Achromatic beamline design for the Petawatt LAser Particle Accelerator (PLAPA)

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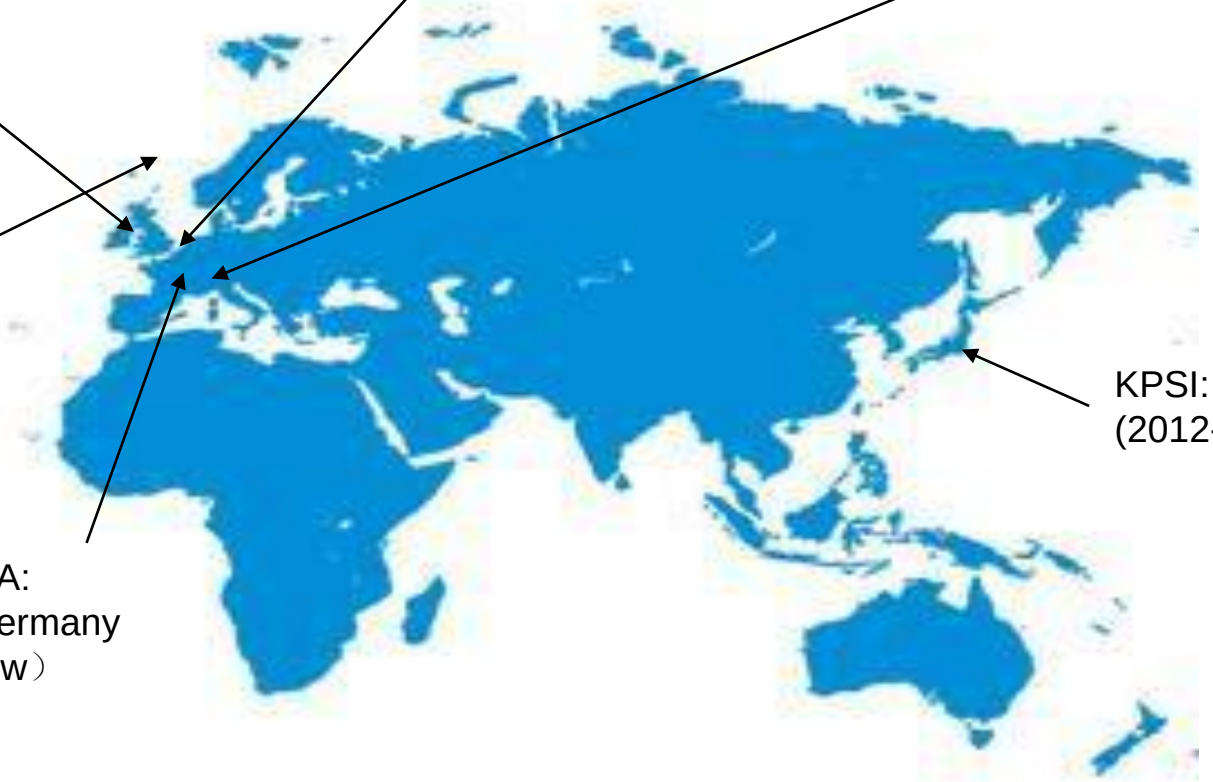
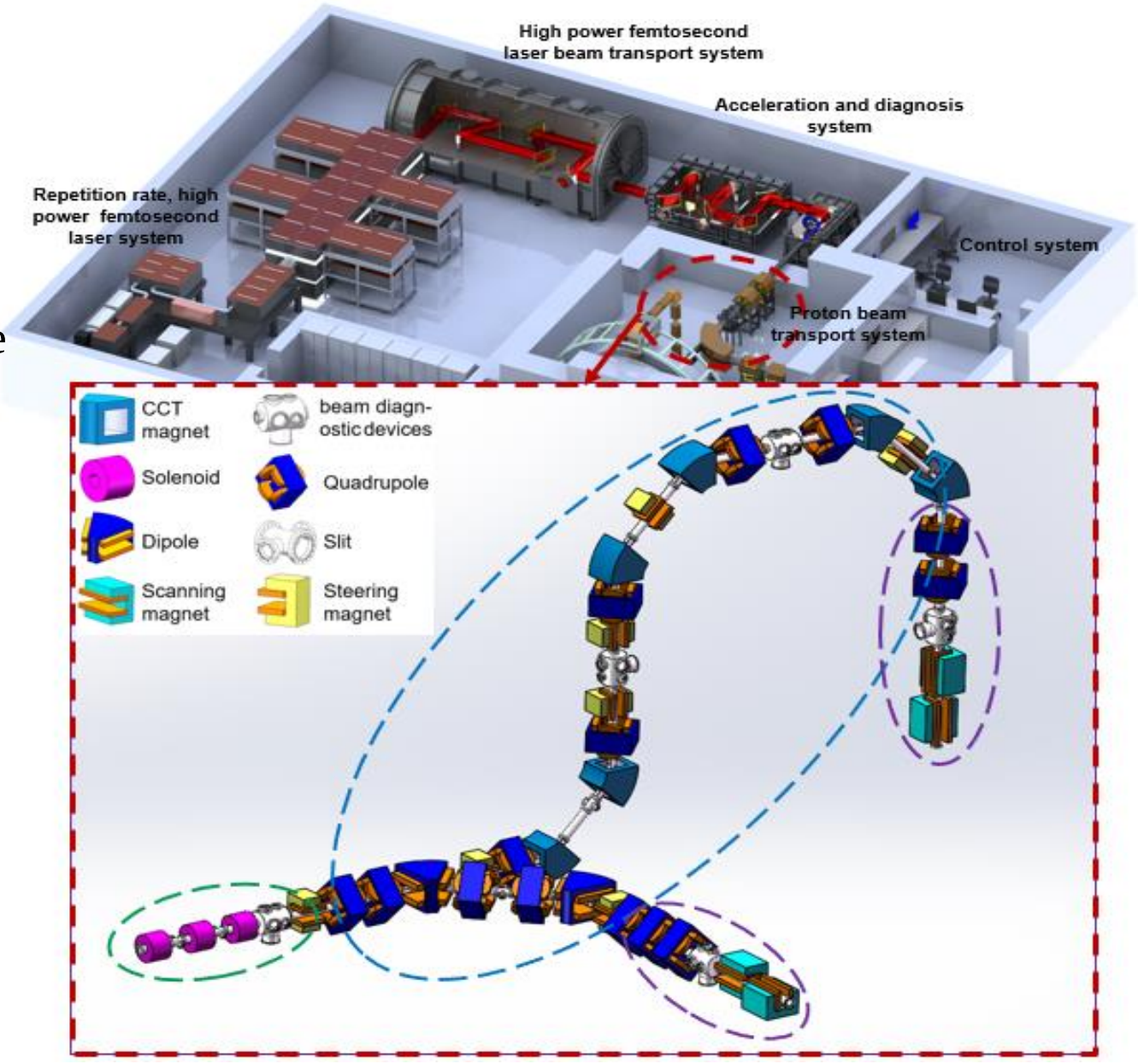
Medical laser proton accelerator has been developed in the world



