
CERN

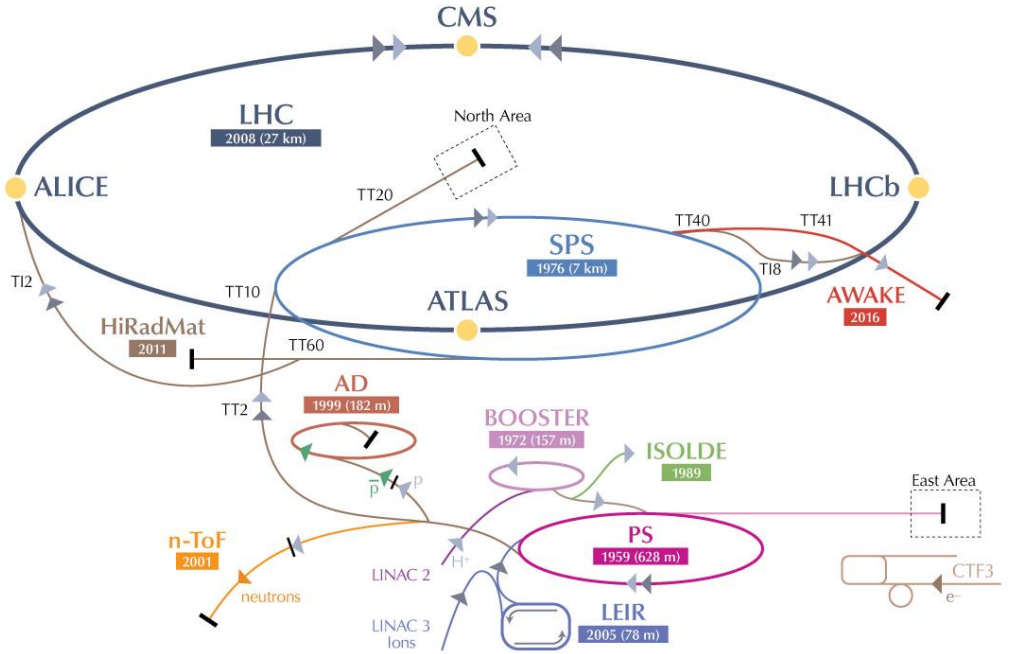
The AWAKE Electron Line Beam Position Monitors

Benjamin Moser BI-ML

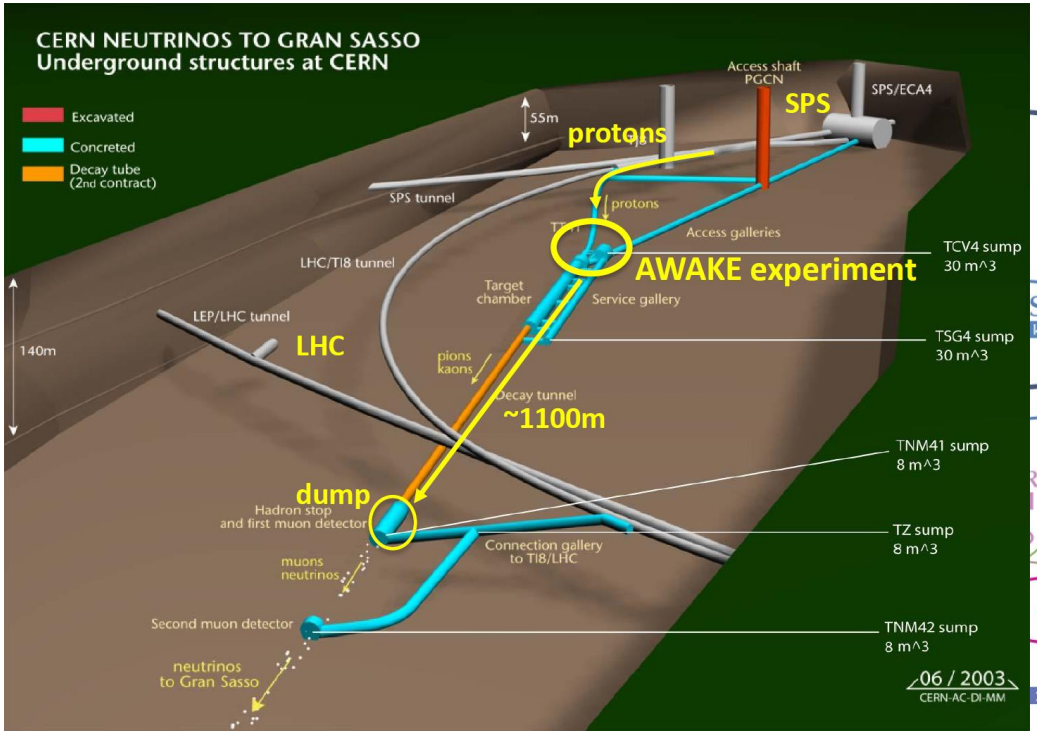
Content

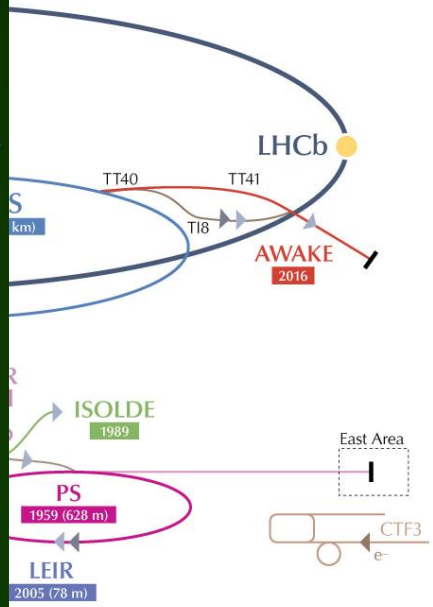
- What is AWAKE
- Experiment set up
- BPMs for electron beam
- BPM tests
- Electronics for BPM

AWAKE site


CMS
LHC
2008 (27 km)
North Area
ALICE
LHCb
TT20
TT40
TT41
SPS
1976 (7 km)
TI8
TI2
TT10
ATLAS
AWAKE
2016
HiRadMat
2011
TT60
AD
1999 (182 m)
TT2
BOOSTER
1972 (157 m)
ISOLDE
1989
East Area
n-ToF
2001
neutrons
PS
1959 (628 m)
LINAC 2
LINAC 3
Ions
LEIR
2005 (78 m)
CTF3

