SuperKEKB e^+ source

design considerations and construction status

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SuperKEKB Injector & e+ source

50 Hz (e+ or e-)
pulse-by-pulse
mode switching

primary e- for e+ prod.
10 nC x 2
HER inj. e-
5 nC x 2

photo cathode
RF gun

1.1 GeV
Damping Ring
circ. 136 m

e+ DR

BCS

ECS

S-band
linac

1.6

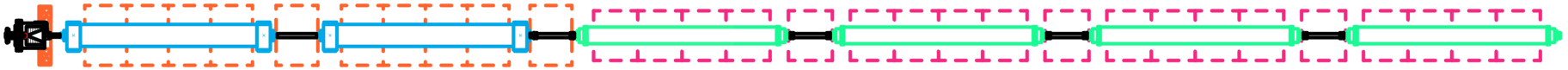
e+ for LER
4.0 GeV
4 nC x 2
$92_{[H]}/7_{[V]}$ um

ECS

primary e-
on target
3.2 GeV
10 nC x 2

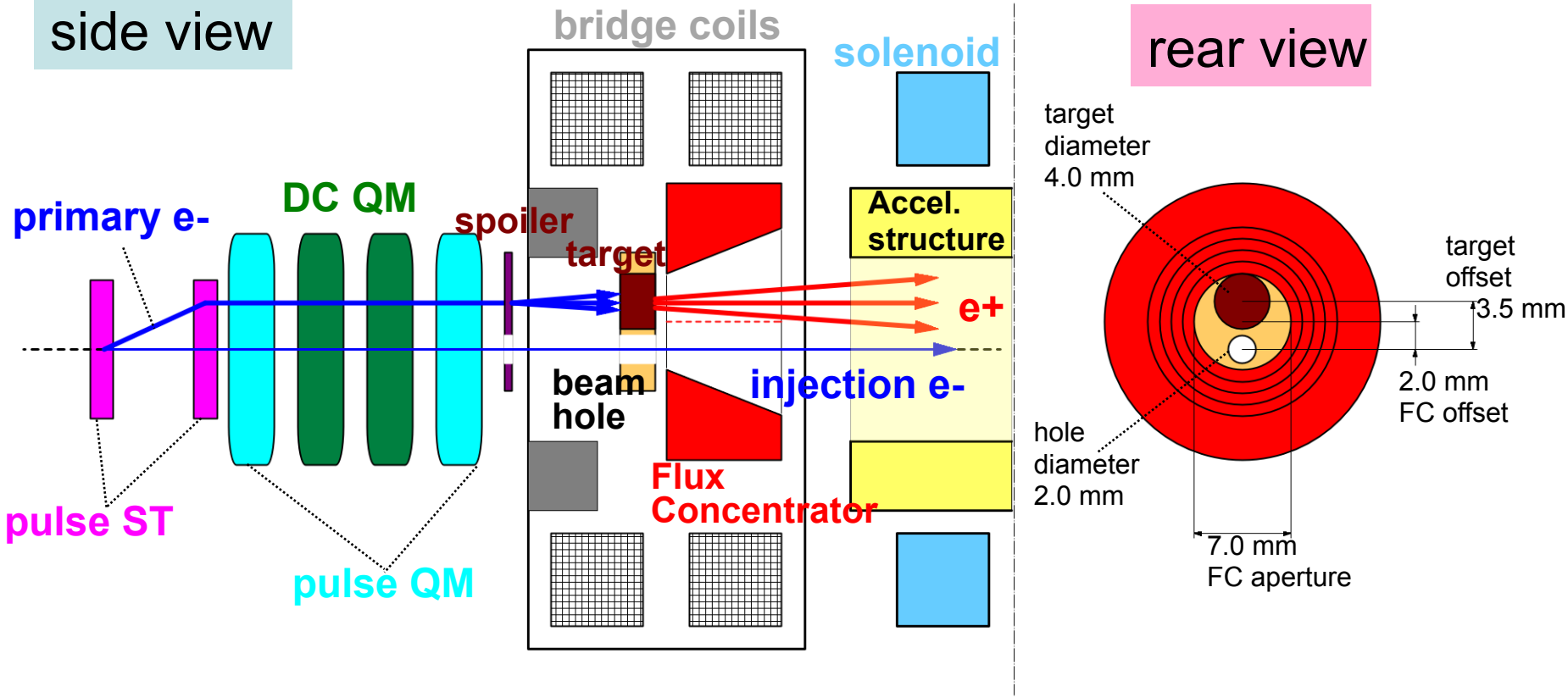
e+ target & AMD
5T FC + 0.4T solenoid
12m ~~L-band structure (35mm)~~
~~or~~ Large Aperture S-band (30mm)
120 MeV capture section

