EUROPEAN
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EXCELLENCE IN
APPLICATIONS

EuPRAXIA

WP7: High energy physics and other pilot applications

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653782.

Summary since Lisbon

Three "parallel beams" with LPWF injector as well as RF injector (RF injector switch-yard needed).

1. High charge electron beam for a positron source and HEP *.
2. X-rays (betatron radiation) for medical imaging *.
3. Gamma-rays and QED studies (Compton source) *.

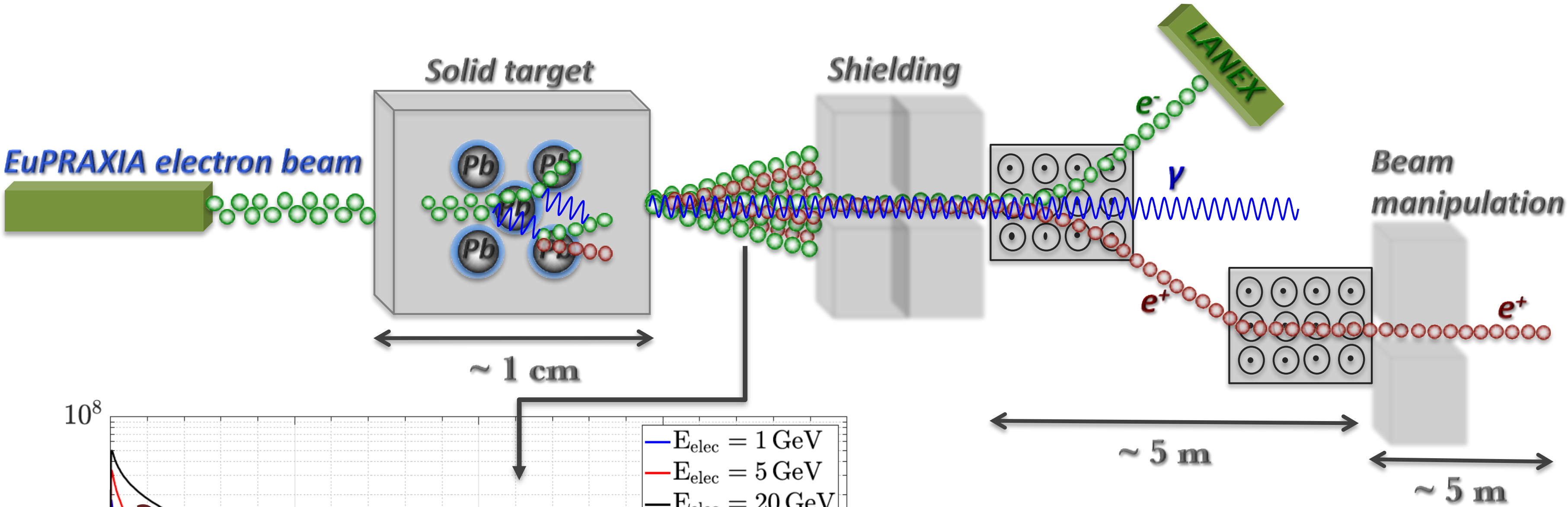
Ad 1. ALEGRO workshop is very supportive; a plan to form a "positron lab" project to use EuPRAXIA positron source. A presentation and a discussion planned at 13th POSIPOL workshop to be held at CERN from 3rd to 5th of September 2018.

