γ-Ray Emitter from Self-Injected (Staged) Thomson Scattering
γ-RESIST

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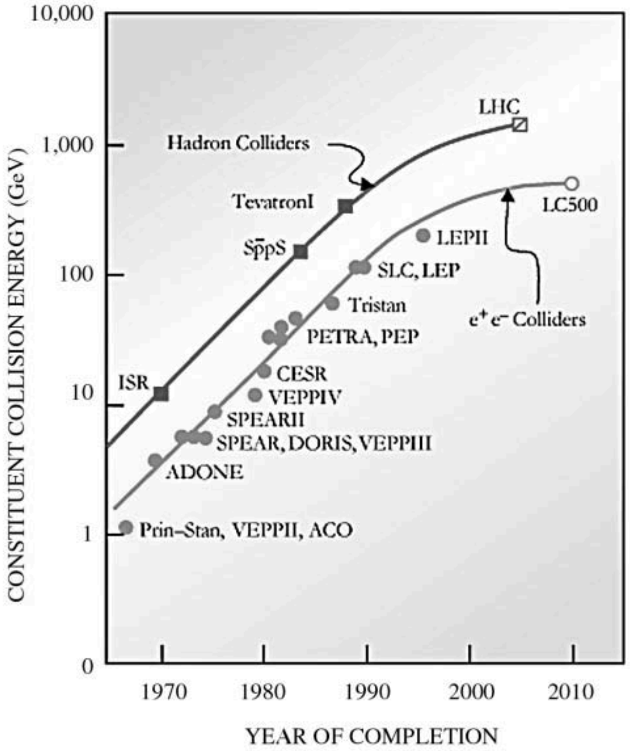
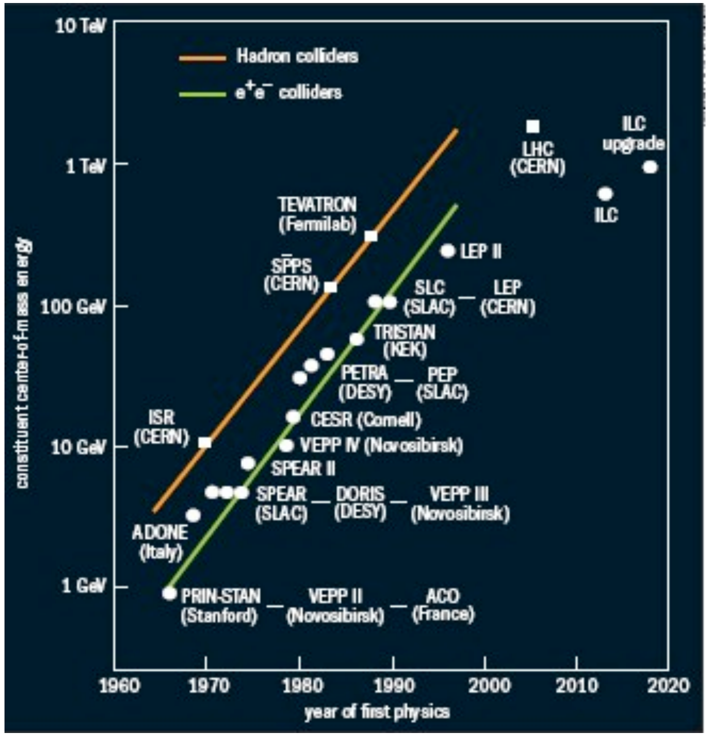
Contents

- Motivations and background (Plasma acceleration);
- Link with activities at LNF (PLASMON-X, Thomson …);
- Objective of γ-*RESIST*;
- Proposed experiments @ FLAME;
- Resources needed

RF accelerators



Ralph W. Aßmann, "Review of Ultra-High Gradient Acceleration Schemes", EPAC 2002



SCIDac Review (DOE): Web site - http://www.scidacreview.org/0601/html/accelerator.html

A possible future alternative: plasmas

T. Tajima and J.M. Dawson, Phys. Rev. Lett. 43, 267 (1979).

Plasma acceleration schemes

LASER INDUCED WAKEFIELDS

Self-Injection: ultra-high gradient (>50 GeV/m), ultrashort bunch (≈fs), high energy spread, strong betatron oscillations, emittance increases rapidly upon exit from the plasma; (S.P.D. Mangles et al., Nature, 431, 535 (2004); C.G.R. Geddes et al., Nature, 431, 538 (2004); J. Faure et al., Nature, 431, 541 (2004));

External injection: inject LINAC bunches into electron plasma wave; low density required to match bunch length => moderate acceleration gradient (≈ GeV/m);

BEAM INDUCED WAKEFIELDS

Use electron bunches to drive wakefields; comb-like LINAC operation allows a witness bunch to gain energy at the expenses of the preceeding bunches; moderate acceleration gradients (*Blumenfeld et al.,* **Energy doubling of 42 GeV electrons in a metre-scale plasma wakefield accelerator,** Nature 445, 741-744 (15 February 2007).

Towards higher quality beams

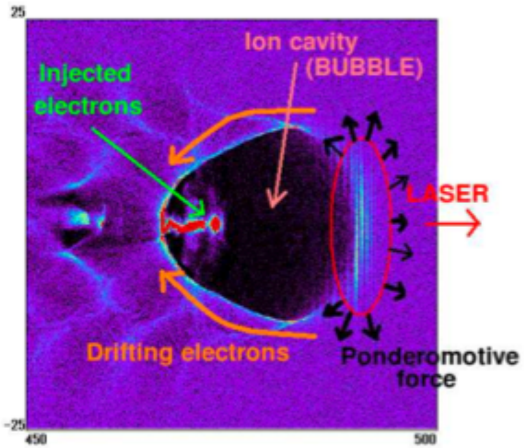
Ultrashort, ultraintense laser pulses can drive a new, highly non linear regime with a powerful injection mechanism that leads to a reduced energy spread.

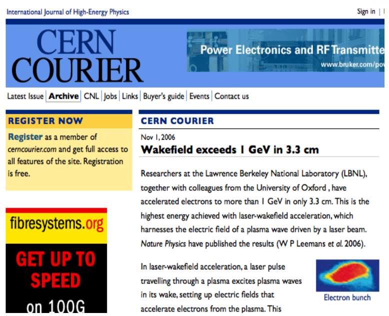
S.P.D. Mangles et al., Nature, 431, 535 (2004); C.G.R. Geddes et al., Nature, 431, 538 (2004); J. Faure et al., Nature, 431, 541 (2004);

Since 2004, systematic production of electron bunches with energy in the hundreds of MeV range and moderate energy spread (5-10%):

- Y. Miura, Appl. Phys. Lett. 86, 251501 (2005)
- C.T. Hsieh, Phys. Rev. Lett. 96, 095001 (2006)
- B. Hidding, Phys. Rev. Lett. 96, 105004 (2006)
- T. Hosokai, Phys. Rev. E 73, 036407 (2006)
- A. Giulietti et al., Phys. Rev. Lett. 101, 105002 (2008)

and many, many more …




International Journal of High-Energy Physics

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Nov 1, 2006

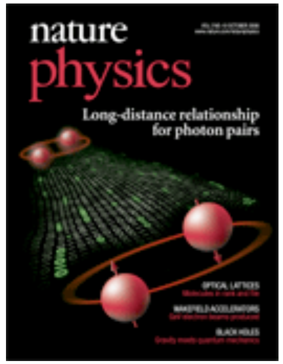
Wakefield exceeds 1 GeV in 3.3 cm

Researchers at the Lawrence Berkeley National Laboratory (LBNL), together with colleagues from the University of Oxford, have accelerated electrons to more than 1 GeV in only 3.3 cm. This is the highest energy achieved with laser-wakefield acceleration, which harnesses the electric field of a plasma wave driven by a laser beam. *Nature Physics* have published the results (W P Leemans *et al.* 2006).

In laser-wakefield acceleration, a laser pulse travelling through a plasma excites plasma waves in its wake, setting up electric fields that accelerate electrons from the plasma. This

Electron bunch

Most recent results from LBL LOASIS group: 1 GeV



"GeV electron beams from a cm-scale accelerator," by W. P. Leemans, B. Nagler, A. J. Gonsalves, Cs. Toth, K. Nakamura, C.G.R. Geddes, E. Esarey, C.B. Schroeder, and S.M. Hooker, October 2006 issue of Nature Physics.

EMERGING STRATEGIES

- Laser-plasma acceleration: perspective
  - Long Term: TeV collider (e.g. "BELLA" project@LBNL, ELI …);
  - Medium term: FEL, Sorgenti X/γ (RAL, LOA, Saclay, Strathclyde and many more;
- Major developments required for accelerators;
  - Laser technology: DPSSL, Fiber laser
  - Target development: jet, cell;
  - Injection control: ionisation, shaping, tunability;
  - Staging: external injection of self injected bunches;

EuCARD, *EuroNNAc* Workshop, CERN, 3 - 6 May'11 (03-06 May 2011)

Our previous work

Pisa ILIL group

Our previous work

LASER-PLASMA ACCELERATION AND RELATED PUBLICATIONS – PRECURSOR ACTIVITY (BEFORE PLASMONX)

•L.A.Gizzi, D.Giulietti, A.Giulietti, P.Audebert, S.Bastiani, J.P.Geindre, A.Mysyrovicz, *Simultaneous measurements of hard X-rays and 2nd harmonic emission in fs laser-target interactions ,* Phys. Rev. Lett. **76** , 2278 (1996).

• L.A.Gizzi, M.Galimberti, A.Giulietti, D.Giulietti, P. Tomassini, M. Borghesi, D.H. Campbell, A. Schiavi, O. Willi, *Relativistic laser interactions with preformed plasma channels and gamma-ray measurements* , Laser and Part. Beams **19** , 181 (2001) D. Giulietti, M. Galimberti, A. Giulietti, L. A. Gizzi, F. Balcou, A. Rousse, J. Ph. Rousseau, M.Borghesi, *High-energy electron beam production by femtosecond laser interactions with exploding-foil plasmas* , Phys. Rev. E **64**, 015402 (R) (2001)

•D. Giulietti, M. Galimberti, A. Giulietti, L.A. Gizzi and P. Tomassini, M. Borghesi, V. Malka and S. Fritzler, M. Pittman and K. Taphouc, *Production of ultra-collimated bunches of multi-MeV electrons by 35-fs laser pulses propagating in exploding-foil plasmas ,* Letter on Phys. Plasmas **9**, 3655 (2002).

•P. Tomassini, A. Giulietti, L.A. Gizzi, R. Numico, M. Galimberti, D. Giulietti, M. Borghesi, *Application of novel techniques for interferogram analysis to laser-plasma femtosecond probing,*Laser and Part. Beams,**20**, 195 (2002).

