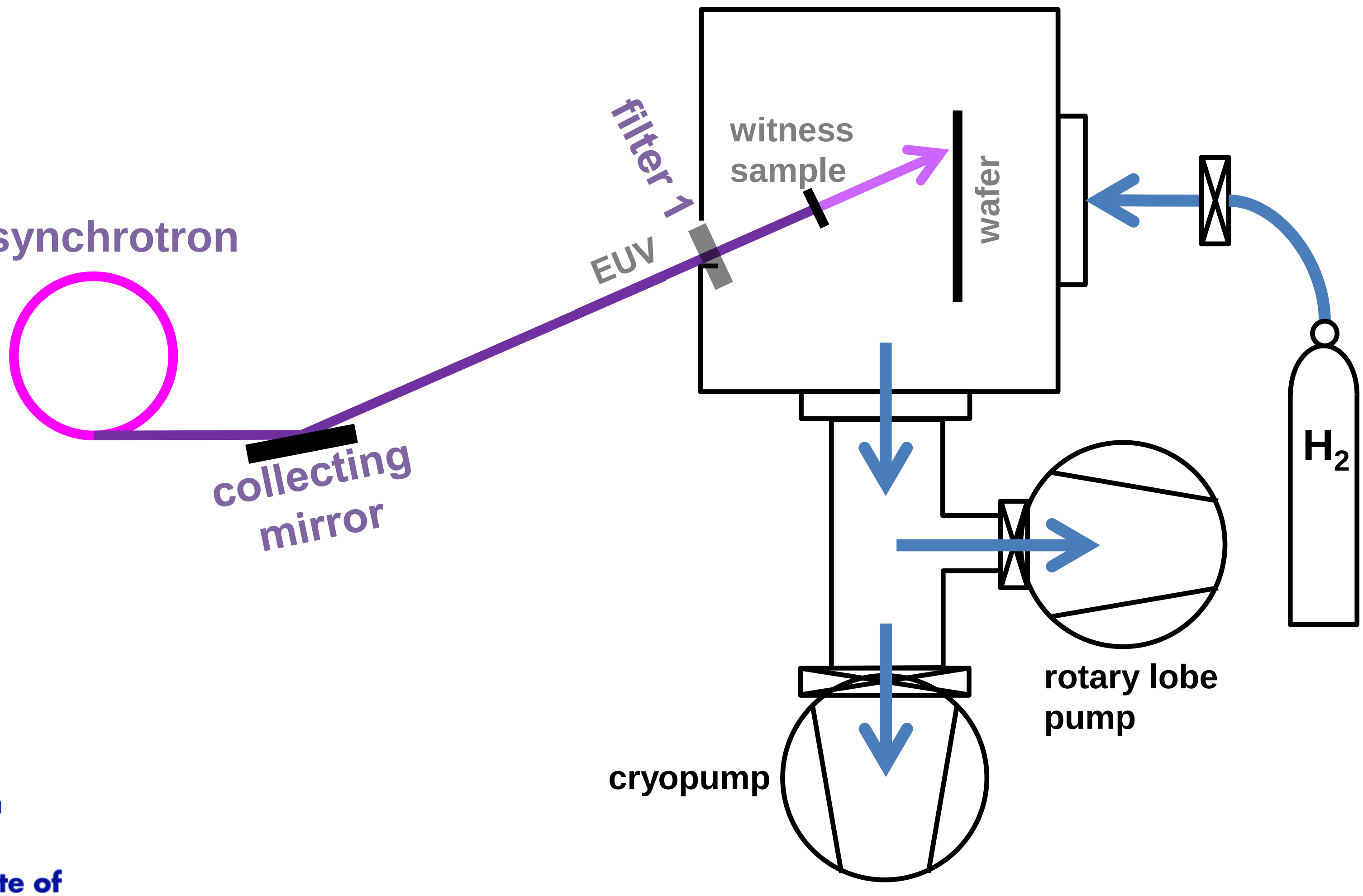


WS intensity:
(10-20) mW/mm²

Wafer power:
~40 mW

Plan to add hydrogen flow

Contaminating vapors diffuse through hydrogen atmosphere from wafer to witness sample.



