Fermilab

Highlights from AAC06: Advanced Accelerator Concepts

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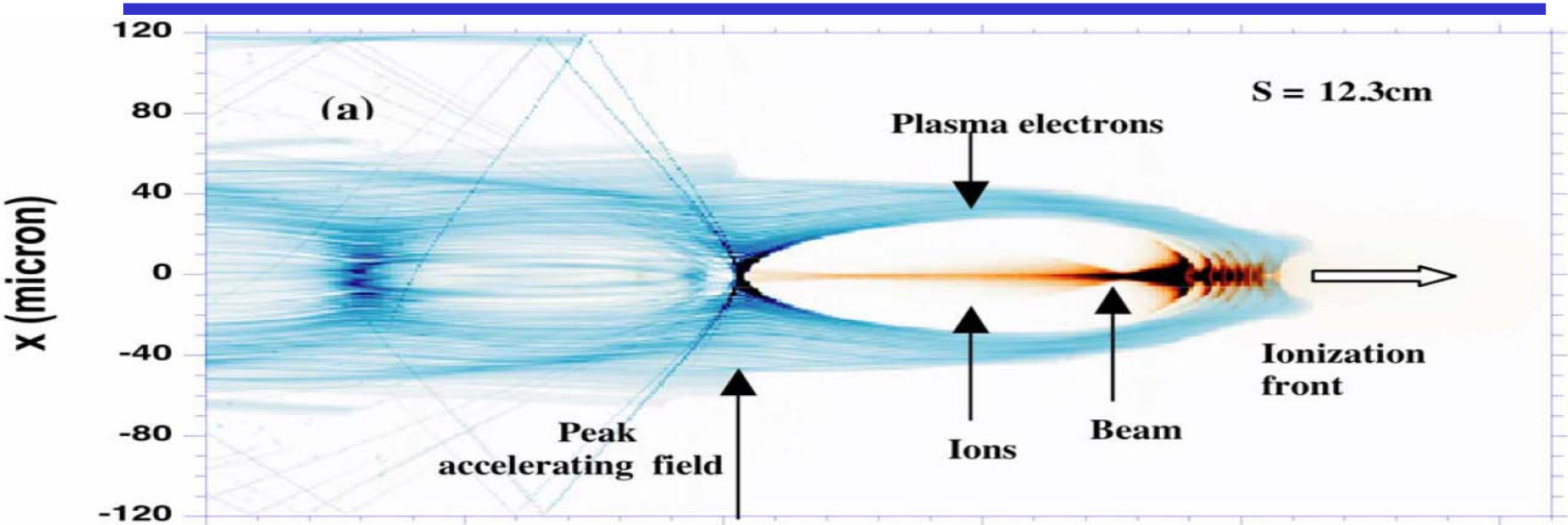
AAC06:

- Lake Geneva, WI
- ~170 participants
  - Nat'l Labs, Universities, SBIR companies, Europe and Japan
  - 3 from Fermilab (Scarpine, Shiltsev and Yoon)
- 5 days +1/2 Sat: 1 ½ days of plenaries and 4 days for 7 WGs:
  - WG1. Computational Accelerator Physic
  - WG2. High-Gradient Structures
  - WG3. High Energy Density Exotic Accel. Schemes
  - WG4. e-Beam Driven Accelerators
  - WG5. Beam Generation, Monitoring, and Control
  - WG6. Laser Plasma Acceleration
  - WG7. EM Structure Based Accelerators

AAC06 Highlights:

- Record High Gradients
  - dE~40 GeV over ~1m →40 GeV/m SLAC FFTB
  - dE~1.1 GeV over ~3.3cm → 33 GeV/m at LBl L'OASIS
- First PASER demonstration
  - CO2 media → low gradient dE
- High brightness proton source
  - laser hits spotted foil
- Materials for high voltage gradient
  - studies
  - theories

