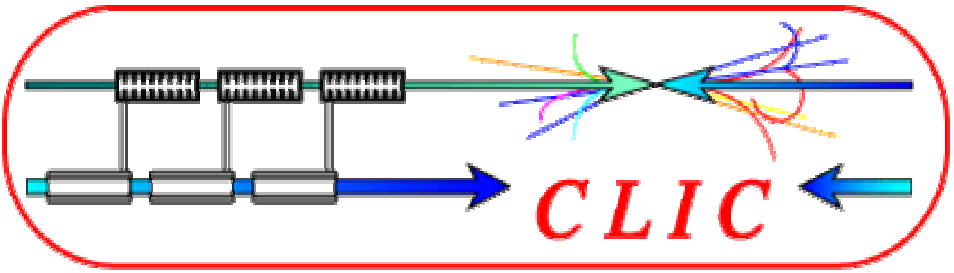


NORTHWESTERN UNIVERSITY

Beam Instrumentation for CTF3 and CLIC

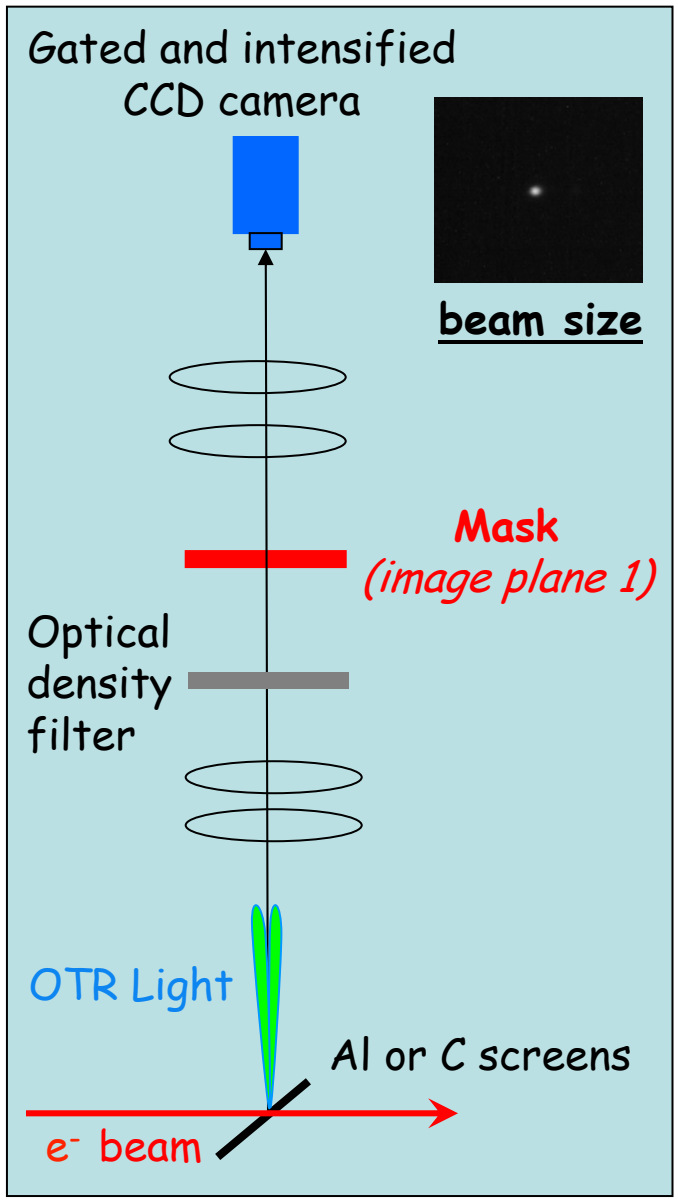
- Beam loss - Beam halo monitoring developments
- CLIC diagnostic
  - Common developments with other projects
  - Specific requirements for CLIC