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Hydrogen pressure and flow rate

How much hydrogen?

pressure	1 mbar (750 mTorr, 100 Pa)
flow rate	enough to remove outgassing of H_2O

Minimum pumping speed to keep up with H_2O outgassing

$$\dot{V}_{\mathrm{pumpMin}} = \frac{Q_{\mathrm{water}}}{P_{\mathrm{H2O}}} = \frac{\left(6\times10^{-7}\ \mathrm{mbar\ L\ s^{-1}}\right)}{\left(1.0\times10^{-7}\ \mathrm{mbar}\right)} = 6\ \mathrm{L\ s^{-1}}$$

Corresponding flow rate

$$Q_{\mathrm{H2min}} = P\dot{V}_{\mathrm{pumpMin}} = 6\ \mathrm{mbar\ L\ s^{-1}} = 360\ \mathrm{sccm}$$

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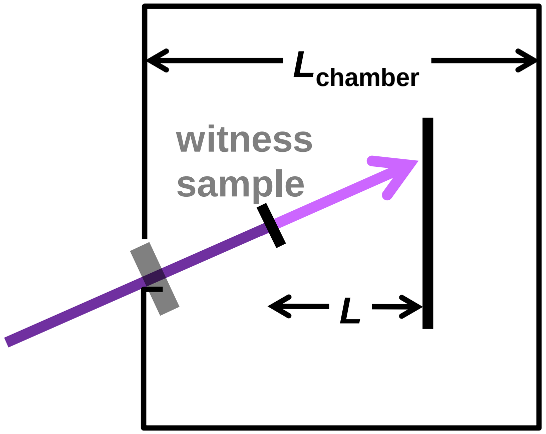
Gas flow vs diffusion

Q: How much time is needed for outgas species to diffuse to the witness sample?
A: 0.03 s



$$t_D \equiv \frac{L^2}{D} = 0.03\ \mathrm{s}$$

Q: How much time is needed for the H_2 flow to sweep out the volume L^3 ?
A: 0.8 s

$$t_{\mathrm{flow}} \simeq \left(\frac{L}{L_{\mathrm{chamber}}}\right)\frac{V_{\mathrm{chamber}}}{\dot{V}_{\mathrm{pump}}} \simeq \left(\frac{0.042\ \mathrm{m}}{0.5\ \mathrm{m}}\right)\frac{(56\ \mathrm{L})}{\left(6\ \mathrm{L\ s^{-1}}\right)} = 0.8\ \mathrm{s} \gg t_D$$

