End Station A Test Beam ESTB & CLIC Wakefield Collimation

Mauro Pivi, SLAC National Accelerator Laboratory
on behalf of ESTB/ESA team

Webex CLIC meeting
June 09, 2011

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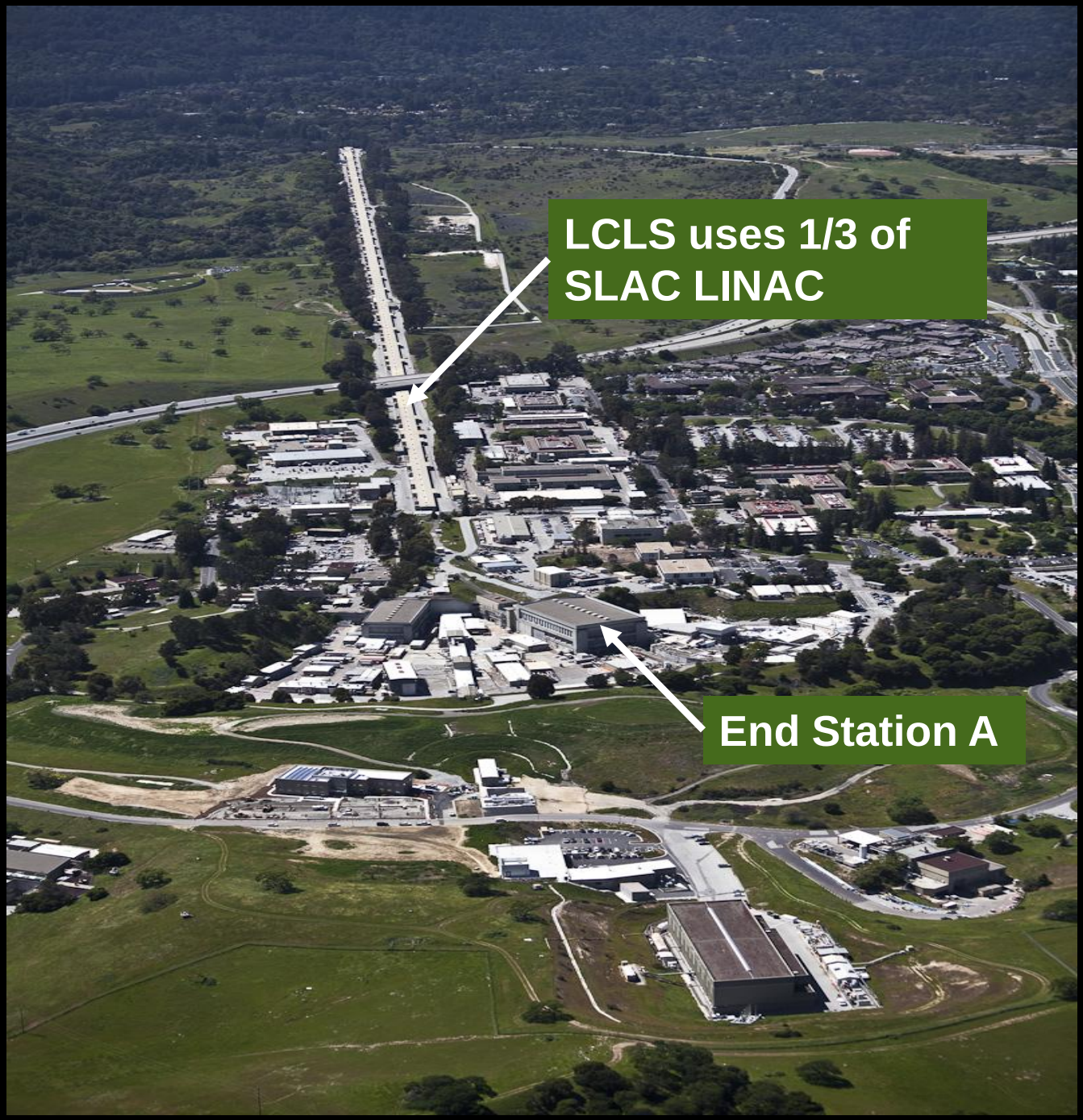
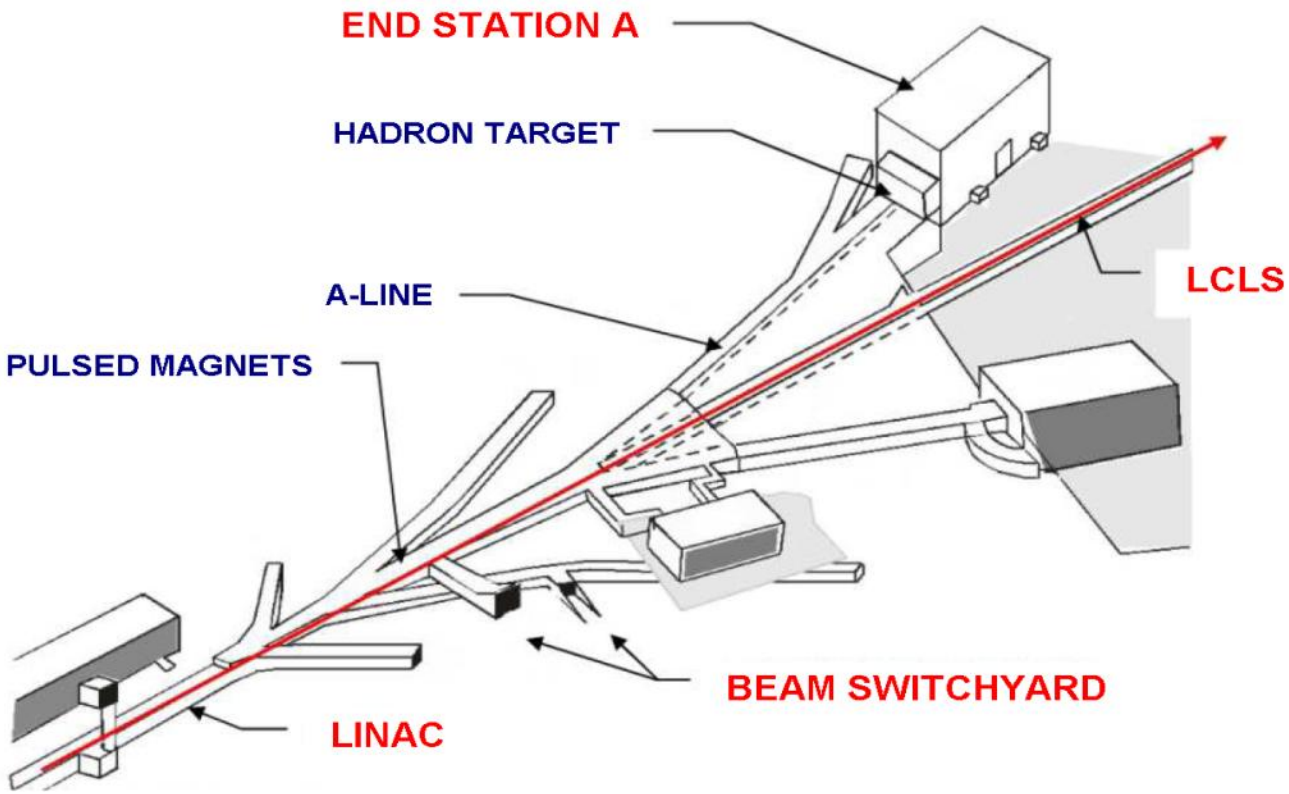

