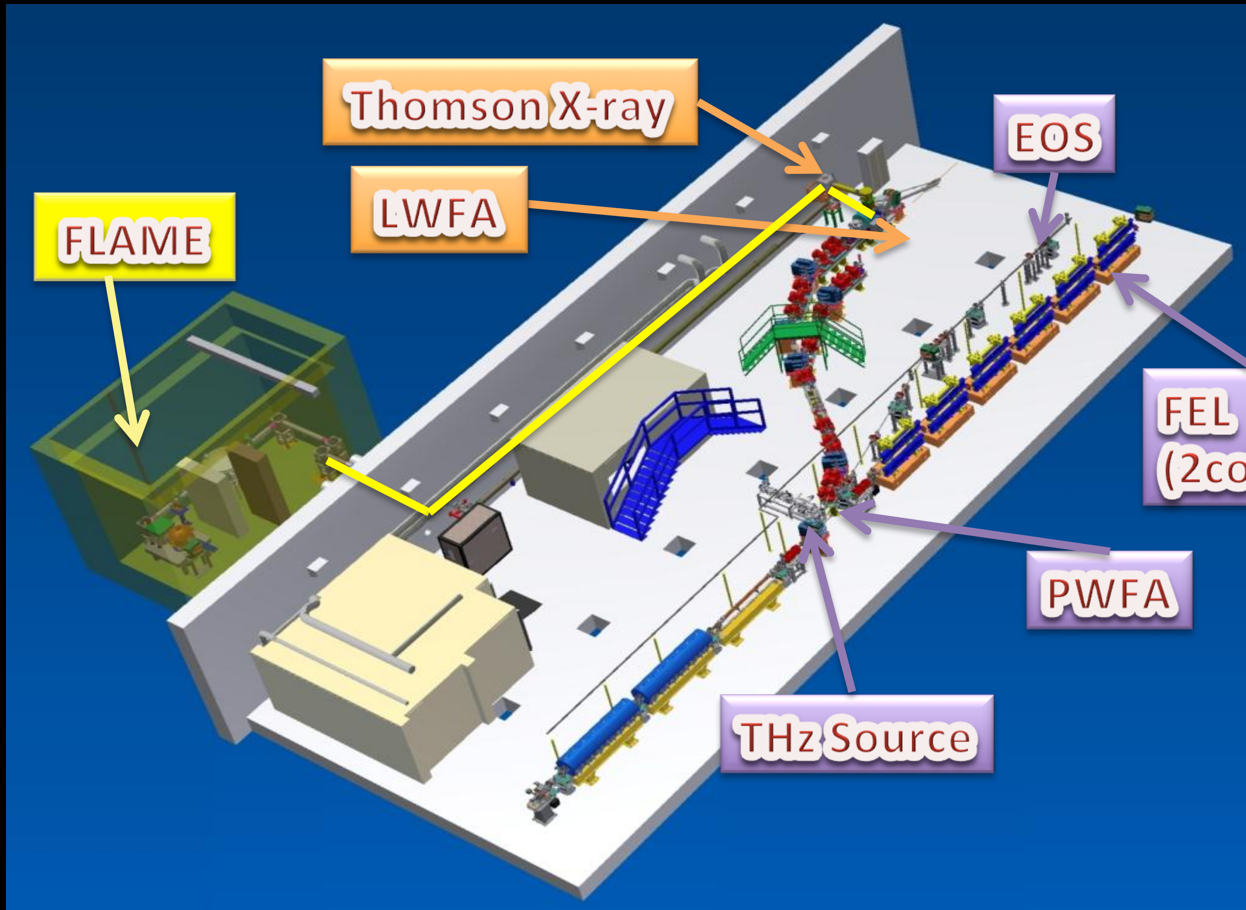
Summary of the SPARC_LAB activities

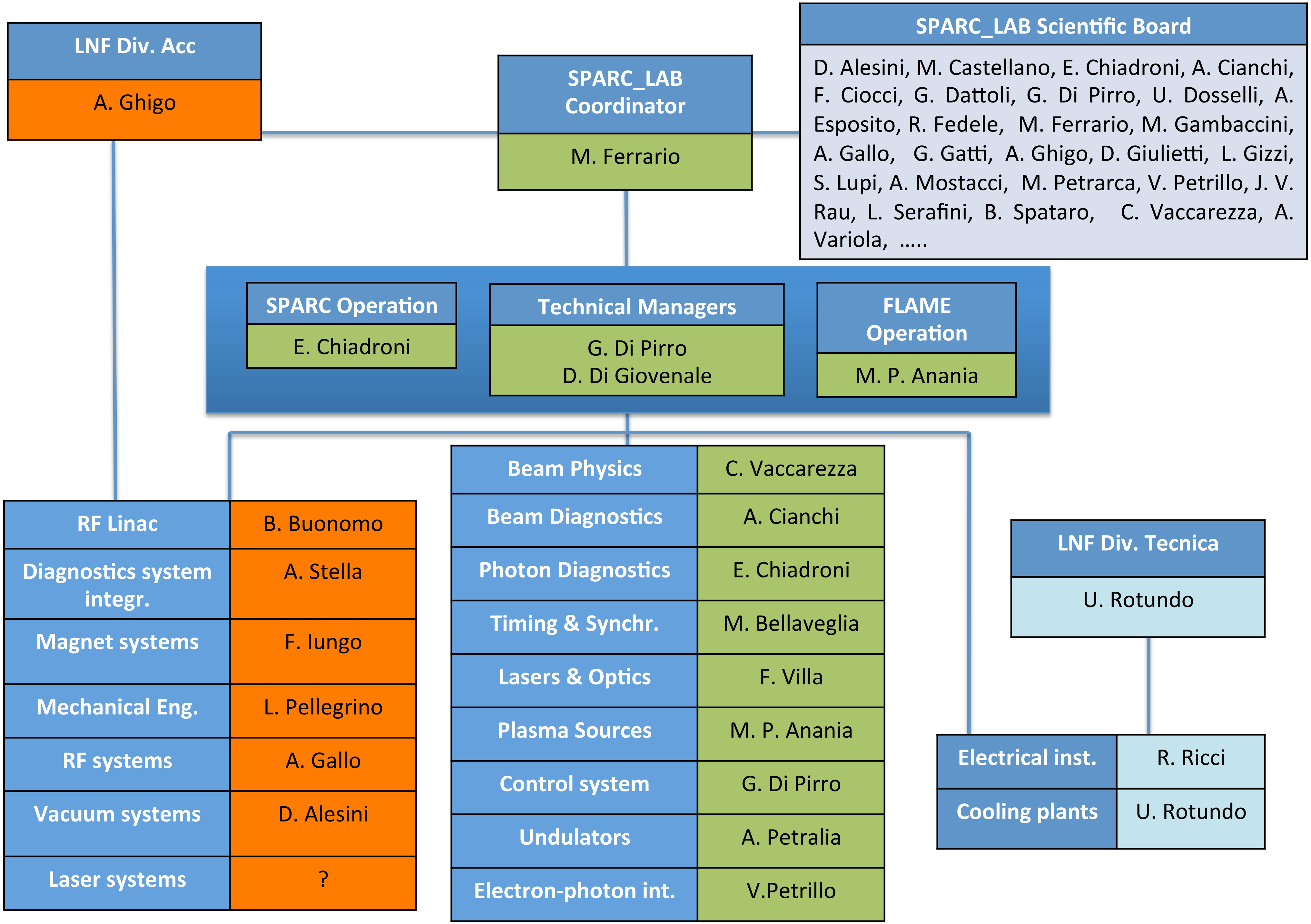
Massimo.Ferrario@LNF.INFN.IT
On behalf of the SPARC_LAB collaboration



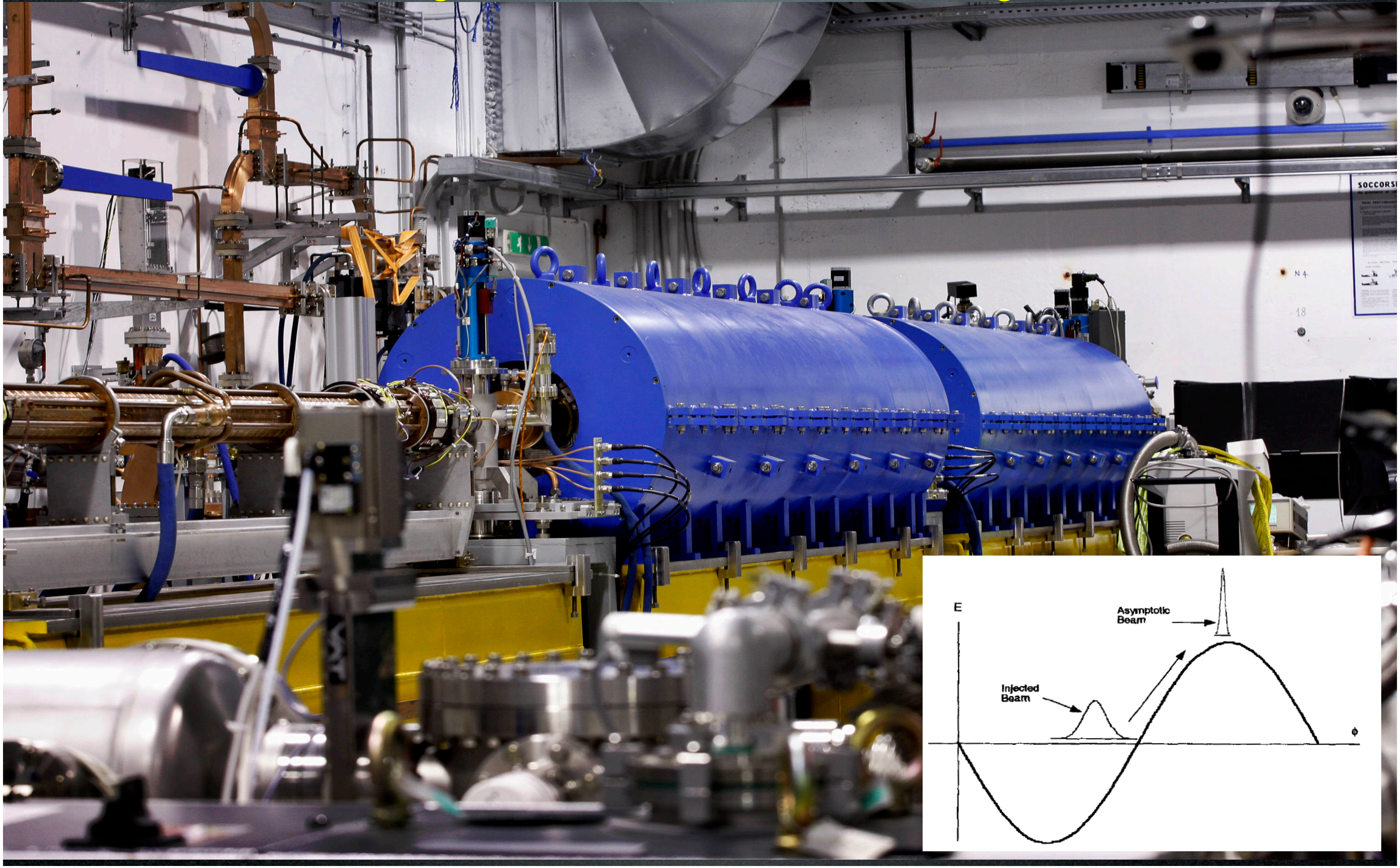
LNF Scientific Committee Meeting - May 18, 2015

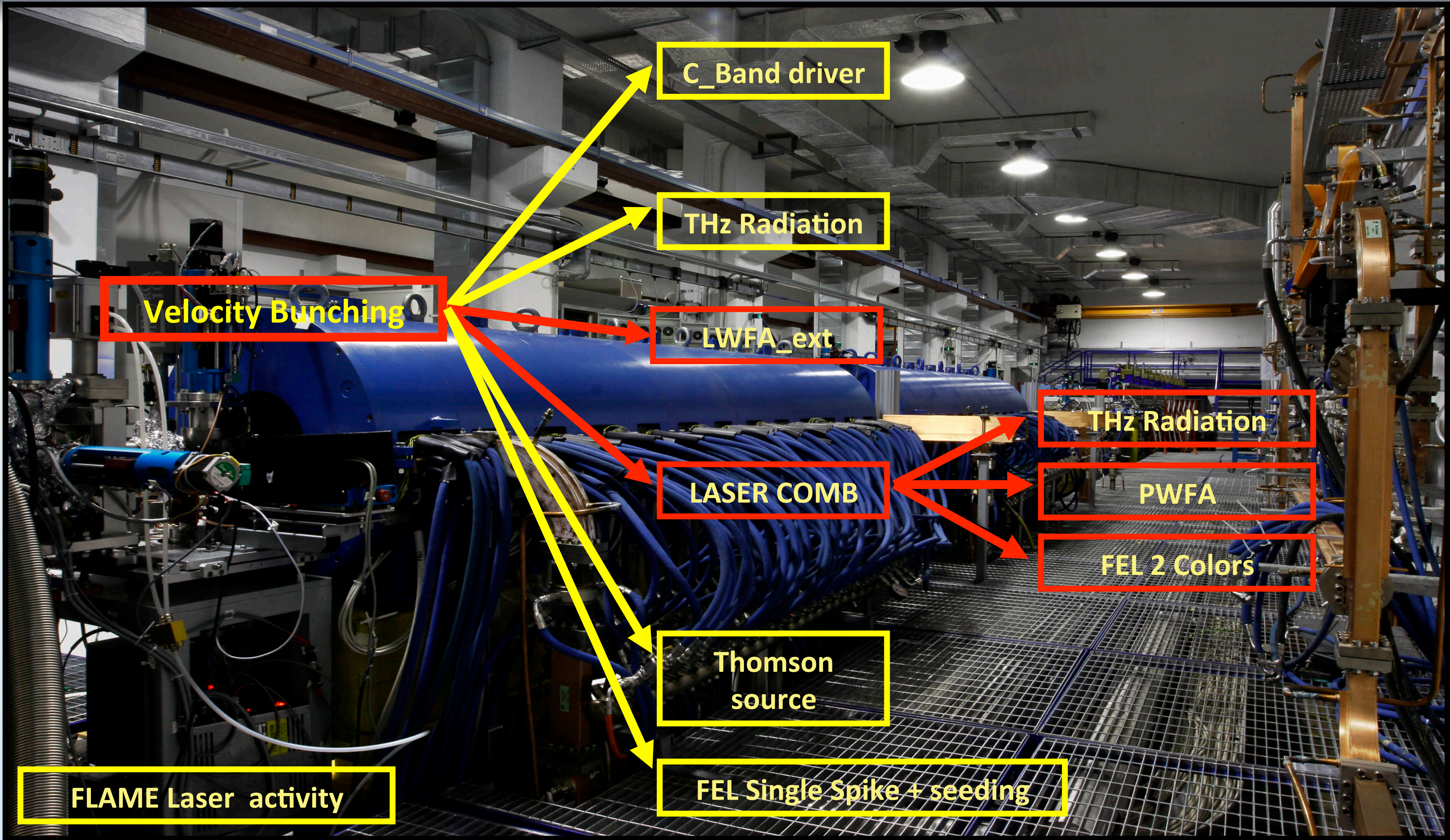
Outline

- Improved integration within DA
- Strong statement from INFN President: highest priority to Plasma Acceleration! => rescheduled experiments
- Experimental beam dynamics results for plasma acceleration
- FLAME status
- Plasma interaction chamber off line test under way
- Next runs with FEL, Thomson and THz


LNF Div. Acc
A. Ghigo
SPARC_LAB Coordinator
M. Ferrario
SPARC_LAB Scientific Board
D. Alesini, M. Castellano, E. Chiadroni, A. Cianchi, F. Ciocci, G. Dattoli, G. Di Pirro, U. Dosselli, A. Esposito, R. Fedele, M. Ferrario, M. Gambaccini, A. Gallo, G. Gatti, A. Ghigo, D. Giulietti, L. Gizzi, S. Lupi, A. Mostacci, M. Petrarca, V. Petrillo, J. V. Rau, L. Serafini, B. Spataro, C. Vaccarezza, A. Variola, ...
SPARC Operation
E. Chiadroni
Technical Managers
G. Di Pirro
D. Di Giovenale
FLAME Operation
M. P. Anania
RF Linac
B. Buonomo
Diagnostics system integr.
A. Stella
Magnet systems
F. Iungo
Mechanical Eng.
L. Pellegrino
RF systems
A. Gallo
Vacuum systems
D. Alesini
Laser systems
?
Beam Physics
C. Vaccarezza
Beam Diagnostics
A. Cianchi
Photon Diagnostics
E. Chiadroni
Timing & Synchr.
M. Bellaveglia
Lasers & Optics
F. Villa
Plasma Sources
M. P. Anania
Control system
G. Di Pirro
Undulators
A. Petralia
Electron-photon int.
V.Petrillo
LNF Div. Tecnica
U. Rotundo
Electrical inst.
R. Ricci
Cooling plants
U. Rotundo

HB photo- injector with Velocity Bunching

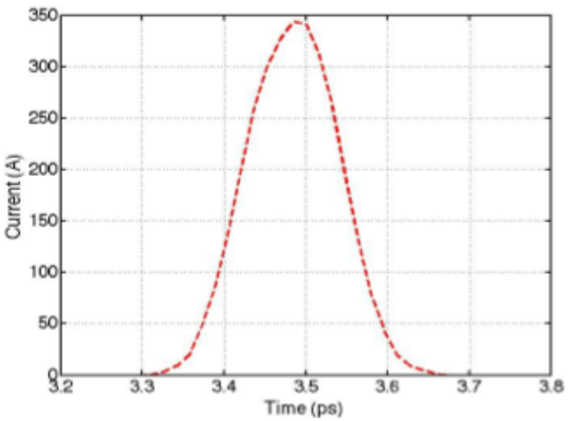


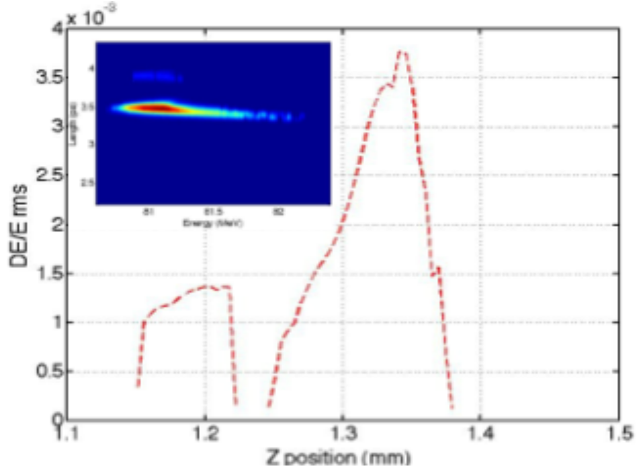


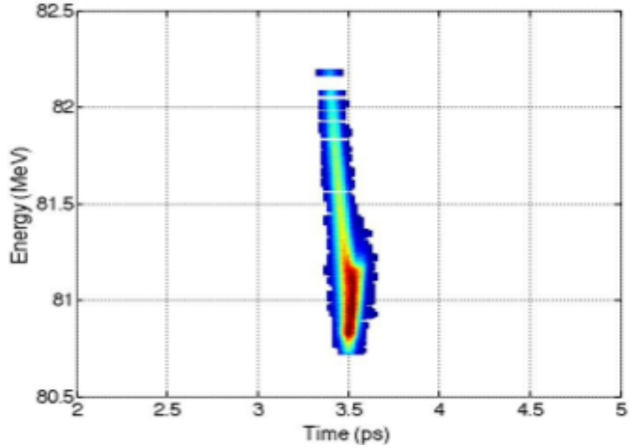
C_Band driver
THz Radiation
Velocity Bunching
LWFA_ext
THz Radiation
LASER COMB
PWFA
FEL 2 Colors
Thomson source
FEL Single Spike + seeding
FLAME Laser activity

SPARC LAB

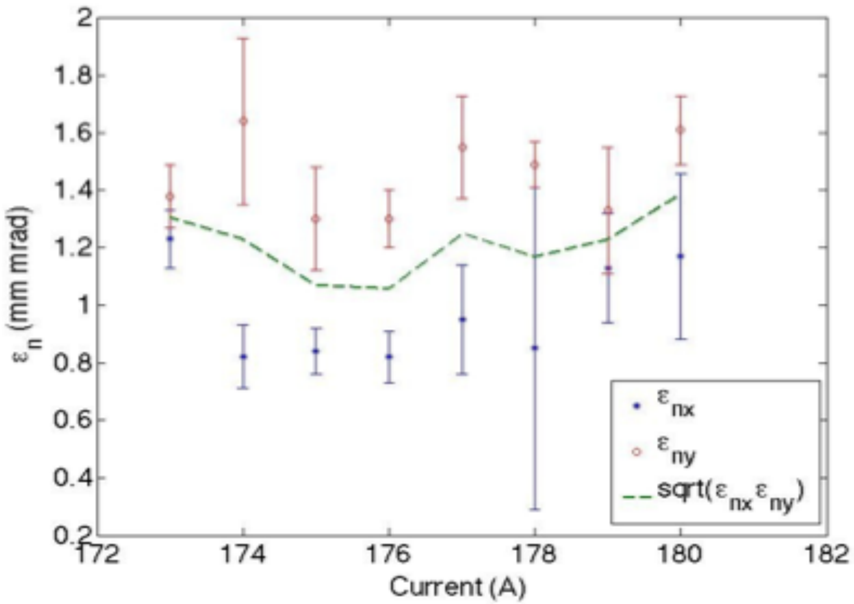
Beam dynamics experimental results:



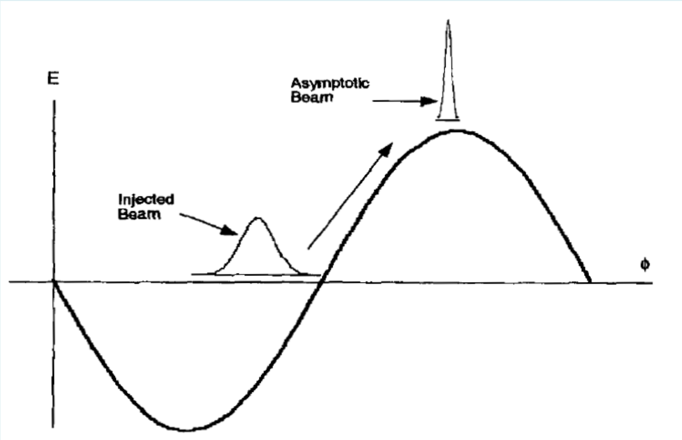


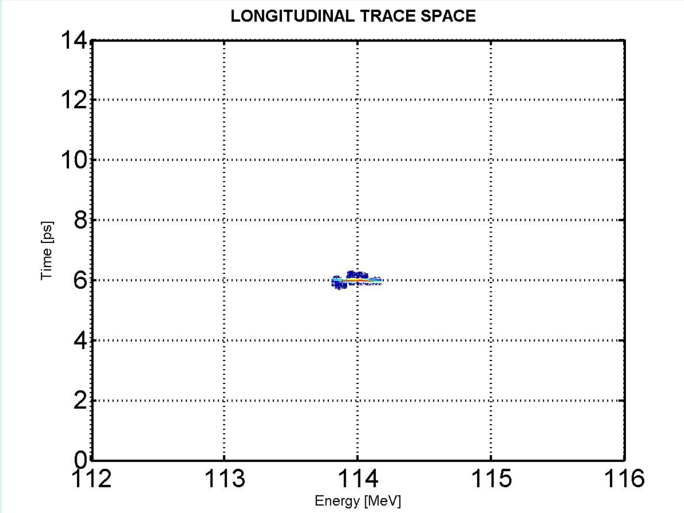


Energy (MeV)	81.23(0.03)
Energy spread (%)	0.35(0.03)
Bunch duration (ps)	0.048(0.001)
TransvEmit (mm mrad)	1.06(0.13)
Charge (pC)	55(4)
LongEmit (keV*mm)	3.37(0.29)



Single Bunch - 20 pC





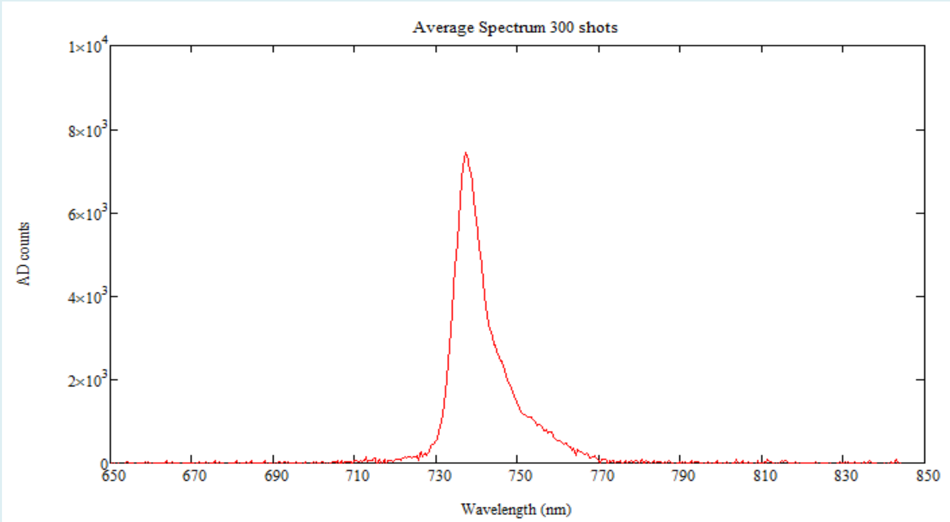
$$\sigma_t = 26\,fs$$

$$\varepsilon_{nx} = 1.2um$$

$$\sigma_E = 0.1\%$$

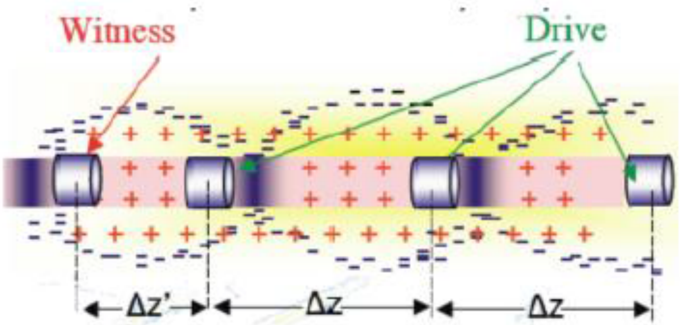
$$I = 400\,A$$

Single Spike FEL ~ 100 fs , 40 μJ



Plasma-based acceleration techniques

resonant-PWFA



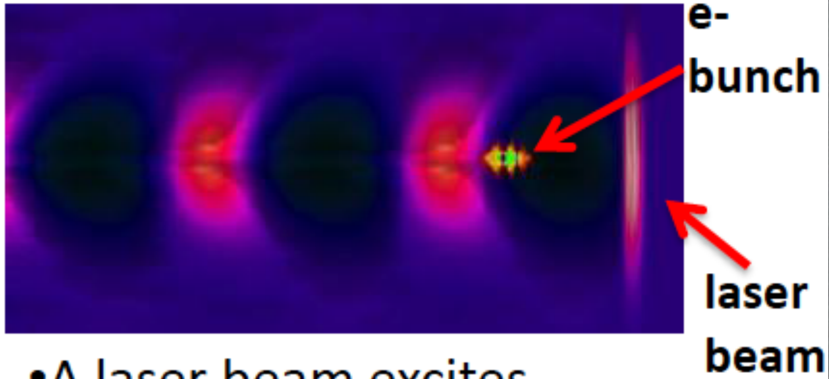
•A train of three electron bunches (driver bunches) is sent through a capillary discharge