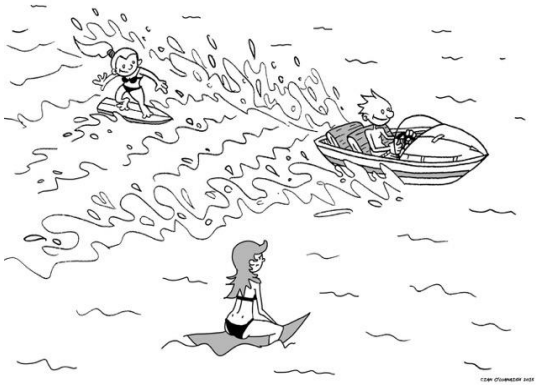
AWAKE site

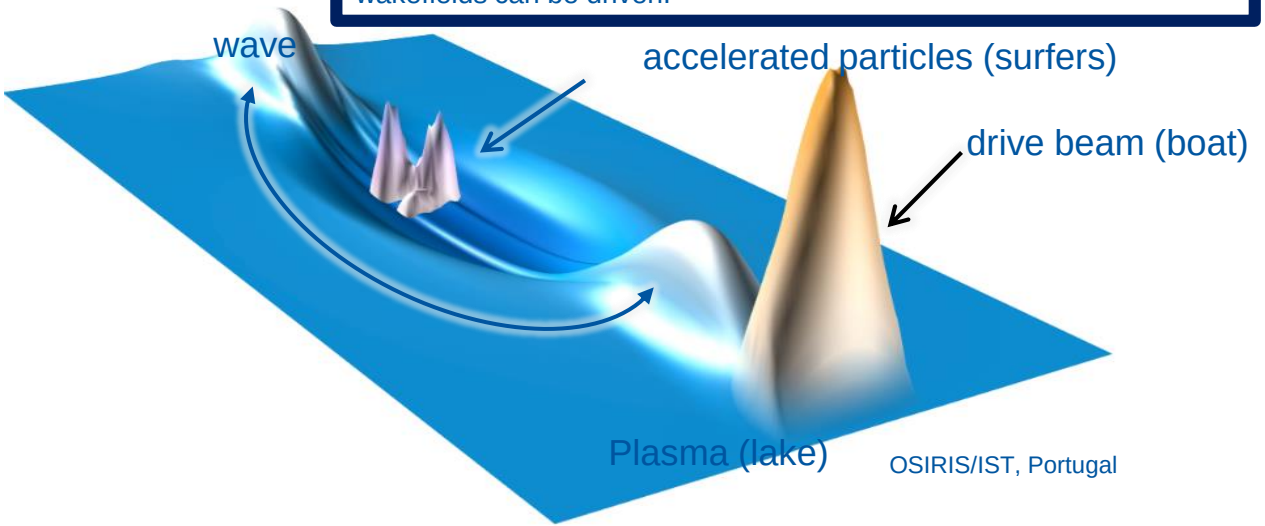

CERN NEUTRINOS TO GRAN SASSO
Underground structures at CERN
Excavated
Concreted
Decay tube
(2nd contract)
55m
Access shaft
PGCN
SPS
SPS/ECA4
protons
SPS tunnel
protons
Access galleries
TCV4 sump
30 m^3
LHC/TI8 tunnel
AWAKE experiment
Target
chamber
Service gallery
LEP/LHC tunnel
LHC
140m
TSG4 sump
30 m^3
pions
kaons
Decay tunnel
~1100m
TNM41 sump
8 m^3
dump
Hadron stop
and first muon detector
TZ sump
8 m^3
Connection gallery
to TI8/LHC
muons
neutrinos
Second muon detector
TNM42 sump
8 m^3
neutrinos
to Gran Sasso
06 / 2003
CERN-AC-DI-MM


LHCb
TT40
TT41
TI8
AWAKE
2016
ISOLDE
1989
East Area
PS
1959 (628 m)
CTF3
e-
LEIR
2005 (78 m)

The Advanced Proton Driven Plasma Wakefield Acceleration Experiment

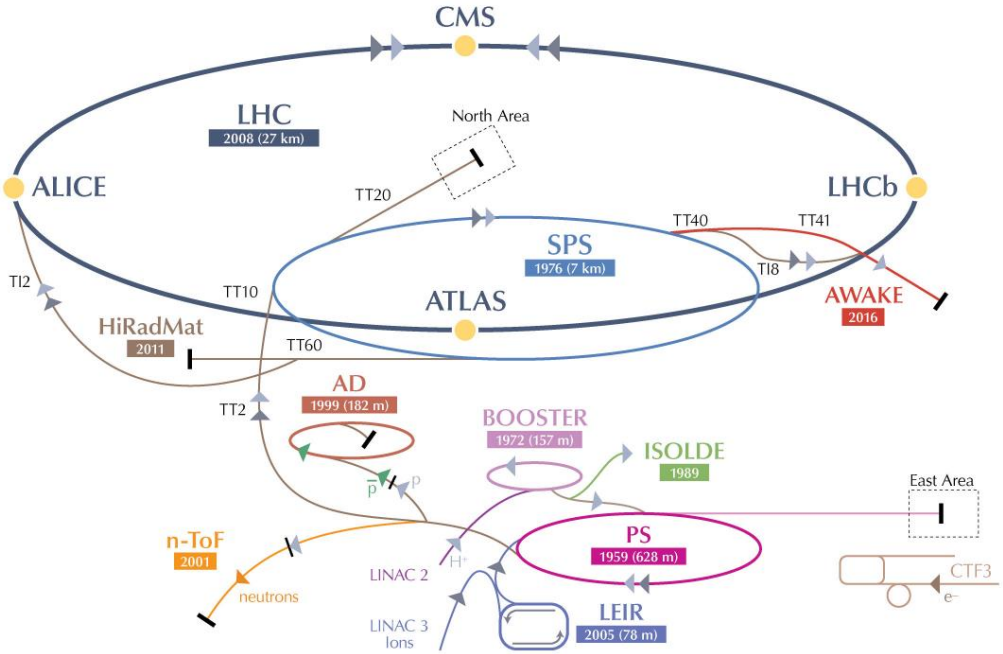
Using plasma to convert **the transverse electric field** of the drive bunch into a **longitudinal electric field in the plasma.** The more energy is available, the longer (distance-wise) these plasma wakefields can be driven.