LCLS uses 1/3 of
SLAC LINAC
End Station A

LCLS and ESA

Use pulsed magnets in the beam switchyard to send LCLS beam to End Station A (ESA)



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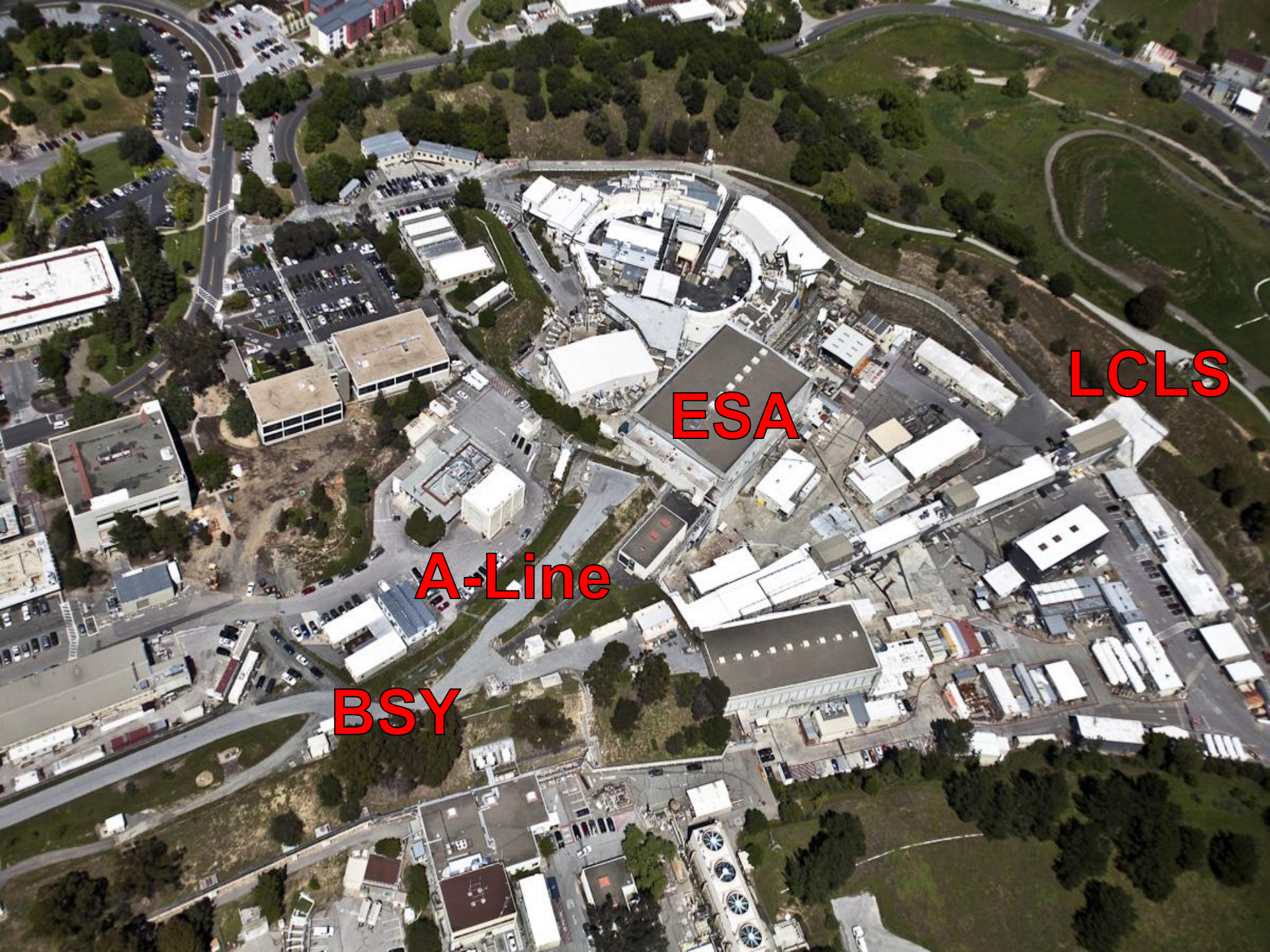
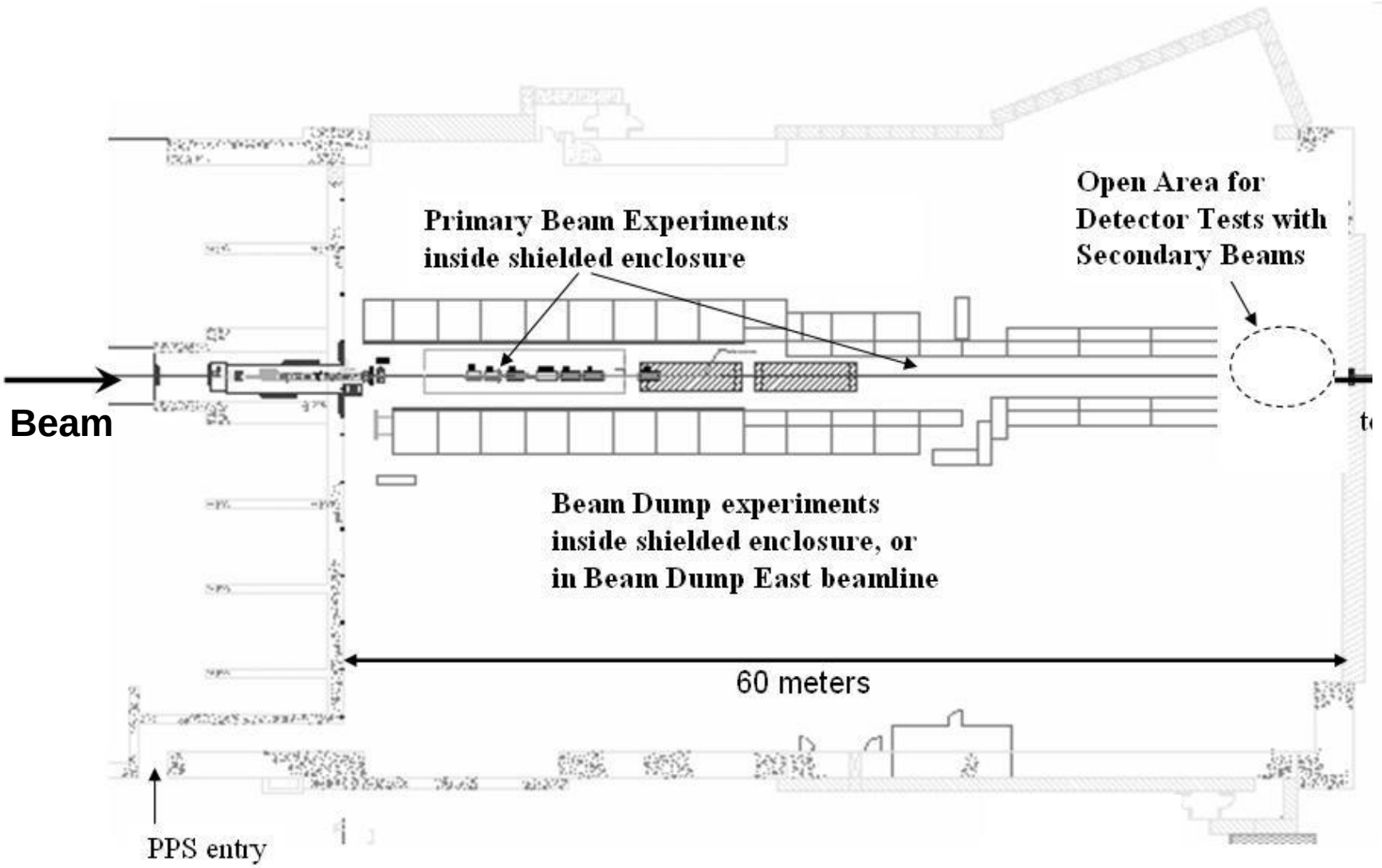