•A resonant plasma wave is then excited in plasma

•A fourth electron beam (witness beam) uses this wave to be accelerated

$n_e = 2 \times 10^{16}\ cm^{-3}$
$\lambda_p = 300 \mu m$
Capillary 1mm
Hydrogen

external injection LWFA



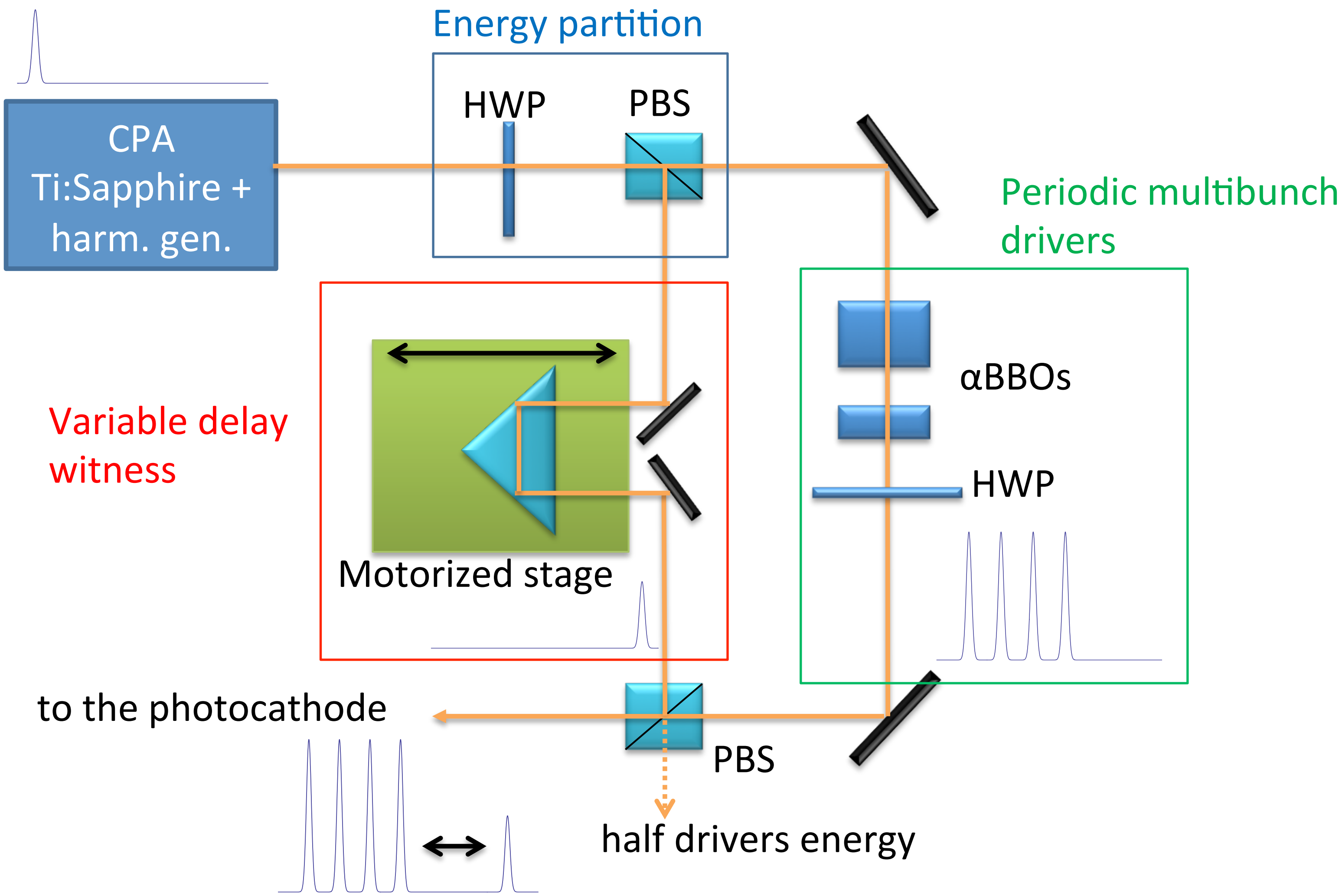
•A laser beam excites plasma waves in a capillary filled with gas

•A high brightness electron beam uses this wave to be accelerated

$n_e = 1 \times 10^{17}\ cm^{-3}$
$\lambda_p = 100 \mu m$
Capillary 100 µm
Hydrogen

Beam Driven Plasma Wake Field Acceleration (COMB exp)

Drivers and witness bunches generation



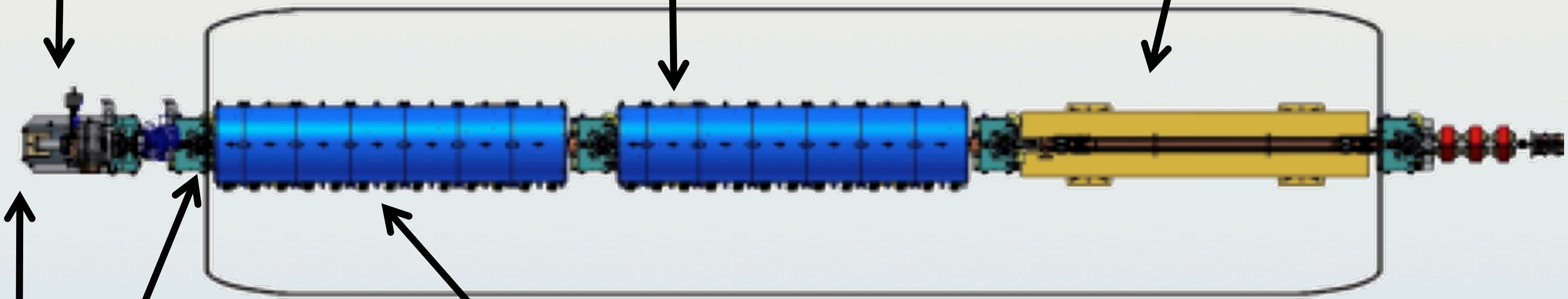
Courtesy F. Villa

Comb beam manipulation

Gun focusing field (~3kG)
Emittance
Bunches current, length

Accelerating field (inj. phase)
Energy spread sub-bunch

Accelerating field (inj. phase)
Energy separation

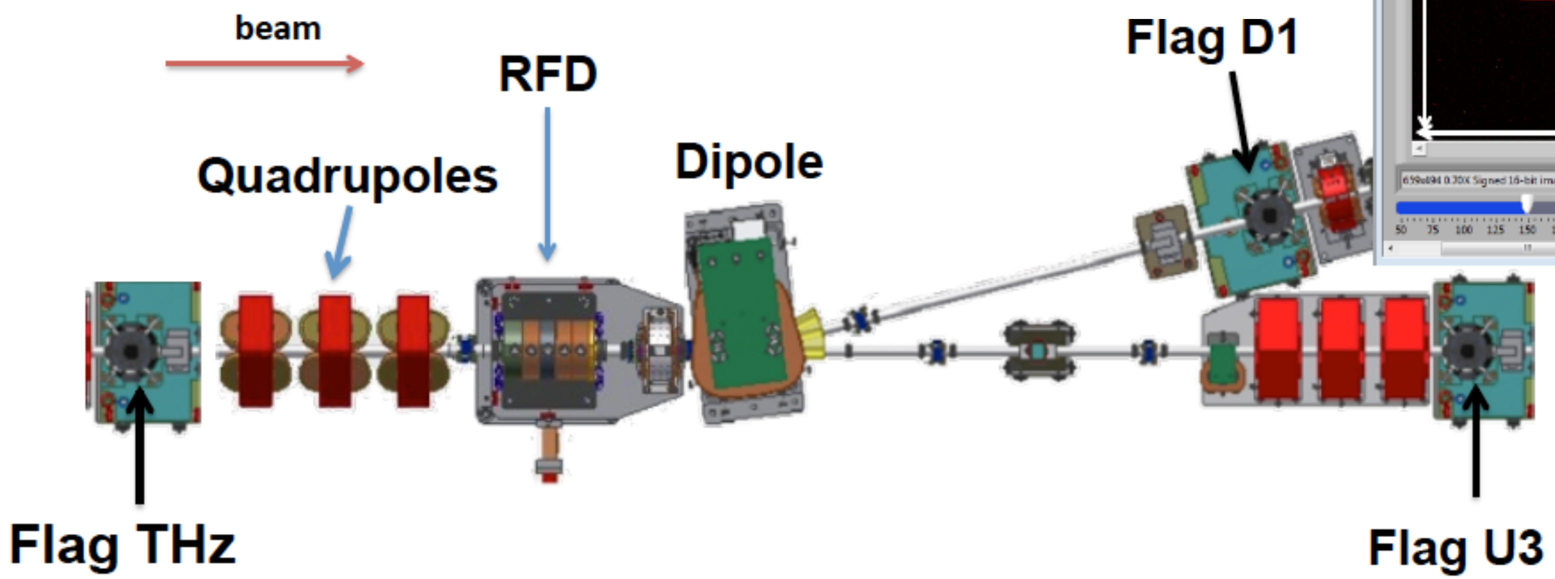


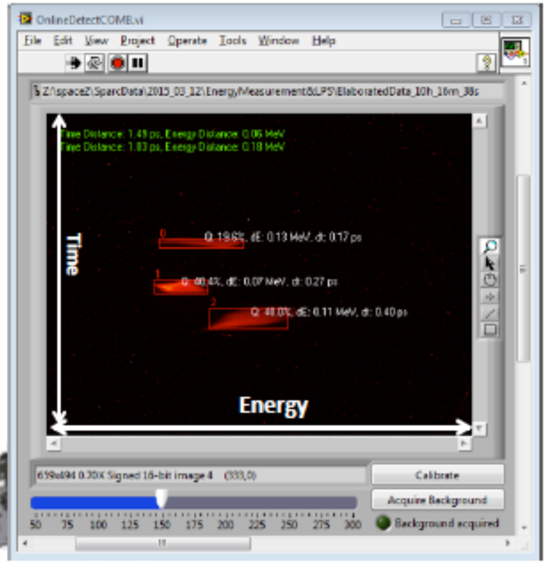
Inj. phase
Bunch spacing
Train length

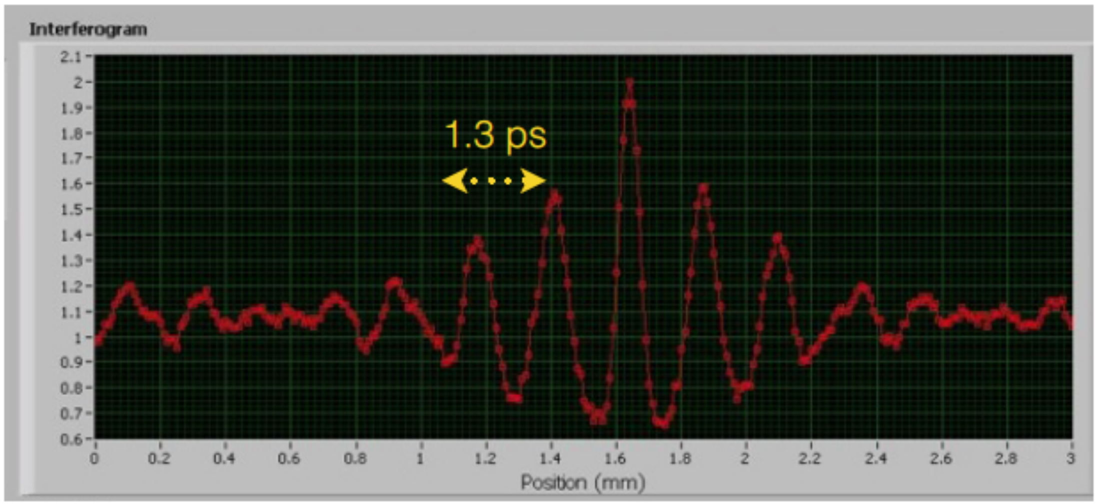
TW focusing field (~300G)
Emittance
Bunches current, length and their max compression phase

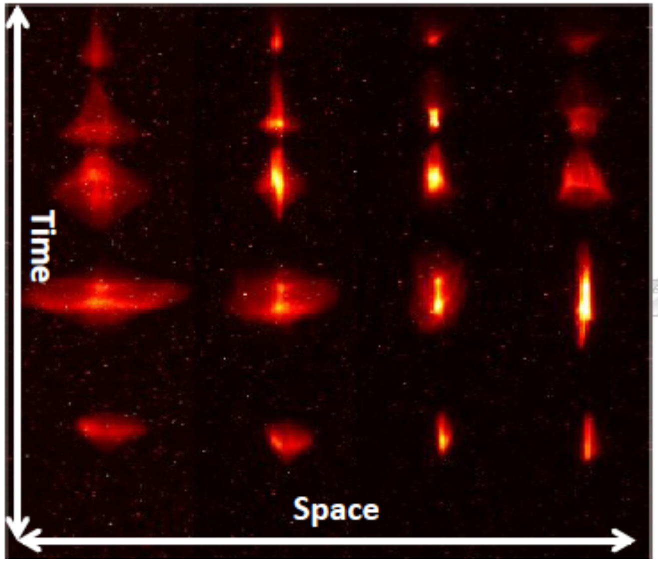
Gun inj. phase and space charge
Bunches distance at the linac entrance
Energy spread

Diagnostics Tools

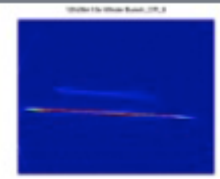
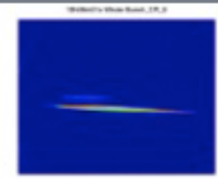
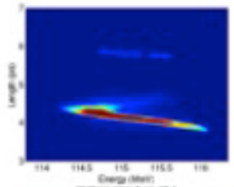
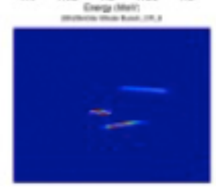
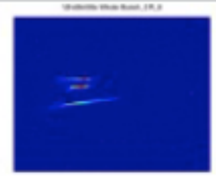
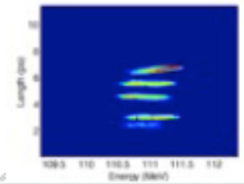




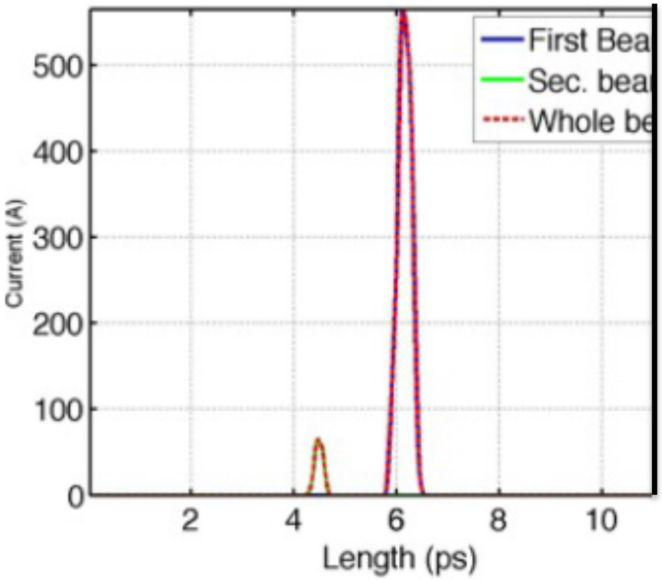




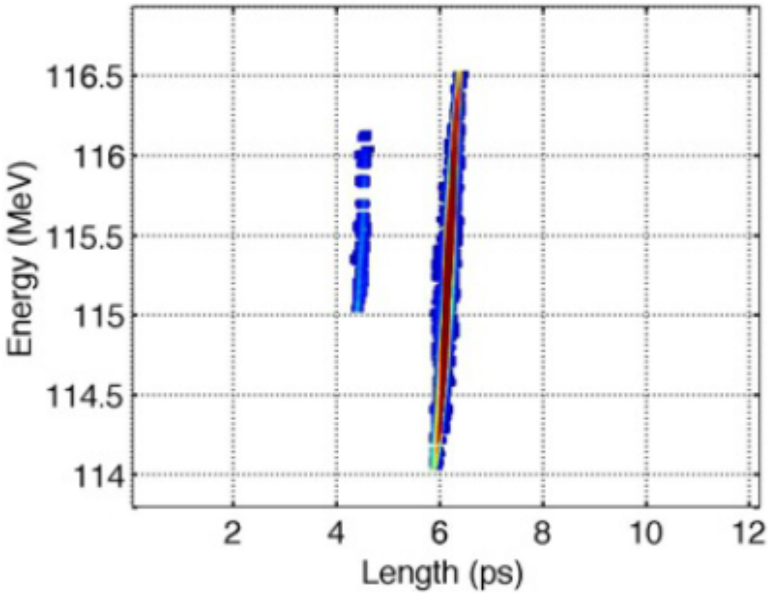
Investigated Configurations

	Charge (pC)	~1.55 ps	~0.6 ps
1 Driver + 1 Witness	200/20		
1 Drivers + 1 Witness	400/20		
2 Drivers + 1 Witness	50/50/20		
4 Drivers + 1 Witness	50/50/50/50/20		
4 Drivers + 1 Witness	ramp/20		

Two Bunches Train

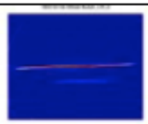


Energy Separation(MeV)
W-D = 0.22(0.05)

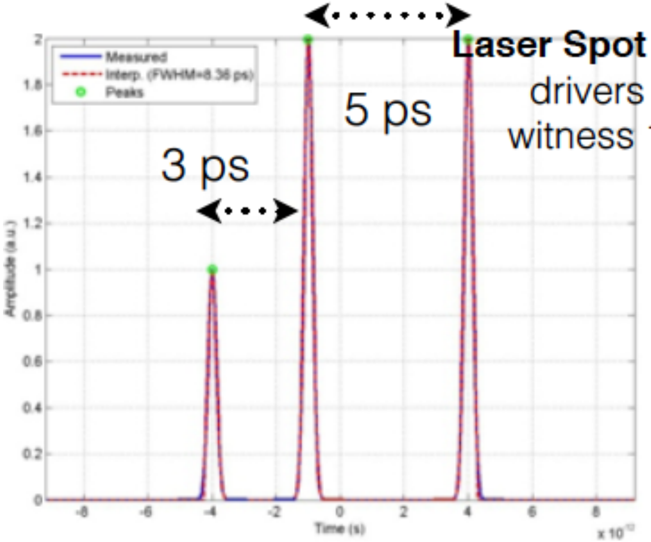


enx_{Driver} = 4.0 (0.3) mm mrad

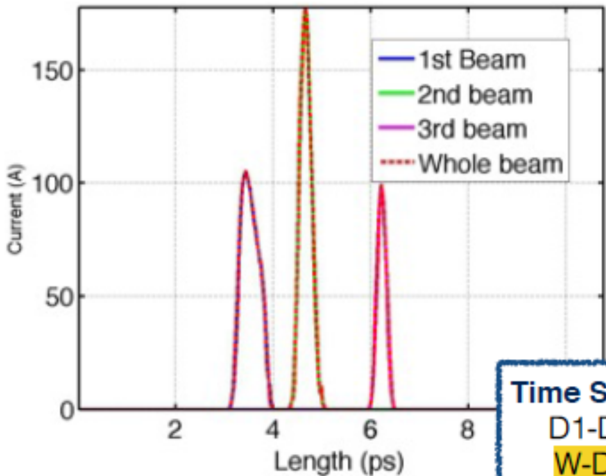
$enx_{Witness}$ = 1.3 (0.1) mm mrad

	Energy spread (%)	Position (ps)	Bunch duration (ps)	Charge (%)	Charge (pC)
Driver Beam	0.515(0.009)	6.152(0.020)	0.096(0.001)	95.49(2.17)	210.09(4.78)
Witness Beam	0.189(0.031)	4.492(0.021)	<0.075(0.003)	4.51(0.77)	9.91(1.69)
Whole Beam	0.508(0.008)	6.080(0.022)	0.345(0.031)	100.00(2.91)	220.00(6.40)

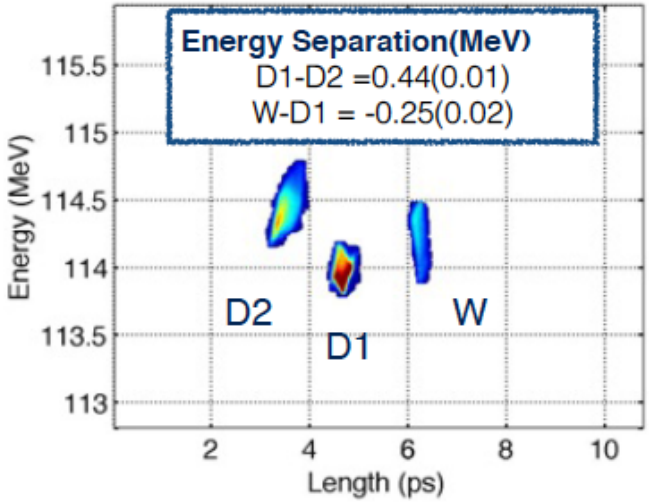
Three Bunches Train



Laser Spot diameter:
drivers 2 mm
witness 1.3 mm



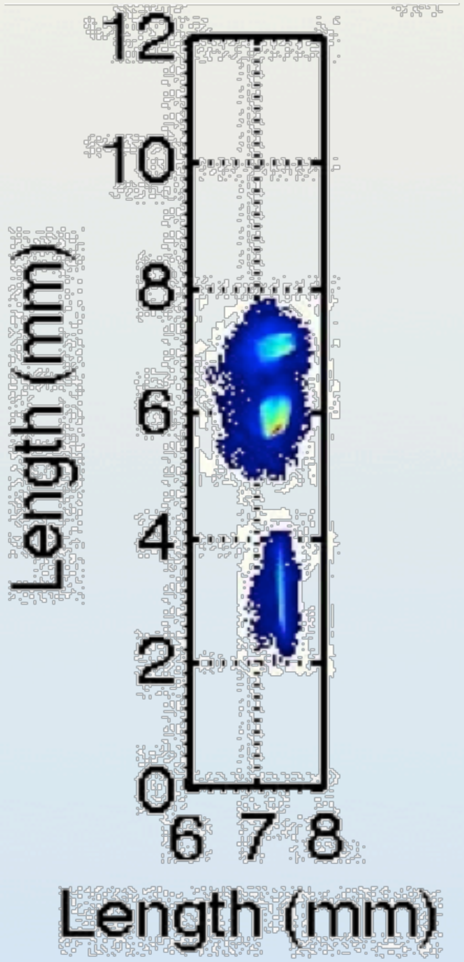
Time Separation(ps)
D1-D2 = -1.16(0.03)
W-D1 = -1.56(0.04)



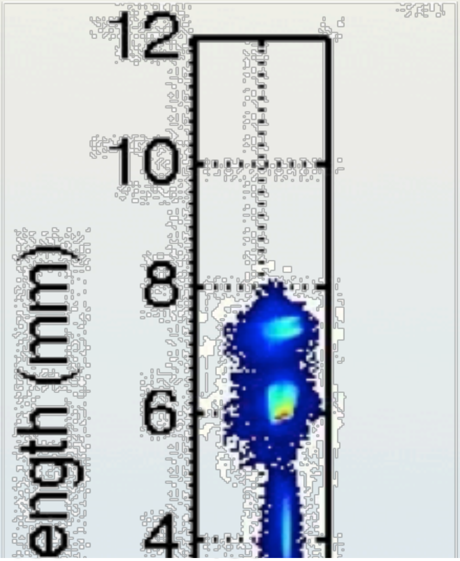
	Energy spread (%)	Position (ps)	Bunch duration* (ps)	Charge (%)	Charge (pC)
Drive Beam 2	0.114(0.001)	3.57(0.02)	0.141(0.001)	39.7(0.3)	51.7(0.4)
Drive Beam 1	0.074(0.001)	4.72(0.03)	0.057(0.001)	41.7(0.3)	54.1(0.4)
Witness Beam	0.135(0.001)	6.28(0.03)	<<0.089(0.000)	18.6(0.1)	24.2(0.2)
Whole Beam	0.203(0.001)	4.55(0.02)	0.987(0.003)	100.0(0.7)	130.0(0.9)