Beam Loss and Beam Halo measurement

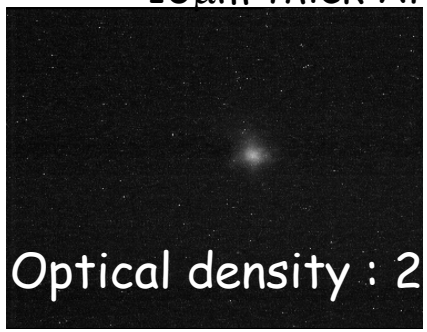
- Beam loss monitoring system is developed for the CTF3 Linac
  - Simulation Work using Geant3.21 and presented by M. Wood
  - Using SIC chambers developed by Northwestern University by M. Velasco and built by Richardson Electronics
  - Using fast amplifier and 100MHz ADC's to measure the time evolution of beam losses along the 1.5μs pulse length

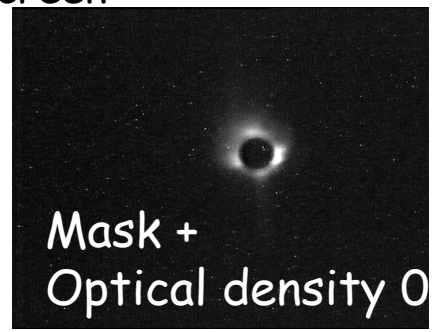
- Beam Halo imaging technique are also developed
  - Based on Optical Transition Radiation screens
  - An dedicated optical manipulation

