Sibyll with charm

Eun-Joo Sein Ahn

with

Ralph Engel, Tom Gaisser, Paolo Lipari, Todor Stanev

ISVHECRI June 30th 2010

Current official Sibyll version is : 2.1

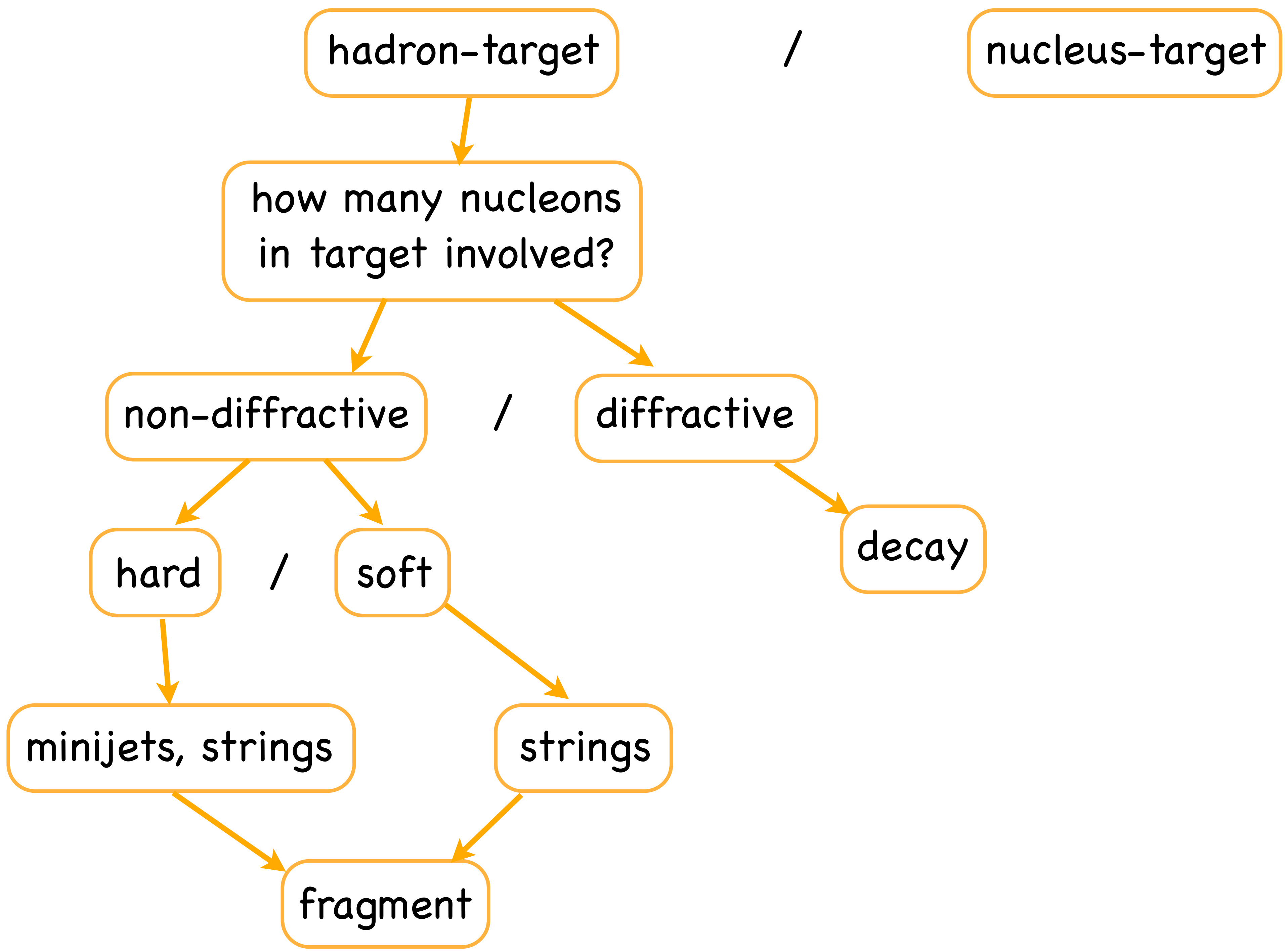
- 2.2 : small improvements from 2.1
  - current version quite successful but has shortcomings as well ;
- 2.2c: above with charm addition
  - include charm: more complete, prompt muons and neutrinos.

