



# Updated ECR for the BGC installation phase for LS2

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# Background

- LHC installation programme first presented to HL-TCC #37 Sept. 2017
  - ECR (LHC-BGC-EC-0001) for the YETS 17/18 installation of a background gas fluorescence measurement approved by LMC #330 in Nov. 2017
  - ECR for the LS2 works prepared (LHC-BGC-EC-0002), and approved by HL-TCC #50 in May 2018
  - Formally approved for LS2 installation by LMC #367 in Nov. 2018
  - REMINDER – this concerns only Phase 1 of the BGC
    - Only the interaction chamber installed
    - No gas curtain for the moment (foreseen for YETS 21/22 & requires additional ECR)
    - This is still the prototype instrument that will be fully replaced for HL-LHC
- This presentation is to explain the new document LHC-BGC-EC-0003, which covers:
  - An update of the design for the LS2 works to the ‘as-built’ version
  - A new request to move the background gas system from the Run 2 location to the BGC location (change of 23m)

# 'As-built' changes from ECR-0002

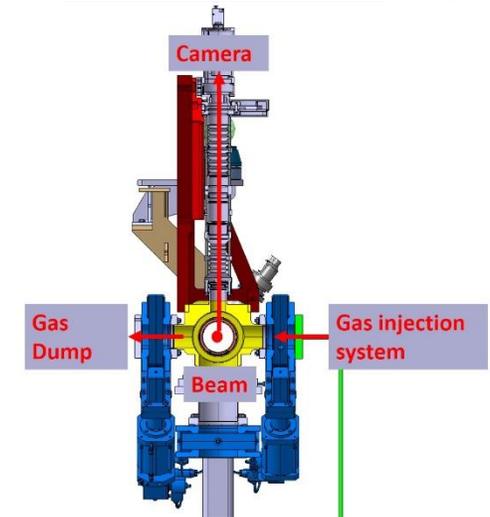
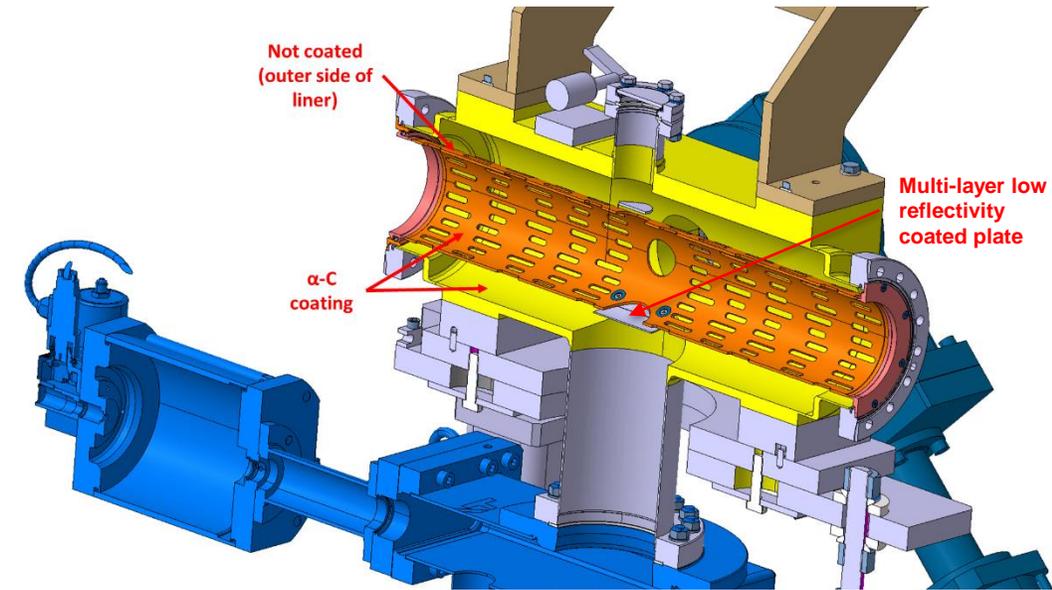
- Blackening coatings to minimize synchrotron radiation light reflection

