Status of EXIN

SPARC

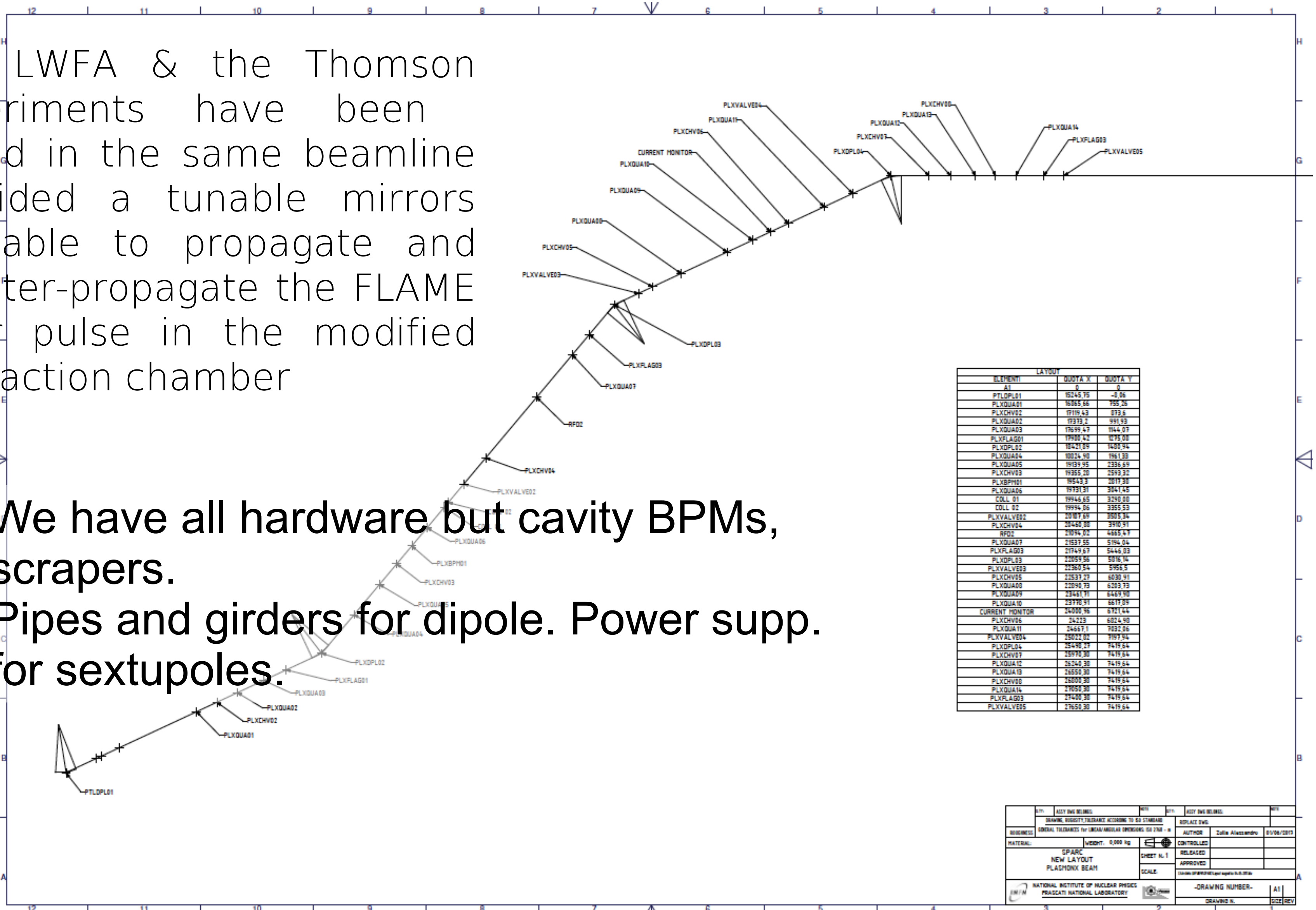
- Beam stability:
  offset:
  pointing:

- Diagnostics sensitivity:
  Charge: after COMB chamber > few of pC; before dogleg: dark current limited few tens pC.
  Transverse: um level.
  Longitudinal: >15 um (EOS). CTR 10-15 fs (possibly down to 2 fs).

Electron line

Exin&Thomson new beamline

The LWFA & the Thomson experiments have been joined in the same beamline provided a tunable mirrors set able to propagate and counter-propagate the FLAME laser pulse in the modified interaction chamber



LAYOUT

ELEMENTI	QUOTA X	QUOTA Y
A1	0	0
PTLDPL01	15245,75	-8,06
PLXQUA01	16065,66	755,26
PLXCHV02	17119,43	873,6
PLXQUA02	17373,2	991,93
PLXQUA03	17699,47	1144,07
PLXFLAG01	17980,42	1275,08
PLXDPL02	18421,09	1480,94
PLXQUA04	18824,90	1961,33
PLXQUA05	19139,95	2336,69
PLXCHV03	19355,20	2593,32
PLXBPM01	19543,3	2817,38
PLXQUA06	19731,31	3041,45
COLL 01	19946,65	3298,08
COLL 02	19994,06	3355,53
PLXVALVE02	20187,69	3585,34
PLXCHV04	20460,88	3910,91
RFD2	21094,02	4665,47
PLXQUA07	21537,55	5194,04
PLXFLAG03	21749,67	5446,83
PLXDPL03	22059,56	5816,14
PLXVALVE03	22360,54	5956,5
PLXCHV05	22537,27	6038,91
PLXQUA08	22890,73	6203,73
PLXQUA09	23461,71	6469,98
PLXQUA10	23778,91	6617,09
CURRENT MONITOR	24000,96	6721,44
PLXCHV06	24223	6824,98
PLXQUA11	24667,1	7032,06
PLXVALVE04	25022,82	7197,94
PLXDPL04	25490,27	7419,64
PLXCHV07	25970,30	7419,64
PLXQUA12	26240,30	7419,64
PLXQUA13	26550,30	7419,64
PLXCHV08	26800,30	7419,64
PLXQUA14	27050,30	7419,64
PLXFLAG03	27400,30	7419,64
PLXVALVE05	27650,30	7419,64

We have all hardware but cavity BPMs, scrapers.
Pipes and girders for dipole. Power supp. for sextupoles.

Electron line

Installed diagnostics:

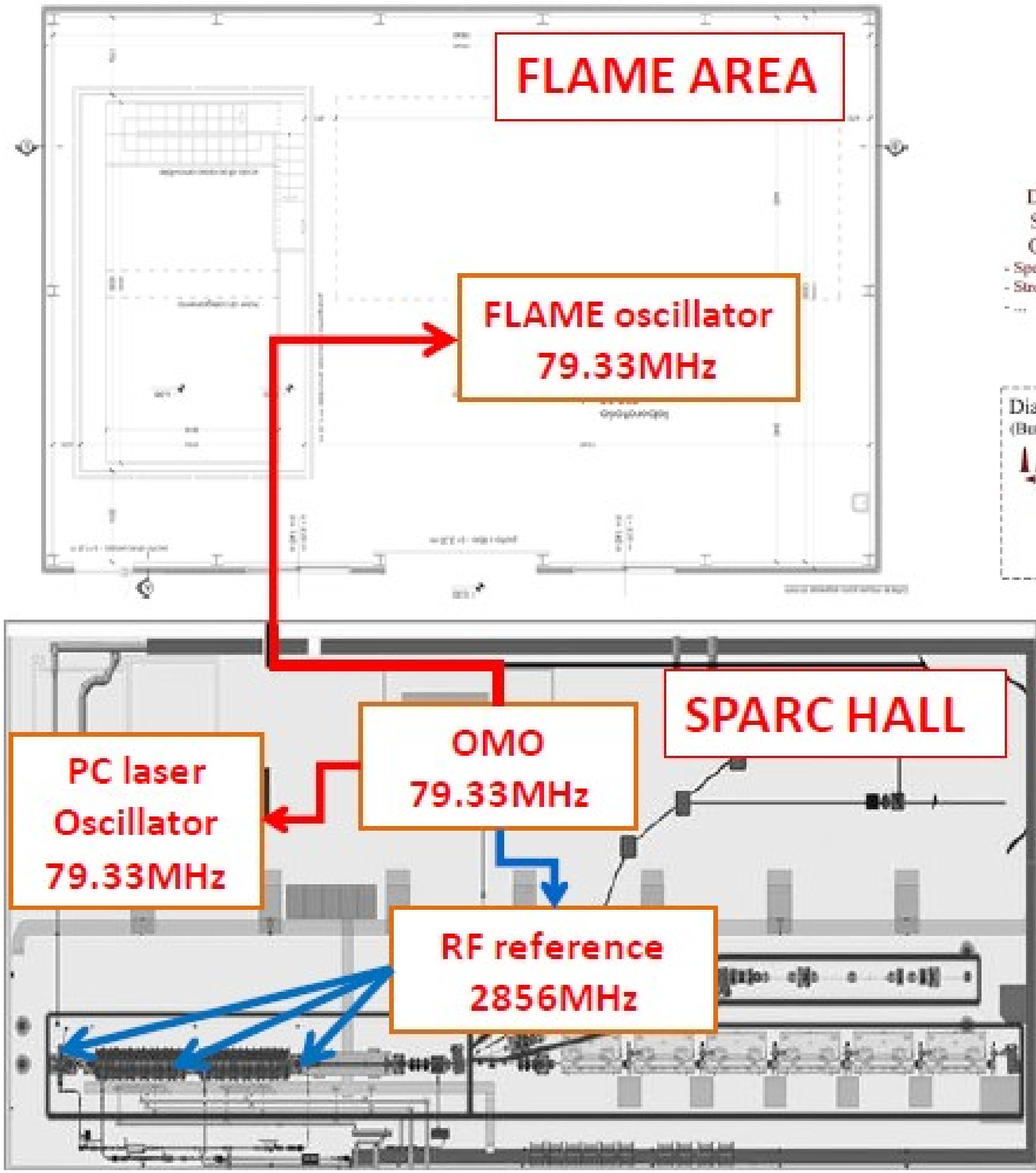
-
-

Missing elements/diagnostics:

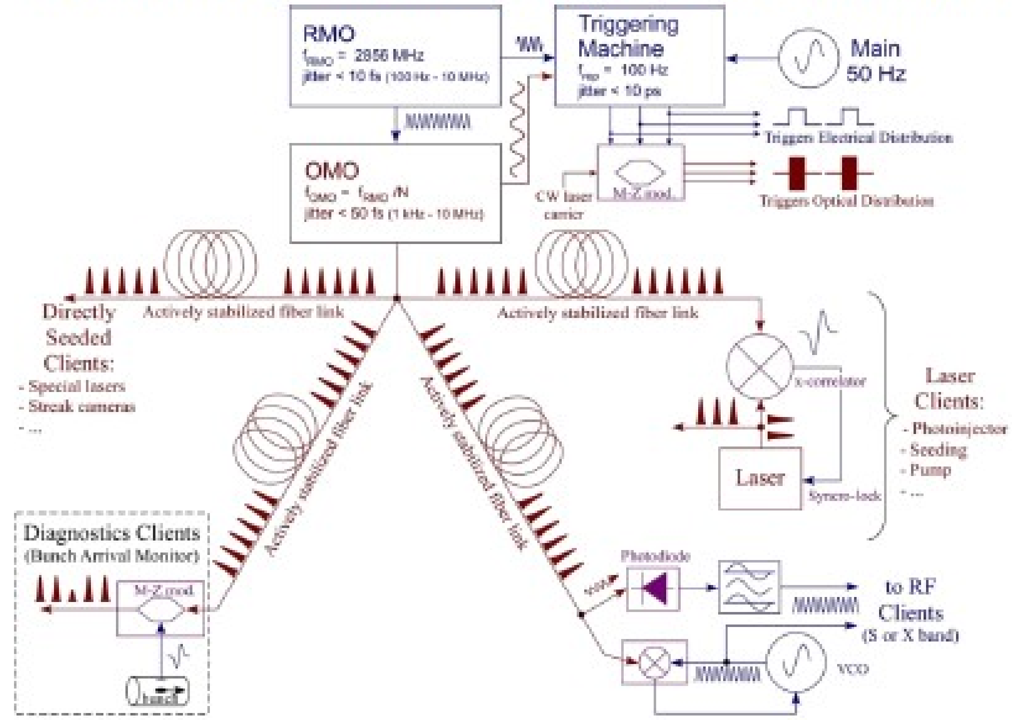
-
-

General layout of SPARC_LAB synchronization system upgrade

Optical architecture foreseen at SPARC_LAB



Typical modern synchronization system layout

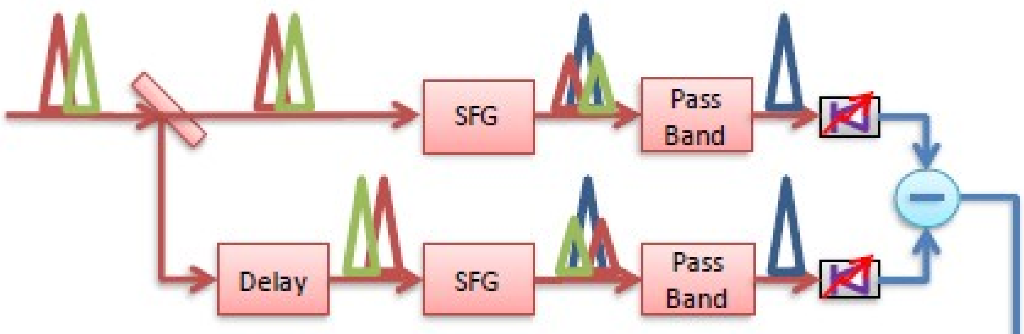


- Present relative jitter performance <50fs RMS (coaxial distribution)
- Upgrade to optical reference signal distribution towards <10fs RMS
- Fiber stabilized link installed and commissioned
- Optical phase detectors (x-correlators) under test @LNF

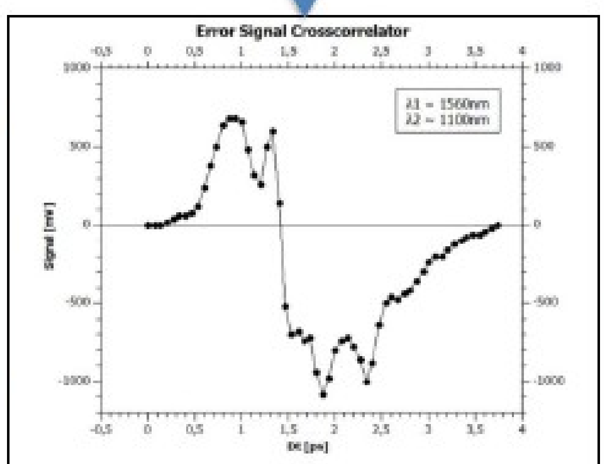
Commissioning of optical phase detectors

