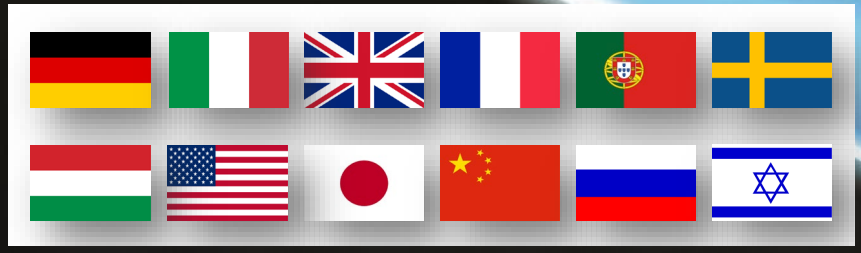
EUROPEAN
PLASMA RESEARCH
ACCELERATOR WITH
EXCELLENCE IN
APPLICATIONS

EuPRAXIA

WP15 Diagnostics

A. Cianchi (University of Rome Tor Vergata)
N. Delerue (LAL)
On behalf of EuPRAXIA WP15 diagnostics group



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Diagnostics deliverable

EUPRAXIA: MILESTONE REPORT

Doc. Identifier:
MS 5.4
Date: February 20, 2019

European Commission

Project Number: 653782

Project Acronym: EuPRAXIA

Project title: European Plasma Research Accelerator with eXcellence In Applications

Milestone Report

M 5.4 Definition of diagnostics before and after the plasma channel

- Contributions from:
  - CEA
  - CNRS
  - Cockroft
  - DESY
  - ELI-Beamlines
  - INFN
- Cost estimation
- Starting point

Introduction

Diagnostics deliverable: done

However, we swept some dirt under the carpet…

HOPA beamlines still out of the report

More than a talk this is an open space to collect and to address questions

Hopefully also to find the answers…

Some important points

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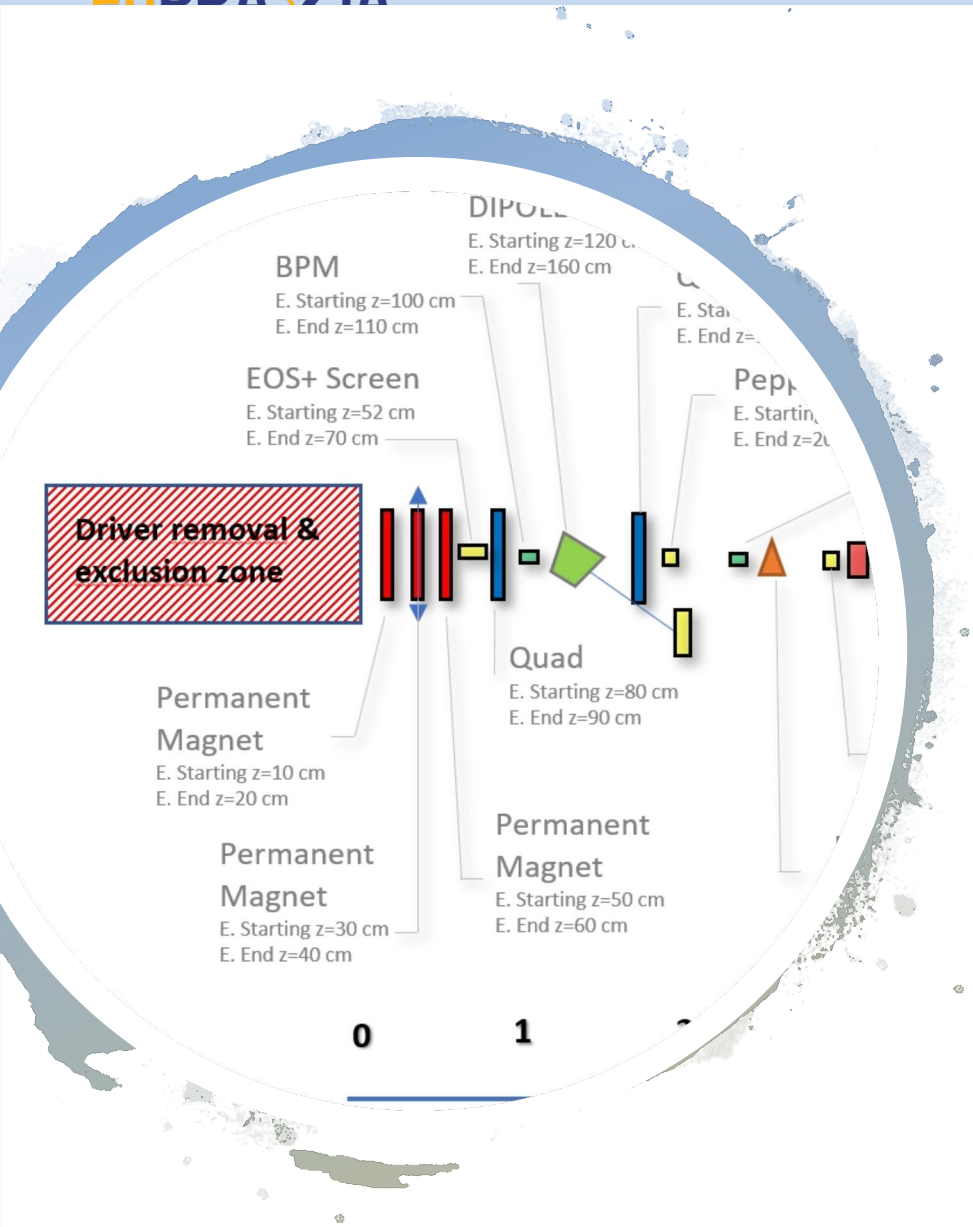
- Today not yet a solution for slice energy spread even in a conventional accelerator
- Driver removal still an open point, we would like to have the beam particles after this stage.