Three bunches: witness position tuning

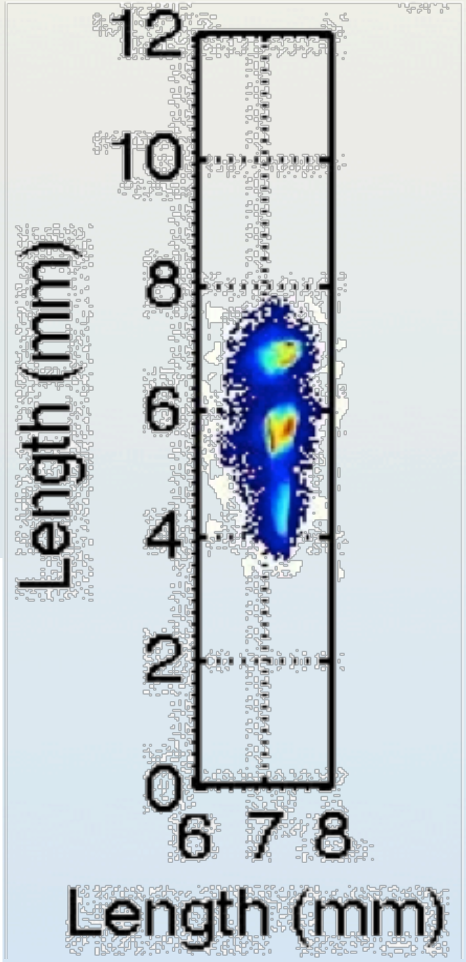
+ 1.67 ps

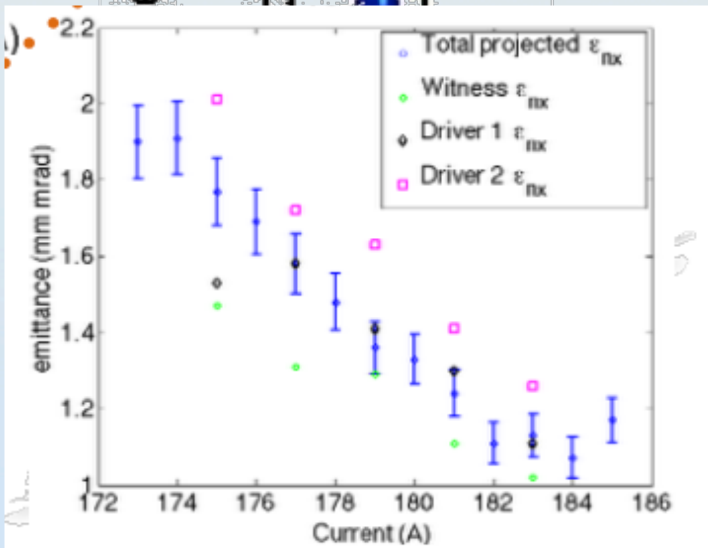


Reference

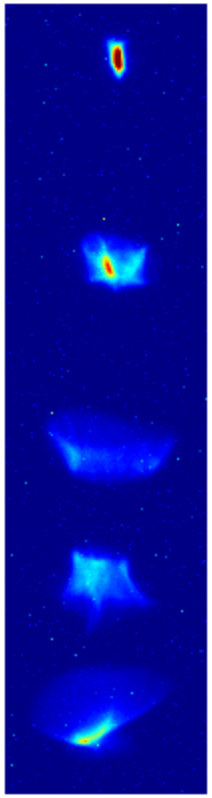


- 1.67 ps





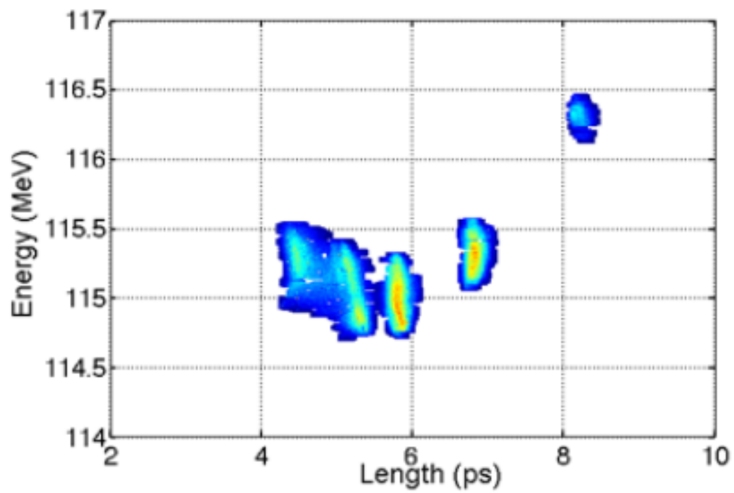
Five Bunches Train



	Energy spread (%)	Position (ps)	Bunch duration* (ps)	Charge (%)	Charge (pC)
Witness Beam	0.050(0.009)	8.213(0.022)	<<0.070(0.002)	4.74(0.71)	11(2)
Drive Beam 4	0.103(0.001)	6.823(0.020)	<<0.080(0.001)	19.10(0.57)	43(1)
Drive Beam 3	0.125(0.002)	5.818(0.019)	<<0.091(0.001)	25.51(0.40)	57.4(0.9)
Drive Beam 2	0.154(0.003)	5.172(0.021)	0.087(0.005)	27.80(0.80)	63(2)
Drive Beam 1	0.170(0.021)	4.624(0.044)	0.311(0.119)	27.80(0.80)	63(2)
Whole Beam	0.278(0.007)	5.667(0.024)	0.970(0.014)	100.00(1.86)	225(4)

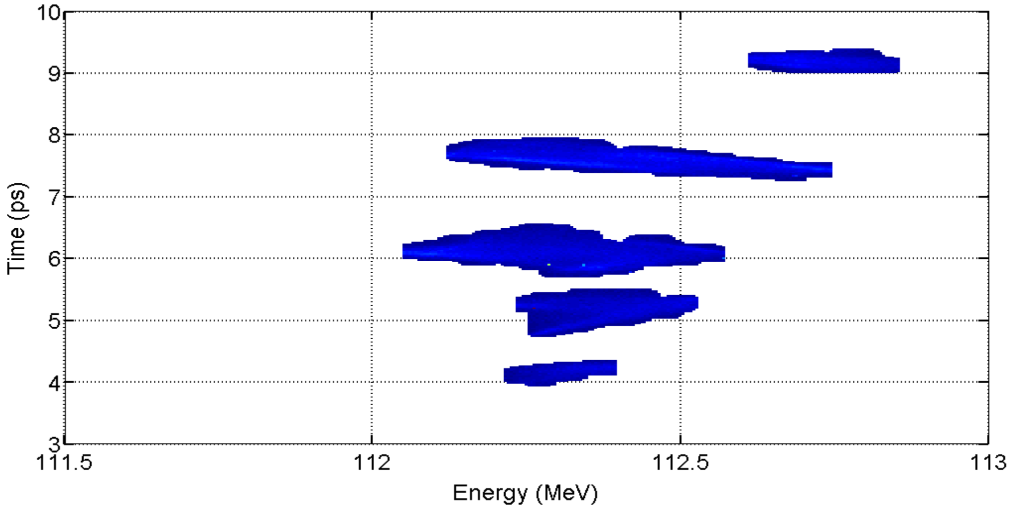
Time Separation(ps)
W-D4 = 1.39(0.02)
D4-D3 = 1.00(0.03)
D3-D2 = 0.65(0.03)
D2-D1 = 0.55(0.05)

Energy Separation(MeV)
W-D4 = 0.98(0.01)
D4-D3 = 0.31(0.01)
D3-D2 = -0.04(0.01)
D2-D1 = 0.20(0.02)

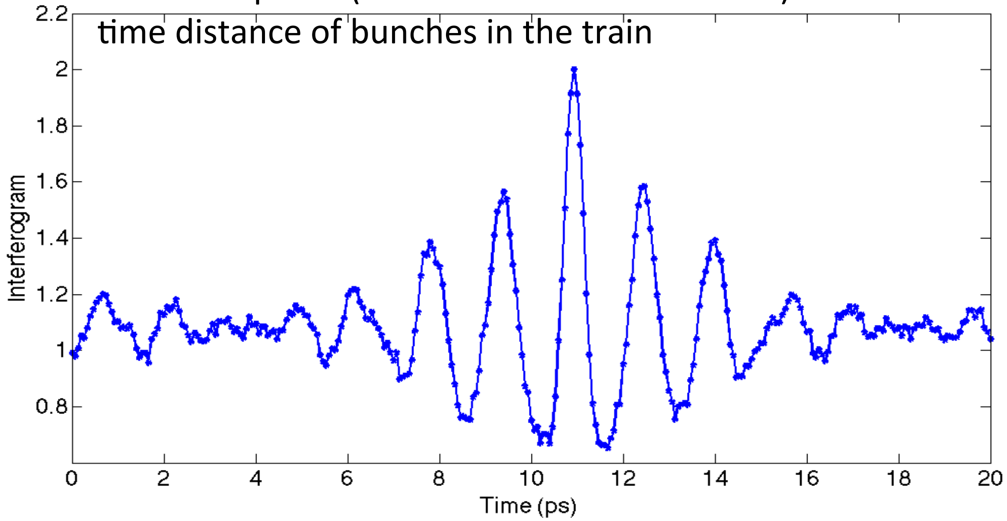


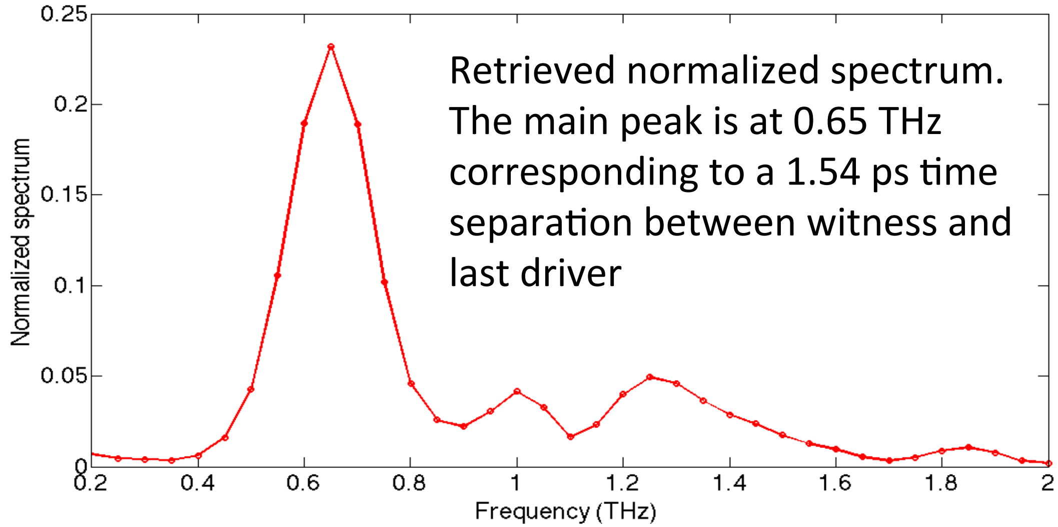
THz CTR measurement

- The Coherent Transition Radiation (CTR) spectrum measured by means of a Michelson interferometer has been used as diagnostics for comb-like electron beams for preparation studies of plasma acceleration experiments
- 4-bunches ramped drivers + 1 witness, 220 pC total charge



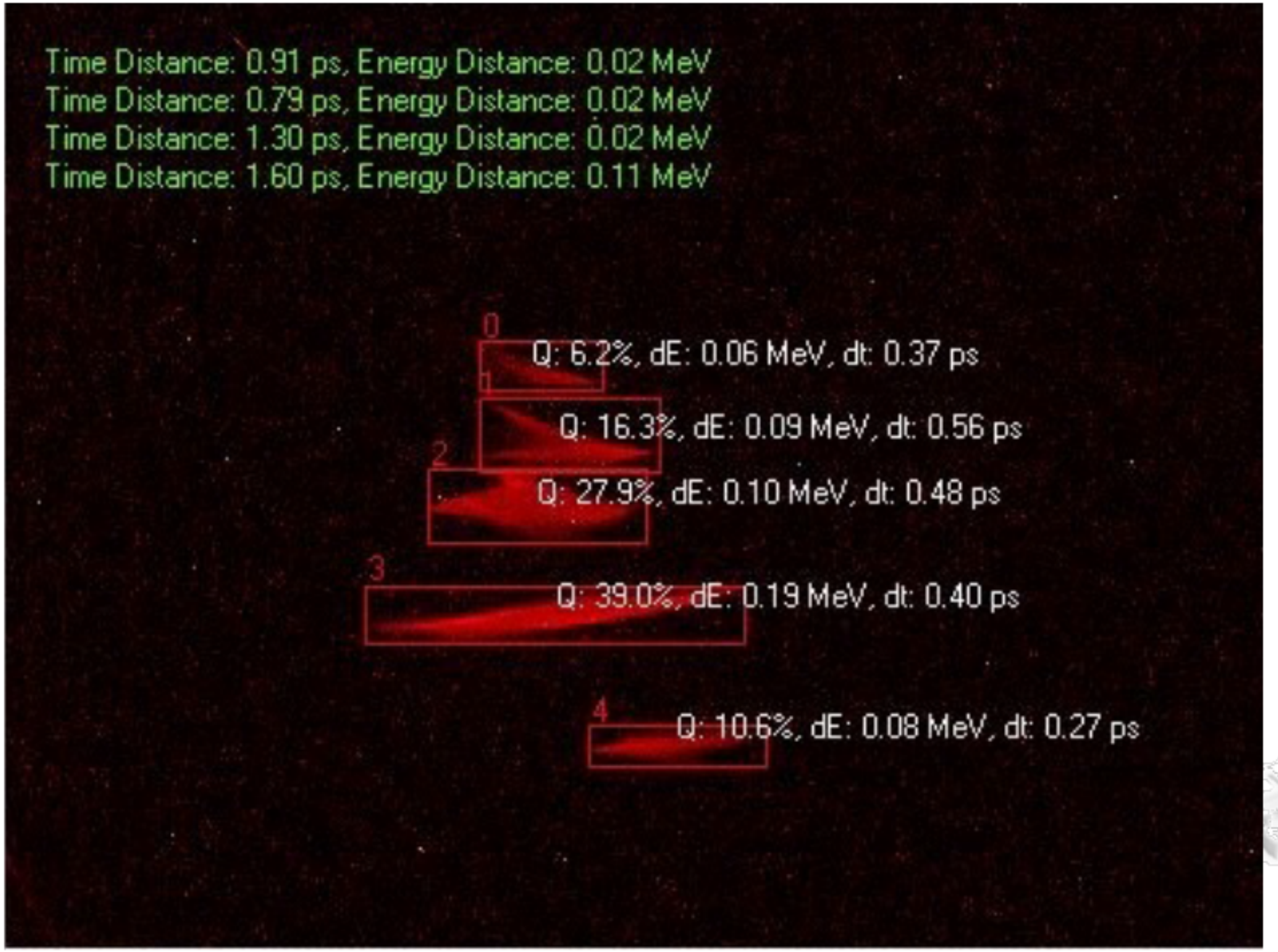
Typical multi-peaked interferogram measured at the linac exit: 2N-1 peaks (N is the number of bunches) occur at the time distance of bunches in the train



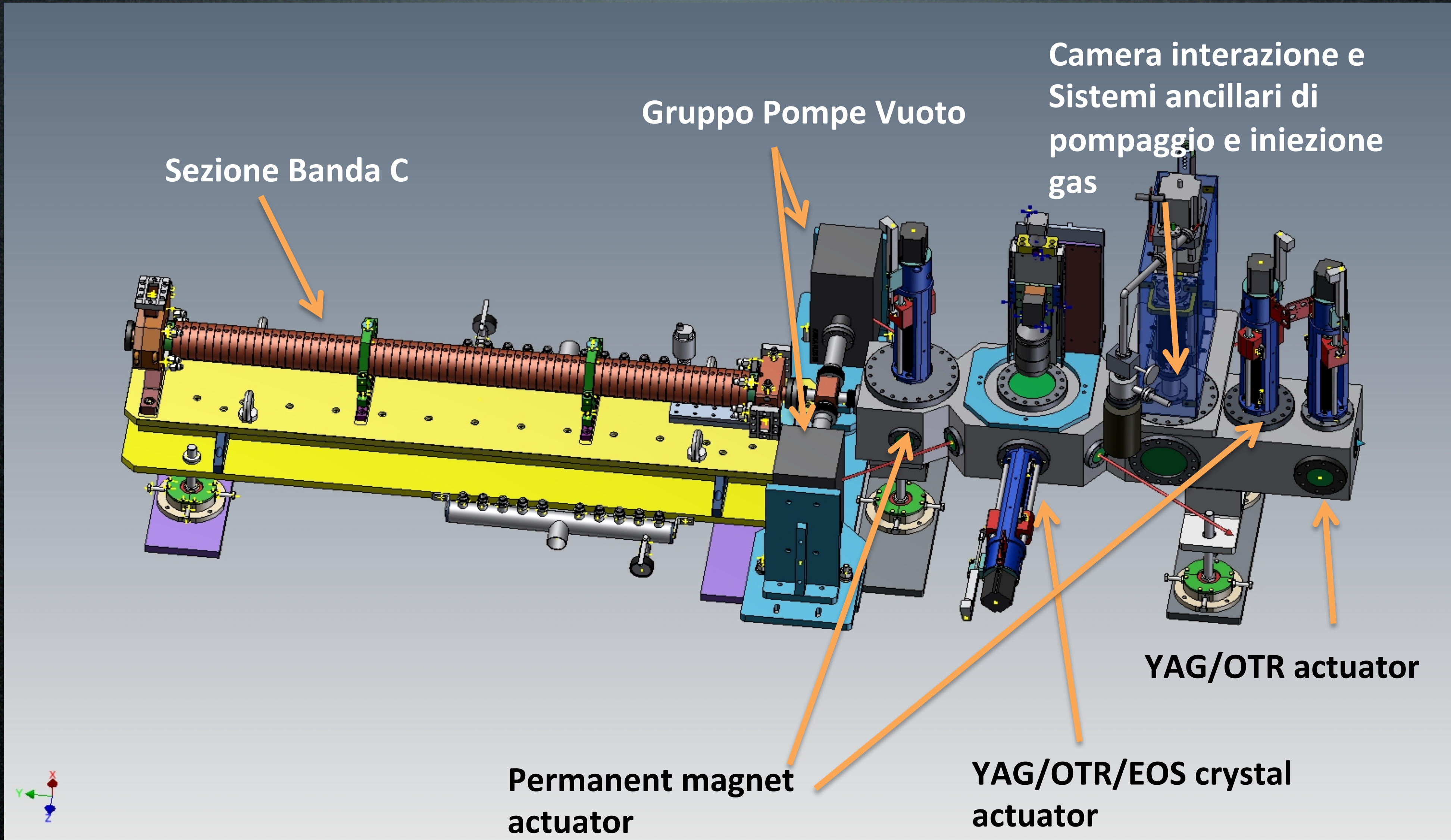


Retrieved normalized spectrum. The main peak is at 0.65 THz corresponding to a 1.54 ps time separation between witness and last driver

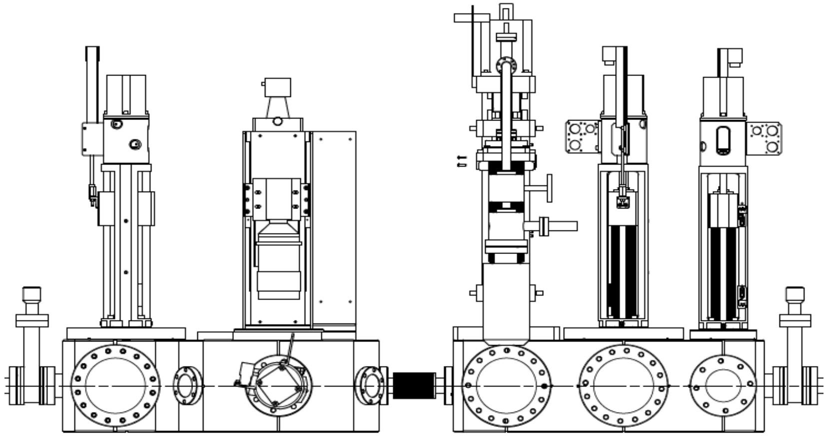
Five Bunches Train: Ramped Charge



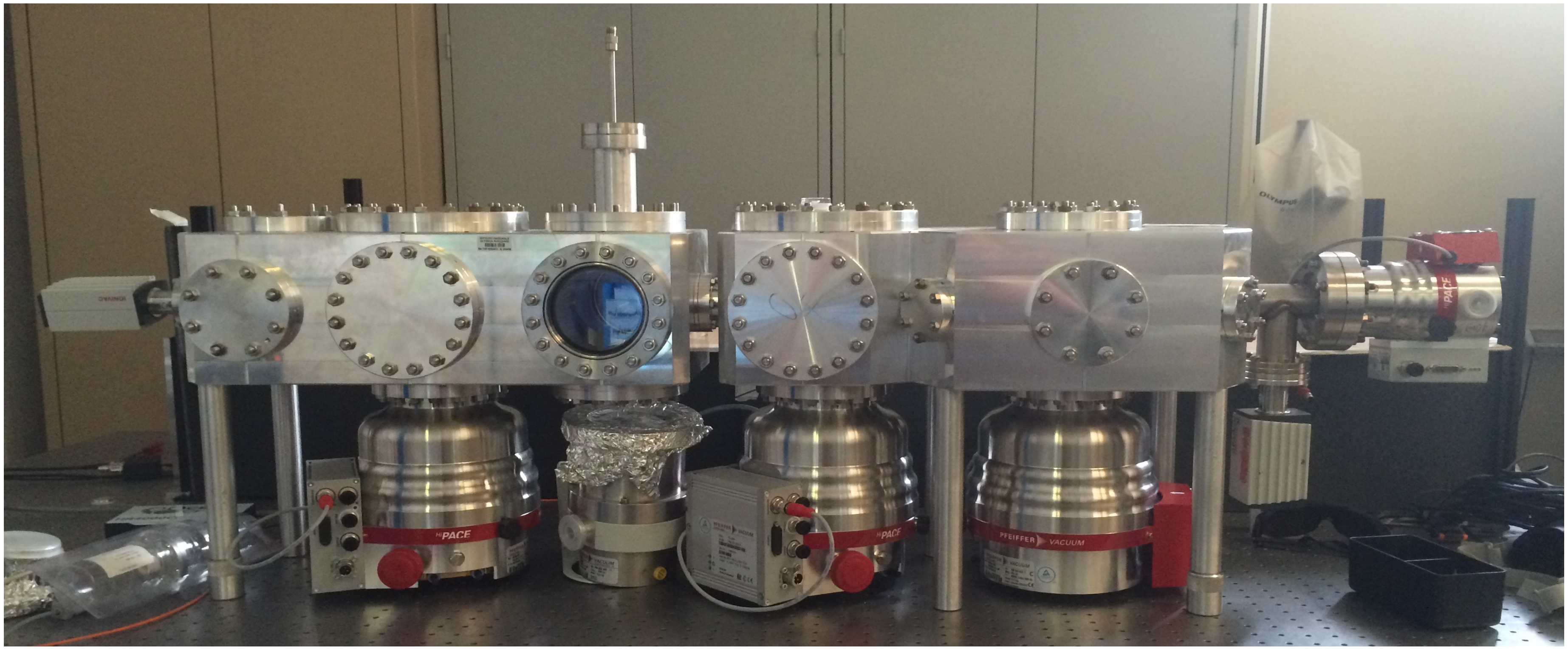
PWFA interaction chamber



Status of the COMB experiment



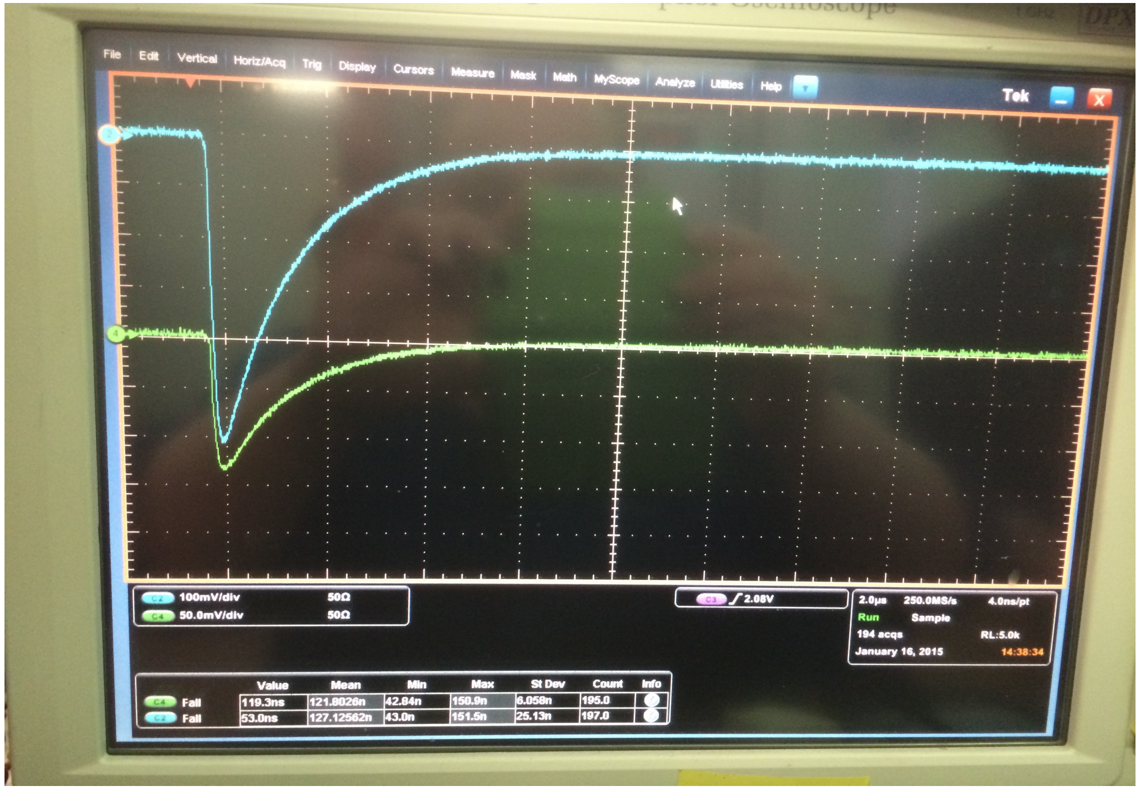
Vacuum chamber has been designed, ordered and already delivered. First vacuum tests (with capillary, using He and Ar) have been performed.