e- for HER
7.0 GeV
5 nC x 2
20 um



(1) TARGET

target offset & beam hole

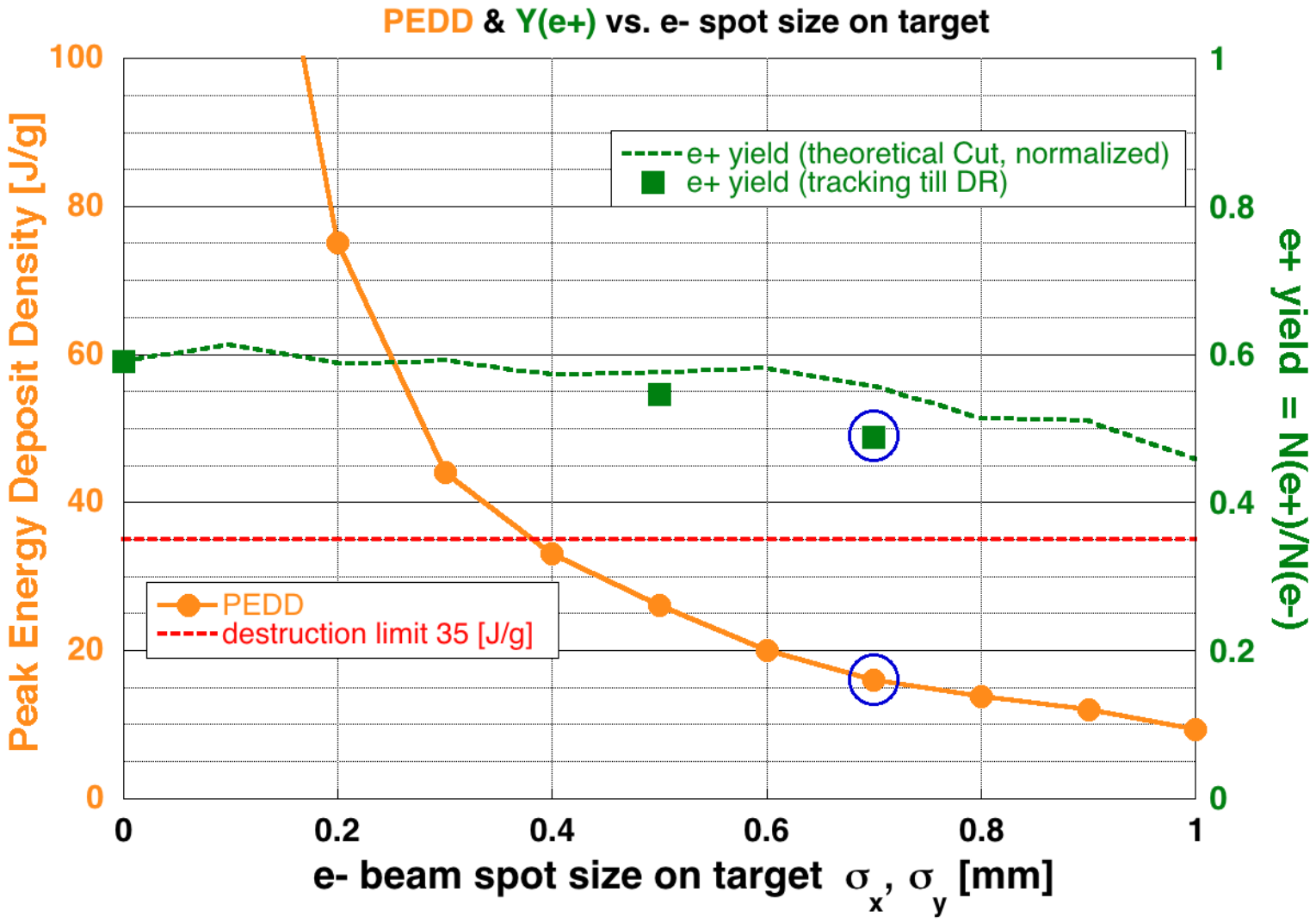


- injection e- beam on axis to preserve low emittance
- primary e- beam 2~3 mm off axis

  (target offset 3.5 mm, FC offset 2.0mm)

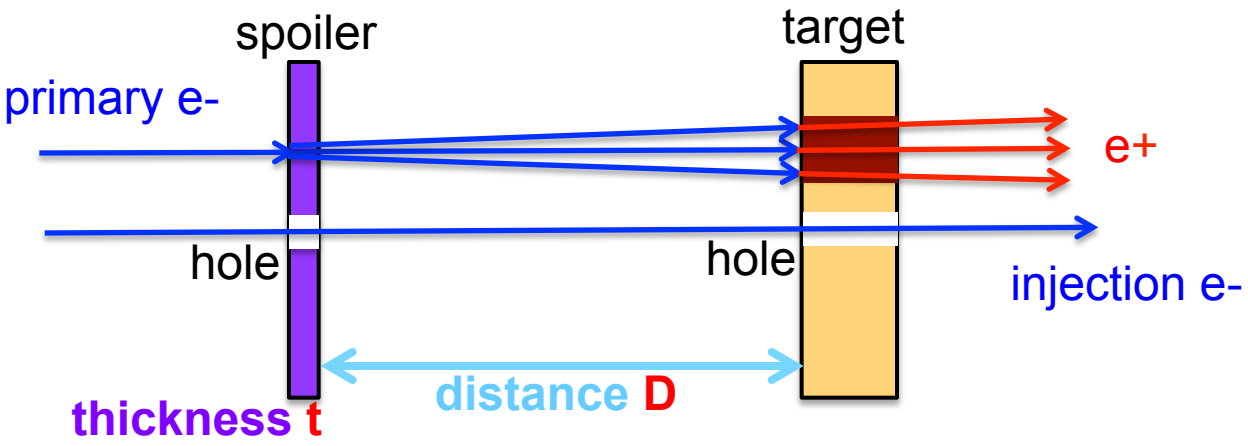
  e+ yield degradation by this offset ~ 10%

target destruction issue



We enlarge design spot size to 0.7 mm for safety margin of factor 2.

