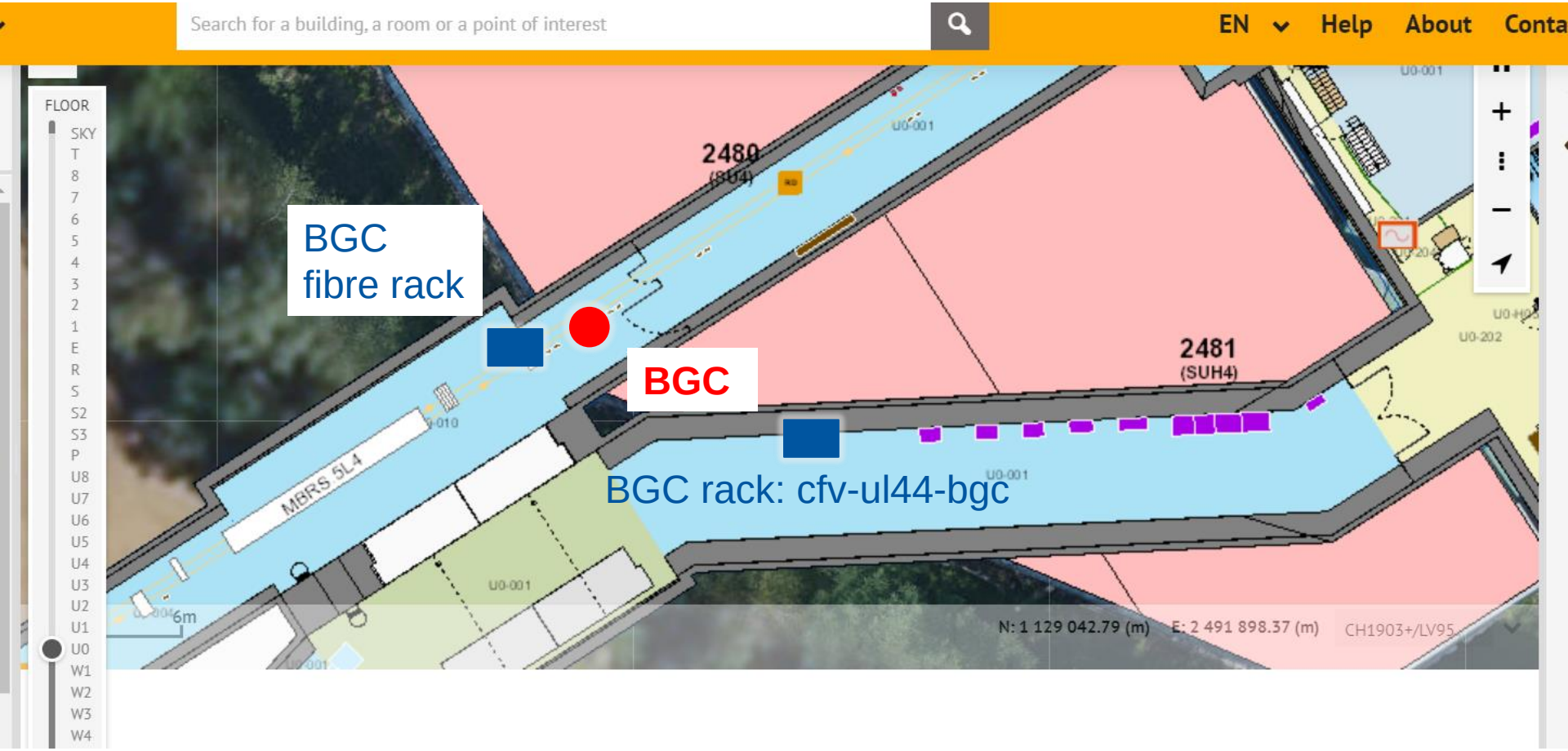
LHC Fluorescence measurements and Run 3 tests