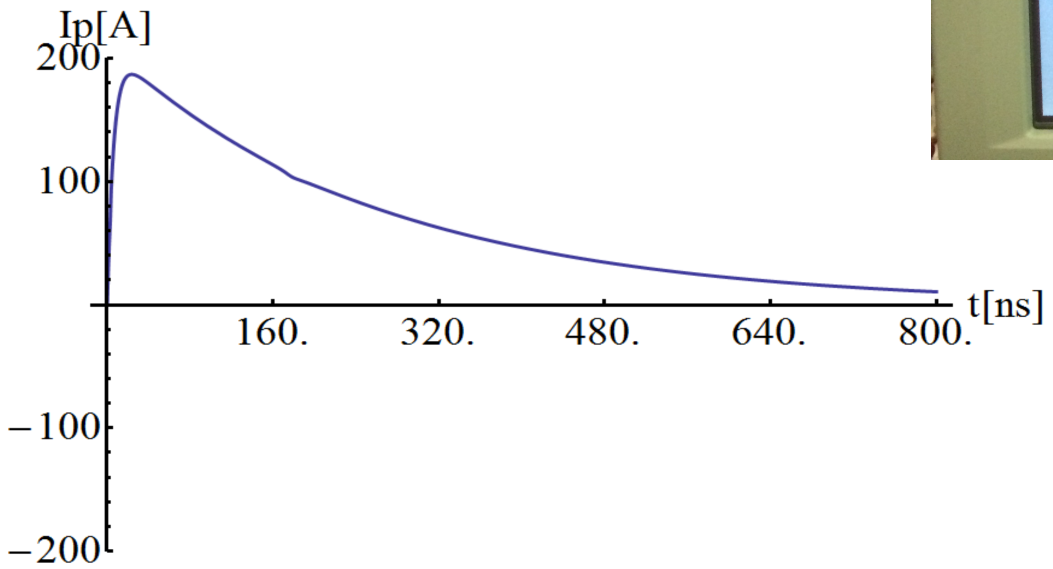


Status of the COMB experiment

Discharge box has been designed, built and tested on a 50 Ohm load, which, with very good agreement, has the expected simulated trend.

It's ready to be used on gas.

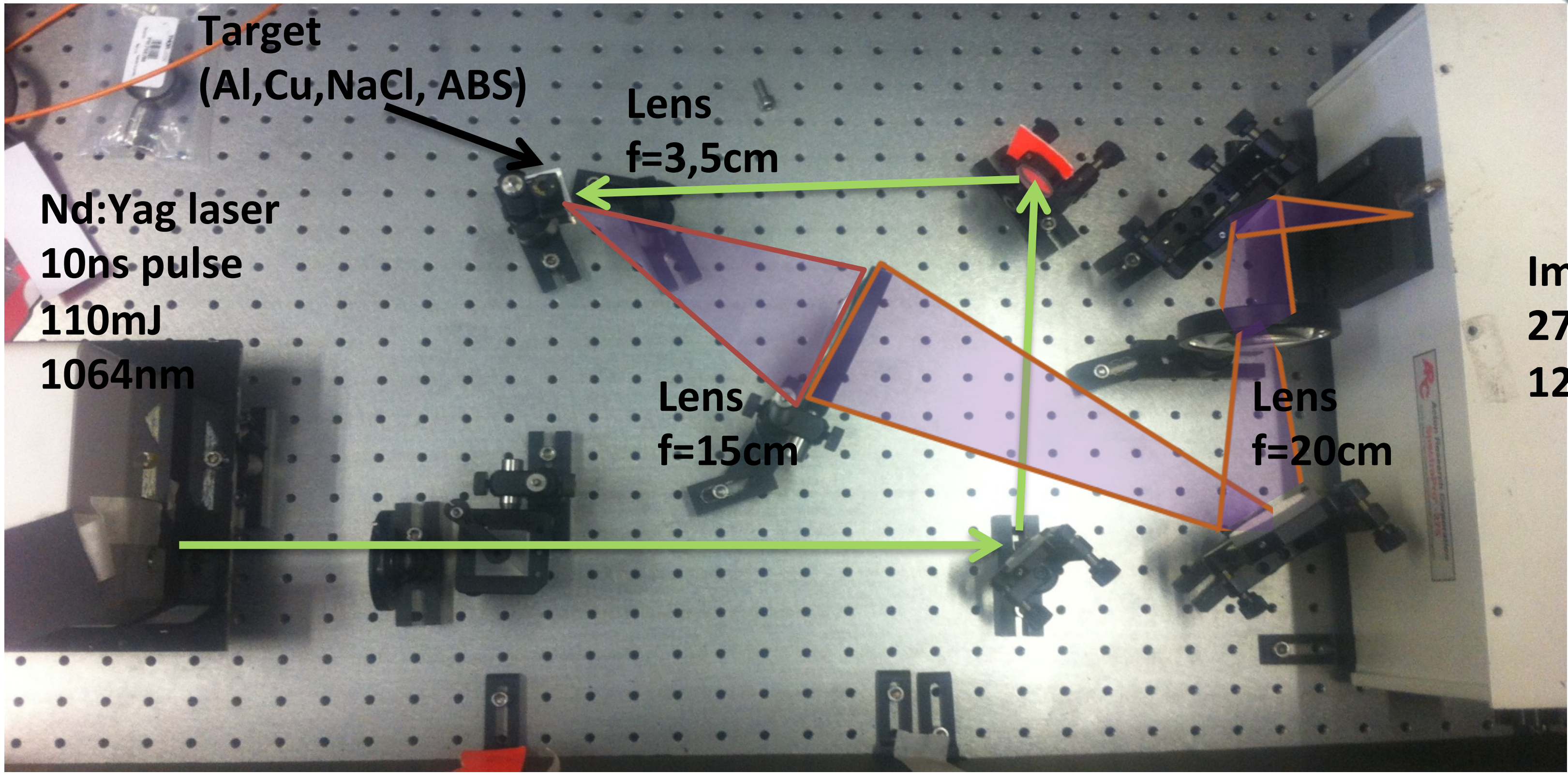




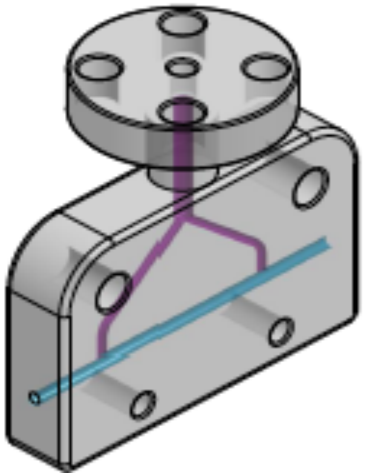
Status of the COMB experiment

Hydrogen generator has already been delivered. For safety reason, however, it's still impossible to use it.

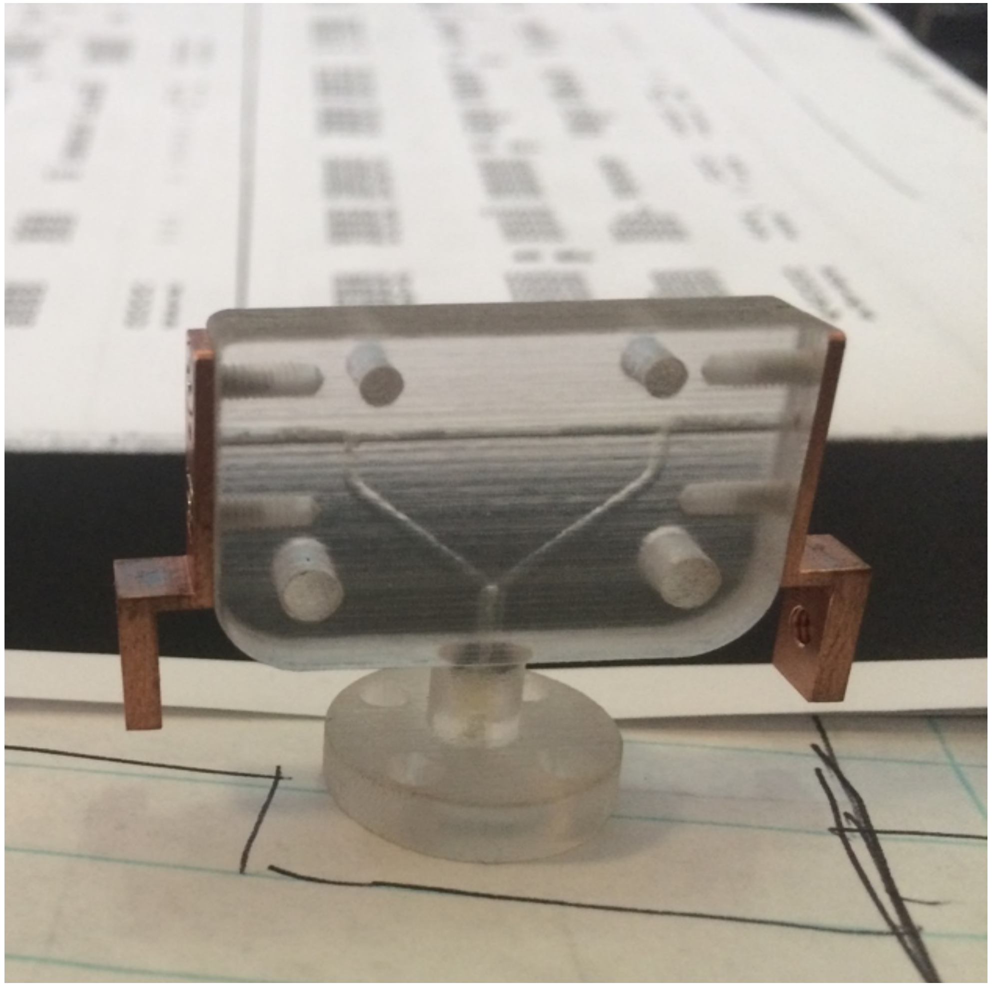
While waiting for hydrogen, we are undertaking the first **spectrometric tests** using solid composite targets illuminated by a high power laser.



Status of the COMB experiment



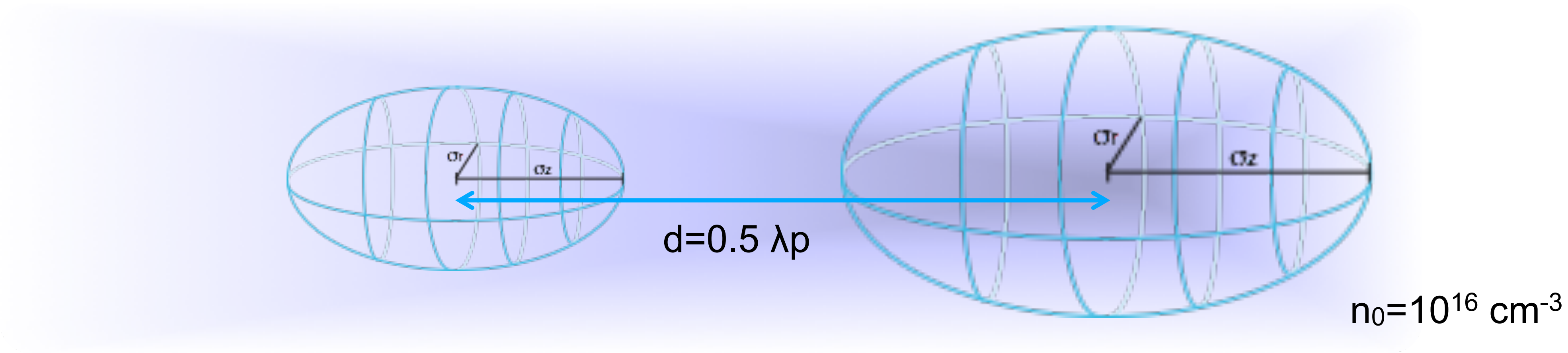
Capillary has been designed and for the moment 3D printer has been used to built it.



However, for the “real” run on the SPARC linac, only the holder will be 3D printed.

Different materials and shapes are overseen to be used, as for example glass, Macor and Sapphire.

Beam dynamics studies

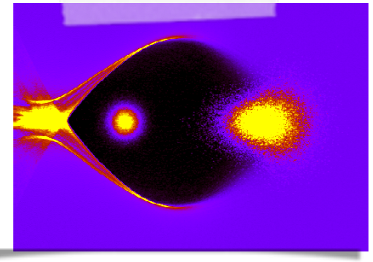


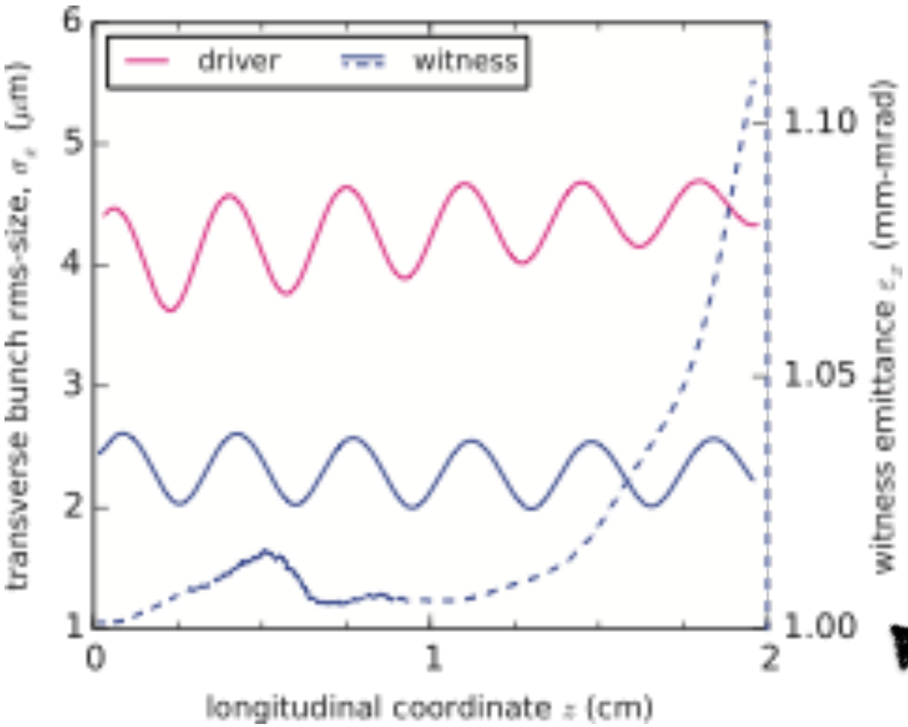
- σz = 10 μm
- σx = 2.45 μm
- εr= 1 mm-mrad
- E=100 MeV (γ~200)
- Q=11 pC
- dγ/γ=0.1%

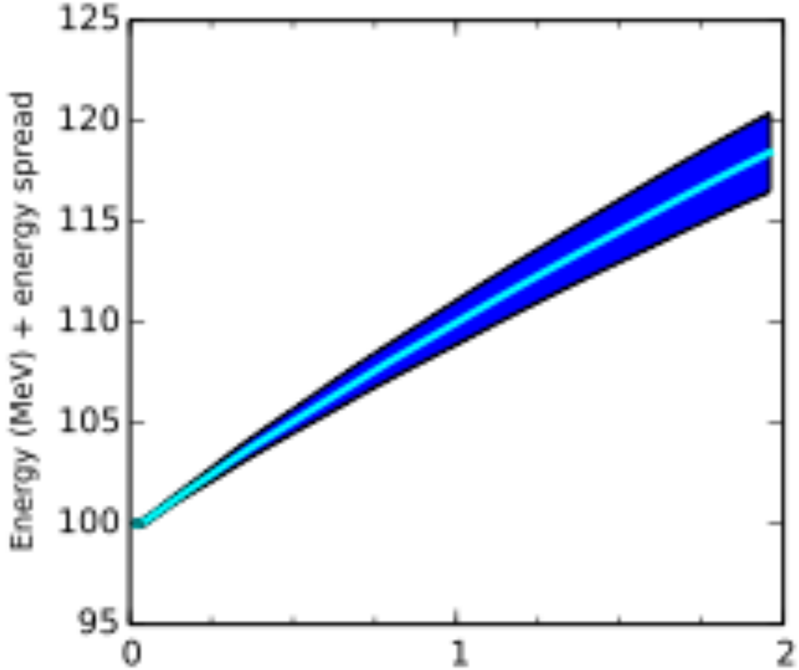
- σz = 25 μm
- σx = 4.4 μm
- εr= 3 mm-mrad
- E=100 MeV
- Q=170 pC
- dγ/γ=0.1%

Courtesy A. Marocchino

ALaDyn sim: ε_x and $d\gamma/\gamma$





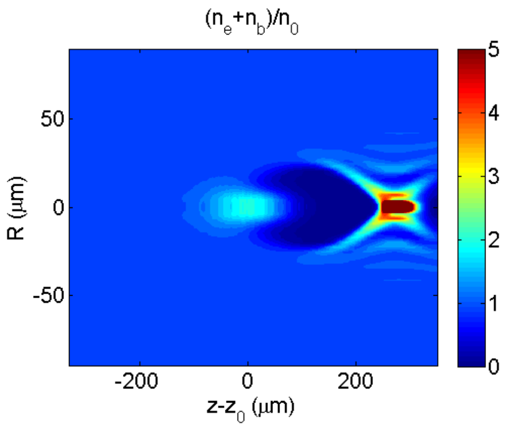


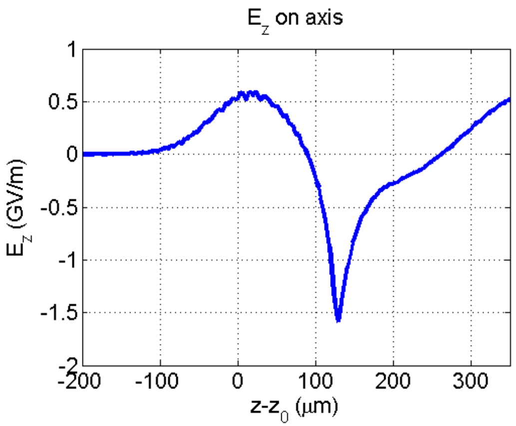
longitudinal coordinate z (cm)

Very ***Low Emittance*** (εx) for the entire acceleration length plot on a different reduced scale

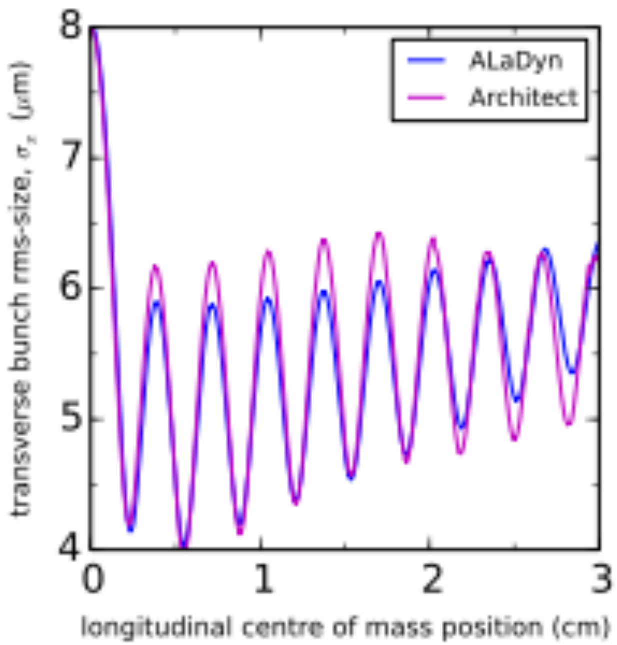
Architect an hybrid approach

- Bunch(es) are treated kinetically
  - background plasma as a fluid
    - systematic scan in no-time



