Trento Institute for
Fundamental Physics
and Applications

UNIVERSITÀ DEGLI STUDI
DI TRENTO

# Beryllium Isotope Analysis


AMS-Italia
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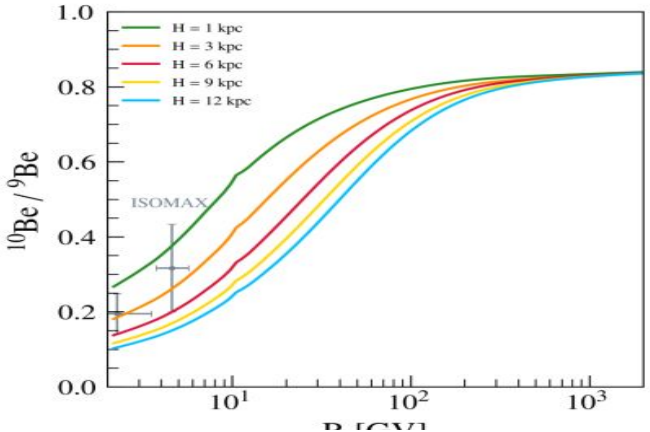
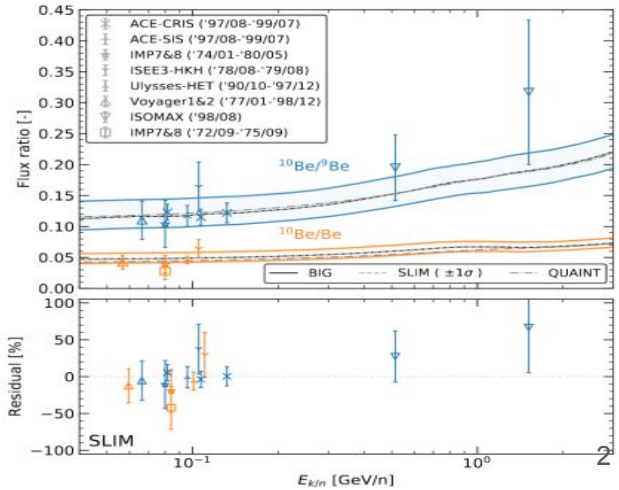
-Abhinandan Dass
-Dr. Francesco Dimiccoli
-Prof. Paolo Zuccon
-Dr. Francesco Nozzoli

# Importance of Beryllium isotope Studies

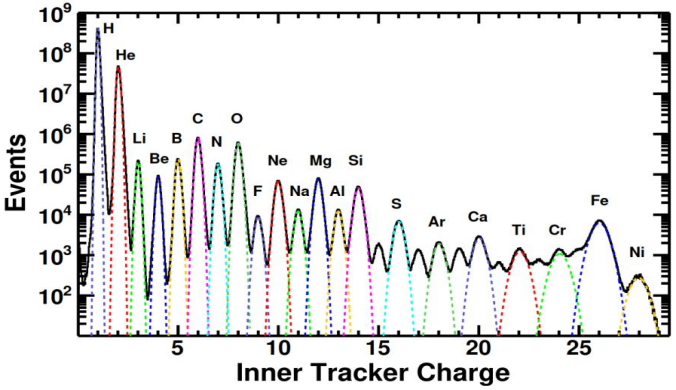
- Beryllium (Be) is produced in the spallation reaction of C, N, O with ISM
- Isotopes of Be that are found in cosmic rays: **$^{7}$Be, $^{9}$Be and $^{10}$Be**
- **$^{10}$Be: β - radioactive**-> Relatively longer life-time
- Constrain confinement time **$H^2/D$** : removes degeneracy between parameters
  - Existing measurements are sparse-> **No real constraint on H values**
  - Prediction from usual tools (eg. B/C) : **LESS precise than real measurement**



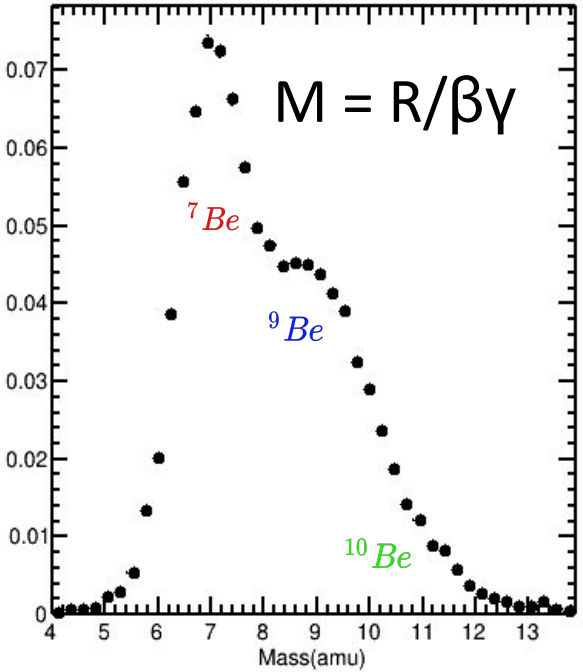
# Measuring Be isotope ratios

**1)** Good charge resolution:
**Selection of Beryllium**




**2)** **Distinction of isotopes**

- Mass from Rigidity (R) and β
- Rigidity from Inner + L1
- β from different sub-detectors




| | ToF | NaF | AgI |
|---|---|---|---|
| Δβ/β | 1% | 0.4% | 0.1% |
| Ekin Energy range | 0.51-1.55 GeV/n | 1.55-3.61 GeV/n | 3.61-12.18 GeV/n |