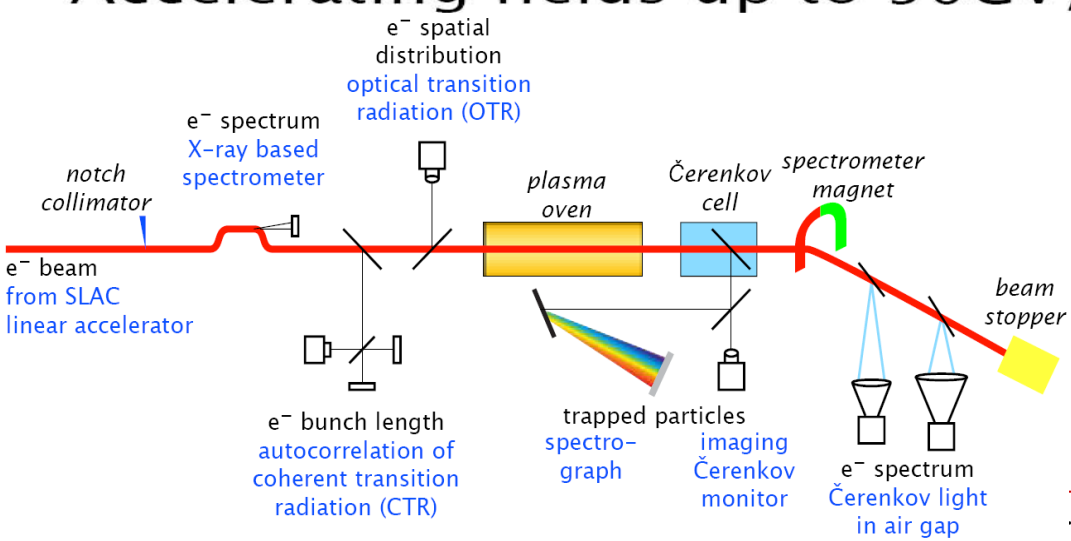
SLAC E-167



Typical wavelength: 50 μm

Accelerating fields up to 50GV/m

$$E_0 = \frac{4\pi\,\varepsilon_0\,c\,m_e}{e}\,\omega_p \approx \sqrt{\frac{n_p}{\mathrm{cm}^{-3}}}\ \frac{\mathrm{V}}{\mathrm{cm}}$$



28-42 GeV beam from Linac

~1.7e10 e-/bunch

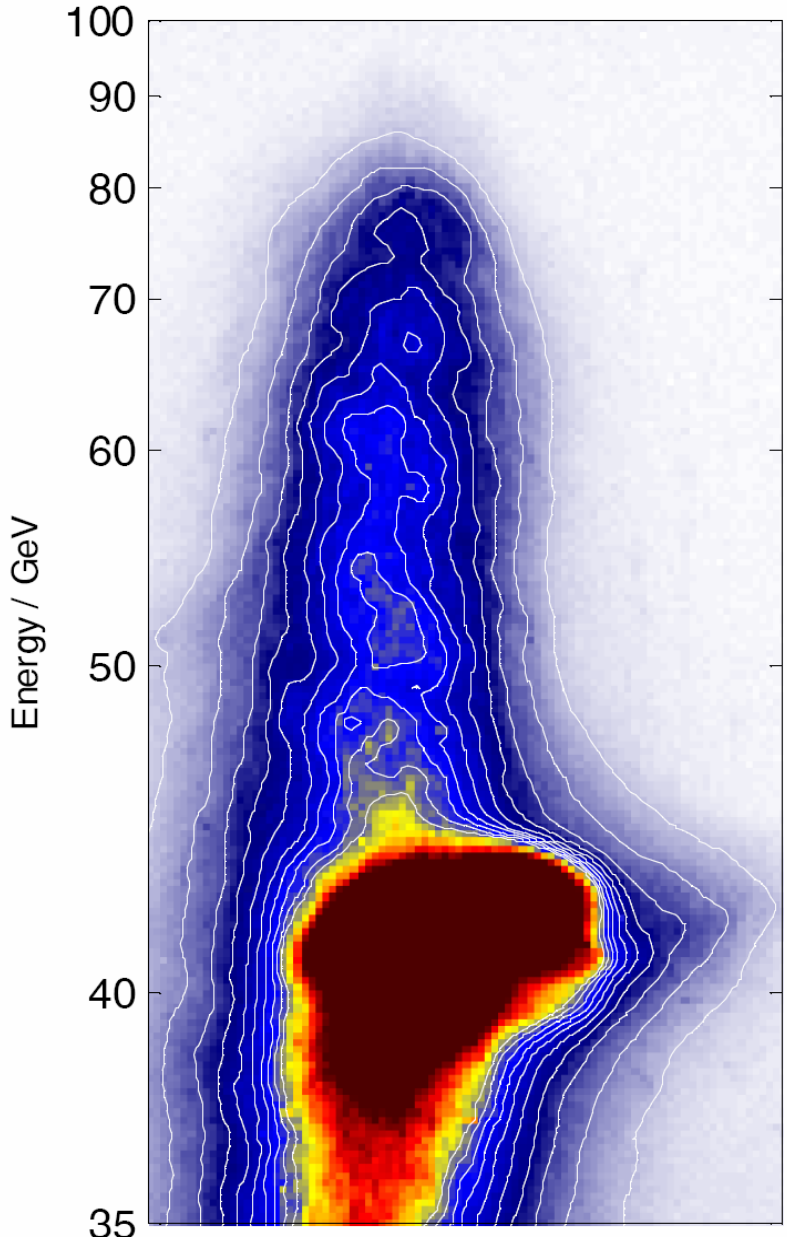
compressed in 20x10x10um (z x y)

