Preliminary Study Concept

- Contains the key components of the future EuPRAXIA facility


- DRAFT -

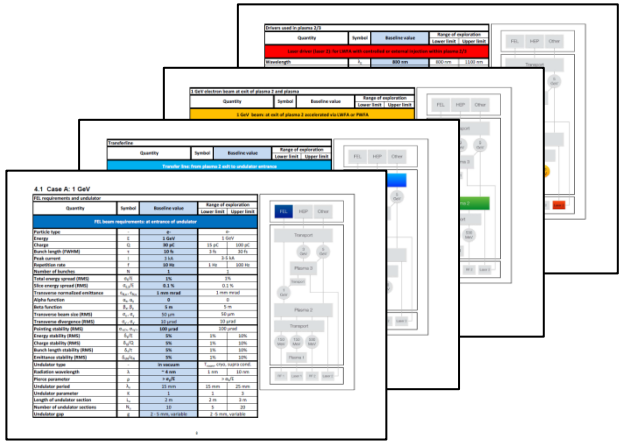
Report on Preliminary Study Concept EuPRAXIA ("European Plasma Research Accelerator with eXcellence In Applications")

- EuPRAXIA Deliverable 1.2 -

26. August 2016 - Version 0.1

Input, comments and feedback received from (status 26.8.2016):

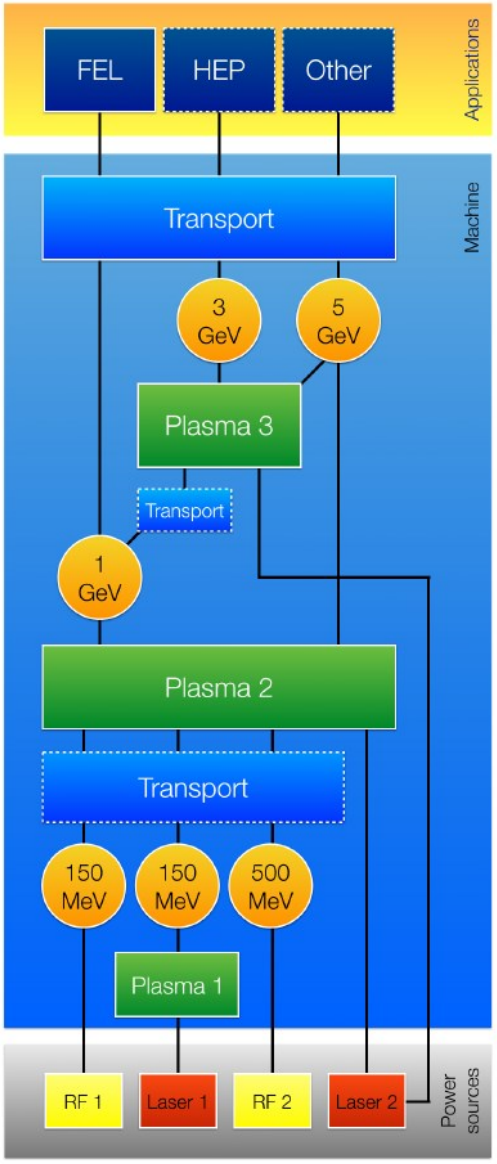
- Input was taken from:
  - 1. SC in Paris
  - Pisa workshop
  - WP4 workshop (100cube laser challenge)



- Further input will come from:
  - Individual WP meetings currently planned in next few weeks (WP3, WP5, WP7, WP9, WP14, …)

