

# ECL forward for the BelleII experiment at SuperKEKB

## **OUTLINE:**

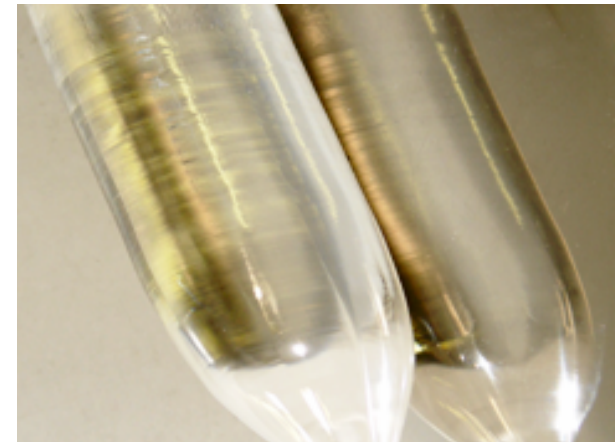
- Introduction
- R&D on pure CsI crystals + front End readout
- future and plans

**FORWARD Calorimeter of BelleII experiment:**

**1150 crystals of CsI(Tl) to be replaced with pure CsI:**

- same dimensions of CsI(Tl) → mechanics
- fast crystal (30 ns decay time) to avoid pile-up and occupancy
- rad-hardness good (report presented at the first JENNIFER General meeting)
- very low light yield

**R&D on readout of the crystals is fundamental for the project to obtain a good energy resolution at relatively low energy with very low light output**



# APD (Avalanche Photodiode) as photosensor for pure CsI crystals

- APD is:
- small good for the mechanics
  - low gain
  - S/N ratio deeply studied during R&D



- Pure CsI:
- low light yield @310nm where the Q.E. (Quantum Efficiency) of the APD is low (APD has max Q.E. around 420nm)
  - very fast prompt emission of the light (30ns)
  - slow component of the light up to 1 $\mu$ s

