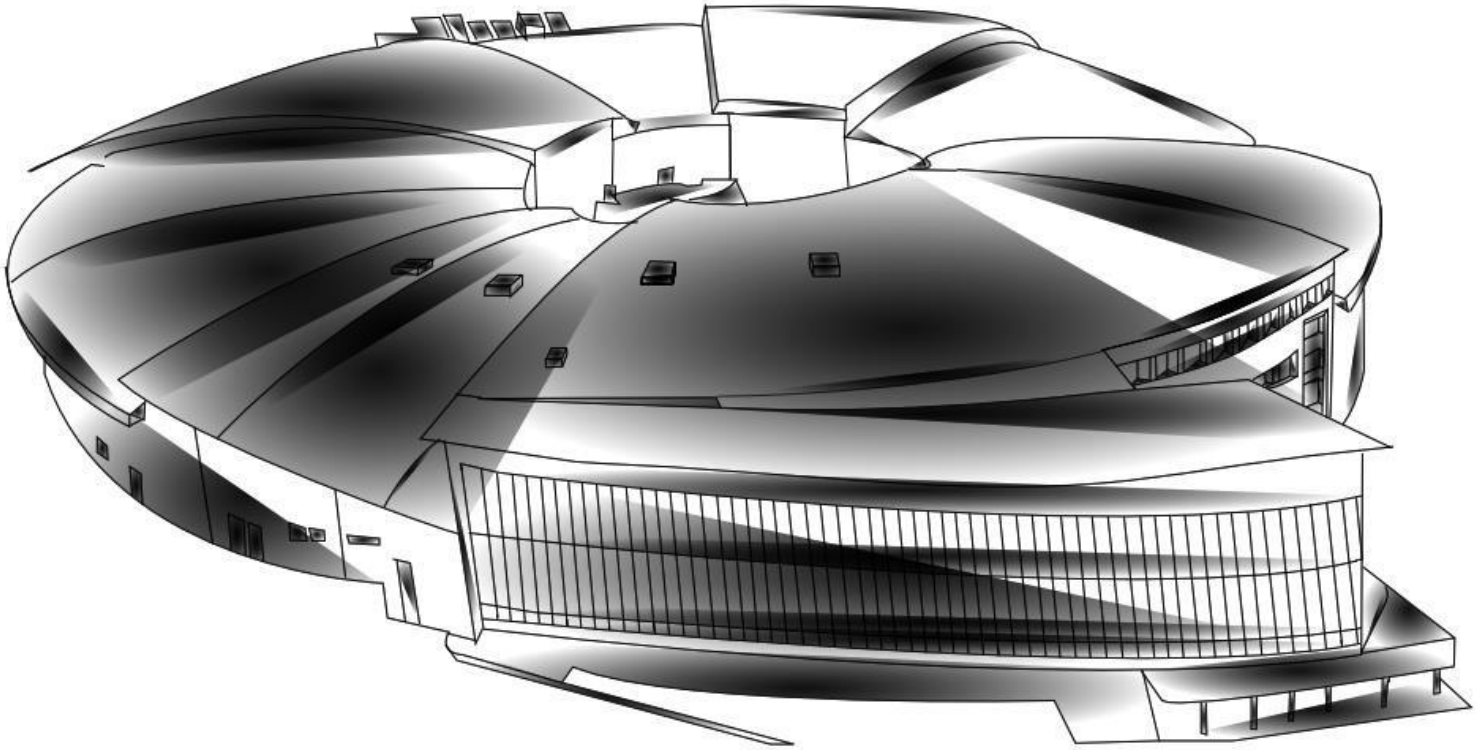
Operating Modes of the ALBA injector



Source: Javier Sanchez Rios

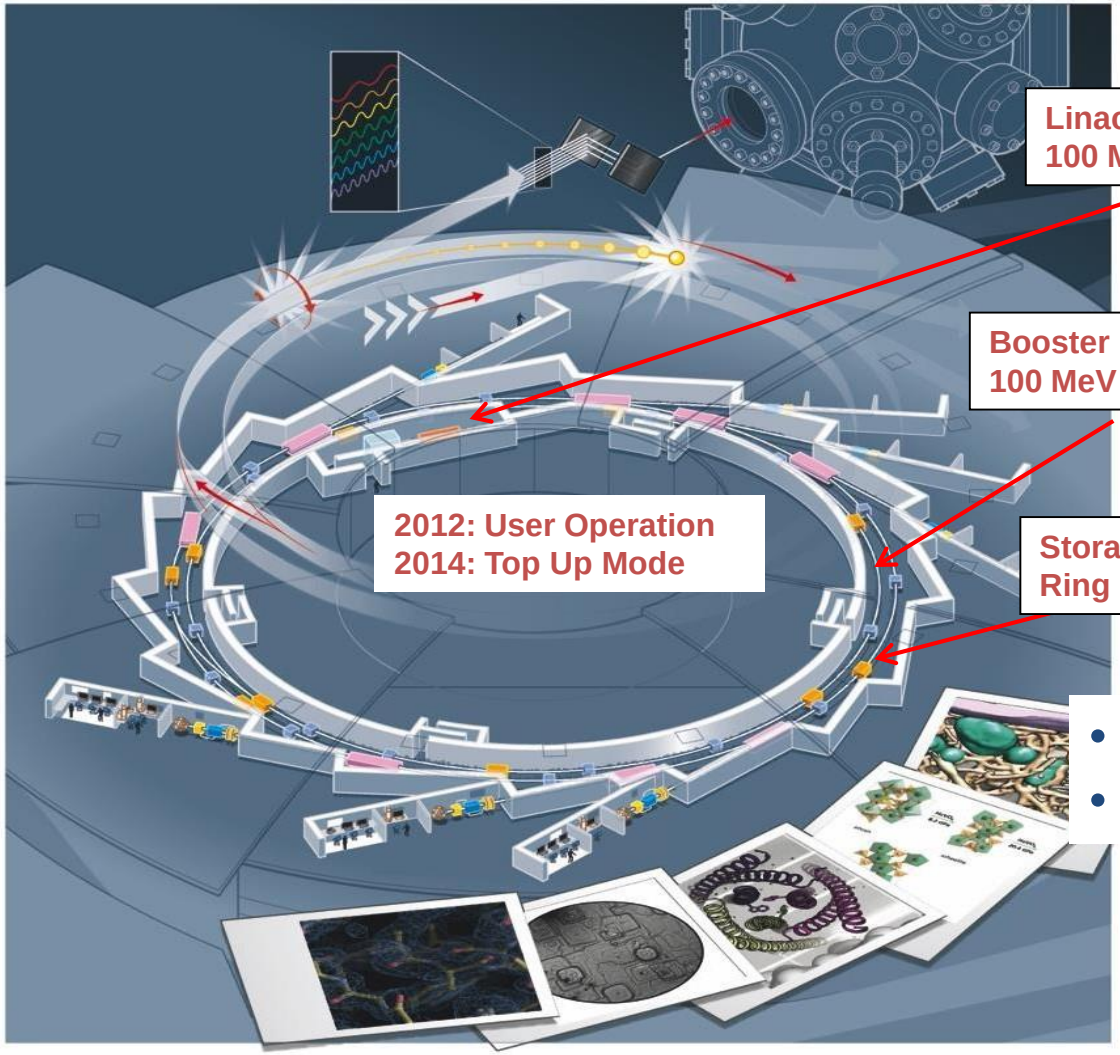
D. Lanaia

Linac & RF Group, ALBA CELLS Synchrotron, Barcelona, Spain

Outline

- ALBA Accelerator Complex
- Injector versatility
- Single Bunch Bucket Selection (SBBS)
- Resume & Conclusion