target protection



- beam spoiler to maintain spot size σ_x , σ_y> 0.7 mm on target
- avoid too small beam spot on spoiler & on target, need monitoring spot sizes and focusing magnet settings
- distance D & thickness t should be optimized considering beam line layout
- at a position D = 3.0 (m), t = 0.5 (mm) for Al plate

(2) CAPTURE SECTION

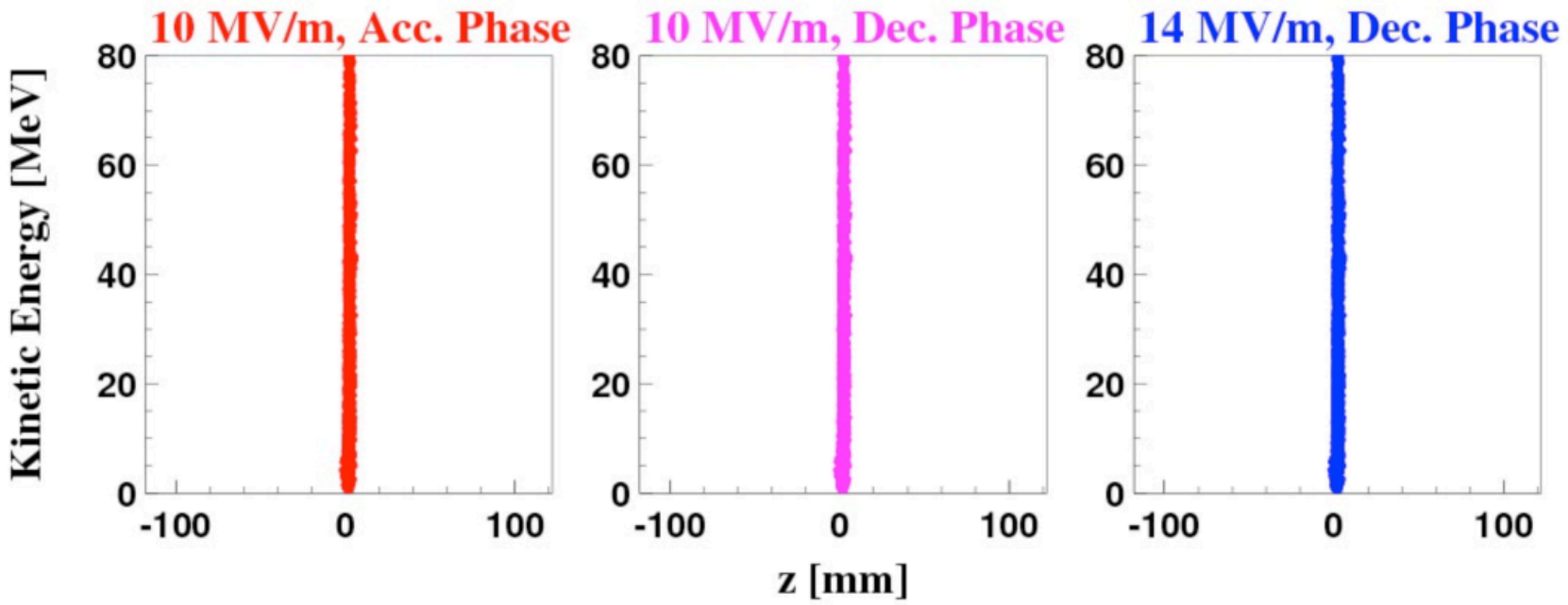
Why we gave up L-band

- larger transverse/longitudinal acceptance with L-band ?
  - overall acceptance predominantly limited by the downstream beam-line acceptance
  - Large aperture S-band structure can give comparable acceptance
- satellite particle elimination with co-prime (1298:2856MHz = 5:11) frequency relation ?
  [satellites make radiation problem at DR injection]
  - S-band high-gradient deceleration can give sufficient satellite elimination
- solenoid gaps for wide L-band wave-guides make deep field dip and significant beam loss
  - Helmholtz-like configuration can avoid field dip, however power consuming

deceleration capture [1]

at target

energy distribution spread widely from low to high energy.