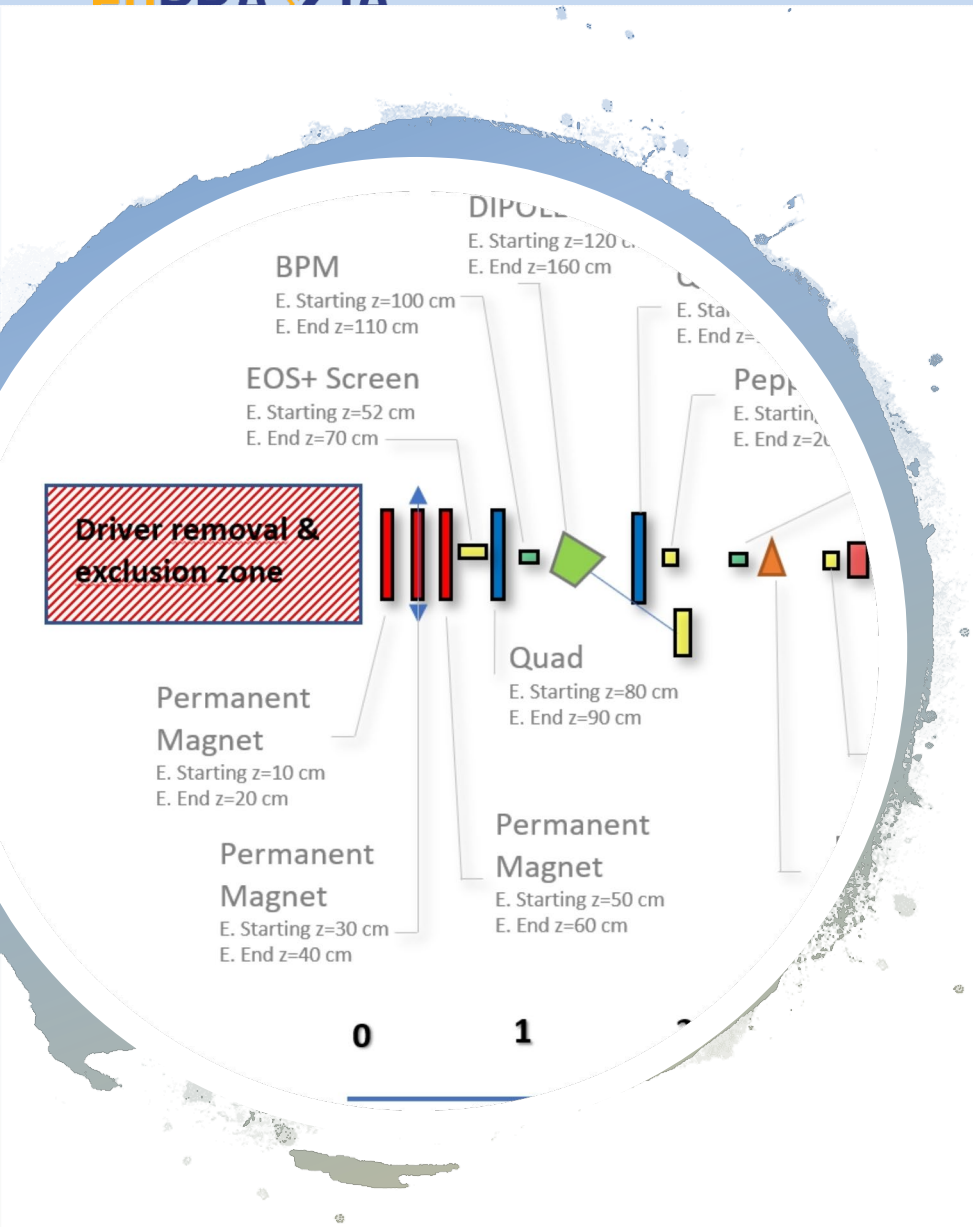
Joint meeting WP5-W15

Today at 20:30 near bar area



Integration

- So far we just put our elements in a reasonable way, using real dimensions, and leaving “enough” space



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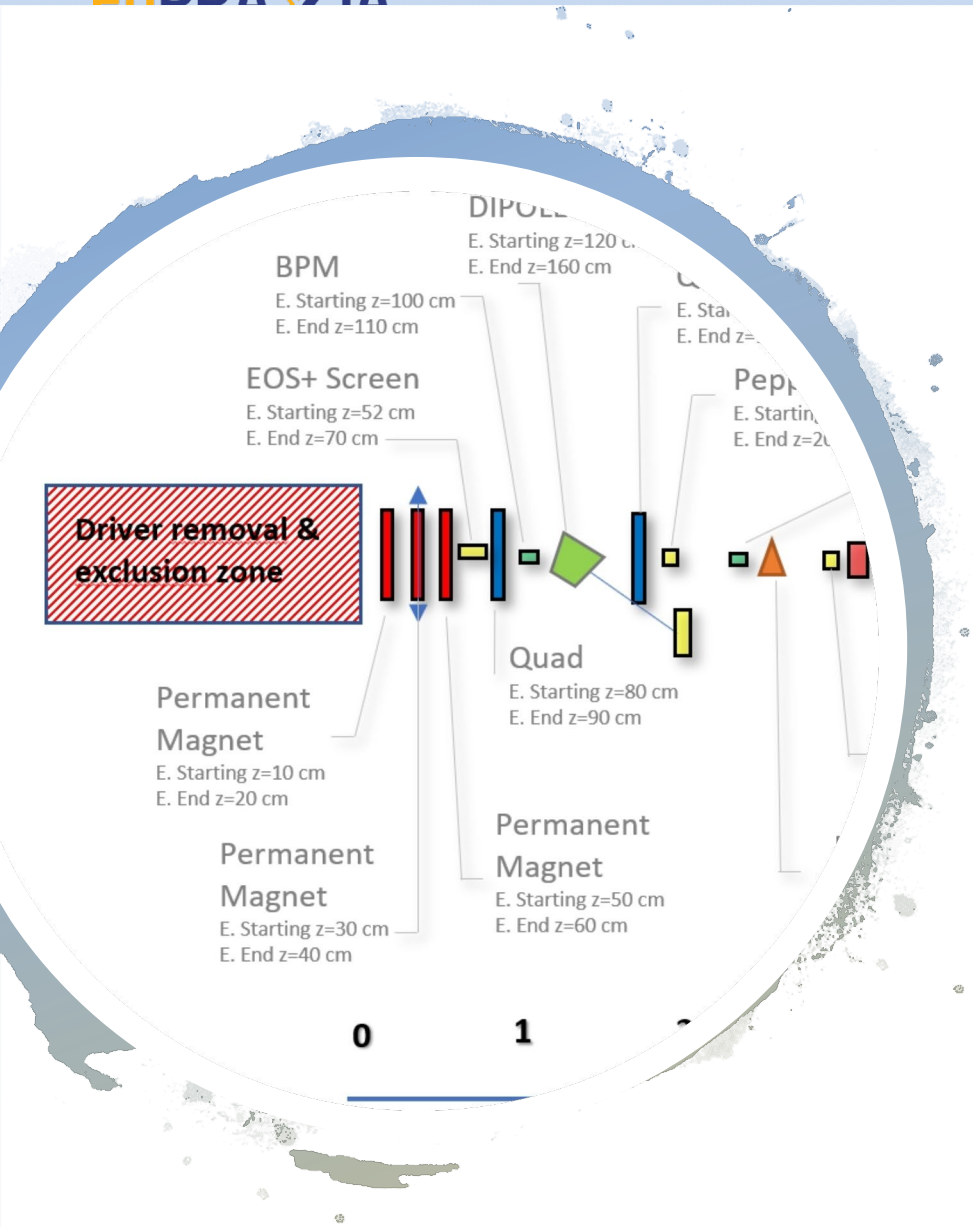
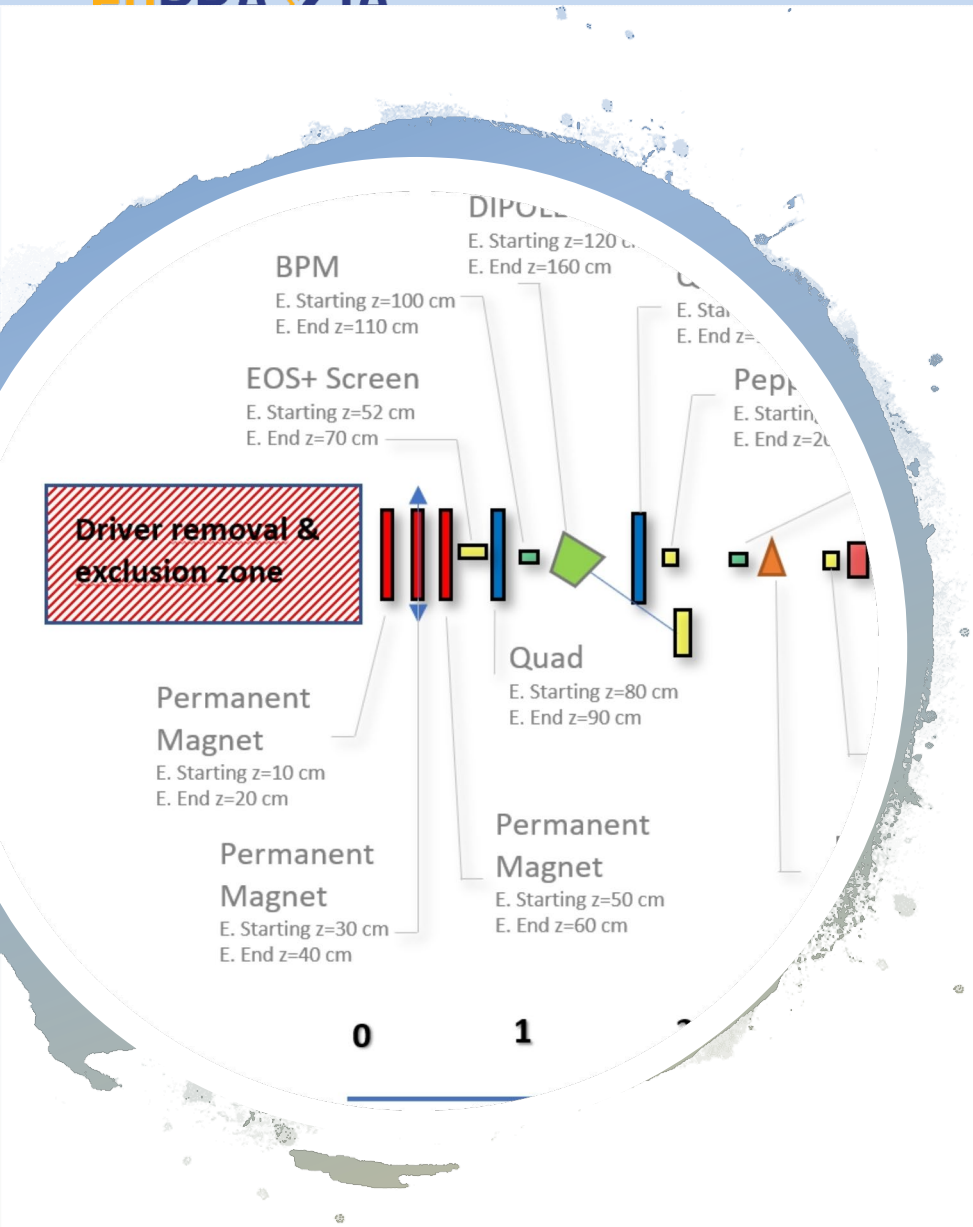