Plasma oven 10→30→85→113 cm

SLAC E-167: Record Energy Gain

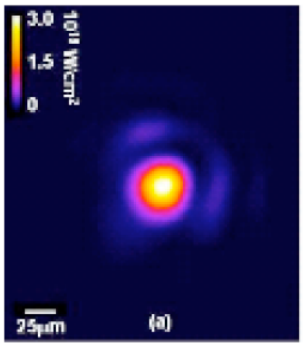
- Plasma length: 85 cm
- Density: $2.7 \cdot 10^{17}\ cm^{-3}$
- Incoming energy: 42 GeV
- Peak energy: 80 GeV

- 0.5% of beam >70GeV
- Plans:
  - free space for LCLS and move to SABER
  - Pre-ionize plasma to overcome hea erosion
  - Two bunch injection
  - accelerate e+
- Far goal: 5x100GeV burner

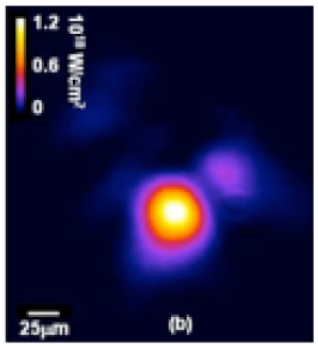


Berkeley Capillary Plasma

Guiding of 40 TW laser pulses:
- in capillary discharge waveguide
- over 33 mm of plasma