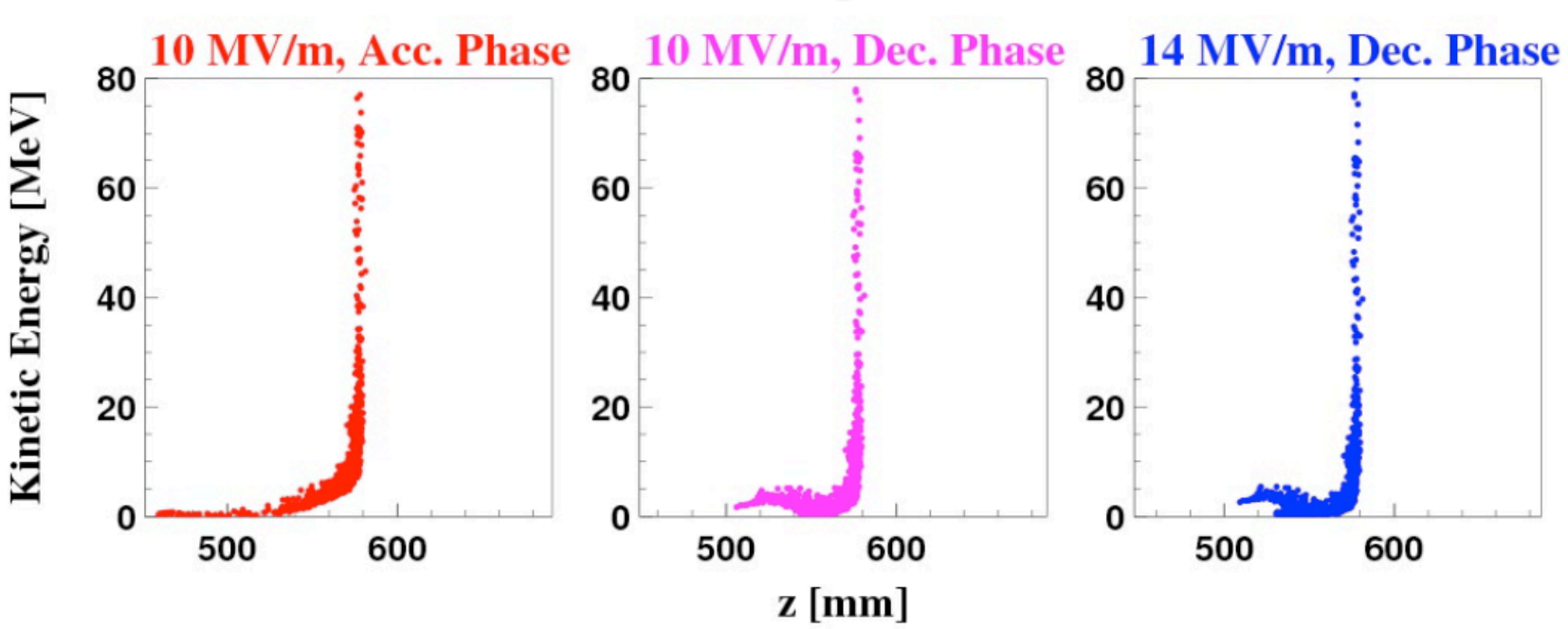


Animation by F. Miyahara

deceleration capture [2]

in 1st cavity

acceleration capture makes plenty of satellite particles.

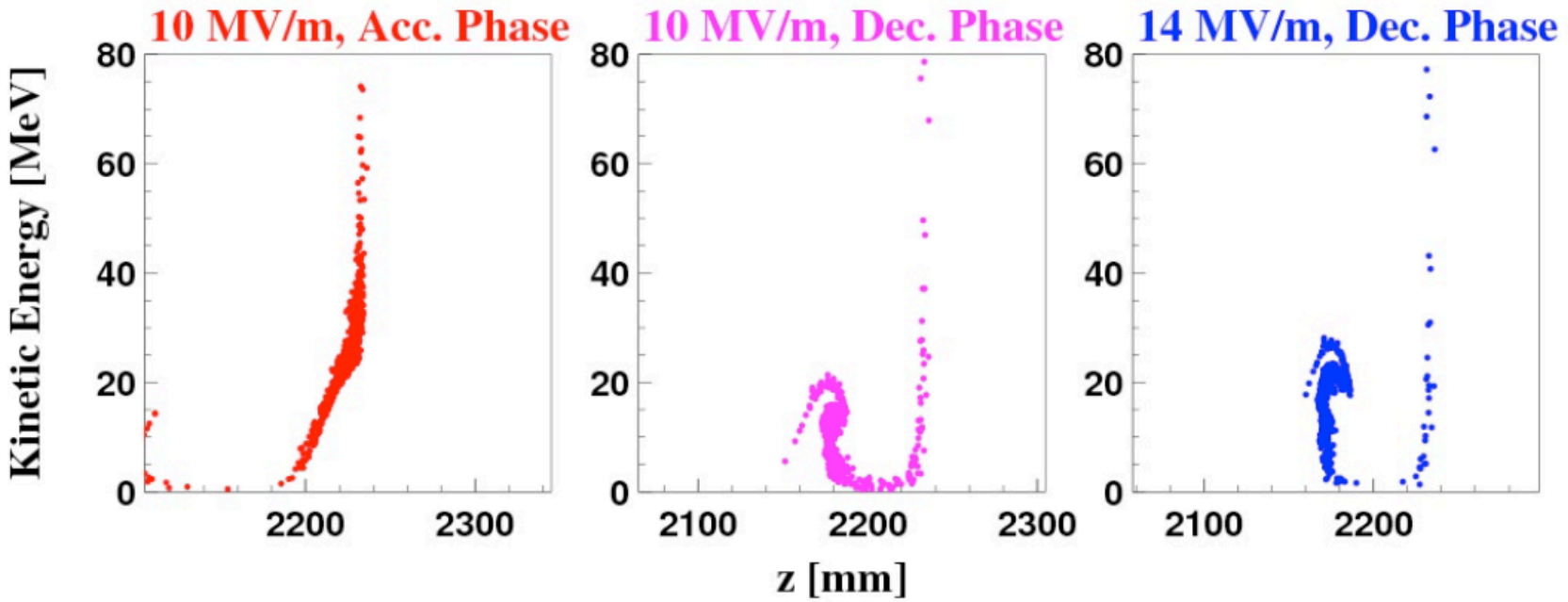


Animation by F. Miyahara

deceleration capture [3]

1st cavity end

decelerated particles experience phase slip and captured.