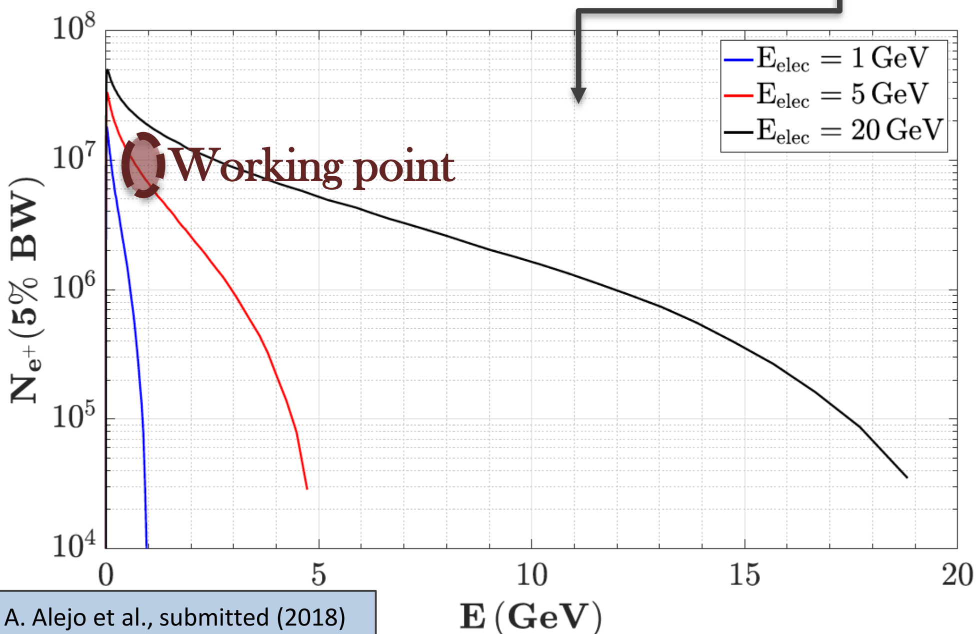
Ad 3. A presentation and a discussion at Probing strong-field QED in electron-photon interactions 21-23 August 2018 at DESY.

A parallel session at this Symposium needed with WP 2, 3 and 5.

* Representative examples of applications at this beam.

High energy positrons





A. Alejo et al., submitted (2018)
Arxiv:1806.02633

Assuming 100 pC at 5 GeV (5%)

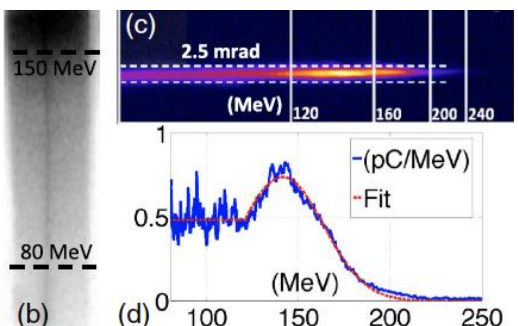
- 10^7 positrons at 1 GeV (5%)
- Source size: **~ 10 micron**
- Divergence: **~ mrad**
- Duration: **few fs**
- Emittance: **< micron**
- Rep. rate: **0.1 – 1 kHz**
- Positrons/s: **10^9 – 10^{10}**

10^8 for 1 nC broadband electron beam

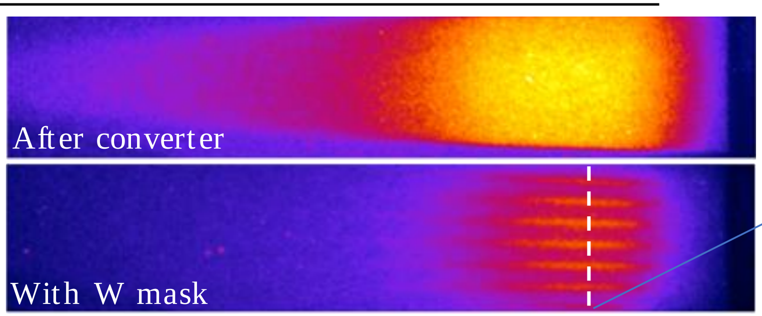
High energy positrons

	Units	FACET-I	FACET-II	LWFA
E	GeV	21	10	1
P	W	7.4	9.6	3
Q_e	pC	350	500	2
σ_x	µm	30	4	10
σ_y	µm	30	4	10
σ_z	µm	50	6.4	0.6
ϵ_x^*	mm mrad	200	7	500
ϵ_y^*	mm mrad	50	3	500
ΔE	%	1.5	1	5
f	Hz	1	1	10 - 10^3
ℓ	$\text{cm}^{-2}\text{s}^{-1}$	5×10^{23}	6×10^{25}	10^{22-24}

- ⌦ **Low energy tunability**
- ⌦ **Same charge per second**
- ⌦ **Comparable transverse size**
- ⌦ **Much shorter beam!**
- ⌦ **Higher normalized emittance**



