The Gamma Factory Beam Tests in SPS and LHC

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Muon Collider Workshop, Padova, 02.07.2018

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Outline

1. Gamma Factory & fundamental and applied physics highlights

2. 2017 Xe+39 MDs results
3. Plans for the 2018 MDs with PB+54, Pb+80 and PB+81
4. Preliminary results of the SPS MD 06.06.2018

5. GF software development

6. Towards the PoP experiment in the SPS

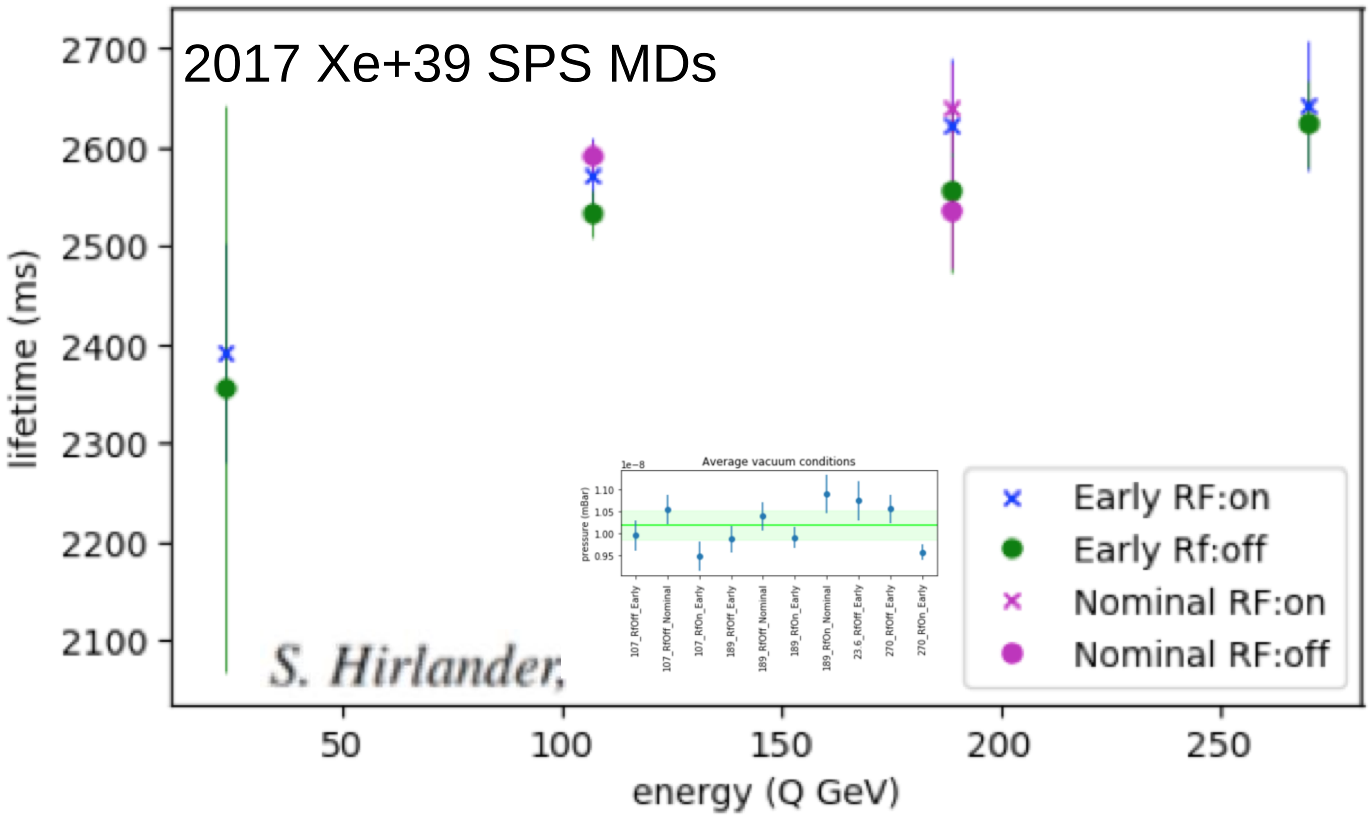
7. Impact/synergy of the GF activities on the on-going and future CERN research programme:
   - AWAKE
   - HL-LHC with iso-scalar beams
   - GF and the CERN muon collider studies (ARIES workshop, July 2018)

9. The way forward

Results of the 2017 Xe+39 MDs and their role in preparation of the 2018 MDs

What we have already learned from the 2017 Xe+39 SPS MDs ?

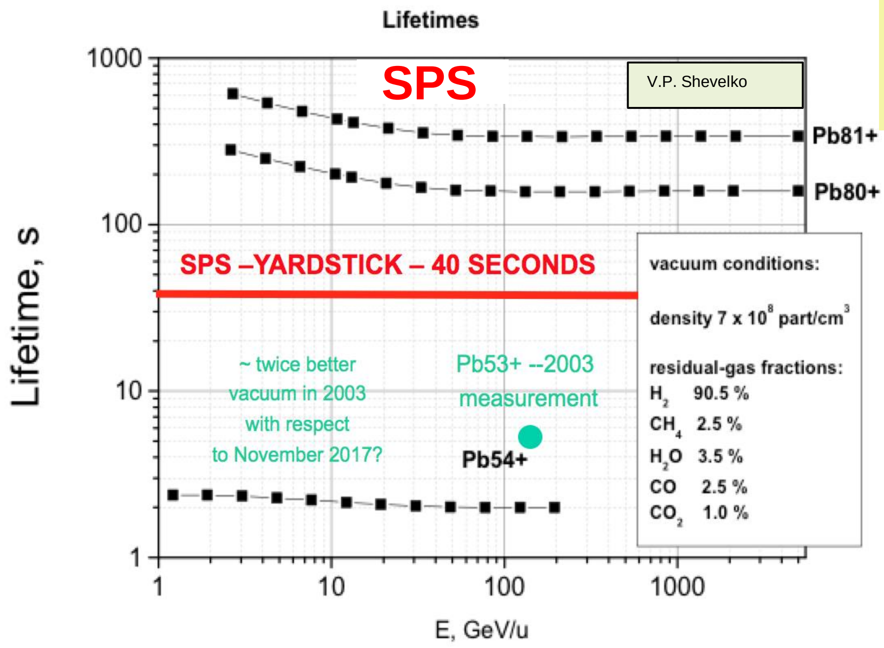
Xe+39 beam life time, as expected, is driven predominantly by the losses of ions due to electron stripping by the rest gas molecules.



What we have already learned from the 2017 Xe+39 runs in the SPS?