- Used to detect relative timing jitter between Optical Master Oscillator (OMO) and slave laser system
- sensitivity up to **10mV/fs** (~3 order of magnitude better than standard electronic mixing technique)
- commercially available product (see picture below from Menlo Systems)
- commissioning of the device in progress @LNF
- Estimated closed loop jitter reduced to <u><10fs RMS</u>

Detected signal from one of the SPARC_LAB x-correlators



Typical x-correlator characteristics (measured at MENLO Systems GMBH)



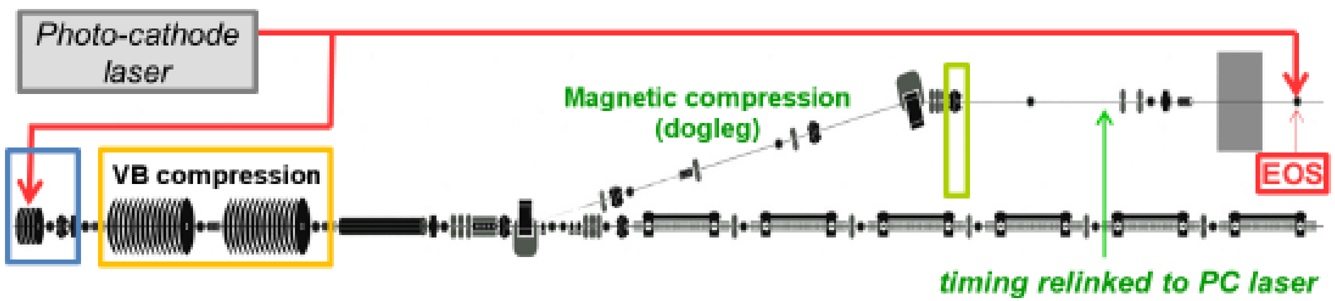
To do list in FLAME clean room

- Renew the layout of the synchronization optical table
  - Enclosure
  - installation of new delay lines
- Locking the system with electrical reference obtained from the OMO laser train in the second fiber to avoid electrical noise (already installed)
- Installation and commissioning of the x-correlator
  - Measuring the OMO-FLAME jitter
  - Lock the system with OMO optical reference
- Upgrade of the FLAME lock electronics
  - Installation of a true S-band front end
  - Optimization of the Error amp and piezo driver

Completion in:

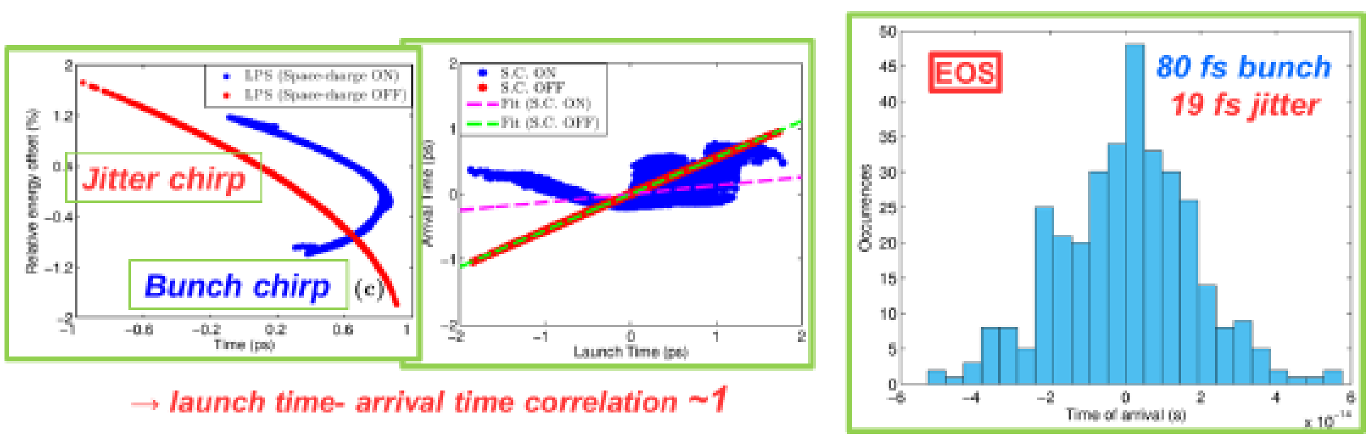
To do list in SPARC bunker

- EOS Diagnostics: SPARC bunch vs FLAME pulse
- Hybrid compression



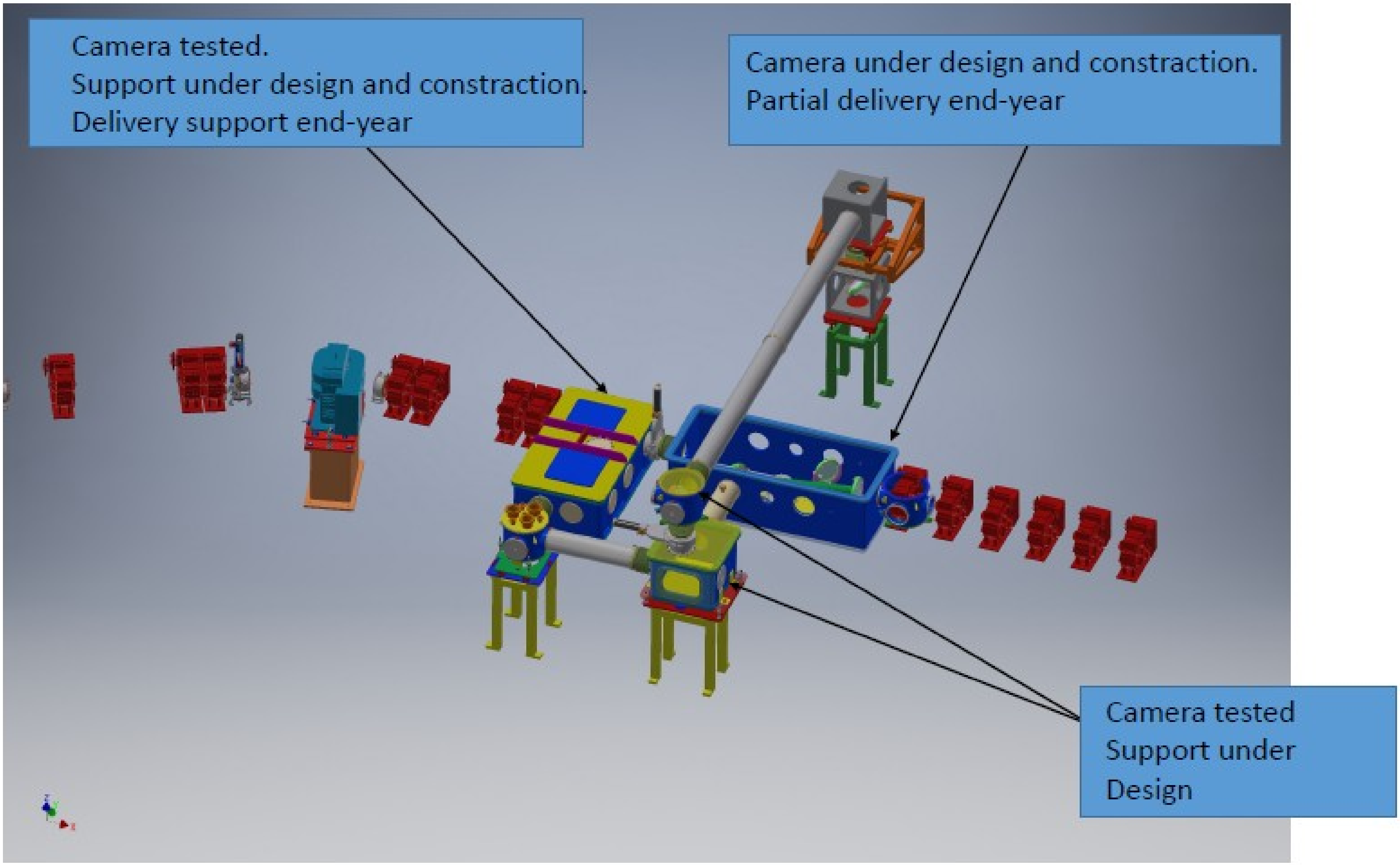
***Hybrid compression**: bunch shortening and relative ATJ reduction*

