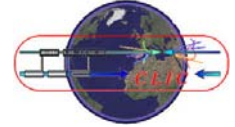




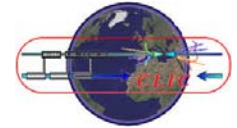
# CLIC (module) instrumentation



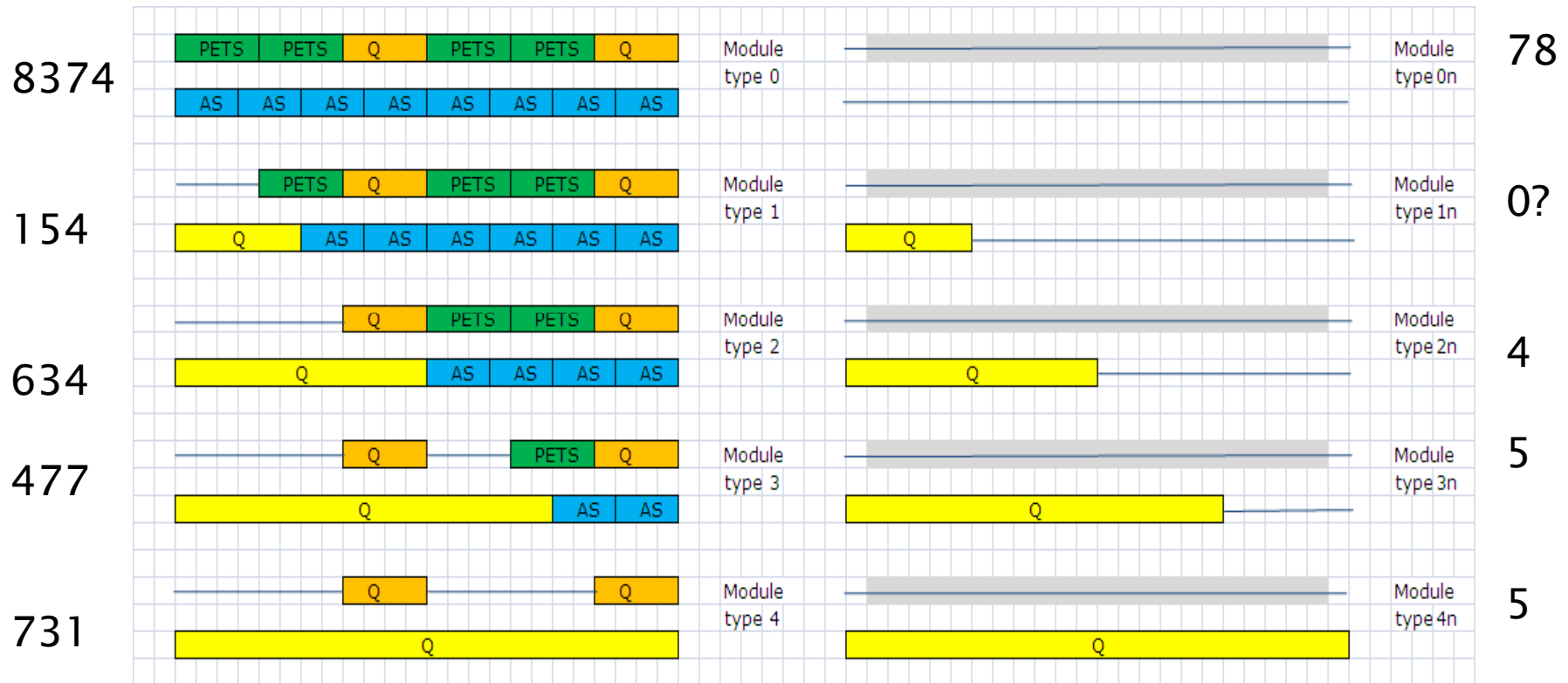
- ❑ Module beam instrumentation
  1. BPM's
  2. Wakefield monitor's
  3. Acquisition system
  
- ❑ Sector beam instrumentation
  1. Transverse profile monitors
  2. Current measurement
  3. Beam loss monitors
  4. Bunch form / length
  5. Beam phase