Outgas molecules will reach WS before being swept away

Protecting the NIST synchrotron (SURF III) from hydrogen

Risks

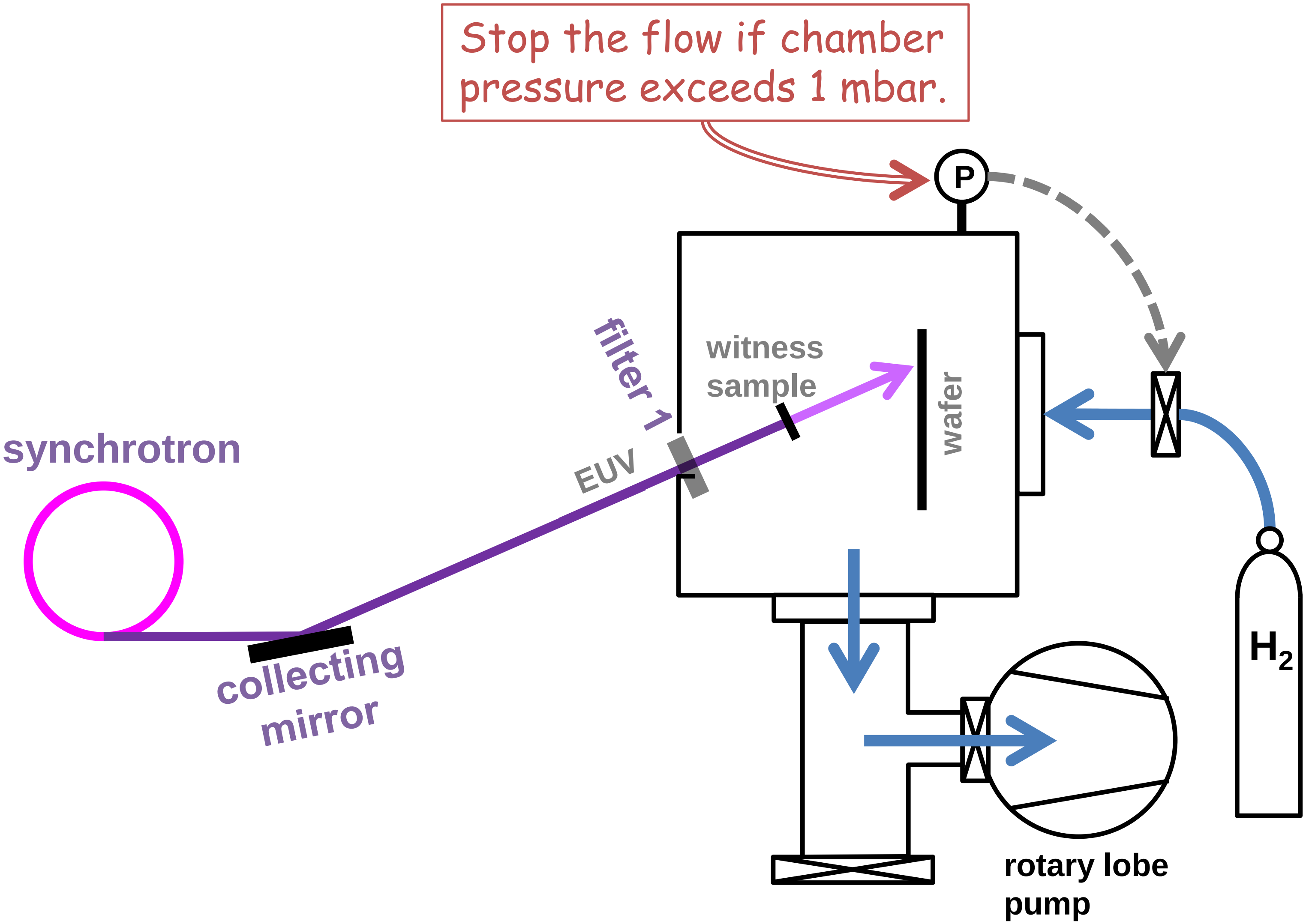
- A large, one-time dose of H_2 could permanently degrade SURF ion pumps
- Ion pumps are integral to the storage ring so cannot be repaired/replaced