Integration

- So far we just put our elements in a reasonable way, using real dimensions, and leaving “enough” space
- Pumping is not yet considered
- So far this machine is correctors free



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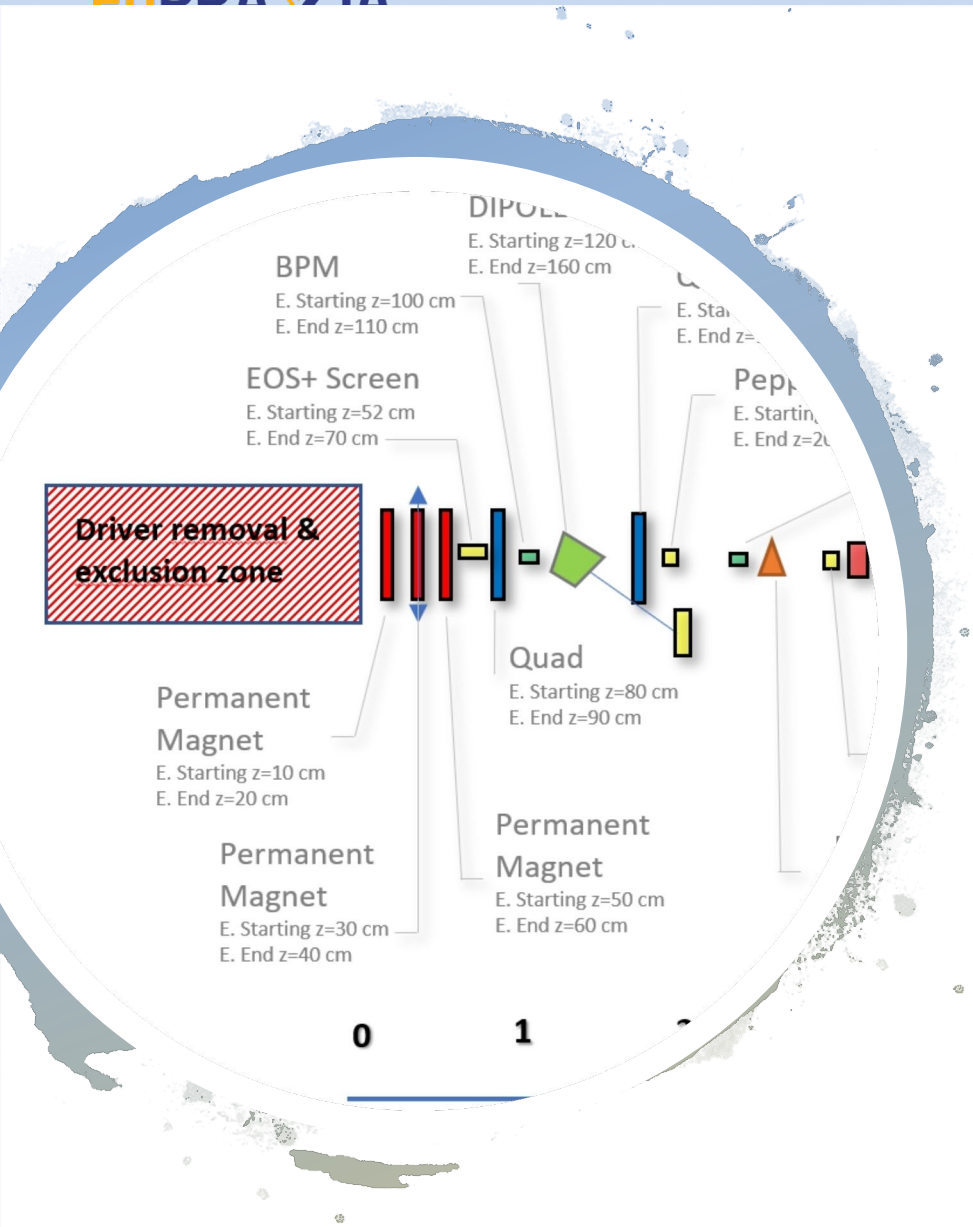
- A cad drawings will be very useful to define better the line.



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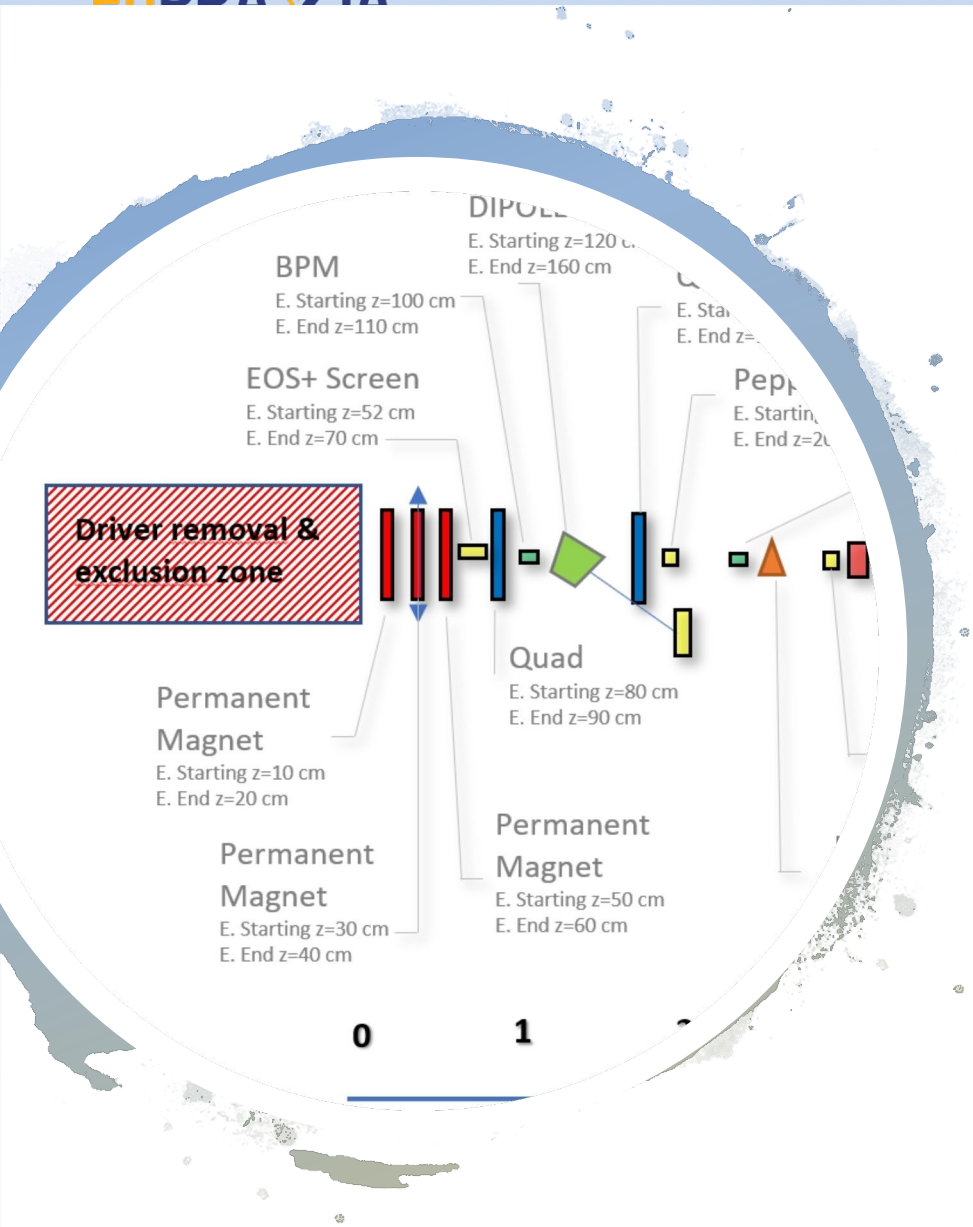
- Is it too much for a CDR?



