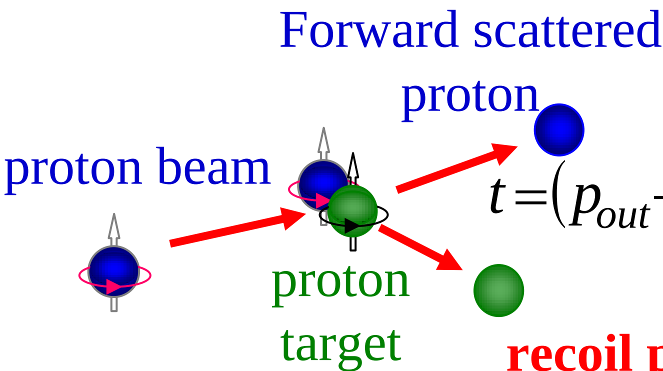
RUN8 HJET Results

RSC meeting 2008/09/12
Hiromi Okada

Contents

I'd apologize the quality of the phone from Japan via SKYPE.
I can't hear your voice without pushing a mute bottom.

Kinetic of the *pp* elastic scattering



$$t=(p_{out}-p_{in})^2<0$$

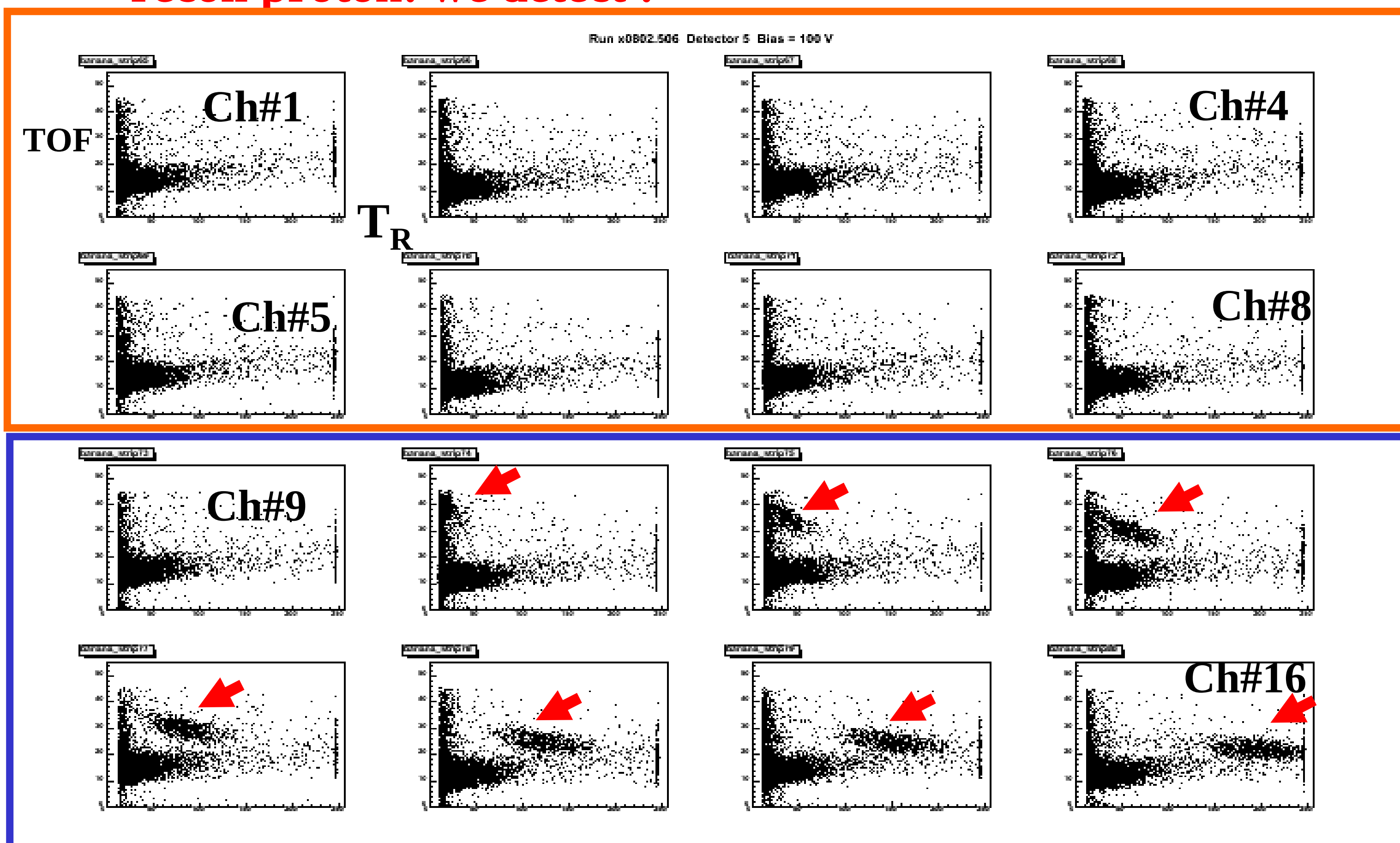
recoil proton: we detect !

θ_R big $\Rightarrow$ T_R big

$\Rightarrow$ small TOF

$0.5 < T_R < 5$ MeV

$80 >$ TOF > 20 ns

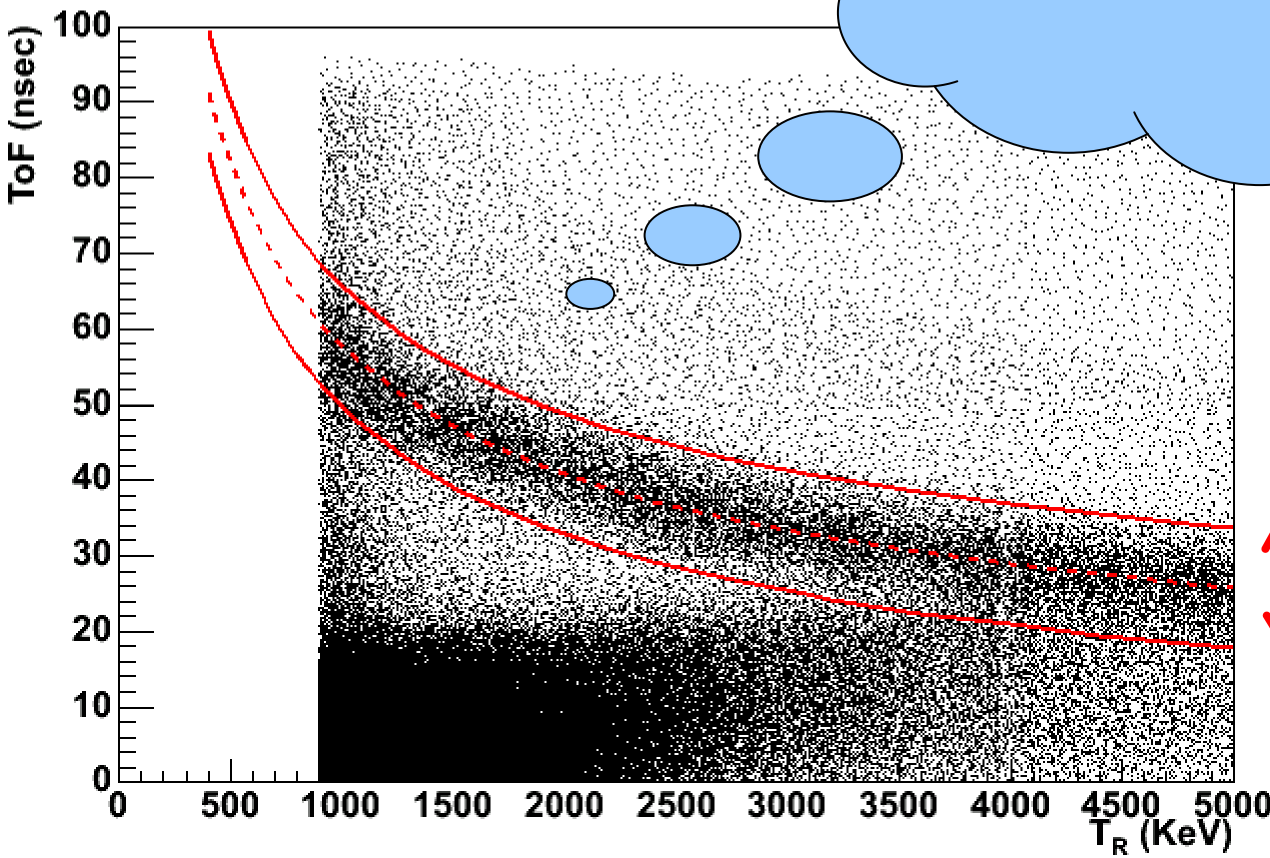


$\mathrm{ch\#} \propto \theta_R$

ToF vs. T_R

Confirm recoil is proton.

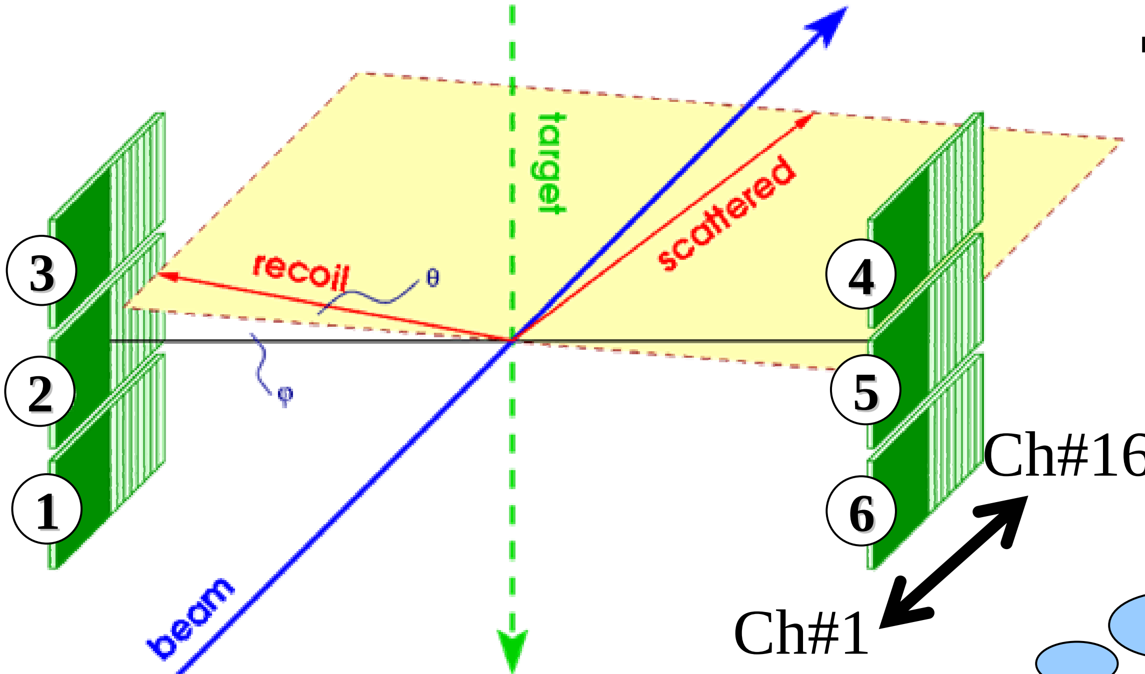
Data from one of detectors.
All statistics for RUN8.
Red line is calculation.