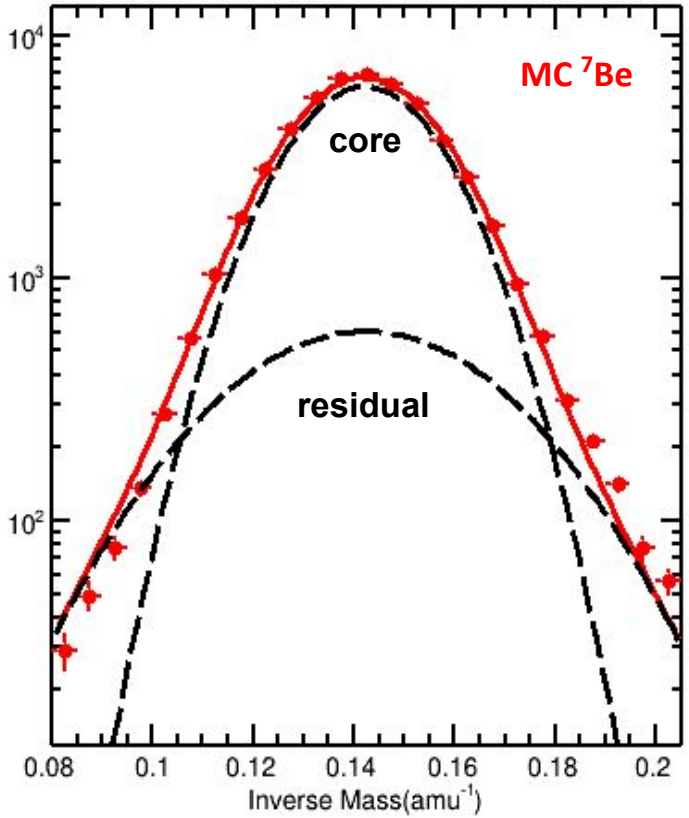
# Beryllium Data Sets

- **General Selections**
  - $\beta_{TOF} > 0.3$
  - ISS is not in SAA
  - Inner Trk: at least one hit each plane
  - $\chi^2_y < 10$
  - L1+Inner fiducial volume
- **Charge Selections (Identify Be and remove fragmentations)**
  - 3.38 < Ly1 Trk< 4.65
  - 3.55 < Inner Trk < 4.45
  - 3.4 < Upper ToF < 5.5
  - RMS(Q) <0.55
- **ToF Quality**
  - $\chi^2_{coo} < 5,\ \chi^2_T < 10$
- **RICH Quality**
  - N_pmt>2 (NaF: 10)
  - N_pe(ring)/N_pe(total)>0.4
  - $|\beta_{TOF} - \beta_{\to RICH}| < 0.06\beta_{RICH}$
  - Remove bad tiles
  - Geometric selections

