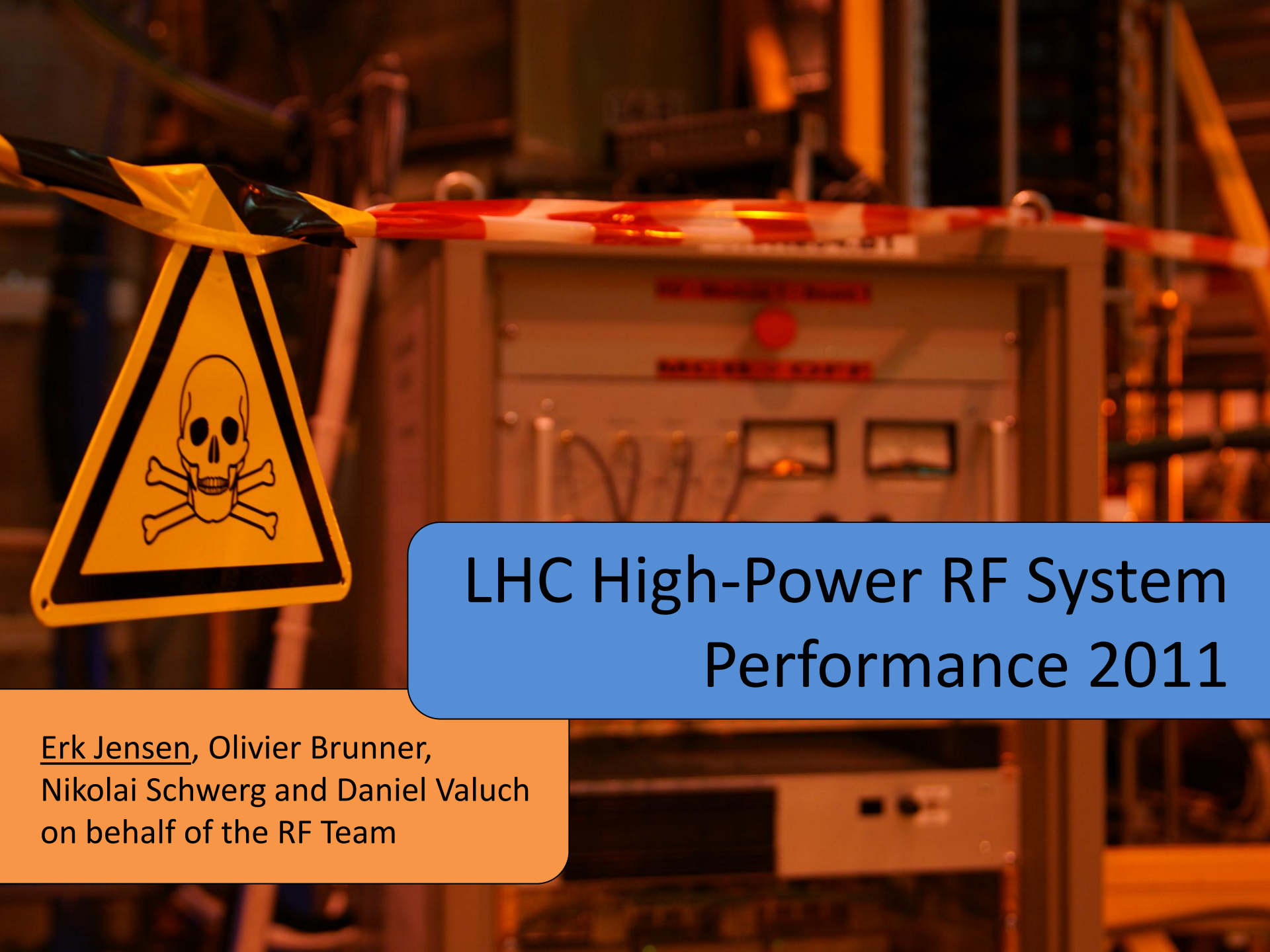
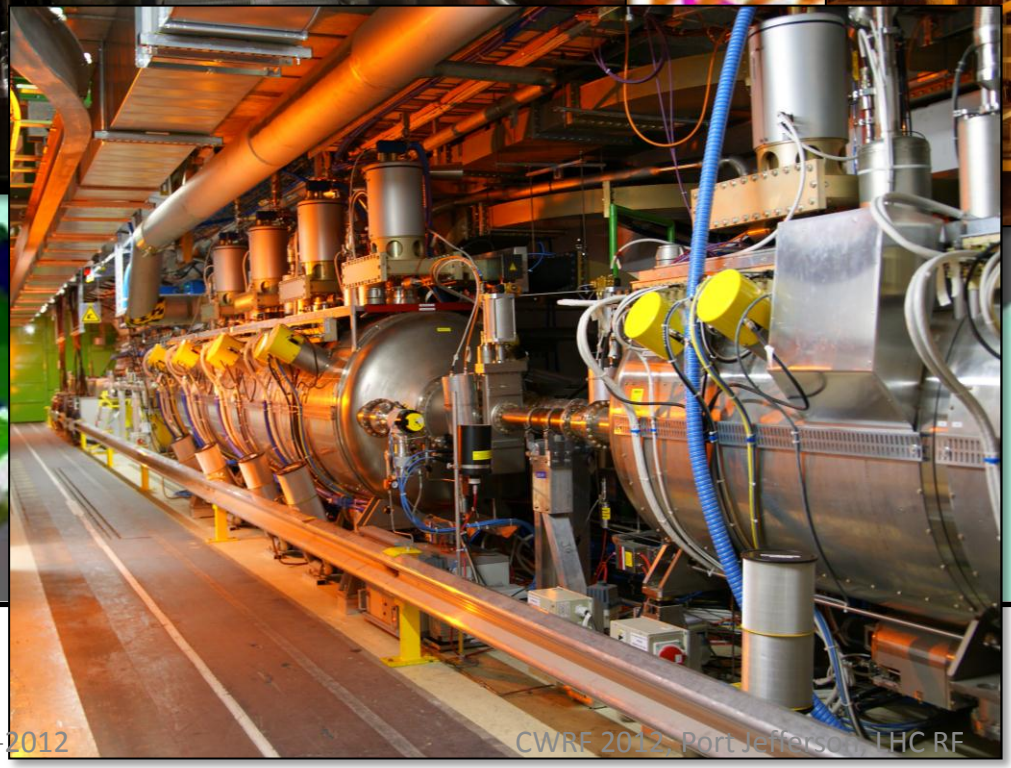