- Petawatt LAser Proton Accelerator (PLAPA)
- The laser system will be a 2-PW, 1-Hz titanium sapphire system
- High peak flux
- Short temporal duration
- Energy level of multi-hundred MeV.



Distinct characteristics

1. Short pulse widths;
2. Wide energy spectra;
3. Large angular spread;
4. A spectrum of secondary particles.

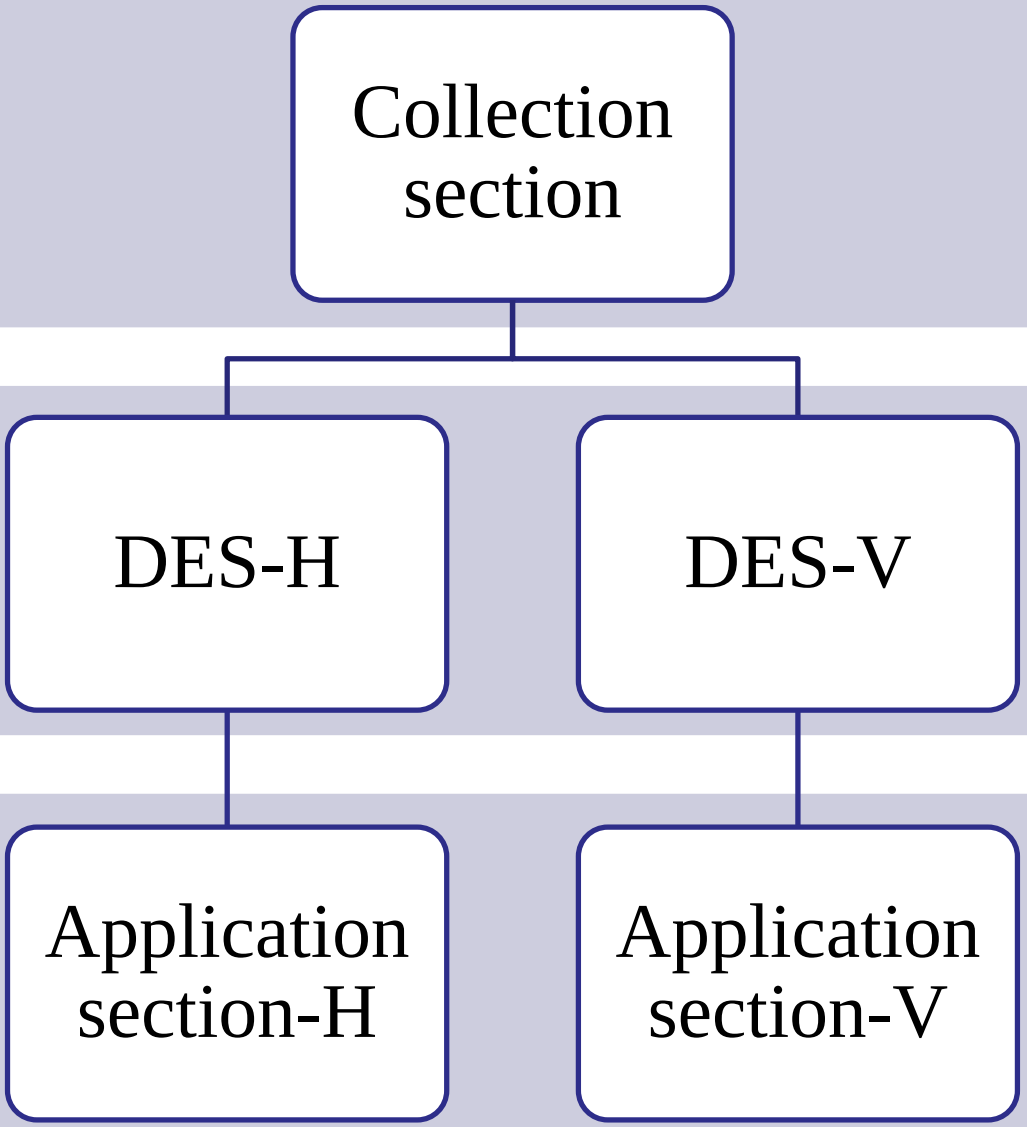
Design objectives

1. Proton beams with energy in the range 40-100 MeV can be transmitted;
