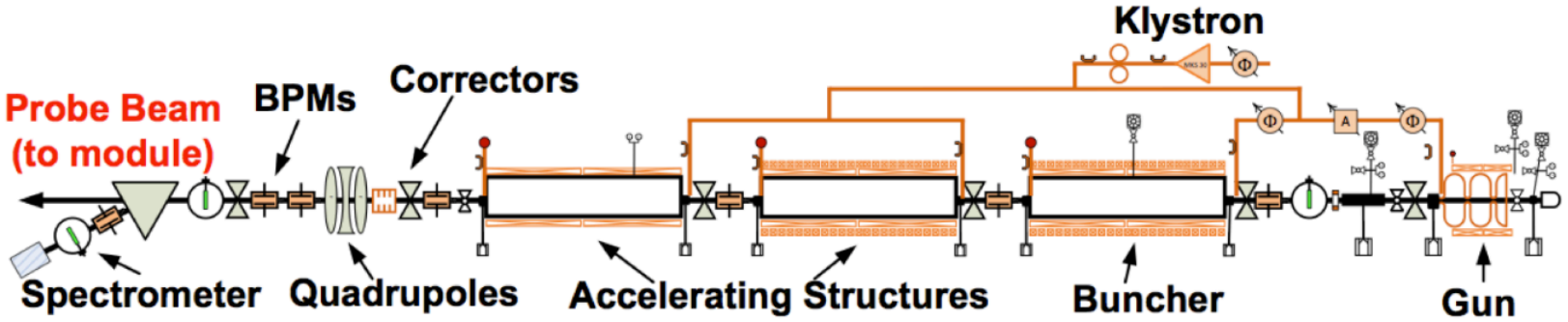
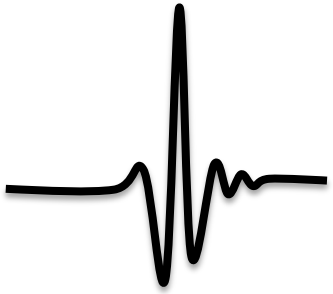
CALIFES Workshop 2016

10-12 October 2016
CERN
Europe/Zurich timezone



Beam parameter (end of linac)	Value range
Energy	80 - 220 MeV
Bunch charge	0.01 - 1.5 nC
Normalized emittances	2 um in both planes
Bunch length	300 um -1.2 mm

THz session



Relative energy spread	1 %
Repetition rate	1 - 5 Hz
Number of micro-bunches in train	Selectable between 1 and >100
Micro-bunch spacing	1.5 GHz

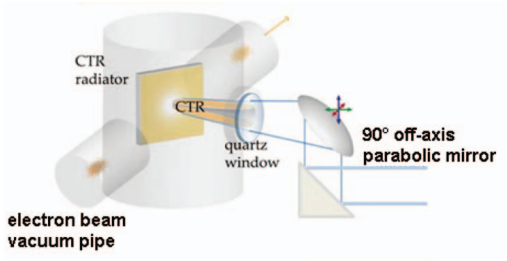
M. Petrarca, University of Rome “Sapienza” and INFN-Roma1