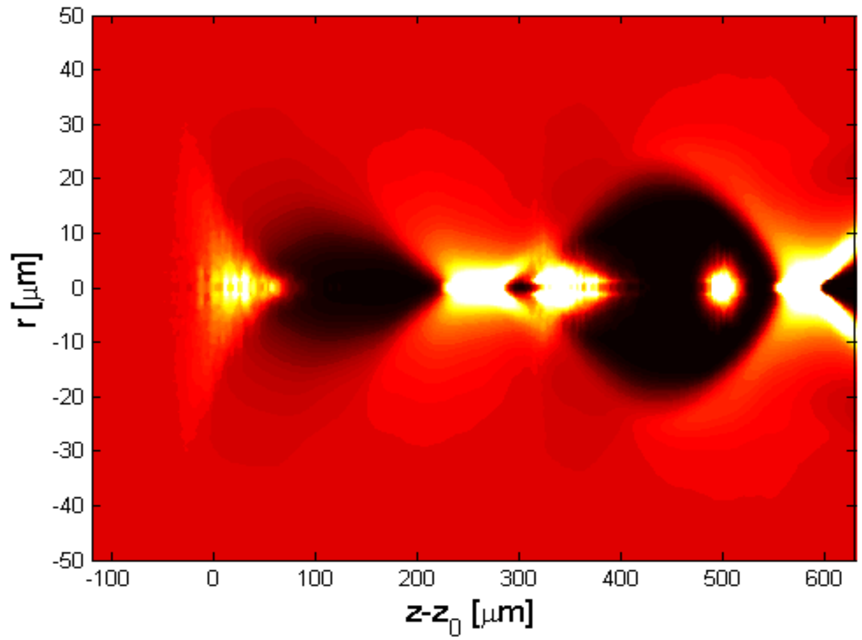


- Good agreement
- Much faster to run



High quality plasma accelerated beams
Comb scheme 3 bunch

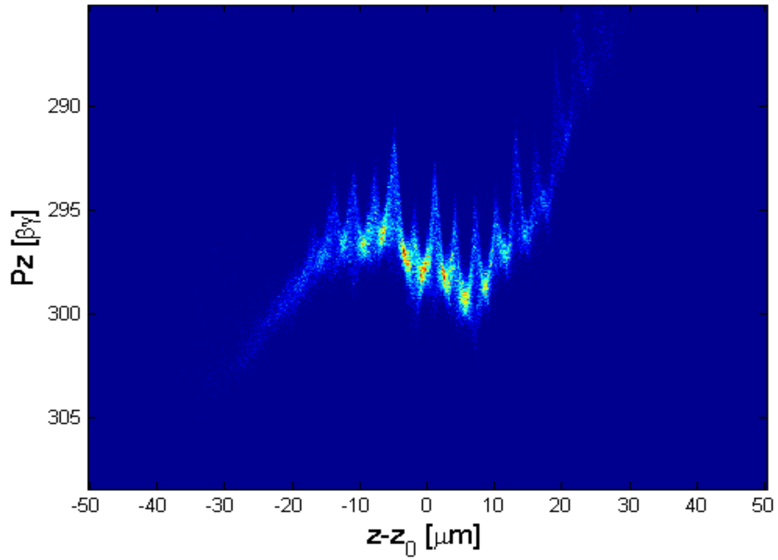
High quality beam



Initial witness parameters

Final witness parameters

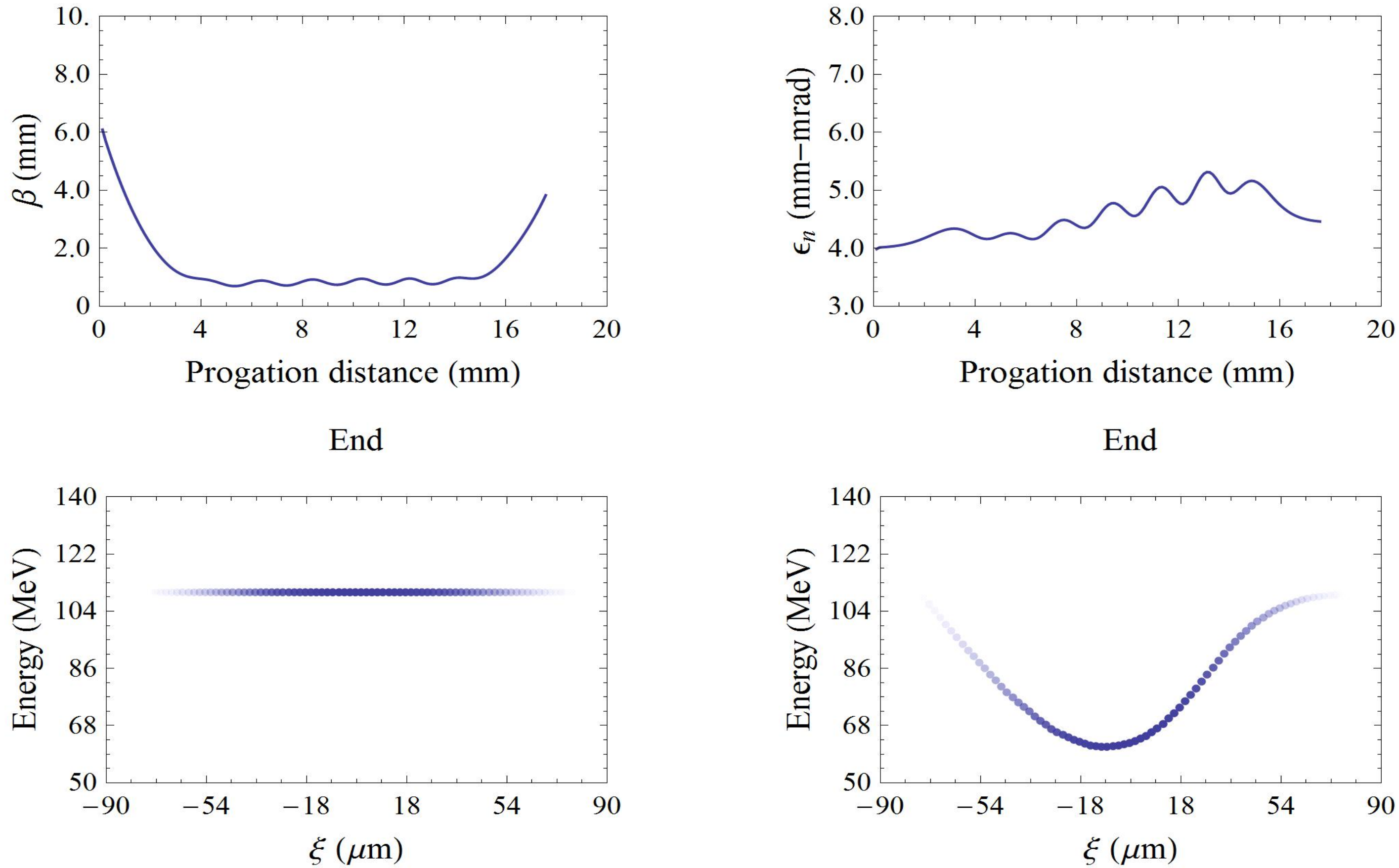
Low energy spread



1.5 GV/m accelerating gradient

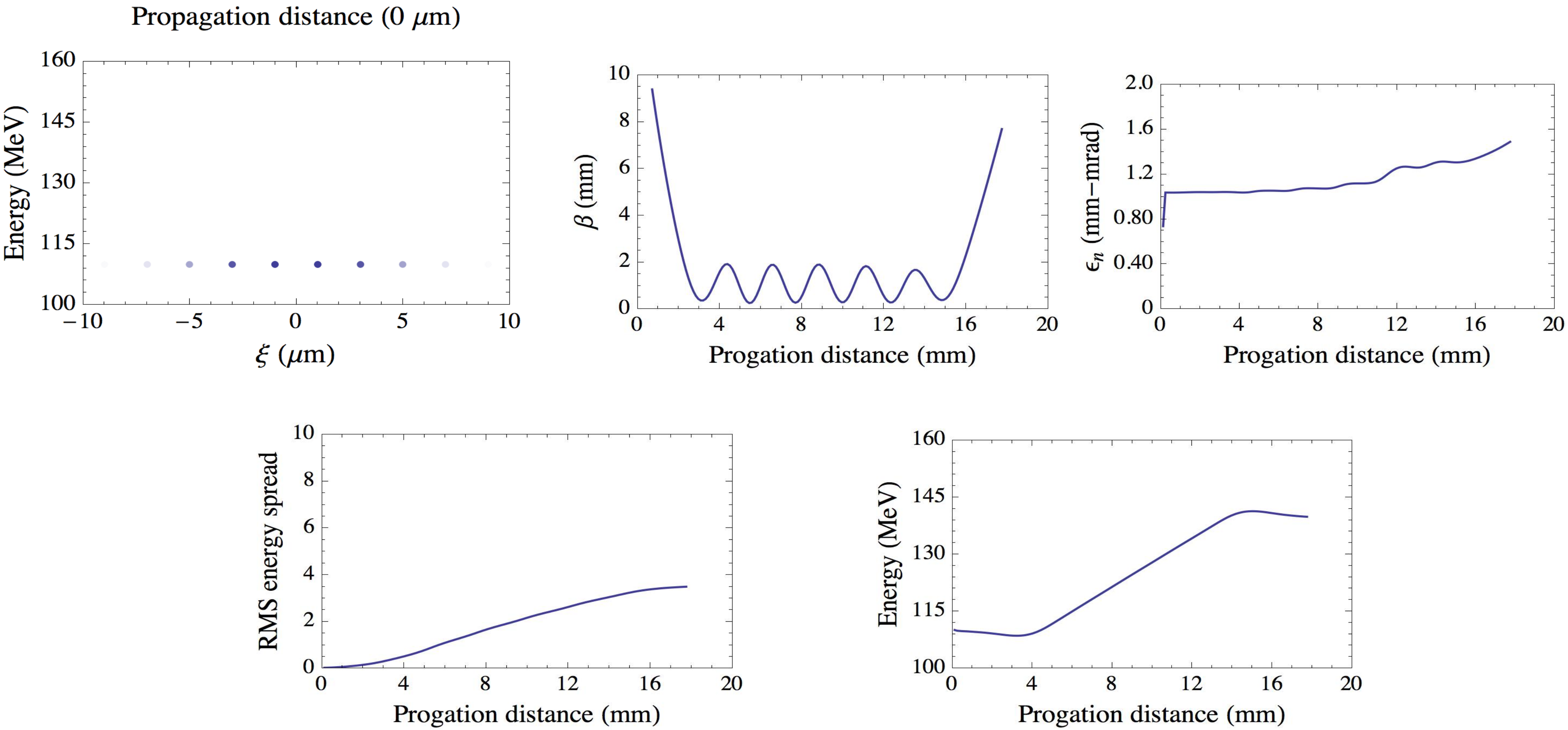
Vorpal simulation: full length of capillary, case 1

- Following the previous steps, the “good” simulations over a full length of a capillary. That is, the plasma is simulated to have a density ramp up, 8 mm uniform density length, and then a mirrored density down ramp.
- Two cases examined based on the previous results. In the first one the beam is matched for a 1.5 mm gaussian density ramp. Results of this case are shown in this slide. Beam parameters are: 600 pC, 4 mm-mrad normalized emittance, 30 micron rms length, 2 mm waist beta (with no plasma), 110 MeV



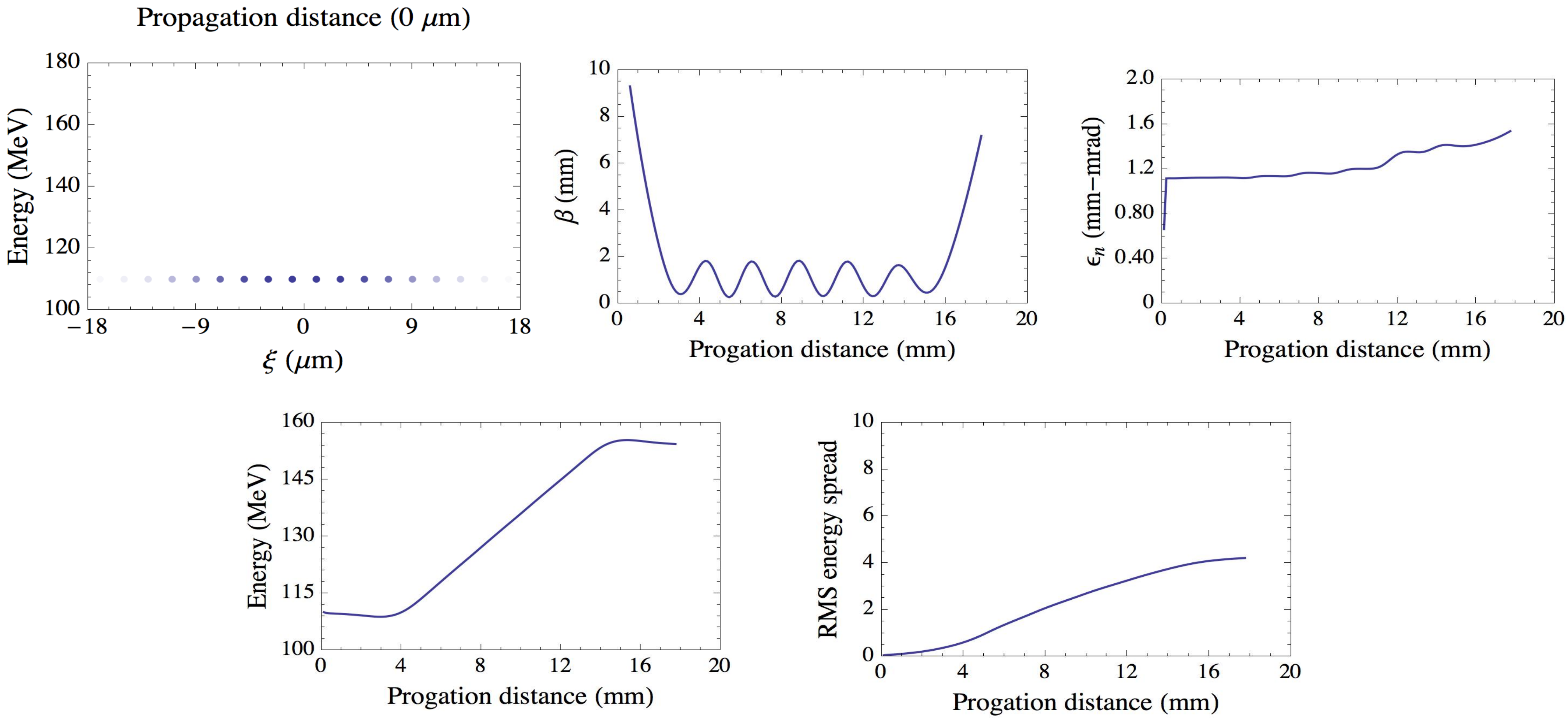
Courtesy J. Rosenzweig and S. Barber

Full VORPAL simulations with witness beam, 12 pC, 3 um σ_ζ



- A 12 pC, 3 micron rms length beam propagates in the plasma, gaining 30 MeV in 8 mm of uniform density plasma (3.75 GeV/m). Emittance grows from ~ 1mm-mrad to 1.5 mm-mrad. RMS energy increases to ~ 4 percent. Note, the beam can be loaded further back in the wake to create larger energy gain.
- More charge to flatten wake (watch out for noise).

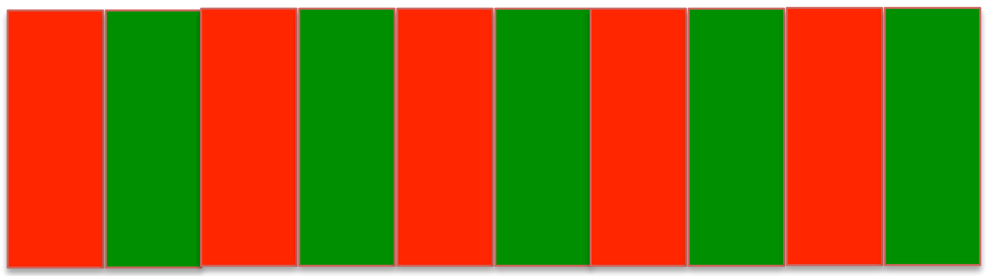
Vorpal simulations with witness beam, 60 pC, 6 um σ_ζ



- A 60 pC, 6 um rms length beam propagates in the plasma wake, gaining 45 MeV in 8 mm of uniform density plasma (5.6 GeV/m). Emittance grows from ~ 1mm-mrad to 1.6 mm-mrad. RMS energy increases to ~ 4 percent. This beam is loaded slightly further back in the wake compared to the previous example, hence the larger energy gain
- Witness beam is strongly mismatched, but causes not major problem.

Proposal for exhaust beam

- Need to accept wide band of energies (60 to 150 MeV)
- Would like to not damage beam optics
- Use periodic focusing with PMQs
  - Not a doublet or triplet, perhaps 8-12 magnets
  - Large energy acceptance without beam striking PMQs

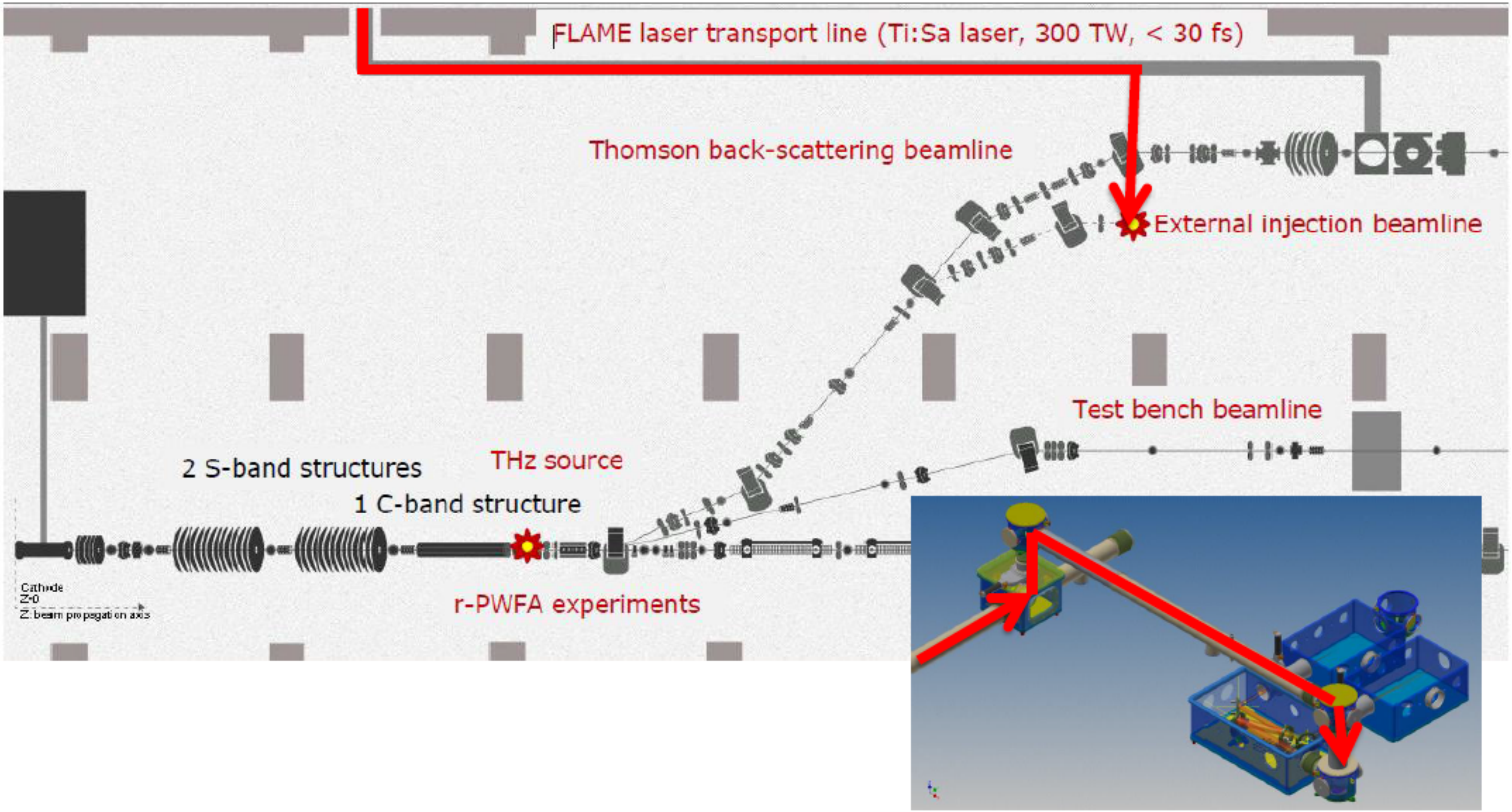


Choices for SPARC exhaust

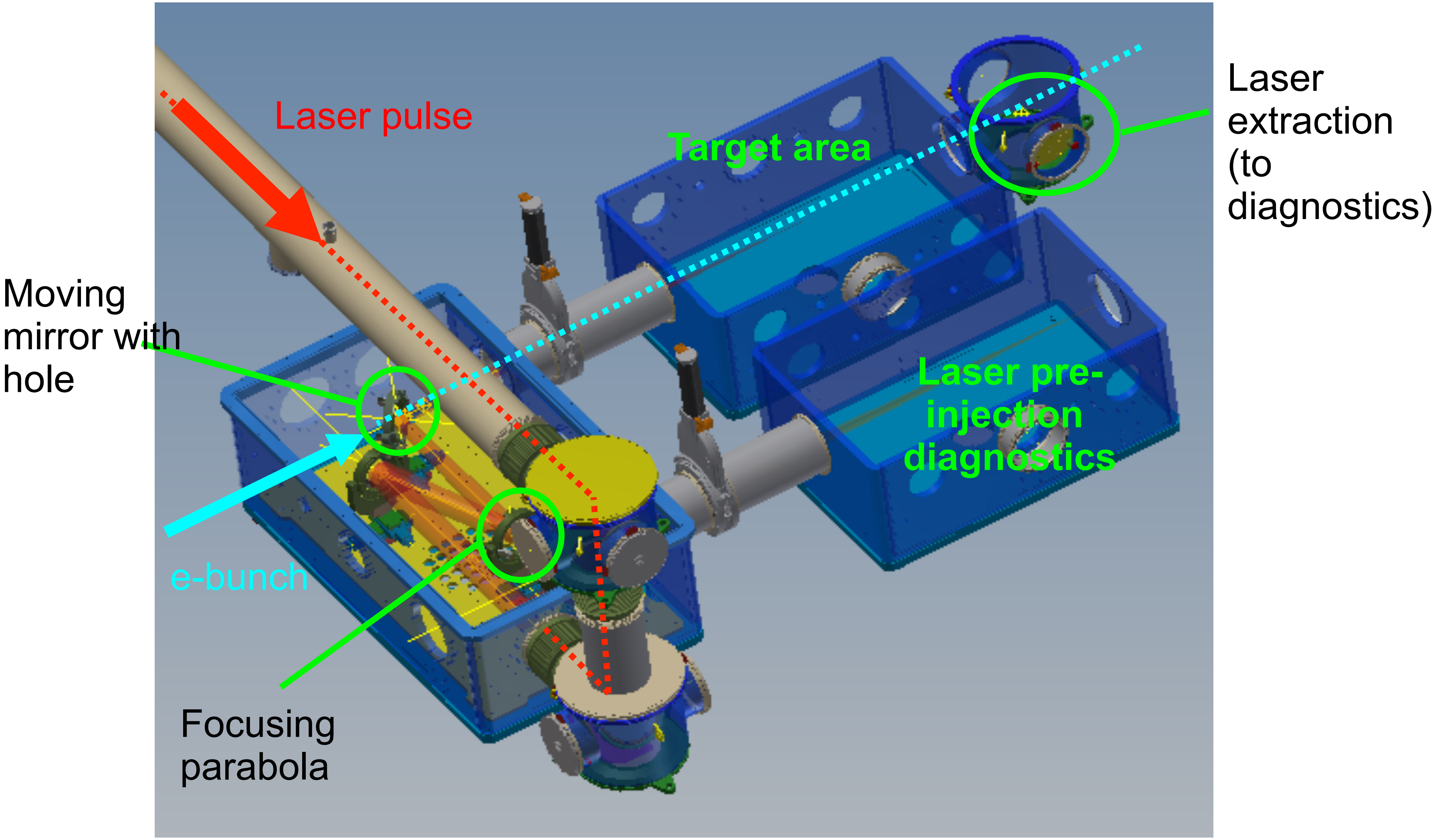
- Nominal $\kappa\, l_q$ is 1.3
- Length 2 cm
- Gradient 450 T/m (7 mm ID)
- Total length 15 cm ($\pi/2$ phase advance for nominal 110 MeV)
- Perfectly collimates 110 MeV
  - Over/under focuses drive/witness
  - Adjustable…

Laser Driven Plasma Wake Field Acceleration (EXIN exp.)

Experimental setup



ExIn interaction chamber



The interaction chamber is in advanced acquisition and testing stage.
Installation is scheduled within the current year.

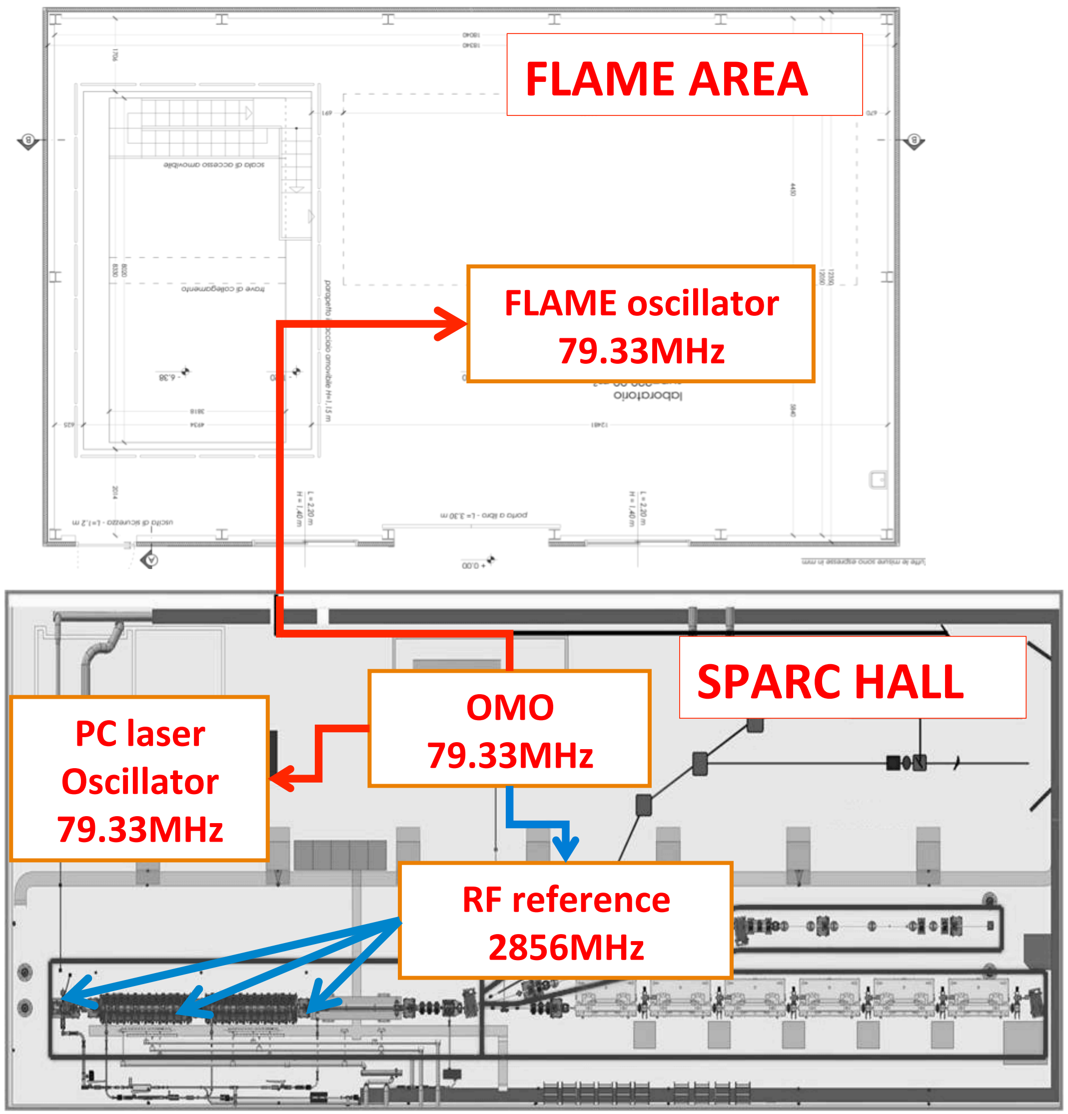
Hexapod for the positioning of the capillary

The H-824 is available in vacuum compatible version.