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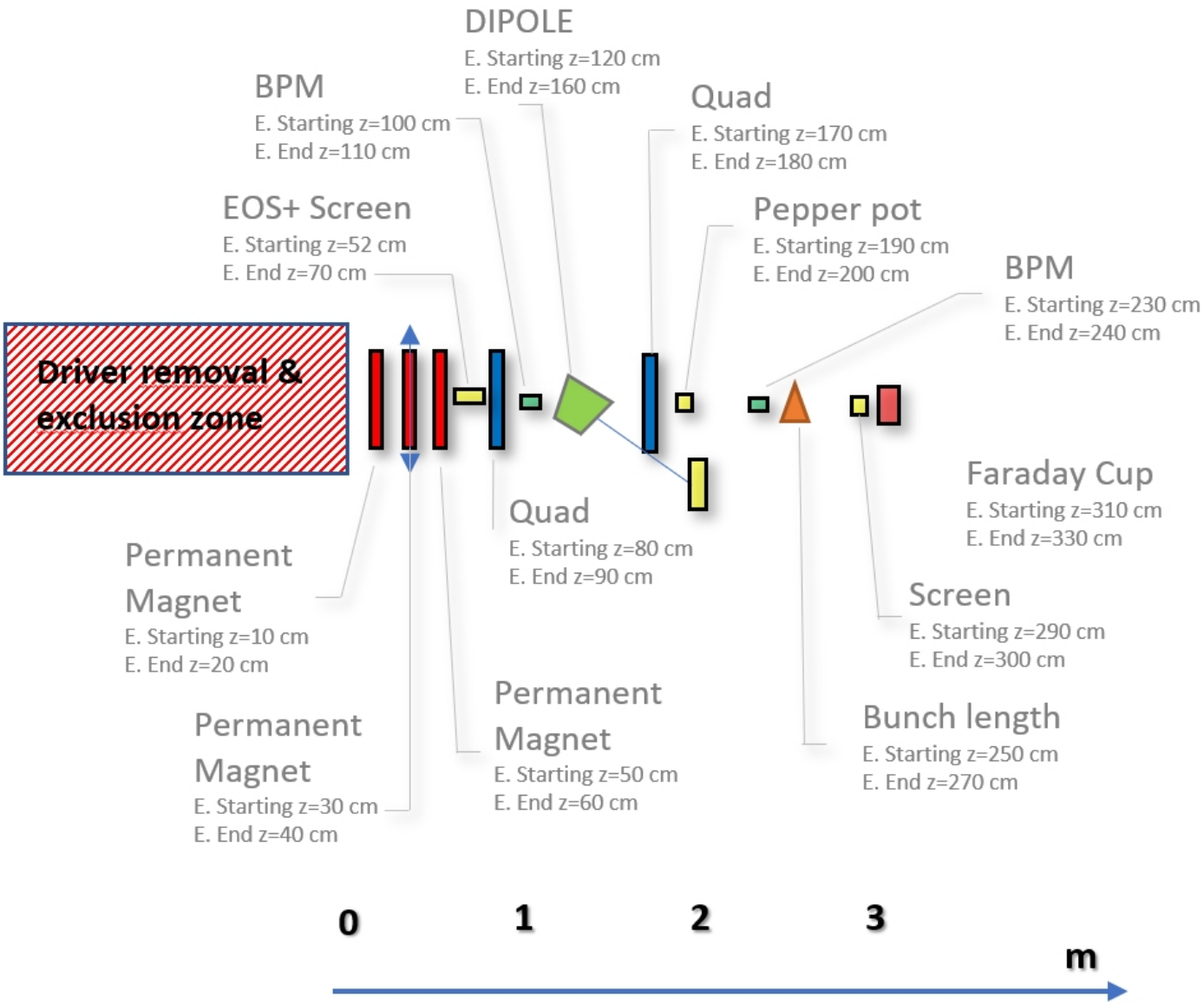
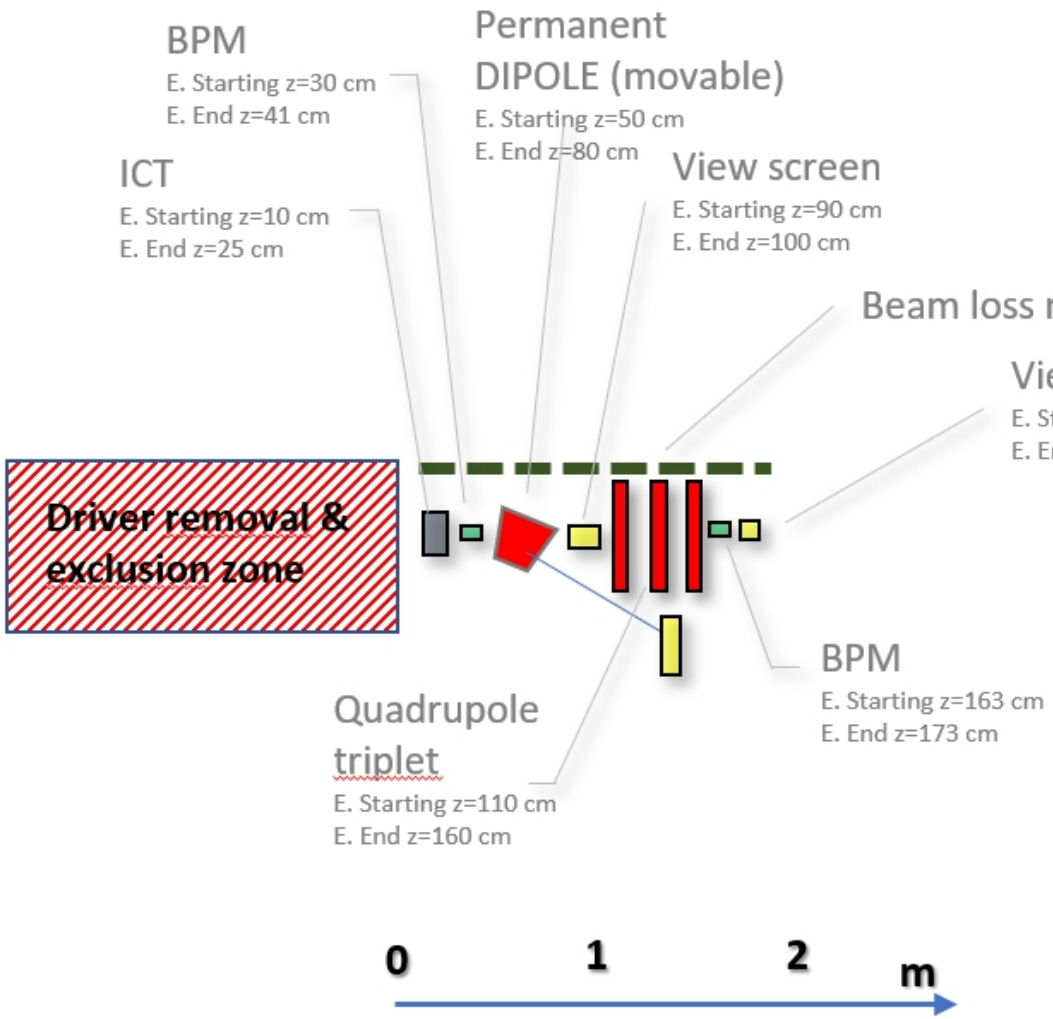
- Pumping is not yet considered
- So far this machine is correctors free
- A cad drawings will be very useful to define better the line.
- Is it too much for a CDR?
- However sooner or later we need it!