THz R&D with CALIFES

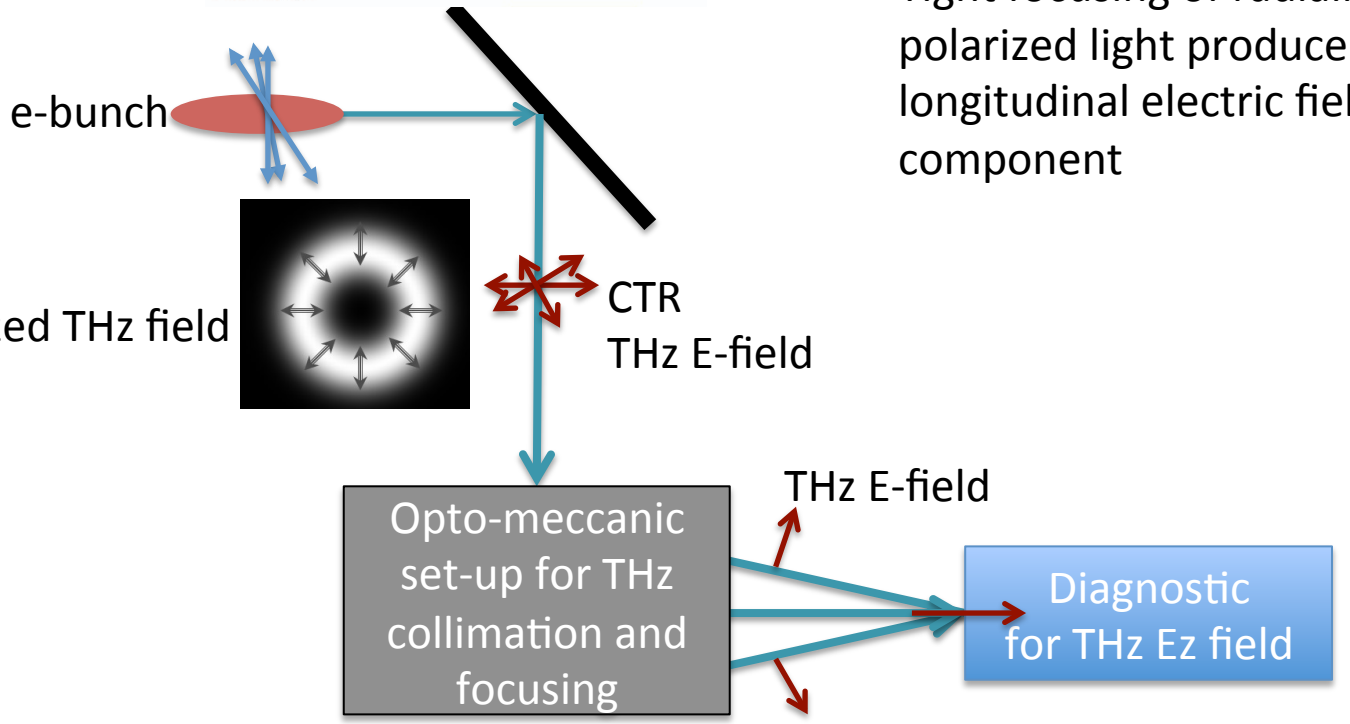
Idea of schedule for THz activity	
Short term (2017)	A. Curcio → THz characterization & shaping. THz Longitudinal field generation & characterization. **= Hands on CALIFES as THz source**
Medium term (2017-2018)	First THz interaction with e-bunch
Long term (2018->)	Facility improvement for THz acceleration scheme. CALIFES as THz and/or as e- beam probe source

THz R&D (short term 2017)

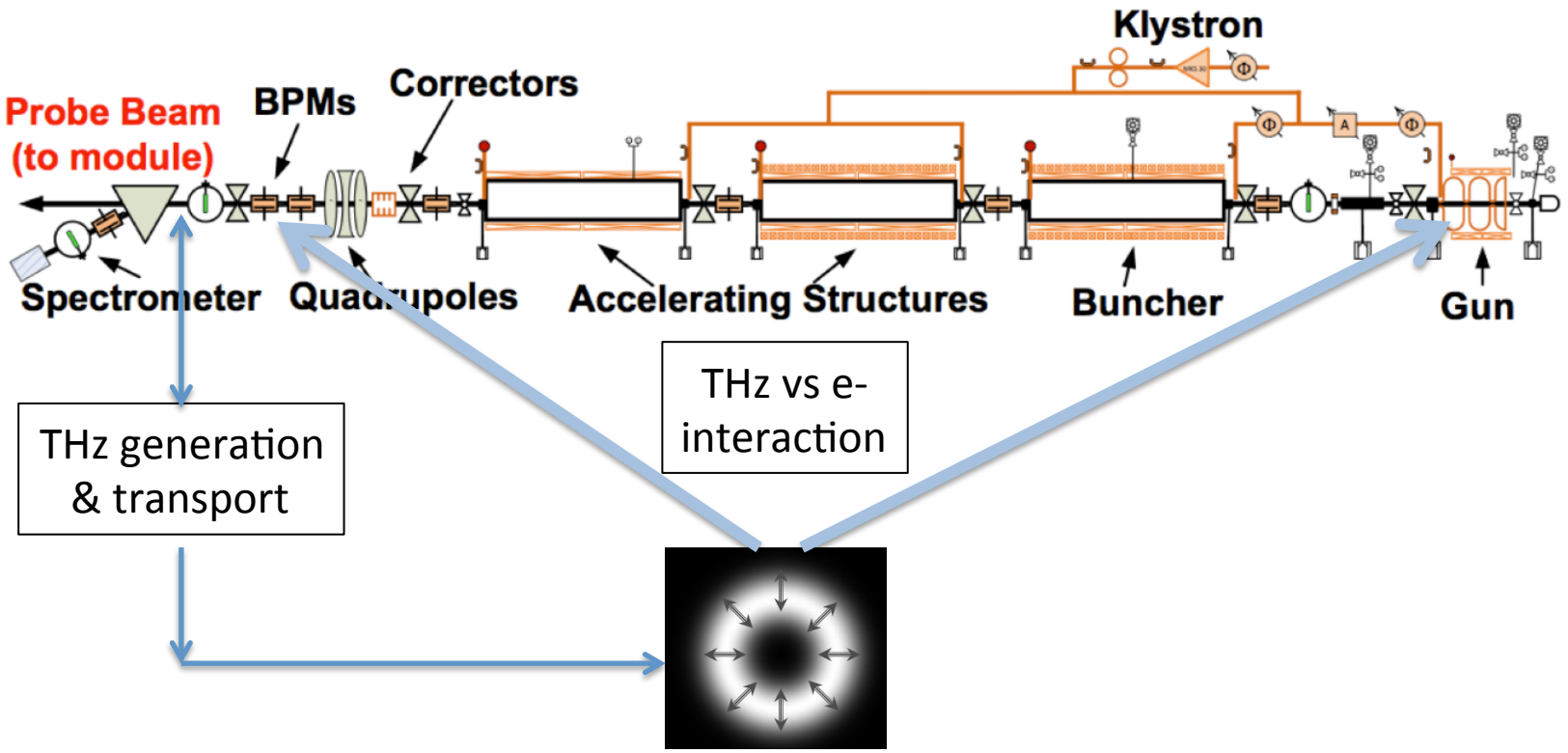
Toward THz acceleration ➔ Characterization of longitudinal component (Ez) of THz field