•L.A.Gizzi, C.A.Cecchetti, M.Galimberti, A.Giulietti, D.Giulietti, L.Labate, S.Laville, P.Tomassini, *Transient ionization in plasmas produced by point-like irradiation of solid Al targets* , Phys. Plasmas **10** 4601 (2003)

•P. Tomassini, M. Galimberti, A. Giulietti, D. Giulietti, L.A. Gizzi, L. Labate, *Spectroscopy of laser-plasma accelerated electrons: a novel concept based on Thomson scattering,* Phys. Plasmas **10** 917 (2003)

•P. Tomassini, M. Galimberti, A. Giulietti, D. Giulietti, L.A. Gizzi, L. Labate, F. Pegoraro, *Production of high-quality electron beams in numerical experiments of laser wakefield acceleration with longitudinal wave breaking,* Phys. Rev. ST - Accelerators and Beams **6** 121301 (2003)

•P. Tomassini, M. Galimberti, A. Giulietti, D. Giulietti, L.A. Gizzi, L. Labate, F. Pegoraro, *Laser Wake Field Acceleration with controlled self-injection by sharp density transition,* Laser Part. Beams **22**, 423 (2004)

•P.Squillacioti, M.Galimberti, L.Labate, P.Tomassini, A.Giulietti, V.Shibkov, F.Zamponi, *Hydrodynamics of microplasmas from thin foils exploded by picosecond laser pulses*, Phys. Plasmas **11** 226 (2004)

•M. Galimberti, A. Giulietti, D. Giulietti, L.A. Gizzi, *SHEEBA: a spatial high energy electron beam analyzer* Rev. Sci. Instrum. **76**, 053303 (2005)

•P. Tomassini, A. Giulietti, D. Giulietti, L.A. Gizzi, *Thomson Backscattering X-rays from ultrarelativistic electron bunches and temporally shaped laser pulses* Appl. Phys. B **80**, 419-436 (2005)

•L.A. Gizzi, M. Galimberti, A. Giulietti, D. Giulietti, P. Köster, L. Labate, P. Tomassini, Ph. Martin, T. Ceccotti, P. D'Oliveira, P. Monot, *Femtosecond interferometry of propagation of a laminar ionization front in a gas*, Phys. Rev. E, **74**, 036403 (2006).

•Giulietti, P. Tomassini, M. Galimberti, D. Giulietti, L.A. Gizzi, P. Köster, L. Labate, T. Ceccotti, P. D'Oliveira, T. Auguste, P. Monot, Ph. Martin, *Pre-pulse effect on intense femtosecond laser pulse propagation in gas*, Phys. Plasmas, **13**, 093103 (2006)

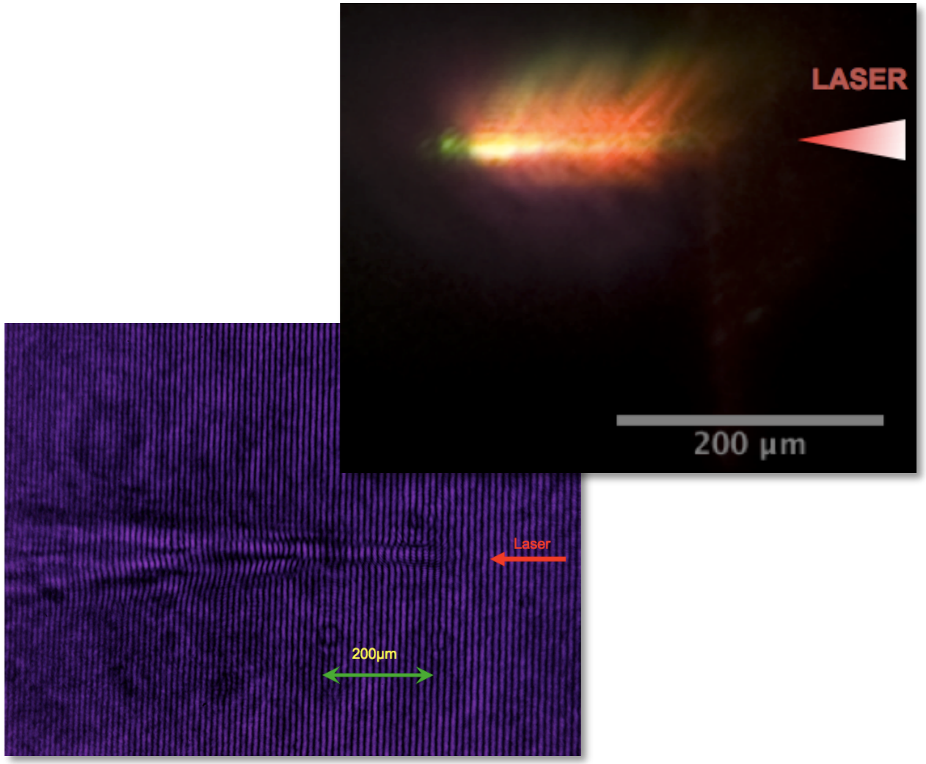
•A. Gamucci, M. Galimberti, D. Giulietti, L.A. Gizzi, L. Labate, C. Petcu, P. Tomassini, A. Giulietti, *Production of hollow cylindrical plasmas for laser guiding in acceleration experiments*, Appl. Phys. B **85**, 611-617 (2006)

•T. Hosokai, K. Kinoshita, T. Ohkubo, A. Maekawa, M. Uesaka, A. Zhidkov, A. Yamazaki, H. Kotaki, M. Kando, K. Nakajima, S. Bulanov, P. Tomassini, A. Giulietti, D. Giulietti, *Observation of strong correlation between quasimonoenergetic electron beam generation by laser wakefield and laser guiding inside a preplasma cavity*, Phys. Rev. E **73**, 036407 (2006)

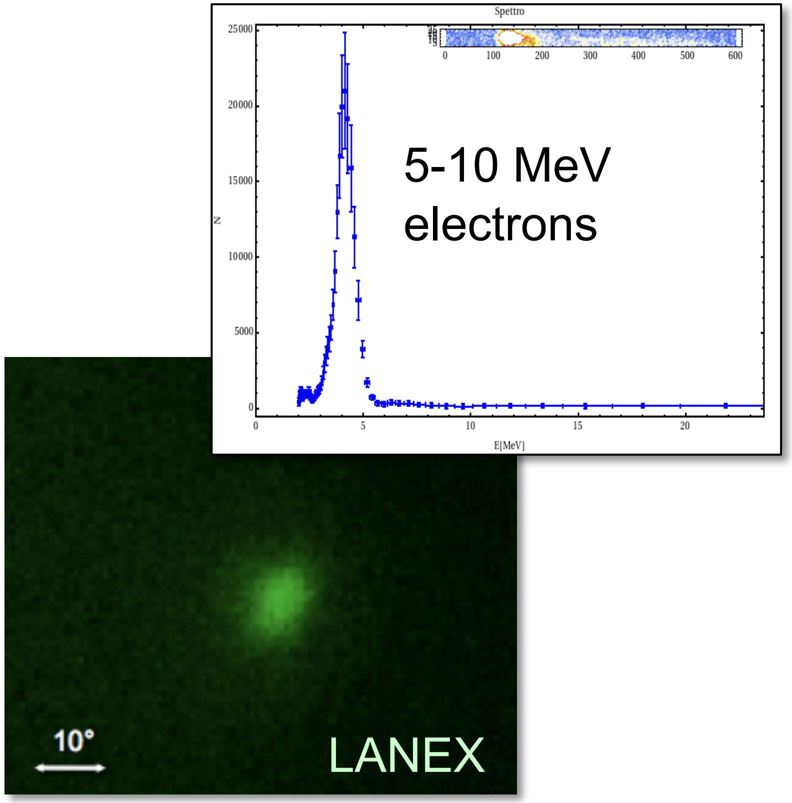
•A. Giulietti, M. Galimberti, A. Gamucci, D. Giuliettia, L.A. Gizzi, P. Koester, L. Labate, P. Tomassini, T. Ceccotti, P. D'Oliveira, T. Auguste, P. Monot and P. Martin, *Search for stable propagation of intense femtosecond laser pulses in gas*
Laser Part. Beams **25**, 513-521 (2007).

(2008) ELECTRON BEAM at <u>TW level</u>

TS and interferometry show self-guiding



Electron bunch from He



- Acceleration regime compatible with laboratory bio-medical applications;
- Rep-rated operation required to enable dose comparison with hostpital LINACs.
- Upgrade in progress to reach IORT energy range 15-30 MeV.

RELATED ACTIVITIES AT LNF

- **PLASMONX (& THOMSON)**
  - LASER(FLAME)-LINAC(SPARC) Thomson scattering (2011-2012) -> BEATS
  - External injection of LINAC Bunches into Laser Wakefield (2012- 2013)
- ***SITE*** (Self-injection Test Experiment)
  - Dedicated to validation of FLAME performance;
    - Partially completed
    - Last run planned summer 2011
- **COMB**
  - Plasma acceleration with particle wakefield
- **LILIA**, **TERASPARC …**

PLASMONX project

PLASma acceleration and MONochromatic X-ray radiation

COMBINING THE HIGH BRIGHTNESS LINAC ACCELERATOR OF THE *SPARC* PROJECT WITH AN ULTRA-SHORT, HIGH ENERGY, >250TW *FLAME* LASER.

Scheduled activity:

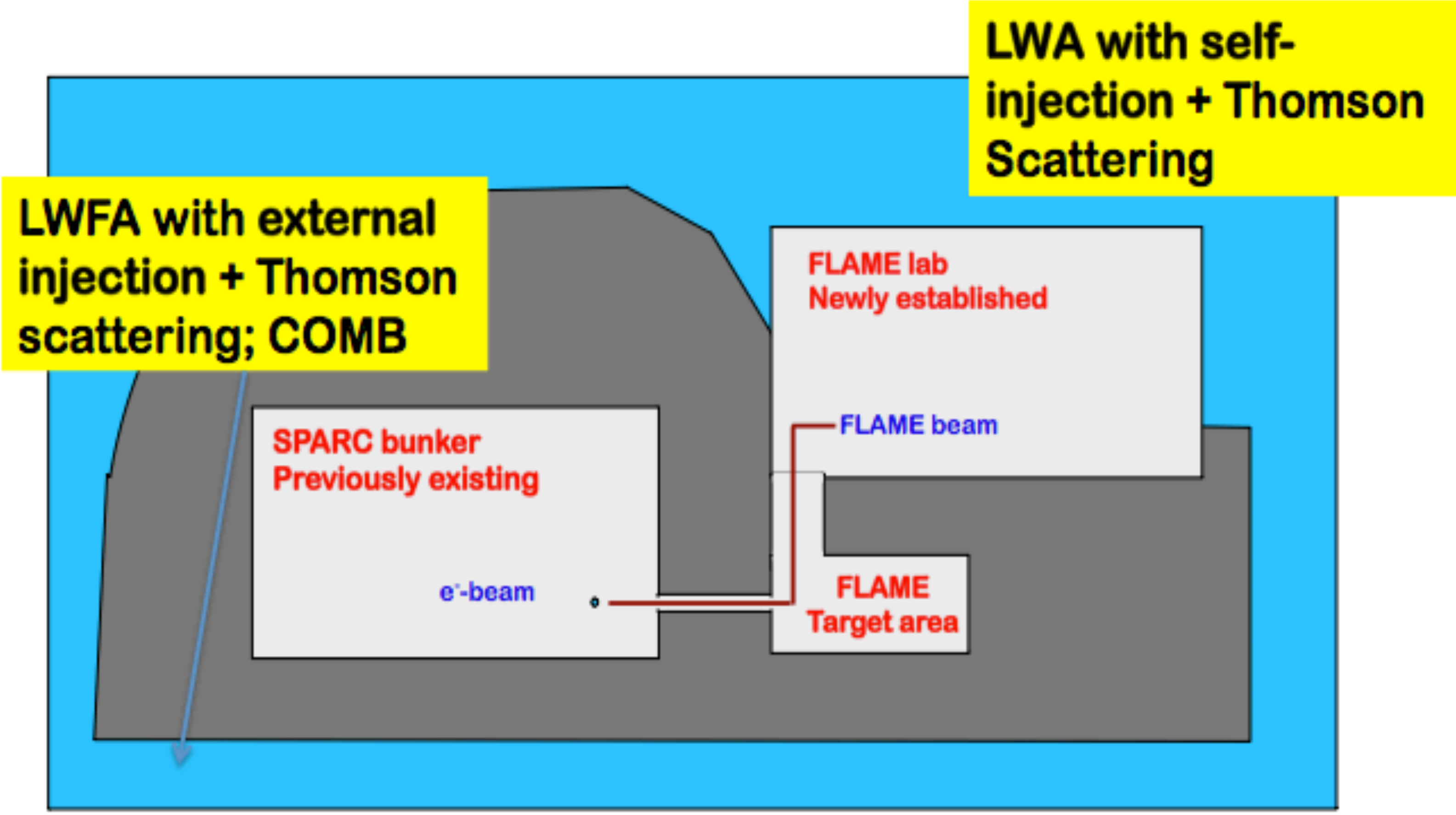
• Linear and Nonlinear Thomson scattering X/γ-ray sources: backscattering of the laser pulse on both LINAC e-beams and LWFA e-beams;

•LWFA with both **externally** injected and **self-injected** beams;

• Intense laser-matter interactions, proton acceleration.