Red solid lines are ±8 nsec bands.

T_R vs. $\theta_R(\propto$ chan.#)

Confirm forward scattered particle is proton.



Data from one of detectors.
All statistics for RUN8.
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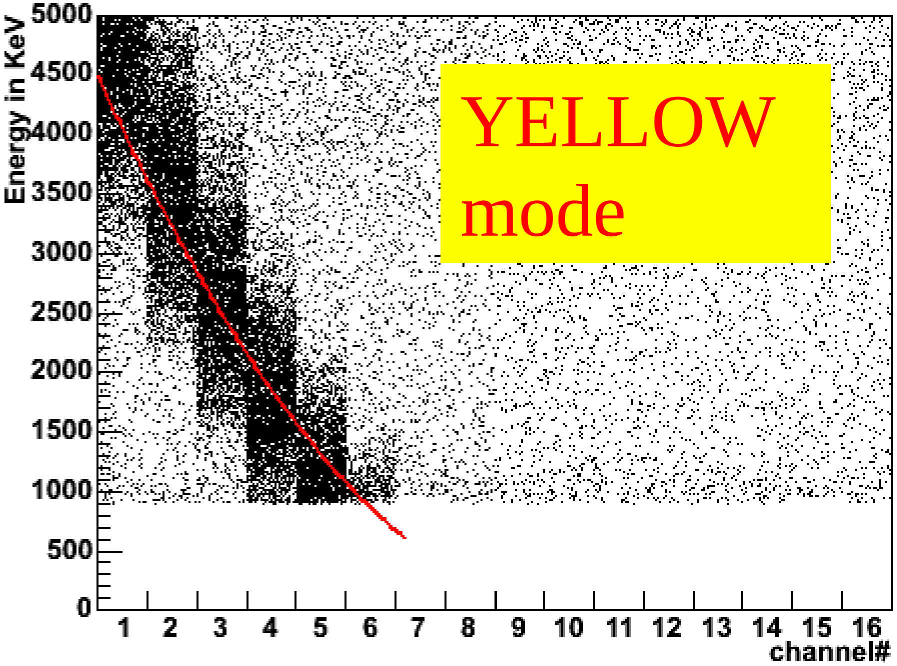
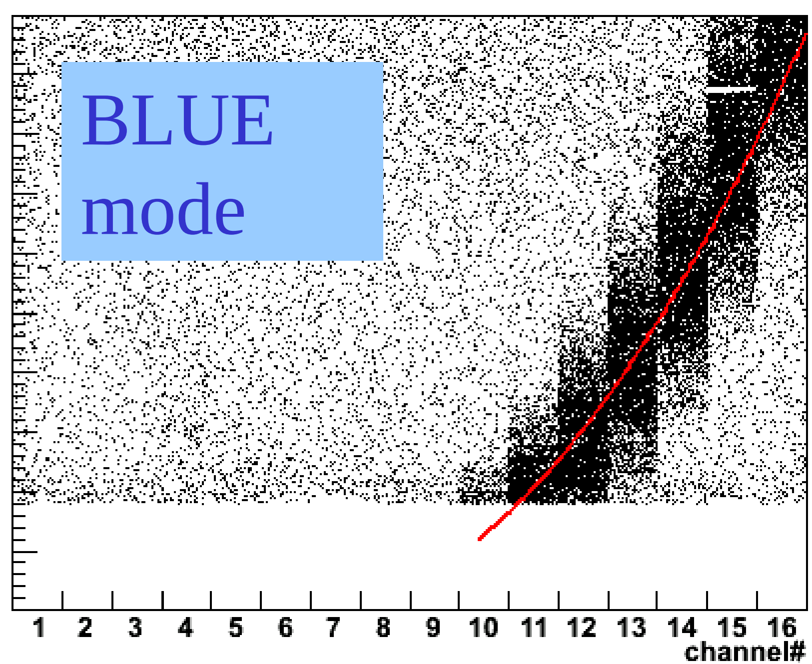
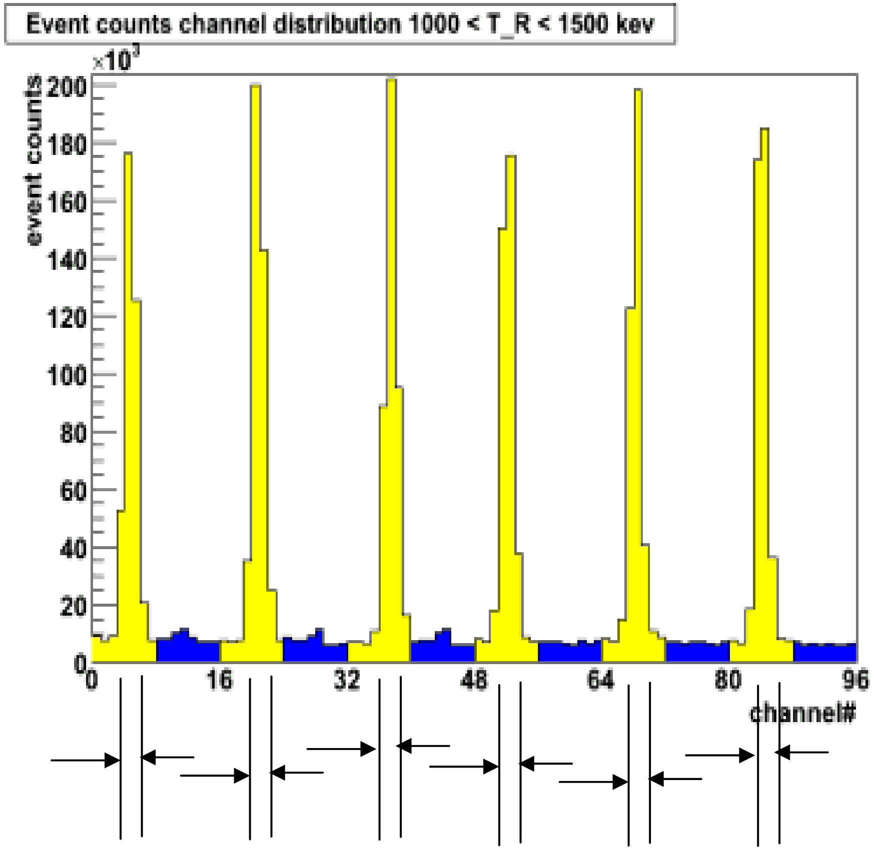
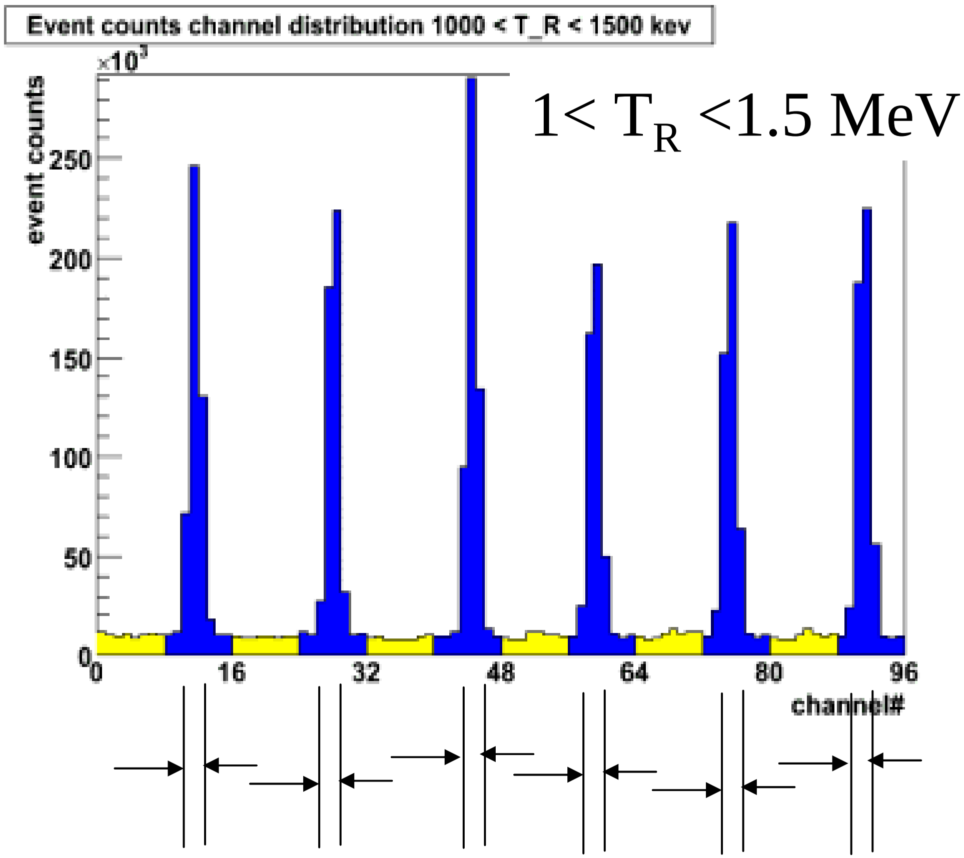




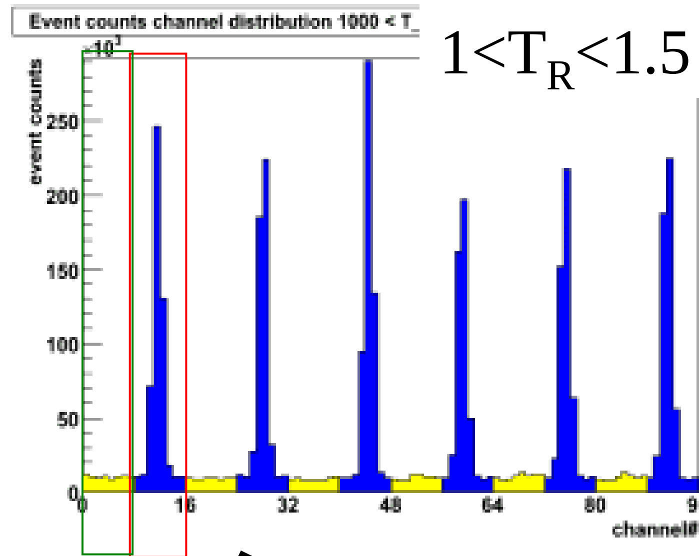
How to pick elastic events
"channel selection method"