The 2017 SPS measurements allowed us to:

1. Constrain the vacuum quality and the rest gas molecular content.
2. Cross-check the simulations used in the extrapolations to other ions species and LHC energies.
3. Calculate the expected Pb+80 and Pb+81 beam life time, for the vacuum conditions of the 2017 Xe+39 runs, which exceeds comfortably the SPS injection + ramping time!
4. Significantly better vacuum in the LHC – lifetime rise by a factor of 100, w.r.t SPS expected (if dominated by the electron stripping in beam-gas collisions)!



Plans for the 2018 MDs

2018 SPS and LHC MDs – strategy

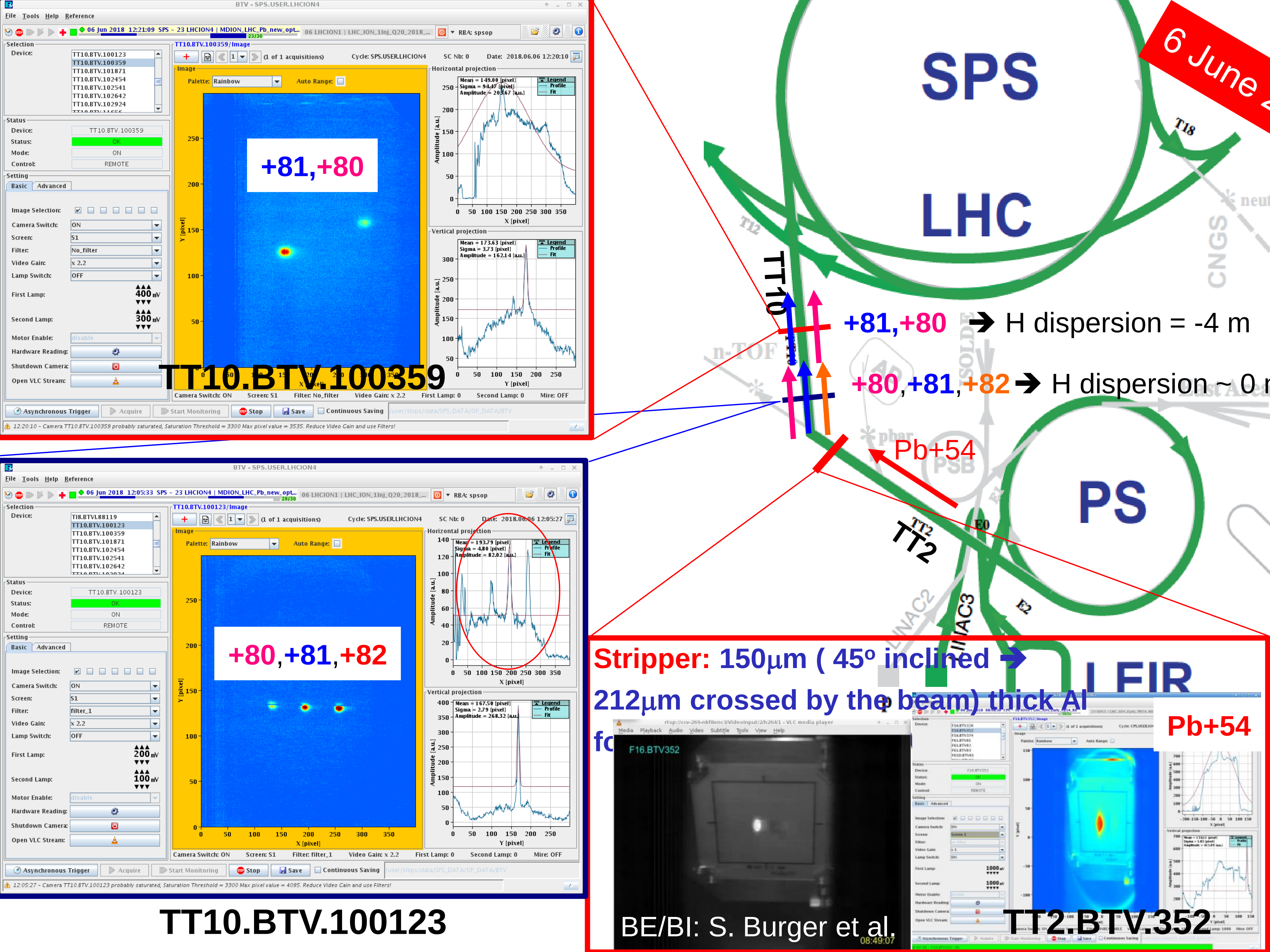
SPS

- Calibrate the 2018 vacuum with the initial PB+54 runs.
- Studies of Pb+54 → Pb+80 and Pb+54 → Pb+81 stripping efficiencies.
- SPS test of the relative importance of multi-electron and single electron losses.
- Measurement of the strength of the intra-beam-stripping processes (intensity and energy dependence of the beam life-time).
- Realistic extrapolation of the beam life-time to the LHC case (following an experimental verification of all the modelling assumption).
- Pb+80 versus Pb+81 choice for the LHC runs.

LHC

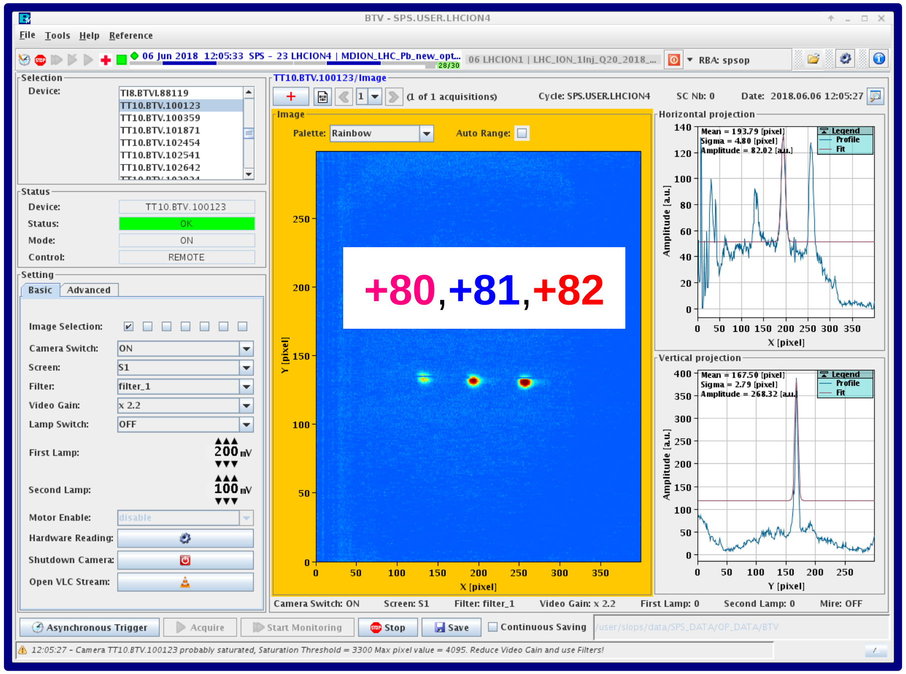
- Start with the life time measurement of a single bunch at the injection energy and at the top energy, loss maps, vacuum quality evolution, beam emittance evolution.
- Vary bunch intensity.
- Study the dynamical vacuum and BLM signals as a function of the number of bunches.