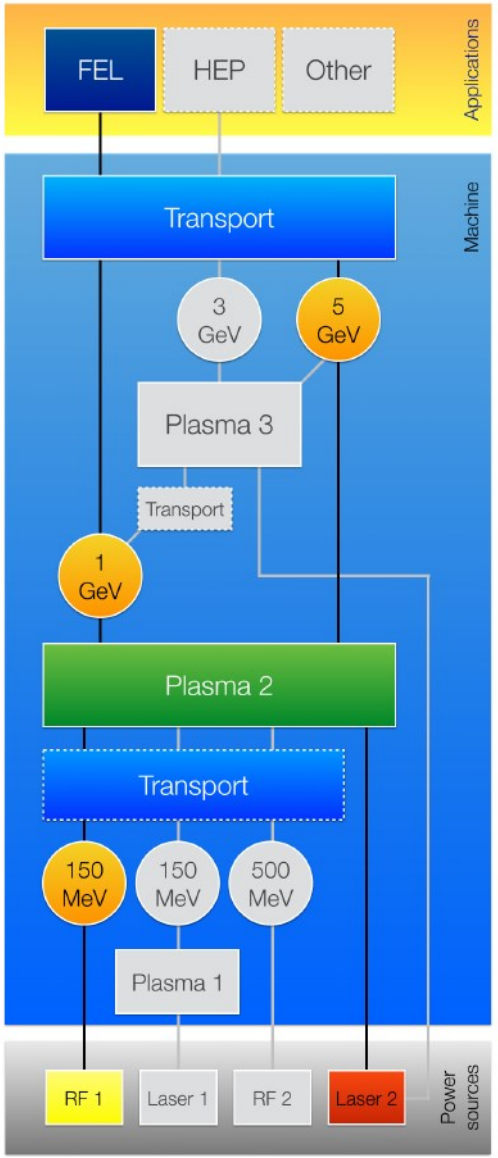
Diagrams & tables

- Diagrams show:
  - study concepts included in EuPRAXIA
  - interplay between WPs
  - connection to applications
- Tables define parameters we want to deliver
- Overview diagram
  - Applications define parameters
  - Realistic RF & LWFA e-beam parameters defined
  - Plasma & transport structures are defined from need and availability
  - RF/Laser infrastructure designed around it



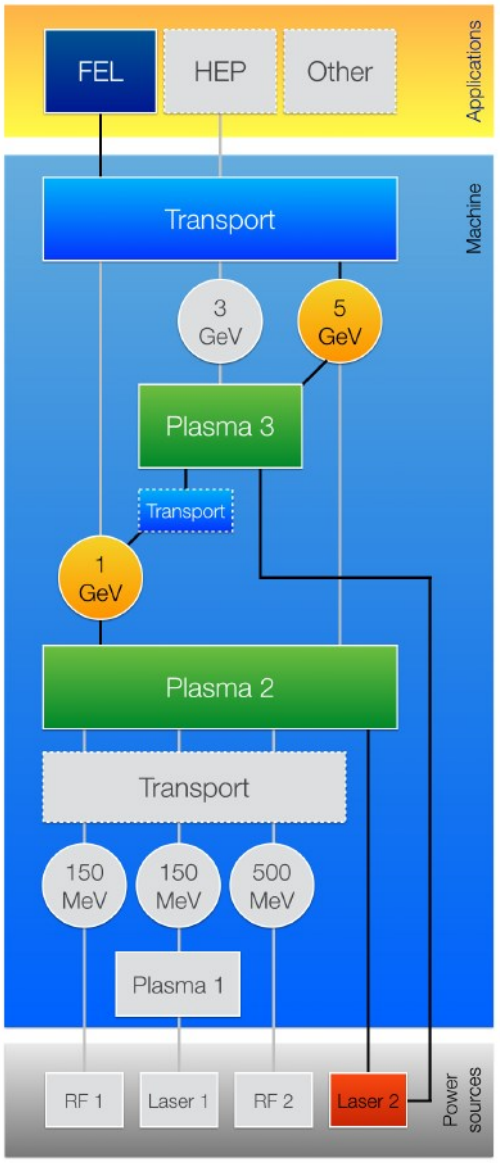
Diagrams

- Purposefully retain multiple paths to multi GeV at this stage
  - External injection of an electron bunch into a laser-driven plasma accelerator.
  - Beam generation and acceleration in a laser-driven plasma accelerator.
  - External injection of an electron bunch into a beam-driven plasma accelerator.
  - Hybrid schemes including both laser-driven and beam-driven plasma acceleration.



