

Event based maximum likelihood fit

$$-\ln \mathcal{L} = \sum_{i=1}^n -\ln(p_{\text{prompt}}(\phi_i, p_{\gamma,i}, \Sigma, a_1 \dots a_4, b_1 \dots b_4)) + \\ \sum_{j=1}^m -\ln \left(p_{\text{sideband}}(\phi_j, p_{\gamma,j}, \Sigma^{\text{bkg}}, a_1^{\text{bkg}} \dots a_4^{\text{bkg}}, b_1^{\text{bkg}} \dots b_4^{\text{bkg}}) \right)$$

where

$$p_{\text{prompt}} = f_{\text{sig}} \cdot \tilde{p}(\phi, p_{\gamma}, \Sigma, a_1 \dots a_4, b_1 \dots b_4) \\ + (1 - f_{\text{sig}}) \cdot \tilde{p}(\phi, p_{\gamma}, \Sigma^{\text{bkg}}, a_1^{\text{bkg}} \dots a_4^{\text{bkg}}, b_1^{\text{bkg}} \dots b_4^{\text{bkg}}) \\ p_{\text{sideband}} = \tilde{p}(\phi, p_{\gamma}, \Sigma^{\text{bkg}}, a_1^{\text{bkg}} \dots a_4^{\text{bkg}}, b_1^{\text{bkg}} \dots b_4^{\text{bkg}})$$

and

$$\tilde{p}(\phi, \Sigma) = \frac{\left(1 + p_{\gamma} \Sigma \cos \left(2 \left(\alpha^{\parallel} - \phi\right)\right)\right) \cdot \left(\sum_{k=0}^4 a_k \sin(k\phi) + b_k \cos(k\phi)\right)}{1 - \frac{1}{2} a_2 p_{\gamma} \Sigma}$$

Event based maximum likelihood fit (in STAN)

define priors and implement log-likelihood, truncate Σ to $[-1, 1]$

```
model{  
  
  //loop over prmpt peak events  
  for(k in 1:N){  
    target+=log(f*mypdf(phi_prmpt[k],pol_prmpt[k],sigma,a,b)+(1-f)*mypdf(phi_prmpt[k],pol_prmpt[k],sigma_bkg,a_bkg,b_bkg));  
  }  
  //loop over sideband events  
  for(k in 1:M){  
    target+=log(mypdf(phi_side[k],pol_side[k],sigma_bkg,a_bkg,b_bkg));  
  }  
  
  //priors for eff. coefficients, non-informative, broadly around 0  
  for(k in 1:4){  
    a[k]~normal(0,0.1);  
    b[k]~normal(0,0.1);  
    a_bkg[k]~normal(0,0.1);  
    b_bkg[k]~normal(0,0.1);  
  }  
  //priors for sigma  
  sigma ~ normal(0,1) T[-1,1];  
  sigma_bkg ~ normal(0,1) T[-1,1];  
}
```

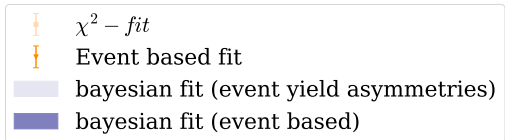
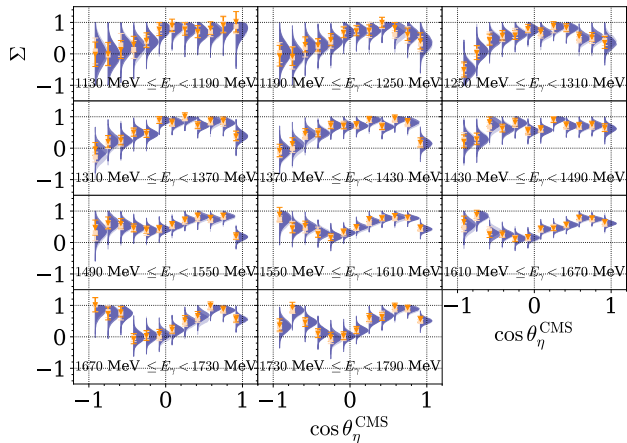
Fit diagnostics