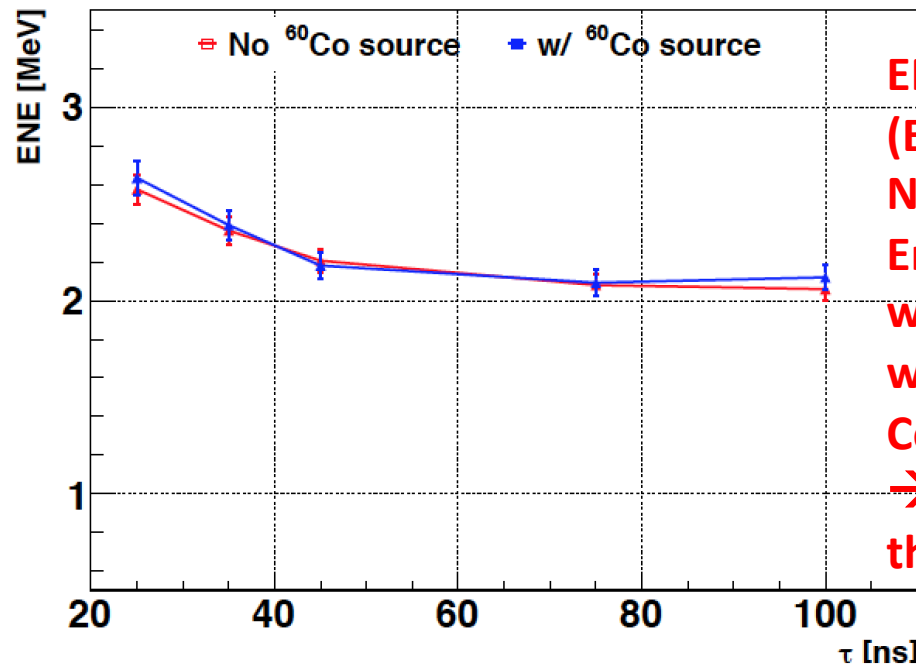
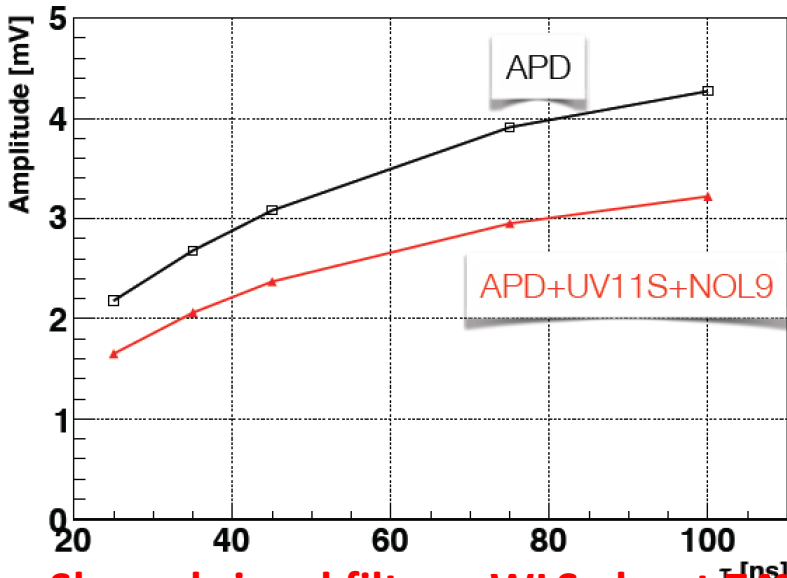
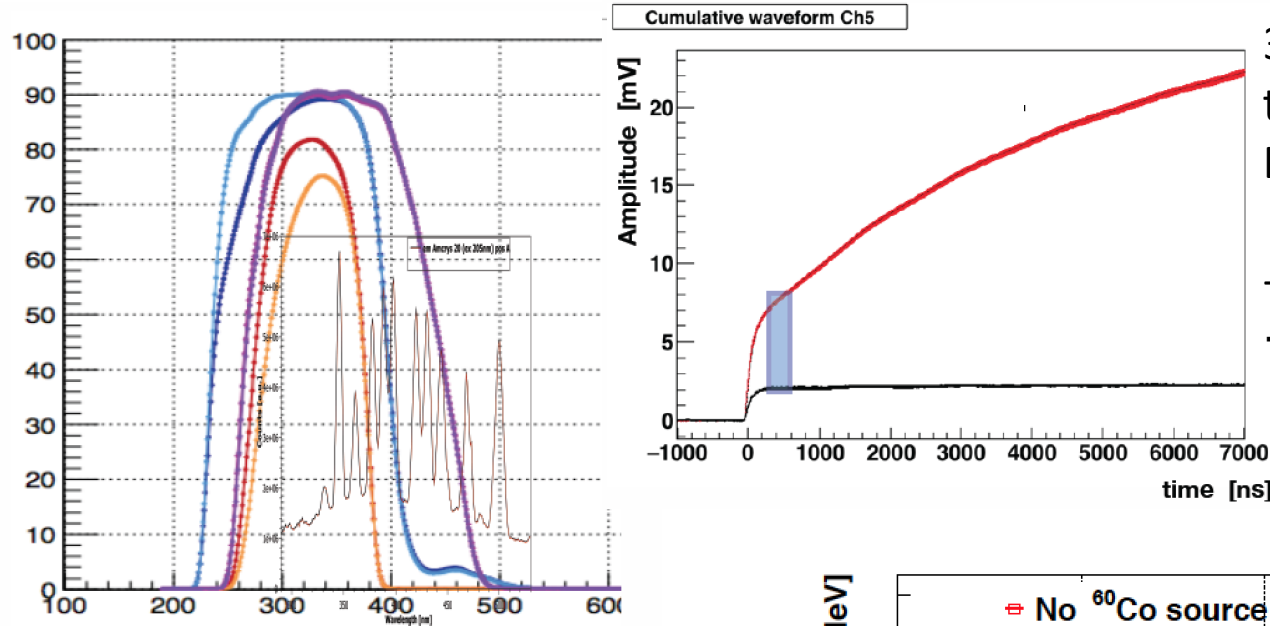