2. Beamlines can provide both horizontal and vertical irradiation;
3. Beam spot with energy dispersion of less than 5%
4. Beam spot diameter is less than 15 mm.

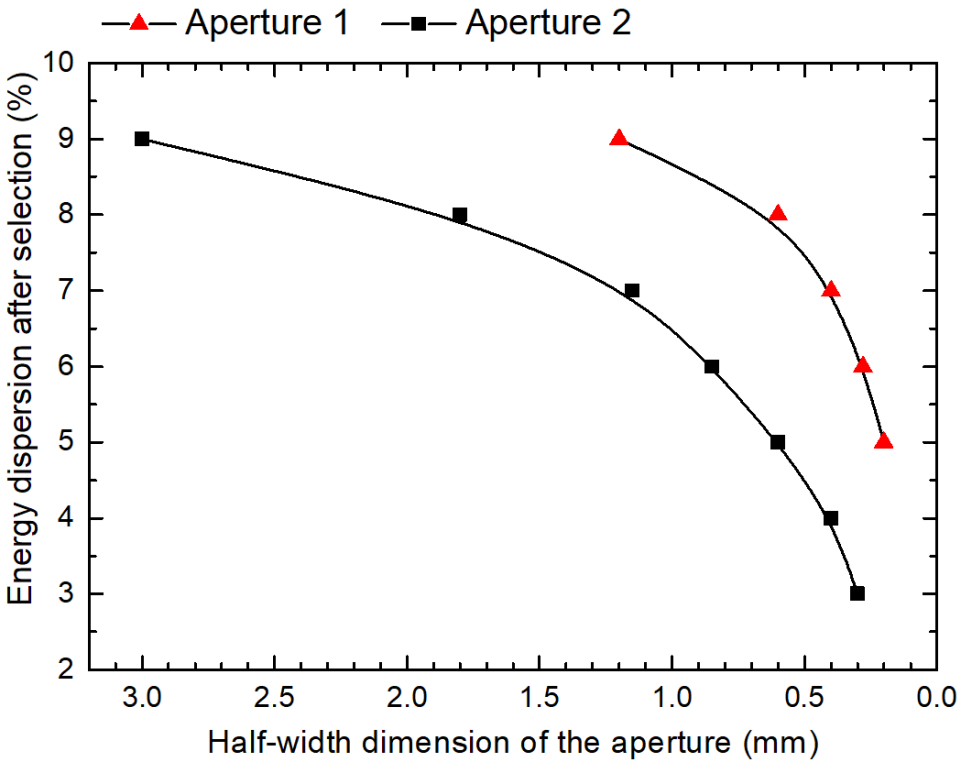
Focus the initial large divergence angle beam and make a preliminary energy selection.

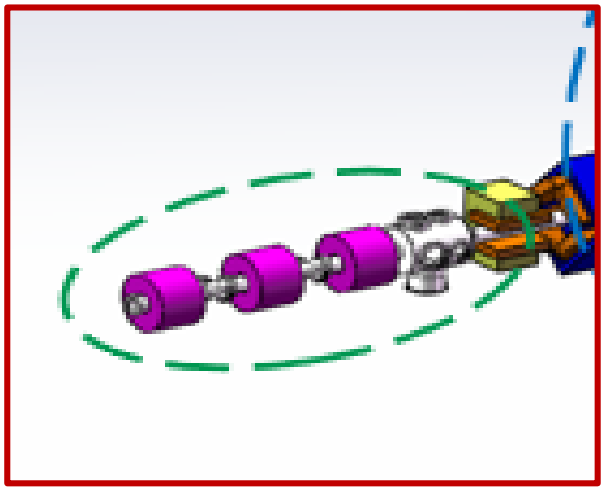
Deflection and Energy Selection (DES) sectionis used to accurate energy selection and removed uncharged particles