- Both a-C and multi-layer coatings are formally approved by VSC

- Orthogonal orientation of the measurement plane

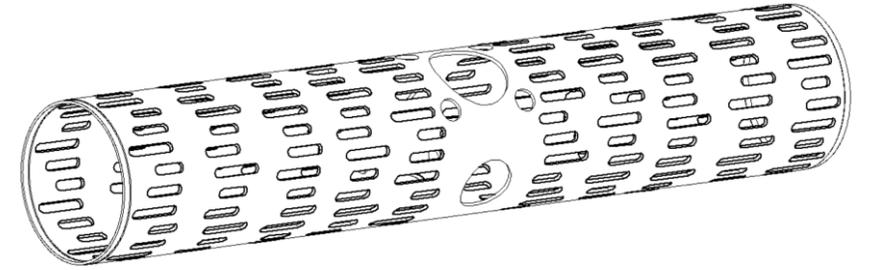
- This has been achieved by reducing the size of the final instrument

- Camera and optics are *ex-vacua* and will be removed for survey

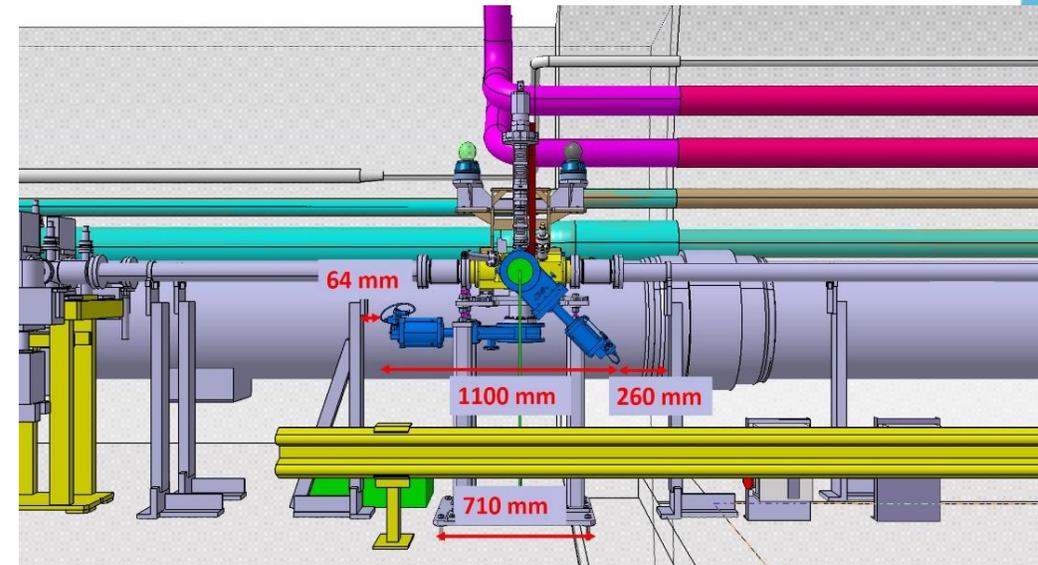


# 'As-built' Changes - 2

- RF liner produced with randomized slot pattern
  - As requested by impedance WG
- Support structure enlarged and stiffened
  - Ensure stability and support for the UHV valves
  - Requires movement of one drift vacuum chamber support by 60mm