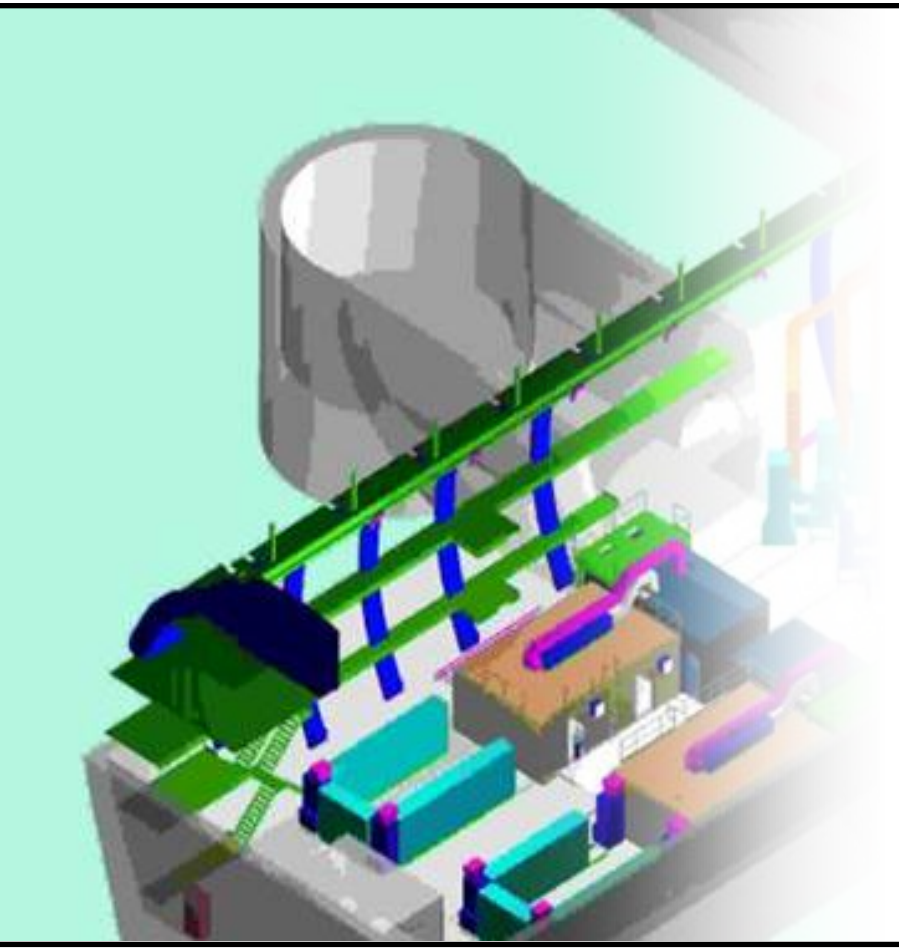
LHC High-Power RF System Performance 2011