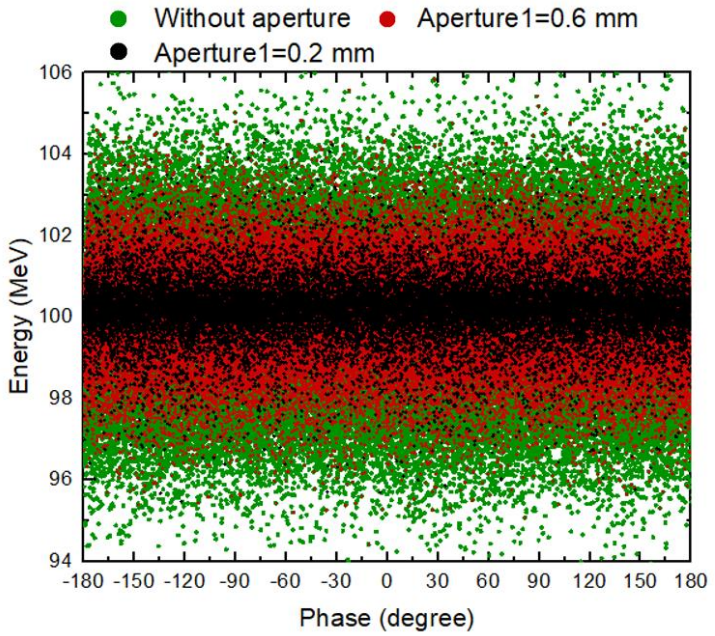
Completes the final beam shaping before irradiation.



Collection section







- Three superconducting high-field solenoids
- Two adjustable apertures between the three solenoids

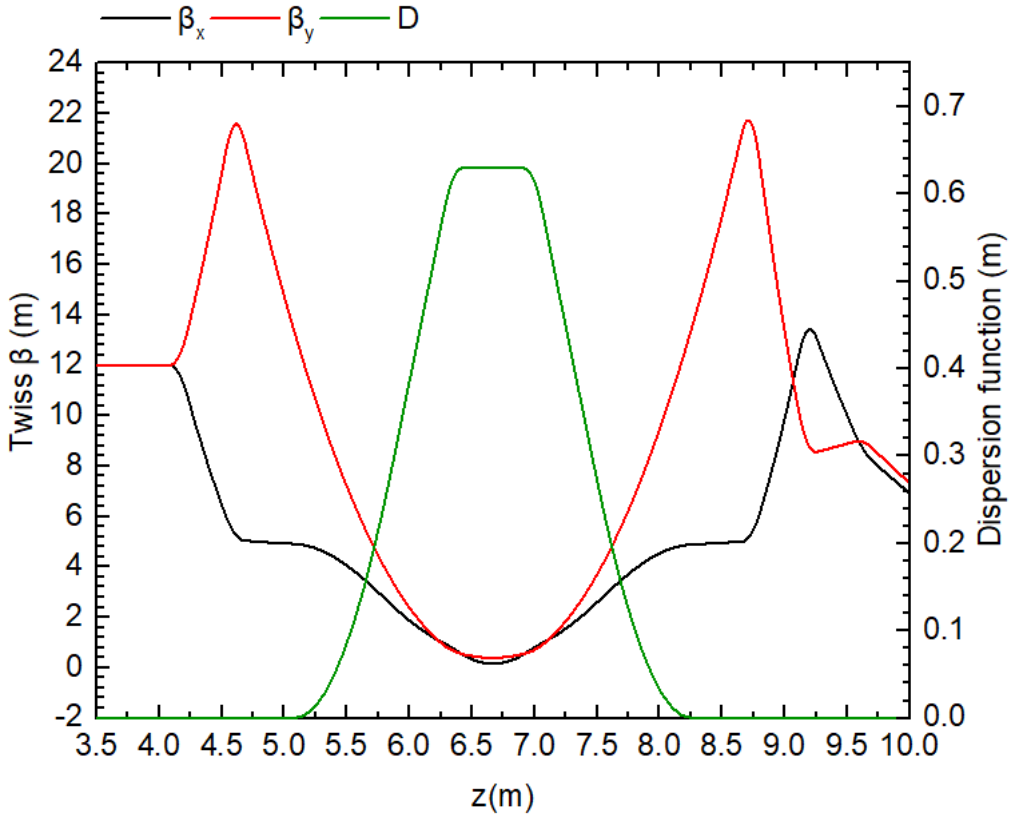
Deflection and Energy Selection (DES) section

