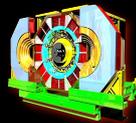


# The Zero Degree Detector at BESIII

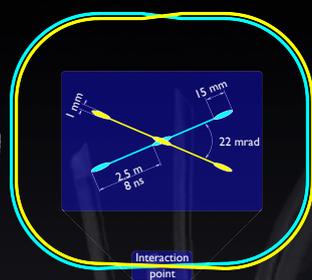


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The **BESIII** experiment installed in the  $e^+e^-$  collider **BEPCII** at the **IHEP** of Beijing is taking data in the 2.0 - 4.6 GeV region since 2009. It has a rich physics program and has already collected the world largest samples of  $J/\psi$  and  $\psi'$ .

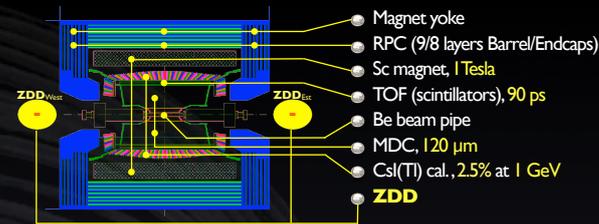
## BEPCII: $e^+e^-$ double ring collider



### Design features

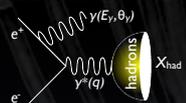
- Beam energy: 1.0-2.3 GeV
- Crossing angle: 22 mrad
- Luminosity:  $10^{33} \text{ cm}^{-2}\text{s}^{-1}$
- Optimum energy: 1.89 GeV
- Energy spread:  $5.16 \times 10^{-4}$
- Number of bunches: 93
- Bunch length: 15 mm
- Total current: 0.91 A
- Circumference: 240 m

## The BESIII experiment and the ZDD



The **BESIII** experiment foresees the installation of two zero-degree detectors, **ZDD**, to measure the energy and directions of photons produced in ISR processes, along the beam line in the forward and backward direction. The first of these detectors, on the East side, has been recently installed.

## Initial State Radiation

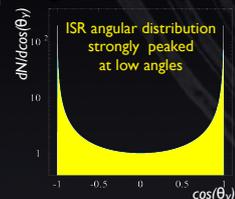


**ISR differential cross section**

$$\frac{d^2\sigma}{dE_\gamma d\theta_\gamma} = W(E_\gamma, \theta_\gamma) \cdot \sigma_{e^+e^- \rightarrow X_{had}}(q^2)$$

radiator function  $e^+e^-$  cross section

- All  $q^2$  at the same time  $\Rightarrow$  better control on systematics
- Detected ISR  $\Rightarrow$  better  $X_{had}$  angular coverage
- CM boost  $\Rightarrow$  at threshold:  $\epsilon \neq 0$  and  $\Delta E \sim 1 \text{ GeV}$

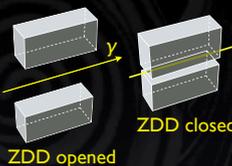


The acceptance at large angle is equivalent to that, **almost point-like**, in forward-backward direction

$$\int_{[20^\circ, 160^\circ]} \frac{dN}{d\cos(\theta_\gamma)} d\cos(\theta_\gamma) \approx \int_{2x[-0.2^\circ, 0.2^\circ]} \frac{dN}{d\cos(\theta_\gamma)} d\cos(\theta_\gamma)$$

A zero-degree radiative photon tagger will suppress most of the background due to misidentified  $\pi^0$ 's.  $\pi^0$ 's are produced with high BR's by  $c\bar{c}$  resonances

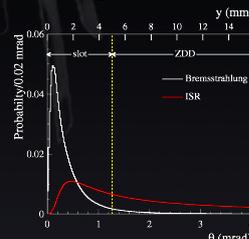
## ZDD concept and design



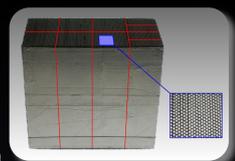
- Two sections: East and West side
- Each section is made of two,  $14 \times 4 \times 6 \text{ cm}^3$  modules: upper and lower
- An empty 10 mm-wide slot between upper and lower module suppresses the Bremsstrahlung background

- Angular distributions for ISR and Bremsstrahlung photons

- The slot suppresses about 50% of ISR signal and more than 90% of the Bremsstrahlung



## The ZDD calorimeter



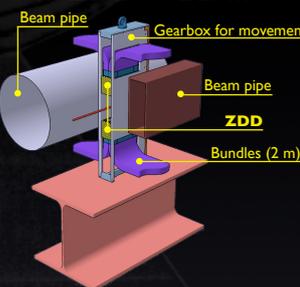
- Each module is a fine sampling lead-scintillating fibers calorimeter (à la KLOE)
- The basic structure consists of an alternating stack of 1 mm fibers layers glued between thin grooved lead foils.
- The ratio fiber:lead:glue in the final composite is 48:42:10
- The density is about  $5 \text{ g/cm}^3$
- The radiation length is  $X_0 = 1.6 \text{ cm}$

- The modules are segmented along the xy plane
- The first layer has a thinner segmentation to have a better x-resolution

### xy plane view

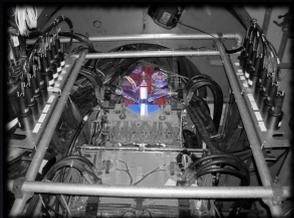
5	4	3	1	beam
10	9	8	2	
			6	←
			7	

## The ZDD at BESIII



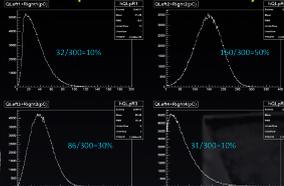
- The light collected by the modules is sent through bundles of clear optical fibers, 2 m long, to 10 Hamamatsu PM's.
- The PM's are installed in an area with low but not negligible magnetic field.

The **ZDD** installed 3.50 m away from the BESIII interaction point along one of the beam pipes in a very crowded area



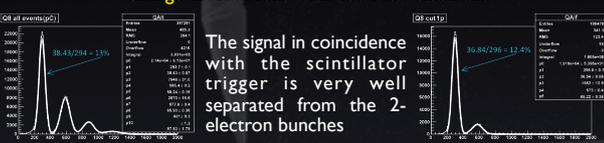
## ZDD at the Frascati Beam Test Facility

### Shower profile across the 4 layers



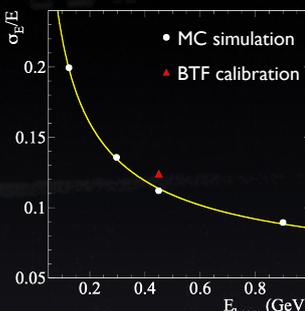
- By means of a calibration with cosmic rays we estimated an average light yield of **5 photo-electron / MeV**.
- Tests at the BTF have been done with **450 MeV bunches of 1, 2, 3 electrons**.
- A scintillator has been used to trigger and select the electron impact point.
- Data have been taken with an **ADC CAEN V792N**.

### Charge distributions with 450 MeV electrons



The signal in coincidence with the scintillator trigger is very well separated from the 2-electron bunches

## ZDD accuracy



The resolution is

$$\frac{\sigma_E}{E} = \frac{D1}{\sqrt{E}} \oplus p_2$$

$p_1 = 6.8\%$   $p_2 = 5.2\%$

The final calibration will be done with Bremsstrahlung data at BESIII