2.2 & 2.2c not public yet, will be shortly

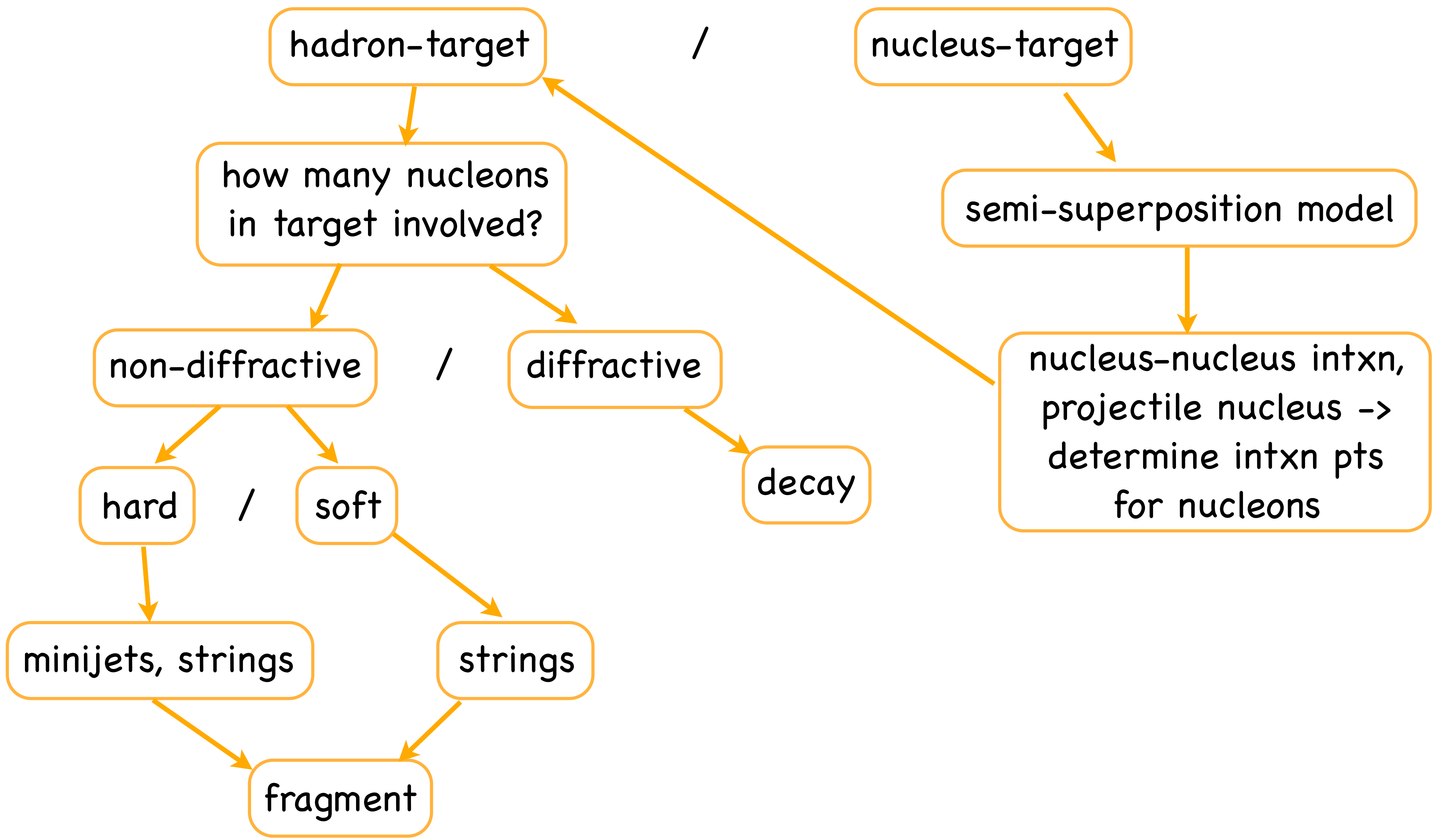
✤ Ingredients of Sibyll :

- dual parton model: quark+antiquark // quark+diquark
- string fragmentation
- minijets
- eikonal formalism
- hard interaction: electron form factor
- soft: minimal Regge theory
- GRV parton distribution functions (post-HERA)
- diffraction: two channel eikonal based on Good-Walker model
- semi-superposition model for nucleus-nucleus interaction
- partons: u, d, s, gl
- projectiles: $\pi^{0,+,-}$, $K^{0,+,-}$, p, n, Nucleus(A=1-56)
- target: Nucleus (A=1-56)
- E_{CM} = 10 - 10^7 GeV (E_{lab} > 100 GeV)