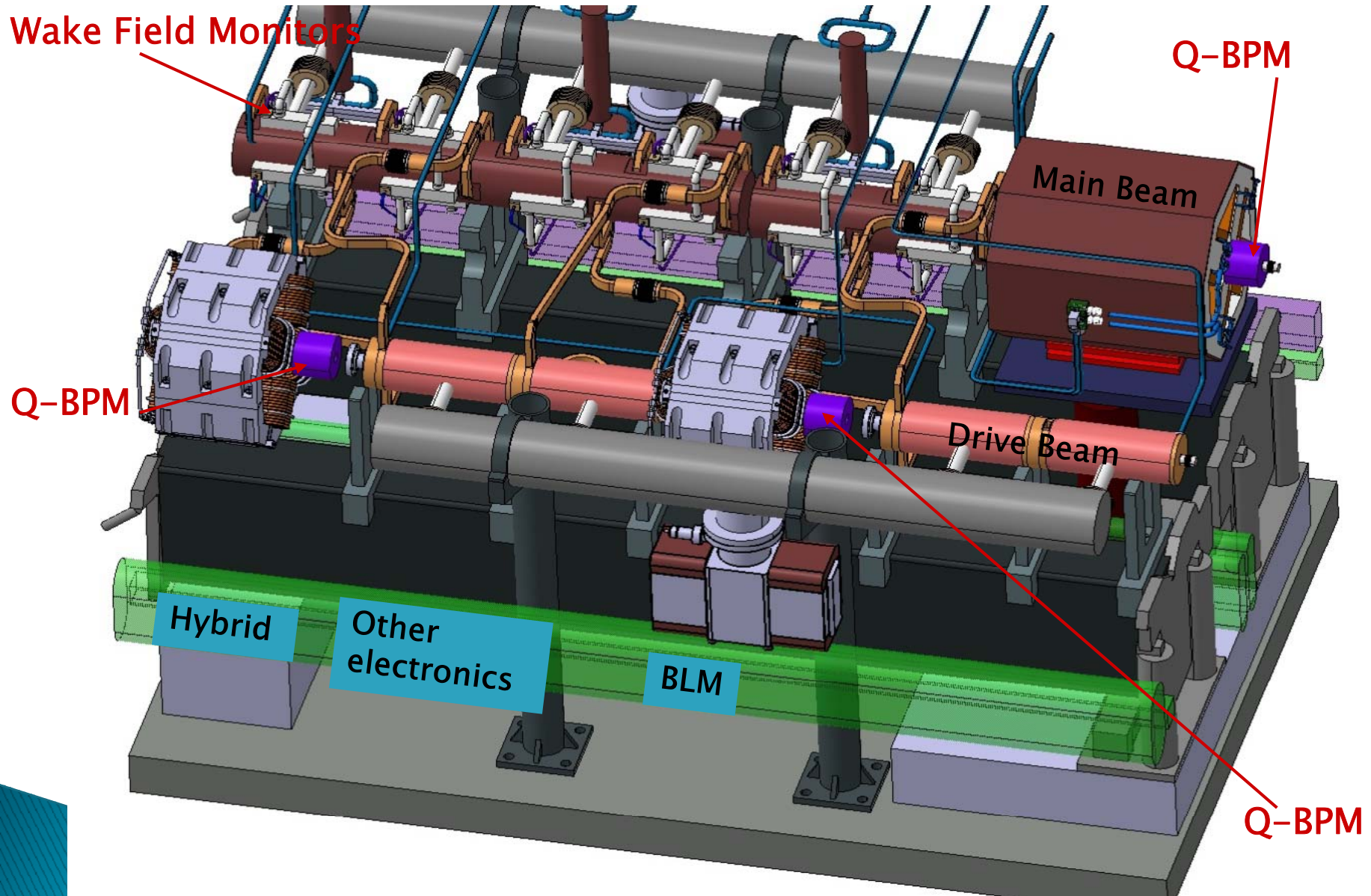
# Module types

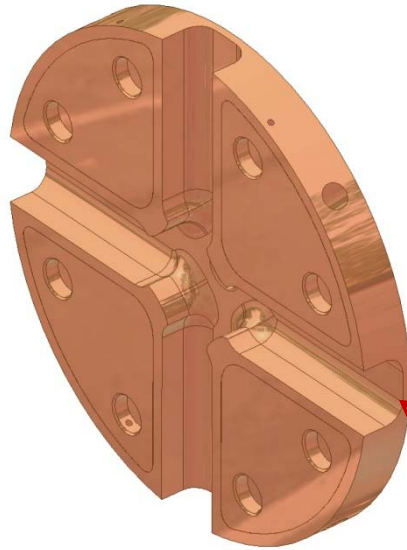
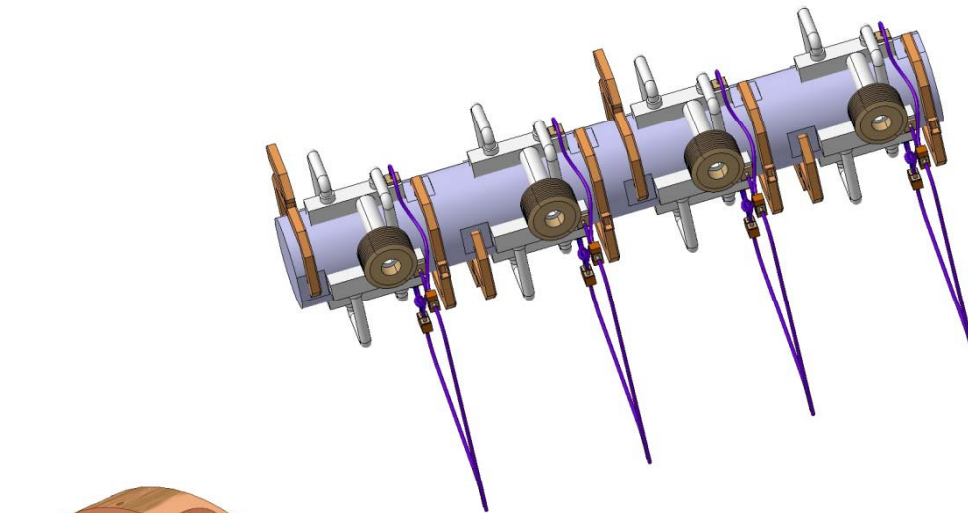