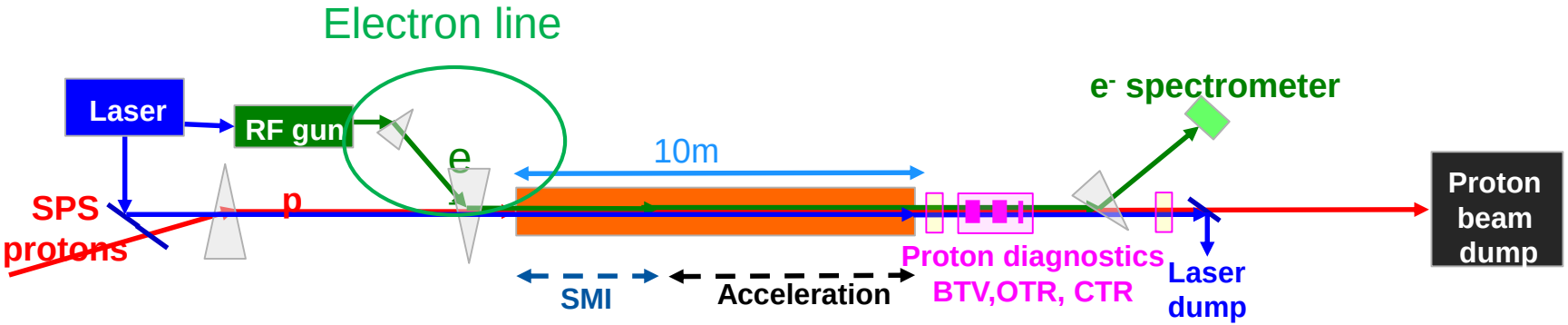


AWAKE Ingredients

- Plasma
- LASER beam
- Proton beam
- Electron beam

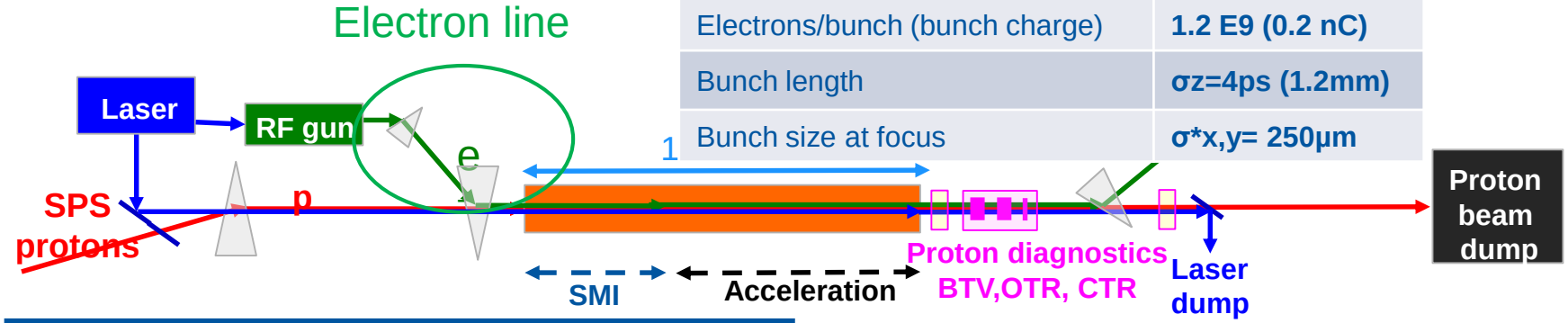


Experiment set up



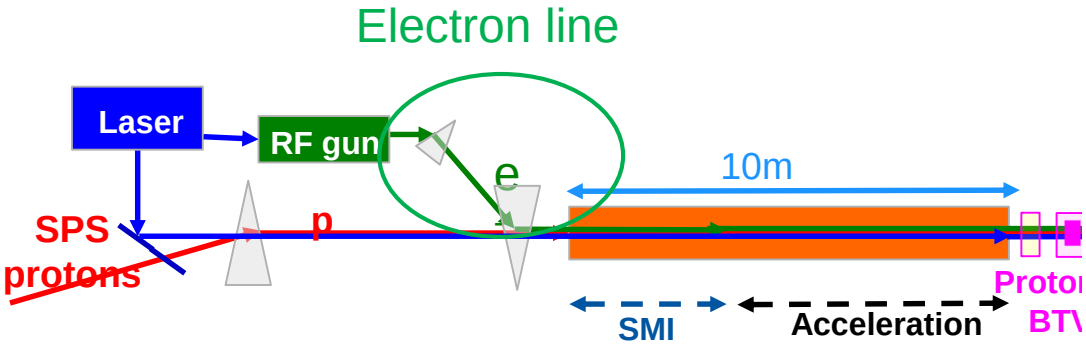
Experiment set up

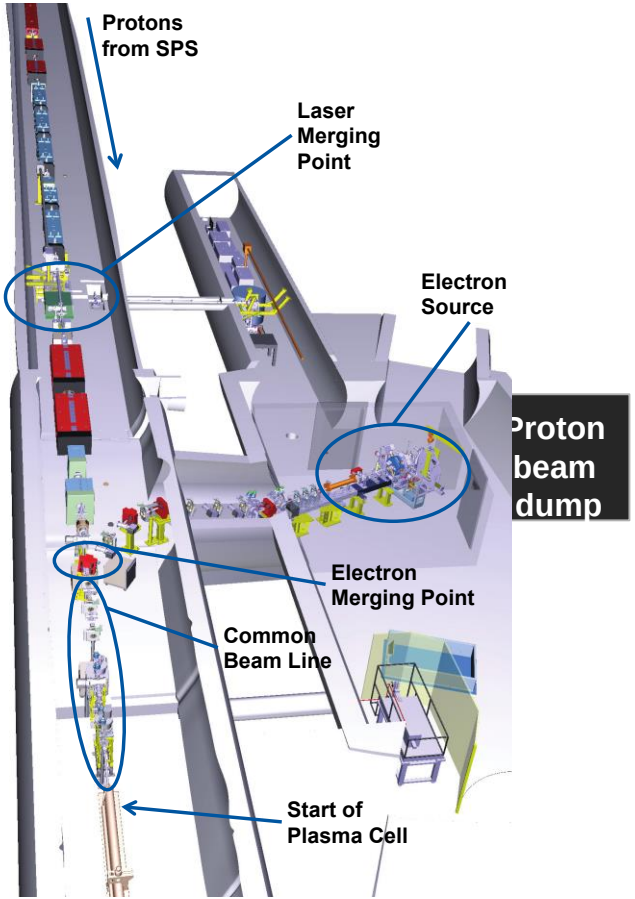
Electron beam	
Momentum	32 MeV/c
Electrons/bunch (bunch charge)	1.2 E9 (0.2 nC)
Bunch length	σz=4ps (1.2mm)
Bunch size at focus	σ*x,y= 250μm



Proton beam	
Momentum	400 GeV/c
Protons/bunch	3 E11
Bunch length	σz=0.4 ns (12 cm)
Bunch size at focus	σ*x,y= 200 μm

