



Calculation of calibration coefficients

Date	@08/21/2023
Event	Research
Tags	Jab_NPS
Note	Based on Carlos' thesis

Elastic collision events: $e + p \rightarrow e' + p'$

- Scattered electrons (e') are detected in the calorimeter
- Recoil protons (p') are detected in the HMS

Calibration coefficient

- According to energy conservation, the energy E_i of scattered electron in event i is:

$$E_i = E_b + M_p - E_i^p$$

where E_b is the beam energy, M_p is the mass of target proton, E_i^p is the energy of proton detected in the HMS

- By comparing E_i with $\sum_j C_j A_j^i$
 - C_j is the calibration coefficient of block j in the calorimeter
 - A_j^i is the amplitude (deposited energy) of block j in event i

we can build $\chi^2 = \sum_i (E_i - \sum_j C_j A_j^i)^2$

- The calibration coefficient C_j can be calculated by minimizing the χ^2 :

$$\frac{\partial \chi^2}{\partial C_k} = -2C_k \sum_i (E_i - \sum_j C_j A_j^i) A_k^i = 0$$

which can be written as:

$$\sum_i E_i A_k^i = \sum_j [\sum_i A_j^i A_k^i] C_j$$

- Then, C_j can be calculated by inverse the matrix $[\sum_i A_j^i A_k^i]$ and multiply $\sum_i E_i A_k^i$

```

for(int iblk = 0; iblk < nbClust; iblk++){
    Int_t ibn = blk_index->at(iblk);
    Double_t ibe = blk_E->at(iblk);

    DATA_COL[ibn]+=ibe*e_hmsE;// Sum the (E_i)(A^i_k)
    esum+=ibe;

    // look at the block number with the highest energy in the cluster
    if(ibe >= emax){
        emax = ibe;
        bn_emax = ibn;
    }

    for(int jblk = 0; jblk < nbClust; jblk++){
        Int_t jbn = blk_index->at(jblk);
        Double_t jbe = blk_E->at(jblk);

        DATA[ibn*nblk+jbn]+=ibe*jbe; // The matrix of (A^i_j)(A^i_k)
    }
}

```

```

Mat.SetMatrixArray(DATA.GetArray());
MatrixCol.SetMatrixArray(DATA_COL.GetArray());
hh_eMat = new TH2F(Mat);

TMatrixF Cj (nblk,1);
Cj.Mult(Mat.Invert(),MatrixCol); //Cj = MatrixCenter.Invert()*MatrixCol

```

The matrix and the calibration coefficients

- Because of an correction of deposited energy when generating the events, $edep_corr = edep*1.04$, most of the calibration coefficients are close to 1