1 BPM per quadrupole  
1WFM per accelerating structure

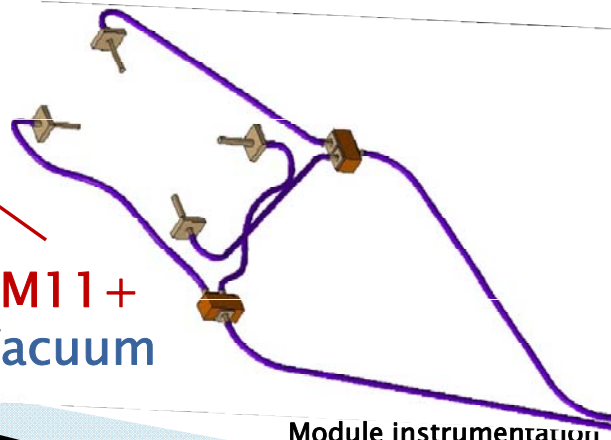


In total 10462 modules per Linac

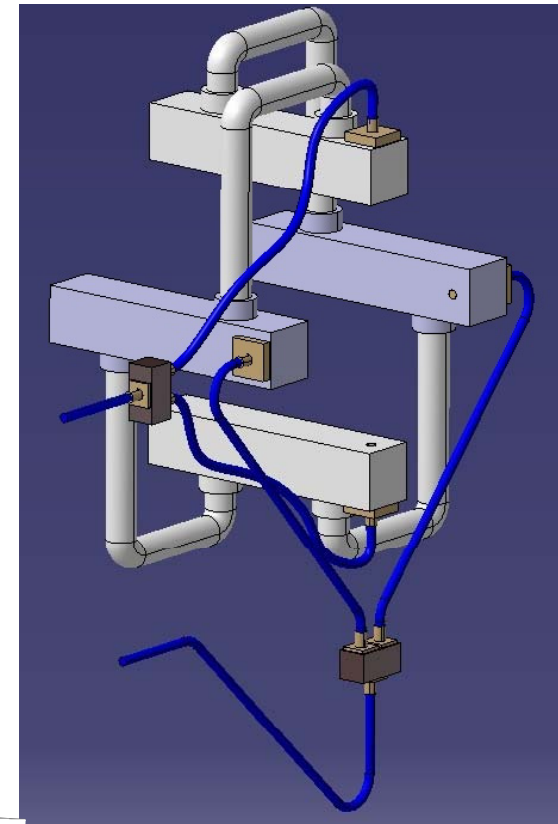




TM11 +  
Vacuum

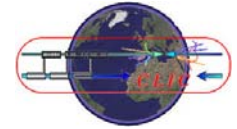


Module instrumentation





# BPM and WFM specifications



## Main beam

**Nominal beam parameters:** Charges/bunch :  $3.7 \cdot 10^9$ , Nb of Bunches: 312, Bunch length: 45 $\mu$ m–70 $\mu$ m, Train length: 156ns

	<i>Accuracy</i>	<i>Resolution</i>	<i>Stability</i>	<i>Range</i>	<i>Bandwidth</i>	<i>Beam tube aperture</i>	<i>Available length</i>	<i>Intercepting device?</i>	<i>How many?</i>	<i>Used in RT Feedback?</i>	<i>Machine protection Item?</i>	<i>Comments</i>	<i>Ref</i>
<b>BPM</b>	5 $\mu$ m	50nm	100nm		35MHz	8.0mm	95/65mm	No	4176	Yes	Yes	Choke BPM? Inductive BPM	CLIC note 764

**Intensity!**

<b>WFM</b>	5 $\mu$ m	<5 $\mu$ m			35MHz	8.0mm?	"-"	No	142812	Yes	No	TM01~16GHz	CLIC note 764
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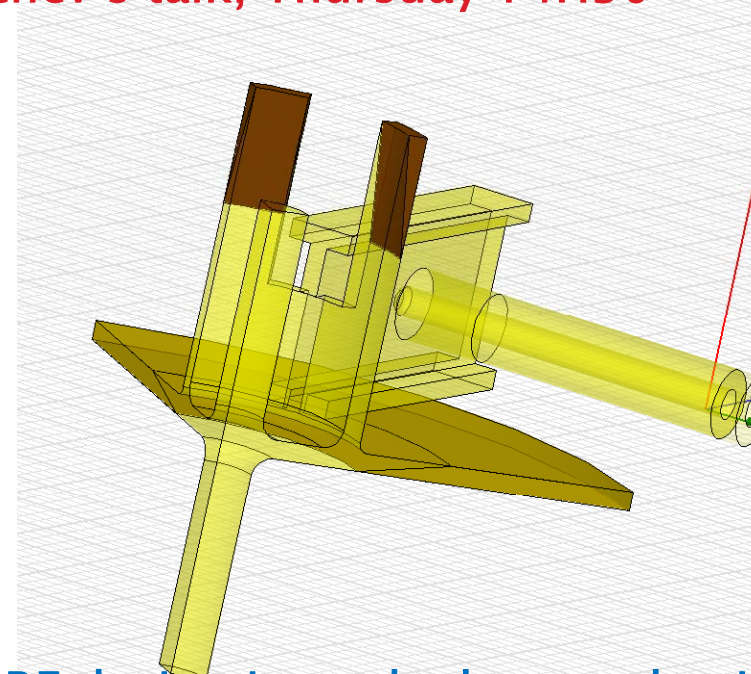
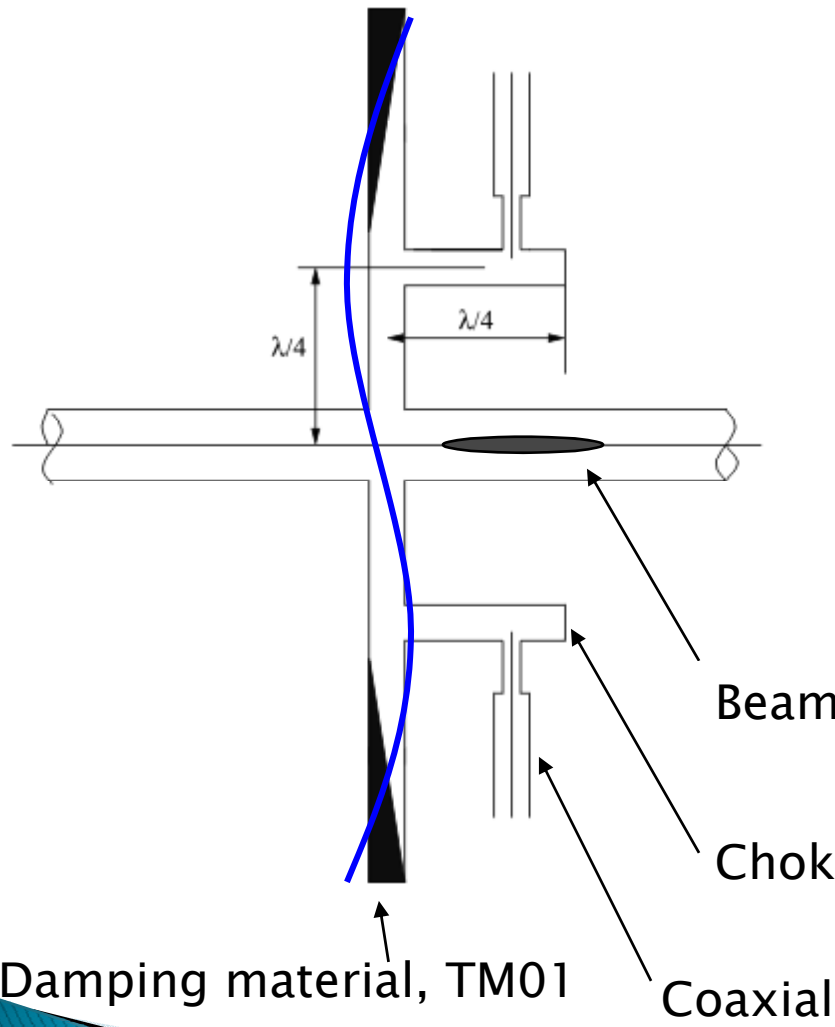
## Drive beam