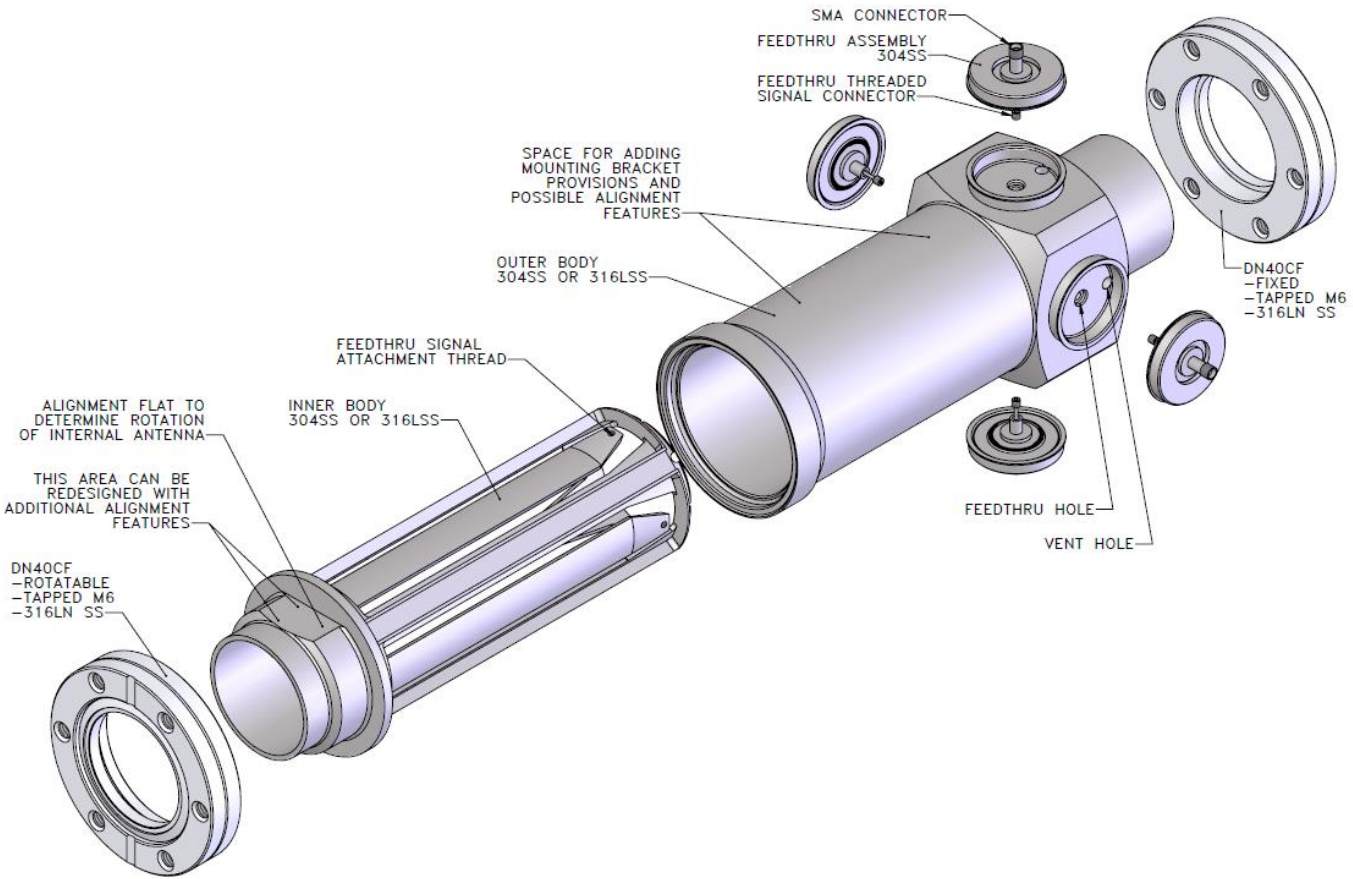
Experiment set up

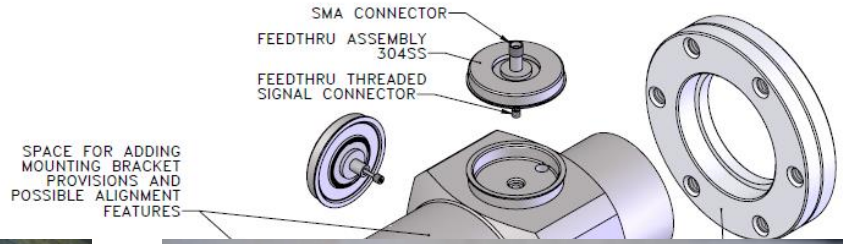




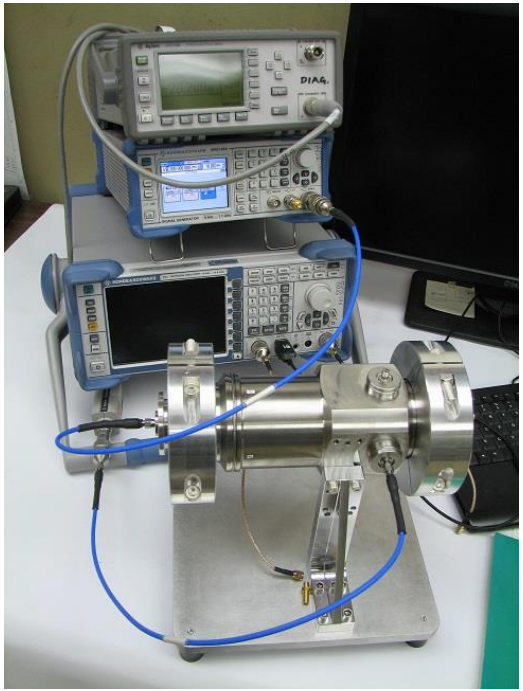
BPMs for electron beam

- Shorted stripline BPMs
- Designed and manufactured by TRIUMF for ARIEL their own LINAC
- Design modified to fit our requirements
- Electronic will also be supplied by TRIUMF
- Electronics modified to adapt to single bunch mode
- Two different Diameters for two different lines