SM, BGC collaboration meeting, 10/12/2020

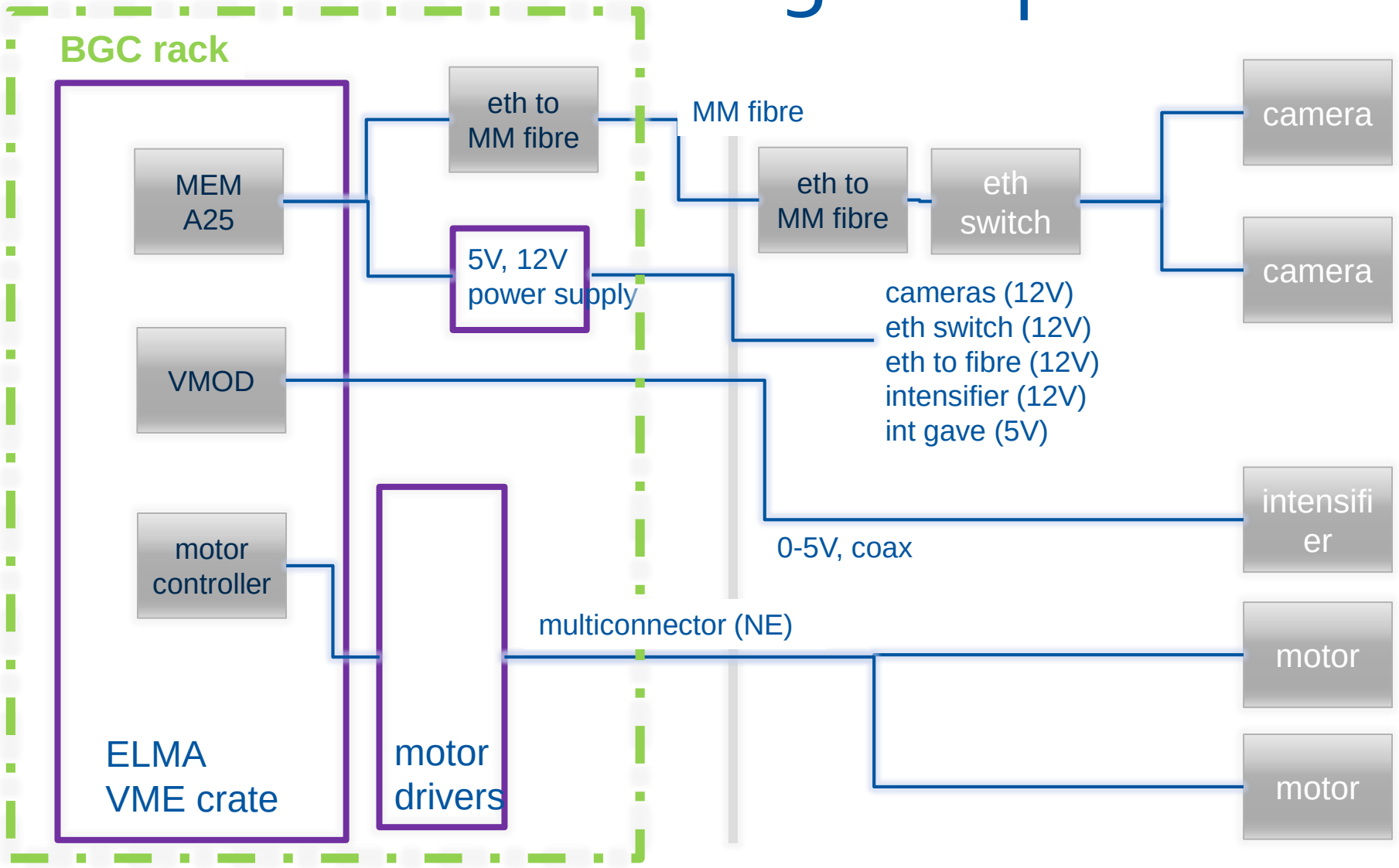
Status of LHC Run 3 setup



Status of LHC Run 3 setup

- Cables **all pulled**:
  - 3x 48 multiconnector cables for motor control, low voltage supply & signals
  - 2x high voltage supply cables (not used in present setup)
  - 2x "CK50" 50 Ω coax cables for fast signals (i.e. TTL gating of intensifier)
- Fibres **all pulled**:
  - 6x MM used for transmission of images
  - 6x SM (not used in present setup)

Status of LHC Run 3 setup



Procurement

- optical fibres (3x MM, 3x SM Rx/Tx lines) — installed
- technical network connection (4 plugs) — installed
- VMW crate: ELMA 6u — ordered
- MEN A25 VME CPU — ordered
- Camera readout:
  - copper SFP (1+1 spare) — delivered
  - XMC mezzanine card (1+2 spares) — ordered
  - eth to fibre converters — delivered
  - eth switch — delivered
  - cameras (CMOS) — ordered
- Motors: REX type chassis + card (5 positions) — CERN syst.
- Power supply (5V, 12V) — CERN syst.
- Intensifier gain: CERN VMOD card — delivered

Open points

- Need support from BI SW team for test/deploy/configure software
- "Slow" timing not yet available at BGC rack, requested.
- **TIMING** presently no fast (ns) control of the intensifier is present. If needed:
  - Rack must be connected to Beam Synchronous Timing (BST)
  - Change control of intensifier gate (VMOD => DAB?). Support needed to program fast gate
- Since calibration target is inserted manually, do we need remote control of vertical position of optical instrument?
- Filter wheel: 6-position, remote-controlled FW used in 2018 LHC tests available (OWIS). Not clear if CI prefers other options.