Erk Jensen, Olivier Brunner,
Nikolai Schwerg and Daniel Valuch
on behalf of the RF Team

LHC RF System



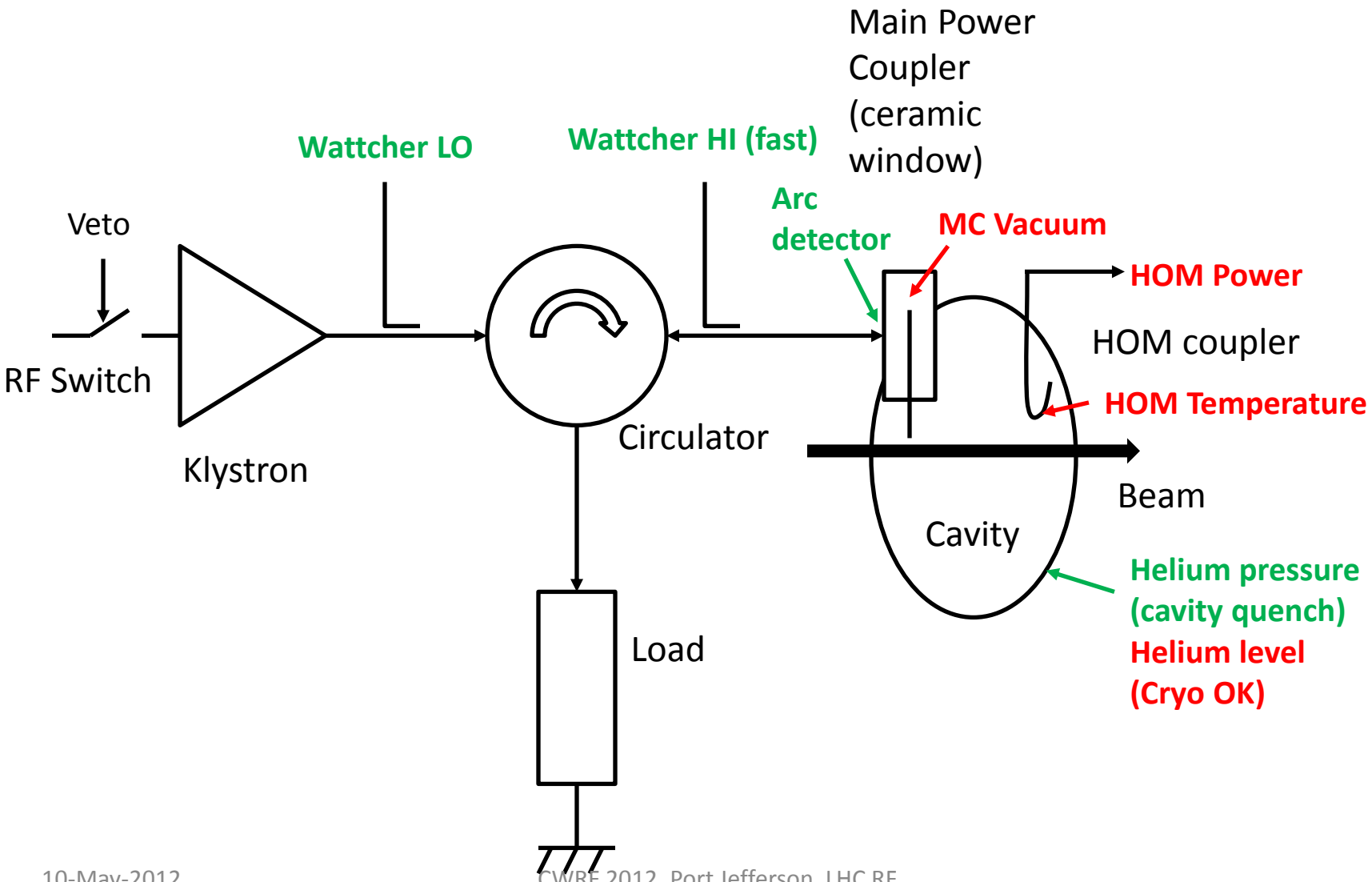
LHC RF System



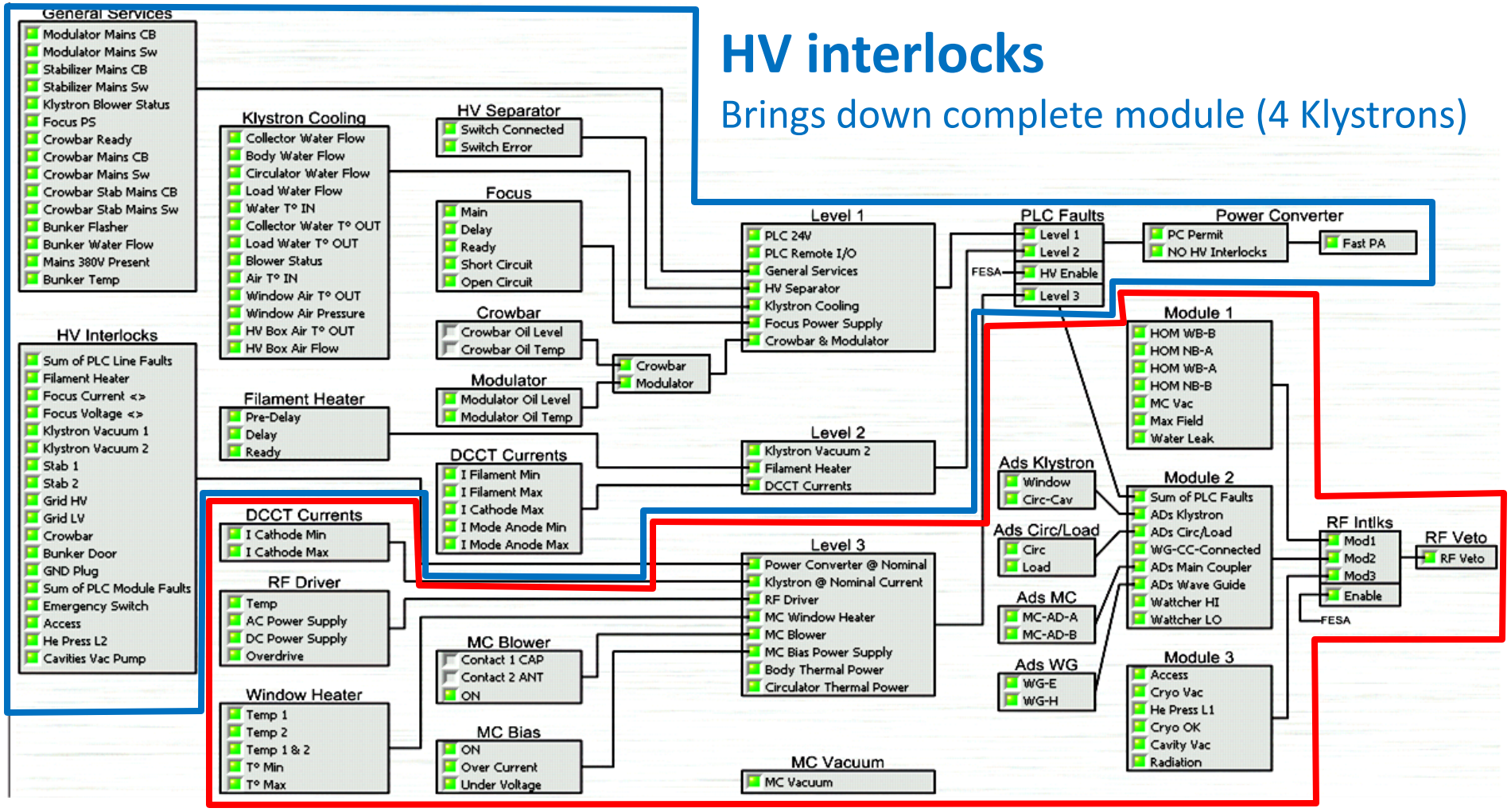
- 16 Klystrons
- 4 SC Cavity Modules
- 300 kW @ 400 MHz

- 1000 Interlocks
- All connected to the beam dump

