EUROPEAN
PLASMA RESEARCH ACCELERATOR
WITH EXCELLENCE IN APPLICATIONS

Status of Beam Physics studies

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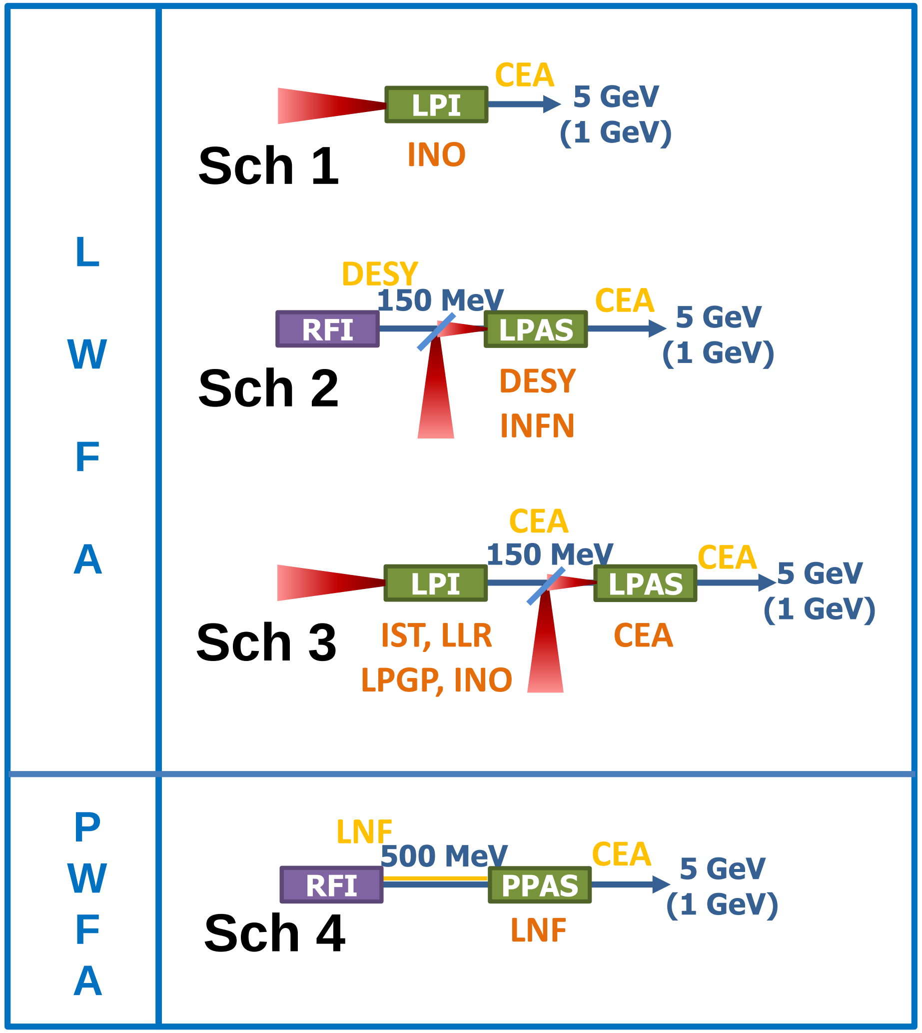
Restricted acceleration schemes