Open points

- Controls for HEL-TS setup:
  - replicate LHC setup (VME)
  - use a standard desktop PC with lab power supply for control of camera / intensifier
- Tests on HEL-TS:
  - need more input for definition of test procedure
  - when? Is May / June 2021 confirmed?
- Optical instrument
  - first on HEL-TS, then installed in LHC during 2021 YETS?
  - two optical instruments?

SNR in LHC BIF tests

full presentation given at May 20 regular meeting:
https://indico.cern.ch/event/912714/

SNR

- SNR for **ions** at **injection**: measured
- SNR for **ions** at **high energy**: estimated by comparing noise levels
- SNR for **protons**: estimated by comparing noise level with ion case. Signal is derived from ion case (normalized by cross section, beam intensity)

SNR

- Use "acceptance" definition of SNR:

DRAFT!

Signal to noise ratio[1] of the image area corresponding to 0.1 mm^2 at the source plane for the highest intensity signal region of a nominal proton beam as measured at the imaging plane in 10 seconds[2].	Ratio	10

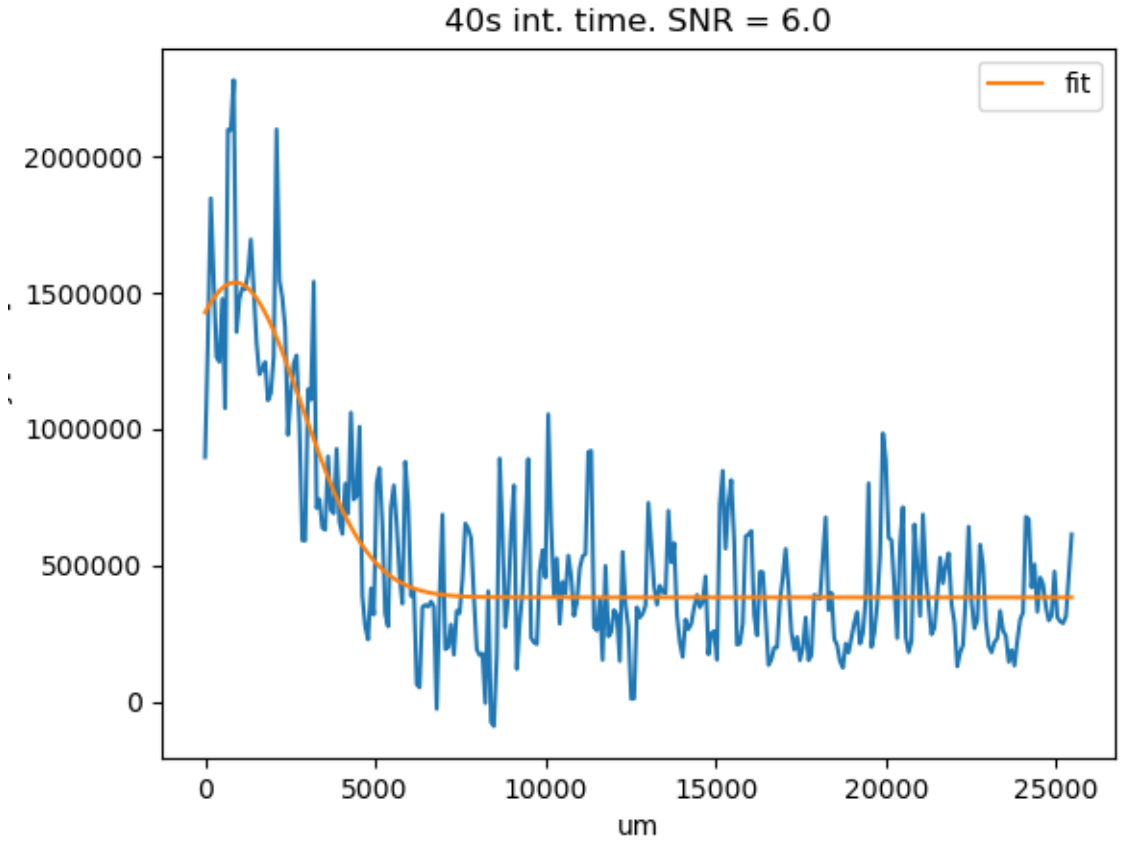
Standard Deviation

[1] Signal is defined as the total intensity in the highest amplitude region of the final image corresponding to an area of 0.1 mm^2 in the source plane. Noise is defined as the ~~variation~~ in the total intensity of regions without signal ~~in the final image corresponding an area of 0.1 mm^2 in the source plane.~~

[2] This value is calculated by scaling the intensity and beam size of the electron beam used to qualify the performance at the Cockcroft Institute, and taking into account the relative difference in expected proton/ electron fluorescence cross section. See Section 3.