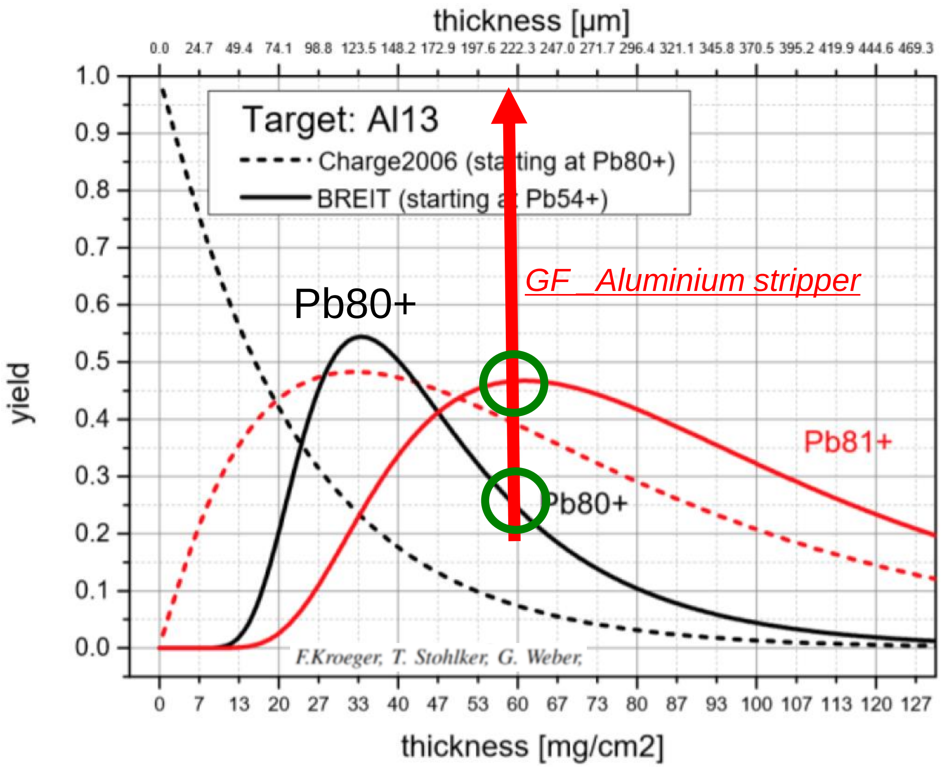
First results of the 2018 MDs



6 June
SPS
LHC
PS
TT10
TT2
+81,+80 ➔ H dispersion = -4 m
+80,+81,+82 ➔ H dispersion ~ 0 m
Pb+54
Stripper: 150µm (45º inclined ➔ 212µm crossed by the beam) thick Al
TT10.BTV.100359
+81,+80
TT10.BTV.100123
+80,+81,+82
F16.BTV352
Pb+54
TT2.BTV.352
BE/BI: S. Burger et al.

