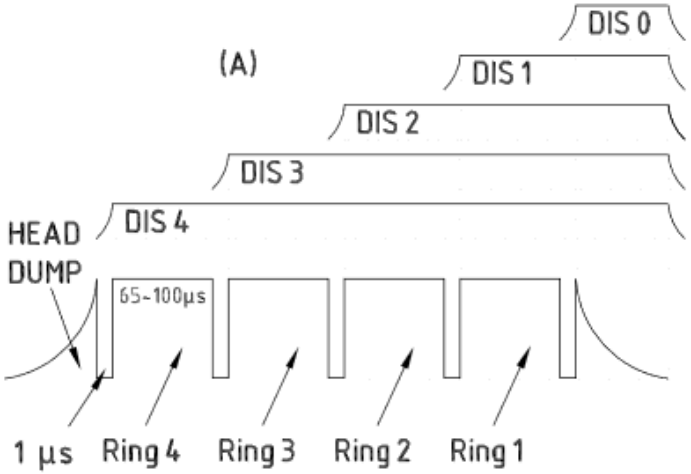
Injection Studies

C. Bracco, V. Forte

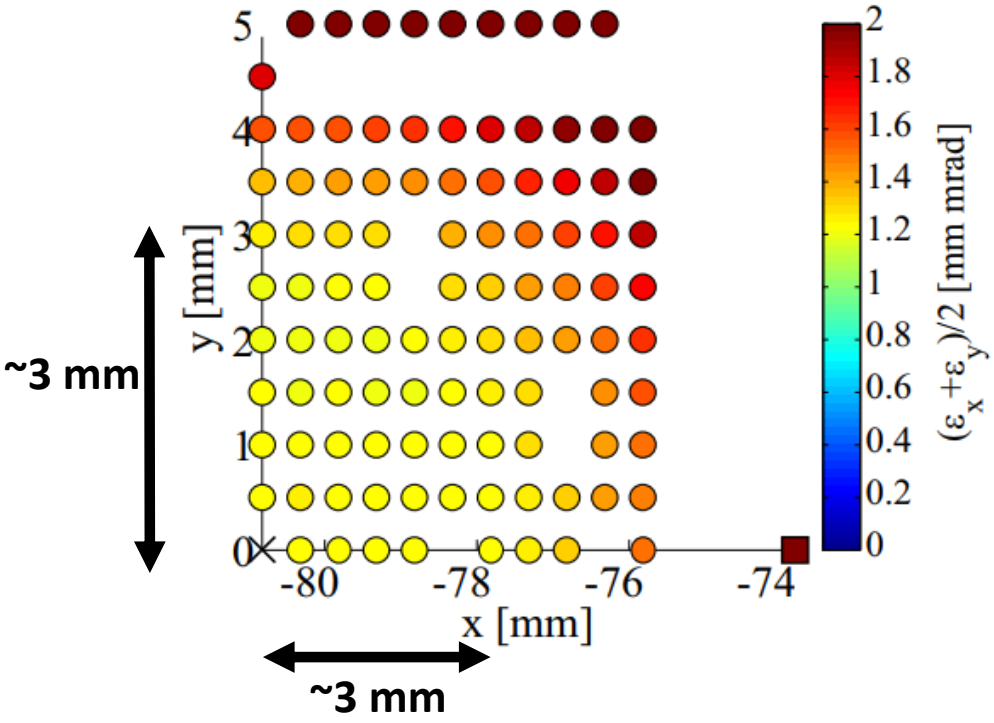
Injection studies assumptions

- For all beams fully matched optics (beta, alpha, dispersion etc.)
- High intensity beams: longitudinal and transverse painting, no optics imperfections or steering errors (only wished offsets in V plane to reach target emittances)
- LHC beams: baseline with no longitudinal or transverse painting, effect of imperfections (optics and **steering**) taken into account for standard HL-LHC beams.
  - Transverse offset along the pulse ≤ 1 mm ➔ precise tailoring of final emittance
- Always considered flat current pulses (need to evaluate impact on achievable intensity if “large” variations along the pulse)
  - Flatness over 400 us or 600 us ➔ integrated intensity per ring (ISOLDE)
  - Flatness along pulse ➔ balanced intensity/ring (both for LHC and ISOLDE beams)
  - ±2% flatness determined assuming that this is the wished uniformity intensity between the different rings (both for LHC and ISOLDE beams)