SNR: ions at injection

Fill 7487, 1/12/2018. Beam intensity 1.3×10^{13} q, 5×10^{-8} mbar Ne



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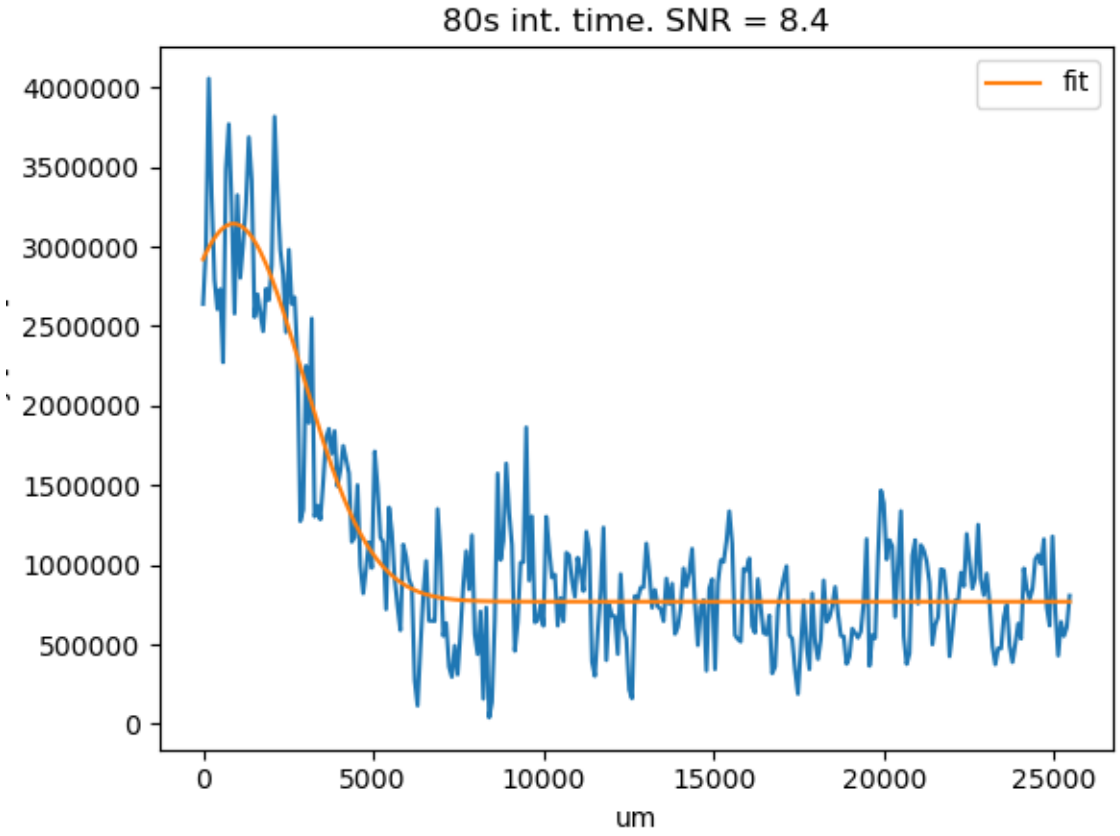

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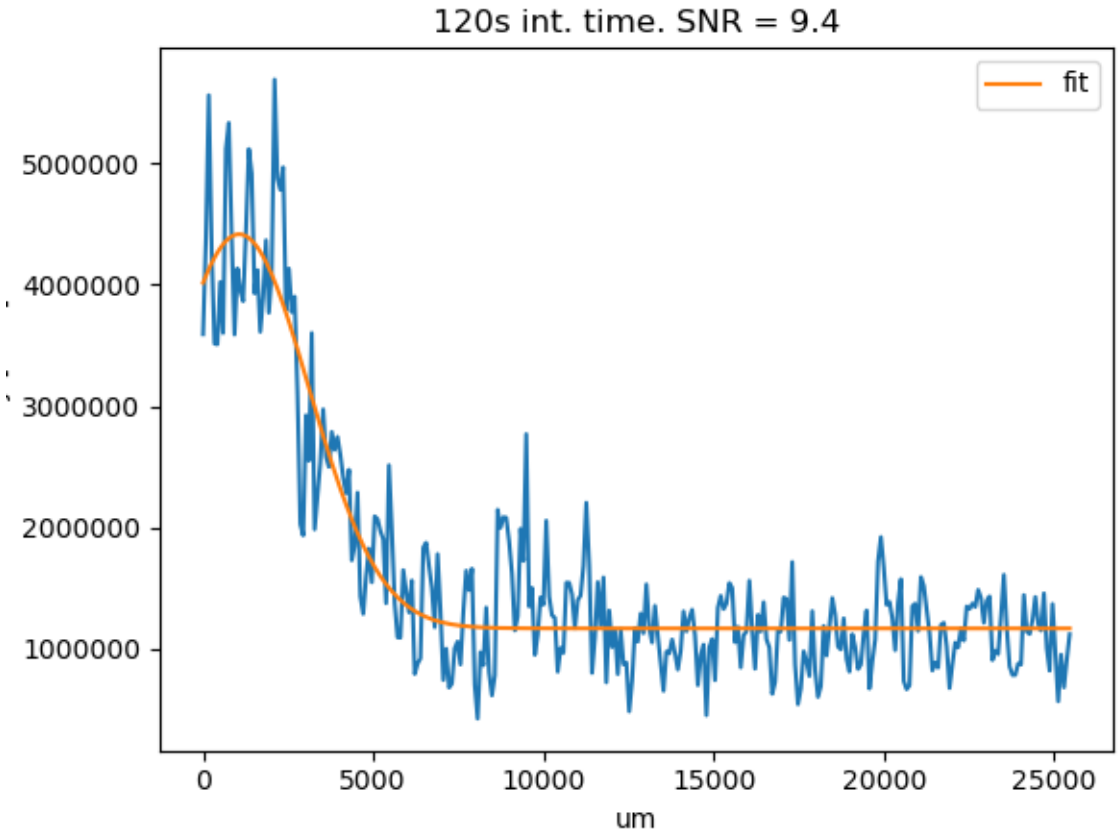