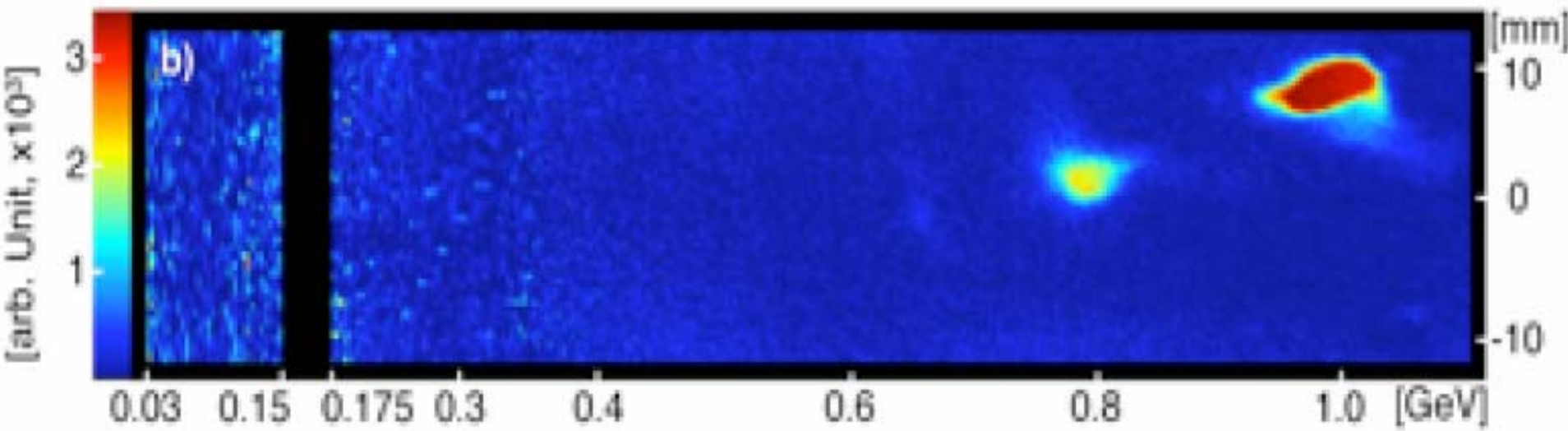


Input spot

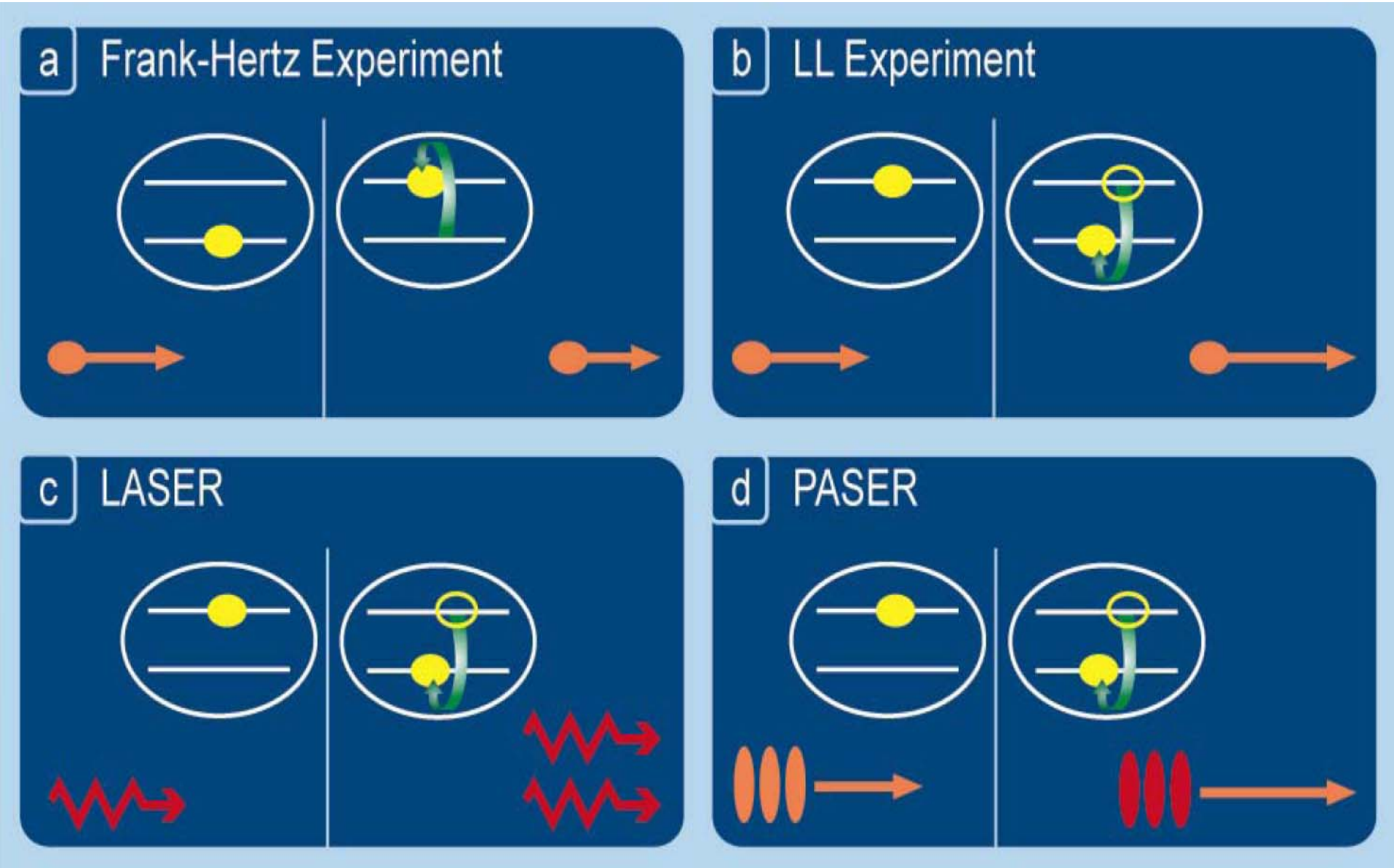


Exit spot

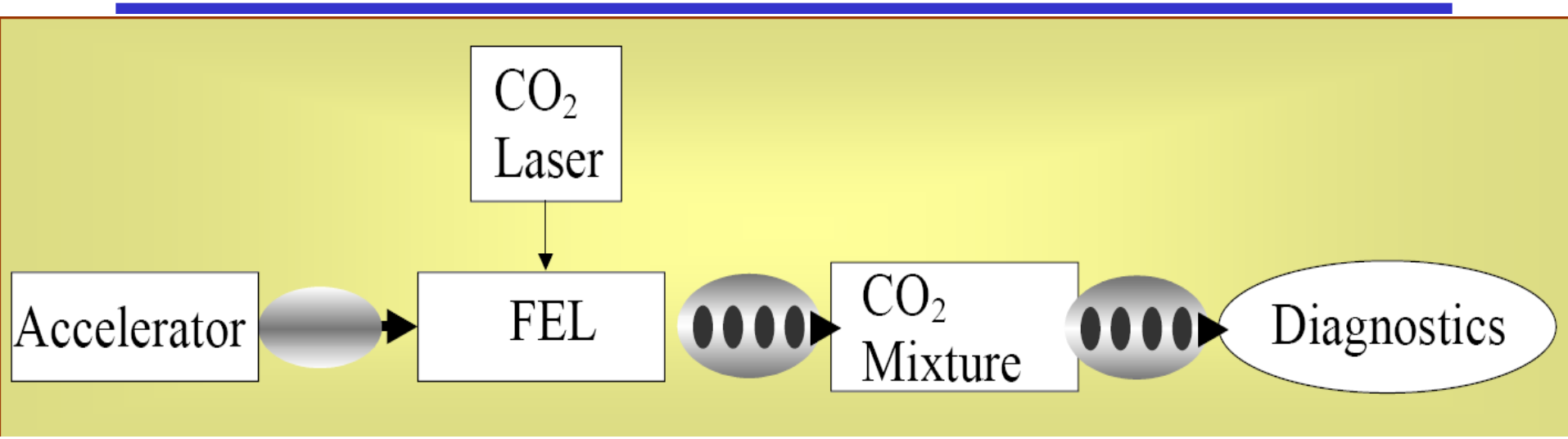
- 40-80 TW laser; 33mm x 0.25mm plasma
- E~1.1 GeV, dE~5%, 50 pC(3e8) e-, 2mrad
- Issues to address:
  - Need lower n_p (de-phasing ~1/n^1.5)
  - Stable generation >1GeV
  - Test two stages
  - External beam injection