June 2018 MDs - first results

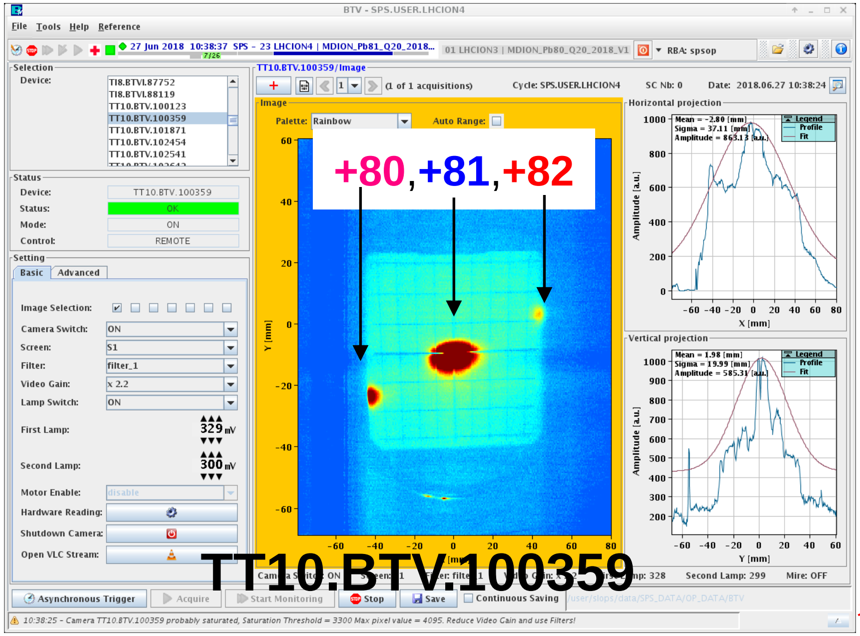


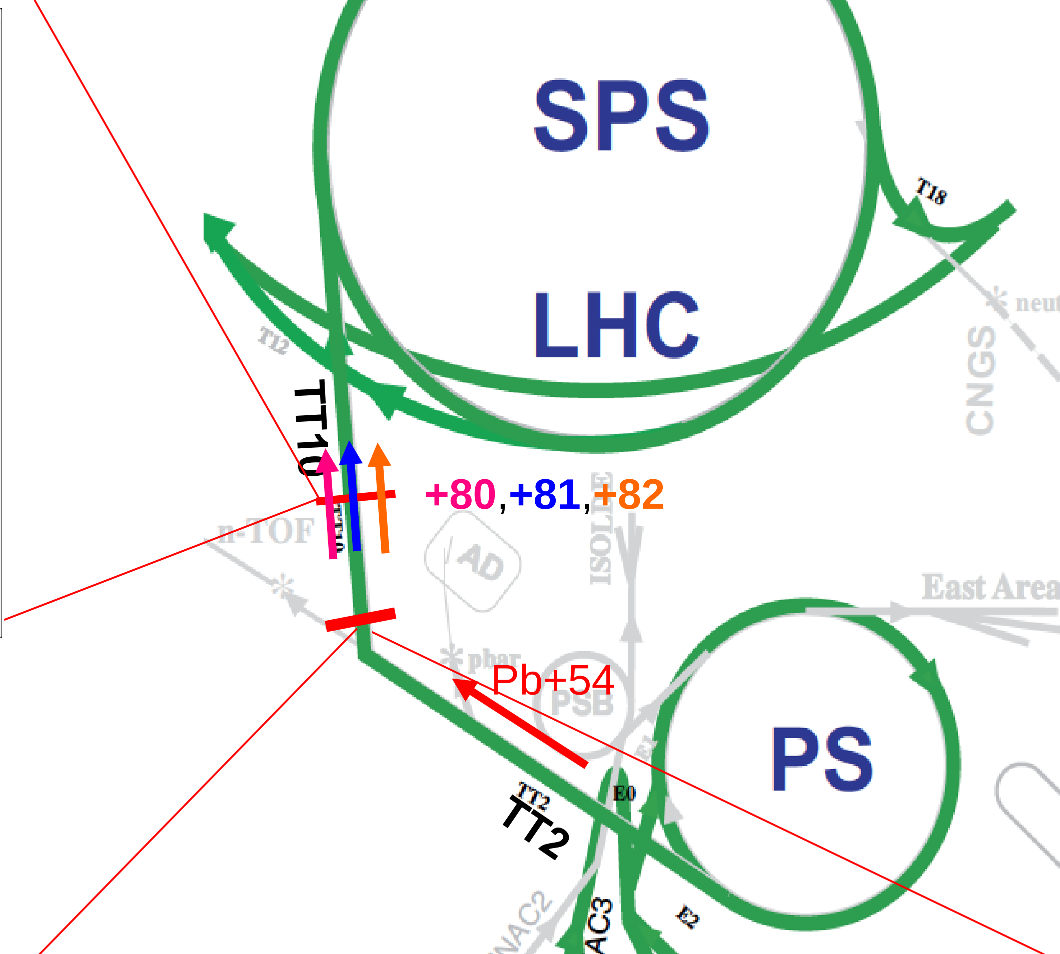


Preliminary BCT measurements suggest:

- 30% stripping efficiency for 80+
- 50% stripping efficiency for 81+

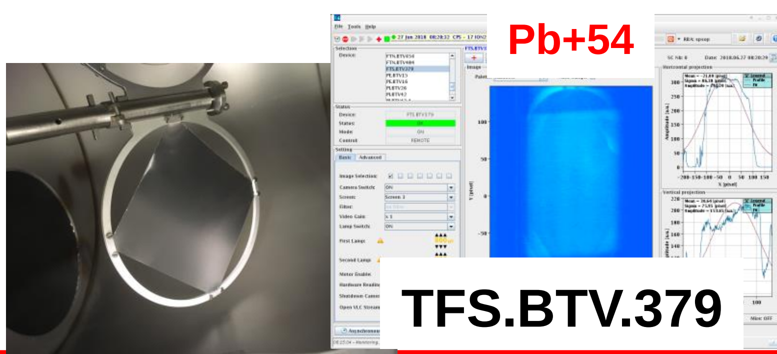
No systematics analysis yet

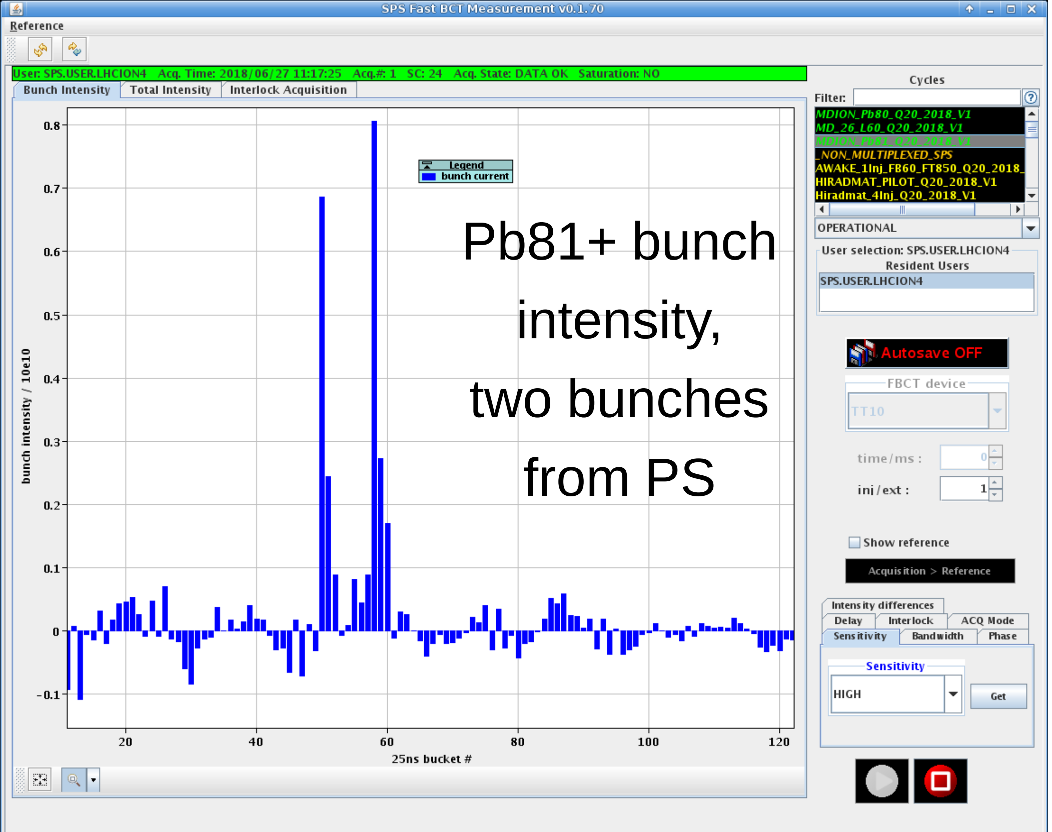




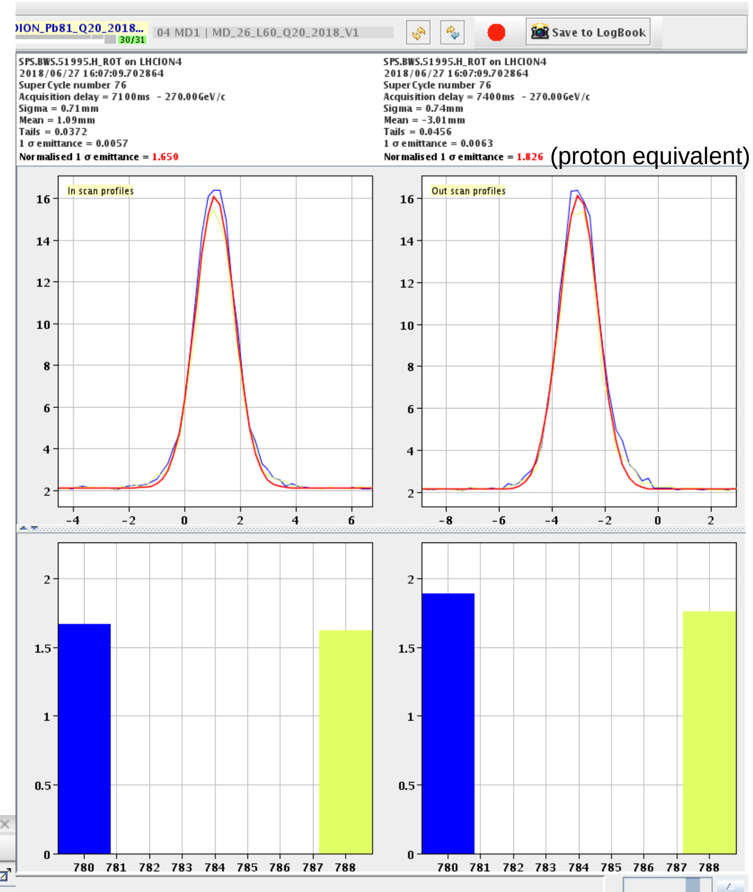
27 June 2018

Stripper: 150µm (45º inclined ➔ 212µm crossed by the beam) thick Al foil



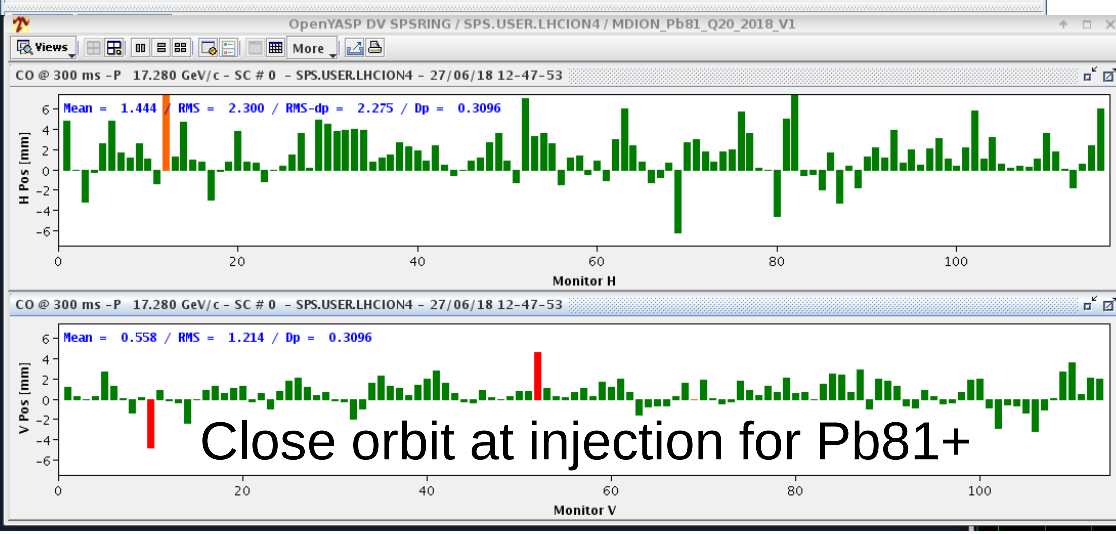


Pb81+ bunch intensity, two bunches from PS

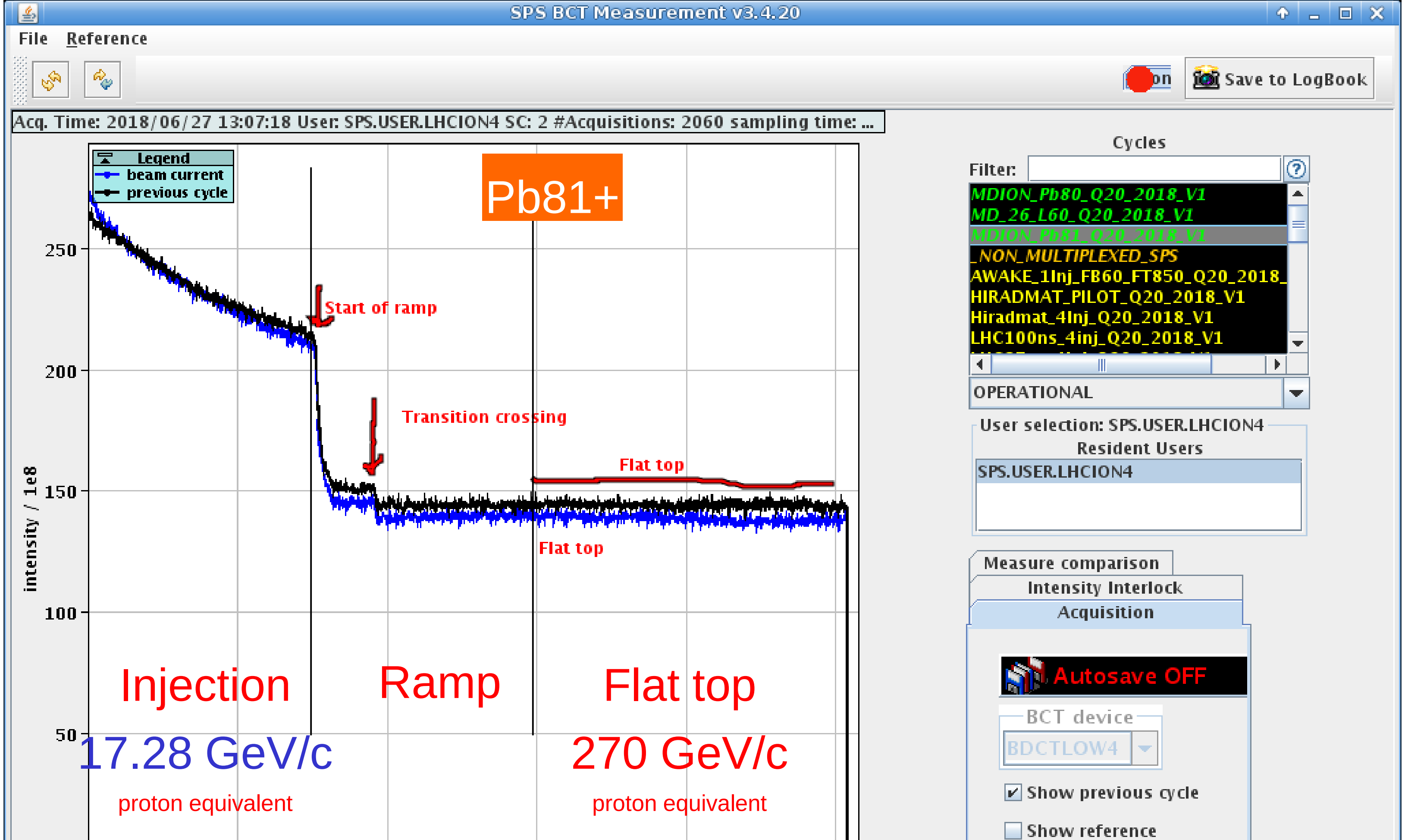


(proton equivalent)