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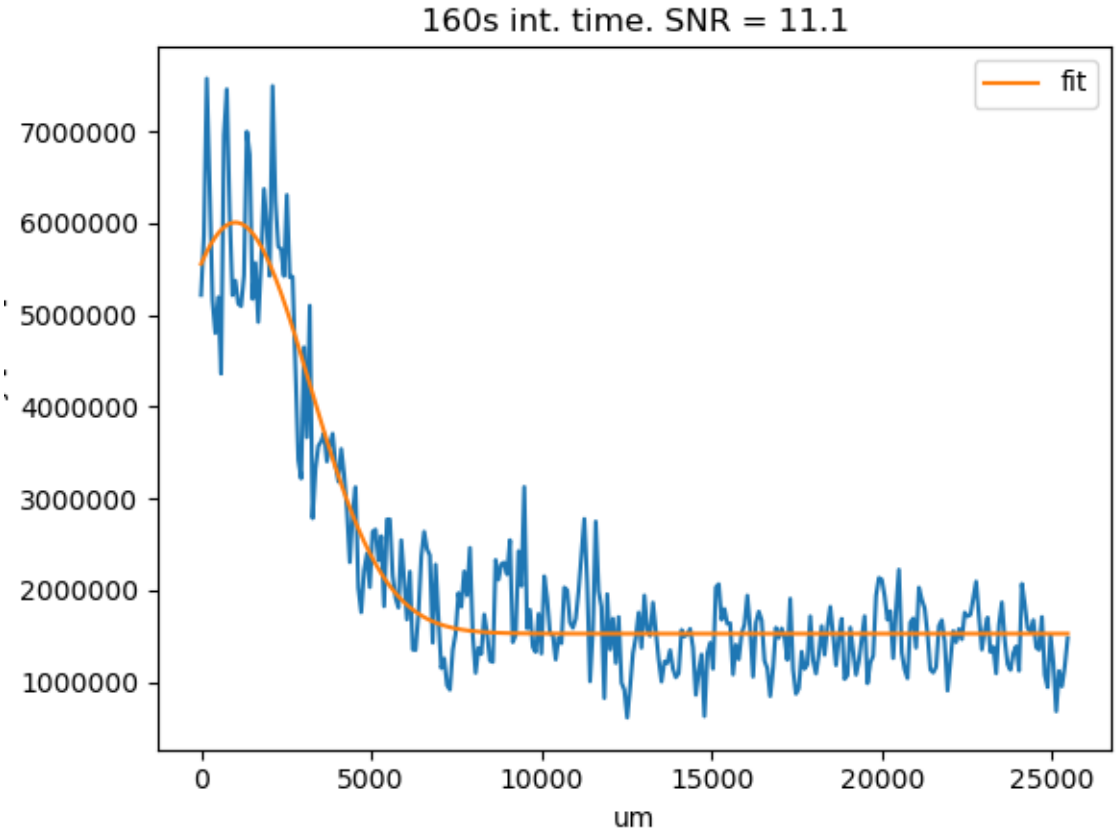