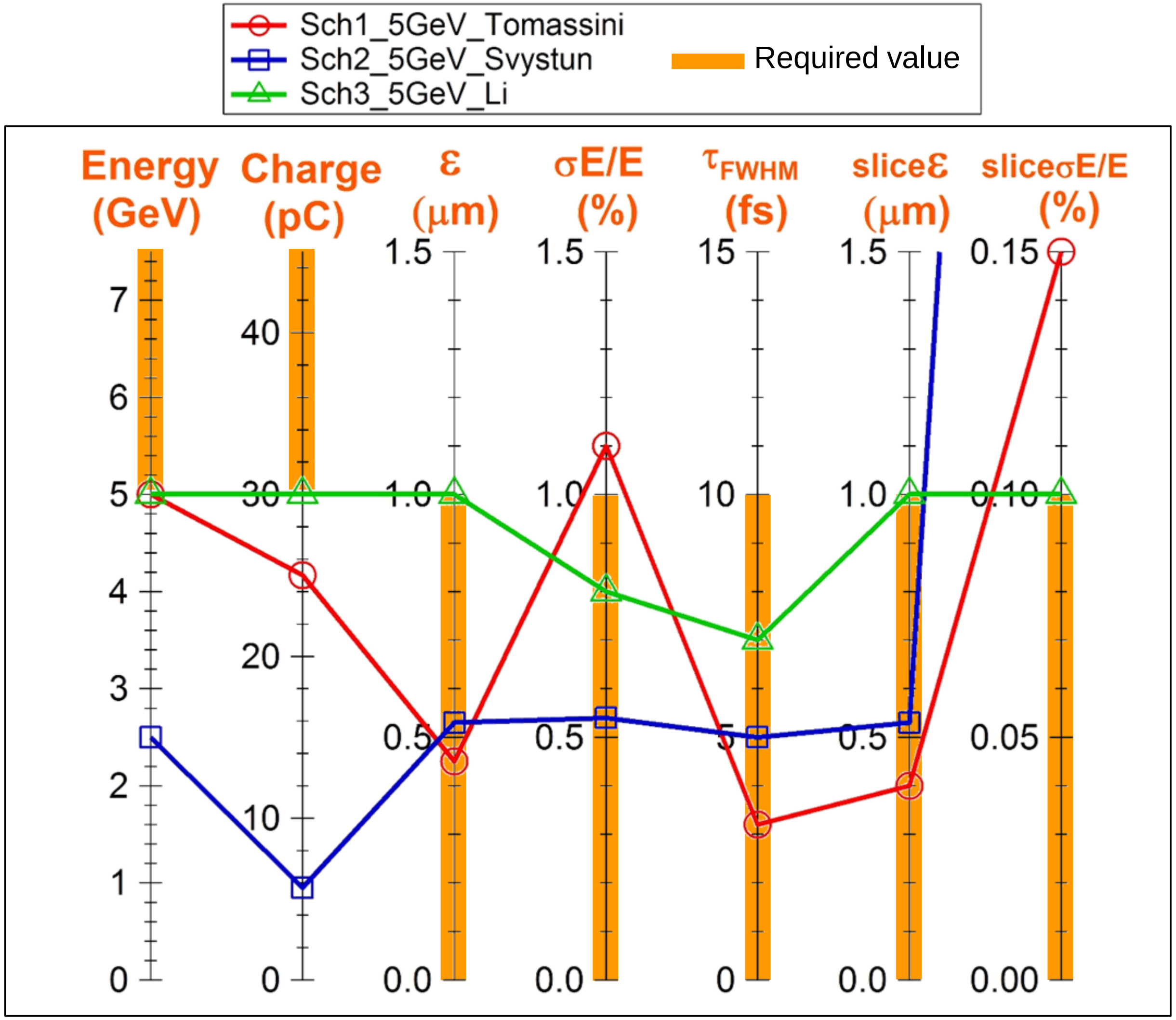
Recall of Strategic Objective:
(Lisbon yearly meeting, nov 2017)