RF power distribution & critical interlocks



RF and HV Interlock chains



Fault Statistics 2011

Highlights:

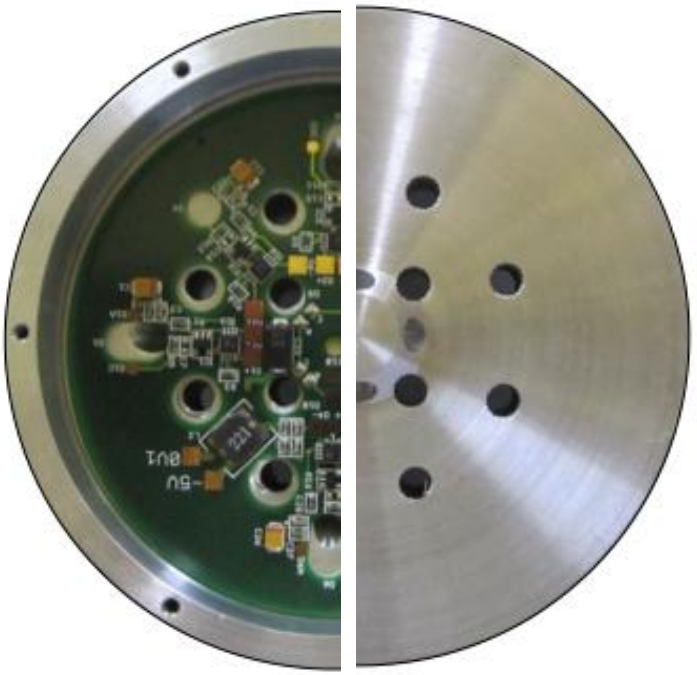
- 78 faults in total
- 11% of all beam dumps
- 2 Faults per week during proton physics
- 6.5 faults per week during ion run
- Bad last week with 13 faults
- 1 RF unit without fault!