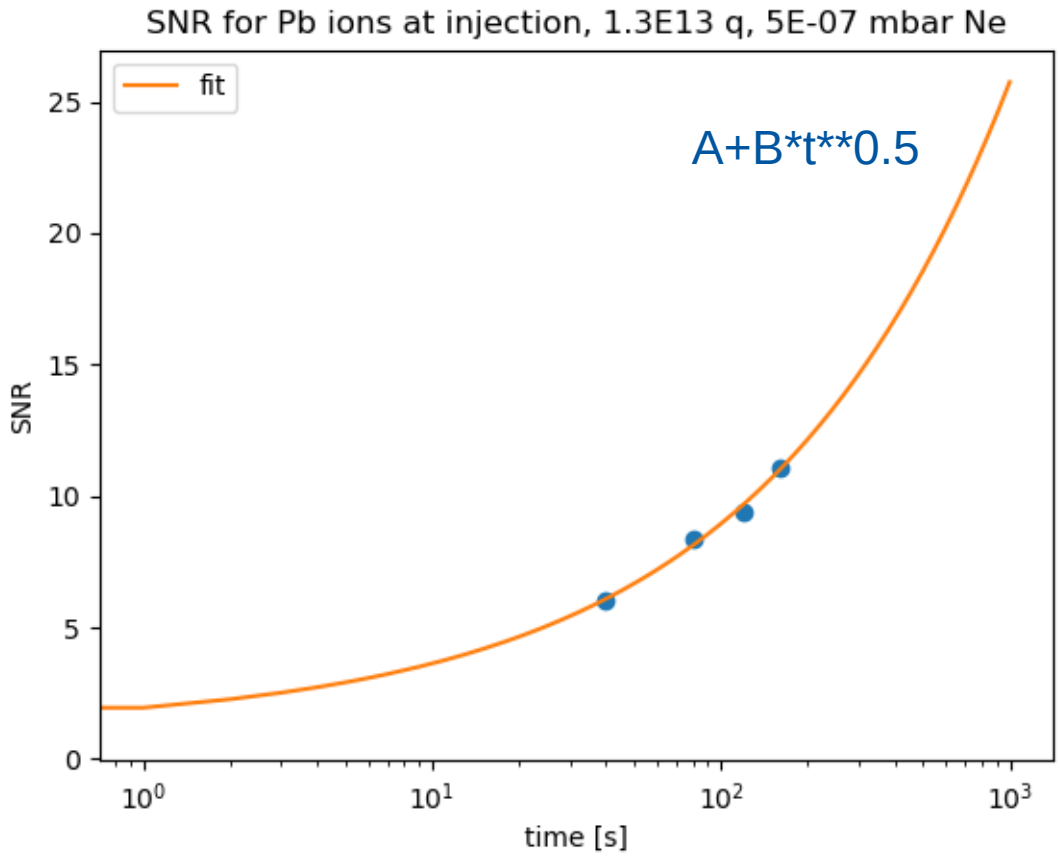
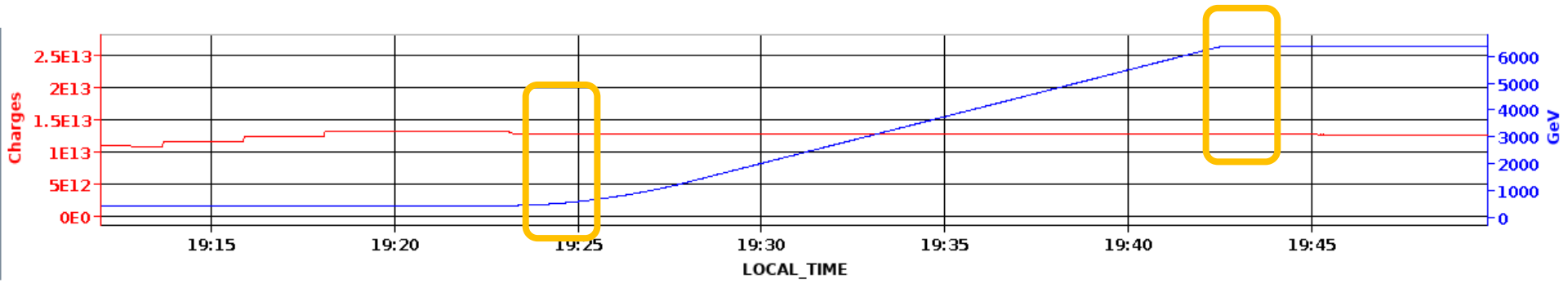