- Accurate energy selection
- Removed uncharged particles

$$a_x = \sqrt{a_{x,0}^2 + \left(D_x \frac{\Delta p}{p}\right)^2}$$

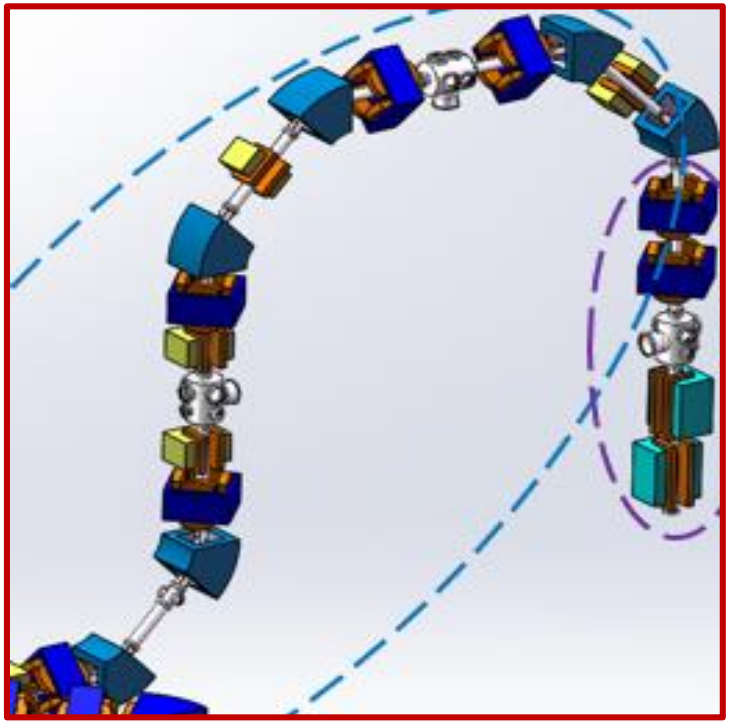
$$D'' + \left[\frac{1}{\rho^2}\frac{2p_0 - p}{p} + \frac{B'}{B\rho}\frac{p_0}{p}\right]D = \frac{1}{\rho}$$

The achromatic lattice design is used.



Deflection and Energy Selection (DES) section

- The curved CCT magnet is used
- It use multiple nested coil pairs to produce a hybrid field of dipole and quadrupole components