**Total statistics:**

- ISS (V7_pass7) ~7.5 years data
- MC (B1220): $^{7}$Be, $^{9}$Be, $^{10}$Be

# Mass Template Modelling (1)

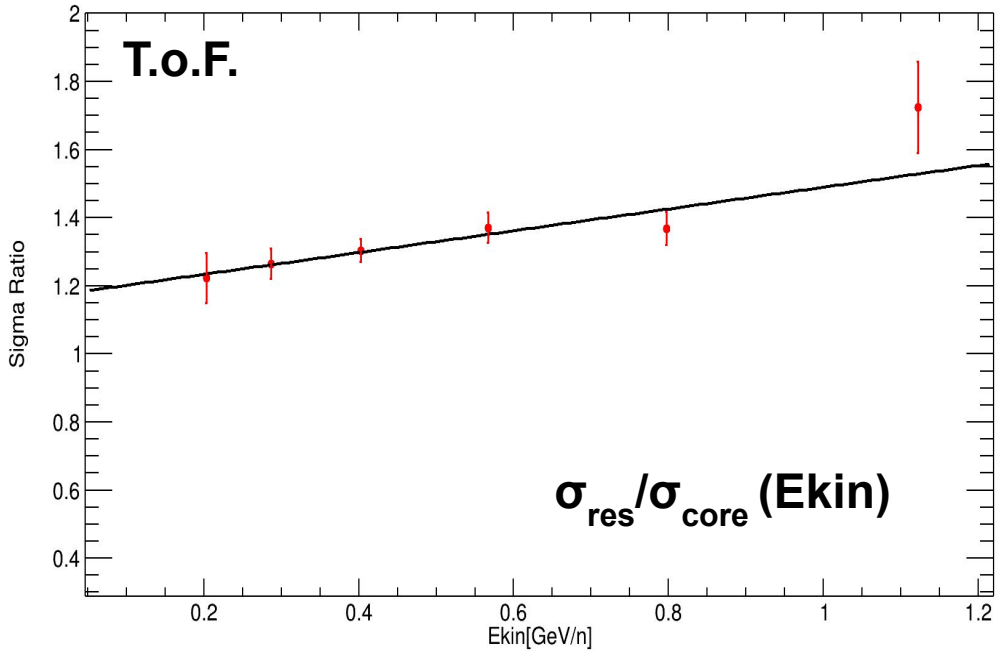



## Model of Inverse mass from MC

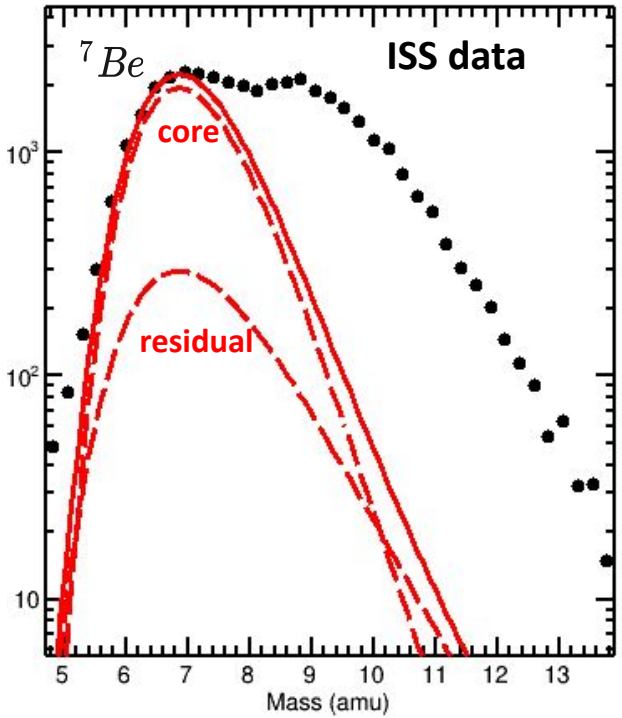
- **Double-gaussian:** Core and residual
- From MC Inverse mass distribution
- Parametrization:
  - $\mathbf{A_{core}}$: Height of core gaussian
  - **μ**: same for core and residual
  - **σ**: dev. St. of core
  - $\mathbf{A_{res}/A_{core}}$: residual/core ratio
  - $\boldsymbol{\sigma_{res}/\sigma_{core}}$: dev. st. of residual by core

# Mass Template Modelling (2)

- Energy dependent parametrization for every parameter
- Simple linear models for parameter evolution
- Independent parametrizations for ToF, NaF and Agl



# Mass distribution fit (1)

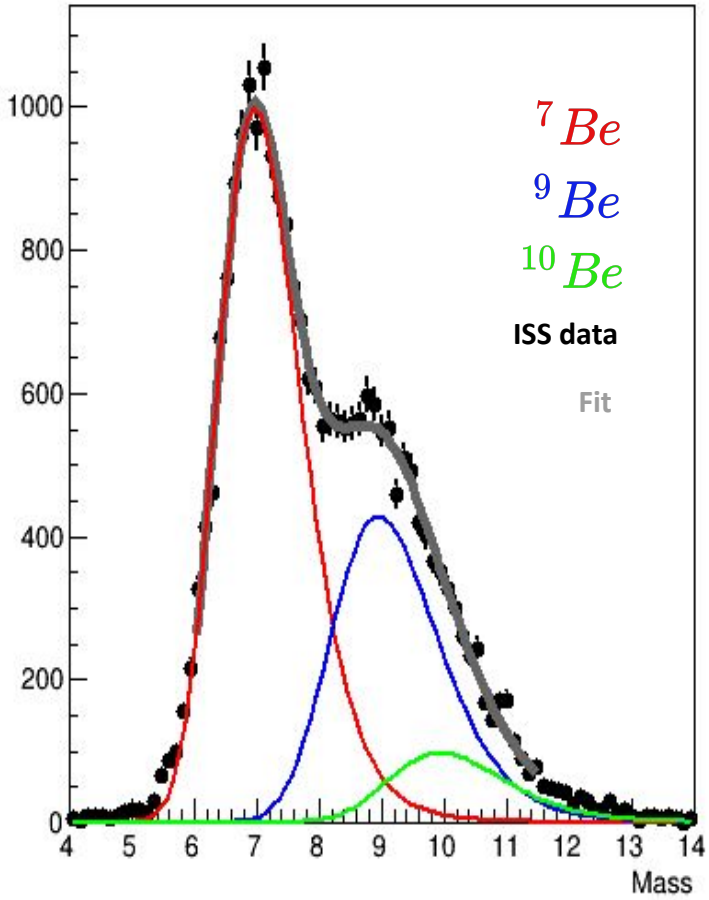



1. We adapt the templates to describe mass distribution

2. We obtain templates for all the isotopes rescaling $^7$Be

   - $\mu_x \rightarrow$ **(x/7)** $\mu_7$
   - $\sigma_x \rightarrow$ **(x/7)** $\sigma_7$