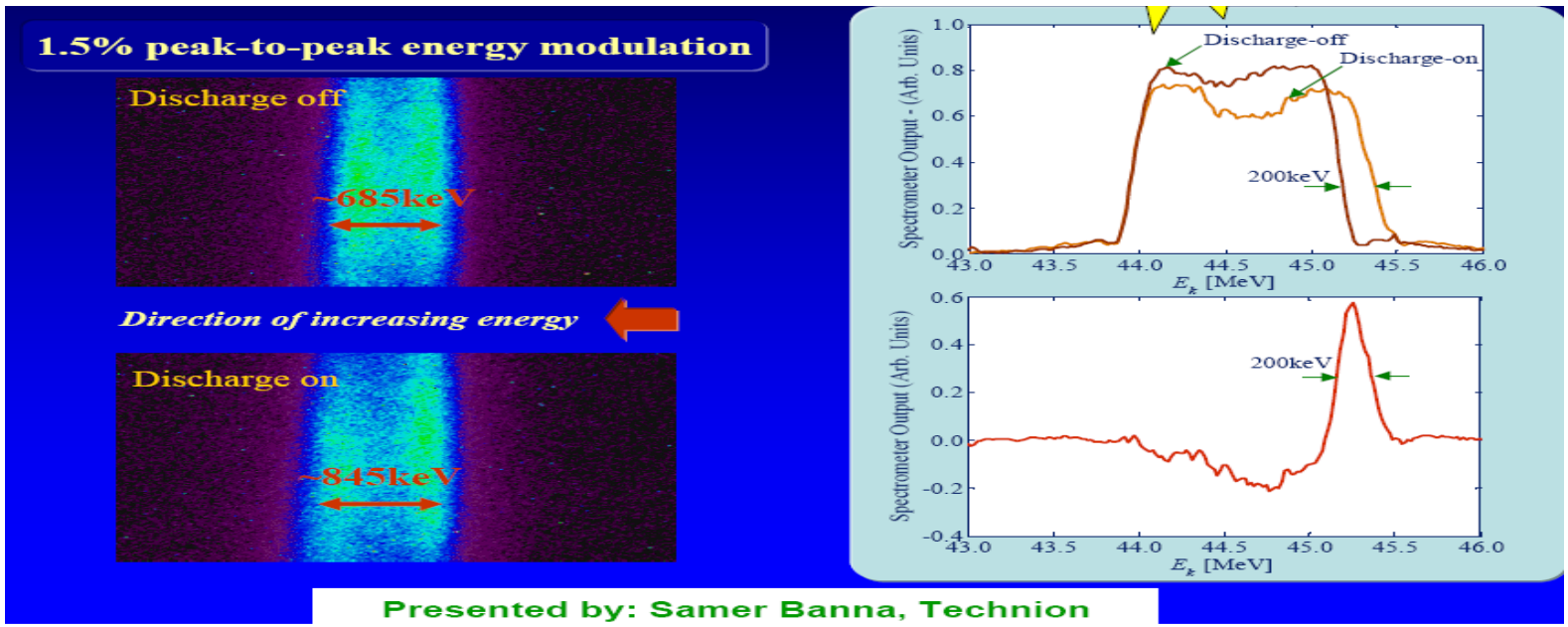


PASER : An Idea

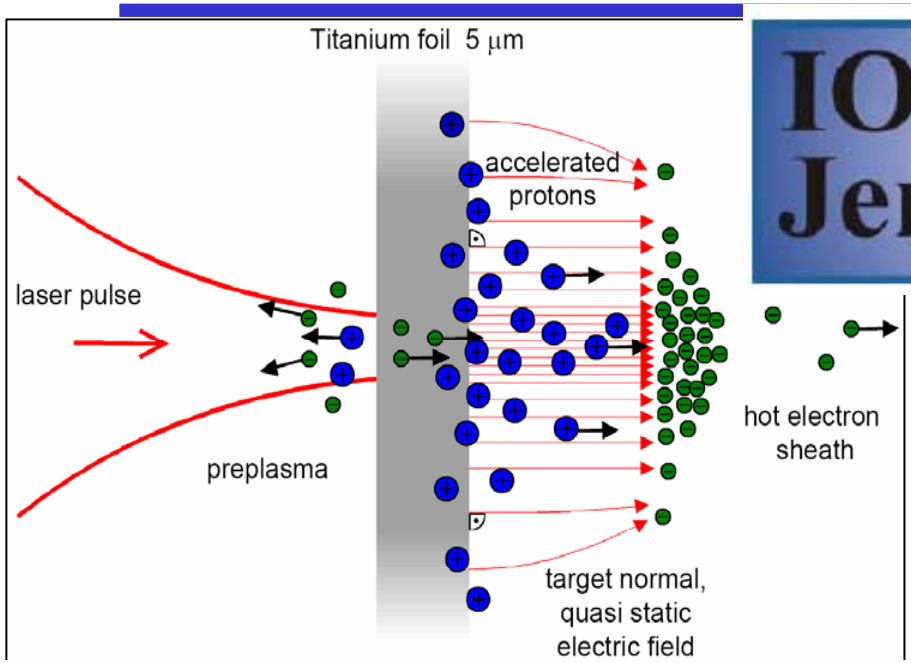


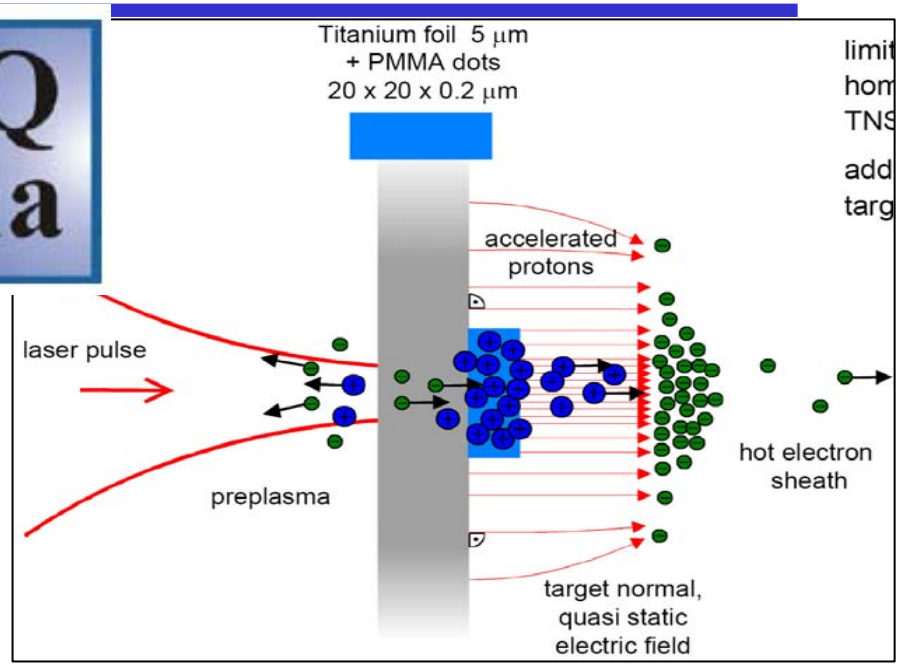
PASER proof-of-principle at BNL

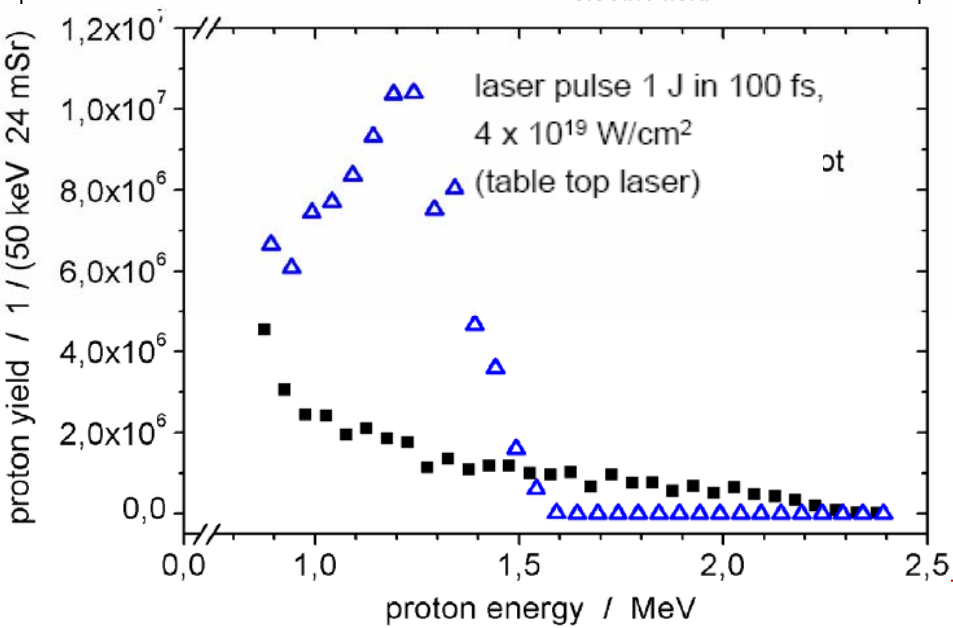




Monochromatic protons from laser hit







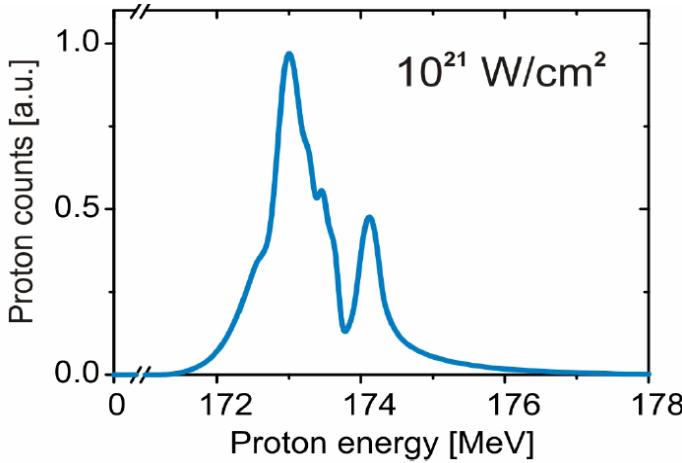
- 1J 100 fs laser → E=1.5 MeV protons dE~+-15%, 1e-3 mm mrad
- 150 J 150 fs laser (2008) → E~180 MeV, dE~1%, 0.1nC very small transv and long emittance
- BNL: CO2 laser

E ~ lambda

N_p ~ L^2

- Thinner foils

for extra accelerati



Experiments and theories of breakdowns

Breakdown fields normalized to copper for various metals

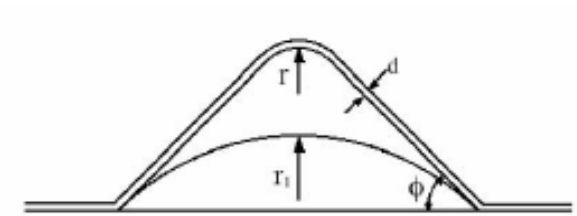
1.0 — 1.13		1.19 — 1.23		1.28 — 1.42	
Cu	1.00	Ni	1.19	Mo	1.28
Ta	1.00	Fe	1.19	Ti	1.32
Tc	1.02	W	1.20	Sc	1.35
Ir	1.02	SS	1.21	Cr	1.39
Zr	1.06	Nb	1.21	V	1.42
Ca	1.06	Al	1.21		
Rh	1.07	Ru	1.22		
Y	1.09	Mg	1.23		
Os	1.10	Co	1.23		
Mn	1.12				