Beam Halo measurement on CTF3 in 2003



Beam : 35MeV, 3.5A, 300ns
10μm thick Al screen

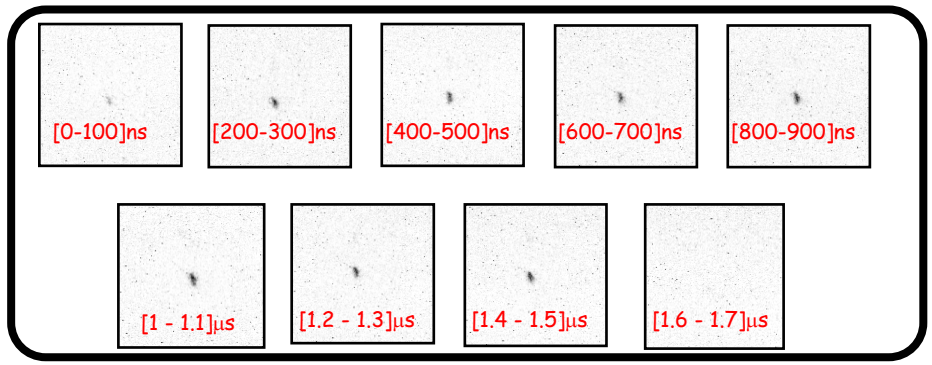




Total dynamic range : 10^4-10^5

Time evolution of the beam profile using a gated camera

100ns Camera (>5ns) gate width

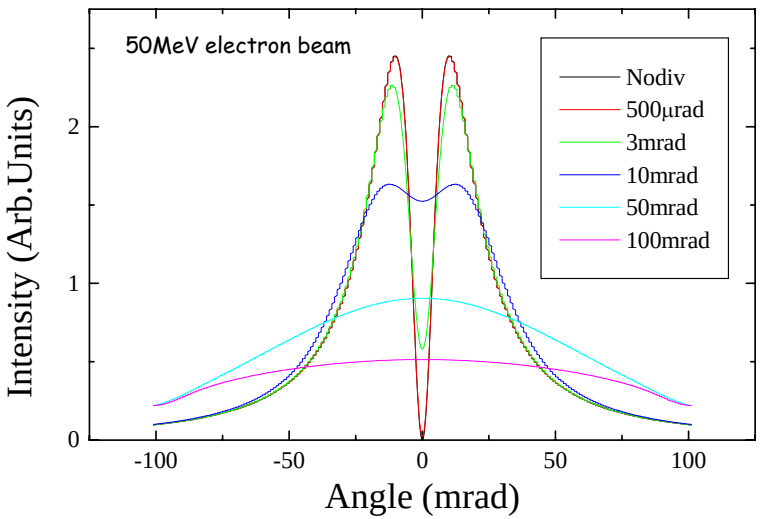


Beam : 140keV, 3.5A, 1.6μs

5μm thick Graphite OTR foil

OTR Angular Distribution

Beam divergence

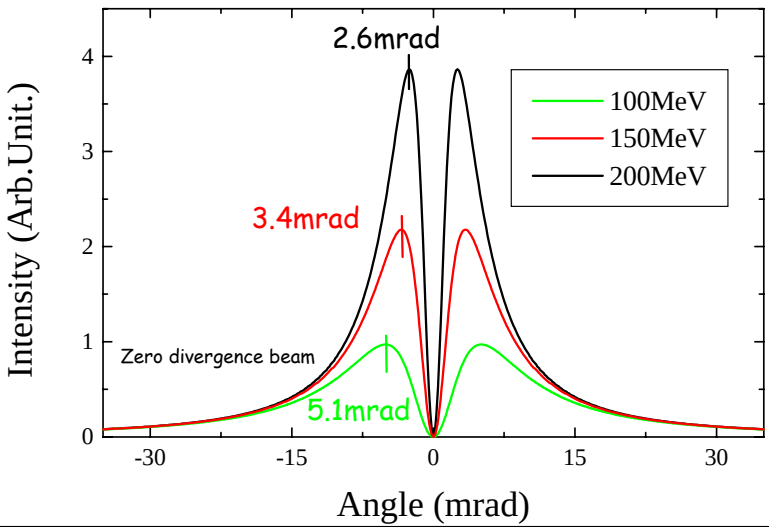


- There is a limitation in the minimum divergence we can measure :

$$\sigma'_{min} \approx \frac{1}{10\gamma}$$

- For $\sigma' > 1/\gamma$, the two lobes pattern disappears
- Small shift of the lobes position for $\sigma' > \sigma'_{min}$
  new position at $1/\gamma + \sigma'/2$