4 chains, 5000 samples, 1000 sample warmup

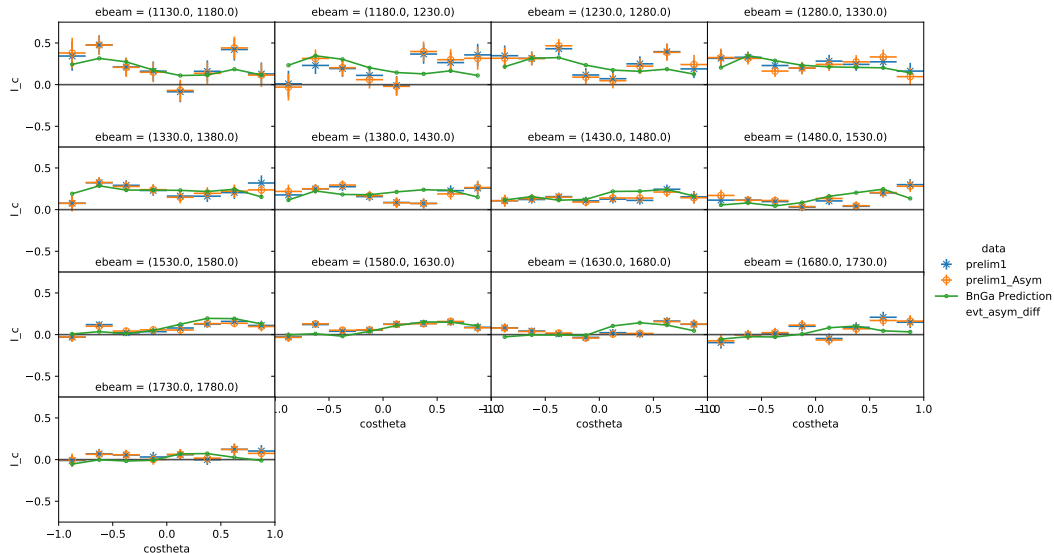
- ▶ ppd checks not possible (similar to "normal" event-based ML fit) → toy MC (?)
- ▶ $\hat{R} = 1$ for all parameters and all fits
- ▶ MCSE of median small: (nsamples chosen s.t. rel. error $\lesssim 0.05$)

../../../../bayes/event_based_fit/mcse.pdf

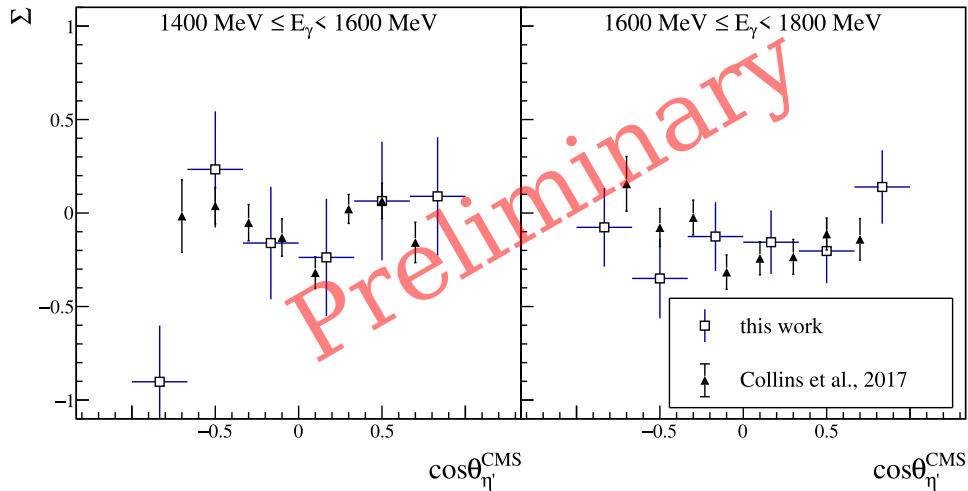
Results



Σ in $\gamma p \rightarrow p 2\pi^0$



Σ in $\gamma p \rightarrow p\eta'$



To Do

- ▶ extract Σ using unbinned maximum likelihood fit for η'
- ▶ apply BAYESIAN approach
- ▶ consider bkg contaminations in results of $\Sigma_{\eta'}$, study toy MC