Consequences

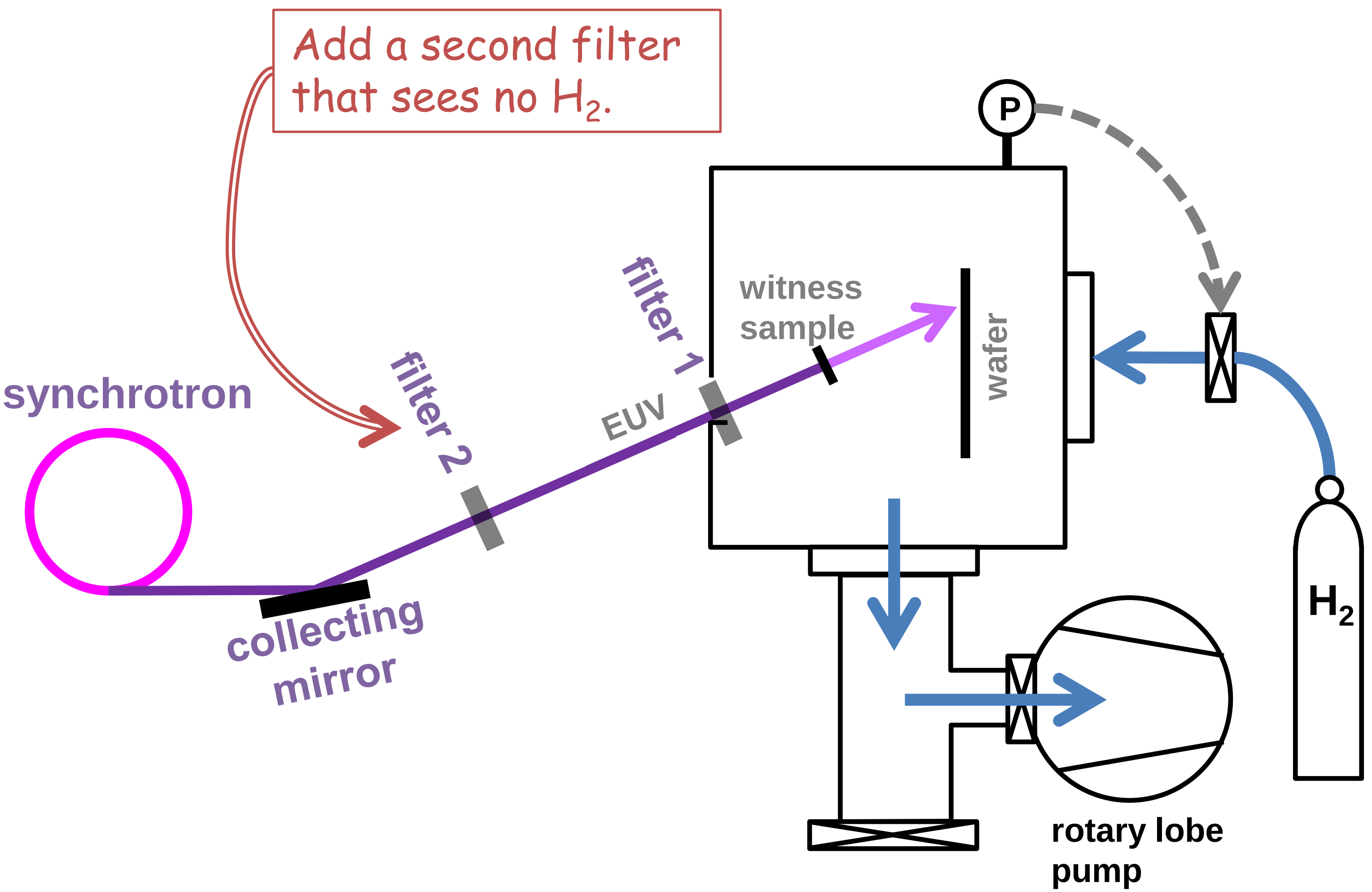
- Damaged ion pumps = **new synchrotron!**

SURF must be protected against a burst of hydrogen.