# Mass distribution fit (2)



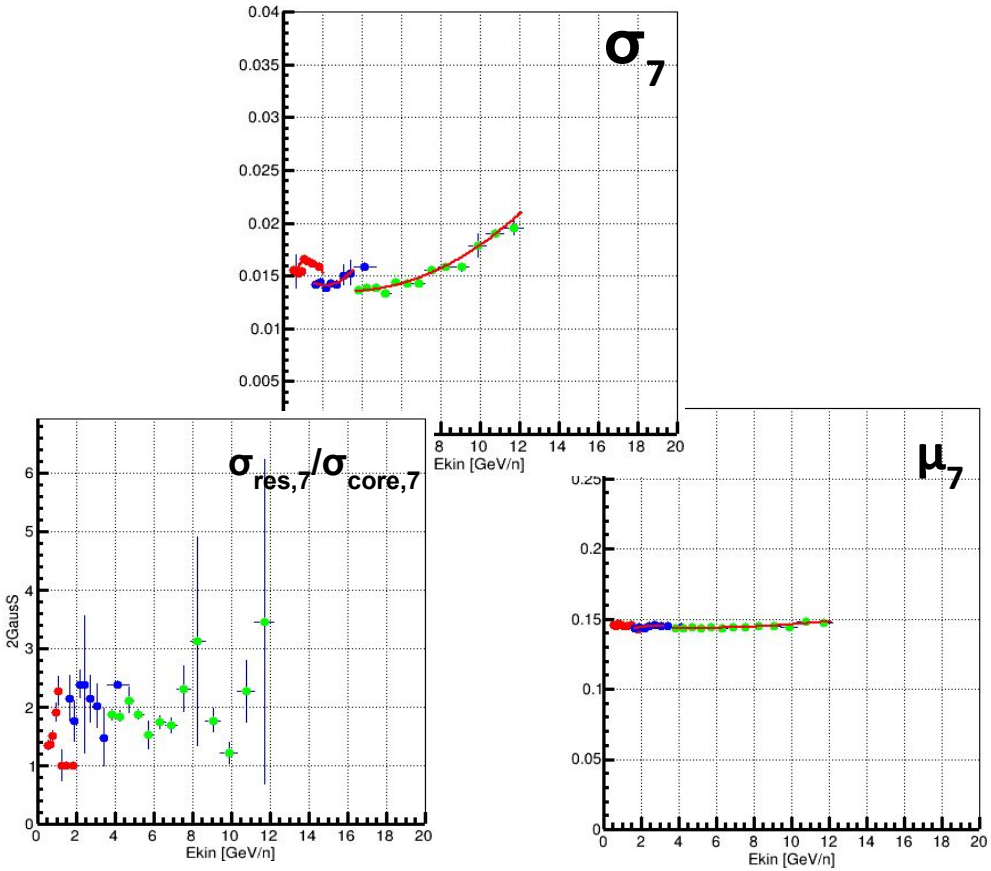

## "Free" parameters of the Full Be Model:

- $A_7$: Height of $^{7}$Be
- $A_9/A_7$: height of $^{9}$Be w.r.t $^{7}$Be
- $A_{10}/A_7$: height of $^{10}$Be w.r.t $^{7}$Be
- $\sigma_7$: dev. st. of $^{7}$Be core gaussian
- $\mu_7$: Mean of $^{7}$Be at peak

## "Shape" Parameters (studied from MC)

- $A_{res,7}/A_{core,7}$
- $\sigma_{res,7}/\sigma_{core,7}$

# Energy dependent fit procedure (Two fits)

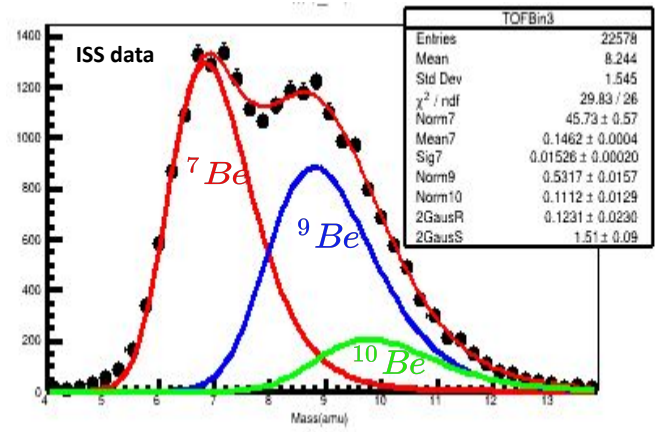



1. **First fit:**
   a. Free parameters loosely constrained
   b. “Shape” parameters constrained around MC parametrized values
2. **Regularization:** Polynomial fit of free parameter trends
3. **Final fit:**
   a. MC parametrizations and polynomials as starting points
   b. ~10% level freedom for param. fit