SNR: ions at injection



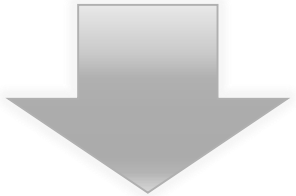
SNR: ions at high energy

- Images (10 ms exp time) acquired during same fill during ramp. Beam intensity slightly decreased (from 1.31E13 to 1.27E13)



SNR: ions at high energy

- Noise
  - $\sigma_{HE} = 8.1 \times \sigma_{LE}$
- Signal
  - $S_{HE} = S_{LE}$ (worst case, same cross section)



$$SNR_{Pb+,HE} = 0.12\ SNR_{Pb+,\ LE}$$

BIF signal from protons

- Signal: normalize by cross section and particle flux:

$$S_{p+} = \frac{\sigma_{p+} N_{p+}}{\sigma_{Pb+} N_{Pb+}} S_{Pb+}$$

where

$\sigma_{p+}/\sigma_{Pb+} = 1/Z^2$

$N_{p+}/N_{Pb+} = Z * I_{p+}/I_{Pb+}$

that is (for equivalent exposure time):

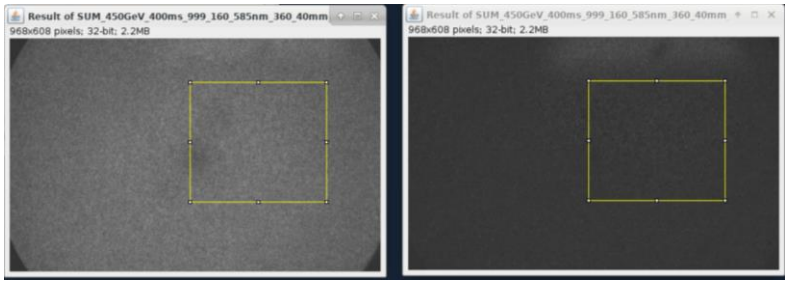
$$S_{p+} = \frac{1}{Z} \frac{I_p}{I_{Pb+}} S_{Pb+}$$

Protons at injection

- Fill 7315 (19/10/2018), beam intensity 2.8×10^{14} q, 5×10^{-7} mbar
  Ne. 100 images at 400 ms exp time (= 40 s exp time)

$$S_{p+} = \frac{1}{Z}\frac{I_p}{I_{Pb+}} S_{Pb+} = \frac{1}{82}\frac{2.8 \times 10^{14}}{1.3 \times 10^{13}} S_{Pb+} = 0.26\, S_{Pb+}$$

$$N_{p+} = 2.5\, N_{Pb+}$$



$$SNR_{p+,LE} = 0.1\, SNR_{pb+,\,LE}$$

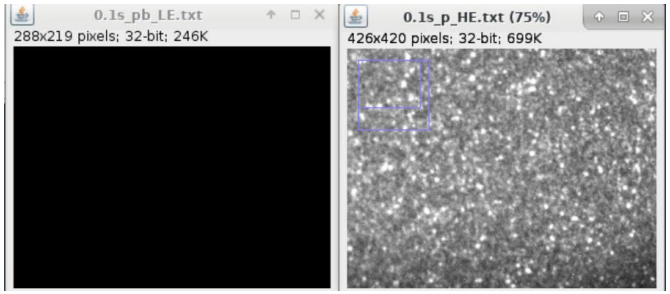
Protons at high energy

- Fill 7314 (18/10/2018), beam intensity 1.31×10^{14} q, 5×10^{-7} mbar Ne. 100 images at 1 ms exp time (= 0.1 s exp time). Digital camera gain = 0 (normally = 36)

$$S_{p+} = \frac{1}{Z}\frac{I_p}{I_{Pb+}} S_{Pb+} = \frac{1}{82}\frac{1.3 \times 10^{14}}{1.3 \times 10^{13}} S_{Pb+} = 0.12\, S_{Pb+}$$

$$N_{p+} = 10^4\, N_{Pb+}$$

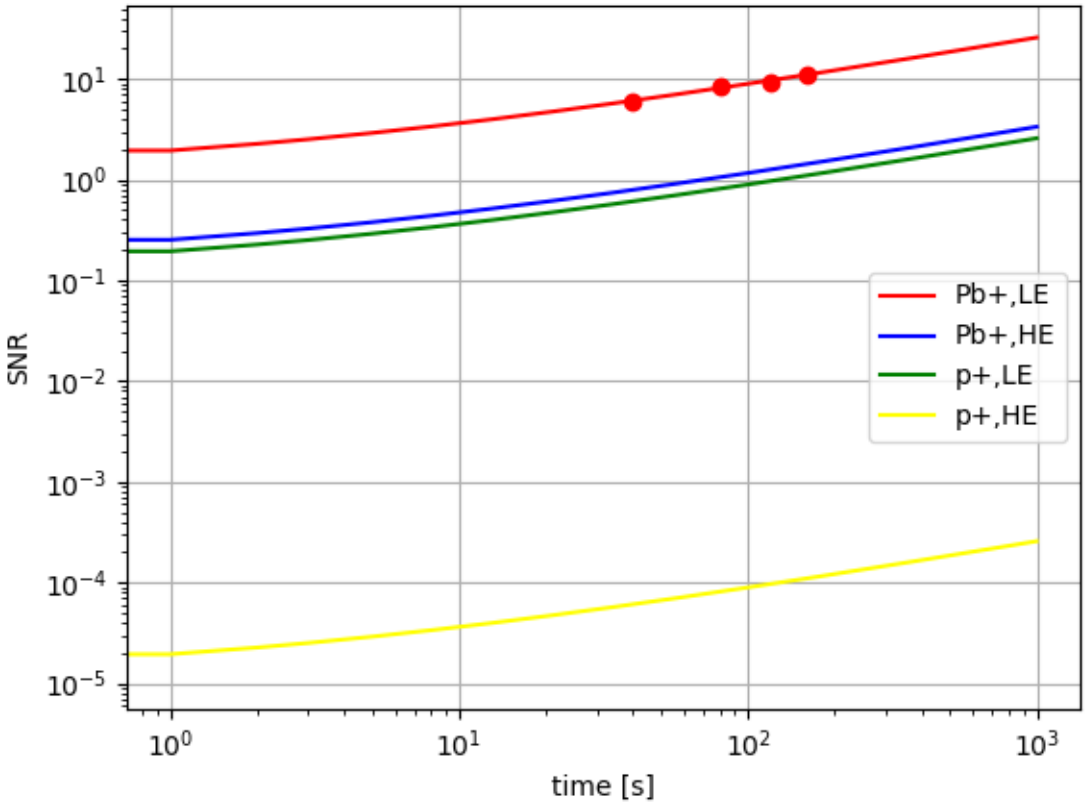
HIGH noise due to SR!