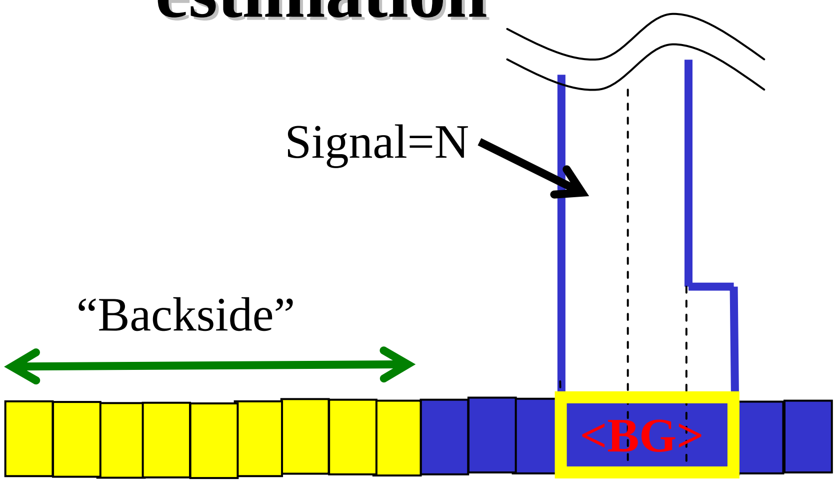
- ✓ **Event distribution as function of channel# for 1 < T_R < 1.5 MeV.**
- ✓ **Distinguishable between "Signal" channels and "non-signal" channels**
- ✓ **2~3 channels are selected for each T_R bin and each detector.**

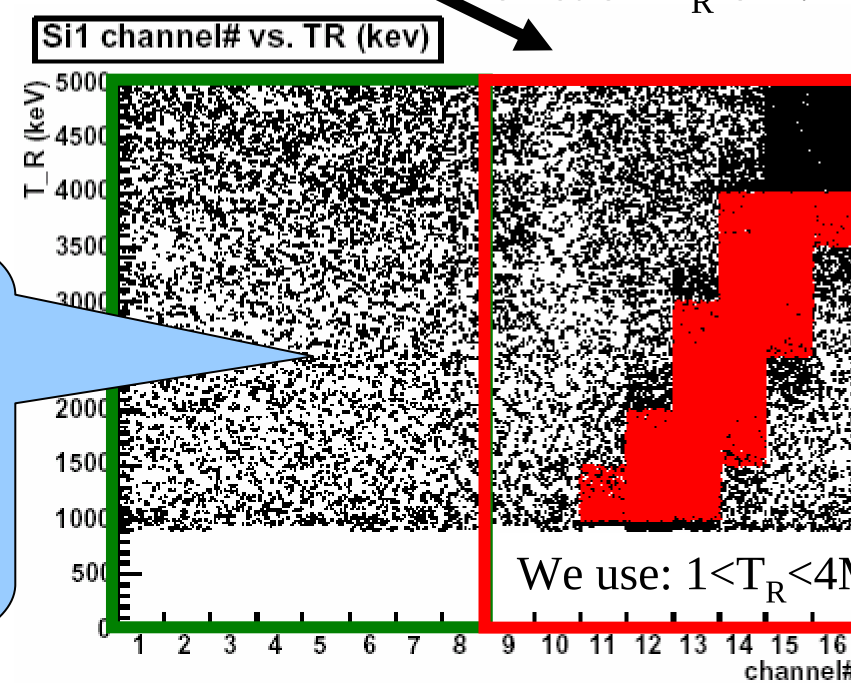
Confirmation of "*signal-channels*" & Background level estimation



$1 < T_R < 1.5$ MeV

Select Signal channels for each T_R bin!





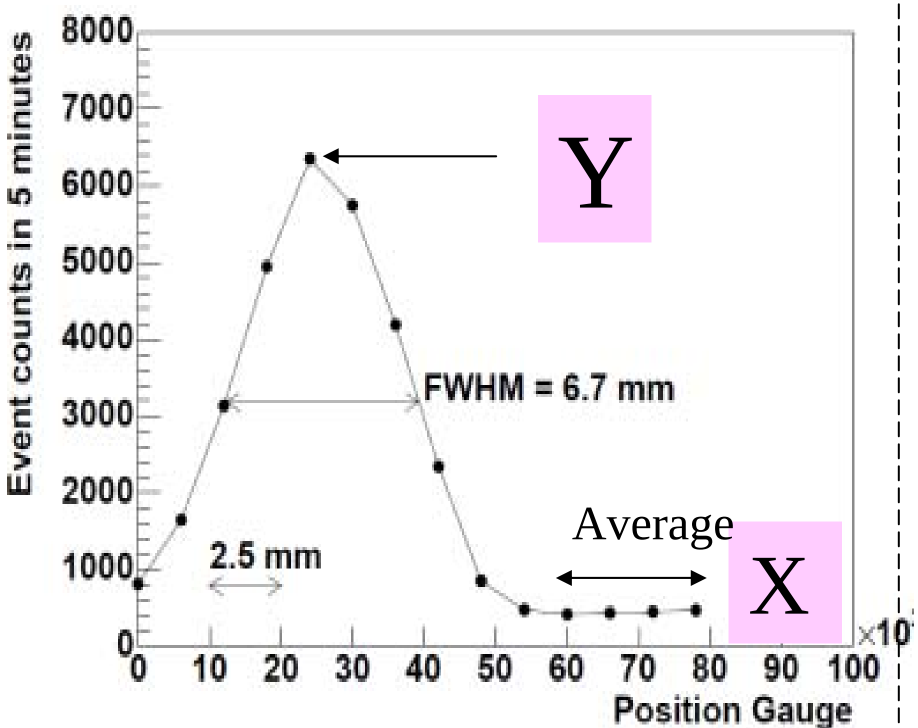
Assuming BG has flat distribution, I estimated <BG> from "backside" detector.

$\langle BG\rangle / (S + \langle BG\rangle) = 7 \pm 1\%$

Higher than previous RUNs!

BG level comparison using "target-profile data"

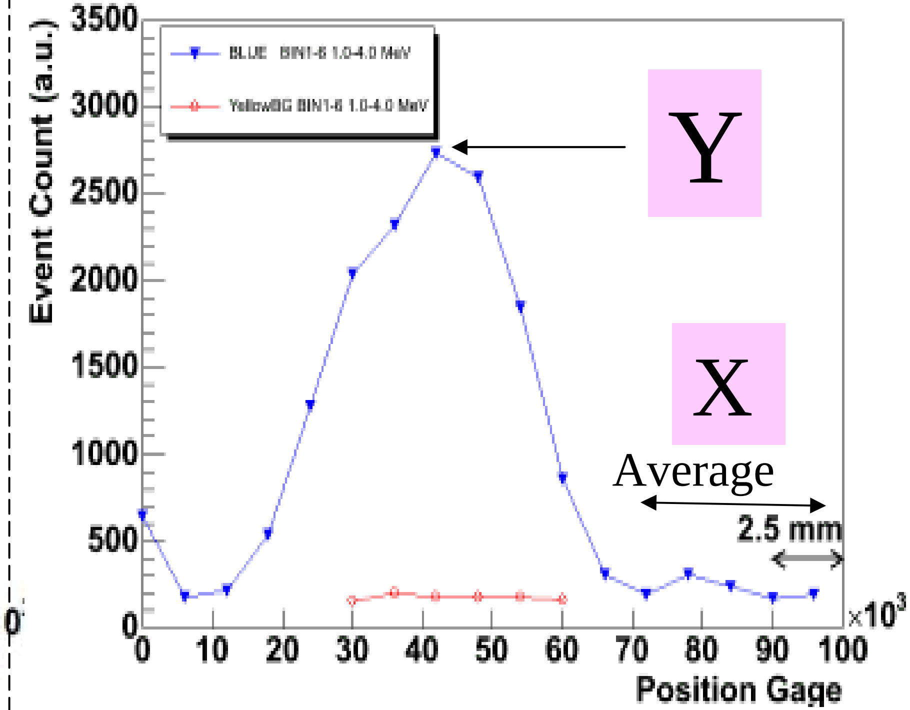
RUN4 0.6 <= T_R <= 4.7 MeV



X/Y = 6 %

- Measured α 3%
- M=3.2%
(→Consistent with H_2~3%)

RUN8 1.0<= T_R <= 4.0 MeV

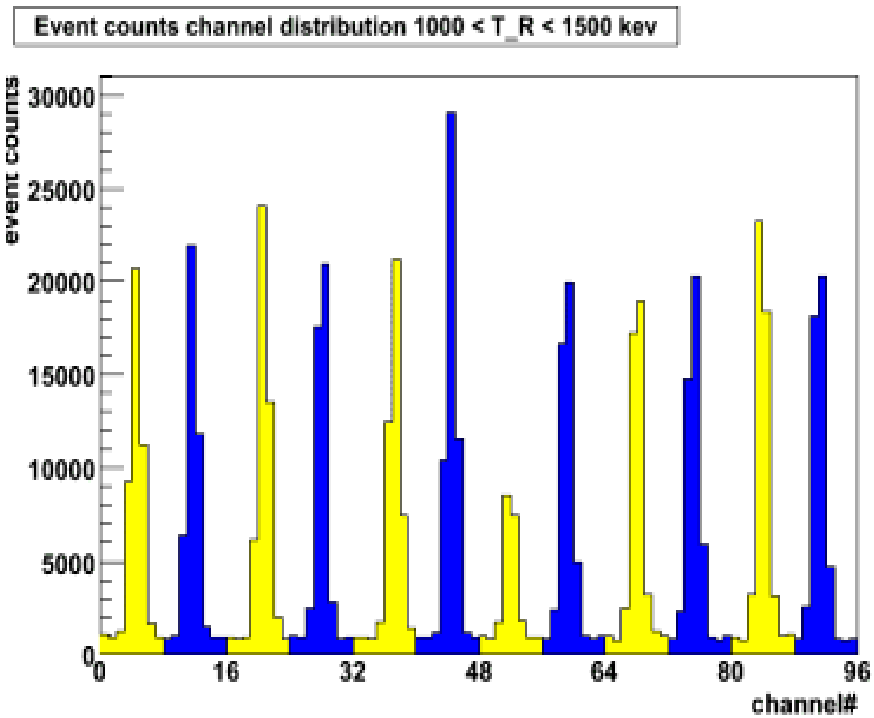


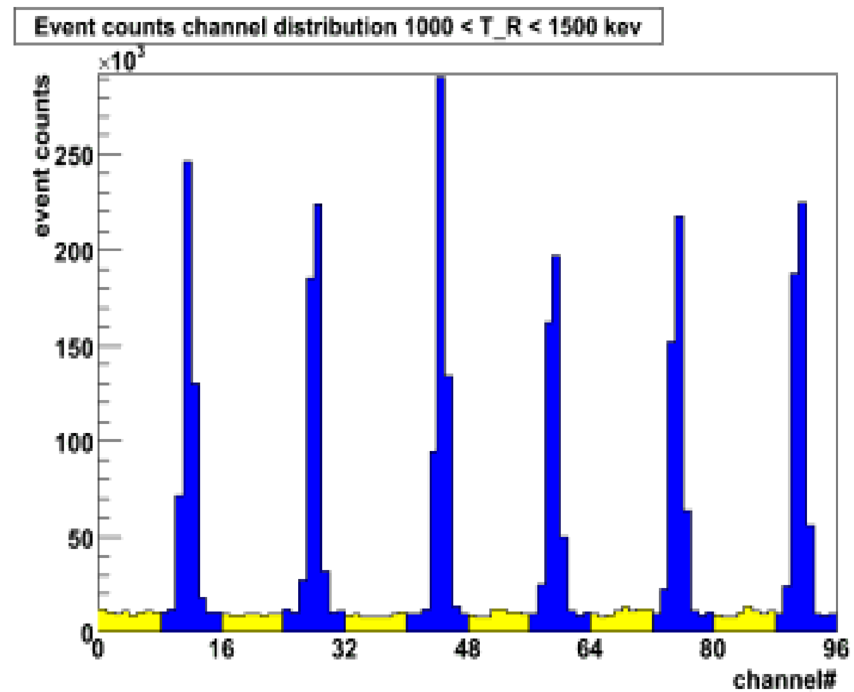
X/Y = 7 % , **no α!**

Factor 2 UP

From where BG events come?