Plan to protect the synchrotron



Plan to protect the synchrotron



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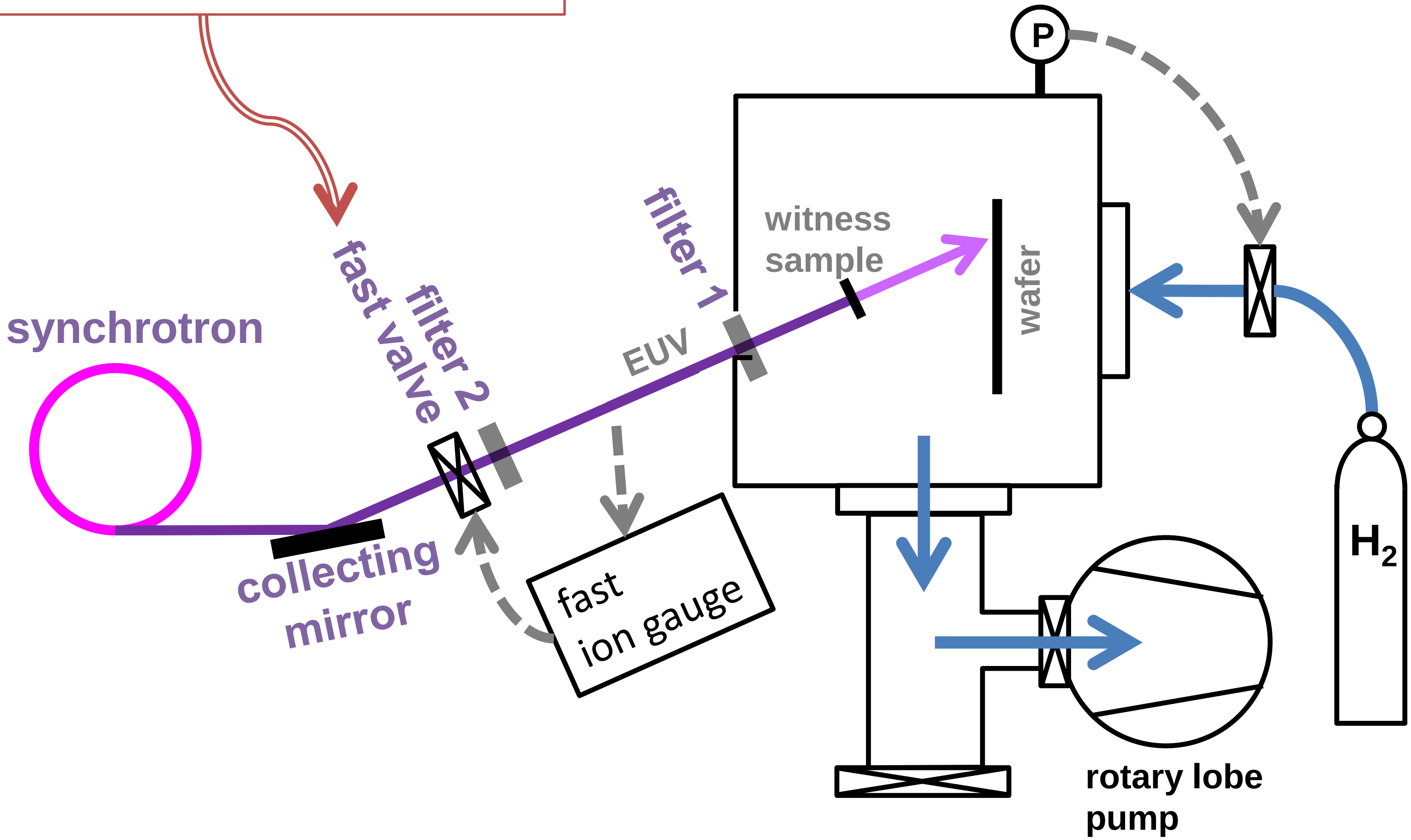
Plan to protect the synchrotron

Shut the fast valve (<10 ms)
if pressure in the beamline rises.



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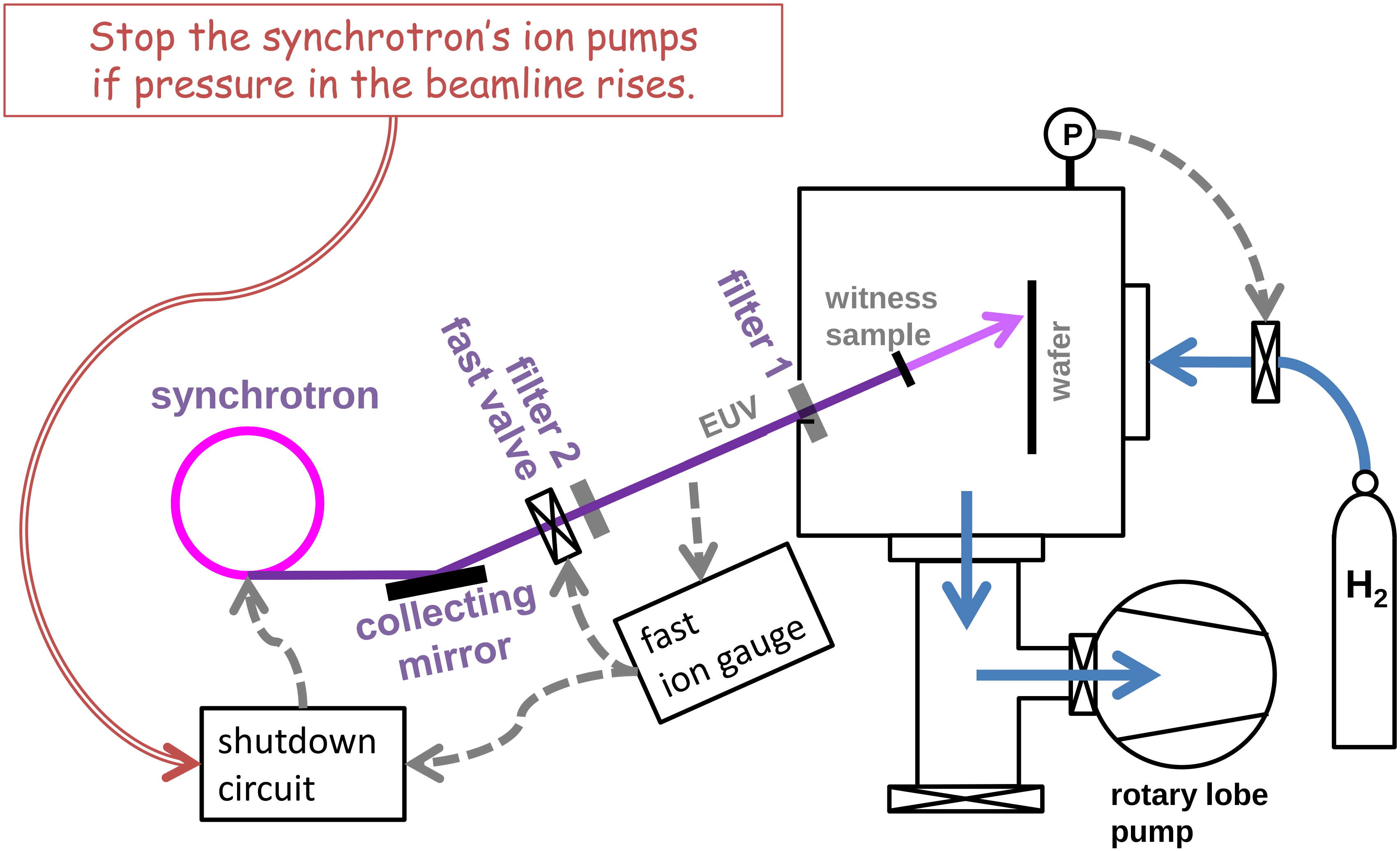
Plan to protect the synchrotron