- Six Degrees of Freedom (XYZ, Pitch, Roll, Yaw)
- Vacuum Compatible Versions
- Load Capacity 10 kg
- Travel Ranges to 45 mm (linear), 25° (rotation)
- 7 Nanometer Resolution
- 300 Nanometer Min. Incremental Motion
- Repeatability ±0.5 Micron
- Very Compact Design
- Self Locking to 10 kg

The hexapod is under test, in the FLAME laboratory, to characterize the features of precision in the positioning of the system

Synchronization System upgrade

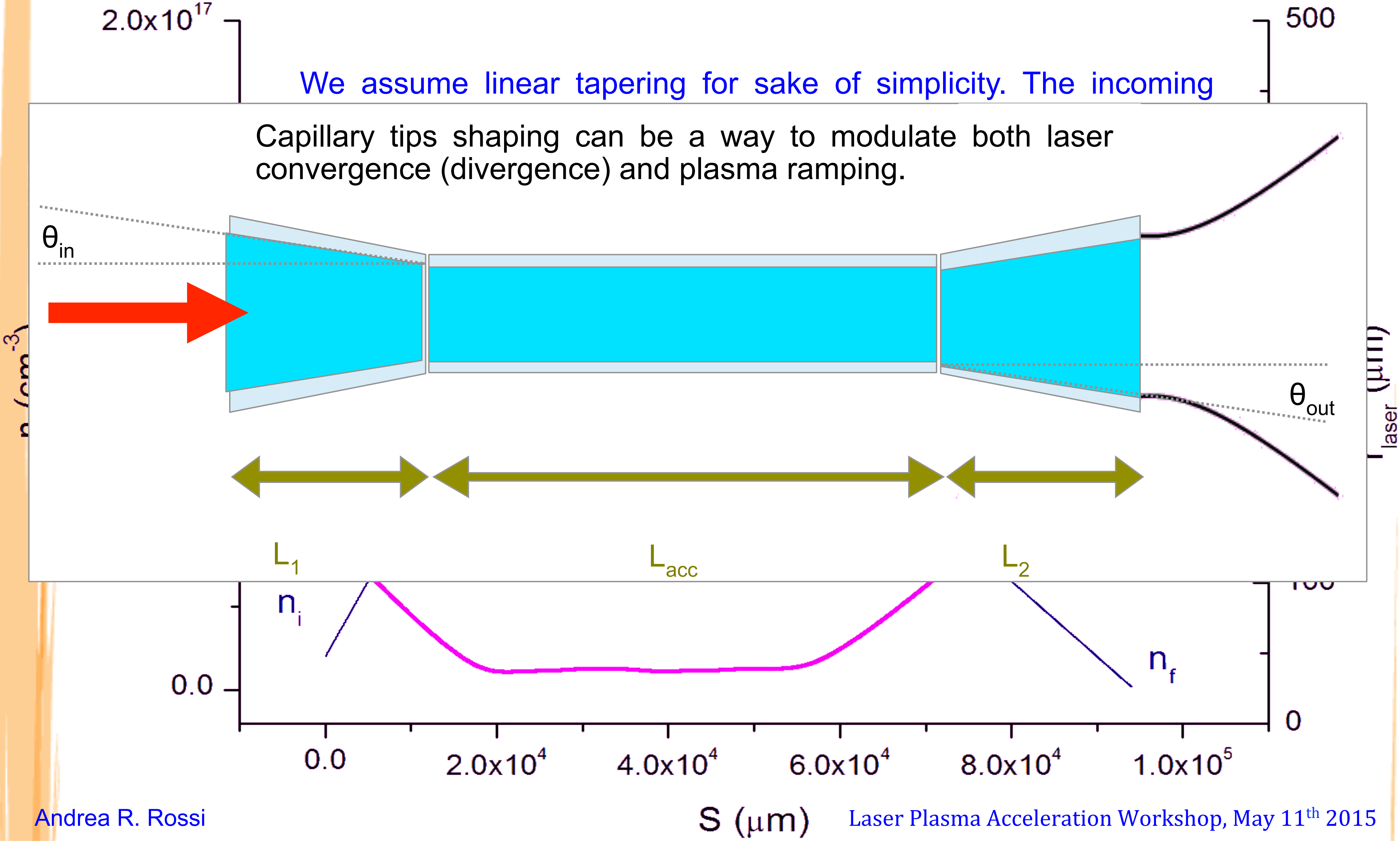


- <u>Optical reference</u>
  - RF reference will be substituted by fiber optical oscillator
  - Fiber laser OMO (Optical Master Oscillator) installed and tested
  - Systems locked through high resolution optical phase monitors (cross-correlators in house and ready to be tested)
  - Fiber link stabilization is ongoing (order placed) to distribute the reference signal
  - **FLAME laser VS electrons estimated time jitter <50fs$_{RMS}$**

Simulation settings

We assume linear tapering for sake of simplicity. The incoming

Capillary tips shaping can be a way to modulate both laser convergence (divergence) and plasma ramping.

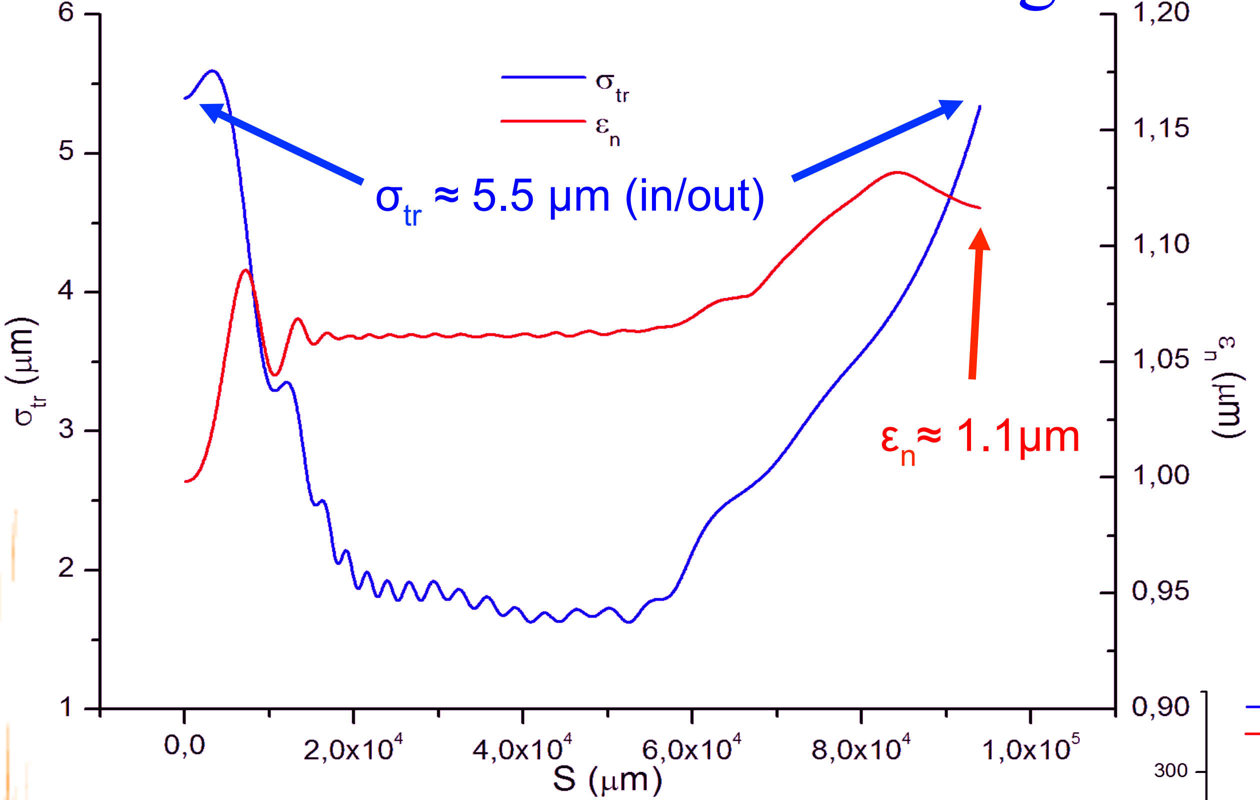


S2E simulation: plasma acceleration

Simulation tool: QFLUID2 by P. Tomassini and A.R. Rossi

- 2D cylindrical.
- Fluid approximation for plasma.
- Bunch macroparticles are fully kinetic.
- Supports quasi linear regimes.
- Laser evolution is self consistent and uses envelope approximation.
- Beam loading effects are included.

Simulation results: matching and focusing/defocusing



Energy gain is in excess of 200 MeV in a 3 cm acceleration length, which means an average electric field in excess of

7 GV/m

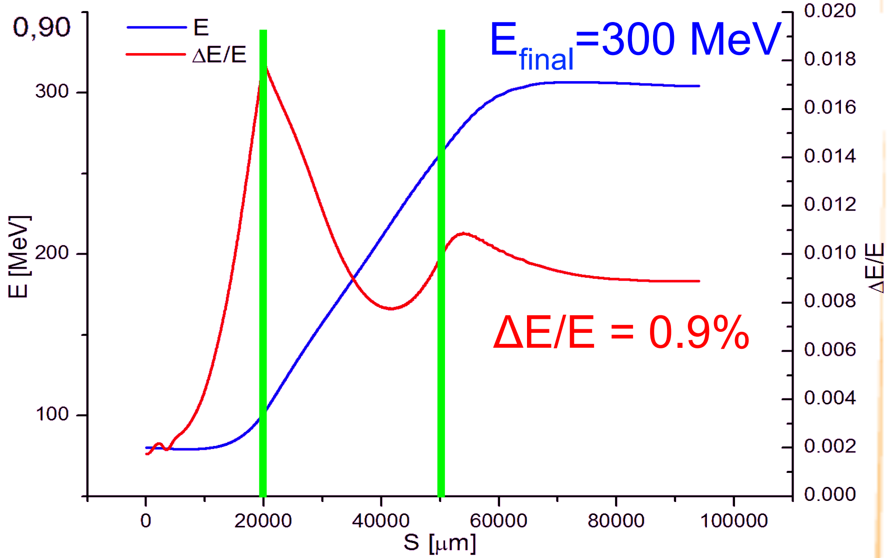
Energy spread is within 1% (a safe threshold for subsequent transport*) and REDUCED IN THE FINAL RAMP due to beam loading and plasma wavelength increase.

* P. Antici et al., J. App. Phys. 112, 044902 (2012).

A very nice matching is obtained by laser focusing method.

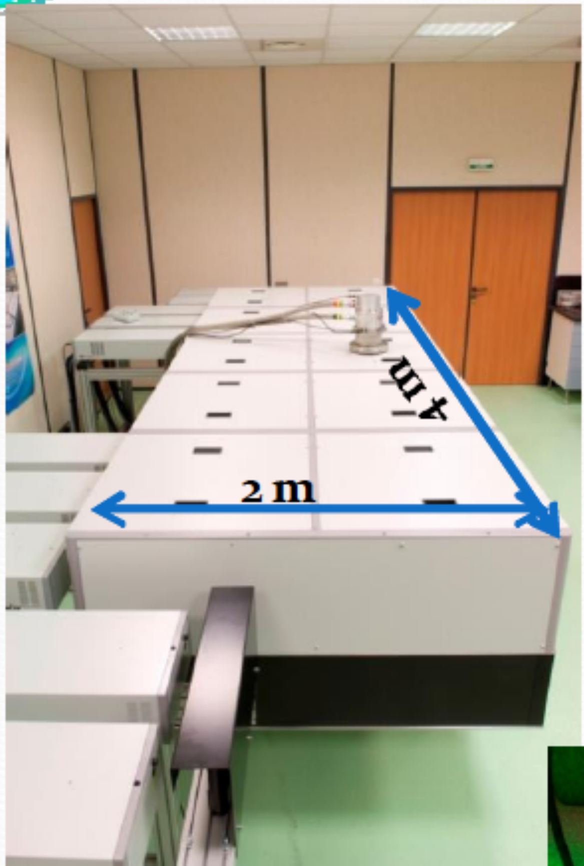
Beam size is reduced to matched size and then increased back to initial value in a quasi-adiabatic transformation.

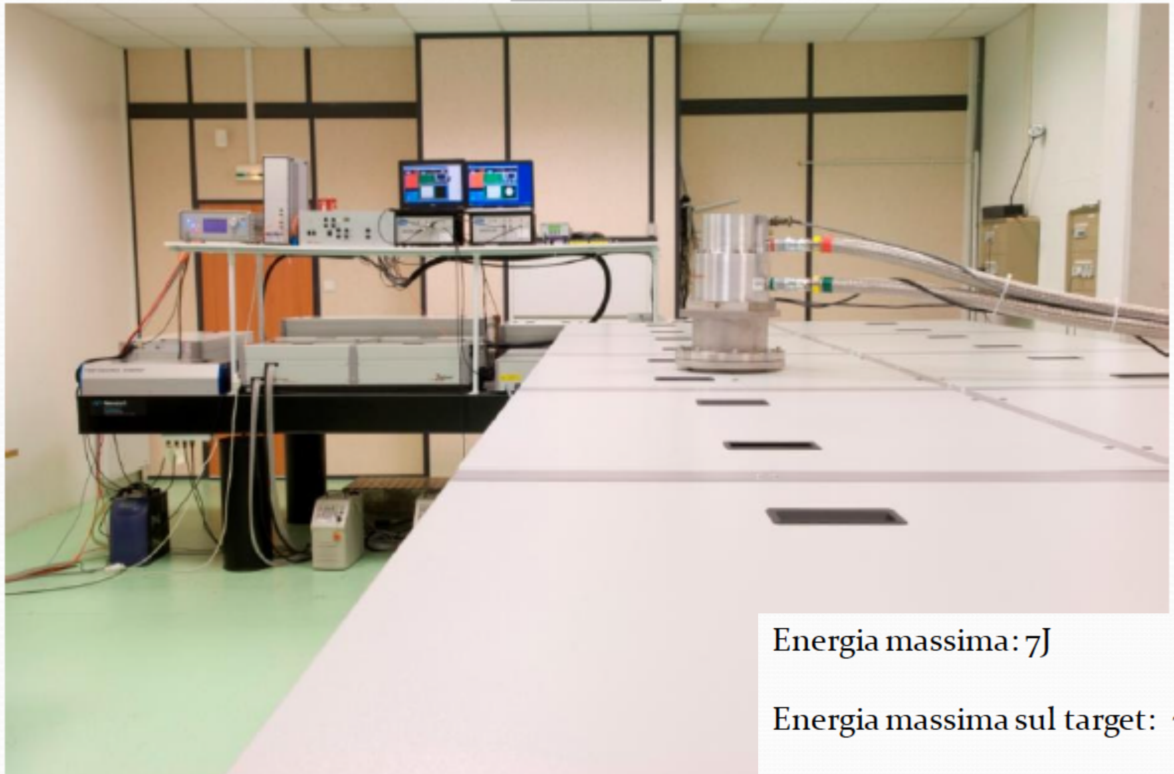
Both initial and final sizes seems to be within manageability of permanent magnet quads.

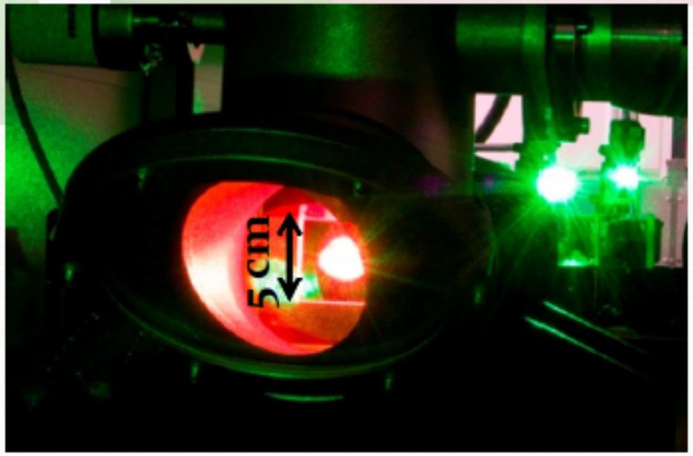


FLAME Laser

Il laser FLAME







Energia massima: 7J

Energia massima sul target: ~5J

Durata minima: 23 fs

Lunghezza d'onda: 800 nm

Larghezza di banda: 60/80 nm

Spot-size @ focus: 10 μm

Potenza massima: ~300 TW

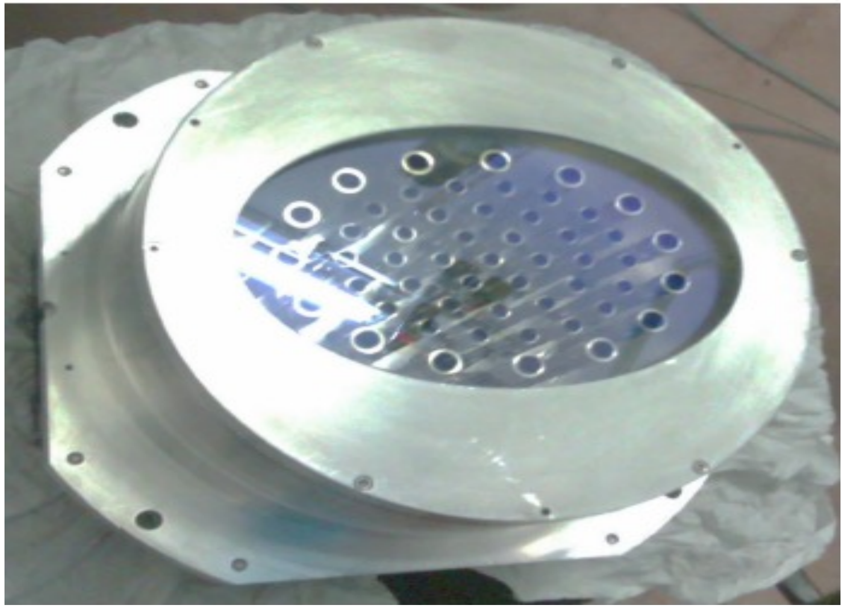
Contrasto: 10^{10}

Status of the FLAME laser

FLAME laser is in general in a good status, delivering about **5.5 J in 35-40 fs** (beside the **alignment problems** we are facing with **the compressor**, which are still giving some spatial chirp – bigger focal spot) with **all the 11 pump lasers working**. We have bought several spare parts (font end pump laser, chillers, pump lasers power supplies, …) but moreover, **the group is expanding**!
(M.P. Anania, A. Zigler, F. Bisesto, A. Curcio, R. Sorchetti, L. Cacciotti, M. Petrarca, M. Galletti)

The biggest issue we are facing, is the **final transport section** which is completely lacking in diagnostics: it is difficult to align and it is impossible to recover the beam while going from vacuum to air and viceversa. To avoid this problem, we are updating the whole transport section, using CCD cameras to diagnose the position of the beam on the most crucial mirrors.

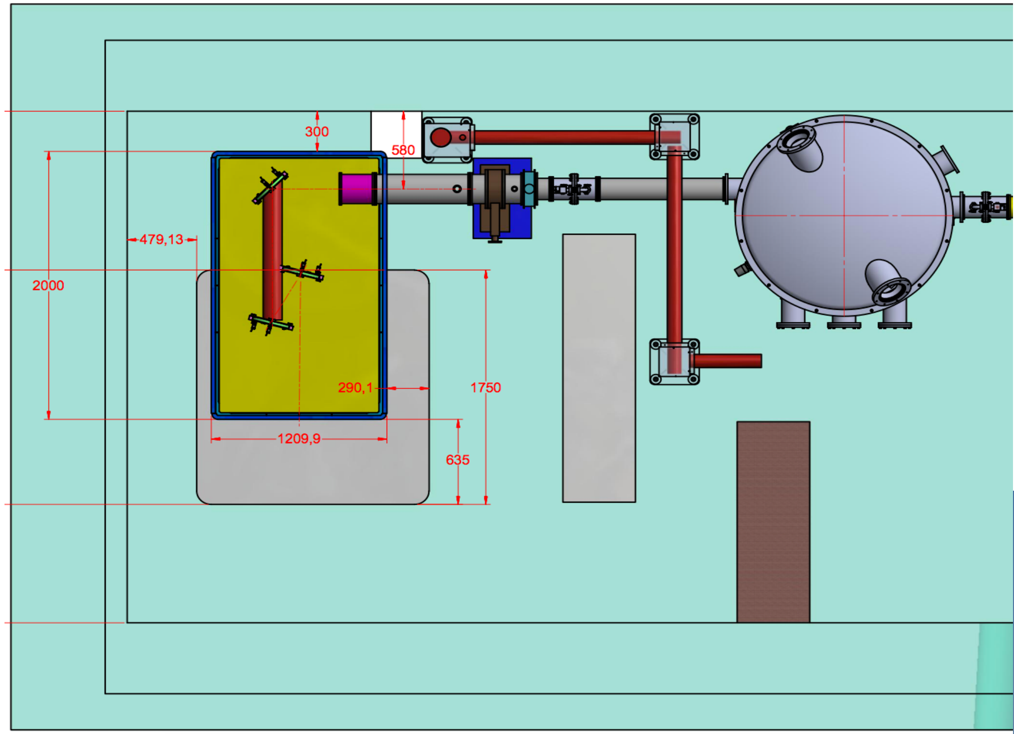
Status of the FLAME laser



Adaptive Optics Upgrade: we are still loosing part of the energy from the focal spot, partially due to the bad status of the off axis parabola (it's damaged) and partially to the transport in the diagnostic line of the adaptive optics.

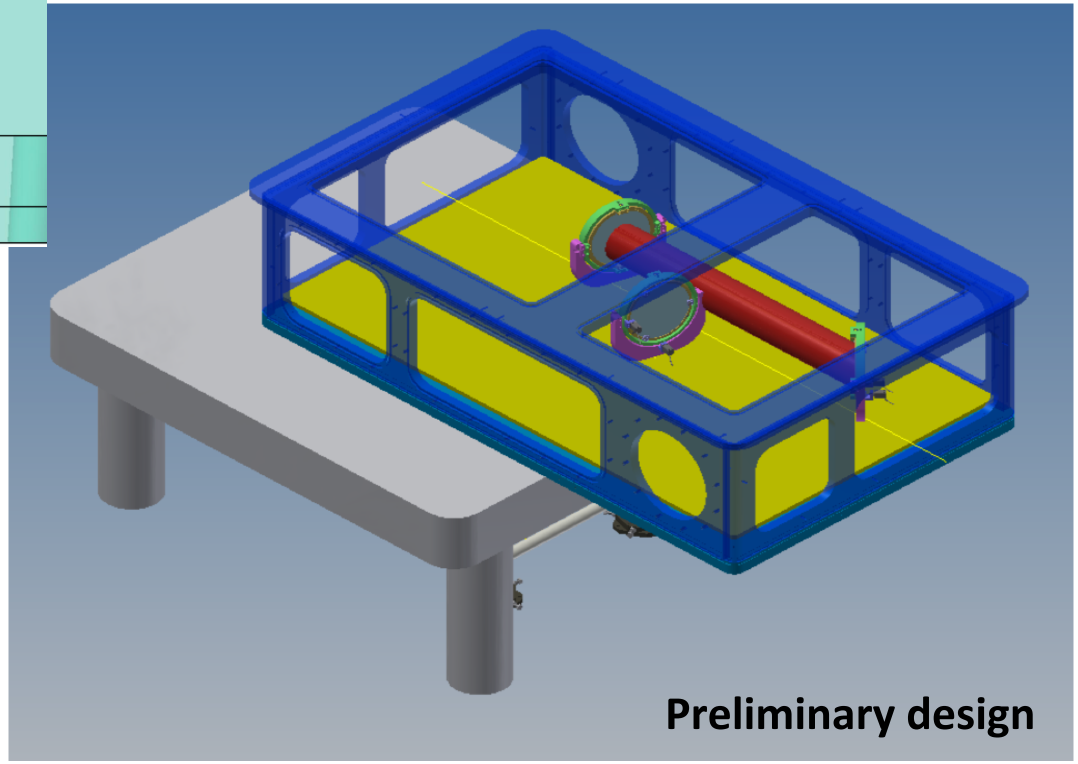
The upgrade of the AO will allow us to measure the aberrations at the focus, so to correct all aberration coming from before and after the adaptive mirror and energy in the focus is expected to reach 70-80% (now is 60% in the best cases, but routinely 40%).

Status of the FLAME laser



Interaction chamber: we are designing a new vacuum chamber for the interaction point in the flame bunker.

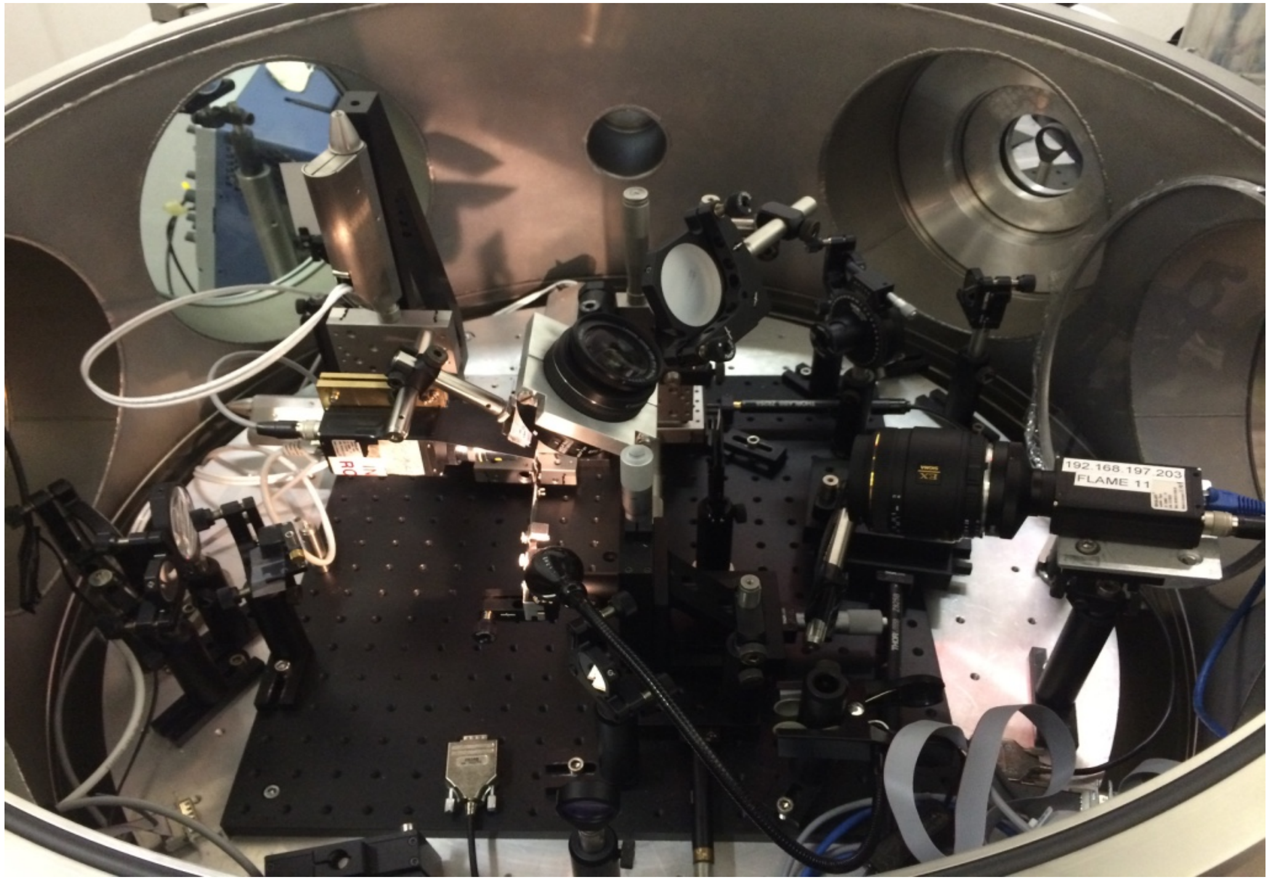
The new vacuum chamber is bigger and can host more diagnostics for the experiments and will also allow us to use different focal length parabolas (so to reach higher intensities).