**Nominal beam parameters:** Charges/bunch :  $5.2 \cdot 10^{10}$ , Nb of Bunches: 2922, Bunch length: 1mm, Train length: 243.7ns

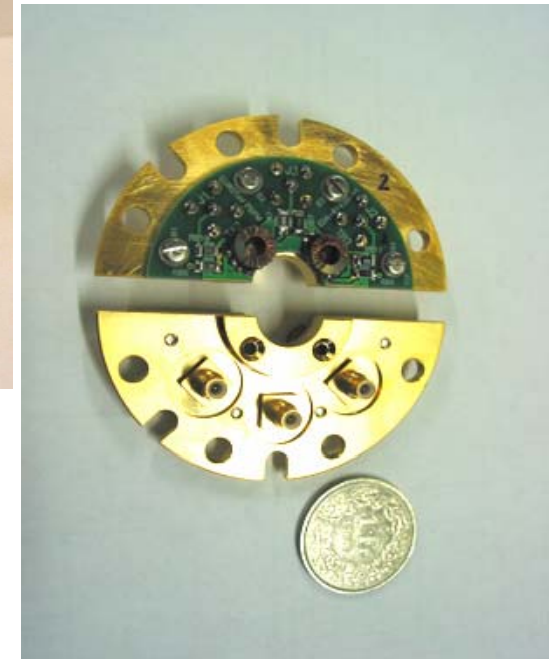
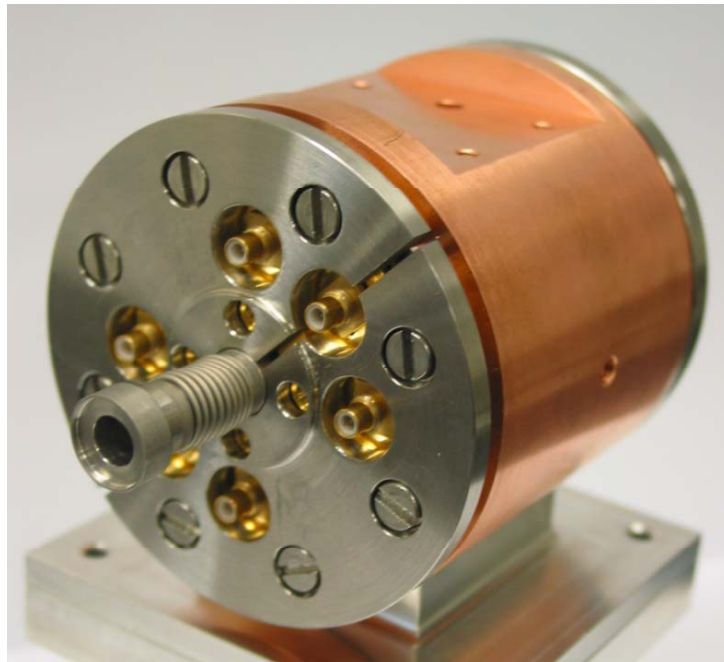
	<i>Accuracy</i>	<i>Resolution</i>	<i>Stability</i>	<i>Range</i>	<i>Bandwidth</i>	<i>Beam tube aperture</i>	<i>Available length</i>	<i>Intercepting device?</i>	<i>How many?</i>	<i>Used in RT Feedback?</i>	<i>Machine protection Item?</i>	<i>Comments</i>	<i>Ref</i>
<b>BPM</b>	20 $\mu$ m	2 $\mu$ m	?	<5mm	35MHz	23mm	104/74mm	No	41480	Yes	Yes	Inductive ? Strip line ?	CLIC note 764