- Providing beam at **5 GeV** meeting 'perfectly' FEL and HEPA requirements

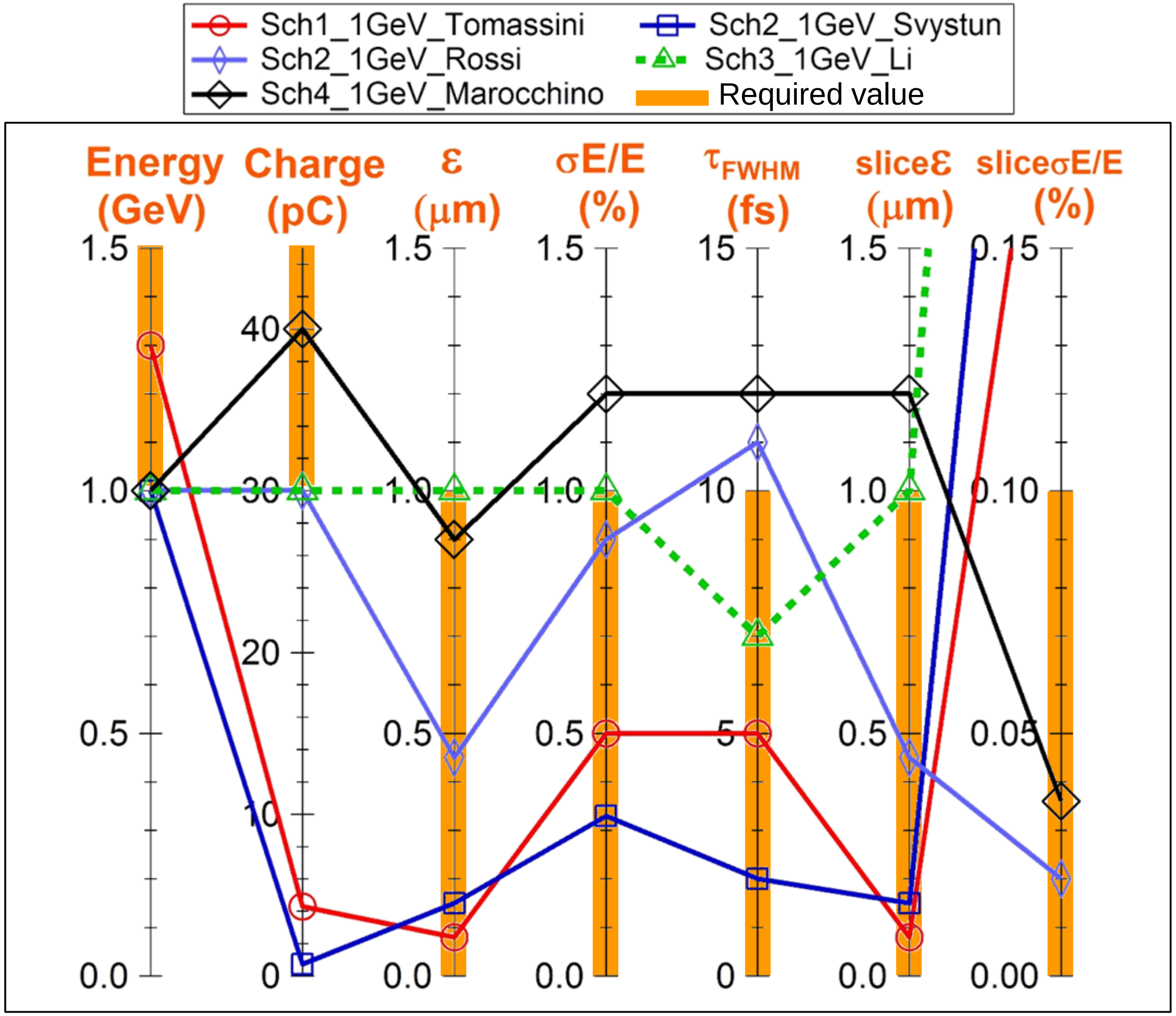
- Providing as well beam at **1 GeV** 'usable' for FEL and HEPA, as a 'commissioning' step