Experiments with the FLAME laser

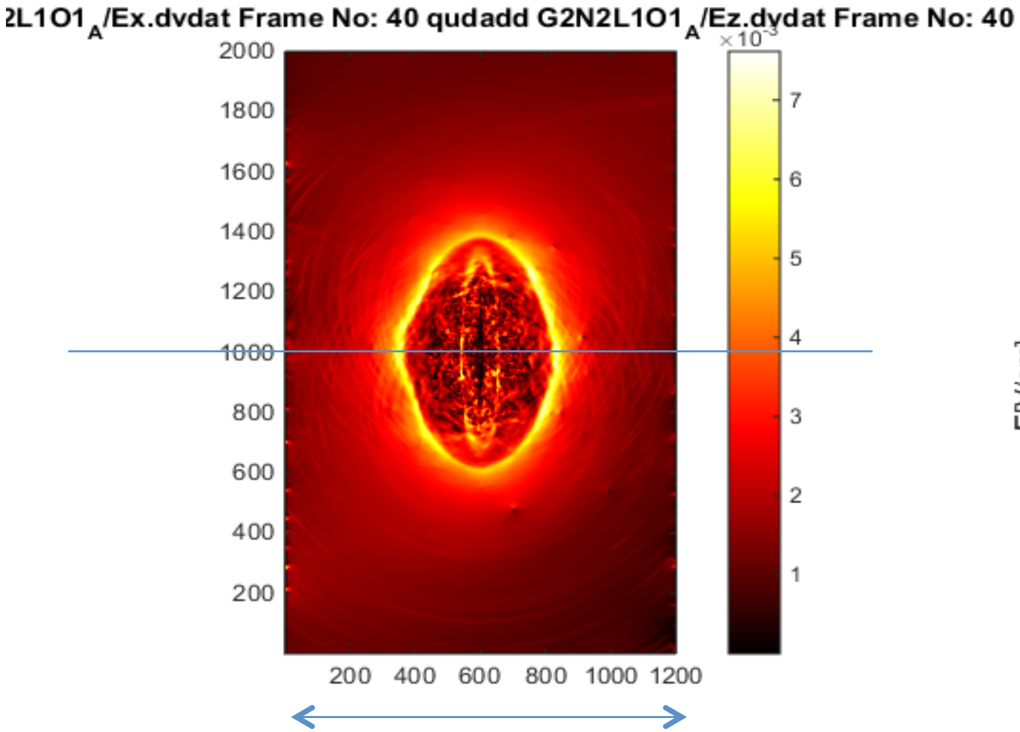
The **goal** of the experiment is to measure electric field emitted by generated particles (both electrons and ions) by means of Electro-Optical Sampling.

Particles are generated by high power laser hitting a solid target.

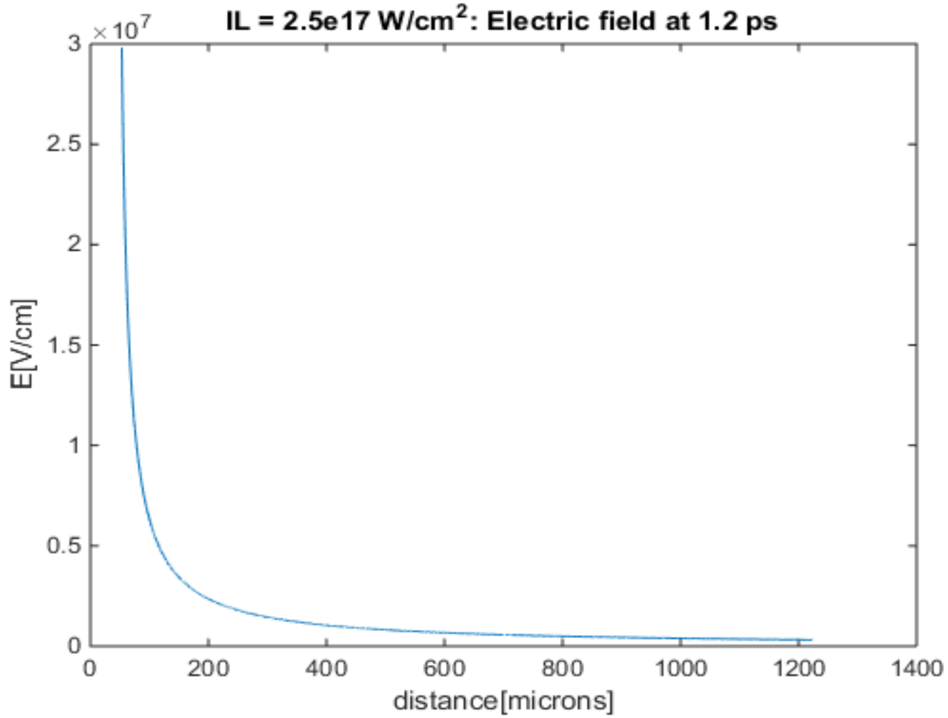


Experiments with the FLAME laser

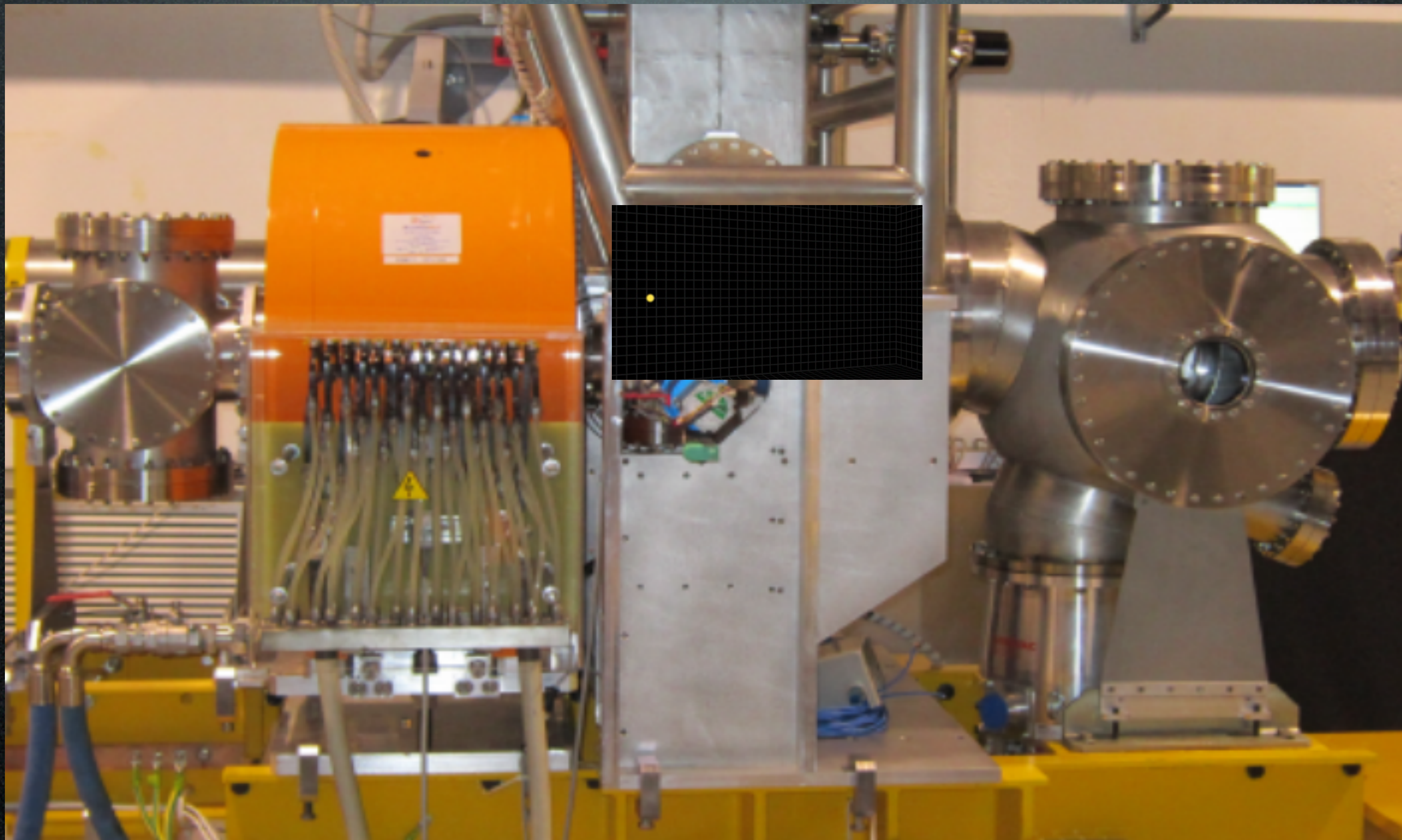
Simulations: Electric field at time 1.2 ps after the laser hits the target.



64 µm



Thomson backscattering



Courtesy C. Vaccarezza

SL-Thomson Source

Since the last run (Feb 2015) the following activity took place:

- Parabolic mirror vacuum chamber mechanical certification for the mirror alignment on electron beam reference axis.
- Misalignment recovery due to the wrong exit angles of the flanges on parabolic mirror chamber
- Alignement survey of the whole interaction section by means of a network referenced alignement laser.
- Alignment survey of the whole double dogleg transfer line (same procedure)
- BCM location shift on Interaction straight section.
- Steerer magnet shift downstream the last triplet quadrupole.

SL-Thomson foreseen activity:

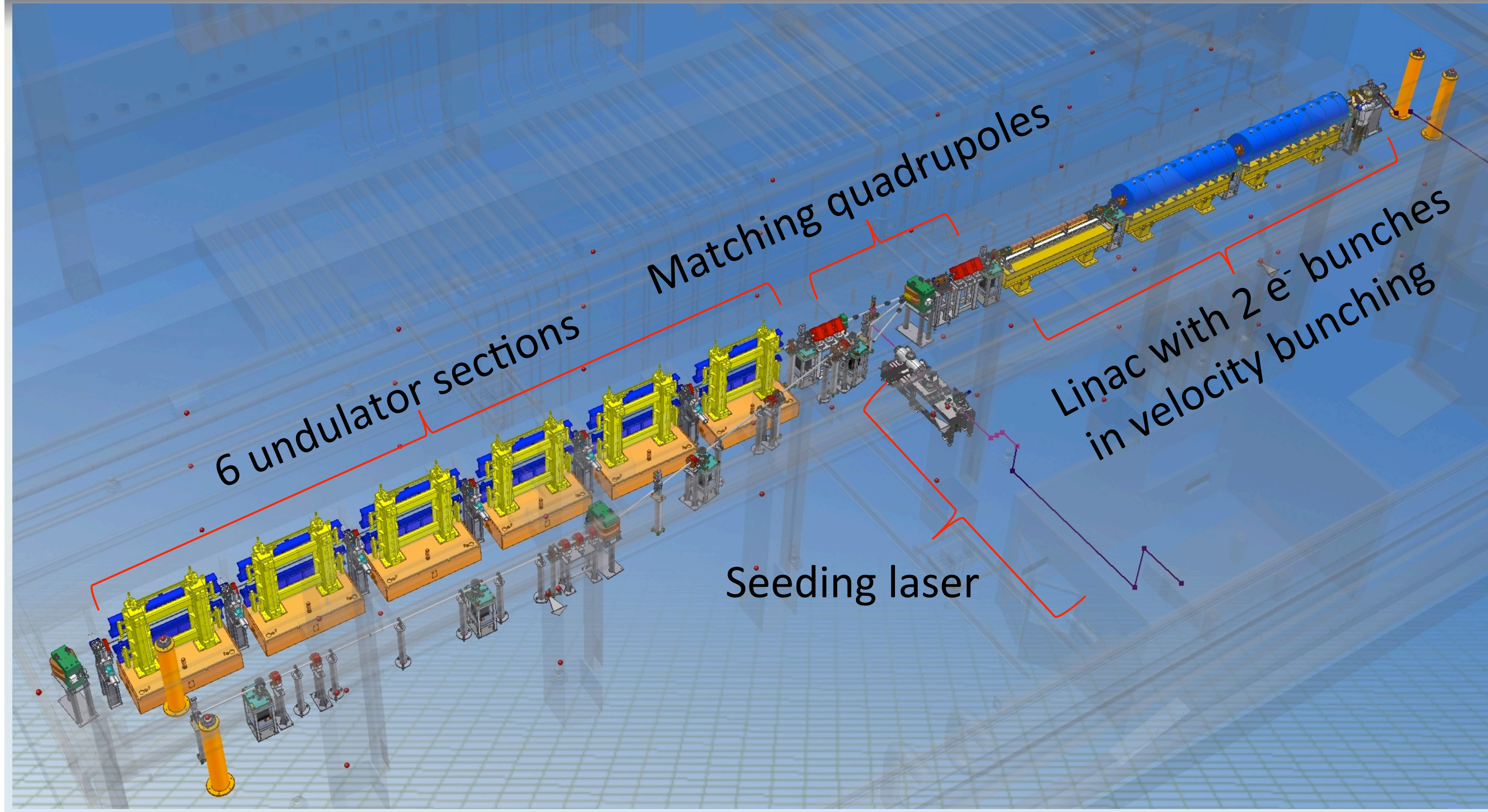
- After the first X-ray signature obtained in Feb 2014, a second collision run will take place from June 14th to July 3rd 2015
- The following activity is foreseen for the three weeks:

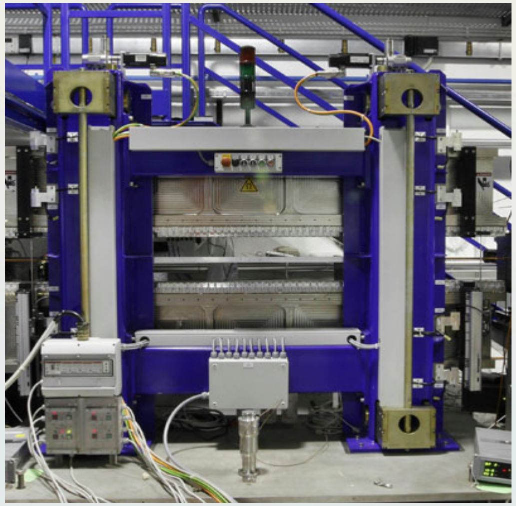
  - e^- beam tuning on June 3-5 for:
  - 50-30 MeV - 200-400 pC
  - Collisions with Flame pulse :
  - 2÷2.5 J, 2ps ,a_w=0.2÷0.3

FEL

Courtesy F. Villa & F. Ciocci

Seeded two color FEL: machine configuration



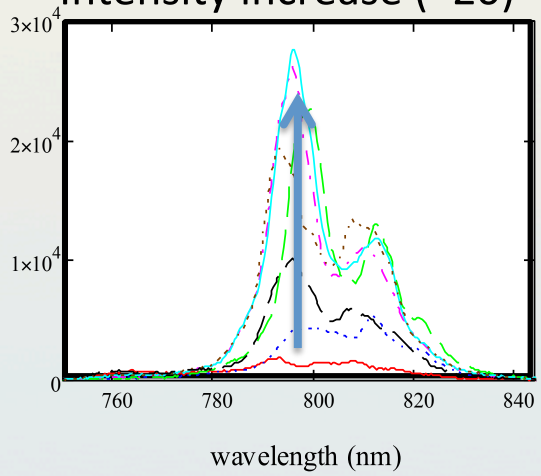


Electron reference parameters:
$k = 1.3$
$\rho = 0.005$
$\lambda_0 = 800$ nm

Period	2.8 cm
Undulator length	2.156.m
No of Periods	77
Gap (nom./min/max)	0.958 / 0.6 / 2.5 cm
K (nom./max/min)	2.145 / 3.2 / 0.38
Remanent field	1.31 T
Blocks per period	4
Block size (h x l x w)	2 x 0.7 x 5 cm

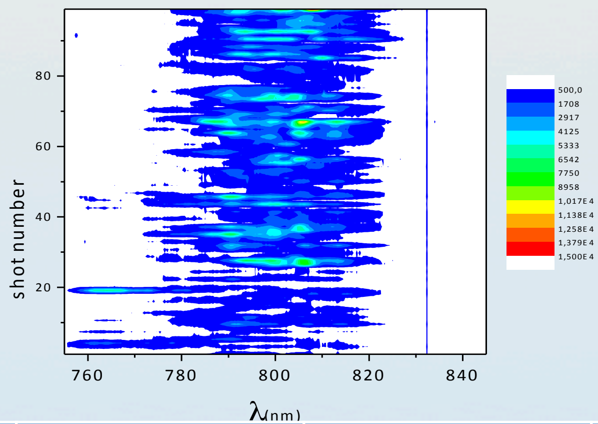
Seeded two color FEL: increased intensity & stability

Intensity increase (~20)

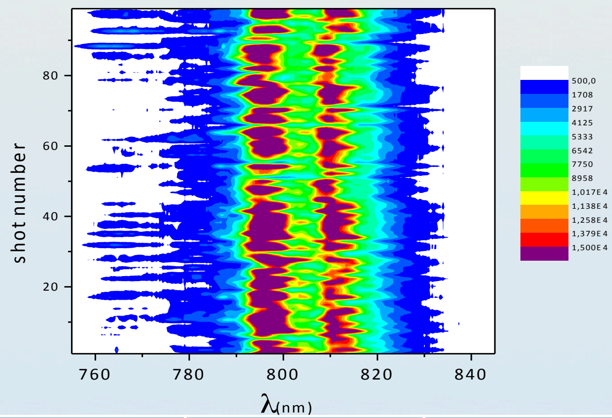


	Seed total energy (measured)	Effective energy on each pulse (calculated)
	811 nJ	10 nJ
	707 nJ	8.5 nJ
	450 nJ	5.5 nJ
	170 nJ	2 nJ
	125 nJ	1.5 nJ
	15 nJ	0.2 nJ
	0 (SASE)	0 (SASE)

SASE



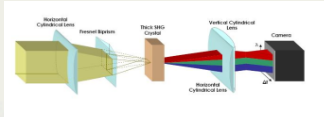
Seeded



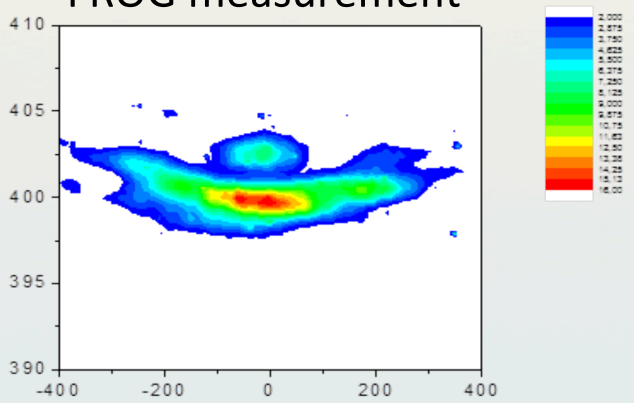
Stability improvements:
Same central wavelenghts
Larger two color probability

	$< \lambda_1 >$	$< \lambda_2 >$	$< \lambda_1 - \lambda_2 >$	$< bw_1 >$	$< bw_2 >$
SASE	790±10	808±6	17±11	9±3	7.8±1
Seeded	792.5±1.5	806.6±1.8	15.1±1.2	3.1±0.5	2.7±0.6

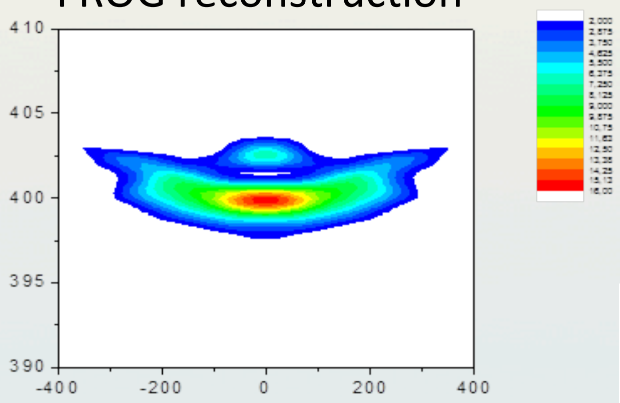
Seeded two color FEL: time domain



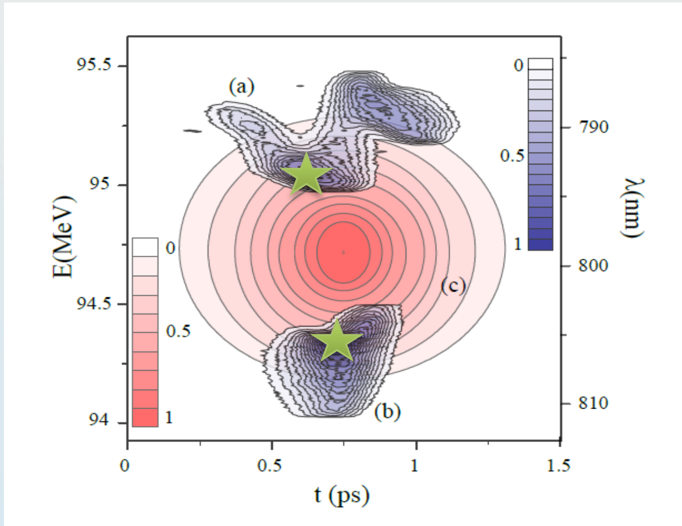
FROG measurement



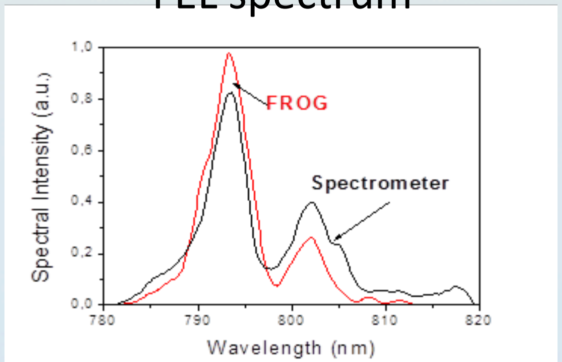
FROG reconstruction



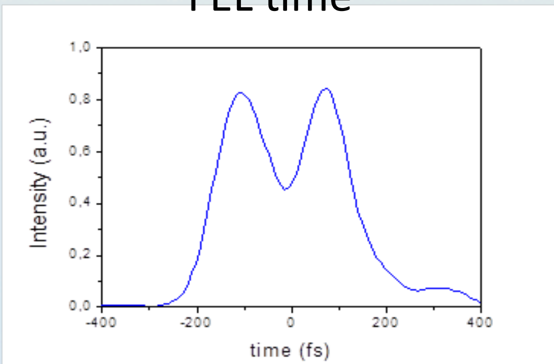
Electron and laser LPS



FEL spectrum



FEL time



FEL 2014, Basel (CH)
SPIE Optics+Optoelectronics 2015, Prague (CZ)

Subm. to PRL

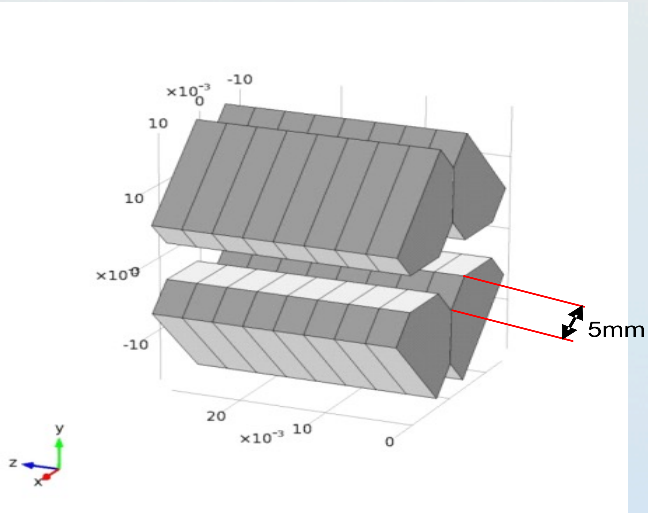
Short period undulator

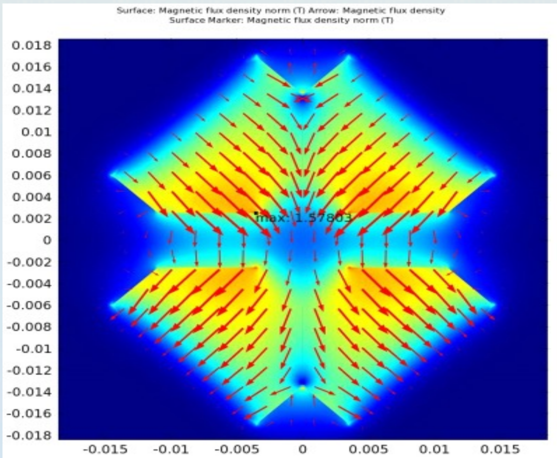
Designed and realized by SPARC group and KYMA S.r.l. collaboration

DELTA[*] like undulator:

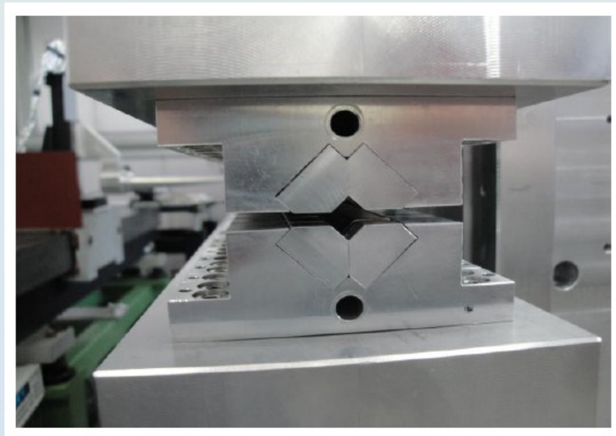
- quatrefoil structure
- focuses both in vertical and radial directions
- high magnetic field homogeneity

$$\lambda_u = 14.0\text{mm, gap g} = 5\text{mm, Br} = 1.22\text{T.}$$





Design of Marcello Quattromini

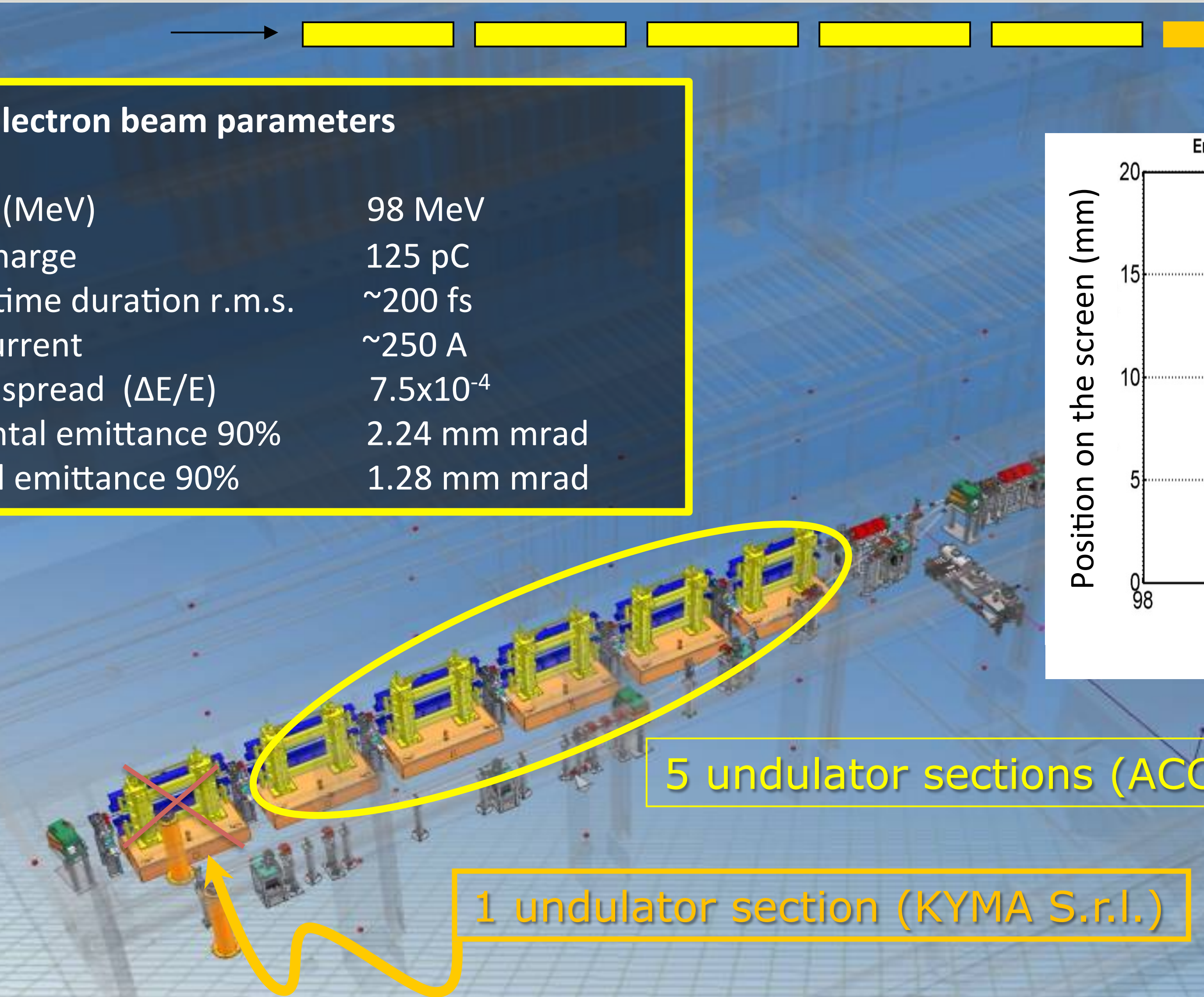


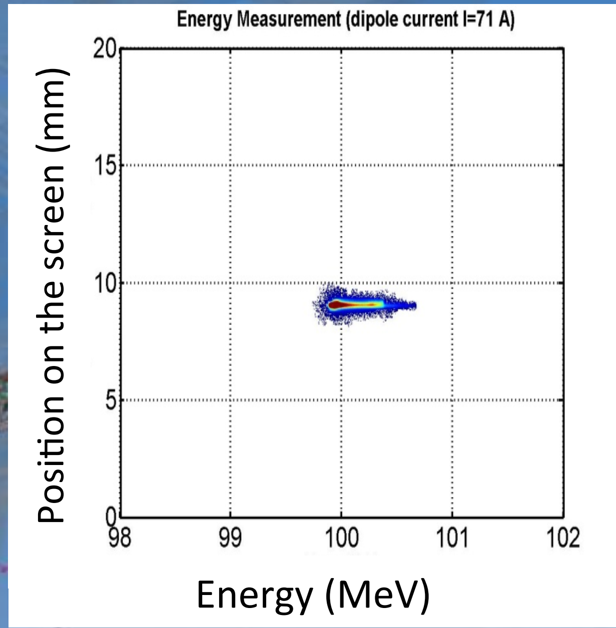
* A.B.Temnykh, Physical Review Special Topics - Accelerators And Beams 11, 120702 (2008)

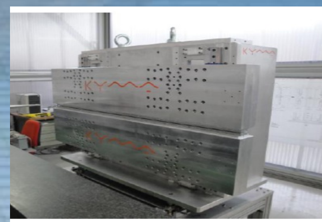
Two stages SASE-FEL : 630nm - 315nm

Electron beam parameters

Energy (MeV)	98 MeV
Total charge	125 pC
Bunch time duration r.m.s.	~200 fs
Peak current	~250 A
Energy spread (ΔE/E)	7.5×10^{-4}
Horizontal emittance 90%	2.24 mm mrad
Vertical emittance 90%	1.28 mm mrad

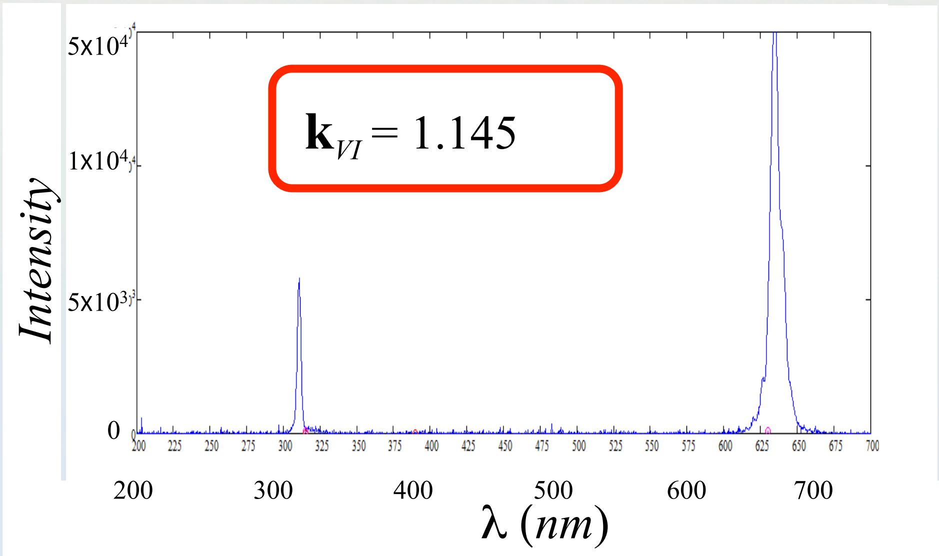






Experimental results

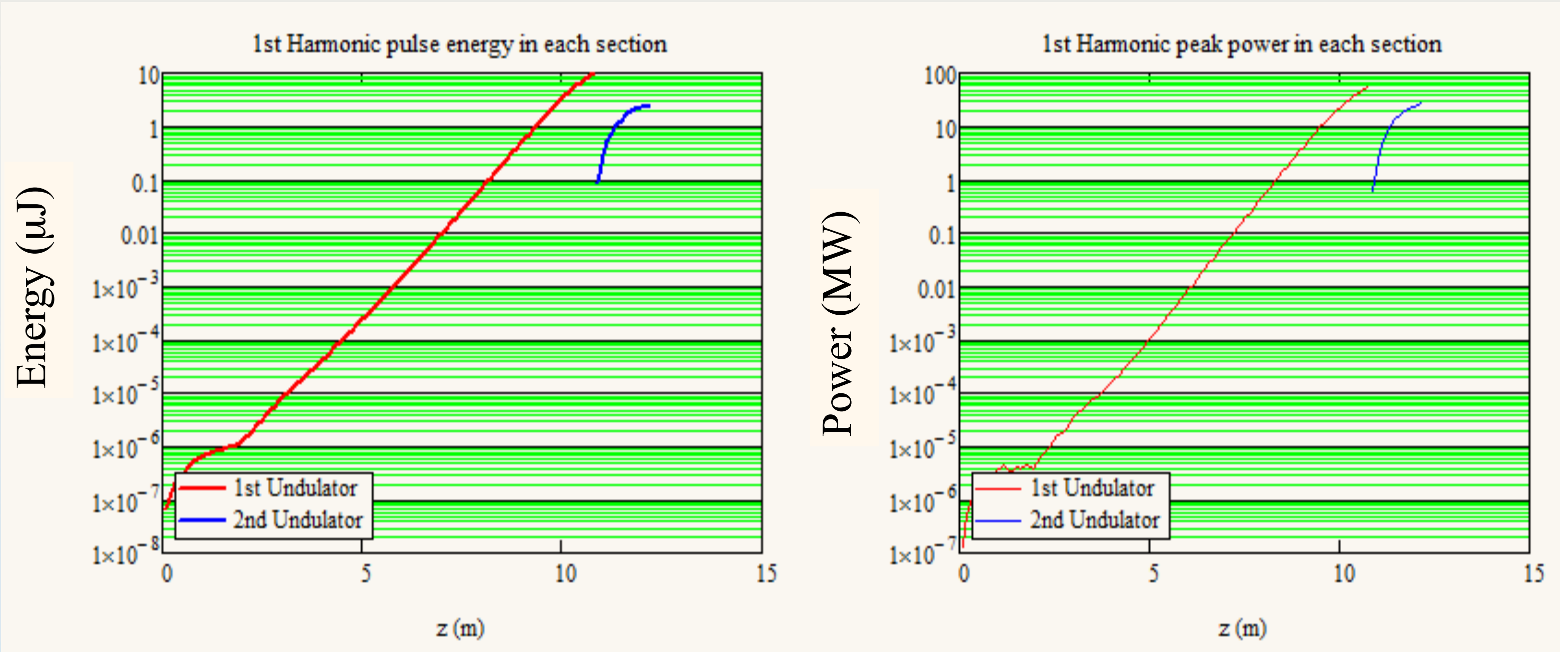
Moving the gaps of the first five sections the signal from the last section starts to grow



and allows to match the K value of the last section

Numerical simulations

The simulations made with ParsiFEL* and Perseo** are in good agreement with the experimental results.



Perseo

output energy and power predicted by Perseo using the working parameters.
If the signal in the first five modules approaches saturation the intensity in the second section decreases, however, if it moves away from the saturation, bunching is preserved and the intensity in the radiator increases.

* G. Dattoli, P.L. Ottaviani and S. Pagnutti, "Booklet for FEL design", ENEA-Edizioni Scientifiche (2008).
** Giannessi L., Proceedings of the 28th International Free Electron Laser Conference, 91-94 (2006)

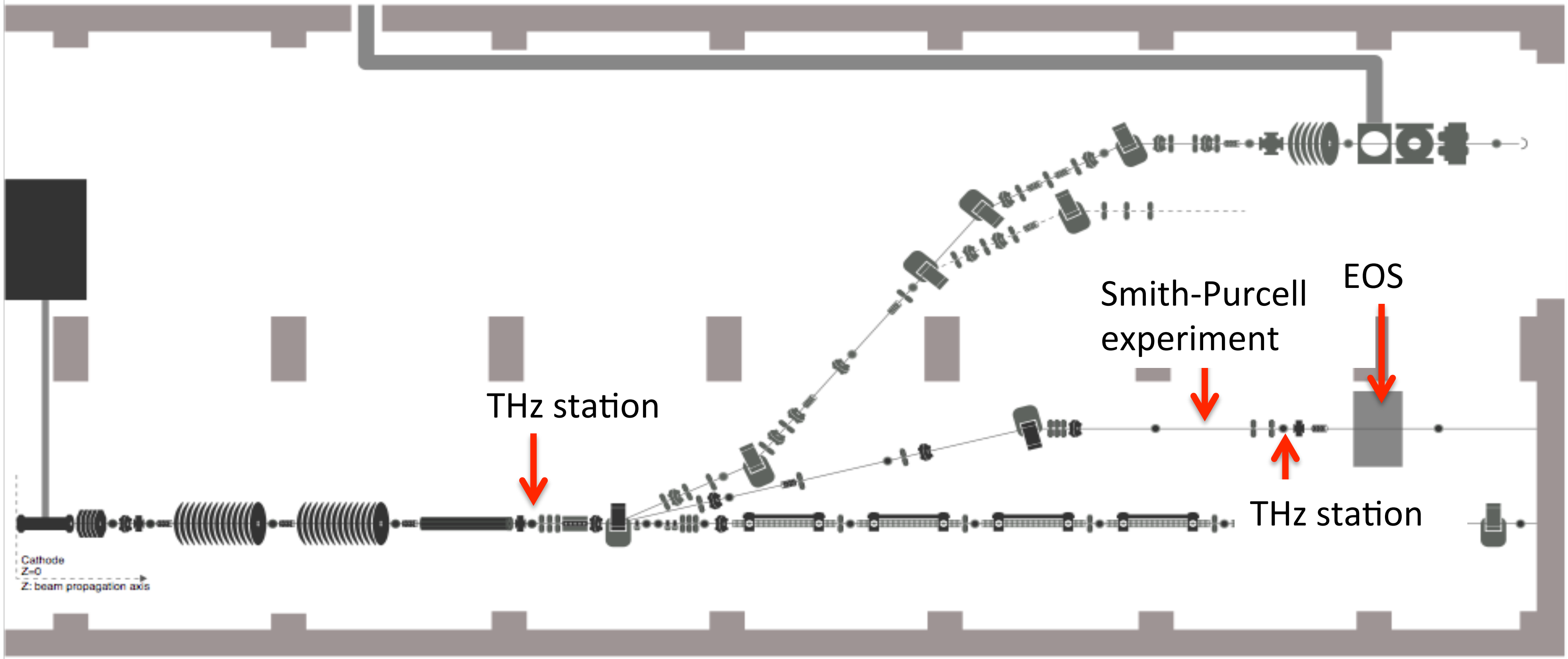
THz

Courtesy E. Chiadroni & S. Lupi

Upgrade of the THz Source and Short-Term Experiments

- Improvement of THz signal
  - dry air purging
- Smith-Purcell Experiment for bunch length diagnostics
  - Collaboration with LAL, Orsay (N. Delerue)
- Strong demand for measuring fs-scale bunch duration
  - Coherent Radiation based techniques
- User's experiments
  - Non-Linear absorption experiments on Topological Insulator

THz stations and related experiments



Smith-Purcell Experiment, LAL, Orsay Collaboration

- Measure the bunch length by using Coherent Smith Purcell Radiation and compare results with EOS technique
- Test Beam parameters

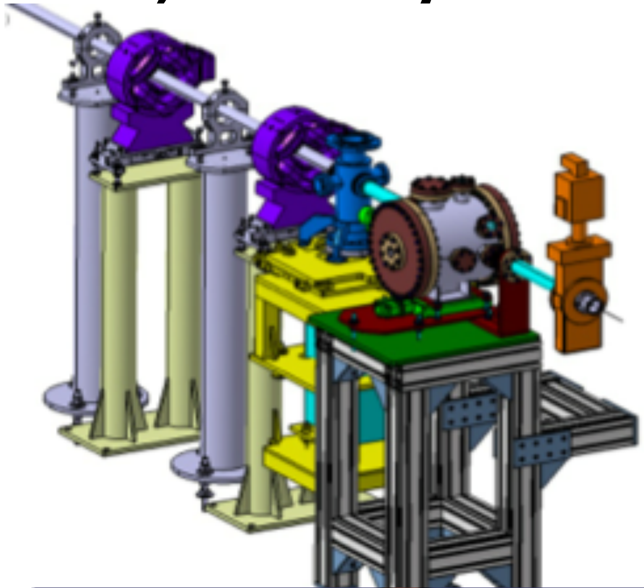
Energy (MeV)	100 – 120
Charge (pC)	>= 300
Length (FWHM, fs)	<= 400 fs
Transverse size (mm)	0.5
Optics	Waist near the grating

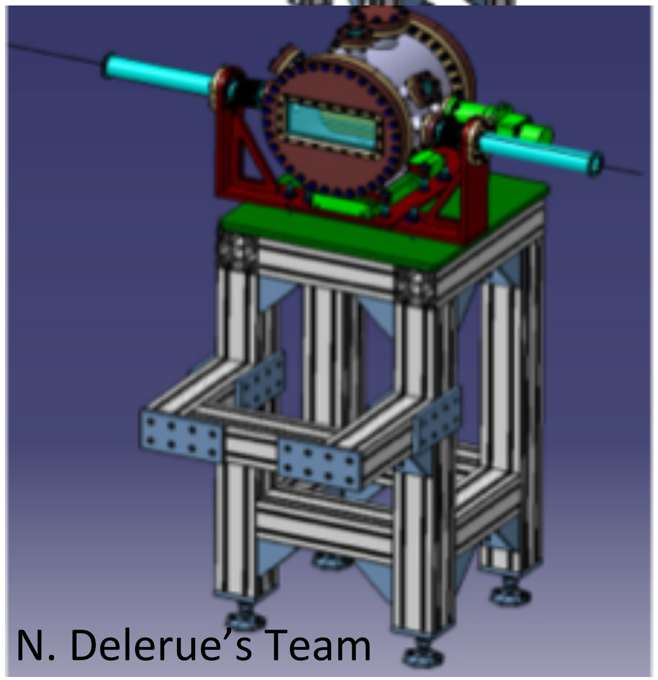
- Timeline

<u>June 8th – 12th</u>: Installation and alignment of the vacuum chamber. Preliminary tests with beam to measure background and calibrate instrumentation.

<u>September ??</u>: First measurement with beam under different compressor factors.

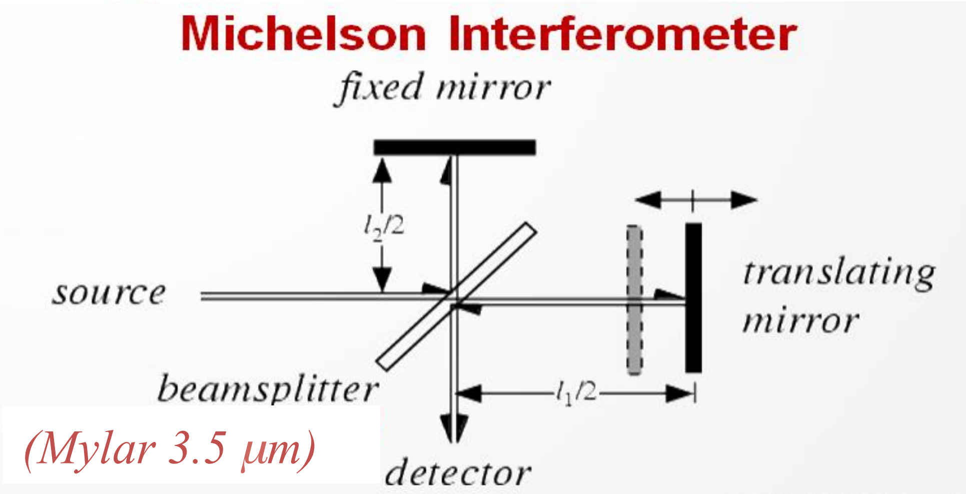
<u>Next year</u>: Full measurement with beam under different compressor factors, and different gratings.



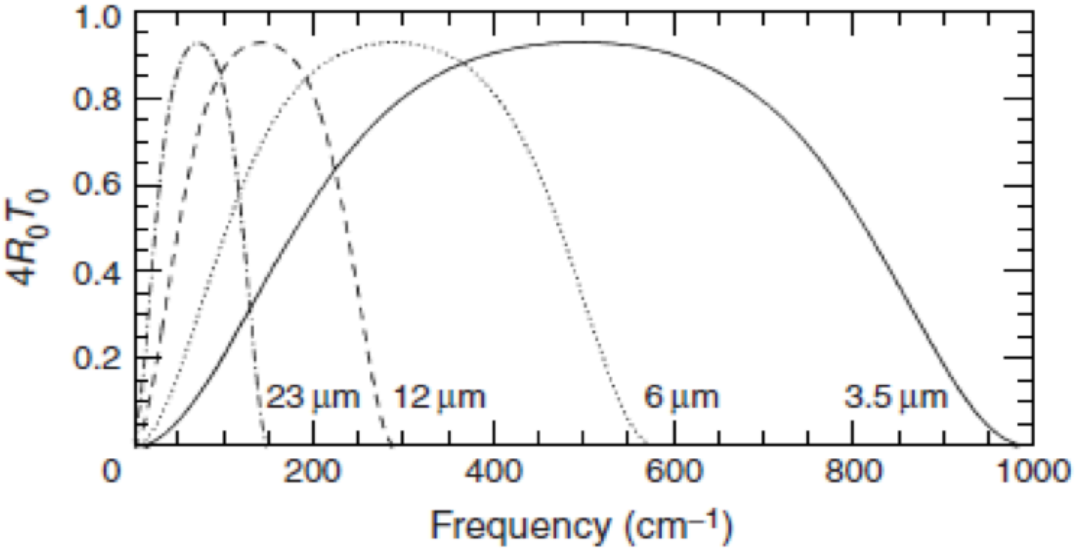


fs-scale Bunch Length Diagnostics

- Autocorrelation measurement of Coherent Transition Radiation spectrum for witness-like bunches
  - Multi-shot technique



Mylar Beam Splitter Efficiency



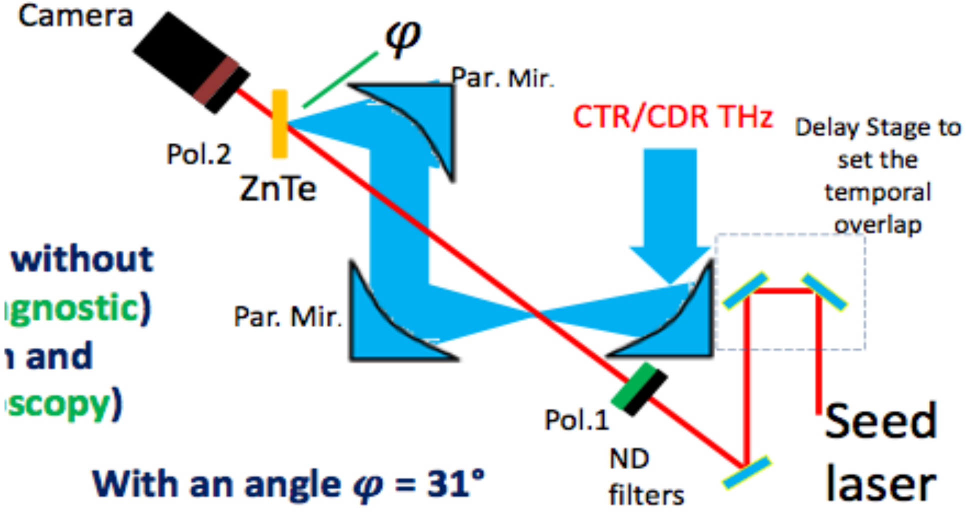
- The efficiency of Mylar beam splitters strongly depends on thickness and radiation wavelength
  - a set of Mylar splitters is needed for a wide-spectrum study

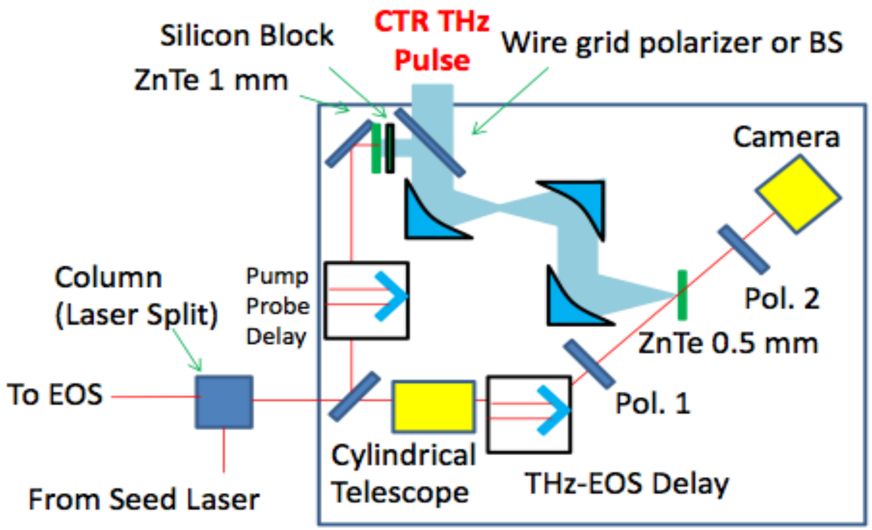
Upgrade of the THz Source and Mid-Term Experiments

- Traditional scanning THz interferometer suffers from shot-to-shot fluctuations
  - Single shot techniques EOS Measurements
- Accessibility
  - Transport out of the bunker

THz Single-Shot EOS Measurements

- EOS based on spatial decoding for
  - Electron beam longitudinal diagnostics
    - no loss of phase information
- Non-linear spectroscopy
  - good frequency resolution and frequency window
- THz pump - THz probe
  - CTR/CDR pump - Laser-based THz probe






Thank
you