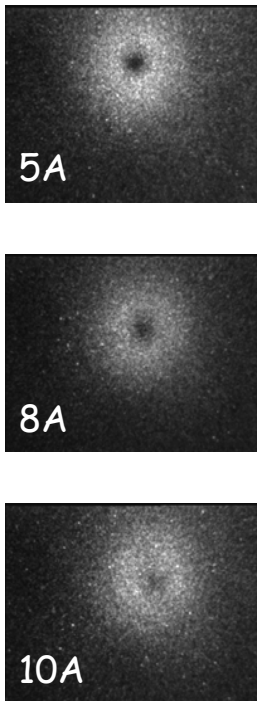
Beam energy

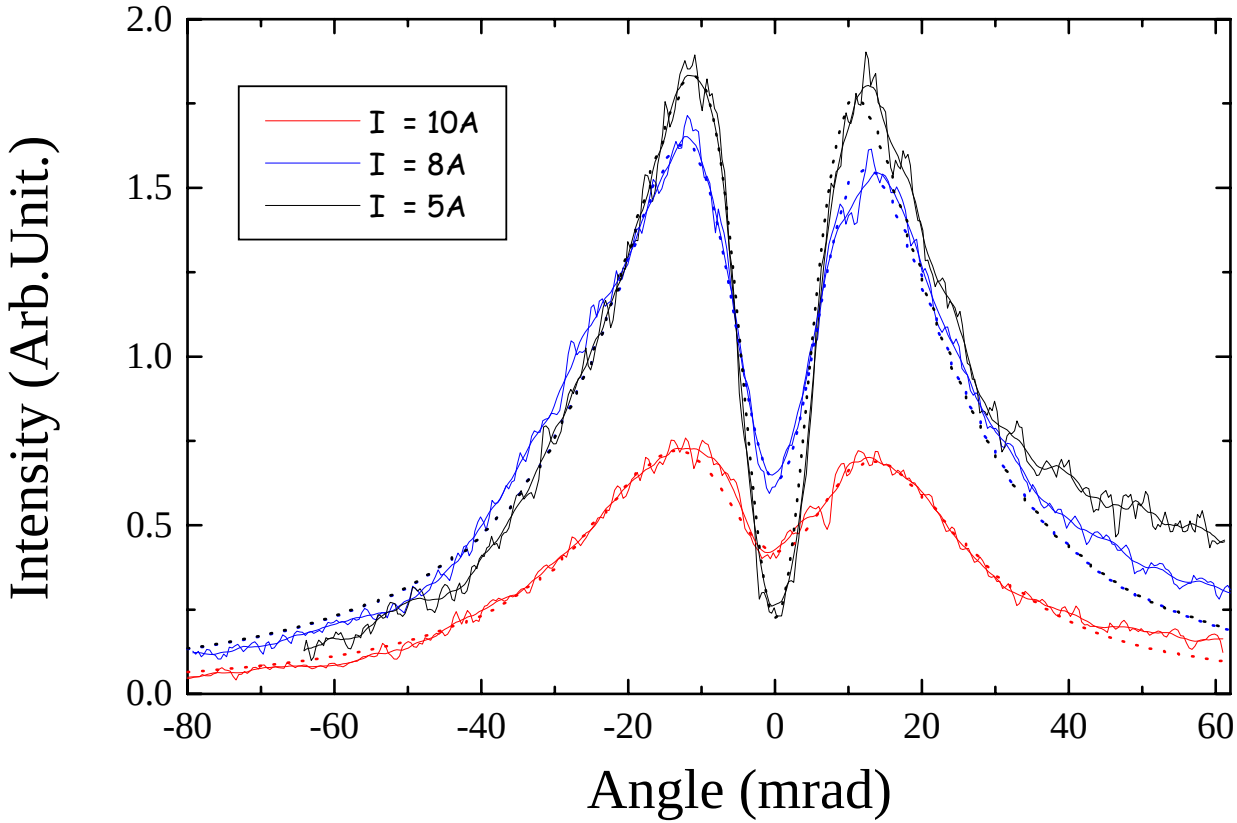


- The two lobes are separated by an angle of $2/\gamma$ *(neglecting the beam divergence)*
- The light intensity increases with the beam energy $\propto \ln(2\gamma)$