LINAC - LASER AREA AT LNF-FRASCATI

A dedicated area for LINAC and LASER combined operations

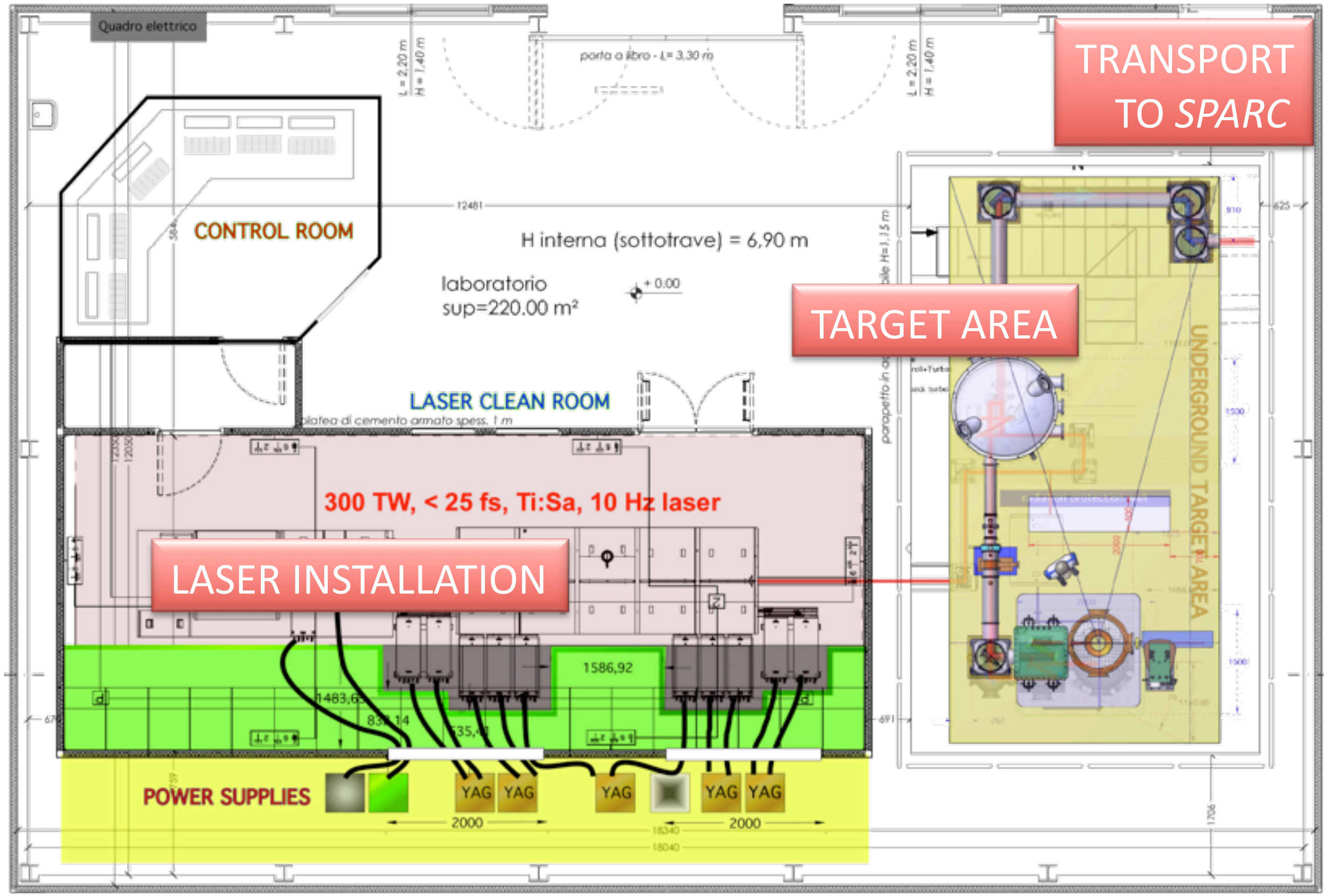


FLAME – A NEW LASER INSTALLATION

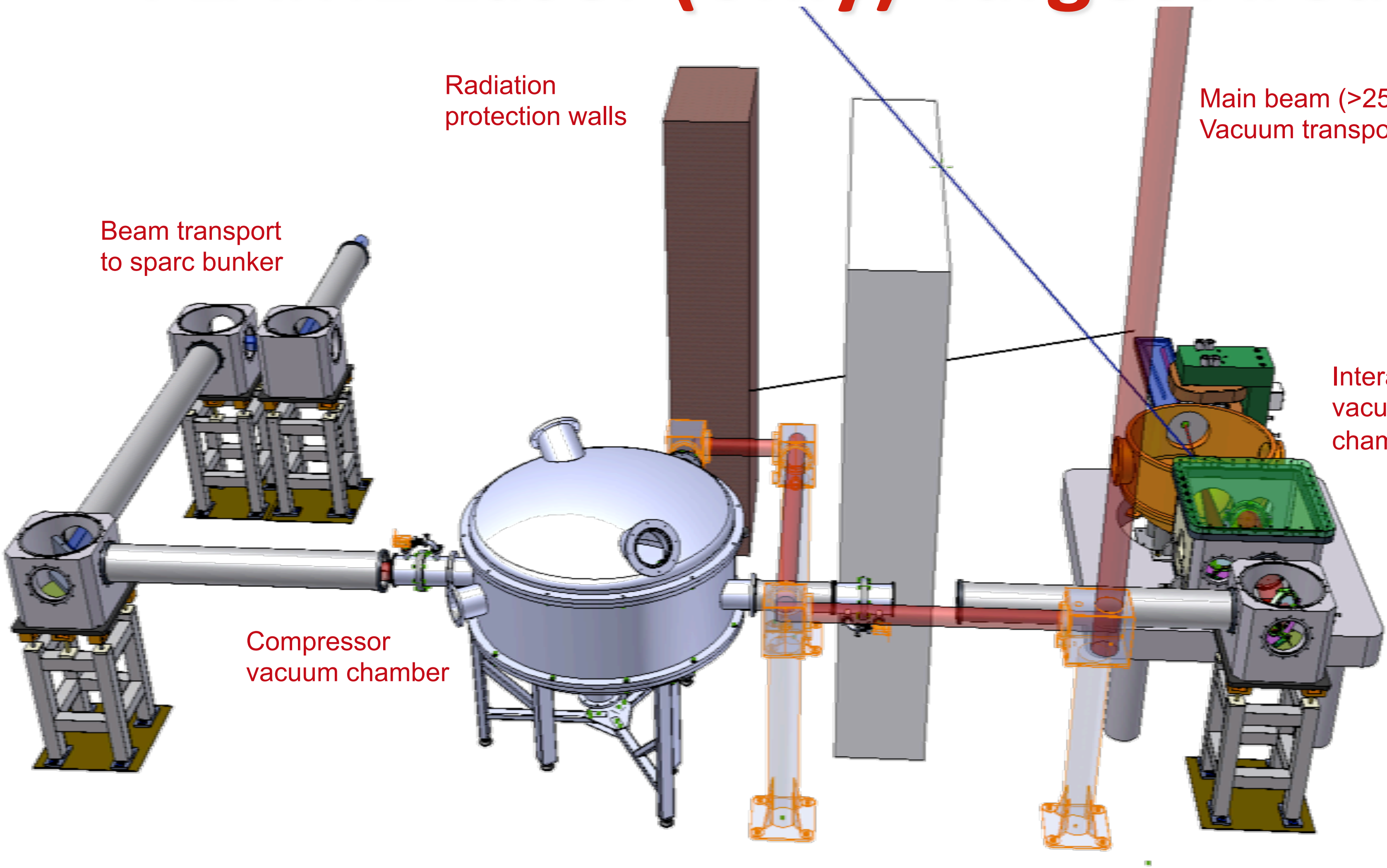
Frascati Laser for Acceleration and Multi-disciplinary Experiments

FLAME LAB: OVERVIEW

LAB INCLUDES *LASER*, RADIOPROTECTED *TARGET AREA* FOR LASER-TARGET EXPERIMENTS AND TRANSPORT OF LASER TO SPARC FOR LASER-LINAC OPERATION

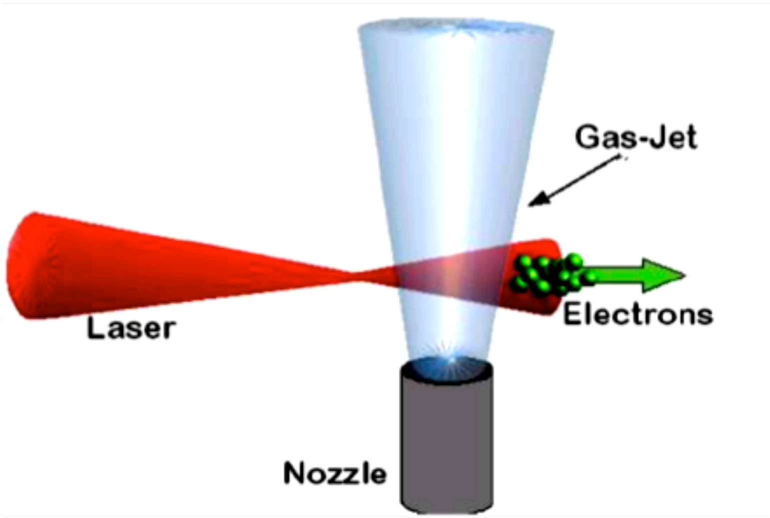


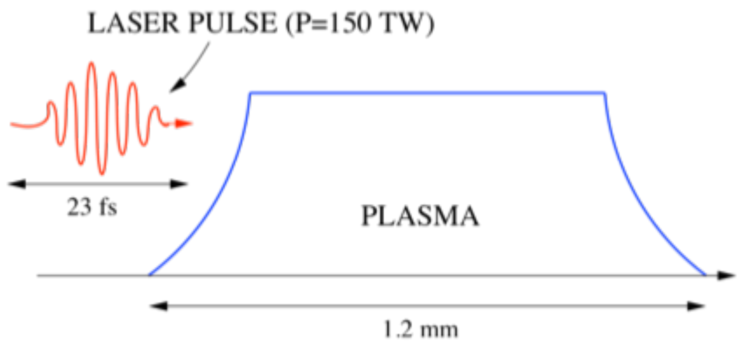
FLAME Laser (only) Target Area



FLAME test experiment on Self-injection

- (Half power) FLAME laser
  - P =150 TW, $\tau_{fwhm} = 24$ fs
  - waist: $w_0 = 8 \div 40$ ($1/e^2$ radius of the laser intensity profile, $w_{fwhm} \simeq 1.2\, w_0$)
  - norm. vector potential $a_0 \equiv \frac{eA_{laser}}{mc^2} = 8.5 \cdot 10^{-10} \sqrt{I[\text{W/cm}^2](\lambda[\mu\text{m}])^2} \geq 2$