$$SNR_{p+,HE} = 10^{-5}\, SNR_{pb+,LE}$$

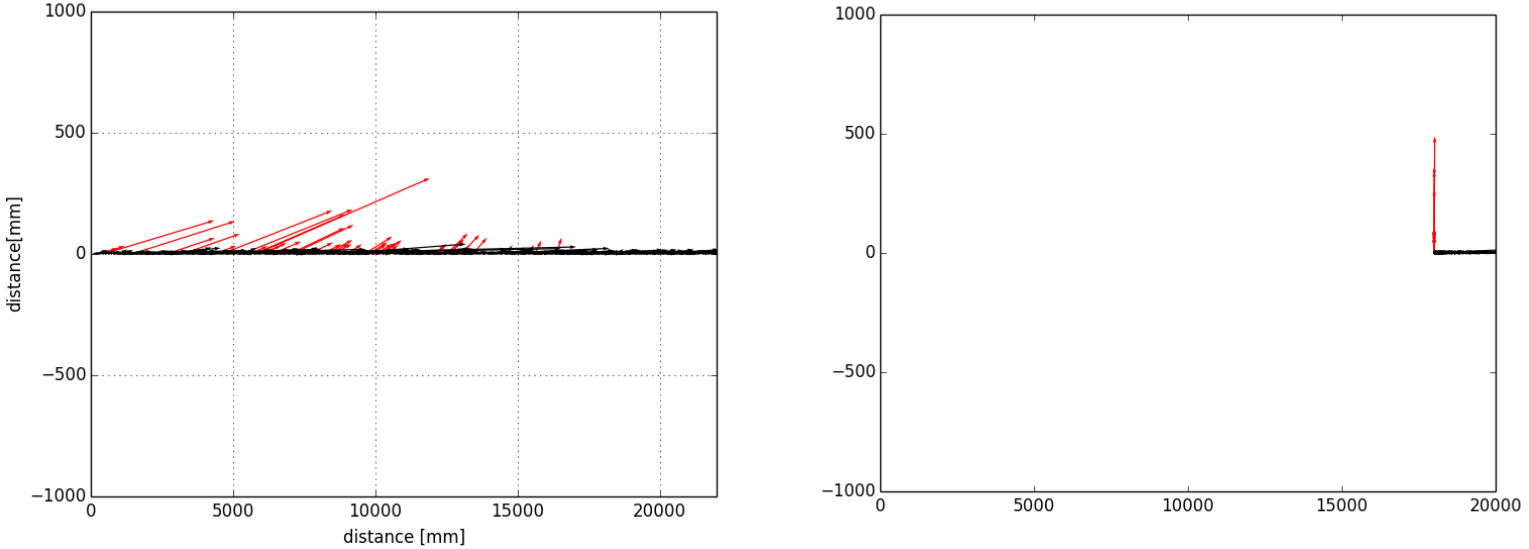
Summary of 2018 LHC tests

Improvement of SNR is IMPERATIVE!



Estimated SNR for V3 instrument

- Monte carlo simulation with BGV vertex data (3.6×10^6 events) for inelastic scattering: estimated **10^{-3} rate of losses** wrt 2018 test case (see presentation at Nov 2018 Collab. meeting)



- Reflectivity of chamber surface: NEG on Cu (R = 44.3%) vs. Polyteknik black coating (R = 0.12 % @ 585 nm) => ~ **3×10^2 reduction**
- Consider Nitrogen (x5 light yield)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