Details:

- 11% Arc Detector
- 22% Klystron Heater
- 22% Crowbar
- 4% Focus Power Supply
- 5% PLC CPU
- 17% Cavities (HOM)
- 19% Misc. and LLRF

Arc Detector

- Parameters inherited from LEP times
- Optical fibres suffer of radiation induced opacity
- False trips due to high energy secondary showers for tunnel sensors
- High demand to increase reliability



"Shower head"
LHC Arc Detector

Separate Talk by D. Valuch on Friday

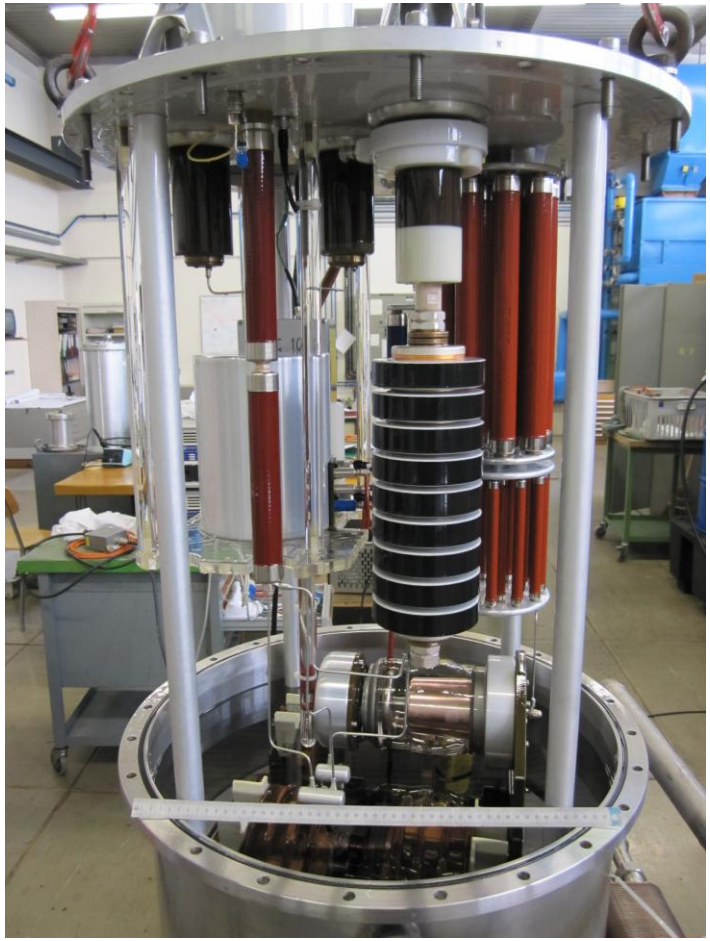
Thyratron Replacement

- Current Thyratron crowbar suffers from spurious trips
- Solid-state replacement developed using Thyristor-Stack
- Measurements very promising and show comparable performance