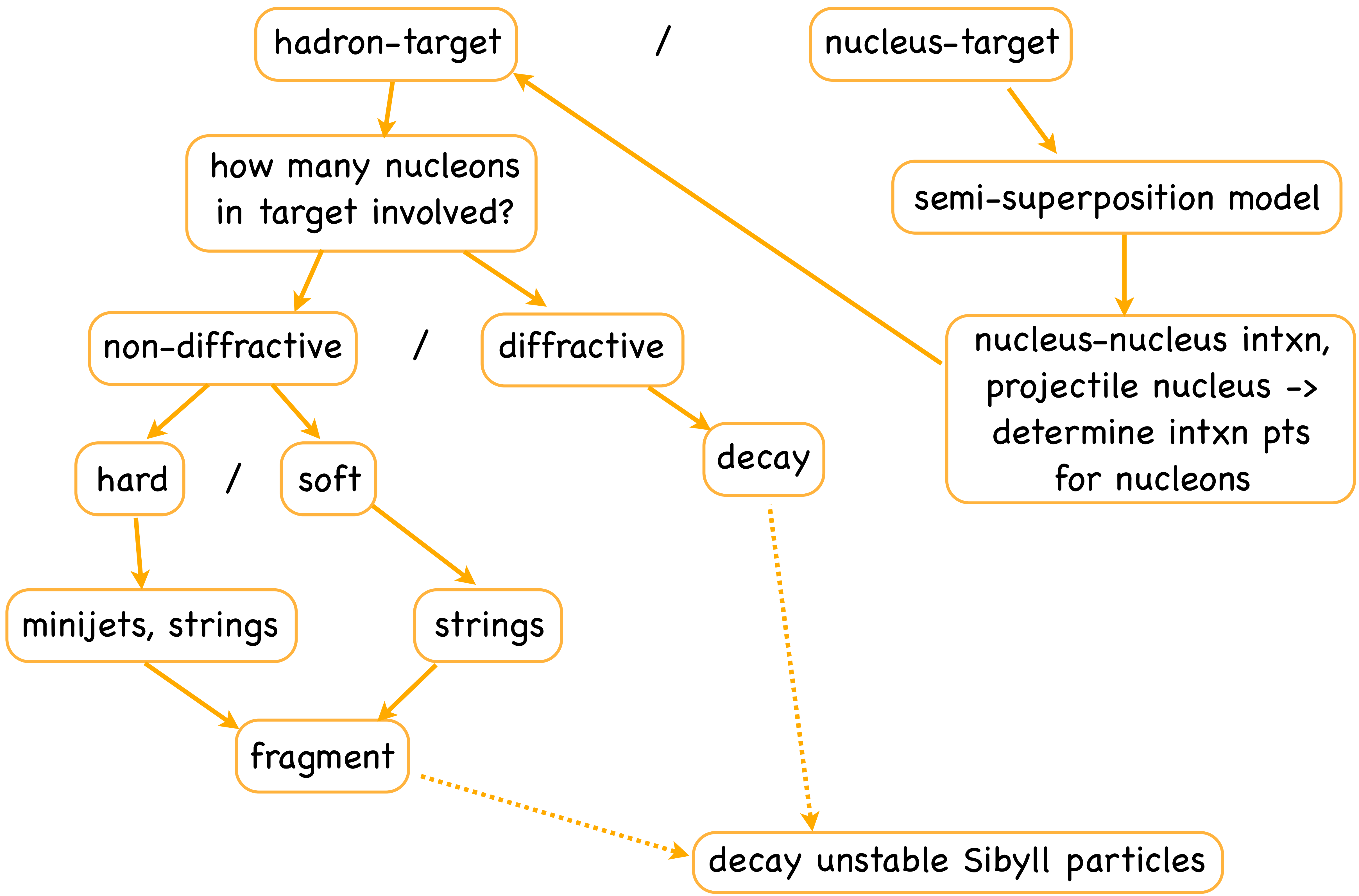
Overall structure



Overall structure



Overall structure



✤ New to 2.2c:

1. Charm quark added

2. Smoother diffraction - non-diffraction transition
   - increase phase-space ("fireball") decay range
   - non-sharp distribution of diffracted particle's energy

3. Minor bugfix
   - better p_T, higher multiplicitiy

4. Increased s quark fraction

✤ Charm addition

- mesons & baryons : D, η_c, J/ψ, Λ_c, Ξ_c, Σ_c, Ω_c

- charm created via branching ratio from s formation:
  - cross section set by branching ratio = 0.004 ($P_{s/u}$ & $P_{us/ud}$ = 0.3)
  - valance s quark do not change to c
  - along string fragmentation, branching ratio from strange qq or dq-dq
  - automatically get leading Λ_c

- $\langle p_T \rangle$ = 1.5 GeV/c for baryons, 1.0 GeV/c for mesons
  - larger $\langle p_T \rangle$ than non-c particles (0.3 - 0.6 GeV/c)

- Peterson/SLAC fragmentation function f(z)

$$f(z) \propto \frac{1}{z\left(1 - \frac{1}{z} - \frac{\epsilon_Q}{1-z}\right)^2} \qquad \epsilon_Q \propto 1/m_Q^2 = 2$$

(other particles use Lund fragmentation function)