OTR Angular Measurements on CTF II in 2002

- Changing the beam divergence using a set of quadrupoles

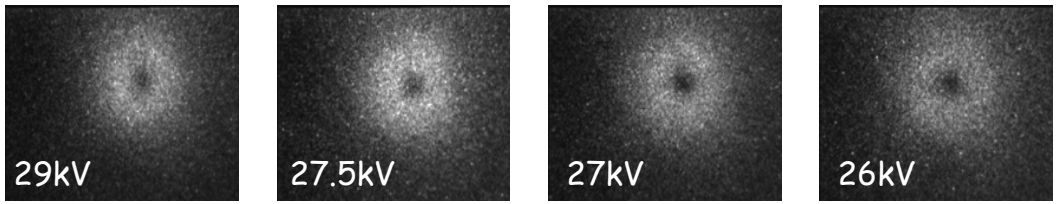


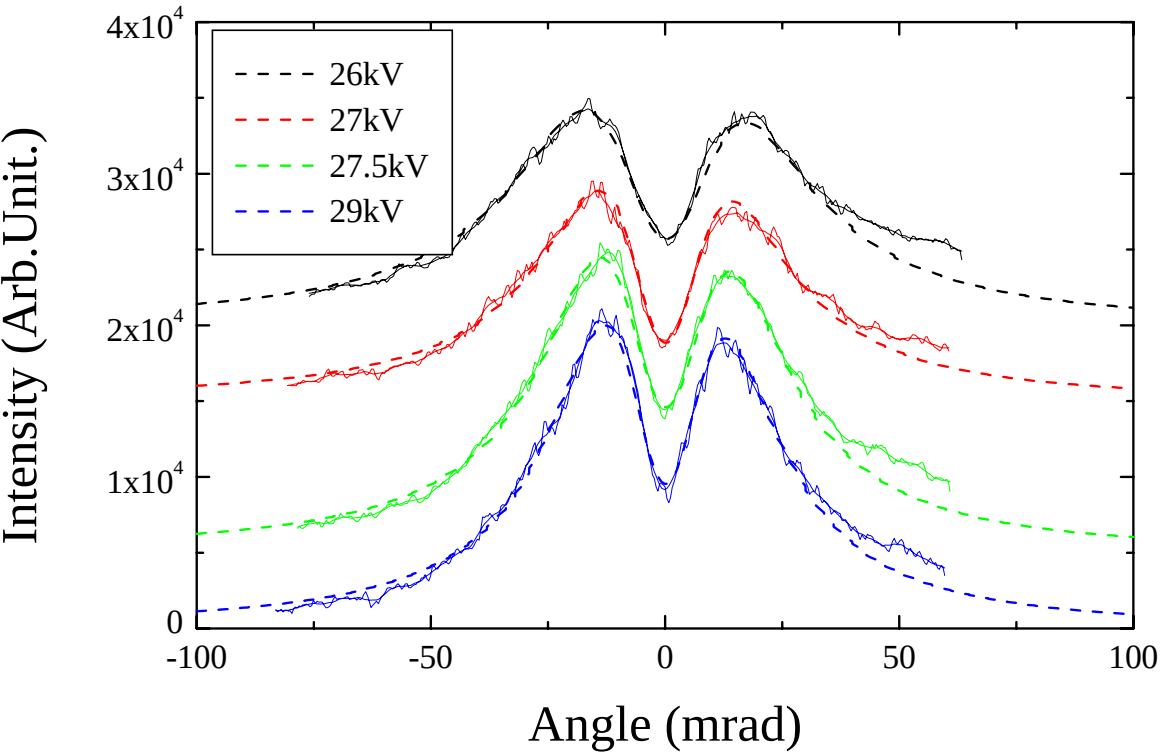


- Measured divergences from 2 to 6 mrad
- The precision was estimated to 0.25mrad

OTR Angular Measurements on CTF II in 2002

- Changing the beam energy with the Klystron (modulator) voltage
- Adjusting the RF phase for a minimum energy dispersion