G. Sarri et al. PRL (2013)

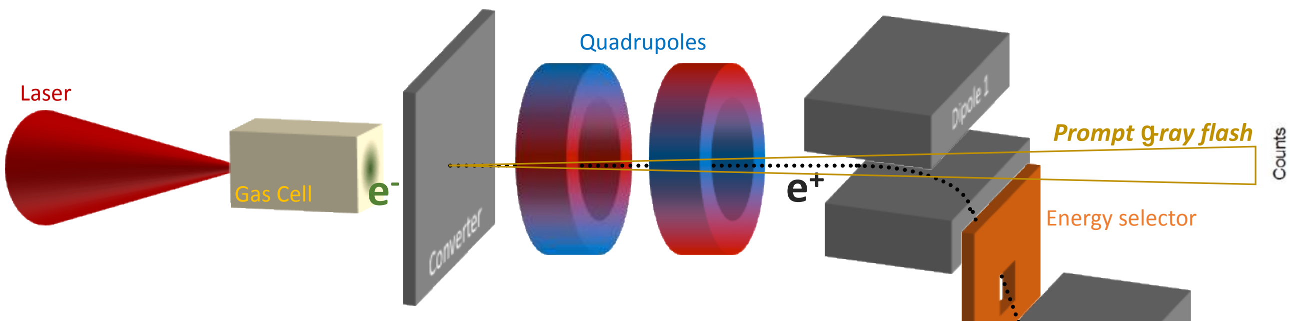


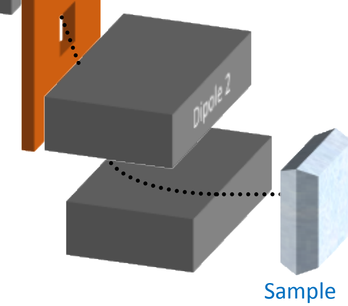
ARIES funded experiment at LYDL, CEA (Feb. 2018)

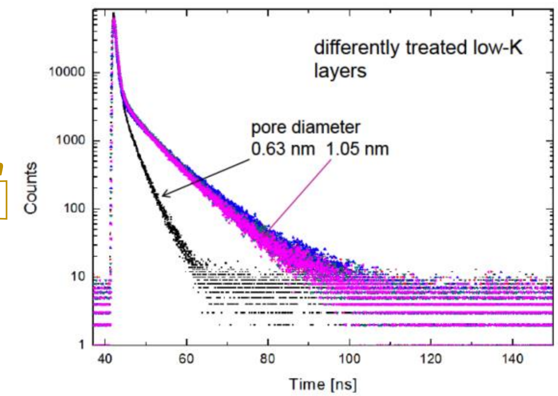
Complementary test-facility for positron acceleration (wake-field or radiofrequency)

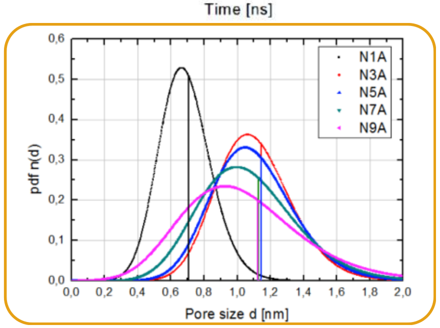
Low energy positrons

- Positron annihilation spectroscopy allows detailed characterization of materials
- **Advantages**: Suitable for any material, detects cracks and imperfections inside samples.
- **Typical disadvantages**: Requires a β^+ source and coincidence detectors (slow)
- **Using laser-driven electron beams can reduce the pulse duration, increase repetition rate and positron flux.**