Pompili, R., et al. "Femtosecond timing-jitter between photo-cathode laser and ultra-short electron bunches by means of hybrid compression." New Journal of Physics 18.8 (2016): 083033.



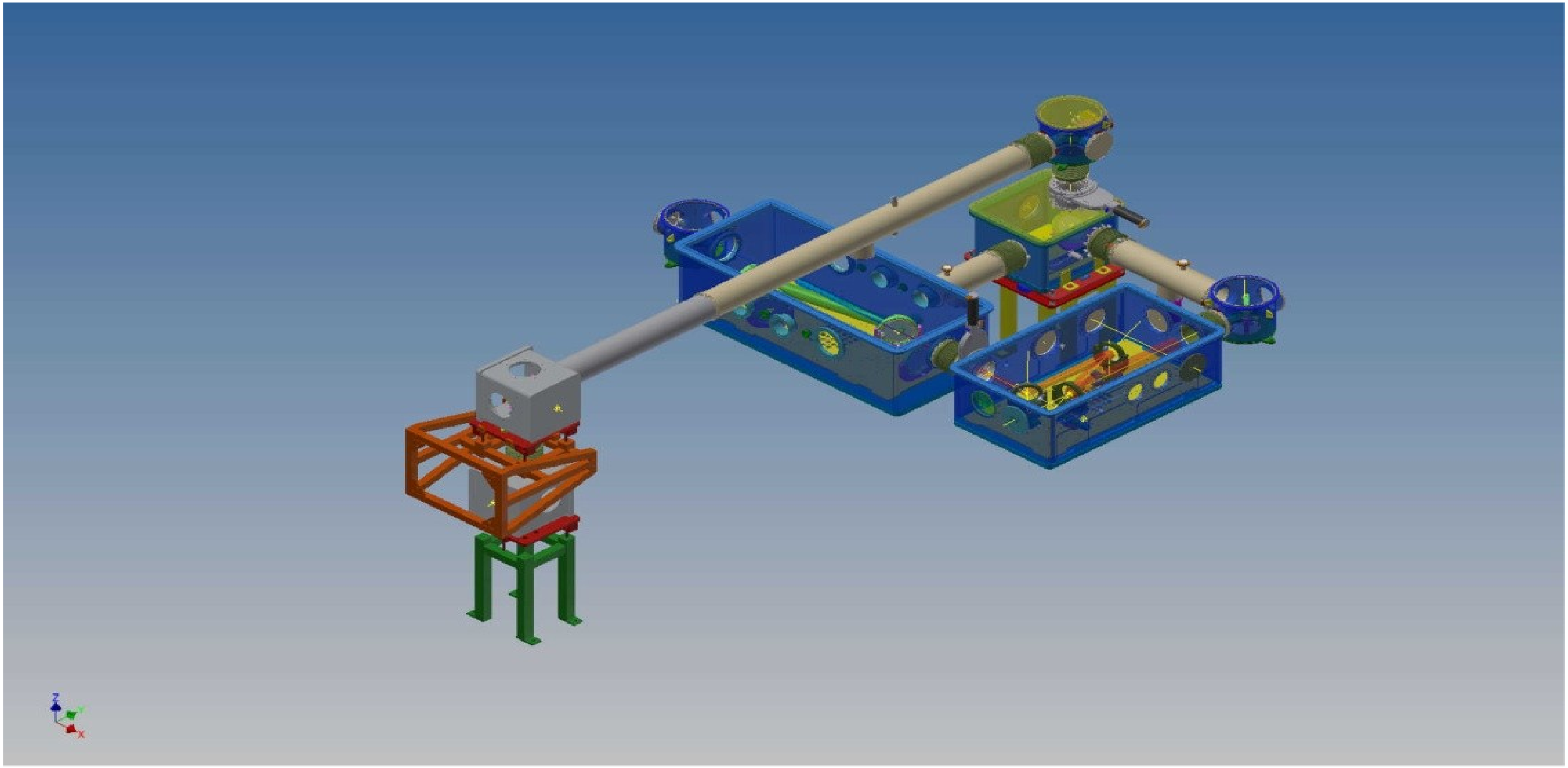
→ launch time- arrival time correlation ~1

Electron line



Thomson – EXIN line status

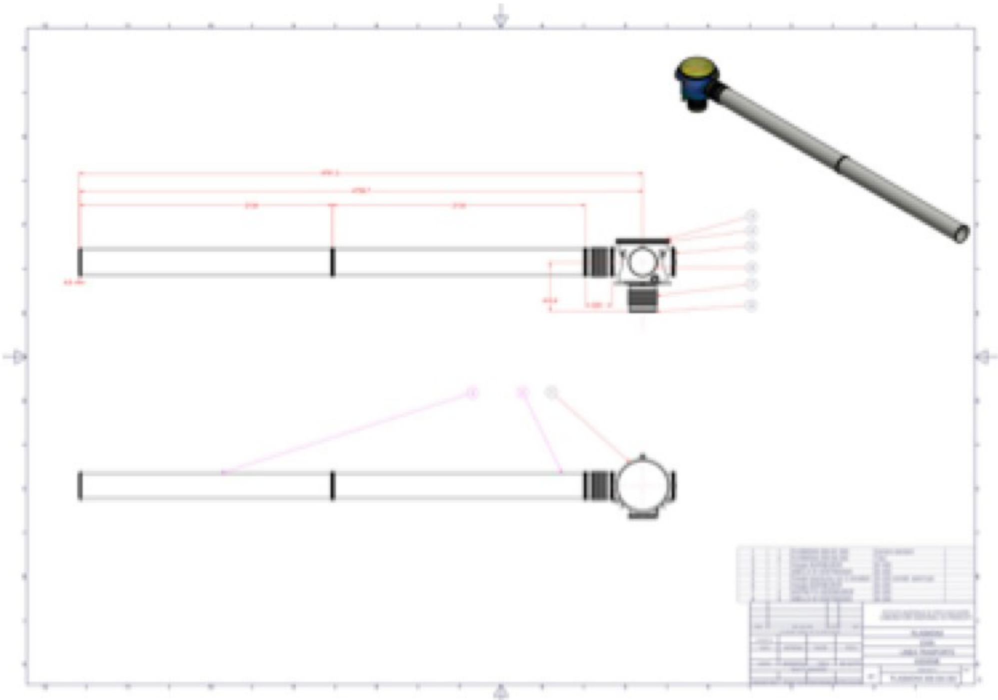
Design of the interaction/transport chambers