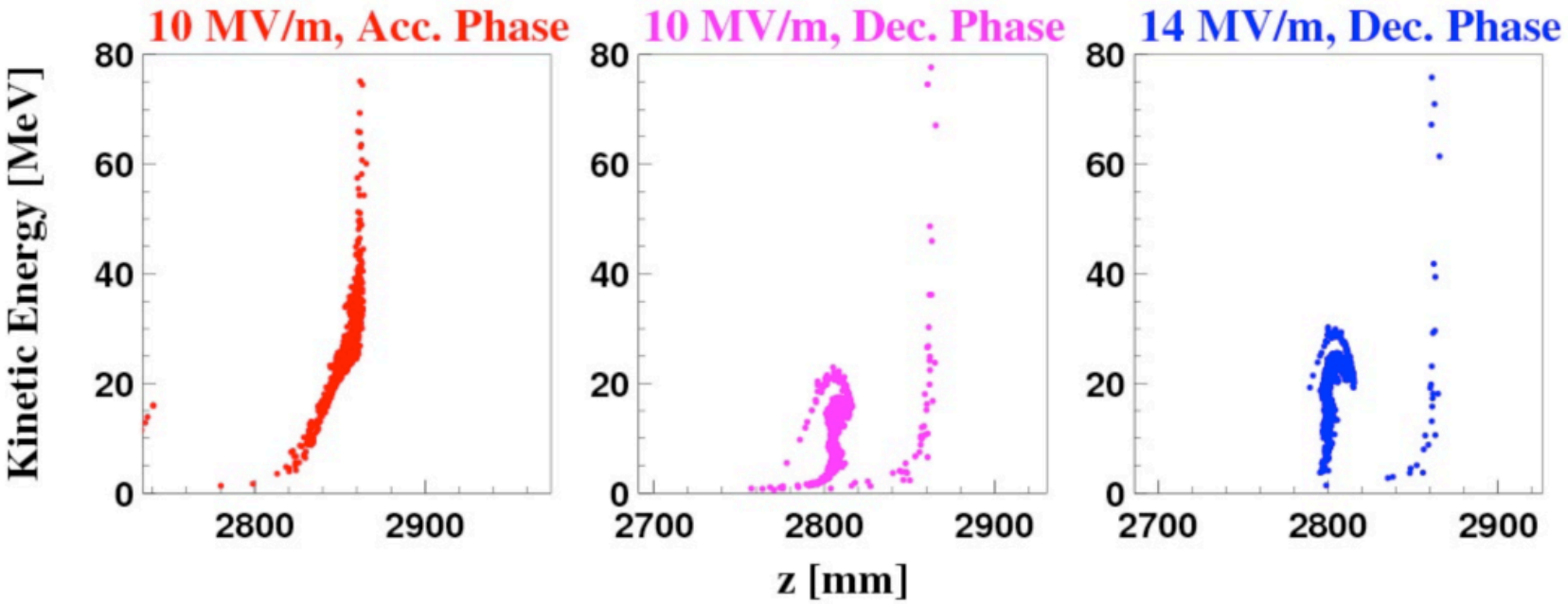


Animation by F. Miyahara

deceleration capture [4]