Be 2.20

Non-metals

B 2.53

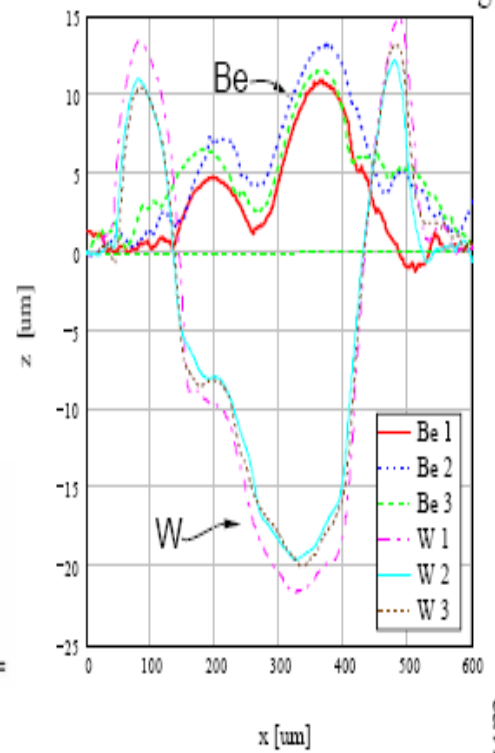
C ~4



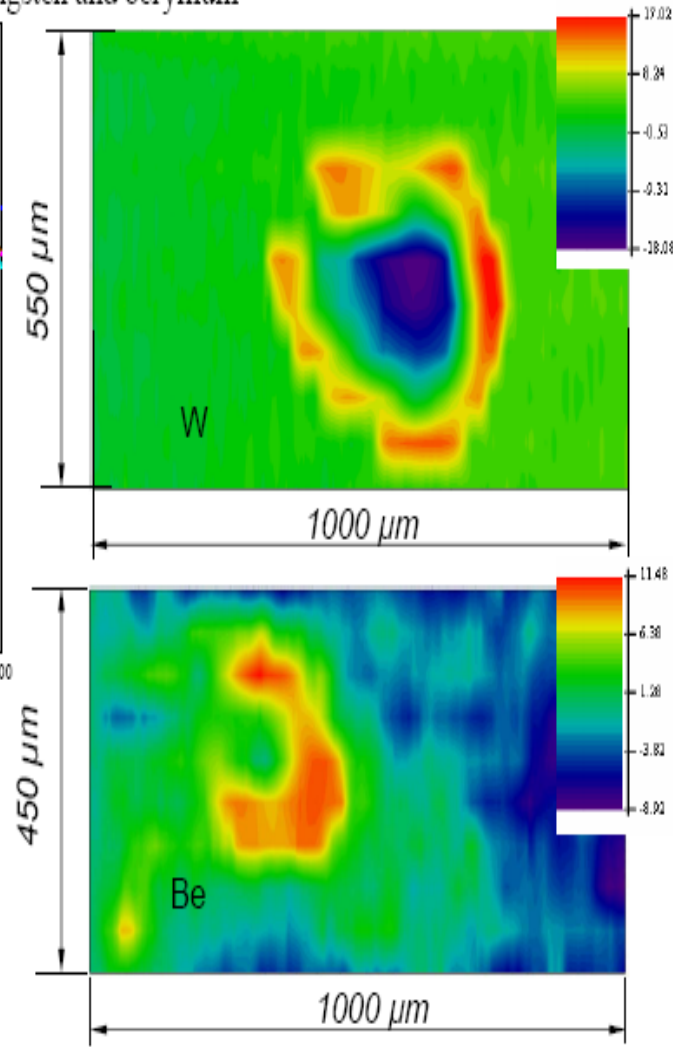
RF and DC breakdown theories:

- Jim Norem, W.Wruelich, P.Wilson:
  - Surface melting under bombardment
  - Incident power, penetration depth, thermal conductivity, diffusion depth, melting point

Profile measurements of impact spot of 120 kV electron beam with same power density for tungsten and beryllium



1D profile through middle of the spot for 6 different spots: 3 beryllium and 3 tungsten.



2D profile

Profiles measured using Dektak Bench-Top Surface Profiler

V. Dolgashev, Y. Higashi, T. Higo, April 2006

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