Alba Accelerator Complex

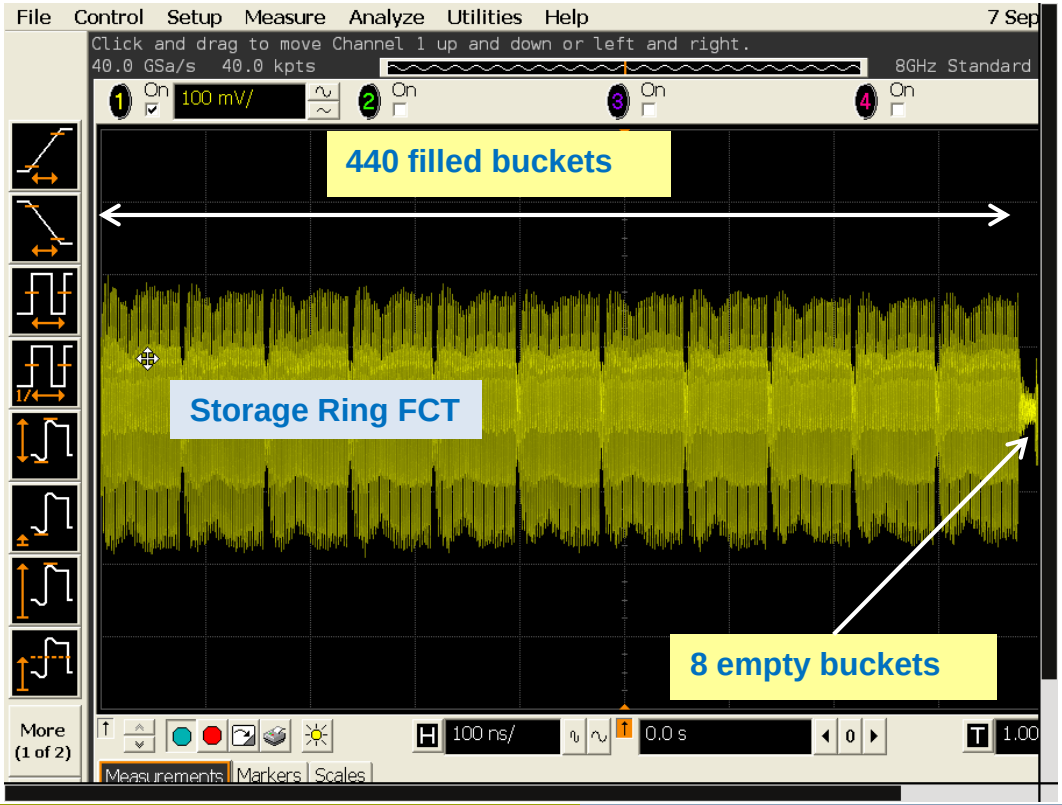


- 8 Operating Beam Lines
- 4 Beam Lines under construction

Synchrotron operation condition

Nominal

- Current in SR: 152 mA (≈ 2 mA refilled)
- SR operation pattern: 440 buckets filled out of 448
- Top up: every 20 min (Injection ≈ 30 sec)



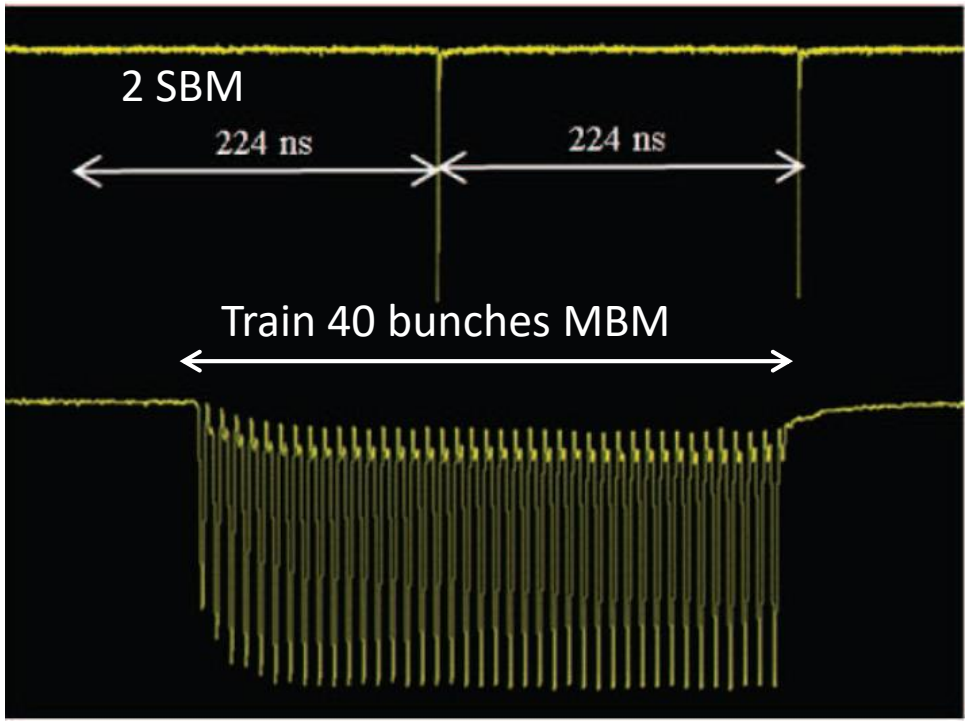
Linac Operation Mode

Single Bunch Mode (SBM)

- Number of bunches per injection: 1-16
- Max charge per SBM: 0.25 nC

Multi Bunch Mode (MBM)

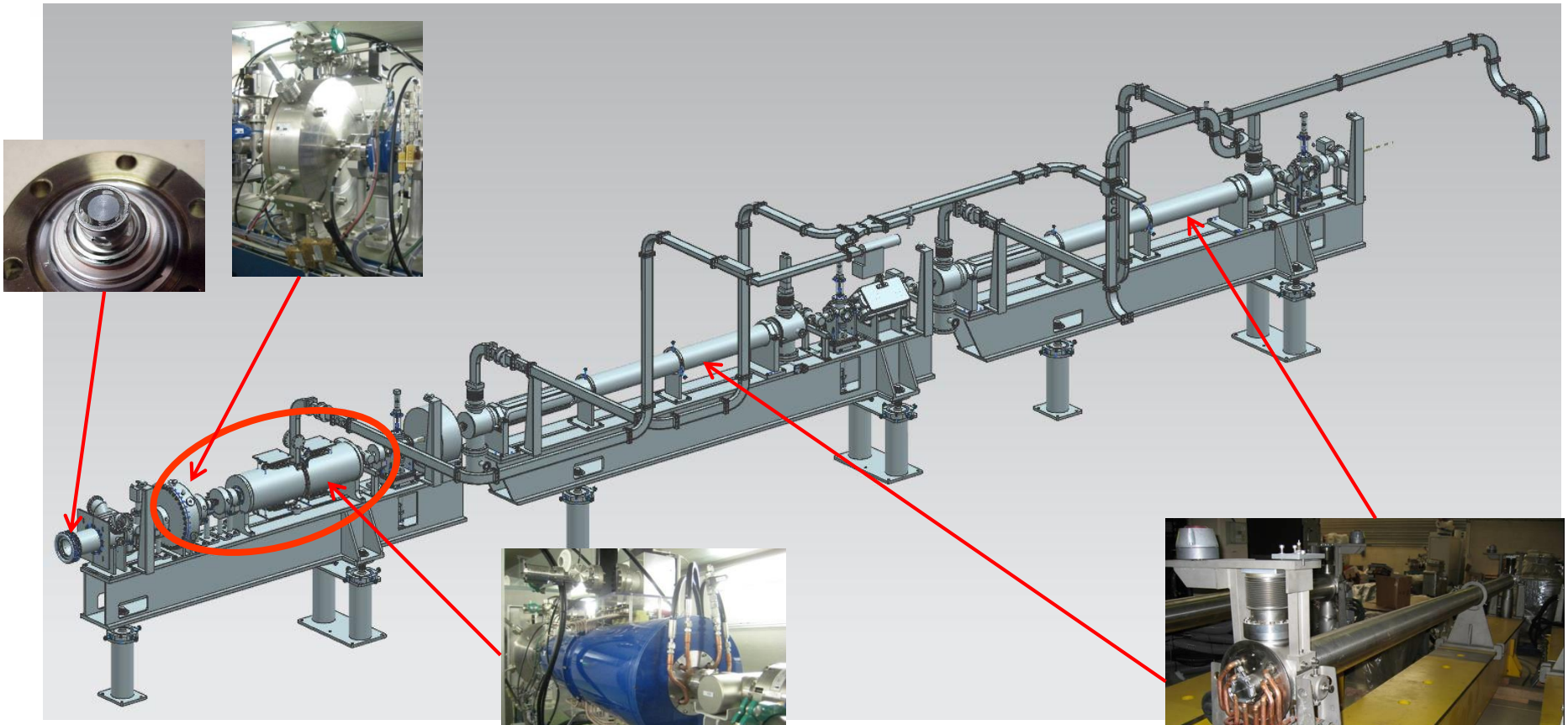
- Time interval between bunches: fixed, 2 ns
- Max charge up to 4 nC