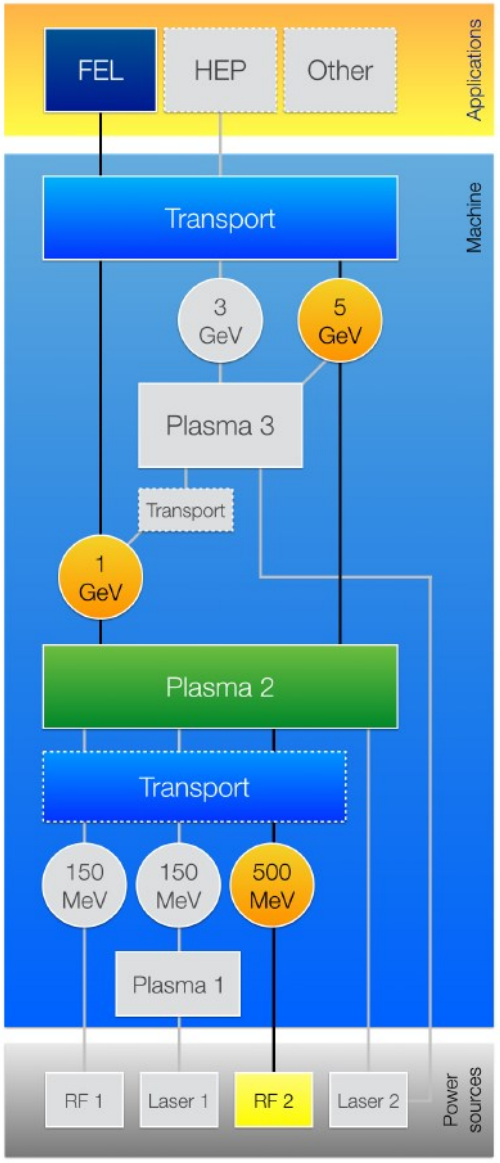
Diagrams

- Purposefully retain multiple paths to multi GeV at this stage
  - External injection of an electron bunch into a laser-driven plasma accelerator.
  - Beam generation and acceleration in a laser-driven plasma accelerator.
  - External injection of an electron bunch into a beam-driven plasma accelerator.
  - Hybrid schemes including both laser-driven and beam-driven plasma acceleration.



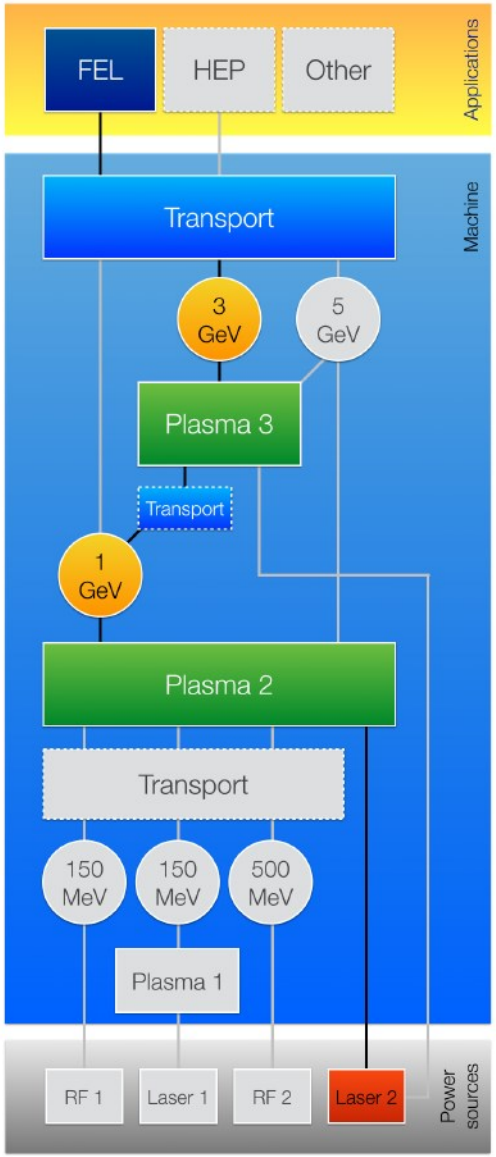
Diagrams

- Purposefully retain multiple paths to multi GeV at this stage
  - External injection of an electron bunch into a laser-driven plasma accelerator.
  - Beam generation and acceleration in a laser-driven plasma accelerator.
  - External injection of an electron bunch into a beam-driven plasma accelerator.
  - Hybrid schemes including both laser-driven and beam-driven plasma acceleration.