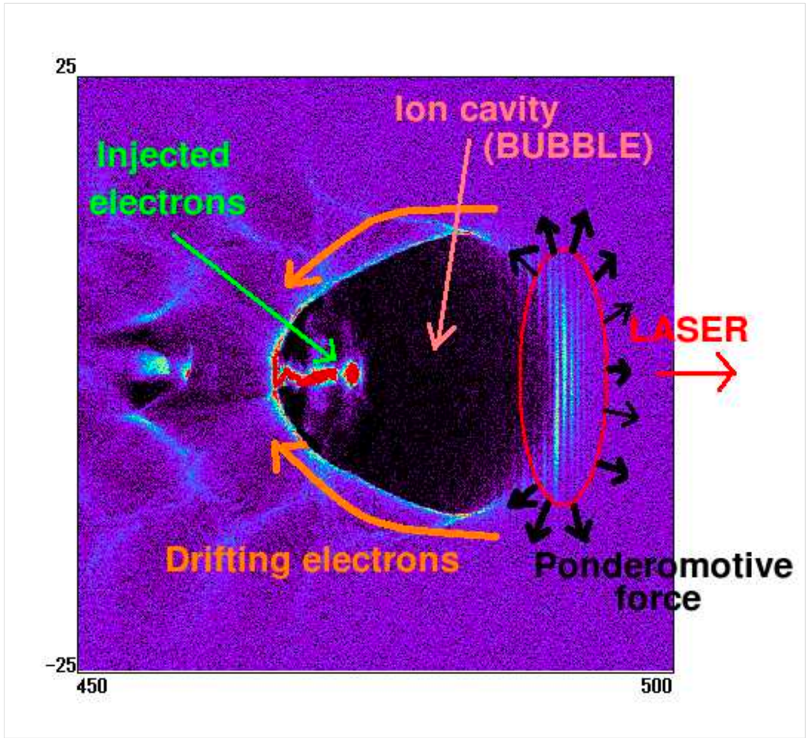
- Two regimes:

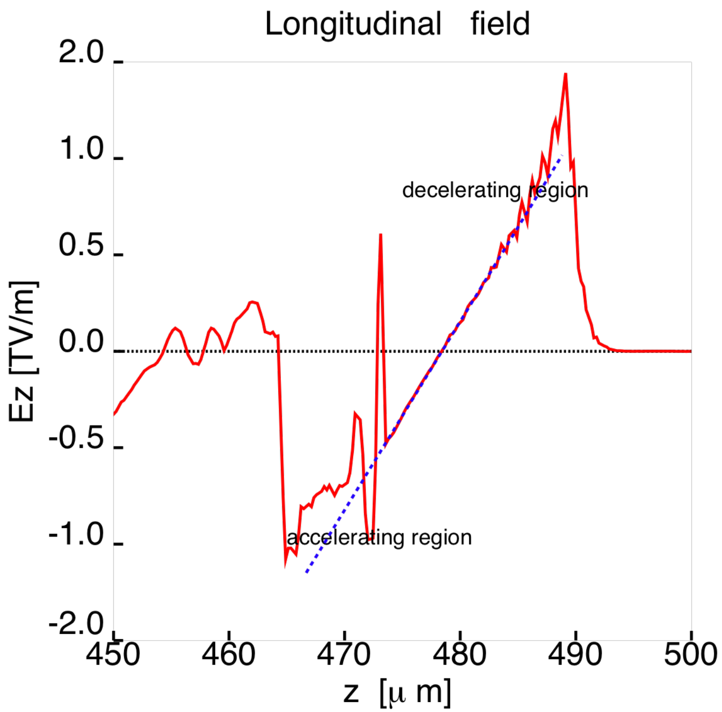
1. $w_0 < \lambda_p \Rightarrow$ **Nonlinear 3D regime (bubble)**
2. $w_0 > \lambda_p \Rightarrow$ **Nonlinear "1D-like" regime** (+ properly modulated gas-jet)

SIMULAZIONI self-injection

(di C. Benedetti et al.,)

- **Nonlinear 3D regime (bubble)** [a]





- $R_{bub} \simeq O(\lambda_p)$ $\quad E_z^{(max)} \simeq 100\sqrt{n_0[\text{cm}^{-3}]} \times a_0$ [V/m]

- $\begin{cases} v_{elect} \simeq c \\ v_{bub} \simeq c(1 - 3\omega_p^2/(2\omega_0^2)) < v_{elect} \Rightarrow \text{acc. length is finite + monochromaticity} \end{cases}$

[a] S. Gordienko and A. Pukhov, Phys. Plas. 12 (2005) / W. Lu *et al.* PRSTAB 10 (2007)

S.I.T.E. acceleration Goal

INPUT parameters

$L_{gasjet} = 4$ mm

$n_e = 3\ 10^{18}$ W/cm^3

$\tau = 30$ fs

$I_0 = 5.2\ 10^{19}$ W/cm^2

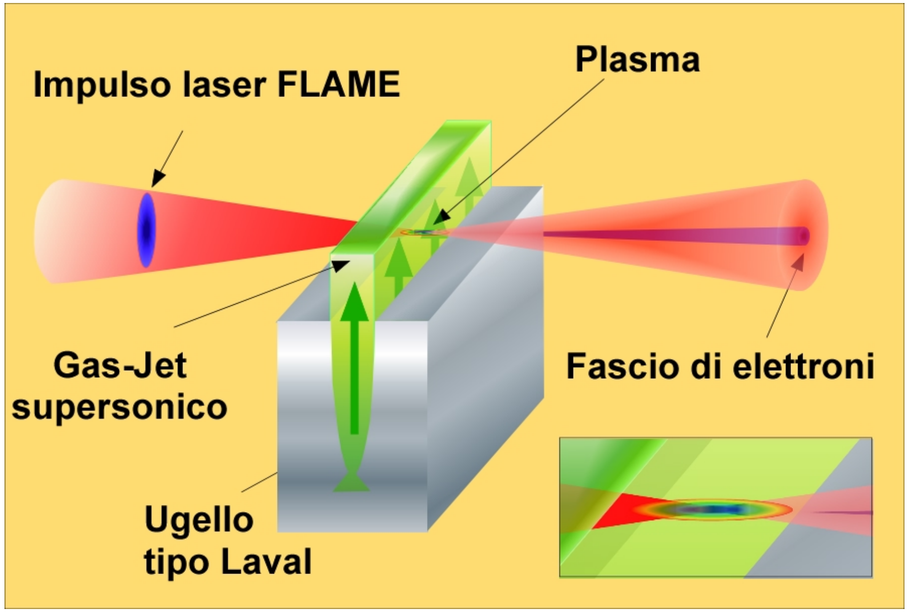
$w_0 = 16$ μm

Keywords:

Compactness, medium to high energy electrons

Reliability (reproducibility and stability)

Moderate to small energy spread



Expected OUTPUT param.

$E = 900$ MeV

$\Delta E = 3.3$ %

$Q = 0.6$ nC

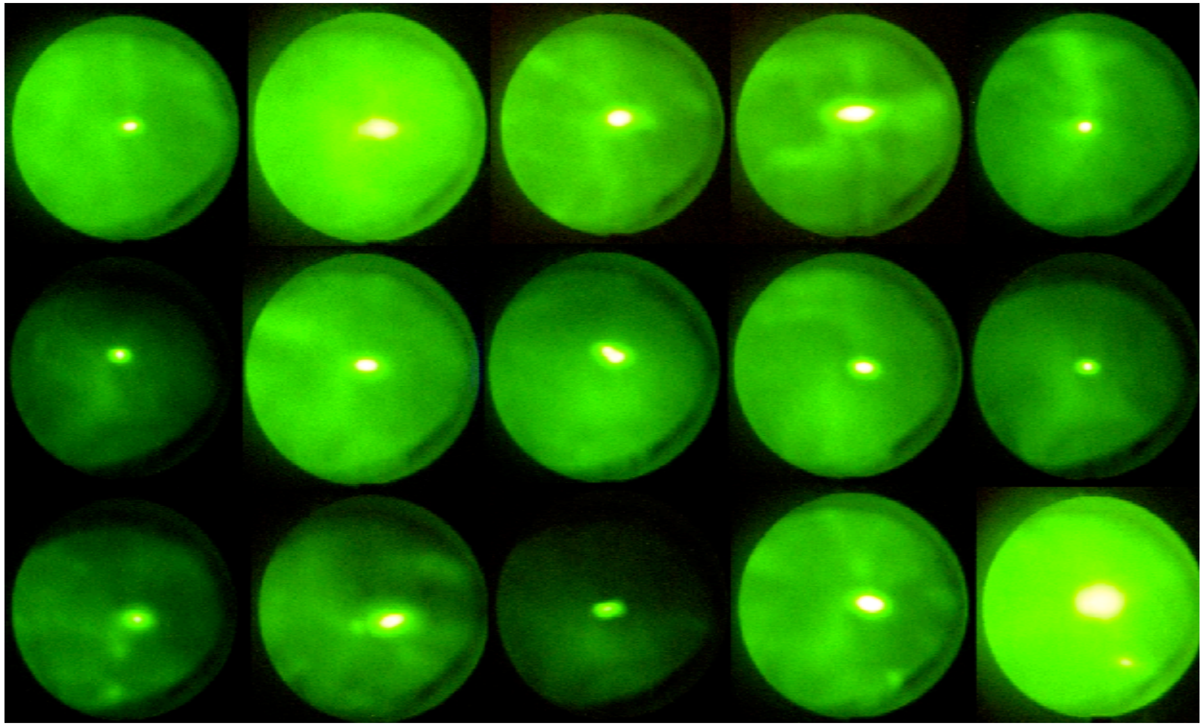
Bunch length = 1.8 μm

Average current = 50 kA

Beam divergence = 2.8 mrad

SITE Experimental results (Dic. 2010)

Highly collimated electron bunches were generated along the laser propagation direction with high reproducibility.



40 mrad

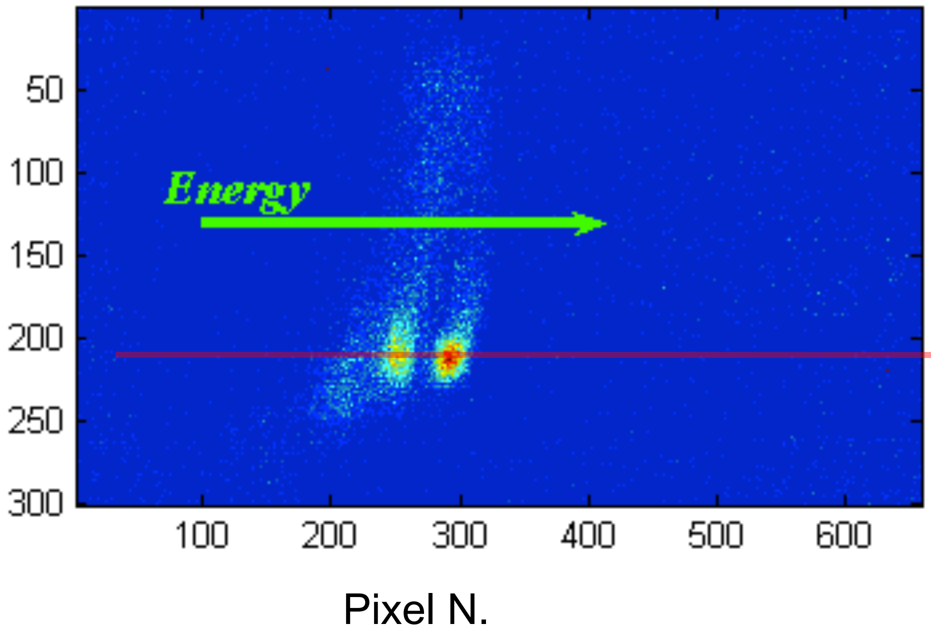
40 mrad

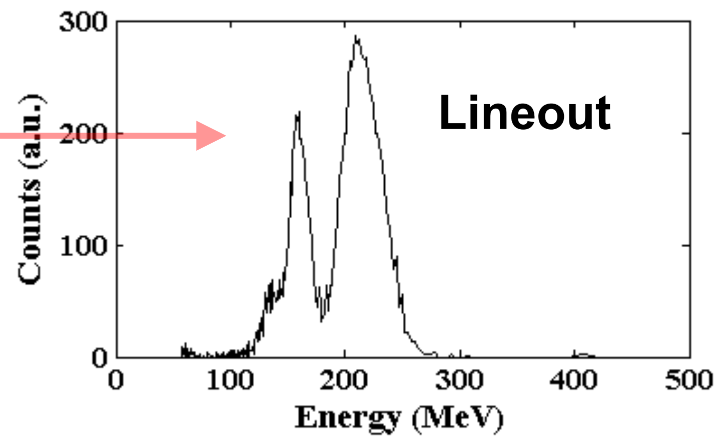
Sample Energy SPECTRUM

Recent spectra acquired at 1 J laser energy on target and 35 fs: expected intensity at focus: 7E18 W/cm2

Energy dispersion with a 0.9 T magnetic dipole

Electrons at lanex screen





Energy of LPA electrons entering the multi 100 MeV range

Self-Injection Test Experiment: preliminary conclusions

- First test run at <50 TW completed successfully;
- Acceleration process established at >100 MeV level;
- Relatively stable production of collimated electrons;
- Next test run at >50 TW planned July 2011;
- Commissioning to be completed by end of 2011.