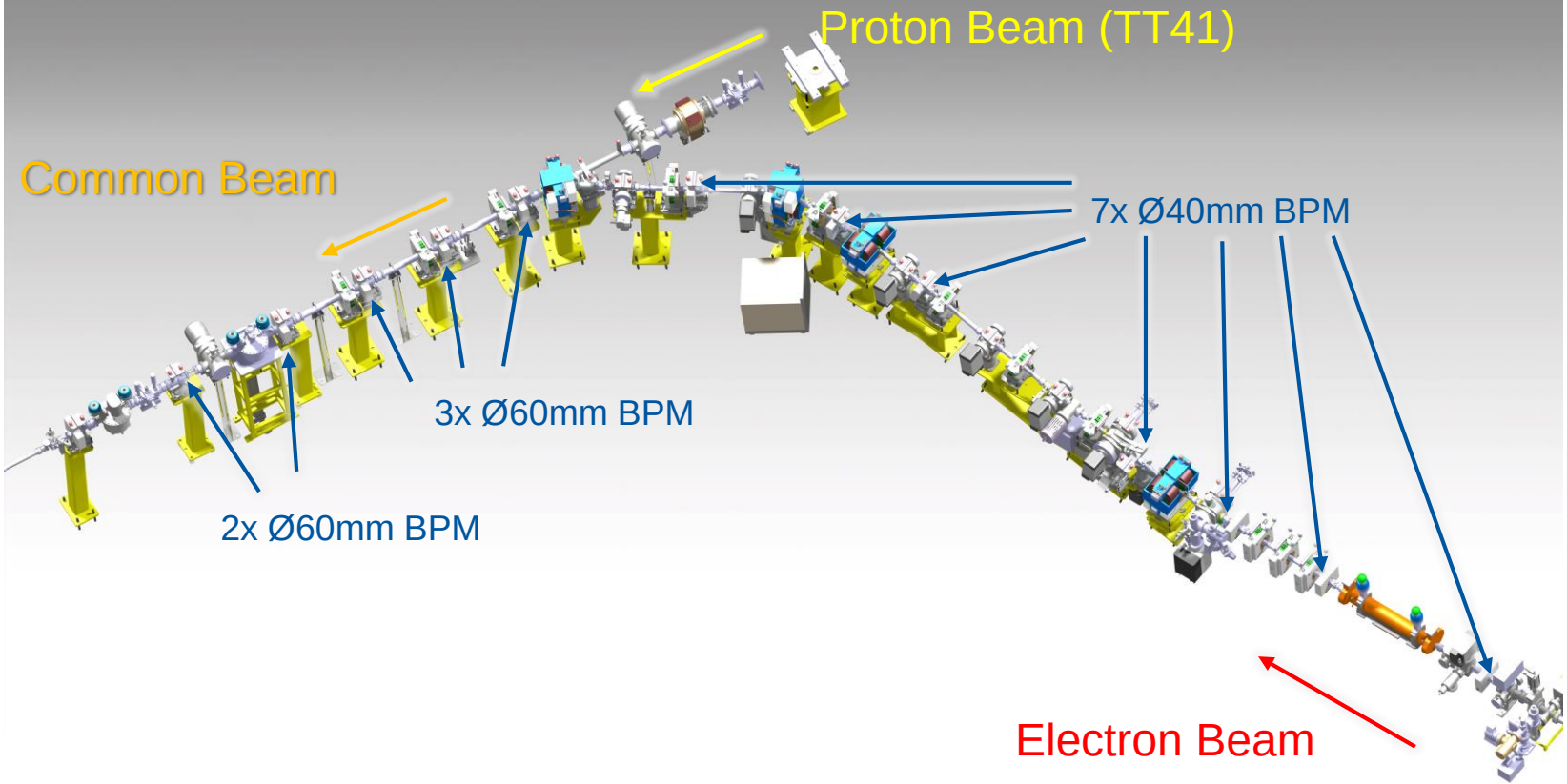

SMA CONNECTOR
FEEDTHRU ASSEMBLY
304SS
FEEDTHRU THREADED
SIGNAL CONNECTOR
SPACE FOR ADDING
MOUNTING BRACKET
PROVISIONS AND
POSSIBLE ALIGNMENT
FEATURES
OUTER BODY
304SS OR 316LSS
DN40CF
–FIXED
–TAPPED M6
–316LN SS
FEEDTHRU SIGNAL
ATTACHMENT THREAD
ALIGNMENT FLAT TO
DETERMINE ROTATION
OF INTERNAL ANTENNA
INNER BODY
304SS OR 316LSS
THIS AREA CAN BE
REDESIGNED WITH
ADDITIONAL ALIGNMENT
FEATURES
DN40CF
–ROTATABLE
–TAPPED M6
–316LN SS
FEEDTHRU HOLE
VENT HOLE


SMA CONNECTOR
FEEDTHRU ASSEMBLY
304SS
FEEDTHRU THREADED
SIGNAL CONNECTOR
SPACE FOR ADDING
MOUNTING BRACKET
PROVISIONS AND
POSSIBLE ALIGNMENT
FEATURES
316LSS

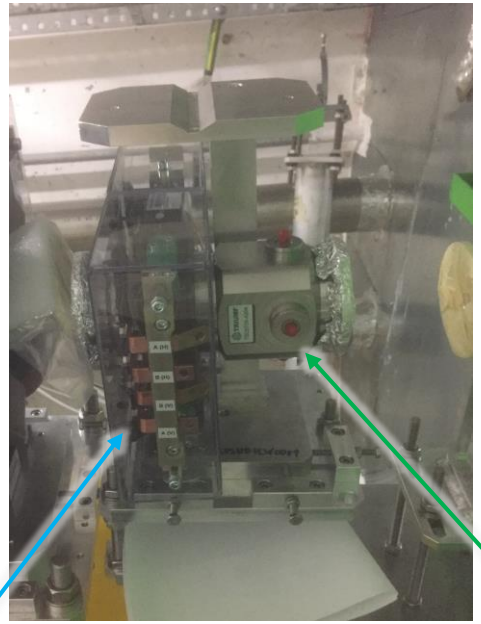
Tests before installation



- Electrical offset and sensitivity measured at TRIUMF during production
- Vacuum leak tested at TRIUMF before shipping
- Vacuum acceptance test done at CERN
- Metrology measurements done at CERN