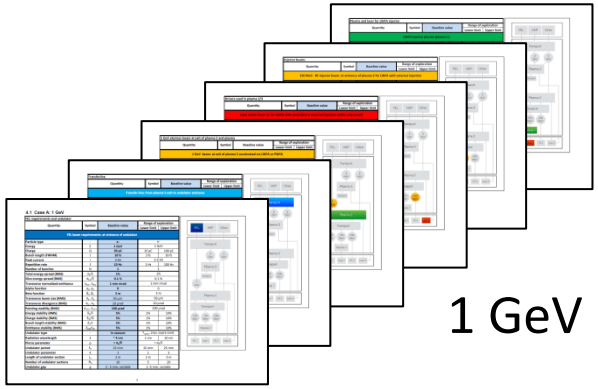
Diagrams

- Purposefully retain multiple paths to multi GeV at this stage
  - External injection of an electron bunch into a laser-driven plasma accelerator.
  - Beam generation and acceleration in a laser-driven plasma accelerator.
  - External injection of an electron bunch into a beam-driven plasma accelerator.
  - Hybrid schemes including both laser-driven and beam-driven plasma acceleration.

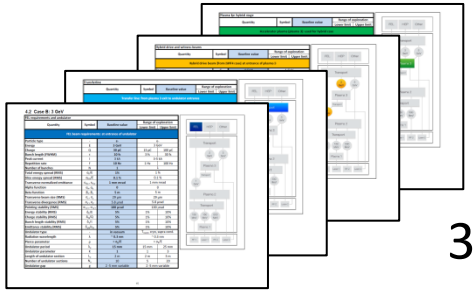


Structure

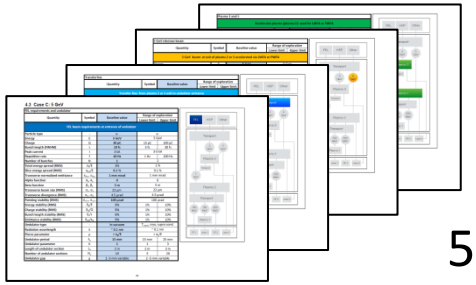
- Set of tables for 1, 3, and 5 GeV
- Tables derived from FEL requirements and goals
- Concept:
  - Start at 1 GeV (soft x-rays, easier) and then push towards 5 GeV (hard x-rays, more difficult)
  - For the study version include alternative solutions: laser-driven , beam-driven, hybrids
- To come: HEP, Other Apps



1 GeV



3 GeV



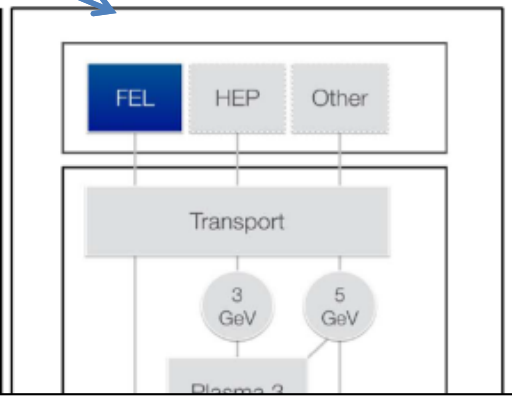
5 GeV

Structure

- Baseline parameter shown in blue with range
- Definitions are in bold print
- Diagram shows which element is being defined