A new project on laser acceleration with self-injection to be started in 2012 is motivated, mature and and timely.

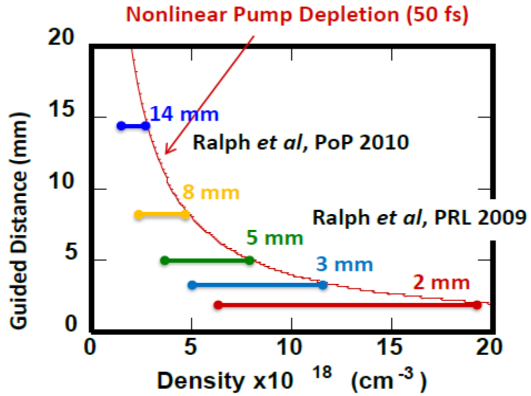
γ-RESIST - Objectives

- Establish a programme on plasma acceleration with self-injection, based upon the successful *SITE* experimental campaign, to:
  - Control Injection and staging for multi-GeV;
  - Demonstrate generation of tuneable γ-ray source for nuclear resonance applications (100 keV- MeV);
  - Explore conditions for experimental confirmation of Landau-Lifshitz equation in *radiation-dominated regime.*

INJECTION CONTROL

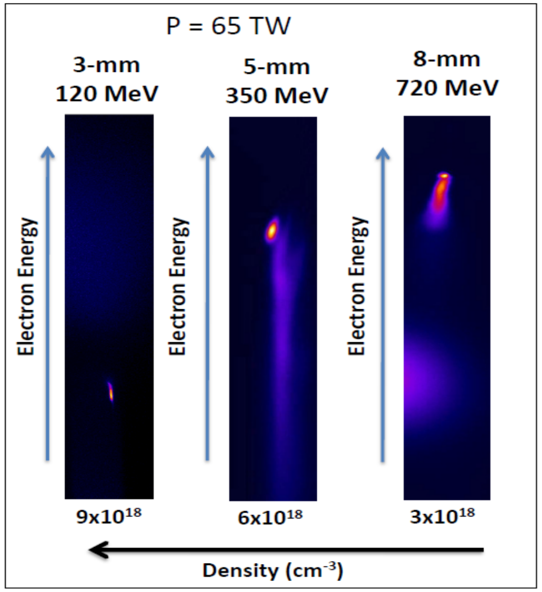
$$\Delta W \propto P^{1/3}(1/n)^{2/3}$$

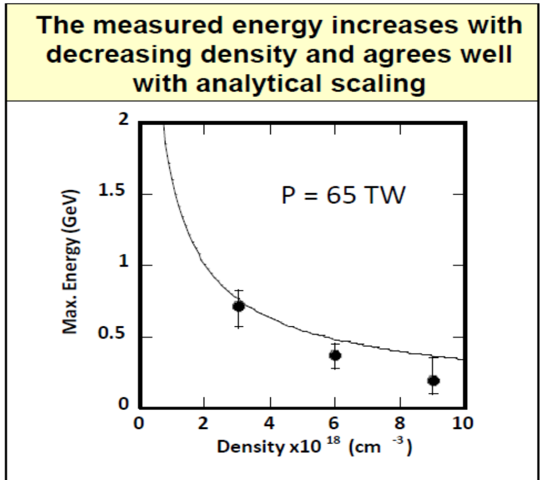
Energy gain increases with lower plasma density as a result of longer accelerating travel...



LLNL

...but is limited:
for self-injection
a minimum plasma
density is required....



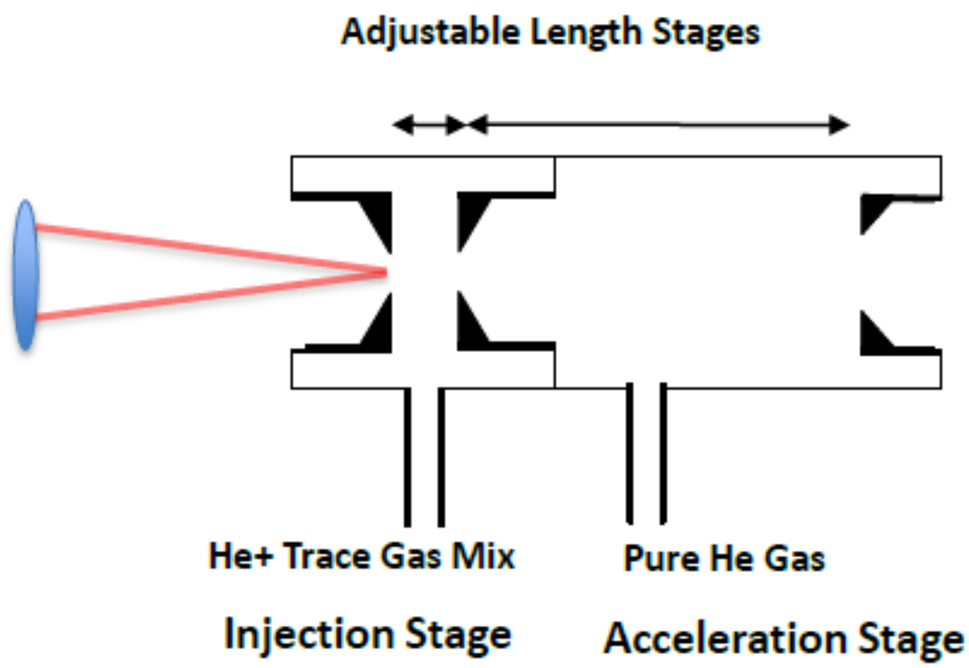


$$E_{\max} = 1.7\left(\frac{P}{100TW}\right)^{1/3}\left(\frac{10^{18}cm^{-3}}{n_e}\right)^{2/3}$$

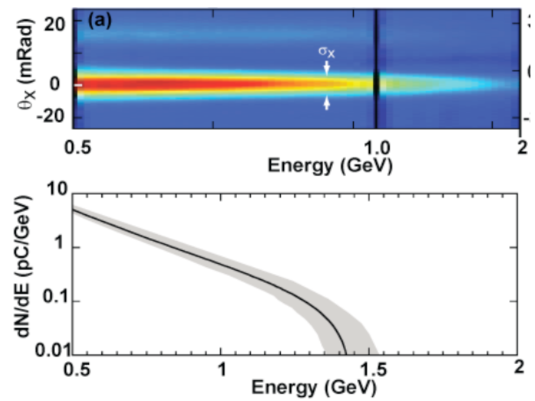
Staging first step:
Decouple Injection and Acceleration

Lower density increase energy gain
but there is a limit needed for
Self-Injecton **!**

Ionization Induced Injection in a separated stage

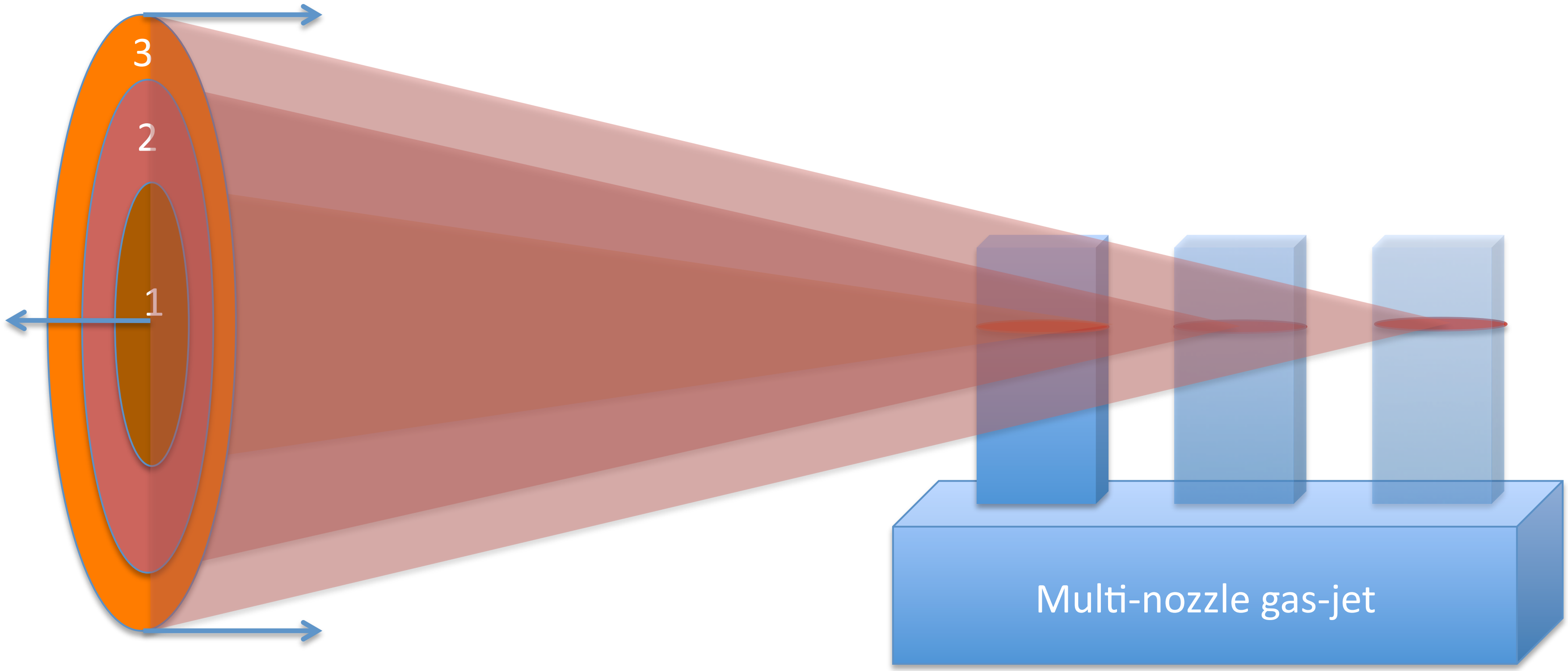


1.5 GeV measured at Callisto laser with 110TW !!



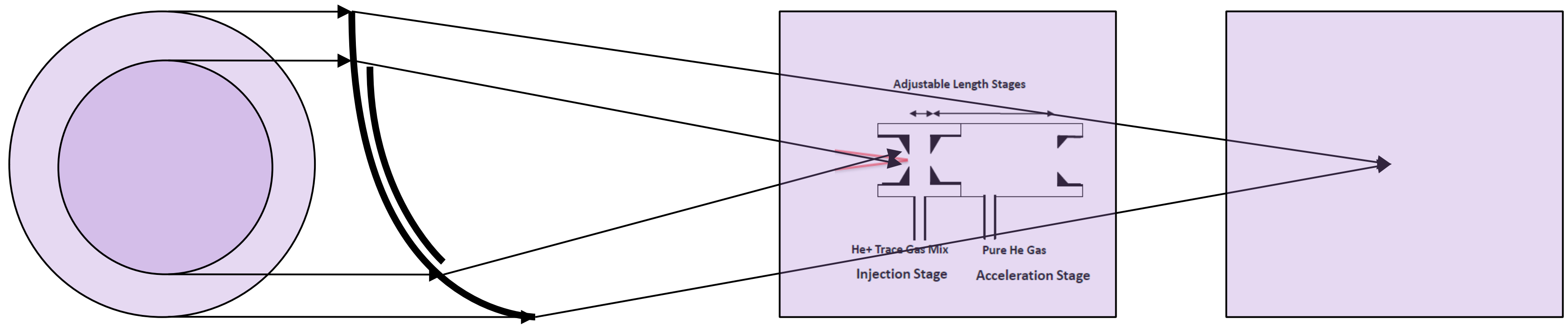
Multi-Staging concept

Custom-made OAP – 1: regular OAP, 2: Annular OAP, 3: Annular OAP
Relative motion along axis to match time of arrival on each gas-jet