See: Paper at IPAC12 by G. Ravida

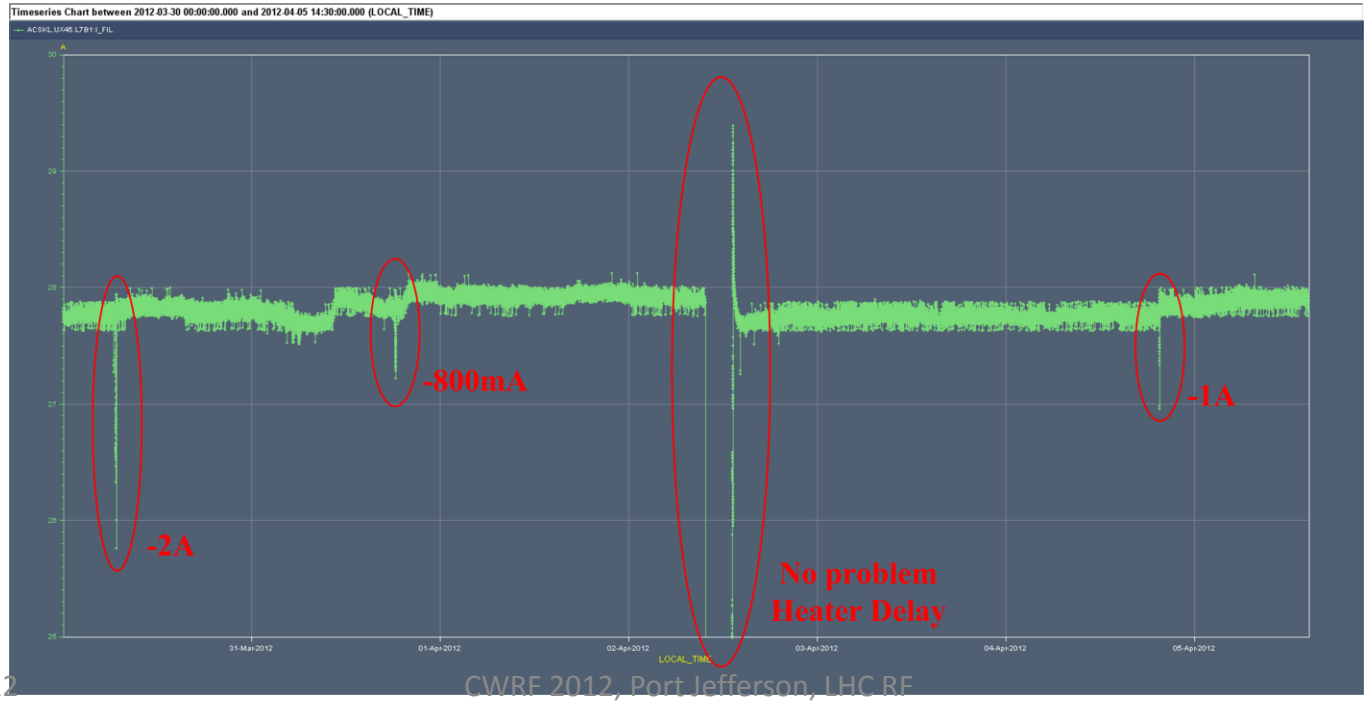
TH5186 Tetrode Replacement

- Klystron DC power increases through the ramp to provide 16 MV at flat top with heavy beam loading
- Mod Anode voltage ~ 15-45 kV, controlled by TH5186 tetrode
- End of production already announced
- New tetrode-less Mod Anode controller ready for tests



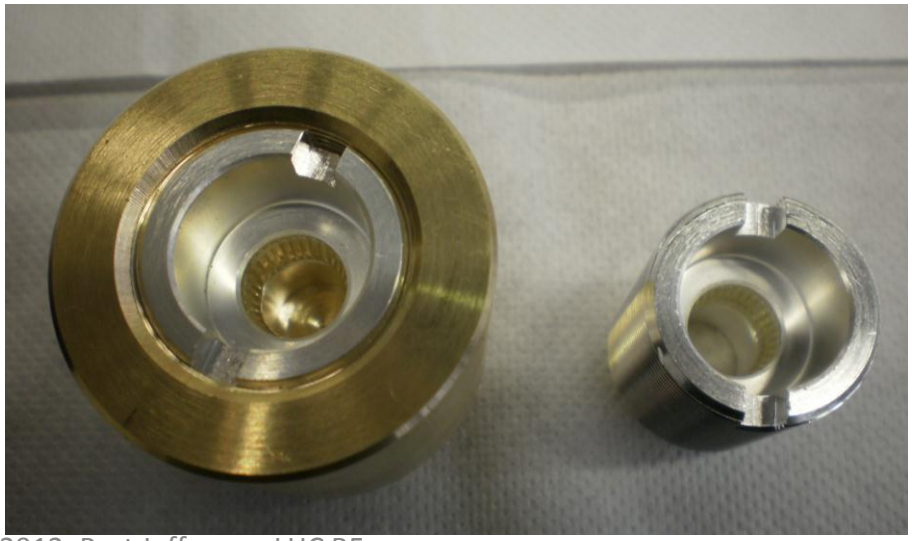
Filament and Cathode Current Measurements, HV connectors

- DCCTs recuperated from LEP (>20 years old)
- Few trips during the year, need to increase reliability and add diagnostic tool