**GOAL:** eliminate the slow component of the light to avoid pile-up between physics events and background from machine

**→ use a filter to select only the fast component**

**→ use a WLS to shift the fast emitted light in the 420nm region to match the APD window**

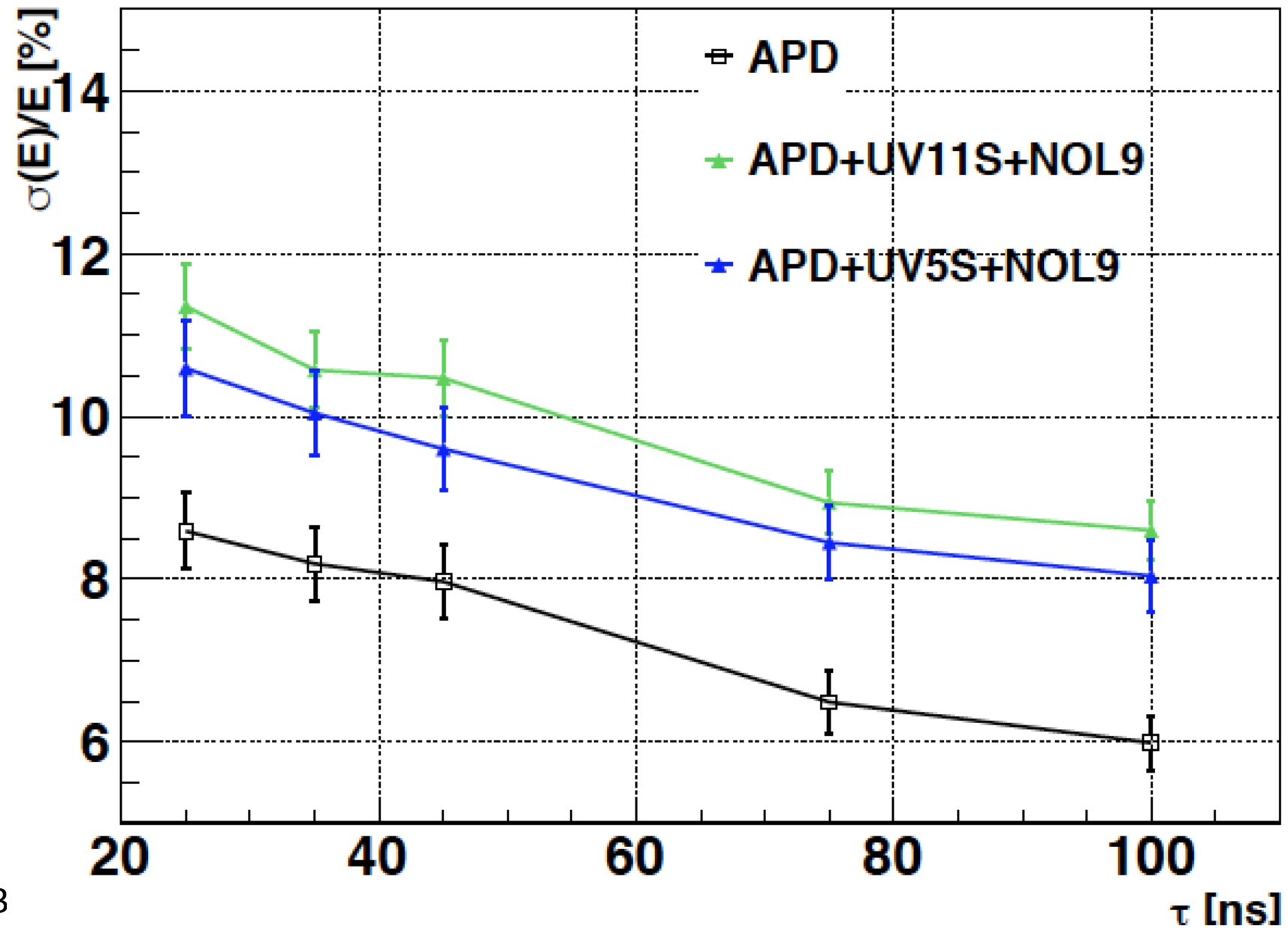
# Filter + WLS (Wavelength Shifter) on pure CsI