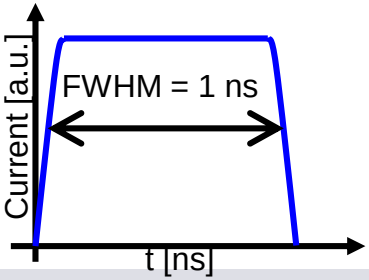


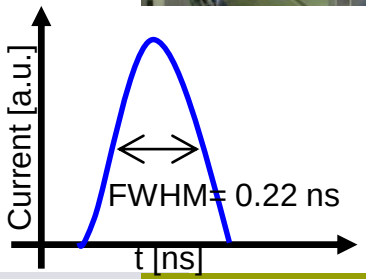
Outline

- ALBA Accelerator Complex
- **Injector versatility**
- Single Bunch Bucket Selection (SBBS)
- Resume & Conclusion

Alba Linac



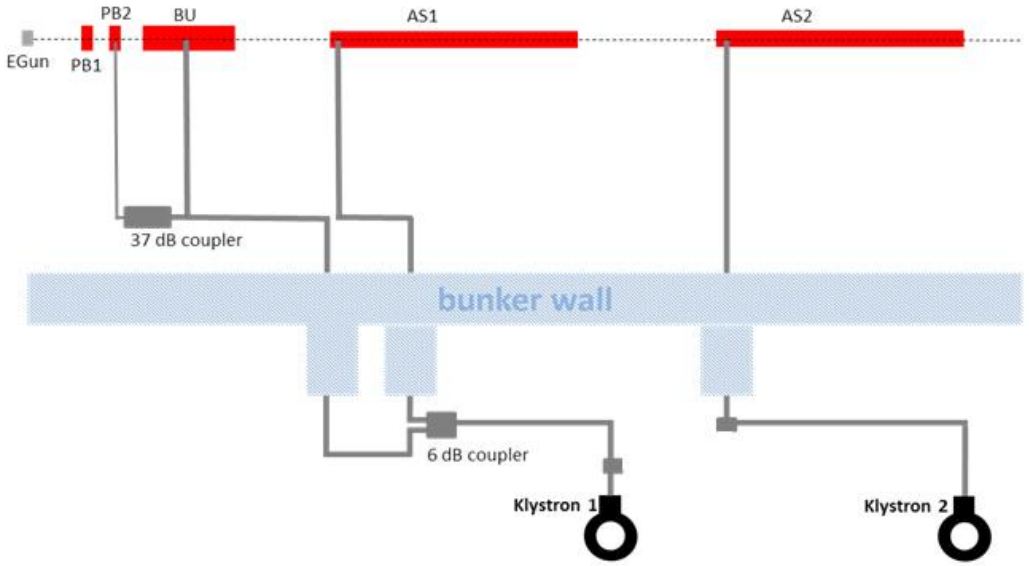




Klystrons and Waveguide system

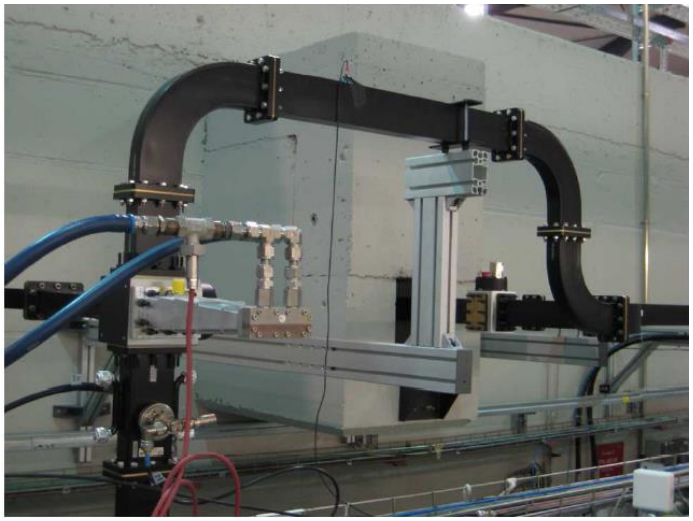
RF power to cavities

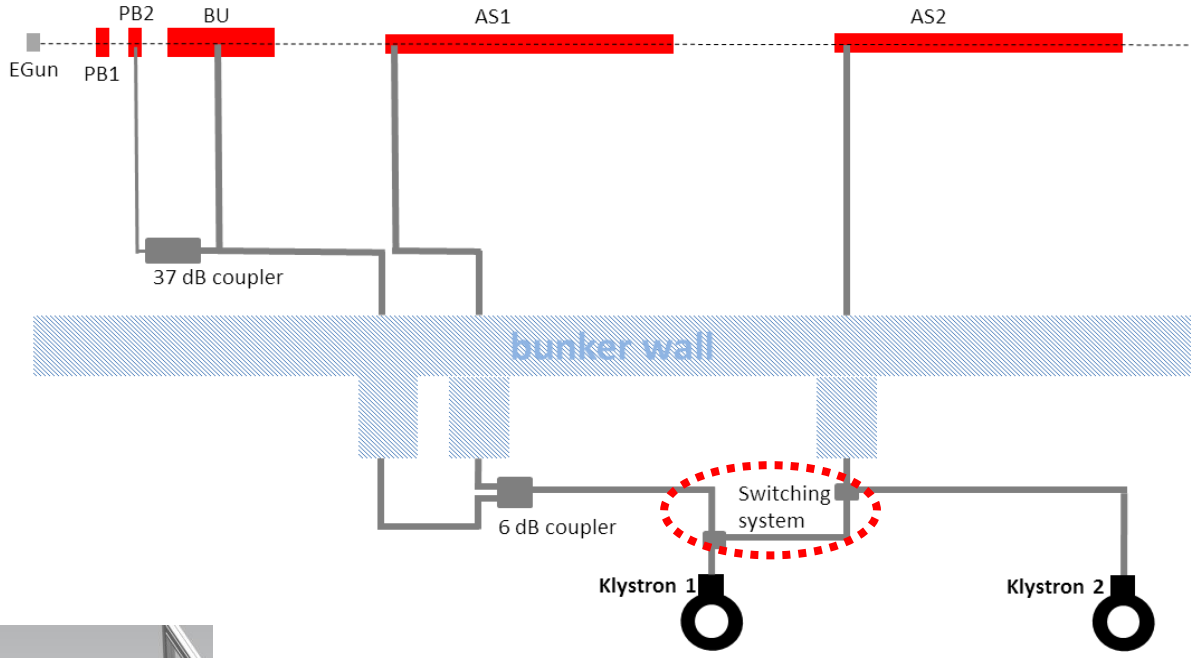
- 2 Klystrons TH2100
- Pulsed at 3 GHz
- 35 MW peak