CTR
Tight focusing of radially polarized light produce large longitudinal electric field component

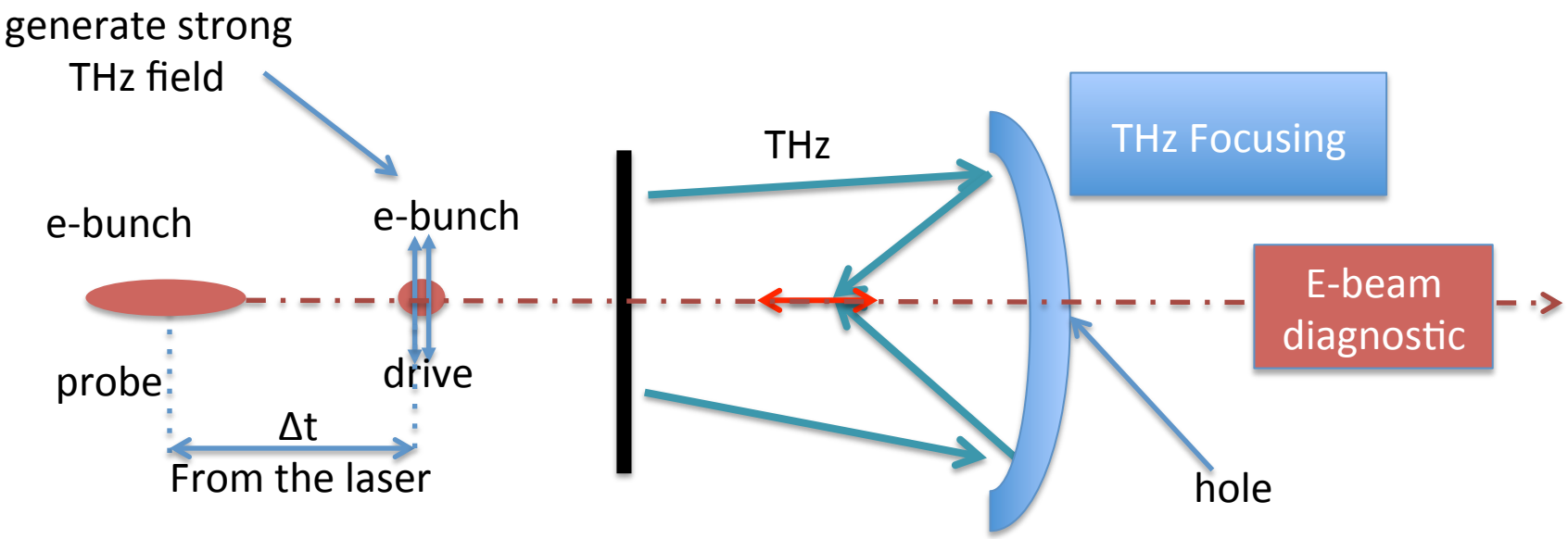


THz vs e- interaction (medium term 2017-2018)