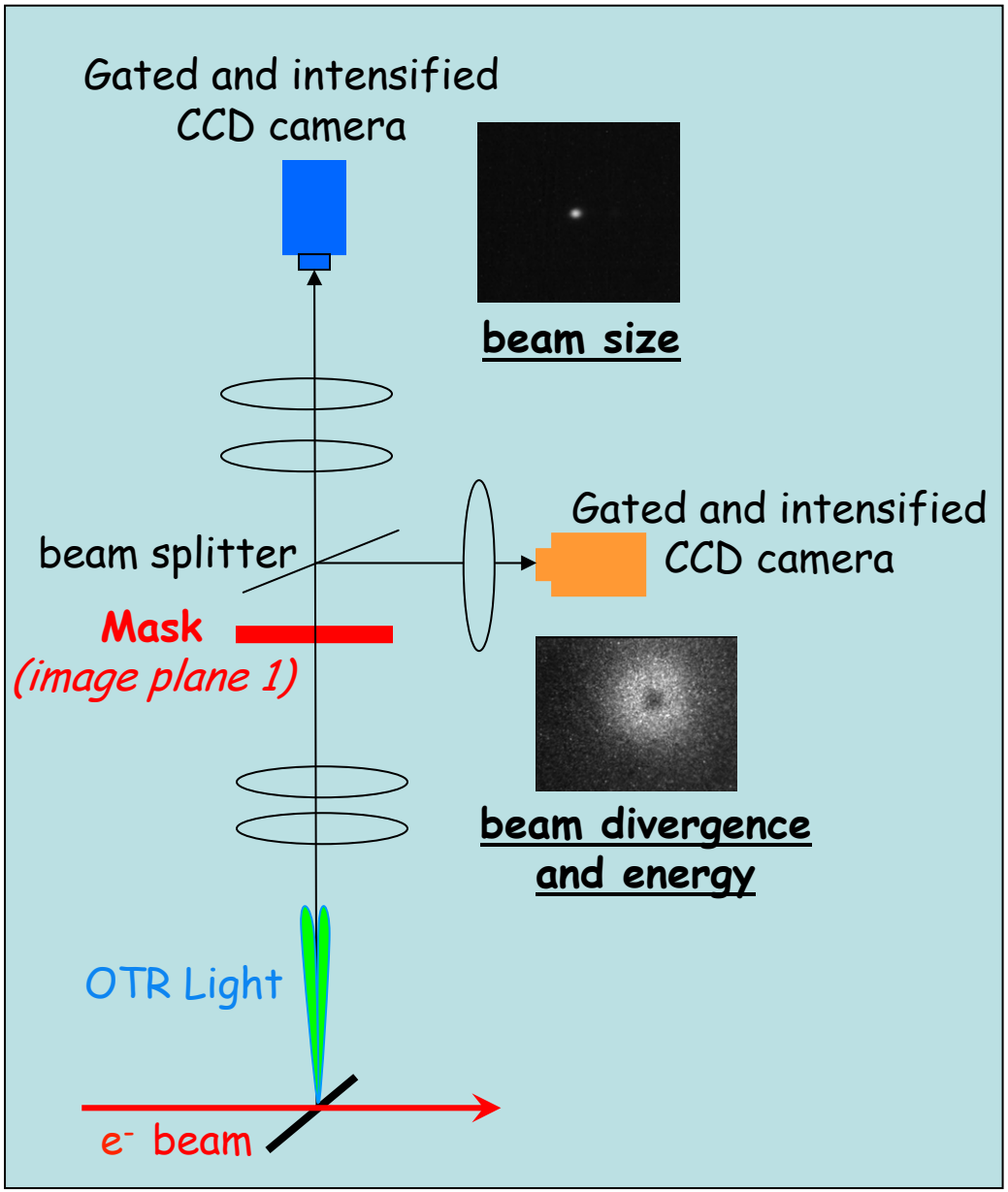




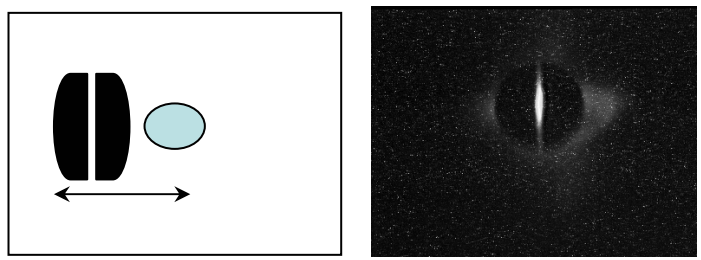
Klystron voltage (kV)	29	27.5
Spectrometer (MeV)	48	45
OTR (MeV)	47.2	44.6

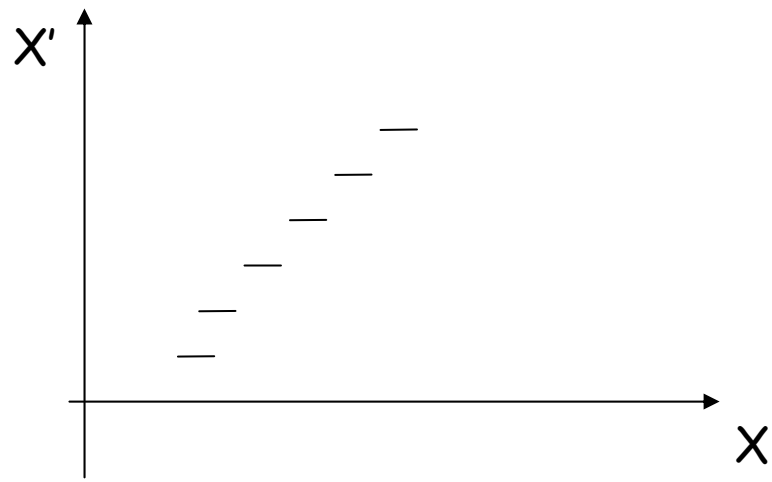
Energy resolution is around 1MeV (3.5%)

Transverse phase space reconstruction



'Slicing the OTR light in the first image plane by displacing the mask and measuring the beam divergence'





Beam diagnostics classification

1- Profile measurements  ← →  RMS values

- *More precise information on the beam characteristic*

2- Single shot measurements  ← →  Sampling measurements

- *Do not care about the beam reproducibility (100% reproducible ?)*
- *No need for precise timing system (tens of fs in our case)*

3- Non interceptive  ← →  Interceptive

- *Can be used for beam study and beam control for on-line monitoring*
- *No risk of damage by the beam itself*

Beam diagnostics classification

Level of Difficulty and Reliability

'Beam diagnostics should help you to understand how the beam behaves, **it should not be the opposite**'

A detector, what for ?