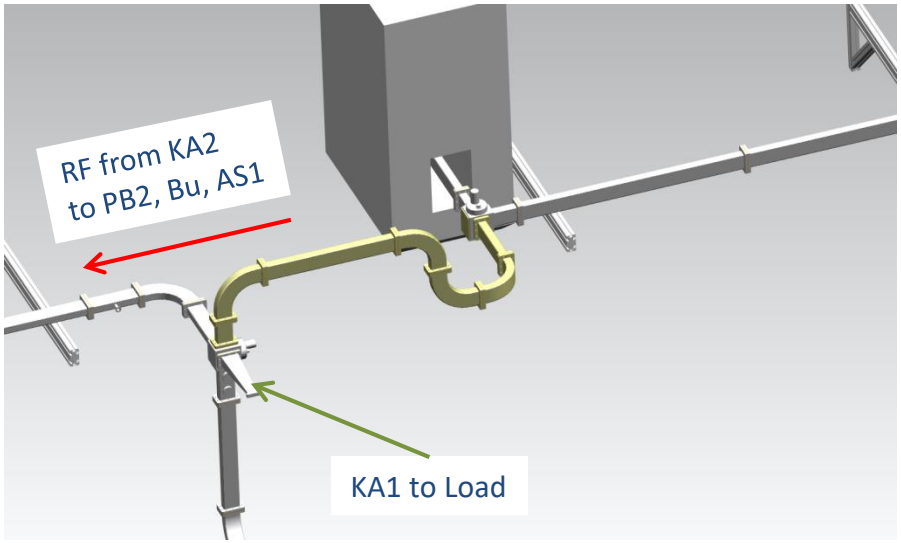


Cavity	Power delivered by
Pre Buncher 1	Solid State Amplifier
Pre buncher 2	KA1
Buncher	KA1
Acc. Structure 1	KA1
Acc. Structure 2	KA2

Klystrons and Waveguide system

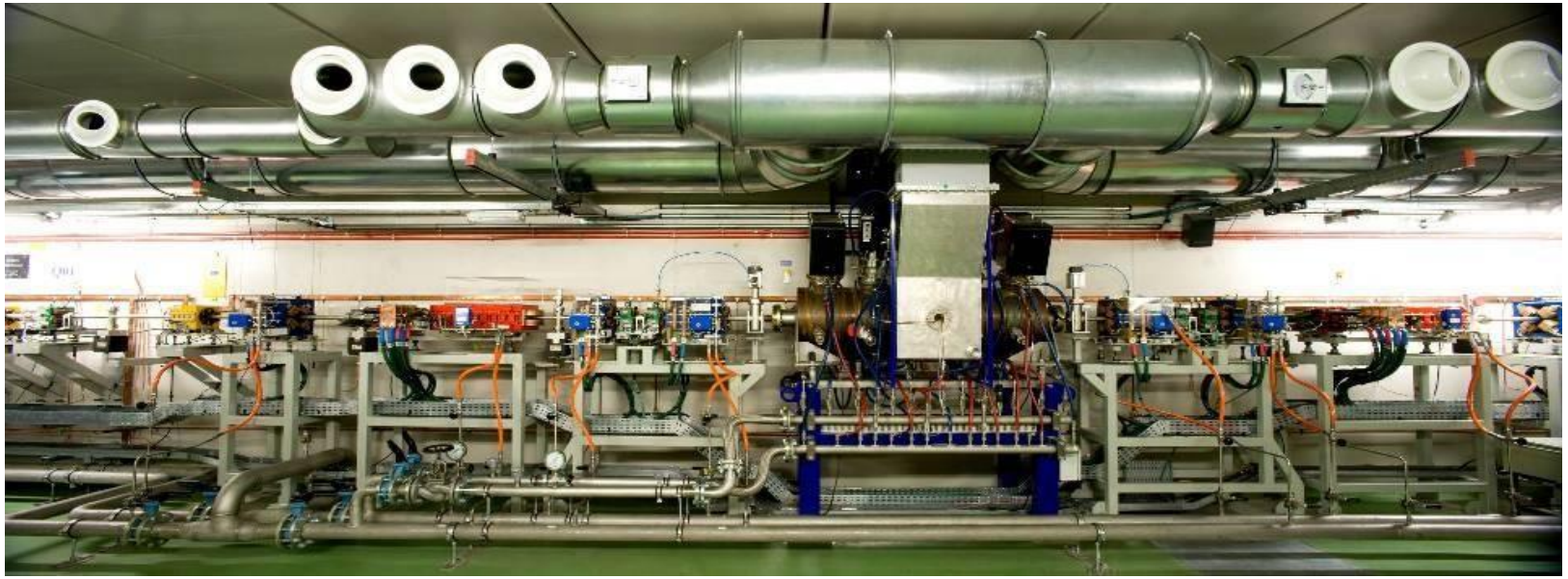






Waveguide upgrade:
S-band switching allow to use either Klystron
Final energy with only 1 Klystron: 67 MeV

Alba Booster



Booster Parameters	Value
Injection energy	100 MeV
Extraction energy	3 GeV
Circumference	249.6 m
RF Frequency	500 MHz
Max e^- current	1 mA
Repetition Rate	3 Hz
Revolution period	832 ns

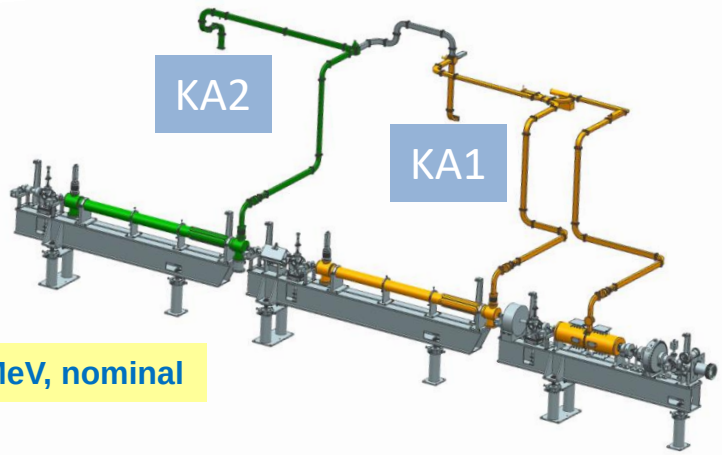
- Designed for 110 MeV
- In 2015 commissioned for 67 MeV [1]
- In 2018 injection at 60 MeV not yet fully commissioned

[1] G. Benedetti et al., "Commissioning of the ALBA injector with 67 MeV Single Klystron Linac", in Proc IPAC'16, Busan, Korea