H&V Emittance ~ 1um rad



Close orbit at injection for Pb81+



Life time at flat top for **Pb81+ ~ 600 s**

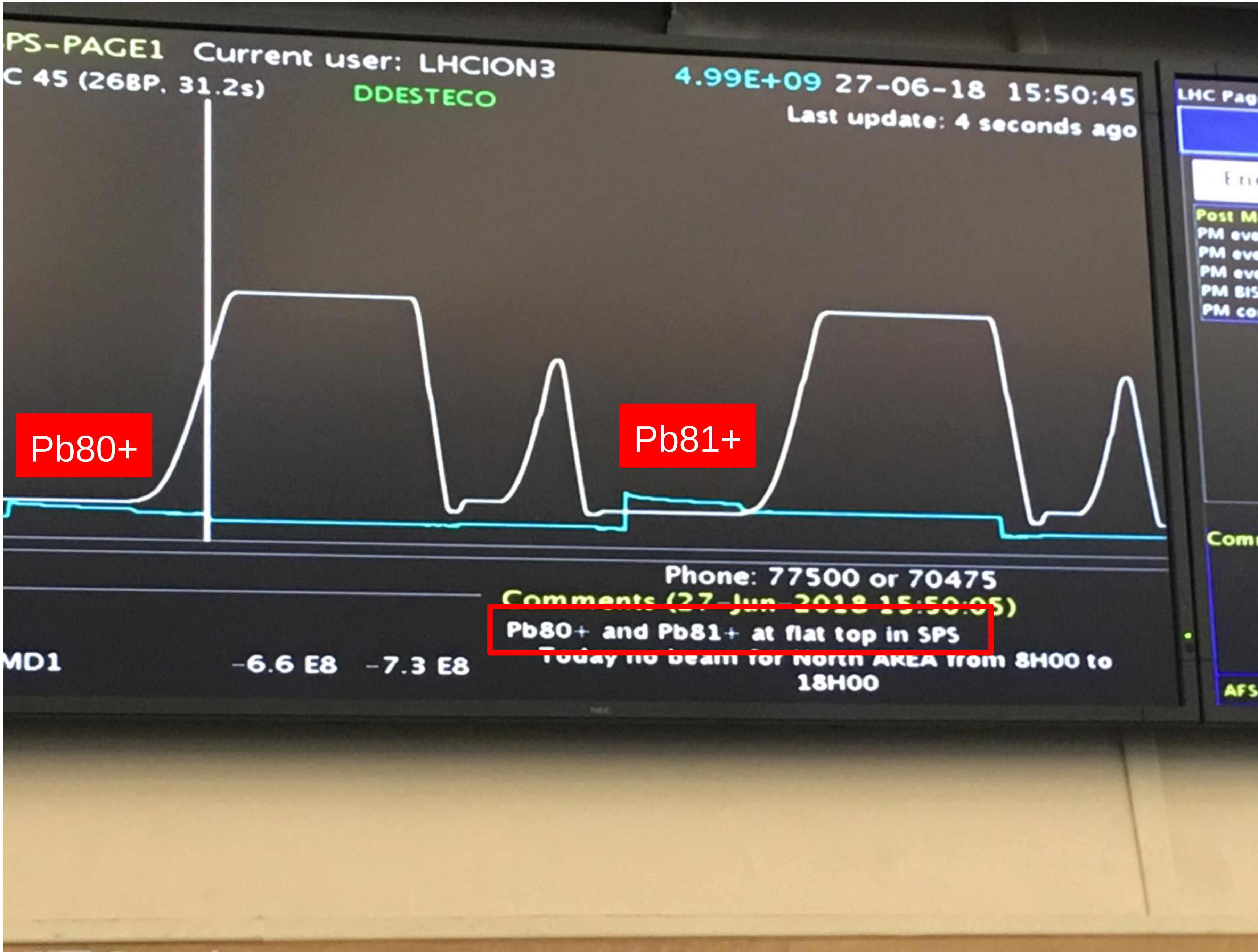
Life time at flat top for **Pb80+ ~ 200 s**

Bunch intensity at flat top

for **Pb81+ = 8e9 elementary charges (enough to be sent to LHC) !!**

No Exception to display...

13:07:18 – Busy acquiring data from SPS.BCTDC.41435 for user SPS.USER.LHCION4...



PS-PAGE1 Current user: LHCION3
C 45 (26BP. 31.2s)
DDESTECO
4.99E+09 27-06-18 15:50:45
Last update: 4 seconds ago
Pb80+
Pb81+
Phone: 77500 or 70475
Pb80+ and Pb81+ at flat top in SPS
MD1
-6.6 E8 -7.3 E8
18H00
LHC Page


Pb80+Pb81+
Champagne!!!!
CERN
SPS

Next Machine Studies

1. Pb81+ accelerated to 450 GeV/c proton equivalent → 04.07.2018!!
   Preparation of the cycle for LHC Machine Study

2. Pb81+ to LHC 4th week of July!!!

Towards the PoP experiment in the SPS

Large number of ion candidates evaluated -- so far two candidates retained…

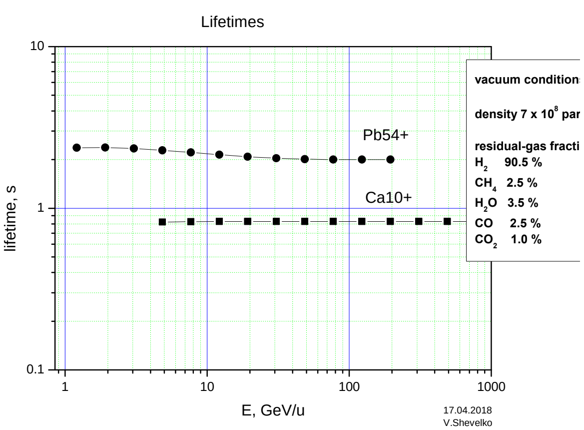
Neon-like Calcium: Ca+10

- ATOMIC GROUND STATE : 1s^2 2s^2 2p^6 $1S_0$
- CHOICE OF EXCITED STATE: 1s^2 2s^2 2p^5 3s $1P_0$
- TRANSITION ENERGY: $E = 352.1$ eV
- LIFE TIME (excited state) : $\tau = 6$ ps