String fragmentation

q or qq at end

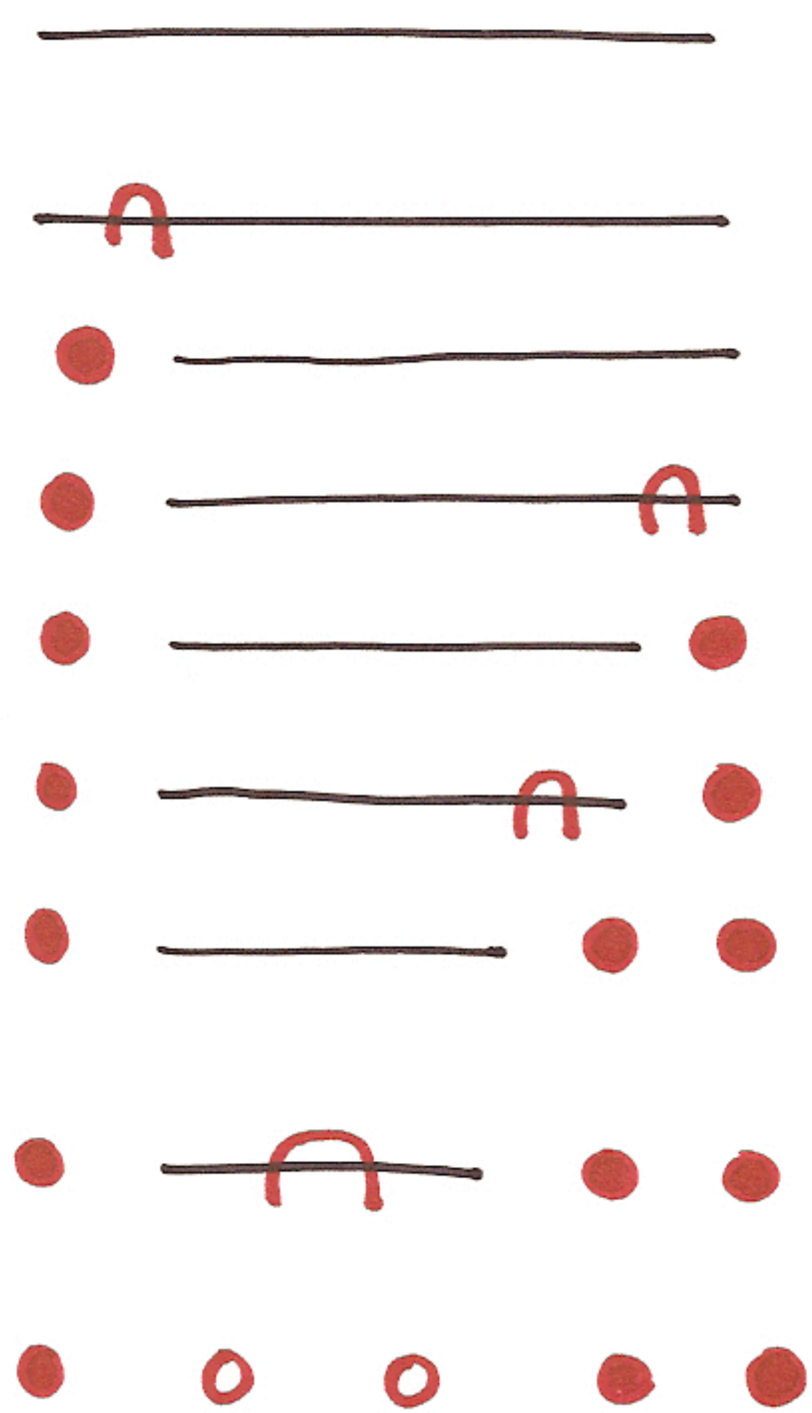
$q\bar{q}$ or qq–$\overline{qq}$ pair inserted