Thomson – EXIN line status

Status di disegni/ordini

PLASMONX.058.000.000 - Trasporto laser

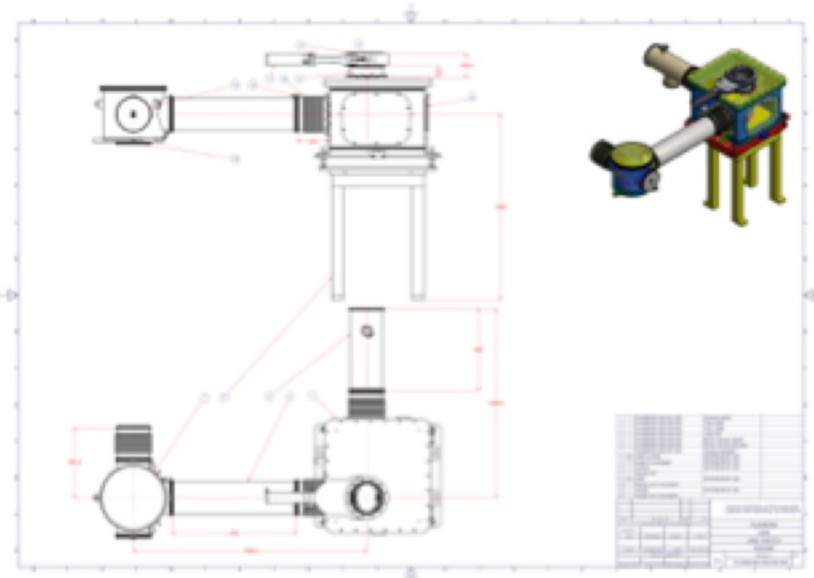


MATERIALE	COSTO PREVISTO	NOTE
Piastre regolazione per camere standard	3000	Da disegnare e ordinare
Carpenteria sostegno 1 camere standard	4000	Da disegnare e ordinare

Thomson – EXIN line status

Status di disegni/ordini

PLASMONX.059.000.000 - Linea switch

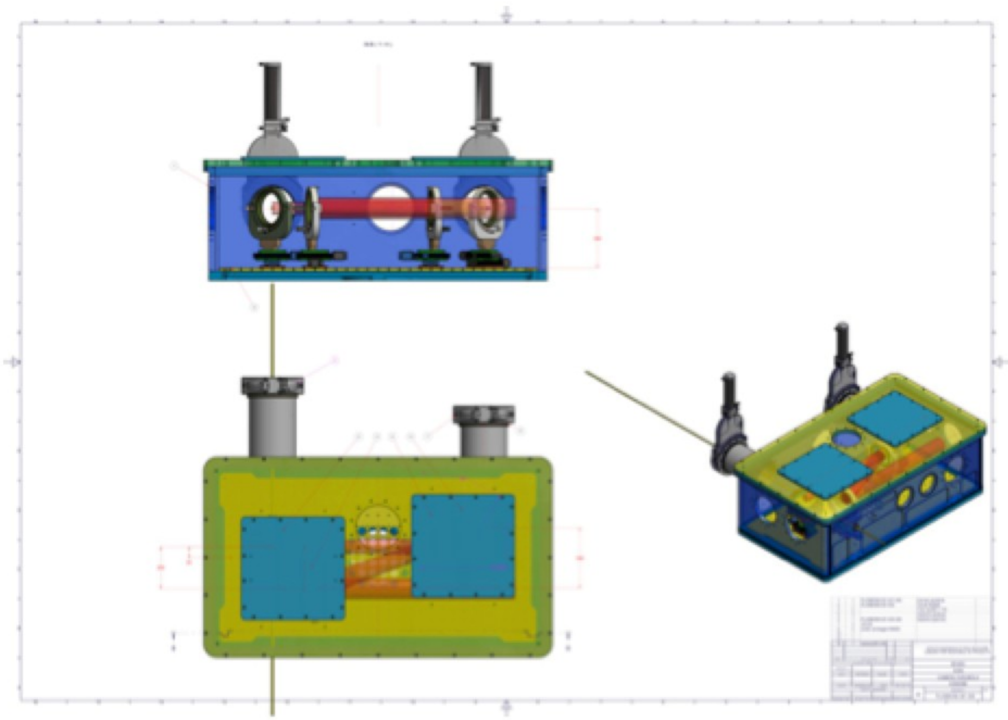


MATERIALE	COSTO PREVISTO	NOTE
Piastre regolazione per camera	3500	Da disegnare e ordinare
Supporto per camera standard	4000	Da disegnare e ordinare
Piastre supp. specchio camera standard	2500	Disegnate

Thomson – EXIN line status

Status di disegni/ordini

PLASMONX.061.000 - Camera parabola

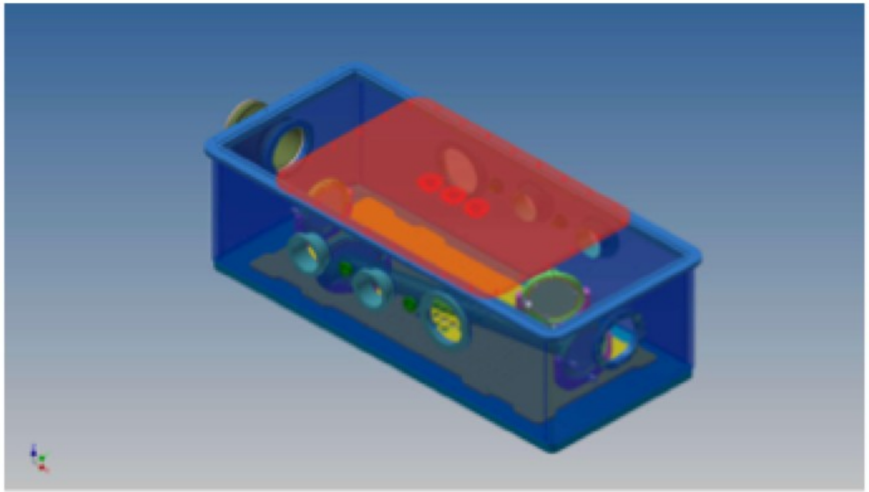


MATERIALE	COSTO PREVISTO	NOTE
Piastre regolazione per camere	3000	Da disegnare e ordinare
Carpenteria sostegno camera	Ordine 9080	Completare il disegno
Valvola vat 12146 PA44	3500	
2 Slitte corsa 50 manuali	13600	
2 Sistemi di pompaggio	29000	Turbine Pfeiffer + scroll Agilent
Componenti meccanici		Da definire

Thomson – EXIN line status

Status di disegni/ordini

PLASMONX.060.000 - Camera capillari



MATERIALE	COSTO PREVISTO	NOTE
Piastre regolazione per camere	3000	Da disegnare e ordinare
Carpenteria sostegno camera	3000	Da disegnare e ordinare
1 gimbal 8"	6000	Ordinare Vacuumfab
2 Slitte corsa 50 motorizzate	12800	
2 driver + controller slitte	2000	
2 Sistemi di pompaggio	29000	Turbine Pfeiffer + scroll Agilent
Camera	Fare ordine integrativo	Ordinata completare i disegni

Thomson – EXIN line status

Status di disegni/ordini

RIEPILOGO LAVORAZIONI E MATERIALI DA ORDINARE

Riepilogo costi preventivati

MATERIALE	COSTO PREVISTO	NOTE
PLASMONX.058	7000	linea di trasporto laser
PLASMONX.059	10000	linea switch
PLASMONX.060	55800	camera capillari plasmonx
PLASMONX.061	49100	camera parabola
TOTALE	121900	

Di questo totale, 93keuro sarebbero ordinabili subito.