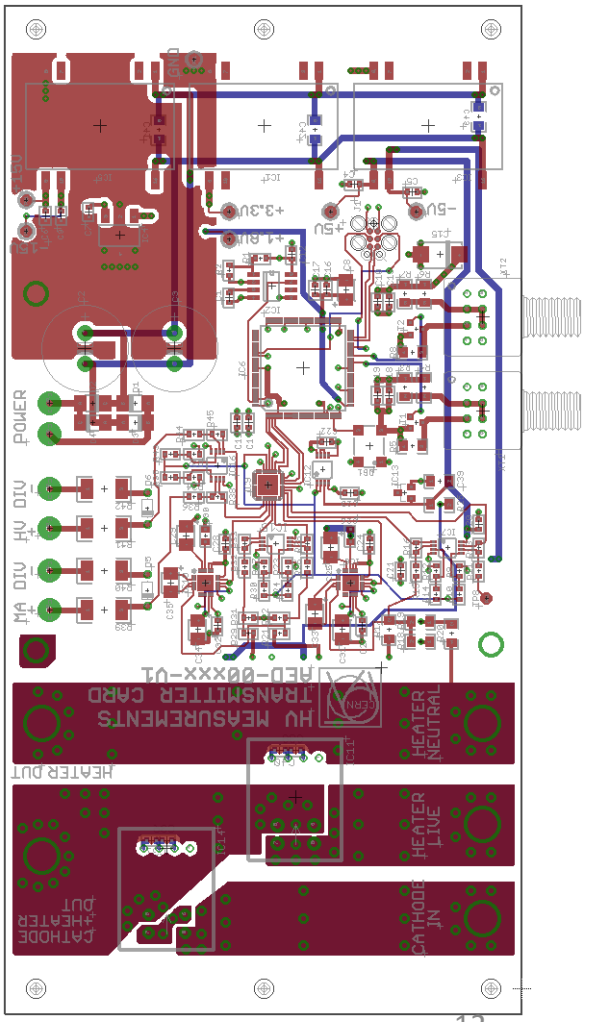
Klystron HV Connectors

- Spring contacts degrade (black deposit)
- Contacts needed to be cleaned repeatedly
- New connector design without springs, but special contacts (Multi-Contact) installed



Filament and Cathode Current Measurements

- New digital system measuring directly in the oil tank ready for tests
- Provides real time current/voltage measurements from the tank
- Data include post mortem waveforms for fault analysis



So far in 2012

- No beam dump due to high power RF
- Only one trip due to filament current

- What had been done during Winter TS?
  - Re-adjusted all thyratron settings
  - 4 boilers
  - Limited cavity fields to 1.2 MV in one cavity
  - Cleaned + verified all high voltage connectors
  - 1 new crowbar (thyristor stack)

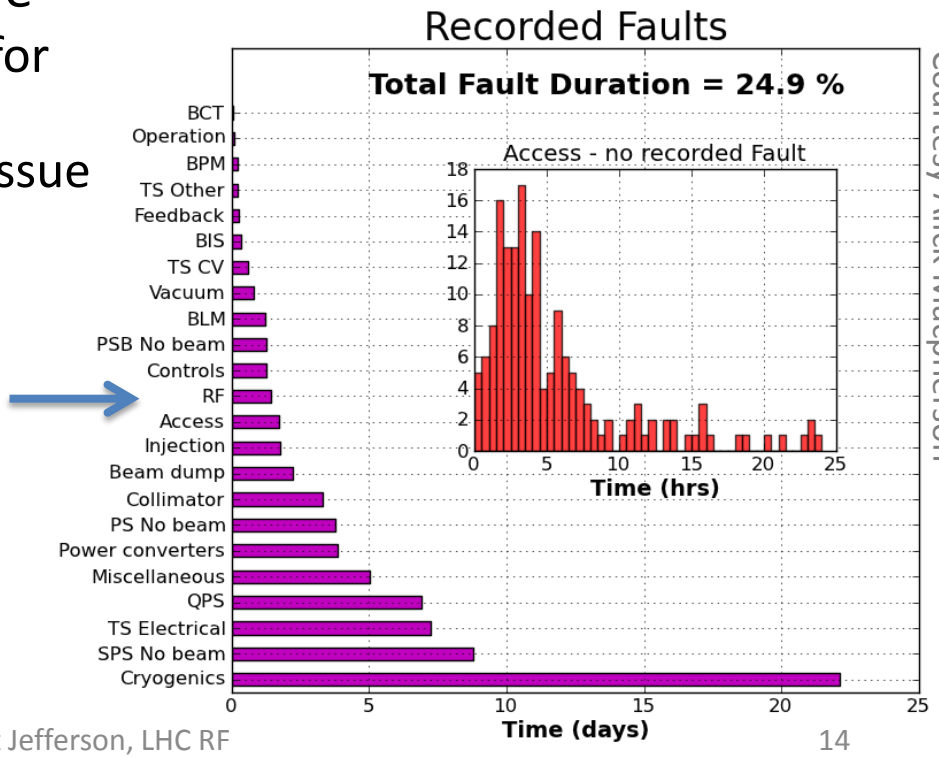
Operational Experience and Plans for LS1 (Dec 2012 to mid 2014)