BG level of "two beams mode" is not double of "single beam mode"!





BG/(SIG+BG) ~ 8%

BG/(SIG+BG) ~ 7%

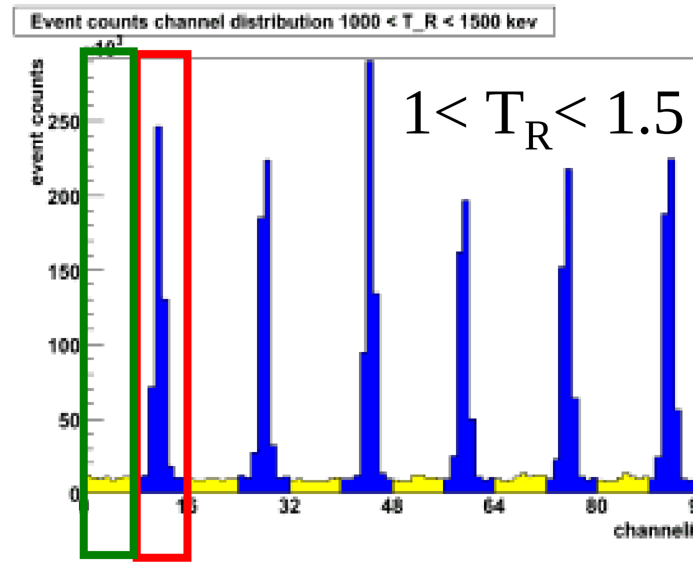
BG level is estimated from "non-signal" strips

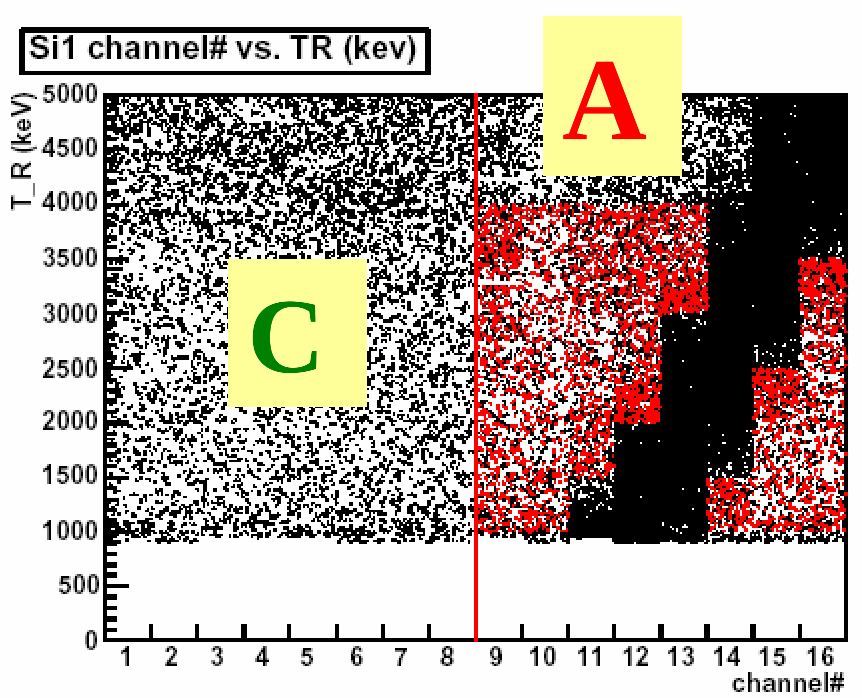
✓ Abort gap data also implies background came from two beams!

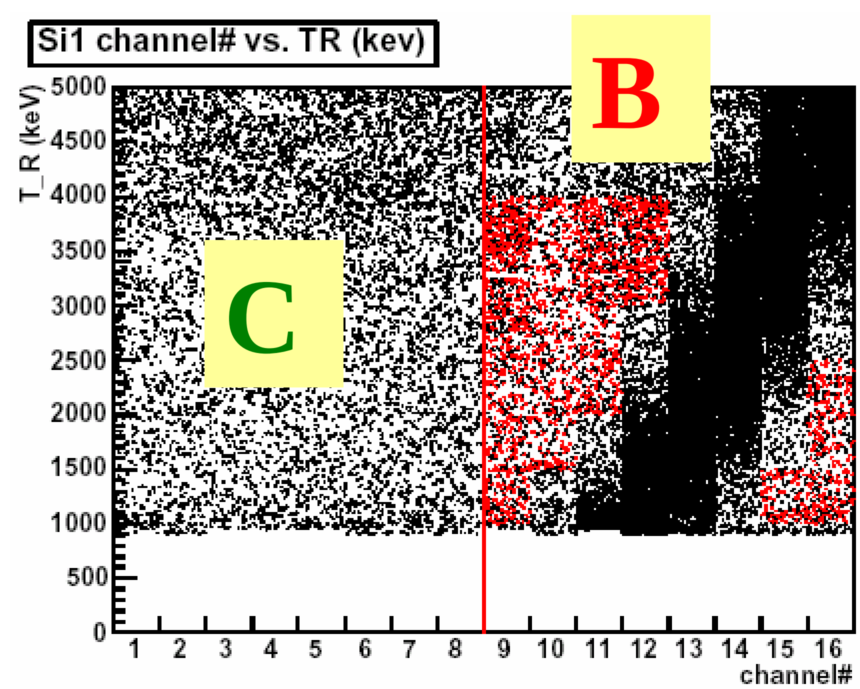
BG is polarized?

Try 2 types of "BG asymmetry"

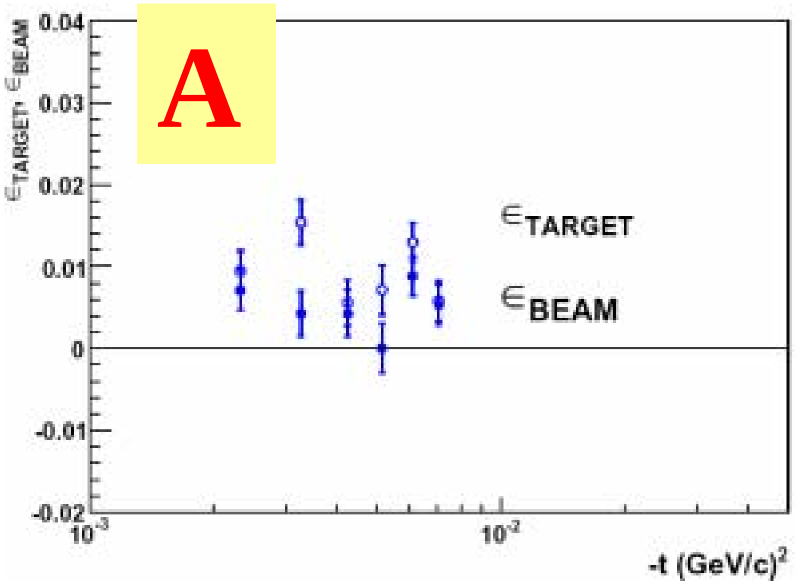
- Non-signal channels of "signal side" detectors.
  - Just avoid "signal channels" **(A)** ε_T^{BG}, ε_B^{BG}
  - Avoid "signal channels and nearest channels" **(B)** ε_T^{BG}, ε_B^{BG}
- Channels of "backside" detectors to check beam asymmetry **(C)** ε_{BLUE}^{BG} , $\varepsilon_{YELLOW}^{BG}$



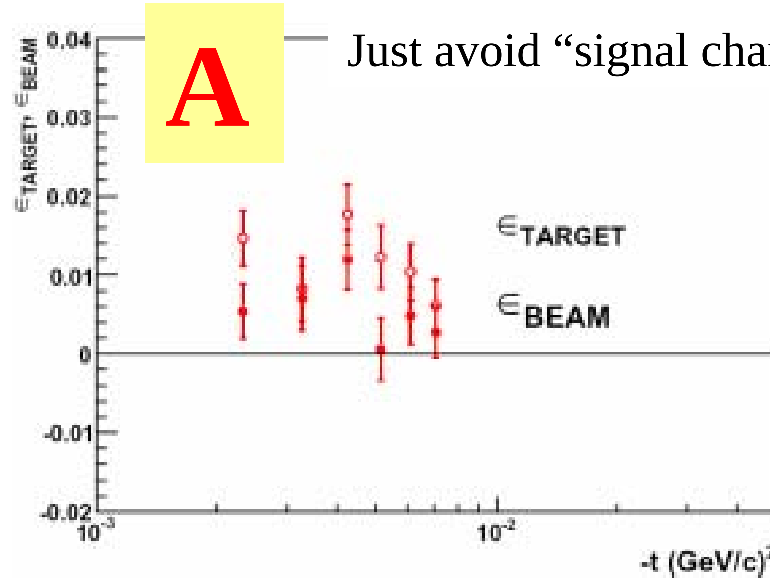


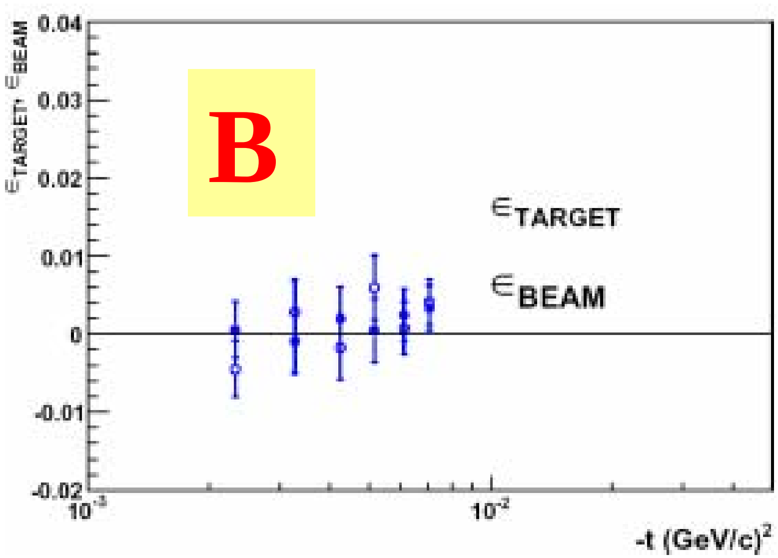


BG is polarized?