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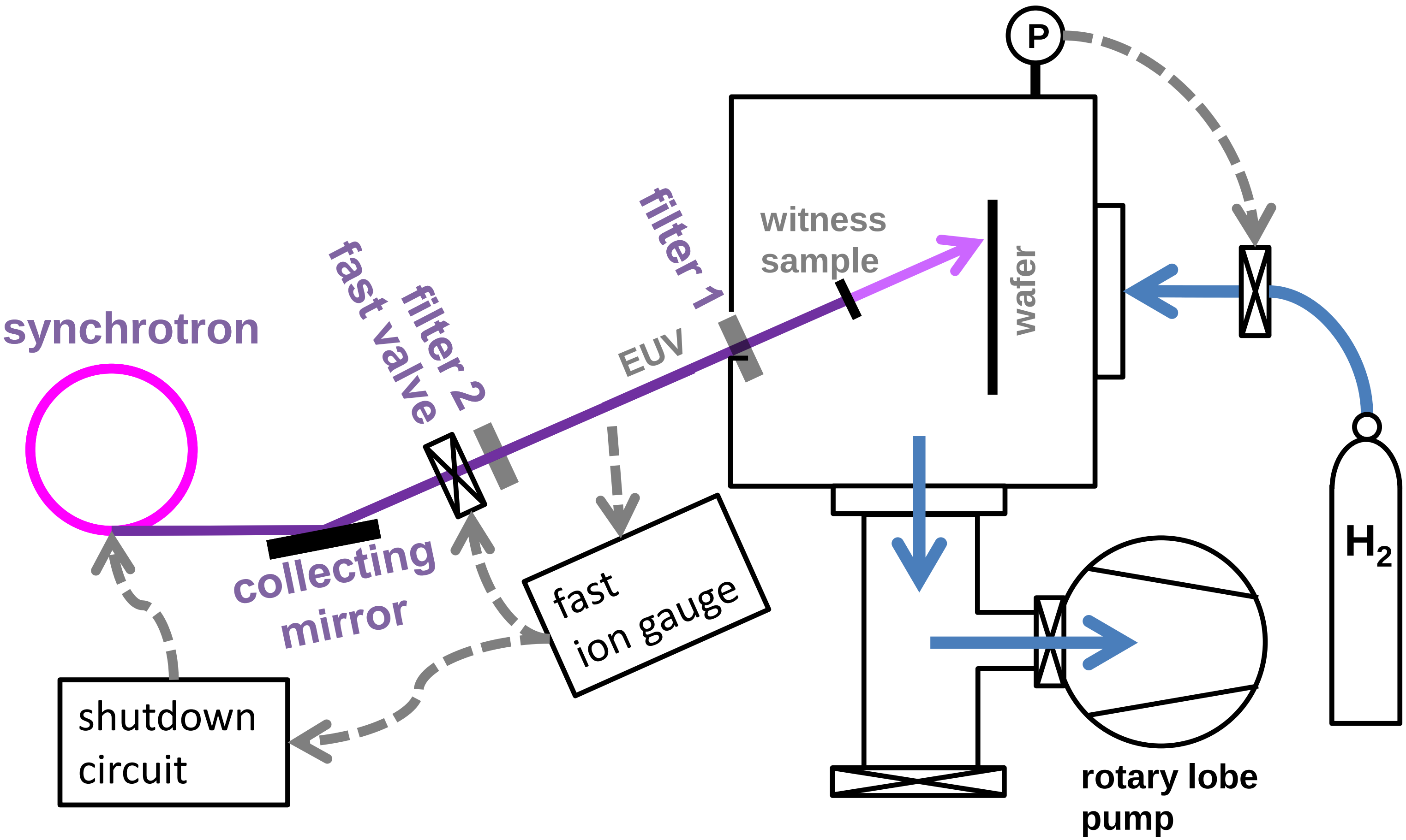
Plan to protect the synchrotron