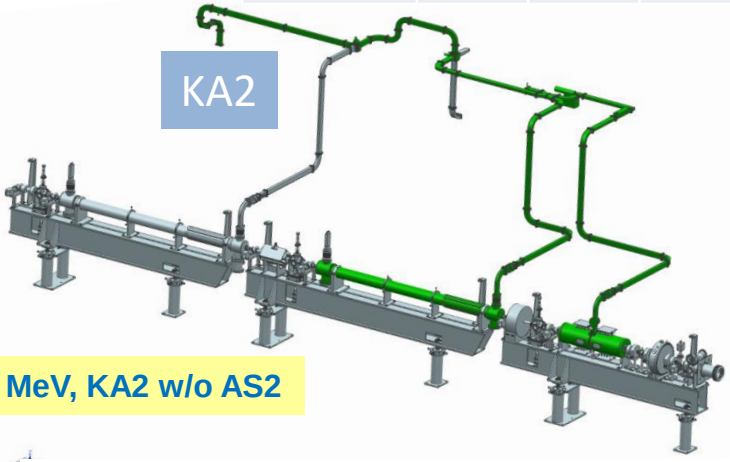
Pre-Injector Modes

Energy [MeV]	KA1	KA2	Cavity filled
110	on	on	AS1+AS2
67	on		AS1
67		on	AS1
67	on	on	AS2

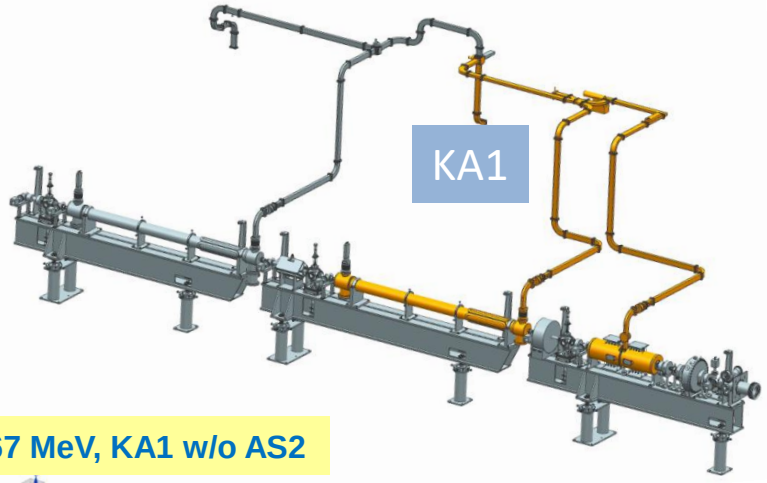
KA1, KA2



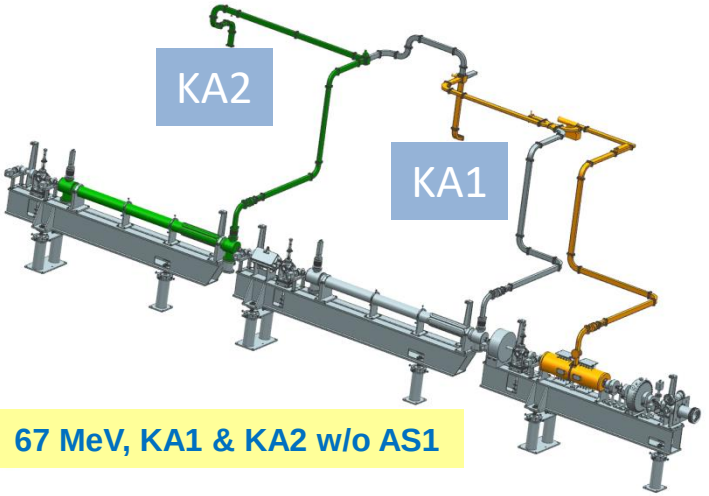
110 MeV, nominal



67 MeV, KA2 w/o AS2



67 MeV, KA1 w/o AS2



67 MeV, KA1 & KA2 w/o AS1

Beam Energy Measurement

Beam Energy measured at diagnostic line after a bending magnet

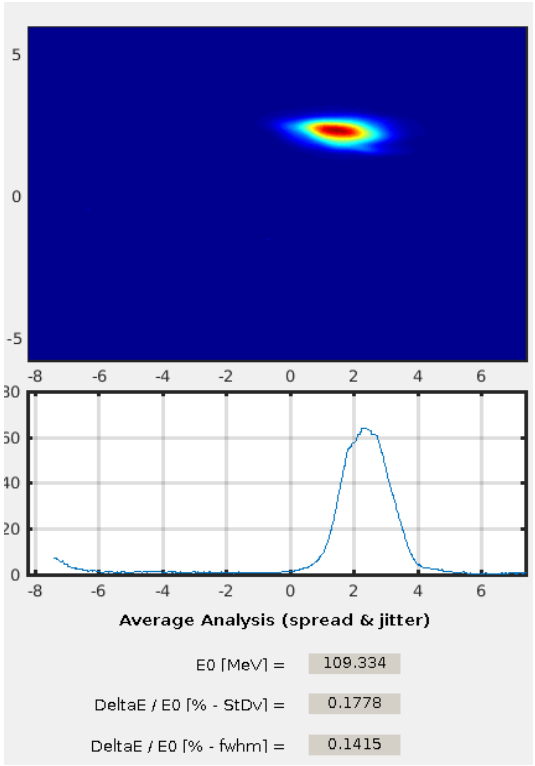
Beam Parameters @ Linac exit

	110 MeV	67 MeV
σ_E/E (%)	0.13	0.14
$\epsilon_{n,x}$ $(\mu m \cdot rad)$	12.3	13.1
α_x	0.4	1.1
β_x (m)	10.1	7.6
$\epsilon_{n,y}$ $(\mu m \cdot rad)$	12.2	18.9
α_y	-0.7	0.6
β_y (m)	32.6	16.2