Original concept: ILIL, 2010

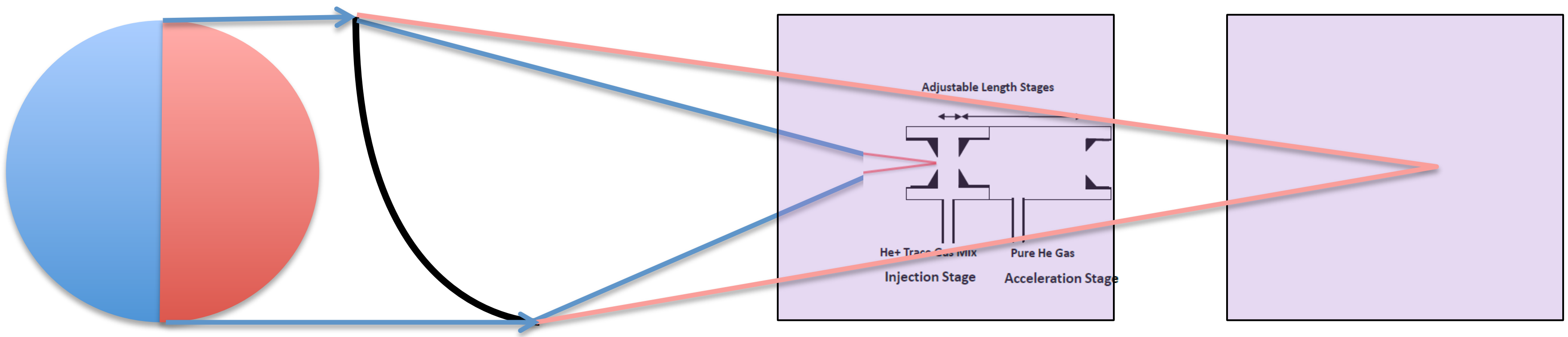
Staging second step: double plasma



Two Concentric Parabolas or Sectors with different focal lenght

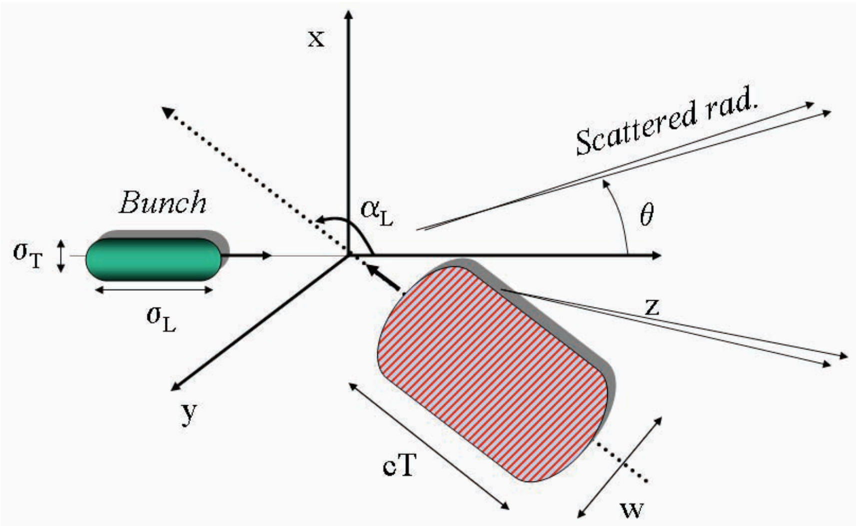
Plasma 1:
Injection + Acceleration1

Plasma 2:
Acceleration only 2



Scaling to n-stage configuration to be investigated

THOMSON Scattering



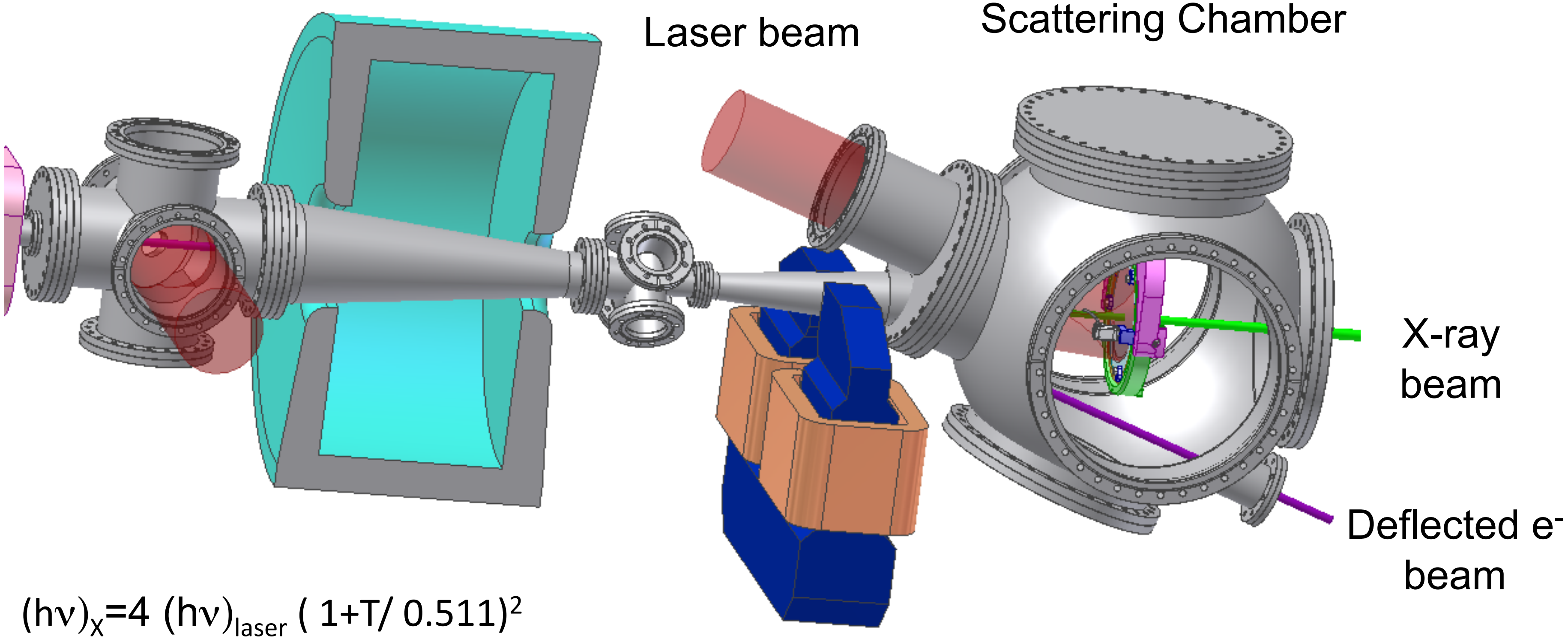
Thomson scattering geometry. The scattered radiation is emitted along the z axis, in a small cone of aperture $1/\gamma_0$.

When $\alpha L = \pi$ the backscattering geometry occurs giving:

i) Radiation with the highest energy $E_{back} \approx 4\gamma^2 E_0$, where E_0 is the energy of laser photons
ii) Best highest overlap of the electron beam and the pulse and
iii) Minimized spurious effects by the transverse ponderomotive forces of the laser.

P. Tomassini, A. Bacci, J. Cary, M. Ferrario, A. Giulietti, D. Giulietti, L.A. Gizzi, L. Labate, L. Serafini, V. Petrillo, C. Vaccarezza
Linear and nonlinear Thomson scattering for advanced X-ray sources in PLASMONX
IEEE Trans. Plasma Science 36, 1782 (2008)

TS INTERACTION REGION AT SPARC



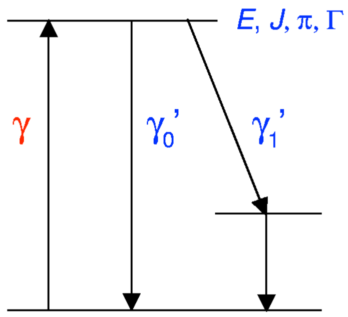
$(h\nu)_X = 4\ (h\nu)_{laser}\ (1+T/\ 0.511)^2$

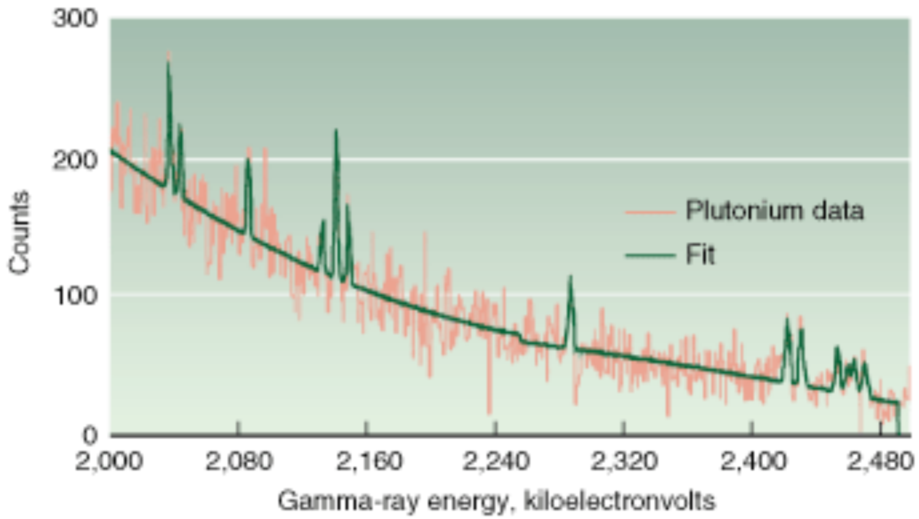
Laser pulse: 6 ps, 5 J
e^- bunch: 1 nC , l2 μm (rms)
X-ray: 10 ps, 10^9 photons per shot
α emission: 12 mrad

$(h\nu)_{laser}$ = 1.2 eV
T = 30.28 MeV
$(h\nu)_X$ = 20 keV for mammography (BEATS)

Extending TS to MeV range?