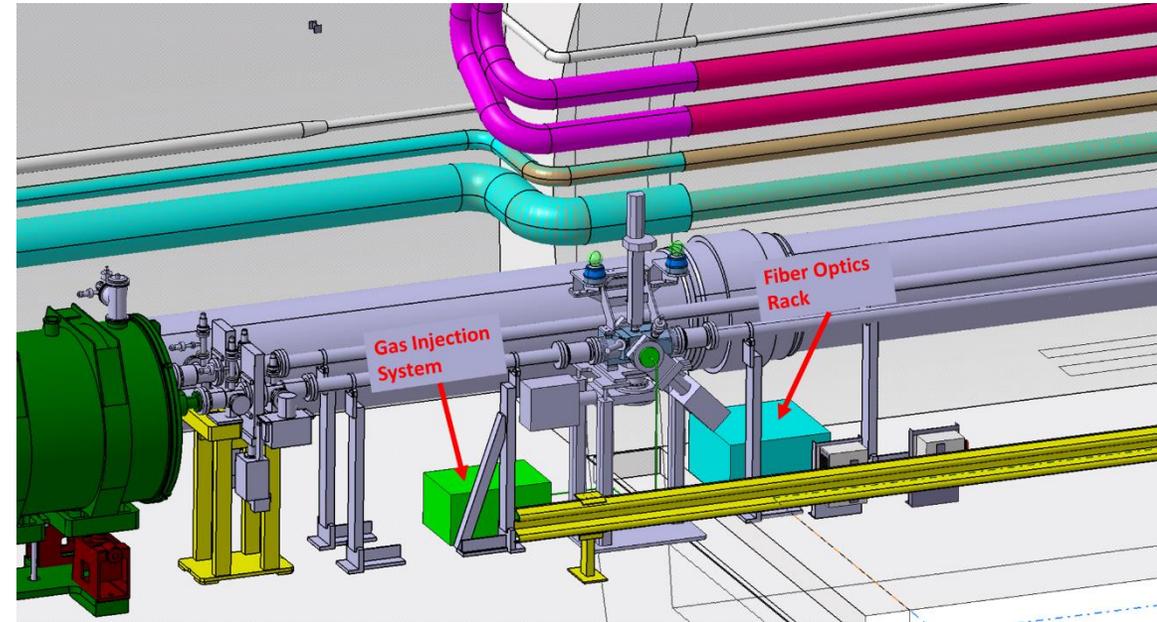
RF liner with randomized slot pattern



Integration model showing request for drift vacuum chamber support displacement

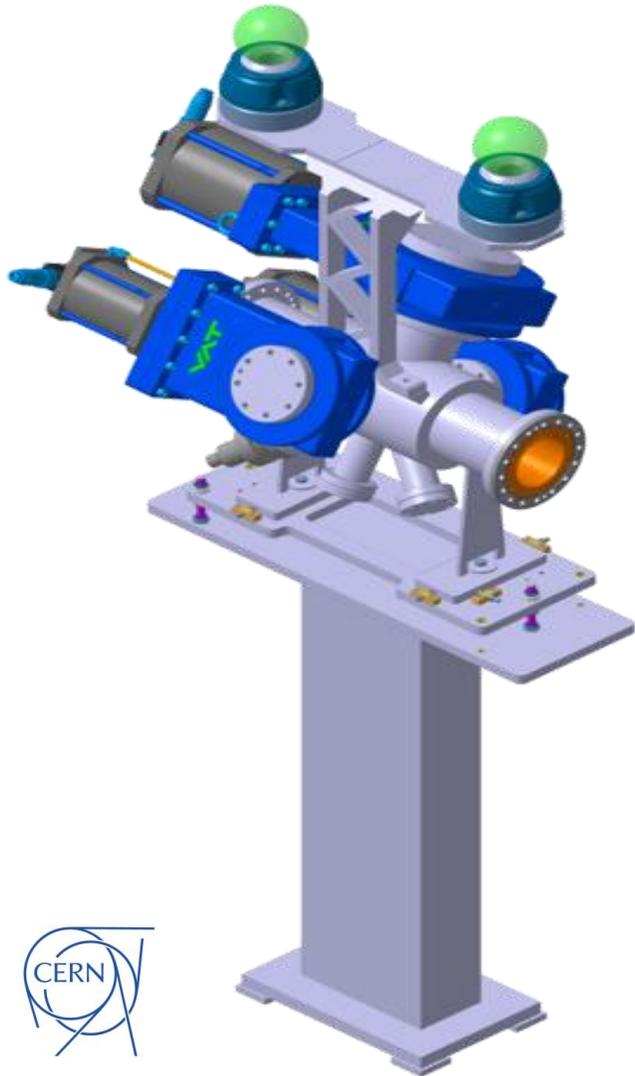
# Re-location of background gas system

- Following the successful initial tests with background gas in 2018 several possible design improvements identified:
  - Low SR reflectivity design and coatings
  - Improved optical system
  - Better optics-to-beam alignment
- Now implemented and should allow for significantly better profile measurements with protons
- Would like these improvements characterized in Run 3 before installation of the gas curtain and concluding on the final design for the HEL
  - Lowering of LHC SR background for the optical system
  - Characterization of fluorescence cross-section with 7 TeV protons

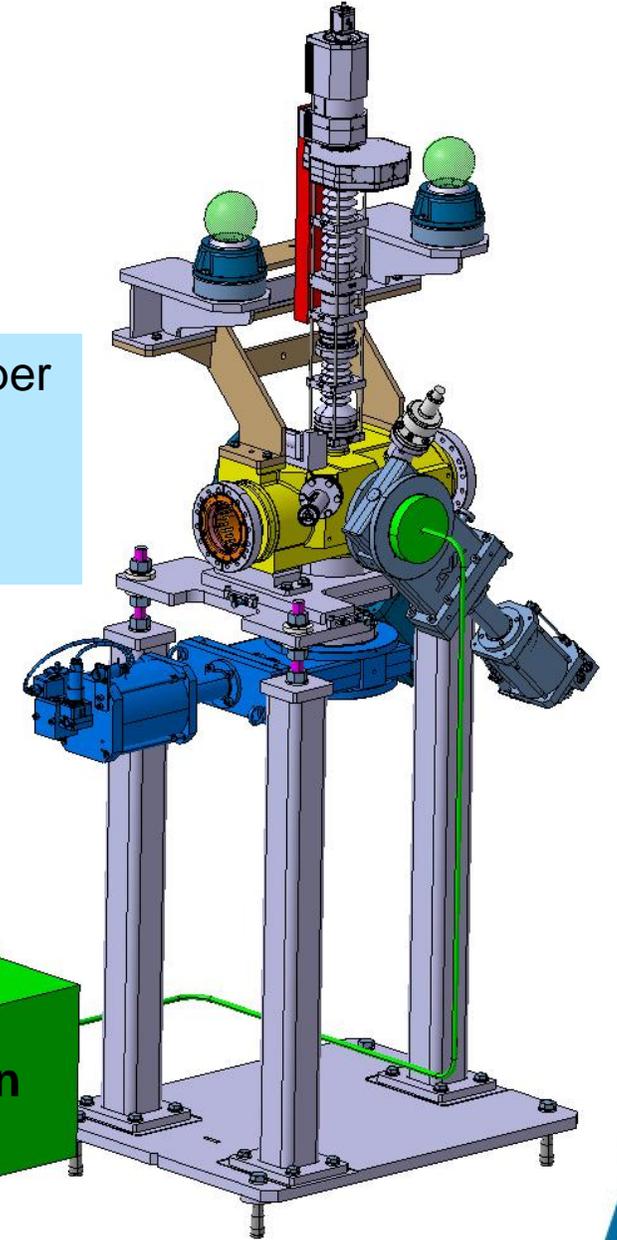


# Instrument evolution from 'old' to 'new' ECR designs

Instrument as-per LHC-BGC-EC-0002 (approved)



Instrument as-per  
LHC-BGC-EC-  
0003  
(requested)



HL-I

# Summary

- A fully approved ECR exists for both the LS2 installation and fluorescence measurement set-up
- This new ECR is an 'as-built' update of the LS2 installation document and adds a request to make further fluorescence measurements in Run 3
  - Cost-neutral for the HL-LHC project
- Detailed agreements with all partners (in particular impedance, survey, transport, integration, vacuum) and either completed or well advanced
  - Cable extensions for background gas system still to be agreed with TE/VSC pending resource availability
  - Final validation test of the survey and alignment operation needed
- BE-BI / WP13 ask for the HL-TCC approval to proceed for LMC approval with this updated ECR for installation in LS2