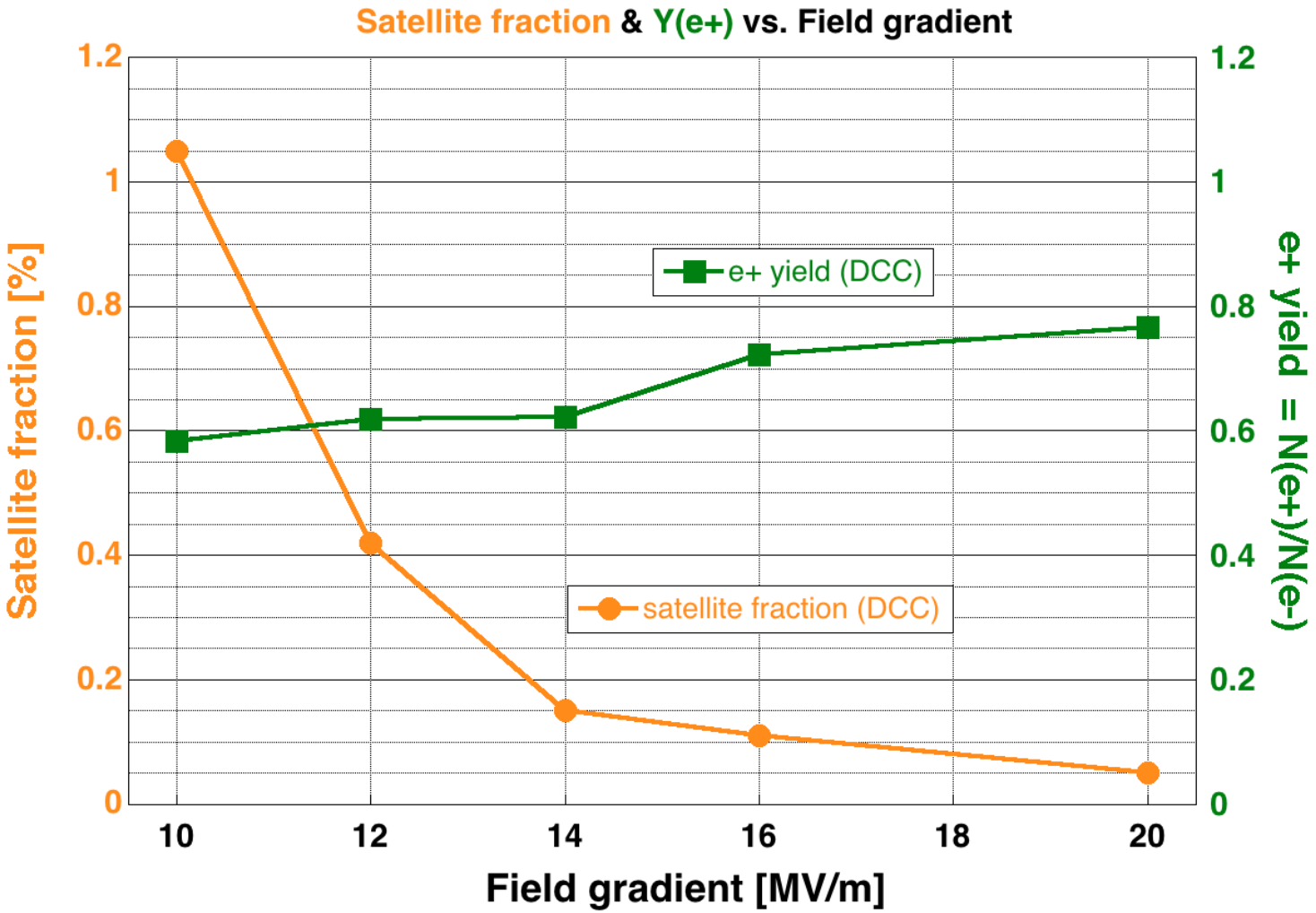
in drift space

low-grad. decelaration makes satellite particles in drift space.



Animation by F. Miyahara

satellite fraction vs. field gradient

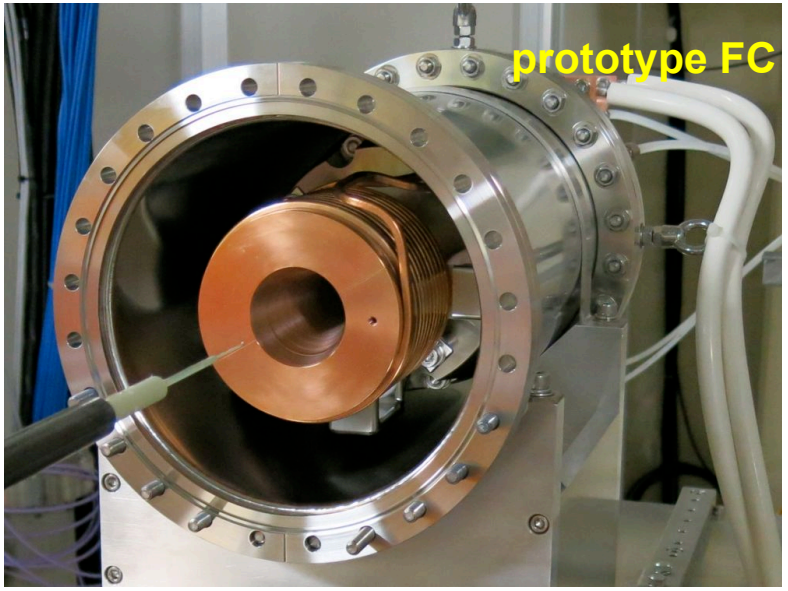


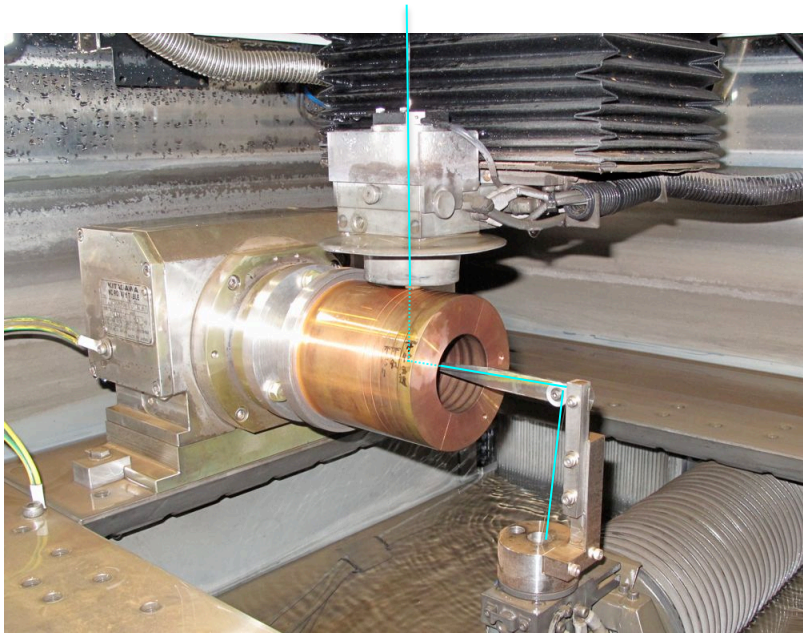
Deceleration field grad. above 14 MV/m preferred for satellite elimination !