Interest is growing for the use **nuclear resonance fluorescence (NRF)** for safety and inspection (e.g. sensitive nuclear materials);



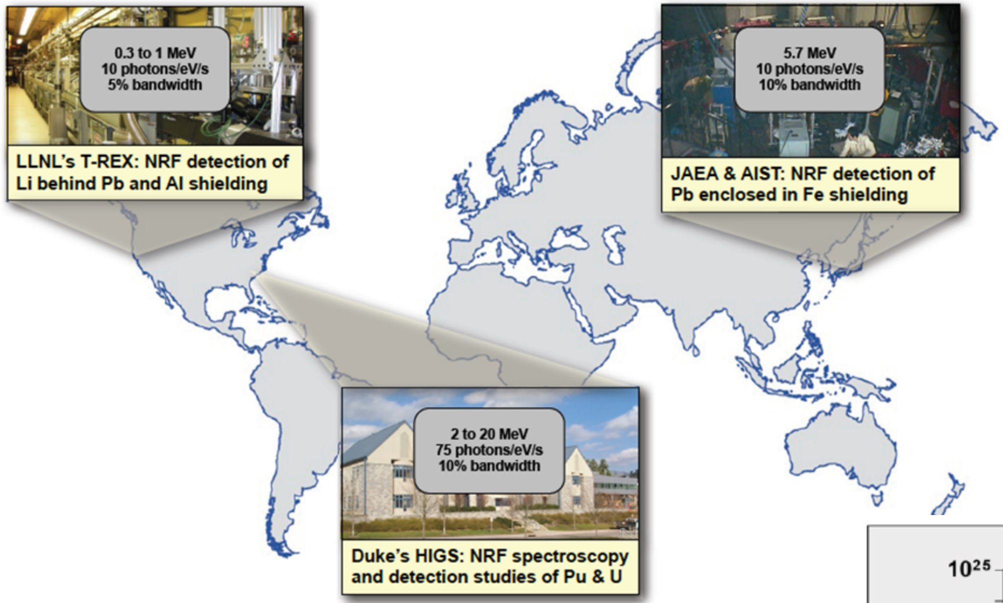


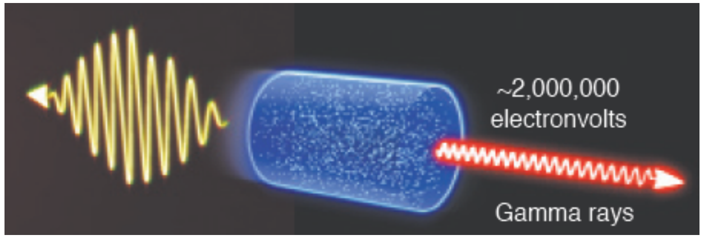
- Typical excited states of nuclei lie in the MeV range and have linewidths of <1 eV;
- Nuclear states decay emitting γ-photons isotropically with characteristic energies;
- These lines, form unique signatures for every isotope.

W. J. Walsh et al., IEEE Nuclear Science Symposium and Medical Imaging Conference, Orlando, Florida, October 25 – 31, 2009.

State of the art

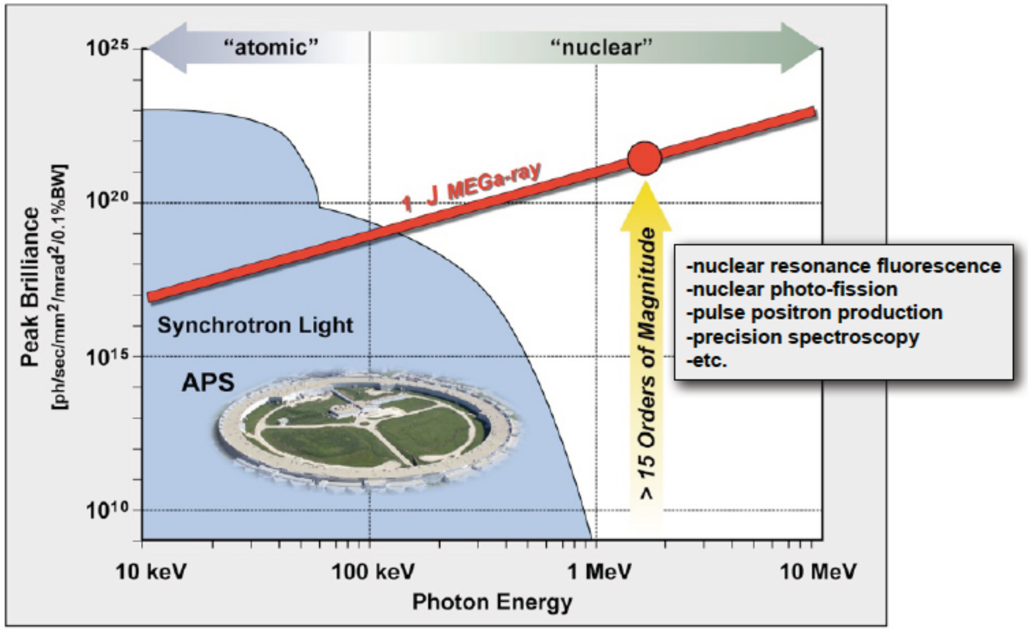
Existing MEGa-ray sources:





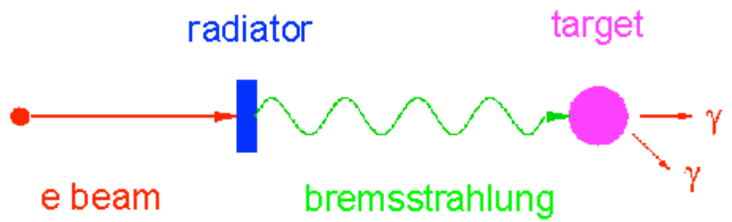
It is a relatively cheap and simple way of enhancing gamma-ray flux by order(s) of magnitude.

The scattered gamma radiation is Doppler upshifted in energy by more than a million times and directed forward in a narrow, polarized, laserlike beam that can be tuned, or adjusted, to different wavelengths!



Current choice of set up for NRF

Standard set up: bremsstrahlung emission of high-Z radiatior

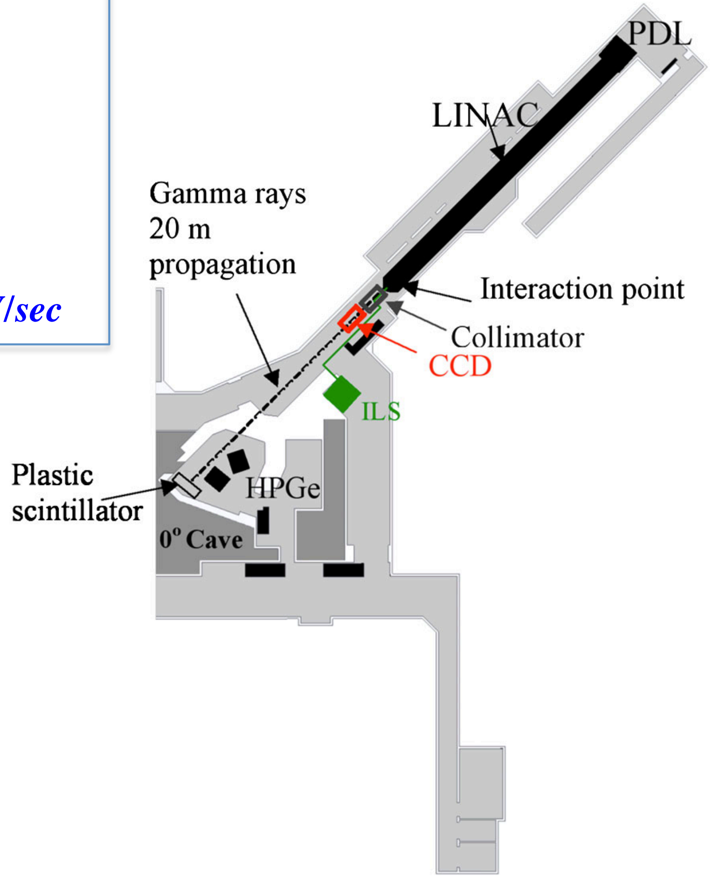


Es. ELBE Facility, Helmholtz-Zentrum Dresden-Rossendorf

Best spectral density for brehmstrahlung sources is 1 $ph/eV/sec$

Most advanced set-up is based upon Thomson scattering of LINAC bunches of laser pulses

Parameter	Specification
Laser pulse duration	20 ps (FWHM)
Laser wavelength	532 nm
Laser spot size	34 μm (rms), 20% energy in spot
Laser energy	150 mJ, 20% compressed
Electron energy	116 MeV
Electron beam spot size	40 μm (rms)
Electron bunch length	20 ps (FWHM)
Electron beam charge	0.5 nC
Normalized emittance	6 mm mrad
jitter factor	2



Expected density for TS source is 10^5 $ph/eV/sec$

NEW approach – TS with Self-Injection

A self-injected driven γ-ray is expected to have **all of the desired characteristics** –

1. high spectral intensity (number of photons per energy interval per second),
2. good monochromaticity $\Delta E\gamma/E\gamma \ll 1$,
3. tunable in a broad energy range
4. a high degree of linear polarization $P\gamma \approx 100\%$.

PROS OF SELF-INJECTED *TS* MeV SOURCE :

- **Reach MeV TS range using existing GeV self-injection configuration;**
- **Ultrashort bunch and ultrashort laser means ultrashort γ-ray source;**
- **Potential for very compact MeV source compared to RF based config.**

CONSTRAINTS FOR TS WITH SELF INJECTION

Actual MEGa-rays → electrons accelerated by photo-injectors, RF cavities and linacs; laser beam used only to oscillate the electrons and generate gamma rays by Thomson scattering.

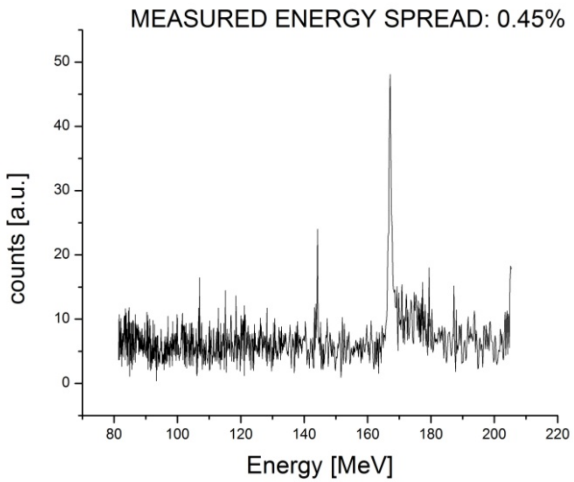
LWFA!! Use the laser both as accelerator and scattering photons!!

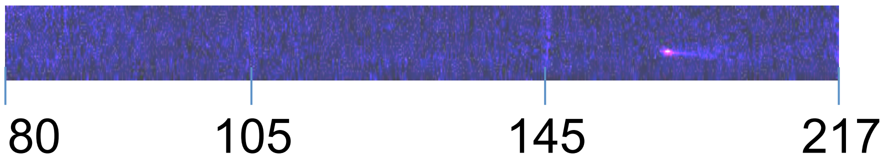
GOAL: **High brightness (MeV spectral density) of the gamma beam**.

PROBLEMS: brightness of the gamma beam depends on:

1. **Number of electrons** of the photon beam; → laser intensity!
2. **Emittance** of electron bunch; → mast be controlled (transport or collision at bubble)!
3. **Energy spread**; → can be minimised (optimizing the acceleration)!
4. **Longitudinal and transversal** electron beam sizes; → can be optimized (transport or collision at bubble)!