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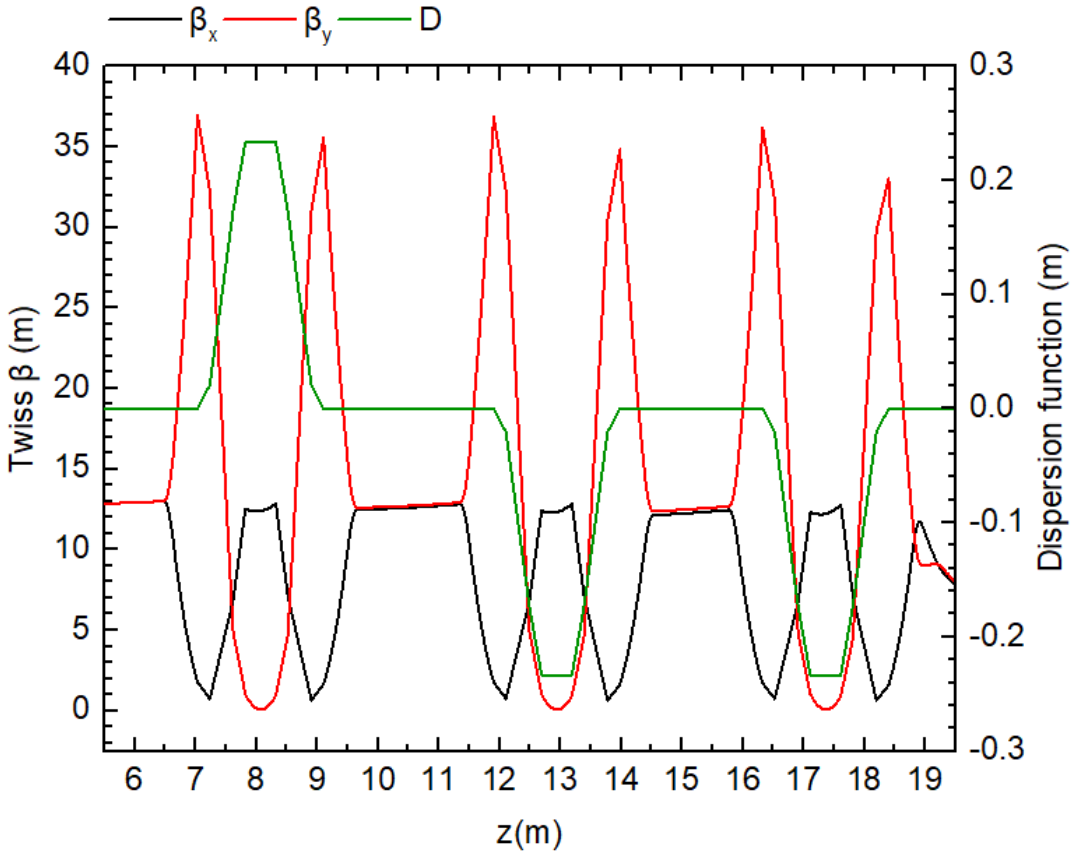