LCLS
ESA
A-Line
BSY

Building 61: ESA



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LCLS/ESTB Beams

LCLS beam

- Energy: **3.5 –13.6 GeV**
- Repetition rate: **120Hz**
- Beam current: 20 to **250 pC**
  - 150 pC preferred by LCLS Users these days
- 350 pC @ 120Hz has been provided
  - This is the current upper limit for the present cathode
  - **Radiation Safety approved 600 pC running!**
- Beam availability > 95%!

ESTB beam

- Kick the LCLS beam into **ESA** @ **5 Hz**
- Primary beam 3.5 -13.6 GeV
  - Determined by LCLS
  - <1.5 x 10^9 e-/pulse (250 pC)
- Clean secondary electrons
  - 1 GeV to 13.6 GeV, 0.1 e-/pulse to 10^9 e-/pulse

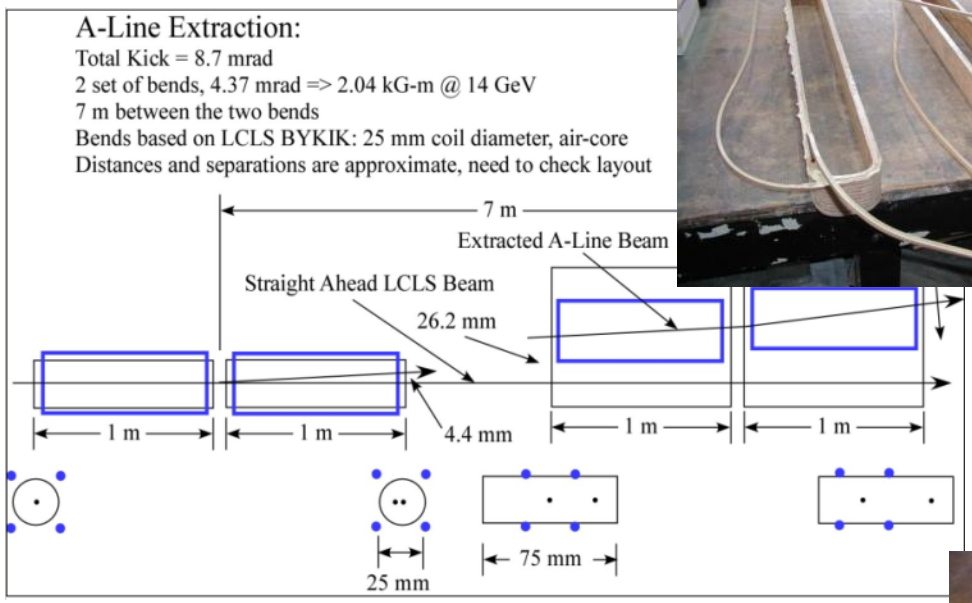
ESTB parameters

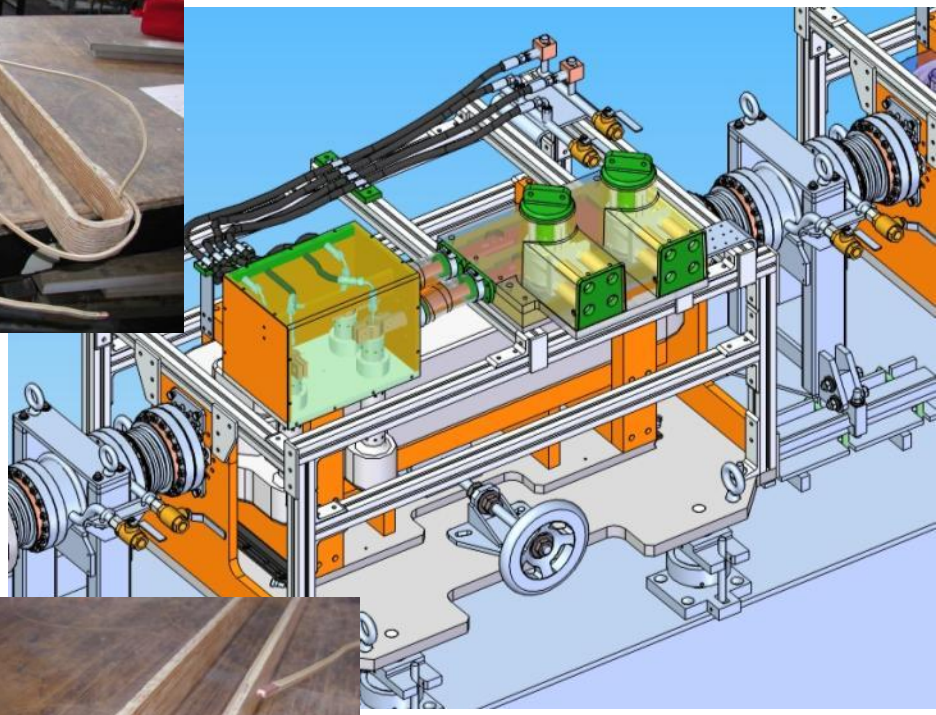