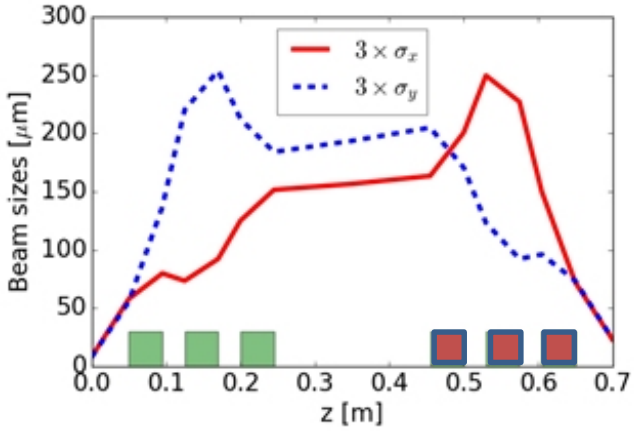
LPI Commissioning beamline



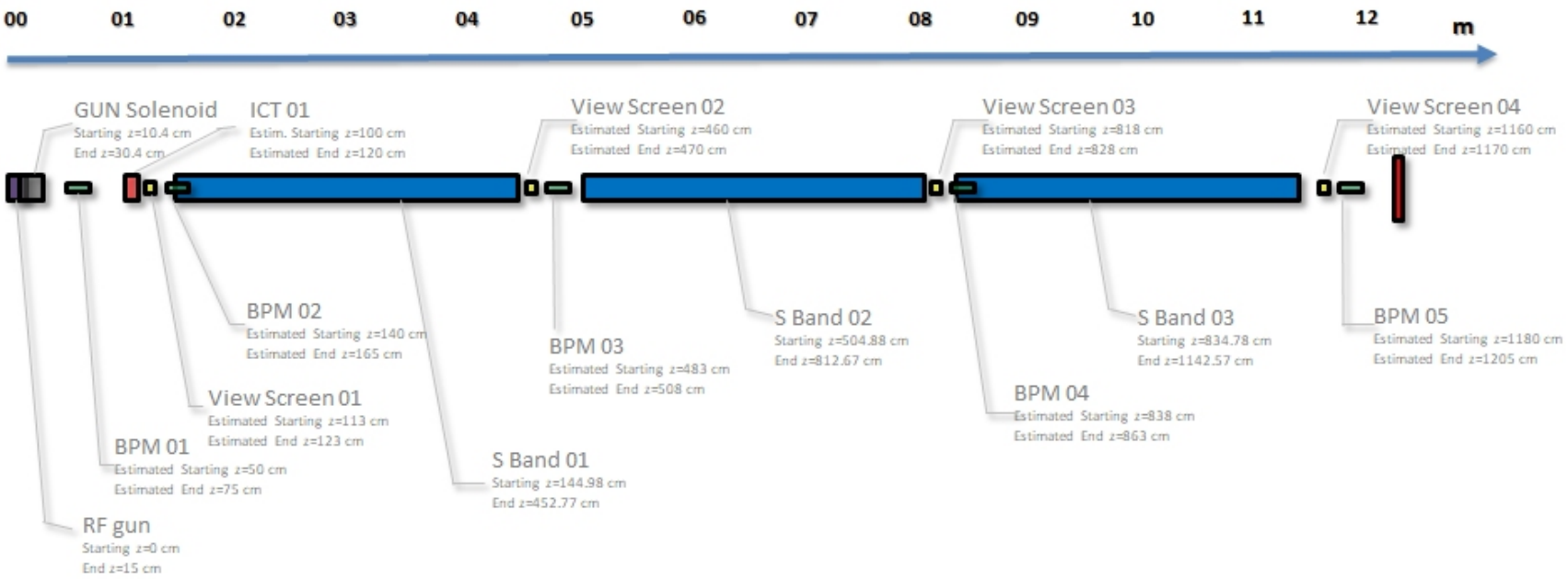
LPI Normal operations



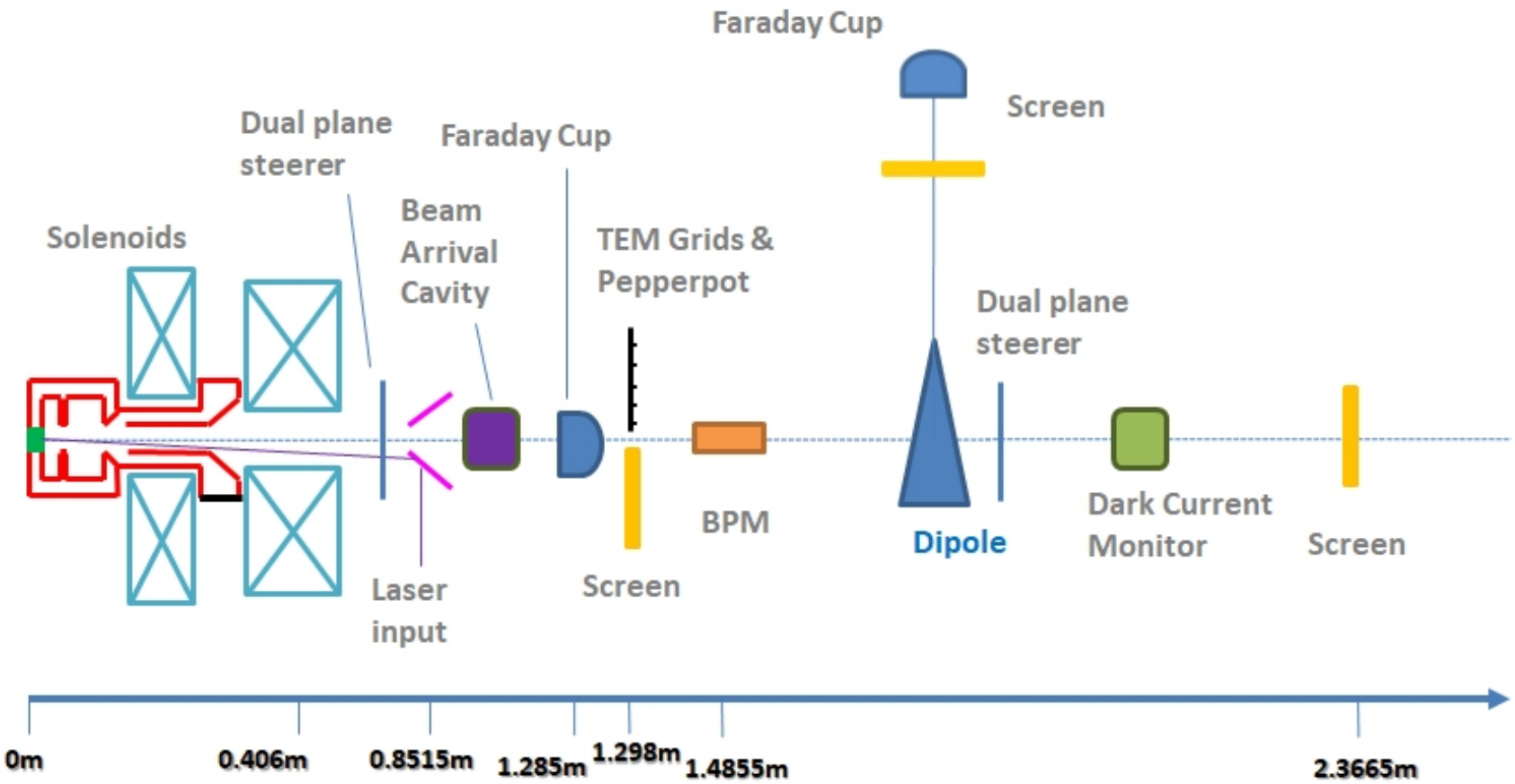
A better integration with beam optics is needed, spectrometer problem