(3) FLUX CONSENTRATOR DEVELOPMENT

Flux Concentrator

- SLAC/IHEP-type spiral-slit FC is fabricated for SuperKEKB
- discharging wire cutting at KEK for slit processing

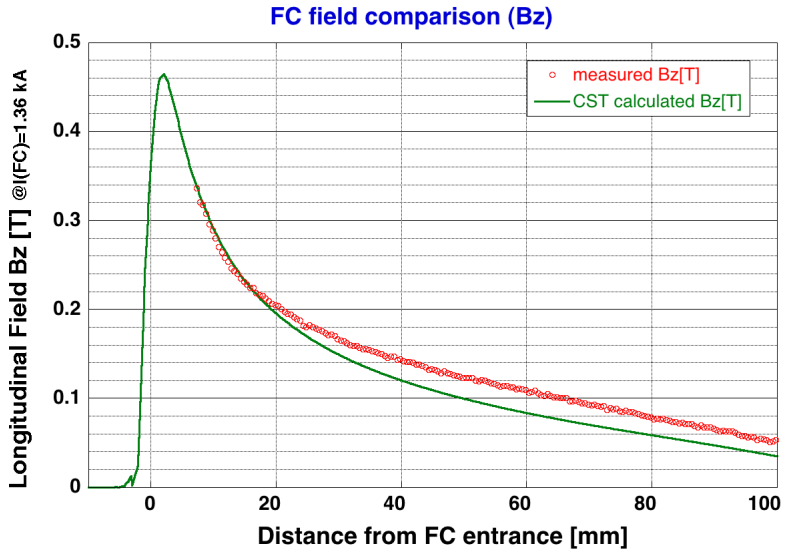


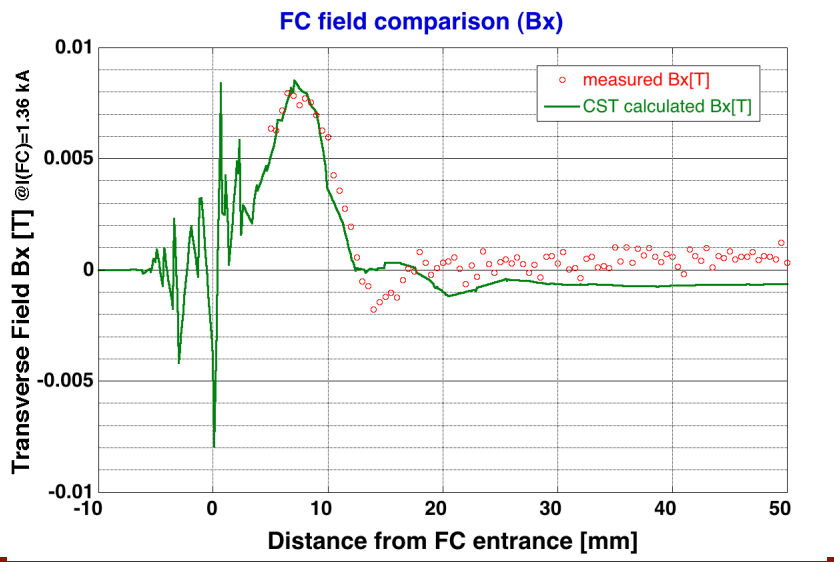


SLAC/IHEP-type FC	parameters
length	100 mm
outer diameter	100 mm
inner diameter (min.)	7 mm
inner diameter max)	52 mm
peak current (for SKB)	12 kA
pulse width	5 us (half-sine)
peak field	3.9 T
inductance	1.0 uH