string end + q/qq -> particle

particle forms, new string end

string mass decrease

final two hadrons



String fragmentation

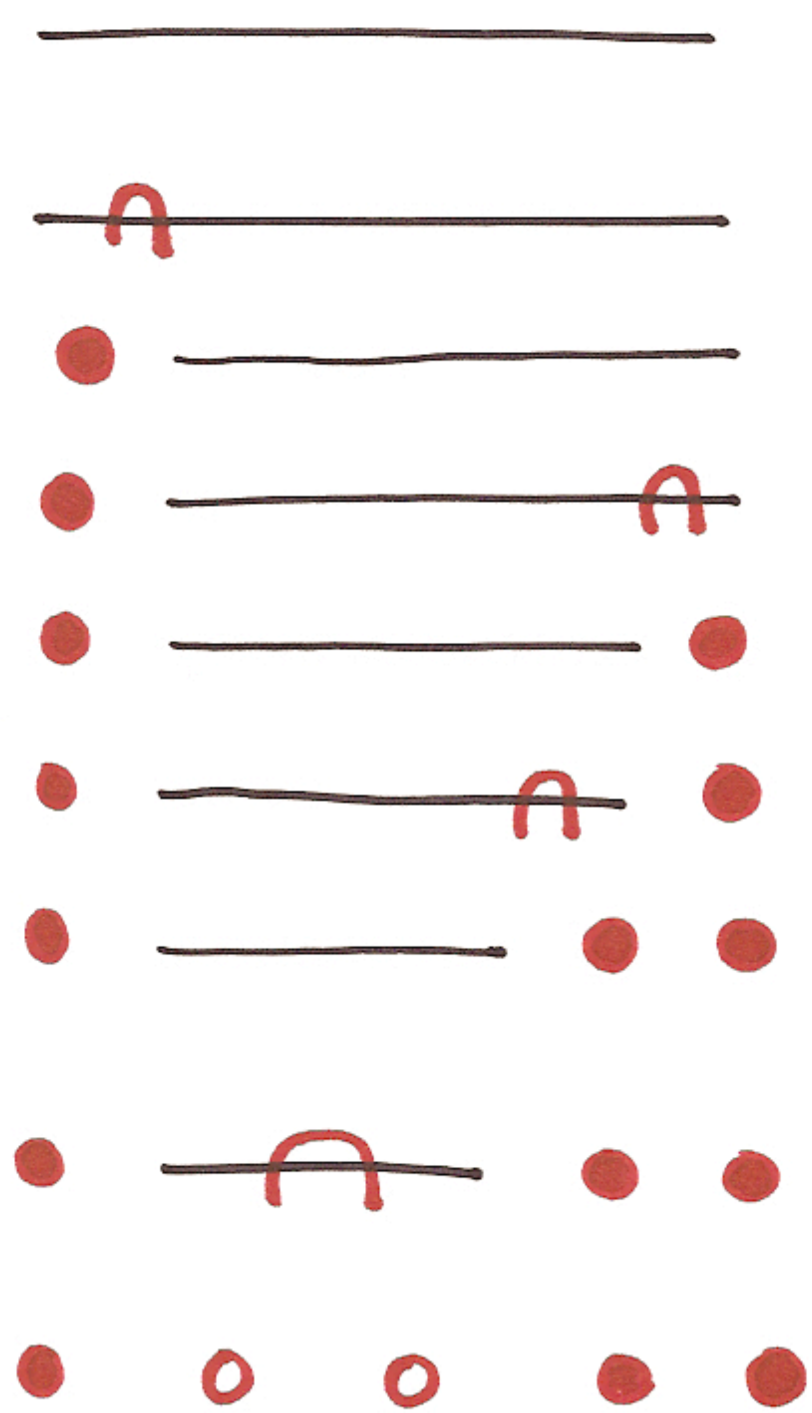
q or qq at end

no charm at ends

$q\bar{q}$ or qq–$\overline{qq}$ pair inserted

string end + q/qq -> particle

particle forms, new string end



s->c conversion

c particles get different p_T & f(z)

string mass decrease

final two hadrons

✤ Experimental data used:

1. LEBC-EHS : E_{lab} = 400 GeV, p-p,

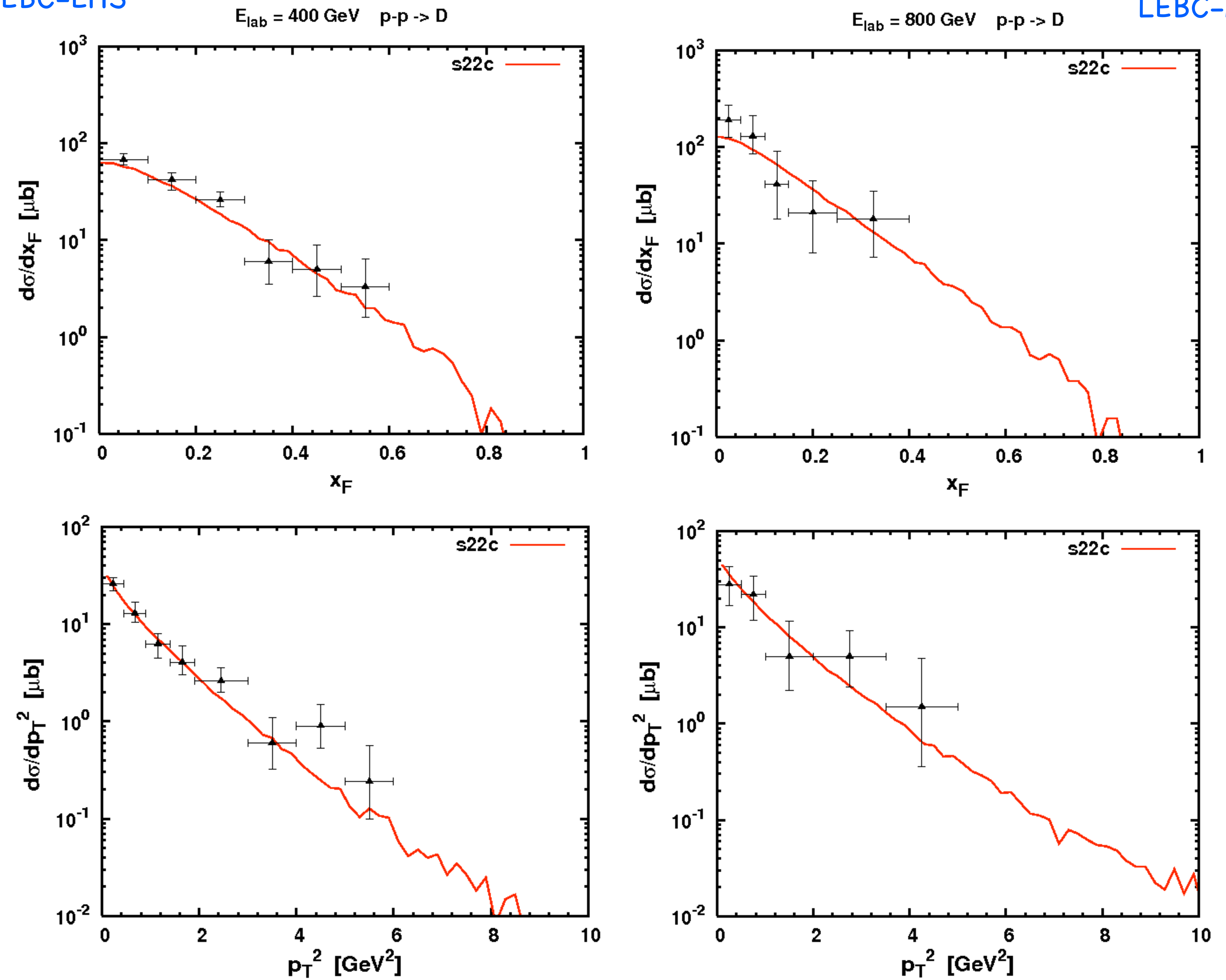
   - all D

2. LEBC-MPS : E_{lab} = 800 GeV, p-p

   - all D

LEBC-EHS

LEBC-MPS



✤ Experimental data used:

1. LEBC-EHS : E_{lab} = 400 GeV, p-p,

   - all D

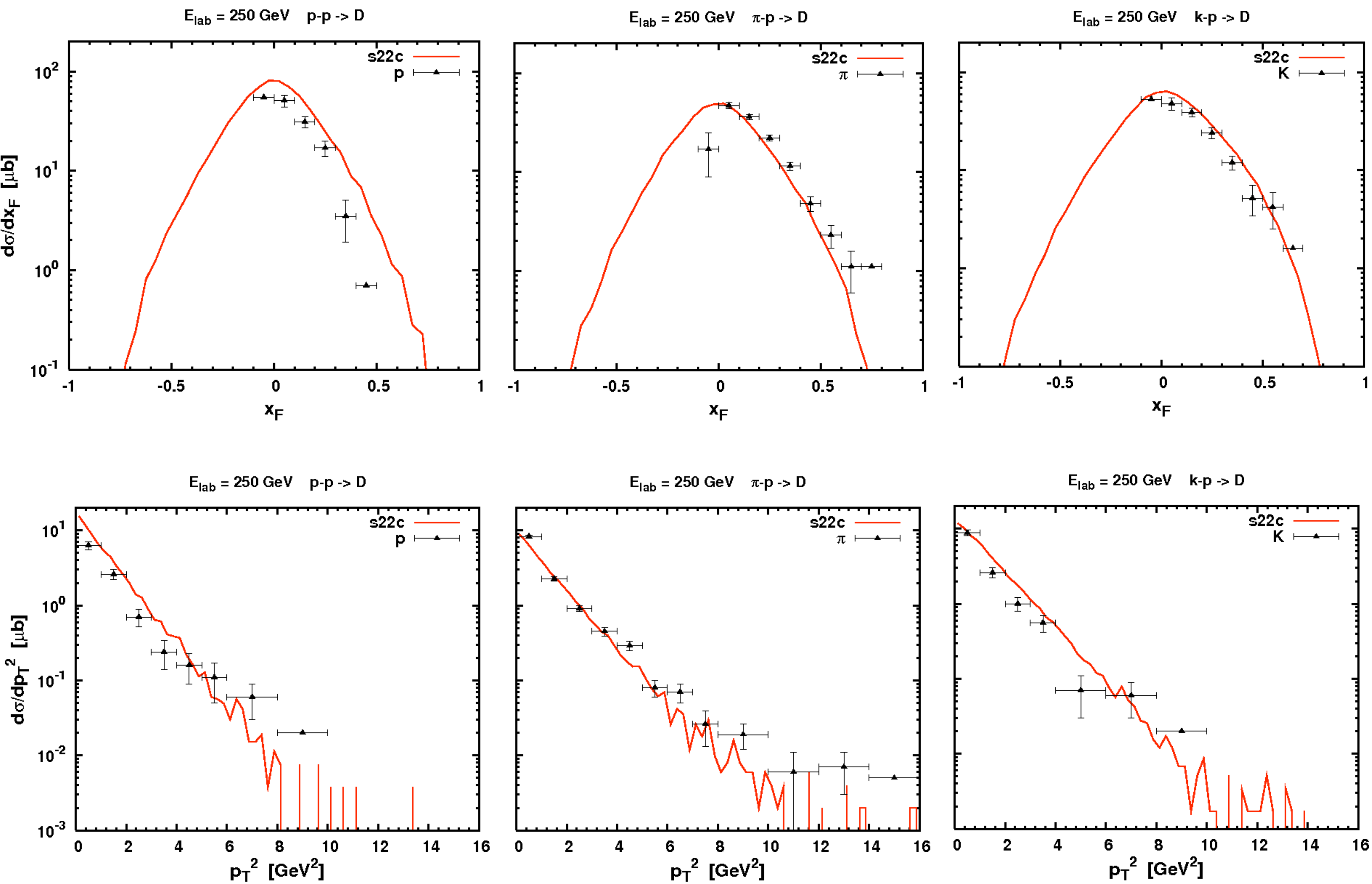
2. LEBC-MPS : E_{lab} = 800 GeV, p-p

   - all D

3. E769 : E_{lab} = 250 GeV p π^{+-} K^{+-} beam on nuclei target (in /nucleon),

   - p target used in simulations - nucleus mass scaling verified
   - all D

E769



E$_{lab}$ = 250 GeV p-p -> D
E$_{lab}$ = 250 GeV π-p -> D
E$_{lab}$ = 250 GeV k-p -> D
s22c
p
π
K
dσ/dx$_F$ [μb]
x$_F$
dσ/dp$_T$^{2} [μb]
p$_T$^{2} [GeV^2]