Table 1.1.1. ESTB primary electron beam parameters and experimental area at the BSY and in ESA

Parameters	BSY	ESA
Energy	4-13.6 GeV	4-13.6 GeV
Repetition Rate	5 Hz	5 Hz
Charge per pulse	0.25 nC	0.25 nC
Energy spread, σ_E /E	0.058%	0.058%
Bunch length rms	10 μm	280 μm
Emittance rms ($\gamma\varepsilon_x$,$\gamma\varepsilon_y$)	(1.2, 0.7) 10^{-6}m-rad	(4, 1) 10^{-6} m-rad
Spot size at waist ($\sigma_{x,y}$)	-	< 10 μm
Drift Space available for experimental apparatus	-	60 m
Transverse space available for experimental apparatus	-	5 x 5 m

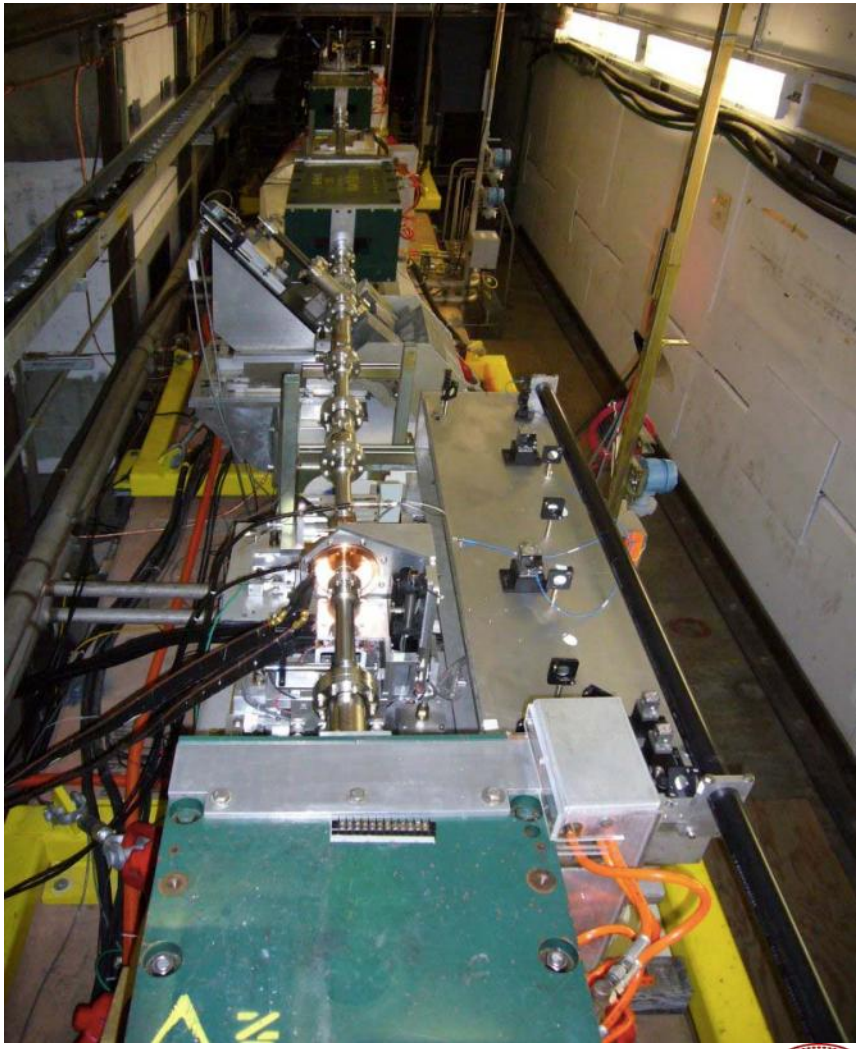
ESTB Hardware Needed

- 4 kicker magnets including power supplies, modulators and vacuum chambers are being manufactured
- Build new PPS system and install new beam dump