FC test stand

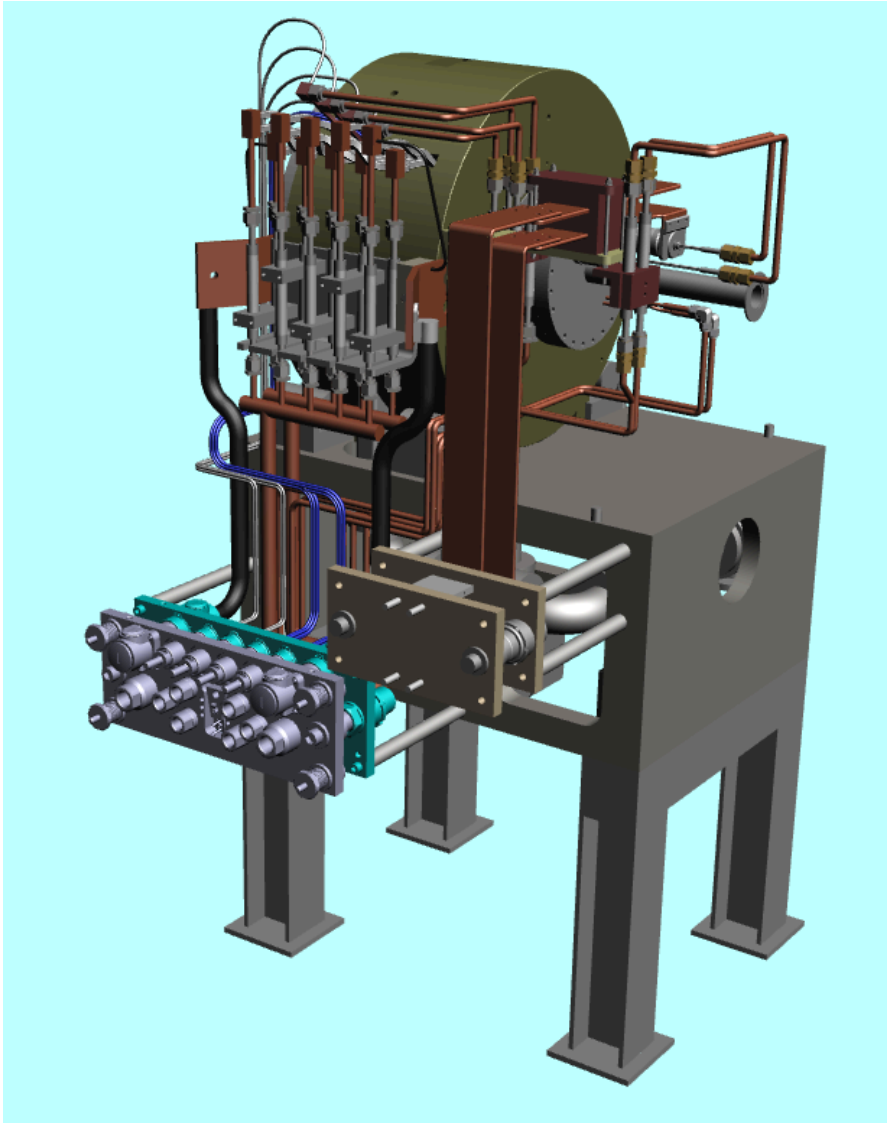
- FC prototype operation started in 2013 Feb.
- low current operation (1.36 kA) in the air for field measurement
- high current operation (~6 kA) successful with no breakdown
- full-current (12 kA) operation with new modulator in 2014 Apr.





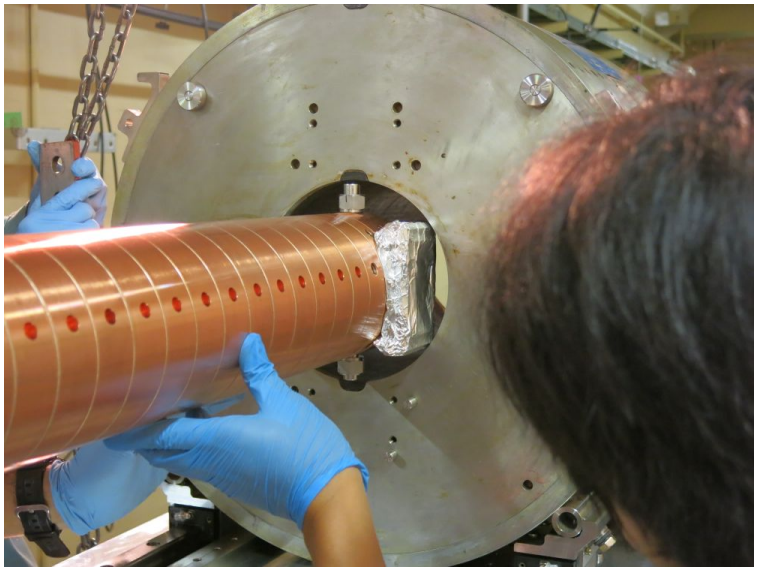
FC assembly

- FC assembly (FC +target + bridge-coils + steering-coils+ vacuum-chamber) in fabrication, completed in 2013 Sep.
- beam-line installation in 2013 Nov.
- beam commissioning at half-current (6kA) start in 2013 Dec.
- operation at test stand at full-current (12 kA) in 2014 Apr.
- beam commissioning at full-current in 2014 Sep.



(4) CONSTRUCTION STATUS

Construction in progress



- Construction of capture section started.
- Large aperture S-band structures and solenoids are carefully installed.

Summary on SuperKEKB e+ source

1) e+ generation at 3mm offset for on-axis e- passage in solenoids
2) beam spoiler for primary e- spot size >= 0.7 mm
3) all (large aperture) S-band capture section, no L-band
4) high gradient deceleration to eliminate satellite particles
5) SLAC/IHEP type flux concentrator prototype test and fabrication
6) construction of capture section in progress

- Linac stand-alone e- preliminary commissioning: 2013 Sept ~
- Linac stand-alone e+ preliminary commissioning: 2013 Dec ~
- Linac full-spec beam commissioning: 2014 Sep ~
- HER(e-) commissioing: 2015 Jan ~
- LER(e+) commissioing w/o DR: 2015 Jan ~
- DR+LER commissioing: 2015 May ~