Simulations already performed for LHC beams

- V. Forte simulations
  - from realistic L4 trains of μ-bunches, NO longitudinal painting, fixed chopping factor at 61% (after optimization), including multi-turn and transverse/longitudinal space charge at PSB injection
  - **"pencil beam" with injection offset at 3.40e12 ppb, 40 mA before chopping (23 turns).**
    - Emittance sensitivity simulations with space charge after 10 ms from injection suggest **max 3 mm of injection offset** to reach 1.2 um



Studies assuming 23mA current before chopping (40 turns for standard HL-LHC beams) with imperfections (optics, steering, BSW fringe fields, etc.) for HL-LHC standard and BCMS beams (from injection to extraction) to be performed.

August 25, 2017 – Beam parameters at injection of each accelerator

		PSB (H^- injection from Linac4)						
		N (10^{11} p)	$\epsilon_{x,y}$ (μm)	E (GeV)	ϵ_z (eVs)	B_l (ns)	$\delta p/p_0$ (10^{-3})	$\Delta Q_{x,y}$
Achieved	Standard	17.73	2.14	0.05	1.0	1100	2.4	(0.51, 0.59)
	BCMS	8.48	1.15	0.05	0.9	1000	2.2	(0.46, 0.56)
LIU target	Standard	34.21	1.72	0.16	1.4	650	1.8	(0.58, 0.69)
	BCMS	17.11	1.36	0.16	1.4	650	1.8	(0.35, 0.43)

Achievable intensities with 25 mA* at PSB

User	Description	Intensity per ring	# turns (65% Chopping Factor)	# turns with 5 % losses in the PSB	Painting
LHC BCMS	BCMS	1.70E12	11	12	No
LHC25 Standard	25 ns LHC single batch	3.40E12	22	23	No
LHCPILOT	LHC pilot	5.00E9	1	1	No
SFTPRO	SPS fixed target	6.00E12	38	40	Yes
AD	AD target	4.00E12	26	27	Yes
TOF	nTOF	9.00E12	58	60	Yes
EASTA/B/C	PS East area	4.50E11	3	3	No
NORMGPS	ISOLDE GPS	1.00E13	64	67	Yes
NORMHRS	ISOLDE HRS	1.60E13	102	108	Yes
STAGISO	ISOLDE special targets	3.50E12	22	24	Yes

* after 65% chopping factor

Achievable intensities with 15 mA* at PSB

User	Description	Intensity per ring	# turns	# turns with 5 % losses in the PSB	Painting
LHC BCMS	BCMS	1.70E12	18	19	No
LHC25 Standard	25 ns LHC single batch	3.40E12	36	38	No
LHCPILOT	LHC pilot	5.00E9	1	1	No
SFTPRO	SPS fixed target	6.00E12	64	67	Yes
AD	AD target	4.00E12	43	45	Yes
TOF	nTOF	9.00E12	96	101	Yes
EASTA/B/C	PS East area	4.50E11	5	5	No
NORMGPS	ISOLDE GPS	1.00E13	107	112	Yes
NORMHRS	ISOLDE HRS	1.60E13	171**	179**	Yes
STAGISO	ISOLDE special targets	3.50E12	37	39	Yes

Possible new study: agree on 1 realistic pulse shape (length and flatness) with optics and steering errors ➔ evaluate impact on integrated intensity and balance between rings

* after 65% chopping factor

** DIS limit = 150 us so maximum intensity 1.34E13 ppr

Simulations including space charge (PSB injection process)

- V. Forte simulations
  - from realistic L4 trains of μ-bunches, NO longitudinal painting, fixed chopping factor at 61% (after optimization), including multi-turn and transverse/longitudinal space charge at PSB injection
  - **with and without painting functions**
  - **Ph.D. thesis (40 mA before chopping)** plus **more data points (30 mA before chopping)** after A. Lombardi request (presented at LIU/HL-LHC Joint Meeting in 2015)
    - ~10% emittance increase at 3.4e12 p → still fine for **LHC25 Standard LIU target emittance ($\varepsilon_{x,y,n}$= 1.7 um)**
    - 23 mA before chopping (~40 turns should be fully simulated with optics mismatch and steering errors)