✤ Experimental data used:

1. LEBC-EHS : E_{lab} = 400 GeV, p-p,

   - all D

2. LEBC-MPS : E_{lab} = 800 GeV, p-p

   - all D

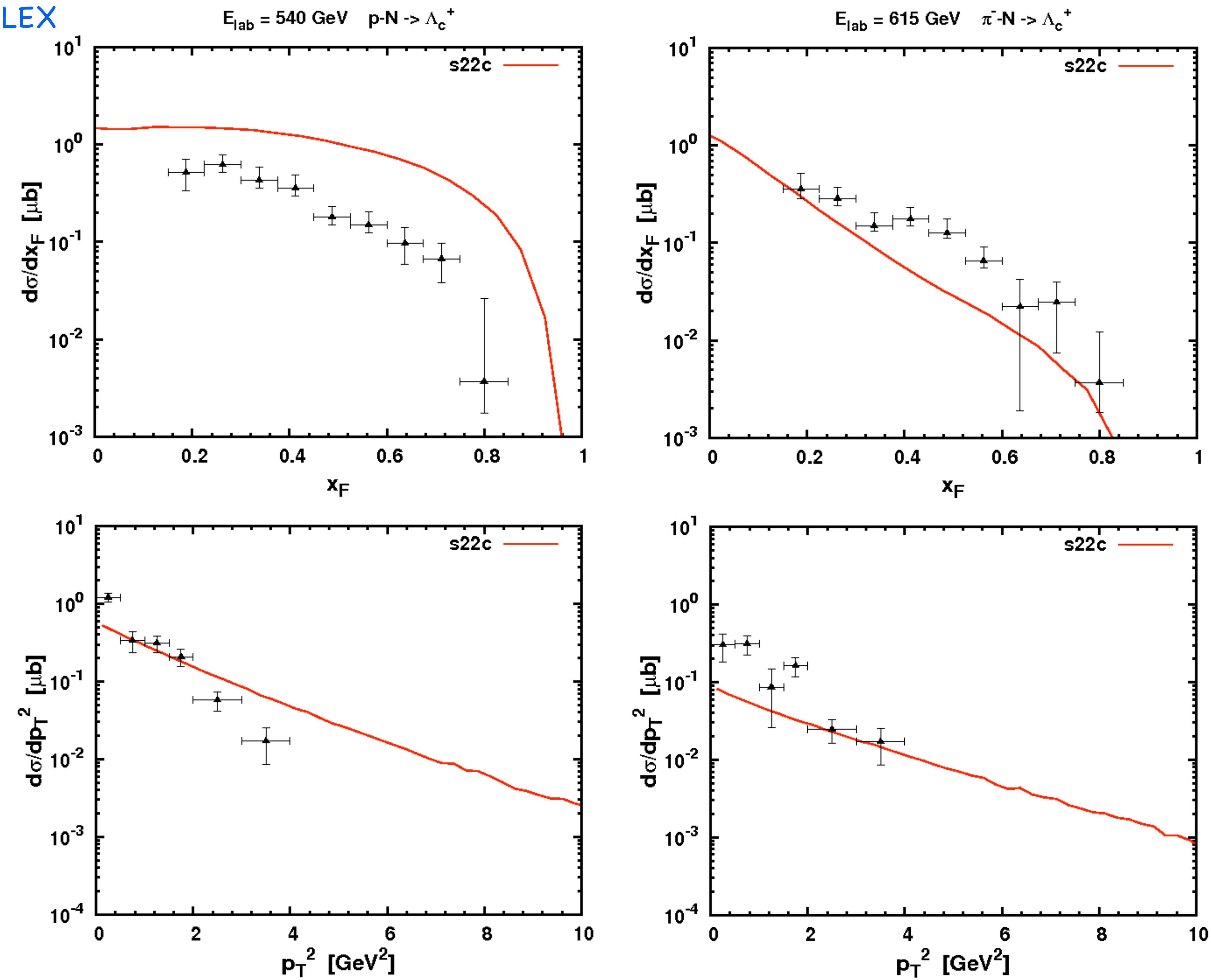
3. E769 : E_{lab} = 250 GeV p π^{+-} K^{+-} beam on nuclei target (in /nucleon),