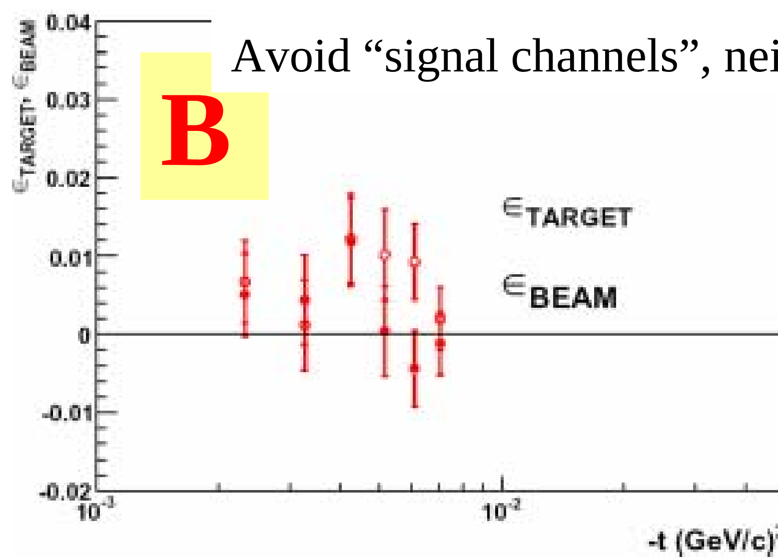


Just avoid “signal channels”





Avoid “signal channels”, neighbors



BG asymmetry

		ε_{TARGET}	ε_{BEAM}	Stat. error
(A) Non-signal channels	Blue mode	0.0102	0.0055	0.0011
	Yellow mode	0.0115	0.0052	0.0015
(B) Non-signal strips, non-neighbor channels	Blue mode	**–0.0015**	**0.0018**	**0.0015**
	Yellow mode	**0.0064**	**0.0019**	**0.0021**

They may include "elastic" events

Consistent with zero!

		ε_{BEAM} with BLUE pat.	ε_{BEAM} with YELLOW pat.	Stat. err
(C) Backside channels	Blue mode	0.0021	–0.0001	0.0010
	Yellow mode	0.0017	0.0025	0.0011

Background is unpolarized with beam spin patterns,

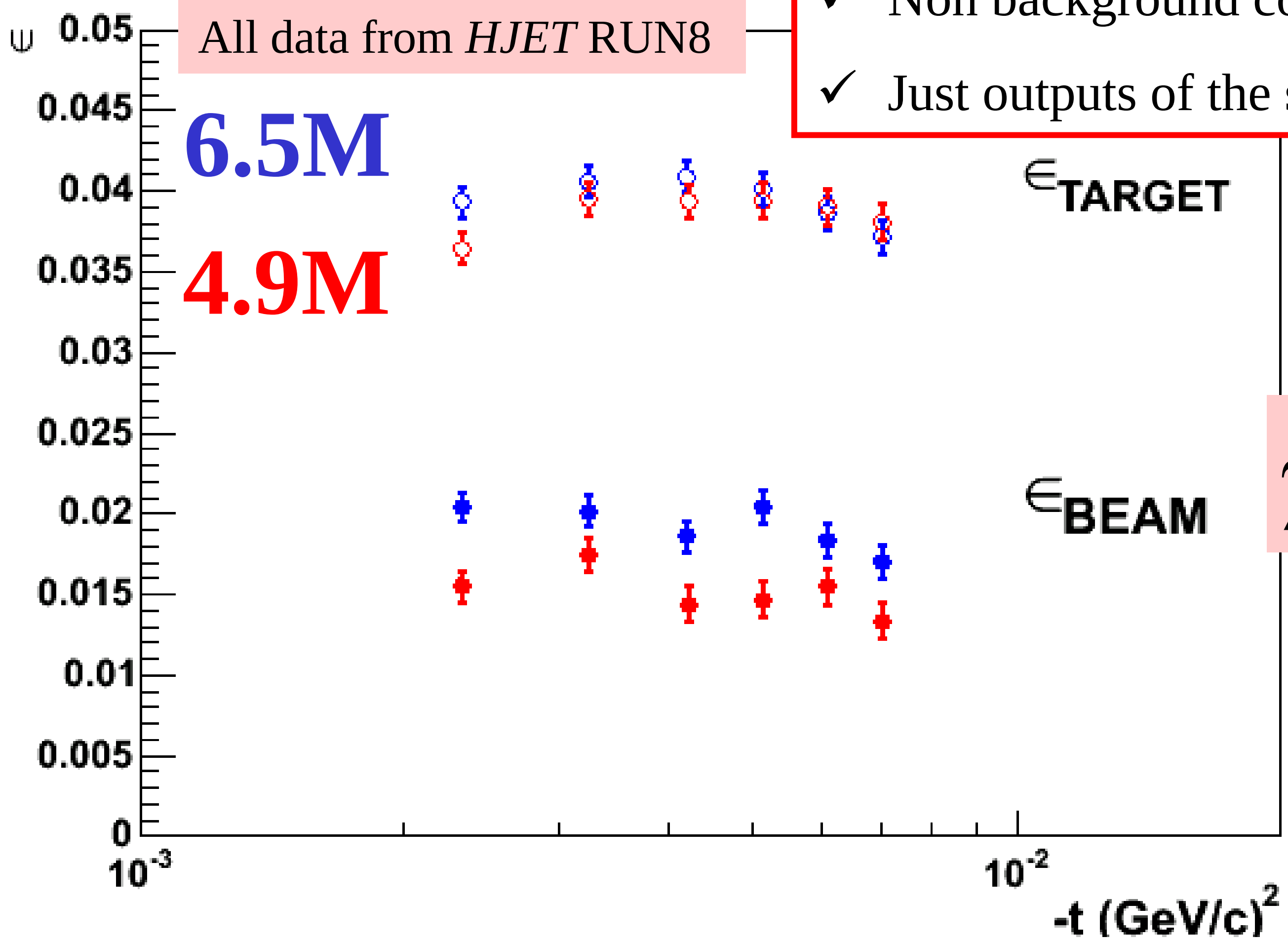
Raw asymmetry

- ✓ Non background correction applied.
- ✓ Just outputs of the square-root-formula.

All data from *HJET* RUN8

6.5M

4.9M



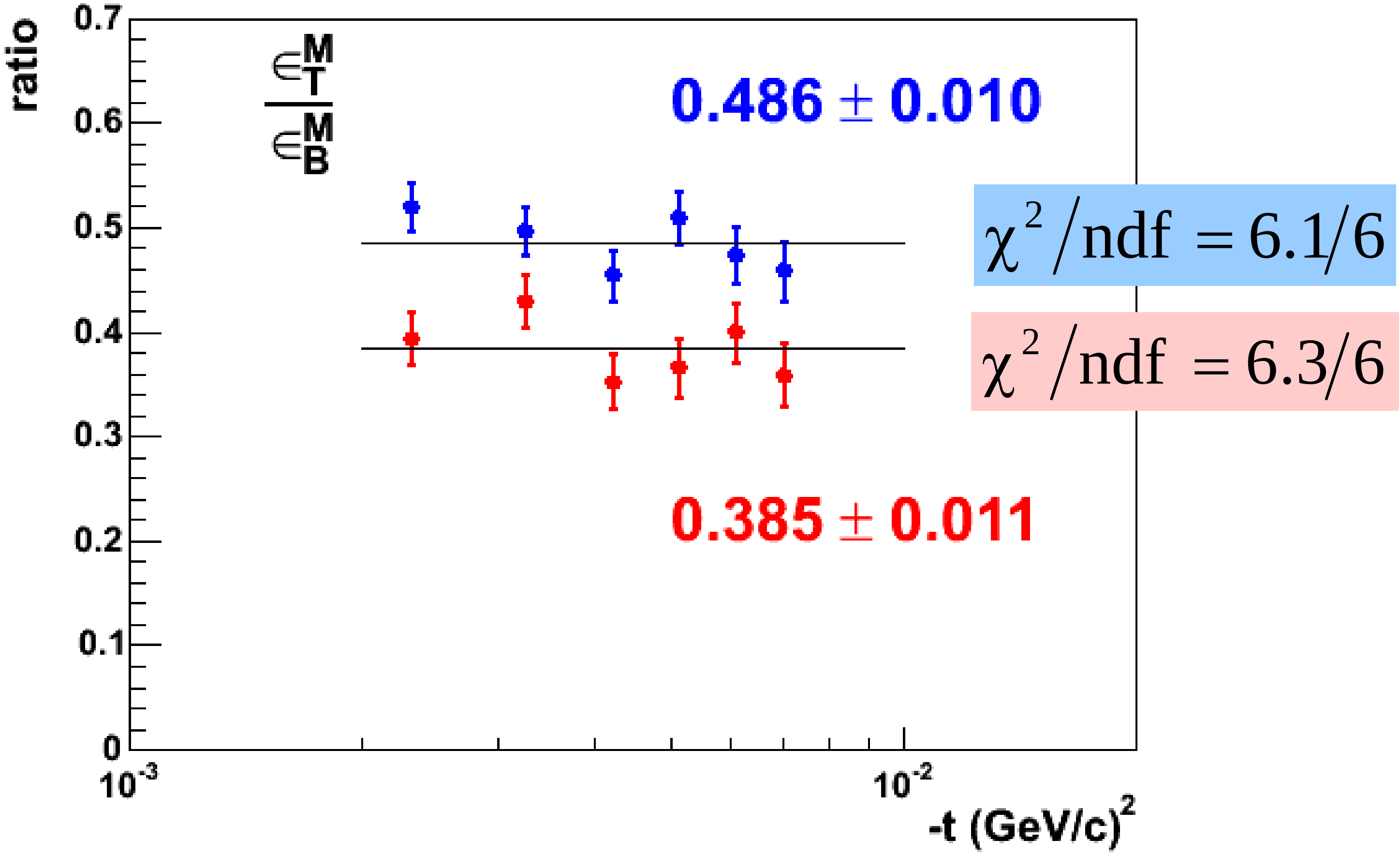
BLUE vs. **YELLOW**

$\chi^2/\mathrm{ndf}=7.0/6$

I combined 6 T_R bins ($1 < T_R < 4$ MeV) statistically to check fill-by-fill stability of ε_B and ε_T. →See backup page 22.