**Intensity!**

See Igor Syrachev's talk, Thursday 14H30



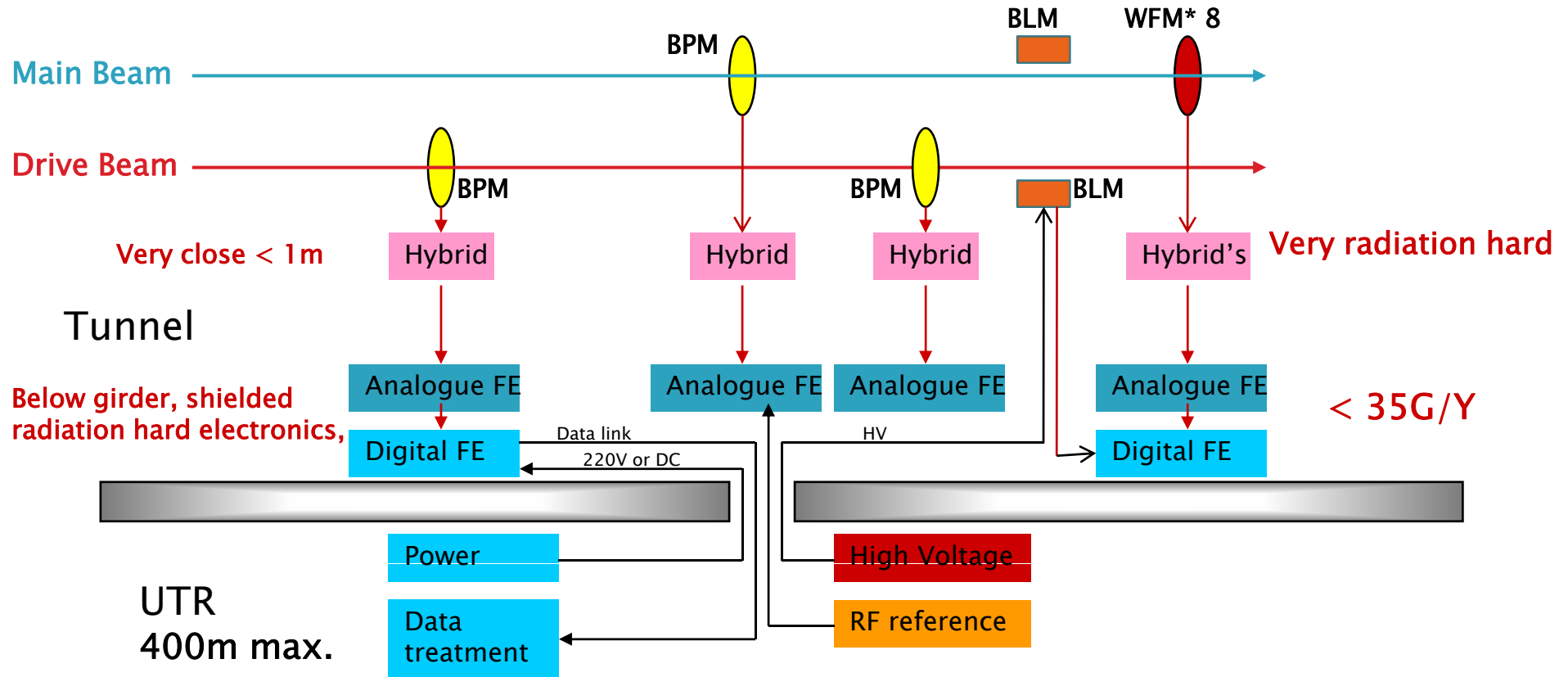
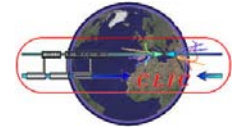
RF design is made, but mechanical design  
Manufacturing still needs to be done!



Measured resolution  
~ 600nm!



Talk by L. Søby, today 15H30

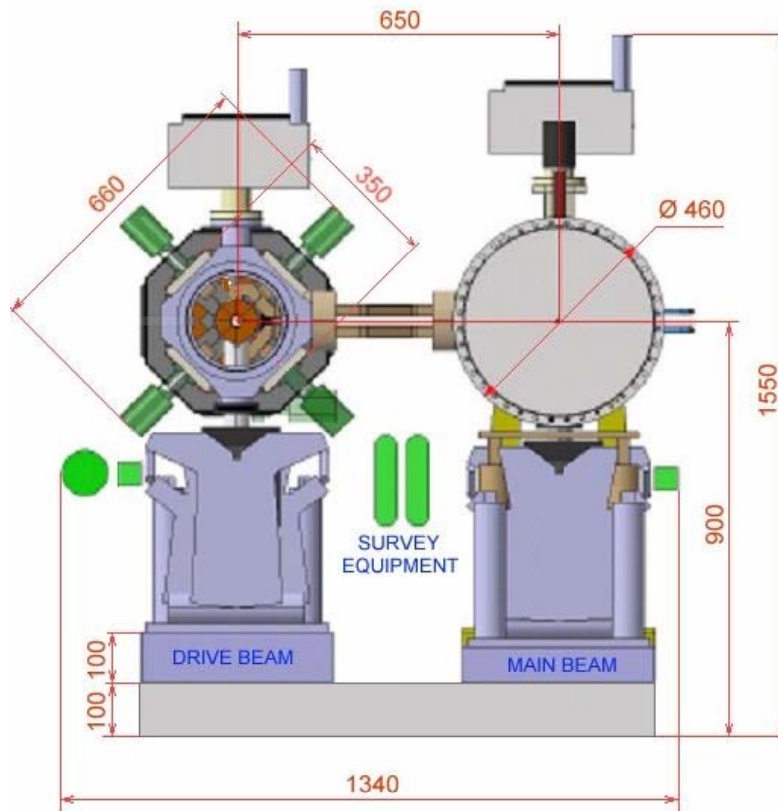


Analogue FE = Down converters, Signal conditioning, Calibration units

Digital FE = Digitizers and control

**OBS: Only 4 cables per module  
But could be further reduced!**





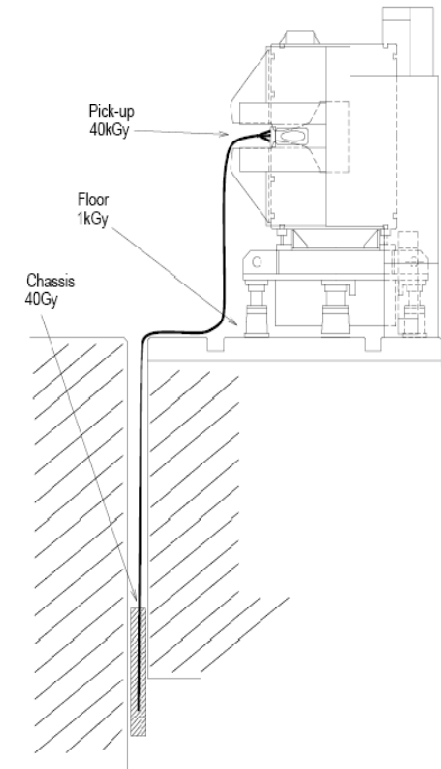
## Radiation levels

- 40kGy/y at 1.3m
- 1kGy/y on the floor
- 40Gy/y in the gap

Electronics can take 30 - 300Gy.  
Careful choice of components and careful design can extend that to a few kGy.