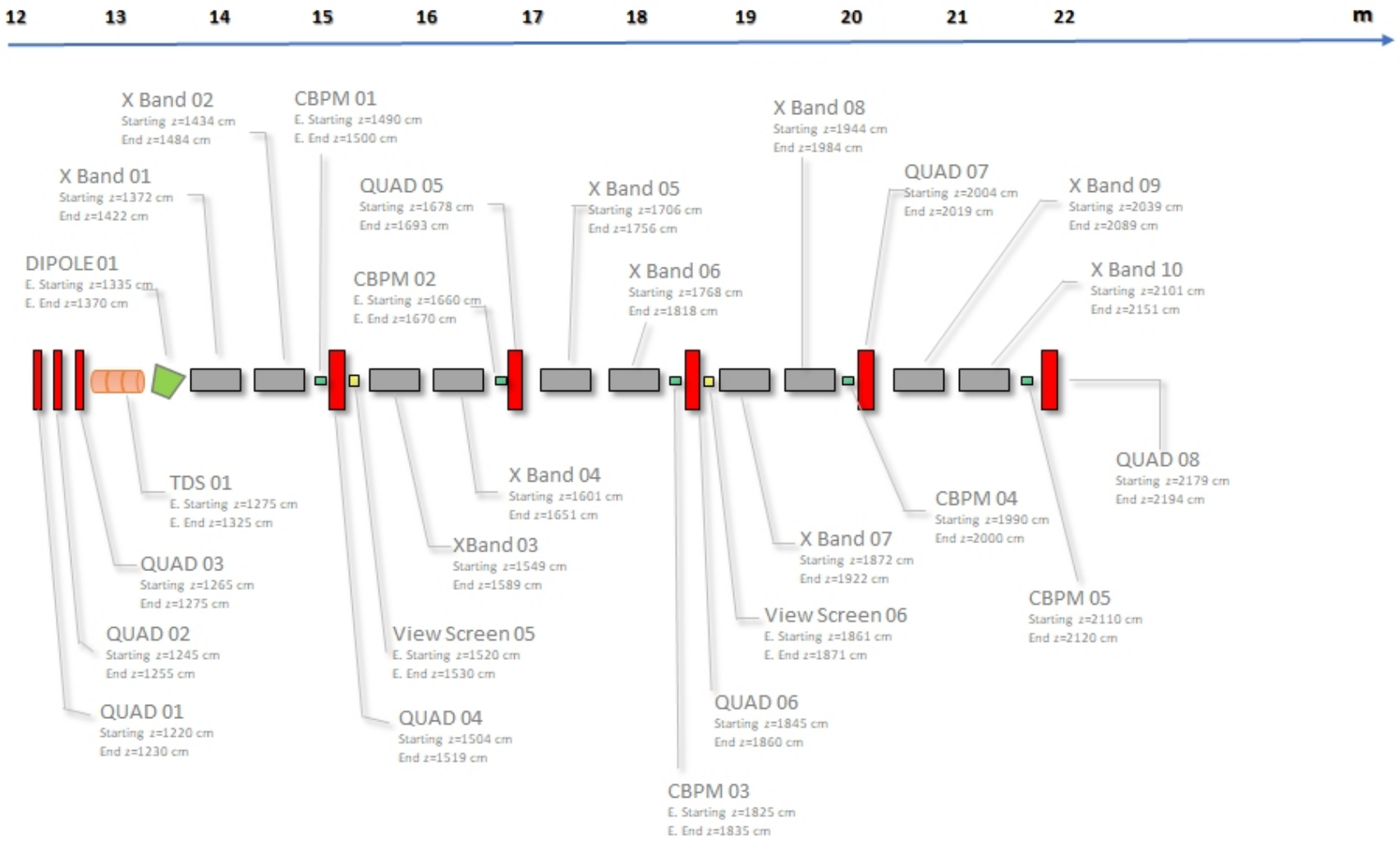
RFI (option1)


00
01
02
03
04
05
06
07
08
09
10
11
12
m
GUN Solenoid
Starting z=10.4 cm
End z=30.4 cm
ICT 01
Estim. Starting z=100 cm
Estimated End z=120 cm
View Screen 02
Estimated Starting z=460 cm
Estimated End z=470 cm
View Screen 03
Estimated Starting z=818 cm
Estimated End z=828 cm
View Screen 04
Estimated Starting z=1160 cm
Estimated End z=1170 cm
BPM 02
Estimated Starting z=140 cm
Estimated End z=165 cm
BPM 03
Estimated Starting z=483 cm
Estimated End z=508 cm
S Band 02
Starting z=504.88 cm
End z=812.67 cm
S Band 03
Starting z=834.78 cm
End z=1142.57 cm
BPM 05
Estimated Starting z=1180 cm
Estimated End z=1205 cm
View Screen 01
Estimated Starting z=113 cm
Estimated End z=123 cm
BPM 01
Estimated Starting z=50 cm
Estimated End z=75 cm
S Band 01
Starting z=144.98 cm
End z=452.77 cm
BPM 04
Estimated Starting z=838 cm
Estimated End z=863 cm
RF gun
Starting z=0 cm
End z=15 cm

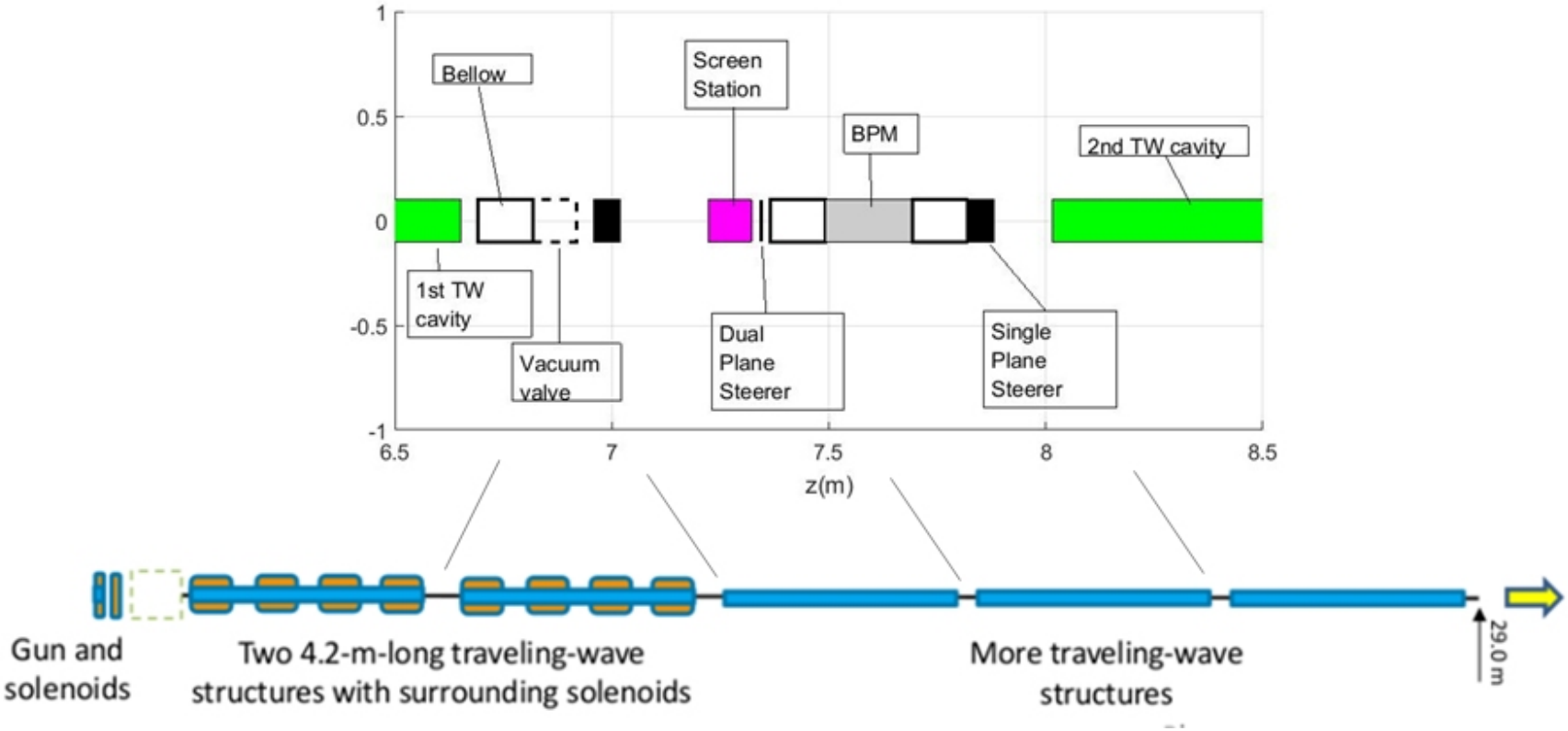
RFI (option 2)


Faraday Cup
Screen
Dual plane steerer
Faraday Cup
Beam Arrival Cavity
Solenoids
TEM Grids & Pepperpot
Dual plane steerer
BPM
Dipole
Dark Current Monitor
Screen
Laser input
Screen
0m
0.406m
0.8515m
1.285m
1.298m
1.4855m
2.3665m