**ENE (Equivalent Noise Energy) with and without Co60 source → ENE is the same**

**Shaped signal filter + WLS about 74%**

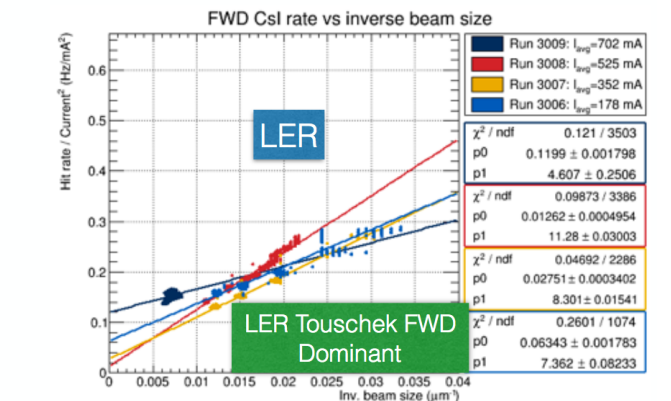
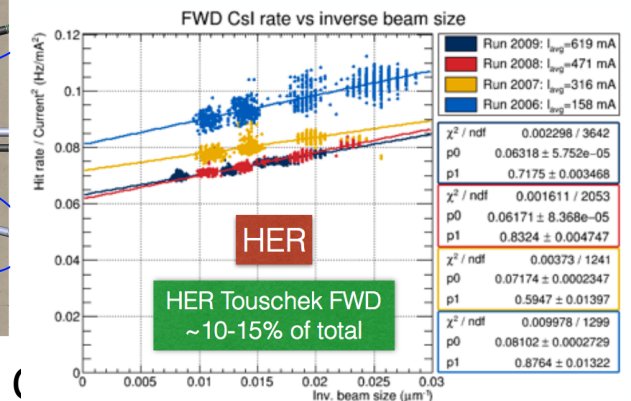
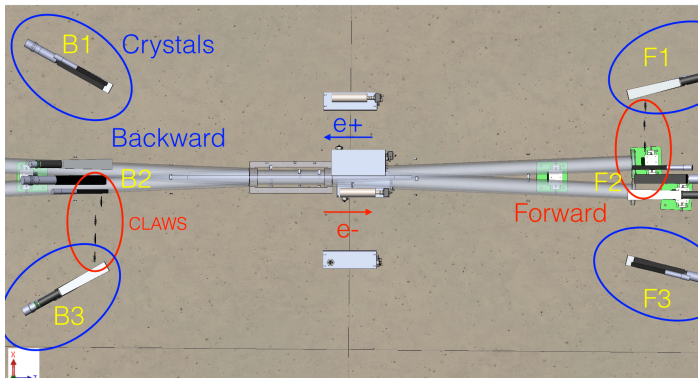
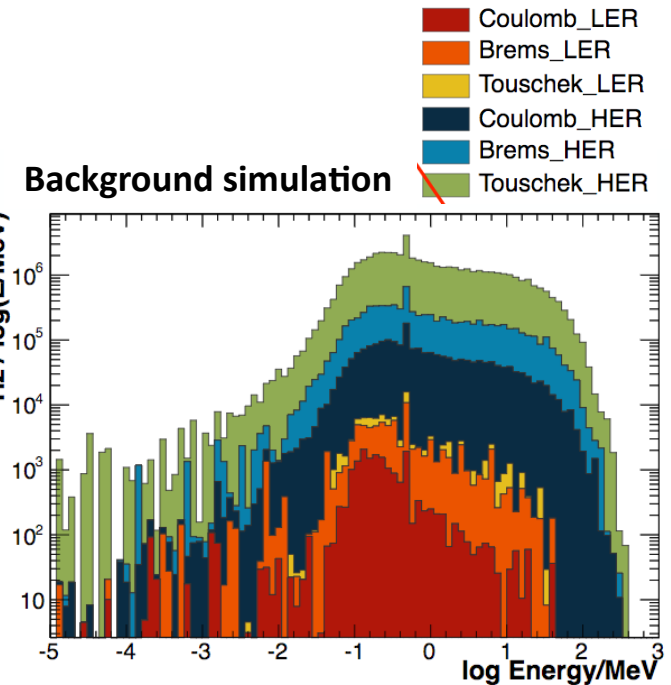
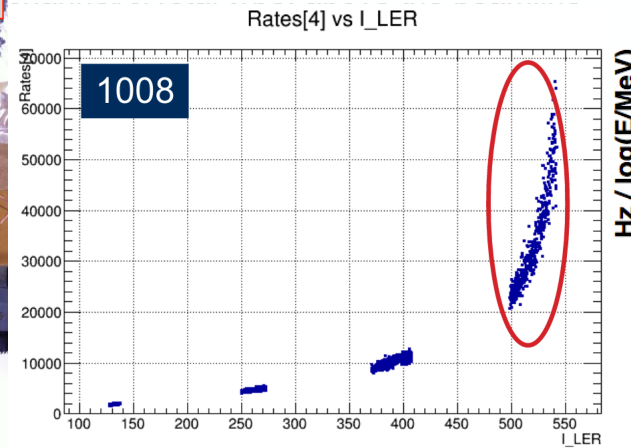
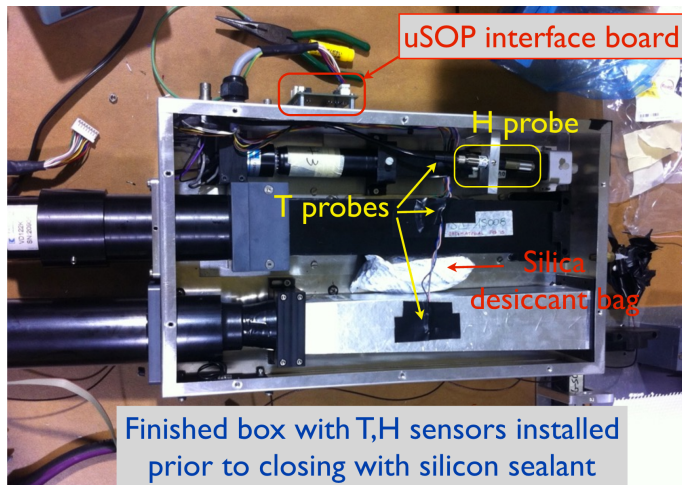
# Resolution