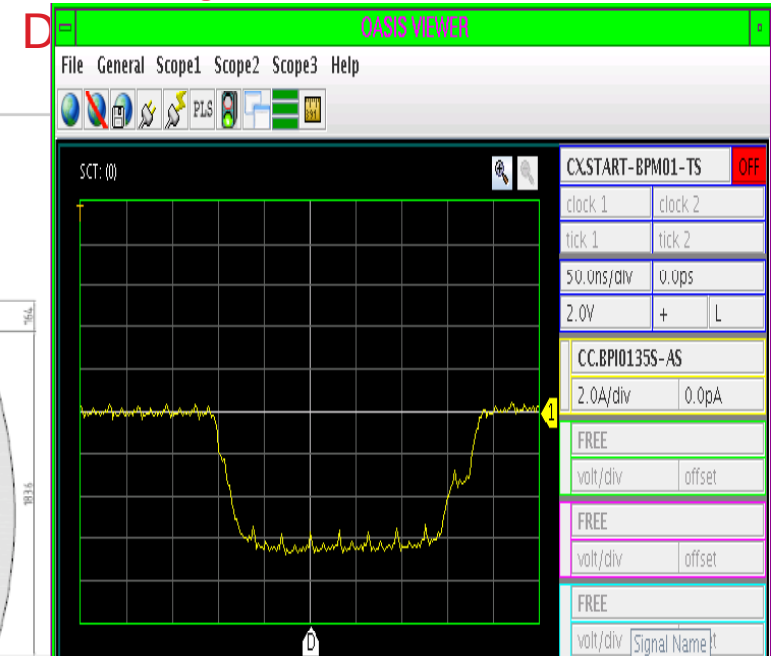
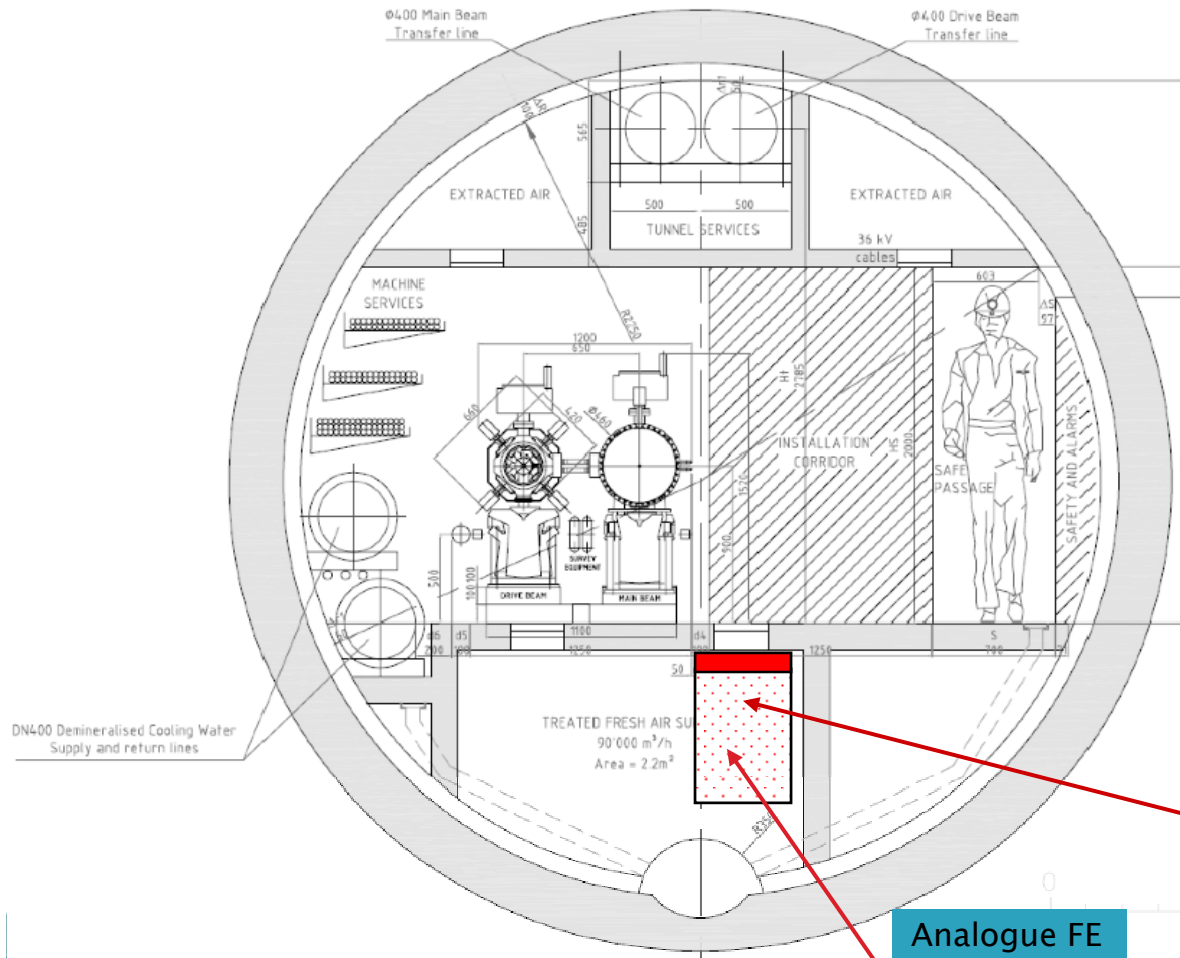
Cable length from PU to pre-amp : 5m  
Double shielded cable