A questo punto si deve stabilire chi fa i disegni mancanti e se questo layout è stato inserito sul layout di SPARC (per definire i pezzi mancanti anche sulla linea di trasporto del laser).

Thomson – EXIN line status

IP chamber (and related) diagnostics:

- Stark broadening
- pointing diagnostics
- EOS (for arrival time)
- cavity BMP

Post interaction diagnostics:

- spectrometer (dipole)
- emittance measure (osè and betatron)
- charge
- LCR (bunch length)

Future experimental steps

(within Thomson whenever possible)

- measure of jitters @ IP

- transport of ultrashort bunches

- EOS SPARC vs FLAME

Photons line status

Laser guiding

Two options:

- plasma channel (discharge capillary):
in house expertise, experimentally demonstrated, durability, ease of production and tweaking.
Stability, discharge dependant, ionization (?), more constraints on laser/capillary parameters

- plasma channel (ionization by laser):
in house expertise, experimentally demonstrated, durability, ease of production and tweaking.

- monomode hollow waveguide
Stability, 1 to 1 relation laser guiding to geometry, full ionization.
Durability, requires optical precision, tweaking (?).

Photons line status

Laser extraction:
- mirror with hole (?);
- ...

Pre- interaction laser diagnostics:
- spot
- ...

Post interaction laser diagnostics:
- spectrometer;
- ...

Future experimental steps

Guiding experiments (est ~ 6 months):

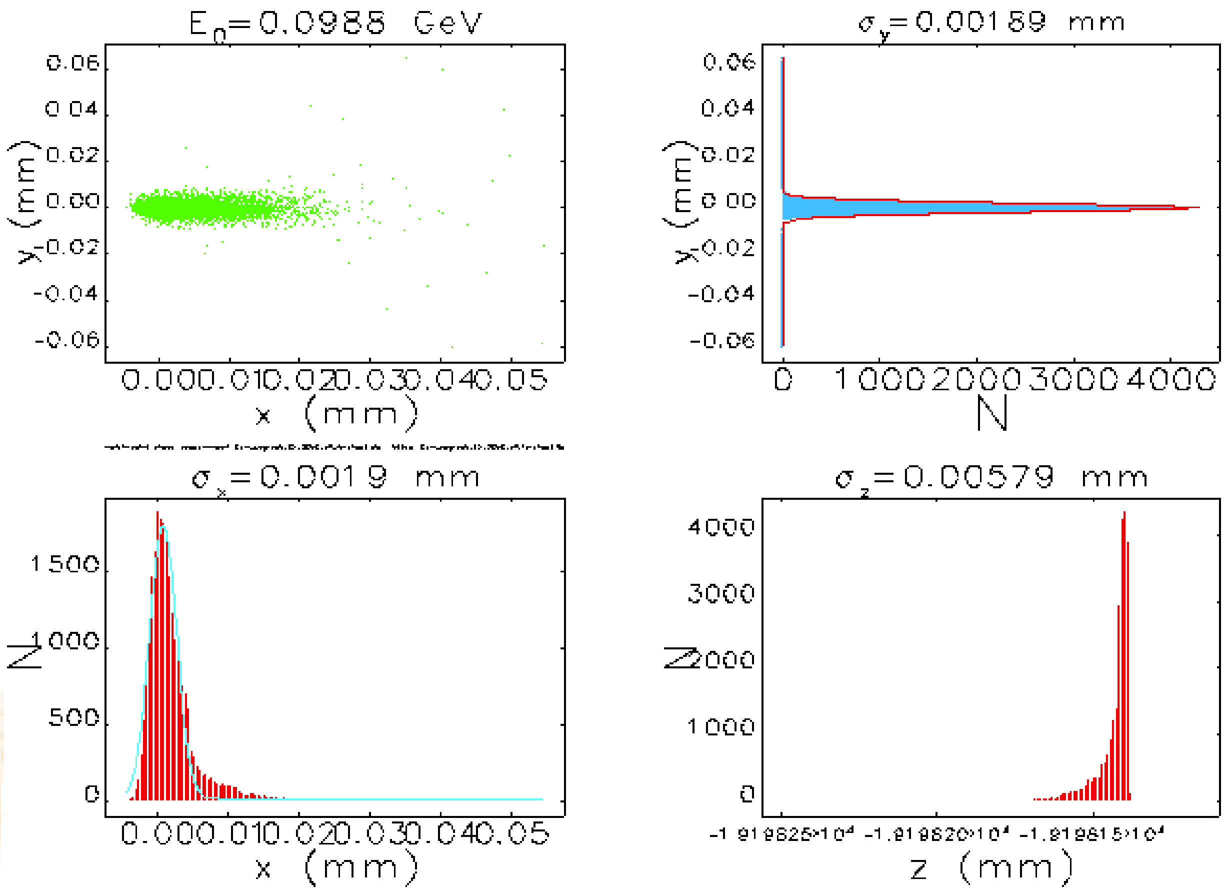
- test and characterize capillaries with different sizes and geometry;
- assess durability;
- gain expertise;
- ...

- determine the guiding method for EXIN

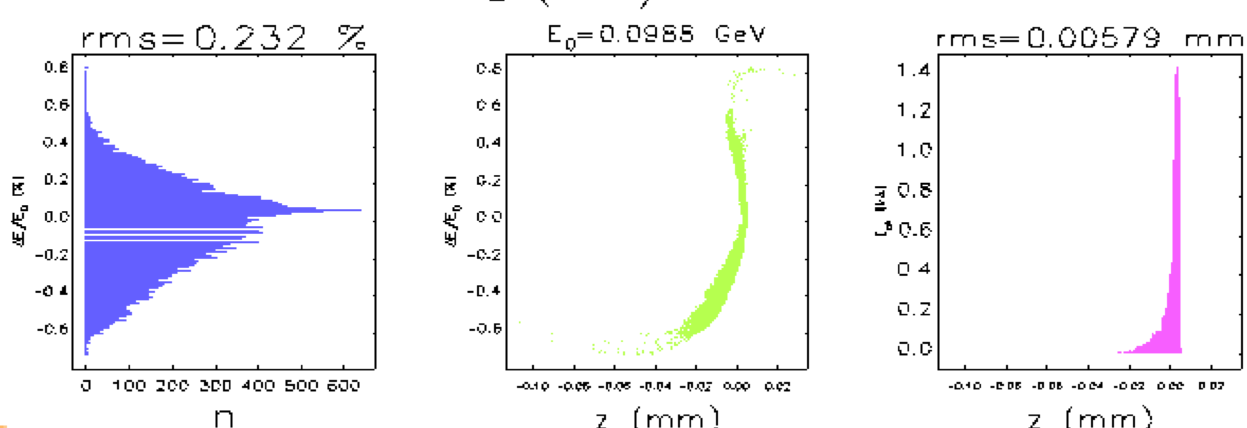
Simulation status: new input beam

- Energy ≈ 100 MeV
- Exin: 30 pC, ≈ 2.6 kA

Simulation status: new input beam



NB: Space charge effects to be checked



Simulation status: old output beam

Plasma Phys. Control. Fusion **58** (2016) 034001 (7pp)