RF System runs well -- few trips per year

(4th dump cause in numbers, 10th in downtime)

➔ still need for increase of reliability

- Klystron Exchange for “age profile”
  - exchanged 1 for multipactor, 1 for gun short
  - 1 dead due to collector design issue (ongoing collector boiler replacement)
- Tetrode Replacement
  - 5 dead per year
- Arc Detector Deployment
- Oil Re-conditioning
- RF Module replacement



Courtesy Alick Macpherson

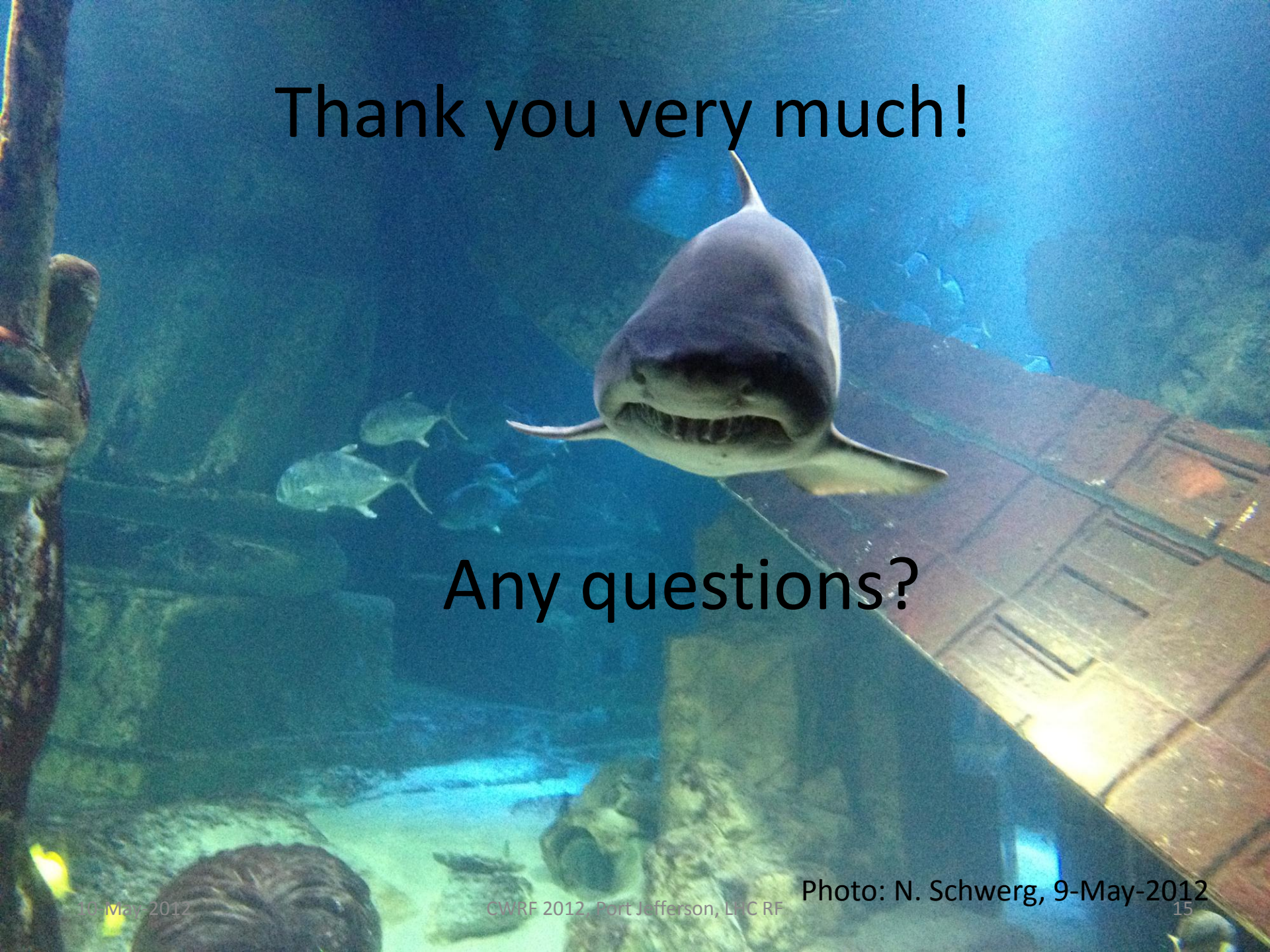


Photo: N. Schwerg, 9-May-2012