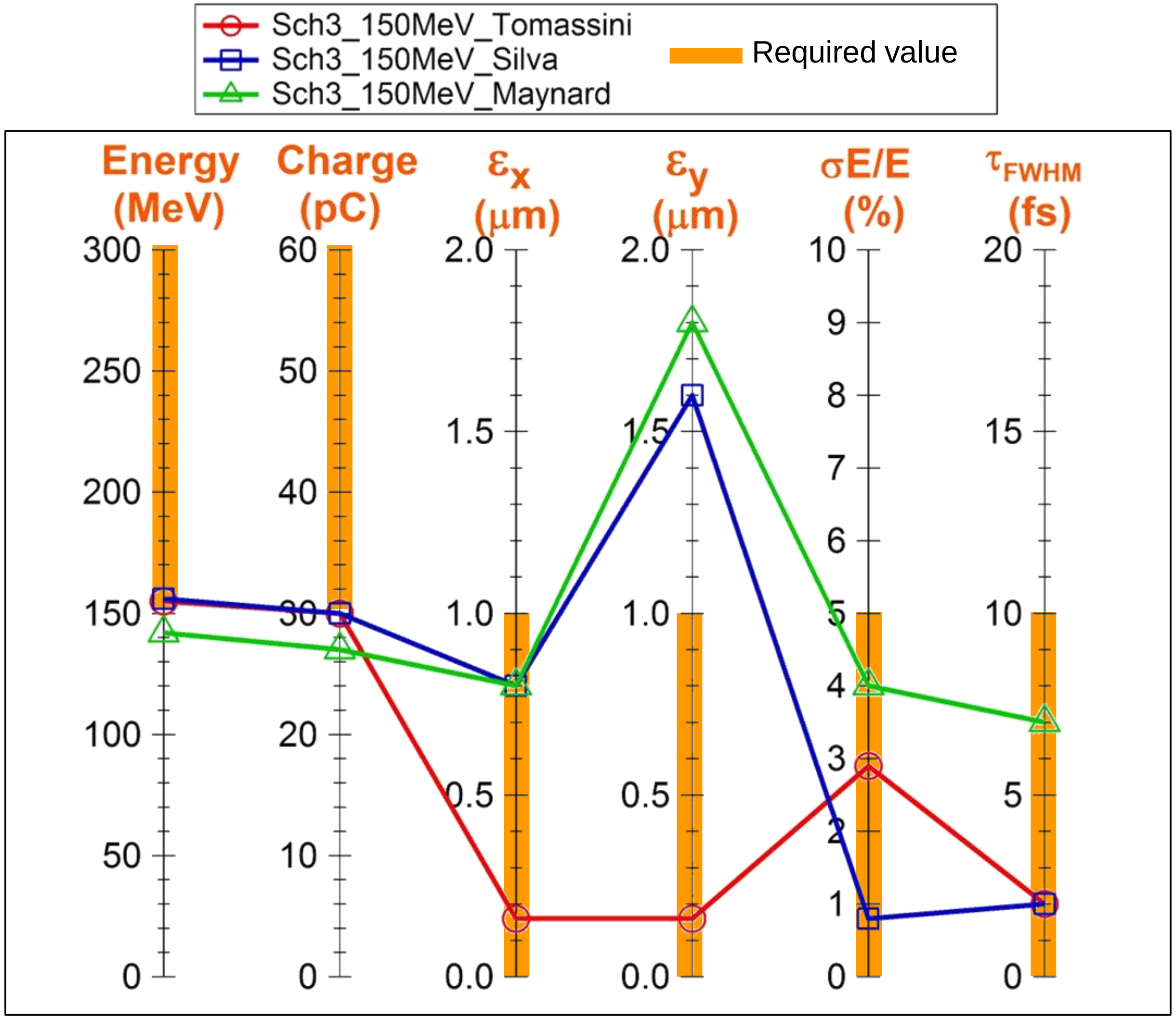
Beam parameters obtained at 5 GeV



Beam parameters obtained at 1 GeV



Beam parameters obtained at 150 MeV



Plasma configurations used in simulations

Horizon 2020

- Plasma H, Ar, N^{5+}, N2 impurity, …
- Longitudinal: uniform plateau
  with ramps at entrance and exit
  Radial: parabolic
- Longitudinal: downramp for auto injection
- Gas jet, or capillary, or cell
- Length and density:
  LPAS 5 GeV: 17-28 cm, 0.1-2.5 10^{17} cm^{-3}
  LPAS 1 GeV: 3-7 cm, 1-5 cm^{-3}
  LPI 150 MeV: 0.6-4 mm, 7-80 10^{17} cm^{-3}