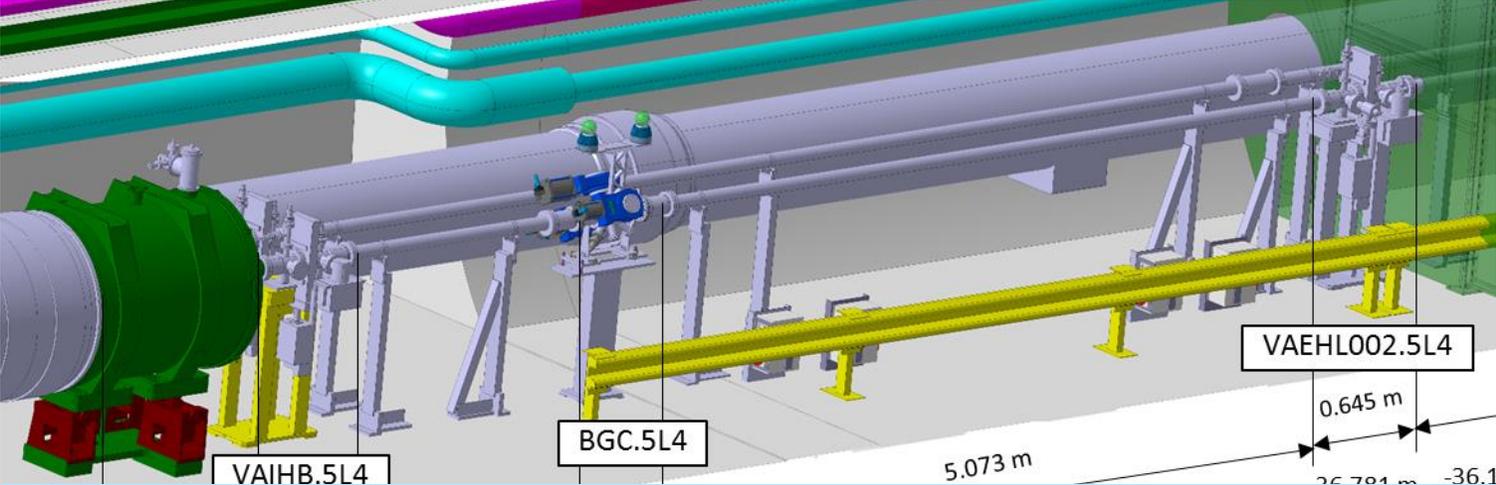


**Thanks for your attention**

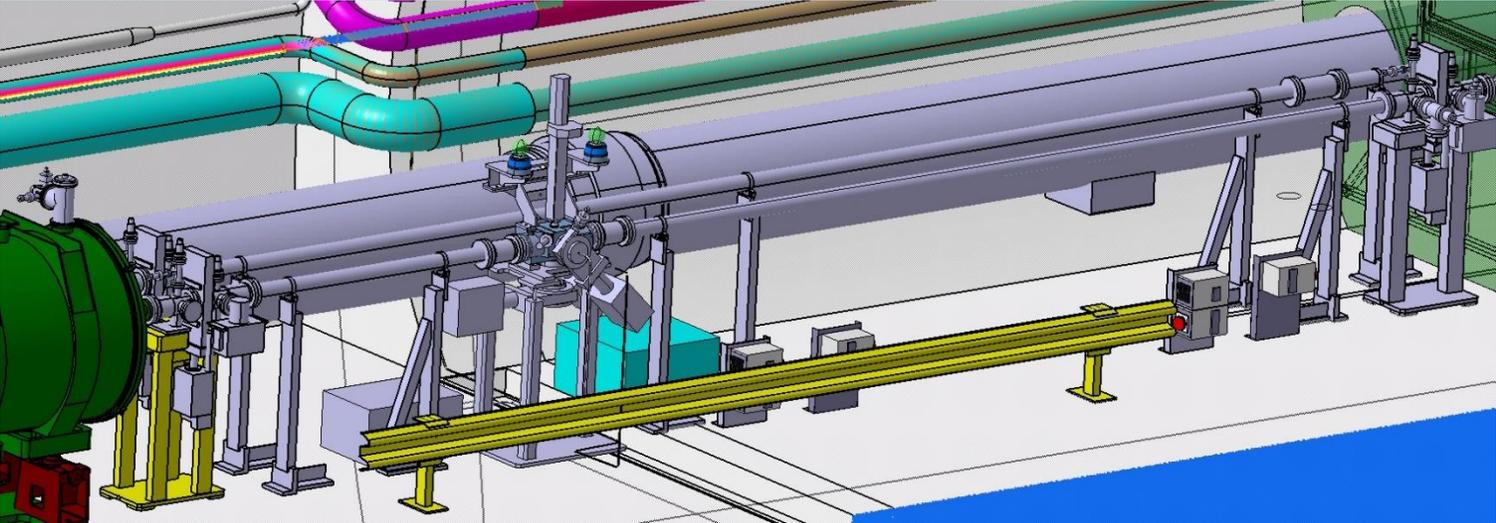


# Differential layout from 'old to 'new' ECR

Sector layout as-per LHC-BGC-EC-0002 (approved)