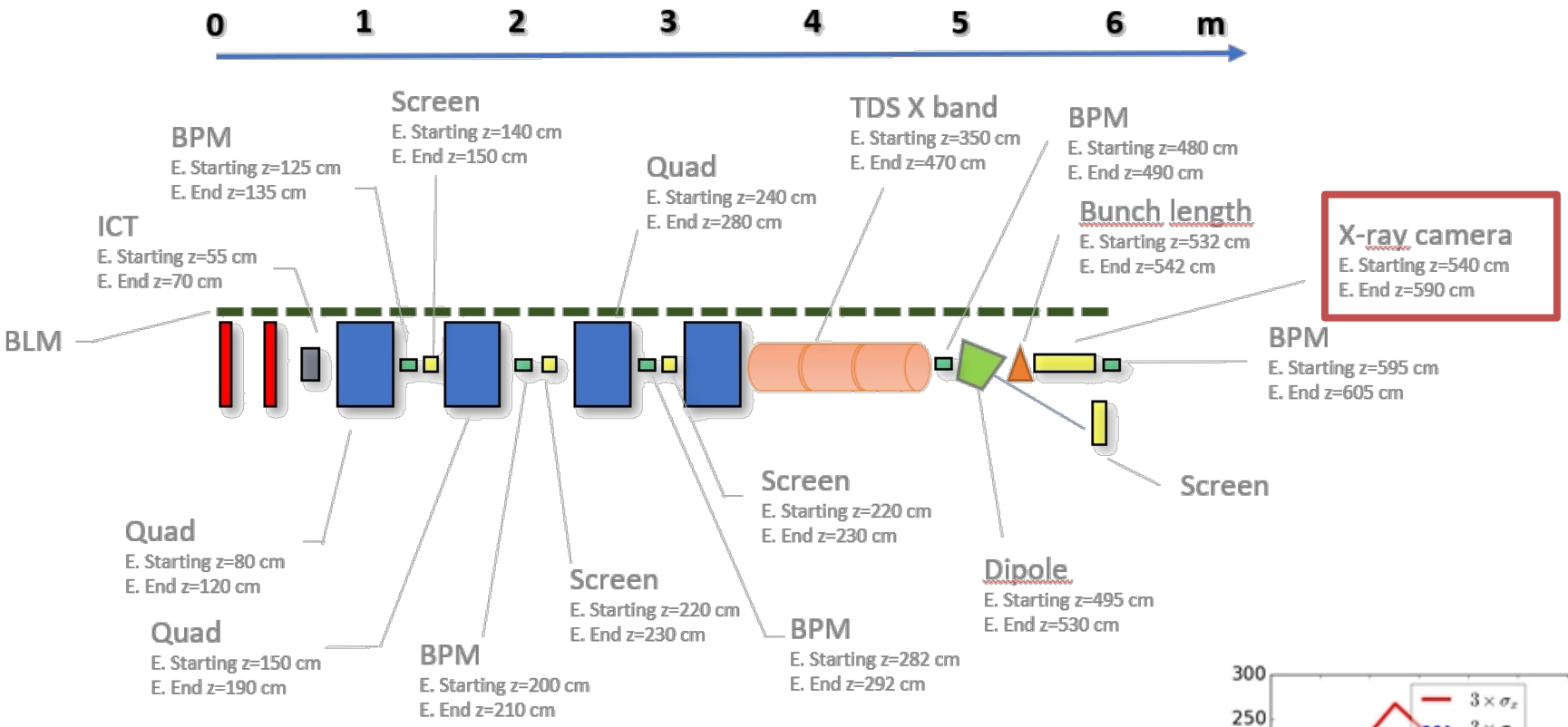
X-band Linac

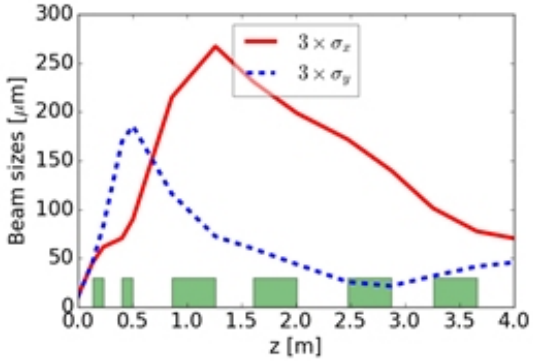

12
13
14
15
16
17
18
19
20
21
22
m
X Band 02
Starting z=1434 cm
End z=1484 cm
CBPM 01
E. Starting z=1490 cm
E. End z=1500 cm
X Band 01
Starting z=1372 cm
End z=1422 cm
QUAD 05
Starting z=1678 cm
End z=1693 cm
X Band 05
Starting z=1706 cm
End z=1756 cm
X Band 08
Starting z=1944 cm
End z=1984 cm
QUAD 07
Starting z=2004 cm
End z=2019 cm
X Band 09
Starting z=2039 cm
End z=2089 cm
DIPOLE 01
E. Starting z=1335 cm
E. End z=1370 cm
CBPM 02
E. Starting z=1660 cm
E. End z=1670 cm
X Band 06
Starting z=1768 cm
End z=1818 cm
X Band 10
Starting z=2101 cm
End z=2151 cm
TDS 01
E. Starting z=1275 cm
E. End z=1325 cm
X Band 04
Starting z=1601 cm
End z=1651 cm
QUAD 08
Starting z=2179 cm
End z=2194 cm
CBPM 04
Starting z=1990 cm
End z=2000 cm
QUAD 03
Starting z=1265 cm
End z=1275 cm
XBand 03
Starting z=1549 cm
End z=1589 cm
X Band 07
Starting z=1872 cm
End z=1922 cm
CBPM 05
Starting z=2110 cm
End z=2120 cm
QUAD 02
Starting z=1245 cm
End z=1255 cm
View Screen 05
E. Starting z=1520 cm
E. End z=1530 cm
View Screen 06
E. Starting z=1861 cm
E. End z=1871 cm
QUAD 01
Starting z=1220 cm
End z=1230 cm
QUAD 04
Starting z=1504 cm
End z=1519 cm
QUAD 06
Starting z=1845 cm
End z=1860 cm
CBPM 03
E. Starting z=1825 cm
E. End z=1835 cm