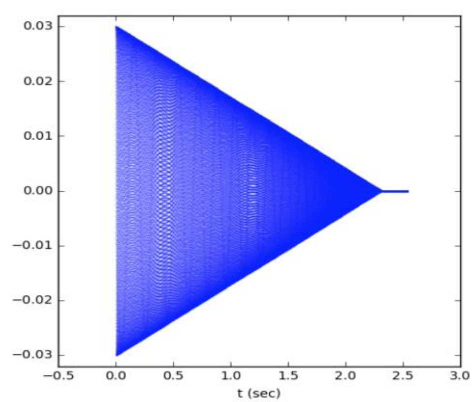
Sodium-like Lead Pb+71

- ATOMIC GROUND STATE : 1s^2 2s^2 2p^6 3s1 $2S_{1/2}$
- CHOICE OF EXCITED STATE: 1s^2 2s^2 2p^5 3p $2P_{1/2}$
- TRANSITION ENERGY: $E = 189$ eV
- LIFE TIME (excited state): $\tau = 18$ ps

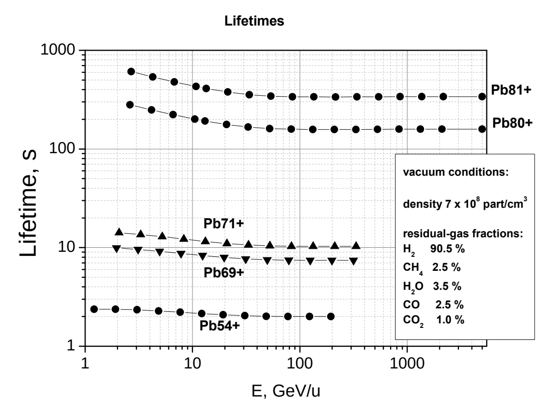
Ca+10 beam life-time in the SPS



Cooling time in the SPS
(~1 ph absorption/ revolution/ion)

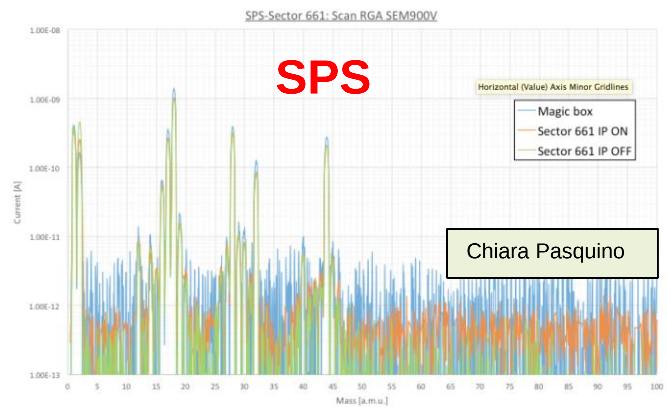


Pb+71 beam life-time in the SPS

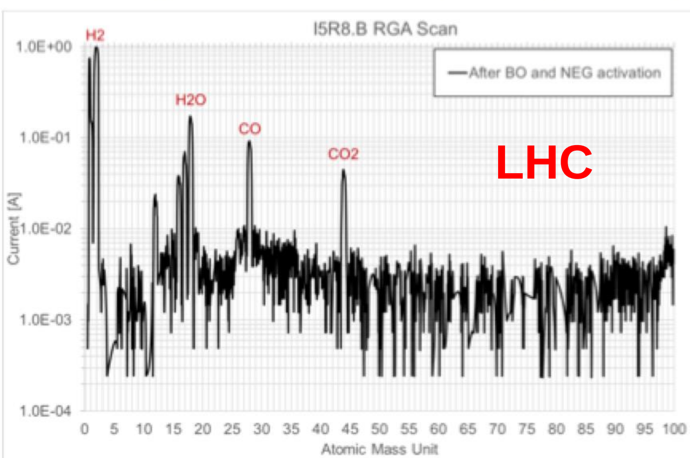


Spares

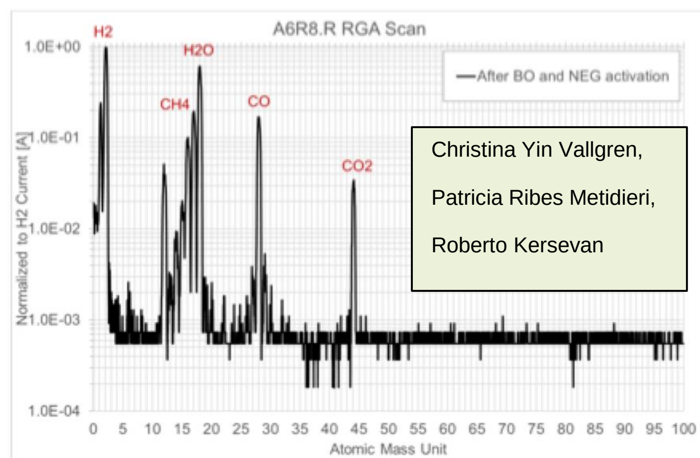
Residual gas composition: SPS and LHC(warm vacuum chamber)



1. Normalized to the H2 peak.
2. H2 as dominant gas after the bake-out and NEG activation.
3. The main gases in the warm LHC vacuum chamber: H2, CO, CO2, CH4 and H2O.