Sector layout as-per LHC-BGC-EC-0003 (requested)



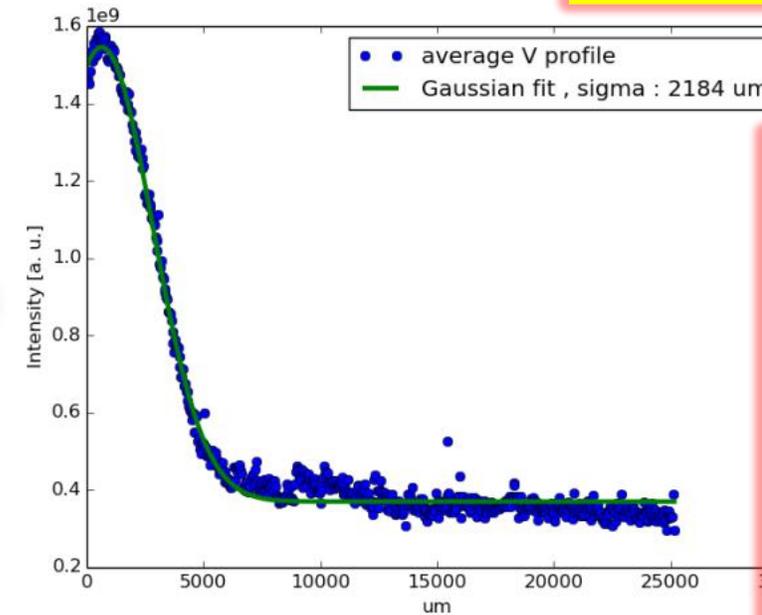
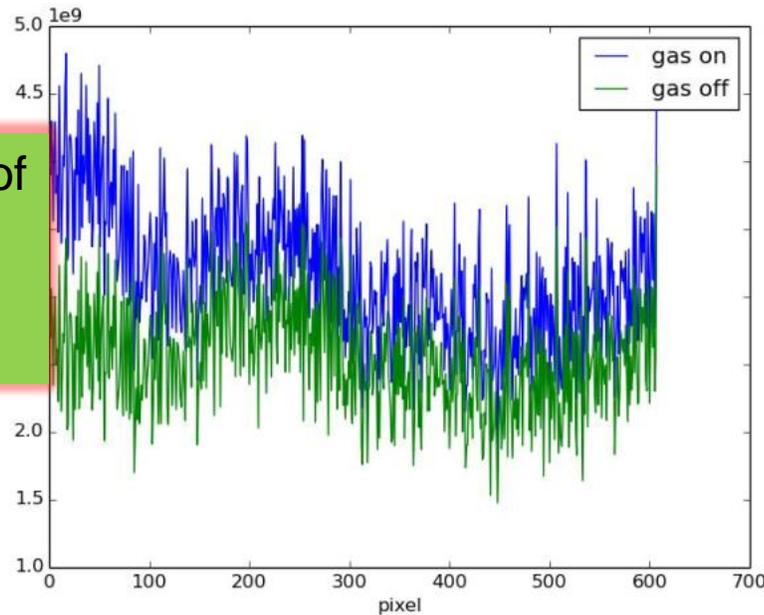
# Background gas fluorescence measurements in 2018