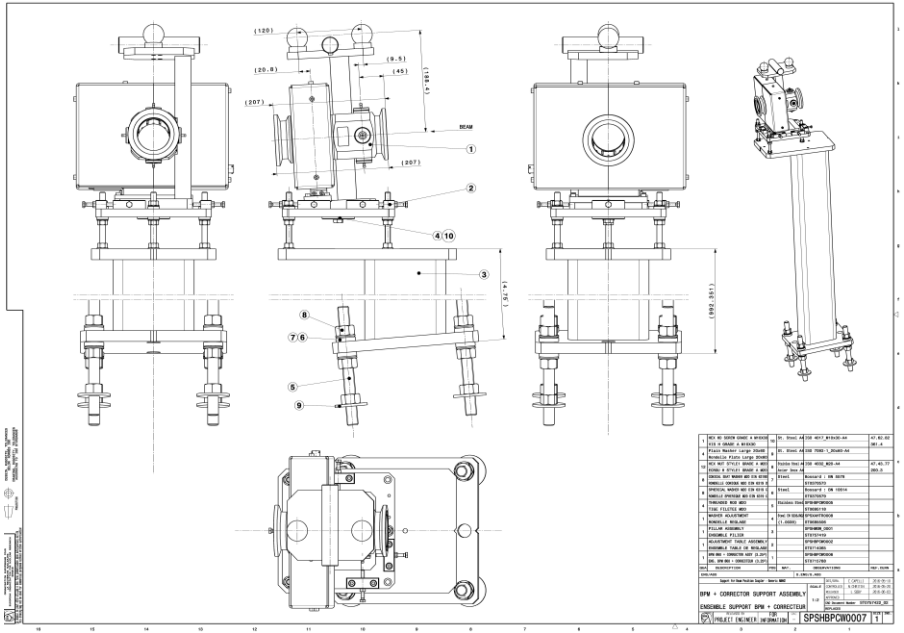

Proton Beam (TT41)
Common Beam
7x Ø40mm BPM
3x Ø60mm BPM
2x Ø60mm BPM
Electron Beam

Collaboration with MSC-MNC



Corrector magnet

BPM



Test of prototype BPMs

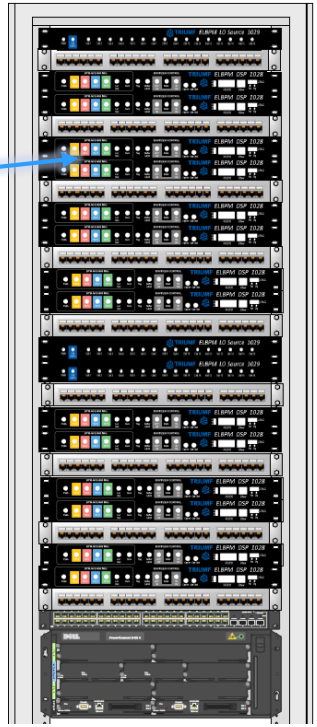
- One prototype BPM Ø40mm was installed in CALIFES and tested with electrons Summer 2016
- One prototype BPM Ø60mm was installed and tested with protons December 2016

Electronics for BPM

- Working Frequency of 404MHz for electron line BPMs
- Working Frequency of 4-5GHz for last two BPMs on common line
- Protection against proton induced signal of ~100V is worked on by TRIUMF.