# BEAST (see C. La Licata talk)

August 2015: 6 pure CsI crystals with phototube readout have been installed around the Interaction Point (IP) for background studies.

February 2016: SuperKEKB starts commissioning



22/09/2016

# Performance studies

## First result: material budget

Negligible effect from material budget on resolution

## Second result: background impact

Large impact, as expected, on resolution

## Third result: ENE (Equivalent Noise Energy)

Important impact on resolution mainly in the BKG configuration

## Fourth result: photostatistic fluctuations (low LY of the pure CsI)

Large impact on resolution

# Summary of the different configurations

Study the resolution @100MeV

CsI(Tl) 12% actual calorimeter, this is the starting point....

Nominal Background:

1<sup>st</sup> configuration (PESSIMISTIC)

- ENE 1.3 MeV
- Nphe/MeV (2 APD) 12.5

$$\sigma(E)/E(\%) = 6\%$$

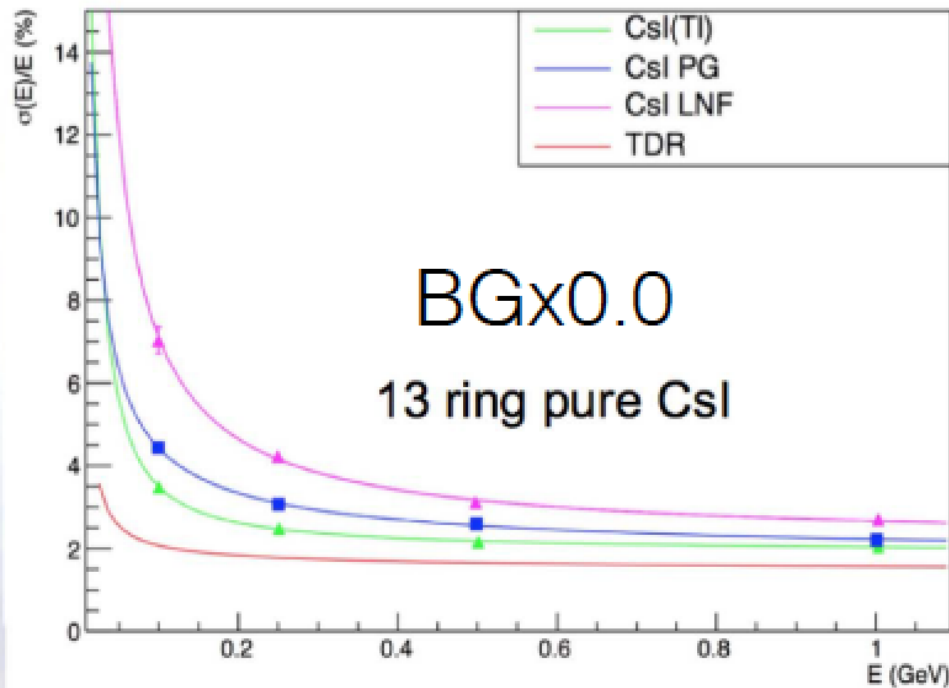
2<sup>nd</sup> configuration (REALISTIC)