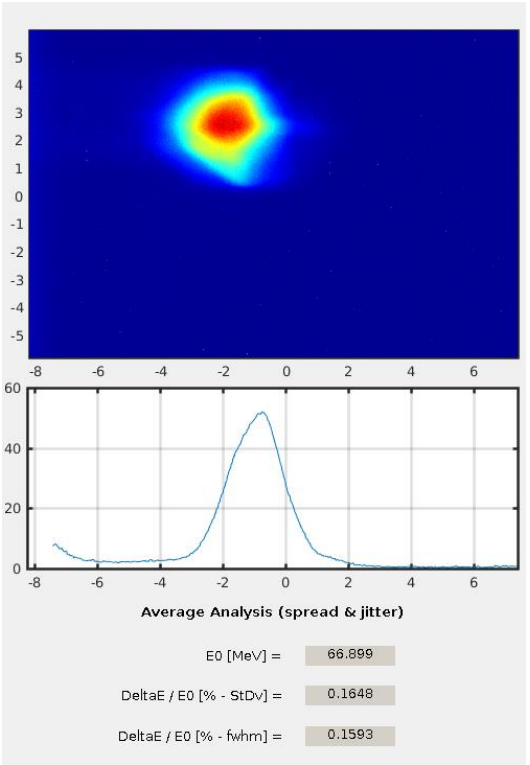
Beam at 67 MeV

- Increase in energy spread
- Different Twiss parameter
- Less beam rigidity

Linac Beam @ 110 MeV



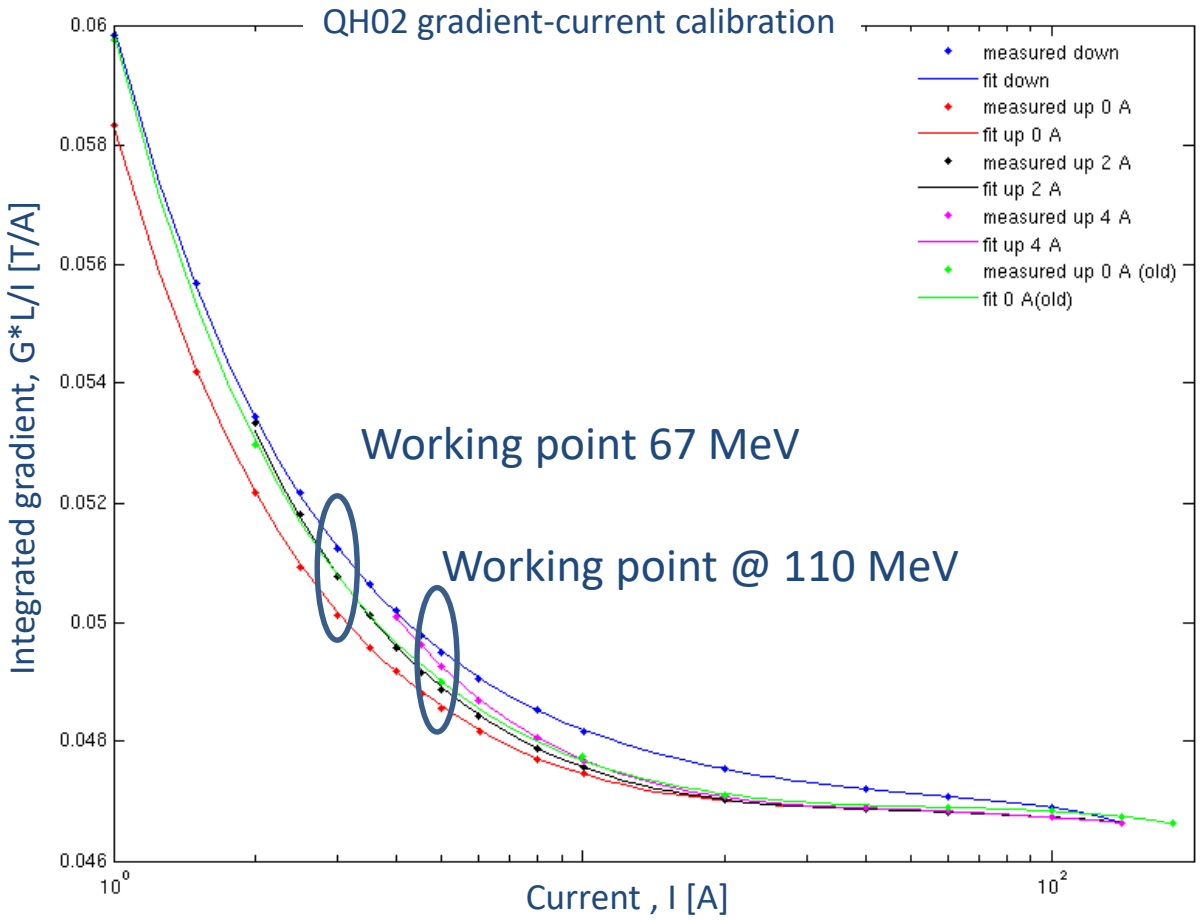
Linac Beam @ 67 MeV



LTB & Booster at 67 MeV

- LTB: Scaling Magnet for 67 MeV
- Booster:
  - Remnant field effects → new quads calibration

Beam injected into the booster but lost after 8ms (10000 turns) hitting a second order resounance

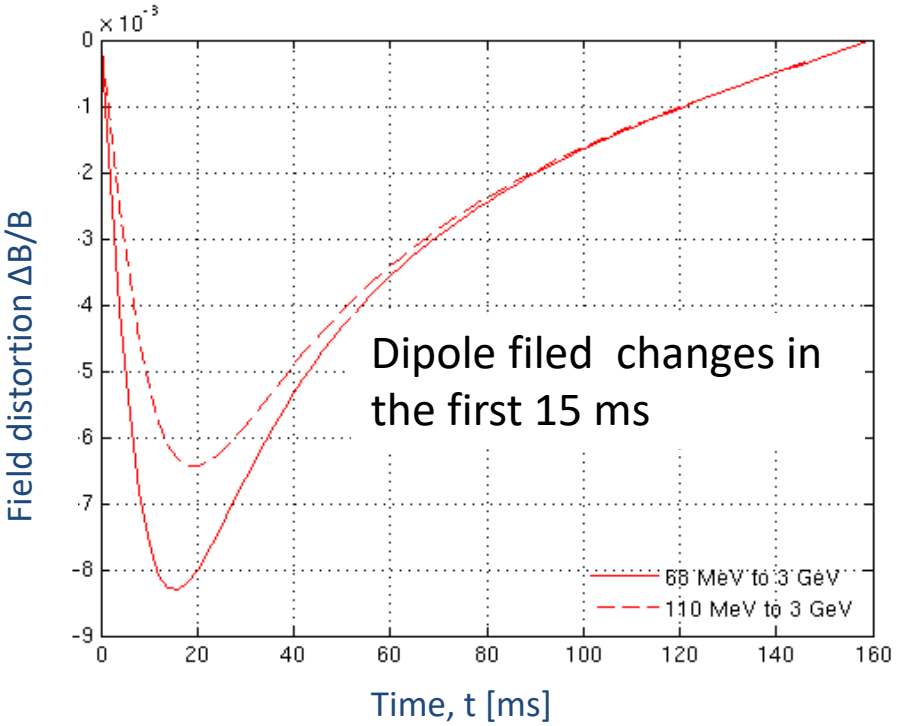


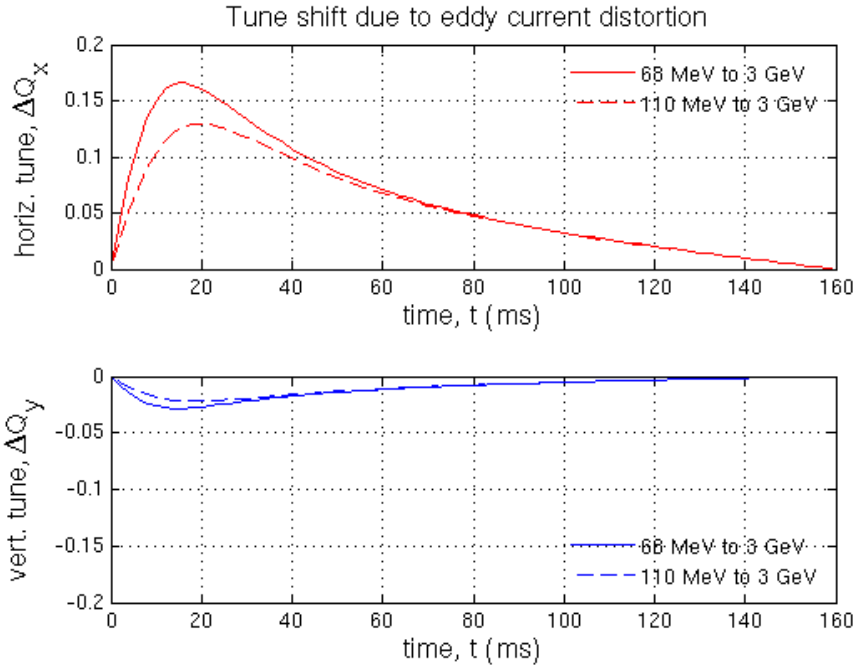
LTB & Booster at 67 MeV

Effect of the Dipole Vacuum Chamber Eddy Currents on the Booster Tunes

Solution: New Booster dipole waveform created applying eddy current compensating factor

Eddy currents dipole distortion





67 MeV mode in operation

- Linac and Booster 67 MeV settings prepared at run start
- Time needed to change from 100 MeV to 67 MeV ≈ 1.5h
- Same settings are used for Booster @ 60 MeV