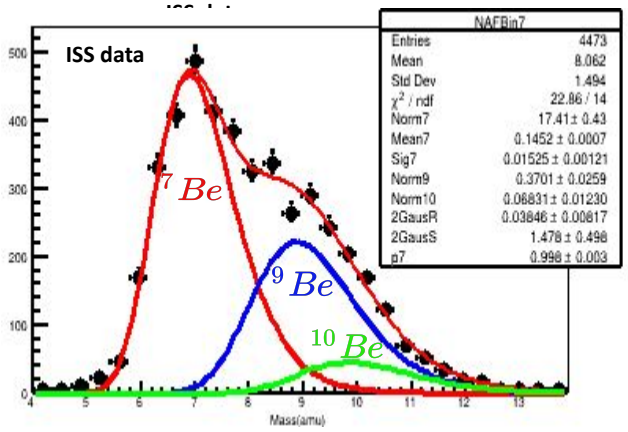
# Examples of Mass fits

: Model fit

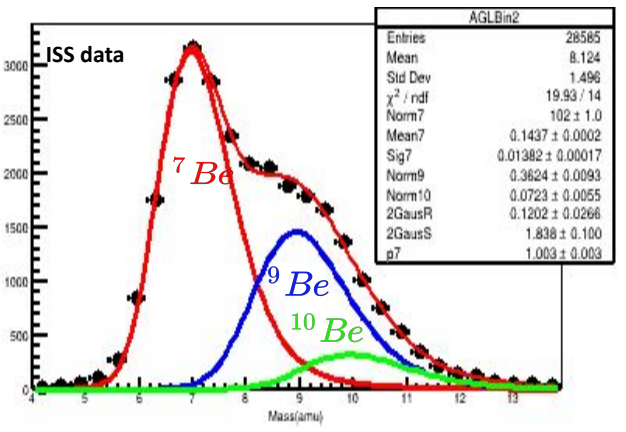
## ToF




## NaF

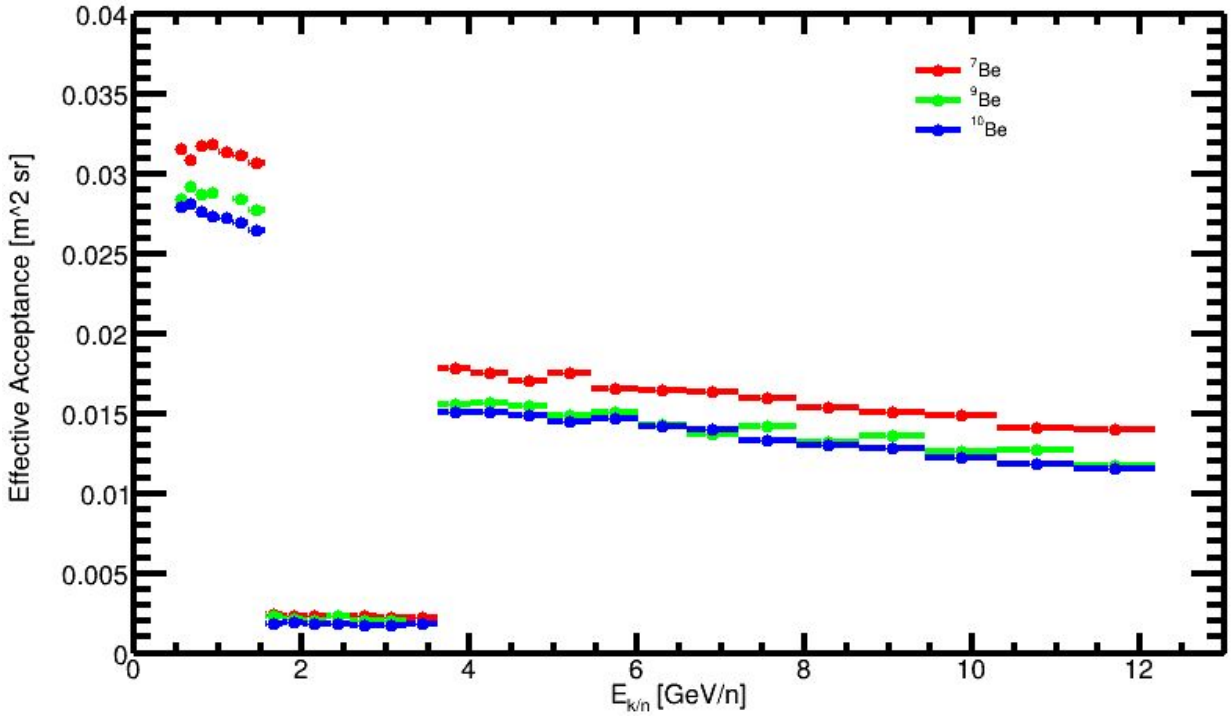



## AgI

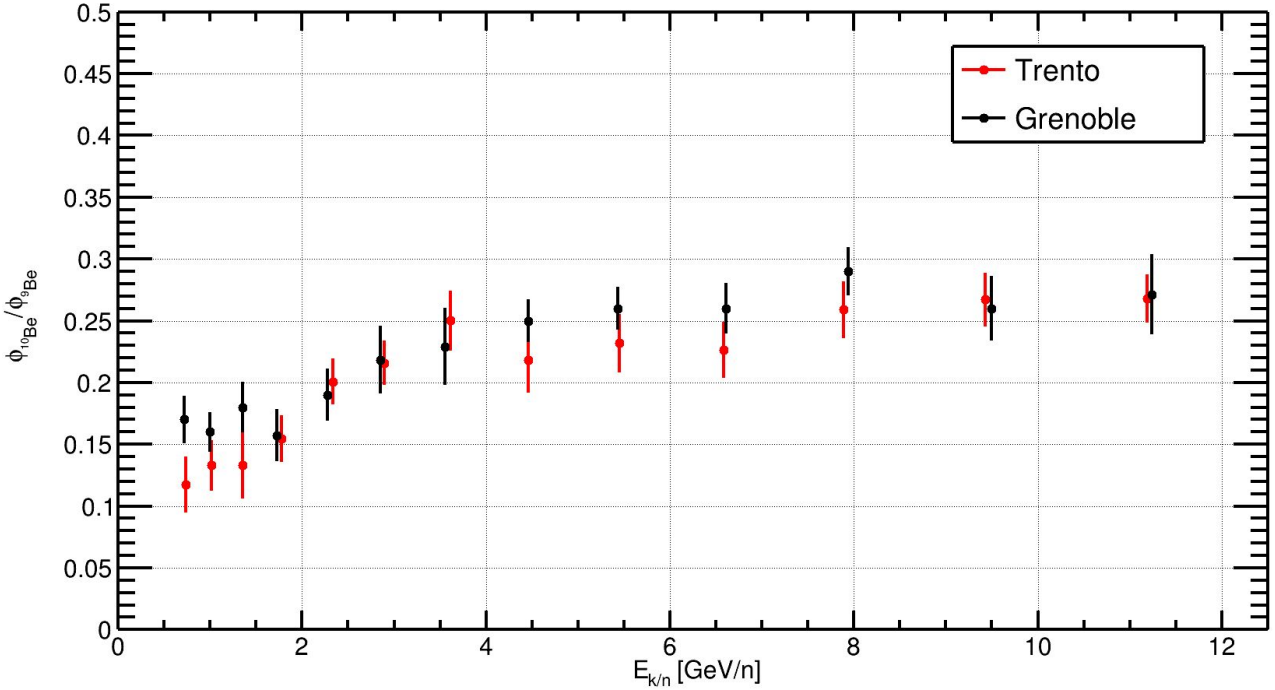


# Effective Acceptance

- L1 pickup correction
- Tracking correction
- Against Interaction
- Beta ToF correction
- Beta NaF correction
- Beta AgI correction
- Fragmentation uncertainty: 5% systematics on 10Be