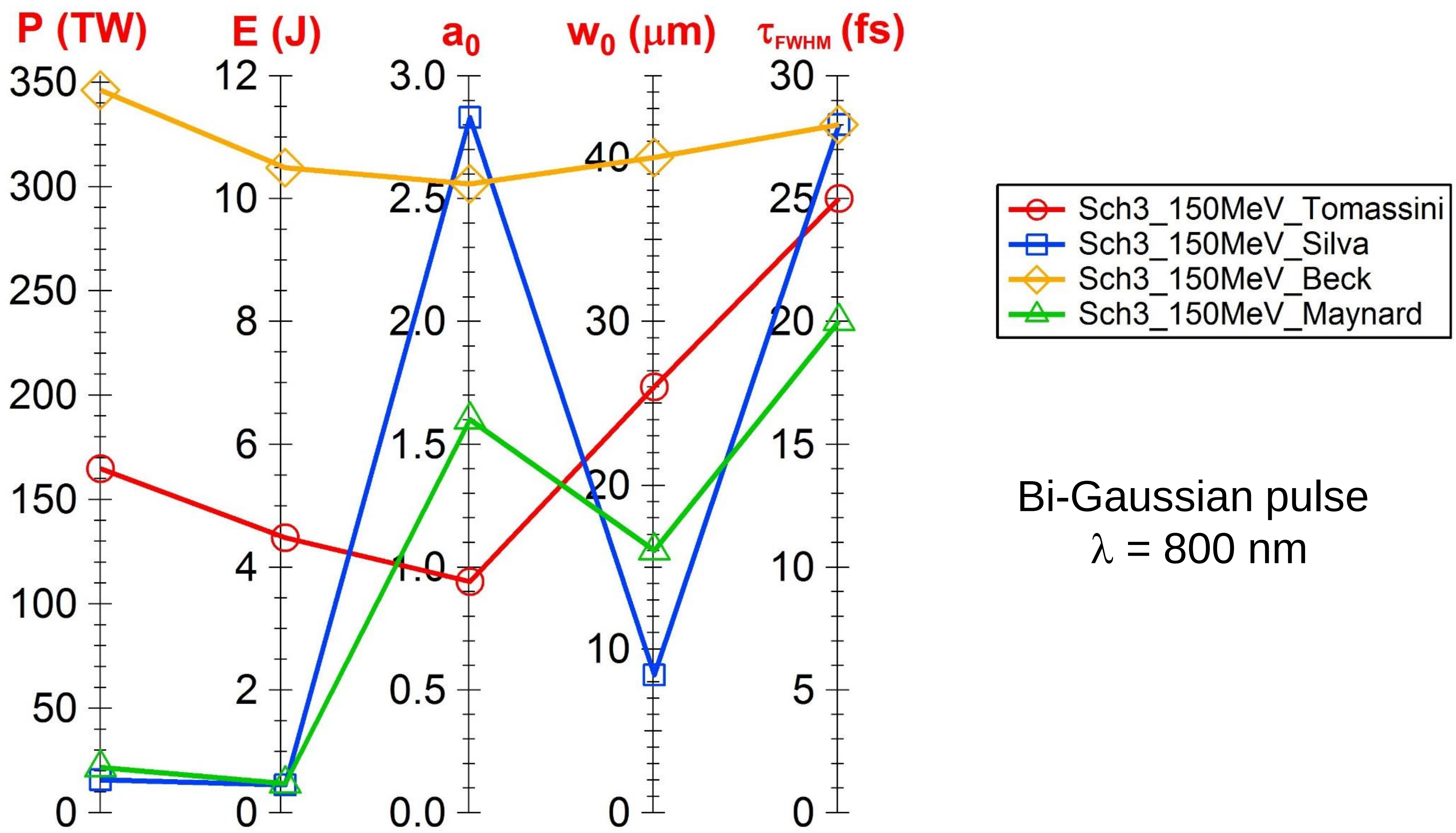
A first estimate is given:
- Realism level
- How to achieve
- Potential imperfections
- Suggestion of alternative