Electronics for BPM

- Rack will be installed in the Tunnel system



Input signal from BPM

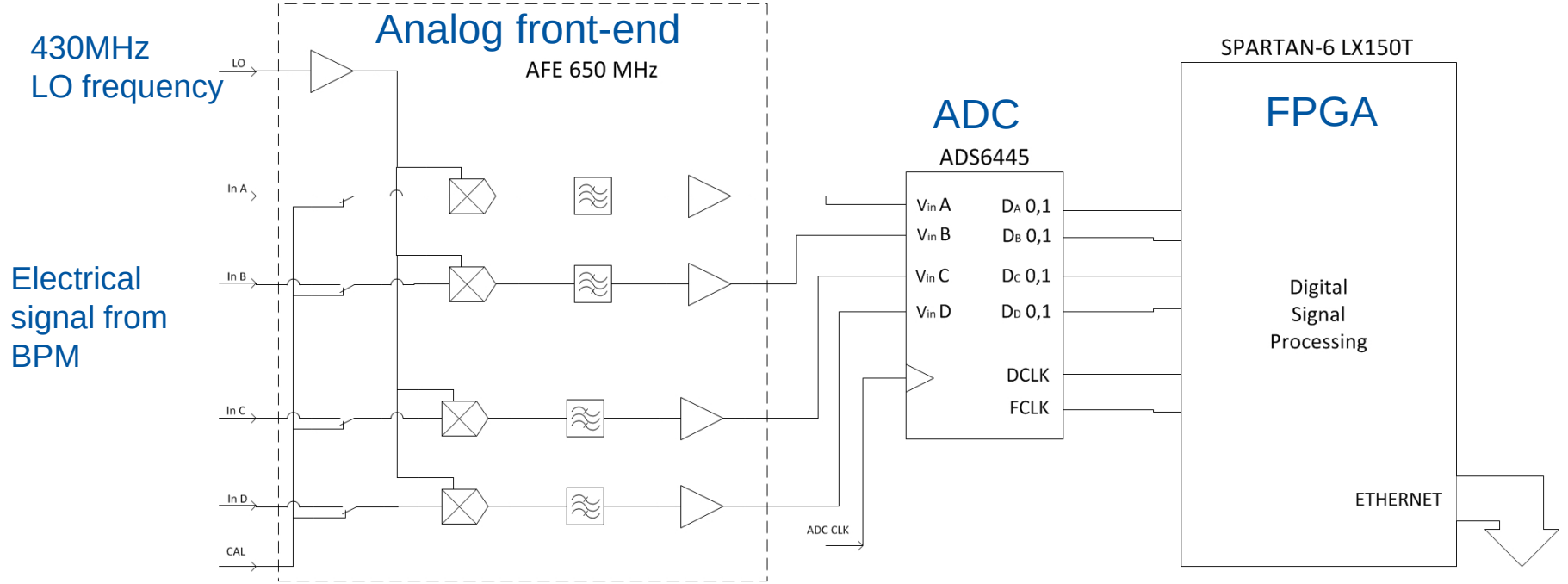
404MHz Calibration

TRIUMF Cables

4.5GHz Local Oscillator and calibration

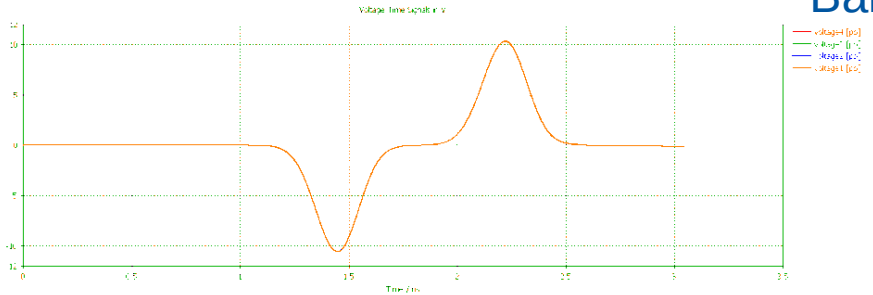
430MHz Local Oscillator

Electronics for BPM 404MHz



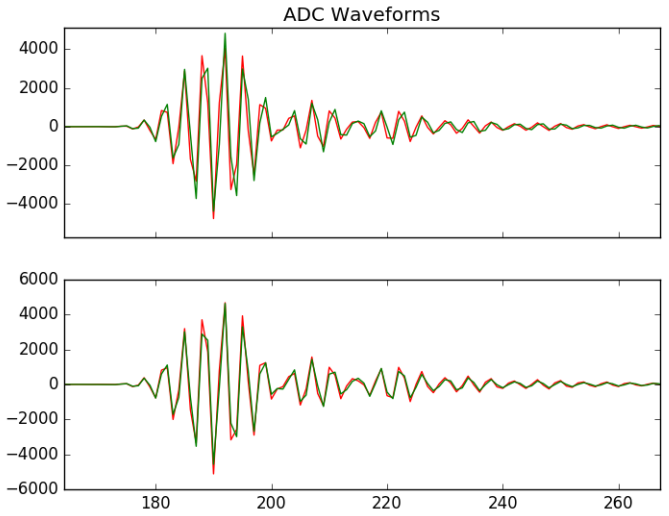
Electronics for BPM 404MHz

Single bunch simulated



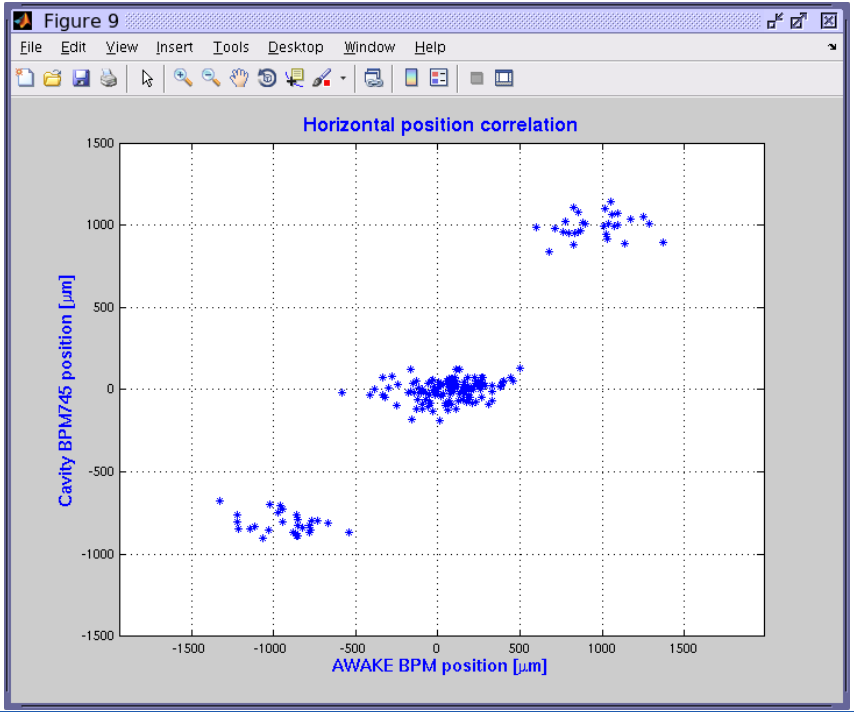
Bandpass filter

Proton beam measured December 2016



Test of prototype BPM in CALIFES

- Electronic noise found, understood to be 110V/220V AC power supply issue

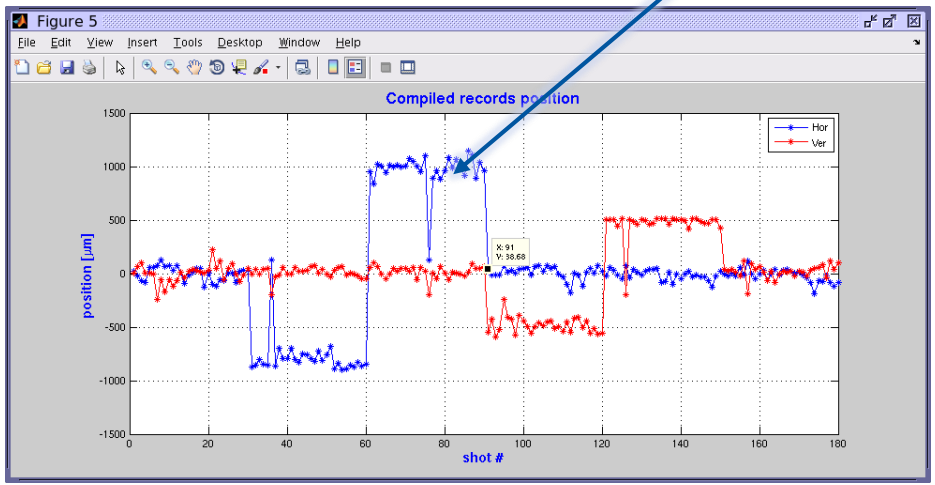


Cavity BPM data: ~ 30-50µm noise/jitter
Stripline BPM: 200-300 µm noise

Test of prototype BPM in CALIFES

- Electron beam measurements at 404MHz
- 100pC bunch charge was used
- Horizontal resolution of 4.3µm
- Vertical resolution of 7.8µm