Physics Procedia 52 (2014) 90 – 99

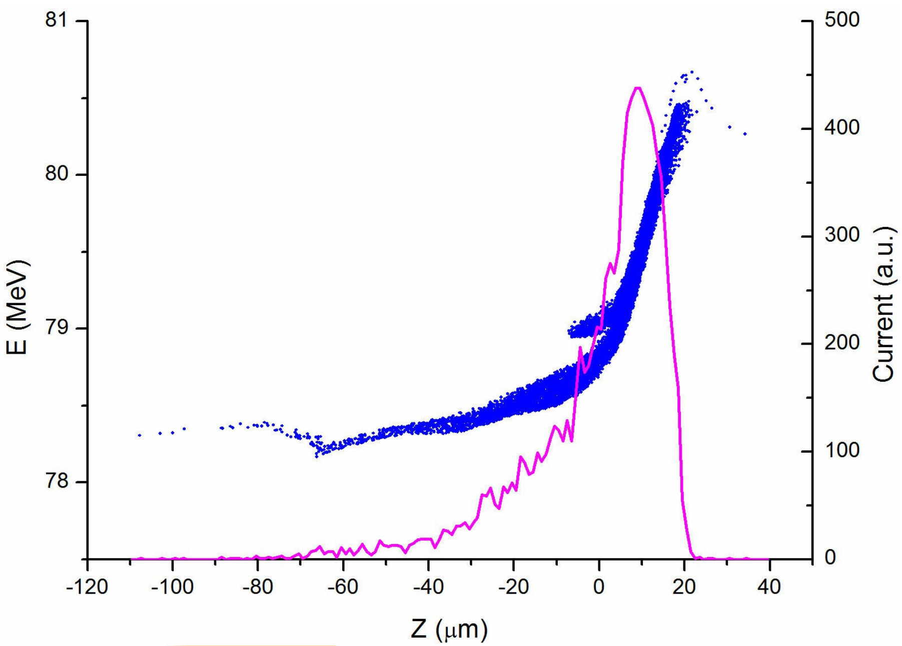
Nuclear Instruments and Methods in Physics Research A 740 (2014) 60–66

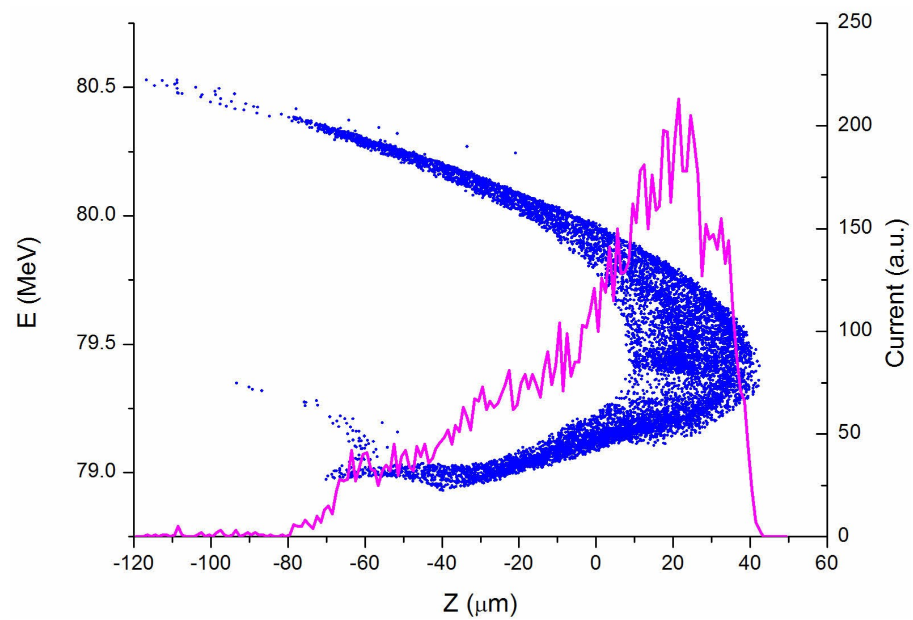
Proceedings of IPAC2012, New Orleans, Louisiana, USA **WEEPPB002**

Latest result: 2015

Before/after dogleg

Before dogleg		After dogleg
$\sigma_x \approx 580\ \mu m$	needs strong focussing down to few μm (needs numerical demonstration)	$\sigma_x \approx 370\ \mu m$ But not in focus …
$\varepsilon_{nx} \approx 1.4\ \mu m$ => OK!	Needs improvement <=	$\varepsilon_{nx} \approx 6.3\ \mu m$
$E \approx 80$ MeV => OK!	OK! <=	$E \approx 80$ MeV
$\Delta\gamma/\gamma \approx 0.7$ % => OK?	OK! <=	$\Delta\gamma/\gamma \approx 0.5$ %
$\sigma_z \approx 16\ \mu m$ (r.m.s.) $l_z \approx 16\ \mu m$ (FWHM)	$l_z \approx 36\ \mu m$ (FWHM.)	$\sigma_z \approx 28\ \mu m$ (r.m.s.)

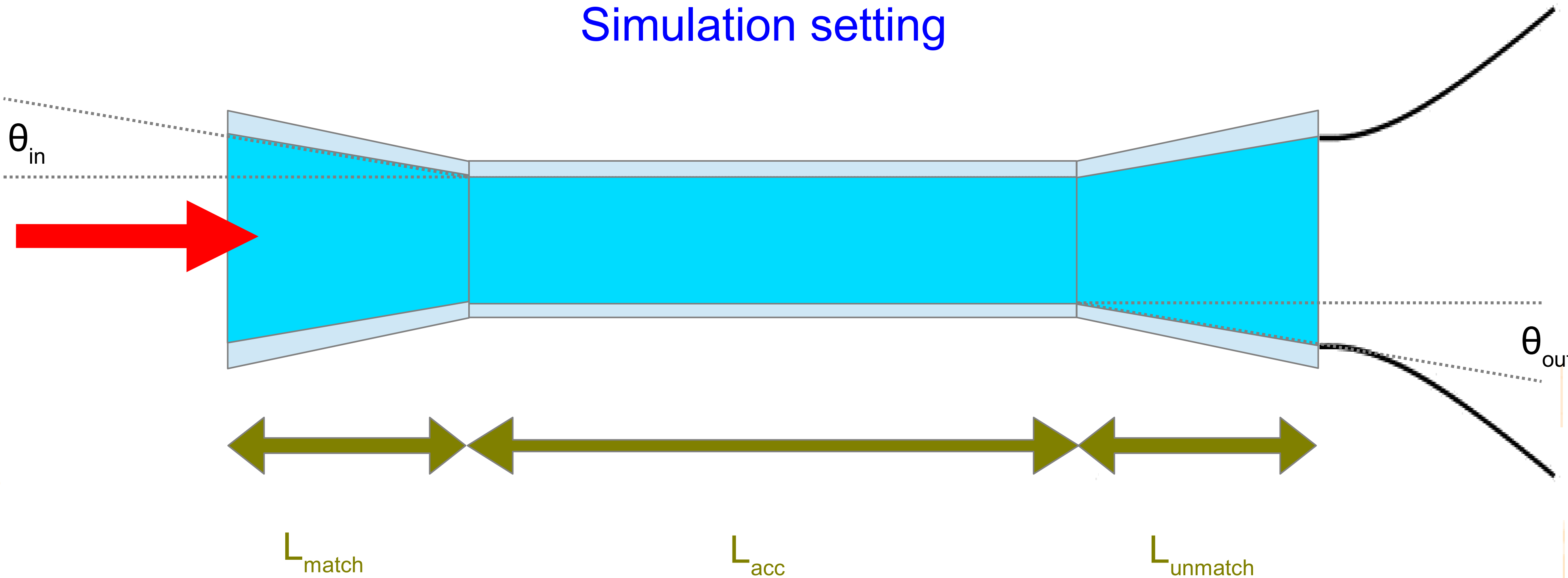




* simulations by R. Pompili

Latest result: 2015

Simulation setting



New parameters must be scanned in order to find good matching/unmatching conditions, together with bunch initial transverse size. Also the shape of capillary tips could be investigated.