Brigitte Cros, T. Audet

Scheme ID	Realistic?	How to achieve	Imperfections	Alternative
Scheme1B P. Tomassini	No (revised)	? more details on requirements are necessary	Described gradient at entrance too sharp	are smoother gradient and transitions acceptable for the scheme?
Scheme 2B E Svystun et al	Yes	Capillary, ramps given by fluid simuls	Low density challenging for parabolic profile, reproducibility to be tested	Gas cell also an option for parabolic profile (OFI plasma) and length smaller than 20 cm
Scheme 2B A Rossi	No	? details on requirements are necessary	Uniformity over 50cm to be determined for a discharge	Promising option: laser created plasma
Scheme 3B T Silva et al	No	Upramp gradient too sharp; Shock for downramp gradient	Gradient fluctuations	Shock injection with a smooth gradient at entrance
Scheme 3B A Beck	No	? beyond state-of-the-art gas jet	Gradients are linear and too sharp	Gas jets with longer, exponential ramps
Scheme 3B G Maynard	yes	Gas cell	Density controlled better than 10%	Double gas jet
Scheme 3B P Tomassini A	Yes	Gas jet far from the nozzle, smooth gradients	Pure nitrogen may induce non uniform distribution: ionization level?	Gas cell, required profile needs to be specified
Scheme 3B P Tomassini B	No (revised)	Separation of areas with "pure" gas difficult inside gas jets	Ramps need to be determined	Two-stage gas cell
Scheme 3B X Li	Yes	Low density channel may be achieved with OFI in gas capillary	Plasma uniformity needs to be specified Delta n is of the order of fluctuations, 10%	Promising option: laser created plasma
Scheme 4B A Marocchino	? yes if uniform plasma	Depends on transverse profile, uniform ok in capillary tube with OFI	Plasma uniformity needs to be specified	-

Laser parameters used in beam simulations

for 150 MeV (LPI)