- As per ECR LHC-BGC-EC-0001, a number of measurements were made during the 2018 run using the existing background gas system from an old instrument (BGI) to locally create a pressure bump of  $5 \times 10^{-8}$  mbar and look for beam-induced fluorescence (BIF) with an *ex-vacua* optical system
- Data was taken for ions and protons and show clear indications of profiles produced from BIF
  - This is the first measurement of BIF in the LHC and is very encouraging for the final BGC instrument, which is designed to produce a larger signal by using a gas jet as opposed to a background gas
  - However, a number of issues were identified during these measurements which have been addressed by detailed changes to the instrument

# Profile from Ions

The issue was that the optics were not aligned on the beam, which highlighted the need for some design changes

Making the sum of several thousand images looks like noise



However, simply subtracting gas-off from gas-on images gives what looks like an offset profile with a sigma of 2.2 mm, which is what you would expect from ions at injection

V Profiles from sum of

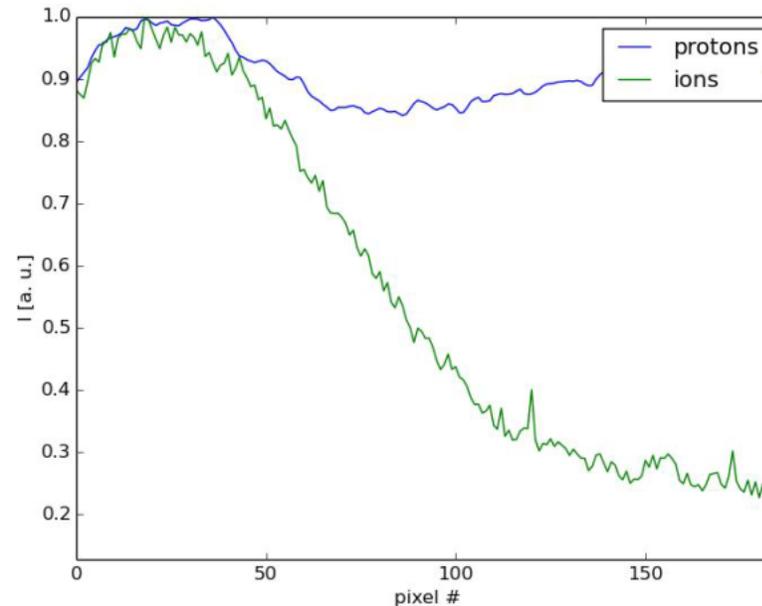
- 3215 images (gas on) => 1285 s integration time
- 1443 images (gas off) => 577 s i.t.

Difference corrected for different integration time, no other adjustable parameter.

Sigma 2.2 mm

# Protons vs ions

This difference is attributed largely to the higher synchrotron radiation background for protons, which can be improved by anti-reflective coatings, design of the liner and improvements to optics.



Measurements were also made with proton beams (normalised on this plot and compared with data for ions). Although there is an image, and the centroid is similar, the signal-to-noise is significantly worse

Protons vs Pb ions profiles normalized for peak intensity

- Ion cross section per particle  $Z^2$  ( $82^2 = 6742$ ) times the one for p.
- Considering higher intensity of p beam ( $2.5E+14$  vs  $0.7E+11$ ): overall expected light yield for ions is **x2** times protons
- However: losses signal is proportional to intensity => **x  $10^{-3}$  S/N wrt Pb+**