- Online Beam stability → non intercepting and reliable

Only have access to a partial information (RMS values,..)

- Beam characterization and beam physics study → full information

Complexity and time consuming

Common development with other e^+-e^- collider projects and 4th generation light source

- Very short bunch length (>100fs)


'Limitations'

- Optical radiation (OTR / ODR)
  - **Streak camera** xxxxxx xxxxxx > 200fs

    *Mitsuru Uesaka et al, **NIMA 406 (1998) 371***
  - **Shot noise frequency spectrum** xxxxxx xxxxxx

    P. Catravas et al, **Physical Review Letters 82 (1999) 5261**
- **Coherent radiation** (CTR / CDR) xxxxxx xxxxxx

  T. Watanabe et al, **NIM A 437 (1999) 1-11 & NIM A 480 (2002) 315–327**
- **RF Pick-Up** xxxxxx xxxxxxx xxxxxx > 500fs

  C. Martinez et al, **CLIC note 2000-020**
- **RF Deflector** xxxxxx xxxxxx xxxxxx

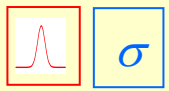
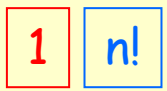
  R. Akre et al, **SLAC-PUB-8864, SLAC-PUB-9241, 2002**
- **RF accelerating phase scan** xxxxxx xxxxxx xxxxxx High charge beam

  D. X. Wang et al, **Physical Review E57 (1998) 2283**
- **Electro Optic Method** xxxxxxx xxxxxx xxxxxx > 70fs

  A. M. MacLeod et al, **Physical Review Letters 88 (2002) 124801**

Common development with other e^+-e^- collider projects and 4th generation light source

- Very few microns beam size along the Linac

				*'Limitations'*
• **Optical Transition Radiation**	xxxxxx	xxxxxx	xxxxxx	For high current density
S. Anderson et al, **KEK-ATF-2001-08**				
• **Optical Diffraction Radiation**	xxxxxx	xxxxxx	xxxxxx	For low beam energy
*T. Muto et al, **Physical Review Letters 90 (2003) 104801***				
• **Solid Wire scanner**	xxxxxx	xxxxxx	xxxxxx	For high current density
• **Laser Wire Scanner**	xxxxxx	xxxxxx	xxxxxx	For low current density & low beam energy
R. Alley et al, **NIM A 379 (1996) 363**				
H. Sakai et al, **Physical Review ST AB 4 (2001) 022801 & ST AB 6 (2003) 092802**				
W.P Leemans et al, **Physical Review Letters 77 (1996) 4182**				

Special CLIC/CTF3 diagnostic requirement

- Problem for the Drive Beam : Very beam charge → Need non destructive monitor

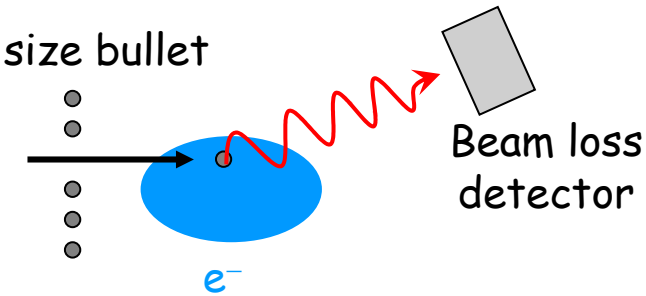
⇒ Specially at low energy where LWS and ODR are not efficient enough

- Drive beam size monitors ? ⇒

- Quadrupolar pick-up

  A. Jansson, **Physical Review STAB & NIM A (2002)**

- Degradable detector
  - 'Kalachnikov' : bullet scanner



- Neutral beam scanner

  C. Dimopoulou, PS/BD note 99-12

- Plasma or gas jet target as forward OTR radiator