Significant capital investment for H_2 upgrade



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Summary: proposed H_2 outgas testing facility

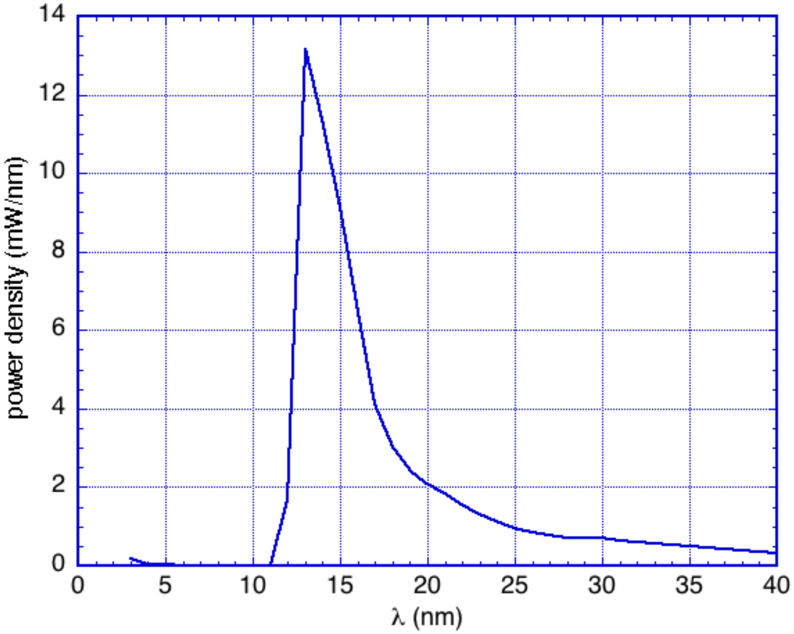
Hydrogen atmosphere
- Max pressure: 1 mbar
- Flow rate: 360 sccm

Average witness sample intensity
- (10-20) mW/mm^2

Average power on wafer
- ~40 mW

Pulse structure of EUV
- Rep rate: 114 MHz
- Pulse duration 1 ns
- Duty factor 10 %

Broad-band EUV on
- witness sample
- AND wafer



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Future plans

Substantial support from NOAA/NASA to study degradation of solar-observing satellite instruments

Requires commitment to one of following options by April 2016

Current plan: modify outgas testing beamline for NOAA program

- Standard outgas tests may require extra time
- Upgrade to H2 configuration would require greater support and time

Optional plan: perform NOAA work on new beamline

- Continued avaliability of standard resist-outgas testing
- Easier upgrade of outgas beamline to H_2 configuration
- Substantially increases cost/time for NOAA work

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