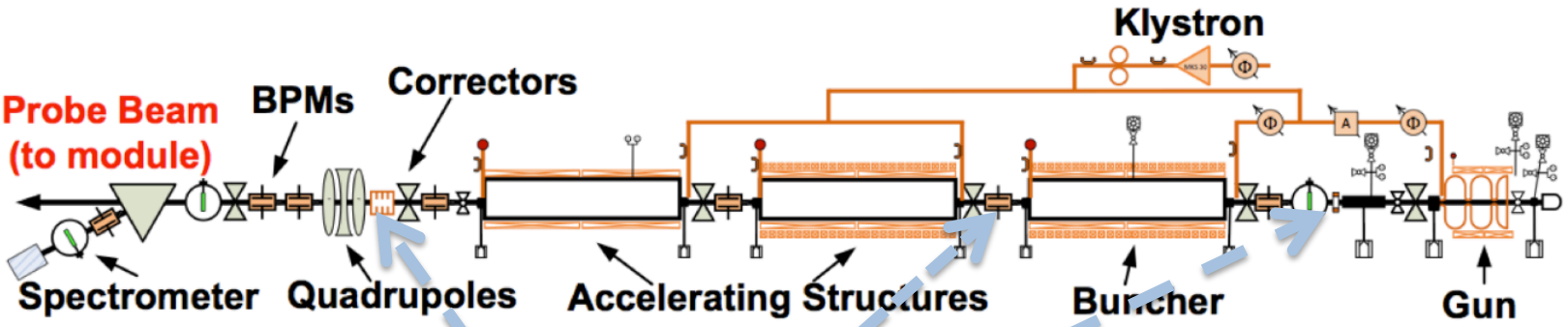


THz vs e- interaction: R&D (medium term 2017-2018)

From previous test the proper focusing optics will be chosen, e-bunch properties and the e-beam diagnostic system will be optimized. A possible scheme:



THz vs e- interaction (long term 2018->)



THz vs e- interaction

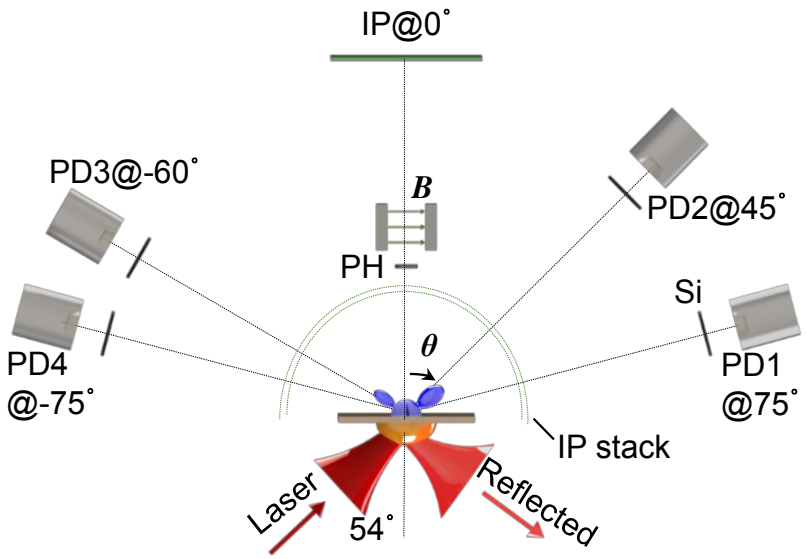
Dedicated THz shaping (focusing; radial pol. ecc..)

Laser based THz generation

Dedicated laser for high intensity THz generation is required
Possibility to use waveguide

THz source as benchmark for laser-solid interaction or dedicated relative diagnostic

Yutong Li et al, PRL 116,205003,(2016)



200 TW laser @ SJTU

6J/30fs/10Hz

- THz energy/angular distributions/polarization/spectra
- Proton energy
- Fast electron angular distributions

➢**New diagnostic for fast electrons**

- e^- Number/charge
- Current
- Length

The role of THz modes of vibration in DNA organisation and gene expression.

On behalf of :
Peter Weightman
Physics Department, University of Liverpool

Experiment: Effects of high peak power THz.

Summary of previous work. Weightman, Phys. Biol. **9** 053001 (2012)
"Evidence is accumulating that terahertz radiation influences biological systems and this need to be clarified in order to establish safe levels of human exposure to this radiation."
None of the previous studies have been carried out in standard tissue culture conditions.
Need to be aware of thermal effects.