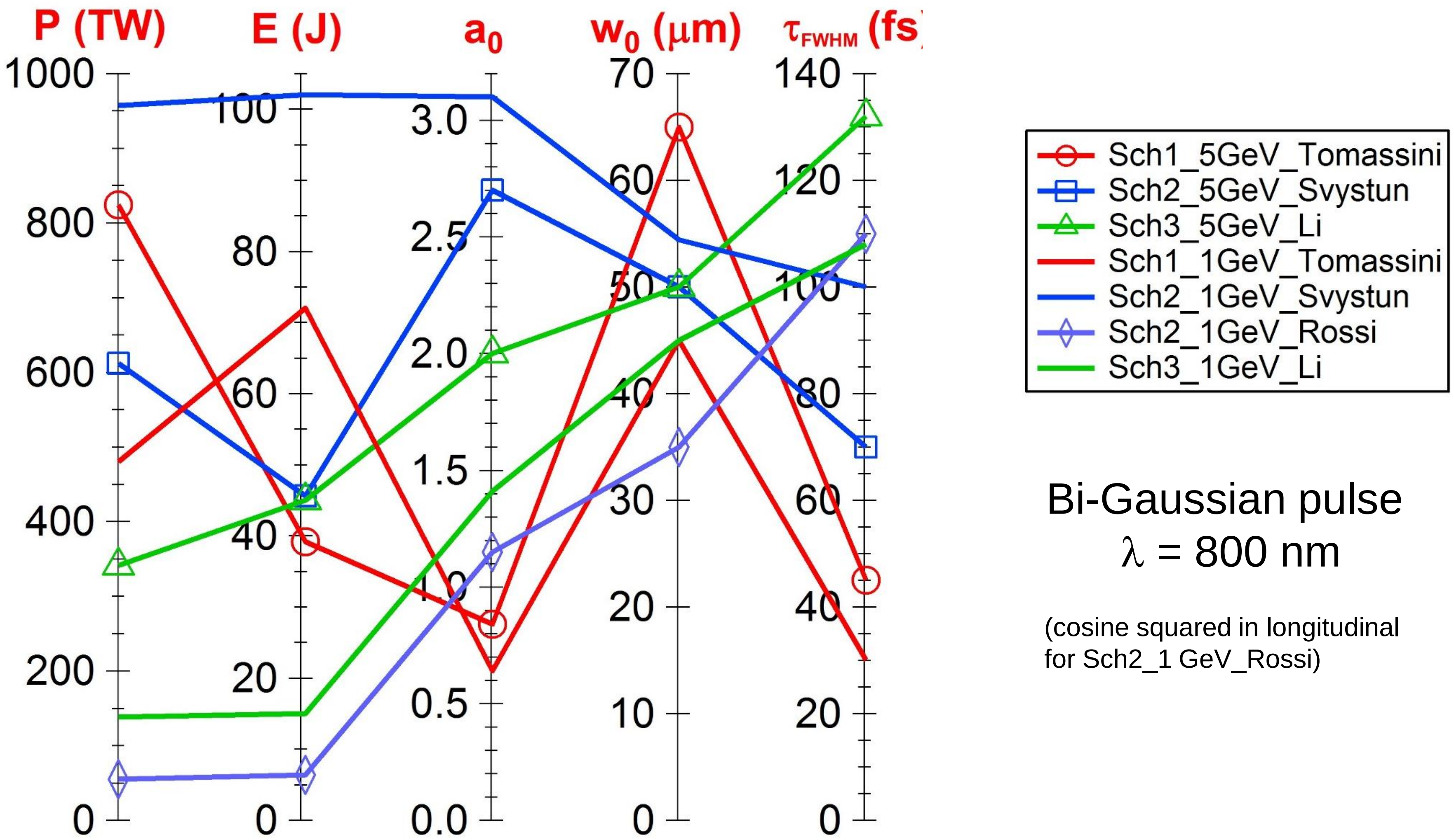


Bi-Gaussian pulse

λ = 800 nm

Laser parameters used in beam simulations

for 5 GeV and 1 GeV (LPAS)



Bi-Gaussian pulse

λ = 800 nm

(cosine squared in longitudinal
for Sch2_1 GeV_Rossi)