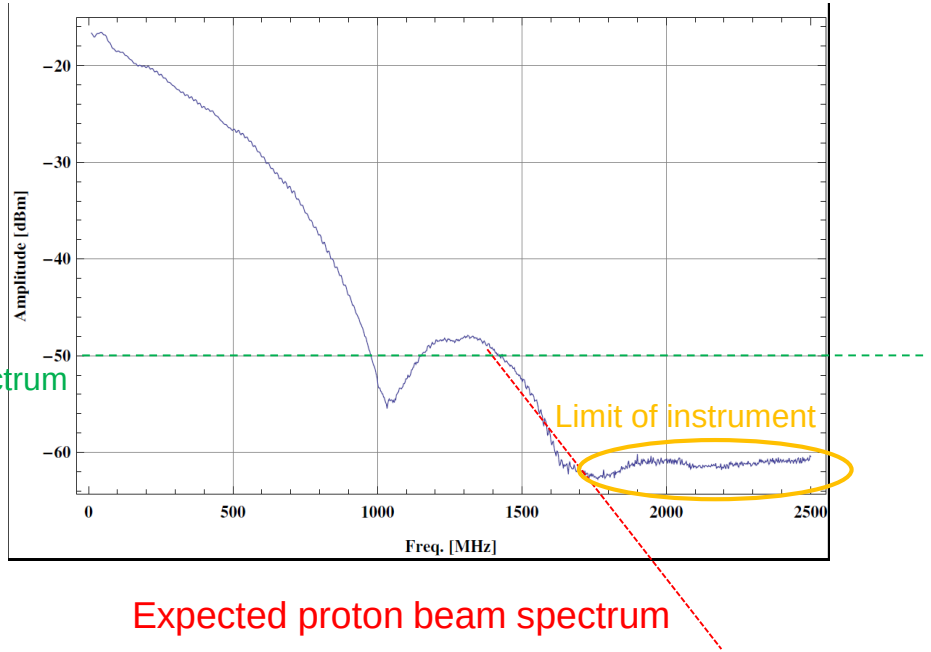
Beam displacement ~2mm



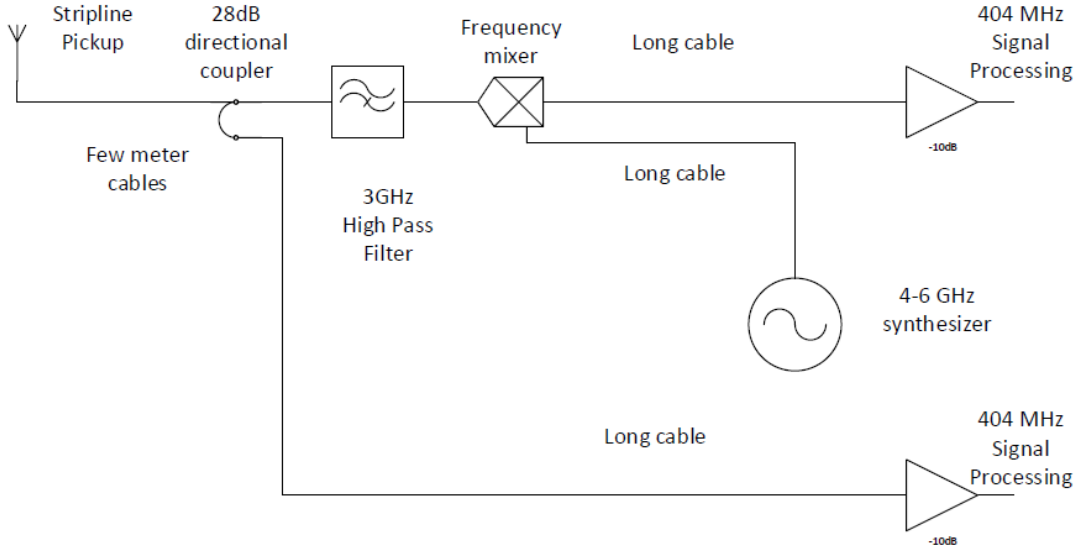
Electronics for BPM 4-5GHz

- Idea is measuring the position of the electrons with protons present
- Different frequency spectrums related to bunch lengths allows to use frequency separation
- Test at 2GHz gave inconclusive results

Bunch spectrum for AWAKE proton beam measured in SPS

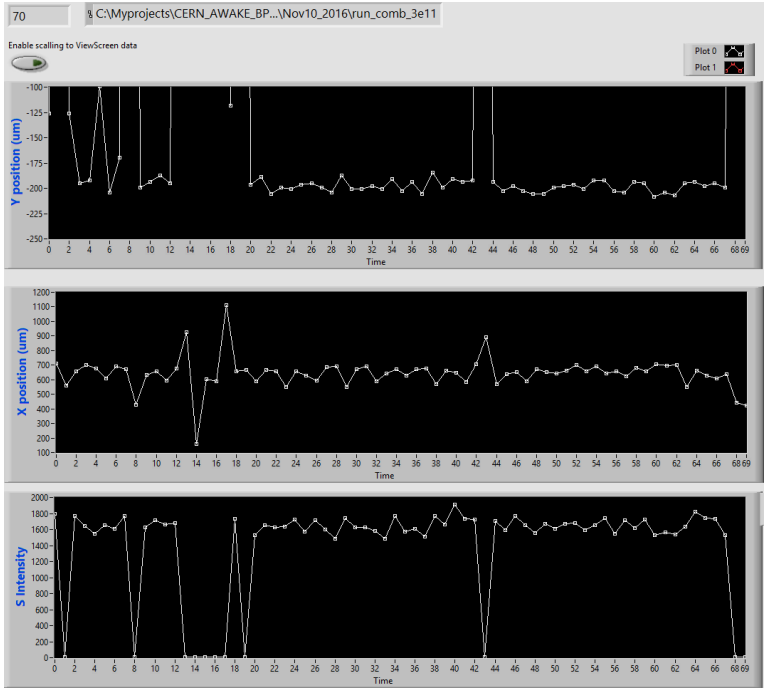


Electronics for BPM 4-5GHz



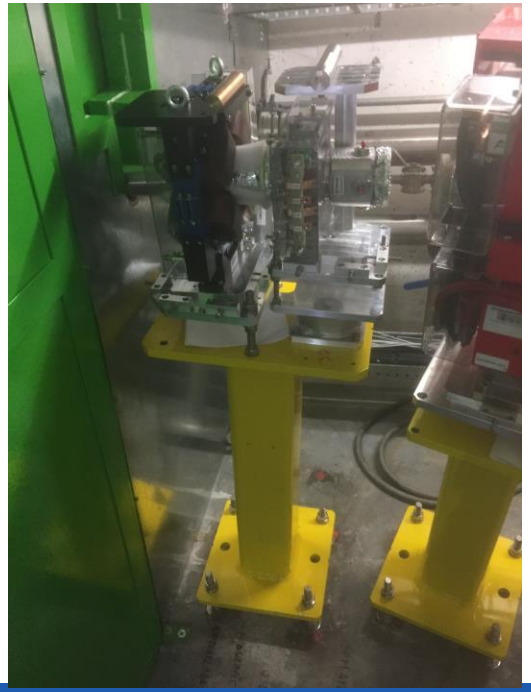
Test of prototype BPM in AWAKE

- Proton measurements at 400MHz with a 40dB attenuator
- Measurements performed remotely from Vancouver.
- Beam trigger delay was found to be 84 us.
- •Large X and Y position fluctuations correspond to missed extractions
- Y position p-p fluctuation is less than 50 um, while X is less than 200 um.



Current status

- All 5 BPMs on the Common line are installed
- BPMs on the electron line will be installed July 2017
- TRIUMF will install the electronics August 2017



Acknowledgments

- TRIUMF
- AWAKE
- Lars Søby
- Stefano Mazzoni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