End Station A Experimental Area



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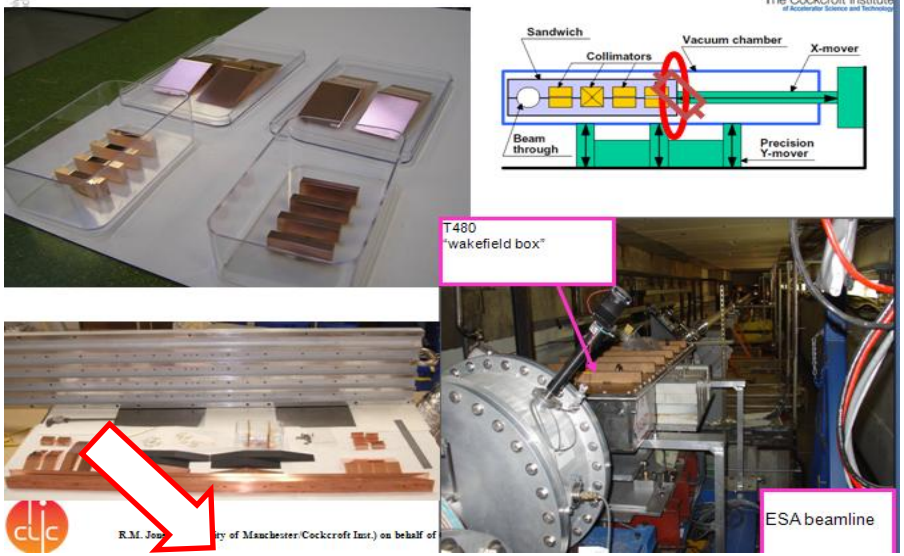
Collimator Wakefield Measurements

R.M. Jones, D. Schulte, R. Tomas, W. Wuensch for the CLIC team

Motivation

- Collimator wakefields may limit CLIC performance
- CLIC parameters sit close to limit of formulae applicability
- Previous experiments in ESA (T-480)[a] show discrepancies with model (is the lack of bunch length measurement the culprit?)
- Non-linear components?

Collimator Hardware



- **Bunch length measurement is critical . New electro-optic bunch length instrumentation (CLIC CDR)**
- **Need BPM resolution in the 100 nm level (partially contributed by CERN)**

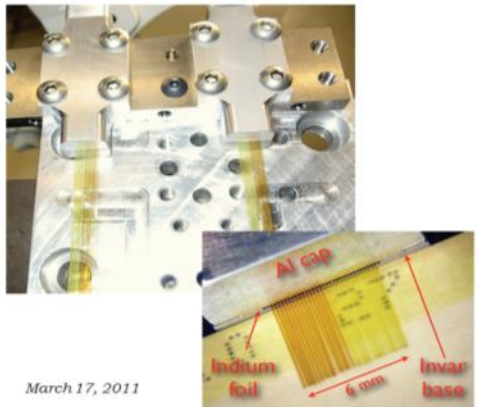
Energy Spectrometer Tests at End Station A

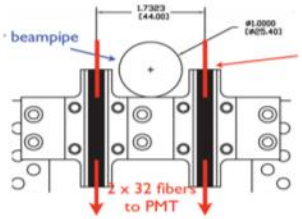
Mike Hildreth

New SR Stripe Detector

E. Torrence (Oregon), SLAC

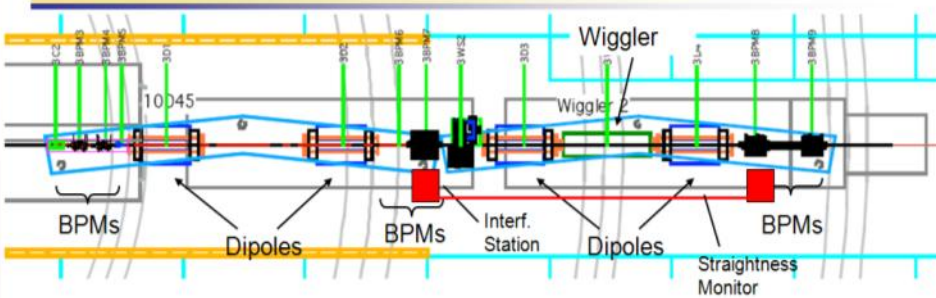
- Next-generation prototype for Energy Measurement test
  - schedule advanced in anticipation of ESA closure/hiatus due to LCLS





March 17, 2011

Next Steps for ESA



- Cross check of spectrometer energy measurements
  - Commission SR-Stripe setup
  - Previous chicane measurements limited by BPM resolution
    - LCLS2 BPMs? (under negotiation)
  - more new hardware/electronics for better resolution/stability
  - aim for 1×10^{-4} relative measurement, cross-calibration
  - Finish what we started!