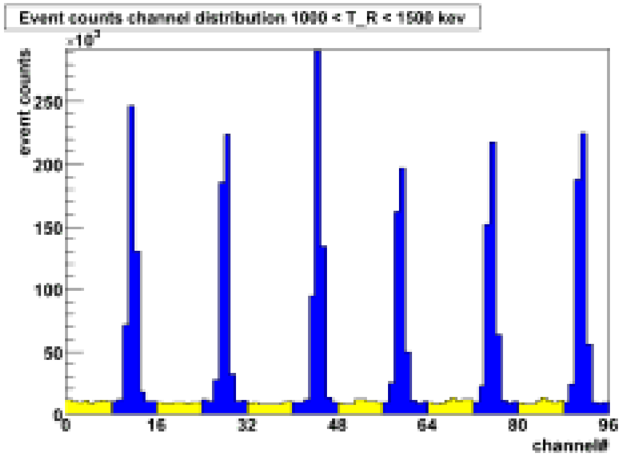
Ratio of raw asymmetries

All data from *HJET* RUN8



- Asymmetry ratio $=\varepsilon_{beam}/\varepsilon_{target}$ does not have -*t* dependence.
- This is consistent with previous RUNs.

Systematic uncertainty



1. **BG contribution**
   - Event distribution of “backside” detector and “non-signal channels” looks flat (= no angle dependence).
   - We **assume** that background distribution under signals are also flat and the same level.
   - Background under the signals contains:
     - Scattering between “Target tail” and “RHIC beams”
     - Beam scraping. This is estimated less than 1% from empty-target data analysis.

2. **Other source?**

Beam polarization

$$P_{beam} = \frac{\varepsilon_B^{mes.}}{\varepsilon_T^{mes.}} \cdot P_{target} \times \left(1 + BG \frac{\varepsilon_B^{BG}}{\varepsilon_B} - BG \frac{\varepsilon_T^{BG}}{\varepsilon_T} \right)$$

Eq.1: see backup

P_{Yellow} **=0.393×0.924× 0.997=0.362**

P_{Blue} **=0.488 ×0.924× 1.009=0.455 (data set-B)**

$$\frac{\Delta P_{beam}}{P_{beam}} = \left.\frac{\Delta P_{beam}}{P_{beam}}\right|_{sys.} \oplus \left.\frac{\Delta P_{beam}}{P_{beam}}\right|_{stat.} \oplus \left.\frac{\Delta P_{beam}}{P_{beam}}\right|_{P_{target}}$$

$$\left.\frac{\Delta P_{beam}}{P_{beam}}\right|_{sys.} = \left.\frac{\Delta P_{beam}}{P_{beam}}\right|_{BG} \oplus \left.\frac{\Delta P_{beam}}{P_{beam}}\right|_{?} \oplus \cancel{\left.\frac{\Delta P_{beam}}{P_{beam}}\right|_{Cut}} \oplus \cancel{\left.\frac{\Delta P_{beam}}{P_{beam}}\right|_{Acc.}}$$

$$\left.\frac{\Delta P_{beam}}{P_{beam}}\right|_{BG} = \left.\frac{\Delta P_{beam}}{P_{beam}}\right|_{tail} \oplus \cancel{\left.\frac{\Delta P_{beam}}{P_{beam}}\right|_{prompt}}$$

Δtof = 6, 10nsec comparison

Remove "edge" energies. Use $1<T_R<4$ MeV range only.

Less than 1%.

Uncertainty and Results

$$\left.\frac{\Delta P_{\mathrm{beam}}}{P_{\mathrm{beam}}}\right|_{\mathrm{stat.}} = \frac{\Delta\left(\varepsilon_{\mathrm{beam}} / \varepsilon_{\mathrm{target}}\right)}{\varepsilon_{\mathrm{beam}} / \varepsilon_{\mathrm{target}}}$$

=0.012/0.393=3.1% YELLOW

=0.012/0.488=2.5% BLUE (data set-B)

$$\left.\frac{\Delta P_{\mathrm{beam}}}{P_{\mathrm{beam}}}\right|_{\mathrm{BG}} \cong \mathrm{BG} \times \left\{ \frac{\Delta\varepsilon_{\mathrm{beam}}^{\mathrm{BG}}}{\varepsilon_{\mathrm{beam}}} \oplus \frac{\Delta\varepsilon_{\mathrm{target}}^{\mathrm{BG}}}{\varepsilon_{\mathrm{target}}} \right\}$$

= 1.1% YELLOW

= 0.6% BLUE

Eq.2, see backup

$$\left.\frac{\Delta P_{\mathrm{beam}}}{P_{\mathrm{beam}}}\right|_{P_{\mathrm{target}}} = 2\%$$

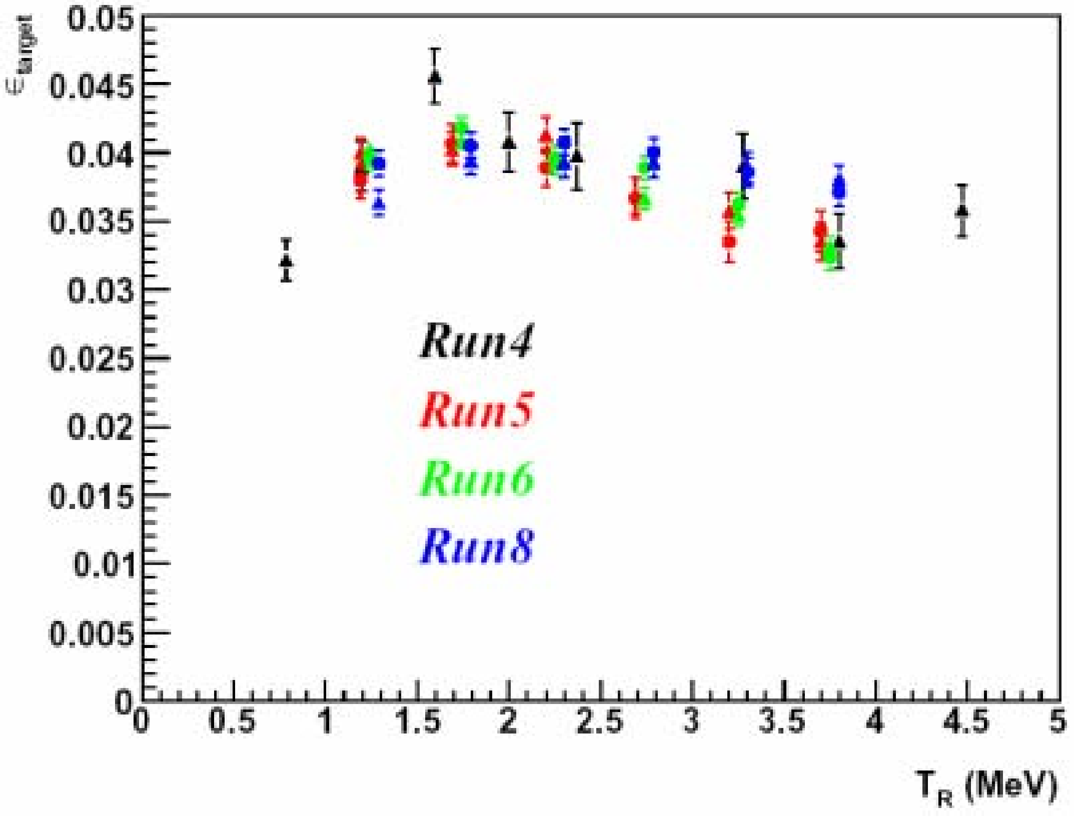
H_2 contamination

RUN8 Polarization (data set-B)

		stat.	sys.	target
P_{Yellow} =0.362,	$\Delta P_{\mathrm{Yellow}} / P_{\mathrm{Yellow}}$ =	$\pm$ 3.1%	$\pm$ 1.1 %	$\pm$ 2%
P_{Blue} =0.455,	$\Delta P_{\mathrm{Blue}} / P_{\mathrm{Blue}}$ =	$\pm$ 2.5%	$\pm$ 0.6 %	$\pm$ 2%

Comparison between years

Asymmetries are in reasonable consistency.



- Asymmetry ratio $=\epsilon_{beam}/\epsilon_{target}$ does not have T_R dependence for every year.
- Background polarization is consistent with zero for every year.
- Asymmetry ratio $=\epsilon_{beam}/\epsilon_{target}$ is robust for every year.

Backups

Eq.1:

$$P_{beam} = \frac{\varepsilon_B^{mes.}\left\{1+BG\cdot\left(1+\varepsilon_B^{BG}/\varepsilon_B^{mes.}\right)\right\}}{\varepsilon_T^{mes.}\left\{1+BG\cdot\left(1+\varepsilon_T^{BG}/\varepsilon_T^{mes.}\right)\right\}}\cdot P_{target}$$

$$\approx \frac{\varepsilon_B^{mes.}}{\varepsilon_T^{mes.}}\cdot P_{target}\left\{1+BG\cdot\left(1+\frac{\varepsilon_B^{BG}}{\varepsilon_B^{mes.}}\right)\right\}\left\{1-BG\cdot\left(1+\frac{\varepsilon_T^{BG}}{\varepsilon_T^{mes.}}\right)\right\}$$

$$\approx \frac{\varepsilon_B^{mes.}}{\varepsilon_T^{mes.}}\cdot P_{target}\times\underline{\left(1+BG\frac{\varepsilon_B^{BG}}{\varepsilon_B^{mes.}}-BG\frac{\varepsilon_T^{BG}}{\varepsilon_T^{mes.}}\right)}$$

Correction factor ***C***

$BG = 0.07$

$\varepsilon_{beam}{}^{BG} = 0.0018$	$\varepsilon_{beam}{}^{BG} = 0.0019$
$\varepsilon_{target}{}^{BG} = -0.0015$	$\varepsilon_{target}{}^{BG} = 0.0064$
$\varepsilon_{beam} = 0.01931$	$\varepsilon_{beam} = 0.0151$
$\varepsilon_{target} = 0.03955$	$\varepsilon_{target} = 0.0384$
C= 1.009	**C=0.997**