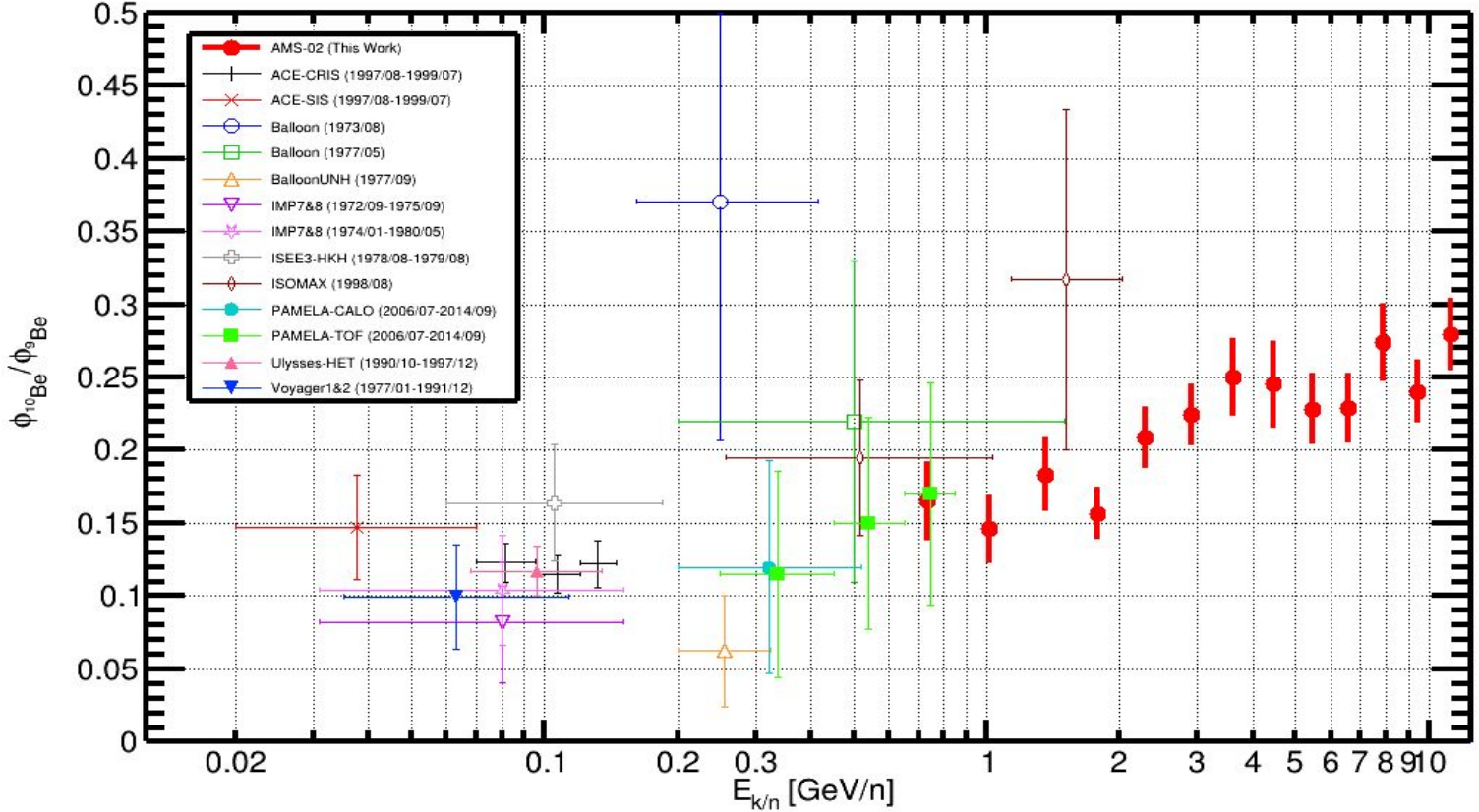


# Be10/Be9 Flux Comparison

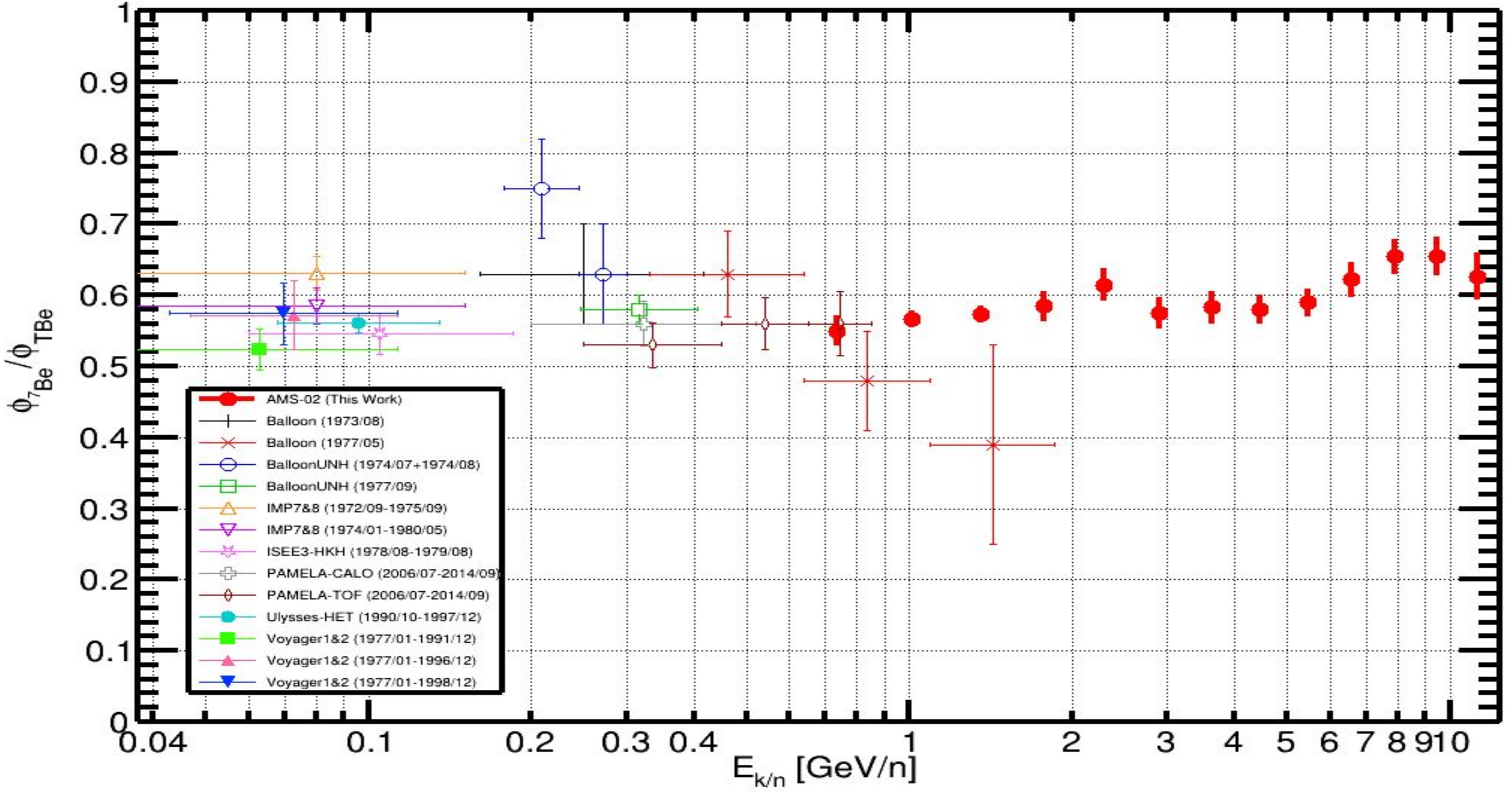



P.S: Grenoble points shifted for comparison

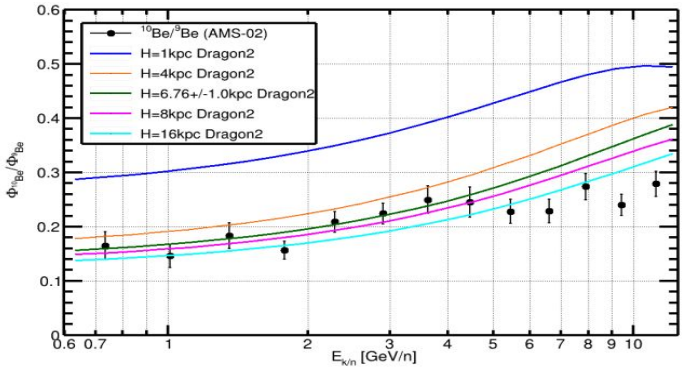
# Be10/Be9 Flux Comparison



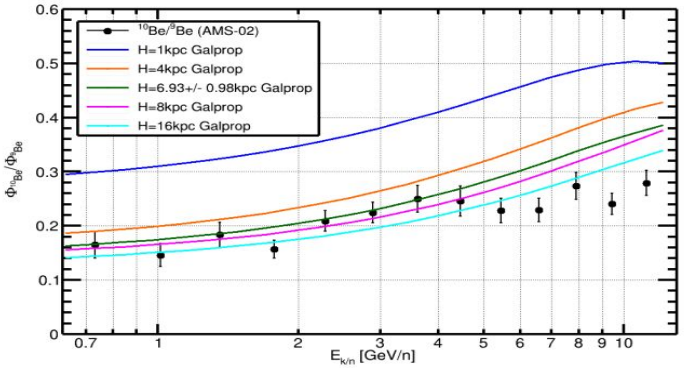
# Be7/Total Be Flux Comparison



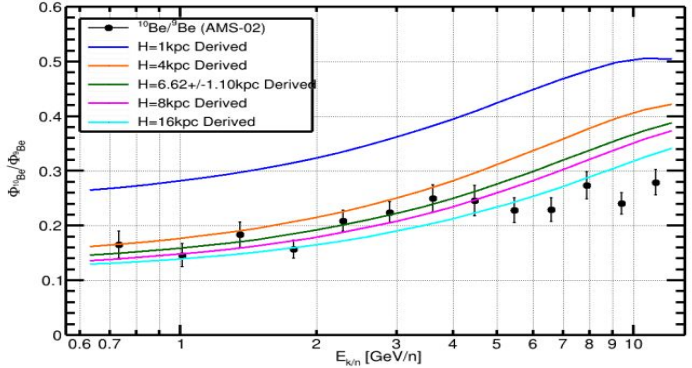
# Halo Thickness Sensitivity



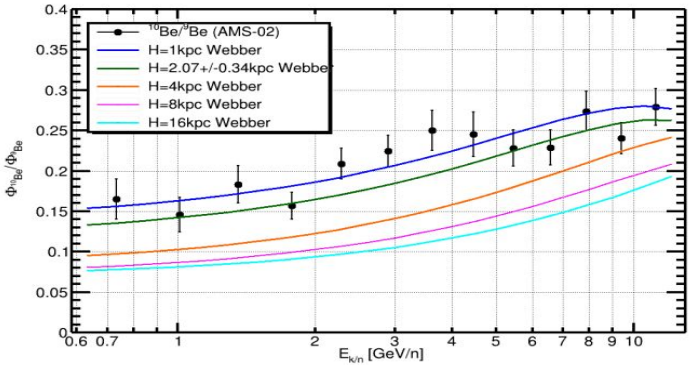

(a) $^{7}Be$




(b) $^{9}Be$




(c) $^{7}Be$




(d) $^{9}Be$

# Conclusion and On-going

- Be Analysis with an analytical bi-gaussian model.
- We did the analysis again with the agreed bin division.
  Rebinned for comparison with other groups
- On going: Flux Calculation and systematics

**Thanks for your attention**