4.1 Case A: 1 GeV

FEL requirements and undulator				
Quantity	Symbol	Baseline value	Range of exploration	
			Lower limit	Upper limit
FEL beam requirements: at entrance of undulator				
Particle type	-	**e-**	e-	
Energy	E	**1 GeV**	1 GeV	
Charge	Q	**30 pC**	15 pC	100 pC
Bunch length (FWHM)	τ	**10 fs**	3 fs	30 fs
Peak current	I	3 kA	3-5 kA	
Repetition rate	f	**10 Hz**	1 Hz	100 Hz



Feedback

Initial feedback received so far

Feedback received so far

- WP3
  - Rather then having only 3 sets of tables (1, 3, 5 GeV)
  - Break down tables in different cases
    - **Case 1**: LWFA with internal injection and acceleration to 1GeV (Case 1A) or 5 GeV (Case 1B).
    - **Case 2:** LWFA with external injection (LWFA) and acceleration to 1GeV (Case 2A) or 5 GeV(Case 2B).
    - **Case 3:** LWFA with external injection (RF) and acceleration to 1GeV (Case 3A) or 5 GeV (Case 3B).
    - **Case 4:** LWFA with internal injection and acceleration to 1GeV and staging to 5 GeV
    - **Case 5:** LWFA with external injection (LWFA) and acceleration to 1GeV and staging to 5 GeV
    - **Case 6**: LWFA with external injection (RF) and acceleration to 1GeV and staging to 5 GeV
    - **Case 7**: PWFA with acceleration to Case 7A:1 GeV or case7C: 5 GeV
    - **Case 8** : Hybrid scheme, LWFA with internal injection (LWFA) and acceleration to 1GeV and staging to 3 GeV

Feedback received so far

- WP4
  - Do we want to set the laser energy/pulse length?
  - What is the requirement for beam synchronization?
  - What transverse pulse shape do we need?
  - Define polarization
  - Define focal spot positions stability requirements
  - Preference for focal spot size & energy requirements, rather then Strehl ratio requirement

Feedback received so far

- WP5
  - For current design, many transport lines are needed.
  - We have to pick favourites
  - Energy spread to high for beam driven case?

500 MeV - RF driver: at entrance of plasma 2 for PWFA				
Energy	E	500 MeV	300 MeV	500 MeV
Charge	Q	250 pC	100 pC	500 pC
Bunch length (FWHM)	τ	100 fs	100 fs	
Peak current per bunch	I	2.5 kA	1 kA	5 kA
Repetition rate	f	≥ 10 Hz	≥ 10 Hz	
Number of bunches	N	≥ 1	≥ 1	
Total energy spread (RMS)	σ_E/E	1%	1%	
Transverse normalized emittance	$\varepsilon_{N,x}$, $\varepsilon_{N,y}$	1 mm mrad	1 mm mrad	
Alpha function	α_x, α_y	0	0	
Beta function	β_x, β_y	100 mm	60 mm	100 mm
Transverse beam size (RMS)	σ_x , σ_y	10 µm	10 µm	10 µm
Transverse divergence (RMS)	$\sigma_{x'}$, $\sigma_{y'}$	100 µrad	167 µrad	100 µrad
Transformer ratio	R	1	1	2
Jitter, beam to global reference (RMS)	$\sigma_{\Delta t}$	10 fs	10 fs	

Feedback received so far

- Stand alone comments received by email:
  - Undulator
    - No range given for the x-ray wavelength in 3 & 5 GeV table
    - Undulator length is 1.995 m (not 2m) with 15mm undulator period
    - It is sufficient to specify RMS undulator parameter. This should be enough to estimate FEL parameters
  - Electron beam
    - Can e-beam be polarized?
  - Laser/user area
    - Are HP lasers usable also in user area not only as drivers?

Discussion/feedback

- This is a draft version and not yet a consistent set

- Please contribute to feedback:
  - here and now
  - via WP meeting minutes/summary
  - via email to andreas.walker@desy.de

- V0.1 feedback deadline: 20. September 2016
- V0.2 will be circulated: 10. October 2016
- Final version released to EU: 31. October 2016