Eq.2:

$$\left.\frac{\Delta P_{beam}}{P_{beam}}\right|_{BG} = BG \times \left\{ \frac{\Delta \varepsilon_{beam}^{BG}}{\varepsilon_{beam}} \oplus \frac{\Delta \varepsilon_{t\arg et}^{BG}}{\varepsilon_{t\arg et}} \right\}$$

$$BG = 0.07$$

$\Delta\varepsilon_{beam}{}^{BG} = \Delta_{\varepsilon target}{}^{BG} = 0.0021$

$\varepsilon_{beam} = 0.0151$

$\varepsilon_{target} = 0.0384$

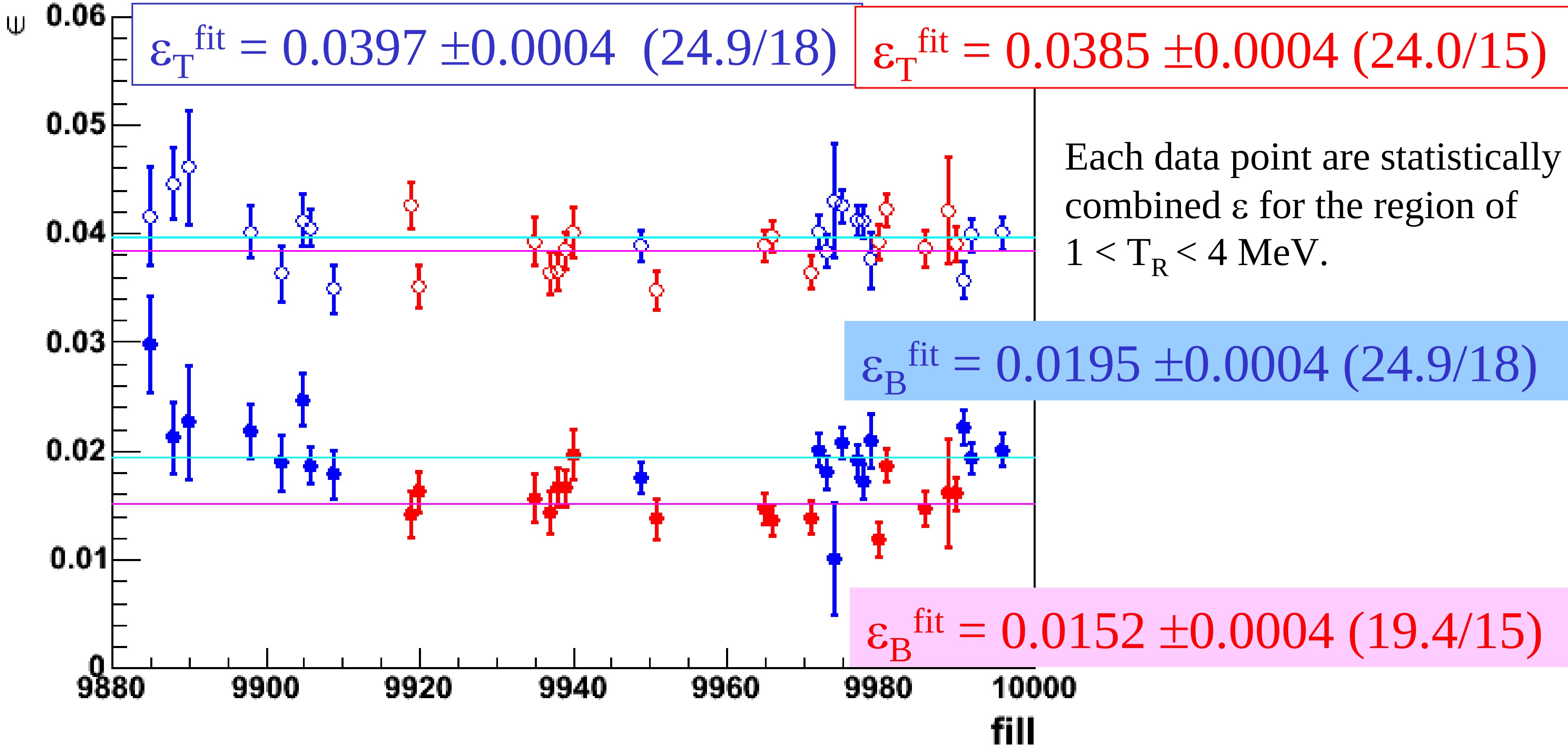
$\Delta\varepsilon_{beam}{}^{BG} = \Delta_{\varepsilon target}{}^{BG} = 0.0015$

$\varepsilon_{beam} = 0.01931$

$\varepsilon_{target} = 0.03955$

$$\left.\frac{\Delta P_{beam}}{P_{beam}}\right|_{BG} \begin{array}{l} =1.1\% \text{ YELLOW} \\ =0.6\% \text{ BLUE} \end{array}$$

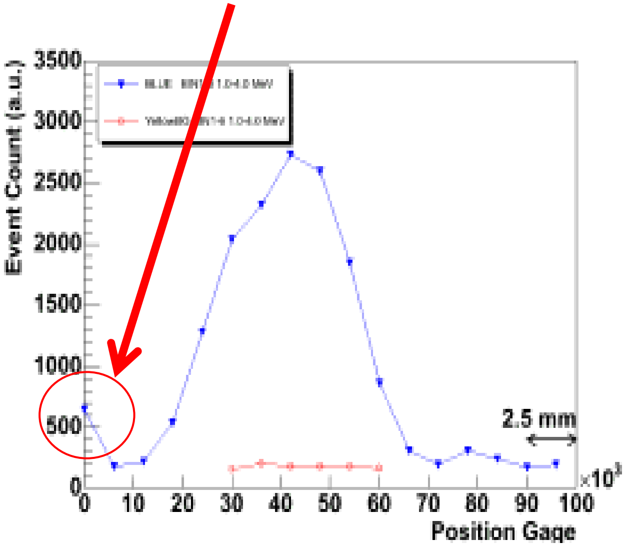
Fill-by-fill raw asymmetries (All data from *HJET* RUN8)



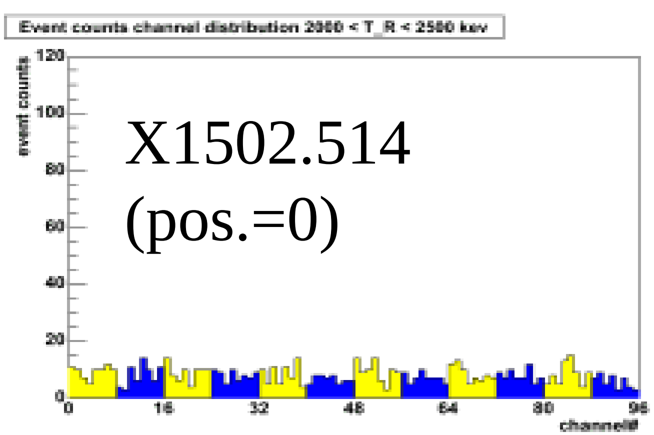
Each data point are statistically combined ε for the region of $1 < T_R < 4$ MeV.

- ✓ $\varepsilon_T / \varepsilon_T = 1.031$ → Due to different background level between B & Y.
- ✓ $\varepsilon_B / \varepsilon_B = 1.283$ → Due to different background level between B & Y + different B & Y beam polarizations.
- ✓ Unpolarized backgrounds are just cancel if we take $\varepsilon_B/\varepsilon_T$!!

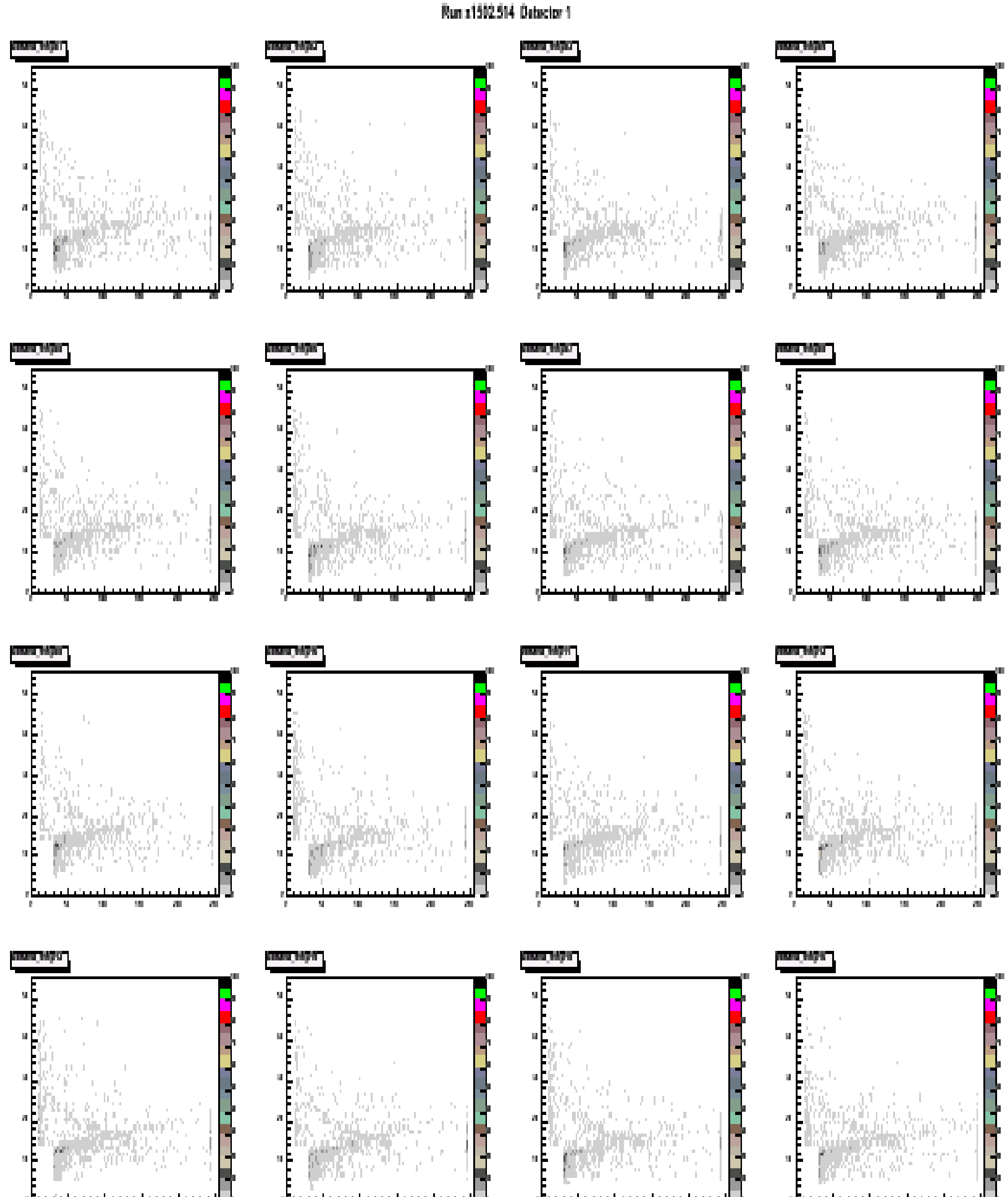
What is happened at position=0 ?



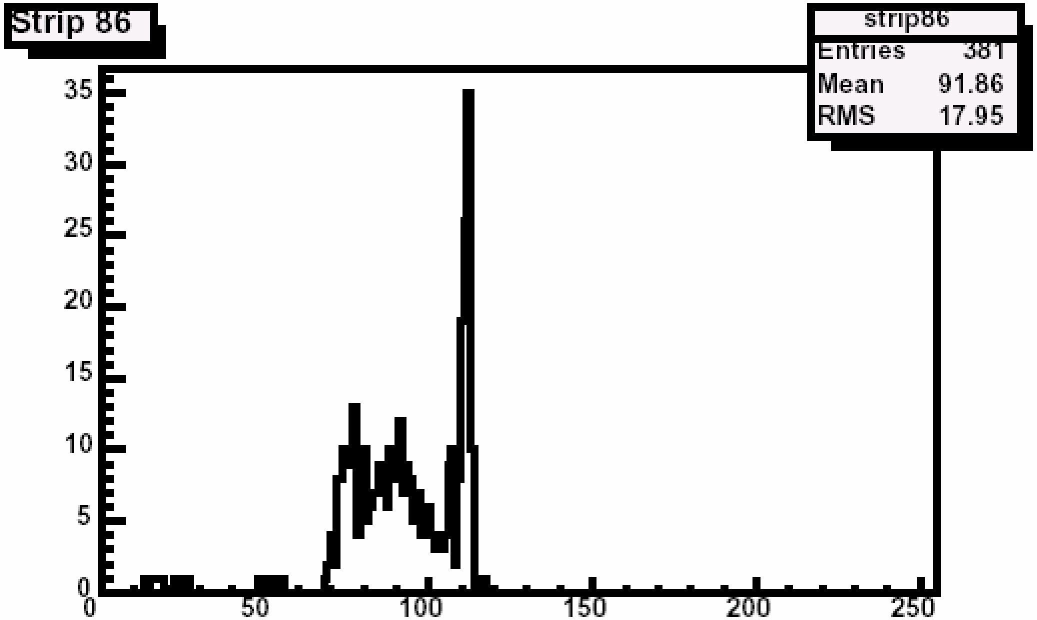
Just normal bananas and event distribution!