Outline

- Linac Operation Modes
- Injector versatility
- **Single Bunch Bucket Selection (SBBS)**
- Resume & Conclusion

Injection Process & Timing upgrade

Timing Limitation

Event based timing generator 8 ns resolution synchronized with MO → **injection only possible into buckets separated by multiple of 8 ns from bucket 0**

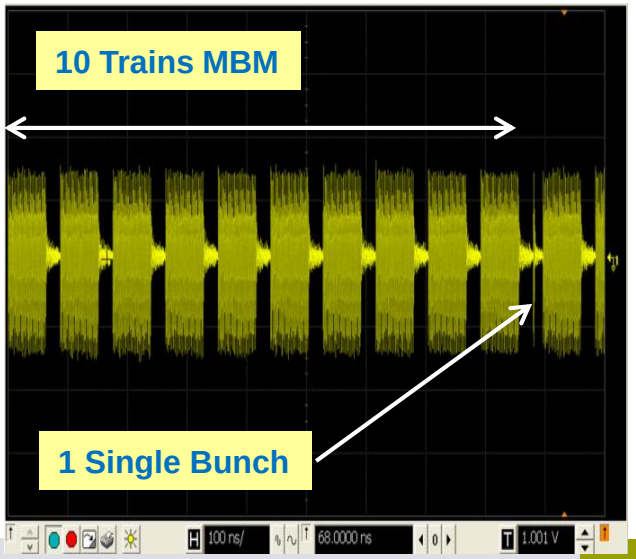
→ No possible to create all filling pattern

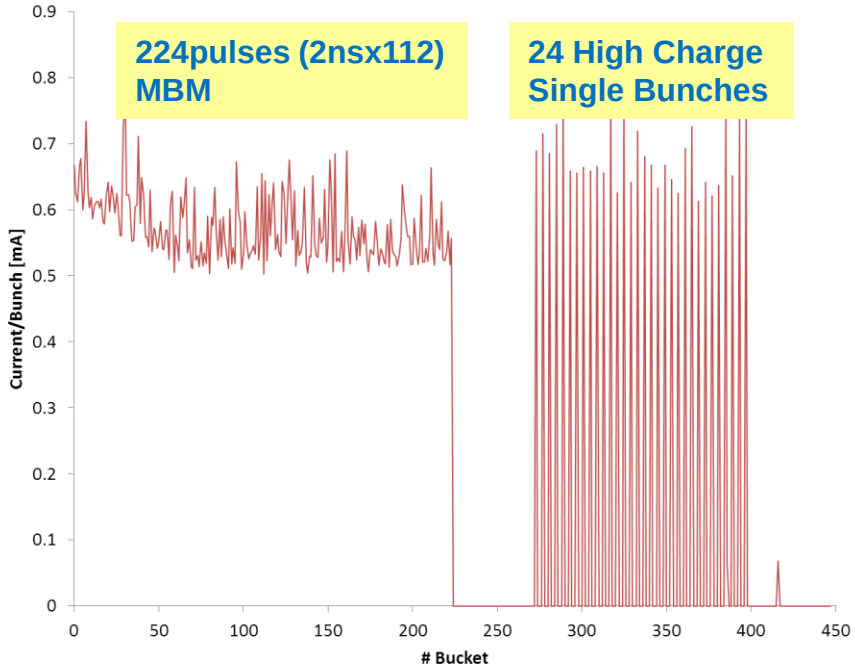
Goals

- Create all possible SR filling pattern (hybrid filling pattern to perform time resolved experiment)

Solution

- Install *cPCI-EVRTG-300* in linac and pulsed → Linac trigger resolution from 8 ns of 1 ns





Single Bunch Bucket Selection (SBBS)

Charge Homogeneity Limitations

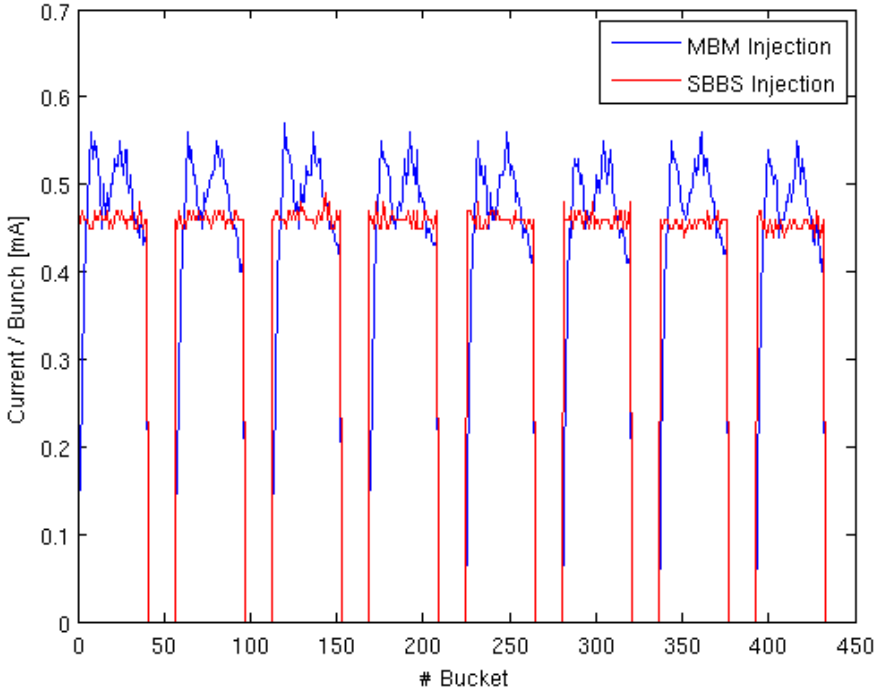
- No charge stability pulse to pulse
- Not uniform distribution of linac multi bunches

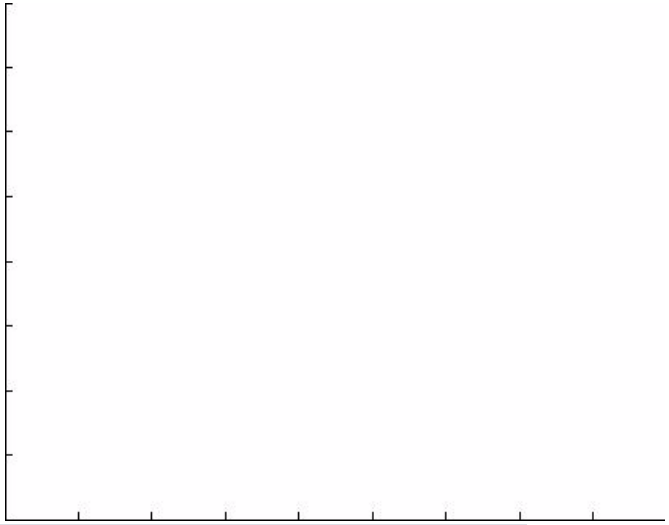
Solution

- Using the new timing
- Algorithm: Compares the current in each bucket with the one of the defined pattern
- Top up the bucket with less current