Collimator Wakefield "Box" in ESA

- Installed and tested in 2007-'08
- Different jaw apertures, coll. lengths
- Tests: optimal materials and geometry to minimize wakefields
- T-480, see papers S. Molloy *et al.*

Slot	Side view	Beam view	
1	α r=1/2 gate	38 mm, h=38 mm	α=335mrad r=1.9mm
2			α=335mrad r=1.4mm
3	L=1000 mm		α=335mrad r=1.4mm
4	7mm		$\alpha=\pi$/2rad r=3.8mm

- "Wakefield box" allows swapping of collimators and adjusting jaw aperture
- measured wakefield kick to the beam by downstream BPMs

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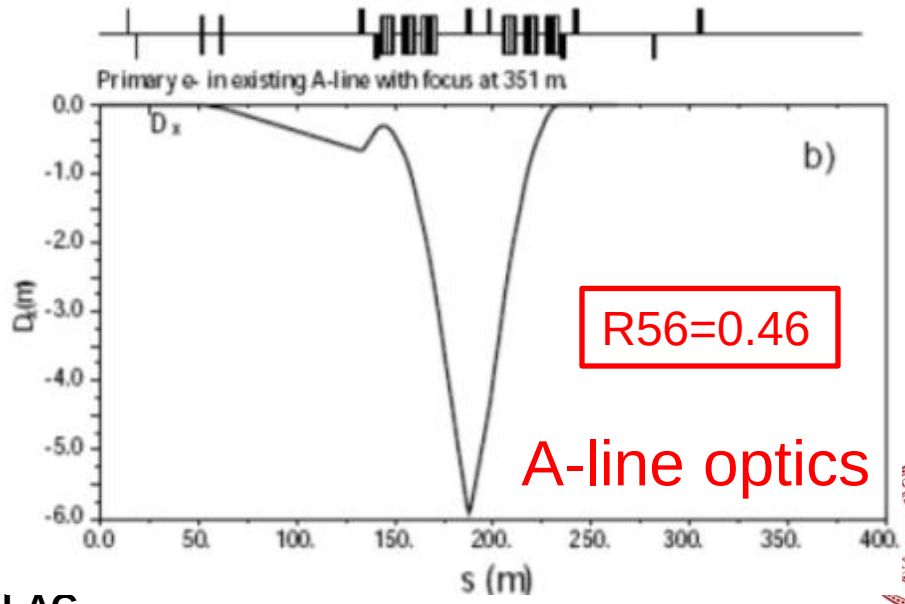
CLIC collimation wakefield

- CLIC bunch length 44 μm
- LCLS beam: 10 μm and smaller
- To first order: bunch length $\sigma_z = \delta_{uE} \times R56.$
- In the A-line, bunch length increase due to 24° bend, large dispersion (6m!) and large R56.

at nominal δ_{uE}=0.06% and R56 = 0.46:

$\sigma_z = \delta_{uE} \times$ R56 = 280um



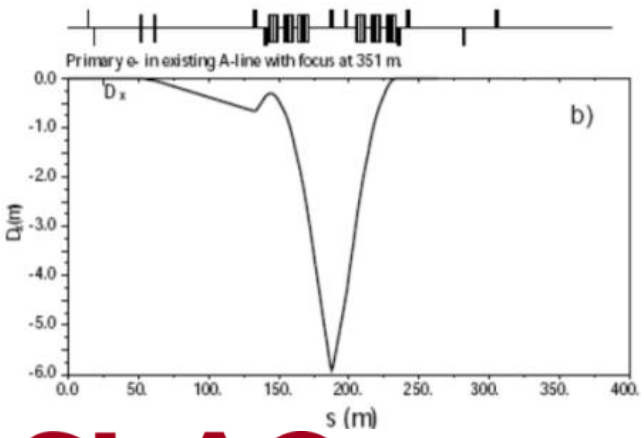
CLIC collimation wakefield

- It is possible to reduce δ_E~0.02% (Z. Huang)
- Bunch lengths of 100 um are possible.

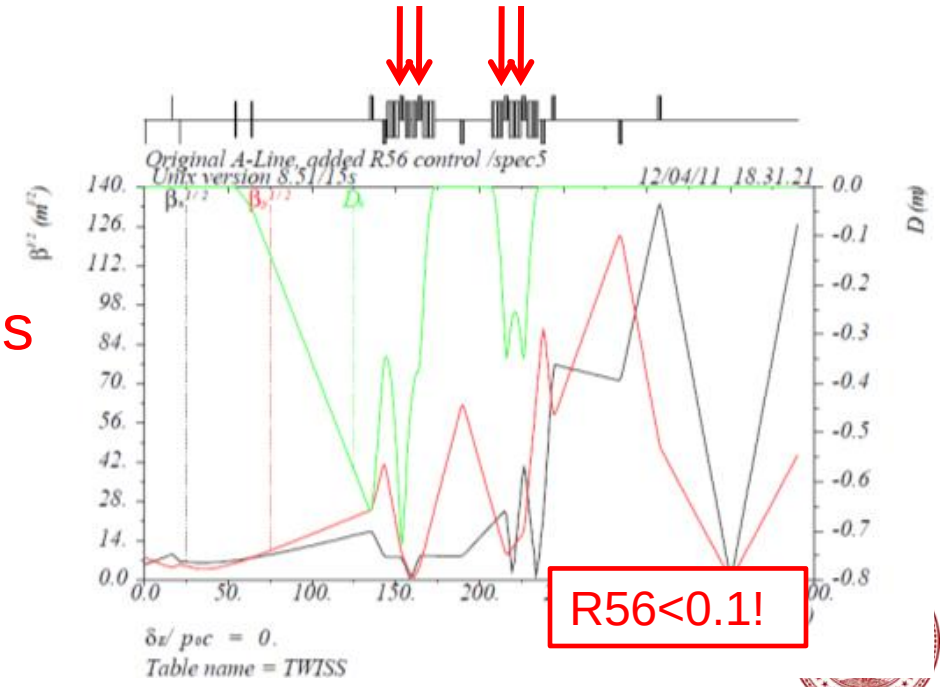
- For smaller bunch length we would need to modify the optics and reduce R56.