X1502.514
(pos.=0)



Am source spectrum



Time0 estimation, stability as a function of run#.

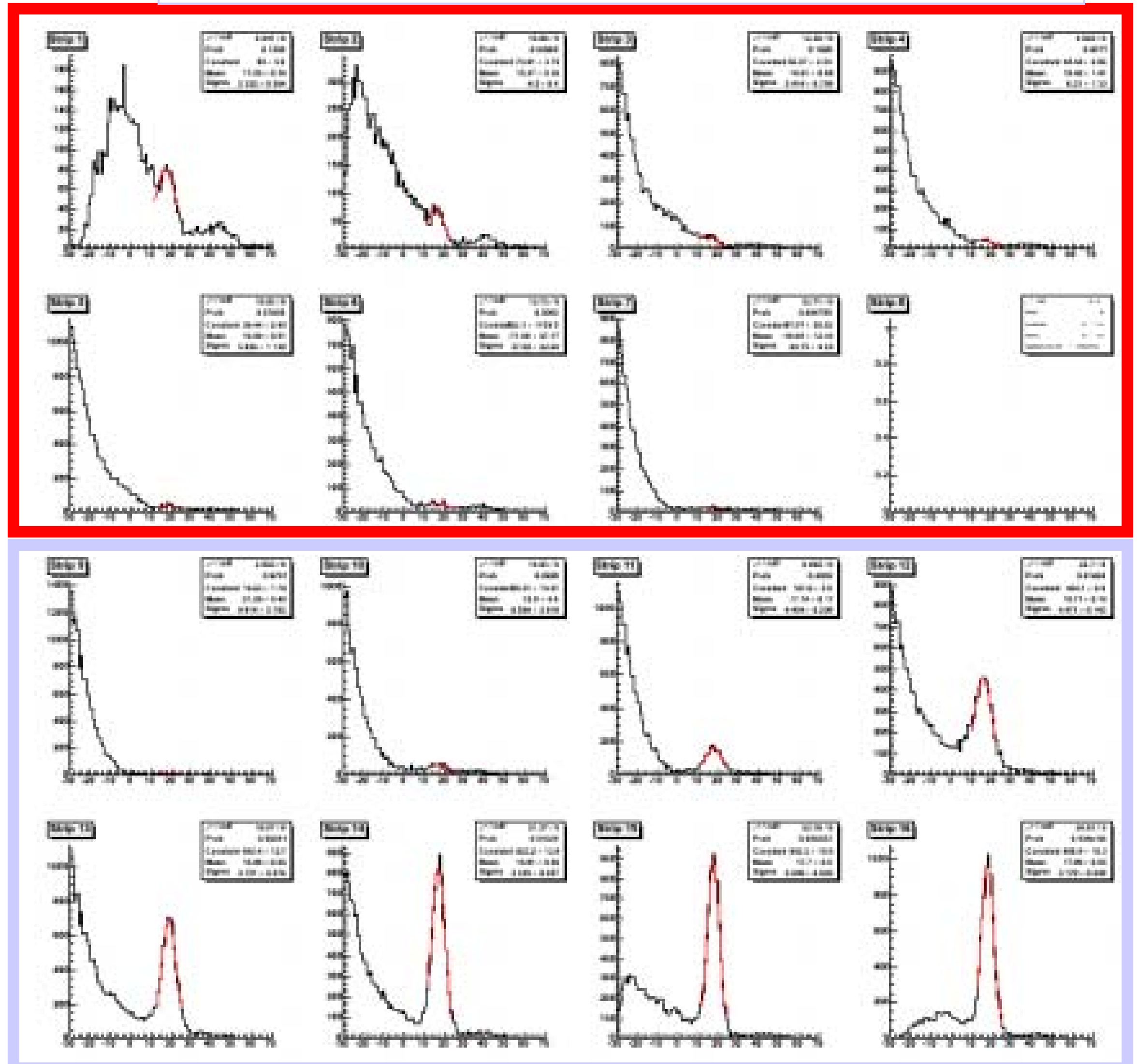
Detect Arrival time

$$\mathrm{time0} = \mathrm{TDC} \times 2.369 - \mathrm{tof}\left(T_R\right)$$

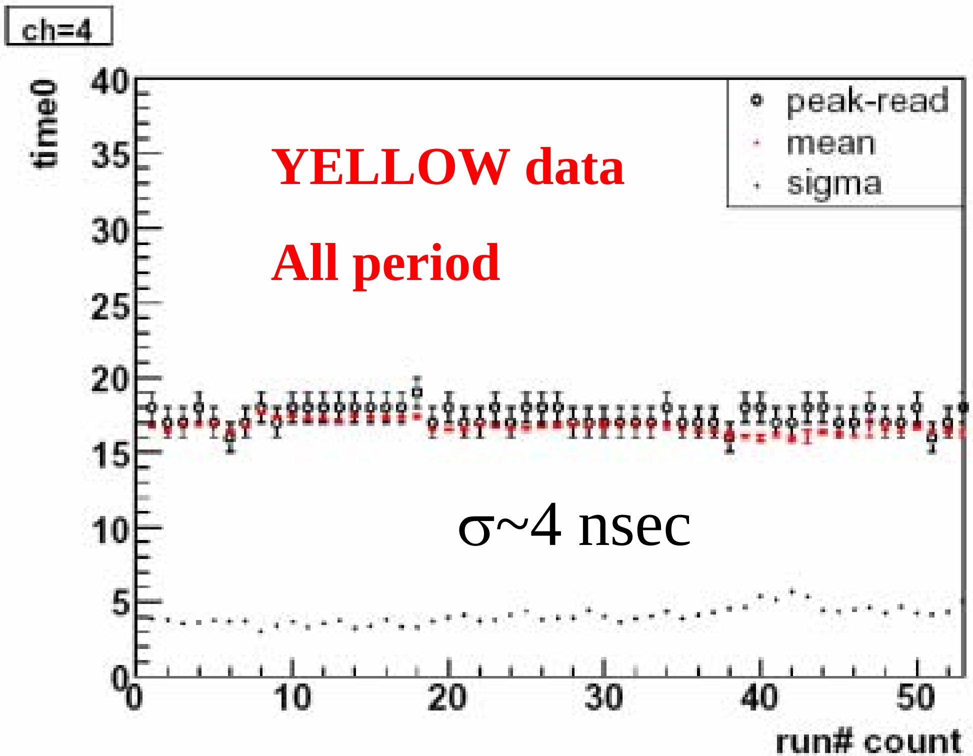
$$\mathrm{tof}\left(T_R\right) = L\sqrt{\frac{2T_R}{M_R}}$$

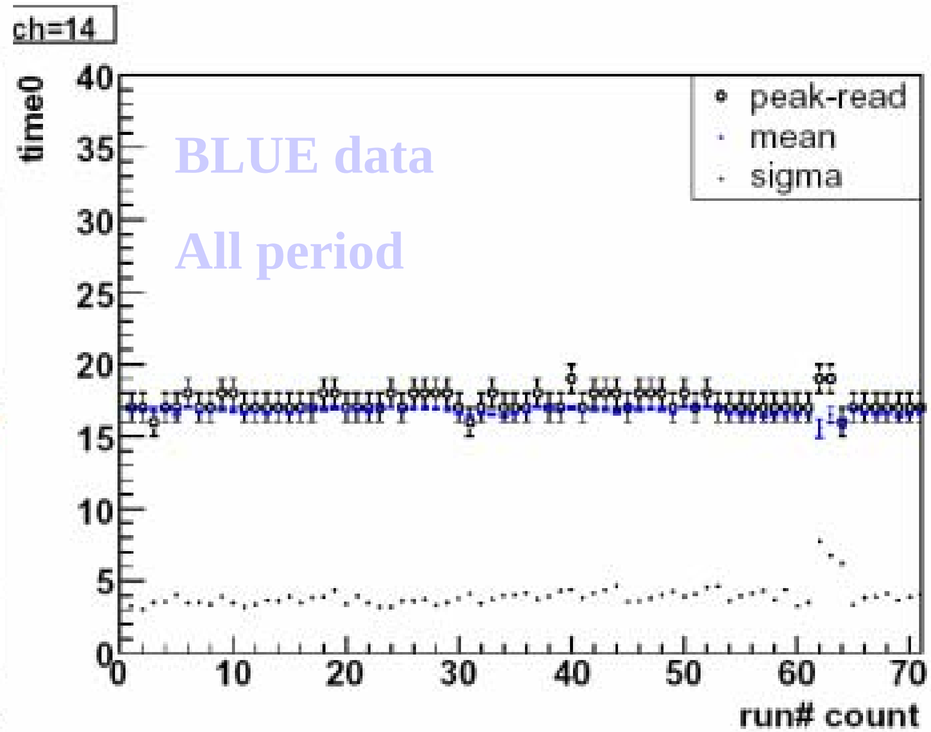
- Try blue and yellow data
- Peak value (fit, peak point)
- Sigma (assume Gaussian)
- How stable they ate?

Time0 distribution of Si#1



Time0 of each channel is stable during RUN8!





- RUN4 σ~3.9nsec (from my thesis)!
- Difference of time0 between "ONLIE" and "OFFLINE" is within 1 nsec.

I can ±8 nsec TOF width cut for offline analysis!

1. Unpol. Contamination from Tom and Willy's e-mail (2005 Nov.)

- > So we all agree to use:
  >
  > P_Target = 0.924 +- 0.018
  >
  > 3% contamination; we might want to add one more digit to this figure
  > **********
  > the ref for target pol is Wise et al, page 757 SPIN 2004. The numbers
  > given there (P+=0.923 and P- = 0.925 or Pave = 0.924 are arrived at as
  > follows:
  >
  > H-ATOM polarization (P+ = 0.957, P- = 0.959, Pave = 0.958
  >
  > The unpol contamination is (3.5+/- 2.0)%
  >
  > the net target pol is calculated as a mean: 0.965x0.958 + 0.035 x
  > zero= 0.924. The (relative) error is 2% = 0.018.
  >