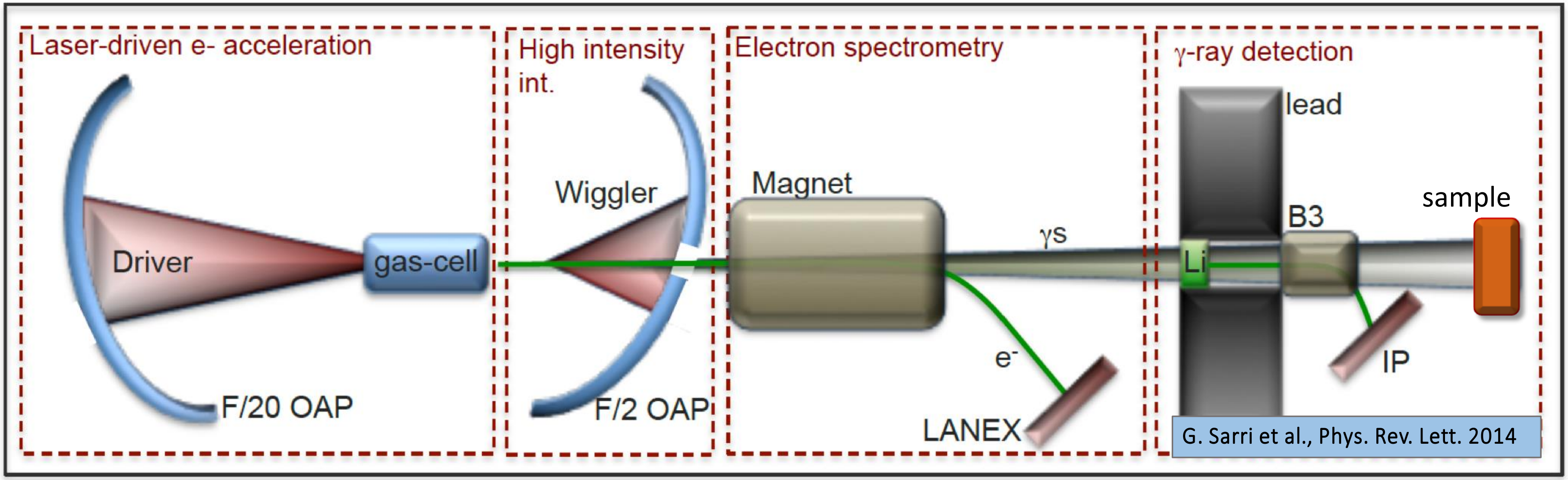


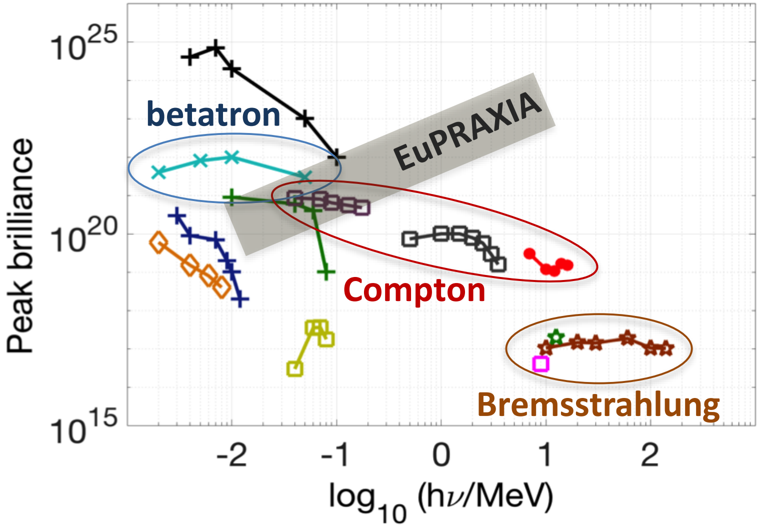
- $>10^8$ e^+/s in a 100keV bin (assuming 100 Hz)
- A set of quadrupoles can be used to collimate the beam.
- The use of electromagnets would allow for quick and on-line energy selection

Collaboration with Innovation at RAL and Rolls Royce

Krause-Rehberg et al. Helmholtz Centre Dresden-Rossendorf

Compton source





Electron beam refocusing down to approx. 10 microns with an overall length of the order of a few metres