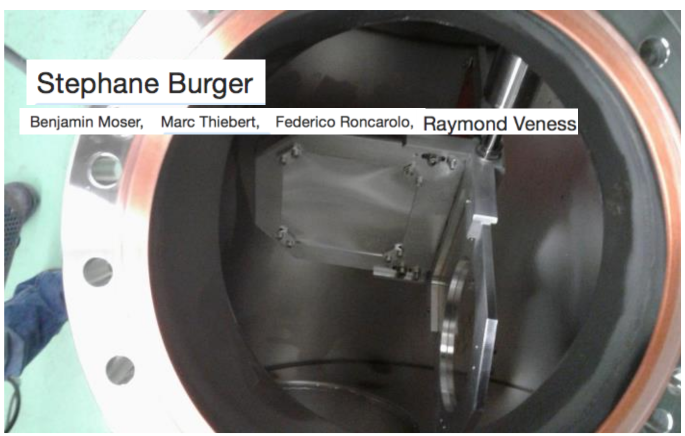


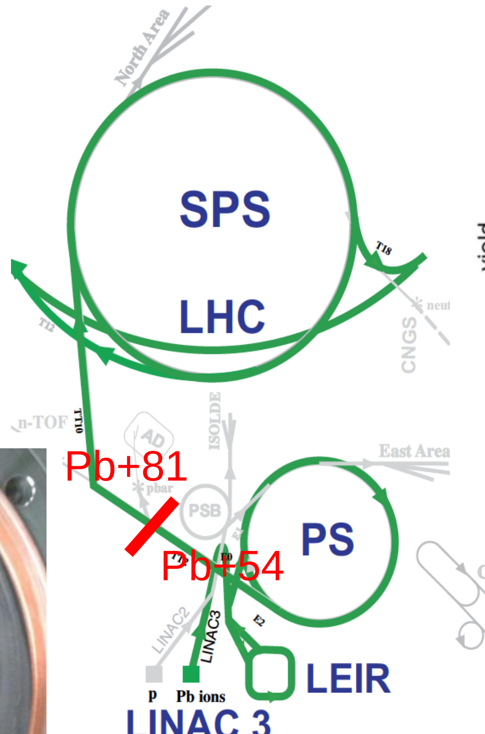
Interconnects between the MKIs

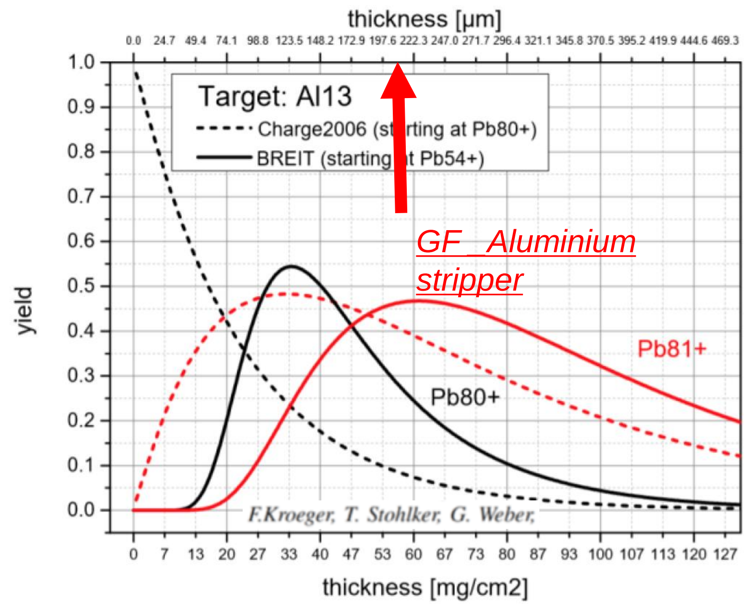


Injection line at Point 8

Ion stripping scheme for the 2018 MDs – the “minimal interference” approach: **Pb+81 beam**







26.01.2018

The 150μm (212μm crossed by the beam as installed at 45 degrees) thick Al foil has been installed on the FT16.BTV352 in the TT2 line!

What we have already learned from the 2017 Xe+39 SPS MDs ?

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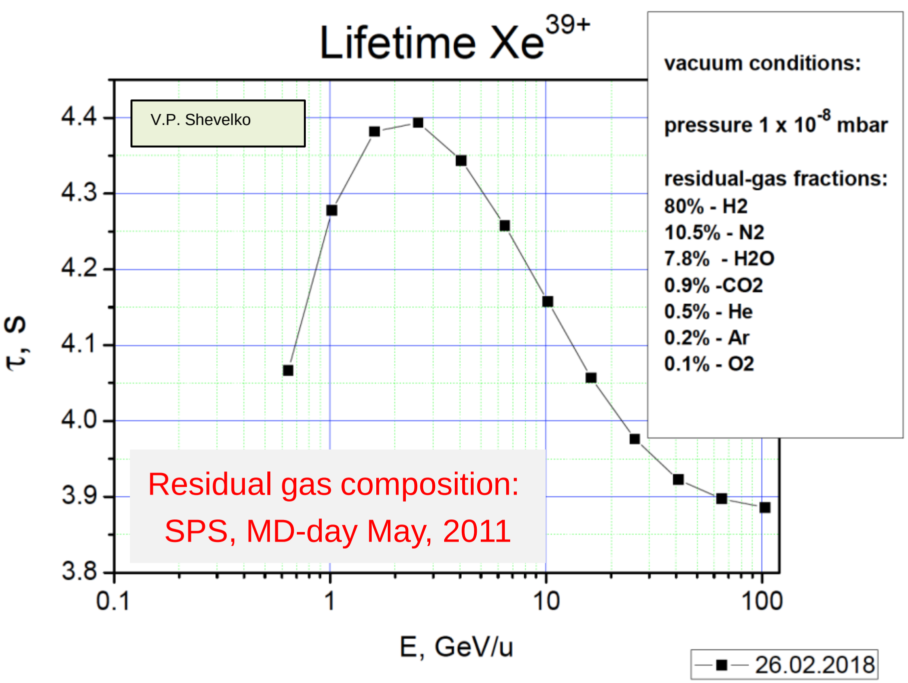

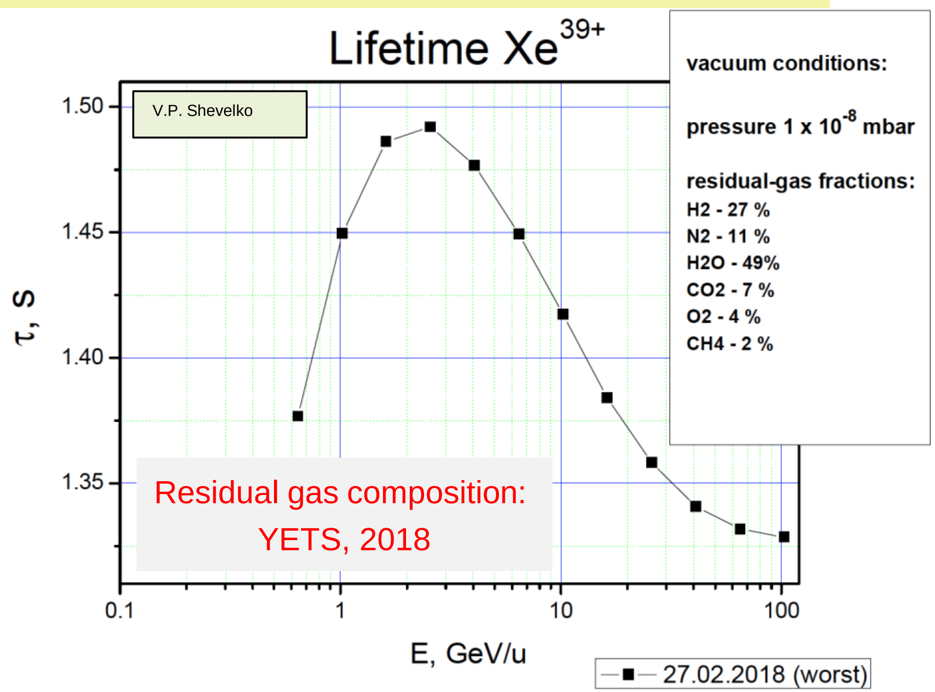

Residual gas composition: Chiara Pasquino