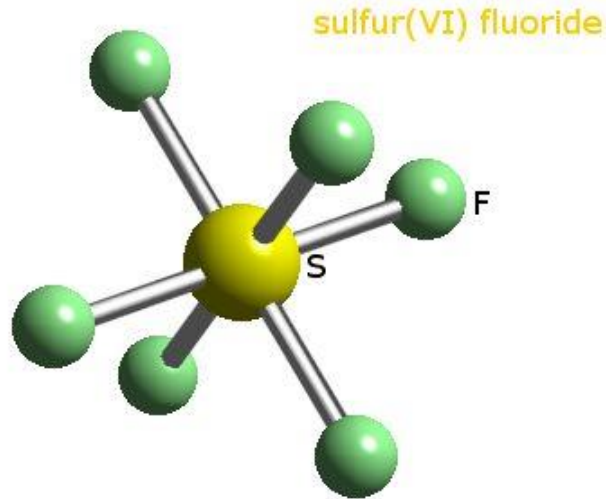


SF₆-free S-band circulator for photo injectors



S. Doebert, SY-RF-MKS, CIPEA Innovation Day, 27th June 2022

Green house gas SF₆ (Sulfur hexafluoride)



- Global warming potential 23900 x Co₂
- remains in the atmosphere up to 3200 years
- Mainly used for electrical insulation

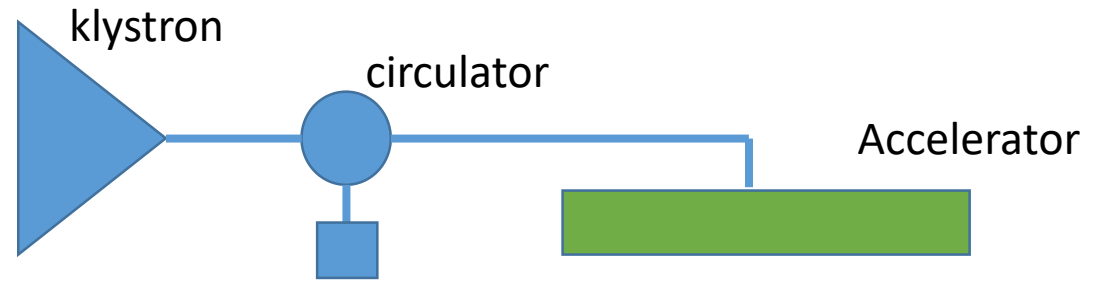
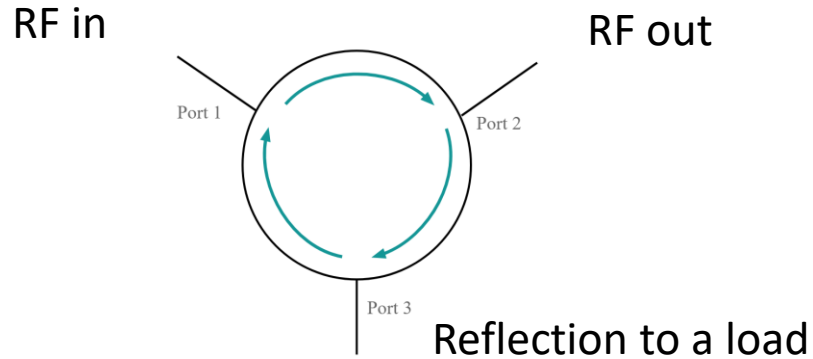
“SF6: The little Gas That Could Make Global Warming Worse”

Forbes 25/5/2021

“1997 Kyoto protocol identified SF6 as one of the six main greenhouse gases”

Forbes 25/5/2021

What is a Circulator ?



Used with SF6 for RF photo injectors in CLEAR and AWAKE at CERN, the DEFT machine at CHUV will need one as well. Many more circulators are used at CERN of course, but not filled with SF6 due to lower peak power

Proposal to develop a SF₆ free circulator

- ❑ Strategy would be to involve existing companies producing circulators and specify a vacuum compatible circulator.
For our application we need 15 MW peak power with a few micro-seconds pulse length and a vacuum < 10⁻⁷ mbar.
- ❑ CERN would provide the high power testing and qualification which those companies typically can not, since they don't have high power RF facilities.
- ❑ Finally a SF₆ free circulator would be on the market which CERN and other institutes could purchase to reduce their greenhouse gas emission

In case of success

Impact at CERN and beyond

- ❖ **In SY-RF we have about 3 kg of SF₆ in our high power waveguide systems which is equivalent to 80 T CO₂. Each time we have to exchange parts or do maintenance we have to empty and refill the systems.**
- ❖ **In case of success we could get rid of most of the SF₆ used in the RF-group which would be great in terms of CERN's green house gas emission and would simplify our systems and their maintenance.**
- ❖ **Possible impact beyond CERN. The use of SF₆ is a pain, expensive and strictly regulated in the EU. Therefore many accelerators would be happy to use such a device if available on the market.**

A rough estimate:

~ 100 high brilliance light source for science which use circulators around the world

~ 4000 medical accelerators for cancer treatment which are at lower power and therefore don't need it right now

But in case of upgrade to VHEE or FLASH such device would be beneficial

Timeline and Resources

- ❖ We estimate to develop a prototype with industry would cost ~ 50 k CHF (based on some budgetary inquiries with industry)
- ❖ Preparing specifications and purchasing and performing the high power testing at CERN would take a certain number of person weeks in our section SY-RF-MKS. (4-6 person weeks distributed over the project)
- ❖ The development would take roughly one year depending on the delivery times. If we could start this fall we would aim to complete the test in 2023.