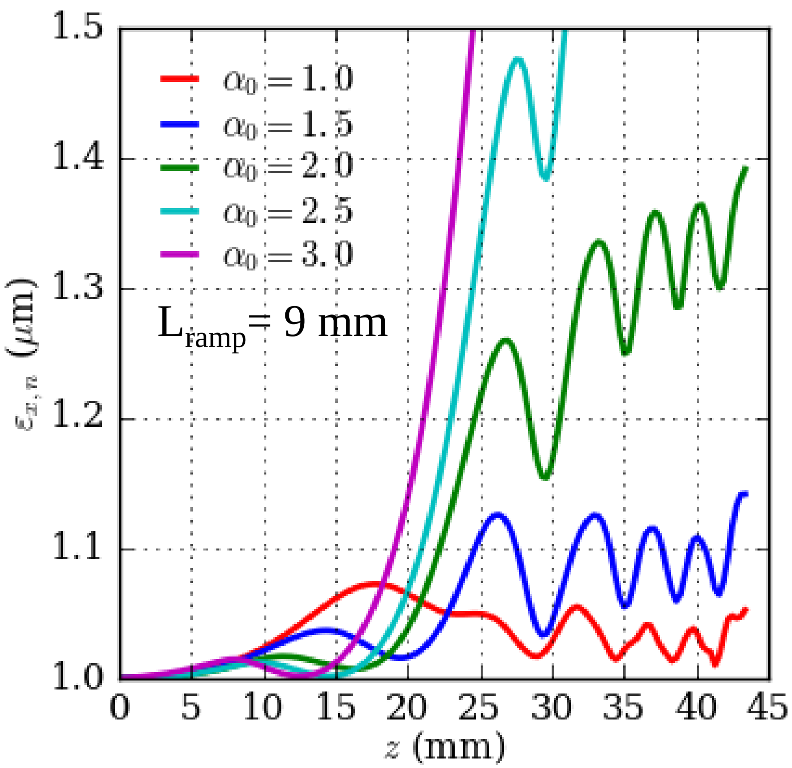
Matching in and out a plasma stage

X. Li, A. Chancé & P.A.P. Nghiem

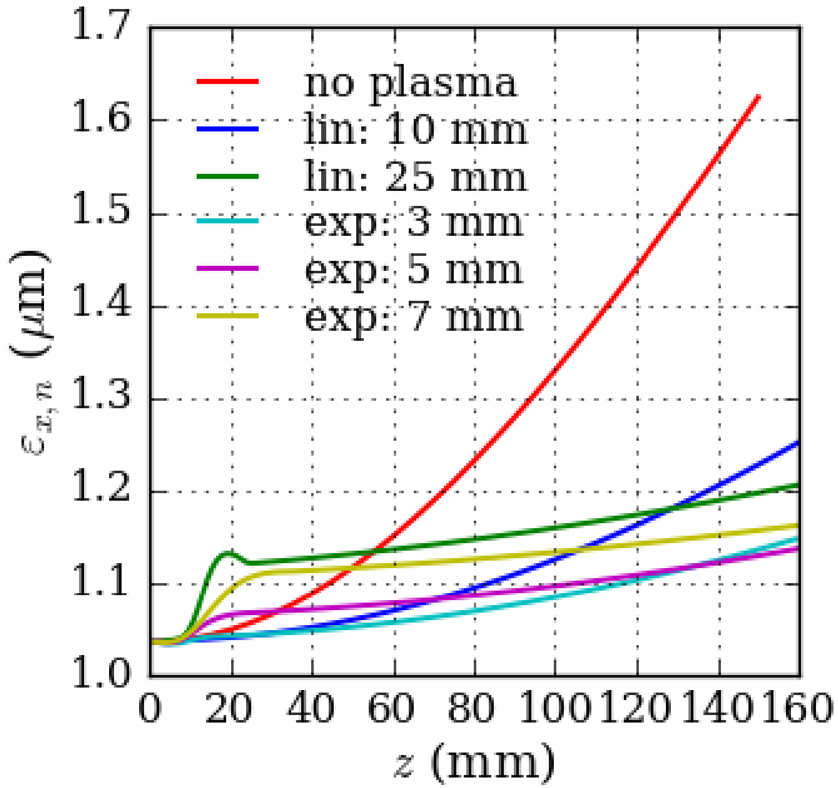
1

Up- and Downramp with Linear or Exponential density profiles have been checked
Optimized length → Minimum emittance growth

In (150 MeV)



Out (5 GeV)



2

Transfer line: number of quadrupoles = number of constraints
6 quadrupoles → emittance growth of only 10% at FEL entrance

Encouraging results **but** all need to be confirmed and consolidated:

For 5 GeV

Sch 1 with REMPI technique is not very far from requirements

Sch 2 with photoinjector 150 MeV "should" give good results but we are still waiting

Sch 3, LPA with weakly nonlinear acc.regime, all the reqirements are met

BUT no margin and still waiting for LPI injection

For 1 GeV

Sch 2, all the requirements are met, BUT with photoinjector at 500 MeV

Sch 3, after only 1 trying, all requirements are met except for slice nrj spread

BUT still waiting for LPI injection

Sch 4, all the requirements are met, BUT with photoinjector at 500 MeV

For LPI 150 MeV (Sch 3)

REMPI: all requirements are met, transfer line remains to be studied