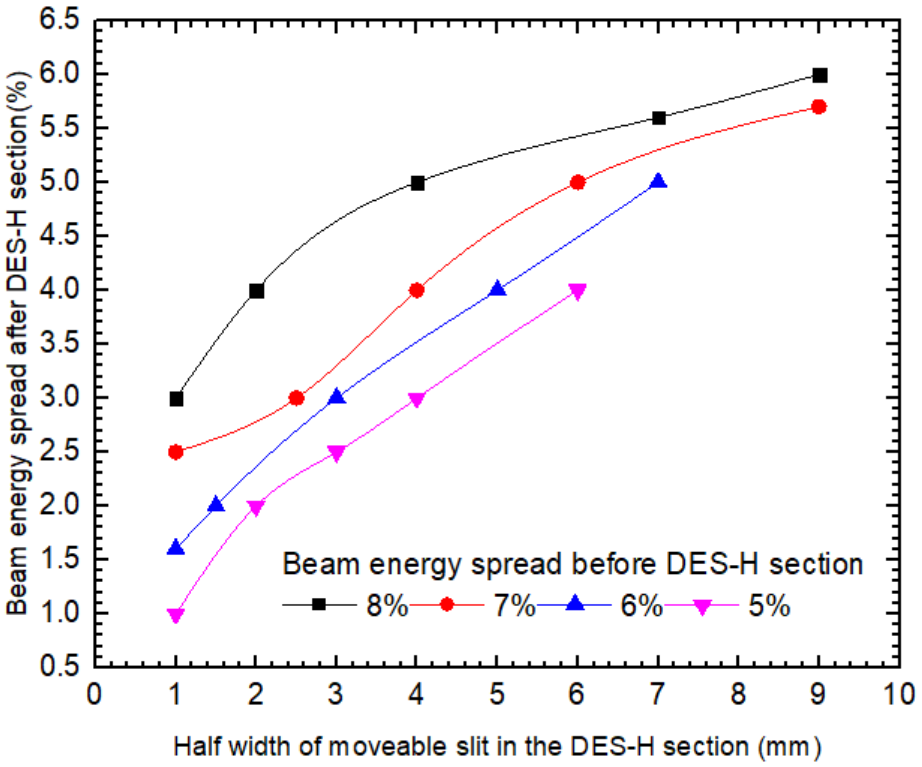
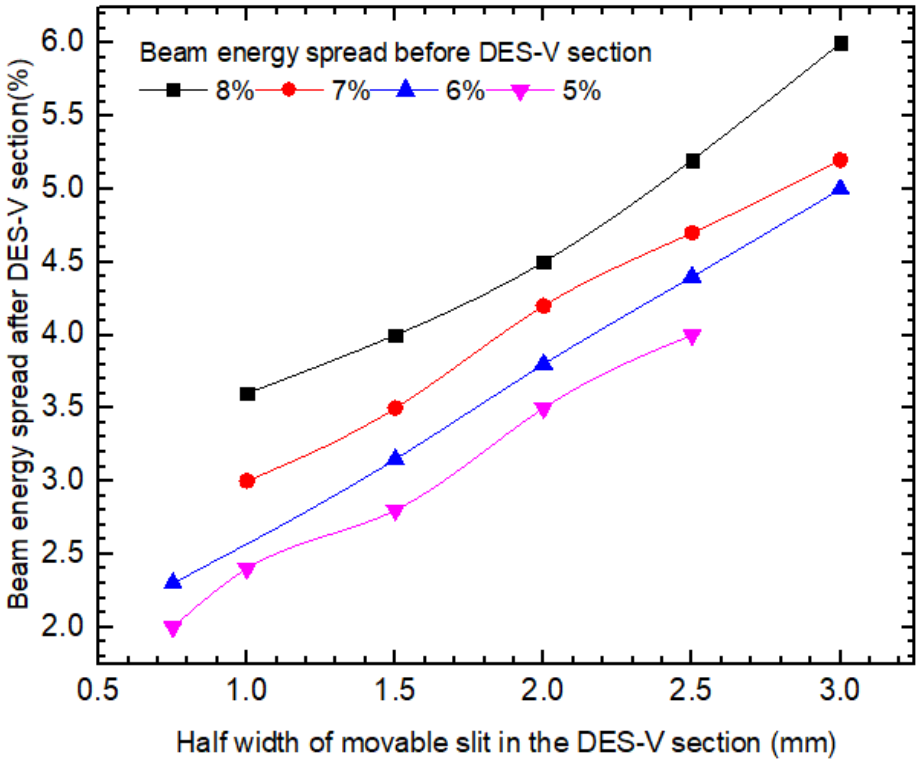
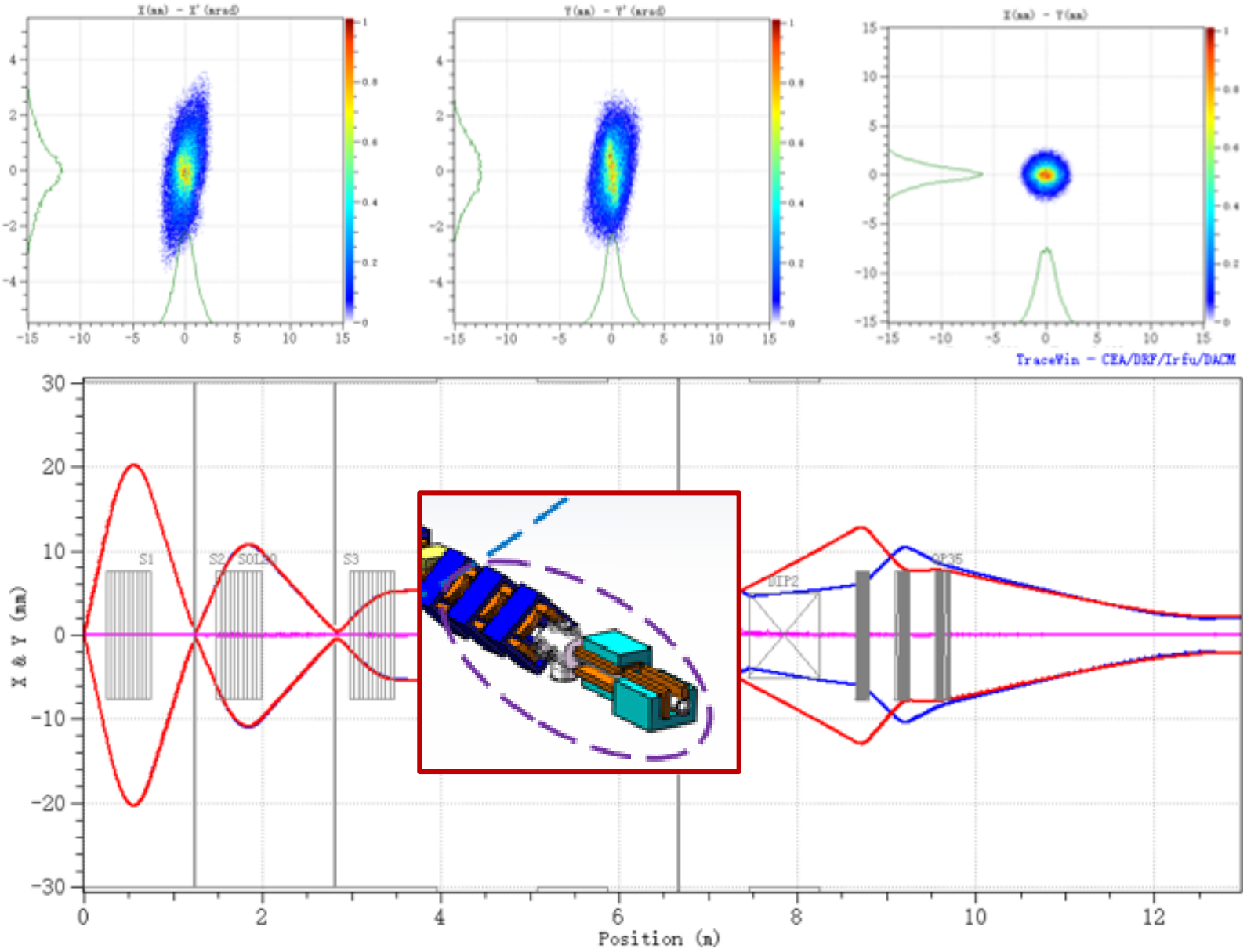