CLIC collimation wakefield

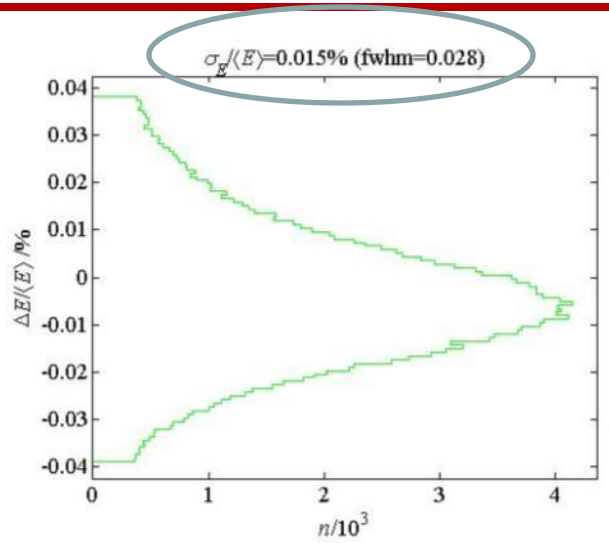
- Solution: installation of 4 available QUADs to reduce dispersion at bends locations:
  - reduce R56 ~0.1 (Ted Fieguth, M. Pivi)
  - with LCLS beam δ_E~0.02% (Z. Huang)
  - $\sigma_z \leq 44$ μm in ESA

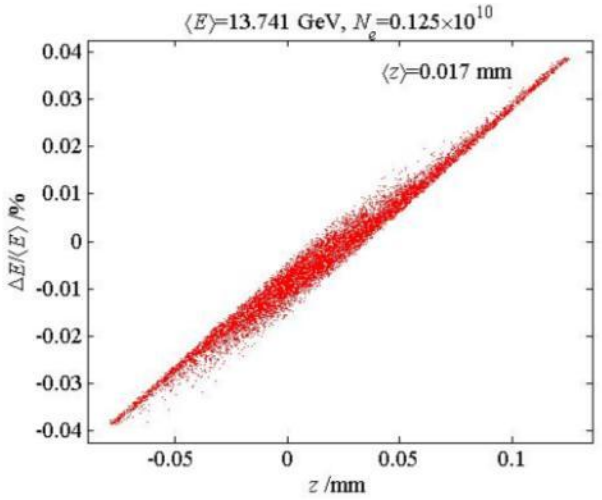


+ 4 Quads



Using LiTrack: example



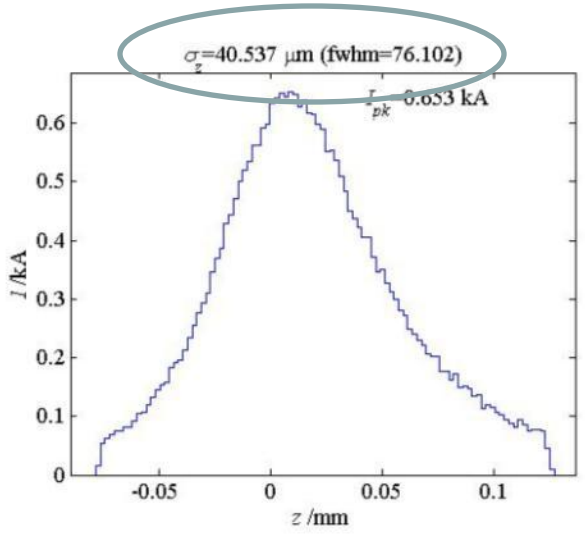


LiTrack simulations (Z. Huang):

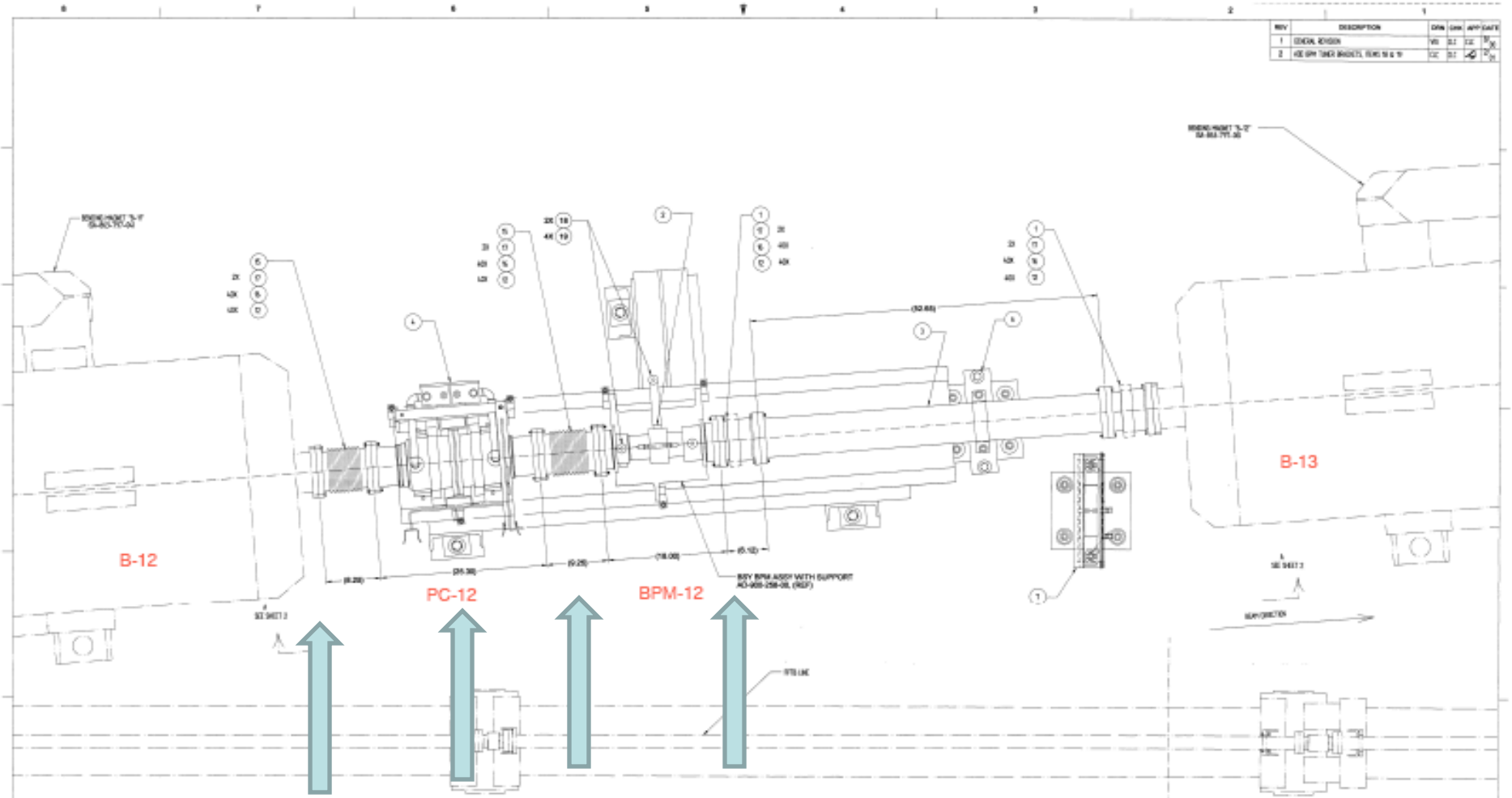
- δ_E~0.015%
- applied 10%energy cut
- R56 = 0.23 m (not 0.1 yet!)
- got σ_z =40 um