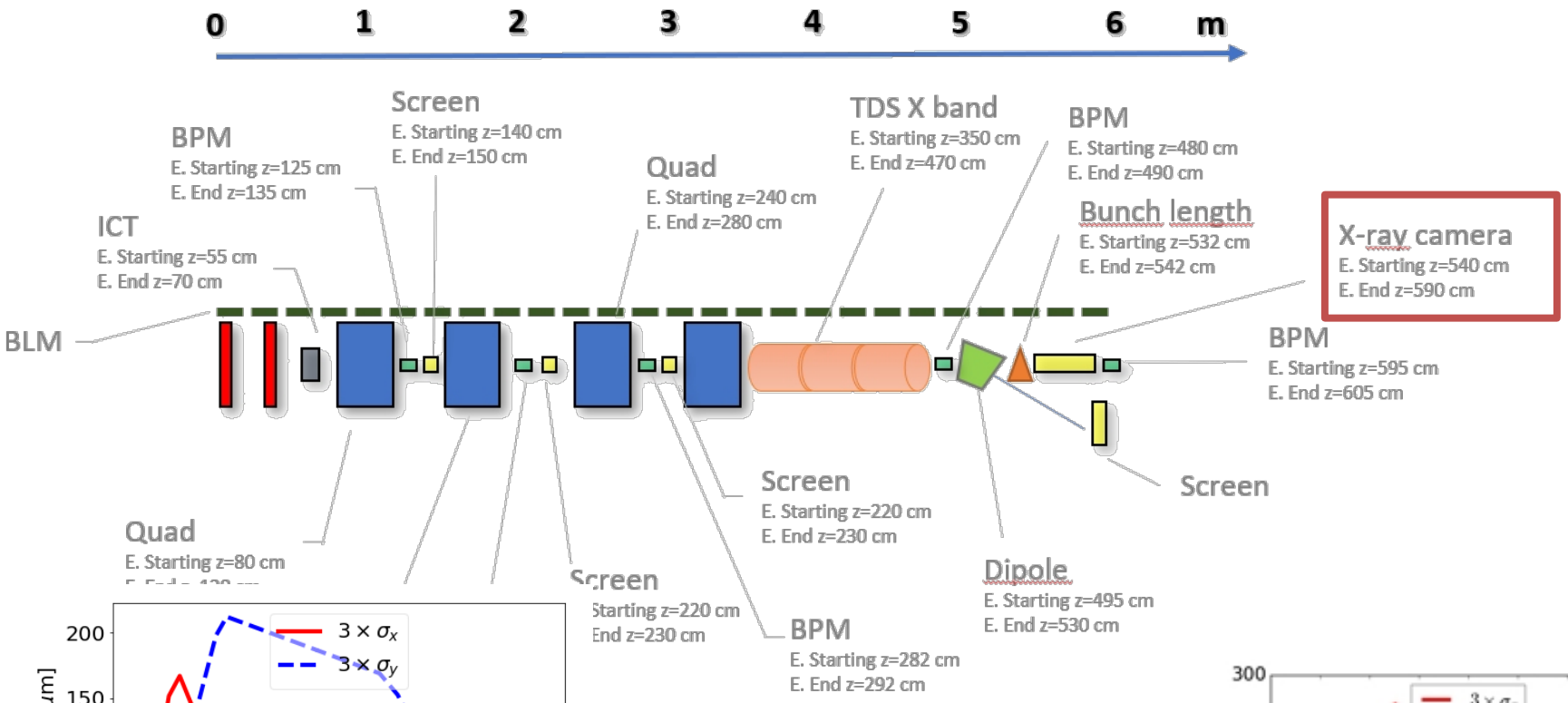
S Band Linac

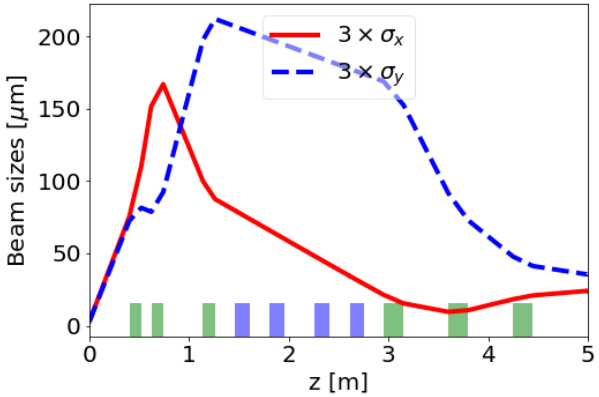

Bellow
Screen Station
BPM
2nd TW cavity
1st TW cavity
Vacuum valve
Dual Plane Steerer
Single Plane Steerer
1
0.5
0
-0.5
-1
6.5
7
7.5
8
8.5
z(m)
Gun and solenoids
Two 4.2-m-long traveling-wave structures with surrounding solenoids
More traveling-wave structures
29.0 m

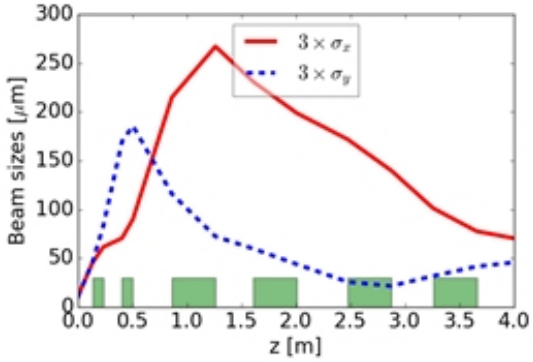
LPAS


0
1
2
3
4
5
6
m
BLM
ICT
E. Starting z=55 cm
E. End z=70 cm
BPM
E. Starting z=125 cm
E. End z=135 cm
Screen
E. Starting z=140 cm
E. End z=150 cm
Quad
E. Starting z=240 cm
E. End z=280 cm
TDS X band
E. Starting z=350 cm
E. End z=470 cm
BPM
E. Starting z=480 cm
E. End z=490 cm
Bunch length
E. Starting z=532 cm
E. End z=542 cm
X-ray camera
E. Starting z=540 cm
E. End z=590 cm
BPM
E. Starting z=595 cm
E. End z=605 cm
Screen
Quad
E. Starting z=80 cm
E. End z=120 cm
Quad
E. Starting z=150 cm
E. End z=190 cm
BPM
E. Starting z=200 cm
E. End z=210 cm
Screen
E. Starting z=220 cm
E. End z=230 cm
BPM
E. Starting z=282 cm
E. End z=292 cm
Screen
E. Starting z=220 cm
E. End z=230 cm
Dipole
E. Starting z=495 cm
E. End z=530 cm


Beam sizes [μm]
z [m]
$3 \times \sigma_x$
$3 \times \sigma_y$
0
50
100
150
200
250
300
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0


0
1
2
3
4
5
6
m
BPM
E. Starting z=125 cm
E. End z=135 cm
Screen
E. Starting z=140 cm
E. End z=150 cm
TDS X band
E. Starting z=350 cm
E. End z=470 cm
BPM
E. Starting z=480 cm
E. End z=490 cm
ICT
E. Starting z=55 cm
E. End z=70 cm
Quad
E. Starting z=240 cm
E. End z=280 cm
Bunch length
E. Starting z=532 cm
E. End z=542 cm
X-ray camera
E. Starting z=540 cm
E. End z=590 cm
BLM
BPM
E. Starting z=595 cm
E. End z=605 cm
Screen
E. Starting z=220 cm
E. End z=230 cm
Screen
Quad
E. Starting z=80 cm
Screen
Starting z=220 cm
End z=230 cm
Dipole
E. Starting z=495 cm
E. End z=530 cm
BPM
E. Starting z=282 cm
E. End z=292 cm

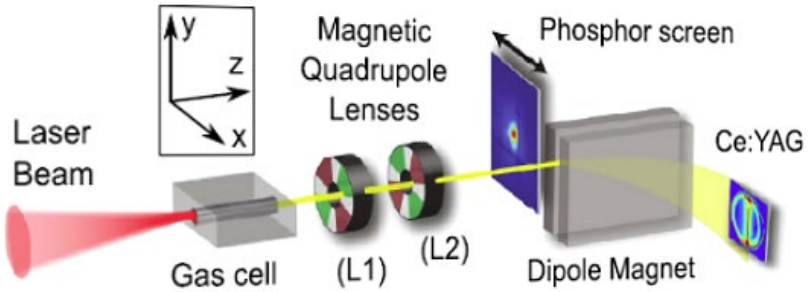

$3 \times \sigma_x$
$3 \times \sigma_y$
Beam sizes [μm]
z [m]


$3 \times \sigma_x$
$3 \times \sigma_y$
Beam sizes [μm]
z [m]

- Cavity BPMs seems to be the best choice for the trajectory but what's about beam position instability?
- Can we have 6 mm aperture?
- Turbo ICT seems to be a good choice for the charge, they can measure down to fC range, but what's about their response to EMI in a laser-plasma environment?

Charge open points

Transverse emittance single shot



Weingartner, Raphael, et al., Physical Review Special Topics Accelerators and Beams 15.11 (2012): 111302
Barber, S. K., et al., Physical Review Letters 119.10 (2017): 104801.
F Li et al 2018 Plasma Phys. Control. Fusion 60 014029
F. Li et al, Plasma Physics and Controlled Fusion 60, 044007 (2018)

- R&D is in progress in different directions
  - CERN is developing Cherenkov diffraction radiation
  - SPARC_LAB is developing optical pepper pot
  - Still open room for high energy pepper pot
  - Multiple screens with plasma lenses

Longitudinal measurements

Are there really already developed single shot diagnostics?

Or maybe there are only proof-of-principle experiment?

Single shot CTR or CSP are not yet ready, experiments are ongoing

X-band TDS are not yet so widespread and require careful tuning to be considered state-of-art

- Betatron radiation overlap between driver and witness
- Reduced possibility to measure the driver alone after the interaction
- No chance to distinguish driver-witness inside the machine (trajectory/charge), only in few points with dispersive (time or energy)…->

Main problems beam driven

Summary of requests

- Give us an evaluation of the different instabilities that we likely have to face

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Summary of requests

- Give us an evaluation of the different instabilities that we likely have to face
- Clearly define the driver (laser/beam) removal
- Give us the particles distributions
- Implement the diagnostics layout in a CAD
- More details about HOPA beamlines
- Support a program of R&D for EuPRAXIA components or help in having machine time (**DI**agnostics **C**luster for **E**upraxia)

- Thank you for your attention

DICE proposals

- Longitudinal measurements
  - X band TDS and comparison on the same accelerator with others single shot measurements based on coherent radiation
- Transverse emittance
  - Test single shot devices with high brightness conventional machine
  - Test single shot device with high brightness plasma accelerator