Does THz influence the expression of genes? Bock et.al. PLoS One 5 e15806 (2010)
Exposed of mouse stem cells to broad band THz centered at ~ 10 THz.
"Extended exposure to broad spectrum THz radiation results in specific changes in cellular function that are closely related to DNA-directed gene transcription"

Does THz influence the replication of DNA? Berns et. al. PNAS **87** 2810 (1990)
Effect of THz radiation on DNA synthesis in mammalian cells by measuring the uptake of tritiated thymidine (T) after exposure to:-
100 pulses of 1.5 THz radiation from a FEL with power level of 1.3 kW per pulse.
THz radiation effects the incorporation of T into DNA and hence DNA replication.
Conclude the effect is unlikely to be thermally mediated.
But transport of cells from tissue culture facility to FEL took 3 hours.

THz interaction
DNA-direct gene transcription
DNA-synthesis

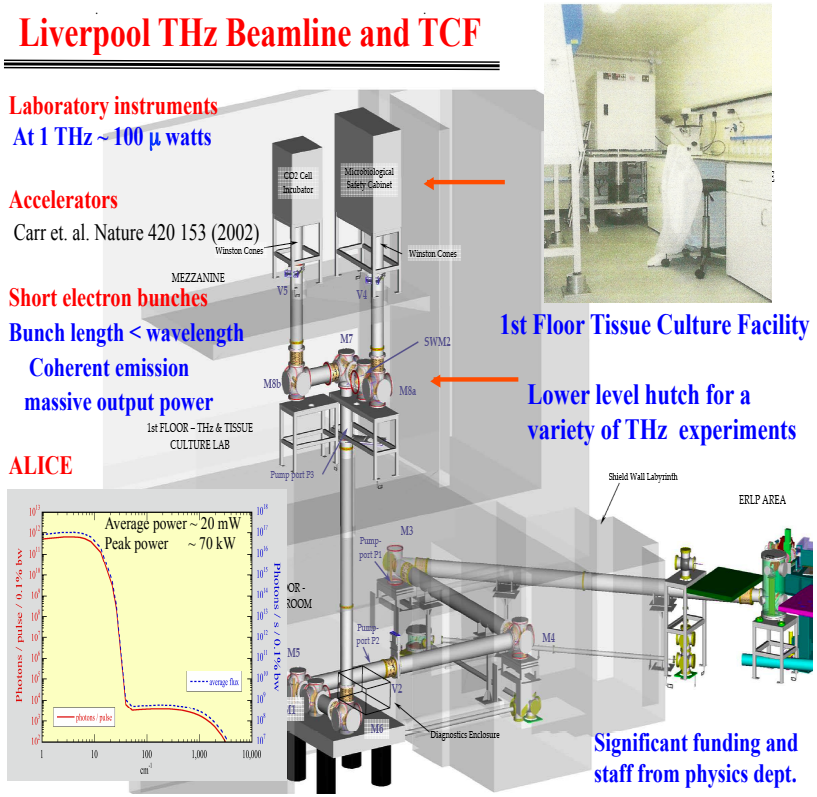
Liverpool Research Programme
1 Determine safe limits of human exposure to THz:- Stem cells, epithelial cells.
2 Investigate the mechanisms of differentiation in stem cells.
3 Investigation of the Frohlich mechanism of biological organisation EPSRC EP/H02235X/1
4 Search for IR/THz signatures of malignancy for esophageal cancer App.Phys.Lett. **102** 53701(2013)

Accelerator Source of THz Radiation Required.

We need short electron bunches

When bunch length < wavelength --> Coherent emission ---> massive output power

Carr et. al. Nature **420** 153 (2002)



1st Floor Tissue Culture Facility

Lower level hutch for a variety of THz experiments

Significant funding and staff from physics dept.

Need:-

High peak power

To stimulate DNA processes.

Low average power

To avoid thermal effects.

A controlled environment.

Broad band source.

Ability to tune wavelengths (filters?)

CALIFES upgrade:

For THz generation → Higher Charge (>1.5nC) and/or short bunch length (100fs)

-> laser shaping and/or HQ cathode requirement

For THz R&D → the possibility to Directly use the THz radiation helps saving time and money

-> dedicated shielded room as close as possible to the source

For THz based proof of principle acceleration schemes:
a second beam line
laser based THz generation (CALIFES as e- source)

Collaborations:

S. Lupi, Univeristy of Rome “La Sapienza”, Italy

E. Chiadroni, LNF-INFN, Italy

M. Ferrario, LNF-INFN, Italy

Yutong Li, Beijing National Laboratory & Institute of Physics, China

Matteo Clerici, University of Glasgow, United Kingdom

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Thank  You