Source: lcls_200pC_6MeV_560um.zd

Elegant (MADX?!) simulations of whole beam line on the way



LiTrack (SLAC)



Removal existing instrumentation in the A-line to make room to 2 m long quadrupoles

50 GEV A-LINE
INSTRUMENT STAND
IS-12 INSTALLATION

ID-663-797-05 2 E

CLIC collimation wakefield

- 4 quadrupoles 2 meter long, aperture 8cm available at SLAC.
- Installation: need removal of existing instrumentation, new stands, power supplies (upgrade), pulling cables, cooling water channels, radiation physics calculations, designers, etc.

- $1.0M+ estimate for 4-quad installation and infrastructures

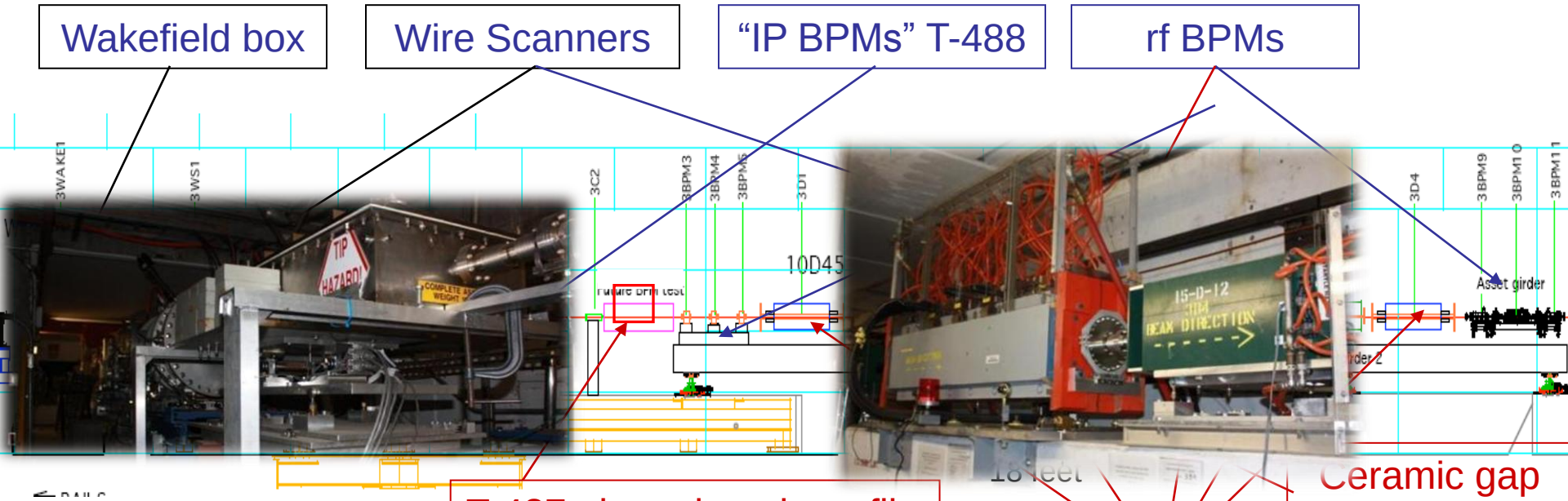
Schedule

- Oct 25th – Nov 1st install 4 BSY kicker magnets
- First ESTB run in November and December (need commissioning time)
- LCLS off from Christmas to end of January
- ESTB running resumes February 2012
- SLAC downtimes are in Aug/Sept and over Christmas for the next years

Summary

- We are excited to re-start ESA/ESTB test beams!
  - Unique High energy test beam line in the US, with plenty of infrastructures and SLAC support for Users
- Beam parameters determined by LCLS. Availability 5Hz +.
- Installation of the full 4 kicker system by end October
  - First ESTB run in November / December 2011
- CLIC collimation wakefield:
  - Wakefield “box” tested/ready for use in ESTB
  - In principle bunch lengths 100 um are possible in ESTB
  - Possible optics upgrade need funding (!) for $\sigma_z \leq$ 44um.
  - ESTB allows sensitivity studies scanning bunch length.
  - Need better bunch length instrumentation + BPMs (UK colleagues!)

ESA Past Experiments



BPM energy spectrometer (T-474/491)

IP BPMs—background studies (T-488)

Synch Stripe

Collimator de

Bunch length

Smith-Purcell

We need rf BPMs possibly LCLS-II type