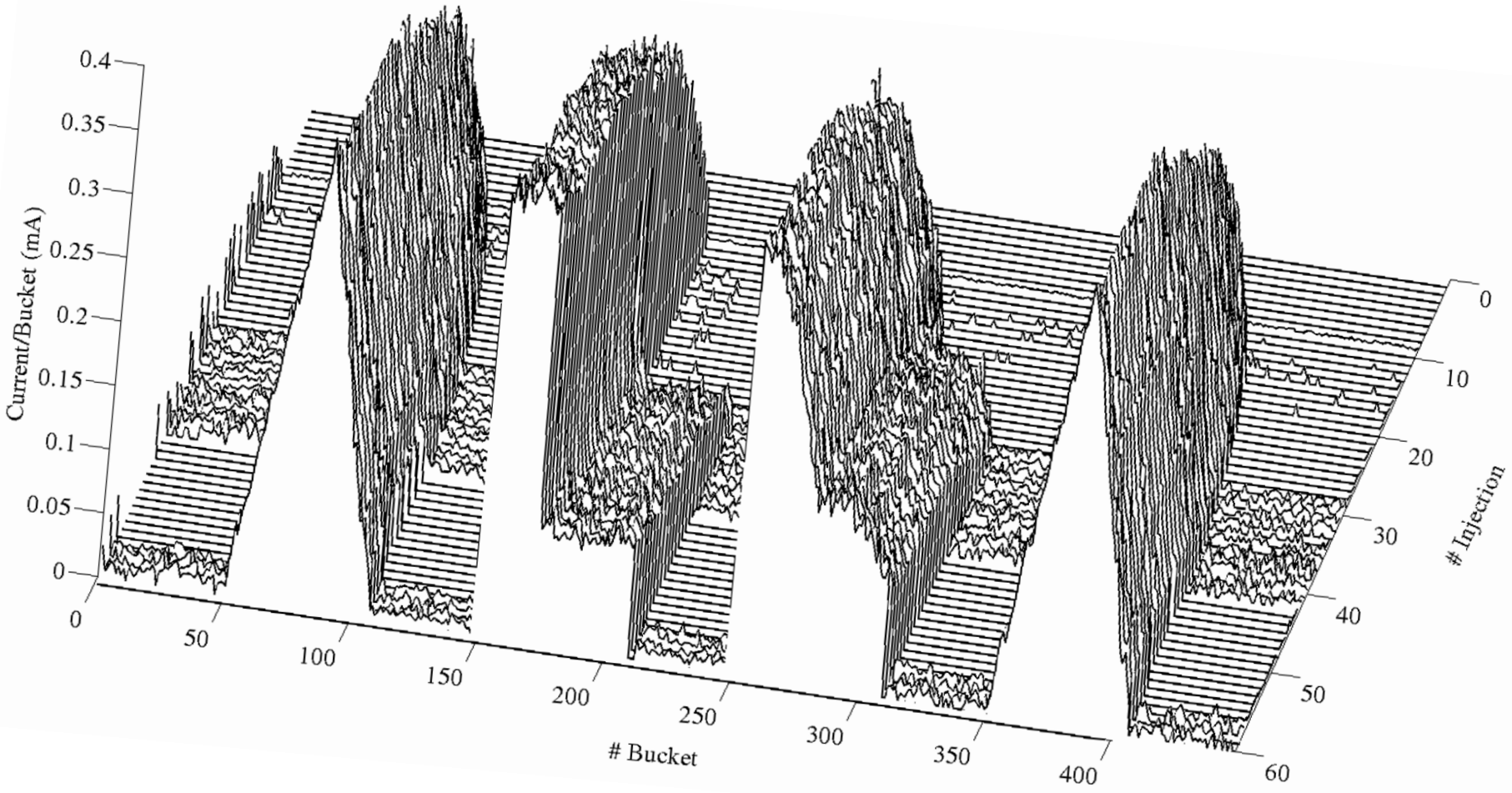
SBBS: Running since 2016 during user operation using a symmetric filling pattern.

SR current uniformity variation from 30% to 10%.



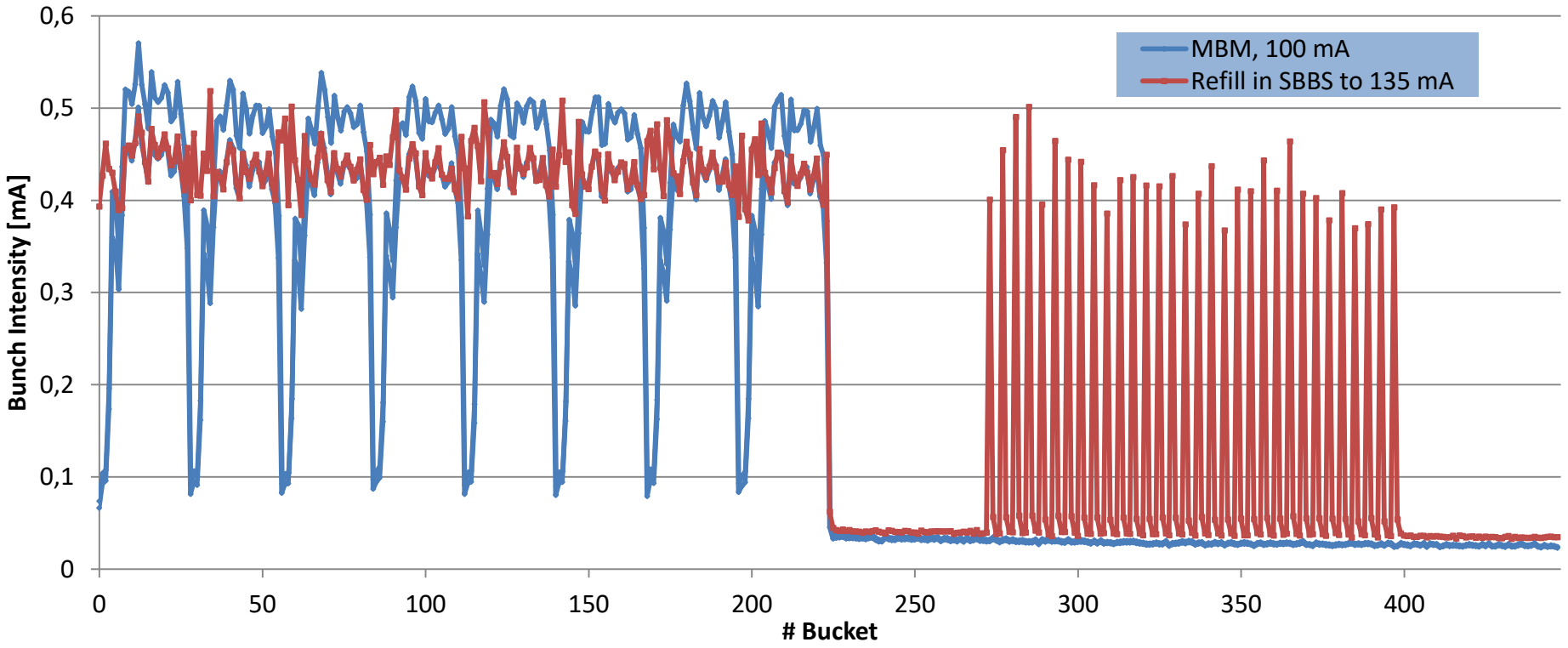


Single Bunch Bucket Selection



Injection Process in SBBS

- 100 mA injected in MBM
- Operator switch to SBBS
- Refill in SBBS up to the desired current
- Top up every 20 min in SBBS



Resume and Conclusion

- ALBA Injectors in user operation from 2012, Top Up mode from 2014
- Improved injector reliability and versatility
  - 110 MeV to 3 GeV
  - 67 MeV (Single Klystron mode) to 3 GeV
    - Achieved with different RF distribution @ Linac
- Single Bunch Bucket Selection Operation mode (SBBS) since 2016
  - Any Filling pattern can now be provided
  - Improvement of charge pulse to pulse stability

Acknowledge:

- ALBA Beam dynamics group

Thank you for your attention!!