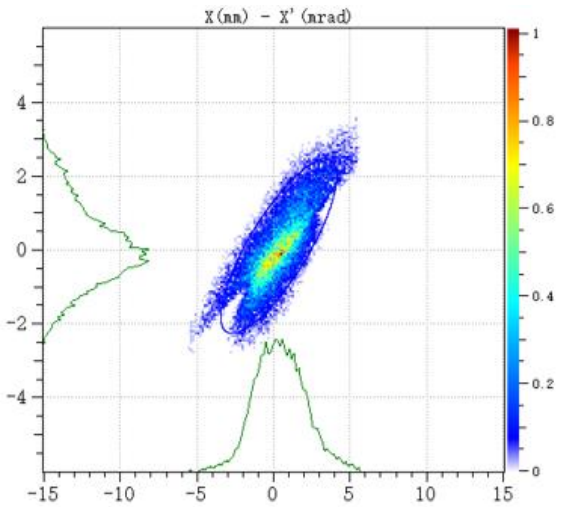
Deflection and Energy Selection (DES) section

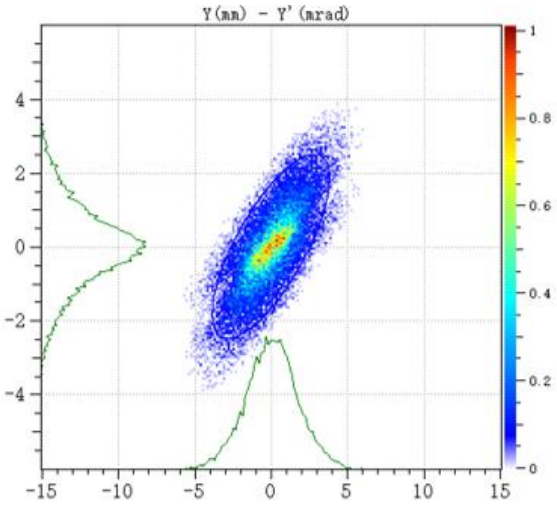


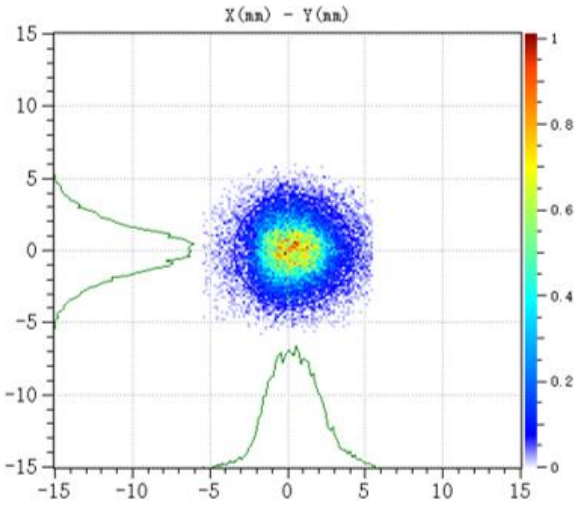


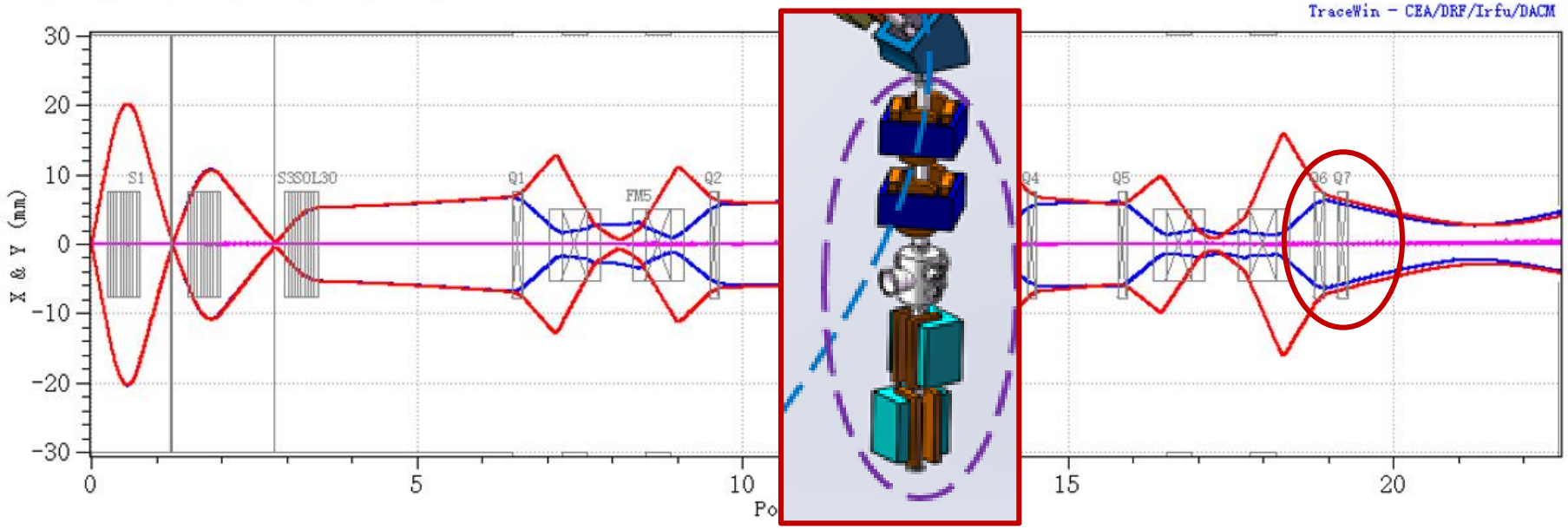
The moveable slit set between DES section remove particles with energy deviation and neutral stray particles produced by laser acceleration.


X(mm) - X'(mrad)
Y(mm) - Y'(mrad)
X(mm) - Y(mm)
TraceWin - CEA/DSM/Irfu/DACM
S1
S2
SOL20
S3
DIP2
QF35
X & Y (mm)
Position (m)


X(mm) - X'(mrad)


Y(mm) - Y'(mrad)


X(mm) - Y(mm)


TraceWin - CEA/DRF/Irfu/DACM
X & Y (mm)
S1
S3SOL30
Q1
FM5
Q2
Q4
Q5
Q6 Q7

Section	Beamline	Length (mm)	Radius (mm)	Maximum magnetic flux density
Collection section	Solenoid 1	500	30	9.05 T
	Solenoid 2	500	30	8.23 T
	Solenoid 3	500	30	6.51 T
DES-H section	DES-H-Q 1-4	150	36	11.45 T/m
Application-H section	APP-H-Q 5	150	36	14.11 T/m
	APP-H-Q 6	150	36	15.07 T/m
	APP-H-Q 7	150	36	3.17 T/m
DES-V section	DES-V-Q 1-5	150	36	9.25 T/m
Application-V section	APP-V-Q 6	150	36	12.47 T/m
	APP-V-Q 7	150	36	1.78 T/m

The beamline of PLAPA has been designed. The whole beamline system can provide horizontal and vertical irradiation modes respectively. By adjusting load current of the element in the beamline, the 40-100 MeV proton beam can be transmitted. A variety of energy selection elements are designed in the beamline to effectively filter particles with large energy spread and neutral stray particles. The energy spread can reach as low as 5% and are continuously adjustable within a certain range. Each bending element of the beamline adopts the design of local achromat.

Thank you

Suggestion is welcome