   - p target used in simulations - nucleus mass scaling verified
   - all D

4. Selex : E_{lab} = 615 GeV (π^-), 540 GeV (p), on nuclei target

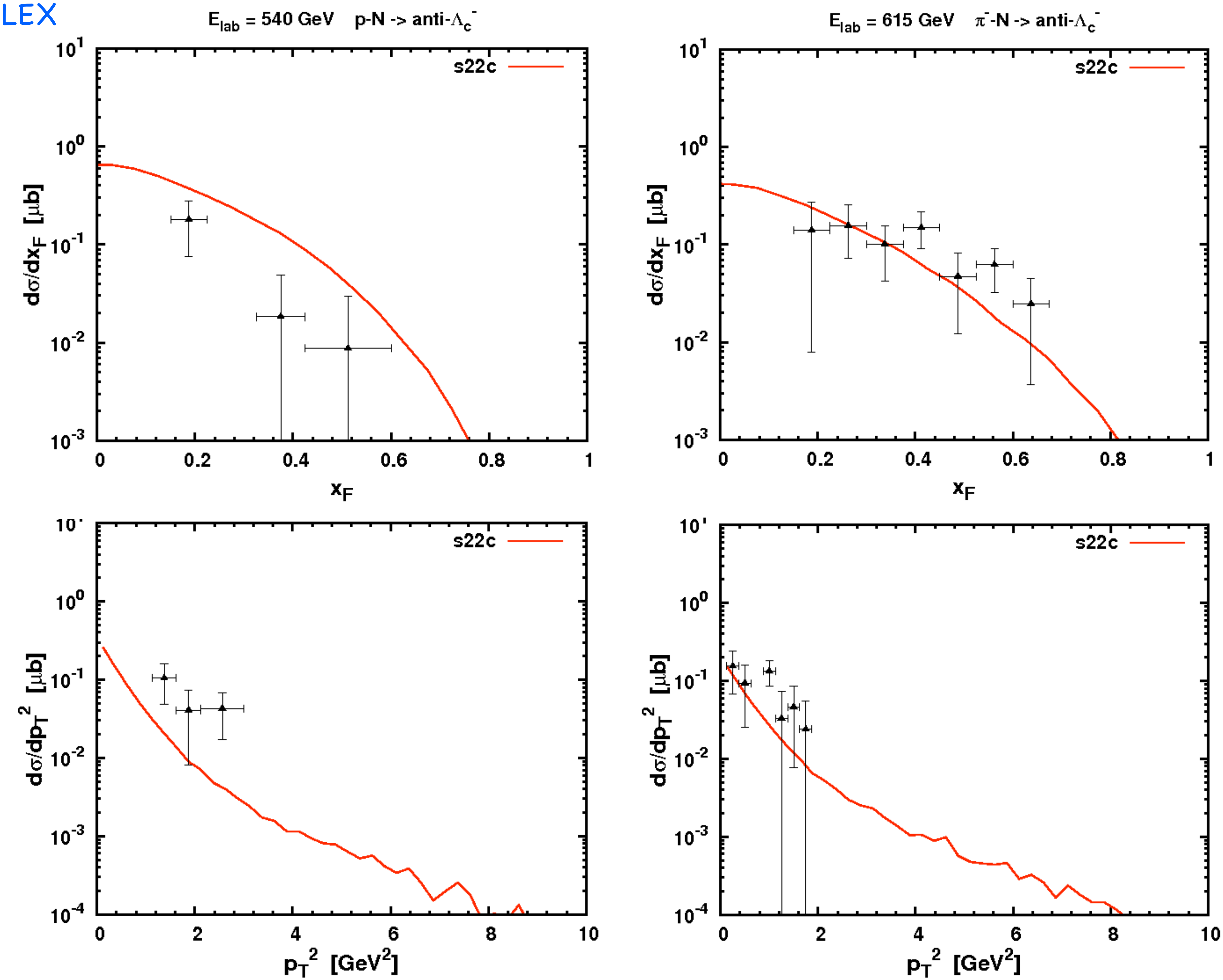
   - N target used in simulations
   - no absolute normalisation given
   - Λ_c & anti-Λ_c

SELEX



E_lab = 540 GeV p-N -> Λc+
E_lab = 615 GeV π⁻-N -> Λc+
s22c
dσ/dx_F [μb]
x_F
dσ/dp_T^2 [μb]
p_T^2 [GeV^2]
10^1
10^0
10^-1
10^-2
10^-3
10^-4
0
0.2
0.4
0.6
0.8
1
2
4
6
8
10

SELEX



E_lab = 540 GeV p-N -> anti-Λc-
E_lab = 615 GeV π--N -> anti-Λc-
s22c
dσ/dxF [μb]
xF
dσ/dpT2 [μb]
pT2 [GeV2]

To do:

- Final minor tuning remains;
- Usage of other experimental data - shortage of charm baryons:
  - E791: 500 GeV, π^- beam-nucleon, D
  - ISR data Λ_c with new normalisation?

To do:

- Final minor tuning remains;
- Usage of other experimental data - shortage of charm baryons:
  - E791: 500 GeV, π^- beam-nucleon, D
  - ISR data Λ_c with new normalisation?

Summary

- Sibyll 2.1 -> 2.2c has charm quark added

- charm forms along strang fragmentation, simple but effective with 4 parameters

- Will be released after final tunings

larger-scale update of Sibyll is underway