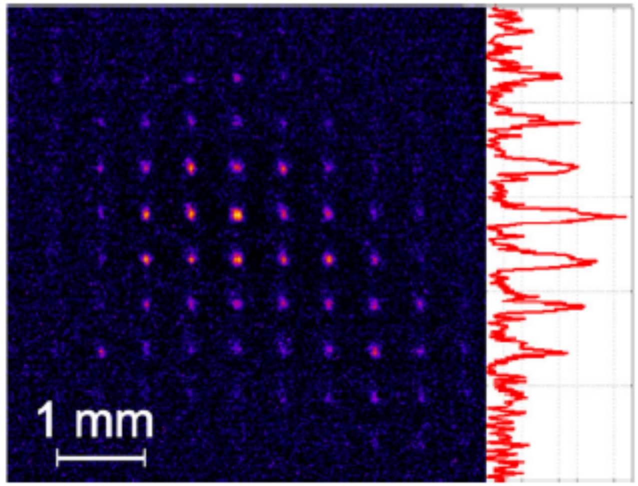
LPA emittance measurements





Measured emittance: $1.1 \pm 0.1\pi$ mm mrad

D. Jaroszinsky
Strathclyde
Scotland



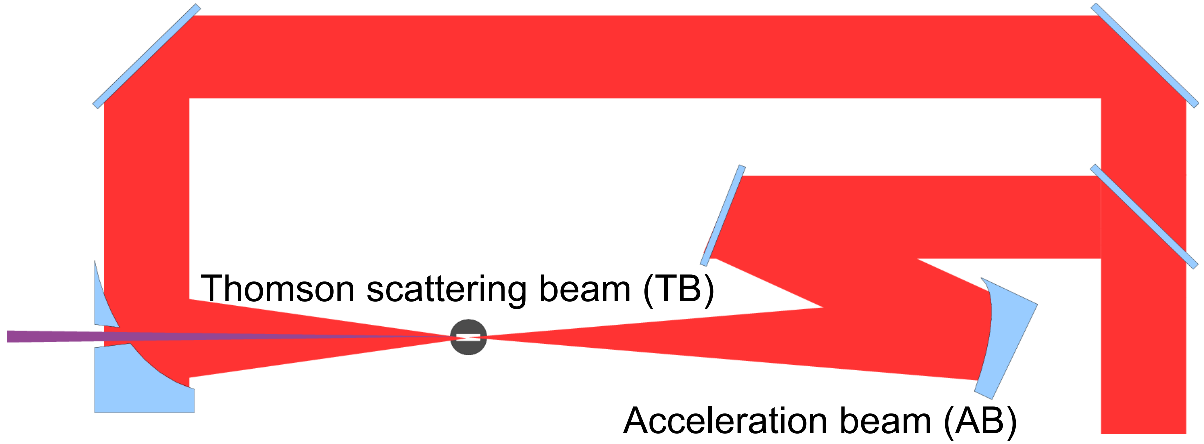
E.Brunetti et al, PRL **105**, 215007 (2010)
M.Wiggins et al, Plasma Phys. Control. Fusion **52**, 124032 (2010)

PARAMETER	T-REX @ LLC	LWFA
Electron energy	~115 MeV	~115 MeV
Energy spread	0,2%	0.45%
Charge	800 pC	20 pC
Bunch length	16 ps	< **1-2 fs** in bubble
Spot size	23x42 µm	few µm in bubble
RMS normalized emittance	4 π mm mrad	«1 π mm mrad (in bubble)

LWFAs can have higher peak currents!!!

TWO BEAM CONFIGURATION AT FLAME 1/2

A possible simple setup for Thomson scattering experiments with self-injected electrons [1/2] (~*compatible with existing setup*)



Main params:

- **AB** *OAP*: f/10, a_0~4-5
- **TB** *OAP*: to be defined (see below), a_0~0.5, but size (→ energy) depending on the e- beam emittance

Reference

The first exeriments has been reported by H. Schwoerer *et al.*, Phys. Rev. Lett. **96**, 014802 (2006)

TWO BEAM CONFIGURATION AT FLAME 2/2

A possible simple setup for Thomson scattering experiments with self-injected electrons [2/2]
(~*compatible with existing setup*)

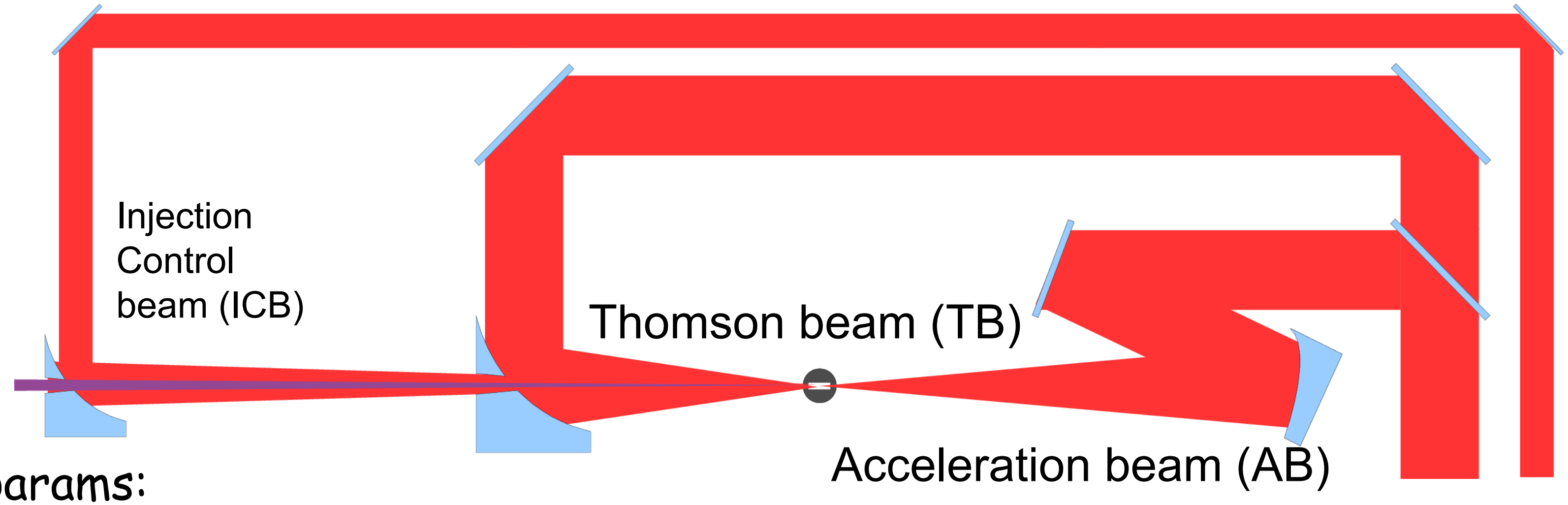
Open issues

- How to get the secondary beam (2 options: leakage from a thin mirror or wavefront division) → Is the pulse duration relevant?
- Where to let the e- and photon beams interact (inside the plasma? Or otherwise is an e- focusing optics needed, depending on the emittance?)
- F/# of the TB OAP to be identified in order to maximize the photon flux (depends upon the extent of the e- bunch inside the bubble?)

THREE BEAM CONFIGURATION AT FLAME

A possible setup for Thomson scattering experiments with self-injected electrons with controlled injection

(~*compatible with existing setup*)



Main params:

- **AB** OAP: f/10, a_0~4-5
- **TB** OAP: to be defined (see below), a_0~0.5, but size (→ energy depending on the e- beam emittance)
- ICB a_0<1 (FLAME "probe beam")

References

-J. Faure *et al.*, Nature **444**, 737 (2006), - X. Davoine *et al.*, Phys. Plasmas **15**, 113102 (2008)

Thomson scattering to test issues of fundamental electrodynamics

TESTING RADIATION FRICTION WITH LASERS?

Radiation Friction: back-reaction of the electron on itself

A classic problem of electrodynamics, with fundamental open questions:

- Does it exist?
- Which models are correct?
- When it dominates the dynamics?
- What is the threshold between Classical and Quantum regimes?

Ultraintense laser interactions offer a perspective for **first, discriminating experiments on RF**

On the route towards “exotic” regimes (collective QED, Schwinger fields, Unruh radiation, ...) Radiation Friction **is met first and must be included in the dynamics**

A PROPOSED EXPERIMENT

A. Di Piazza,* K. Z. Hatsagortsyan,† and C. H. Keitel,
“Strong Signatures of Radiation Reaction below the Radiation-Dominated Regime“,
Phys.Rev.Lett. **102**, 254802 (2009)

In interaction between a superintense laser pulse (5 X 10^{22} W/cm^2) and 40 MeV counter-propagating electrons,
the angle- and frequency resolved Thomson scattering spectrum shows signatures of RF effects.

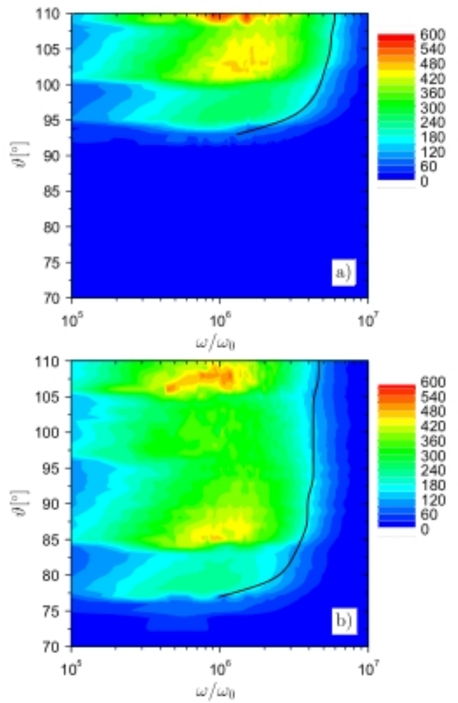


FIG. 2 (color online). Angle resolved spectral energy $dW/d\omega d\Omega$ in sr^{-1} emitted by the electron at $\varphi = 180°$ without (a) and with (b) RR. The electron and the laser field parameters are the same as in Fig. 1.

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WHY ALL-OPTICAL SET-UP?

Coupling a laser-plasma accelerator with a colliding laser pulse would offer several advantages:

- high number of electrons in a **short** (~fs) bunch allows a more intense Thomson Scattering signal
- the all optical set-up makes **synchronization** easier

First experiments on Thomson Scattering on FLAME within γ-Resist could help to optimize set-up, to calibrate detectors, etc., for an evaluation of experimental feasibility with a higher (10X) intensity laser

A laser-plasma simulation model with Radiation Friction effects included **already developed** and **used** for 3D simulations

M.Tamburini, F.Pegoraro, A. Di Piazza, C.H.Keitel, A.Macchi, New J. Phys. **10** (2010) 123005;
M.Tamburini, T.V.Liseykina, F.Pegoraro, A.Macchi, in preparation (2011)

First Year (2012)

- Develop injection (ionisation, optical, cold …) – current experimental set up
  - Compare targets (cell and pulsed gas-jet)
  - Test gas-mixtures for injection control;
- Design two- and three laser pulse experimental configuration (counter-propagating main + transverse)
- TDR of γ-resist including tunable MeV γ-ray source

Personale – Sezioni ed FTE 2012 (evolving …)

- **PISA**
  - M.P. Anania (A.R., 70%), G. Bussolino (T.I. CNR, 60%), G. Cristoforetti (T.I. CNR, 20%), L.A.Gizzi (T.I. CNR, 60%) L. Labate (T.I. CNR, 70%), T. Levato (A.R. CNR, 80%), A. Macchi (T.I. CNR, 10%) – Totale 3,7 FTE
- **FRASCATI**
  - A. Bacci (20%), M. Ferrario (20%), C. Gatti (20%) G. Gatti (50%), A. Ghigo (10%), N. Pathak (80%), A. R. Rossi (20%), C. Vaccarezza (10%) – Totale 2,3 FTE
- **MILANO (V. Celoria)**
  - V. Petrillo (20%) L. Serafini (20%)
- **BOLOGNA**
  - P. Londrillo (% TBD), A. Sgattoni (% TBD), G. Turchetti

Richieste finanziarie 2012

- **PISA**
  - Missioni Interne (10k€): Missioni Frascati e Bologna
  - Missioni Estere (4k€): Glasgow, RAL, Parigi
  - …
- **LNF**
  - Missioni Estere (1k€)
  - Costruzione apparati (modifications for two beam set-up) 10 k€

- **Milano**
  - Missioni Interne (Li-Pisa) 2 k€

- **Bologna**
  - Missioni interne (Bo-Pisa) 2 k€
  - Calcolo (già disp 2012) …