## Radiation in PS



**Radiation reduced by a factor 1000!!.**

## LAPP digital FE



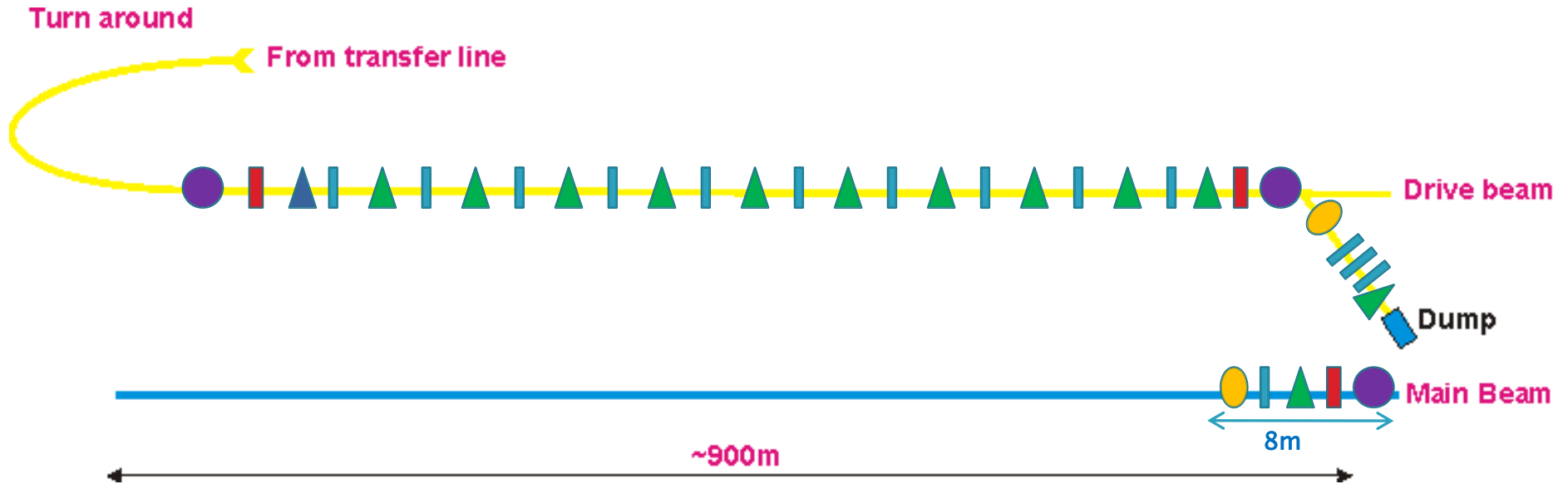
**< 35GY/Y**

**Analogue FE**

= Down converters, Signal conditioning, Calibration units

**Digital FE**

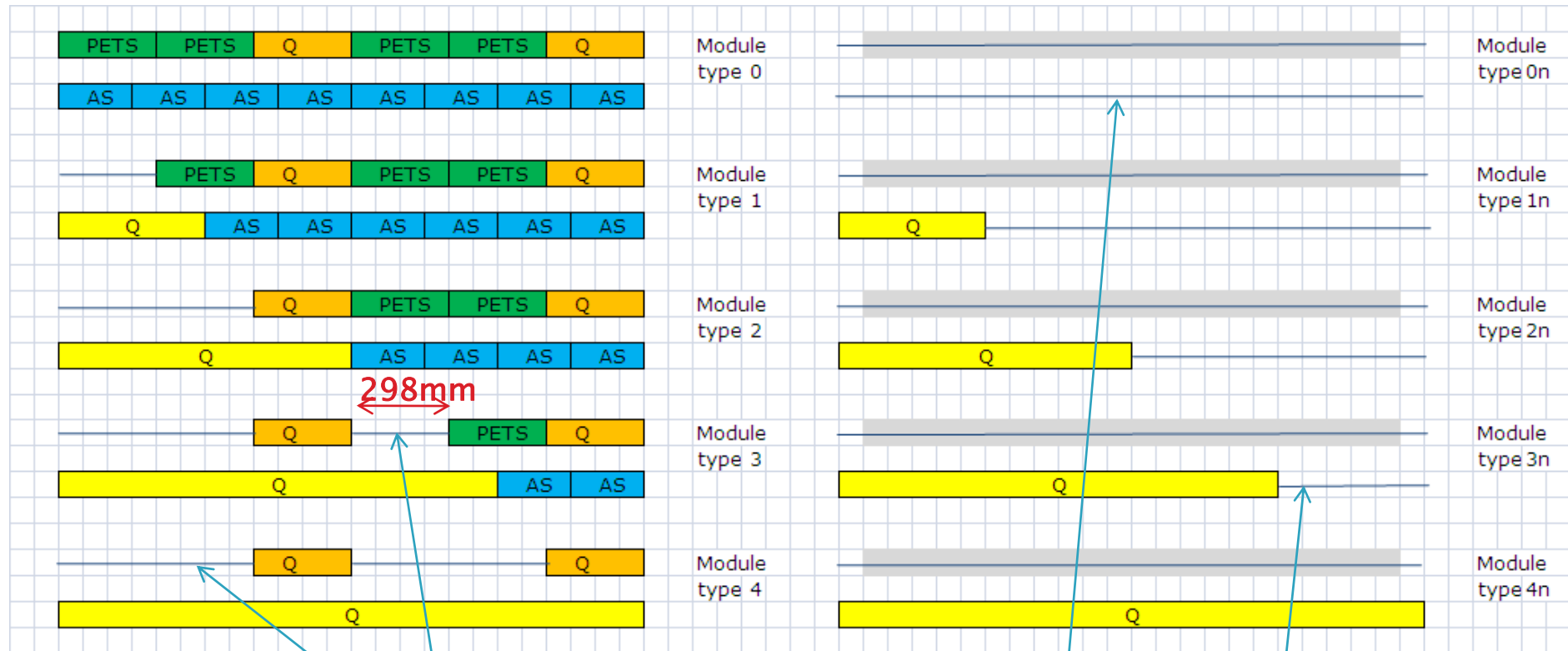
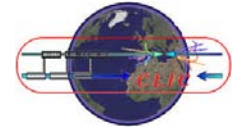
= Digitizers and control