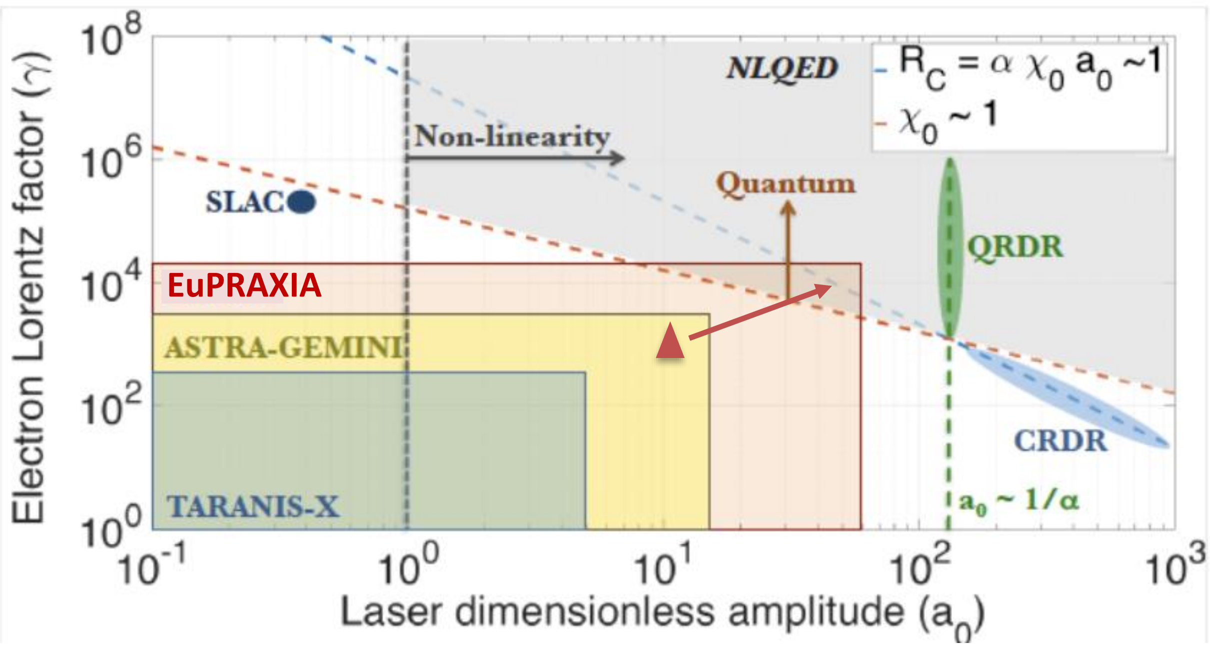
- Narrow-bandwidth (~ 4%) x-ray photons
- Tuneable energy between 10s of keV to MeVs
- 5 fs, 10 micron spot, few mrad
- Peak brilliance of approx. 10^{22} ph s^{-1} mm^{-2} $mrad^{-2}$

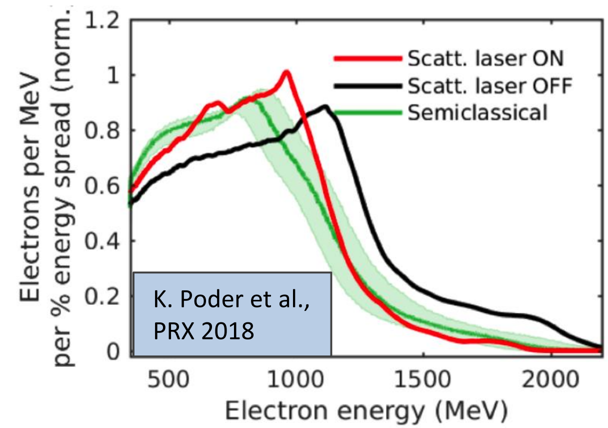
One of the brightest narrowband x-ray sources available

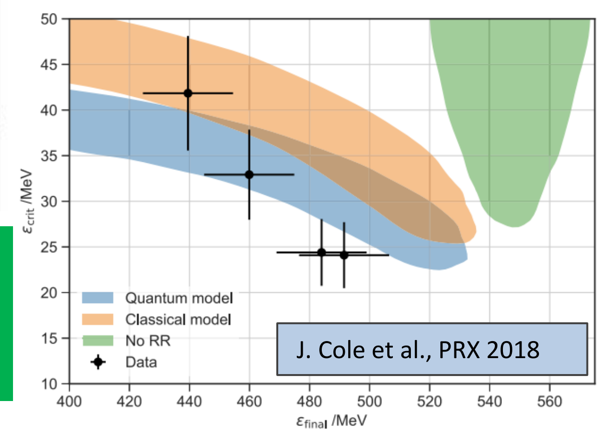
High-field QED

Unique opportunity to have a **narrowband ultra-relativistic electron beam** synchronized with a **PW-scale laser at a high repetition rate**