The input bunch is RP bunch with half length 20 pC charge and around 1% transverse size

Latest result: 2015

Final beam

$\varepsilon_{nx} \approx 2.4\ \mu m$

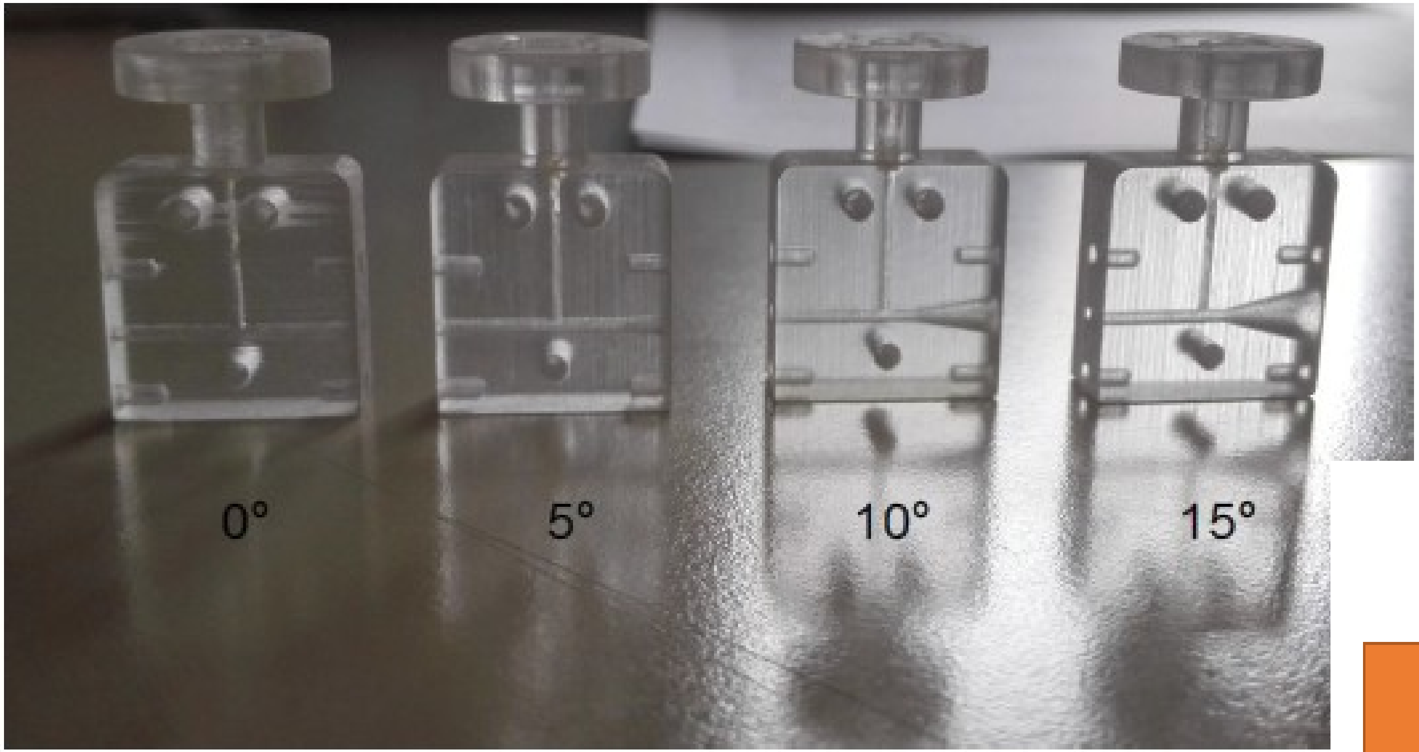
$E \approx 260$ MeV

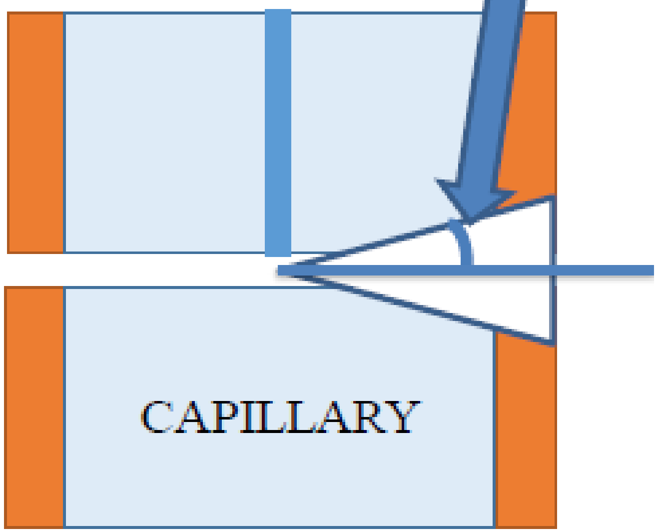
$q \approx 12$ pC

$Ez \approx 3.8$ GV/m

$\Delta\gamma/\gamma \approx 0.8\ \%$

Capillary lab

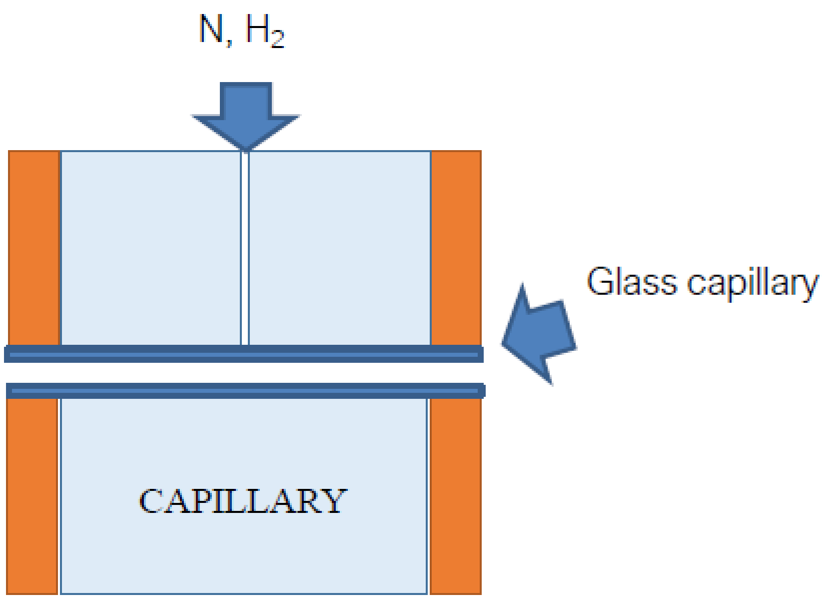




E. Brentegani is taking care of theory/simulation aspect.

Capillary lab

We are also investigating the possibility to use glass capillaries (routinely produced at LNF)



- Less prone to ablation
- More reliable inner shape for lower radius
- Holder can still be printed

We are still working on the mechanical criticity of the glass capillary (hard to make holes for gas filling).

Next experimental campaign in Plasma Lab (no laser time machine)
Until next March

I personally think this activity should be strongly supported with at least 1 more dedicated h.r.