- ENE 1.3 MeV
- Nphe/MeV (2APD) 25

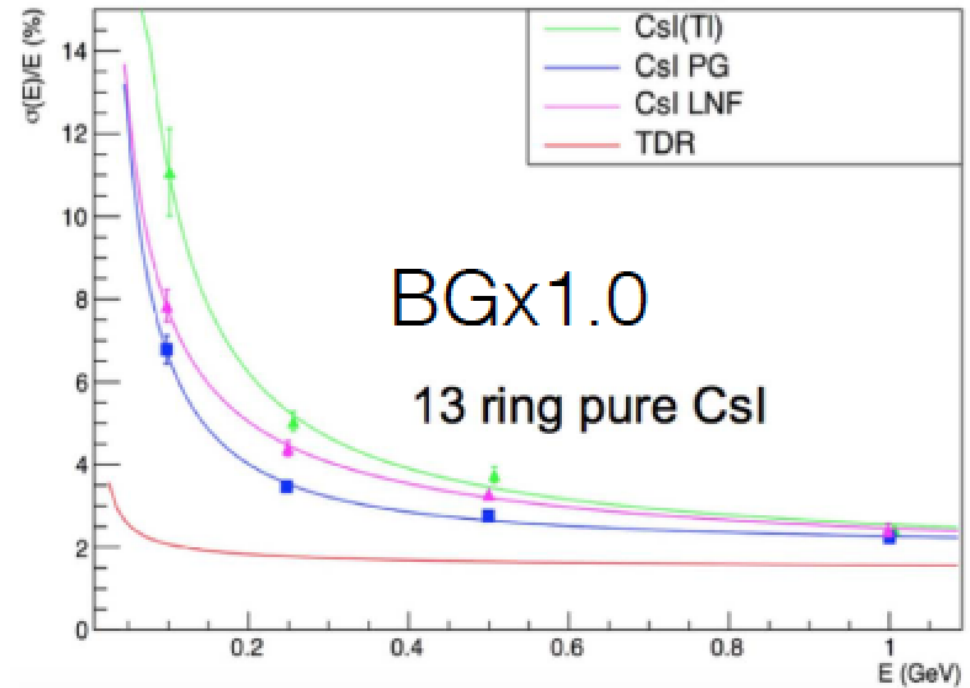
$$\sigma(E)/E(\%) = 4.8\%$$



FWD ECL Resolution

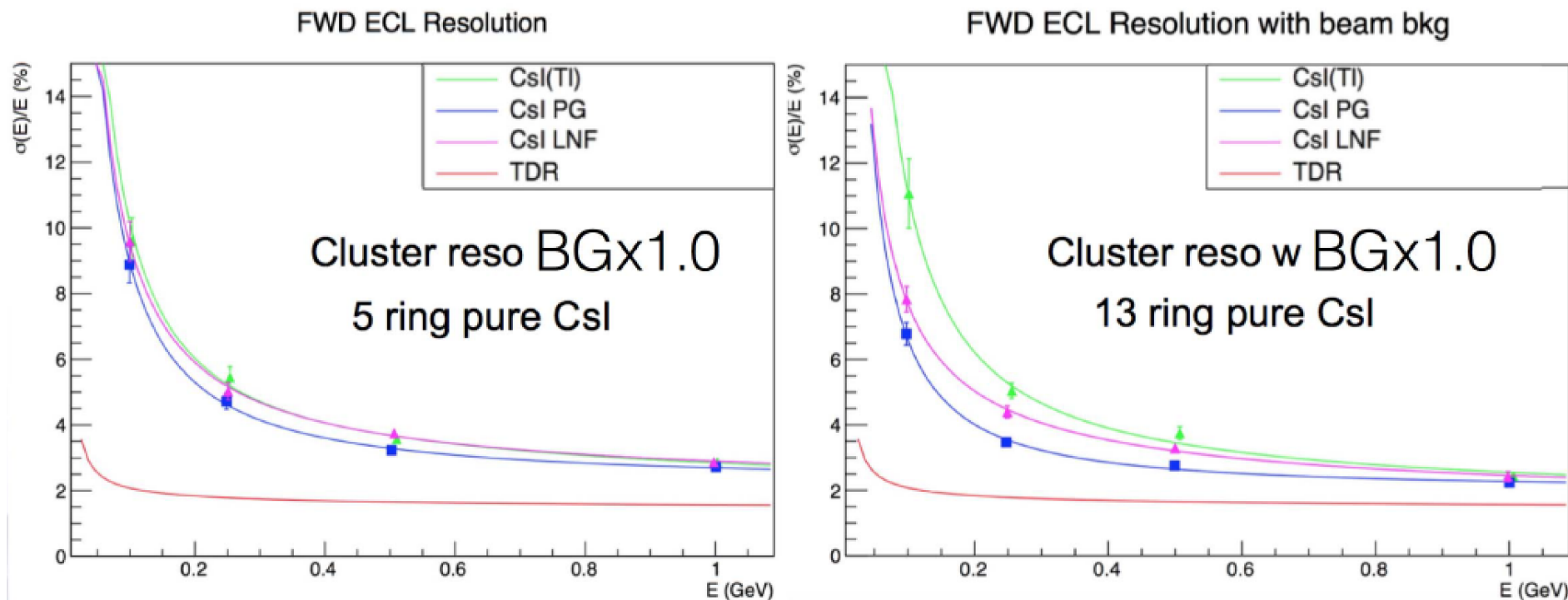


FWD ECL Resolution with beam bkg



**PG: ENE 0.7 MeV and 25 ph-e/MeV**  
**LNF: ENE 1.3 MeV and 6 ph-e/MeV**

# Performance studies

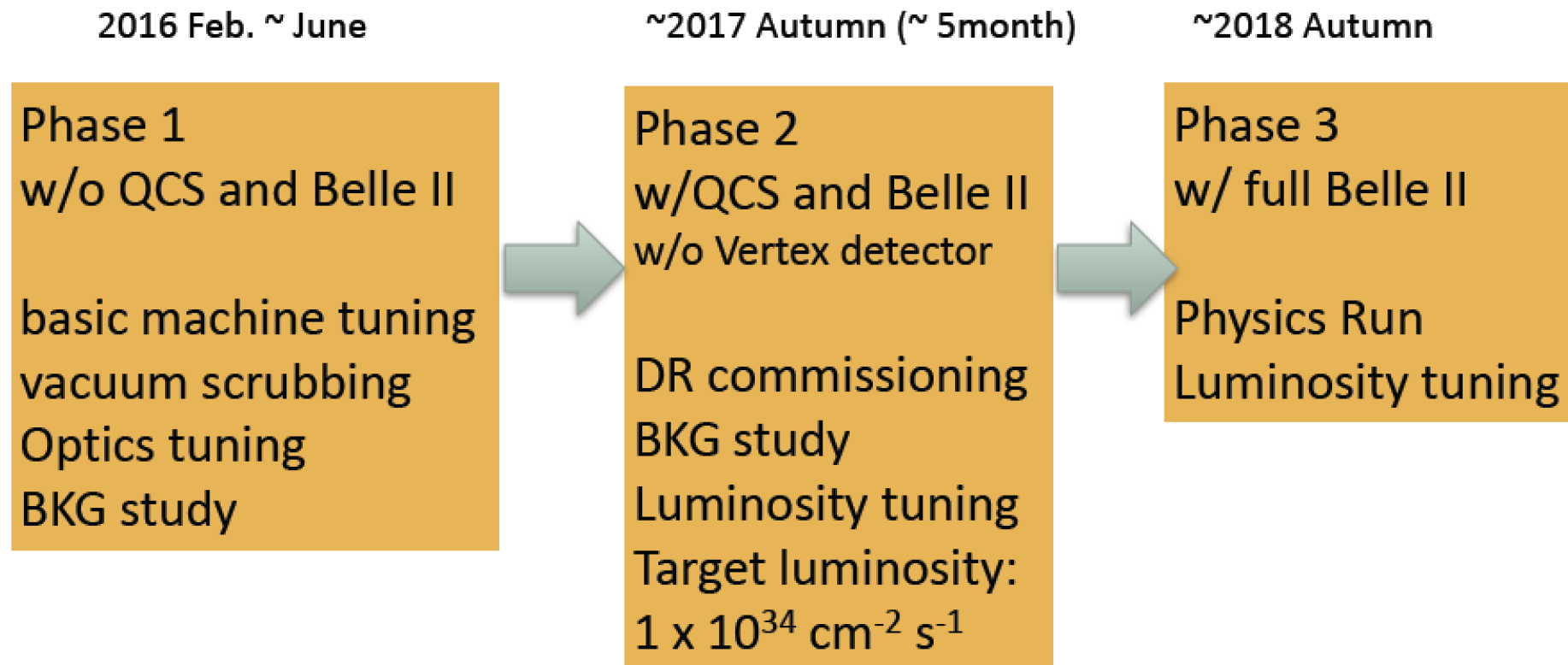


- Nominal background (BG =1) degrade the resolution by a factor 10%
- With BG=1 ENE + photostatistic fluctuations degrade resolution of a factor 20% each
- With current simulation → energy resolution @100 MeV about 5% (to be compared to 12% CsI(Tl))

# Planning

## SuperKEKB Commissioning Phases

Y. Funakoshi at June '16 B2GM



# Planning

Due to the delay of the SuperKEKB operations (about one year) the decision on the FWD EMC upgrade has also been delayed

- a task force has been settled (C. Cecchi co-chair) to finish the R&D and take the final decision

## JENNIFER DELIVERABLES:

- FWD ECL TDR 10 months (Feb. 2016) → R&D report March 2017, 24 months
- Commissioning report FWD ECL (48 months) → TDR when Background studies will be available as they are crucial

# Conclusions

- R&D is going on and is approaching the final steps
- Filter + WLS on pure CsI give good results → ECL FWD detector is not affected by presence of BKG a slightly loss of signal is observed (74% of the light is retained after shaping)
- CsI(Tl) + APD shows good level of noise → to be tested at more stable values of APD Gain
- Performance studies are ongoing → pure CsI is better in presence of BKG than CsI(Tl) with the present level of BKG and with the actual clustering → clustering is a key ingredient for these studies and to understand how CsI(Tl) can be improved
- Besides the delay non directly coming from the ECL group the ECL FWD Task Force will decide on the upgrade max in 1 year from now and there is still a slot of opportunity for the installation and commissioning of the detector which will have sensible impact on the physics results.