Studies of high-field quantum electrodynamics **(> Schwinger field)** and access exotic phenomena such as: **quantum radiation reaction, photon-photon scattering, pair production**







Unique facility for high-field QED:
- high-energy
- narrow bandwidth
- stability

High-field QED

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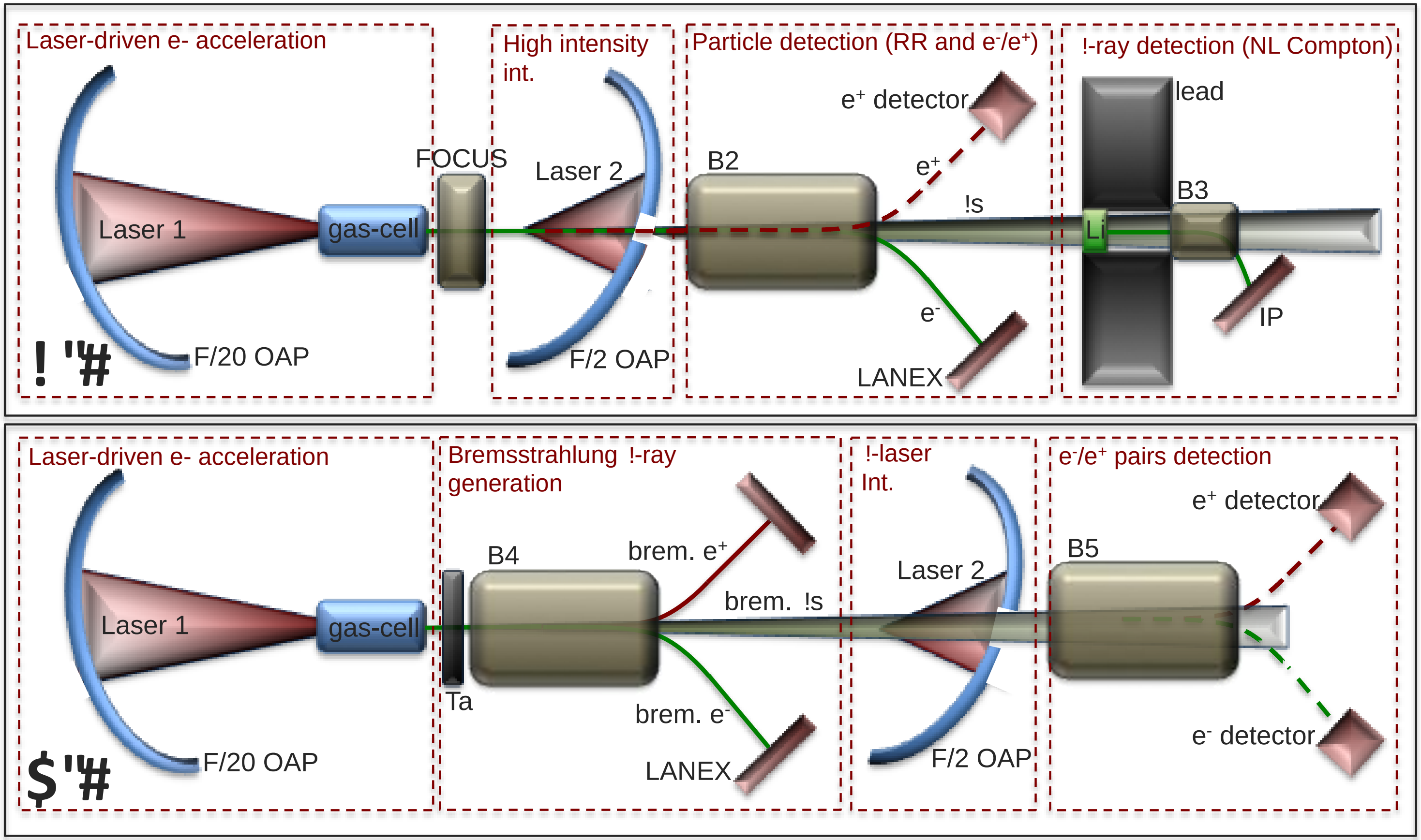

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