- | Transverse profile monitors, DB=13pc, L~300mm
- Fast (12GHz) BPM, L~100mm, Energy
- Form factor, Fast bunch shape measurement, L~500mm
- ▲ Slow current measurement, DB / 50m, L~150mm, 1%
- ▲ Slow current measurement, DB=1, L~150mm, 0.1%
- Beam Phase    ■ Segmented dump, Energy



# Module types



~40 # type-0 per sector

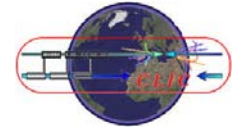
Use "empty" space for "sector" beam instrumentation

Module length: 2.010 m

~4 type "xn" per sector at extraction



# Beam loss monitoring



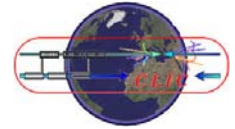
- Beam Loss Monitoring should provide additional monitoring information to the beam current measurements, in the regime *where the other devices are insensitive* ( $\ll$  % loss of beam current)
- Important for *tune up* and failure monitoring
- Detectors should *time resolve* the losses within the pulse, time resolution?
- Develop monitors capable to *disentangle losses* from the Main or/and the Drive Beams.
- One technical solution would be to design the BLMs of the Main Beam with an energy threshold slightly higher than the Drive Beam energy.
- BLM must be included in the existing module layouts, but requires *no extra* longitudinal space.

## Specifications

	<i>Accuracy</i>	<i>Resolution</i>	<i>Stability</i>	<i>Bandwidth</i>	<i>Beam tube aperture</i>	<i>Available length</i>	<i>Intercepting device?</i>	<i>How many?</i>	<i>Used in RT Feedback?</i>	<i>Machine protection Item?</i>	<i>Comments</i>	<i>Ref</i>
<b>Beam loss</b>	?	<b>1%/ Bunch</b>	?	<b>20MHz</b>	“-”	“-	<b>No</b>	<b>/50m</b>	<b>No</b>	<b>Yes</b>		



# Specifications of sector instruments



## Main beam

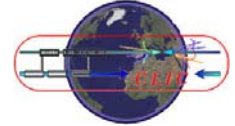
	<i>Accuracy</i>	<i>Resolution</i>	<i>Bandwidth</i>	<i>Beam tube aperture</i>	<i>Stability</i>	<i>Non-intercepting device?</i>	<i>How many?</i>	<i>Used in RT Feedback?</i>	<i>Machine protection Item ?</i>	<i>Comments</i>	<i>Ref</i>
<b>Intensity</b>	<b>0.1%</b>						<b>48</b>	<b>No</b>	<b>Yes</b>		
<b>Beam Size / Emittance</b>	<b>10%</b>	<b>2%</b>				<b>yes</b>	<b>48</b>	<b>No</b>	<b>No</b>		
<b>Energy</b>	<b>0.10%</b>					<b>yes</b>	<b>4</b>	<b>Yes</b>			
<b>Energy Spread</b>								<b>?</b>			
<b>Bunch Length</b>										<b>single shot</b>	
<b>Beam Loss</b>											
<b>Beam Phase</b>		<b>0.1°</b>					<b>48</b>	<b>Yes</b>	<b>No</b>		

## Drive beam

	<i>Accuracy</i>	<i>Resolution</i>	<i>Range</i>	<i>Bandwidth</i>	<i>Beam tube aperture</i>	<i>Stability</i>	<i>Non-intercepting device?</i>	<i>How many?</i>	<i>Used in RT Feedback?</i>	<i>Machine protection Item ?</i>	<i>Comments</i>	<i>Ref</i>
<b>Intensity</b>	<b>0.1%</b>			<b>20MHz</b>	<b>23mm</b>		<b>Yes</b>	<b>48</b>	<b>No</b>	<b>Yes</b>		
<b>Intensity</b>	<b>1%</b>			<b>20MHZ</b>	<b>23mm</b>		<b>Yes</b>	<b>~864</b>	<b>No</b>	<b>Yes</b>		
<b>Beam Size / Emittance</b>	<b>50um</b>				<b>23mm</b>		<b>No</b>	<b>312</b>	<b>No</b>	<b>No</b>		
<b>Energy</b>	<b>10um</b>		<b>10mm</b>	<b>12GHz</b>	<b>?</b>			<b>48</b>	<b>No</b>	<b>No</b>		
<b>Energy Spread</b>					<b>?</b>							
<b>Bunch Length</b>	<b>1%</b>				<b>23mm</b>			<b>96</b>	<b>No</b>	<b>No</b>	<b>single shot</b>	
<b>Beam Phase</b>					<b>23mm</b>			<b>48</b>				



# Summery



- ❑ **Module instrumentation is mainly BPM's and WFM. Requirements are well defined.**
- ❑ **A dedicated study and design of CLIC BPM's and WFM is needed.**
- ❑ **Space must be foreseen for electronics on the module and in a radiation shielded location within a few meters, i.e. in the floor.**
- ❑ **A digital front-end, reduces significantly the cable costs.**
- ❑ **Dive beam SECTOR instruments should be designed for type 1-4 modules.**
- ❑ **Main beam SECTOR instruments can only be foreseen close to extraction region on module types 0n-3n.**
- ❑ **Specifications are crude but under the way**